CUY-90-14.90

PID 77332/85531

APPENDIX GE-06

CUY 90 Field Monitoring Reports
(Reference Document)

State of Ohio
Department of Transportation
Jolene M. Molitoris, Director

Innerbelt Bridge
Construction Contract Group 1 (CCG1)

Revision Date: December 1, 2009

CUY-90-1524
Central Viaduct
PID No. 20752

Monitoring Services
Annual Report

June 1, 2006

RICHLAND ENGINEERING LIMITED
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100109

June 2, 2006

Ohio Department of Transportation
5500 Transportation Boulevard
Garfield Heights, Ohio 43215

Attn: Mr. Mike Malloy

Re: CUY-90-1524
Central Viaduct
PID No. 20752
Monitoring Services
Annual Report

Dear Mr. Malloy:

Enclosed are two (2) copies of the following information:

- BBC&M Engineering, Inc.'s Annual Report dated May 2006 with information on the inclinometer readings taken through April 2006.
- Richland Engineering Limited schematic drawings of span 1 and 2, north and south truss measurements; relative span lengths; deck expansion joint openings; seat elevations; tabulations of pier location data; and plots of pier location data through October 2005.
- A. Huckelbridge tiltmeter data for pier 1 and the west end pier from July 27, 1999 through May 3, 2006.
- R. Liang's annual instrumentation monitoring report dated May 2006.
- CD containing electronic files of the letter and annual report in .pdf format.

Note: For discussion, North is assumed to the left, perpendicular to the local centerline of bridge, toward Lake Erie.

The rock anchors were tensioned in April 1999 which put the stabilization structure in service. Site grading work was complete in May 1999. The span 1 superstructure was relocated in August 1999.

A "West End Slope and Substructure Evaluation" May 2005 was prepared by Richland Engineering Limited, BBC&M Engineering, Inc., Arthur Huckelbridge, and Robert Liang. The study was prepared for ODOT and evaluated the suitability of the existing west end pier, pier 1, west end slope, and slope stabilization structure for reuse in a rehabilitated structure.

The last annual report was dated May 25, 2005, for data collected through April 2005.

We have the following observations on the data collected:

1. A shallow failure plane is evident in data from inclinometers B-203, B-303, and B-110. B-203 and B-303 are located upslope of pier 1 and show an average rate of movement at the shallow failure plane of 0.06 inches per year. B-110 was destroyed in mid-March 2006, by excavation activities performed to repair a failed bulkhead to the north. Inclinometer B-110 was located north of pier 1 and showed an average rate of movement at the shallow failure plane of 0.15 inches per year.

2. A deep failure plane is evident in data from inclinometers B-102, B-105, B-107, B-108, B-110, B-203, B-204, and B-303. B-102 and B-107 are located at the top of the slope west of the west end pier and show an average rate of movement at the deep failure plane of 0.02 inches per year. B-203 and B-303 are located upslope of pier 1 and show an average rate of movement at the deep failure plane of 0.08 inches per year. B-204 is located between the pier 1 legs and shows an average rate of movement at the deep failure plane of 0.05 inches per year. Inclinometer B-105 is located south of the drilled shaft structure and shows an average rate of movement at the deep failure plane of 0.20 inches per year. Inclinometer B-108 is located north of the anchor structure and shows an average rate of movement at the deep failure plane of 0.03 inches per year. Inclinometer B-110 was located north of pier 1 and shows an average rate of movement at the deep failure plane of 0.01 inches per year.

3. Inclinometer B-105 and B-108 can no longer be read due to deflection of the casings.

4 The movement rates at the shallow and deep failure planes have been consistent or slightly decreased since 1999.

5. Inclinometer B-101, at the top of the slope west of the west end pier, has shown no significant movement since it was installed.

6. BBC&M's inclinometer P#9N is the same inclinometer tube as Dr. Liang's inclinometer #9B. The readings are consistent and similar showing about 0.4 inch top displacement and a bending deflection 50 feet down the shaft of about 0.8 inch.

7. Piezometer readings have shown no significant change from previous readings. The maximum change in water elevation during the past year occurred in B-105 blue and varied by 1.9 feet. Piezometers B-105 pink and B-105 blue continue to indicate an elevated water level.

8. The Calipered Crack Distance measurements at the top of the concrete slope protection by the west end pier show no significant change. The measurements are showing an average movement of 0.06 inches per year since 1999.

9. No aggregate piles were observed at the site in the area adjacent to the south right of way fence in April 2006. A large aggregate pile was observed in April and July 2001, January 2002, September and October 2003, and January 2004, south of the right of way fence. No large aggregate pile has been observed in the area since January 2004. A relatively small aggregate pile was observed in July and October, 2005, and February, 2006.

10. Comparing October 2005 survey measurements with October 2000 data, it appears that the west end pier and/or pier 1 have moved in relation to each other with the span 1 distance increasing and the span 2 distance decreasing about 0.64 inches.

11. No significant change in the position of the west end pier legs or rockers has been measured since October 2000.

12. The position of the top of each of the north and south legs of pier 1 appear to have moved toward the river approximately 0.70 inches and 0.94 inches, respectively, since October 2000.

13. The drilled shaft structure appears to be rotating with the south end moving ahead of the north end about 0.72 inches since October 2000.

14. There has been no significant change (less than 0.4 inches) in the pier seat elevations.

15. In 1999, truss span 1 and 75% of span 2 were relocated to the west by approximately 3 inches to reopen the expansion joint in span 2. Since the relocation, maximum expansion joint openings have been measured of 2.38 inches at the north curb and 1.88 inches at the south curb. During the past year the openings varied from 0.75 inch to 1.75 inches at the north curb and 0.38 inch to 1.13 inches at the south curb for steel temperatures ranging between 26˚ and 74˚F. It appears that about 0.63 inches of expansion opening has been lost since October 2000.

16. Tiltmeter readings have been relatively steady for the past year showing rates and magnitudes of movement similar to past readings with the exception of tiltmeter #1. Tiltmeter #1 had a westward tilt, correcting the previous 15 months of continuous eastward tilt. There is indication of movement of the top of the pier 1 legs with temperature changes. The west end pier legs appear to be continuing their long-term trends of spreading (north west end pier tilting to the north and south west end pier tilting toward the south) and both west end piers tilting toward the river. The truss and approach span superstructures have rocker nests to accommodate movement in the transverse direction, minimizing the impact of the west end pier tilting on the structure.

17. The instrumentation readings in the rock anchors, driven piles, and tieback beams have been steady. The instrumentation readings in the drilled shafts have shown a continued increase in bending moments. Inclinometers in the drilled shafts are also showing increased deflections.

18. The 17 rock anchors are made up of 16 strands of 0.6 inch diameter 270 ksi steel material. The anchors were initially tensioned to ±10% of the design load. Actual measured values in the 4 anchors being monitored were 490 kips to 600 kips at lock-off. After initial losses the anchors had a gradual reduction in load on the order of 3% to 9% in the first year. Present load levels in the anchors being monitored are 365 kips to 487 kips. The rock anchor loads continue to decrease at a slow rate.

19. The 34 anchor structure piles are HP14x89 steel piles. Actual measured values in the 5 piles being monitored were 370 kips to 470 kips for piles #17, 18, 19, and 34 with pile #1 measured at 606 kips. There is significant bending (up to 203 kip-ft.) in some of the piles at the gage locations. The gages are located at the top of the pile. The pile loads have increased very slowly since the stabilization structure was loaded.

20. The tiebacks that are being monitored between the anchor structure and the drilled shaft structure are W8x35 rolled steel sections. Actual measured values in the 5 tiebacks being monitored were 112 kips to 144 kips at the anchor structure end, and 39 to 113 kips at the drilled shaft structure end. There is significant bending (up to 52 kip-ft.) in the tiebacks at the gage locations at the ends of the tiebacks. There is less bending in the tiebacks at the drilled shaft structure end. The tieback loads increased with time for the first year, but have become steady over the past four years with one exception. The load in tieback #26 has continued to slowly increase on the driven pile end cap. The tieback forces oscillate through one cycle in a year due to the seasonal change in temperature. The tieback forces are up to 20 kips higher during the winter than in the summer months.

21. There are seventeen 72 inch diameter reinforced concrete filled drilled shafts in the drilled shaft structure. Actual moments measured in the drilled shafts were a maximum of 1,800 kip-feet at a depth of 95 feet in Shaft #9. The moments in the drilled shafts have been increasing with time at a fairly constant rate.

22. Dr. Liang has been monitoring 7 inclinometers in 6 of the drilled shafts. The inclinometers indicate a gradual change in the deflection of the shafts with deflection at the top varying from 0.2 to 1.2 inches and the maximum deflection below the top of the shaft at 1.6 inches in the longitudinal direction.

We have the following comments regarding the evaluation and monitoring data:

1. There is movement at the shallow failure plane within the influence of the stabilization structure, but it is moving at a slower rate than the adjacent soil mass. The movement is at a consistent rate of about 0.06 inches per year.

2. There is movement at the deep failure plane within the influence of the stabilization structure, but it is also moving at a slower rate than the adjacent soil mass. The movement is at a consistent rate of about 0.05 inches per year.

3. The tops of the west end pier legs have not moved significantly since October 2000, the year after the superstructure was relocated.

4. The tops of the pier 1 legs have moved toward the river and closed the span 2 expansion joint about 0.63 inches since October 2000.

5. The pier 1 and truss superstructure instrumentation performed for the "West End Slope and Substructure Evaluation Study" has shown that the tops of the pier 1 legs are moving west and east with expansion and contraction movement of the steel superstructure. The movement and horizontal thrust in the superstructure varies with temperature.

6. The substructure stabilization structure was originally designed using “LPILE” computer software to calculate forces and member design loads. The Contractor was given loads and designed the rock anchors, anchor structure and tiebacks to resist those loads.

   Under a separate ODOT sponsored research project Dr.Robert Liang prepared a finite element analysis of the stabilization structure as it was being constructed (“Long Term Monitoring at CUY-90-15.24 Bridge Project,” December 31, 1999).

   The original design loads, the finite element analysis (FEA), and the range of measured values are compared in the attached table.

   a. Rock anchor loads are less than design and FEA values and continue to decrease at a slow rate.

   b. The loads in the piles are higher than expected. The anchor structure pile gages are located near the top of the piles in an area of localized bending. The combined axial load and bending may have exceeded the 36 ksi yield value of the steel. However, the piles will redistribute the load in the redundant system through yielding before failure would occur.

   c. The axial tension in the tiebacks is less than the design load and slightly higher than the loads calculated by FEA. Again, combined axial load and bending may approach yield at isolated locations, but the members should not fail.

   d. The moment in the piles and tiebacks and the bending in the drilled shafts indicates a rotation of the anchor structure concrete cap about the transverse axis of the cap.

   e. The drilled shaft measured moments and deflections are well below the design values. The increasing moments and deflections measured in the drilled shafts both indicate increased bending in the shafts. The bending is expected as the soil mass lateral loading is gradually transferred to the drilled shafts. The rate of moment increase appears to be constant.

7. The stabilization structure is currently performing adequately with only some minor concern for the high loads in the anchor structure piles. The stabilization structure has slowed the rate of creep movement in the soil mass within its influence.

7. The stabilization structure is currently performing adequately with only some minor concern for the high loads in the anchor structure piles. The stabilization structure has slowed the rate of creep movement in the soil mass within its influence.

8. Loading and pressures within the stabilization structure and the influenced soil mass are continuing to increase at a uniform slow rate. The rate of change of moment in the drilled shafts has not slowed. The stabilization structure was designed with the concept that the structure and soil mass would reach equilibrium at some time in the future when loads and deflections would remain constant. However, the "West End Slope and Substructure Evaluation Study" has suggested that the stabilization structure may have a finite life. The creep movement at the failure planes has historically moved at a very slow rate, and data collected over the past 7 years indicates that the overall rate of movement is not slowing.

We have the following recommendations:

1. Install new inclinometers in the vicinity of existing abandoned inclinometers B-105 and B-108 immediately adjacent to the stabilization structure.

2. Install new inclinometers in the area of original inclinometers B-106 (south) and B-110 (north) to monitor the slope movement outside of the influence of the stabilization structure.

The next readings are scheduled about July 15, 2006. The monitoring will continue by the same parties under a new agreement between ODOT and Michael Baker Jr., Inc.

Please contact us if you have any questions.

Very truly yours,

RICHLAND ENGINEERING LIMITED

Dean A. Palmer, P.E.

DAP:lm
Enc.
cc: Craig Hebebrand, District 12 w/enc.
Tim Keller, Office of Structures w/enc.
Gene Geiger, Office of Geotechnical Services w/enc.
Tom Lefchik, FHWA w/enc.
Steve Pasternack, BBC&M w/enc.
Art Huckelbridge w/enc.
Robert Liang w/enc.
Bob Parker, Michael Baker Jr., Inc. w/enc.
Rick Engel, E.L. Robinson Engineering Co., w/enc.

COMPARISON OF MEMBER LOADS
DESIGN VALUES AND MEASURED VALUES
CUY-90-1524 SLOPE STABILIZATION STRUCTURE

MEMBER	DESIGN	FINITE ELEMENT ANALYSIS	January 2001 MEASURED	January 2002 MEASURED	April 2003 MEASURED	April 2004 MEASURED
Rock Anchors	550 kips	550 kips	430 to 530 kips	400 to 510 kips	380 to 501 kips	370 to 494 ki
Anchor Structure Piles						
Axial Load	279 kips	310 kips	358 to 566 kips	362 to 583 kips	365 to 585 kips	368 to 594 ki
Moment	None	80 kip-feet	32 to 192 kip-feet	8 to 191 kip-feet	49 to 192 kip-feet	49 to 199 kip-f
Tiebacks						
Axial Load - Anchor End	192 kips	100 kips	101 to 124 kips	99 to 124 kips	108 to 134 kips	111 to 139 ki
Axial Load - Drilled Shaft End	192 kips	100 kips	58 to 111 kips	55 to 112 kips	46 to 110 kips	45 to 113 kip
Moment - Anchor End	None	80 kip-feet	13 to 42 kip-feet	13 to 43 kip-feet	14 to 48 kip-feet	14 to 49 kip-fe
Moment - Drilled Shaft End	None	80 kip-feet	1 to 29 kip-feet	1 to 30 kip-feet	2 to 29 kip-feet	1 to 30 kip-fe
Drilled Shafts						
Deflection at Top	2.0 inch	0.4 inch	0.2 inch	-0.2 to 0.6 inch	-0.1 to 0.7 inch	0.1 to 1.1 inc
Maximum Deflection Below Top	4.0 inch	0.1 inch	0.4 inch	1.0 inch	1.3 inch	1.5 inch
Maximum Moment	3,141 kip-feet	800 kip-feet	1,000 kip-feet	1,045 kip-feet	1,400 kip-feet	1,600 kip-fee
Maximum Axial Force	458 kips	420 kips	1,100 kips	2,382 kips	3,000 kips	3,250 kips

BBC&M ENGINEERING, INC.
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Phone (216) 901-1000 Fax (216) 901-9996

May 22, 2006
012 00829.100

Richland Engineering Limited
Mr. Dean A. Palmer, P.E.
29 North Park Street
Mansfield, Ohio 44902

Re: CUY-90-15.24
Inclinometer Readings
2005-2006 Annual Report

Dear Mr. Palmer:

This Annual Report summarizes the data obtained during the period of July, 2005 to April, 2006. In July, 2005 a total of 10 inclinometers, 6 piezometers and 2 calipered crack locations were currently being monitored. As of the end of the quarterly readings in April, 2006, the number of active inclinometers was reduced from 10 to 7. The inclinometers at B-105, B-108, and B-110 have been moved to the inactive list of inclinometers for the project. The reasons for eliminating these inclinometers from the monitoring program are subsequently discussed. The number of active piezometers and calipered crack locations has remained unchanged as of April, 2006.

Included with this report in the Appendix is the following:

1) A Bridge Plan showing the locations of the instrumentation;
2) Incremental and Cumulative Deflection vs. Depth plots for all inclinometers;
3) Time vs. Displacement plots;
4) Calipered Surface Distance table;
5) Linear Regression Plot with 95% Confidence Interval for B-303.

Inclinometers

B-105 Inclinometer

One inclinometer that has been removed from the active list for the subject project is the inclinometer at B-105. On January 4, 2006, BBCM personnel attempted to read the inclinometer at B-105. No unusual problems were observed in lowering the probe down to the bottom of the casing. However, when the probe was pulled up, it became lodged in

the "kink" in the pipe present at about 110 feet below the existing ground surface where a distinctive shear plane has been observed. In an attempt to dislodge the probe, BBCM personnel had to pull hard on the cable, which apparently damaged cable connections as error messages on the data collector were observed. The cable was sent to the Durham Geo Slope Indicator Company (DGSI) for repair in Mukilteo, Washington, near Seattle. The remaining inclinometer, piezometer, and caliper readings for the quarter were taken on February 1, 2006, when the repaired cable was returned to BBCM.

BBCM decided that the inclinometer at B-105 had passed its "useful" life and would no longer be monitored by BBCM as of January, 2006 to prevent the possibility of further damage or even loss of equipment. The last successful readings taken from the B-105 inclinometer were in October, 2005. BBCM has been authorized by ODOT District 12 to install a replacement inclinometer for the B-105 inclinometer, which is expected to be completed by the end of May, 2006.

B-108 and B-110 Inclinometers

Another inclinometer that has been removed from the active list of inclinometers for the subject project is the B-108 inclinometer. During the January, 2006 reading of the B-108 inclinometer, the data became erratic near the observed slip plane at a depth of 120 feet below the ground surface. These issues were able to be corrected in the field and reasonable readings were obtained. BBCM personnel has periodically encountered difficulties lowering the probe passed the "kink" at the observed shear plane depth of 120 feet, although, it had not been as problematic as the B-105 inclinometer, where the inclinometer equipment was ultimately damaged. Due to the damage risk to the inclinometer monitoring equipment, in addition to the B-105 inclinometer, the B-108 inclinometer was believed to have passed its "useful" life and it was stated in BBCM's quarterly report dated February 7, 2006, that BBCM would no longer monitor the B-108 inclinometer.

In mid-March, 2006, BBCM personnel observed major excavation activities being performed apparently in an effort to repair the failed bulkhead in the vicinity of the inclinometer at B-110. BBCM suggested to Richland Engineering Limited (REL) that additional readings should be taken at the nearest inclinometers to the B-110 inclinometer, which was destroyed as a result of the excavation activities. Per a telephone conversation with Mr. David Rinehart of REL on March 21, 2006, BBCM received authorization to read the nearest inclinometers to the B-110 inclinometer. On March, 22, 2006, one set of readings was taken from each of the inclinometers at B-107, B-203, B-303, B-204, and even the previously inactivated B-108 inclinometer. Due to the excavation activities and the sensitive nature of the west abutment area when modifications are made to the slope, BBCM decided it was critical to attempt a reading in the B-108 inclinometer to determine if any slope movements were accelerated by the excavation activities. A dummy probe was rented from DGSI, which is of similar size and shape as a real inclinometer but much less expensive. The dummy probe was lowered down the B-108 inclinometer on March 22, 2006 to determine if there would be issues with the probe becoming lodged in the "kink" at the slip plane depth of 120 feet.

After the dummy probe was lowered to depth and subsequently raised successfully out of the inclinometer casing, it was determined that it would be safe to use the inclinometer probe to read the B-108 inclinometer. A reading was taken in the B-108 inclinometer on March, 22, 2006.

An additional reading was also taken at B-108 during the regular quarterly readings in April, 2006. However, BBCM has been authorized by ODOT District 12 to install a replacement inclinometer for the B-108 inclinometer, which is expected to be completed by the end of May, 2006. Consequently, readings will no longer be taken in the B-108 inclinometer unless otherwise requested by ODOT District 12 or REL.

New Inclinometers

In addition to installing replacement inclinometers at B-105 and B-108, BBCM has been authorized by ODOT District 12 to install nine (9) new inclinometers mainly on the west side of the existing I-90 bridge as part of an extended subsurface study of the west abutment and central pier (pylon) of the proposed CUY-90-15.24 bridge over the Cuyahoga River. Based on BBCM's accepted proposal, dated February 1, 2006, monitoring of all the old active and new inclinometers will begin in July, 2006. Baseline readings of the new inclinometers will take place sometime before the July quarterly readings. There have been some discussions with District 12 about replacing the B-110 inclinometer; however, a decision had not yet been made at the time this report was prepared.

Inclinometer Data Observations

Twist measurements were performed in January, 2005 on the 10 inclinometers that were active at the time. All the data sets presented in the Appendix have been corrected to account for the measured twist of the inclinometer casings. The Cumulative and Incremental Deflection plots in the Appendix show one reading from each of the previous four quarters plus the readings taken in some of the inclinometers in March. The Time-Displacement plots, however, include at least one reading from each year since the initial set of readings. As no readings were able to be taken from the B-105 and B-110 inclinometers this quarter, the last four readings taken from these inclinometers are included on the Cumulative and Incremental Deflection plots.

Lateral deflections from slope inclinometer measurements contain both random and systematic errors. DGSI gives the following orders of accuracy for slope inclinometer measurements as follows:

1) Ordinary precision of ± 0.3 inches per 100 ft of casing using standard installation procedures;
2) Higher Precision of ± 0.1 inches per 100 ft of casing with careful survey practices and error correction during data reduction; and
3) Highest Precision of ± 0.05 inches per 100 ft of casing with careful survey and data selection from redundant data sets and excellent installation of the casing.

The data presented herein are considered to have a precision in the range of ± 0.1 to ± 0.2 inches per 100 ft. Hence, any displacements (especially on deep failure planes) on the order of about 0.2 inches could be due to data errors and not actual field movements. The actual rates of slope movement are in the range of 0.1 inches per year on the two slide planes. Therefore, all discussions regarding trends in the data will be developed based upon multiple years of data.

The rates of movement were computed using linear regression for the depth ranges shown on the Time-Displacement plots in the Appendix. Linear regression provided a best-fit match through the data points on each of the time-displacement curves. The time period for the linear regression was chosen based on a visual observation of each curve at the time when the rate was believed to have last changed significantly. For each analyzed slide plane the 95% confidence interval of the regression falls within the range of the expected precision of the inclinometer measurements (about 0.2 inches per 100 ft). Therefore, it is the opinion of BBCM that rates of movements have remained relatively constant (with only slight changes subsequently discussed) over the selected time ranges, the shortest of which is 4 ½ years for B-204. A plot of the linear regression and the 95% confidence interval is provided for B-303 in the Appendix.

Table 1 below summarizes the average rates of movement for the shallow and deep failure planes and time ranges chosen for each inclinometer. In all cases, the time range extends to the last set of readings taken within each respective inclinometer. The inclinometers where movements have been observed have been divided into four categories based on location as follows; the immediate vicinity of the Pier 1 area (B-105, B-108, and B-204), upslope from Pier 1 (B-203, B-303), well outside the Pier 1 area (B-110), and south of West End Pier (B-102, B-107).

Table 1a: Average Rate of Movement in Inclinometers on the Shallow Failure Plane

Shallow Failure Plane			
Inclinometer	**Location**	**Time Range**	**Avg. Rate of Movement (in/yr)**
B-203	Upslope from Pier 1	Apr-99 to Apr-06	0.03
B-303	Upslope from Pier 1	Apr-99 to Apr-06	0.08
Average Rate of Movement – Upslope from Pier 1			**0.06**
B-110	Well Outside of Pier 1 Area	Jul-99 to Jan-06	0.15

Table 1b: Average Rate of Movement in Inclinometers on the Deep Failure Plane

Deep Failure Plane			
Inclinometer	**Location**	**Date Range**	**Avg. Rate of Movement (in/yr)**
B-102	South of West End Pier	Oct-00 to Apr-06	0.02
B-107	South of West End Pier	Apr-00 to Apr-06	0.015
Average Rate of Movement – South of West End Pier			**0.02**
B-105	Immediate Vicinity of Pier 1 Area	Apr-99 to Oct-05[1]	0.20
B-108	Immediate Vicinity of Pier 1 Area	Apr-00[1] to Apr-06	0.03
B-204	Immediate Vicinity of Pier 1 Area	Aug-01[1] to Apr-06	0.05
B-203	Upslope from Pier 1	Apr-99 to Apr-06	0.03
B-303	Upslope from Pier 1	Apr-99 to Apr-06	0.12
Avg. Rate of Movement – Upslope/Immediate Vicinity of Pier 1			**0.09**
B-110	Well Outside of Pier 1 Area	Nov-95 to Jan-06	0.01

1 Inclinometer reinitialized on the shown date, which does not necessarily indicate the date when a significant change in the rate of movement occurred

In the immediate vicinity of the Pier 1 area, no shallow movements have been observed since completion of construction of the Pier 1 stabilization system. However, at B-105, the data indicates that the inclinometer continues to progressively lean towards the river to a depth of 70 feet below the ground surface, possibly due to progressive outward movement of the bulkhead at that location. Upslope from Pier 1, the movement of the shallow slide plane continues at an average rate of about 0.06 inches per year.

In the immediate vicinity and upslope from the Pier 1 area, the deep failure plane shows continued movement at an average rate of about 0.09 inches per year (0.05 in/yr at B-204). This is a slight decrease from that reported in BBCM's 2004-2005 Revised Annual Report dated May 23, 2005, in which the average rate of about 0.10 inches per year (0.06 in/yr at B-204) was observed. South of the West End Pier, the deep failure plane continues to move at an average rate of about 0.02 inches per year. However, the B-101 inclinometer has indicated nominal movement since its installation.

Inclinometer P-9N (installed in one of the drilled shafts) indicates the top of the drilled shaft is being laterally restrained and that the maximum lateral deflection is about 0.85

inches and occurs at approximately 50 feet from the top of the inclinometer casing. Note that the inclinometer has shown nominal movement over the past four quarterly readings.

No accelerated movements have yet been observed in any of the inclinometers as a result of the excavation activities in the vicinity of the B-110 inclinometer on the west (or north) side of the I-90 bridge.

Piezometers

Of the twelve (12) piezometers initially installed for CUY-90-15.24 project, only six (6) are actively monitored. Table 2 below summarizes the piezometer readings over the last four quarters and provides the existing ground surface elevation at each of the piezometer locations.

Table 2: Piezometer Readings for the Last Four Quarters

Piezometer Identifier		Ground Surface Elevation (ft)	Water Elevation (ft)			
			July 14, 2005	*October 12, 2005*	*February 1, 2006*	*April 20, 2006*
101	Green	676.6	626.5	626.5	627.7	627.0
101	Pink	676.6	625.7	625.5	625.2	625.7
105	Pink	585.6	586.4	585.8	584.8	585.8
105	Blue	585.6	591.6	590.7	589.7	590.2
107	Orange	662.3	620.2	620.2	620.2	620.7
303	Green	627.0	602.8	602.4	601.9	602.1

Piezometers are identified both by number and color to specify the location and the depth of the instrumentation. The readings from the piezometers exhibited similar readings throughout the year. The maximum change in water level occurred in B-105 blue, which varied by 1.9 feet. The piezometer in B-105 blue indicated an elevated water level ranging from 4.1 to 6.0 feet above the existing ground surface. Additionally, the B-105 pink piezometer indicated a water level ranging from -0.8 feet below to 0.8 feet above the existing ground surface. It is possible that the elevated water pressure in B-105 may be attributed to a thin silt seam sandwiched between fairly thick clayey layers located near the base of the piles supporting Pier 1 and the percolation of natural gas out of the underlying Devonian Ohio Shale. These elevated pore pressures can have a detrimental effect on slope stability and the rate of slope creep.

New Piezometers

In addition to installing new inclinometers, BBCM has also been authorized by ODOT District 12 to install eighteen (18) vibrating wire piezometers as part of the extended subsurface study. In addition to the inclinometers (both old and new), monitoring of all the old active and new piezometers will begin in July, 2006 with baseline readings of the

new piezometers occurring simultaneously with the new inclinometers, which will take place sometime before the July quarterly readings.

Additional Field Measurements and Observations

The calipered crack distances have been monitored since June, 1999. These calipered locations measure the gap between the sidewalk for University Road and the concrete apron surrounding the west end piers and slope. Initially, three locations were monitored; the left, center, and right calipered locations. However, only the left and right calipered locations are currently monitored because in August, 1999, the center calipered location became inaccessible.

The left and right calipered locations are located just west and east of the existing I-90 bridge centerline, respectively (see the Bridge Plan in the Appendix). The readings have been included in the Appendix of this report along with Calipered Distance Readings versus Time plots. Close inspection of the data in the plots indicates the possibility of general trends of movement at the calipered locations. The data is somewhat oscillatory, which is likely due to the seasonal temperature fluctuations affecting the concrete combined with human error due to the interpretation of the center of the nails. In the data plots, linear trendlines were added to estimate the average rate of separation/closure per year. The left calipered location indicates the gap is continuing to open at a rate of about 0.06 inches per year. The right calipered location indicates the gap is continuing to close at a rate of about 0.03 inches per year. The movements are relatively small (½ of an inch or less since June, 1999) and are highly subject to the interpretation of the center of the nails, thus it is inconclusive that these movements have been caused by the observed slope movements. Continuing observation of these locations is needed in order to adequately determine if judgment error and weather conditions are the main cause of the observed trends or if they are indeed caused by slope movements.

There was no aggregate pile observed in April, 2006 adjacent to the south right-of-way fence. A large aggregate pile was last observed in January, 2004. A relatively small aggregate pile was observed in July and October, 2005, and February, 2006.

Closing

This report completes the work authorized under the current agreement. However, there will likely be some residual budget remaining on the current agreement. As previously discussed, monitoring of all the old active and new instrumentation will begin in July, 2006 with baseline readings of the new instrumentation to take place sometime before the July quarterly readings. ODOT District 12 has requested that any monitoring associated with this next phase be invoiced under the current agreement until the residual budget has been entirely exhausted. Afterwards, monitoring for the project will be invoiced under the new agreement, which has been currently authorized through the end of the year 2007. We understand that we will continue to submit quarterly and annual reports to REL; however, the timing of the submission of the future Annual Reports has not yet been finalized.

We appreciate being of continued service during this project. Please contact our office if you have any questions or require additional information.

Respectfully submitted,

BBC&M ENGINEERING, INC.
Cleveland, Ohio

FOR

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Stephen C. Pasternack, Ph.D., P.E.
Senior Project Engineer

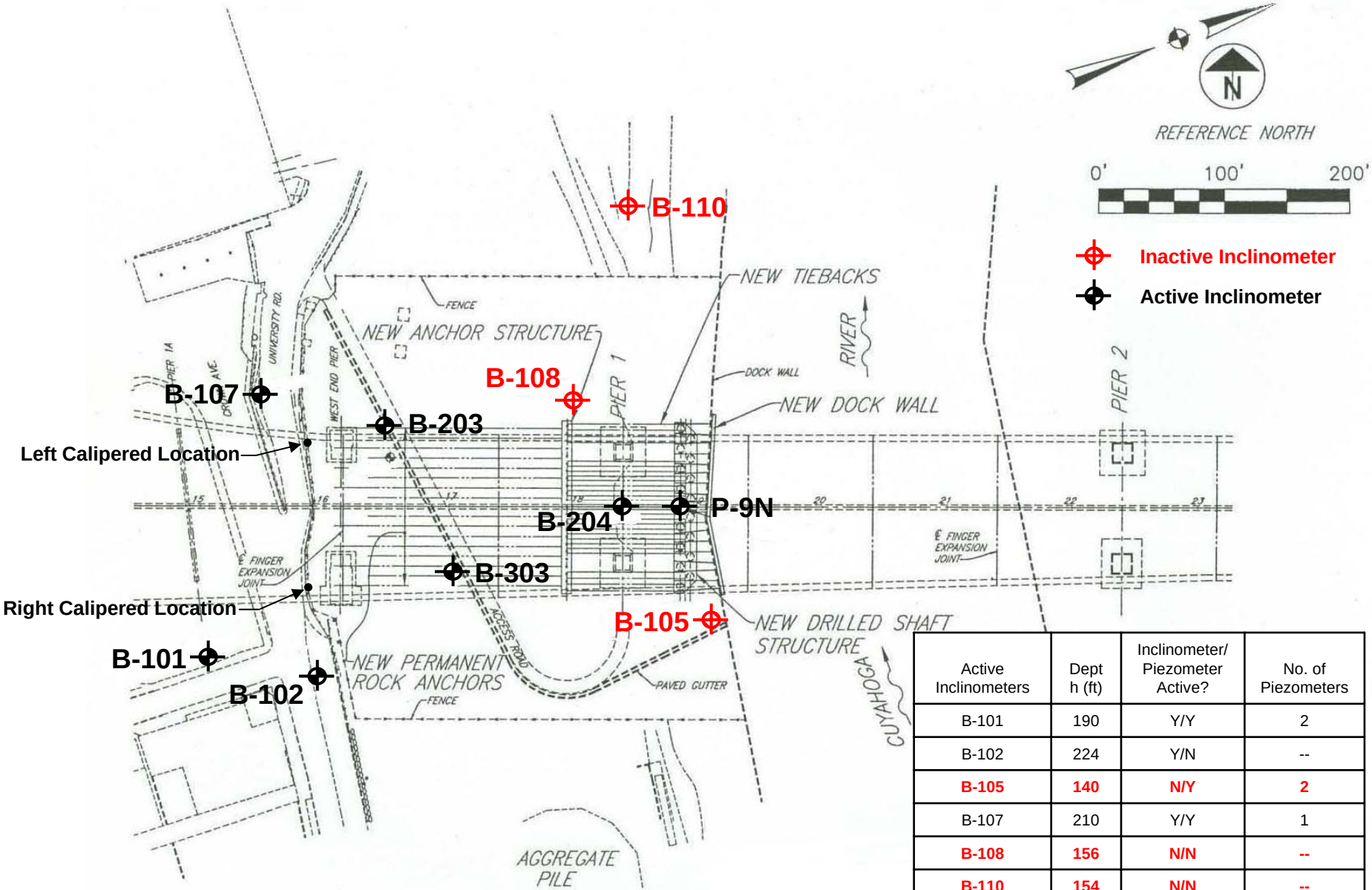
JLS/scp
Submitted: 3 copies (also e-mailed to Richland Engineering at reltd@r-e-l.com)
Attachments: Appendix

File: 012-00829-100 05-06 Annual Report.doc

APPENDIX

(listed in order, CI = Cumulative and Incremental Displacement Plot, TD = Time-Displacement Plot)

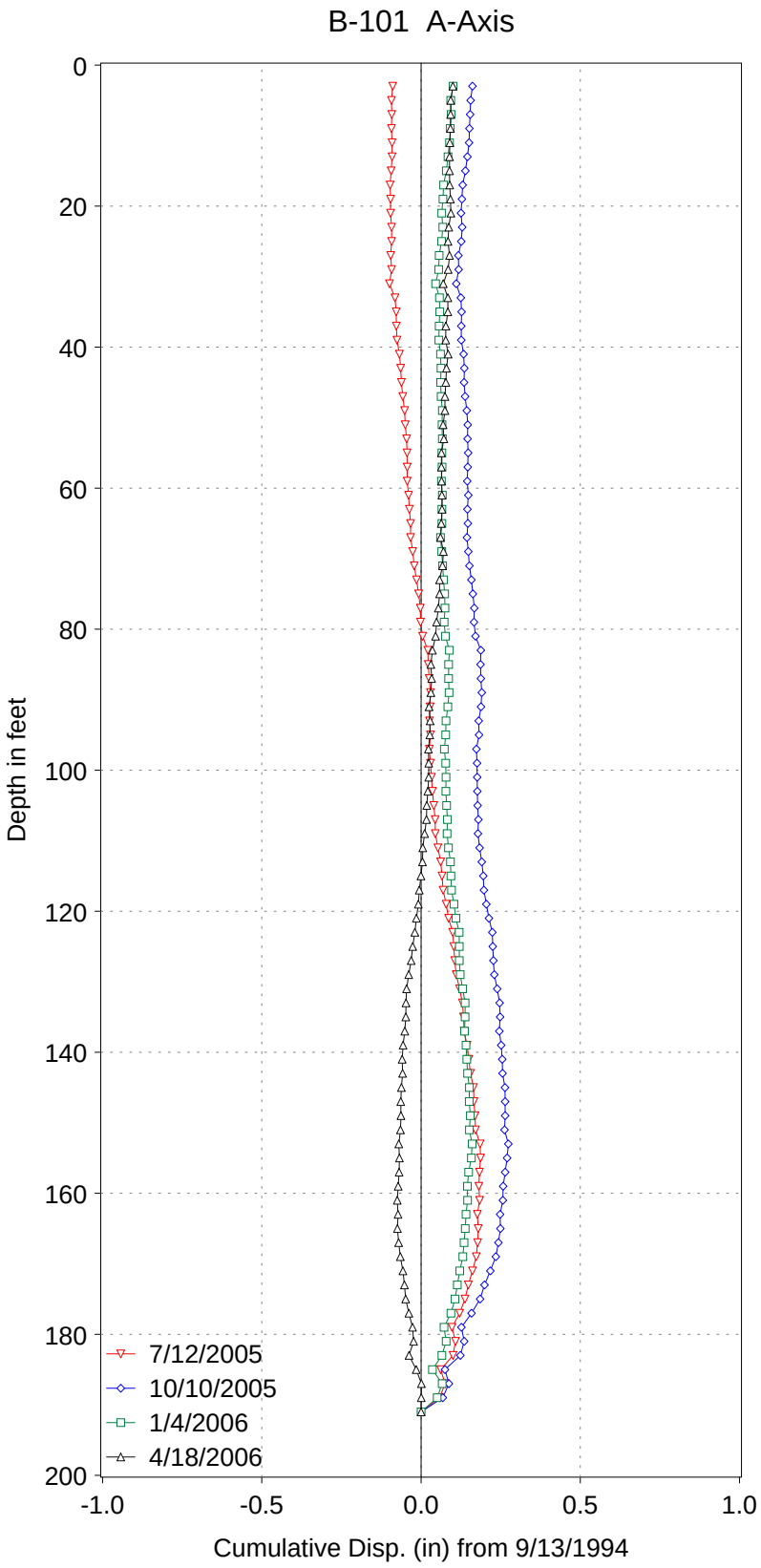
-Bridge Plan
-B-101 A-Axis - CI
-B-101 B-Axis - CI
-B-102 A-Axis - CI
-B-102 B-Axis - CI
-B-102 A-Axis - TD
-B-105 A-Axis - CI
-B-105 B-Axis - CI
-B-105 A-Axis - TD
-B-107 A-Axis - CI
-B-107 B-Axis - CI
-B-107 A-Axis - TD
-B-108 A-Axis - CI
-B-108 B-Axis - CI
-B-108 A-Axis - TD
-B-110 A-Axis - CI
-B-110 B-Axis - CI
-B-110 A-Axis - TD
-B-203 A-Axis - CI
-B-203 B-Axis - CI
-B-203 A-Axis - TD
-B-204 A-Axis - CI
-B-204 B-Axis - CI
-B-204 A-Axis - TD
-B-303 A-Axis - CI
-B-303 B-Axis - CI
-B-303 A-Axis - TD
-P-9N A-Axis - CI
-P-9N B-Axis - CI
-Linear Regression and 95% - Confidence Interval Plot for B-303
-Calipered Surface Distance Table
-Left Calipered Location Plot
-Right Calipered Location Plot

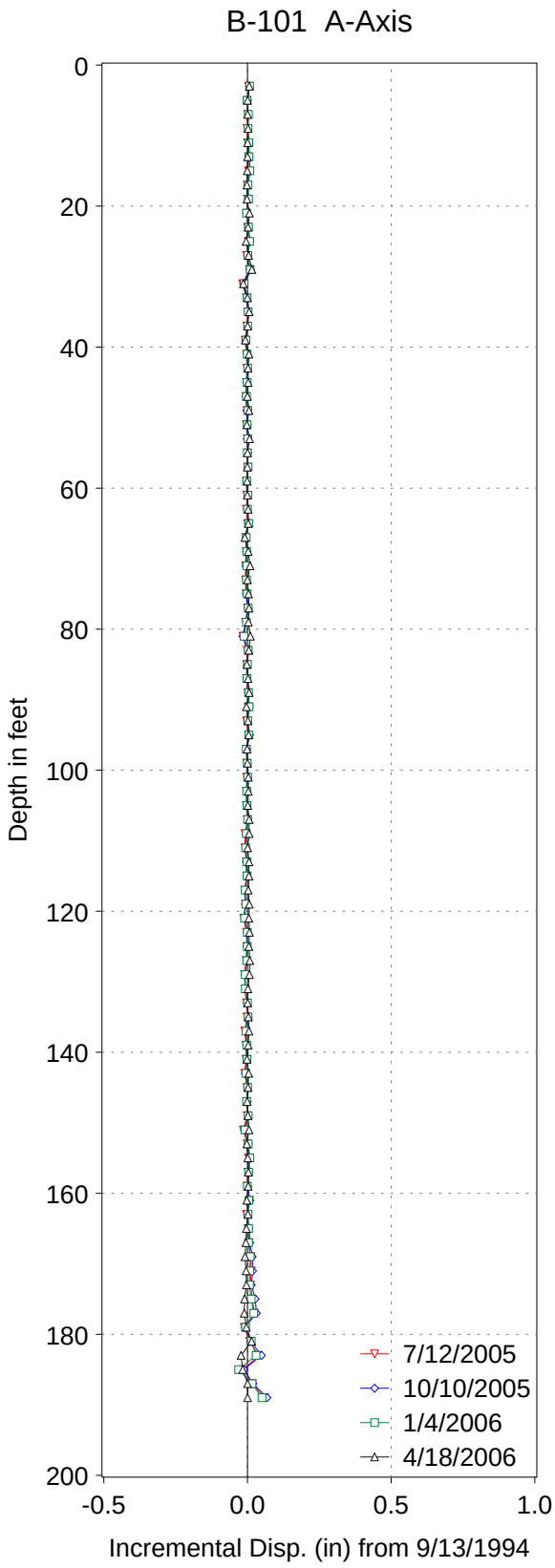


Note: Inclinometers B-105, B-108, and B-110 (destroyed) will no longer be monitored by BBCM. Replacement inclinometers for B-105 and B-108 are planned to be installed by the end of May, 2006.

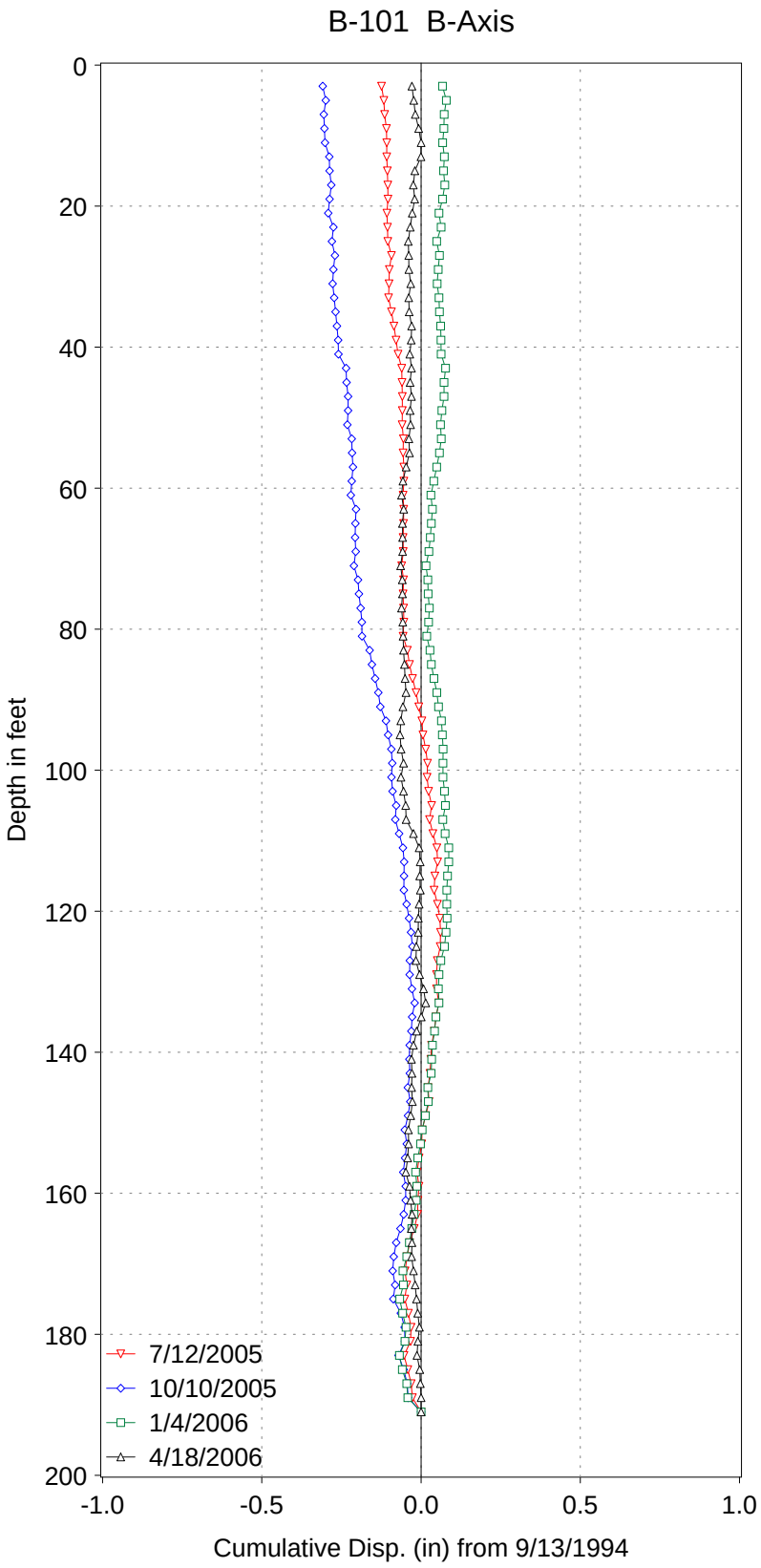
BRIDGE PLAN

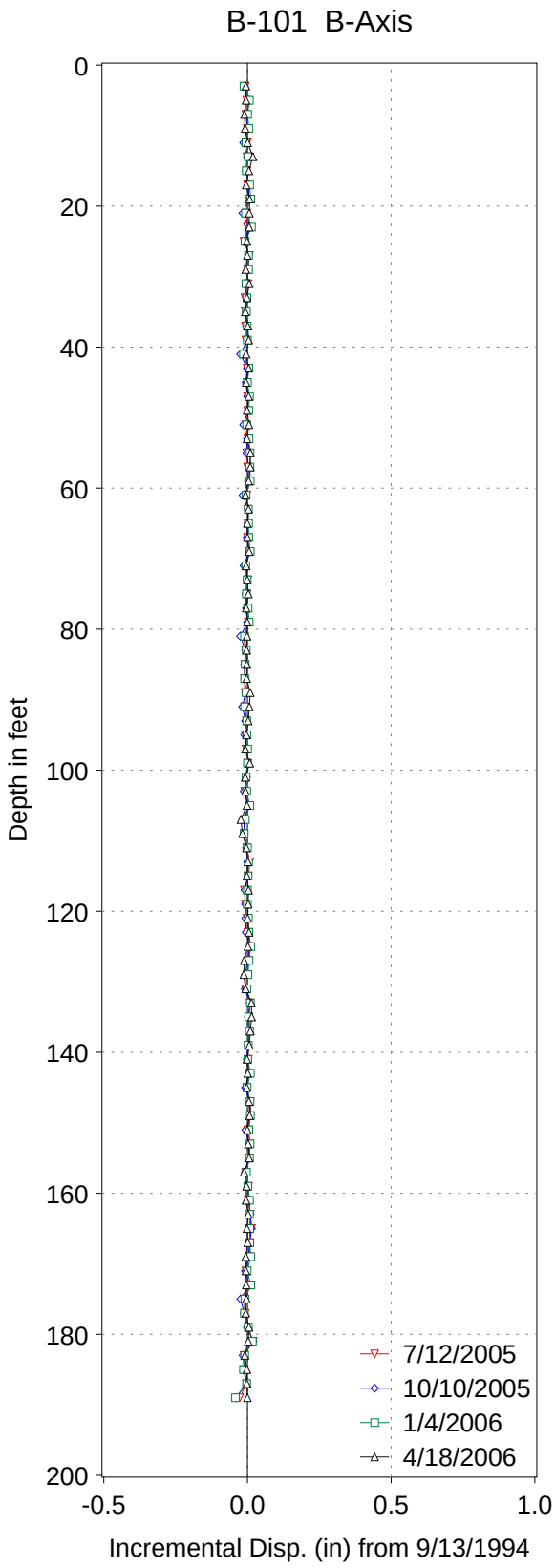
Active Inclinometers	Depth (ft)	Inclinometer/ Piezometer Active?	No. of Piezometers
B-101	190	Y/Y	2
B-102	224	Y/N	--
B-105	**140**	**N/Y**	**2**
B-107	210	Y/Y	1
B-108	**156**	**N/N**	**--**
B-110	**154**	**N/N**	**--**
B-203	192	Y/N	--
B-204	134	Y/N	--
B-303	180	Y/Y	1
P-9N	150	Y/N	--



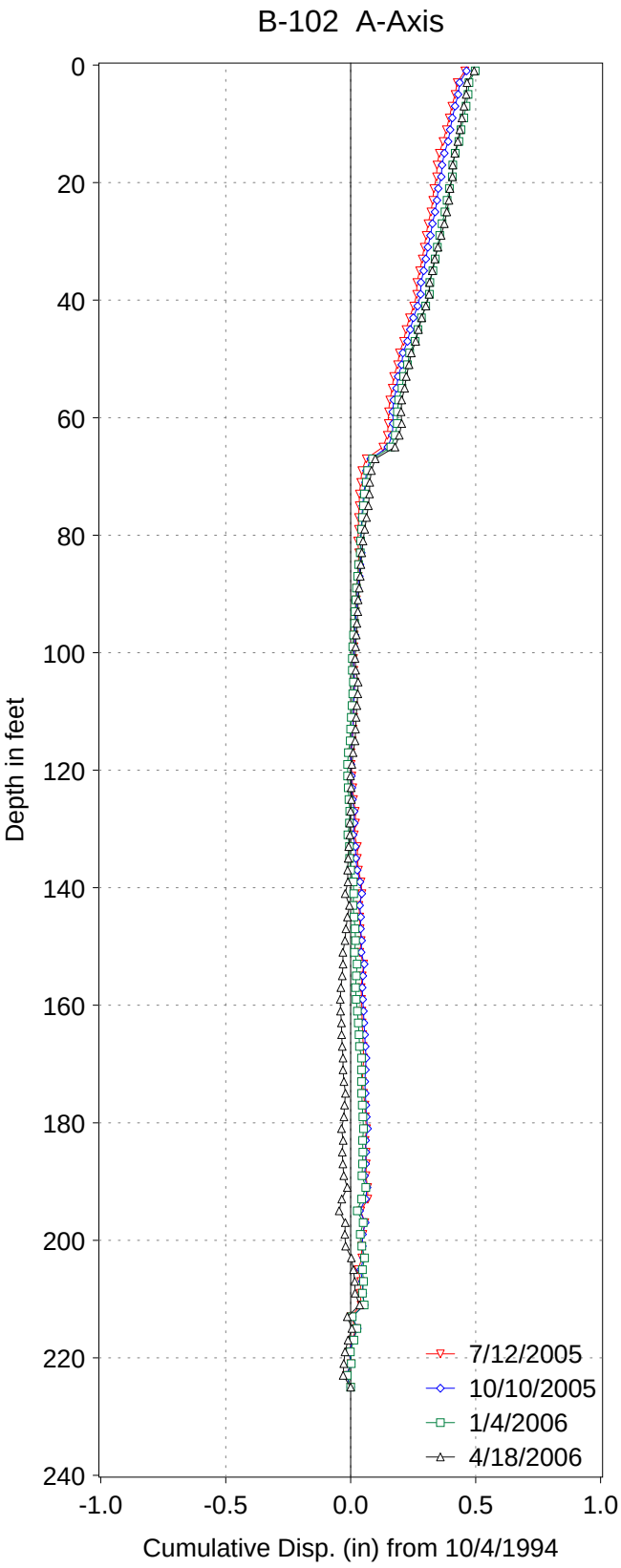


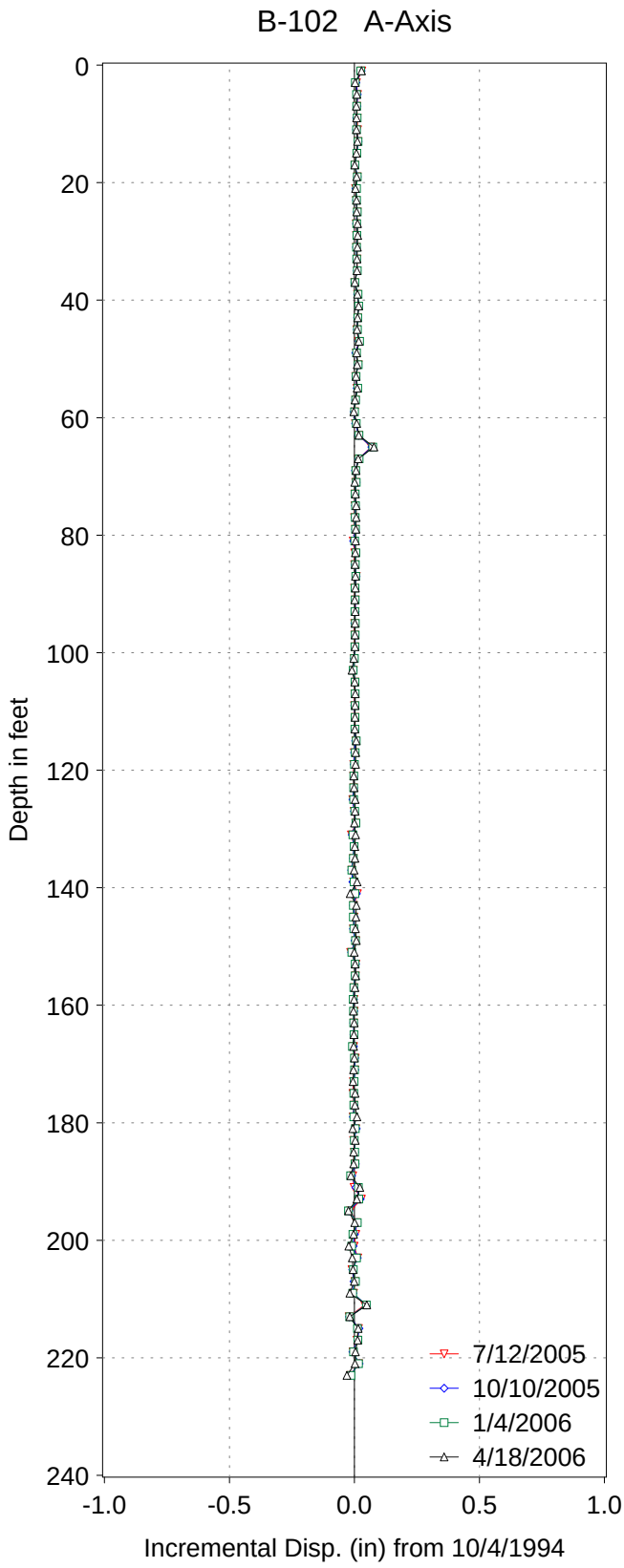
B-101
-Includes readings from the last four quarters.
-Data sets not corrected for "depth-positioning" error.



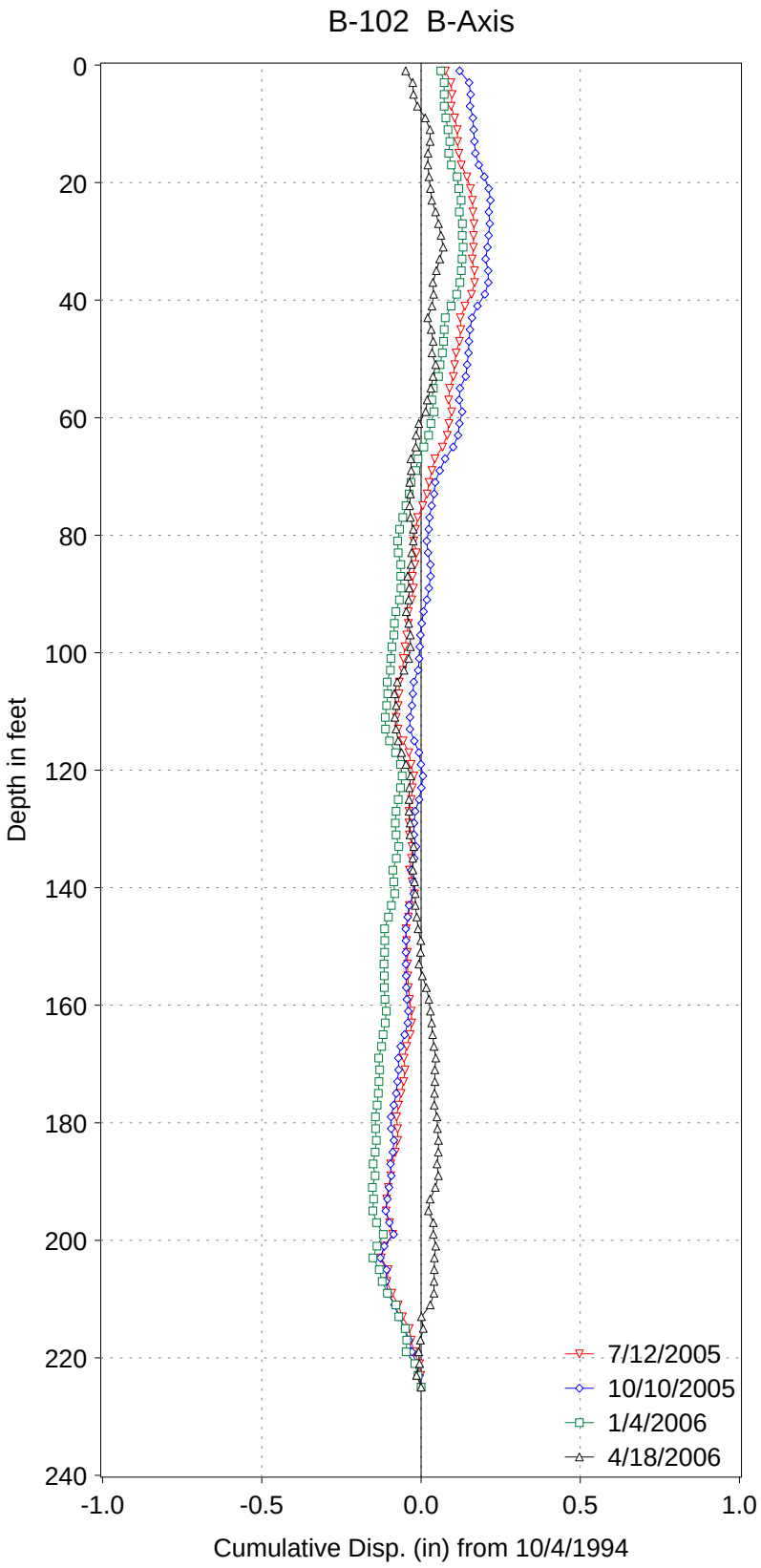


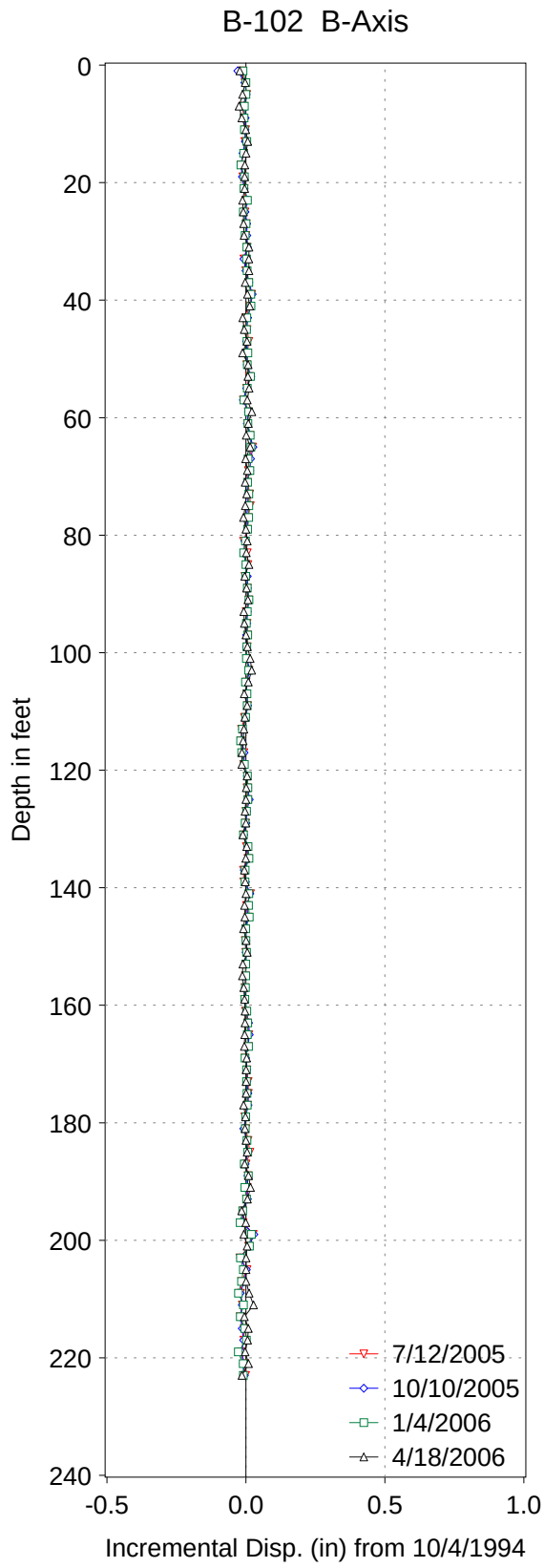
B-101
-Includes readings from the last four quarters.
-Data sets not corrected for "depth-positioning" error.



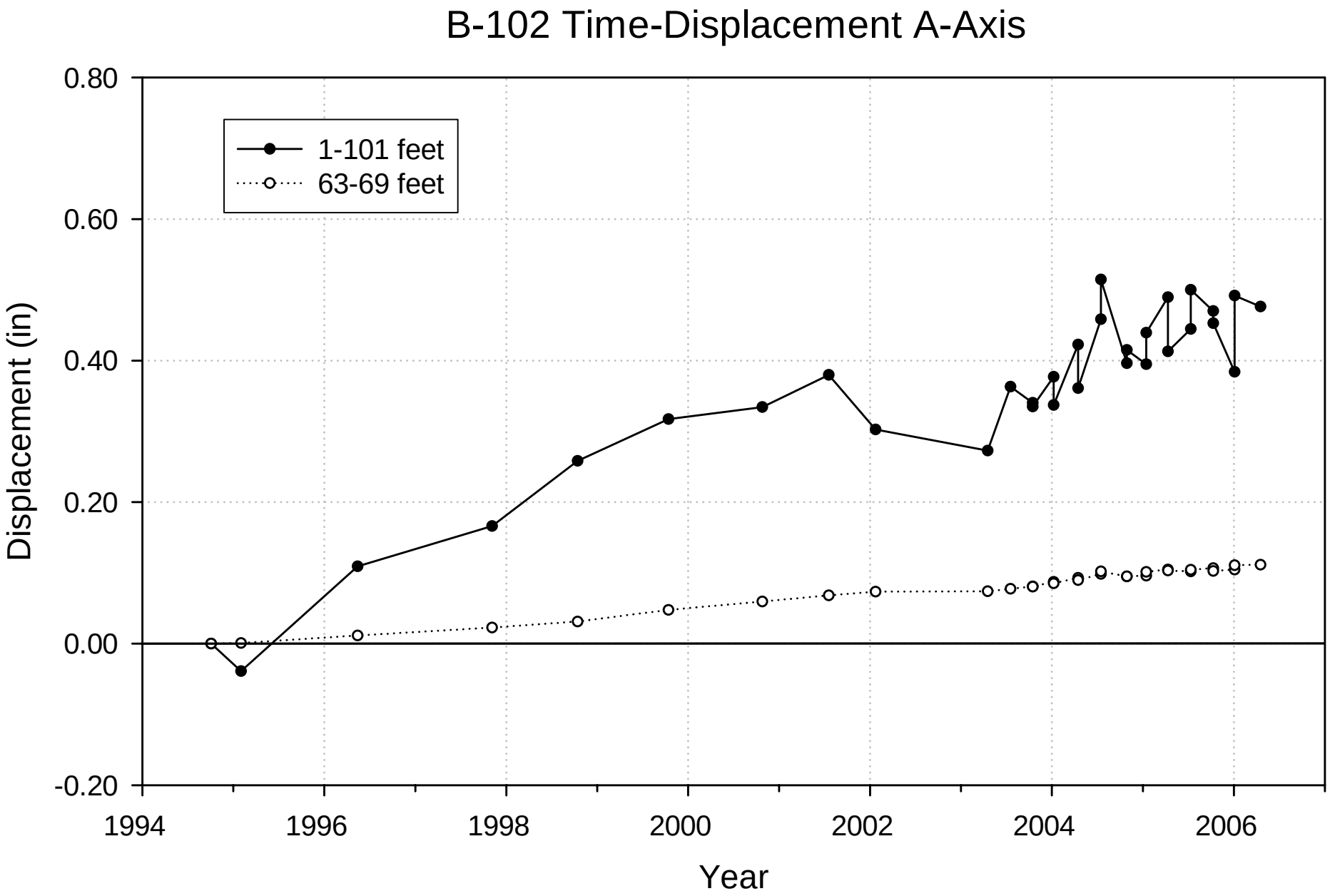


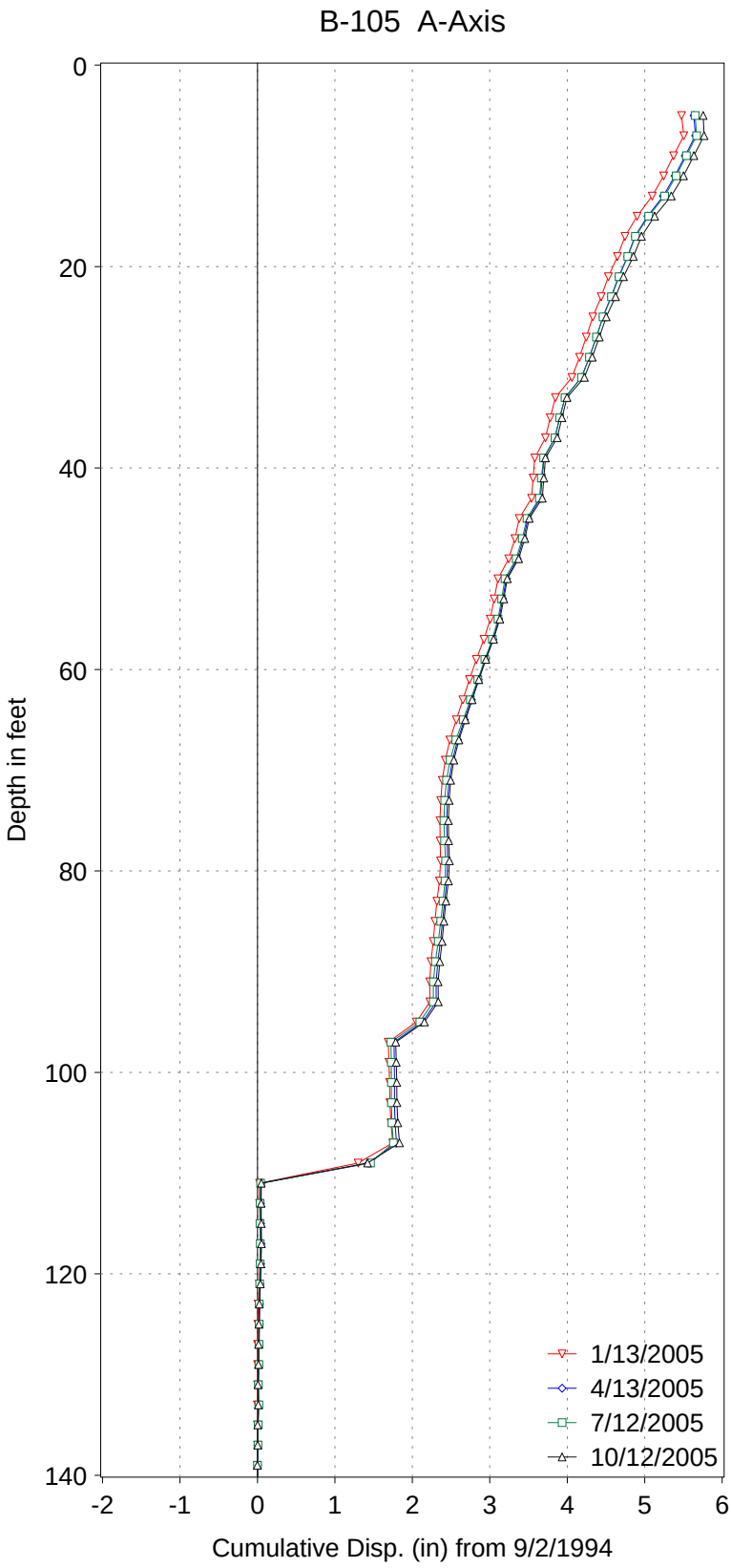
B-102
-Includes readings from the last four quarters.

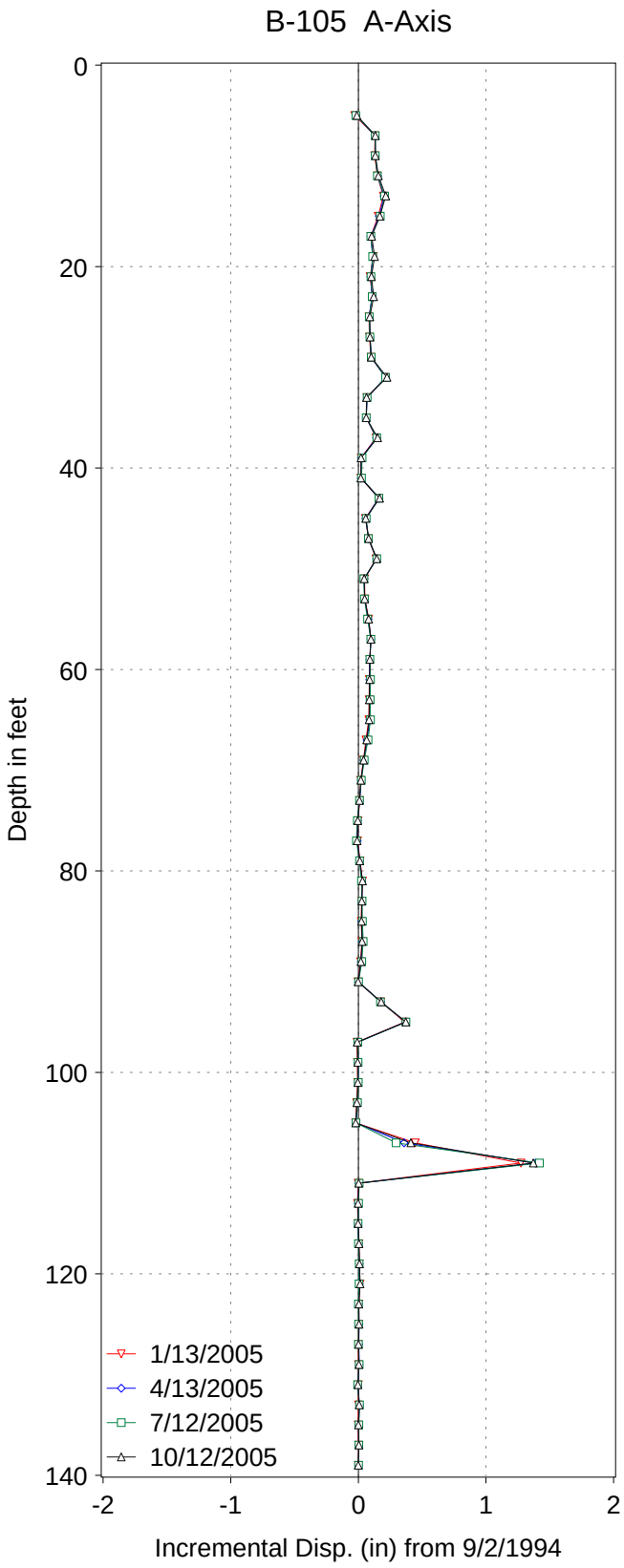




B-102
-Includes readings from the last four quarters.

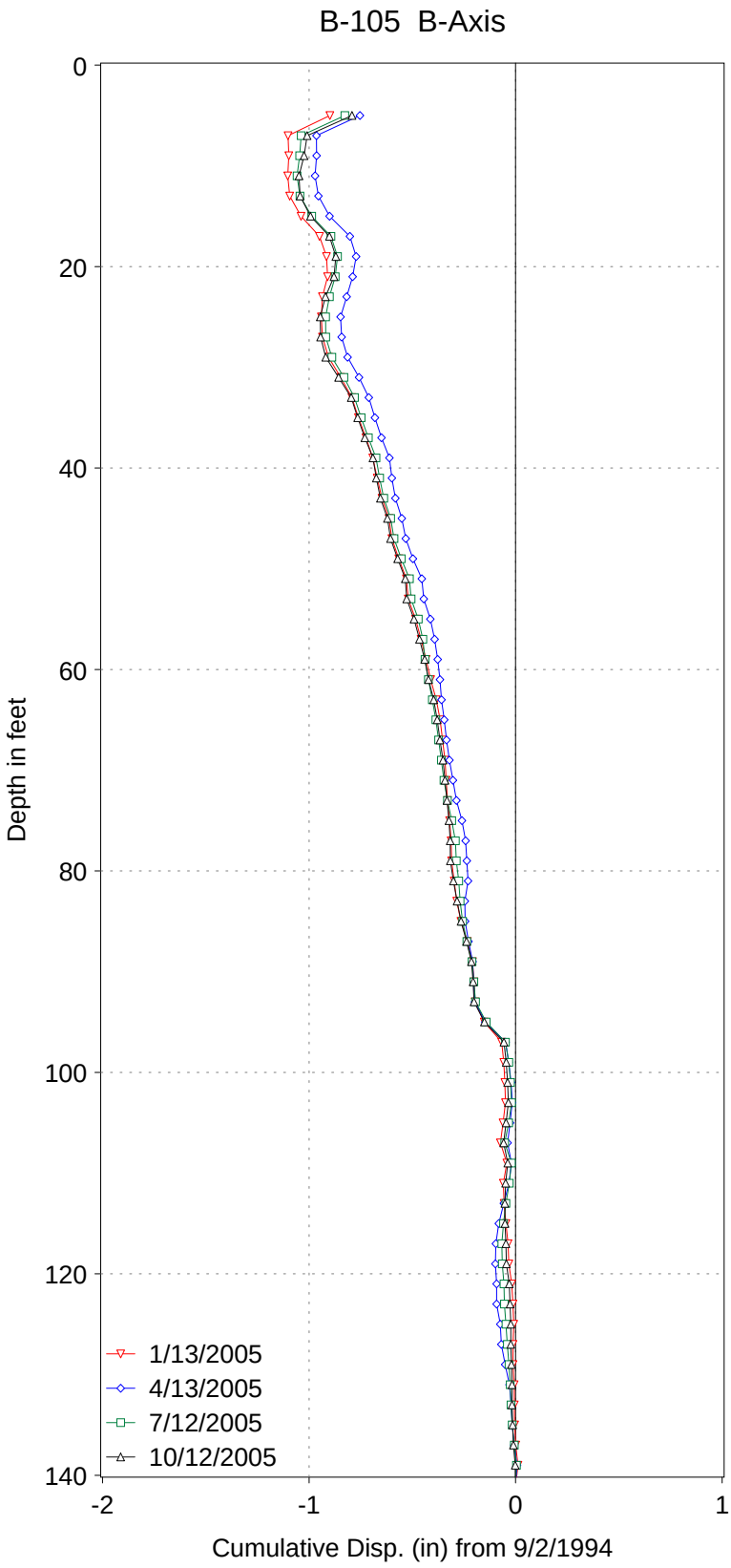

B-102 Time-Displacement A-Axis
1-101 feet
63-69 feet
Displacement (in)
0.80
0.60
0.40
0.20
0.00
-0.20
1994
1996
1998
2000
2002
2004
2006
Year

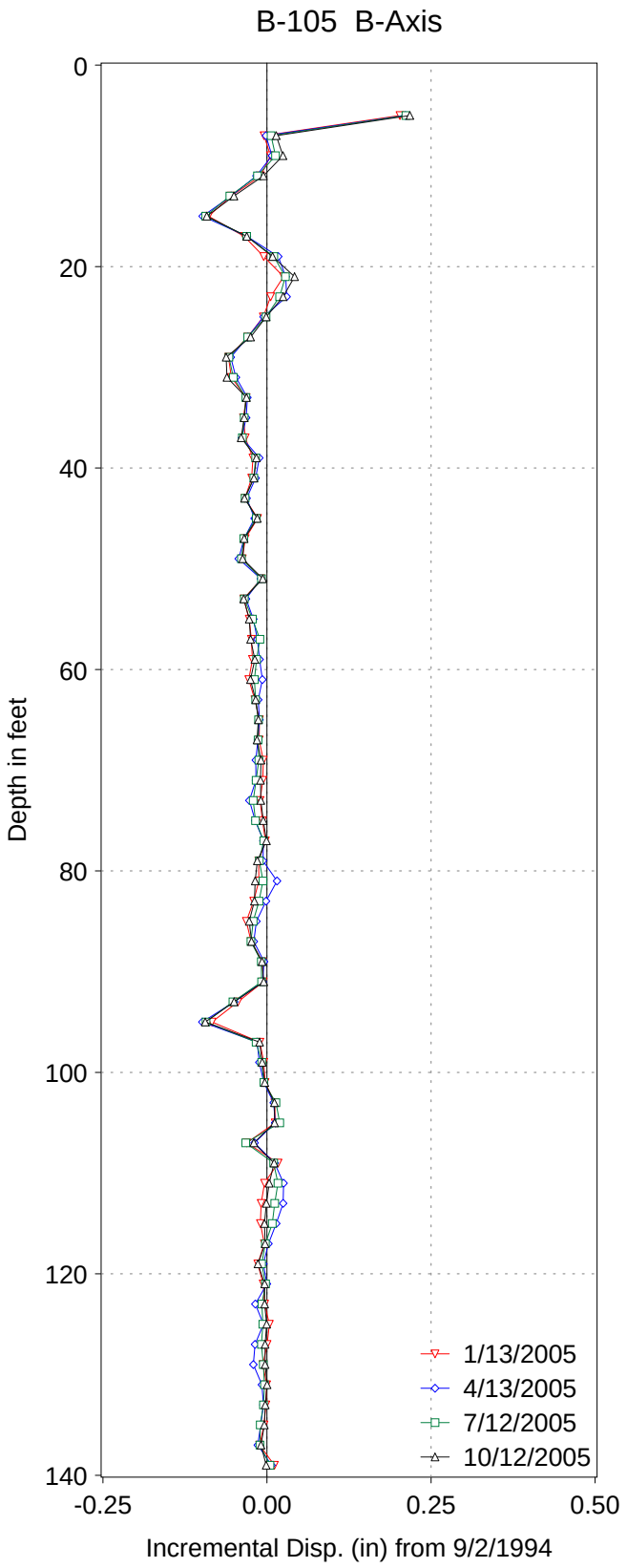




B-105

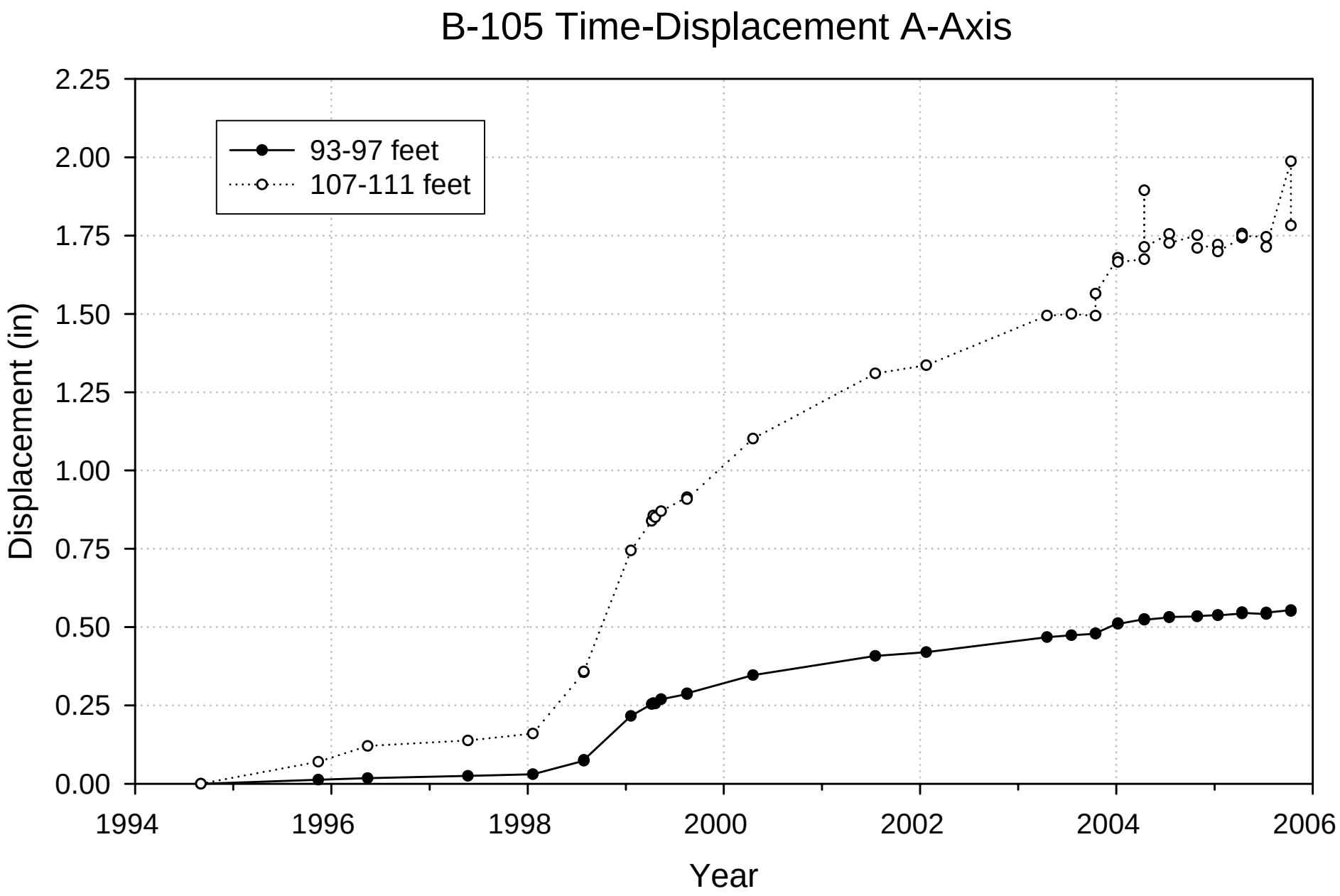
-Plot shows one reading from the last four quarters it was monitored.
-To be replaced. Is no longer monitored by BBCM.



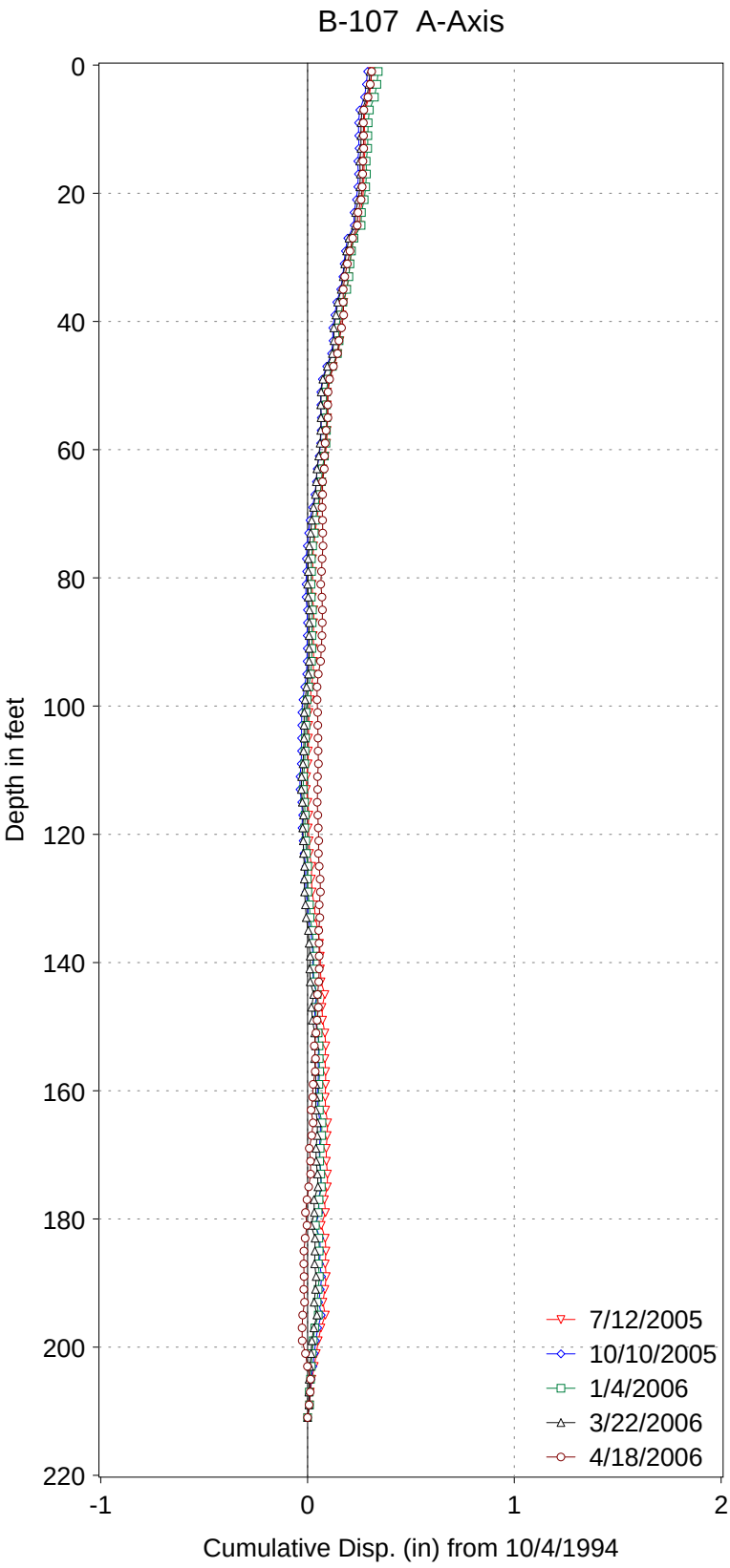


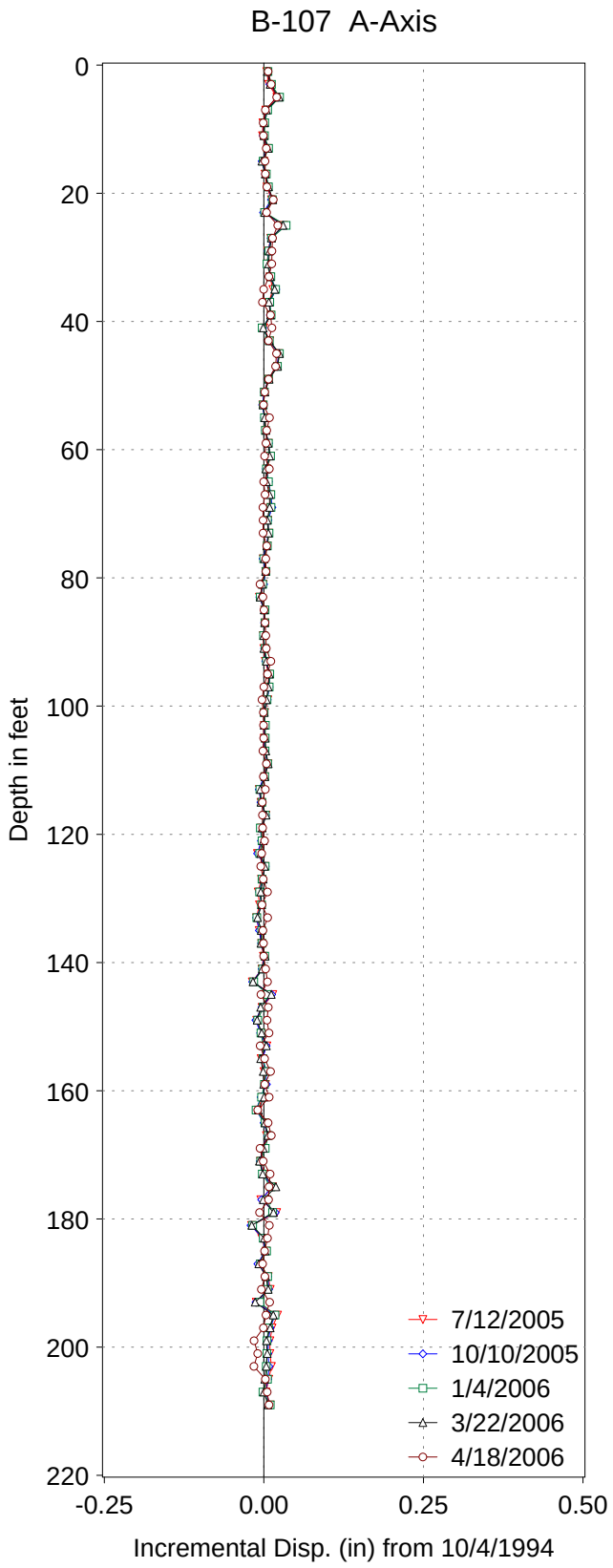
B-105

-Plot shows one reading from the last four quarters it was monitored.
-To be replaced. Is no longer monitored by BBCM.

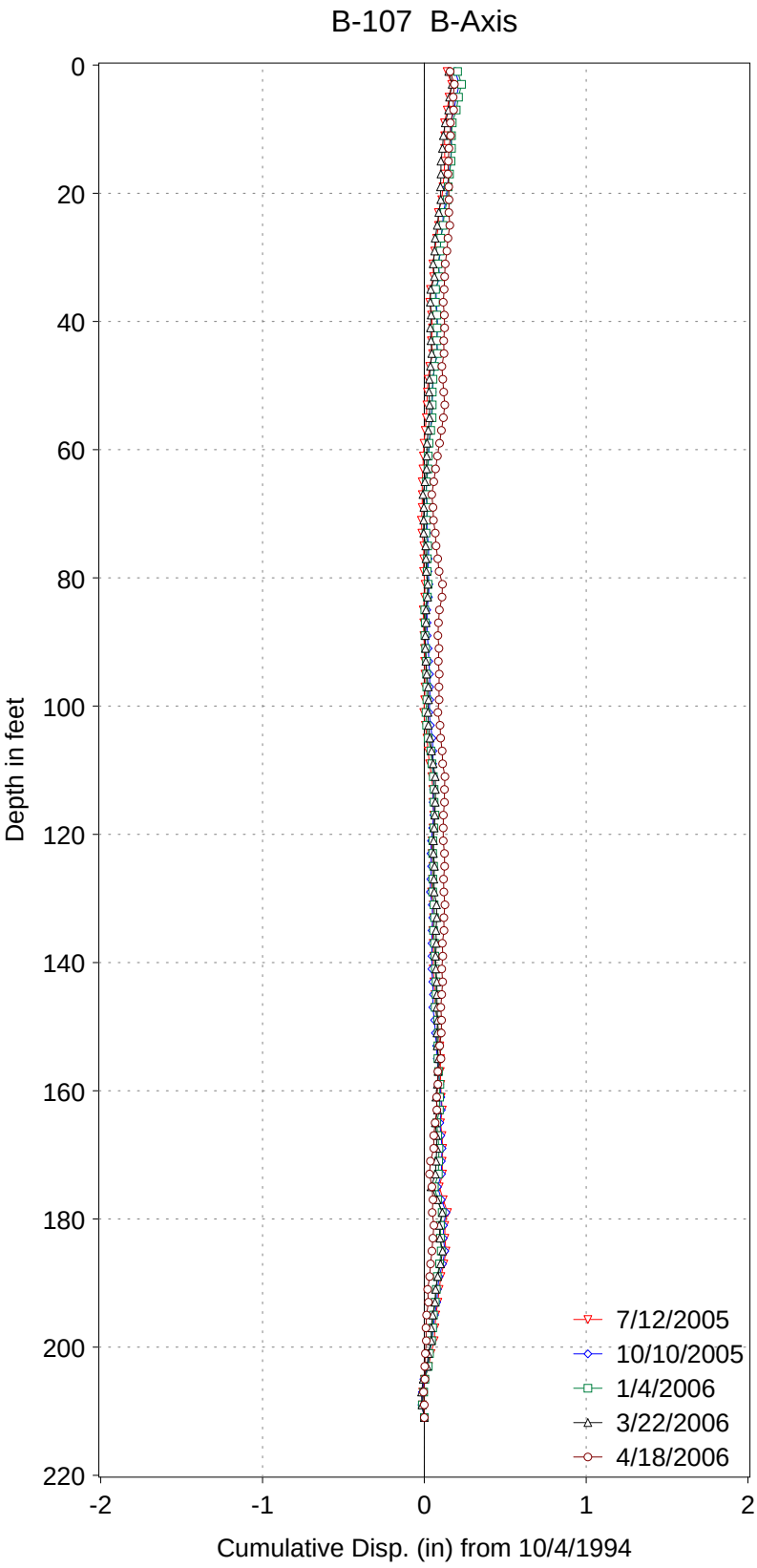


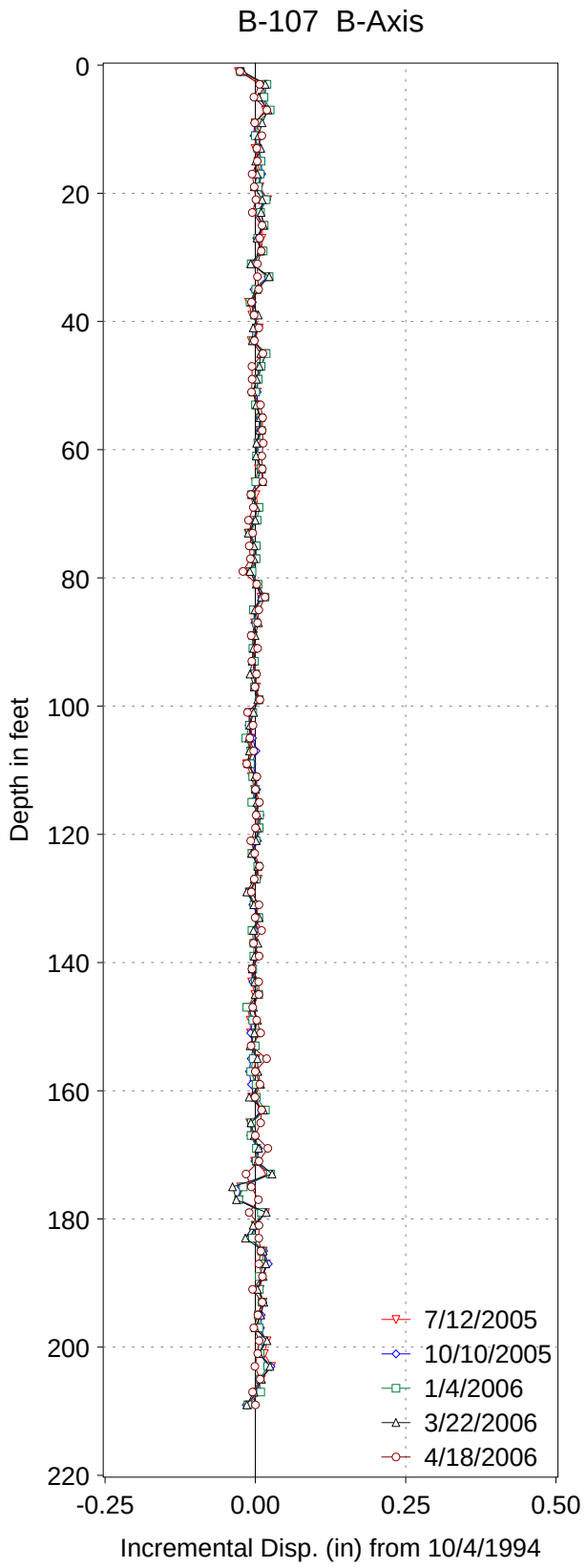
Note: This is the final time-displacement plot through October 2005 as BBCM is no longer monitoring this inclinometer.



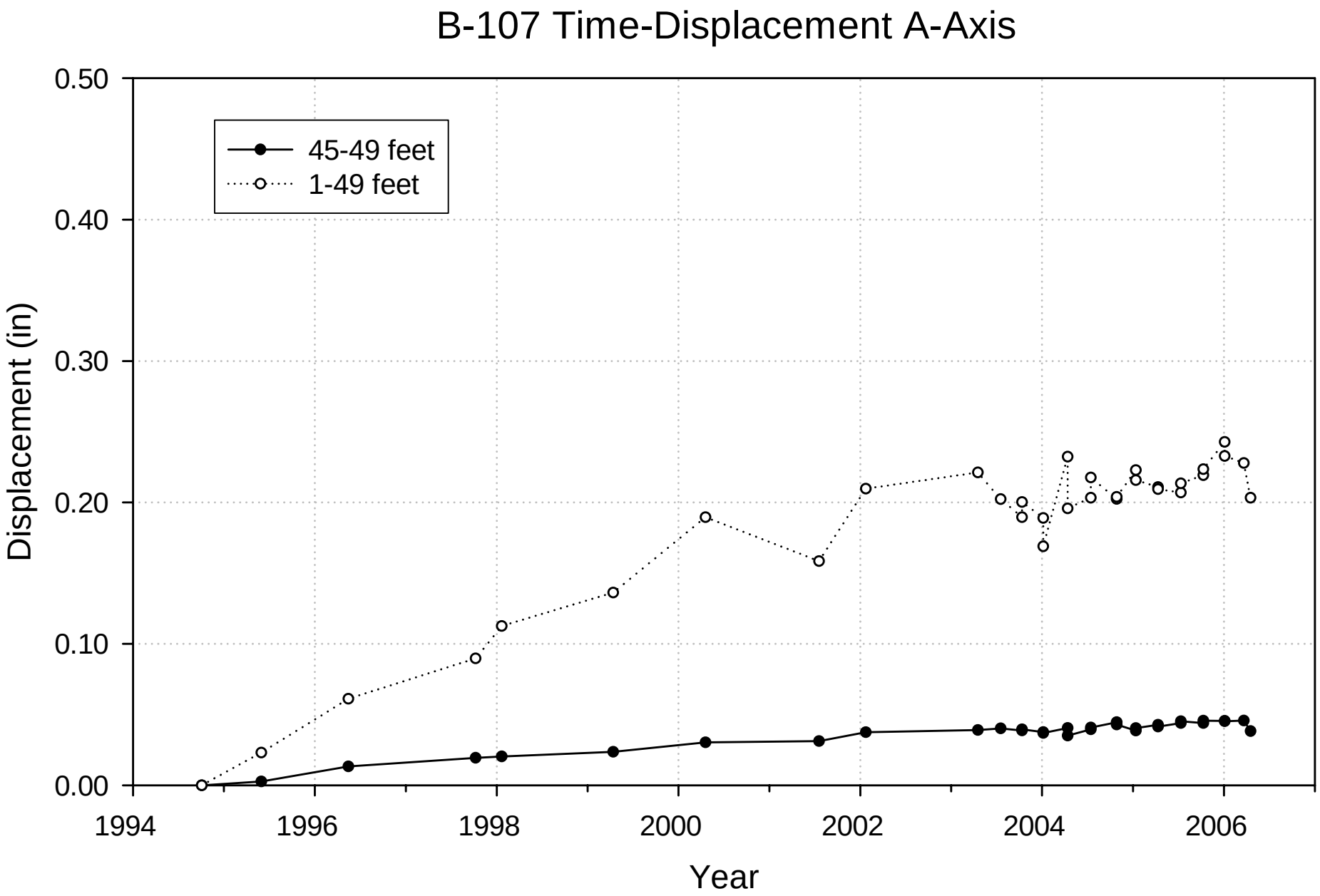


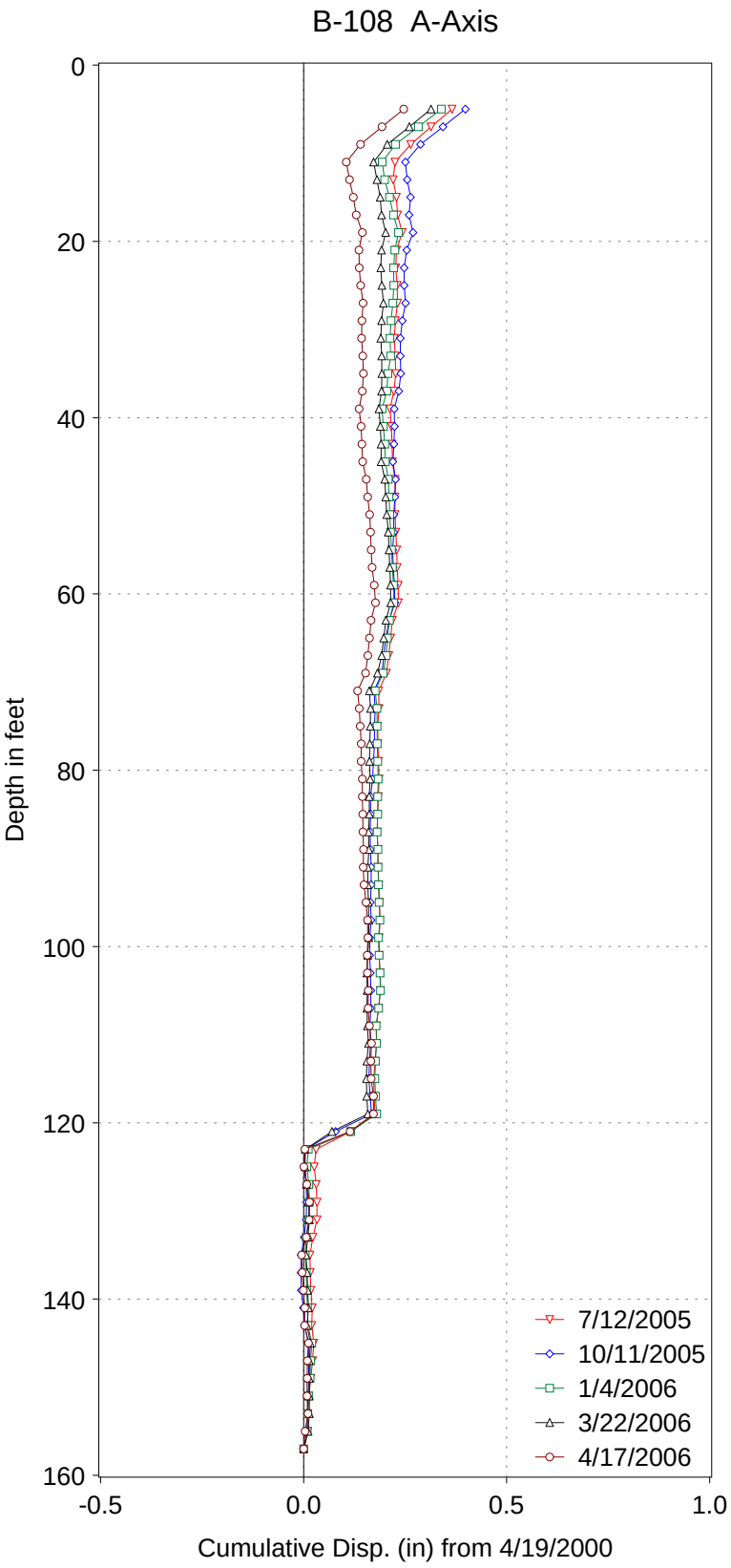
B-107
-Includes readings from the last four quarters (and in March).

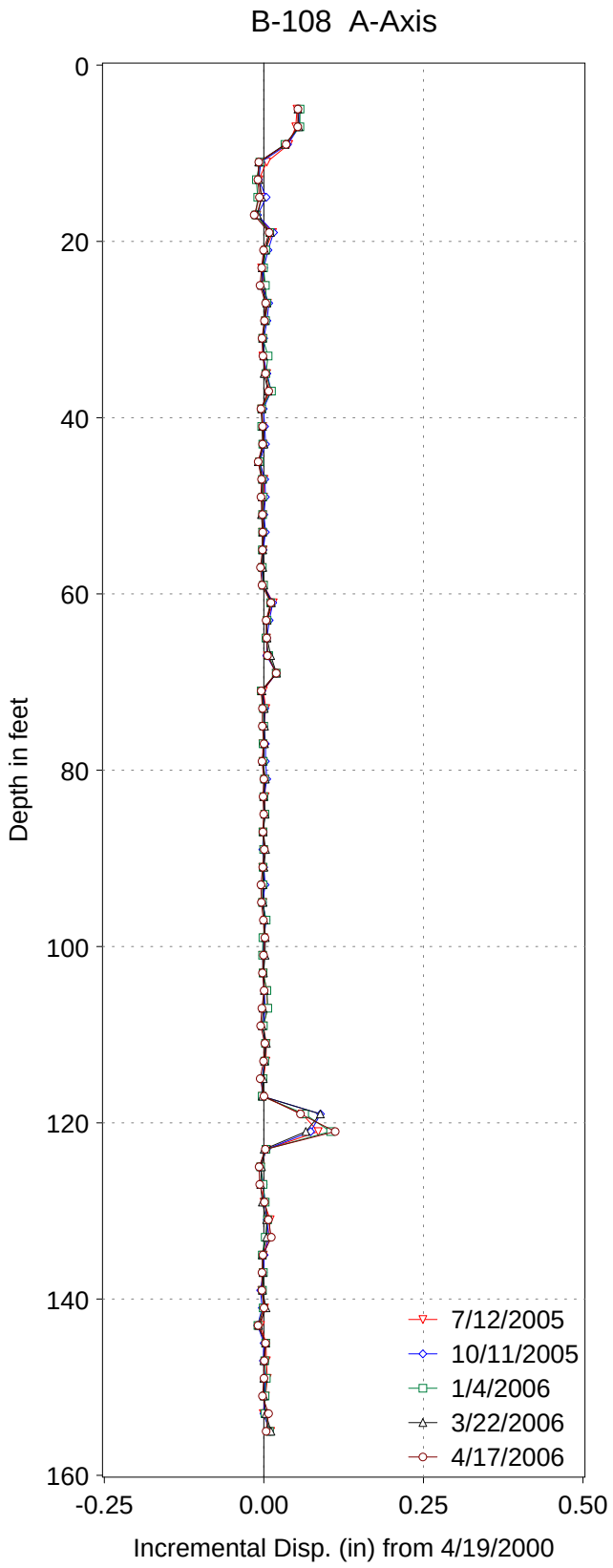




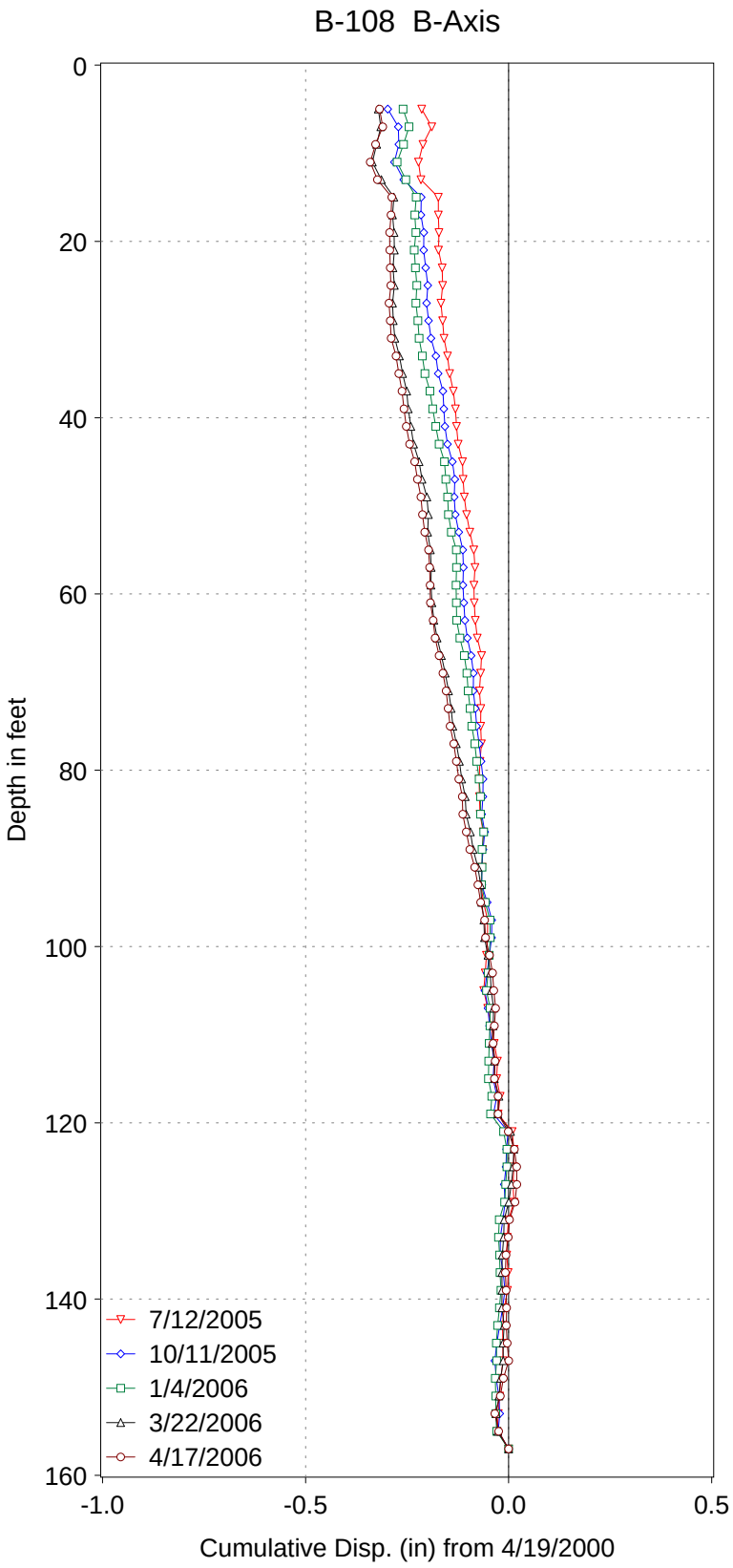
B-107
-Includes readings from the last four quarters (and in March).

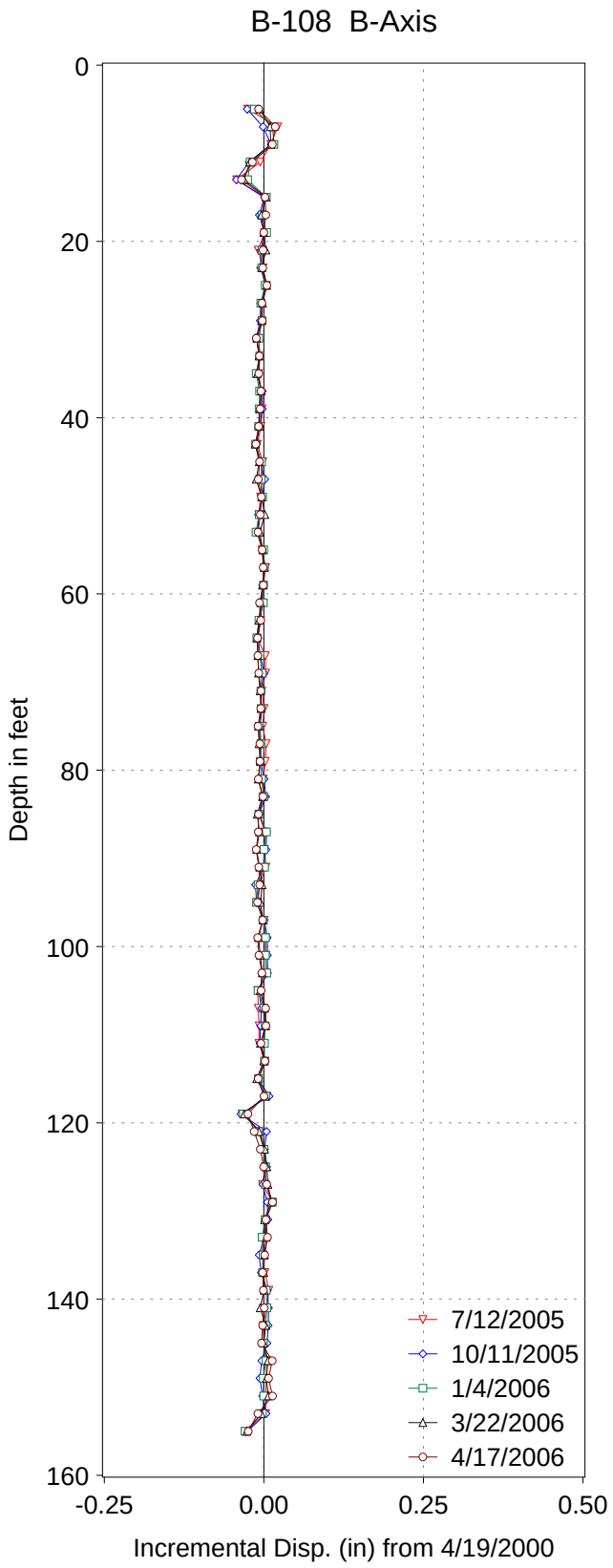

B-107 Time-Displacement A-Axis
45-49 feet
1-49 feet
Displacement (in)
0.50
0.40
0.30
0.20
0.10
0.00
1994
1996
1998
2000
2002
2004
2006
Year



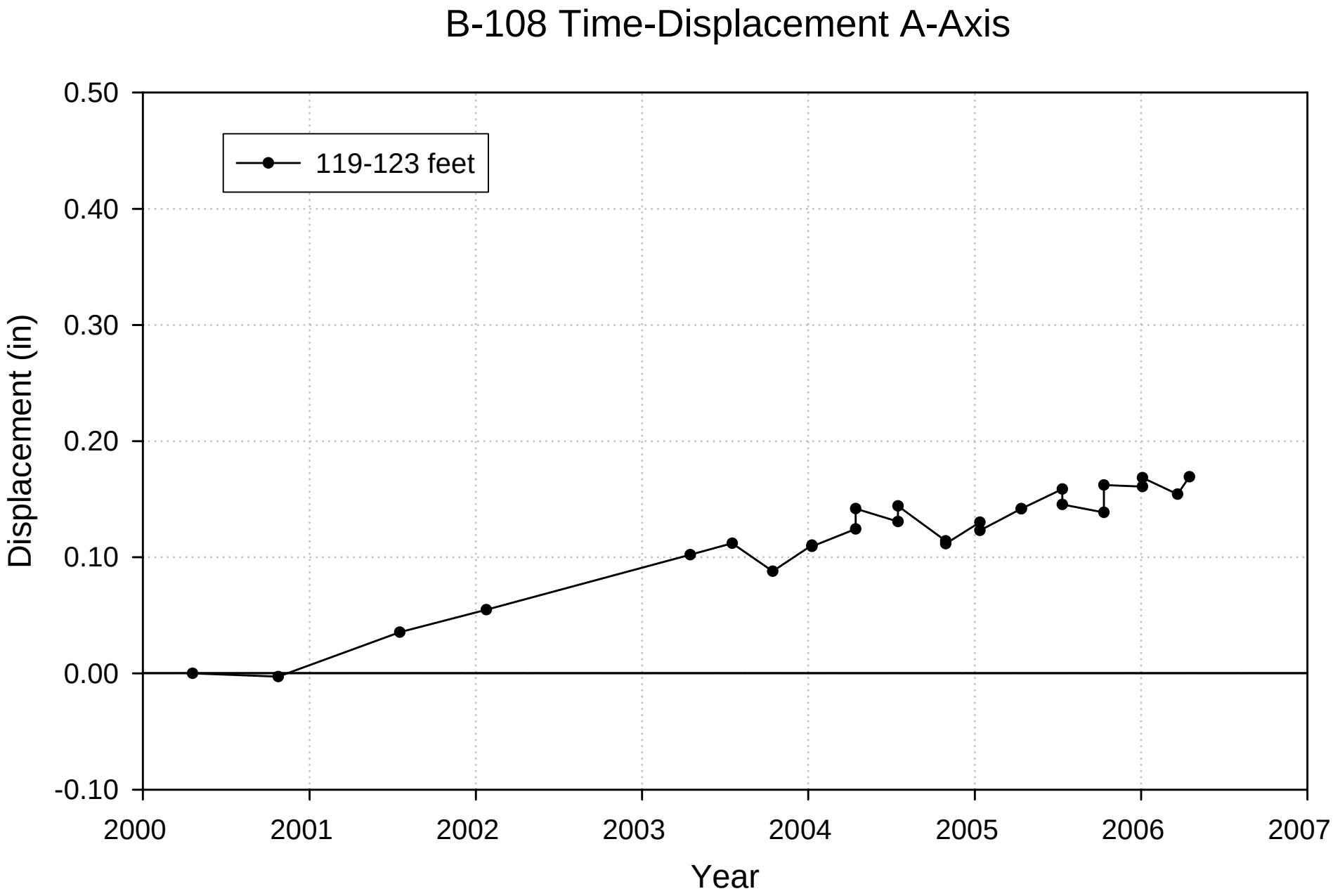


B-108
-Includes readings from the last four quarters (and in March).
-To be replaced; therefore, will no longer be monitored by BBCM.

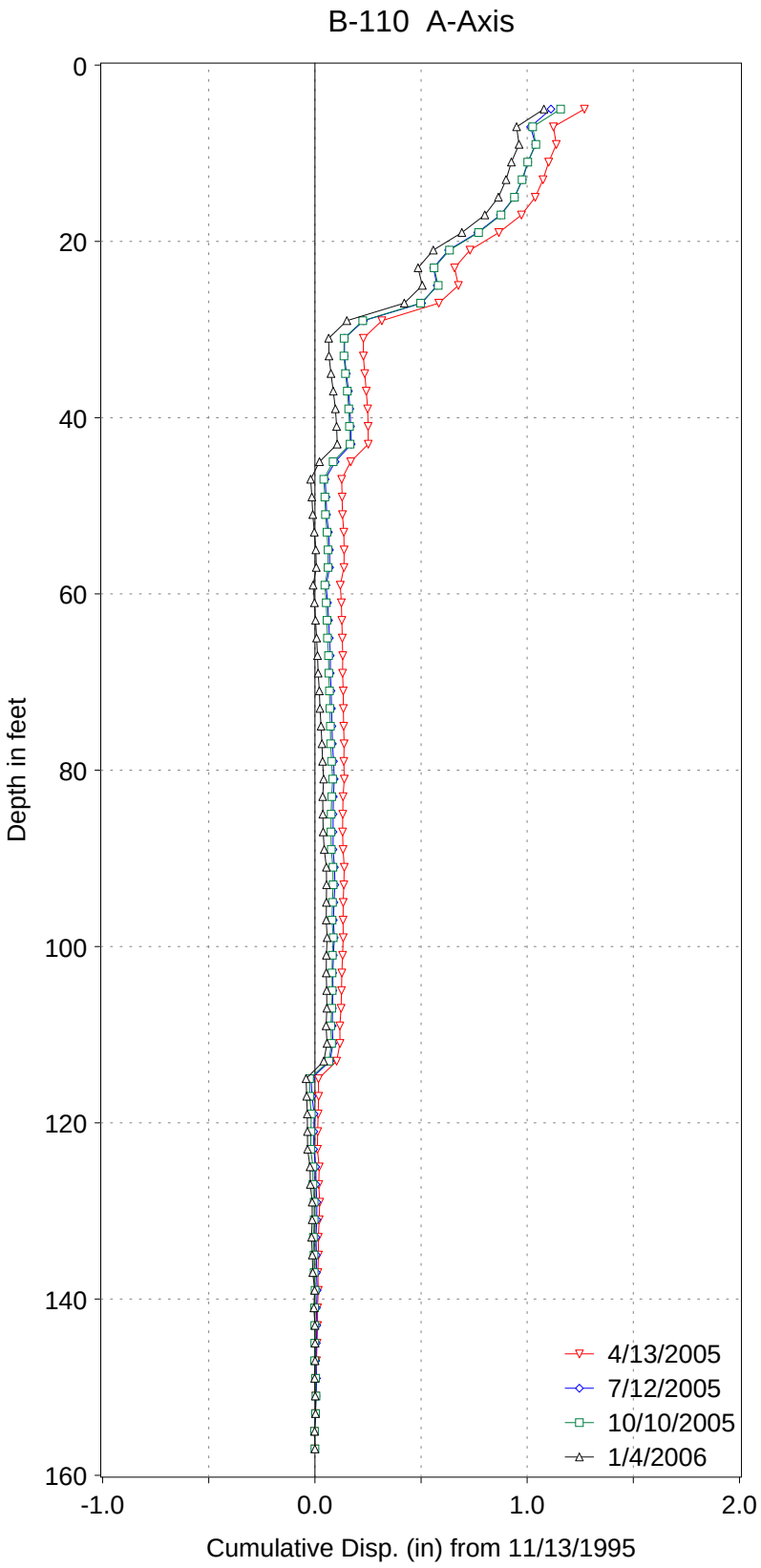


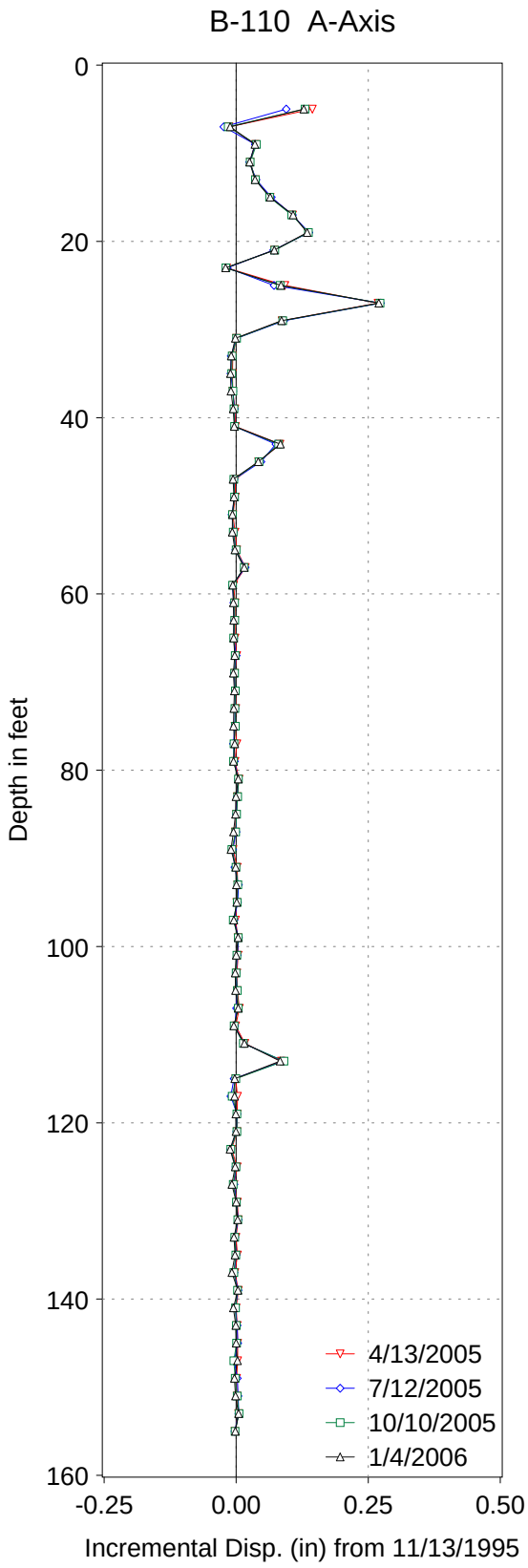


B-108
-Includes readings from the last four quarters (and in March).
-To be replaced; therefore, will no longer be monitored by BBCM.

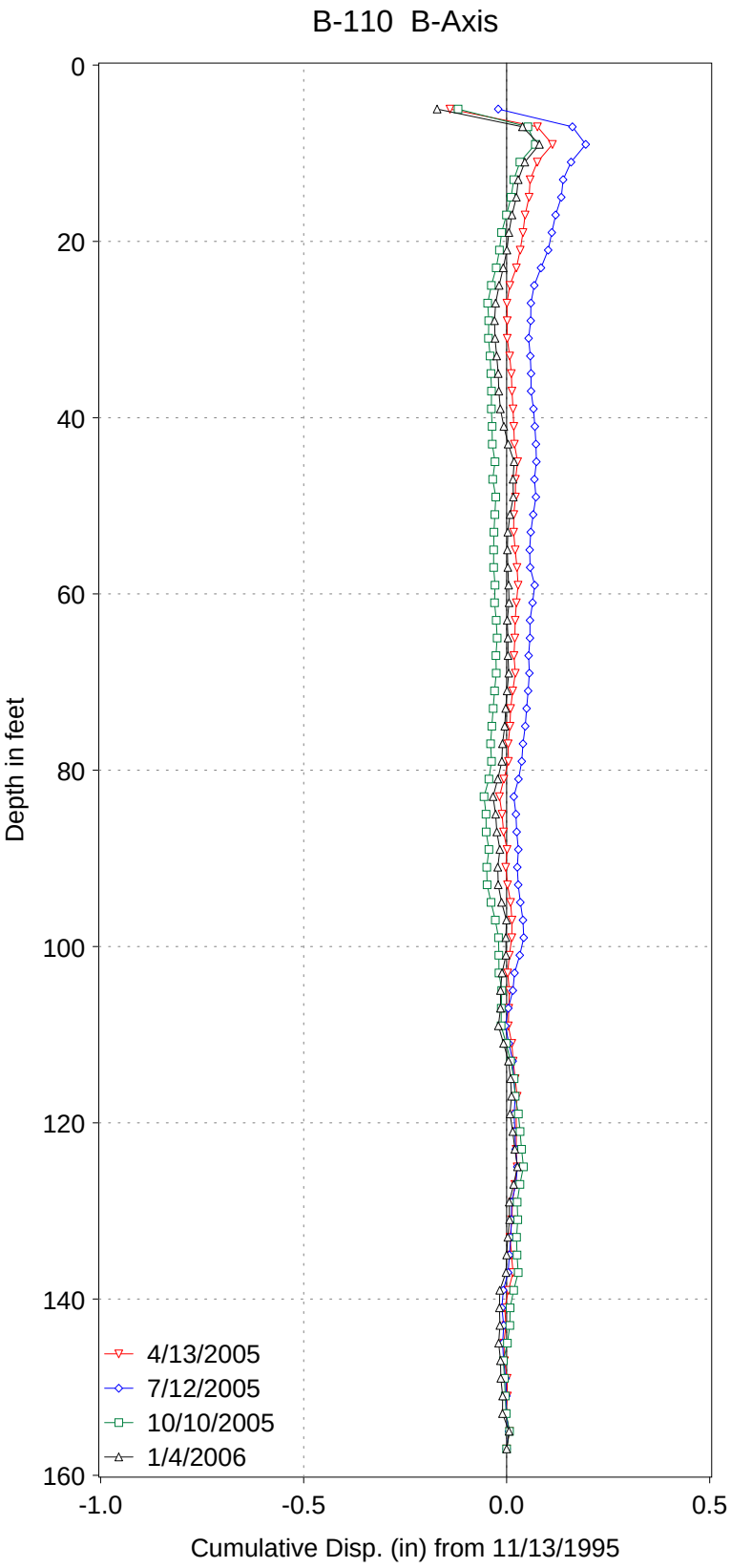


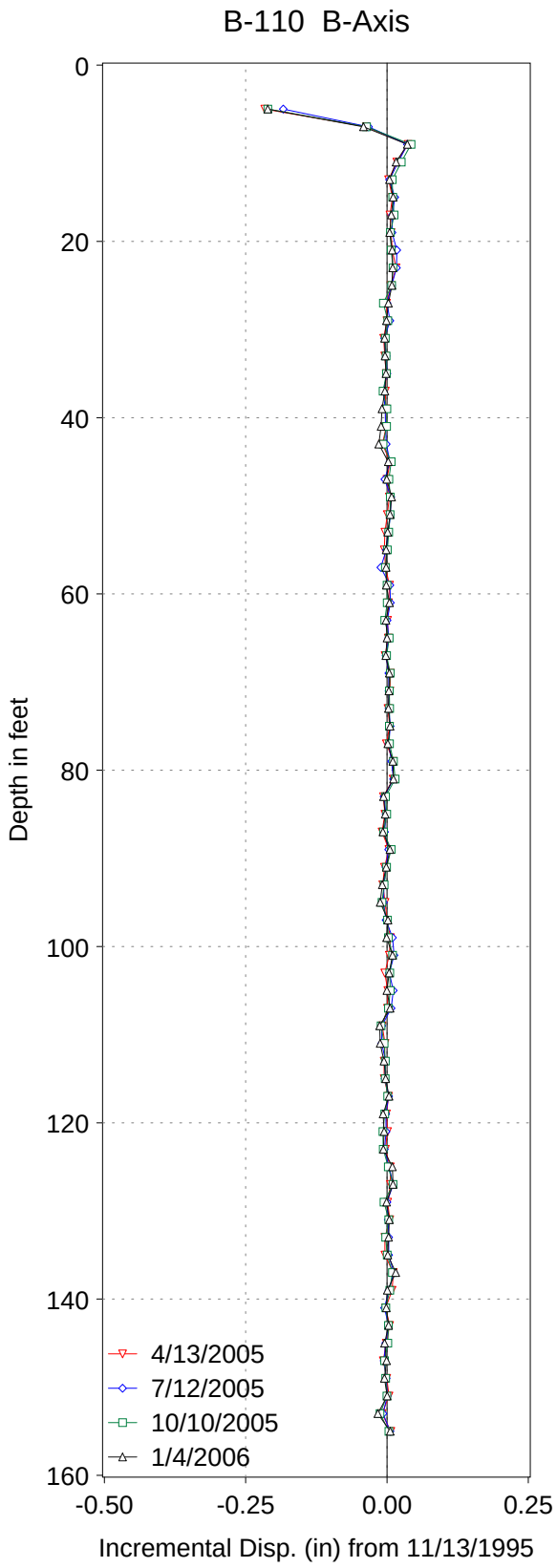
Note: This is the final time-displacement plot through April 2006 as this inclinometer is scheduled to be replaced; therefore, BBCM will no longer monitor this inclinometer.



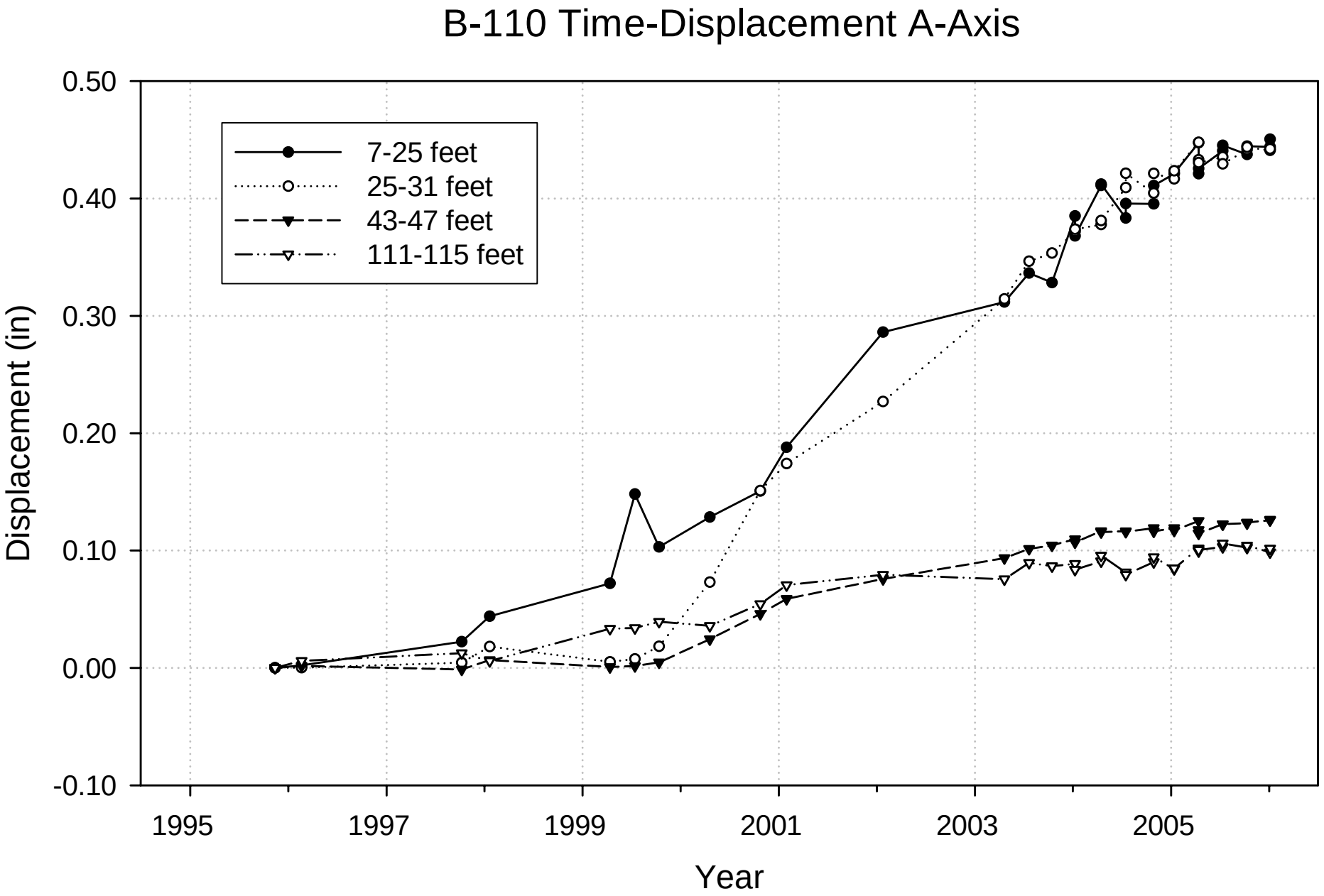


B-110
-Inclinometer destroyed in March by excavation activities performed by others.
-Plots shows one reading from the previous four quarters.

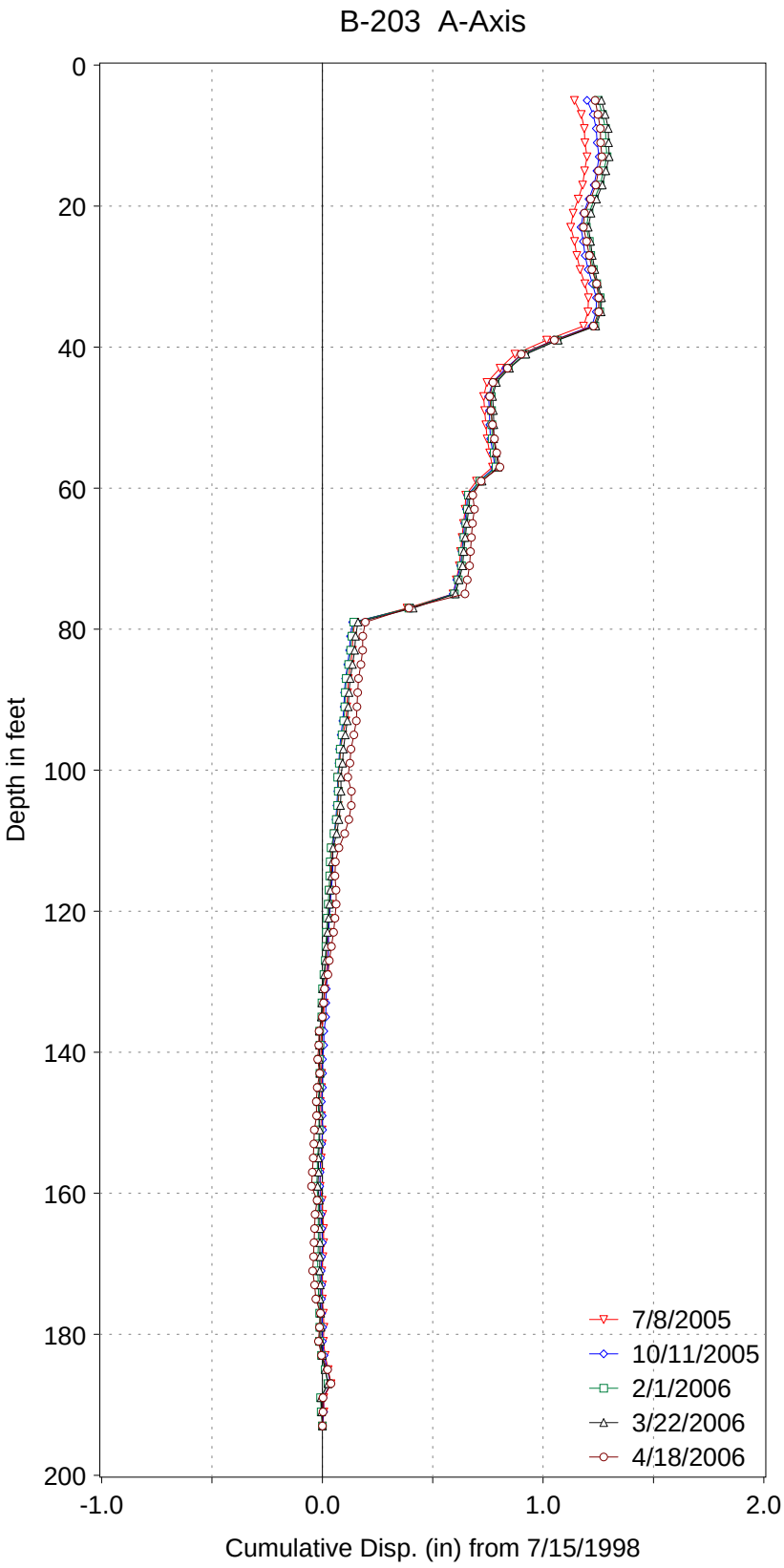


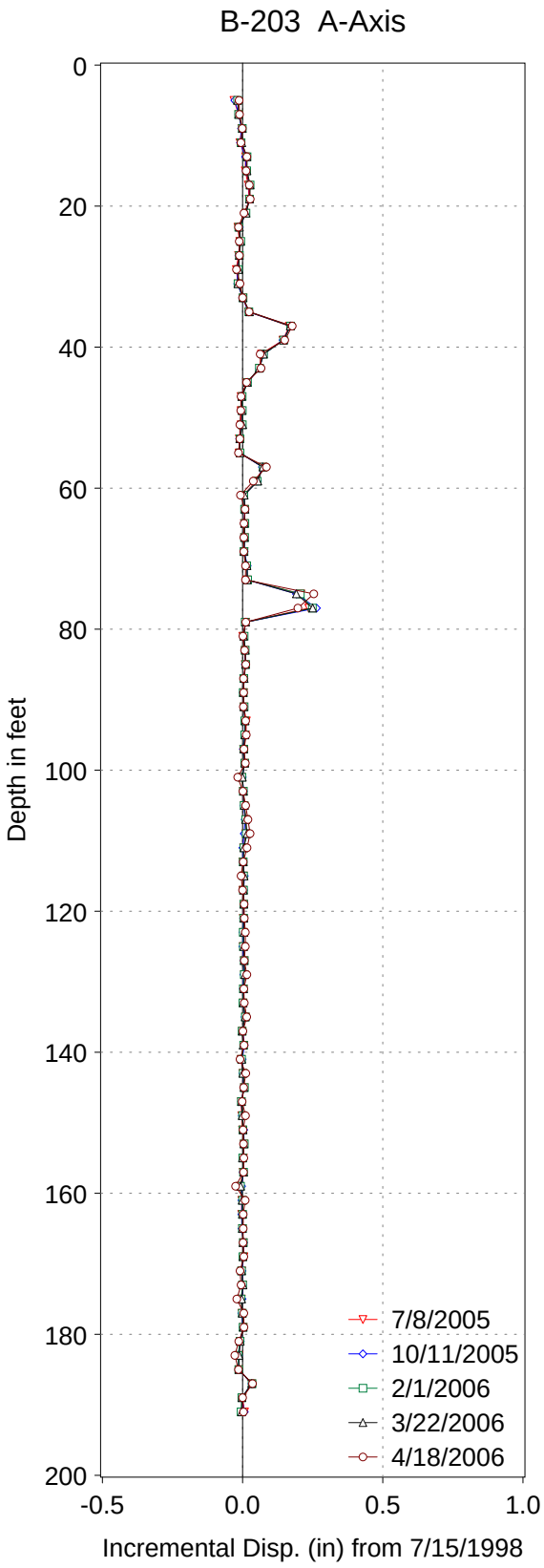


B-110
-Inclinometer destroyed in March by excavation activities performed by others.
-Plot shows one reading from the previous four quarters.

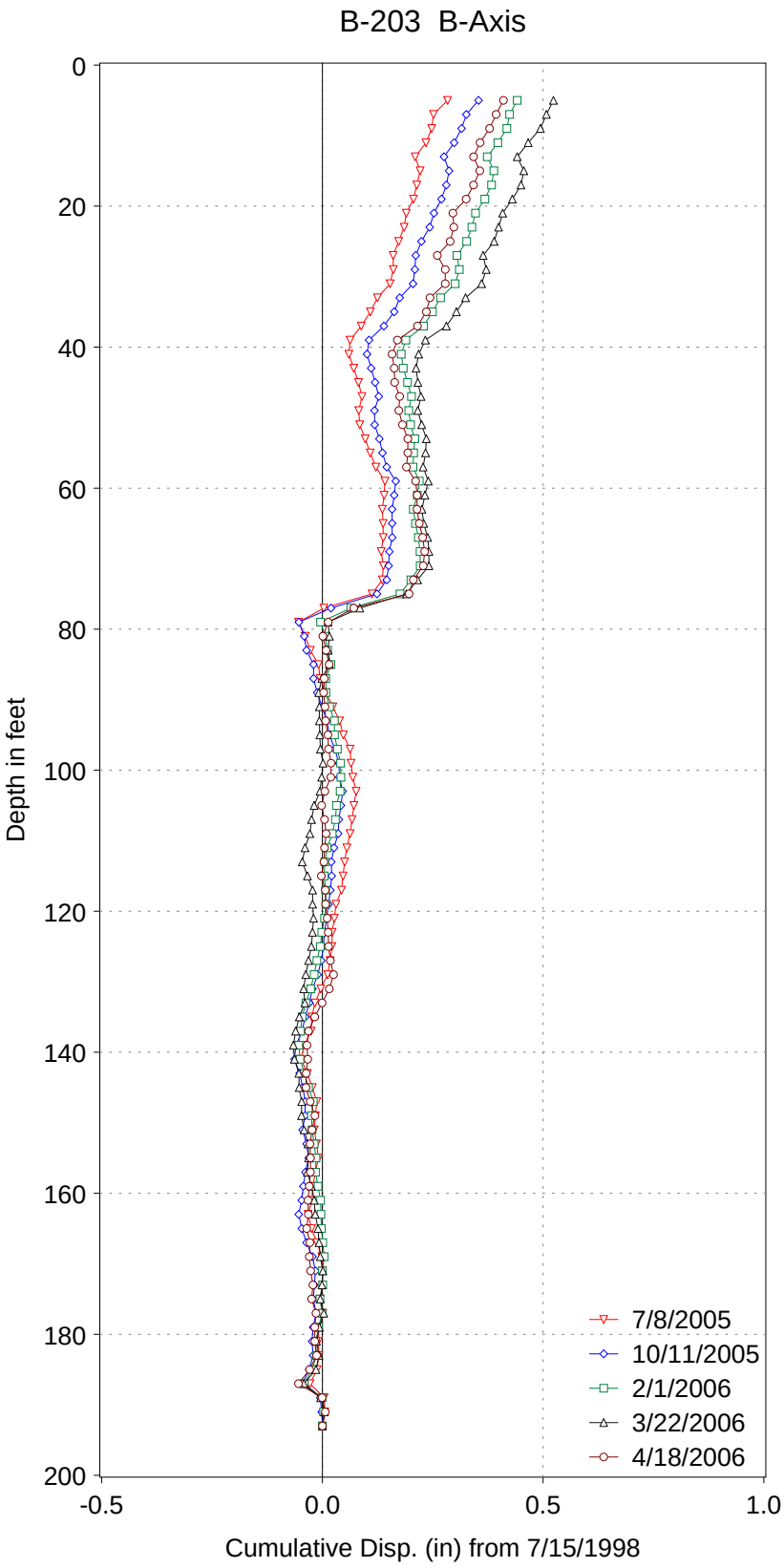


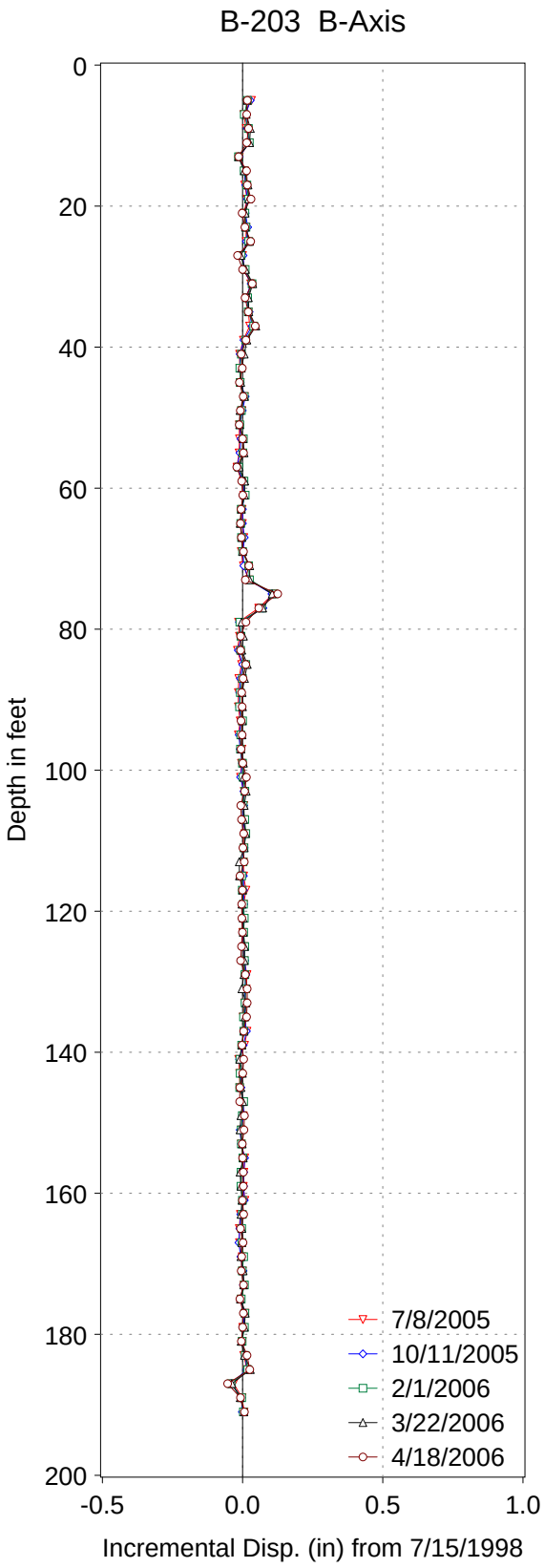
Note: This is the final time-displacement plot through January 2006 as this inclinometer was destroyed by excavation activities performed by others.



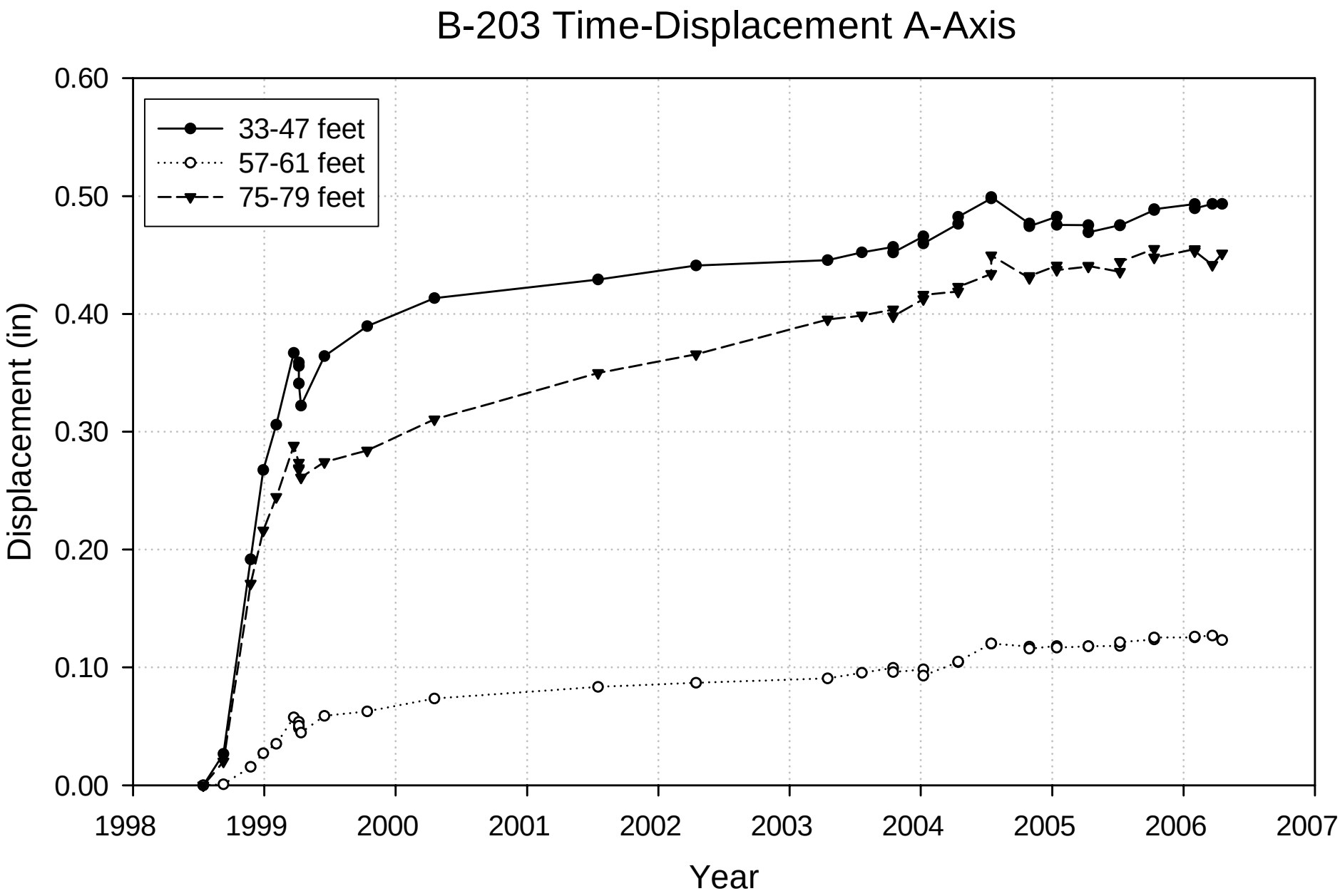


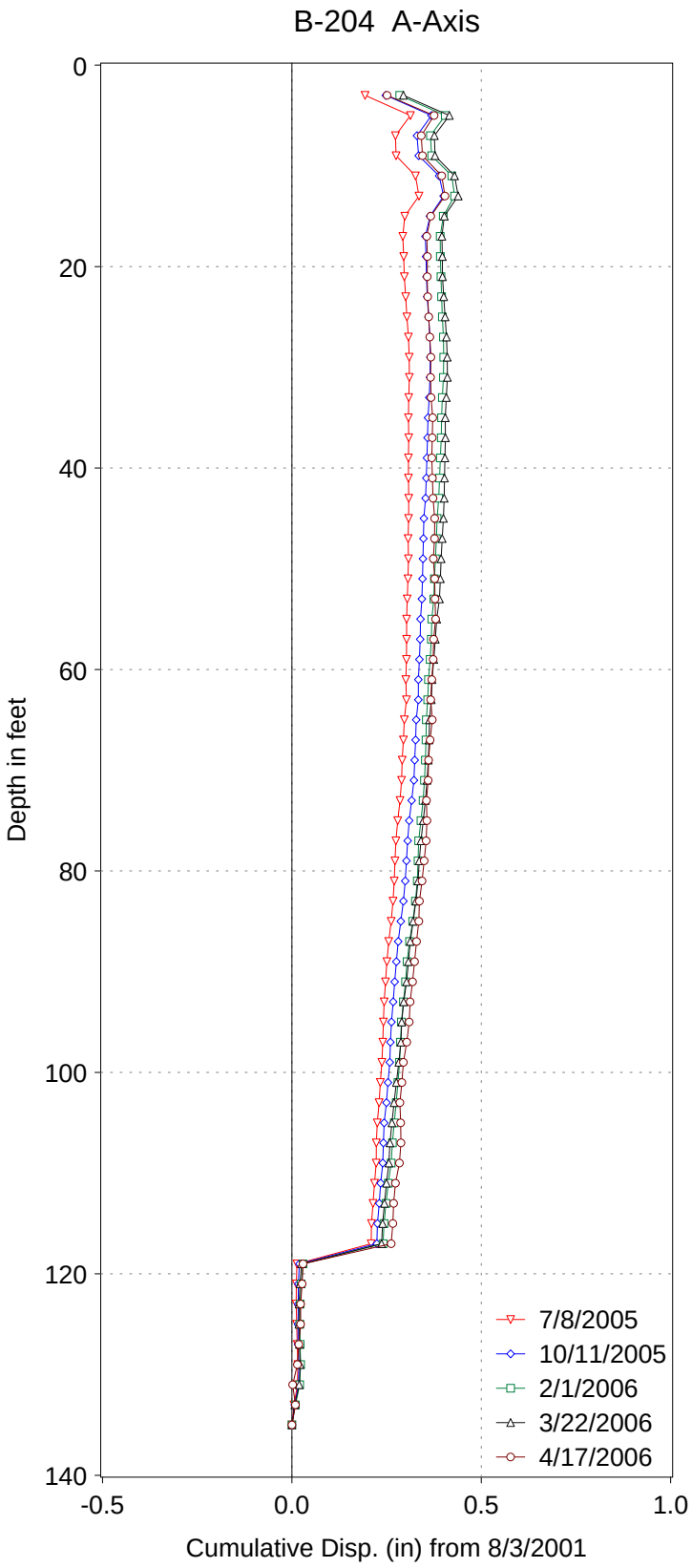
B-203
-Includes readings from the last four quarters (and in March).

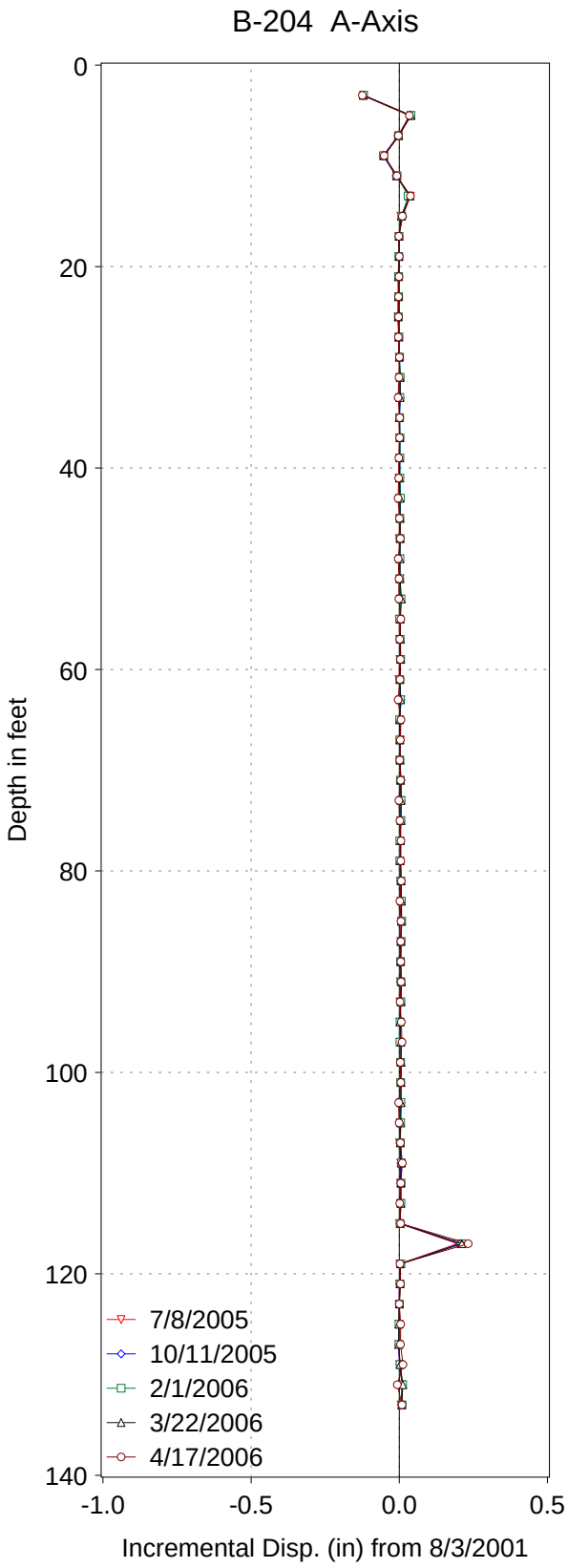




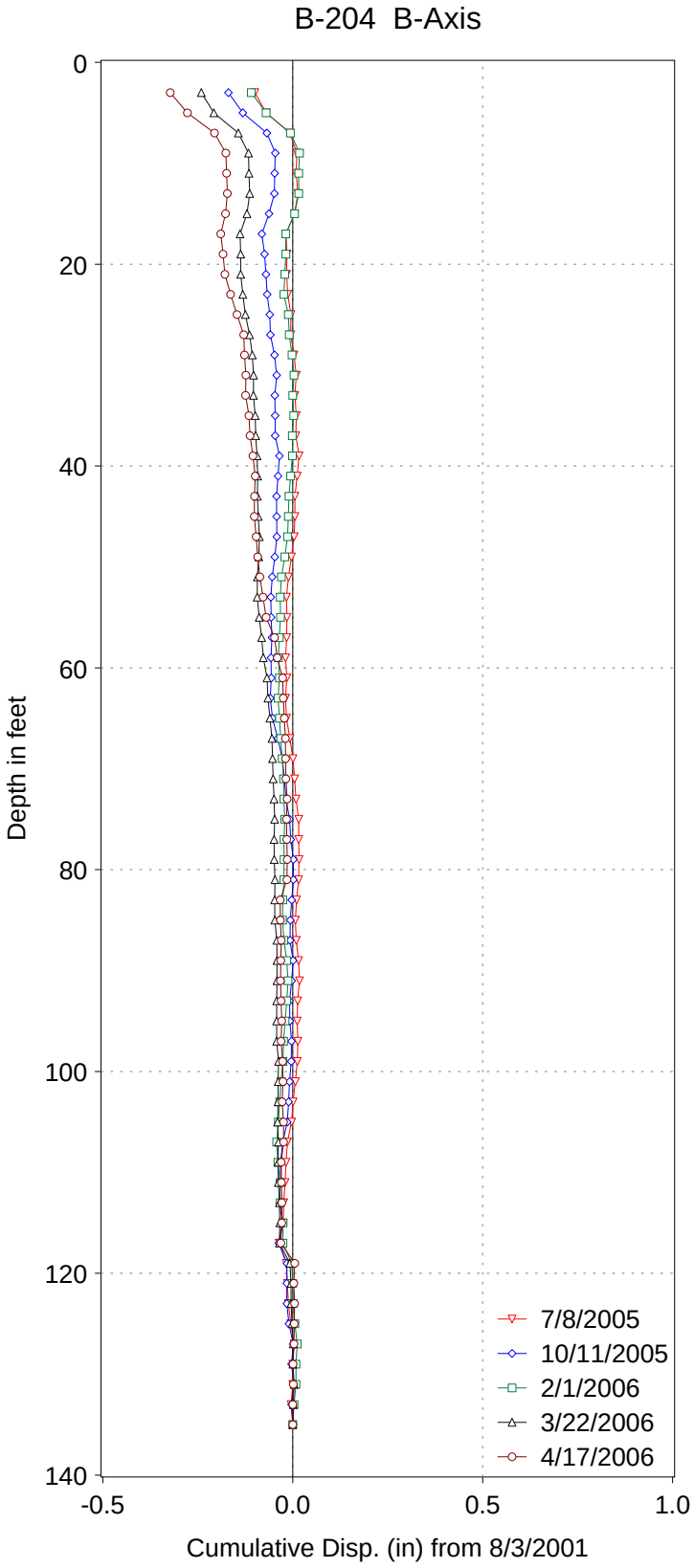
B-203
-Includes readings from the last four quarters (and in March).

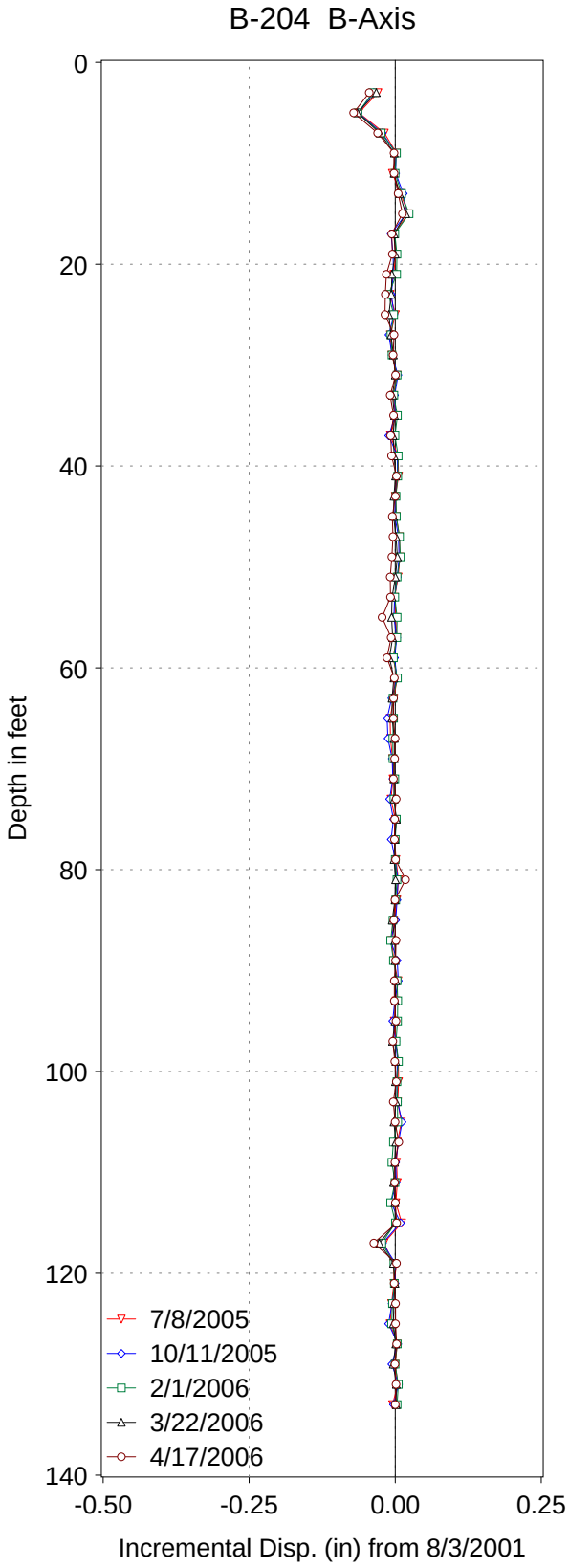

B-203 Time-Displacement A-Axis
33-47 feet
57-61 feet
75-79 feet
Displacement (in)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year



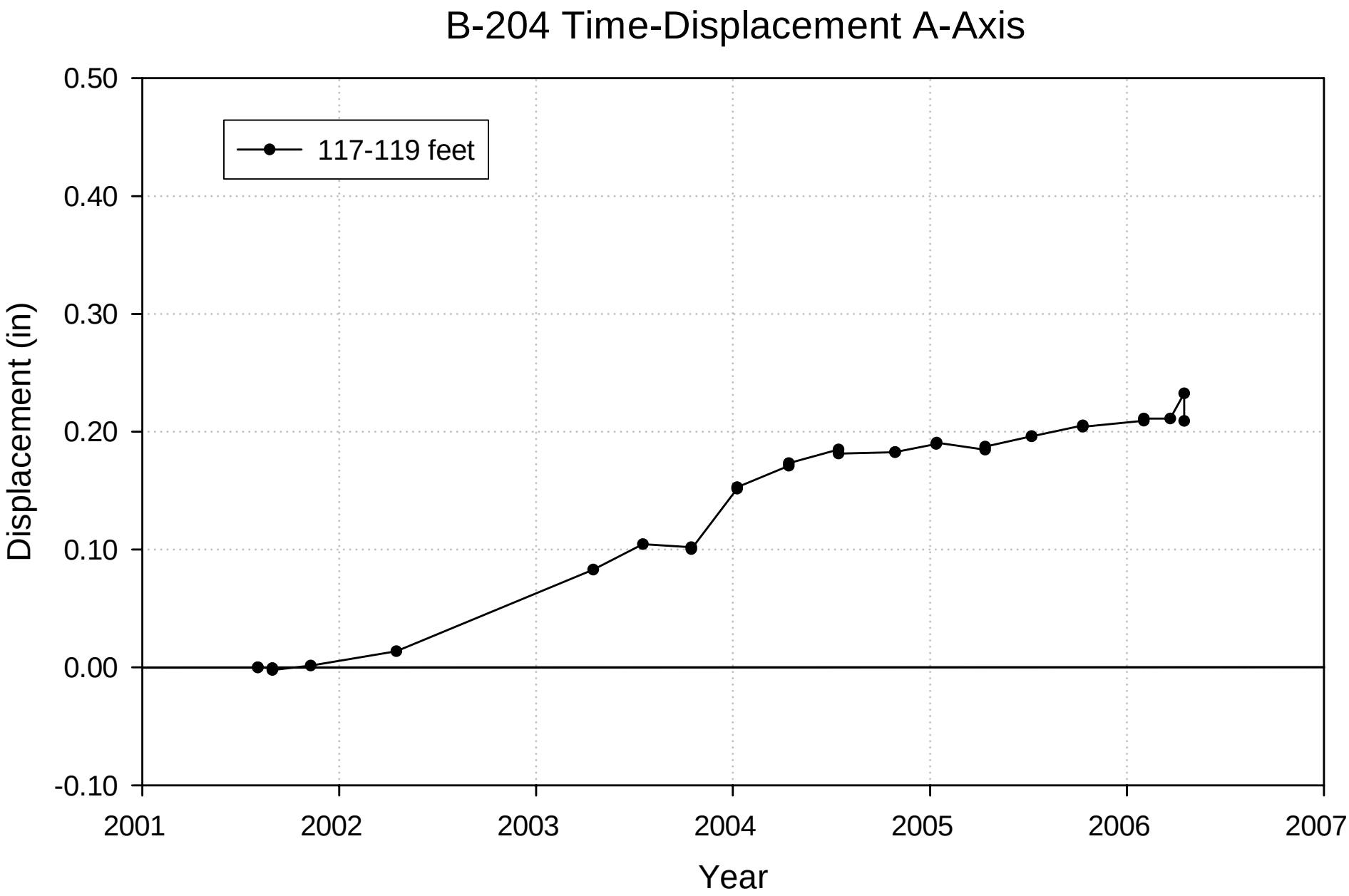


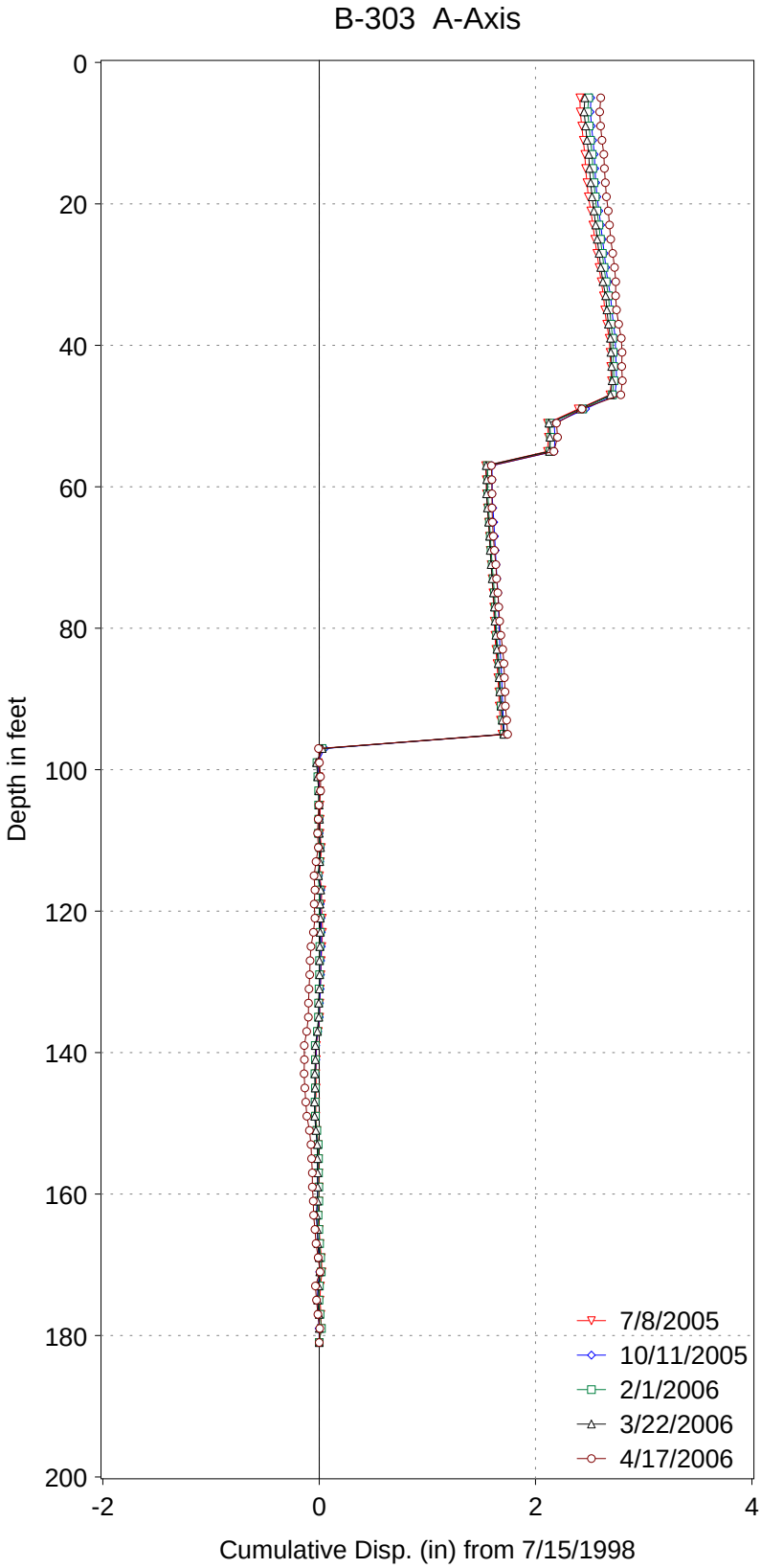
B-204
-Includes readings from the last four quarters (and in March).

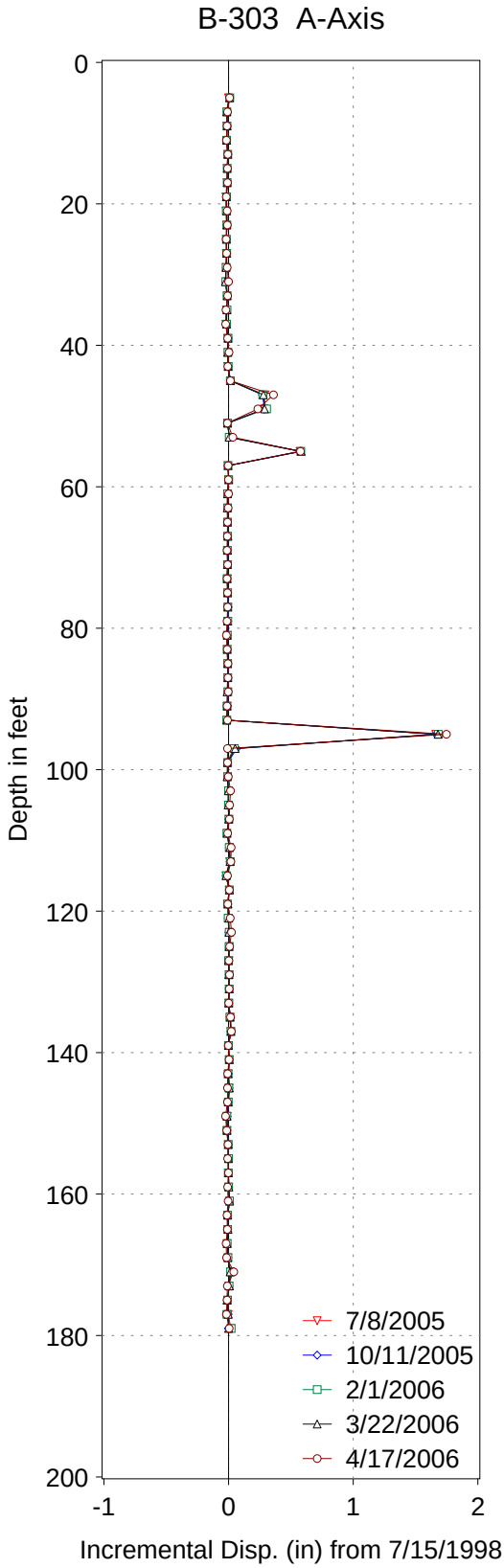




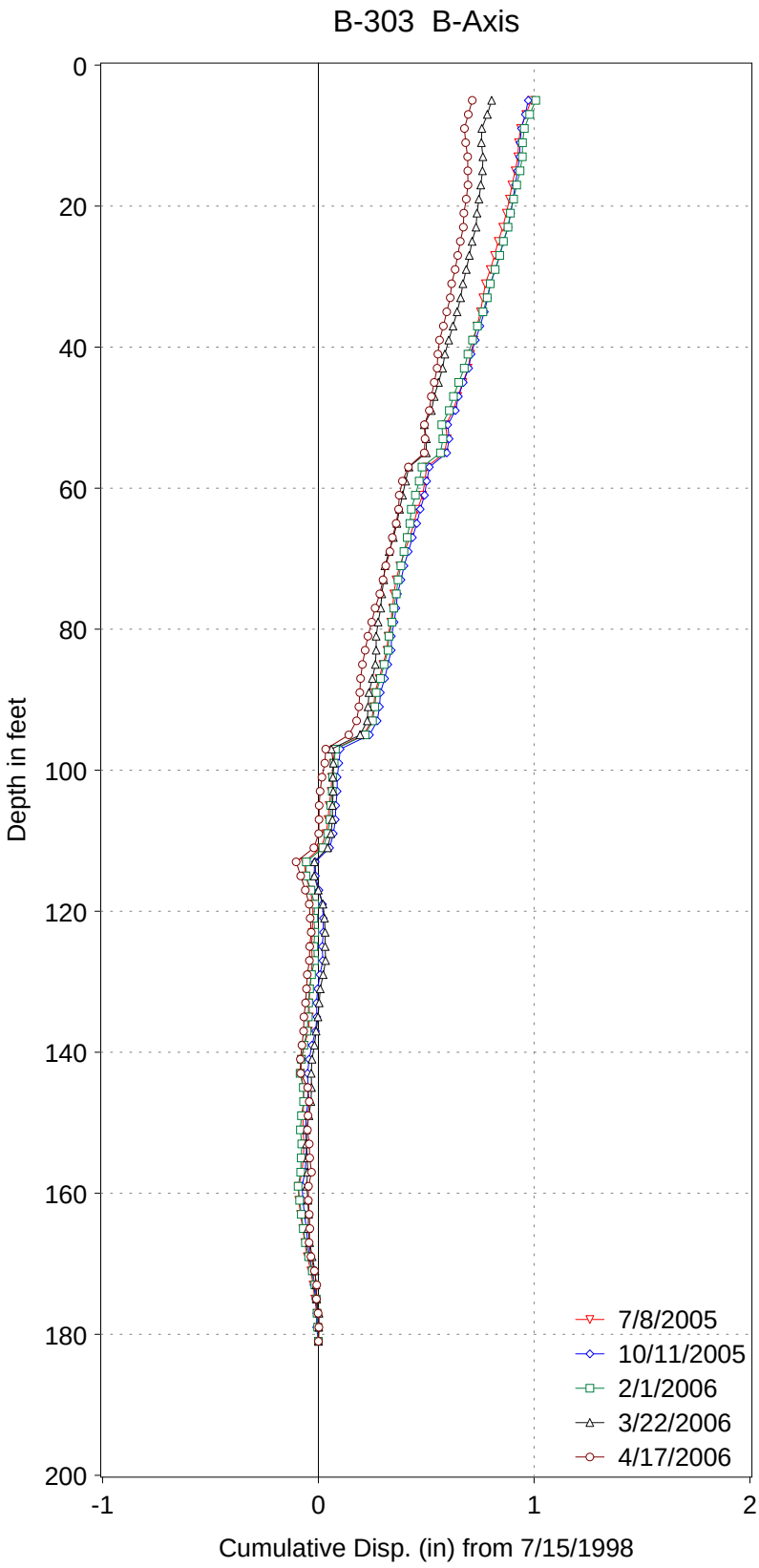
B-204
-Includes readings from the last four quarters (and in March).

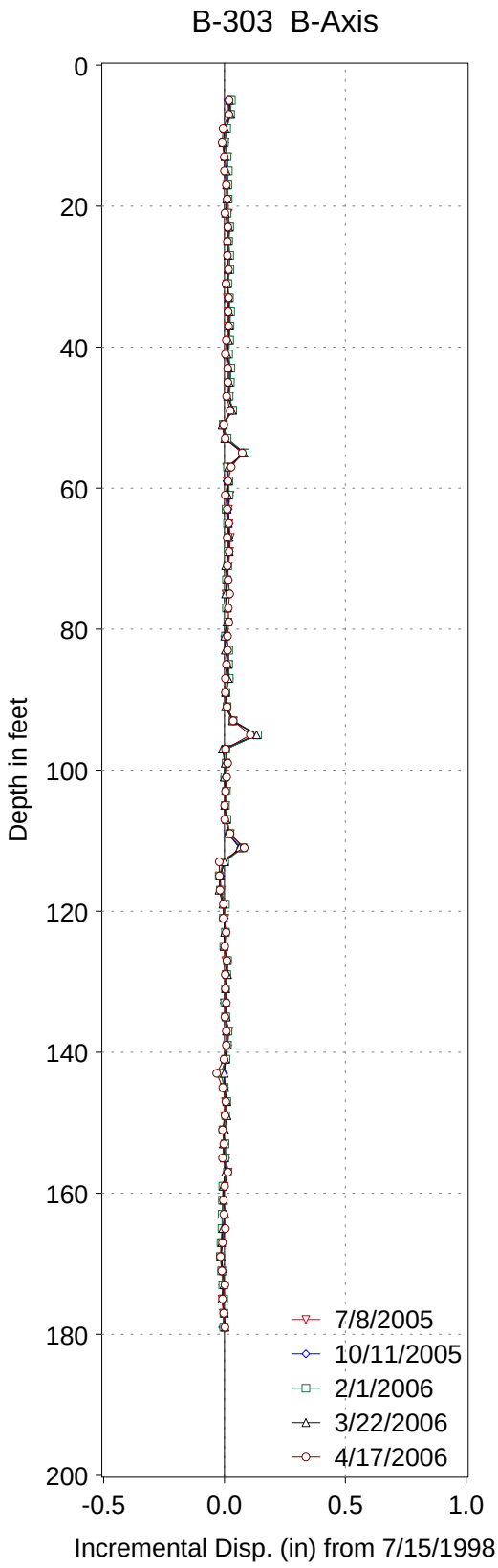

B-204 Time-Displacement A-Axis
117-119 feet
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
Displacement (in)
2001
2002
2003
2004
2005
2006
2007
Year



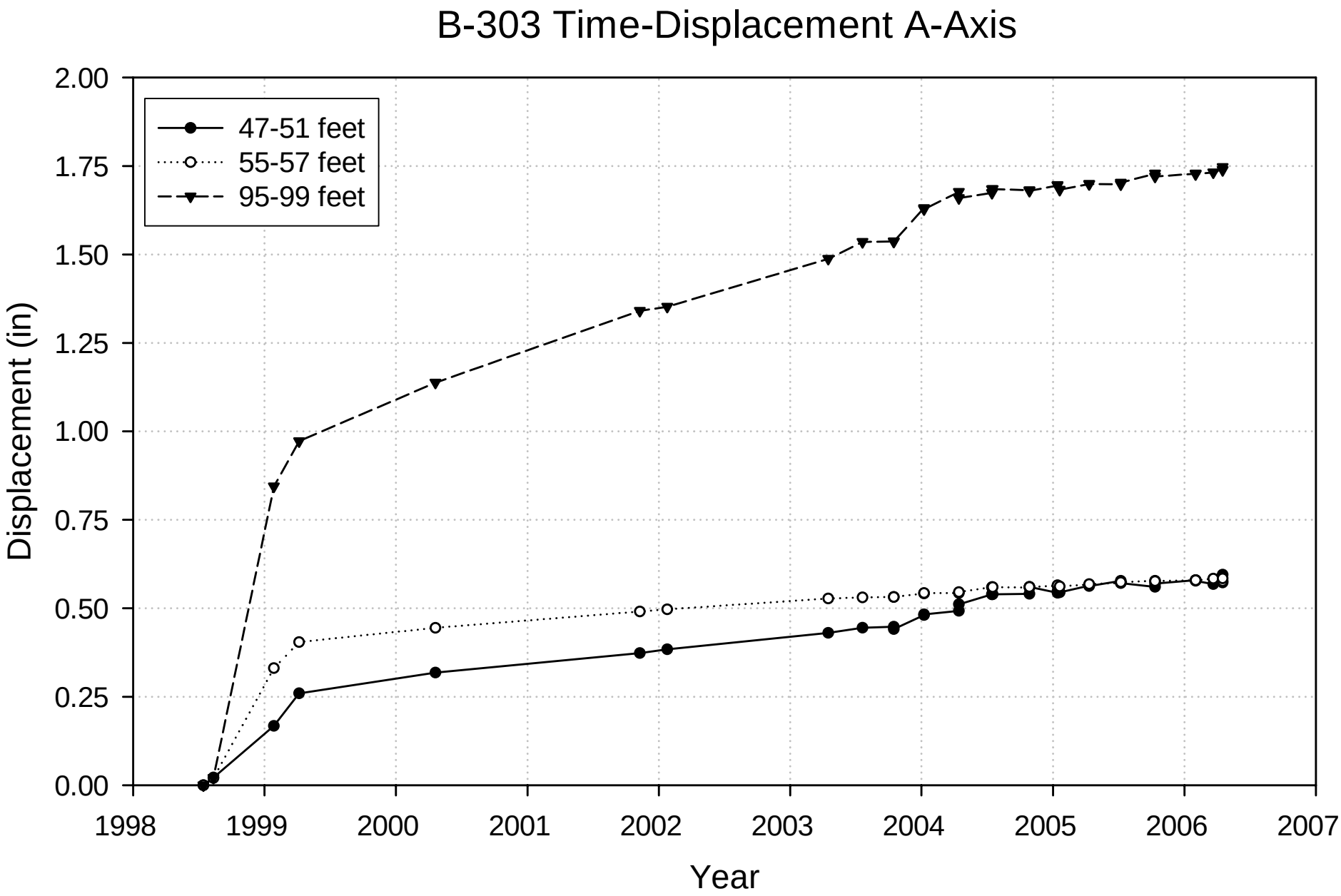


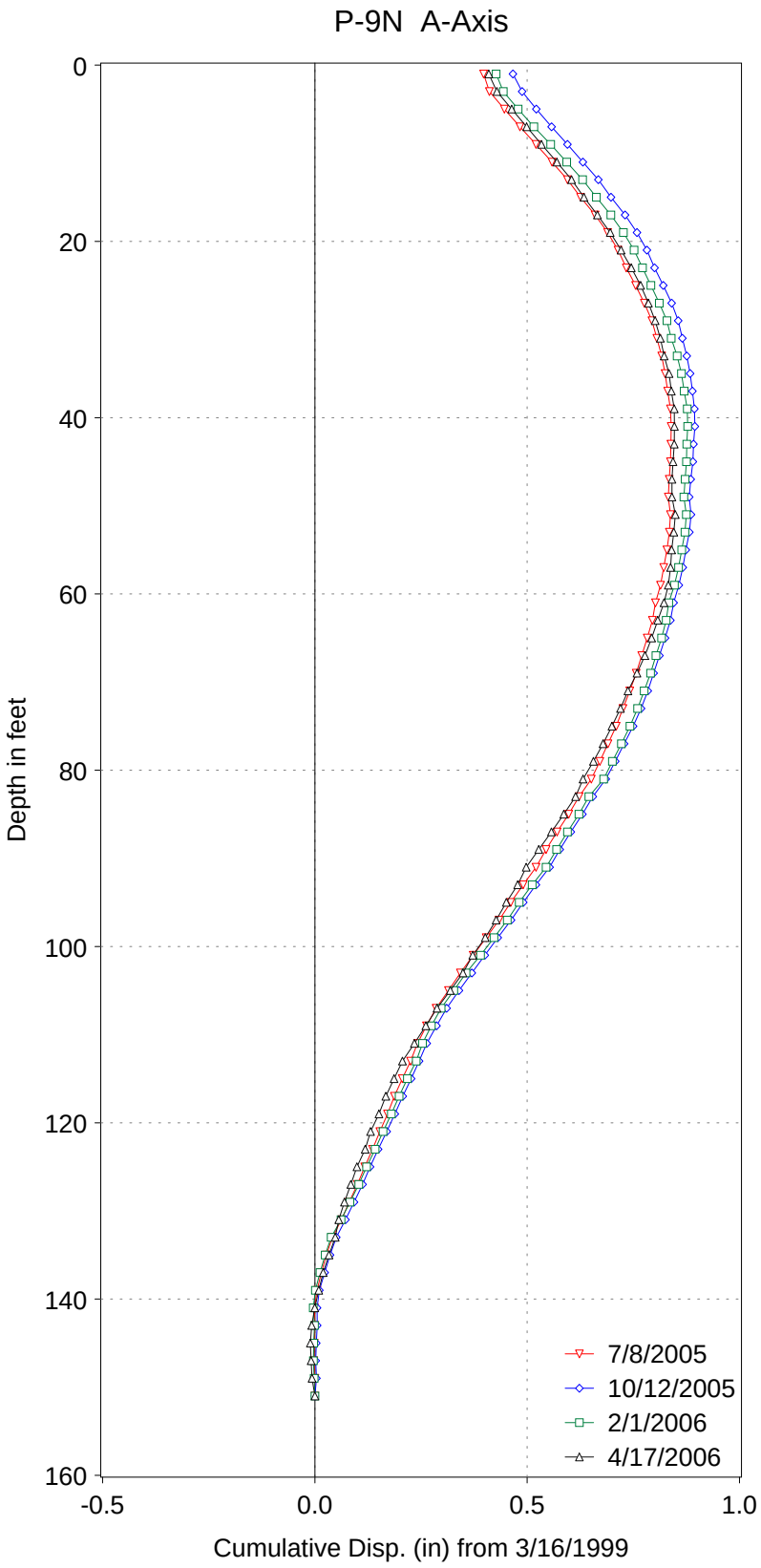
B-303
-Includes readings from the last four quarters (and in March).

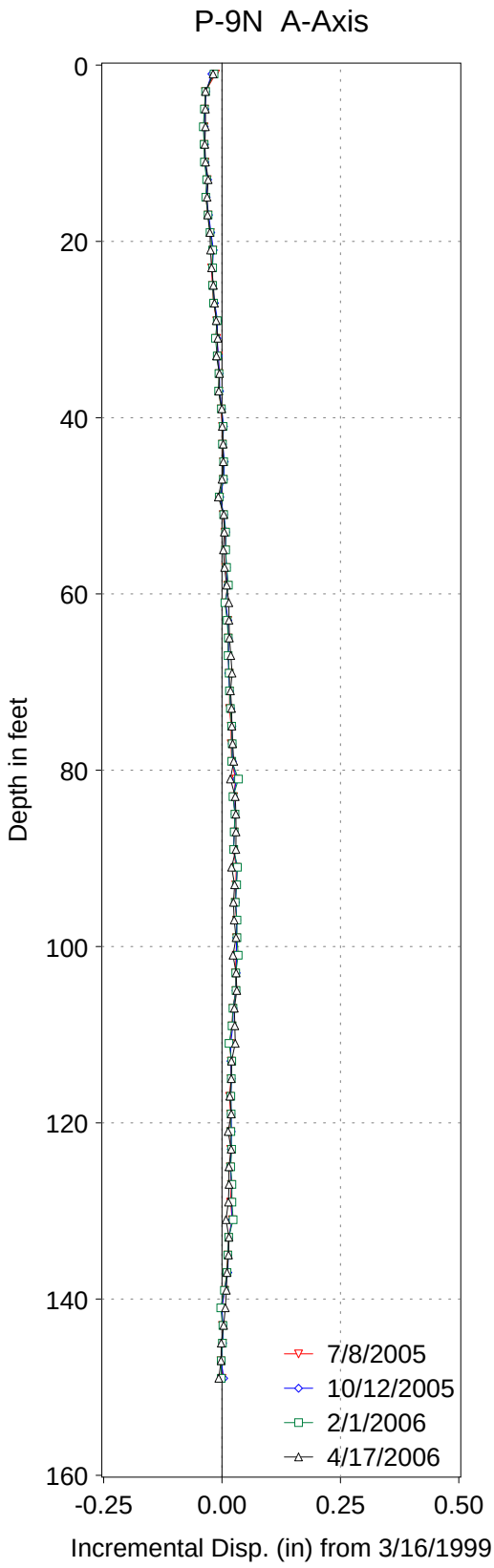




B-303
-Includes readings from the last four quarters (and in March).

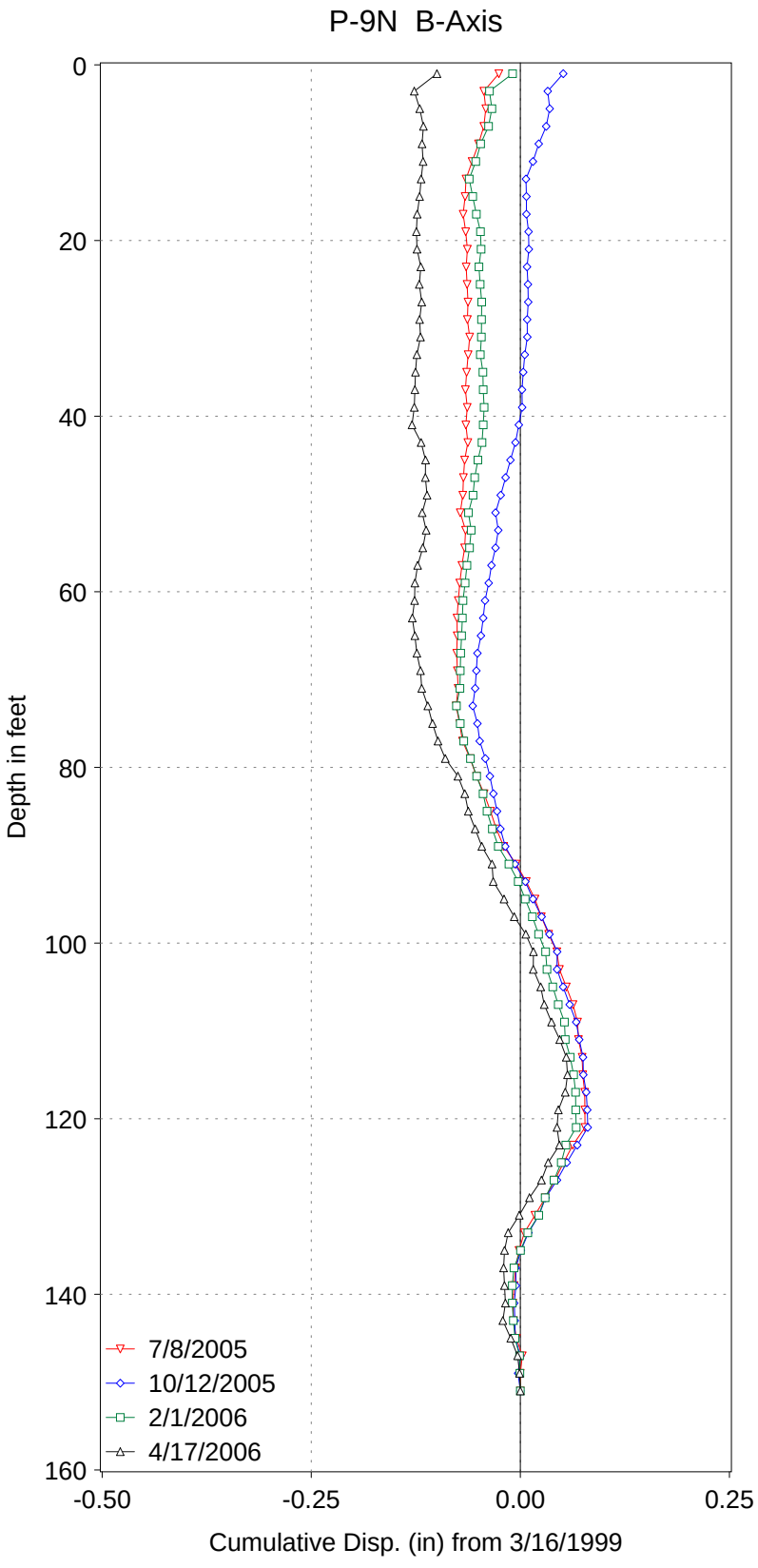

B-303 Time-Displacement A-Axis
47-51 feet
55-57 feet
95-99 feet
Displacement (in)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

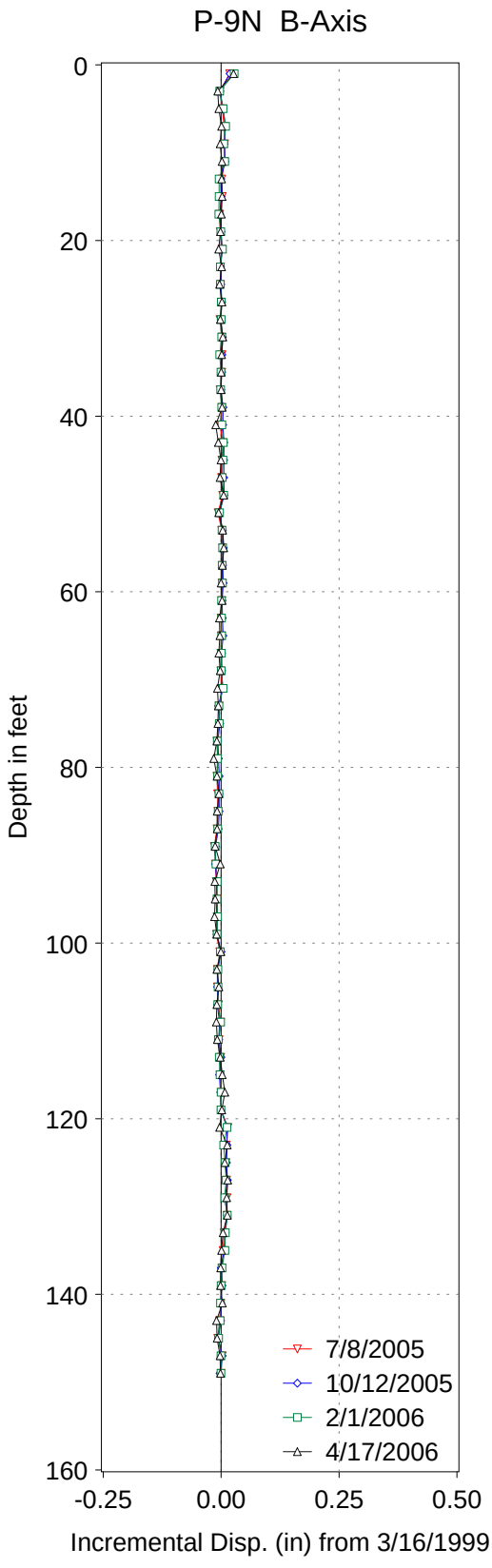




P-9N

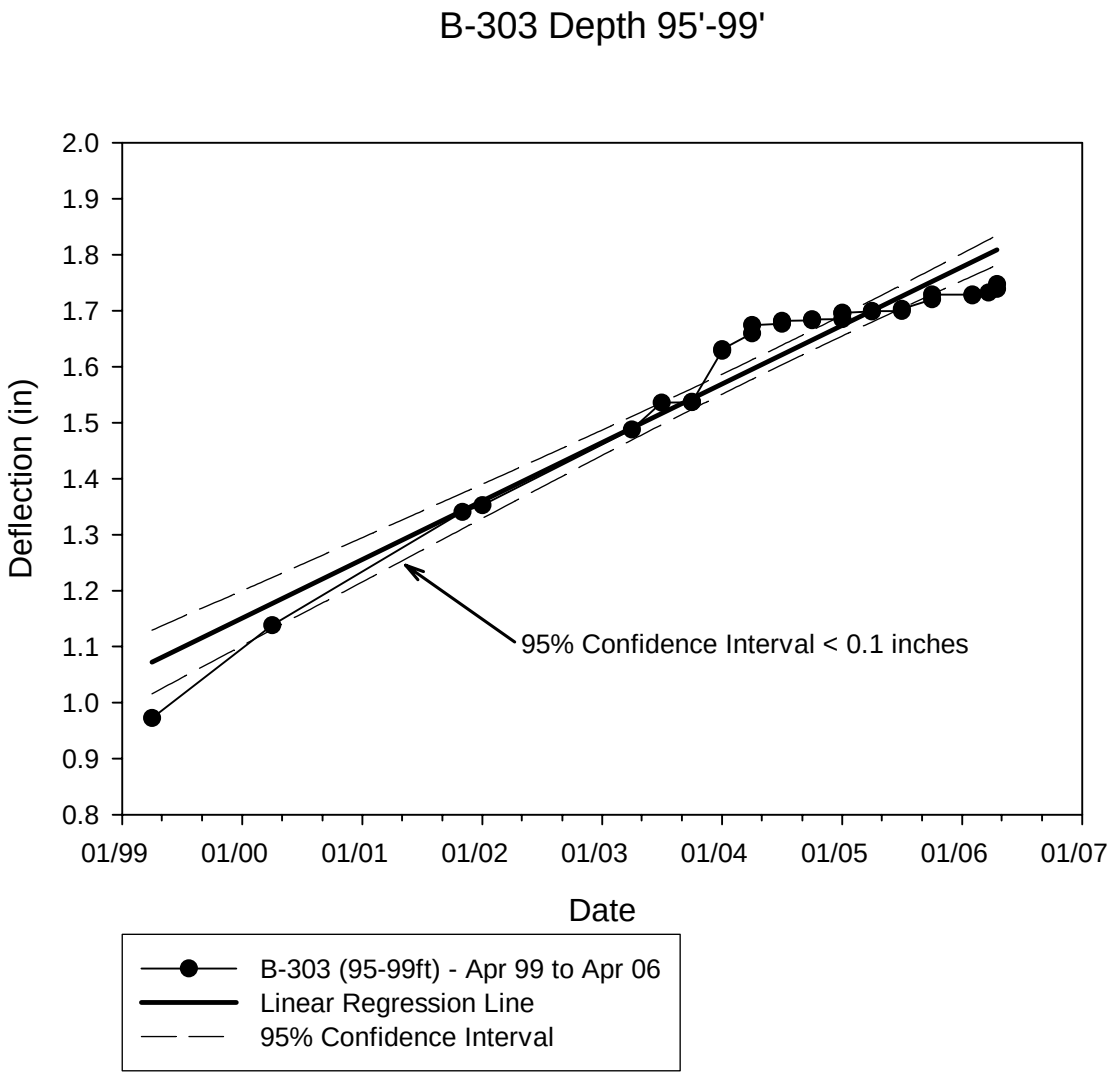
-Includes readings from the last four quarters.





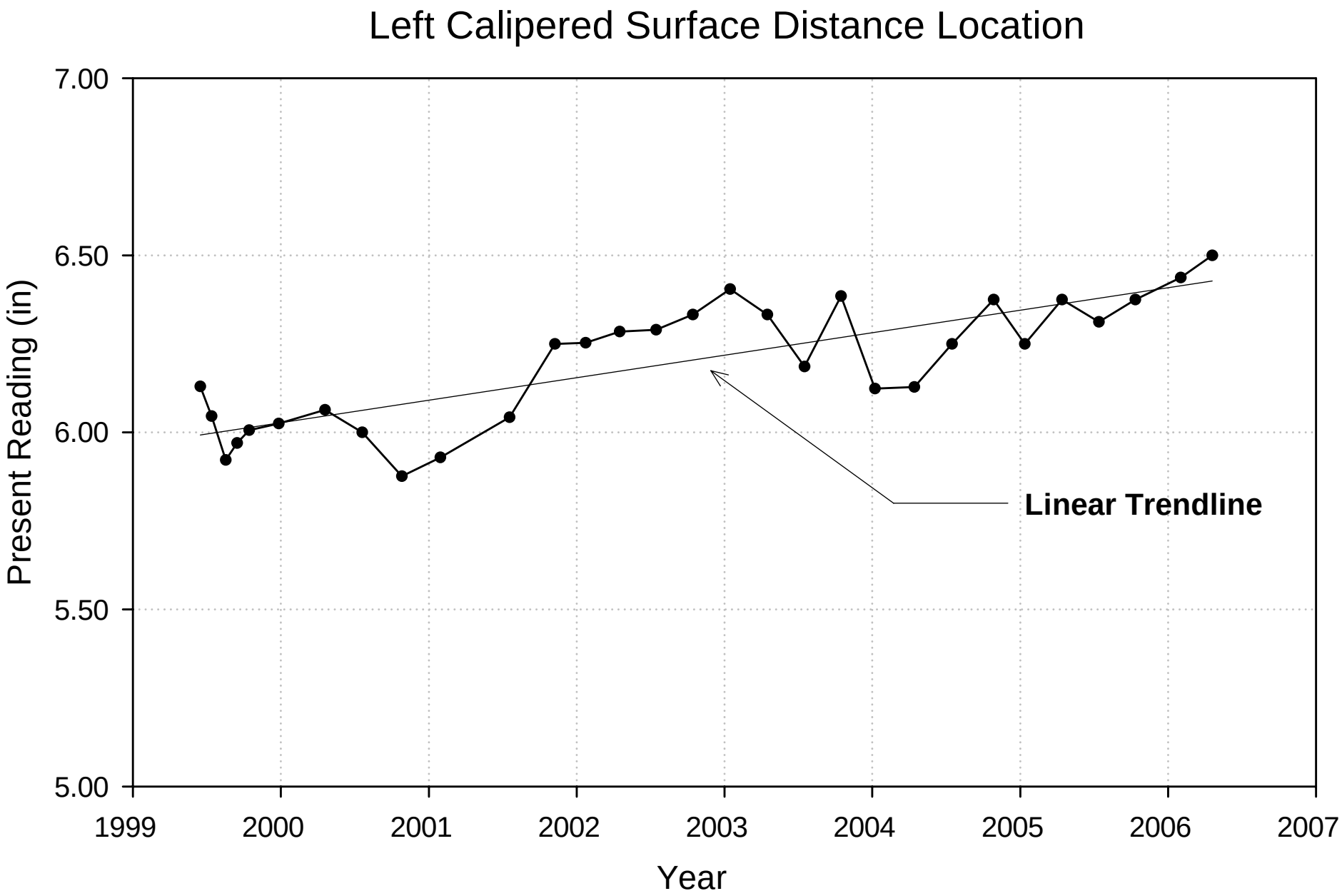
P-9N

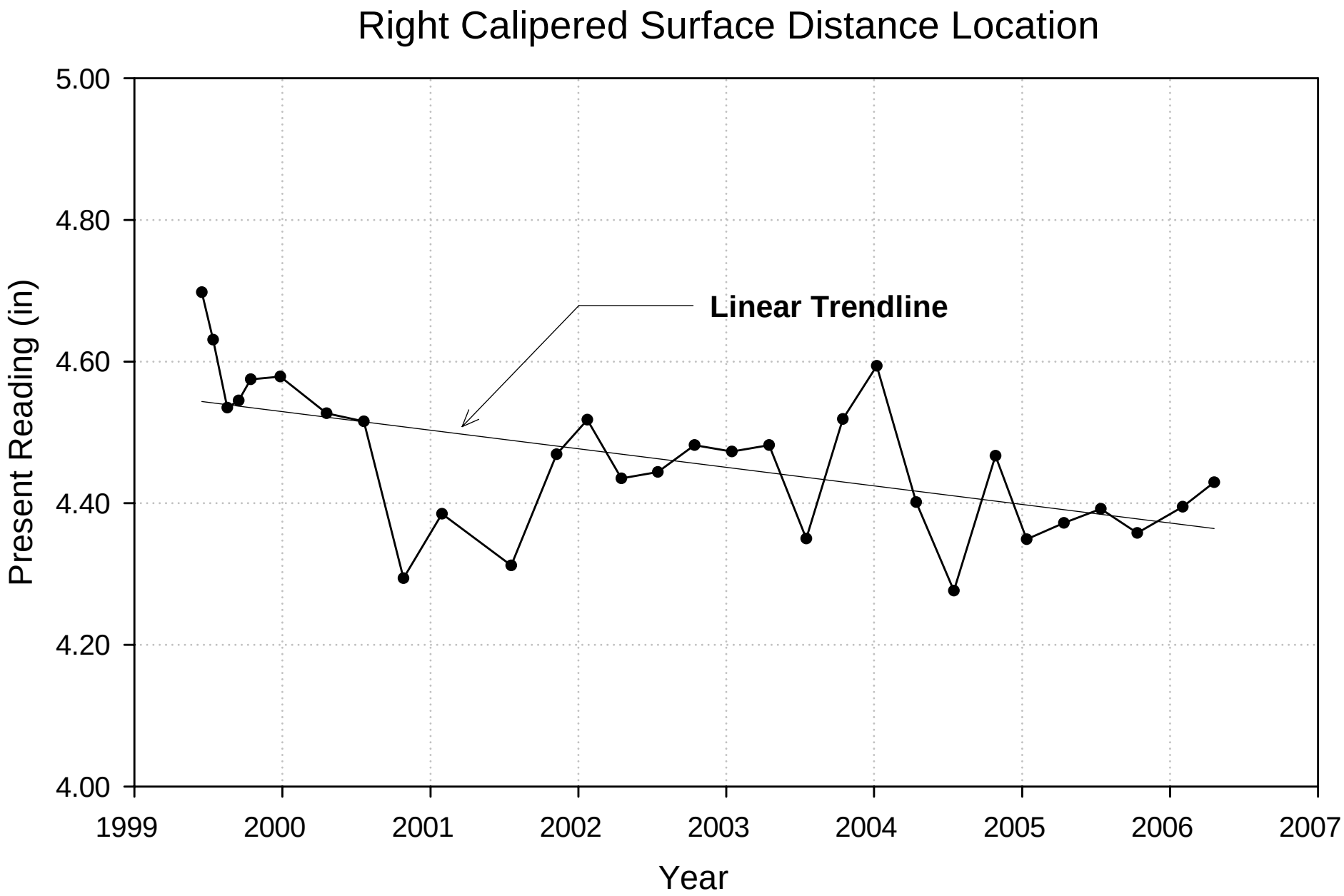
-Includes readings from the last four quarters.

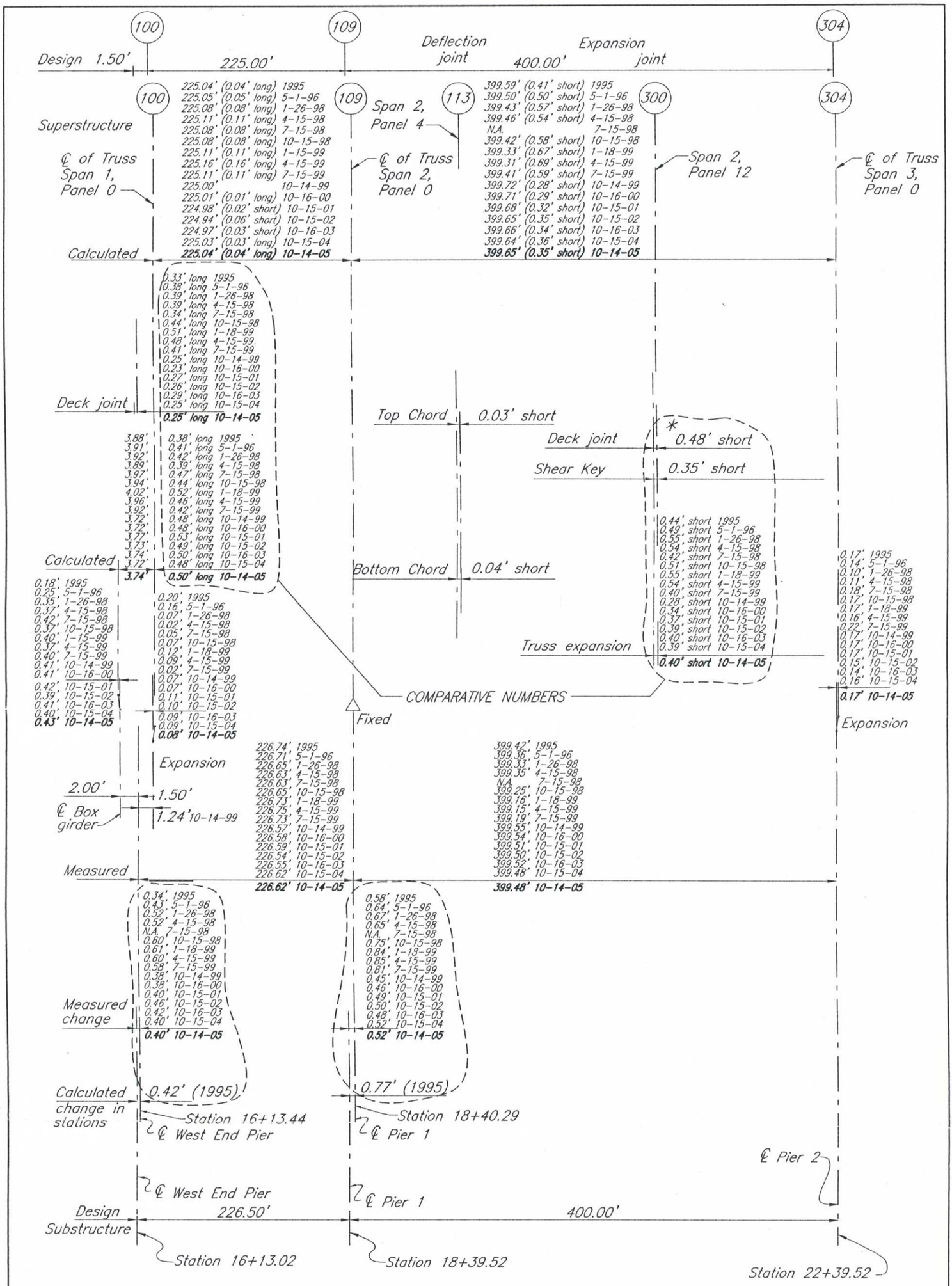

B-303 Depth 95'-99'
Deflection (in)
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
01/99
01/00
01/01
01/02
01/03
01/04
01/05
01/06
01/07
Date
95% Confidence Interval < 0.1 inches
B-303 (95-99ft) - Apr 99 to Apr 06
Linear Regression Line
95% Confidence Interval

CALIPERED SURFACE DISTANCE TABLE
CUY-90-15.24

Date	Left Pier Calipered Surface Distance		Center Line Calipered Surface Distance		Right Pier Calipered Surface Distance	
	Present reading	Change (in.)	Present reading	Change (in.)	Present reading	Change (in.)
10/15/99	6.006	--	Not Accessible		4.575	--
12/27/99	6.025	0.019	Not Accessible		4.579	0.004
04/19/00	6.064	0.039	Not Accessible		4.527	-0.052
07/20/00	6.000	-0.064	Not Accessible		4.516	-0.011
10/26/00	5.876	-0.124	Not Accessible		4.294	-0.222
01/29/01	5.929	0.053	Not Accessible		4.385	0.091
04/17/01	Not Accessible		Not Accessible		Not Accessible	
07/19/01	6.043	0.114	Not Accessible		4.312	-0.073
11/08/01	6.250	0.207	Not Accessible		4.469	0.157
01/23/02	6.253	0.003	Not Accessible		4.518	0.049
04/17/02	6.285	0.032	Not Accessible		4.435	-0.083
07/16/02	6.290	0.005	Not Accessible		4.444	0.009
10/15/02	6.333	0.043	Discontinued		4.482	0.038
01/15/03	6.405	0.072			4.473	-0.009
04/17/03	6.333	-0.072			4.482	0.009
07/18/03	6.186	-0.147			4.350	-0.132
10/16/03	6.385	0.199			4.519	0.169
01/08/04	6.124	-0.261			4.594	0.075
04/14/04	6.129	0.005			4.402	-0.193
07/16/04	6.250	0.122			4.277	-0.125
10/27/04	6.375	0.125			4.467	0.190
01/12/05	6.250	-0.125			4.349	-0.118
04/14/05	6.375	0.125			4.372	0.023
07/14/05	6.313	-0.063			4.392	0.020
10/12/05	6.375	0.063			4.358	-0.034
02/01/06	6.438	0.063			4.395	0.037
04/20/06	6.500	0.125			4.430	0.072


Left Calipered Surface Distance Location
7.00
6.50
6.00
5.50
5.00
Present Reading (in)
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year
Linear Trendline


Right Calipered Surface Distance Location
Linear Trendline
Present Reading (in)
5.00
4.80
4.60
4.40
4.20
4.00
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year



*1972 Joint repositioned open 0.21'
1998 Joint closed 0.27'
0.48'

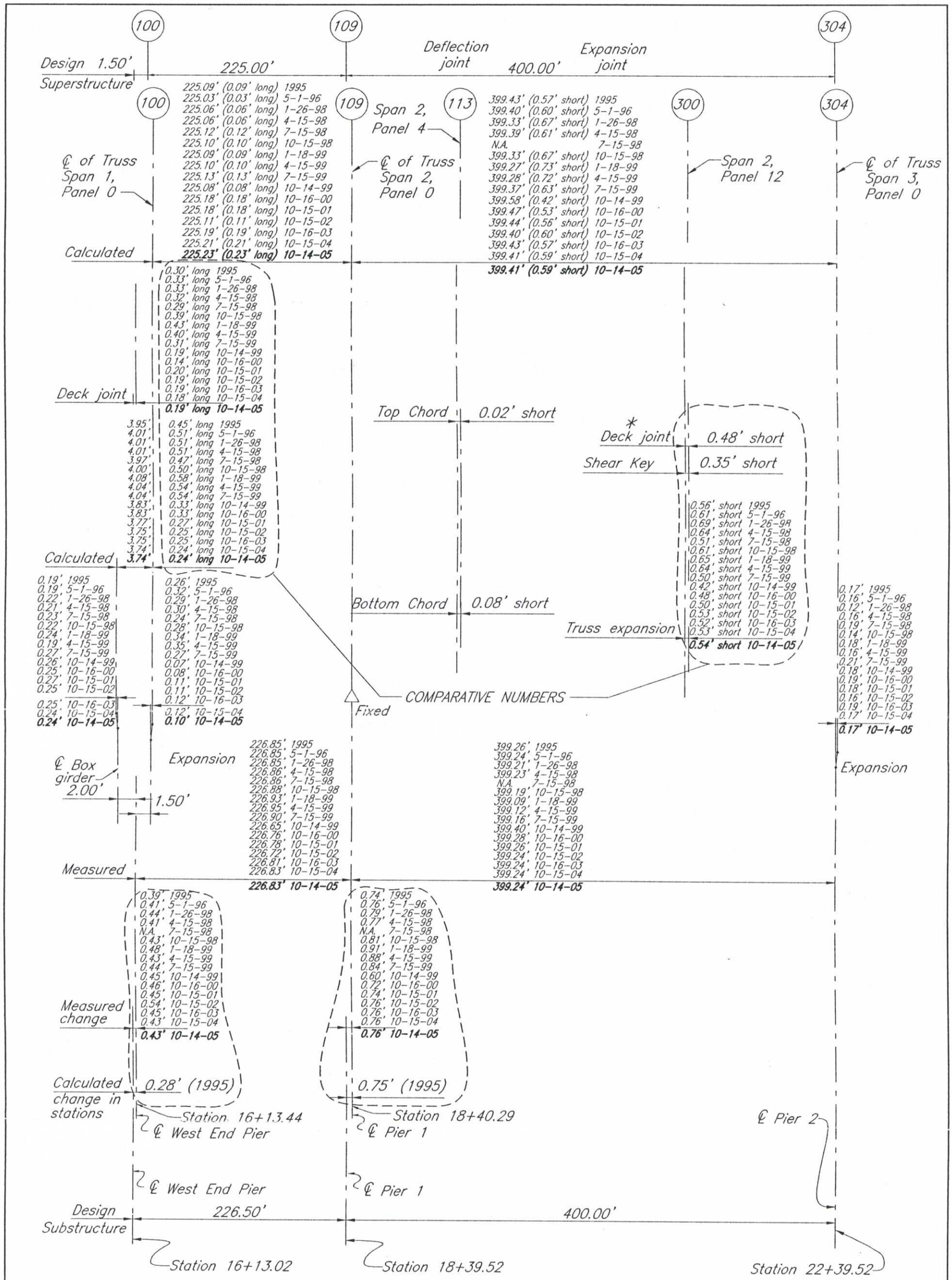
(100) – Panel Number given in Original Construction drawings

Summary of Truss Measurements

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

SCHEMATIC – NORTH TRUSS @ 60° F (10-14-05)
CUY-90-1524

10/10/2005 Measurements, CUY90SCH.DWG



* 1972 Joint repositioned open 0.21'
1998 Joint closed 0.27'
0.48'

(100) – Panel Number given in Original Construction drawings

Summary of Truss Measurements

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

SCHEMATIC – SOUTH TRUSS @ 60° F (10-14-05)
CUY-90-1524

10/19/2005 Measurements/CUY90SCH.DWG

RELATIVE SPAN LENGTHS

(Distance between points set on consecutive piers)

	Span 1		Span 2	
	North Truss	South Truss	North Truss	South Truss
1985	215.35	215.30	399.49	399.74
1988	215.47	215.46	399.38	399.57
1989	215.48	215.44	399.36	399.59
1990	215.48	215.45	399.35	399.56
1991	215.48	215.42	399.29	399.57
1992	215.51	215.50	399.30	399.52
1993	215.46	215.49	399.34	399.51
1994	215.47	215.44	399.31	399.52
1995	215.49	215.45	399.34	399.55
5 / 1996	215.46	215.45	399.28	399.53
8 / 1996	215.45	215.46	399.28	399.54
9 / 1997	215.45	215.48	399.29	399.53
1 / 1998	215.40	215.45	399.25	399.50
4 / 1998	215.38	215.46	399.27	399.52
7 /1998	215.35	215.44	¥	¥
10 / 1998	215.40	215.48	399.16	399.47
12 / 1998	215.48	215.53	399.08	399.41
1 / 1999	215.48	215.53	399.08	399.39
4 / 1999	215.51	215.55	399.07	399.41
10 / 1999	215.48	215.50	399.11	399.45
***10/ 1999	215.56	215.66	398.98	399.25
10/2000	215.57	215.77	398.97	399.13
10/2001	215.58	215.79	398.94	399.12
10/2002	215.53	215.73	398.93	399.10
10/2003	215.55	215.82	398.95	399.10
10/2004	215.61	215.84	398.91	399.09
Net Change	0.02	0.15	-0.06	-0.18
Design	215.25	215.10	399.92	400.29
10/2005	215.58	215.81	398.92	399.08
Change from 10/04 to 10/05	-0.03	-0.03	0.01	-0.01

¥ Points destroyed during construction. New points set atop of pier 2, first reading taken 10/15/98

Net change is current reading compared to the last compatible reading (10/1999)

*** Bridge relocated

CUY-90-1524
100109

DECK EXPANSION JOINT OPENINGS

Finger Type Joints

Measurements are in inches.

Date	Temp (F)	West End Pier North	West End Pier South	Near Pier 2 North	Near Pier 2 South	Near Pier 4 North	Near Pier 4 South
Expansion Distance		476 feet		650 feet			
Design	60˚	3.25	3.25	3.25	3.25	3.25	3.25
06-01-70	80˚	4.00		0.00		N.A.	
09-19-75	60˚	5.25		2.00		N.A.	
05-08-78	60˚	4.75	5.50	2.00	2.00	3.25	2.50
07-30-81	75˚	5.50	5.50	2.25	2.25	3.25	2.75
06-09-83	70˚	5.00	5.00	1.50	1.50	2.75	2.25
07-31-85	73˚	5.25	4.75	1.50	1.00	2.75	2.25
10-31-88	40˚	7.75	8.38	1.50	0.75	3.81	3.38
11-01-89	50˚	7.75	7.00	1.13	0.63	3.25	3.13
10-26-90	50˚	7.75	7.25	1.00	0.50	3.00	3.00
09-30-91	55˚	7.50	7.00	0.88	0.00	3.00	3.00
10-13-92	60˚	7.25	6.81	0.63	0.00	2.50	2.50
10-01-93	50˚	7.50	7.13	0.75	0.31	2.75	2.63
09-01-94	63˚	7.25	6.38	0.31	0.00	2.88	1.88
09-08-95	60˚	7.00	6.63	0.44	0.00	2.00	1.88
09-05-96	77˚	6.50	6.63	0.38	0.00	1.25	1.00
09-19-97	75˚	6.88	7.00	0.31	0.06	1.68	1.42
09-24-98	69˚	7.63	7.00	0.00	0.00	1.88	1.75

Date	Temp (F)	West End Pier		Near Pier 2		Near Pier 4	
		North	South	North	South	North	South
10-14-99	45˚	6.19	5.50	2.38	1.88	3.13	2.75
10-16-00	55˚	6.00	4.88	1.75	1.25	2.56	2.43
04-23-01	70˚	5.50	4.25	1.38	0.63	2.13	1.75
07-16-01	80˚	5.00	3.88	1.00	0.25	1.50	1.25
10-15-01	50˚	6.63	5.63	1.63	1.06	3.25	2.75
1-15-02	30˚	6.88	6.25	2.13	1.50	3.88	3.50
4-15-02	61˚	6.00	5.25	1.38	0.88	2.50	2.38
7-15-02	76˚	5.13	4.13	1.13	0.50	1.75	1.50
10-17-02	48˚	7.00	6.38	1.75	1.25	3.25	2.88
11-1-02	35˚	7.25	6.13	1.88	1.38	3.63	3.38
1-15-03	7˚	8.13	6.63	2.38	1.88	5.00	4.75
4-15-03	67˚	5.63	4.63	1.25	0.63	2.25	2.00
7-15-03	74˚	5.38	4.38	1.00	0.50	2.00	1.63
10-16-03	46˚	7.00	5.75	1.50	1.13	3.25	3.13
1-15-04	11˚	8.00	6.75	2.00	1.38	4.63	4.00
4-15-04	41˚	6.88	5.75	1.38	0.88	3.50	3.25
7-15-04	67˚	5.63	4.75	1.00	0.50	2.13	1.75
10-15-04	50˚	6.38	5.50	1.25	0.75	3.00	2.75
1-15-05	12˚	7.75	7.00	2.00	1.38	4.63	4.25
4-16-05	47˚	6.50	5.63	1.25	0.75	3.25	2.88
7-16-05	74˚	5.50	4.50	0.75	0.375	1.75	1.63
10-14-05	51˚	6.25	5.50	1.13	0.63	2.81	2.56
1-16-06	26˚	7.63	6.38	1.75	1.13	4.13	3.75
4-14-06	65˚	5.75	4.88	0.75	0.50	2.25	2.00

N.A. - No measurements available

PIER TILT

(The difference between the coordinates of the points set on the pier seat and the points at the ground line using the first year measured as the zero point. A positive value indicates top tilt to the north or east. A negative value indicates top tilt to the south or west.)

Pier	Direction	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 8/96	REL 9/97	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05
WEP North (Inside)	N	=====	-0.03	-0.05	0.66	-0.01	=====	0.03	0.03	0.06	0.06	0.02	0.08	0.07	0.10	0.12	0.10	0.10	0.08	0.14	0.09	0.08	0.09
	E	=====	0.14	0.32	0.55	0.24	=====	-0.00	-0.02	-0.00	0.04	0.11	0.03	0.00	0.01	0.01	0.04	0.02	0.01	0.03	0.05	0.02	0.04
WEP North (Outside)	N	=====	-------	=====	NA	0.03	=====	0.02	0.06	0.04	0.05	0.08	0.02	0.03	0.02	-0.00	-0.04	-0.02	-0.04	0.01	-0.02	-0.03	0.04
	E	=====	-------	=====	NA	-0.04	=====	-0.02	-0.01	-0.01	0.01	-0.02	0.01	0.02	-0.03	-0.04	-0.01	-0.03	-0.03	-0.03	-0.05	-0.02	0.02
WEP South (Inside)	N	=====	0.02	0.03	0.04	0.03	=====	0.01	0.02	0.02	0.03	0.05	-0.03	0.01	0.04	-0.02	-0.00	0.03	0.07	0.04	0.04	0.04	0.07
	E	=====	-0.16	-0.05	-0.08	-0.06	=====	0.02	0.02	0.00	0.02	-0.05	0.02	0.02	0.03	0.02	0.03	0.04	0.05	0.06	-0.01	0.01	0.04
WEP South (Outside)	N	=====	-------	=====	0.01	-0.01	=====	-0.01	-0.01	0.02	0.03	-0.01	NA	0.02	0.03	0.02	0.02	0.02	0.04	0.01	0.01	0.01	0.01
	E	=====	-------	=====	-0.05	-0.02	=====	0.01	0.03	0.04	0.07	0.12	NA	0.07	0.05	0.07	0.09	0.08	0.10	0.08	0.06	0.06	0.10
Pier 1 North (Inside)	N	=====	-------	=====	0.01	0.03	=====	-0.00	0.00	0.02	0.03	0.02	NA	NA	0.04	0.09	0.06	0.06	0.09	0.07	0.09	0.11	0.05
	E	=====	-------	=====	0.06	0.06	=====	0.01	0.02	-0.04	-0.04	0.04	NA	NA	-0.03	-0.05	0.05	0.06	0.03	0.02	0.01	0.06	0.05
Pier 1 North (Outside)	N	=====	-------	=====	NA	-0.14	-0.11	-0.13	-0.12	-0.13	-0.13	-0.05	-0.08	-0.09	-0.13	-0.05	-0.08	-0.12	-0.06	-0.02	-0.04	0.02	-0.00
	E	=====	-------	=====	NA	0.27	0.26	0.25	0.26	0.24	0.22	0.21	0.26	0.26	0.27	0.24	0.33	0.30	0.33	0.30	0.27	0.35	0.35
Pier 1 South (Inside)	N	=====	0.10	0.05	0.07	0.11	0.09	0.06	0.06	0.07	0.05	0.15	NA	NA	0.12	0.16	0.20	0.18	0.22	0.24	0.21	0.23	0.24
	E	=====	-0.20	0.05	0.03	0.05	0.04	0.05	0.07	0.06	0.02	0.05	NA	NA	0.03	-0.03	0.05	0.17	0.17	0.08	0.09	0.16	0.16
Pier 1 South (Outside)	N	=====	-------	=====	0.01	0.02	0.02	0.04	0.02	0.05	0.04	0.02	0.09	0.09	0.10	0.09	0.16	0.14	0.17	0.20	0.19	0.21	0.19
	E	=====	-------	=====	-0.07	-0.01	-0.06	-0.03	-0.01	-0.04	-0.06	0.04	-0.07	-0.06	-0.06	-0.13	-0.04	0.06	0.10	0.01	0.03	0.05	0.08
Pier 2 North (Inside)	N	=====	0.04	0.03	0.07	0.03	0.01	NA	-0.01	0.03	NA	=====	0.03	0.06	0.06	0.06	0.03	0.00	0.04	0.02	0.04	0.04	0.01
	E	=====	-0.07	-0.08	-0.05	-0.04	-0.04	NA	-0.09	-0.05	NA	=====	-0.03	-0.12	-0.08	-0.06	-0.07	-0.07	-0.10	-0.12	-0.08	-0.04	-0.04
Pier 2 South (Inside)	N	=====	0.03	0.03	0.04	0.03	0.02	NA	0.10	0.07	NA	=====	-0.00	0.04	-0.03	-0.08	-0.03	-0.02	0.01	0.02	0.01	0.02	0.00
	E	=====	-0.11	-0.11	-0.08	-0.07	-0.03	NA	-0.05	-0.03	NA	=====	-0.04	-0.14	0.02	0.00	-0.02	-0.08	-0.06	-0.11	-0.07	-0.06	-0.06

------- No reading taken. (Point not set.)

===== First reading (Point set/reset)

NA Information Not Available

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PIER SIDE COORDINATES

(Reference Point Locations on Sides of Piers)

Pier	Direction	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 5/96	REL 8/96	REL 1997	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05
WEP North (Inside)	N	5162.58	5162.67	5162.69	5161.99	5162.66	-------	5161.00	5160.98	5160.96	5160.92	5160.94	5160.96	5160.89	5160.93	5160.93	5160.90	5160.89	5160.89	5160.88	5160.86	5160.89	5160.90	5160.90
	E	4879.46	4879.32	4879.17	4878.94	4879.23	-------	4884.16	4884.18	4884.26	4884.27	4884.27	4884.22	4884.30	4884.32	4884.29	4884.29	4884.29	4884.30	4884.33	4884.34	4884.29	4884.34	4884.34
WEP North (Outside)	N	-------	-------	5184.24	NA	5184.22	-------	5184.04	5184.03	5183.97	5183.98	5183.99	5183.94	5183.99	5184.01	5184.06	5184.06	5184.06	5184.04	5184.04	5184.03	5184.04	5184.03	5183.98
	E	-------	-------	4887.48	NA	4887.51	-------	4888.05	4888.09	4888.14	4888.16	4888.19	4888.24	4888.20	4888.19	4888.21	4888.23	4888.23	4888.25	4888.25	4888.28	4888.28	4888.26	4888.26
WEP South (Inside)	N	5088.80	5088.86	5088.87	5088.86	5088.85	-------	5076.56	5076.51	5076.53	5076.52	5076.50	5076.49	5076.53	5076.53	5076.49	5076.53	5076.51	5076.45	5076.42	5076.46	5076.45	5076.46	5076.43
	E	4854.36	4854.51	4854.43	4854.46	4854.43	-------	4857.97	4857.97	4857.98	4858.01	4858.02	4858.10	4858.02	4858.05	4858.00	4858.02	4858.03	4858.01	4858.02	4858.04	4858.03	4858.04	4858.05
WEP South (Outside)	N	-------	-------	5051.47	5051.45	5051.45	-------	5051.41	5051.37	5051.40	5051.38	5051.34	5051.40	NA	5051.37	5051.35	5051.34	5051.33	5051.32	5051.30	5051.33	5051.34	5051.33	5051.34
	E	-------	-------	4840.79	4840.84	4840.80	-------	4841.07	4841.08	4841.07	4841.08	4841.07	4841.04	NA	4841.10	4841.08	4841.08	4841.08	4841.08	4841.08	4841.12	4841.07	4841.09	4841.09
Pier 1 North (Inside)	N	-------	-------	5087.19	5087.15	5087.09	-------	5086.18	5086.17	5086.17	5086.14	5086.14	5086.16	§	§	5086.13	5086.09	5086.06	5086.08	5086.06	5086.06	5086.05	5086.07	5086.10
	E	-------	-------	5093.22	5093.16	5093.17	-------	5095.93	5095.94	5095.94	5096.01	5096.03	5096.01	§	§	5096.16	5096.15	5096.17	5096.16	5096.21	5096.20	5096.19	5096.23	5096.23
Pier 1 North (Outside)	N	-------	-------	5100.04	NA	5100.11	5100.12	5100.13	5100.13	5100.12	5100.13	5100.12	5100.06	5100.08	5100.09	5100.12	5100.06	5100.03	5100.09	5100.04	5099.98	5100.01	5099.99	5099.99
	E	-------	-------	5098.27	NA	5098.01	5098.03	5098.06	5098.08	5098.08	5098.11	5098.15	5098.22	5098.24	5098.24	5098.24	5098.25	5098.27	5098.30	5098.29	5098.31	5098.32	5098.31	5098.32
Pier 1 South (Inside)	N	5014.59	5014.57	5014.66	5014.61	5014.55	5014.59	5014.60	5014.61	5014.62	5014.61	5014.61	5014.56	§	§	5014.59	5014.53	5014.53	5014.54	5014.52	5014.53	5014.55	5014.55	5014.53
	E	5068.67	5068.93	5068.70	5068.68	5068.65	5068.68	5068.68	5068.70	5068.67	5068.70	5068.74	5068.78	§	§	5068.84	5068.87	5068.96	5068.94	5068.99	5069.04	5069.04	5069.01	5069.03
Pier 1 South (Outside)	N	-------	-------	5001.94	5001.90	5001.87	5001.89	5001.90	5001.87	5001.90	5001.86	5001.86	5001.91	5001.83	5001.84	5001.84	5001.83	5001.80	5001.82	5001.81	5001.81	5001.80	5001.81	5001.83
	E	-------	-------	5063.39	5063.42	5063.34	5063.39	5063.41	5063.42	5063.38	5063.43	5063.46	5063.42	5063.56	5063.58	5063.56	5063.61	5063.69	5063.69	5063.70	5063.74	5063.74	5063.76	5063.75
Pier 2 North (Inside)	N	4954.01	4953.99	4953.99	4953.97	4953.95	4953.95	4953.97	NA	4953.95	4953.95	¥	4953.96	4953.96	4953.93	4953.93	4953.92	4953.94	4953.96	4953.94	4953.94	4953.95	4953.96	4953.97
	E	5469.91	5470.01	5470.04	5469.99	5470.02	5470.03	5470.00	NA	5470.03	5470.03	¥	5469.96	5469.97	5470.05	5470.01	5470.01	5469.99	5469.99	5470.02	5470.00	5469.97	5469.97	5469.98
Pier 2 South (Inside)	N	4883.44	4883.44	4883.44	4883.46	4883.38	4883.39	4883.40	NA	4883.31	4883.37	‡	4883.33	4883.40	4883.35	4883.42	4883.44	4883.40	4883.37	4883.34	4883.37	4883.36	4883.35	4883.39
	E	5445.32	5445.45	5445.46	5445.41	5445.40	5445.40	5445.36	NA	5445.37	5445.39	‡	5445.45	5445.40	5445.50	5445.35	5445.37	5445.38	5445.41	5445.42	5445.40	5445.39	5445.41	5445.41

-------	No reading taken (point not yet set).
NA	Information not available.
¥	Points destroyed during construction. New points set
‡	Unable to shoot points due to rock piles next to piers
§	Shots were not taken due to heat tent for rock anchor placement procedure.

DIFFERENTIAL MOVEMENT

(A positive value indicates movement to the north or east.
A negative value indicates movement to the south or west.)

Pier	Point	Direction	85-88 *	88-89 ‡	89-90 ‡	90-91 ‡	91-92	92-93	93-94	94-95	95-5/96	95-8/96	8/96-97	97-1/98	1/98-4/98	4/98-7/98	7/98-10/98	10/98-12/98	10/98-1/99	1/99-3/99	3/99-4/99	1/99-4/99	4/99-7/99	7/99-10/99	10/99-10/00	10/00-10/01	10/01-10/02	10/02-10/03	10/03-10/04	10/04-10/05	¤ Net Change
WEP North	50	N	-0.05	0.03	-0.00	0.03	0.06	-0.00	0.00	0.00	0.02	0.00	0.01	-0.02	-0.01	0.02	-0.01	-0.02	0.04	NA	NA	0.03	-0.02	-0.03	-0.01	-0.02	0.04	-0.02	-0.01	0.02	0.13
Pier Seat		E	-0.50	0.01	0.01	-0.00	0.00	0.03	-0.00	-0.02	0.07	-0.00	0.02	0.06	0.02	0.05	0.02	-0.01	-0.00	NA	NA	-0.02	0.00	0.03	-0.01	0.01	0.03	-0.03	0.02	0.03	0.32
WEP South	60	N	-0.05	0.01	0.01	0.01	0.09	0.02	-0.00	-0.02	0.02	0.03	-0.04	0.03	-0.00	-0.01	0.01	NA	0.04	NA	NA	-0.01	-0.03	-0.01	-0.01	0.00	0.00	-0.00	0.00	-0.00	0.10
Pier Seat		E	-0.50	0.02	0.00	-0.02	-0.02	0.03	0.01	-0.02	0.03	-0.02	0.02	0.01	0.01	0.03	0.02	NA	0.03	NA	NA	-0.04	0.02	0.02	-0.00	0.02	0.02	-0.07	0.02	0.04	0.13
Pier 1 North	30	N	-0.02	-0.02	0.03	-0.04	0.07	0.04	-0.03	-0.03	0.00	0.04	-0.01	0.00	-0.01	0.00	0.01	-0.01	0.00	NA	NA	-0.01	0.02	-0.06	0.01	0.01	-0.02	0.01	0.04	-0.02	0.03
Pier Seat		E	-0.37	0.01	0.00	0.01	0.03	-0.02	0.00	0.01	0.04	-0.01	0.01	0.01	0.01	0.02	0.07	0.07	0.00	NA	NA	0.01	-0.02	0.11	0.01	0.02	-0.02	-0.01	0.08	-0.00	0.42
Pier 1 South	40	N	-0.01	0.01	0.04	-0.08	0.08	0.04	-0.02	-0.03	0.02	0.02	-0.02	0.01	-0.01	-0.01	0.04	-0.02	0.01	NA	NA	0.01	-0.01	0.04	-0.00	0.02	0.03	-0.02	0.03	-0.01	0.16
Pier Seat		E	-0.33	-0.00	0.01	-0.06	0.06	0.02	-0.04	-0.01	0.03	-0.02	0.04	-0.02	0.02	0.01	0.06	0.03	0.03	NA	NA	-0.02	-0.03	0.18	0.10	0.04	-0.04	0.02	0.04	0.02	0.48
Pier 2 North	10	N	-0.06	0.02	0.02	-0.14	0.02	-0.01	0.02	-0.07	-0.00	0.00	0.01	-0.05	0.03	NA	§	-0.02	0.00	NA	NA	0.01	-0.02	-0.01	-0.01	0.02	-0.02	0.03	0.01	-0.02	-0.04
Pier Seat		E	-0.47	-0.00	-0.01	-0.05	0.03	0.02	-0.02	0.03	-0.01	-0.01	0.03	-0.04	0.04	NA	§	-0.01	0.00	NA	NA	-0.00	0.02	-0.03	0.00	-0.01	-0.03	0.01	0.04	0.00	-0.01
Pier 2 South	20	N	-0.09	0.01	0.00	-0.13	0.03	-0.00	0.03	-0.10	0.01	0.01	-0.00	-0.02	0.03	NA	§	0.01	0.00	NA	NA	-0.00	-0.03	0.01	-0.02	-0.01	0.04	-0.01	0.00	0.01	0.01
Pier Seat		E	-0.50	0.01	-0.01	-0.05	0.02	0.01	-0.02	0.01	0.01	-0.01	0.03	-0.05	0.04	NA	§	-0.03	0.00	NA	NA	0.00	0.01	-0.02	-0.02	0.03	-0.06	0.02	0.04	0.00	-0.04
Anchor Structure	502	N												¥	-0.00	0.03	-0.01	NA	0.02	-0.05	0.01	0.02	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
North		E												¥	0.05	0.01	0.05	NA	0.07	0.01	0.01	-0.04	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure	501	N												¥	-0.04	0.05	-0.00	NA	0.05	-0.03	0.02	0.02	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Center		E												¥	0.03	0.08	0.00	NA	0.07	-0.00	0.01	-0.06	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure	500	N												¥	-0.05	0.06	-0.01	NA	0.03	-0.02	-0.00	0.01	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
South		E												¥	0.03	0.05	-0.00	NA	0.06	0.03	0.01	-0.07	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Drilled Shaft Cap	700	N																		£	0.01	0.03	-0.01	-0.03	0.03	0.00	0.00	0.01	0.02	0.00	0.07
North		E																		£	-0.00	-0.03	-0.01	0.03	0.00	0.01	0.03	-0.02	0.00	0.01	0.02
Drilled Shaft Cap	701	N																		£	-0.00	0.02	0.00	-0.04	0.03	-0.00	0.02	-0.00	0.01	0.01	0.05
Center		E																		£	0.01	-0.04	-0.00	0.02	-0.00	0.02	0.02	-0.00	-0.01	0.03	0.06
Drilled Shaft Cap	702	N																		£	0.01	0.01	0.01	-0.02	0.02	0.01	0.01	0.00	0.01	0.00	0.05
South		E																		£	0.01	-0.04	0.00	0.03	0.01	0.03	0.02	-0.00	0.03	0.00	0.09

* Monumentation damaged by earth moving operations.

‡ Monuments appear to have been displaced 6" along the bridge.

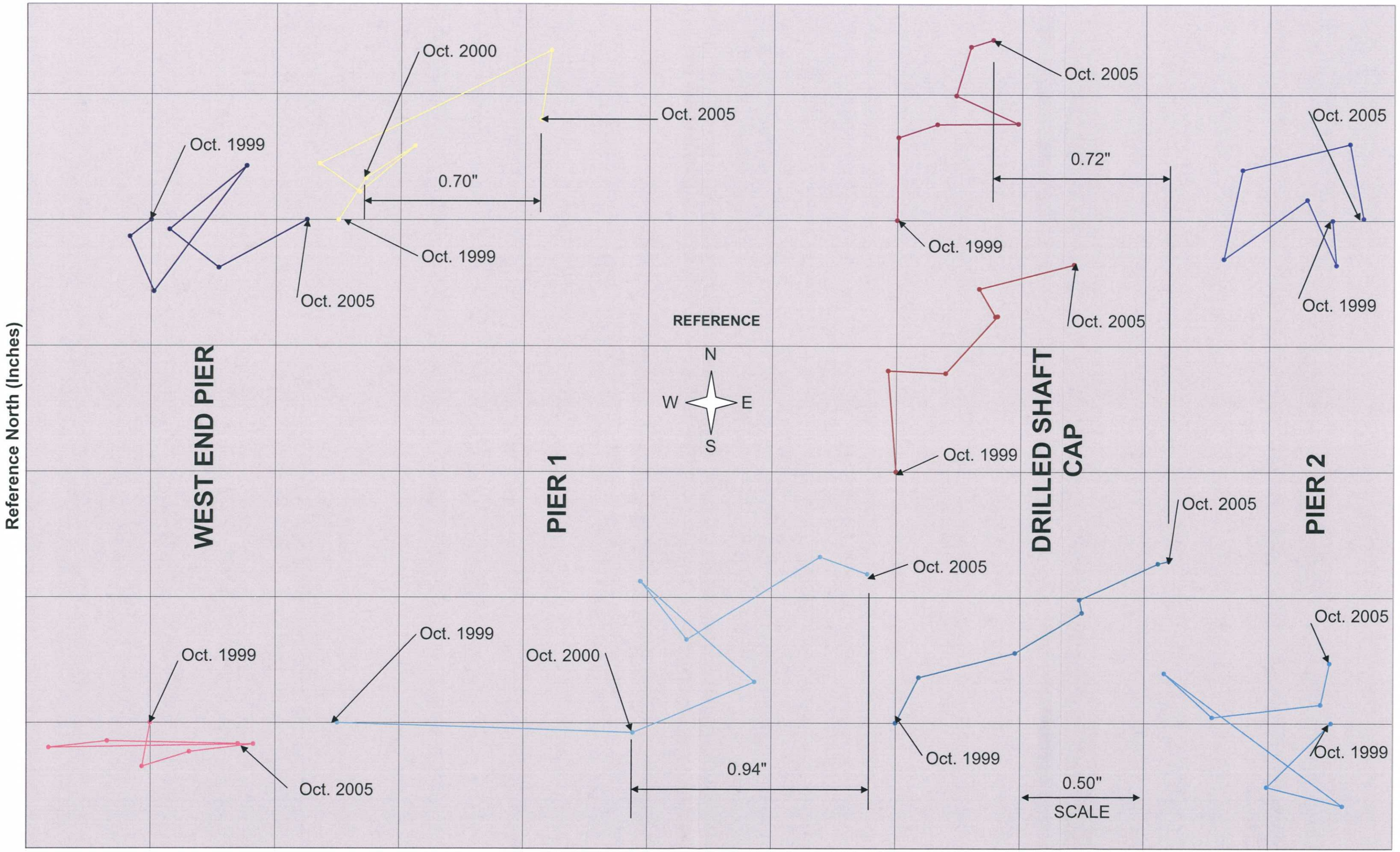
¥ First measurements taken 2/26/98

§ First measurements taken 10/15/98

¤ Net change is initial reading compared to the last compatible reading

£ First measurements taken 3/08/99

¥¥ No future shots will be taken due to anchor structure being buried



PIER SEAT COORDINATES

PIER SEAT COORDINATES

(Reference Point Locations on Top of Piers)

Pier	Direction	B&N 1985[4]	REL 1988‡	REL 1989‡	REL 1990‡	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 5/96	REL 8/96	REL 9/97	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 3/99	REL 4/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05
WEP North	N	5114.58	5114.53	5114.55	5114.55	5114.58	5114.64	5114.64	5114.65	5114.65	5114.67	5114.67	5114.68	5114.66	5114.65	5114.67	5114.66	5114.64	5114.68	N.A.	N.A.	5114.71	5114.69	5114.66	5114.65	5114.63	5114.67	5114.65	5114.64	5114.66
	E	4840.08	4839.58	4839.59	4839.59	4839.59	4839.59	4839.62	4839.62	4839.60	4839.67	4839.67	4839.69	4839.75	4839.77	4839.82	4839.84	4839.83	4839.83	N.A.	N.A.	4839.81	4839.81	4839.85	4839.84	4839.85	4839.88	4839.85	4839.87	4839.90
WEP South	N	5033.90	5033.84	5033.85	5033.86	5033.87	5033.96	5033.98	5033.98	5033.96	5033.98	5034.01	5033.96	5033.99	5033.99	5033.98	5033.99	NA	5033.99	N.A.	N.A.	5033.99	5033.96	5033.95	5033.94	5033.94	5033.94	5033.94	5033.95	5033.94
	E	4839.62	4839.12	4839.14	4839.14	4839.12	4839.11	4839.14	4839.15	4839.13	4839.15	4839.13	4839.15	4839.16	4839.17	4839.20	4839.22	NA	4839.23	N.A.	N.A.	4839.19	4839.21	4839.22	4839.22	4839.24	4839.26	4839.19	4839.21	4839.25
Pier 1 North	N	5124.44	5124.42	5124.40	5124.43	5124.39	5124.46	5124.50	5124.47	5124.44	5124.44	5124.48	5124.46	5124.47	5124.46	5124.46	5124.47	5124.47 £	5124.47	N.A.	N.A.	5124.46	5124.48	5124.42	5124.43	5124.44	5124.43	5124.43	5124.47	5124.45
	E	5055.20	5054.83	5054.84	5054.84	5054.85	5054.88	5054.86	5054.86	5054.87	5054.91	5054.90	5054.92	5054.93	5054.94	5054.95	5055.02	5055.09 £	5055.09	N.A.	N.A.	5055.10	5055.07	5055.18	5055.19	5055.21	5055.19	5055.18	5055.25	5055.25
Pier 1 South	N	5034.50	5034.49	5034.49	5034.53	5034.45	5034.53	5034.57	5034.55	5034.52	5034.54	5034.56	5034.54	5034.55	5034.54	5034.53	5034.57	5034.55 £	5034.56	N.A.	N.A.	5034.57	5034.56	5034.60	5034.59	5034.61	5034.64	5034.62	5034.65	5034.65
	E	5054.91	5054.59	5054.58	5054.60	5054.54	5054.60	5054.62	5054.59	5054.57	5054.60	5054.59	5054.63	5054.61	5054.63	5054.64	5054.70	5054.73 £	5054.76	N.A.	N.A.	5054.74	5054.71	5054.89	5054.99	5055.03	5054.99	5055.00	5055.05	5055.06
Pier 2 North	N	5124.60	5124.53	5124.55	5124.57	5124.43	5124.46	5124.45	5124.48	5124.40	5124.40	5124.40	5124.41	5124.37	5124.40	¥	5124.44	5124.42	5124.42	N.A.	N.A.	5124.43	5124.41	5124.40	5124.39	5124.41	5124.39	5124.42	5124.43	5124.41
	E	5454.68	5454.21	5454.21	5454.20	5454.14	5454.18	5454.20	5454.18	5454.21	5454.19	5454.19	5454.21	5454.17	5454.21	¥	5454.18	5454.17	5454.17	N.A.	N.A.	5454.17	5454.18	5454.16	5454.16	5454.15	5454.12	5454.13	5454.16	5454.17
Pier 2 South	N	5024.98	5024.89	5024.91	5024.91	5024.78	5024.81	5024.81	5024.84	5024.74	5024.76	5024.76	5024.76	5024.75	5024.78	¥	5024.72	5024.73	5024.73	N.A.	N.A.	5024.73	5024.70	5024.71	5024.69	5024.68	5024.73	5024.71	5024.72	5024.73
	E	5454.54	5454.04	5454.06	5454.04	5453.99	5454.01	5454.01	5453.99	5454.00	5454.01	5454.00	5454.04	5453.99	5454.03	¥	5454.05	5454.03	5454.03	N.A.	N.A.	5454.03	5454.04	5454.02	5454.00	5454.02	5453.96	5453.98	5454.01	5454.02
Anchor Structure North	N													5143.42	5143.42	5143.45	5143.44	NA	5143.44	5143.39	5143.41	5143.43	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
	E													5018.39	5018.44	5018.44	5018.50	NA	5018.54	5018.55	5018.56	5018.52	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure Center	N													5075.81	5075.77	5075.82	5075.81	NA	5075.82	5075.78	5075.80	5075.82	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
	E													5018.37	5018.40	5018.48	5018.48	NA	5018.58	5018.58	5018.59	5018.53	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure South	N													5009.41	5009.36	5009.42	5009.42	NA	5009.42	5009.40	5009.40	5009.41	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
	E													5018.53	5018.56	5018.61	5018.61	NA	5018.75	5018.77	5018.78	5018.71	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Drilled Shaft Cap North	N																			5138.49	5138.50	5138.53	5138.52	5138.49	5138.52	5138.52	5138.52	5138.53	5138.55	5138.55
	E																			5109.81	5109.81	5109.78	5109.77	5109.80	5109.80	5109.81	5109.84	5109.82	5109.83	5109.83
Drilled Shaft Cap Center	N																			5074.42	5074.41	5074.43	5074.44	5074.40	5074.43	5074.43	5074.45	5074.45	5074.46	5074.47
	E																			5109.81	5109.82	5109.79	5109.78	5109.81	5109.81	5109.83	5109.84	5109.84	5109.84	5109.87
Drilled Shaft Cap South	N																			5010.31	5010.32	5010.33	5010.33	5010.31	5010.32	5010.33	5010.35	5010.35	5010.36	5010.36
	E																			5109.83	5109.83	5109.80	5109.80	5109.83	5109.84	5109.87	5109.89	5109.89	5109.92	5109.92

* Monumentation damaged by earth moving operations.

‡ Monuments appear to have been displaced 6" along the bridge.

¥ Points destroyed durning construction. New points set. First reading taken 10/15/98

£ Monumentation removed for new pier caps for jacking procedure. New points set and first readings taken 12/29/98

¥¥ No future shots will be taken due to anchor structure being buried

SEAT ELEVATIONS

POINT NO.	DESCRIPTION	10/17/94	02/26/98	04/15/98	07/15/98	07/22/98	10/15/98	1/19/99	3/5/99	4/15/99	7/15/99	10/14/99	10/16/00	10/15/01	10/15/02	10/16/03	10/14/04	10/14/05
WEST END PIER SOUTH																		
103	ROD IN PIER SEAT	667.18	667.15	667.18	667.18	-	667.14	667.16	-	667.17	667.17	667.16	667.16	667.20	667.17	667.17	667.19	667.15
401	ROD IN SOUTH FACE	-	677.91	677.93	677.92	-	677.92	677.93	-	677.93	677.92	677.91	677.92	677.94	677.93	677.92	677.94	677.91
402	ROD IN NORTH FACE	-	670.79	670.81	670.80	-	670.78	670.80	-	670.79	670.80	670.78	670.80	670.83	670.80	670.80	670.81	670.78
WEST END PIER NORTH																		
	ROD IN PIER SEAT																	
102	Destroyed	667.04	667.03	667.07	667.05	-	667.04	667.03	-	667.04	-	-	-	-	-	-	-	-
802	(SET 7/16/99)									-	667.02	667.01	667.01	667.05	667.01	667.02	667.03	667.00
404	ROD IN NORTH FACE	-	660.83	660.86	660.86	-	660.82	660.88	-	660.84	660.85	660.84	660.84	660.87	660.85	660.84	660.86	660.82
PIER 1 NORTH																		
	ROD IN PIER SEAT																	
104	Destroyed	626.29	626.33	-	626.38	-	626.32	-	-	-	-	-	-	-	-	-	-	-
606	(SET 7/22/98)							626.35	-	626.33	626.34	626.33	626.33	626.34	626.30	626.33	626.34	626.31
607	(SET 12/29/98)							626.32	-	626.30	626.30	-	-	-	-	-	-	-
608	(SET 12/29/98)							626.24	-	626.21	626.21	626.22	626.23	626.23	626.22	626.23	626.23	626.20
609	(SET 12/29/98)							626.23	-	626.22	626.21	626.21	626.21	-	-	-	-	-
903	(SET 10/13/99)											626.30	626.30	626.30	626.33	626.30	626.30	626.27
902	(SET 10/13/99)											626.25	626.26	626.26	626.25	626.26	626.25	626.23
308	ROD IN NORTH FACE	-	604.51	-	-	-	604.48	604.51	-	604.55	604.52	604.50	604.50	604.52	604.51	604.51	604.52	604.49
407	ROD IN SOUTH FACE	-	-	-	-	-	604.25	§	-	604.26	604.28	604.23	604.24	604.27	604.25	604.25	604.26	604.23
PIER 1 SOUTH																		
	ROD IN PIER SEAT																	
105	Destroyed	626.25	626.27	-	626.34	626.32	626.28	-	-	-	-	-	-	-	-	-	-	-
602	(SET 7/22/98)	-	-	-	-	626.29	626.24	626.25	-	626.23	626.23	-	-	-	-	-	-	-
603	(SET 12/29/98)							626.26	-	626.25	626.24	-	-	-	-	-	-	-
604	(SET 12/29/98)							626.23	-	626.21	626.20	-	-	-	-	-	-	-
605	(SET 12/29/98)							626.24	-	626.22	626.21	-	-	-	-	-	-	-
901	(SET 10/13/99)											626.22	626.23	626.23	626.22	626.23	626.22	626.20
900	(SET 10/13/99)											626.21	626.22	626.22	626.21	626.22	626.21	626.19
306	ROD IN NORTH FACE	-	606.55	-	-	-	606.53	§	-	606.51	606.54	606.50	606.50	606.52	606.51	606.51	606.51	606.49
305	ROD IN SOUTH FACE	-	607.33	-	-	-	607.33	607.32	-	607.31	607.34	607.29	607.30	607.32	607.31	607.31	607.33	607.30
PIER 2 NORTH																		
	ROD IN PIER SEAT																	
601	(SET 7/22/98)	-	-	-	-	628.65	628.58	628.66	-	628.62	628.65	628.63	628.64	628.65	628.65	628.64	628.61	628.61
206	ROD IN SOUTH FACE	-	586.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
610	ROD IN SOUTH FACE (SET 7/22/98)	-	-	-	-	-	586.09	586.15	-	-	586.11	586.12	586.14	586.16	586.18	586.17	586.18	586.15
PIER 2 SOUTH																		
600	ROD IN PIER SEAT (SET 7/22/98)	-	-	-	-	628.78	628.72	628.77	-	628.76	628.78	628.76	628.78	628.78	628.76	628.77	628.73	628.75
207	ROD IN NORTH FACE	-	586.08	-	-	-	586.07	586.10	-	-	586.16	586.16	586.10	586.11	586.13	586.12	586.13	586.11
ANCHOR STRUCTURE																		
500	ROD SOUTH END	-	591.00	-	-	591.00	590.97	590.98	591.00	590.99	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
501	ROD CENTER +-	-	590.96	-	-	590.97	590.94	590.96	590.96	590.96	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
502	ROD NORTH END	-	590.98	-	-	590.99	590.97	590.99	590.99	590.99	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
DRILLED SHAFT CAP (SET 3/4/99)																		
700	BRASS DISK NORTH END	-	-	-	-	-	-	-	589.61	589.62	589.66	589.65	589.65	589.66	589.66	589.67	589.68	589.65
701	BRASS DISK CENTER +-	-	-	-	-	-	-	-	589.66	589.66	589.68	589.68	589.69	589.69	589.69	589.70	589.71	589.68
702	BRASS DISK SOUTH END	-	-	-	-	-	-	-	589.62	589.62	589.63	589.64	589.65	589.65	589.64	589.66	589.66	589.63
CONTROL POINT																		
64	PK IN CONC DRIVE	633.37	633.30	-	-	633.31	633.26	633.27	-	633.22	633.23	633.22	633.22	633.23	633.21	633.21	633.22	633.16 ***

| Calculated from top of concrete using an average rod height

§ Shots were not taken due to heat tent for rock anchor placement procedure.

¥¥ No future shots will be taken due to anchor structure being buried

*** Head of Nail Missing

CHANGE IN PIER TILTS

(The change in tilts are difference between the coordinates and elevations of the points set on the pier seat and side of the pier. The first angle of compatible data is set to zero and compared to the preceding years A positive value indicates top tilt to the north or east. A negative value indicates top tilt to the south or west.)

Pier	Direction	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 8/96	REL 9/97	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05
WEP North (Inside)	N	NA	NA	NA	NA	NA	0.00 º	0.01 º	0.00 º	0.01 º	0.01 º	0.00 º	0.01 º	0.01 º	0.02 º	0.02 º	0.02 º	0.02 º	0.01 º	0.02 º	0.01 º	0.01 º	0.01 º
	E	NA	NA	NA	NA	NA	0.00 º	-0.00 º	-0.00 º	-0.00 º	0.01 º	0.02 º	0.00 º	0.00 º	0.00 º	0.00 º	0.01 º	0.00 º	0.00 º	0.00 º	0.01 º	0.00 º	0.01 º
WEP North (Outside)	N	NA	NA	NA	NA	NA	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	0.01 º	0.00 º	0.00 º	0.00 º	-0.00 º	-0.00 º	-0.00 º	-0.00 º	0.00 º	-0.00 º	-0.00 º	0.00 º
	E	NA	NA	NA	NA	NA	0.00 º	-0.00 º	-0.00 º	-0.00 º	0.00 º	-0.00 º	0.00 º	0.00 º	-0.00 º	-0.01 º	-0.00 º	-0.00 º	-0.00 º	-0.00 º	-0.01 º	-0.00 º	0.00 º
WEP South (Inside)	N	NA	NA	NA	NA	NA	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	0.01 º	-0.00 º	0.00 º	0.01 º	-0.00 º	-0.00 º	0.00 º	0.01 º	0.00 º	0.00 º	0.00 º	0.01 º
	E	NA	NA	NA	NA	NA	0.00 º	0.01 º	0.01 º	0.00 º	0.01 º	-0.03 º	0.01 º	0.01 º	0.02 º	0.01 º	0.02 º	0.03 º	0.03 º	0.03 º	-0.00 º	0.00 º	0.02 º
WEP South (Outside)	N	NA	NA	NA	NA	NA	0.00 º	-0.01 º	-0.01 º	0.02 º	0.05 º	-0.02 º	NA	0.03 º	0.05 º	0.03 º	0.03 º	0.02 º	0.05 º	0.02 º	0.01 º	0.02 º	0.01 º
	E	NA	NA	NA	NA	NA	0.00 º	0.06 º	0.16 º	0.19 º	0.37 º	0.62 º	NA	0.36 º	0.26 º	0.36 º	0.45 º	0.41 º	0.52 º	0.42 º	0.32 º	0.29 º	0.52 º
Pier 1 North (Inside)	N	NA	NA	NA	0.00 º	0.01 º	0.63 º	0.63 º	0.63 º	0.64 º	0.65 º	0.64 º	NA	NA	0.65 º	0.69 º	0.67 º	0.67 º	0.68 º	0.68 º	0.68 º	0.70 º	0.66 º
	E	NA	NA	NA	NA	NA	0.00 º	0.00 º	0.01 º	-0.02 º	-0.02 º	0.03 º	NA	NA	-0.02 º	-0.03 º	0.03 º	0.03 º	0.02 º	0.01 º	0.01 º	0.03 º	0.03 º
Pier 1 North (Outside)	N	NA	NA	NA	NA	0.00 º	0.03 º	0.01 º	0.02 º	0.00 º	0.01 º	0.11 º	0.06 º	0.05 º	0.01 º	0.10 º	0.06 º	0.02 º	0.09 º	0.14 º	0.11 º	0.18 º	0.16 º
	E	NA	NA	NA	NA	0.00 º	-0.01 º	-0.01 º	-0.00 º	-0.02 º	-0.03 º	-0.03 º	-0.01 º	-0.00 º	0.00 º	-0.02 º	0.03 º	0.02 º	0.03 º	0.01 º	-0.00 º	0.04 º	0.04 º
Pier 1 South (Inside)	N	0.00 º	0.14 º	0.07 º	0.11 º	0.15 º	0.13 º	0.08 º	0.09 º	0.09 º	0.07 º	0.21 º	NA	NA	0.17 º	0.23 º	0.29 º	0.26 º	0.31 º	0.35 º	0.29 º	0.33 º	0.35 º
	E	0.00 º	-0.38 º	0.10 º	0.07 º	0.10 º	0.08 º	0.10 º	0.13 º	0.12 º	0.05 º	0.09 º	NA	NA	0.05 º	-0.06 º	0.10 º	0.33 º	0.32 º	0.15 º	0.18 º	0.31 º	0.32 º
Pier 1 South (Outside)	N	NA	NA	NA	0.00 º	0.01 º	0.01 º	0.02 º	0.00 º	0.03 º	0.02 º	0.01 º	0.06 º	0.06 º	0.07 º	0.06 º	0.11 º	0.10 º	0.12 º	0.14 º	0.13 º	0.15 º	0.13 º
	E	NA	NA	NA	0.00 º	0.16 º	0.03 º	0.11 º	0.16 º	0.08 º	0.03 º	0.29 º	0.01 º	0.04 º	0.03 º	-0.15 º	0.08 º	0.33 º	0.42 º	0.21 º	0.26 º	0.30 º	0.37 º
Pier 2 North (Inside)	N	0.00 º	0.00 º	0.00 º	0.01 º	0.00 º	0.00 º	NA	-0.00 º	0.00 º	NA	0.00 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º
	E	0.00 º	-0.08 º	-0.09 º	-0.05 º	-0.05 º	-0.05 º	NA	-0.10 º	-0.06 º	NA	0.00 º	-0.04 º	-0.15 º	-0.10 º	-0.08 º	-0.09 º	-0.09 º	-0.13 º	-0.15 º	-0.10 º	-0.05 º	-0.06 º
Pier 2 South (Inside)	N	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	NA	0.01 º	0.01 º	NA	0.00 º	-0.00 º	0.00 º	-0.00 º	-0.01 º	-0.00 º	-0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º
	E	0.00 º	-0.14 º	-0.14 º	-0.10 º	-0.09 º	-0.03 º	NA	-0.06 º	-0.04 º	NA	0.00 º	-0.07 º	-0.20 º	0.00 º	-0.02 º	-0.05 º	-0.13 º	-0.10 º	-0.16 º	-0.12 º	-0.10 º	-0.10 º

0.00 º	First reading (Tilt set/reset)
NA	Information Not Available

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May 03, 2006

RE: CUY-90-15.24 Monitoring

Mr. Dean Palmer, P.E.
Richland Engineering Limited
29 N. Park St.
Mansfield, OH 44902

Dear Dean:

The most recent tiltmeter readings on the the west abutment and pier 1 of the innerbelt bridge were taken of May 3, 2006. The results are plotted on the enclosed chart. Noticeable changes since the January 2006 reading occurred at the west abutment on tiltmeter #2 (continuing to tilt "northward"), tiltmeter #4 (continuing to tilt "southward"), tiltmeter #3 (tilting "eastward") and tiltmeter #1 (rather inexplicably correcting itself with a "westward" tilt). Little change was noted for tiltmeters #5 through #8, all located on pier 1.

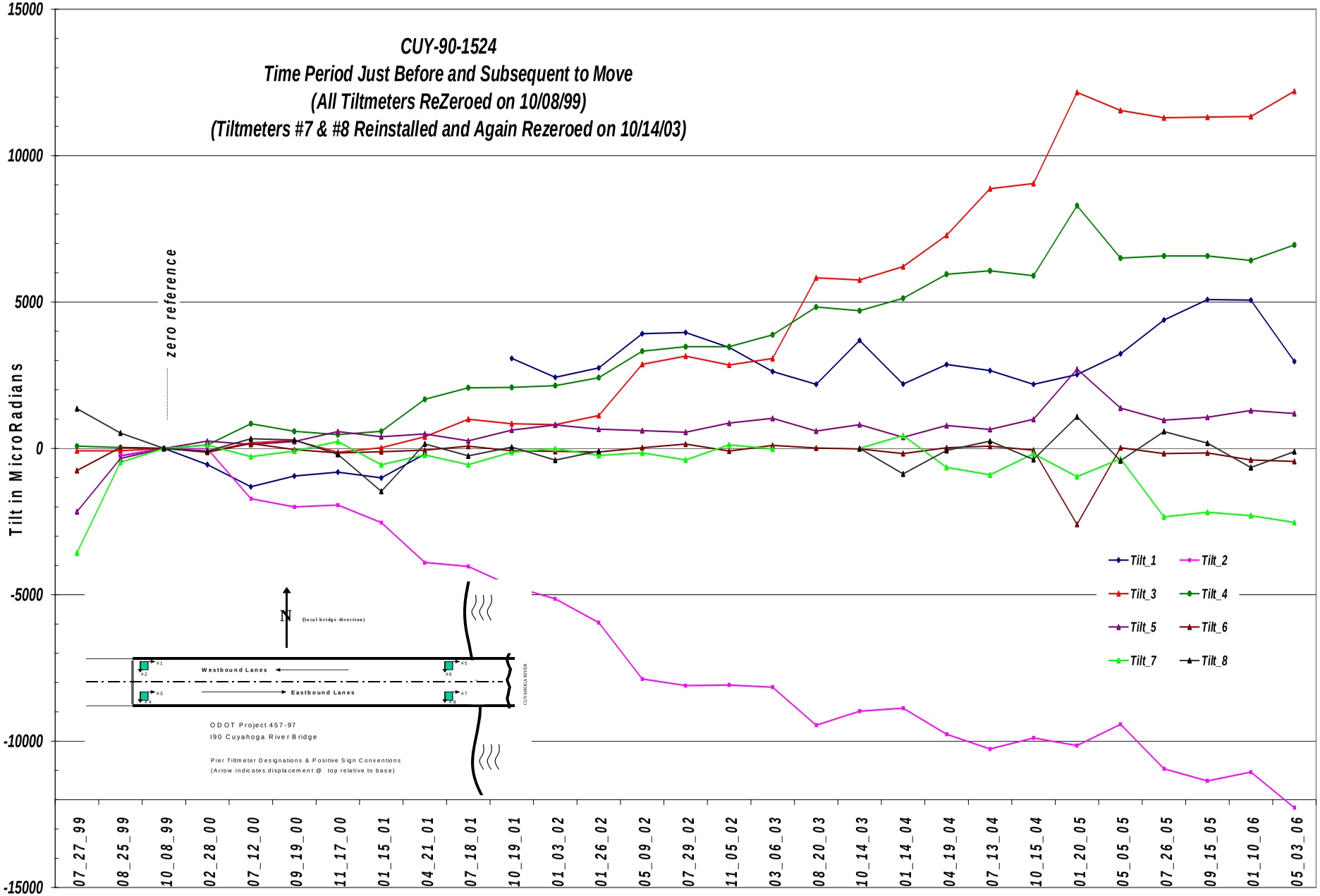
Over the past year, since May of 2005, the "continuous" monitoring of pier 1 was discontinued and the data logger retrieved. The "quick-disconnect" electrical connectors were again reattached to tiltmeters #5 through #8, such that quarterly readings could again be taken with a hand held digital mulit-meter. Quarterly readings have subsequently been taken.

In general, over the 12 month period, the tiltmeter readings have been continuing their established trends, though, with the exception of tiltmeter #2, at a somewhat decreased rate. Tiltmeter #2 is continuing to indicate a steady and on-going "northward" tilt of the northern west end abutment structure. Pier 1 would appear, from the tiltmeter readings, to be stable, although from the continuous monitoring in early 2005, it is known that considerable thermal loads are applied to pier 1, and substantial short-term thermal movements occur.

Feel free to contact me should you have questions.

Regards,

Art Huckelbridge, D.Eng., P.E.


CUY-90-1524
Time Period Just Before and Subsequent to Move
(All Tiltmeters ReZeroed on 10/08/99)
(Tiltmeters #7 & #8 Reinstalled and Again Rezeroed on 10/14/03)
zero reference
Tilt in MicroRadians
15000
10000
5000
0
-5000
-10000
-15000
07_27_99
08_25_99
10_08_99
02_28_00
07_12_00
09_19_00
11_17_00
01_15_01
04_21_01
07_18_01
10_19_01
01_03_02
01_26_02
05_09_02
07_29_02
11_05_02
03_06_03
08_20_03
10_14_03
01_14_04
04_19_04
07_13_04
10_15_04
01_20_05
05_05_05
07_26_05
09_15_05
01_10_06
05_03_06
Tilt_1
Tilt_2
Tilt_3
Tilt_4
Tilt_5
Tilt_6
Tilt_7
Tilt_8
N
(local bridge direction)
Westbound Lanes
Eastbound Lanes
#1
#2
#3
#4
#5
#6
#7
#8
CUYAHOGA RIVER
ODOT Project 457-97
I90 Cuyahoga River Bridge
Pier Tiltmeter Designations & Positive Sign Conventions
(Arrow indicates displacement @ top relative to base)

LONG TERM MONITORING AT CUY-90-15.24 BRIDGE PROJECT

Annual Report for Year 2005

Robert Y. Liang

May 2006

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I. Introduction

This is an Annual Report on the monitoring results of the stabilization structures at the CUY-90-15.24 west end slope for the period between 5/1/2005 and 5/1/2006. The strain gages and slope inclinometers (SI) previously installed in the stabilization structures between 1997 and 1999 have been monitored continuously. Since the beginning of the monitoring, quarterly reports and annual reports have been submitted to document the monitoring results. Although this is the sixth annual report, for completeness, the presentation of the monitored and deduced data will cover the period from the beginning of monitoring to the last reading taken in April 2006.

The plane view of the general layout of the stabilization structures is shown in Fig. 1, where the instrumented foundation structures are marked. A total of five tie-beams were instrumented with strain gages at both ends of the beams, as shown in Fig. 2, where the gage numbering system was indicated. A total of five driven piles (#1, #17, #18, #19, and #34) were each instrumented with four strain gages near the top of the pile, as shown in Fig. 3. Rock anchors #1, #8, #9, and #17 were each instrumented with a load cell at the anchor head. Finally, drilled shafts #1 and #9 were instrumented with sister-bar type of strain gages. The locations of these strain gages in the drilled shafts and the gage designation numbers are depicted in Fig. 4 and Fig. 5 for shaft #1 and shaft #9, respectively. Furthermore, drilled shafts #1, #3, #8, #9, #10, and #17 shown in Fig. 6, was each embedded with slope inclinometer casings for monitoring shafts deflections.

II. Monitoring Results

II.1 Rock Anchors:

Recorded numerical values of load cells at the anchor heads are summarized in Table 1. Also, the load versus time plot for each anchor is shown in Fig. 7. Between 4/2005 and 4/2006, the recorded anchor loads remain fairly steady.

II.2 Tie-Beams:

The strain readings from the gages in the tie-beams have been converted into axial forces and bending moments and are summarized in Table 2 and Table 3 for the beam end at the driven pile cap side and the beam end at the drilled shaft cap side, respectively. The plots of the axial force versus time for five monitored tie-beams are presented in Fig. 8 and Fig. 9 for the drilled shaft cap side and the driven pile cap side, respectively. The average axial forces of all five monitored tie-beams on the pile cap side and the drilled shaft cap side are plotted respectively in Fig. 10. The average axial forces appear to oscillate within a small range.

The deduced major bending moments for each of the five monitored tie-beams are shown in Fig. 11 and Fig. 12 for the pile cap side and drilled shaft cap side, respectively. The average bending moments for all five monitored tie-beams for the drilled shaft side and the pile cap side are shown respectively in Fig. 13. These average bending moments on both sides of the tie-beams showed no noticeable amount of variation.

II.3 Driven Piles:

The strain readings from the strain gages on the driven piles have been converted into the bending moments and axial forces for each of the five monitored driven piles and are summarized in Table 4. The axial forces versus time and the major bending moments versus time are plotted in Fig. 14 and Fig. 15, respectively. During the past year, there was no significant variation in the monitored data.

II.4 Drilled Shafts:

The bending moments in the drilled shaft #9 at different elevations are shown in Fig. 16. The deduced bending moments at the depth of 95 ft below the cap top showed continuing increase, but with reduced rate. The bending moments in the drilled shaft #1 at different elevations are shown in Fig. 17. Please note that the bending moments shown in Fig. 17 are smaller than those shown in Fig. 16. This is because the moments measured in shaft #9 (Fig. 16) are in the major bending direction, while the moments measured in shaft #1 are not in the major bending direction.

The distribution of bending moments along the depth of the drilled shafts is depicted in Fig. 18 and Fig. 19 for shaft #9 and shaft #1, respectively.

II.5 Inclinometer reading:

Four separate readings were taken over the last year for all seven inclinometer casings embedded in the drilled shafts. The incremental and cumulative deflection plots in the A-

direction (toward river direction) are presented in Figs. 20 to 26. In general, there was a very little movement that can be observed in all inclinometer readings.

III. Concluding Remark

Based on examination of the monitoring data collected over the last year, the stabilization structures in the slope experienced a fairly steady state of forces and moments. There were no noticeable drilled shaft deflections over the last year. There was no observed sudden and big jump in the monitoring data. However, it is important to continue the monitoring of these slope stabilization structures, the ground movement, and the superstructure, particularly in light of the expected new construction activities in the near future.

Table 1 Numerical reading of anchor load as a function of time for anchors #1, #8, #9 and #17

Date	Anchor #1 Load, kips	Anchor #8 Load, kips	Anchor #9 Load, kips	Anchor #17 Load, kips	Comment
4/7/1999		560			Anchor Lock off
4/8/1999	489			499	
4/14/1999	460	473	596 (Lock off)	461	
5/7/1999	452	473	572	445	End of construction
7/1/1999	446	468	564	439	
10/1/1999	441	467	560	440	
1/1/2000	439	461	555	424	
4/1/2000	432	453	546	414	
7/1/2000	431	451	521	415	
10/1/2000	431	451	519	416	
1/1/2001	430	455	517	400	
4/1/2001	421	443	513	397	
7/1/2001	422	443	510	399	
10/1/2001	425	445	512	403	
1/1/2002	424	444	511	398	
4/1/2002	421	440	508	386	
7/1/2002	419	439	506	391	
10/1/2002	423	442	508	396	
1/1/2003	423	435	508	389	
4/15/2003	416	427	501	380	
8/07/2003	416	428	503	384	
10/07/2003	418	429	504	387	
12/31/2003	417	426	503	378	
4/13/2004	408	418	494	370	
7/13/2004	409	419	494	374	
10/08/2004	411	422	496	377	
1/07/2005	411	421	495	374	
4/08/2005	407	414	485	366	
7/18/2005	407	415	485	370	
11/12/2005	410	419	489	374	
1/10/2006	409	417	487	369	
4/9/2006	399	411	487	365	

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap Side)

Tie #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
1	7/1/1999	-47.1	68.5	551.7	681.8	313.73	10.70	616.75	252.30	375.15	83.06	-40.28	-2.75
	7/15/1999	-70.1	53.8	538.8	666.8	297.33	-8.15	602.80	234.35	360.30	78.72	-40.60	-2.82
	8/15/1999	10.7	114.3	613.7	728.1	366.70	62.50	670.90	312.20	421.20	97.09	-40.43	-2.44
	8/31/1999	12.0	114.3	617.3	732.8	369.10	63.15	675.05	314.65	423.55	97.73	-40.67	-2.44
	9/15/1999	13.1	113.5	619.7	737.5	370.95	63.30	678.60	316.40	425.50	98.22	-40.89	-2.44
	9/30/1999	29.6	122.3	634.4	753.4	384.93	75.95	693.90	332.00	437.85	101.92	-41.07	-2.37
	10/15/1999	34.7	123.9	637.8	757.9	388.58	79.30	697.85	336.25	440.90	102.88	-41.11	-2.34
	10/31/1999	39.8	127.2	646.6	762	393.90	83.50	704.30	343.20	444.60	104.29	-41.26	-2.27
	11/15/1999	62.3	139.3	662.9	780.1	411.15	100.80	721.50	362.60	459.70	108.86	-41.25	-2.18
	11/30/1999	73.7	146.3	670.6	788.6	419.80	110.00	729.60	372.15	467.45	111.15	-41.18	-2.13
	12/15/1999	72.8	143.6	668.9	789.7	418.75	108.20	729.30	370.85	466.65	110.87	-41.28	-2.15
	12/31/1999	88.8	152.1	680.1	802.5	430.88	120.45	741.30	384.45	477.30	114.08	-41.26	-2.08
	3/31/2000	95.3	158.7	682.5	825.2	440.43	127.00	753.85	388.90	491.95	116.61	-41.66	-2.31
	6/30/2000	60.2	138.2	662.7	804.5	416.40	99.20	733.60	361.45	471.35	110.25	-42.16	-2.46
	9/30/2000	50.1	142.5	668.8	795.7	414.28	96.30	732.25	359.45	469.10	109.69	-42.26	-2.46
	1/13/2001	109.5	179.9	712.3	845.5	461.80	144.70	778.90	410.90	512.70	122.27	-42.15	-2.28
	4/20/2001	126.8	283.2	715.3	881.9	501.80	205.00	798.60	421.05	582.55	132.86	-39.45	-3.62
	7/16/2001	68.3	149.8	674.3	837.1	432.38	109.05	755.70	371.30	493.45	114.48	-42.98	-2.74
	10/9/2001	71.4	157.1	685.5	840.8	438.70	114.25	763.15	378.45	498.95	116.15	-43.12	-2.70
	1/9/2002	102.7	177.8	713	872	466.38	140.25	792.50	407.85	524.90	123.48	-43.35	-2.62
	4/12/2002	125.5	192.8	738.6	904.9	490.45	159.15	821.75	432.05	548.85	129.86	-44.04	-2.62
	7/18/2002	62.3	151.8	706.334	859.6	445.01	107.05	782.97	384.32	505.70	117.82	-44.92	-2.72
	10/8/2002	43.7	151.1	711.3	846.7	438.20	97.40	779.00	377.50	498.90	116.02	-45.30	-2.72
	1/8/2003	84.7	180.5	748.5	891.8	476.38	132.60	820.15	416.60	536.15	126.13	-45.69	-2.68
	4/15/2003	96.1	191.9	739.9	989.3	504.30	144.00	864.60	418.00	590.60	133.52	-47.89	-3.87
	7/1/2003	57.4	168	713	959	474.35	112.70	836.00	385.20	563.50	125.59	-48.07	-3.99
	10/7/2003	42.1	166.8	714	946.6	467.38	104.45	830.30	378.05	556.70	123.75	-48.24	-4.00
	12/31/2003	80	197.9	753.9	985.1	504.23	138.95	869.50	416.95	591.50	133.50	-48.55	-3.91
	4/13/2004	92	208.9	760.4	1006.6	516.98	150.45	883.50	426.20	607.75	136.88	-48.72	-4.07
	7/13/2004	14.6	163.9	707.3	954.4	460.05	89.25	830.85	360.95	559.15	121.81	-49.29	-4.44
	10/8/2004	-8.6	233.4	704.6	941	467.60	112.40	822.80	348.00	587.20	123.81	-47.21	-5.36
	1/7/2005	19.5	190.4	746.5	982.5	484.73	104.95	864.50	383.00	586.45	128.34	-50.48	-4.56
	4/8/2005	3.4	397.6	751.6	1003.4	539.00	200.50	877.50	377.50	700.50	142.71	-44.99	-7.24
	7/18/2005	3.1	164.3	709.7	969.6	461.68	83.70	839.65	356.40	566.95	122.24	-50.24	-4.72
	8/26/2005	3.1	157.5	702.5	956.3	454.85	80.30	829.40	352.80	556.90	120.43	-49.78	-4.57
	10/11/2005	3.1	164.2	712.6	960.1	460.00	83.65	836.35	357.85	562.15	121.79	-50.02	-4.58
	1/10/2006	3.1	191.9	742.5	997	483.63	97.50	869.75	372.80	594.45	128.05	-51.32	-4.97
	4/9/2006	3.5	205.3	750.7	1018.8	494.58	104.40	884.75	377.10	612.05	130.95	-51.86	-5.26

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap Side) (cont'd)

Tie #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
12	7/1/1999	374.9	6	549.6	471.8	350.58	190.45	510.70	462.25	238.90	92.82	-21.28	5.00
	7/15/1999	368.6	-3.6	544.2	467.3	344.13	182.50	505.75	456.40	231.85	91.11	-21.48	5.03
	8/15/1999	373.7	0.2	569.4	485.2	357.13	186.95	527.30	471.55	242.70	94.56	-22.62	5.13
	8/31/1999	368.4	-4.7	567	486.2	354.23	181.85	526.60	467.70	240.75	93.79	-22.91	5.08
	9/15/1999	365.9	-9.2	565.3	485.1	351.78	178.35	525.20	465.60	237.95	93.14	-23.05	5.10
	9/30/1999	364.6	-11.7	570.1	487.6	352.65	176.45	528.85	467.35	237.95	93.37	-23.42	5.14
	10/15/1999	361.7	-14.8	569.9	487.4	351.05	173.45	528.65	465.80	236.30	92.95	-23.61	5.14
	10/31/1999	362.8	-13.5	575.6	493.1	354.50	174.65	534.35	469.20	239.80	93.86	-23.91	5.14
	11/15/1999	365.0	-11.5	581.4	498	358.23	176.75	539.70	473.20	243.25	94.85	-24.12	5.15
	11/30/1999	365.6	-11.8	583.7	500.1	359.40	176.90	541.90	474.65	244.15	95.16	-24.26	5.16
	12/15/1999	368.0	-9.2	589.7	504.2	363.18	179.40	546.95	478.85	247.50	96.16	-24.43	5.18
	12/31/1999	369.0	-8	592.9	506.6	365.13	180.50	549.75	480.95	249.30	96.67	-24.54	5.19
	3/31/2000	379.6	7.3	617	524.1	382.00	193.45	570.55	498.30	265.70	101.14	-25.06	5.21
	6/30/2000	376.1	4.4	608.9	519.1	377.13	190.25	564.00	492.50	261.75	99.85	-24.84	5.17
	9/30/2000	360.7	-12.3	588.3	503.5	360.05	174.20	545.90	474.50	245.60	95.33	-24.70	5.13
	1/13/2001	372.1	2.2	618.1	526.1	379.63	187.15	572.10	495.10	264.15	100.51	-25.58	5.17
	4/20/2001	387.6	21	645.8	549.2	400.90	204.30	597.50	516.70	285.10	106.15	-26.13	5.19
	7/16/2001	374.6	6.5	621.5	532.9	383.88	190.55	577.20	498.05	269.70	101.64	-25.70	5.12
	10/9/2001	360.9	-9.4	598.9	515.8	366.55	175.75	557.35	479.90	253.20	97.05	-25.36	5.08
	1/9/2002	363.5	-2.5	611.5	524.5	374.25	180.50	568.00	487.50	261.00	99.09	-25.75	5.07
	4/12/2002	381.7	16.9	642.7	550.5	397.95	199.30	596.60	512.20	283.70	105.37	-26.40	5.12
	7/18/2002	375	10.5	629	544.7	389.80	192.75	586.85	502.00	277.60	103.21	-26.19	5.03
	10/8/2002	357.7	-9.6	599.2	523	367.58	174.05	561.10	478.45	256.70	97.32	-25.72	4.97
	1/8/2003	367.3	6.5	626.7	542.7	385.80	186.90	584.70	497.00	274.60	102.15	-26.44	4.98
	4/15/2003	385.9	27.3	655.3	566.2	408.68	206.60	610.75	520.60	296.75	108.20	-26.86	5.01
	7/1/2003	384.7	26.3	649.2	565.6	406.45	205.50	607.40	516.95	295.95	107.62	-26.71	4.95
	10/7/2003	360.6	3.5	613	539.7	379.20	182.05	576.35	486.80	271.60	100.40	-26.20	4.82
	12/31/2003	372	19.4	636	558.3	396.43	195.70	597.15	504.00	288.85	104.96	-26.68	4.82
	4/13/2004	389.4	39.8	665.5	583.1	419.45	214.60	624.30	527.45	311.45	111.06	-27.23	4.84
	7/13/2004	379.5	27.7	643.3	571.1	405.40	203.60	607.20	511.40	299.40	107.34	-26.82	4.75
	10/8/2004	361.6	10.3	615.2	550.9	384.50	185.95	583.05	488.40	280.60	101.80	-26.39	4.66
	1/7/2005	367.5	16.1	630.6	561.5	393.93	191.80	596.05	499.05	288.80	104.30	-26.87	4.71
	4/8/2005	388.2	35.6	662.3	587.2	418.33	211.90	624.75	525.25	311.40	110.76	-27.44	4.79
	7/18/2005	382.6	26.3	647.7	580.1	409.18	204.45	613.90	515.15	303.20	108.34	-27.21	4.75
	8/26/2005	373.6	15.7	629.8	566.8	396.48	194.65	598.30	501.70	291.25	104.97	-26.83	4.71
	10/11/2005	365.9	6.1	617.8	557.9	386.93	186.00	587.85	491.85	282.00	102.45	-26.71	4.70
	1/10/2006	376.2	17.5	639	572.2	401.23	196.85	605.60	507.60	294.85	106.23	-27.16	4.77
	4/9/2006	393.8	32.7	665.7	594	421.55	213.25	629.85	529.75	313.35	111.61	-27.69	4.85

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap Side) (cont'd)

Tie #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
13	7/1/1999	306.3	72.2	490.8	675.2	386.13	189.25	583.00	398.55	373.70	102.23	-26.17	0.56
	7/15/1999	288.0	53.1	484.2	670.6	373.98	170.55	577.40	386.10	361.85	99.02	-27.04	0.54
	8/15/1999	280.9	61.8	506.3	693.7	385.68	171.35	600.00	393.60	377.75	102.12	-28.49	0.36
	8/31/1999	270.4	52.1	503.1	691.4	379.25	161.25	597.25	386.75	371.75	100.41	-28.98	0.34
	9/15/1999	261.3	43.9	501.2	689.9	374.08	152.60	595.55	381.25	366.90	99.04	-29.44	0.32
	9/30/1999	257.1	40.7	503.1	690.7	372.90	148.90	596.90	380.10	365.70	98.73	-29.77	0.32
	10/15/1999	250.1	33.8	501.2	691	369.03	141.95	596.10	375.65	362.40	97.71	-30.18	0.30
	10/31/1999	251.4	38	507.6	697.6	373.65	144.70	602.60	379.50	367.80	98.93	-30.43	0.26
	11/15/1999	253.9	41.6	512.1	701.9	377.38	147.75	607.00	383.00	371.75	99.92	-30.52	0.25
	11/30/1999	253.5	41.2	513.6	704.4	378.18	147.35	609.00	383.55	372.80	100.13	-30.68	0.24
	12/15/1999	255.8	46.7	519.1	709.3	382.73	151.25	614.20	387.45	378.00	101.33	-30.77	0.21
	12/31/1999	256.7	48.9	522.3	712.4	385.08	152.80	617.35	389.50	380.65	101.96	-30.87	0.20
	3/31/2000	267.5	64.6	542.8	734.2	402.28	166.05	638.50	405.15	399.40	106.51	-31.40	0.13
	6/30/2000	258.9	46.4	531.2	726.1	390.65	152.65	628.65	395.05	386.25	103.43	-31.63	0.20
	9/30/2000	237.1	10.1	504.9	705.9	364.50	123.60	605.40	371.00	358.00	96.51	-32.02	0.29
	1/13/2001	254.0	40.9	535.1	734.6	391.15	147.45	634.85	394.55	387.75	103.56	-32.39	0.15
	4/20/2001	275.4	72.6	561.4	763.7	418.28	174.00	662.55	418.40	418.15	110.75	-32.47	0.01
	7/16/2001	255.3	37.7	534.8	740.9	392.18	146.50	637.85	395.05	389.30	103.84	-32.65	0.13
	10/9/2001	235.7	7.5	510.6	719.6	368.35	121.60	615.10	373.15	363.55	97.53	-32.80	0.22
	1/9/2002	240	18.9	523.3	731	378.30	129.45	627.15	381.65	374.95	100.16	-33.08	0.15
	4/12/2002	263.4	58.5	554.8	763	409.93	160.95	658.90	409.10	410.75	108.54	-33.09	-0.04
	7/18/2002	255.5	40.1	566.1	754.5	404.05	147.80	660.30	410.80	397.30	106.98	-34.06	0.30
	10/8/2002	231.2	3.4	508.7	726.1	367.35	117.30	617.40	369.95	364.75	97.26	-33.24	0.12
	1/8/2003	249.4	38.5	540.1	754.4	395.60	143.95	647.25	394.75	396.45	104.74	-33.45	-0.04
	4/15/2003	276.4	78.5	571.6	784.9	427.85	177.45	678.25	424.00	431.70	113.28	-33.28	-0.17
	7/1/2003	273	69	561.4	779.9	420.83	171.00	670.65	417.20	424.45	111.42	-33.21	-0.16
	10/7/2003	246.6	22.5	524.7	744.6	384.60	134.55	634.65	385.65	383.55	101.83	-33.24	0.05
	12/31/2003	264.8	58.9	552.8	770.1	411.65	161.85	661.45	408.80	414.50	108.99	-33.20	-0.13
	4/13/2004	291.3	97.7	584	803.2	444.05	194.50	693.60	437.65	450.45	117.57	-33.17	-0.29
	7/13/2004	275.5	64.3	556.1	781	419.23	169.90	668.55	415.80	422.65	111.00	-33.14	-0.15
	10/8/2004	252.8	29.9	527.5	755.8	391.50	141.35	641.65	390.15	392.85	103.66	-33.25	-0.06
	1/7/2005	264	50.8	544.5	770.6	407.48	157.40	657.55	404.25	410.70	107.89	-33.24	-0.14
	4/8/2005	289.9	90.7	576	802	439.65	190.30	689.00	432.95	446.35	116.41	-33.14	-0.30
	7/18/2005	277.8	67.7	556.4	787.1	422.25	172.75	671.75	417.10	427.40	111.80	-33.16	-0.23
	8/26/2005	266.7	46.5	539.8	771.9	406.23	156.60	655.85	403.25	409.20	107.56	-33.18	-0.13
	10/11/2005	257.2	33.8	526.8	760.8	394.65	145.50	643.80	392.00	397.30	104.49	-33.12	-0.12
	1/10/2006	269.3	59.9	551.2	780.4	415.20	164.60	665.80	410.25	420.15	109.93	-33.31	-0.22
	4/9/2006	289.9	90	576.3	806.2	440.60	189.95	691.25	433.10	448.10	116.66	-33.32	-0.34

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap Side) (cont'd)

Tie #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
14	7/1/1999	445.4	53.9	802	298.7	400.00	249.65	550.35	623.70	176.30	105.91	-19.98	10.02
	7/15/1999	440.5	34.4	799.5	280.7	388.78	237.45	540.10	620.00	157.55	102.94	-20.11	10.36
	8/15/1999	455.6	40.8	837.6	284.6	404.65	248.20	561.10	646.60	162.70	107.14	-20.79	10.84
	8/31/1999	452.7	30.7	837.1	274.1	398.65	241.70	555.60	644.90	152.40	105.55	-20.86	11.03
	9/15/1999	448.5	21.7	836.8	266.2	393.30	235.10	551.50	642.65	143.95	104.13	-21.03	11.17
	9/30/1999	447.0	16.1	838.5	260.8	390.60	231.55	549.65	642.75	138.45	103.42	-21.14	11.30
	10/15/1999	446.5	8.8	839.3	255.1	387.43	227.65	547.20	642.90	131.95	102.58	-21.24	11.45
	10/31/1999	450.9	11.7	847.9	257.8	392.08	231.30	552.85	649.40	134.75	103.81	-21.37	11.53
	11/15/1999	455.9	16.1	856.2	259.8	397.00	236.00	558.00	656.05	137.95	105.11	-21.40	11.61
	11/30/1999	456.3	15.5	858.3	259	397.28	235.90	558.65	657.30	137.25	105.19	-21.45	11.65
	12/15/1999	461.3	20.5	865.6	261.7	402.28	240.90	563.65	663.45	141.10	106.51	-21.45	11.70
	12/31/1999	463.4	22.5	871.6	262.9	405.10	242.95	567.25	667.50	142.70	107.26	-21.55	11.76
	3/31/2000	477.8	35.6	903.8	282.7	424.98	256.70	593.25	690.80	159.15	112.52	-22.37	11.91
	6/30/2000	469.2	17.4	889.7	267.4	410.93	243.30	578.55	679.45	142.40	108.80	-22.28	12.03
	9/30/2000	453.5	-23.5	856.8	240.4	381.80	215.00	548.60	655.15	108.45	101.09	-22.17	12.25
	1/13/2001	476.9	5	891.3	257.6	407.70	240.95	574.45	684.10	131.30	107.95	-22.16	12.38
	4/20/2001	494.8	40.8	932.8	281.2	437.40	267.80	607.00	713.80	161.00	115.81	-22.54	12.38
	7/16/2001	475.7	4.9	900.7	255.9	409.30	240.30	578.30	688.20	130.40	108.37	-22.46	12.50
	10/9/2001	459.3	-30.8	870.4	236.8	383.93	214.25	553.60	664.85	103.00	101.65	-22.55	12.59
	1/9/2002	468.8	-18.5	883.7	241.5	393.88	225.15	562.60	676.25	111.50	104.29	-22.43	12.65
	4/12/2002	492.8	22.5	926.5	270.2	428.00	257.65	598.35	709.65	146.35	113.32	-22.64	12.62
	7/18/2002	483.5	3.8	911.9	257.3	414.13	243.65	584.60	697.70	130.55	109.65	-22.66	12.71
	10/8/2002	462.7	-35	875.6	233	384.08	213.85	554.30	669.15	99.00	101.69	-22.63	12.77
	1/8/2003	485.5	2.5	912.6	253.9	413.63	244.00	583.25	699.05	128.20	109.52	-22.55	12.79
	4/15/2003	501.9	612.9	952.7	285.1	588.15	557.40	618.90	727.30	449.00	155.72	-4.09	6.23
	7/1/2003	521.6	28.8	943.4	278.1	442.98	275.20	610.75	732.50	153.45	117.29	-22.30	12.97
	10/7/2003	472.3	-16.5	903.8	247.5	401.78	227.90	575.65	688.05	115.50	106.38	-23.11	12.83
	12/31/2003	495.5	18.6	939.3	268.7	430.53	257.05	604.00	717.40	143.65	113.99	-23.06	12.85
	4/13/2004	504.6	68.9	989	299.2	465.43	286.75	644.10	746.80	184.05	123.23	-23.75	12.61
	7/13/2004	487.3	36.7	961.8	277.7	440.88	262.00	619.75	724.55	157.20	116.73	-23.78	12.71
	10/8/2004	468.9	-0.5	928.8	256.4	413.40	234.20	592.60	698.85	127.95	109.46	-23.82	12.79
	1/7/2005	485.2	21.4	952.7	269.7	432.25	253.30	611.20	718.95	145.55	114.45	-23.79	12.85
	4/8/2005	512.9	68.8	998.7	302.5	470.73	290.85	650.60	755.80	185.65	124.63	-23.91	12.77
	7/18/2005	498.2	40	977.1	286.8	450.53	269.10	631.95	737.65	163.40	119.29	-24.11	12.86
	8/26/2005	486.3	17.1	955.5	271.8	432.68	251.70	613.65	720.90	144.45	114.56	-24.05	12.91
	10/11/2005	478.8	2.4	942.6	263.6	421.85	240.60	603.10	710.70	133.00	111.69	-24.09	12.94
	1/10/2006	497.9	28.2	970.6	280.6	444.33	263.05	625.60	734.25	154.40	117.64	-24.09	12.99
	4/9/2006	519.6	65.1	1008.9	306	474.90	292.35	657.45	764.25	185.55	125.74	-24.26	12.96

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap Side) (cont'd)

Tie #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
26	7/1/1999	468.3	92.2	387.7	511.7	364.98	280.25	449.70	428.00	301.95	96.63	-11.26	2.82
	7/15/1999	460.1	81	381.5	505.7	357.08	270.55	443.60	420.80	293.35	94.54	-11.50	2.86
	8/15/1999	482.3	96.1	410.7	526	378.78	289.20	468.35	446.50	311.05	100.29	-11.91	3.03
	8/31/1999	490.3	101.9	422.4	535	387.40	296.10	478.70	456.35	318.45	102.57	-12.14	3.09
	9/15/1999	491.0	101.4	426.3	536.4	388.78	296.20	481.35	458.65	318.90	102.94	-12.30	3.13
	9/30/1999	497.9	106.7	434.7	543.6	395.73	302.30	489.15	466.30	325.15	104.78	-12.42	3.16
	10/15/1999	505.0	112.3	443.2	550.9	402.85	308.65	497.05	474.10	331.60	106.66	-12.52	3.19
	10/31/1999	515.6	118.8	452.5	560.9	411.95	317.20	506.70	484.05	339.85	109.07	-12.59	3.23
	11/15/1999	525.0	128.3	463.4	570.2	421.73	326.65	516.80	494.20	349.25	111.66	-12.64	3.25
	11/30/1999	532.5	134.9	471.5	576.8	428.93	333.70	524.15	502.00	355.85	113.57	-12.66	3.27
	12/15/1999	534.1	138.1	476.5	580.2	432.23	336.10	528.35	505.30	359.15	114.44	-12.78	3.27
	12/31/1999	540.4	144.3	484.4	587.2	439.08	342.35	535.80	512.40	365.75	116.25	-12.86	3.29
	3/31/2000	551.1	156	501.3	602.1	452.63	353.55	551.70	526.20	379.05	119.84	-13.17	3.30
	6/30/2000	533.5	137.3	477.6	577.9	431.58	335.40	527.75	505.55	357.60	114.27	-12.78	3.31
	9/30/2000	539.6	136.8	480.7	575.1	433.05	338.20	527.90	510.15	355.95	114.66	-12.61	3.45
	1/13/2001	571.4	169.7	522.7	611.8	468.90	370.55	567.25	547.05	390.75	124.15	-13.07	3.50
	4/20/2001	580.2	184.8	537.9	624.6	481.88	382.50	581.25	559.05	404.70	127.59	-13.21	3.46
	7/16/2001	555.8	159.1	508	598.6	455.38	357.45	553.30	531.90	378.85	120.57	-13.02	3.43
	10/9/2001	556.2	154.1	506	595.8	453.03	355.15	550.90	531.10	374.95	119.95	-13.01	3.50
	1/9/2002	572	170.3	527.3	614.7	471.08	371.15	571.00	549.65	392.50	124.73	-13.28	3.52
	4/12/2002	584.6	187.7	546.3	632.8	487.85	386.15	589.55	565.45	410.25	129.17	-13.52	3.48
	7/18/2002	559.5	162.1	516.1	606	460.93	360.80	561.05	537.80	384.05	122.04	-13.31	3.44
	10/8/2002	557	154.4	511	599.8	455.55	355.70	555.40	534.00	377.10	120.62	-13.27	3.51
	1/8/2003	591	189.2	552.8	639	493.00	390.10	595.90	571.90	414.10	130.53	-13.68	3.54
	4/15/2003	597.9	204.3	567.5	650.5	505.05	401.10	609.00	582.70	427.40	133.72	-13.82	3.48
	7/1/2003	580.7	184.3	545.4	632.5	485.73	382.50	588.95	563.05	408.40	128.61	-13.72	3.46
	10/7/2003	578.2	176.3	538	627	479.88	377.25	582.50	558.10	401.65	127.06	-13.64	3.50
	12/31/2003	610.3	207.7	572.6	661.6	513.05	409.00	617.10	591.45	434.65	135.84	-13.83	3.51
	4/13/2004	617.1	224.2	589.5	675.7	526.63	420.65	632.60	603.30	449.95	139.43	-14.09	3.44
	7/13/2004	584	186.6	549.1	642.6	490.58	385.30	595.85	566.55	414.60	129.89	-13.99	3.40
	10/8/2004	581.8	181.2	543.7	638.3	486.25	381.50	591.00	562.75	409.75	128.74	-13.92	3.43
	1/7/2005	609.9	209	574.8	669.1	515.70	409.45	621.95	592.35	439.05	136.54	-14.12	3.43
	4/8/2005	617.5	225	590.2	683.9	529.15	421.25	637.05	603.85	454.45	140.10	-14.34	3.35
	7/18/2005	590.4	192.7	554.7	656	498.45	391.55	605.35	572.55	424.35	131.97	-14.21	3.32
	8/26/2005	584.4	183.1	544	647.8	489.83	383.75	595.90	564.20	415.45	129.69	-14.10	3.33
	10/11/2005	589.3	185.9	548.5	652	493.93	387.60	600.25	568.90	418.95	130.78	-14.13	3.36
	1/10/2006	616	216.1	582.8	683.4	524.58	416.05	633.10	599.40	449.75	138.89	-14.42	3.35
	4/9/2006	629	235.4	605.8	701.1	542.83	432.20	653.45	617.40	468.25	143.72	-14.70	3.34

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft Cap Side)

Tie #	Date	ε_5	ε_6	ε_7	ε_8	Avg. ε	$(\varepsilon_5+\varepsilon_6)/2$	$(\varepsilon_7+\varepsilon_8)/2$	$(\varepsilon_5+\varepsilon_7)/2$	$(\varepsilon_6+\varepsilon_8)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
1	7/1/1999	-115.0	299.7	422.9	109.6	179.30	92.35	266.25	153.95	204.65	47.47	-11.56	-1.14
	7/15/1999	-122.0	289	405.2	95.6	166.95	83.50	250.40	141.60	192.30	44.20	-11.09	-1.14
	8/15/1999	-139.4	265.8	401.5	101.8	157.43	63.20	251.65	131.05	183.80	41.68	-12.52	-1.18
	8/31/1999	-144.1	258.4	394.7	99.6	152.15	57.15	247.15	125.30	179.00	40.28	-12.63	-1.20
	9/15/1999	-144.1	255.9	395.1	102	152.23	55.90	248.55	125.50	178.95	40.30	-12.80	-1.20
	9/30/1999	-141.7	260.4	408.3	112.3	159.83	59.35	260.30	133.30	186.35	42.32	-13.35	-1.19
	10/15/1999	-138.1	275.3	441.9	138.4	179.38	68.60	290.15	151.90	206.85	47.49	-14.72	-1.23
	10/31/1999	-148.1	272.7	430.1	118.5	168.30	62.30	274.30	141.00	195.60	44.56	-14.09	-1.22
	11/15/1999	-142.3	278.9	446.6	134.9	179.53	68.30	290.75	152.15	206.90	47.53	-14.78	-1.23
	11/30/1999	-137.9	284.4	462	150.8	189.83	73.25	306.40	162.05	217.60	50.26	-15.49	-1.24
	12/15/1999	-135.4	290	463.8	152.5	192.73	77.30	308.15	164.20	221.25	51.03	-15.34	-1.28
	12/31/1999	-126.8	301.4	481.4	168.9	206.23	87.30	325.15	177.30	235.15	54.60	-15.81	-1.30
	3/31/2000	-133.9	283.1	455.7	149.6	188.63	74.60	302.65	160.90	216.35	49.94	-15.16	-1.24
	6/30/2000	-157.3	230.6	397.4	119.3	147.50	36.65	258.35	120.05	174.95	39.05	-14.73	-1.23
	9/30/2000	-142.8	237.4	427.4	156.8	169.70	47.30	292.10	142.30	197.10	44.93	-16.27	-1.23
	1/13/2001	-118.2	295.4	511.7	182.5	217.85	88.60	347.10	196.75	238.95	57.68	-17.18	-0.95
	4/20/2001	-128.9	270.9	454	163.4	189.85	71.00	308.70	162.55	217.15	50.27	-15.80	-1.22
	7/16/2001	-146.4	213.9	384.1	133.3	146.23	33.75	258.70	118.85	173.60	38.72	-14.95	-1.23
	10/9/2001	-135.7	237.5	439.4	178.3	179.88	50.90	308.85	151.85	207.90	47.63	-17.14	-1.26
	1/9/2002	-120.2	281.4	483	190.7	208.73	80.60	336.85	181.40	236.05	55.26	-17.03	-1.22
	4/12/2002	-133.2	263.6	441.1	154.2	181.43	65.20	297.65	153.95	208.90	48.04	-15.45	-1.23
	7/18/2002	-158.1	191.2	355.6	118	126.68	16.55	236.80	98.75	154.60	33.54	-14.64	-1.25
	10/8/2002	-149.2	192.4	391.7	156.3	147.80	21.60	274.00	121.25	174.35	39.13	-16.77	-1.19
	1/8/2003	-123.2	268.7	469.3	191.8	201.65	72.75	330.55	173.05	230.25	53.39	-17.13	-1.28
	4/15/2003	-137.5	248.4	427.1	157.1	173.78	55.45	292.10	144.80	202.75	46.01	-15.73	-1.30
	7/1/2003	-159.7	183.9	351.2	124.6	125.00	12.10	237.90	95.75	154.25	33.10	-15.01	-1.31
	10/7/2003	-146.6	206.4	412.6	177.8	162.55	29.90	295.20	133.00	192.10	43.04	-17.63	-1.32
	12/31/2003	-135.4	243.4	450.4	190	187.10	54.00	320.20	157.50	216.70	49.54	-17.69	-1.33
	4/13/2004	-144.6	228.6	422.1	168	168.53	42.00	295.05	138.75	198.30	44.62	-16.82	-1.33
	7/13/2004	-179.1	155.6	334.2	117.5	107.05	-11.75	225.85	77.55	136.55	28.34	-15.79	-1.32
	10/8/2004	-169	170.9	373.7	152.9	132.13	0.95	263.30	102.35	161.90	34.98	-17.44	-1.33
	1/7/2005	-145.5	227.8	440.5	188.2	177.75	41.15	314.35	147.50	208.00	47.06	-18.16	-1.36
	4/8/2005	-159.4	209.2	398.5	148.8	149.28	24.90	273.65	119.55	179.00	39.52	-16.53	-1.33
	7/18/2005	-182.8	141.5	330.3	131.3	105.08	-20.65	230.80	73.75	136.40	27.82	-16.71	-1.40
	8/26/2005	-184	140.7	341.3	131.3	107.33	-21.65	236.30	78.65	136.00	28.42	-17.14	-1.28
	10/11/2005	-174.2	159.1	370.9	131.3	121.78	-7.55	251.10	98.35	145.20	32.24	-17.19	-1.05
	1/10/2006	-152.5	216.4	430.7	131.3	156.48	31.95	281.00	139.10	173.85	41.43	-16.55	-0.78
	4/9/2006	-157.2	206.1	413	131.3	148.30	24.45	272.15	127.90	168.70	39.27	-16.46	-0.91

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft Cap Side) (cont'd)

Tie #	Date	ε_5	ε_6	ε_7	ε_8	Avg. ε	$(\varepsilon_5+\varepsilon_6)/2$	$(\varepsilon_7+\varepsilon_8)/2$	$(\varepsilon_5+\varepsilon_7)/2$	$(\varepsilon_6+\varepsilon_8)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
12	7/1/1999	356.2	257	201.2	275.1	272.38	306.60	238.15	278.70	266.05	72.12	4.55	0.28
	7/15/1999	353.8	251.6	188.4	273.4	266.80	302.70	230.90	271.10	262.50	70.64	4.77	0.19
	8/15/1999	350.0	242.8	195.3	301.1	272.30	296.40	248.20	272.65	271.95	72.10	3.20	0.02
	8/31/1999	350.2	247.8	201.7	307.9	276.90	299.00	254.80	275.95	277.85	73.31	2.94	-0.04
	9/15/1999	349.8	249.1	203.6	314	279.13	299.45	258.80	276.70	281.55	73.90	2.70	-0.11
	9/30/1999	352.2	256.8	212.1	322.7	285.95	304.50	267.40	282.15	289.75	75.71	2.47	-0.17
	10/15/1999	352.6	257.7	225.5	337.3	293.28	305.15	281.40	289.05	297.50	77.65	1.58	-0.19
	10/31/1999	361.0	268.5	222.6	333.7	296.45	314.75	278.15	291.80	301.10	78.49	2.43	-0.21
	11/15/1999	364.5	273.1	237.1	353.6	307.08	318.80	295.35	300.80	313.35	81.30	1.56	-0.28
	11/30/1999	367.6	276.3	249.1	369.4	315.60	321.95	309.25	308.35	322.85	83.56	0.84	-0.32
	12/15/1999	370.6	280.7	248.5	364.3	316.03	325.65	306.40	309.55	322.50	83.67	1.28	-0.29
	12/31/1999	371.2	282.5	254.8	368.8	319.33	326.85	311.80	313.00	325.65	84.55	1.00	-0.28
	3/31/2000	376.0	289.2	244.7	361.1	317.75	332.60	302.90	310.35	325.15	84.13	1.97	-0.33
	6/30/2000	358.4	247.7	207.4	329.3	285.70	303.05	268.35	282.90	288.50	75.64	2.31	-0.13
	9/30/2000	357.6	235.9	230.1	366.4	297.50	296.75	298.25	293.85	301.15	78.77	-0.10	-0.16
	1/13/2001	382.0	289.5	264.4	384.8	330.18	335.75	324.60	323.20	337.15	87.42	0.74	-0.31
	4/20/2001	382.9	294.9	260.1	378.2	329.03	338.90	319.15	321.50	336.55	87.12	1.31	-0.34
	7/16/2001	352.4	249.4	219.2	330.6	287.90	300.90	274.90	285.80	290.00	76.23	1.73	-0.09
	10/9/2001	357.7	267.9	262.1	382	317.43	312.80	322.05	309.90	324.95	84.04	-0.61	-0.34
	1/9/2002	385.8	301.2	285.1	395.6	341.93	343.50	340.35	335.45	348.40	90.53	0.21	-0.29
	4/12/2002	390.9	310.2	263.2	370.1	333.60	350.55	316.65	327.05	340.15	88.33	2.25	-0.29
	7/18/2002	346.39	265.03	220.4	323.3	288.78	305.71	271.85	283.39	294.17	76.46	2.25	-0.24
	10/8/2002	344.5	265.3	252.4	363.5	306.43	304.90	307.95	298.45	314.40	81.13	-0.20	-0.36
	1/8/2003	385.9	308.5	295.9	394.3	346.15	347.20	345.10	340.90	351.40	91.65	0.14	-0.24
	4/15/2003	392.4	317.3	275.8	371.1	339.15	354.85	323.45	334.10	344.20	89.80	2.09	-0.23
	7/1/2003	360	288.1	238.7	332.8	304.90	324.05	285.75	299.35	310.45	80.73	2.55	-0.25
	10/7/2003	357.1	284.5	277.7	372.1	322.85	320.80	324.90	317.40	328.30	85.48	-0.27	-0.24
	12/31/2003	387.7	318.7	304.1	392.5	350.75	353.20	348.30	345.90	355.60	92.87	0.33	-0.22
	4/13/2004	389.4	324.2	294.9	381.2	347.43	356.80	338.05	342.15	352.70	91.99	1.25	-0.24
	7/13/2004	348	285.8	241	324.8	299.90	316.90	282.90	294.50	305.30	79.40	2.26	-0.24
	10/8/2004	342.4	281.8	269.4	353.1	311.68	312.10	311.25	305.90	317.45	82.52	0.06	-0.26
	1/7/2005	374.1	315.2	302.9	382.8	343.75	344.65	342.85	338.50	349.00	91.01	0.12	-0.24
	4/8/2005	386.7	328.9	284.3	365	341.23	357.80	324.65	335.50	346.95	90.35	2.20	-0.26
	7/18/2005	343.2	285.5	242.4	322.1	298.30	314.35	282.25	292.80	303.80	78.98	2.13	-0.25
	8/26/2005	337	278.7	250.1	331.1	299.23	307.85	290.60	293.55	304.90	79.23	1.15	-0.25
	10/11/2005	338.7	283.6	264.1	348.6	308.75	311.15	306.35	301.40	316.10	81.75	0.32	-0.33
	1/10/2006	371.5	317.4	297	373.5	339.85	344.45	335.25	334.25	345.45	89.98	0.61	-0.25
	4/9/2006	377.4	324.1	290.6	368.2	340.08	350.75	329.40	334.00	346.15	90.04	1.42	-0.27

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft Cap Side) (cont'd)

Tie #	Date	ε_5	ε_6	ε_7	ε_8	Avg. ε	$(\varepsilon_5+\varepsilon_6)/2$	$(\varepsilon_7+\varepsilon_8)/2$	$(\varepsilon_5+\varepsilon_7)/2$	$(\varepsilon_6+\varepsilon_8)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
13	7/1/1999	177.4	380.2	417.6	236.2	302.85	278.80	326.90	297.50	308.20	80.19	-3.20	-0.24
	7/15/1999	173.8	378	412.7	230.2	298.68	275.90	321.45	293.25	304.10	79.08	-3.03	-0.24
	8/15/1999	172.8	380.2	439.6	252.6	311.30	276.50	346.10	306.20	316.40	82.42	-4.63	-0.23
	8/31/1999	172.6	378	445.8	257.5	313.48	275.30	351.65	309.20	317.75	83.00	-5.07	-0.19
	9/15/1999	170.9	377.2	447.2	261	314.08	274.05	354.10	309.05	319.10	83.16	-5.32	-0.23
	9/30/1999	176.4	380.7	455.9	269.3	320.58	278.55	362.60	316.15	325.00	84.88	-5.59	-0.20
	10/15/1999	176.7	378.9	468.1	279.5	325.80	277.80	373.80	322.40	329.20	86.26	-6.38	-0.15
	10/31/1999	182.4	385.8	502.1	273.8	336.03	284.10	387.95	342.25	329.80	88.97	-6.90	0.28
	11/15/1999	186.8	392.4	482.7	292	338.48	289.60	387.35	334.75	342.20	89.62	-6.50	-0.17
	11/30/1999	189.8	396.8	638.9	305.6	382.78	293.30	472.25	414.35	351.20	101.35	-11.89	1.41
	12/15/1999	193.5	401.1	516.7	302.2	353.38	297.30	409.45	355.10	351.65	93.56	-7.45	0.08
	12/31/1999	194.7	406.1	507.2	308	354.00	300.40	407.60	350.95	357.05	93.73	-7.12	-0.14
	3/31/2000	194.8	409	492.7	298.7	348.80	301.90	395.70	343.75	353.85	92.35	-6.23	-0.23
	6/30/2000	177.7	389.4	467.2	278.7	328.25	283.55	372.95	322.45	334.05	86.91	-5.94	-0.26
	9/30/2000	174.2	385.1	496.7	308	341.00	279.65	402.35	335.45	346.55	90.29	-8.15	-0.25
	1/13/2001	200.0	418.2	530.3	318.6	366.78	309.10	424.45	365.15	368.40	97.11	-7.67	-0.07
	4/20/2001	194.1	416.2	512.8	310.6	358.43	305.15	411.70	353.45	363.40	94.90	-7.08	-0.22
	7/16/2001	166.5	386.2	469	273.8	323.88	276.35	371.40	317.75	330.00	85.75	-6.32	-0.27
	10/9/2001	171.5	389.1	514.8	315.2	347.65	280.30	415.00	343.15	352.15	92.05	-8.95	-0.20
	1/9/2002	193.6	413.6	539.3	324.6	367.78	303.60	431.95	366.45	369.10	97.38	-8.53	-0.06
	4/12/2002	198.8	418.5	509.3	299.2	356.45	308.65	404.25	354.05	358.85	94.38	-6.35	-0.11
	7/18/2002	161.4	379.1	462.4	262.6	316.38	270.25	362.50	311.90	320.85	83.77	-6.13	-0.20
	10/8/2002	155.8	373.6	686.8	301.1	379.33	264.70	493.95	421.30	337.35	100.43	-15.24	1.88
	1/8/2003	193.1	414	547.6	331	371.43	303.55	439.30	370.35	372.50	98.34	-9.02	-0.05
	4/15/2003	195.8	419.9	560.6	305.7	370.50	307.85	433.15	378.20	362.80	98.10	-8.33	0.34
	7/1/2003	172.1	394.8	479.4	273.9	330.05	283.45	376.65	325.75	334.35	87.39	-6.19	-0.19
	10/7/2003	169	389.1	527.1	317.5	350.68	279.05	422.30	348.05	353.30	92.85	-9.52	-0.12
	12/31/2003	196.2	423.2	560.3	334.7	378.60	309.70	447.50	378.25	378.95	100.24	-9.16	-0.02
	4/13/2004	197.9	424.7	546.1	321.7	372.60	311.30	433.90	372.00	373.20	98.65	-8.15	-0.03
	7/13/2004	155.6	383.5	482.7	266.1	321.98	269.55	374.40	319.15	324.80	85.25	-6.97	-0.13
	10/8/2004	152.2	378.4	519	298.6	337.05	265.30	408.80	335.60	338.50	89.24	-9.54	-0.06
	1/7/2005	180.6	410.6	556.1	324.9	368.05	295.60	440.50	368.35	367.75	97.45	-9.63	0.01
	4/8/2005	188.3	419.5	529.1	301	359.48	303.90	415.05	358.70	360.25	95.18	-7.39	-0.03
	7/18/2005	150.7	376.8	482.9	262.2	318.15	263.75	372.55	316.80	319.50	84.24	-7.23	-0.06
	8/26/2005	144.7	373.1	494.1	275.3	321.80	258.90	384.70	319.40	324.20	85.20	-8.36	-0.11
	10/11/2005	146.5	375.2	533.7	291.5	336.73	260.85	412.60	340.10	333.35	89.15	-10.09	0.15
	1/10/2006	176	407.1	548.8	313.5	361.35	291.55	431.15	362.40	360.30	95.67	-9.28	0.05
	4/9/2006	180.6	412.1	538.7	307.8	359.80	296.35	423.25	359.65	359.95	95.26	-8.43	-0.01

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft Cap Side) (cont'd)

Tie #	Date	ε_5	ε_6	ε_7	ε_8	Avg. ε	$(\varepsilon_5+\varepsilon_6)/2$	$(\varepsilon_7+\varepsilon_8)/2$	$(\varepsilon_5+\varepsilon_7)/2$	$(\varepsilon_6+\varepsilon_8)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
14	7/1/1999	199.5	418.4	473.6	323.8	353.83	308.95	398.70	336.55	371.10	93.68	-5.96	-0.77
	7/15/1999	194.3	414.4	461.1	314.4	346.05	304.35	387.75	327.70	364.40	91.62	-5.54	-0.82
	8/15/1999	191.0	402.1	488.7	347.5	357.33	296.55	418.10	339.85	374.80	94.61	-8.08	-0.78
	8/31/1999	189.5	395.4	496	352.6	358.38	292.45	424.30	342.75	374.00	94.89	-8.76	-0.70
	9/15/1999	186.8	391.6	503.6	359.8	360.45	289.20	431.70	345.20	375.70	95.44	-9.47	-0.68
	9/30/1999	188.5	396.7	516	369	367.55	292.60	442.50	352.25	382.85	97.32	-9.96	-0.69
	10/15/1999	235.3	403	530.4	378.9	386.90	319.15	454.65	382.85	390.95	102.44	-9.01	-0.18
	10/31/1999	202.7	418.5	524.2	371.5	379.23	310.60	447.85	363.45	395.00	100.41	-9.12	-0.71
	11/15/1999	208.9	426.2	548.2	393.2	394.13	317.55	470.70	378.55	409.70	104.35	-10.18	-0.70
	11/30/1999	212.9	429.2	566.6	409.5	404.55	321.05	488.05	389.75	419.35	107.11	-11.10	-0.66
	12/15/1999	216.9	433.5	561.4	403.7	403.88	325.20	482.55	389.15	418.60	106.93	-10.46	-0.66
	12/31/1999	220.7	443.8	566.6	407.4	409.63	332.25	487.00	393.65	425.60	108.46	-10.28	-0.72
	3/31/2000	215.2	438.2	567.9	406.5	406.95	326.70	487.20	391.55	422.35	107.75	-10.67	-0.69
	6/30/2000	191.3	415.8	542.4	380.7	382.55	303.55	461.55	366.85	398.25	101.29	-10.50	-0.70
	9/30/2000	183.3	409.8	571	409.9	393.50	296.55	490.45	377.15	409.85	104.19	-12.89	-0.73
	1/13/2001	215.4	447.2	588.9	421.9	418.35	331.30	505.40	402.15	434.55	110.77	-11.57	-0.73
	4/20/2001	210.2	445.1	586.6	415.7	414.40	327.65	501.15	398.40	430.40	109.72	-11.53	-0.72
	7/16/2001	171.2	413	554.5	377.7	379.10	292.10	466.10	362.85	395.35	100.37	-11.56	-0.73
	10/9/2001	178.5	417.9	596.2	418.8	402.85	298.20	507.50	387.35	418.35	106.66	-13.91	-0.69
	1/9/2002	206.2	445.9	606.4	430	422.13	326.05	518.20	406.30	437.95	111.77	-12.77	-0.71
	4/12/2002	208.6	449.5	584.1	408.1	412.58	329.05	496.10	396.35	428.80	109.24	-11.10	-0.73
	7/18/2002	161.7	410.1	551.9	368.5	373.05	285.90	460.20	356.80	389.30	98.77	-11.58	-0.73
	10/8/2002	160.2	405.5	592.3	407.7	391.43	282.85	500.00	376.25	406.60	103.64	-14.43	-0.68
	1/8/2003	202	449.1	620.2	437.7	427.25	325.55	528.95	411.10	443.40	113.12	-13.52	-0.72
	4/15/2003	205.4	453.6	590	409.8	414.70	329.50	499.90	397.70	431.70	109.80	-11.32	-0.76
	7/1/2003	171.9	426.9	559.5	377.3	383.90	299.40	468.40	365.70	402.10	101.65	-11.23	-0.82
	10/7/2003	172	424.4	600.8	422.4	404.90	298.20	511.60	386.40	423.40	107.21	-14.18	-0.83
	12/31/2003	205.6	461.3	624.2	444.9	434.00	333.45	534.55	414.90	453.10	114.91	-13.36	-0.86
	4/13/2004	204.7	463.4	611.5	433.1	428.18	334.05	522.30	408.10	448.25	113.37	-12.51	-0.90
	7/13/2004	159.6	424.2	566.4	383.7	383.48	291.90	475.05	363.00	403.95	101.53	-12.17	-0.92
	10/8/2004	153	416.8	590.5	409.5	392.45	284.90	500.00	371.75	413.15	103.91	-14.30	-0.93
	1/7/2005	192.8	454.9	627.8	446.9	430.60	323.85	537.35	410.30	450.90	114.01	-14.19	-0.91
	4/8/2005	205.2	467.5	600.9	425.2	424.70	336.35	513.05	403.05	446.35	112.45	-11.74	-0.97
	7/18/2005	154.9	424.1	560.9	385.2	381.28	289.50	473.05	357.90	404.65	100.95	-12.20	-1.05
	8/26/2005	168.3	416.1	569.1	391.2	386.18	292.20	480.15	368.70	403.65	102.25	-12.49	-0.78
	10/11/2005	152.5	418.5	590.5	413.4	393.73	285.50	501.95	371.50	415.95	104.25	-14.38	-1.00
	1/10/2006	190.7	455.4	615	436.7	424.45	323.05	525.85	402.85	446.05	112.38	-13.48	-0.97
	4/9/2006	196.7	460.2	612.3	436.6	426.45	328.45	524.45	404.50	448.40	112.91	-13.03	-0.98

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft Cap Side) (cont'd)

Tie #	Date	ε_5	ε_6	ε_7	ε_8	Avg. ε	$(\varepsilon_5+\varepsilon_6)/2$	$(\varepsilon_7+\varepsilon_8)/2$	$(\varepsilon_5+\varepsilon_7)/2$	$(\varepsilon_6+\varepsilon_8)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
26	7/1/1999	222.2	-19.9	305.2	560	266.88	101.15	432.60	263.70	270.05	70.66	-22.03	-0.14
	7/15/1999	207.8	-36.8	294.3	540.9	251.55	85.50	417.60	251.05	252.05	66.60	-22.07	-0.02
	8/15/1999	189.9	-53.4	320.4	546.8	250.93	68.25	433.60	255.15	246.70	66.44	-24.28	0.19
	8/31/1999	184.8	-60	330.2	555.2	252.55	62.40	442.70	257.50	247.60	66.87	-25.27	0.22
	9/15/1999	185.7	-57.2	336.6	558.2	255.83	64.25	447.40	261.15	250.50	67.73	-25.46	0.24
	9/30/1999	187.5	-53.7	349.9	570.1	263.45	66.90	460.00	268.70	258.20	69.75	-26.12	0.24
	10/15/1999	195.3	-50.5	375.2	601.5	280.38	72.40	488.35	285.25	275.50	74.23	-27.64	0.22
	10/31/1999	197.3	-39.9	370.8	589.7	279.48	78.70	480.25	284.05	274.90	74.00	-26.69	0.20
	11/15/1999	202.5	-32.3	385.9	601.1	289.30	85.10	493.50	294.20	284.40	76.60	-27.14	0.22
	11/30/1999	206.5	-27.3	398.1	613.9	297.80	89.60	506.00	302.30	293.30	78.85	-27.67	0.20
	12/15/1999	216.1	-19.5	401.6	620.9	304.78	98.30	511.25	308.85	300.70	80.70	-27.44	0.18
	12/31/1999	223.8	-15	410.7	633.4	313.23	104.40	522.05	317.25	309.20	82.93	-27.76	0.18
	3/31/2000	203.5	-16	395.7	633.5	304.18	93.75	514.60	299.60	308.75	80.54	-27.97	-0.20
	6/30/2000	149.3	-41	371.2	553.8	258.33	54.15	462.50	260.25	256.40	68.40	-27.14	0.09
	9/30/2000	154.3	-22.3	411.5	580.2	280.93	66.00	495.85	282.90	278.95	74.38	-28.57	0.09
	1/13/2001	197.9	7.7	446.8	627.1	319.88	102.80	536.95	322.35	317.40	84.69	-28.85	0.11
	4/20/2001	167.6	1.3	434.9	589.5	298.33	84.45	512.20	301.25	295.40	78.99	-28.43	0.13
	7/16/2001	112.8	-20.6	409.7	555.1	264.25	46.10	482.40	261.25	267.25	69.97	-29.00	-0.13
	10/9/2001	136.9	-5.4	451.7	582.7	291.48	65.75	517.20	294.30	288.65	77.17	-30.00	0.13
	1/9/2002	176.6	9	461.6	618.2	316.35	92.80	539.90	319.10	313.60	83.76	-29.71	0.12
	4/12/2002	158.20	3.40	438	581.00	295.25	80.80	509.70	298.30	292.20	78.17	-28.50	0.14
	7/18/2002	86.10	-23.70	405	503.86	242.87	31.20	454.53	245.65	240.08	64.30	-28.13	0.12
	10/8/2002	96.1	2.90	445.20	562.80	276.75	49.50	504.00	270.65	282.85	73.28	-30.21	-0.27
	1/8/2003	165.9	41.91	480.40	628.48	329.17	103.91	554.44	323.15	335.20	87.16	-29.94	-0.27
	4/15/2003	147.5	33.95	455.30	592.01	307.19	90.73	523.65	301.40	312.98	81.33	-28.77	-0.26
	7/1/2003	88.2	9.66	424.1	577.30	274.82	48.93	500.70	256.15	293.48	72.76	-30.02	-0.84
	10/7/2003	103.5	24.24	466.9	574.34	292.25	63.87	520.62	285.20	299.29	77.38	-30.35	-0.32
	12/31/2003	130.5	44.68	481.6	566.95	305.93	87.59	524.27	306.05	305.81	81.00	-29.02	0.01
	4/13/2004	118.2	42.08	471.6	585.31	304.30	80.14	528.45	294.90	313.69	80.57	-29.79	-0.42
	7/13/2004	49.6	8.40	430.9	548.80	259.43	29.00	489.85	240.25	278.60	68.69	-30.63	-0.86
	10/8/2004	54.7	18.19	457.3	588.15	279.59	36.45	522.72	256.00	303.17	74.03	-32.32	-1.06
	1/7/2005	108.7	42.65	486.4	597.82	308.89	75.67	542.11	297.55	320.23	81.78	-31.00	-0.51
	4/8/2005	91.7	33.99	457.3	601.47	296.12	62.85	529.39	274.50	317.73	78.40	-31.01	-0.97
	7/18/2005	28.7	12.91	432.3	605.33	269.81	20.81	518.82	230.50	309.12	71.44	-33.10	-1.76
	8/26/2005	31.4	16.85	447.8	588.39	271.11	24.13	518.10	239.60	302.62	71.78	-32.83	-1.41
	10/11/2005	43.7	14.58	464.4	588.60	277.82	29.14	526.50	254.05	301.59	73.56	-33.05	-1.06
	1/10/2006	96.3	14.58	483.8	588.60	295.82	55.44	536.20	290.05	301.59	78.32	-31.95	-0.26
	4/9/2006	87.1	29.40	477	588.60	295.52	58.25	532.80	282.05	309.00	78.25	-31.54	-0.60

Table 4 Driven Pile Forces and Bending Moments

Pile #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
1	07/01/99	903.00	42.30	679.00	-	541.43	472.65	679.00	791.00	42.30	456.92	-73.98	99.88
	07/15/99	918.00	48.00	885.00	-	617.00	483.00	885.00	901.50	48.00	520.69	-144.12	113.86
	07/31/00	932.43	51.99	887.34	-	623.92	492.21	887.34	909.89	51.99	526.53	-141.66	114.44
	08/15/99	940.56	34.46	923.00	-	632.67	487.51	923.00	931.78	34.46	533.91	-156.13	119.70
	08/30/99	948.68	31.28	931.09	-	637.02	489.98	931.09	939.89	31.28	537.58	-158.14	121.21
	09/15/99	955.75	27.83	938.36	-	640.65	491.79	938.36	947.06	27.83	540.64	-160.10	122.62
	09/30/99	959.08	23.03	947.01	-	643.04	491.06	947.01	953.05	23.03	542.66	-163.47	124.06
	10/15/99	963.38	18.85	954.86	-	645.70	491.12	954.86	959.12	18.85	544.90	-166.26	125.43
	10/31/99	973.25	5.58	968.30	-	649.04	489.42	968.30	970.78	5.58	547.73	-171.69	128.76
	11/15/99	973.34	1.26	977.48	-	650.69	487.30	977.48	975.41	1.26	549.12	-175.74	129.95
	11/30/99	975.73	-2.84	980.87	-	651.25	486.45	980.87	978.30	-2.84	549.59	-177.26	130.88
	12/15/99	974.96	-2.47	982.11	-	651.53	486.25	982.11	978.54	-2.47	549.83	-177.77	130.87
	12/31/99	974.03	-54.00	984.71		634.91	460.02	984.71	979.37	-54.00	535.80	-188.11	137.85
	03/31/00	964.52	3.86	981.83	-	650.07	484.19	981.83	973.17	3.86	548.59	-178.41	129.31
	06/30/00	977.80	-36.92	980.73	-	640.54	470.44	980.73	979.27	-36.92	540.55	-182.94	135.56
	09/30/00	1009.20	-10.20	1005.99	-	668.33	499.50	1005.99	1007.60	-10.20	564.01	-181.58	135.77
	01/13/01	1014.1	-29.45	1029.11	-	671.26	492.33	1029.11	1021.61	-29.45	566.48	-192.44	140.21
	04/20/01	1008.3	-18.69	1022.57	-	670.72	494.79	1022.57	1015.42	-18.69	566.02	-189.21	137.95
	07/10/01	1030.4	-8.368	1019.56	-	680.53	511.02	1019.56	1024.98	-8.37	574.30	-182.32	137.85
	10/09/01	1054.3	-20.51	1038.65	-	690.80	516.87	1038.65	1046.45	-20.51	582.96	-187.07	142.33
	01/09/02	1055.96	-29.65	1045.80	-	690.70	513.15	1045.80	1050.88	-29.65	582.88	-190.96	144.14
	04/12/02	1041.9	-24.82	1040.36	-	685.81	508.54	1040.36	1041.13	-24.82	578.76	-190.66	142.20
	07/19/02	1062.21	-17.26	1035.12	17.14	693.36	522.47	1035.12	1048.67	-17.26	585.12	-183.79	142.20
	10/08/02	1086.38	-30.07	1049.75	-6.63	702.02	528.16	1049.75	1068.06	-30.07	592.43	-187.00	146.49
	01/08/03	1080.45	-42.89	1062.94	0.41	700.17	518.78	1062.94	1071.70	-42.89	590.87	-195.09	148.69
	04/15/03	1059.37	-29.65	1049.86	22.95	693.19	514.86	1049.86	1054.62	-29.65	584.99	-191.81	144.64
	06/01/03	1064.93	-31.16	1053.52	21.00	695.77	516.89	1053.52	1059.23	-31.16	587.16	-192.39	145.46
	08/07/03	1083.86	-27.66	1053.40	9.26	703.20	528.10	1053.40	1068.63	-27.66	593.43	-188.33	146.25
	10/07/03	1095.56	-38.67	1066.64	-0.69	707.84	528.45	1066.64	1081.10	-38.67	597.35	-192.95	149.38
	12/31/03	1100.15	-54.88	1082.97	-0.89	709.41	522.64	1082.97	1091.56	-54.88	598.68	-200.89	152.93
	04/13/04	1080.17	-43.67	1074.07	21.65	703.52	518.25	1074.07	1077.12	-43.67	593.70	-199.27	149.51
	07/13/04	1101.53	-34.89	1072.49	10.76	713.04	533.32	1072.49	1087.01	-34.89	601.74	-193.30	149.66
	10/08/04	1122.82	-45.70	1085.57	-8.86	720.90	538.56	1085.57	1104.19	-45.70	608.36	-196.11	153.40
	01/07/05	1116.60	-58.49	1097.39	-8.94	718.50	529.06	1097.39	1107.00	-58.49	606.34	-203.76	155.48
	04/08/05	1099.01	-52.77	1096.58	5.48	714.28	523.12	1096.58	1097.80	-52.77	602.78	-205.59	153.49
	07/18/05	1116.44	-41.55	1096.58	-2.36	723.82	537.44	1096.58	1106.51	-41.55	610.83	-200.46	153.15
	08/26/05	1128.14	-43.63	1095.73	-10.20	726.75	542.26	1095.73	1111.93	-43.63	613.30	-198.43	154.15
	11/12/05	1127.45	-44.76	1095.72	-9.67	726.14	541.34	1095.72	1111.58	-44.76	612.79	-198.75	154.26
	01/10/06	1129.36	-64.30	1095.72	-19.70	720.26	532.53	1095.72	1112.54	-64.30	607.83	-201.91	156.99
	04/09/06	1114.90	-55.20	1095.72	-1.14	718.47	529.85	1095.72	1105.31	-55.20	606.32	-202.87	154.81

Table 4 Driven Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
17	07/01/99	575.00	589.00	243.00	-	469.00	582.00	243.00	409.00	589.00	395.79	121.54	-24.01
	07/15/99	585.00	602.00	237.00	-	474.67	593.50	237.00	411.00	602.00	400.57	127.81	-25.48
	07/31/00	594.35	611.17	230.68	-	478.73	602.76	230.68	412.52	611.17	404.00	133.40	-26.50
	08/15/99	596.87	611.09	242.58	336.68	446.81	603.98	289.63	419.73	473.89	377.06	112.70	-7.22
	08/30/99	601.58	616.82	241.00	-	486.47	609.20	241.00	421.29	616.82	410.53	132.00	-26.08
	09/15/99	605.96	622.42	240.47	-	489.62	614.19	240.47	423.22	622.42	413.19	133.98	-26.57
	09/30/99	609.62	624.20	240.71	336.98	452.88	616.91	288.85	425.17	480.59	382.18	117.62	-7.39
	10/15/99	612.87	629.40	240.27	336.21	454.69	621.14	288.24	426.57	482.81	383.71	119.35	-7.50
	10/31/99	616.45	631.80	243.11	336.29	456.91	624.13	289.70	429.78	484.05	385.59	119.90	-7.24
	11/15/99	619.54	632.45	245.83	337.79	458.90	626.00	291.81	432.69	485.12	387.27	119.81	-6.99
	11/30/99	623.35	635.58	248.71	340.31	461.99	629.47	294.51	436.03	487.95	389.87	120.09	-6.93
	12/15/99	624.21	637.77	247.77	339.95	462.43	630.99	293.86	435.99	488.86	390.24	120.87	-7.05
	12/31/99	626.60	640.86	249.37	341.45	464.57	633.73	295.41	437.99	491.16	392.05	121.29	-7.09
	03/31/00	634.53	648.30	254.69	346.89	471.10	641.41	300.79	444.61	497.60	397.56	122.12	-7.07
	06/30/00	640.05	652.80	250.99	342.06	471.48	646.43	296.53	445.52	497.43	397.88	125.44	-6.93
	09/30/00	647.16	661.13	247.62	336.78	473.17	654.14	292.20	447.39	498.96	399.31	129.76	-6.88
	01/13/01	654.06	665.11	256.39	342.22	479.45	659.59	299.31	455.23	503.67	404.61	129.16	-6.46
	04/20/01	654.43	664.71	260.37	345.47	481.25	659.57	302.92	457.40	505.09	406.12	127.86	-6.36
	07/10/01	661.46	672.1	256.15	342.75	483.11	666.78	299.45	458.80	507.43	407.70	131.69	-6.49
	10/09/01	668.36	679	251.93	338.20	484.37	673.68	295.06	460.14	508.60	408.76	135.74	-6.46
	01/09/02	671.08	683.47	252.17	337.92	486.16	677.28	295.04	461.63	510.69	410.27	137.04	-6.55
	04/12/02	669.17	680.02	256.68	342.06	486.98	674.60	299.37	462.93	511.04	410.96	134.52	-6.42
	07/19/02	671.69	683.96	253.27	272.93	470.46	677.83	263.10	462.48	478.44	397.02	148.69	-2.13
	10/08/02	678.60	692.21	247.01	332.37	487.54	685.40	289.69	462.80	512.29	411.44	141.87	-6.60
	01/08/03	678.44	689.32	251.28	334.22	488.31	683.88	292.75	464.86	511.77	412.09	140.22	-6.26
	04/15/03	679.45	692.45	254.73	341.09	491.93	685.95	297.91	467.09	516.77	415.14	139.12	-6.63
	06/01/03	678.76	689.85	256.43	341.09	491.53	684.30	298.76	467.60	515.47	414.80	138.22	-6.39
	08/07/03	682.33	695.54	251.15	336.74	491.44	688.94	293.95	466.74	516.14	414.73	141.61	-6.59
	10/07/03	686.23	700.57	250.14	334.87	492.95	693.40	292.50	468.19	517.72	416.00	143.73	-6.61
	12/31/03	689.48	700.61	257.04	341.05	497.05	695.05	299.04	473.26	520.83	419.46	141.97	-6.35
	04/13/04	689.24	699.88	260.70	346.65	499.12	694.56	303.68	474.97	523.27	421.21	140.14	-6.44
	07/13/04	693.10	667.59	255.46	341.33	489.37	680.34	298.39	474.28	504.46	412.98	136.93	-4.03
	10/08/04	699.03	710.89	250.83	337.39	499.53	704.96	294.11	474.93	524.14	421.56	147.30	-6.56
	01/07/05	699.07	711.46	253.31	339.95	500.95	705.26	296.63	476.19	525.70	422.75	146.50	-6.61
	04/08/05	696.43	708.09	257.94	343.81	501.57	702.26	300.87	477.18	525.95	423.27	143.90	-6.51
	07/18/05	699.56	708.33	253.71	338.36	499.99	703.94	296.04	476.64	523.35	421.94	146.24	-6.23
	08/26/05	702.04	711.17	250.91	335.97	500.02	706.61	293.44	476.47	523.57	421.97	148.13	-6.28
	11/12/05	701.95	699.60	251.68	337.06	497.57	700.78	294.37	476.82	518.33	419.90	145.70	-5.54
	01/10/06	705.16	715.03	253.47	339.58	503.31	710.10	296.53	479.32	527.31	424.75	148.27	-6.40
	04/09/06	703.94	713.04	259.52	343.20	504.93	708.49	301.36	481.73	528.12	426.11	145.96	-6.19

Table 4 Driven Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
18	07/01/99	546.00	501.00	248.00	173	367.00	523.50	210.50	397.00	337.00	309.71	112.21	8.00
	07/15/99	557.00	513.00	243.00	229	385.50	535.00	236.00	400.00	371.00	325.32	107.20	3.87
	07/31/00	565.55	519.94	239.54	224.26	387.32	542.75	231.90	402.55	372.10	326.86	111.44	4.06
	08/15/99	567.71	520.14	230.56	232.51	387.73	543.93	231.54	399.14	376.33	327.21	112.00	3.04
	08/30/99	573.72	526.52	247.46	232.87	395.14	550.12	240.17	410.59	379.70	333.46	111.12	4.12
	09/15/99	578.06	532.08	246.65	233.61	397.60	555.07	240.13	412.36	382.85	335.53	112.91	3.94
	09/30/99	582.49	534.97	247.46	234.05	399.74	558.73	240.76	414.98	384.51	337.34	114.00	4.06
	10/15/99	586.68	538.17	247.25	235.23	401.83	562.43	241.24	416.97	386.70	339.11	115.15	4.04
	10/31/99	590.77	539.40	249.37	235.6	403.79	565.09	242.49	420.07	387.50	340.75	115.66	4.34
	11/15/99	592.65	540.65	251.68	237.47	405.61	566.65	244.58	422.17	389.06	342.30	115.47	4.42
	11/30/99	596.63	527.25	254.12	239.69	404.42	561.94	246.91	425.38	383.47	341.29	112.94	5.59
	12/15/99	599.47	545.53	254.12	239.05	409.54	572.50	246.59	426.80	392.29	345.61	116.84	4.60
	12/31/99	601.54	548.45	255.38	239.17	411.14	575.00	247.28	428.46	393.81	346.96	117.49	4.62
	03/31/00	610.32	554.87	262.08	243.60	417.72	582.59	252.84	436.20	399.23	352.51	118.22	4.93
	06/30/00	616.94	539.60	260.98	238.93	414.11	578.27	249.96	438.96	389.26	349.47	117.70	6.63
	09/30/00	625.63	400.76	255.58	232.18	378.54	513.19	243.88	440.61	316.47	319.45	96.55	16.56
	01/13/01	632.37	566.69	264.44	235.84	424.83	599.53	250.14	448.40	401.26	358.52	125.26	6.29
	04/20/01	632.58	561.53	268.38	236.21	424.67	597.05	252.29	450.48	398.87	358.38	123.60	6.88
	07/10/01	639.68	569.29	264.64	234.54	427.04	604.49	249.59	452.16	401.91	360.38	127.23	6.70
	10/09/01	646.51	576.52	259.81	232.14	428.74	611.51	245.97	453.16	404.33	361.82	131.05	6.51
	01/09/02	650.89	576.84	259.68	230.92	429.59	613.87	245.30	455.29	403.88	362.53	132.14	6.86
	04/12/02	650.12	570.1	264.192	232.55	429.24	610.11	248.37	457.16	401.33	362.24	129.69	7.45
	07/19/02	653.45	572.46	260.90	226.38	428.30	612.96	243.64	457.18	399.42	361.44	132.40	7.71
	10/08/02	659.69	581.14	254.65	222.68	429.54	620.41	238.66	457.17	401.91	362.49	136.86	7.37
	01/08/03	657.76	576.89	257.57	224.47	429.17	617.32	241.02	457.67	400.68	362.18	134.91	7.60
	04/15/03	661.78	576.19	262.16	228.04	432.04	618.99	245.10	461.97	402.12	364.60	134.04	7.98
	06/01/03	661.37	572.66	264.07	227.59	431.43	617.02	245.83	462.72	400.13	364.08	133.07	8.35
	08/07/03	665.76	577.29	258.18	222.76	431.00	621.53	240.47	461.97	400.03	363.72	136.61	8.26
	10/07/03	669.26	582.73	256.11	222.56	432.66	625.99	239.33	462.68	402.65	365.13	138.62	8.01
	12/31/03	670.27	581.39	262.53	229.62	435.95	625.83	246.08	466.40	405.51	367.90	136.15	8.12
	04/13/04	669.42	576.64	266.47	232.35	436.22	623.03	249.41	467.94	404.49	368.12	133.95	8.46
	07/13/04	672.95	578.63	261.80	224.79	434.54	625.79	243.29	467.37	401.71	366.71	137.13	8.76
	10/08/04	677.95	587.12	255.42	222.31	435.70	632.53	238.87	466.68	404.72	367.69	141.14	8.27
	01/07/05	677.50	586.02	257.61	226.05	436.80	631.76	241.83	467.56	406.04	368.61	139.80	8.21
	04/08/05	674.17	580.83	263.14	227.80	436.48	627.50	245.47	468.65	404.31	368.35	136.96	8.58
	07/18/05	677.87	580.70	259.40	221.74	434.93	629.29	240.57	468.63	401.22	367.04	139.36	8.99
	08/26/05	679.25	583.30	256.27	219.43	434.56	631.28	237.85	467.76	401.37	366.73	141.05	8.86
	11/12/05	679.13	583.14	256.88	220.08	434.81	631.13	238.48	468.00	401.61	366.93	140.77	8.86
	01/10/06	679.45	587.32	257.33	223.00	436.78	633.39	240.17	468.39	405.16	368.60	140.97	8.43
	04/09/06	679.57	583.14	263.01	226.46	438.05	631.36	244.74	471.29	404.80	369.67	138.61	8.87

Table 4 Driven Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
19	07/01/99	566.97	586.00	298.00	228.9	419.97	576.49	263.45	432.49	407.45	354.41	112.23	3.34
	07/15/99	580.00	597.00	294.00	224	423.75	588.50	259.00	437.00	410.50	357.60	118.13	3.54
	07/31/00	588.71	606.46	291.38	218.62	426.29	597.59	255.00	440.05	412.54	359.75	122.82	3.67
	08/15/99	591.02	607.35	300.95	227.92	431.81	599.19	264.44	445.99	417.64	364.40	120.01	3.78
	08/30/99	595.94	613.52	300.59	229.63	434.92	604.73	265.11	448.27	421.58	367.03	121.76	3.56
	09/15/99	599.88	617.91	300.67	229.54	437.00	608.90	265.11	450.28	423.73	368.78	123.25	3.54
	09/30/99	603.53	621.65	302.70	229.75	439.41	612.59	266.23	453.12	425.70	370.82	124.18	3.66
	10/15/99	607.51	625.02	302.29	229.71	441.13	616.27	266.00	454.90	427.37	372.27	125.57	3.67
	10/31/99	611.37	627.25	306.07	229.7	443.60	619.31	267.89	458.72	428.48	374.35	125.99	4.03
	11/15/99	613.61	627.78	308.31	232.67	445.59	620.70	270.49	460.96	430.23	376.04	125.55	4.10
	11/30/99	616.29	630.54	313.83	234.7	448.84	623.42	274.27	465.06	432.62	378.78	125.17	4.33
	12/15/99	617.83	631.44	314.03	234.9	449.55	624.64	274.47	465.93	433.17	379.38	125.54	4.37
	12/31/99	619.94	634.20	314.36	236.45	451.24	627.07	275.41	467.15	435.33	380.80	126.08	4.25
	03/31/00	629.45	639.44	320.33	239.74	457.24	634.44	280.03	474.89	439.59	385.86	127.06	4.71
	06/30/00	636.15	643.50	317.81	51.91	412.34	639.83	184.86	476.98	347.71	347.98	163.11	17.25
	09/30/00	646.59	651.99	312.33	231.29	460.55	649.29	271.81	479.46	441.64	388.66	135.33	5.04
	01/13/01	653.45	657.07	320.21	236.77	466.88	655.26	278.49	486.83	446.92	394.00	135.08	5.32
	04/20/01	651.46	653.21	324.03	237.42	466.53	652.34	280.72	487.74	445.32	393.71	133.23	5.66
	07/10/01	658.86	661.17	320.61	235.03	468.92	660.01	277.82	489.74	448.10	395.72	137.02	5.55
	10/09/01	667.35	669.26	315.37	230.97	470.74	668.30	273.17	491.36	450.11	397.25	141.66	5.50
	01/09/02	670.88	671.77	315.66	229.71	472.00	671.33	272.68	493.27	450.74	398.32	142.92	5.67
	04/12/02	667.71	665.64	321.06	231.62	471.51	666.68	276.34	494.39	448.63	397.90	139.94	6.10
	07/19/02	673.44	667.87	319.88	227.72	472.23	670.66	273.80	496.66	447.79	398.51	142.28	6.52
	10/08/02	681.93	676.18	313.24	222.91	473.56	679.05	268.07	497.58	449.54	399.64	147.34	6.41
	01/08/03	682.42	673.60	316.88	225.03	474.48	678.01	270.96	499.65	449.32	400.42	145.93	6.71
	04/15/03	686.11	672.95	321.26	228.37	477.17	679.53	274.81	503.69	450.66	402.69	145.10	7.07
	06/01/03	685.30	670.80	322.48	227.84	476.60	678.05	275.16	503.89	449.32	402.21	144.44	7.28
	08/07/03	689.12	675.35	317.28	223.09	476.21	682.23	270.18	503.20	449.22	401.87	147.72	7.20
	10/07/03	694.48	681.03	314.64	222.27	478.11	687.76	268.46	504.56	451.65	403.47	150.32	7.06
	12/31/03	695.94	680.95	322.73	229.34	482.24	688.45	276.03	509.33	455.15	406.96	147.86	7.23
	04/13/04	695.62	676.77	330.77	231.41	483.64	686.19	281.09	513.19	454.09	408.15	145.23	7.88
	07/13/04	700.37	679.61	327.88	224.22	483.02	689.99	276.05	514.13	451.92	407.62	148.40	8.30
	10/08/04	706.18	688.67	321.87	221.22	484.48	697.43	271.54	514.03	454.94	408.86	152.68	7.88
	01/07/05	705.37	688.14	324.72	224.55	485.69	696.75	274.63	515.04	456.35	409.88	151.34	7.83
	04/08/05	702.85	682.86	329.75	226.66	485.53	692.86	278.21	516.30	454.76	409.74	148.66	8.21
	07/18/05	706.50	683.55	327.15	219.55	484.19	695.03	273.35	516.83	451.55	408.61	151.18	8.71
	08/26/05	708.05	686.48	322.81	217.89	483.80	697.26	270.35	515.43	452.18	408.28	153.05	8.44
	11/12/05	707.97	686.27	323.74	218.33	484.08	697.12	271.04	515.85	452.30	408.51	152.76	8.48
	01/10/06	710.04	690.54	324.68	221.62	486.72	700.29	273.15	517.36	456.08	410.74	153.13	8.17
	04/09/06	709.47	686.72	329.75	224.34	487.57	698.10	277.05	519.61	455.53	411.46	150.95	8.55

Table 4 Driven Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
34	07/01/99	271.75	436.00	261.00	583.00	387.94	353.88	422.00	266.38	509.50	327.38	-24.42	-32.43
	07/15/99	279.00	617.00	253.00	583.00	433.00	448.00	418.00	266.00	600.00	365.41	10.76	-44.56
	07/31/00	282.79	647.00	243.64	585.13	439.64	464.90	414.39	263.22	616.07	371.01	18.11	-47.07
	08/15/99	272.89	690.09	251.16	614.66	457.20	481.49	432.91	262.03	652.38	385.83	17.42	-52.07
	08/30/99	265.66	576.80	245.14	627.09	428.67	421.23	436.12	255.40	601.95	361.76	-5.34	-46.23
	09/15/99	265.08	802.81	242.34	635.26	486.37	533.95	438.80	253.71	719.04	410.45	34.11	-62.07
	09/30/99	260.50	807.40	238.64	642.65	487.30	533.95	440.65	249.57	725.03	411.23	33.45	-63.43
	10/15/99	256.43	811.14	234.46	648.58	487.65	533.79	441.52	245.45	729.86	411.53	33.08	-64.62
	10/31/99	240.47	824.02	221.62	665.31	487.86	532.25	443.47	231.05	744.67	411.70	31.83	-68.52
	11/15/99	241.93	831.45	224.75	676.77	493.73	536.69	450.76	233.34	754.11	416.65	30.81	-69.47
	11/30/99	240.47	835.88	224.26	648.85	487.37	538.18	436.56	232.37	742.37	411.29	36.43	-68.03
	12/15/99	241.41	836.77	222.35	684.04	496.14	539.09	453.20	231.88	760.41	418.69	30.79	-70.51
	12/31/99	242.22	836.08	224.14	684.93	496.84	539.15	454.54	233.18	760.51	419.29	30.34	-70.35
	03/31/00	257.37	828.85	237.38	675.92	499.88	543.11	456.65	247.38	752.38	421.85	31.00	-67.37
	06/30/00	266.43	846.32	225.20	500.93	459.72	556.37	363.06	245.81	673.62	387.96	69.30	-57.07
	09/30/00	257.37	895.02	196.89	705.00	513.57	576.19	450.94	227.13	800.01	433.40	44.90	-76.42
	01/13/01	247.90	856.11	197.37	729.58	507.74	552.01	463.47	222.64	792.84	428.48	31.74	-76.07
	04/20/01	44.66	883.01	212.28	457.21	399.29	463.83	334.74	128.47	670.11	336.96	46.28	-72.25
	07/10/01	-279.94	502.86	204.24	66.21	123.34	111.46	135.22	-37.85	284.53	104.09	-8.52	-43.01
	10/09/01	442.16	725.37	50.98	1199.89	604.60	583.76	625.44	246.57	962.63	510.22	-14.94	-95.52
	01/09/02	263.63	616.73	159.27	765.05	451.17	440.18	462.16	211.45	690.89	380.74	-7.88	-63.96
	04/12/02	67.35	579.97	58.13	501.01	301.61	323.66	279.57	62.74	540.49	254.53	15.81	-63.73
	07/19/02	288.69	941.04	187.83	727.59	536.29	614.86	457.71	238.26	834.31	452.57	56.34	-79.51
	10/08/02	277.15	962.54	162.58	740.98	535.81	619.84	451.78	219.86	851.76	452.17	60.25	-84.29
	01/08/03	256.07	949.53	162.24	758.66	531.62	602.80	460.45	209.15	854.10	448.64	51.04	-86.04
	04/15/03	277.19	928.37	189.53	744.52	534.90	602.78	467.03	233.36	836.45	451.41	48.67	-80.45
	06/01/03	277.96	939.01	184.90	749.68	537.89	608.49	467.29	231.43	844.35	453.93	50.62	-81.76
	08/07/03	288.69	965.09	171.66	750.09	543.88	626.89	460.87	230.17	857.59	458.98	59.52	-83.70
	10/07/03	274.96	978.21	155.53	762.84	542.89	626.58	459.19	215.25	870.53	458.14	60.01	-87.41
	12/31/03	258.26	983.57	156.83	795.22	548.47	620.92	476.03	207.55	889.40	462.86	51.95	-90.96
	04/13/04	281.17	960.30	188.88	781.65	553.00	620.73	485.27	235.03	870.97	466.68	48.57	-84.84
	07/13/04	302.86	991.98	173.93	772.27	560.26	647.42	473.10	238.40	882.12	472.80	62.50	-85.87
	10/08/04	295.63	1004.49	151.19	786.40	559.43	650.06	468.80	223.41	895.45	472.10	64.99	-89.65
	01/07/05	277.35	997.91	148.79	798.02	555.52	637.63	473.41	213.07	897.97	468.80	58.88	-91.36
	04/08/05	286.74	978.21	166.99	788.76	555.17	632.47	477.87	226.86	883.49	468.51	55.43	-87.59
	07/18/05	304.00	1000.02	160.94	783.60	562.14	652.01	472.27	232.47	891.81	474.39	64.44	-87.96
	08/26/05	301.85	1018.4	147.73	791.81	564.94	660.12	469.77	224.79	905.09	476.76	68.24	-90.75
	11/12/05	300.51	1018.3	147.82	793.35	564.99	659.40	470.58	224.16	905.83	476.80	67.70	-90.93
	01/10/06	274.59	1009.4	138.15	808.34	557.62	642.00	473.24	206.37	908.87	470.58	60.50	-93.71
	04/09/06	283.04	986.09	160.45	798.02	556.90	634.57	479.23	221.74	892.06	469.97	55.69	-89.42

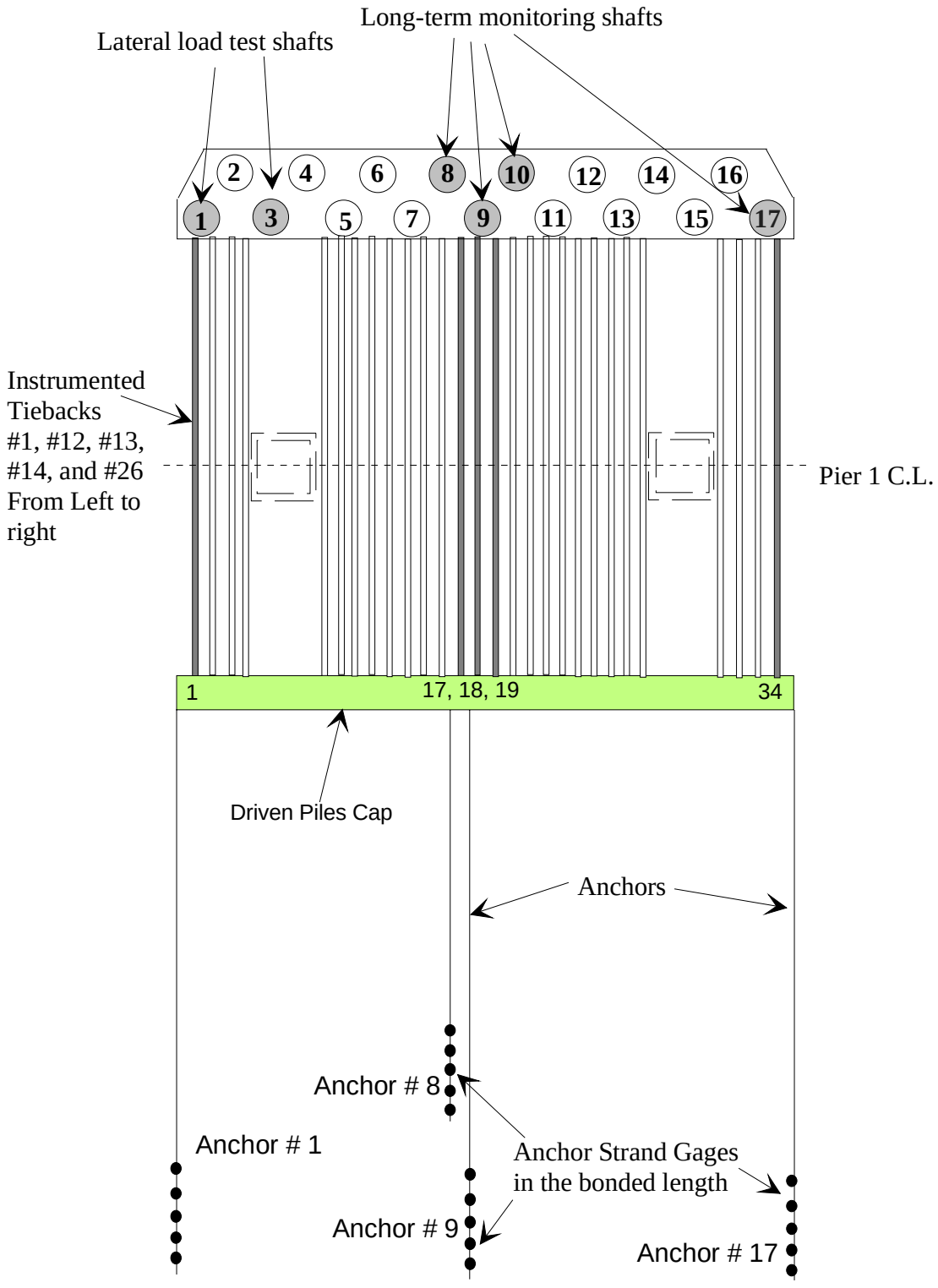


Fig.1 Plan view of the entire stabilization system and the locations of instrumented foundation elements.

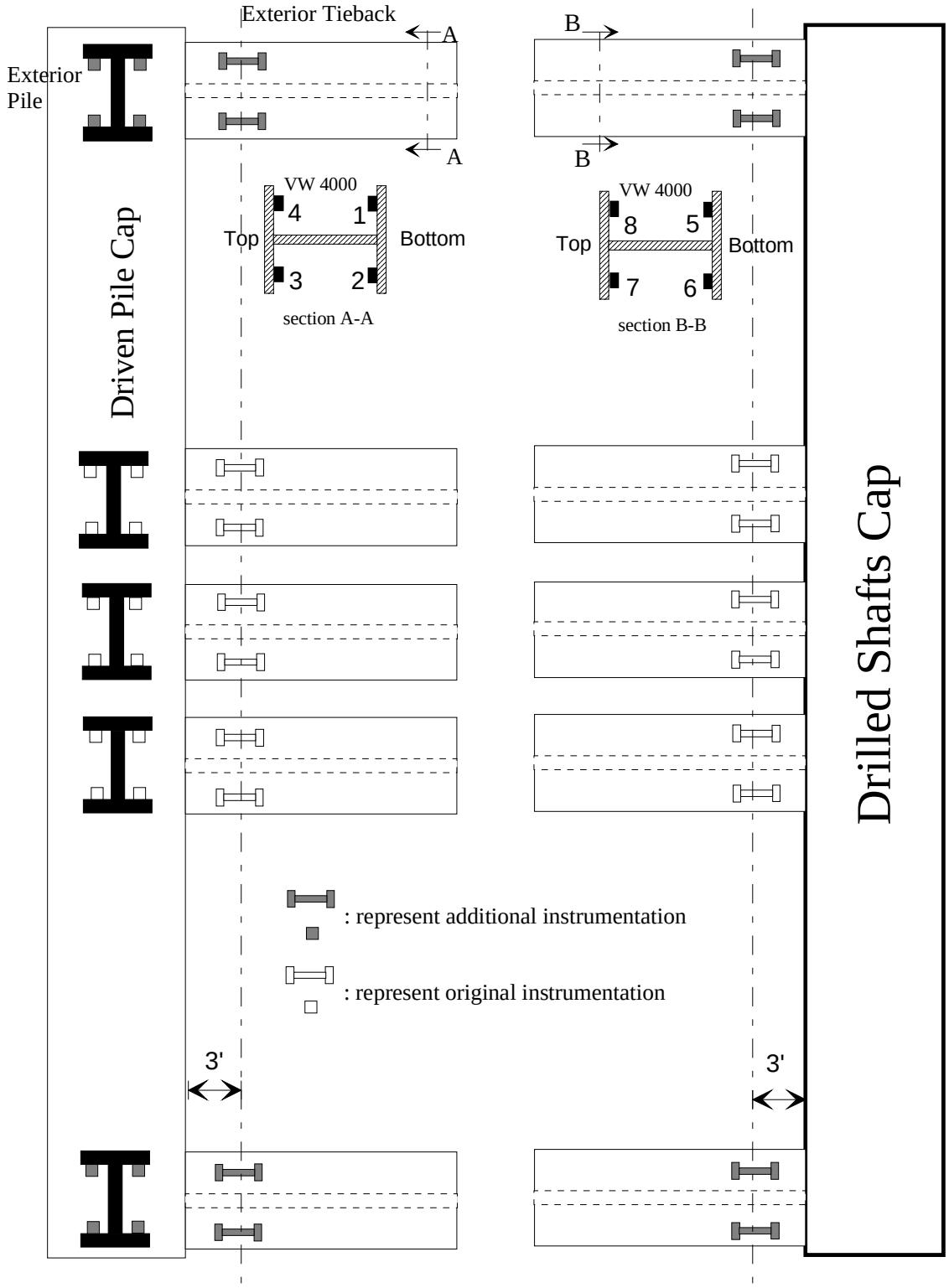


Fig. 2 Instrumentation of tie-beams for long term monitoring

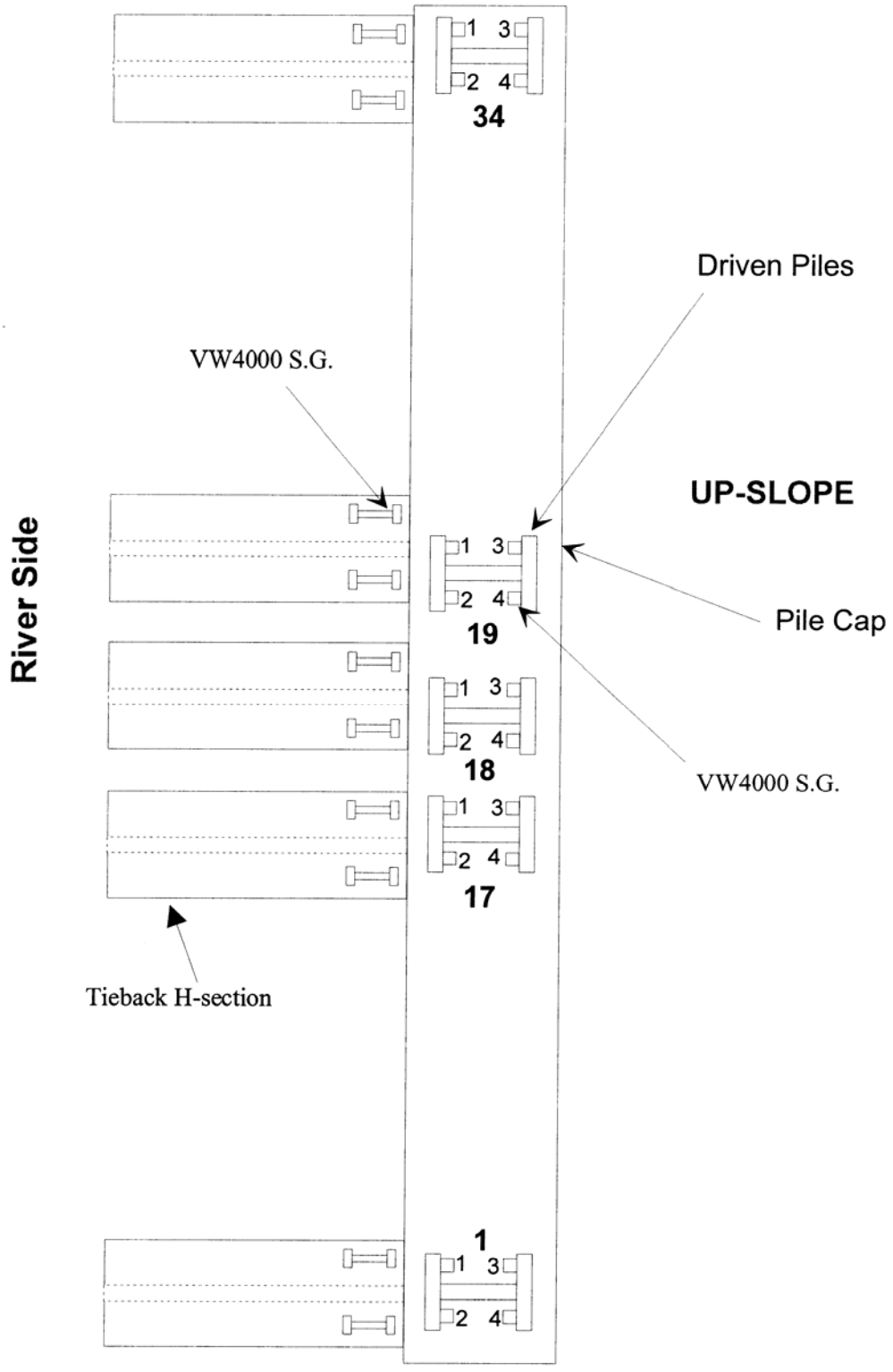


Fig.3 Schematic of gage locations on the driven piles.

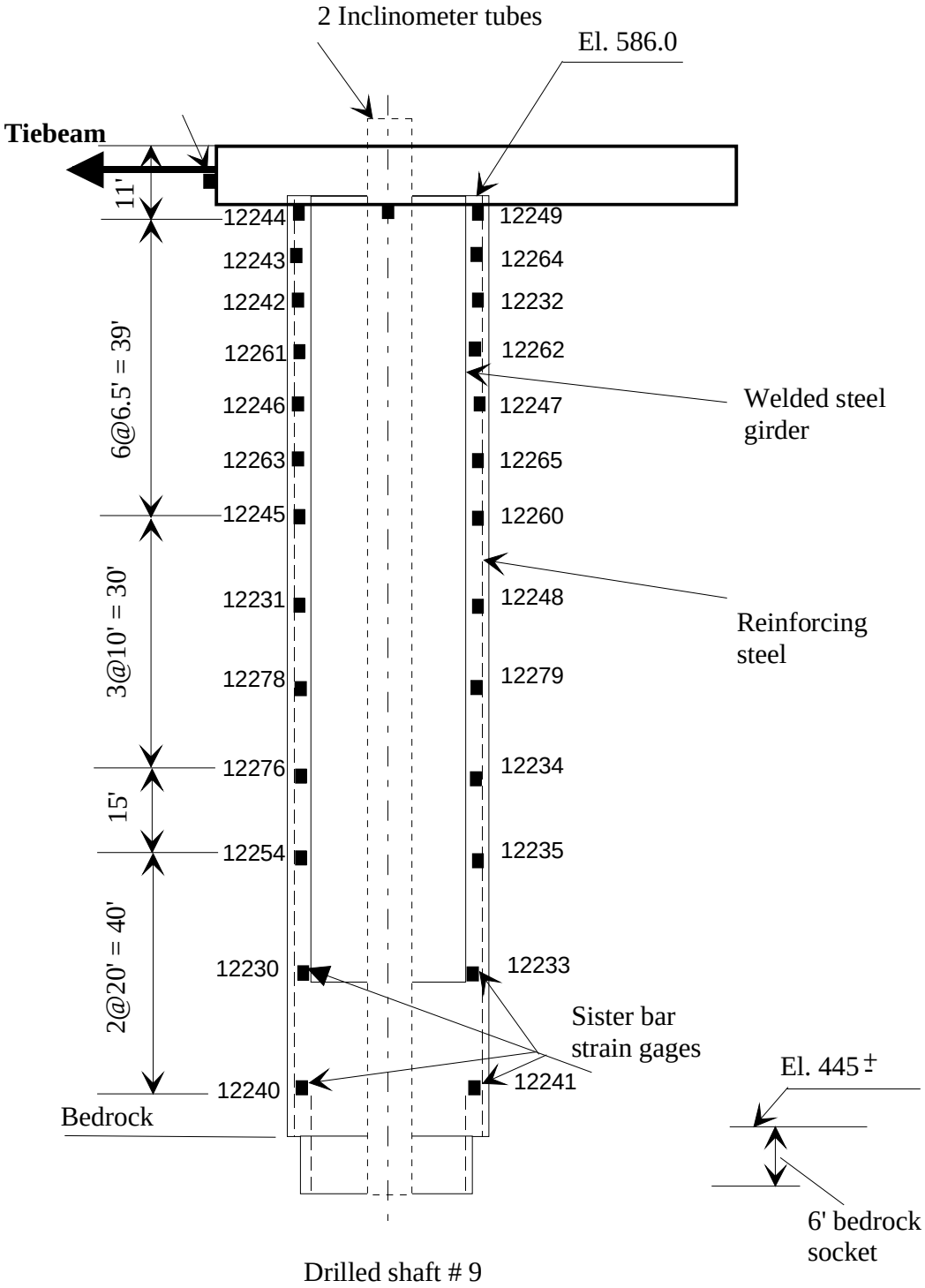


Fig.4 Location and designation of the strain gages in shaft # 9.

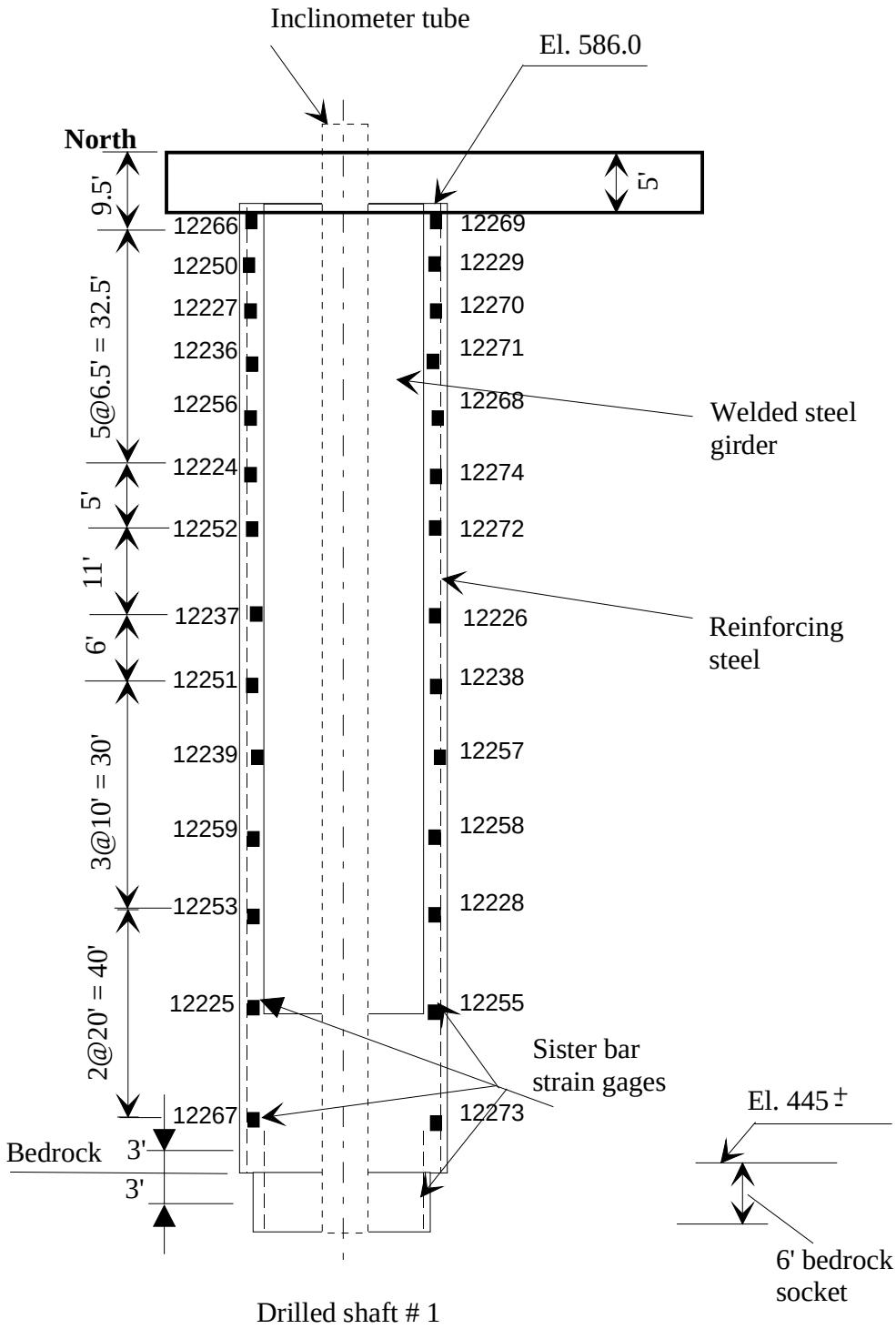


Fig.5: Locations and designations of the strain gages in shaft # 1.

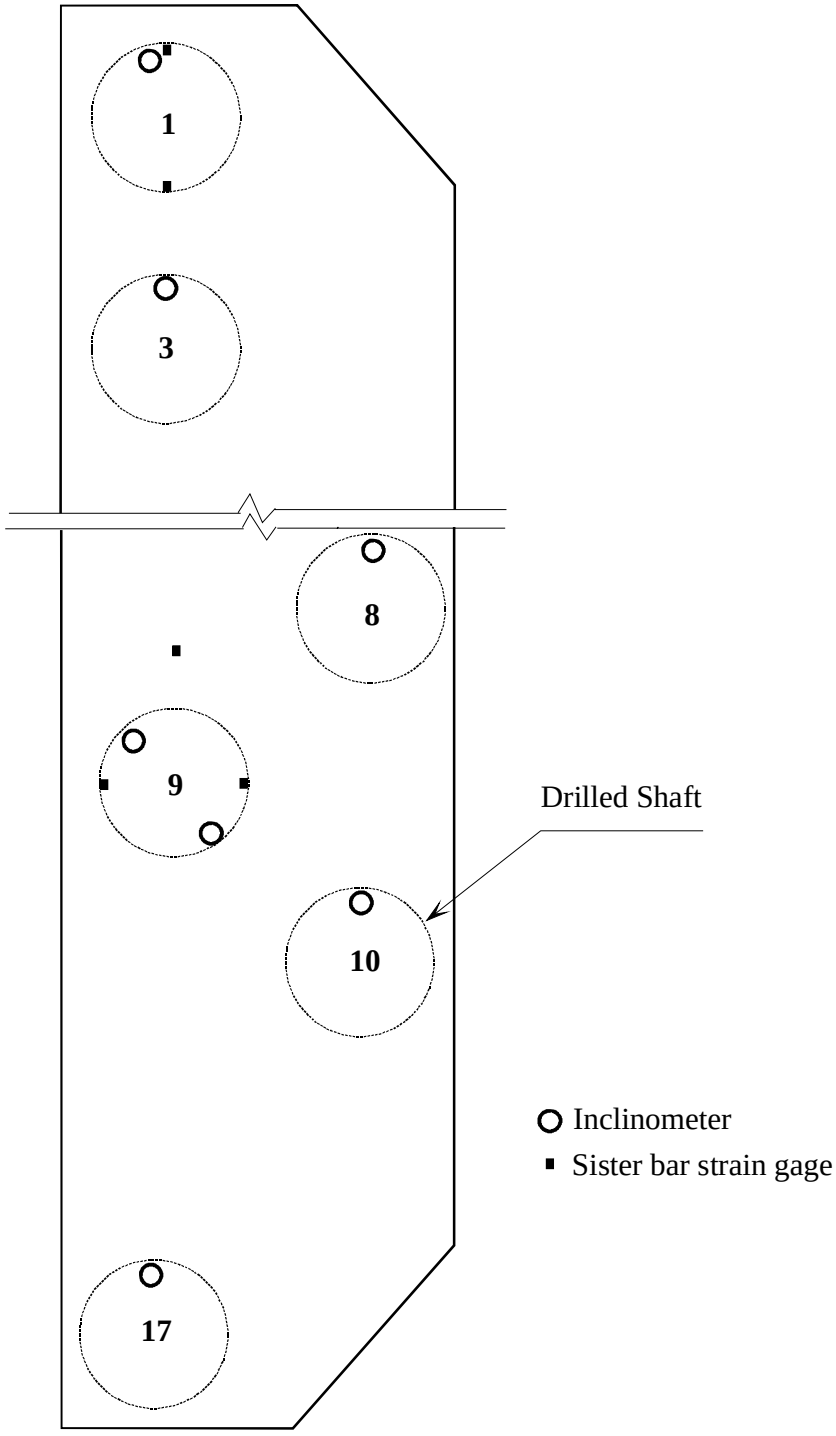


Fig. 6 Location of inclinometers in the drilled shaft cap

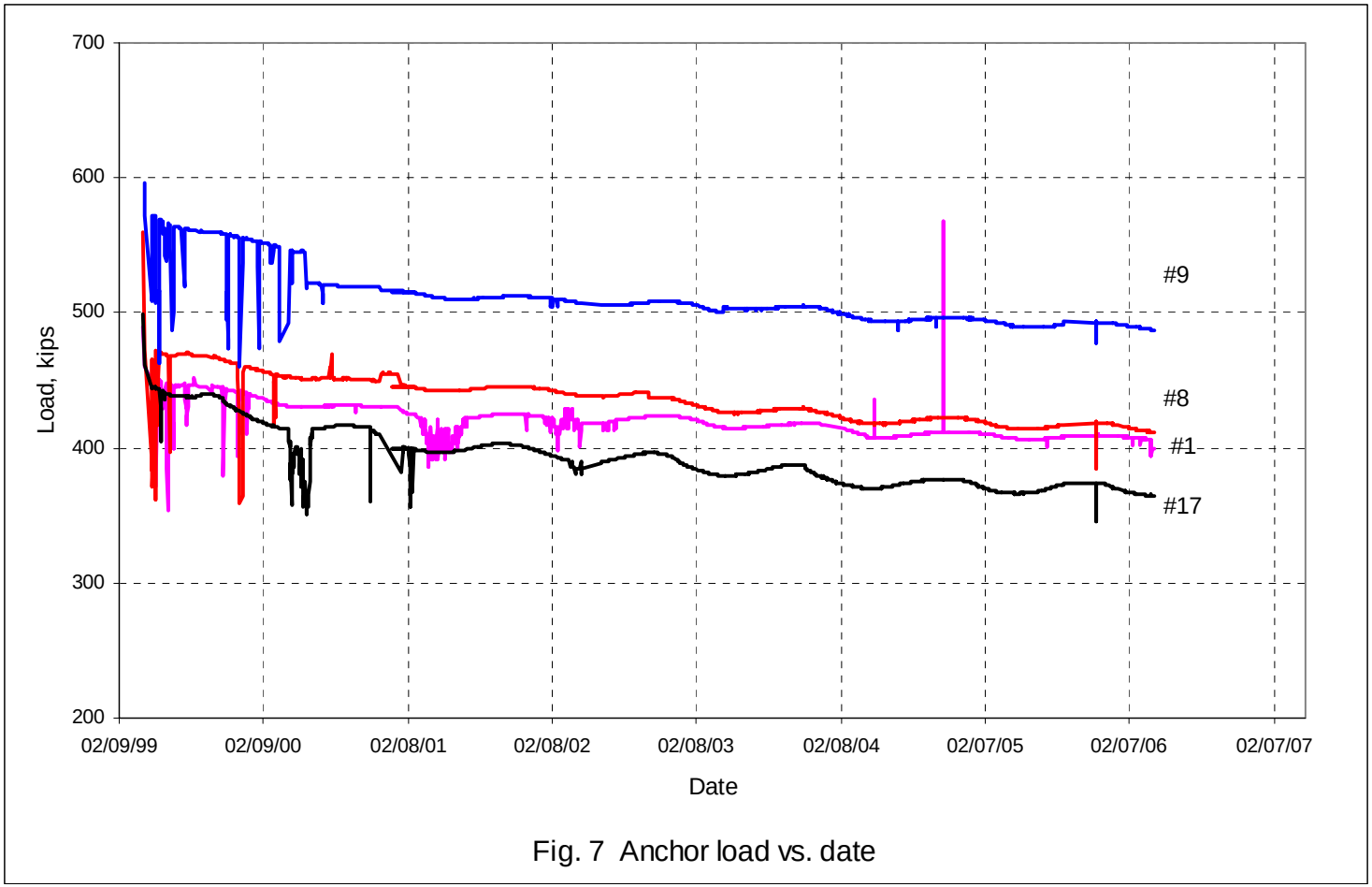


Fig. 7 Anchor load vs. date

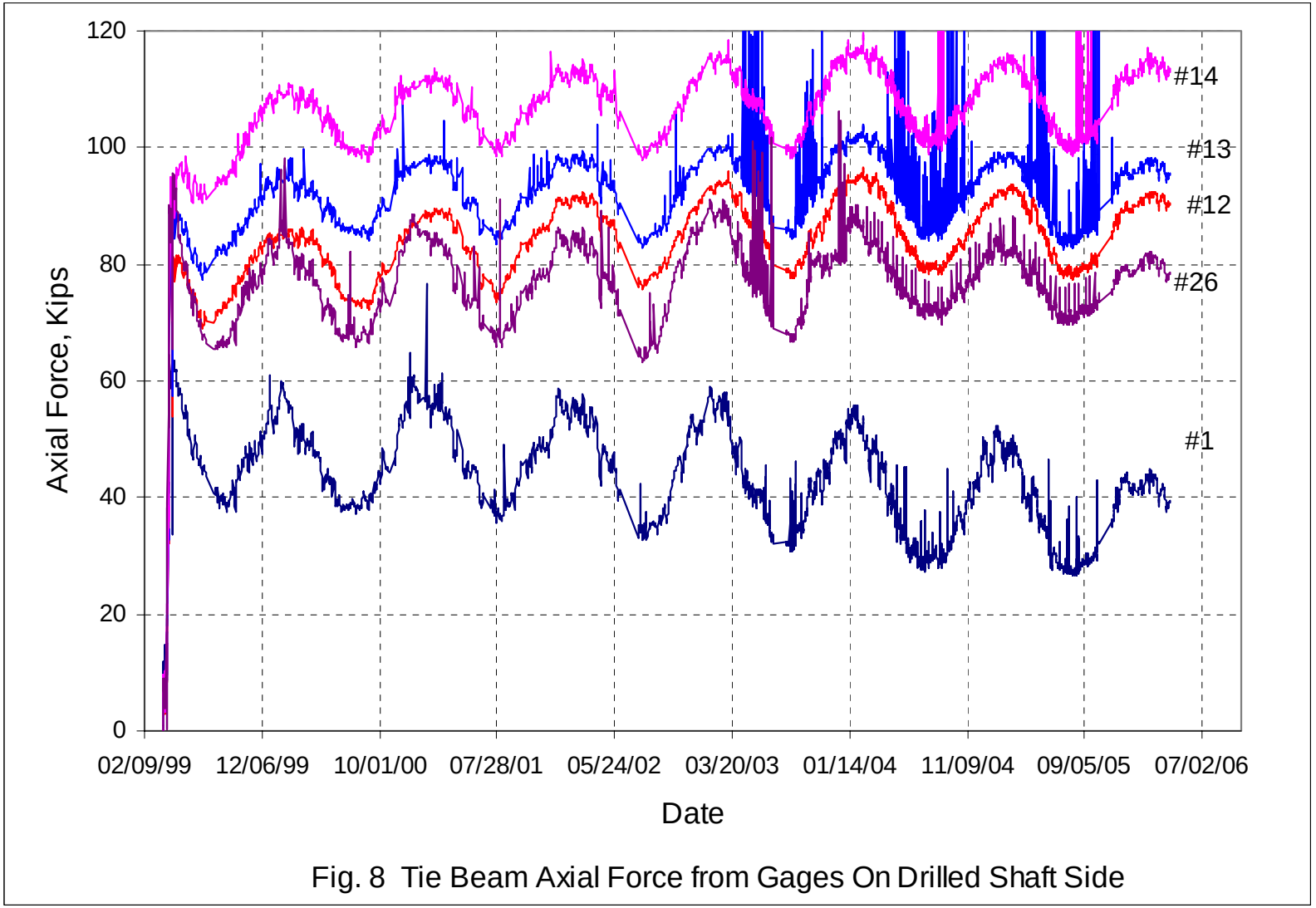


Fig. 8 Tie Beam Axial Force from Gages On Drilled Shaft Side

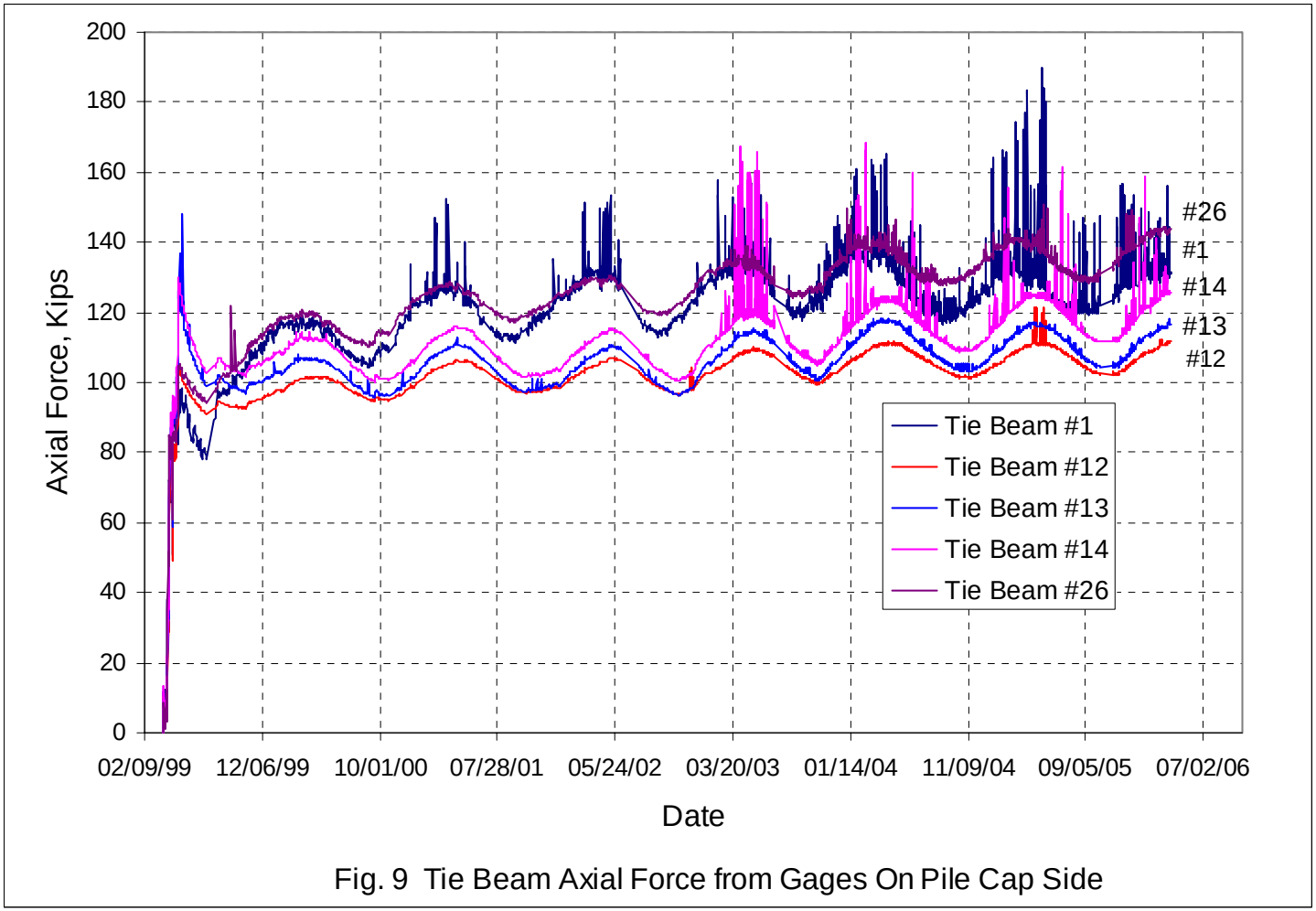


Fig. 9 Tie Beam Axial Force from Gages On Pile Cap Side

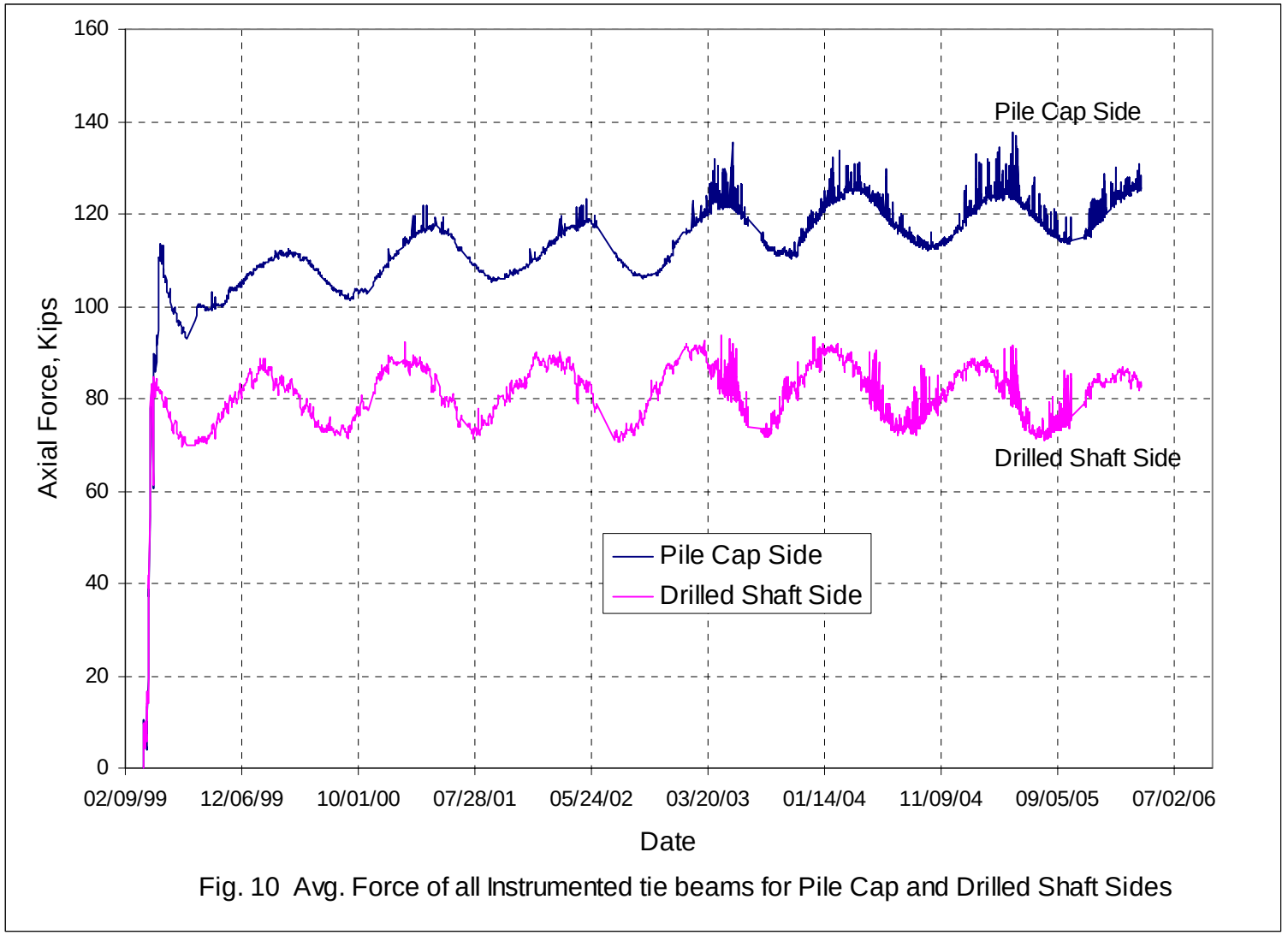


Fig. 10 Avg. Force of all Instrumented tie beams for Pile Cap and Drilled Shaft Sides

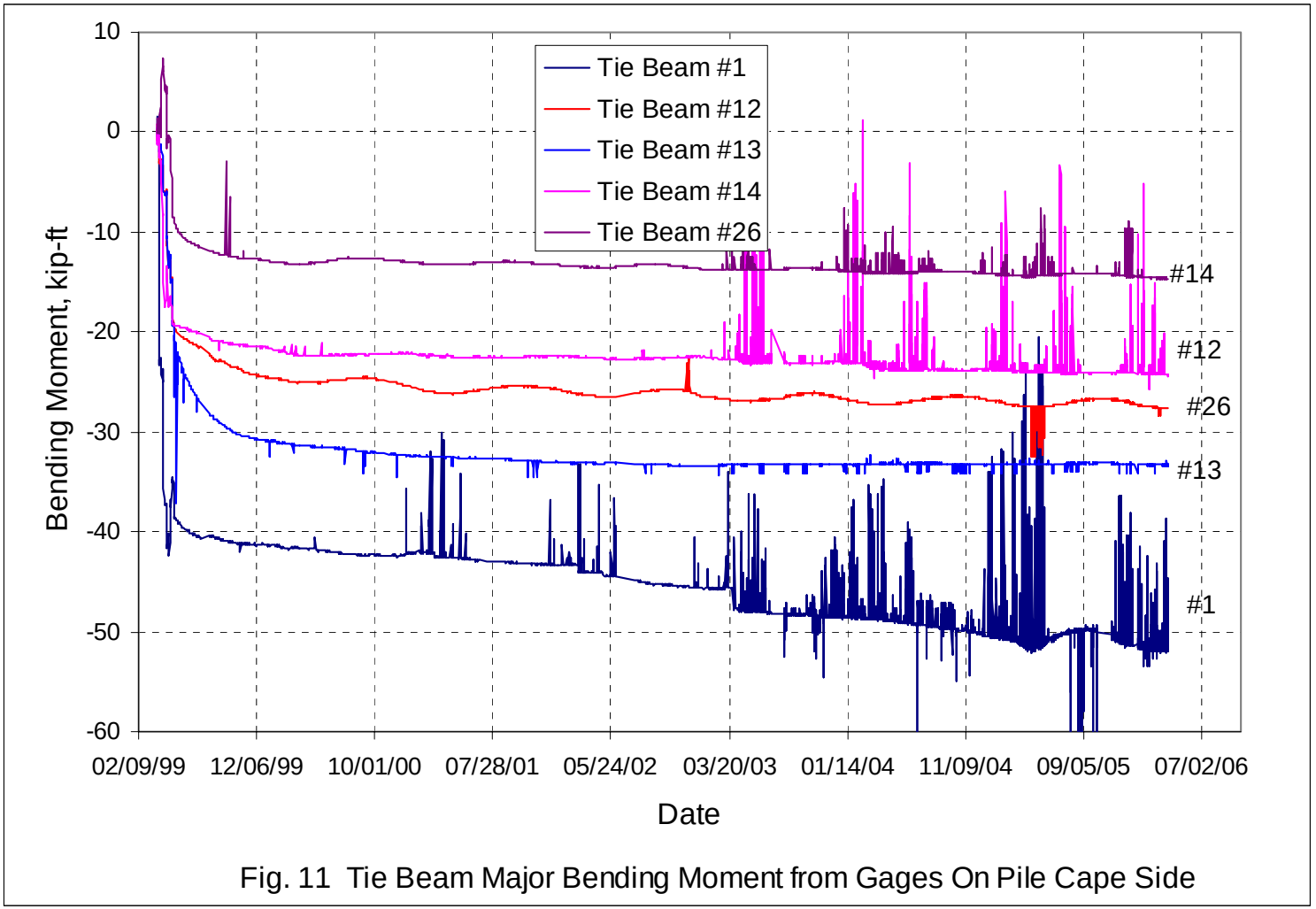


Fig. 11 Tie Beam Major Bending Moment from Gages On Pile Cape Side

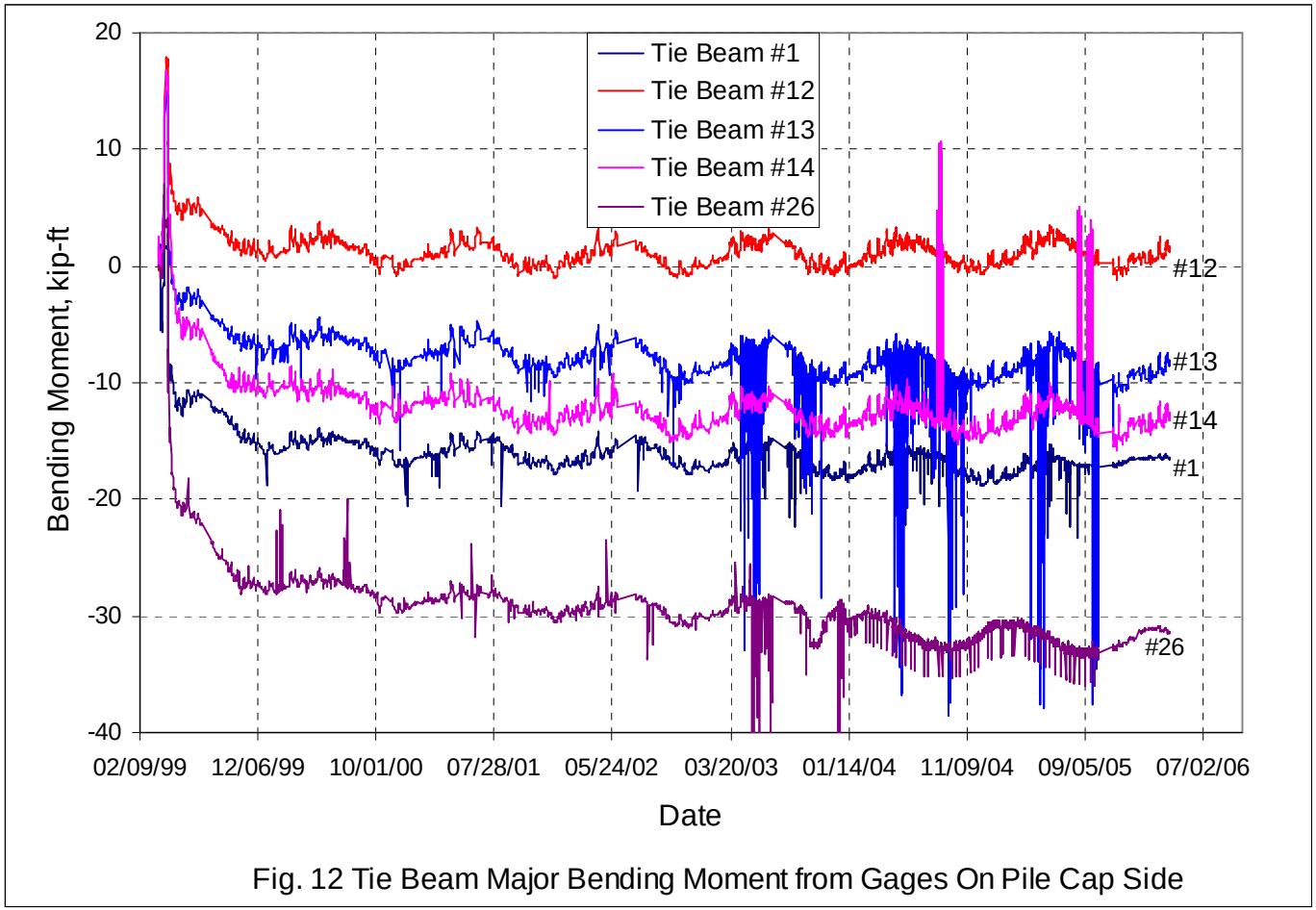


Fig. 12 Tie Beam Major Bending Moment from Gages On Pile Cap Side

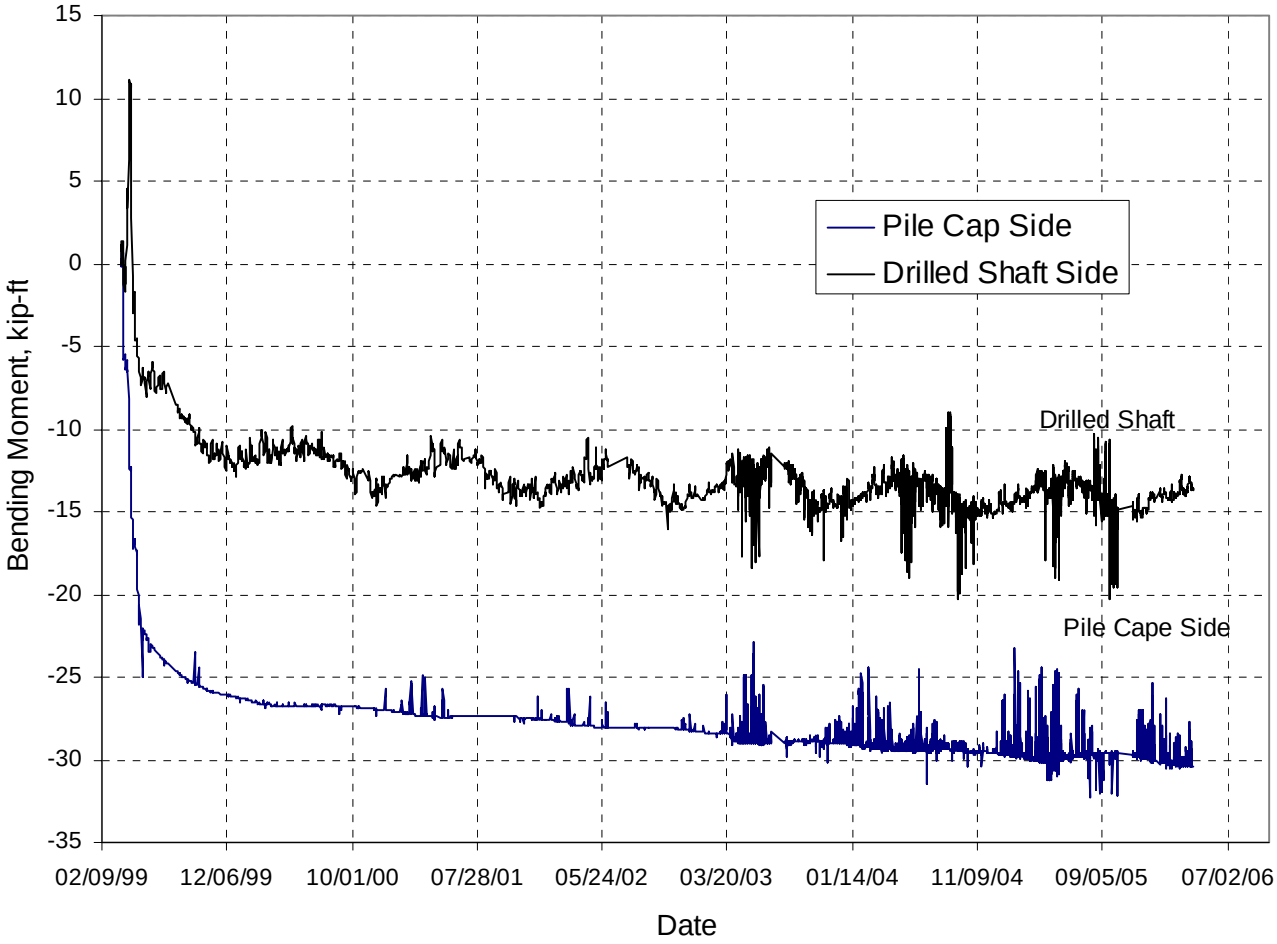


Fig. 13 Tie Beam Avg. Major Bending Moment From Gages for Pile Cap and Drilled Shaft Sides

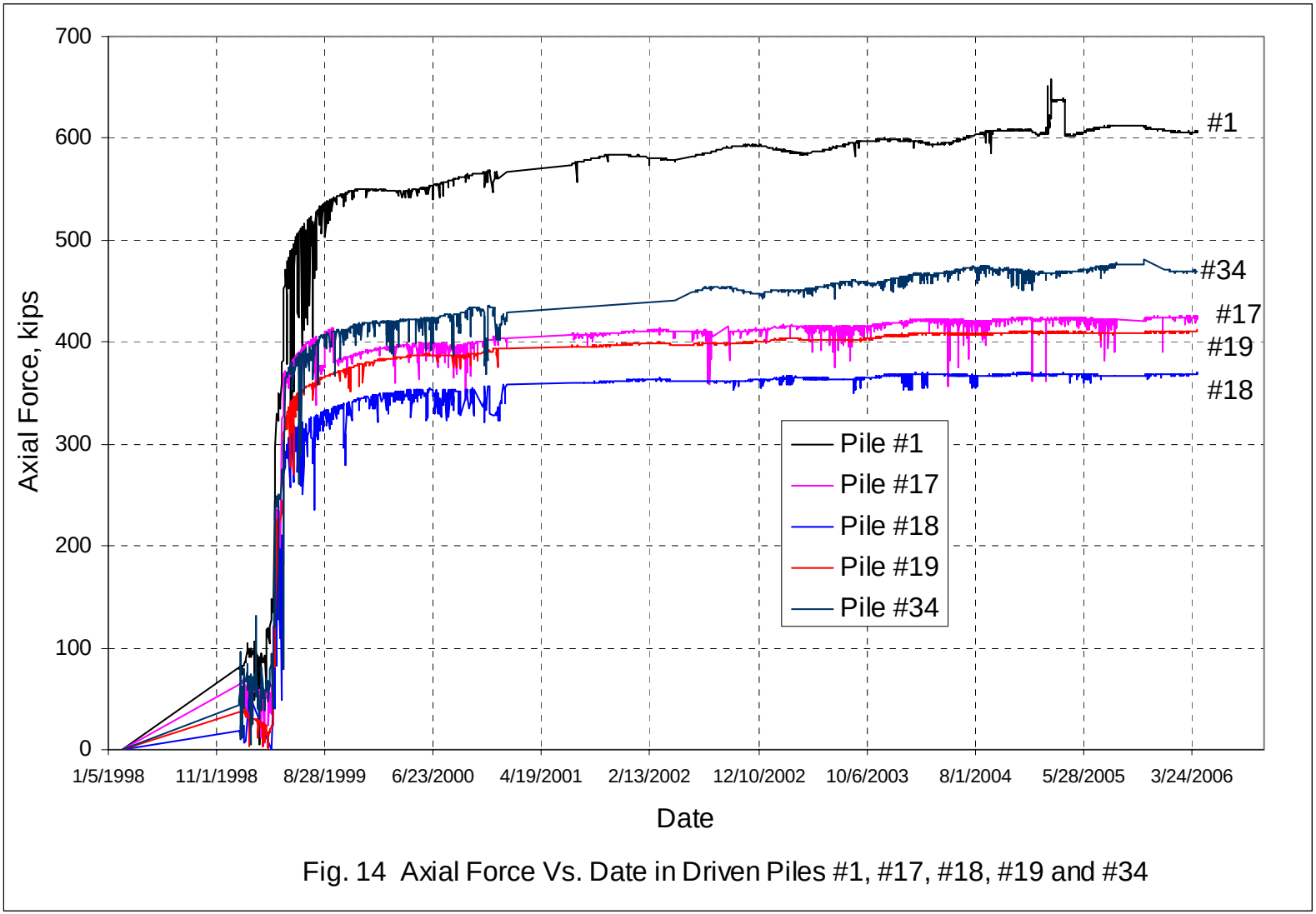


Fig. 14 Axial Force Vs. Date in Driven Piles #1, #17, #18, #19 and #34

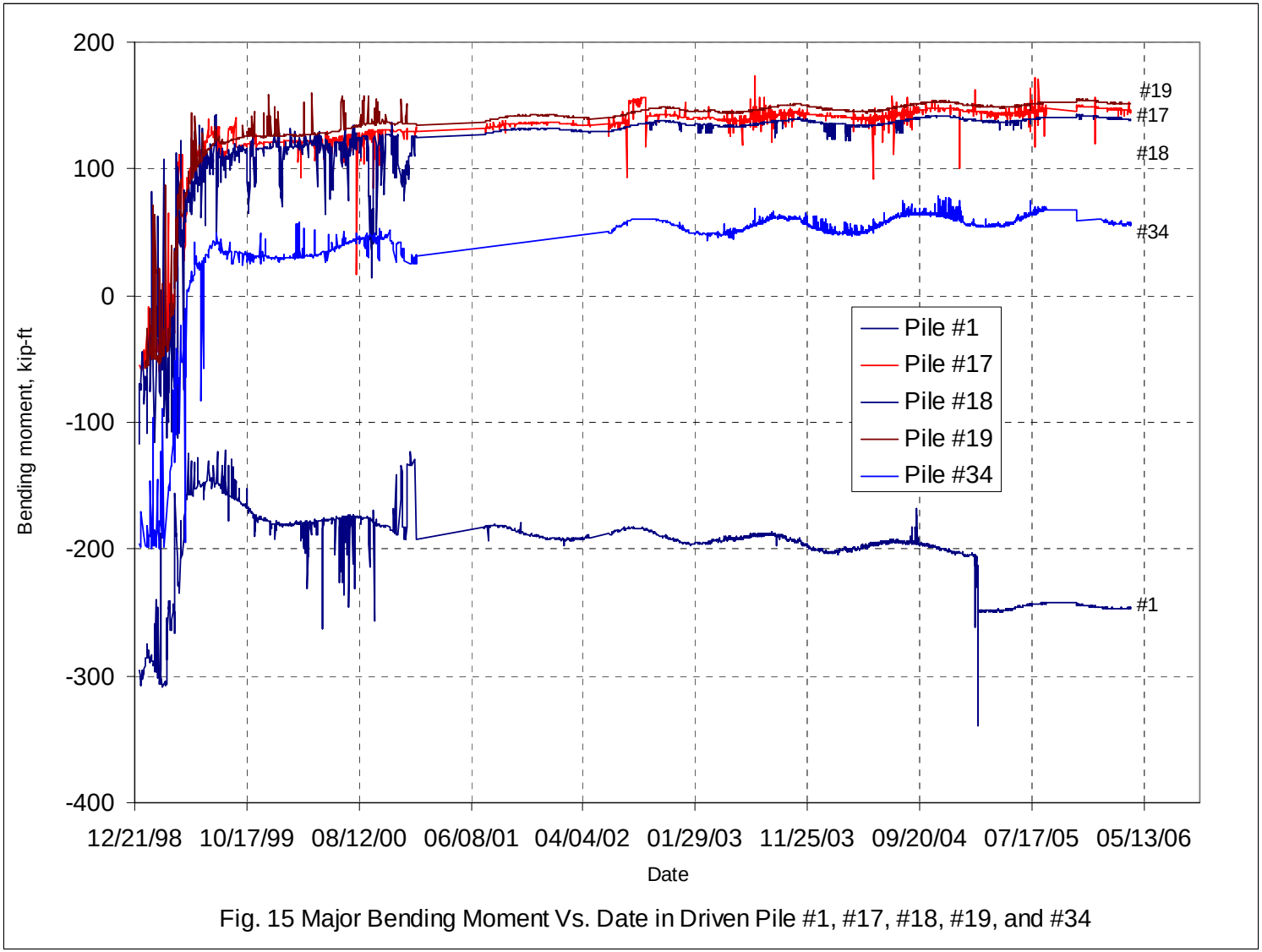


Fig. 15 Major Bending Moment Vs. Date in Driven Pile #1, #17, #18, #19, and #34

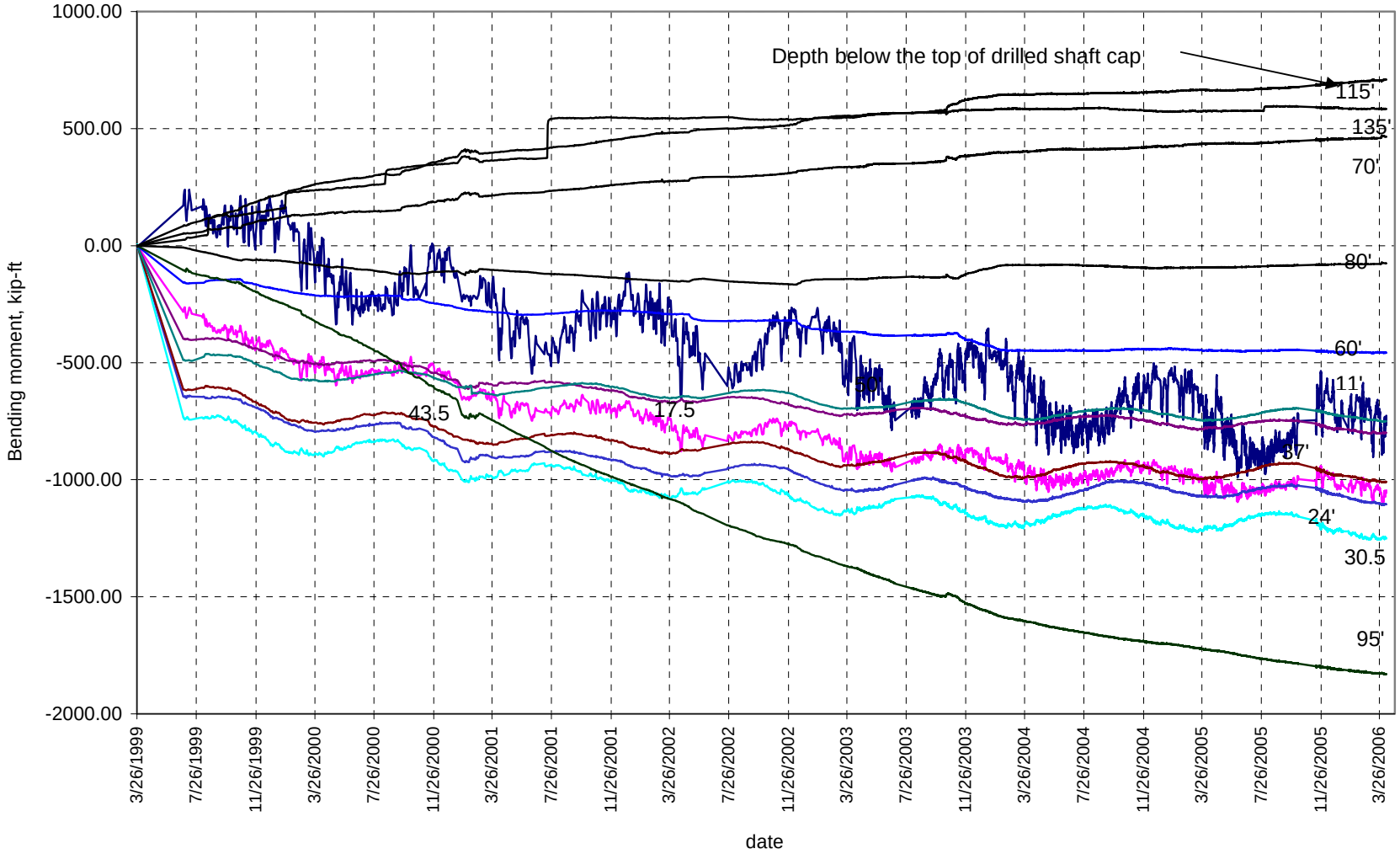


Fig. 16 Shaft #9, Bending moment vs. date in different elevations below the top of cap

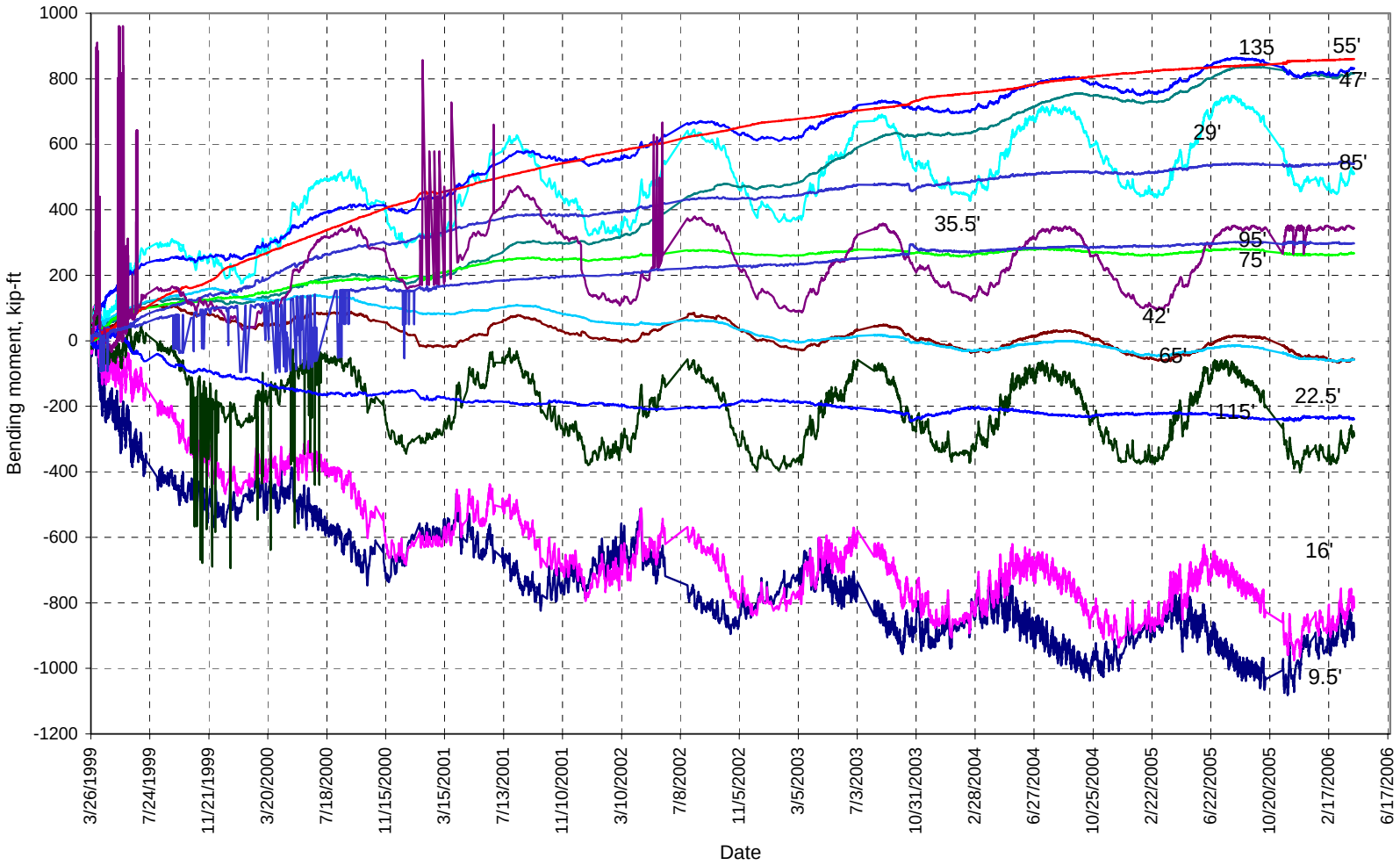
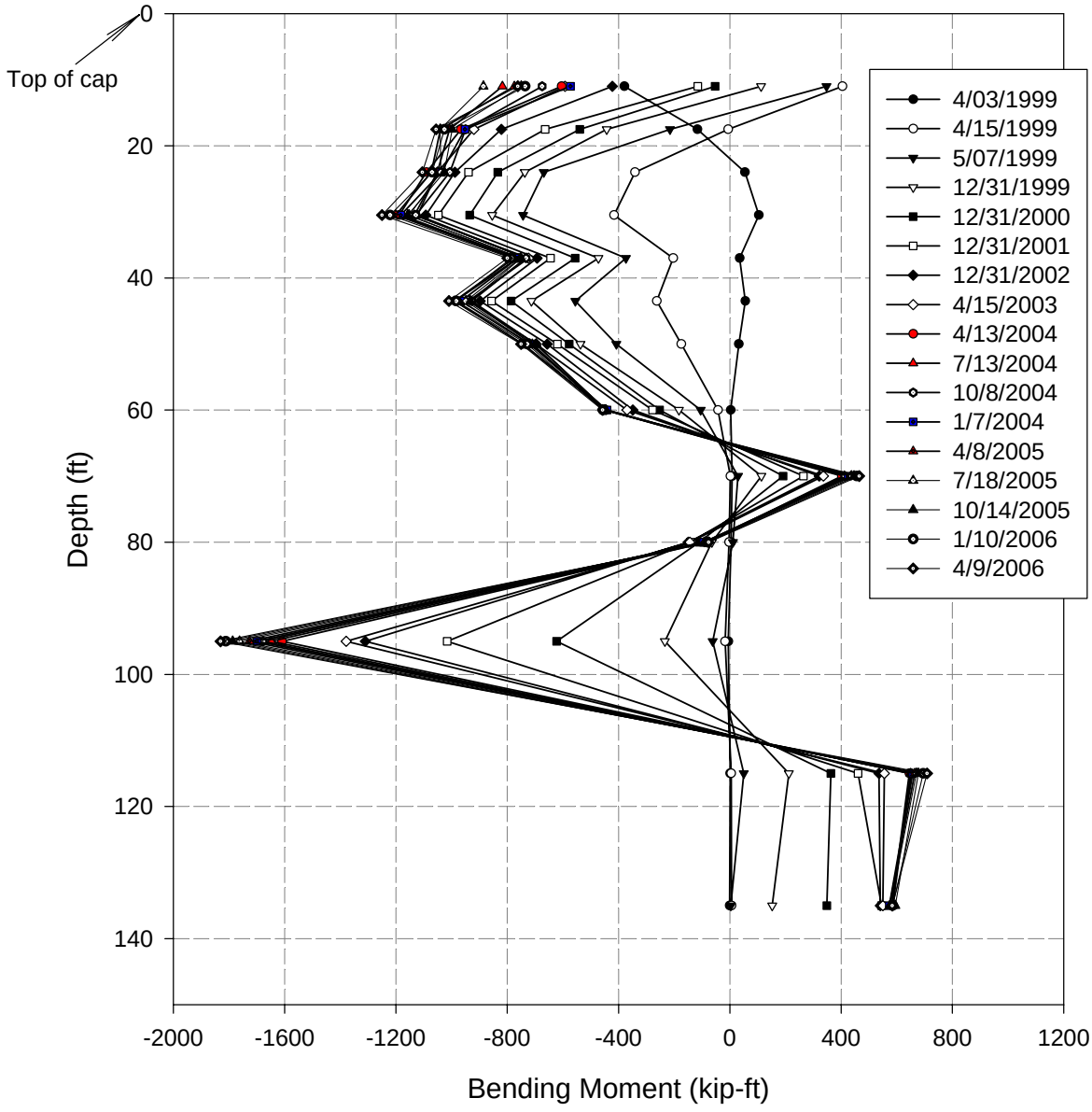
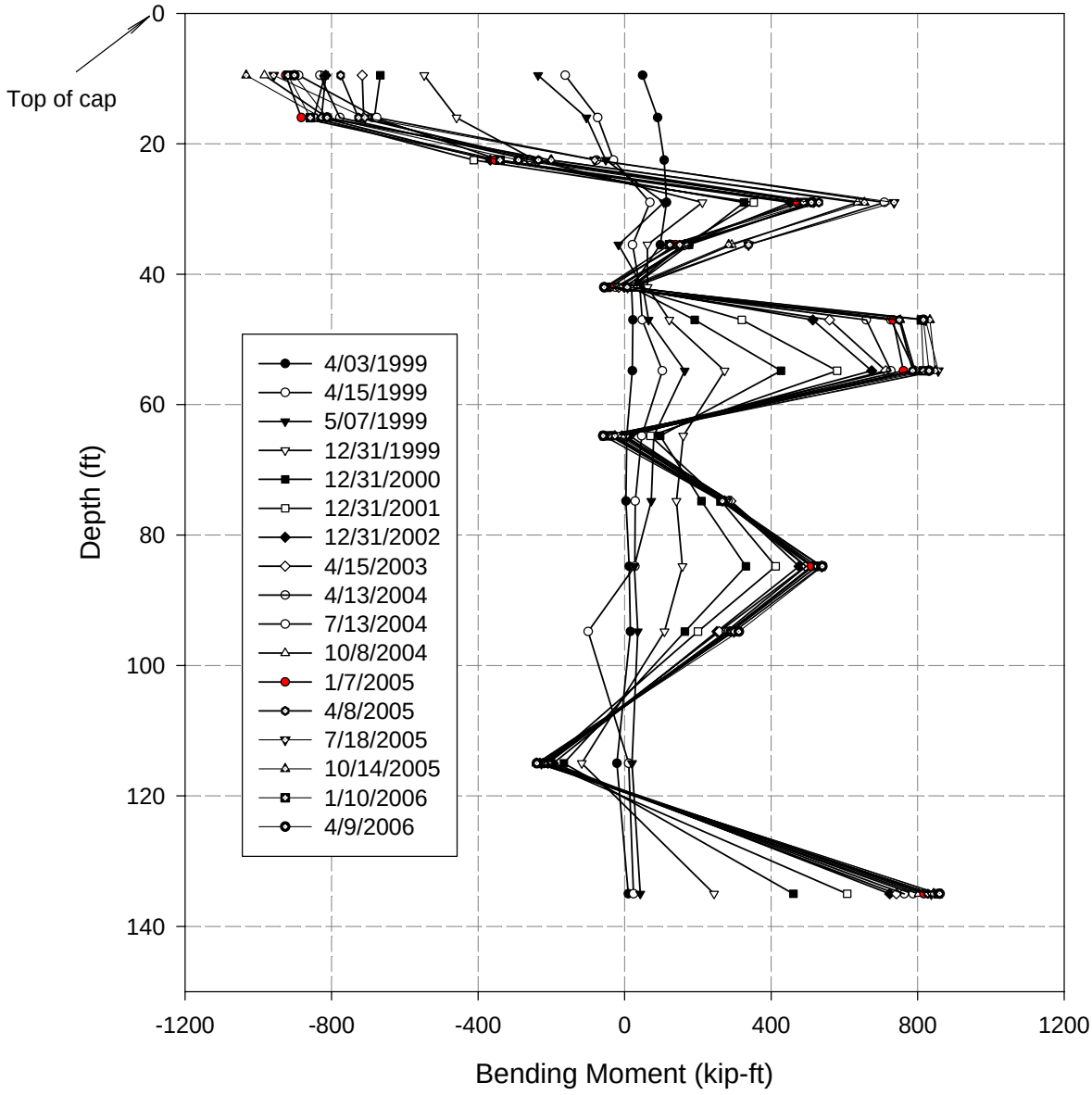


Fig. 17 Shaft #1, Bending moment vs. date in different elevations below the top of cap



4/03/99: before tensioning anchors; 4/14/99: after tensioning anchors;
4/23/99: start of backfilling; 5/07/99: construction was completed

Fig. 18 Shaft # 9, Bending Moment vs. depth



4/03/99: before tensioning anchors; 4/14/99: after tensioning anchors;
4/23/99: start of backfilling; 5/07/99: construction was completed

Fig. 19 Shaft # 1, Bending Moment vs. depth

Fig. 20 Inclinometer # 1 Displacement in the A + Direction
Downslope (River direction) Base Line Reading 1/13/1999

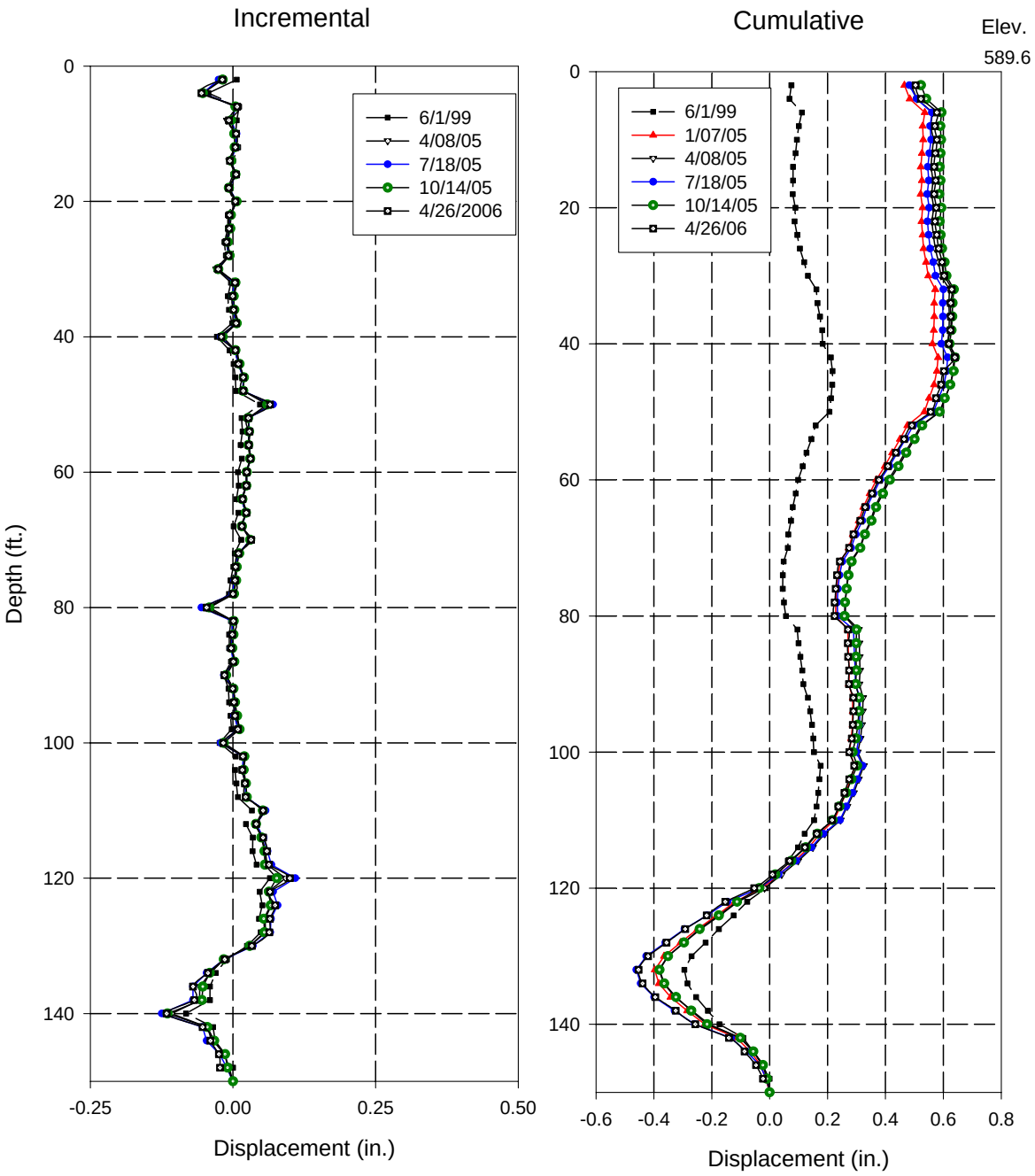


Fig. 21 Inclinometer # 3 Displacement in the A + Direction
Downslope (River direction) Base Line Reading 1/13/1999

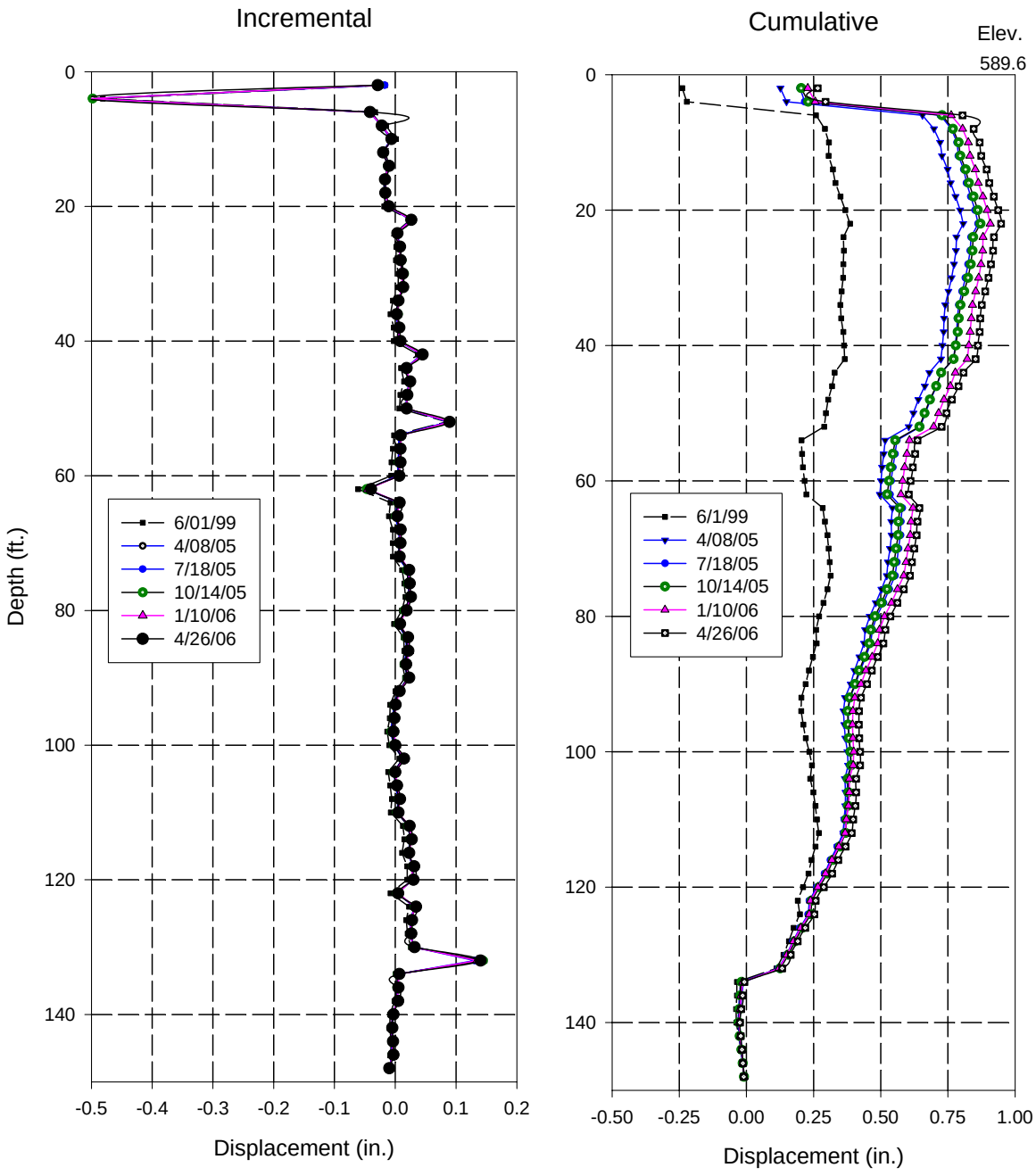


Fig. 22 Inclinometer # 8 Displacement in the A + Direction
Downslope (River direction) Base Line reading 12/11/1998

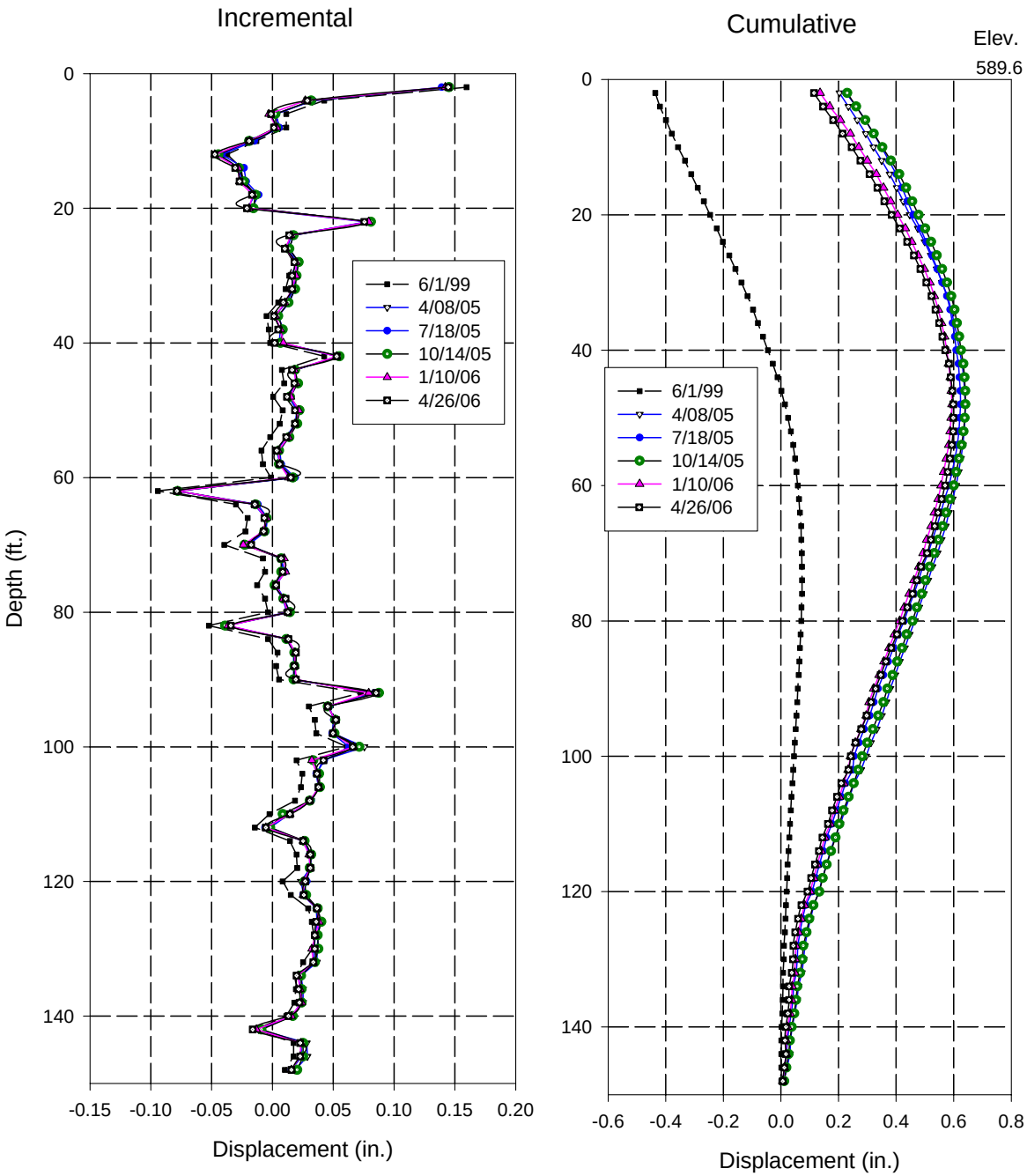


Fig. 23 Inclinometer # 9A Displacement in the A + Direction
Downslope (River direction) Base Line reading 12/11/1998

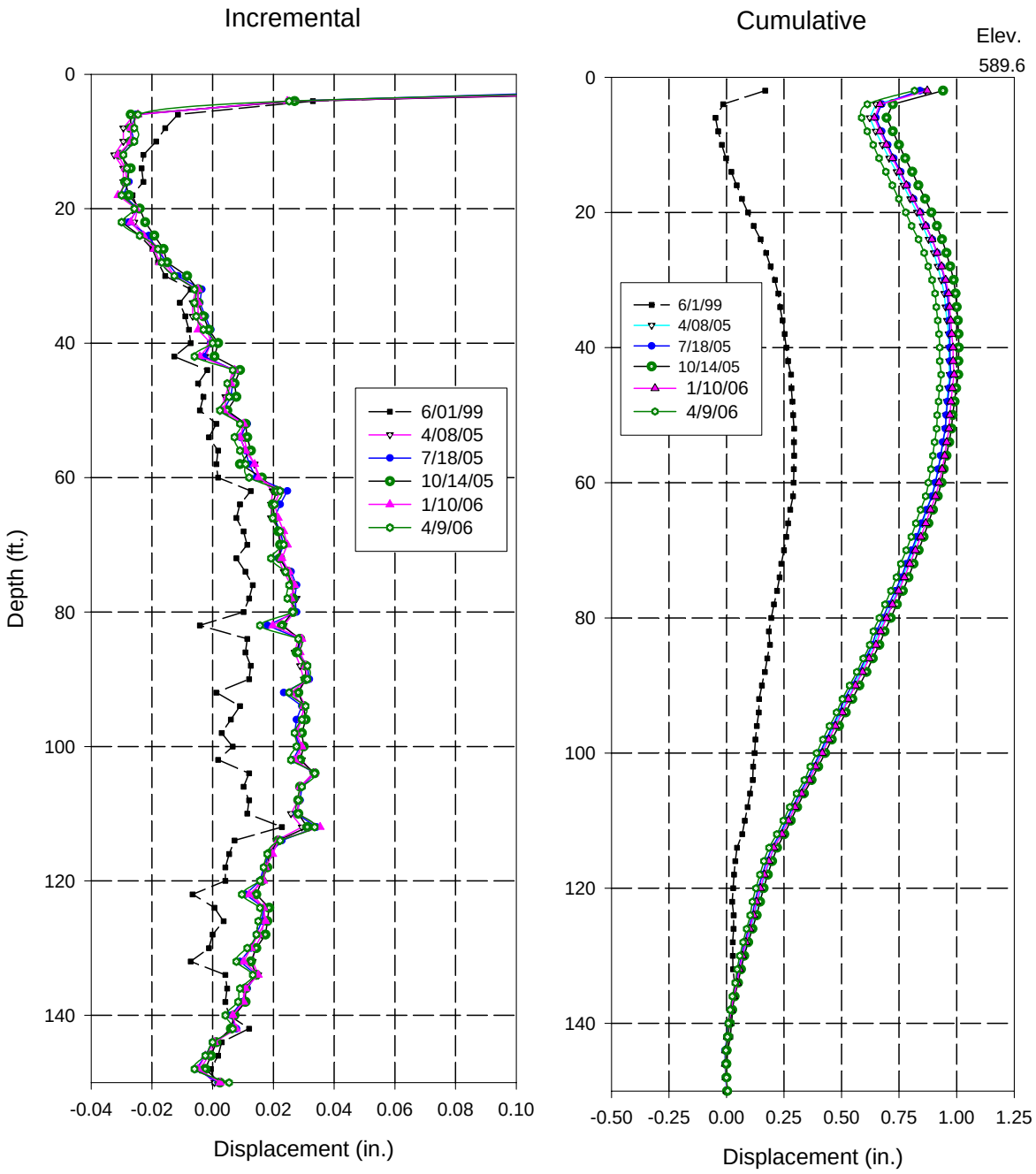


Fig. 24 Inclinometer # 9B Displacement in the A + Direction
Downslope (River direction) Base Line reading 3/06/1999

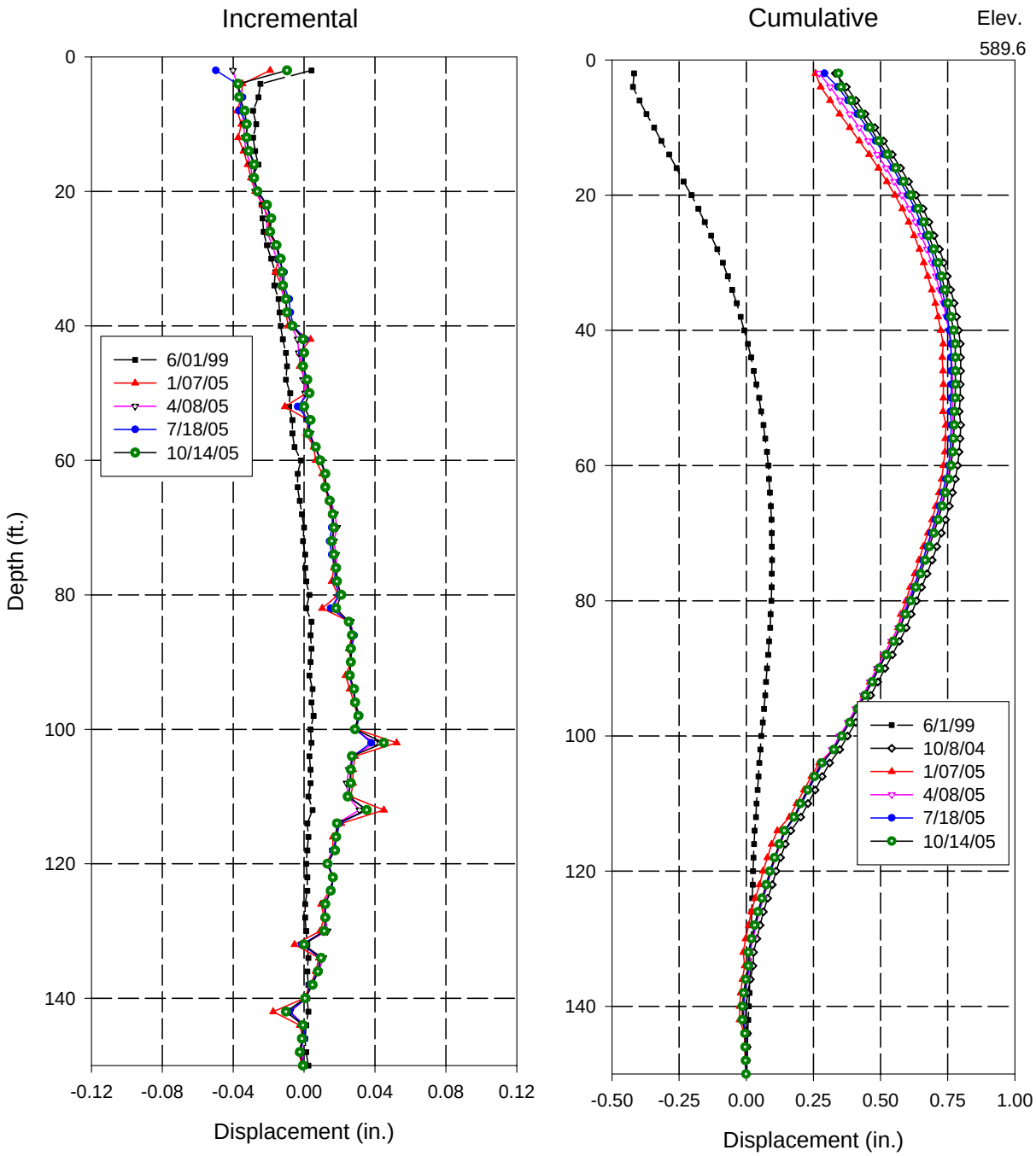


Fig. 25 Inclinometer # 10 Displacement in the A + Direction
Downslope (River direction) Base Line reading 3/06/1999

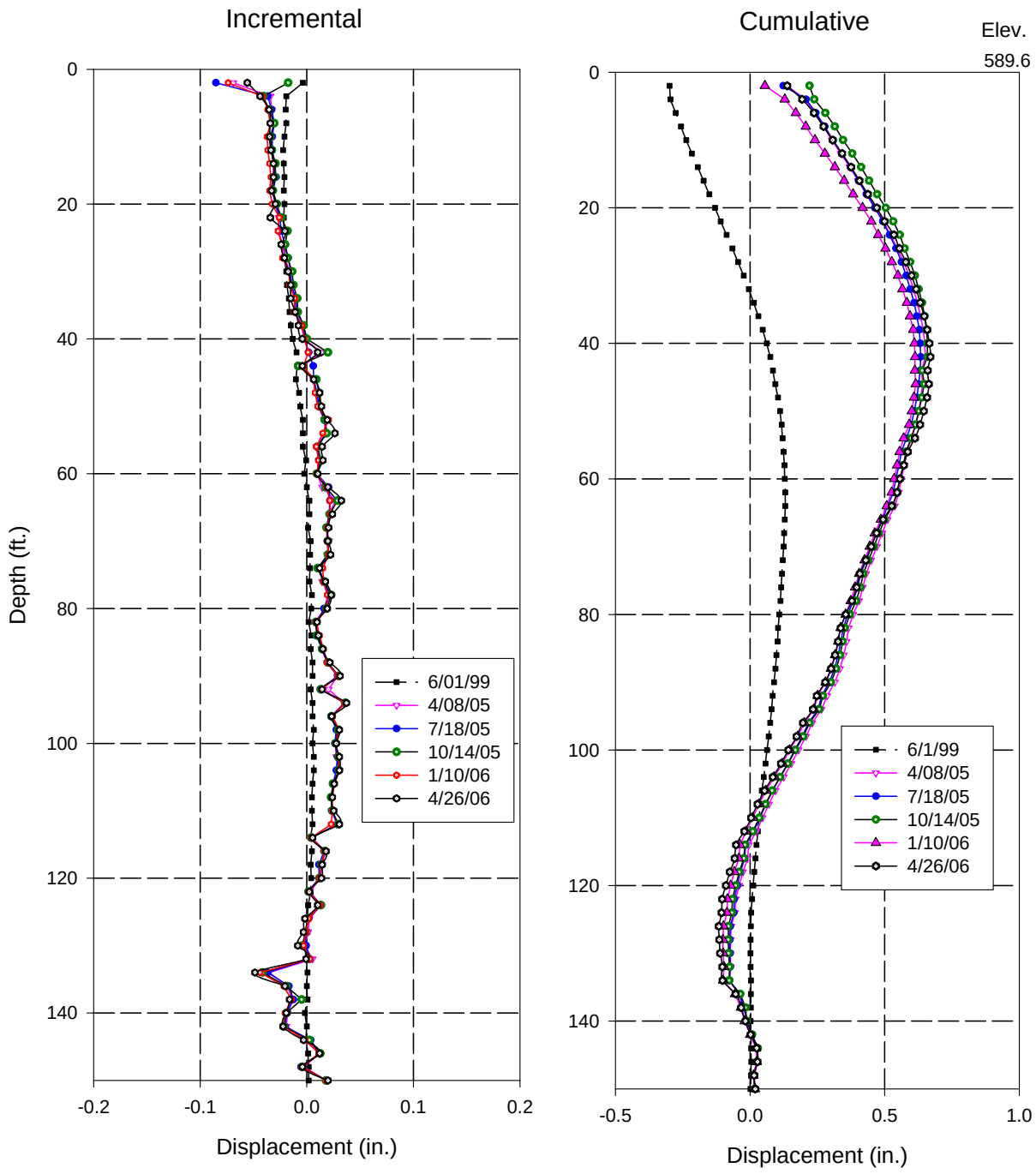
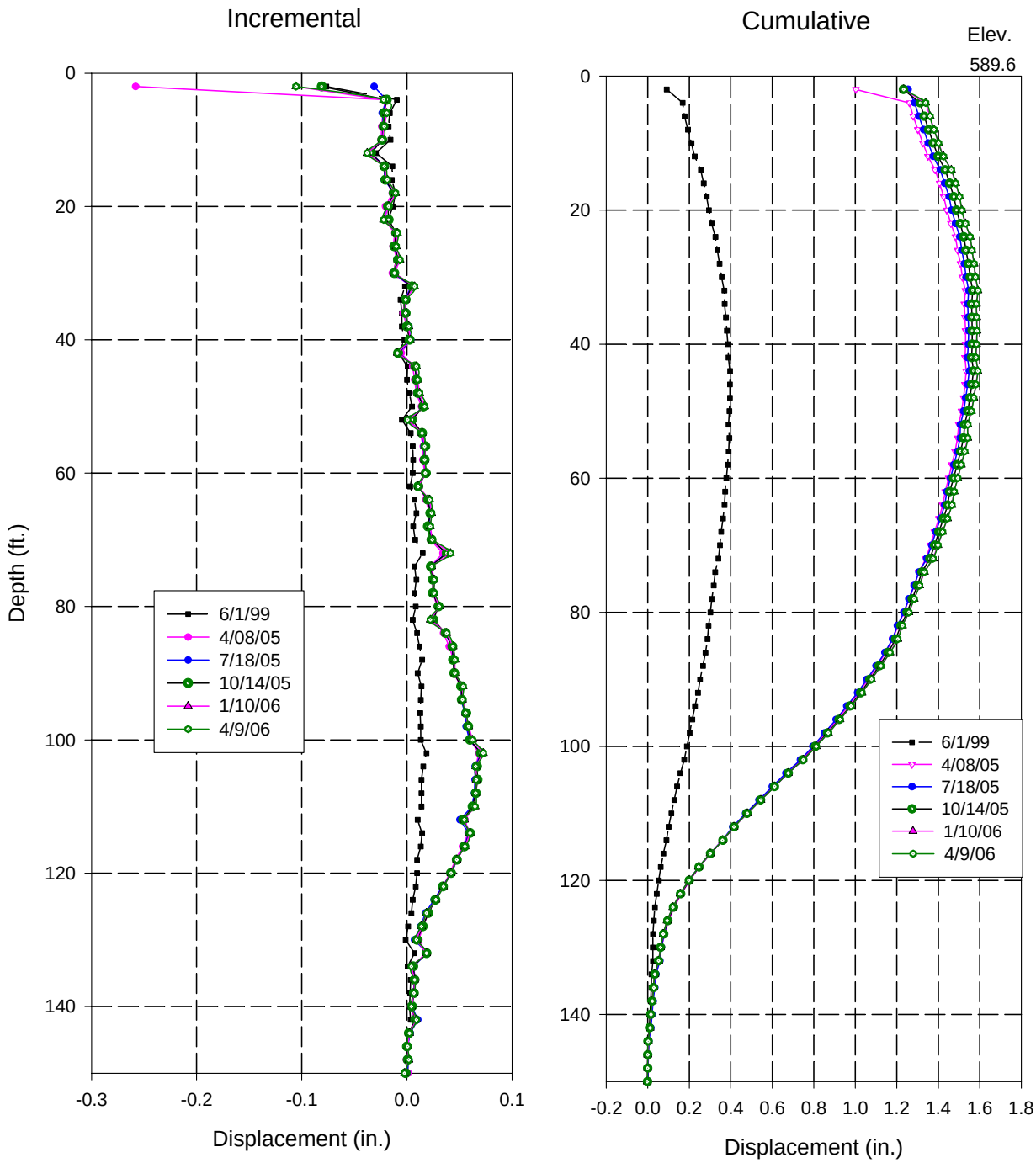


Fig. 26 Inclinometer # 17 Displacement in the A + Direction
Downslope (River direction) Base Line reading 12/11/1998



RICHLAND ENGINEERING LIMITED
29 North Park Street, Mansfield, Ohio 44902-1769 • 419-524-0074 FAX 419-524-1812

106017

August 11, 2006

Ohio Department of Transportation
5500 Transportation Boulevard
Garfield Heights, Ohio 44125-5396

Attn: Mr. Mike Malloy

Re: CUY-90-1524
Central Viaduct
PID No. 20752
Slope and Pier Monitoring Services
Interim Report

Dear Mr. Malloy:

The following is our report on monitoring activity and collected data for the west slope of the Cuyahoga River and Bridge No. CUY-90-1524 west end pier, pier 1, and slope stabilization structure. The last report of data was June 1, 2006 for data collected through April 2006. This report is for data collected through July 2006.

The current slope monitoring began in 1994. The stabilization structure was constructed and the span 1 superstructure was relocated in 1999. The stabilization structure monitoring began in 1999. Additional slope monitoring north of the existing bridge began in 2006.

BBC&M Engineering, Inc. obtained inclinometer readings, piezometer readings, and calipered crack distances between July 11 through 24, 2006. Seven inclinometers and 6 piezometers installed between 1994 and 1999 continue to be monitored. During March through June 2006, three replacement inclinometers, 9 new inclinometers, and 18 new piezometers were installed. The new instrumentation is in the area north of the existing bridge where the Central Viaduct Bridge replacement is anticipated to be constructed. Only the initial readings were obtained from the new instrumentation. The older instrumentation continues to indicate movements of the shallow and deep failure planes at consistent rates. There was a large aggregate pile on a portion of the property adjacent to the south right of way fence in July 2006.

The property owner north of the right of way fence had a contractor repair the failed sheet pile dock wall at the river's edge. Earth was excavated from behind the wall and moved up the hillside. The top of the sheet pile wall was pulled back with cables anchored to an apparently abandoned-in-place piece of earthmoving equipment. A large hole remains behind the dock wall. As of July 2006, it appears that this is the extent of the repair. No accelerated movements of the failure planes have yet been observed due to the contractor's excavation activities.

Richland Engineering Limited measured expansion joint openings at the west end pier, near pier 2, and near pier 4 on July 14, 2006. The deck expansion joint openings have closed in proportion to the temperature (78 degrees) expansion of the bridge. The joint near pier 2 is almost closed.

Art Huckelbridge obtained tiltmeter readings at the west end pier and pier 1 on July 24, 2006. The tiltmeters show rates and magnitudes of movement similar to past readings.

Robert Liang monitored instrumentation on July 24, 25, and 26, 2006. The instrumentation readings in the rock anchors, driven piles, tieback beams, drilled shafts, and inclinometers showed no significant change.

The next readings are scheduled about October 15, 2006. The project has been authorized for continued monitoring through October 2009.

Please contact us if you have any questions (email reltd@r-e-l.com). Copies of detailed quarterly reports are available upon request.

Very truly yours,

RICHLAND ENGINEERING LIMITED

Dean A. Palmer, P.E.

DAP:dap

cc: Craig Hebebrand, District 12
Youssef Seif, District 12
Tim Keller, Office of Structures
Gene Geiger, Office of Geotechnical Services
Tom Lefchik, FHWA
Steve Pasternack, BBC&M Engineering, Inc., Dublin
Jeff Snyder, BBC&M Engineering, Inc., Valley View
Art Huckelbridge
Robert Liang
Rick Engel, E.L. Robinson Engineering Co.
Bob Parker, Michael Baker, Jr., Inc.

JULY 2006 QUARTERLY REPORT
FIELD MONITORING SERVICES
CUY-90-14.92/15.24
CLEVELAND, OHIO

Report to

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

Prepared by

BBC&M ENGINEERING, INC.
CLEVELAND, OHIO

August 2006

BBC&M Engineering, Inc.
8555 Sweet Valley Drive, Suite S, Valley View, OH 44125-4254
Phone (216) 901-1000 Fax (216) 901-9996

August 4, 2006
012 00946.300

Mr. Dean A. Palmer, P.E.
Richland Engineering Limited
29 North Park Street
Mansfield, Ohio 44902

Re: CUY-90-14.92/15.24 Bridge
Quarterly Report - Field Monitoring Services
July 2006 (Third Quarter)

Dear Mr. Palmer:

In accordance with our proposal dated February 1, 2006, BBC&M Engineering, Inc. (BBCM) has completed the field monitoring services for the July, 2006 quarter as part of the CUY-90-14.92/15.24 project. This quarterly report contains the data obtained from all the actively monitored instrumentation (inclinometers, piezometers, and calipered distance locations), discussions of observations of the data, and general site observations.

We appreciate being of continued service during this project. The next quarterly readings are scheduled to take place around October 15, 2006. Please contact our office if you have any questions or require additional information.

Respectfully submitted,

BBC&M ENGINEERING, INC.
Cleveland, Ohio

Jeffrey L. Snyder, M.S., E.I.
Staff Engineer

Peter S. Lee, Ph.D., P.E.
Senior Project Engineer

JLS/psl

cc: Mr. Robert B. Parker, P.E.
Michael Baker Jr., Inc.

Submitted: pdf copy submitted to Richland Engineering at reltd@r-e-l.com and Michael Baker Jr., Inc. at BParker@mbakercorp.com

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Introduction

Of the 14 inclinometers and 12 pneumatic piezometers installed by BBCM between 1994 and 1999, seven (7) inclinometers (B-101, B-102, B-107, B-203, B-204, B-303, and P-9N) and six (6) pneumatic piezometers at B-101 and B-105 (2 piezometers each), as well as B-107 and B-303 are still actively monitored. This remaining active instrumentation is associated with the CUY-90-15.24 project. During the period of March through June, 2006, BBCM installed 12 new inclinometers (including three replacement inclinometers) and 18 vibrating wire (VW) piezometers. These newly installed inclinometers and piezometers are associated with the CUY-90-14.92 project. A Summary Table and Site Plan of Active Instrumentation are submitted as Plates 1 and 2 of the Appendix. Quarterly readings were taken at the new and remaining active inclinometers and piezometers during the period of July 11 through 24, 2006.

Replacement Inclinometers

In mid-March, 2006, major excavation activities in an effort to repair a section of failed bulkhead resulted in the destruction of the B-110 inclinometer. A letter from BBCM to Michael Baker Jr., Inc., and dated March 16, 2006 discussing the excavation is provided as Plates 62 to 71 in the Appendix. Additionally, the B-105 and B-108 inclinometers have become unreadable due to excessive displacement at the observed slide planes. Replacement inclinometers were installed at B-105A and B-108A immediately adjacent to the inactivated inclinometers. Also, per ODOT's request, BBCM installed a replacement inclinometer for B-110 at Boring B-05-16 adjacent to the right-of-way fence near B-110. The B-05-16 inclinometer is located within the existing ODOT right-of-way. These replacement inclinometers were installed at depths ranging from 156 to 168 feet below the existing ground surface. Baseline (initial) readings were taken at these replacement inclinometers on June 21 and 22, 2006.

New Inclinometers

New inclinometers were also installed at B-05-01 through B-05-04, B-05-07, B-05-08, and B-05-11 through B-05-13. These new inclinometers were installed at depths ranging from 134 to 228 feet below the existing ground surface. Baseline readings were taken at these new inclinometers between June 21 through 26, 2006.

Discussion of Instrumentation Data

Inclinometers

Spiral (twist) measurements were performed in January, 2005 on the ten (10) inclinometers that were active at the time. Spiral measurements were also performed on June 28 and 29, 2006 on the twelve (12) new inclinometers. All the data sets presented in the Appendix have been corrected to account for the measured spiral of the inclinometer casings. The Cumulative and Incremental Displacement vs. Depth plots in the Appendix show at least one reading per quarter up to four quarters plus the extra readings taken in some of inclinometers in March, 2006. The

Displacement vs. Time plots, however, include at least one reading from each year since the baseline readings.

Lateral deflections from slope inclinometer measurements contain both random and systematic errors. Durham Geo Slope Indicator Company (DGSI) gives the following orders of accuracy for slope inclinometer measurements as follows:

1) Ordinary precision of ± 0.3 inches per 100 ft of casing using standard installation procedures;
2) Higher Precision of ± 0.1 inches per 100 ft of casing with careful survey practices and error correction during data reduction; and
3) Highest Precision of ± 0.05 inches per 100 ft of casing with careful survey and data selection from redundant data sets and excellent installation of the casing.

The data presented herein are considered to have a precision in the range of ± 0.1 to ± 0.2 inches per 100 ft. Hence, any displacements (especially on deep failure planes) on the order of about 0.1 inches could be due to data errors and not actual field movements. The actual rates of slope movement in active inclinometers range from about 0.02 to 0.12 inches per year on the two slide planes.

The rates of movement were computed using linear regression for the depth ranges shown on the Displacement vs. Time plots in the Appendix. Linear regression provided a best-fit match through the data points on each of the Displacement vs. Time curves. The time period for the linear regression was chosen based on a visual observation of each curve at the time when the rate was believed to have last changed significantly. While some of the inclinometers indicate a decreased rate of movement since 2004, the 95% confidence interval of the regression of each analyzed slide plane falls within the range of the expected precision of the inclinometer measurements (about 0.1 inches per 100 ft). Therefore, it is inconclusive whether this is an actual change in the average rate of movement or a false trend caused by the limitations in the data due to the accuracy of the measurements. Several years of data showing a consistent trend or changes in rates greater than the accuracy level of the measurements are necessary to draw conclusions that the average rate has in fact changed. Therefore, all discussions regarding trends in the data are developed based upon multiple years of data.

In general, there are observed movements that correspond to two major slide planes, termed the shallow and deep failure planes. In some of the inclinometers, multiple slide planes may be observed in the shallow or deep failure zones (i.e. B-203 and B-303). In such cases, the multiple slide planes have been grouped together and referred to as part of either the shallow or deep failure plane, whichever is deemed more appropriate. Consequently, the magnitude and rate of movements subsequently discussed are the summation of the relative movements of the individual slide planes within either the shallow or deep failure plane. This is done in an attempt to quantify the total relative movements that would be transferred to a pier or the stabilization structure.

Systematic Error Correction

Systematic errors are correctable errors observed in inclinometer data and are caused by one or more of the following factors: sensor bias-shift, rotation (sensor alignment shift), sensitivity drift, depth positioning error (DPE), and casing inclination/curvature. The data presented in this report have been analyzed and corrected for common systematic errors such as bias-shift and rotation, where necessary.

The uncorrected data obtained in B-05-08 and B-05-12 was observed to be unusual such as displacement within the bedrock or relatively large deep displacements not observed in nearby inclinometers. Thus it was determined that the displacements were not likely real. As error detection was performed on the data, it became apparent that the bias-shift and/or rotation were not the causes of the unusual displacements.

The data for B-05-08 and B-05-12 was sent to Mr. Erik Mikkelsen of Geometron for error detection analysis. Mr. Mikkelsen has published a paper titled "Advances in Inclinometer Data Analysis" (Symposium on Field Measurements in Geomechanics, FMGM September 2003, Oslo, Norway), which discusses correction procedures for many of the aforementioned systematic errors. In Mr. Mikkelsen's opinion, DPE and bias-shift were the systematic errors evident in the B-05-08 and B-05-12 inclinometer data. DPE is a common error caused mainly by settlement (shortening) of the casing and/or change in probe depth control (human error) in inclinometers with significant built-in curvatures. In February, 2005, the data for B-101 was also sent to Mr. Mikkelsen who believed that DPE was the cause of the unusual displacement observed in the inclinometer. The readings for B-101, B-05-08, and B-05-12 inclinometers have been corrected for DPE and bias-shift and the resulting plots are submitted as Plates 3, 4, 36, 37, 40, and 41 of the Appendix.

Active BBCM Inclinometers Installed between 1994 and 1999

The shallow failure plane upslope from Pier 1 appears to continually be moving at an average rate of about 0.06 inches per year (April 1999-present) as indicated in inclinometers at B-203 and B-303. In the immediate vicinity of the Pier 1 area (B-204), no shallow slip-plane movements have been observed since completion of construction of the Pier 1 stabilization system.

South of the West End Pier, inclinometers at B-102 and B-107 indicate the deep failure plane continues to move at an average rate of about 0.02 inches per year (Apr 00-present). The B-101 inclinometer has indicated nominal movement since its installation. The deep failure plane as indicated by inclinometers at B-203, B-204, and B-303 indicates movement at an average rate of about 0.07 inches per year in the immediate vicinity and upslope from Pier 1 (Apr 99-present).

Inclinometer P-9N (installed in one of the drilled shafts) indicates the top of the drilled shaft is being laterally restrained and that the maximum lateral deflection is about 0.85 inches and occurs at approximately 40 to 50 feet from the top of the inclinometer casing. Note that the inclinometer has shown nominal movement over the past four quarterly readings.

No accelerated movements have yet been observed in any of the inclinometers (installed between 1994 and 1999) as a result of the excavation activities in the vicinity of B-110 on the west side of the I-90 Bridge.

New BBCM Inclinometers Installed in 2006

Small surficial movement in the upper 15 feet has been observed at the B-05-16 inclinometer (see Plates 44 and 45 of the Appendix). Possible cantilever displacement similar in shape to the cantilever displacements observed in B-102 and B-107 has been observed in the B-05-12 to a depth of 30 feet (see Plates 40 and 41 of the Appendix). The relative displacement between the baseline (6/22/06) reading and the current (7/24/06) reading has been observed to be about 0.15 inches. It is possible the displacements at B-05-16 and B-05-12 may be a result of the ongoing excavation activities near B-110. The surficial displacement at B-05-16 is expected due to the scarp and tension cracks that have been observed in the vicinity of the inclinometer. The magnitude of displacement in B-05-12 was not observed in other nearby inclinometers such as B-107 and B-05-02. A small sinkhole (approx. 1' dia.) was observed by BBCM personnel in March, 2006 in the pavement of University Road in the vicinity of B-05-12. It is not known how long the sinkhole has been there and as of July, 2006, the sinkhole did not seem to have become larger. Thus, it is inconclusive whether the observed displacement in B-05-12 is a true displacement. Additional readings over a period of a few months are needed in B-05-12 to evaluate whether a general trend is observed which would indicate the displacement may be real.

Distinct movement has not yet been observed in the inclinometers at B-105A, B-108A, B-05-01 through B-05-04, B-05-07, B-05-08, B-05-11 and B-05-13. Based on the relatively slow rates of movement of the slide planes observed at the site over the past several years, observed displacements were not yet anticipated in the new inclinometers within the time period between baseline and quarterly readings, which were taken no more than 1 month apart. Additionally, multiple readings over a given time period are needed to observe general trends.

Piezometers

In Tables 1 and 2 provided in the following sections, a summary of the measured total head (h_t), is provided for each pneumatic or VW piezometer. Additionally, plots of Total Head vs. Time are provided in the Appendix. For the pneumatic piezometers at B-101, B-105, B-107, and B-303, the measured water elevation (in feet) was reported in BBCM's previous quarterly and annual reports. This water elevation is equivalent to the total head (h_t, in feet).

The total head (h_t) is calculated using the following equations:

$$h_t = h_e + h_p$$
$$h_p = u/\gamma_w$$

where h_e is the elevation head or the elevation where the piezometer was installed, h_p is the pressure head, u is the pore pressure reading, and γ_w is the unit weight of water.

Pneumatic Piezometers

The results of the remaining active pneumatic piezometer readings taken on July 14, 2006 are summarized in Table 1 below. Pneumatic piezometers are identified both by boring number and ribbon color to specify the location and the depth of the instrumentation. Two piezometers at B-101 and B-103 required ribbon replacement. The new ribbon color is noted in parenthesis in Table 1.

Table 1: Summary of Readings for the Active Pneumatic Piezometers – CUY-90-15.24

Piezometer Identifier		Ground Surface Elevation (ft)	Elevation Head, h_e (ft)	Pore Pressure Reading, u (psi)	Total Head, h_t (ft)
B-101 (P-1*)	green (orange)	676.6	626.3	0.1	626.5
	pink	676.6	552.3	31.7	625.5
B-105 (P-3*)	pink	585.6	497.6	38.8	587.1
	blue	585.6	479.9	48.6	592.1
B-107 (P-5*)	orange	662.3	562.3	25.6	621.4
B-303 (P-2*)	green (pink)	627.0	586.2	7.1	602.6

*BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers.

All the piezometers have exhibited slightly higher readings than those recorded in April, 2006 except both B-101 piezometers, which exhibited slightly lower readings. Note that the piezometers at B-105 continue to indicate an elevated water pressure (i.e. a total head above the ground surface, artesian conditions). It is possible that the elevated water pressure in B-105 may be attributed to a thin silt seam sandwiched between fairly thick clay layers located near the base of the piles supporting Pier 1 and the percolation of natural gas out of the underlying Devonian Ohio Shale. These elevated pore pressures can have a detrimental effect on slope stability and the rate of slope creep.

Total Head vs. Time plots, which provide the measured total head from 1994 to the present, have been submitted as Plates 46 through 49 in the Appendix of this report.

Vibrating Wire (VW) Piezometers

The VW piezometers have been placed at various depths with 2 piezometers at each of the 9 offset boring locations. The VW piezometers were installed on 1¼-inch PVC pipe encased in grout with a cable attached to the VW piezometer. Each cable runs up through the PVC pipe and is attached to a MiniLogger, which stores the pore pressure data. A flush mount protective cover was installed at each offset boring location to house the two MiniLoggers. Readings are taken by Miniloggers every 8 hours; however, this time interval can be adjusted upon request.

Table 2 provides a summary of the maximum and minimum values of all the pressure readings taken from the time of installation to the time when the collected data was downloaded from VW Miniloggers on either July 14 or July 17, 2006. The VW piezometers are identified by boring number, MiniLogger serial number, and depth the piezometer was installed. The VW piezometers also measure the ground temperature around the piezometer. The maximum and minimum temperature readings are also provided in Table 2.

Table 2: Summary of Readings for the VW Piezometers – CUY-90-14.92

Piezometer Identifier		Time Interval of Readings Reported*	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-01	21961 - 65 ft	5/26/06 to 7/14/06	14.4/14.1	675.4	610.4	11.7/11.1	637.4/636.1
	21967 - 95 ft	5/26/06 to 7/14/06	13.5/13.3	675.4	580.4	21.9/20.5	630.9/627.6
B-05-02	21963 - 46 ft	5/22/06 to 7/17/06	12.2/12.1	617.9	571.9	8.5/8.0	591.5/590.3
	21951 - 122 ft	5/22/06 to 7/17/06	12.3/12.2	617.9	495.9	40.7/40.0	589.7/588.3
B-05-03	21957 - 32 ft	5/16/06 to 7/17/06	11.9/11.6	605.1	573.1	8.1/7.5	591.8/590.4
	21965 - 112 ft	5/16/06 to 7/17/06	12.5/12.5	605.1	493.1	42.8/41.2	591.8/588.2
B-05-04	21958 - 59 ft	5/18/06 to 7/17/06	13.1/13.0	600.8	541.8	18.2/17.8	583.7/582.9
	21952 - 119 ft	5/18/06 to 7/17/06	13.2/13.2	600.8	481.8	45.3/45.2	586.4/586.1
B-05-07	21966 - 102 ft	6/8/06 to 7/14/06	12.9/12.5	678.9	576.9	27.8/24.4	641.0/633.1
	21956 - 220 ft	6/8/06 to 7/14/06	12.1/12.0	678.9	458.9	73.0/67.5	627.4/614.6
B-05-08	21954 - 65.5 ft	5/30/06 to 7/14/06	12.9/12.7	679.9	614.4	12.0/11.8	642.2/641.5
	21959 - 110.5 ft	5/30/06 to 7/14/06	12.6/12.4	679.9	569.4	29.6/29.1	637.6/636.6
B-05-11	21968 - 95 ft	6/9/06 to 7/14/06	13.0/12.8	675.1	580.1	23.4/23.2	634.2/633.7
	21953 - 130 ft	6/9/06 to 7/14/06	12.9/12.7	675.1	545.1	35.8/35.1	627.8/626.1
B-05-12	21960 - 75 ft	5/24/06 to 7/14/06	13.0/12.9	652.7	577.7	17.6/16.4	618.4/615.5
	21964 - 120 ft	5/24/06 to 7/14/06	12.6/12.5	652.7	532.7	34.3/33.0	611.8/609.0
B-05-13	21962 - 60 ft	6/12/06 to 7/17/06	13.0/12.6	580.0	520.0	23.5/23.1	574.3/573.3
	21955 - 135 ft	6/12/06 to 7/17/06	13.2/13.0	580.0	445.0	60.9/60.7	585.5/585.2

*Readings generally were taken every 8 hours during the reported time interval.

The 21955 piezometer in B-05-13 installed at a depth of 135 feet exhibits an elevated water pressure (i.e. a total head above the ground surface, artesian conditions) similar to that observed in the pneumatic piezometers at B-105 previously discussed. The elevated water pressure observed in the 21955 piezometer may be attributed to a silt/sand layer sandwiched between clay and shale layers and percolation of natural gas out of the underlying Devonian Ohio Shale into the silt/sand layer. During drilling of Boring B-05-13, gas pockets were encountered during rock coring.

Total Head vs. Time plots have been submitted as Plates 50 through 58 in the Appendix of this report. In a few of the VW piezometers, the total head decreased by as much as 13 feet (i.e., B-05-07) from the initial reading. A gas pocket was encountered during drilling near the top of the shale bedrock in Boring B-05-07. The soil pore pressures may be reducing back to normal conditions in B-05-07. Also, DGSI has stated in the user's manual for the VW piezometer that "drilling a borehole and backfilling it temporarily changes the pore-water pressure in the ground, so readings that are taken immediately after installation will not be good datum readings. Recovery of the natural pore-water pressure may take a few hours to a few weeks, depending on the permeability of the soil." DGSI also suggests recovery of the pore-water pressure is indicated by observation of stable readings for several consecutive days. The readings have been generally stable in all of the VW piezometers for a period of at least two weeks prior to downloading of the data.

Additional Field Measurements and Observations

The left and right calipered locations, which have been monitored since June, 1999, are located just east and west of the I-90 bridge centerline, respectively (see the Site Plan of Active Instrumentation, Plate 2 in the Appendix). A Calipered Surface Distance Table and Calipered Distance Readings vs. Time plots have been included as Plates 59 through 61 in the Appendix. Close inspection of the data in the plots indicates the possibility of general trends of movement at the calipered locations. The data is somewhat oscillatory, which is likely due to the seasonal temperature fluctuations affecting the concrete combined with human error due to the interpretation of the center of the nails. In the data plots, linear trendlines were added to estimate the average rate of separation/closure per year. The left calipered location indicates the gap is continuing to open at a rate of about 0.06 inches per year. The right calipered location indicates the gap is continuing to close at a rate of about 0.03 inches per year. The movements are relatively small (½ of an inch or less since June, 1999) and are highly subject to the interpretation of the center of the nails, thus it is inconclusive that these movements have been caused by the observed slope movements. Continued observation of these calipered locations is needed in order to adequately determine if judgment error and weather conditions are the main cause of the observed trends or if they are indeed caused by slope movements.

In July, 2006, a large aggregate pile covered roughly half of the eastern portion of the property currently being used to stockpile aggregate adjacent to the east right-of-way fence. A relatively small aggregate pile also covered roughly half of the western portion of this same stockpile property.

As previously discussed, a large excavation near the west right-of-way fence was first observed by BBCM personnel in March, 2006. A letter from BBCM to Michael Baker Jr., Inc., and dated March 16, 2006 discussing the excavation is provided as Plates 62 to 71 in the Appendix. The excavation was performed in an effort to repair the failed bulkhead. As of July, 2006, the repair effort appears to be ongoing as the bulkhead did not appear to be fully repaired and the large excavation had not yet been backfilled.

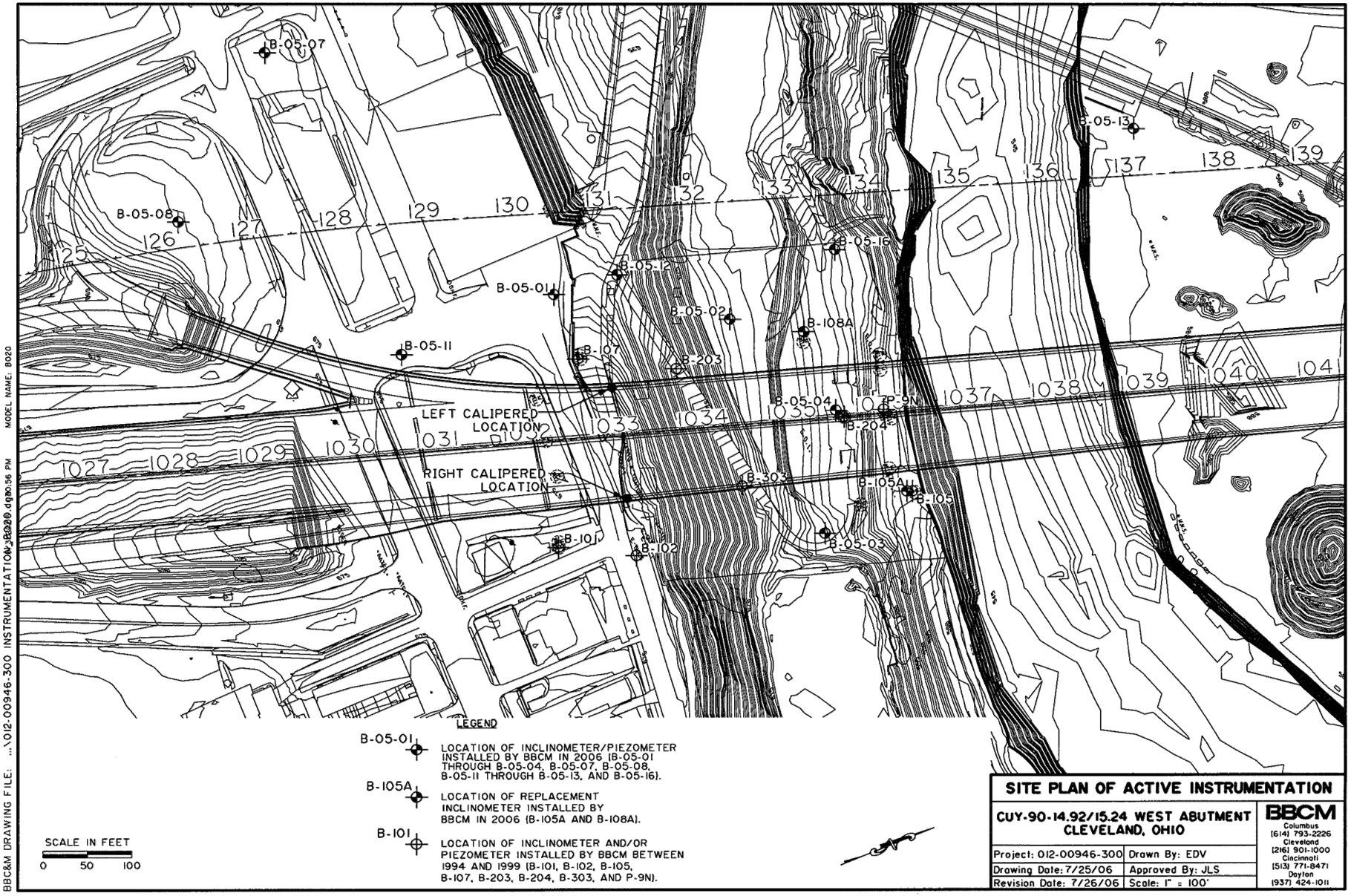
APPENDIX

CUY-90-14.92/15.24 INSTRUMENTATION MONITORING

SUMMARY OF ACTIVE INSTRUMENTATION
CUY-90-14.92/15.24

Active Instrumentation	Active Inclinometer ?	Inclinometer Depth (ft)	Active Piezometer?	VW or Pneumatic?	# of Active Piezometers	Piezometer Depth(s) Below Existing G.S. (ft)	Instrumentation Installation Date
B-101	Y	190	Y	Pneumatic	2	50.3, 124.3	Aug-Sep 1994
B-102	Y	224	N	---	---	---	Sep 1994
B-105	N	---	Y	Pneumatic	2	88, 105.7	Aug 1994
B-105A	Y	156	N	---	---	---	May 2006
B-107	Y	210	Y	Pneumatic	1	100	Sep 1994
B-108A	Y	168	N	---	---	---	Apr-May 2006
B-203	Y	192	N	---	---	---	Aug 1996
B-204	Y	134	N	---	---	---	Jul 1998
B-303	Y	180	Y	Pneumatic	1	40.8	Aug 1994*, Jul 1998
P-9N	Y	150	N	---	---	---	Feb 1999
B-05-01	Y	228	Y	VW	2	65, 95	Apr-May 2006
B-05-02	Y	178	Y	VW	2	46, 122	Apr-May 2006
B-05-03	Y	168	Y	VW	2	32, 112	Apr-May 2006
B-05-04	Y	172	Y	VW	2	59, 119	Mar-May 2006
B-05-07	Y	226	Y	VW	2	102, 220	Apr-Jun 2006
B-05-08	Y	226	Y	VW	2	65.5, 110.5	Apr-May 2006
B-05-11	Y	226	Y	VW	2	95, 130	Apr-Jun 2006
B-05-12	Y	210	Y	VW	2	75, 120	Apr-May 2006
B-05-13	Y	134	Y	VW	2	60, 135	May-Jun 2006
B-05-16	Y	162	N	---	---	---	Jun 2006

*The pneumatic piezometer was actually installed at BBCM Boring P-2 in August, 1994. However, the piezometer has since been renamed to B-303 due to its close proximity to the active inclinometer at B-303 (which was installed in July, 1998).



BBC&M DRAWING FILE: ...\012-00946-300 INSTRUMENTATION\2020.dgn 8:36 PM MODEL NAME: B020

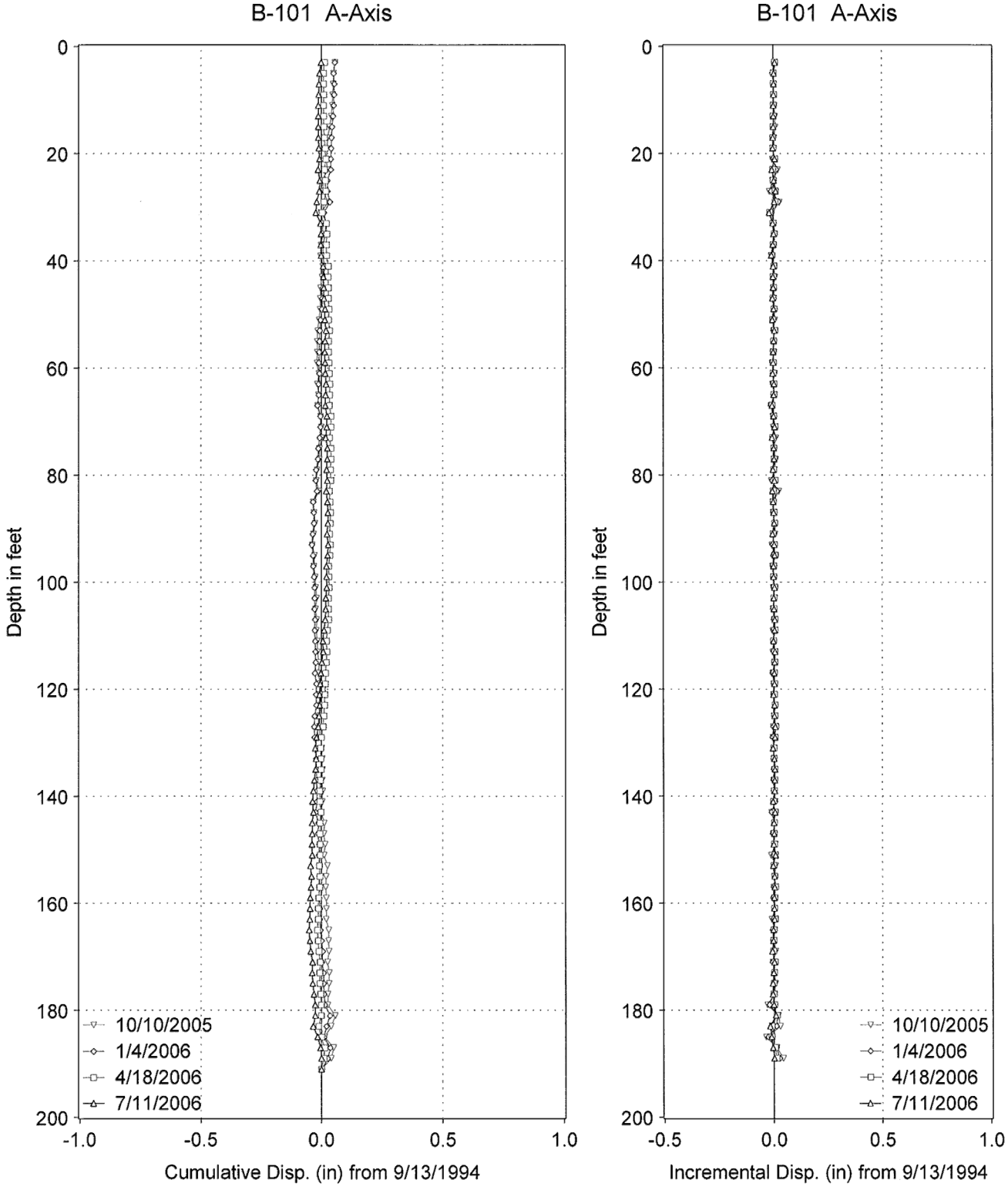
SITE PLAN OF ACTIVE INSTRUMENTATION

CUY-90-14.92/15.24 WEST ABUTMENT
CLEVELAND, OHIO

Project: 012-00946-300	Drawn By: EDV
Drawing Date: 7/25/06	Approved By: JLS
Revision Date: 7/26/06	Scale: 1" = 100'

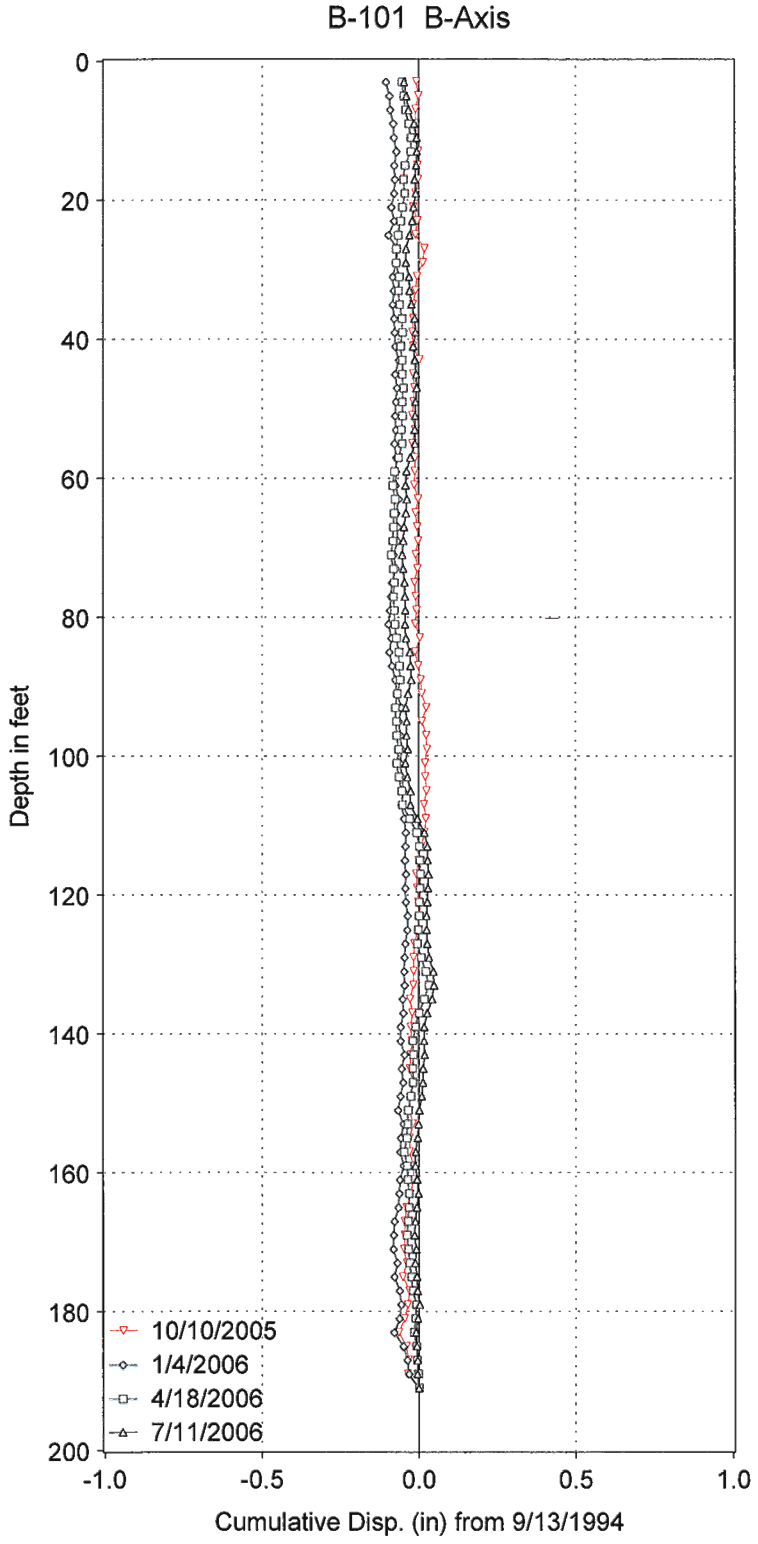
BBCM
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

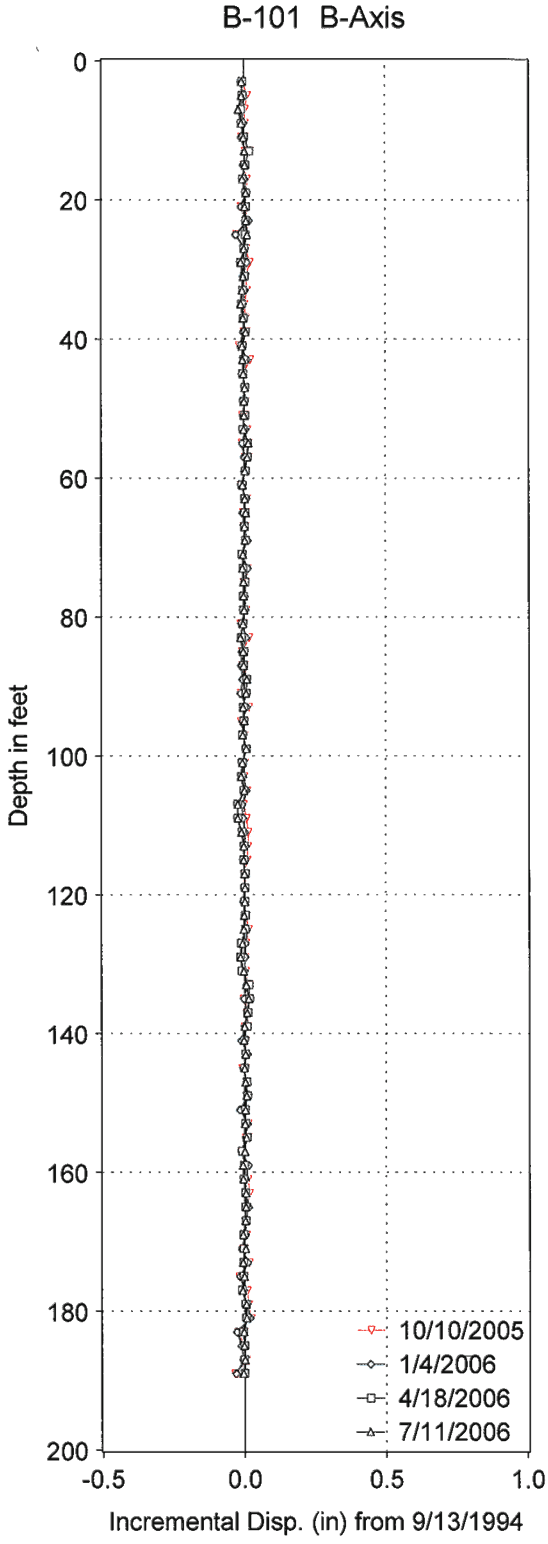
PLATE 2



B-101
-Includes readings from the last four quarters.
-Readings have been corrected for depth positioning error.

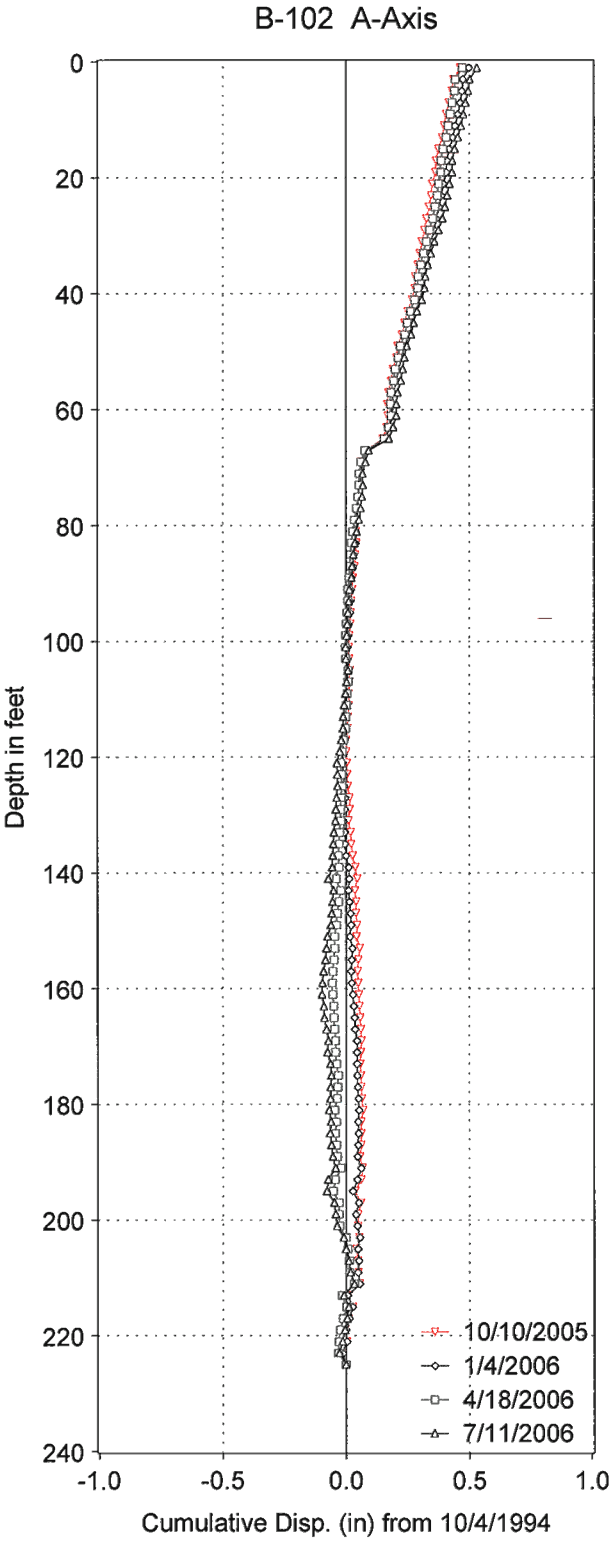
PLATE 3

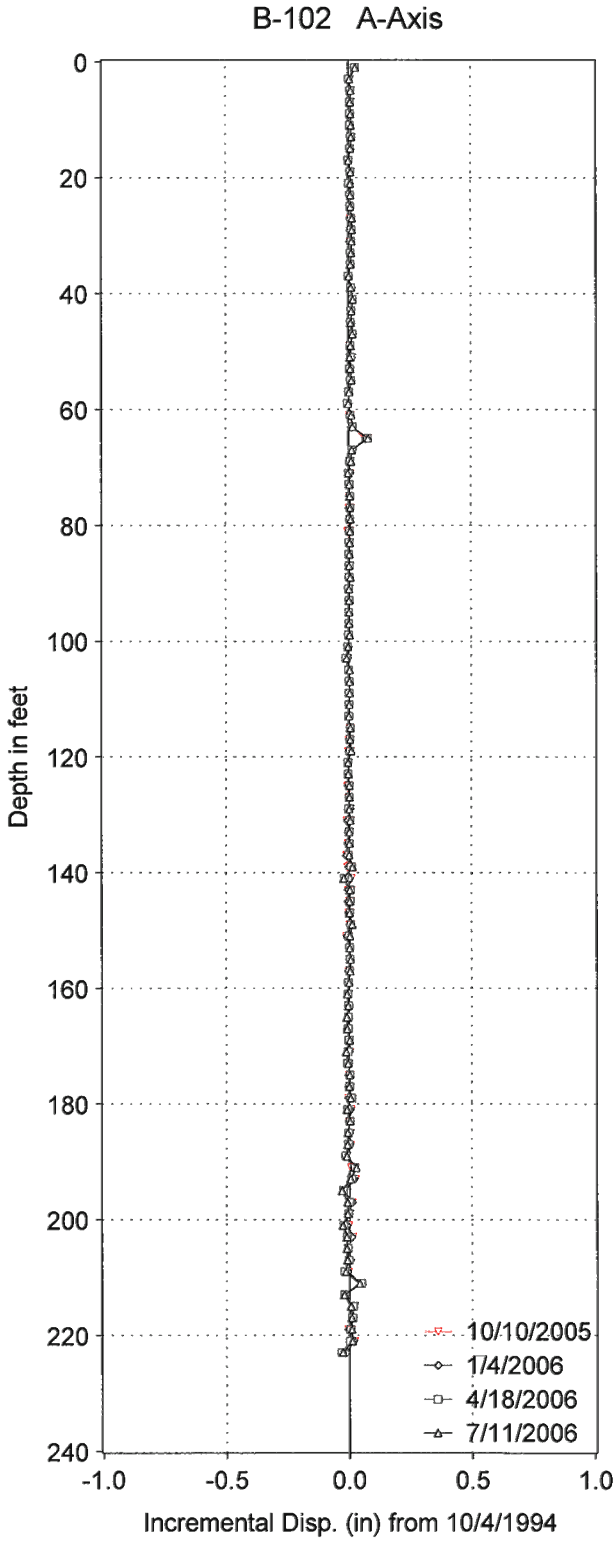




B-101
-Includes readings from the last four quarters.
-Readings have been corrected for depth positioning error.

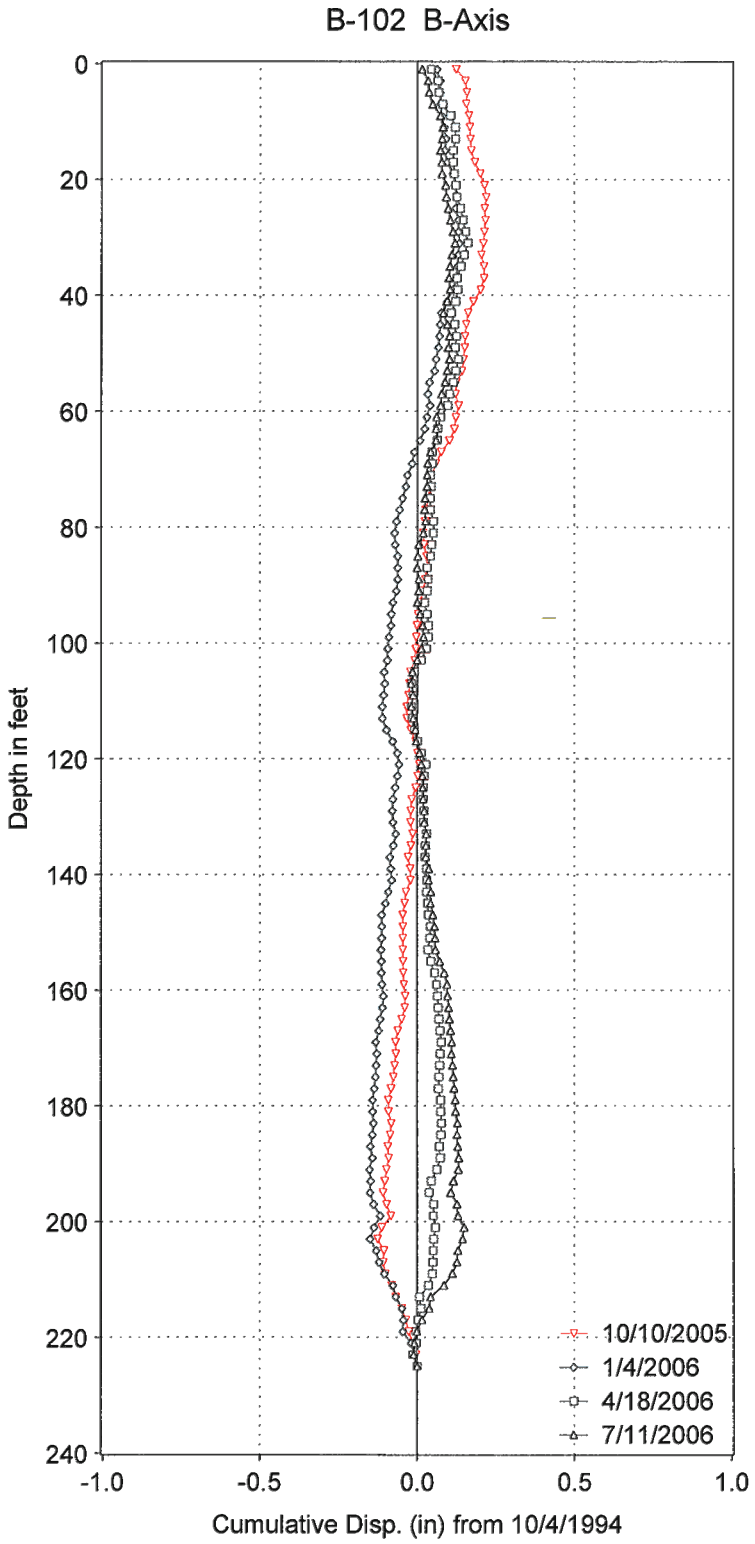
PLATE 4

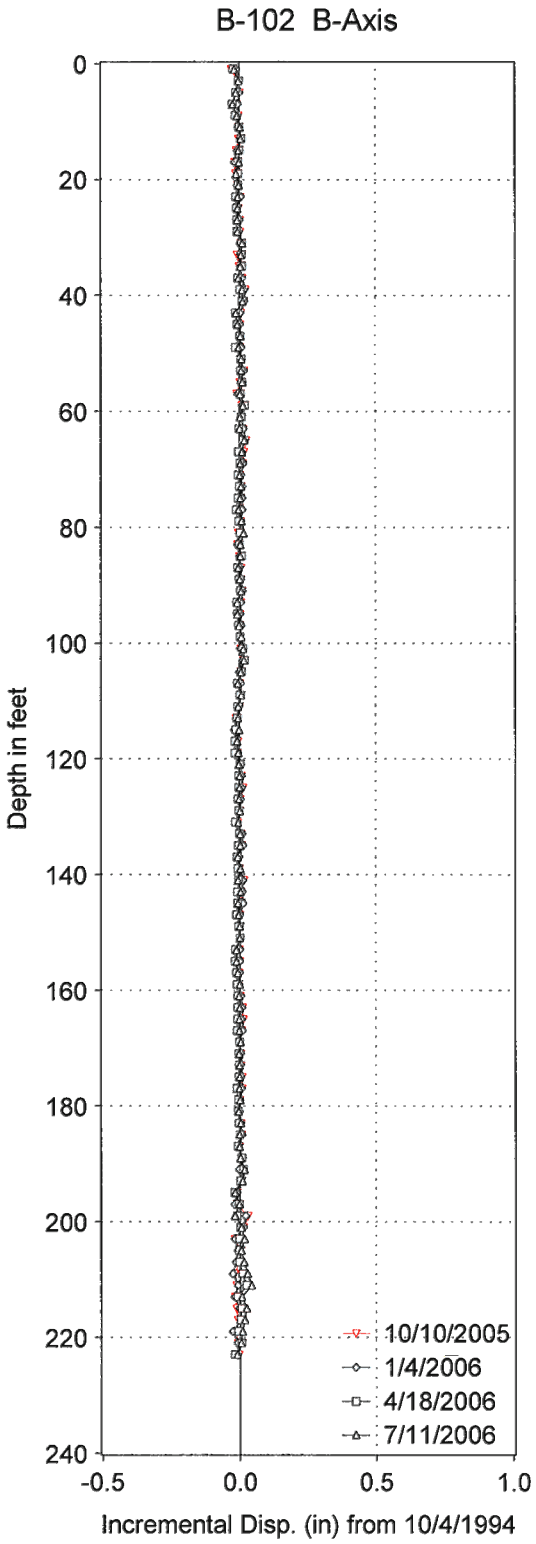




B-102
-Includes readings from the last four quarters.

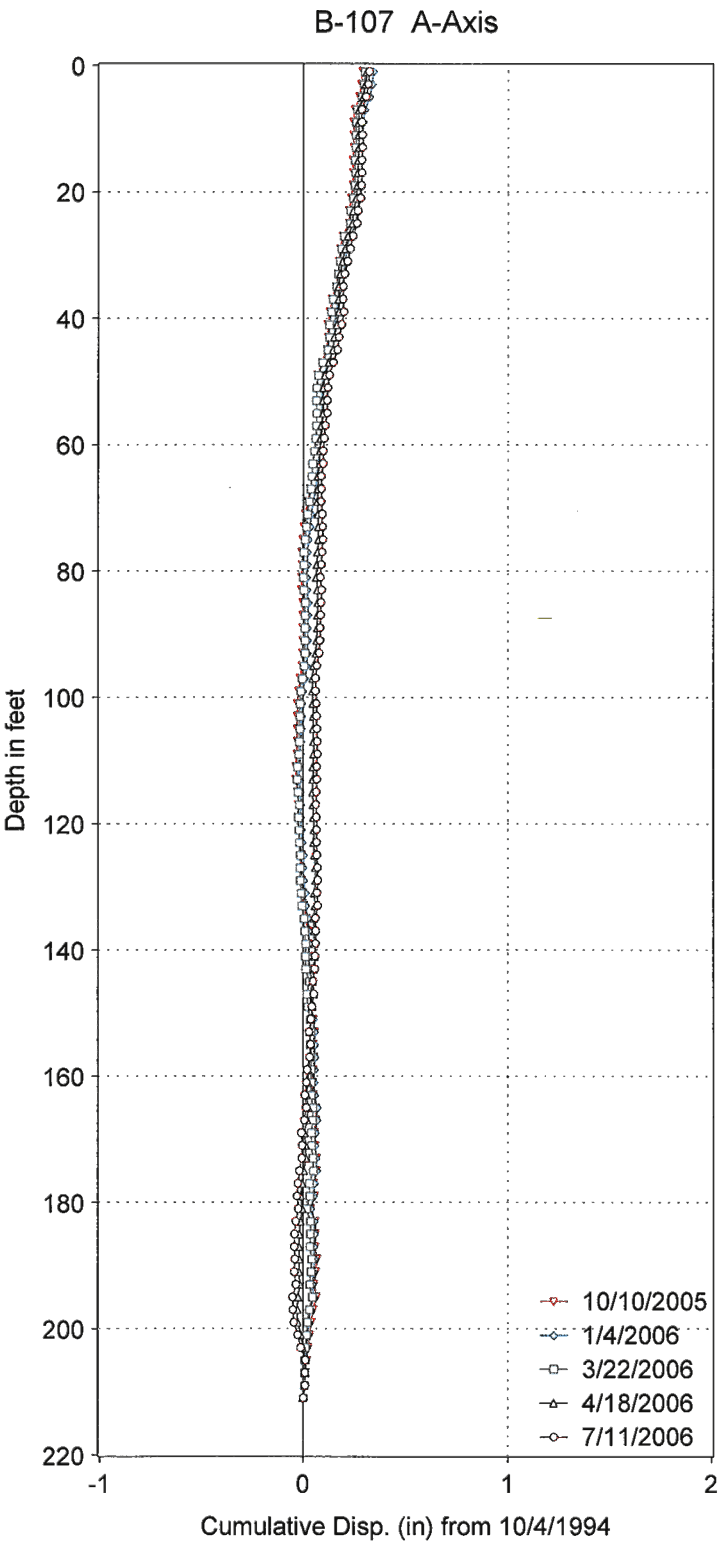
PLATE 5

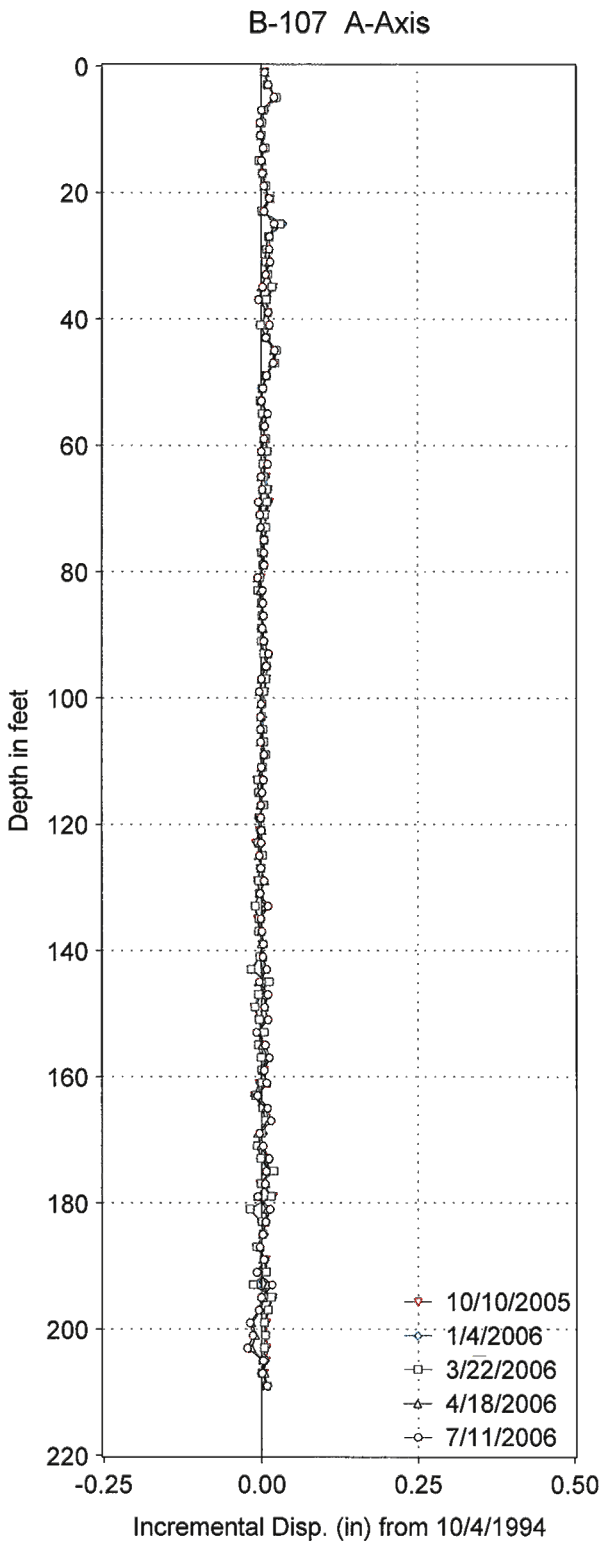




B-102
-Includes readings from the last four quarters.

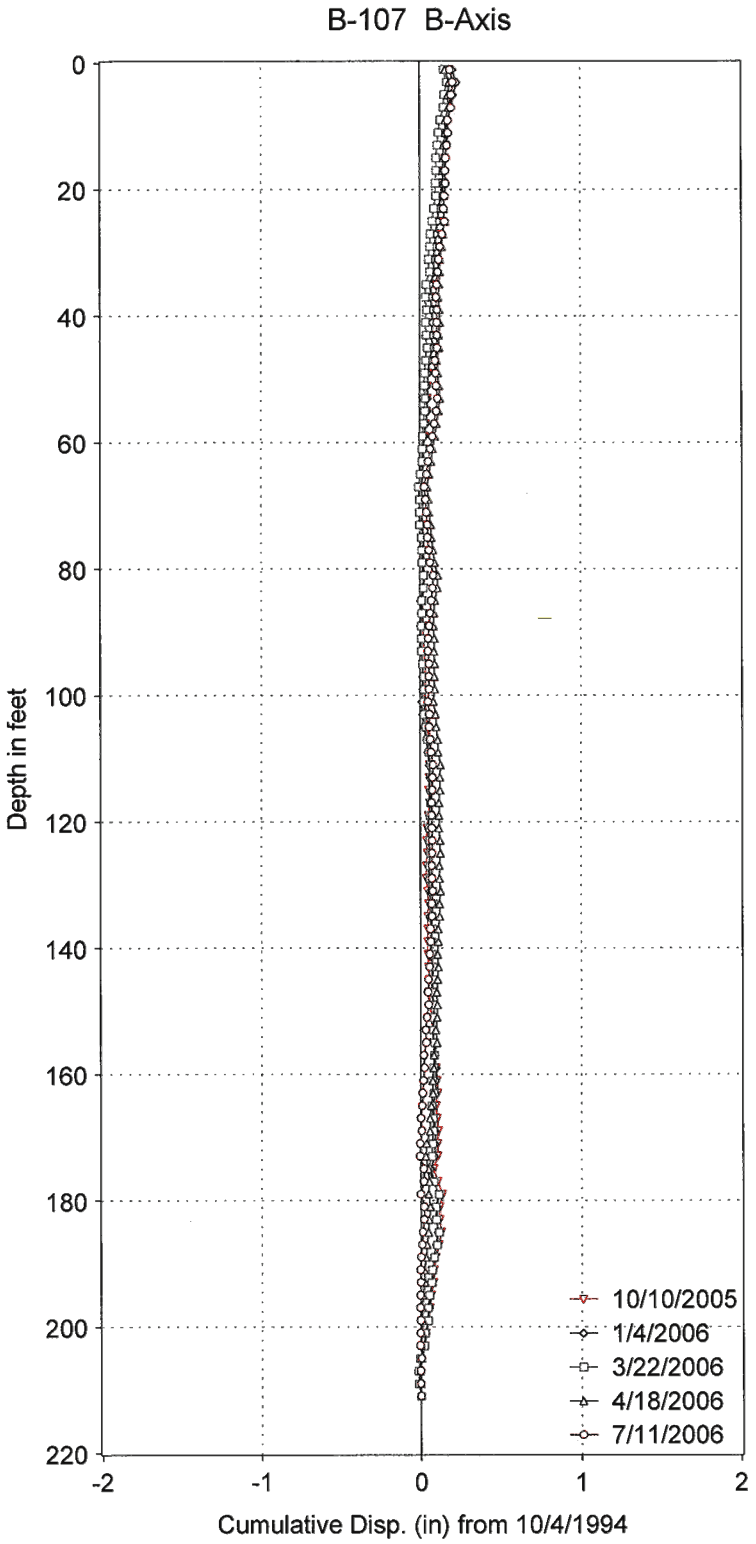
PLATE 6

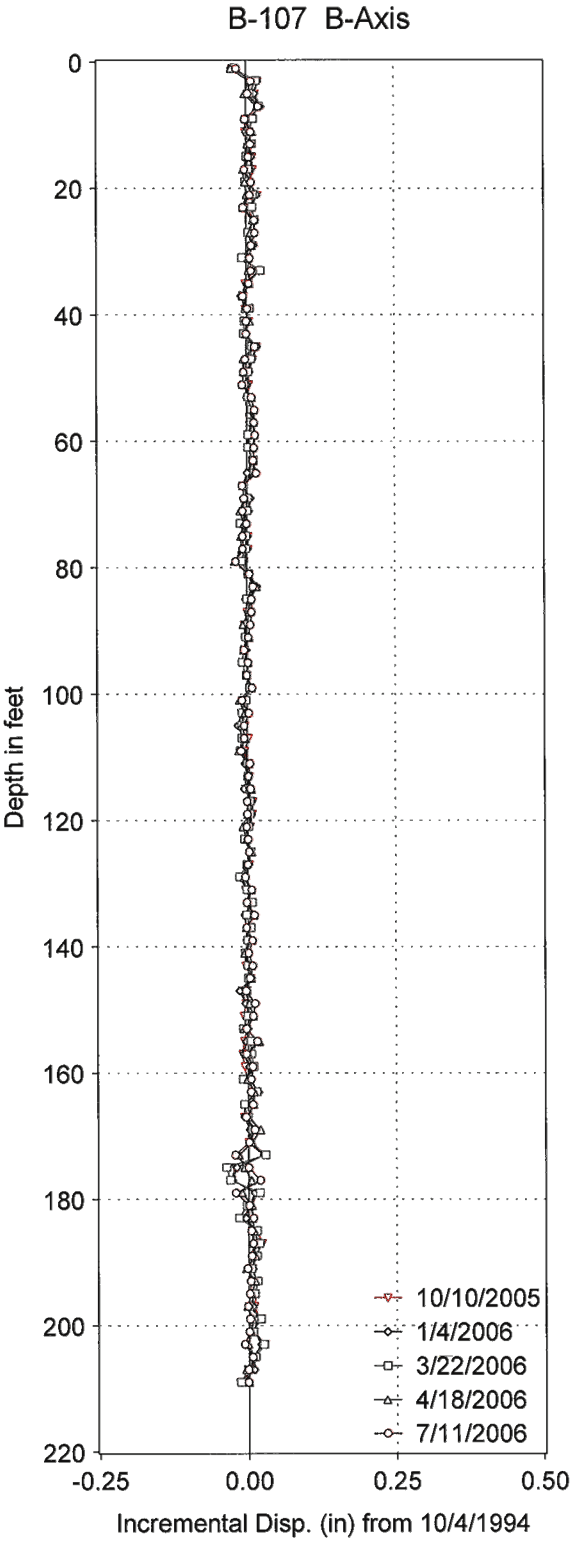




B-107
-Includes readings from the last four quarters (and in March).

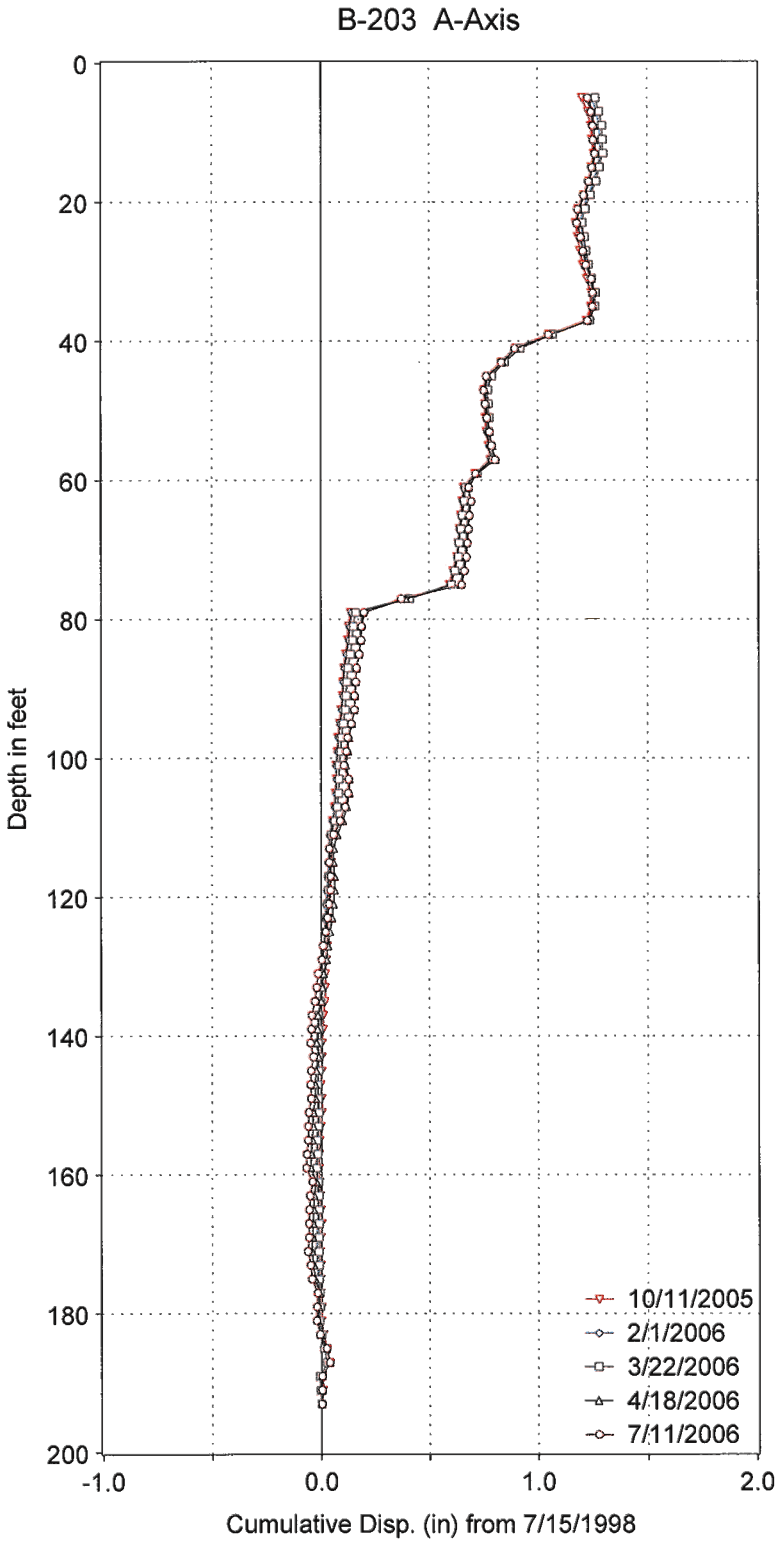
PLATE 7

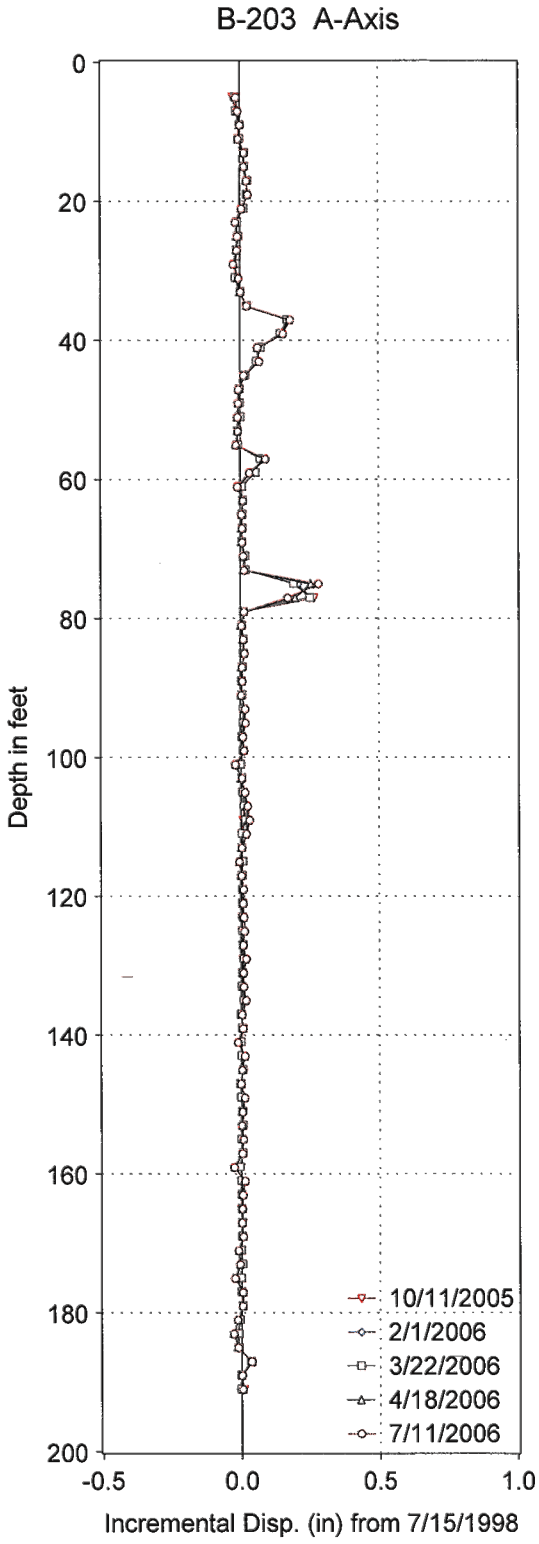




B-107
-Includes readings from the last four quarters (and in March).

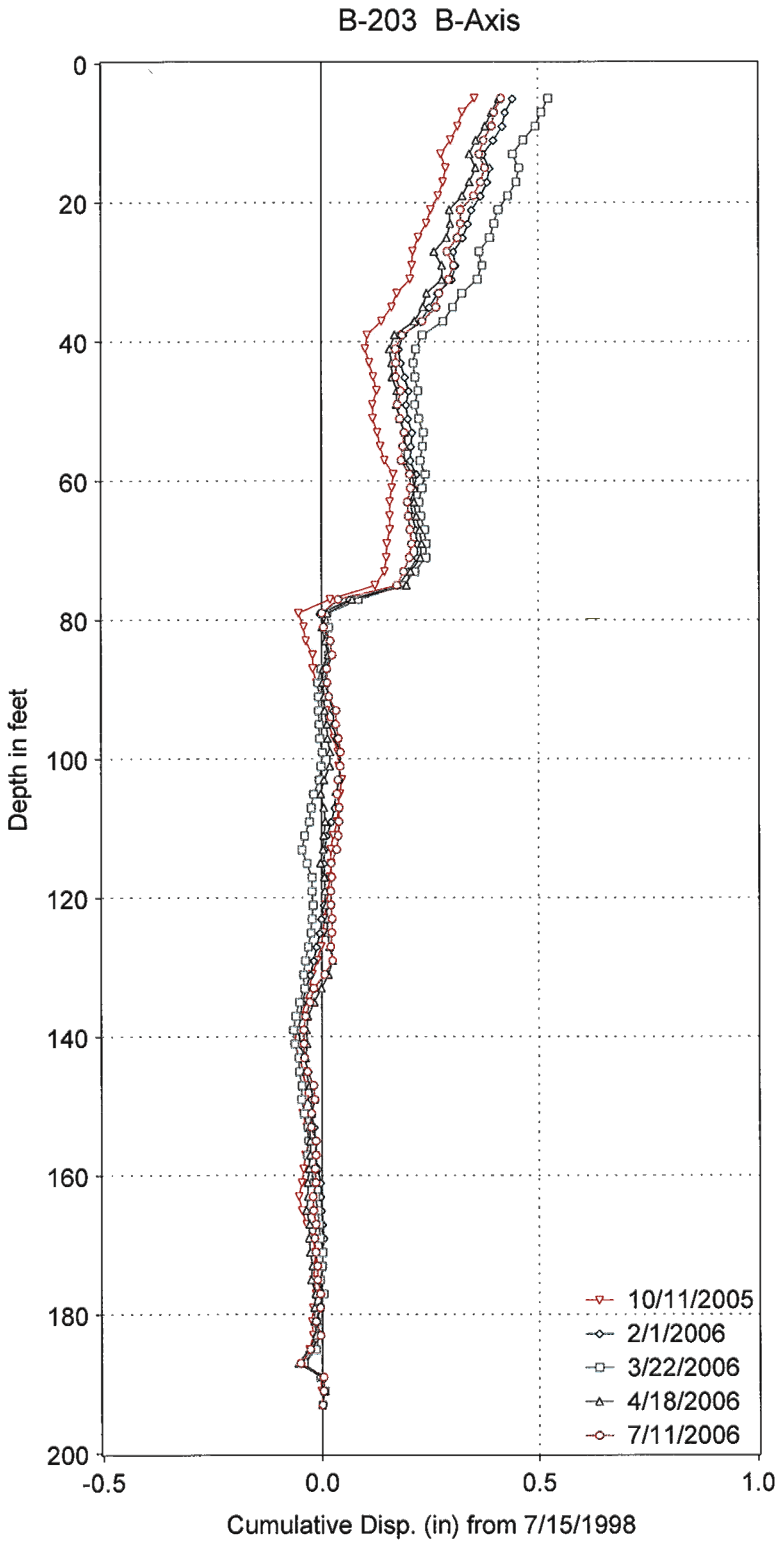
PLATE 8

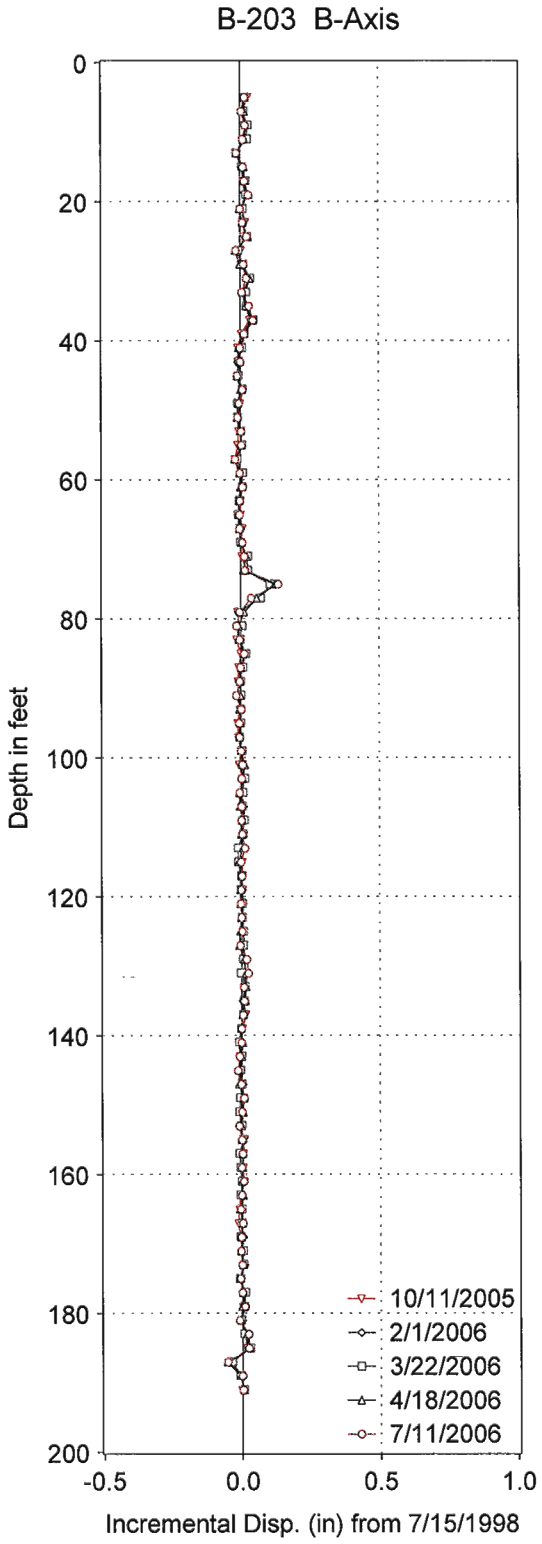




B-203
-Includes readings from the last four quarters (and in March).

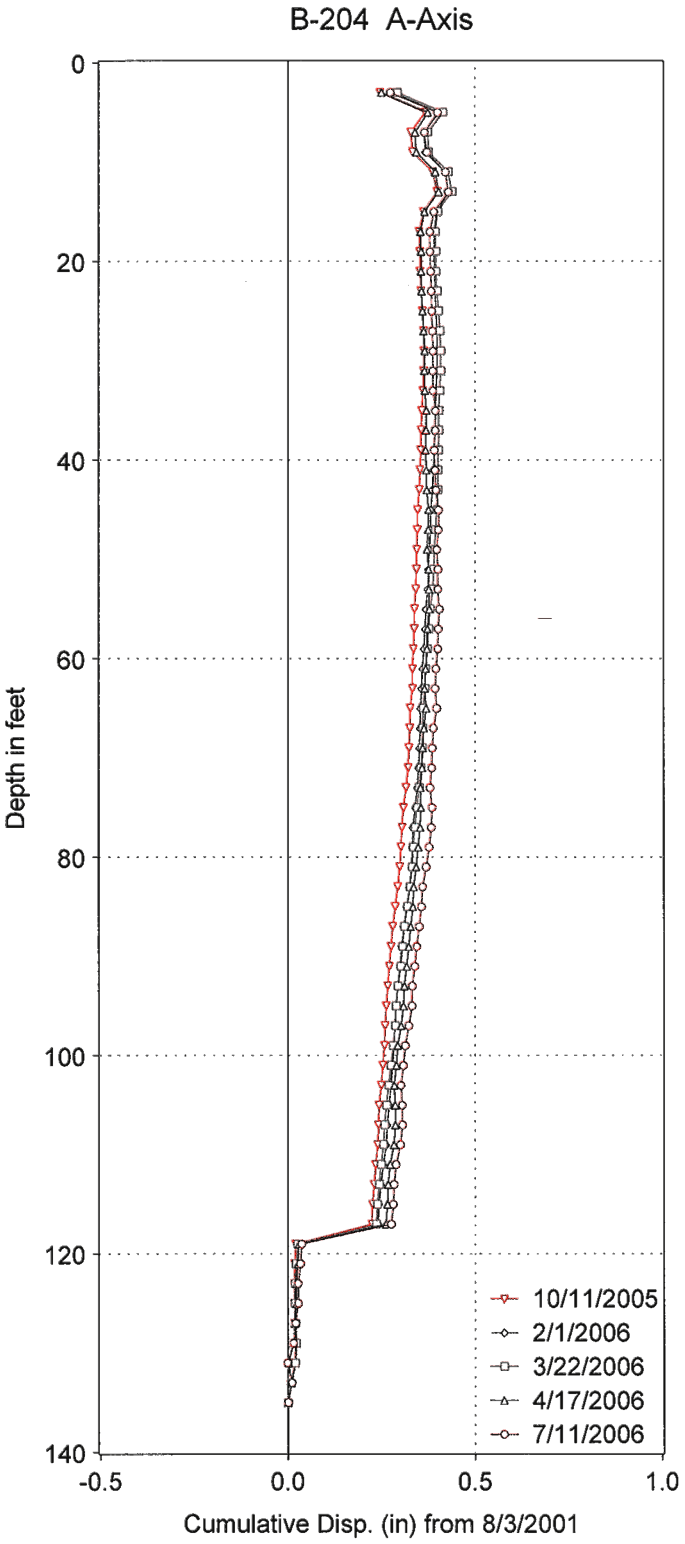
PLATE 9

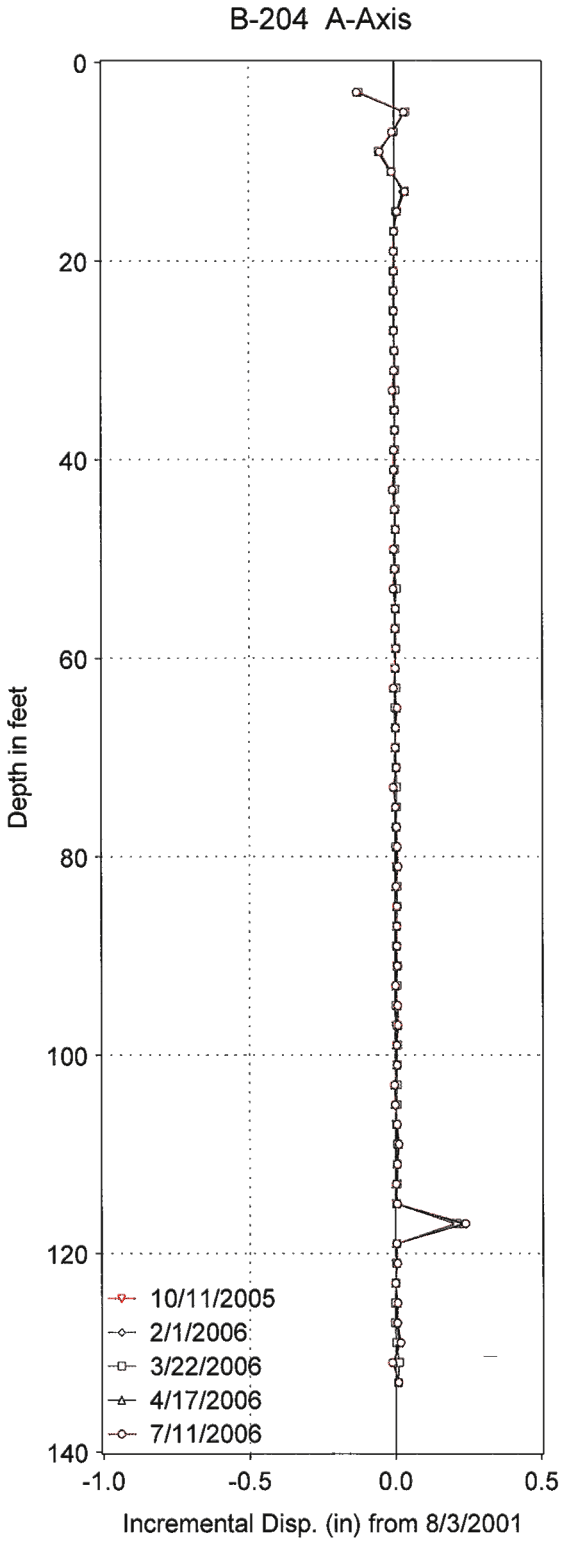




B-203
-Includes readings from the last four quarters (and in March).

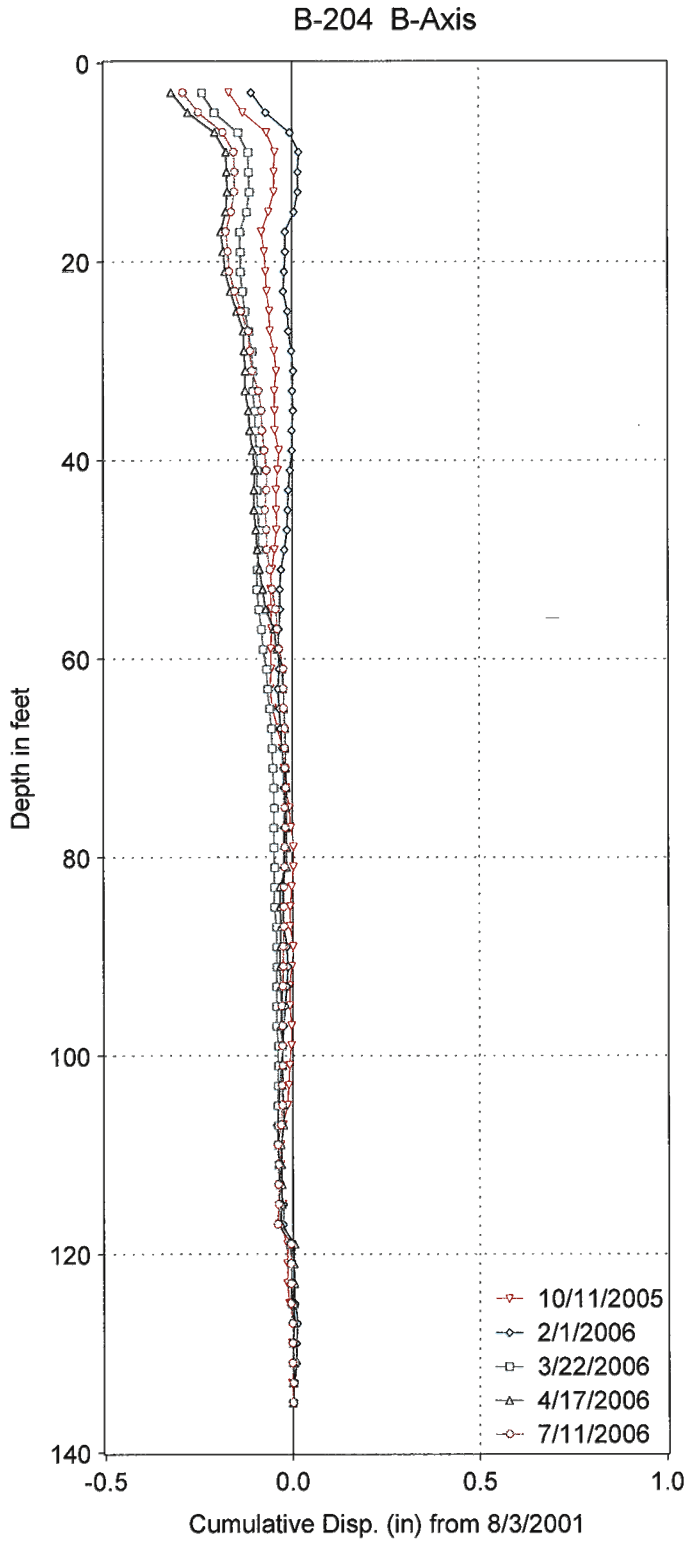
PLATE 10

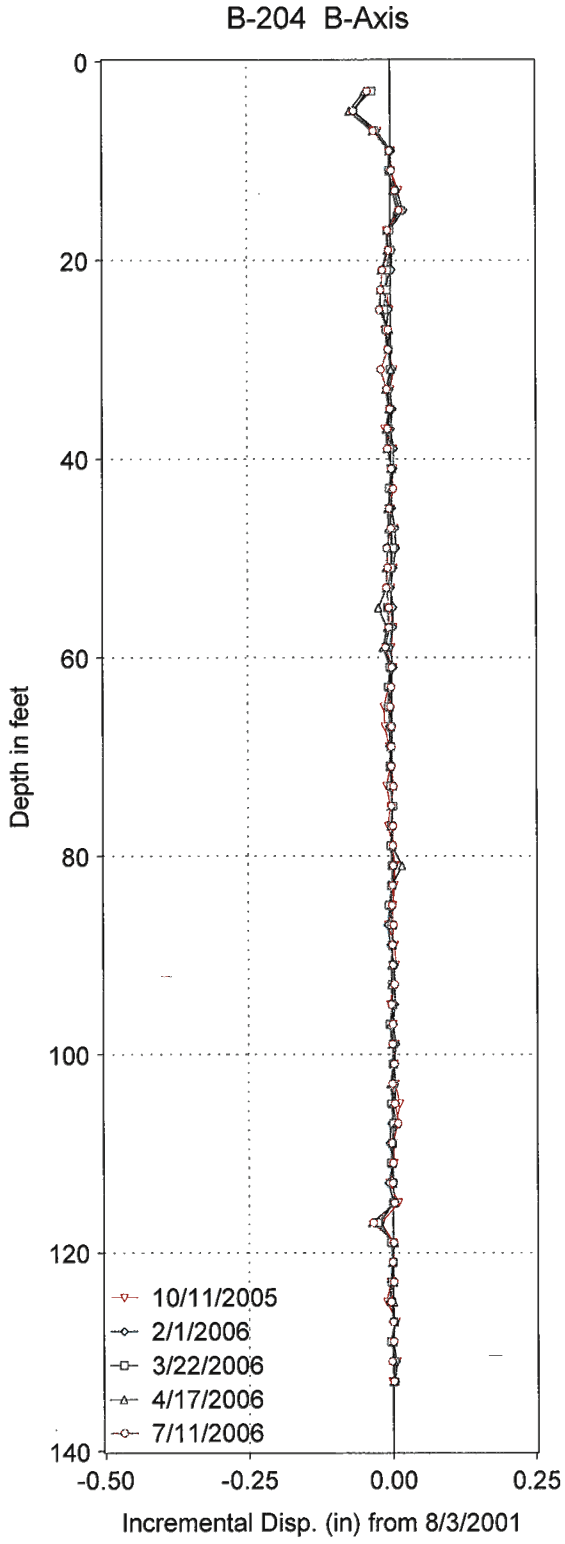




B-204
-Includes readings from the last four quarters (and in March).

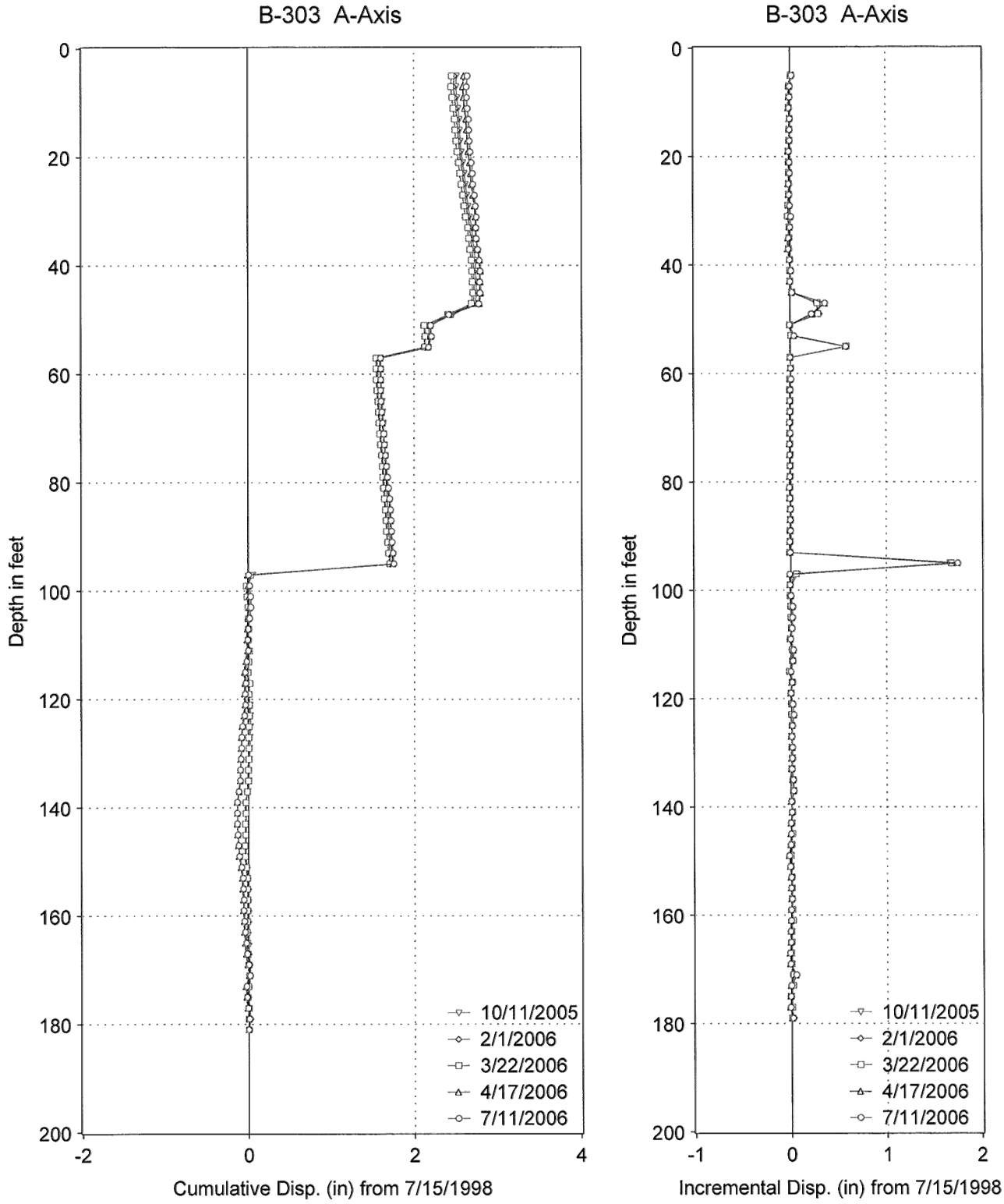
PLATE 11





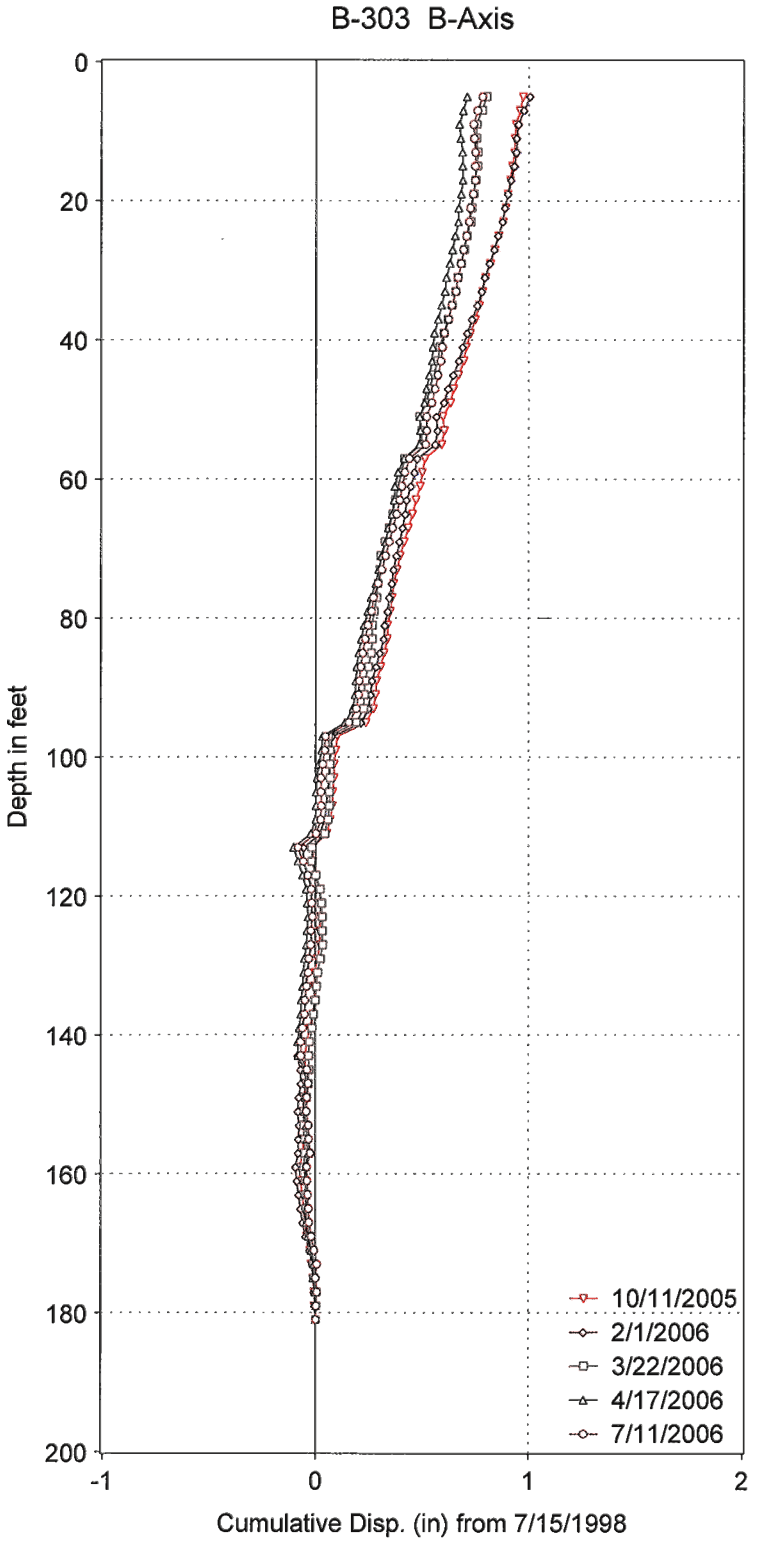
B-204
-Includes readings from the last four quarters (and in March).

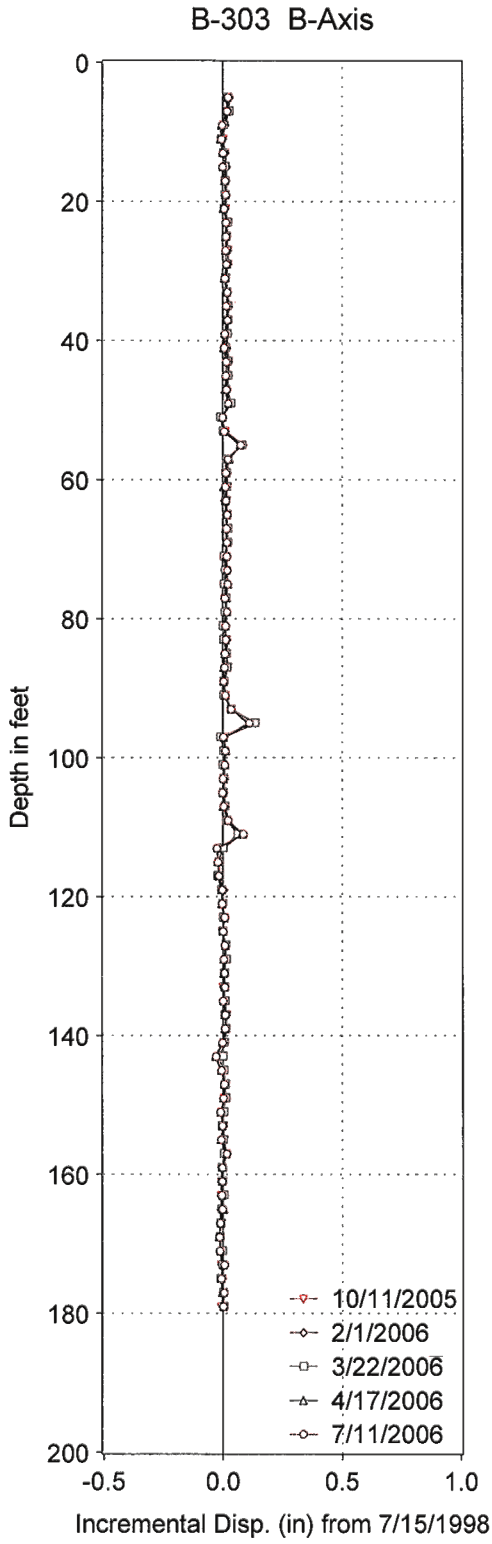
PLATE 12



B-303
-Includes readings from the last four quarters (and in March).

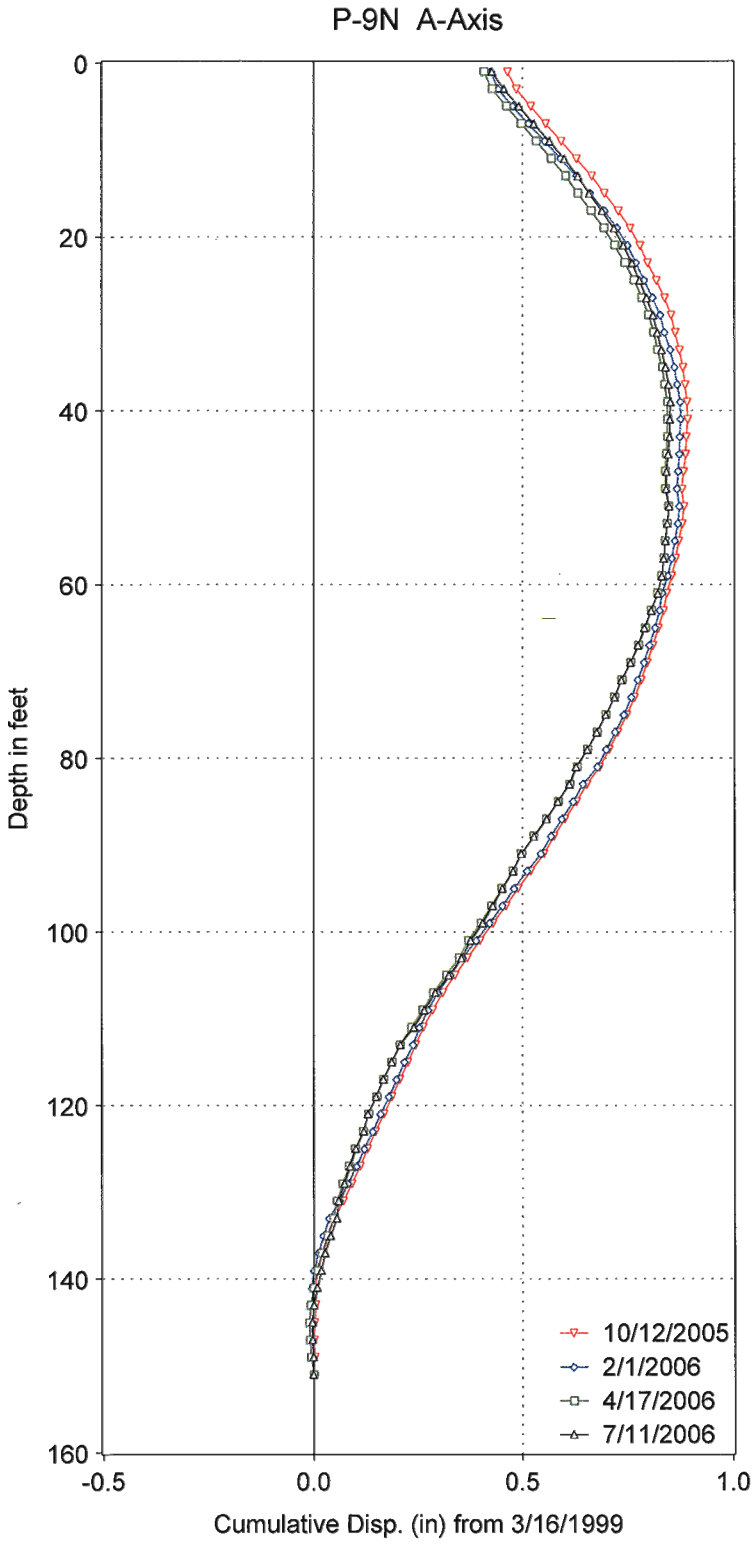
PLATE 13

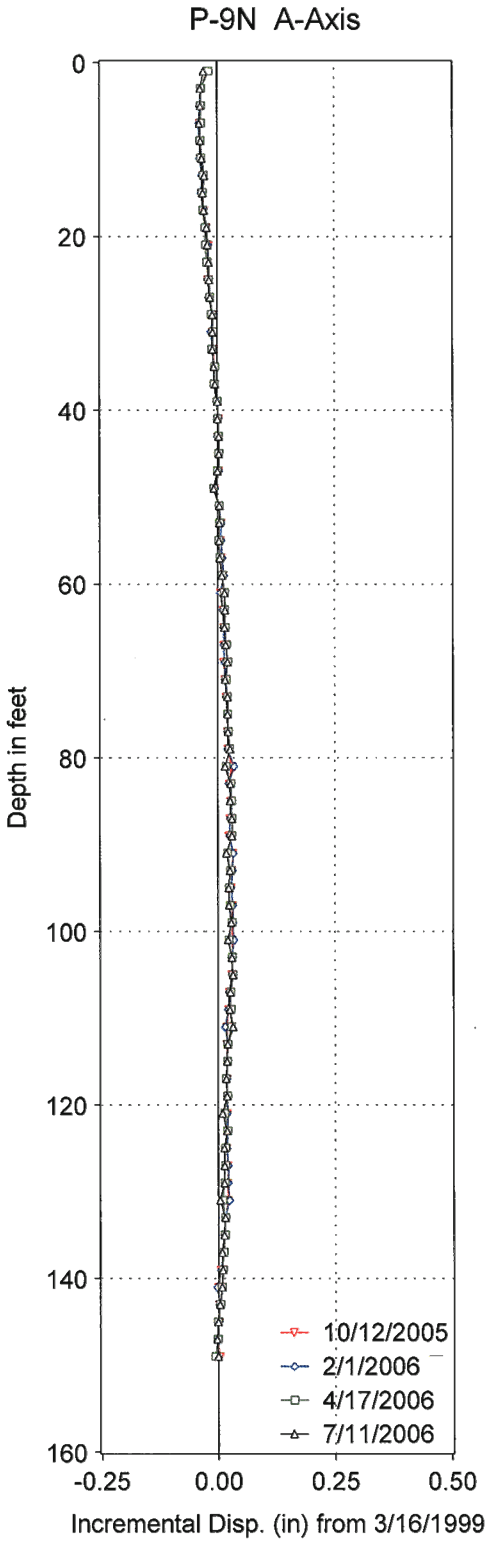




B-303
-Includes readings from the last four quarters (and in March).

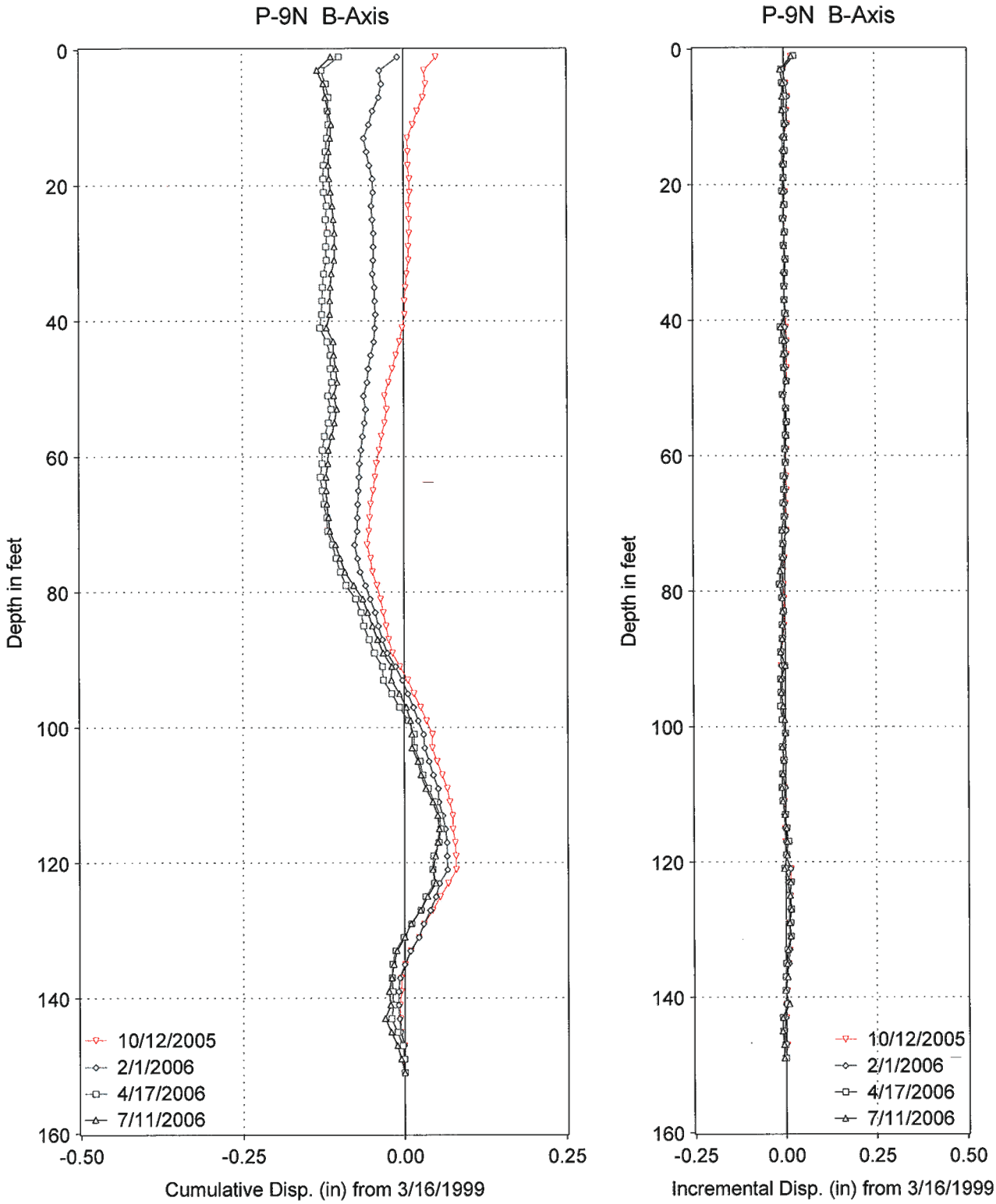
PLATE 14





P-9N
-Includes readings from the last four quarters.

PLATE 15



P-9N
-Includes readings from the last four quarters.

PLATE 16

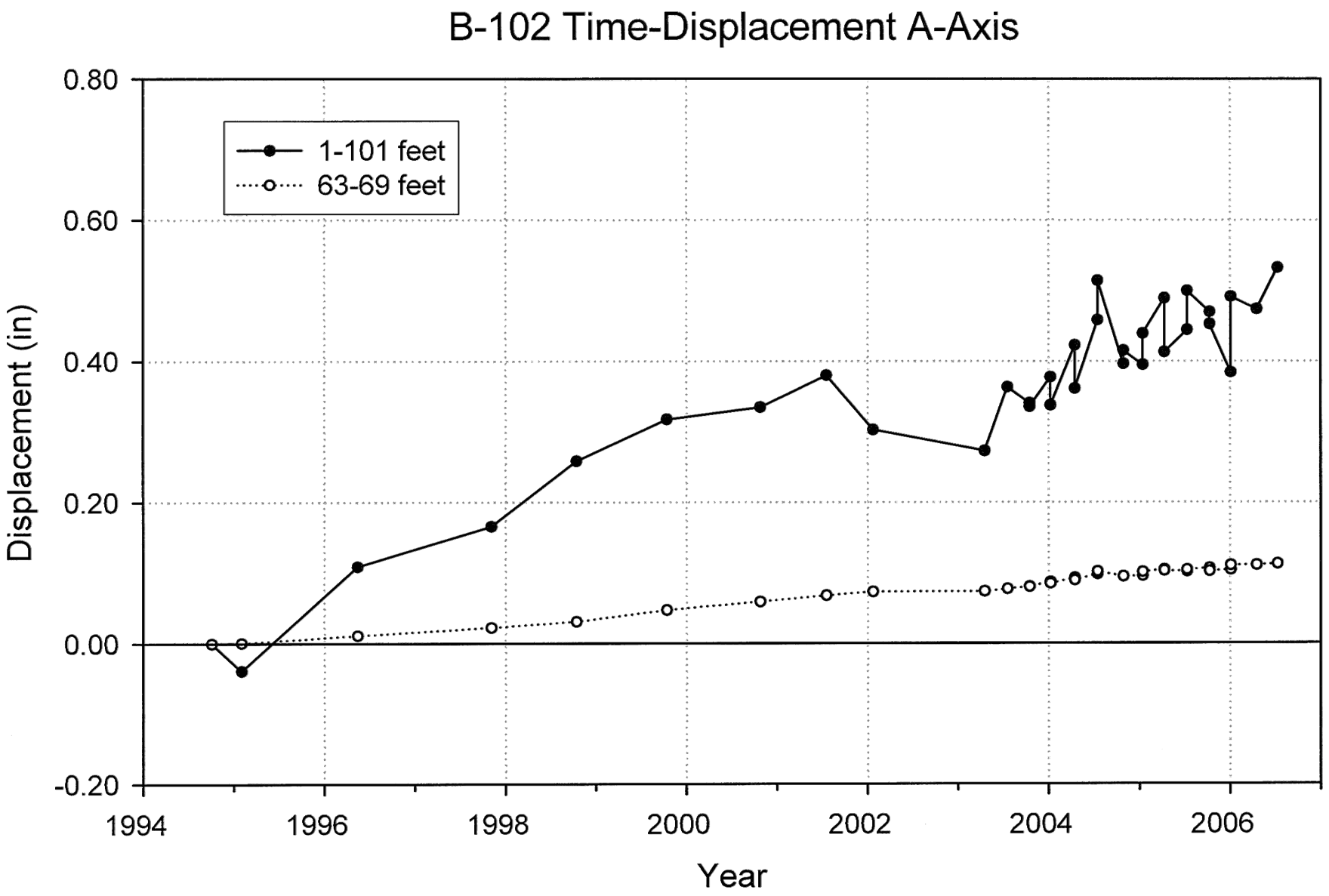

B-102 Time-Displacement A-Axis
1-101 feet
63-69 feet
Displacement (in)
0.80
0.60
0.40
0.20
0.00
-0.20
1994
1996
1998
2000
2002
2004
2006
Year

PLATE 17

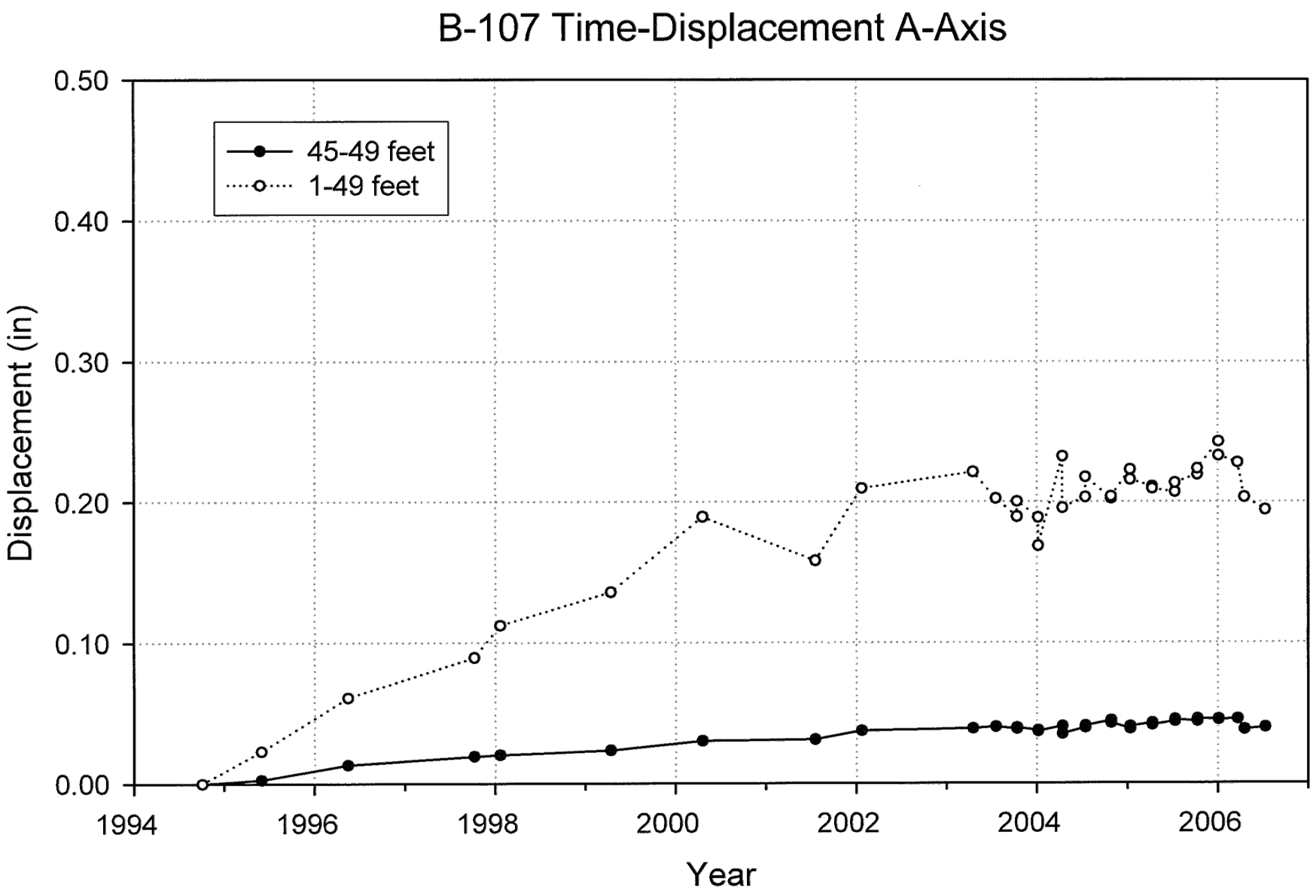

B-107 Time-Displacement A-Axis
45-49 feet
1-49 feet
Displacement (in)
0.50
0.40
0.30
0.20
0.10
0.00
1994
1996
1998
2000
2002
2004
2006
Year

PLATE 18

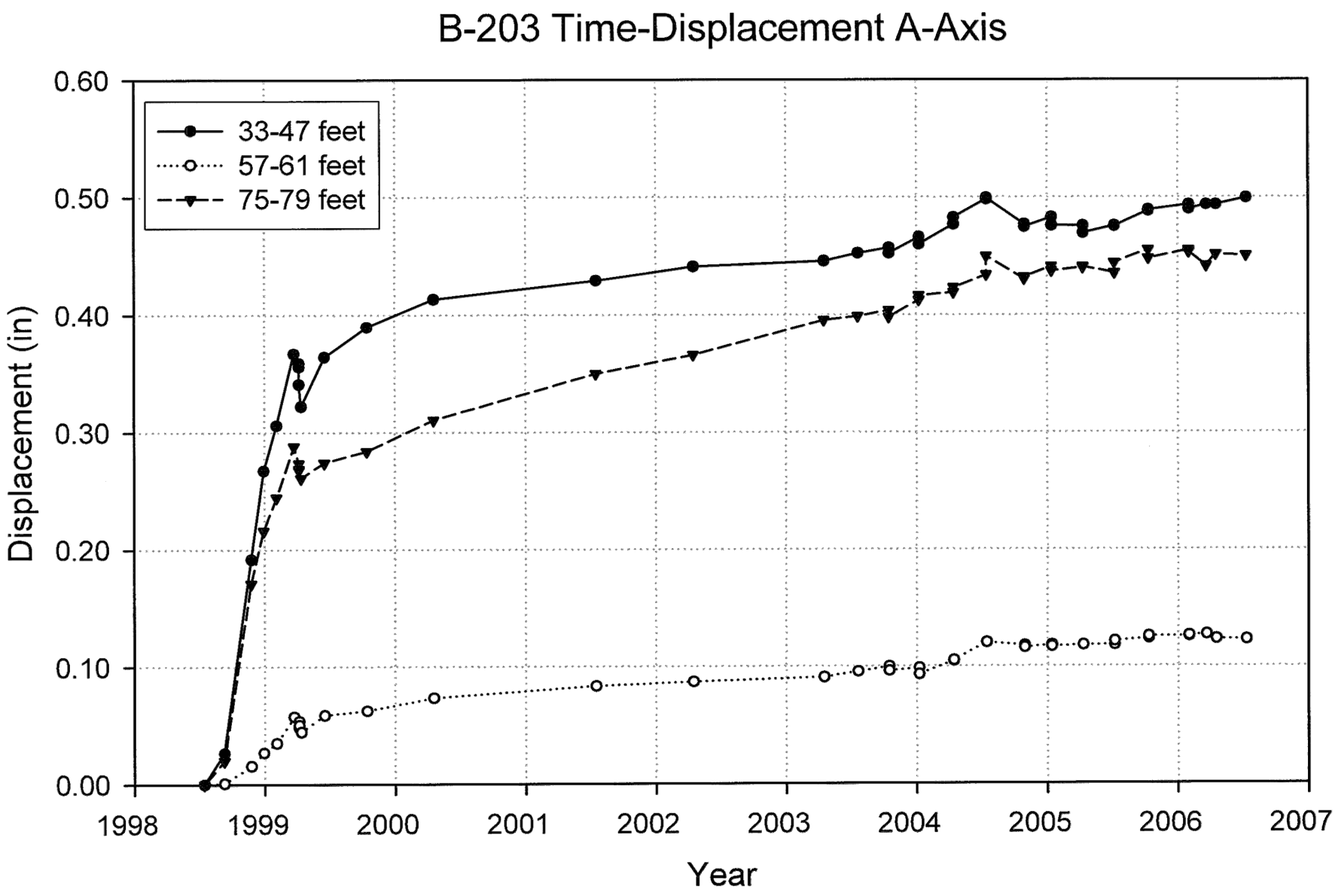

B-203 Time-Displacement A-Axis
33-47 feet
57-61 feet
75-79 feet
Displacement (in)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

PLATE 19

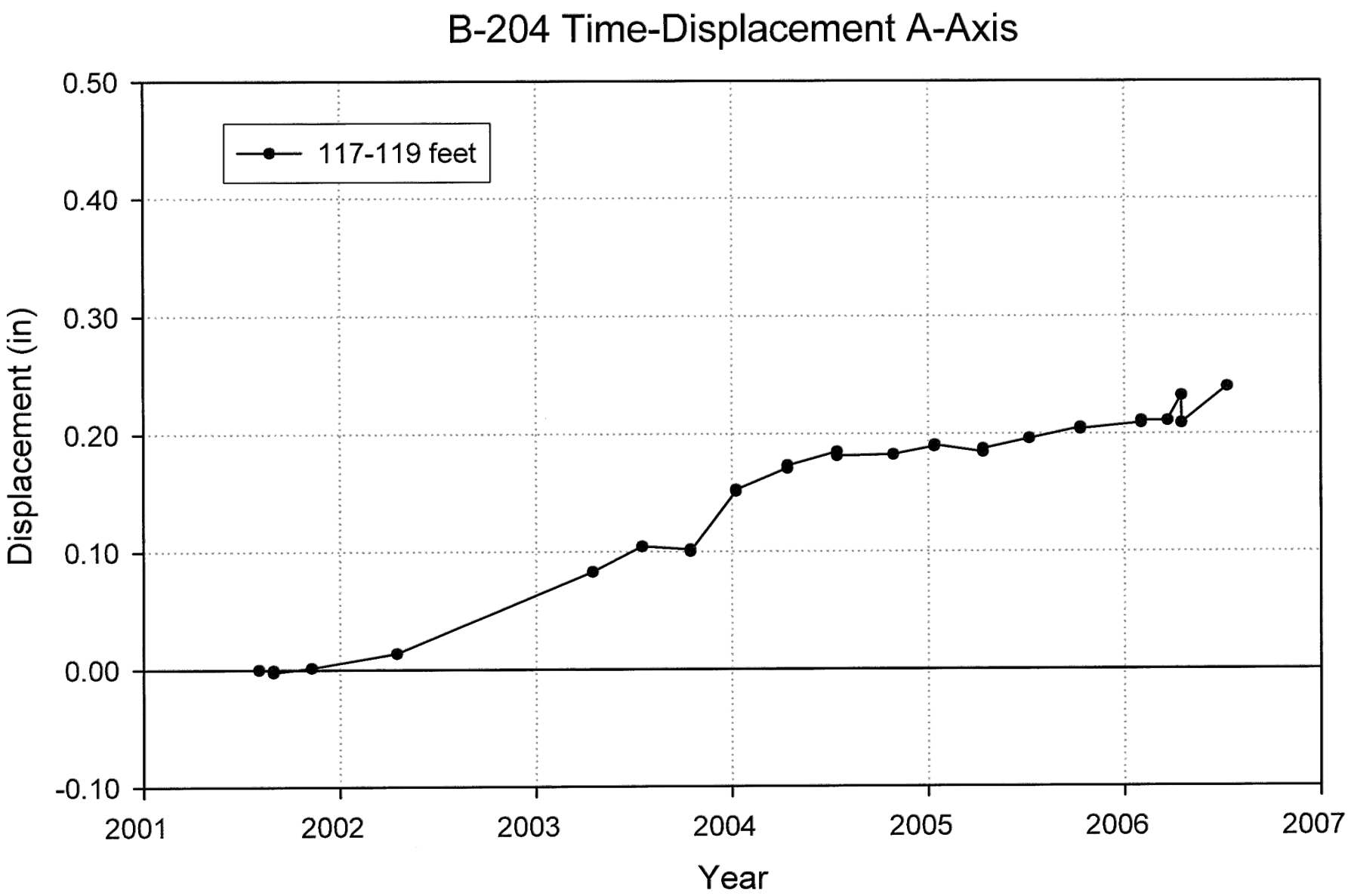

B-204 Time-Displacement A-Axis
117-119 feet
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
Displacement (in)
2001
2002
2003
2004
2005
2006
2007
Year

PLATE 20

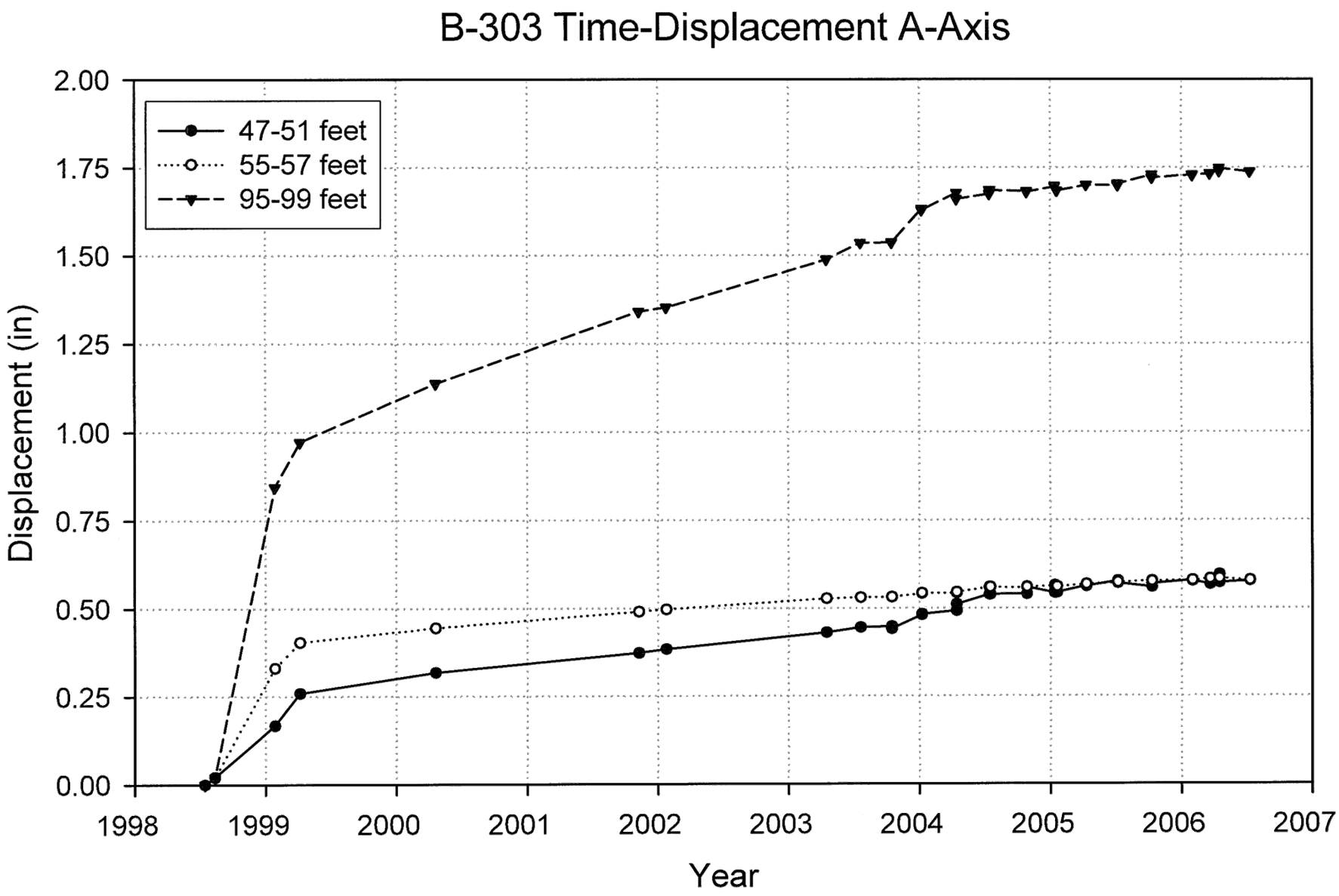
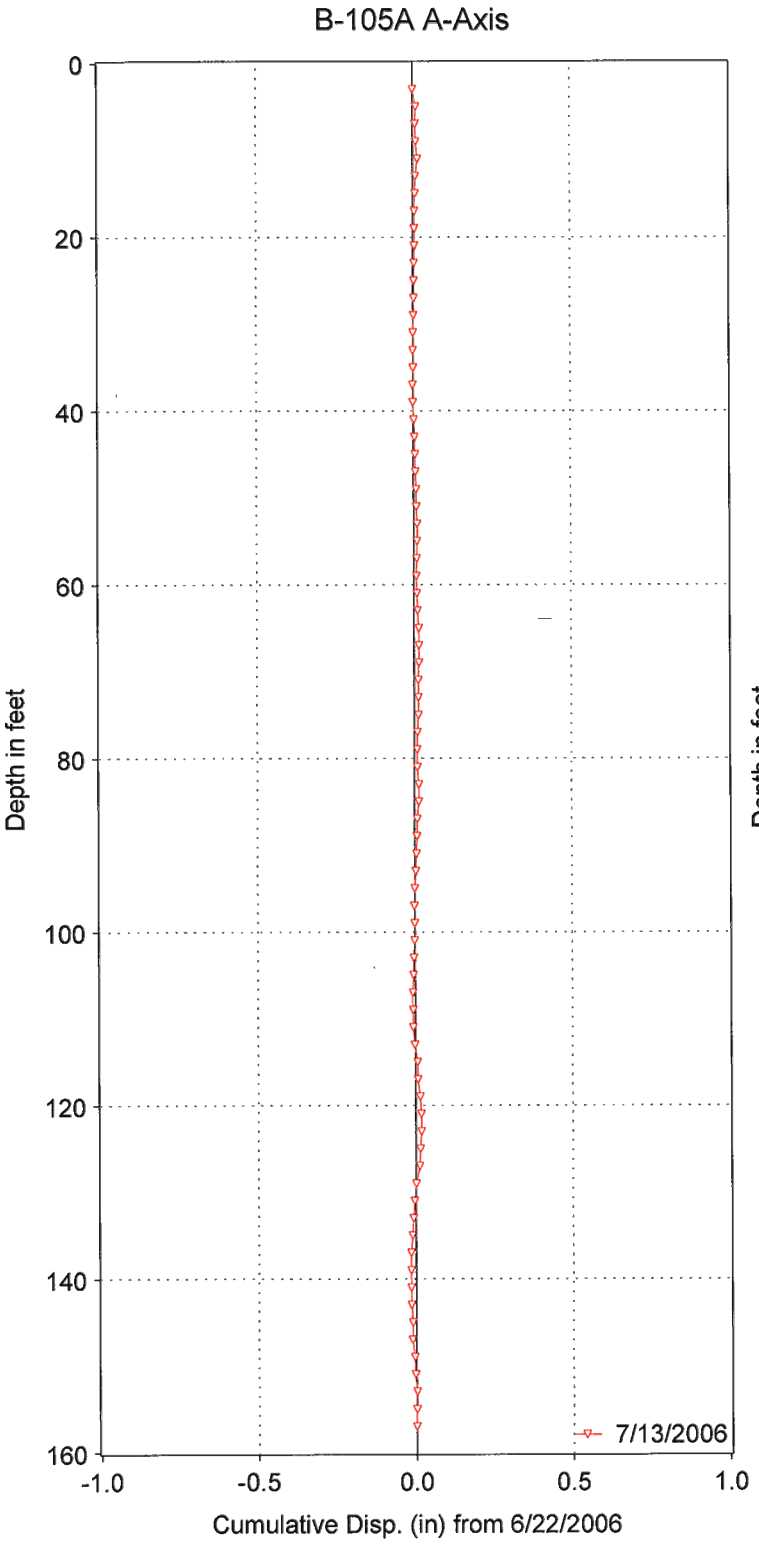
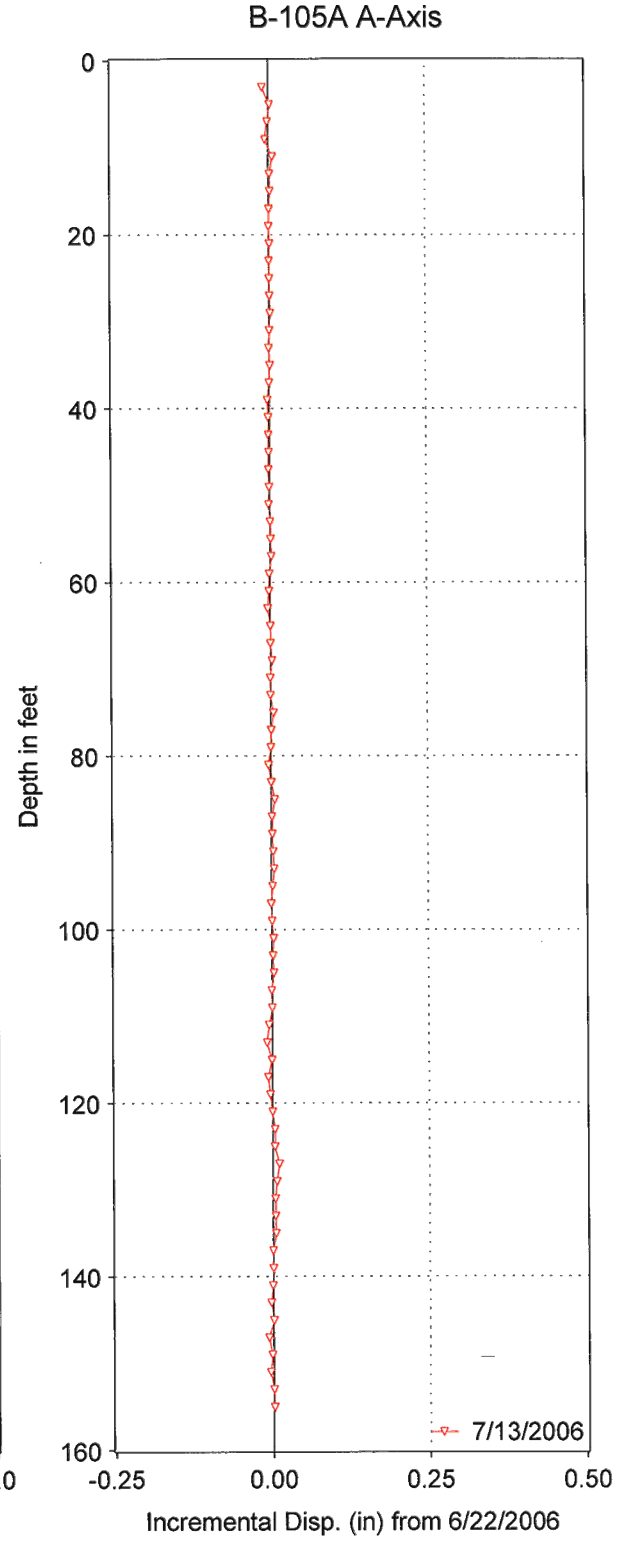

B-303 Time-Displacement A-Axis
47-51 feet
55-57 feet
95-99 feet
Displacement (in)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

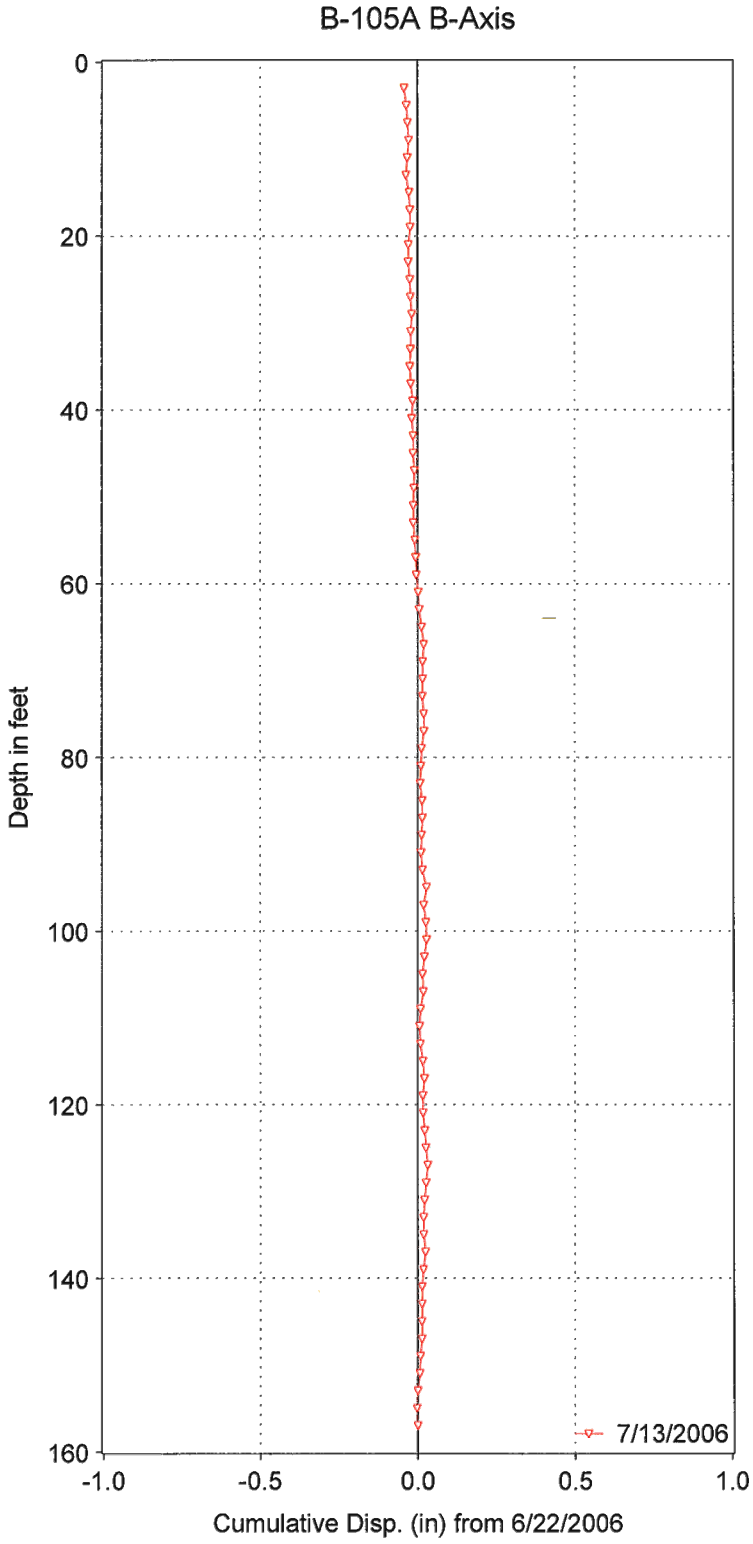
PLATE 21

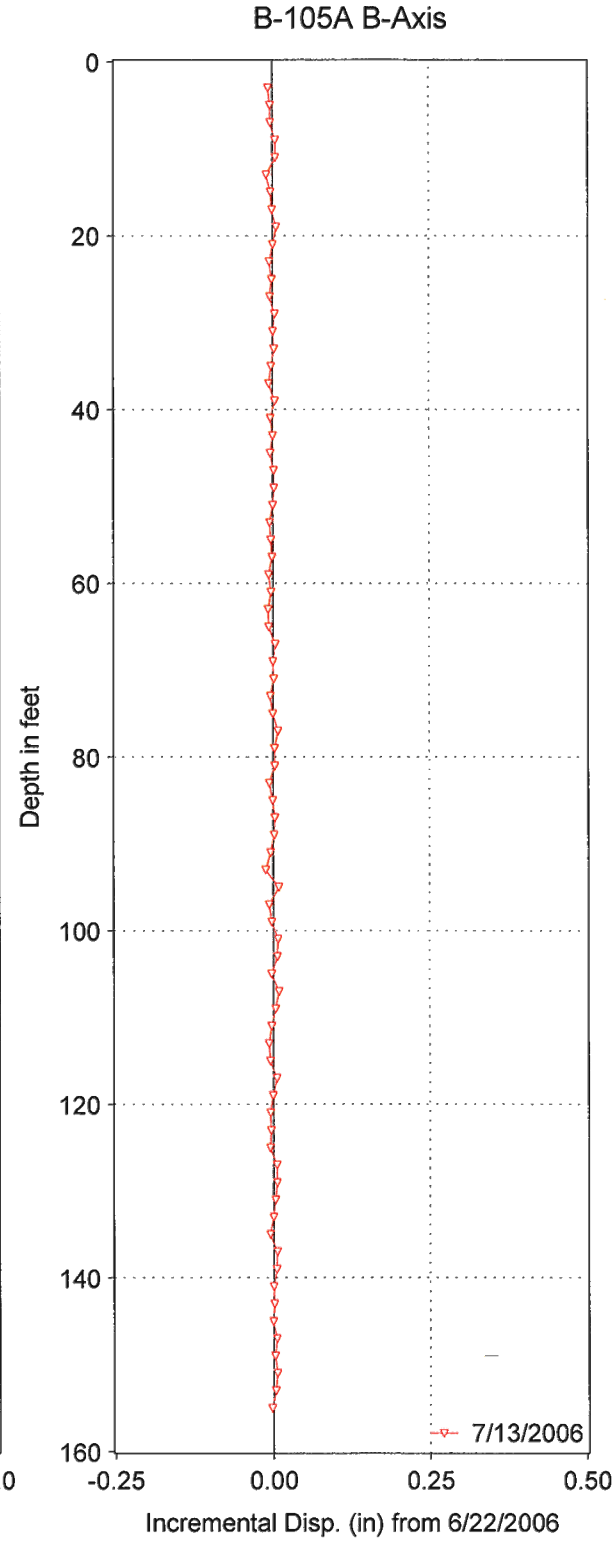




B-105A

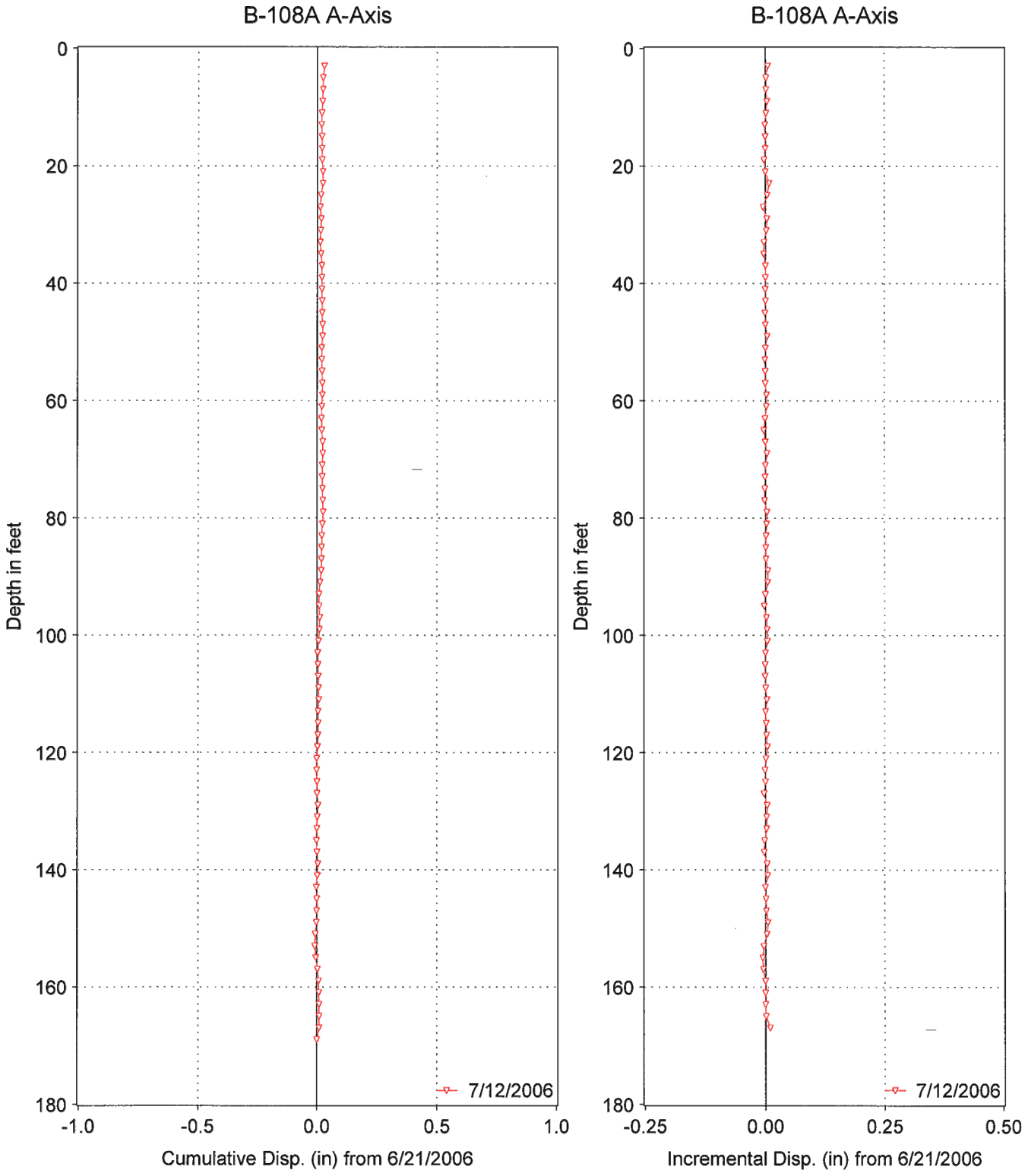
PLATE 22





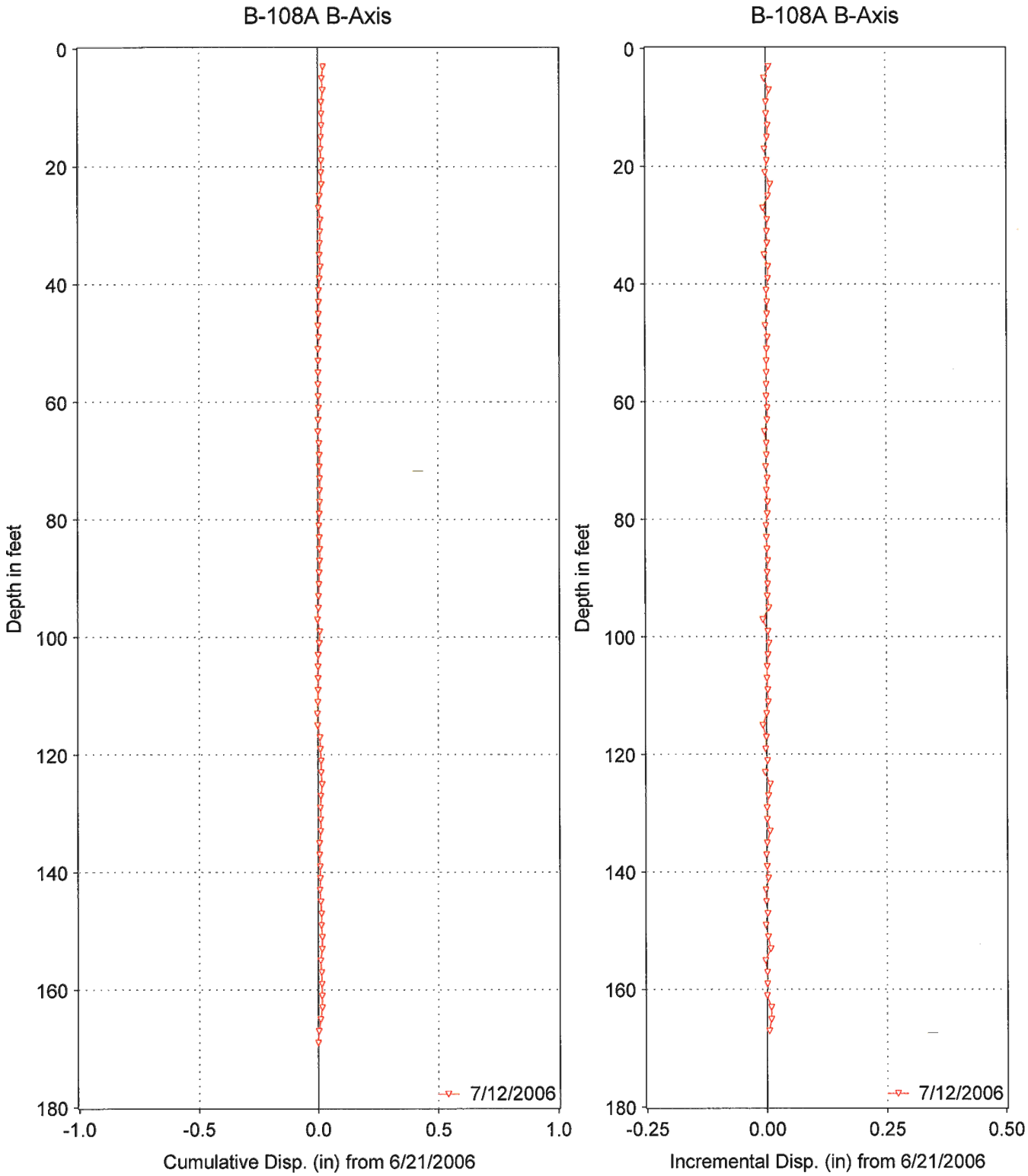
B-105A

PLATE 23



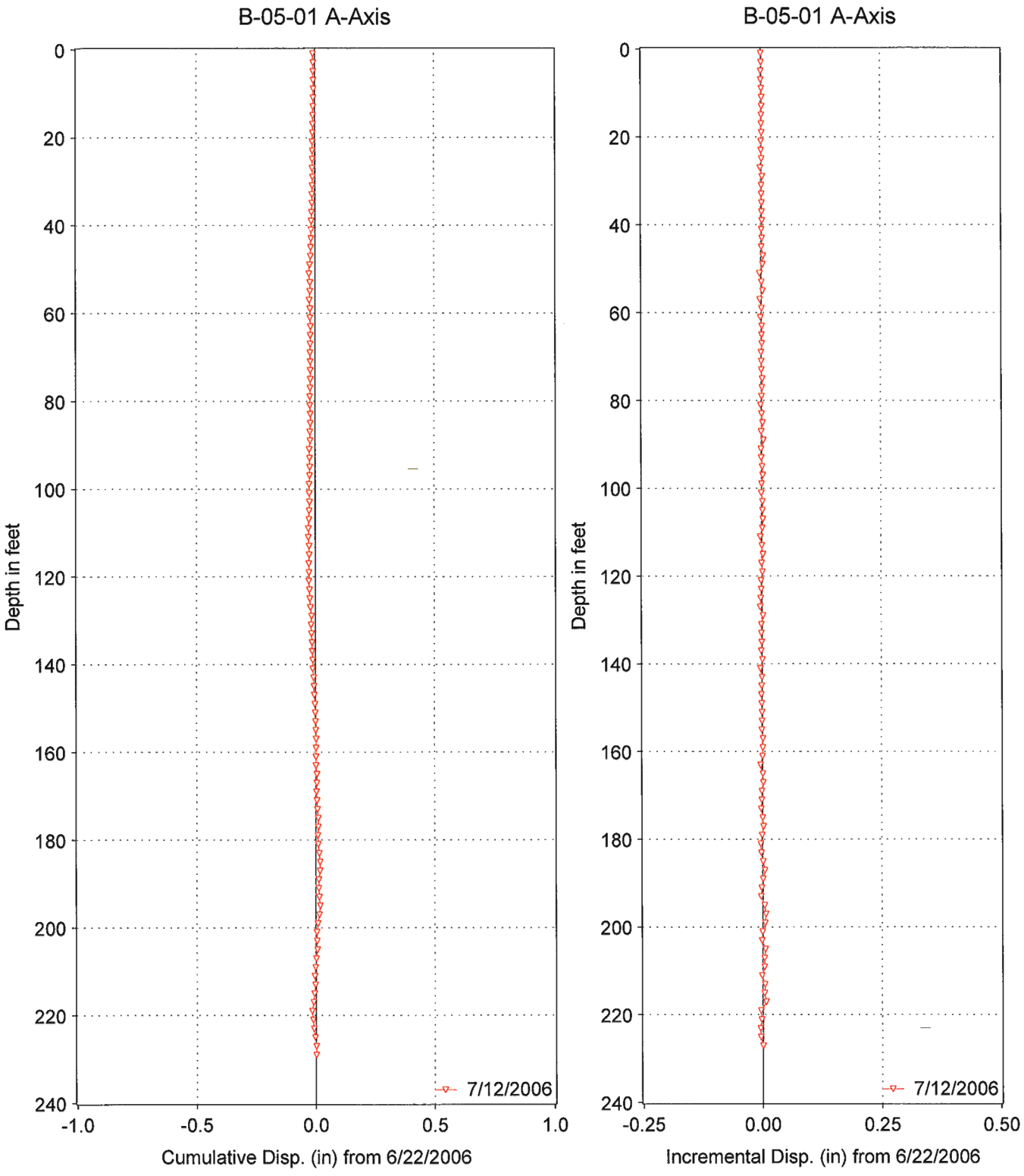
B-108A

PLATE 24



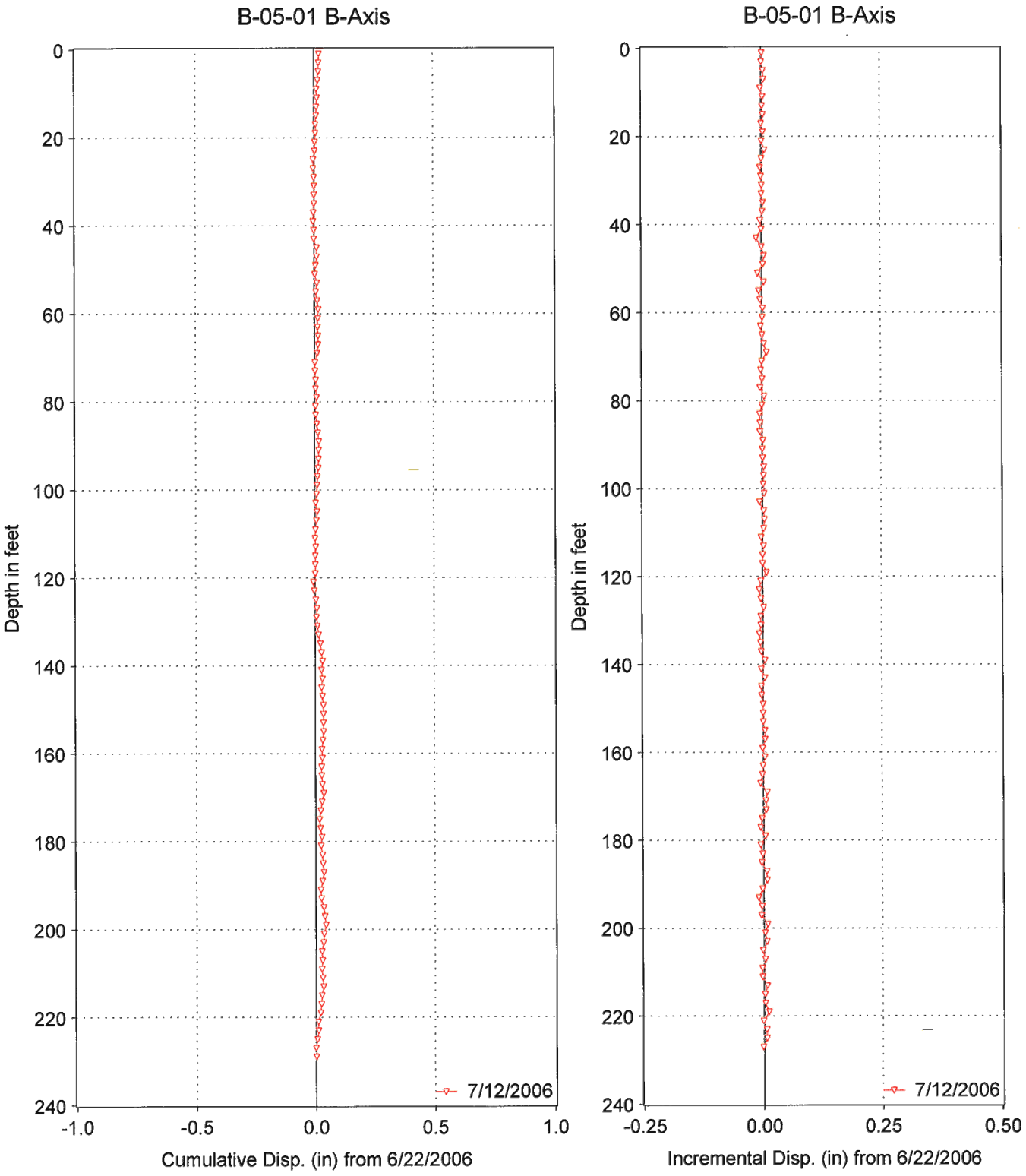
B-108A

PLATE 25



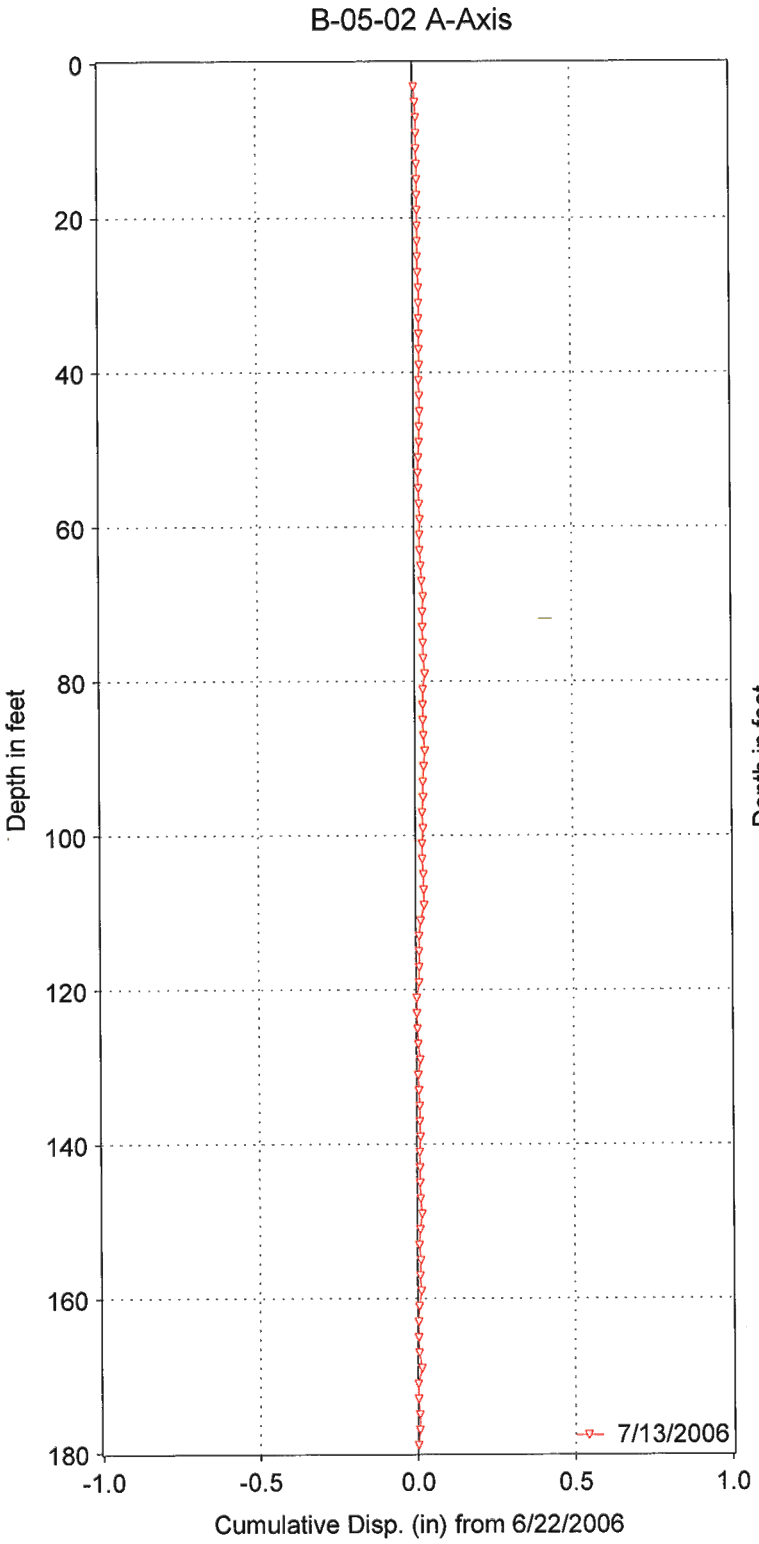
B-05-01

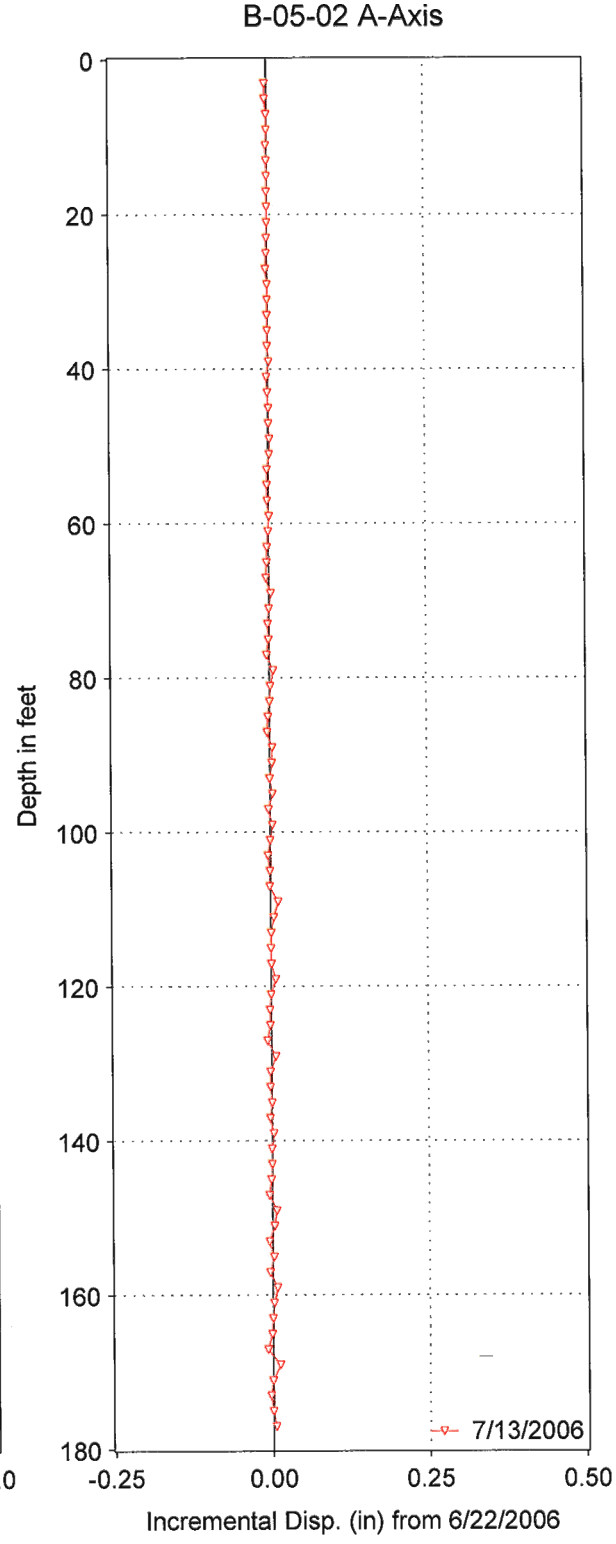
PLATE 26



B-05-01

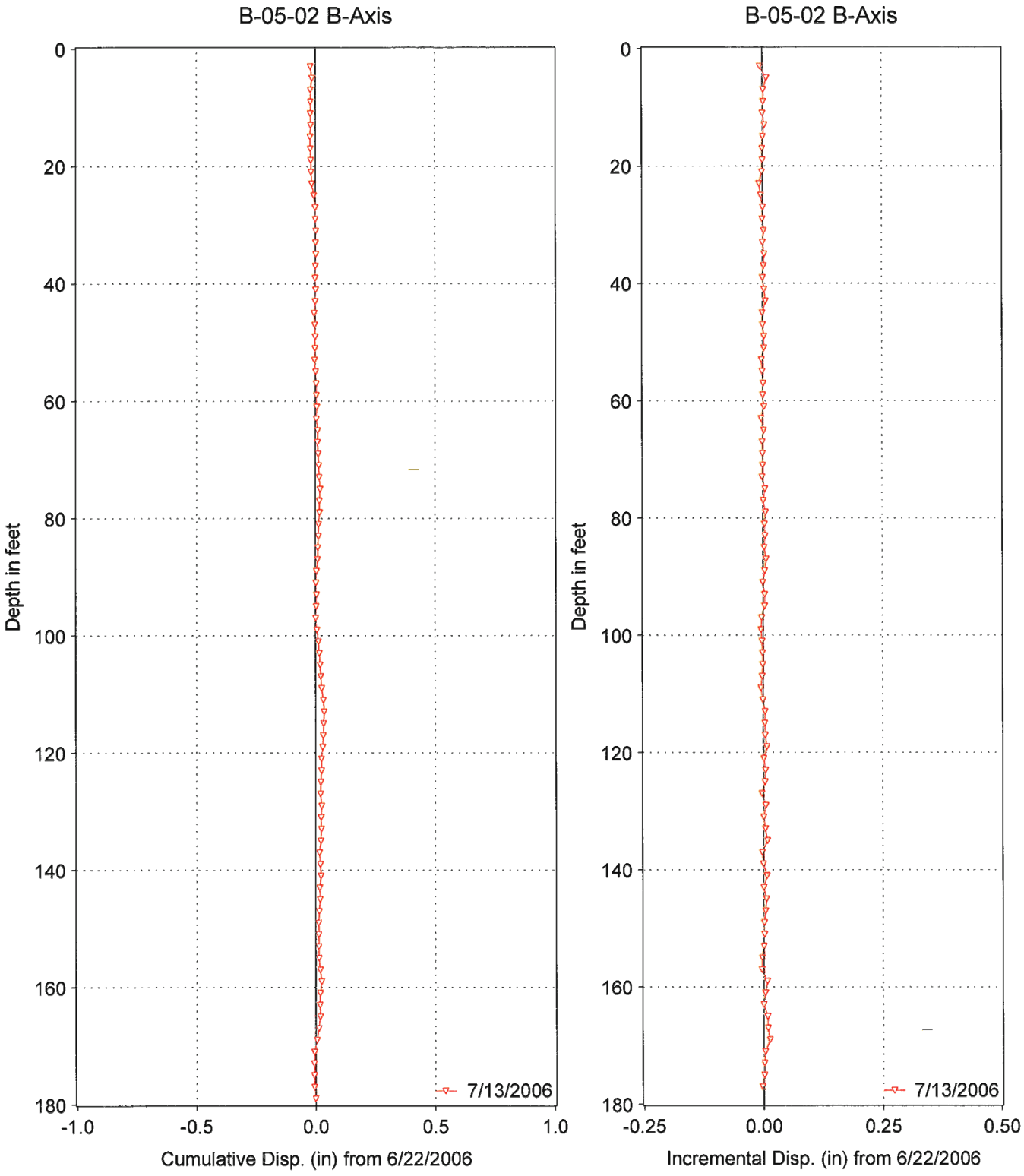
PLATE 27





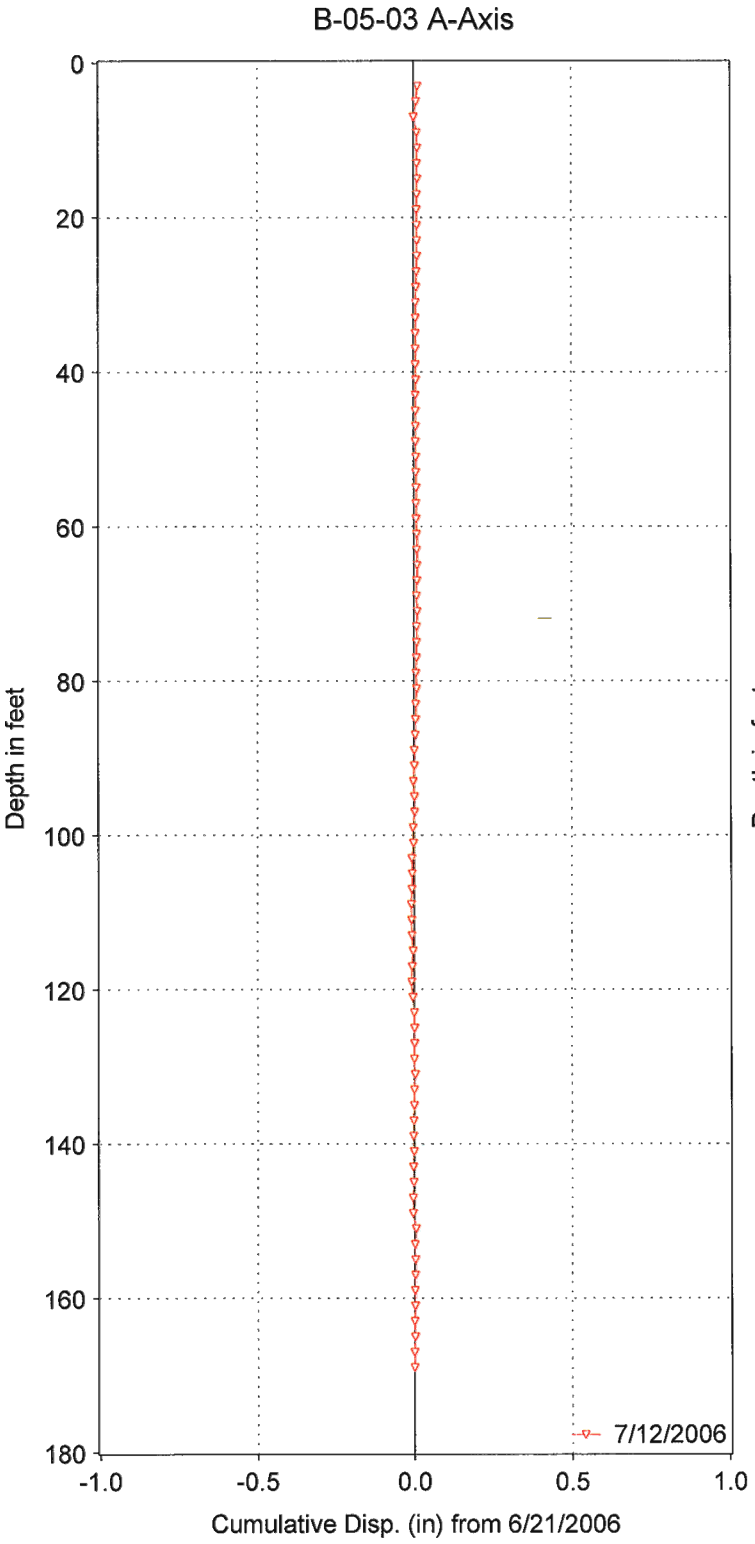
B-05-02

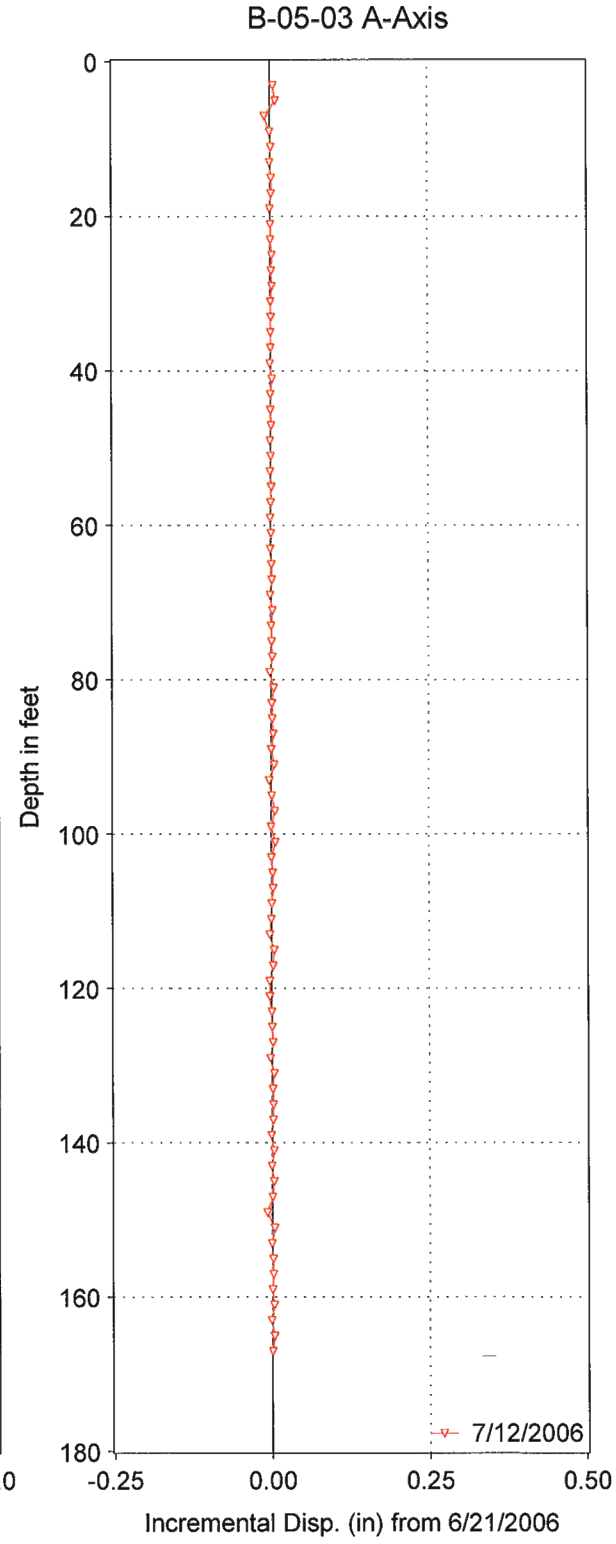
PLATE 28



B-05-02

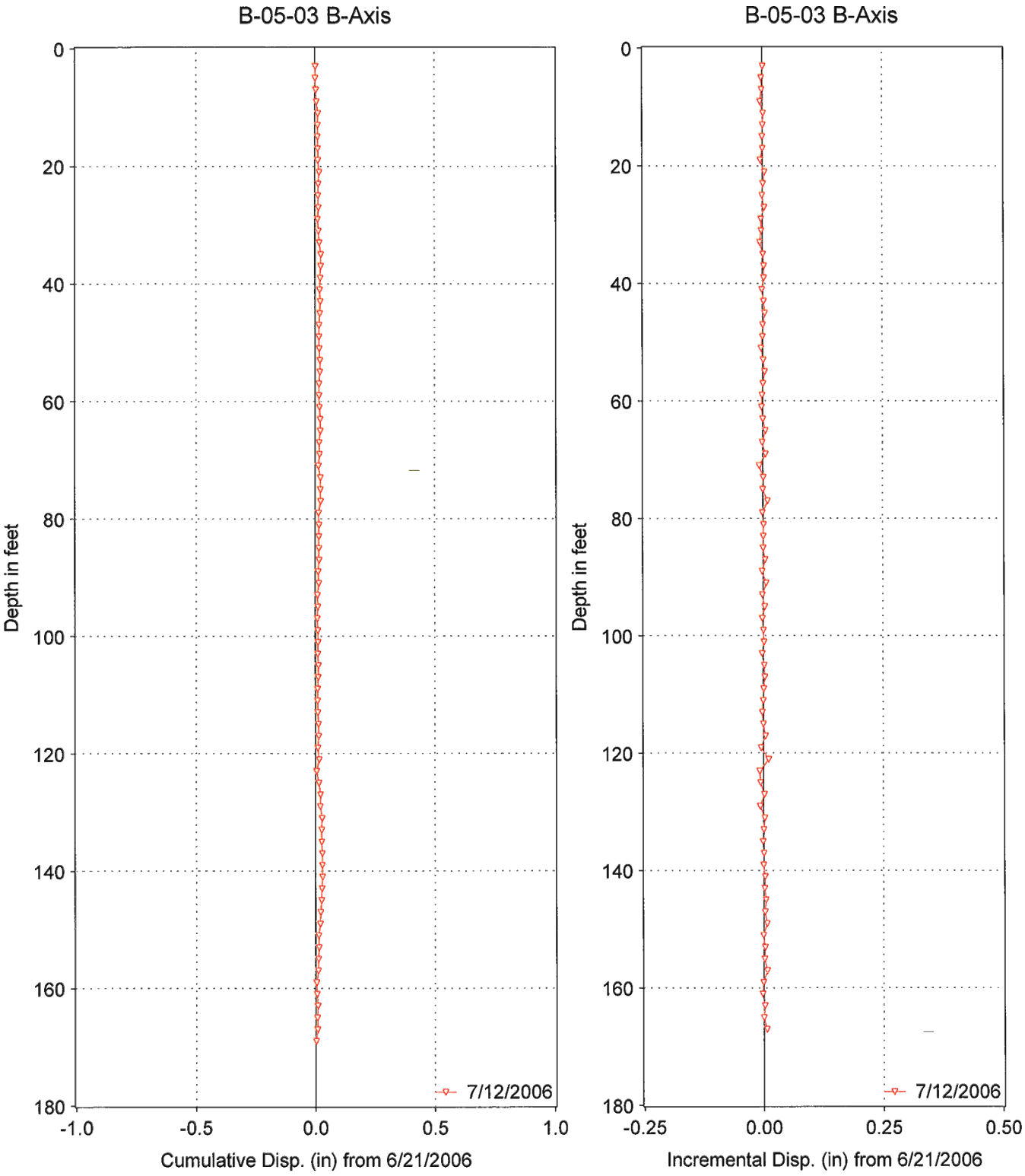
PLATE 29





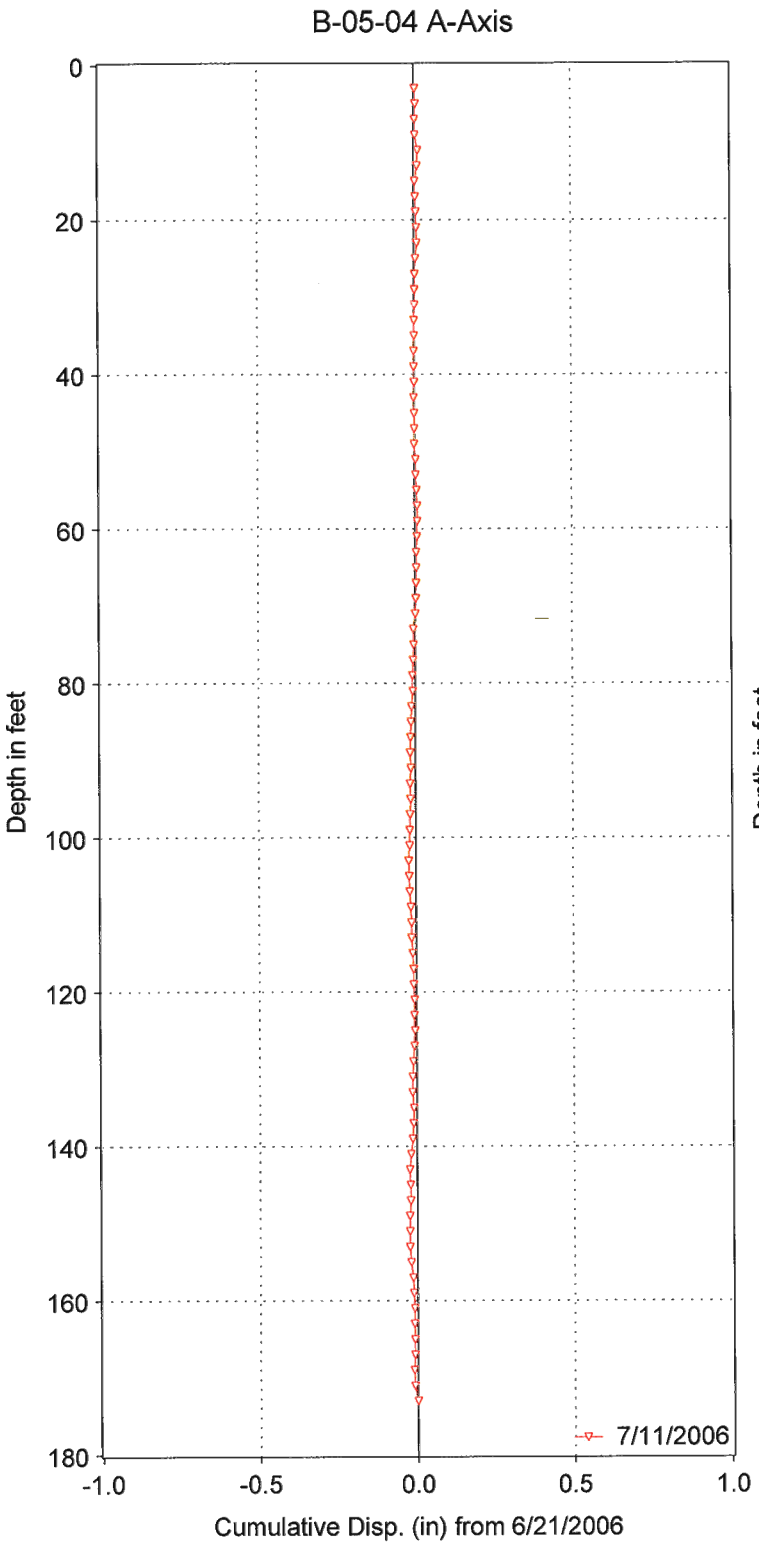
B-05-03

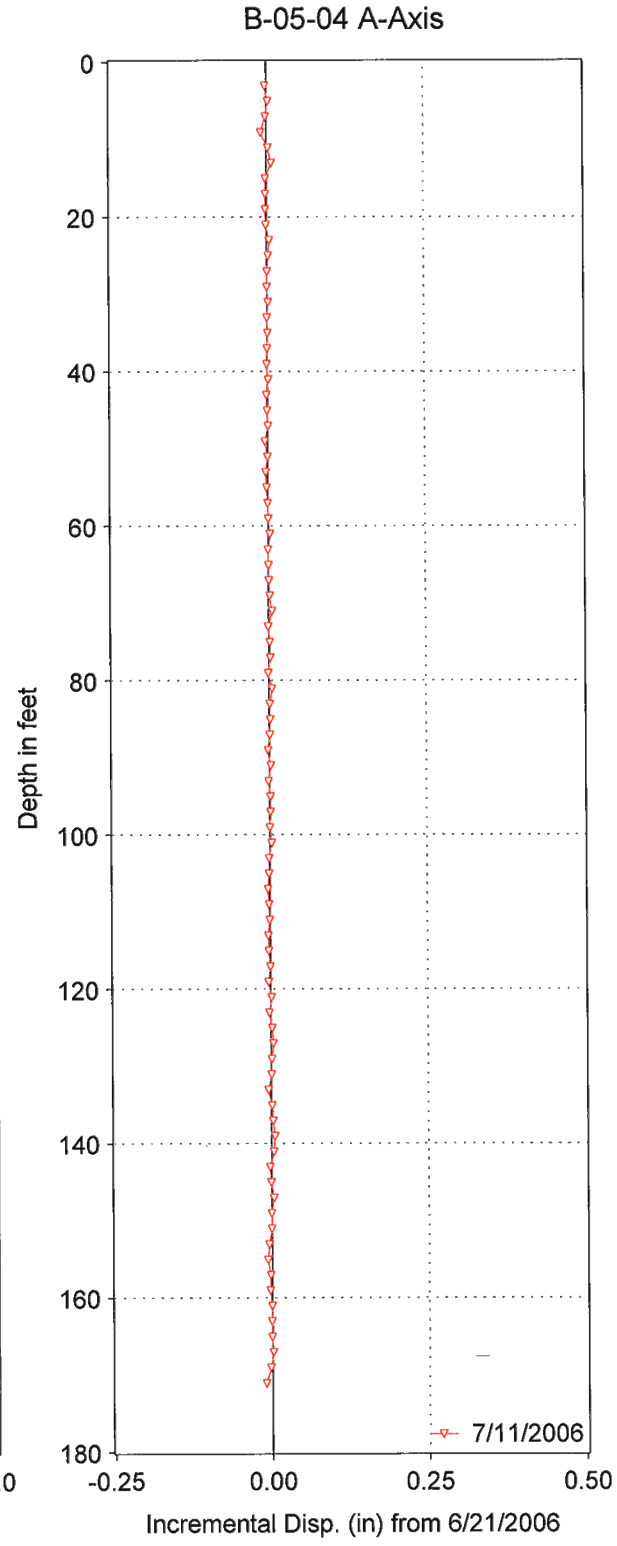
PLATE 30



B-05-03

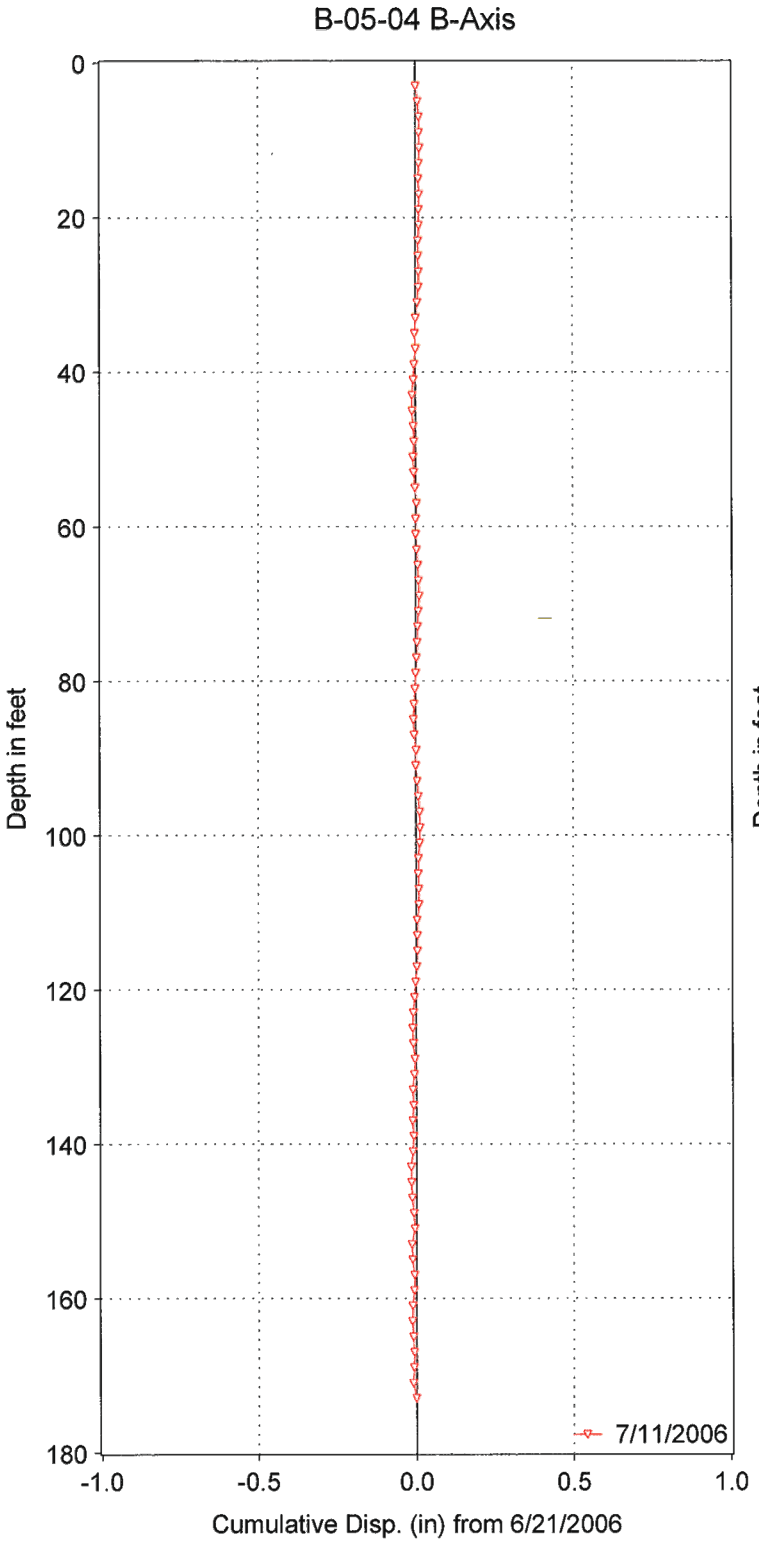
PLATE 31

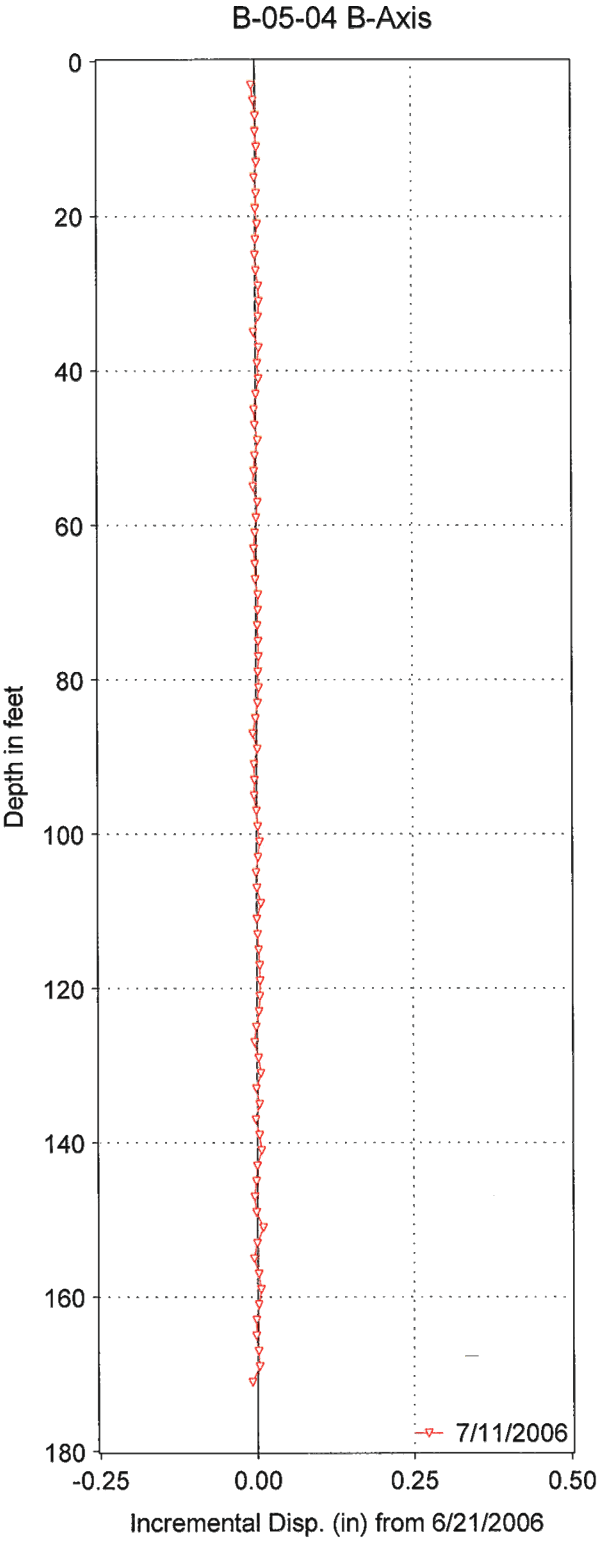




B-05-04

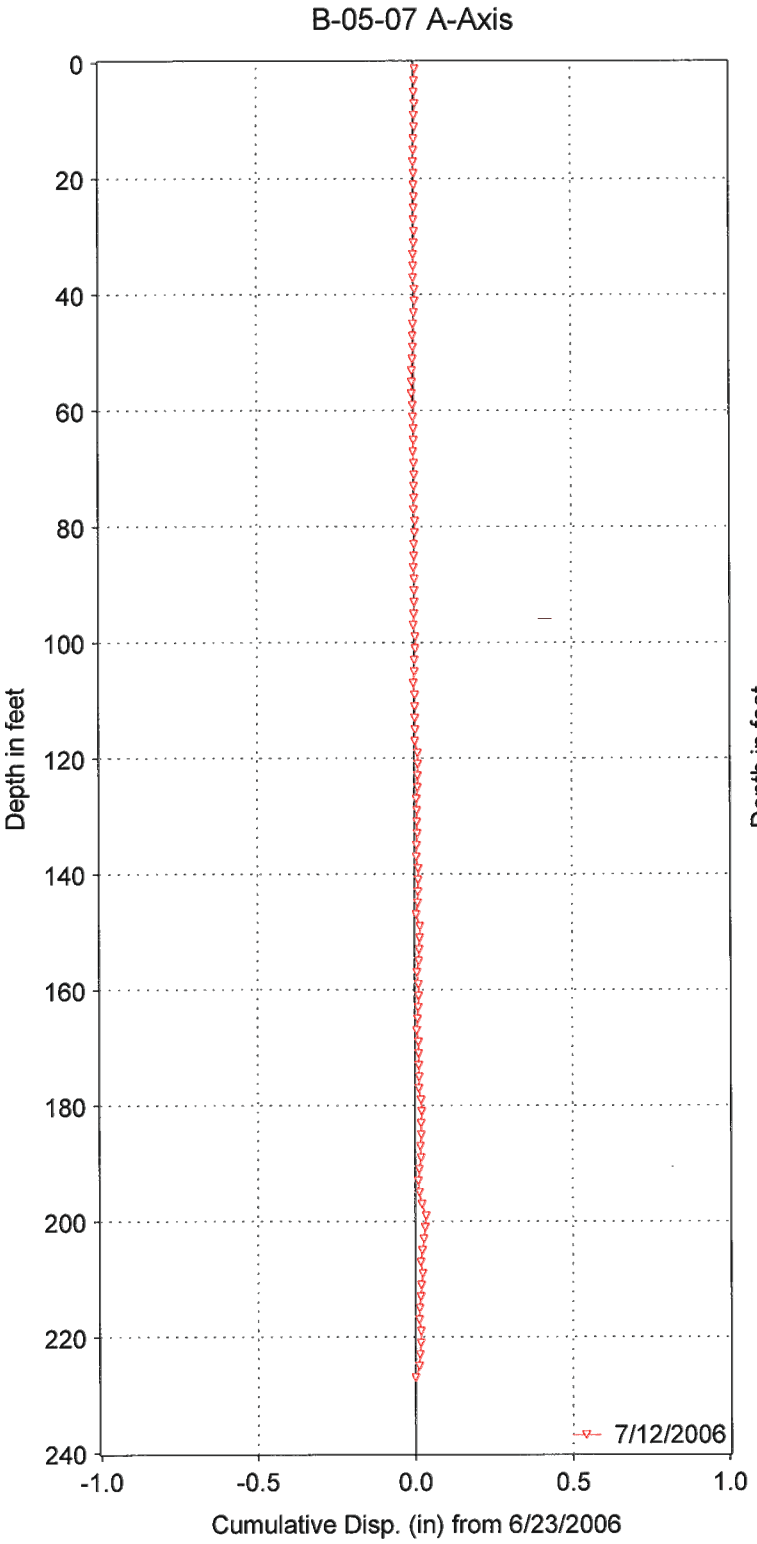
PLATE 32

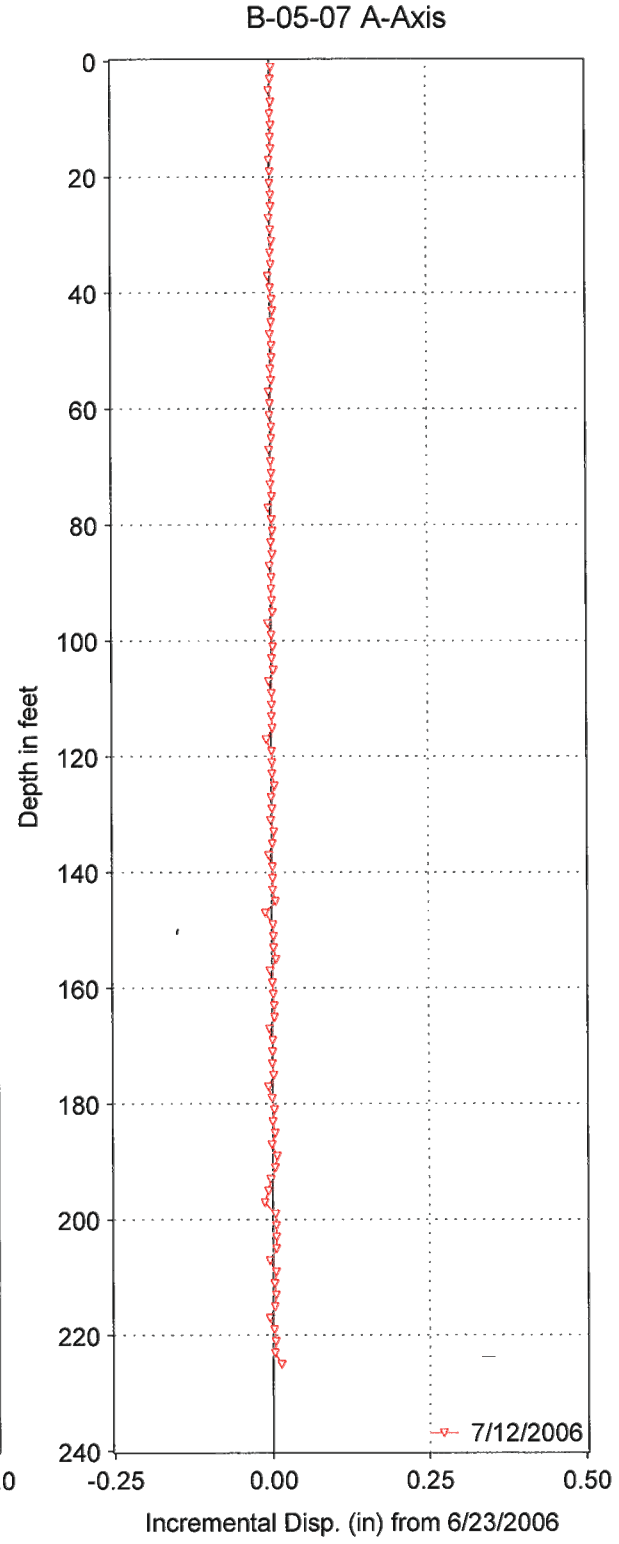




B-05-04

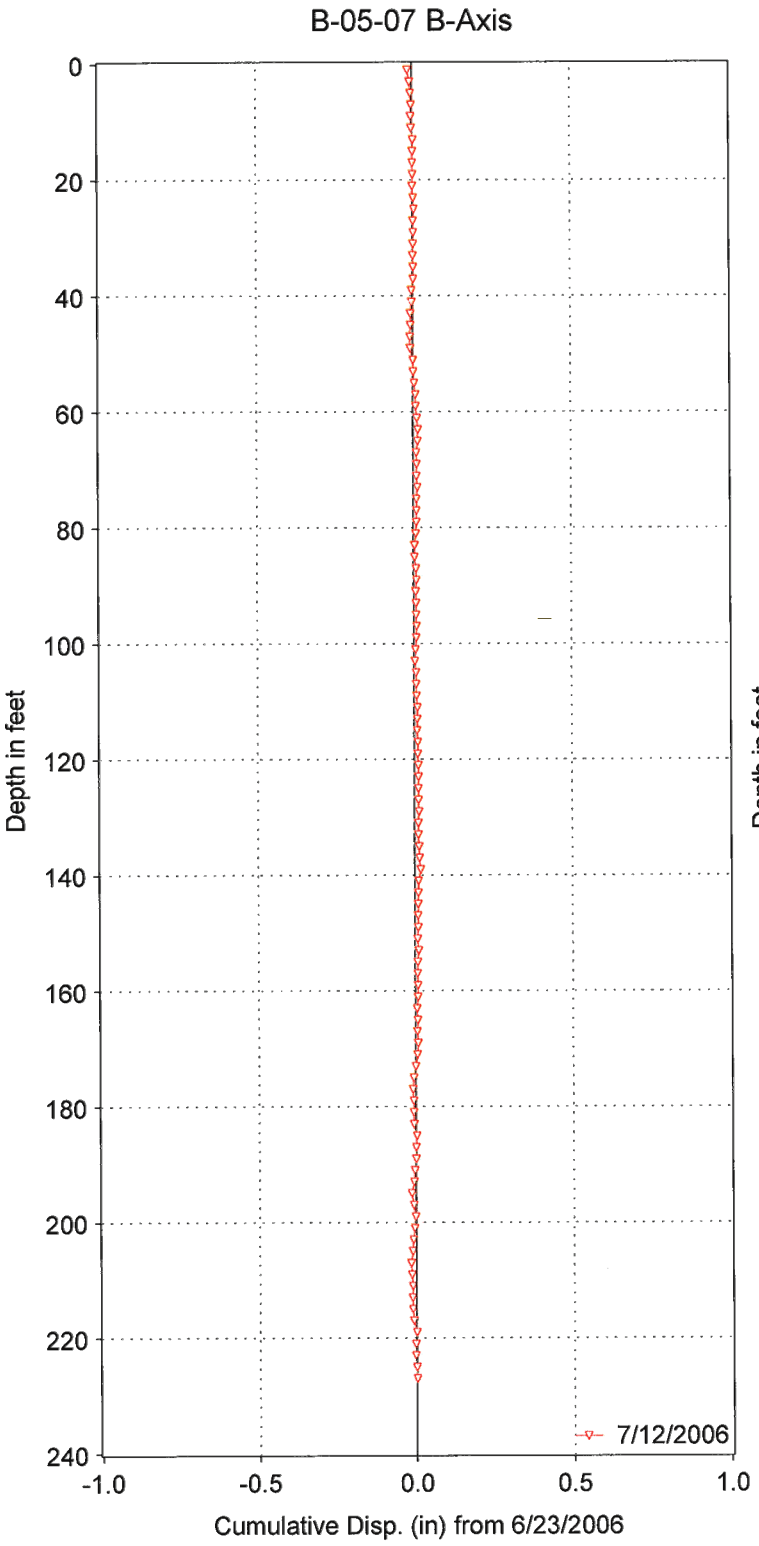
PLATE 33

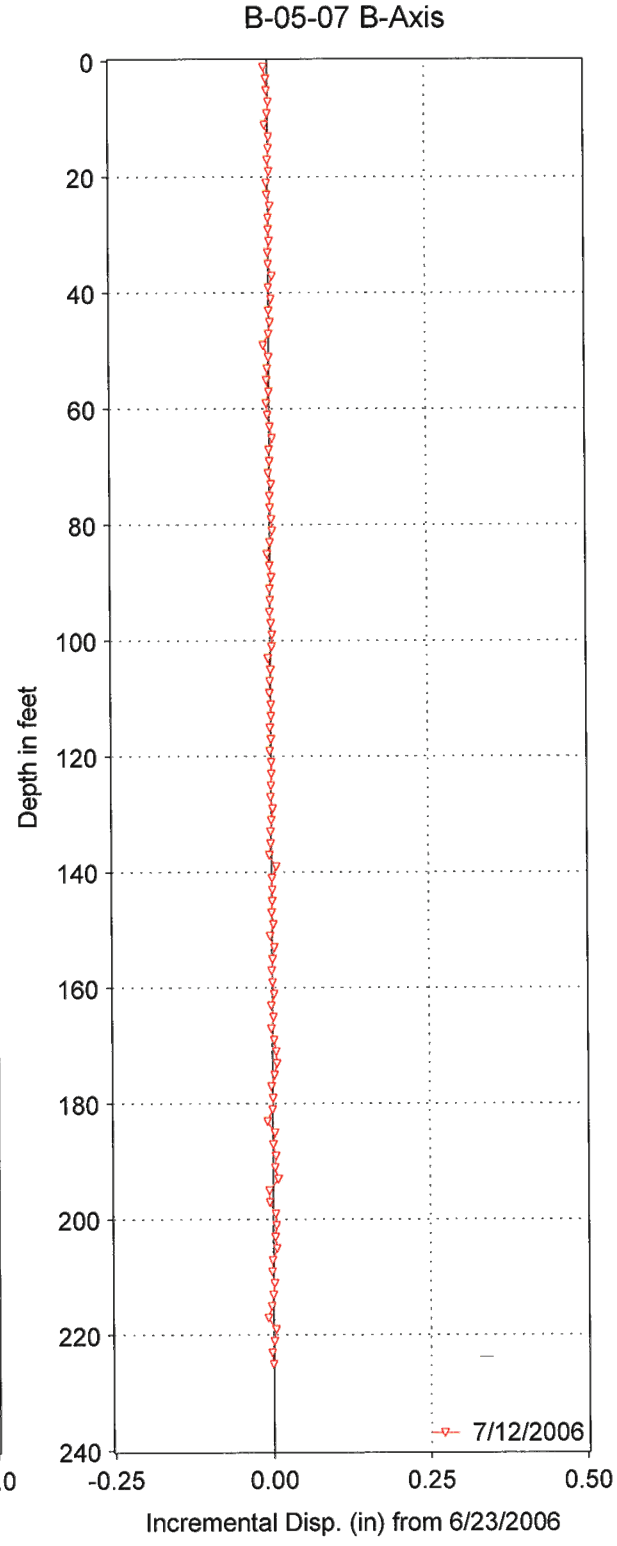




B-05-07

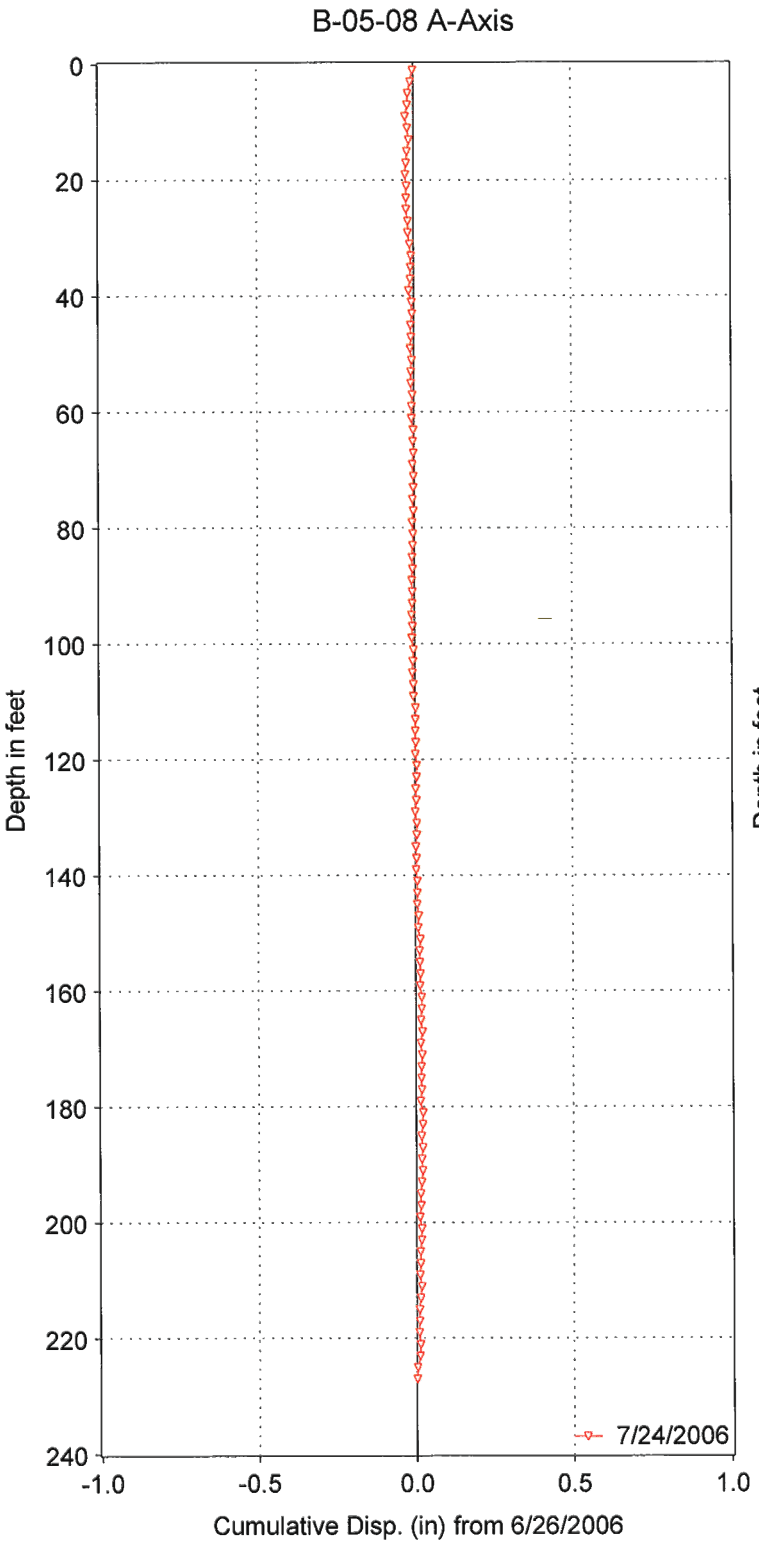
PLATE 34

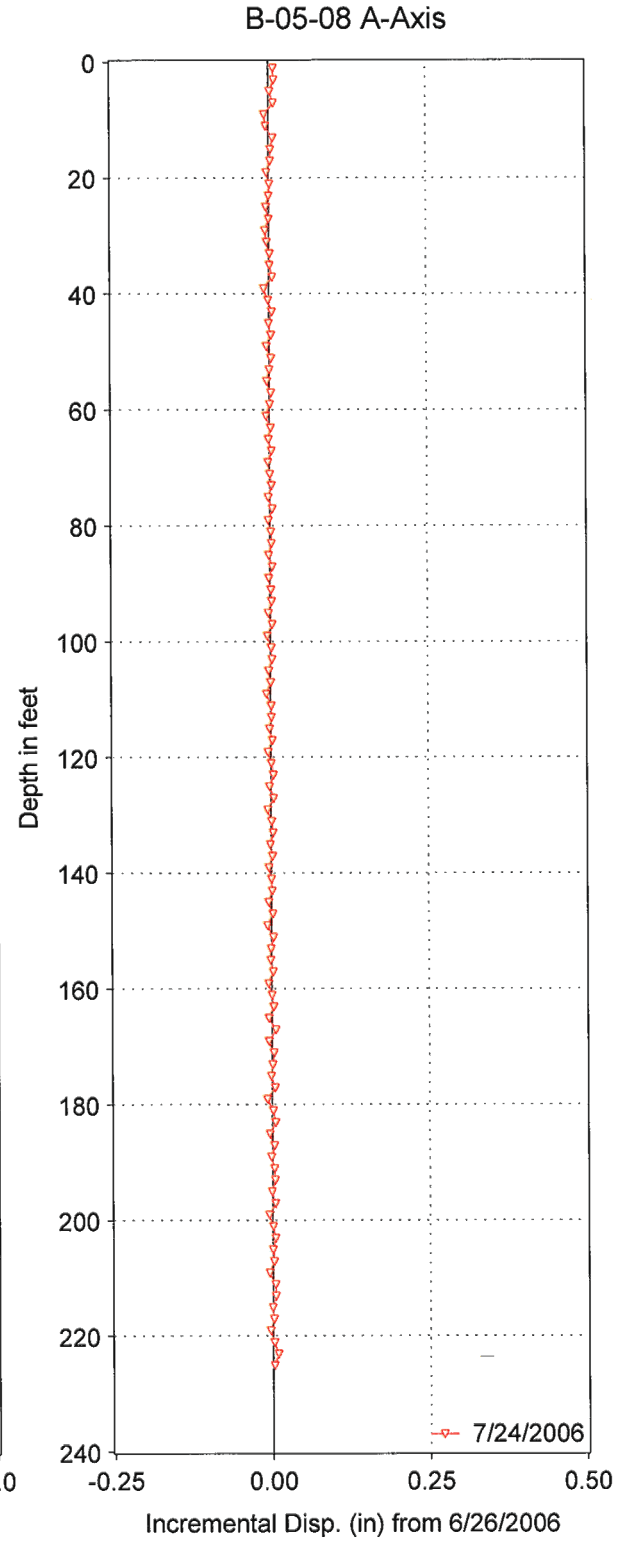




B-05-07

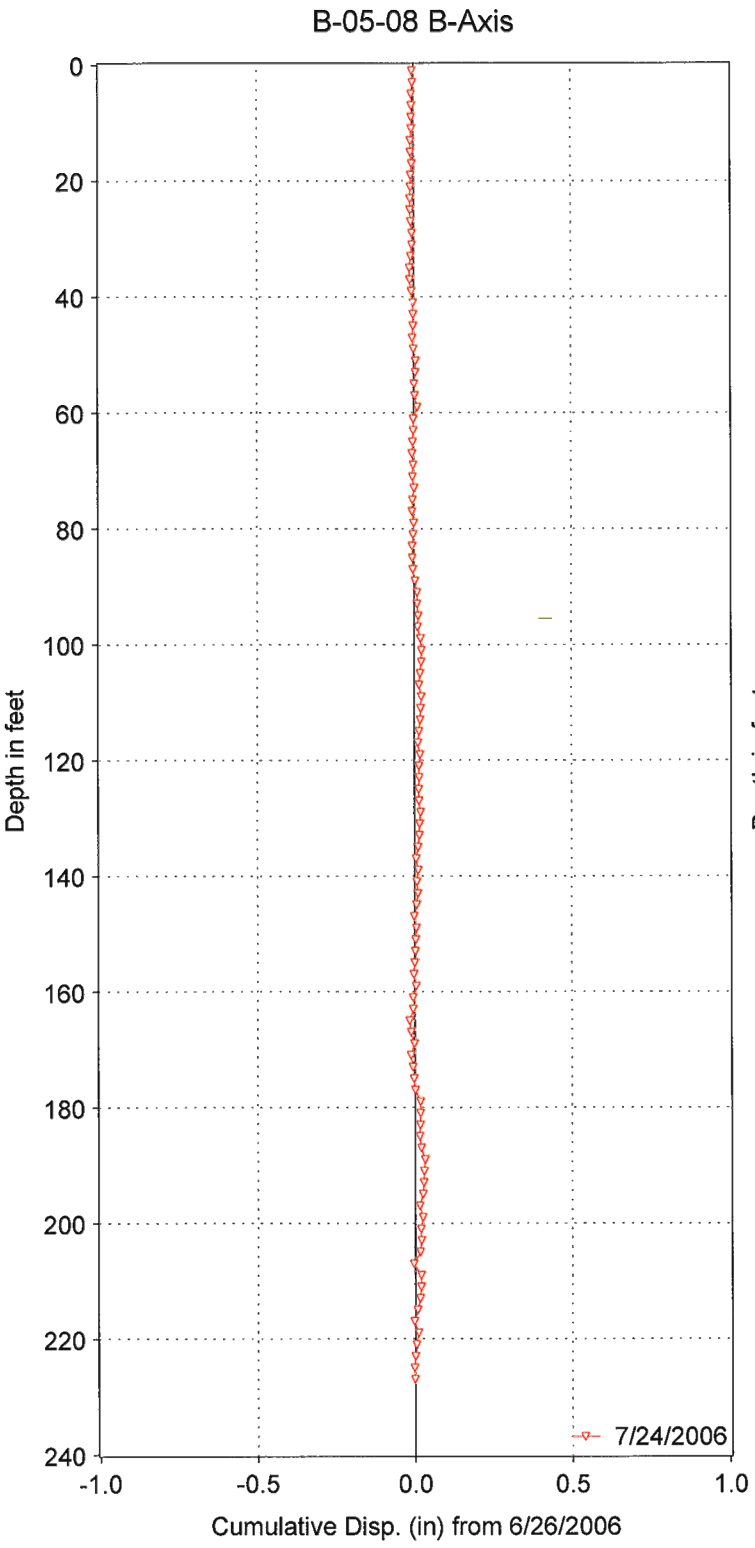
PLATE 35

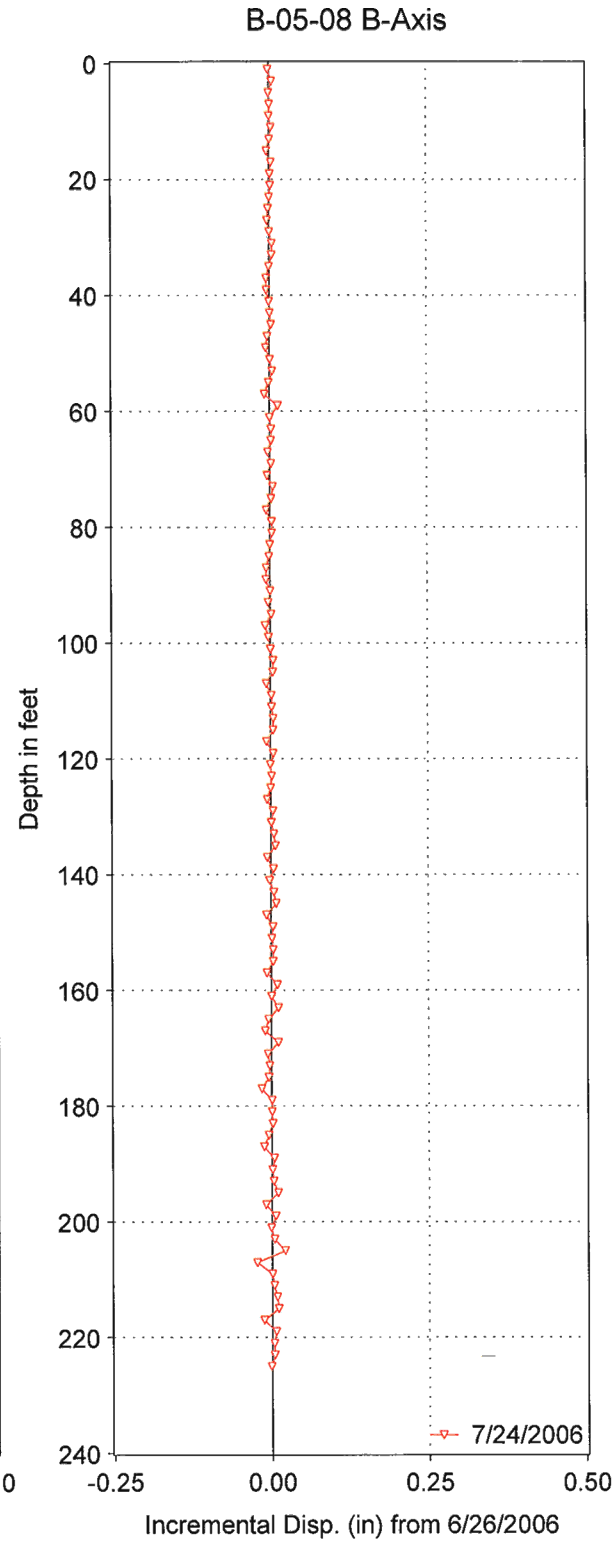




B-05-08
-The reading has been corrected for depth positioning error.

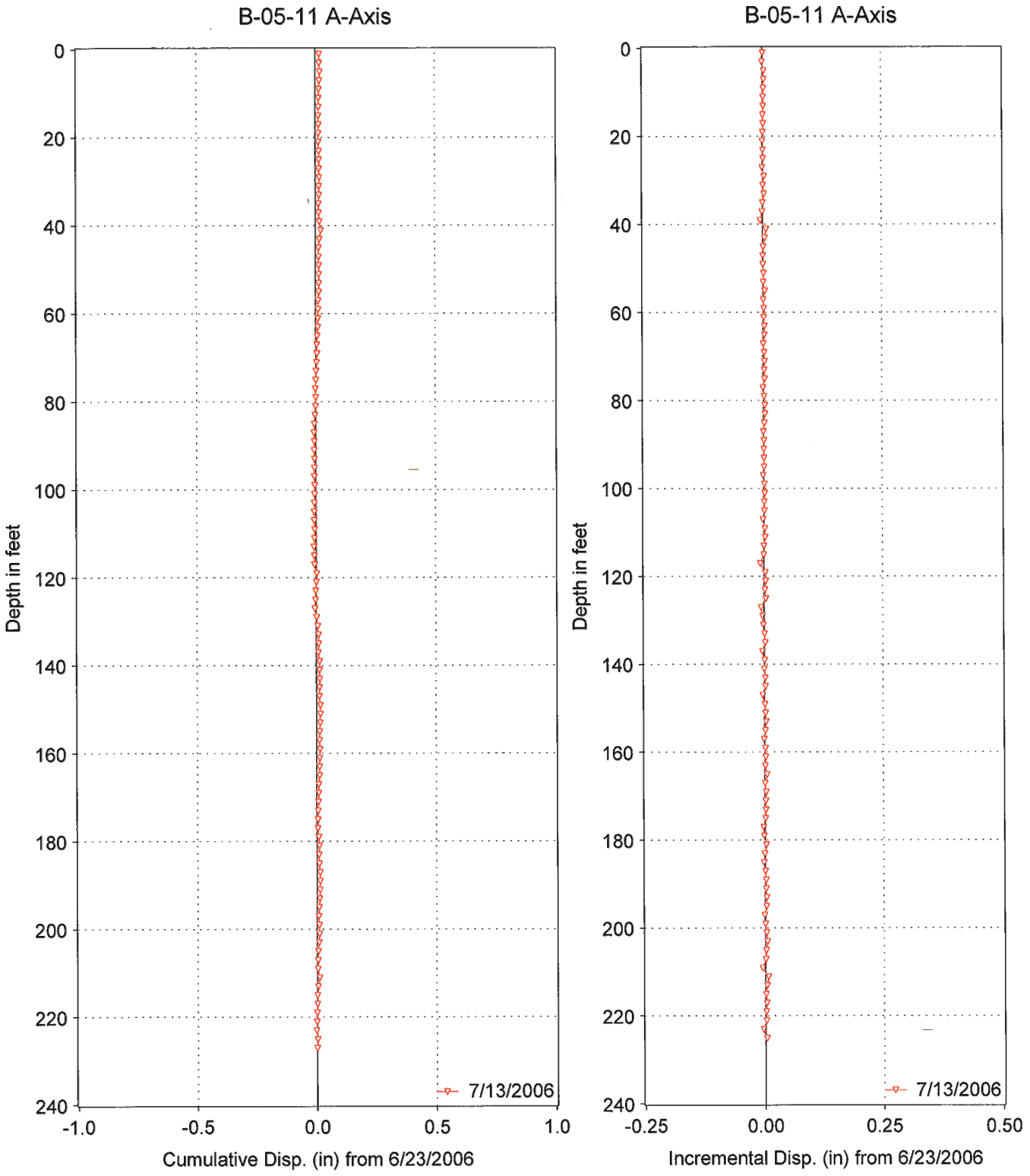
PLATE 36





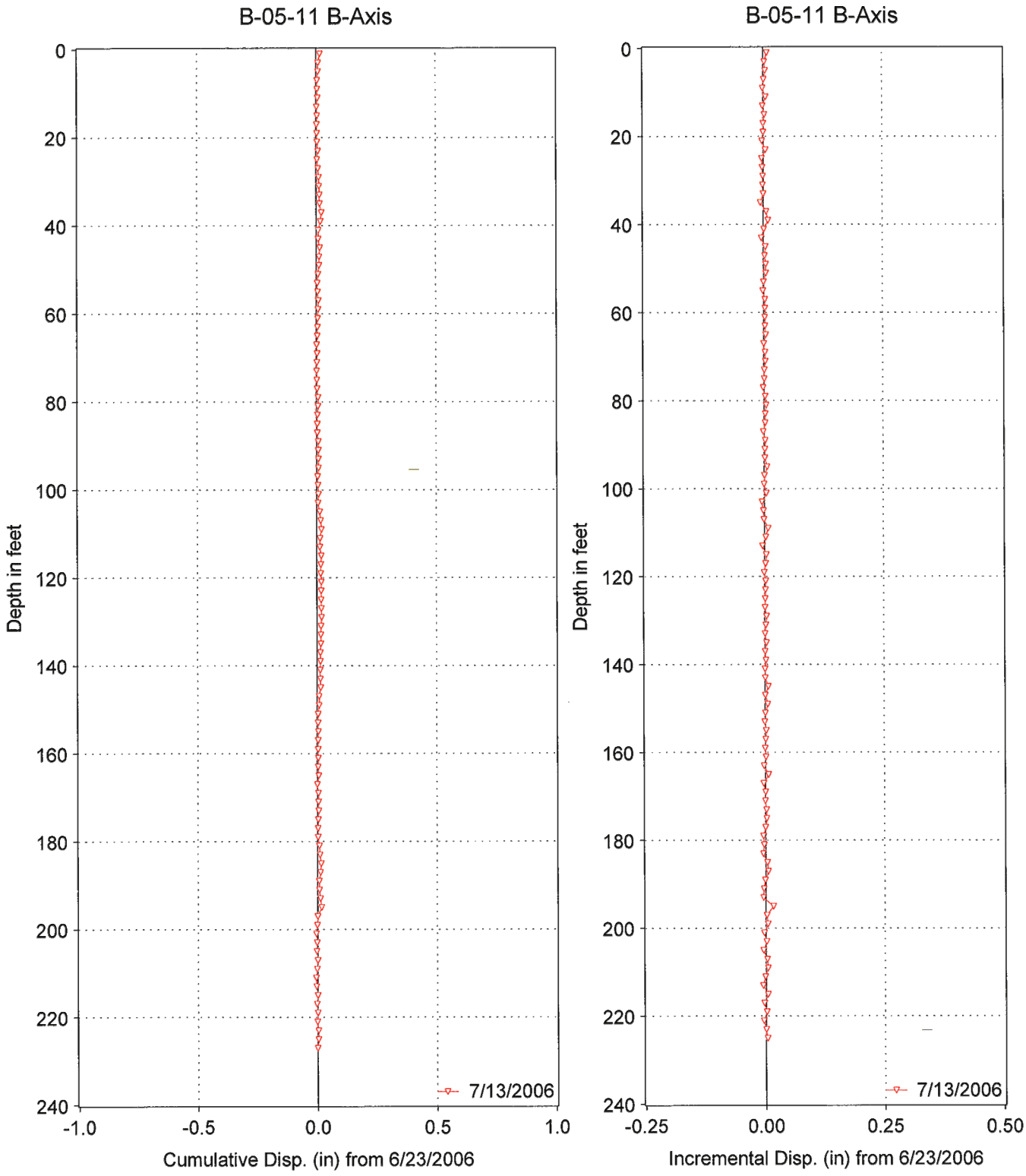
B-05-08
-The reading has been corrected for depth positioning error.

PLATE 37



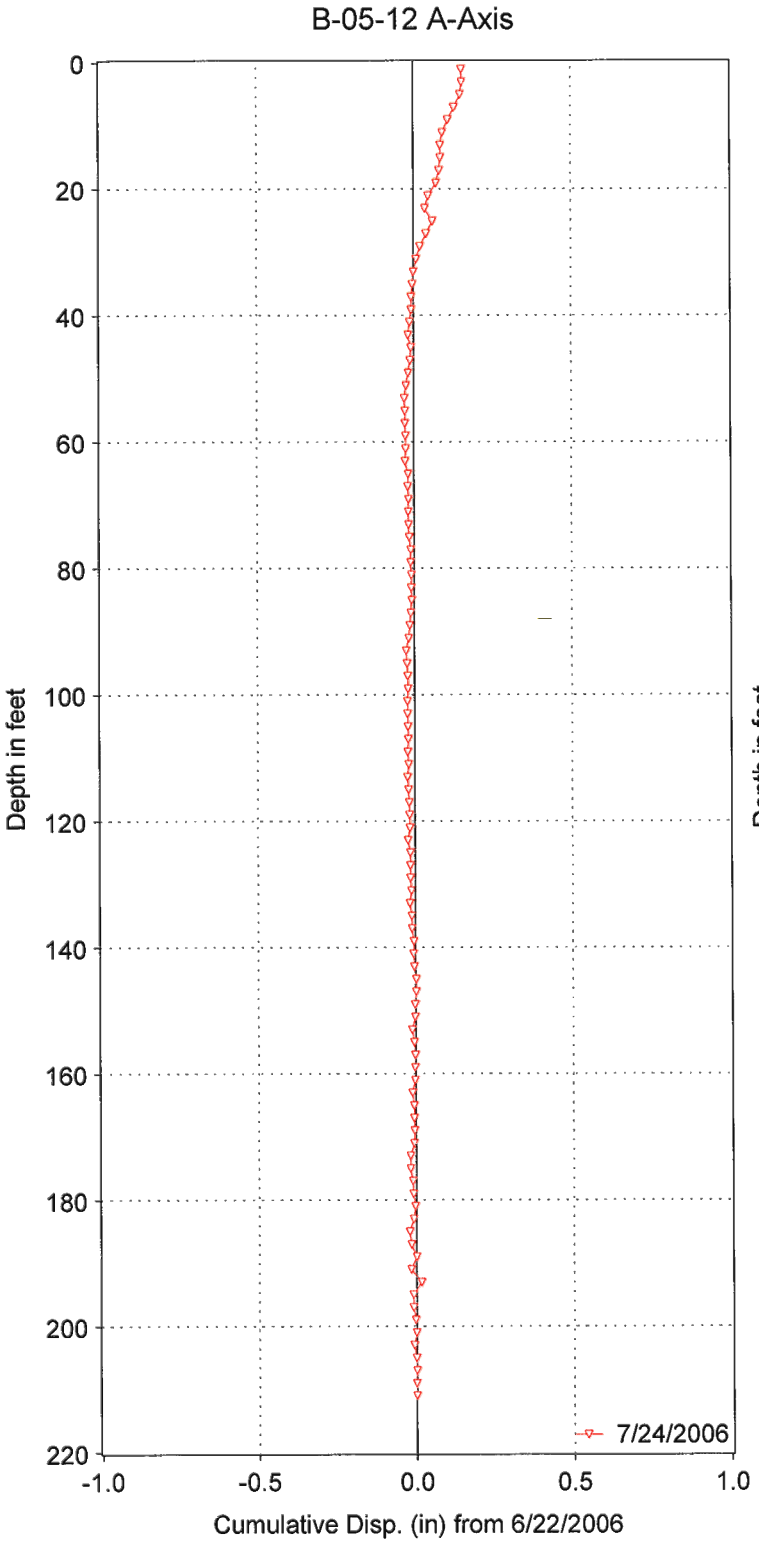
B-05-11

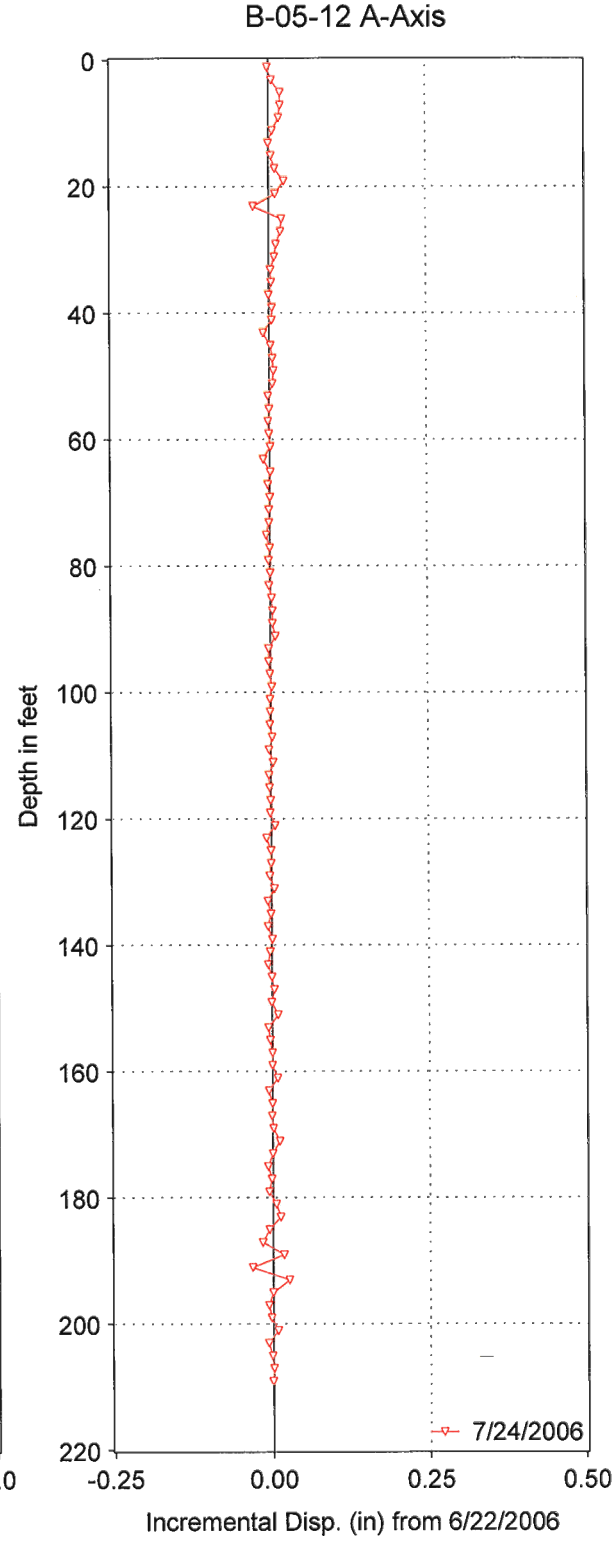
PLATE 38



B-05-11

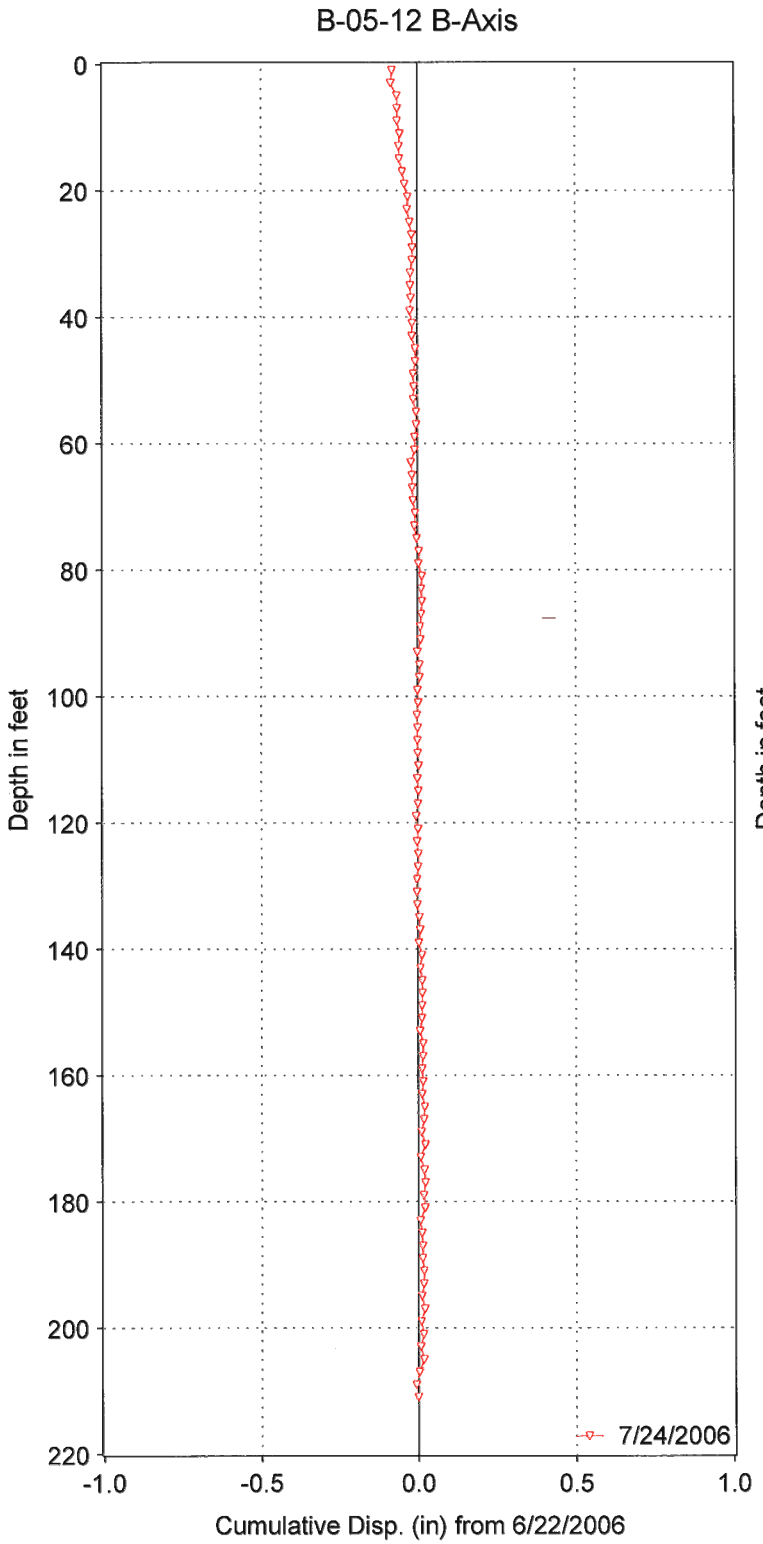
PLATE 39

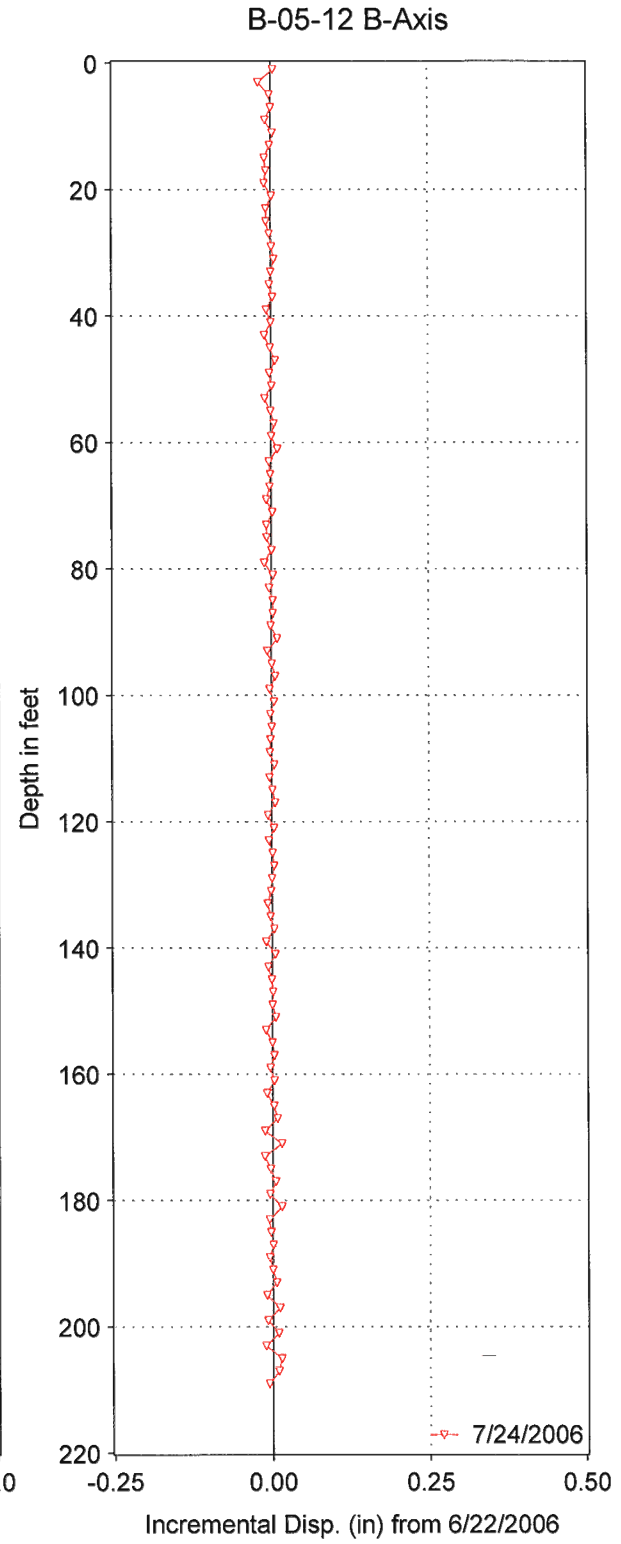




B-05-12
-The reading has been corrected for depth positioning error.

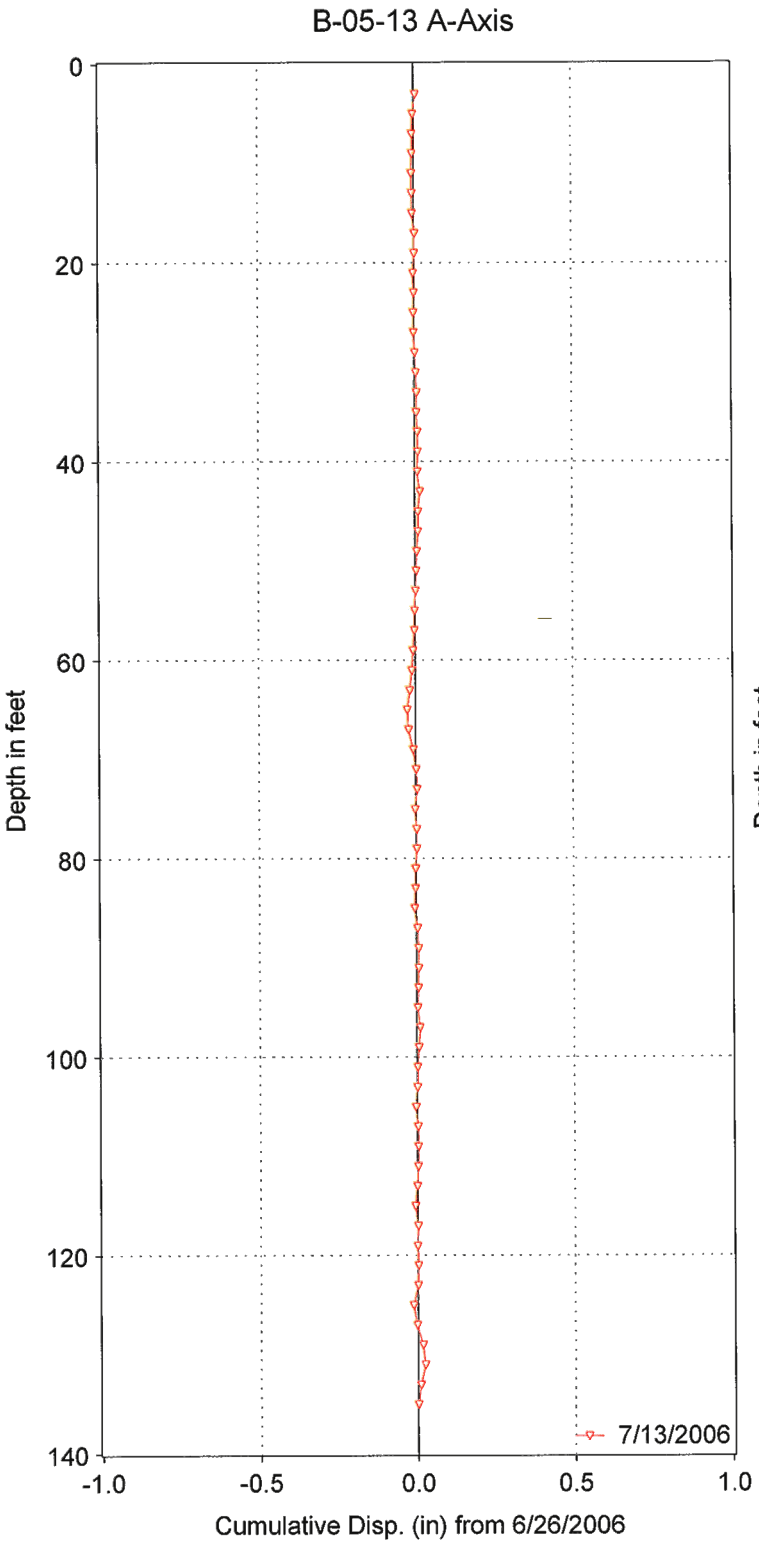
PLATE 40

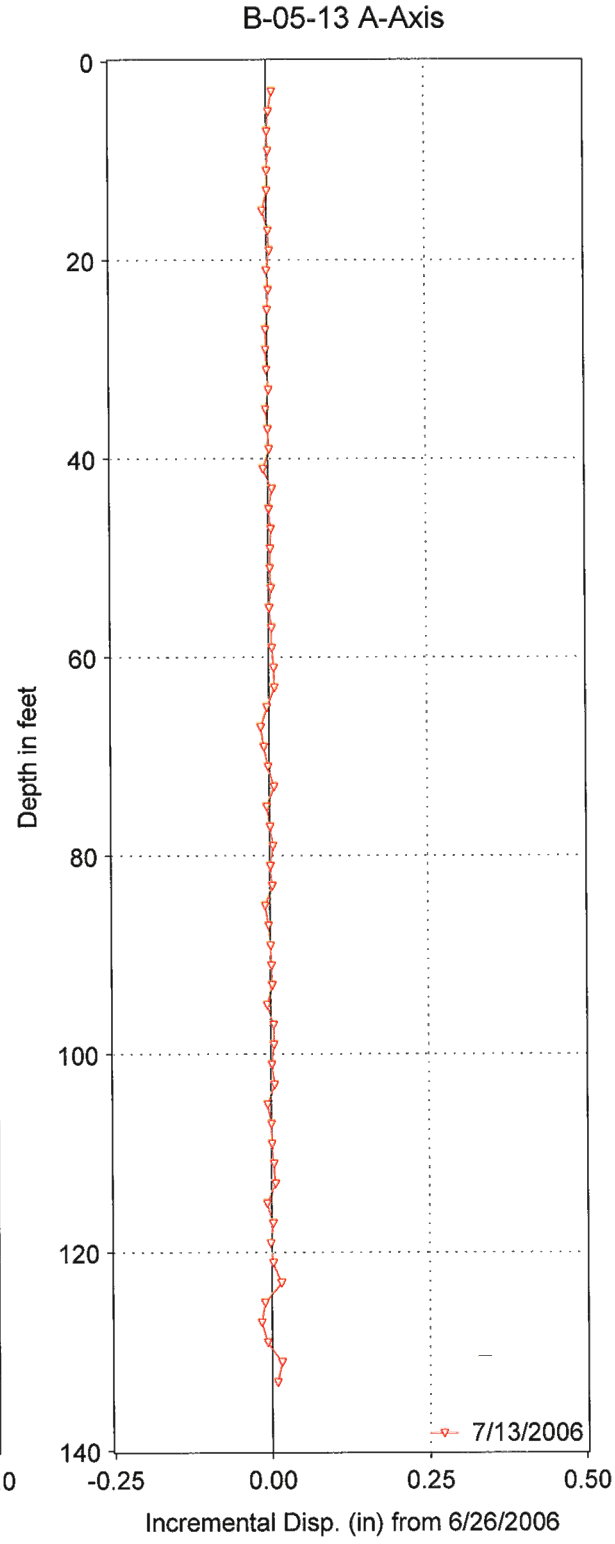




B-05-12
-The reading has been corrected for depth positioning error.

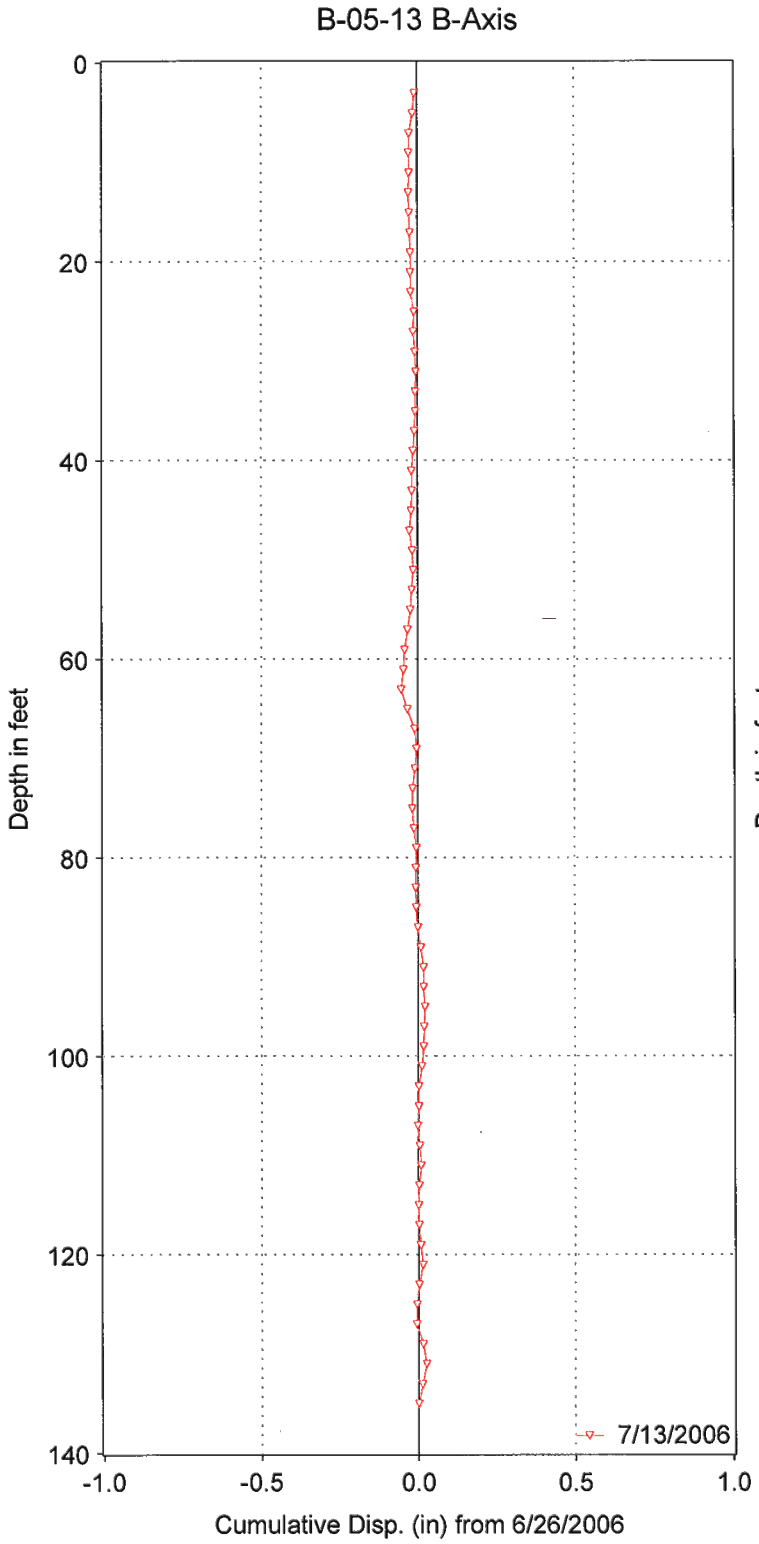
PLATE 41

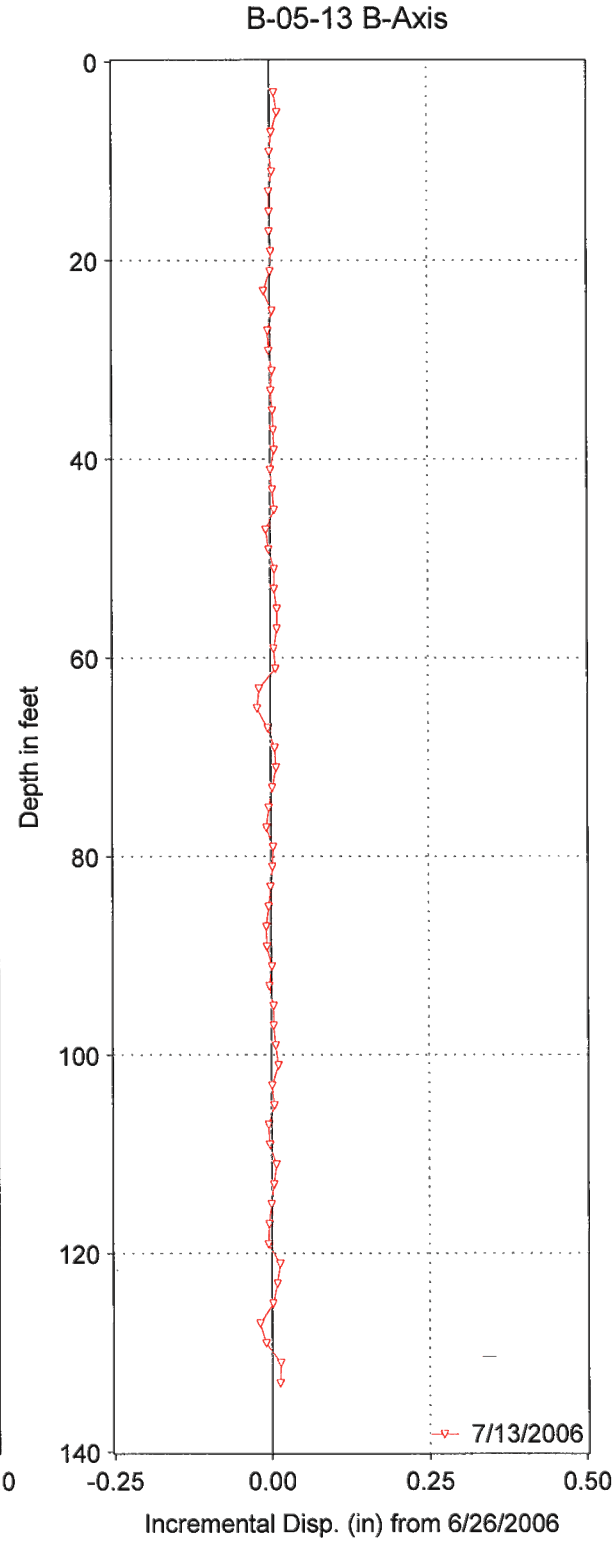




B-05-13

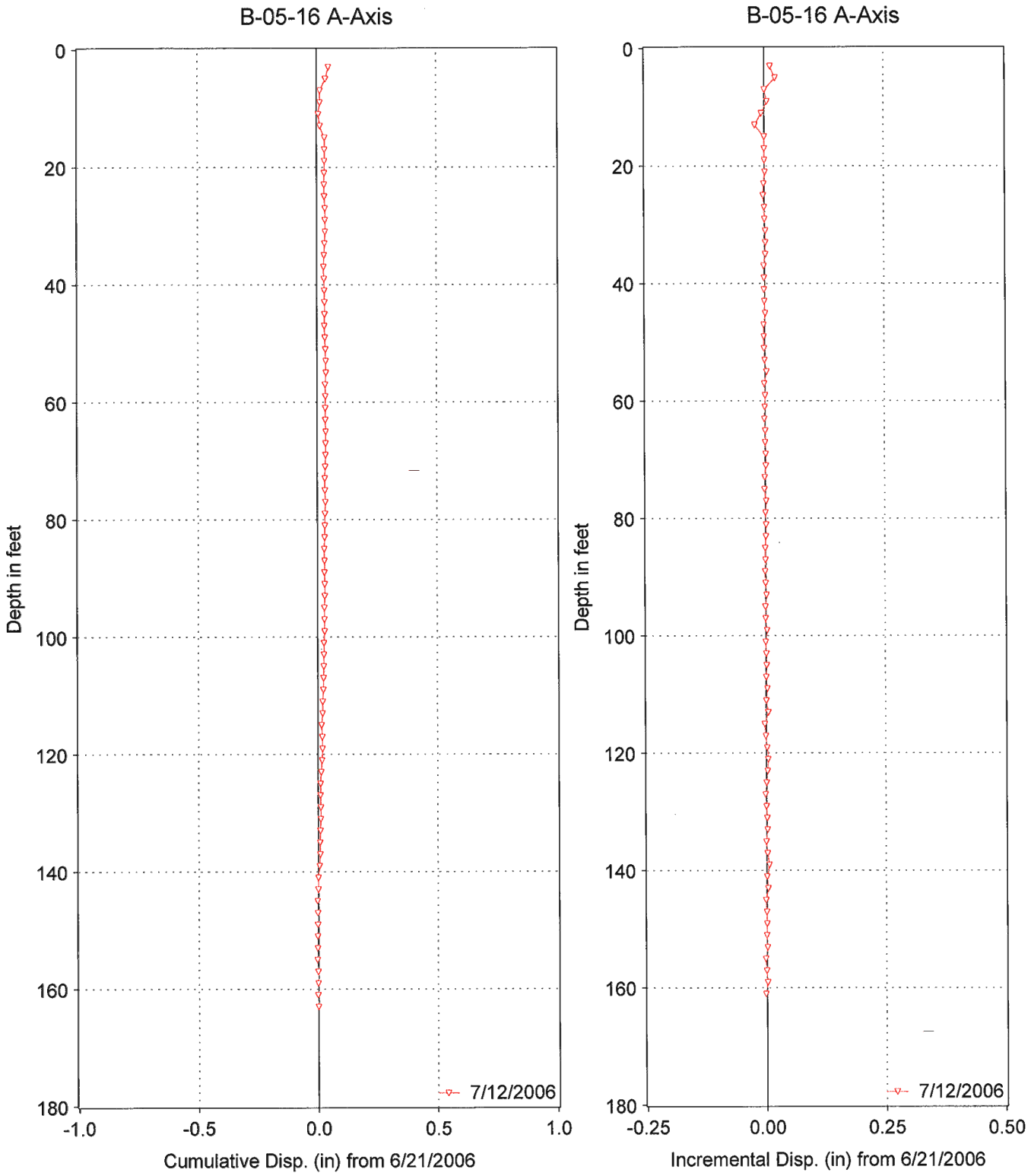
PLATE 42





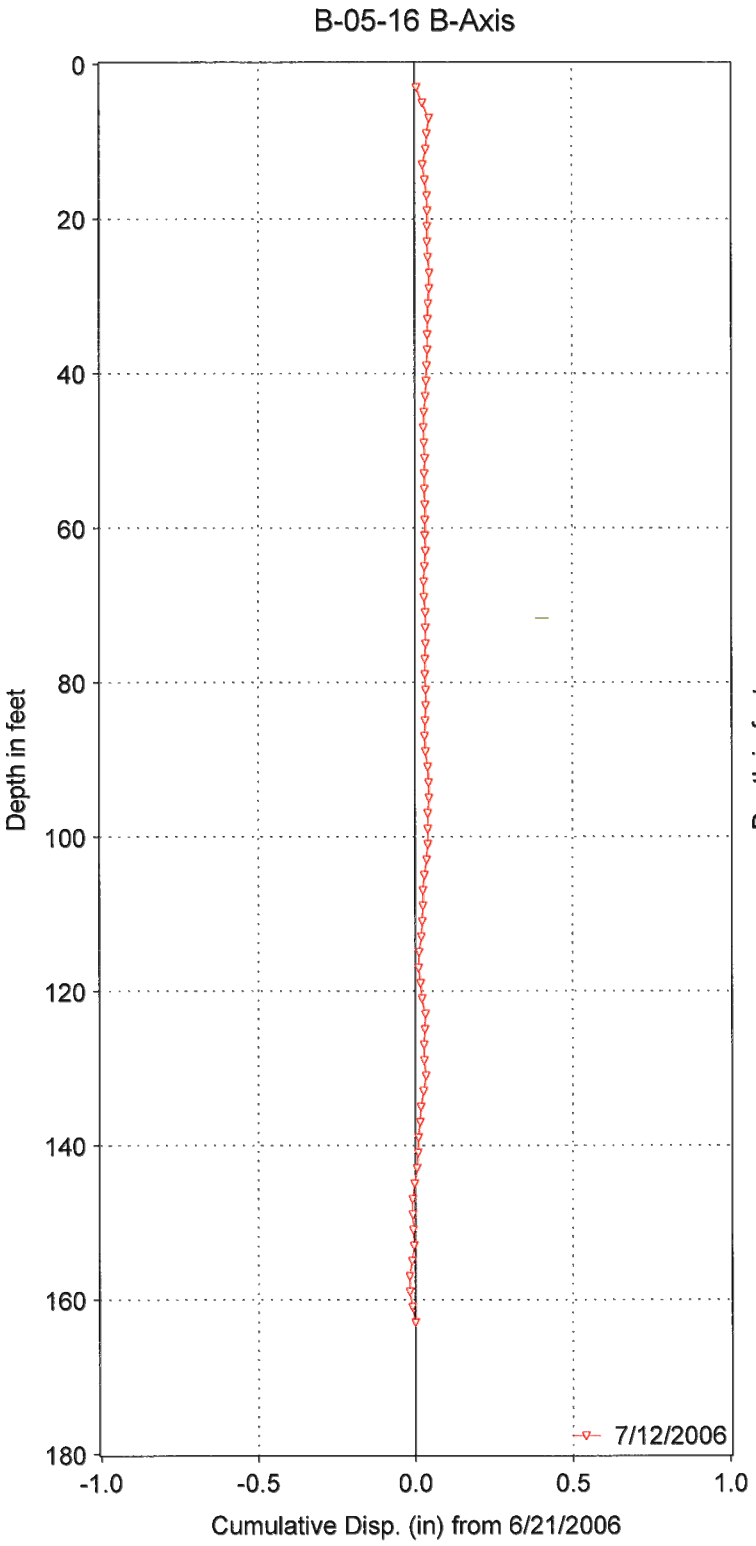
B-05-13

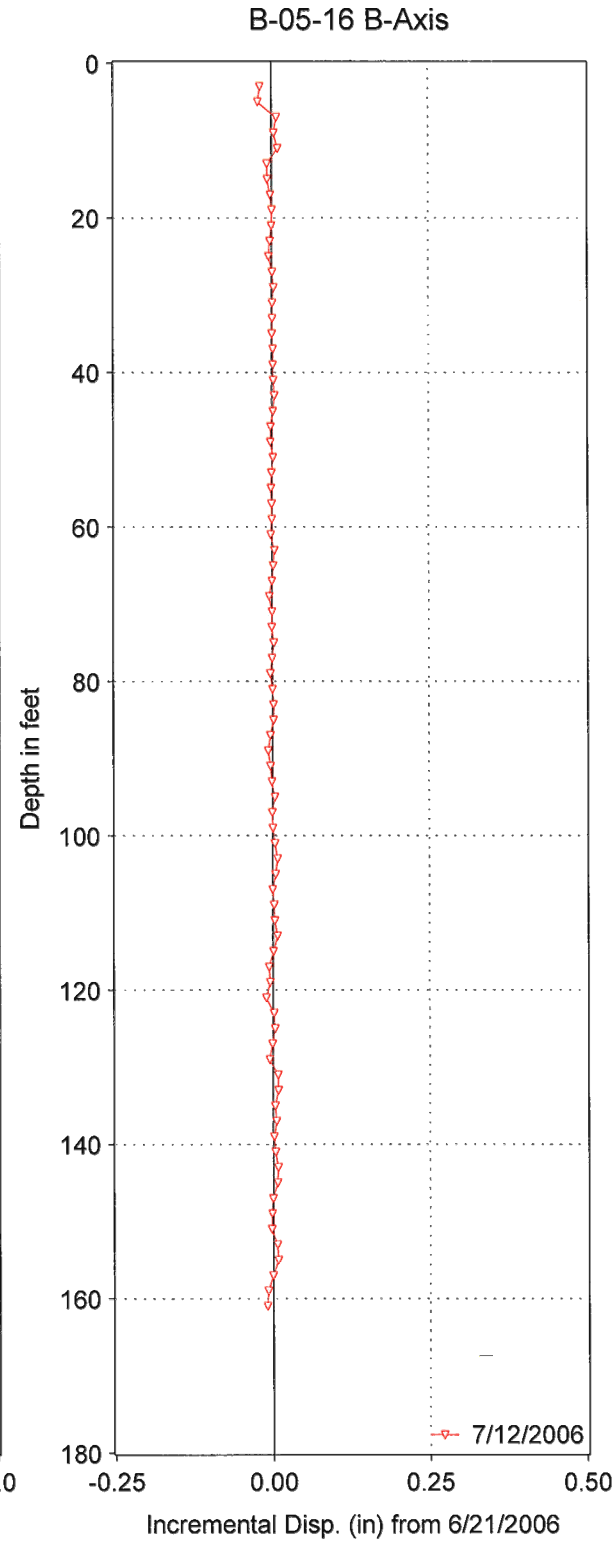
PLATE 43



B-05-16

PLATE 44





B-05-16

PLATE 45

B-101 Pneumatic Piezometer Readings

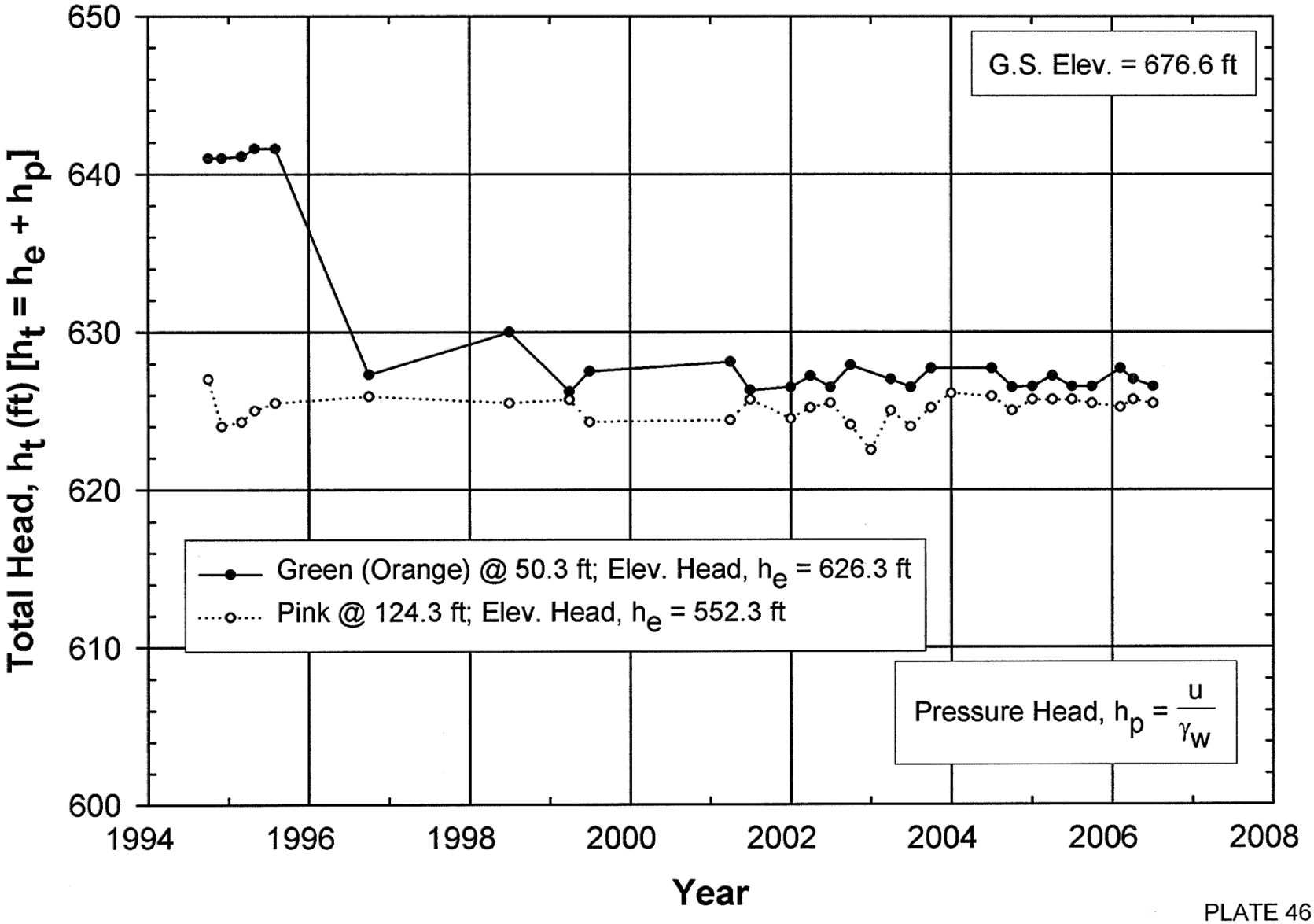


PLATE 46

B-105 Pneumatic Piezometer Readings

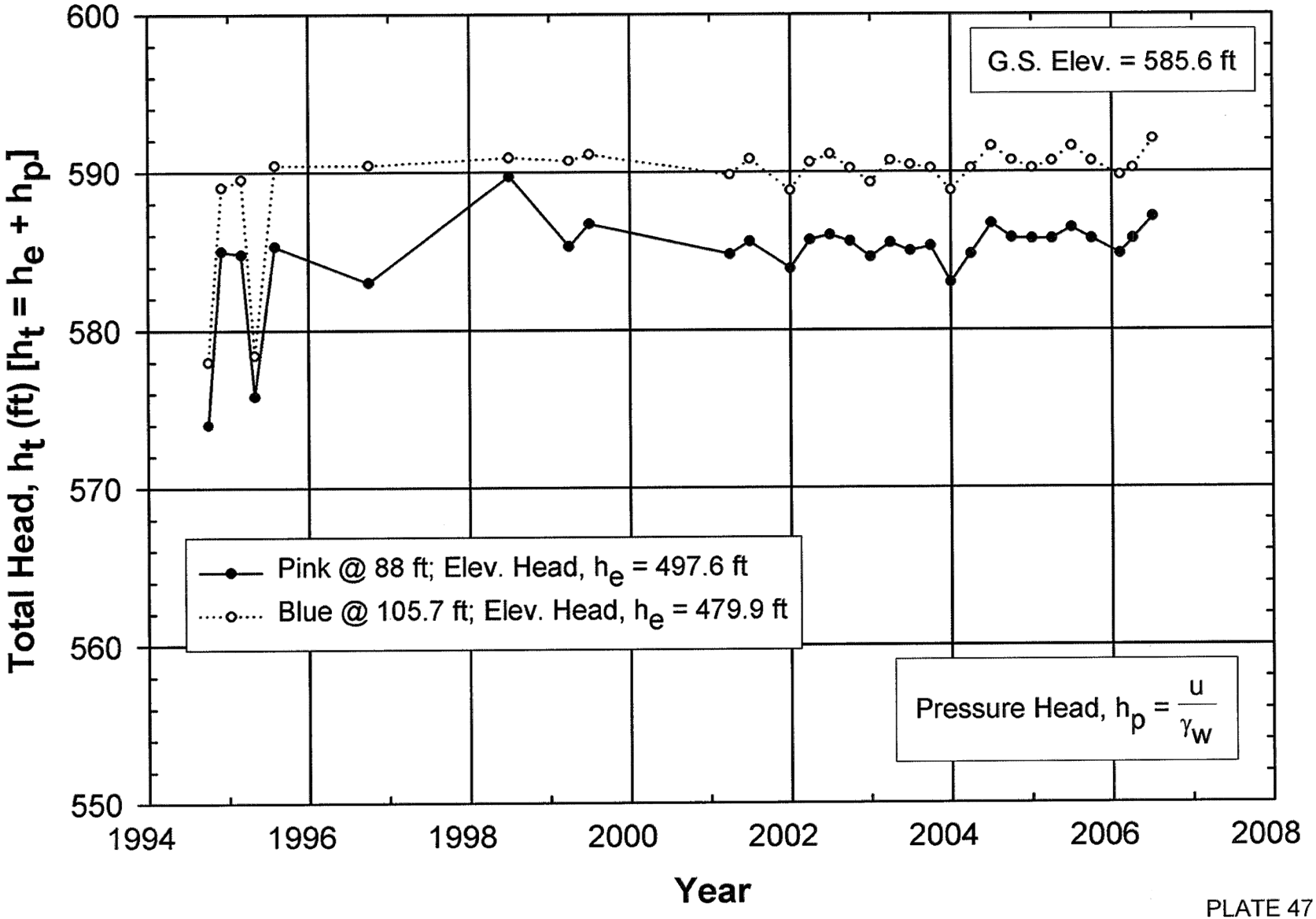


PLATE 47

B-107 Pneumatic Piezometer Readings

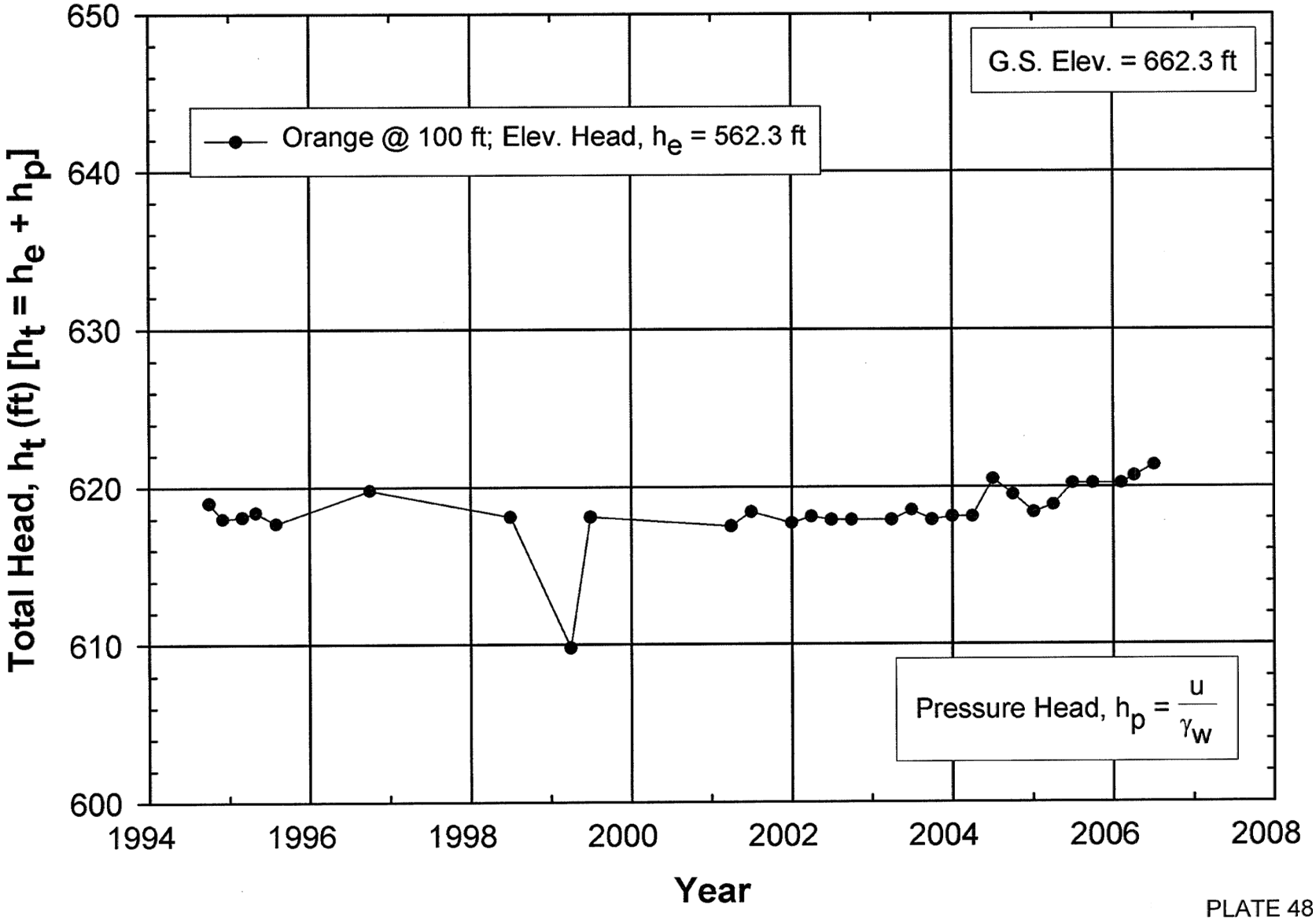


PLATE 48

B-303 Pneumatic Piezometer Readings

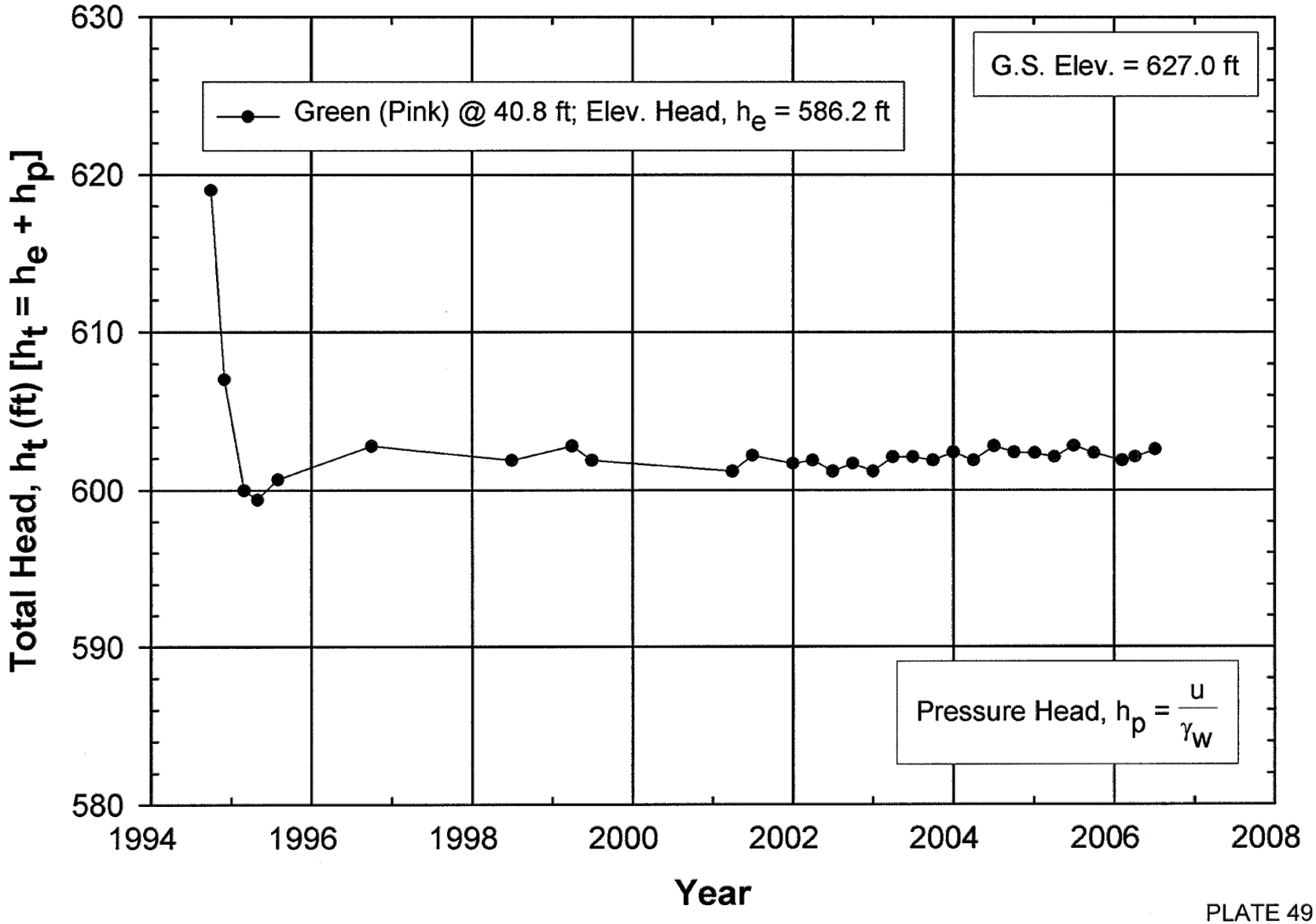


PLATE 49

B-05-01 VW Piezometer Readings

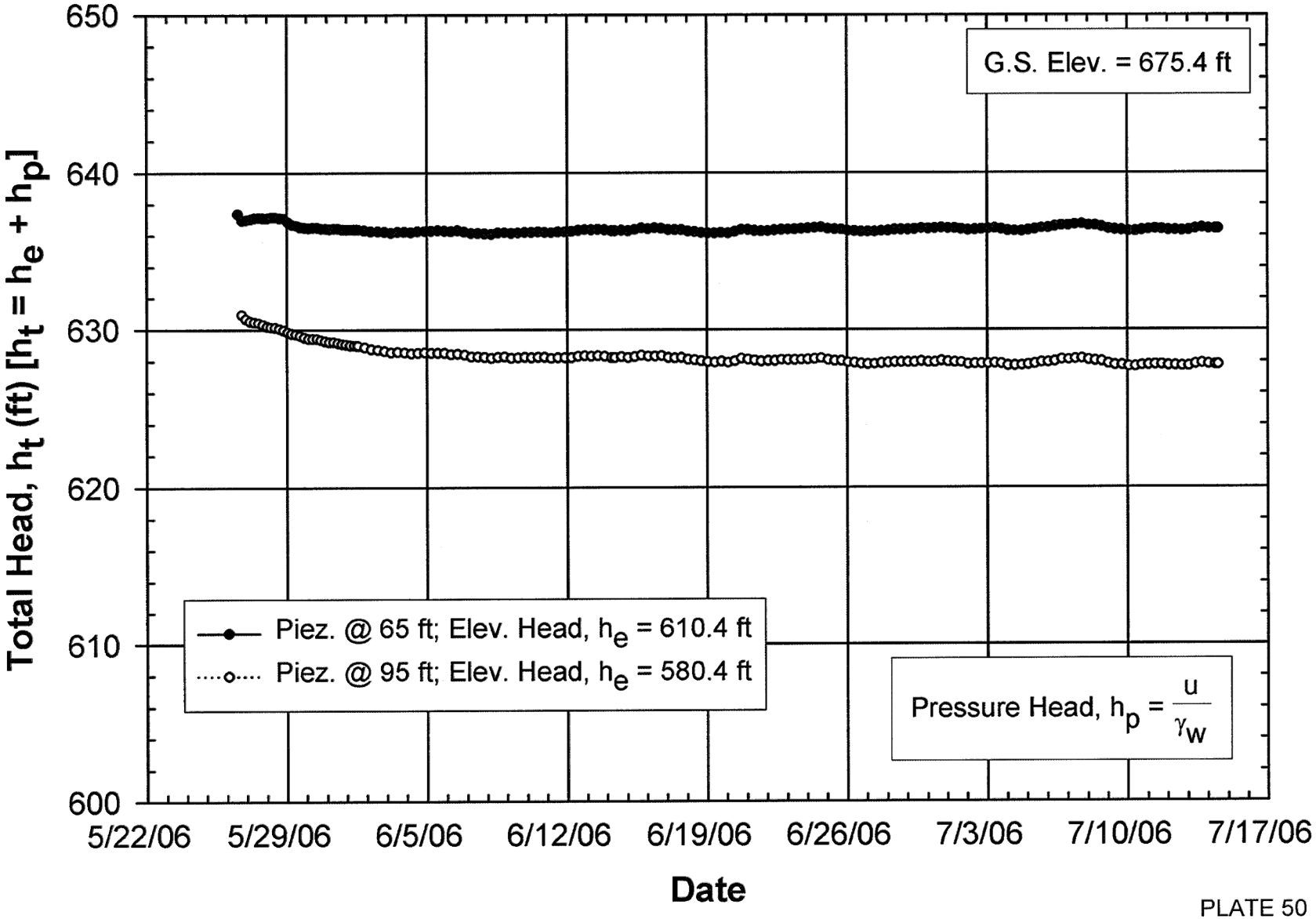


PLATE 50

B-05-02 VW Piezometer Readings

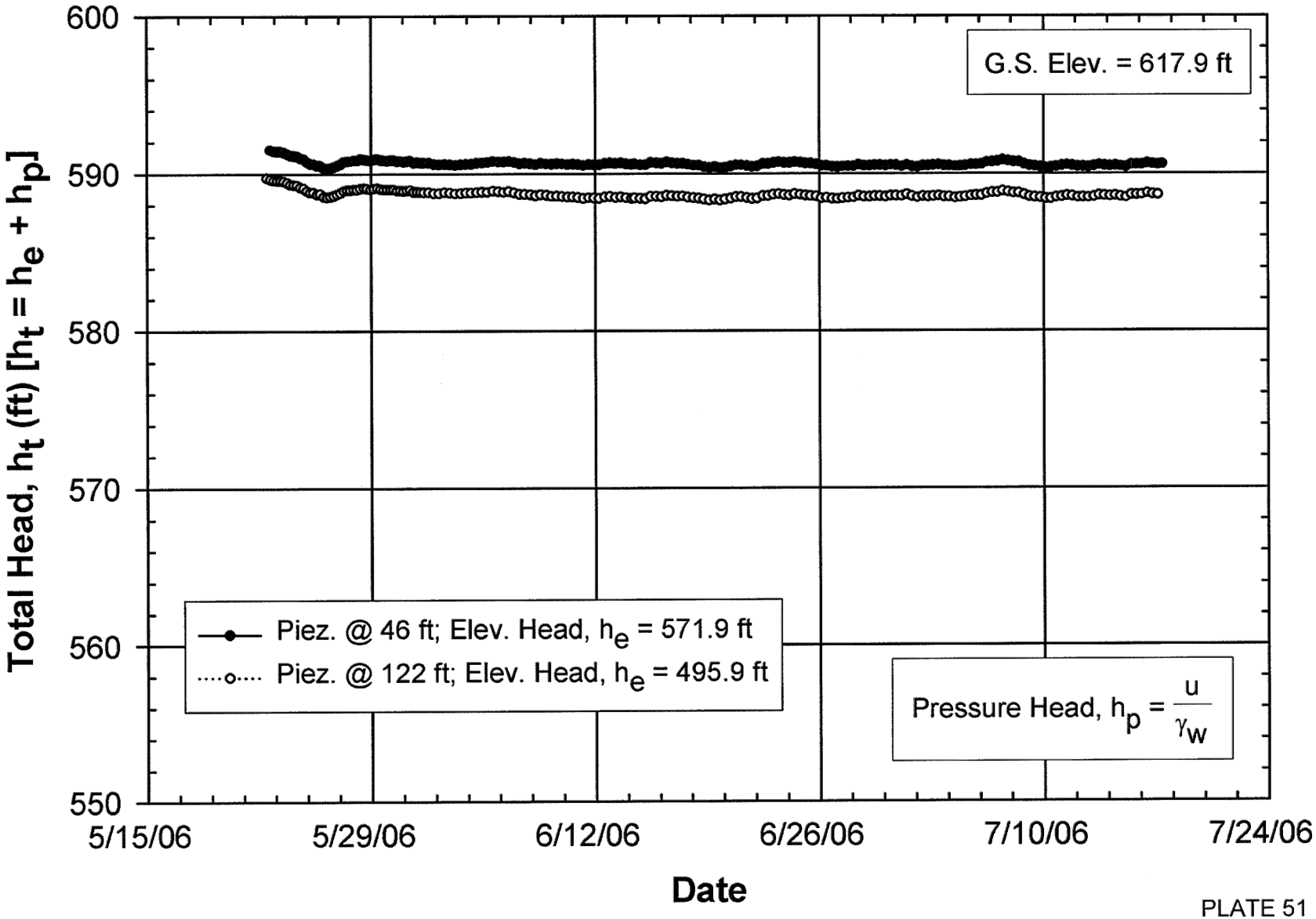


PLATE 51

B-05-03 VW Piezometer Readings

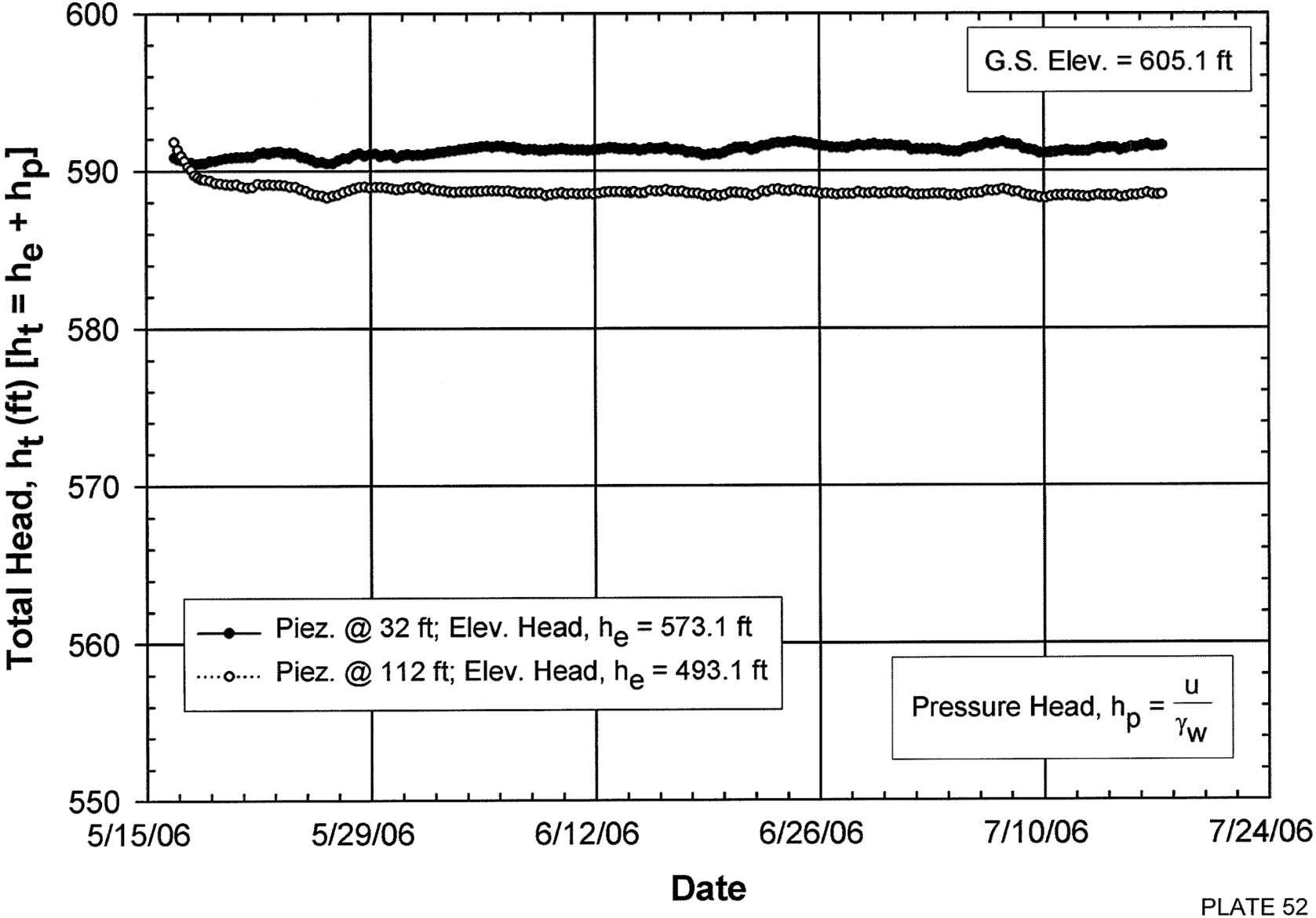


PLATE 52

B-05-04 VW Piezometer Readings

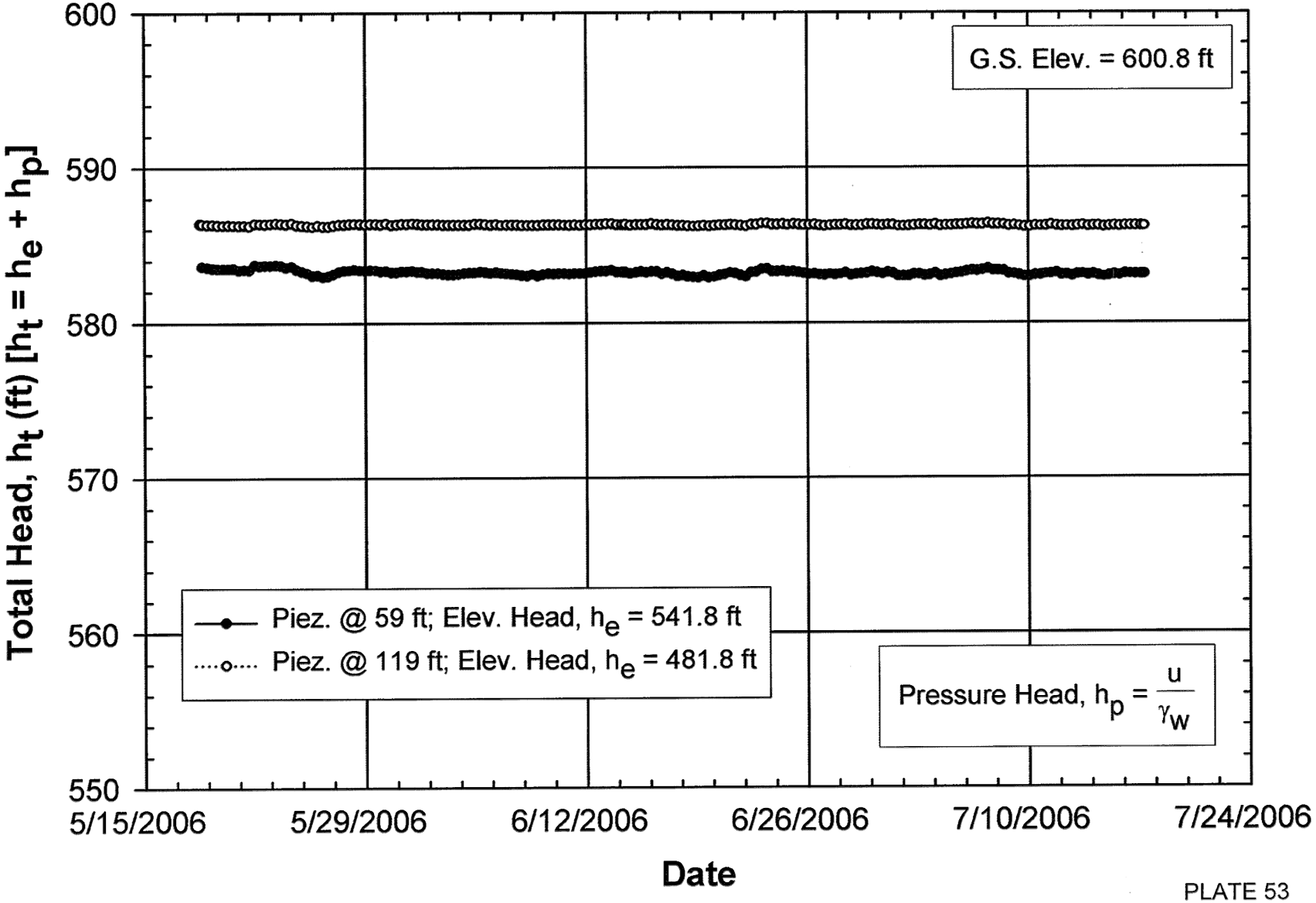


PLATE 53

B-05-07 VW Piezometer Readings

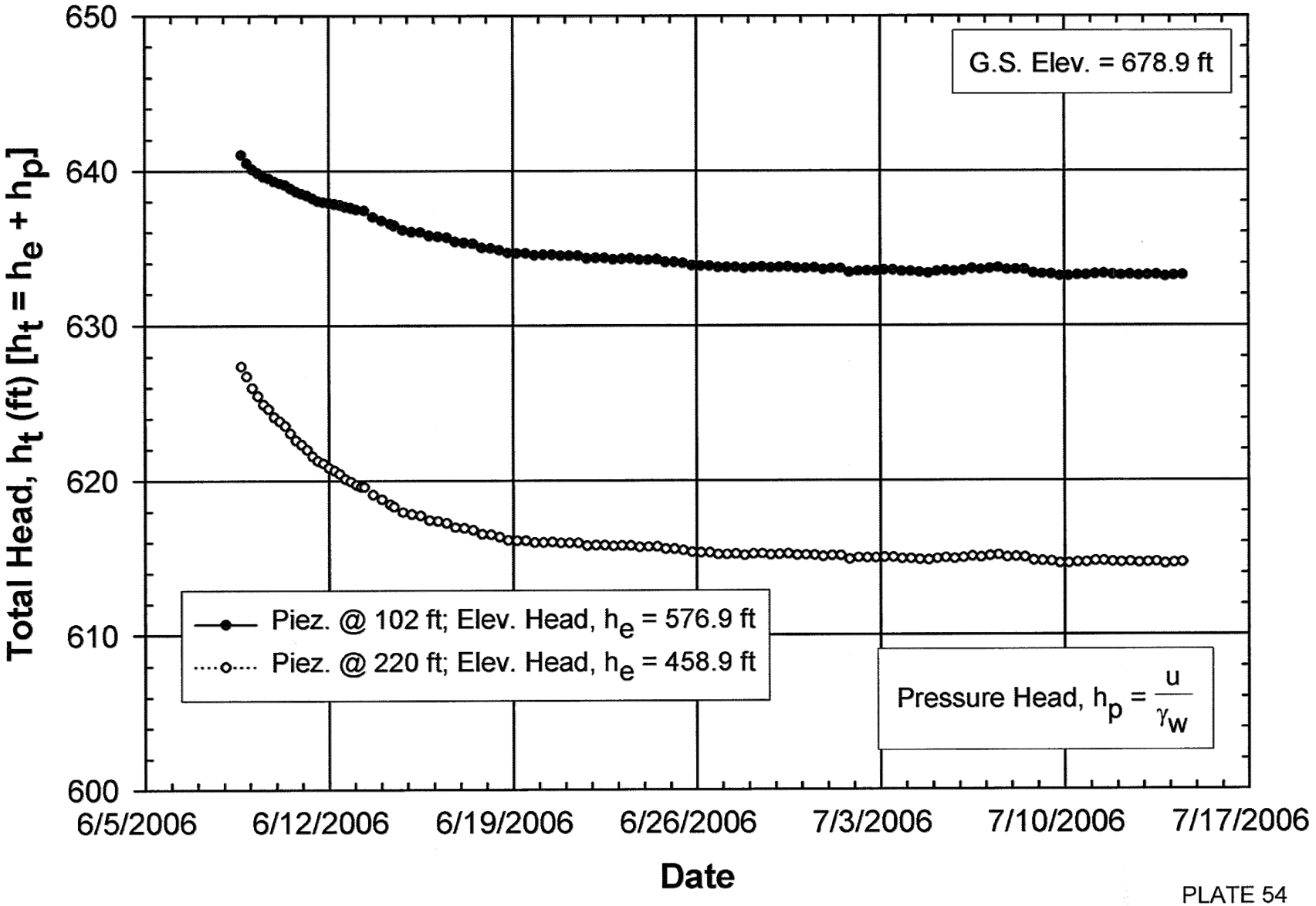


PLATE 54

B-05-08 VW Piezometer Readings

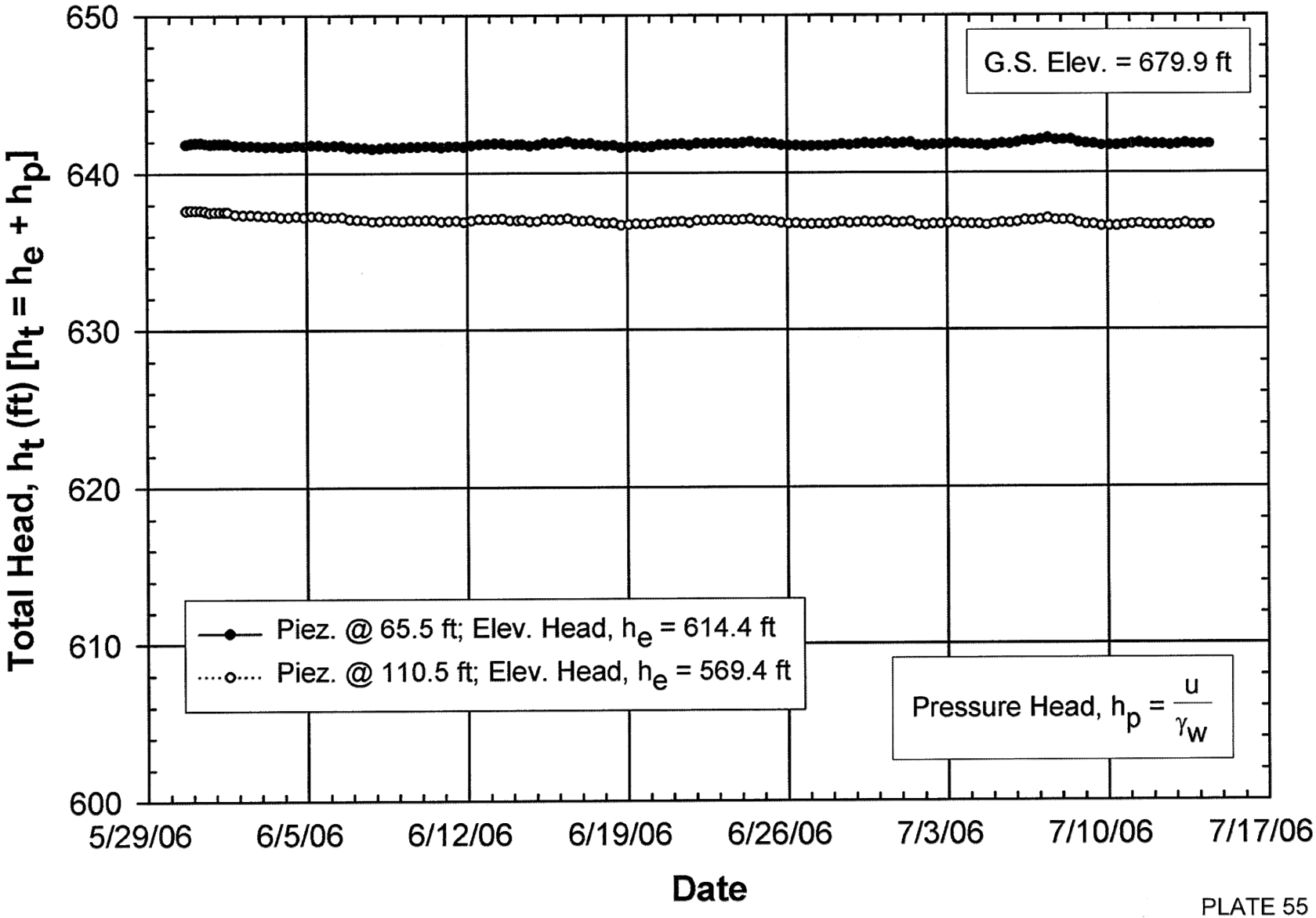


PLATE 55

B-05-11 VW Piezometer Readings

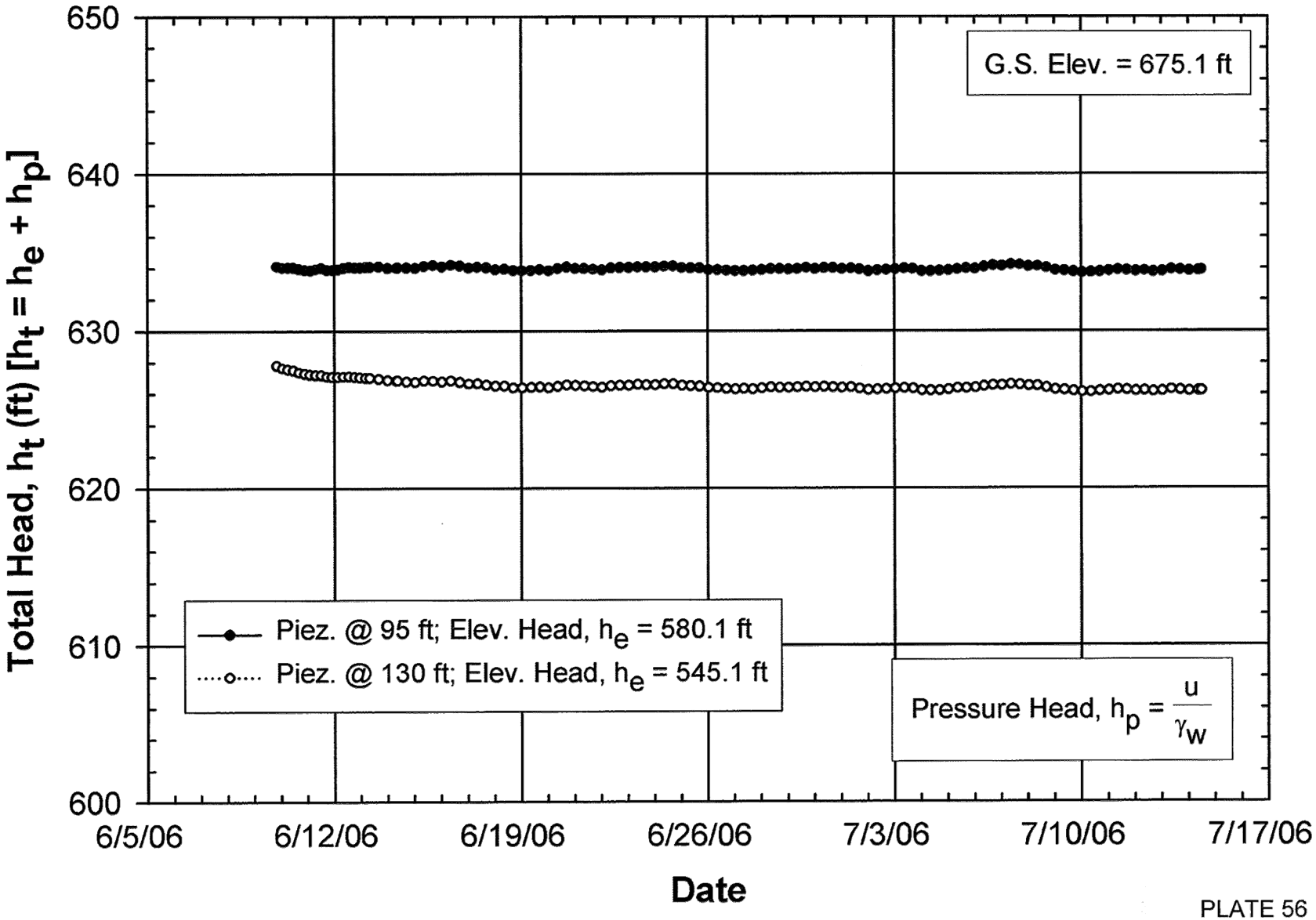


PLATE 56

B-05-12 VW Piezometer Readings

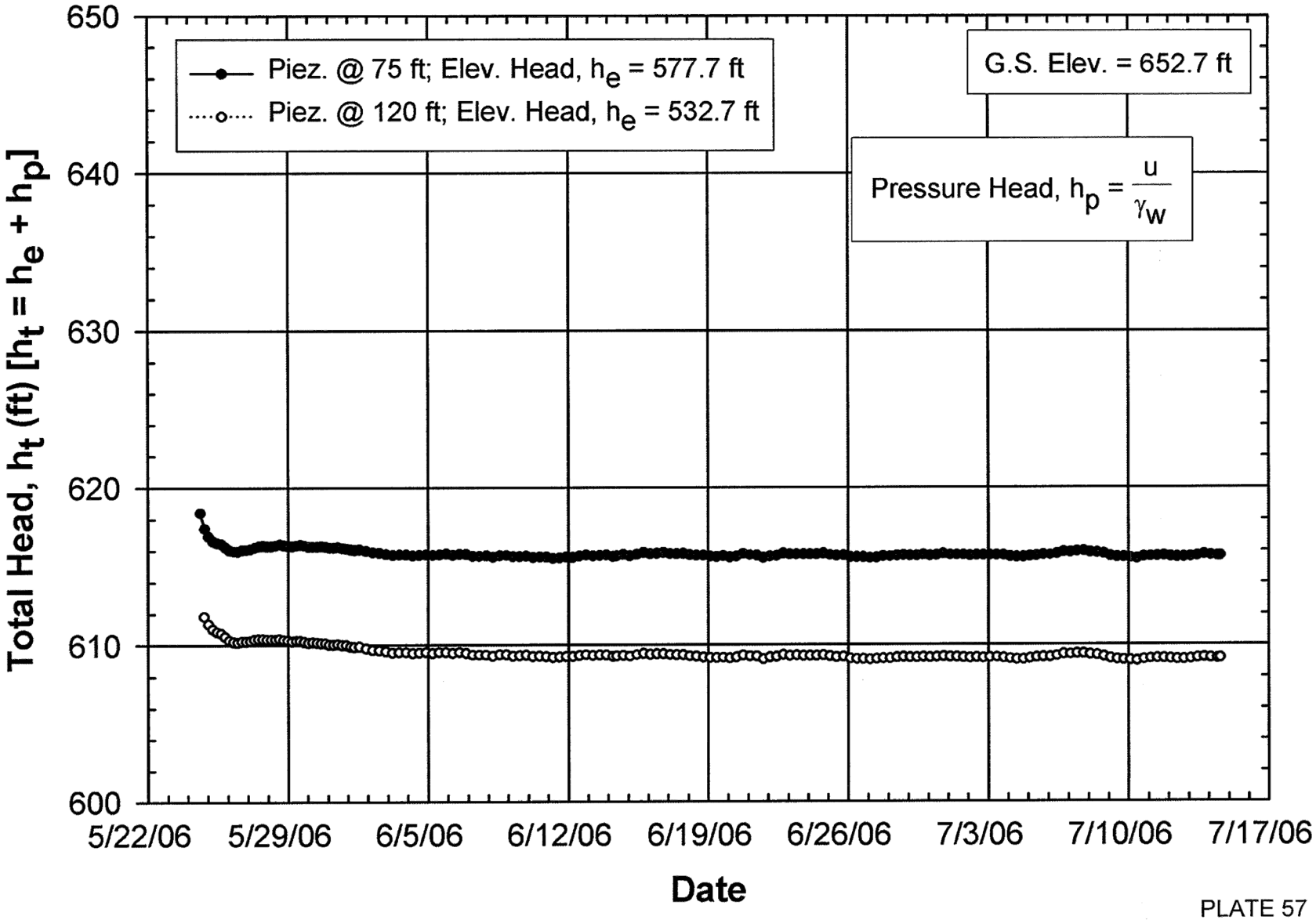


PLATE 57

B-05-13 VW Piezometer Readings

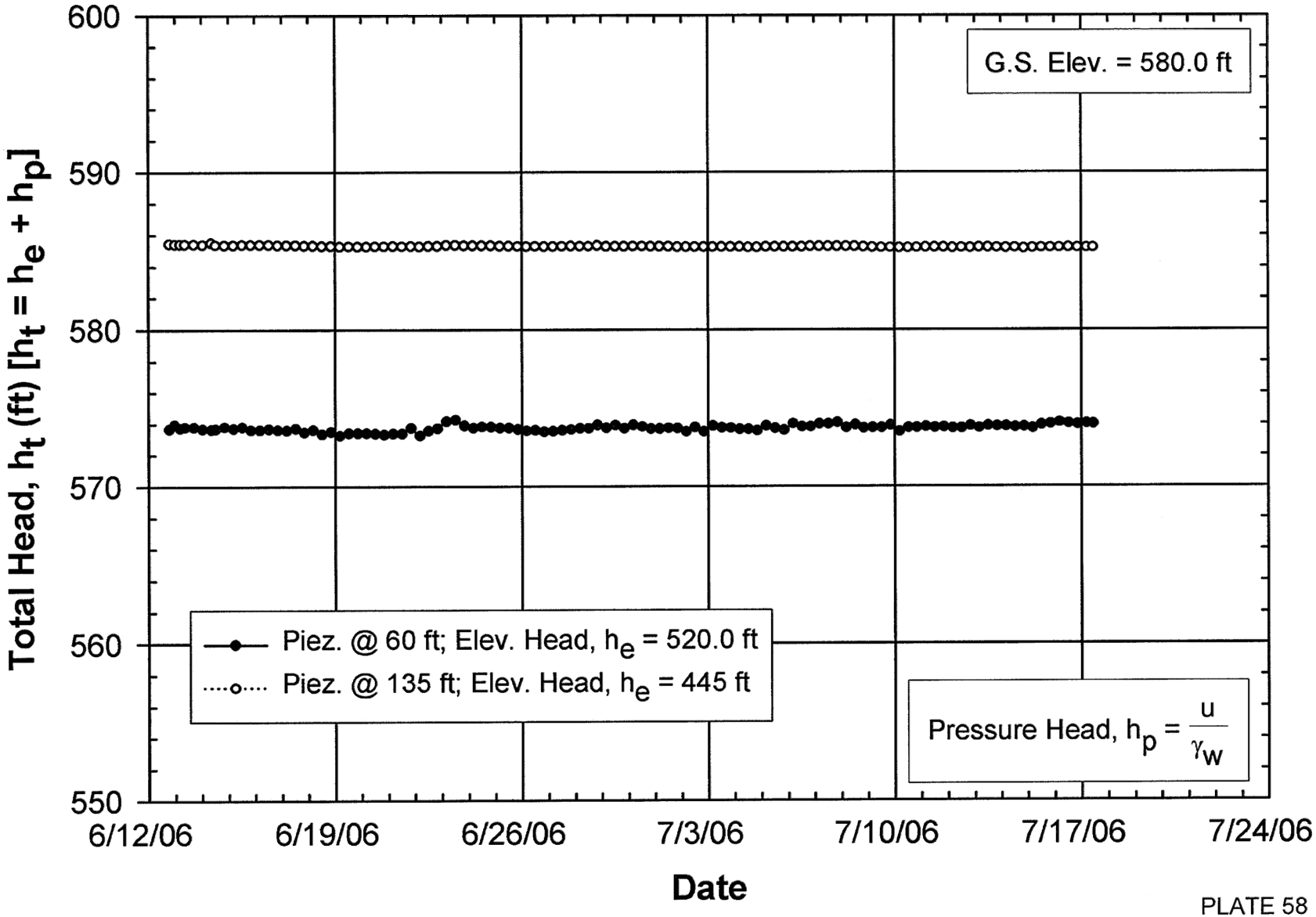


PLATE 58

CALIPERED SURFACE DISTANCE TABLE
CUY-90-15.24

Date	Left Pier Calipered Surface Distance		Center Line Calipered Surface Distance		Right Pier Calipered Surface Distance	
	Present reading	Change (in.)	Present reading	Change (in.)	Present reading	Change (in.)
10/15/99	6.006	--	Not Accessible		4.575	--
12/27/99	6.025	0.019	Not Accessible		4.579	0.004
04/19/00	6.064	0.039	Not Accessible		4.527	-0.052
07/20/00	6.000	-0.064	Not Accessible		4.516	-0.011
10/26/00	5.876	-0.124	Not Accessible		4.294	-0.222
01/29/01	5.929	0.053	Not Accessible		4.385	0.091
04/17/01	Not Accessible		Not Accessible		Not Accessible	
07/19/01	6.043	0.114	Not Accessible		4.312	-0.073
11/08/01	6.250	0.207	Not Accessible		4.469	0.157
01/23/02	6.253	0.003	Not Accessible		4.518	0.049
04/17/02	6.285	0.032	Not Accessible		4.435	-0.083
07/16/02	6.290	0.005	Not Accessible		4.444	0.009
10/15/02	6.333	0.043	Discontinued		4.482	0.038
01/15/03	6.405	0.072			4.473	-0.009
04/17/03	6.333	-0.072			4.482	0.009
07/18/03	6.186	-0.147			4.350	-0.132
10/16/03	6.385	0.199			4.519	0.169
01/08/04	6.124	-0.261			4.594	0.075
04/14/04	6.129	0.005			4.402	-0.193
07/16/04	6.250	0.122			4.277	-0.125
10/27/04	6.375	0.125			4.467	0.190
01/12/05	6.250	-0.125			4.349	-0.118
04/14/05	6.375	0.125			4.372	0.023
07/14/05	6.313	-0.063			4.392	0.020
10/12/05	6.375	0.063			4.358	-0.034
02/01/06	6.438	0.063			4.395	0.037
04/20/06	6.500	0.063			4.430	0.035
07/14/06	6.375	-0.125			4.381	-0.049

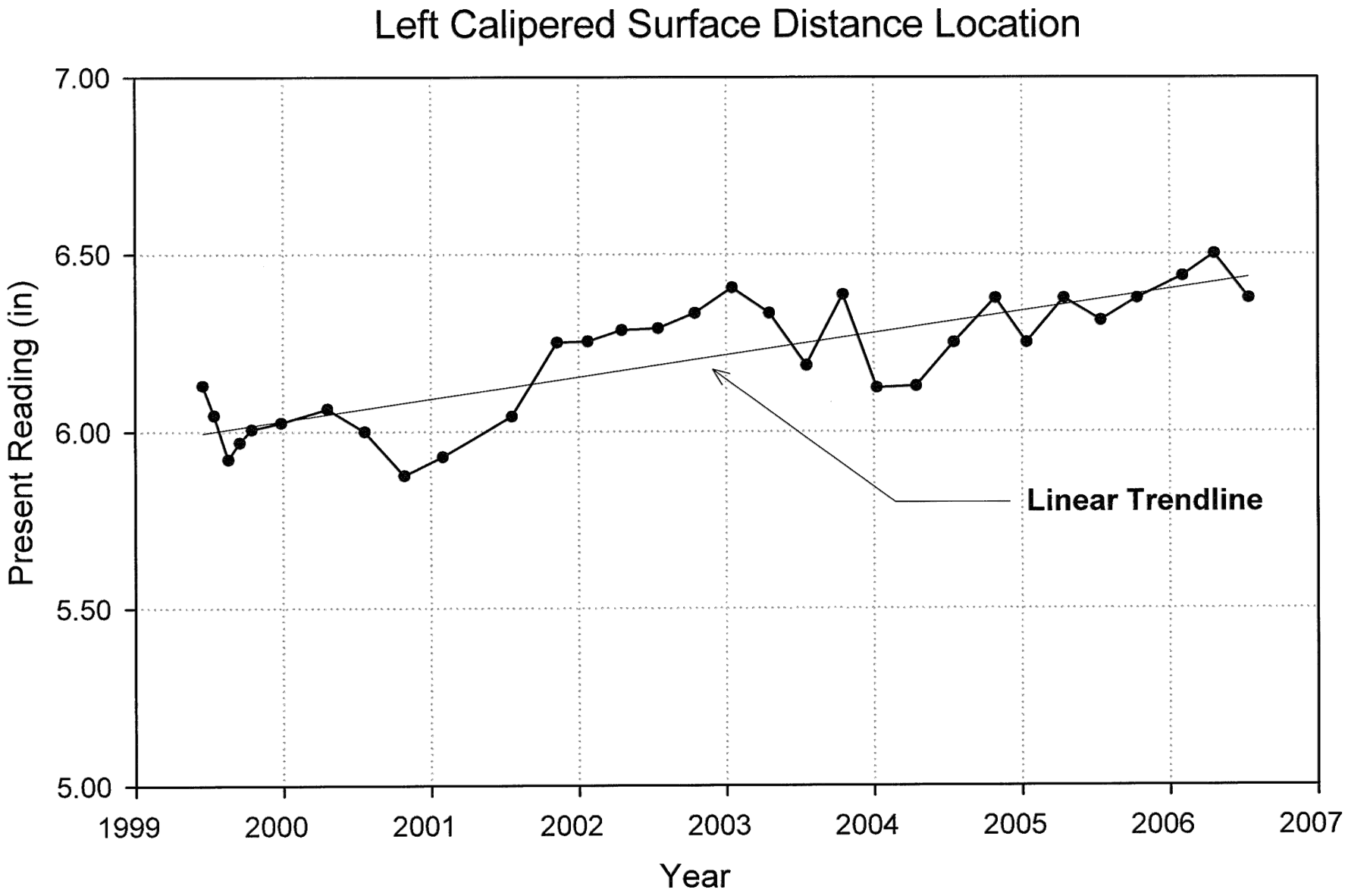

Left Calipered Surface Distance Location
7.00
6.50
6.00
5.50
5.00
Present Reading (in)
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year
Linear Trendline

PLATE 60

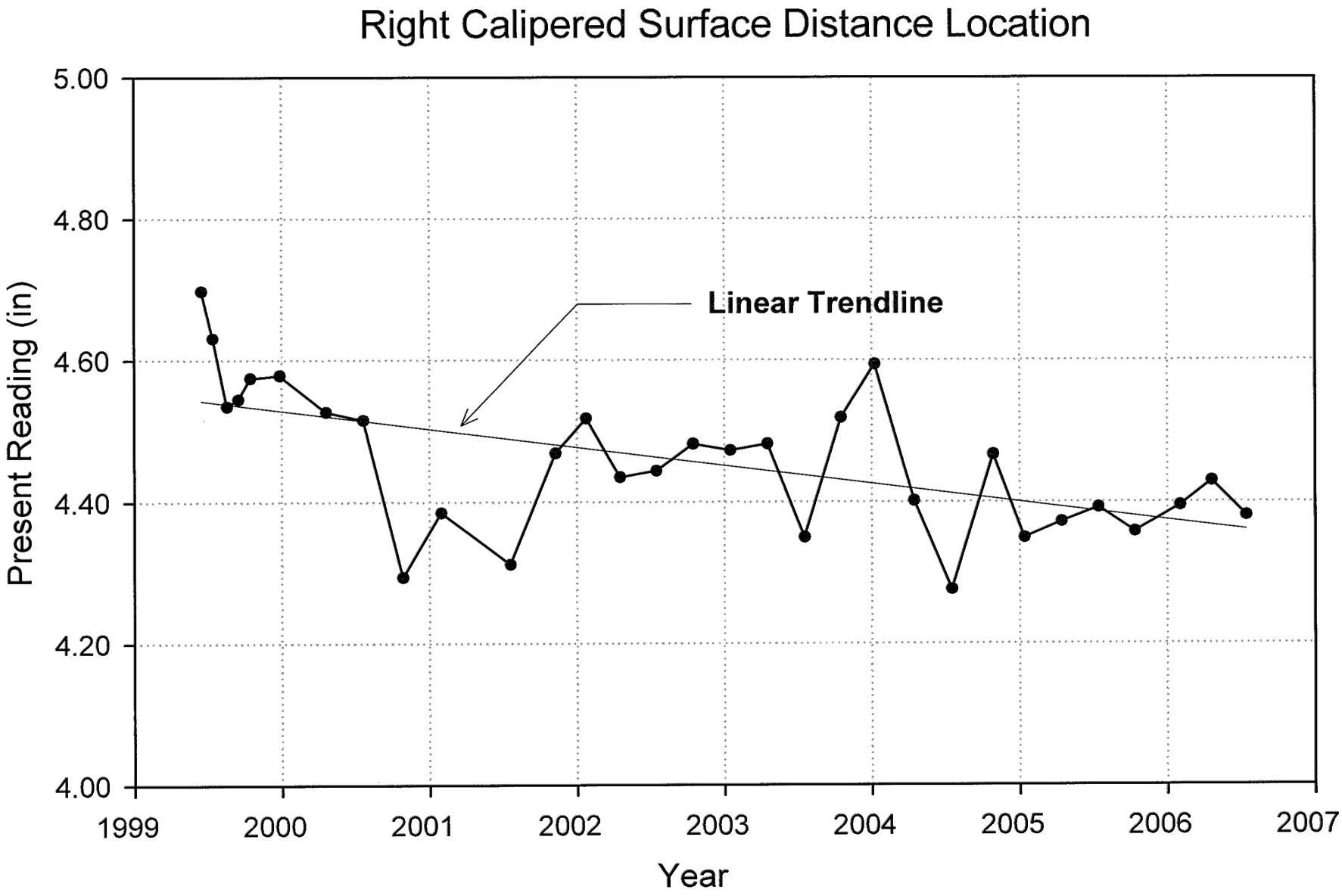

Right Calipered Surface Distance Location
5.00
4.80
4.60
4.40
4.20
4.00
Present Reading (in)
Linear Trendline
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

PLATE 61

BBCM

BBC&M ENGINEERING, INC. 8555 Sweet Valley Drive, Suite S, Valley View, Ohio 44125-4254
Phone (216) 901-1000 Fax (216) 901-9996

March 16, 2006
Inc_B110 Removal.doc

Mr. Robert B. Parker, P.E.
Ohio Manager/Assistant Vice President
Michael Baker Jr., Inc.
The Halle Building
1228 Euclid Avenue, Suite 1050
Cleveland, Ohio 44115

Re: Excavation and Removal of Inclinometer B-110
CUY-90-15.24 Bridge
Cleveland, Cuyahoga County, Ohio

Dear Mr. Parker:

During field operations associated with the subsurface investigation for the CUY-90-15.24 West Abutment project, BBCM personnel observed the results of recent excavation activities near inclinometer B-110. Inclinometer B-110 is northeast of the existing I-90 bridge alignment as illustrated in Plate 1. **These excavation activities could have a potentially negative impact on the overall stability of the existing I-90 bridge and may accelerate movement of the hillside adjacent to the bridge.**

Cook Paving Construction Co., Inc. vehicles were noted at the site as shown in Plate 2. Approximately 20 feet of material has been excavated adjacent to the Cuyahoga River and has been stockpiled upslope near University Avenue. Plates 3 and 4 illustrate the stockpiled material near University Avenue. Plates 5 and 6 illustrate the excavation area adjacent to the Cuyahoga River. In the process of excavation, it appears the existing inclinometer B-110 has been either destroyed or buried and is now unreadable. Plate 7 illustrates crewmen apparently preparing to pull back the sheetpile wall.

Removing material at the toe of the local slide that is actively occurring near B-110 and placing that material upslope has at least four negative impacts.

1. Resistance at the toe of the local slide has been removed, which is expected to reduce the stability of the local slide in the vicinity of inclinometer B-110;
2. Additional fill has been placed at the top of the hillside adjacent to University Avenue thus adding to the driving force, which is expected to reduce the stability of the local slide in the vicinity of inclinometer B-110;
3. Resistance at the toe of the west bank slope large slide mass beneath the I-90 bridge has been removed and it is expected to reduce the stability and/or increase the creep rate since inclinometer readings indicate the slope is creeping more or less toward inclinometer B-110 as illustrated in Plate 8, which was taken from BBCM's 2005 report

to Richland Engineering; and,

4. Inclinometer B-110 is now unreadable, which negatively impacts BBCM's ability to monitor creep behavior at the toe of the slope northwest of the existing I-90 bridge as there are no other inclinometers in the immediate vicinity.

In addition to the negative impact these activities have on the existing bridge structure, **it could also have a potentially negative impact of the stability of the hillside beneath the proposed near north and far north bridge alignments. BBCM will need updated ground surface topographic information to adequately perform the stability analysis within cross section A-A** as stated in our Revised Cost Proposal, dated February 1, 2006, of Subsurface Investigation/Instrumentation for the West Abutment of the proposed CUY-90-15.24 Bridge.

BBCM wants to emphasize that the excavation activities presented herein **could have a potentially negative impact on the overall stability of the existing I-90 bridge, proposed near north alignment, and proposed far north alignment and these activities may accelerate movement of the hillside.** As such, BBCM recommends advising ODOT of the noted excavation activities as quickly as possible. Furthermore, BBCM requests that the design team keep BBCM informed of any measures ODOT takes, if any, as these excavation activities and any ODOT measures could affect BBCM's recommendations pertaining to Subsurface Investigation/Instrumentation for the West Abutment of the proposed CUY-90-15.24 Bridge.

We appreciate the opportunity to be of service to you and look forward to continued collaboration in the future. Please do not hesitate to call our office should you require further information.

Respectfully submitted,
BBC&M Engineering, Inc.
Cleveland, Ohio

Donald C. Wotring

Donald C. Wotring, Ph.D.
Project Engineer

Peter Lee

Peter S. Lee, Ph.D., P.E.
Senior Project Engineer

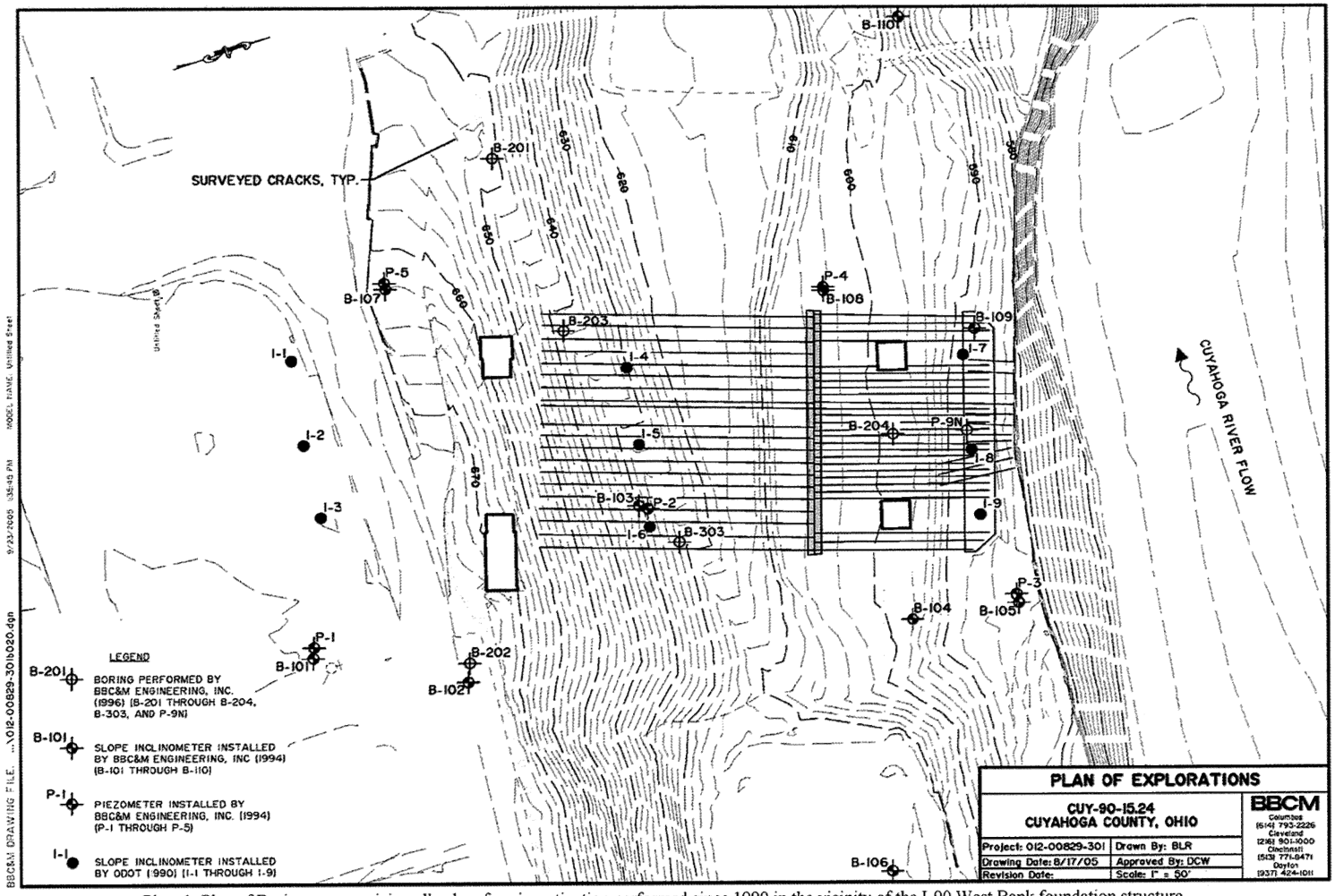


Plate 1: Plan of Borings summarizing all subsurface investigation performed since 1990 in the vicinity of the I-90 West Bank foundation structure.

Plate 2: Looking northwest from University Avenue at crew vehicle (Cook).

Plate 3: View from platform near cold storage warehouse. The stockpile of recently excavated material is located at the top of the hillside near the excavator.

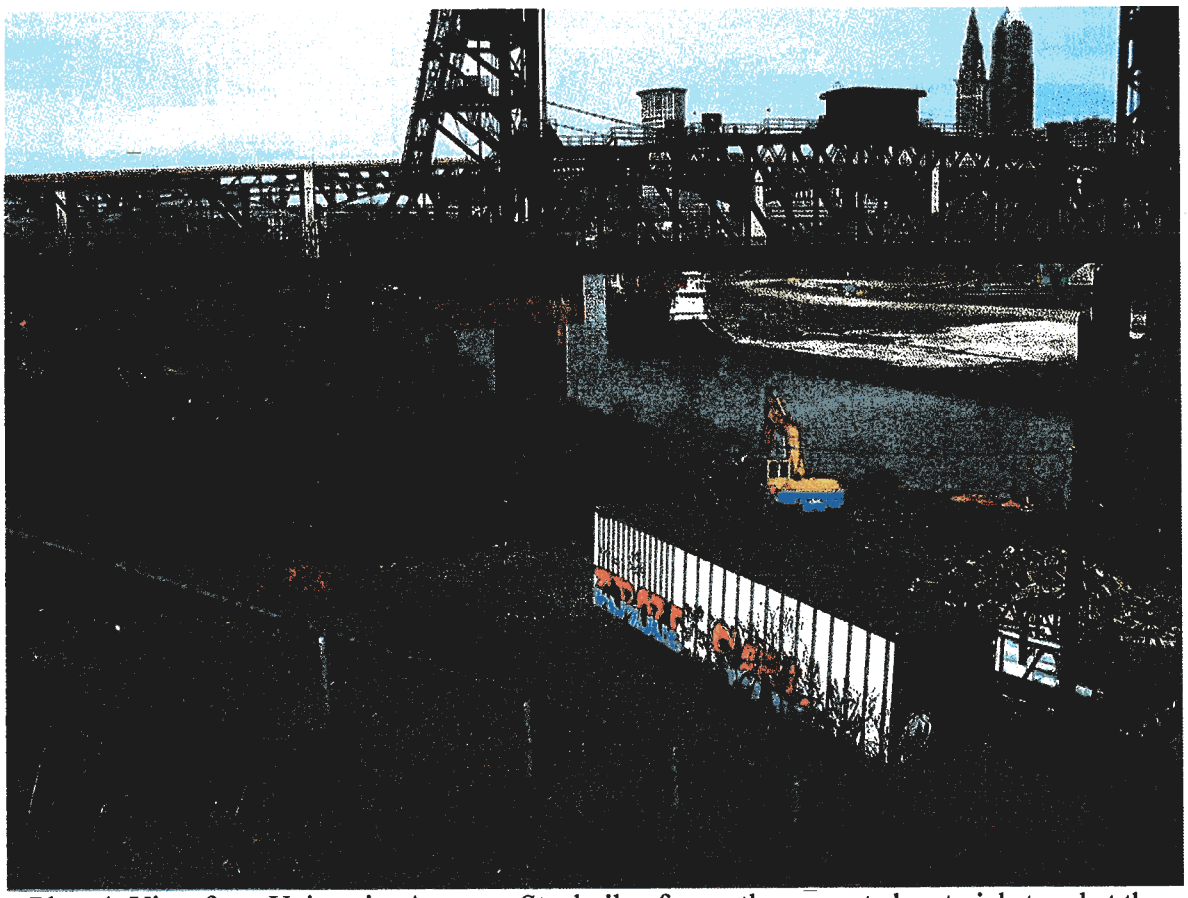


Plate 4: View from University Avenue. Stockpile of recently excavated material stored at the

Plate 5: Looking west at area of excavation. Visual observation indicates that approximately 20 feet of material was removed and placed upslope. The stockpile of material is visible at the upper left corner of this picture.

Plate 6: Looking west at excavation area.

Plate 7: Looking northwest at crew apparently preparing to pull back sheet pile wall.

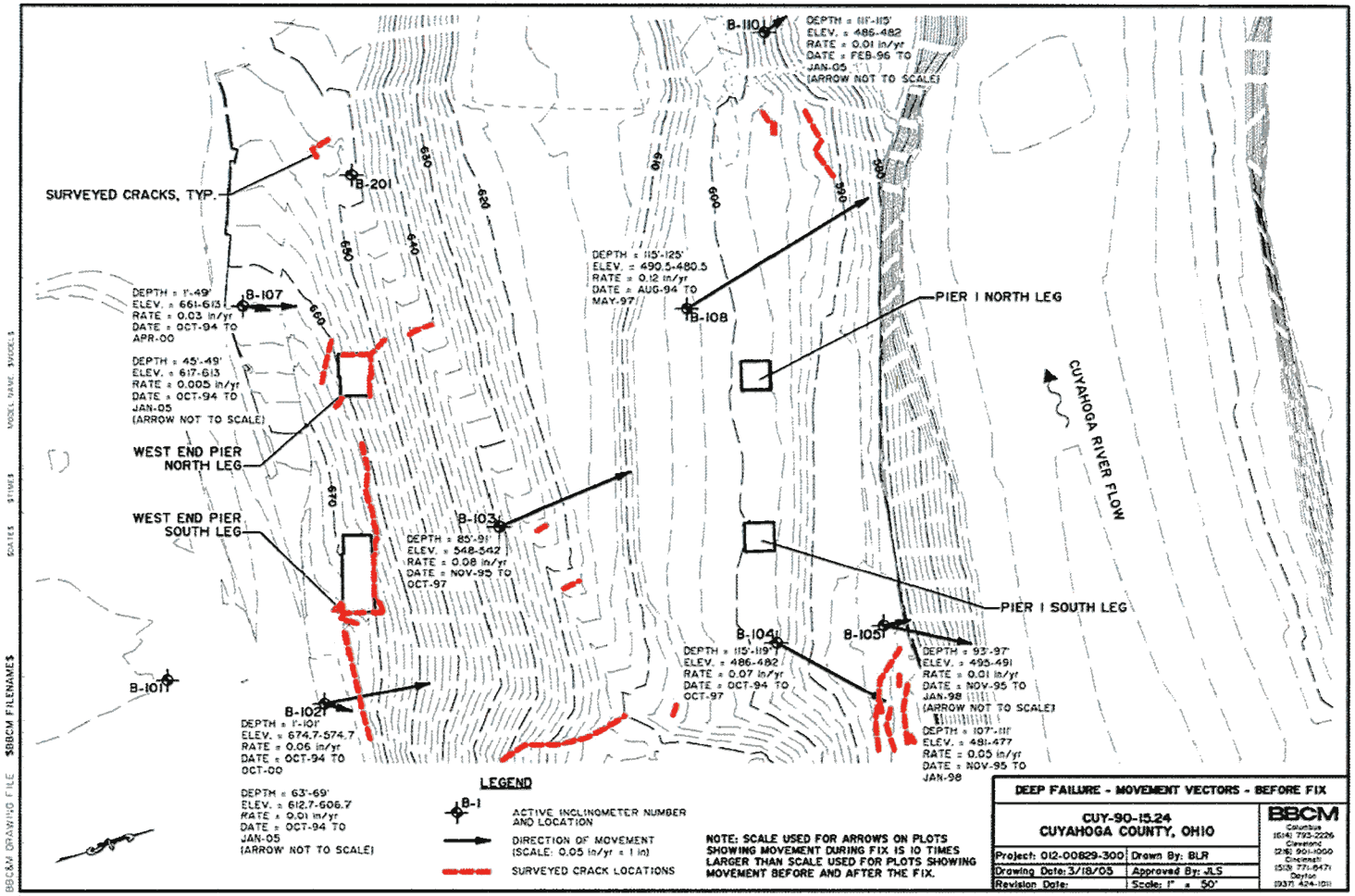


FIGURE 10

Plate 8: Movement vectors associated with the deep failure plane prior to constructing the stabilization structure. This figure was taken from BBCM's 2005 report to Richland Engineering.

106017
~~100109~~

Richland Engineering Limited

From: "arthur huckelbridge" <aah4@case.edu>
To: "'Richland Engineering Limited'" <reltd@r-e-l.com>
Sent: Monday, July 24, 2006 11:46 PM
Attach: tilts 7_06.ppt
Subject: RE: CUY-90-15.24, PID 20752, Monitoring

Dean:

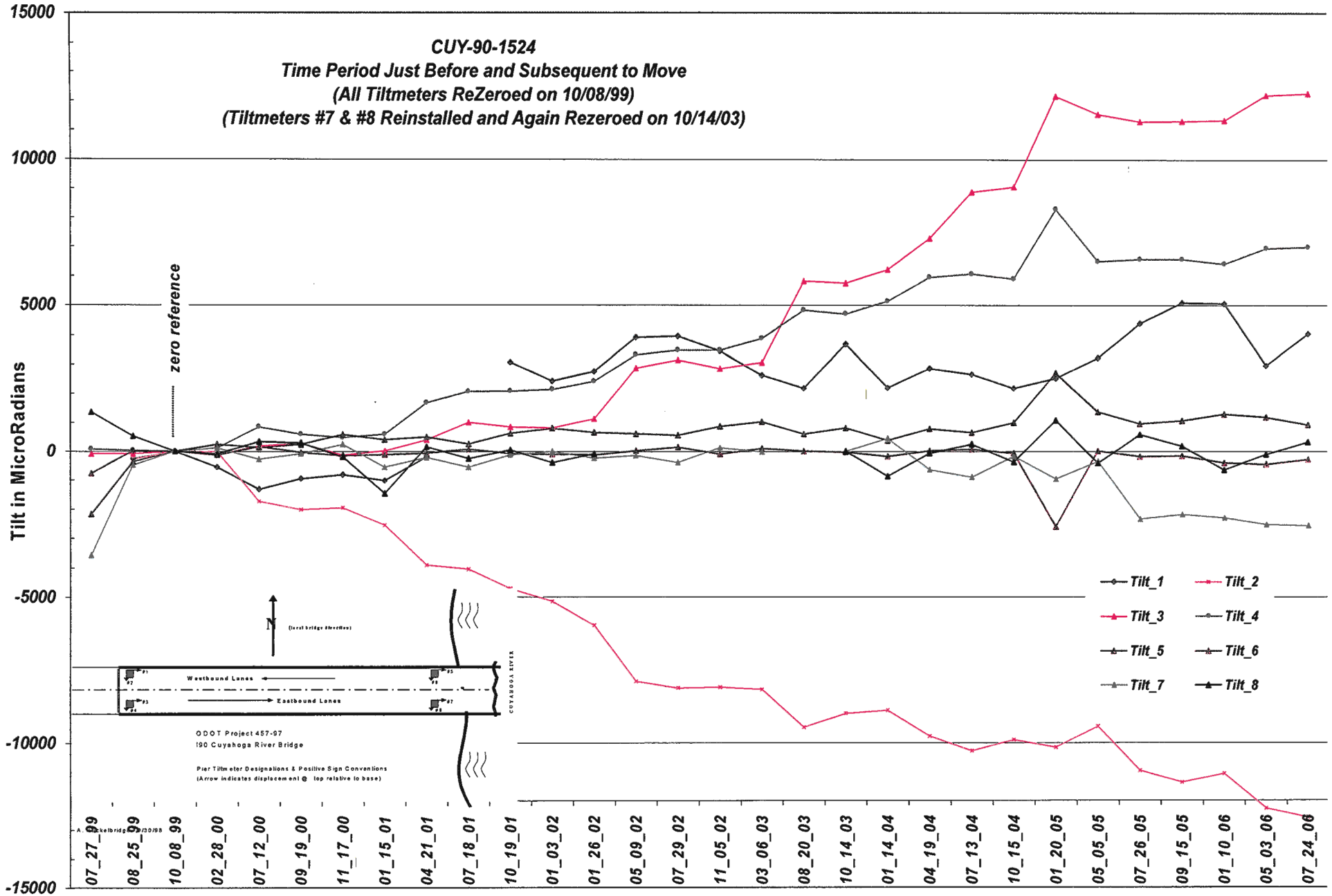
Attached are the tiltmeter readings from this month. The readings at tiltmeters 1 – 4 continue their historical trends. Tiltmeters 5 – 8 are, by comparison, much more stable. Let me know if you have questions.

Regards,

Art

PS Recently got back from a visit to Scotland and to the Czech Republic – both marvelous places !

This e-mail, including any files transmitted with it, is confidential. It is intended solely for the use of the individual or entity to whom it is addressed. If you are not the intended recipient or the person responsible for delivering the e-mail to the intended recipient, be advised that you have received this e-mail in error, and that any use, dissemination, forwarding, printing, or copying of this e-mail is strictly prohibited.


CUY-90-1524
Time Period Just Before and Subsequent to Move
(All Tiltmeters ReZeroed on 10/08/99)
(Tiltmeters #7 & #8 Reinstalled and Again Rezeroed on 10/14/03)
Tilt in MicroRadians
15000
10000
5000
0
-5000
-10000
-15000
zero reference
Tilt_1
Tilt_2
Tilt_3
Tilt_4
Tilt_5
Tilt_6
Tilt_7
Tilt_8
07_27_99
08_25_99
10_08_99
02_28_00
07_12_00
09_19_00
11_17_00
01_15_01
04_21_01
07_18_01
10_19_01
01_03_02
01_26_02
05_09_02
07_29_02
11_05_02
03_06_03
08_20_03
10_14_03
01_14_04
04_19_04
07_13_04
10_15_04
01_20_05
05_05_05
07_26_05
09_15_05
01_10_06
05_03_06
07_24_06
Westbound Lanes
Eastbound Lanes
ODOT Project 457-97
I90 Cuyahoga River Bridge
Pier Tiltmeter Designations & Positive Sign Conventions
(Arrow indicates displacement @ top relative to base)

1060017

Robert Y. Liang, Ph.D., P.E
8441 Timber Tr.
Brecksville, Ohio 44141

Cell Phone: (440) 725-7425
e-mail: RYLIANG@AOL.COM

July 29, 2006

Mr. Dean Palmer, P.E.
Richland Engineering, Ltd.
29 North Park St.
Mansfield, OH 44902

Ref: CUY-90-14.52, PID No. 77332

Dear Mr. Palmer:

Attached in this letter is the processed monitoring data for the stabilization structures for the referenced project. We went to the site on July 24, 25, and 26 to download the data, take the inclinometer readings, and provide maintenance of the on-site data logger and batteries. The data are processed and enclosed as tables and figures. We did not observe any significant change in the strain readings during the quarter between April 2006 and July 2006. The inclinometer readings showed no significant movement in A-direction, with some very minor movement in B-direction. As the movement is small, we will continue to keep a closer look at the inclinometer reading during next quarterly reading.

Please call me at (440) 725-7425, if you have any question.

Sincerely,

Robert Liang

Robert Liang

Shaft 1: Bending moment along shaft, kip-ft

Depth, ft / Date	9.50	16.00	22.50	29.00	35.50	42.00	47.00	54.80	64.80	74.80	84.80	94.80	115.00	135.00
7/01/1999	-357.65	-148.91	-2.99	242.13	107.23	94.27	103.67	221.87	109.32	92.67	66.77	48.25	-38.94	91.57
1/08/2003	-774.82	-792.90	-360.63	403.12	139.71	-1.79	473.87	620.31	11.19	262.65	439.51	230.65	-179.60	668.90
4/15/2003	-657.74	-650.00	-232.57	481.71	156.43	-14.02	517.65	659.68	2.44	268.91	457.85	238.57	-192.49	684.79
7/01/2003	-763.24	-602.42	-72.91	660.28	319.17	32.14	588.57	715.87	14.21	278.09	474.99	251.23	-206.00	702.94
8/07/2003	-817.04	-638.73	-81.08	678.00	343.79	44.44	615.09	726.92	17.44	279.15	477.58	254.31	-210.32	708.78
10/07/2003	-913.81	-801.08	-248.05	552.54	251.84	20.93	623.30	710.92	6.80	271.90	474.43	265.38	-225.46	720.58
12/31/2003	-870.9	-838.68	-322.24	476.14	168.18	-13.93	630.87	701.76	-19.51	263.35	479.49	275.24	-220.96	748.57
4/13/2004	-831.87	-777.37	-255.87	514.98	175.37	-24.83	659.66	727.03	-27.47	269.67	495.81	277.88	-211.65	763.52
7/13/2004	-889.99	-676.85	-77.13	709.38	338.24	22.05	727.23	792.27	-5.75	281.70	512.30	283.50	-221.34	787.54
10/08/2004	-983.05	-812.00	-201.66	636.33	293.00	16.71	752.87	793.14	-7.37	272.19	514.89	286.68	-231.10	803.15
1/07/2005	-925.21	-882.29	-353.38	471.75	139.59	-39.87	733.05	761.38	-34.60	264.10	510.62	288.64	-223.06	817.18
4/08/2005	-775.03	-726.00	-235.05	530.47	150.69	-53.27	749.88	786.67	-40.37	267.30	525.48	290.73	-219.80	828.14
7/18/2005	-957.73	-709.43	-81.75	735.77	338.65	7.97	821.52	856.49	-16.82	278.53	538.72	298.79	-226.87	837.24
8/26/2005	-1005.57	-755.34	-117.03	721.71	336.36	13.60	835.13	860.64	-16.18	278.76	539.43	301.65	-233.64	840.82
10/11/2005	-1033.08	-827.24	-199.79	654.90	284.17	7.2946	833.72	848.04	-26.29	273.50	537.36	299.33	-240.08	843.25
1/10/2006	-918.83	-858.03	-339.71	489.13	122.55	-48.55	810.18	815.92	-54.94	262.93	536.10	298.82	-234.11	855.77
4/9/2006	-901.14	-812.00	-289.67	510.35	123.88	-55.75	815.90	831.32	-58.19	267.19	540.25	311.97	-239.53	860.00
7/19/2006	-958.11	-696.52	-82.70	726.22	300.21	-4.96	875.09	898.74	-34.15	279.81	562.98	305.74	-236.04	865.74

Shaft 9: Bending moment along shaft, kip-ft

Depth, ft / Date	11	17.5	24	30.5	37	43.25	50	60	70	80	95	115	135
7/01/1999	-67.89	-31.81	8.56	12.84	20.80	19.57	14.07	0.61	9.79	11.62	-33.33	18.35	26.30
1/08/2003	-347.44	-803.74	-998.93	-1106.33	-698.39	-903.77	-661.43	-353.18	324.27	-148.11	-1315.52	540.06	541.35
4/15/2003	-592.31	-919.80	-1050.61	-1133.34	-723.59	-939.66	-696.63	-369.12	336.59	-143.51	-1378.77	555.20	549.67
7/01/2003	-666.55	-902.38	-1016.77	-1090.93	-713.88	-914.42	-686.74	-395.16	340.01	-144.29	-1435.98	557.09	553.50
8/07/2003	-687.84	-917.20	-1003.18	-1072.98	-695.58	-886.87	-664.36	-384.64	352.00	-133.30	-1462.27	566.15	565.69
10/07/2003	-490.45	-863.81	-1007.81	-1107.14	-708.81	-891.63	-656.83	-378.93	360.91	-134.77	-1498.83	577.44	567.18
12/31/2003	-514.68	-913.27	-1054.9	-1163.2	-741.63	-949.18	-697.72	-421.12	390.01	-101.42	-1555.5	633.83	579.35
4/13/2004	-604.44	-966.22	-1090.5	-1188.0	-761.54	-987.22	-743.54	-446.54	402.54	-82.56	-1609.1	644.77	582.97
7/13/2004	-817.01	-1007.24	-1051.35	-1122.59	-730.91	-933.53	-709.92	-447.66	411.36	-83.06	-1648.19	649.10	585.94
10/08/2004	-674.74	-949.72	-1005.93	-1128.49	-732.60	-927.74	-697.54	-445.16	413.37	-90.78	-1677.71	652.24	581.64
1/07/2005	-572.76	-951.94	-1036.44	-1183.00	-760.90	-966.49	-718.51	-441.27	424.15	-94.18	-1699.91	657.05	573.07
4/08/2005	-773.86	-1039.72	-1072.89	-1200.56	-775.89	-989.82	-743.85	-446.59	435.56	-92.57	-1726.57	664.45	574.55
7/18/2005	-885.57	-1041.08	-1038.29	-1152.24	-752.36	-948.63	-719.09	-449.39	438.06	-89.12	-1762.02	670.82	576.24
8/26/2005	-835.50	-1020.01	-1028.45	-1146.98	-746.96	-933.35	-702.48	-447.31	442.02	-86.41	-1773.96	672.92	595.07
10/11/2005	-749.53	-997.40	-1026.45	-1157.47	-750.11	-932.26	-695.29	-445.61	446.57	-84.01	-1786.07	677.93	594.21
1/10/2006	-735.54	-1025.94	-1070.26	-1220.95	-784.71	-983.06	-728.35	-455.60	455.80	-79.41	-1811.10	694.94	585.21
4/9/2006	-761.63	-1055.46	-1104.66	-1250.13	-799.79	-1009.40	-750.25	-456.86	465.33	-75.95	-1830.39	709.25	584.13
7/19/2006	-978.46	-1095.84	-1069.88	-1181.41	-764.38	-964.94	-725.66	-456.93	467.47	-66.95	-1860.01	728.28	590.74

Tie Beam Forces and Bending Moments (Driven Pile Cap Side)

Tie #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
	7/1/1999	-47.1	68.5	551.7	681.8	313.73	10.70	616.75	252.30	375.15	83.06	-40.28	-2.75
	7/15/1999	-70.1	53.8	538.8	666.8	297.33	-8.15	602.80	234.35	360.30	78.72	-40.60	-2.82
	8/15/1999	10.7	114.3	613.7	728.1	366.70	62.50	670.90	312.20	421.20	97.09	-40.43	-2.44
	8/31/1999	12.0	114.3	617.3	732.8	369.10	63.15	675.05	314.65	423.55	97.73	-40.67	-2.44
	9/15/1999	13.1	113.5	619.7	737.5	370.95	63.30	678.60	316.40	425.50	98.22	-40.89	-2.44
	9/30/1999	29.6	122.3	634.4	753.4	384.93	75.95	693.90	332.00	437.85	101.92	-41.07	-2.37
	10/15/1999	34.7	123.9	637.8	757.9	388.58	79.30	697.85	336.25	440.90	102.88	-41.11	-2.34
	10/31/1999	39.8	127.2	646.6	762	393.90	83.50	704.30	343.20	444.60	104.29	-41.26	-2.27
	11/15/1999	62.3	139.3	662.9	780.1	411.15	100.80	721.50	362.60	459.70	108.86	-41.25	-2.18
	11/30/1999	73.7	146.3	670.6	788.6	419.80	110.00	729.60	372.15	467.45	111.15	-41.18	-2.13
	12/15/1999	72.8	143.6	668.9	789.7	418.75	108.20	729.30	370.85	466.65	110.87	-41.28	-2.15
	12/31/1999	88.8	152.1	680.1	802.5	430.88	120.45	741.30	384.45	477.30	114.08	-41.26	-2.08
	3/31/2000	95.3	158.7	682.5	825.2	440.43	127.00	753.85	388.90	491.95	116.61	-41.66	-2.31
	6/30/2000	60.2	138.2	662.7	804.5	416.40	99.20	733.60	361.45	471.35	110.25	-42.16	-2.46
	9/30/2000	50.1	142.5	668.8	795.7	414.28	96.30	732.25	359.45	469.10	109.69	-42.26	-2.46
	1/13/2001	109.5	179.9	712.3	845.5	461.80	144.70	778.90	410.90	512.70	122.27	-42.15	-2.28
	4/20/2001	126.8	283.2	715.3	881.9	501.80	205.00	798.60	421.05	582.55	132.86	-39.45	-3.62
	7/16/2001	68.3	149.8	674.3	837.1	432.38	109.05	755.70	371.30	493.45	114.48	-42.98	-2.74
	10/9/2001	71.4	157.1	685.5	840.8	438.70	114.25	763.15	378.45	498.95	116.15	-43.12	-2.70
1	1/9/2002	102.7	177.8	713	872	466.38	140.25	792.50	407.85	524.90	123.48	-43.35	-2.62
	4/12/2002	125.5	192.8	738.6	904.9	490.45	159.15	821.75	432.05	548.85	129.86	-44.04	-2.62
	7/18/2002	62.3	151.8	706.334	859.6	445.01	107.05	782.97	384.32	505.70	117.82	-44.92	-2.72
	10/8/2002	43.7	151.1	711.3	846.7	438.20	97.40	779.00	377.50	498.90	116.02	-45.30	-2.72
	1/8/2003	84.7	180.5	748.5	891.8	476.38	132.60	820.15	416.60	536.15	126.13	-45.69	-2.68
	4/15/2003	96.1	191.9	739.9	989.3	504.30	144.00	864.60	418.00	590.60	133.52	-47.89	-3.87
	7/1/2003	57.4	168	713	959	474.35	112.70	836.00	385.20	563.50	125.59	-48.07	-3.99
	10/7/2003	42.1	166.8	714	946.6	467.38	104.45	830.30	378.05	556.70	123.75	-48.24	-4.00
	12/31/2003	80	197.9	753.9	985.1	504.23	138.95	869.50	416.95	591.50	133.50	-48.55	-3.91
	4/13/2004	92	208.9	760.4	1006.6	516.98	150.45	883.50	426.20	607.75	136.88	-48.72	-4.07
	7/13/2004	14.6	163.9	707.3	954.4	460.05	89.25	830.85	360.95	559.15	121.81	-49.29	-4.44
	10/8/2004	-8.6	233.4	704.6	941	467.60	112.40	822.80	348.00	587.20	123.81	-47.21	-5.36
	1/7/2005	19.5	190.4	746.5	982.5	484.73	104.95	864.50	383.00	586.45	128.34	-50.48	-4.56
	4/8/2005	3.4	397.6	751.6	1003.4	539.00	200.50	877.50	377.50	700.50	142.71	-44.99	-7.24
	7/18/2005	3.1	164.3	709.7	969.6	461.68	83.70	839.65	356.40	566.95	122.24	-50.24	-4.72
	8/26/2005	3.1	157.5	702.5	956.3	454.85	80.30	829.40	352.80	556.90	120.43	-49.78	-4.57
	10/11/2005	3.1	164.2	712.6	960.1	460.00	83.65	836.35	357.85	562.15	121.79	-50.02	-4.58
	1/10/2006	3.1	191.9	742.5	997	483.63	97.50	869.75	372.80	594.45	128.05	-51.32	-4.97
	4/9/2006	3.5	205.3	750.7	1018.8	494.58	104.40	884.75	377.10	612.05	130.95	-51.86	-5.26
	7/19/2006	3.5	166.6	703.7	975.5	462.33	85.05	839.60	353.60	571.05	122.41	-50.15	-4.87

Tie Beam Forces and Bending Moments (Driven Pile Cap Side) (cont'd)

Tie #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
12	7/1/1999	374.9	6	549.6	471.8	350.58	190.45	510.70	462.25	238.90	92.82	-21.28	5.00
	7/15/1999	368.6	-3.6	544.2	467.3	344.13	182.50	505.75	456.40	231.85	91.11	-21.48	5.03
	8/15/1999	373.7	0.2	569.4	485.2	357.13	186.95	527.30	471.55	242.70	94.56	-22.62	5.13
	8/31/1999	368.4	-4.7	567	486.2	354.23	181.85	526.60	467.70	240.75	93.79	-22.91	5.08
	9/15/1999	365.9	-9.2	565.3	485.1	351.78	178.35	525.20	465.60	237.95	93.14	-23.05	5.10
	9/30/1999	364.6	-11.7	570.1	487.6	352.65	176.45	528.85	467.35	237.95	93.37	-23.42	5.14
	10/15/1999	361.7	-14.8	569.9	487.4	351.05	173.45	528.65	465.80	236.30	92.95	-23.61	5.14
	10/31/1999	362.8	-13.5	575.6	493.1	354.50	174.65	534.35	469.20	239.80	93.86	-23.91	5.14
	11/15/1999	365.0	-11.5	581.4	498	358.23	176.75	539.70	473.20	243.25	94.85	-24.12	5.15
	11/30/1999	365.6	-11.8	583.7	500.1	359.40	176.90	541.90	474.65	244.15	95.16	-24.26	5.16
	12/15/1999	368.0	-9.2	589.7	504.2	363.18	179.40	546.95	478.85	247.50	96.16	-24.43	5.18
	12/31/1999	369.0	-8	592.9	506.6	365.13	180.50	549.75	480.95	249.30	96.67	-24.54	5.19
	3/31/2000	379.6	7.3	617	524.1	382.00	193.45	570.55	498.30	265.70	101.14	-25.06	5.21
	6/30/2000	376.1	4.4	608.9	519.1	377.13	190.25	564.00	492.50	261.75	99.85	-24.84	5.17
	9/30/2000	360.7	-12.3	588.3	503.5	360.05	174.20	545.90	474.50	245.60	95.33	-24.70	5.13
	1/13/2001	372.1	2.2	618.1	526.1	379.63	187.15	572.10	495.10	264.15	100.51	-25.58	5.17
	4/20/2001	387.6	21	645.8	549.2	400.90	204.30	597.50	516.70	285.10	106.15	-26.13	5.19
	7/16/2001	374.6	6.5	621.5	532.9	383.88	190.55	577.20	498.05	269.70	101.64	-25.70	5.12
	10/9/2001	360.9	-9.4	598.9	515.8	366.55	175.75	557.35	479.90	253.20	97.05	-25.36	5.08
	1/9/2002	363.5	-2.5	611.5	524.5	374.25	180.50	568.00	487.50	261.00	99.09	-25.75	5.07
	4/12/2002	381.7	16.9	642.7	550.5	397.95	199.30	596.60	512.20	283.70	105.37	-26.40	5.12
	7/18/2002	375	10.5	629	544.7	389.80	192.75	586.85	502.00	277.60	103.21	-26.19	5.03
	10/8/2002	357.7	-9.6	599.2	523	367.58	174.05	561.10	478.45	256.70	97.32	-25.72	4.97
	1/8/2003	367.3	6.5	626.7	542.7	385.80	186.90	584.70	497.00	274.60	102.15	-26.44	4.98
	4/15/2003	385.9	27.3	655.3	566.2	408.68	206.60	610.75	520.60	296.75	108.20	-26.86	5.01
	7/1/2003	384.7	26.3	649.2	565.6	406.45	205.50	607.40	516.95	295.95	107.62	-26.71	4.95
	10/7/2003	360.6	3.5	613	539.7	379.20	182.05	576.35	486.80	271.60	100.40	-26.20	4.82
	12/31/2003	372	19.4	636	558.3	396.43	195.70	597.15	504.00	288.85	104.96	-26.68	4.82
	4/13/2004	389.4	39.8	665.5	583.1	419.45	214.60	624.30	527.45	311.45	111.06	-27.23	4.84
	7/13/2004	379.5	27.7	643.3	571.1	405.40	203.60	607.20	511.40	299.40	107.34	-26.82	4.75
	10/8/2004	361.6	10.3	615.2	550.9	384.50	185.95	583.05	488.40	280.60	101.80	-26.39	4.66
	1/7/2005	367.5	16.1	630.6	561.5	393.93	191.80	596.05	499.05	288.80	104.30	-26.87	4.71
	4/8/2005	388.2	35.6	662.3	587.2	418.33	211.90	624.75	525.25	311.40	110.76	-27.44	4.79
	7/18/2005	382.6	26.3	647.7	580.1	409.18	204.45	613.90	515.15	303.20	108.34	-27.21	4.75
	8/26/2005	373.6	15.7	629.8	566.8	396.48	194.65	598.30	501.70	291.25	104.97	-26.83	4.71
	10/11/2005	365.9	6.1	617.8	557.9	386.93	186.00	587.85	491.85	282.00	102.45	-26.71	4.70
	1/10/2006	376.2	17.5	639	572.2	401.23	196.85	605.60	507.60	294.85	106.23	-27.16	4.77
	4/9/2006	393.8	32.7	665.7	594	421.55	213.25	629.85	529.75	313.35	111.61	-27.69	4.85
	7/19/2006	384.2	20.3	646.2	582.7	408.35	202.25	614.45	515.20	301.50	108.12	-27.39	4.79

Tie Beam Forces and Bending Moments (Driven Pile Cap Side) (cont'd)

Tie #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
	7/1/1999	306.3	72.2	490.8	675.2	386.13	189.25	583.00	398.55	373.70	102.23	-26.17	0.56
	7/15/1999	288.0	53.1	484.2	670.6	373.98	170.55	577.40	386.10	361.85	99.02	-27.04	0.54
	8/15/1999	280.9	61.8	506.3	693.7	385.68	171.35	600.00	393.60	377.75	102.12	-28.49	0.36
	8/31/1999	270.4	52.1	503.1	691.4	379.25	161.25	597.25	386.75	371.75	100.41	-28.98	0.34
	9/15/1999	261.3	43.9	501.2	689.9	374.08	152.60	595.55	381.25	366.90	99.04	-29.44	0.32
	9/30/1999	257.1	40.7	503.1	690.7	372.90	148.90	596.90	380.10	365.70	98.73	-29.77	0.32
	10/15/1999	250.1	33.8	501.2	691	369.03	141.95	596.10	375.65	362.40	97.71	-30.18	0.30
	10/31/1999	251.4	38	507.6	697.6	373.65	144.70	602.60	379.50	367.80	98.93	-30.43	0.26
	11/15/1999	253.9	41.6	512.1	701.9	377.38	147.75	607.00	383.00	371.75	99.92	-30.52	0.25
	11/30/1999	253.5	41.2	513.6	704.4	378.18	147.35	609.00	383.55	372.80	100.13	-30.68	0.24
	12/15/1999	255.8	46.7	519.1	709.3	382.73	151.25	614.20	387.45	378.00	101.33	-30.77	0.21
	12/31/1999	256.7	48.9	522.3	712.4	385.08	152.80	617.35	389.50	380.65	101.96	-30.87	0.20
	3/31/2000	267.5	64.6	542.8	734.2	402.28	166.05	638.50	405.15	399.40	106.51	-31.40	0.13
	6/30/2000	258.9	46.4	531.2	726.1	390.65	152.65	628.65	395.05	386.25	103.43	-31.63	0.20
	9/30/2000	237.1	10.1	504.9	705.9	364.50	123.60	605.40	371.00	358.00	96.51	-32.02	0.29
	1/13/2001	254.0	40.9	535.1	734.6	391.15	147.45	634.85	394.55	387.75	103.56	-32.39	0.15
	4/20/2001	275.4	72.6	561.4	763.7	418.28	174.00	662.55	418.40	418.15	110.75	-32.47	0.01
	7/16/2001	255.3	37.7	534.8	740.9	392.18	146.50	637.85	395.05	389.30	103.84	-32.65	0.13
	10/9/2001	235.7	7.5	510.6	719.6	368.35	121.60	615.10	373.15	363.55	97.53	-32.80	0.22
13	1/9/2002	240	18.9	523.3	731	378.30	129.45	627.15	381.65	374.95	100.16	-33.08	0.15
	4/12/2002	263.4	58.5	554.8	763	409.93	160.95	658.90	409.10	410.75	108.54	-33.09	-0.04
	7/18/2002	255.5	40.1	566.1	754.5	404.05	147.80	660.30	410.80	397.30	106.98	-34.06	0.30
	10/8/2002	231.2	3.4	508.7	726.1	367.35	117.30	617.40	369.95	364.75	97.26	-33.24	0.12
	1/8/2003	249.4	38.5	540.1	754.4	395.60	143.95	647.25	394.75	396.45	104.74	-33.45	-0.04
	4/15/2003	276.4	78.5	571.6	784.9	427.85	177.45	678.25	424.00	431.70	113.28	-33.28	-0.17
	7/1/2003	273	69	561.4	779.9	420.83	171.00	670.65	417.20	424.45	111.42	-33.21	-0.16
	10/7/2003	246.6	22.5	524.7	744.6	384.60	134.55	634.65	385.65	383.55	101.83	-33.24	0.05
	12/31/2003	264.8	58.9	552.8	770.1	411.65	161.85	661.45	408.80	414.50	108.99	-33.20	-0.13
	4/13/2004	291.3	97.7	584	803.2	444.05	194.50	693.60	437.65	450.45	117.57	-33.17	-0.29
	7/13/2004	275.5	64.3	556.1	781	419.23	169.90	668.55	415.80	422.65	111.00	-33.14	-0.15
	10/8/2004	252.8	29.9	527.5	755.8	391.50	141.35	641.65	390.15	392.85	103.66	-33.25	-0.06
	1/7/2005	264	50.8	544.5	770.6	407.48	157.40	657.55	404.25	410.70	107.89	-33.24	-0.14
	4/8/2005	289.9	90.7	576	802	439.65	190.30	689.00	432.95	446.35	116.41	-33.14	-0.30
	7/18/2005	277.8	67.7	556.4	787.1	422.25	172.75	671.75	417.10	427.40	111.80	-33.16	-0.23
	8/26/2005	266.7	46.5	539.8	771.9	406.23	156.60	655.85	403.25	409.20	107.56	-33.18	-0.13
	10/11/2005	257.2	33.8	526.8	760.8	394.65	145.50	643.80	392.00	397.30	104.49	-33.12	-0.12
	1/10/2006	269.3	59.9	551.2	780.4	415.20	164.60	665.80	410.25	420.15	109.93	-33.31	-0.22
	4/9/2006	289.9	90	576.3	806.2	440.60	189.95	691.25	433.10	448.10	116.66	-33.32	-0.34
	7/19/2006	277.7	63.9	553.8	787.8	420.80	170.80	670.80	415.75	425.85	111.42	-33.23	-0.23

Tie Beam Forces and Bending Moments (Driven Pile Cap Side) (cont'd)

Tie #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
14	7/1/1999	445.4	53.9	802	298.7	400.00	249.65	550.35	623.70	176.30	105.91	-19.98	10.02
	7/15/1999	440.5	34.4	799.5	280.7	388.78	237.45	540.10	620.00	157.55	102.94	-20.11	10.36
	8/15/1999	455.6	40.8	837.6	284.6	404.65	248.20	561.10	646.60	162.70	107.14	-20.79	10.84
	8/31/1999	452.7	30.7	837.1	274.1	398.65	241.70	555.60	644.90	152.40	105.55	-20.86	11.03
	9/15/1999	448.5	21.7	836.8	266.2	393.30	235.10	551.50	642.65	143.95	104.13	-21.03	11.17
	9/30/1999	447.0	16.1	838.5	260.8	390.60	231.55	549.65	642.75	138.45	103.42	-21.14	11.30
	10/15/1999	446.5	8.8	839.3	255.1	387.43	227.65	547.20	642.90	131.95	102.58	-21.24	11.45
	10/31/1999	450.9	11.7	847.9	257.8	392.08	231.30	552.85	649.40	134.75	103.81	-21.37	11.53
	11/15/1999	455.9	16.1	856.2	259.8	397.00	236.00	558.00	656.05	137.95	105.11	-21.40	11.61
	11/30/1999	456.3	15.5	858.3	259	397.28	235.90	558.65	657.30	137.25	105.19	-21.45	11.65
	12/15/1999	461.3	20.5	865.6	261.7	402.28	240.90	563.65	663.45	141.10	106.51	-21.45	11.70
	12/31/1999	463.4	22.5	871.6	262.9	405.10	242.95	567.25	667.50	142.70	107.26	-21.55	11.76
	3/31/2000	477.8	35.6	903.8	282.7	424.98	256.70	593.25	690.80	159.15	112.52	-22.37	11.91
	6/30/2000	469.2	17.4	889.7	267.4	410.93	243.30	578.55	679.45	142.40	108.80	-22.28	12.03
	9/30/2000	453.5	-23.5	856.8	240.4	381.80	215.00	548.60	655.15	108.45	101.09	-22.17	12.25
	1/13/2001	476.9	5	891.3	257.6	407.70	240.95	574.45	684.10	131.30	107.95	-22.16	12.38
	4/20/2001	494.8	40.8	932.8	281.2	437.40	267.80	607.00	713.80	161.00	115.81	-22.54	12.38
	7/16/2001	475.7	4.9	900.7	255.9	409.30	240.30	578.30	688.20	130.40	108.37	-22.46	12.50
	10/9/2001	459.3	-30.8	870.4	236.8	383.93	214.25	553.60	664.85	103.00	101.65	-22.55	12.59
	1/9/2002	468.8	-18.5	883.7	241.5	393.88	225.15	562.60	676.25	111.50	104.29	-22.43	12.65
	4/12/2002	492.8	22.5	926.5	270.2	428.00	257.65	598.35	709.65	146.35	113.32	-22.64	12.62
	7/18/2002	483.5	3.8	911.9	257.3	414.13	243.65	584.60	697.70	130.55	109.65	-22.66	12.71
	10/8/2002	462.7	-35	875.6	233	384.08	213.85	554.30	669.15	99.00	101.69	-22.63	12.77
	1/8/2003	485.5	2.5	912.6	253.9	413.63	244.00	583.25	699.05	128.20	109.52	-22.55	12.79
	4/15/2003	501.9	612.9	952.7	285.1	588.15	557.40	618.90	727.30	449.00	155.72	-4.09	6.23
	7/1/2003	521.6	28.8	943.4	278.1	442.98	275.20	610.75	732.50	153.45	117.29	-22.30	12.97
	10/7/2003	472.3	-16.5	903.8	247.5	401.78	227.90	575.65	688.05	115.50	106.38	-23.11	12.83
	12/31/2003	495.5	18.6	939.3	268.7	430.53	257.05	604.00	717.40	143.65	113.99	-23.06	12.85
	4/13/2004	504.6	68.9	989	299.2	465.43	286.75	644.10	746.80	184.05	123.23	-23.75	12.61
	7/13/2004	487.3	36.7	961.8	277.7	440.88	262.00	619.75	724.55	157.20	116.73	-23.78	12.71
	10/8/2004	468.9	-0.5	928.8	256.4	413.40	234.20	592.60	698.85	127.95	109.46	-23.82	12.79
	1/7/2005	485.2	21.4	952.7	269.7	432.25	253.30	611.20	718.95	145.55	114.45	-23.79	12.85
	4/8/2005	512.9	68.8	998.7	302.5	470.73	290.85	650.60	755.80	185.65	124.63	-23.91	12.77
	7/18/2005	498.2	40	977.1	286.8	450.53	269.10	631.95	737.65	163.40	119.29	-24.11	12.86
	8/26/2005	486.3	17.1	955.5	271.8	432.68	251.70	613.65	720.90	144.45	114.56	-24.05	12.91
	10/11/2005	478.8	2.4	942.6	263.6	421.85	240.60	603.10	710.70	133.00	111.69	-24.09	12.94
	1/10/2006	497.9	28.2	970.6	280.6	444.33	263.05	625.60	734.25	154.40	117.64	-24.09	12.99
	4/9/2006	519.6	65.1	1008.9	306	474.90	292.35	657.45	764.25	185.55	125.74	-24.26	12.96
	7/19/2006	505.7	73.4	984.2	290.7	463.50	289.55	637.45	744.95	182.05	122.72	-23.12	12.61

Tie Beam Forces and Bending Moments (Driven Pile Cap Side) (cont'd)

Tie #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
26	7/1/1999	468.3	92.2	387.7	511.7	364.98	280.25	449.70	428.00	301.95	96.63	-11.26	2.82
	7/15/1999	460.1	81	381.5	505.7	357.08	270.55	443.60	420.80	293.35	94.54	-11.50	2.86
	8/15/1999	482.3	96.1	410.7	526	378.78	289.20	468.35	446.50	311.05	100.29	-11.91	3.03
	8/31/1999	490.3	101.9	422.4	535	387.40	296.10	478.70	456.35	318.45	102.57	-12.14	3.09
	9/15/1999	491.0	101.4	426.3	536.4	388.78	296.20	481.35	458.65	318.90	102.94	-12.30	3.13
	9/30/1999	497.9	106.7	434.7	543.6	395.73	302.30	489.15	466.30	325.15	104.78	-12.42	3.16
	10/15/1999	505.0	112.3	443.2	550.9	402.85	308.65	497.05	474.10	331.60	106.66	-12.52	3.19
	10/31/1999	515.6	118.8	452.5	560.9	411.95	317.20	506.70	484.05	339.85	109.07	-12.59	3.23
	11/15/1999	525.0	128.3	463.4	570.2	421.73	326.65	516.80	494.20	349.25	111.66	-12.64	3.25
	11/30/1999	532.5	134.9	471.5	576.8	428.93	333.70	524.15	502.00	355.85	113.57	-12.66	3.27
	12/15/1999	534.1	138.1	476.5	580.2	432.23	336.10	528.35	505.30	359.15	114.44	-12.78	3.27
	12/31/1999	540.4	144.3	484.4	587.2	439.08	342.35	535.80	512.40	365.75	116.25	-12.86	3.29
	3/31/2000	551.1	156	501.3	602.1	452.63	353.55	551.70	526.20	379.05	119.84	-13.17	3.30
	6/30/2000	533.5	137.3	477.6	577.9	431.58	335.40	527.75	505.55	357.60	114.27	-12.78	3.31
	9/30/2000	539.6	136.8	480.7	575.1	433.05	338.20	527.90	510.15	355.95	114.66	-12.61	3.45
	1/13/2001	571.4	169.7	522.7	611.8	468.90	370.55	567.25	547.05	390.75	124.15	-13.07	3.50
	4/20/2001	580.2	184.8	537.9	624.6	481.88	382.50	581.25	559.05	404.70	127.59	-13.21	3.46
	7/16/2001	555.8	159.1	508	598.6	455.38	357.45	553.30	531.90	378.85	120.57	-13.02	3.43
	10/9/2001	556.2	154.1	506	595.8	453.03	355.15	550.90	531.10	374.95	119.95	-13.01	3.50
	1/9/2002	572	170.3	527.3	614.7	471.08	371.15	571.00	549.65	392.50	124.73	-13.28	3.52
	4/12/2002	584.6	187.7	546.3	632.8	487.85	386.15	589.55	565.45	410.25	129.17	-13.52	3.48
	7/18/2002	559.5	162.1	516.1	606	460.93	360.80	561.05	537.80	384.05	122.04	-13.31	3.44
	10/8/2002	557	154.4	511	599.8	455.55	355.70	555.40	534.00	377.10	120.62	-13.27	3.51
	1/8/2003	591	189.2	552.8	639	493.00	390.10	595.90	571.90	414.10	130.53	-13.68	3.54
	4/15/2003	597.9	204.3	567.5	650.5	505.05	401.10	609.00	582.70	427.40	133.72	-13.82	3.48
	7/1/2003	580.7	184.3	545.4	632.5	485.73	382.50	588.95	563.05	408.40	128.61	-13.72	3.46
	10/7/2003	578.2	176.3	538	627	479.88	377.25	582.50	558.10	401.65	127.06	-13.64	3.50
	12/31/2003	610.3	207.7	572.6	661.6	513.05	409.00	617.10	591.45	434.65	135.84	-13.83	3.51
	4/13/2004	617.1	224.2	589.5	675.7	526.63	420.65	632.60	603.30	449.95	139.43	-14.09	3.44
	7/13/2004	584	186.6	549.1	642.6	490.58	385.30	595.85	566.55	414.60	129.89	-13.99	3.40
	10/8/2004	581.8	181.2	543.7	638.3	486.25	381.50	591.00	562.75	409.75	128.74	-13.92	3.43
	1/7/2005	609.9	209	574.8	669.1	515.70	409.45	621.95	592.35	439.05	136.54	-14.12	3.43
	4/8/2005	617.5	225	590.2	683.9	529.15	421.25	637.05	603.85	454.45	140.10	-14.34	3.35
	7/18/2005	590.4	192.7	554.7	656	498.45	391.55	605.35	572.55	424.35	131.97	-14.21	3.32
	8/26/2005	584.4	183.1	544	647.8	489.83	383.75	595.90	564.20	415.45	129.69	-14.10	3.33
	10/11/2005	589.3	185.9	548.5	652	493.93	387.60	600.25	568.90	418.95	130.78	-14.13	3.36
	1/10/2006	616	216.1	582.8	683.4	524.58	416.05	633.10	599.40	449.75	138.89	-14.42	3.35
	4/9/2006	629	235.4	605.8	701.1	542.83	432.20	653.45	617.40	468.25	143.72	-14.70	3.34
	7/19/2006	595.8	199	563.1	668.3	506.55	397.40	615.70	579.45	433.65	134.12	-14.51	3.27

Tie Beam Forces and Bending Moments (Drilled Shaft Cap Side)

Tie #	Date	ε_5	ε_6	ε_7	ε_8	Avg. ε	$(\varepsilon_5+\varepsilon_6)/2$	$(\varepsilon_7+\varepsilon_8)/2$	$(\varepsilon_5+\varepsilon_7)/2$	$(\varepsilon_6+\varepsilon_8)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
1	7/1/1999	-115.0	299.7	422.9	109.6	179.30	92.35	266.25	153.95	204.65	47.47	-11.56	-1.14
	7/15/1999	-122.0	289	405.2	95.6	166.95	83.50	250.40	141.60	192.30	44.20	-11.09	-1.14
	8/15/1999	-139.4	265.8	401.5	101.8	157.43	63.20	251.65	131.05	183.80	41.68	-12.52	-1.18
	8/31/1999	-144.1	258.4	394.7	99.6	152.15	57.15	247.15	125.30	179.00	40.28	-12.63	-1.20
	9/15/1999	-144.1	255.9	395.1	102	152.23	55.90	248.55	125.50	178.95	40.30	-12.80	-1.20
	9/30/1999	-141.7	260.4	408.3	112.3	159.83	59.35	260.30	133.30	186.35	42.32	-13.35	-1.19
	10/15/1999	-138.1	275.3	441.9	138.4	179.38	68.60	290.15	151.90	206.85	47.49	-14.72	-1.23
	10/31/1999	-148.1	272.7	430.1	118.5	168.30	62.30	274.30	141.00	195.60	44.56	-14.09	-1.22
	11/15/1999	-142.3	278.9	446.6	134.9	179.53	68.30	290.75	152.15	206.90	47.53	-14.78	-1.23
	11/30/1999	-137.9	284.4	462	150.8	189.83	73.25	306.40	162.05	217.60	50.26	-15.49	-1.24
	12/15/1999	-135.4	290	463.8	152.5	192.73	77.30	308.15	164.20	221.25	51.03	-15.34	-1.28
	12/31/1999	-126.8	301.4	481.4	168.9	206.23	87.30	325.15	177.30	235.15	54.60	-15.81	-1.30
	3/31/2000	-133.9	283.1	455.7	149.6	188.63	74.60	302.65	160.90	216.35	49.94	-15.16	-1.24
	6/30/2000	-157.3	230.6	397.4	119.3	147.50	36.65	258.35	120.05	174.95	39.05	-14.73	-1.23
	9/30/2000	-142.8	237.4	427.4	156.8	169.70	47.30	292.10	142.30	197.10	44.93	-16.27	-1.23
	1/13/2001	-118.2	295.4	511.7	182.5	217.85	88.60	347.10	196.75	238.95	57.68	-17.18	-0.95
	4/20/2001	-128.9	270.9	454	163.4	189.85	71.00	308.70	162.55	217.15	50.27	-15.80	-1.22
	7/16/2001	-146.4	213.9	384.1	133.3	146.23	33.75	258.70	118.85	173.60	38.72	-14.95	-1.23
	10/9/2001	-135.7	237.5	439.4	178.3	179.88	50.90	308.85	151.85	207.90	47.63	-17.14	-1.26
	1/9/2002	-120.2	281.4	483	190.7	208.73	80.60	336.85	181.40	236.05	55.26	-17.03	-1.22
	4/12/2002	-133.2	263.6	441.1	154.2	181.43	65.20	297.65	153.95	208.90	48.04	-15.45	-1.23
	7/18/2002	-158.1	191.2	355.6	118	126.68	16.55	236.80	98.75	154.60	33.54	-14.64	-1.25
	10/8/2002	-149.2	192.4	391.7	156.3	147.80	21.60	274.00	121.25	174.35	39.13	-16.77	-1.19
	1/8/2003	-123.2	268.7	469.3	191.8	201.65	72.75	330.55	173.05	230.25	53.39	-17.13	-1.28
	4/15/2003	-137.5	248.4	427.1	157.1	173.78	55.45	292.10	144.80	202.75	46.01	-15.73	-1.30
	7/1/2003	-159.7	183.9	351.2	124.6	125.00	12.10	237.90	95.75	154.25	33.10	-15.01	-1.31
	10/7/2003	-146.6	206.4	412.6	177.8	162.55	29.90	295.20	133.00	192.10	43.04	-17.63	-1.32
	12/31/2003	-135.4	243.4	450.4	190	187.10	54.00	320.20	157.50	216.70	49.54	-17.69	-1.33
	4/13/2004	-144.6	228.6	422.1	168	168.53	42.00	295.05	138.75	198.30	44.62	-16.82	-1.33
	7/13/2004	-179.1	155.6	334.2	117.5	107.05	-11.75	225.85	77.55	136.55	28.34	-15.79	-1.32
	10/8/2004	-169	170.9	373.7	152.9	132.13	0.95	263.30	102.35	161.90	34.98	-17.44	-1.33
	1/7/2005	-145.5	227.8	440.5	188.2	177.75	41.15	314.35	147.50	208.00	47.06	-18.16	-1.36
	4/8/2005	-159.4	209.2	398.5	148.8	149.28	24.90	273.65	119.55	179.00	39.52	-16.53	-1.33
	7/18/2005	-182.8	141.5	330.3	131.3	105.08	-20.65	230.80	73.75	136.40	27.82	-16.71	-1.40
	8/26/2005	-184	140.7	341.3	131.3	107.33	-21.65	236.30	78.65	136.00	28.42	-17.14	-1.28
	10/11/2005	-174.2	159.1	370.9	131.3	121.78	-7.55	251.10	98.35	145.20	32.24	-17.19	-1.05
	1/10/2006	-152.5	216.4	430.7	131.3	156.48	31.95	281.00	139.10	173.85	41.43	-16.55	-0.78
	4/9/2006	-157.2	206.1	413	131.3	148.30	24.45	272.15	127.90	168.70	39.27	-16.46	-0.91
	7/19/2006	-189.4	135.9	330	131.3	101.95	-26.75	230.65	70.30	133.60	26.99	-17.11	-1.42

Tie Beam Forces and Bending Moments (Drilled Shaft Cap Side) (cont'd)

Tie #	Date	ε_5	ε_6	ε_7	ε_8	Avg. ε	$(\varepsilon_5+\varepsilon_6)/2$	$(\varepsilon_7+\varepsilon_8)/2$	$(\varepsilon_5+\varepsilon_7)/2$	$(\varepsilon_6+\varepsilon_8)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
12	7/1/1999	356.2	257	201.2	275.1	272.38	306.60	238.15	278.70	266.05	72.12	4.55	0.28
	7/15/1999	353.8	251.6	188.4	273.4	266.80	302.70	230.90	271.10	262.50	70.64	4.77	0.19
	8/15/1999	350.0	242.8	195.3	301.1	272.30	296.40	248.20	272.65	271.95	72.10	3.20	0.02
	8/31/1999	350.2	247.8	201.7	307.9	276.90	299.00	254.80	275.95	277.85	73.31	2.94	-0.04
	9/15/1999	349.8	249.1	203.6	314	279.13	299.45	258.80	276.70	281.55	73.90	2.70	-0.11
	9/30/1999	352.2	256.8	212.1	322.7	285.95	304.50	267.40	282.15	289.75	75.71	2.47	-0.17
	10/15/1999	352.6	257.7	225.5	337.3	293.28	305.15	281.40	289.05	297.50	77.65	1.58	-0.19
	10/31/1999	361.0	268.5	222.6	333.7	296.45	314.75	278.15	291.80	301.10	78.49	2.43	-0.21
	11/15/1999	364.5	273.1	237.1	353.6	307.08	318.80	295.35	300.80	313.35	81.30	1.56	-0.28
	11/30/1999	367.6	276.3	249.1	369.4	315.60	321.95	309.25	308.35	322.85	83.56	0.84	-0.32
	12/15/1999	370.6	280.7	248.5	364.3	316.03	325.65	306.40	309.55	322.50	83.67	1.28	-0.29
	12/31/1999	371.2	282.5	254.8	368.8	319.33	326.85	311.80	313.00	325.65	84.55	1.00	-0.28
	3/31/2000	376.0	289.2	244.7	361.1	317.75	332.60	302.90	310.35	325.15	84.13	1.97	-0.33
	6/30/2000	358.4	247.7	207.4	329.3	285.70	303.05	268.35	282.90	288.50	75.64	2.31	-0.13
	9/30/2000	357.6	235.9	230.1	366.4	297.50	296.75	298.25	293.85	301.15	78.77	-0.10	-0.16
	1/13/2001	382.0	289.5	264.4	384.8	330.18	335.75	324.60	323.20	337.15	87.42	0.74	-0.31
	4/20/2001	382.9	294.9	260.1	378.2	329.03	338.90	319.15	321.50	336.55	87.12	1.31	-0.34
	7/16/2001	352.4	249.4	219.2	330.6	287.90	300.90	274.90	285.80	290.00	76.23	1.73	-0.09
	10/9/2001	357.7	267.9	262.1	382	317.43	312.80	322.05	309.90	324.95	84.04	-0.61	-0.34
	1/9/2002	385.8	301.2	285.1	395.6	341.93	343.50	340.35	335.45	348.40	90.53	0.21	-0.29
	4/12/2002	390.9	310.2	263.2	370.1	333.60	350.55	316.65	327.05	340.15	88.33	2.25	-0.29
	7/18/2002	346.39	265.03	220.4	323.3	288.78	305.71	271.85	283.39	294.17	76.46	2.25	-0.24
	10/8/2002	344.5	265.3	252.4	363.5	306.43	304.90	307.95	298.45	314.40	81.13	-0.20	-0.36
	1/8/2003	385.9	308.5	295.9	394.3	346.15	347.20	345.10	340.90	351.40	91.65	0.14	-0.24
	4/15/2003	392.4	317.3	275.8	371.1	339.15	354.85	323.45	334.10	344.20	89.80	2.09	-0.23
	7/1/2003	360	288.1	238.7	332.8	304.90	324.05	285.75	299.35	310.45	80.73	2.55	-0.25
	10/7/2003	357.1	284.5	277.7	372.1	322.85	320.80	324.90	317.40	328.30	85.48	-0.27	-0.24
	12/31/2003	387.7	318.7	304.1	392.5	350.75	353.20	348.30	345.90	355.60	92.87	0.33	-0.22
	4/13/2004	389.4	324.2	294.9	381.2	347.43	356.80	338.05	342.15	352.70	91.99	1.25	-0.24
	7/13/2004	348	285.8	241	324.8	299.90	316.90	282.90	294.50	305.30	79.40	2.26	-0.24
	10/8/2004	342.4	281.8	269.4	353.1	311.68	312.10	311.25	305.90	317.45	82.52	0.06	-0.26
	1/7/2005	374.1	315.2	302.9	382.8	343.75	344.65	342.85	338.50	349.00	91.01	0.12	-0.24
	4/8/2005	386.7	328.9	284.3	365	341.23	357.80	324.65	335.50	346.95	90.35	2.20	-0.26
	7/18/2005	343.2	285.5	242.4	322.1	298.30	314.35	282.25	292.80	303.80	78.98	2.13	-0.25
	8/26/2005	337	278.7	250.1	331.1	299.23	307.85	290.60	293.55	304.90	79.23	1.15	-0.25
	10/11/2005	338.7	283.6	264.1	348.6	308.75	311.15	306.35	301.40	316.10	81.75	0.32	-0.33
	1/10/2006	371.5	317.4	297	373.5	339.85	344.45	335.25	334.25	345.45	89.98	0.61	-0.25
	4/9/2006	377.4	324.1	290.6	368.2	340.08	350.75	329.40	334.00	346.15	90.04	1.42	-0.27
	7/19/2006	341.9	289.2	238.8	315.3	296.30	315.55	277.05	290.35	302.25	78.45	2.56	-0.27

Tie Beam Forces and Bending Moments (Drilled Shaft Cap Side) (cont'd)

Tie #	Date	ε_5	ε_6	ε_7	ε_8	Avg. ε	$(\varepsilon_5+\varepsilon_6)/2$	$(\varepsilon_7+\varepsilon_8)/2$	$(\varepsilon_5+\varepsilon_7)/2$	$(\varepsilon_6+\varepsilon_8)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
13	7/1/1999	177.4	380.2	417.6	236.2	302.85	278.80	326.90	297.50	308.20	80.19	-3.20	-0.24
	7/15/1999	173.8	378	412.7	230.2	298.68	275.90	321.45	293.25	304.10	79.08	-3.03	-0.24
	8/15/1999	172.8	380.2	439.6	252.6	311.30	276.50	346.10	306.20	316.40	82.42	-4.63	-0.23
	8/31/1999	172.6	378	445.8	257.5	313.48	275.30	351.65	309.20	317.75	83.00	-5.07	-0.19
	9/15/1999	170.9	377.2	447.2	261	314.08	274.05	354.10	309.05	319.10	83.16	-5.32	-0.23
	9/30/1999	176.4	380.7	455.9	269.3	320.58	278.55	362.60	316.15	325.00	84.88	-5.59	-0.20
	10/15/1999	176.7	378.9	468.1	279.5	325.80	277.80	373.80	322.40	329.20	86.26	-6.38	-0.15
	10/31/1999	182.4	385.8	502.1	273.8	336.03	284.10	387.95	342.25	329.80	88.97	-6.90	0.28
	11/15/1999	186.8	392.4	482.7	292	338.48	289.60	387.35	334.75	342.20	89.62	-6.50	-0.17
	11/30/1999	189.8	396.8	638.9	305.6	382.78	293.30	472.25	414.35	351.20	101.35	-11.89	1.41
	12/15/1999	193.5	401.1	516.7	302.2	353.38	297.30	409.45	355.10	351.65	93.56	-7.45	0.08
	12/31/1999	194.7	406.1	507.2	308	354.00	300.40	407.60	350.95	357.05	93.73	-7.12	-0.14
	3/31/2000	194.8	409	492.7	298.7	348.80	301.90	395.70	343.75	353.85	92.35	-6.23	-0.23
	6/30/2000	177.7	389.4	467.2	278.7	328.25	283.55	372.95	322.45	334.05	86.91	-5.94	-0.26
	9/30/2000	174.2	385.1	496.7	308	341.00	279.65	402.35	335.45	346.55	90.29	-8.15	-0.25
	1/13/2001	200.0	418.2	530.3	318.6	366.78	309.10	424.45	365.15	368.40	97.11	-7.67	-0.07
	4/20/2001	194.1	416.2	512.8	310.6	358.43	305.15	411.70	353.45	363.40	94.90	-7.08	-0.22
	7/16/2001	166.5	386.2	469	273.8	323.88	276.35	371.40	317.75	330.00	85.75	-6.32	-0.27
	10/9/2001	171.5	389.1	514.8	315.2	347.65	280.30	415.00	343.15	352.15	92.05	-8.95	-0.20
	1/9/2002	193.6	413.6	539.3	324.6	367.78	303.60	431.95	366.45	369.10	97.38	-8.53	-0.06
	4/12/2002	198.8	418.5	509.3	299.2	356.45	308.65	404.25	354.05	358.85	94.38	-6.35	-0.11
	7/18/2002	161.4	379.1	462.4	262.6	316.38	270.25	362.50	311.90	320.85	83.77	-6.13	-0.20
	10/8/2002	155.8	373.6	686.8	301.1	379.33	264.70	493.95	421.30	337.35	100.43	-15.24	1.88
	1/8/2003	193.1	414	547.6	331	371.43	303.55	439.30	370.35	372.50	98.34	-9.02	-0.05
	4/15/2003	195.8	419.9	560.6	305.7	370.50	307.85	433.15	378.20	362.80	98.10	-8.33	0.34
	7/1/2003	172.1	394.8	479.4	273.9	330.05	283.45	376.65	325.75	334.35	87.39	-6.19	-0.19
	10/7/2003	169	389.1	527.1	317.5	350.68	279.05	422.30	348.05	353.30	92.85	-9.52	-0.12
	12/31/2003	196.2	423.2	560.3	334.7	378.60	309.70	447.50	378.25	378.95	100.24	-9.16	-0.02
	4/13/2004	197.9	424.7	546.1	321.7	372.60	311.30	433.90	372.00	373.20	98.65	-8.15	-0.03
	7/13/2004	155.6	383.5	482.7	266.1	321.98	269.55	374.40	319.15	324.80	85.25	-6.97	-0.13
	10/8/2004	152.2	378.4	519	298.6	337.05	265.30	408.80	335.60	338.50	89.24	-9.54	-0.06
	1/7/2005	180.6	410.6	556.1	324.9	368.05	295.60	440.50	368.35	367.75	97.45	-9.63	0.01
	4/8/2005	188.3	419.5	529.1	301	359.48	303.90	415.05	358.70	360.25	95.18	-7.39	-0.03
	7/18/2005	150.7	376.8	482.9	262.2	318.15	263.75	372.55	316.80	319.50	84.24	-7.23	-0.06
	8/26/2005	144.7	373.1	494.1	275.3	321.80	258.90	384.70	319.40	324.20	85.20	-8.36	-0.11
	10/11/2005	146.5	375.2	533.7	291.5	336.73	260.85	412.60	340.10	333.35	89.15	-10.09	0.15
	1/10/2006	176	407.1	548.8	313.5	361.35	291.55	431.15	362.40	360.30	95.67	-9.28	0.05
	4/9/2006	180.6	412.1	538.7	307.8	359.80	296.35	423.25	359.65	359.95	95.26	-8.43	-0.01
	7/19/2006	149.4	377.4	480.1	259.8	316.68	263.40	369.95	314.75	318.60	83.85	-7.08	-0.09

Tie Beam Forces and Bending Moments (Drilled Shaft Cap Side) (cont'd)

Tie #	Date	ε_5	ε_6	ε_7	ε_8	Avg. ε	$(\varepsilon_5+\varepsilon_6)/2$	$(\varepsilon_7+\varepsilon_8)/2$	$(\varepsilon_5+\varepsilon_7)/2$	$(\varepsilon_6+\varepsilon_8)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
	7/1/1999	199.5	418.4	473.6	323.8	353.83	308.95	398.70	336.55	371.10	93.68	-5.96	-0.77
	7/15/1999	194.3	414.4	461.1	314.4	346.05	304.35	387.75	327.70	364.40	91.62	-5.54	-0.82
	8/15/1999	191.0	402.1	488.7	347.5	357.33	296.55	418.10	339.85	374.80	94.61	-8.08	-0.78
	8/31/1999	189.5	395.4	496	352.6	358.38	292.45	424.30	342.75	374.00	94.89	-8.76	-0.70
	9/15/1999	186.8	391.6	503.6	359.8	360.45	289.20	431.70	345.20	375.70	95.44	-9.47	-0.68
	9/30/1999	188.5	396.7	516	369	367.55	292.60	442.50	352.25	382.85	97.32	-9.96	-0.69
	10/15/1999	235.3	403	530.4	378.9	386.90	319.15	454.65	382.85	390.95	102.44	-9.01	-0.18
	10/31/1999	202.7	418.5	524.2	371.5	379.23	310.60	447.85	363.45	395.00	100.41	-9.12	-0.71
	11/15/1999	208.9	426.2	548.2	393.2	394.13	317.55	470.70	378.55	409.70	104.35	-10.18	-0.70
	11/30/1999	212.9	429.2	566.6	409.5	404.55	321.05	488.05	389.75	419.35	107.11	-11.10	-0.66
	12/15/1999	216.9	433.5	561.4	403.7	403.88	325.20	482.55	389.15	418.60	106.93	-10.46	-0.66
	12/31/1999	220.7	443.8	566.6	407.4	409.63	332.25	487.00	393.65	425.60	108.46	-10.28	-0.72
	3/31/2000	215.2	438.2	567.9	406.5	406.95	326.70	487.20	391.55	422.35	107.75	-10.67	-0.69
	6/30/2000	191.3	415.8	542.4	380.7	382.55	303.55	461.55	366.85	398.25	101.29	-10.50	-0.70
	9/30/2000	183.3	409.8	571	409.9	393.50	296.55	490.45	377.15	409.85	104.19	-12.89	-0.73
	1/13/2001	215.4	447.2	588.9	421.9	418.35	331.30	505.40	402.15	434.55	110.77	-11.57	-0.73
	4/20/2001	210.2	445.1	586.6	415.7	414.40	327.65	501.15	398.40	430.40	109.72	-11.53	-0.72
	7/16/2001	171.2	413	554.5	377.7	379.10	292.10	466.10	362.85	395.35	100.37	-11.56	-0.73
	10/9/2001	178.5	417.9	596.2	418.8	402.85	298.20	507.50	387.35	418.35	106.66	-13.91	-0.69
14	1/9/2002	206.2	445.9	606.4	430	422.13	326.05	518.20	406.30	437.95	111.77	-12.77	-0.71
	4/12/2002	208.6	449.5	584.1	408.1	412.58	329.05	496.10	396.35	428.80	109.24	-11.10	-0.73
	7/18/2002	161.7	410.1	551.9	368.5	373.05	285.90	460.20	356.80	389.30	98.77	-11.58	-0.73
	10/8/2002	160.2	405.5	592.3	407.7	391.43	282.85	500.00	376.25	406.60	103.64	-14.43	-0.68
	1/8/2003	202	449.1	620.2	437.7	427.25	325.55	528.95	411.10	443.40	113.12	-13.52	-0.72
	4/15/2003	205.4	453.6	590	409.8	414.70	329.50	499.90	397.70	431.70	109.80	-11.32	-0.76
	7/1/2003	171.9	426.9	559.5	377.3	383.90	299.40	468.40	365.70	402.10	101.65	-11.23	-0.82
	10/7/2003	172	424.4	600.8	422.4	404.90	298.20	511.60	386.40	423.40	107.21	-14.18	-0.83
	12/31/2003	205.6	461.3	624.2	444.9	434.00	333.45	534.55	414.90	453.10	114.91	-13.36	-0.86
	4/13/2004	204.7	463.4	611.5	433.1	428.18	334.05	522.30	408.10	448.25	113.37	-12.51	-0.90
	7/13/2004	159.6	424.2	566.4	383.7	383.48	291.90	475.05	363.00	403.95	101.53	-12.17	-0.92
	10/8/2004	153	416.8	590.5	409.5	392.45	284.90	500.00	371.75	413.15	103.91	-14.30	-0.93
	1/7/2005	192.8	454.9	627.8	446.9	430.60	323.85	537.35	410.30	450.90	114.01	-14.19	-0.91
	4/8/2005	205.2	467.5	600.9	425.2	424.70	336.35	513.05	403.05	446.35	112.45	-11.74	-0.97
	7/18/2005	154.9	424.1	560.9	385.2	381.28	289.50	473.05	357.90	404.65	100.95	-12.20	-1.05
	8/26/2005	168.3	416.1	569.1	391.2	386.18	292.20	480.15	368.70	403.65	102.25	-12.49	-0.78
	10/11/2005	152.5	418.5	590.5	413.4	393.73	285.50	501.95	371.50	415.95	104.25	-14.38	-1.00
	1/10/2006	190.7	455.4	615	436.7	424.45	323.05	525.85	402.85	446.05	112.38	-13.48	-0.97
	4/9/2006	196.7	460.2	612.3	436.6	426.45	328.45	524.45	404.50	448.40	112.91	-13.03	-0.98
	7/19/2006	159.7	426.1	562.3	382.1	382.55	292.90	472.20	361.00	404.10	101.29	-11.92	-0.97

Tie Beam Forces and Bending Moments (Drilled Shaft Cap Side) (cont'd)

Tie #	Date	ε_5	ε_6	ε_7	ε_8	Avg. ε	$(\varepsilon_5+\varepsilon_6)/2$	$(\varepsilon_7+\varepsilon_8)/2$	$(\varepsilon_5+\varepsilon_7)/2$	$(\varepsilon_6+\varepsilon_8)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
26	7/1/1999	222.2	-19.9	305.2	560	266.88	101.15	432.60	263.70	270.05	70.66	-22.03	-0.14
	7/15/1999	207.8	-36.8	294.3	540.9	251.55	85.50	417.60	251.05	252.05	66.60	-22.07	-0.02
	8/15/1999	189.9	-53.4	320.4	546.8	250.93	68.25	433.60	255.15	246.70	66.44	-24.28	0.19
	8/31/1999	184.8	-60	330.2	555.2	252.55	62.40	442.70	257.50	247.60	66.87	-25.27	0.22
	9/15/1999	185.7	-57.2	336.6	558.2	255.83	64.25	447.40	261.15	250.50	67.73	-25.46	0.24
	9/30/1999	187.5	-53.7	349.9	570.1	263.45	66.90	460.00	268.70	258.20	69.75	-26.12	0.24
	10/15/1999	195.3	-50.5	375.2	601.5	280.38	72.40	488.35	285.25	275.50	74.23	-27.64	0.22
	10/31/1999	197.3	-39.9	370.8	589.7	279.48	78.70	480.25	284.05	274.90	74.00	-26.69	0.20
	11/15/1999	202.5	-32.3	385.9	601.1	289.30	85.10	493.50	294.20	284.40	76.60	-27.14	0.22
	11/30/1999	206.5	-27.3	398.1	613.9	297.80	89.60	506.00	302.30	293.30	78.85	-27.67	0.20
	12/15/1999	216.1	-19.5	401.6	620.9	304.78	98.30	511.25	308.85	300.70	80.70	-27.44	0.18
	12/31/1999	223.8	-15	410.7	633.4	313.23	104.40	522.05	317.25	309.20	82.93	-27.76	0.18
	3/31/2000	203.5	-16	395.7	633.5	304.18	93.75	514.60	299.60	308.75	80.54	-27.97	-0.20
	6/30/2000	149.3	-41	371.2	553.8	258.33	54.15	462.50	260.25	256.40	68.40	-27.14	0.09
	9/30/2000	154.3	-22.3	411.5	580.2	280.93	66.00	495.85	282.90	278.95	74.38	-28.57	0.09
	1/13/2001	197.9	7.7	446.8	627.1	319.88	102.80	536.95	322.35	317.40	84.69	-28.85	0.11
	4/20/2001	167.6	1.3	434.9	589.5	298.33	84.45	512.20	301.25	295.40	78.99	-28.43	0.13
	7/16/2001	112.8	-20.6	409.7	555.1	264.25	46.10	482.40	261.25	267.25	69.97	-29.00	-0.13
	10/9/2001	136.9	-5.4	451.7	582.7	291.48	65.75	517.20	294.30	288.65	77.17	-30.00	0.13
	1/9/2002	176.6	9	461.6	618.2	316.35	92.80	539.90	319.10	313.60	83.76	-29.71	0.12
	4/12/2002	158.20	3.40	438	581.00	295.25	80.80	509.70	298.30	292.20	78.17	-28.50	0.14
	7/18/2002	86.10	-23.70	405	503.86	242.87	31.20	454.53	245.65	240.08	64.30	-28.13	0.12
	10/8/2002	96.1	2.90	445.20	562.80	276.75	49.50	504.00	270.65	282.85	73.28	-30.21	-0.27
	1/8/2003	165.9	41.91	480.40	628.48	329.17	103.91	554.44	323.15	335.20	87.16	-29.94	-0.27
	4/15/2003	147.5	33.95	455.30	592.01	307.19	90.73	523.65	301.40	312.98	81.33	-28.77	-0.26
	7/1/2003	88.2	9.66	424.1	577.30	274.82	48.93	500.70	256.15	293.48	72.76	-30.02	-0.84
	10/7/2003	103.5	24.24	466.9	574.34	292.25	63.87	520.62	285.20	299.29	77.38	-30.35	-0.32
	12/31/2003	130.5	44.68	481.6	566.95	305.93	87.59	524.27	306.05	305.81	81.00	-29.02	0.01
	4/13/2004	118.2	42.08	471.6	585.31	304.30	80.14	528.45	294.90	313.69	80.57	-29.79	-0.42
	7/13/2004	49.6	8.40	430.9	548.80	259.43	29.00	489.85	240.25	278.60	68.69	-30.63	-0.86
	10/8/2004	54.7	18.19	457.3	588.15	279.59	36.45	522.72	256.00	303.17	74.03	-32.32	-1.06
	1/7/2005	108.7	42.65	486.4	597.82	308.89	75.67	542.11	297.55	320.23	81.78	-31.00	-0.51
	4/8/2005	91.7	33.99	457.3	601.47	296.12	62.85	529.39	274.50	317.73	78.40	-31.01	-0.97
	7/18/2005	28.7	12.91	432.3	605.33	269.81	20.81	518.82	230.50	309.12	71.44	-33.10	-1.76
	8/26/2005	31.4	16.85	447.8	588.39	271.11	24.13	518.10	239.60	302.62	71.78	-32.83	-1.41
	10/11/2005	43.7	14.58	464.4	588.60	277.82	29.14	526.50	254.05	301.59	73.56	-33.05	-1.06
	1/10/2006	96.3	14.58	483.8	588.60	295.82	55.44	536.20	290.05	301.59	78.32	-31.95	-0.26
	4/9/2006	87.1	29.40	477	588.60	295.52	58.25	532.80	282.05	309.00	78.25	-31.54	-0.60
	7/19/1906	18.4	-2.90	430.9	588.60	258.75	7.75	509.75	224.65	292.85	68.51	-33.36	-1.53

Driven Pile Forces and Bending Moments

Tie #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
	07/01/99	903.00	42.30	679.00	-	541.43	472.65	679.00	791.00	42.30	456.92	-73.98	99.88
	07/15/99	918.00	48.00	885.00	-	617.00	483.00	885.00	901.50	48.00	520.69	-144.12	113.86
	07/31/00	932.43	51.99	887.34	-	623.92	492.21	887.34	909.89	51.99	526.53	-141.66	114.44
	08/15/99	940.56	34.46	923.00	-	632.67	487.51	923.00	931.78	34.46	533.91	-156.13	119.70
	08/30/99	948.68	31.28	931.09	-	637.02	489.98	931.09	939.89	31.28	537.58	-158.14	121.21
	09/15/99	955.75	27.83	938.36	-	640.65	491.79	938.36	947.06	27.83	540.64	-160.10	122.62
	09/30/99	959.08	23.03	947.01	-	643.04	491.06	947.01	953.05	23.03	542.66	-163.47	124.06
	10/15/99	963.38	18.85	954.86	-	645.70	491.12	954.86	959.12	18.85	544.90	-166.26	125.43
	10/31/99	973.25	5.58	968.30	-	649.04	489.42	968.30	970.78	5.58	547.73	-171.69	128.76
	11/15/99	973.34	1.26	977.48	-	650.69	487.30	977.48	975.41	1.26	549.12	-175.74	129.95
	11/30/99	975.73	-2.84	980.87	-	651.25	486.45	980.87	978.30	-2.84	549.59	-177.26	130.88
	12/15/99	974.96	-2.47	982.11	-	651.53	486.25	982.11	978.54	-2.47	549.83	-177.77	130.87
	12/31/99	974.03	-54.00	984.71		634.91	460.02	984.71	979.37	-54.00	535.80	-188.11	137.85
	03/31/00	964.52	3.86	981.83	-	650.07	484.19	981.83	973.17	3.86	548.59	-178.41	129.31
	06/30/00	977.80	-36.92	980.73	-	640.54	470.44	980.73	979.27	-36.92	540.55	-182.94	135.56
	09/30/00	1009.20	-10.20	1005.99	-	668.33	499.50	1005.99	1007.60	-10.20	564.01	-181.58	135.77
	01/13/01	1014.1	-29.45	1029.11	-	671.26	492.33	1029.11	1021.61	-29.45	566.48	-192.44	140.21
	04/20/01	1008.3	-18.69	1022.57	-	670.72	494.79	1022.57	1015.42	-18.69	566.02	-189.21	137.95
	07/10/01	1030.4	-8.368	1019.56	-	680.53	511.02	1019.56	1024.98	-8.37	574.30	-182.32	137.85
	10/09/01	1054.3	-20.51	1038.65	-	690.80	516.87	1038.65	1046.45	-20.51	582.96	-187.07	142.33
1	01/09/02	1055.96	-29.65	1045.80	-	690.70	513.15	1045.80	1050.88	-29.65	582.88	-190.96	144.14
	04/12/02	1041.9	-24.82	1040.36	-	685.81	508.54	1040.36	1041.13	-24.82	578.76	-190.66	142.20
	07/19/02	1062.21	-17.26	1035.12	17.14	693.36	522.47	1035.12	1048.67	-17.26	585.12	-183.79	142.20
	10/08/02	1086.38	-30.07	1049.75	-6.63	702.02	528.16	1049.75	1068.06	-30.07	592.43	-187.00	146.49
	01/08/03	1080.45	-42.89	1062.94	0.41	700.17	518.78	1062.94	1071.70	-42.89	590.87	-195.09	148.69
	04/15/03	1059.37	-29.65	1049.86	22.95	693.19	514.86	1049.86	1054.62	-29.65	584.99	-191.81	144.64
	06/01/03	1064.93	-31.16	1053.52	21.00	695.77	516.89	1053.52	1059.23	-31.16	587.16	-192.39	145.46
	08/07/03	1083.86	-27.66	1053.40	9.26	703.20	528.10	1053.40	1068.63	-27.66	593.43	-188.33	146.25
	10/07/03	1095.56	-38.67	1066.64	-0.69	707.84	528.45	1066.64	1081.10	-38.67	597.35	-192.95	149.38
	12/31/03	1100.15	-54.88	1082.97	-0.89	709.41	522.64	1082.97	1091.56	-54.88	598.68	-200.89	152.93
	04/13/04	1080.17	-43.67	1074.07	21.65	703.52	518.25	1074.07	1077.12	-43.67	593.70	-199.27	149.51
	07/13/04	1101.53	-34.89	1072.49	10.76	713.04	533.32	1072.49	1087.01	-34.89	601.74	-193.30	149.66
	10/08/04	1122.82	-45.70	1085.57	-8.86	720.90	538.56	1085.57	1104.19	-45.70	608.36	-196.11	153.40
	01/07/05	1116.60	-58.49	1097.39	-8.94	718.50	529.06	1097.39	1107.00	-58.49	606.34	-203.76	155.48
	04/08/05	1099.01	-52.77	1096.58	5.48	714.28	523.12	1096.58	1097.80	-52.77	602.78	-205.59	153.49
	07/18/05	1116.44	-41.55	1096.58	-2.36	723.82	537.44	1096.58	1106.51	-41.55	610.83	-200.46	153.15
	08/26/05	1128.14	-43.63	1095.73	-10.20	726.75	542.26	1095.73	1111.93	-43.63	613.30	-198.43	154.15
	11/12/05	1127.45	-44.76	1095.72	-9.67	726.14	541.34	1095.72	1111.58	-44.76	612.79	-198.75	154.26
	01/10/06	1129.36	-64.30	1095.72	-19.70	720.26	532.53	1095.72	1112.54	-64.30	607.83	-201.91	156.99
	04/09/06	1114.90	-55.20	1095.72	-1.14	718.47	529.85	1095.72	1105.31	-55.20	606.32	-202.87	154.81
	07/19/06	1130.94	-46.83	1095.72	-9.42	726.61	542.05	1095.72	1113.33	-46.83	613.19	-198.50	154.77

Driven Pile Forces and Bending Moments (cont'd)

Tie #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
	07/01/99	575.00	589.00	243.00	-	469.00	582.00	243.00	409.00	589.00	395.79	121.54	-24.01
	07/15/99	585.00	602.00	237.00	-	474.67	593.50	237.00	411.00	602.00	400.57	127.81	-25.48
	07/31/00	594.35	611.17	230.68	-	478.73	602.76	230.68	412.52	611.17	404.00	133.40	-26.50
	08/15/99	596.87	611.09	242.58	336.68	446.81	603.98	289.63	419.73	473.89	377.06	112.70	-7.22
	08/30/99	601.58	616.82	241.00	-	486.47	609.20	241.00	421.29	616.82	410.53	132.00	-26.08
	09/15/99	605.96	622.42	240.47	-	489.62	614.19	240.47	423.22	622.42	413.19	133.98	-26.57
	09/30/99	609.62	624.20	240.71	336.98	452.88	616.91	288.85	425.17	480.59	382.18	117.62	-7.39
	10/15/99	612.87	629.40	240.27	336.21	454.69	621.14	288.24	426.57	482.81	383.71	119.35	-7.50
	10/31/99	616.45	631.80	243.11	336.29	456.91	624.13	289.70	429.78	484.05	385.59	119.90	-7.24
	11/15/99	619.54	632.45	245.83	337.79	458.90	626.00	291.81	432.69	485.12	387.27	119.81	-6.99
	11/30/99	623.35	635.58	248.71	340.31	461.99	629.47	294.51	436.03	487.95	389.87	120.09	-6.93
	12/15/99	624.21	637.77	247.77	339.95	462.43	630.99	293.86	435.99	488.86	390.24	120.87	-7.05
	12/31/99	626.60	640.86	249.37	341.45	464.57	633.73	295.41	437.99	491.16	392.05	121.29	-7.09
	03/31/00	634.53	648.30	254.69	346.89	471.10	641.41	300.79	444.61	497.60	397.56	122.12	-7.07
	06/30/00	640.05	652.80	250.99	342.06	471.48	646.43	296.53	445.52	497.43	397.88	125.44	-6.93
	09/30/00	647.16	661.13	247.62	336.78	473.17	654.14	292.20	447.39	498.96	399.31	129.76	-6.88
	01/13/01	654.06	665.11	256.39	342.22	479.45	659.59	299.31	455.23	503.67	404.61	129.16	-6.46
	04/20/01	654.43	664.71	260.37	345.47	481.25	659.57	302.92	457.40	505.09	406.12	127.86	-6.36
	07/10/01	661.46	672.1	256.15	342.75	483.11	666.78	299.45	458.80	507.43	407.70	131.69	-6.49
	10/09/01	668.36	679	251.93	338.20	484.37	673.68	295.06	460.14	508.60	408.76	135.74	-6.46
17	01/09/02	671.08	683.47	252.17	337.92	486.16	677.28	295.04	461.63	510.69	410.27	137.04	-6.55
	04/12/02	669.17	680.02	256.68	342.06	486.98	674.60	299.37	462.93	511.04	410.96	134.52	-6.42
	07/19/02	671.69	683.96	253.27	272.93	470.46	677.83	263.10	462.48	478.44	397.02	148.69	-2.13
	10/08/02	678.60	692.21	247.01	332.37	487.54	685.40	289.69	462.80	512.29	411.44	141.87	-6.60
	01/08/03	678.44	689.32	251.28	334.22	488.31	683.88	292.75	464.86	511.77	412.09	140.22	-6.26
	04/15/03	679.45	692.45	254.73	341.09	491.93	685.95	297.91	467.09	516.77	415.14	139.12	-6.63
	06/01/03	678.76	689.85	256.43	341.09	491.53	684.30	298.76	467.60	515.47	414.80	138.22	-6.39
	08/07/03	682.33	695.54	251.15	336.74	491.44	688.94	293.95	466.74	516.14	414.73	141.61	-6.59
	10/07/03	686.23	700.57	250.14	334.87	492.95	693.40	292.50	468.19	517.72	416.00	143.73	-6.61
	12/31/03	689.48	700.61	257.04	341.05	497.05	695.05	299.04	473.26	520.83	419.46	141.97	-6.35
	04/13/04	689.24	699.88	260.70	346.65	499.12	694.56	303.68	474.97	523.27	421.21	140.14	-6.44
	07/13/04	693.10	667.59	255.46	341.33	489.37	680.34	298.39	474.28	504.46	412.98	136.93	-4.03
	10/08/04	699.03	710.89	250.83	337.39	499.53	704.96	294.11	474.93	524.14	421.56	147.30	-6.56
	01/07/05	699.07	711.46	253.31	339.95	500.95	705.26	296.63	476.19	525.70	422.75	146.50	-6.61
	04/08/05	696.43	708.09	257.94	343.81	501.57	702.26	300.87	477.18	525.95	423.27	143.90	-6.51
	07/18/05	699.56	708.33	253.71	338.36	499.99	703.94	296.04	476.64	523.35	421.94	146.24	-6.23
	08/26/05	702.04	711.17	250.91	335.97	500.02	706.61	293.44	476.47	523.57	421.97	148.13	-6.28
	11/12/05	701.95	699.60	251.68	337.06	497.57	700.78	294.37	476.82	518.33	419.90	145.70	-5.54
	01/10/06	705.16	715.03	253.47	339.58	503.31	710.10	296.53	479.32	527.31	424.75	148.27	-6.40
	04/09/06	703.94	713.04	259.52	343.20	504.93	708.49	301.36	481.73	528.12	426.11	145.96	-6.19
	07/19/06	708.37	716.01	256.84	339.95	505.29	712.19	298.39	482.61	527.98	426.42	148.35	-6.05

Driven Pile Forces and Bending Moments (cont'd)

Tie #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
18	07/01/99	546.00	501.00	248.00	173	367.00	523.50	210.50	397.00	337.00	309.71	112.21	8.00
	07/15/99	557.00	513.00	243.00	229	385.50	535.00	236.00	400.00	371.00	325.32	107.20	3.87
	07/31/00	565.55	519.94	239.54	224.26	387.32	542.75	231.90	402.55	372.10	326.86	111.44	4.06
	08/15/99	567.71	520.14	230.56	232.51	387.73	543.93	231.54	399.14	376.33	327.21	112.00	3.04
	08/30/99	573.72	526.52	247.46	232.87	395.14	550.12	240.17	410.59	379.70	333.46	111.12	4.12
	09/15/99	578.06	532.08	246.65	233.61	397.60	555.07	240.13	412.36	382.85	335.53	112.91	3.94
	09/30/99	582.49	534.97	247.46	234.05	399.74	558.73	240.76	414.98	384.51	337.34	114.00	4.06
	10/15/99	586.68	538.17	247.25	235.23	401.83	562.43	241.24	416.97	386.70	339.11	115.15	4.04
	10/31/99	590.77	539.40	249.37	235.6	403.79	565.09	242.49	420.07	387.50	340.75	115.66	4.34
	11/15/99	592.65	540.65	251.68	237.47	405.61	566.65	244.58	422.17	389.06	342.30	115.47	4.42
	11/30/99	596.63	527.25	254.12	239.69	404.42	561.94	246.91	425.38	383.47	341.29	112.94	5.59
	12/15/99	599.47	545.53	254.12	239.05	409.54	572.50	246.59	426.80	392.29	345.61	116.84	4.60
	12/31/99	601.54	548.45	255.38	239.17	411.14	575.00	247.28	428.46	393.81	346.96	117.49	4.62
	03/31/00	610.32	554.87	262.08	243.60	417.72	582.59	252.84	436.20	399.23	352.51	118.22	4.93
	06/30/00	616.94	539.60	260.98	238.93	414.11	578.27	249.96	438.96	389.26	349.47	117.70	6.63
	09/30/00	625.63	400.76	255.58	232.18	378.54	513.19	243.88	440.61	316.47	319.45	96.55	16.56
	01/13/01	632.37	566.69	264.44	235.84	424.83	599.53	250.14	448.40	401.26	358.52	125.26	6.29
	04/20/01	632.58	561.53	268.38	236.21	424.67	597.05	252.29	450.48	398.87	358.38	123.60	6.88
	07/10/01	639.68	569.29	264.64	234.54	427.04	604.49	249.59	452.16	401.91	360.38	127.23	6.70
	10/09/01	646.51	576.52	259.81	232.14	428.74	611.51	245.97	453.16	404.33	361.82	131.05	6.51
	01/09/02	650.89	576.84	259.68	230.92	429.59	613.87	245.30	455.29	403.88	362.53	132.14	6.86
	04/12/02	650.12	570.1	264.192	232.55	429.24	610.11	248.37	457.16	401.33	362.24	129.69	7.45
	07/19/02	653.45	572.46	260.90	226.38	428.30	612.96	243.64	457.18	399.42	361.44	132.40	7.71
	10/08/02	659.69	581.14	254.65	222.68	429.54	620.41	238.66	457.17	401.91	362.49	136.86	7.37
	01/08/03	657.76	576.89	257.57	224.47	429.17	617.32	241.02	457.67	400.68	362.18	134.91	7.60
	04/15/03	661.78	576.19	262.16	228.04	432.04	618.99	245.10	461.97	402.12	364.60	134.04	7.98
	06/01/03	661.37	572.66	264.07	227.59	431.43	617.02	245.83	462.72	400.13	364.08	133.07	8.35
	08/07/03	665.76	577.29	258.18	222.76	431.00	621.53	240.47	461.97	400.03	363.72	136.61	8.26
	10/07/03	669.26	582.73	256.11	222.56	432.66	625.99	239.33	462.68	402.65	365.13	138.62	8.01
	12/31/03	670.27	581.39	262.53	229.62	435.95	625.83	246.08	466.40	405.51	367.90	136.15	8.12
	04/13/04	669.42	576.64	266.47	232.35	436.22	623.03	249.41	467.94	404.49	368.12	133.95	8.46
	07/13/04	672.95	578.63	261.80	224.79	434.54	625.79	243.29	467.37	401.71	366.71	137.13	8.76
	10/08/04	677.95	587.12	255.42	222.31	435.70	632.53	238.87	466.68	404.72	367.69	141.14	8.27
	01/07/05	677.50	586.02	257.61	226.05	436.80	631.76	241.83	467.56	406.04	368.61	139.80	8.21
	04/08/05	674.17	580.83	263.14	227.80	436.48	627.50	245.47	468.65	404.31	368.35	136.96	8.58
	07/18/05	677.87	580.70	259.40	221.74	434.93	629.29	240.57	468.63	401.22	367.04	139.36	8.99
	08/26/05	679.25	583.30	256.27	219.43	434.56	631.28	237.85	467.76	401.37	366.73	141.05	8.86
	11/12/05	679.13	583.14	256.88	220.08	434.81	631.13	238.48	468.00	401.61	366.93	140.77	8.86
	01/10/06	679.45	587.32	257.33	223.00	436.78	633.39	240.17	468.39	405.16	368.60	140.97	8.43
	04/09/06	679.57	583.14	263.01	226.46	438.05	631.36	244.74	471.29	404.80	369.67	138.61	8.87
	07/19/06	683.27	585.78	260.94	222.31	438.08	634.53	241.63	472.11	404.05	369.69	140.86	9.08

Driven Pile Forces and Bending Moments (cont'd)

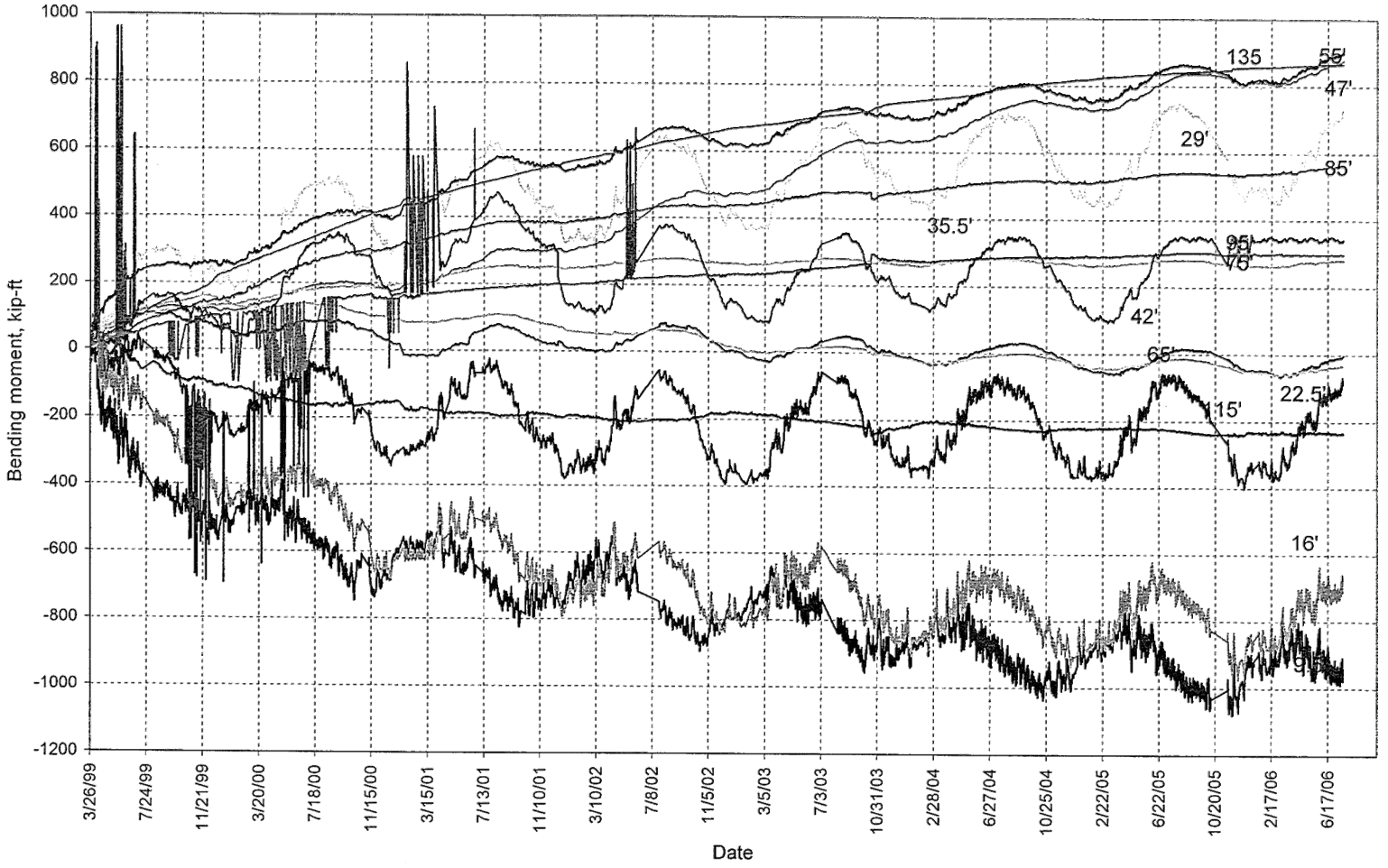
Tie #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
19	07/01/99	566.97	586.00	298.00	228.9	419.97	576.49	263.45	432.49	407.45	354.41	112.23	3.34
	07/15/99	580.00	597.00	294.00	224	423.75	588.50	259.00	437.00	410.50	357.60	118.13	3.54
	07/31/00	588.71	606.46	291.38	218.62	426.29	597.59	255.00	440.05	412.54	359.75	122.82	3.67
	08/15/99	591.02	607.35	300.95	227.92	431.81	599.19	264.44	445.99	417.64	364.40	120.01	3.78
	08/30/99	595.94	613.52	300.59	229.63	434.92	604.73	265.11	448.27	421.58	367.03	121.76	3.56
	09/15/99	599.88	617.91	300.67	229.54	437.00	608.90	265.11	450.28	423.73	368.78	123.25	3.54
	09/30/99	603.53	621.65	302.70	229.75	439.41	612.59	266.23	453.12	425.70	370.82	124.18	3.66
	10/15/99	607.51	625.02	302.29	229.71	441.13	616.27	266.00	454.90	427.37	372.27	125.57	3.67
	10/31/99	611.37	627.25	306.07	229.7	443.60	619.31	267.89	458.72	428.48	374.35	125.99	4.03
	11/15/99	613.61	627.78	308.31	232.67	445.59	620.70	270.49	460.96	430.23	376.04	125.55	4.10
	11/30/99	616.29	630.54	313.83	234.7	448.84	623.42	274.27	465.06	432.62	378.78	125.17	4.33
	12/15/99	617.83	631.44	314.03	234.9	449.55	624.64	274.47	465.93	433.17	379.38	125.54	4.37
	12/31/99	619.94	634.20	314.36	236.45	451.24	627.07	275.41	467.15	435.33	380.80	126.08	4.25
	03/31/00	629.45	639.44	320.33	239.74	457.24	634.44	280.03	474.89	439.59	385.86	127.06	4.71
	06/30/00	636.15	643.50	317.81	51.91	412.34	639.83	184.86	476.98	347.71	347.98	163.11	17.25
	09/30/00	646.59	651.99	312.33	231.29	460.55	649.29	271.81	479.46	441.64	388.66	135.33	5.04
	01/13/01	653.45	657.07	320.21	236.77	466.88	655.26	278.49	486.83	446.92	394.00	135.08	5.32
	04/20/01	651.46	653.21	324.03	237.42	466.53	652.34	280.72	487.74	445.32	393.71	133.23	5.66
	07/10/01	658.86	661.17	320.61	235.03	468.92	660.01	277.82	489.74	448.10	395.72	137.02	5.55
	10/09/01	667.35	669.26	315.37	230.97	470.74	668.30	273.17	491.36	450.11	397.25	141.66	5.50
	01/09/02	670.88	671.77	315.66	229.71	472.00	671.33	272.68	493.27	450.74	398.32	142.92	5.67
	04/12/02	667.71	665.64	321.06	231.62	471.51	666.68	276.34	494.39	448.63	397.90	139.94	6.10
	07/19/02	673.44	667.87	319.88	227.72	472.23	670.66	273.80	496.66	447.79	398.51	142.28	6.52
	10/08/02	681.93	676.18	313.24	222.91	473.56	679.05	268.07	497.58	449.54	399.64	147.34	6.41
	01/08/03	682.42	673.60	316.88	225.03	474.48	678.01	270.96	499.65	449.32	400.42	145.93	6.71
	04/15/03	686.11	672.95	321.26	228.37	477.17	679.53	274.81	503.69	450.66	402.69	145.10	7.07
	06/01/03	685.30	670.80	322.48	227.84	476.60	678.05	275.16	503.89	449.32	402.21	144.44	7.28
	08/07/03	689.12	675.35	317.28	223.09	476.21	682.23	270.18	503.20	449.22	401.87	147.72	7.20
	10/07/03	694.48	681.03	314.64	222.27	478.11	687.76	268.46	504.56	451.65	403.47	150.32	7.06
	12/31/03	695.94	680.95	322.73	229.34	482.24	688.45	276.03	509.33	455.15	406.96	147.86	7.23
	04/13/04	695.62	676.77	330.77	231.41	483.64	686.19	281.09	513.19	454.09	408.15	145.23	7.88
	07/13/04	700.37	679.61	327.88	224.22	483.02	689.99	276.05	514.13	451.92	407.62	148.40	8.30
	10/08/04	706.18	688.67	321.87	221.22	484.48	697.43	271.54	514.03	454.94	408.86	152.68	7.88
	01/07/05	705.37	688.14	324.72	224.55	485.69	696.75	274.63	515.04	456.35	409.88	151.34	7.83
	04/08/05	702.85	682.86	329.75	226.66	485.53	692.86	278.21	516.30	454.76	409.74	148.66	8.21
	07/18/05	706.50	683.55	327.15	219.55	484.19	695.03	273.35	516.83	451.55	408.61	151.18	8.71
	08/26/05	708.05	686.48	322.81	217.89	483.80	697.26	270.35	515.43	452.18	408.28	153.05	8.44
	11/12/05	707.97	686.27	323.74	218.33	484.08	697.12	271.04	515.85	452.30	408.51	152.76	8.48
	01/10/06	710.04	690.54	324.68	221.62	486.72	700.29	273.15	517.36	456.08	410.74	153.13	8.17
	04/09/06	709.47	686.72	329.75	224.34	487.57	698.10	277.05	519.61	455.53	411.46	150.95	8.55
	07/19/06	714.26	690.38	328.09	220.57	488.32	702.32	274.33	521.17	455.47	412.10	153.44	8.76

Driven Pile Forces and Bending Moments (cont'd)

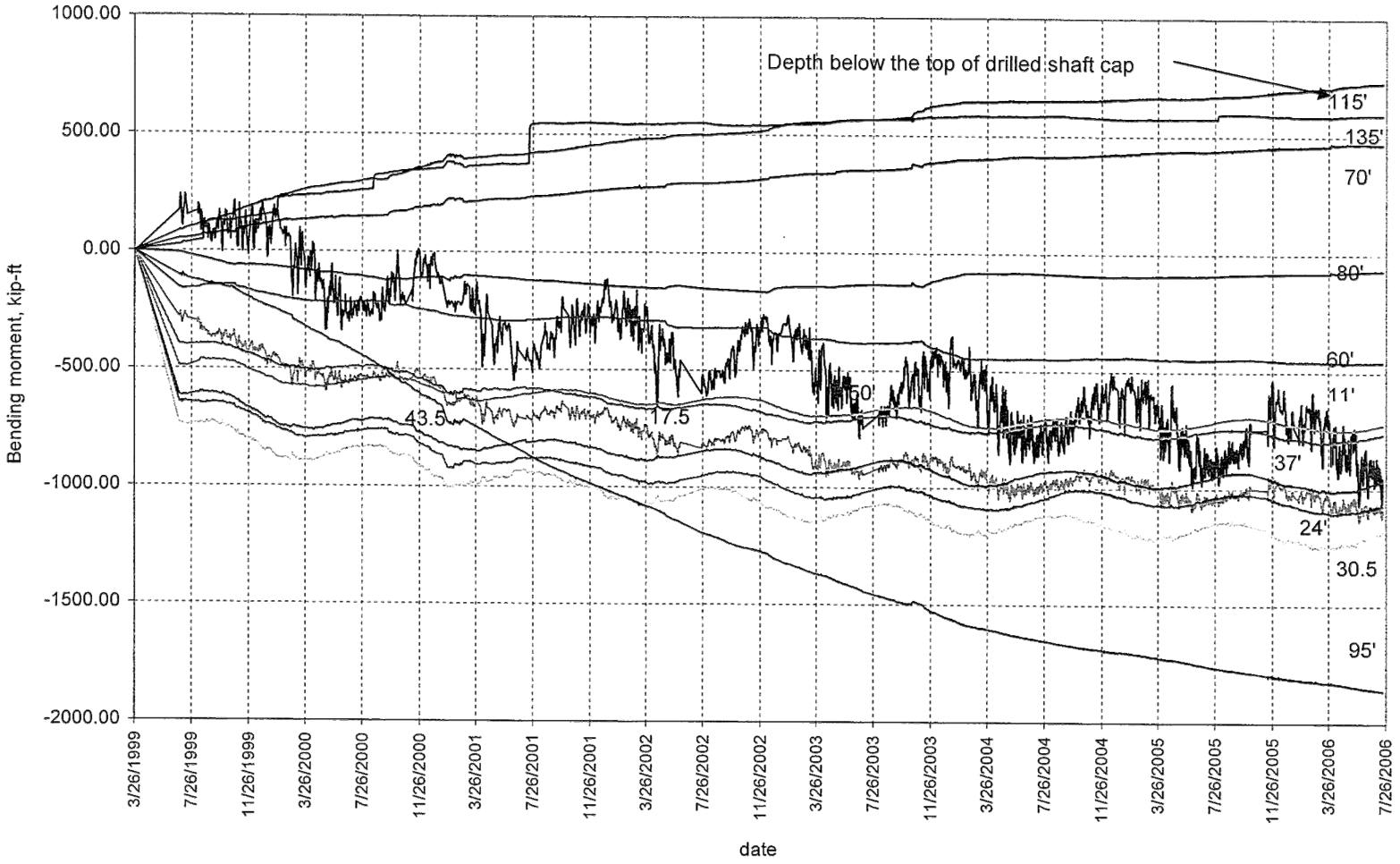
Tie #	Date	ε_1	ε_2	ε_3	ε_4	Avg. ε	$(\varepsilon_1+\varepsilon_2)/2$	$(\varepsilon_3+\varepsilon_4)/2$	$(\varepsilon_1+\varepsilon_3)/2$	$(\varepsilon_2+\varepsilon_4)/2$	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
34	07/01/99	271.75	436.00	261.00	583.00	387.94	353.88	422.00	266.38	509.50	327.38	-24.42	-32.43
	07/15/99	279.00	617.00	253.00	583.00	433.00	448.00	418.00	266.00	600.00	365.41	10.76	-44.56
	07/31/00	282.79	647.00	243.64	585.13	439.64	464.90	414.39	263.22	616.07	371.01	18.11	-47.07
	08/15/99	272.89	690.09	251.16	614.66	457.20	481.49	432.91	262.03	652.38	385.83	17.42	-52.07
	08/30/99	265.66	576.80	245.14	627.09	428.67	421.23	436.12	255.40	601.95	361.76	-5.34	-46.23
	09/15/99	265.08	802.81	242.34	635.26	486.37	533.95	438.80	253.71	719.04	410.45	34.11	-62.07
	09/30/99	260.50	807.40	238.64	642.65	487.30	533.95	440.65	249.57	725.03	411.23	33.45	-63.43
	10/15/99	256.43	811.14	234.46	648.58	487.65	533.79	441.52	245.45	729.86	411.53	33.08	-64.62
	10/31/99	240.47	824.02	221.62	665.31	487.86	532.25	443.47	231.05	744.67	411.70	31.83	-68.52
	11/15/99	241.93	831.45	224.75	676.77	493.73	536.69	450.76	233.34	754.11	416.65	30.81	-69.47
	11/30/99	240.47	835.88	224.26	648.85	487.37	538.18	436.56	232.37	742.37	411.29	36.43	-68.03
	12/15/99	241.41	836.77	222.35	684.04	496.14	539.09	453.20	231.88	760.41	418.69	30.79	-70.51
	12/31/99	242.22	836.08	224.14	684.93	496.84	539.15	454.54	233.18	760.51	419.29	30.34	-70.35
	03/31/00	257.37	828.85	237.38	675.92	499.88	543.11	456.65	247.38	752.38	421.85	31.00	-67.37
	06/30/00	266.43	846.32	225.20	500.93	459.72	556.37	363.06	245.81	673.62	387.96	69.30	-57.07
	09/30/00	257.37	895.02	196.89	705.00	513.57	576.19	450.94	227.13	800.01	433.40	44.90	-76.42
	01/13/01	247.90	856.11	197.37	729.58	507.74	552.01	463.47	222.64	792.84	428.48	31.74	-76.07
	04/20/01	44.66	883.01	212.28	457.21	399.29	463.83	334.74	128.47	670.11	336.96	46.28	-72.25
	07/10/01	-279.94	502.86	204.24	66.21	123.34	111.46	135.22	-37.85	284.53	104.09	-8.52	-43.01
	10/09/01	442.16	725.37	50.98	1199.89	604.60	583.76	625.44	246.57	962.63	510.22	-14.94	-95.52
	01/09/02	263.63	616.73	159.27	765.05	451.17	440.18	462.16	211.45	690.89	380.74	-7.88	-63.96
	04/12/02	67.35	579.97	58.13	501.01	301.61	323.66	279.57	62.74	540.49	254.53	15.81	-63.73
	07/19/02	288.69	941.04	187.83	727.59	536.29	614.86	457.71	238.26	834.31	452.57	56.34	-79.51
	10/08/02	277.15	962.54	162.58	740.98	535.81	619.84	451.78	219.86	851.76	452.17	60.25	-84.29
	01/08/03	256.07	949.53	162.24	758.66	531.62	602.80	460.45	209.15	854.10	448.64	51.04	-86.04
	04/15/03	277.19	928.37	189.53	744.52	534.90	602.78	467.03	233.36	836.45	451.41	48.67	-80.45
	06/01/03	277.96	939.01	184.90	749.68	537.89	608.49	467.29	231.43	844.35	453.93	50.62	-81.76
	08/07/03	288.69	965.09	171.66	750.09	543.88	626.89	460.87	230.17	857.59	458.98	59.52	-83.70
	10/07/03	274.96	978.21	155.53	762.84	542.89	626.58	459.19	215.25	870.53	458.14	60.01	-87.41
	12/31/03	258.26	983.57	156.83	795.22	548.47	620.92	476.03	207.55	889.40	462.86	51.95	-90.96
	04/13/04	281.17	960.30	188.88	781.65	553.00	620.73	485.27	235.03	870.97	466.68	48.57	-84.84
	07/13/04	302.86	991.98	173.93	772.27	560.26	647.42	473.10	238.40	882.12	472.80	62.50	-85.87
	10/08/04	295.63	1004.49	151.19	786.40	559.43	650.06	468.80	223.41	895.45	472.10	64.99	-89.65
	01/07/05	277.35	997.91	148.79	798.02	555.52	637.63	473.41	213.07	897.97	468.80	58.88	-91.36
	04/08/05	286.74	978.21	166.99	788.76	555.17	632.47	477.87	226.86	883.49	468.51	55.43	-87.59
	07/18/05	304.00	1000.02	160.94	783.60	562.14	652.01	472.27	232.47	891.81	474.39	64.44	-87.96
	08/26/05	301.85	1018.4	147.73	791.81	564.94	660.12	469.77	224.79	905.09	476.76	68.24	-90.75
	11/12/05	300.51	1018.3	147.82	793.35	564.99	659.40	470.58	224.16	905.83	476.80	67.70	-90.93
	01/10/06	274.59	1009.4	138.15	808.34	557.62	642.00	473.24	206.37	908.87	470.58	60.50	-93.71
	04/09/06	283.04	986.09	160.45	798.02	556.90	634.57	479.23	221.74	892.06	469.97	55.69	-89.42
	07/19/06	295.67	1009.41	149.73	796.56	562.84	652.54	473.14	222.70	902.98	474.98	64.32	-90.75

Numerical reading of anchor load as a function of time for anchors #1, #8, #9 and #17

Date	Anchor #1 Load, kips	Anchor #8 Load, kips	Anchor #9 Load, kips	Anchor #17 Load, kips	Comment
4/7/1999		560			Anchor Lock off
4/8/1999	489			499	
4/14/1999	460	473	596 (Lock off)	461	
5/7/1999	452	473	572	445	End of construction
7/1/1999	446	468	564	439	
10/1/1999	441	467	560	440	
1/1/2000	439	461	555	424	
4/1/2000	432	453	546	414	
7/1/2000	431	451	521	415	
10/1/2000	431	451	519	416	
1/1/2001	430	455	517	400	
4/1/2001	421	443	513	397	
7/1/2001	422	443	510	399	
10/1/2001	425	445	512	403	
1/1/2002	424	444	511	398	
4/1/2002	421	440	508	386	
7/1/2002	419	439	506	391	
10/1/2002	423	442	508	396	
1/1/2003	423	435	508	389	
4/15/2003	416	427	501	380	
8/07/2003	416	428	503	384	
10/07/2003	418	429	504	387	
12/31/2003	417	426	503	378	
4/13/2004	408	418	494	370	
7/13/2004	409	419	494	374	
10/08/2004	411	422	496	377	
1/07/2005	411	421	495	374	
4/08/2005	407	414	485	366	
7/18/2005	407	415	485	370	
11/12/2005	410	419	489	374	
1/10/2006	409	417	487	369	
4/9/2006	399	411	487	365	
7/19/2006	399	412	487	368	



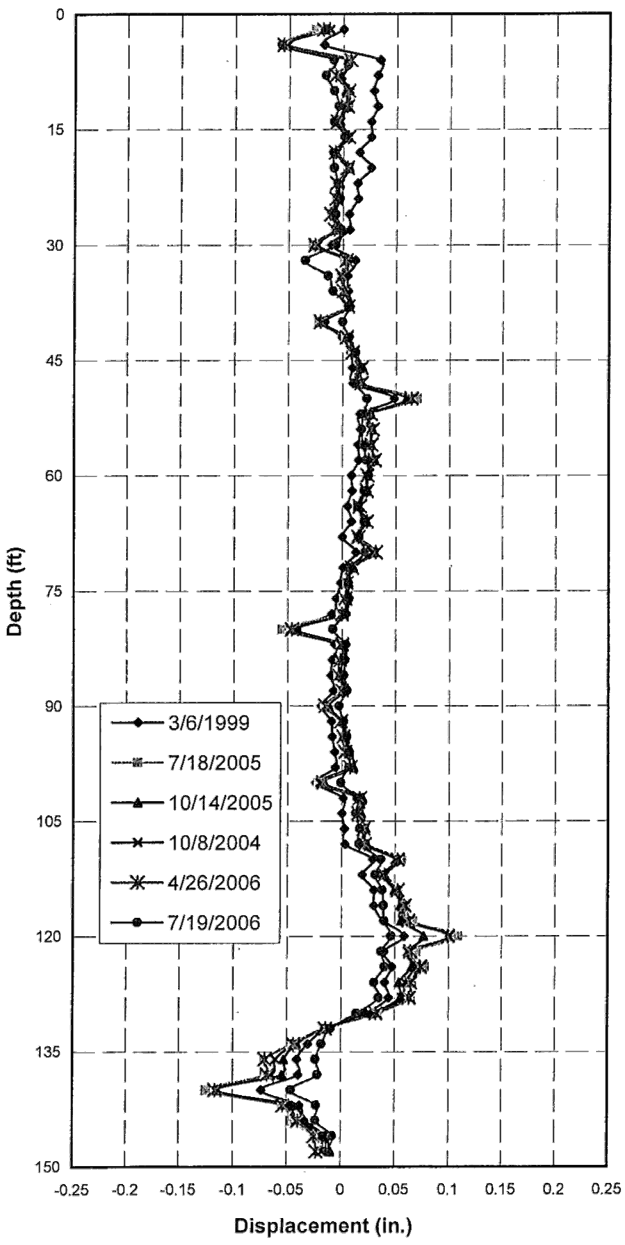
Shaft #1, Bending moment vs. date in different elevations below the top of cap



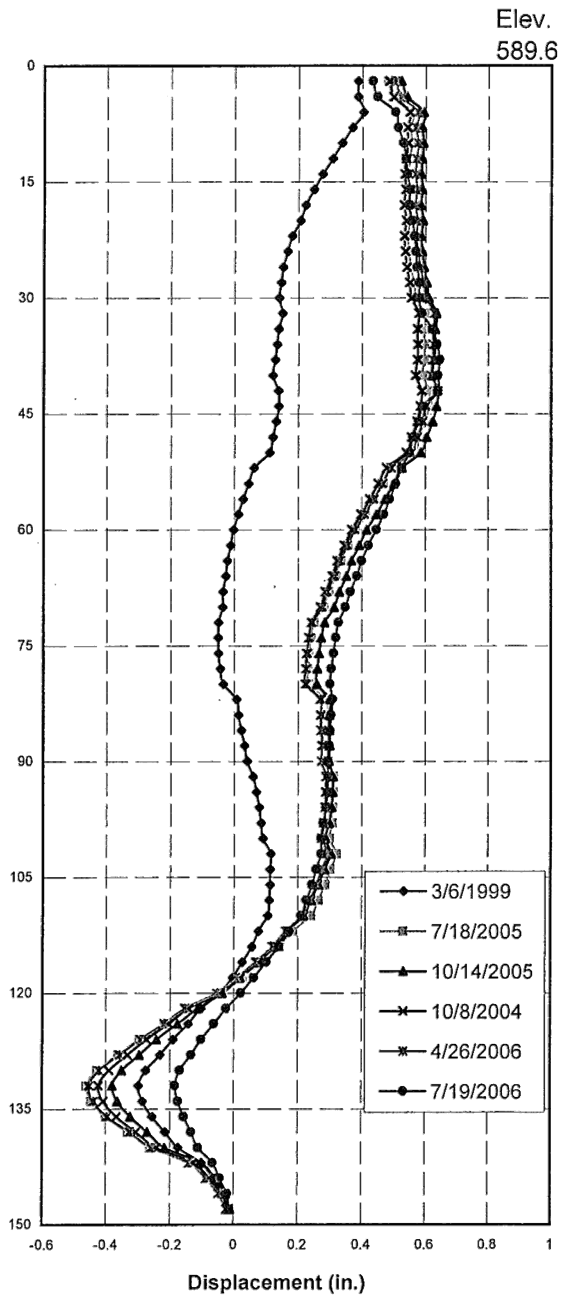
Shaft #9, Bending moment vs. date in different elevations below the top of cap

Inclinometer #1 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

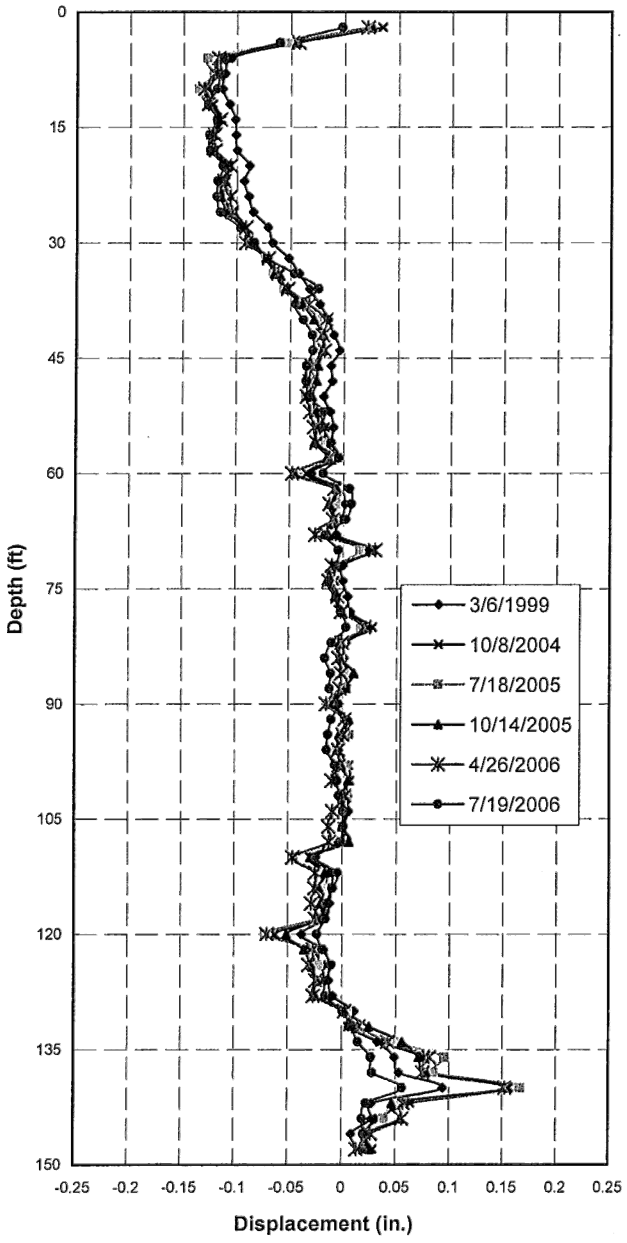


Cumulative



Inclinometer #1 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



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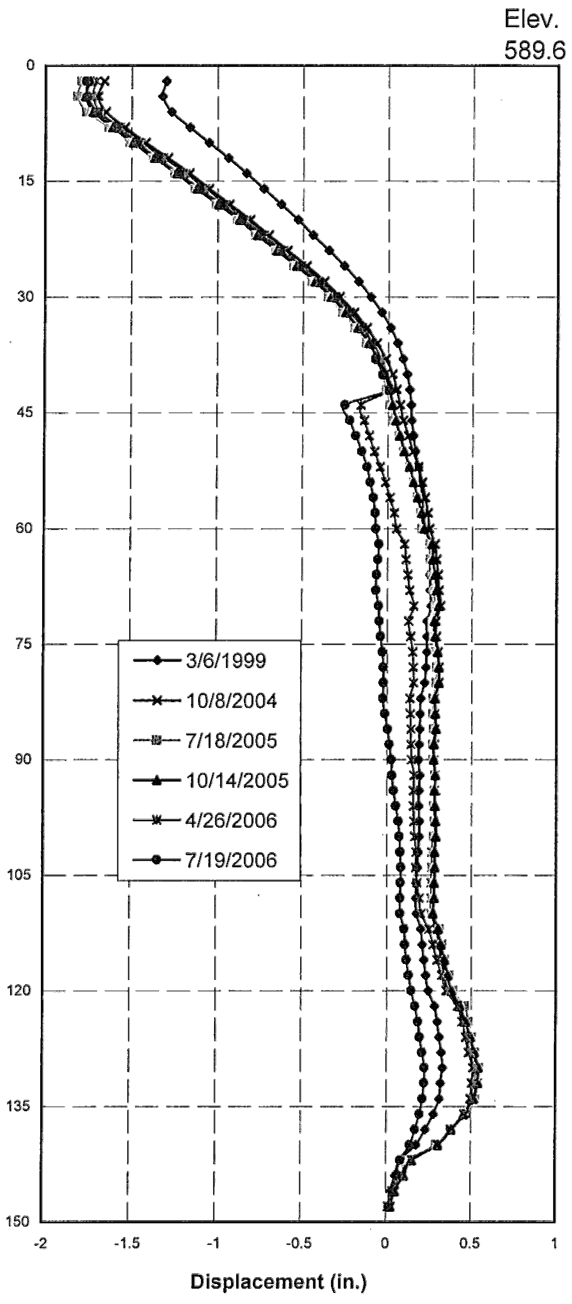

Inclinometer #3 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

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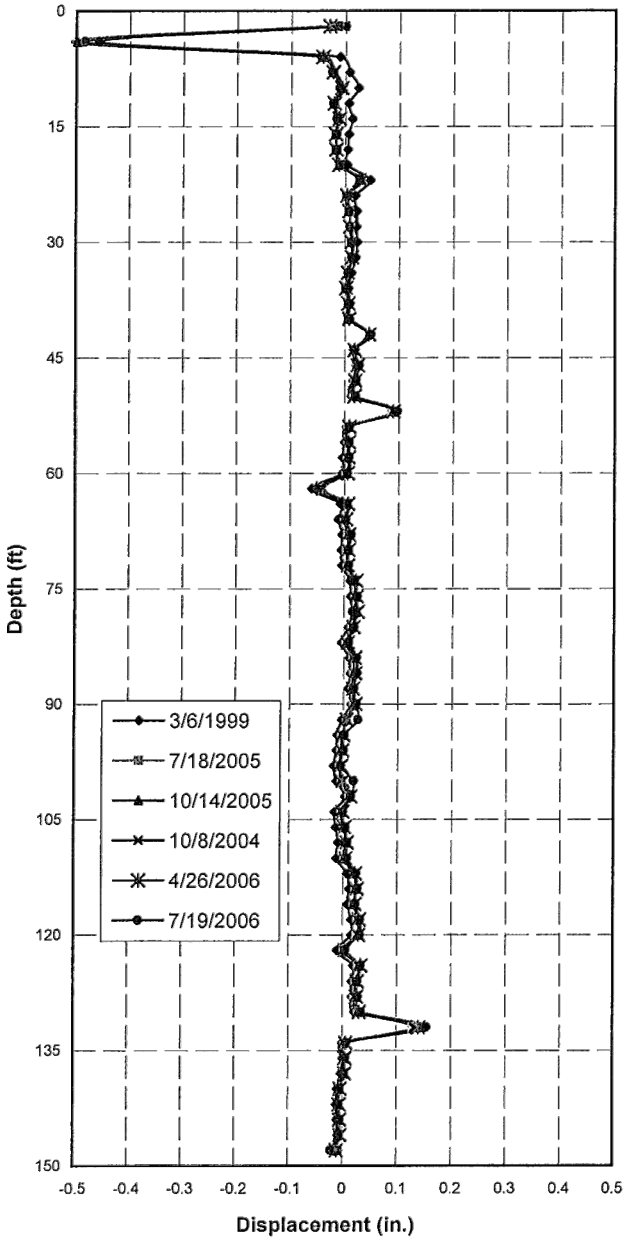
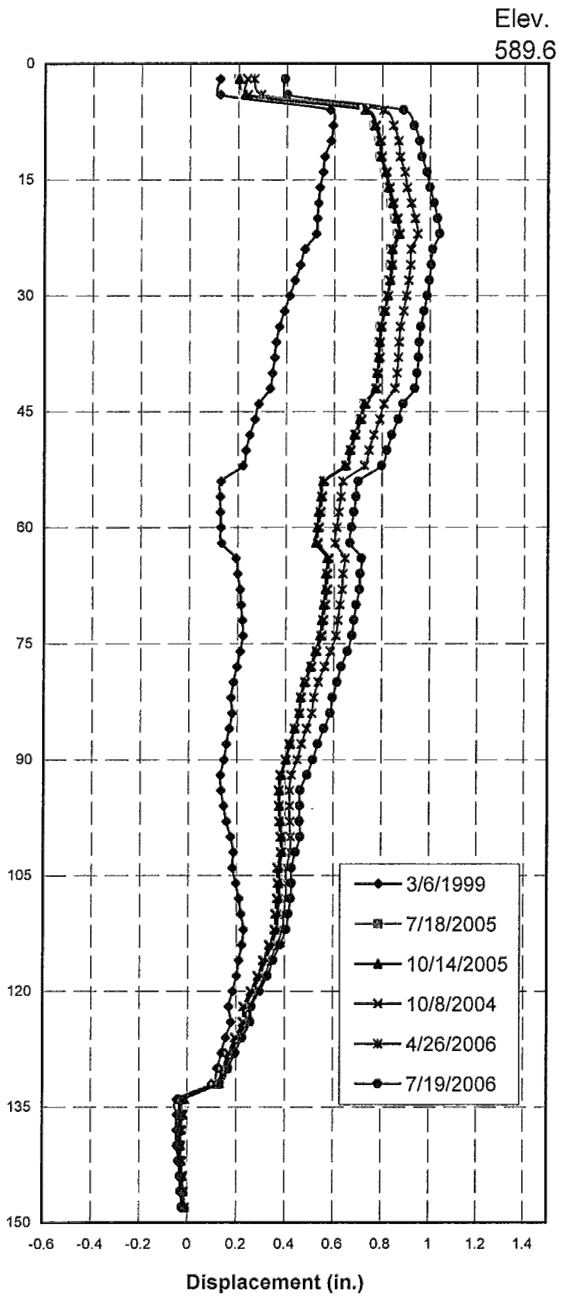


Cumulative



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Downslope (River direction) Base Line 12/11/1998

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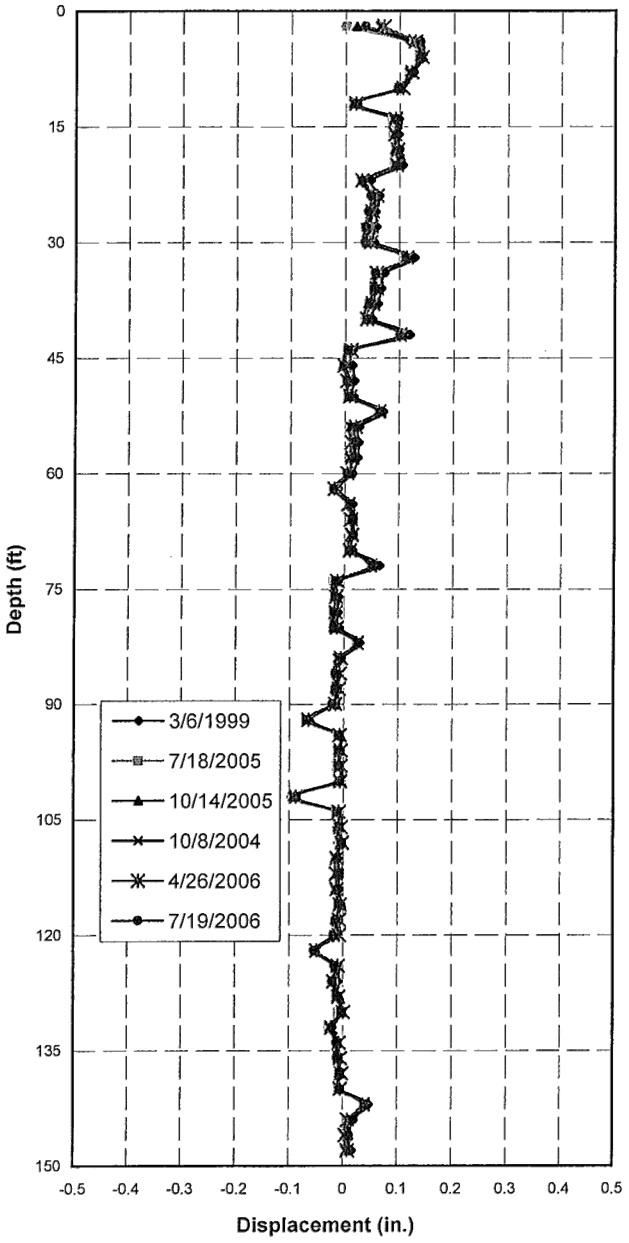

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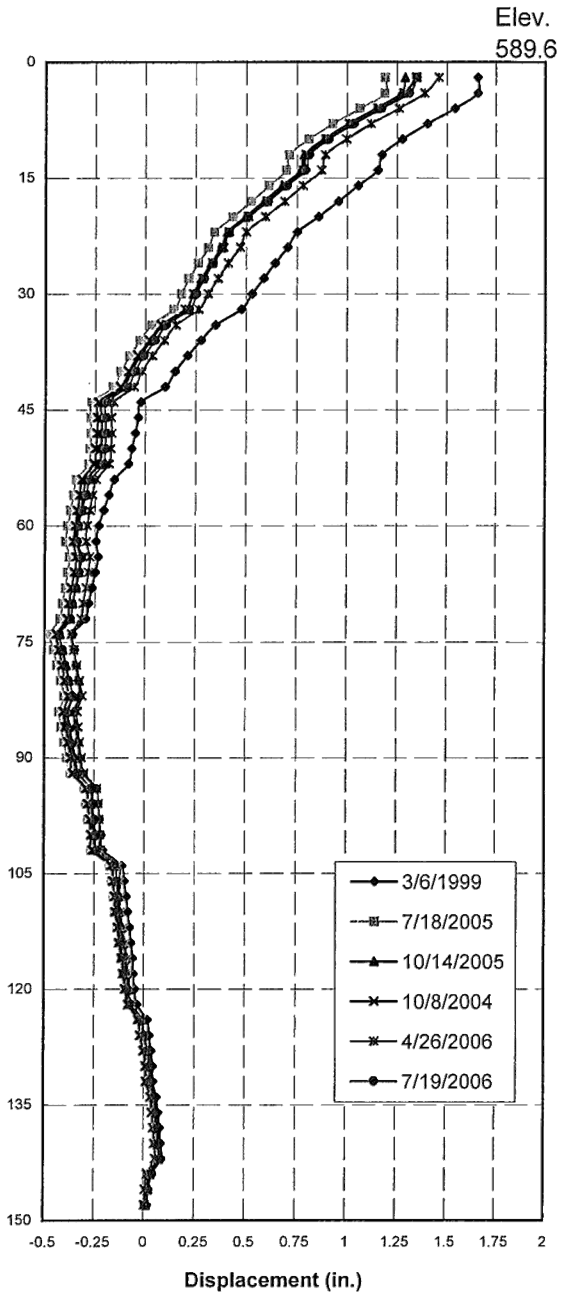
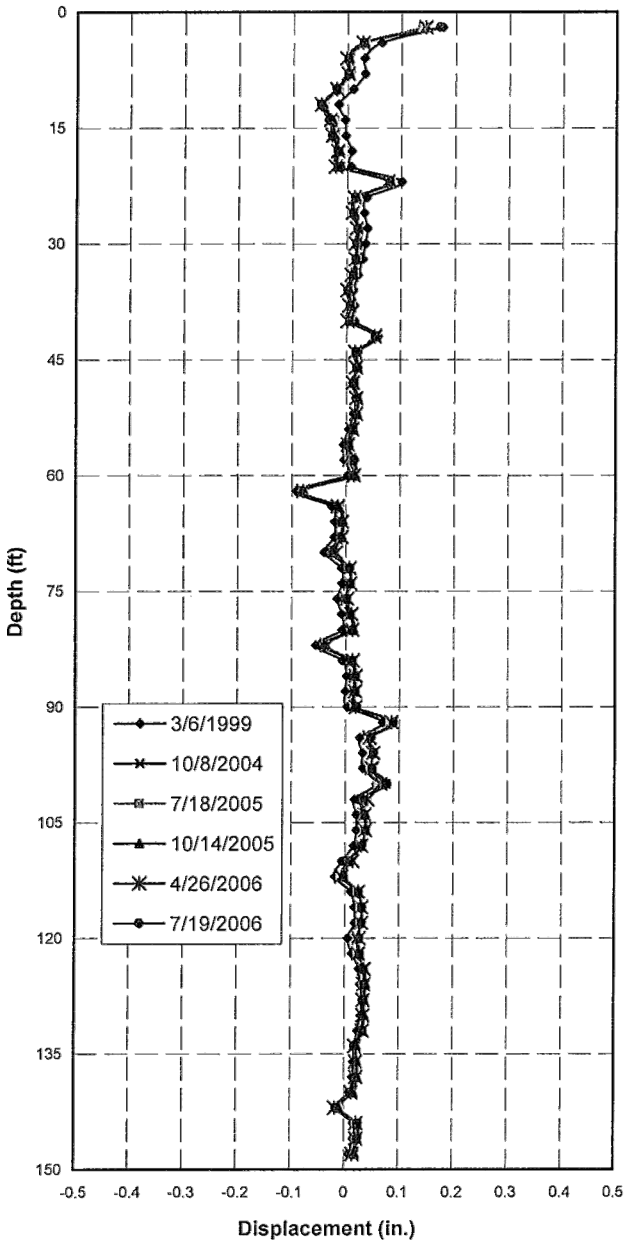


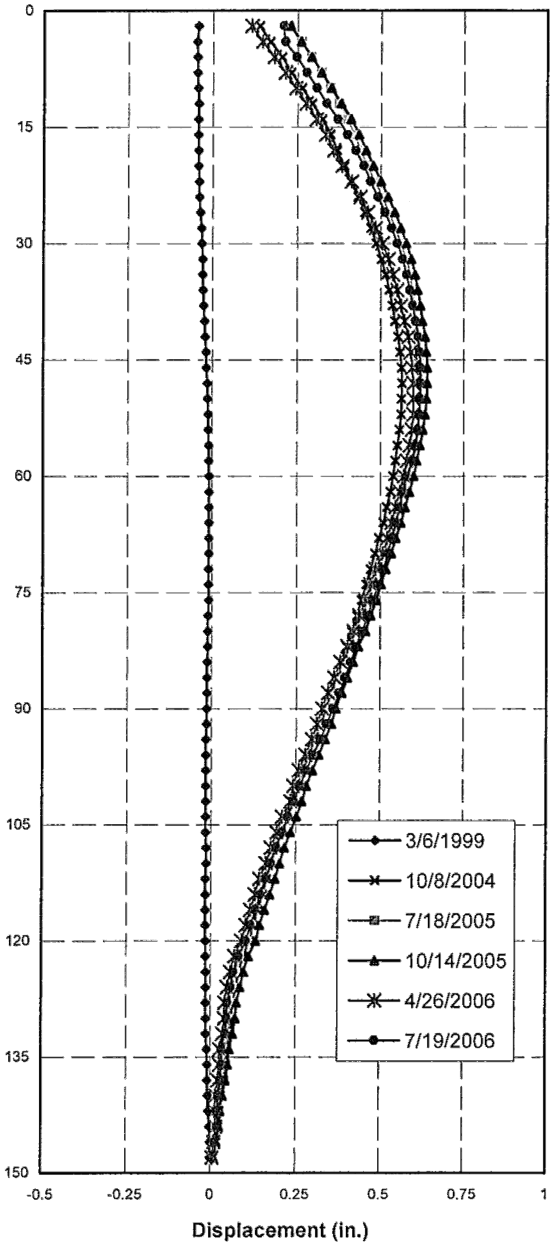
Inclinometer #8 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



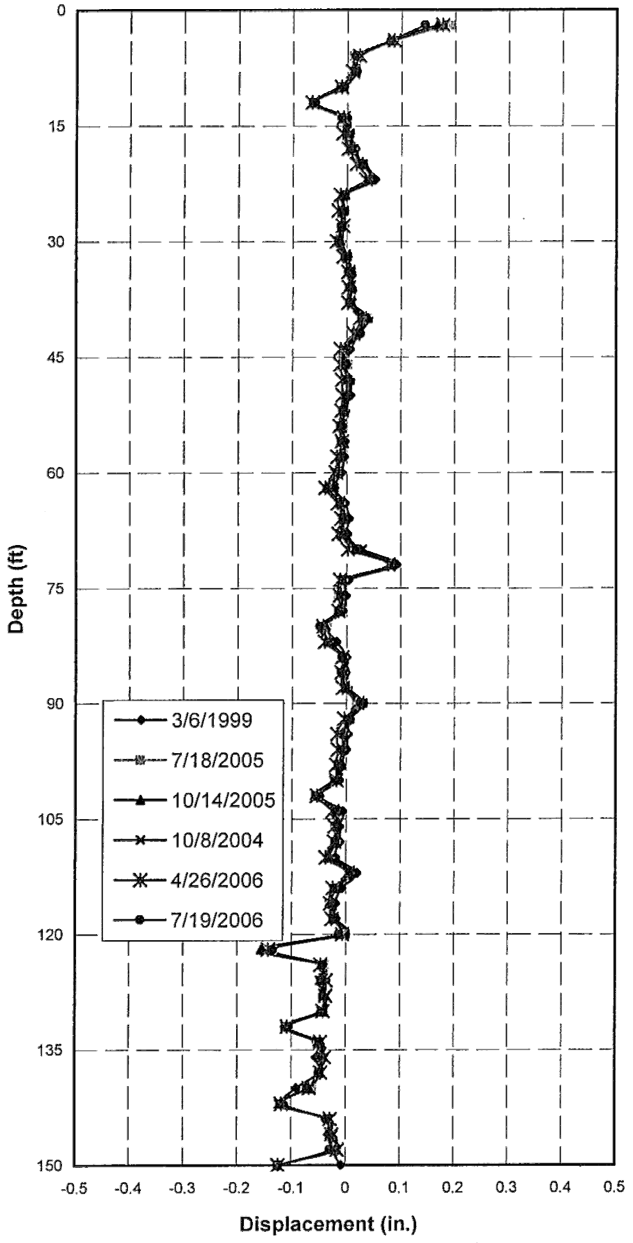
Cumulative

Elev.
589.6



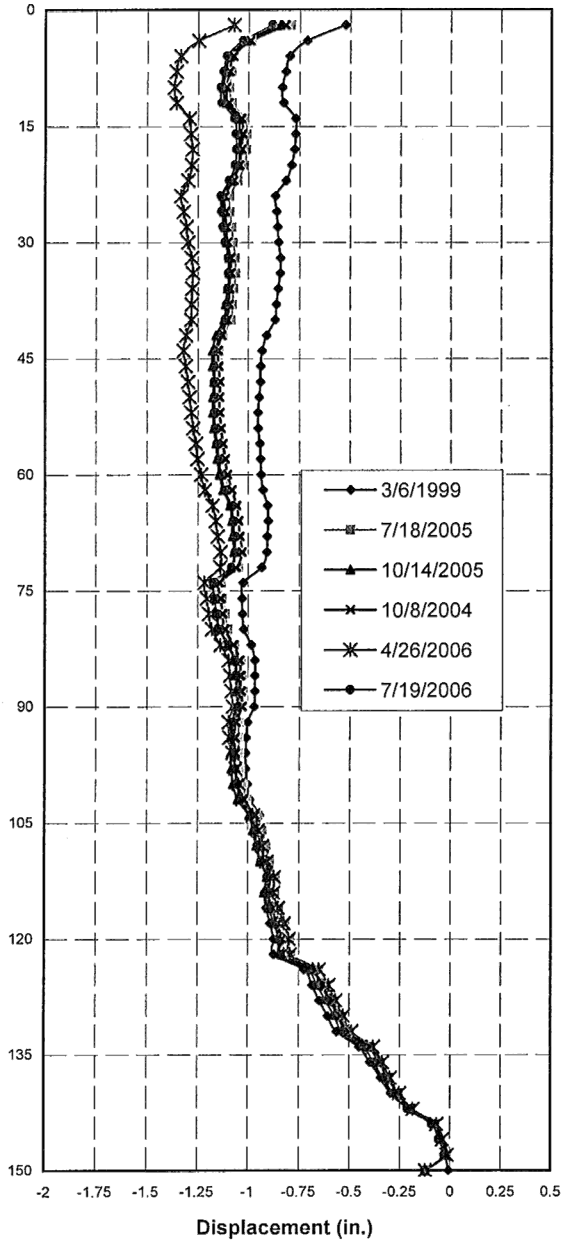
Inclinometer #8 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



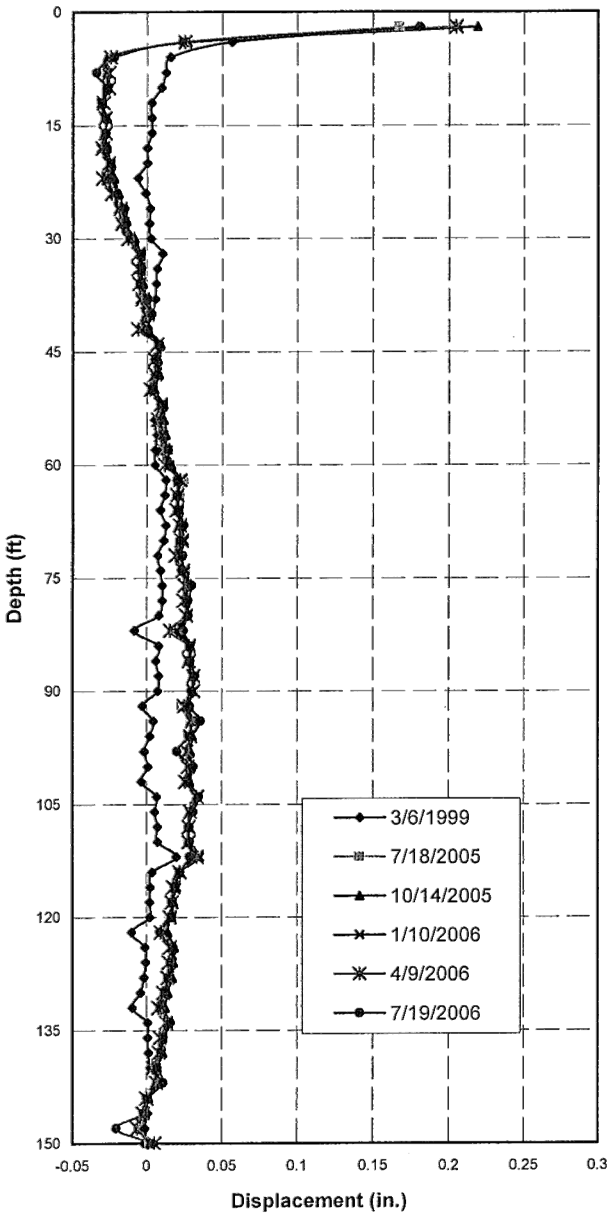
Cumulative

Elev.
589.6

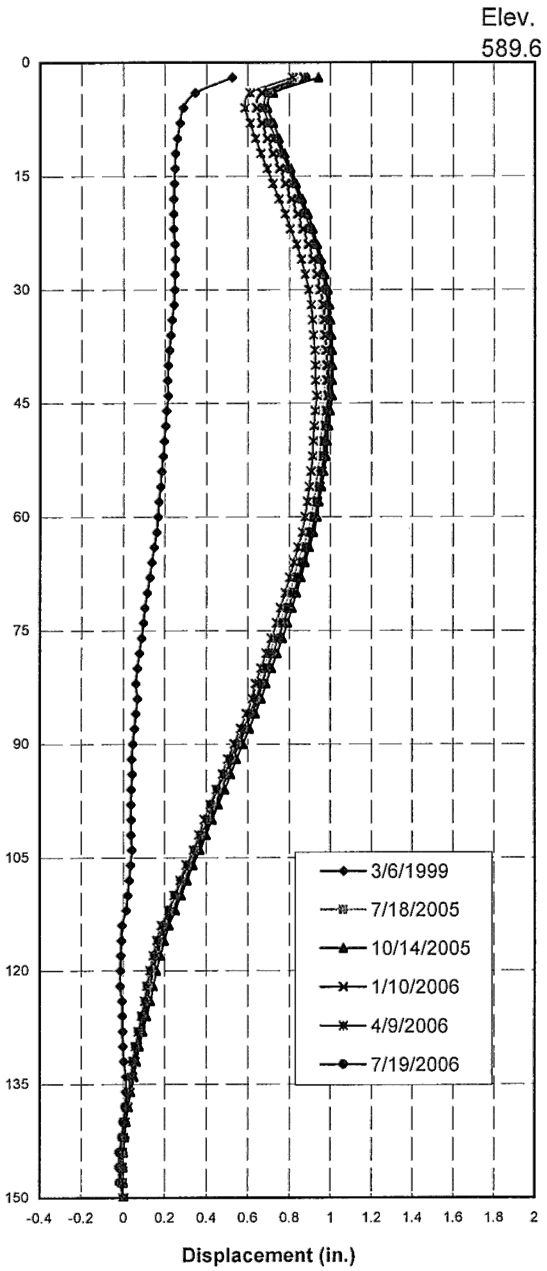


Inclinometer #9A Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

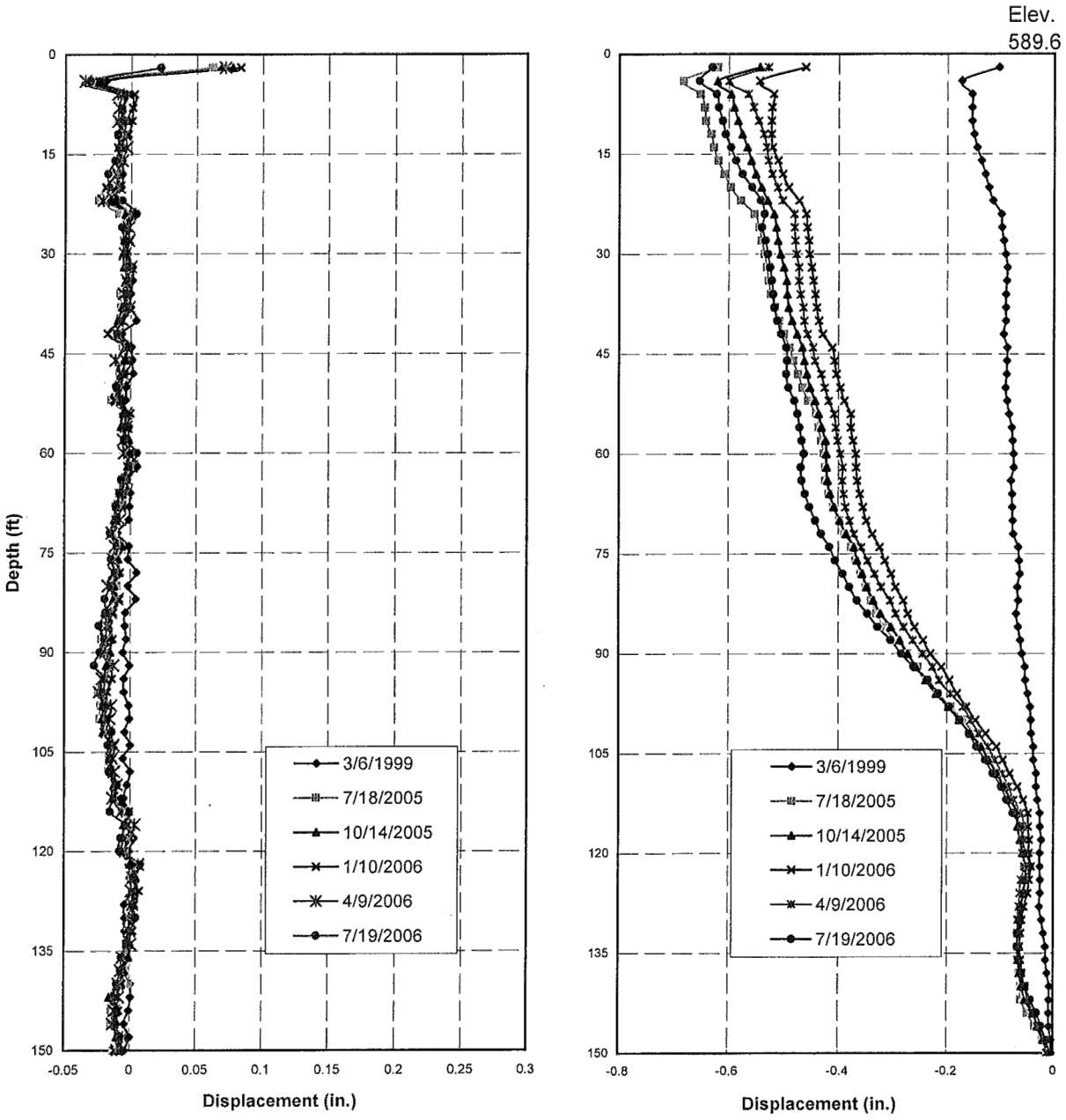
Incremental



Cumulative

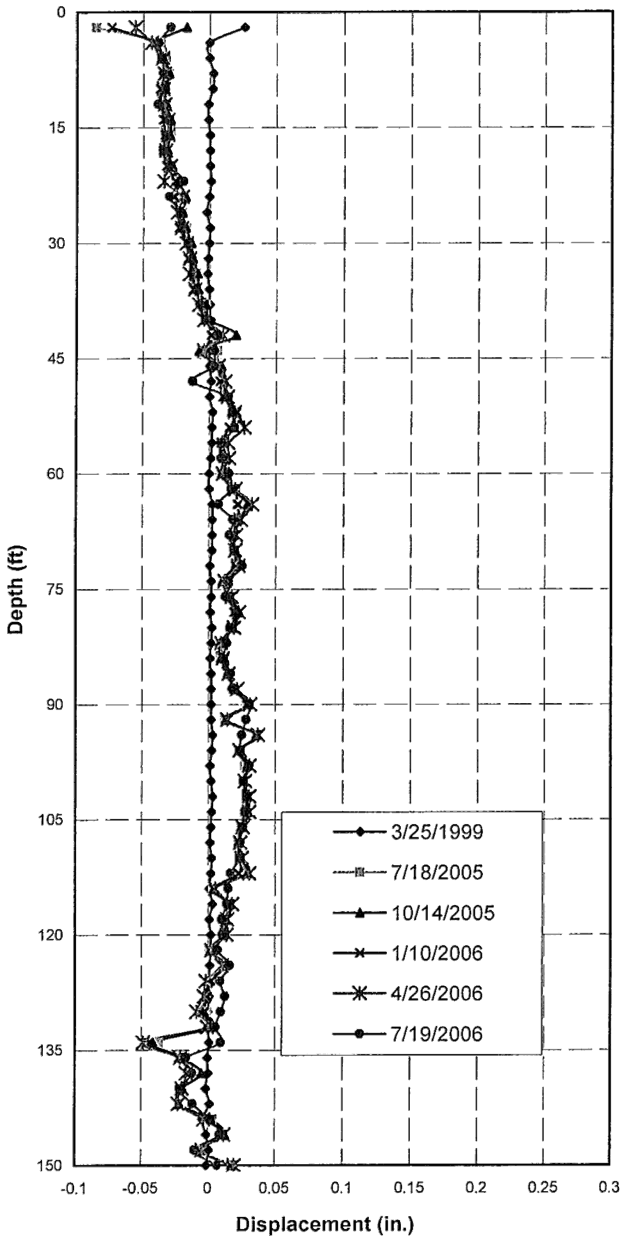


Inclinometer #9A Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998



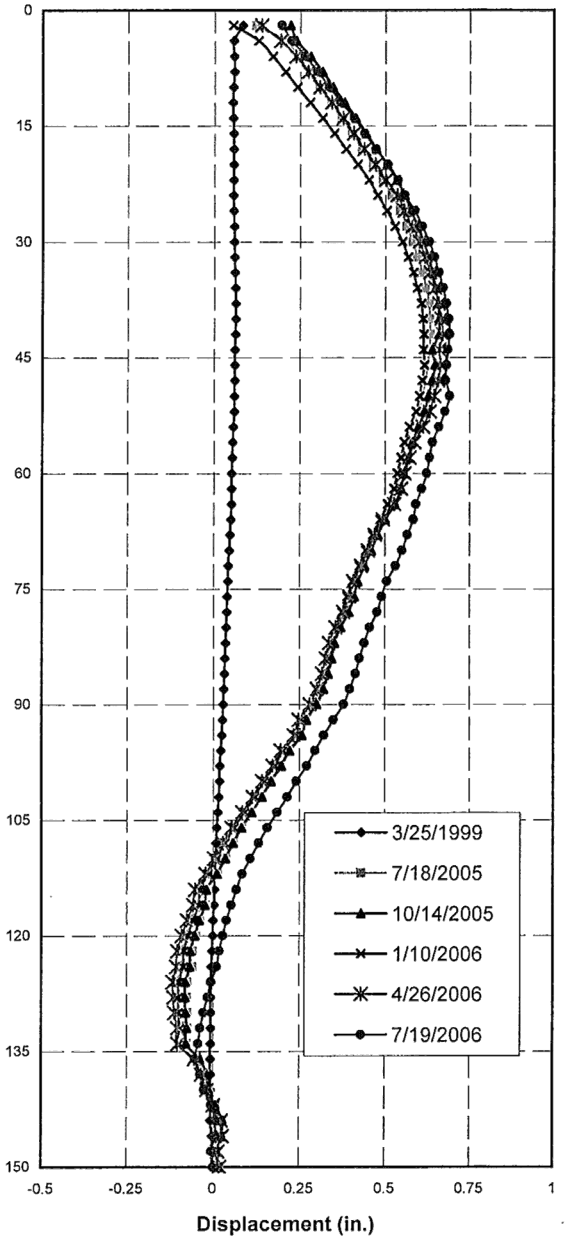
Inclinometer #10 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

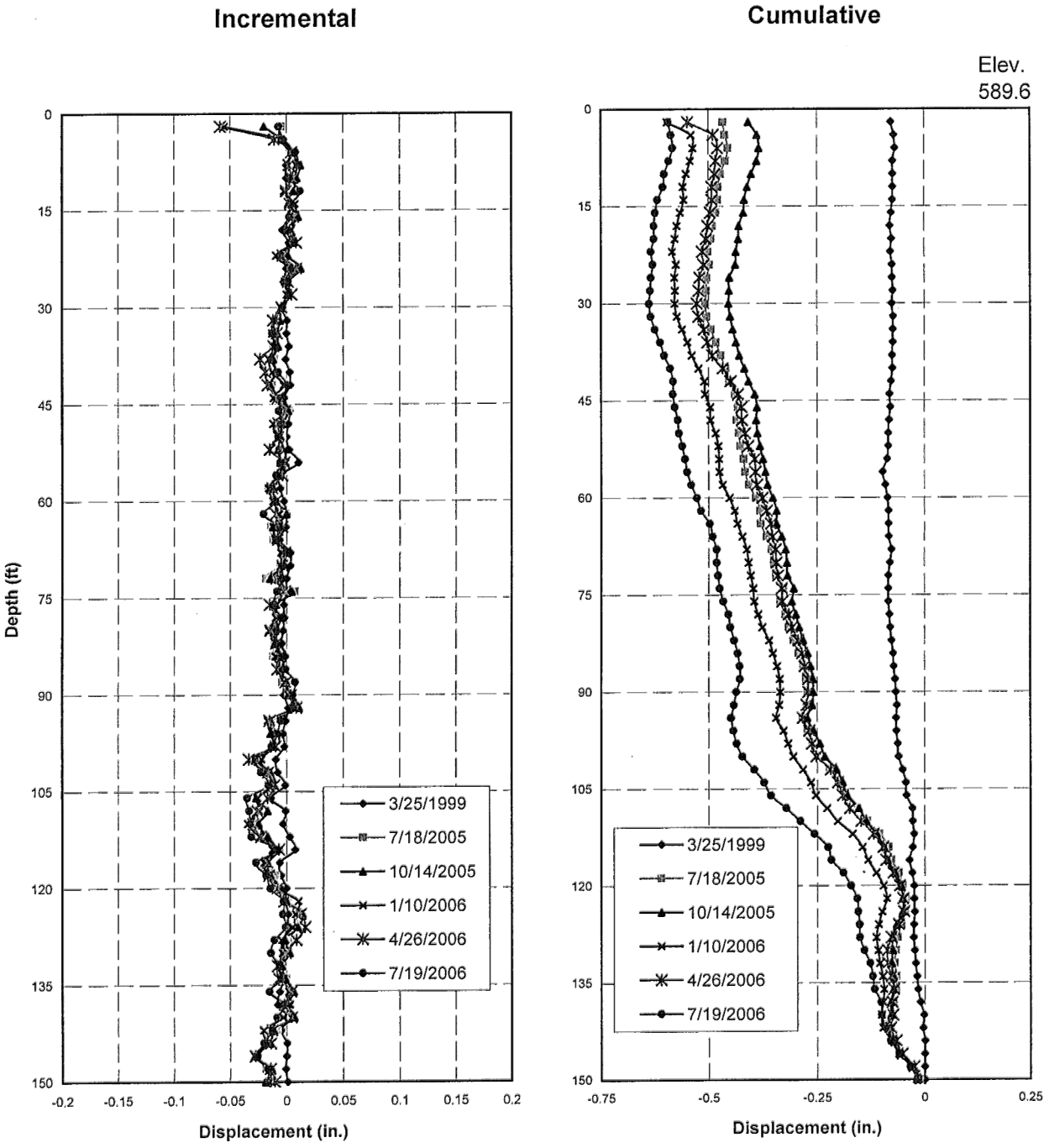


Cumulative

Elev.
589.6

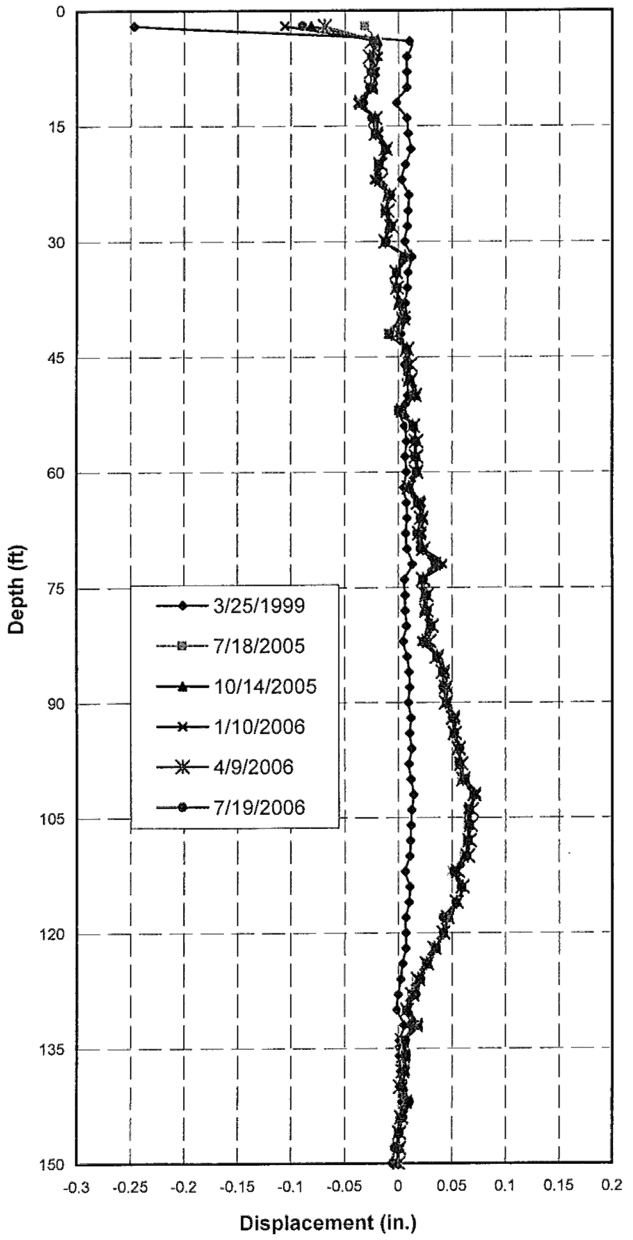


Inclinometer #10 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998



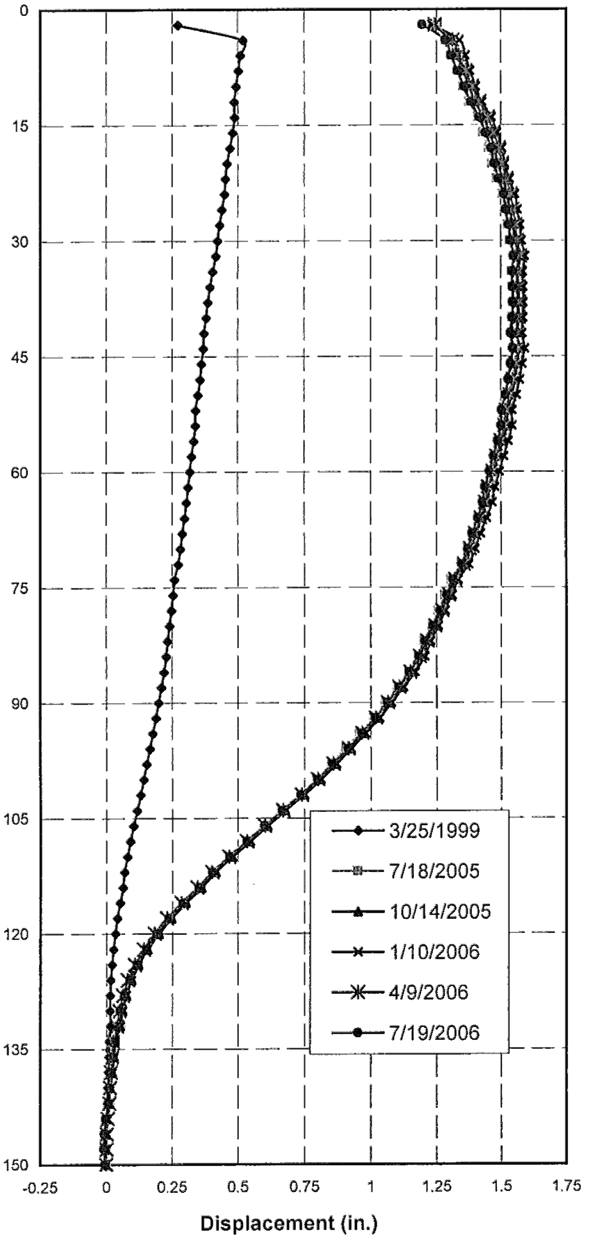
Inclinometer #17 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



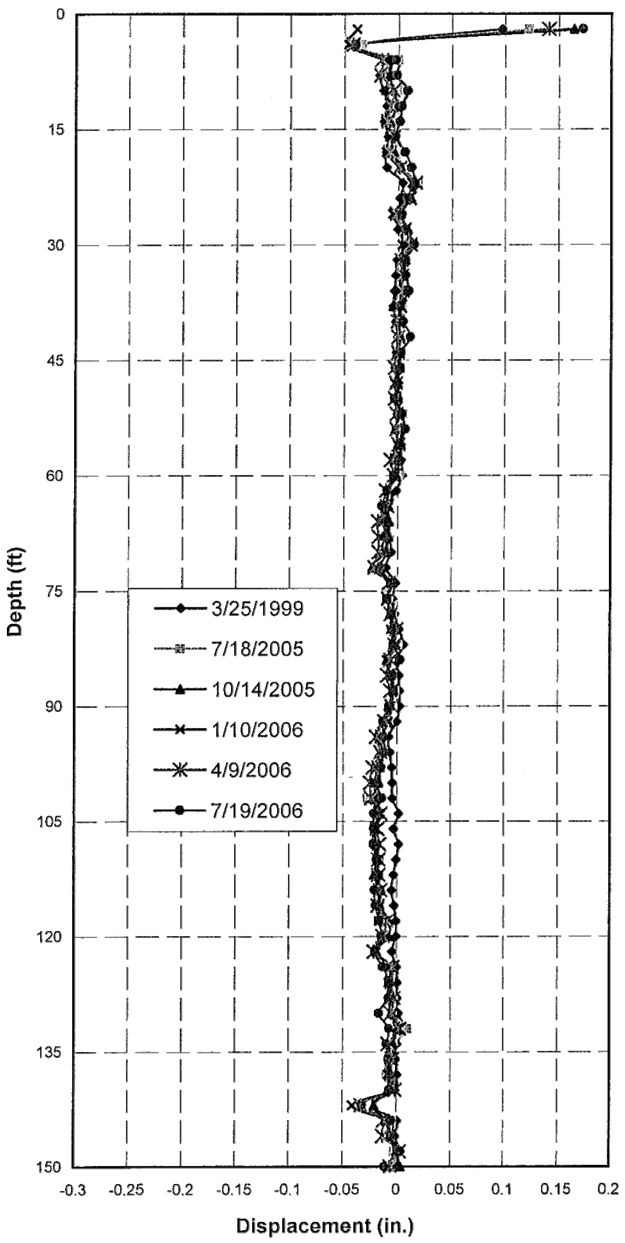
Cumulative

Elev.
589.6

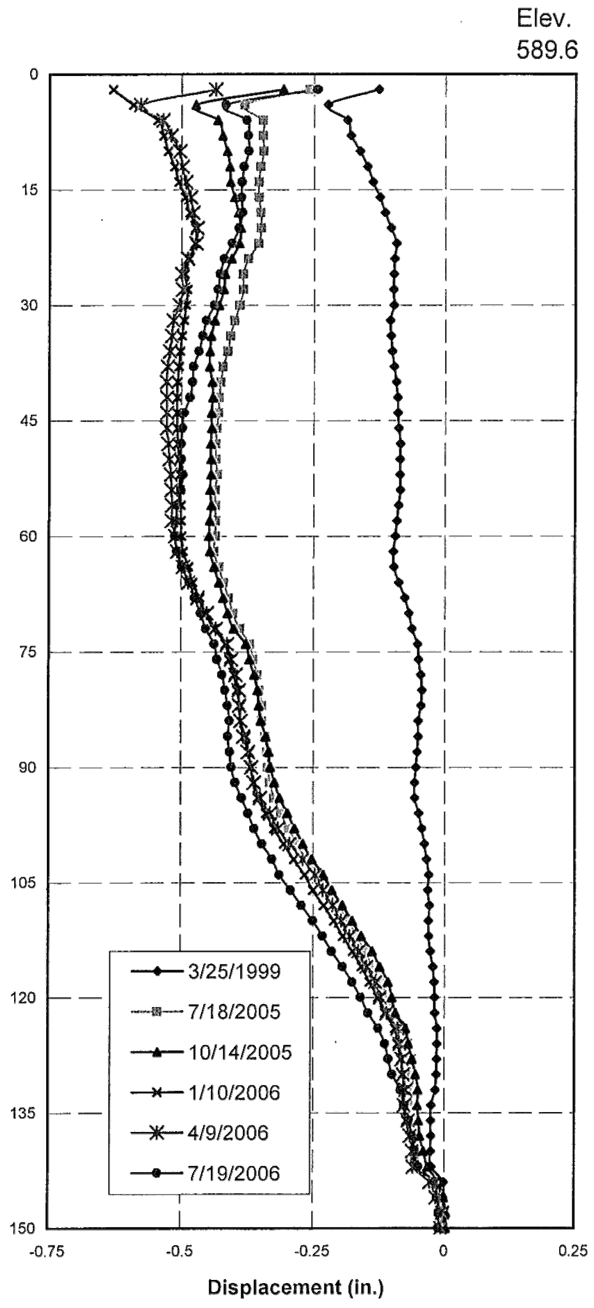


Inclinometer #17 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



Cumulative



RICHLAND ENGINEERING LIMITED
29 North Park Street, Mansfield, Ohio 44902-1769 • 419-524-0074 FAX 419-524-1812

106017

November 29, 2006

Ohio Department of Transportation
5500 Transportation Boulevard
Garfield Heights, Ohio 44125-5396

Attn: Mr. Mike Malloy

Re: CUY-90-1524
Central Viaduct
PID No. 20752
Slope and Pier Monitoring Services
Interim Report

Dear Mr. Malloy:

The following is our report on monitoring activity and collected data for the west slope of the Cuyahoga River and Bridge No. CUY-90-1524 west end pier, pier 1, and slope stabilization structure. The last report of data was August 11, 2006 for data collected through July 2006. This report is for data collected through October 2006.

The current slope monitoring began in 1994. The stabilization structure was constructed and the span 1 superstructure was relocated in 1999. The stabilization structure monitoring began in 1999. Additional slope monitoring north of the existing bridge began in 2006.

BBC&M Engineering, Inc. obtained inclinometer readings, piezometer readings, and calipered crack distances between October 12 through 18, 2006. Seven inclinometers and 6 piezometers installed between 1994 and 1999 continue to be monitored. Three replacement inclinometers, 9 new inclinometers, and 18 new piezometers were installed March through June 2006 were also monitored. The older instrumentation continues to indicate movements of the shallow and deep failure planes at relatively consistent rates. The new inclinometers do not indicate any defined displacements. The new piezometer total head values were relatively constant during the current reporting period. There was a large aggregate pile covering about one-third of the southeastern portion of the property adjacent to the south right of way fence in October 2006. The property owner north of the right of way fence had a contractor repair the failed sheet pile dock wall at the river's edge in Spring 2006. As of October 2006, no accelerated movements of the failure planes have yet been observed due to the contractor's excavation activities.

Richland Engineering Limited measured expansion joint openings at the west end pier, near pier 2, and near pier 4 on October 16, 2006. The deck expansion joint opening on the north side of the expansion joint near pier 2 has closed slightly (0.13") since October 2005. Substructure elevations; relative span 1 and span 2 lengths; and pier monument coordinates were measured on October 16, 2006. No significant change in locations from previous data was noted.

Art Huckelbridge obtained tiltmeter readings at the west end pier and pier 1 on October 17, 2006. The tiltmeters show positions and magnitudes of movement similar to past readings.

Robert Liang monitored instrumentation on October 17 and 18, 2006. The instrumentation readings in the rock anchors, driven piles, tieback beams, drilled shafts, and inclinometers showed no significant movement during this quarter.

The next readings are scheduled about January 15, 2006. The project has been authorized for continued monitoring through October 2009.

Please contact us if you have any questions (email reltd@r-e-l.com). Copies of detailed quarterly reports are available upon request.

Very truly yours,

RICHLAND ENGINEERING LIMITED

Dean A. Palmer, P.E.

DAP:dap

cc: Craig Hebebrand, District 12
Youssef Seif, District 12
Tim Keller, Office of Structures
Gene Geiger, Office of Geotechnical Services
Tom Lefchik, FHWA
Steve Pasternack, BBC&M Engineering, Inc., Dublin
Jeff Snyder, BBC&M Engineering, Inc., Valley View
Art Huckelbridge
Robert Liang
Rick Engel, E.L. Robinson Engineering Co.
Bob Parker, Michael Baker, Jr., Inc.

OCTOBER 2006 QUARTERLY REPORT
FIELD MONITORING SERVICES
CUY-90-14.92/15.24
CLEVELAND, OHIO

Report to

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

Prepared by

BBC&M ENGINEERING, INC.
CLEVELAND, OHIO

November 2006

BBCM
SOLUTIONS TO BUILD ON

November 9, 2006
012 00946.300

Mr. Dean A. Palmer, P.E.
Richland Engineering Limited
29 North Park Street
Mansfield, Ohio 44902

Re: CUY-90-14.92/15.24 Bridge
Quarterly Report - Field Monitoring Services
October 2006 (Fourth Quarter)

Dear Mr. Palmer:

In accordance with our proposal dated February 1, 2006, BBC&M Engineering, Inc. (BBCM) has completed the field monitoring services for the October, 2006 quarter as part of the CUY-90-14.92/15.24 project. This quarterly report contains the data obtained from all the actively monitored instrumentation (inclinometers, piezometers, and calipered distance locations), discussions of observations of the data, and general site observations.

We appreciate being of continued service during this project. The next quarterly readings are scheduled to take place around January 15, 2006. Please contact our office if you have any questions or require additional information.

Respectfully submitted,

BBC&M ENGINEERING, INC.
Cleveland, Ohio

Jeffrey L. Snyder, M.S., E.I.
Staff Engineer

Stephen C. Pasternack, Ph.D., P.E.
Senior Project Engineer

JLS/scp

cc: Mr. Robert B. Parker, P.E.
Michael Baker Jr., Inc.

Submitted: pdf copy submitted to Richland Engineering at reltd@r-e-l.com and Michael Baker Jr., Inc. at BParker@mbakercorp.com

8555 Sweet Valley Dr., Ste. S • Valley View, OH 44125-4210 • Phone 216.901.1000 • Fax 216.901.9996

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APPENDIX

Plate No.

General Information

Summary Table of Active Instrumentation 1
Site Plan of Active Instrumentation 2

Plots for Active BBCM Inclinometers Installed from 1994 to 1999–CUY-90-15.24

Cumulative and Incremental Displacement versus Depth Plots

B-101 – A and B-Axis 3-4
B-102 – A and B-Axis 5-6
B-107 – A and B-Axis 7-8
B-203 – A and B-Axis 9-10
B-204 – A and B-Axis 11-12
B-303 – A and B-Axis 13-14
P-9N – A and B-Axis 15-16

Displacement versus Time Plots

B-102 – A-Axis 17
B-107 – A-Axis 18
B-203 – A-Axis 19
B-204 – A-Axis 20
B-303 – A-Axis 21

Plots for Replacement Inclinometers Installed by BBCM in 2006 – CUY-90-15.24

Cumulative and Incremental Displacement versus Depth Plots

B-105A – A and B-Axis 22-23
B-108A – A and B-Axis 24-25

Plots for Inclinometers Installed by BBCM in 2006 – CUY-90-14.92

Cumulative and Incremental Displacement versus Depth Plots

B-05-01 – A and B-Axis 26-27
B-05-02 – A and B-Axis 28-29
B-05-03 – A and B-Axis 30-31
B-05-04 – A and B-Axis 32-33
B-05-07 – A and B-Axis 34-35
B-05-08 – A and B-Axis 36-37
B-05-11 – A and B-Axis 38-39
B-05-12 – A and B-Axis 40-41
B-05-13 – A and B-Axis 42-43
B-05-16 – A and B-Axis 44-45

APPENDIX (continued)

Plate No.

Plots for Active Pneumatic Piezometers Installed by BBCM in 1994 – CUY-90-15.24

Total Head (h_t) versus Time Plots

B-101 (P-1) 46
B-105 (P-3) 47
B-107 (P-5) 48
B-303 (P-2) 49

Plots for Vibrating Wire (VW) Piezometers Installed by BBCM in 2006 – CUY-90-14.92

Total Head (h_t) versus Time Plots

B-05-01 50
B-05-02 51
B-05-03 52
B-05-04 53
B-05-07 54
B-05-08 55
B-05-11 56
B-05-12 57
B-05-13 58

Calipered Surface Distance Data – CUY-90-15.24

Calipered Surface Distance Table 59
Calipered Distance Readings versus Time Plot - Left Calipered Location 60
Calipered Distance Readings versus Time Plot - Right Calipered Location 61

Introduction

Of the 14 inclinometers and 12 pneumatic piezometers installed by BBCM between 1994 and 1999, seven (7) inclinometers (B-101, B-102, B-107, B-203, B-204, B-303, and P-9N) and six (6) pneumatic piezometers at B-101 and B-105 (2 piezometers each), as well as B-107 and B-303 are still actively monitored. This remaining active instrumentation is associated with the CUY-90-15.24 project. During the period of March through June, 2006, BBCM installed 12 new inclinometers (including 3 replacement inclinometers) and 18 vibrating wire (VW) piezometers. These newly installed inclinometers and piezometers are associated with the CUY-90-14.92 project. A Summary Table and Site Plan of Active Instrumentation are submitted as Plates 1 and 2 of the Appendix. Quarterly readings were taken at the new and remaining active inclinometers and piezometers during the period of October 12 through October 18, 2006.

Replacement Inclinometers

In mid-March, 2006, major excavation activities in an effort to repair a section of failed bulkhead resulted in the destruction of the B-110 inclinometer. Additionally, the B-105 and B-108 inclinometers have become unreadable due to excessive displacement at the observed slide planes. Replacement inclinometers were installed at B-105A and B-108A immediately adjacent to the inactivated inclinometers. Also, per ODOT's request, BBCM installed a replacement inclinometer for B-110 at Boring B-05-16 adjacent to the right-of-way fence near B-110. The B-05-16 inclinometer is located within the existing ODOT right-of-way. These replacement inclinometers were installed at depths ranging from 156 to 168 feet below the existing ground surface. Baseline (initial) readings were taken at these replacement inclinometers on June 21 and 22, 2006.

New Inclinometers

New inclinometers were also installed at B-05-01 through B-05-04, B-05-07, B-05-08, and B-05-11 through B-05-13. These new inclinometers were installed at depths ranging from 134 to 228 feet below the existing ground surface. Baseline readings were taken at these new inclinometers from June 21 through June 26, 2006.

Discussion of Instrumentation Data

Inclinometers

Spiral (twist) measurements were performed in January, 2005 on the ten (10) inclinometers that were active at the time. Spiral measurements were also performed on June 28 and June 29, 2006 on the twelve (12) new inclinometers. All the data sets presented in the Appendix have been corrected to account for the measured spiral of the inclinometer casings. The Cumulative and Incremental Displacement vs. Depth plots in the Appendix show at least one reading per quarter up to four quarters plus the extra readings taken in some of the inclinometers in March, 2006. The Displacement vs. Time plots, however, include at least one reading from each year since the baseline readings.

Lateral deflections from slope inclinometer measurements contain both random and systematic errors. Durham Geo Slope Indicator Company (DGSI) gives the following orders of accuracy for slope inclinometer measurements as follows:

1) Ordinary precision of ± 0.3 inches per 100 ft of casing using standard installation procedures;
2) Higher Precision of ± 0.1 inches per 100 ft of casing with careful survey practices and error correction during data reduction; and
3) Highest Precision of ± 0.05 inches per 100 ft of casing with careful survey and data selection from redundant data sets and excellent casing installation.

The data presented herein are considered to have a precision in the range of ± 0.1 to ± 0.2 inches per 100 ft. **Hence, any displacements (especially on deep failure planes) on the order of about 0.1 inches could be due to data errors and not actual field movements.** The actual estimated rates of slope movement in active inclinometers range from about 0.02 to 0.10 inches per year on the two slide planes.

The rates of movement were computed using linear regression for the depth ranges shown on the Displacement vs. Time plots in the Appendix. Linear regression provided a best-fit match through the data points on each of the Displacement vs. Time curves. The time period for the linear regression was chosen based on a visual observation of each curve at the time when the rate was believed to have last changed **significantly**. While some of the inclinometers indicate a decreased rate of movement since 2004 (subsequently discussed), the 95% confidence interval of the regression of each analyzed slide plane falls within the range of the expected precision of the inclinometer measurements (about 0.1 inches per 100 ft). Therefore, it is inconclusive whether this is an actual change in the average rate of movement or a false trend caused by the limitations in the data due to the accuracy of the measurements. Several years of data showing a consistent trend or changes in rates greater than the accuracy level of the measurements are necessary to draw conclusions that the average rate has in fact changed. Therefore, all discussions regarding trends in the data are developed based upon multiple years of data.

In general, there are observed movements that correspond to two major slide planes, termed the shallow and deep failure planes. In some of the inclinometers, multiple slide planes may be observed within the shallow or deep failure zones (i.e. B-203 and B-303). In such cases, the multiple slide planes have been grouped together and referred to as part of either the shallow or deep failure plane, whichever is deemed more appropriate. Consequently, the magnitude and rate of movements subsequently discussed are the summation of the relative movements of the individual slide planes within either the shallow or deep failure plane. This is done in an attempt to quantify the total relative movements that would be transferred to a pier or the stabilization structure.

Systematic Error Correction

Systematic errors are correctable errors observed in inclinometer data and are caused by one or more of the following factors: sensor bias-shift, rotation (sensor alignment shift), sensitivity drift, depth positioning error (DPE), and casing inclination/curvature. The data presented in this report

have been analyzed and corrected for more common systematic errors such as bias-shift and rotation, where necessary. In addition to the DPE errors observed in the inclinometers at B-101, B-05-08, and B-05-12, as reported in the July 2006 Quarterly Report, minor DPE errors were also observed in readings taken from eight (8) additional inclinometers (B-107, B-05-01, B-05-02, B-05-04, B-05-11, B-05-13, B-05-16, and B-105A). DPE is a common error caused mainly by settlement (shortening) of the casing and/or change in probe depth control (human error, elongation/shortening of cable, or changing cables) in inclinometers with significant built-in curvatures. The readings for these eleven (11) inclinometers have been corrected for DPE.

Active BBCM Inclinometers Installed between 1994 and 1999

The shallow failure plane upslope from Pier 1 appears to be moving at an average rate of about 0.05 inches per year (April 1999-present) as indicated in inclinometers at B-203 and B-303. This is a slight decrease from the rate of about 0.06 inches per year as reported in the July 2006 Quarterly Report. The B-203 and B-303 inclinometers also indicate a possible decrease in the average rate of movement in the shallow failure plane since about July, 2004 (see Plates 19 and 21 in the Appendix). In the immediate vicinity of the Pier 1 area (B-204), no shallow slip-plane movements have been observed since completion of construction of the Pier 1 stabilization system.

South of the West End Pier, inclinometers at B-102 and B-107 indicate the deep failure plane is moving at an average rate of about 0.03 inches per year (Apr 00-present). This is a slight increase from the rate of about 0.02 inches per year as reported in the July 2006 Quarterly Report. The B-101 inclinometer has indicated nominal movement since its installation. Upslope from Pier 1, inclinometers at B-203, B-204, and B-303 indicate the deep failure plane is moving at an average rate of about 0.06 inches per year (Apr 99-present). This is a slight decrease from the rate of about 0.07 inches per year as reported in the July 2006 Quarterly Report. The B-203, B-204, and B-303 inclinometers also indicate a possible decrease in the average rate of movement in the deep failure plane since about July, 2004 (see Plates 19 through 21 in the Appendix).

Inclinometer P-9N (installed in one of the drilled shafts) indicates the top of the drilled shaft is being laterally restrained and that the maximum lateral deflection is about 0.85 inches and occurs approximately 40 to 50 feet below the top of the inclinometer casing.

No accelerated movements have <u>yet</u> been observed in any of the inclinometers (installed between 1994 and 1999) as a result of the excavation activities in the vicinity of B-110 (or B-05-16) on the west side of the I-90 Bridge.

New BBCM Inclinometers Installed in 2006

Small surficial movement of about $1/8^{th}$ of an inch in the upper 10 to 15 feet has been observed at the B-05-16 inclinometer over a 4-month period (see Plates 44 and 45 of the Appendix). It is possible the displacement observed at B-05-16 may be a result of the ongoing excavation activities near B-110. The surficial displacement at B-05-16 is expected due to the scarp and tension cracks that have been observed in the vicinity of the inclinometer.

Possible cantilever displacement similar in shape to the cantilever displacements observed in B-102 and B-107 was observed in B-05-12 to a depth of 30 feet (see Plates 40 and 41 of the Appendix). However, there was no observed displacement between the July and October, 2006 readings. The magnitude and location of the displacement in B-05-12 was not observed in other nearby inclinometers such as B-107 and B-05-02. The small sinkhole (approx. 1' dia.) that was observed by BBCM personnel in March, 2006 in the pavement of University Road in the vicinity of B-05-12 did not appear to be any larger as of October, 2006. Thus, it is inconclusive whether the observed displacement in B-05-12 is a true displacement. Additional readings are needed in B-05-12 to evaluate whether a general trend is observed which would indicate the displacement may be real. It may eventually be necessary to use the July 2006 reading as the baseline reading if it becomes apparent the displacement is a result of random and/or systematic errors.

Possible slide planes have been observed in the inclinometers at B-108A and B-05-02 at depths of 120 and 110 feet, respectively. The depth of potential displacement in B-108A is nearly identical with the observed slide plane in the inactive inclinometer at B-108, which is only about 10 feet away from B-108A. Additional readings are needed to evaluate whether these are true displacements.

Distinct movement has not yet been observed in the inclinometers at B-105A, B-05-01, B-05-03, B-05-04, B-05-07, B-05-08, B-05-11 and B-05-13. Based on the relatively slow rates of movement of the slide planes observed at the site over the past several years, observed displacements may not yet be evident within the time period between baseline and quarterly readings, which have been taken over a 4-month period. Additionally, multiple readings over a period of a few years are needed to observe general trends.

Piezometers

In Tables 1 and 2 provided in the following sections, a summary of the measured total head (h_t), is provided for each pneumatic or VW piezometer. Additionally, plots of Total Head vs. Time are provided in the Appendix. For the pneumatic piezometers at B-101, B-105, B-107, and B-303, the measured water elevation (in feet) was reported in BBCM's quarterly and annual reports submitted prior to the July 2006 Quarterly Report. This water elevation is equivalent to the total head (h_t, in feet).

The total head (h_t) is calculated using the following equations:

$$h_t = h_e + h_p$$
$$h_p = u/\gamma_w$$

where h_e is the elevation head (elevation where the piezometer was installed), h_p is the pressure head, u is the pore pressure reading, and γ_w is the unit weight of water.

Pneumatic Piezometers

The results of the remaining active pneumatic piezometer readings taken on October 18, 2006 are summarized in Table 1 below. Pneumatic piezometers are identified both by boring number

and ribbon color to specify the location and the depth of the instrumentation. In July, 2006, two piezometers at B-101 and B-303 required ribbon replacement. The new ribbon colors are noted in parenthesis in Table 1.

Table 1: Summary of Readings for the Active Pneumatic Piezometers – CUY-90-15.24

Piezometer Identifier		Ground Surface Elevation (ft)	Elevation Head, h_e (ft)	Pore Pressure Reading, u (psi)	Total Head, h_t (ft)
B-101 (P-1*)	green (orange)	676.6	626.3	0.0**	626.3**
	pink	676.6	552.3	31.5	625.0
B-105 (P-3*)	pink	585.6	497.6	38.3	586.0
	blue	585.6	479.9	47.9	590.4
B-107 (P-5*)	orange	662.3	562.3	25.2	620.5
B-303 (P-2*)	green (pink)	627.0	586.2	6.9	602.1

*BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers.
**Pneumatic piezometers *cannot* read negative pressure (i.e., a water level below the depth of the pneumatic piezometer). Thus, it is unknown whether this is an accurate pressure reading.

All the piezometers have exhibited slightly lower readings than those recorded in July, 2006. Note that the piezometers at B-105 continue to indicate an elevated water pressure (i.e. a total head above the ground surface, artesian conditions). It is possible that the elevated water pressure in B-105 may be attributed to a thin silt seam sandwiched between fairly thick clay layers located near the base of the piles supporting Pier 1 or the percolation of natural gas out of the underlying Devonian Ohio Shale. These elevated pore pressures can have a detrimental effect on slope stability and the rate of slope creep.

Total Head vs. Time plots, which provide the measured total head from 1994 to the present, have been submitted as Plates 46 through 49 in the Appendix of this report.

Vibrating Wire (VW) Piezometers

The VW piezometers have been placed at various depths with 2 piezometers at each of the 9 offset boring locations. The VW piezometers were installed on 1¼-inch PVC pipe encased in grout with a cable attached to the VW piezometer. Each cable runs up through the PVC pipe and is attached to a MiniLogger, which stores the pore pressure data. A flush mount protective cover was installed at each offset boring location to house the two MiniLoggers. Readings are taken by Miniloggers every 8 hours; however, this time interval can be adjusted upon request.

Table 2 provides a summary of the maximum and minimum values of all the pressure readings taken from mid-July (end of previous reporting period) to the time when the collected data was downloaded from VW Miniloggers on October 18, 2006. The VW piezometers are identified by boring number, MiniLogger serial number, and depth the piezometer was installed. The VW

piezometers also measure the ground temperature around the piezometer. The maximum and minimum temperature readings are also provided in Table 2.

Table 2: Summary of Readings for the VW Piezometers – CUY-90-14.92

Piezometer Identifier		Time Interval of Readings Reported*	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-01	21961 - 65 ft	7/14/06 to 10/18/06	14.1/13.7	675.4	610.4	12.2/11.2	638.6/636.4
	21967 - 95 ft	7/14/06 to 10/18/06	13.3/13.2	675.4	580.4	21.3/20.5	629.5/627.7
B-05-02	21963 - 46 ft	7/17/06 to 10/18/06	12.1/12.1	617.9	571.9	8.2/7.8	590.9/589.8
	21951 - 122 ft	7/17/06 to 10/18/06	12.2/12.2	617.9	495.9	40.4/39.9	589.0/588.0
B-05-03	21957 - 32 ft	7/17/06 to 10/18/06	11.9/11.6	605.1	573.1	8.0/7.1	591.6/589.5
	21965 - 112 ft	7/17/06 to 10/18/06	12.5/12.5	605.1	493.1	41.4/40.8	588.7/587.2
B-05-04	21958 - 59 ft	7/17/06 to 10/18/06	13.0/13.0	600.8	541.8	18.1/17.6	583.5/582.3
	21952 - 119 ft	7/17/06 to 10/18/06	13.2/13.1	600.8	481.8	45.3/44.7	586.3/585.1
B-05-07	21966 - 102 ft	7/14/06 to 10/18/06	12.5/12.4	678.9	576.9	24.5/23.8	633.3/631.8
	21956 - 220 ft	7/14/06 to 10/18/06	12.0/11.9	678.9	458.9	68.3/67.4	616.4/614.4
B-05-08	21954 - 65.5 ft	7/14/06 to 10/18/06	12.7/12.7	679.9	614.4	12.2/11.7	642.6/641.5
	21959 - 110.5 ft	7/14/06 to 10/18/06	12.4/12.4	679.9	569.4	29.2/28.8	636.9/635.8
B-05-11	21968 - 95 ft	7/14/06 to 10/18/06	12.8/12.5	675.1	580.1	23.5/23.1	634.4/633.4
	21953 - 130 ft	7/14/06 to 10/18/06	12.7/12.6	675.1	545.1	35.4/35.0	626.8/625.8
B-05-12	21960 - 75 ft	7/14/06 to 10/18/06	12.9/12.9	652.7	577.7	17.0/16.4	616.9/615.5
	21964 - 120 ft	7/14/06 to 10/18/06	12.5/12.5	652.7	532.7	33.7/33.1	610.4/609.0
B-05-13	21962 - 60 ft	7/17/06 to 10/18/06	12.6/12.6	580.0	520.0	24.3/23.4	576.1/574.0
	21955 - 135 ft	7/17/06 to 10/18/06	13.0/12.9	580.0	445.0	60.8/58.2	585.2/579.3

*Readings generally were taken every 8 hours during the reported time interval.

During the current reporting period from mid-July to mid-October of 2006, the total head values were relatively constant with a difference between maximum and minimum total head values no more than 2.5 feet (see Table 2) in all the VW piezometers except the 21955 piezometer in B-05-13, subsequently discussed. Total Head vs. Time plots have been submitted as Plates 50 through 58 in the Appendix of this report.

During the previous reporting period from late May to mid-July, a few of the VW piezometers exhibited a total head decrease as much as 13 feet (i.e., B-05-07) from the initial reading. A gas pocket was encountered during drilling near the top of the shale bedrock in Boring B-05-07. The soil pore pressures may have been reducing back to normal conditions in B-05-07. Also, DGSI has stated in the user's manual for the VW piezometer that "drilling a borehole and backfilling it temporarily changes the pore-water pressure in the ground, so readings that are taken immediately after installation will not be good datum readings. Recovery of the natural pore-water pressure may take a few hours to a few weeks, depending on the permeability of the soil." DGSI also suggests recovery of the pore-water pressure is indicated by observation of stable readings for several consecutive days. The readings have generally been stable in all of the VW piezometers since the beginning of July.

The 21955 piezometer in B-05-13 installed at a depth of 135 feet exhibited a maximum change of nearly 6 feet over the reporting period shown in Table 2. Between 10:34 am and 6:34 pm on September 12, 2006, the MiniLogger recorded a decrease in pressure of 1.35 psi which corresponds to a change in total head of 3.1 feet. Sixteen (16) hours later, the recorded pressure reached a minimum of 58.2 psi, a total decrease of 2.49 psi or 5.7 feet total head over a 24-hour period. The recorded pressures then increased incrementally, until nearly eight (8) days later, the total head was within 1 foot of the total head recorded prior to the dramatic pressure decrease. The Total head vs. Time plot shown on Plate 58 in the Appendix illustrates these changes. The total head over the current reporting period ranged between 585.2 feet and 579.3 feet (see Table 2) indicating that there is an elevated water pressure (i.e. a total head above the ground surface, artesian conditions) at this location similar to that observed in the pneumatic piezometers at B-105 previously discussed. During drilling of Boring B-05-13, gas pockets were encountered during rock coring which leads us to believe the elevated water pressure observed in the 21955 piezometer may be mostly attributed to percolation of natural gas out of the underlying Devonian Ohio Shale into the silt/sand layer. This silt/sand layer, which overlies the shale, is underlain by clay that could confine the natural gas to the sand/silt layer due to the low permeability of clay soil. For reasons unknown at this time, the flow of natural gas may have been temporarily disrupted resulting in the dramatic pressure decrease.

Additional Field Measurements and Observations

The left and right calipered locations, which have been monitored since June, 1999, are located just east and west of the I-90 bridge centerline, respectively (see the Site Plan of Active Instrumentation, Plate 2 in the Appendix). A Calipered Surface Distance Table and Calipered Distance Readings vs. Time plots have been included as Plates 59 through 61 in the Appendix. Close inspection of the data in the plots indicates the possibility of general trends of movement at the calipered locations. The data is somewhat oscillatory, which is likely due to the seasonal temperature fluctuations affecting the concrete combined with human error due to the interpretation of the center of the nails. In the data plots, linear trendlines were added to estimate the average rate of separation/closure per year. The left calipered location indicates the gap is continuing to open at a rate of about 0.06 inches per year. The right calipered location indicates the gap is continuing to close at a rate of about 0.03 inches per year. The movements are relatively small (½ of an inch or less since June, 1999) and are highly subject to the interpretation of the center of the nails, thus it is inconclusive that these movements have been

caused by the observed slope movements. Continued observation of these calipered locations is needed in order to adequately determine if judgment error and weather conditions are the main cause of the observed trends or if they are indeed caused by slope movements.

In October, 2006, a large aggregate pile covered roughly one-third of the property currently being used to stockpile aggregate adjacent to the east right-of-way fence. The large aggregate pile was located primarily on the southeastern portion of the property.

As previously discussed, a large excavation near the west right-of-way fence was first observed by BBCM personnel in March, 2006. The excavation was performed in an effort to repair the failed bulkhead. As of October, 2006, the repair effort appears to be ongoing as the bulkhead did not appear to be fully repaired and the large excavation had not yet been backfilled.

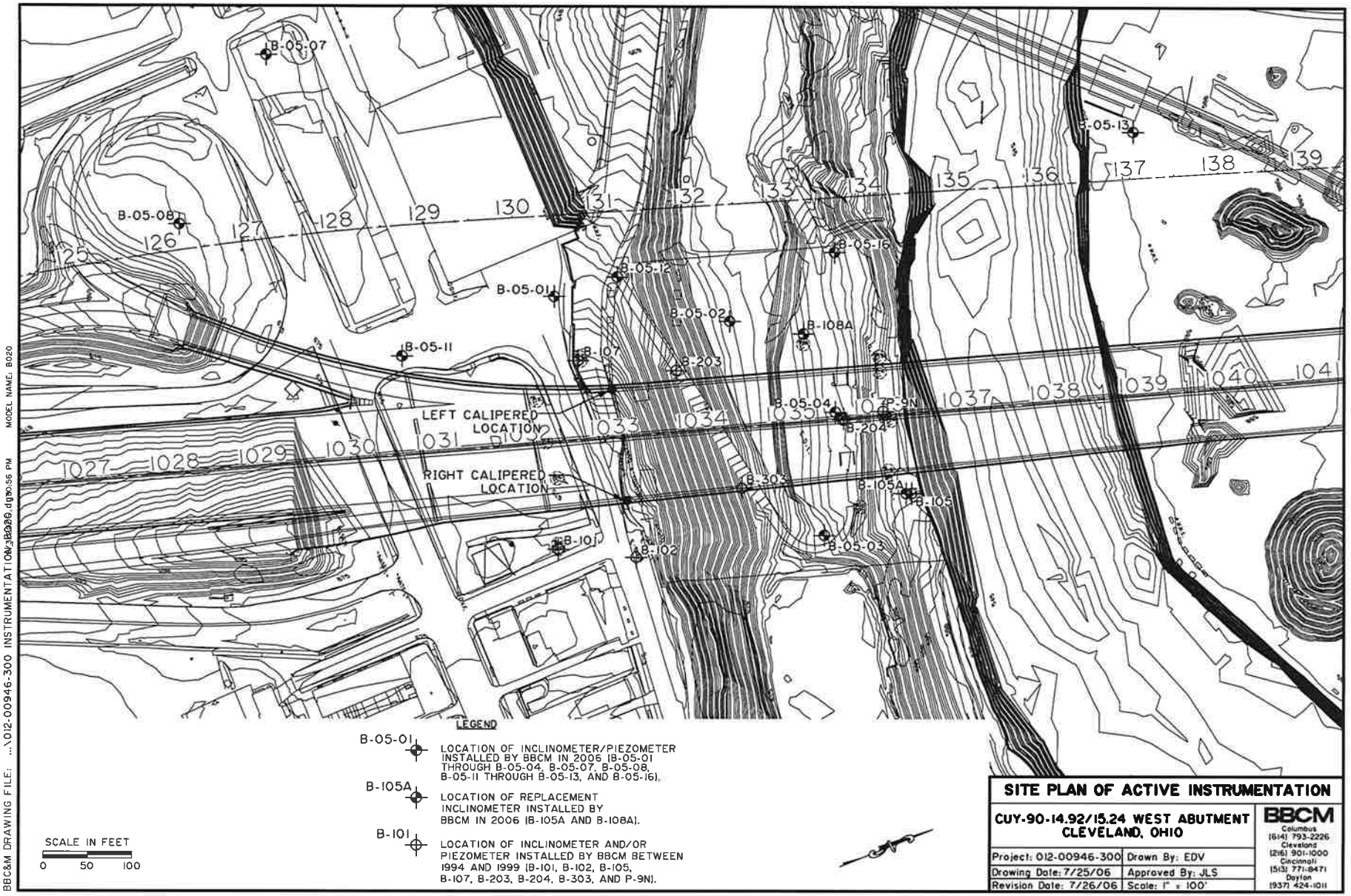
APPENDIX

CUY-90-14.92/15.24 INSTRUMENTATION MONITORING

SUMMARY OF ACTIVE INSTRUMENTATION
CUY-90-14.92/15.24

Active Instrumentation	Active Inclinometer ?	Inclinometer Depth (ft)	Active Piezometer?	VW or Pneumatic?	# of Active Piezometers	Piezometer Depth(s) Below Existing G.S. (ft)	Instrumentation Installation Date
B-101	Y	190	Y	Pneumatic	2	50.3, 124.3	Aug-Sep 1994
B-102	Y	224	N	---	---	---	Sep 1994
B-105	N	---	Y	Pneumatic	2	88, 105.7	Aug 1994
B-105A	Y	156	N	---	---	---	May 2006
B-107	Y	210	Y	Pneumatic	1	100	Sep 1994
B-108A	Y	168	N	---	---	---	Apr-May 2006
B-203	Y	192	N	---	---	---	Aug 1996
B-204	Y	134	N	---	---	---	Jul 1998
B-303	Y	180	Y	Pneumatic	1	40.8	Aug 1994*, Jul 1998
P-9N	Y	150	N	---	---	---	Feb 1999
B-05-01	Y	228	Y	VW	2	65, 95	Apr-May 2006
B-05-02	Y	178	Y	VW	2	46, 122	Apr-May 2006
B-05-03	Y	168	Y	VW	2	32, 112	Apr-May 2006
B-05-04	Y	172	Y	VW	2	59, 119	Mar-May 2006
B-05-07	Y	224	Y	VW	2	102, 220	Apr-Jun 2006
B-05-08	Y	226	Y	VW	2	65.5, 110.5	Apr-May 2006
B-05-11	Y	226	Y	VW	2	95, 130	Apr-Jun 2006
B-05-12	Y	210	Y	VW	2	75, 120	Apr-May 2006
B-05-13	Y	134	Y	VW	2	60, 135	May-Jun 2006
B-05-16	Y	162	N	---	---	---	Jun 2006

*The pneumatic piezometer was actually installed at BBCM Boring P-2 in August, 1994. However, the piezometer has since been renamed to B-303 due to its close proximity to the active inclinometer at B-303 (which was installed in July, 1998).



BBC&M DRAWING FILE: ...\012-00946-300 INSTRUMENTATION\012-00946-300.dgn 9:56 PM MODEL NAME: B020

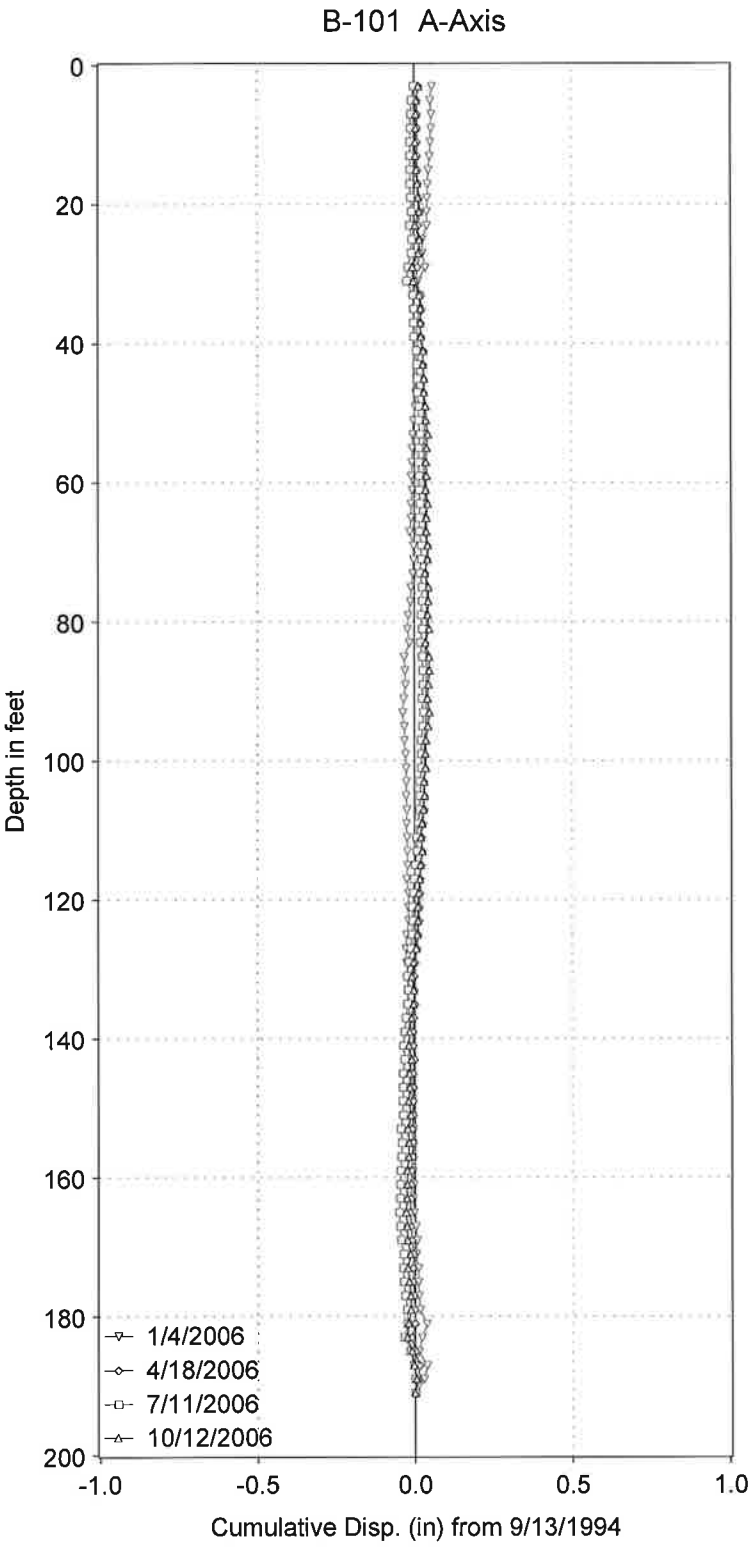
SITE PLAN OF ACTIVE INSTRUMENTATION

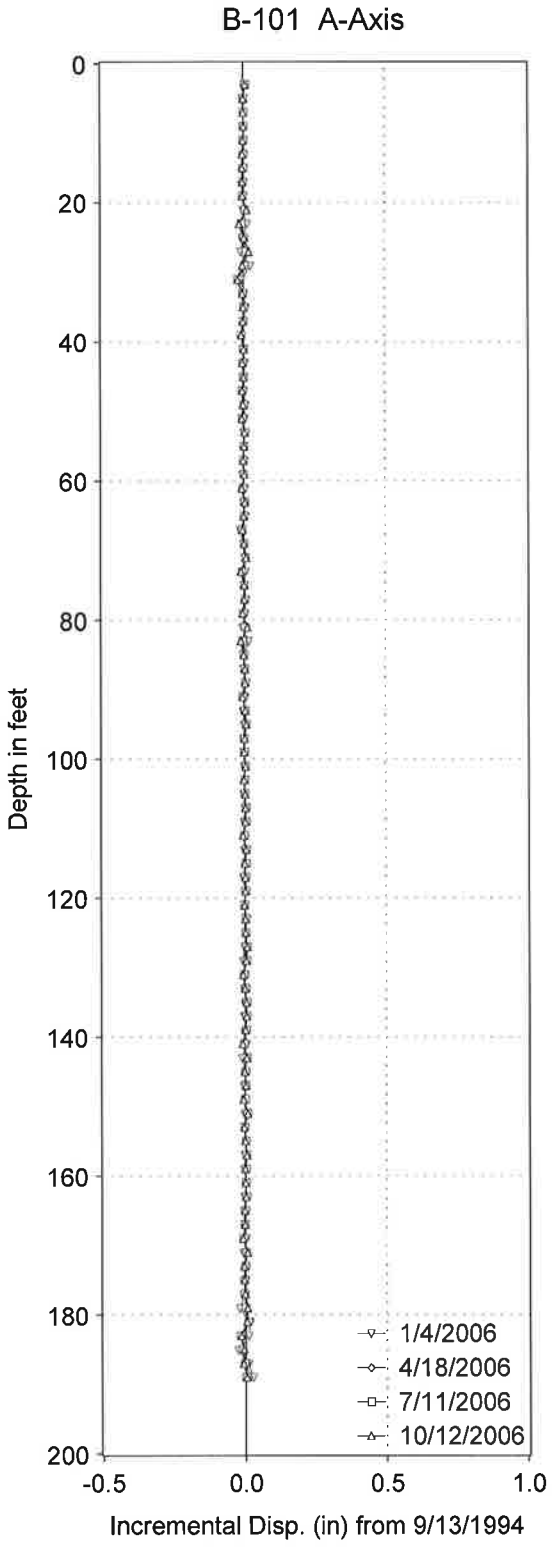
CUY-90-14.92/15.24 WEST ABUTMENT
CLEVELAND, OHIO

BBCM
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

Project: 012-00946-300	Drawn By: EDV
Drawing Date: 7/25/06	Approved By: JLS
Revision Date: 7/26/06	Scale: 1" = 100'

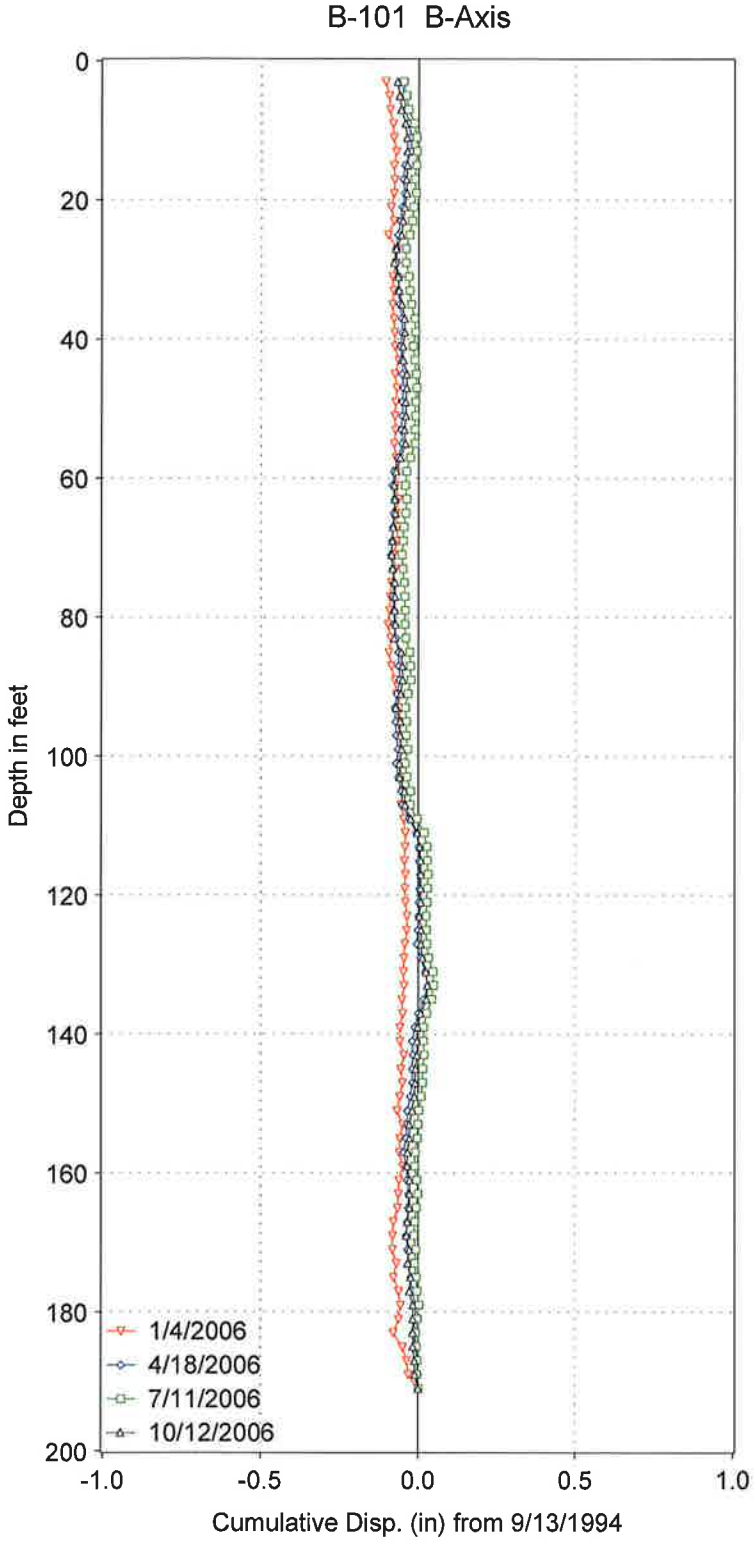
PLATE 2

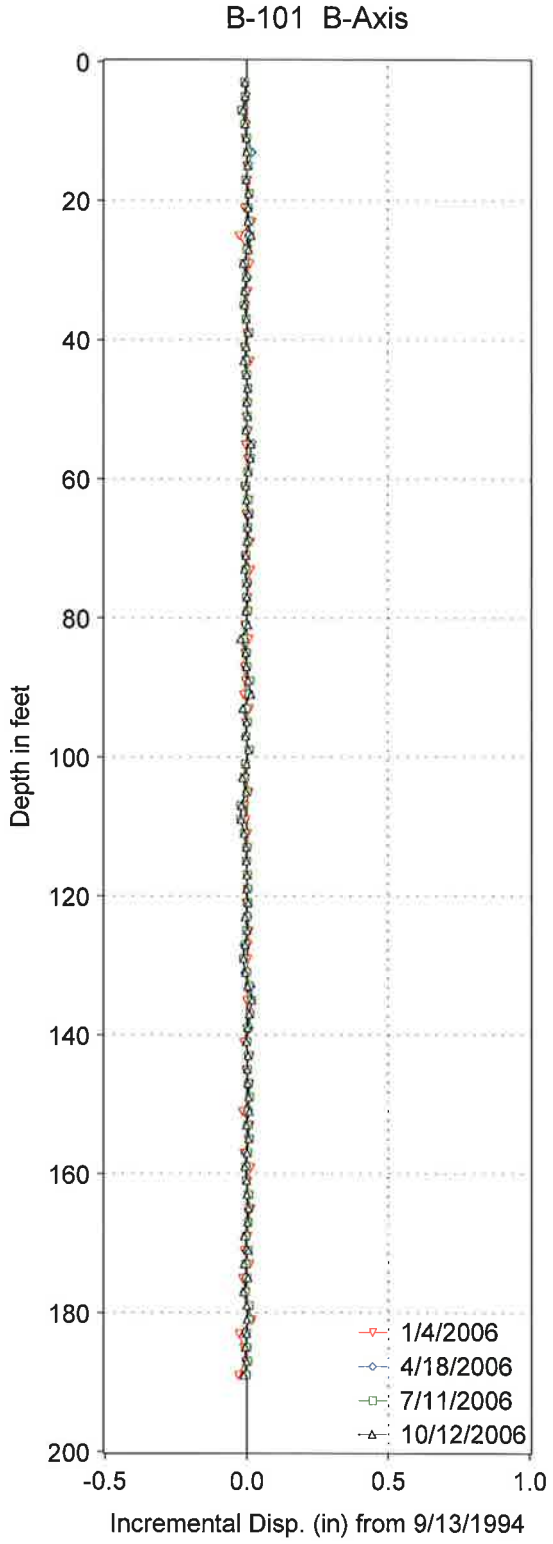




B-101
-Includes readings from the last four quarters.

PLATE 3





B-101
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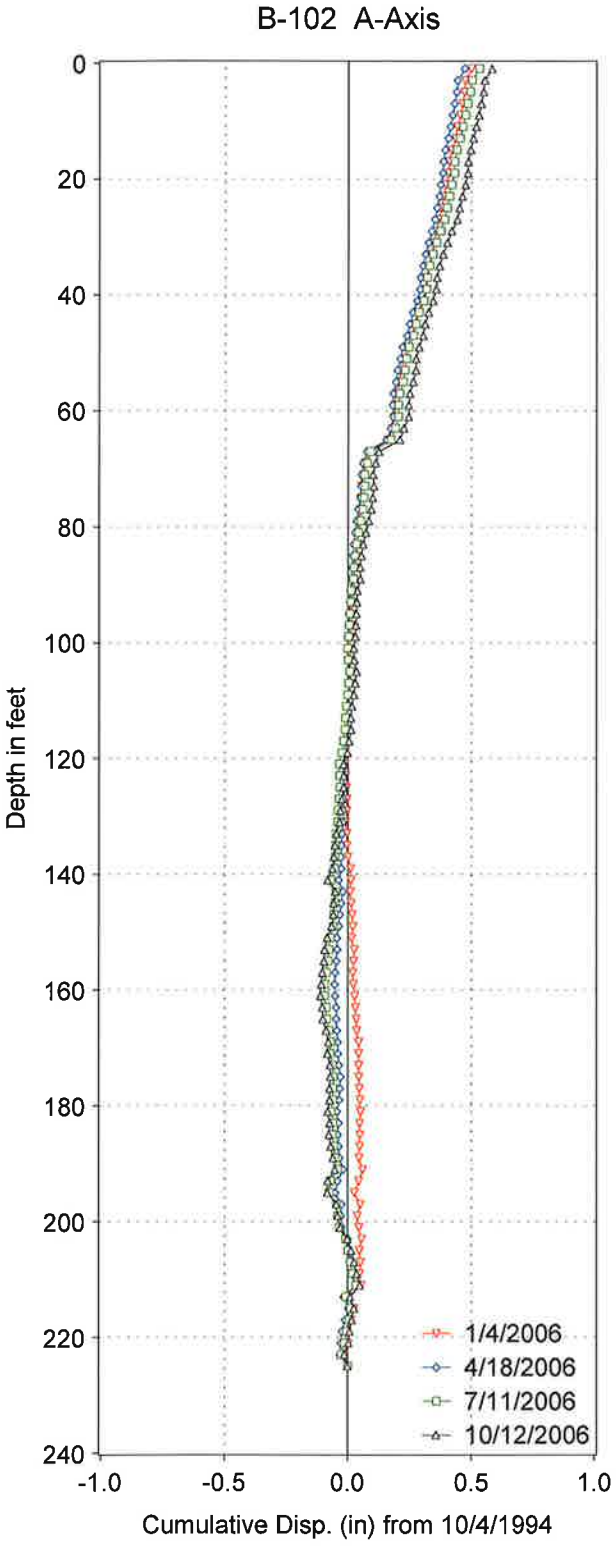
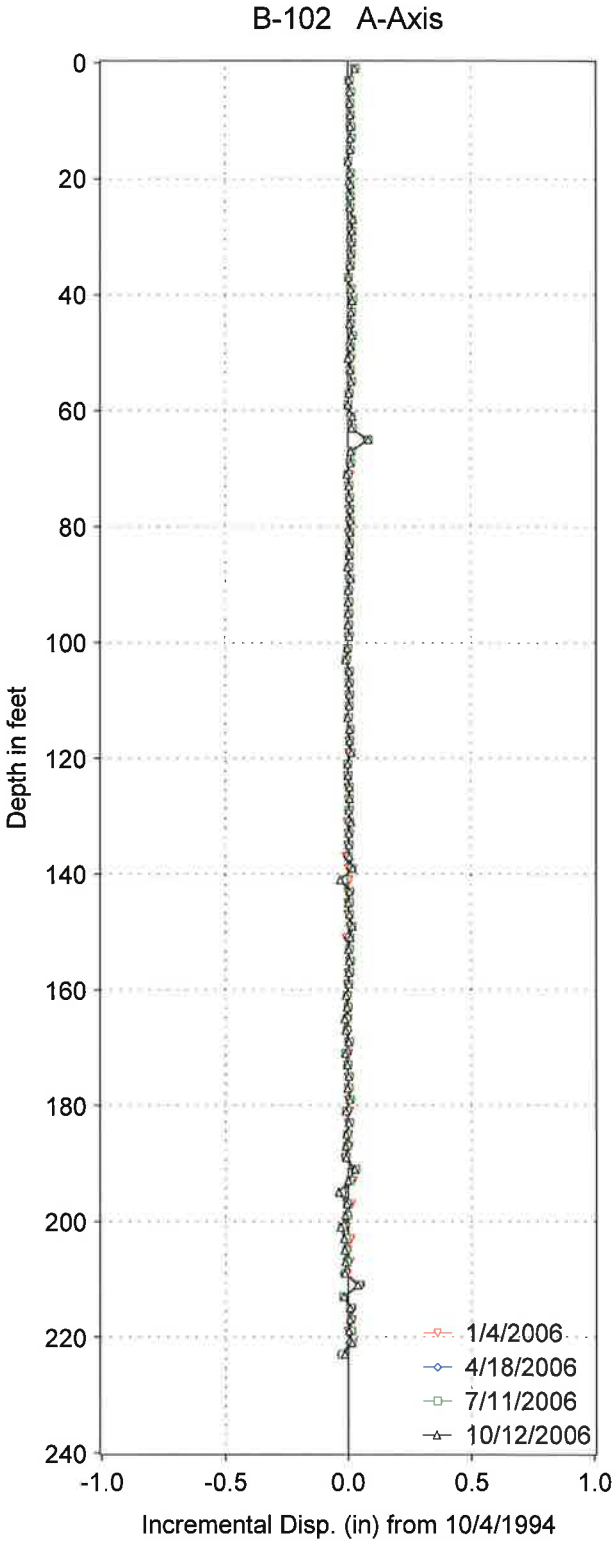
PLATE 4





B-102
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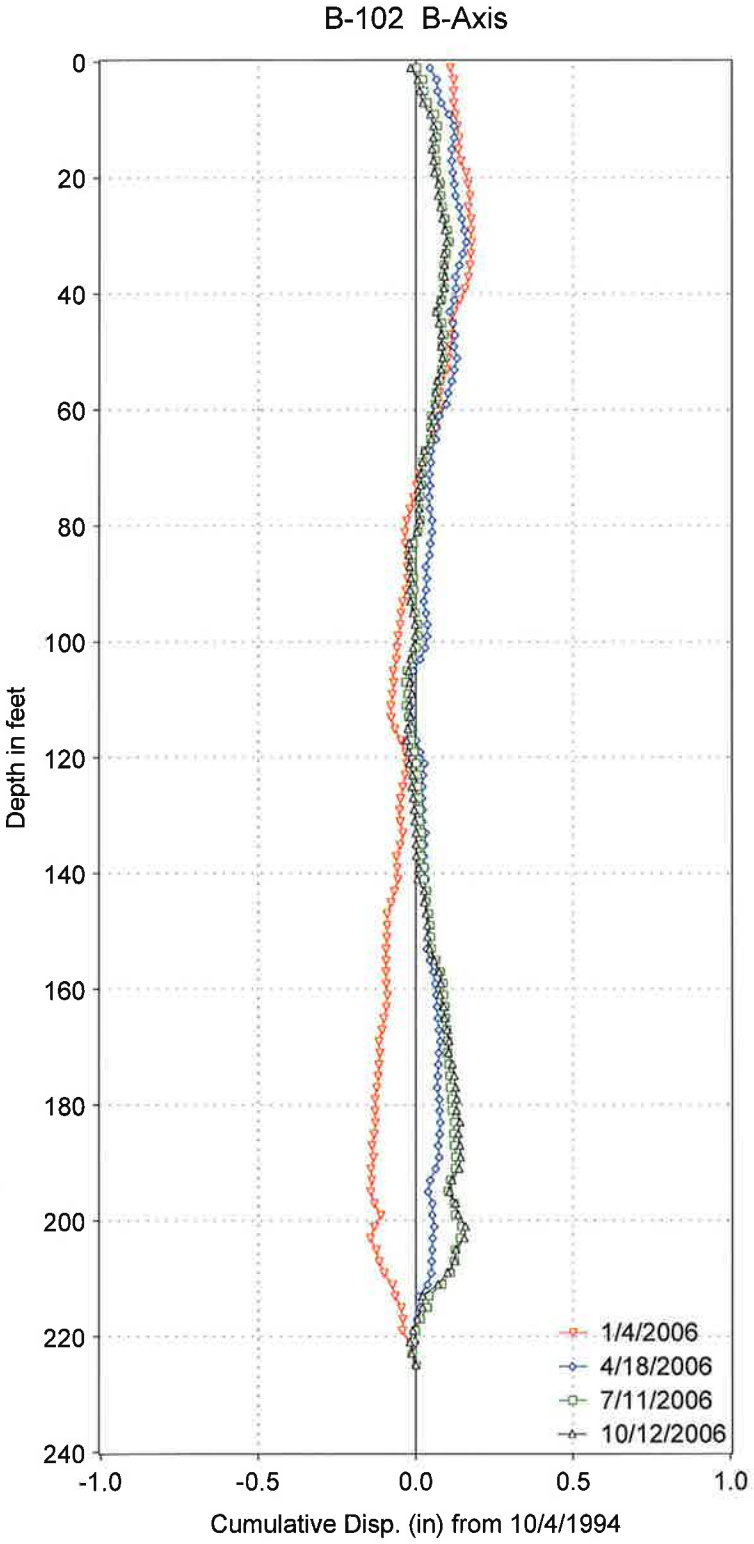
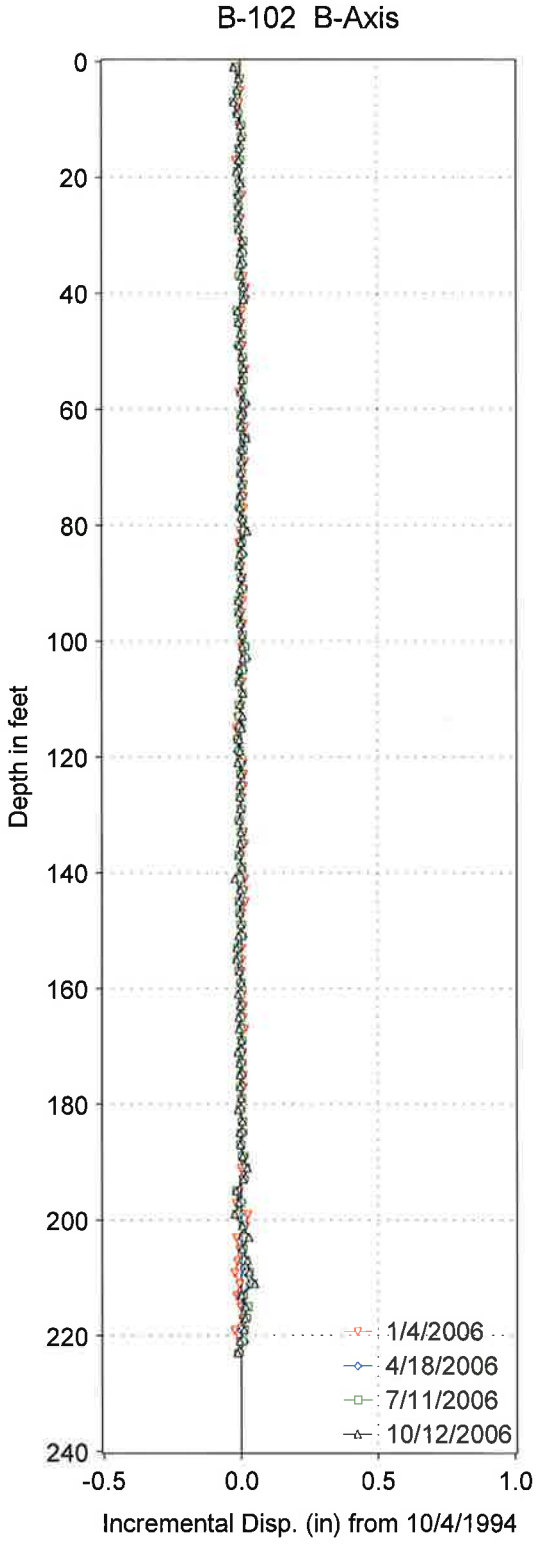
PLATE 5





B-102
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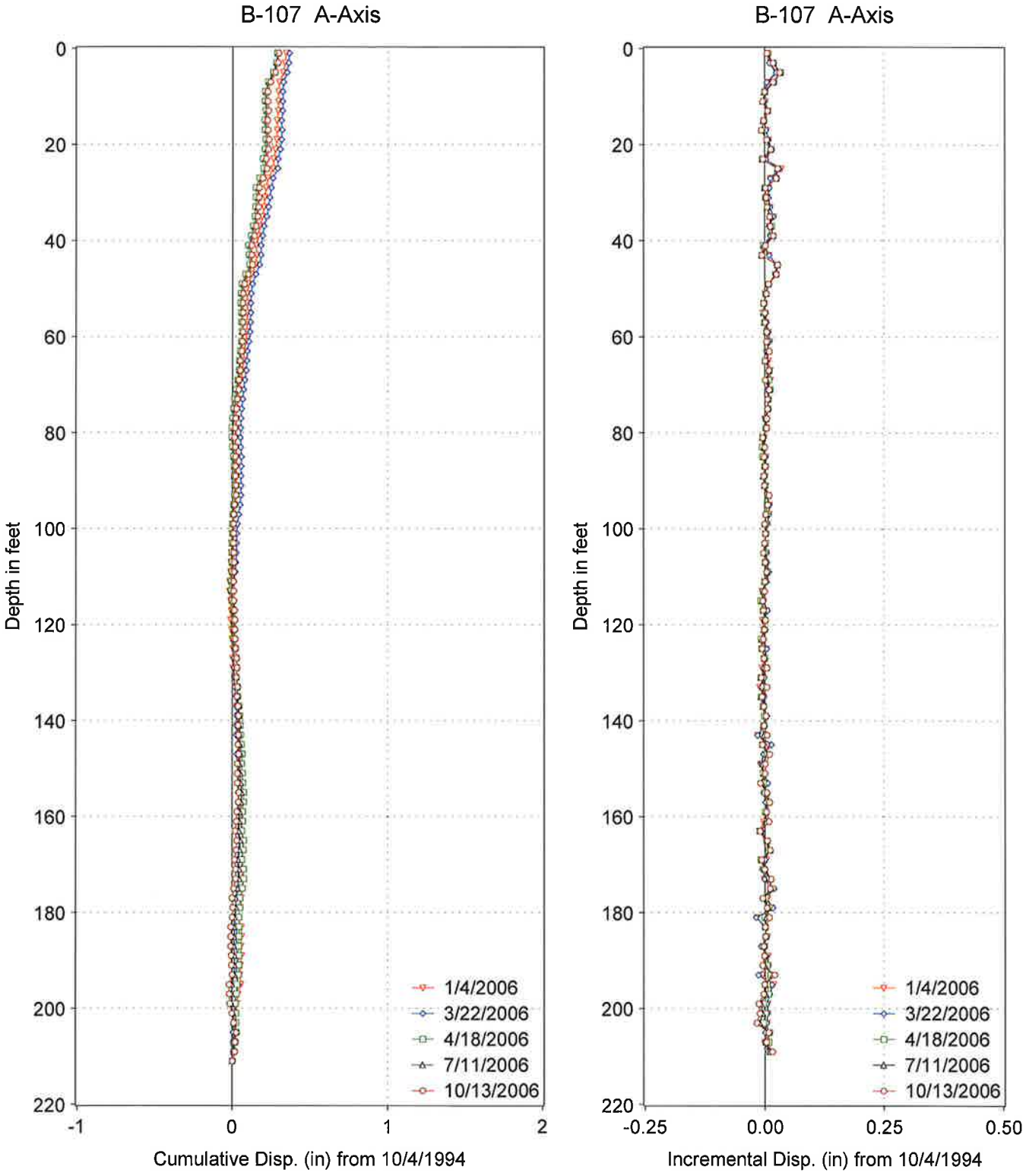
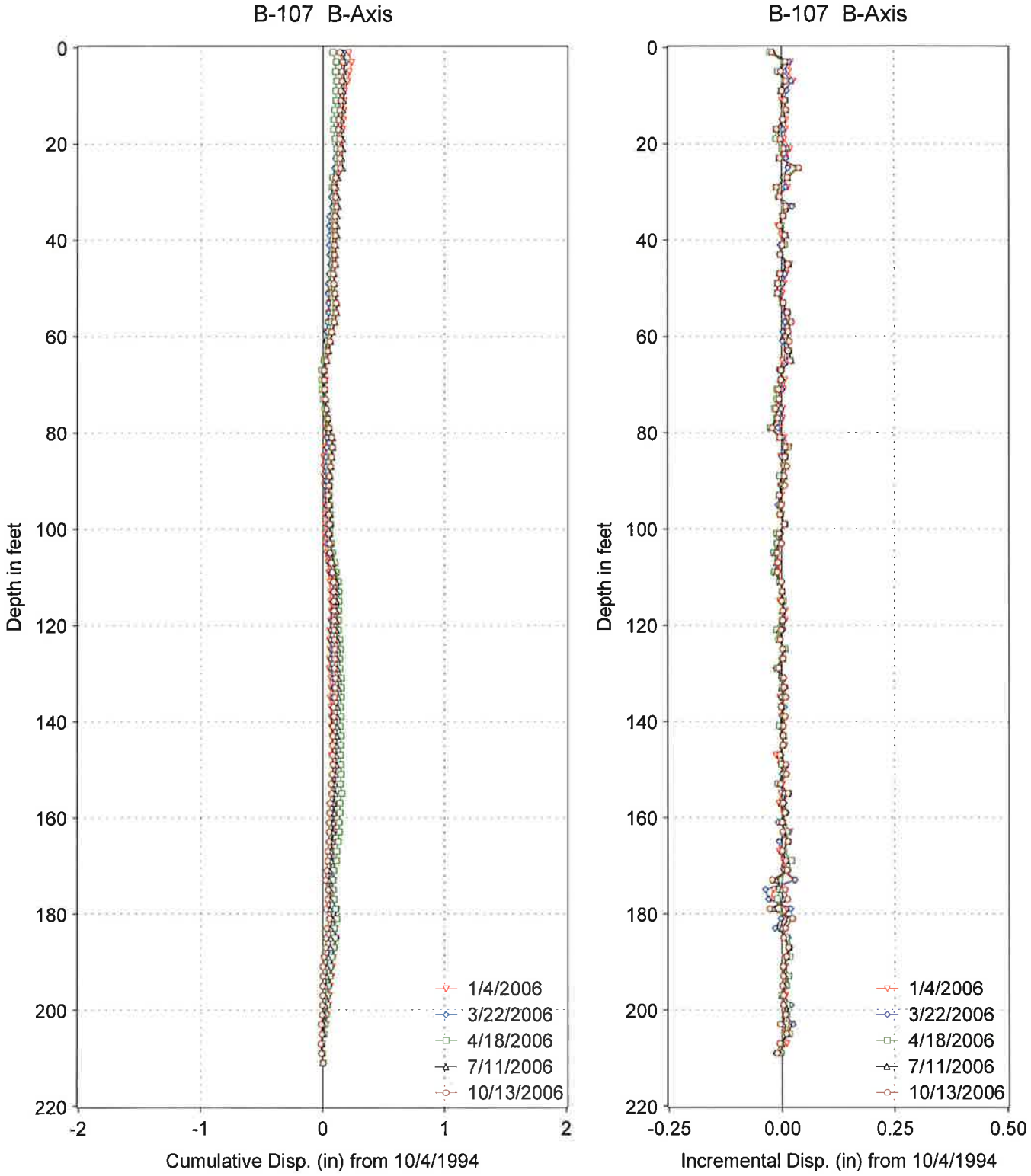
PLATE 6



B-107
-Includes readings from the last four quarters (and in March).

PLATE 7



B-107
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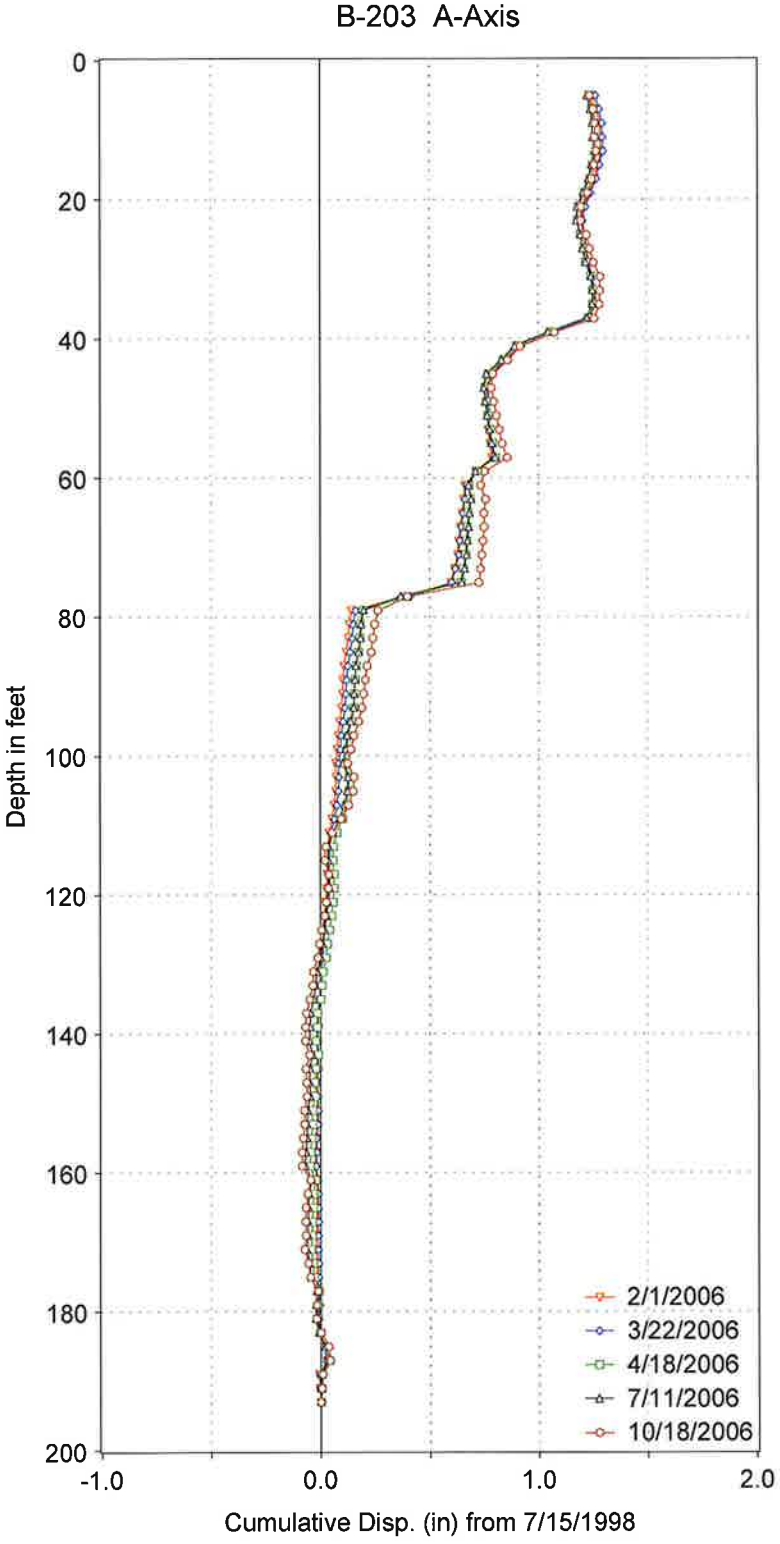
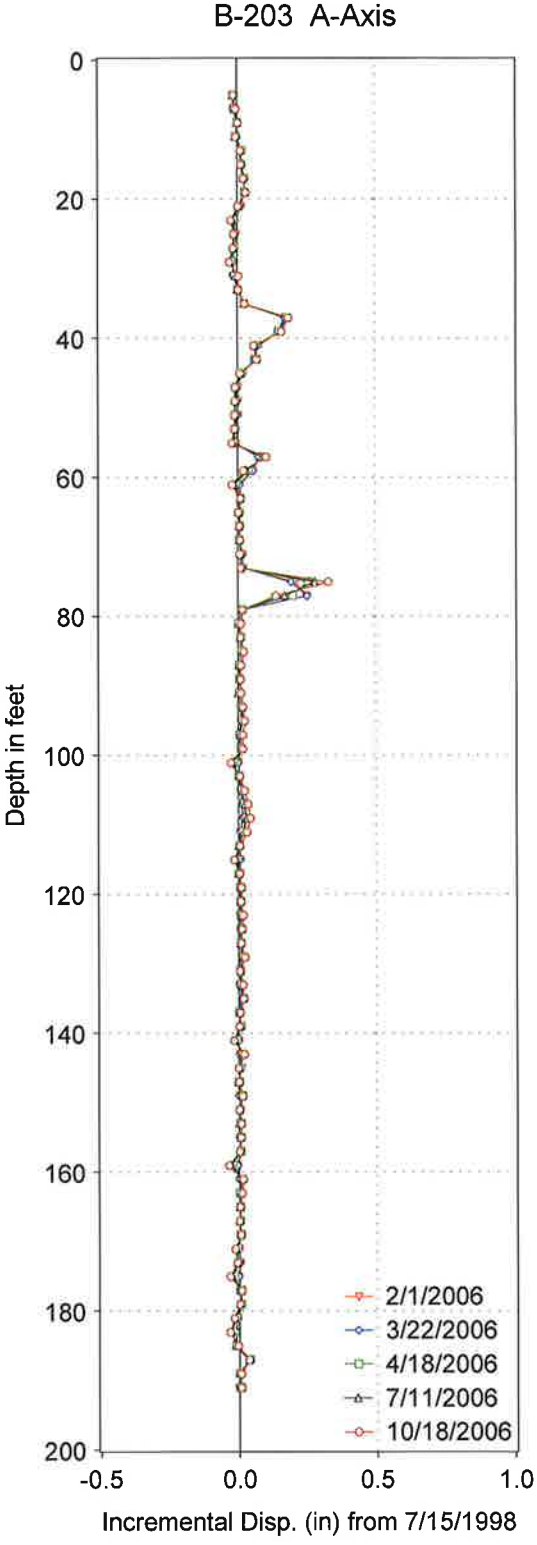
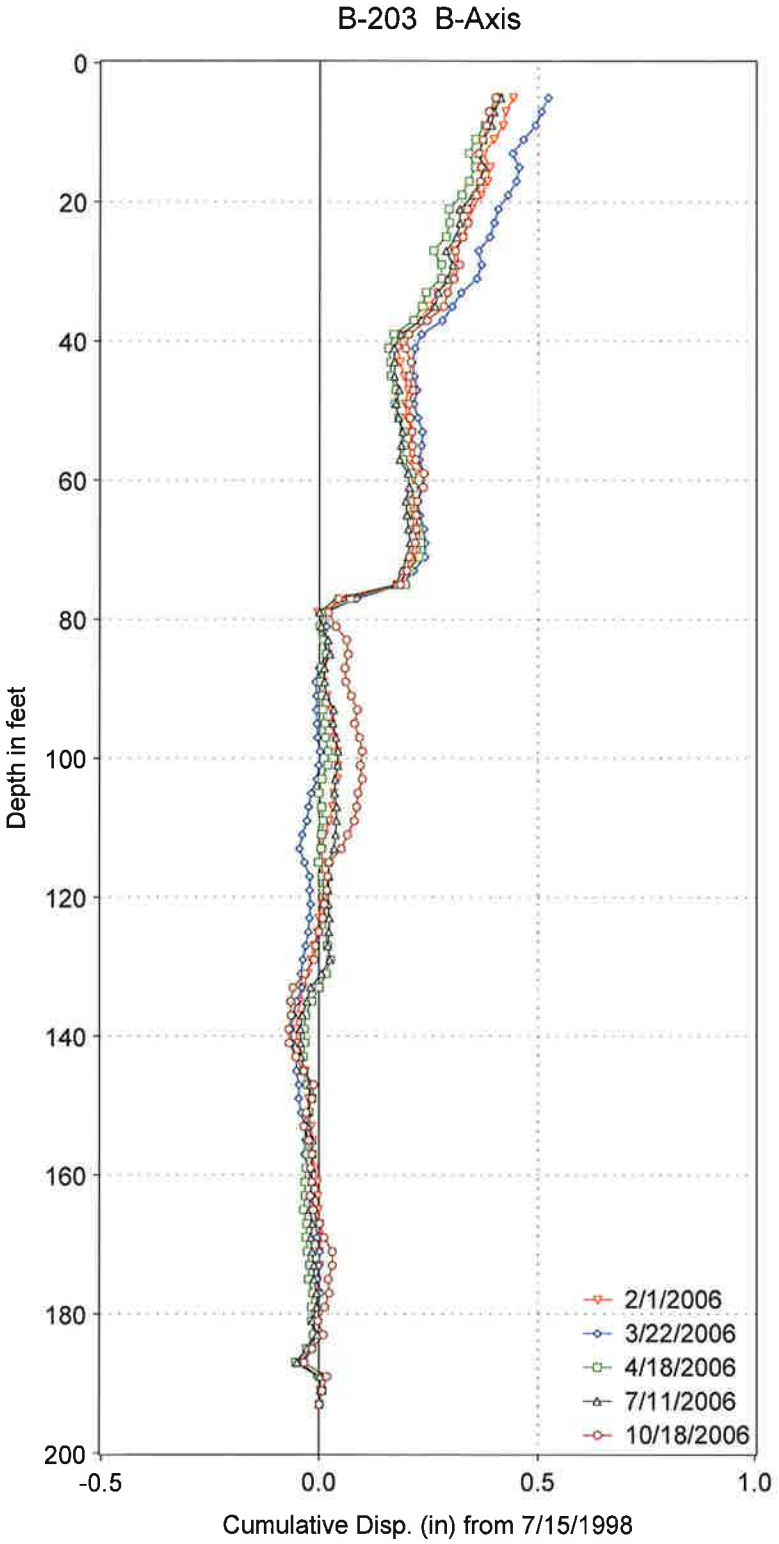
PLATE 8

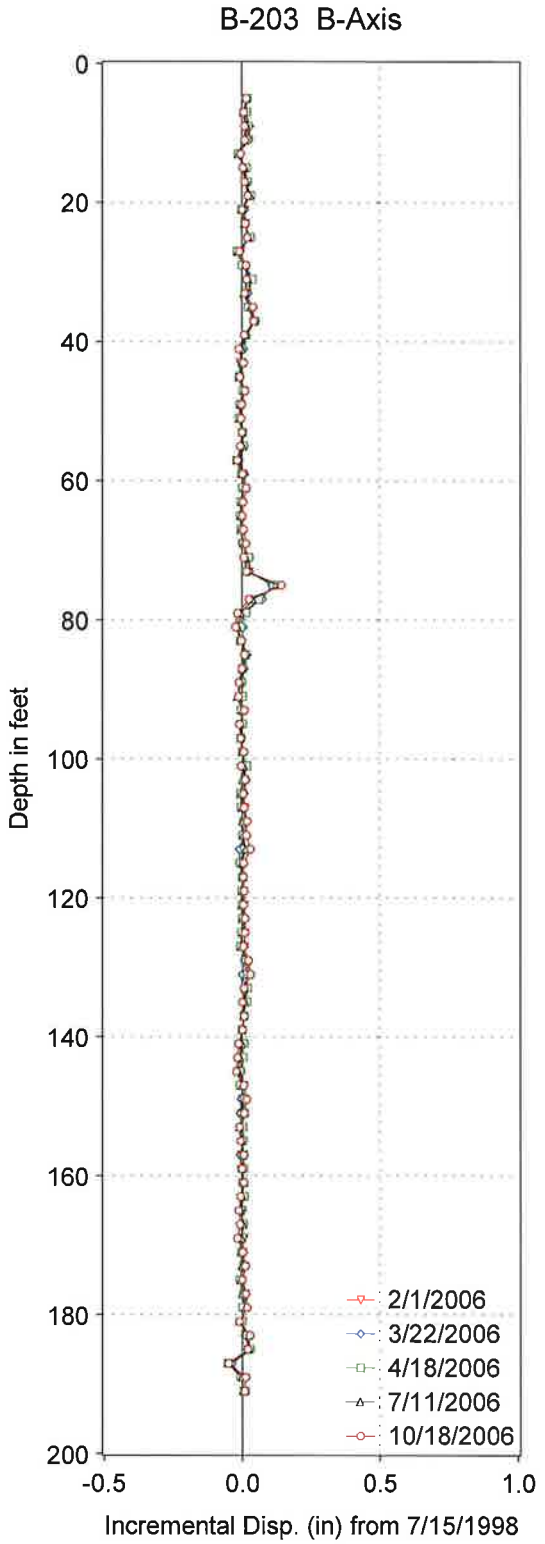




B-203
-Includes readings from the last four quarters (and in March).

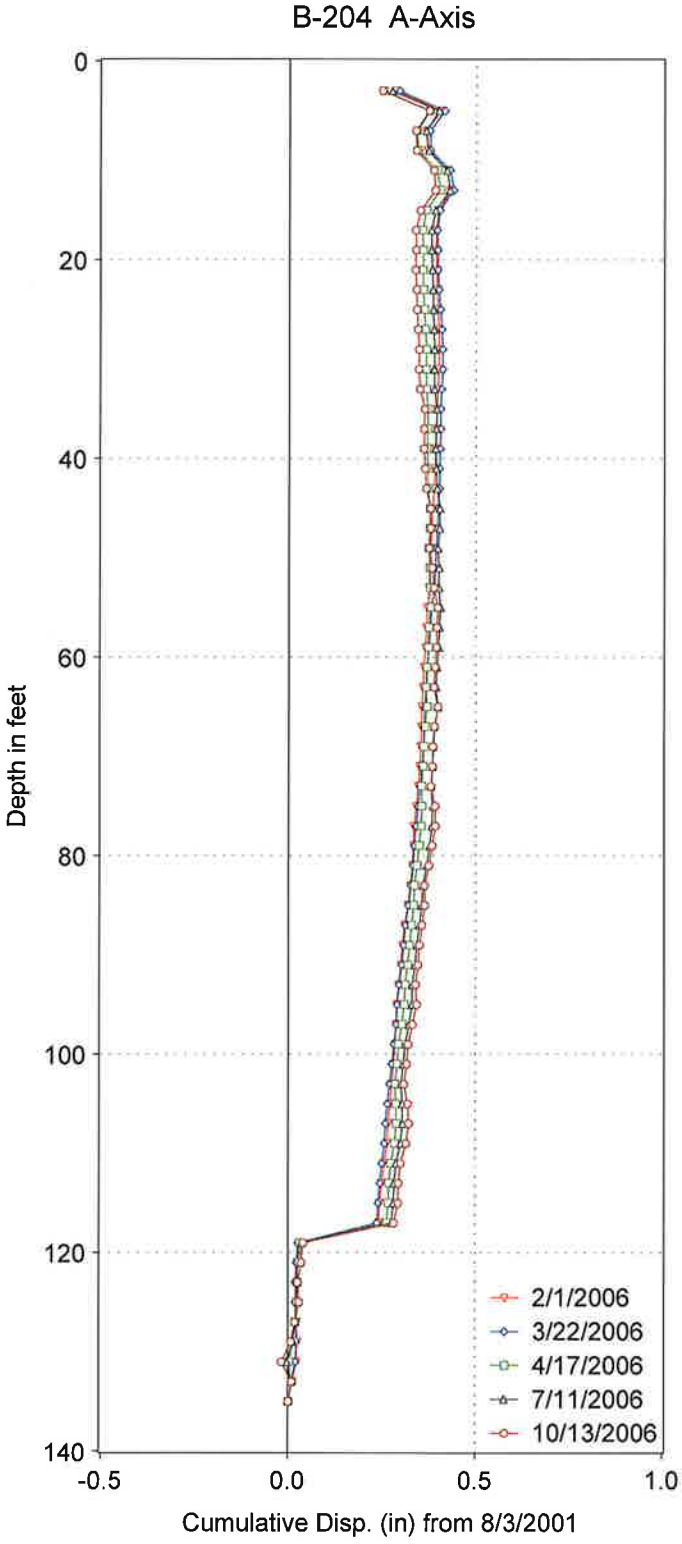
PLATE 9

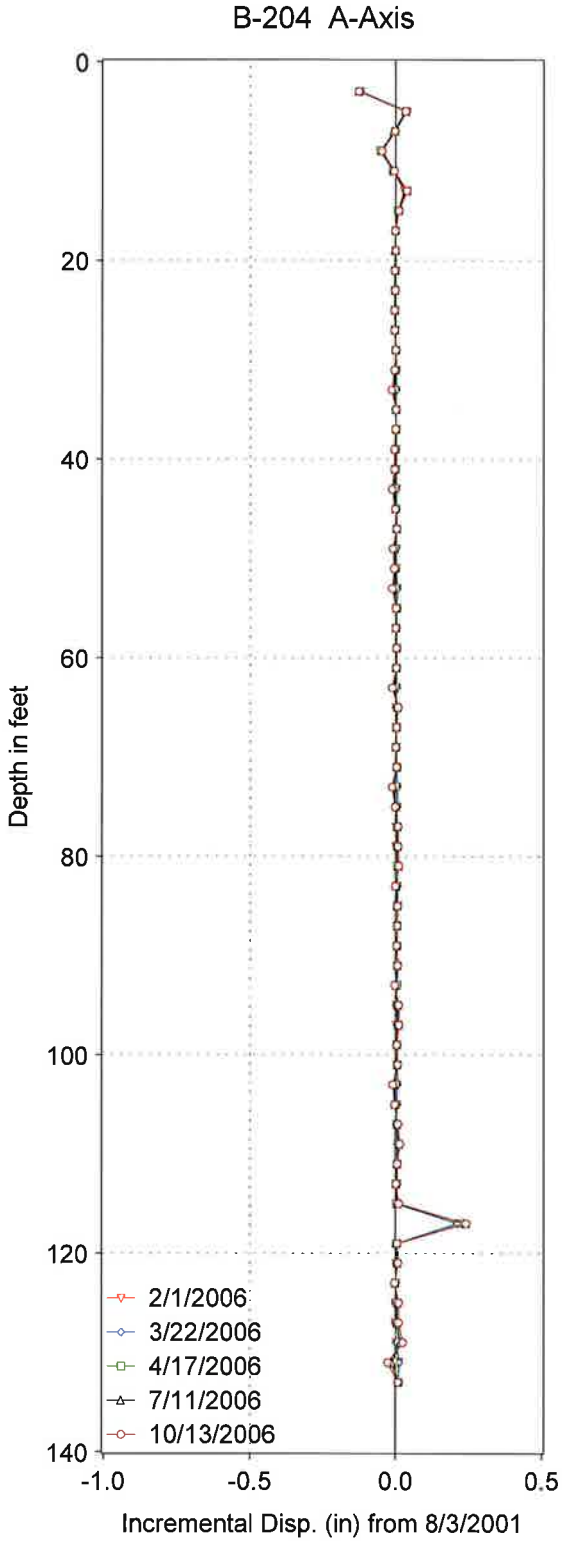




B-203
-Includes readings from the last four quarters (and in March).

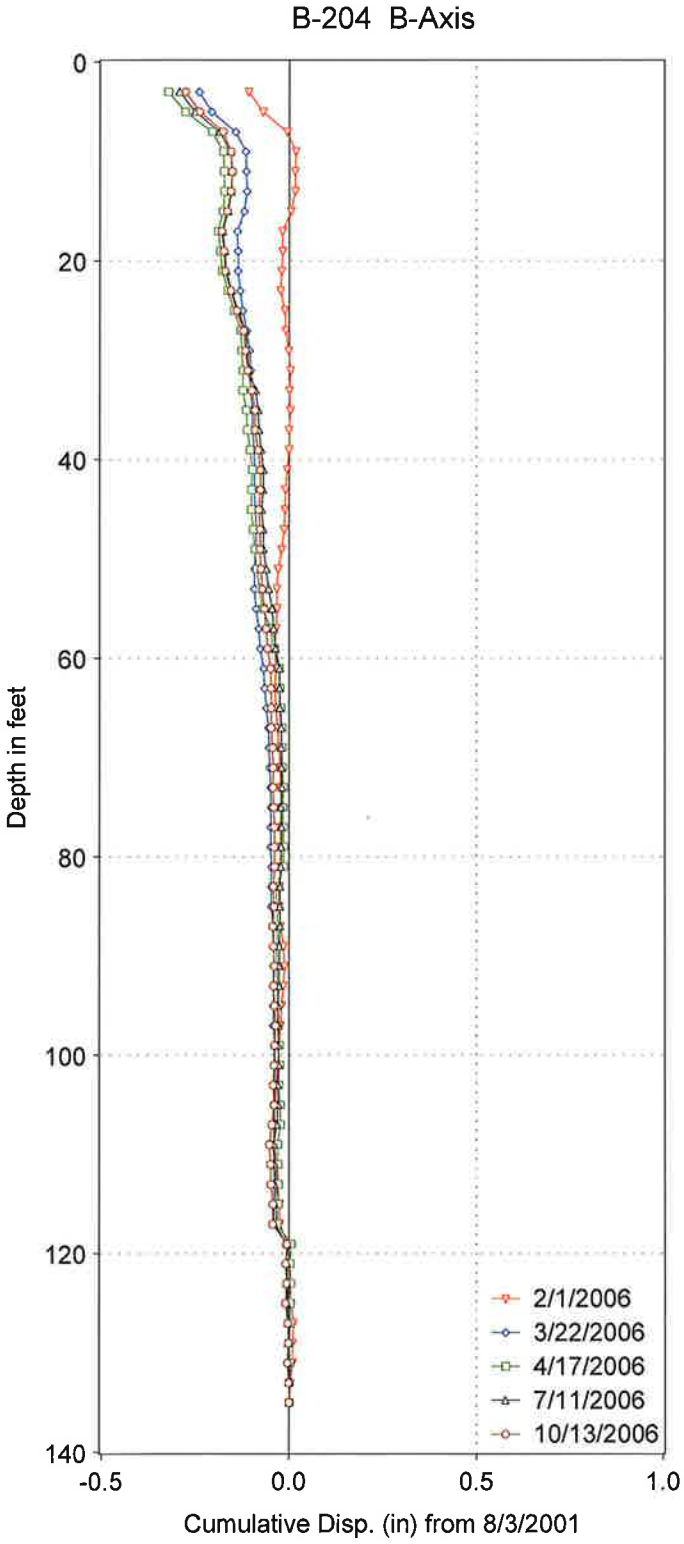
PLATE 10

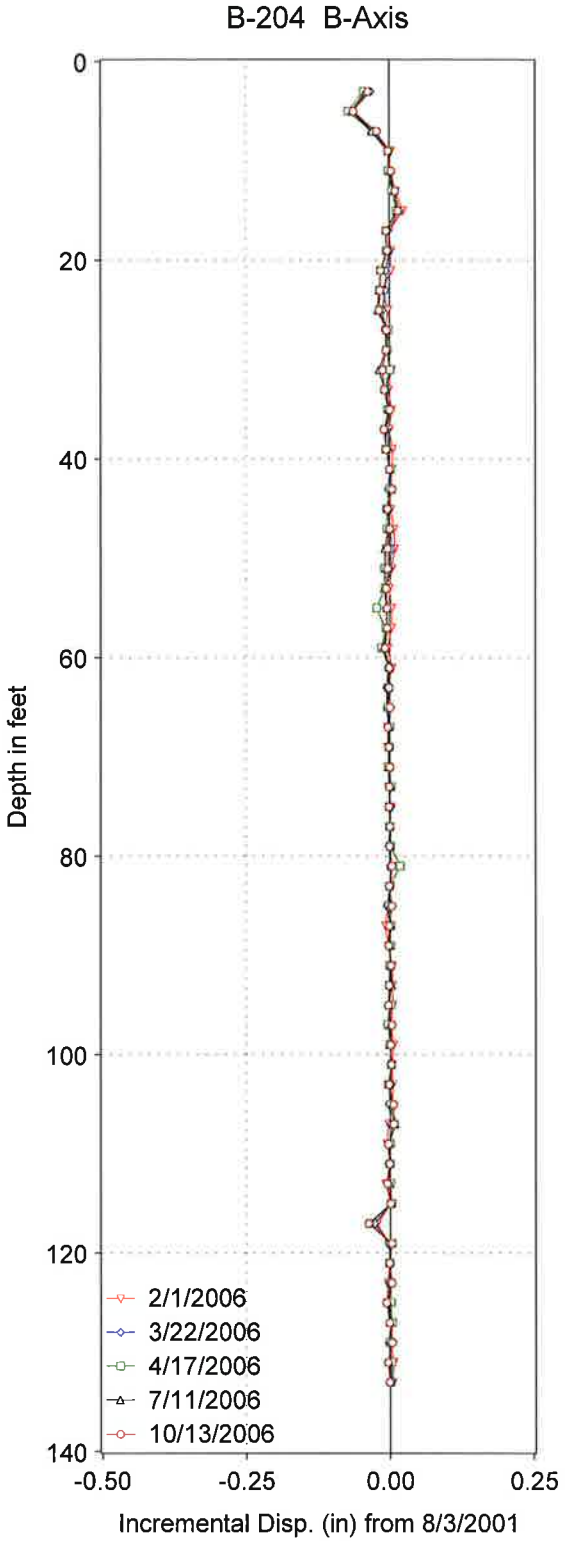




B-204
-Includes readings from the last four quarters (and in March).

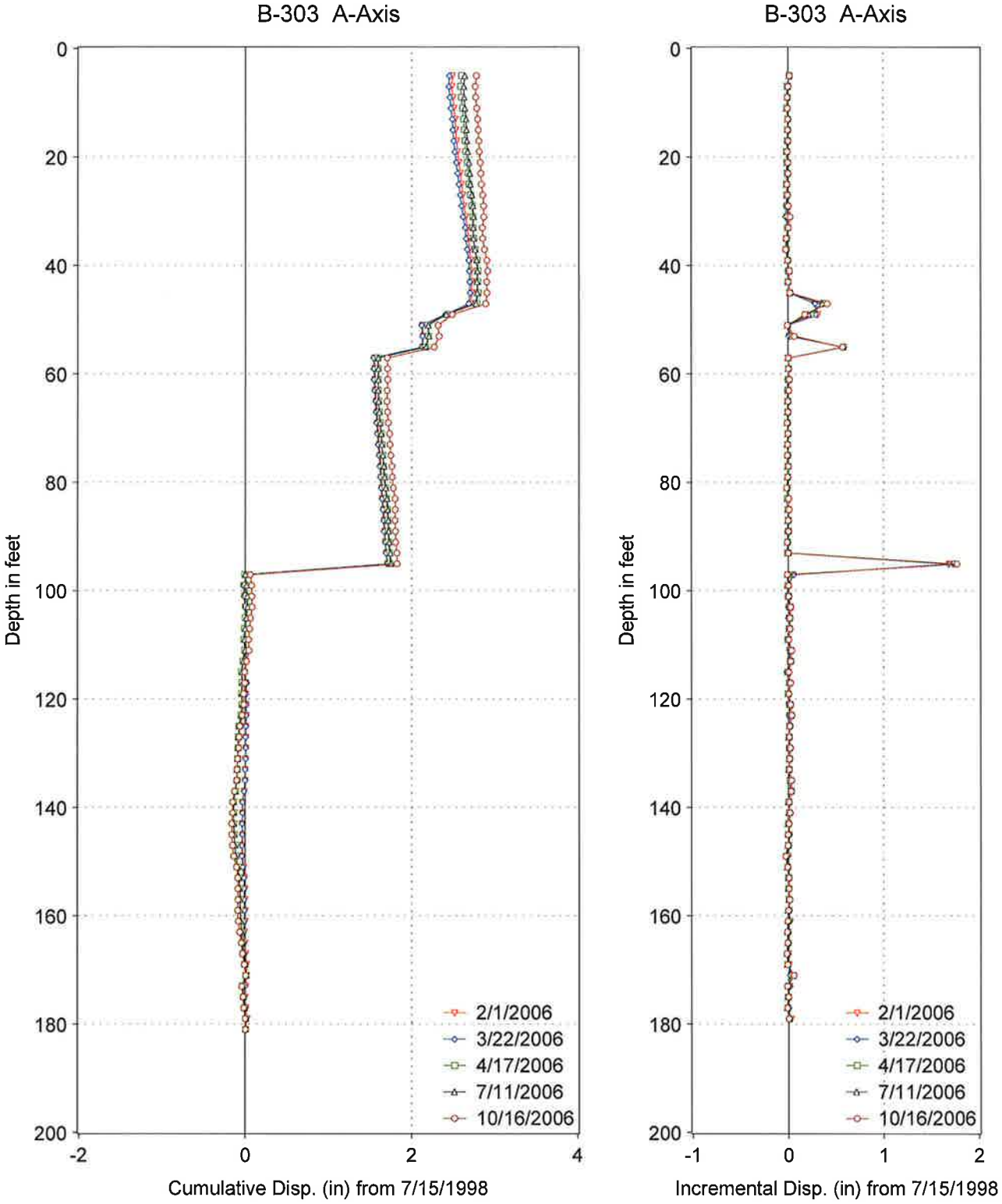
PLATE 11





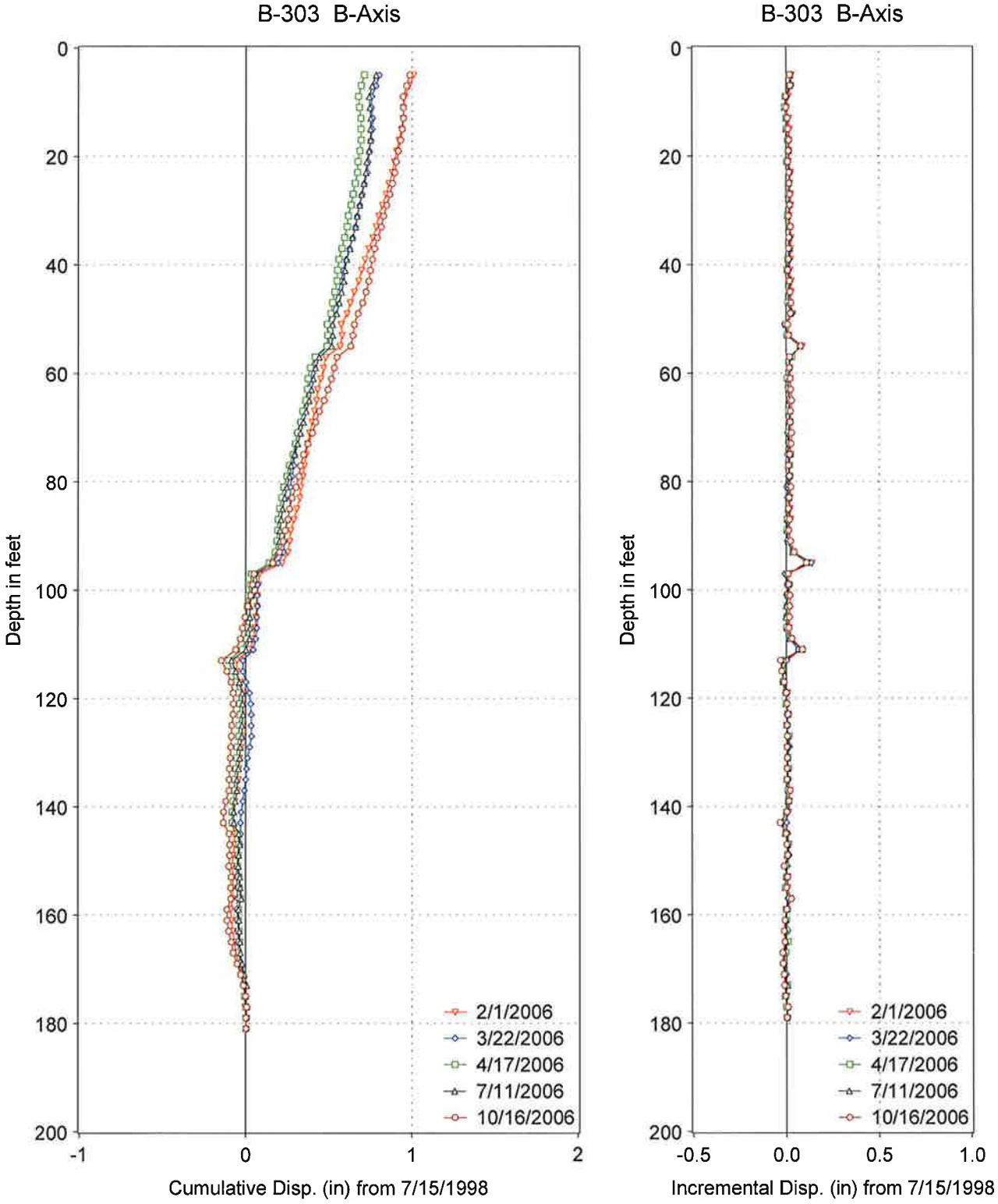
B-204
-Includes readings from the last four quarters (and in March).

PLATE 12



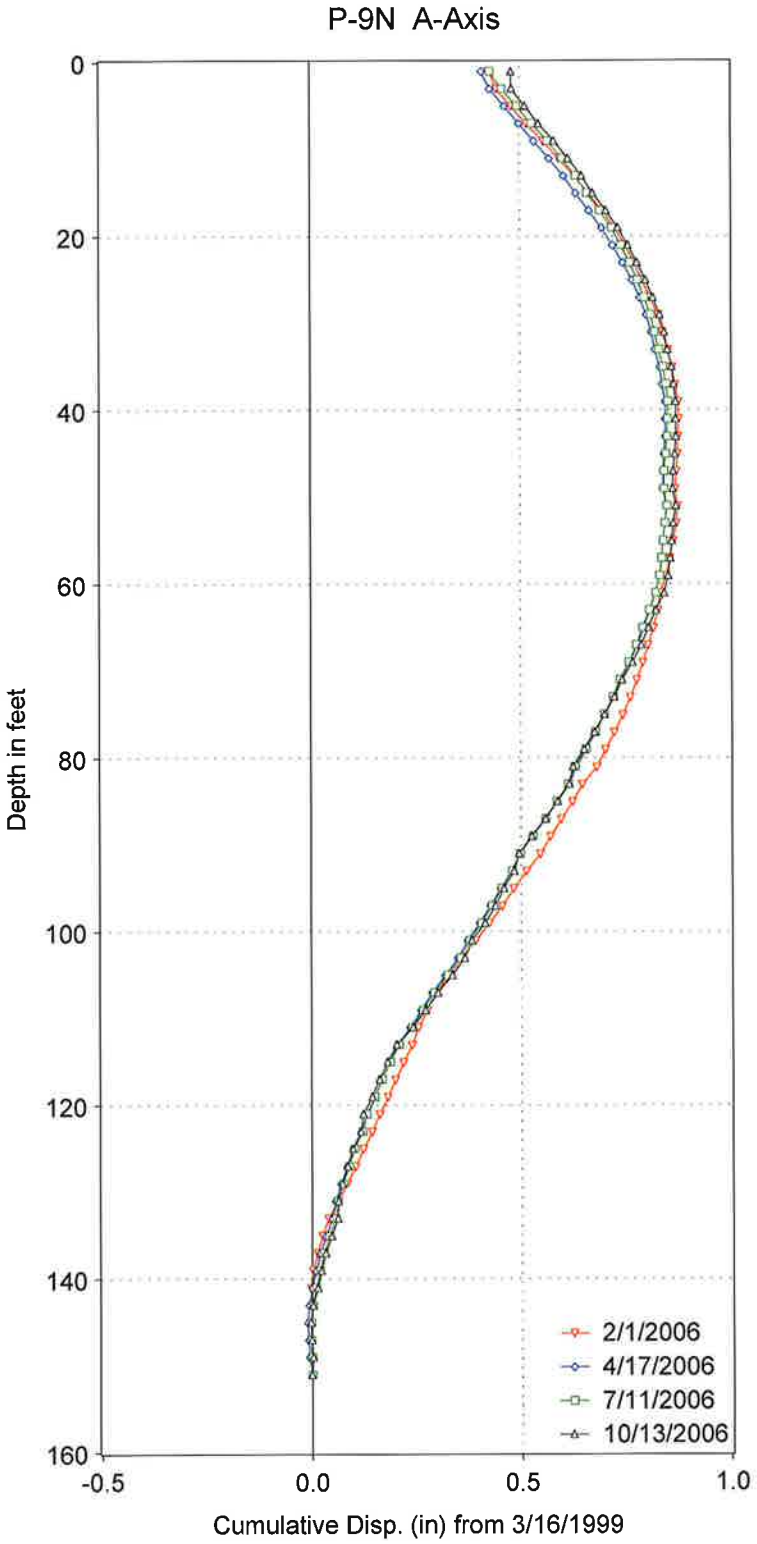
B-303
-Includes readings from the last four quarters (and in March).

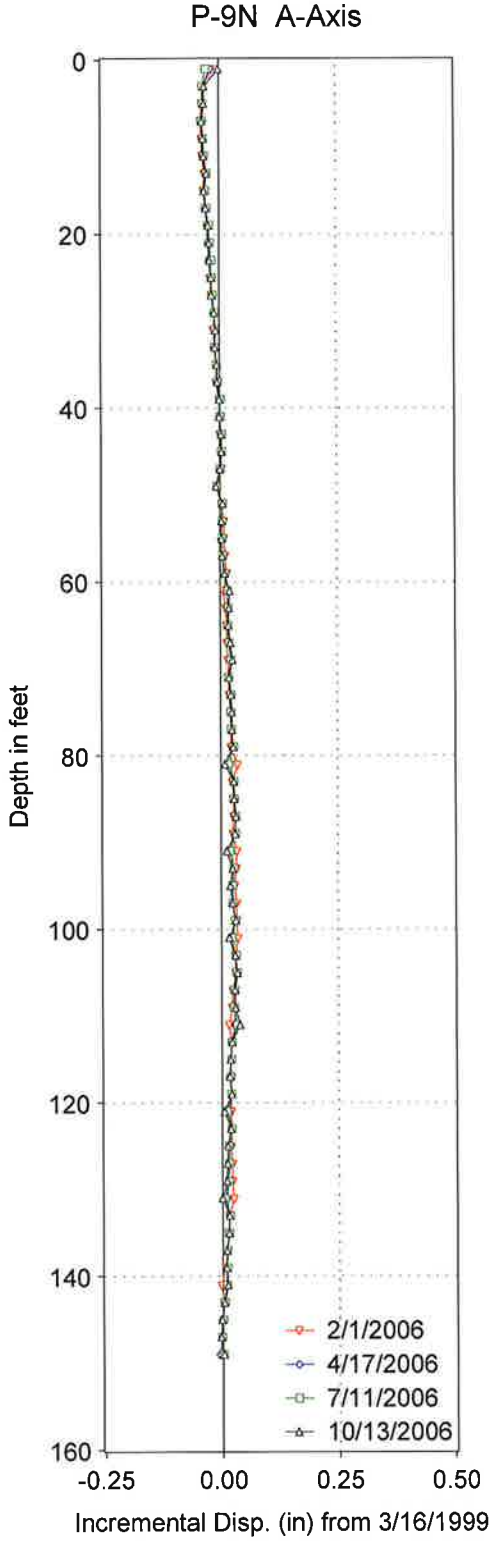
PLATE 13



B-303
-Includes readings from the last four quarters (and in March).

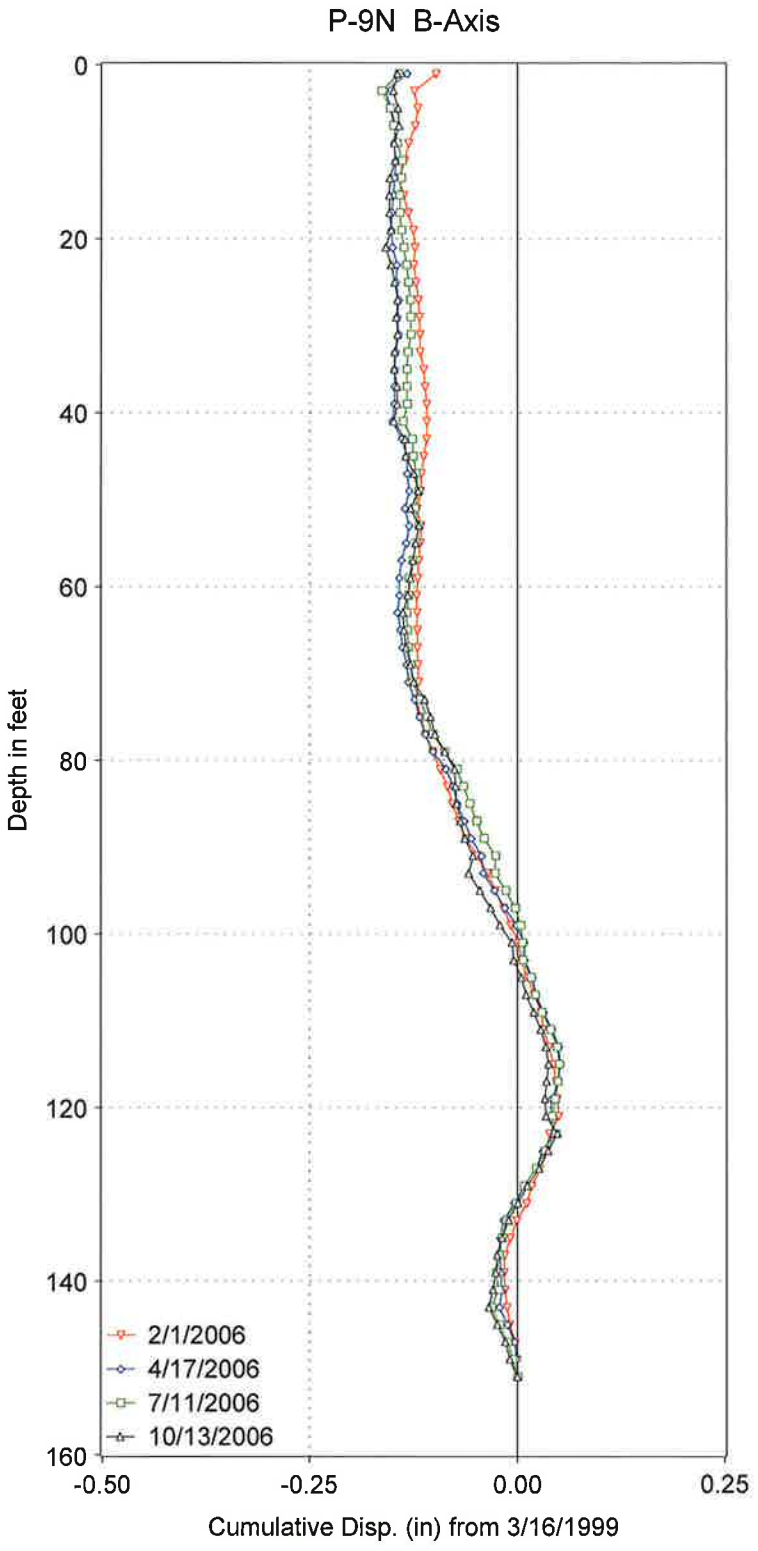
PLATE 14

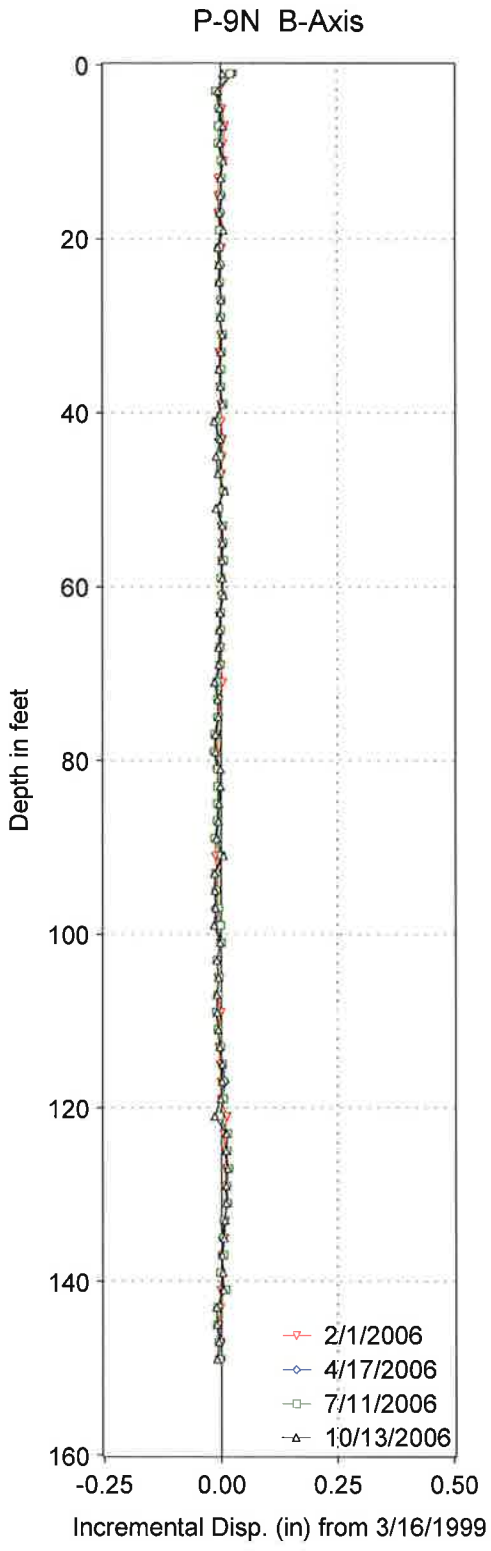




P-9N
-Includes readings from the last four quarters.

PLATE 15





P-9N
-Includes readings from the last four quarters.

PLATE 16

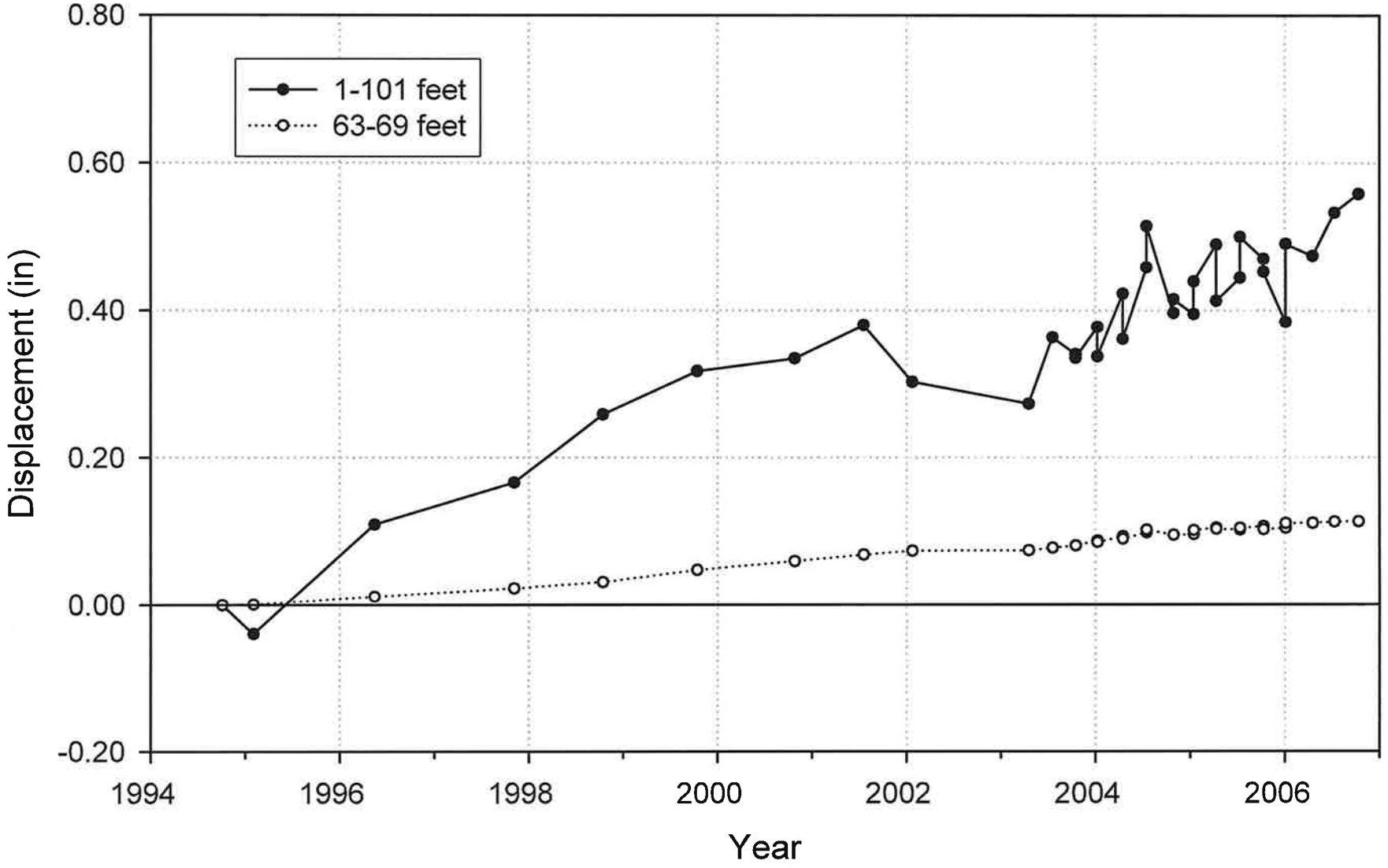

B-102 Time-Displacement A-Axis
1-101 feet
63-69 feet
Displacement (in)
0.80
0.60
0.40
0.20
0.00
-0.20
1994
1996
1998
2000
2002
2004
2006
Year

PLATE 17

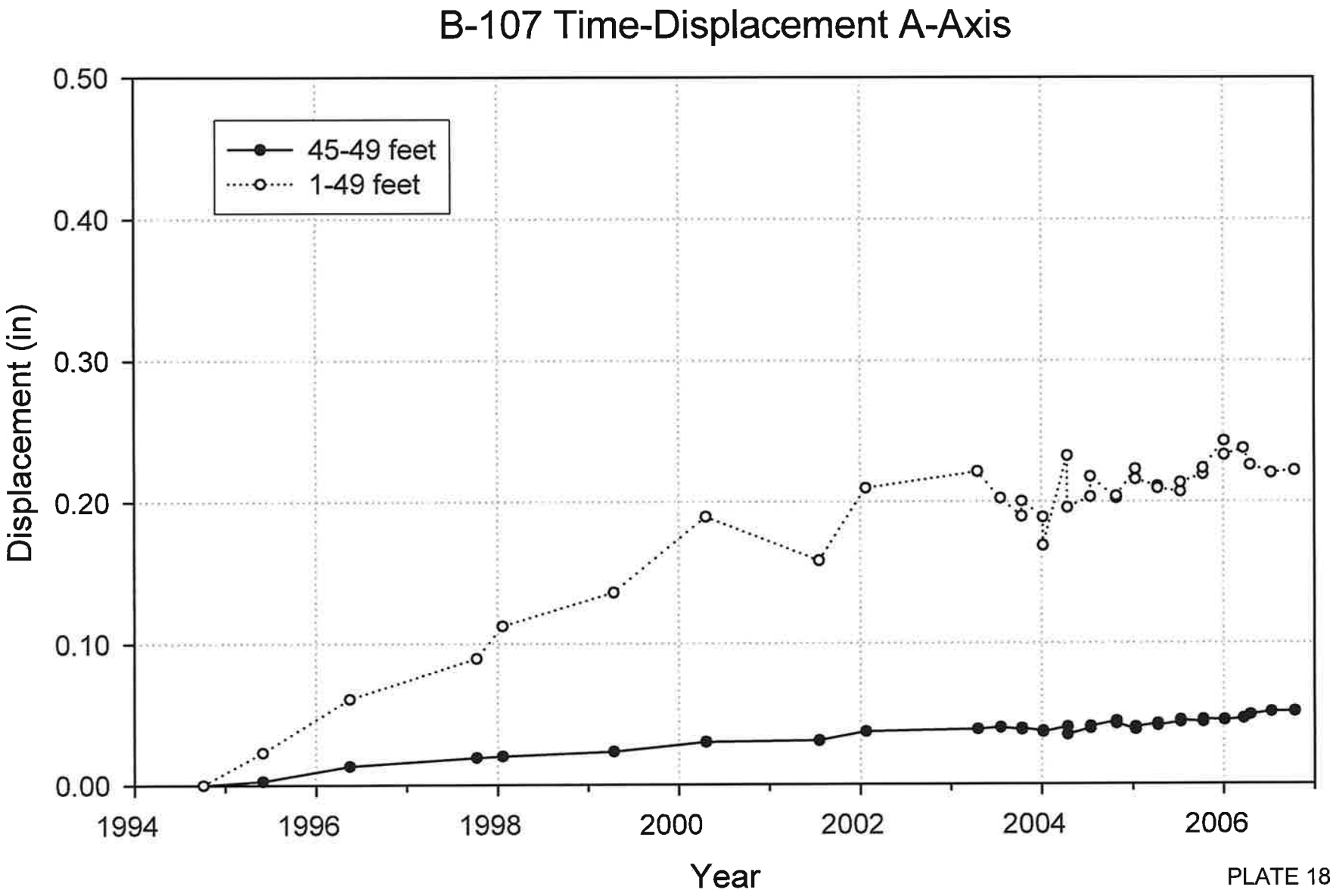

B-107 Time-Displacement A-Axis
45-49 feet
1-49 feet
Displacement (in)
0.50
0.40
0.30
0.20
0.10
0.00
1994
1996
1998
2000
2002
2004
2006
Year

PLATE 18

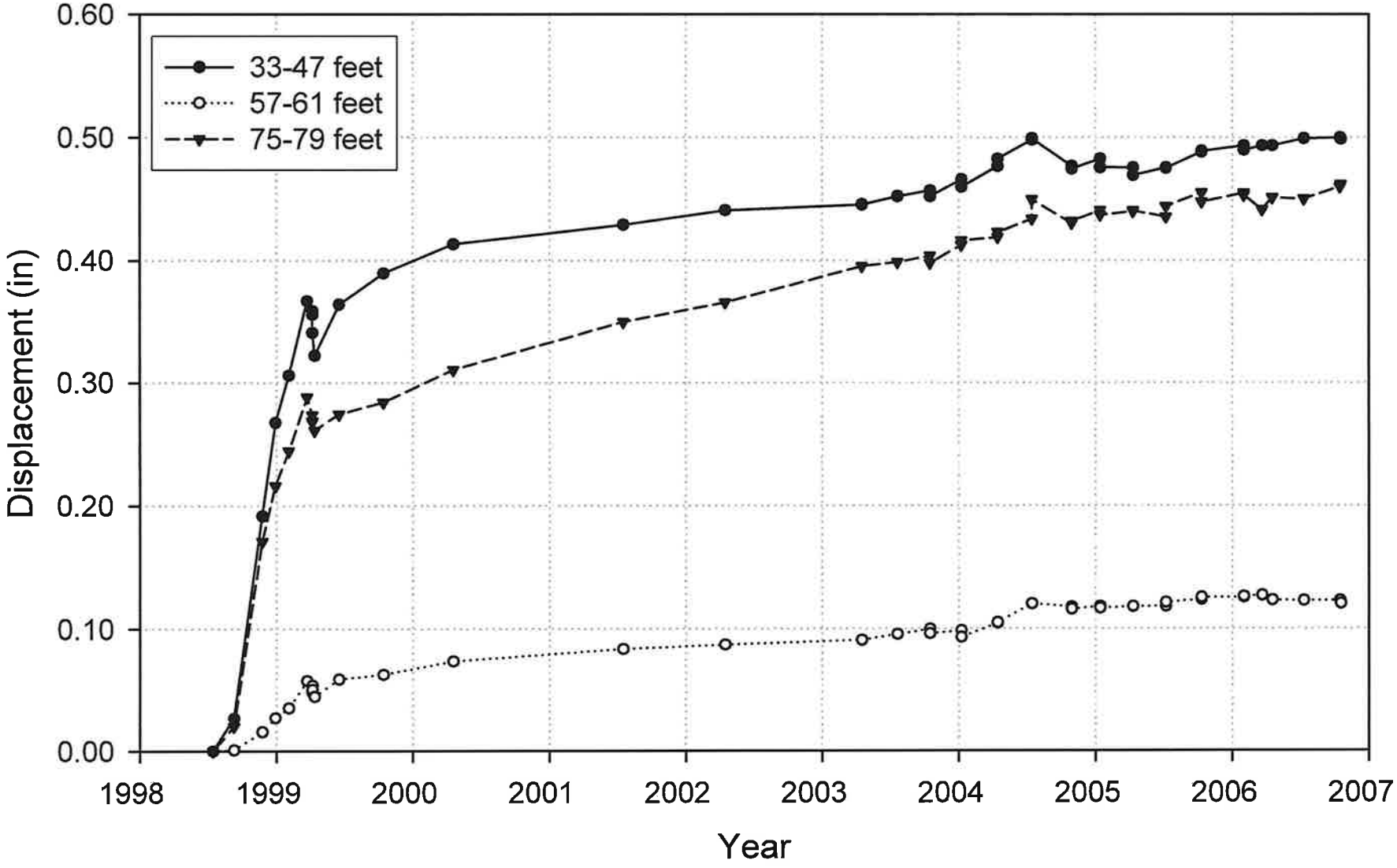

B-203 Time-Displacement A-Axis
33-47 feet
57-61 feet
75-79 feet
Displacement (in)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

PLATE 19

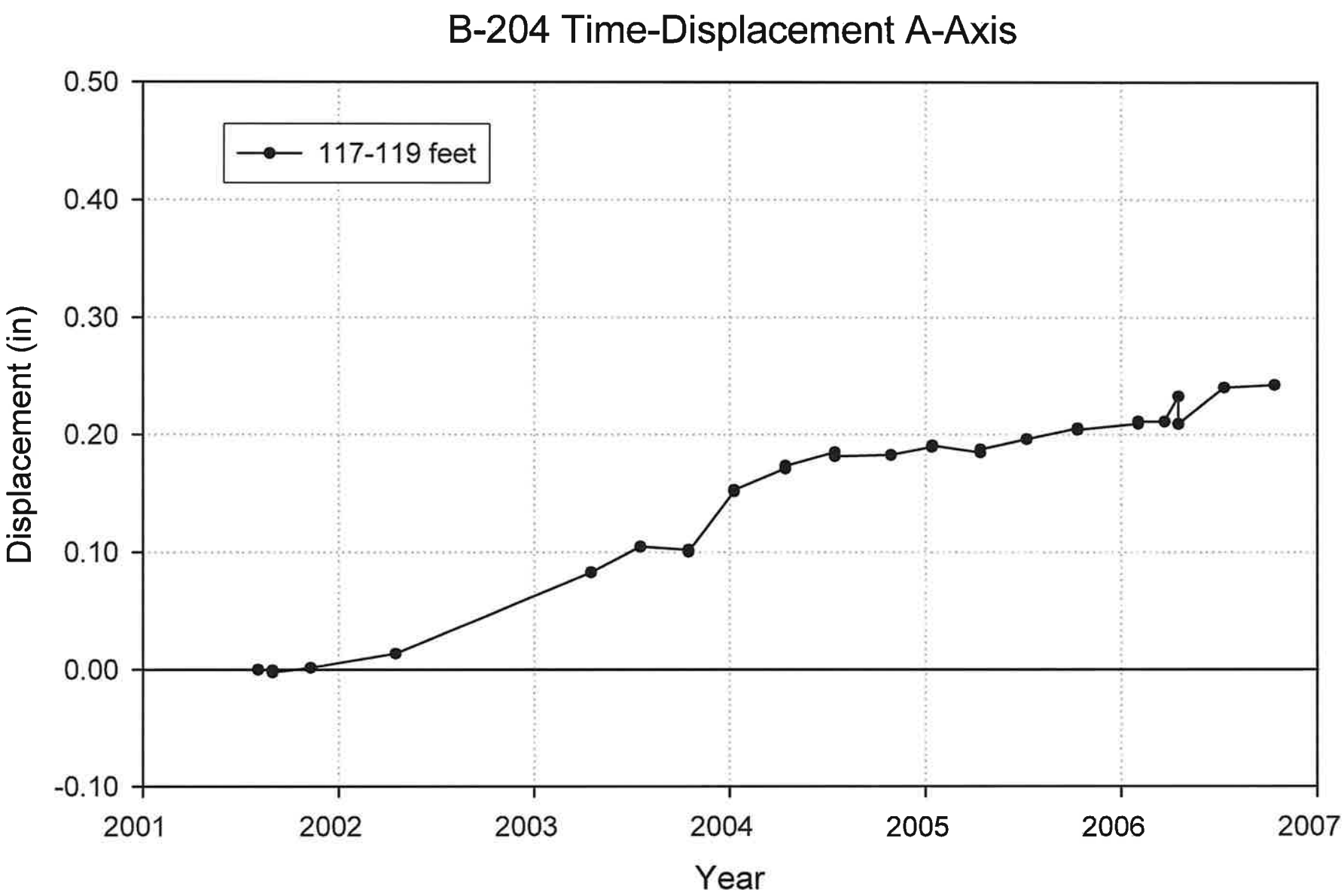

B-204 Time-Displacement A-Axis
117-119 feet
Displacement (in)
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
2001
2002
2003
2004
2005
2006
2007
Year

PLATE 20

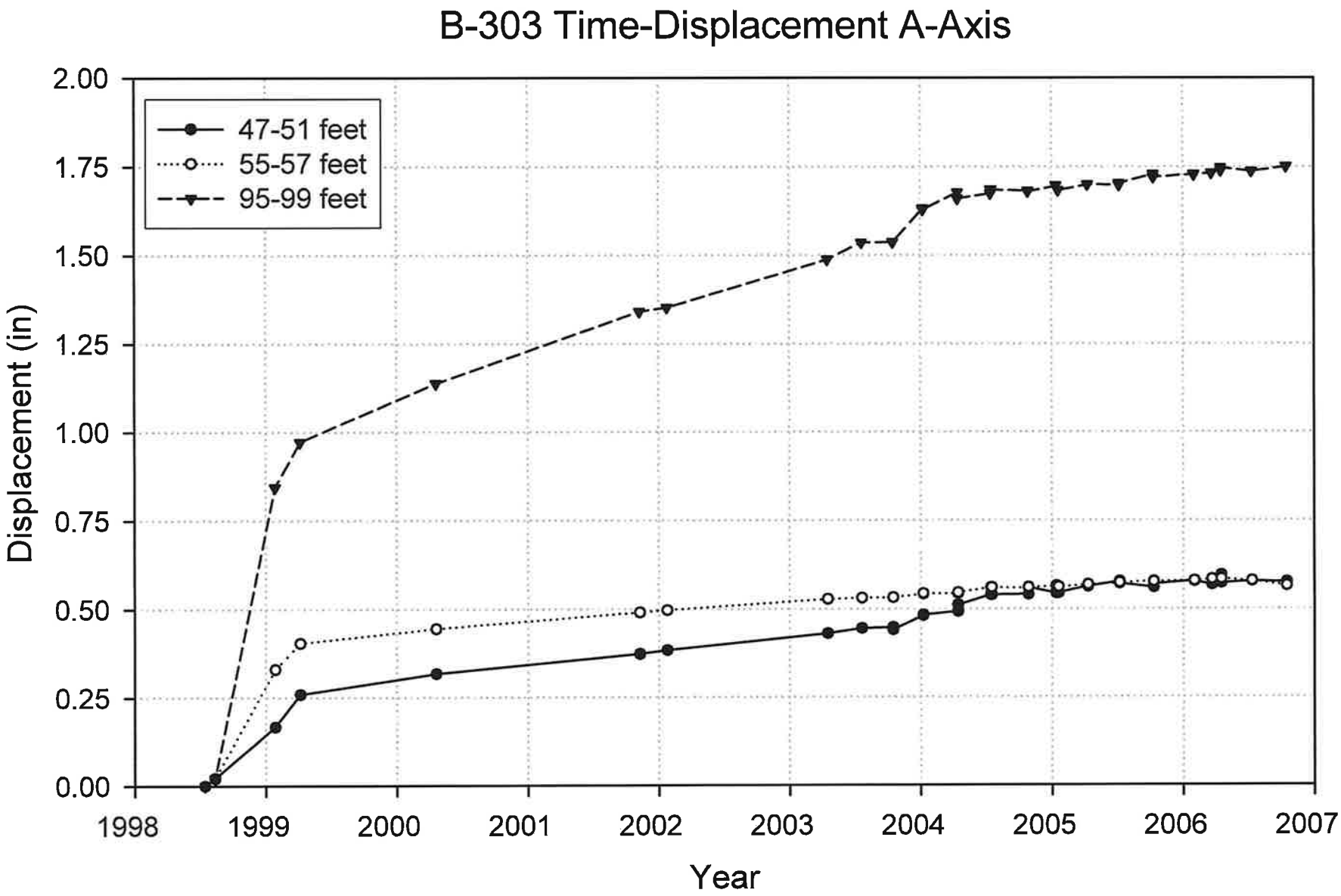
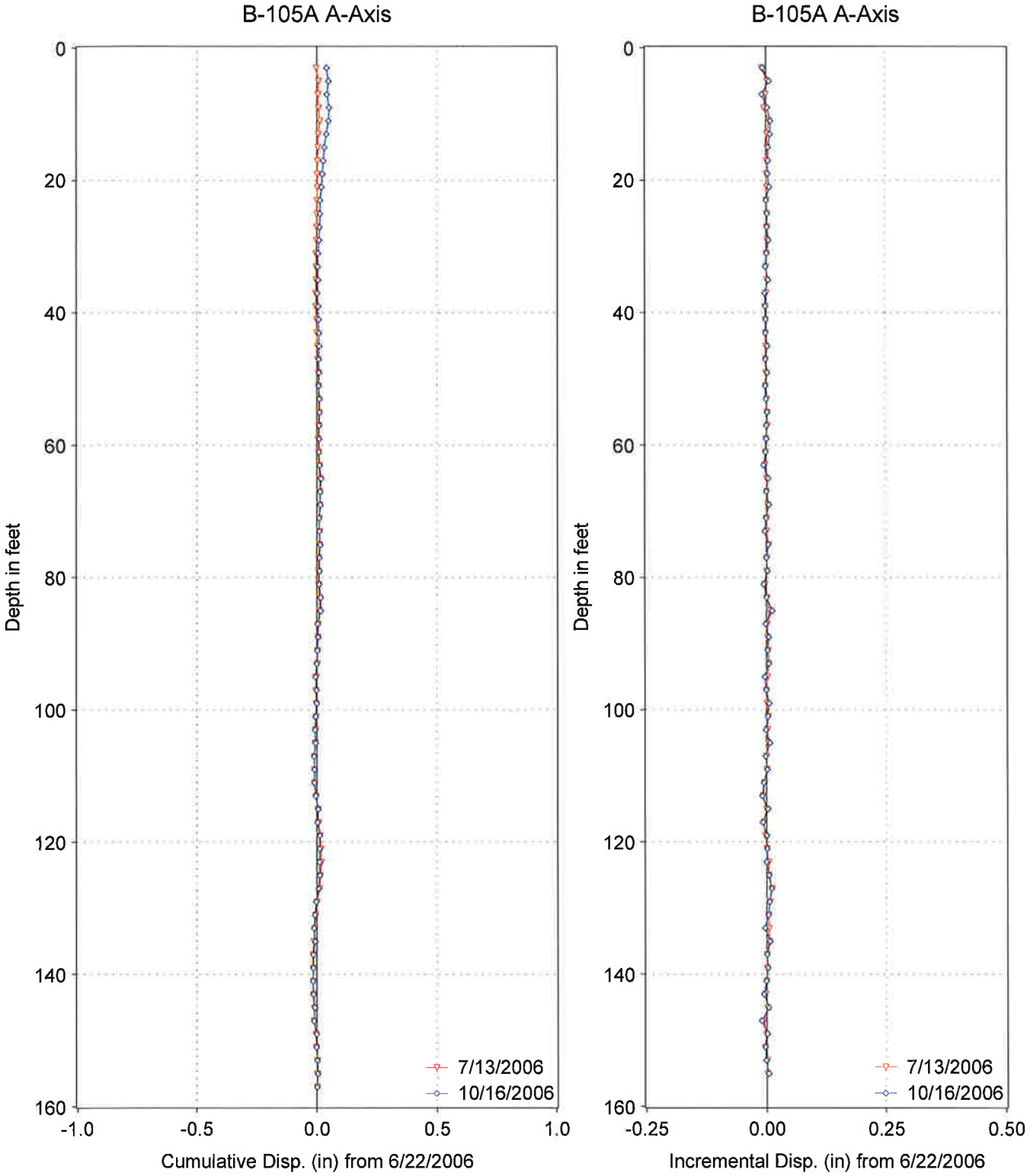
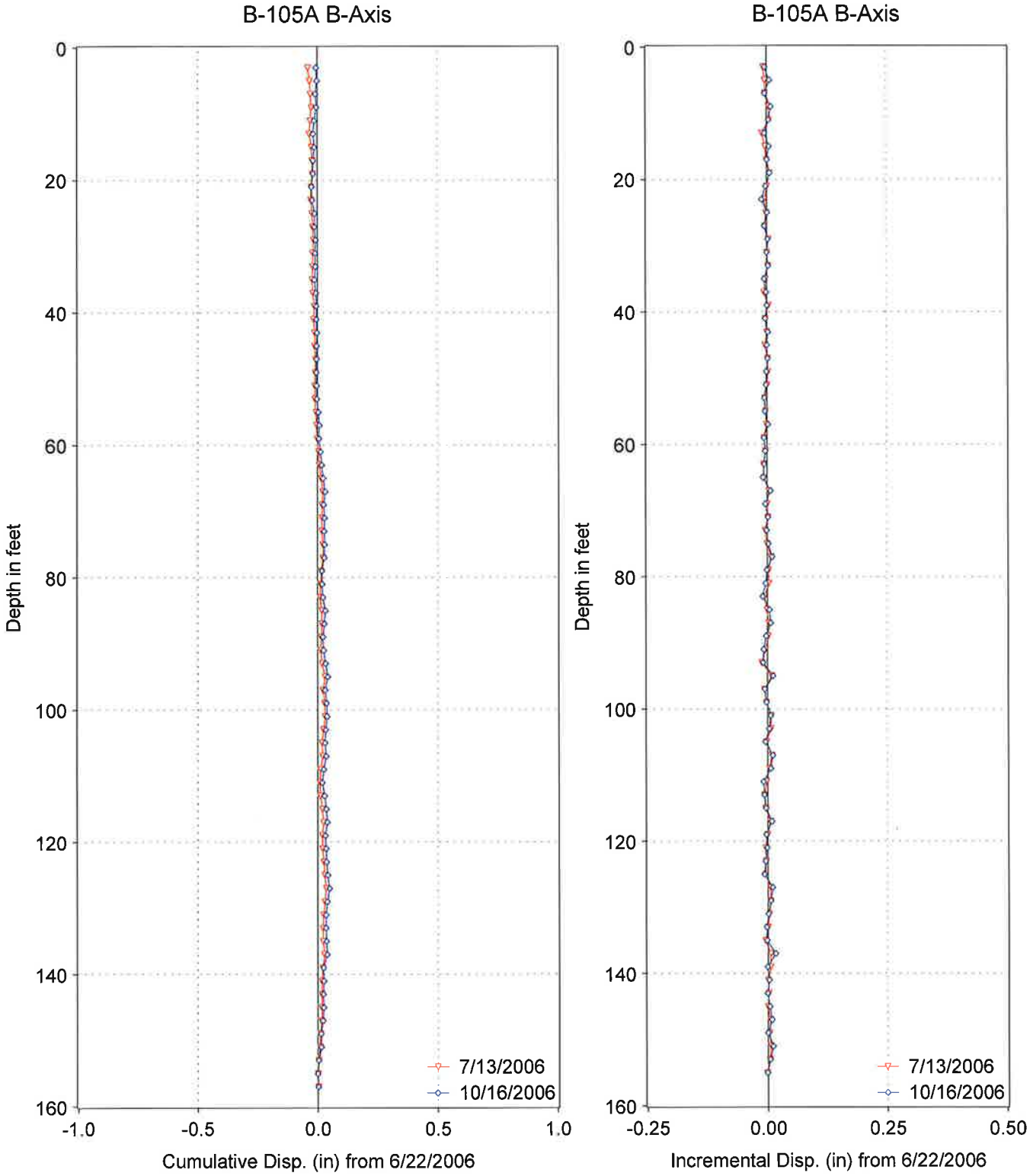

B-303 Time-Displacement A-Axis
47-51 feet
55-57 feet
95-99 feet
Displacement (in)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

PLATE 21



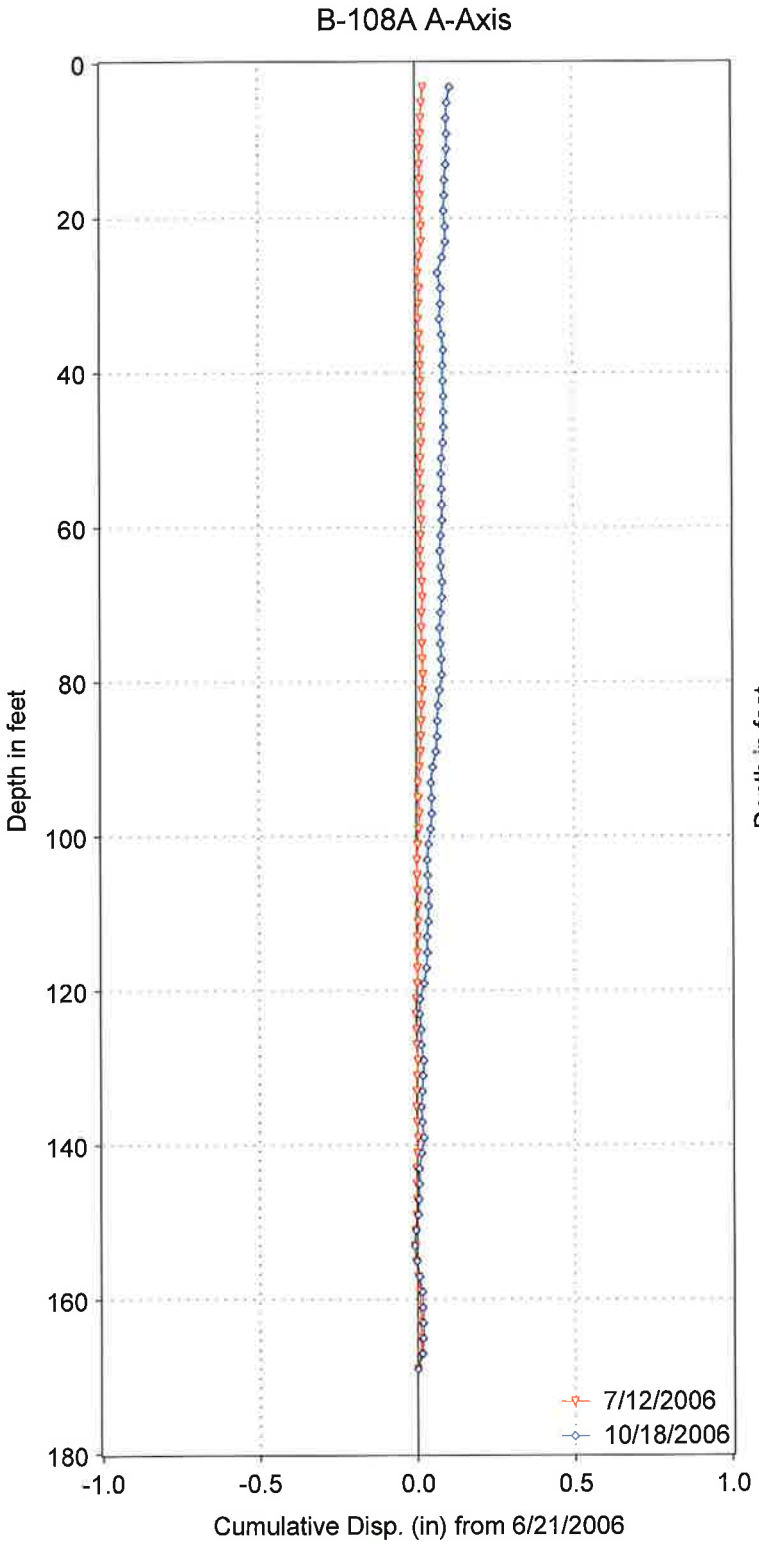
B-105A

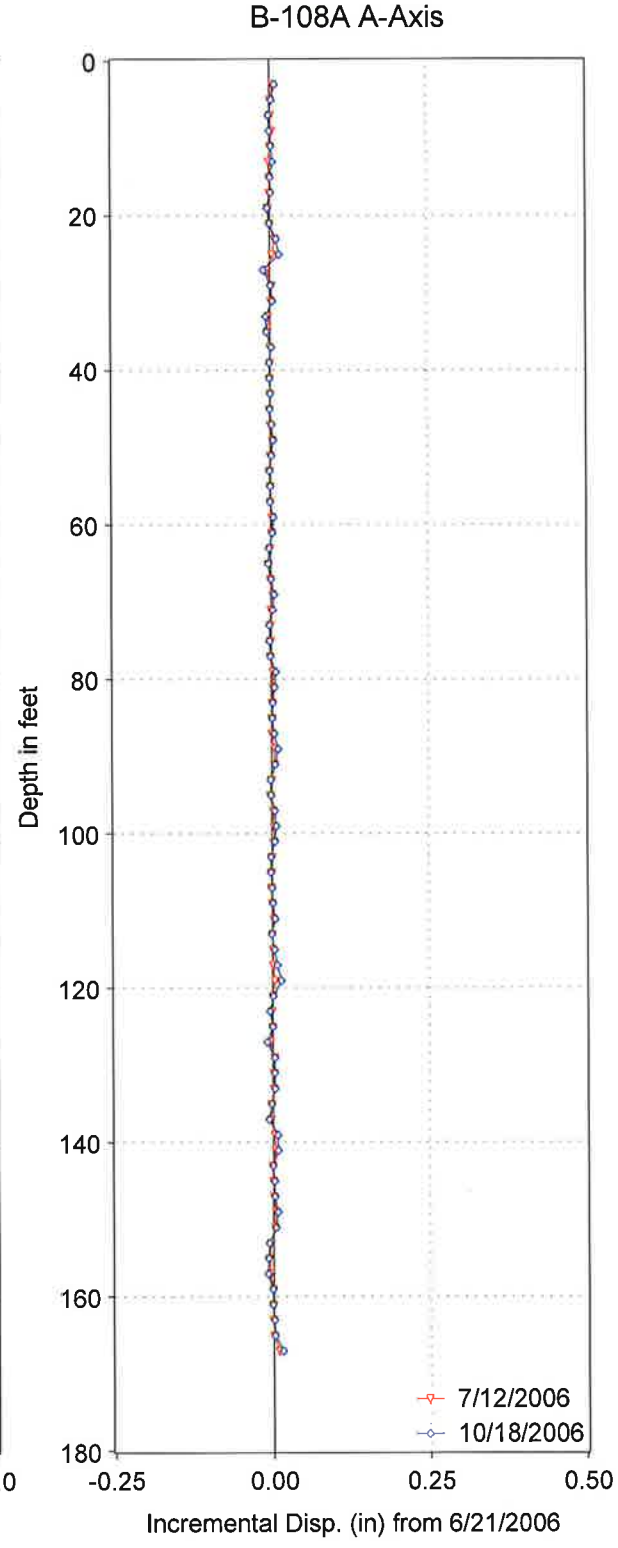
PLATE 22



B-105A

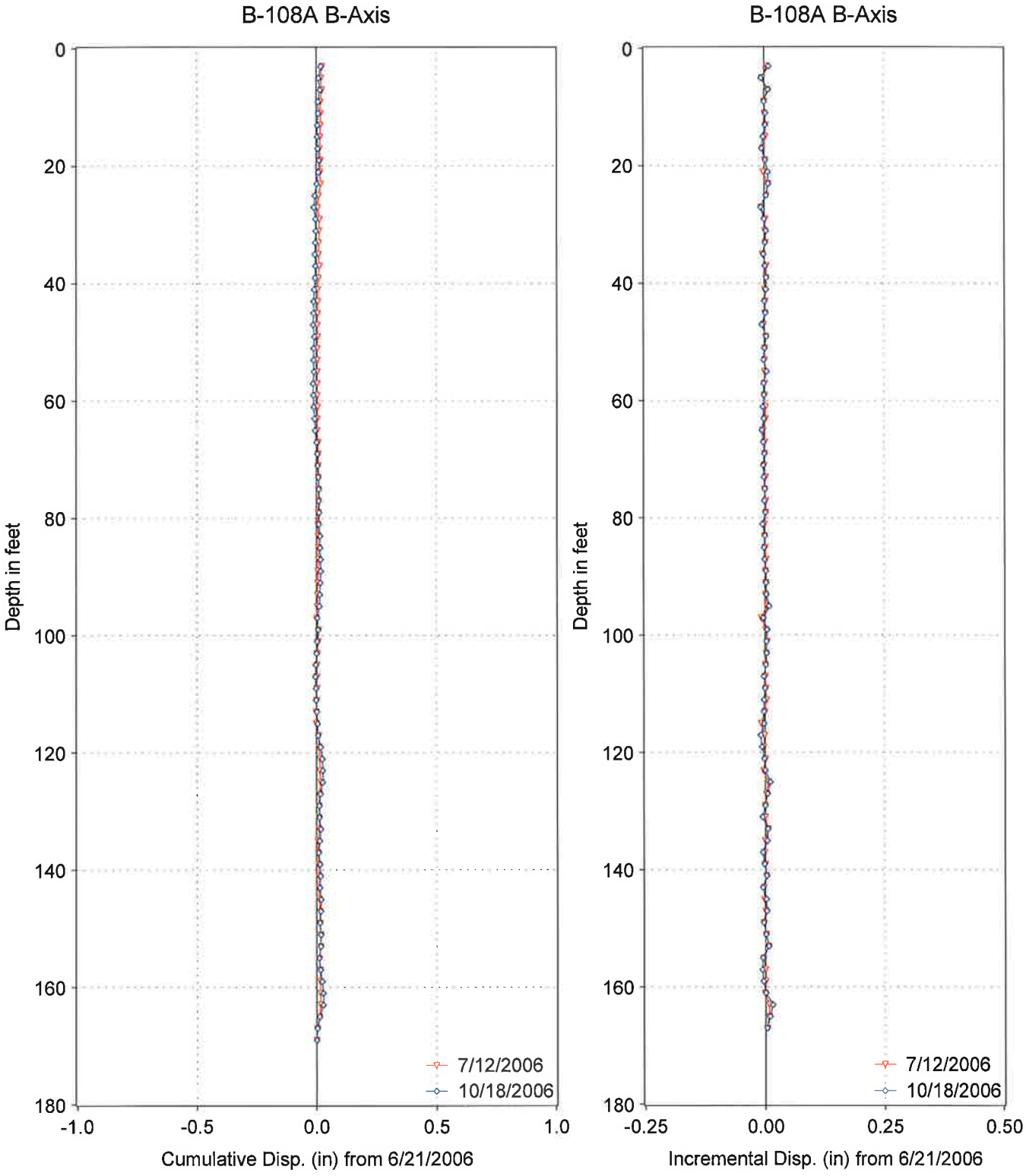
PLATE 23





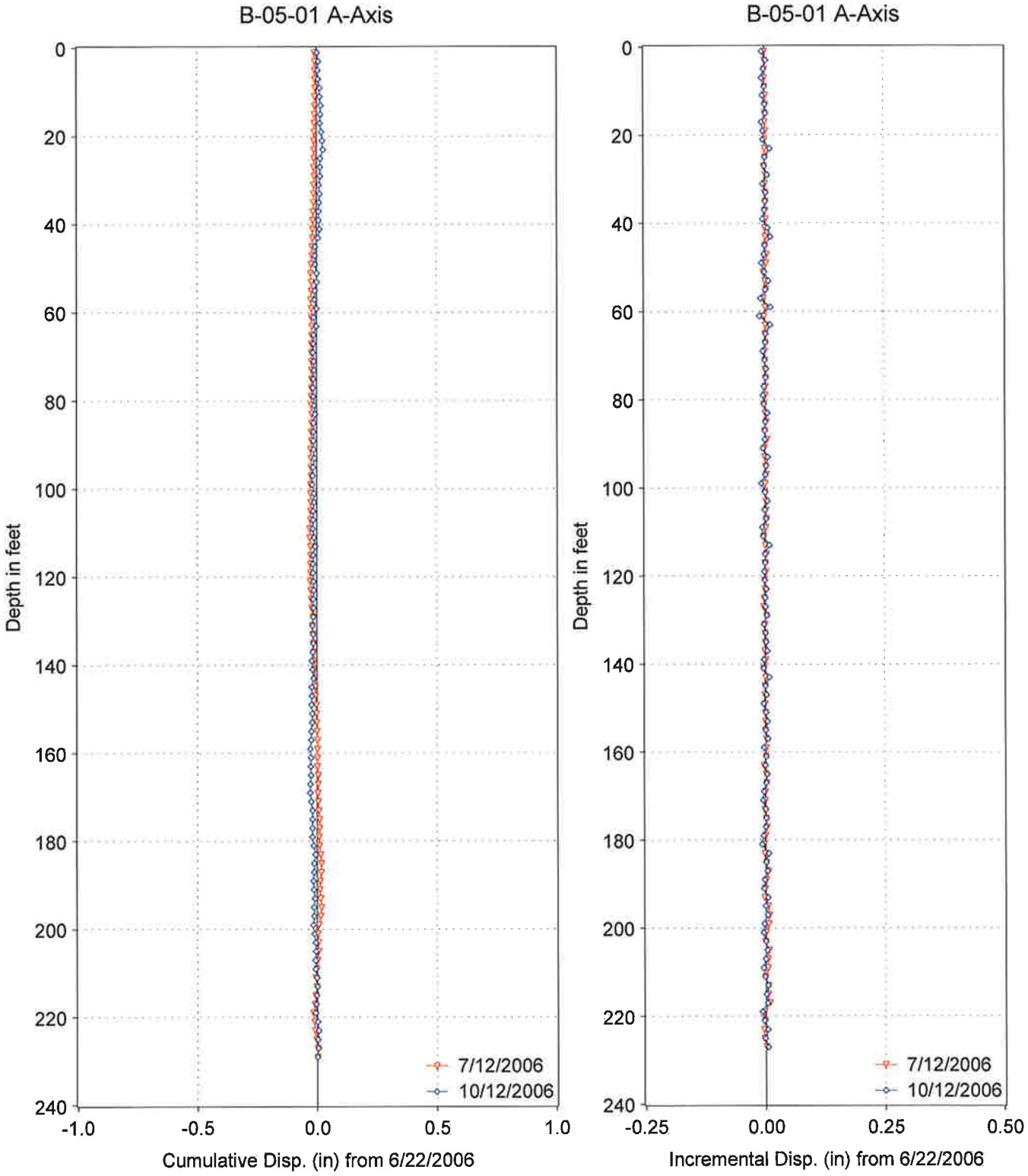
B-108A

PLATE 24



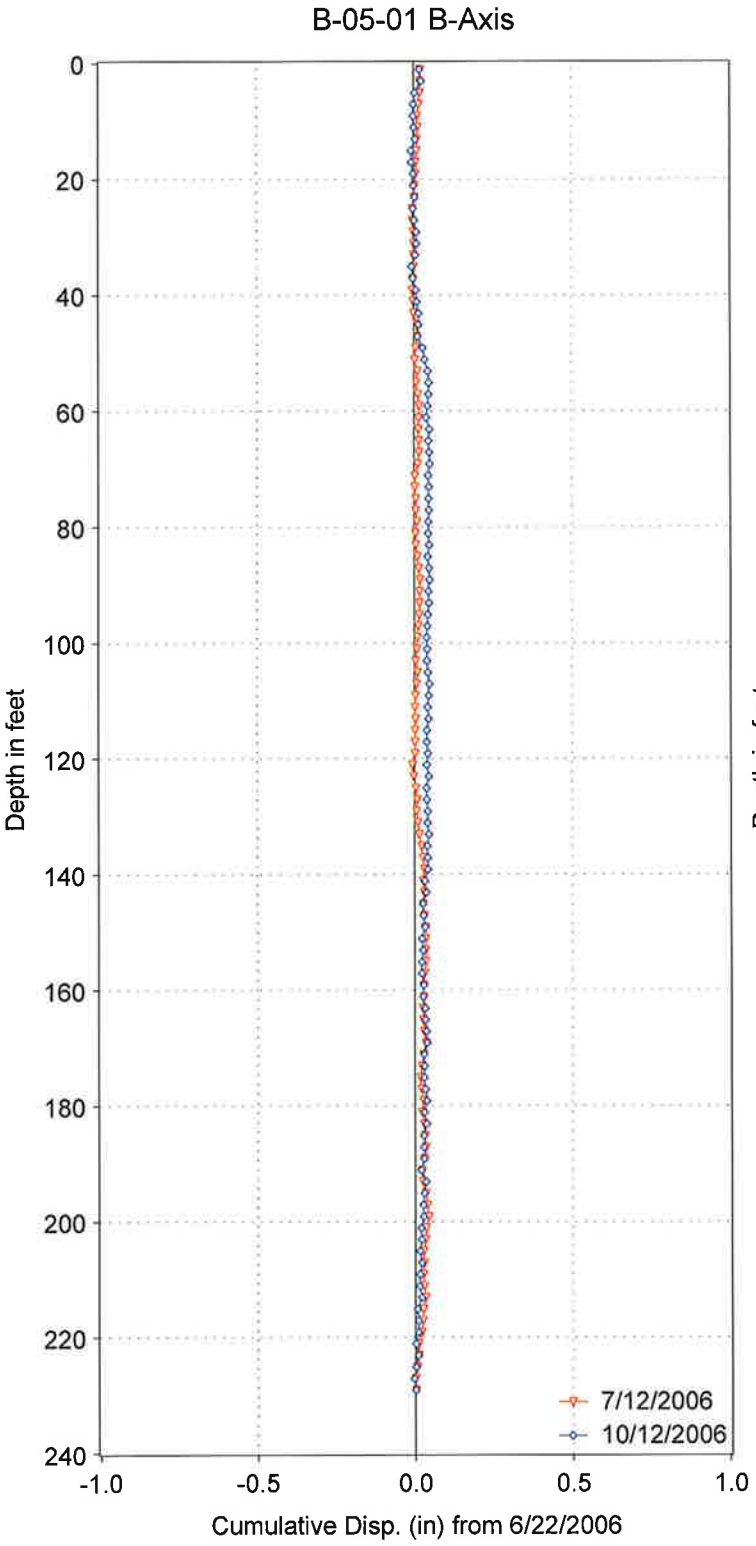
B-108A

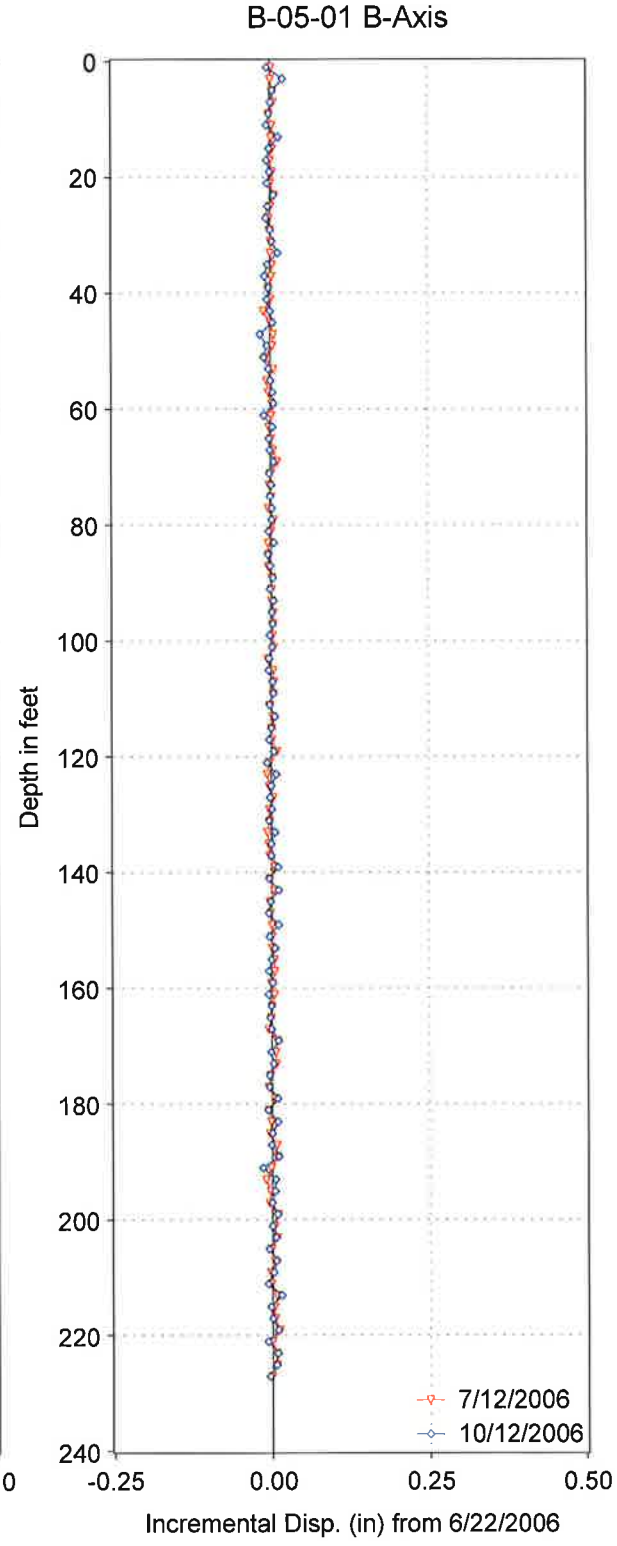
PLATE 25



B-05-01

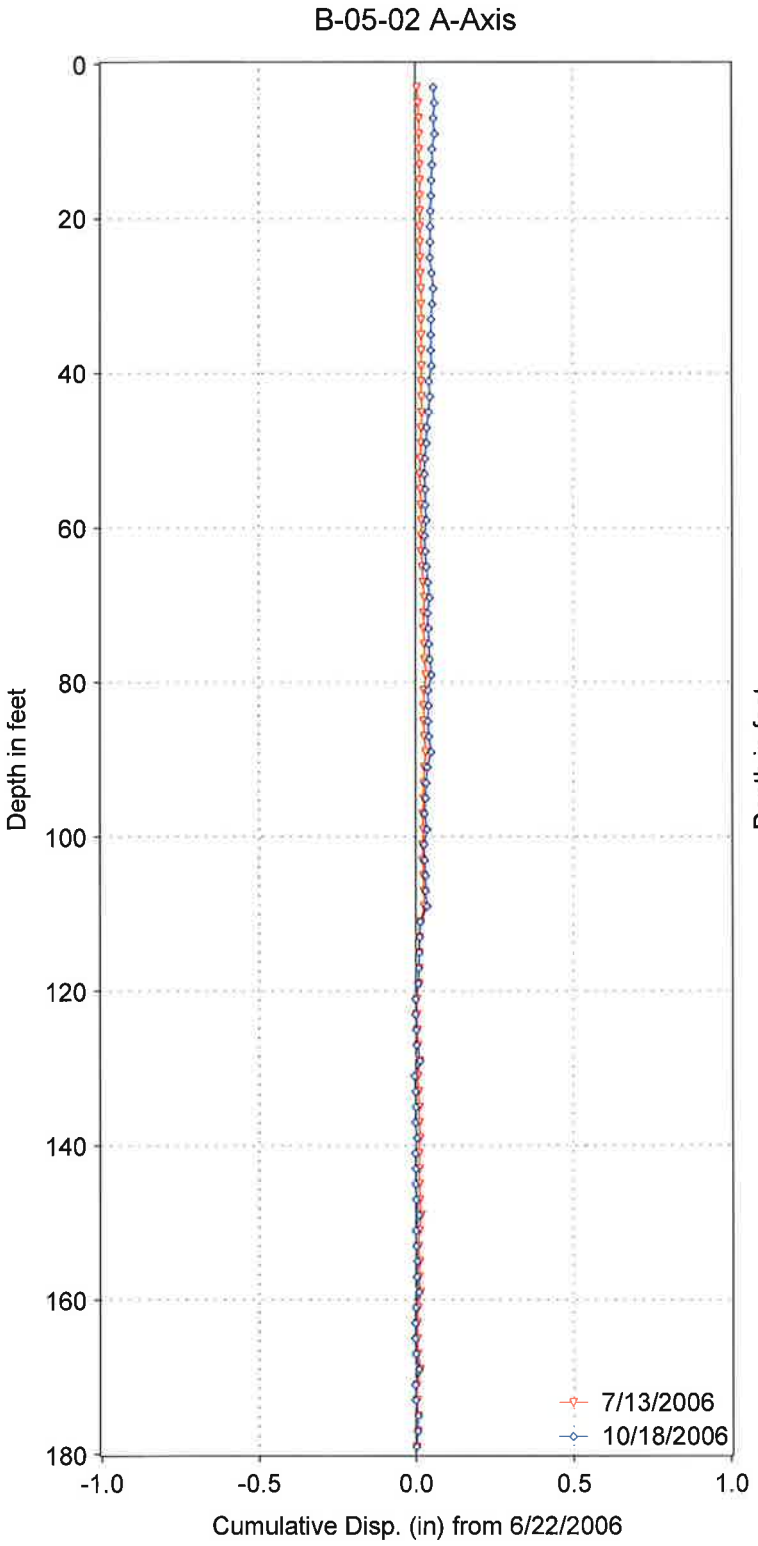
PLATE 26

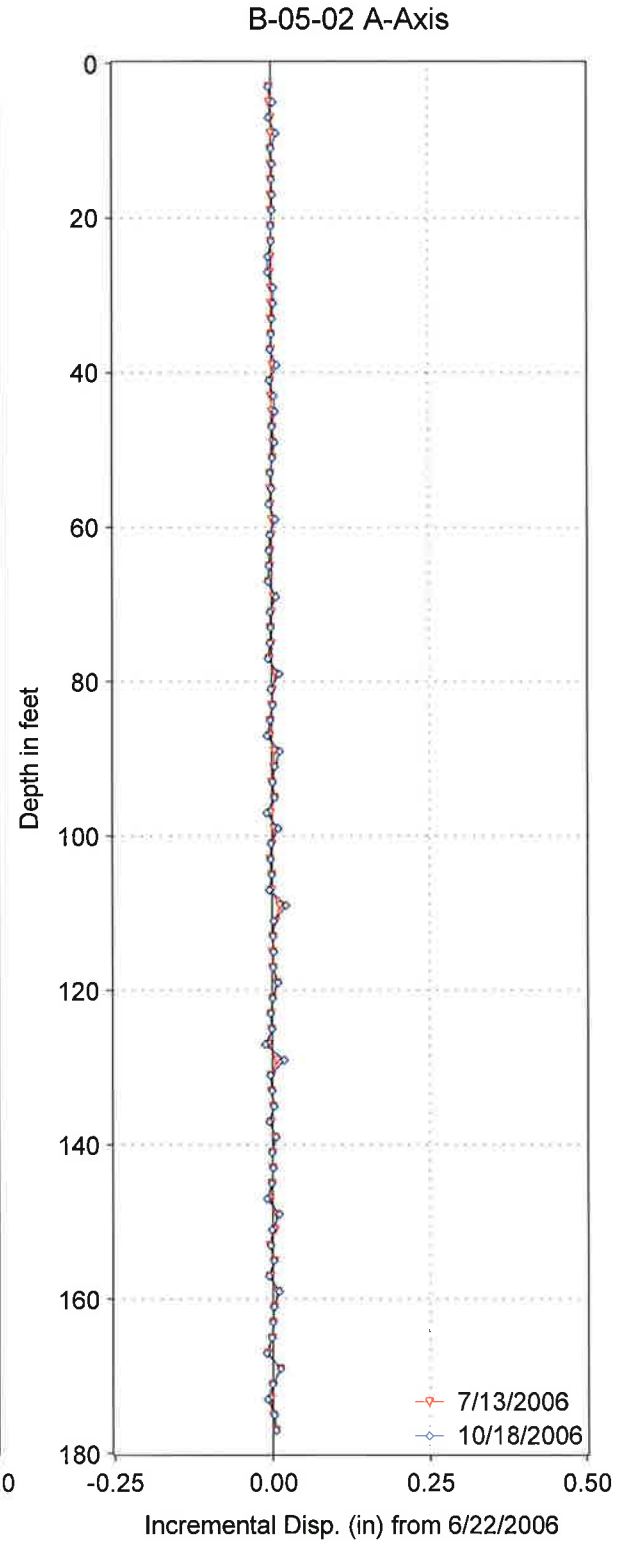




B-05-01

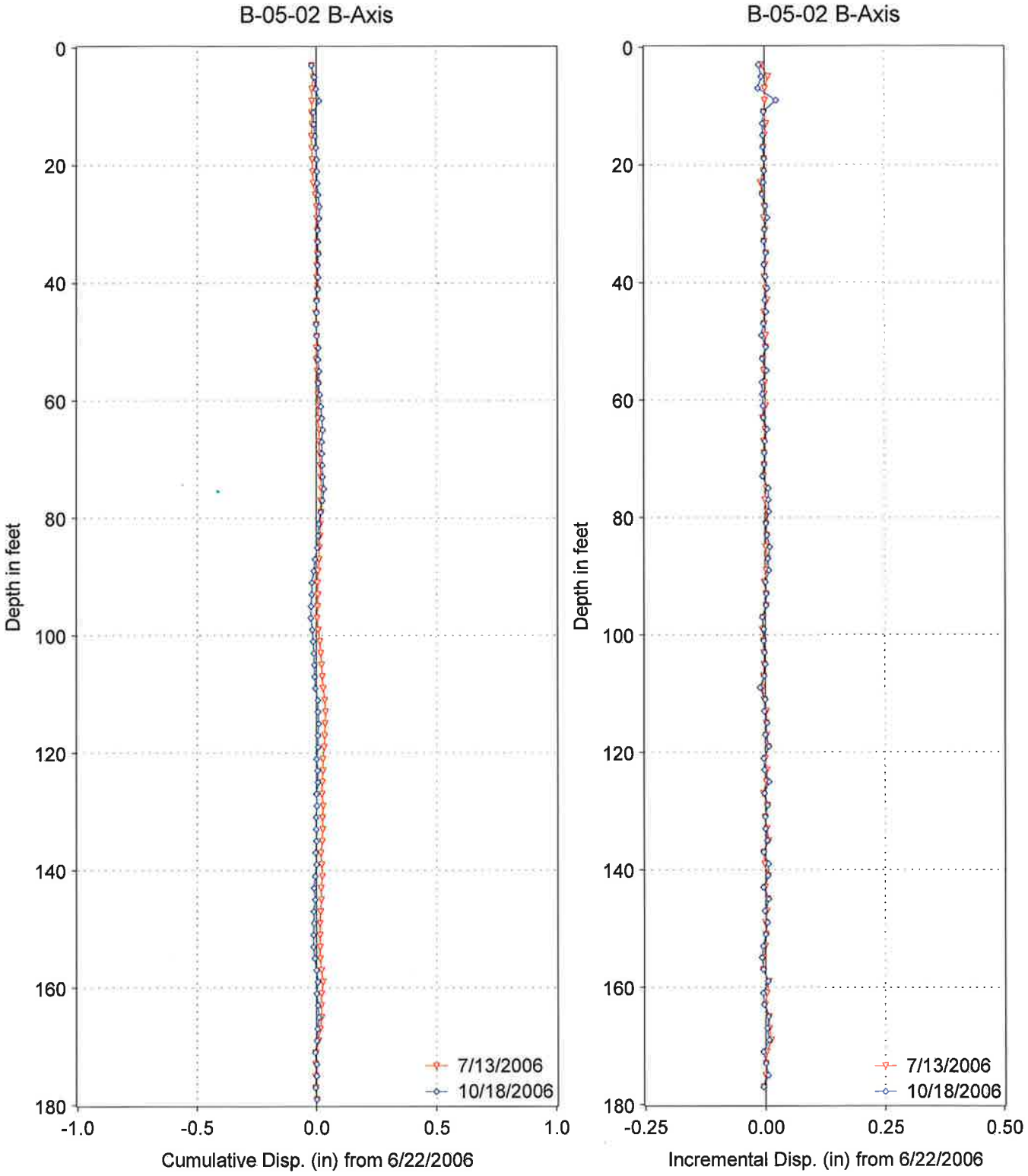
PLATE 27





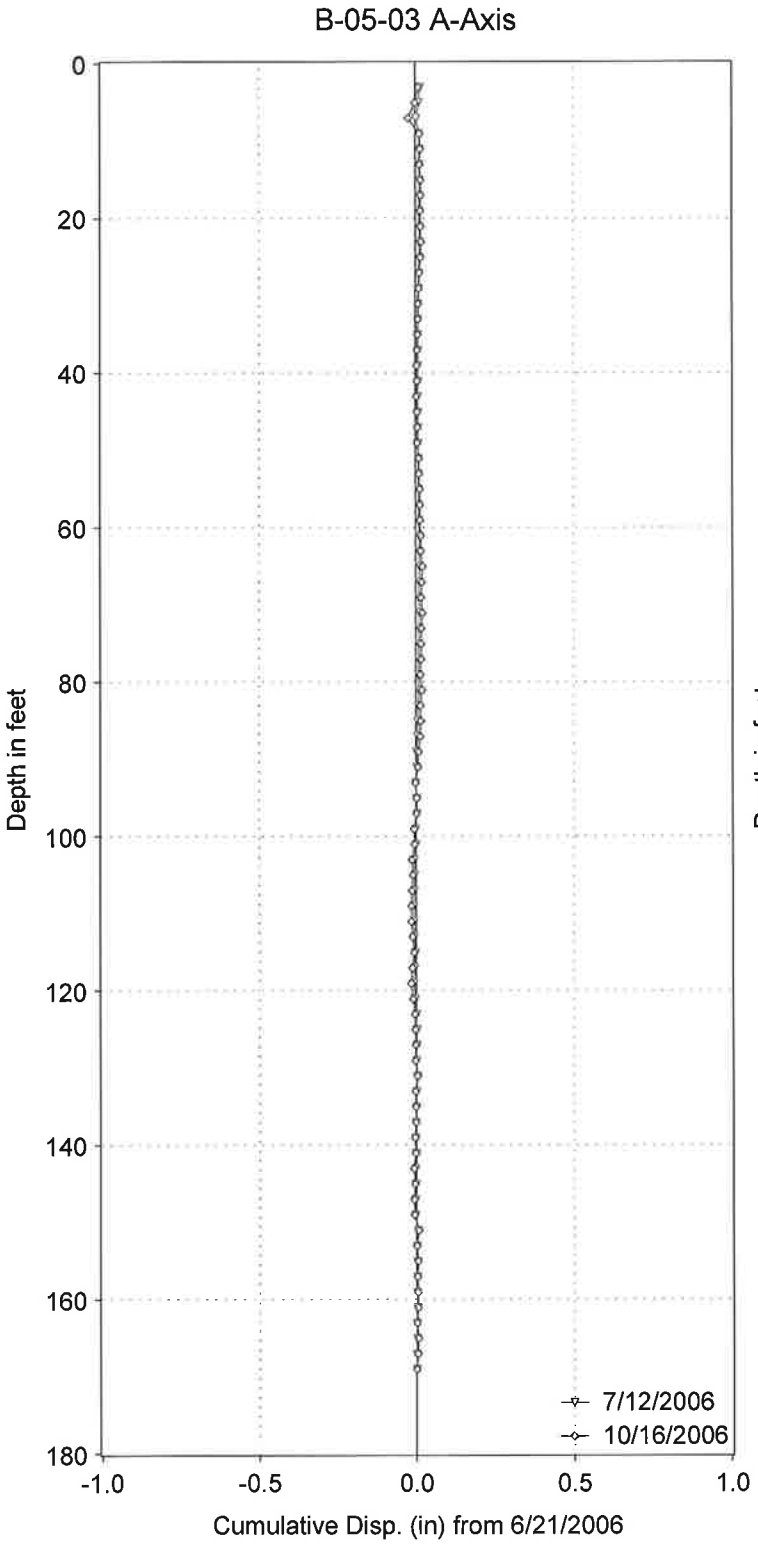
B-05-02

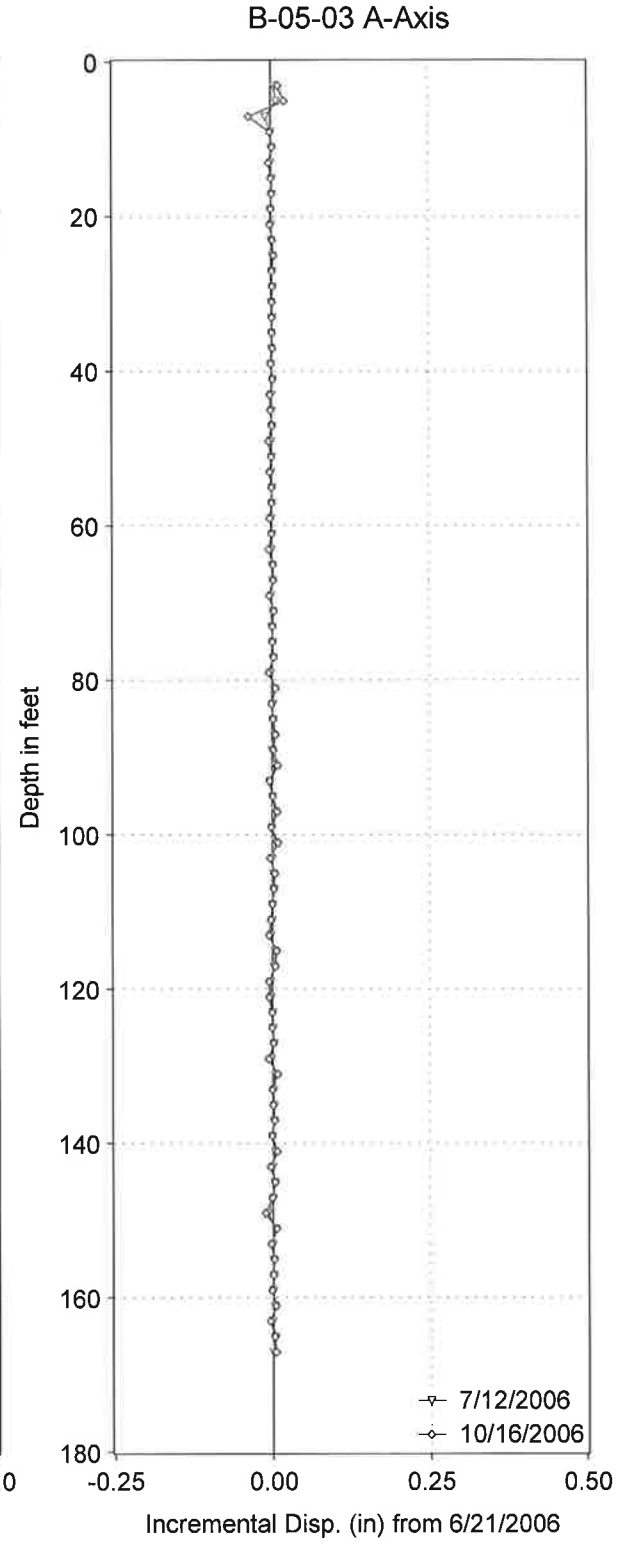
PLATE 28



B-05-02

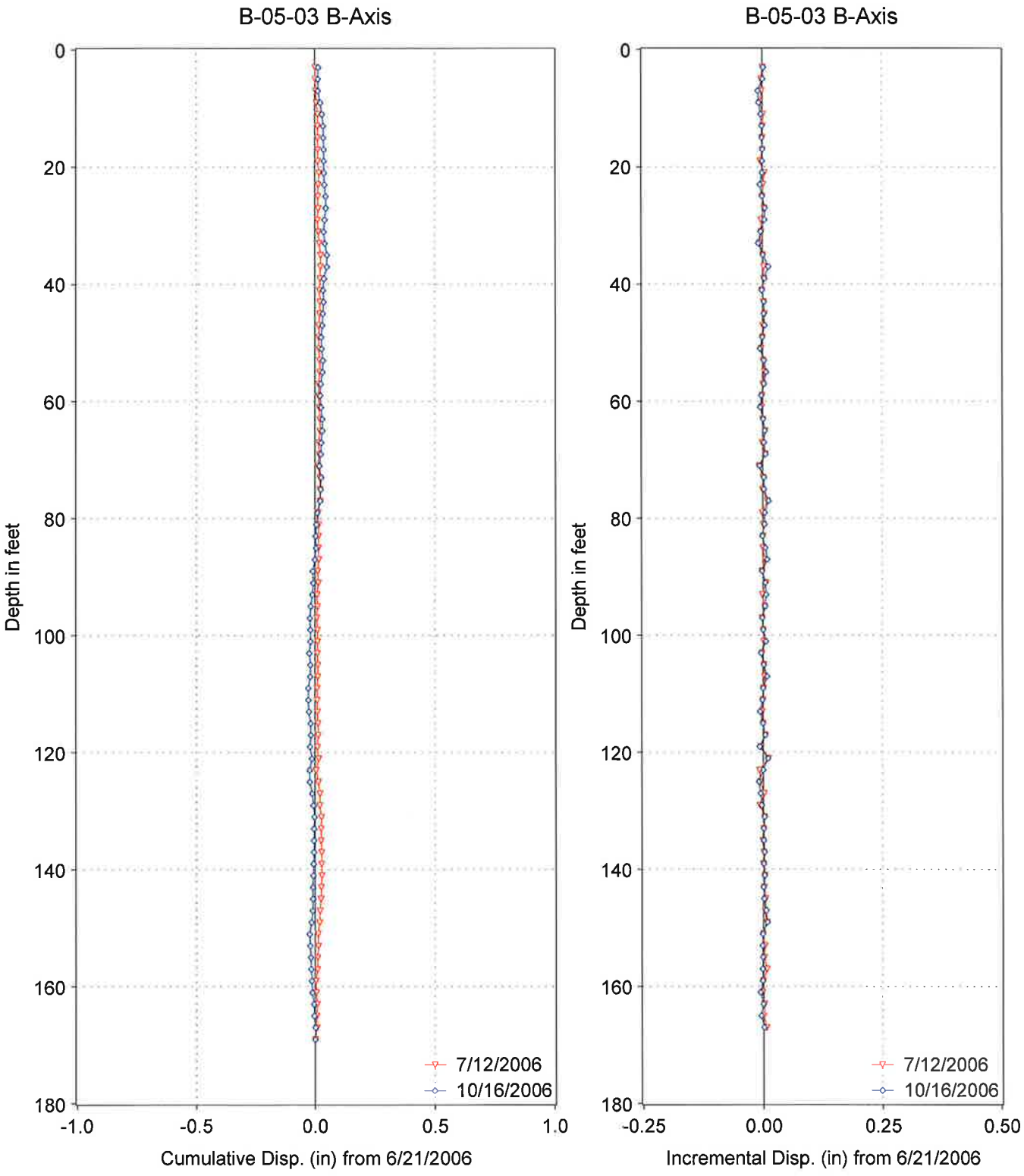
PLATE 29





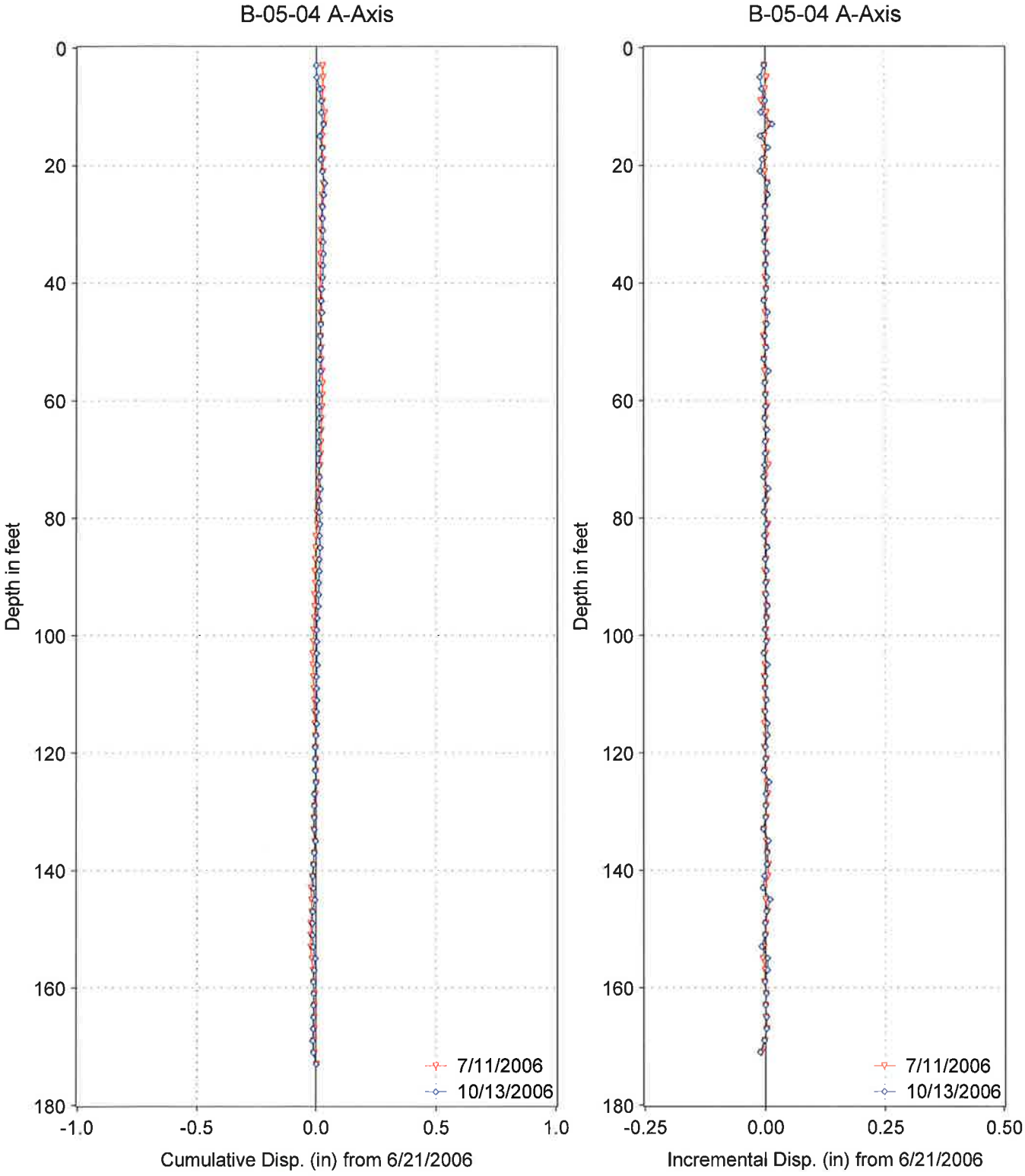
B-05-03

PLATE 30



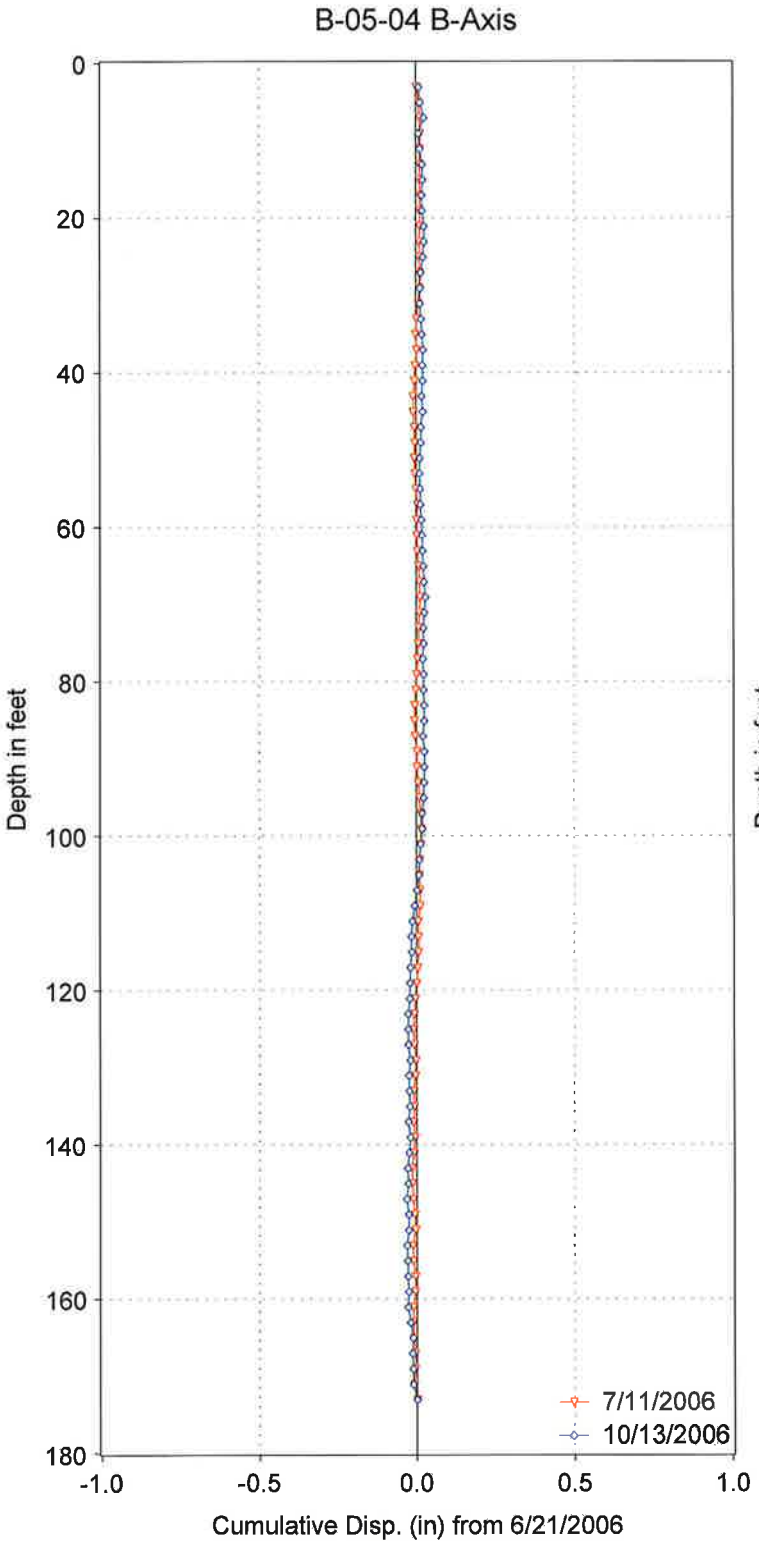
B-05-03

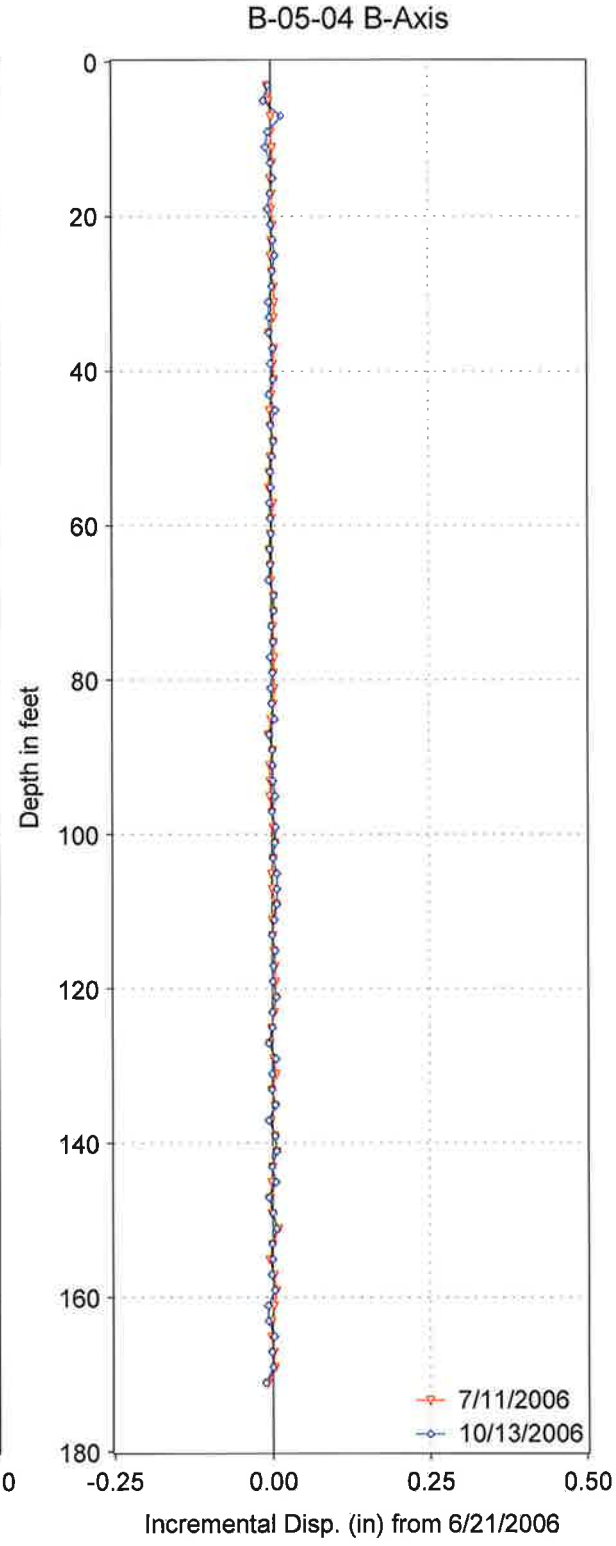
PLATE 31



B-05-04

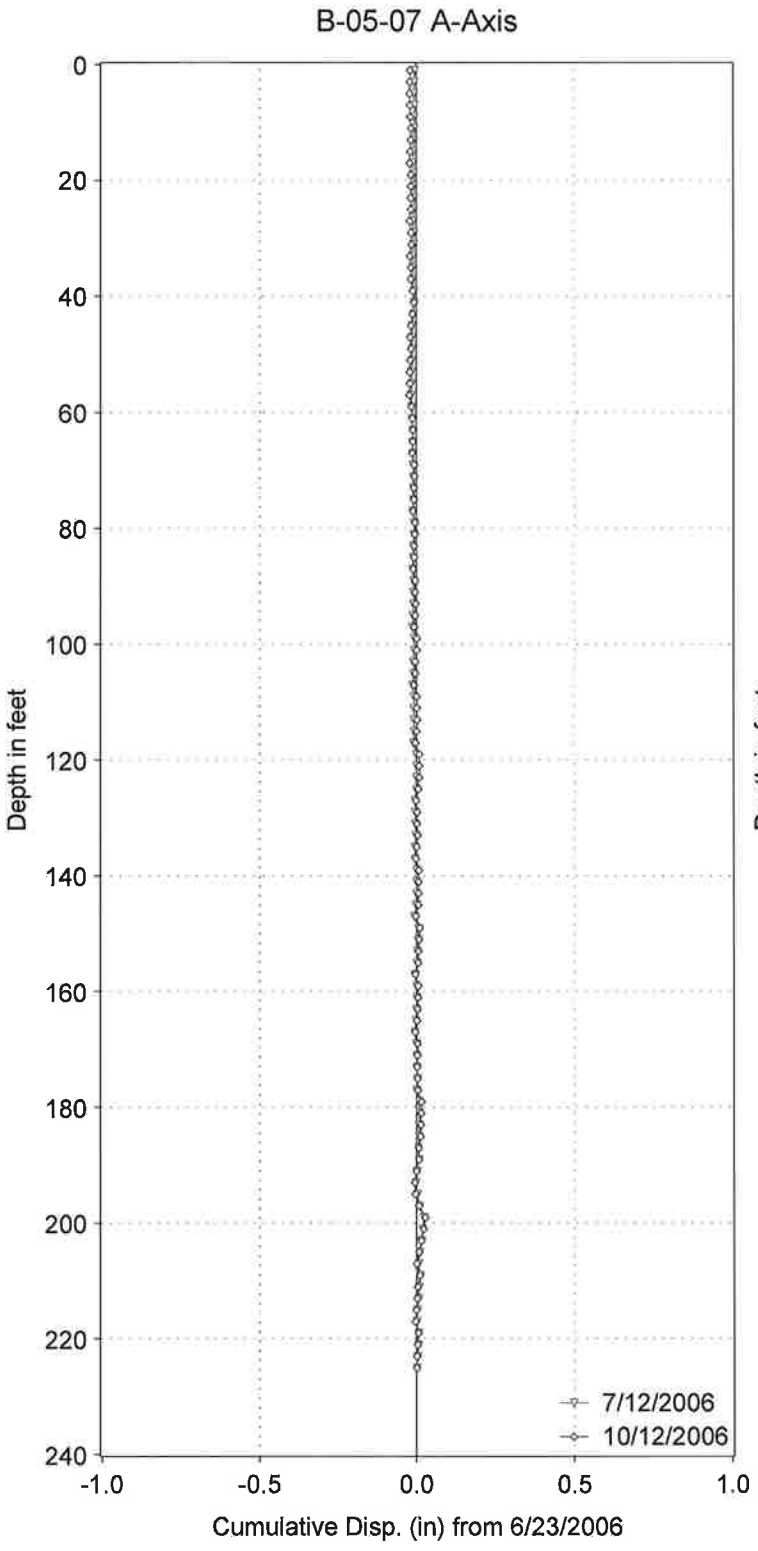
PLATE 32

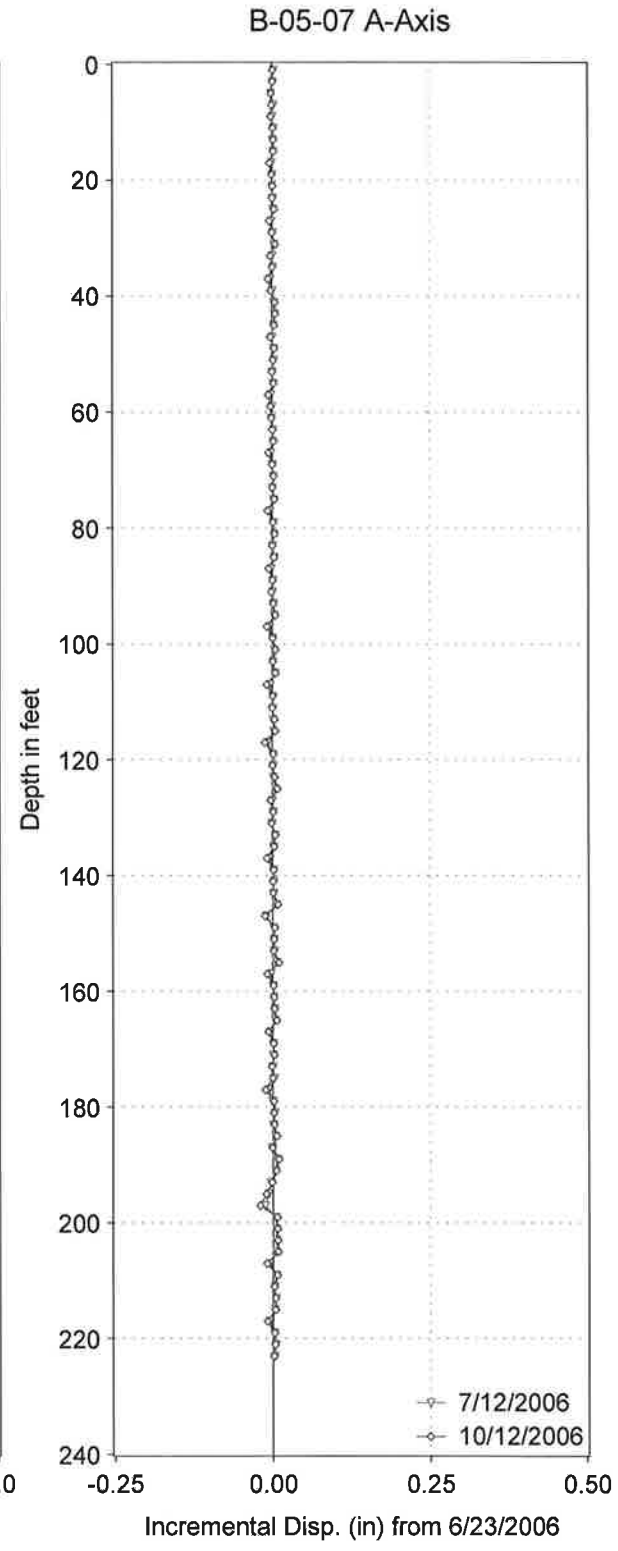




B-05-04

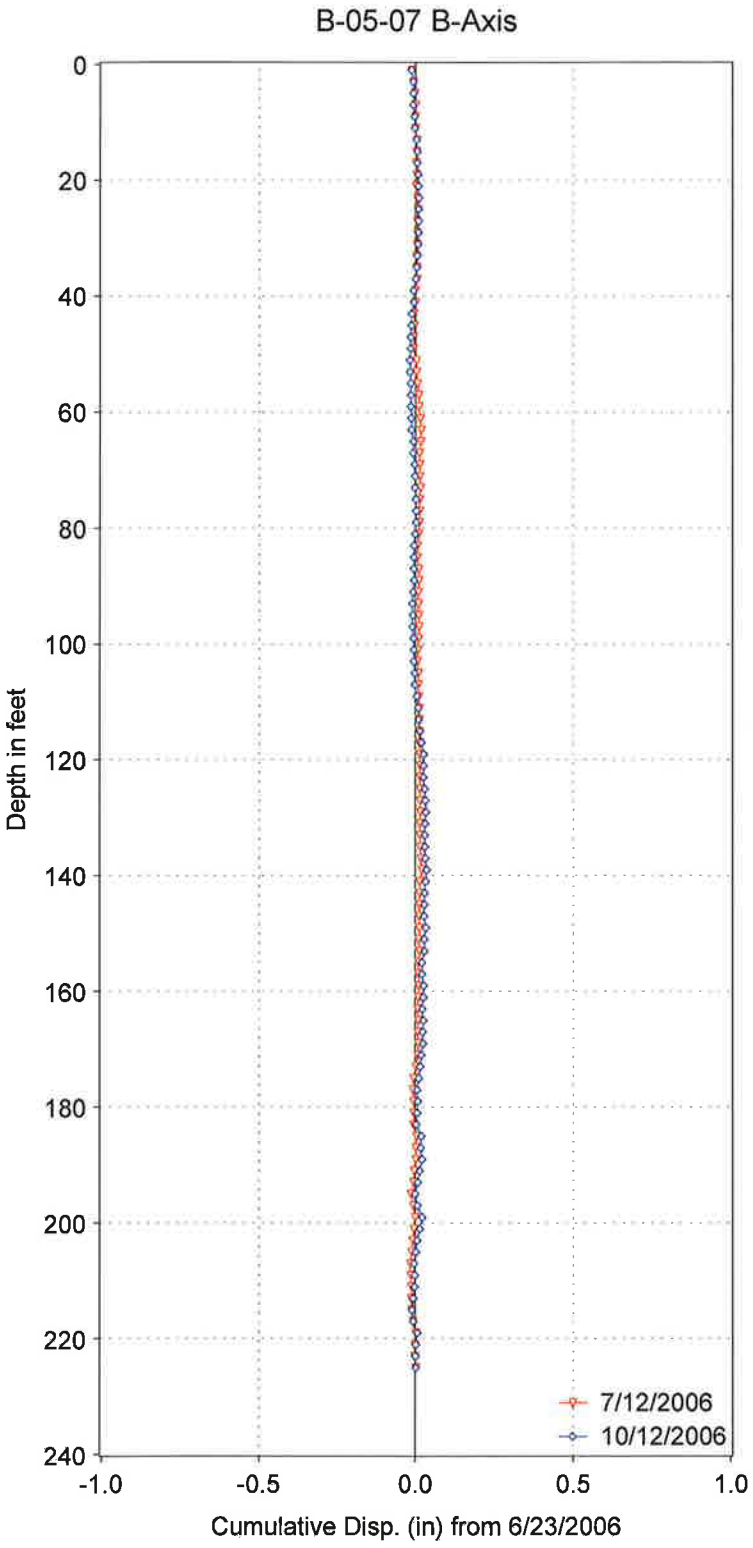
PLATE 33

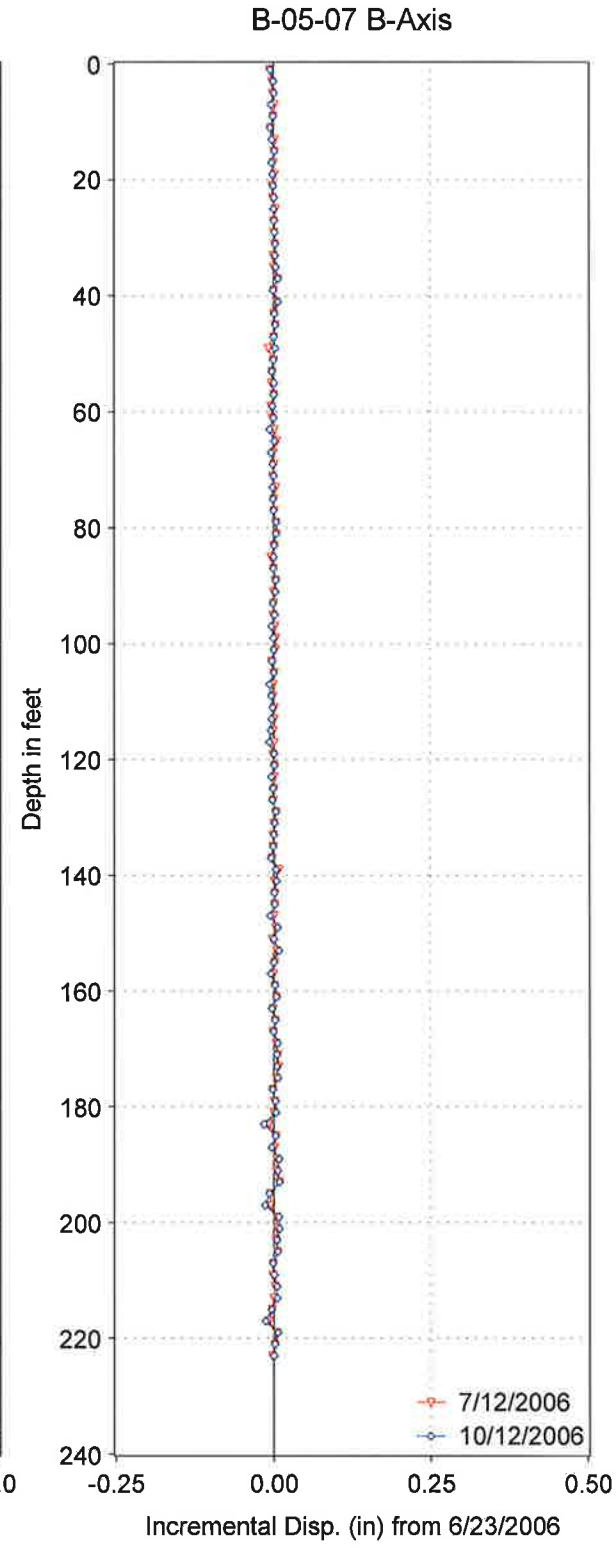




B-05-07

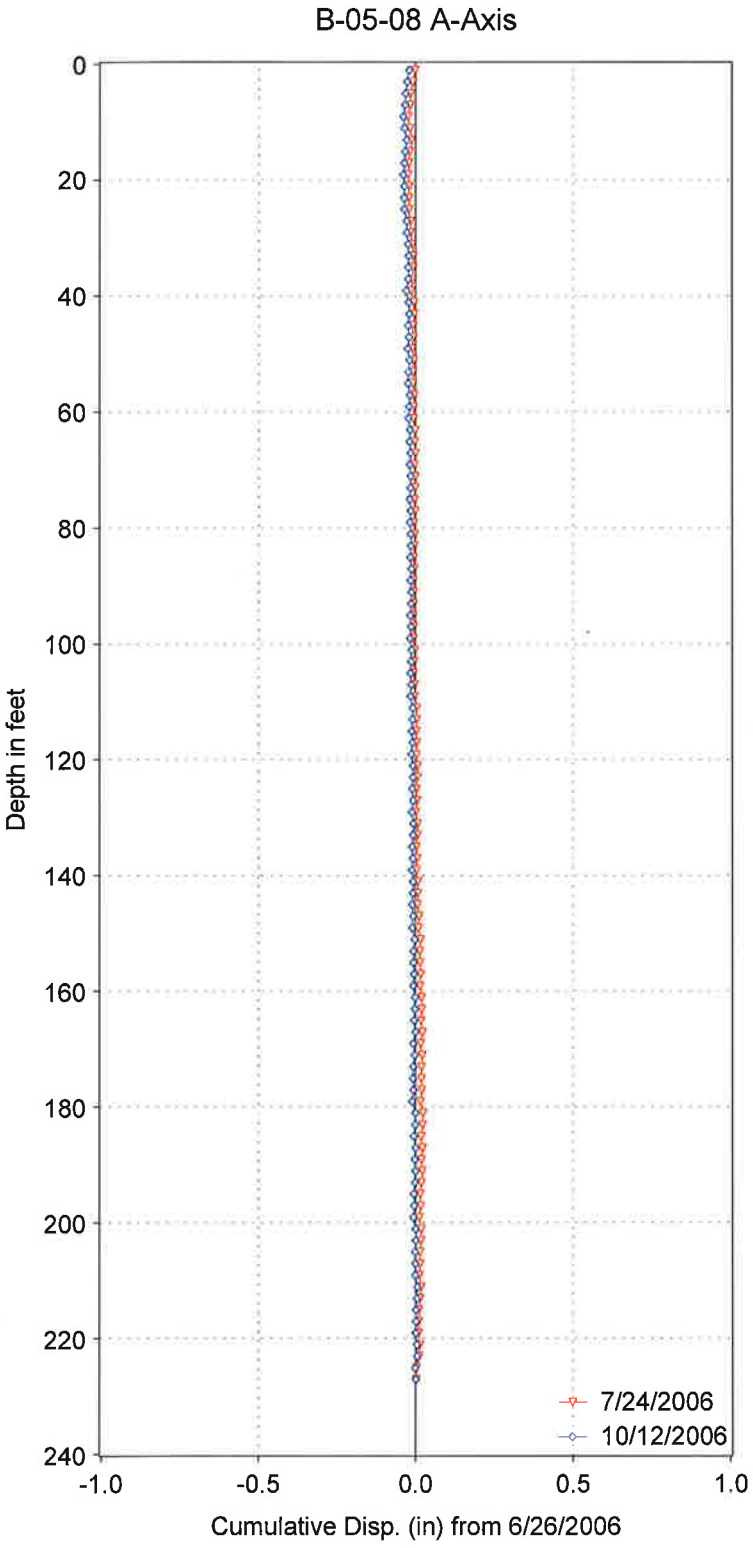
PLATE 34

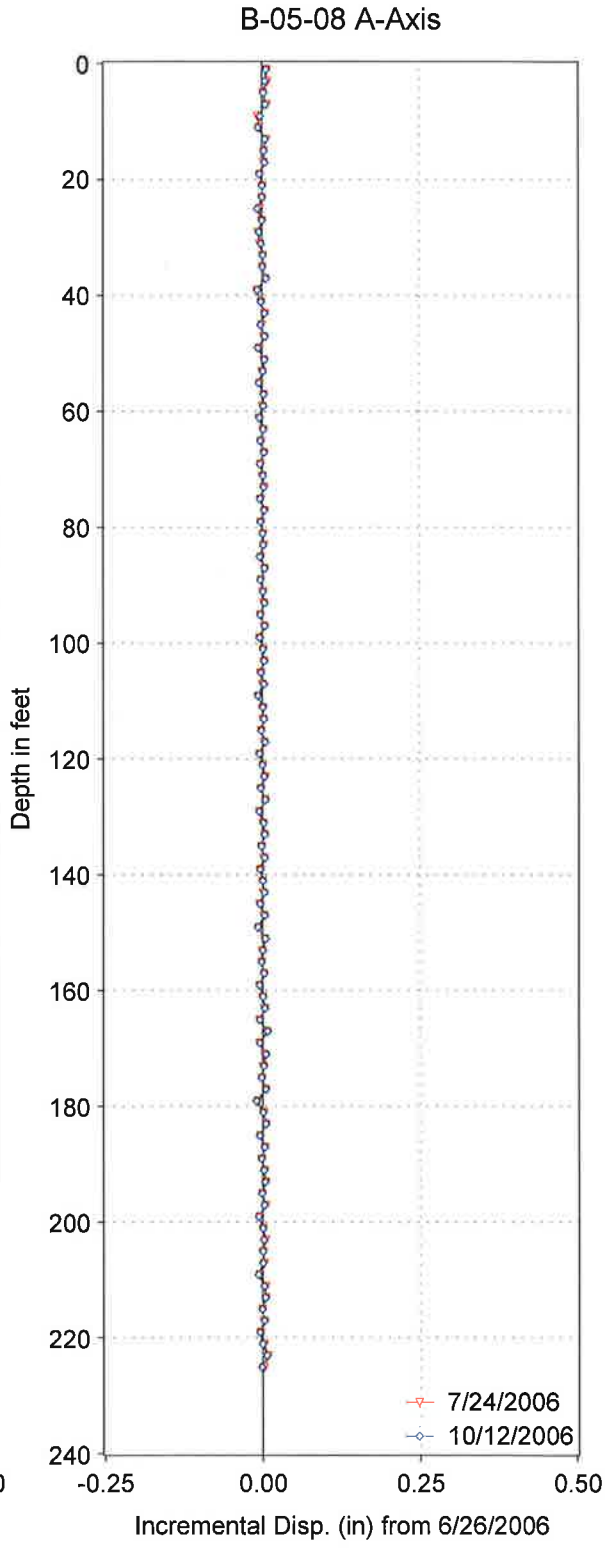




B-05-07

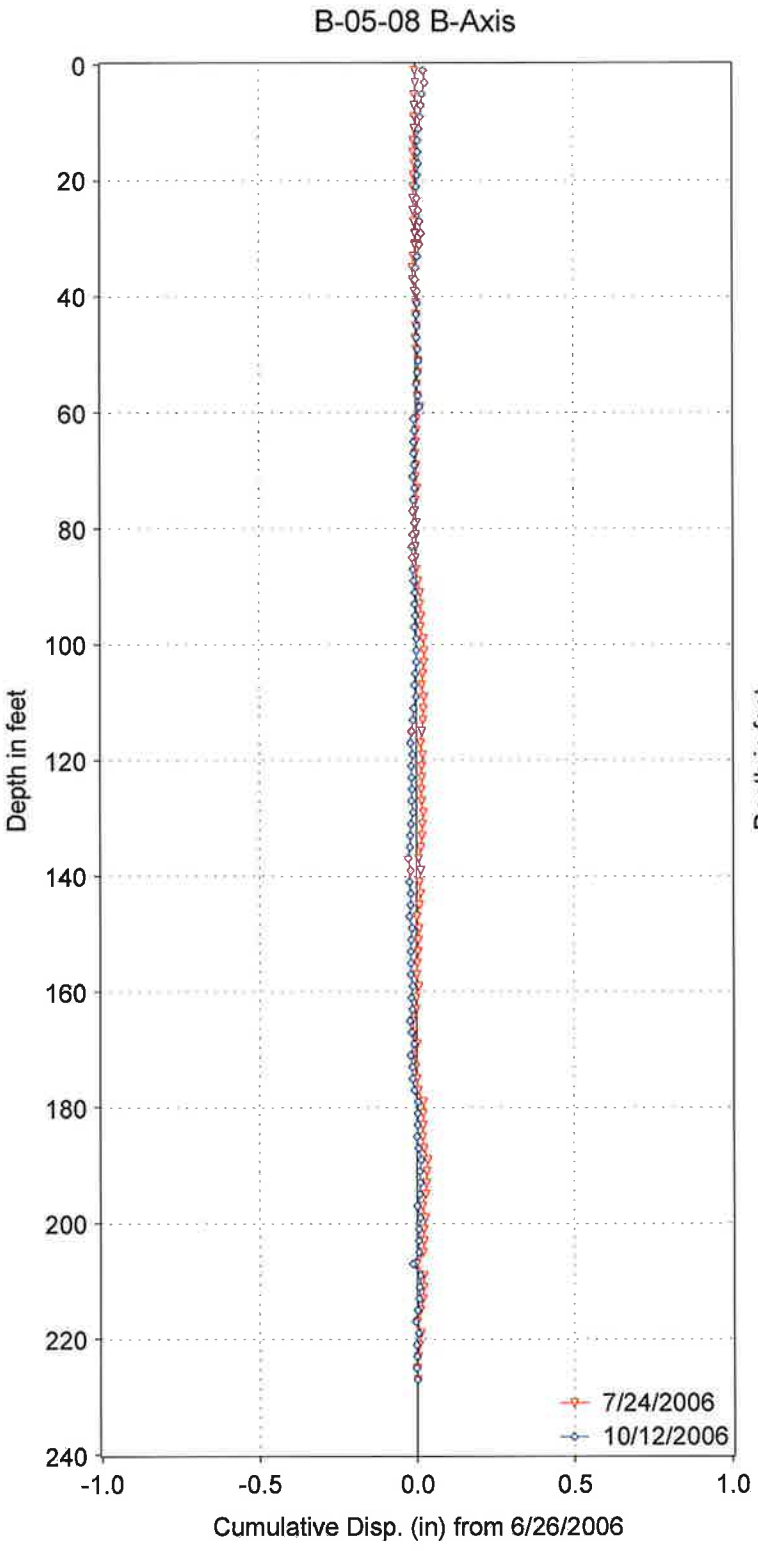
PLATE 35

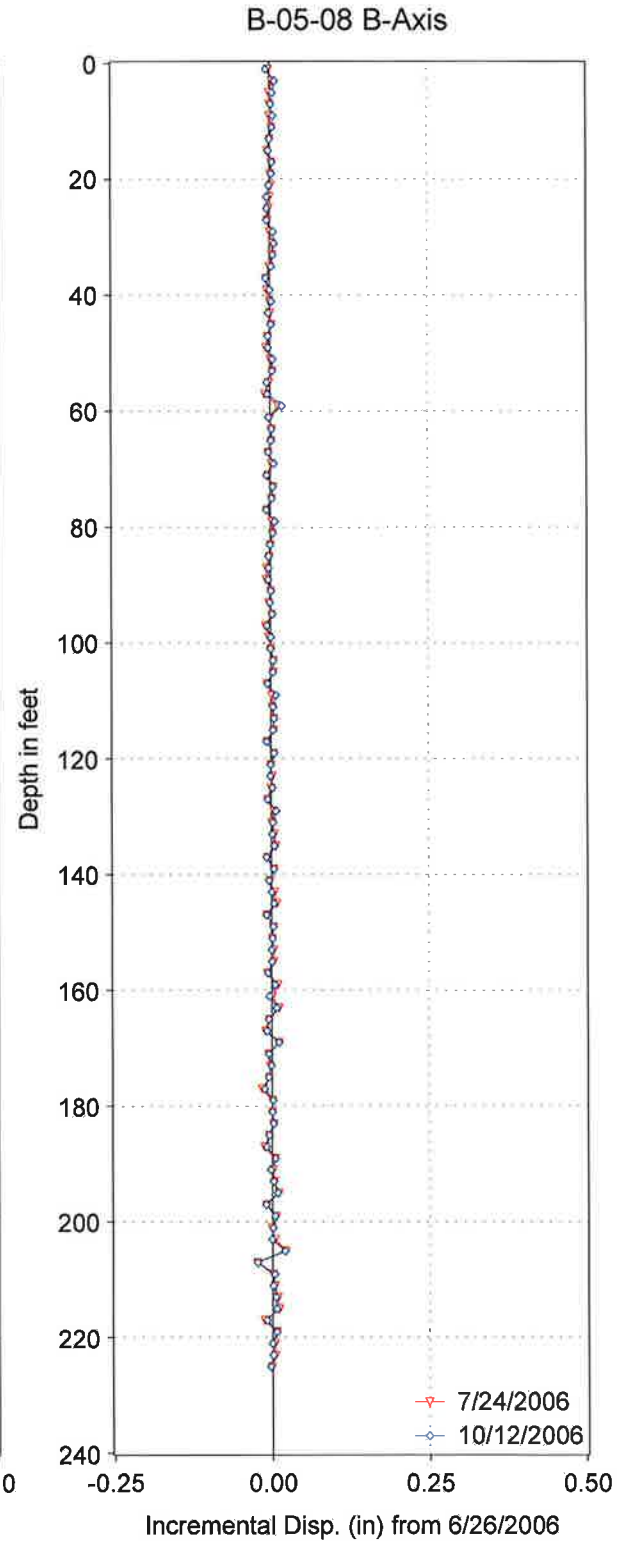




B-05-08

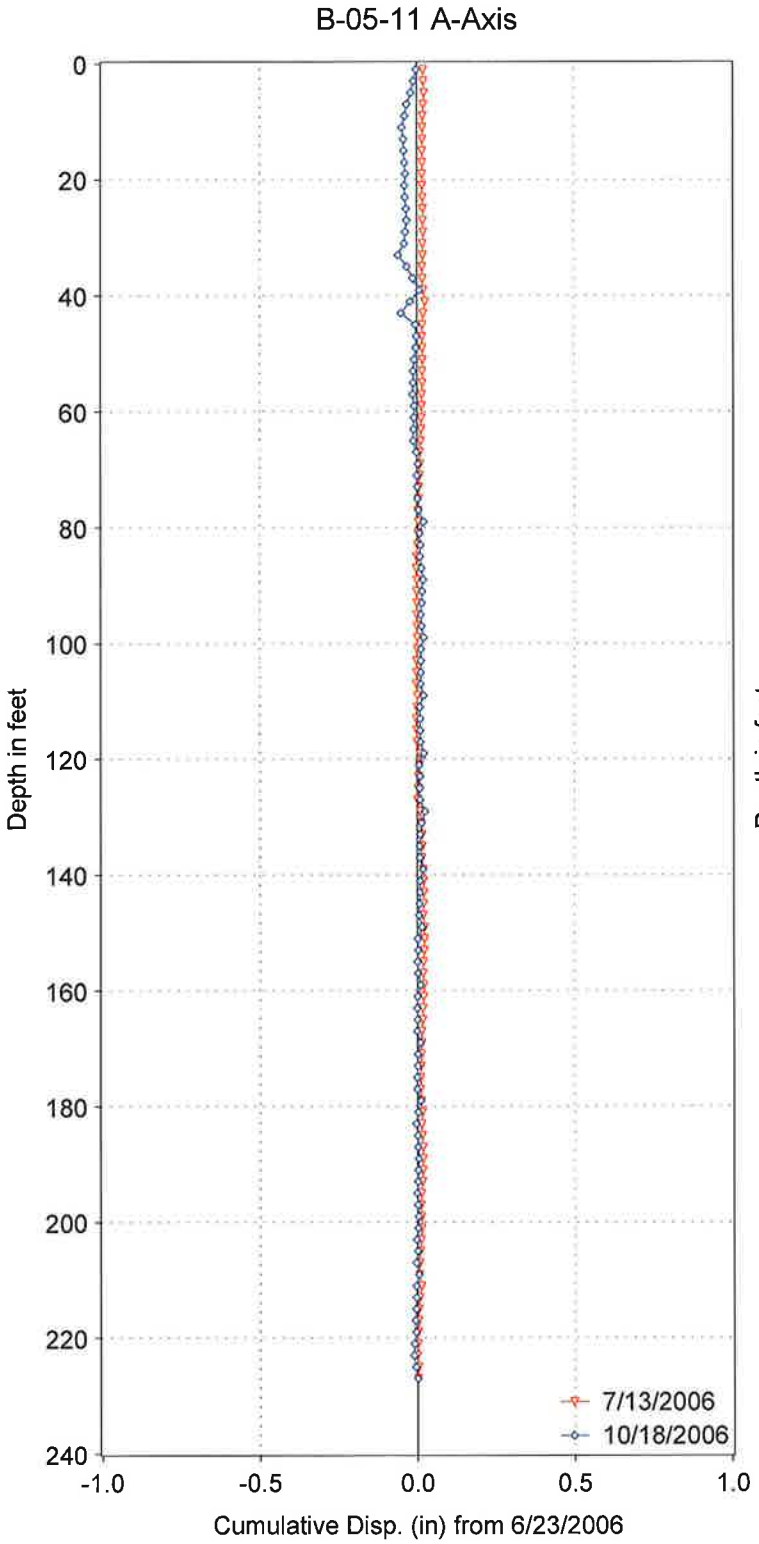
PLATE 36

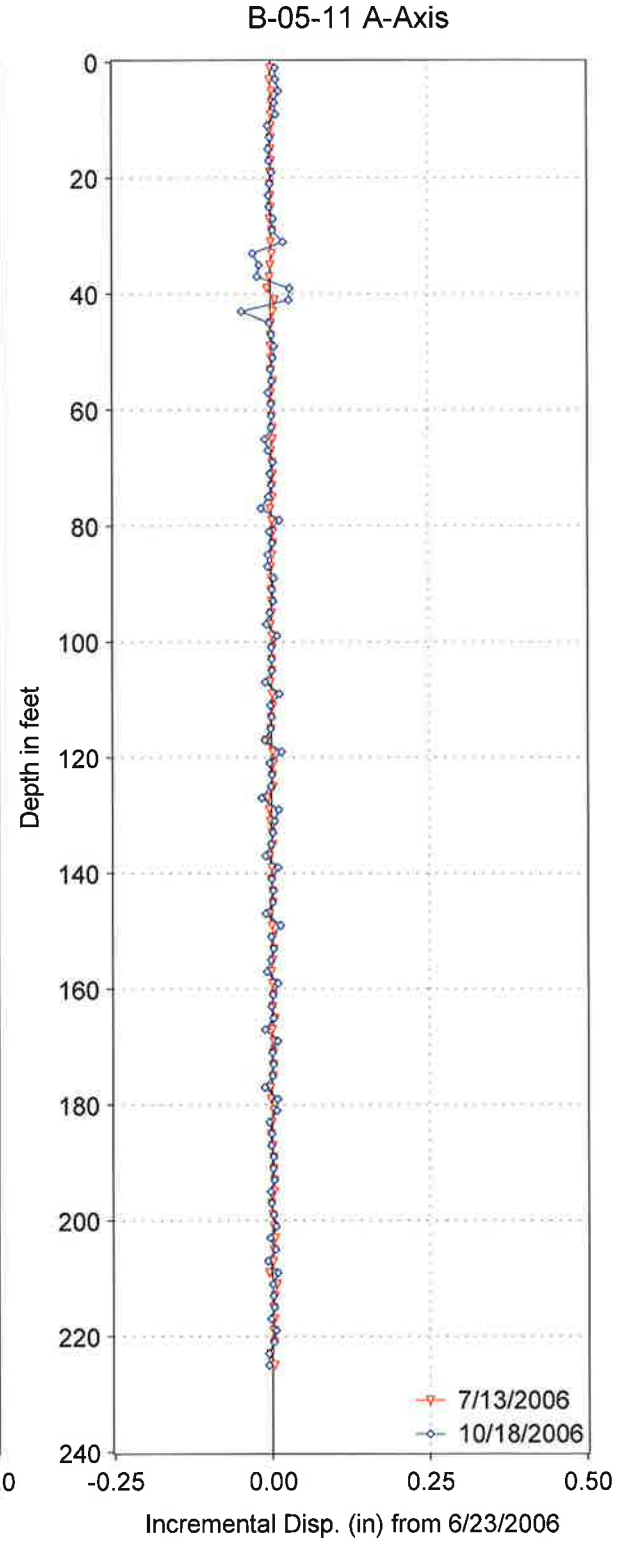




B-05-08

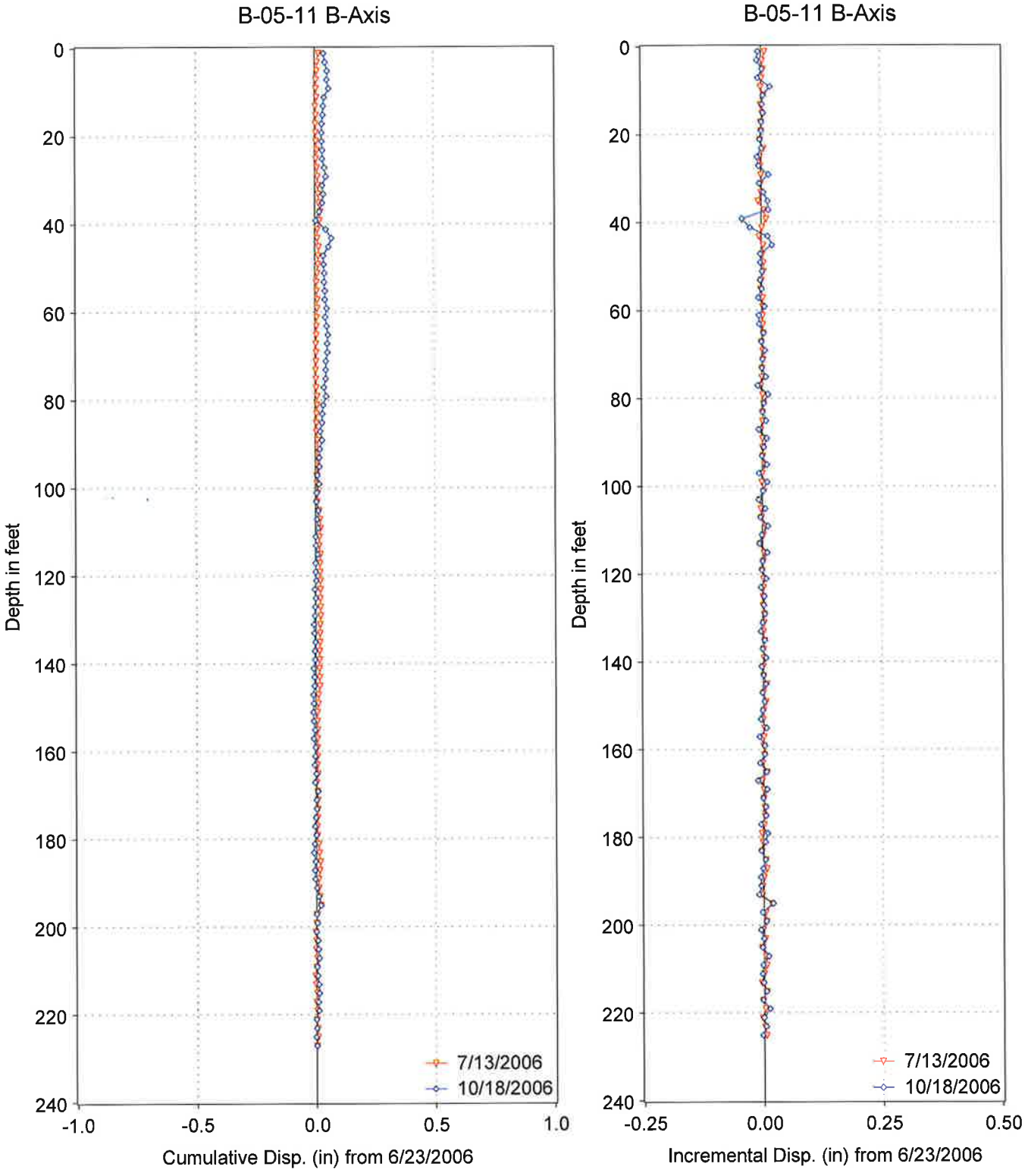
PLATE 37





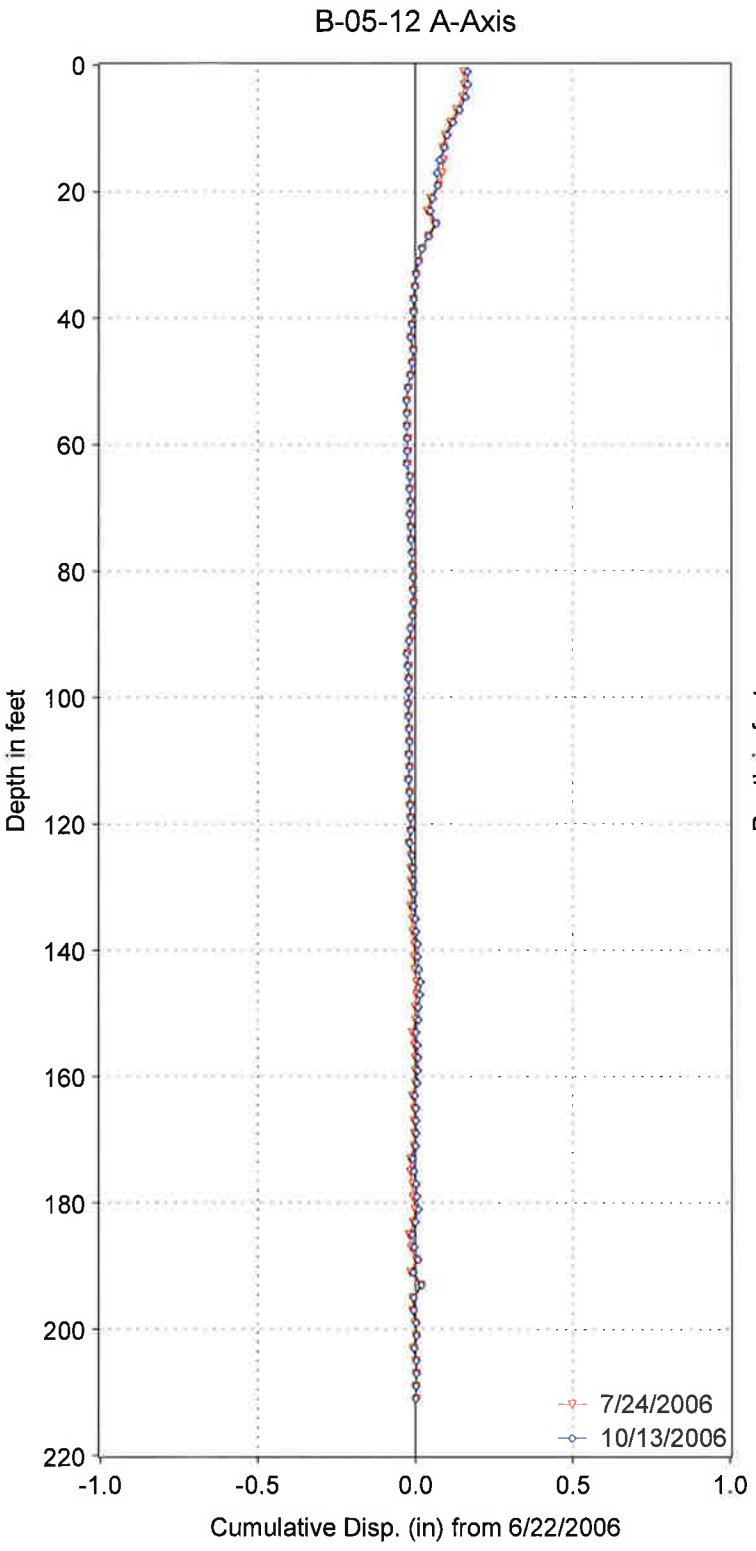
B-05-11

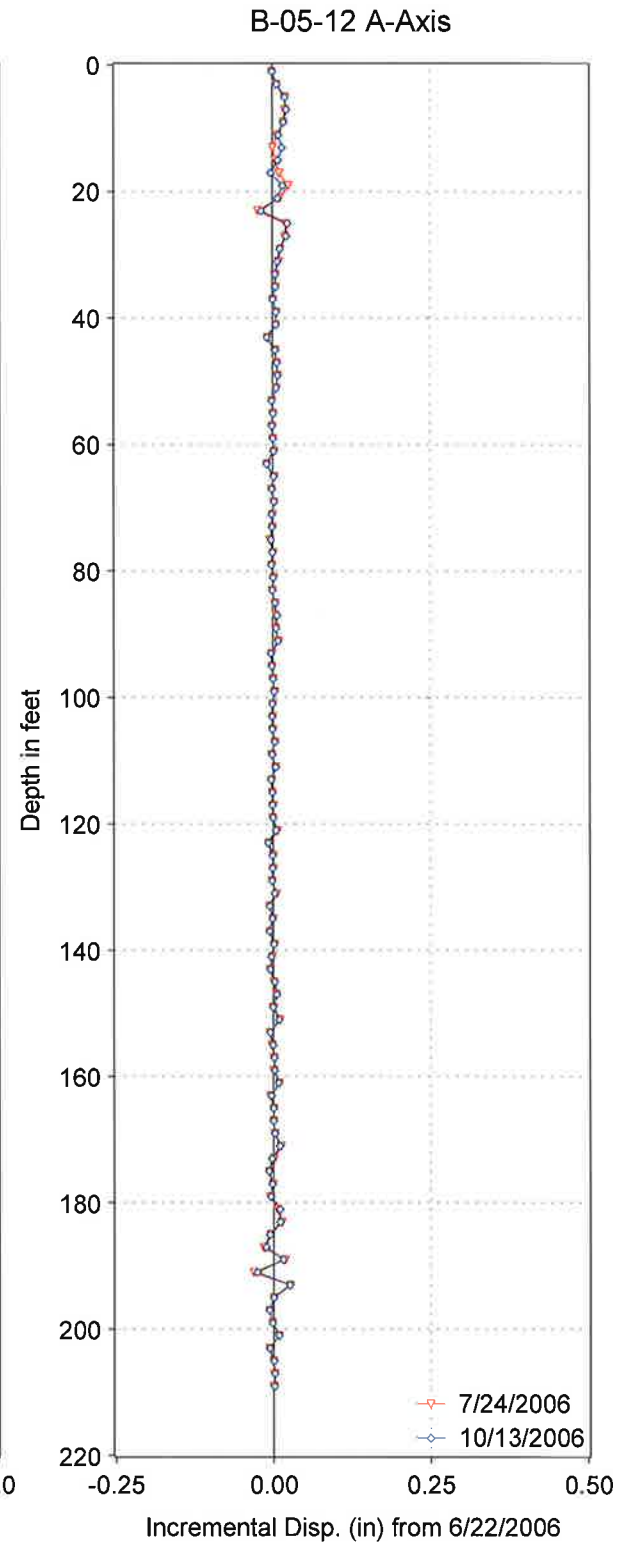
PLATE 38



B-05-11

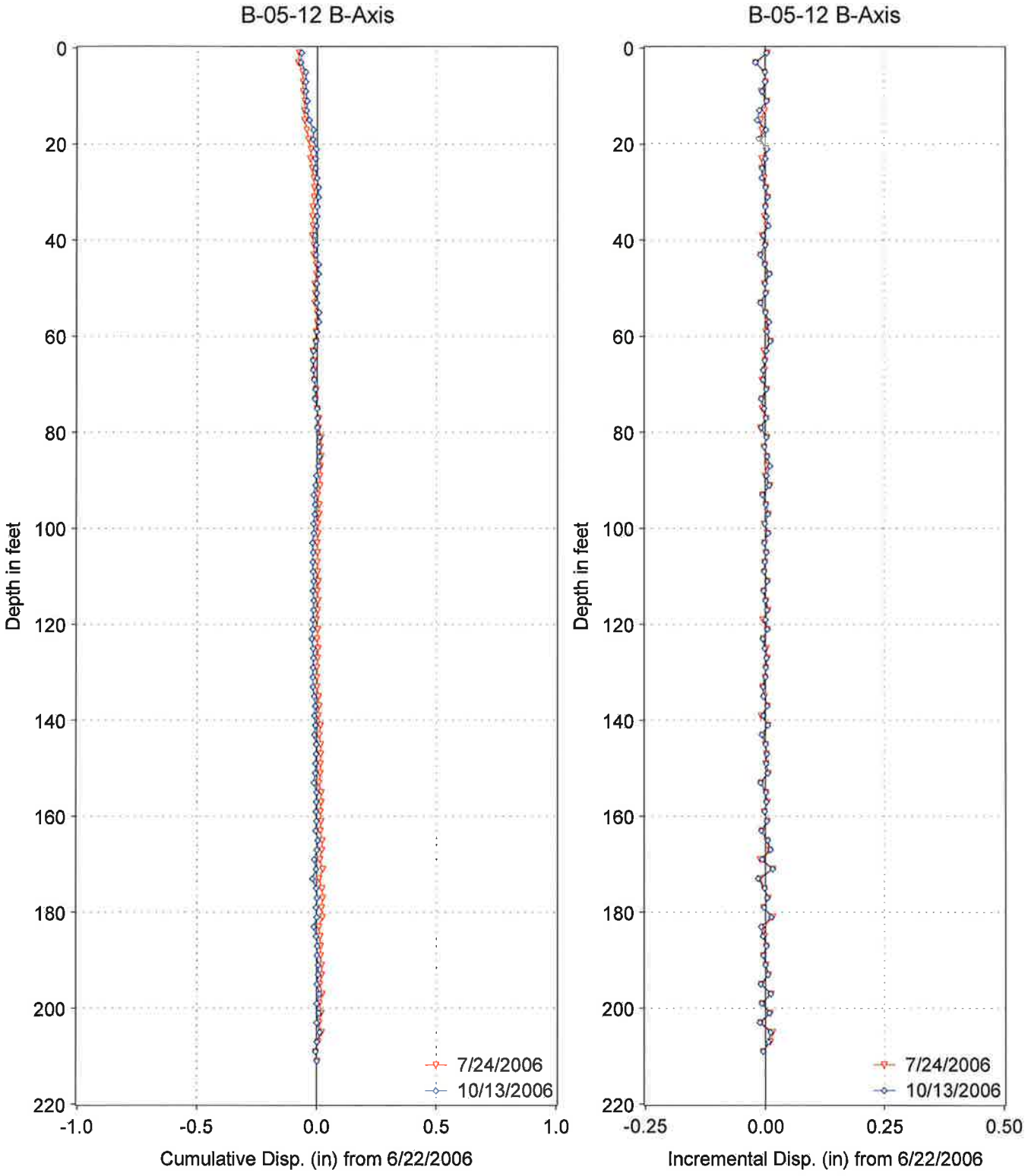
PLATE 39





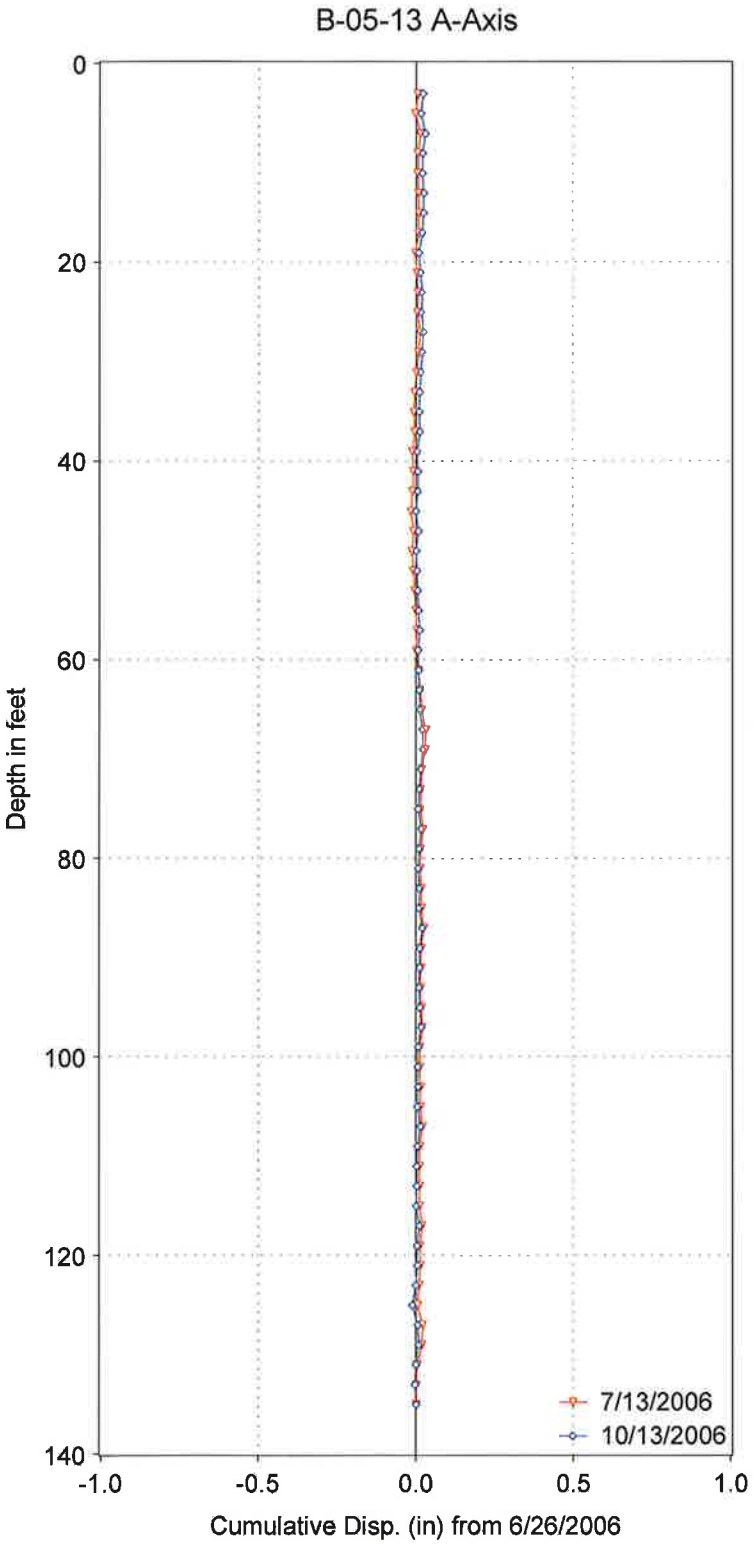
B-05-12

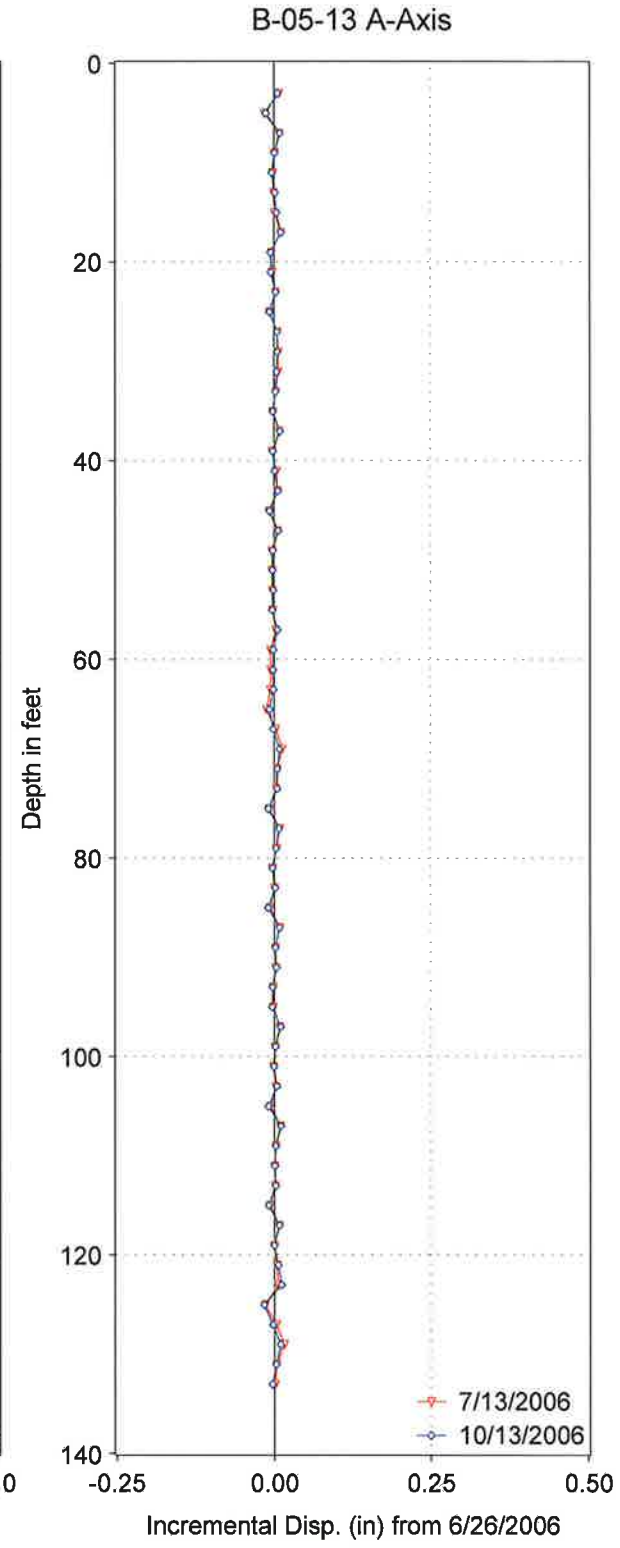
PLATE 40



B-05-12

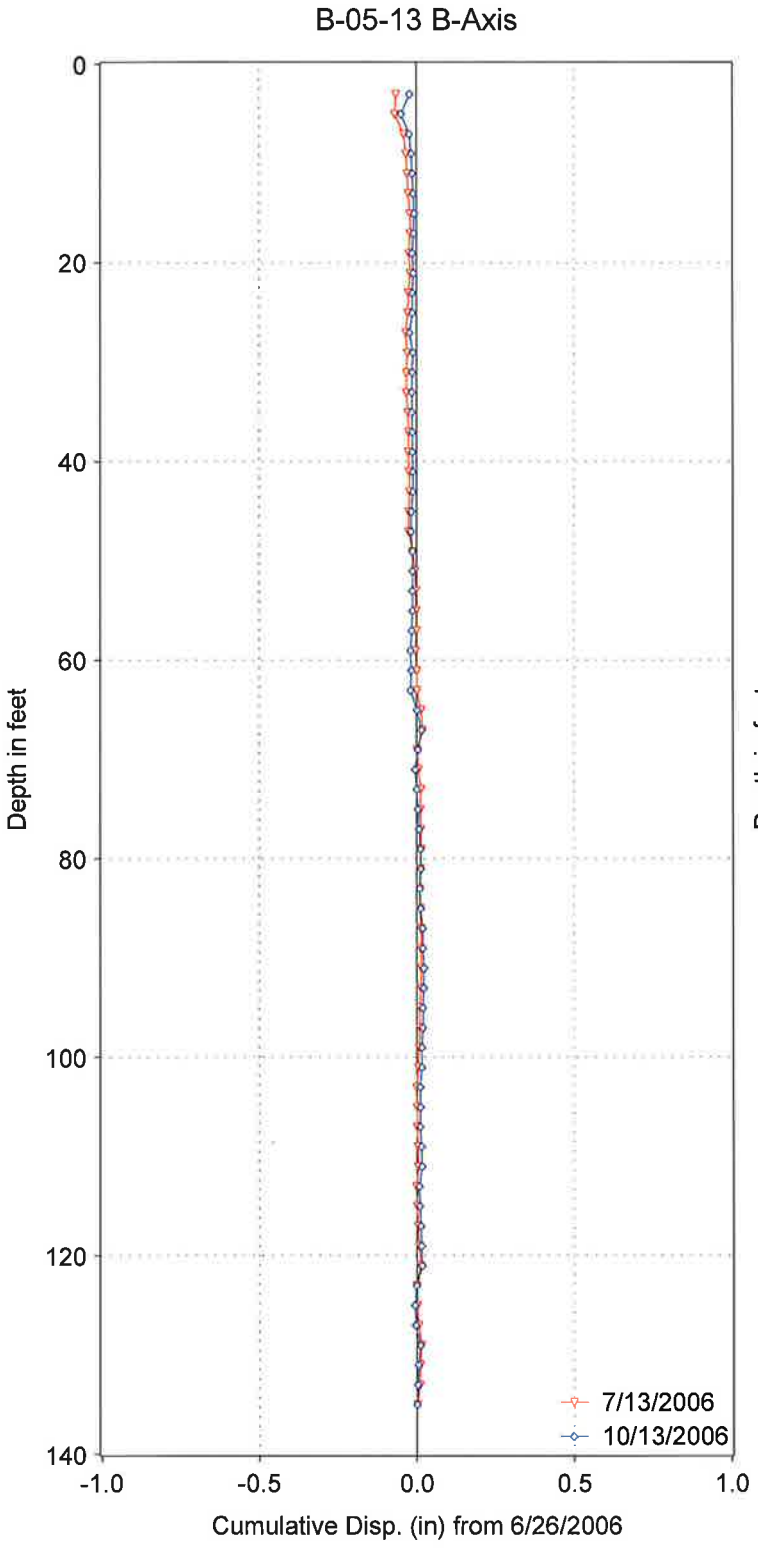
PLATE 41

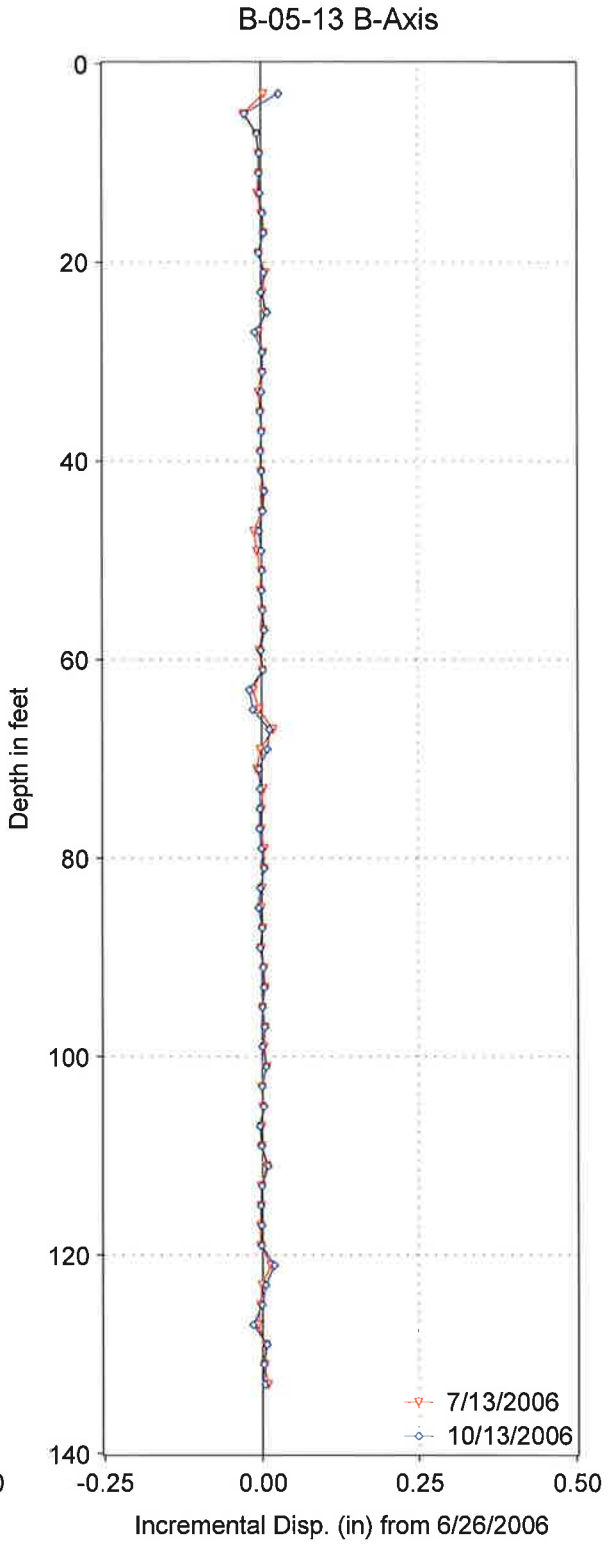




B-05-13

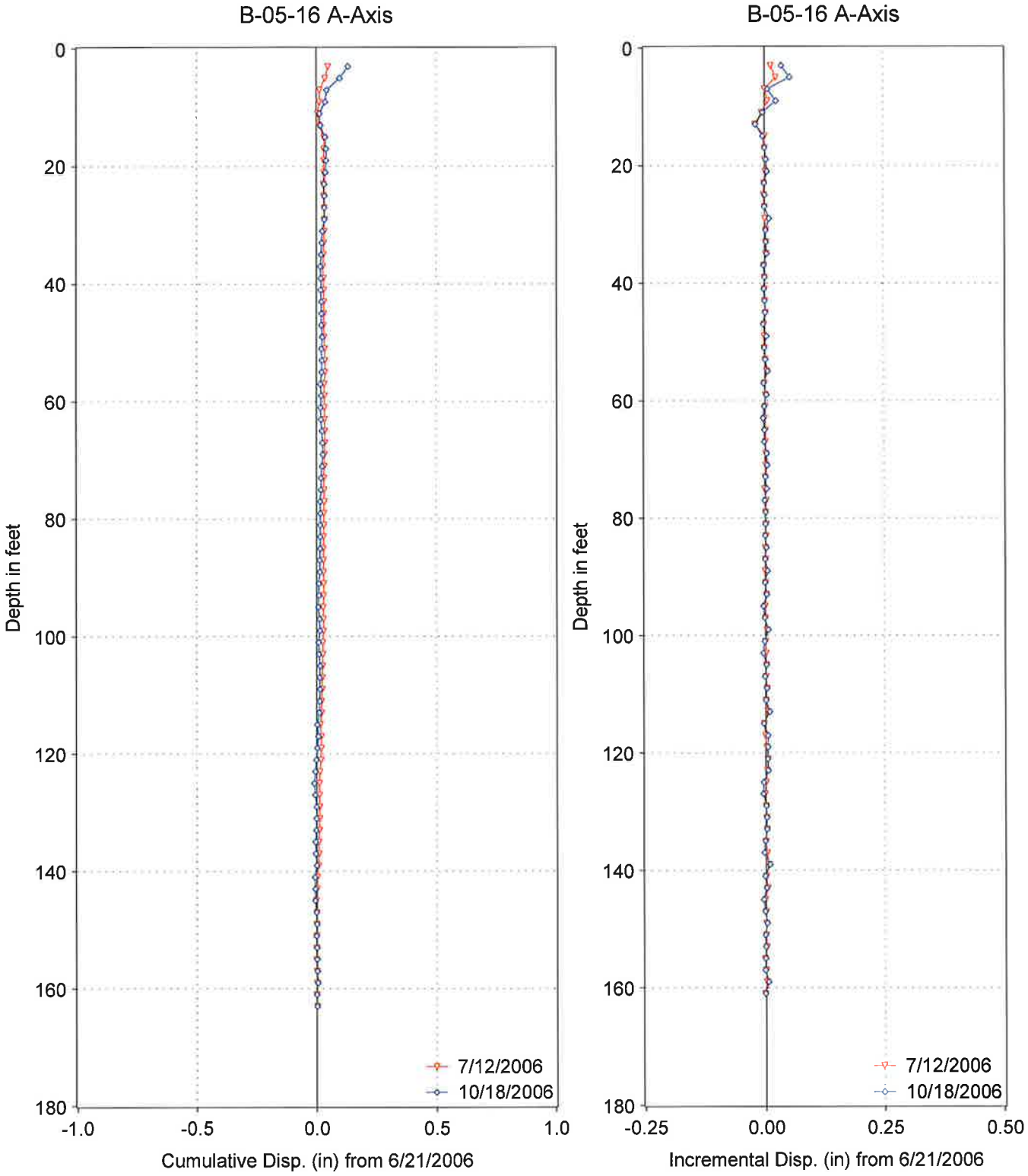
PLATE 42





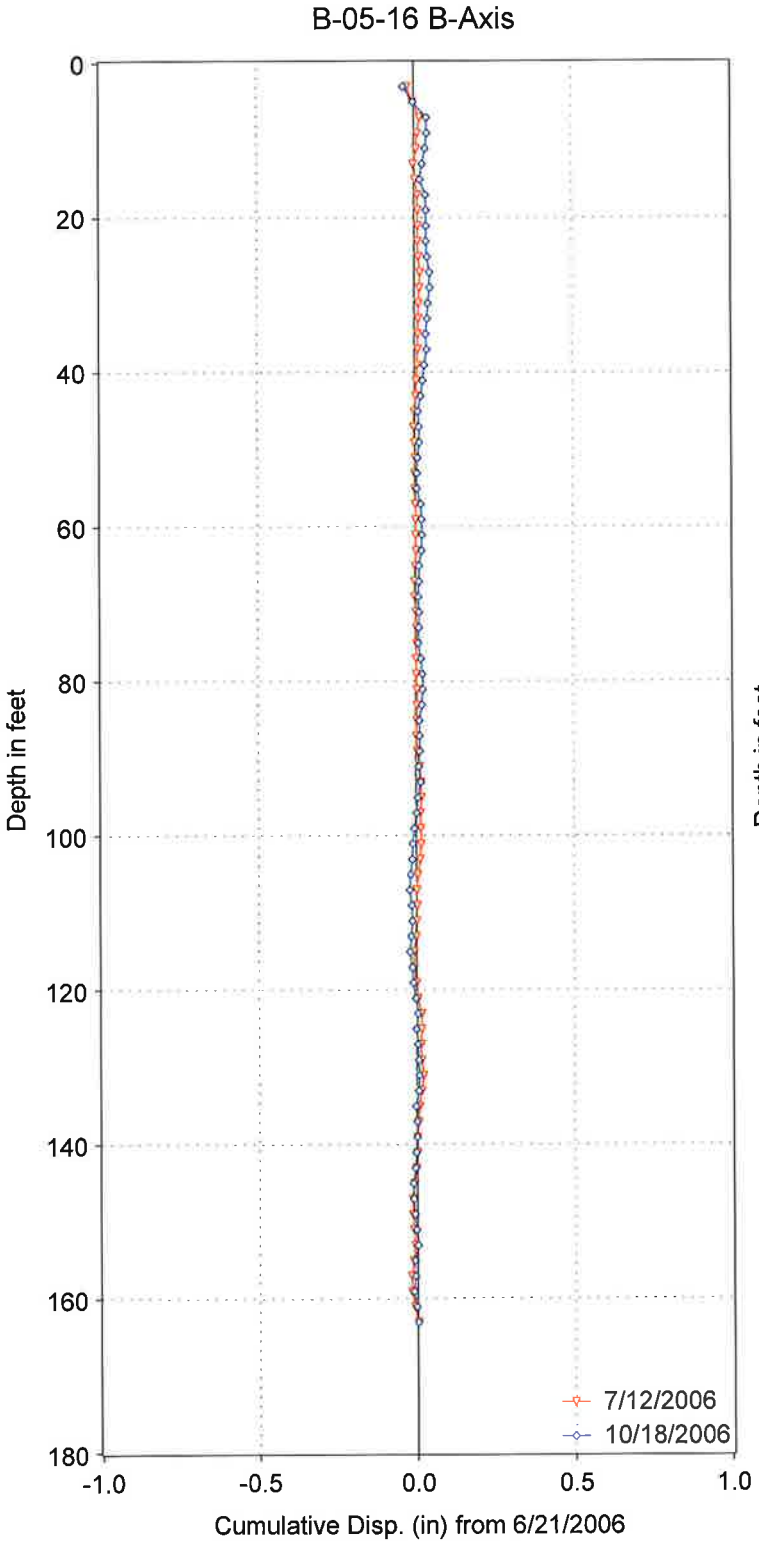
B-05-13

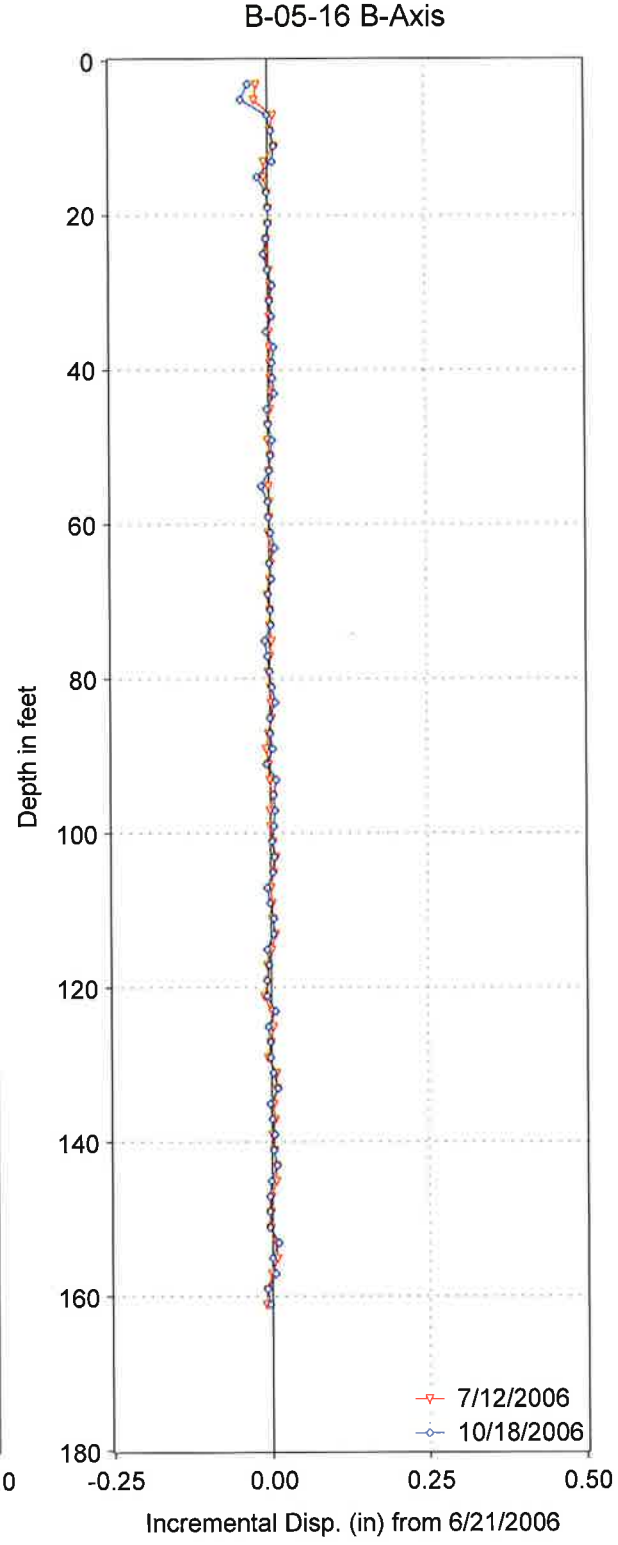
PLATE 43



B-05-16

PLATE 44





B-05-16

PLATE 45

B-101 Pneumatic Piezometer Readings

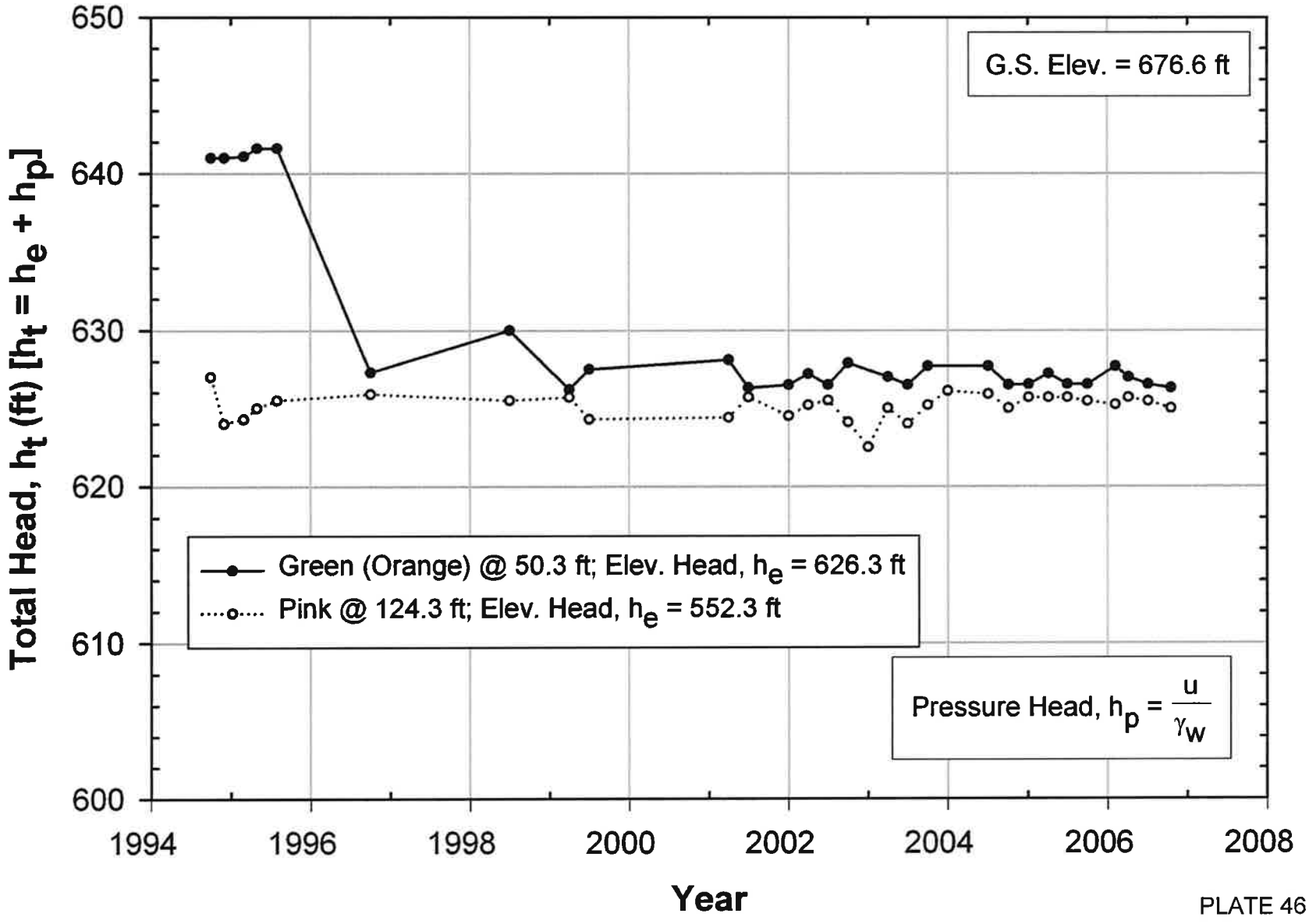


PLATE 46

B-105 Pneumatic Piezometer Readings

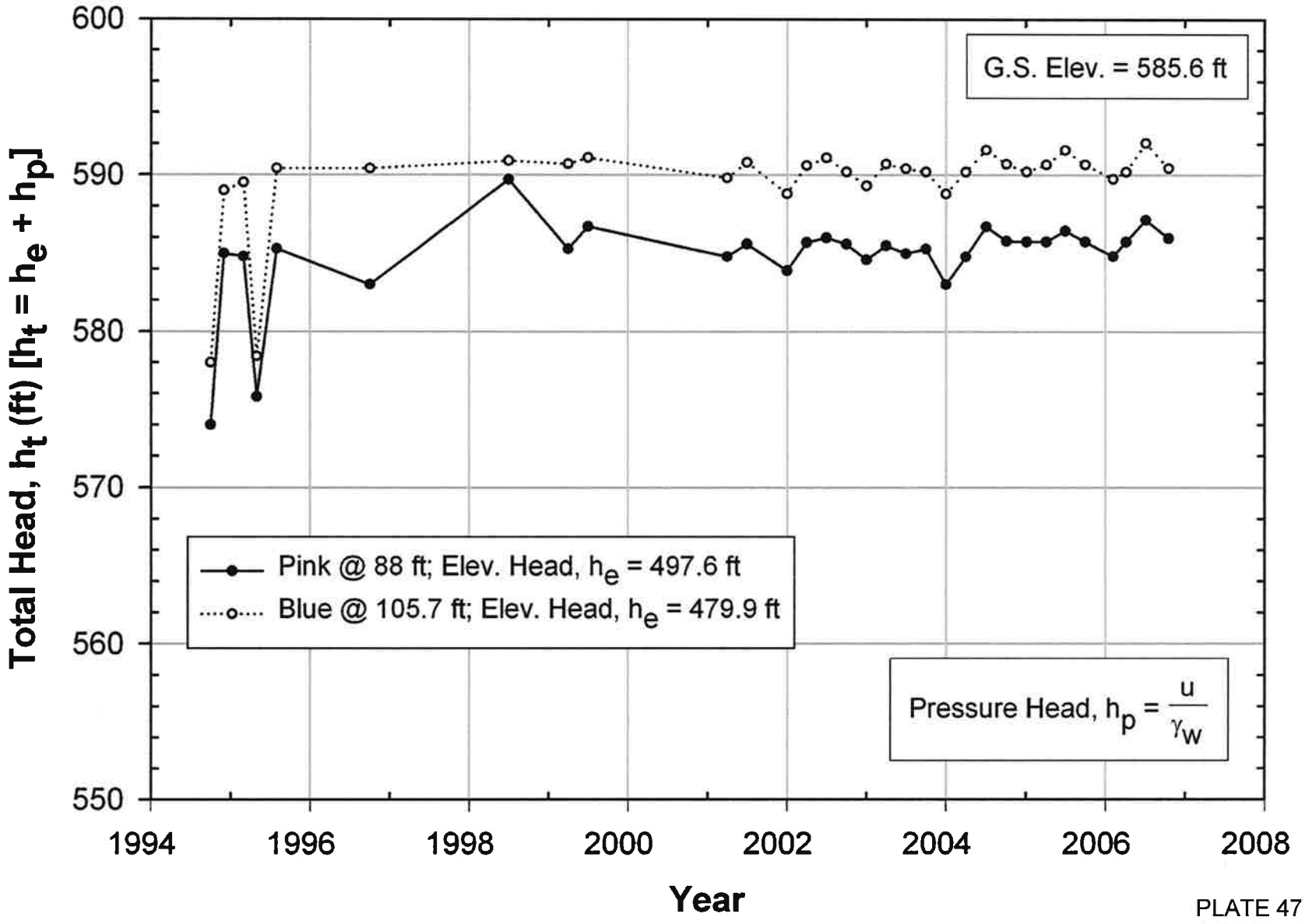


PLATE 47

B-107 Pneumatic Piezometer Readings

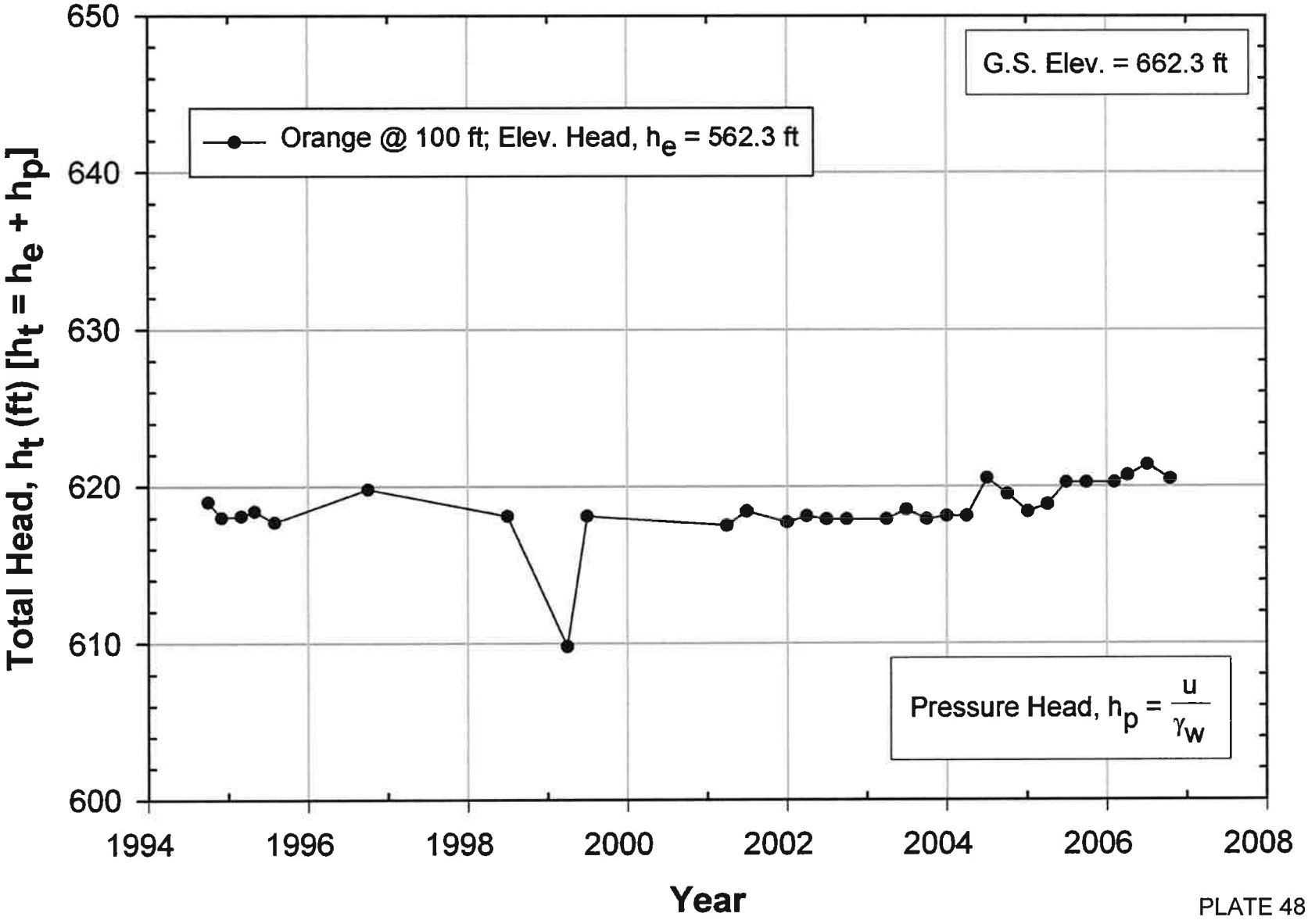


PLATE 48

B-303 Pneumatic Piezometer Readings

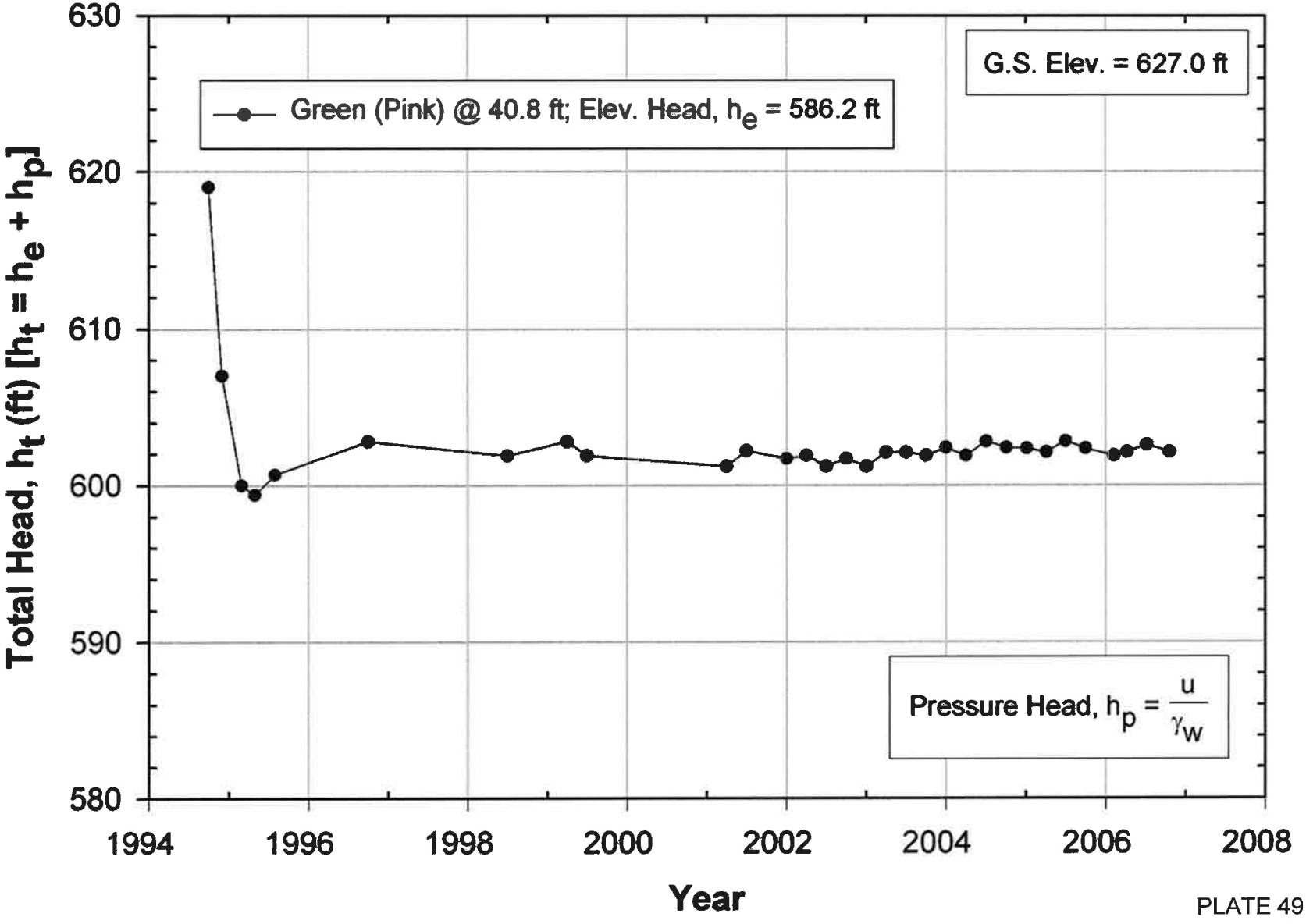


PLATE 49

B-05-01 VW Piezometer Readings

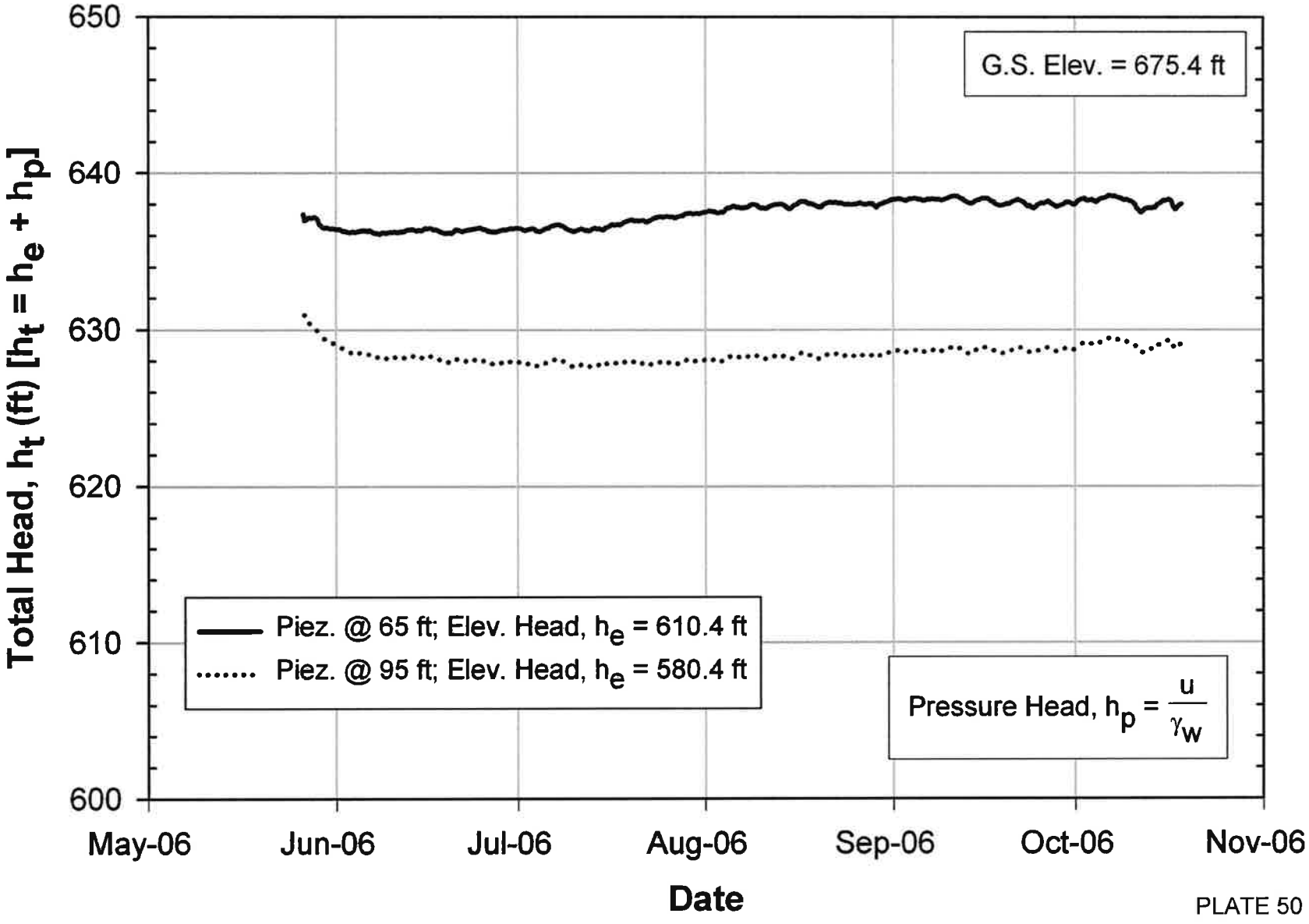


PLATE 50

B-05-02 VW Piezometer Readings

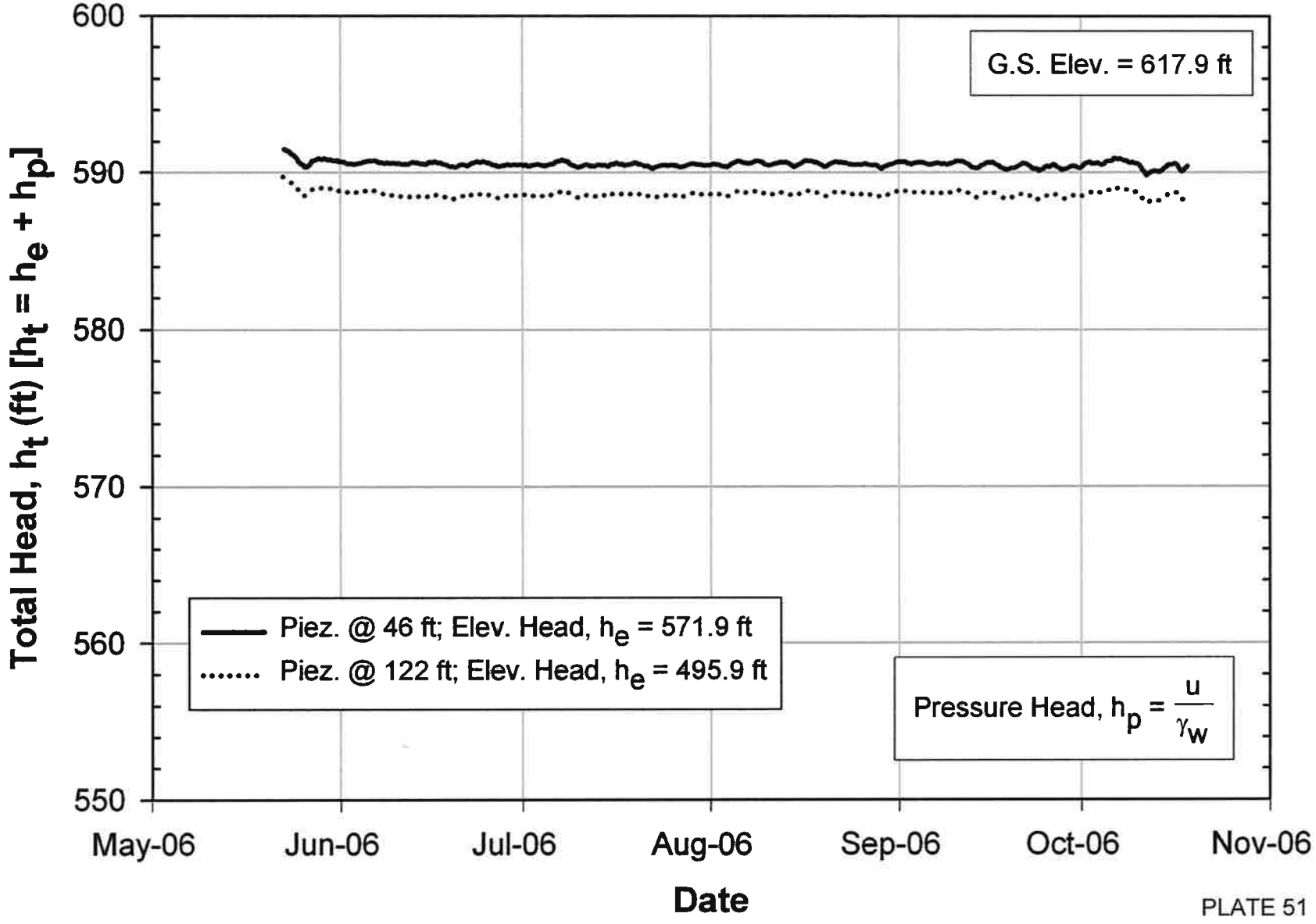


PLATE 51

B-05-03 VW Piezometer Readings

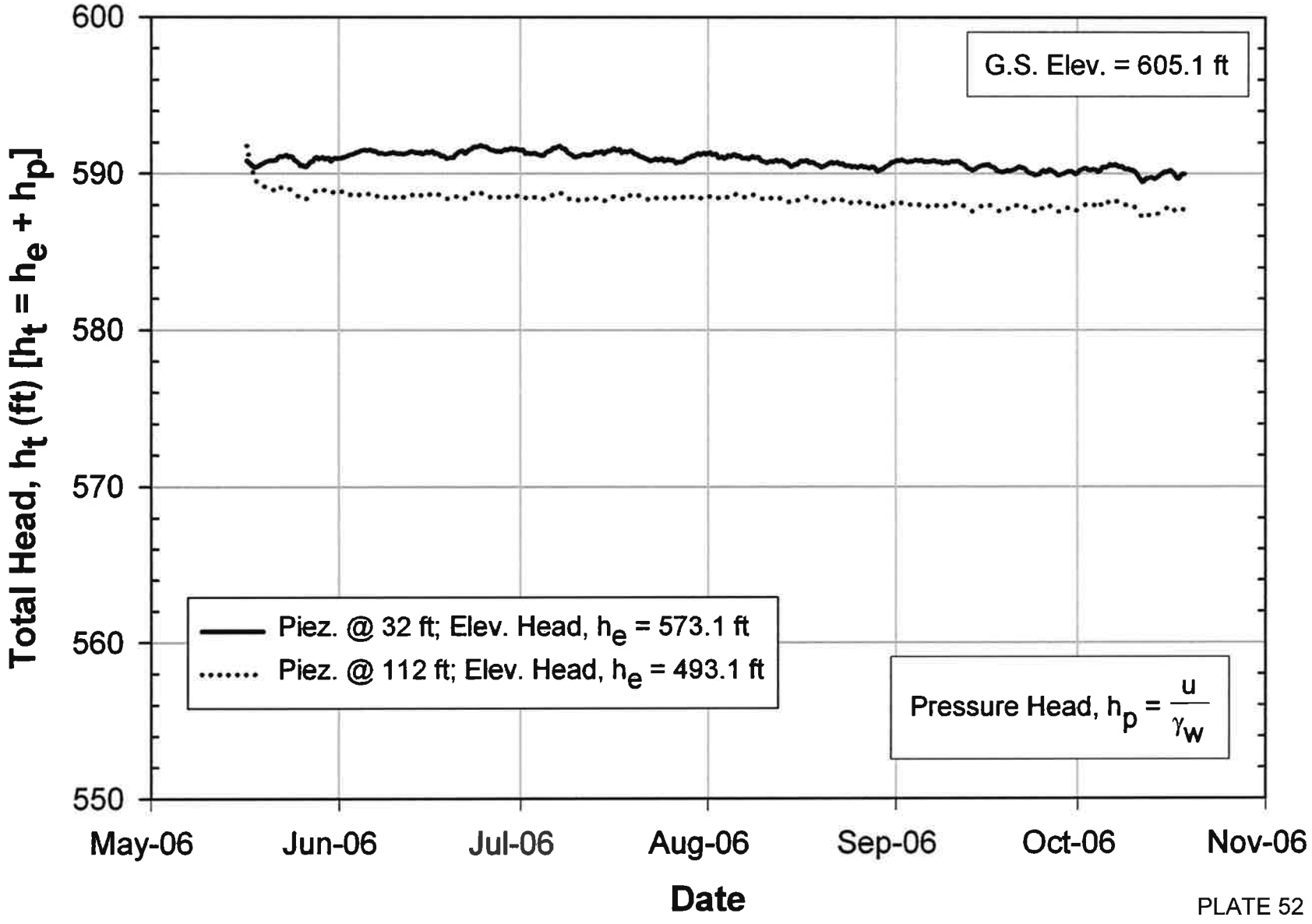


PLATE 52

B-05-04 VW Piezometer Readings

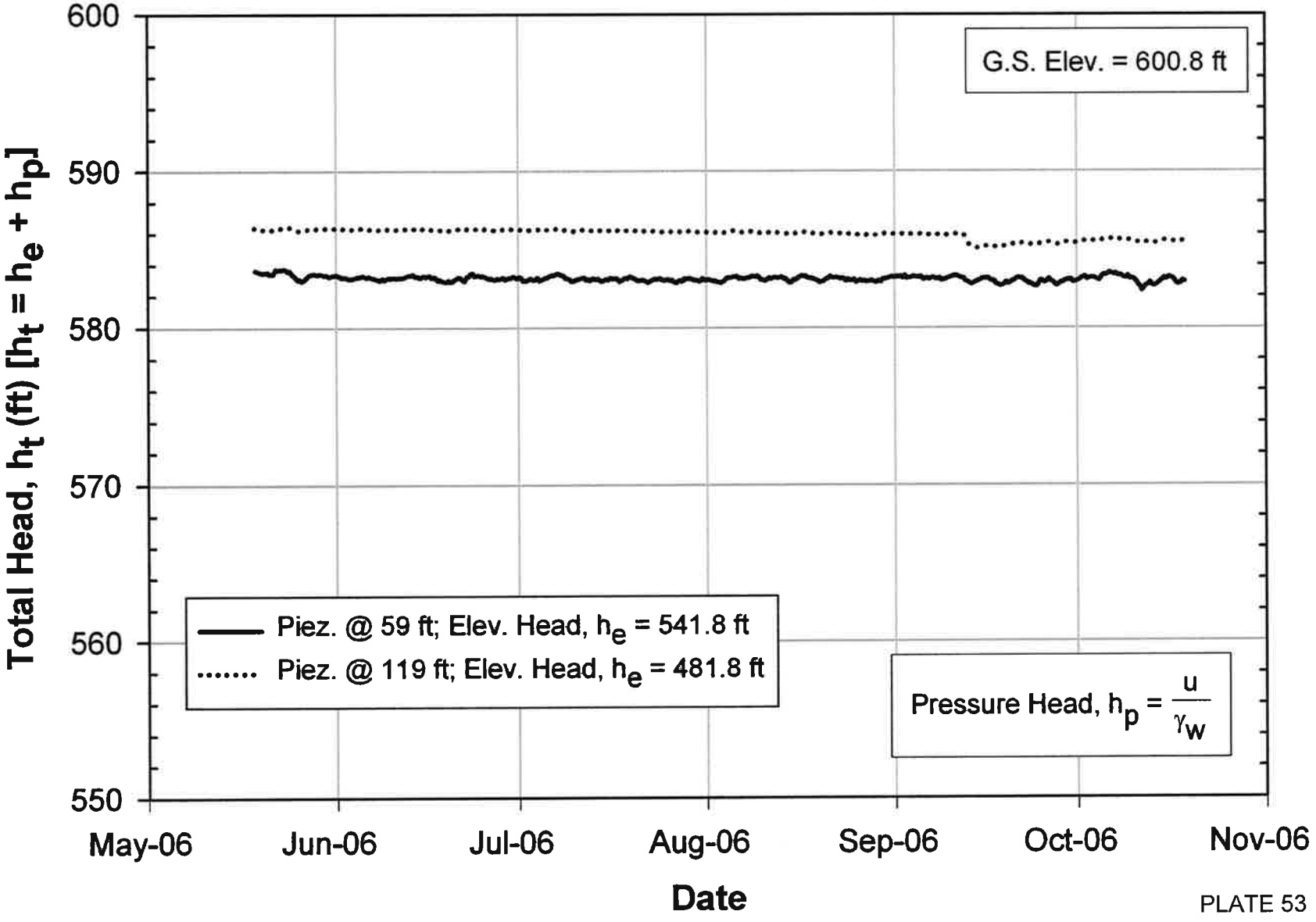


PLATE 53

B-05-07 VW Piezometer Readings

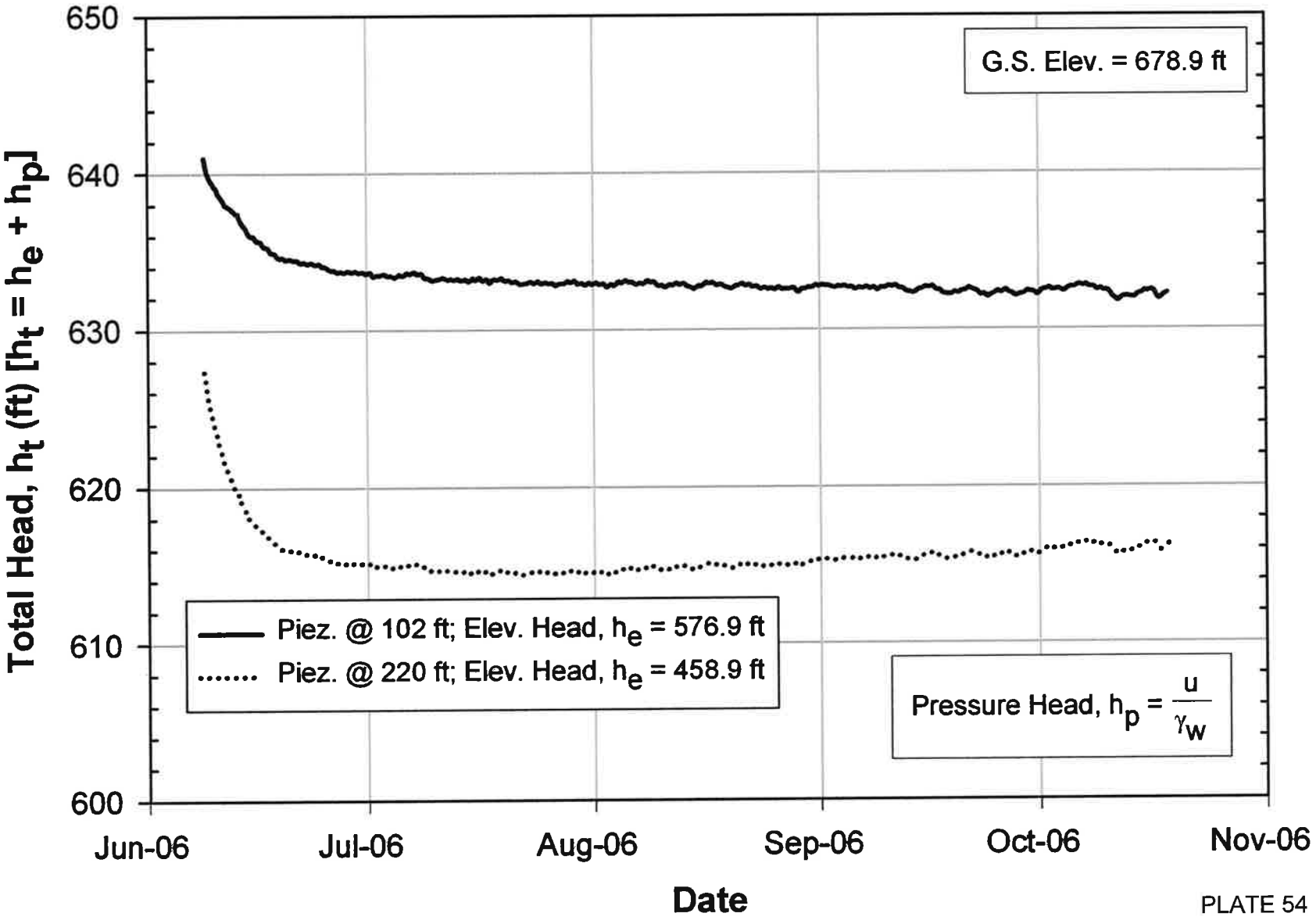


PLATE 54

B-05-08 VW Piezometer Readings

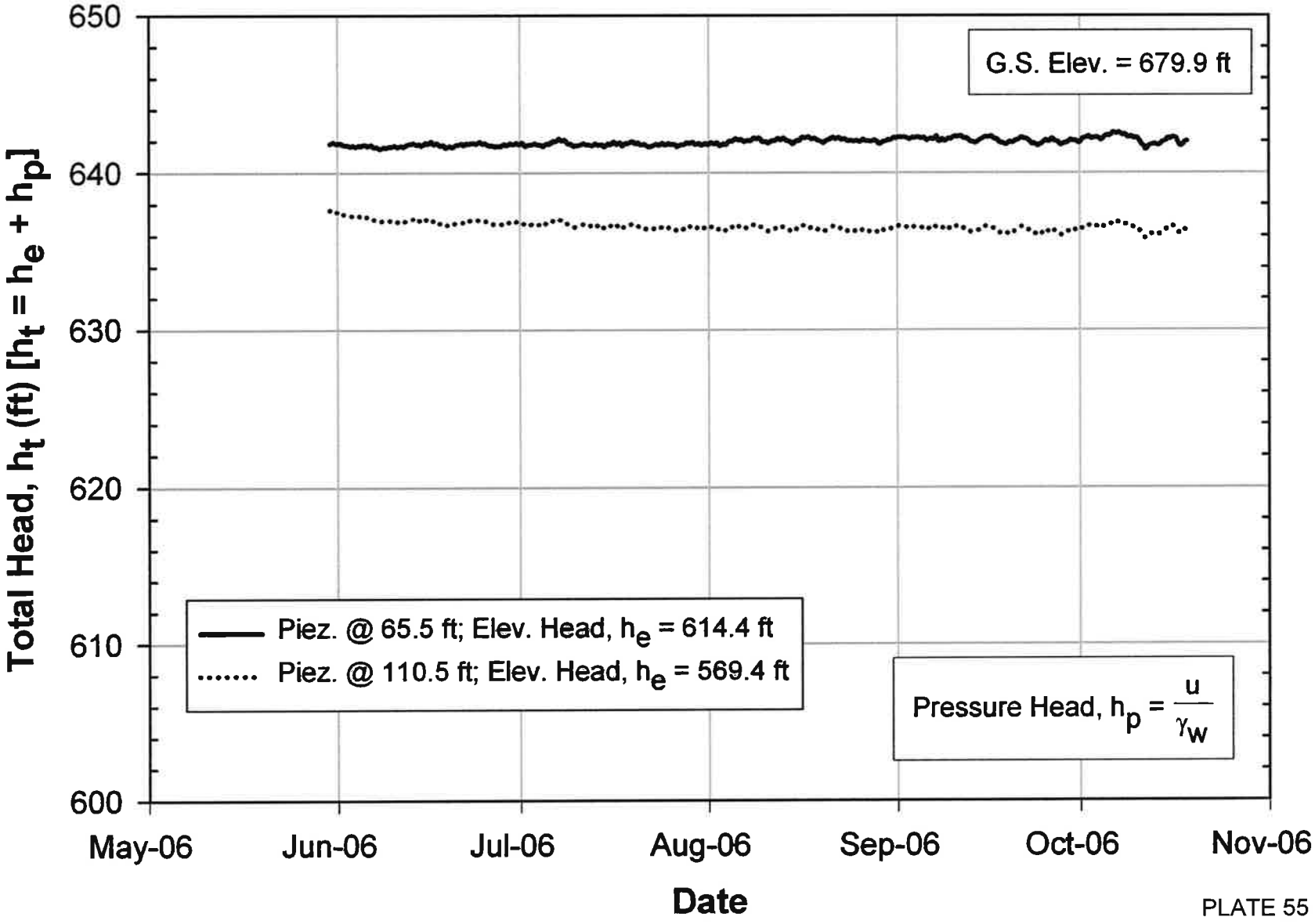


PLATE 55

B-05-11 VW Piezometer Readings

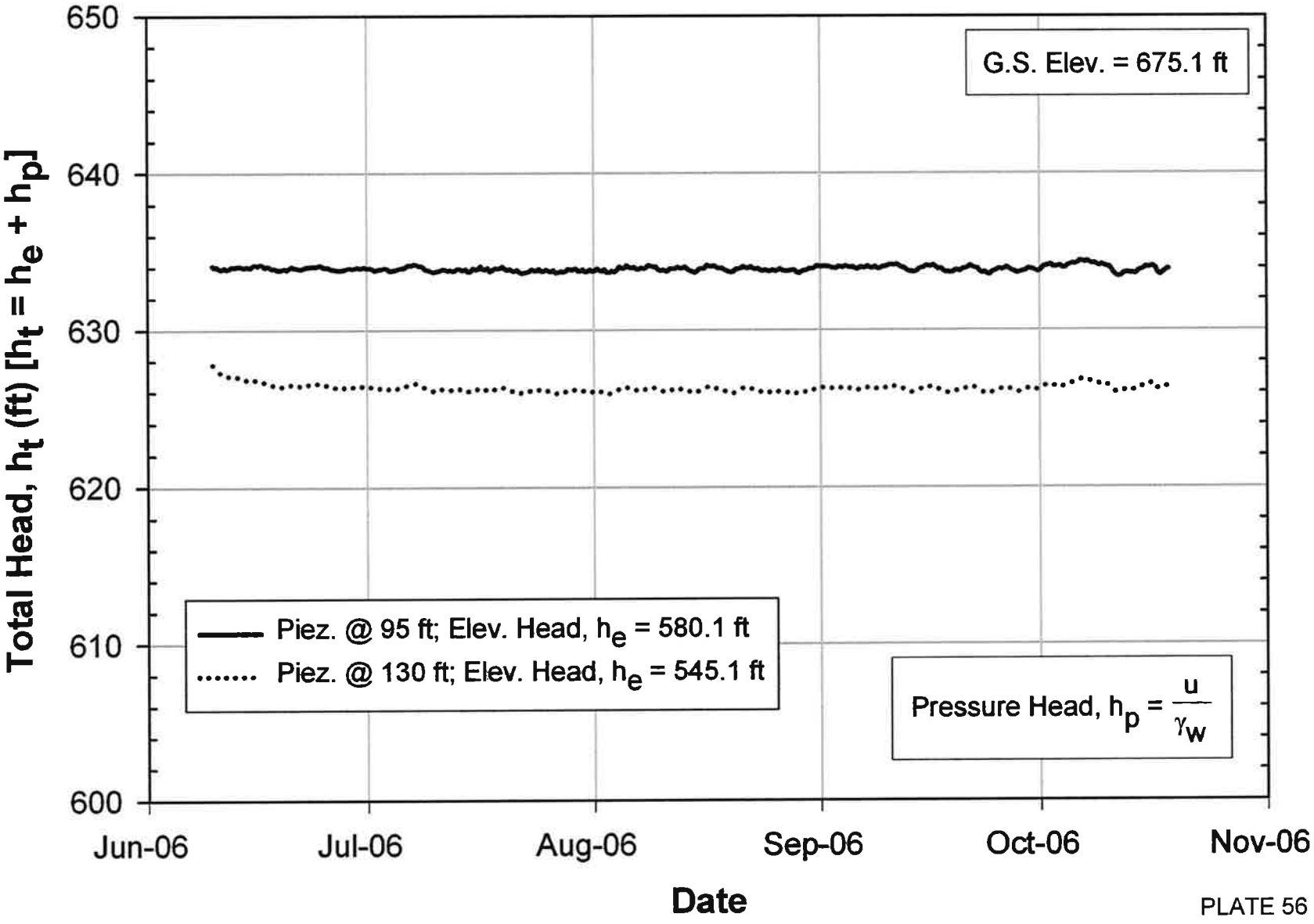


PLATE 56

B-05-12 VW Piezometer Readings

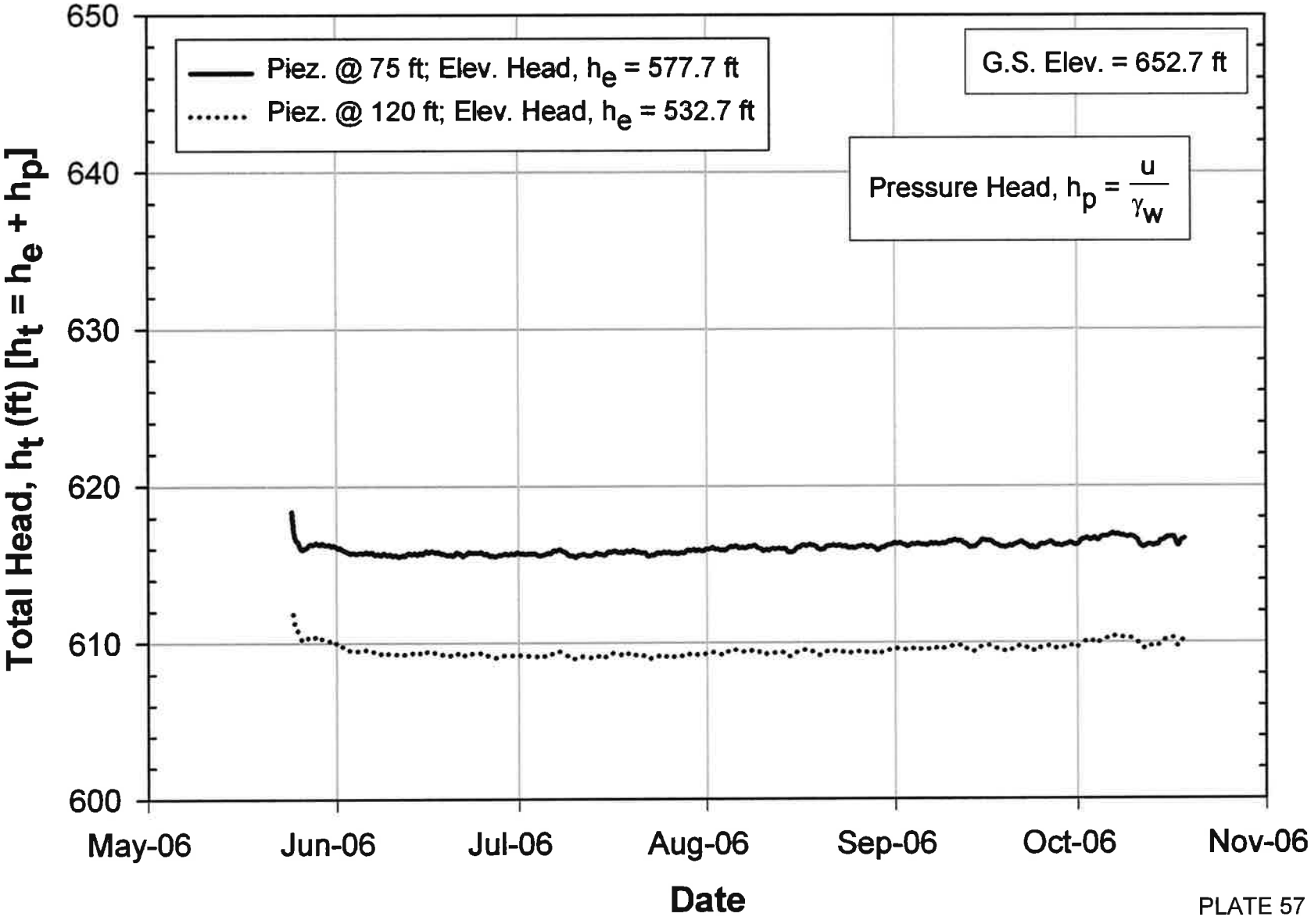


PLATE 57

B-05-13 VW Piezometer Readings

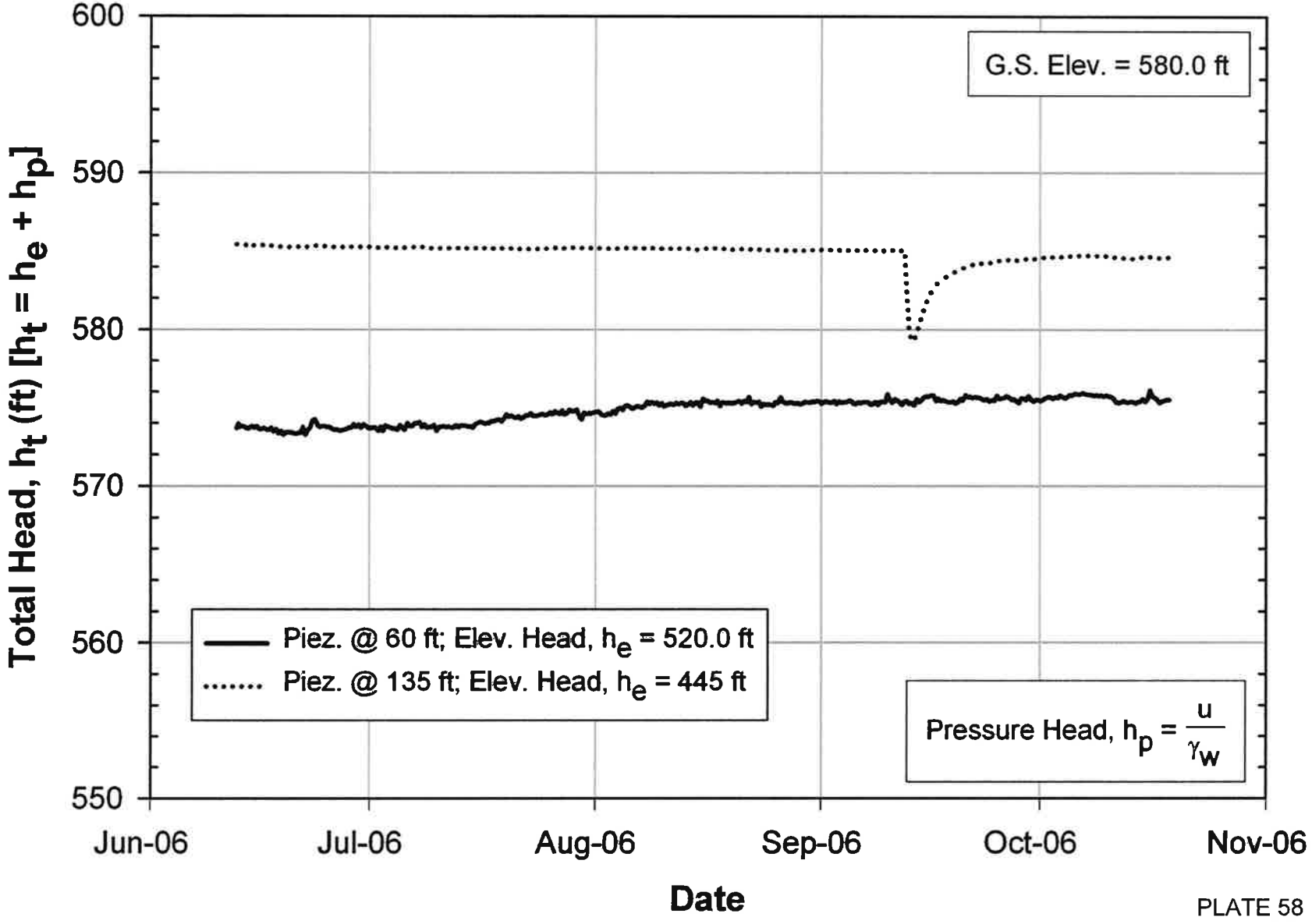


PLATE 58

CALIPERED SURFACE DISTANCE TABLE
CUY-90-15.24

Date	Left Pier Calipered Surface Distance		Center Line Calipered Surface Distance		Right Pier Calipered Surface Distance	
	Present reading	Change (in.)	Present reading	Change (in.)	Present reading	Change (in.)
12/27/99	6.025	--	Not Accessible		4.579	--
04/19/00	6.064	0.039	Not Accessible		4.527	-0.052
07/20/00	6.000	-0.064	Not Accessible		4.516	-0.011
10/26/00	5.876	-0.124	Not Accessible		4.294	-0.222
01/29/01	5.929	0.053	Not Accessible		4.385	0.091
04/17/01	Not Accessible		Not Accessible		Not Accessible	
07/19/01	6.043	0.114	Not Accessible		4.312	-0.073
11/08/01	6.250	0.207	Not Accessible		4.469	0.157
01/23/02	6.253	0.003	Not Accessible		4.518	0.049
04/17/02	6.285	0.032	Not Accessible		4.435	-0.083
07/16/02	6.290	0.005	Not Accessible		4.444	0.009
10/15/02	6.333	0.043	Discontinued		4.482	0.038
01/15/03	6.405	0.072			4.473	-0.009
04/17/03	6.333	-0.072			4.482	0.009
07/18/03	6.186	-0.147			4.350	-0.132
10/16/03	6.385	0.199			4.519	0.169
01/08/04	6.124	-0.261			4.594	0.075
04/14/04	6.129	0.005			4.402	-0.193
07/16/04	6.250	0.122			4.277	-0.125
10/27/04	6.375	0.125			4.467	0.190
01/12/05	6.250	-0.125			4.349	-0.118
04/14/05	6.375	0.125			4.372	0.023
07/14/05	6.313	-0.063			4.392	0.020
10/12/05	6.375	0.063			4.358	-0.034
02/01/06	6.438	0.063			4.395	0.037
04/20/06	6.500	0.063			4.430	0.035
07/14/06	6.375	-0.125			4.381	-0.049
10/18/06	6.438	0.063			4.400	0.020

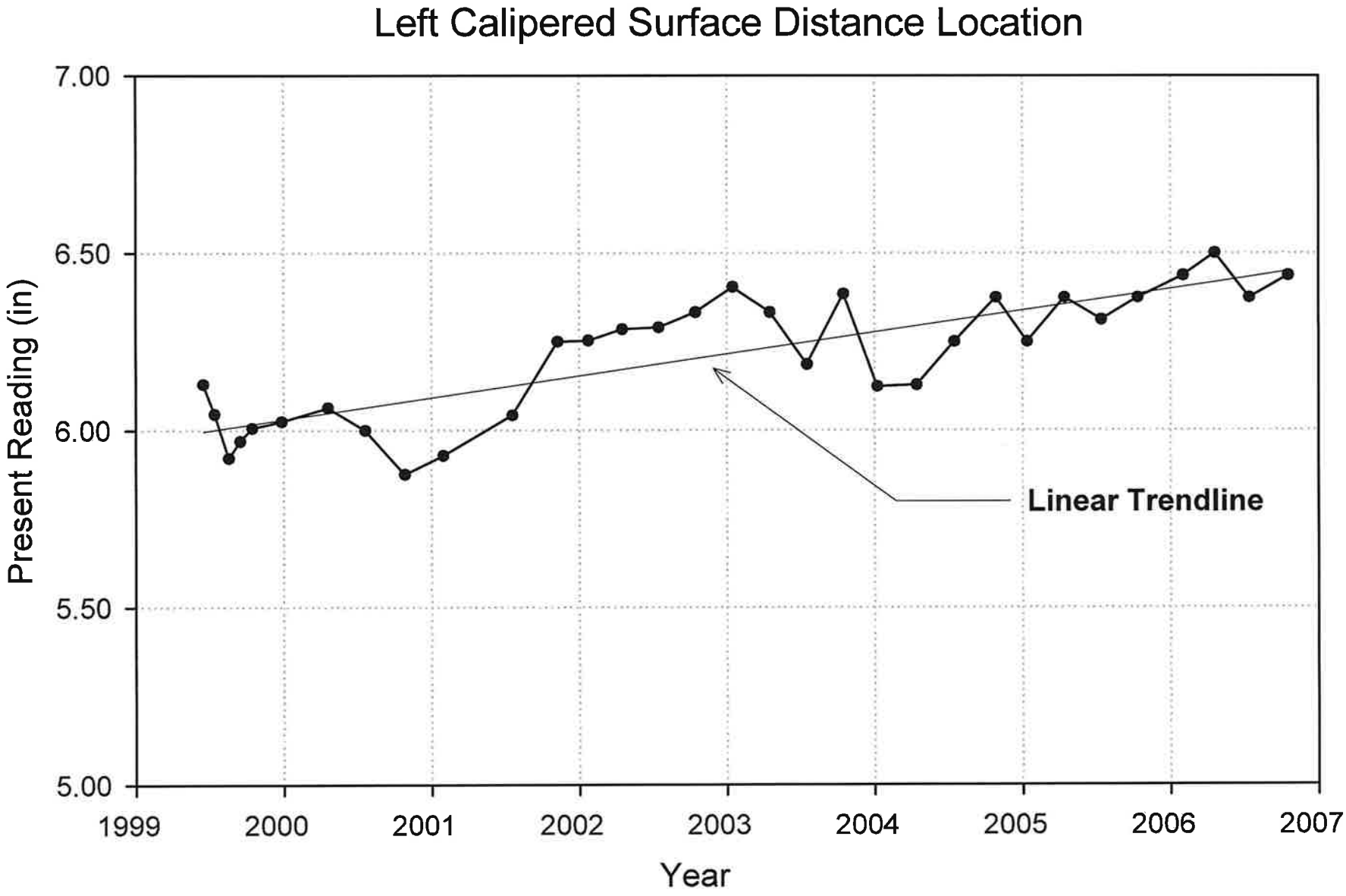

Left Calipered Surface Distance Location
7.00
6.50
6.00
5.50
5.00
Present Reading (in)
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year
Linear Trendline

PLATE 60

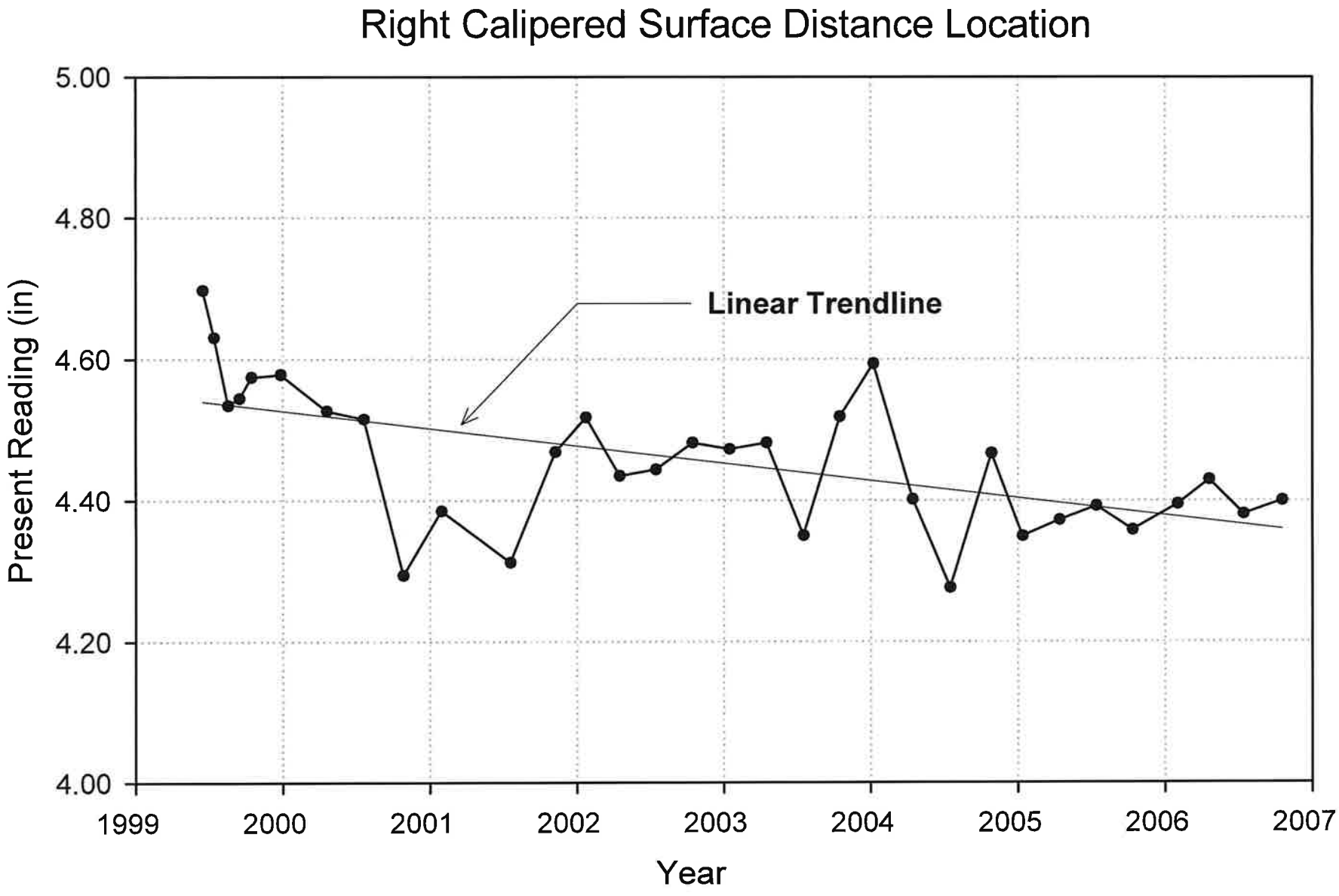

Right Calipered Surface Distance Location
5.00
4.80
4.60
4.40
4.20
4.00
Present Reading (in)
Linear Trendline
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

PLATE 61

Richland Engineering Limited 1106017

From: "arthur huckelbridge" <aah4@case.edu>
To: "'Richland Engineering Limited'" <reltd@r-e-l.com>
Sent: Wednesday, October 18, 2006 12:03 PM
Attach: tilts 10_17_06.ppt; IN06_010.doc
Subject: RE: CUY-90-15.24 Monitoring

Dean:

Attached are the tiltmeter readings through October 17, 2006. The latest readings are consistent with historical trends, with small decreases actually indicated on most tiltmeters. Let me know if you have questions.

Regards,

Art

From: Richland Engineering Limited [mailto:reltd@r-e-l.com]
Sent: Tuesday, October 10, 2006 4:45 PM
To: Robert Liang; Arthur Huckelbridge; Jeff Snyder
Subject: CUY-90-15.24 Monitoring

Gentlemen,

A reminder that the monitoring data collection should be performed around October 15.

Thank you,
Dean Palmer

Richland Engineering Limited
Mansfield, Ohio
(419)524-0074

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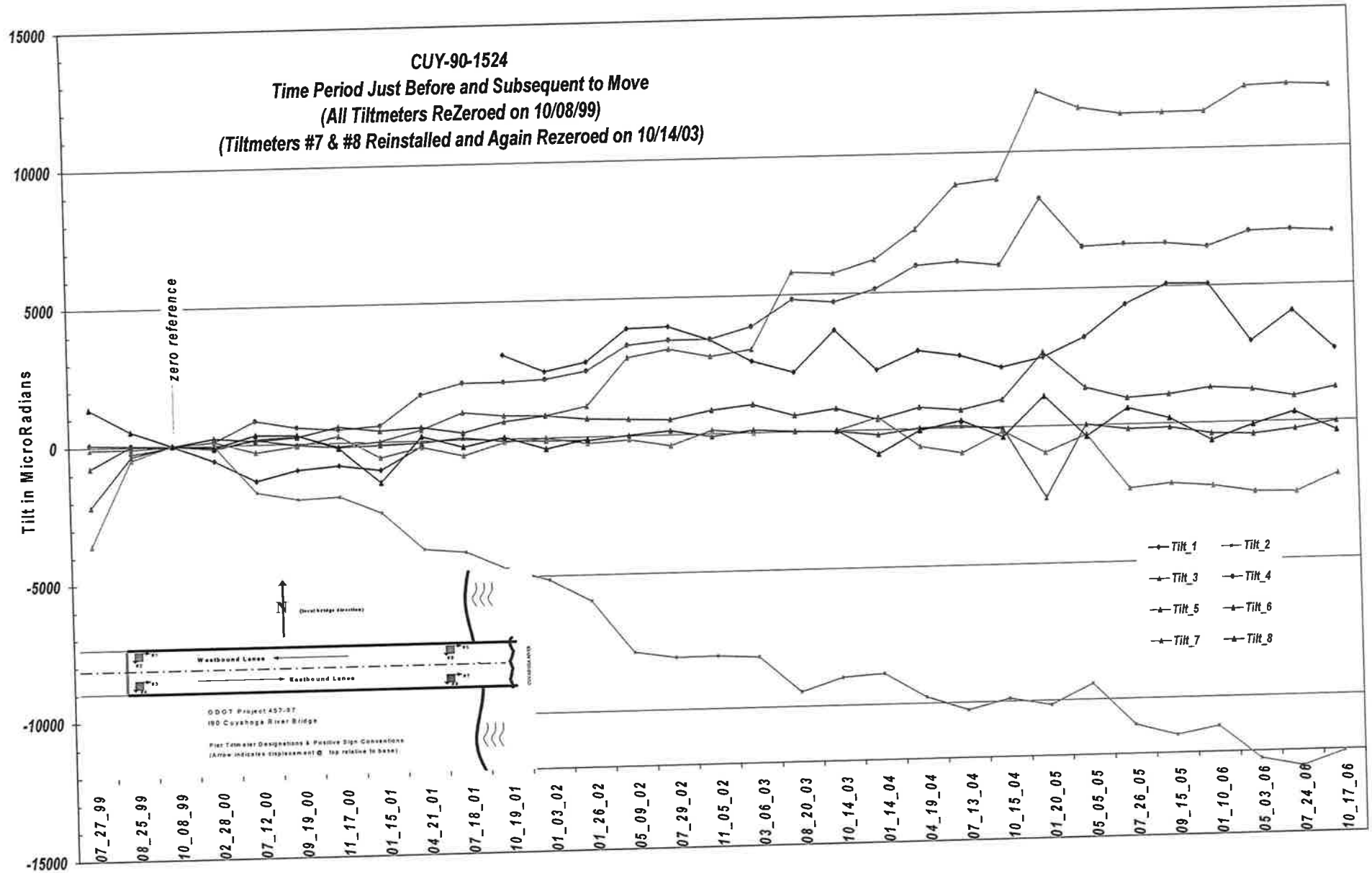

CUY-90-1524
Time Period Just Before and Subsequent to Move
(All Tiltmeters ReZeroed on 10/08/99)
(Tiltmeters #7 & #8 Reinstalled and Again Rezeroed on 10/14/03)
Tilt in MicroRadians
15000
10000
5000
0
-5000
-10000
-15000
zero reference
Tilt_1
Tilt_2
Tilt_3
Tilt_4
Tilt_5
Tilt_6
Tilt_7
Tilt_8
Westbound Lanes
Eastbound Lanes
ODOT Project 457-97
I90 Cuyahoga River Bridge
07_27_99
08_25_99
10_08_99
02_28_00
07_12_00
09_19_00
11_17_00
01_15_01
04_21_01
07_18_01
10_19_01
01_03_02
01_26_02
05_09_02
07_29_02
11_05_02
03_06_03
08_20_03
10_14_03
01_14_04
04_19_04
07_13_04
10_15_04
01_20_05
05_05_05
07_26_05
09_15_05
01_10_06
05_03_06
07_24_06
10_17_06

Robert Y. Liang, Ph.D., P.E
8441 Timber Tr.
Brecksville, Ohio 44141

Cell Phone: (440) 725-7425
e-mail: RYLIANG@AOL.COM

November 20, 2006

Mr. Dean Palmer, P.E.
Richland Engineering, Ltd.
29 North Park St.
Mansfield, OH 44902

Ref: CUY-90-14.52, PID No. 77332

Dear Mr. Palmer:

Attached in this letter is the processed monitoring data for the stabilization structures at the referenced project site. We went to the site on October 17 and 18 to download the data and to take the inclinometer readings. The on-site data logger was maintained and the batteries were replaced as well. Based on the processed data, we did not observe any significant change in the strain readings during the quarter between July 2006 and October 2006. The inclinometer readings showed no significant movement in this quarter.

Please call me at (440) 725-7425, if you have any question.

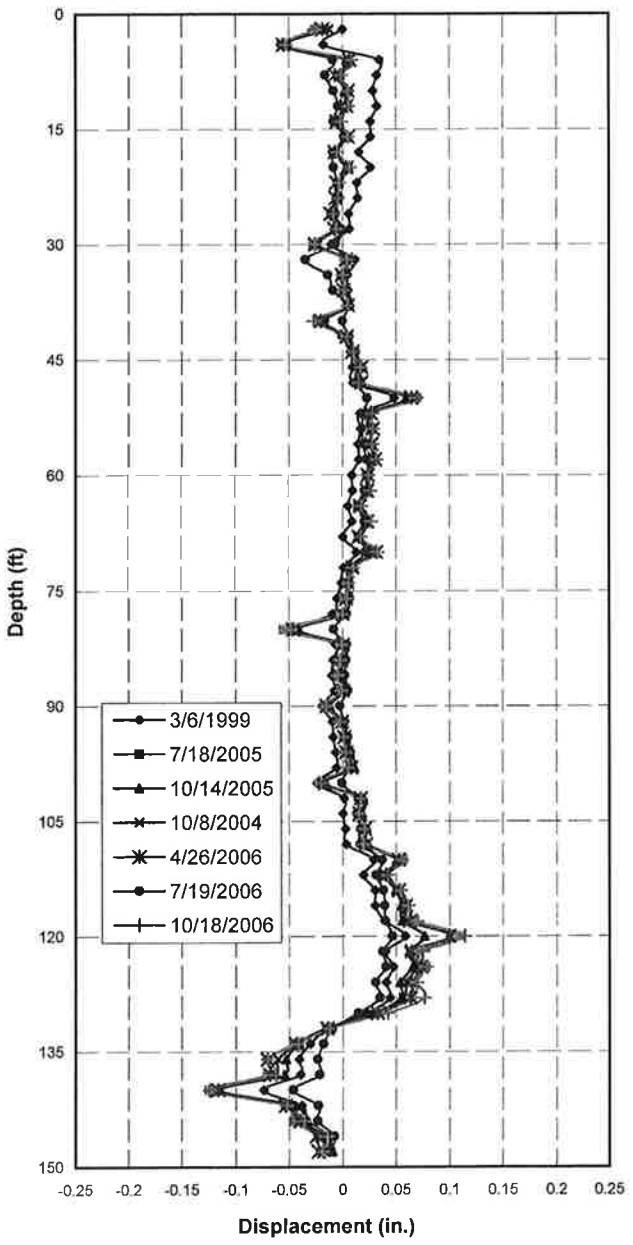
Sincerely,

Robert Liang

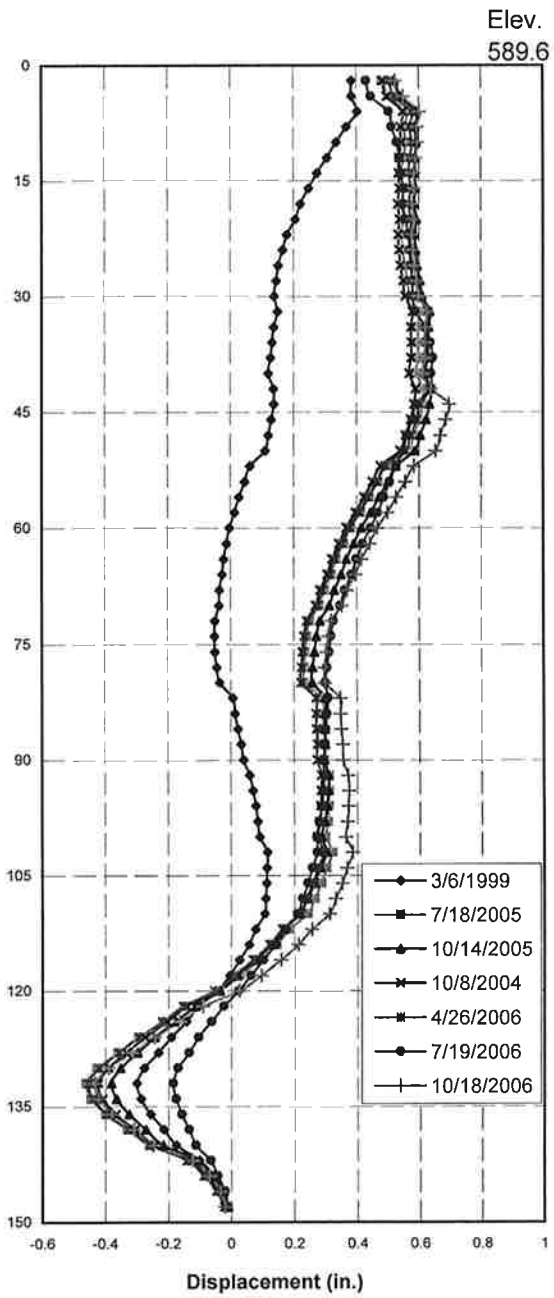
RECEIVED
NOV 24 2006
RICHLAND ENGINEERING LIMITED

Inclinometer #1 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

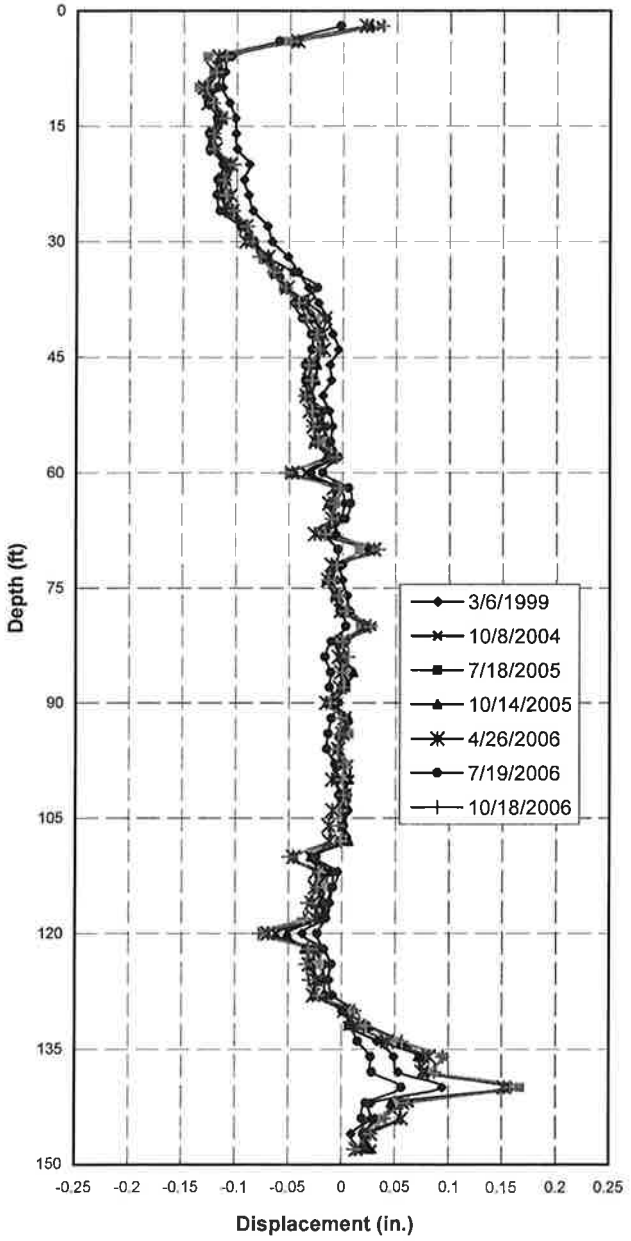


Cumulative

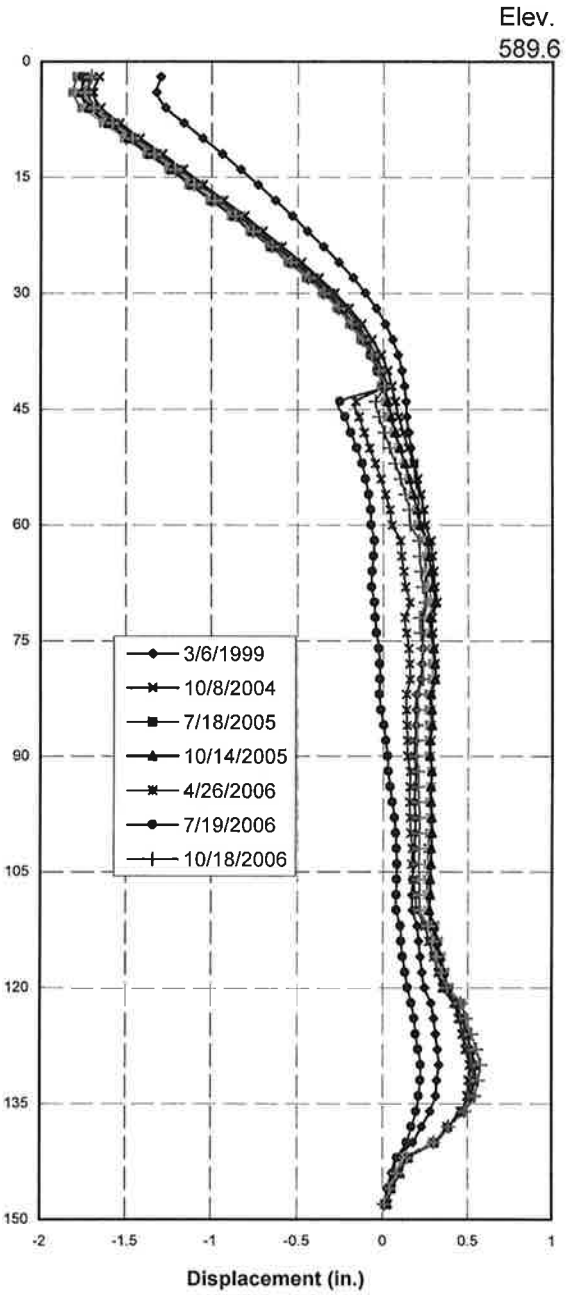


Inclinometer #1 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

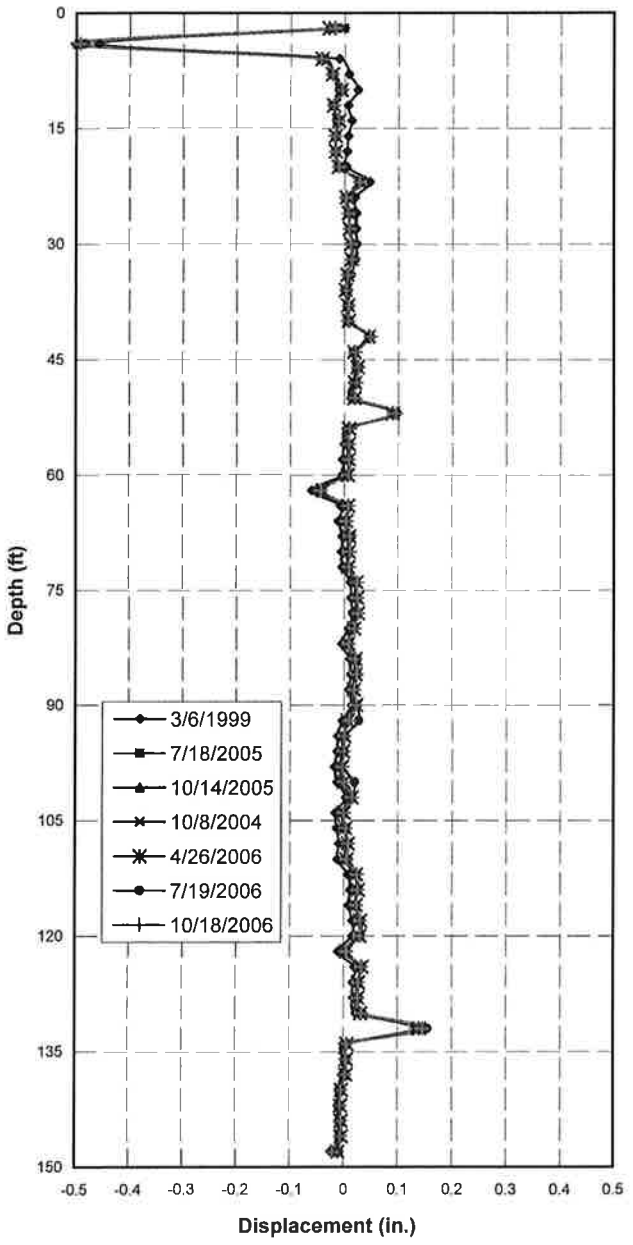


Cumulative

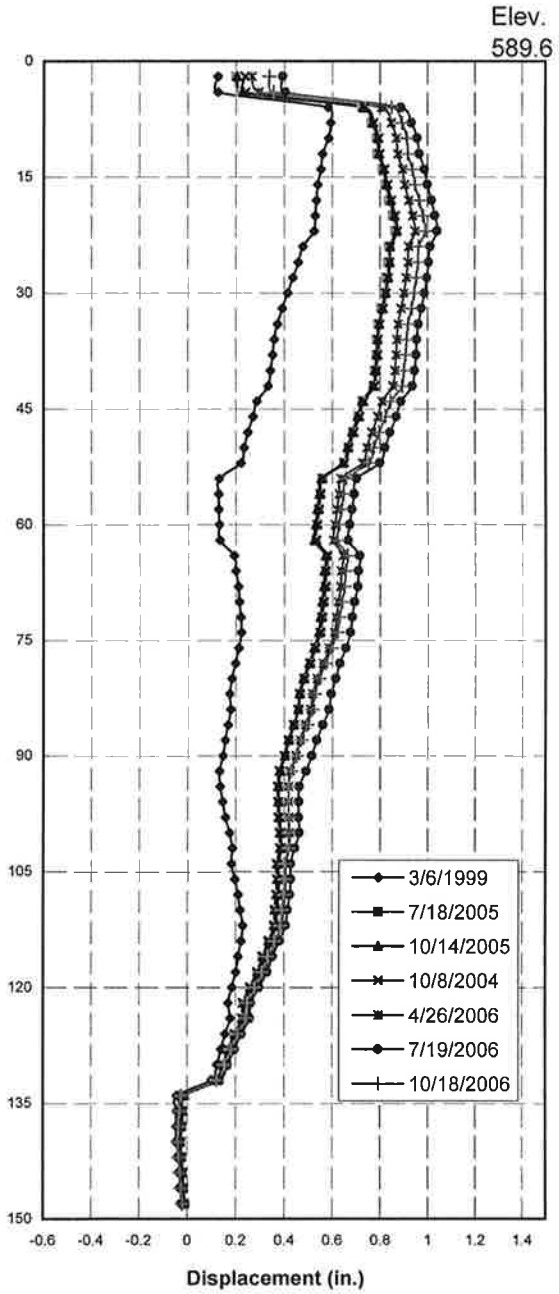


Inclinometer #3 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

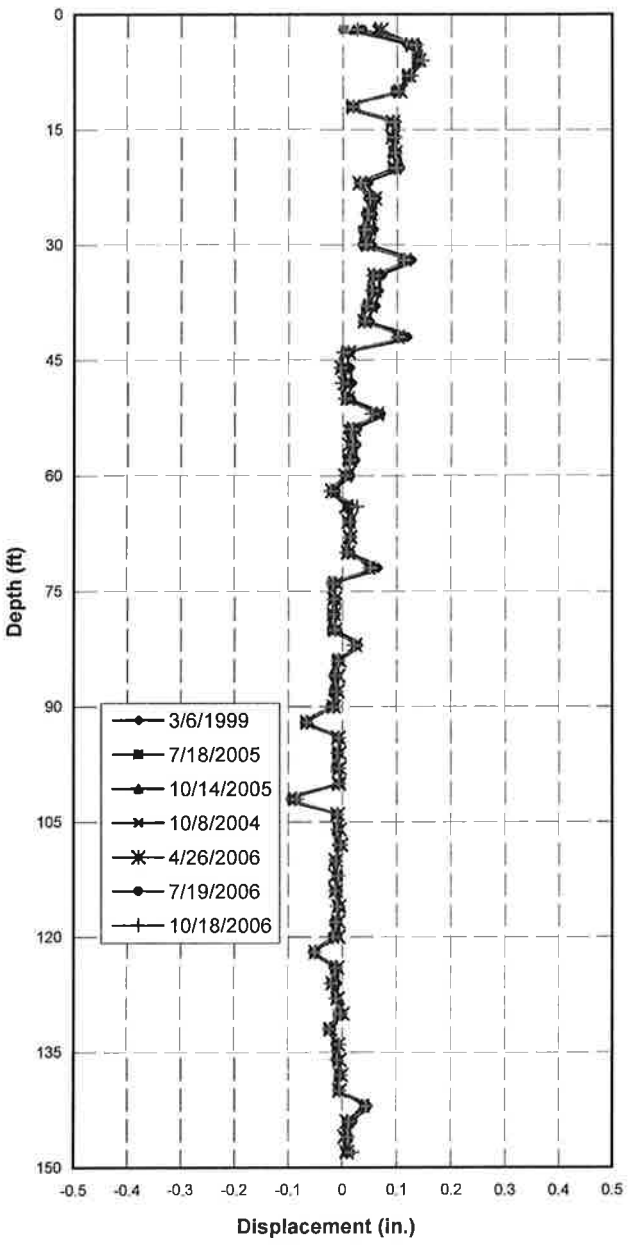


Cumulative

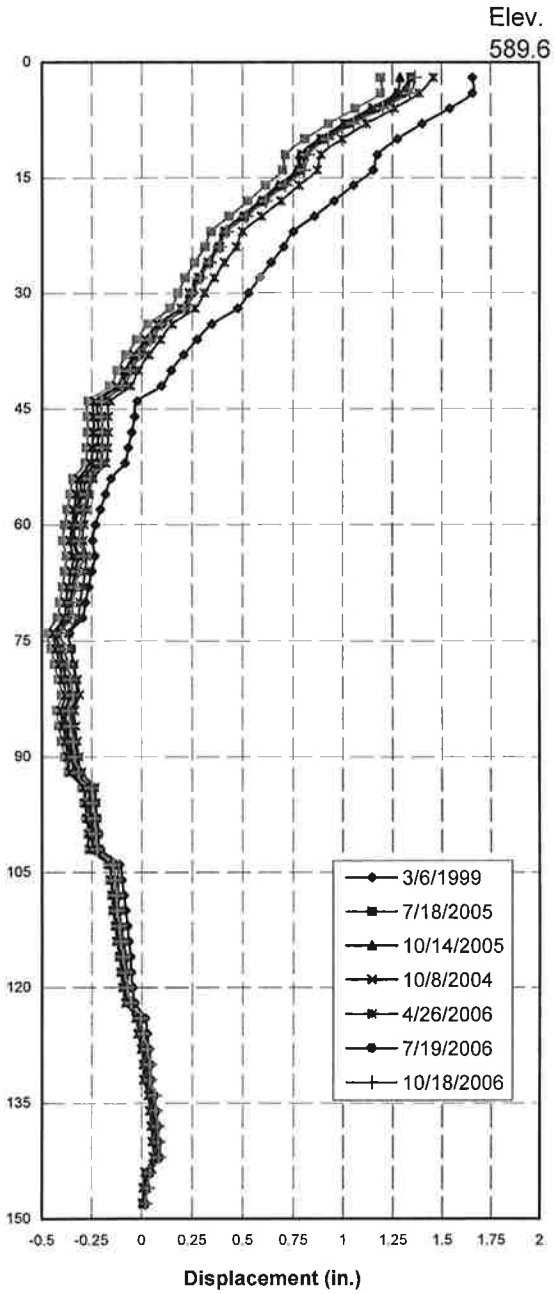


Inclinometer #3 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

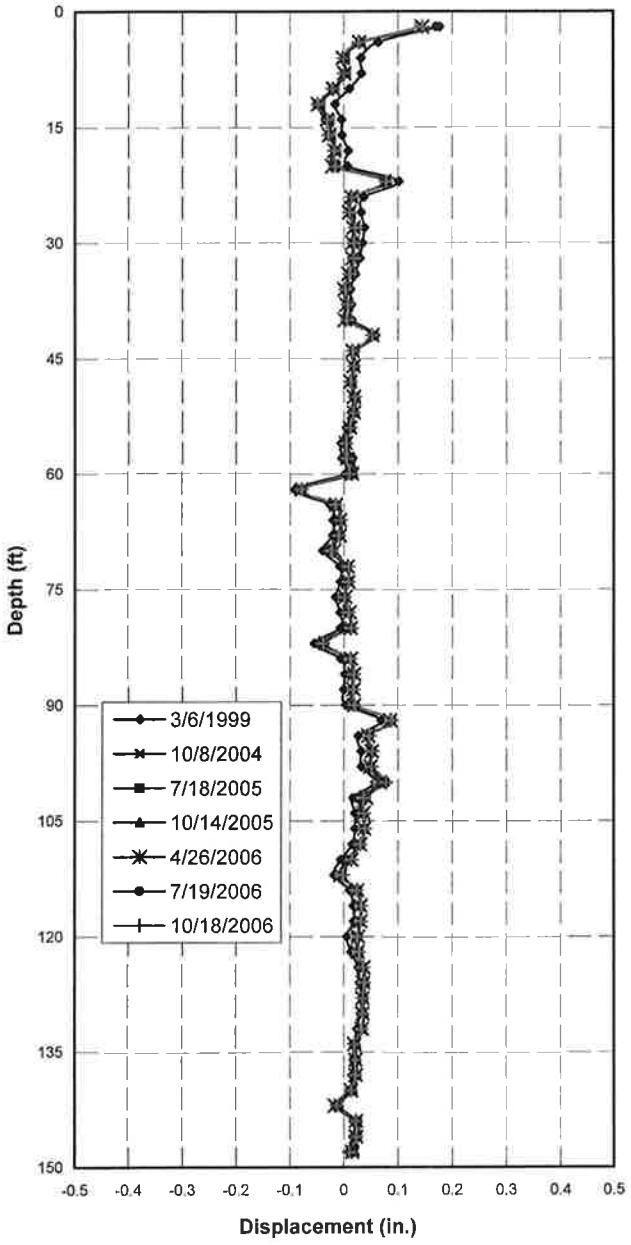


Cumulative

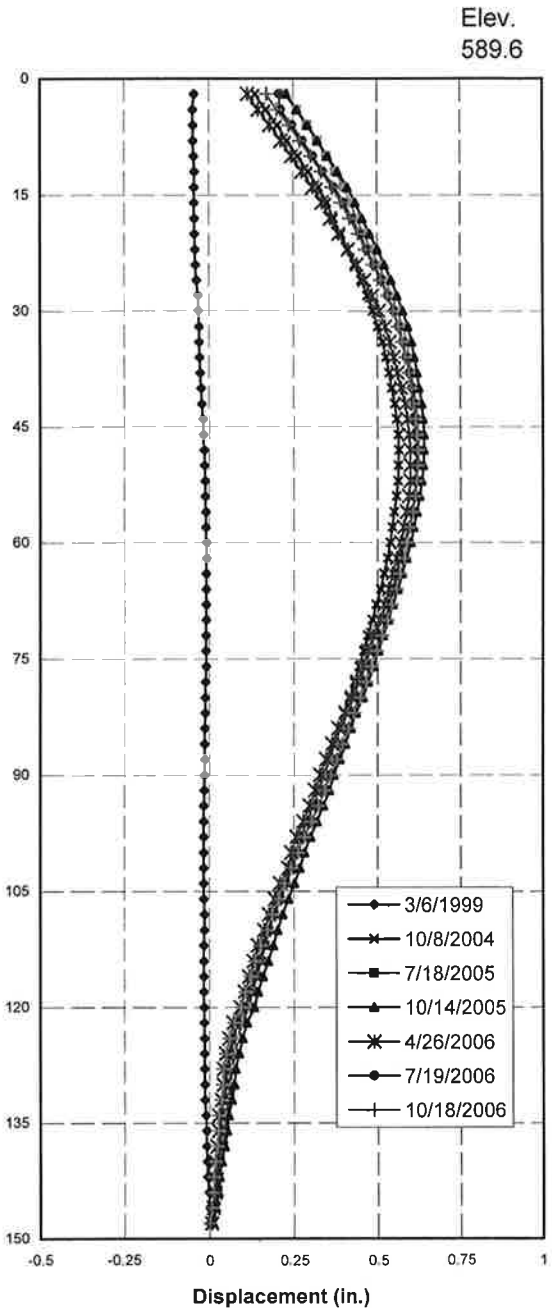


Inclinometer #8 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

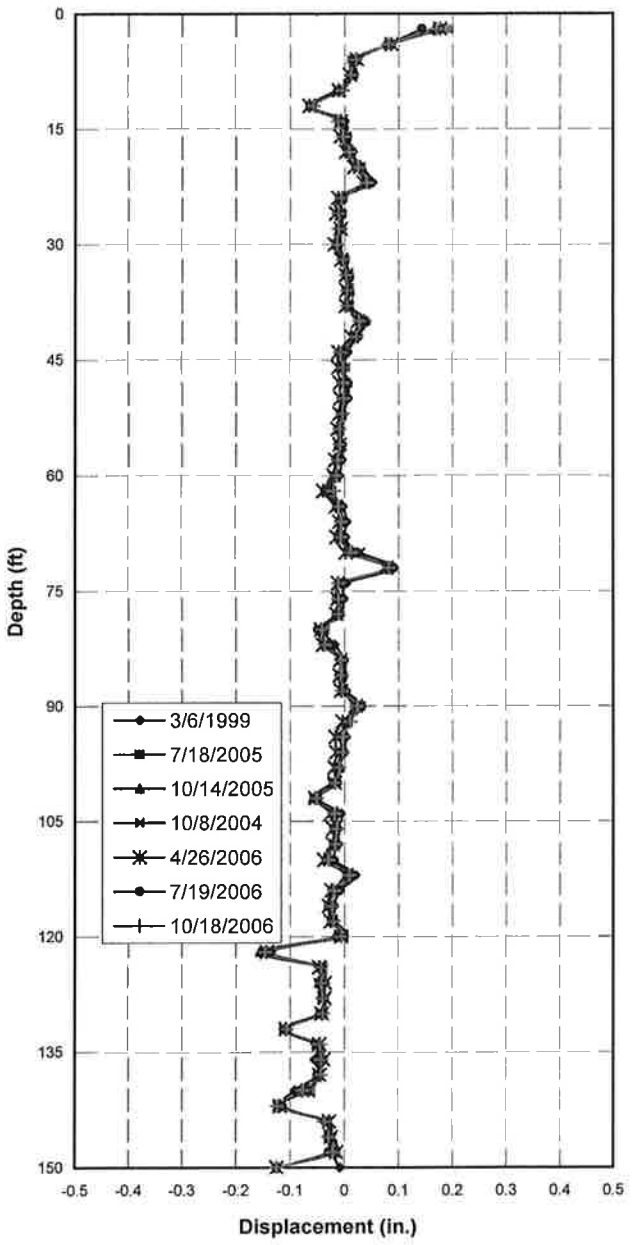


Cumulative

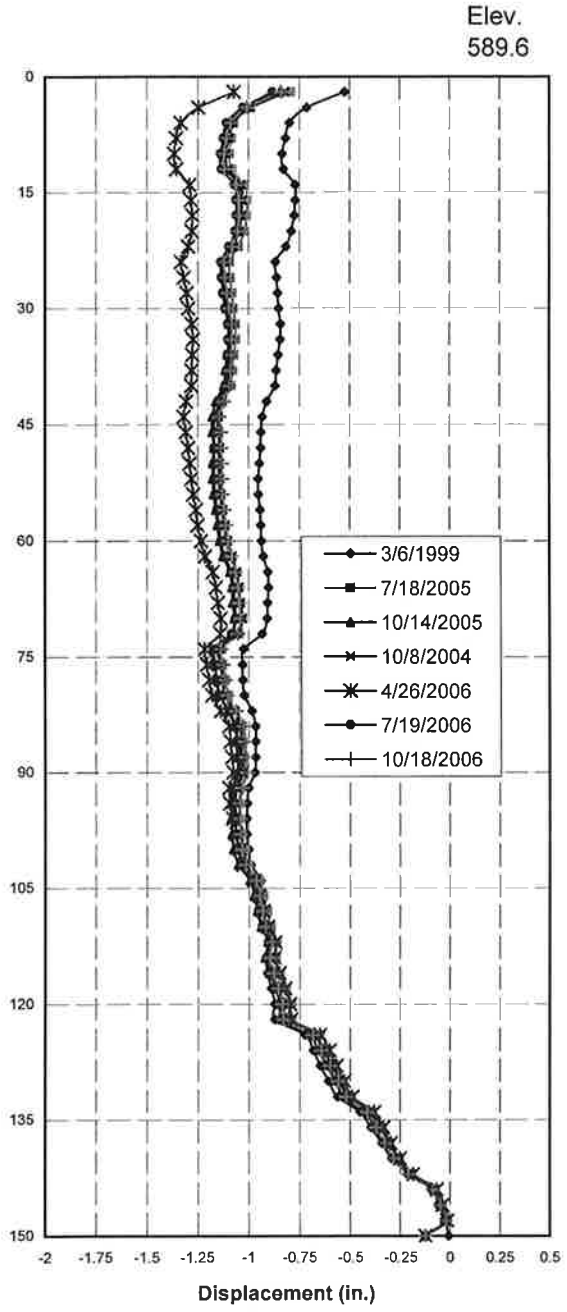


Inclinometer #8 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

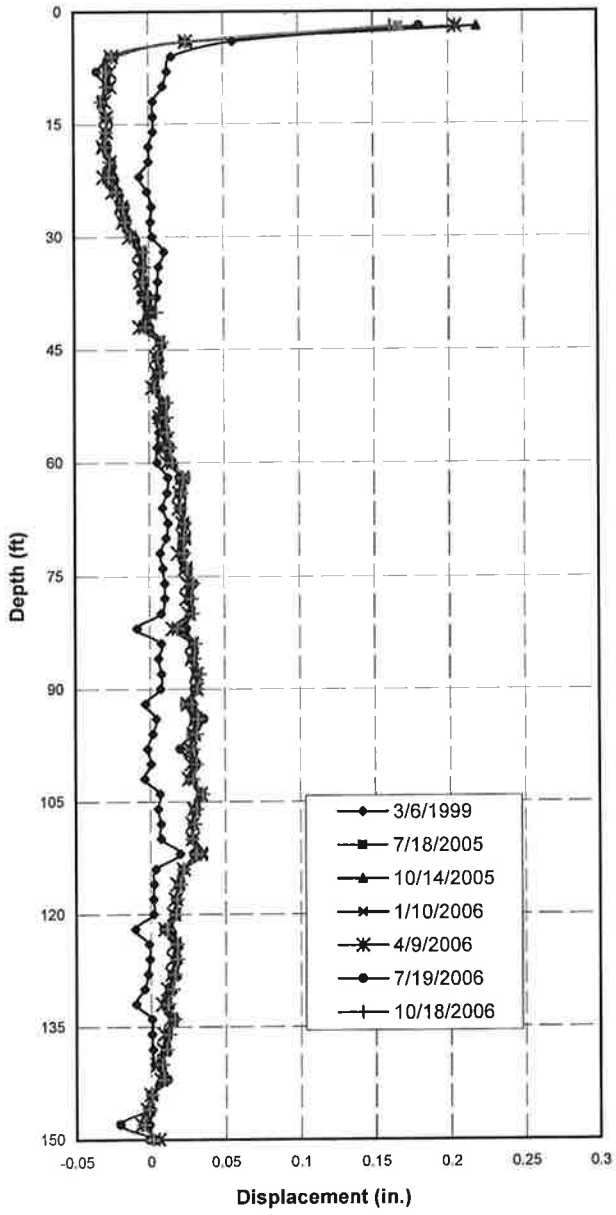


Cumulative

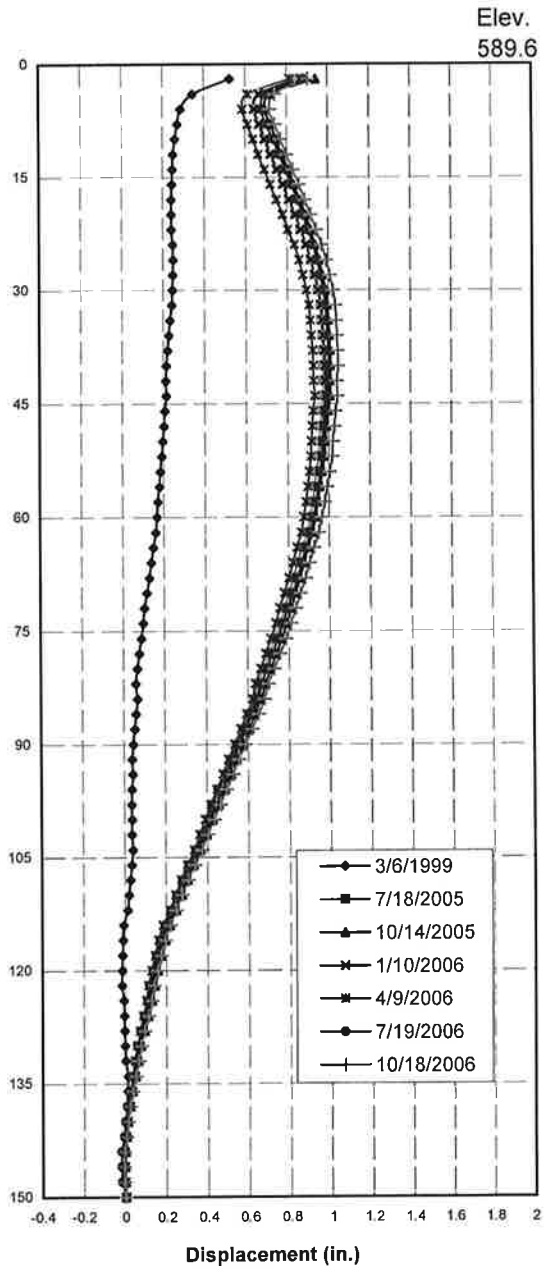


Inclinometer #9A Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

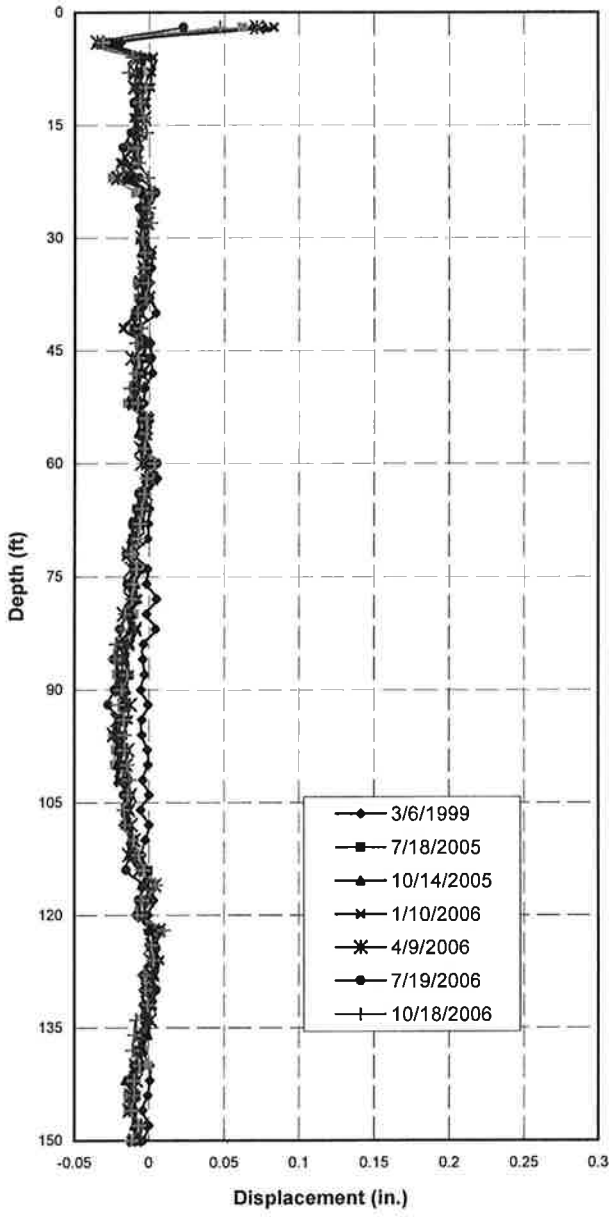


Cumulative

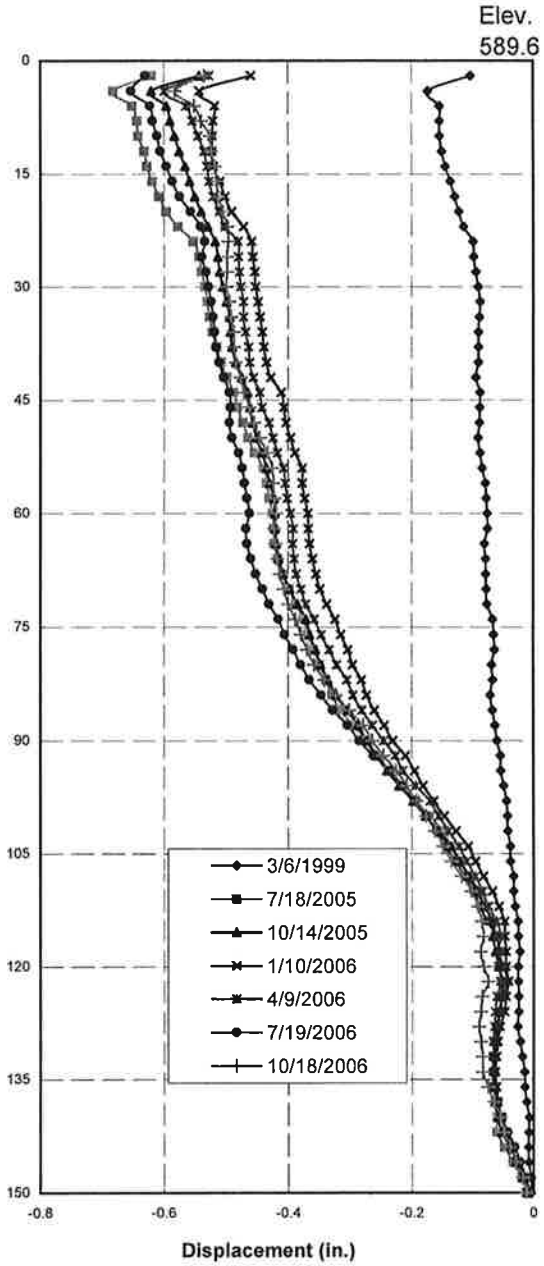


Inclinometer #9A Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

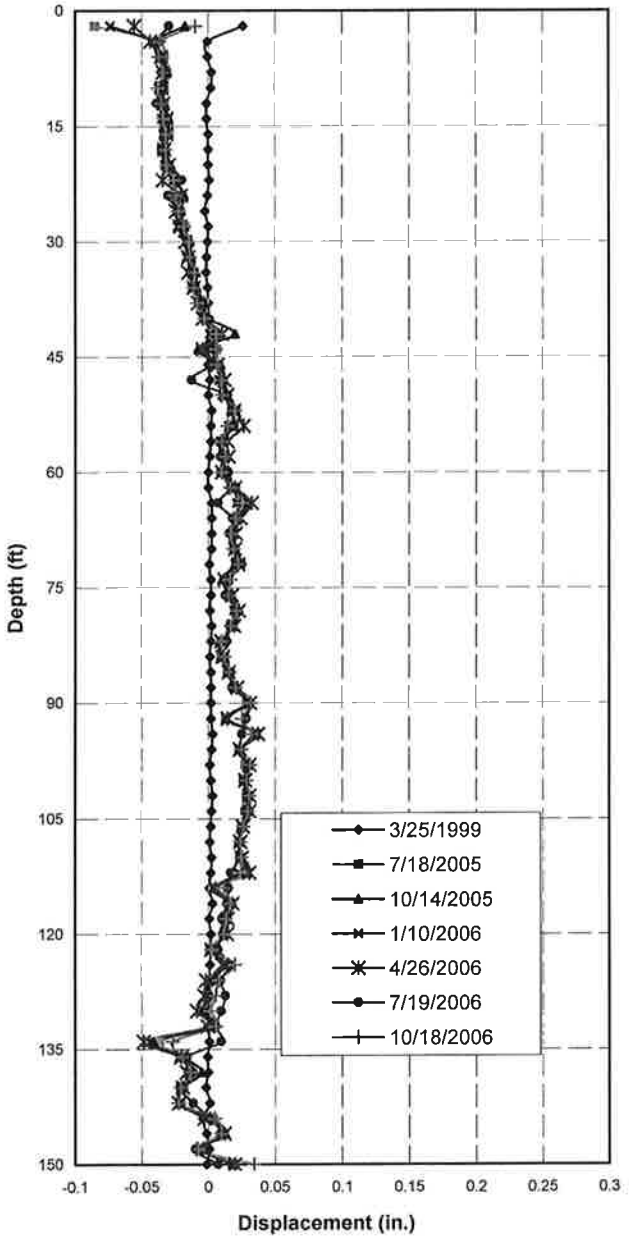


Cumulative

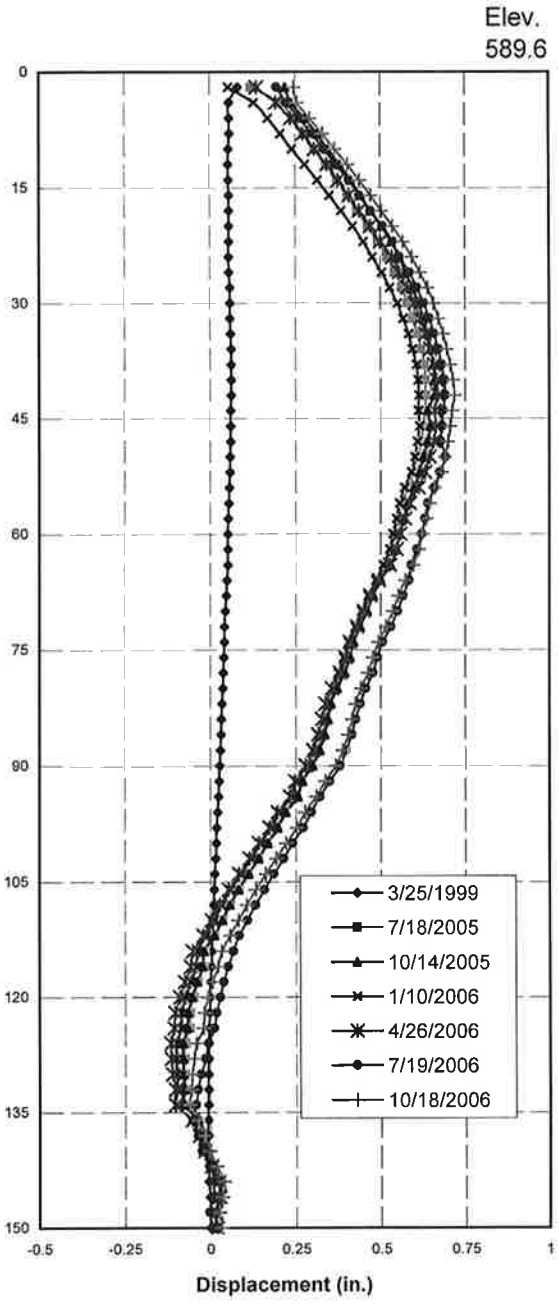


Inclinometer #10 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

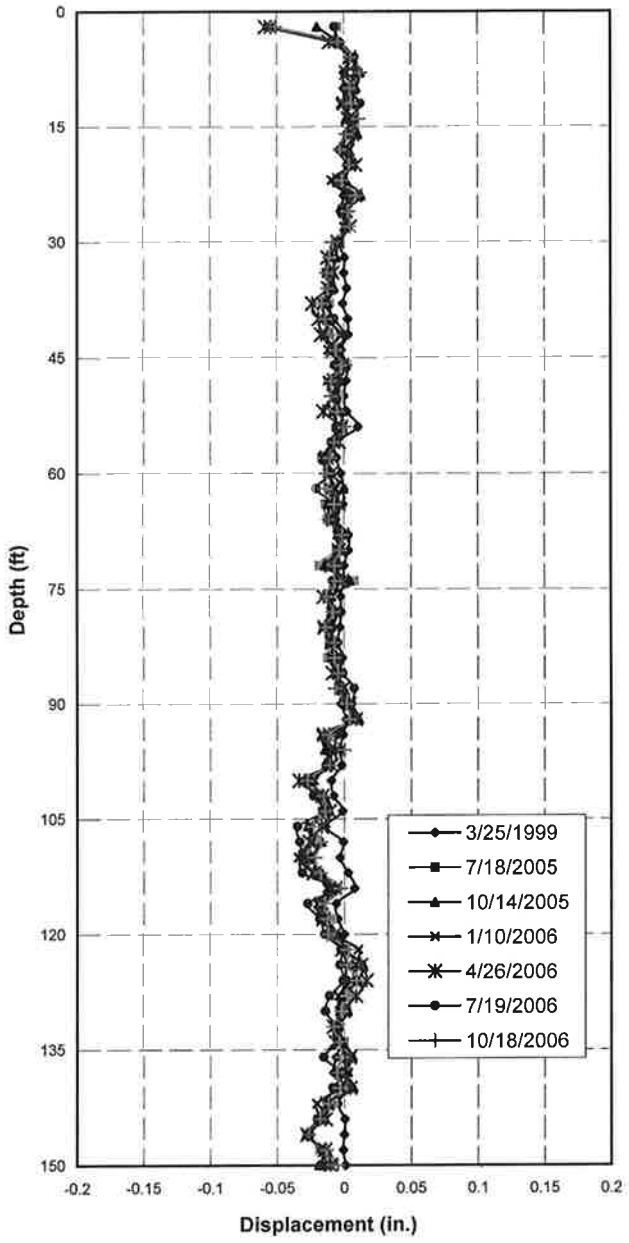


Cumulative

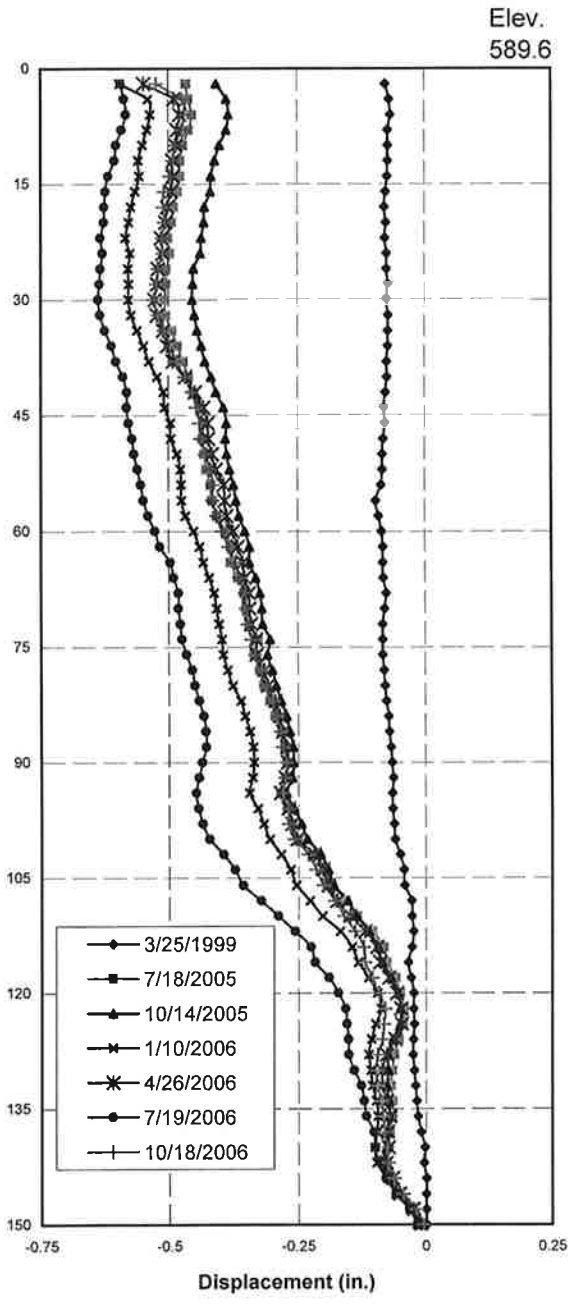


Inclinometer #10 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

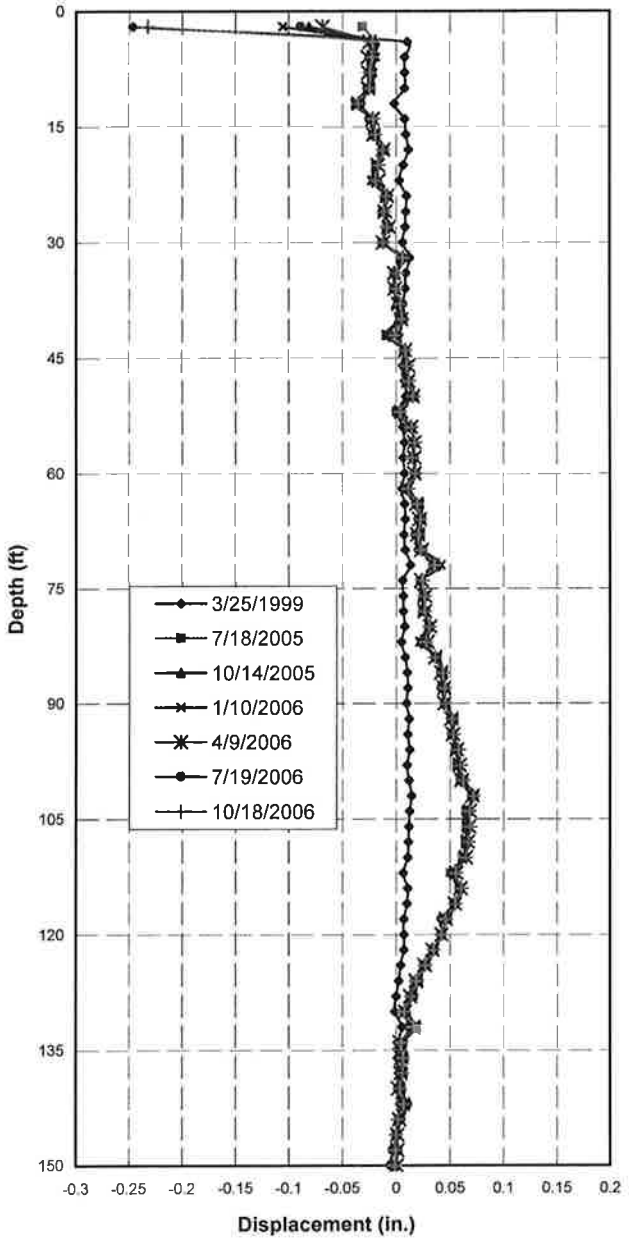


Cumulative

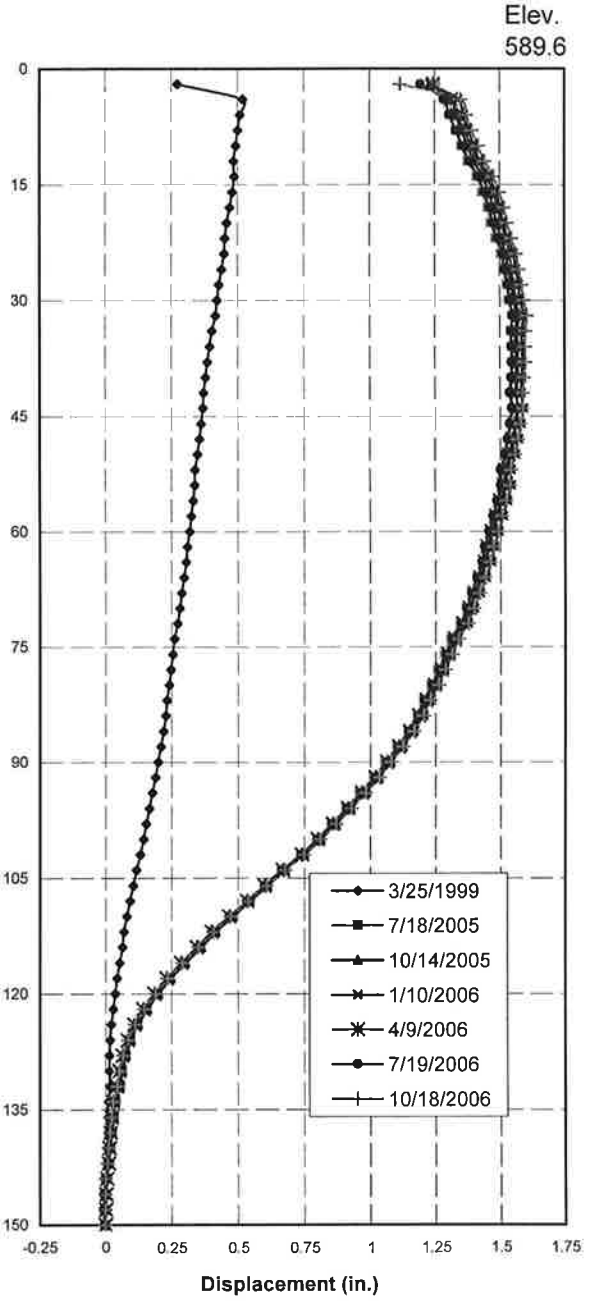


Inclinometer #17 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

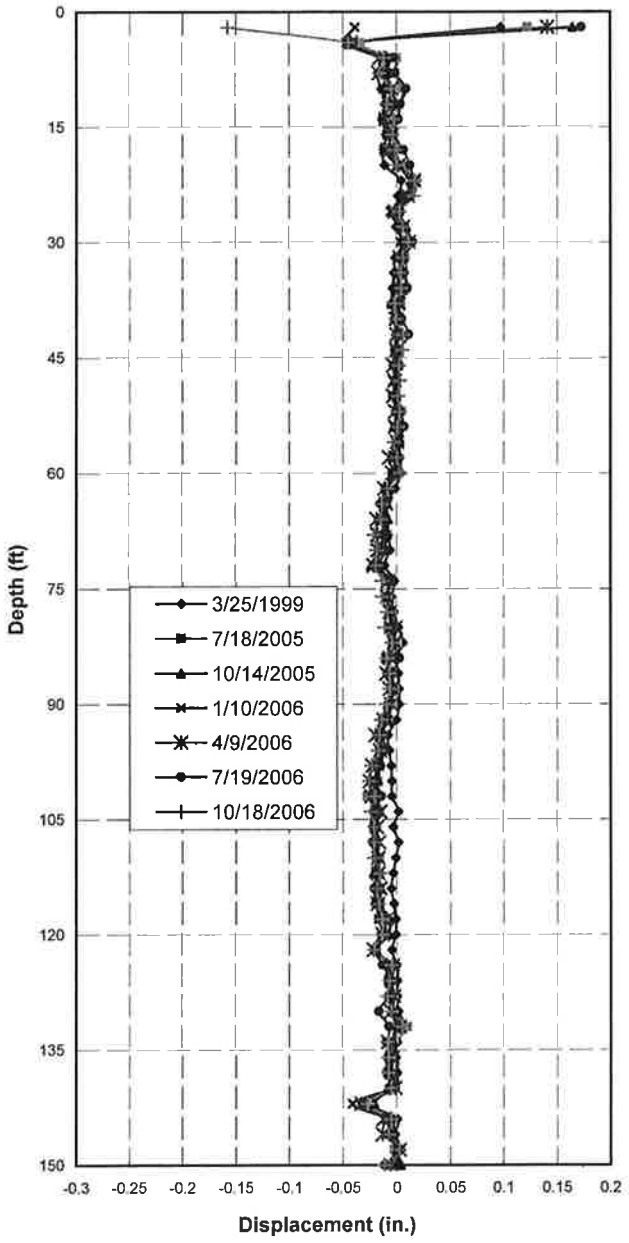


Cumulative

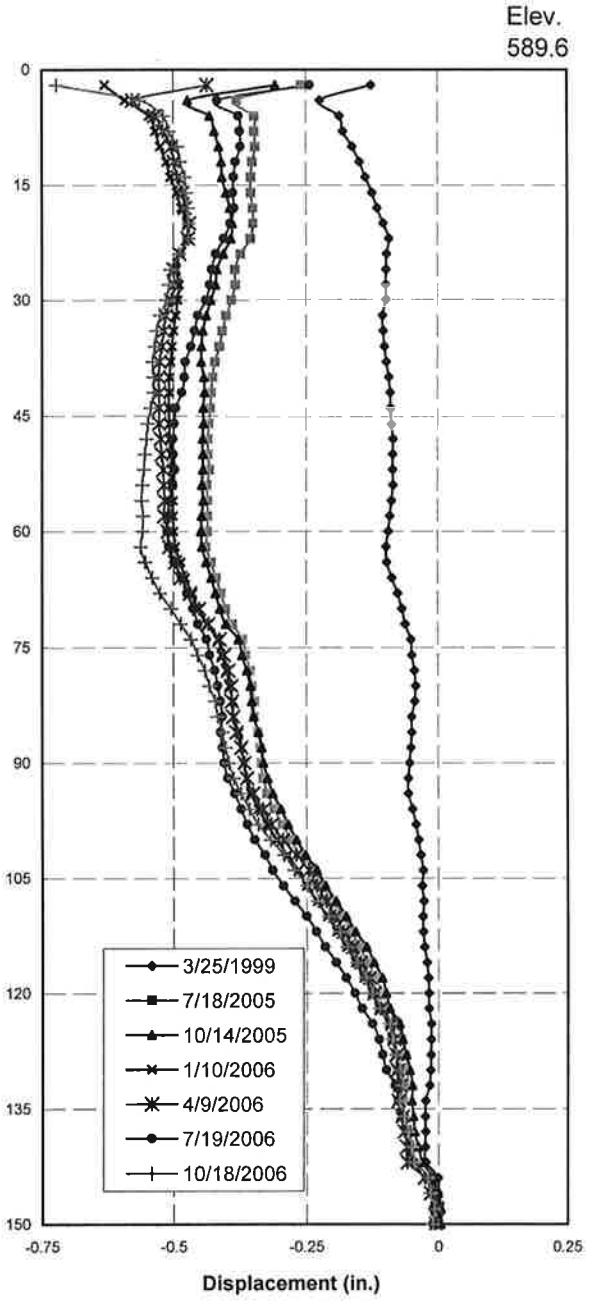


Inclinometer #17 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



Cumulative



Shaft 1: Bending moment along shaft, kip-ft

Depth, ft / Date	9.5	16	22.5	29	35.5	42	47	54.8	64.8	74.8	84.8	94.8	115	135
7/1/1999	-357.65	-148.91	-2.99	242.13	107.23	94.27	103.67	221.87	109.32	92.67	66.77	48.25	-38.94	91.57
1/8/2003	-774.82	-792.9	-360.63	403.12	139.71	-1.79	473.87	620.31	11.19	262.65	439.51	230.65	-179.6	668.9
4/15/2003	-657.74	-650	-232.57	481.71	156.43	-14.02	517.65	659.68	2.44	268.91	457.85	238.57	-192.49	684.79
7/1/2003	-763.24	-602.42	-72.91	660.28	319.17	32.14	588.57	715.87	14.21	278.09	474.99	251.23	-206	702.94
8/7/2003	-817.04	-638.73	-81.08	678	343.79	44.44	615.09	726.92	17.44	279.15	477.58	254.31	-210.32	708.78
10/7/2003	-913.81	-801.08	-248.05	552.54	251.84	20.93	623.3	710.92	6.8	271.9	474.43	265.38	-225.46	720.58
12/31/2003	-870.9	-838.68	-322.24	476.14	168.18	-13.93	630.87	701.76	-19.51	263.35	479.49	275.24	-220.96	748.57
4/13/2004	-831.87	-777.37	-255.87	514.98	175.37	-24.83	659.66	727.03	-27.47	269.67	495.81	277.88	-211.65	763.52
7/13/2004	-889.99	-676.85	-77.13	709.38	338.24	22.05	727.23	792.27	-5.75	281.7	512.3	283.5	-221.34	787.54
10/8/2004	-983.05	-812	-201.66	636.33	293	16.71	752.87	793.14	-7.37	272.19	514.89	286.68	-231.1	803.15
1/7/2005	-925.21	-882.29	-353.38	471.75	139.59	-39.87	733.05	761.38	-34.6	264.1	510.62	288.64	-223.06	817.18
4/8/2005	-775.03	-726	-235.05	530.47	150.69	-53.27	749.88	786.67	-40.37	267.3	525.48	290.73	-219.8	828.14
7/18/2005	-957.73	-709.43	-81.75	735.77	338.65	7.97	821.52	856.49	-16.82	278.53	538.72	298.79	-226.87	837.24
8/26/2005	-1005.57	-755.34	-117.03	721.71	336.36	13.6	835.13	860.64	-16.18	278.76	539.43	301.65	-233.64	840.82
10/11/2005	-1033.08	-827.24	-199.79	654.9	284.17	7.2946	833.72	848.04	-26.29	273.5	537.36	299.33	-240.08	843.25
1/10/2006	-918.83	-858.03	-339.71	489.13	122.55	-48.55	810.18	815.92	-54.94	262.93	536.1	298.82	-234.11	855.77
4/9/2006	-901.14	-812	-289.67	510.35	123.88	-55.75	815.9	831.32	-58.19	267.19	540.25	311.97	-239.53	860
7/19/2006	-975.46	-709.09	-86.84	727.21	303.99	-3.19	876.46	899.71	-33.29	280.02	563.21	306.55	-235.87	865.96
10/18/2006	-1030.45	-848.40	-245.88	609.17	218.59	-17.57	872.05	872.96	-49.65	267.05	557.80	306.95	-246.77	873.58

Shaft 9: Bending moment along shaft, kip-ft

Depth, ft / Date	11	17.5	24	30.5	37	43.25	50	60	70	80	95	115	135
7/1/1999	-67.89	-31.81	8.56	12.84	20.8	19.57	14.07	0.61	9.79	11.62	-33.33	18.35	26.3
1/8/2003	-347.44	-803.74	-998.93	-1106.33	-698.39	-903.77	-661.43	-353.18	324.27	-148.11	-1315.52	540.06	541.35
4/15/2003	-592.31	-919.8	-1050.61	-1133.34	-723.59	-939.66	-696.63	-369.12	336.59	-143.51	-1378.77	555.2	549.67
7/1/2003	-666.55	-902.38	-1016.77	-1090.93	-713.88	-914.42	-686.74	-395.16	340.01	-144.29	-1435.98	557.09	553.5
8/7/2003	-687.84	-917.2	-1003.18	-1072.98	-695.58	-886.87	-664.36	-384.64	352	-133.3	-1462.27	566.15	565.69
10/7/2003	-490.45	-863.81	-1007.81	-1107.14	-708.81	-891.63	-656.83	-378.93	360.91	-134.77	-1498.83	577.44	567.18
12/31/2003	-514.68	-913.27	-1054.9	-1163.2	-741.63	-949.18	-697.72	-421.12	390.01	-101.42	-1555.5	633.83	579.35
4/13/2004	-604.44	-966.22	-1090.5	-1188	-761.54	-987.22	-743.54	-446.54	402.54	-82.56	-1609.1	644.77	582.97
7/13/2004	-817.01	-1007.24	-1051.35	-1122.59	-730.91	-933.53	-709.92	-447.66	411.36	-83.06	-1648.19	649.1	585.94
10/8/2004	-674.74	-949.72	-1005.93	-1128.49	-732.6	-927.74	-697.54	-445.16	413.37	-90.78	-1677.71	652.24	581.64
1/7/2005	-572.76	-951.94	-1036.44	-1183	-760.9	-966.49	-718.51	-441.27	424.15	-94.18	-1699.91	657.05	573.07
4/8/2005	-773.86	-1039.72	-1072.89	-1200.56	-775.89	-989.82	-743.85	-446.59	435.56	-92.57	-1726.57	664.45	574.55
7/18/2005	-885.57	-1041.08	-1038.29	-1152.24	-752.36	-948.63	-719.09	-449.39	438.06	-89.12	-1762.02	670.82	576.24
8/26/2005	-835.5	-1020.01	-1028.45	-1146.98	-746.96	-933.35	-702.48	-447.31	442.02	-86.41	-1773.96	672.92	595.07
10/11/2005	-749.53	-997.4	-1026.45	-1157.47	-750.11	-932.26	-695.29	-445.61	446.57	-84.01	-1786.07	677.93	594.21
1/10/2006	-735.54	-1025.94	-1070.26	-1220.95	-784.71	-983.06	-728.35	-455.6	455.8	-79.41	-1811.1	694.94	585.21
4/9/2006	-761.63	-1055.46	-1104.66	-1250.13	-799.79	-1009.4	-750.25	-456.86	465.33	-75.95	-1830.39	709.25	584.13
7/19/2006	-986.65	-1097.57	-1069.44	-1182.51	-765.49	-967.32	-726.98	-458.20	468.35	-67.36	-1860.26	728.74	591.17
10/18/2006	-785.55	-1028.56	-1059.04	-1198.03	-770.44	-962.79	-714.95	-455.21	472.24	-63.08	-1878.38	742.33	587.52

Tie Beam Forces and Bending Moments (Driven Pile Cap side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
1	7/1/1999	-47.1	68.5	551.7	681.8	313.73	10.70	616.75	252.30	375.15	83.06	-40.28	-2.75
	7/15/1999	-70.1	53.8	538.8	666.8	297.33	-8.15	602.80	234.35	360.30	78.72	-40.60	-2.82
	8/15/1999	10.7	114.3	613.7	728.1	366.70	62.50	670.90	312.20	421.20	97.09	-40.43	-2.44
	8/31/1999	12.0	114.3	617.3	732.8	369.10	63.15	675.05	314.65	423.55	97.73	-40.67	-2.44
	9/15/1999	13.1	113.5	619.7	737.5	370.95	63.30	678.60	316.40	425.50	98.22	-40.89	-2.44
	9/30/1999	29.6	122.3	634.4	753.4	384.93	75.95	693.90	332.00	437.85	101.92	-41.07	-2.37
	10/15/1999	34.7	123.9	637.8	757.9	388.58	79.30	697.85	336.25	440.90	102.88	-41.11	-2.34
	10/31/1999	39.8	127.2	646.6	762	393.90	83.50	704.30	343.20	444.60	104.29	-41.26	-2.27
	11/15/1999	62.3	139.3	662.9	780.1	411.15	100.80	721.50	362.60	459.70	108.86	-41.25	-2.18
	11/30/1999	73.7	146.3	670.6	788.6	419.80	110.00	729.60	372.15	467.45	111.15	-41.18	-2.13
	12/15/1999	72.8	143.6	668.9	789.7	418.75	108.20	729.30	370.85	466.65	110.87	-41.28	-2.15
	12/31/1999	88.8	152.1	680.1	802.5	430.88	120.45	741.30	384.45	477.30	114.08	-41.26	-2.08
	3/31/2000	95.3	158.7	682.5	825.2	440.43	127.00	753.85	388.90	491.95	116.61	-41.66	-2.31
	6/30/2000	60.2	138.2	662.7	804.5	416.40	99.20	733.60	361.45	471.35	110.25	-42.16	-2.46
	9/30/2000	50.1	142.5	668.8	795.7	414.28	96.30	732.25	359.45	469.10	109.69	-42.26	-2.46
	1/13/2001	109.5	179.9	712.3	845.5	461.80	144.70	778.90	410.90	512.70	122.27	-42.15	-2.28
	4/20/2001	126.8	283.2	715.3	881.9	501.80	205.00	798.60	421.05	582.55	132.86	-39.45	-3.62
	7/16/2001	68.3	149.8	674.3	837.1	432.38	109.05	755.70	371.30	493.45	114.48	-42.98	-2.74
	10/9/2001	71.4	157.1	685.5	840.8	438.70	114.25	763.15	378.45	498.95	116.15	-43.12	-2.70
	1/9/2002	102.7	177.8	713	872	466.38	140.25	792.50	407.85	524.90	123.48	-43.35	-2.62
	4/12/2002	125.5	192.8	738.6	904.9	490.45	159.15	821.75	432.05	548.85	129.86	-44.04	-2.62
	7/18/2002	62.3	151.8	706.334	859.6	445.01	107.05	782.97	384.32	505.70	117.82	-44.92	-2.72
	10/8/2002	43.7	151.1	711.3	846.7	438.20	97.40	779.00	377.50	498.90	116.02	-45.30	-2.72
	1/8/2003	84.7	180.5	748.5	891.8	476.38	132.60	820.15	416.60	536.15	126.13	-45.69	-2.68
	4/15/2003	96.1	191.9	739.9	989.3	504.30	144.00	864.60	418.00	590.60	133.52	-47.89	-3.87
	7/1/2003	57.4	168	713	959	474.35	112.70	836.00	385.20	563.50	125.59	-48.07	-3.99
	10/7/2003	42.1	166.8	714	946.6	467.38	104.45	830.30	378.05	556.70	123.75	-48.24	-4.00
	12/31/2003	80	197.9	753.9	985.1	504.23	138.95	869.50	416.95	591.50	133.50	-48.55	-3.91
	4/13/2004	92	208.9	760.4	1006.6	516.98	150.45	883.50	426.20	607.75	136.88	-48.72	-4.07
	7/13/2004	14.6	163.9	707.3	954.4	460.05	89.25	830.85	360.95	559.15	121.81	-49.29	-4.44
	10/8/2004	-8.6	233.4	704.6	941	467.60	112.40	822.80	348.00	587.20	123.81	-47.21	-5.36
	1/7/2005	19.5	190.4	746.5	982.5	484.73	104.95	864.50	383.00	586.45	128.34	-50.48	-4.56
	4/8/2005	3.4	397.6	751.6	1003.4	539.00	200.50	877.50	377.50	700.50	142.71	-44.99	-7.24
	7/18/2005	3.1	164.3	709.7	969.6	461.68	83.70	839.65	356.40	566.95	122.24	-50.24	-4.72
	8/26/2005	3.1	157.5	702.5	956.3	454.85	80.30	829.40	352.80	556.90	120.43	-49.78	-4.57
	10/11/2005	3.1	164.2	712.6	960.1	460.00	83.65	836.35	357.85	562.15	121.79	-50.02	-4.58
	1/10/2006	3.1	191.9	742.5	997	483.63	97.50	869.75	372.80	594.45	128.05	-51.32	-4.97
	4/9/2006	3.5	205.3	750.7	1018.8	494.58	104.40	884.75	377.10	612.05	130.95	-51.86	-5.26
	7/19/2006	3.5	166.6	703.7	975.5	462.33	85.05	839.60	353.60	571.05	122.41	-50.15	-4.87
	10/18/2006	3.5	170.2	709	967.5	462.55	86.85	838.25	356.25	568.85	122.47	-49.94	-4.76

	7/1/1999	374.9	6	549.6	471.8	350.58	190.45	510.70	462.25	238.90	92.82	-21.28	5.00
	7/15/1999	368.6	-3.6	544.2	467.3	344.13	182.50	505.75	456.40	231.85	91.11	-21.48	5.03
	8/15/1999	373.7	0.2	569.4	485.2	357.13	186.95	527.30	471.55	242.70	94.56	-22.62	5.13
	8/31/1999	368.4	-4.7	567	486.2	354.23	181.85	526.60	467.70	240.75	93.79	-22.91	5.08
	9/15/1999	365.9	-9.2	565.3	485.1	351.78	178.35	525.20	465.60	237.95	93.14	-23.05	5.10
	9/30/1999	364.6	-11.7	570.1	487.6	352.65	176.45	528.85	467.35	237.95	93.37	-23.42	5.14
	10/15/1999	361.7	-14.8	569.9	487.4	351.05	173.45	528.65	465.80	236.30	92.95	-23.61	5.14
	10/31/1999	362.8	-13.5	575.6	493.1	354.50	174.65	534.35	469.20	239.80	93.86	-23.91	5.14
	11/15/1999	365.0	-11.5	581.4	498	358.23	176.75	539.70	473.20	243.25	94.85	-24.12	5.15
	11/30/1999	365.6	-11.8	583.7	500.1	359.40	176.90	541.90	474.65	244.15	95.16	-24.26	5.16
	12/15/1999	368.0	-9.2	589.7	504.2	363.18	179.40	546.95	478.85	247.50	96.16	-24.43	5.18
	12/31/1999	369.0	-8	592.9	506.6	365.13	180.50	549.75	480.95	249.30	96.67	-24.54	5.19
	3/31/2000	379.6	7.3	617	524.1	382.00	193.45	570.55	498.30	265.70	101.14	-25.06	5.21
	6/30/2000	376.1	4.4	608.9	519.1	377.13	190.25	564.00	492.50	261.75	99.85	-24.84	5.17
	9/30/2000	360.7	-12.3	588.3	503.5	360.05	174.20	545.90	474.50	245.60	95.33	-24.70	5.13
	1/13/2001	372.1	2.2	618.1	526.1	379.63	187.15	572.10	495.10	264.15	100.51	-25.58	5.17
	4/20/2001	387.6	21	645.8	549.2	400.90	204.30	597.50	516.70	285.10	106.15	-26.13	5.19
	7/16/2001	374.6	6.5	621.5	532.9	383.88	190.55	577.20	498.05	269.70	101.64	-25.70	5.12
	10/9/2001	360.9	-9.4	598.9	515.8	366.55	175.75	557.35	479.90	253.20	97.05	-25.36	5.08
12	1/9/2002	363.5	-2.5	611.5	524.5	374.25	180.50	568.00	487.50	261.00	99.09	-25.75	5.07
	4/12/2002	381.7	16.9	642.7	550.5	397.95	199.30	596.60	512.20	283.70	105.37	-26.40	5.12
	7/18/2002	375	10.5	629	544.7	389.80	192.75	586.85	502.00	277.60	103.21	-26.19	5.03
	10/8/2002	357.7	-9.6	599.2	523	367.58	174.05	561.10	478.45	256.70	97.32	-25.72	4.97
	1/8/2003	367.3	6.5	626.7	542.7	385.80	186.90	584.70	497.00	274.60	102.15	-26.44	4.98
	4/15/2003	385.9	27.3	655.3	566.2	408.68	206.60	610.75	520.60	296.75	108.20	-26.86	5.01
	7/1/2003	384.7	26.3	649.2	565.6	406.45	205.50	607.40	516.95	295.95	107.62	-26.71	4.95
	10/7/2003	360.6	3.5	613	539.7	379.20	182.05	576.35	486.80	271.60	100.40	-26.20	4.82
	12/31/2003	372	19.4	636	558.3	396.43	195.70	597.15	504.00	288.85	104.96	-26.68	4.82
	4/13/2004	389.4	39.8	665.5	583.1	419.45	214.60	624.30	527.45	311.45	111.06	-27.23	4.84
	7/13/2004	379.5	27.7	643.3	571.1	405.40	203.60	607.20	511.40	299.40	107.34	-26.82	4.75
	10/8/2004	361.6	10.3	615.2	550.9	384.50	185.95	583.05	488.40	280.60	101.80	-26.39	4.66
	1/7/2005	367.5	16.1	630.6	561.5	393.93	191.80	596.05	499.05	288.80	104.30	-26.87	4.71
	4/8/2005	388.2	35.6	662.3	587.2	418.33	211.90	624.75	525.25	311.40	110.76	-27.44	4.79
	7/18/2005	382.6	26.3	647.7	580.1	409.18	204.45	613.90	515.15	303.20	108.34	-27.21	4.75
	8/26/2005	373.6	15.7	629.8	566.8	396.48	194.65	598.30	501.70	291.25	104.97	-26.83	4.71
	10/11/2005	365.9	6.1	617.8	557.9	386.93	186.00	587.85	491.85	282.00	102.45	-26.71	4.70
	1/10/2006	376.2	17.5	639	572.2	401.23	196.85	605.60	507.60	294.85	106.23	-27.16	4.77
	4/9/2006	393.8	32.7	665.7	594	421.55	213.25	629.85	529.75	313.35	111.61	-27.69	4.85
	7/19/2006	384.2	20.3	646.2	582.7	408.35	202.25	614.45	515.20	301.50	108.12	-27.39	4.79
	10/18/2006	365	-2	614.4	558.2	383.90	181.50	586.30	489.70	278.10	101.65	-26.90	4.74

Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	306.3	72.2	490.8	675.2	386.13	189.25	583.00	398.55	373.70	102.23	-26.17	0.56
	7/15/1999	288.0	53.1	484.2	670.6	373.98	170.55	577.40	386.10	361.85	99.02	-27.04	0.54
	8/15/1999	280.9	61.8	506.3	693.7	385.68	171.35	600.00	393.60	377.75	102.12	-28.49	0.36
	8/31/1999	270.4	52.1	503.1	691.4	379.25	161.25	597.25	386.75	371.75	100.41	-28.98	0.34
	9/15/1999	261.3	43.9	501.2	689.9	374.08	152.60	595.55	381.25	366.90	99.04	-29.44	0.32
	9/30/1999	257.1	40.7	503.1	690.7	372.90	148.90	596.90	380.10	365.70	98.73	-29.77	0.32
	10/15/1999	250.1	33.8	501.2	691	369.03	141.95	596.10	375.65	362.40	97.71	-30.18	0.30
	10/31/1999	251.4	38	507.6	697.6	373.65	144.70	602.60	379.50	367.80	98.93	-30.43	0.26
	11/15/1999	253.9	41.6	512.1	701.9	377.38	147.75	607.00	383.00	371.75	99.92	-30.52	0.25
	11/30/1999	253.5	41.2	513.6	704.4	378.18	147.35	609.00	383.55	372.80	100.13	-30.68	0.24
	12/15/1999	255.8	46.7	519.1	709.3	382.73	151.25	614.20	387.45	378.00	101.33	-30.77	0.21
	12/31/1999	256.7	48.9	522.3	712.4	385.08	152.80	617.35	389.50	380.65	101.96	-30.87	0.20
	3/31/2000	267.5	64.6	542.8	734.2	402.28	166.05	638.50	405.15	399.40	106.51	-31.40	0.13
	6/30/2000	258.9	46.4	531.2	726.1	390.65	152.65	628.65	395.05	386.25	103.43	-31.63	0.20
	9/30/2000	237.1	10.1	504.9	705.9	364.50	123.60	605.40	371.00	358.00	96.51	-32.02	0.29
	1/13/2001	254.0	40.9	535.1	734.6	391.15	147.45	634.85	394.55	387.75	103.56	-32.39	0.15
	4/20/2001	275.4	72.6	561.4	763.7	418.28	174.00	662.55	418.40	418.15	110.75	-32.47	0.01
	7/16/2001	255.3	37.7	534.8	740.9	392.18	146.50	637.85	395.05	389.30	103.84	-32.65	0.13
	10/9/2001	235.7	7.5	510.6	719.6	368.35	121.60	615.10	373.15	363.55	97.53	-32.80	0.22
13	1/9/2002	240	18.9	523.3	731	378.30	129.45	627.15	381.65	374.95	100.16	-33.08	0.15
	4/12/2002	263.4	58.5	554.8	763	409.93	160.95	658.90	409.10	410.75	108.54	-33.09	-0.04
	7/18/2002	255.5	40.1	566.1	754.5	404.05	147.80	660.30	410.80	397.30	106.98	-34.06	0.30
	10/8/2002	231.2	3.4	508.7	726.1	367.35	117.30	617.40	369.95	364.75	97.26	-33.24	0.12
	1/8/2003	249.4	38.5	540.1	754.4	395.60	143.95	647.25	394.75	396.45	104.74	-33.45	-0.04
	4/15/2003	276.4	78.5	571.6	784.9	427.85	177.45	678.25	424.00	431.70	113.28	-33.28	-0.17
	7/1/2003	273	69	561.4	779.9	420.83	171.00	670.65	417.20	424.45	111.42	-33.21	-0.16
	10/7/2003	246.6	22.5	524.7	744.6	384.60	134.55	634.65	385.65	383.55	101.83	-33.24	0.05
	12/31/2003	264.8	58.9	552.8	770.1	411.65	161.85	661.45	408.80	414.50	108.99	-33.20	-0.13
	4/13/2004	291.3	97.7	584	803.2	444.05	194.50	693.60	437.65	450.45	117.57	-33.17	-0.29
	7/13/2004	275.5	64.3	556.1	781	419.23	169.90	668.55	415.80	422.65	111.00	-33.14	-0.15
	10/8/2004	252.8	29.9	527.5	755.8	391.50	141.35	641.65	390.15	392.85	103.66	-33.25	-0.06
	1/7/2005	264	50.8	544.5	770.6	407.48	157.40	657.55	404.25	410.70	107.89	-33.24	-0.14
	4/8/2005	289.9	90.7	576	802	439.65	190.30	689.00	432.95	446.35	116.41	-33.14	-0.30
	7/18/2005	277.8	67.7	556.4	787.1	422.25	172.75	671.75	417.10	427.40	111.80	-33.16	-0.23
	8/26/2005	266.7	46.5	539.8	771.9	406.23	156.60	655.85	403.25	409.20	107.56	-33.18	-0.13
	10/11/2005	257.2	33.8	526.8	760.8	394.65	145.50	643.80	392.00	397.30	104.49	-33.12	-0.12
	1/10/2006	269.3	59.9	551.2	780.4	415.20	164.60	665.80	410.25	420.15	109.93	-33.31	-0.22
	4/9/2006	289.9	90	576.3	806.2	440.60	189.95	691.25	433.10	448.10	116.66	-33.32	-0.34
	7/19/2006	277.7	63.9	553.8	787.8	420.80	170.80	670.80	415.75	425.85	111.42	-33.23	-0.23
	10/18/2006	253.3	27.9	523.7	757.8	390.68	140.60	640.75	388.50	392.85	103.44	-33.24	-0.10

14	7/1/1999	445.4	53.9	802	298.7	400.00	249.65	550.35	623.70	176.30	105.91	-19.98	10.02
	7/15/1999	440.5	34.4	799.5	280.7	388.78	237.45	540.10	620.00	157.55	102.94	-20.11	10.36
	8/15/1999	455.6	40.8	837.6	284.6	404.65	248.20	561.10	646.60	162.70	107.14	-20.79	10.84
	8/31/1999	452.7	30.7	837.1	274.1	398.65	241.70	555.60	644.90	152.40	105.55	-20.86	11.03
	9/15/1999	448.5	21.7	836.8	266.2	393.30	235.10	551.50	642.65	143.95	104.13	-21.03	11.17
	9/30/1999	447.0	16.1	838.5	260.8	390.60	231.55	549.65	642.75	138.45	103.42	-21.14	11.30
	10/15/1999	446.5	8.8	839.3	255.1	387.43	227.65	547.20	642.90	131.95	102.58	-21.24	11.45
	10/31/1999	450.9	11.7	847.9	257.8	392.08	231.30	552.85	649.40	134.75	103.81	-21.37	11.53
	11/15/1999	455.9	16.1	856.2	259.8	397.00	236.00	558.00	656.05	137.95	105.11	-21.40	11.61
	11/30/1999	456.3	15.5	858.3	259	397.28	235.90	558.65	657.30	137.25	105.19	-21.45	11.65
	12/15/1999	461.3	20.5	865.6	261.7	402.28	240.90	563.65	663.45	141.10	106.51	-21.45	11.70
	12/31/1999	463.4	22.5	871.6	262.9	405.10	242.95	567.25	667.50	142.70	107.26	-21.55	11.76
	3/31/2000	477.8	35.6	903.8	282.7	424.98	256.70	593.25	690.80	159.15	112.52	-22.37	11.91
	6/30/2000	469.2	17.4	889.7	267.4	410.93	243.30	578.55	679.45	142.40	108.80	-22.28	12.03
	9/30/2000	453.5	-23.5	856.8	240.4	381.80	215.00	548.60	655.15	108.45	101.09	-22.17	12.25
	1/13/2001	476.9	5	891.3	257.6	407.70	240.95	574.45	684.10	131.30	107.95	-22.16	12.38
	4/20/2001	494.8	40.8	932.8	281.2	437.40	267.80	607.00	713.80	161.00	115.81	-22.54	12.38
	7/16/2001	475.7	4.9	900.7	255.9	409.30	240.30	578.30	688.20	130.40	108.37	-22.46	12.50
	10/9/2001	459.3	-30.8	870.4	236.8	383.93	214.25	553.60	664.85	103.00	101.65	-22.55	12.59
	1/9/2002	468.8	-18.5	883.7	241.5	393.88	225.15	562.60	676.25	111.50	104.29	-22.43	12.65
	4/12/2002	492.8	22.5	926.5	270.2	428.00	257.65	598.35	709.65	146.35	113.32	-22.64	12.62
	7/18/2002	483.5	3.8	911.9	257.3	414.13	243.65	584.60	697.70	130.55	109.65	-22.66	12.71
	10/8/2002	462.7	-35	875.6	233	384.08	213.85	554.30	669.15	99.00	101.69	-22.63	12.77
	1/8/2003	485.5	2.5	912.6	253.9	413.63	244.00	583.25	699.05	128.20	109.52	-22.55	12.79
	4/15/2003	501.9	612.9	952.7	285.1	588.15	557.40	618.90	727.30	449.00	155.72	-4.09	6.23
	7/1/2003	521.6	28.8	943.4	278.1	442.98	275.20	610.75	732.50	153.45	117.29	-22.30	12.97
	10/7/2003	472.3	-16.5	903.8	247.5	401.78	227.90	575.65	688.05	115.50	106.38	-23.11	12.83
	12/31/2003	495.5	18.6	939.3	268.7	430.53	257.05	604.00	717.40	143.65	113.99	-23.06	12.85
	4/13/2004	504.6	68.9	989	299.2	465.43	286.75	644.10	746.80	184.05	123.23	-23.75	12.61
	7/13/2004	487.3	36.7	961.8	277.7	440.88	262.00	619.75	724.55	157.20	116.73	-23.78	12.71
	10/8/2004	468.9	-0.5	928.8	256.4	413.40	234.20	592.60	698.85	127.95	109.46	-23.82	12.79
	1/7/2005	485.2	21.4	952.7	269.7	432.25	253.30	611.20	718.95	145.55	114.45	-23.79	12.85
	4/8/2005	512.9	68.8	998.7	302.5	470.73	290.85	650.60	755.80	185.65	124.63	-23.91	12.77
	7/18/2005	498.2	40	977.1	286.8	450.53	269.10	631.95	737.65	163.40	119.29	-24.11	12.86
	8/26/2005	486.3	17.1	955.5	271.8	432.68	251.70	613.65	720.90	144.45	114.56	-24.05	12.91
	10/11/2005	478.8	2.4	942.6	263.6	421.85	240.60	603.10	710.70	133.00	111.69	-24.09	12.94
	1/10/2006	497.9	28.2	970.6	280.6	444.33	263.05	625.60	734.25	154.40	117.64	-24.09	12.99
	4/9/2006	519.6	65.1	1008.9	306	474.90	292.35	657.45	764.25	185.55	125.74	-24.26	12.96
	7/19/2006	505.7	73.4	984.2	290.7	463.50	289.55	637.45	744.95	182.05	122.72	-23.12	12.61
	10/18/2006	484	-5.7	946.5	265.8	422.65	239.15	606.15	715.25	130.05	111.91	-24.39	13.11

Tie Beam Forces and Bending Moments (Driven Pile Cap side)(cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
26	7/1/1999	468.3	92.2	387.7	511.7	364.98	280.25	449.70	428.00	301.95	96.63	-11.26	2.82
	7/15/1999	460.1	81	381.5	505.7	357.08	270.55	443.60	420.80	293.35	94.54	-11.50	2.86
	8/15/1999	482.3	96.1	410.7	526	378.78	289.20	468.35	446.50	311.05	100.29	-11.91	3.03
	8/31/1999	490.3	101.9	422.4	535	387.40	296.10	478.70	456.35	318.45	102.57	-12.14	3.09
	9/15/1999	491.0	101.4	426.3	536.4	388.78	296.20	481.35	458.65	318.90	102.94	-12.30	3.13
	9/30/1999	497.9	106.7	434.7	543.6	395.73	302.30	489.15	466.30	325.15	104.78	-12.42	3.16
	10/15/1999	505.0	112.3	443.2	550.9	402.85	308.65	497.05	474.10	331.60	106.66	-12.52	3.19
	10/31/1999	515.6	118.8	452.5	560.9	411.95	317.20	506.70	484.05	339.85	109.07	-12.59	3.23
	11/15/1999	525.0	128.3	463.4	570.2	421.73	326.65	516.80	494.20	349.25	111.66	-12.64	3.25
	11/30/1999	532.5	134.9	471.5	576.8	428.93	333.70	524.15	502.00	355.85	113.57	-12.66	3.27
	12/15/1999	534.1	138.1	476.5	580.2	432.23	336.10	528.35	505.30	359.15	114.44	-12.78	3.27
	12/31/1999	540.4	144.3	484.4	587.2	439.08	342.35	535.80	512.40	365.75	116.25	-12.86	3.29
	3/31/2000	551.1	156	501.3	602.1	452.63	353.55	551.70	526.20	379.05	119.84	-13.17	3.30
	6/30/2000	533.5	137.3	477.6	577.9	431.58	335.40	527.75	505.55	357.60	114.27	-12.78	3.31
	9/30/2000	539.6	136.8	480.7	575.1	433.05	338.20	527.90	510.15	355.95	114.66	-12.61	3.45
	1/13/2001	571.4	169.7	522.7	611.8	468.90	370.55	567.25	547.05	390.75	124.15	-13.07	3.50
	4/20/2001	580.2	184.8	537.9	624.6	481.88	382.50	581.25	559.05	404.70	127.59	-13.21	3.46
	7/16/2001	555.8	159.1	508	598.6	455.38	357.45	553.30	531.90	378.85	120.57	-13.02	3.43
	10/9/2001	556.2	154.1	506	595.8	453.03	355.15	550.90	531.10	374.95	119.95	-13.01	3.50
	1/9/2002	572	170.3	527.3	614.7	471.08	371.15	571.00	549.65	392.50	124.73	-13.28	3.52
	4/12/2002	584.6	187.7	546.3	632.8	487.85	386.15	589.55	565.45	410.25	129.17	-13.52	3.48
	7/18/2002	559.5	162.1	516.1	606	460.93	360.80	561.05	537.80	384.05	122.04	-13.31	3.44
	10/8/2002	557	154.4	511	599.8	455.55	355.70	555.40	534.00	377.10	120.62	-13.27	3.51
	1/8/2003	591	189.2	552.8	639	493.00	390.10	595.90	571.90	414.10	130.53	-13.68	3.54
	4/15/2003	597.9	204.3	567.5	650.5	505.05	401.10	609.00	582.70	427.40	133.72	-13.82	3.48
	7/1/2003	580.7	184.3	545.4	632.5	485.73	382.50	588.95	563.05	408.40	128.61	-13.72	3.46
	10/7/2003	578.2	176.3	538	627	479.88	377.25	582.50	558.10	401.65	127.06	-13.64	3.50
	12/31/2003	610.3	207.7	572.6	661.6	513.05	409.00	617.10	591.45	434.65	135.84	-13.83	3.51
	4/13/2004	617.1	224.2	589.5	675.7	526.63	420.65	632.60	603.30	449.95	139.43	-14.09	3.44
	7/13/2004	584	186.6	549.1	642.6	490.58	385.30	595.85	566.55	414.60	129.89	-13.99	3.40
	10/8/2004	581.8	181.2	543.7	638.3	486.25	381.50	591.00	562.75	409.75	128.74	-13.92	3.43
	1/7/2005	609.9	209	574.8	669.1	515.70	409.45	621.95	592.35	439.05	136.54	-14.12	3.43
	4/8/2005	617.5	225	590.2	683.9	529.15	421.25	637.05	603.85	454.45	140.10	-14.34	3.35
	7/18/2005	590.4	192.7	554.7	656	498.45	391.55	605.35	572.55	424.35	131.97	-14.21	3.32
	8/26/2005	584.4	183.1	544	647.8	489.83	383.75	595.90	564.20	415.45	129.69	-14.10	3.33
	10/11/2005	589.3	185.9	548.5	652	493.93	387.60	600.25	568.90	418.95	130.78	-14.13	3.36
	1/10/2006	616	216.1	582.8	683.4	524.58	416.05	633.10	599.40	449.75	138.89	-14.42	3.35
	4/9/2006	629	235.4	605.8	701.1	542.83	432.20	653.45	617.40	468.25	143.72	-14.70	3.34
	7/19/2006	595.8	199	563.1	668.3	506.55	397.40	615.70	579.45	433.65	134.12	-14.51	3.27
	10/18/2006	595.6	193	557.4	662.8	502.20	394.30	610.10	576.50	427.90	132.97	-14.34	3.33

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
1	7/1/1999	-115.0	299.7	422.9	109.6	179.30	92.35	266.25	153.95	204.65	47.47	-11.56	-1.14
	7/15/1999	-122.0	289	405.2	95.6	166.95	83.50	250.40	141.60	192.30	44.20	-11.09	-1.14
	8/15/1999	-139.4	265.8	401.5	101.8	157.43	63.20	251.65	131.05	183.80	41.68	-12.52	-1.18
	8/31/1999	-144.1	258.4	394.7	99.6	152.15	57.15	247.15	125.30	179.00	40.28	-12.63	-1.20
	9/15/1999	-144.1	255.9	395.1	102	152.23	55.90	248.55	125.50	178.95	40.30	-12.80	-1.20
	9/30/1999	-141.7	260.4	408.3	112.3	159.83	59.35	260.30	133.30	186.35	42.32	-13.35	-1.19
	10/15/1999	-138.1	275.3	441.9	138.4	179.38	68.60	290.15	151.90	206.85	47.49	-14.72	-1.23
	10/31/1999	-148.1	272.7	430.1	118.5	168.30	62.30	274.30	141.00	195.60	44.56	-14.09	-1.22
	11/15/1999	-142.3	278.9	446.6	134.9	179.53	68.30	290.75	152.15	206.90	47.53	-14.78	-1.23
	11/30/1999	-137.9	284.4	462	150.8	189.83	73.25	306.40	162.05	217.60	50.26	-15.49	-1.24
	12/15/1999	-135.4	290	463.8	152.5	192.73	77.30	308.15	164.20	221.25	51.03	-15.34	-1.28
	12/31/1999	-126.8	301.4	481.4	168.9	206.23	87.30	325.15	177.30	235.15	54.60	-15.81	-1.30
	3/31/2000	-133.9	283.1	455.7	149.6	188.63	74.60	302.65	160.90	216.35	49.94	-15.16	-1.24
	6/30/2000	-157.3	230.6	397.4	119.3	147.50	36.65	258.35	120.05	174.95	39.05	-14.73	-1.23
	9/30/2000	-142.8	237.4	427.4	156.8	169.70	47.30	292.10	142.30	197.10	44.93	-16.27	-1.23
	1/13/2001	-118.2	295.4	511.7	182.5	217.85	88.60	347.10	196.75	238.95	57.68	-17.18	-0.95
	4/20/2001	-128.9	270.9	454	163.4	189.85	71.00	308.70	162.55	217.15	50.27	-15.80	-1.22
	7/16/2001	-146.4	213.9	384.1	133.3	146.23	33.75	258.70	118.85	173.60	38.72	-14.95	-1.23
	10/9/2001	-135.7	237.5	439.4	178.3	179.88	50.90	308.85	151.85	207.90	47.63	-17.14	-1.26
	1/9/2002	-120.2	281.4	483	190.7	208.73	80.60	336.85	181.40	236.05	55.26	-17.03	-1.22
	4/12/2002	-133.2	263.6	441.1	154.2	181.43	65.20	297.65	153.95	208.90	48.04	-15.45	-1.23
	7/18/2002	-158.1	191.2	355.6	118	126.68	16.55	236.80	98.75	154.60	33.54	-14.64	-1.25
	10/7/2002	-149.2	192.4	391.7	156.3	147.80	21.60	274.00	121.25	174.35	39.13	-16.77	-1.19
	1/8/2003	-123.2	268.7	469.3	191.8	201.65	72.75	330.55	173.05	230.25	53.39	-17.13	-1.28
	4/15/2003	-137.5	248.4	427.1	157.1	173.78	55.45	292.10	144.80	202.75	46.01	-15.73	-1.30
	7/1/2003	-159.7	183.9	351.2	124.6	125.00	12.10	237.90	95.75	154.25	33.10	-15.01	-1.31
	10/7/2003	-146.6	206.4	412.6	177.8	162.55	29.90	295.20	133.00	192.10	43.04	-17.63	-1.32
	12/31/2003	-135.4	243.4	450.4	190	187.10	54.00	320.20	157.50	216.70	49.54	-17.69	-1.33
	4/13/2004	-144.6	228.6	422.1	168	168.53	42.00	295.05	138.75	198.30	44.62	-16.82	-1.33
	7/13/2004	-179.1	155.6	334.2	117.5	107.05	-11.75	225.85	77.55	136.55	28.34	-15.79	-1.32
	10/8/2004	-169	170.9	373.7	152.9	132.13	0.95	263.30	102.35	161.90	34.98	-17.44	-1.33
	1/7/2005	-145.5	227.8	440.5	188.2	177.75	41.15	314.35	147.50	208.00	47.06	-18.16	-1.36
	4/8/2005	-159.4	209.2	398.5	148.8	149.28	24.90	273.65	119.55	179.00	39.52	-16.53	-1.33
	7/18/2005	-182.8	141.5	330.3	131.3	105.08	-20.65	230.80	73.75	136.40	27.82	-16.71	-1.40
	8/26/2005	-184	140.7	341.3	131.3	107.33	-21.65	236.30	78.65	136.00	28.42	-17.14	-1.28
	10/11/2005	-174.2	159.1	370.9	131.3	121.78	-7.55	251.10	98.35	145.20	32.24	-17.19	-1.05
	1/10/2006	-152.5	216.4	430.7	131.3	156.48	31.95	281.00	139.10	173.85	41.43	-16.55	-0.78
	4/9/2006	-157.2	206.1	413	131.3	148.30	24.45	272.15	127.90	168.70	39.27	-16.46	-0.91
	7/19/2006	-189.4	135.9	330	131.3	101.95	-26.75	230.65	70.30	133.60	26.99	-17.11	-1.42
	10/18/2006	-170.5	170.2	390.6	131.3	130.40	-0.15	260.95	110.05	150.75	34.53	-17.35	-0.91

12	7/1/1999	356.2	257	201.2	275.1	272.38	306.60	238.15	278.70	266.05	72.12	4.55	0.28
	7/15/1999	353.8	251.6	188.4	273.4	266.80	302.70	230.90	271.10	262.50	70.64	4.77	0.19
	8/15/1999	350.0	242.8	195.3	301.1	272.30	296.40	248.20	272.65	271.95	72.10	3.20	0.02
	8/31/1999	350.2	247.8	201.7	307.9	276.90	299.00	254.80	275.95	277.85	73.31	2.94	-0.04
	9/15/1999	349.8	249.1	203.6	314	279.13	299.45	258.80	276.70	281.55	73.90	2.70	-0.11
	9/30/1999	352.2	256.8	212.1	322.7	285.95	304.50	267.40	282.15	289.75	75.71	2.47	-0.17
	10/15/1999	352.6	257.7	225.5	337.3	293.28	305.15	281.40	289.05	297.50	77.65	1.58	-0.19
	10/31/1999	361.0	268.5	222.6	333.7	296.45	314.75	278.15	291.80	301.10	78.49	2.43	-0.21
	11/15/1999	364.5	273.1	237.1	353.6	307.08	318.80	295.35	300.80	313.35	81.30	1.56	-0.28
	11/30/1999	367.6	276.3	249.1	369.4	315.60	321.95	309.25	308.35	322.85	83.56	0.84	-0.32
	12/15/1999	370.6	280.7	248.5	364.3	316.03	325.65	306.40	309.55	322.50	83.67	1.28	-0.29
	12/31/1999	371.2	282.5	254.8	368.8	319.33	326.85	311.80	313.00	325.65	84.55	1.00	-0.28
	3/31/2000	376.0	289.2	244.7	361.1	317.75	332.60	302.90	310.35	325.15	84.13	1.97	-0.33
	6/30/2000	358.4	247.7	207.4	329.3	285.70	303.05	268.35	282.90	288.50	75.64	2.31	-0.13
	9/30/2000	357.6	235.9	230.1	366.4	297.50	296.75	298.25	293.85	301.15	78.77	-0.10	-0.16
	1/13/2001	382.0	289.5	264.4	384.8	330.18	335.75	324.60	323.20	337.15	87.42	0.74	-0.31
	4/20/2001	382.9	294.9	260.1	378.2	329.03	338.90	319.15	321.50	336.55	87.12	1.31	-0.34
	7/16/2001	352.4	249.4	219.2	330.6	287.90	300.90	274.90	285.80	290.00	76.23	1.73	-0.09
	10/9/2001	357.7	267.9	262.1	382	317.43	312.80	322.05	309.90	324.95	84.04	-0.61	-0.34
	1/9/2002	385.8	301.2	285.1	395.6	341.93	343.50	340.35	335.45	348.40	90.53	0.21	-0.29
	4/12/2002	390.9	310.2	263.2	370.1	333.60	350.55	316.65	327.05	340.15	88.33	2.25	-0.29
	7/18/2002	346.39	265.03	220.4	323.3	288.78	305.71	271.85	283.39	294.17	76.46	2.25	-0.24
	10/7/2002	344.5	265.3	252.4	363.5	306.43	304.90	307.95	298.45	314.40	81.13	-0.20	-0.36
	1/8/2003	385.9	308.5	295.9	394.3	346.15	347.20	345.10	340.90	351.40	91.65	0.14	-0.24
	4/15/2003	392.4	317.3	275.8	371.1	339.15	354.85	323.45	334.10	344.20	89.80	2.09	-0.23
	7/1/2003	360	288.1	238.7	332.8	304.90	324.05	285.75	299.35	310.45	80.73	2.55	-0.25
	10/7/2003	357.1	284.5	277.7	372.1	322.85	320.80	324.90	317.40	328.30	85.48	-0.27	-0.24
	12/31/2003	387.7	318.7	304.1	392.5	350.75	353.20	348.30	345.90	355.60	92.87	0.33	-0.22
	4/13/2004	389.4	324.2	294.9	381.2	347.43	356.80	338.05	342.15	352.70	91.99	1.25	-0.24
	7/13/2004	348	285.8	241	324.8	299.90	316.90	282.90	294.50	305.30	79.40	2.26	-0.24
	10/8/2004	342.4	281.8	269.4	353.1	311.68	312.10	311.25	305.90	317.45	82.52	0.06	-0.26
	1/7/2005	374.1	315.2	302.9	382.8	343.75	344.65	342.85	338.50	349.00	91.01	0.12	-0.24
	4/8/2005	386.7	328.9	284.3	365	341.23	357.80	324.65	335.50	346.95	90.35	2.20	-0.26
	7/18/2005	343.2	285.5	242.4	322.1	298.30	314.35	282.25	292.80	303.80	78.98	2.13	-0.25
	8/26/2005	337	278.7	250.1	331.1	299.23	307.85	290.60	293.55	304.90	79.23	1.15	-0.25
	10/11/2005	338.7	283.6	264.1	348.6	308.75	311.15	306.35	301.40	316.10	81.75	0.32	-0.33
	1/10/2006	371.5	317.4	297	373.5	339.85	344.45	335.25	334.25	345.45	89.98	0.61	-0.25
	4/9/2006	377.4	324.1	290.6	368.2	340.08	350.75	329.40	334.00	346.15	90.04	1.42	-0.27
	7/19/2006	341.9	289.2	238.8	315.3	296.30	315.55	277.05	290.35	302.25	78.45	2.56	-0.27
	10/18/2006	342.7	289.5	274.8	354.5	315.38	316.10	314.65	308.75	322.00	83.50	0.10	-0.30

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
13	7/1/1999	177.4	380.2	417.6	236.2	302.85	278.80	326.90	297.50	308.20	80.19	-3.20	-0.24
	7/15/1999	173.8	378	412.7	230.2	298.68	275.90	321.45	293.25	304.10	79.08	-3.03	-0.24
	8/15/1999	172.8	380.2	439.6	252.6	311.30	276.50	346.10	306.20	316.40	82.42	-4.63	-0.23
	8/31/1999	172.6	378	445.8	257.5	313.48	275.30	351.65	309.20	317.75	83.00	-5.07	-0.19
	9/15/1999	170.9	377.2	447.2	261	314.08	274.05	354.10	309.05	319.10	83.16	-5.32	-0.23
	9/30/1999	176.4	380.7	455.9	269.3	320.58	278.55	362.60	316.15	325.00	84.88	-5.59	-0.20
	10/15/1999	176.7	378.9	468.1	279.5	325.80	277.80	373.80	322.40	329.20	86.26	-6.38	-0.15
	10/31/1999	182.4	385.8	502.1	273.8	336.03	284.10	387.95	342.25	329.80	88.97	-6.90	0.28
	11/15/1999	186.8	392.4	482.7	292	338.48	289.60	387.35	334.75	342.20	89.62	-6.50	-0.17
	11/30/1999	189.8	396.8	638.9	305.6	382.78	293.30	472.25	414.35	351.20	101.35	-11.89	1.41
	12/15/1999	193.5	401.1	516.7	302.2	353.38	297.30	409.45	355.10	351.65	93.56	-7.45	0.08
	12/31/1999	194.7	406.1	507.2	308	354.00	300.40	407.60	350.95	357.05	93.73	-7.12	-0.14
	3/31/2000	194.8	409	492.7	298.7	348.80	301.90	395.70	343.75	353.85	92.35	-6.23	-0.23
	6/30/2000	177.7	389.4	467.2	278.7	328.25	283.55	372.95	322.45	334.05	86.91	-5.94	-0.26
	9/30/2000	174.2	385.1	496.7	308	341.00	279.65	402.35	335.45	346.55	90.29	-8.15	-0.25
	1/13/2001	200.0	418.2	530.3	318.6	366.78	309.10	424.45	365.15	368.40	97.11	-7.67	-0.07
	4/20/2001	194.1	416.2	512.8	310.6	358.43	305.15	411.70	353.45	363.40	94.90	-7.08	-0.22
	7/16/2001	166.5	386.2	469	273.8	323.88	276.35	371.40	317.75	330.00	85.75	-6.32	-0.27
	10/9/2001	171.5	389.1	514.8	315.2	347.65	280.30	415.00	343.15	352.15	92.05	-8.95	-0.20
	1/9/2002	193.6	413.6	539.3	324.6	367.78	303.60	431.95	366.45	369.10	97.38	-8.53	-0.06
	4/12/2002	198.8	418.5	509.3	299.2	356.45	308.65	404.25	354.05	358.85	94.38	-6.35	-0.11
	7/18/2002	161.4	379.1	462.4	262.6	316.38	270.25	362.50	311.90	320.85	83.77	-6.13	-0.20
	10/7/2002	155.8	373.6	686.8	301.1	379.33	264.70	493.95	421.30	337.35	100.43	-15.24	1.88
	1/8/2003	193.1	414	547.6	331	371.43	303.55	439.30	370.35	372.50	98.34	-9.02	-0.05
	4/15/2003	195.8	419.9	560.6	305.7	370.50	307.85	433.15	378.20	362.80	98.10	-8.33	0.34
	7/1/2003	172.1	394.8	479.4	273.9	330.05	283.45	376.65	325.75	334.35	87.39	-6.19	-0.19
	10/7/2003	169	389.1	527.1	317.5	350.68	279.05	422.30	348.05	353.30	92.85	-9.52	-0.12
	12/31/2003	196.2	423.2	560.3	334.7	378.60	309.70	447.50	378.25	378.95	100.24	-9.16	-0.02
	4/13/2004	197.9	424.7	546.1	321.7	372.60	311.30	433.90	372.00	373.20	98.65	-8.15	-0.03
	7/13/2004	155.6	383.5	482.7	266.1	321.98	269.55	374.40	319.15	324.80	85.25	-6.97	-0.13
	10/8/2004	152.2	378.4	519	298.6	337.05	265.30	408.80	335.60	338.50	89.24	-9.54	-0.06
	1/7/2005	180.6	410.6	556.1	324.9	368.05	295.60	440.50	368.35	367.75	97.45	-9.63	0.01
	4/8/2005	188.3	419.5	529.1	301	359.48	303.90	415.05	358.70	360.25	95.18	-7.39	-0.03
	7/18/2005	150.7	376.8	482.9	262.2	318.15	263.75	372.55	316.80	319.50	84.24	-7.23	-0.06
	8/26/2005	144.7	373.1	494.1	275.3	321.80	258.90	384.70	319.40	324.20	85.20	-8.36	-0.11
	10/11/2005	146.5	375.2	533.7	291.5	336.73	260.85	412.60	340.10	333.35	89.15	-10.09	0.15
	1/10/2006	176	407.1	548.8	313.5	361.35	291.55	431.15	362.40	360.30	95.67	-9.28	0.05
	4/9/2006	180.6	412.1	538.7	307.8	359.80	296.35	423.25	359.65	359.95	95.26	-8.43	-0.01
	7/19/2006	149.4	377.4	480.1	259.8	316.68	263.40	369.95	314.75	318.60	83.85	-7.08	-0.09
	10/18/2006	155.2	382.8	532.6	304.1	343.68	269.00	418.35	343.90	343.45	90.99	-9.93	0.01

	7/1/1999	199.5	418.4	473.6	323.8	353.83	308.95	398.70	336.55	371.10	93.68	-5.96	-0.77
	7/15/1999	194.3	414.4	461.1	314.4	346.05	304.35	387.75	327.70	364.40	91.62	-5.54	-0.82
	8/15/1999	191.0	402.1	488.7	347.5	357.33	296.55	418.10	339.85	374.80	94.61	-8.08	-0.78
	8/31/1999	189.5	395.4	496	352.6	358.38	292.45	424.30	342.75	374.00	94.89	-8.76	-0.70
	9/15/1999	186.8	391.6	503.6	359.8	360.45	289.20	431.70	345.20	375.70	95.44	-9.47	-0.68
	9/30/1999	188.5	396.7	516	369	367.55	292.60	442.50	352.25	382.85	97.32	-9.96	-0.69
	10/15/1999	235.3	403	530.4	378.9	386.90	319.15	454.65	382.85	390.95	102.44	-9.01	-0.18
	10/31/1999	202.7	418.5	524.2	371.5	379.23	310.60	447.85	363.45	395.00	100.41	-9.12	-0.71
	11/15/1999	208.9	426.2	548.2	393.2	394.13	317.55	470.70	378.55	409.70	104.35	-10.18	-0.70
	11/30/1999	212.9	429.2	566.6	409.5	404.55	321.05	488.05	389.75	419.35	107.11	-11.10	-0.66
	12/15/1999	216.9	433.5	561.4	403.7	403.88	325.20	482.55	389.15	418.60	106.93	-10.46	-0.66
	12/31/1999	220.7	443.8	566.6	407.4	409.63	332.25	487.00	393.65	425.60	108.46	-10.28	-0.72
	3/31/2000	215.2	438.2	567.9	406.5	406.95	326.70	487.20	391.55	422.35	107.75	-10.67	-0.69
	6/30/2000	191.3	415.8	542.4	380.7	382.55	303.55	461.55	366.85	398.25	101.29	-10.50	-0.70
	6/30/2000	183.3	409.8	571	409.9	393.50	296.55	490.45	377.15	409.85	104.19	-12.89	-0.73
	1/13/2001	215.4	447.2	588.9	421.9	418.35	331.30	505.40	402.15	434.55	110.77	-11.57	-0.73
	4/20/2001	210.2	445.1	586.6	415.7	414.40	327.65	501.15	398.40	430.40	109.72	-11.53	-0.72
	7/16/2001	171.2	413	554.5	377.7	379.10	292.10	466.10	362.85	395.35	100.37	-11.56	-0.73
	10/9/2001	178.5	417.9	596.2	418.8	402.85	298.20	507.50	387.35	418.35	106.66	-13.91	-0.69
14	1/9/2002	206.2	445.9	606.4	430	422.13	326.05	518.20	406.30	437.95	111.77	-12.77	-0.71
	4/12/2002	208.6	449.5	584.1	408.1	412.58	329.05	496.10	396.35	428.80	109.24	-11.10	-0.73
	7/18/2002	161.7	410.1	551.9	368.5	373.05	285.90	460.20	356.80	389.30	98.77	-11.58	-0.73
	10/7/2002	160.2	405.5	592.3	407.7	391.43	282.85	500.00	376.25	406.60	103.64	-14.43	-0.68
	1/8/2003	202	449.1	620.2	437.7	427.25	325.55	528.95	411.10	443.40	113.12	-13.52	-0.72
	4/15/2003	205.4	453.6	590	409.8	414.70	329.50	499.90	397.70	431.70	109.80	-11.32	-0.76
	7/1/2003	171.9	426.9	559.5	377.3	383.90	299.40	468.40	365.70	402.10	101.65	-11.23	-0.82
	10/7/2003	172	424.4	600.8	422.4	404.90	298.20	511.60	386.40	423.40	107.21	-14.18	-0.83
	12/31/2003	205.6	461.3	624.2	444.9	434.00	333.45	534.55	414.90	453.10	114.91	-13.36	-0.86
	4/13/2004	204.7	463.4	611.5	433.1	428.18	334.05	522.30	408.10	448.25	113.37	-12.51	-0.90
	7/13/2004	159.6	424.2	566.4	383.7	383.48	291.90	475.05	363.00	403.95	101.53	-12.17	-0.92
	10/8/2004	153	416.8	590.5	409.5	392.45	284.90	500.00	371.75	413.15	103.91	-14.30	-0.93
	1/7/2005	192.8	454.9	627.8	446.9	430.60	323.85	537.35	410.30	450.90	114.01	-14.19	-0.91
	4/8/2005	205.2	467.5	600.9	425.2	424.70	336.35	513.05	403.05	446.35	112.45	-11.74	-0.97
	7/18/2005	154.9	424.1	560.9	385.2	381.28	289.50	473.05	357.90	404.65	100.95	-12.20	-1.05
	8/26/2005	168.3	416.1	569.1	391.2	386.18	292.20	480.15	368.70	403.65	102.25	-12.49	-0.78
	10/11/2005	152.5	418.5	590.5	413.4	393.73	285.50	501.95	371.50	415.95	104.25	-14.38	-1.00
	1/10/2006	190.7	455.4	615	436.7	424.45	323.05	525.85	402.85	446.05	112.38	-13.48	-0.97
	4/9/2006	196.7	460.2	612.3	436.6	426.45	328.45	524.45	404.50	448.40	112.91	-13.03	-0.98
	7/19/2006	159.7	426.1	562.3	382.1	382.55	292.90	472.20	361.00	404.10	101.29	-11.92	-0.97
	10/18/2006	161.9	425.9	600.5	422.5	402.70	293.90	511.50	381.20	424.20	106.62	-14.46	-0.96

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
26	7/1/1999	222.2	-19.9	305.2	560	266.88	101.15	432.60	263.70	270.05	70.66	-22.03	-0.14
	7/15/1999	207.8	-36.8	294.3	540.9	251.55	85.50	417.60	251.05	252.05	66.60	-22.07	-0.02
	8/15/1999	189.9	-53.4	320.4	546.8	250.93	68.25	433.60	255.15	246.70	66.44	-24.28	0.19
	8/31/1999	184.8	-60	330.2	555.2	252.55	62.40	442.70	257.50	247.60	66.87	-25.27	0.22
	9/15/1999	185.7	-57.2	336.6	558.2	255.83	64.25	447.40	261.15	250.50	67.73	-25.46	0.24
	9/30/1999	187.5	-53.7	349.9	570.1	263.45	66.90	460.00	268.70	258.20	69.75	-26.12	0.24
	10/15/1999	195.3	-50.5	375.2	601.5	280.38	72.40	488.35	285.25	275.50	74.23	-27.64	0.22
	10/31/1999	197.3	-39.9	370.8	589.7	279.48	78.70	480.25	284.05	274.90	74.00	-26.69	0.20
	11/15/1999	202.5	-32.3	385.9	601.1	289.30	85.10	493.50	294.20	284.40	76.60	-27.14	0.22
	11/30/1999	206.5	-27.3	398.1	613.9	297.80	89.60	506.00	302.30	293.30	78.85	-27.67	0.20
	12/15/1999	216.1	-19.5	401.6	620.9	304.78	98.30	511.25	308.85	300.70	80.70	-27.44	0.18
	12/31/1999	223.8	-15	410.7	633.4	313.23	104.40	522.05	317.25	309.20	82.93	-27.76	0.18
	3/31/2000	203.5	-16	395.7	633.5	304.18	93.75	514.60	299.60	308.75	80.54	-27.97	-0.20
	6/30/2000	149.3	-41	371.2	553.8	258.33	54.15	462.50	260.25	256.40	68.40	-27.14	0.09
	6/30/2000	154.3	-22.3	411.5	580.2	280.93	66.00	495.85	282.90	278.95	74.38	-28.57	0.09
	1/13/2001	197.9	7.7	446.8	627.1	319.88	102.80	536.95	322.35	317.40	84.69	-28.85	0.11
	4/20/2001	167.6	1.3	434.9	589.5	298.33	84.45	512.20	301.25	295.40	78.99	-28.43	0.13
	7/16/2001	112.8	-20.6	409.7	555.1	264.25	46.10	482.40	261.25	267.25	69.97	-29.00	-0.13
	10/9/2001	136.9	-5.4	451.7	582.7	291.48	65.75	517.20	294.30	288.65	77.17	-30.00	0.13
	1/9/2002	176.6	9	461.6	618.2	316.35	92.80	539.90	319.10	313.60	83.76	-29.71	0.12
	4/12/2002	158.20	3.40	438	581.00	295.25	80.80	509.70	298.30	292.20	78.17	-28.50	0.14
	7/18/2002	86.10	-23.70	405	503.86	242.87	31.20	454.53	245.65	240.08	64.30	-28.13	0.12
	10/7/2002	96.1	2.90	445.20	562.80	276.75	49.50	504.00	270.65	282.85	73.28	-30.21	-0.27
	1/8/2003	165.9	41.91	480.40	628.48	329.17	103.91	554.44	323.15	335.20	87.16	-29.94	-0.27
	4/15/2003	147.5	33.95	455.30	592.01	307.19	90.73	523.65	301.40	312.98	81.33	-28.77	-0.26
	7/1/2003	88.2	9.66	424.1	577.30	274.82	48.93	500.70	256.15	293.48	72.76	-30.02	-0.84
	10/7/2003	103.5	24.24	466.9	574.34	292.25	63.87	520.62	285.20	299.29	77.38	-30.35	-0.32
	12/31/2003	130.5	44.68	481.6	566.95	305.93	87.59	524.27	306.05	305.81	81.00	-29.02	0.01
	4/13/2004	118.2	42.08	471.6	585.31	304.30	80.14	528.45	294.90	313.69	80.57	-29.79	-0.42
	7/13/2004	49.6	8.40	430.9	548.80	259.43	29.00	489.85	240.25	278.60	68.69	-30.63	-0.86
	10/8/2004	54.7	18.19	457.3	588.15	279.59	36.45	522.72	256.00	303.17	74.03	-32.32	-1.06
	1/7/2005	108.7	42.65	486.4	597.82	308.89	75.67	542.11	297.55	320.23	81.78	-31.00	-0.51
	4/8/2005	91.7	33.99	457.3	601.47	296.12	62.85	529.39	274.50	317.73	78.40	-31.01	-0.97
	7/18/2005	28.7	12.91	432.3	605.33	269.81	20.81	518.82	230.50	309.12	71.44	-33.10	-1.76
	8/26/2005	31.4	16.85	447.8	588.39	271.11	24.13	518.10	239.60	302.62	71.78	-32.83	-1.41
	10/11/2005	43.7	14.58	464.4	588.60	277.82	29.14	526.50	254.05	301.59	73.56	-33.05	-1.06
	1/10/2006	96.3	14.58	483.8	588.60	295.82	55.44	536.20	290.05	301.59	78.32	-31.95	-0.26
	4/9/1906	87.1	29.40	477	588.60	295.52	58.25	532.80	282.05	309.00	78.25	-31.54	-0.60
	7/19/1906	18.4	-2.90	430.9	588.60	258.75	7.75	509.75	224.65	292.85	68.51	-33.36	-1.53
	10/18/1906	61.1	14.58	483.2	588.60	286.87	37.84	535.90	272.15	301.59	75.95	-33.10	-0.66

Pile Forces and Bending Moments

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
1	07/01/99	903.00	42.30	679.00	-	541.43	472.65	679.00	791.00	42.30	456.92	-73.98	99.88
	07/15/99	918.00	48.00	885.00	-	617.00	483.00	885.00	901.50	48.00	520.69	-144.12	113.86
	07/31/00	932.43	51.99	887.34	-	623.92	492.21	887.34	909.89	51.99	526.53	-141.66	114.44
	08/15/99	940.56	34.46	923.00	-	632.67	487.51	923.00	931.78	34.46	533.91	-156.13	119.70
	08/30/99	948.68	31.28	931.09	-	637.02	489.98	931.09	939.89	31.28	537.58	-158.14	121.21
	09/15/99	955.75	27.83	938.36	-	640.65	491.79	938.36	947.06	27.83	540.64	-160.10	122.62
	09/30/99	959.08	23.03	947.01	-	643.04	491.06	947.01	953.05	23.03	542.66	-163.47	124.06
	10/15/99	963.38	18.85	954.86	-	645.70	491.12	954.86	959.12	18.85	544.90	-166.26	125.43
	10/31/99	973.25	5.58	968.30	-	649.04	489.42	968.30	970.78	5.58	547.73	-171.69	128.76
	11/15/99	973.34	1.26	977.48	-	650.69	487.30	977.48	975.41	1.26	549.12	-175.74	129.95
	11/30/99	975.73	-2.84	980.87	-	651.25	486.45	980.87	978.30	-2.84	549.59	-177.26	130.88
	12/15/99	974.96	-2.47	982.11	-	651.53	486.25	982.11	978.54	-2.47	549.83	-177.77	130.87
	12/31/99	974.03	-54.00	984.71		634.91	460.02	984.71	979.37	-54.00	535.80	-188.11	137.85
	03/31/00	964.52	3.86	981.83	-	650.07	484.19	981.83	973.17	3.86	548.59	-178.41	129.31
	06/30/00	977.80	-36.92	980.73	-	640.54	470.44	980.73	979.27	-36.92	540.55	-182.94	135.56
	09/30/00	1009.20	-10.20	1005.99	-	668.33	499.50	1005.99	1007.60	-10.20	564.01	-181.58	135.77
	01/13/01	1014.12	-29.4495	1029.11	-	671.26	492.33	1029.11	1021.61	-29.45	566.48	-192.44	140.21
	04/20/01	1008.27	-18.6852	1022.57	-	670.72	494.79	1022.57	1015.42	-18.69	566.02	-189.21	137.95
	07/10/01	1030.41	-8.36772	1019.56	-	680.53	511.02	1019.56	1024.98	-8.37	574.30	-182.32	137.85
	10/09/01	1054.25	-20.5131	1038.65	-	690.80	516.87	1038.65	1046.45	-20.51	582.96	-187.07	142.33
	01/09/02	1055.96	-29.65	1045.80	-	690.70	513.15	1045.80	1050.88	-29.65	582.88	-190.96	144.14
	04/12/02	1041.9	-24.8188	1040.36	-	685.81	508.54	1040.36	1041.13	-24.82	578.76	-190.66	142.20
	07/19/02	1062.21	-17.26	1035.12	17.14	693.36	522.47	1035.12	1048.67	-17.26	585.12	-183.79	142.20
	10/08/02	1086.38	-30.07	1049.75	-6.63	702.02	528.16	1049.75	1068.06	-30.07	592.43	-187.00	146.49
	01/08/03	1080.45	-42.89	1062.94	0.41	700.17	518.78	1062.94	1071.70	-42.89	590.87	-195.09	148.69
	04/15/03	1059.37	-29.65	1049.86	22.95	693.19	514.86	1049.86	1054.62	-29.65	584.99	-191.81	144.64
	06/01/03	1064.93	-31.16	1053.52	21.00	695.77	516.89	1053.52	1059.23	-31.16	587.16	-192.39	145.46
	08/07/03	1083.86	-27.66	1053.40	9.26	703.20	528.10	1053.40	1068.63	-27.66	593.43	-188.33	146.25
	10/07/03	1095.56	-38.67	1066.64	-0.69	707.84	528.45	1066.64	1081.10	-38.67	597.35	-192.95	149.38
	12/31/03	1100.15	-54.88	1082.97	-0.89	709.41	522.64	1082.97	1091.56	-54.88	598.68	-200.89	152.93
	04/13/04	1080.17	-43.67	1074.07	21.65	703.52	518.25	1074.07	1077.12	-43.67	593.70	-199.27	149.51
	07/13/04	1101.53	-34.89	1072.49	10.76	713.04	533.32	1072.49	1087.01	-34.89	601.74	-193.30	149.66
	10/08/04	1122.82	-45.70	1085.57	-8.86	720.90	538.56	1085.57	1104.19	-45.70	608.36	-196.11	153.40
	01/07/05	1116.60	-58.49	1097.39	-8.94	718.50	529.06	1097.39	1107.00	-58.49	606.34	-203.76	155.48
	04/08/05	1099.01	-52.77	1096.58	5.48	714.28	523.12	1096.58	1097.80	-52.77	602.78	-205.59	153.49
	07/18/05	1116.44	-41.55	1096.58	-2.36	723.82	537.44	1096.58	1106.51	-41.55	610.83	-200.46	153.15
	08/26/05	1128.14	-43.63	1095.73	-10.20	726.75	542.26	1095.73	1111.93	-43.63	613.30	-198.43	154.15
	11/12/05	1127.45	-44.76	1095.72	-9.67	726.14	541.34	1095.72	1111.58	-44.76	612.79	-198.75	154.26
	01/10/06	1129.36	-64.30	1095.72	-19.70	720.26	532.53	1095.72	1112.54	-64.30	607.83	-201.91	156.99
	04/09/06	1114.90	-55.20	1095.72	-1.14	718.47	529.85	1095.72	1105.31	-55.20	606.32	-202.87	154.81
	07/19/06	1130.94	-46.83	1095.72	-9.42	726.61	542.05	1095.72	1113.33	-46.83	613.19	-198.50	154.77
	10/18/06	1154.91	-58.29	1095.72	-27.50	730.78	548.31	1095.72	1125.32	-58.29	616.71	-196.26	157.89

	07/01/99	575.00	589.00	243.00	-	469.00	582.00	243.00	409.00	589.00	395.79	121.54	-24.01
	07/15/99	585.00	602.00	237.00	-	474.67	593.50	237.00	411.00	602.00	400.57	127.81	-25.48
	07/30/99	594.35	611.17	230.68	-	478.73	602.76	230.68	412.52	611.17	404.00	133.40	-26.50
	08/15/99	596.87	611.09	242.58	336.68	446.81	603.98	289.63	419.73	473.89	377.06	112.70	-7.22
	08/31/99	601.58	616.82	241.00	-	486.47	609.20	241.00	421.29	616.82	410.53	132.00	-26.08
	09/15/99	605.96	622.42	240.47	-	489.62	614.19	240.47	423.22	622.42	413.19	133.98	-26.57
	09/30/99	609.62	624.20	240.71	336.98	452.88	616.91	288.85	425.17	480.59	382.18	117.62	-7.39
	10/15/99	612.87	629.40	240.27	336.21	454.69	621.14	288.24	426.57	482.81	383.71	119.35	-7.50
	10/31/99	616.45	631.80	243.11	336.29	456.91	624.13	289.70	429.78	484.05	385.59	119.90	-7.24
	11/15/99	619.54	632.45	245.83	337.79	458.90	626.00	291.81	432.69	485.12	387.27	119.81	-6.99
	11/30/99	623.35	635.58	248.71	340.31	461.99	629.47	294.51	436.03	487.95	389.87	120.09	-6.93
	12/15/99	624.21	637.77	247.77	339.95	462.43	630.99	293.86	435.99	488.86	390.24	120.87	-7.05
	12/31/99	626.60	640.86	249.37	341.45	464.57	633.73	295.41	437.99	491.16	392.05	121.29	-7.09
	03/31/00	634.53	648.30	254.69	346.89	471.10	641.41	300.79	444.61	497.60	397.56	122.12	-7.07
	06/30/00	640.05	652.80	250.99	342.06	471.48	646.43	296.53	445.52	497.43	397.88	125.44	-6.93
	09/30/00	647.16	661.13	247.62	336.78	473.17	654.14	292.20	447.39	498.96	399.31	129.76	-6.88
	01/13/01	654.063	665.1119	256.39	342.22	479.45	659.59	299.31	455.23	503.67	404.61	129.16	-6.46
	04/20/01	654.429	664.7057	260.37	345.47	481.25	659.57	302.92	457.40	505.09	406.12	127.86	-6.36
	07/10/01	661.456	672.0985	256.15	342.75	483.11	666.78	299.45	458.80	507.43	407.70	131.69	-6.49
	10/09/01	668.361	679.0039	251.93	338.20	484.37	673.68	295.06	460.14	508.60	408.76	135.74	-6.46
17	01/09/02	671.083	683.4721	252.17	337.92	486.16	677.28	295.04	461.63	510.69	410.27	137.04	-6.55
	04/12/02	669.17	680.02	256.68	342.06	486.98	674.60	299.37	462.93	511.04	410.96	134.52	-6.42
	07/19/02	671.69	683.96	253.27	272.93	470.46	677.83	263.10	462.48	478.44	397.02	148.69	-2.13
	10/08/02	678.60	692.21	247.01	332.37	487.54	685.40	289.69	462.80	512.29	411.44	141.87	-6.60
	01/08/03	678.44	689.32	251.28	334.22	488.31	683.88	292.75	464.86	511.77	412.09	140.22	-6.26
	04/15/03	679.45	692.45	254.73	341.09	491.93	685.95	297.91	467.09	516.77	415.14	139.12	-6.63
	06/01/03	678.76	689.85	256.43	341.09	491.53	684.30	298.76	467.60	515.47	414.80	138.22	-6.39
	08/07/03	682.33	695.54	251.15	336.74	491.44	688.94	293.95	466.74	516.14	414.73	141.61	-6.59
	10/07/03	686.23	700.57	250.14	334.87	492.95	693.40	292.50	468.19	517.72	416.00	143.73	-6.61
	12/31/03	689.48	700.61	257.04	341.05	497.05	695.05	299.04	473.26	520.83	419.46	141.97	-6.35
	04/13/04	689.24	699.88	260.70	346.65	499.12	694.56	303.68	474.97	523.27	421.21	140.14	-6.44
	07/13/04	693.10	667.59	255.46	341.33	489.37	680.34	298.39	474.28	504.46	412.98	136.93	-4.03
	10/08/04	699.03	710.89	250.83	337.39	499.53	704.96	294.11	474.93	524.14	421.56	147.30	-6.56
	01/07/05	699.07	711.46	253.31	339.95	500.95	705.26	296.63	476.19	525.70	422.75	146.50	-6.61
	04/08/05	696.43	708.09	257.94	343.81	501.57	702.26	300.87	477.18	525.95	423.27	143.90	-6.51
	07/18/05	699.56	708.33	253.71	338.36	499.99	703.94	296.04	476.64	523.35	421.94	146.24	-6.23
	08/26/05	702.04	711.17	250.91	335.97	500.02	706.61	293.44	476.47	523.57	421.97	148.13	-6.28
	11/12/05	701.95	699.60	251.68	337.06	497.57	700.78	294.37	476.82	518.33	419.90	145.70	-5.54
	01/10/06	705.16	715.03	253.47	339.58	503.31	710.10	296.53	479.32	527.31	424.75	148.27	-6.40
	04/09/06	703.94	713.04	259.52	343.20	504.93	708.49	301.36	481.73	528.12	426.11	145.96	-6.19
	07/19/06	708.37	716.01	256.84	339.95	505.29	712.19	298.39	482.61	527.98	426.42	148.35	-6.05
	10/18/06	713.29	721.25	251.76	334.02	505.08	717.27	292.89	482.52	527.63	426.24	152.14	-6.02

Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
18	07/01/99	546.00	501.00	248.00	173	367.00	523.50	210.50	397.00	337.00	309.71	112.21	8.00
	07/15/99	557.00	513.00	243.00	229	385.50	535.00	236.00	400.00	371.00	325.32	107.20	3.87
	07/30/99	565.55	519.94	239.54	224.26	387.32	542.75	231.90	402.55	372.10	326.86	111.44	4.06
	08/15/99	567.71	520.14	230.56	232.51	387.73	543.93	231.54	399.14	376.33	327.21	112.00	3.04
	08/31/99	573.72	526.52	247.46	232.87	395.14	550.12	240.17	410.59	379.70	333.46	111.12	4.12
	09/15/99	578.06	532.08	246.65	233.61	397.60	555.07	240.13	412.36	382.85	335.53	112.91	3.94
	09/30/99	582.49	534.97	247.46	234.05	399.74	558.73	240.76	414.98	384.51	337.34	114.00	4.06
	10/15/99	586.68	538.17	247.25	235.23	401.83	562.43	241.24	416.97	386.70	339.11	115.15	4.04
	10/31/99	590.77	539.40	249.37	235.6	403.79	565.09	242.49	420.07	387.50	340.75	115.66	4.34
	11/15/99	592.65	540.65	251.68	237.47	405.61	566.65	244.58	422.17	389.06	342.30	115.47	4.42
	11/30/99	596.63	527.25	254.12	239.69	404.42	561.94	246.91	425.38	383.47	341.29	112.94	5.59
	12/15/99	599.47	545.53	254.12	239.05	409.54	572.50	246.59	426.80	392.29	345.61	116.84	4.60
	12/31/99	601.54	548.45	255.38	239.17	411.14	575.00	247.28	428.46	393.81	346.96	117.49	4.62
	03/31/00	610.32	554.87	262.08	243.60	417.72	582.59	252.84	436.20	399.23	352.51	118.22	4.93
	06/30/00	616.94	539.60	260.98	238.93	414.11	578.27	249.96	438.96	389.26	349.47	117.70	6.63
	09/30/00	625.63	400.76	255.58	232.18	378.54	513.19	243.88	440.61	316.47	319.45	96.55	16.56
	01/13/01	632.372	566.6896	264.44	235.84	424.83	599.53	250.14	448.40	401.26	358.52	125.26	6.29
	04/20/01	632.575	561.5309	268.38	236.21	424.67	597.05	252.29	450.48	398.87	358.38	123.60	6.88
	07/10/01	639.684	569.2893	264.64	234.54	427.04	604.49	249.59	452.16	401.91	360.38	127.23	6.70
	10/09/01	646.508	576.5197	259.81	232.14	428.74	611.51	245.97	453.16	404.33	361.82	131.05	6.51
	01/09/02	650.895	576.8446	259.68	230.92	429.59	613.87	245.30	455.29	403.88	362.53	132.14	6.86
	04/12/02	650.123	570.1017	264.192	232.55	429.24	610.11	248.37	457.16	401.33	362.24	129.69	7.45
	07/19/02	653.45	572.46	260.90	226.38	428.30	612.96	243.64	457.18	399.42	361.44	132.40	7.71
	10/08/02	659.69	581.14	254.65	222.68	429.54	620.41	238.66	457.17	401.91	362.49	136.86	7.37
	01/08/03	657.76	576.89	257.57	224.47	429.17	617.32	241.02	457.67	400.68	362.18	134.91	7.60
	04/15/03	661.78	576.19	262.16	228.04	432.04	618.99	245.10	461.97	402.12	364.60	134.04	7.98
	06/01/03	661.37	572.66	264.07	227.59	431.43	617.02	245.83	462.72	400.13	364.08	133.07	8.35
	08/07/03	665.76	577.29	258.18	222.76	431.00	621.53	240.47	461.97	400.03	363.72	136.61	8.26
	10/07/03	669.26	582.73	256.11	222.56	432.66	625.99	239.33	462.68	402.65	365.13	138.62	8.01
	12/31/03	670.27	581.39	262.53	229.62	435.95	625.83	246.08	466.40	405.51	367.90	136.15	8.12
	04/13/04	669.42	576.64	266.47	232.35	436.22	623.03	249.41	467.94	404.49	368.12	133.95	8.46
	07/13/04	672.95	578.63	261.80	224.79	434.54	625.79	243.29	467.37	401.71	366.71	137.13	8.76
	10/08/04	677.95	587.12	255.42	222.31	435.70	632.53	238.87	466.68	404.72	367.69	141.14	8.27
	01/07/05	677.50	586.02	257.61	226.05	436.80	631.76	241.83	467.56	406.04	368.61	139.80	8.21
	04/08/05	674.17	580.83	263.14	227.80	436.48	627.50	245.47	468.65	404.31	368.35	136.96	8.58
	07/18/05	677.87	580.70	259.40	221.74	434.93	629.29	240.57	468.63	401.22	367.04	139.36	8.99
	08/26/05	679.25	583.30	256.27	219.43	434.56	631.28	237.85	467.76	401.37	366.73	141.05	8.86
	11/12/05	679.13	583.14	256.88	220.08	434.81	631.13	238.48	468.00	401.61	366.93	140.77	8.86
	01/10/06	679.45	587.32	257.33	223.00	436.78	633.39	240.17	468.39	405.16	368.60	140.97	8.43
	04/09/06	679.57	583.14	263.01	226.46	438.05	631.36	244.74	471.29	404.80	369.67	138.61	8.87
	07/19/06	683.27	585.78	260.94	222.31	438.08	634.53	241.63	472.11	404.05	369.69	140.86	9.08
	10/18/06	687.01	592.40	255.09	218.66	438.29	639.70	236.88	471.05	405.53	369.87	144.42	8.74

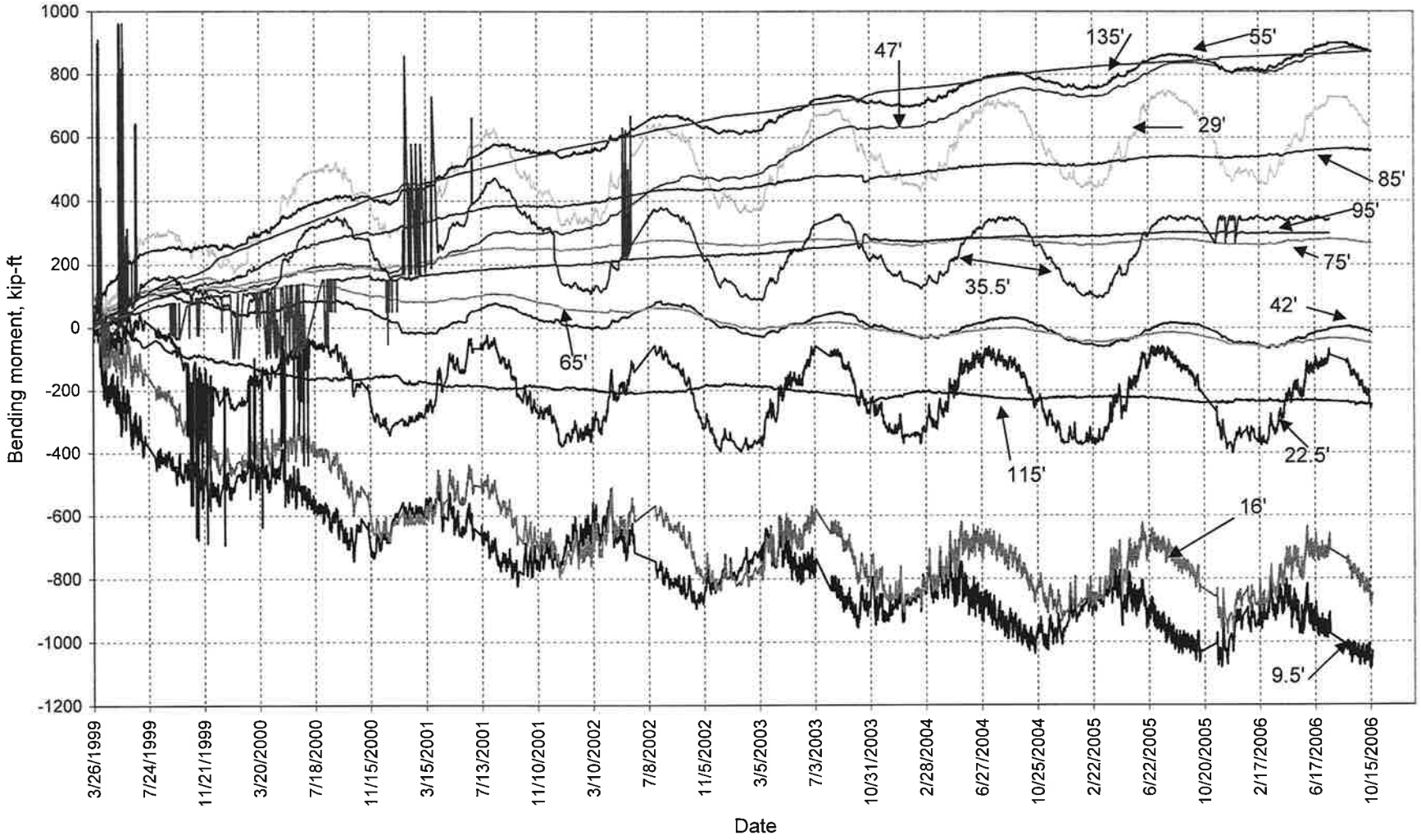
	07/01/99	566.97	586.00	298.00	228.9	419.97	576.49	263.45	432.49	407.45	354.41	112.23	3.34
	07/15/99	580.00	597.00	294.00	224	423.75	588.50	259.00	437.00	410.50	357.60	118.13	3.54
	07/30/99	588.71	606.46	291.38	218.62	426.29	597.59	255.00	440.05	412.54	359.75	122.82	3.67
	08/15/99	591.02	607.35	300.95	227.92	431.81	599.19	264.44	445.99	417.64	364.40	120.01	3.78
	08/31/99	595.94	613.52	300.59	229.63	434.92	604.73	265.11	448.27	421.58	367.03	121.76	3.56
	09/15/99	599.88	617.91	300.67	229.54	437.00	608.90	265.11	450.28	423.73	368.78	123.25	3.54
	09/30/99	603.53	621.65	302.70	229.75	439.41	612.59	266.23	453.12	425.70	370.82	124.18	3.66
	10/15/99	607.51	625.02	302.29	229.71	441.13	616.27	266.00	454.90	427.37	372.27	125.57	3.67
	10/31/99	611.37	627.25	306.07	229.7	443.60	619.31	267.89	458.72	428.48	374.35	125.99	4.03
	11/15/99	613.61	627.78	308.31	232.67	445.59	620.70	270.49	460.96	430.23	376.04	125.55	4.10
	11/30/99	616.29	630.54	313.83	234.7	448.84	623.42	274.27	465.06	432.62	378.78	125.17	4.33
	12/15/99	617.83	631.44	314.03	234.9	449.55	624.64	274.47	465.93	433.17	379.38	125.54	4.37
	12/31/99	619.94	634.20	314.36	236.45	451.24	627.07	275.41	467.15	435.33	380.80	126.08	4.25
	03/31/00	629.45	639.44	320.33	239.74	457.24	634.44	280.03	474.89	439.59	385.86	127.06	4.71
	06/30/00	636.15	643.50	317.81	51.91	412.34	639.83	184.86	476.98	347.71	347.98	163.11	17.25
	09/30/00	646.59	651.99	312.33	231.29	460.55	649.29	271.81	479.46	441.64	388.66	135.33	5.04
	01/13/01	653.454	657.0691	320.21	236.77	466.88	655.26	278.49	486.83	446.92	394.00	135.08	5.32
	04/20/01	651.464	653.2102	324.03	237.42	466.53	652.34	280.72	487.74	445.32	393.71	133.23	5.66
	07/10/01	658.856	661.1717	320.61	235.03	468.92	660.01	277.82	489.74	448.10	395.72	137.02	5.55
	10/09/01	667.346	669.2551	315.37	230.97	470.74	668.30	273.17	491.36	450.11	397.25	141.66	5.50
19	01/09/02	670.88	671.7736	315.66	229.71	472.00	671.33	272.68	493.27	450.74	398.32	142.92	5.67
	04/12/02	667.71	665.64	321.06	231.62	471.51	666.68	276.34	494.39	448.63	397.90	139.94	6.10
	07/19/02	673.44	667.87	319.88	227.72	472.23	670.66	273.80	496.66	447.79	398.51	142.28	6.52
	10/08/02	681.93	676.18	313.24	222.91	473.56	679.05	268.07	497.58	449.54	399.64	147.34	6.41
	01/08/03	682.42	673.60	316.88	225.03	474.48	678.01	270.96	499.65	449.32	400.42	145.93	6.71
	04/15/03	686.11	672.95	321.26	228.37	477.17	679.53	274.81	503.69	450.66	402.69	145.10	7.07
	06/01/03	685.30	670.80	322.48	227.84	476.60	678.05	275.16	503.89	449.32	402.21	144.44	7.28
	08/07/03	689.12	675.35	317.28	223.09	476.21	682.23	270.18	503.20	449.22	401.87	147.72	7.20
	10/07/03	694.48	681.03	314.64	222.27	478.11	687.76	268.46	504.56	451.65	403.47	150.32	7.06
	12/31/03	695.94	680.95	322.73	229.34	482.24	688.45	276.03	509.33	455.15	406.96	147.86	7.23
	04/13/04	695.62	676.77	330.77	231.41	483.64	686.19	281.09	513.19	454.09	408.15	145.23	7.88
	07/13/04	700.37	679.61	327.88	224.22	483.02	689.99	276.05	514.13	451.92	407.62	148.40	8.30
	10/08/04	706.18	688.67	321.87	221.22	484.48	697.43	271.54	514.03	454.94	408.86	152.68	7.88
	01/07/05	705.37	688.14	324.72	224.55	485.69	696.75	274.63	515.04	456.35	409.88	151.34	7.83
	04/08/05	702.85	682.86	329.75	226.66	485.53	692.86	278.21	516.30	454.76	409.74	148.66	8.21
	07/18/05	706.50	683.55	327.15	219.55	484.19	695.03	273.35	516.83	451.55	408.61	151.18	8.71
	08/26/05	708.05	686.48	322.81	217.89	483.80	697.26	270.35	515.43	452.18	408.28	153.05	8.44
	11/12/05	707.97	686.27	323.74	218.33	484.08	697.12	271.04	515.85	452.30	408.51	152.76	8.48
	01/10/06	710.04	690.54	324.68	221.62	486.72	700.29	273.15	517.36	456.08	410.74	153.13	8.17
	04/09/06	709.47	686.72	329.75	224.34	487.57	698.10	277.05	519.61	455.53	411.46	150.95	8.55
	07/19/06	714.26	690.38	328.09	220.57	488.32	702.32	274.33	521.17	455.47	412.10	153.44	8.76
	10/18/06	718.93	696.80	321.91	216.75	488.60	707.86	269.33	520.42	456.77	412.33	157.22	8.49

Pile Forces and Bending Moments (cont'd)

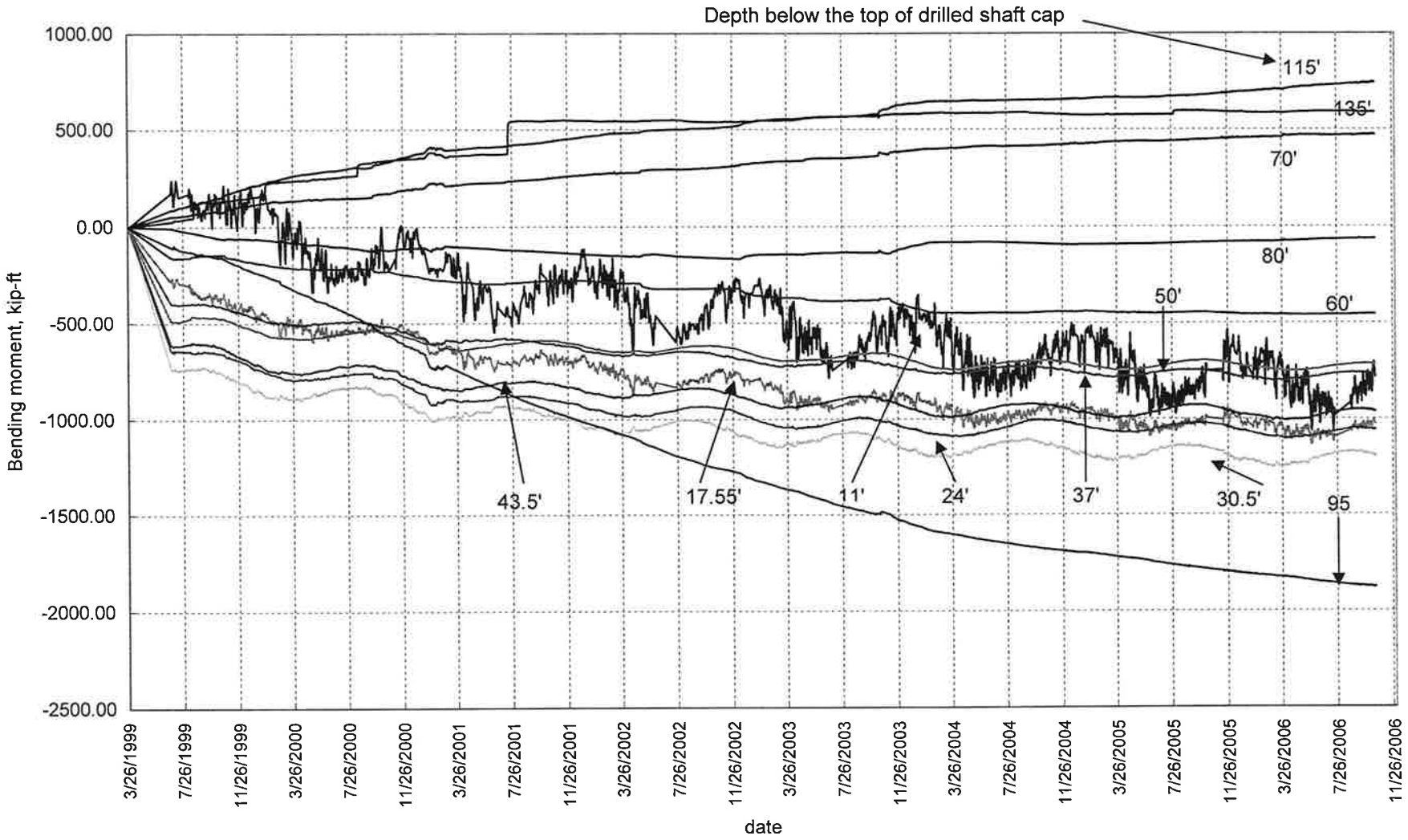
Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
34	07/01/99	271.75	436.00	261.00	583.00	387.94	353.88	422.00	266.38	509.50	327.38	-24.42	-32.43
	07/15/99	279.00	617.00	253.00	583.00	433.00	448.00	418.00	266.00	600.00	365.41	10.76	-44.56
	07/30/99	282.79	647.00	243.64	585.13	439.64	464.90	414.39	263.22	616.07	371.01	18.11	-47.07
	08/15/99	272.89	690.09	251.16	614.66	457.20	481.49	432.91	262.03	652.38	385.83	17.42	-52.07
	08/31/99	265.66	576.80	245.14	627.09	428.67	421.23	436.12	255.40	601.95	361.76	-5.34	-46.23
	09/15/99	265.08	802.81	242.34	635.26	486.37	533.95	438.80	253.71	719.04	410.45	34.11	-62.07
	09/30/99	260.50	807.40	238.64	642.65	487.30	533.95	440.65	249.57	725.03	411.23	33.45	-63.43
	10/15/99	256.43	811.14	234.46	648.58	487.65	533.79	441.52	245.45	729.86	411.53	33.08	-64.62
	10/31/99	240.47	824.02	221.62	665.31	487.86	532.25	443.47	231.05	744.67	411.70	31.83	-68.52
	11/15/99	241.93	831.45	224.75	676.77	493.73	536.69	450.76	233.34	754.11	416.65	30.81	-69.47
	11/31/99	240.47	835.88	224.26	648.85	487.37	538.18	436.56	232.37	742.37	411.29	36.43	-68.03
	12/15/99	241.41	836.77	222.35	684.04	496.14	539.09	453.20	231.88	760.41	418.69	30.79	-70.51
	12/31/99	242.22	836.08	224.14	684.93	496.84	539.15	454.54	233.18	760.51	419.29	30.34	-70.35
	03/31/00	257.37	828.85	237.38	675.92	499.88	543.11	456.65	247.38	752.38	421.85	31.00	-67.37
	06/30/00	266.43	846.32	225.20	500.93	459.72	556.37	363.06	245.81	673.62	387.96	69.30	-57.07
	09/30/00	257.37	895.02	196.89	705.00	513.57	576.19	450.94	227.13	800.01	433.40	44.90	-76.42
	01/13/01	247.90	856.11	197.37	729.58	507.74	552.01	463.47	222.64	792.84	428.48	31.74	-76.07
	04/20/01	44.66	883.01	212.28	457.21	399.29	463.83	334.74	128.47	670.11	336.96	46.28	-72.25
	07/10/01	-279.94	502.86	204.24	66.21	123.34	111.46	135.22	-37.85	284.53	104.09	-8.52	-43.01
	10/09/01	442.16	725.37	50.98	1199.89	604.60	583.76	625.44	246.57	962.63	510.22	-14.94	-95.52
	01/09/02	263.63	616.73	159.27	765.05	451.17	440.18	462.16	211.45	690.89	380.74	-7.88	-63.96
	04/12/02	67.35	579.97	58.13	501.01	301.61	323.66	279.57	62.74	540.49	254.53	15.81	-63.73
	07/19/02	288.69	941.04	187.83	727.59	536.29	614.86	457.71	238.26	834.31	452.57	56.34	-79.51
	10/08/02	277.15	962.54	162.58	740.98	535.81	619.84	451.78	219.86	851.76	452.17	60.25	-84.29
	01/08/03	256.07	949.53	162.24	758.66	531.62	602.80	460.45	209.15	854.10	448.64	51.04	-86.04
	04/15/03	277.19	928.37	189.53	744.52	534.90	602.78	467.03	233.36	836.45	451.41	48.67	-80.45
	06/01/03	277.96	939.01	184.90	749.68	537.89	608.49	467.29	231.43	844.35	453.93	50.62	-81.76
	08/07/03	288.69	965.09	171.66	750.09	543.88	626.89	460.87	230.17	857.59	458.98	59.52	-83.70
	10/07/03	274.96	978.21	155.53	762.84	542.89	626.58	459.19	215.25	870.53	458.14	60.01	-87.41
	12/31/03	258.26	983.57	156.83	795.22	548.47	620.92	476.03	207.55	889.40	462.86	51.95	-90.96
	04/13/04	281.17	960.30	188.88	781.65	553.00	620.73	485.27	235.03	870.97	466.68	48.57	-84.84
	07/13/04	302.86	991.98	173.93	772.27	560.26	647.42	473.10	238.40	882.12	472.80	62.50	-85.87
	10/08/04	295.63	1004.49	151.19	786.40	559.43	650.06	468.80	223.41	895.45	472.10	64.99	-89.65
	01/07/05	277.35	997.91	148.79	798.02	555.52	637.63	473.41	213.07	897.97	468.80	58.88	-91.36
	04/08/05	286.74	978.21	166.99	788.76	555.17	632.47	477.87	226.86	883.49	468.51	55.43	-87.59
	07/18/05	304.00	1000.02	160.94	783.60	562.14	652.01	472.27	232.47	891.81	474.39	64.44	-87.96
	08/26/05	301.85	1018.4	147.73	791.81	564.94	660.12	469.77	224.79	905.09	476.76	68.24	-90.75
	11/12/05	300.51	1018.3	147.82	793.35	564.99	659.40	470.58	224.16	905.83	476.80	67.70	-90.93
	01/10/06	274.59	1009.41	138.15	808.34	557.62	642.00	473.24	206.37	908.87	470.58	60.50	-93.71
	04/09/06	283.04	986.09	160.45	798.02	556.90	634.57	479.23	221.74	892.06	469.97	55.69	-89.42
	07/19/06	295.67	1009.41	149.73	796.56	562.84	652.54	473.14	222.70	902.98	474.98	64.32	-90.75
	10/18/06	284.79	1030.77	131.20	808.38	563.79	657.78	469.79	207.99	919.58	475.78	67.40	-94.92

Numerical reading of anchor load as a function of time for anchors #1, #8, #9 and #17

Date	Anchor #1 Load, kips	Anchor #8 Load, kips	Anchor #9 Load, kips	Anchor #17 Load, kips	Comment
4/7/1999		560			
4/8/1999	489			499	Anchor Lock off
4/14/1999	460	473	596 (Lock off)	461	
5/7/1999	452	473	572	445	End of construction
7/1/1999	446	468	564	439	
10/1/1999	441	467	560	440	
1/1/2000	439	461	555	424	
4/1/2000	432	453	546	414	
7/1/2000	431	451	521	415	
10/1/2000	431	451	519	416	
1/1/2001	430	455	517	400	
4/1/2001	421	443	513	397	
7/1/2001	422	443	510	399	
10/1/2001	425	445	512	403	
1/1/2002	424	444	511	398	
4/1/2002	421	440	508	386	
7/1/2002	419	439	506	391	
10/1/2002	423	442	508	396	
1/1/2003	423	435	508	389	
4/15/2003	416	427	501	380	
8/7/2003	416	428	503	384	
10/7/2003	418	429	504	387	
12/31/2003	417	426	503	378	
4/13/2004	408	418	494	370	
7/13/2004	409	419	494	374	
10/8/2004	411	422	496	377	
1/7/2005	411	421	495	374	
4/8/2005	407	414	485	366	
7/18/2005	407	415	485	370	
11/12/2005	410	419	489	374	
1/10/2006	409	417	487	369	
4/9/2006	399	411	487	365	
7/19/2006	399	412	487	368	
10/18/2006	407	415	490	372	



Shaft #1, Bending moment vs. date in different elevations below the top of cap



Shaft #9, Bending moment vs. date in different elevations below the top of cap

RICHLAND ENGINEERING LIMITED
29 North Park Street, Mansfield, Ohio 44902-1769 • 419-524-0074 FAX 419-524-1812

106017

February 13, 2007

Ohio Department of Transportation
5500 Transportation Boulevard
Garfield Heights, Ohio 44125-5396

Attn: Mr. Mike Malloy

Re: CUY-90-1524
Central Viaduct
PID No. 20752
Slope and Pier Monitoring Services
Interim Report

Dear Mr. Malloy:

The following is our report on monitoring activity and collected data for the west slope of the Cuyahoga River and Bridge No. CUY-90-1524 west end pier, pier 1, and slope stabilization structure. The last report of data was November 29, 2006 for data collected through October 2006. This report is for data collected through January 2007.

The slope monitoring began in 1994. The stabilization structure was constructed and the span 1 superstructure was relocated in 1999. The stabilization structure monitoring began in 1999. Additional slope monitoring north of the existing bridge began in 2006.

BBC&M Engineering, Inc. obtained inclinometer readings, piezometer readings, and calipered crack distances between January 16 through 19, 2007. Seven inclinometers and 6 piezometers installed between 1994 and 1999 continue to be monitored. Three replacement inclinometers, 9 new inclinometers, and 18 new piezometers installed March through June 2006 were also monitored. The older instrumentation continues to indicate movements of the shallow and deep failure planes at relatively consistent rates. Some of the inclinometers are beginning to indicate possible slide planes at four different depths. Additional readings are needed in these inclinometers to evaluate whether these are true displacements. The piezometer total head values were relatively constant during the current reporting period. There were two small aggregate piles adjacent to the south right of way fence in January 2007. The property owner north of the right of way fence had a contractor repair the failed sheet pile dock wall at the river's edge in Spring 2006. As of January 2007, no accelerated movements of the failure planes have yet been observed due to the contractor's excavation activities.

A new small potential landslide was observed near the north right of way fence adjacent to the river on the southern edge of the large excavation.

Richland Engineering Limited measured expansion joint openings at the west end pier, near pier 2, and near pier 4 on January 15, 2007. The deck expansion joint opening near pier 2 opened 1/8" since October 2006 with a 9° drop in steel temperature.

Art Huckelbridge obtained tiltmeter readings at the west end pier and pier 1 on January 23, 2007. The tiltmeters show positions and magnitudes of movement similar to past readings.

Robert Liang monitored instrumentation on January 17 and 18, 2007. The instrumentation readings in the rock anchors, driven piles, tieback beams, drilled shafts, and inclinometers showed no significant change during this quarter.

The next readings are scheduled about April 15, 2006. An annual report will be submitted in May. The project has been authorized for continued monitoring through October 2007.

Please contact us if you have any questions (email reltd@r-e-l.com). Copies of detailed quarterly reports are available upon request.

Very truly yours,

RICHLAND ENGINEERING LIMITED

Dean A. Palmer, P.E.

DAP:dap

cc: Craig Hebebrand, District 12
Youssef Seif, District 12
Tim Keller, Office of Structures
Gene Geiger, Office of Geotechnical Services
Tom Lefchik, FHWA
Steve Pasternack, BBC&M Engineering, Inc., Dublin
Jeff Snyder, BBC&M Engineering, Inc., Valley View
Art Huckelbridge
Robert Liang
Rick Engel, E.L. Robinson Engineering Co.
Bob Parker, Michael Baker, Jr., Inc.

JANUARY 2007 QUARTERLY REPORT
FIELD MONITORING SERVICES
CUY-90-14.92/15.24
CLEVELAND, OHIO

Report to

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

Prepared by

BBC&M ENGINEERING, INC.
CLEVELAND, OHIO

February 2007

February 9, 2007
012-00946-300

BBCM
SOLUTIONS TO BUILD ON

Mr. Dean A. Palmer, P.E.
Richland Engineering Limited
29 North Park Street
Mansfield, Ohio 44902

Re: CUY-90-14.92/15.24 Bridge
Quarterly Report - Field Monitoring Services
January 2007 (First Quarter)

Dear Mr. Palmer:

In accordance with our proposal dated February 1, 2006, BBC&M Engineering, Inc. (BBCM) has completed the field monitoring services for the January 2007 quarter as part of the CUY-90-14.92/15.24 project. This quarterly report contains the data obtained from all the actively monitored instrumentation (inclinometers, piezometers, and calipered distance locations), discussions of observations of the data, and general site observations.

We appreciate being of continued service during this project. The next quarterly readings are scheduled to take place around April 15, 2007. Please contact our office if you have any questions or require additional information.

Sincerely,
BBC&M ENGINEERING, INC.
Cleveland, Ohio

Jeffrey L. Snyder, M.S., E.I.
Staff Engineer

Stephen C. Pasternack, Ph.D., P.E.
Senior Project Engineer

JLS/jls

cc: Mr. Robert B. Parker, P.E. (Michael Baker Jr., Inc.)

Submitted: pdf copy submitted to Richland Engineering at reltd@r-e-l.com and Michael Baker Jr., Inc. at BParker@mbakercorp.com

8555 Sweet Valley Dr., Ste. S • Valley View, OH 44125-4210 • Phone 216.901.1000 • Fax 216. 901.9996

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Introduction

Of the 14 inclinometers and 12 pneumatic piezometers installed by BBCM between 1994 and 1999, seven (7) inclinometers (B-101, B-102, B-107, B-203, B-204, B-303, and P-9N) and six (6) pneumatic piezometers at B-101 and B-105 (2 piezometers each), as well as B-107 and B-303 are still actively monitored. This remaining active instrumentation is associated with the CUY-90-15.24 project. During the period of March 2006 through June 2006, BBCM installed 12 new inclinometers (including 3 replacement inclinometers) and 18 vibrating wire (VW) piezometers. These newly installed inclinometers and piezometers are associated with the CUY-90-14.92 project. A Summary Table and Site Plan of Active Instrumentation are submitted as Plates 1 and 2 of the Appendix. Quarterly readings were taken at the new and remaining active inclinometers and piezometers during the period of January 16 through January 19, 2007.

Replacement Inclinometers

In mid-March 2006, excavation was performed at the toe of the slope adjacent to ODOT property in an effort to repair a section of failed bulkhead, which resulted in the destruction of the B-110 inclinometer. Additionally, the B-105 and B-108 inclinometers have become unreadable due to excessive displacement at the observed slide planes. Replacement inclinometers were installed at B-105A and B-108A immediately adjacent to the inactivated inclinometers. Also, per ODOT's request, BBCM installed a replacement inclinometer for B-110 at Boring B-05-16 adjacent to the right-of-way fence near where B-110 used to be located (see Plate 2 of the Appendix). The B-05-16 inclinometer is located within the existing ODOT right-of-way. These replacement inclinometers were installed at depths ranging from 156 feet to 168 feet below the existing ground surface. Baseline (initial) readings were taken at these replacement inclinometers on June 21 and 22, 2006.

New Inclinometers

New inclinometers were also installed at B-05-01 through B-05-04, B-05-07, B-05-08, and B-05-11 through B-05-13. These new inclinometers were installed at depths ranging from 134 feet to 228 feet below the existing ground surface. Baseline readings were taken at these new inclinometers from June 21 through June 26, 2006.

Discussion of Instrumentation Data

Inclinometers

Spiral (twist) measurements were performed in January 2005 on the ten (10) inclinometers that were active at the time. Spiral measurements were also performed on June 28 and June 29, 2006 on the twelve (12) new inclinometers. All the data sets presented in the Appendix have been corrected to account for the measured spiral of the inclinometer casings. The Cumulative and Incremental Displacement vs. Depth

plots in the Appendix show at least one reading per quarter up to four quarters plus additional readings taken in some of the inclinometers in March 2006. The Displacement vs. Time plots, however, include at least one reading from each year since the baseline readings.

Lateral deflections from slope inclinometer measurements contain both random and systematic errors. Durham Geo Slope Indicator Company (DGSI) provides typical displacement accuracy threshold for slope inclinometer measurements as follows:

1) Ordinary precision of ± 0.3 inches per 100 ft of casing using standard installation procedures;
2) Higher Precision of ± 0.1 inches per 100 ft of casing with careful survey practices and error correction during data reduction; and,
3) Highest Precision of ± 0.05 inches per 100 ft of casing with careful survey and data selection from redundant data sets and excellent casing installation.

BBCM considers the inclinometer measured displacement data presented herein to have a precision in the range of ± 0.1 to ± 0.2 inches per 100 ft. **Hence, any measured displacement (especially along deep failure planes) on the order of about 0.1 inches could be due to data precision errors and not actual field movements.** The actual estimated rates of slope movement in active inclinometers range from about 0.02 inches per year to 0.10 inches per year on the two slide planes.

The rates of movement were computed using linear regression for the depth ranges shown on the Displacement vs. Time plots in the Appendix. The rates of movement are discussed in more detail in subsequent sections of this submittal. Linear regression provided a best-fit match through the data points on each of the Displacement vs. Time curves. The time period for the linear regression (see time periods presented in Tables 1a and 1b of 2005-2006 Annual Monitoring Report, dated May 22, 2006) was chosen based on a visual observation of each curve at the time when the rate was believed to have last changed **significantly**. While some of the inclinometers indicate a decreased rate of movement since 2004 (subsequently discussed), the 95% confidence interval of the regression of each analyzed slide plane falls within the range of the expected precision of the inclinometer measurements (about 0.1 inches per 100 ft). Therefore, it is inconclusive whether this is an actual change in the average rate of movement or a false trend caused by the limitations in the data due to the accuracy of the measurements. However, if the measured rates of movement are indeed decreasing, the likely result is that greater load is being transferred from the creeping soil mass to the stabilization structure. Several years of data showing a consistent trend or changes in rates greater than the accuracy level of the measurements are necessary to draw conclusions that the average rate has in fact changed. Therefore, all discussions regarding trends in the data are developed based upon multiple years of data.

In general, there are observed movements that correspond to two major slide planes, termed the shallow and deep failure planes. In some of the inclinometers, multiple slide planes may be observed within the shallow or deep failure zones (i.e. B-203 and B-

303). In such cases, the multiple slide planes have been grouped together and referred to as part of either the shallow or deep failure plane, whichever is deemed more appropriate. Consequently, the magnitude and rate of movements subsequently discussed are the summation of the relative movements of the individual slide planes within either the shallow or deep failure plane. This summation is performed in an attempt to quantify the total relative soil movement that would be transferred to a pier or the stabilization structure.

Systematic Error Correction

Systematic errors are correctable errors observed in inclinometer data and are caused by one or more of the following factors: sensor bias-shift, rotation (sensor alignment shift), sensitivity drift, depth positioning error (DPE), and casing inclination/curvature. The data presented in this report have been analyzed and corrected for more common systematic errors such as bias-shift and rotation, where necessary. In addition to the DPE errors observed in the inclinometers at B-101, B-05-08, and B-05-12, as reported in the July 2006 Quarterly Report, minor DPE errors were also observed in readings taken from eight (8) additional inclinometers (B-107, B-05-01, B-05-02, B-05-04, B-05-11, B-05-13, B-05-16, and B-105A). DPE is a common error caused mainly by settlement (shortening) of the casing and/or change in probe depth control (human error, elongation/shortening of cable, or changing cables) in inclinometers with significant built-in curvatures. The readings presented in the Appendix for these eleven (11) inclinometers have been corrected for DPE.

Active BBCM Inclinometers Installed between 1994 and 1999

The shallow failure plane upslope from Pier 1 appears to be moving at an average rate of about 0.05 inches per year (from April 1999 to the present) as indicated in inclinometers at B-203 and B-303. The B-203 and B-303 inclinometers indicate a possible decrease in the average rate of movement in the shallow failure plane since about July 2004 (see Plates 19 and 21 in the Appendix). In the immediate vicinity of the Pier 1 area (B-204), no shallow slip-plane movements have been observed since completion of construction of the Pier 1 stabilization system.

South of the West End Pier, inclinometers at B-102 and B-107 indicate the deep failure plane is moving at an average rate of about 0.03 inches per year (from April 2000 to the present). The B-101 inclinometer has indicated nominal movement since its installation. Upslope from Pier 1, inclinometers at B-203, B-204, and B-303 indicate the deep failure plane is moving at an average rate of about 0.06 inches per year (from April 1999 to the present). The B-203, B-204, and B-303 inclinometers indicate a possible decrease in the average rate of movement in the deep failure plane since about July 2004 (see Plates 19 through 21 in the Appendix).

Inclinometer P-9N (installed in one of the drilled shafts) indicates the top of the drilled shaft is restrained laterally and that the maximum lateral deflection is about 0.85 inches and occurs approximately 40 to 50 feet below the top of the inclinometer casing.

No accelerated movements have been observed as a result of the excavation activities in the vicinity of B-110 (or B-05-16) on the west side of the I-90 Bridge in any of the inclinometers installed between 1994 and 1999.

Active BBCM Inclinometers Installed in 2006

Surficial movement of about 0.3 inches in the upper 10 to 15 feet has been observed at the B-05-16 inclinometer over a 7-month period (see Plates 44 and 45 of the Appendix). Additionally, a slip-plane movement of about 0.1 inches has been observed in B-05-16 at a depth of about 29 feet. It is likely the displacements observed at B-05-16 are a result of the open excavation in the vicinity of the removed inclinometer B-110. The displacements at B-05-16 are expected due to the scarps and tension cracks that have been observed in the vicinity of the inclinometer.

Possible cantilever displacement, similar in shape to the cantilever displacements observed in B-102 and B-107, was observed in B-05-12 to a depth of 30 feet (see Plates 40 and 41 of the Appendix). However, there has been no observed displacement since the July 2006 readings. The magnitude and location of the displacement in B-05-12 was not observed in other nearby inclinometers such as B-107 and B-05-02. The small sinkhole (approx. 1' dia.) that was observed by BBCM personnel in March 2006 in the pavement of University Road in the vicinity of B-05-12 did not appear to be any larger as of October 2006. The sinkhole was not able to be observed in January 2007, as it was covered by various objects stored or discarded in the area in addition to snow cover. It is likely that the observed displacement in B-05-12 is not a true displacement. The data was "re-initialized" to the July 24, 2006 reading as opposed to the June 22, 2006 reading and new Cumulative and Incremental vs. Displacement plots were generated, which are submitted as Plates 40A and 41A in the Appendix. As of January 2007, these "re-initialized" plots for B-05-12 do not indicate any observable displacements. Additional readings are needed in B-05-12 to confirm that the displacement in B-05-12 is not a true displacement and is the result of random and/or systematic errors.

Multiple possible slide planes have been observed in some of the new and replacement inclinometers, which are listed as follows:

- In B-105A at a depth of 85 feet (see Plate 22 in the Appendix);
- In B-108A at depths of 25 and 120 feet (see Plate 24 in the Appendix);
- In B-05-02 at depths of 109 and 129 feet (see Plate 28 in the Appendix); and,
- In B-05-03 at a depth of 37 feet (see Plates 30 and 31 in the Appendix);

The potential displacement at 120 feet in B-108A is nearly identical with the observed slide plane in the inactive inclinometer at B-108, which is only about 10 feet away from B-108A. Additional readings are needed in these inclinometers to evaluate whether these are true displacements.

Distinct movement has not been observed in the inclinometers at B-05-01, B-05-04, B-05-07, B-05-08, B-05-11 and B-05-13. Based on the relatively slow rates of movement of the slide planes observed at the site over the past several years, observed displacements may not yet be evident within the time period between baseline and current readings, which have been taken over a 7-month period. Multiple readings over a period of a few years are likely needed to measure definitive displacement trends.

Piezometers

In Tables 1 and 2 provided in the following sections, a summary of the measured total head (h_t), is provided for each pneumatic or VW piezometer. Additionally, plots of Total Head vs. Time are provided in the Appendix. For the pneumatic piezometers at B-101, B-105, B-107, and B-303, the measured water elevation (in feet) was reported in BBCM's quarterly and annual reports submitted prior to the July 2006 Quarterly Report. This water elevation is equivalent to the total head (h_t, in feet).

The total head (h_t) is calculated using the following equations:

$$h_t = h_e + h_p$$
$$h_p = u/\gamma_w$$

where h_e is the elevation head (elevation where the piezometer was installed), h_p is the pressure head, u is the pore pressure reading, and γ_w is the unit weight of water.

Pneumatic Piezometers

The results of the active pneumatic piezometer readings taken on January 19, 2007 are summarized in Table 1 below. Pneumatic piezometers are identified both by boring number and ribbon color to specify the location and depth of the instrumentation.

Table 1: Summary of Readings for Active Pneumatic Piezometers – CUY-90-15.24

Piezometer Identifier		Ground Surface Elevation (ft)	Elevation Head, h_e (ft)	Pore Pressure Reading, u (psi)	Total Head, h_t (ft)
B-101 (P-1*)	orange	676.6	626.3	0.0**	626.3**
	pink	676.6	552.3	31.3	624.5
B-105 (P-3*)	pink	585.6	497.6	38.3	586.0
	blue	585.6	479.9	47.8	590.2
B-107 (P-5*)	orange	662.3	562.3	25.2	620.5
B-303 (P-2*)	pink	627.0	586.2	7.0	602.4

*BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers.

**Pneumatic piezometers *cannot* read negative pressure (i.e., a water level below the depth of the pneumatic piezometer). Thus, it is unknown whether this is an accurate pressure reading.

All the piezometers have exhibited either the same or slightly lower readings than those recorded in October 2006, except the piezometer at B-303, which exhibited a slightly higher reading. Note that the piezometers at B-105 continue to indicate an elevated water pressure (i.e. a total head above the ground surface, artesian conditions). It is possible that the elevated water pressure in B-105 may be attributed to either a thin silt seam sandwiched between fairly thick clay layers located near the base of the piles supporting Pier 1, or the percolation of natural gas out of the underlying Devonian Ohio Shale. Elevated pore pressures can have a detrimental effect on slope stability and may increase the rate of slope creep.

Total Head vs. Time plots, which provide the measured total head from 1994 to the present, have been submitted as Plates 46 through 49 in the Appendix of this report.

Vibrating Wire (VW) Piezometers

The VW piezometers have been placed at various depths with 2 piezometers at each of the nine (9) offset boring locations. The VW piezometers were installed on 1¼-inch PVC pipe encased in grout with a cable attached to the VW piezometer. Each cable runs up through the PVC pipe and is attached to a MiniLogger, which stores the pore pressure data. A flush mount protective cover was installed at each offset boring location to house the two MiniLoggers. Readings are taken by Miniloggers every 8 hours; however, this time interval can be adjusted upon request.

Table 2 provides a summary of the maximum and minimum values of all the pressure readings taken from October 18, 2006 (end of previous reporting period) to the time when the collected data was downloaded from VW Miniloggers on January 19, 2007. The VW piezometers are identified by boring number, MiniLogger serial number, and depth the piezometer was installed. The VW piezometers also measure the ground temperature around the piezometer. The maximum and minimum temperature readings are also provided in Table 2.

Table 2: Summary of Readings for VW Piezometers – CUY-90-14.92

Piezometer Identifier		Time Interval of Readings Reported*	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-01	21961 - 65 ft	10/18/06 to 1/19/07	14.0/13.7	675.4	610.4	12.3/11.6	638.8/637.1
	21967 - 95 ft	10/18/06 to 1/19/07	13.3/13.2	675.4	580.4	22.3/20.9	631.9/628.7
B-05-02	21963 - 46 ft	10/18/06 to 1/19/07	12.2/12.1	617.9	571.9	8.5/7.8	591.5/589.8
	21951 - 122 ft	10/18/06 to 1/19/07	12.2/12.2	617.9	495.9	40.7/39.9	589.7/588.0

*Readings generally were taken every 8 hours during the reported time interval.

Table 2: Summary of Readings for VW Piezometers – CUY-90-14.92 (continued)

Piezometer Identifier		Time Interval of Readings Reported*	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-03	21957 - 32 ft	10/18/06 to 1/19/07	12.4/11.9	605.1	573.1	8.2/7.1	592.0/589.5
	21965 - 112 ft	10/18/06 to 1/19/07	12.5/12.5	605.1	493.1	41.5/40.8	589.0/587.3
B-05-04	21958 - 59 ft	10/18/06 to 1/19/07	13.0/13.0	600.8	541.8	18.3/17.7	583.9/582.6
	21952 - 119 ft	10/18/06 to 1/19/07	13.2/13.1	600.8	481.8	45.1/44.9	586.0/585.4
B-05-07	21966 - 102 ft	10/18/06 to 1/19/07	12.5/12.4	678.9	576.9	24.3/23.7	633.0/631.5
	21956 - 220 ft	10/18/06 to 1/19/07	12.0/11.9	678.9	458.9	69.7/68.0	619.6/615.9
B-05-08	21954 - 65.5 ft	10/18/06 to 1/19/07	12.7/12.7	679.9	614.4	12.5/11.7	643.3/641.4
	21959 - 110.5 ft	10/18/06 to 1/19/07	12.4/12.4	679.9	569.4	29.6/28.8	637.8/635.9
B-05-11	21968 - 95 ft	10/18/06 to 1/19/07	12.8/12.7	675.1	580.1	23.7/23.1	634.8/633.3
	21953 - 130 ft	10/18/06 to 1/19/07	12.6/12.6	675.1	545.1	36.0/35.0	628.2/626.0
B-05-12	21960 - 75 ft	10/18/06 to 1/19/07	12.9/12.8	652.7	577.7	18.0/16.7	619.2/616.2
	21964 - 120 ft	10/18/06 to 1/19/07	12.5/12.5	652.7	532.7	35.1/33.4	613.7/609.9
B-05-13	21962 - 60 ft	10/18/06 to 1/19/07	12.6/12.6	580.0	520.0	24.4/24.0	576.3/575.3
	21955 - 135 ft	10/18/06 to 1/19/07	12.9/12.8	580.0	445.0	60.7/60.5	585.0/584.6

*Readings generally were taken every 8 hours during the reported time interval.

During the current reporting period from mid-October 2006 to mid-January 2007, the total head values were relatively constant with a difference between maximum and minimum total head values no more than 3.8 feet (see Table 2) in all the VW piezometers. Four (4) VW piezometers (21967 at B-05-01, 21956 at B-05-07, and 21960 and 21964 at B-05-07) indicated a gradual increase in the pore pressures during the current reporting period. Total Head vs. Time plots have been submitted as Plates 50 through 58 in the Appendix of this report.

During the initial reporting period from late May 2006 to mid-July 2006, a few of the VW piezometers exhibited a total head decrease as much as 13 feet (i.e., B-05-07) from the initial reading. A gas pocket was encountered during drilling near the top of the shale bedrock in Boring B-05-07. The soil pore pressures may have been reducing back to normal conditions in B-05-07. Also, DGSI has stated in the user's manual for the VW

piezometer that "drilling a borehole and backfilling it temporarily changes the pore-water pressure in the ground, so readings that are taken immediately after installation will not be good datum readings. Recovery of the natural pore-water pressure may take a few hours to a few weeks, depending on the permeability of the soil." DGSI also suggests recovery of the pore-water pressure is indicated by observation of stable readings for several consecutive days. The readings have generally been stable in all of the VW piezometers since the beginning of July 2006.

During the previous reporting period from mid-July 2006 to mid-October 2006, the 21955 piezometer in B-05-13 installed at a depth of 135 feet exhibited a maximum reduction in total head of nearly 6 feet over a 24-hour period in mid-September 2006 (see Plate 58 in the Appendix). This rapid pore pressure change was not observed in the 21955 piezometer during the current reporting period. The 21955 piezometer in B-05-13 installed at a depth of 135 feet exhibits an elevated water pressure (i.e. a total head above the ground surface, artesian conditions) similar to that observed in the pneumatic piezometers at B-105 previously discussed. The elevated water pressure observed in the 21955 piezometer may be attributed to a silt/sand layer sandwiched between clay and shale layers and percolation of natural gas out of the underlying Devonian Ohio Shale into the silt/sand layer. During drilling of Boring B-05-13, gas pockets were encountered during rock coring.

Additional Field Measurements and Observations

The left and right calipered locations (see the Site Plan of Active Instrumentation, Plate 2 in the Appendix), which have been monitored since June 1999, are located just east and west of the I-90 bridge centerline, respectively. A Calipered Surface Distance Table and Calipered Distance Readings vs. Time plots have been included as Plates 59 through 61 in the Appendix. Close inspection of the data in the plots indicates the possibility of general movement trends at the calipered locations. The data is somewhat oscillatory, which is likely due to the seasonal temperature fluctuations affecting the concrete combined with human measurement error. In the data plots, linear trendlines were added to estimate the average rate of separation/closure per year. The left calipered location indicates the gap is continuing to open at a rate of about 0.06 inches per year. The right calipered location indicates the gap is closing at a rate of about 0.02 inches per year. This is a slight decrease from the rate of about 0.03 inches per year as reported in the October 2006 Quarterly Report. The movements are relatively small (½ of an inch or less since June 1999) and are sensitive to the interpretation of the center of the nails. Thus it is inconclusive that these movements have been caused by the observed slope movements. Continued observation of these calipered locations is needed in order to adequately determine if judgment error and weather conditions are the main cause of the observed trends or if they are indeed caused by slope movements.

In January 2007, two relatively small aggregate piles, approximately 20 feet to 30 feet high, were located approximately 120 feet from the east right-of-way fence.

As previously discussed, a large excavation near the west right-of-way fence was first observed by BBCM personnel in March 2006. The excavation was performed in an effort to repair the failed bulkhead. As of January 2007, the repair effort appears to be ongoing as the bulkhead did not appear to be fully repaired and the large excavation had not yet been backfilled.

On January 18, 2007, while taking readings at the B-05-13 inclinometer across the Cuyahoga River, BBCM personnel observed a potential small landslide that may have occurred since the quarterly readings were last taken in October 2006. This small landslide area is located near the west right-of-way fence just north of B-05-16, adjacent to the river and on the eastern edge of the large excavation. Note that relatively large displacements were observed in the B-05-16 inclinometer, as previously discussed. Pictures of this landslide location were taken on January 19, 2007, but due to the snow fall night before the photo was taken, the landslide area was snow covered. The approximate extent of the landslide, as visually observed, is sketched on two photos of the general landslide area, which are submitted as Plates 62 and 63 in the Appendix.

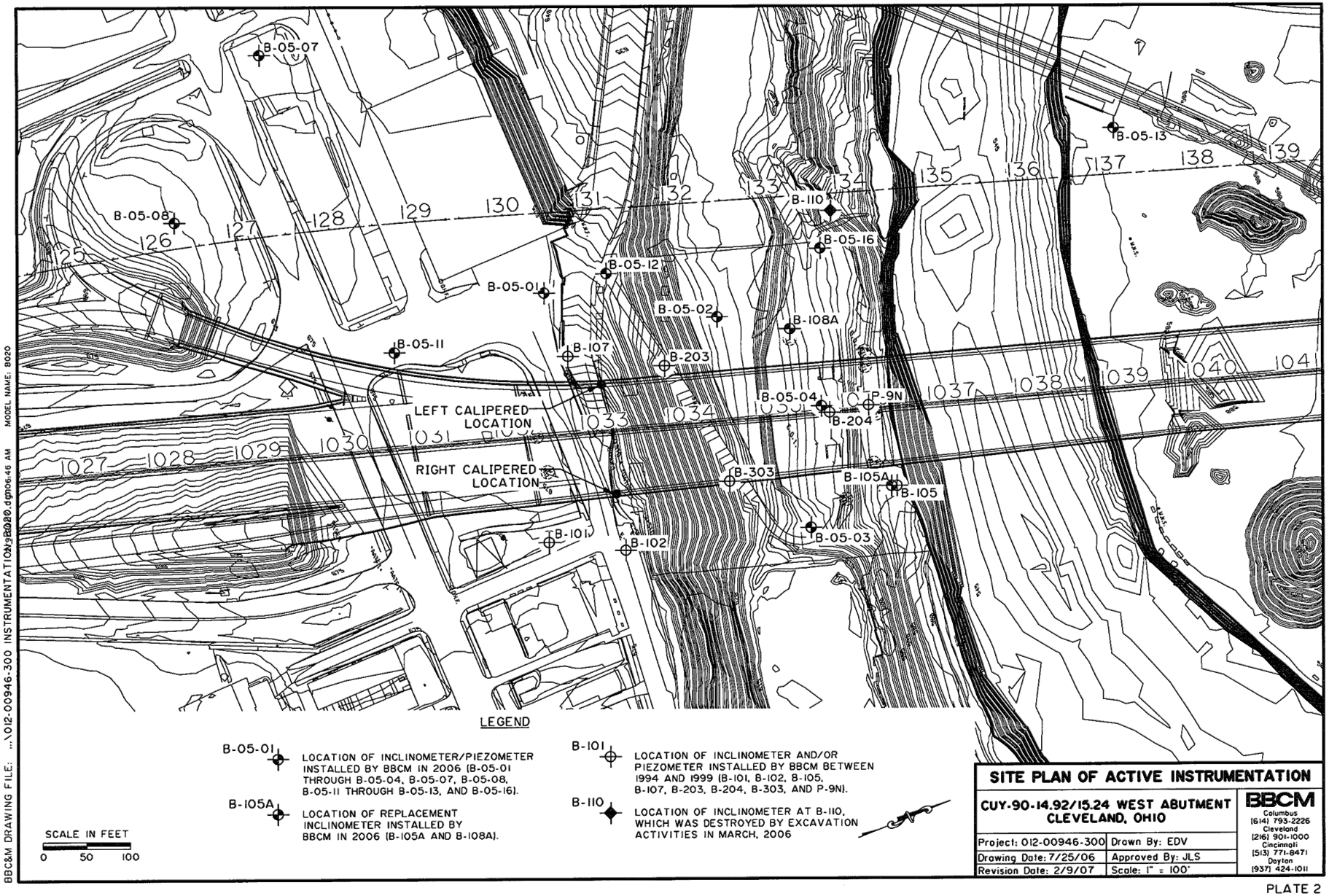
APPENDIX

CUY-90-14.92/15.24 INSTRUMENTATION MONITORING

SUMMARY OF ACTIVE INSTRUMENTATION
CUY-90-14.92/15.24

Active Instrumentation	Active Inclinometer ?	Inclinometer Depth (ft)	Active Piezometer?	VW or Pneumatic?	# of Active Piezometers	Piezometer Depth(s) Below Existing G.S. (ft)	Instrumentation Installation Date
B-101	Y	190	Y	Pneumatic	2	50.3, 124.3	Aug-Sep 1994
B-102	Y	224	N	---	---	---	Sep 1994
B-105	N	---	Y	Pneumatic	2	88, 105.7	Aug 1994
B-105A	Y	156	N	---	---	---	May 2006
B-107	Y	210	Y	Pneumatic	1	100	Sep 1994
B-108A	Y	168	N	---	---	---	Apr-May 2006
B-203	Y	190	N	---	---	---	Aug 1996
B-204	Y	134	N	---	---	---	Jul 1998
B-303	Y	178	Y	Pneumatic	1	40.8	Aug 1994*, Jul 1998
P-9N	Y	150	N	---	---	---	Feb 1999
B-05-01	Y	228	Y	VW	2	65, 95	Apr-May 2006
B-05-02	Y	178	Y	VW	2	46, 122	Apr-May 2006
B-05-03	Y	168	Y	VW	2	32, 112	Apr-May 2006
B-05-04	Y	172	Y	VW	2	59, 119	Mar-May 2006
B-05-07	Y	224	Y	VW	2	102, 220	Apr-Jun 2006
B-05-08	Y	226	Y	VW	2	65.5, 110.5	Apr-May 2006
B-05-11	Y	226	Y	VW	2	95, 130	Apr-Jun 2006
B-05-12	Y	210	Y	VW	2	75, 120	Apr-May 2006
B-05-13	Y	134	Y	VW	2	60, 135	May-Jun 2006
B-05-16	Y	162	N	---	---	---	Jun 2006

*The pneumatic piezometer was actually installed at BBCM Boring P-2 in August, 1994. However, the piezometer has since been renamed to B-303 due to its close proximity to the active inclinometer at B-303 (which was installed in July, 1998).



LEGEND

B-05-01 — LOCATION OF INCLINOMETER/PIEZOMETER INSTALLED BY BBCM IN 2006 (B-05-01 THROUGH B-05-04, B-05-07, B-05-08, B-05-11 THROUGH B-05-13, AND B-05-16).

B-105A — LOCATION OF REPLACEMENT INCLINOMETER INSTALLED BY BBCM IN 2006 (B-105A AND B-108A).

B-101 — LOCATION OF INCLINOMETER AND/OR PIEZOMETER INSTALLED BY BBCM BETWEEN 1994 AND 1999 (B-101, B-102, B-105, B-107, B-203, B-204, B-303, AND P-9N).

B-110 — LOCATION OF INCLINOMETER AT B-110, WHICH WAS DESTROYED BY EXCAVATION ACTIVITIES IN MARCH, 2006

SCALE IN FEET
0 50 100

BBC&M DRAWING FILE: ...\012-00946-300 INSTRUMENTATION\dgn\012-00946-300.dgn06:46 AM MODEL NAME: B020

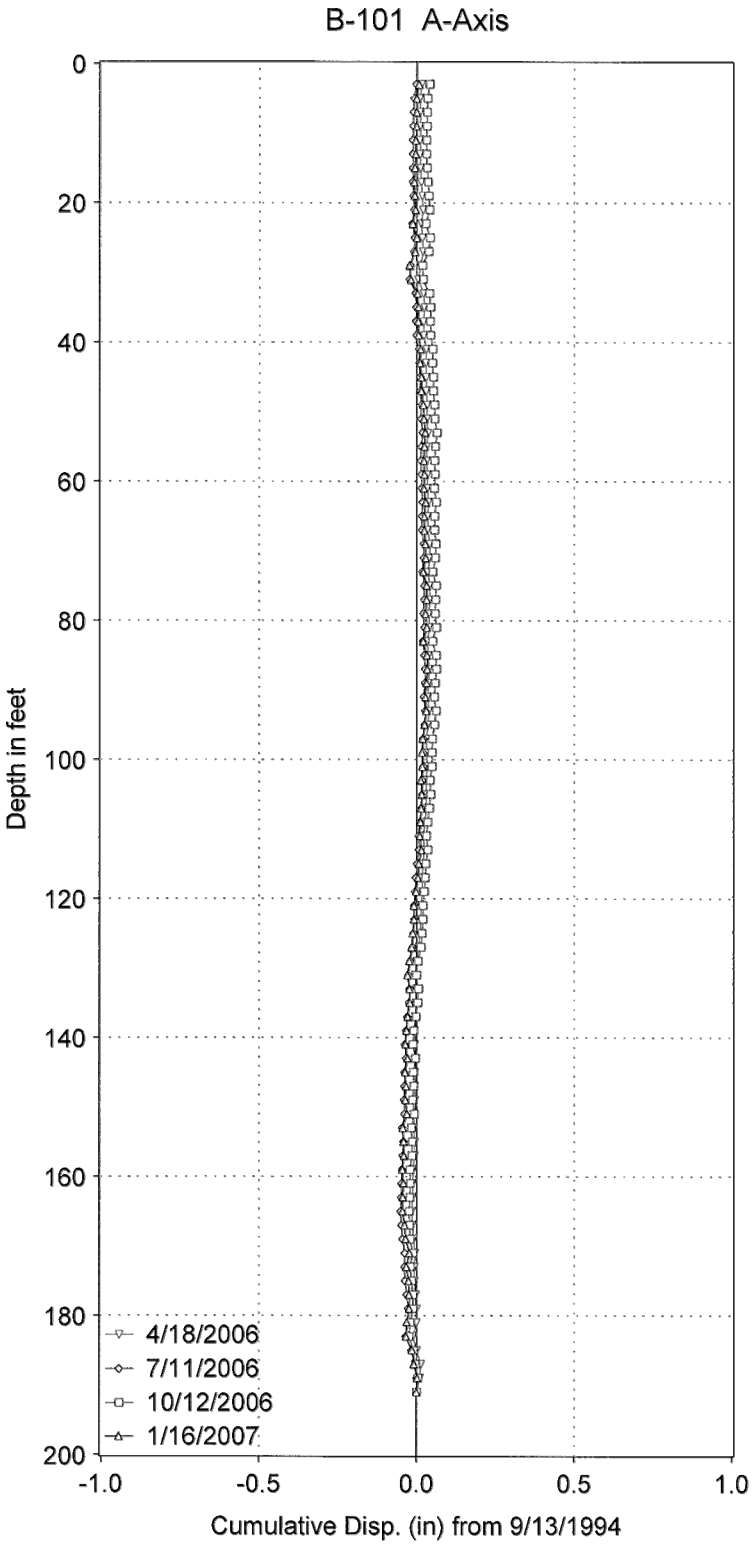
SITE PLAN OF ACTIVE INSTRUMENTATION

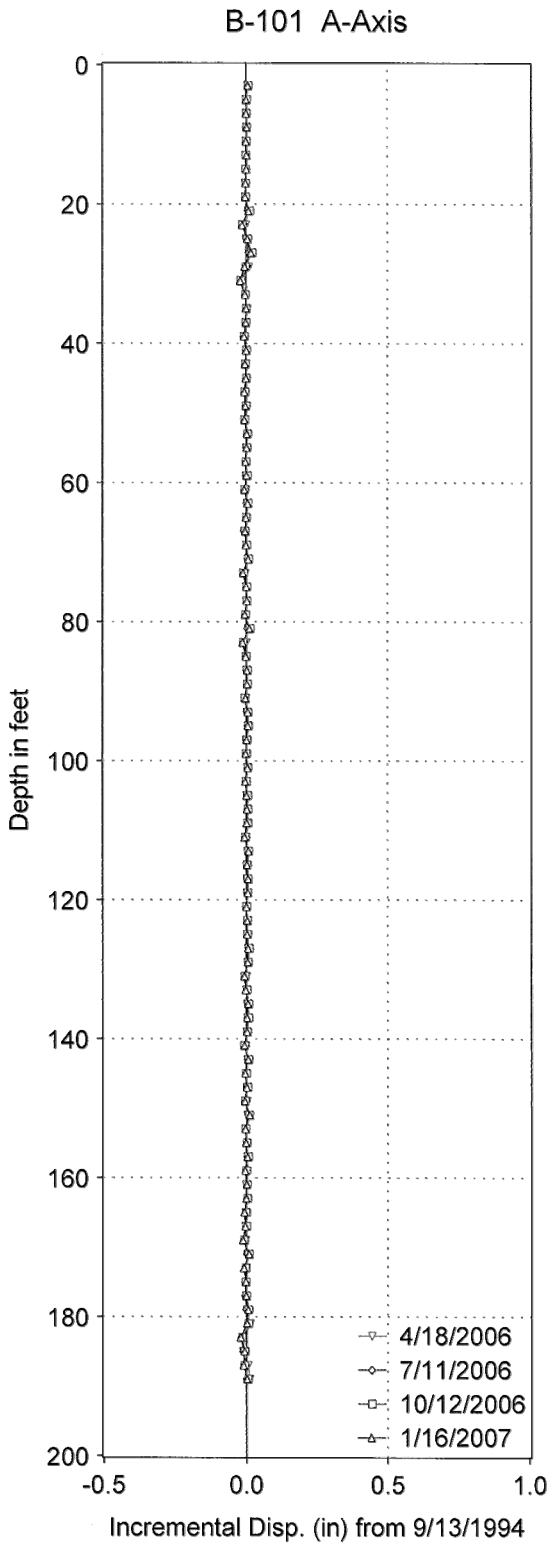
CUY-90-14.92/15.24 WEST ABUTMENT
CLEVELAND, OHIO

Project: 012-00946-300	Drawn By: EDV
Drawing Date: 7/25/06	Approved By: JLS
Revision Date: 2/9/07	Scale: 1" = 100'

BBCM
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

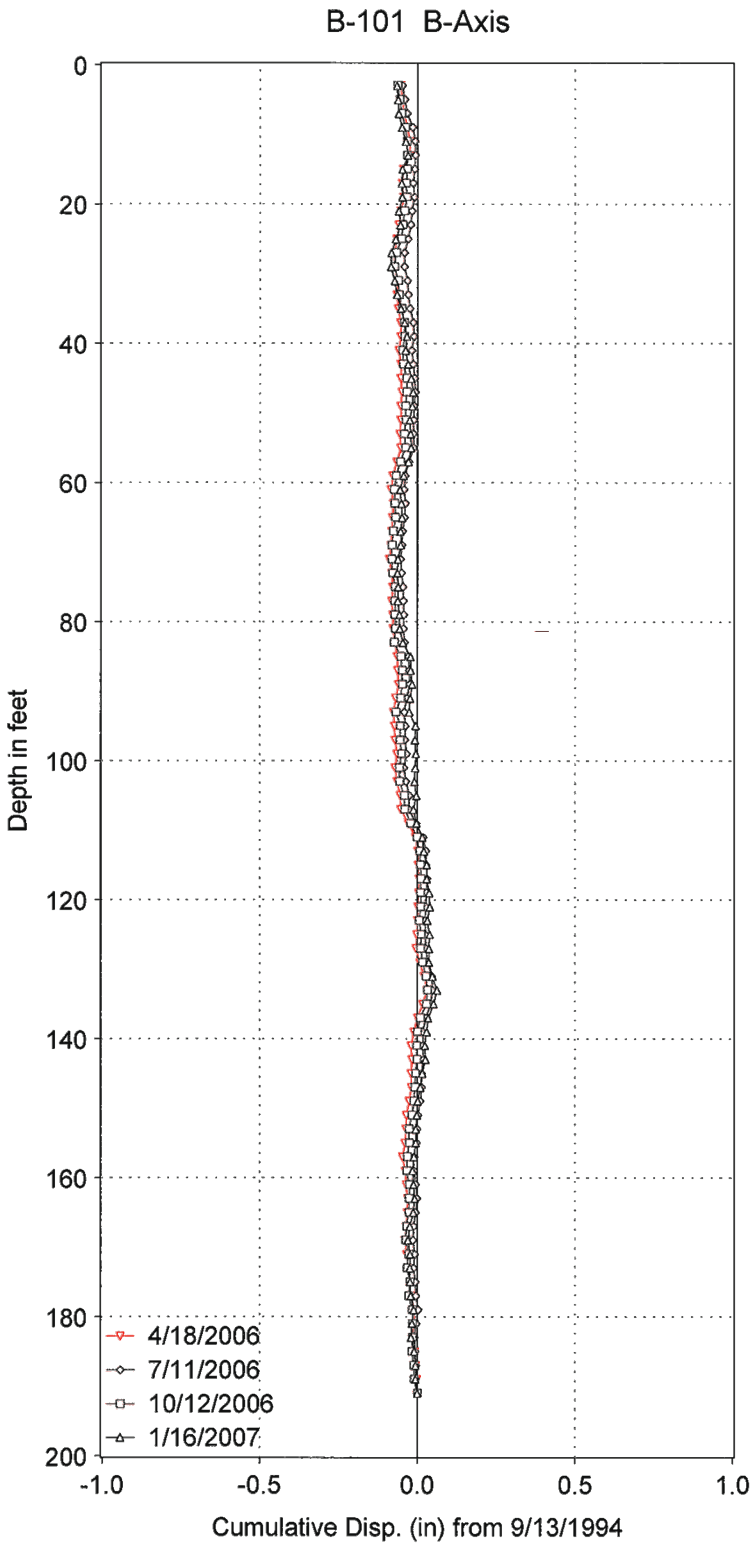
PLATE 2

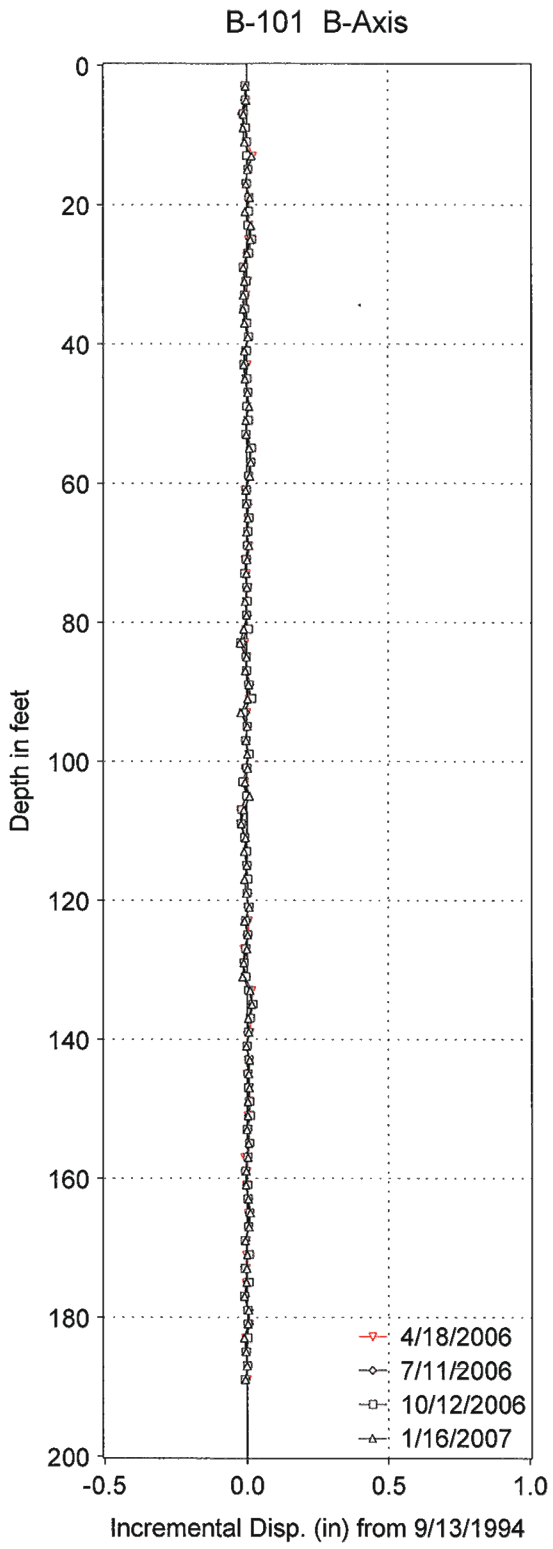




B-101
-Includes readings from the last four quarters.

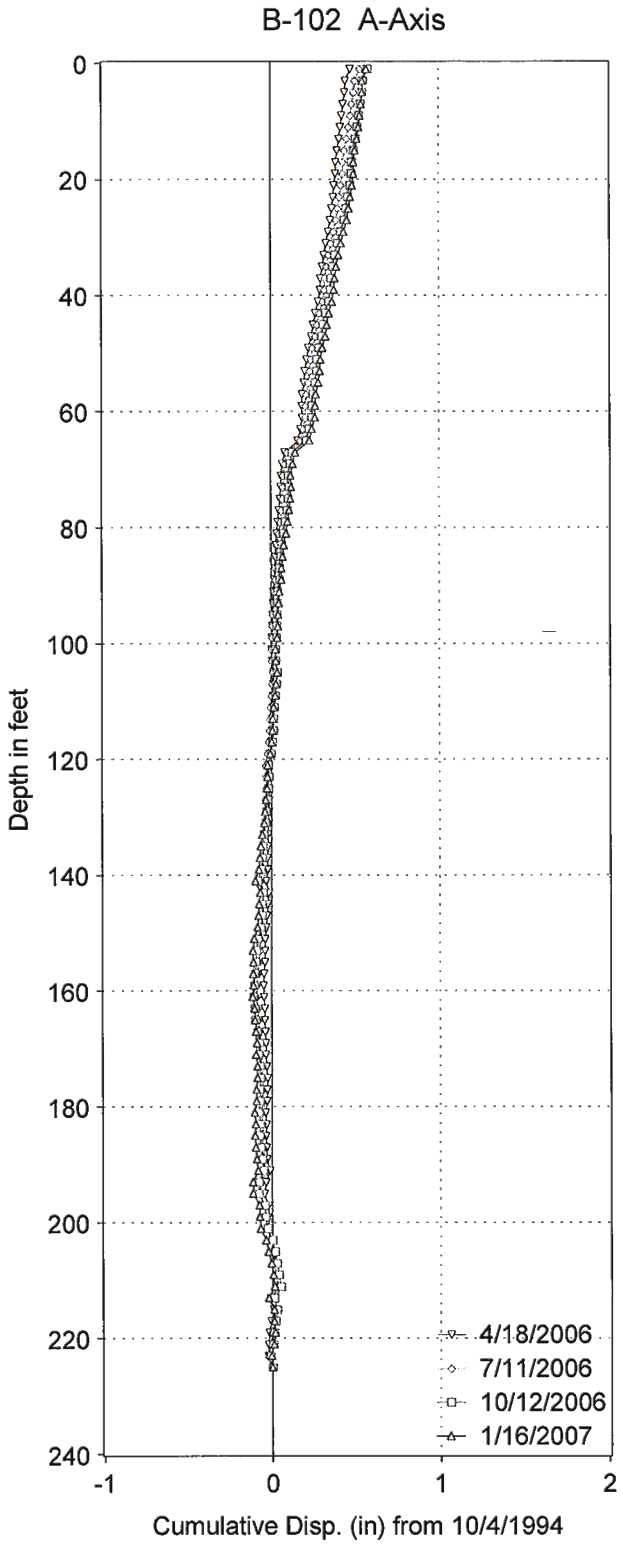
PLATE 3

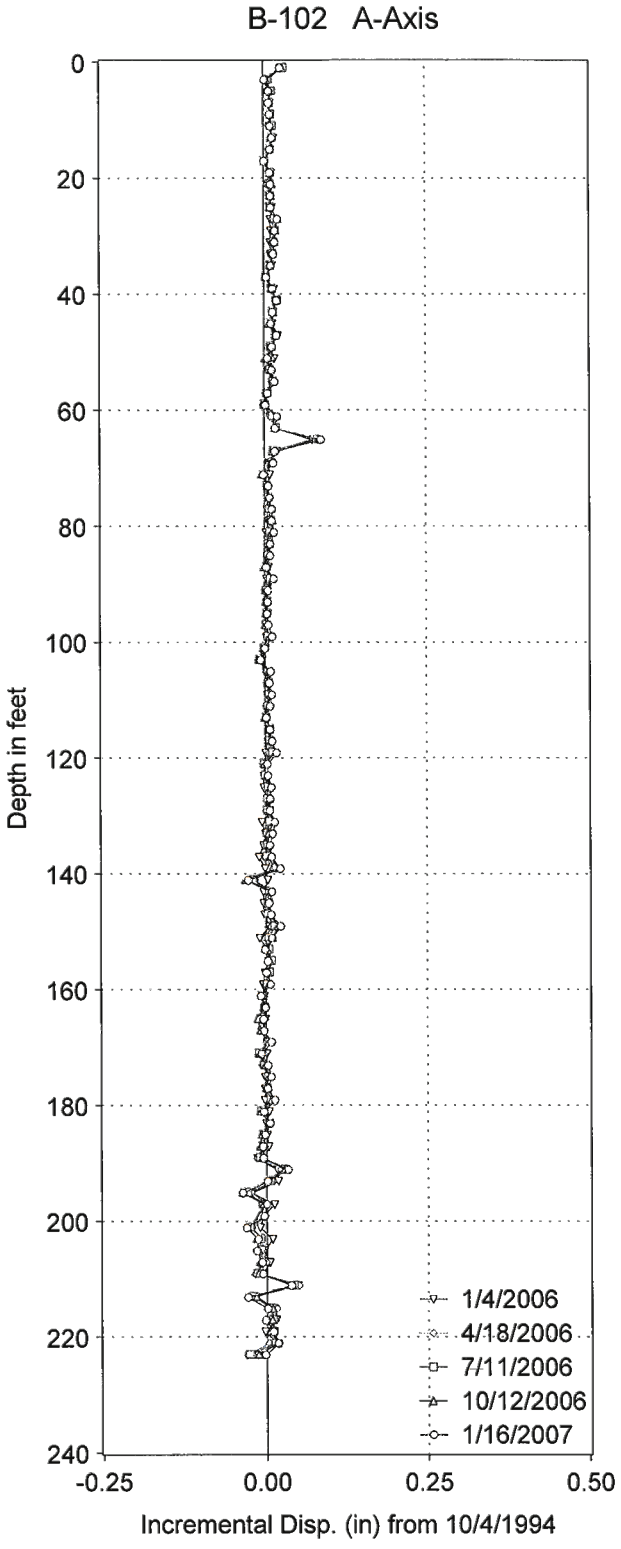




B-101
-Includes readings from the last four quarters.

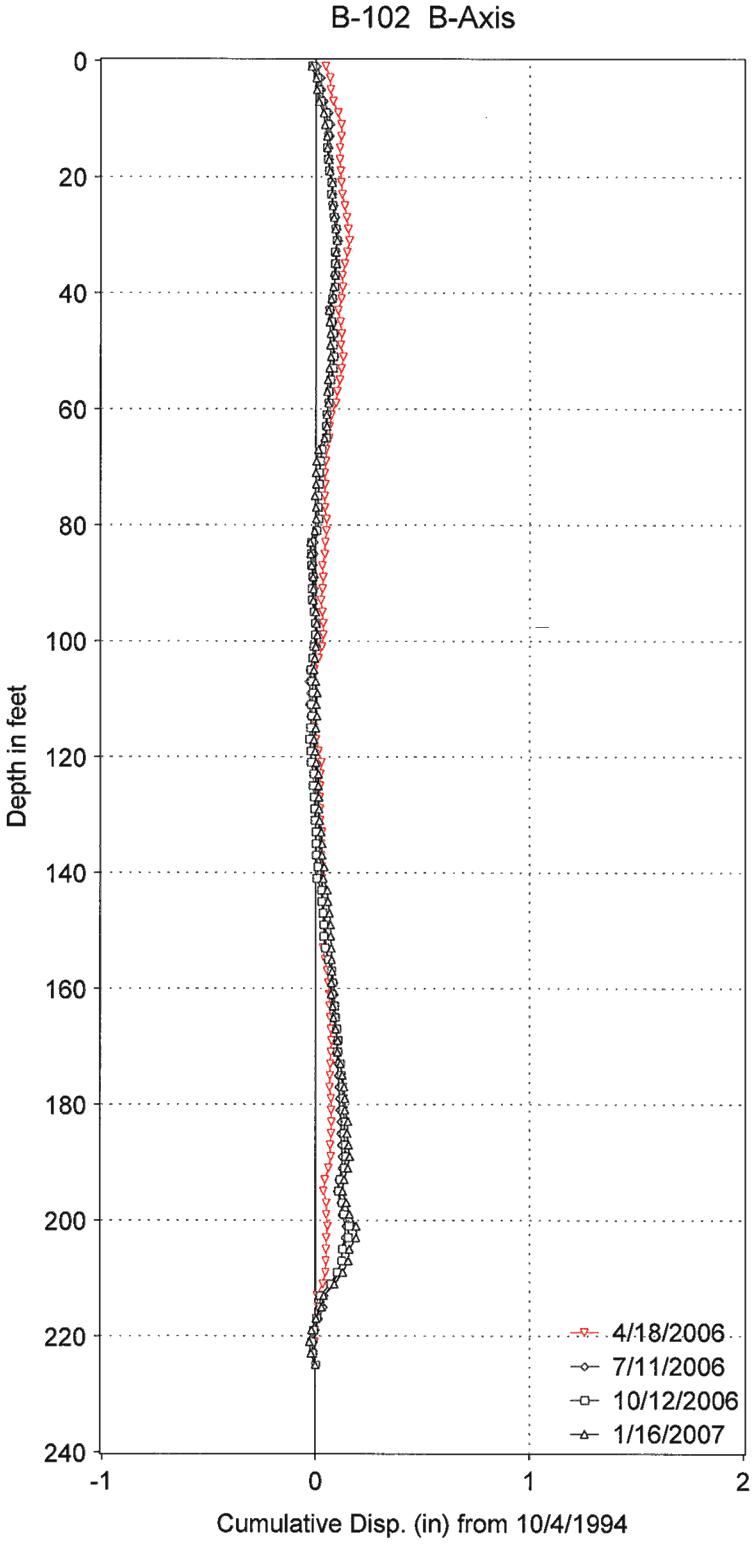
PLATE 4

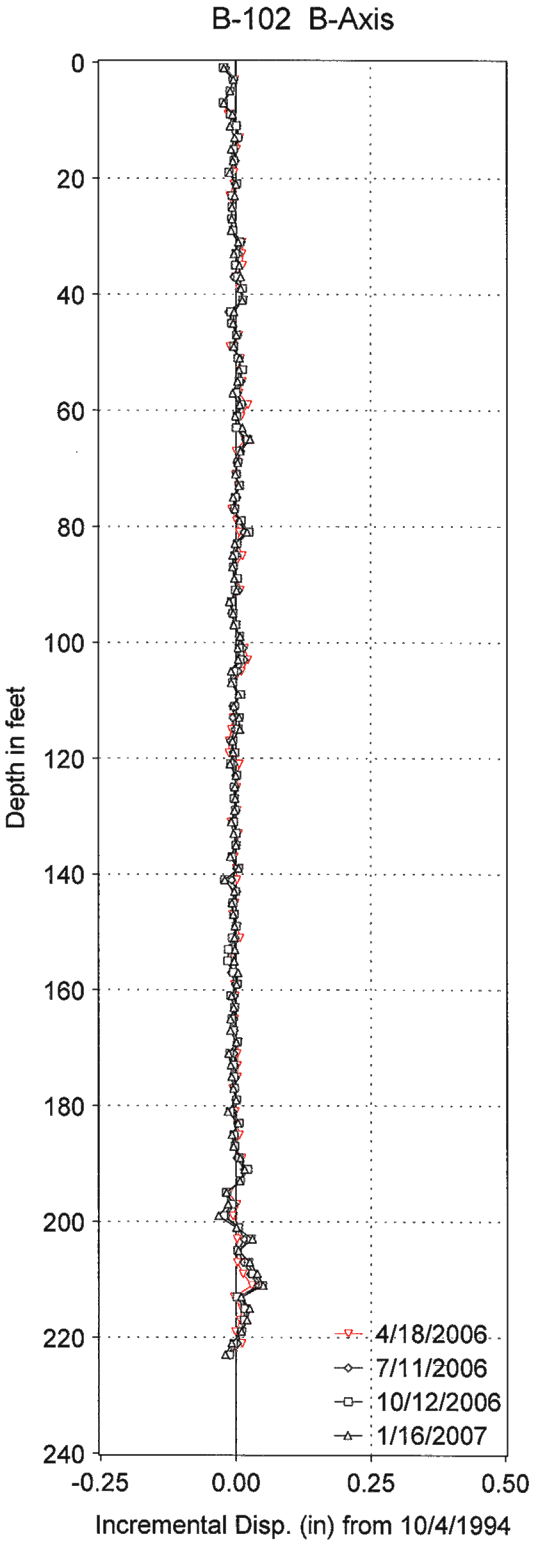




B-102
-Includes readings from the last four quarters.

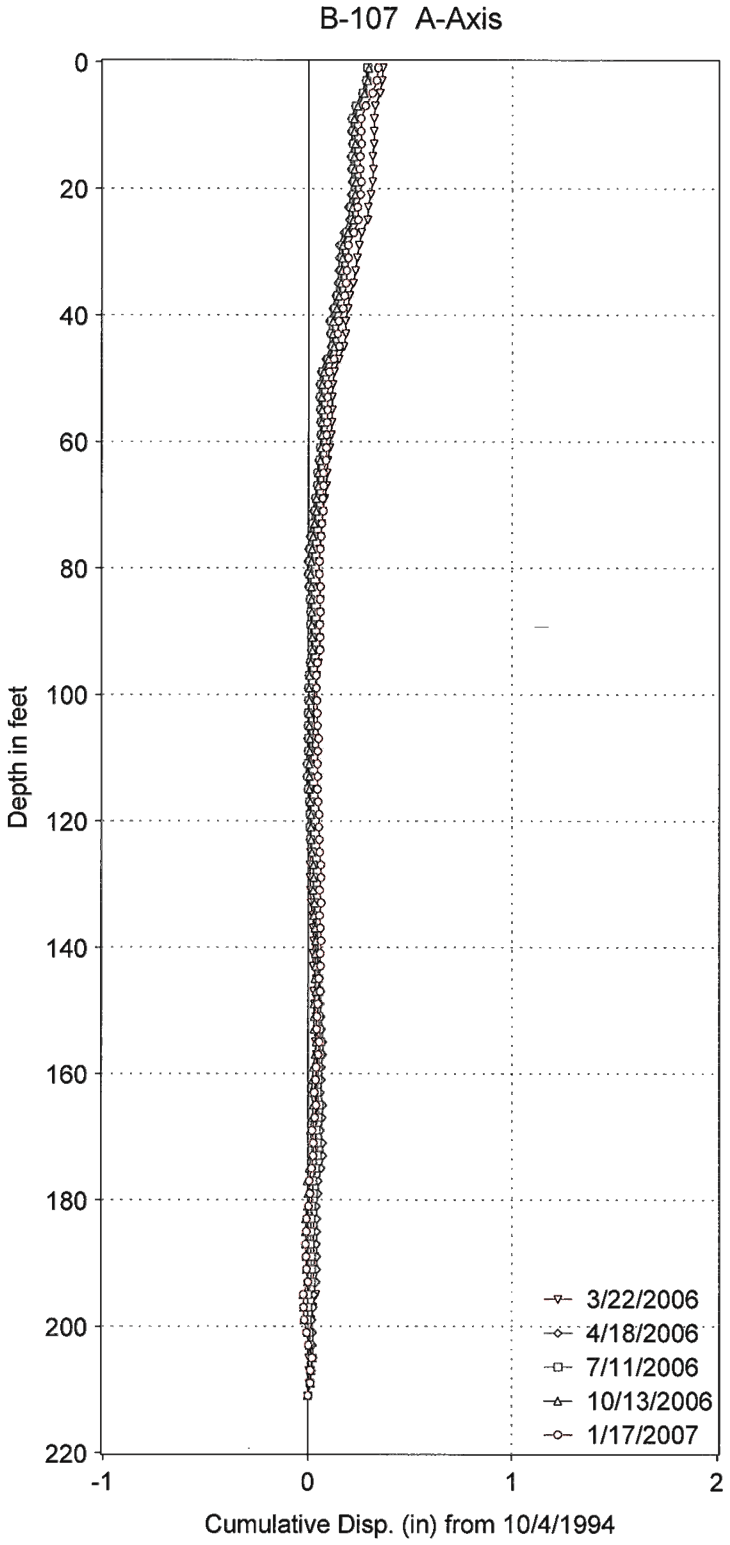
PLATE 5

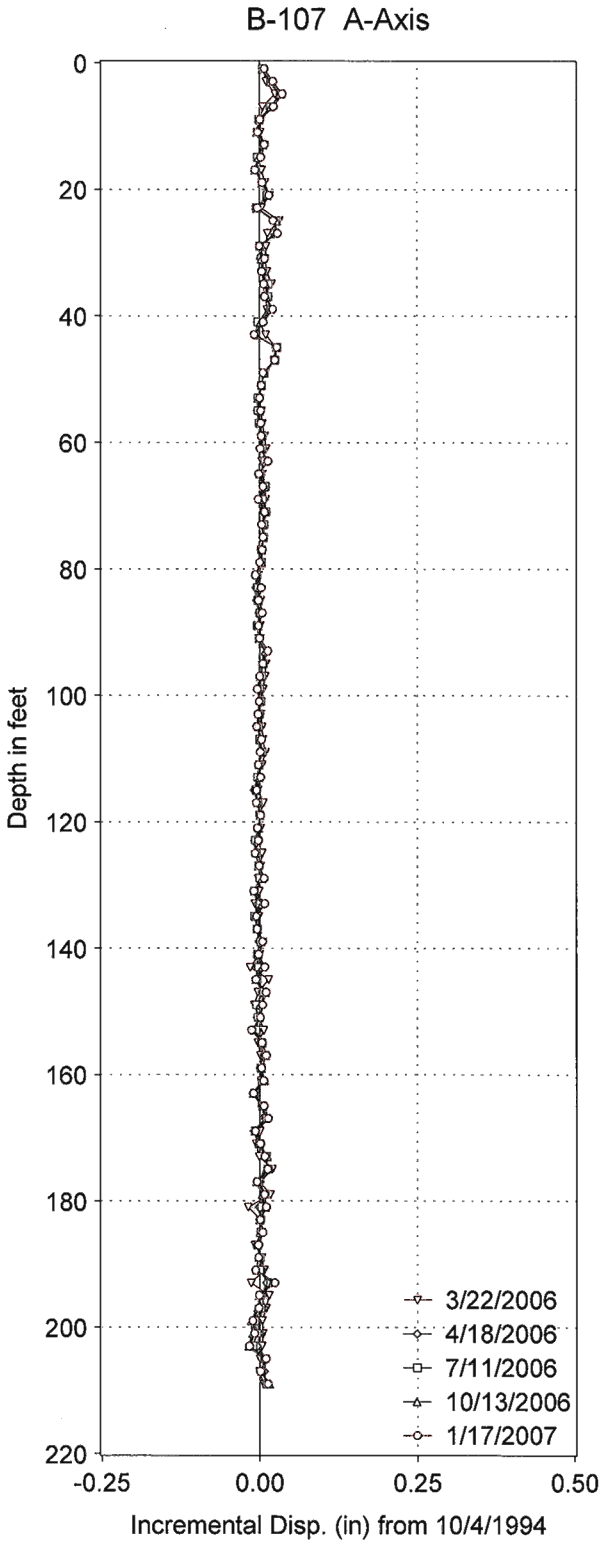




B-102
-Includes readings from the last four quarters.

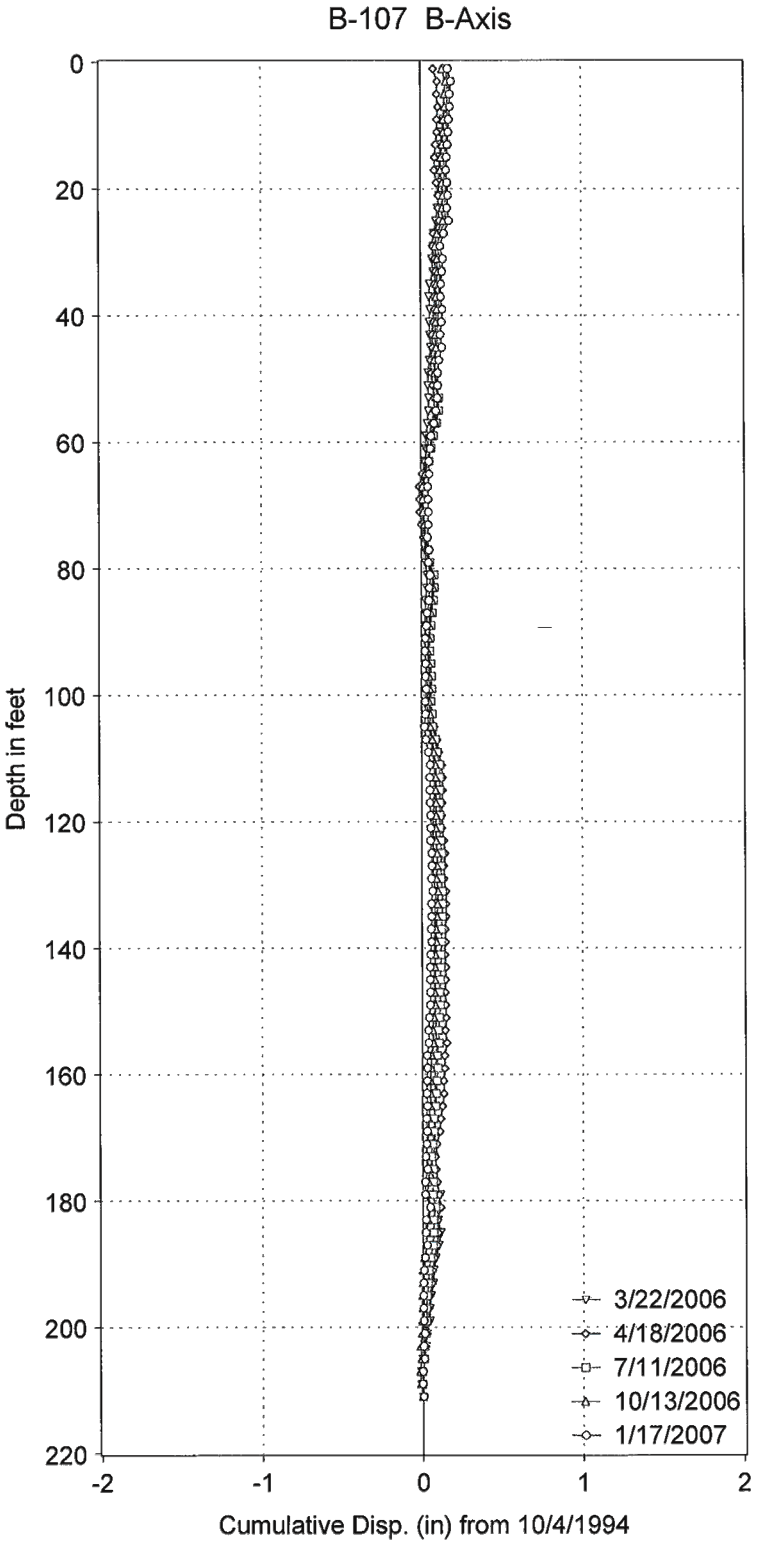
PLATE 6

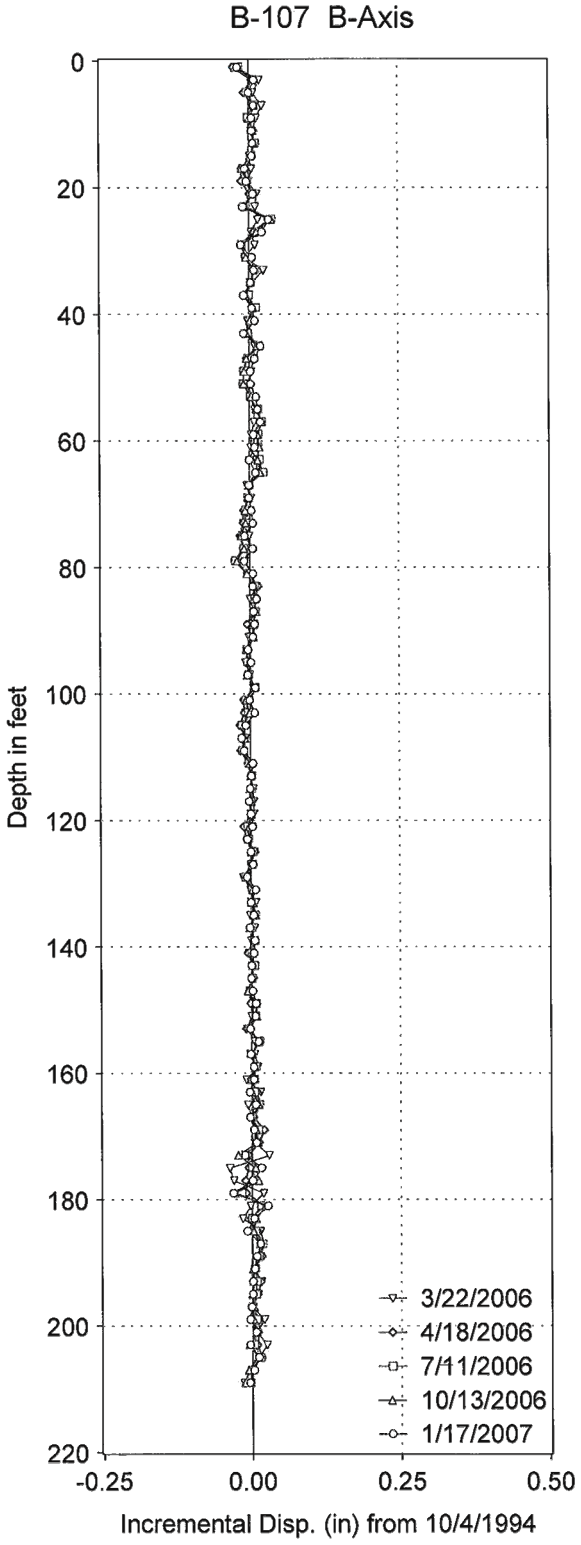




B-107
-Includes readings from the last four quarters (and in March, 2006).

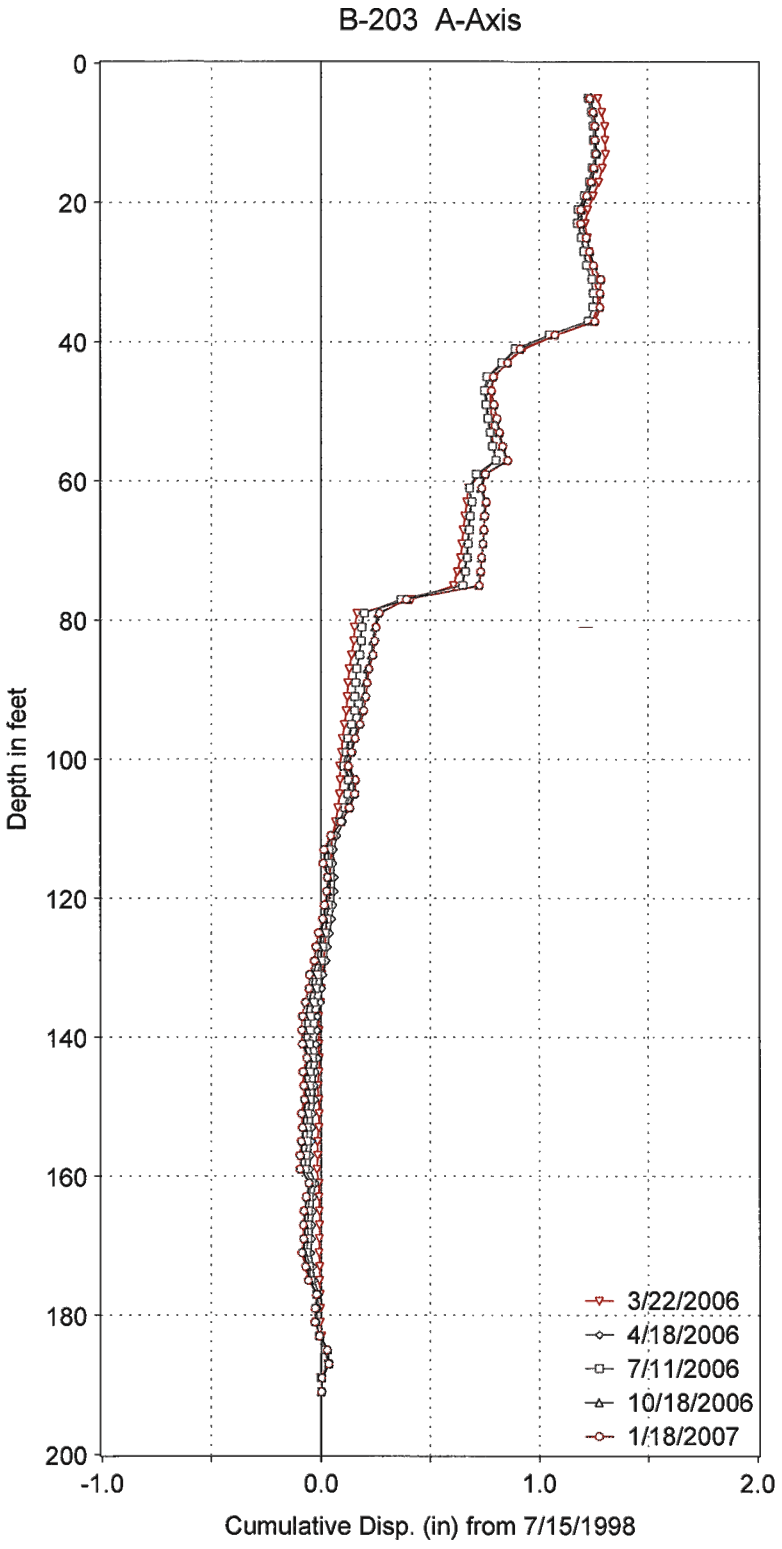
PLATE 7

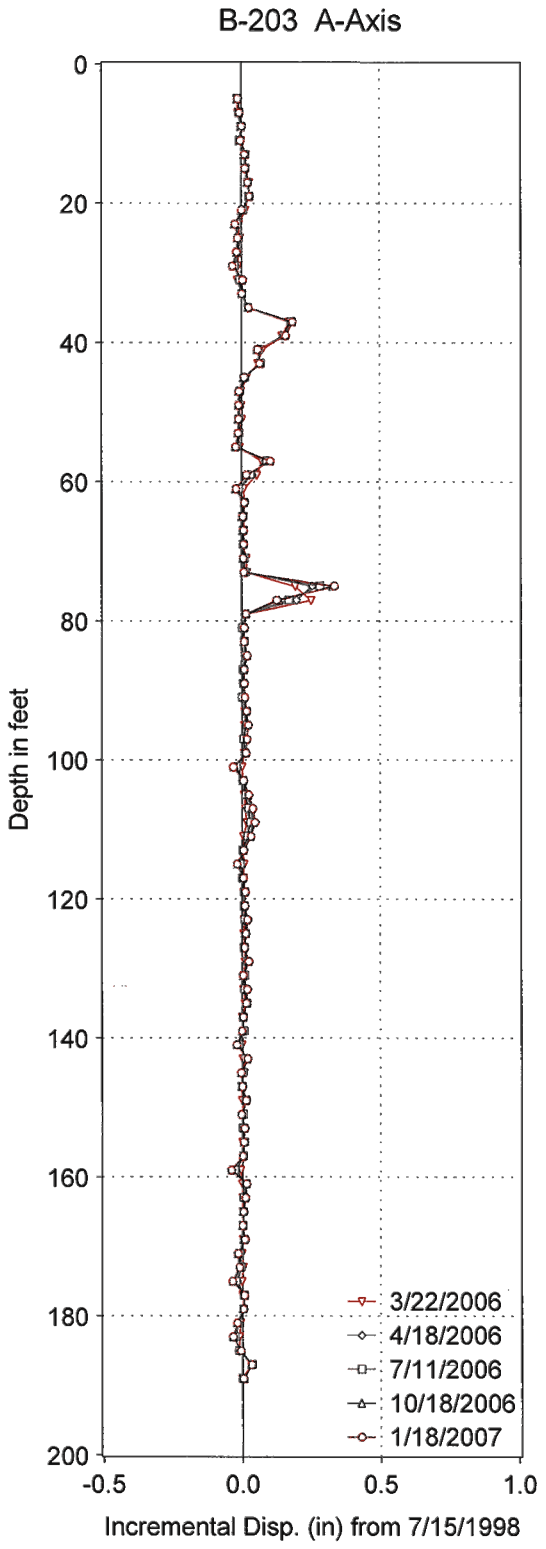




B-107
-Includes readings from the last four quarters (and in March, 2006).

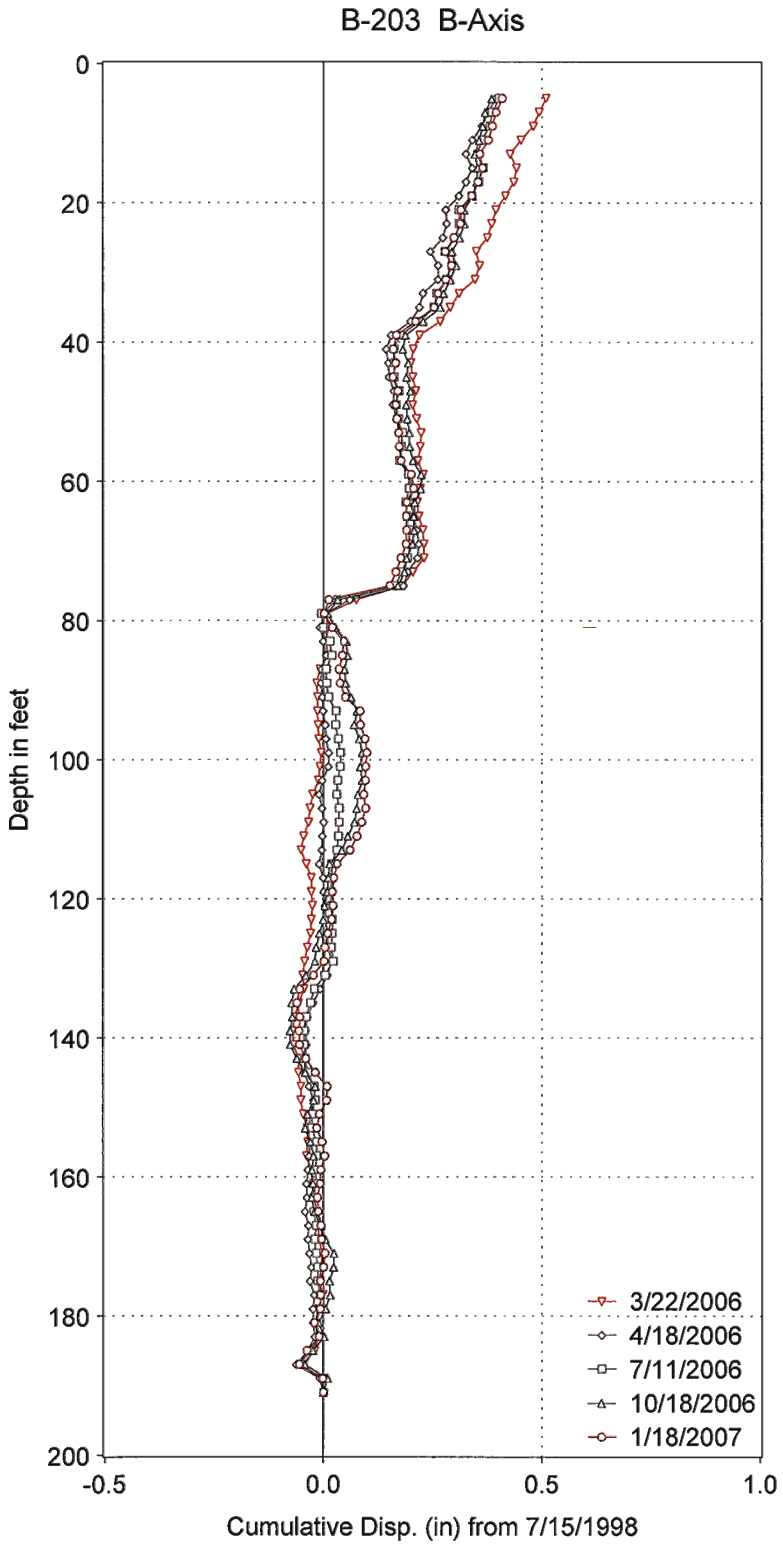
PLATE 8

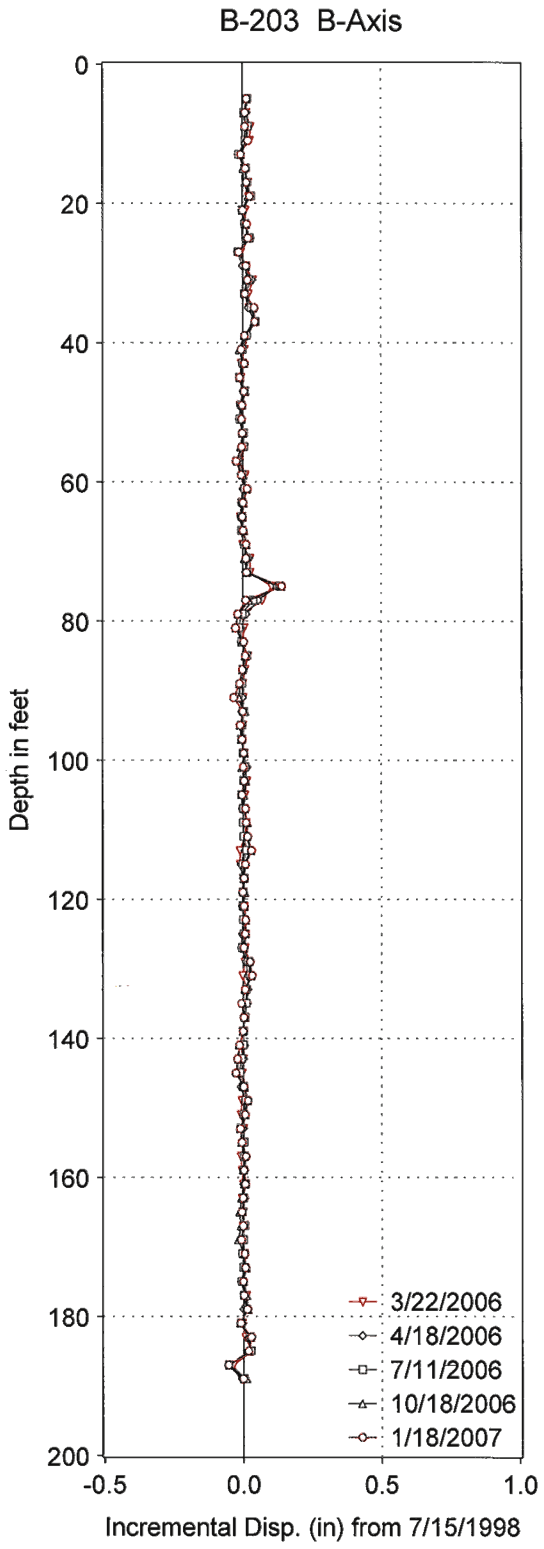




B-203
-Includes readings from the last four quarters (and in March, 2006).

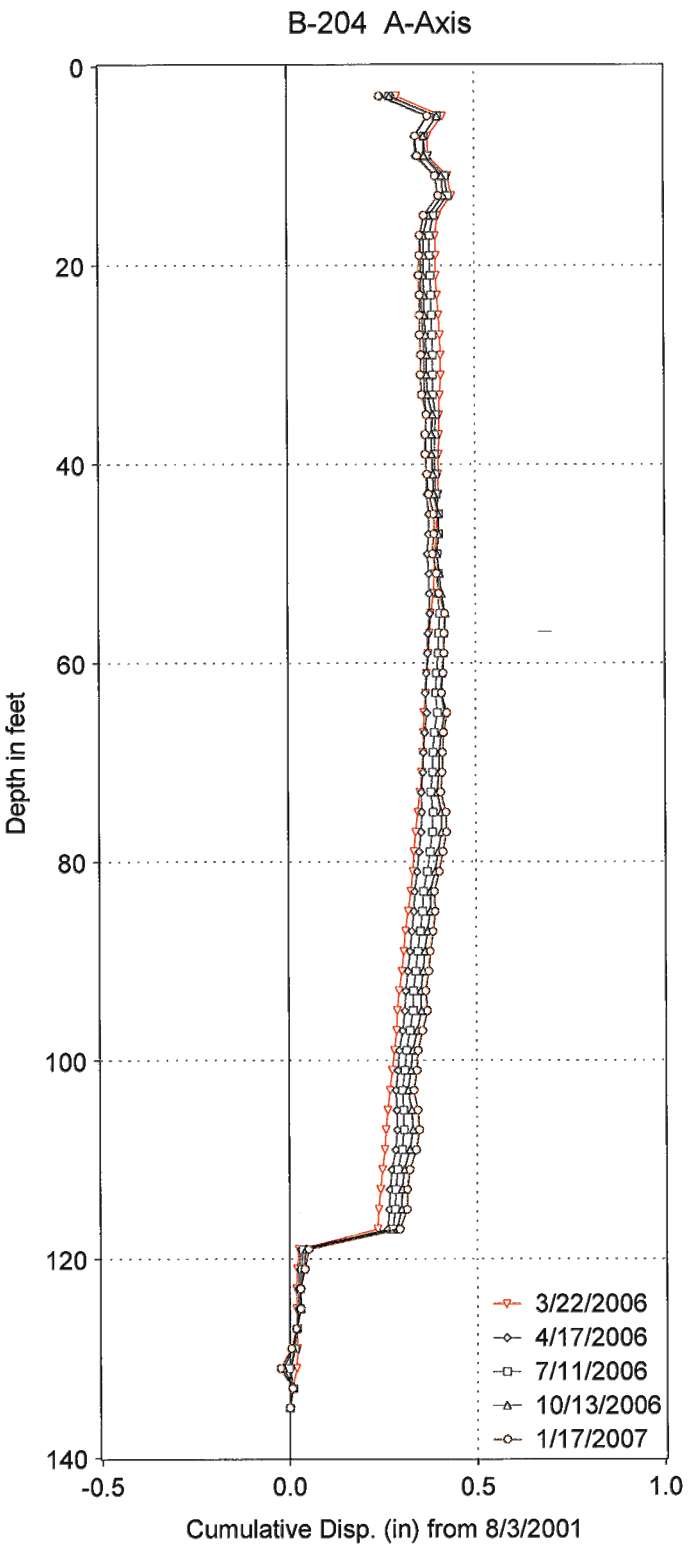
PLATE 9

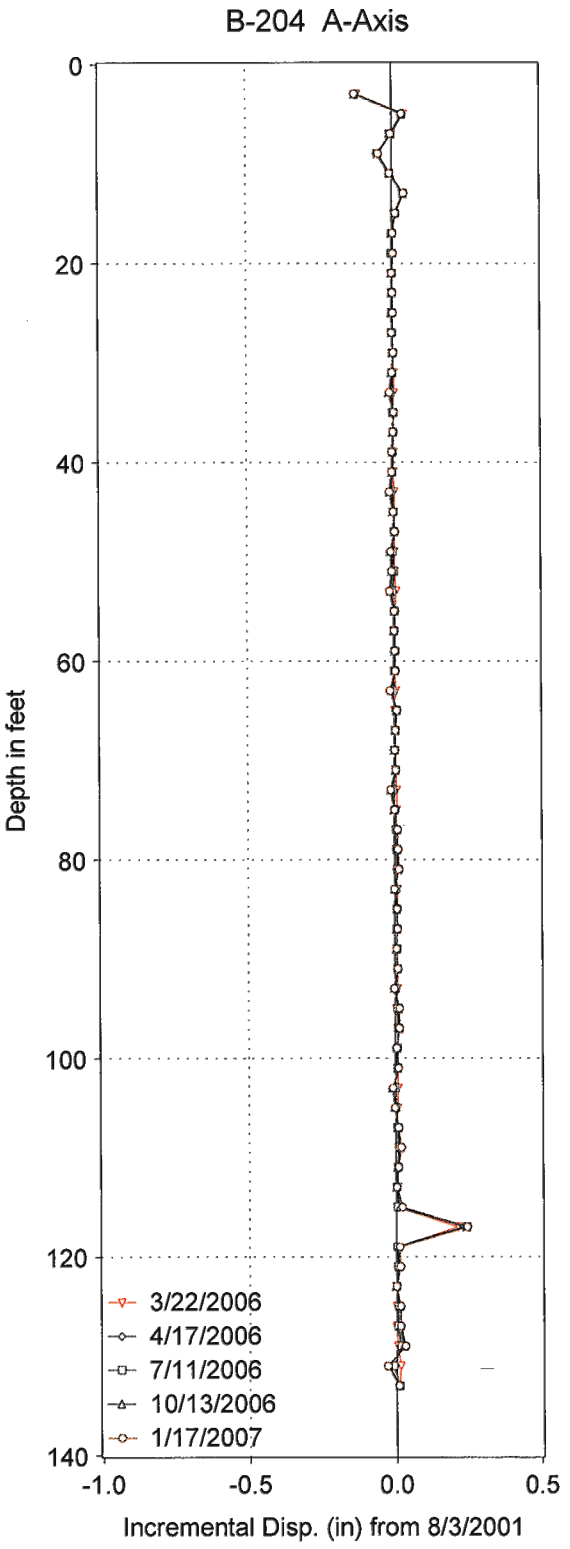




B-203
-Includes readings from the last four quarters (and in March, 2006).

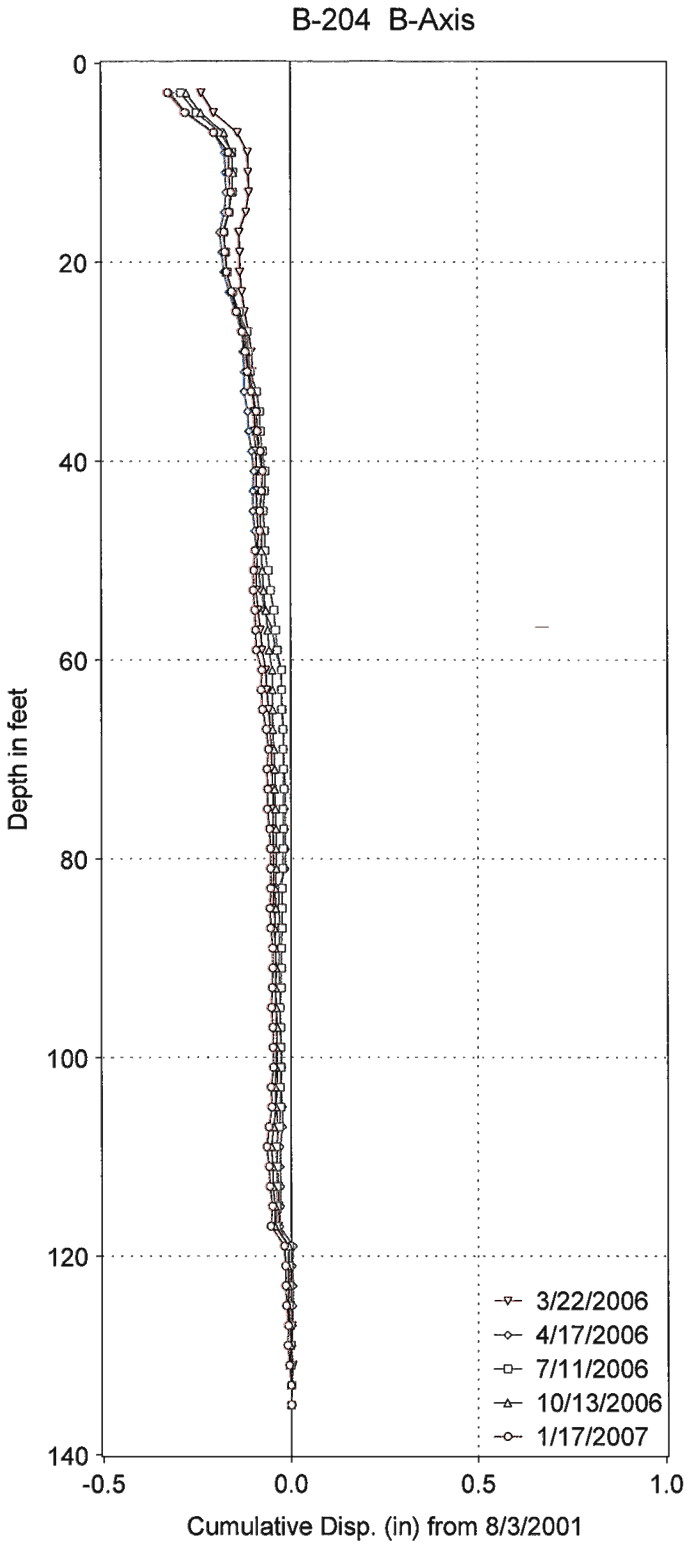
PLATE 10

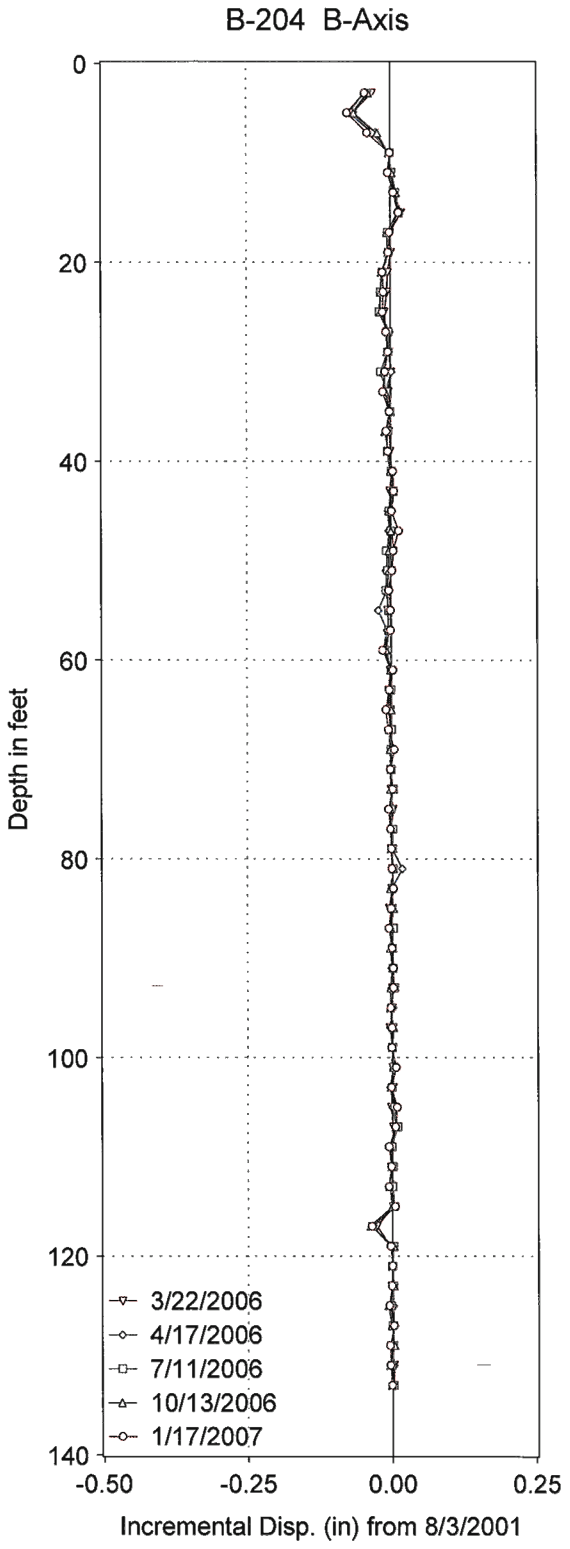




B-204
-Includes readings from the last four quarters (and in March, 2006).

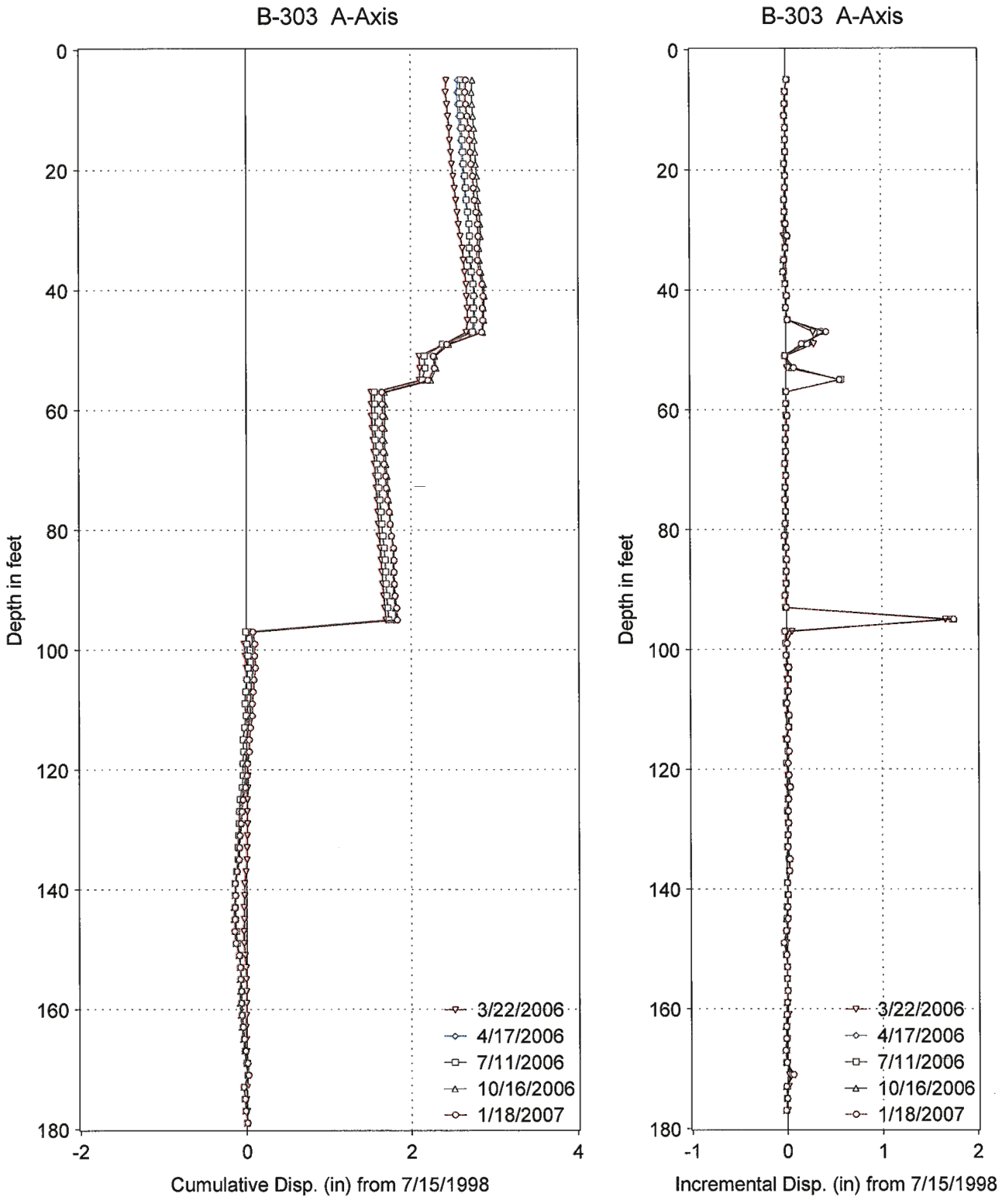
PLATE 11





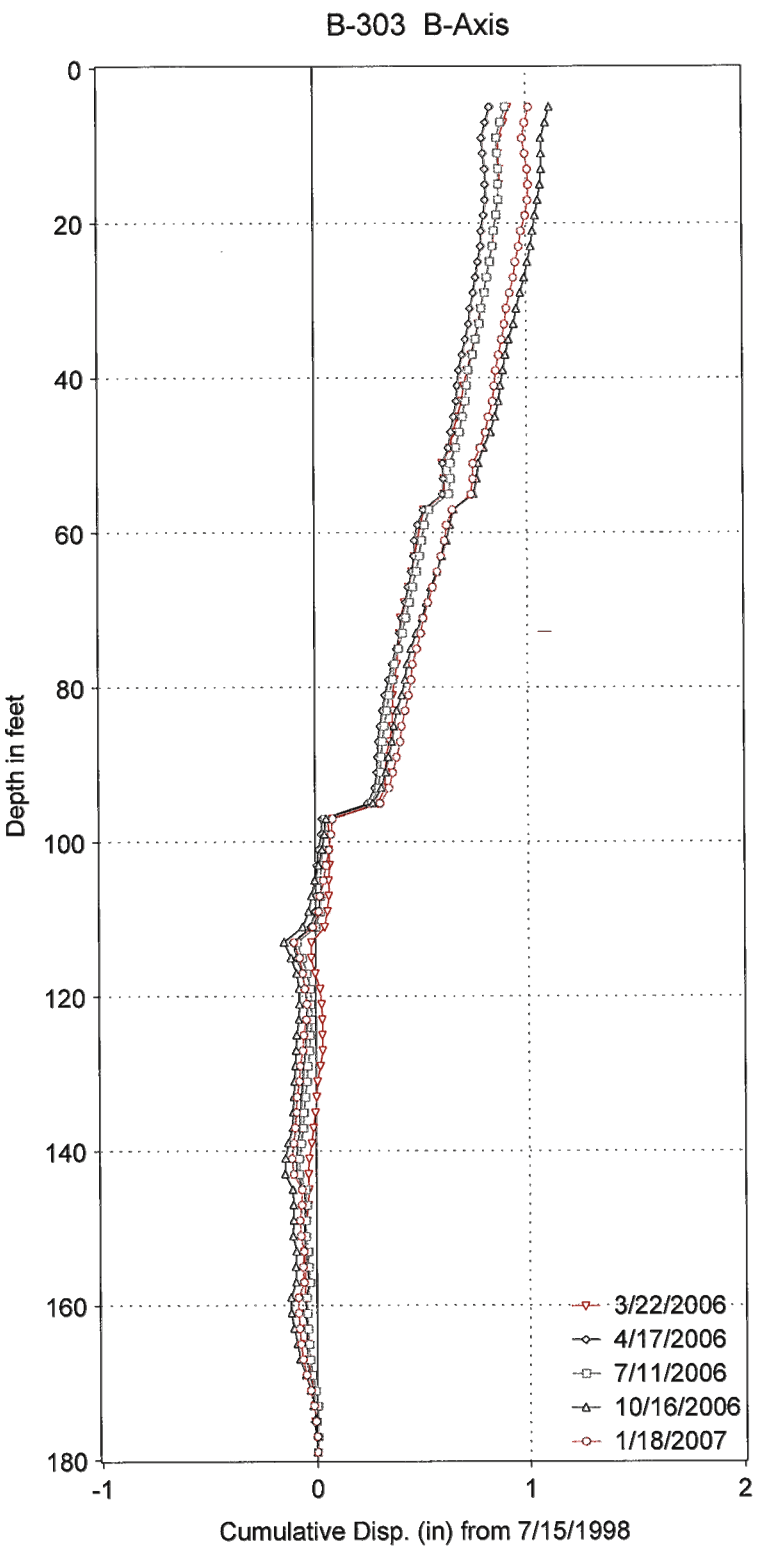
B-204
-Includes readings from the last four quarters (and in March, 2006).

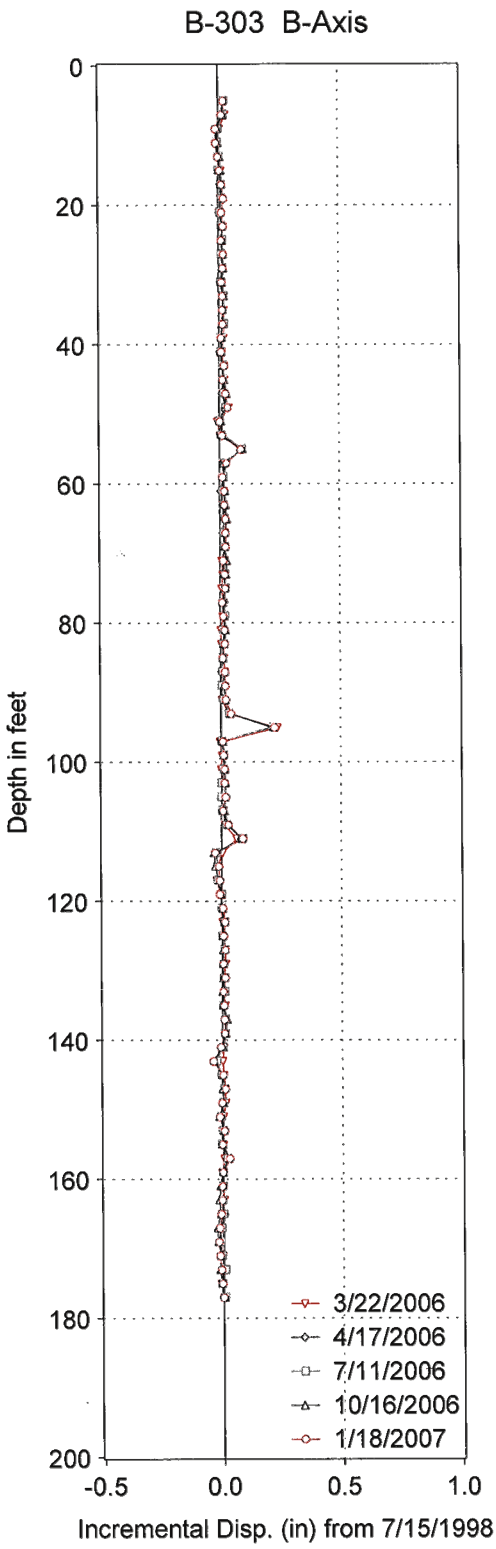
PLATE 12



B-303
-Includes readings from the last four quarters (and in March, 2006).

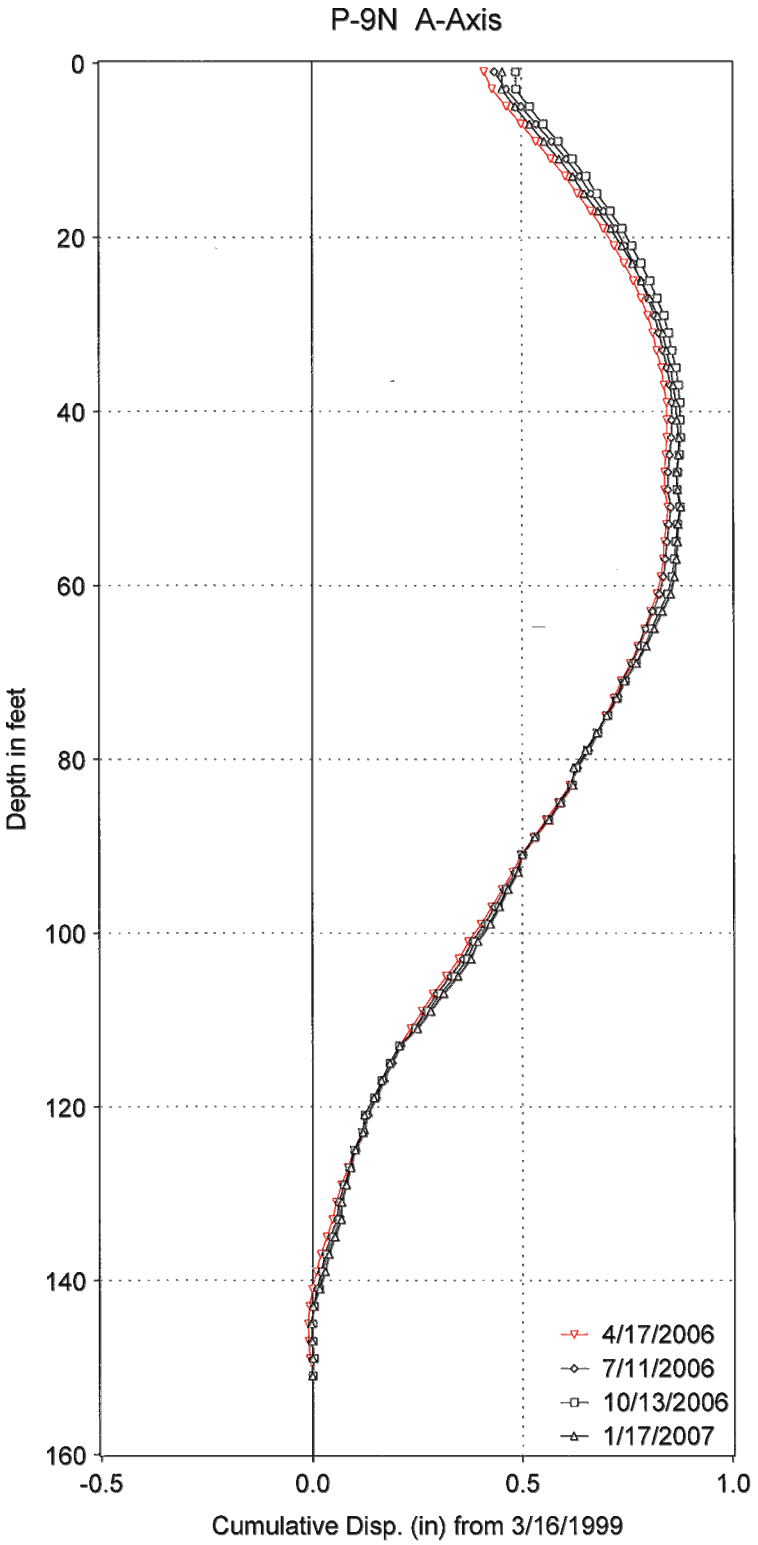
PLATE 13

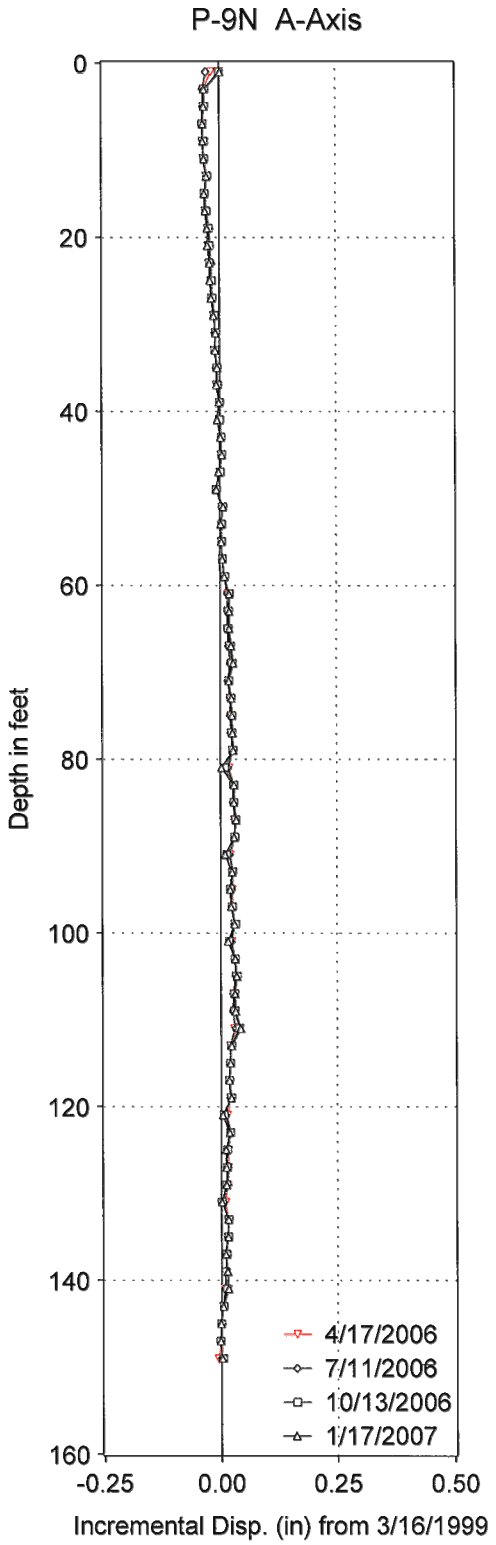




B-303
-Includes readings from the last four quarters (and in March, 2006).

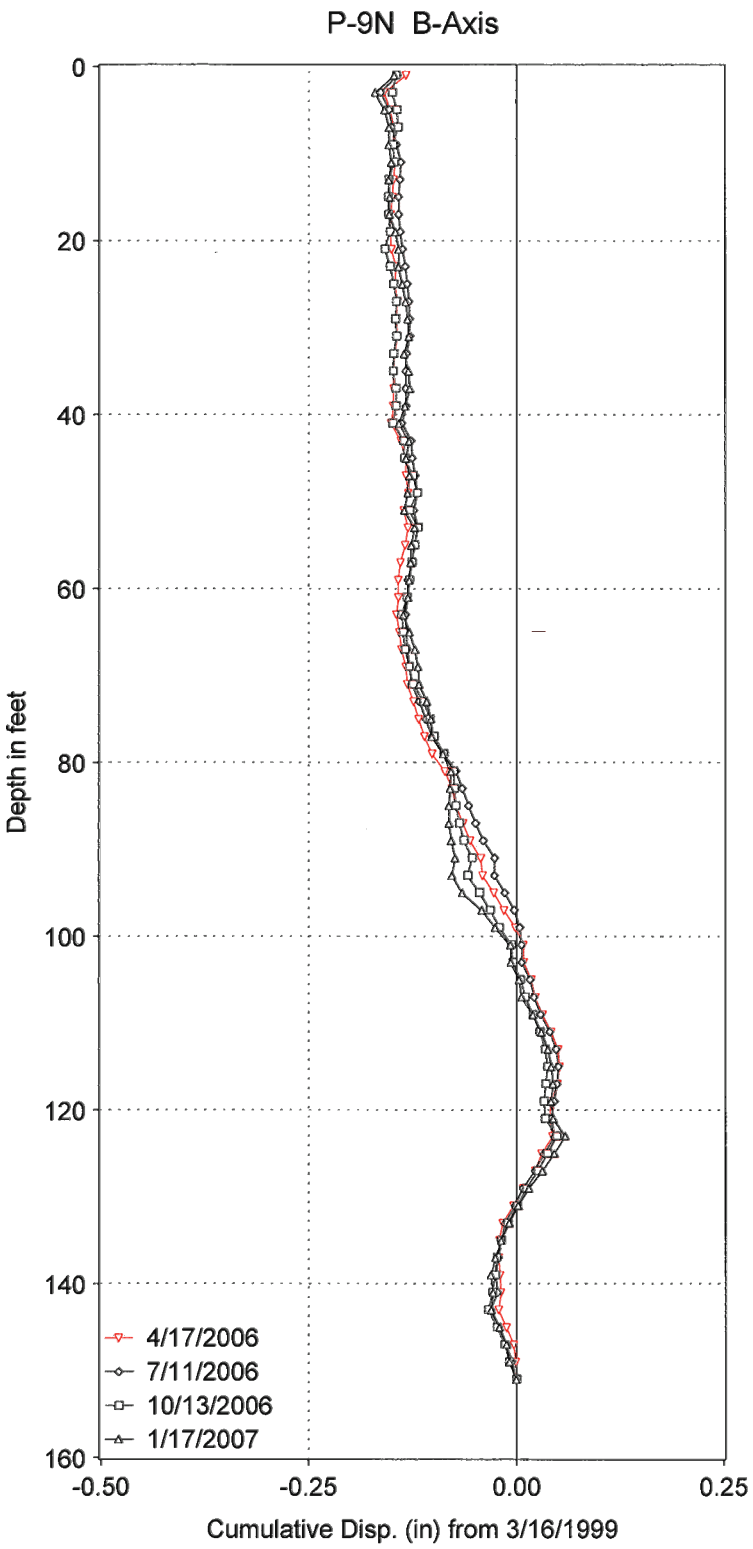
PLATE 14

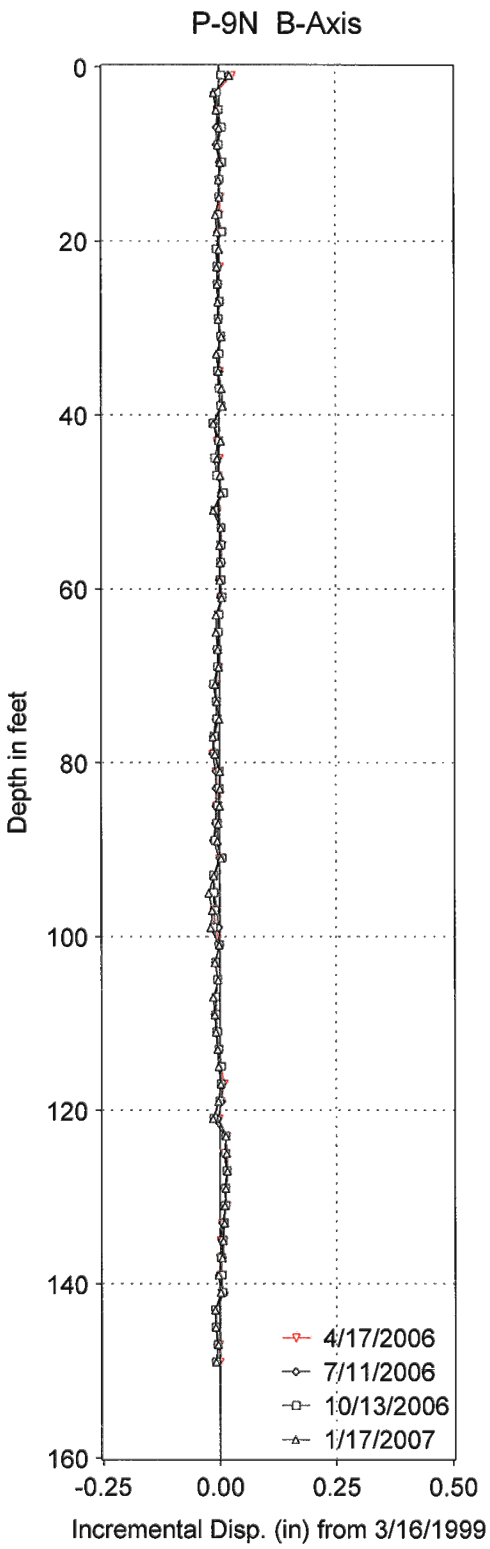




P-9N
-Includes readings from the last four quarters.

PLATE 15





P-9N
-Includes readings from the last four quarters.

PLATE 16

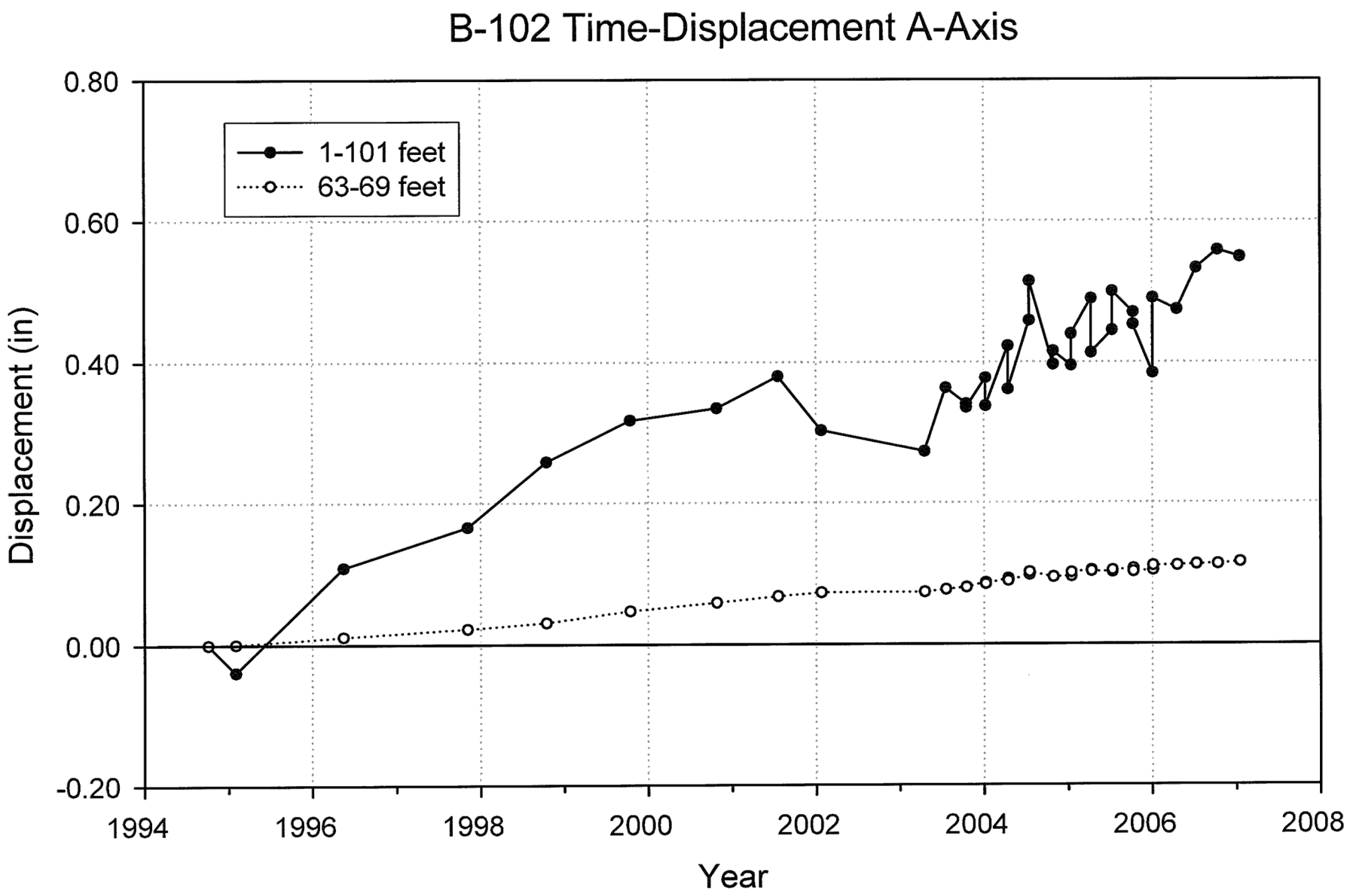

B-102 Time-Displacement A-Axis
1-101 feet
63-69 feet
Displacement (in)
0.80
0.60
0.40
0.20
0.00
-0.20
1994
1996
1998
2000
2002
2004
2006
2008
Year

PLATE 17

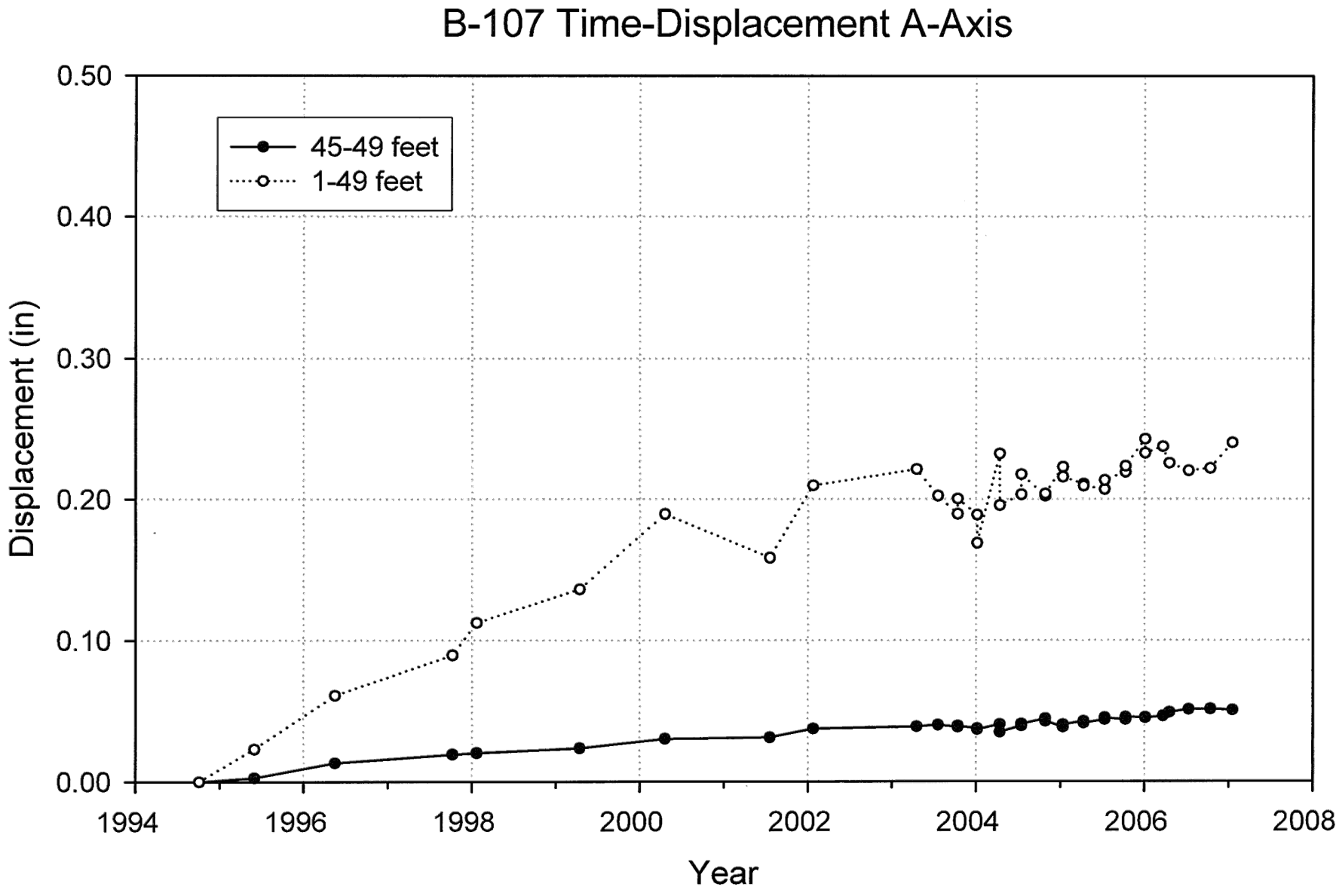

B-107 Time-Displacement A-Axis
45-49 feet
1-49 feet
Displacement (in)
0.50
0.40
0.30
0.20
0.10
0.00
1994
1996
1998
2000
2002
2004
2006
2008
Year

PLATE 18

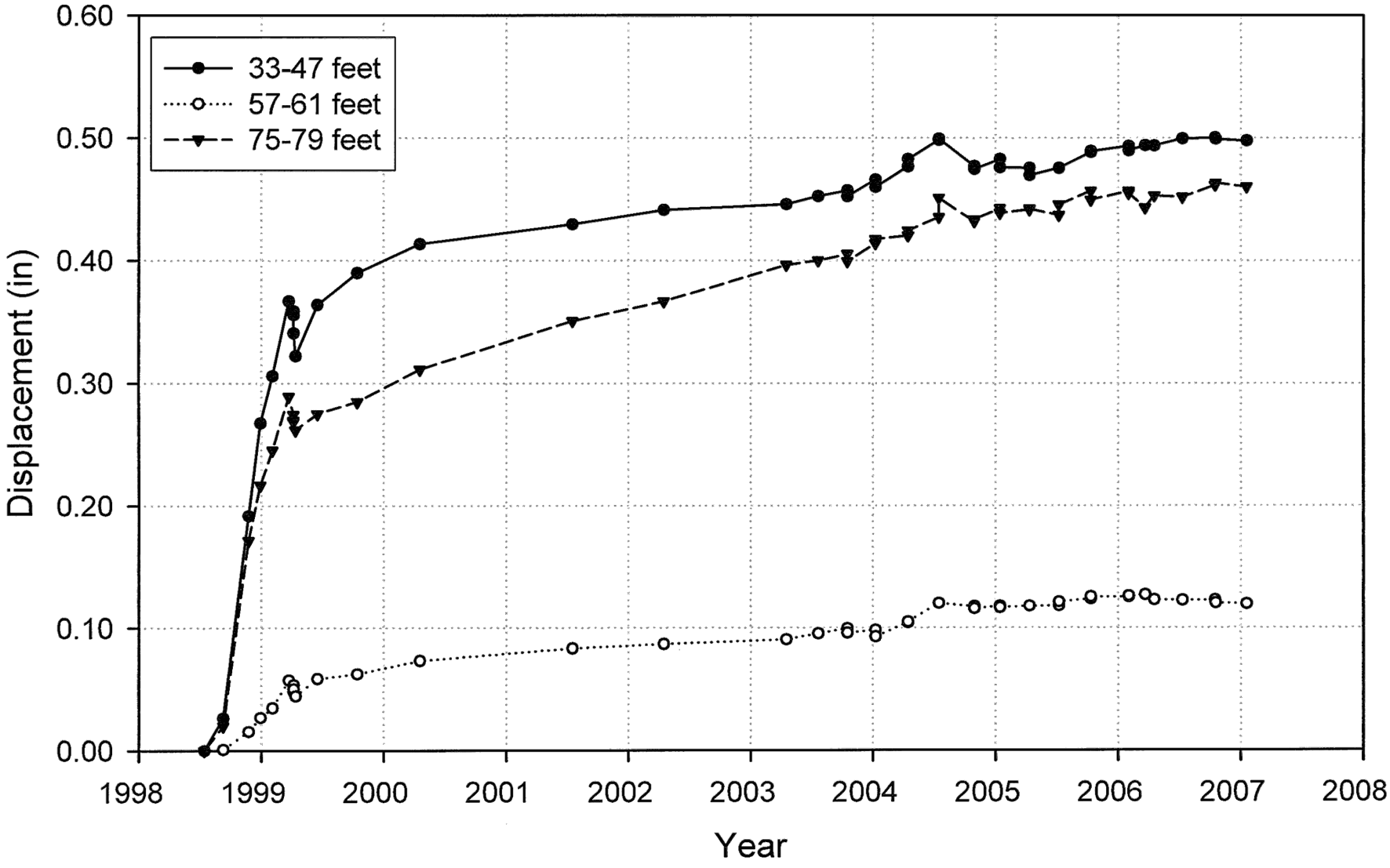

B-203 Time-Displacement A-Axis
33-47 feet
57-61 feet
75-79 feet
Displacement (in)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year

PLATE 19

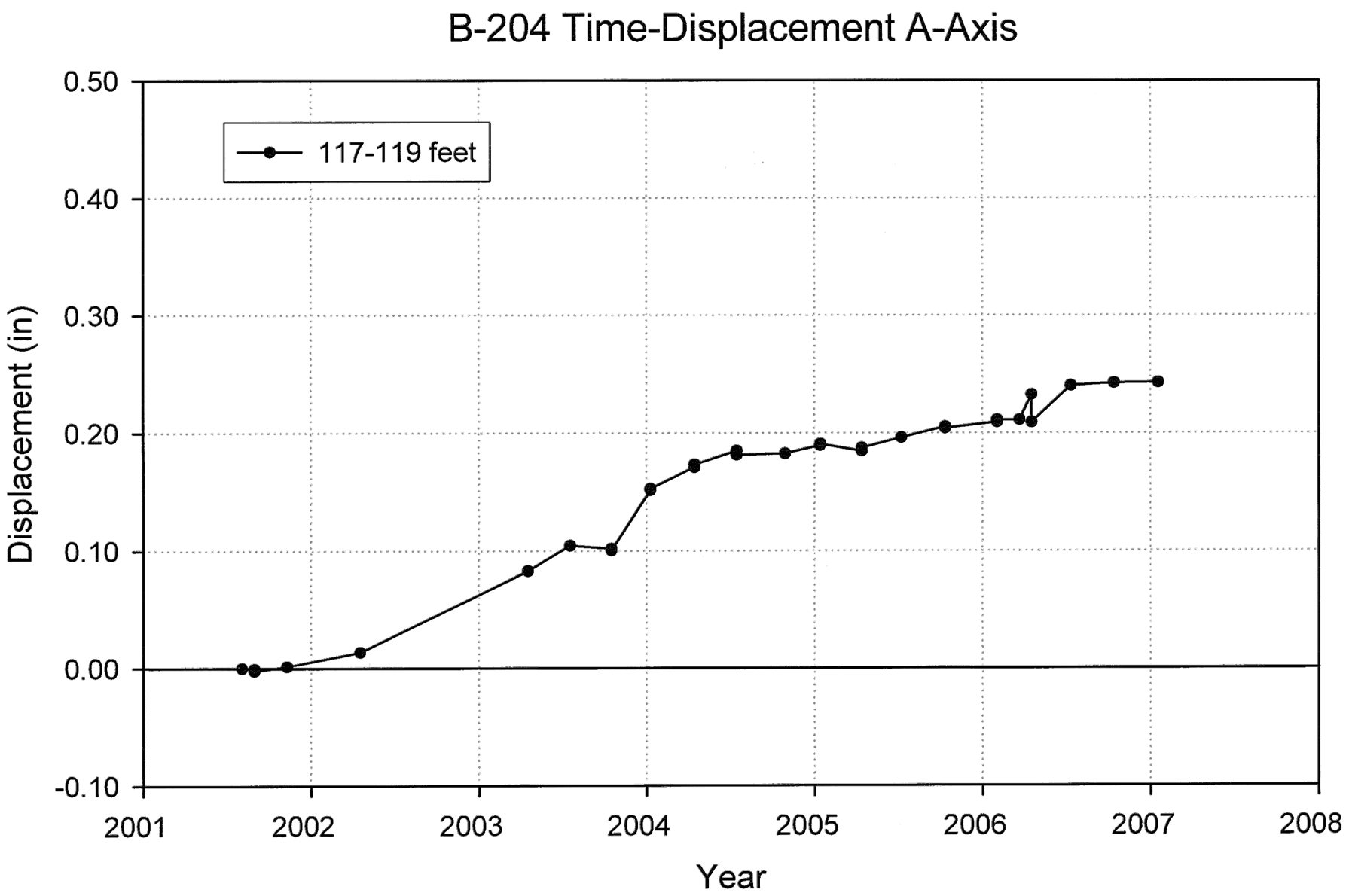

B-204 Time-Displacement A-Axis
117-119 feet
Displacement (in)
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
2001
2002
2003
2004
2005
2006
2007
2008
Year

PLATE 20

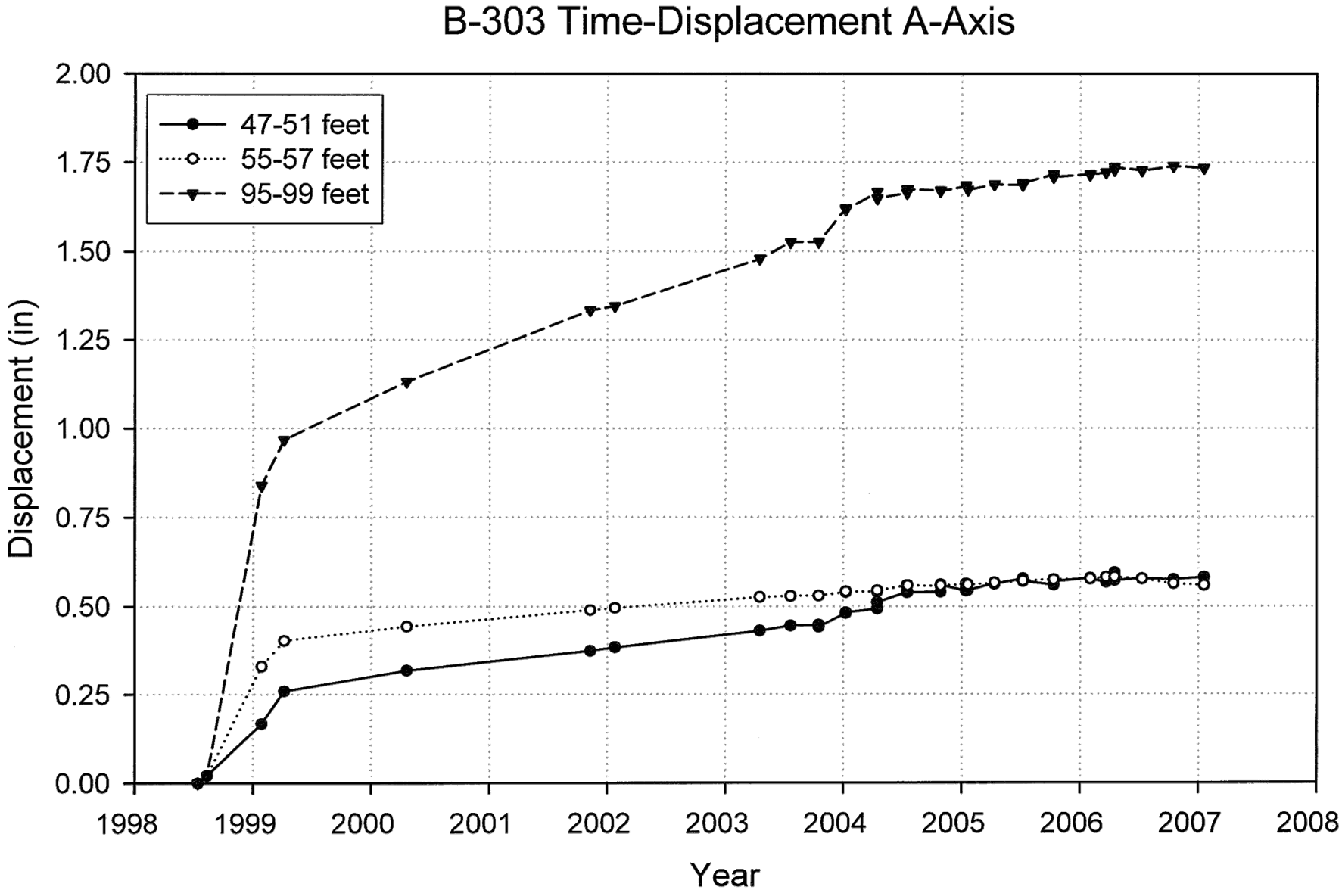
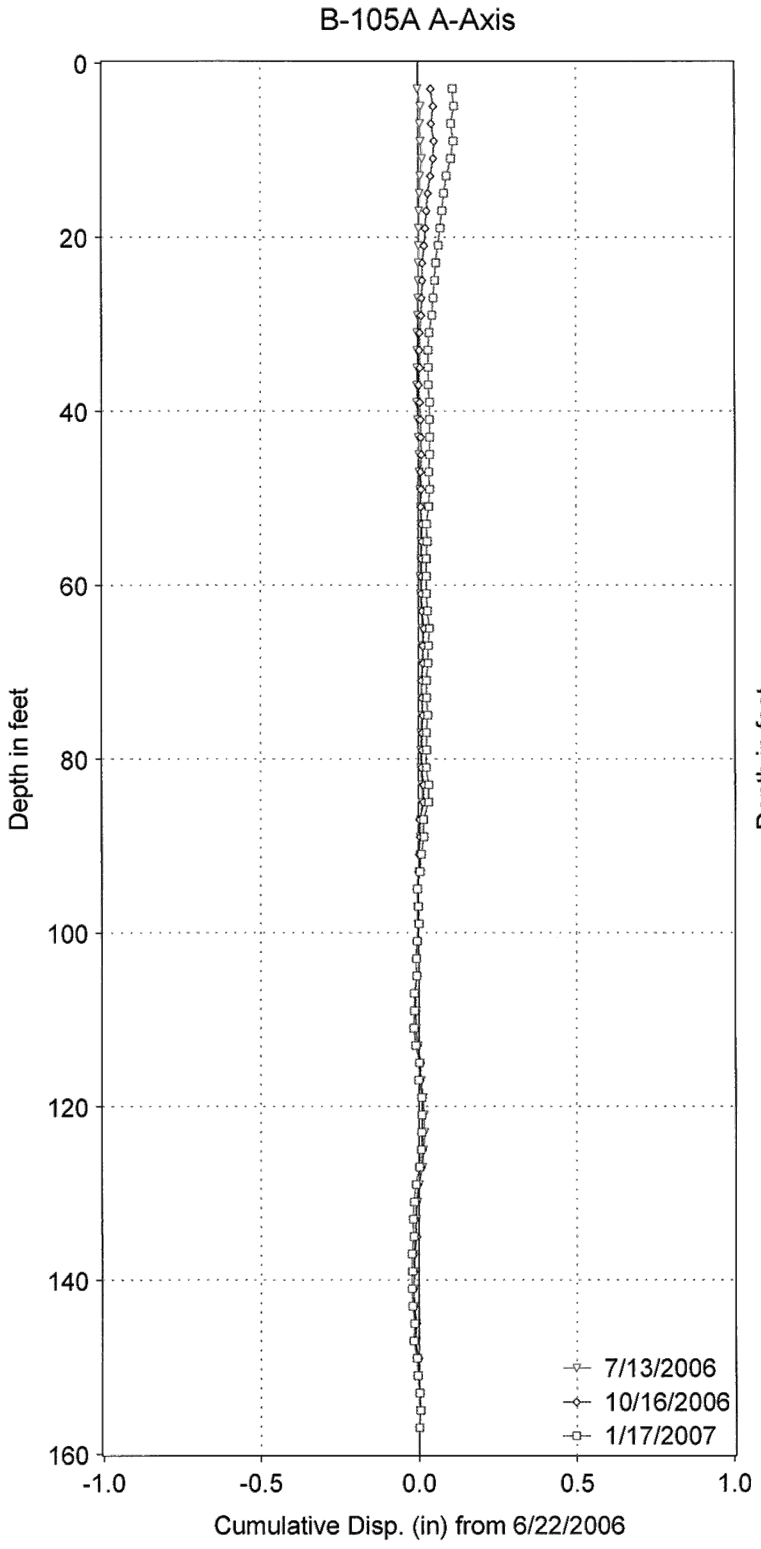
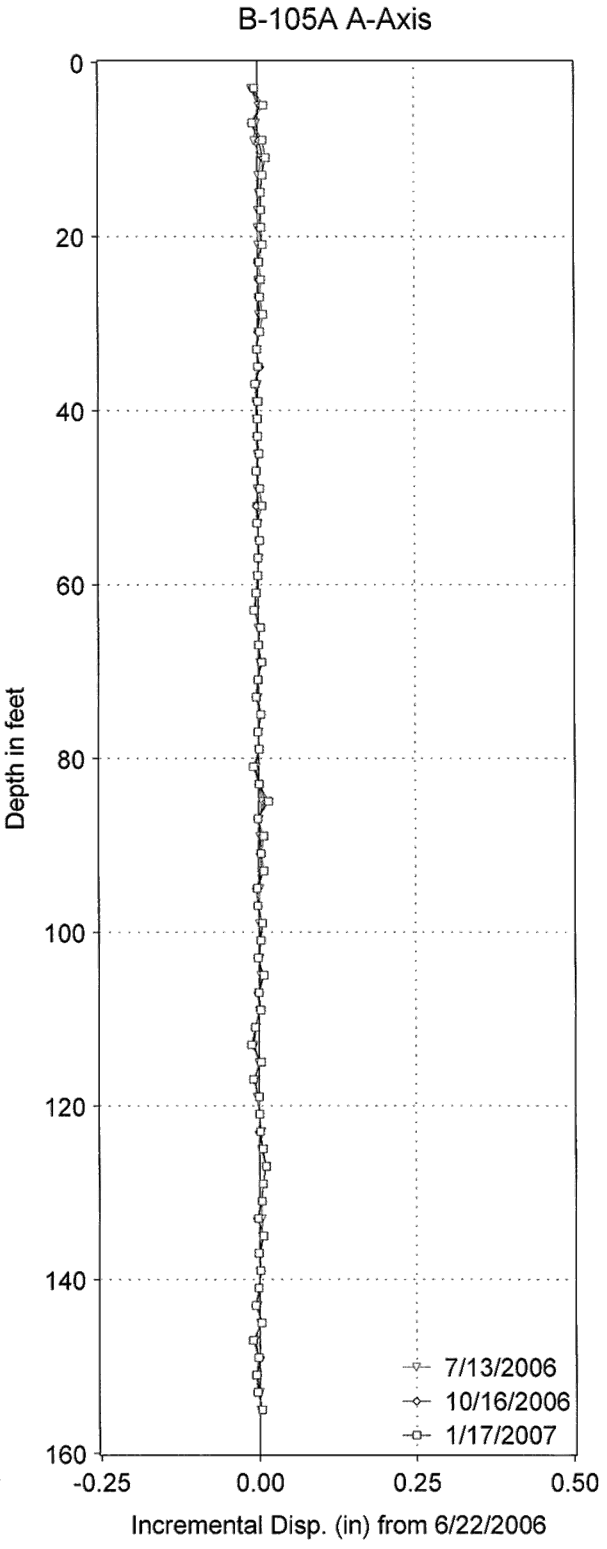

B-303 Time-Displacement A-Axis
47-51 feet
55-57 feet
95-99 feet
Displacement (in)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year

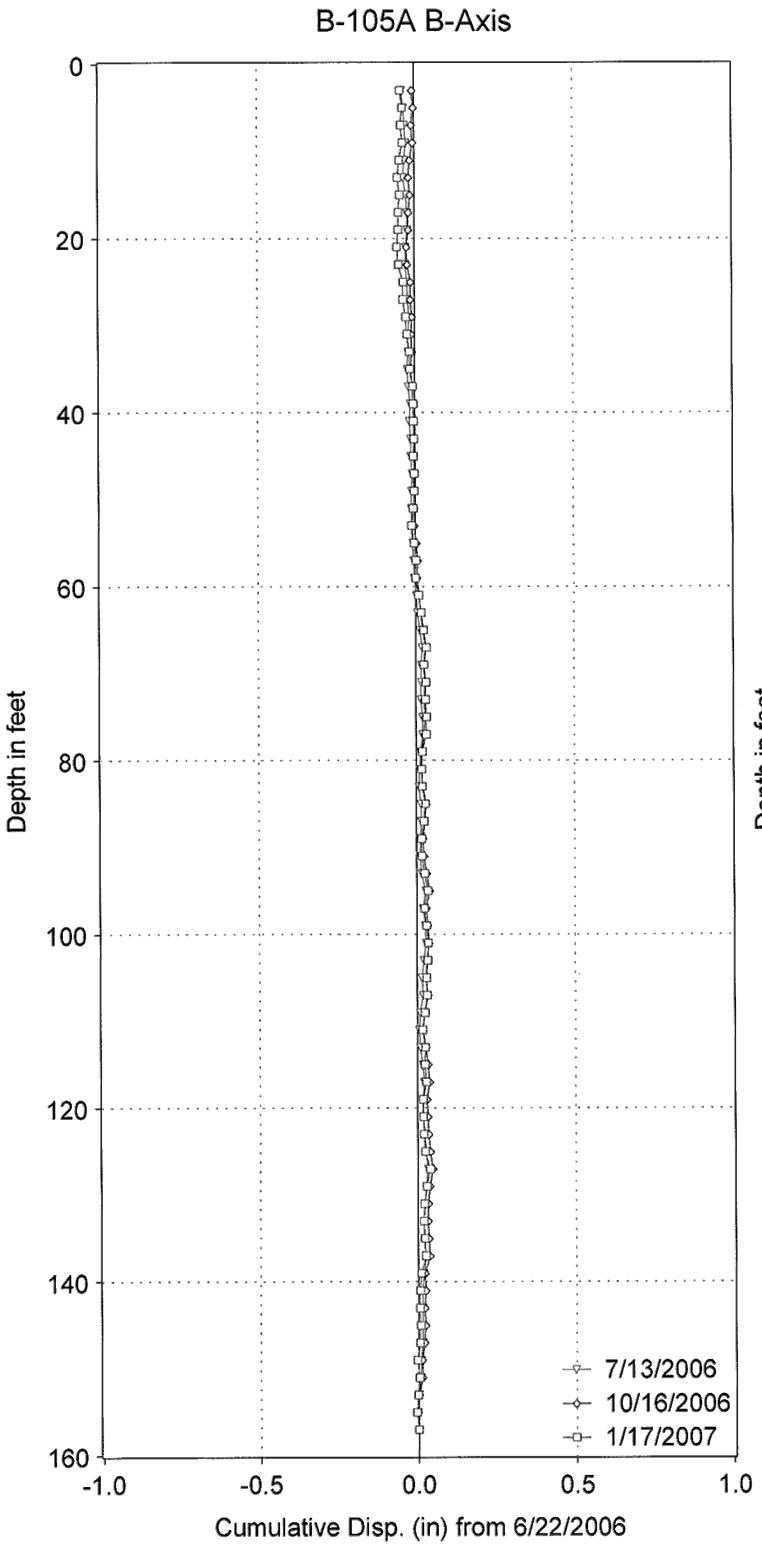
PLATE 21

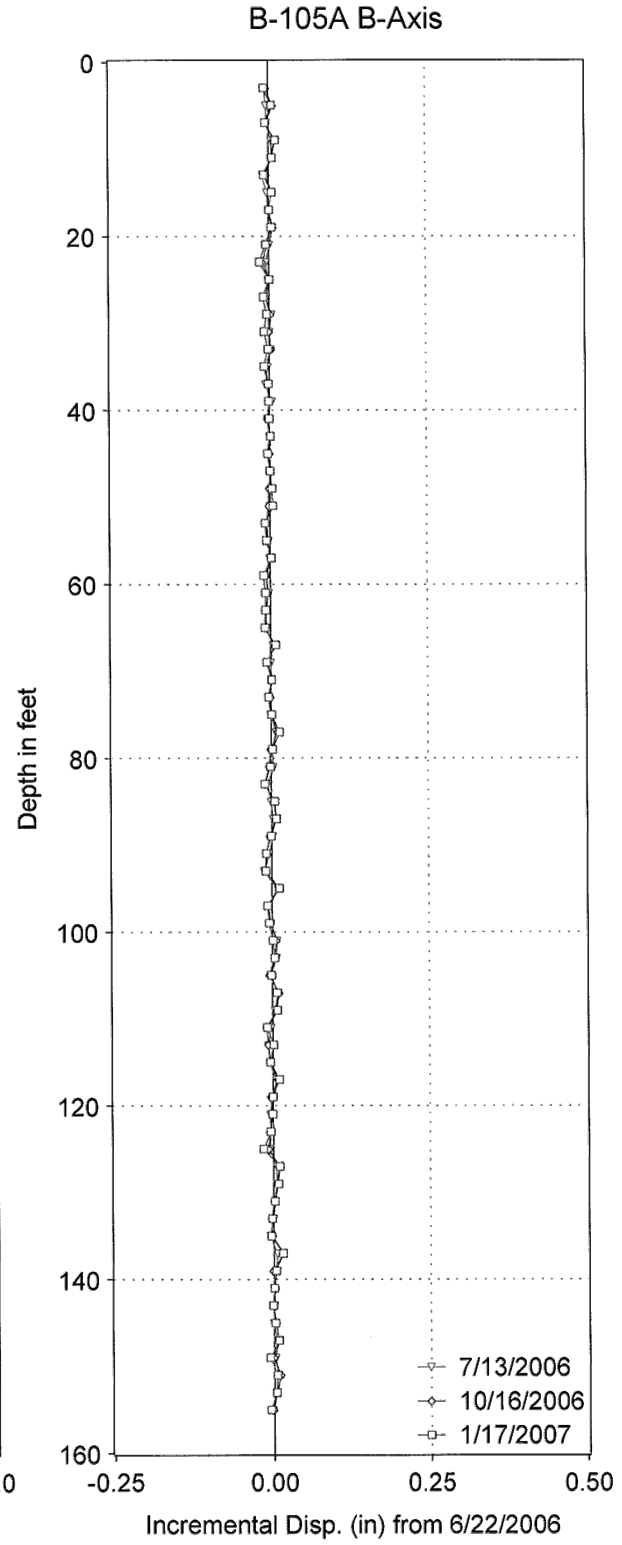




B-105A

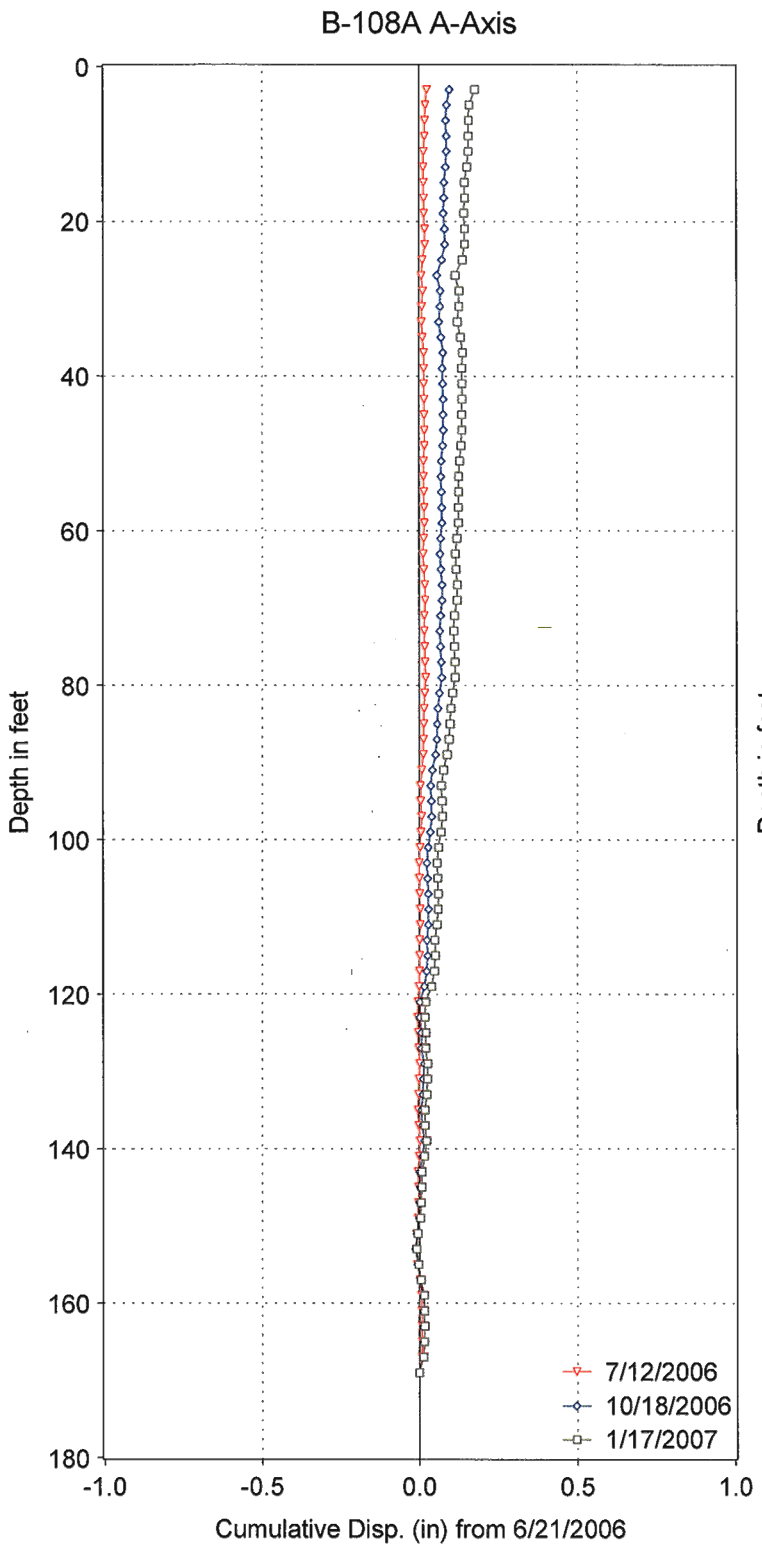
PLATE 22

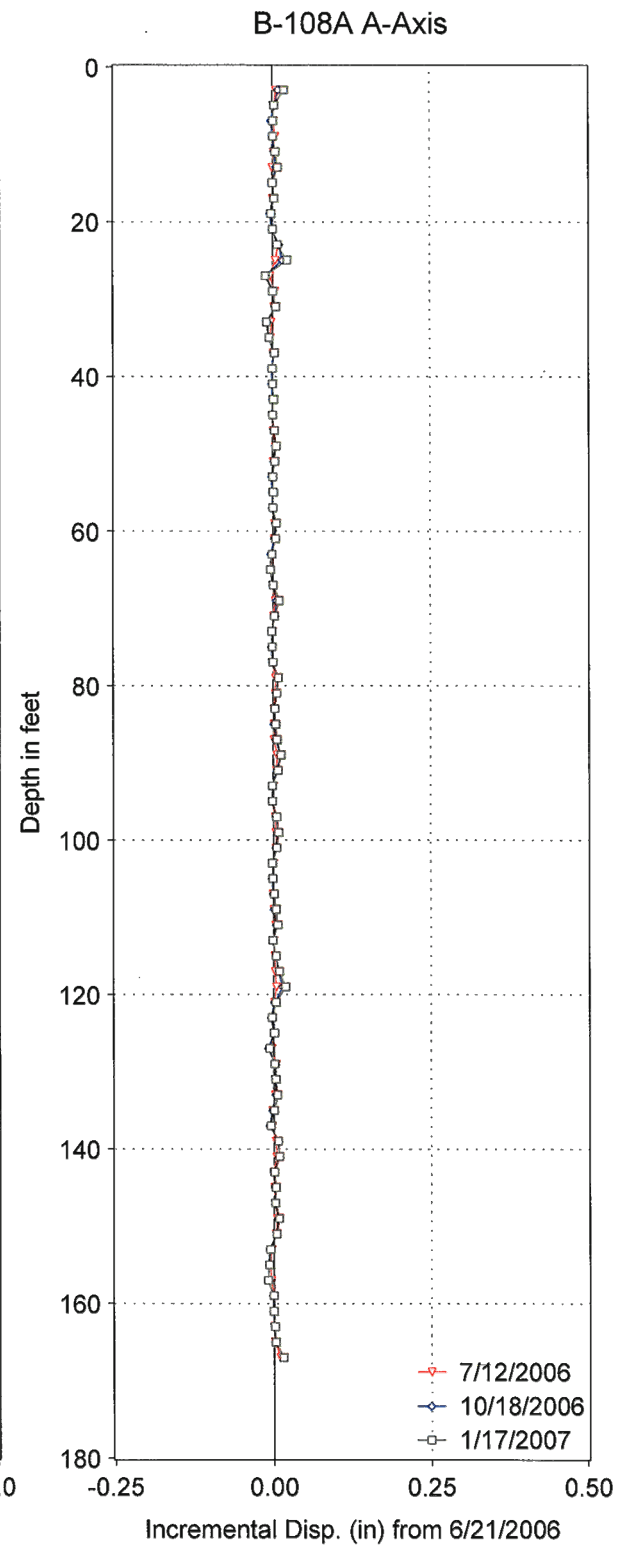




B-105A

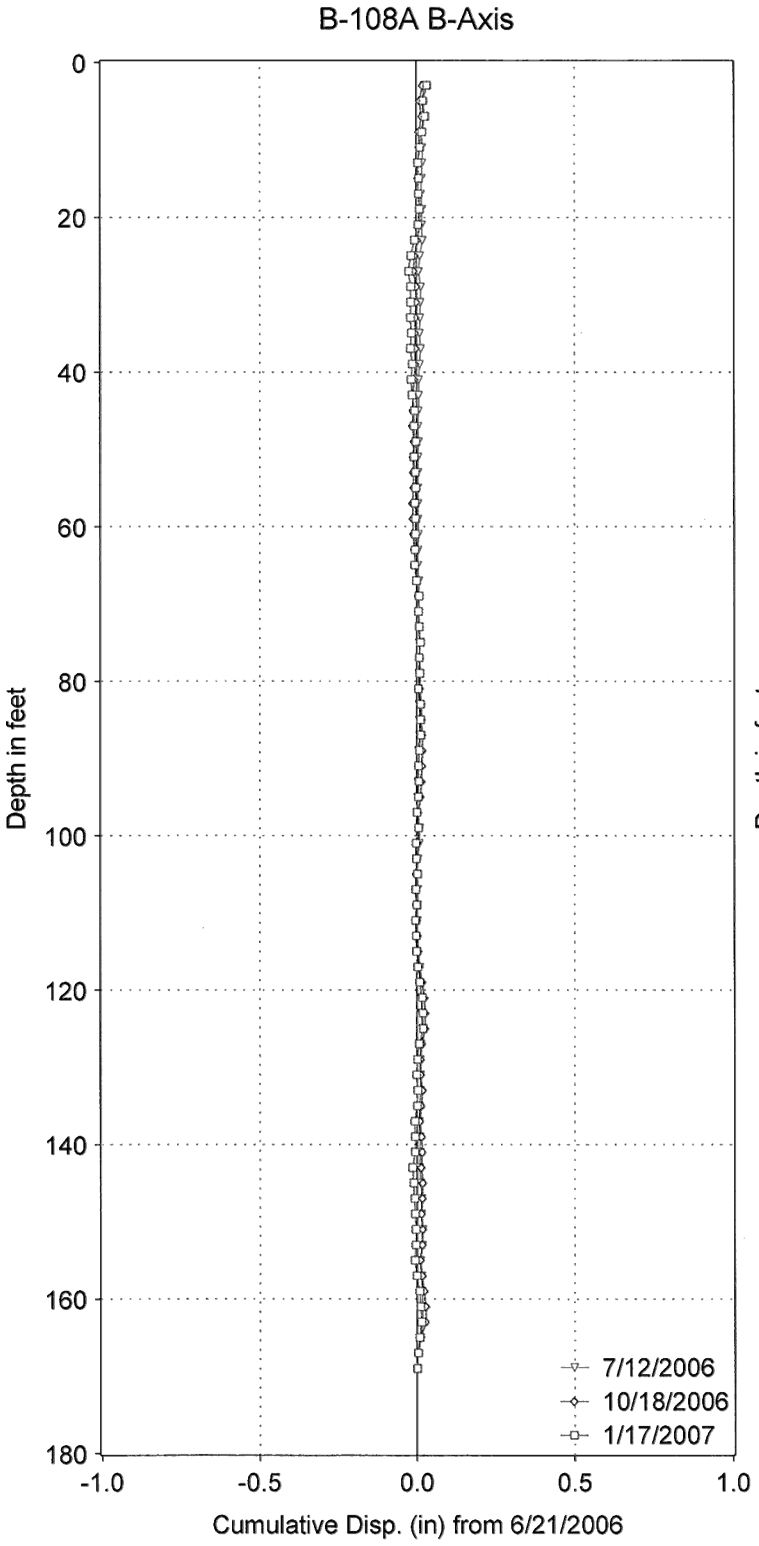
PLATE 23

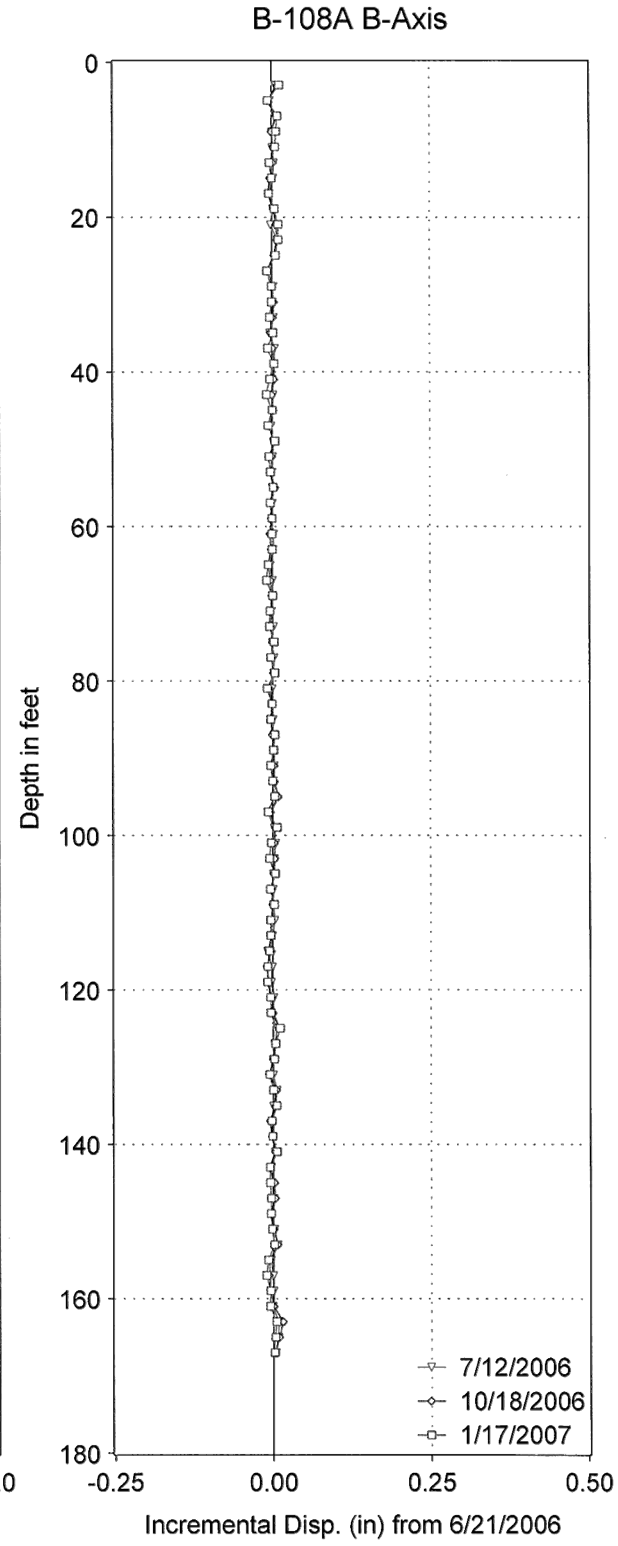




B-108A

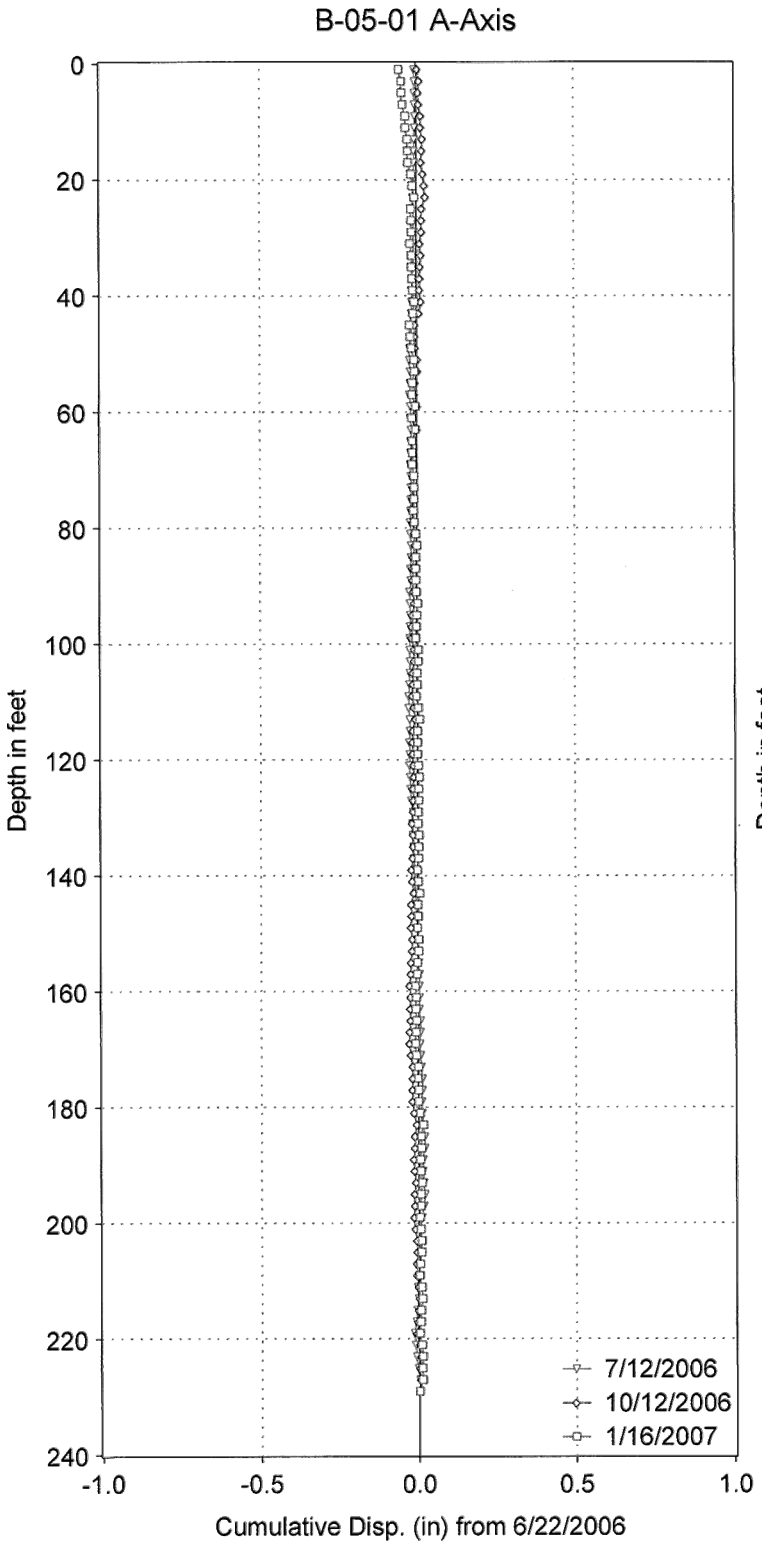
PLATE 24

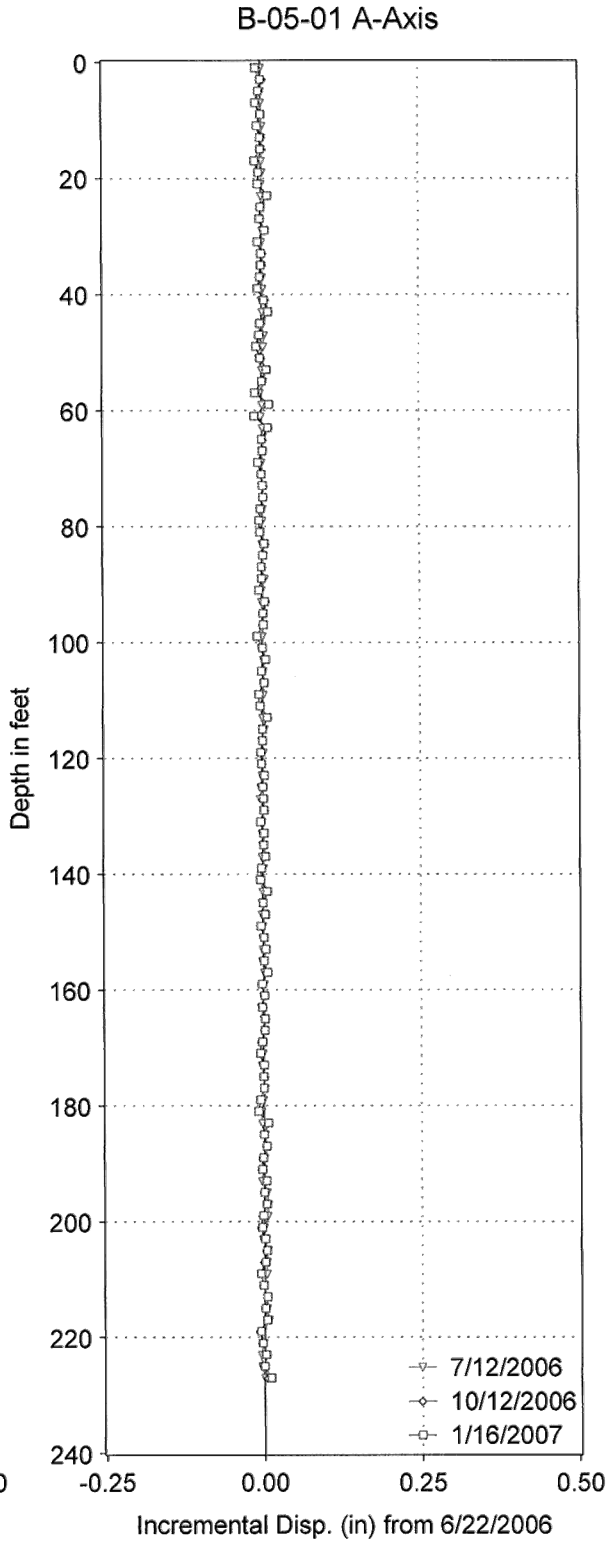




B-108A

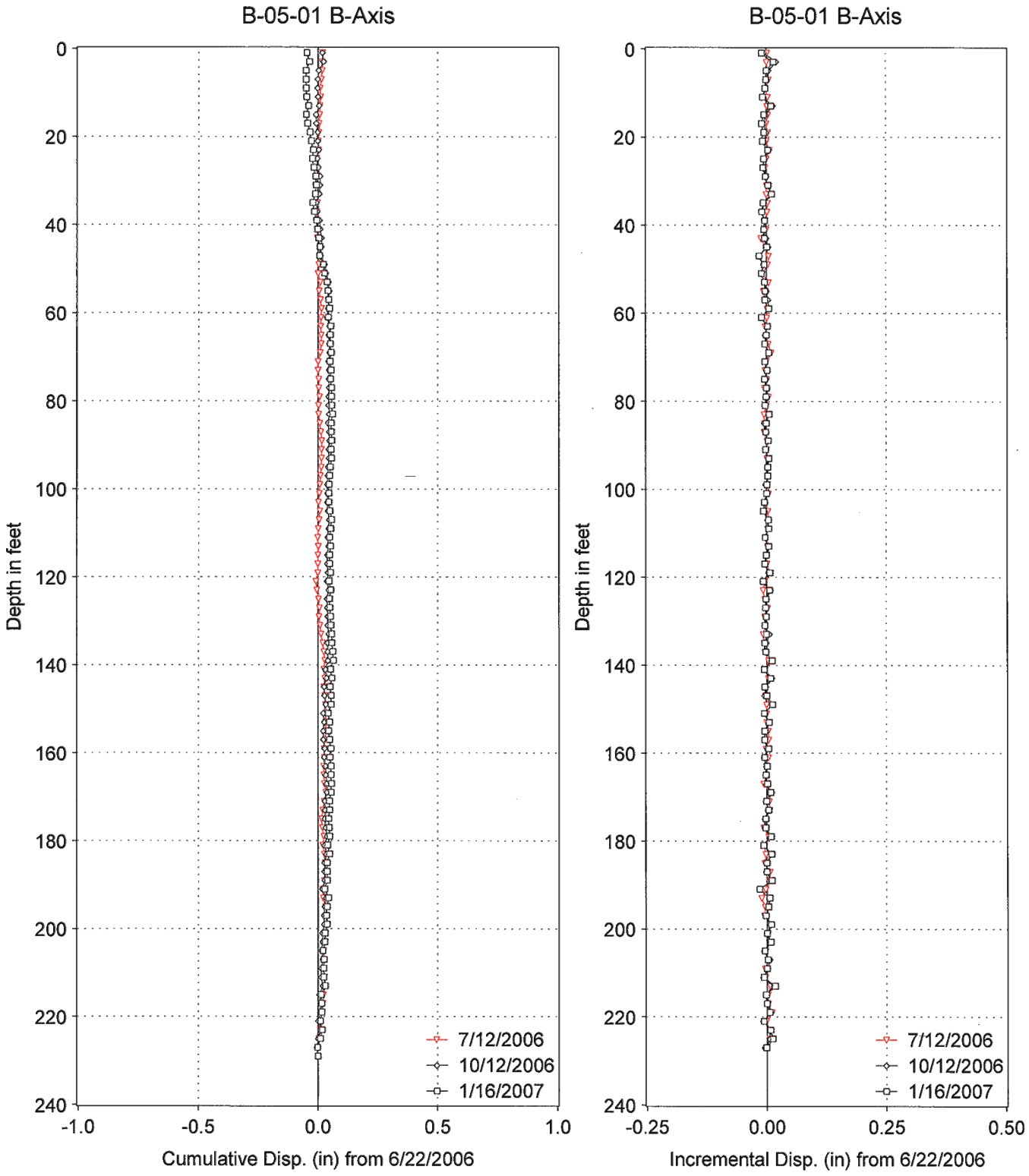
PLATE 25





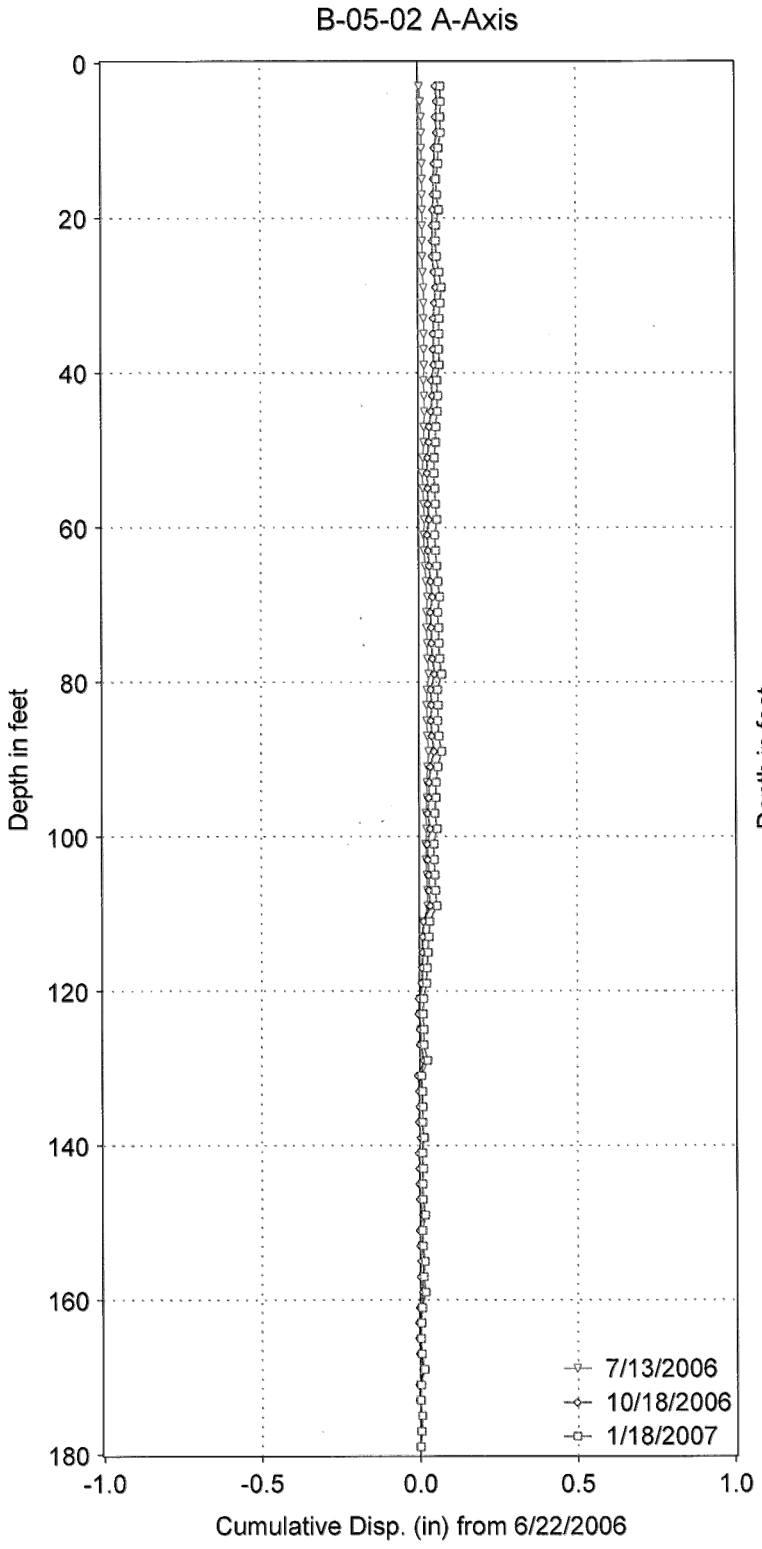
B-05-01

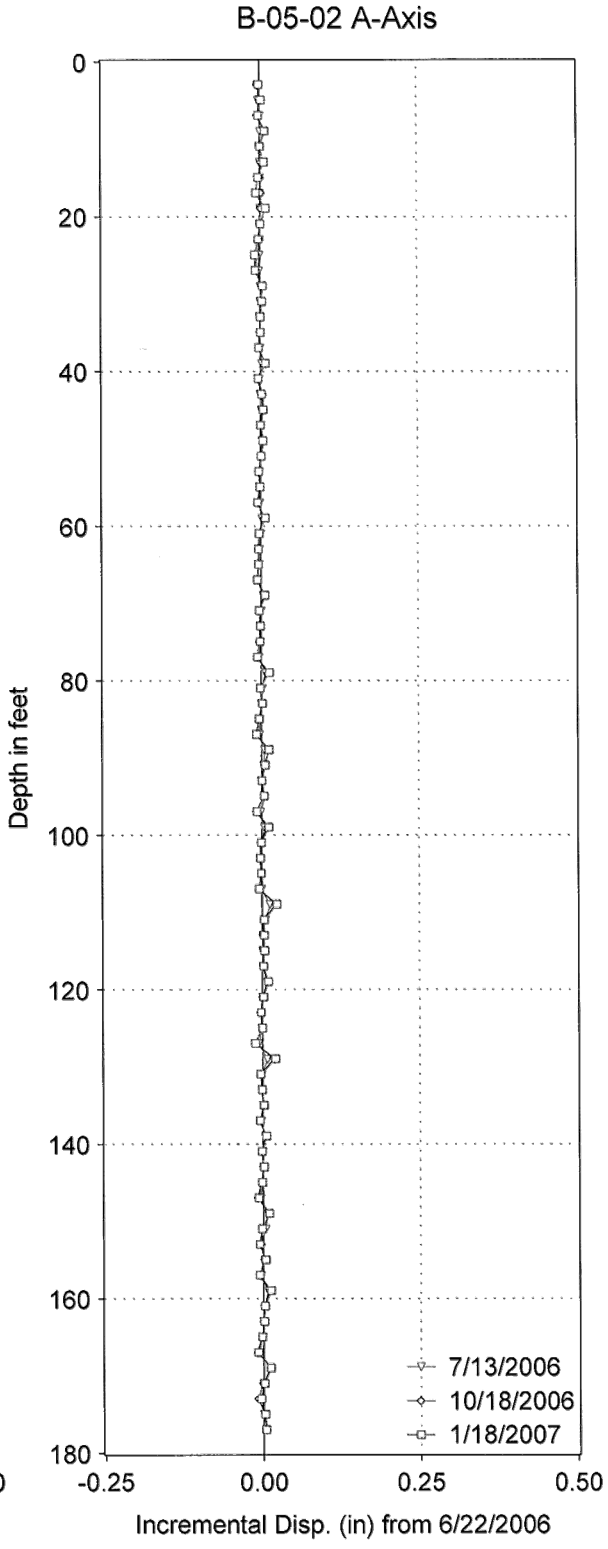
PLATE 26



B-05-01

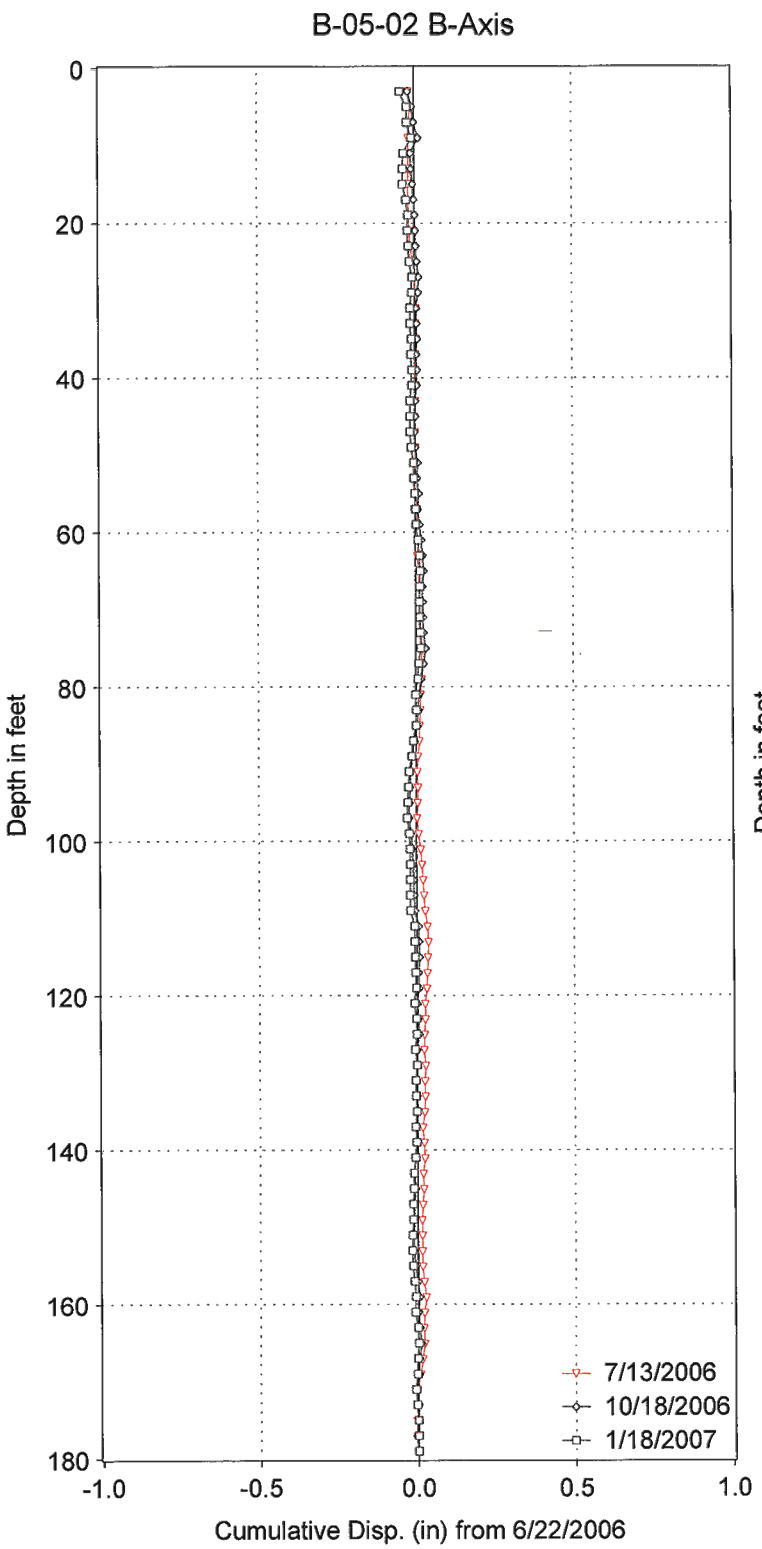
PLATE 27

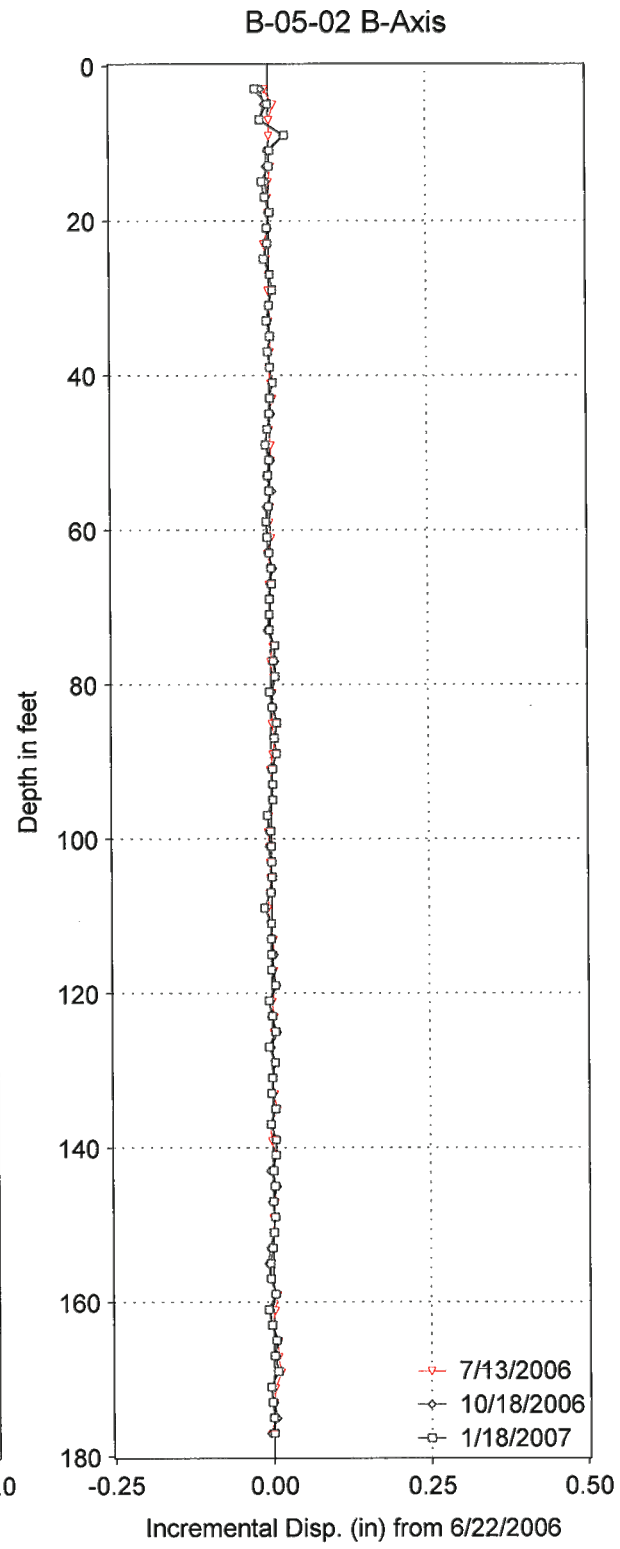




B-05-02

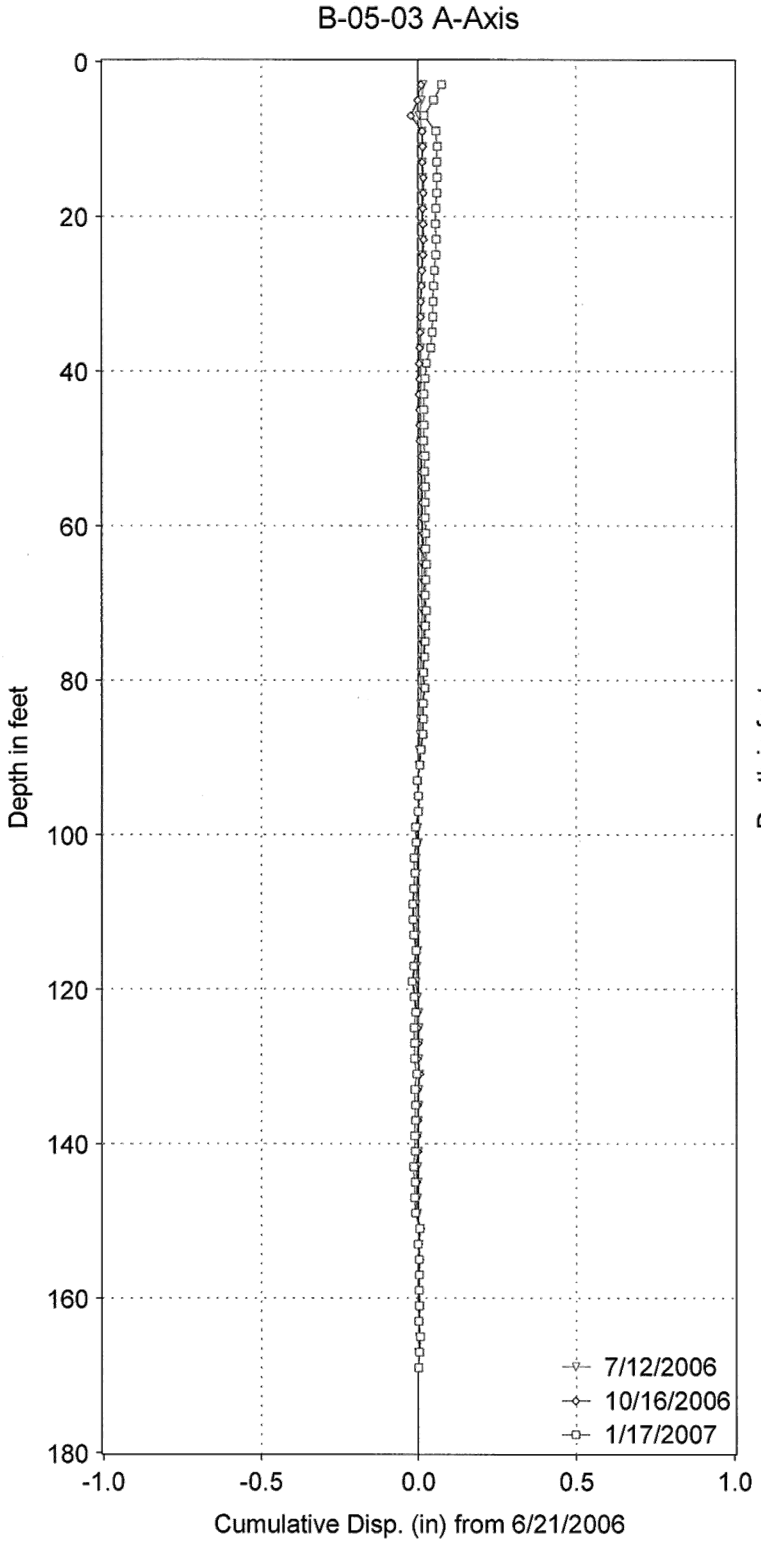
PLATE 28

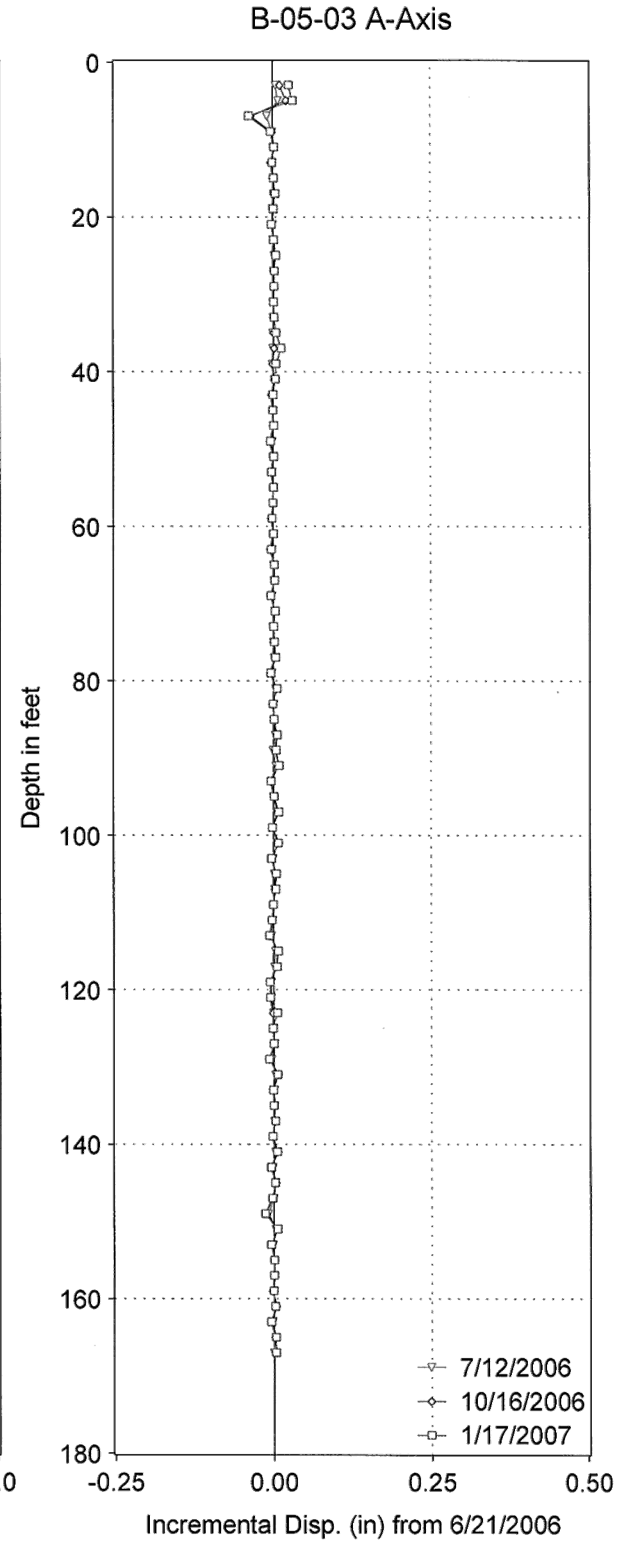




B-05-02

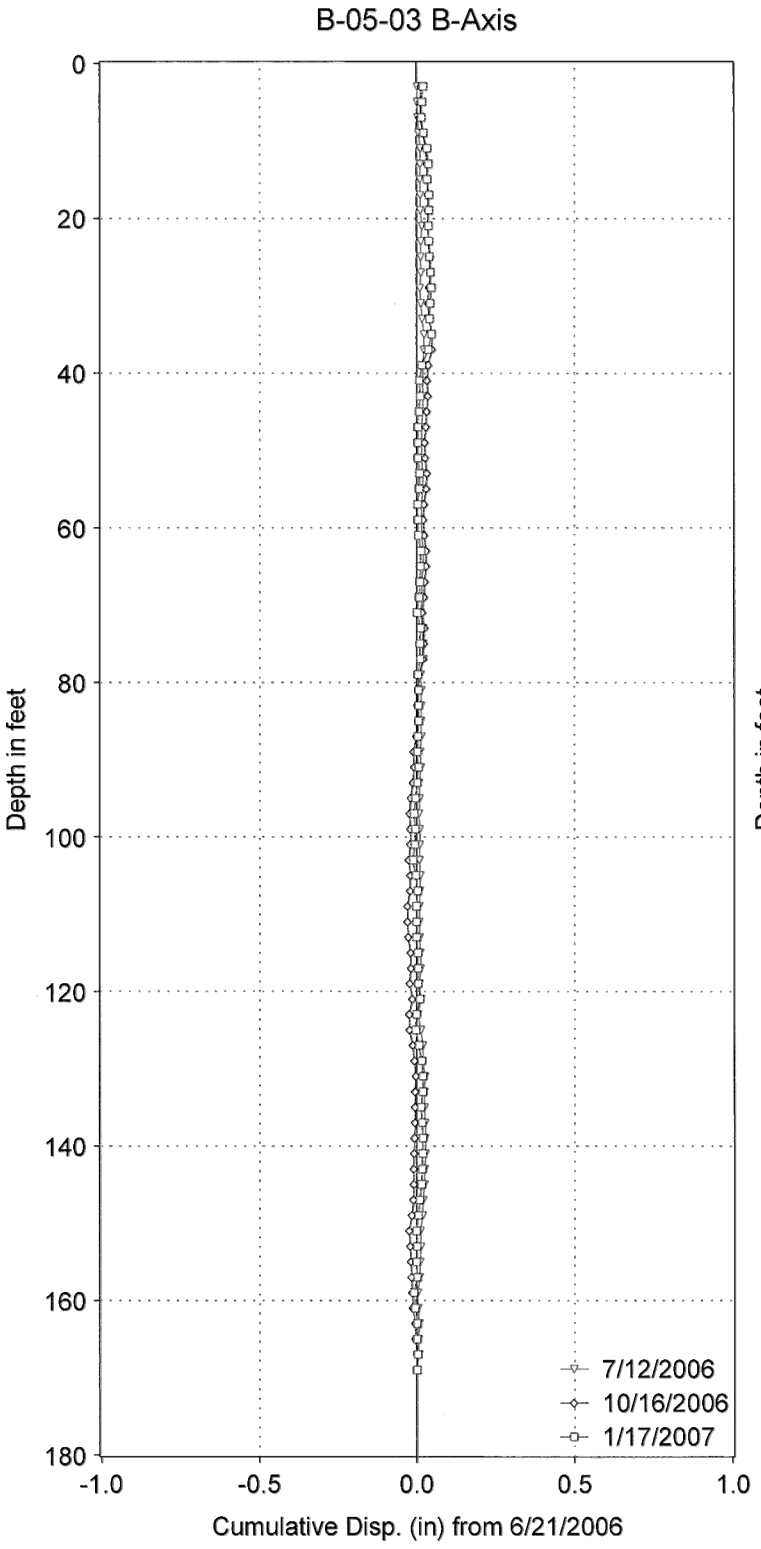
PLATE 29

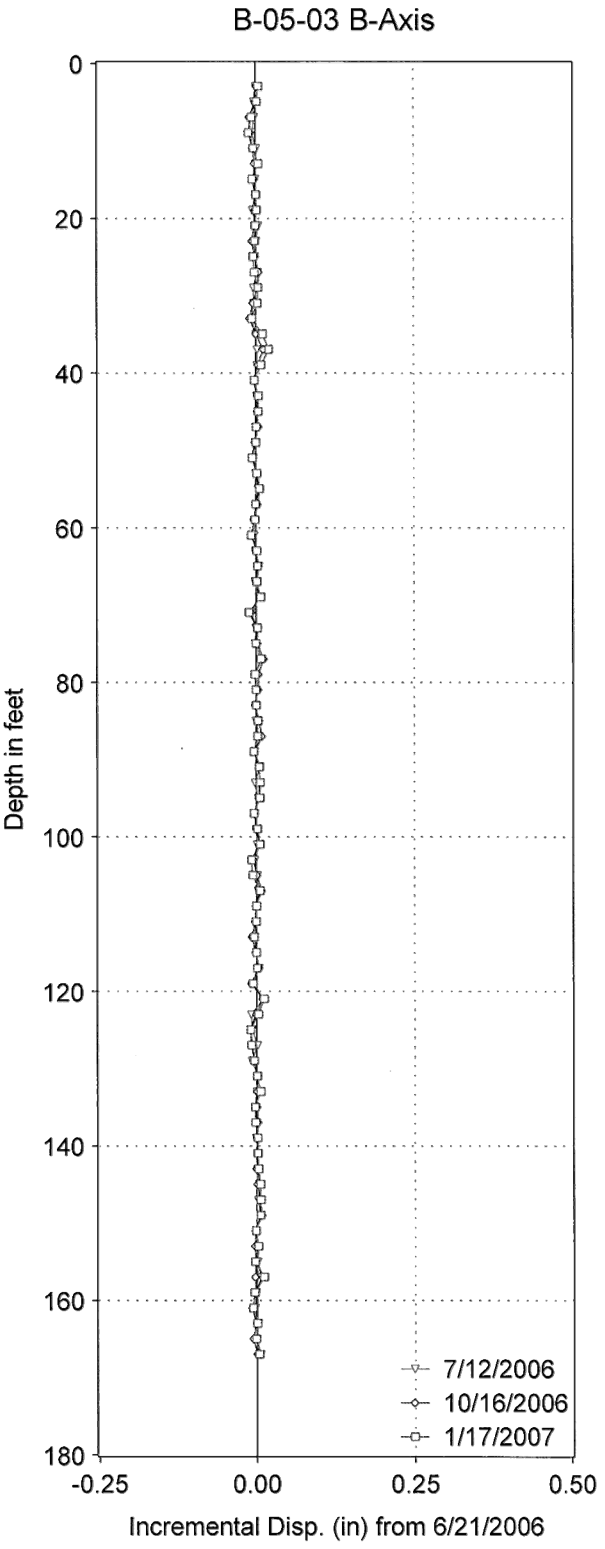




B-05-03

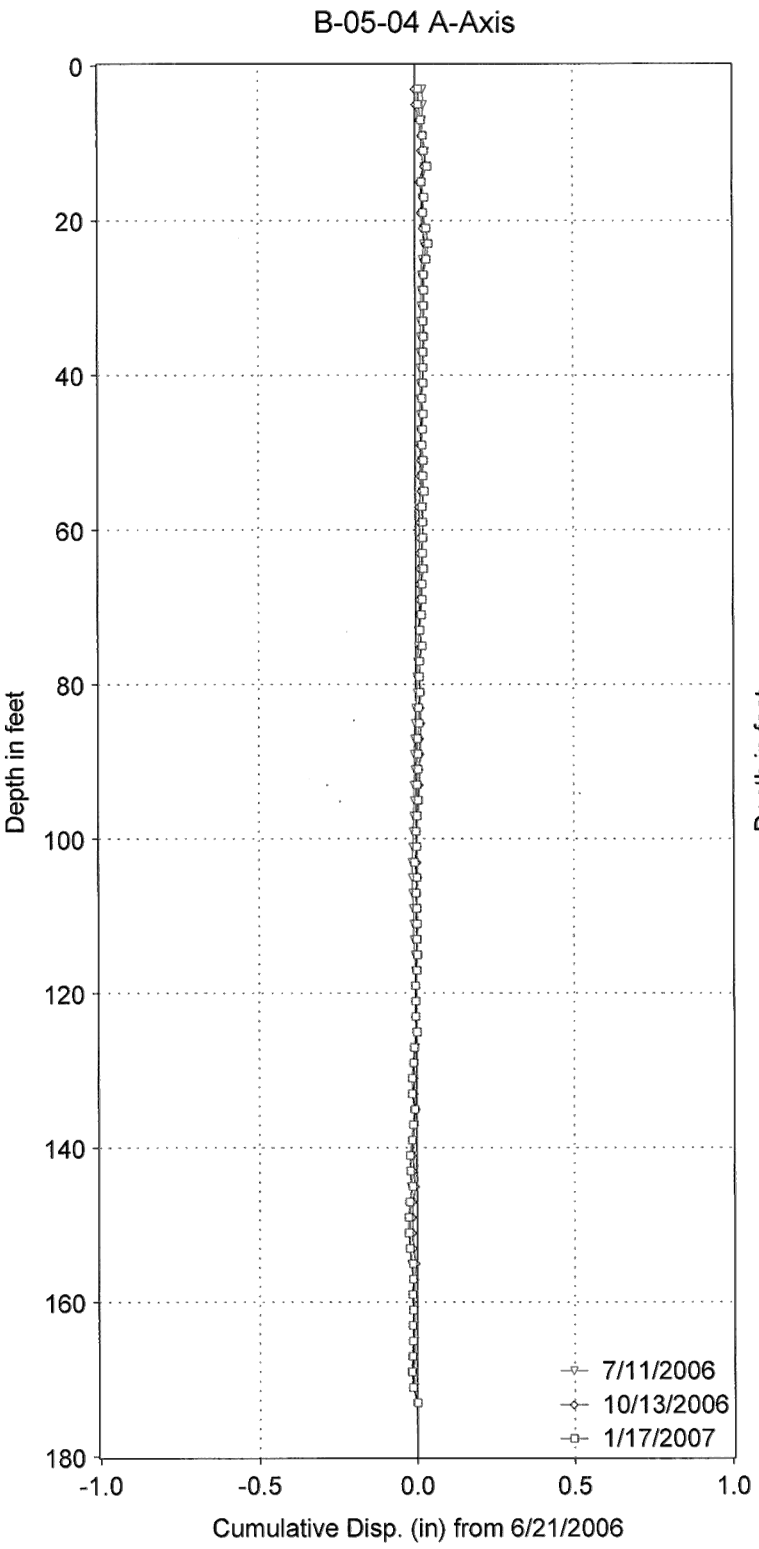
PLATE 30

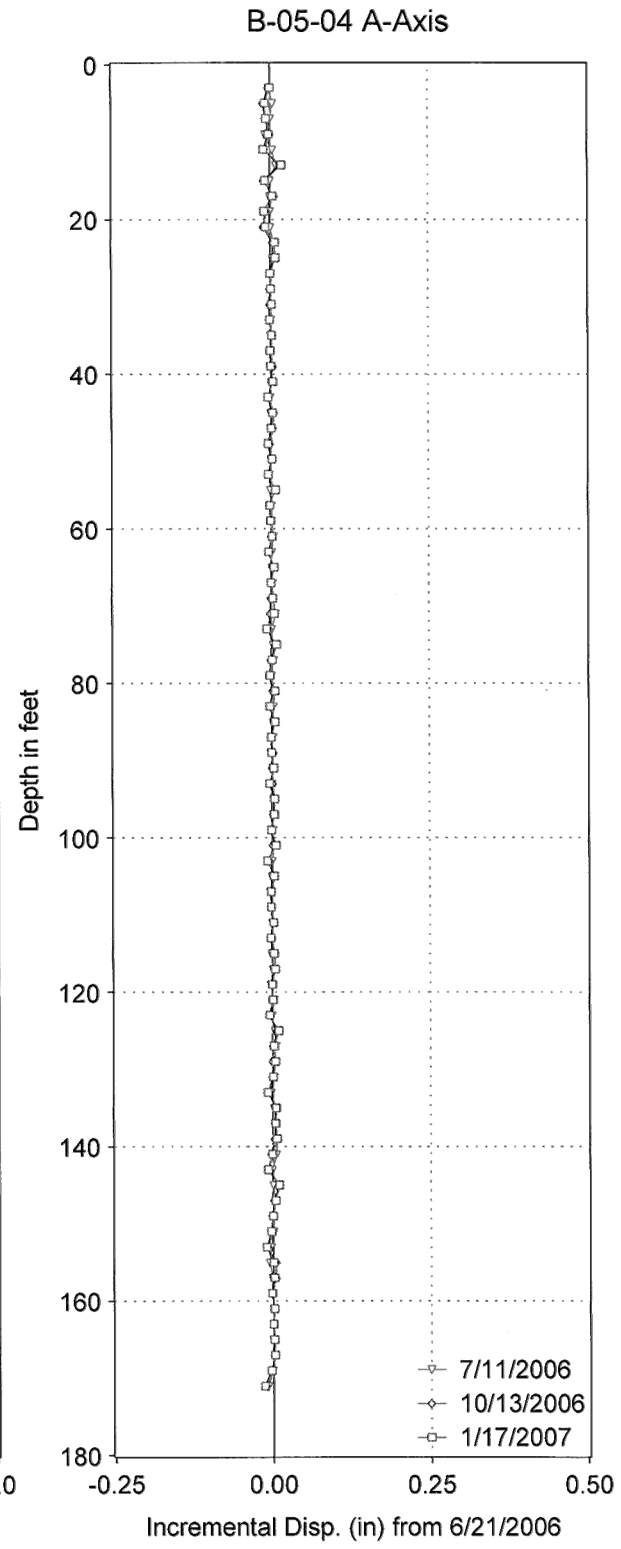




B-05-03

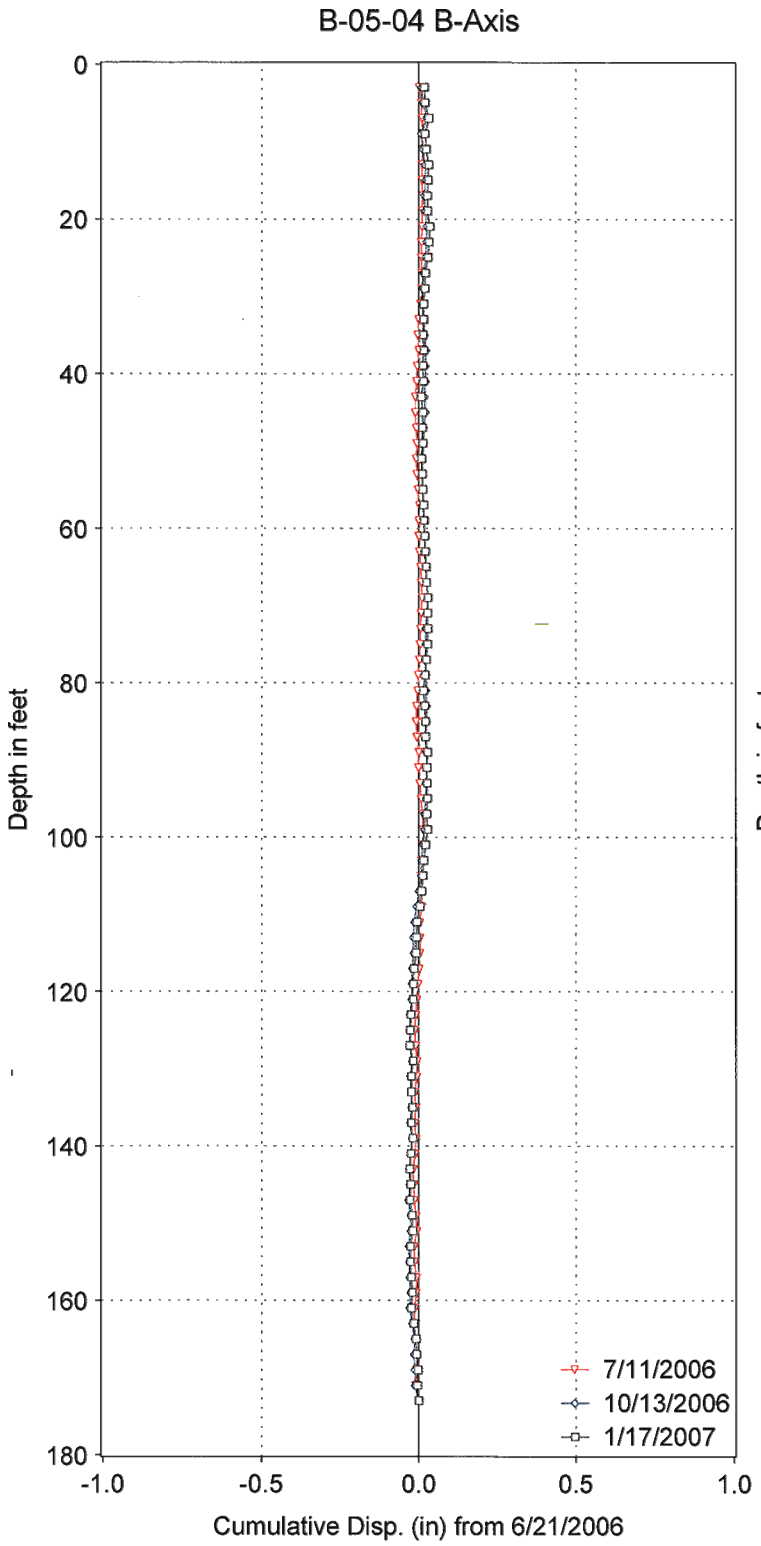
PLATE 31

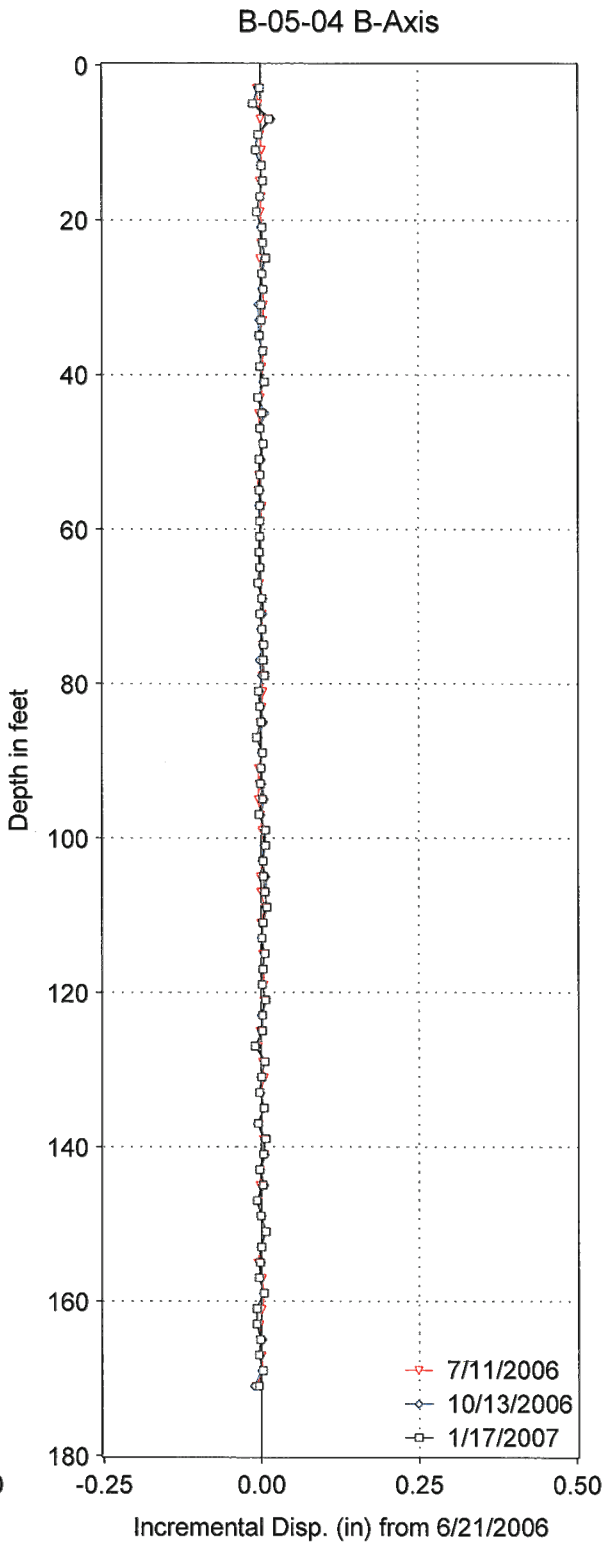




B-05-04

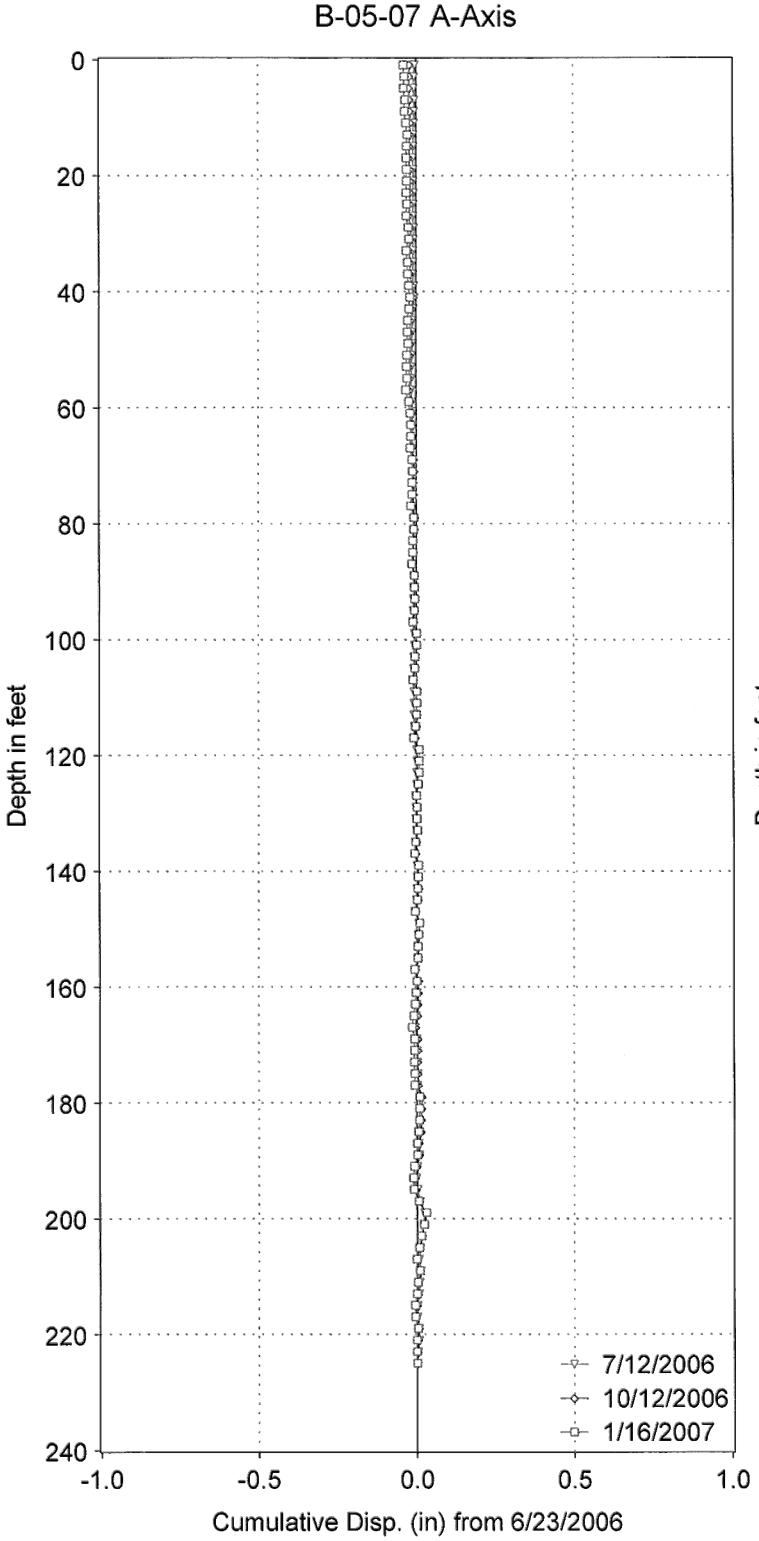
PLATE 32

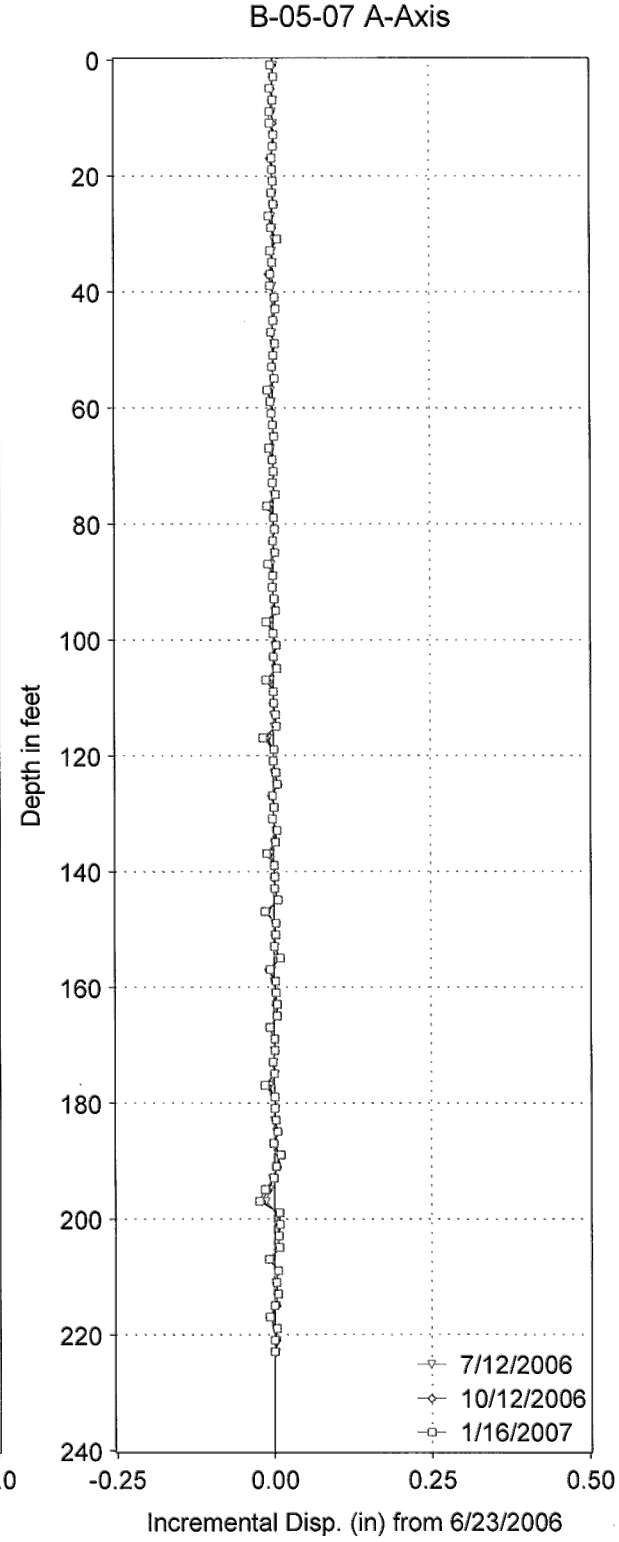




B-05-04

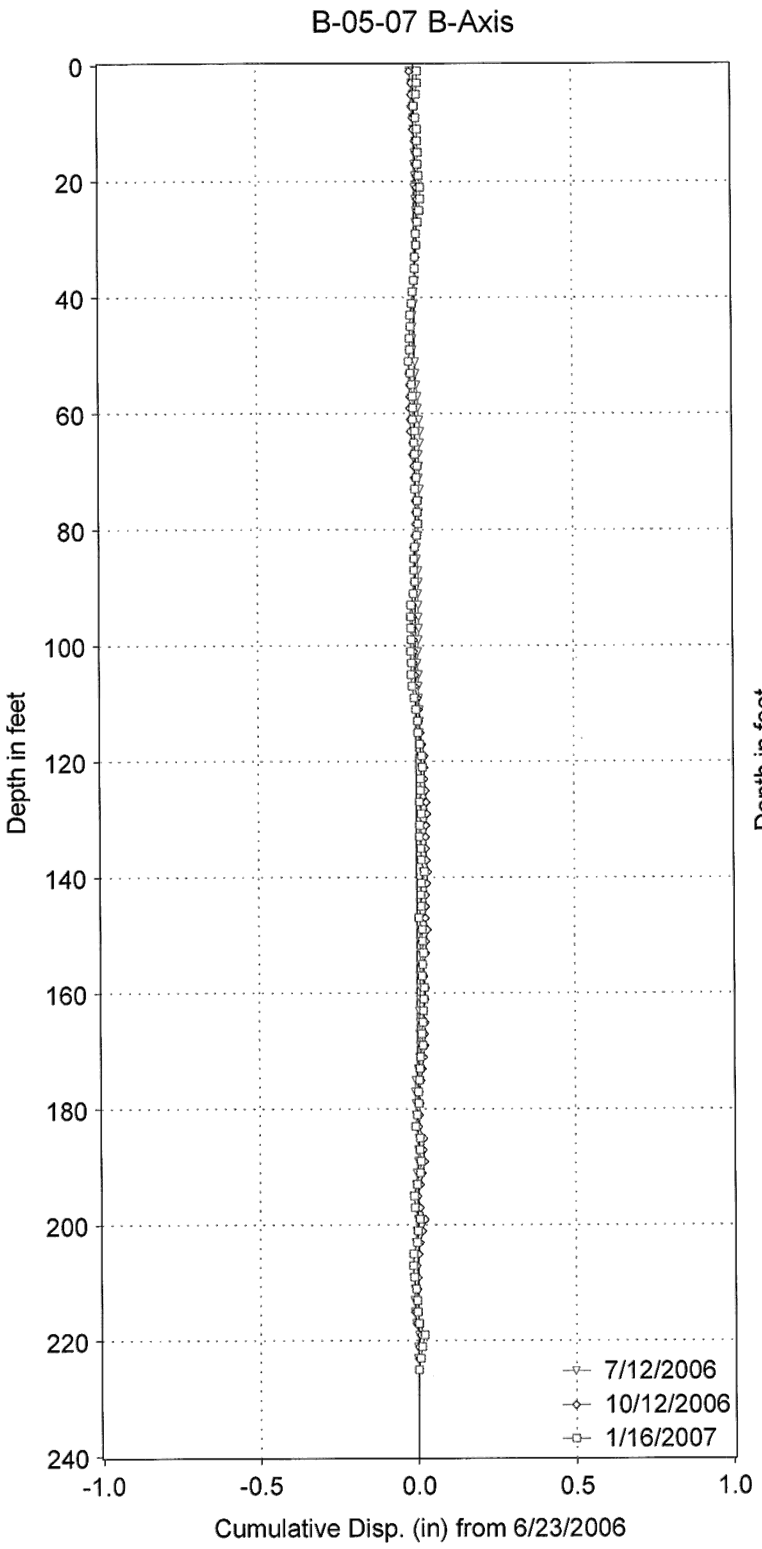
PLATE 33

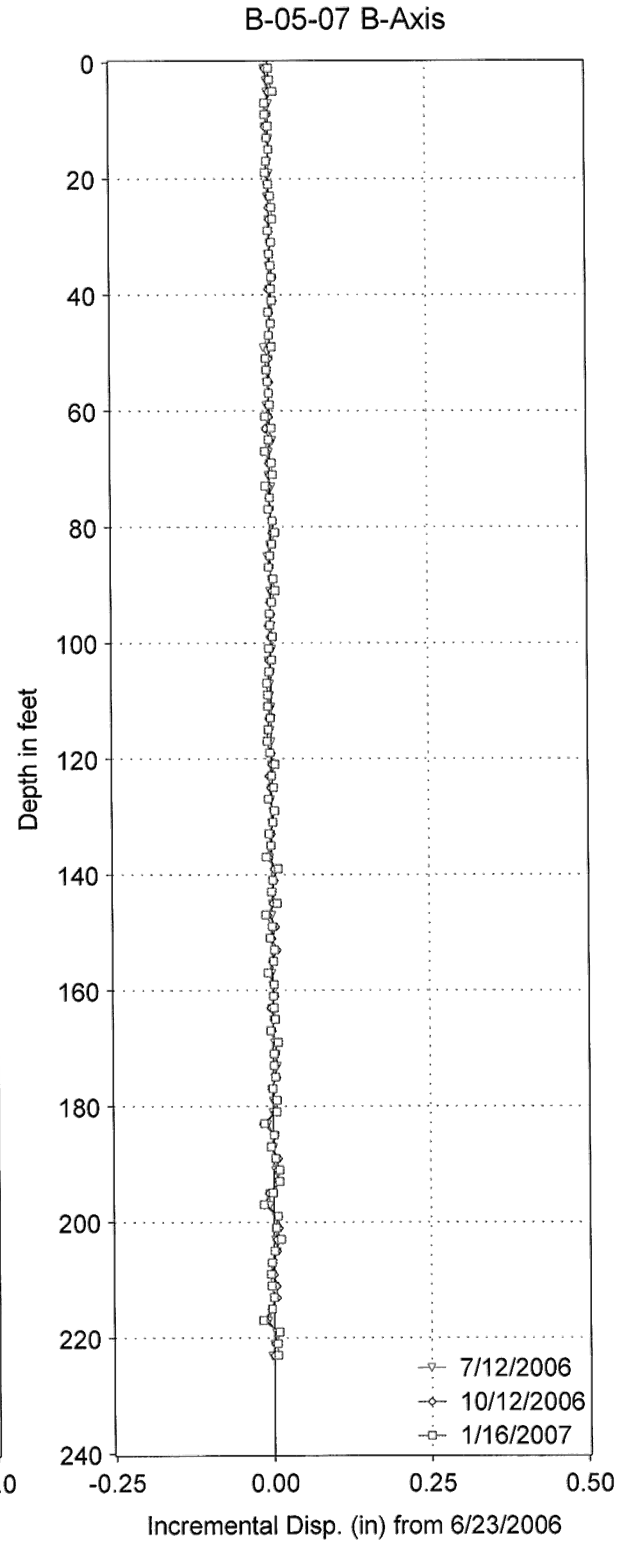




B-05-07

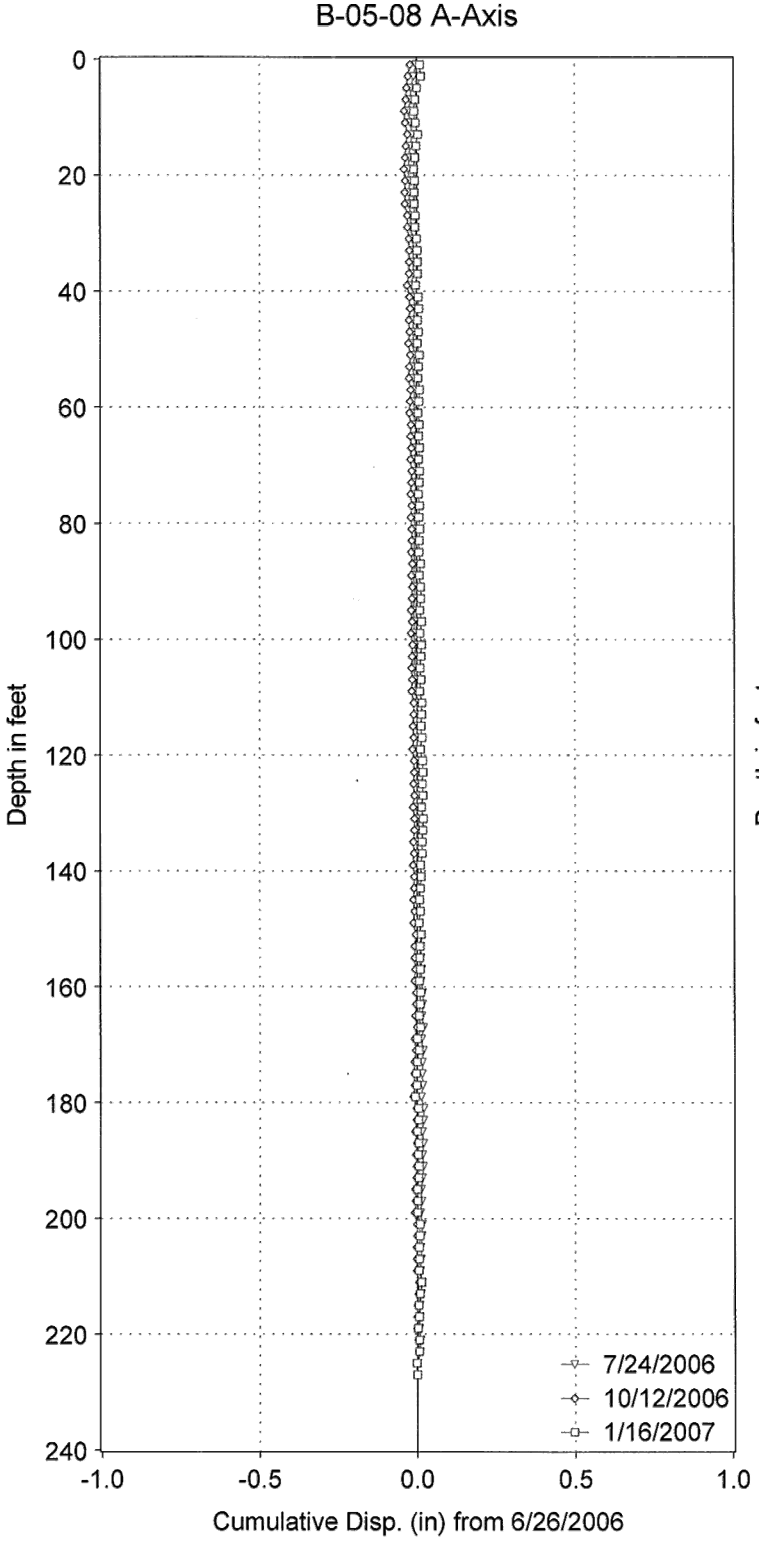
PLATE 34

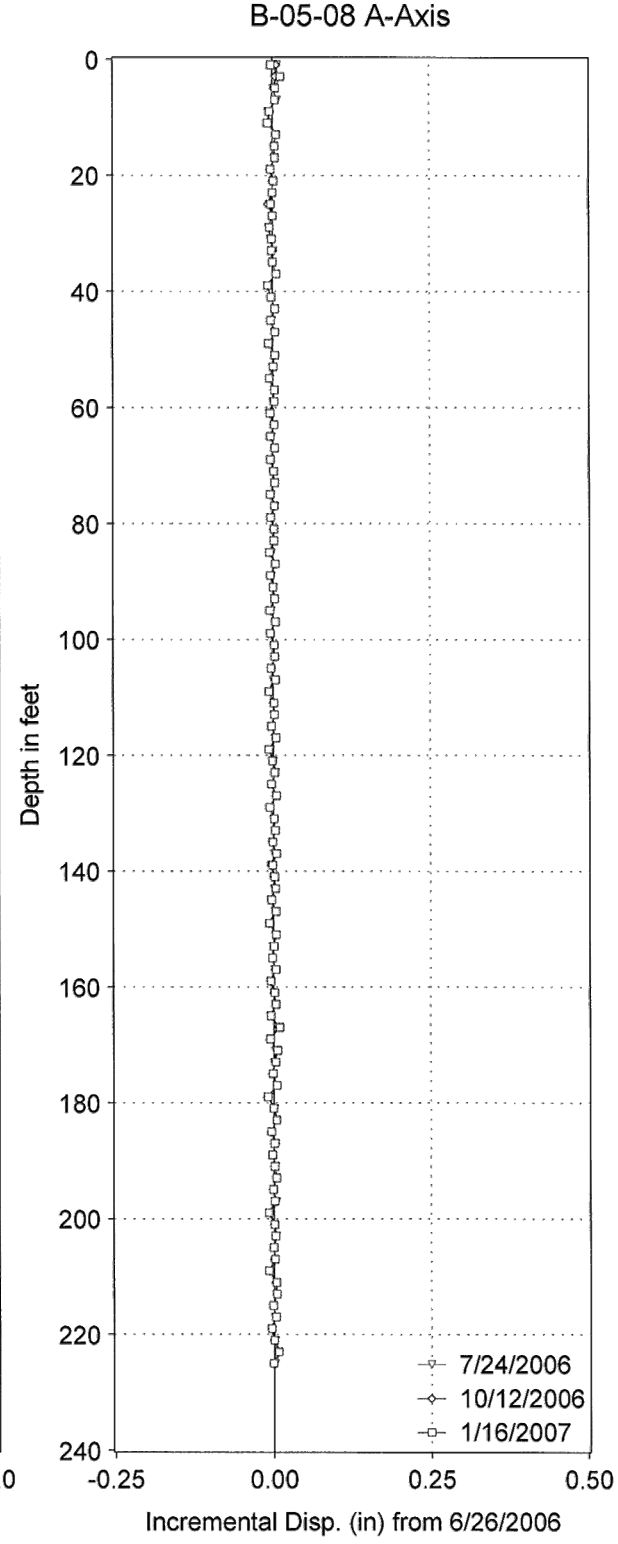




B-05-07

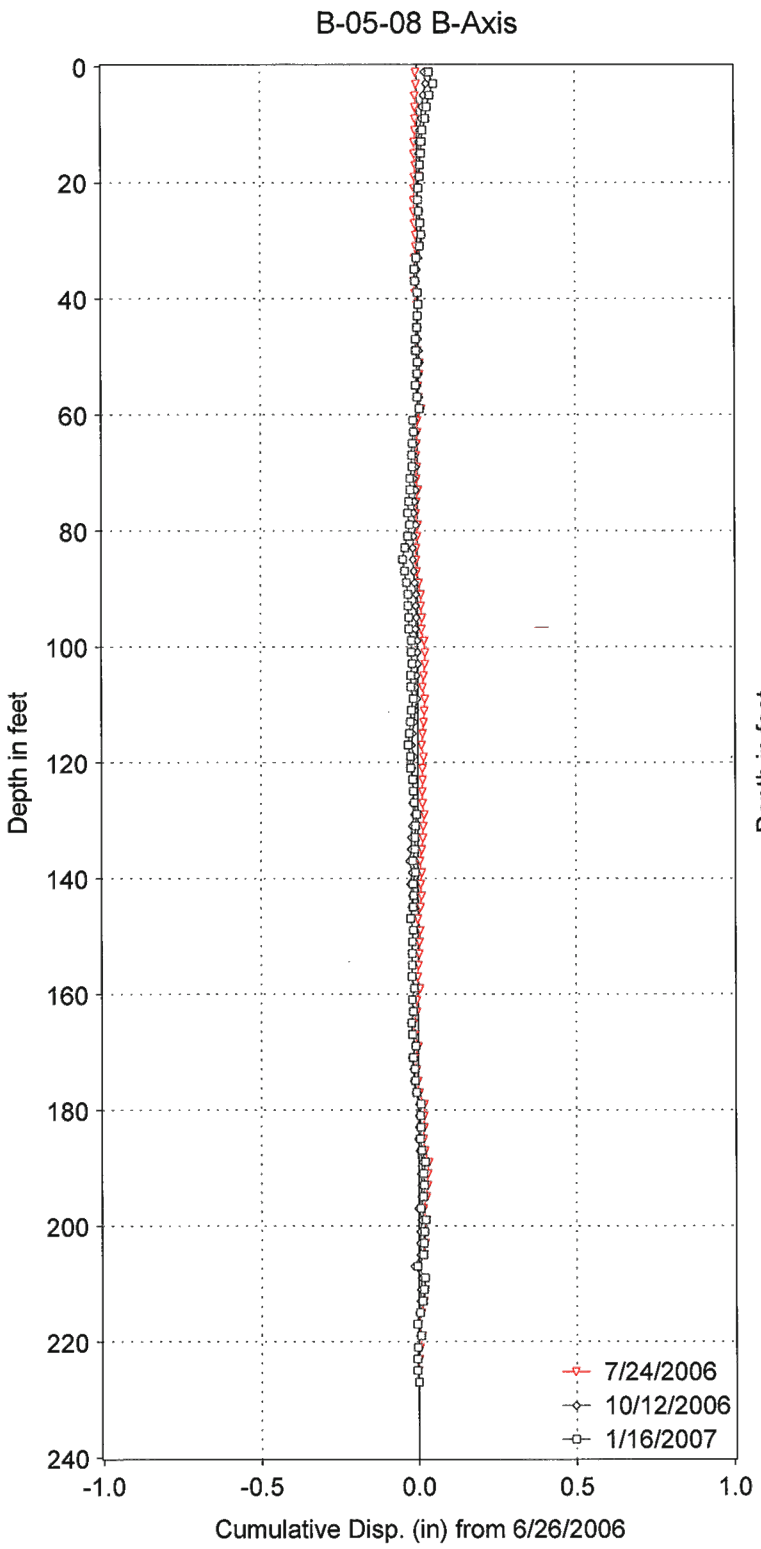
PLATE 35

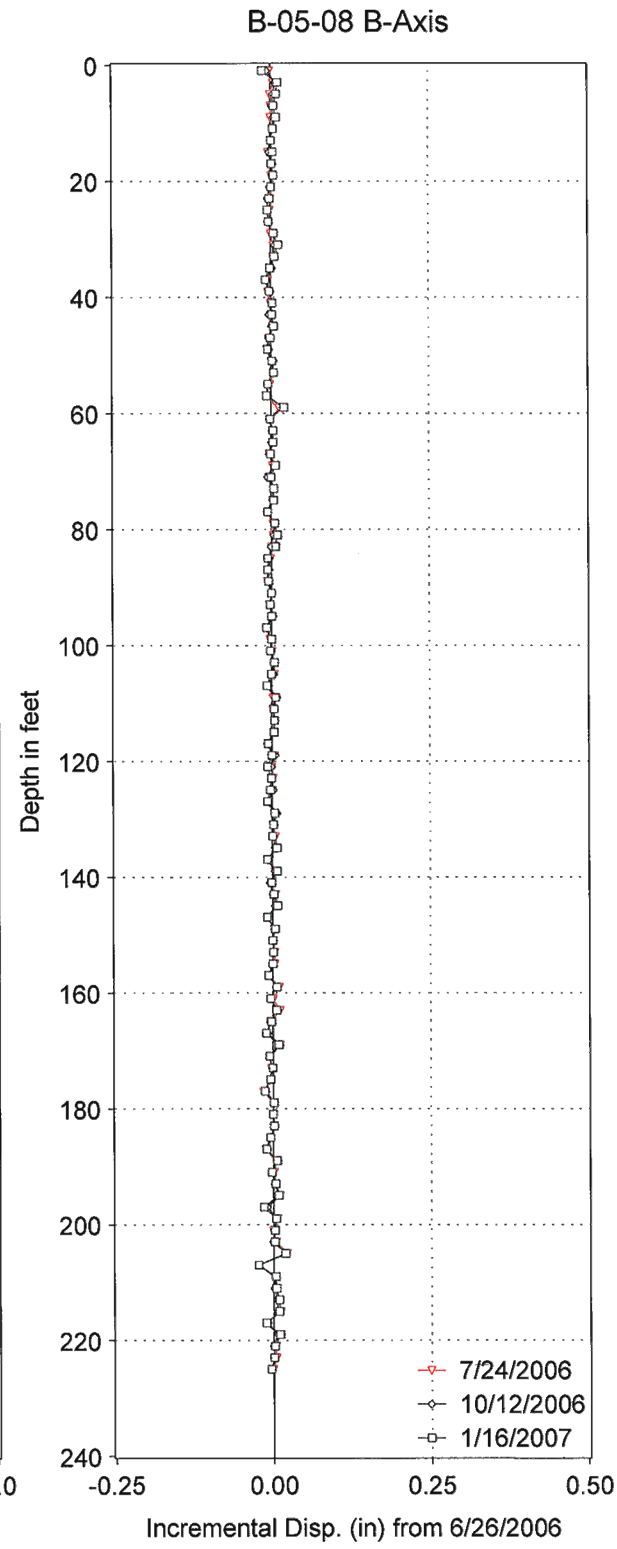




B-05-08

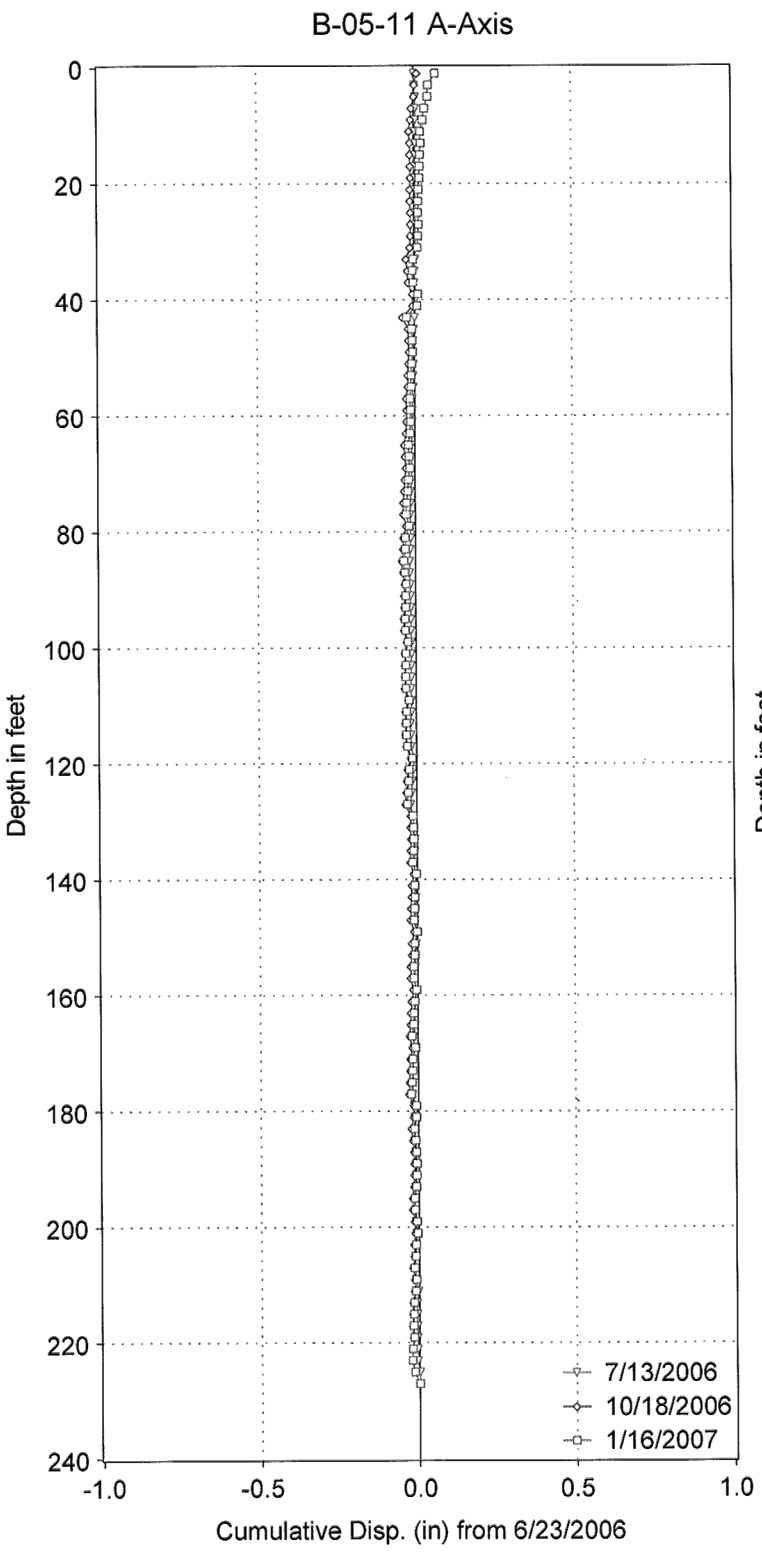
PLATE 36

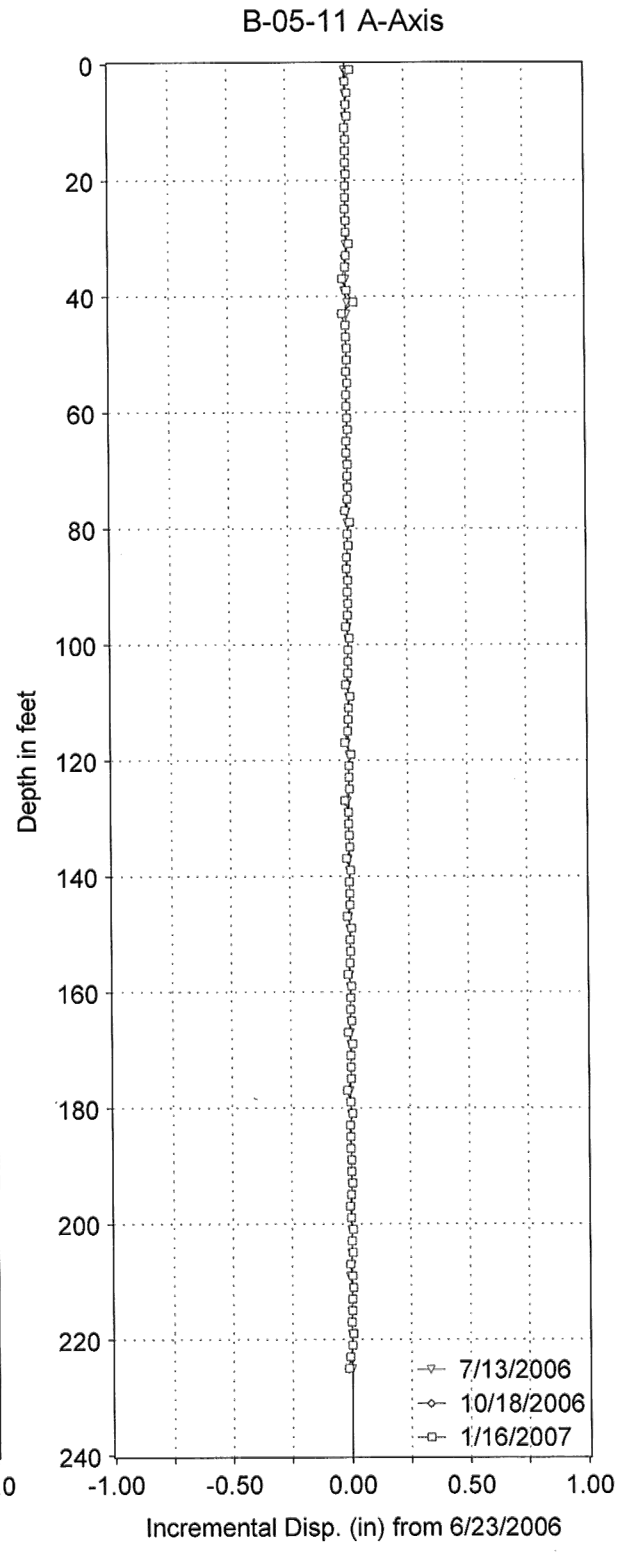




B-05-08

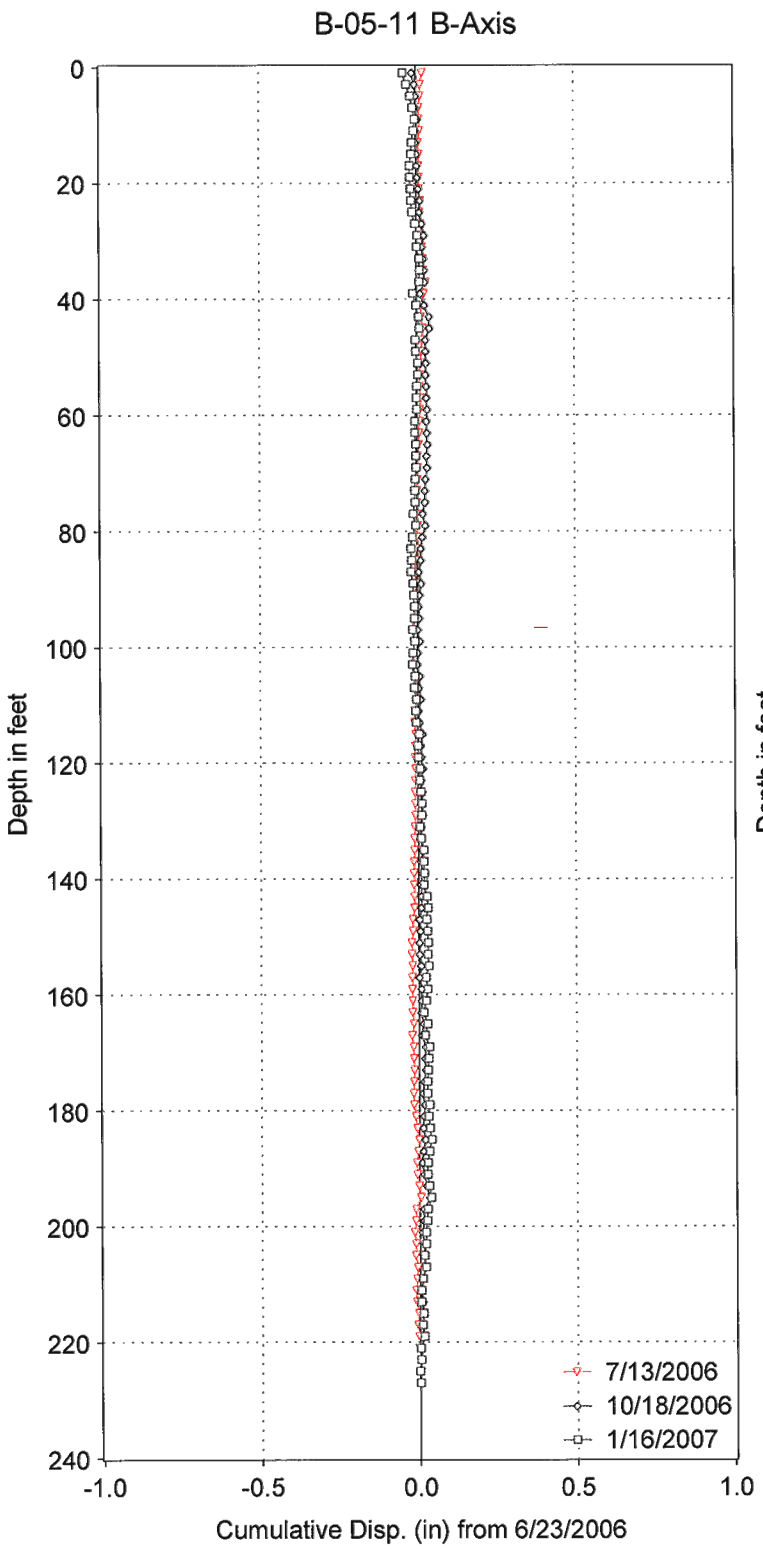
PLATE 37

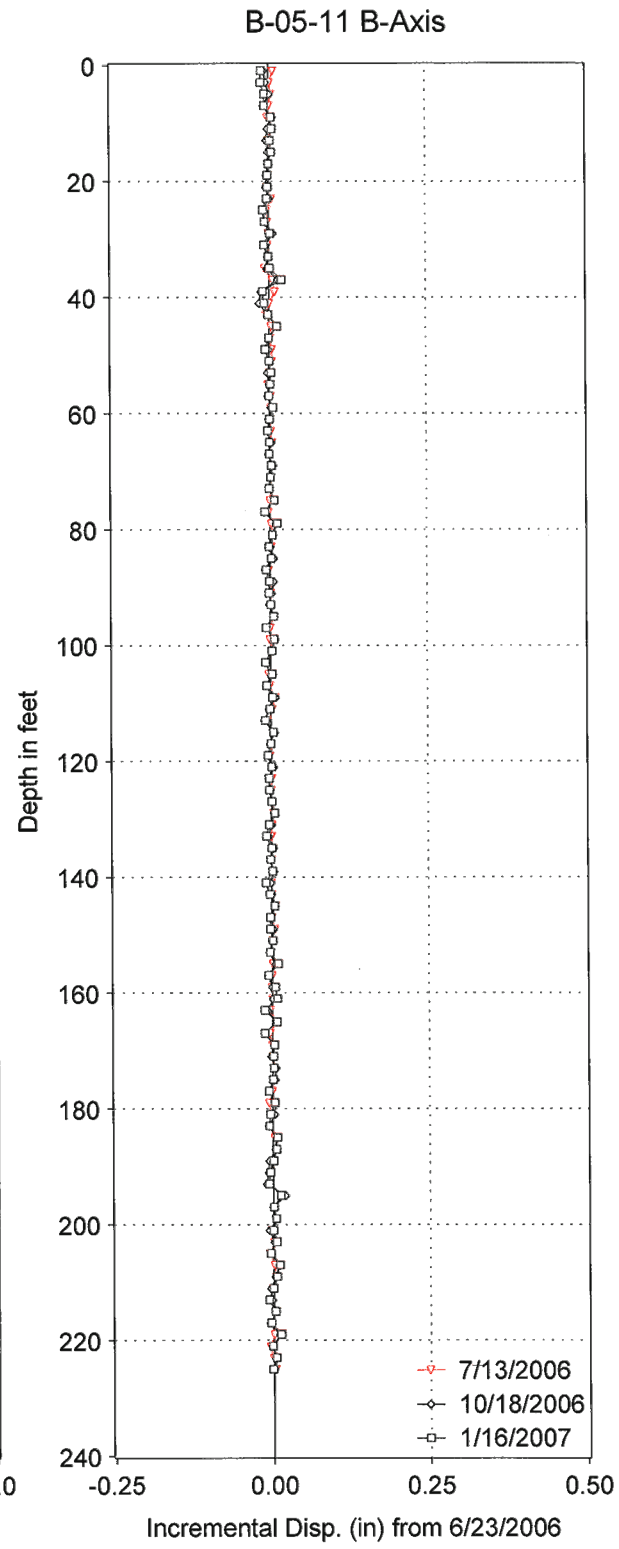




B-05-11

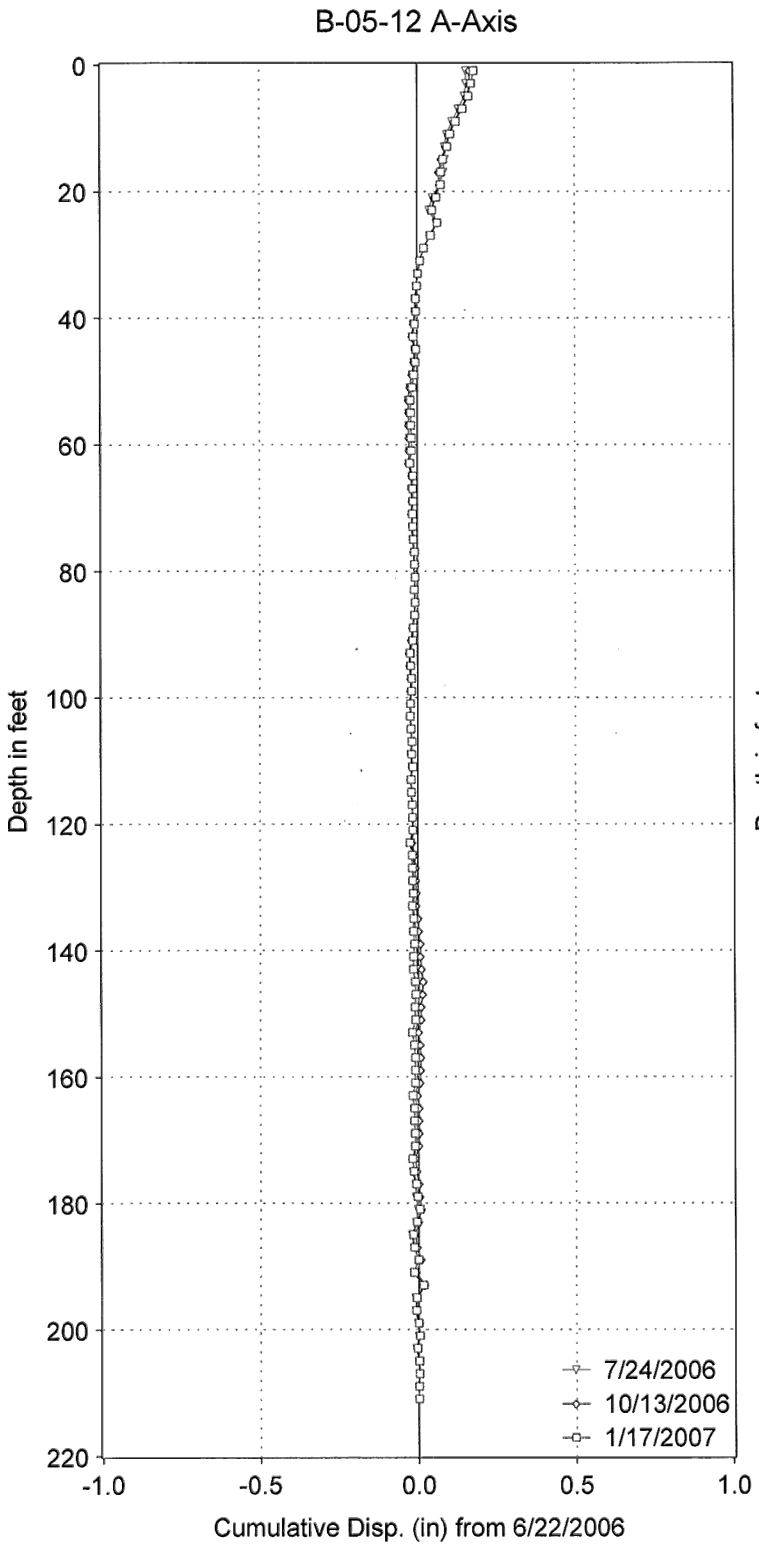
PLATE 38

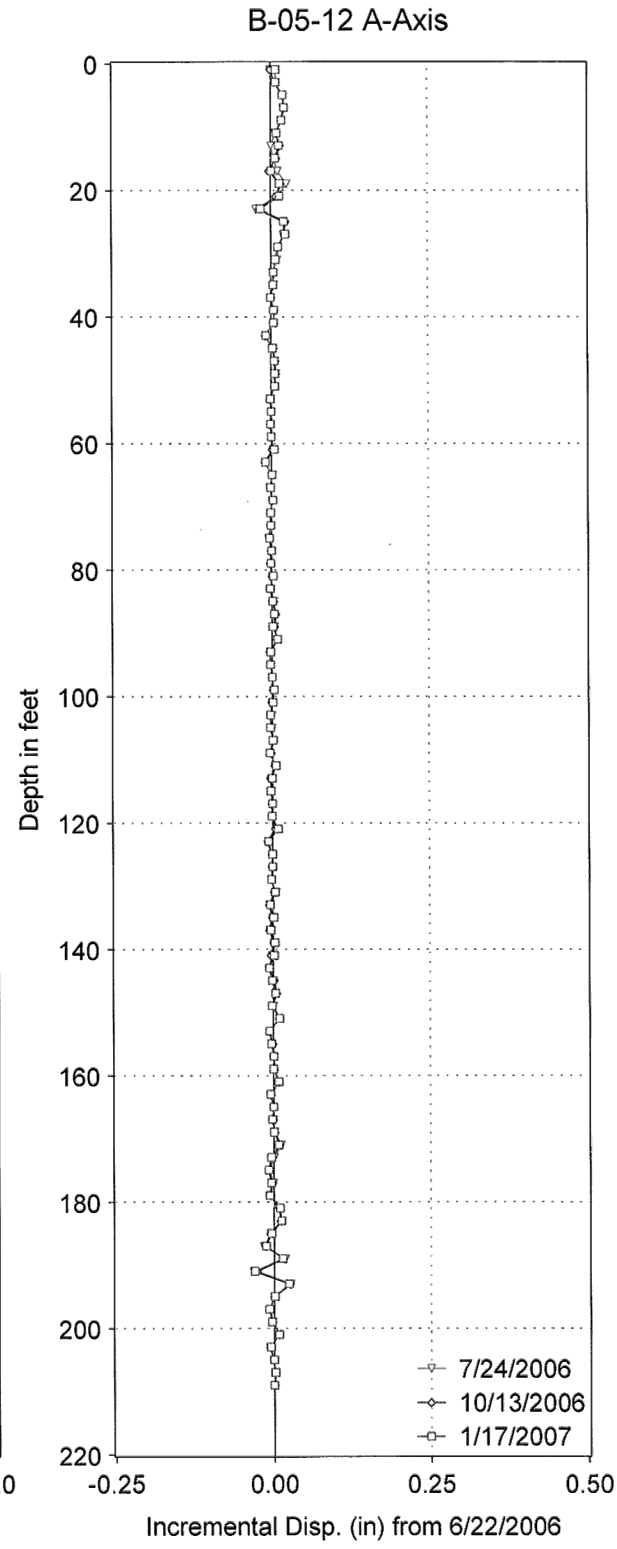




B-05-11

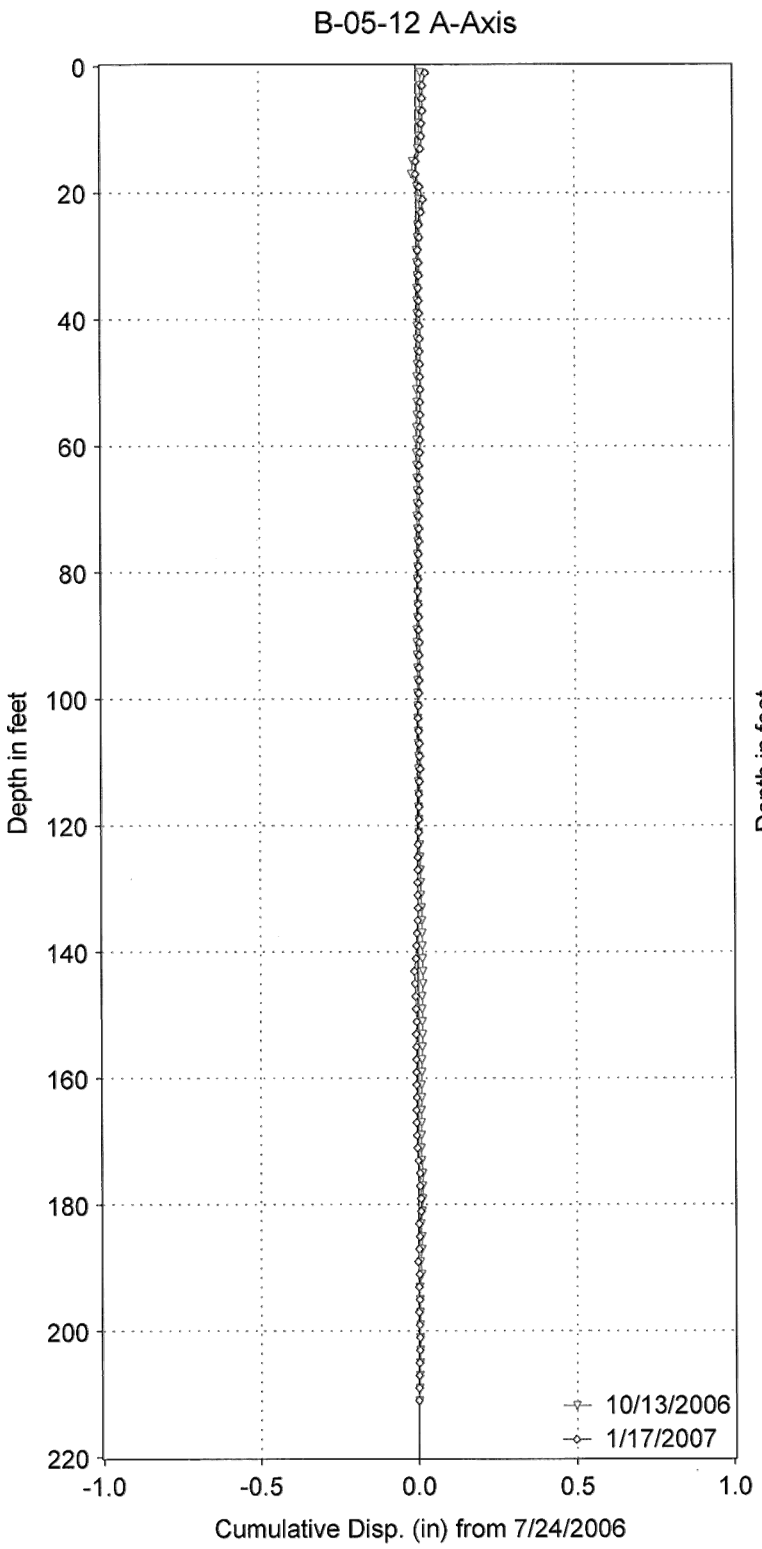
PLATE 39

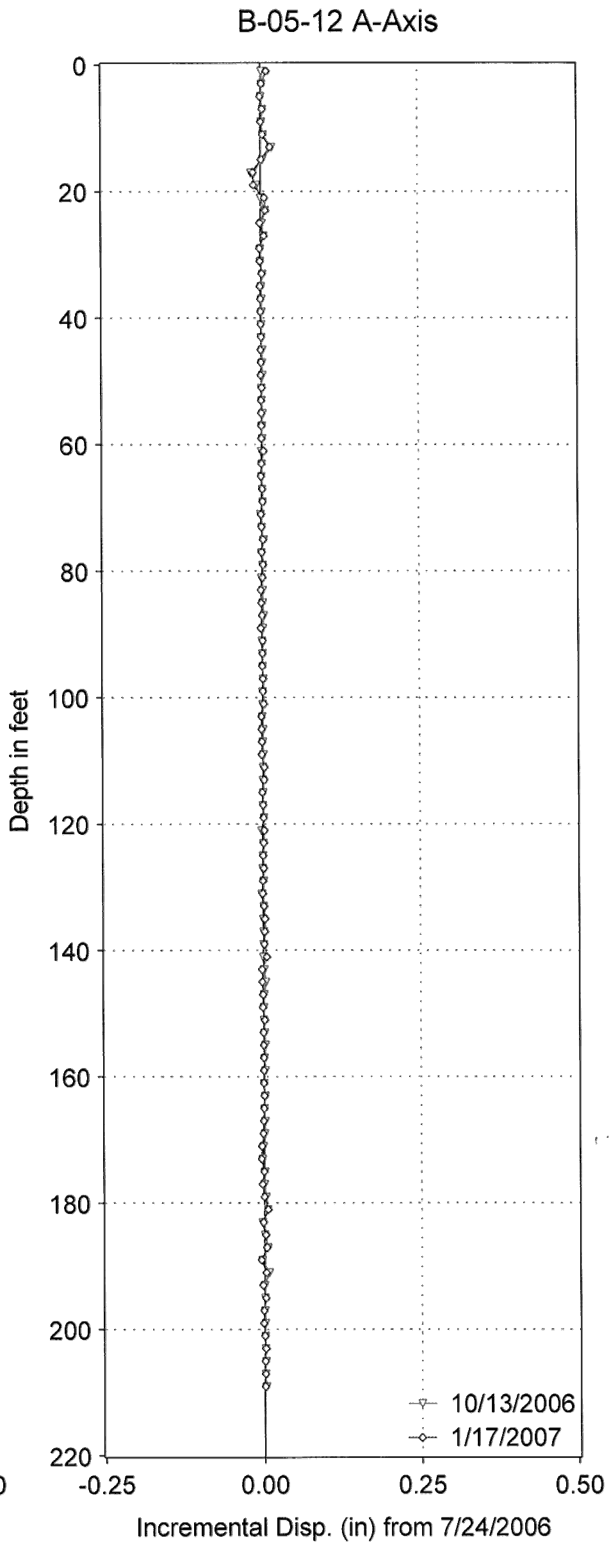




B-05-12

PLATE 40

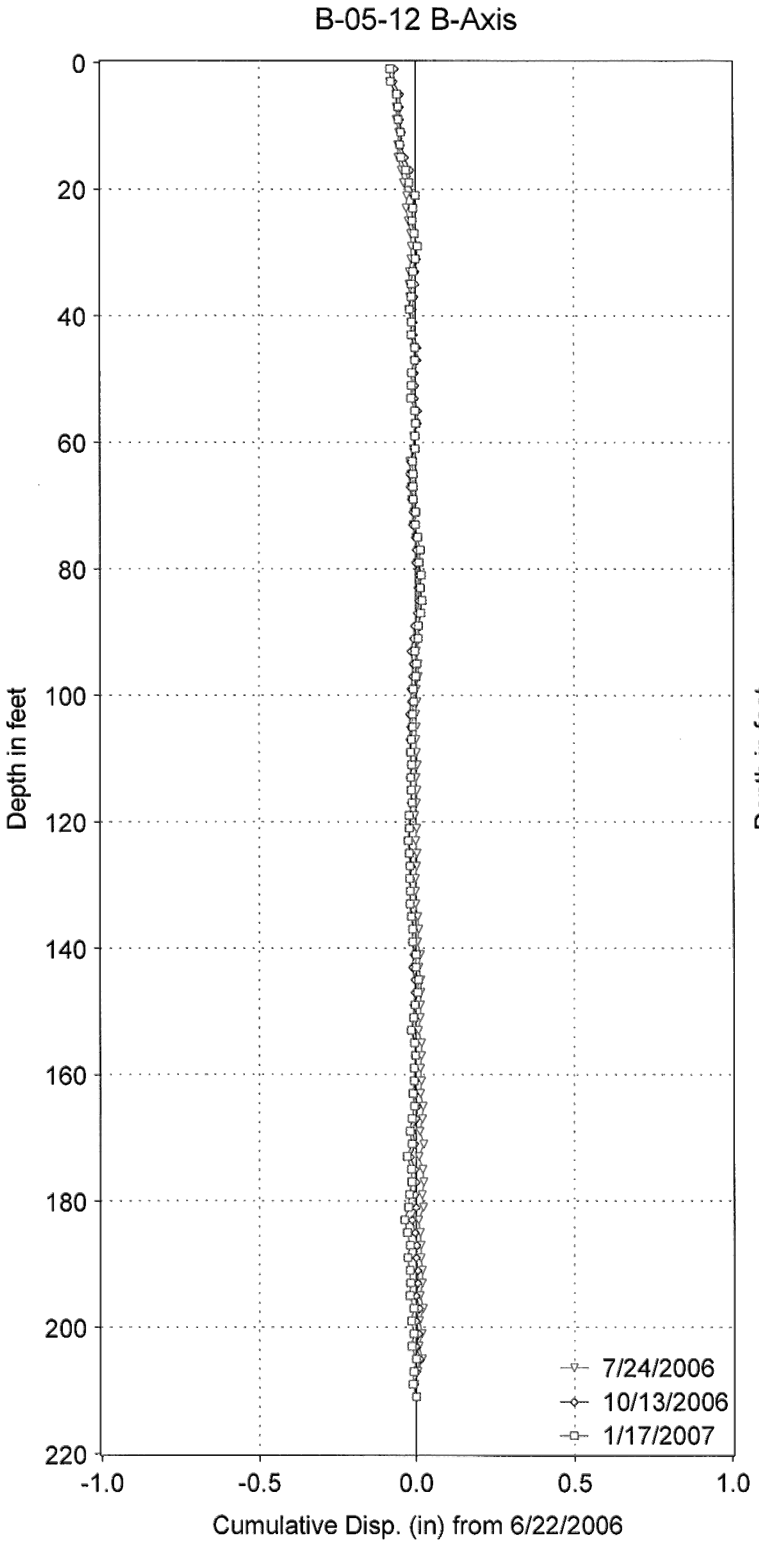


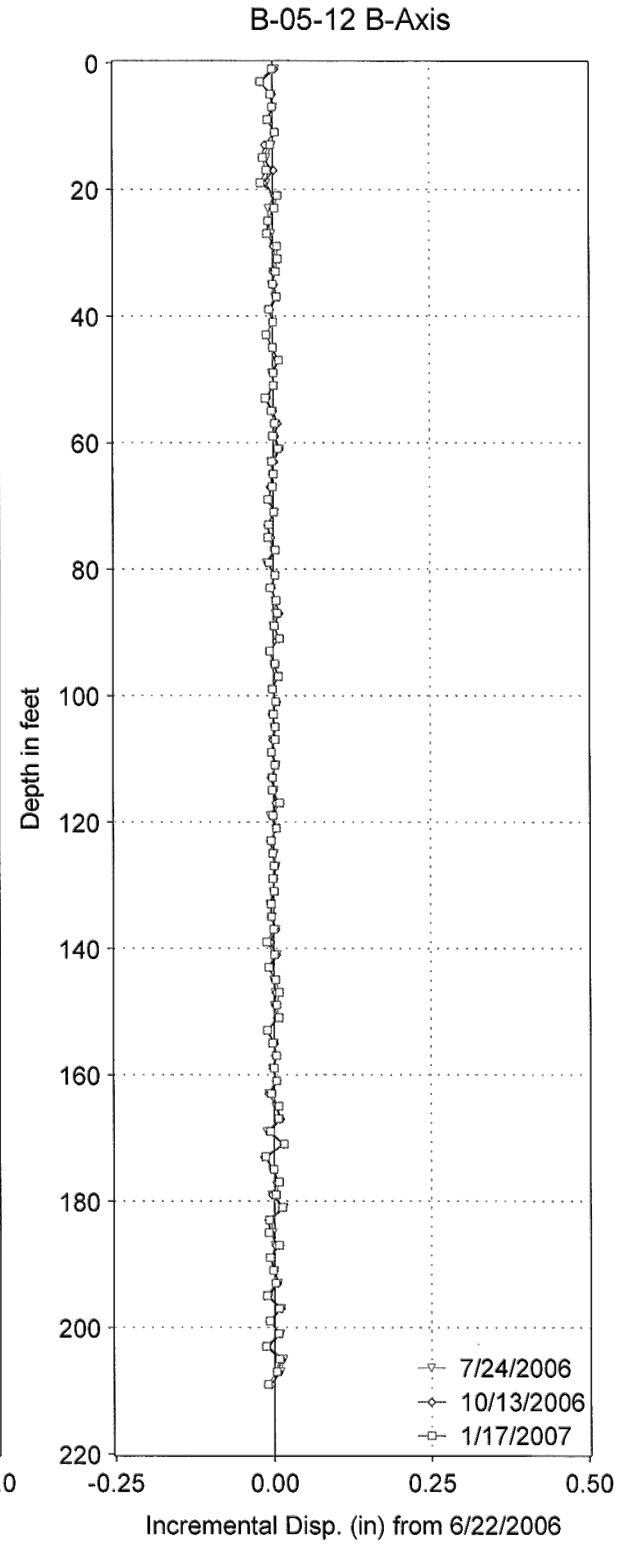


B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

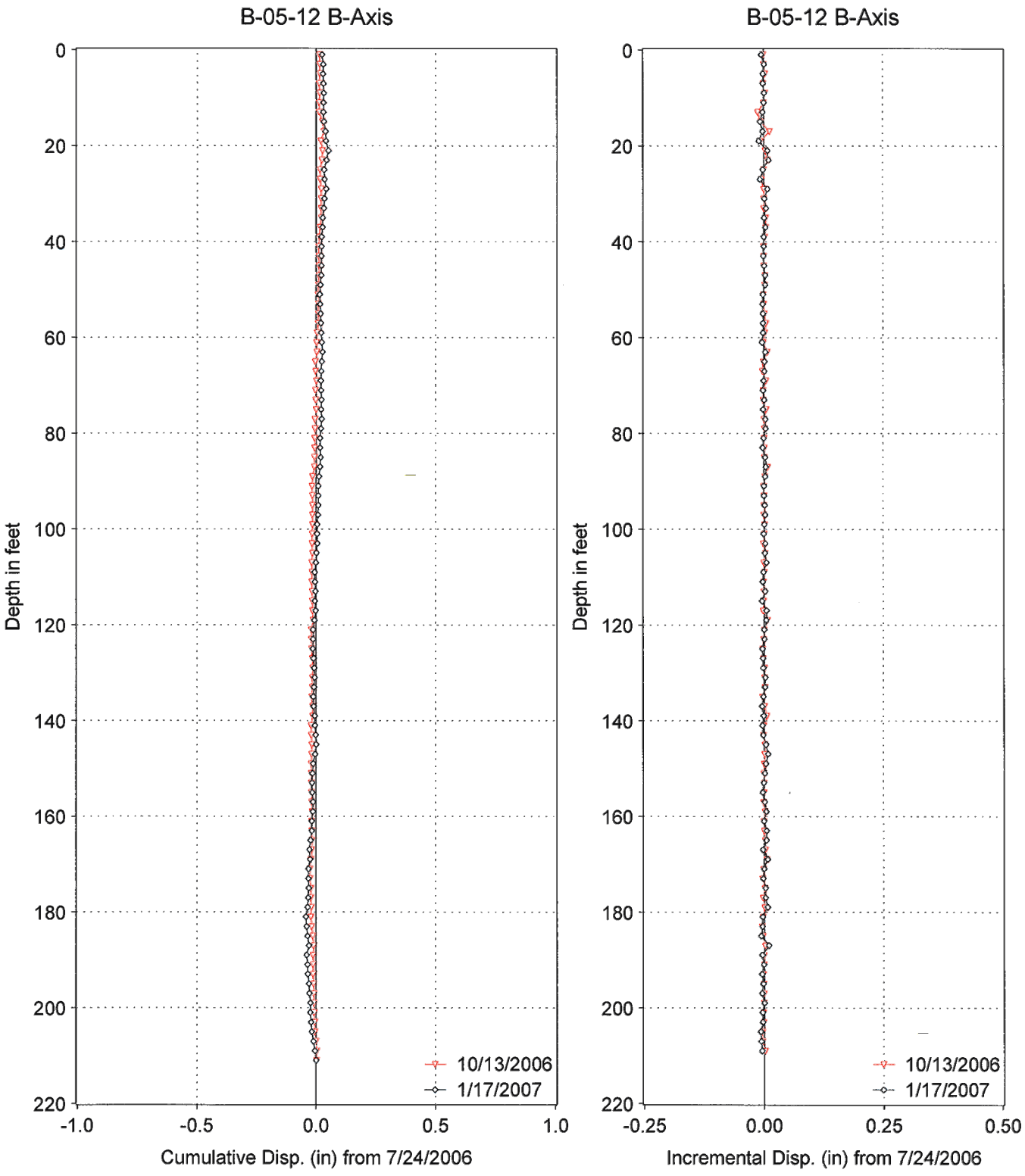
PLATE 40A





B-05-12

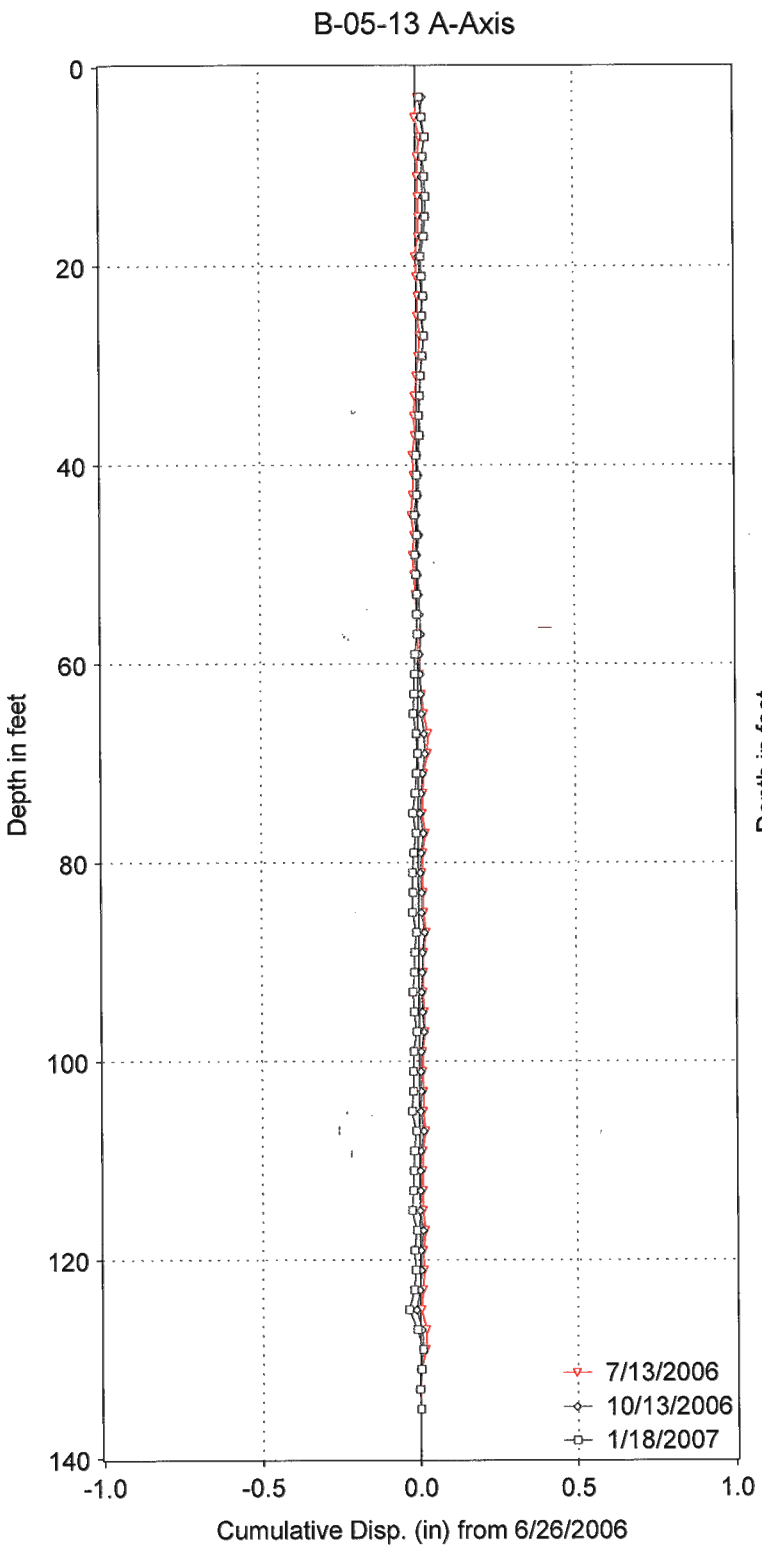
PLATE 41

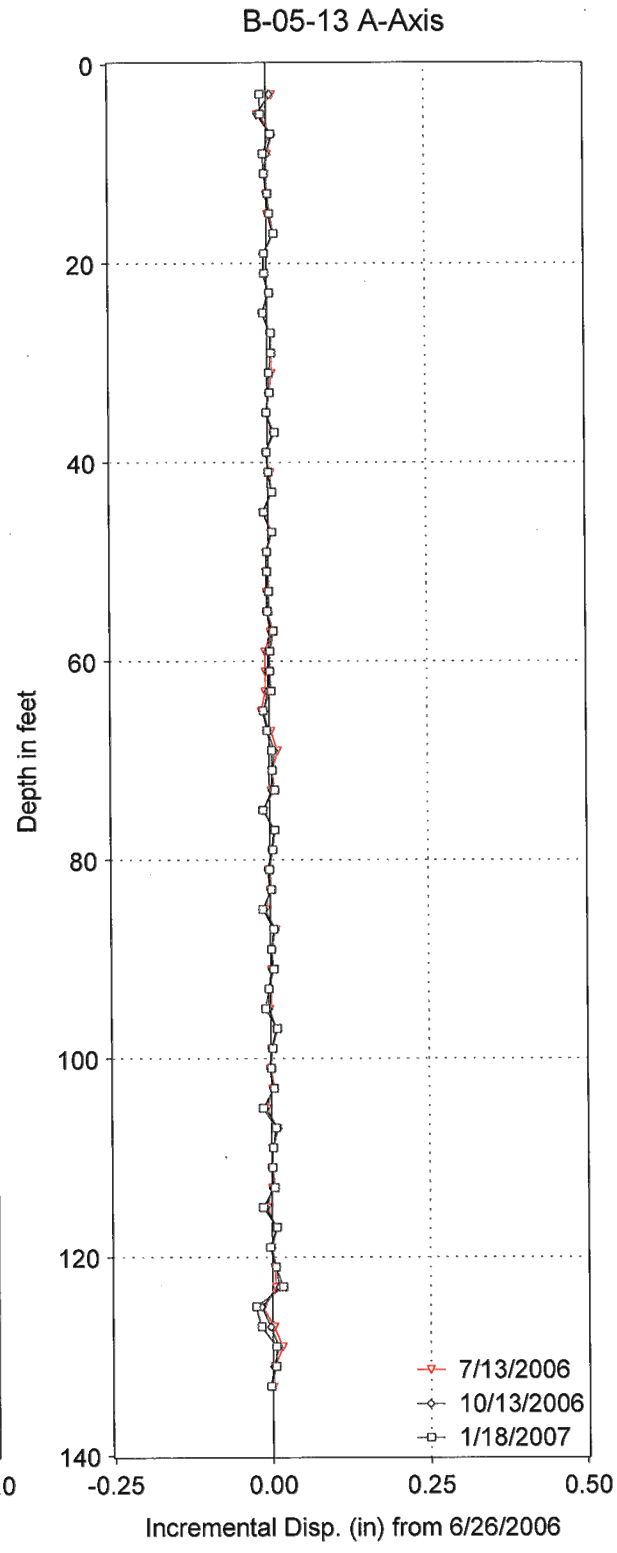


B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

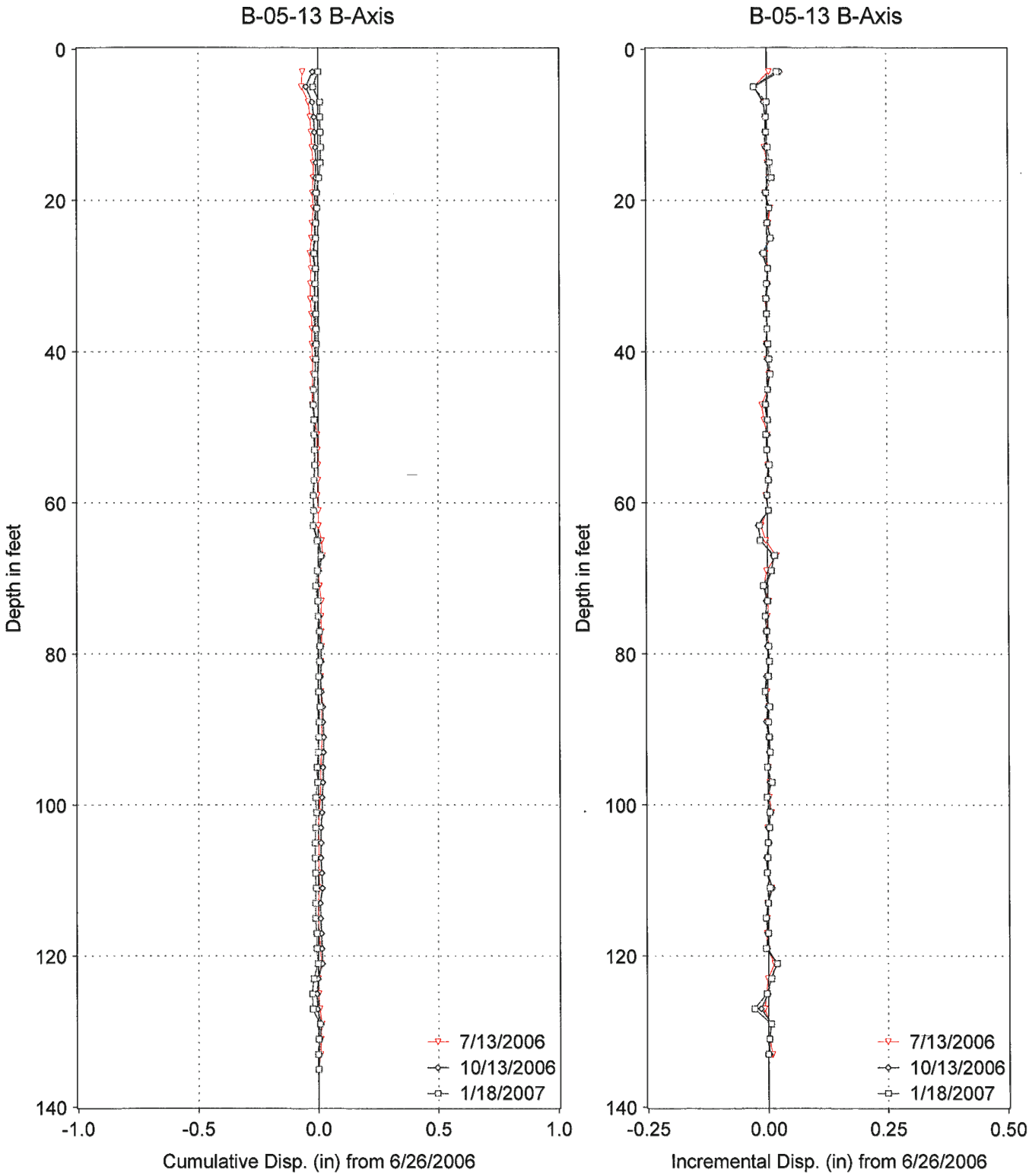
PLATE 41A





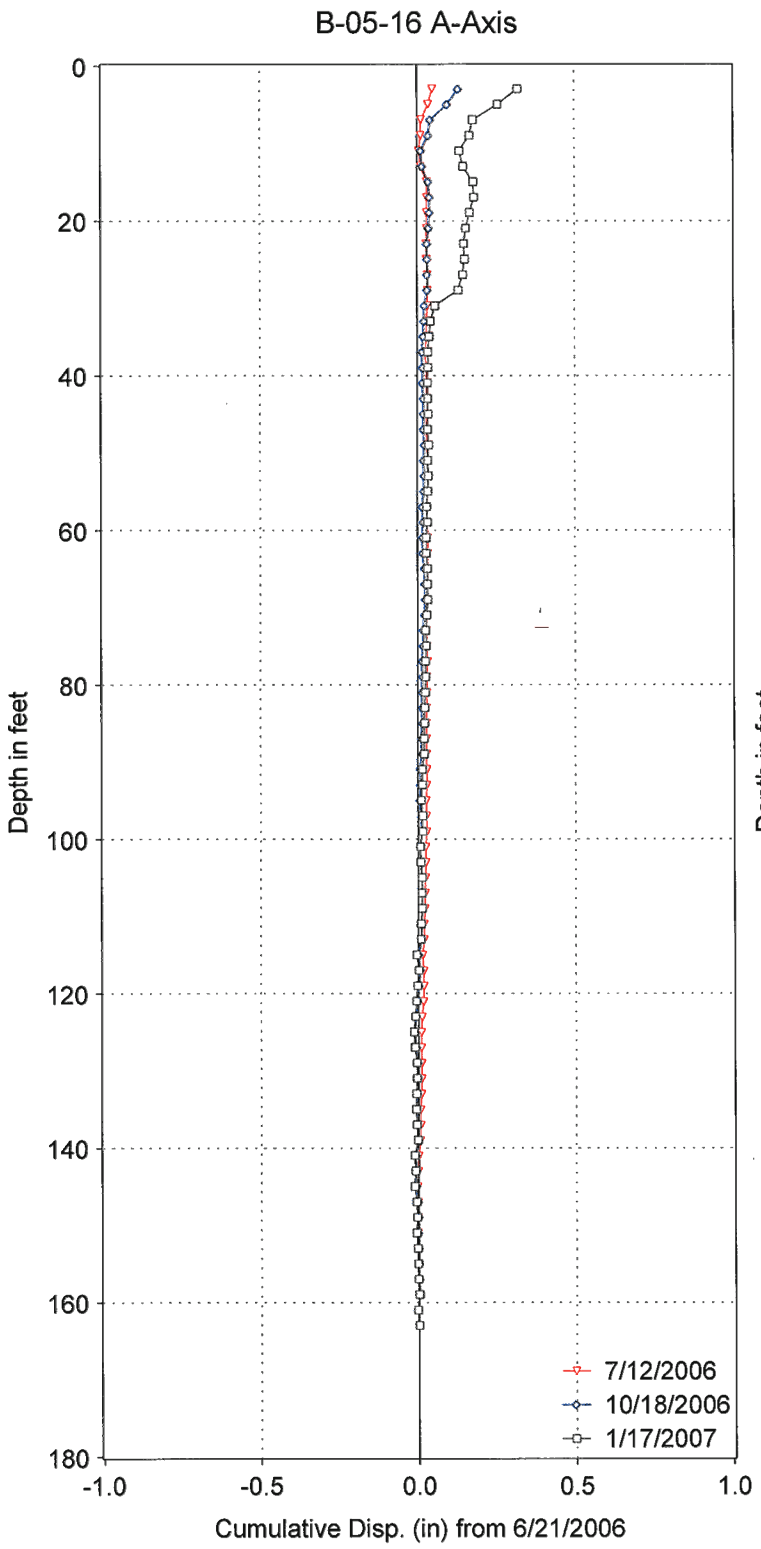
B-05-13

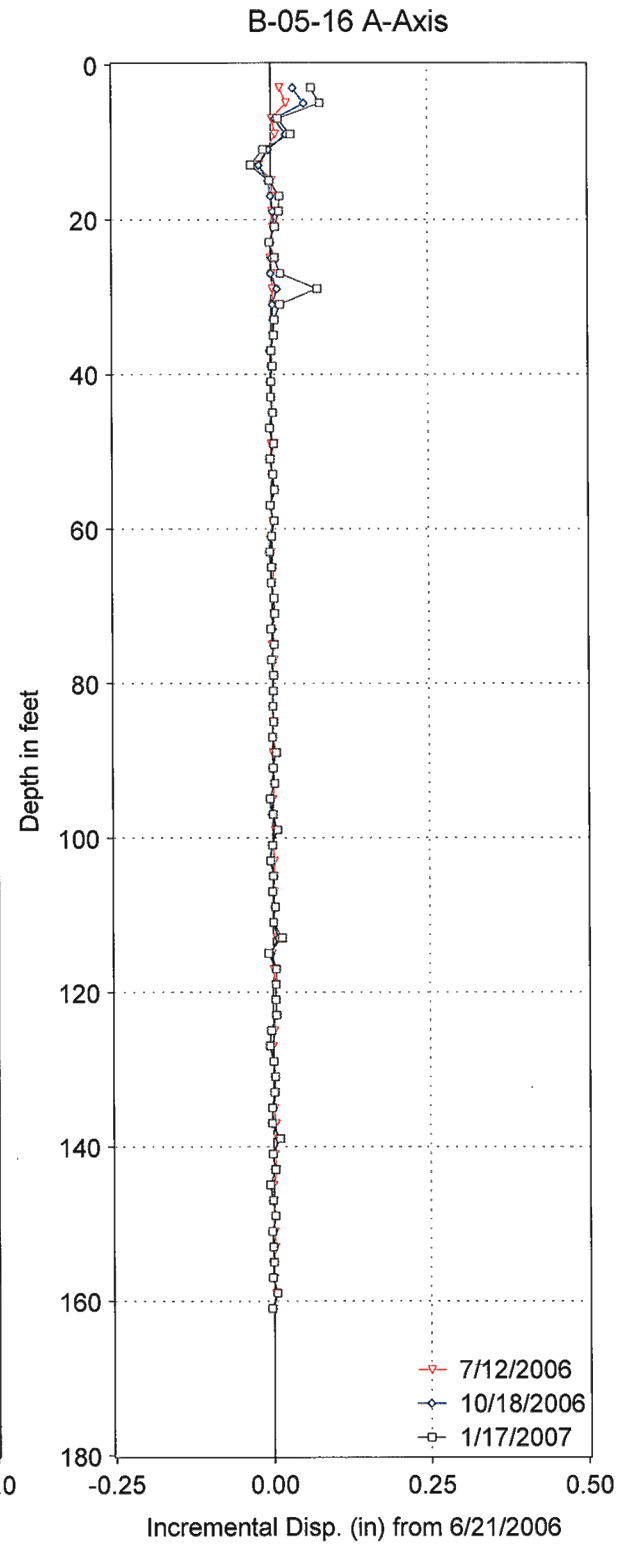
PLATE 42



B-05-13

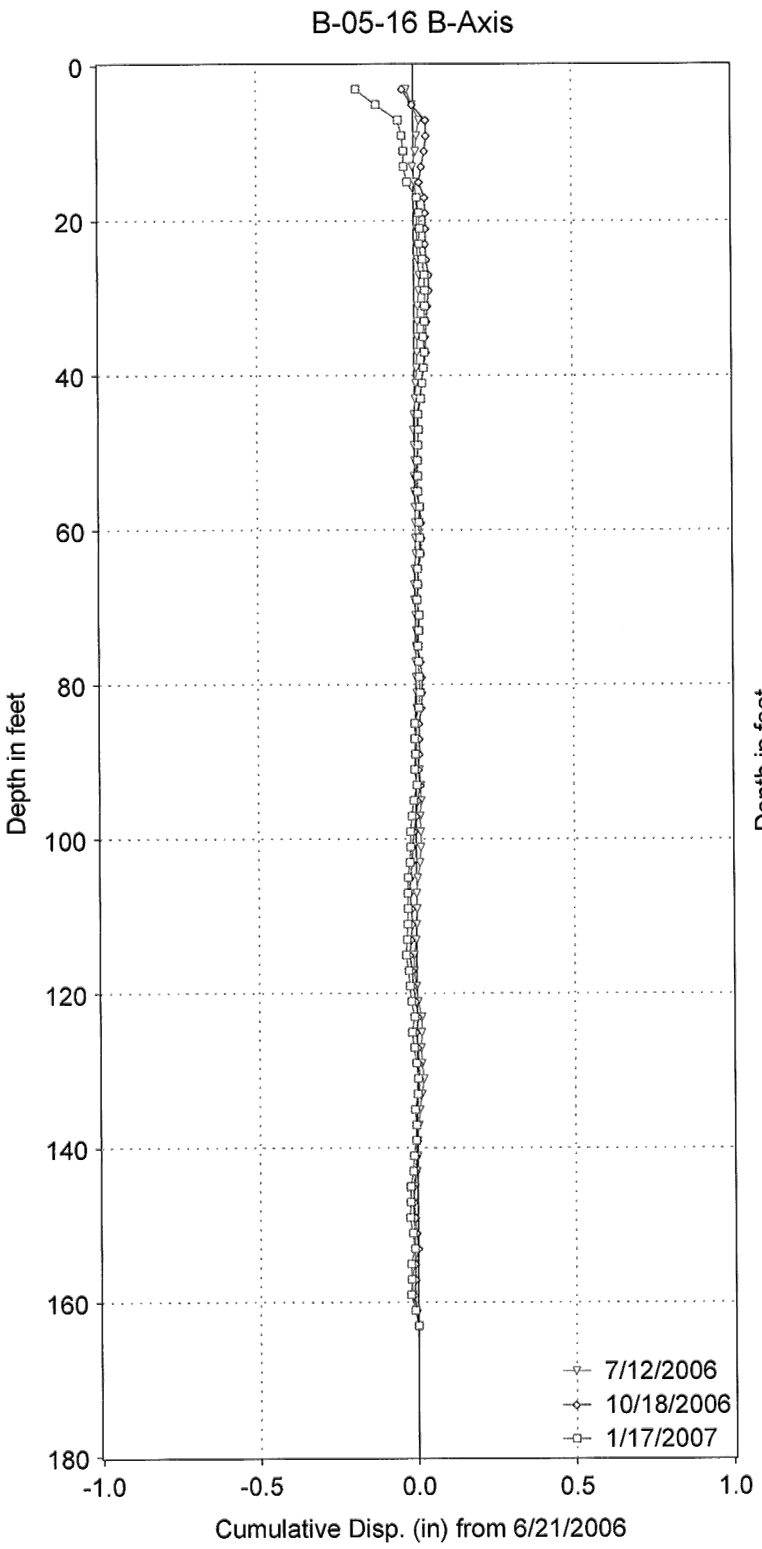
PLATE 43

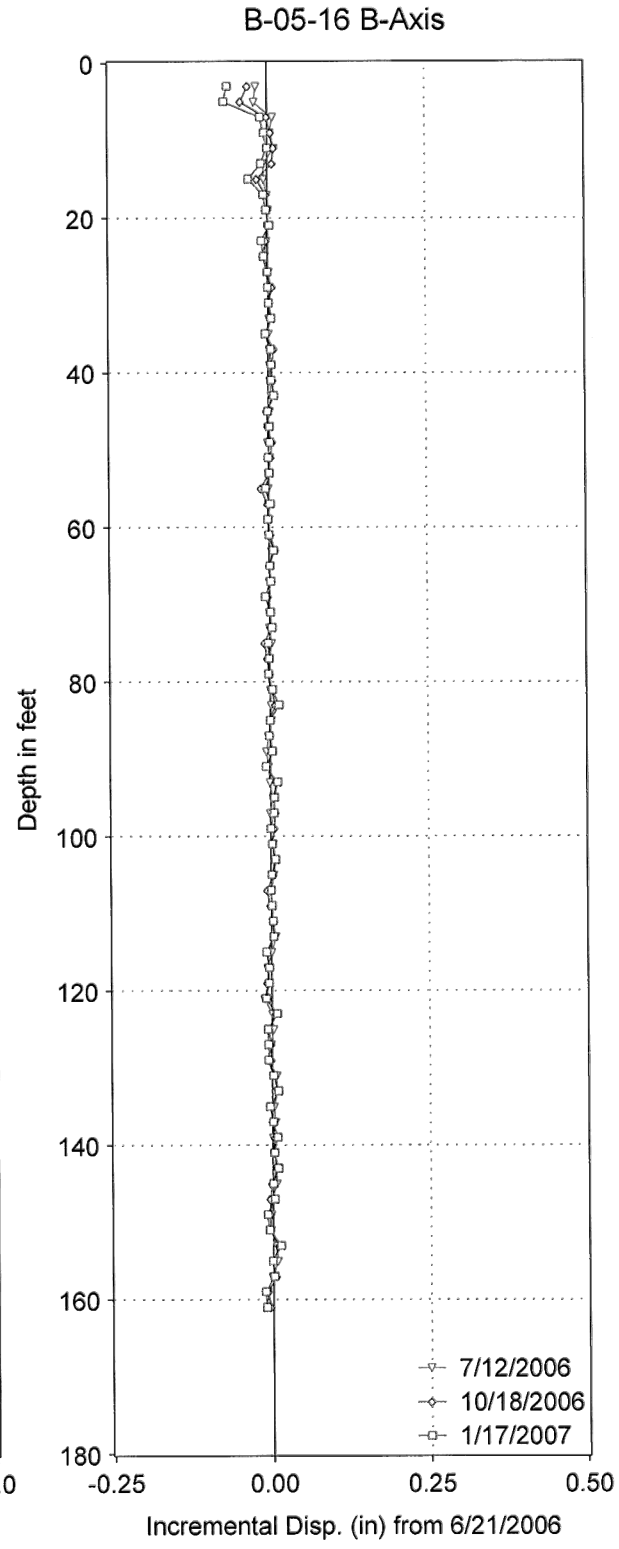




B-05-16

PLATE 44





B-05-16

PLATE 45

B-101 Pneumatic Piezometer Readings

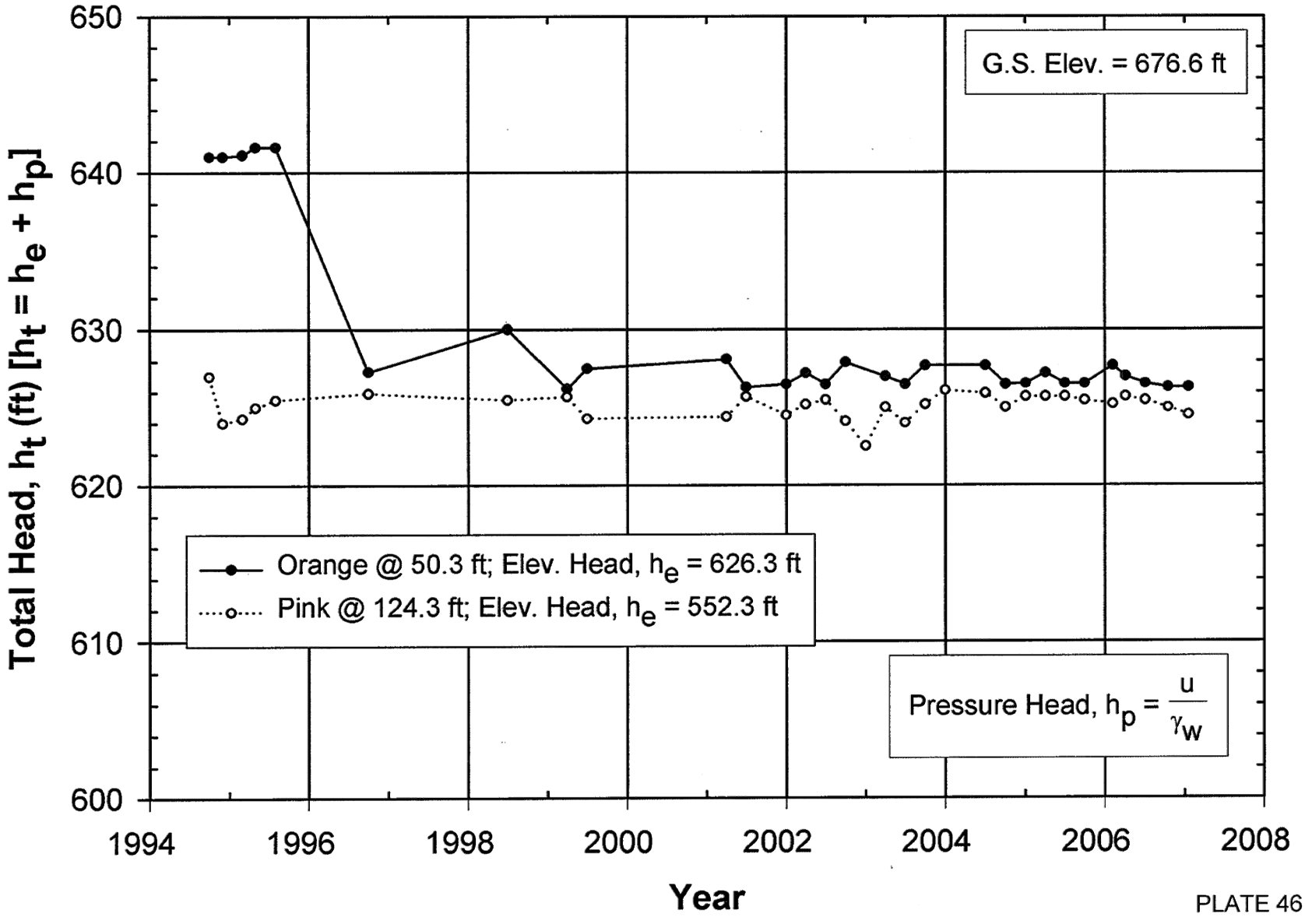


PLATE 46

B-105 Pneumatic Piezometer Readings

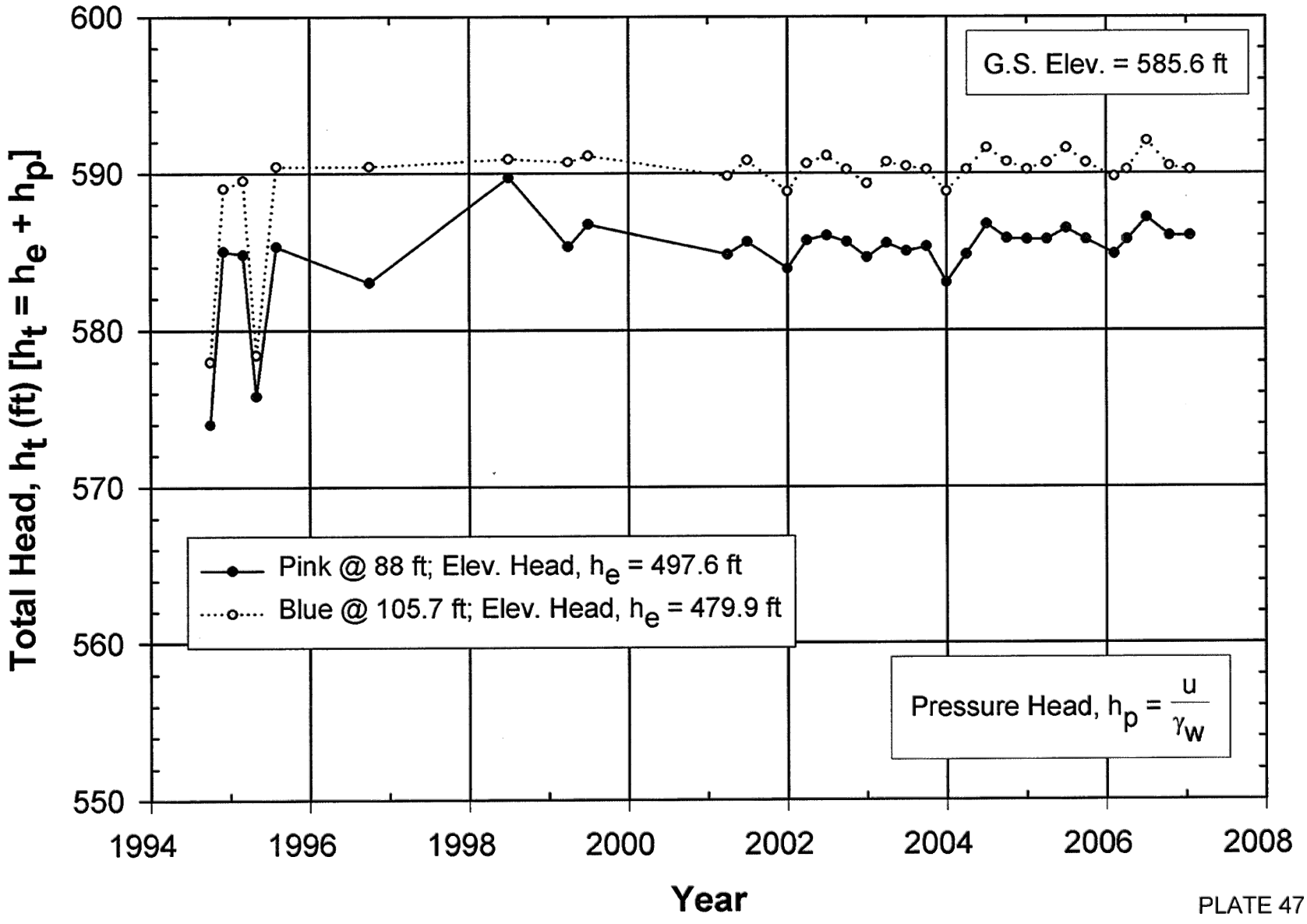


PLATE 47

B-107 Pneumatic Piezometer Readings

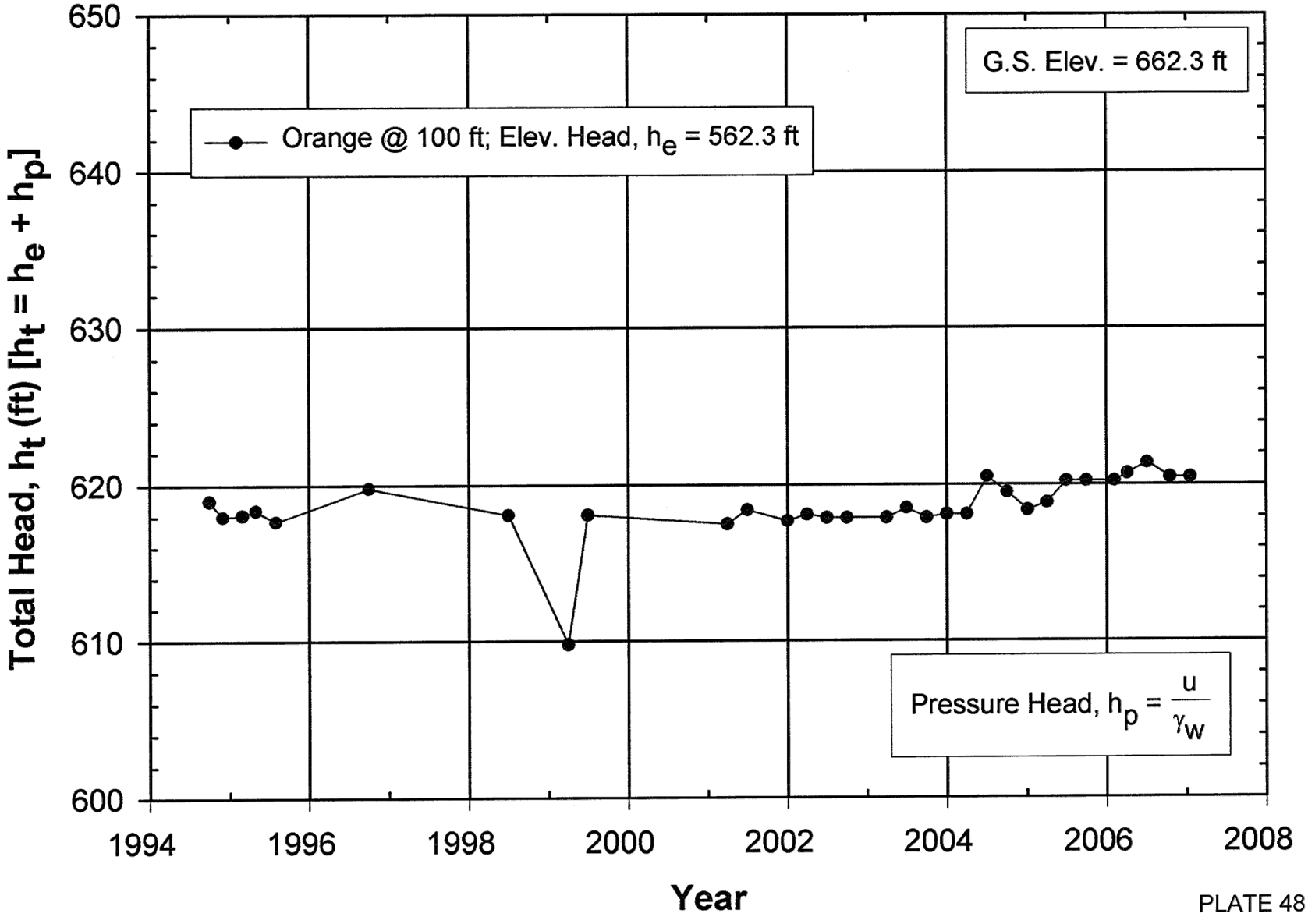


PLATE 48

B-303 Pneumatic Piezometer Readings

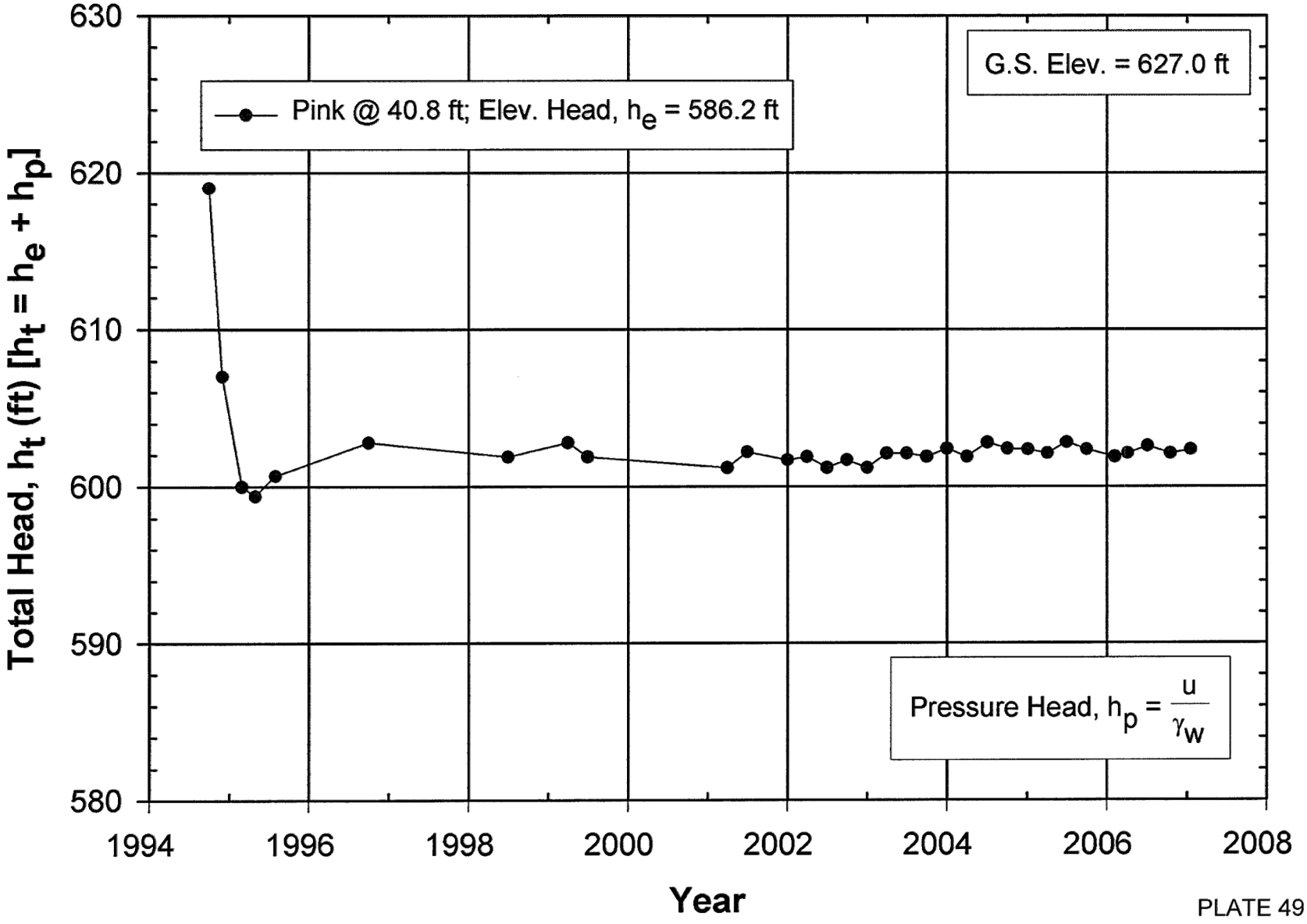


PLATE 49

B-05-01 VW Piezometer Readings

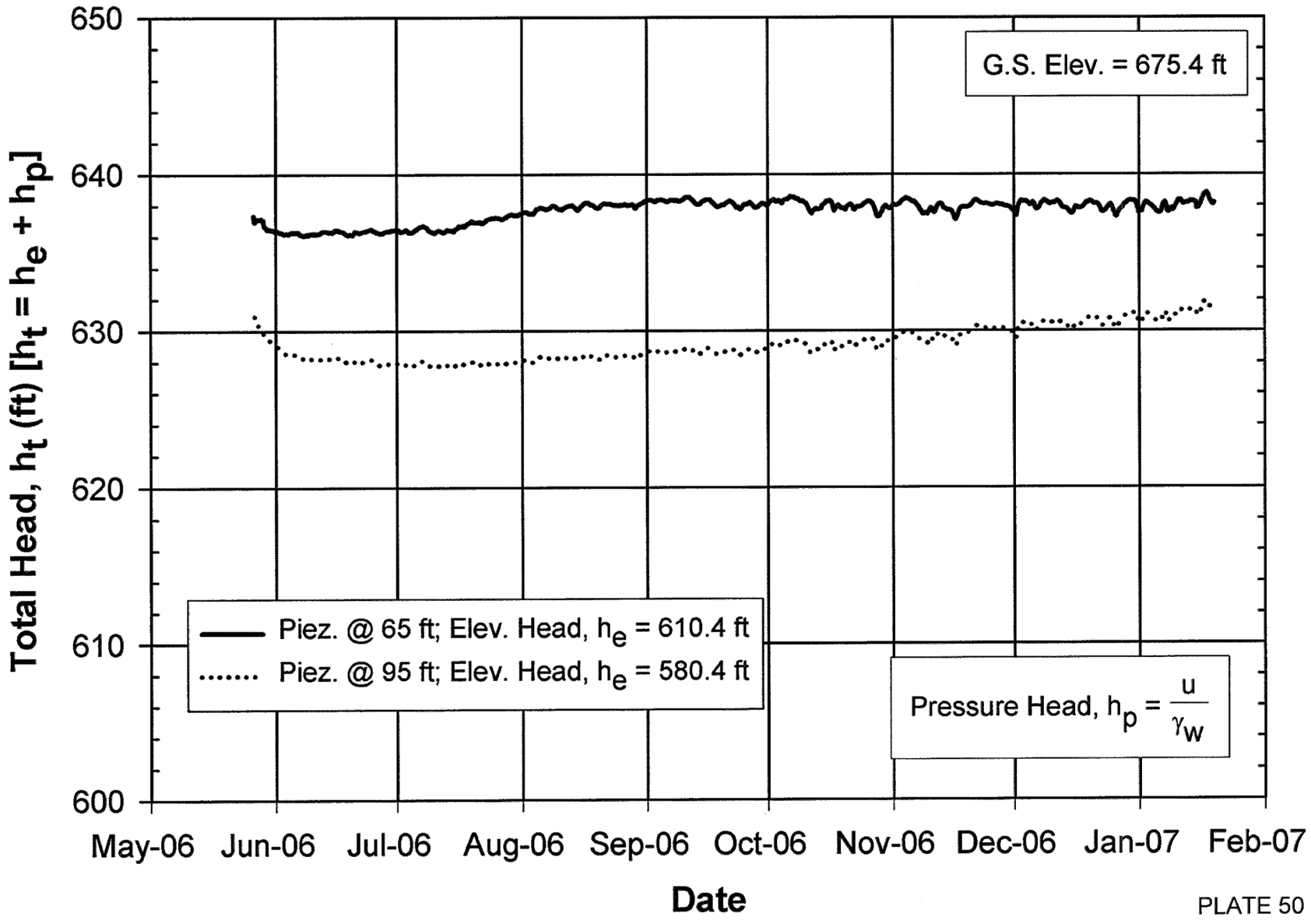


PLATE 50

B-05-02 VW Piezometer Readings

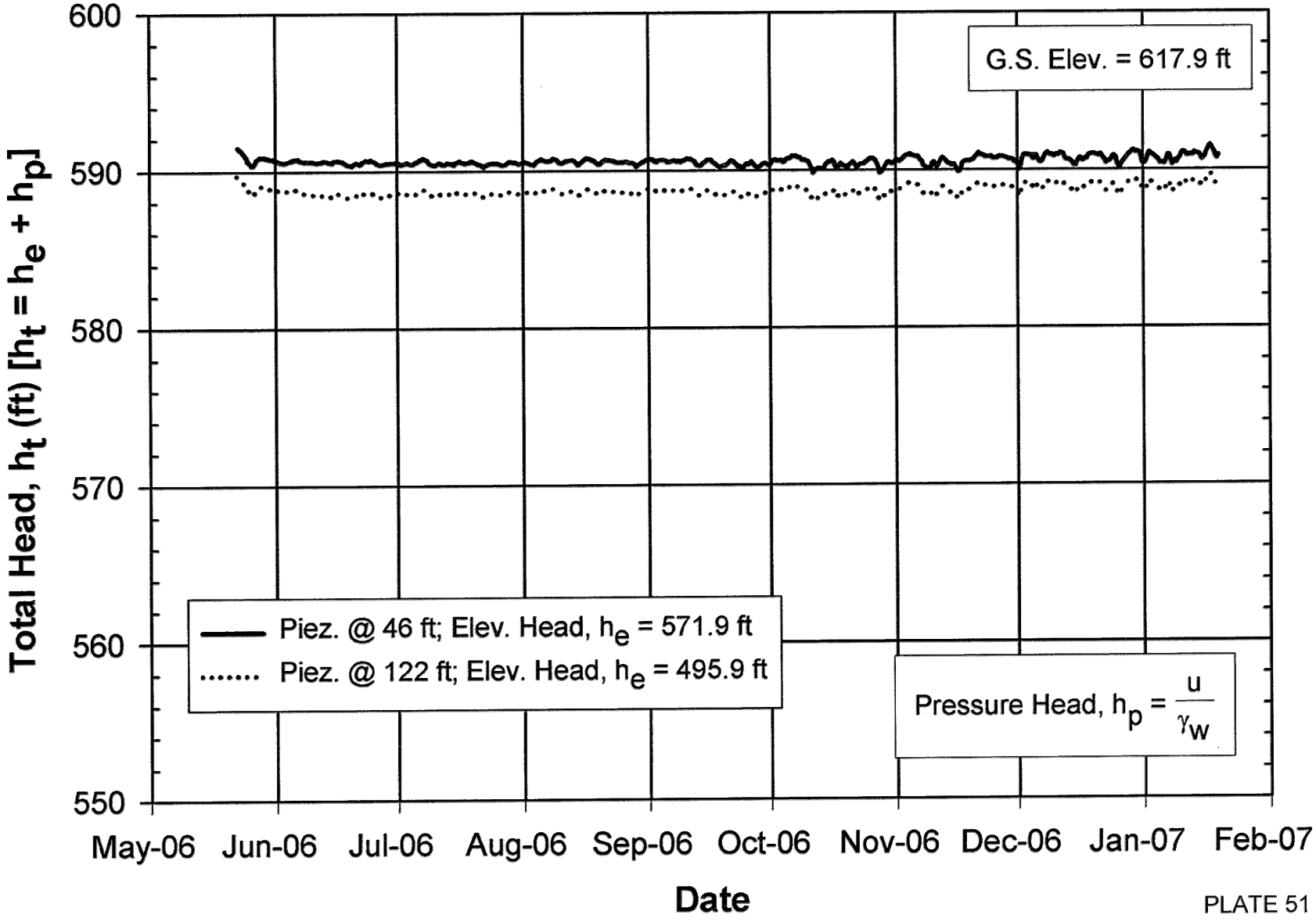


PLATE 51

B-05-03 VW Piezometer Readings

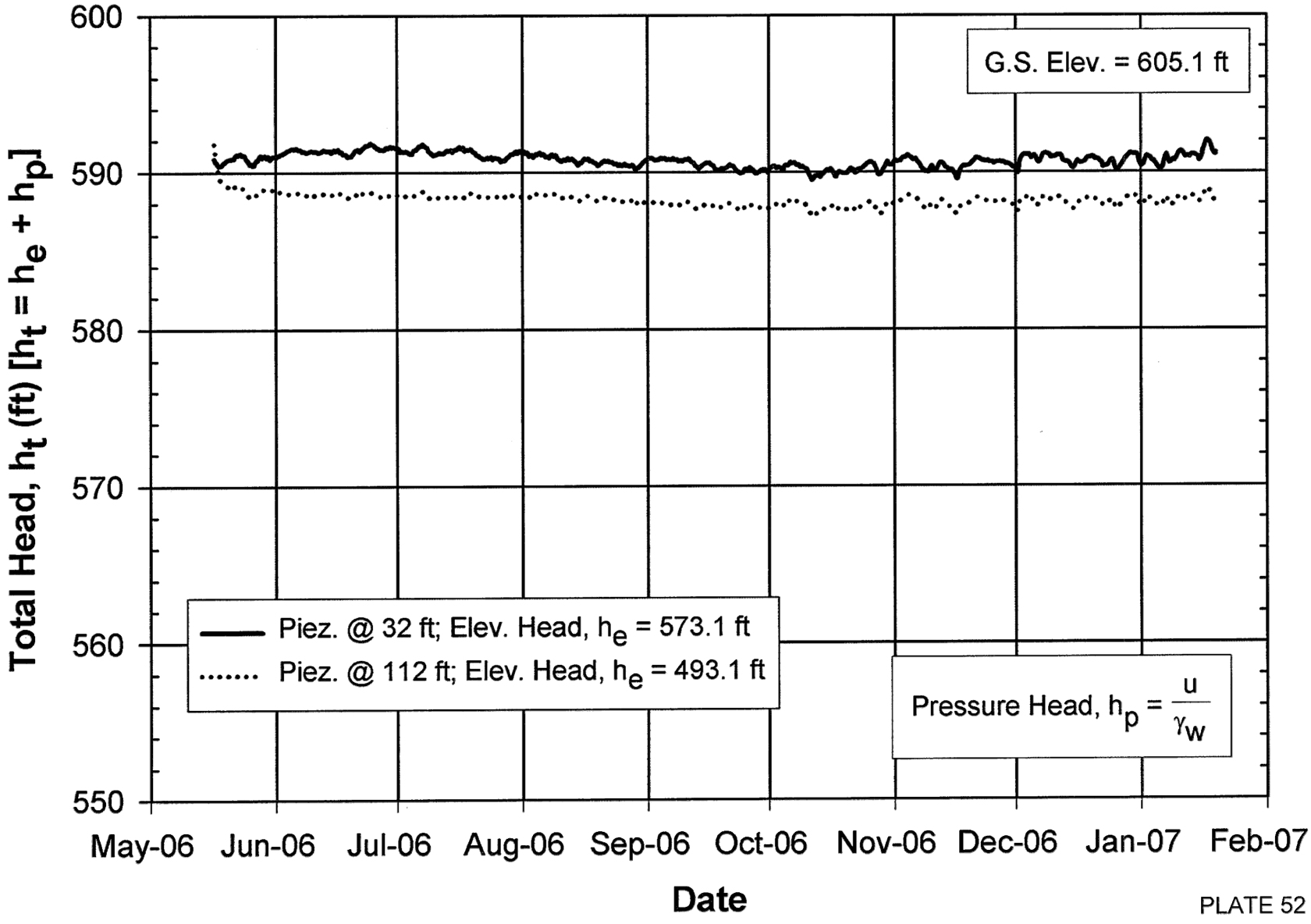


PLATE 52

B-05-04 VW Piezometer Readings

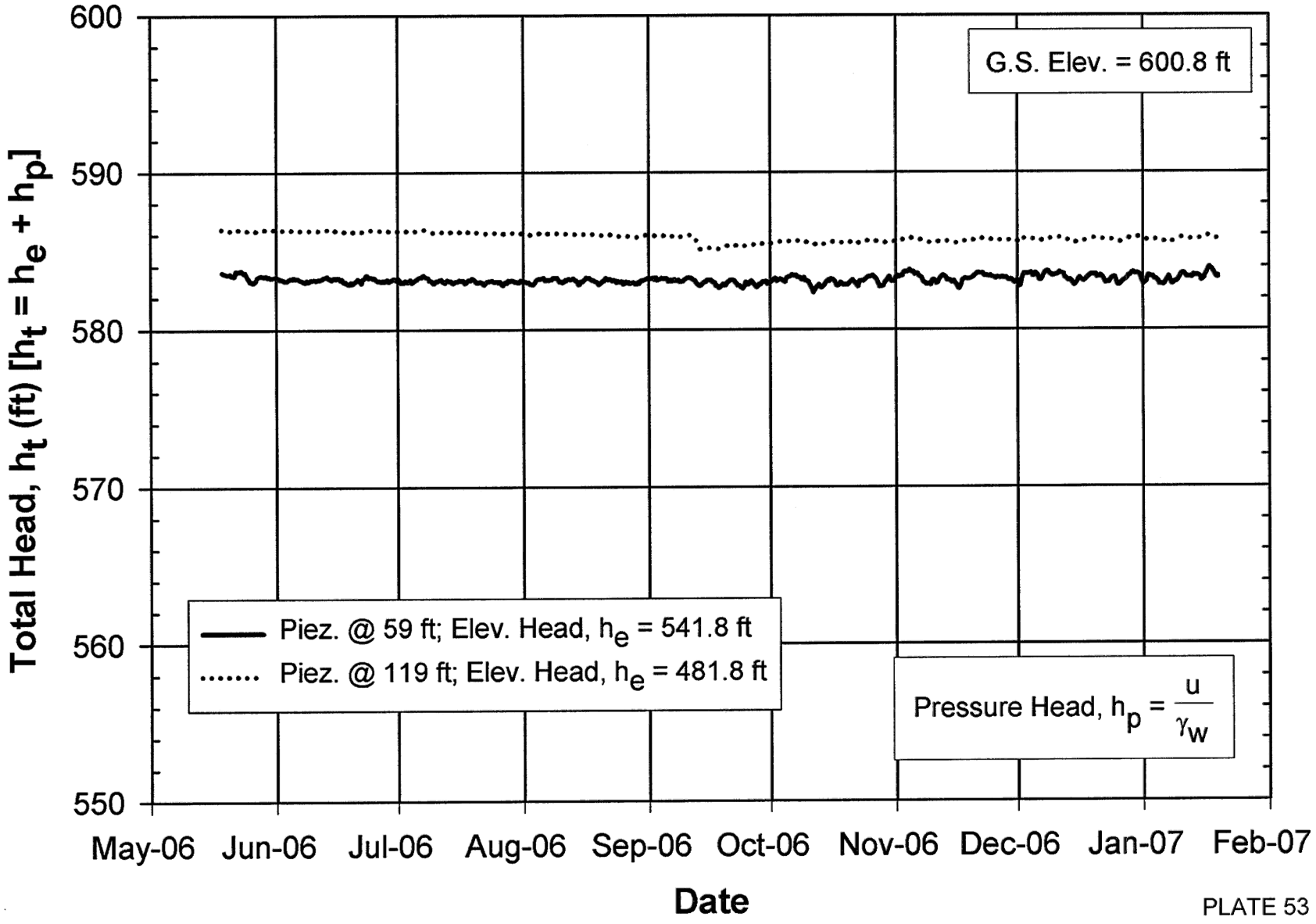


PLATE 53

B-05-07 VW Piezometer Readings

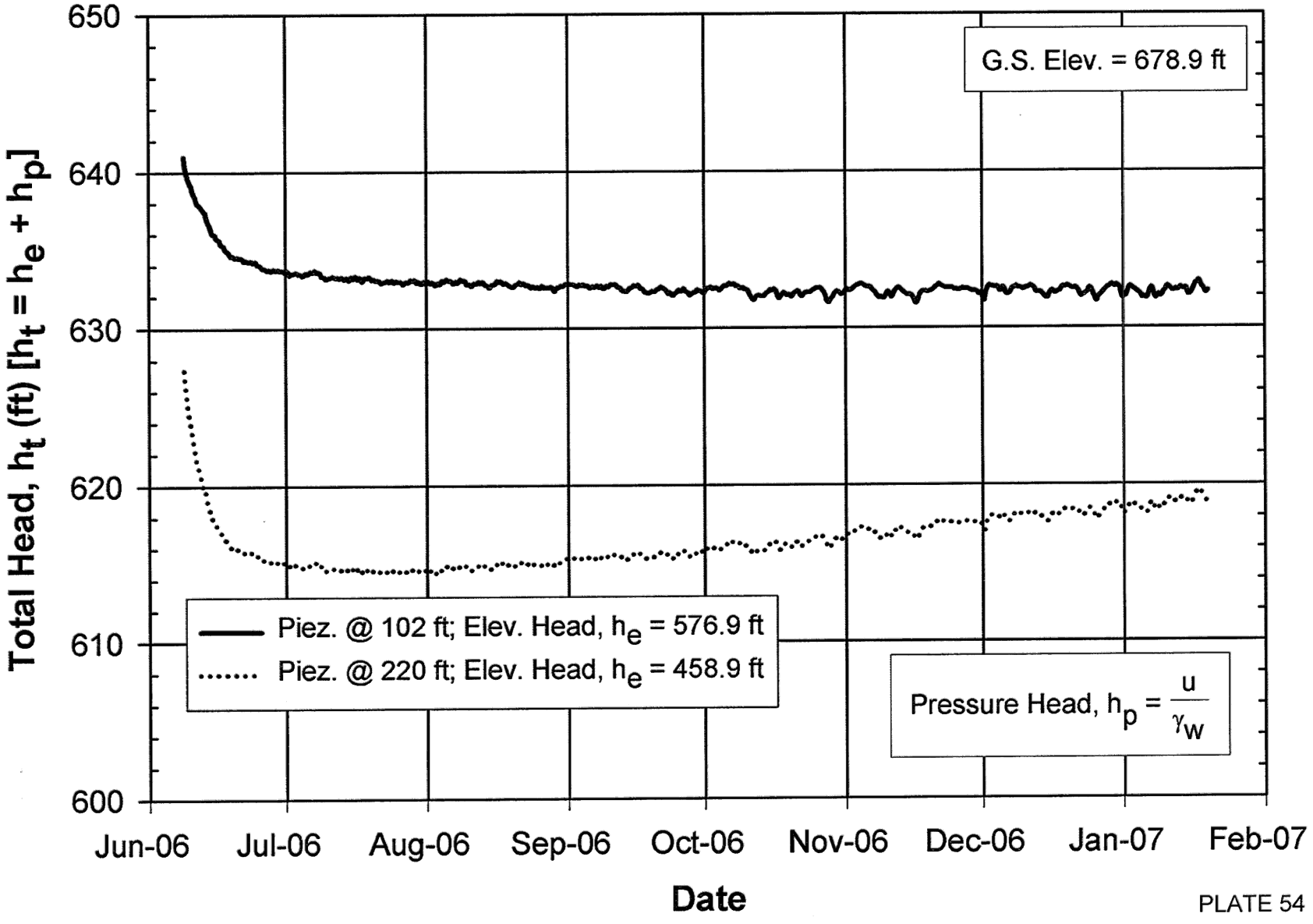


PLATE 54

B-05-08 VW Piezometer Readings

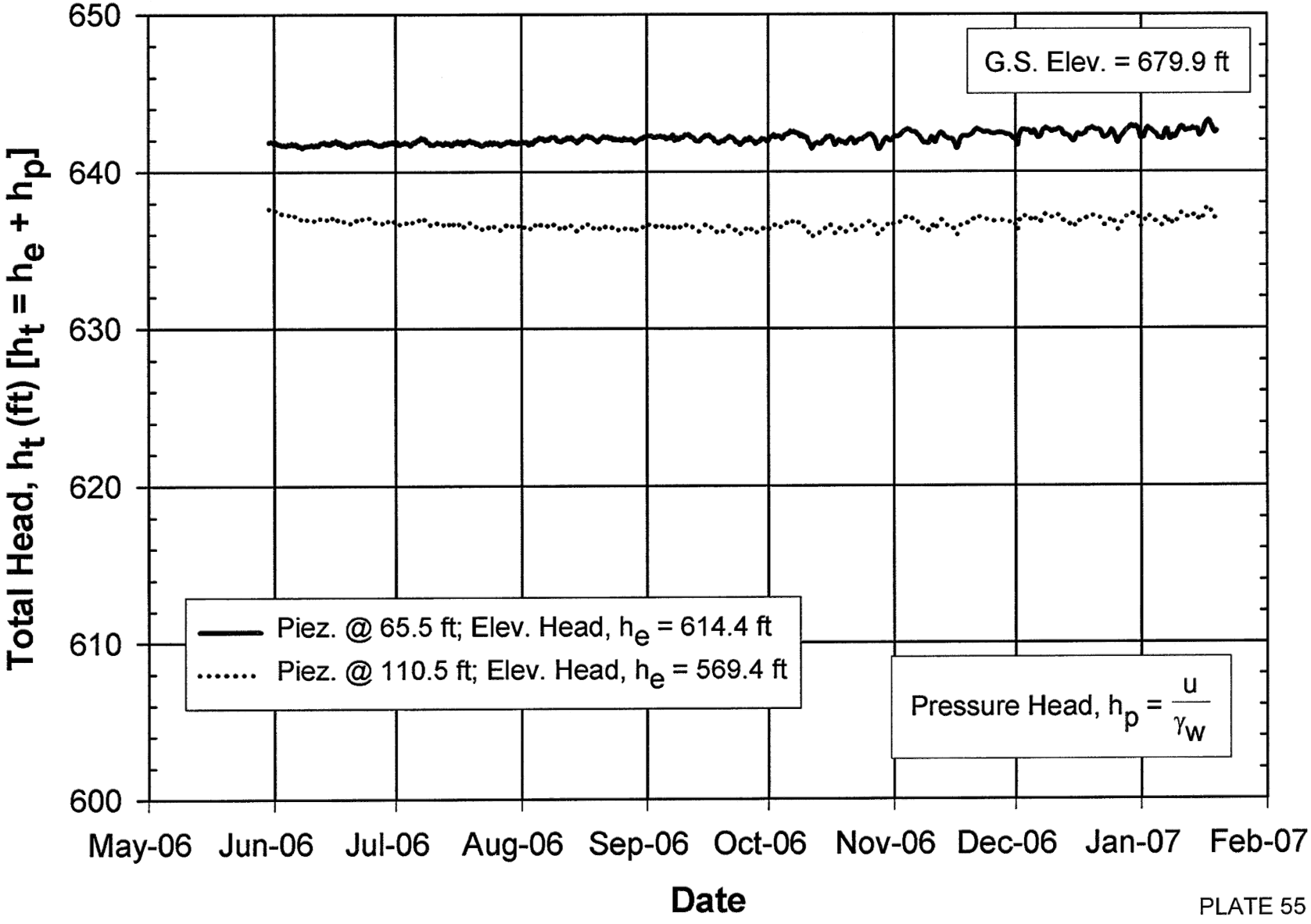


PLATE 55

B-05-11 VW Piezometer Readings

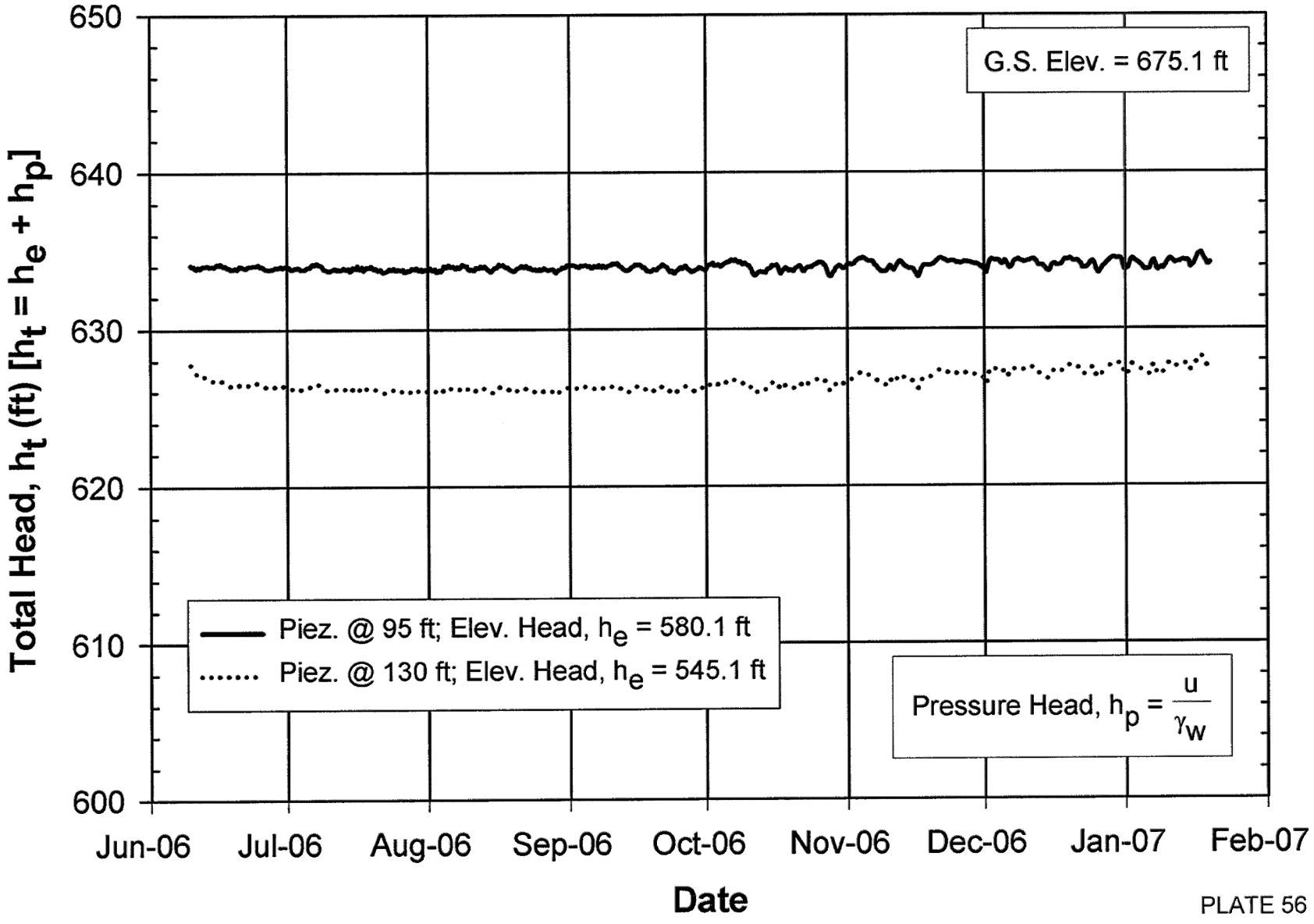


PLATE 56

B-05-12 VW Piezometer Readings

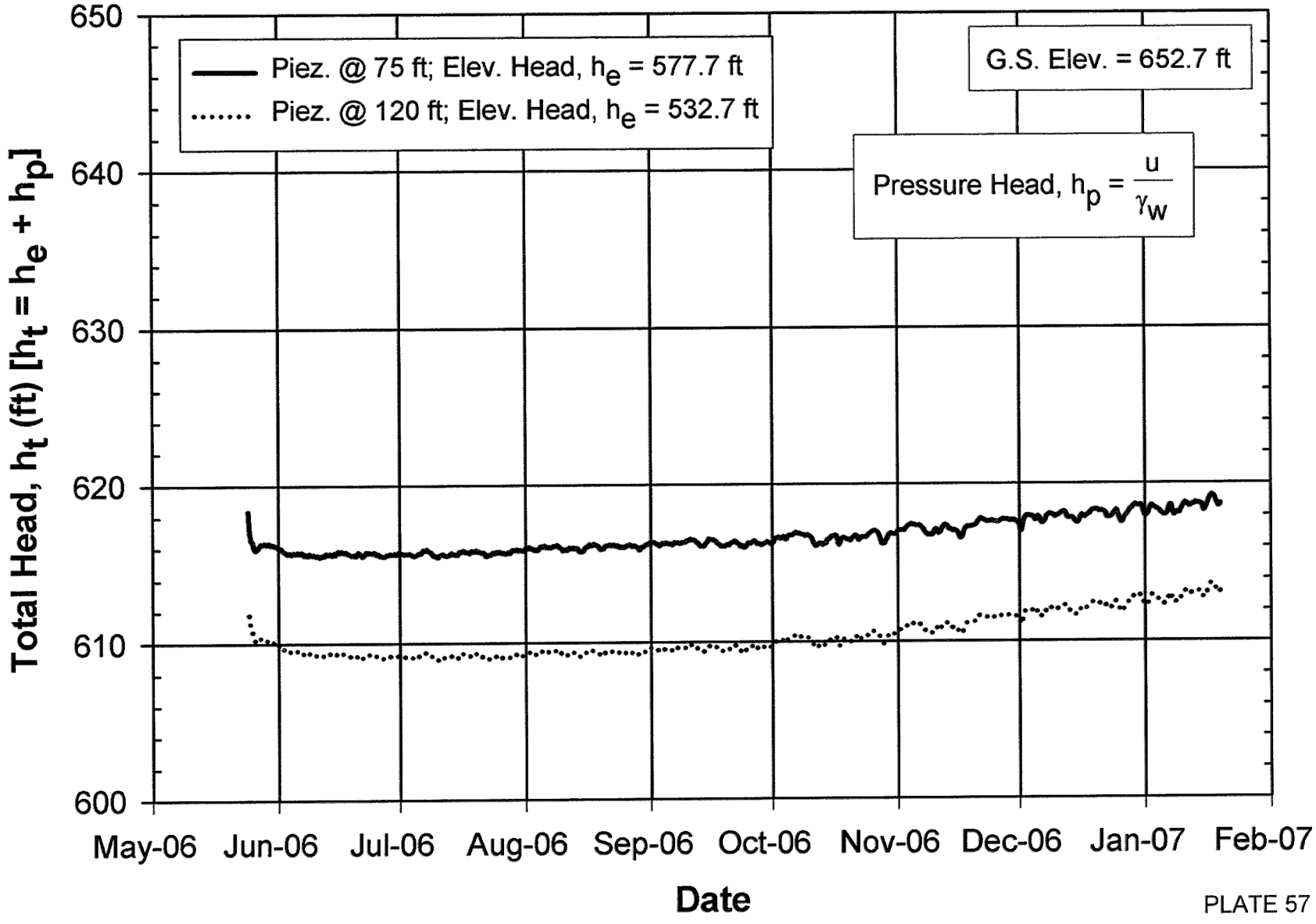


PLATE 57

B-05-13 VW Piezometer Readings

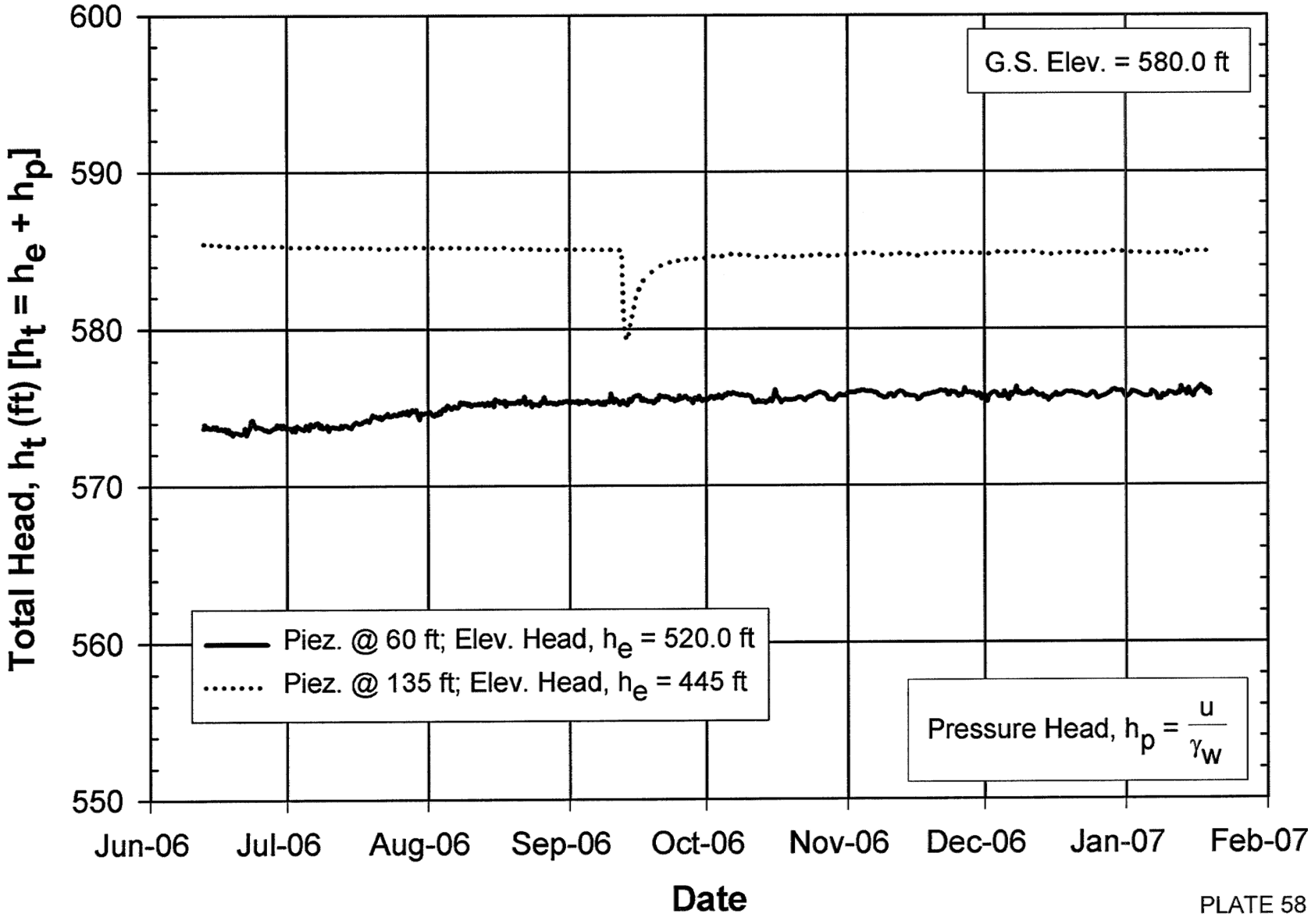


PLATE 58

CALIPERED SURFACE DISTANCE TABLE
CUY-90-15.24

Date	Left Pier Calipered Surface Distance		Center Line Calipered Surface Distance		Right Pier Calipered Surface Distance	
	Present reading	Change (in.)	Present reading	Change (in.)	Present reading	Change (in.)
04/19/00	6.064	--	Not Accessible		4.527	--
07/20/00	6.000	-0.064	Not Accessible		4.516	-0.011
10/26/00	5.876	-0.124	Not Accessible		4.294	-0.222
01/29/01	5.929	0.053	Not Accessible		4.385	0.091
04/17/01	Not Accessible		Not Accessible		Not Accessible	
07/19/01	6.043	0.114	Not Accessible		4.312	-0.073
11/08/01	6.250	0.207	Not Accessible		4.469	0.157
01/23/02	6.253	0.003	Not Accessible		4.518	0.049
04/17/02	6.285	0.032	Not Accessible		4.435	-0.083
07/16/02	6.290	0.005	Not Accessible		4.444	0.009
10/15/02	6.333	0.043	Discontinued		4.482	0.038
01/15/03	6.405	0.072			4.473	-0.009
04/17/03	6.333	-0.072			4.482	0.009
07/18/03	6.186	-0.147			4.350	-0.132
10/16/03	6.385	0.199			4.519	0.169
01/08/04	6.124	-0.261			4.594	0.075
04/14/04	6.129	0.005			4.402	-0.193
07/16/04	6.250	0.122			4.277	-0.125
10/27/04	6.375	0.125			4.467	0.190
01/12/05	6.250	-0.125			4.349	-0.118
04/14/05	6.375	0.125			4.372	0.023
07/14/05	6.313	-0.063			4.392	0.020
10/12/05	6.375	0.063			4.358	-0.034
02/01/06	6.438	0.063			4.395	0.037
04/20/06	6.500	0.063			4.430	0.035
07/14/06	6.375	-0.125			4.381	-0.049
10/18/06	6.438	0.063			4.400	0.020
01/19/07	6.500	0.062			4.506	0.106

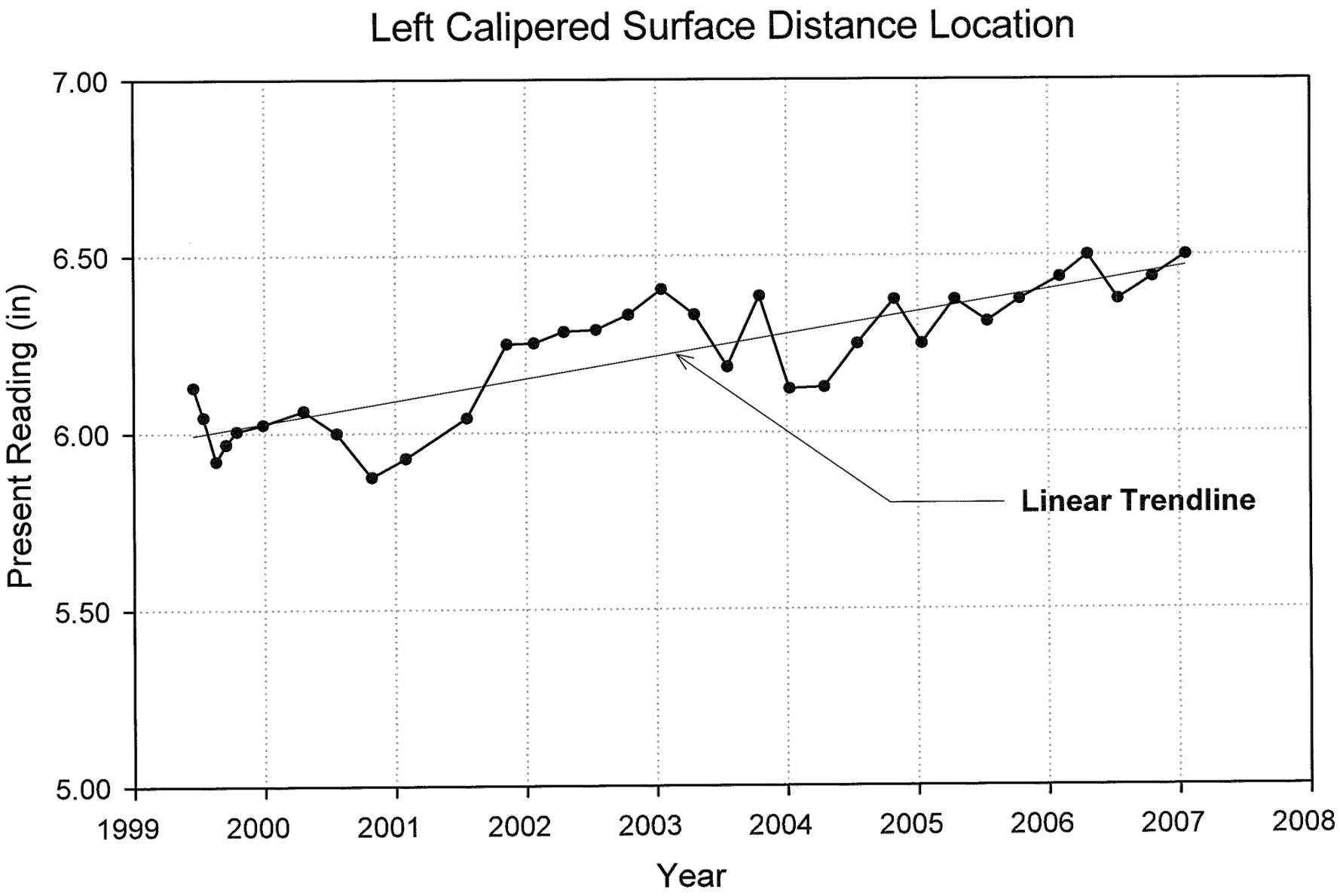

Left Calipered Surface Distance Location
7.00
6.50
6.00
5.50
5.00
Present Reading (in)
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Linear Trendline

PLATE 60

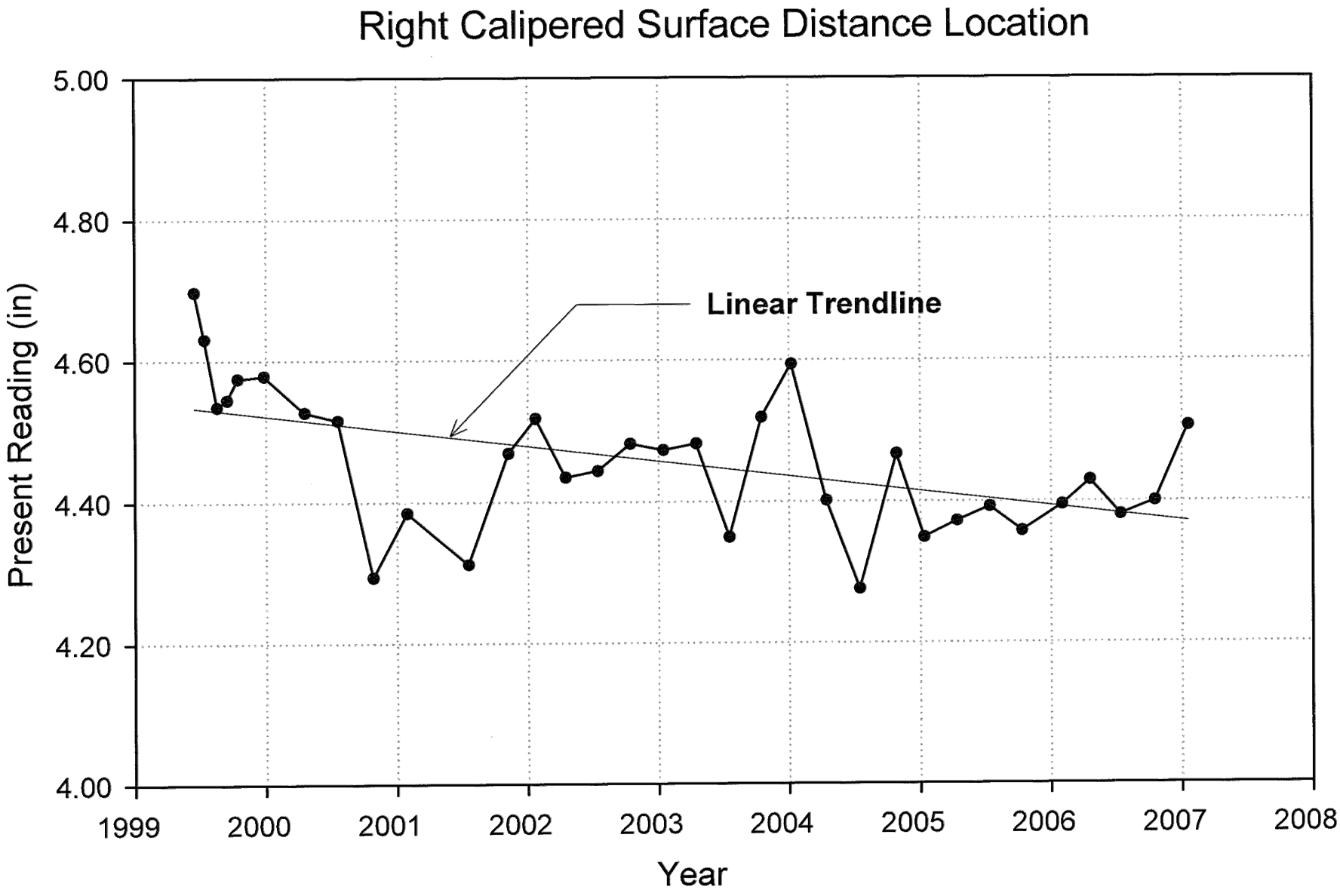

Right Calipered Surface Distance Location
5.00
4.80
4.60
4.40
4.20
4.00
Present Reading (in)
Linear Trendline
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year

PLATE 61

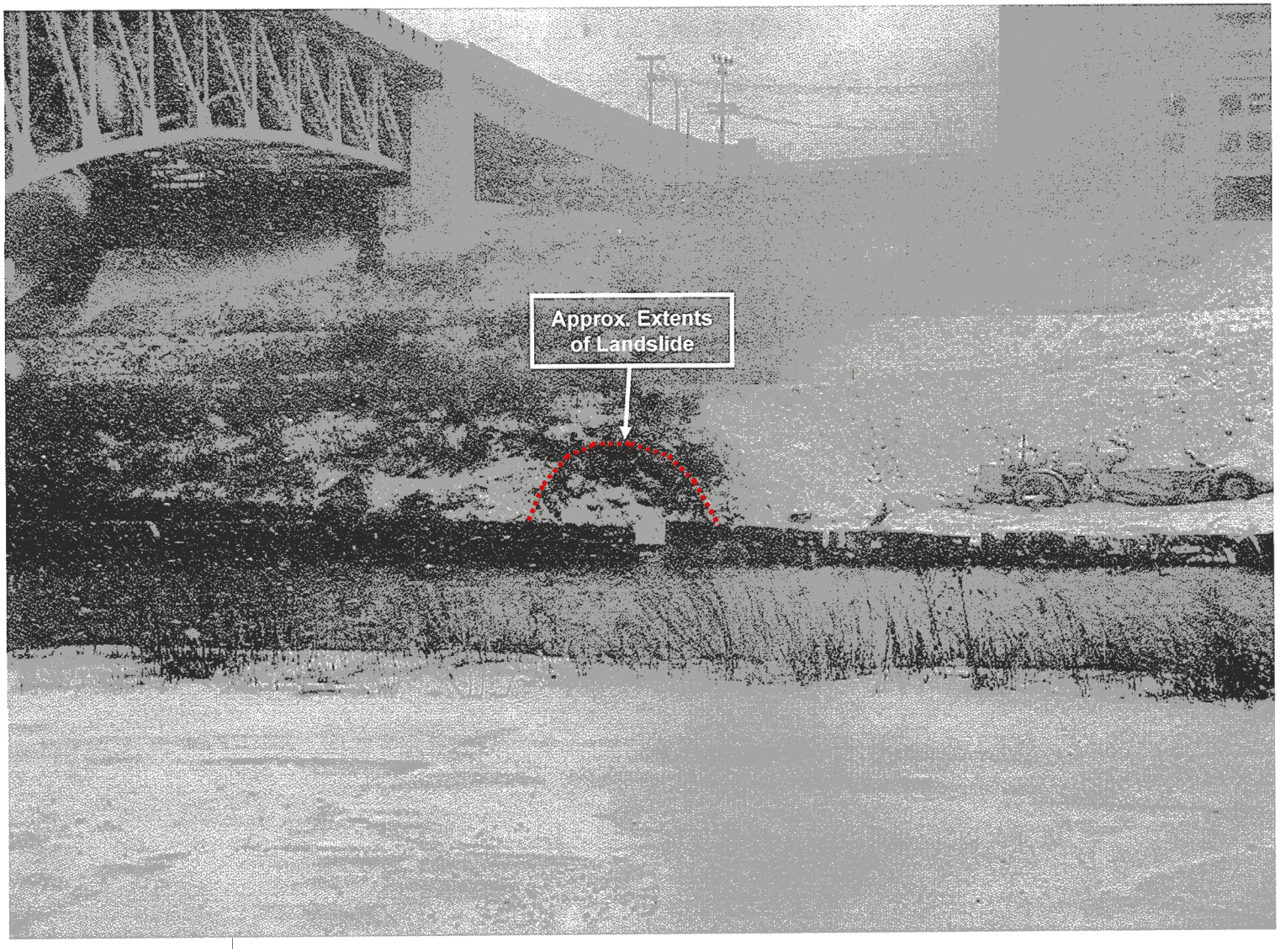


PLATE 62

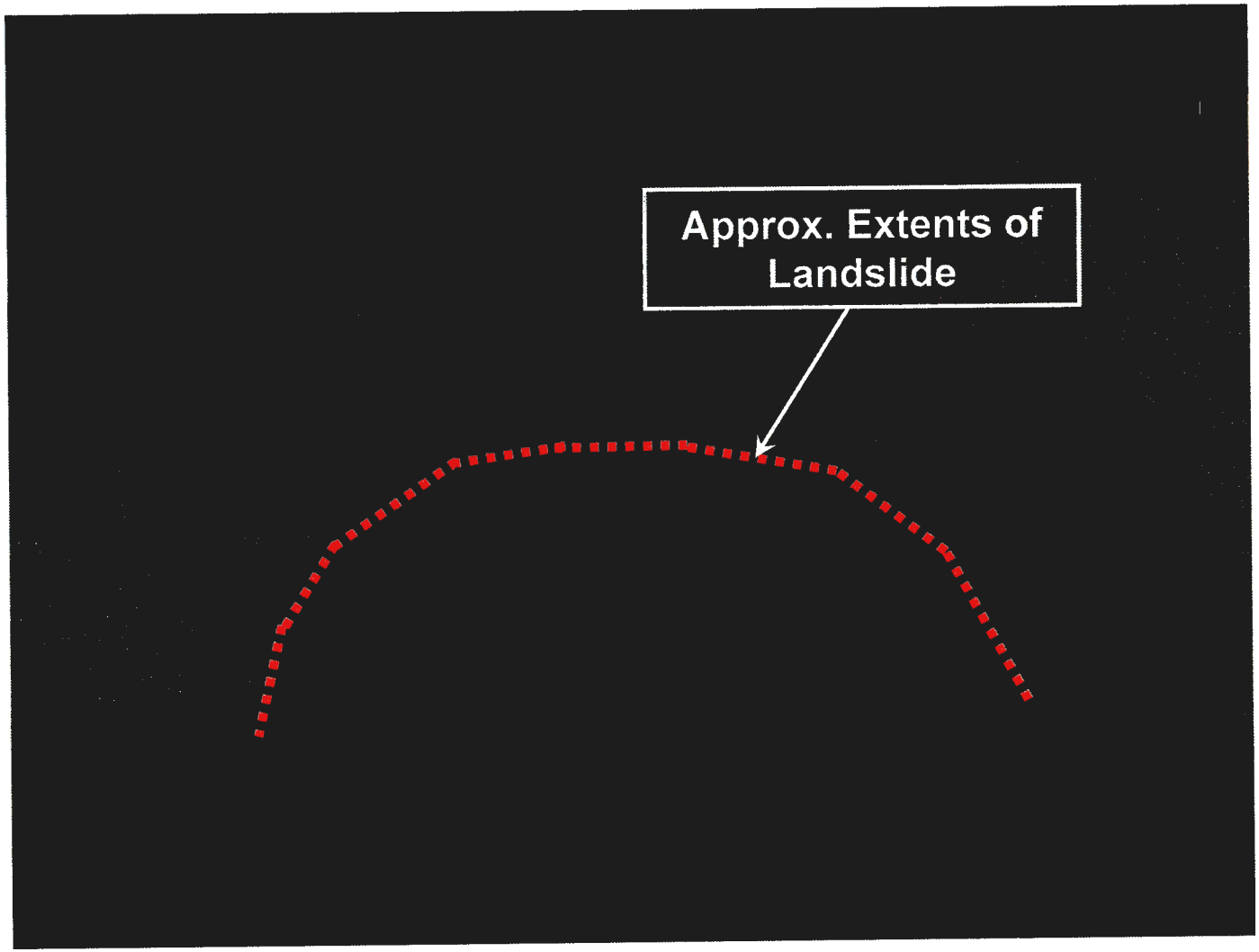


PLATE 63

CUY-90-1524
106017

DECK EXPANSION JOINT OPENINGS

Finger Type Joints

Measurements are in inches.

Date	Temp (F)	West End Pier North	West End Pier South	Near Pier 2 North	Near Pier 2 South	Near Pier 4 North	Near Pier 4 South
Expansion Distance		476 feet		650 feet			
Design	60°	3.25	3.25	3.25	3.25	3.25	3.25
06-01-70	80°	4.00		0.00		N.A.	
09-19-75	60°	5.25		2.00		N.A.	
05-08-78	60°	4.75	5.50	2.00	2.00	3.25	2.50
07-30-81	75°	5.50	5.50	2.25	2.25	3.25	2.75
06-09-83	70°	5.00	5.00	1.50	1.50	2.75	2.25
07-31-85	73°	5.25	4.75	1.50	1.00	2.75	2.25
10-31-88	40°	7.75	8.38	1.50	0.75	3.81	3.38
11-01-89	50°	7.75	7.00	1.13	0.63	3.25	3.13
10-26-90	50°	7.75	7.25	1.00	0.50	3.00	3.00
09-30-91	55°	7.50	7.00	0.88	0.00	3.00	3.00
10-13-92	60°	7.25	6.81	0.63	0.00	2.50	2.50
10-01-93	50°	7.50	7.13	0.75	0.31	2.75	2.63
09-01-94	63°	7.25	6.38	0.31	0.00	2.88	1.88
09-08-95	60°	7.00	6.63	0.44	0.00	2.00	1.88
09-05-96	77°	6.50	6.63	0.38	0.00	1.25	1.00
09-19-97	75°	6.88	7.00	0.31	0.06	1.68	1.42
09-24-98	69°	7.63	7.00	0.00	0.00	1.88	1.75
10-14-99	45°	6.19	5.50	2.38	1.88	3.13	2.75
10-16-00	55°	6.00	4.88	1.75	1.25	2.56	2.43
04-23-01	70°	5.50	4.25	1.38	0.63	2.13	1.75
07-16-01	80°	5.00	3.88	1.00	0.25	1.50	1.25
10-15-01	50°	6.63	5.63	1.63	1.06	3.25	2.75

Date	Temp (F)	West End Pier		Near Pier 2		Near Pier 4	
		North	South	North	South	North	South
1-15-02	30°	6.88	6.25	2.13	1.50	3.88	3.50
4-15-02	61°	6.00	5.25	1.38	0.88	2.50	2.38
7-15-02	76°	5.13	4.13	1.13	0.50	1.75	1.50
10-17-02	48°	7.00	6.38	1.75	1.25	3.25	2.88
11-1-02	35°	7.25	6.13	1.88	1.38	3.63	3.38
1-15-03	7°	8.13	6.63	2.38	1.88	5.00	4.75
4-15-03	67°	5.63	4.63	1.25	0.63	2.25	2.00
7-15-03	74°	5.38	4.38	1.00	0.50	2.00	1.63
10-16-03	46°	7.00	5.75	1.50	1.13	3.25	3.13
1-15-04	11°	8.00	6.75	2.00	1.38	4.63	4.00
4-15-04	41°	6.88	5.75	1.38	0.88	3.50	3.25
7-15-04	67°	5.63	4.75	1.00	0.50	2.13	1.75
10-15-04	50°	6.38	5.50	1.25	0.75	3.00	2.75
1-15-05	12°	7.75	7.00	2.00	1.38	4.63	4.25
4-16-05	47°	6.50	5.63	1.25	0.75	3.25	2.88
7-16-05	74°	5.50	4.50	0.75	0.375	1.75	1.63
10-14-05	51°	6.25	5.50	1.13	0.63	2.81	2.56
1-16-06	26°	7.63	6.38	1.75	1.13	4.13	3.75
4-14-06	65°	5.75	4.88	0.75	0.50	2.25	2.00
7-14-06	78°	5.00	4.00	0.63	0.19	1.63	1.25
10-16-06	50°	6.50	5.88	1.00	0.75	3.25	3.00
1-15-07	41°	7.00	6.13	1.13	0.88	3.56	3.38

N.A. - No measurements available

106017
~~106109~~

Richland Engineering Limited

From: "arthur huckelbridge" <aah4@case.edu>
To: "'Richland Engineering Limited'" <reltd@r-e-l.com>
Sent: Wednesday, January 24, 2007 12:25 PM
Attach: tilts_Jan07.ppt
Subject: RE: CUY-90-15.24 Monitoring

Dean:

Attached is the updated plot of tiltmeter readings, including the Jan 07 reading. With the exception of tiltmeter 2, which continues its slow drift toward the "north", the remaining readings seem to holding pretty stable. Let me know if you have any questions.

Regards,

Art

From: Richland Engineering Limited [mailto:reltd@r-e-l.com]
Sent: Thursday, January 11, 2007 10:32 AM
To: Robert Liang; Arthur Huckelbridge; Jeff Snyder
Subject: CUY-90-15.24 Monitoring

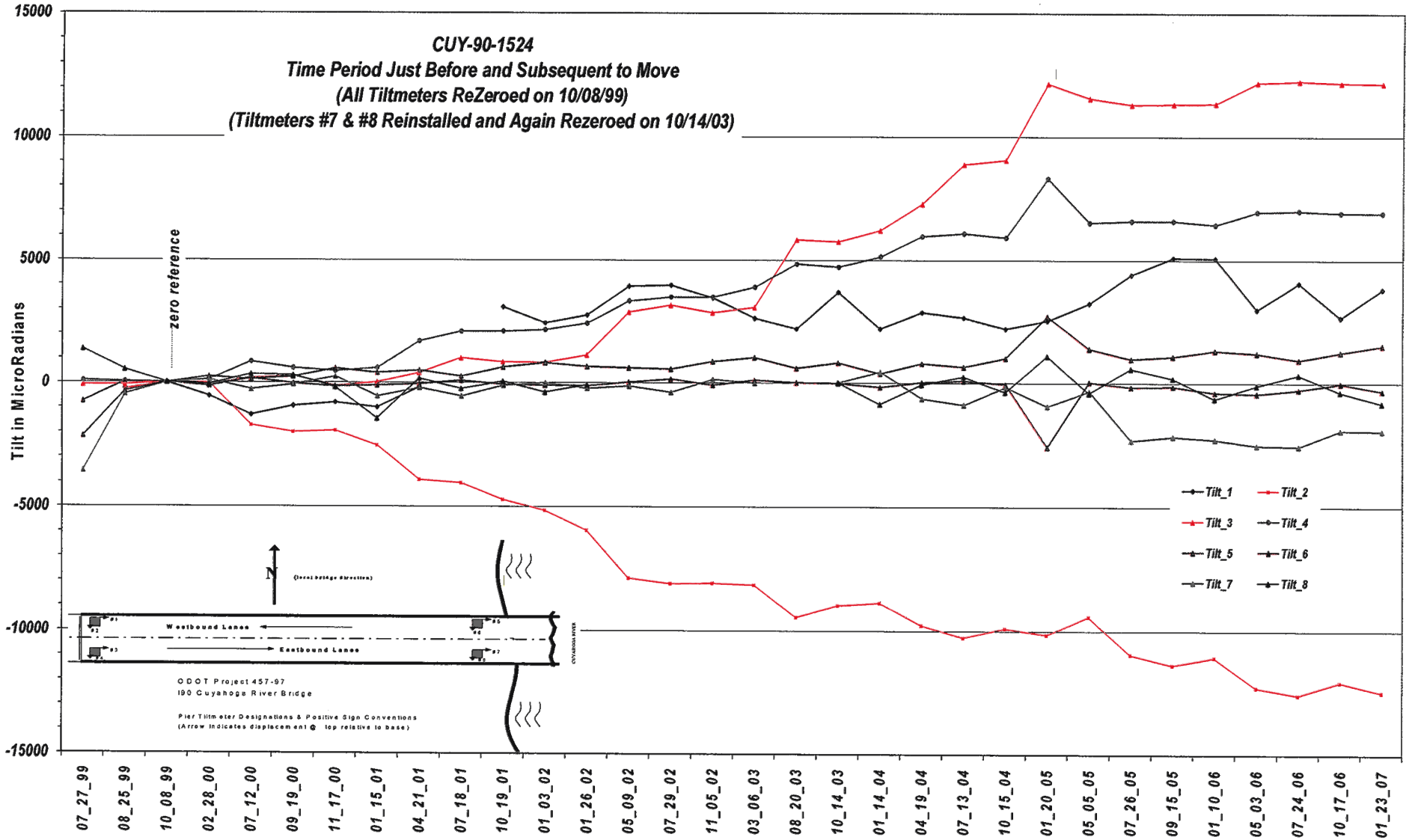
Gentlemen,

The monitoring data collection should be performed about January 15, 2007.

Thank you,
Dean Palmer

Richland Engineering Limited
Mansfield, Ohio
(419)524-0074

This e-mail, including any files transmitted with it, is confidential. It is intended solely for the use of the individual or entity to whom it is addressed. If you are not the intended recipient or the person responsible for delivering the e-mail to the intended recipient, be advised that you have received this e-mail in error, and that any use, dissemination, forwarding, printing, or copying of this e-mail is strictly prohibited.


CUY-90-1524
Time Period Just Before and Subsequent to Move
(All Tiltmeters ReZeroed on 10/08/99)
(Tiltmeters #7 & #8 Reinstalled and Again Rezeroed on 10/14/03)
Tilt in MicroRadians
15000
10000
5000
0
-5000
-10000
-15000
zero reference
Tilt_1
Tilt_2
Tilt_3
Tilt_4
Tilt_5
Tilt_6
Tilt_7
Tilt_8
N
Westbound Lanes
Eastbound Lanes
ODOT Project 457-97
I90 Cuyahoga River Bridge
Pier Tiltmeter Designations & Positive Sign Conventions
(Arrow indicates displacement @ top relative to base)
07_27_99
08_25_99
10_08_99
02_28_00
07_12_00
09_19_00
11_17_00
01_15_01
04_21_01
07_18_01
10_19_01
01_03_02
01_26_02
05_09_02
07_29_02
11_05_02
03_06_03
08_20_03
10_14_03
01_14_04
04_19_04
07_13_04
10_15_04
01_20_05
05_05_05
07_26_05
09_15_05
01_10_06
05_03_06
07_24_06
10_17_06
01_23_07

Robert Y. Liang, Ph.D., P.E
8441 Timber Tr.
Brecksville, Ohio 44141

Cell Phone: (440) 725-7425
e-mail: RYLIANG@AOL.COM

January 29, 2007

Mr. Dean Palmer, P.E.
Richland Engineering, Ltd.
29 North Park St.
Mansfield, OH 44902

Ref: CUY-90-14.52, PID No. 77332

Dear Mr. Palmer:

Attached in this letter is the processed monitoring data for the stabilization structures at the referenced project site. We went to the site on January 17 and January 18 to download the data and to take the inclinometer readings. The on-site data logger was maintained and the batteries were replaced as well.

As can be seen from the processed data, there was no noticeable significant changes in the strain readings during the quarter between October 2006 and December 2006. The inclinometer readings showed that there was no significant movement occurred in this quarter.

Please call me at (440) 725-7425, if you have any question.

Sincerely,

Robert Liang

RECEIVED
JAN 30 2007
RICHLAND ENGINEERING LIMITED

Tie Beam Forces and Bending Moments (Driven Pile Cap side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	-47.1	68.5	551.7	681.8	313.73	10.70	616.75	252.30	375.15	83.06	-40.28	-2.75
	7/15/1999	-70.1	53.8	538.8	666.8	297.33	-8.15	602.80	234.35	360.30	78.72	-40.60	-2.82
	8/15/1999	10.7	114.3	613.7	728.1	366.70	62.50	670.90	312.20	421.20	97.09	-40.43	-2.44
	8/31/1999	12.0	114.3	617.3	732.8	369.10	63.15	675.05	314.65	423.55	97.73	-40.67	-2.44
	9/15/1999	13.1	113.5	619.7	737.5	370.95	63.30	678.60	316.40	425.50	98.22	-40.89	-2.44
	9/30/1999	29.6	122.3	634.4	753.4	384.93	75.95	693.90	332.00	437.85	101.92	-41.07	-2.37
	10/15/1999	34.7	123.9	637.8	757.9	388.58	79.30	697.85	336.25	440.90	102.88	-41.11	-2.34
	10/31/1999	39.8	127.2	646.6	762	393.90	83.50	704.30	343.20	444.60	104.29	-41.26	-2.27
	11/15/1999	62.3	139.3	662.9	780.1	411.15	100.80	721.50	362.60	459.70	108.86	-41.25	-2.18
	11/30/1999	73.7	146.3	670.6	788.6	419.80	110.00	729.60	372.15	467.45	111.15	-41.18	-2.13
	12/15/1999	72.8	143.6	668.9	789.7	418.75	108.20	729.30	370.85	466.65	110.87	-41.28	-2.15
	12/31/1999	88.8	152.1	680.1	802.5	430.88	120.45	741.30	384.45	477.30	114.08	-41.26	-2.08
	3/31/2000	95.3	158.7	682.5	825.2	440.43	127.00	753.85	388.90	491.95	116.61	-41.66	-2.31
	6/30/2000	60.2	138.2	662.7	804.5	416.40	99.20	733.60	361.45	471.35	110.25	-42.16	-2.46
	9/30/2000	50.1	142.5	668.8	795.7	414.28	96.30	732.25	359.45	469.10	109.69	-42.26	-2.46
	1/13/2001	109.5	179.9	712.3	845.5	461.80	144.70	778.90	410.90	512.70	122.27	-42.15	-2.28
	4/20/2001	126.8	283.2	715.3	881.9	501.80	205.00	798.60	421.05	582.55	132.86	-39.45	-3.62
	7/16/2001	68.3	149.8	674.3	837.1	432.38	109.05	755.70	371.30	493.45	114.48	-42.98	-2.74
	10/9/2001	71.4	157.1	685.5	840.8	438.70	114.25	763.15	378.45	498.95	116.15	-43.12	-2.70
	1/9/2002	102.7	177.8	713	872	466.38	140.25	792.50	407.85	524.90	123.48	-43.35	-2.62
1	4/12/2002	125.5	192.8	738.6	904.9	490.45	159.15	821.75	432.05	548.85	129.86	-44.04	-2.62
	7/18/2002	62.3	151.8	706.334	859.6	445.01	107.05	782.97	384.32	505.70	117.82	-44.92	-2.72
	10/8/2002	43.7	151.1	711.3	846.7	438.20	97.40	779.00	377.50	498.90	116.02	-45.30	-2.72
	1/8/2003	84.7	180.5	748.5	891.8	476.38	132.60	820.15	416.60	536.15	126.13	-45.69	-2.68
	4/15/2003	96.1	191.9	739.9	989.3	504.30	144.00	864.60	418.00	590.60	133.52	-47.89	-3.87
	7/1/2003	57.4	168	713	959	474.35	112.70	836.00	385.20	563.50	125.59	-48.07	-3.99
	10/7/2003	42.1	166.8	714	946.6	467.38	104.45	830.30	378.05	556.70	123.75	-48.24	-4.00
	12/31/2003	80	197.9	753.9	985.1	504.23	138.95	869.50	416.95	591.50	133.50	-48.55	-3.91
	4/13/2004	92	208.9	760.4	1006.6	516.98	150.45	883.50	426.20	607.75	136.88	-48.72	-4.07
	7/13/2004	14.6	163.9	707.3	954.4	460.05	89.25	830.85	360.95	559.15	121.81	-49.29	-4.44
	10/8/2004	-8.6	233.4	704.6	941	467.60	112.40	822.80	348.00	587.20	123.81	-47.21	-5.36
	1/7/2005	19.5	190.4	746.5	982.5	484.73	104.95	864.50	383.00	586.45	128.34	-50.48	-4.56
	4/8/2005	3.4	397.6	751.6	1003.4	539.00	200.50	877.50	377.50	700.50	142.71	-44.99	-7.24
	7/18/2005	3.1	164.3	709.7	969.6	461.68	83.70	839.65	356.40	566.95	122.24	-50.24	-4.72
	8/26/2005	3.1	157.5	702.5	956.3	454.85	80.30	829.40	352.80	556.90	120.43	-49.78	-4.57
	10/11/2005	3.1	164.2	712.6	960.1	460.00	83.65	836.35	357.85	562.15	121.79	-50.02	-4.58
	1/10/2006	3.1	191.9	742.5	997	483.63	97.50	869.75	372.80	594.45	128.05	-51.32	-4.97
	4/9/2006	3.5	205.3	750.7	1018.8	494.58	104.40	884.75	377.10	612.05	130.95	-51.86	-5.26
	7/19/2006	3.5	166.6	703.7	975.5	462.33	85.05	839.60	353.60	571.05	122.41	-50.15	-4.87
	10/18/2006	3.5	170.2	709	967.5	462.55	86.85	838.25	356.25	568.85	122.47	-49.94	-4.76
	1/18/2007	3.5	209.1	748.7	1013.1	493.60	106.30	880.90	376.10	611.10	130.69	-51.48	-5.26

	7/1/1999	374.9	6	549.6	471.8	350.58	190.45	510.70	462.25	238.90	92.82	-21.28	5.00
	7/15/1999	368.6	-3.6	544.2	467.3	344.13	182.50	505.75	456.40	231.85	91.11	-21.48	5.03
	8/15/1999	373.7	0.2	569.4	485.2	357.13	186.95	527.30	471.55	242.70	94.56	-22.62	5.13
	8/31/1999	368.4	-4.7	567	486.2	354.23	181.85	526.60	467.70	240.75	93.79	-22.91	5.08
	9/15/1999	365.9	-9.2	565.3	485.1	351.78	178.35	525.20	465.60	237.95	93.14	-23.05	5.10
	9/30/1999	364.6	-11.7	570.1	487.6	352.65	176.45	528.85	467.35	237.95	93.37	-23.42	5.14
	10/15/1999	361.7	-14.8	569.9	487.4	351.05	173.45	528.65	465.80	236.30	92.95	-23.61	5.14
	10/31/1999	362.8	-13.5	575.6	493.1	354.50	174.65	534.35	469.20	239.80	93.86	-23.91	5.14
	11/15/1999	365.0	-11.5	581.4	498	358.23	176.75	539.70	473.20	243.25	94.85	-24.12	5.15
	11/30/1999	365.6	-11.8	583.7	500.1	359.40	176.90	541.90	474.65	244.15	95.16	-24.26	5.16
	12/15/1999	368.0	-9.2	589.7	504.2	363.18	179.40	546.95	478.85	247.50	96.16	-24.43	5.18
	12/31/1999	369.0	-8	592.9	506.6	365.13	180.50	549.75	480.95	249.30	96.67	-24.54	5.19
	3/31/2000	379.6	7.3	617	524.1	382.00	193.45	570.55	498.30	265.70	101.14	-25.06	5.21
	6/30/2000	376.1	4.4	608.9	519.1	377.13	190.25	564.00	492.50	261.75	99.85	-24.84	5.17
	9/30/2000	360.7	-12.3	588.3	503.5	360.05	174.20	545.90	474.50	245.60	95.33	-24.70	5.13
	1/13/2001	372.1	2.2	618.1	526.1	379.63	187.15	572.10	495.10	264.15	100.51	-25.58	5.17
	4/20/2001	387.6	21	645.8	549.2	400.90	204.30	597.50	516.70	285.10	106.15	-26.13	5.19
	7/16/2001	374.6	6.5	621.5	532.9	383.88	190.55	577.20	498.05	269.70	101.64	-25.70	5.12
	10/9/2001	360.9	-9.4	598.9	515.8	366.55	175.75	557.35	479.90	253.20	97.05	-25.36	5.08
	1/9/2002	363.5	-2.5	611.5	524.5	374.25	180.50	568.00	487.50	261.00	99.09	-25.75	5.07
12	4/12/2002	381.7	16.9	642.7	550.5	397.95	199.30	596.60	512.20	283.70	105.37	-26.40	5.12
	7/18/2002	375	10.5	629	544.7	389.80	192.75	586.85	502.00	277.60	103.21	-26.19	5.03
	10/8/2002	357.7	-9.6	599.2	523	367.58	174.05	561.10	478.45	256.70	97.32	-25.72	4.97
	1/8/2003	367.3	6.5	626.7	542.7	385.80	186.90	584.70	497.00	274.60	102.15	-26.44	4.98
	4/15/2003	385.9	27.3	655.3	566.2	408.68	206.60	610.75	520.60	296.75	108.20	-26.86	5.01
	7/1/2003	384.7	26.3	649.2	565.6	406.45	205.50	607.40	516.95	295.95	107.62	-26.71	4.95
	10/7/2003	360.6	3.5	613	539.7	379.20	182.05	576.35	486.80	271.60	100.40	-26.20	4.82
	12/31/2003	372	19.4	636	558.3	396.43	195.70	597.15	504.00	288.85	104.96	-26.68	4.82
	4/13/2004	389.4	39.8	665.5	583.1	419.45	214.60	624.30	527.45	311.45	111.06	-27.23	4.84
	7/13/2004	379.5	27.7	643.3	571.1	405.40	203.60	607.20	511.40	299.40	107.34	-26.82	4.75
	10/8/2004	361.6	10.3	615.2	550.9	384.50	185.95	583.05	488.40	280.60	101.80	-26.39	4.66
	1/7/2005	367.5	16.1	630.6	561.5	393.93	191.80	596.05	499.05	288.80	104.30	-26.87	4.71
	4/8/2005	388.2	35.6	662.3	587.2	418.33	211.90	624.75	525.25	311.40	110.76	-27.44	4.79
	7/18/2005	382.6	26.3	647.7	580.1	409.18	204.45	613.90	515.15	303.20	108.34	-27.21	4.75
	8/26/2005	373.6	15.7	629.8	566.8	396.48	194.65	598.30	501.70	291.25	104.97	-26.83	4.71
	10/11/2005	365.9	6.1	617.8	557.9	386.93	186.00	587.85	491.85	282.00	102.45	-26.71	4.70
	1/10/2006	376.2	17.5	639	572.2	401.23	196.85	605.60	507.60	294.85	106.23	-27.16	4.77
	4/9/2006	393.8	32.7	665.7	594	421.55	213.25	629.85	529.75	313.35	111.61	-27.69	4.85
	7/19/2006	384.2	20.3	646.2	582.7	408.35	202.25	614.45	515.20	301.50	108.12	-27.39	4.79
	10/18/2006	365	-2	614.4	558.2	383.90	181.50	586.30	489.70	278.10	101.65	-26.90	4.74
	1/18/2007	376	9.6	635.9	573.9	398.85	192.80	604.90	505.95	291.75	105.60	-27.39	4.80

Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	306.3	72.2	490.8	675.2	386.13	189.25	583.00	398.55	373.70	102.23	-26.17	0.56
	7/15/1999	288.0	53.1	484.2	670.6	373.98	170.55	577.40	386.10	361.85	99.02	-27.04	0.54
	8/15/1999	280.9	61.8	506.3	693.7	385.68	171.35	600.00	393.60	377.75	102.12	-28.49	0.36
	8/31/1999	270.4	52.1	503.1	691.4	379.25	161.25	597.25	386.75	371.75	100.41	-28.98	0.34
	9/15/1999	261.3	43.9	501.2	689.9	374.08	152.60	595.55	381.25	366.90	99.04	-29.44	0.32
	9/30/1999	257.1	40.7	503.1	690.7	372.90	148.90	596.90	380.10	365.70	98.73	-29.77	0.32
	10/15/1999	250.1	33.8	501.2	691	369.03	141.95	596.10	375.65	362.40	97.71	-30.18	0.30
	10/31/1999	251.4	38	507.6	697.6	373.65	144.70	602.60	379.50	367.80	98.93	-30.43	0.26
	11/15/1999	253.9	41.6	512.1	701.9	377.38	147.75	607.00	383.00	371.75	99.92	-30.52	0.25
	11/30/1999	253.5	41.2	513.6	704.4	378.18	147.35	609.00	383.55	372.80	100.13	-30.68	0.24
	12/15/1999	255.8	46.7	519.1	709.3	382.73	151.25	614.20	387.45	378.00	101.33	-30.77	0.21
	12/31/1999	256.7	48.9	522.3	712.4	385.08	152.80	617.35	389.50	380.65	101.96	-30.87	0.20
	3/31/2000	267.5	64.6	542.8	734.2	402.28	166.05	638.50	405.15	399.40	106.51	-31.40	0.13
	6/30/2000	258.9	46.4	531.2	726.1	390.65	152.65	628.65	395.05	386.25	103.43	-31.63	0.20
	9/30/2000	237.1	10.1	504.9	705.9	364.50	123.60	605.40	371.00	358.00	96.51	-32.02	0.29
	1/13/2001	254.0	40.9	535.1	734.6	391.15	147.45	634.85	394.55	387.75	103.56	-32.39	0.15
	4/20/2001	275.4	72.6	561.4	763.7	418.28	174.00	662.55	418.40	418.15	110.75	-32.47	0.01
	7/16/2001	255.3	37.7	534.8	740.9	392.18	146.50	637.85	395.05	389.30	103.84	-32.65	0.13
	10/9/2001	235.7	7.5	510.6	719.6	368.35	121.60	615.10	373.15	363.55	97.53	-32.80	0.22
	1/9/2002	240	18.9	523.3	731	378.30	129.45	627.15	381.65	374.95	100.16	-33.08	0.15
13	4/12/2002	263.4	58.5	554.8	763	409.93	160.95	658.90	409.10	410.75	108.54	-33.09	-0.04
	7/18/2002	255.5	40.1	566.1	754.5	404.05	147.80	660.30	410.80	397.30	106.98	-34.06	0.30
	10/8/2002	231.2	3.4	508.7	726.1	367.35	117.30	617.40	369.95	364.75	97.26	-33.24	0.12
	1/8/2003	249.4	38.5	540.1	754.4	395.60	143.95	647.25	394.75	396.45	104.74	-33.45	-0.04
	4/15/2003	276.4	78.5	571.6	784.9	427.85	177.45	678.25	424.00	431.70	113.28	-33.28	-0.17
	7/1/2003	273	69	561.4	779.9	420.83	171.00	670.65	417.20	424.45	111.42	-33.21	-0.16
	10/7/2003	246.6	22.5	524.7	744.6	384.60	134.55	634.65	385.65	383.55	101.83	-33.24	0.05
	12/31/2003	264.8	58.9	552.8	770.1	411.65	161.85	661.45	408.80	414.50	108.99	-33.20	-0.13
	4/13/2004	291.3	97.7	584	803.2	444.05	194.50	693.60	437.65	450.45	117.57	-33.17	-0.29
	7/13/2004	275.5	64.3	556.1	781	419.23	169.90	668.55	415.80	422.65	111.00	-33.14	-0.15
	10/8/2004	252.8	29.9	527.5	755.8	391.50	141.35	641.65	390.15	392.85	103.66	-33.25	-0.06
	1/7/2005	264	50.8	544.5	770.6	407.48	157.40	657.55	404.25	410.70	107.89	-33.24	-0.14
	4/8/2005	289.9	90.7	576	802	439.65	190.30	689.00	432.95	446.35	116.41	-33.14	-0.30
	7/18/2005	277.8	67.7	556.4	787.1	422.25	172.75	671.75	417.10	427.40	111.80	-33.16	-0.23
	8/26/2005	266.7	46.5	539.8	771.9	406.23	156.60	655.85	403.25	409.20	107.56	-33.18	-0.13
	10/11/2005	257.2	33.8	526.8	760.8	394.65	145.50	643.80	392.00	397.30	104.49	-33.12	-0.12
	1/10/2006	269.3	59.9	551.2	780.4	415.20	164.60	665.80	410.25	420.15	109.93	-33.31	-0.22
	4/9/2006	289.9	90	576.3	806.2	440.60	189.95	691.25	433.10	448.10	116.66	-33.32	-0.34
	7/19/2006	277.7	63.9	553.8	787.8	420.80	170.80	670.80	415.75	425.85	111.42	-33.23	-0.23
	10/18/2006	253.3	27.9	523.7	757.8	390.68	140.60	640.75	388.50	392.85	103.44	-33.24	-0.10
	1/18/2007	267.4	54.9	546.5	778.5	411.83	161.15	662.50	406.95	416.70	109.04	-33.32	-0.22

	7/1/1999	445.4	53.9	802	298.7	400.00	249.65	550.35	623.70	176.30	105.91	-19.98	10.02
	7/15/1999	440.5	34.4	799.5	280.7	388.78	237.45	540.10	620.00	157.55	102.94	-20.11	10.36
	8/15/1999	455.6	40.8	837.6	284.6	404.65	248.20	561.10	646.60	162.70	107.14	-20.79	10.84
	8/31/1999	452.7	30.7	837.1	274.1	398.65	241.70	555.60	644.90	152.40	105.55	-20.86	11.03
	9/15/1999	448.5	21.7	836.8	266.2	393.30	235.10	551.50	642.65	143.95	104.13	-21.03	11.17
	9/30/1999	447.0	16.1	838.5	260.8	390.60	231.55	549.65	642.75	138.45	103.42	-21.14	11.30
	10/15/1999	446.5	8.8	839.3	255.1	387.43	227.65	547.20	642.90	131.95	102.58	-21.24	11.45
	10/31/1999	450.9	11.7	847.9	257.8	392.08	231.30	552.85	649.40	134.75	103.81	-21.37	11.53
	11/15/1999	455.9	16.1	856.2	259.8	397.00	236.00	558.00	656.05	137.95	105.11	-21.40	11.61
	11/30/1999	456.3	15.5	858.3	259	397.28	235.90	558.65	657.30	137.25	105.19	-21.45	11.65
	12/15/1999	461.3	20.5	865.6	261.7	402.28	240.90	563.65	663.45	141.10	106.51	-21.45	11.70
	12/31/1999	463.4	22.5	871.6	262.9	405.10	242.95	567.25	667.50	142.70	107.26	-21.55	11.76
	3/31/2000	477.8	35.6	903.8	282.7	424.98	256.70	593.25	690.80	159.15	112.52	-22.37	11.91
	6/30/2000	469.2	17.4	889.7	267.4	410.93	243.30	578.55	679.45	142.40	108.80	-22.28	12.03
	9/30/2000	453.5	-23.5	856.8	240.4	381.80	215.00	548.60	655.15	108.45	101.09	-22.17	12.25
	1/13/2001	476.9	5	891.3	257.6	407.70	240.95	574.45	684.10	131.30	107.95	-22.16	12.38
	4/20/2001	494.8	40.8	932.8	281.2	437.40	267.80	607.00	713.80	161.00	115.81	-22.54	12.38
	7/16/2001	475.7	4.9	900.7	255.9	409.30	240.30	578.30	688.20	130.40	108.37	-22.46	12.50
	10/9/2001	459.3	-30.8	870.4	236.8	383.93	214.25	553.60	664.85	103.00	101.65	-22.55	12.59
	1/9/2002	468.8	-18.5	883.7	241.5	393.88	225.15	562.60	676.25	111.50	104.29	-22.43	12.65
14	4/12/2002	492.8	22.5	926.5	270.2	428.00	257.65	598.35	709.65	146.35	113.32	-22.64	12.62
	7/18/2002	483.5	3.8	911.9	257.3	414.13	243.65	584.60	697.70	130.55	109.65	-22.66	12.71
	10/8/2002	462.7	-35	875.6	233	384.08	213.85	554.30	669.15	99.00	101.69	-22.63	12.77
	1/8/2003	485.5	2.5	912.6	253.9	413.63	244.00	583.25	699.05	128.20	109.52	-22.55	12.79
	4/15/2003	501.9	612.9	952.7	285.1	588.15	557.40	618.90	727.30	449.00	155.72	-4.09	6.23
	7/1/2003	521.6	28.8	943.4	278.1	442.98	275.20	610.75	732.50	153.45	117.29	-22.30	12.97
	10/7/2003	472.3	-16.5	903.8	247.5	401.78	227.90	575.65	688.05	115.50	106.38	-23.11	12.83
	12/31/2003	495.5	18.6	939.3	268.7	430.53	257.05	604.00	717.40	143.65	113.99	-23.06	12.85
	4/13/2004	504.6	68.9	989	299.2	465.43	286.75	644.10	746.80	184.05	123.23	-23.75	12.61
	7/13/2004	487.3	36.7	961.8	277.7	440.88	262.00	619.75	724.55	157.20	116.73	-23.78	12.71
	10/8/2004	468.9	-0.5	928.8	256.4	413.40	234.20	592.60	698.85	127.95	109.46	-23.82	12.79
	1/7/2005	485.2	21.4	952.7	269.7	432.25	253.30	611.20	718.95	145.55	114.45	-23.79	12.85
	4/8/2005	512.9	68.8	998.7	302.5	470.73	290.85	650.60	755.80	185.65	124.63	-23.91	12.77
	7/18/2005	498.2	40	977.1	286.8	450.53	269.10	631.95	737.65	163.40	119.29	-24.11	12.86
	8/26/2005	486.3	17.1	955.5	271.8	432.68	251.70	613.65	720.90	144.45	114.56	-24.05	12.91
	10/11/2005	478.8	2.4	942.6	263.6	421.85	240.60	603.10	710.70	133.00	111.69	-24.09	12.94
	1/10/2006	497.9	28.2	970.6	280.6	444.33	263.05	625.60	734.25	154.40	117.64	-24.09	12.99
	4/9/2006	519.6	65.1	1008.9	306	474.90	292.35	657.45	764.25	185.55	125.74	-24.26	12.96
	7/19/2006	505.7	73.4	984.2	290.7	463.50	289.55	637.45	744.95	182.05	122.72	-23.12	12.61
	10/18/2006	484	-5.7	946.5	265.8	422.65	239.15	606.15	715.25	130.05	111.91	-24.39	13.11
	1/18/2007	503	21.5	974.4	282.5	445.35	262.25	628.45	738.70	152.00	117.92	-24.34	13.14

Tie Beam Forces and Bending Moments (Driven Pile Cap side)(cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	468.3	92.2	387.7	511.7	364.98	280.25	449.70	428.00	301.95	96.63	-11.26	2.82
	7/15/1999	460.1	81	381.5	505.7	357.08	270.55	443.60	420.80	293.35	94.54	-11.50	2.86
	8/15/1999	482.3	96.1	410.7	526	378.78	289.20	468.35	446.50	311.05	100.29	-11.91	3.03
	8/31/1999	490.3	101.9	422.4	535	387.40	296.10	478.70	456.35	318.45	102.57	-12.14	3.09
	9/15/1999	491.0	101.4	426.3	536.4	388.78	296.20	481.35	458.65	318.90	102.94	-12.30	3.13
	9/30/1999	497.9	106.7	434.7	543.6	395.73	302.30	489.15	466.30	325.15	104.78	-12.42	3.16
	10/15/1999	505.0	112.3	443.2	550.9	402.85	308.65	497.05	474.10	331.60	106.66	-12.52	3.19
	10/31/1999	515.6	118.8	452.5	560.9	411.95	317.20	506.70	484.05	339.85	109.07	-12.59	3.23
	11/15/1999	525.0	128.3	463.4	570.2	421.73	326.65	516.80	494.20	349.25	111.66	-12.64	3.25
	11/30/1999	532.5	134.9	471.5	576.8	428.93	333.70	524.15	502.00	355.85	113.57	-12.66	3.27
	12/15/1999	534.1	138.1	476.5	580.2	432.23	336.10	528.35	505.30	359.15	114.44	-12.78	3.27
	12/31/1999	540.4	144.3	484.4	587.2	439.08	342.35	535.80	512.40	365.75	116.25	-12.86	3.29
	3/31/2000	551.1	156	501.3	602.1	452.63	353.55	551.70	526.20	379.05	119.84	-13.17	3.30
	6/30/2000	533.5	137.3	477.6	577.9	431.58	335.40	527.75	505.55	357.60	114.27	-12.78	3.31
	9/30/2000	539.6	136.8	480.7	575.1	433.05	338.20	527.90	510.15	355.95	114.66	-12.61	3.45
	1/13/2001	571.4	169.7	522.7	611.8	468.90	370.55	567.25	547.05	390.75	124.15	-13.07	3.50
	4/20/2001	580.2	184.8	537.9	624.6	481.88	382.50	581.25	559.05	404.70	127.59	-13.21	3.46
	7/16/2001	555.8	159.1	508	598.6	455.38	357.45	553.30	531.90	378.85	120.57	-13.02	3.43
	10/9/2001	556.2	154.1	506	595.8	453.03	355.15	550.90	531.10	374.95	119.95	-13.01	3.50
	1/9/2002	572	170.3	527.3	614.7	471.08	371.15	571.00	549.65	392.50	124.73	-13.28	3.52
26	4/12/2002	584.6	187.7	546.3	632.8	487.85	386.15	589.55	565.45	410.25	129.17	-13.52	3.48
	7/18/2002	559.5	162.1	516.1	606	460.93	360.80	561.05	537.80	384.05	122.04	-13.31	3.44
	10/8/2002	557	154.4	511	599.8	455.55	355.70	555.40	534.00	377.10	120.62	-13.27	3.51
	1/8/2003	591	189.2	552.8	639	493.00	390.10	595.90	571.90	414.10	130.53	-13.68	3.54
	4/15/2003	597.9	204.3	567.5	650.5	505.05	401.10	609.00	582.70	427.40	133.72	-13.82	3.48
	7/1/2003	580.7	184.3	545.4	632.5	485.73	382.50	588.95	563.05	408.40	128.61	-13.72	3.46
	10/7/2003	578.2	176.3	538	627	479.88	377.25	582.50	558.10	401.65	127.06	-13.64	3.50
	12/31/2003	610.3	207.7	572.6	661.6	513.05	409.00	617.10	591.45	434.65	135.84	-13.83	3.51
	4/13/2004	617.1	224.2	589.5	675.7	526.63	420.65	632.60	603.30	449.95	139.43	-14.09	3.44
	7/13/2004	584	186.6	549.1	642.6	490.58	385.30	595.85	566.55	414.60	129.89	-13.99	3.40
	10/8/2004	581.8	181.2	543.7	638.3	486.25	381.50	591.00	562.75	409.75	128.74	-13.92	3.43
	1/7/2005	609.9	209	574.8	669.1	515.70	409.45	621.95	592.35	439.05	136.54	-14.12	3.43
	4/8/2005	617.5	225	590.2	683.9	529.15	421.25	637.05	603.85	454.45	140.10	-14.34	3.35
	7/18/2005	590.4	192.7	554.7	656	498.45	391.55	605.35	572.55	424.35	131.97	-14.21	3.32
	8/26/2005	584.4	183.1	544	647.8	489.83	383.75	595.90	564.20	415.45	129.69	-14.10	3.33
	10/11/2005	589.3	185.9	548.5	652	493.93	387.60	600.25	568.90	418.95	130.78	-14.13	3.36
	1/10/2006	616	216.1	582.8	683.4	524.58	416.05	633.10	599.40	449.75	138.89	-14.42	3.35
	4/9/2006	629	235.4	605.8	701.1	542.83	432.20	653.45	617.40	468.25	143.72	-14.70	3.34
	7/19/2006	595.8	199	563.1	668.3	506.55	397.40	615.70	579.45	433.65	134.12	-14.51	3.27
	10/18/2006	595.6	193	557.4	662.8	502.20	394.30	610.10	576.50	427.90	132.97	-14.34	3.33
	1/18/2007	622.2	223.4	590.2	694.6	532.60	422.80	642.40	606.20	459.00	141.02	-14.59	3.30

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	-115.0	299.7	422.9	109.6	179.30	92.35	266.25	153.95	204.65	47.47	-11.56	-1.14
	7/15/1999	-122.0	289	405.2	95.6	166.95	83.50	250.40	141.60	192.30	44.20	-11.09	-1.14
	8/15/1999	-139.4	265.8	401.5	101.8	157.43	63.20	251.65	131.05	183.80	41.68	-12.52	-1.18
	8/31/1999	-144.1	258.4	394.7	99.6	152.15	57.15	247.15	125.30	179.00	40.28	-12.63	-1.20
	9/15/1999	-144.1	255.9	395.1	102	152.23	55.90	248.55	125.50	178.95	40.30	-12.80	-1.20
	9/30/1999	-141.7	260.4	408.3	112.3	159.83	59.35	260.30	133.30	186.35	42.32	-13.35	-1.19
	10/15/1999	-138.1	275.3	441.9	138.4	179.38	68.60	290.15	151.90	206.85	47.49	-14.72	-1.23
	10/31/1999	-148.1	272.7	430.1	118.5	168.30	62.30	274.30	141.00	195.60	44.56	-14.09	-1.22
	11/15/1999	-142.3	278.9	446.6	134.9	179.53	68.30	290.75	152.15	206.90	47.53	-14.78	-1.23
	11/30/1999	-137.9	284.4	462	150.8	189.83	73.25	306.40	162.05	217.60	50.26	-15.49	-1.24
	12/15/1999	-135.4	290	463.8	152.5	192.73	77.30	308.15	164.20	221.25	51.03	-15.34	-1.28
	12/31/1999	-126.8	301.4	481.4	168.9	206.23	87.30	325.15	177.30	235.15	54.60	-15.81	-1.30
	3/31/2000	-133.9	283.1	455.7	149.6	188.63	74.60	302.65	160.90	216.35	49.94	-15.16	-1.24
	6/30/2000	-157.3	230.6	397.4	119.3	147.50	36.65	258.35	120.05	174.95	39.05	-14.73	-1.23
	9/30/2000	-142.8	237.4	427.4	156.8	169.70	47.30	292.10	142.30	197.10	44.93	-16.27	-1.23
	1/13/2001	-118.2	295.4	511.7	182.5	217.85	88.60	347.10	196.75	238.95	57.68	-17.18	-0.95
	4/20/2001	-128.9	270.9	454	163.4	189.85	71.00	308.70	162.55	217.15	50.27	-15.80	-1.22
	7/16/2001	-146.4	213.9	384.1	133.3	146.23	33.75	258.70	118.85	173.60	38.72	-14.95	-1.23
	10/9/2001	-135.7	237.5	439.4	178.3	179.88	50.90	308.85	151.85	207.90	47.63	-17.14	-1.26
	1/9/2002	-120.2	281.4	483	190.7	208.73	80.60	336.85	181.40	236.05	55.26	-17.03	-1.22
1	4/12/2002	-133.2	263.6	441.1	154.2	181.43	65.20	297.65	153.95	208.90	48.04	-15.45	-1.23
	7/18/2002	-158.1	191.2	355.6	118	126.68	16.55	236.80	98.75	154.60	33.54	-14.64	-1.25
	10/7/2002	-149.2	192.4	391.7	156.3	147.80	21.60	274.00	121.25	174.35	39.13	-16.77	-1.19
	1/8/2003	-123.2	268.7	469.3	191.8	201.65	72.75	330.55	173.05	230.25	53.39	-17.13	-1.28
	4/15/2003	-137.5	248.4	427.1	157.1	173.78	55.45	292.10	144.80	202.75	46.01	-15.73	-1.30
	7/1/2003	-159.7	183.9	351.2	124.6	125.00	12.10	237.90	95.75	154.25	33.10	-15.01	-1.31
	10/7/2003	-146.6	206.4	412.6	177.8	162.55	29.90	295.20	133.00	192.10	43.04	-17.63	-1.32
	12/31/2003	-135.4	243.4	450.4	190	187.10	54.00	320.20	157.50	216.70	49.54	-17.69	-1.33
	4/13/2004	-144.6	228.6	422.1	168	168.53	42.00	295.05	138.75	198.30	44.62	-16.82	-1.33
	7/13/2004	-179.1	155.6	334.2	117.5	107.05	-11.75	225.85	77.55	136.55	28.34	-15.79	-1.32
	10/8/2004	-169	170.9	373.7	152.9	132.13	0.95	263.30	102.35	161.90	34.98	-17.44	-1.33
	1/7/2005	-145.5	227.8	440.5	188.2	177.75	41.15	314.35	147.50	208.00	47.06	-18.16	-1.36
	4/8/2005	-159.4	209.2	398.5	148.8	149.28	24.90	273.65	119.55	179.00	39.52	-16.53	-1.33
	7/18/2005	-182.8	141.5	330.3	131.3	105.08	-20.65	230.80	73.75	136.40	27.82	-16.71	-1.40
	8/26/2005	-184	140.7	341.3	131.3	107.33	-21.65	236.30	78.65	136.00	28.42	-17.14	-1.28
	10/11/2005	-174.2	159.1	370.9	131.3	121.78	-7.55	251.10	98.35	145.20	32.24	-17.19	-1.05
	1/10/2006	-152.5	216.4	430.7	131.3	156.48	31.95	281.00	139.10	173.85	41.43	-16.55	-0.78
	4/9/2006	-157.2	206.1	413	131.3	148.30	24.45	272.15	127.90	168.70	39.27	-16.46	-0.91
	7/19/2006	-189.4	135.9	330	131.3	101.95	-26.75	230.65	70.30	133.60	26.99	-17.11	-1.42
	10/18/2006	-170.5	170.2	390.6	131.3	130.40	-0.15	260.95	110.05	150.75	34.53	-17.35	-0.91
	1/18/2007	-145.4	217.2	448.1	131.3	162.80	35.90	289.70	151.35	174.25	43.10	-16.87	-0.51

	7/1/1999	356.2	257	201.2	275.1	272.38	306.60	238.15	278.70	266.05	72.12	4.55	0.28
	7/15/1999	353.8	251.6	188.4	273.4	266.80	302.70	230.90	271.10	262.50	70.64	4.77	0.19
	8/15/1999	350.0	242.8	195.3	301.1	272.30	296.40	248.20	272.65	271.95	72.10	3.20	0.02
	8/31/1999	350.2	247.8	201.7	307.9	276.90	299.00	254.80	275.95	277.85	73.31	2.94	-0.04
	9/15/1999	349.8	249.1	203.6	314	279.13	299.45	258.80	276.70	281.55	73.90	2.70	-0.11
	9/30/1999	352.2	256.8	212.1	322.7	285.95	304.50	267.40	282.15	289.75	75.71	2.47	-0.17
	10/15/1999	352.6	257.7	225.5	337.3	293.28	305.15	281.40	289.05	297.50	77.65	1.58	-0.19
	10/31/1999	361.0	268.5	222.6	333.7	296.45	314.75	278.15	291.80	301.10	78.49	2.43	-0.21
	11/15/1999	364.5	273.1	237.1	353.6	307.08	318.80	295.35	300.80	313.35	81.30	1.56	-0.28
	11/30/1999	367.6	276.3	249.1	369.4	315.60	321.95	309.25	308.35	322.85	83.56	0.84	-0.32
	12/15/1999	370.6	280.7	248.5	364.3	316.03	325.65	306.40	309.55	322.50	83.67	1.28	-0.29
	12/31/1999	371.2	282.5	254.8	368.8	319.33	326.85	311.80	313.00	325.65	84.55	1.00	-0.28
	3/31/2000	376.0	289.2	244.7	361.1	317.75	332.60	302.90	310.35	325.15	84.13	1.97	-0.33
	6/30/2000	358.4	247.7	207.4	329.3	285.70	303.05	268.35	282.90	288.50	75.64	2.31	-0.13
	9/30/2000	357.6	235.9	230.1	366.4	297.50	296.75	298.25	293.85	301.15	78.77	-0.10	-0.16
	1/13/2001	382.0	289.5	264.4	384.8	330.18	335.75	324.60	323.20	337.15	87.42	0.74	-0.31
	4/20/2001	382.9	294.9	260.1	378.2	329.03	338.90	319.15	321.50	336.55	87.12	1.31	-0.34
	7/16/2001	352.4	249.4	219.2	330.6	287.90	300.90	274.90	285.80	290.00	76.23	1.73	-0.09
	10/9/2001	357.7	267.9	262.1	382	317.43	312.80	322.05	309.90	324.95	84.04	-0.61	-0.34
	1/9/2002	385.8	301.2	285.1	395.6	341.93	343.50	340.35	335.45	348.40	90.53	0.21	-0.29
12	4/12/2002	390.9	310.2	263.2	370.1	333.60	350.55	316.65	327.05	340.15	88.33	2.25	-0.29
	7/18/2002	346.39	265.03	220.4	323.3	288.78	305.71	271.85	283.39	294.17	76.46	2.25	-0.24
	10/7/2002	344.5	265.3	252.4	363.5	306.43	304.90	307.95	298.45	314.40	81.13	-0.20	-0.36
	1/8/2003	385.9	308.5	295.9	394.3	346.15	347.20	345.10	340.90	351.40	91.65	0.14	-0.24
	4/15/2003	392.4	317.3	275.8	371.1	339.15	354.85	323.45	334.10	344.20	89.80	2.09	-0.23
	7/1/2003	360	288.1	238.7	332.8	304.90	324.05	285.75	299.35	310.45	80.73	2.55	-0.25
	10/7/2003	357.1	284.5	277.7	372.1	322.85	320.80	324.90	317.40	328.30	85.48	-0.27	-0.24
	12/31/2003	387.7	318.7	304.1	392.5	350.75	353.20	348.30	345.90	355.60	92.87	0.33	-0.22
	4/13/2004	389.4	324.2	294.9	381.2	347.43	356.80	338.05	342.15	352.70	91.99	1.25	-0.24
	7/13/2004	348	285.8	241	324.8	299.90	316.90	282.90	294.50	305.30	79.40	2.26	-0.24
	10/8/2004	342.4	281.8	269.4	353.1	311.68	312.10	311.25	305.90	317.45	82.52	0.06	-0.26
	1/7/2005	374.1	315.2	302.9	382.8	343.75	344.65	342.85	338.50	349.00	91.01	0.12	-0.24
	4/8/2005	386.7	328.9	284.3	365	341.23	357.80	324.65	335.50	346.95	90.35	2.20	-0.26
	7/18/2005	343.2	285.5	242.4	322.1	298.30	314.35	282.25	292.80	303.80	78.98	2.13	-0.25
	8/26/2005	337	278.7	250.1	331.1	299.23	307.85	290.60	293.55	304.90	79.23	1.15	-0.25
	10/11/2005	338.7	283.6	264.1	348.6	308.75	311.15	306.35	301.40	316.10	81.75	0.32	-0.33
	1/10/2006	371.5	317.4	297	373.5	339.85	344.45	335.25	334.25	345.45	89.98	0.61	-0.25
	4/9/2006	377.4	324.1	290.6	368.2	340.08	350.75	329.40	334.00	346.15	90.04	1.42	-0.27
	7/19/2006	341.9	289.2	238.8	315.3	296.30	315.55	277.05	290.35	302.25	78.45	2.56	-0.27
	10/18/2006	342.7	289.5	274.8	354.5	315.38	316.10	314.65	308.75	322.00	83.50	0.10	-0.30
	1/18/2007	368.4	316.6	305.5	385	343.88	342.50	345.25	336.95	350.80	91.05	-0.18	-0.31

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	177.4	380.2	417.6	236.2	302.85	278.80	326.90	297.50	308.20	80.19	-3.20	-0.24
	7/15/1999	173.8	378	412.7	230.2	298.68	275.90	321.45	293.25	304.10	79.08	-3.03	-0.24
	8/15/1999	172.8	380.2	439.6	252.6	311.30	276.50	346.10	306.20	316.40	82.42	-4.63	-0.23
	8/31/1999	172.6	378	445.8	257.5	313.48	275.30	351.65	309.20	317.75	83.00	-5.07	-0.19
	9/15/1999	170.9	377.2	447.2	261	314.08	274.05	354.10	309.05	319.10	83.16	-5.32	-0.23
	9/30/1999	176.4	380.7	455.9	269.3	320.58	278.55	362.60	316.15	325.00	84.88	-5.59	-0.20
	10/15/1999	176.7	378.9	468.1	279.5	325.80	277.80	373.80	322.40	329.20	86.26	-6.38	-0.15
	10/31/1999	182.4	385.8	502.1	273.8	336.03	284.10	387.95	342.25	329.80	88.97	-6.90	0.28
	11/15/1999	186.8	392.4	482.7	292	338.48	289.60	387.35	334.75	342.20	89.62	-6.50	-0.17
	11/30/1999	189.8	396.8	638.9	305.6	382.78	293.30	472.25	414.35	351.20	101.35	-11.89	1.41
	12/15/1999	193.5	401.1	516.7	302.2	353.38	297.30	409.45	355.10	351.65	93.56	-7.45	0.08
	12/31/1999	194.7	406.1	507.2	308	354.00	300.40	407.60	350.95	357.05	93.73	-7.12	-0.14
	3/31/2000	194.8	409	492.7	298.7	348.80	301.90	395.70	343.75	353.85	92.35	-6.23	-0.23
	6/30/2000	177.7	389.4	467.2	278.7	328.25	283.55	372.95	322.45	334.05	86.91	-5.94	-0.26
	9/30/2000	174.2	385.1	496.7	308	341.00	279.65	402.35	335.45	346.55	90.29	-8.15	-0.25
	1/13/2001	200.0	418.2	530.3	318.6	366.78	309.10	424.45	365.15	368.40	97.11	-7.67	-0.07
	4/20/2001	194.1	416.2	512.8	310.6	358.43	305.15	411.70	353.45	363.40	94.90	-7.08	-0.22
	7/16/2001	166.5	386.2	469	273.8	323.88	276.35	371.40	317.75	330.00	85.75	-6.32	-0.27
	10/9/2001	171.5	389.1	514.8	315.2	347.65	280.30	415.00	343.15	352.15	92.05	-8.95	-0.20
	1/9/2002	193.6	413.6	539.3	324.6	367.78	303.60	431.95	366.45	369.10	97.38	-8.53	-0.06
13	4/12/2002	198.8	418.5	509.3	299.2	356.45	308.65	404.25	354.05	358.85	94.38	-6.35	-0.11
	7/18/2002	161.4	379.1	462.4	262.6	316.38	270.25	362.50	311.90	320.85	83.77	-6.13	-0.20
	10/7/2002	155.8	373.6	686.8	301.1	379.33	264.70	493.95	421.30	337.35	100.43	-15.24	1.88
	1/8/2003	193.1	414	547.6	331	371.43	303.55	439.30	370.35	372.50	98.34	-9.02	-0.05
	4/15/2003	195.8	419.9	560.6	305.7	370.50	307.85	433.15	378.20	362.80	98.10	-8.33	0.34
	7/1/2003	172.1	394.8	479.4	273.9	330.05	283.45	376.65	325.75	334.35	87.39	-6.19	-0.19
	10/7/2003	169	389.1	527.1	317.5	350.68	279.05	422.30	348.05	353.30	92.85	-9.52	-0.12
	12/31/2003	196.2	423.2	560.3	334.7	378.60	309.70	447.50	378.25	378.95	100.24	-9.16	-0.02
	4/13/2004	197.9	424.7	546.1	321.7	372.60	311.30	433.90	372.00	373.20	98.65	-8.15	-0.03
	7/13/2004	155.6	383.5	482.7	266.1	321.98	269.55	374.40	319.15	324.80	85.25	-6.97	-0.13
	10/8/2004	152.2	378.4	519	298.6	337.05	265.30	408.80	335.60	338.50	89.24	-9.54	-0.06
	1/7/2005	180.6	410.6	556.1	324.9	368.05	295.60	440.50	368.35	367.75	97.45	-9.63	0.01
	4/8/2005	188.3	419.5	529.1	301	359.48	303.90	415.05	358.70	360.25	95.18	-7.39	-0.03
	7/18/2005	150.7	376.8	482.9	262.2	318.15	263.75	372.55	316.80	319.50	84.24	-7.23	-0.06
	8/26/2005	144.7	373.1	494.1	275.3	321.80	258.90	384.70	319.40	324.20	85.20	-8.36	-0.11
	10/11/2005	146.5	375.2	533.7	291.5	336.73	260.85	412.60	340.10	333.35	89.15	-10.09	0.15
	1/10/2006	176	407.1	548.8	313.5	361.35	291.55	431.15	362.40	360.30	95.67	-9.28	0.05
	4/9/2006	180.6	412.1	538.7	307.8	359.80	296.35	423.25	359.65	359.95	95.26	-8.43	-0.01
	7/19/2006	149.4	377.4	480.1	259.8	316.68	263.40	369.95	314.75	318.60	83.85	-7.08	-0.09
	10/18/2006	155.2	382.8	532.6	304.1	343.68	269.00	418.35	343.90	343.45	90.99	-9.93	0.01
	1/18/2007	179.5	407.9	563.5	330.9	370.45	293.70	447.20	371.50	369.40	98.08	-10.20	0.05

	7/1/1999	199.5	418.4	473.6	323.8	353.83	308.95	398.70	336.55	371.10	93.68	-5.96	-0.77
	7/15/1999	194.3	414.4	461.1	314.4	346.05	304.35	387.75	327.70	364.40	91.62	-5.54	-0.82
	8/15/1999	191.0	402.1	488.7	347.5	357.33	296.55	418.10	339.85	374.80	94.61	-8.08	-0.78
	8/31/1999	189.5	395.4	496	352.6	358.38	292.45	424.30	342.75	374.00	94.89	-8.76	-0.70
	9/15/1999	186.8	391.6	503.6	359.8	360.45	289.20	431.70	345.20	375.70	95.44	-9.47	-0.68
	9/30/1999	188.5	396.7	516	369	367.55	292.60	442.50	352.25	382.85	97.32	-9.96	-0.69
	10/15/1999	235.3	403	530.4	378.9	386.90	319.15	454.65	382.85	390.95	102.44	-9.01	-0.18
	10/31/1999	202.7	418.5	524.2	371.5	379.23	310.60	447.85	363.45	395.00	100.41	-9.12	-0.71
	11/15/1999	208.9	426.2	548.2	393.2	394.13	317.55	470.70	378.55	409.70	104.35	-10.18	-0.70
	11/30/1999	212.9	429.2	566.6	409.5	404.55	321.05	488.05	389.75	419.35	107.11	-11.10	-0.66
	12/15/1999	216.9	433.5	561.4	403.7	403.88	325.20	482.55	389.15	418.60	106.93	-10.46	-0.66
	12/31/1999	220.7	443.8	566.6	407.4	409.63	332.25	487.00	393.65	425.60	108.46	-10.28	-0.72
	3/31/2000	215.2	438.2	567.9	406.5	406.95	326.70	487.20	391.55	422.35	107.75	-10.67	-0.69
	6/30/2000	191.3	415.8	542.4	380.7	382.55	303.55	461.55	366.85	398.25	101.29	-10.50	-0.70
	6/30/2000	183.3	409.8	571	409.9	393.50	296.55	490.45	377.15	409.85	104.19	-12.89	-0.73
	1/13/2001	215.4	447.2	588.9	421.9	418.35	331.30	505.40	402.15	434.55	110.77	-11.57	-0.73
	4/20/2001	210.2	445.1	586.6	415.7	414.40	327.65	501.15	398.40	430.40	109.72	-11.53	-0.72
	7/16/2001	171.2	413	554.5	377.7	379.10	292.10	466.10	362.85	395.35	100.37	-11.56	-0.73
	10/9/2001	178.5	417.9	596.2	418.8	402.85	298.20	507.50	387.35	418.35	106.66	-13.91	-0.69
	1/9/2002	206.2	445.9	606.4	430	422.13	326.05	518.20	406.30	437.95	111.77	-12.77	-0.71
14	4/12/2002	208.6	449.5	584.1	408.1	412.58	329.05	496.10	396.35	428.80	109.24	-11.10	-0.73
	7/18/2002	161.7	410.1	551.9	368.5	373.05	285.90	460.20	356.80	389.30	98.77	-11.58	-0.73
	10/7/2002	160.2	405.5	592.3	407.7	391.43	282.85	500.00	376.25	406.60	103.64	-14.43	-0.68
	1/8/2003	202	449.1	620.2	437.7	427.25	325.55	528.95	411.10	443.40	113.12	-13.52	-0.72
	4/15/2003	205.4	453.6	590	409.8	414.70	329.50	499.90	397.70	431.70	109.80	-11.32	-0.76
	7/1/2003	171.9	426.9	559.5	377.3	383.90	299.40	468.40	365.70	402.10	101.65	-11.23	-0.82
	10/7/2003	172	424.4	600.8	422.4	404.90	298.20	511.60	386.40	423.40	107.21	-14.18	-0.83
	12/31/2003	205.6	461.3	624.2	444.9	434.00	333.45	534.55	414.90	453.10	114.91	-13.36	-0.86
	4/13/2004	204.7	463.4	611.5	433.1	428.18	334.05	522.30	408.10	448.25	113.37	-12.51	-0.90
	7/13/2004	159.6	424.2	566.4	383.7	383.48	291.90	475.05	363.00	403.95	101.53	-12.17	-0.92
	10/8/2004	153	416.8	590.5	409.5	392.45	284.90	500.00	371.75	413.15	103.91	-14.30	-0.93
	1/7/2005	192.8	454.9	627.8	446.9	430.60	323.85	537.35	410.30	450.90	114.01	-14.19	-0.91
	4/8/2005	205.2	467.5	600.9	425.2	424.70	336.35	513.05	403.05	446.35	112.45	-11.74	-0.97
	7/18/2005	154.9	424.1	560.9	385.2	381.28	289.50	473.05	357.90	404.65	100.95	-12.20	-1.05
	8/26/2005	168.3	416.1	569.1	391.2	386.18	292.20	480.15	368.70	403.65	102.25	-12.49	-0.78
	10/11/2005	152.5	418.5	590.5	413.4	393.73	285.50	501.95	371.50	415.95	104.25	-14.38	-1.00
	1/10/2006	190.7	455.4	615	436.7	424.45	323.05	525.85	402.85	446.05	112.38	-13.48	-0.97
	4/9/2006	196.7	460.2	612.3	436.6	426.45	328.45	524.45	404.50	448.40	112.91	-13.03	-0.98
	7/19/2006	159.7	426.1	562.3	382.1	382.55	292.90	472.20	361.00	404.10	101.29	-11.92	-0.97
	10/18/2006	161.9	425.9	600.5	422.5	402.70	293.90	511.50	381.20	424.20	106.62	-14.46	-0.96
	1/18/2007	192.2	454.2	638.5	460	436.23	323.20	549.25	415.35	457.10	115.50	-15.02	-0.94

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

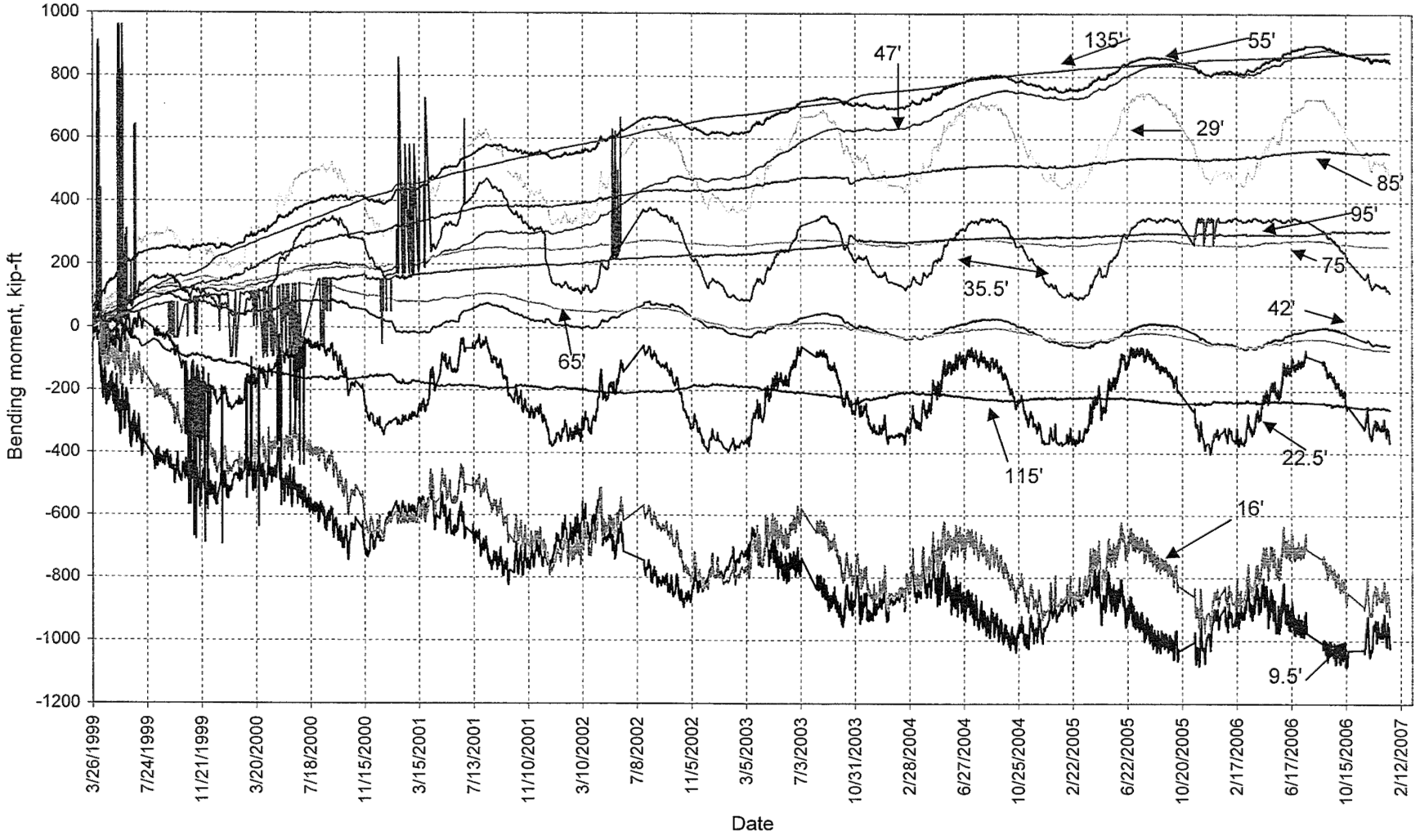
Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	222.2	-19.9	305.2	560	266.88	101.15	432.60	263.70	270.05	70.66	-22.03	-0.14
	7/15/1999	207.8	-36.8	294.3	540.9	251.55	85.50	417.60	251.05	252.05	66.60	-22.07	-0.02
	8/15/1999	189.9	-53.4	320.4	546.8	250.93	68.25	433.60	255.15	246.70	66.44	-24.28	0.19
	8/31/1999	184.8	-60	330.2	555.2	252.55	62.40	442.70	257.50	247.60	66.87	-25.27	0.22
	9/15/1999	185.7	-57.2	336.6	558.2	255.83	64.25	447.40	261.15	250.50	67.73	-25.46	0.24
	9/30/1999	187.5	-53.7	349.9	570.1	263.45	66.90	460.00	268.70	258.20	69.75	-26.12	0.24
	10/15/1999	195.3	-50.5	375.2	601.5	280.38	72.40	488.35	285.25	275.50	74.23	-27.64	0.22
	10/31/1999	197.3	-39.9	370.8	589.7	279.48	78.70	480.25	284.05	274.90	74.00	-26.69	0.20
	11/15/1999	202.5	-32.3	385.9	601.1	289.30	85.10	493.50	294.20	284.40	76.60	-27.14	0.22
	11/30/1999	206.5	-27.3	398.1	613.9	297.80	89.60	506.00	302.30	293.30	78.85	-27.67	0.20
	12/15/1999	216.1	-19.5	401.6	620.9	304.78	98.30	511.25	308.85	300.70	80.70	-27.44	0.18
	12/31/1999	223.8	-15	410.7	633.4	313.23	104.40	522.05	317.25	309.20	82.93	-27.76	0.18
	3/31/2000	203.5	-16	395.7	633.5	304.18	93.75	514.60	299.60	308.75	80.54	-27.97	-0.20
	6/30/2000	149.3	-41	371.2	553.8	258.33	54.15	462.50	260.25	256.40	68.40	-27.14	0.09
	6/30/2000	154.3	-22.3	411.5	580.2	280.93	66.00	495.85	282.90	278.95	74.38	-28.57	0.09
	1/13/2001	197.9	7.7	446.8	627.1	319.88	102.80	536.95	322.35	317.40	84.69	-28.85	0.11
	4/20/2001	167.6	1.3	434.9	589.5	298.33	84.45	512.20	301.25	295.40	78.99	-28.43	0.13
	7/16/2001	112.8	-20.6	409.7	555.1	264.25	46.10	482.40	261.25	267.25	69.97	-29.00	-0.13
	10/9/2001	136.9	-5.4	451.7	582.7	291.48	65.75	517.20	294.30	288.65	77.17	-30.00	0.13
	1/9/2002	176.6	9	461.6	618.2	316.35	92.80	539.90	319.10	313.60	83.76	-29.71	0.12
26	4/12/2002	158.20	3.40	438	581.00	295.25	80.80	509.70	298.30	292.20	78.17	-28.50	0.14
	7/18/2002	86.10	-23.70	405	503.86	242.87	31.20	454.53	245.65	240.08	64.30	-28.13	0.12
	10/7/2002	96.1	2.90	445.20	562.80	276.75	49.50	504.00	270.65	282.85	73.28	-30.21	-0.27
	1/8/2003	165.9	41.91	480.40	628.48	329.17	103.91	554.44	323.15	335.20	87.16	-29.94	-0.27
	4/15/2003	147.5	33.95	455.30	592.01	307.19	90.73	523.65	301.40	312.98	81.33	-28.77	-0.26
	7/1/2003	88.2	9.66	424.1	577.30	274.82	48.93	500.70	256.15	293.48	72.76	-30.02	-0.84
	10/7/2003	103.5	24.24	466.9	574.34	292.25	63.87	520.62	285.20	299.29	77.38	-30.35	-0.32
	12/31/2003	130.5	44.68	481.6	566.95	305.93	87.59	524.27	306.05	305.81	81.00	-29.02	0.01
	4/13/2004	118.2	42.08	471.6	585.31	304.30	80.14	528.45	294.90	313.69	80.57	-29.79	-0.42
	7/13/2004	49.6	8.40	430.9	548.80	259.43	29.00	489.85	240.25	278.60	68.69	-30.63	-0.86
	10/8/2004	54.7	18.19	457.3	588.15	279.59	36.45	522.72	256.00	303.17	74.03	-32.32	-1.06
	1/7/2005	108.7	42.65	486.4	597.82	308.89	75.67	542.11	297.55	320.23	81.78	-31.00	-0.51
	4/8/2005	91.7	33.99	457.3	601.47	296.12	62.85	529.39	274.50	317.73	78.40	-31.01	-0.97
	7/18/2005	28.7	12.91	432.3	605.33	269.81	20.81	518.82	230.50	309.12	71.44	-33.10	-1.76
	8/26/2005	31.4	16.85	447.8	588.39	271.11	24.13	518.10	239.60	302.62	71.78	-32.83	-1.41
	10/11/2005	43.7	14.58	464.4	588.60	277.82	29.14	526.50	254.05	301.59	73.56	-33.05	-1.06
	1/10/2006	96.3	14.58	483.8	588.60	295.82	55.44	536.20	290.05	301.59	78.32	-31.95	-0.26
	4/9/1906	87.1	29.40	477	588.60	295.52	58.25	532.80	282.05	309.00	78.25	-31.54	-0.60
	7/19/1906	18.4	-2.90	430.9	588.60	258.75	7.75	509.75	224.65	292.85	68.51	-33.36	-1.53
	10/18/1906	61.1	14.58	483.2	588.60	286.87	37.84	535.90	272.15	301.59	75.95	-33.10	-0.66
	1/18/2007	99.2	14.58	505.9	588.60	302.07	56.89	547.25	302.55	301.59	79.98	-32.59	0.02

Shaft 1: Bending moment along shaft, kip-ft

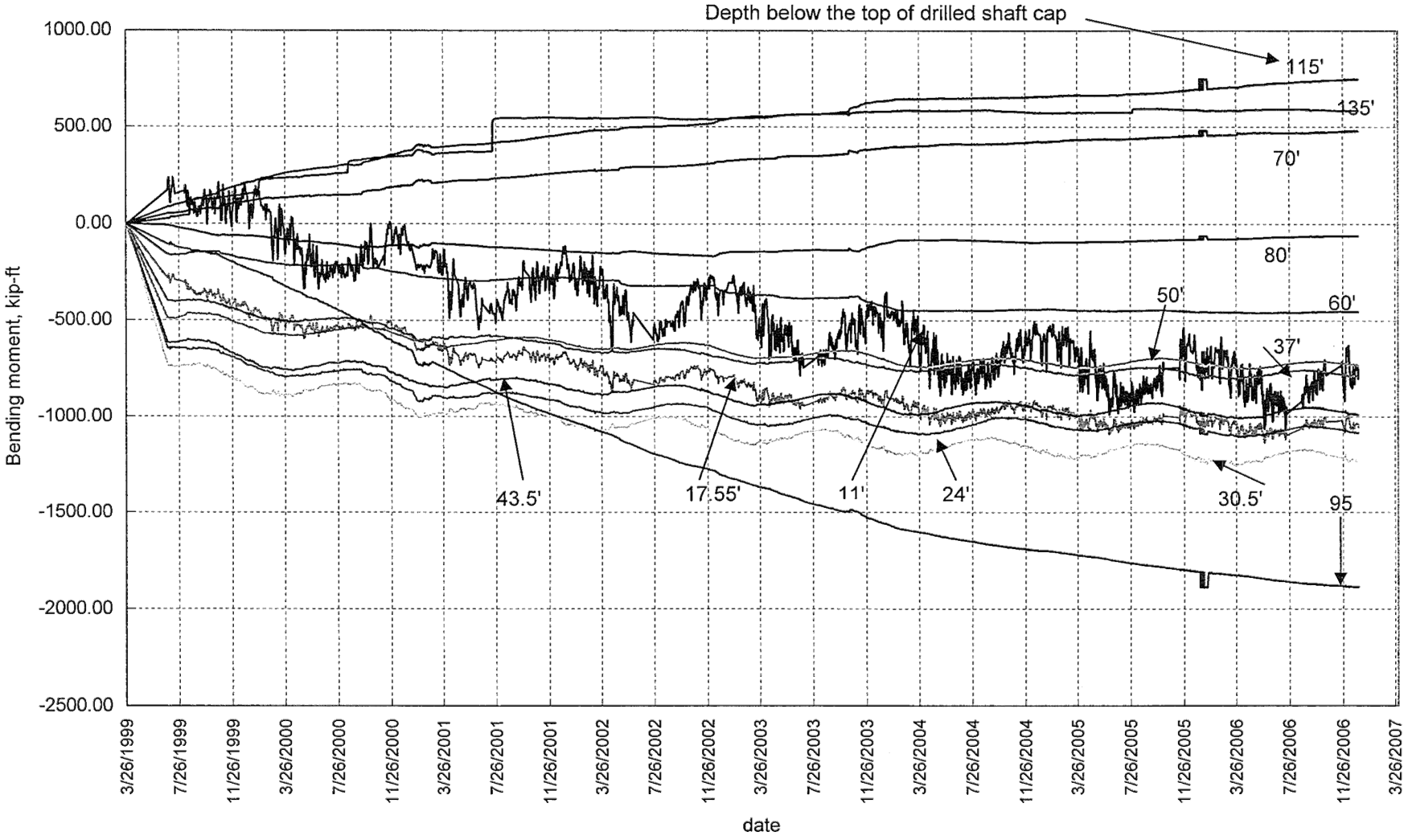
Depth, ft / Date	9.5	16	22.5	29	35.5	42	47	54.8	64.8	74.8	84.8	94.8	115	135
7/1/1999	-357.65	-148.91	-2.99	242.13	107.23	94.27	103.67	221.87	109.32	92.67	66.77	48.25	-38.94	91.57
1/8/2003	-774.82	-792.9	-360.63	403.12	139.71	-1.79	473.87	620.31	11.19	262.65	439.51	230.65	-179.6	668.9
4/15/2003	-657.74	-650	-232.57	481.71	156.43	-14.02	517.65	659.68	2.44	268.91	457.85	238.57	-192.49	684.79
7/1/2003	-763.24	-602.42	-72.91	660.28	319.17	32.14	588.57	715.87	14.21	278.09	474.99	251.23	-206	702.94
8/7/2003	-817.04	-638.73	-81.08	678	343.79	44.44	615.09	726.92	17.44	279.15	477.58	254.31	-210.32	708.78
10/7/2003	-913.81	-801.08	-248.05	552.54	251.84	20.93	623.3	710.92	6.8	271.9	474.43	265.38	-225.46	720.58
12/31/2003	-870.9	-838.68	-322.24	476.14	168.18	-13.93	630.87	701.76	-19.51	263.35	479.49	275.24	-220.96	748.57
4/13/2004	-831.87	-777.37	-255.87	514.98	175.37	-24.83	659.66	727.03	-27.47	269.67	495.81	277.88	-211.65	763.52
7/13/2004	-889.99	-676.85	-77.13	709.38	338.24	22.05	727.23	792.27	-5.75	281.7	512.3	283.5	-221.34	787.54
10/8/2004	-983.05	-812	-201.66	636.33	293	16.71	752.87	793.14	-7.37	272.19	514.89	286.68	-231.1	803.15
1/7/2005	-925.21	-882.29	-353.38	471.75	139.59	-39.87	733.05	761.38	-34.6	264.1	510.62	288.64	-223.06	817.18
4/8/2005	-775.03	-726	-235.05	530.47	150.69	-53.27	749.88	786.67	-40.37	267.3	525.48	290.73	-219.8	828.14
7/18/2005	-957.73	-709.43	-81.75	735.77	338.65	7.97	821.52	856.49	-16.82	278.53	538.72	298.79	-226.87	837.24
8/26/2005	-1005.57	-755.34	-117.03	721.71	336.36	13.6	835.13	860.64	-16.18	278.76	539.43	301.65	-233.64	840.82
10/11/2005	-1033.08	-827.24	-199.79	654.9	284.17	7.2946	833.72	848.04	-26.29	273.5	537.36	299.33	-240.08	843.25
1/10/2006	-918.83	-858.03	-339.71	489.13	122.55	-48.55	810.18	815.92	-54.94	262.93	536.1	298.82	-234.11	855.77
4/9/2006	-901.14	-812	-289.67	510.35	123.88	-55.75	815.9	831.32	-58.19	267.19	540.25	311.97	-239.53	860
7/19/2006	-975.46	-709.09	-86.84	727.21	303.99	-3.19	876.46	899.71	-33.29	280.02	563.21	306.55	-235.87	865.96
10/18/2006	-1030.45	-848.40	-245.88	609.17	218.59	-17.57	872.05	872.96	-49.65	267.05	557.80	306.95	-246.77	873.58
1/18/2007	-1015.18	-915.62	-363.79	485.63	115.44	-53.84	856.23	849.07	-71.01	257.71	555.06	310.45	-258.05	878.10

Shaft 9: Bending moment along shaft, kip-ft

Depth, ft / Date	11	17.5	24	30.5	37	43.25	50	60	70	80	95	115	135
7/1/1999	-67.89	-31.81	8.56	12.84	20.8	19.57	14.07	0.61	9.79	11.62	-33.33	18.35	26.3
1/8/2003	-347.44	-803.74	-998.93	-1106.33	-698.39	-903.77	-661.43	-353.18	324.27	-148.11	-1315.52	540.06	541.35
4/15/2003	-592.31	-919.8	-1050.61	-1133.34	-723.59	-939.66	-696.63	-369.12	336.59	-143.51	-1378.77	555.2	549.67
7/1/2003	-666.55	-902.38	-1016.77	-1090.93	-713.88	-914.42	-686.74	-395.16	340.01	-144.29	-1435.98	557.09	553.5
8/7/2003	-687.84	-917.2	-1003.18	-1072.98	-695.58	-886.87	-664.36	-384.64	352	-133.3	-1462.27	566.15	565.69
10/7/2003	-490.45	-863.81	-1007.81	-1107.14	-708.81	-891.63	-656.83	-378.93	360.91	-134.77	-1498.83	577.44	567.18
12/31/2003	-514.68	-913.27	-1054.9	-1163.2	-741.63	-949.18	-697.72	-421.12	390.01	-101.42	-1555.5	633.83	579.35
4/13/2004	-604.44	-966.22	-1090.5	-1188	-761.54	-987.22	-743.54	-446.54	402.54	-82.56	-1609.1	644.77	582.97
7/13/2004	-817.01	-1007.24	-1051.35	-1122.59	-730.91	-933.53	-709.92	-447.66	411.36	-83.06	-1648.19	649.1	585.94
10/8/2004	-674.74	-949.72	-1005.93	-1128.49	-732.6	-927.74	-697.54	-445.16	413.37	-90.78	-1677.71	652.24	581.64
1/7/2005	-572.76	-951.94	-1036.44	-1183	-760.9	-966.49	-718.51	-441.27	424.15	-94.18	-1699.91	657.05	573.07
4/8/2005	-773.86	-1039.72	-1072.89	-1200.56	-775.89	-989.82	-743.85	-446.59	435.56	-92.57	-1726.57	664.45	574.55
7/18/2005	-885.57	-1041.08	-1038.29	-1152.24	-752.36	-948.63	-719.09	-449.39	438.06	-89.12	-1762.02	670.82	576.24
8/26/2005	-835.5	-1020.01	-1028.45	-1146.98	-746.96	-933.35	-702.48	-447.31	442.02	-86.41	-1773.96	672.92	595.07
10/11/2005	-749.53	-997.4	-1026.45	-1157.47	-750.11	-932.26	-695.29	-445.61	446.57	-84.01	-1786.07	677.93	594.21
1/10/2006	-735.54	-1025.94	-1070.26	-1220.95	-784.71	-983.06	-728.35	-455.6	455.8	-79.41	-1811.1	694.94	585.21
4/9/2006	-761.63	-1055.46	-1104.66	-1250.13	-799.79	-1009.4	-750.25	-456.86	465.33	-75.95	-1830.39	709.25	584.13
7/19/2006	-986.65	-1097.57	-1069.44	-1182.51	-765.49	-967.32	-726.98	-458.20	468.35	-67.36	-1860.26	728.74	591.17
10/18/2006	-785.55	-1028.56	-1059.04	-1198.03	-770.44	-962.79	-714.95	-455.21	472.24	-63.08	-1878.38	742.33	587.52
1/18/2007	-652.26	-1012.08	-1093.82	-1249.92	-798.31	-1001.31	-738.72	-453.20	481.92	-62.15	-1891.06	749.16	583.45



Shaft #1, Bending moment vs. date in different elevations below the top of cap



Shaft #9, Bending moment vs. date in different elevations below the top of cap

Pile Forces and Bending Moments

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	903.00	42.30	679.00	-	541.43	472.65	679.00	791.00	42.30	456.92	-73.98	99.88
	07/15/99	918.00	48.00	885.00	-	617.00	483.00	885.00	901.50	48.00	520.69	-144.12	113.86
	07/31/00	932.43	51.99	887.34	-	623.92	492.21	887.34	909.89	51.99	526.53	-141.66	114.44
	08/15/99	940.56	34.46	923.00	-	632.67	487.51	923.00	931.78	34.46	533.91	-156.13	119.70
	08/30/99	948.68	31.28	931.09	-	637.02	489.98	931.09	939.89	31.28	537.58	-158.14	121.21
	09/15/99	955.75	27.83	938.36	-	640.65	491.79	938.36	947.06	27.83	540.64	-160.10	122.62
	09/30/99	959.08	23.03	947.01	-	643.04	491.06	947.01	953.05	23.03	542.66	-163.47	124.06
	10/15/99	963.38	18.85	954.86	-	645.70	491.12	954.86	959.12	18.85	544.90	-166.26	125.43
	10/31/99	973.25	5.58	968.30	-	649.04	489.42	968.30	970.78	5.58	547.73	-171.69	128.76
	11/15/99	973.34	1.26	977.48	-	650.69	487.30	977.48	975.41	1.26	549.12	-175.74	129.95
	11/30/99	975.73	-2.84	980.87	-	651.25	486.45	980.87	978.30	-2.84	549.59	-177.26	130.88
	12/15/99	974.96	-2.47	982.11	-	651.53	486.25	982.11	978.54	-2.47	549.83	-177.77	130.87
	12/31/99	974.03	-54.00	984.71		634.91	460.02	984.71	979.37	-54.00	535.80	-188.11	137.85
	03/31/00	964.52	3.86	981.83	-	650.07	484.19	981.83	973.17	3.86	548.59	-178.41	129.31
	06/30/00	977.80	-36.92	980.73	-	640.54	470.44	980.73	979.27	-36.92	540.55	-182.94	135.56
	09/30/00	1009.20	-10.20	1005.99	-	668.33	499.50	1005.99	1007.60	-10.20	564.01	-181.58	135.77
	01/13/01	1014.12	-29.4495	1029.11	-	671.26	492.33	1029.11	1021.61	-29.45	566.48	-192.44	140.21
	04/20/01	1008.27	-18.6852	1022.57	-	670.72	494.79	1022.57	1015.42	-18.69	566.02	-189.21	137.95
	07/10/01	1030.41	-8.36772	1019.56	-	680.53	511.02	1019.56	1024.98	-8.37	574.30	-182.32	137.85
	10/09/01	1054.25	-20.5131	1038.65	-	690.80	516.87	1038.65	1046.45	-20.51	582.96	-187.07	142.33
	01/09/02	1055.96	-29.65	1045.80	-	690.70	513.15	1045.80	1050.88	-29.65	582.88	-190.96	144.14
1	04/12/02	1041.9	-24.8188	1040.36	-	685.81	508.54	1040.36	1041.13	-24.82	578.76	-190.66	142.20
	07/19/02	1062.21	-17.26	1035.12	17.14	693.36	522.47	1035.12	1048.67	-17.26	585.12	-183.79	142.20
	10/08/02	1086.38	-30.07	1049.75	-6.63	702.02	528.16	1049.75	1068.06	-30.07	592.43	-187.00	146.49
	01/08/03	1080.45	-42.89	1062.94	0.41	700.17	518.78	1062.94	1071.70	-42.89	590.87	-195.09	148.69
	04/15/03	1059.37	-29.65	1049.86	22.95	693.19	514.86	1049.86	1054.62	-29.65	584.99	-191.81	144.64
	06/01/03	1064.93	-31.16	1053.52	21.00	695.77	516.89	1053.52	1059.23	-31.16	587.16	-192.39	145.46
	08/07/03	1083.86	-27.66	1053.40	9.26	703.20	528.10	1053.40	1068.63	-27.66	593.43	-188.33	146.25
	10/07/03	1095.56	-38.67	1066.64	-0.69	707.84	528.45	1066.64	1081.10	-38.67	597.35	-192.95	149.38
	12/31/03	1100.15	-54.88	1082.97	-0.89	709.41	522.64	1082.97	1091.56	-54.88	598.68	-200.89	152.93
	04/13/04	1080.17	-43.67	1074.07	21.65	703.52	518.25	1074.07	1077.12	-43.67	593.70	-199.27	149.51
	07/13/04	1101.53	-34.89	1072.49	10.76	713.04	533.32	1072.49	1087.01	-34.89	601.74	-193.30	149.66
	10/08/04	1122.82	-45.70	1085.57	-8.86	720.90	538.56	1085.57	1104.19	-45.70	608.36	-196.11	153.40
	01/07/05	1116.60	-58.49	1097.39	-8.94	718.50	529.06	1097.39	1107.00	-58.49	606.34	-203.76	155.48
	04/08/05	1099.01	-52.77	1096.58	5.48	714.28	523.12	1096.58	1097.80	-52.77	602.78	-205.59	153.49
	07/18/05	1116.44	-41.55	1096.58	-2.36	723.82	537.44	1096.58	1106.51	-41.55	610.83	-200.46	153.15
	08/26/05	1128.14	-43.63	1095.73	-10.20	726.75	542.26	1095.73	1111.93	-43.63	613.30	-198.43	154.15
	11/12/05	1127.45	-44.76	1095.72	-9.67	726.14	541.34	1095.72	1111.58	-44.76	612.79	-198.75	154.26
	01/10/06	1129.36	-64.30	1095.72	-19.70	720.26	532.53	1095.72	1112.54	-64.30	607.83	-201.91	156.99
	04/09/06	1114.90	-55.20	1095.72	-1.14	718.47	529.85	1095.72	1105.31	-55.20	606.32	-202.87	154.81
	07/19/06	1130.94	-46.83	1095.72	-9.42	726.61	542.05	1095.72	1113.33	-46.83	613.19	-198.50	154.77
	10/18/06	1154.91	-58.29	1095.72	-27.50	730.78	548.31	1095.72	1125.32	-58.29	616.71	-196.26	157.89
	01/18/07	1139.55	-68.49	1095.72	-21.73	722.26	535.53	1095.72	1117.64	-68.49	609.52	-200.84	158.23

	07/01/99	575.00	589.00	243.00	-	469.00	582.00	243.00	409.00	589.00	395.79	121.54	-24.01
	07/15/99	585.00	602.00	237.00	-	474.67	593.50	237.00	411.00	602.00	400.57	127.81	-25.48
	07/30/99	594.35	611.17	230.68	-	478.73	602.76	230.68	412.52	611.17	404.00	133.40	-26.50
	08/15/99	596.87	611.09	242.58	336.68	446.81	603.98	289.63	419.73	473.89	377.06	112.70	-7.22
	08/31/99	601.58	616.82	241.00	-	486.47	609.20	241.00	421.29	616.82	410.53	132.00	-26.08
	09/15/99	605.96	622.42	240.47	-	489.62	614.19	240.47	423.22	622.42	413.19	133.98	-26.57
	09/30/99	609.62	624.20	240.71	336.98	452.88	616.91	288.85	425.17	480.59	382.18	117.62	-7.39
	10/15/99	612.87	629.40	240.27	336.21	454.69	621.14	288.24	426.57	482.81	383.71	119.35	-7.50
	10/31/99	616.45	631.80	243.11	336.29	456.91	624.13	289.70	429.78	484.05	385.59	119.90	-7.24
	11/15/99	619.54	632.45	245.83	337.79	458.90	626.00	291.81	432.69	485.12	387.27	119.81	-6.99
	11/30/99	623.35	635.58	248.71	340.31	461.99	629.47	294.51	436.03	487.95	389.87	120.09	-6.93
	12/15/99	624.21	637.77	247.77	339.95	462.43	630.99	293.86	435.99	488.86	390.24	120.87	-7.05
	12/31/99	626.60	640.86	249.37	341.45	464.57	633.73	295.41	437.99	491.16	392.05	121.29	-7.09
	03/31/00	634.53	648.30	254.69	346.89	471.10	641.41	300.79	444.61	497.60	397.56	122.12	-7.07
	06/30/00	640.05	652.80	250.99	342.06	471.48	646.43	296.53	445.52	497.43	397.88	125.44	-6.93
	09/30/00	647.16	661.13	247.62	336.78	473.17	654.14	292.20	447.39	498.96	399.31	129.76	-6.88
	01/13/01	654.063	665.1119	256.39	342.22	479.45	659.59	299.31	455.23	503.67	404.61	129.16	-6.46
	04/20/01	654.429	664.7057	260.37	345.47	481.25	659.57	302.92	457.40	505.09	406.12	127.86	-6.36
	07/10/01	661.456	672.0985	256.15	342.75	483.11	666.78	299.45	458.80	507.43	407.70	131.69	-6.49
	10/09/01	668.361	679.0039	251.93	338.20	484.37	673.68	295.06	460.14	508.60	408.76	135.74	-6.46
	01/09/02	671.083	683.4721	252.17	337.92	486.16	677.28	295.04	461.63	510.69	410.27	137.04	-6.55
17	04/12/02	669.17	680.02	256.68	342.06	486.98	674.60	299.37	462.93	511.04	410.96	134.52	-6.42
	07/19/02	671.69	683.96	253.27	272.93	470.46	677.83	263.10	462.48	478.44	397.02	148.69	-2.13
	10/08/02	678.60	692.21	247.01	332.37	487.54	685.40	289.69	462.80	512.29	411.44	141.87	-6.60
	01/08/03	678.44	689.32	251.28	334.22	488.31	683.88	292.75	464.86	511.77	412.09	140.22	-6.26
	04/15/03	679.45	692.45	254.73	341.09	491.93	685.95	297.91	467.09	516.77	415.14	139.12	-6.63
	06/01/03	678.76	689.85	256.43	341.09	491.53	684.30	298.76	467.60	515.47	414.80	138.22	-6.39
	08/07/03	682.33	695.54	251.15	336.74	491.44	688.94	293.95	466.74	516.14	414.73	141.61	-6.59
	10/07/03	686.23	700.57	250.14	334.87	492.95	693.40	292.50	468.19	517.72	416.00	143.73	-6.61
	12/31/03	689.48	700.61	257.04	341.05	497.05	695.05	299.04	473.26	520.83	419.46	141.97	-6.35
	04/13/04	689.24	699.88	260.70	346.65	499.12	694.56	303.68	474.97	523.27	421.21	140.14	-6.44
	07/13/04	693.10	667.59	255.46	341.33	489.37	680.34	298.39	474.28	504.46	412.98	136.93	-4.03
	10/08/04	699.03	710.89	250.83	337.39	499.53	704.96	294.11	474.93	524.14	421.56	147.30	-6.56
	01/07/05	699.07	711.46	253.31	339.95	500.95	705.26	296.63	476.19	525.70	422.75	146.50	-6.61
	04/08/05	696.43	708.09	257.94	343.81	501.57	702.26	300.87	477.18	525.95	423.27	143.90	-6.51
	07/18/05	699.56	708.33	253.71	338.36	499.99	703.94	296.04	476.64	523.35	421.94	146.24	-6.23
	08/26/05	702.04	711.17	250.91	335.97	500.02	706.61	293.44	476.47	523.57	421.97	148.13	-6.28
	11/12/05	701.95	699.60	251.68	337.06	497.57	700.78	294.37	476.82	518.33	419.90	145.70	-5.54
	01/10/06	705.16	715.03	253.47	339.58	503.31	710.10	296.53	479.32	527.31	424.75	148.27	-6.40
	04/09/06	703.94	713.04	259.52	343.20	504.93	708.49	301.36	481.73	528.12	426.11	145.96	-6.19
	07/19/06	708.37	716.01	256.84	339.95	505.29	712.19	298.39	482.61	527.98	426.42	148.35	-6.05
	10/18/06	713.29	721.25	251.76	334.02	505.08	717.27	292.89	482.52	527.63	426.24	152.14	-6.02
	01/18/07	712.84	717.96	256.52	336.54	505.96	715.40	296.53	484.68	527.25	426.98	150.17	-5.68

Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	546.00	501.00	248.00	173	367.00	523.50	210.50	397.00	337.00	309.71	112.21	8.00
	07/15/99	557.00	513.00	243.00	229	385.50	535.00	236.00	400.00	371.00	325.32	107.20	3.87
	07/30/99	565.55	519.94	239.54	224.26	387.32	542.75	231.90	402.55	372.10	326.86	111.44	4.06
	08/15/99	567.71	520.14	230.56	232.51	387.73	543.93	231.54	399.14	376.33	327.21	112.00	3.04
	08/31/99	573.72	526.52	247.46	232.87	395.14	550.12	240.17	410.59	379.70	333.46	111.12	4.12
	09/15/99	578.06	532.08	246.65	233.61	397.60	555.07	240.13	412.36	382.85	335.53	112.91	3.94
	09/30/99	582.49	534.97	247.46	234.05	399.74	558.73	240.76	414.98	384.51	337.34	114.00	4.06
	10/15/99	586.68	538.17	247.25	235.23	401.83	562.43	241.24	416.97	386.70	339.11	115.15	4.04
	10/31/99	590.77	539.40	249.37	235.6	403.79	565.09	242.49	420.07	387.50	340.75	115.66	4.34
	11/15/99	592.65	540.65	251.68	237.47	405.61	566.65	244.58	422.17	389.06	342.30	115.47	4.42
	11/30/99	596.63	527.25	254.12	239.69	404.42	561.94	246.91	425.38	383.47	341.29	112.94	5.59
	12/15/99	599.47	545.53	254.12	239.05	409.54	572.50	246.59	426.80	392.29	345.61	116.84	4.60
	12/31/99	601.54	548.45	255.38	239.17	411.14	575.00	247.28	428.46	393.81	346.96	117.49	4.62
	03/31/00	610.32	554.87	262.08	243.60	417.72	582.59	252.84	436.20	399.23	352.51	118.22	4.93
	06/30/00	616.94	539.60	260.98	238.93	414.11	578.27	249.96	438.96	389.26	349.47	117.70	6.63
	09/30/00	625.63	400.76	255.58	232.18	378.54	513.19	243.88	440.61	316.47	319.45	96.55	16.56
	01/13/01	632.372	566.6896	264.44	235.84	424.83	599.53	250.14	448.40	401.26	358.52	125.26	6.29
	04/20/01	632.575	561.5309	268.38	236.21	424.67	597.05	252.29	450.48	398.87	358.38	123.60	6.88
	07/10/01	639.684	569.2893	264.64	234.54	427.04	604.49	249.59	452.16	401.91	360.38	127.23	6.70
	10/09/01	646.508	576.5197	259.81	232.14	428.74	611.51	245.97	453.16	404.33	361.82	131.05	6.51
	01/09/02	650.895	576.8446	259.68	230.92	429.59	613.87	245.30	455.29	403.88	362.53	132.14	6.86
18	04/12/02	650.123	570.1017	264.192	232.55	429.24	610.11	248.37	457.16	401.33	362.24	129.69	7.45
	07/19/02	653.45	572.46	260.90	226.38	428.30	612.96	243.64	457.18	399.42	361.44	132.40	7.71
	10/08/02	659.69	581.14	254.65	222.68	429.54	620.41	238.66	457.17	401.91	362.49	136.86	7.37
	01/08/03	657.76	576.89	257.57	224.47	429.17	617.32	241.02	457.67	400.68	362.18	134.91	7.60
	04/15/03	661.78	576.19	262.16	228.04	432.04	618.99	245.10	461.97	402.12	364.60	134.04	7.98
	06/01/03	661.37	572.66	264.07	227.59	431.43	617.02	245.83	462.72	400.13	364.08	133.07	8.35
	08/07/03	665.76	577.29	258.18	222.76	431.00	621.53	240.47	461.97	400.03	363.72	136.61	8.26
	10/07/03	669.26	582.73	256.11	222.56	432.66	625.99	239.33	462.68	402.65	365.13	138.62	8.01
	12/31/03	670.27	581.39	262.53	229.62	435.95	625.83	246.08	466.40	405.51	367.90	136.15	8.12
	04/13/04	669.42	576.64	266.47	232.35	436.22	623.03	249.41	467.94	404.49	368.12	133.95	8.46
	07/13/04	672.95	578.63	261.80	224.79	434.54	625.79	243.29	467.37	401.71	366.71	137.13	8.76
	10/08/04	677.95	587.12	255.42	222.31	435.70	632.53	238.87	466.68	404.72	367.69	141.14	8.27
	01/07/05	677.50	586.02	257.61	226.05	436.80	631.76	241.83	467.56	406.04	368.61	139.80	8.21
	04/08/05	674.17	580.83	263.14	227.80	436.48	627.50	245.47	468.65	404.31	368.35	136.96	8.58
	07/18/05	677.87	580.70	259.40	221.74	434.93	629.29	240.57	468.63	401.22	367.04	139.36	8.99
	08/26/05	679.25	583.30	256.27	219.43	434.56	631.28	237.85	467.76	401.37	366.73	141.05	8.86
	11/12/05	679.13	583.14	256.88	220.08	434.81	631.13	238.48	468.00	401.61	366.93	140.77	8.86
	01/10/06	679.45	587.32	257.33	223.00	436.78	633.39	240.17	468.39	405.16	368.60	140.97	8.43
	04/09/06	679.57	583.14	263.01	226.46	438.05	631.36	244.74	471.29	404.80	369.67	138.61	8.87
	07/19/06	683.27	585.78	260.94	222.31	438.08	634.53	241.63	472.11	404.05	369.69	140.86	9.08
	10/18/06	687.01	592.40	255.09	218.66	438.29	639.70	236.88	471.05	405.53	369.87	144.42	8.74
	01/18/07	685.10	588.58	259.16	221.83	438.67	636.84	240.49	472.13	405.20	370.19	142.10	8.93

	07/01/99	566.97	586.00	298.00	228.9	419.97	576.49	263.45	432.49	407.45	354.41	112.23	3.34
	07/15/99	580.00	597.00	294.00	224	423.75	588.50	259.00	437.00	410.50	357.60	118.13	3.54
	07/30/99	588.71	606.46	291.38	218.62	426.29	597.59	255.00	440.05	412.54	359.75	122.82	3.67
	08/15/99	591.02	607.35	300.95	227.92	431.81	599.19	264.44	445.99	417.64	364.40	120.01	3.78
	08/31/99	595.94	613.52	300.59	229.63	434.92	604.73	265.11	448.27	421.58	367.03	121.76	3.56
	09/15/99	599.88	617.91	300.67	229.54	437.00	608.90	265.11	450.28	423.73	368.78	123.25	3.54
	09/30/99	603.53	621.65	302.70	229.75	439.41	612.59	266.23	453.12	425.70	370.82	124.18	3.66
	10/15/99	607.51	625.02	302.29	229.71	441.13	616.27	266.00	454.90	427.37	372.27	125.57	3.67
	10/31/99	611.37	627.25	306.07	229.7	443.60	619.31	267.89	458.72	428.48	374.35	125.99	4.03
	11/15/99	613.61	627.78	308.31	232.67	445.59	620.70	270.49	460.96	430.23	376.04	125.55	4.10
	11/30/99	616.29	630.54	313.83	234.7	448.84	623.42	274.27	465.06	432.62	378.78	125.17	4.33
	12/15/99	617.83	631.44	314.03	234.9	449.55	624.64	274.47	465.93	433.17	379.38	125.54	4.37
	12/31/99	619.94	634.20	314.36	236.45	451.24	627.07	275.41	467.15	435.33	380.80	126.08	4.25
	03/31/00	629.45	639.44	320.33	239.74	457.24	634.44	280.03	474.89	439.59	385.86	127.06	4.71
	06/30/00	636.15	643.50	317.81	51.91	412.34	639.83	184.86	476.98	347.71	347.98	163.11	17.25
	09/30/00	646.59	651.99	312.33	231.29	460.55	649.29	271.81	479.46	441.64	388.66	135.33	5.04
	01/13/01	653.454	657.0691	320.21	236.77	466.88	655.26	278.49	486.83	446.92	394.00	135.08	5.32
	04/20/01	651.464	653.2102	324.03	237.42	466.53	652.34	280.72	487.74	445.32	393.71	133.23	5.66
	07/10/01	658.856	661.1717	320.61	235.03	468.92	660.01	277.82	489.74	448.10	395.72	137.02	5.55
	10/09/01	667.346	669.2551	315.37	230.97	470.74	668.30	273.17	491.36	450.11	397.25	141.66	5.50
	01/09/02	670.88	671.7736	315.66	229.71	472.00	671.33	272.68	493.27	450.74	398.32	142.92	5.67
19	04/12/02	667.71	665.64	321.06	231.62	471.51	666.68	276.34	494.39	448.63	397.90	139.94	6.10
	07/19/02	673.44	667.87	319.88	227.72	472.23	670.66	273.80	496.66	447.79	398.51	142.28	6.52
	10/08/02	681.93	676.18	313.24	222.91	473.56	679.05	268.07	497.58	449.54	399.64	147.34	6.41
	01/08/03	682.42	673.60	316.88	225.03	474.48	678.01	270.96	499.65	449.32	400.42	145.93	6.71
	04/15/03	686.11	672.95	321.26	228.37	477.17	679.53	274.81	503.69	450.66	402.69	145.10	7.07
	06/01/03	685.30	670.80	322.48	227.84	476.60	678.05	275.16	503.89	449.32	402.21	144.44	7.28
	08/07/03	689.12	675.35	317.28	223.09	476.21	682.23	270.18	503.20	449.22	401.87	147.72	7.20
	10/07/03	694.48	681.03	314.64	222.27	478.11	687.76	268.46	504.56	451.65	403.47	150.32	7.06
	12/31/03	695.94	680.95	322.73	229.34	482.24	688.45	276.03	509.33	455.15	406.96	147.86	7.23
	04/13/04	695.62	676.77	330.77	231.41	483.64	686.19	281.09	513.19	454.09	408.15	145.23	7.88
	07/13/04	700.37	679.61	327.88	224.22	483.02	689.99	276.05	514.13	451.92	407.62	148.40	8.30
	10/08/04	706.18	688.67	321.87	221.22	484.48	697.43	271.54	514.03	454.94	408.86	152.68	7.88
	01/07/05	705.37	688.14	324.72	224.55	485.69	696.75	274.63	515.04	456.35	409.88	151.34	7.83
	04/08/05	702.85	682.86	329.75	226.66	485.53	692.86	278.21	516.30	454.76	409.74	148.66	8.21
	07/18/05	706.50	683.55	327.15	219.55	484.19	695.03	273.35	516.83	451.55	408.61	151.18	8.71
	08/26/05	708.05	686.48	322.81	217.89	483.80	697.26	270.35	515.43	452.18	408.28	153.05	8.44
	11/12/05	707.97	686.27	323.74	218.33	484.08	697.12	271.04	515.85	452.30	408.51	152.76	8.48
	01/10/06	710.04	690.54	324.68	221.62	486.72	700.29	273.15	517.36	456.08	410.74	153.13	8.17
	04/09/06	709.47	686.72	329.75	224.34	487.57	698.10	277.05	519.61	455.53	411.46	150.95	8.55
	07/19/06	714.26	690.38	328.09	220.57	488.32	702.32	274.33	521.17	455.47	412.10	153.44	8.76
	10/18/06	718.93	696.80	321.91	216.75	488.60	707.86	269.33	520.42	456.77	412.33	157.22	8.49
	01/18/07	717.19	692.98	326.63	219.88	489.17	705.08	273.25	521.91	456.43	412.81	154.82	8.73

Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
34	07/01/99	271.75	436.00	261.00	583.00	387.94	353.88	422.00	266.38	509.50	327.38	-24.42	-32.43
	07/15/99	279.00	617.00	253.00	583.00	433.00	448.00	418.00	266.00	600.00	365.41	10.76	-44.56
	07/30/99	282.79	647.00	243.64	585.13	439.64	464.90	414.39	263.22	616.07	371.01	18.11	-47.07
	08/15/99	272.89	690.09	251.16	614.66	457.20	481.49	432.91	262.03	652.38	385.83	17.42	-52.07
	08/31/99	265.66	576.80	245.14	627.09	428.67	421.23	436.12	255.40	601.95	361.76	-5.34	-46.23
	09/15/99	265.08	802.81	242.34	635.26	486.37	533.95	438.80	253.71	719.04	410.45	34.11	-62.07
	09/30/99	260.50	807.40	238.64	642.65	487.30	533.95	440.65	249.57	725.03	411.23	33.45	-63.43
	10/15/99	256.43	811.14	234.46	648.58	487.65	533.79	441.52	245.45	729.86	411.53	33.08	-64.62
	10/31/99	240.47	824.02	221.62	665.31	487.86	532.25	443.47	231.05	744.67	411.70	31.83	-68.52
	11/15/99	241.93	831.45	224.75	676.77	493.73	536.69	450.76	233.34	754.11	416.65	30.81	-69.47
	11/31/99	240.47	835.88	224.26	648.85	487.37	538.18	436.56	232.37	742.37	411.29	36.43	-68.03
	12/15/99	241.41	836.77	222.35	684.04	496.14	539.09	453.20	231.88	760.41	418.69	30.79	-70.51
	12/31/99	242.22	836.08	224.14	684.93	496.84	539.15	454.54	233.18	760.51	419.29	30.34	-70.35
	03/31/00	257.37	828.85	237.38	675.92	499.88	543.11	456.65	247.38	752.38	421.85	31.00	-67.37
	06/30/00	266.43	846.32	225.20	500.93	459.72	556.37	363.06	245.81	673.62	387.96	69.30	-57.07
	09/30/00	257.37	895.02	196.89	705.00	513.57	576.19	450.94	227.13	800.01	433.40	44.90	-76.42
	01/13/01	247.90	856.11	197.37	729.58	507.74	552.01	463.47	222.64	792.84	428.48	31.74	-76.07
	04/20/01	44.66	883.01	212.28	457.21	399.29	463.83	334.74	128.47	670.11	336.96	46.28	-72.25
	07/10/01	-279.94	502.86	204.24	66.21	123.34	111.46	135.22	-37.85	284.53	104.09	-8.52	-43.01
	10/09/01	442.16	725.37	50.98	1199.89	604.60	583.76	625.44	246.57	962.63	510.22	-14.94	-95.52
	01/09/02	263.63	616.73	159.27	765.05	451.17	440.18	462.16	211.45	690.89	380.74	-7.88	-63.96
	04/12/02	67.35	579.97	58.13	501.01	301.61	323.66	279.57	62.74	540.49	254.53	15.81	-63.73
	07/19/02	288.69	941.04	187.83	727.59	536.29	614.86	457.71	238.26	834.31	452.57	56.34	-79.51
	10/08/02	277.15	962.54	162.58	740.98	535.81	619.84	451.78	219.86	851.76	452.17	60.25	-84.29
	01/08/03	256.07	949.53	162.24	758.66	531.62	602.80	460.45	209.15	854.10	448.64	51.04	-86.04
	04/15/03	277.19	928.37	189.53	744.52	534.90	602.78	467.03	233.36	836.45	451.41	48.67	-80.45
	06/01/03	277.96	939.01	184.90	749.68	537.89	608.49	467.29	231.43	844.35	453.93	50.62	-81.76
	08/07/03	288.69	965.09	171.66	750.09	543.88	626.89	460.87	230.17	857.59	458.98	59.52	-83.70
	10/07/03	274.96	978.21	155.53	762.84	542.89	626.58	459.19	215.25	870.53	458.14	60.01	-87.41
	12/31/03	258.26	983.57	156.83	795.22	548.47	620.92	476.03	207.55	889.40	462.86	51.95	-90.96
	04/13/04	281.17	960.30	188.88	781.65	553.00	620.73	485.27	235.03	870.97	466.68	48.57	-84.84
	07/13/04	302.86	991.98	173.93	772.27	560.26	647.42	473.10	238.40	882.12	472.80	62.50	-85.87
	10/08/04	295.63	1004.49	151.19	786.40	559.43	650.06	468.80	223.41	895.45	472.10	64.99	-89.65
	01/07/05	277.35	997.91	148.79	798.02	555.52	637.63	473.41	213.07	897.97	468.80	58.88	-91.36
	04/08/05	286.74	978.21	166.99	788.76	555.17	632.47	477.87	226.86	883.49	468.51	55.43	-87.59
	07/18/05	304.00	1000.02	160.94	783.60	562.14	652.01	472.27	232.47	891.81	474.39	64.44	-87.96
	08/26/05	301.85	1018.4	147.73	791.81	564.94	660.12	469.77	224.79	905.09	476.76	68.24	-90.75
	11/12/05	300.51	1018.3	147.82	793.35	564.99	659.40	470.58	224.16	905.83	476.80	67.70	-90.93
	01/10/06	274.59	1009.41	138.15	808.34	557.62	642.00	473.24	206.37	908.87	470.58	60.50	-93.71
	04/09/06	283.04	986.09	160.45	798.02	556.90	634.57	479.23	221.74	892.06	469.97	55.69	-89.42
	07/19/06	295.67	1009.41	149.73	796.56	562.84	652.54	473.14	222.70	902.98	474.98	64.32	-90.75
	10/18/06	284.79	1030.77	131.20	808.38	563.79	657.78	469.79	207.99	919.58	475.78	67.40	-94.92
	01/18/07	270.29	1012.82	134.82	813.33	557.81	641.55	474.08	202.55	913.08	470.74	60.04	-94.78

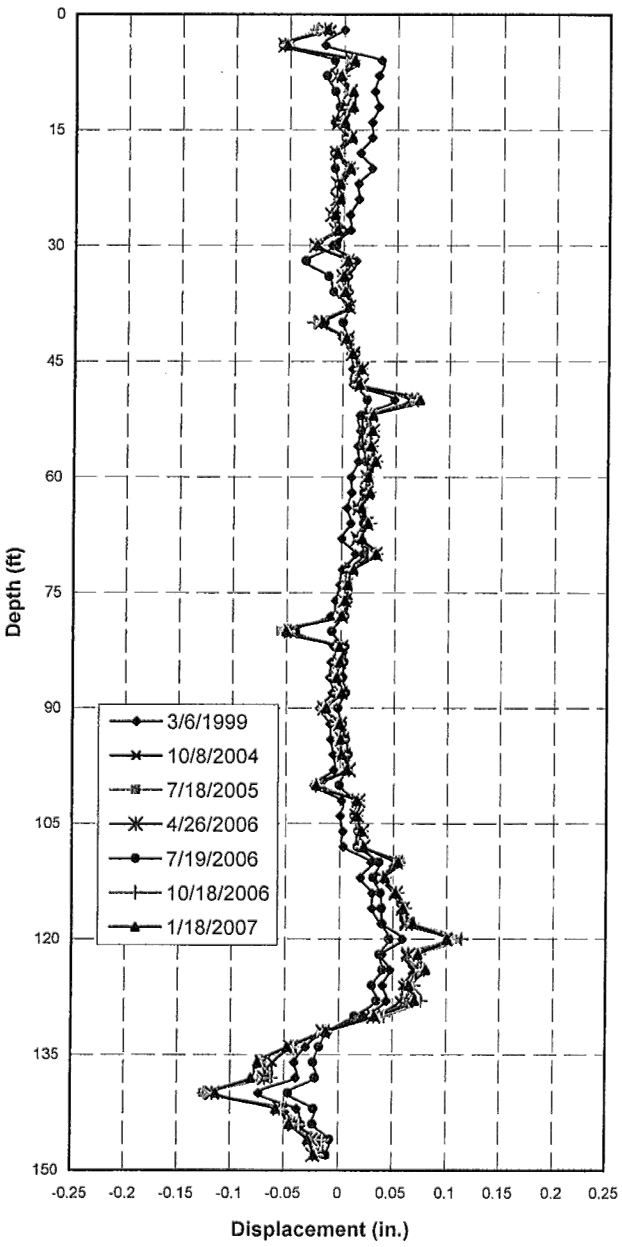
Numerical reading of anchor load as a function of time for anchors #1, #8, #9 and #17

Date	Anchor #1 Load, kips	Anchor #8 Load, kips	Anchor #9 Load, kips	Anchor #17 Load, kips	Comment
4/7/1999		560			
4/8/1999	489			499	Anchor Lock off
4/14/1999	460	473	596 (Lock off)	461	
5/7/1999	452	473	572	445	End of construction
7/1/1999	446	468	564	439	
10/1/1999	441	467	560	440	
1/1/2000	439	461	555	424	
4/1/2000	432	453	546	414	
7/1/2000	431	451	521	415	
10/1/2000	431	451	519	416	
1/1/2001	430	455	517	400	
4/1/2001	421	443	513	397	
7/1/2001	422	443	510	399	
10/1/2001	425	445	512	403	
1/1/2002	424	444	511	398	
4/1/2002	421	440	508	386	
7/1/2002	419	439	506	391	
10/1/2002	423	442	508	396	
1/1/2003	423	435	508	389	
4/15/2003	416	427	501	380	
8/7/2003	416	428	503	384	
10/7/2003	418	429	504	387	
12/31/2003	417	426	503	378	
4/13/2004	408	418	494	370	
7/13/2004	409	419	494	374	
10/8/2004	411	422	496	377	
1/7/2005	411	421	495	374	
4/8/2005	407	414	485	366	
7/18/2005	407	415	485	370	
11/12/2005	410	419	489	374	
1/10/2006	409	417	487	369	
4/9/2006	399	411	487	365	
7/19/2006	399	412	487	368	
10/18/2006	407.3	414.8	489.6	371.7	
~~10/18/2006~~	405	412	487	366	

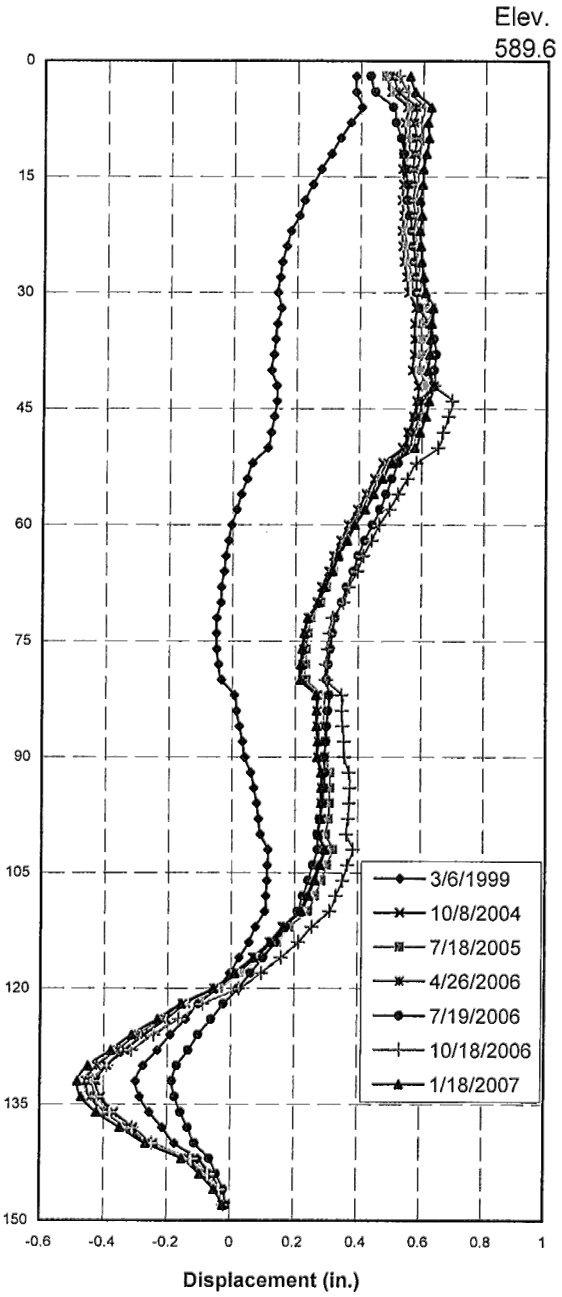
1/18/07

Inclinometer #1 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

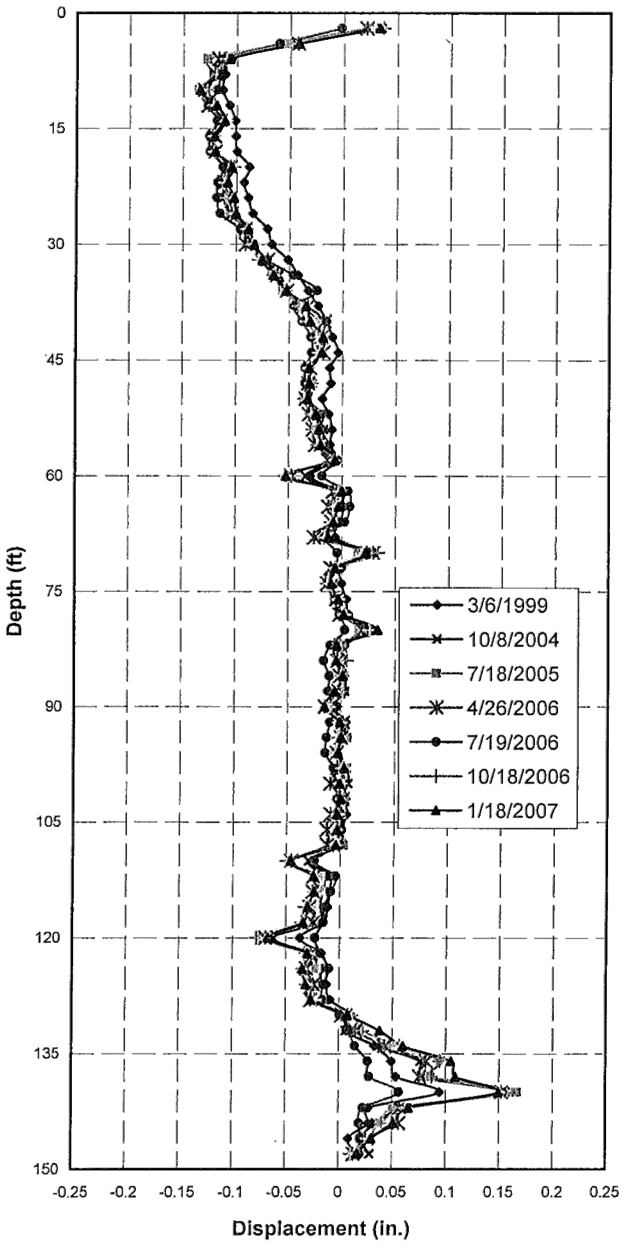


Cumulative



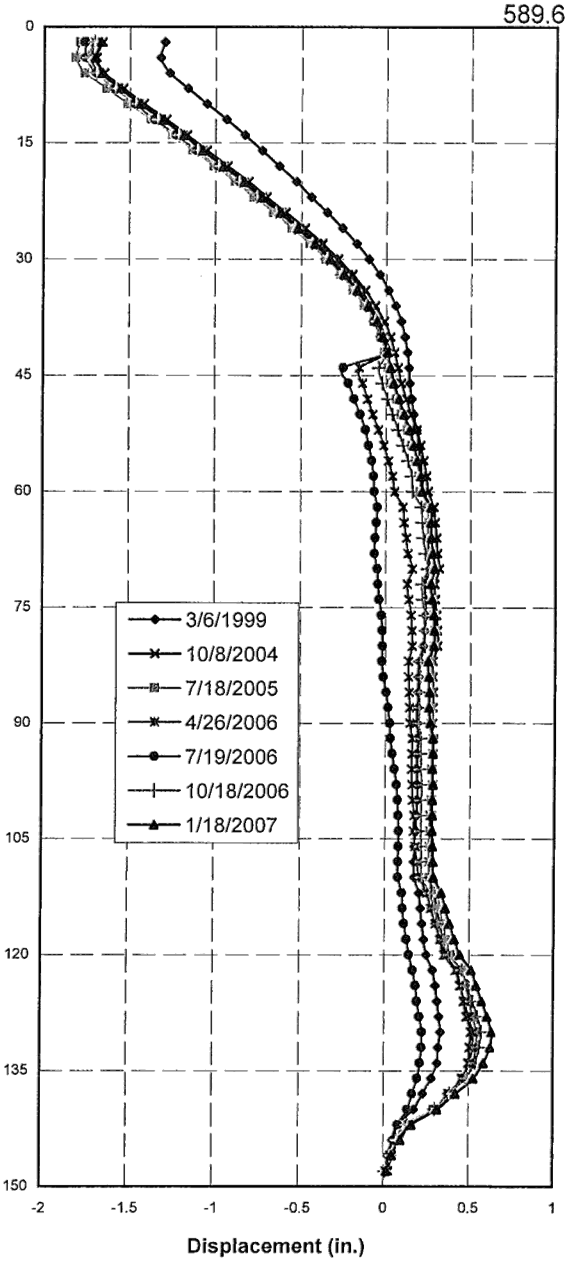
Inclinometer #1 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



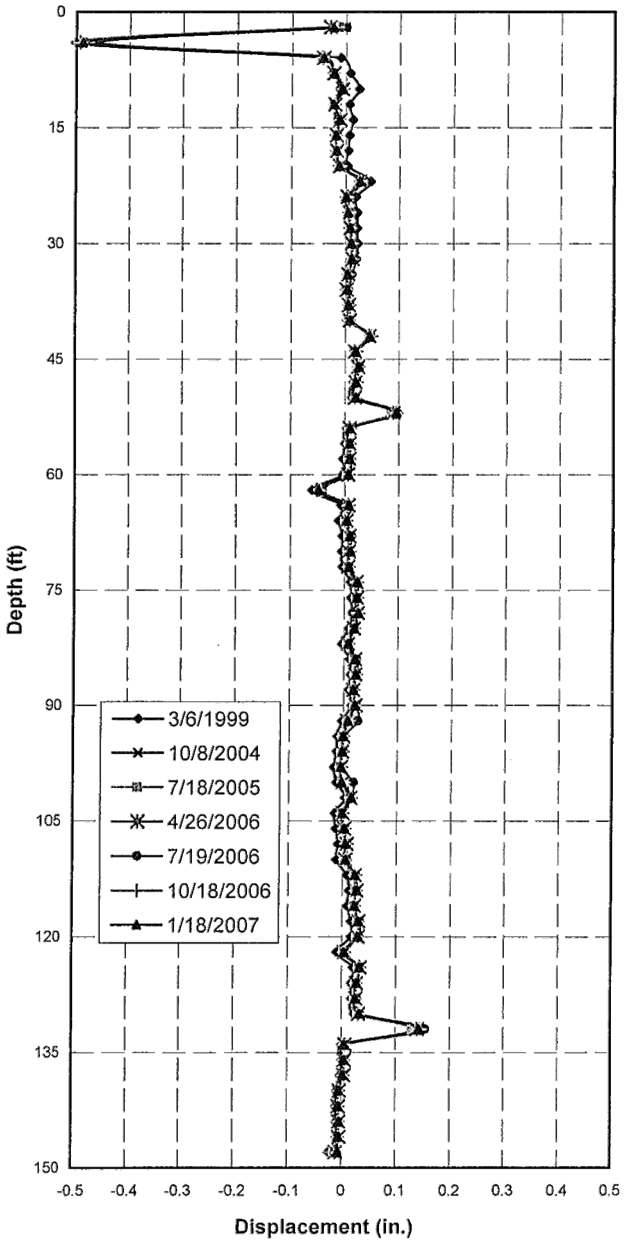
Cumulative

Elev.
589.6

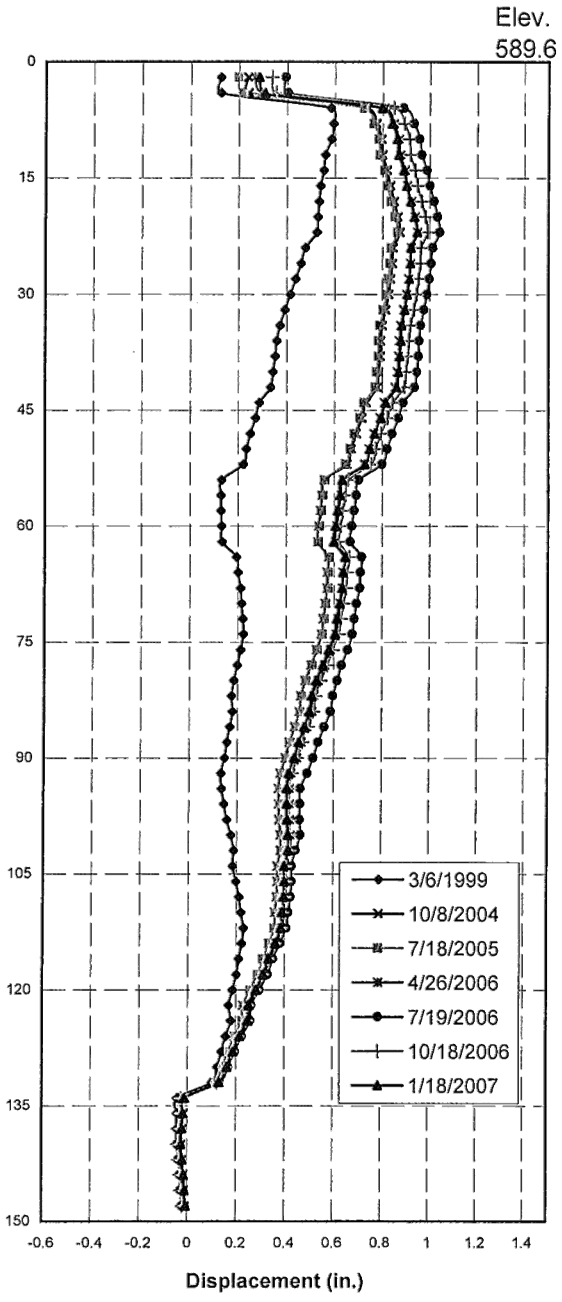


Inclinometer #3 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

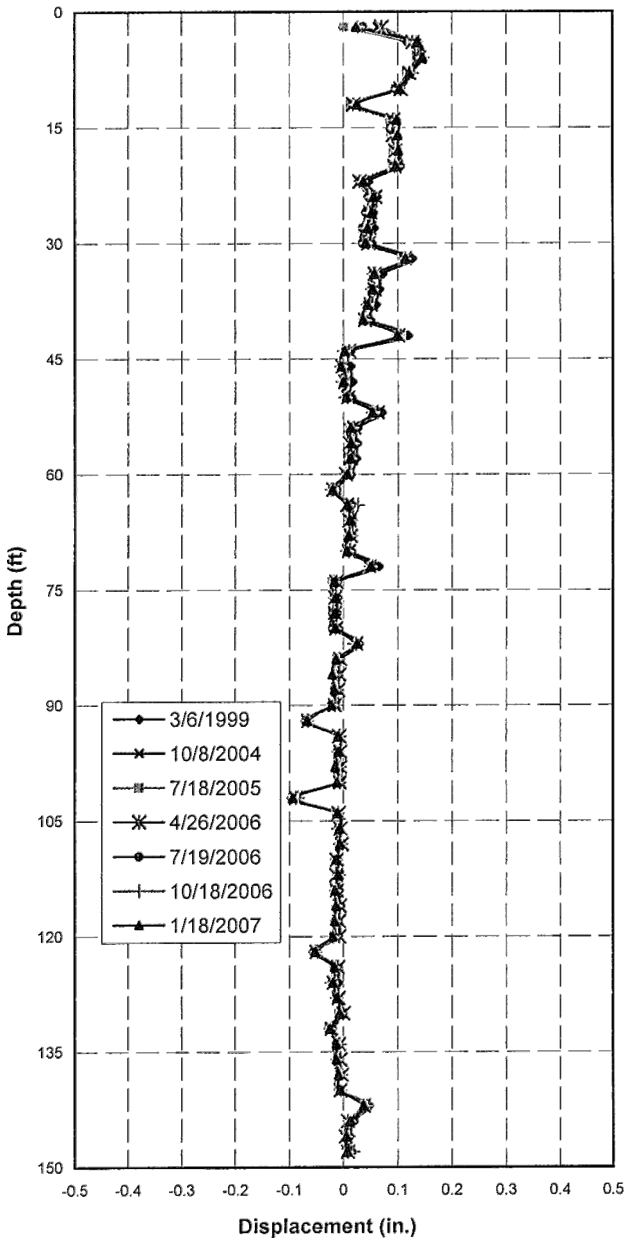


Cumulative



Inclinometer #3 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



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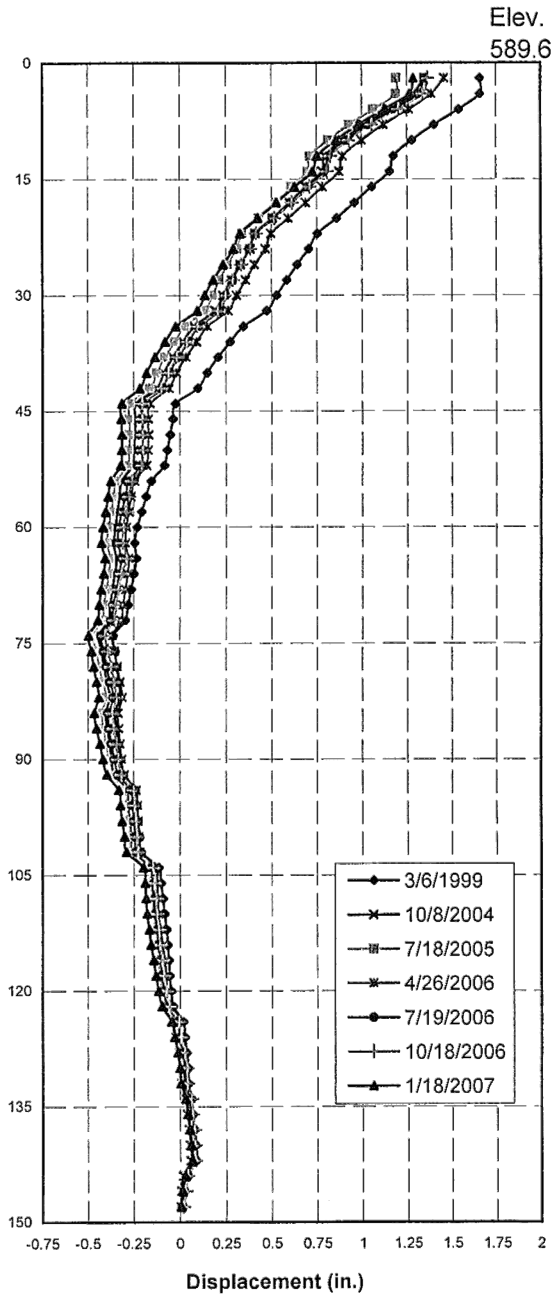
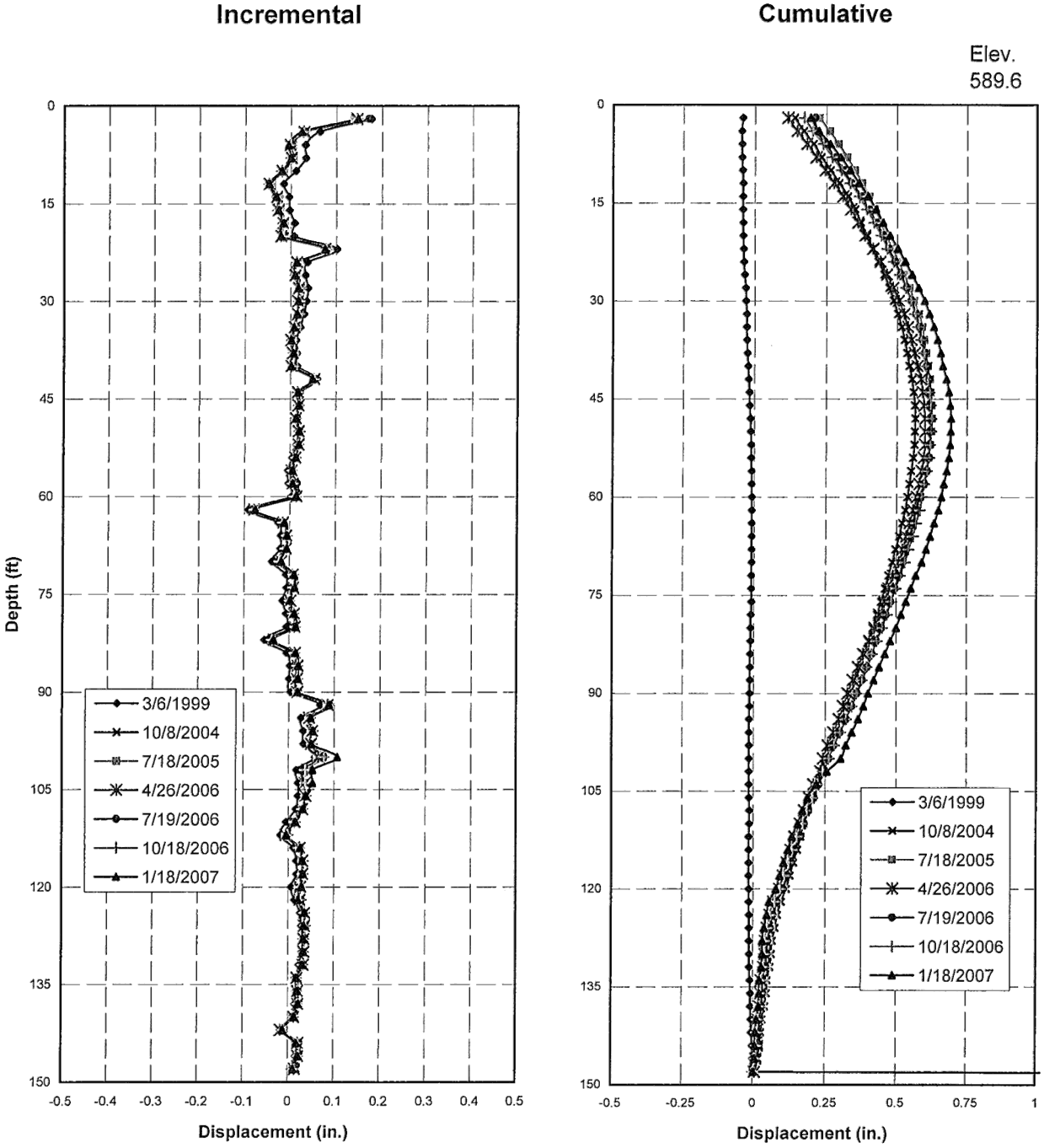
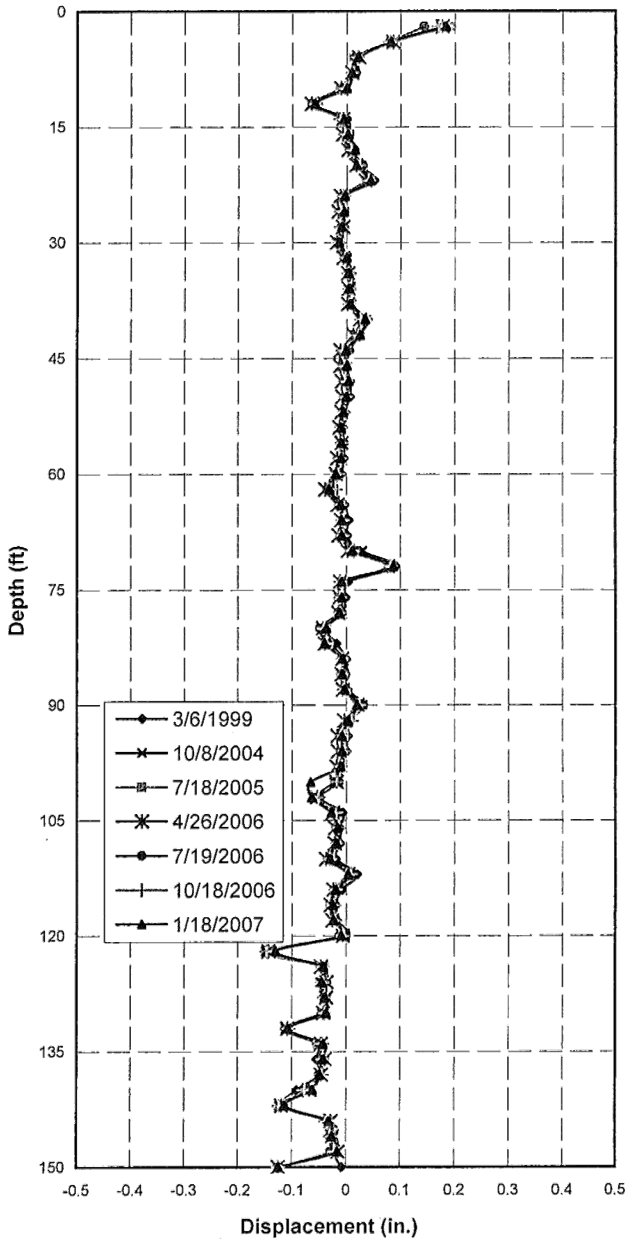


Inclinometer #8 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998



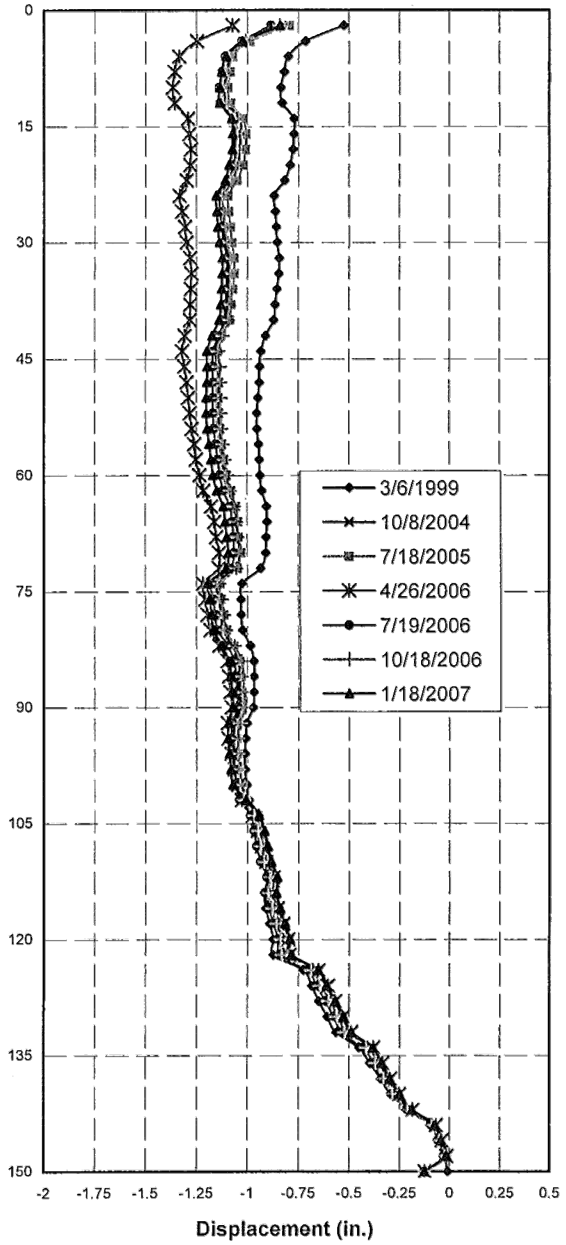
Inclinometer #8 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



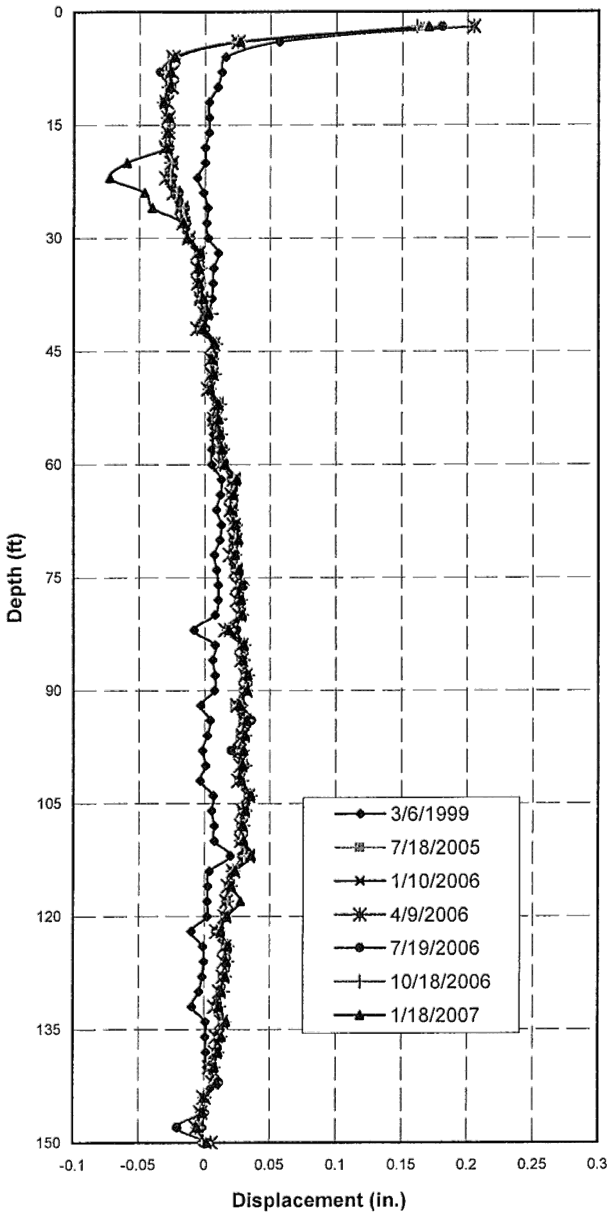
Cumulative

Elev.
589.6

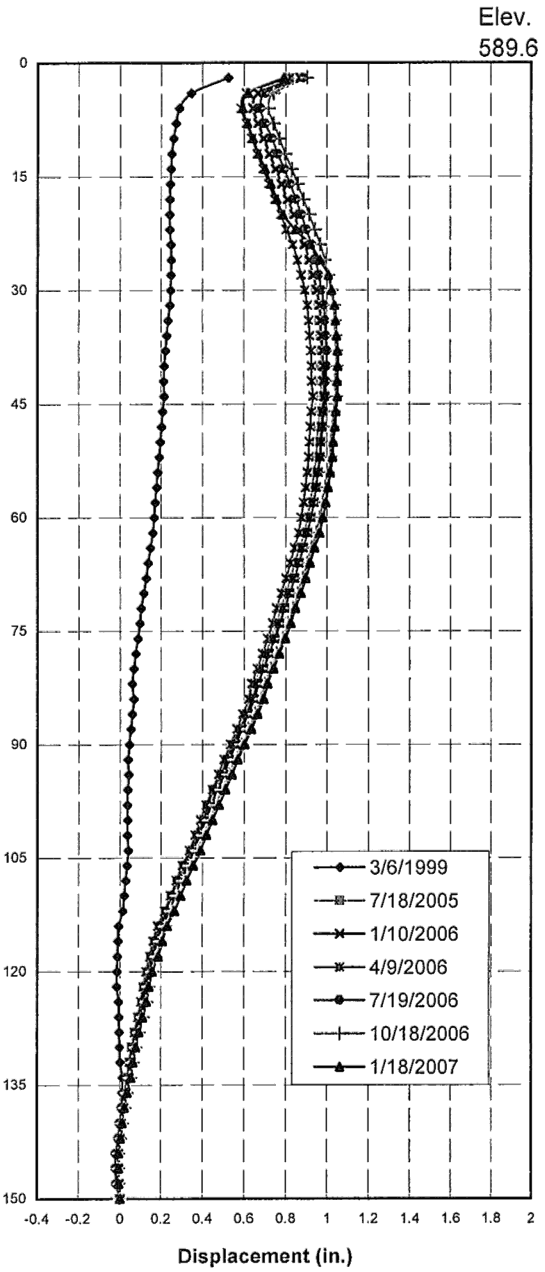


Inclinometer #9A Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

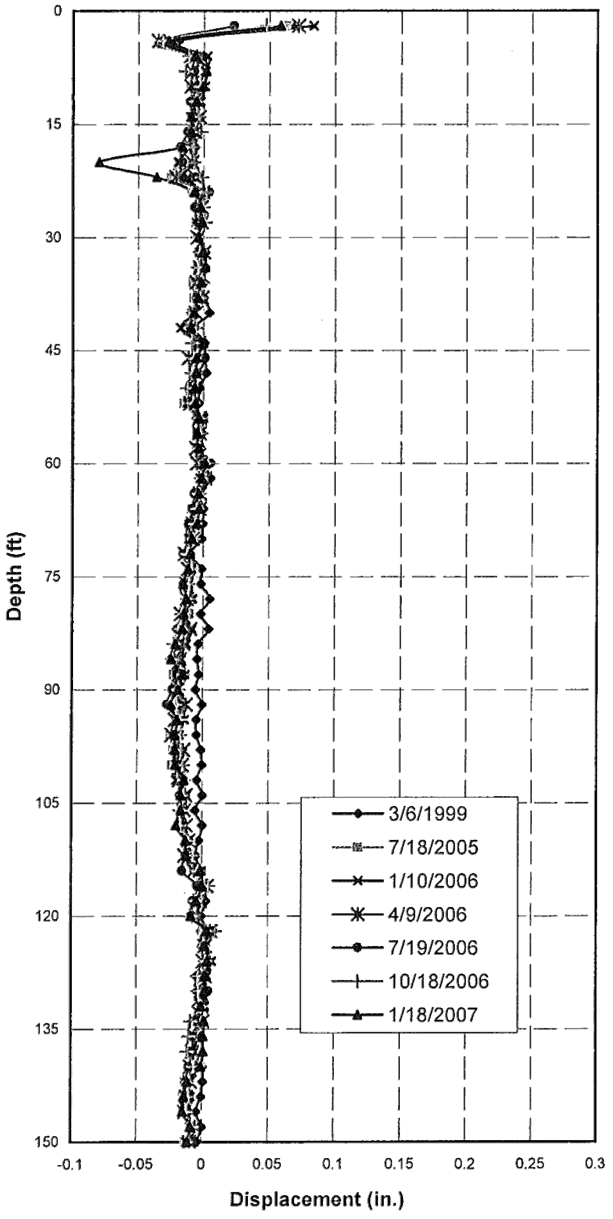


Cumulative



Inclinometer #9A Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



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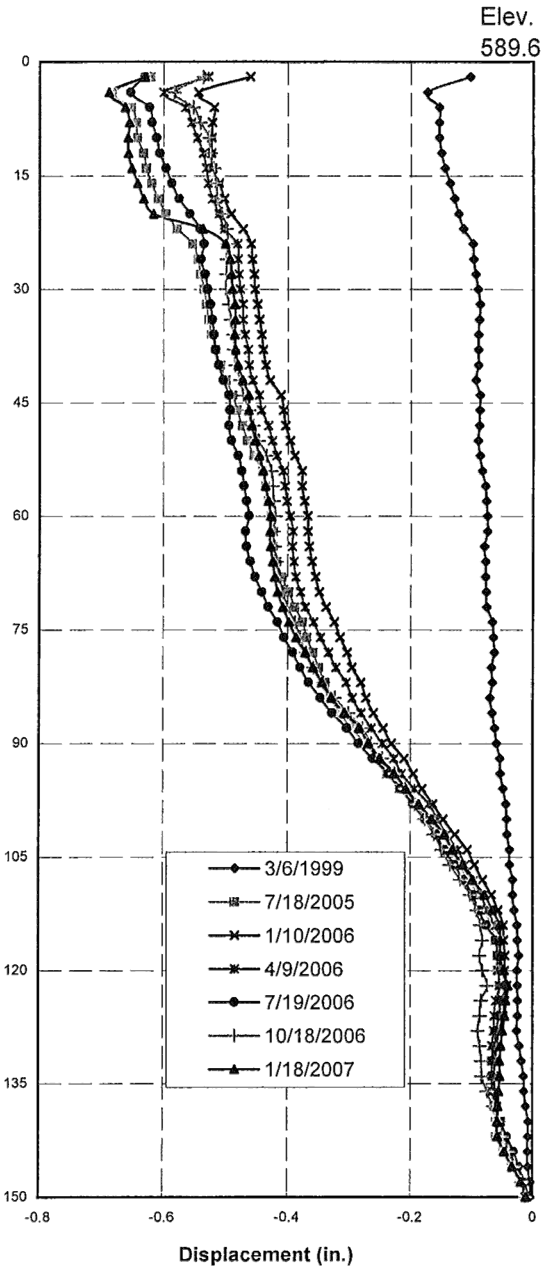

Inclinometer #10 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

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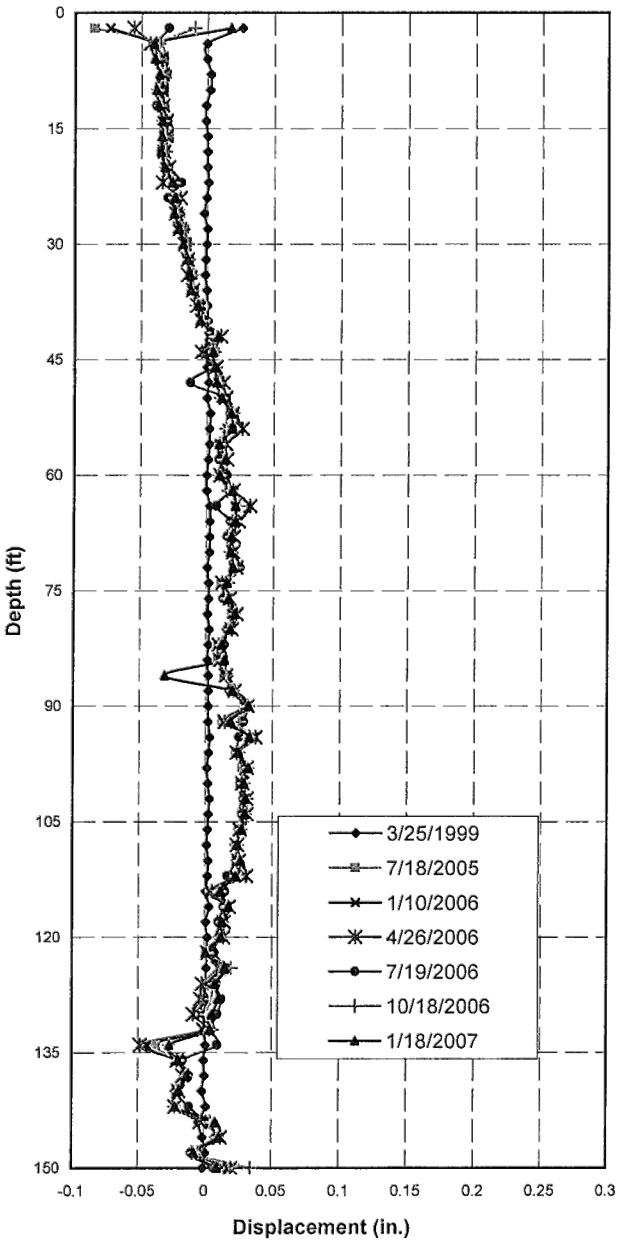

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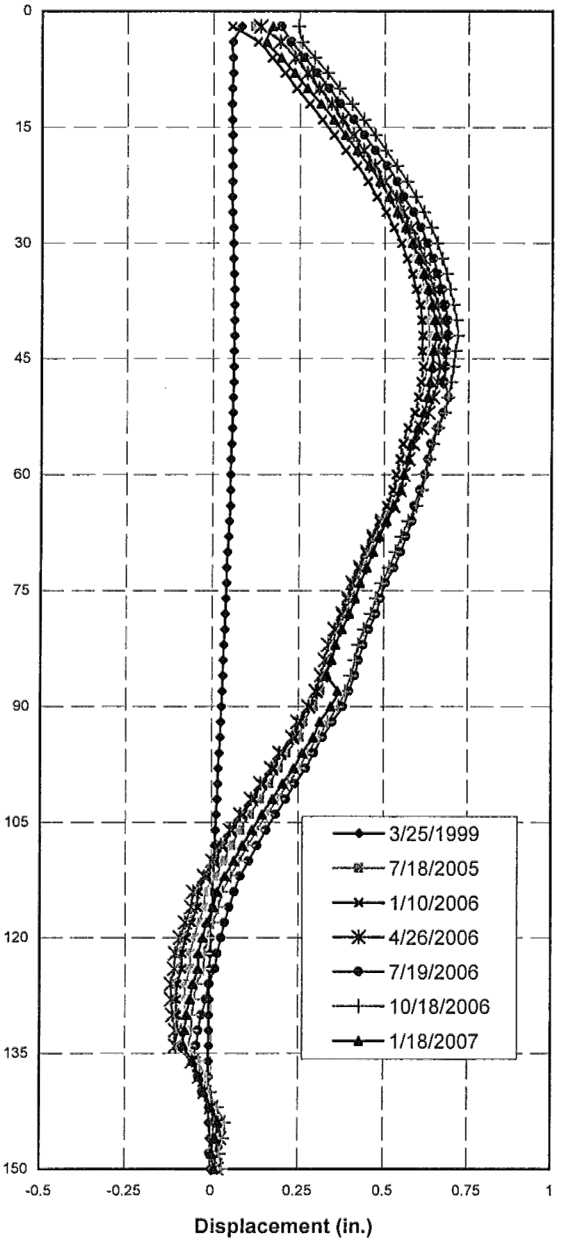

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Downslope (River direction) Base Line 12/11/1998

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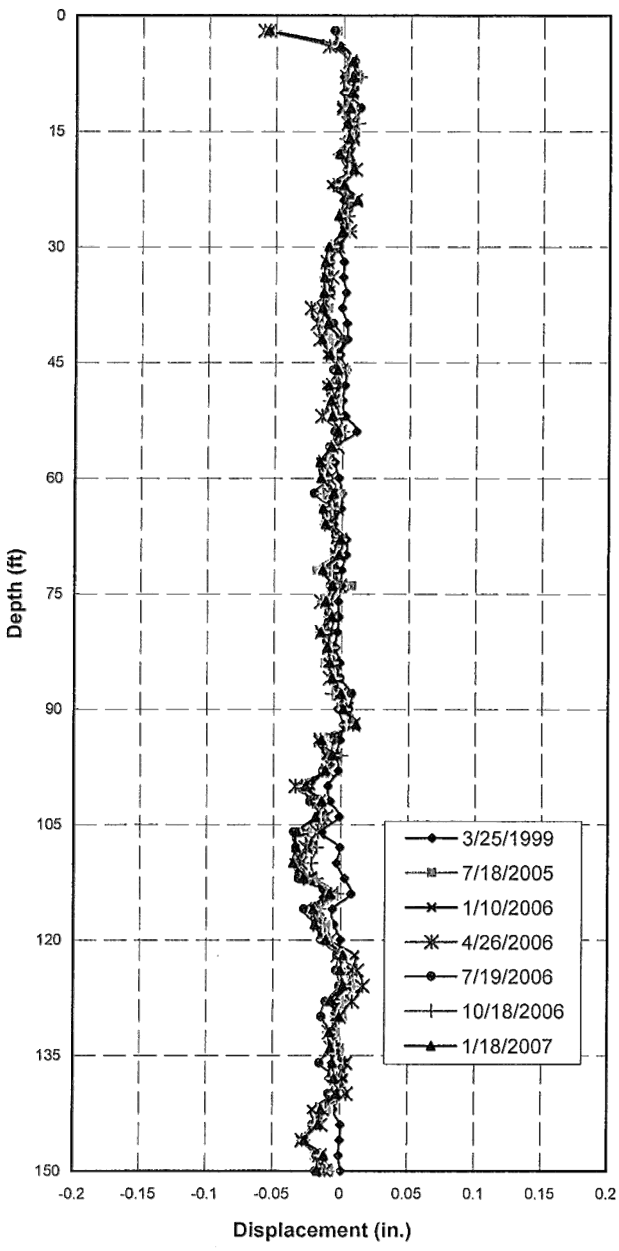

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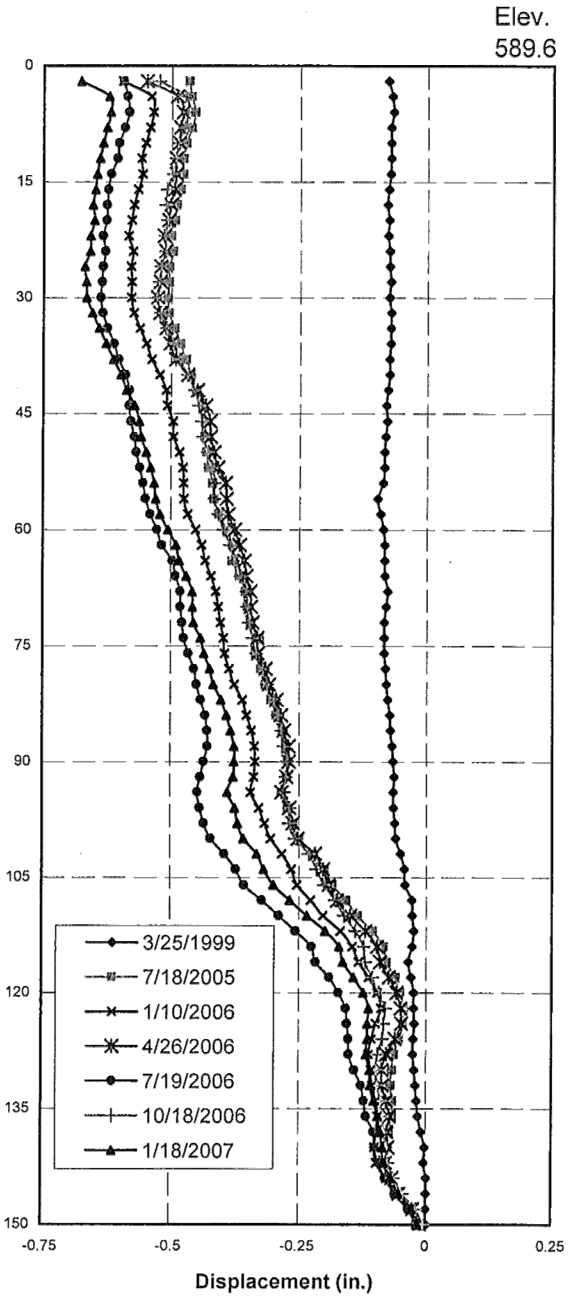

Inclinometer #17 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

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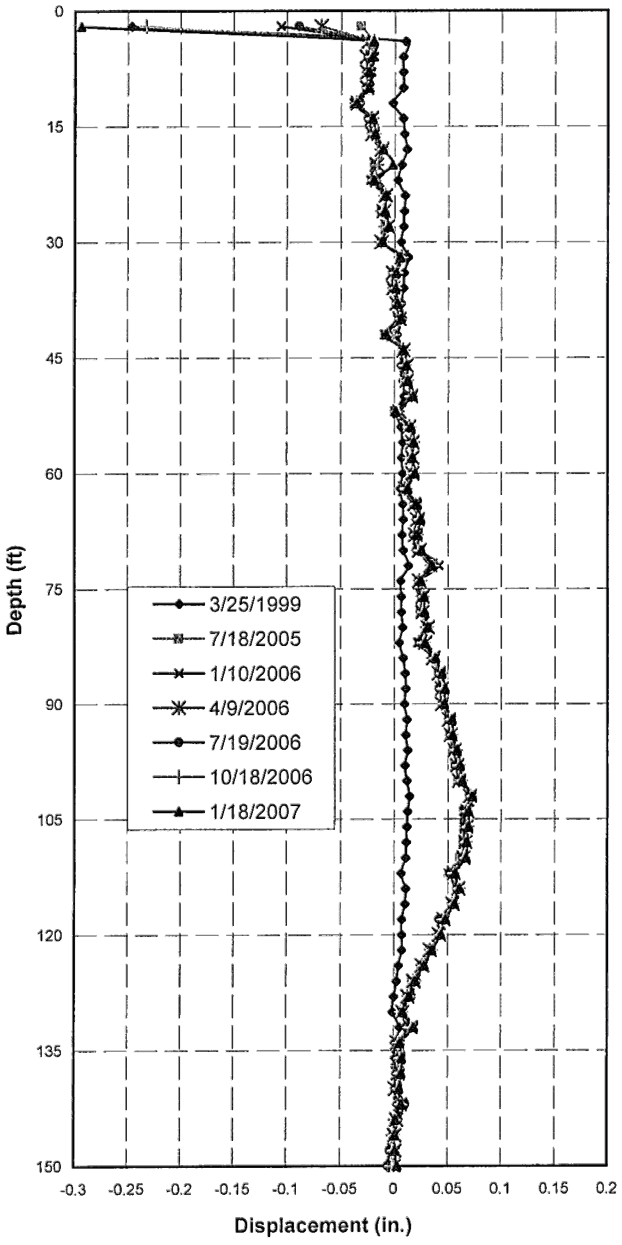

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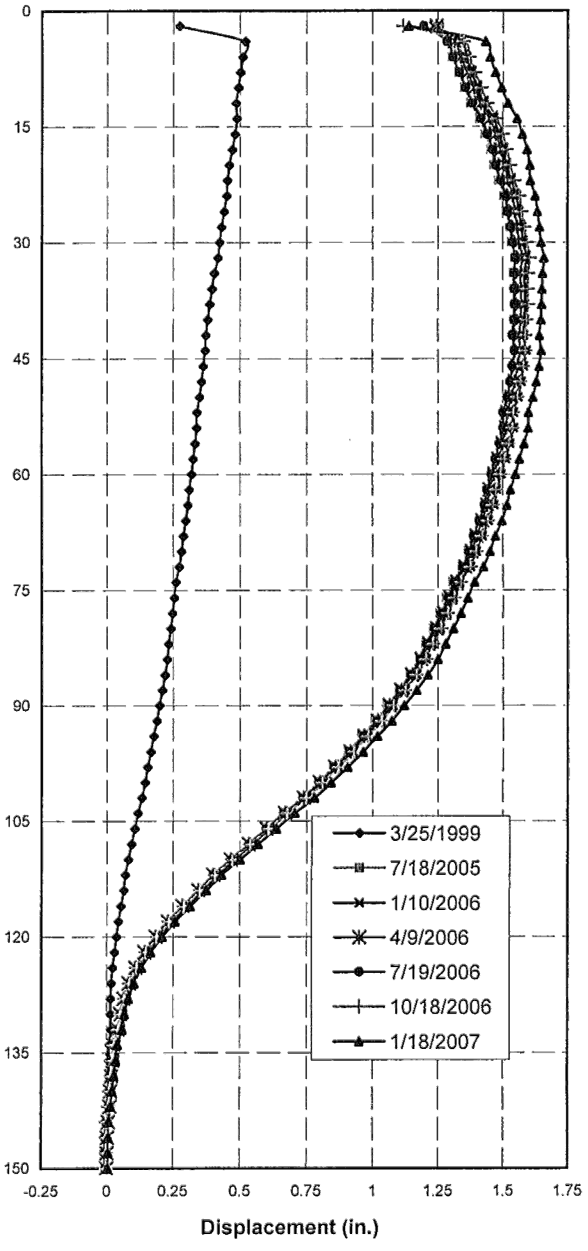
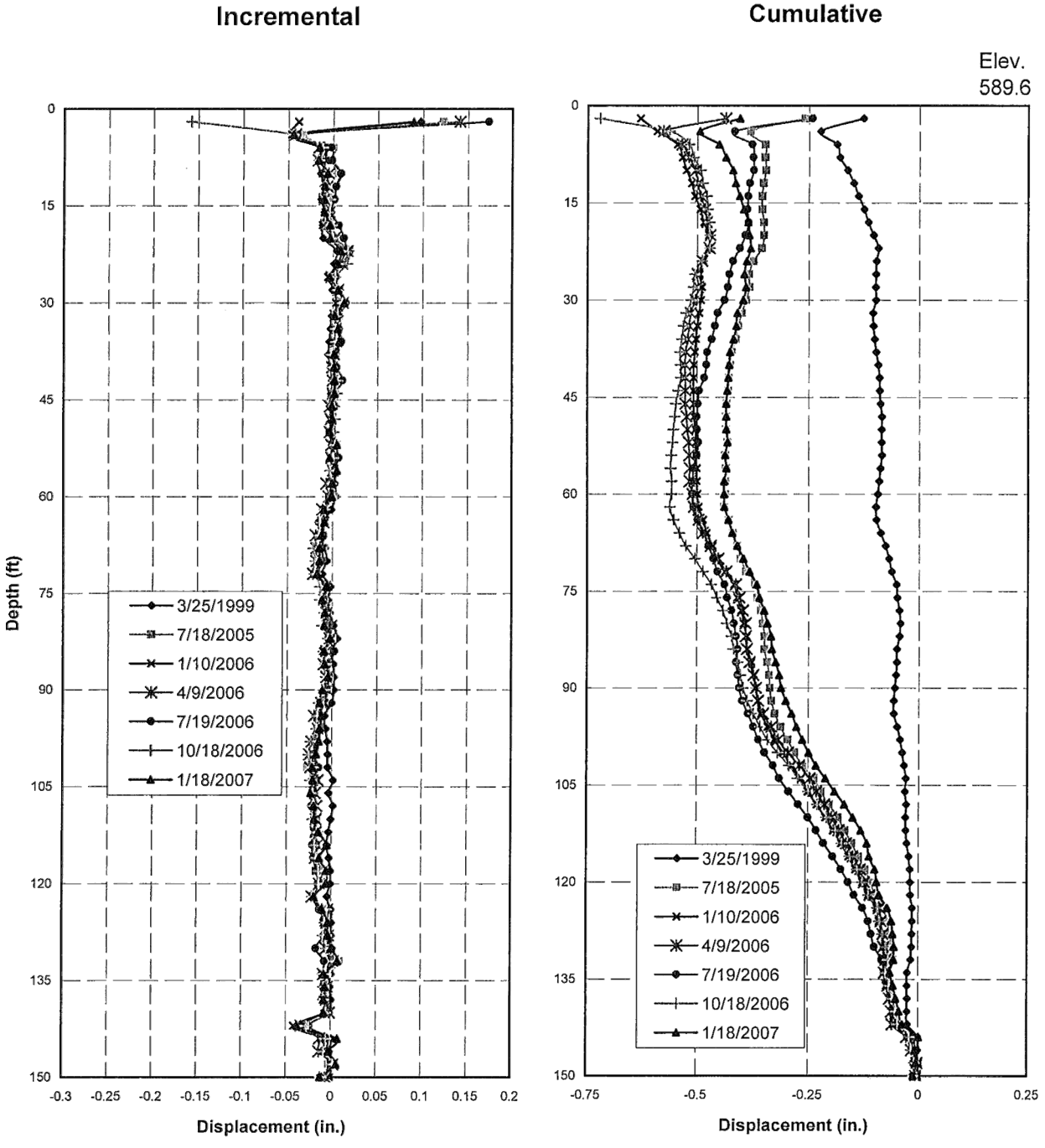


Inclinometer #17 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998



CUY-90-1524
Central Viaduct
PID No. 77332

Monitoring Services
Annual Report

June 1, 2007

RICHLAND ENGINEERING LIMITED
29 North Park Street, Mansfield, Ohio 44902-1769 • 419-524-0074 FAX 419-524-1812

106017

June 1, 2007

Ohio Department of Transportation
5500 Transportation Boulevard
Garfield Heights, Ohio 44125

Attn: Mr. Michael Malloy, P.E.

Re: CUY-90-1524
Central Viaduct
PID No. 77332
Monitoring Services
Annual Report

Dear Mr. Malloy:

Enclosed are two (2) copies of the following information:

- BBC&M Engineering, Inc.'s Annual Report dated May 2007 with information on the inclinometer readings taken through April 2007.
- Richland Engineering Limited schematic drawings of span 1 and 2, north and south truss measurements; relative span lengths; deck expansion joint openings; seat elevations; tabulations of pier location data; and plots of pier location data through October 2006.
- A. Huckelbridge tiltmeter data for pier 1 and the west end pier from July 27, 1999 through April 24, 2007.
- R. Liang annual instrumentation monitoring report dated May 2007.
- CD containing electronic files of the letter and annual report in .pdf format.

Note: For discussion, North is assumed to the left, perpendicular to the local centerline of bridge, toward Lake Erie.

The rock anchors were tensioned in April 1999 which put the stabilization structure in service. Site grading work was completed in May 1999. The span 1 superstructure was relocated in August 1999.

A study entitled "West End Slope and Substructure Evaluation," May 2005, was prepared by Richland Engineering Limited, BBC&M Engineering, Inc., Arthur Huckelbridge, and Robert Liang. The study was prepared for ODOT and evaluated the suitability of the existing west end pier, pier 1, west end slope, and slope stabilization structure for reuse in a rehabilitated structure.

The last annual report was dated June 1, 2006, for data collected through April 2006.

We have the following observations on the data collected:

1. A shallow failure plane is evident in data from inclinometers B-203, B-303, and B-110. B-203 and B-303 are located upslope of pier 1 and show an average rate of movement at the shallow failure plane of 0.05 inches per year. The average rate of movement of the shallow failure plane appears to have decreased to about 0.03 inches per year from 2004 to the present. B-110 was destroyed in mid-March 2006, by excavation activities performed in an attempt to repair a failed bulkhead to the north. Inclinometer B-110 was located north of pier 1 and showed an average rate of movement at the shallow failure plane of 0.15 inches per year. Replacement inclinometer B-05-16 was installed adjacent to the right-of-way fence near the previous location of B-110 and baseline readings were taken in June 2006. The top 30 feet of B-05-16 has shown some movement in the past year.

2. A deep failure plane is evident in data from inclinometers B-102, B-107, B-203, B-204, and B-303. B-102 and B-107 are located at the top of the slope west of the west end pier and show an average rate of movement at the deep failure plane of 0.03 inches per year. B-203 and B-303 are located upslope of pier 1 and B-204 is located between the pier 1 legs. The average rate of movement at the deep failure plane in the area of pier 1 is 0.06 inches per year. The average rate of movement of the deep failure plane in the immediate vicinity and upslope from the pier 1 area appears to have decreased to about 0.02 inches per year from 2004 to the present.

3. Inclinometers B-105 and B-108 can no longer be read due to deflection of the casings.

4. Replacement inclinometers B-105A and B-108A were installed next to the inactivated inclinometers in April and May 2006. Baseline readings were taken at these inclinometers in June 2006. Possible slide planes have been observed. However, it may be several years before evidence of any slide planes is well defined.

5. New inclinometers were installed at B-05-01 through B-05-04, B-05-07, B-05-08 and B-05-11 through B-05-13, between April and June 2006. Baseline readings were taken at these inclinometers in June 2006. Possible slide planes have been observed in B-05-02 and B-05-03. However, it may be several years before evidence of any slide planes is well defined.

6. Inclinometer B-101, at the top of the slope west of the west end pier, has shown no significant movement since it was installed.

7. BBC&M's inclinometer P#9N is the same inclinometer tube as Dr. Liang's inclinometer #9B. Inclinometer #9B was blocked and no longer readable when Dr. Liang took the April 2007 measurements. BBC&M's readings show about 0.45 inch top displacement and a bending deflection 40 to 50 feet down the shaft of about 0.9 inches.

8. Pneumatic piezometer readings have shown no significant change from previous readings. The maximum change in water elevation during the past year occurred in B-105 blue and varied by 1.9 feet. Piezometers B-105 pink and B-105 blue continue to indicate an elevated water level.

9. New vibrating wire piezometers were installed in offset boreholes at B-05-01 through B-05-04, B-05-07, B-05-08 and B-05-11 through B-05-13, between May and June 2006. Two piezometers were installed at each of the nine locations. The piezometers have shown stable or gradually increasing pore pressures. Piezometer B-05-13 exhibited a sudden pressure decrease in September 2006, but has since recovered.

10. The Calipered Crack Distance measurements at the top of the concrete slope protection by the west end pier show no significant change. The measurements are showing an average movement of 0.06 inches per year since 1999.

11. Aggregate piles of varying sizes and locations were observed at the site in the area adjacent to the south right-of-way fence. A large aggregate pile was observed in July and October 2006, south of the right-of-way fence. Relatively small aggregate piles were observed in July 2006, and January and April 2007.

12. BBC&M personnel observed a small landslide appearing in January 2007 located at the north right of way line on the west side of the river. The landslide is near the excavation performed for the dock wall repair on the adjacent property.

13. Comparing October 2006 survey measurements with October 2000 data, it appears that the west end pier and pier 1 have moved toward the river with the span 1 distance showing little change and the span 2 distance decreasing about 0.78 inches.

14. The position of the north and south west end pier legs have moved toward the river approximately 0.90 inches and 0.56 inches, respectively, since October 2000.

15. The position of the top of each of the north and south legs of pier 1 appear to have moved toward the river approximately 0.62 inches and 0.85 inches, respectively, since October 2000.

16. The drilled shaft structure appears to be rotating with the south end moving ahead of the north end about 0.69 inches since October 2000.

17. There has been no significant change (less than 0.6 inches) in the pier seat elevations.

18. In 1999, truss span 1 and 75% of span 2 were relocated to the west by approximately 3 inches to reopen the expansion joint in span 2. Since the relocation, maximum expansion joint openings have been measured of 2.38 inches at the north curb and 1.88 inches at the south curb. During the past year the openings varied from 0.63 inch to 1.38 inches at the north curb and 0.19 inch to 0.88 inch at the south curb for steel temperatures ranging between 34˚ and 78˚F. It appears that about 0.83 inches of expansion opening has been lost since October 2000.

19. Tiltmeter readings have been relatively steady for the past year showing rates and magnitudes of movement similar to past readings. Tiltmeter #2 indicates a continued increase in the "northward" inclination of the north leg of the west end pier. There is indication of movement of the top of the pier 1 legs with temperature changes. The west end pier legs appear to be continuing their long-term trends of spreading (north west end pier tilting to the north and south west end pier tilting toward the south) and both west end piers tilting toward the river. The truss and approach span superstructures have rocker nests to accommodate movement in the transverse direction, minimizing the impact of the west end pier tilting on the structure.

20. The instrumentation readings in the rock anchors, driven piles, and tieback beams have been steady. The instrumentation readings in the drilled shafts have shown a continued increase in bending moments. Inclinometers in the drilled shafts are also showing increased deflections.

21. The 17 rock anchors are made up of 16 strands of 0.6 inch diameter 270 ksi steel material. The anchors were initially tensioned to ±10% of the design load. Actual measured values in the 4 anchors being monitored were 490 kips to 600 kips at lock-off. After initial losses the anchors had a gradual reduction in load on the order of 3% to 9% in the first year. Present load levels in the anchors being monitored are 361 kips to 501 kips. The rock anchor loads continue to decrease at a slow rate.

22. The 34 anchor structure piles are HP 14x89 steel piles. Actual measured values in the 5 piles being monitored were 371 kips to 472 kips for piles #17, 18, 19, and 34 with pile #1 measured at 608 kips. There is significant bending (up to 202 kip-ft.) in some of the piles at the gage locations. The gages are located at the top of the pile. The pile loads have increased very slowly since the stabilization structure was loaded.

23. The tiebacks that are being monitored between the anchor structure and the drilled shaft structure are W8x35 rolled steel sections. Actual measured values in the 5 tiebacks being monitored were 110 kips to 143 kips at the anchor structure end, and 39 to 113 kips at the drilled shaft structure end. There is significant bending (up to 51 kip-ft.) in the tiebacks at the gage locations at the ends of the tiebacks. There is less bending in the tiebacks at the drilled shaft structure end. The tieback loads increased with time for the first year, but have become steady over the past six years with one exception. The load in tieback #26 has continued to slowly increase on the driven pile end cap. The tieback forces oscillate through one cycle in

a year due to the seasonal change in temperature. The tieback forces are up to 15 kips higher during the winter than in the summer months.

24. There are seventeen 72 inch diameter reinforced concrete filled drilled shafts in the drilled shaft structure. Actual moments measured in the drilled shafts were a maximum of 1,900 kip-feet at a depth of 95 feet in Shaft #9. The moments in the drilled shafts have been increasing with time at a fairly constant rate.

25. Dr. Liang has been monitoring 7 inclinometers in 6 of the drilled shafts. The inclinometers indicate a gradual change in the deflection of the shafts with deflection at the top varying from 0.3 to 1.1 inches and the maximum deflection below the top of the shaft at 1.65 inches in the longitudinal direction.

We have the following comments regarding the evaluation and monitoring data:

1. There is movement at the shallow failure plane within the influence of the stabilization structure, but it is moving at a slower rate than the adjacent soil mass. The movement is at an average rate of about 0.05 inches per year since 1999. This rate appears to have decreased to about 0.03 inches per year from 2004 to the present.

2. There is movement at the deep failure plane within the influence of the stabilization structure, but it is also moving at a slower rate than the adjacent soil mass. The average rate of movement south of the west end pier is 0.03 inches per year. The average rate of movement in the pier 1 area appears to have decreased in the last few years. The average rate of movement from April 1999 to April 2007 is 0.06 inches per year, but from October 2004 to April 2007 the rate has decreased to 0.02 inches per year.

3. The tops of the west end pier and pier 1 legs have moved toward the river and closed the span 2 expansion joint about 0.83 inches since October 2000.

4. The pier 1 and truss superstructure instrumentation performed for the "West End Slope and Substructure Evaluation Study" has shown that the tops of the pier 1 legs are moving west and east with expansion and contraction movement of the steel superstructure. The movement and horizontal thrust in the superstructure varies with temperature.

5. The substructure stabilization structure was originally designed using "LPILE" computer software to calculate forces and member design loads. The Contractor was given loads and designed the rock anchors, anchor structure and tiebacks to resist those loads.

   Under a separate ODOT sponsored research project Dr. Robert Liang prepared a finite element analysis of the stabilization structure as it was being constructed ("Long Term Monitoring at CUY-90-1524 Bridge Project," December 31, 1999).

The original design loads, the finite element analysis (FEA), and the range of measured values are compared in the attached table.

a. Rock anchor loads are less than design and FEA values and generally continue to decrease at a slow rate.

b. The loads in the piles are higher than expected. The anchor structure pile gages are located near the top of the piles in an area of localized bending. The combined axial load and bending may have exceeded the 36 ksi yield value of the steel. However, the piles will redistribute the load in the redundant system through yielding before failure would occur.

c. The axial tension in the tiebacks is less than the design load and slightly higher than the loads calculated by FEA. Again, combined axial loads and bending may approach yield at isolated locations, but the members should not fail.

d. The moment in the piles and tiebacks and the bending in the drilled shafts indicates a rotation of the anchor structure concrete cap about the transverse axis of the cap.

e. The drilled shaft measured moments and deflections are well below the design values. The increasing moments and deflections measured in the drilled shafts both indicate increased bending in the shafts. The bending is expected as the soil mass lateral loading is gradually transferred to the drilled shafts. The rate of moment increase appears to be constant.

6. The stabilization structure is currently performing adequately with only some minor concern for the high loads in the anchor structure piles. The stabilization structure has slowed the rate of creep movement in the soil mass within its influence.

7. Loading and pressures within the stabilization structure and the influenced soil mass are continuing to increase at a slow rate. The rate of change of moment in the drilled shafts has not slowed. The stabilization structure was designed with the concept that the structure and soil mass would reach equilibrium at some time in the future when loads and deflections would remain constant. However, the "West End Slope and Substructure Evaluation Study" has suggested that the stabilization structure may have a finite life. The creep movement at the failure planes has historically moved at a very slow rate. The data collected over the past 8 years indicates that there is still movement at the failure planes, but within the last few years this movement appears to be slowing.

The next readings are scheduled about July 15, 2007. The monitoring will continue by the same parties under the agreement between ODOT and Michael Baker Jr., Inc.

Please contact us if you have any questions.

Very truly yours,

RICHLAND ENGINEERING LIMITED

Dean A. Palmer, P.E.

JDB:sk
Enc.
cc: Craig Hebebrand, District 12, w/enc.
Tim Keller, Office of Structures, w/enc.
Gene Geiger, Office of Geotechnical Services, w/enc.
Tom Lefchik, FHWA, w/enc.
Steve Pasternack, BBC&M Inc., w/enc.
Art Huckelbridge, w/enc.
Robert Liang, w/enc.
Bob Parker, Michael Baker Jr., Inc., w/enc.
Rick Engel, E.L. Robinson Engineering Co., w/enc.

COMPARISON OF MEMBER LOADS
DESIGN VALUES AND MEASURED VALUES
CUY-90-1524 SLOPE STABILIZATION STRUCTURE

MEMBER	DESIGN	FINITE ELEMENT ANALYSIS	January 2001 MEASURED	January 2002 MEASURED	April 2003 MEASURED	April 2004 MEASURED	April 2005 MEASURED	April 2006 MEASURED	April 2007 MEASURED
Rock Anchors	550 kips	550 kips	430 to 530 kips	400 to 510 kips	380 to 501 kips	370 to 494 kips	366 to 494 kips	365 to 487 kips	361 to 501 kips
Anchor Structure Piles									
Axial Load	279 kips	310 kips	358 to 566 kips	362 to 583 kips	365 to 585 kips	368 to 594 kips	368 to 603 kips	370 to 606 kips	371 to 608 kips
Moment	None	80 kip-feet	32 to 192 kip-feet	8 to 191 kip-feet	49 to 192 kip-feet	49 to 199 kip-feet	55 to 206 kip-feet	56 to 203 kip-feet	57 to 202 kip-feet
Tiebacks									
Axial Load - Anchor End	192 kips	100 kips	101 to 124 kips	99 to 124 kips	108 to 134 kips	111 to 139 kips	111 to 143 kips	112 to 144 kips	110 to 143 kips
Axial Load - Drilled Shaft End	192 kips	100 kips	58 to 111 kips	55 to 112 kips	46 to 110 kips	45 to 113 kips	40 to 112 kips	39 to 113 kips	39 to 113 kips
Moment - Anchor End	None	80 kip-feet	13 to 42 kip-feet	13 to 43 kip-feet	14 to 48 kip-feet	14 to 49 kip-feet	14 to 45 kip-feet	15 to 52 kip-feet	15 to 51 kip-feet
Moment - Drilled Shaft End	None	80 kip-feet	1 to 29 kip-feet	1 to 30 kip-feet	2 to 29 kip-feet	1 to 30 kip-feet	2 to 31 kip-feet	1 to 32 kip-feet	2 to 32 kip-feet
Drilled Shafts									
Deflection at Top	2.0 inch	0.4 inch	0.2 inch	-0.2 to 0.6 inch	-0.1 to 0.7 inch	0.1 to 1.1 inch	0.1 to 1.0 inch	0.2 to 1.2 inch	0.3 to 1.1 inch
Maximum Deflection Below Top	4.0 inch	0.1 inch	0.4 inch	1.0 inch	1.3 inch	1.5 inch	1.5 inch	1.6 inch	1.65 inch
Maximum Moment	3,141 kip-feet	800 kip-feet	1,000 kip-feet	1,045 kip-feet	1,400 kip-feet	1,600 kip-feet	1,700 kip-feet	1,800 kip-feet	1,900 kip-feet
Maximum Axial Force	458 kips	420 kips	1,100 kips	2,382 kips	3,000 kips	3,250 kips	----	----	----

2006-2007 ANNUAL REPORT
FIELD MONITORING SERVICES
CUY-90-14.52/15.24
PID #77332
CLEVELAND, OHIO

Report to

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

Prepared by

BBC&M ENGINEERING, INC.
CLEVELAND, OHIO

May 2007

May 4, 2007
012-00946-300

BBCM
SOLUTIONS TO BUILD ON

Mr. Dean A. Palmer, P.E.
Richland Engineering Limited
29 North Park Street
Mansfield, Ohio 44902

Re: CUY-90-14.52/15.24 Bridge
2006-2007 Annual Report - Field Monitoring Services
PID No. 77332

Dear Mr. Palmer:

In accordance with our proposal dated February 1, 2006, BBC&M Engineering, Inc. (BBCM) has completed the field monitoring services during the period of June 2006 through April 2007 as part of the CUY-90-14.52/15.24 project. Quarterly reports were submitted to Richland Engineering Limited in August 2006, November 2006, and February, 2007 for quarterly readings taken in July 2006, October 2006, and January 2007, respectively. A quarterly report was not submitted summarizing the data obtained in April 2007 per your request via an e-mail dated February 9, 2007. This annual report summarizes the data obtained from all the actively monitored instrumentation (inclinometers, piezometers, and calipered distance locations), discussions of observations of the data, and general site observations.

We appreciate being of continued service during this project. The next quarterly readings are scheduled to take place around July 15, 2007. Please contact our office if you have any questions or require additional information.

Sincerely,
BBC&M ENGINEERING, INC.
Cleveland, Ohio

Jeffrey L. Snyder, M.S., E.I.
Staff Engineer

Stephen C. Pasternack, Ph.D., P.E.
Senior Project Engineer

STATE OF OHIO
STEPHEN C. PASTERNACK
47758
REGISTERED PROFESSIONAL ENGINEER

JLS/jls

Submitted: 2 hard copies (1 bound, 1 unbound) and 1 pdf copy on CD

8555 Sweet Valley Dr., Ste. S • Valley View, OH 44125-4210 • Phone 216.901.1000 • Fax 216. 901.9996

EXECUTIVE SUMMARY

Quarterly readings were taken at the new and remaining active inclinometers and piezometers in July and October 2006, and January and April 2007.

Inclinometers

Active BBCM Inclinometers Installed between 1994 and 1999

In general, there are observed movements that correspond to two major slide planes, termed the shallow and deep failure planes. In the immediate vicinity of the Pier 1 area, no shallow slip-plane movements have been observed since completion of construction of the Pier 1 stabilization system. The shallow failure plane upslope from the Pier 1 area is moving at an average rate of about 0.05 inches per year from April 1999 to April 2007. The average rate of movement of the shallow failure plane upslope from the Pier 1 area appears to have decreased to about 0.03 inches per year from 2004 to the present. South of the West End Pier, the deep failure plane is moving at an average rate of about 0.03 inches per year. The B-101 inclinometer has indicated nominal movement since its installation. In the immediate vicinity and upslope from the Pier 1 area, the deep failure plane is moving at an average rate of about 0.06 inches per year from April 1999 (August 2001 in B-204) to April 2007. The average rate of movement of the deep failure plane in the Pier 1 area also appears to have decreased to about 0.02 inches per year from 2004 to the present.

No accelerated rates of movement have been observed as a result of the excavation activities in the vicinity of B-110 (or B-05-16) on the west side of the I-90 Bridge in any of the inclinometers installed between 1994 and 1999.

Active BBCM Inclinometers Installed in 2006

A relative displacement of about 0.2 inches has been recorded in B-05-16 at depths of 10 feet and 29 feet over a 10-month period.

Multiple possible slide planes have been observed in some of the new and replacement inclinometers, which are listed as follows:

- In B-105A at a depth of 20 to 30 feet;
- In B-108A at depths of 25 and 120 feet;
- In B-05-02 at depths of 109 and 129 feet; and,
- In B-05-03 at a depth of 37 feet;

Distinct movement has not been observed in the remaining seven (7) inclinometers. However, displacements may not yet be evident within the time period between the baseline and the current readings. Multiple readings over a period of a few years are likely needed to measure definitive displacement trends.

Pneumatic Piezometers

The readings for the pneumatic piezometers exhibited similar readings between the four quarters. The B-105 blue piezometer indicated an elevated water pressure with the total head ranging from 4.6 to 6.5 feet above the existing ground surface. Additionally, the B-105 pink piezometer indicated an elevated total head ranging from 0.4 to 1.5 feet above the existing ground surface.

Vibrating Wire (VW) Piezometers

After an initial stabilization period in which some of the piezometers indicated a total head decrease as much as 13 feet, the readings have generally been stable in the VW piezometers since the beginning of July 2006. Since July 2006, four (4) of 18 VW piezometers have indicated a gradual increase in the pore pressures during the current reporting period. The 21955 piezometer in B-05-13 exhibited a sudden pressure decrease of 2.5 psi (5.7 feet of total head) during a 24-hour period in September 2006. The pore pressures have since recovered to the pressure levels recorded prior to the dramatic decrease. Gas pockets were encountered during rock coring in B-05-13.

Additional Field Observations

BBCM personnel observed evidence of a potential small landslide during the January 2007 quarterly readings that may have occurred after the quarterly readings were taken in October 2006. This small landslide area is located near the west right-of-way fence just north of B-05-16, adjacent to the river and on the eastern edge of the large excavation. It appears that progressive failure in this landslide area has occurred between the January and April 2007 readings.

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1.0 INTRODUCTION

This Annual Report presents the results and evaluation of data collected from July 2006 to April 2007 in instrumentation installed by BBC&M Engineering, Inc. (BBCM) at or near the West Abutment of the existing I-90 Central Viaduct Bridge.

Of the 14 inclinometers and 12 pneumatic piezometers installed by BBCM between 1994 and 1999, seven (7) inclinometers (B-101, B-102, B-107, B-203, B-204, B-303 and P-9N) and six (6) pneumatic piezometers at B-101 and B-105 (2 piezometers each), as well as B-107 and B-303 are still actively monitored. This active instrumentation was associated with the CUY-90-15.24 project. During the period of March through June 2006, BBCM installed 12 new inclinometers (including 3 replacement inclinometers) and 18 vibrating wire (VW) piezometers. These newly installed inclinometers and piezometers are associated with the CUY-90-14.52 Innerbelt project. A Summary Table and Site Plan of Active Instrumentation are submitted as Plates 1 and 2 of the Appendix. Quarterly readings were taken at the new and remaining active inclinometers and piezometers in July and October 2006, and January and April 2007.

1.1 Replacement Inclinometers

In mid-March 2006, excavation was performed at the toe of the slope adjacent to ODOT property in an effort to repair a section of failed bulkhead, which resulted in the destruction of the B-110 inclinometer. Additionally, the B-105 and B-108 inclinometers have become unreadable due to excessive displacement at the observed slide planes. Readings were last taken in the B-105, B-108 and B-110 inclinometers in October 2005, April 2006 and January 2006, respectively. Replacement inclinometers were installed at B-105A and B-108A in April and May 2006, immediately adjacent to the inactivated inclinometers. Also, per ODOT's request, BBCM installed a replacement inclinometer for B-110 at Boring B-05-16 in June 2006, adjacent to the right-of-way fence near where B-110 used to be located (see Plate 2 of the Appendix). The B-05-16 inclinometer is located within the existing ODOT right-of-way. These replacement inclinometers were installed at depths ranging from 156 to 168 feet below existing grade. Baseline (initial) readings were taken at these replacement inclinometers on June 21 and 22, 2006.

1.2 New Inclinometers

New inclinometers were also installed at B-05-01 through B-05-04, B-05-07, B-05-08 and B-05-11 through B-05-13, between April and June 2006. These new inclinometers were installed at depths ranging from 134 to 228 feet below existing grade. Baseline readings were taken at these inclinometers between June 21 and June 26, 2006. The locations, types, and number of inclinometers were determined by ODOT.

1.3 New Piezometers

New VW piezometers were installed in offset boreholes at B-05-01 through B-05-04, B-05-07, B-05-08 and B-05-11 through B-05-13, between May and June 2006. Two (2)

VW piezometers were installed at each of the nine (9) locations at depths ranging from 32 to 220 feet below existing grade. Once installation was complete, the VW piezometers automatically began taking readings at 5-hour intervals. A few weeks after installation, the reading interval was increased to 8 hours between readings. The location, depth and number of VW piezometers to be installed were determined by BBCM based on existing inclinometer data and the results from cone penetration tests (CPT) performed by Ohio University during March and April 2006 adjacent to the proposed borehole locations. This task was reviewed and accepted/modified by ODOT prior to commencing field work.

2.0 DISCUSSION OF INSTRUMENTATION DATA

2.1 Inclinometers

Spiral (twist) measurements were performed in January 2005 on the 10 inclinometers that were active at the time. Spiral measurements were also performed on June 28 and June 29, 2006 on the 12 new/replacement inclinometers. All the data sets presented in the Appendix have been corrected to account for the measured spiral of the inclinometer casings.

The Cumulative and Incremental Displacement vs. Depth plots in the Appendix show one reading from each of the previous four quarters. Additionally, the Displacement vs. Time plots include at least one reading from each year since the baseline readings.

Lateral deflections from slope inclinometer measurements contain both random and systematic errors. Durham Geo Slope Indicator Company (DGSI) provides typical displacement accuracy threshold for slope inclinometer measurements as follows:

1) Ordinary precision of ± 0.3 inches per 100 ft of casing using standard installation procedures;
2) Higher Precision of ± 0.1 inches per 100 ft of casing with careful survey practices and error correction during data reduction; and,
3) Highest Precision of ± 0.05 inches per 100 ft of casing with careful survey and data selection from redundant data sets and excellent casing installation.

BBCM considers the inclinometer measured displacement data presented herein to have a precision in the range of ± 0.1 to ± 0.2 inches per 100 ft. **Hence, any measured displacement (especially along deep failure planes) on the order of about 0.1 inches could be due to data precision errors and not actual field movements.** The actual estimated rates of slope movement in active inclinometers range from about 0.02 inches per year to 0.10 inches per year on the two slide planes.

The rates of movement were computed using linear regression for the depth ranges shown on the Displacement vs. Time plots in the Appendix. The rates of movement are discussed in more detail in subsequent sections of this report. Linear regression provided a best-fit match through the data points on each of the Displacement vs. Time

curves. The time period for the linear regression (see time periods presented in Tables 1a and 1b in Section 2.1.2) was chosen based on a visual observation of each curve at the time when the rate was believed to have last changed significantly (typically in 1999 or 2000 just after the end of construction of the Pier 1 stabilization structure). Some of the inclinometers indicate a somewhat decreased rate of movement since 2004, which is subsequently discussed. Linear regression was also performed on the data in some of the inclinometers over a time period from 2004 to the present (see Tables 1a and 1b). However, the 95% confidence interval of the regression of each analyzed slide plane from 1999 or 2000 to the present falls within the range of the expected precision of the inclinometer measurements (about 0.1 inches per 100 ft). Therefore, it is inconclusive whether the observed decrease in the rate of movement in 2004 in some inclinometers is an actual change in the average rate of movement or a false trend caused by the limitations in the data due to the accuracy of the measurements. Regardless, if the measured rates of movement are indeed decreasing, the likely result is that greater load is being transferred from the creeping soil mass to the stabilization structure. Several years of data showing a consistent trend or changes in rates greater than the accuracy level of the measurements are necessary to draw conclusions that the average rate has in fact changed. Therefore, all discussions regarding trends in the data are developed based upon multiple years of data.

In general, there are observed movements that correspond to two major slide planes, termed the shallow and deep failure planes. In some of the inclinometers, multiple slide planes may be observed within the shallow or deep failure zones (i.e. B-203 and B-303). In such cases, the multiple slide planes have been grouped together and referred to as part of either the shallow or deep failure plane, whichever is deemed more appropriate. Consequently, the magnitude and rate of movements subsequently discussed are the summation of the relative movements of the individual slide planes within either the shallow or deep failure plane. This summation is performed in an attempt to quantify the total relative soil movement that would be transferred to a pier or the stabilization structure.

2.1.1 Systematic Error Correction

Systematic errors are correctable errors observed in inclinometer data and are caused by one or more of the following factors: sensor bias-shift, rotation (sensor alignment shift), sensitivity drift, depth positioning error (DPE), and casing inclination/curvature. The data presented in this report have been analyzed and corrected for more common systematic errors such as bias-shift and rotation, where necessary.

The uncorrected data obtained in B-05-08 and B-05-12 in July 2006 was observed to be unusual, such as displacement within the bedrock or relatively large deep displacements not observed in nearby inclinometers. Thus it was determined that the displacements were not likely real. As error detection was performed on the data, it became apparent that bias shift and/or rotation were not the major causes of the unusual displacements. The data for B-05-08 and B-05-12 was sent to Mr. Erik Mikkelsen of Geometron for error detection analysis. Mr. Mikkelsen has published a

paper titled "Advances in Inclinometer Data Analysis" (Symposium on Field Measurements in Geomechanics, FMGM September 2003, Oslo, Norway), which discusses correction procedures for many of the aforementioned systematic errors. In Mr. Mikkelsen's opinion, DPE and bias-shift were the systematic errors evident in the B-05-08 and B-05-12 inclinometer data. DPE is a common error mainly caused by settlement (shortening) of the casing and/or change in probe depth control (human error) in inclinometers with significant built-in curvatures. In February 2005, the data for B-101 was also sent to Mr. Mikkelsen who believed that DPE was the cause of the unusual displacements observed in the inclinometer. The readings for B-101, B-05-08, and B-05-12 inclinometers have been corrected for DPE as well as bias-shift and the resulting plots are submitted as Plates 3, 4, 36, 37, 40 and 41 of the Appendix.

In addition to the DPE errors observed in B-101, B-05-08, and B-05-12, minor DPE errors were also observed in readings from nine (9) inclinometers (B-107, B-05-01, B-05-02, B-05-04, B-05-07, B-05-11, B-05-13, B-05-16 and B-105A). The readings presented in the Appendix for these nine (9) inclinometers have also been corrected for DPE.

2.1.2 Summary of Observed Movements

Active BBCM Inclinometers Installed between 1994 and 1999

Tables 1a and 1b below summarize the average rates of movement for the shallow and deep failure planes and the various time ranges chosen for each active inclinometer installed between 1994 and 1999 where consistent movements have been observed. The time ranges shown in these tables extend to the last set of readings taken within each respective inclinometer. The inclinometers where movements have been observed have been divided into three (3) categories based on location as follows:

- The immediate vicinity of the Pier 1 area (B-204);
- Upslope from Pier 1 (B-203, B-303); and,
- South of the West End Pier (B-102 and B-107).

Table 1a: Average Rate of Movement in Inclinometers – Shallow Failure Plane

Shallow Failure Plane					
Inclinometer	Location	Time Range (from 1999)	Avg. Rate of Movement (in/yr)	Time Range (from 2004)	Avg. Rate of Movement (in/yr)
B-203	Upslope from Pier 1	Apr-99 to Apr-07	0.03	Oct-04 to Apr-07	0.02
B-303	Upslope from Pier 1	Apr-99 to Apr-07	0.07	Jan-05 to Apr-07	0.04
Avg. Rate of Movement – Upslope from Pier 1			0.05		0.03

Table 1b: Average Rate of Movement in Inclinometers – Deep Failure Plane

Deep Failure Plane					
Inclinometer	Location	Time Range (from 1999)	Avg. Rate of Movement (in/yr)	Time Range (from 2004)	Avg. Rate of Movement (in/yr)
B-102	South of West End Pier	Oct-99 to Apr-07	0.04	N/A[1]	N/A[1]
B-107	South of West End Pier	Apr-00 to Apr-07	0.015	N/A[1]	N/A[1]
Avg. Rate of Movement – South of West End Pier			0.03		N/A
B-204	Immediate Vicinity of Pier 1 Area	Aug-01[2] to Apr-07	0.05	Oct-04 to Apr-07	0.03
B-203	Upslope from Pier 1	Apr-99 to Apr-07	0.03	Oct-04 to Apr-07	0.01
B-303	Upslope from Pier 1	Apr-99 to Apr-07	0.10	Jan-04 to Apr-07	0.03
Avg. Rate of Movement – Pier 1 Area			0.06		0.02

1 Change of rate not observed in these inclinometers from 2004 to the present.
2 Inclinometer reinitialized on the shown date, which does not necessarily indicate the date when a significant change in the rate of movement occurred

In the immediate vicinity of the Pier 1 area (B-204), no shallow slip-plane movements have been observed since completion of construction of the Pier 1 stabilization system. The shallow failure plane upslope from the Pier 1 area (B-203 and B-303) is moving at an average rate of about 0.05 inches per year from April 1999 to April 2007. This is a slight decrease from that reported in BBCM's 2005-2006 Annual Report dated May 22, 2006, in which the average rate of about 0.06 inches per year was observed. As indicated in Table 1a, the average rate of movement of the shallow failure plane in B-203 and B-203 appears to have decreased to about 0.03 inches per year from 2004 to the present. This rate decrease is illustrated in the Displacement vs. Time plots submitted as Plates 19 and 21 in the Appendix.

South of the West End Pier (B-102 and B-107), the deep failure plane is moving at an average rate of about 0.03 inches per year. This is a slight increase from that reported in the BBCM 2005-2006 Annual Report, in which the average rate of about 0.02 inches per year was observed. The B-101 inclinometer has indicated nominal movement since its installation. In the immediate vicinity and upslope from the Pier 1 area (B-203, B-204 and B-303), the deep failure plane was observed to be moving at an average rate of about 0.06 inches per year from April 1999 (August 2001 in B-204) to April 2007. In the BBCM 2005-2006 Annual Report, the average rate of movement in the Pier 1 area was reported to be about 0.09 inches per year. However, note that rates of movement observed in the B-105 and B-108 inclinometers, which are now inactive, are not included in the average movement rates provided in this report. As was observed in the shallow failure plane in B-203 and B-303, the average rate of movement of the deep failure plane in the Pier 1 area appears to have decreased to about 0.02 inches per year from 2004 to the present (see Table 1b and Plates 19 through 21 in the Appendix).

Inclinometer P-9N (installed in one of the drilled shafts) indicates the top of the drilled shaft is restrained laterally and that the maximum lateral deflection is nearly 0.90 inches and occurs approximately 40 to 50 feet below the top of the inclinometer casing.

No accelerated rates of movement have been observed as a result of the excavation activities in the vicinity of B-110 (or B-05-16) on the west side of the I-90 Bridge in any of the inclinometers installed between 1994 and 1999.

Active BBCM Inclinometers Installed in 2006

A relative displacement of about 0.2 inches has been observed in the upper 10 feet of the B-05-16 inclinometer over a 10-month period (see Plates 44 and 45 of the Appendix). Additionally, a slip-plane movement of about 0.2 inches has been observed in B-05-16 at a depth of about 29 feet. It is likely the displacements observed at B-05-16 are a result of the open excavation in the vicinity of the removed inclinometer B-110. The displacements at B-05-16 are expected due to the scarps and tension cracks that have been observed in the area downslope of the inclinometer.

Possible cantilever displacement, similar in shape to the cantilever displacements observed in B-102 and B-107, was observed in B-05-12 to a depth of 30 feet (see Plates 40 and 41 of the Appendix). However, there has been no observed displacement since the July 2006 readings. The magnitude and location of the displacement in B-05-12 was not observed in other nearby inclinometers such as B-107 and B-05-02. A small sinkhole (approx. 1' dia.) was first observed by BBCM personnel in March 2006 in the pavement of University Road in the vicinity of B-05-12. This sinkhole did not appear to be any larger as of October 2006. The sinkhole was only partially visible in January and April 2007, as it was covered by concrete barriers. It is likely that the observed displacement in B-05-12 is not a true displacement. The data was "re-initialized" to the July 24, 2006 reading as opposed to the June 22, 2006 reading and new Cumulative and Incremental vs. Displacement plots were generated, which are submitted as Plates 40A and 41A in the Appendix. As of April 2007, these "re-initialized" plots for B-05-12 do not indicate any observable displacements. Additional readings are needed in B-05-12 to confirm that the displacement in B-05-12 is not a true displacement and is the result of random and/or systematic errors.

Multiple possible slide planes have been observed in some of the new and replacement inclinometers, which are listed as follows:

- In B-105A at a depth of 20 to 30 feet (see Plate 22 in the Appendix);
- In B-108A at depths of 25 and 120 feet (see Plate 24 in the Appendix);
- In B-05-02 at depths of 109 and 129 feet (see Plate 28 in the Appendix); and,
- In B-05-03 at a depth of 37 feet (see Plates 30 and 31 in the Appendix);

The potential displacement at 120 feet in B-108A is nearly identical with the observed slide plane in the inactive inclinometer at B-108, which is only about 10 feet away from B-108A. Additional readings are needed in these inclinometers to evaluate whether these are true displacements.

Distinct movement has not been observed in the inclinometers at B-05-01, B-05-04, B-05-07, B-05-08, B-05-11 and B-05-13. Based on the relatively slow rates of movement of the slide planes observed at the site over the past several years, observed displacements may not yet be evident within the time period between baseline and current readings, which have been taken over a 10-month period. Multiple readings over a period of a few years are likely needed to measure definitive displacement trends.

2.2 Piezometers

Tables 2 and 3 provided in the following sections present a summary of the measured total head (h_t) for each pneumatic or VW piezometer. Additionally, plots of Total Head vs. Time are provided in the Appendix. For the pneumatic piezometers at B-101, B-105, B-107, and B-303, the measured water elevation (in feet) was reported in BBCM's quarterly and annual reports submitted prior to the July 2006 Quarterly Report. This water elevation is equivalent to the total head (h_t, in feet).

The total head (h_t) is calculated using the following equations:

$$h_t = h_e + h_p$$
$$h_p = u/\gamma_w$$

where h_e is the elevation head (elevation where the piezometer was installed), h_p is the pressure head, u is the pore pressure reading, and γ_w is the unit weight of water. The pore pressure readings (u) are measured and recorded in units of pounds per square inch (psi). The remaining variables of these equations (h_e, h_p, h_t, and γ_w) are in units of feet and pounds requiring u to be converted to pounds per square foot (psf).

2.2.1 Pneumatic Piezometers

The results of the active pneumatic piezometer readings taken over the last four (4) quarters are summarized in Table 2 below. Pneumatic piezometers are identified both by boring number and ribbon color to specify the location and depth of the instrumentation. Two (2) piezometers at B-101 and B-103 required ribbon replacement in July 2006. The new ribbon color is noted in parenthesis in Table 2.

Table 2: Summary of Readings for Active Pneumatic Piezometers – CUY-90-15.24

Piezometer Identifier		Ground Surface Elevation (ft)	Elevation Head, h_e (ft)	Pore Pressure Readings (u) and Computed Total Head (h_t) Values				
				Piezo. Data	July 14, 2006	October 18, 2006	January 19, 2007	April 18, 2007
B-101 (P-1[1])	green (orange)	676.6	626.3	u (psi)	0.1	0.0[2]	0.0[2]	0.0[2]
				h_t (ft)	626.5	626.3	626.3	626.3
	pink	676.6	552.3	u (psi)	31.7	31.5	31.3	31.7
				h_t (ft)	625.5	625.0	624.5	625.5
B-105 (P-3[1])	pink	585.6	497.6	u (psi)	38.8	38.3	38.3	38.4
				h_t (ft)	587.1	586.0	586.0	586.2
	blue	585.6	479.9	u (psi)	48.6	47.9	47.8	48.0
				h_t (ft)	592.1	590.4	590.2	590.7
B-107 (P-5[1])	orange	662.3	562.3	u (psi)	25.6	25.2	25.2	25.1
				h_t (ft)	621.4	620.5	620.5	620.2
B-303 (P-2[1])	green (pink)	627.0	586.2	u (psi)	7.1	6.9	7.0	6.9
				h_t (ft)	602.6	602.1	602.4	602.1

1 BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers.
2 Pneumatic piezometers *cannot* read negative pressure (i.e., a water level below the depth of the pneumatic piezometer). Thus, it is unknown whether this is an accurate pressure reading.

The readings for the pneumatic piezometers exhibited similar readings between the four quarters. The maximum change in total head occurred at B-105 blue, which varied by as much as 1.9 feet. The B-105 blue piezometer indicated an elevated water pressure (i.e., a total head above the ground surface, artesian conditions) with the total head ranging from 4.6 to 6.5 feet above the existing ground surface. Additionally, the B-105 pink piezometer indicated an elevated total head ranging from 0.4 to 1.5 feet above the existing ground surface. It is possible that the elevated water pressure in B-105 may be attributed to either a thin silt seam sandwiched between fairly thick clay layers located near the base of the piles supporting Pier 1, or the percolation of natural gas out of the underlying Devonian Ohio Shale. Elevated pore pressures can have a detrimental effect on slope stability and may increase the rate of slope creep.

Total Head vs. Time plots, which provide the measured total head from 1994 to the present, have been submitted as Plates 46 through 49 in the Appendix of this report.

2.2.2 Vibrating Wire (VW) Piezometers

The VW piezometers have been placed at various depths with two (2) piezometers at each of the nine (9) offset boring locations. The VW piezometers were installed on 1¼-inch PVC pipe encased in grout with a cable attached to the VW piezometer. Each cable runs up through the PVC pipe and is attached to a MiniLogger, which stores the pore pressure data. A flush mount protective cover was installed at each offset boring

location to house the two MiniLoggers. Readings are taken by Miniloggers every 8 hours; however, this time interval can be adjusted upon request.

Table 3 provides a summary of the maximum and minimum values of all the pressure readings taken from the time of installation to the time when the collected data was last downloaded from VW Miniloggers on April 18, 2007. The VW Miniloggers were installed between May 16, 2006 and June 12, 2006 and data has been downloaded from each VW MiniLogger once per quarter. The VW piezometers are identified by boring number, MiniLogger serial number, and depth the piezometer was installed. The VW piezometers also measure the ground temperature around the piezometer. The maximum and minimum temperature readings are also provided in Table 3.

Table 3: Summary of Readings for VW Piezometers – CUY-90-14.52

Piezometer Identifier		Time Interval of Readings Reported[1]	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-01	21961 - 65 ft	5/26/06 to 4/18/07	14.4/13.7	675.4	610.4	12.6/11.1	639.4/636.1
	21967 - 95 ft	5/26/06 to 4/18/07	13.5/13.2	675.4	580.4	23.1/20.5	633.8/627.6
B-05-02	21963 - 46 ft	5/22/06 to 4/18/07	12.2/12.1	617.9	571.9	8.5/7.8	591.5/589.8
	21951 - 122 ft	5/22/06 to 4/18/07	12.3/12.1	617.9	495.9	40.7/39.9	589.8/588.0
B-05-03	21957 - 32 ft	5/16/06 to 4/18/07	12.5/11.6	605.1	573.1	8.2/7.1	592.0/589.5
	21965 - 112 ft	5/16/06 to 4/18/07	12.5/12.5	605.1	493.1	42.8/40.8	591.8/587.2
B-05-04	21958 - 59 ft	5/18/06 to 4/18/07	13.1/12.9	600.8	541.8	18.3/17.6	583.9/582.3
	21952 - 119 ft	5/18/06 to 4/18/07	13.2/13.1	600.8	481.8	45.3/44.7	586.4/585.1
B-05-07	21966 - 102 ft	6/8/06 to 4/18/07	12.9/12.4	678.9	576.9	27.8/23.7	641.0/631.5
	21956 - 220 ft	6/8/06 to 4/18/07	12.1/11.9	678.9	458.9	73.0/67.4	627.4/614.4
B-05-08	21954 - 65.5 ft	5/30/06 to 4/18/07	12.9/12.6	679.9	614.4	12.6/11.7	643.6/641.4
	21959 - 110.5 ft	5/30/06 to 4/18/07	12.6/12.4	679.9	569.4	29.7/28.8	637.9/635.8
B-05-11	21968 - 95 ft	6/9/06 to 4/18/07	13.0/12.5	675.1	580.1	23.9/23.1	635.1/633.3
	21953 - 130 ft	6/9/06 to 4/18/07	12.9/12.6	675.1	545.1	36.3/35.0	628.9/625.8

1 Readings generally were taken every 8 hours during the reported time interval.

Table 3: Summary of Readings for VW Piezometers – CUY-90-14.52 (continued)

Piezometer Identifier		Time Interval of Readings Reported[1]	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-12	21960 - 75 ft	5/24/06 to 4/18/07	13.0/12.8	652.7	577.7	18.4/16.4	620.2/615.5
	21964 - 120 ft	5/24/06 to 4/18/07	12.6/12.5	652.7	532.7	35.9/33.0	615.6/609.0
B-05-13	21962 - 60 ft	6/12/06 to 4/18/07	13.0/12.6	580.0	520.0	24.4/23.1	576.4/573.3
	21955 - 135 ft	6/12/06 to 4/18/07	13.2/12.8	580.0	445.0	60.9/58.2	585.5/579.3

1 Readings generally were taken every 8 hours during the reported time interval.

Total Head vs. Time plots have been submitted as Plates 50 through 58 in the Appendix of this report.

A few of the VW piezometers exhibited a total head decrease as much as 13 feet (i.e., B-05-07) from the initial reading. A gas pocket was encountered during drilling near the top of the shale bedrock in Boring B-05-07. The soil pore pressures may have been reducing back to normal conditions in B-05-07. Also, DGSI has stated in the user's manual for the VW piezometer that "drilling a borehole and backfilling it temporarily changes the pore-water pressure in the ground, so readings that are taken immediately after installation will not be good datum readings. Recovery of the natural pore-water pressure may take a few hours to a few weeks, depending on the permeability of the soil." DGSI also suggests recovery of the pore-water pressure is indicated by observation of stable readings for several consecutive days. The readings have generally been stable in the VW piezometers since the beginning of July 2006. After the initial stabilization period, four (4) VW piezometers (21967 at B-05-01, 21956 at B-05-07, and 21960 and 21964 at B-05-12) have indicated a gradual increase in the pore pressures during the current reporting period.

The 21955 piezometer in B-05-13 installed at a depth of about 135 feet exhibited a maximum change in the total head of more than 6 feet over the current reporting period shown in Table 3. Between 10:34am and 6:34pm on September 12, 2006, the MiniLogger recorded a decrease in pressure of 1.35 psi which corresponds to a change in total head of 3.1 feet. Sixteen (16) hours later, the recorded pressure reached a minimum of 58.19 psi, a total decrease of 2.49 psi or 5.7 feet total head over a 24-hour period. The recorded pressures then increased incrementally, until nearly eight (8) days later, the total head was within 1 foot of the total head recorded prior to the dramatic pressure decrease. The Total Head vs. Time plot shown on Plate 58 in the Appendix illustrates these changes. This rapid pore pressure change has not been observed in the 21955 piezometer since September 2006. The total head over the reporting period was as high as 5.5 feet above the existing ground surface at Elevation 580 (see Table 3) indicating that there is an elevated water pressure (i.e., total head above the ground surface, artesian conditions) at this location similar to that observed in the pneumatic

piezometers at B-105 previously discussed. During drilling of Boring B-05-13, gas pockets were encountered during rock coring, which leads us to believe the elevated water pressure observed in the 21955 piezometer may be mostly attributed to percolation of natural gas out of the underlying Devonian Ohio Shale into the sandy silt layer where the piezometer was installed. This sandy silt layer, which overlies the shale, underlies a clay layer that could confine the natural gas to the sandy silt layer due to the low permeability of clays. For reasons unknown at this time, the flow of natural gas may have been temporarily disrupted resulting in the dramatic pressure decrease.

3.0 ADDITIONAL FIELD MEASUREMENTS AND OBSERVATIONS

3.1 Calipered Surface Distance Locations

The left and right calipered locations (see the Site Plan of Active Instrumentation, Plate 2 in the Appendix), which have been monitored since June 1999, are located just east and west of the I-90 Bridge centerline, respectively. Initially, three (3) locations were monitored, which included a center calipered location. However, the center calipered location became inaccessible in August 1999. A Calipered Surface Distance Table and Calipered Distance Readings vs. Time plots have been included as Plates 59 through 61 in the Appendix.

Close inspection of the data in the plots indicates the possibility of general movement trends at the calipered locations. The data is somewhat oscillatory, which is likely due to the seasonal temperature fluctuations affecting the concrete combined with human measurement error. In the data plots, linear trendlines were added to estimate the average rate of separation/closure per year. The left calipered location indicates the gap is continuing to open at a rate of about 0.06 inches per year, which is equivalent to the rate reported in the 2005-2006 Annual Report for Field Monitoring Services, dated May 22, 2006. The right calipered location indicates the gap is closing at a rate of about 0.02 inches per year. This is a slight decrease from the rate of about 0.03 inches per year as reported in the 2005-2006 Annual Report. The movements are relatively small (½ of an inch or less since June 1999) and are sensitive to the interpretation of the center of the nails. Thus it is inconclusive that these movements have been caused by the observed slope movements. Continued observation of these calipered locations is needed in order to adequately determine if judgment error and weather conditions are the main cause of the observed trends or if they are indeed caused by slope movements.

3.2 Stockpiling of Aggregate Adjacent to East Right-of-Way Fence

The property adjacent to the east right-of-way fence is currently being used to stockpile aggregate. Aggregate piles of varying sizes and locations were observed during each of the quarterly visits to the site. Relatively large aggregate piles covering no more than approximately one-half of the property were observed in July 2006 and October 2006. These large aggregate piles were located primarily on the eastern portion of the property. Relatively small aggregate piles were also observed in July 2006 and January

and April 2007. Stockpiling of large aggregate piles could have a significant impact on slope movements at the site.

3.3 Excavation Activities Adjacent to West Right-of-Way Fence

As previously discussed, a large excavation near the west right-of-way fence was first observed by BBCM personnel in mid-March 2006. The excavation was performed in an effort to repair the failed bulkhead. A letter from BBCM to Michael Baker Jr., Inc., and dated March 16, 2006 discussing the excavation is provided as Plates 62 to 71 in the Appendix. As of April 2007, the repair effort appears to be unfinished at this time as the bulkhead does not appear to be fully repaired and the large excavation has not yet been backfilled. On January 18, 2007, while taking readings at the B-05-13 inclinometer across the Cuyahoga River, BBCM personnel observed evidence of a potential small landslide that may have occurred after the quarterly readings were taken in October 2006. This small landslide area is located near the west right-of-way fence just north of B-05-16, adjacent to the river and on the eastern edge of the large excavation. Note that relatively large displacements were observed in the B-05-16 inclinometer, as previously discussed. Pictures of this landslide location were taken on January 19, 2007, but due to the snow fall the night before the photo was taken, the landslide area was snow covered. Additional photos of the landslide area were taken on April 18, 2007. The approximate extent and location of the landslide and scarps, as visually observed, is sketched on site photos taken in both January and April 2007. These site photos have been submitted as Plates 72 through 77 in the Appendix. It appears that progressive failure in this landslide area has occurred between the January and April 2007 readings.

APPENDIX

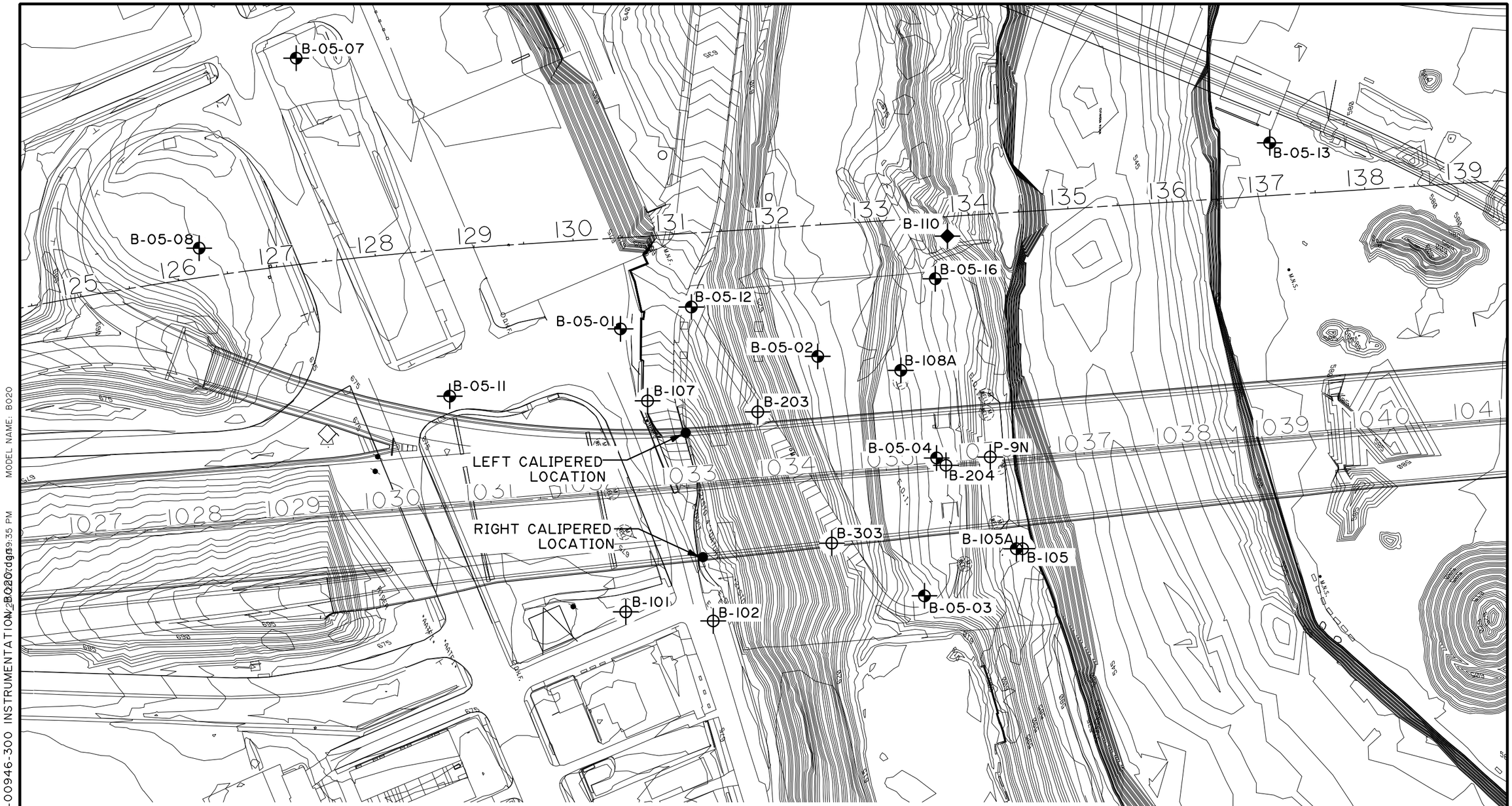
CUY-90-14.52/15.24 INSTRUMENTATION MONITORING

SUMMARY OF ACTIVE INSTRUMENTATION
CUY-90-14.52/15.24

Active Instrumentation	Active Inclinometer ?	Inclinometer Depth (ft)	Active Piezometer?	VW or Pneumatic?	# of Active Piezometers	Piezometer Depth(s) Below Existing G.S. (ft)	Instrumentation Installation Date
B-101	Y	190	Y*	Pneumatic*	2*	50.3, 124.3	Aug-Sep 1994
B-102	Y	224	N	---	---	---	Sep 1994
B-105	N	---	Y*	Pneumatic*	2*	88, 105.7	Aug 1994
B-105A	Y	156	N	---	---	---	May 2006
B-107	Y	210	Y	Pneumatic*	1*	100	Sep 1994
B-108A	Y	168	N	---	---	---	Apr-May 2006
B-203	Y	190	N	---	---	---	Aug 1996
B-204	Y	134	N	---	---	---	Jul 1998
B-303	Y	178	Y**	Pneumatic**	1**	40.8	Aug 1994**, Jul 1998
P-9N	Y	150	N	---	---	---	Feb 1999
B-05-01	Y	228	Y	VW	2	65, 95	Apr-May 2006
B-05-02	Y	178	Y	VW	2	46, 122	Apr-May 2006
B-05-03	Y	168	Y	VW	2	32, 112	Apr-May 2006
B-05-04	Y	172	Y	VW	2	59, 119	Mar-May 2006
B-05-07	Y	224	Y	VW	2	102, 220	Apr-Jun 2006
B-05-08	Y	226	Y	VW	2	65.5, 110.5	Apr-May 2006
B-05-11	Y	226	Y	VW	2	95, 130	Apr-Jun 2006
B-05-12	Y	210	Y	VW	2	75, 120	Apr-May 2006
B-05-13	Y	134	Y	VW	2	60, 135	May-Jun 2006
B-05-16	Y	162	N	---	---	---	Jun 2006

*BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers (i.e. P-1 to B-101, P-3 to B-105, and P-5 to B-107).

**The pneumatic piezometer was actually installed in August 1994 at Boring P-2 in the vicinity of the B-103 inclinometer (now inactive). However, the piezometer has since been renamed to B-303 due to its close proximity to the active inclinometer at B-303, which was installed in July 1998.



LEGEND

B-05-01 — LOCATION OF INCLINOMETER/PIEZOMETER INSTALLED BY BBCM IN 2006 (B-05-01 THROUGH B-05-04, B-05-07, B-05-08, B-05-11 THROUGH B-05-13, AND B-05-16).

B-105A — LOCATION OF REPLACEMENT INCLINOMETER INSTALLED BY BBCM IN 2006 (B-105A AND B-108A).

B-101 — LOCATION OF INCLINOMETER AND/OR PIEZOMETER INSTALLED BY BBCM BETWEEN 1994 AND 1999 (B-101, B-102, B-105, B-107, B-203, B-204, B-303, AND P-9N).

B-110 — LOCATION OF INCLINOMETER AT B-110, WHICH WAS DESTROYED BY EXCAVATION ACTIVITIES IN MARCH, 2006

SCALE IN FEET
0 50 100

SITE PLAN OF ACTIVE INSTRUMENTATION

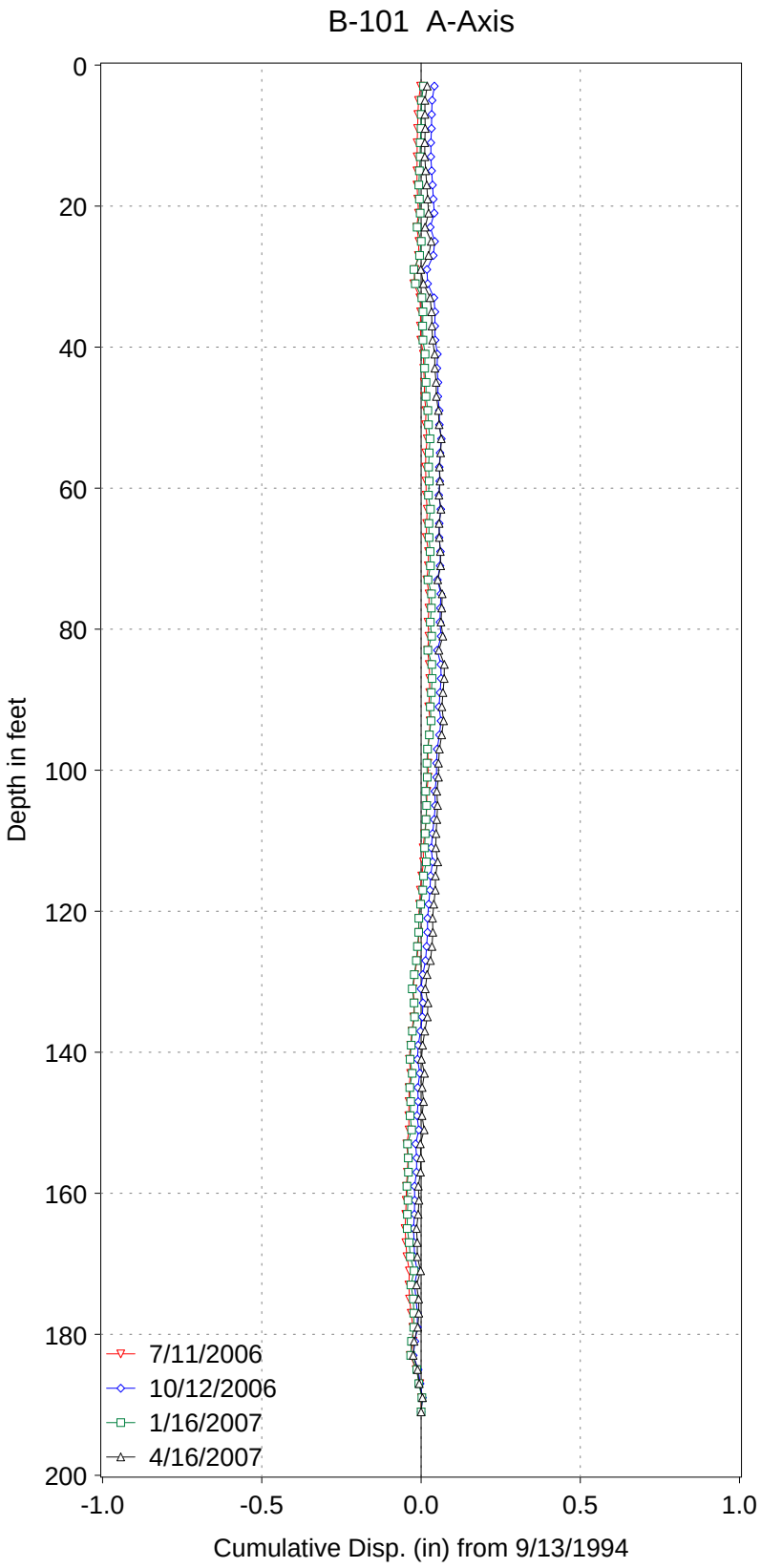
CUY-90-14.52/15.24 WEST ABUTMENT CLEVELAND, OHIO

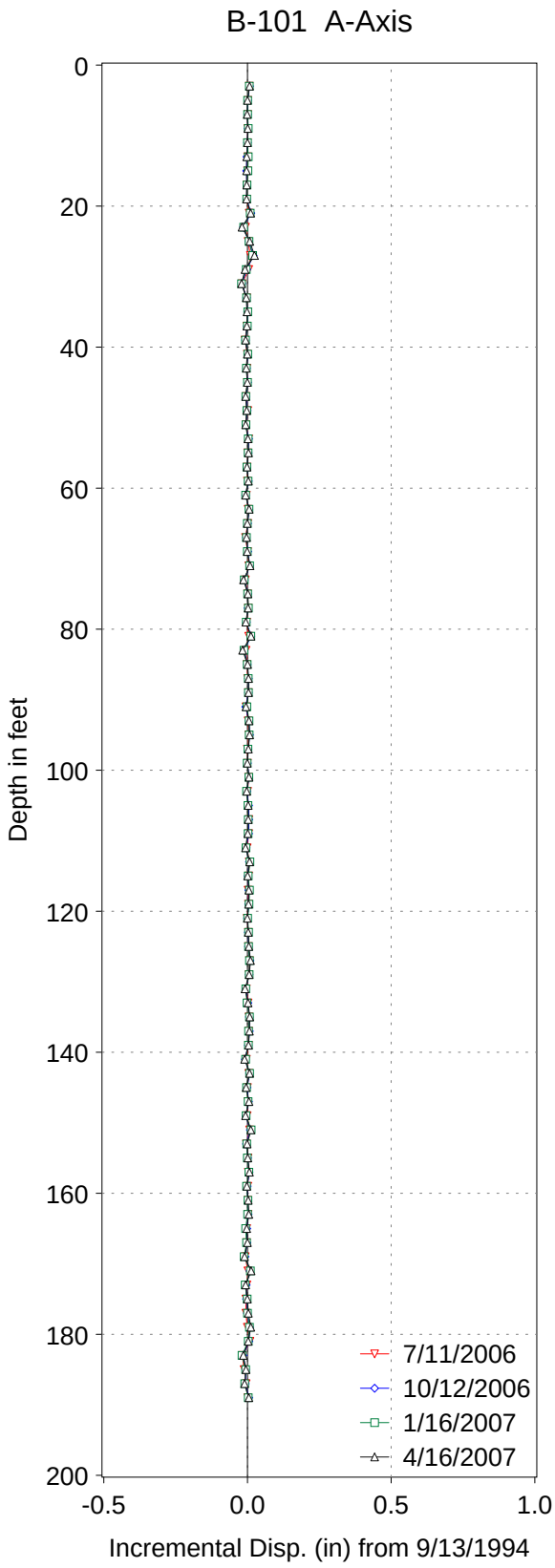
Project: 012-00946-300	Drawn By: EDV
Drawing Date: 7/25/06	Approved By: JLS
Revision Date: 2/9/07	Scale: 1" = 100'

BBCM
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

PLATE 2

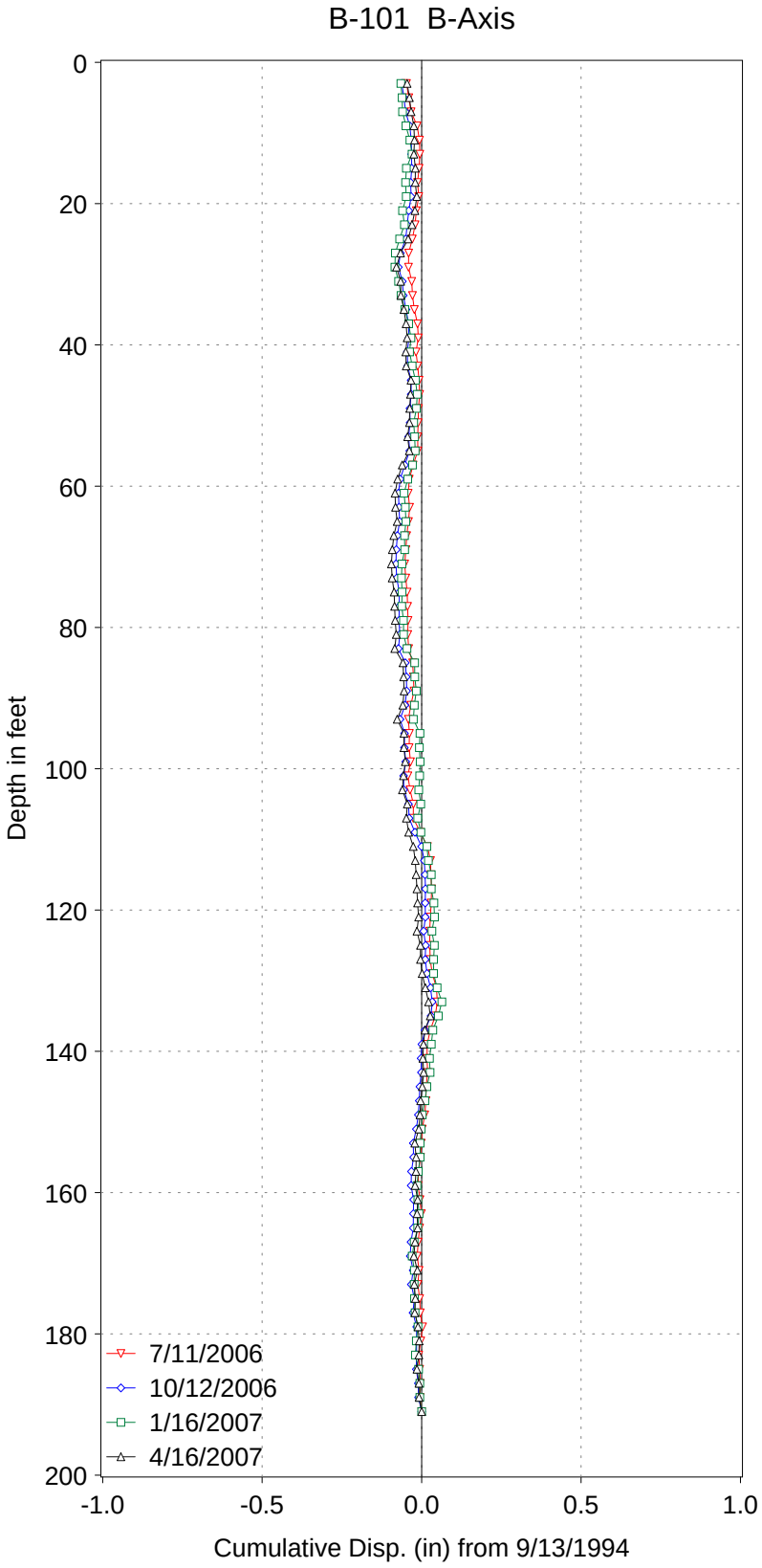
BBC&M DRAWING FILE: ...\012-00946-300 INSTRUMENTATION_B020.dgn 2/9/2007 9:35 PM MODEL NAME: B020

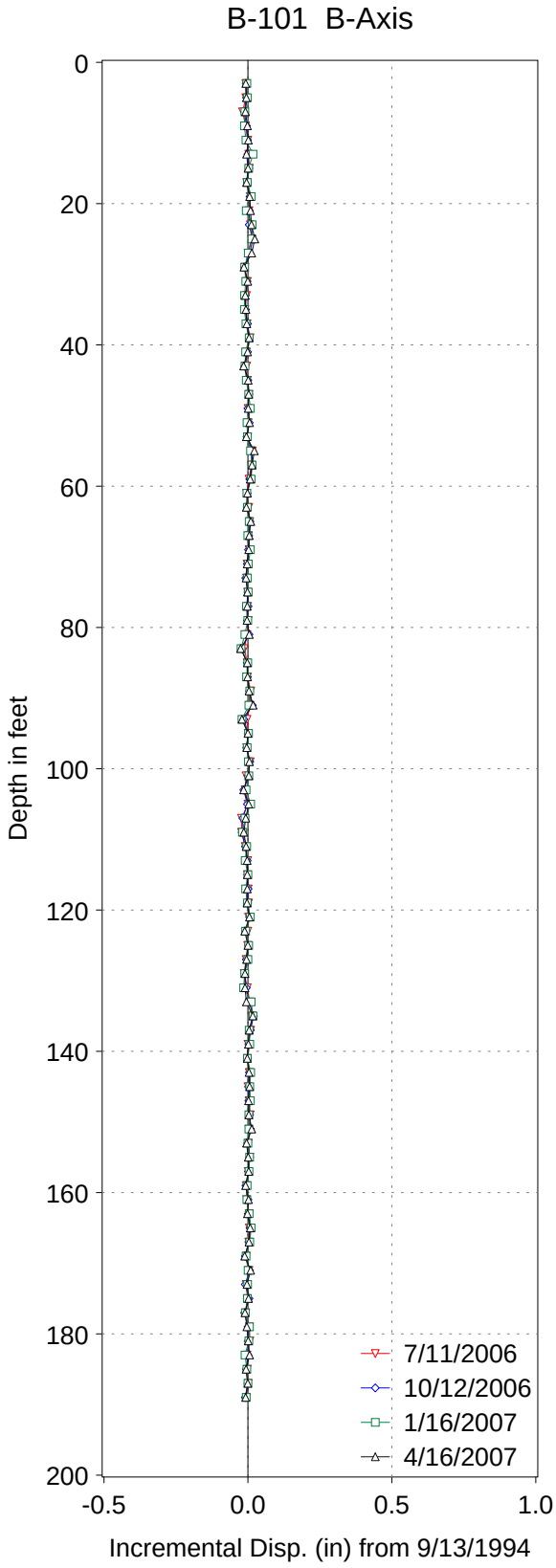




B-101
-Includes readings from the last four quarters.

PLATE 3

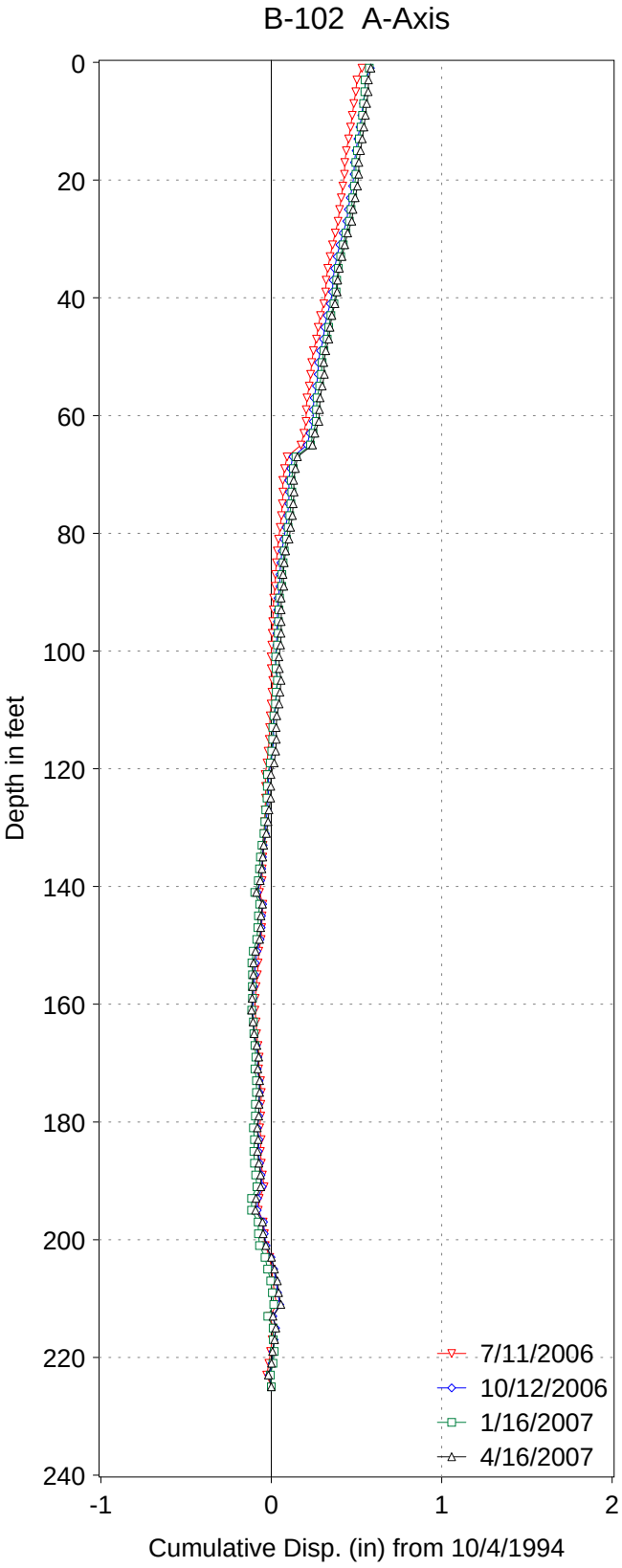


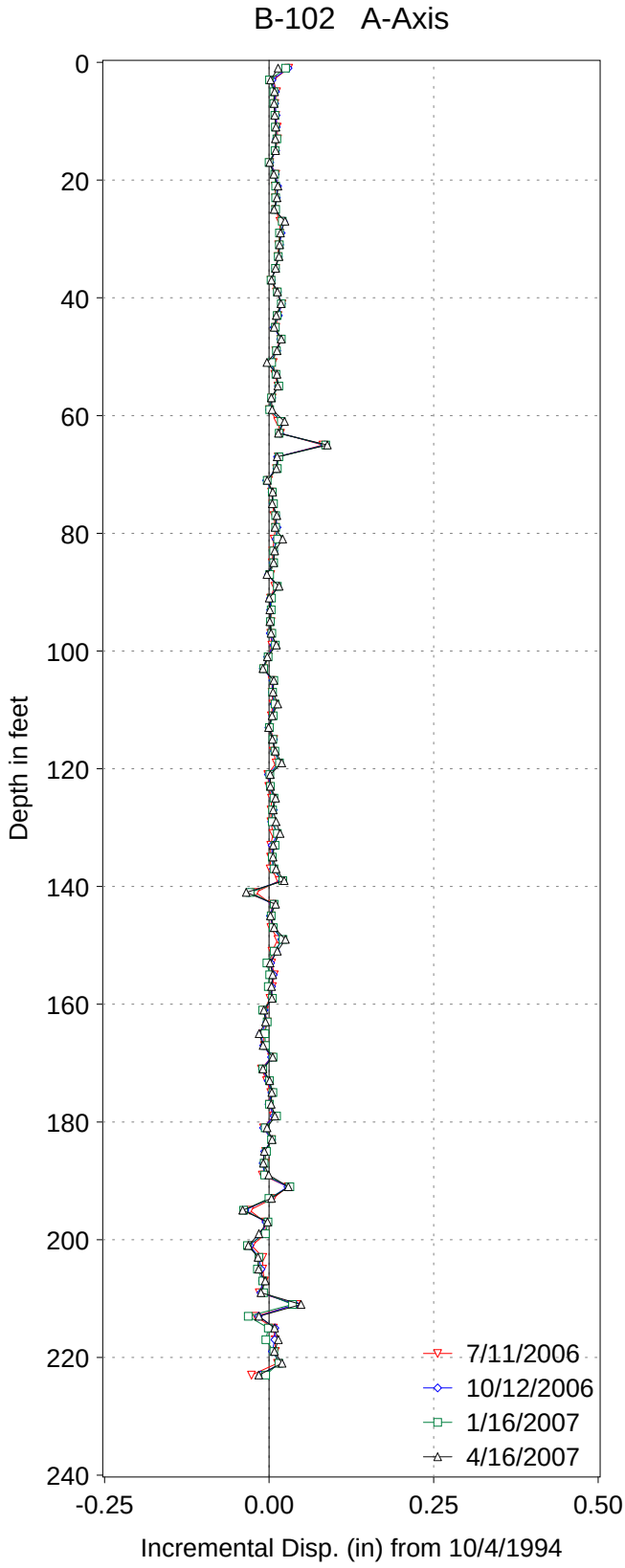


B-101

-Includes readings from the last four quarters.

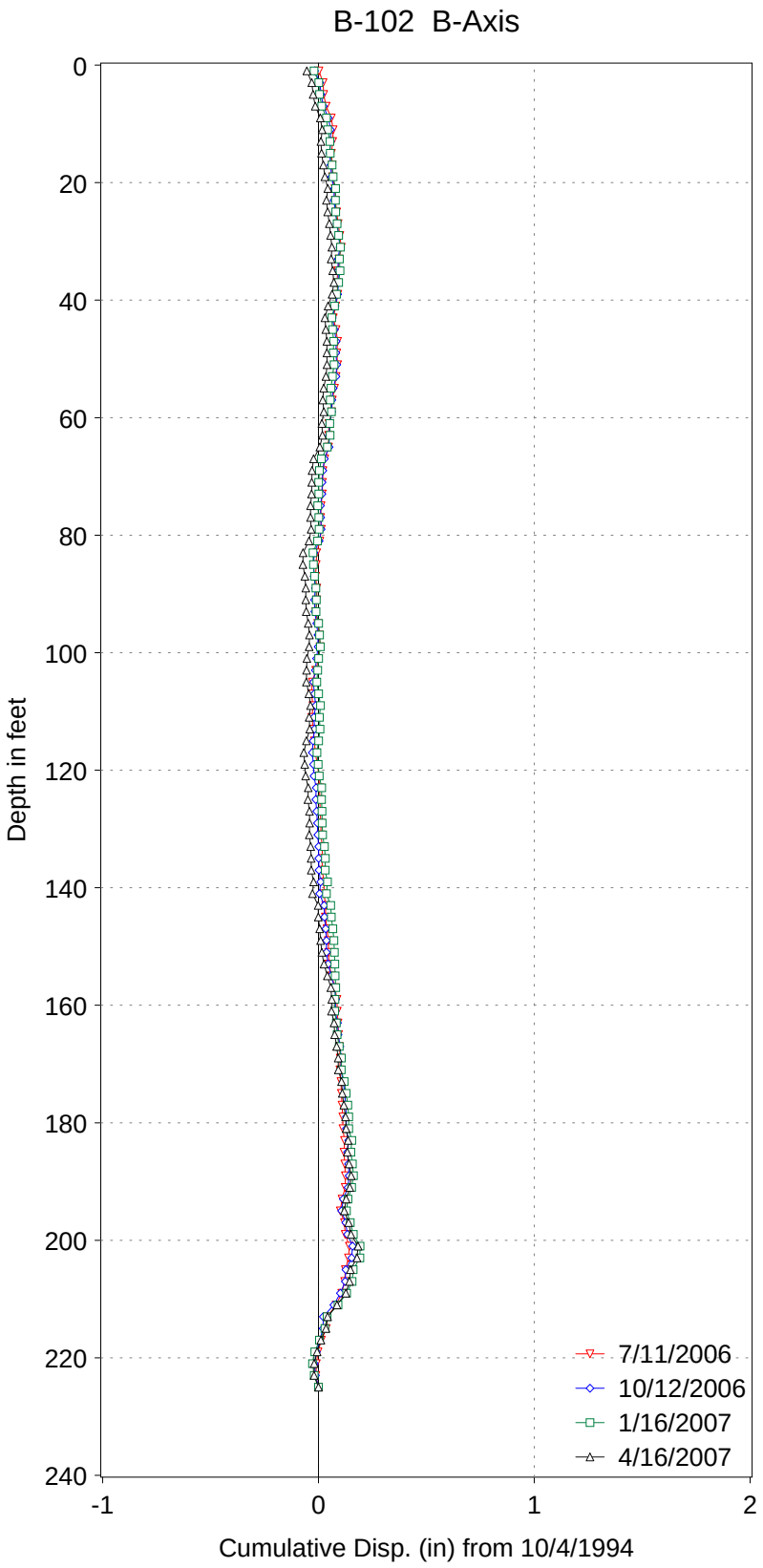
PLATE 4

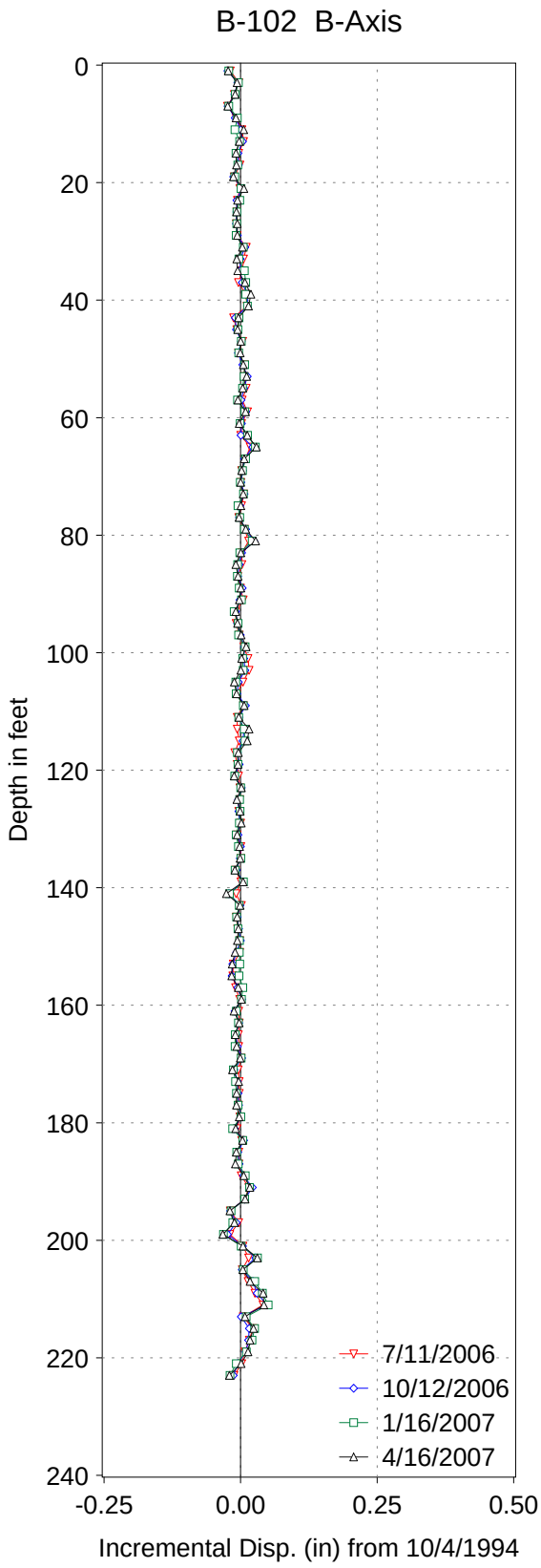




B-102
-Includes readings from the last four quarters.

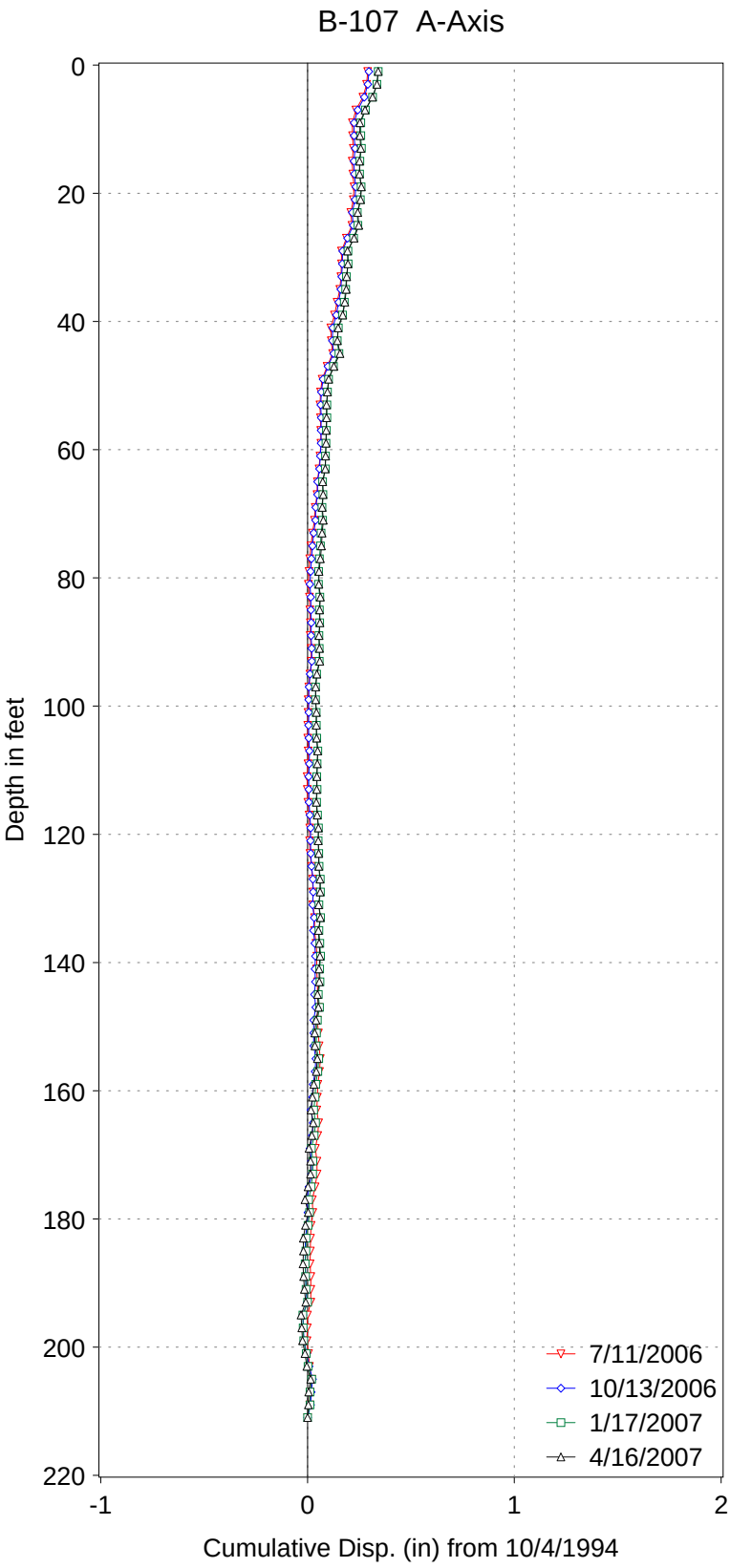
PLATE 5

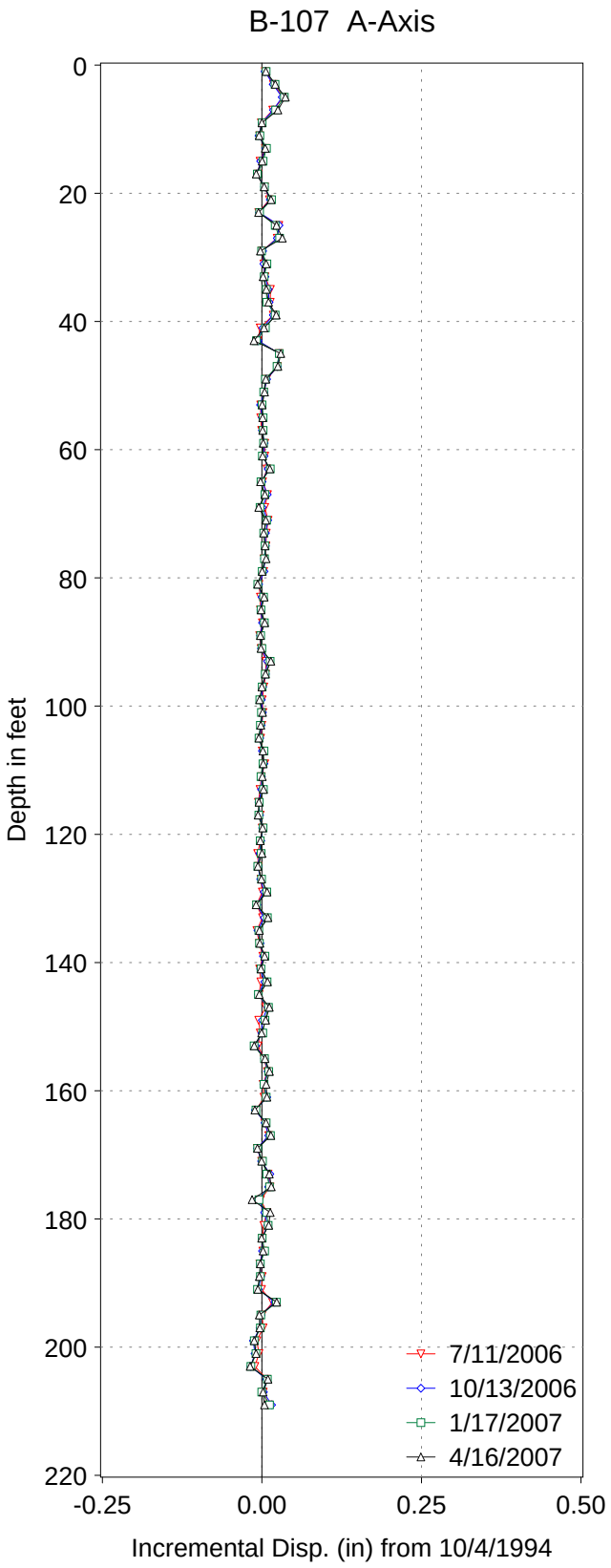




B-102
-Includes readings from the last four quarters.

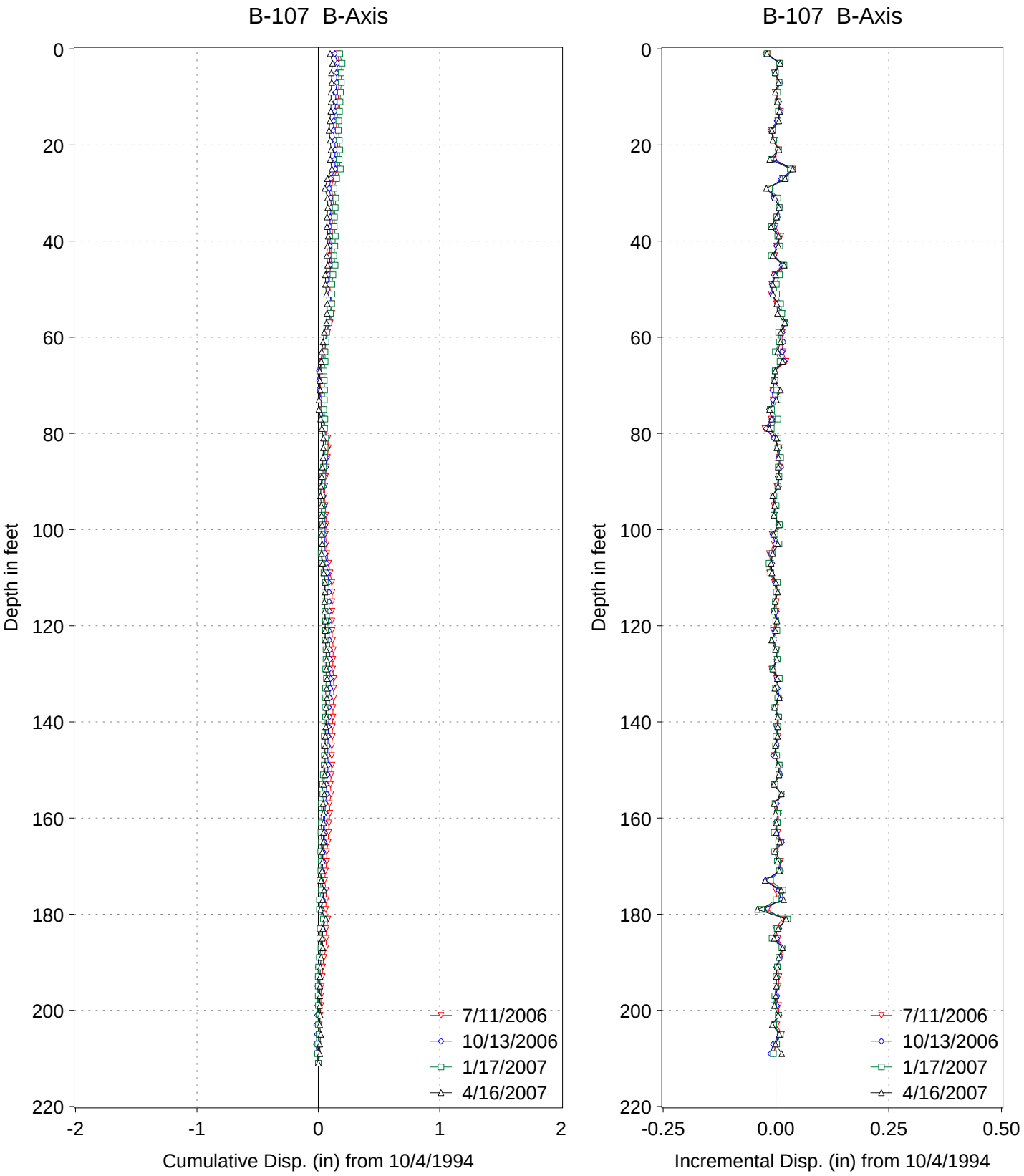
PLATE 6





B-107
-Includes readings from the last four quarters.

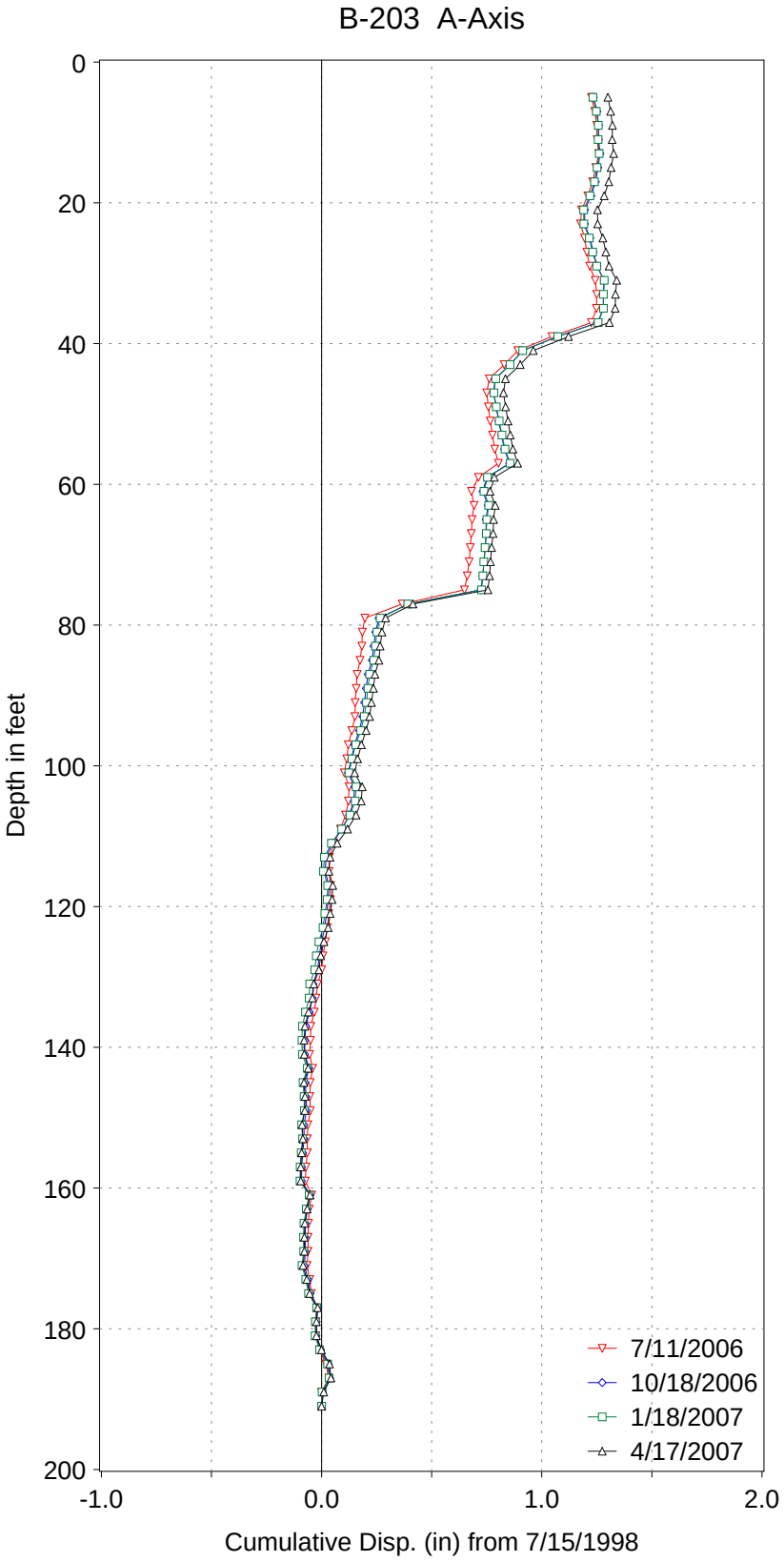
PLATE 7

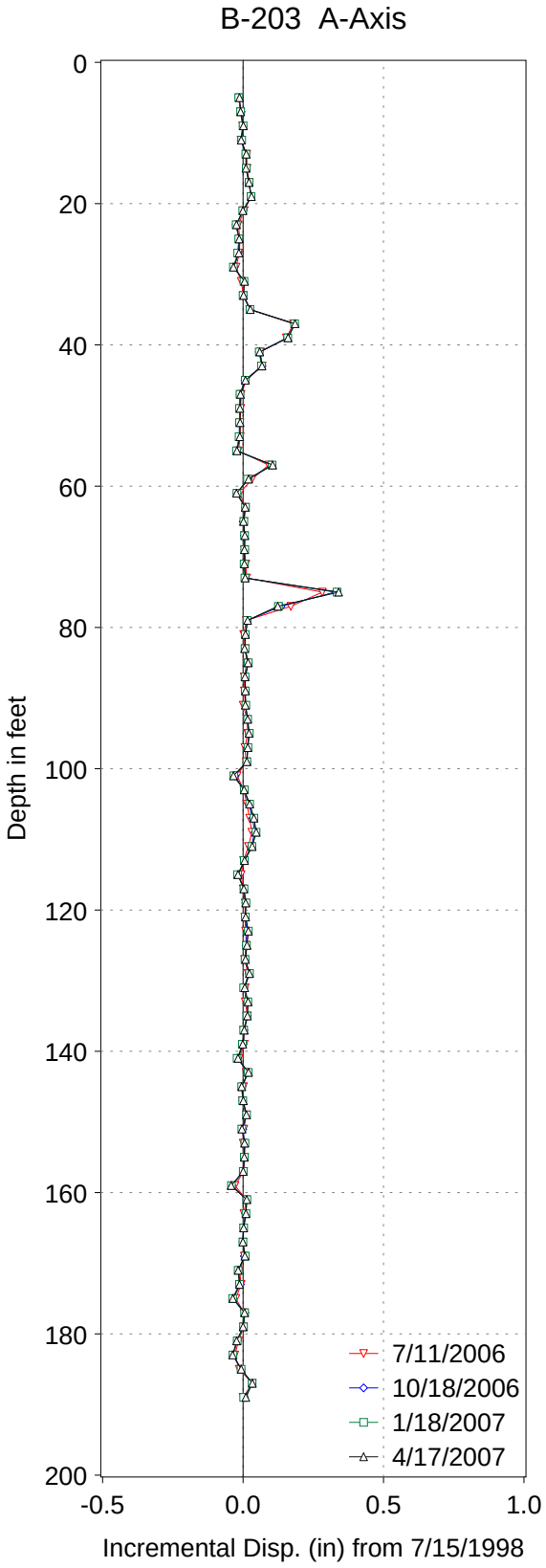


B-107

-Includes readings from the last four quarters.

PLATE 8

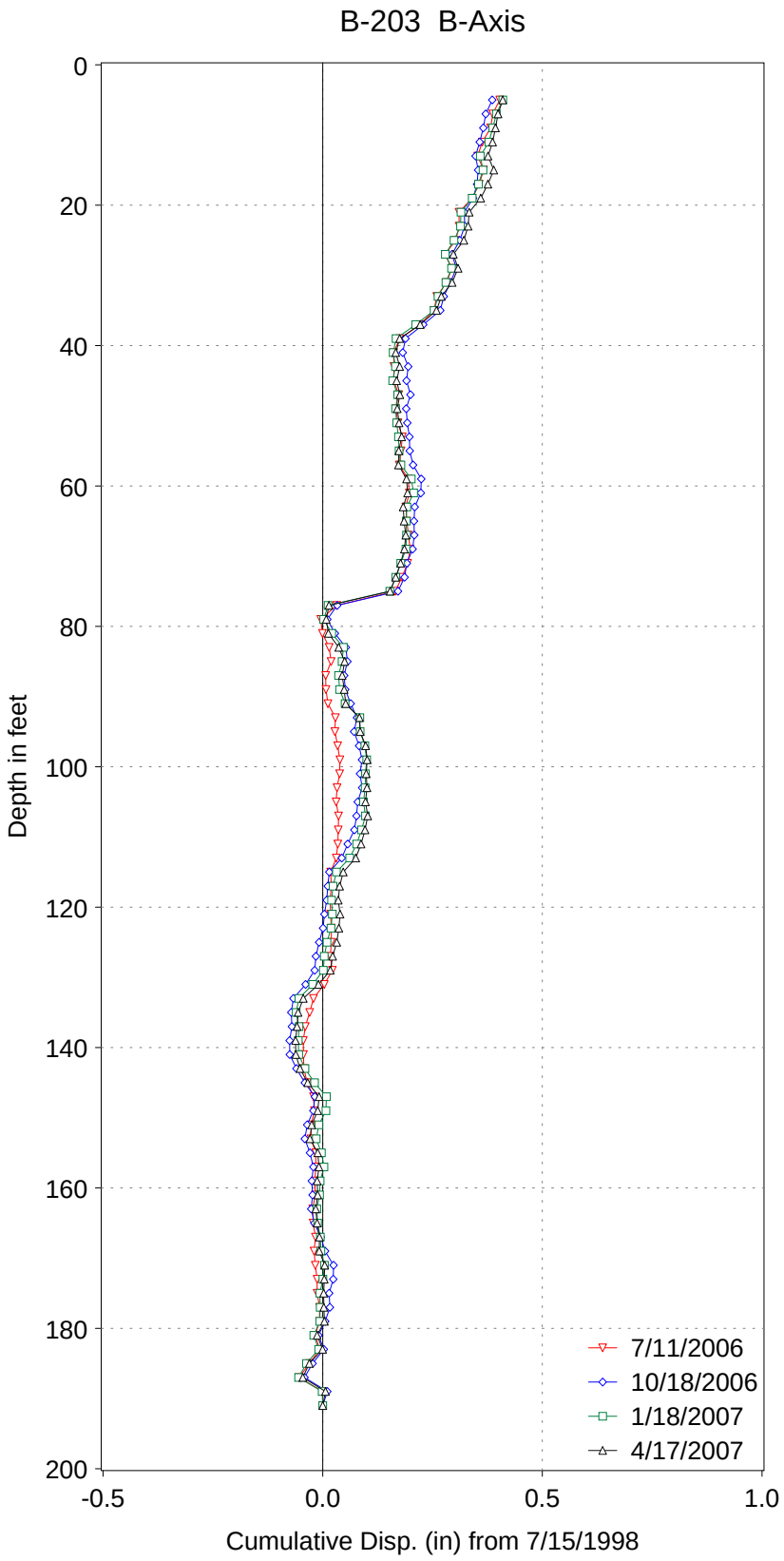


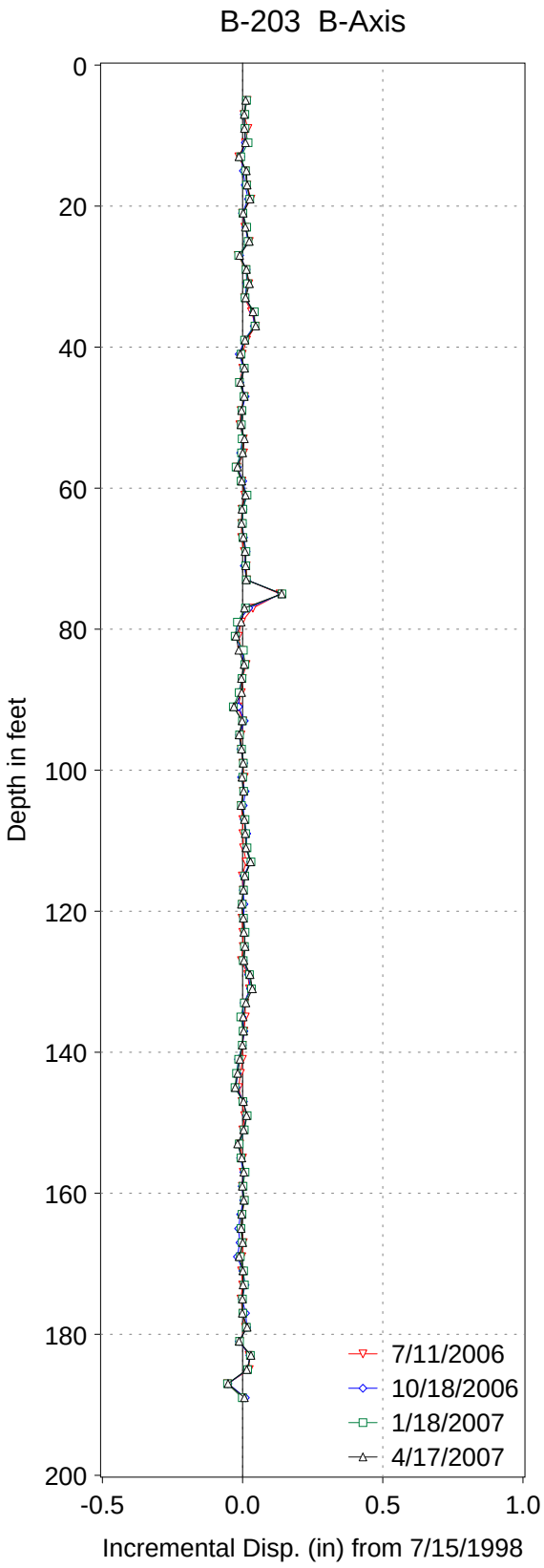


B-203

-Includes readings from the last four quarters.

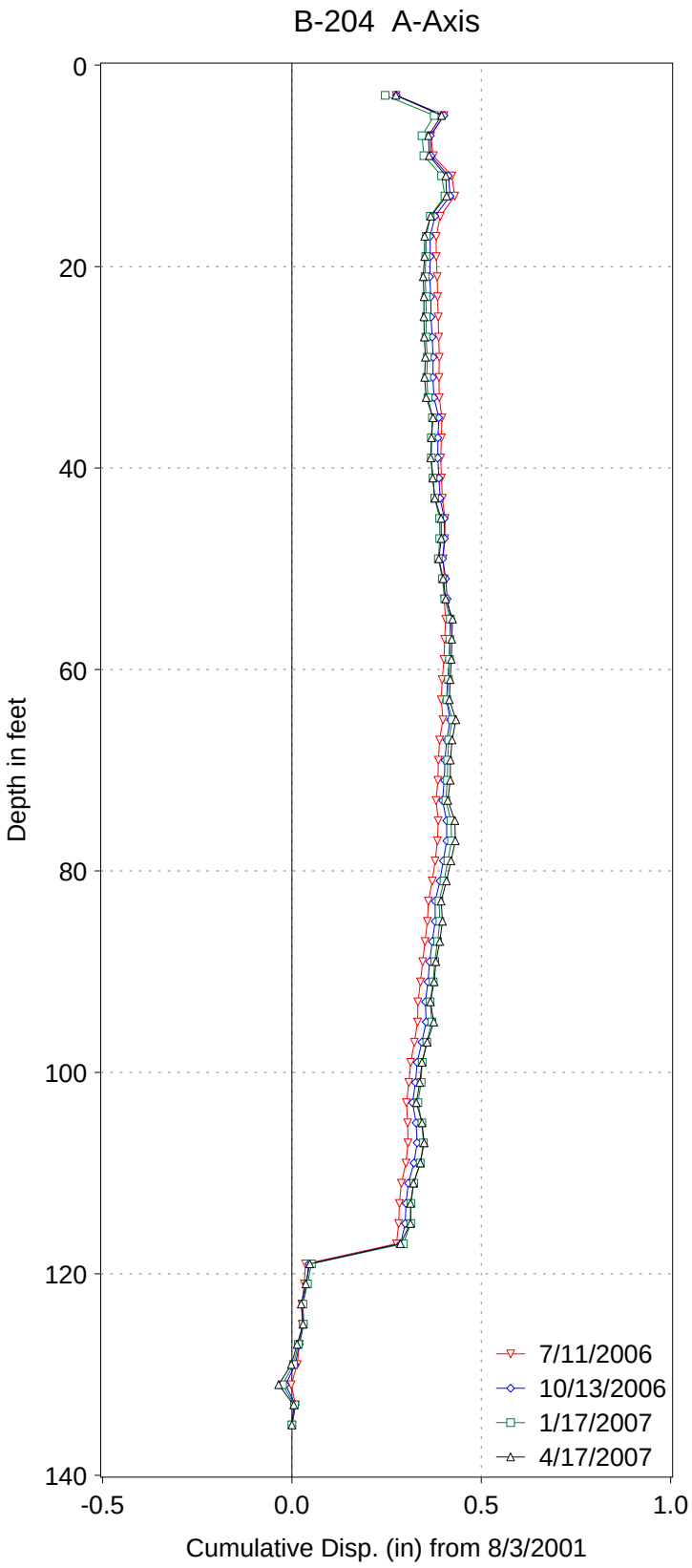
PLATE 9

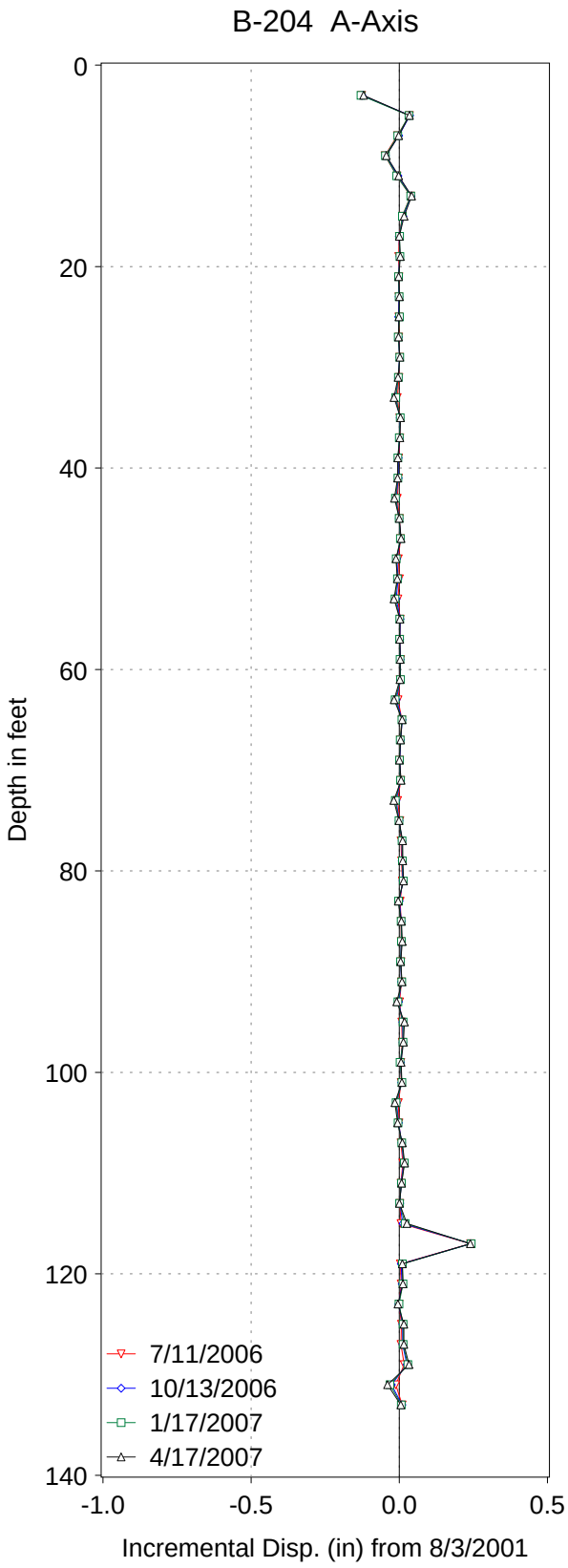




B-203
-Includes readings from the last four quarters.

PLATE 10

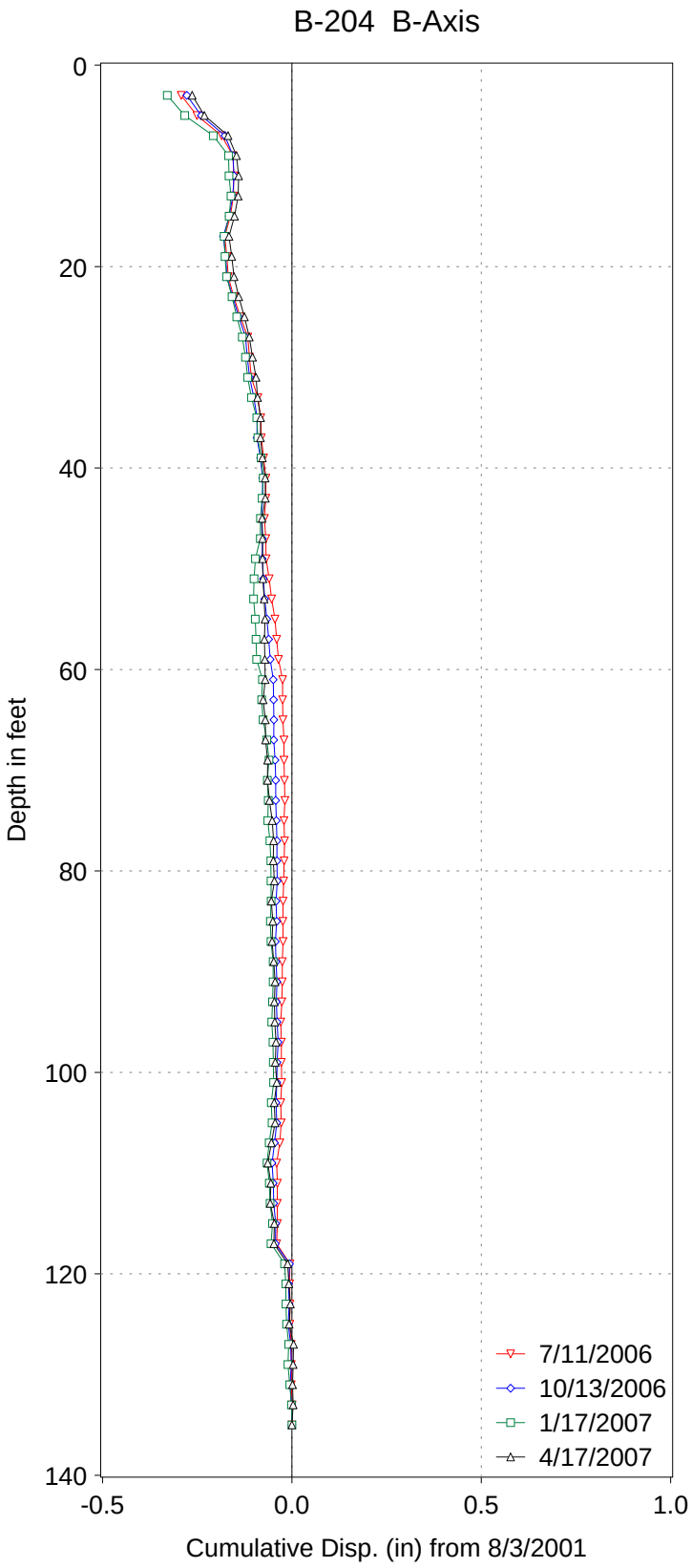


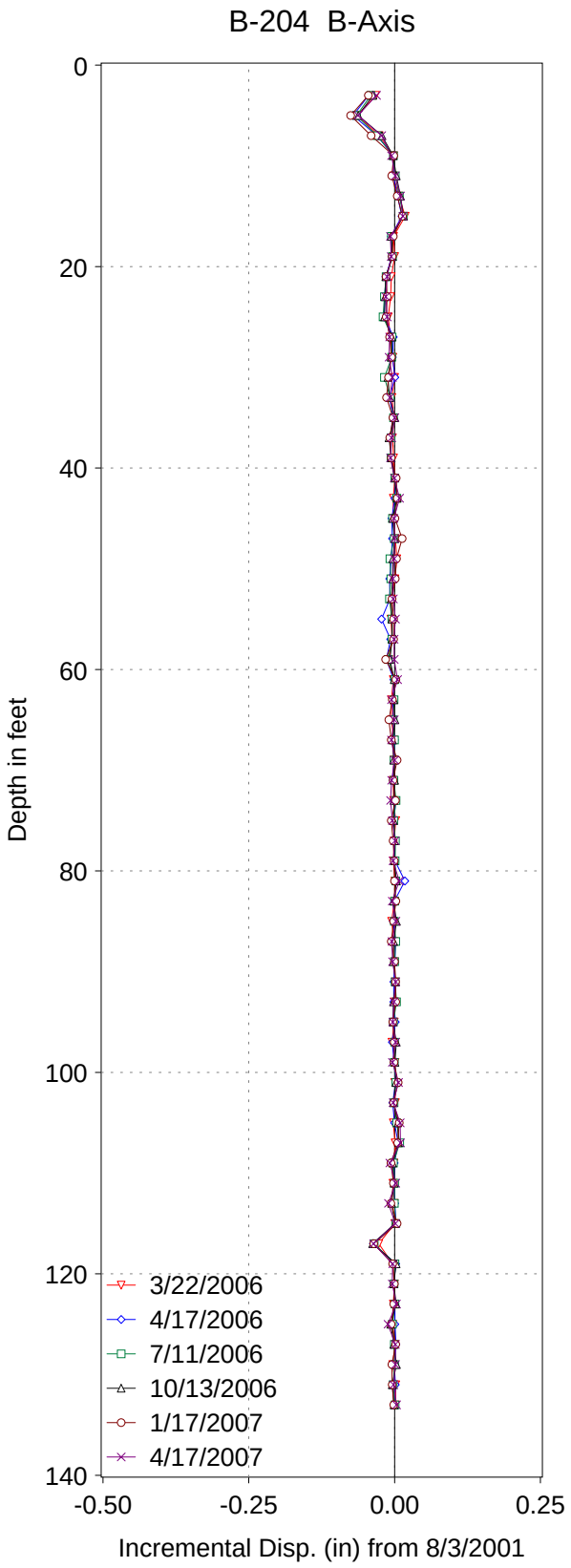


B-204

-Includes readings from the last four quarters.

PLATE 11

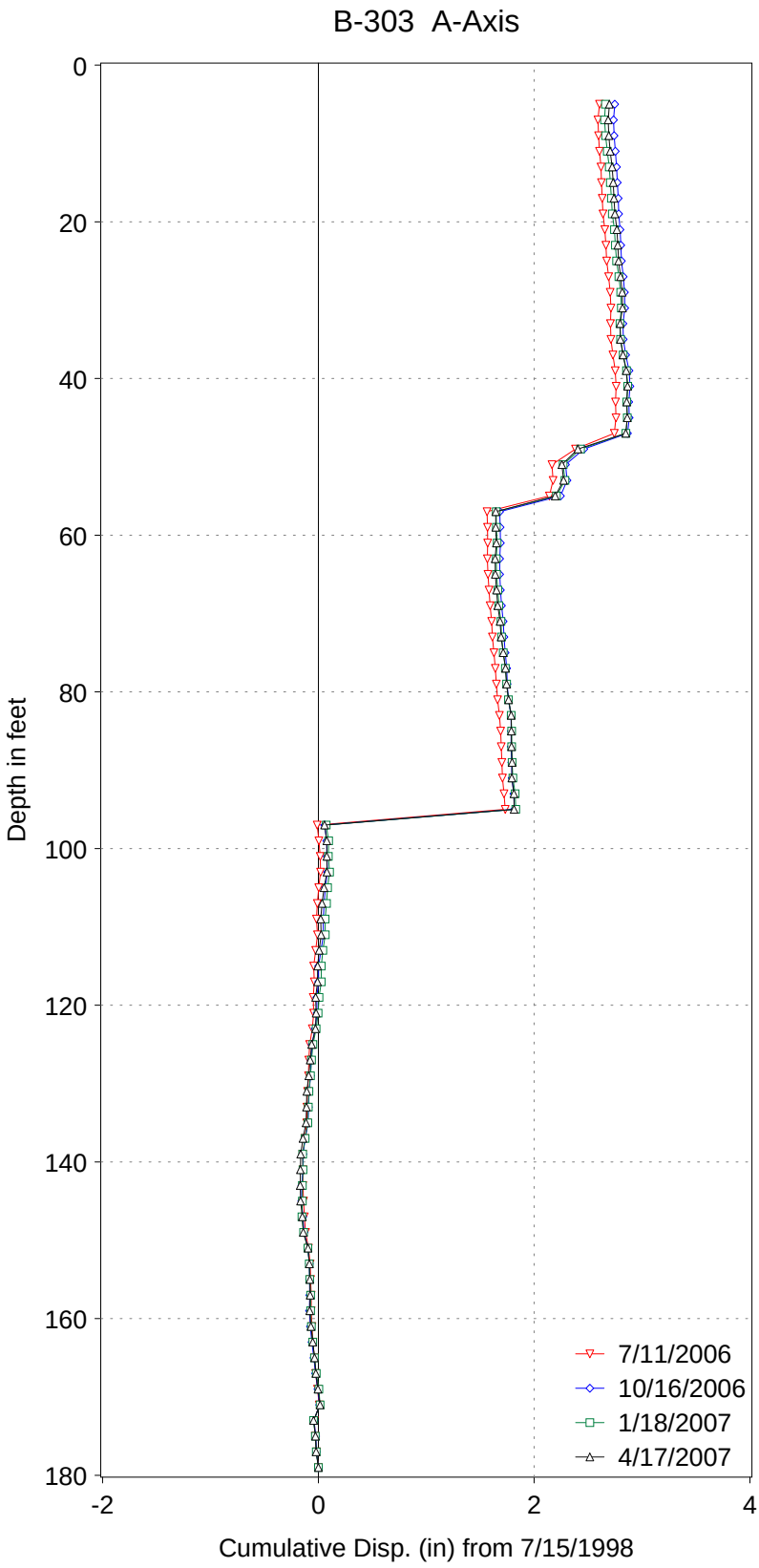


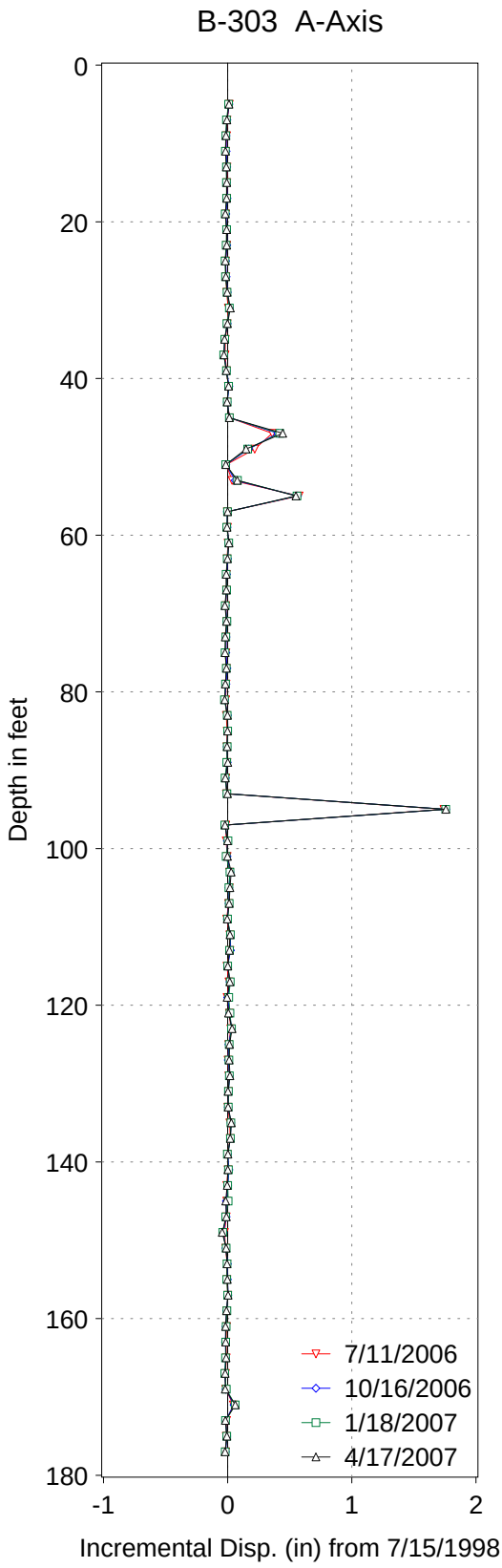


B-204

-Includes readings from the last four quarters.

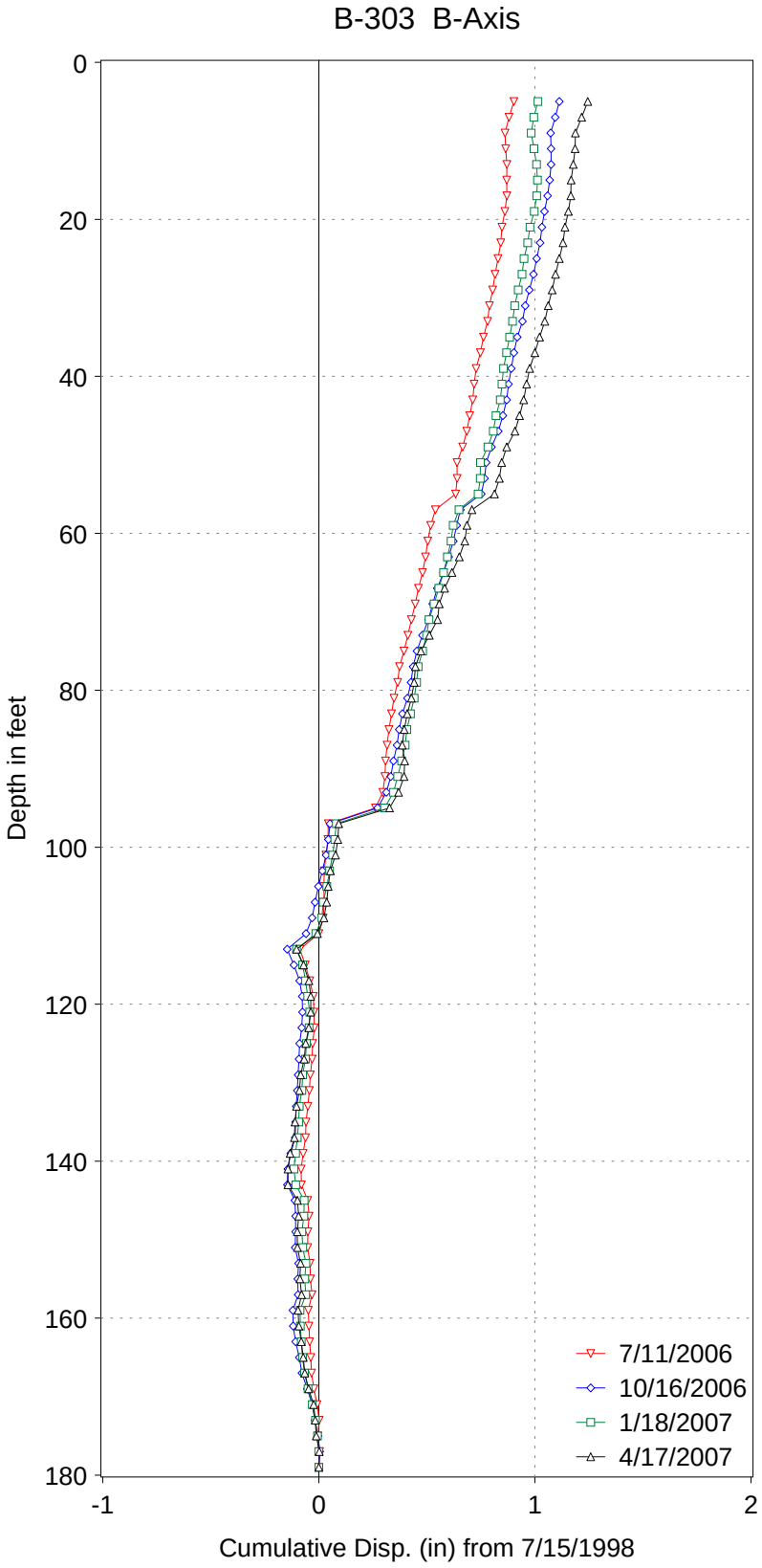
PLATE 12

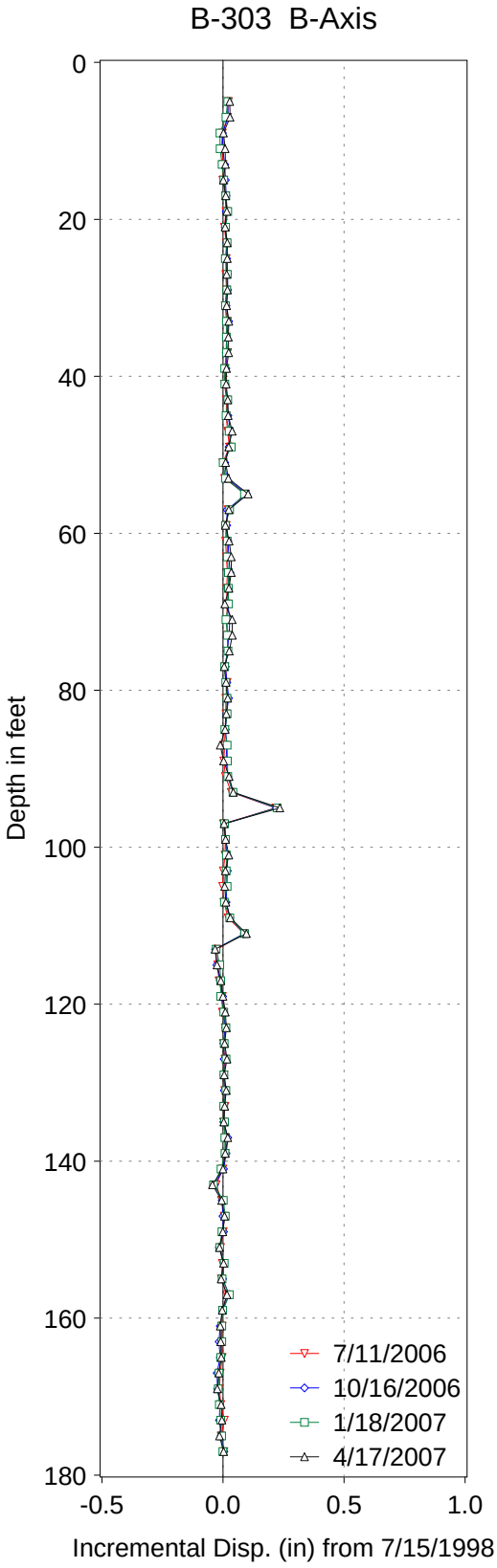




B-303
-Includes readings from the last four quarters.

PLATE 13

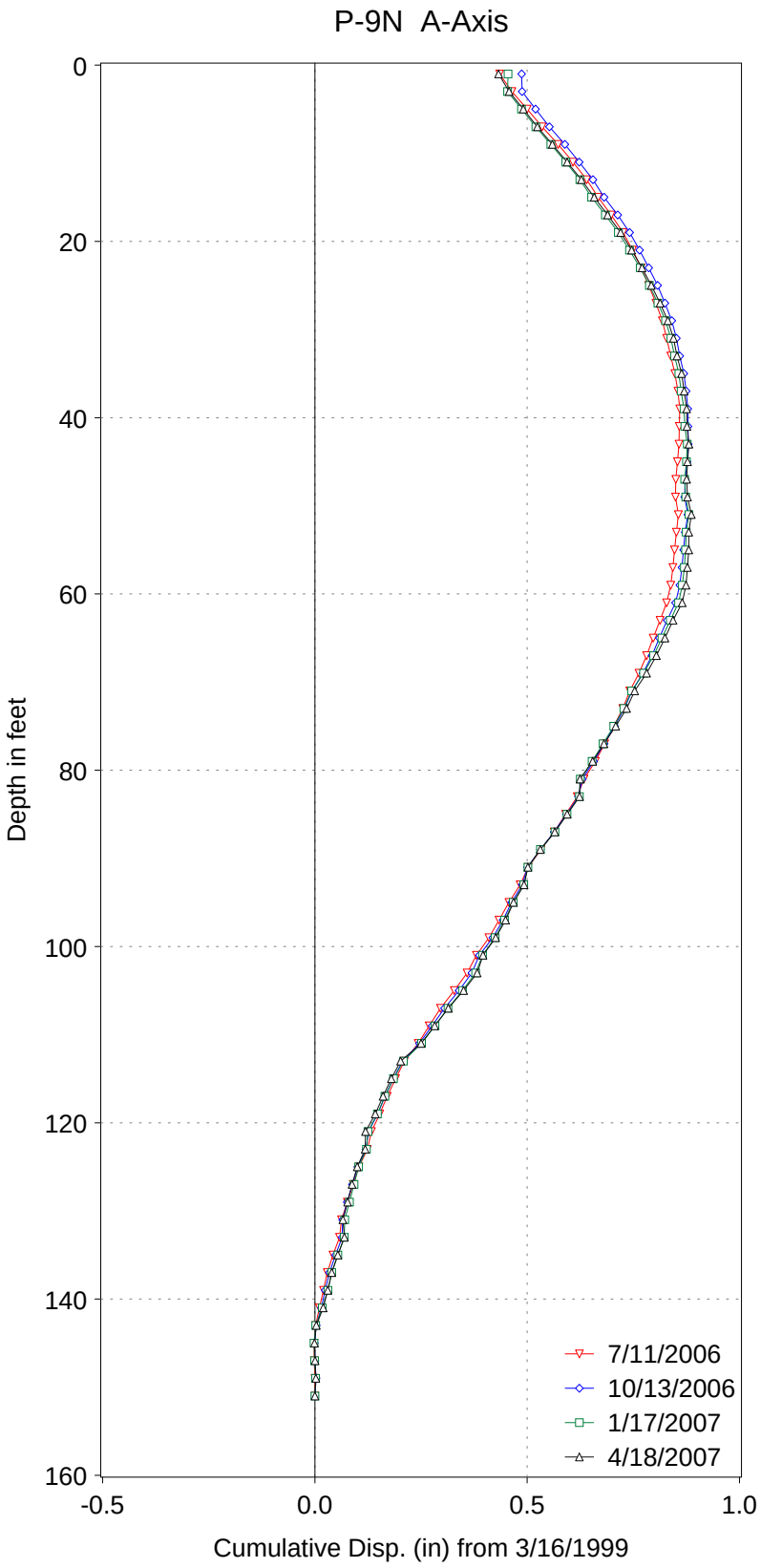


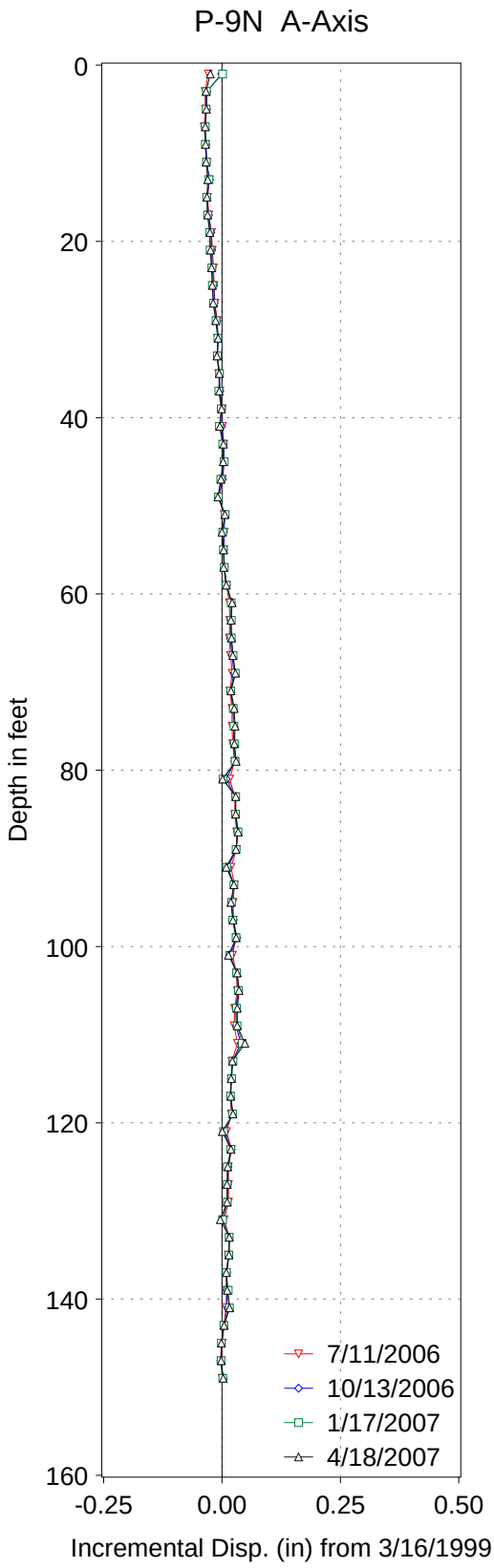


B-303

-Includes readings from the last four quarters.

PLATE 14

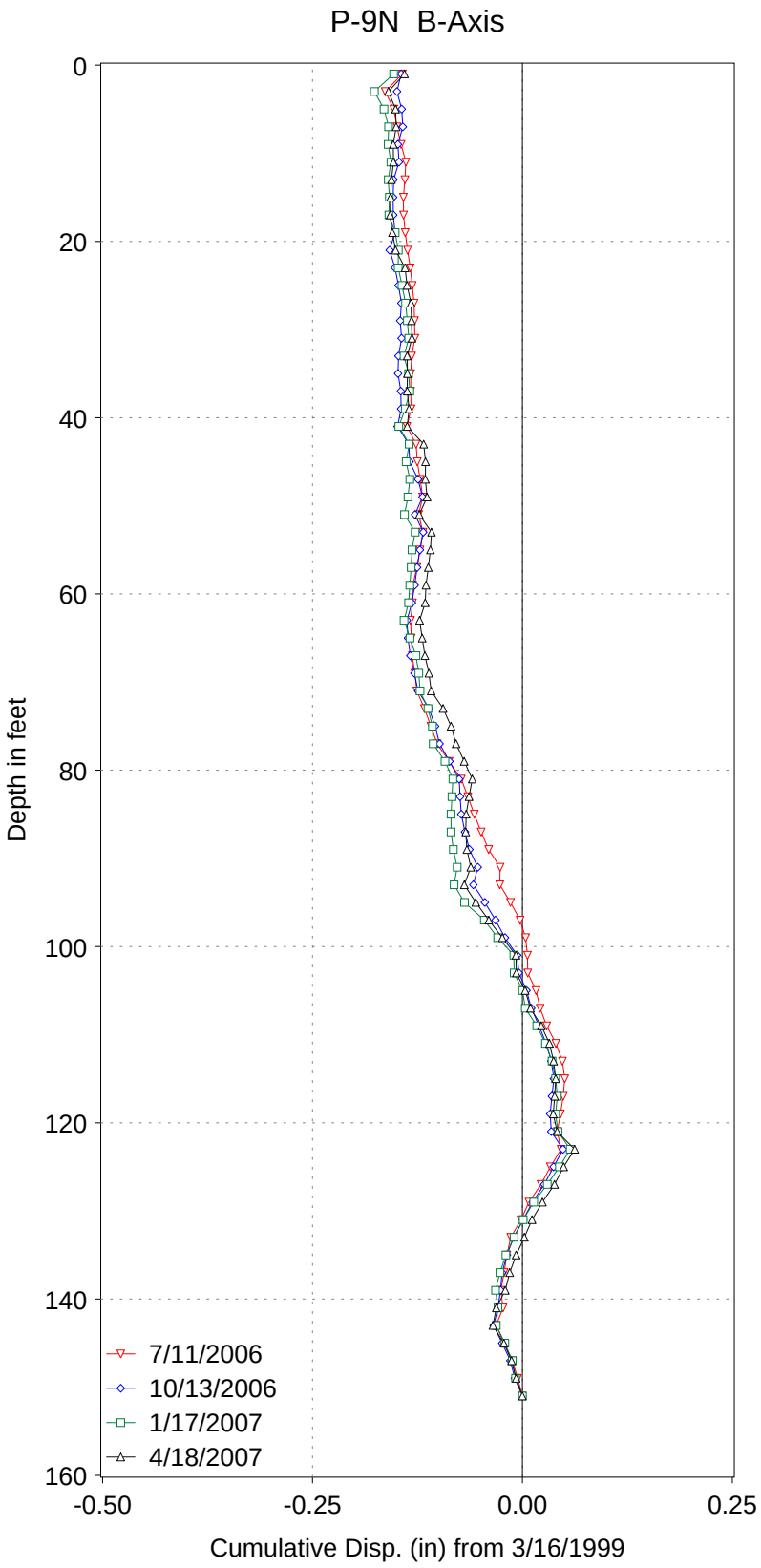


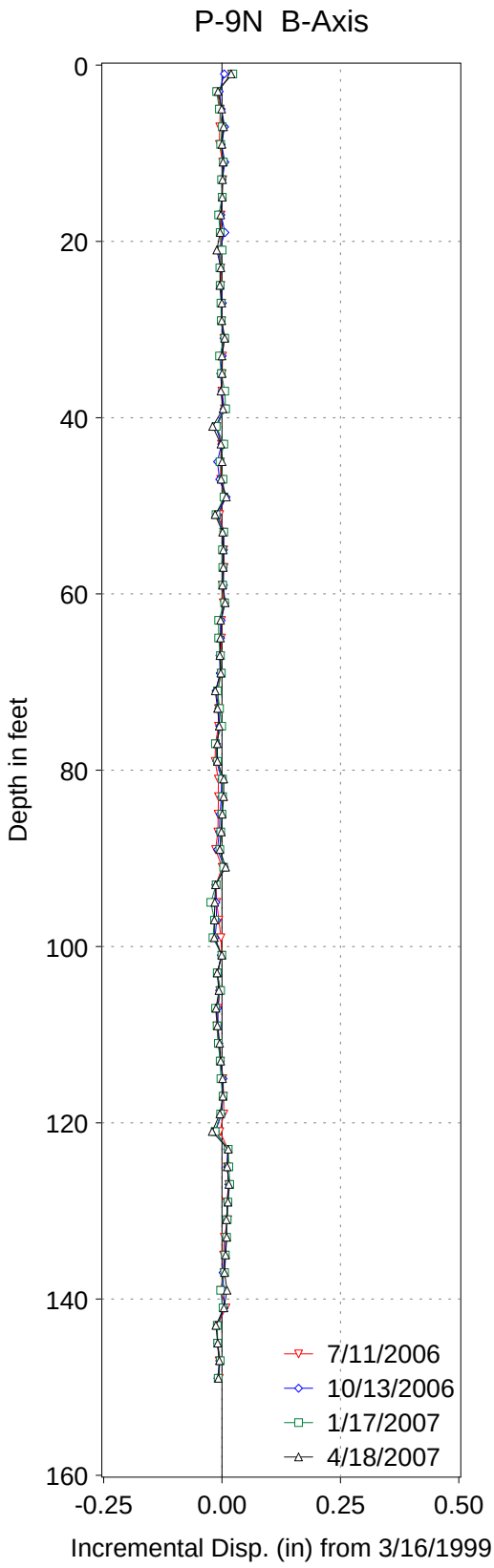


P-9N

-Includes readings from the last four quarters.

PLATE 15





P-9N

-Includes readings from the last four quarters.

PLATE 16

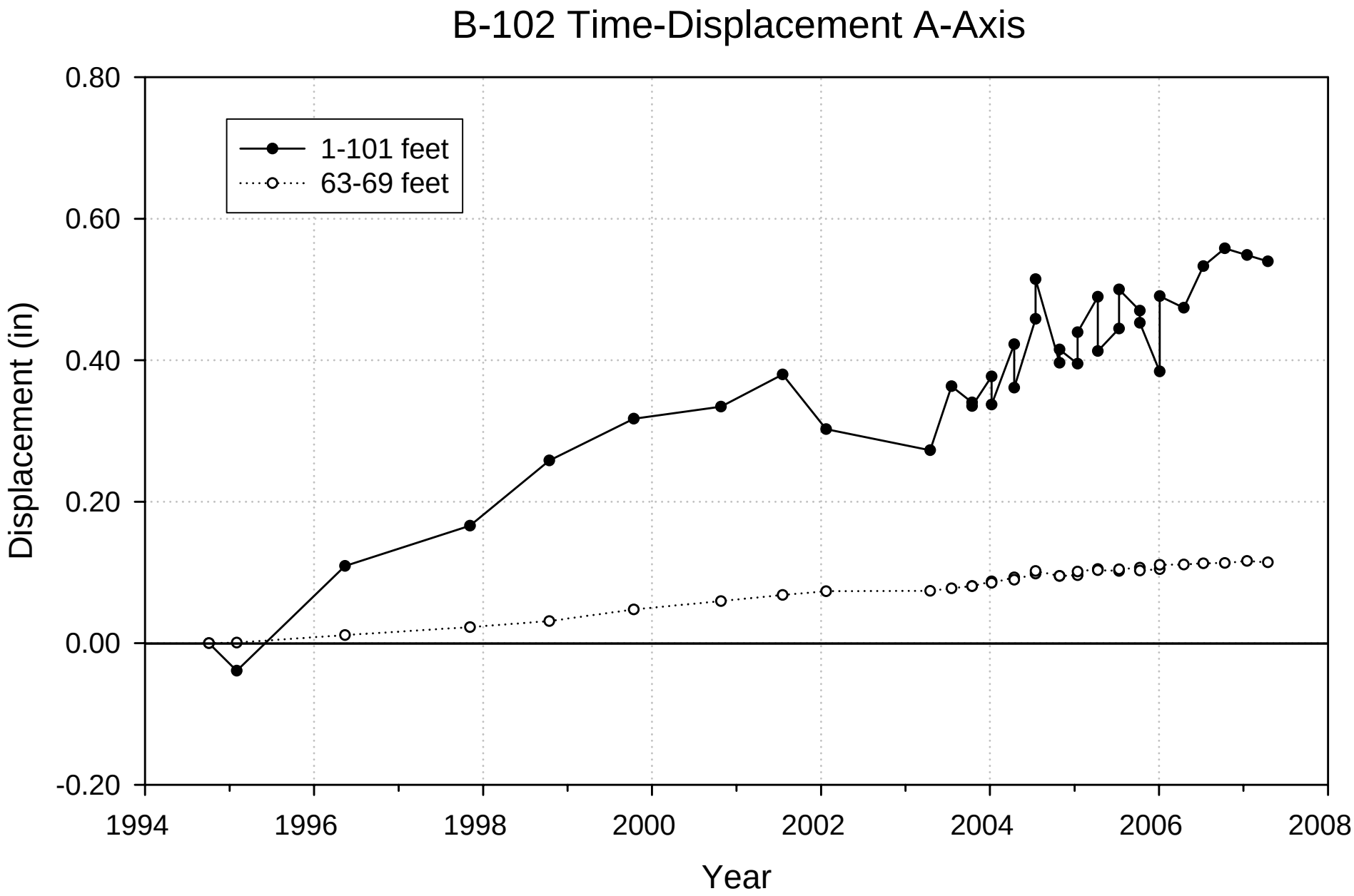

B-102 Time-Displacement A-Axis
1-101 feet
63-69 feet
Displacement (in)
0.80
0.60
0.40
0.20
0.00
-0.20
1994
1996
1998
2000
2002
2004
2006
2008
Year

PLATE 17

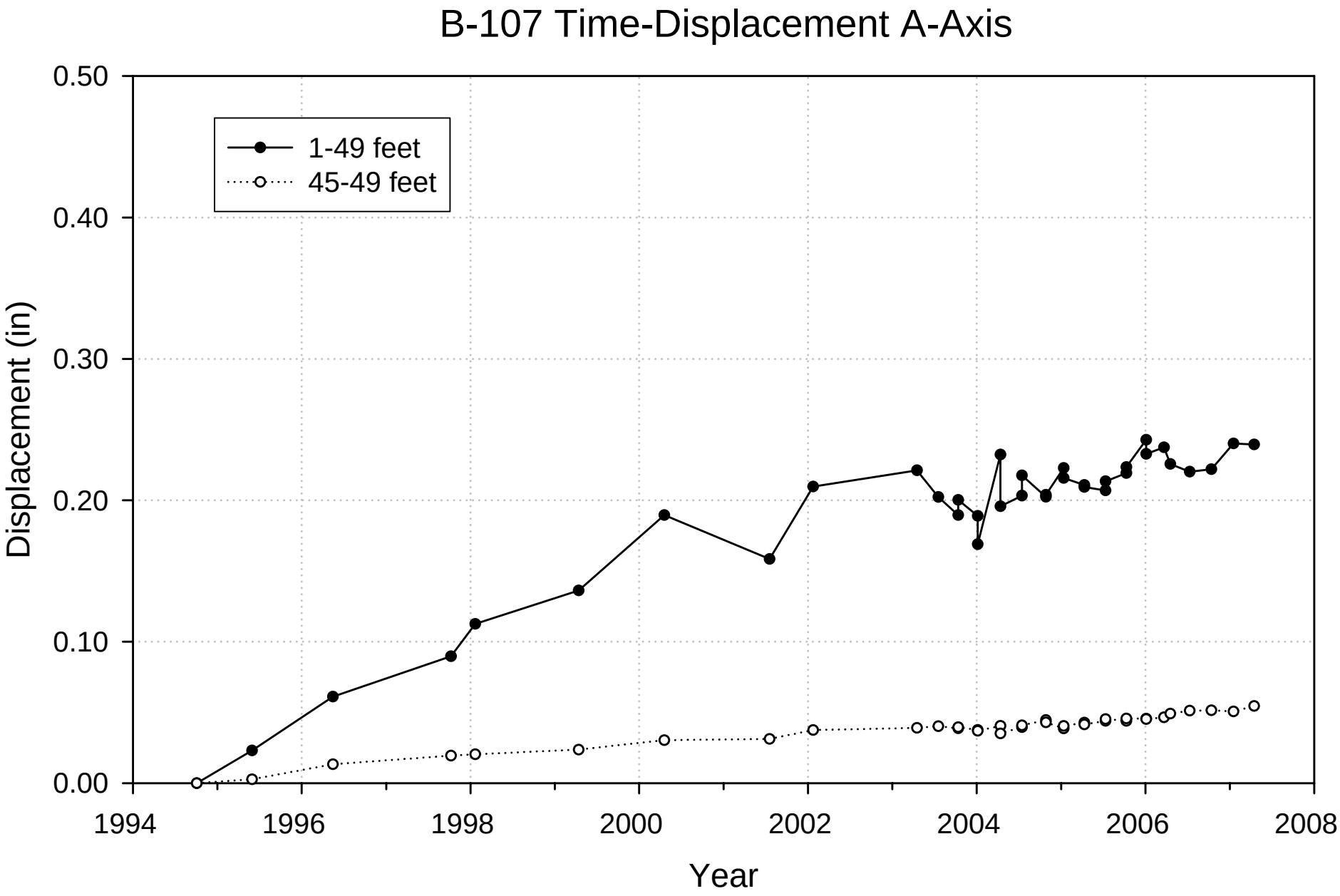

B-107 Time-Displacement A-Axis
1-49 feet
45-49 feet
Displacement (in)
0.50
0.40
0.30
0.20
0.10
0.00
1994
1996
1998
2000
2002
2004
2006
2008
Year

PLATE 18

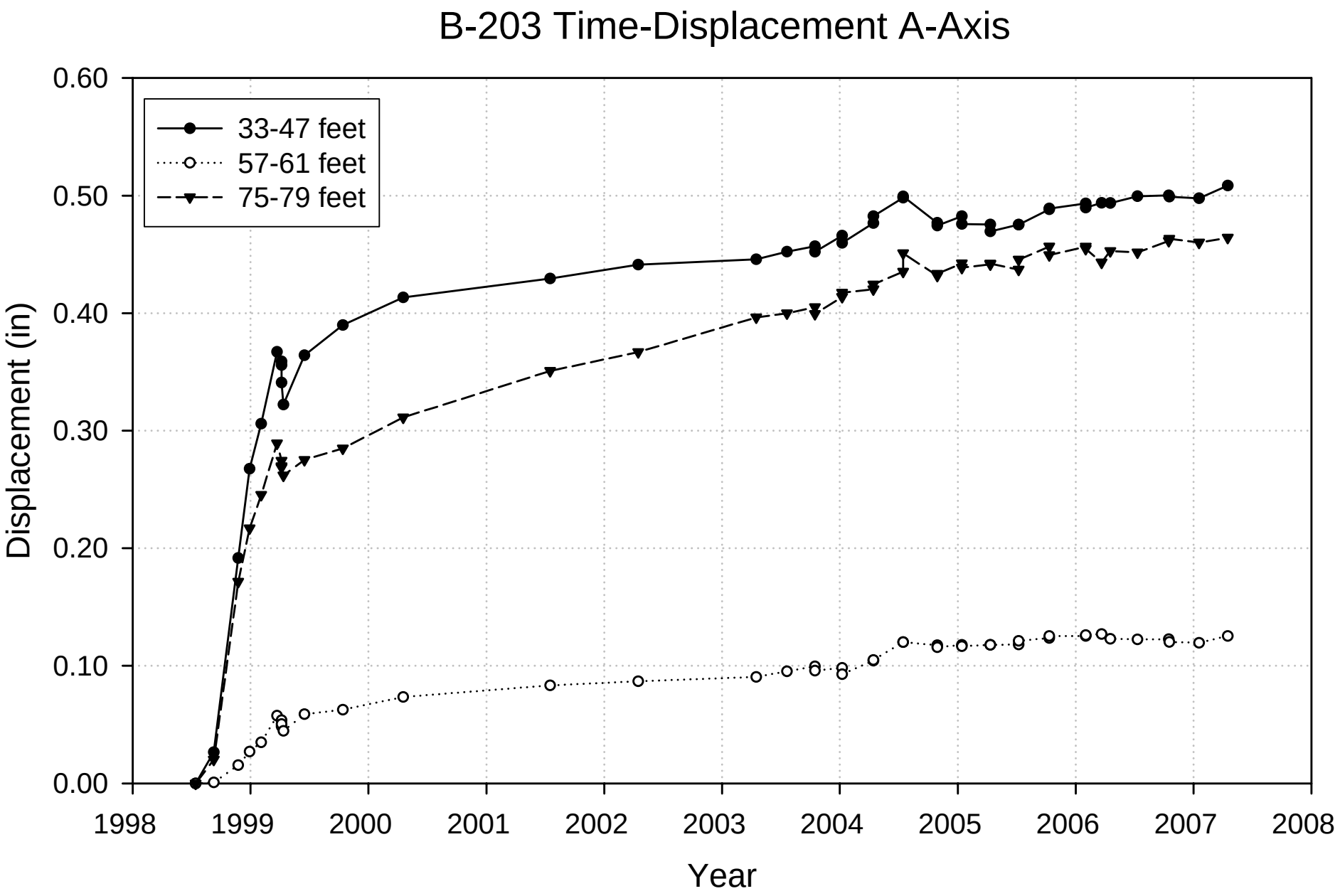

B-203 Time-Displacement A-Axis
33-47 feet
57-61 feet
75-79 feet
Displacement (in)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year

PLATE 19

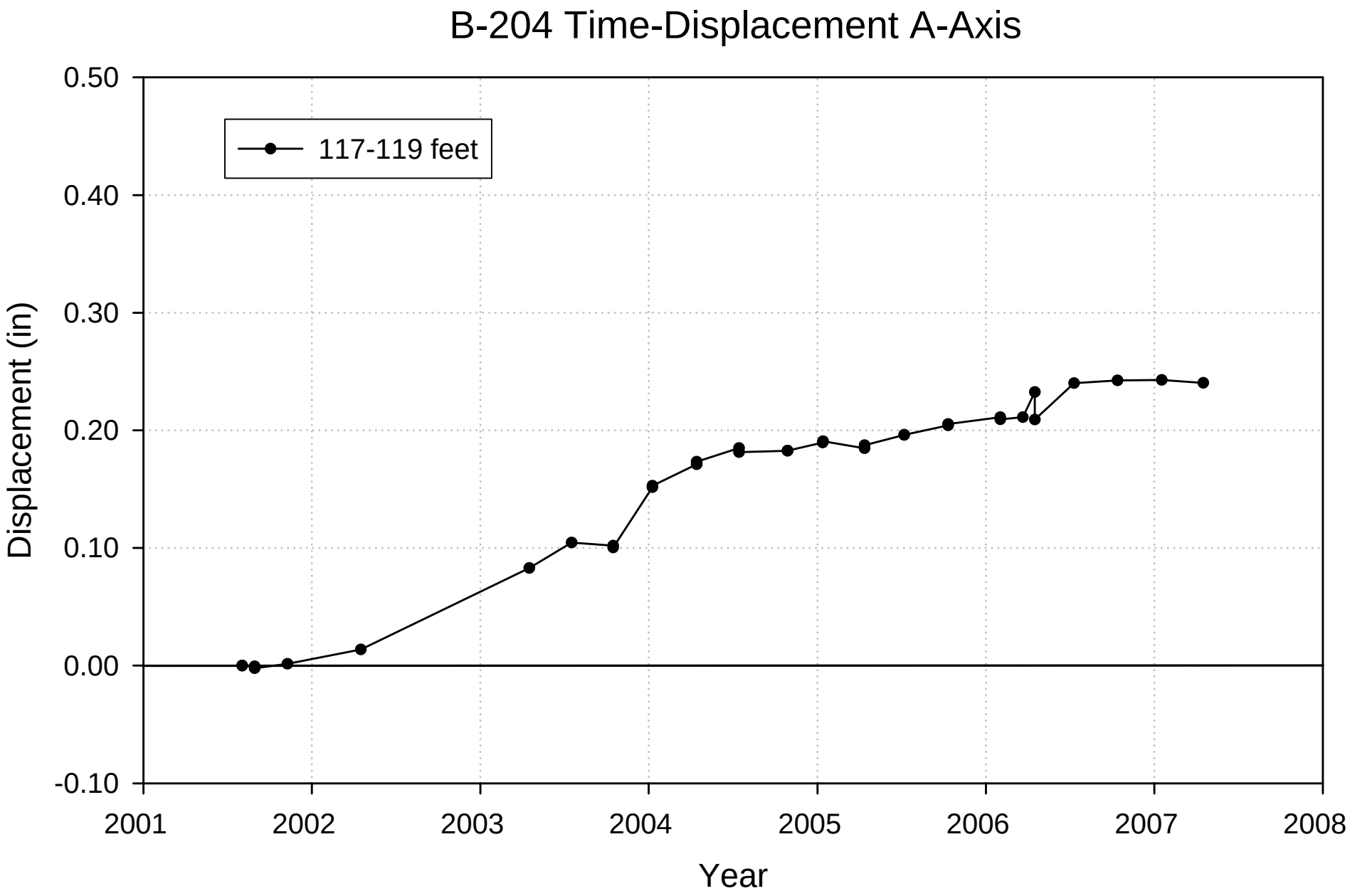

B-204 Time-Displacement A-Axis
117-119 feet
Displacement (in)
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
2001
2002
2003
2004
2005
2006
2007
2008
Year

PLATE 20

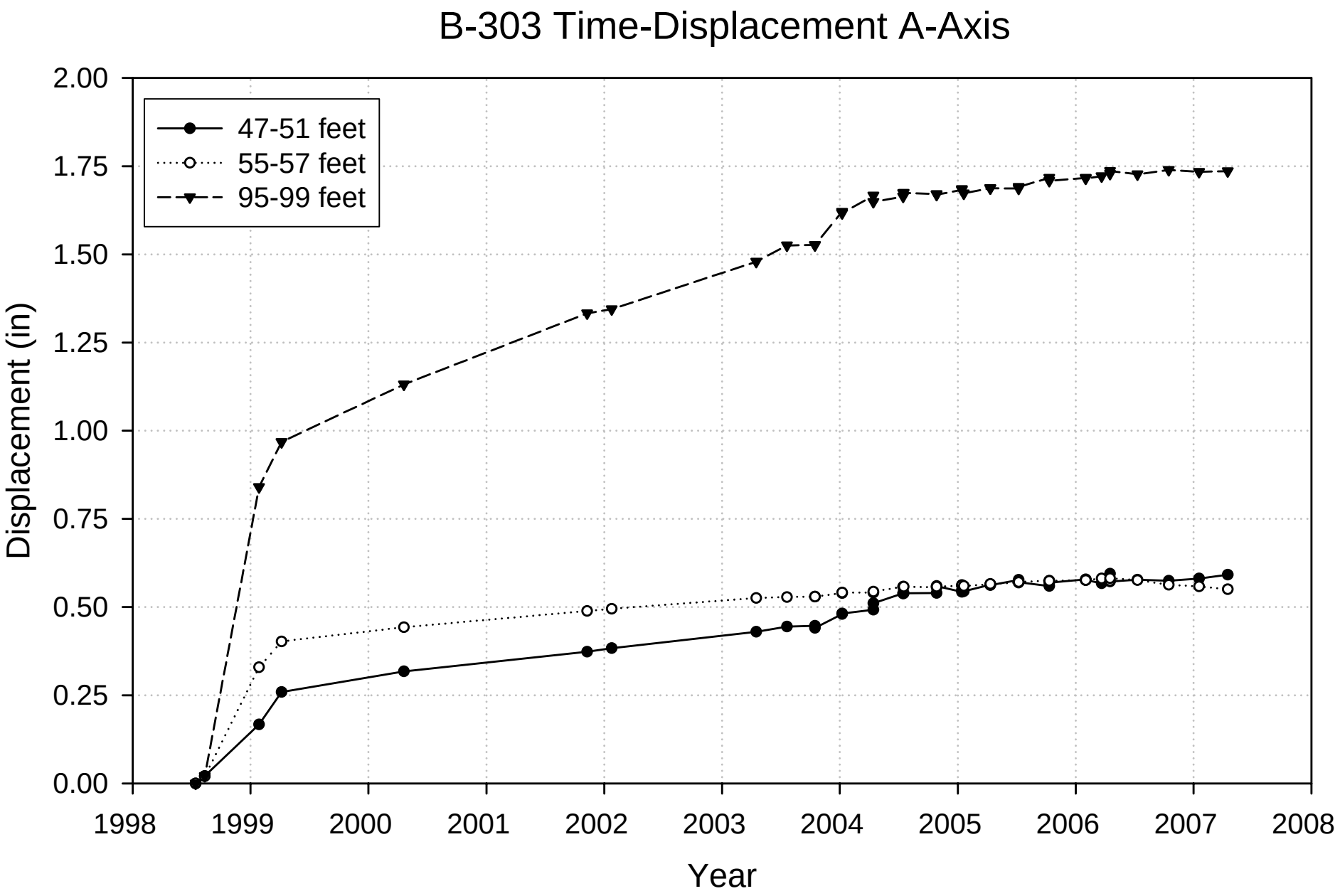
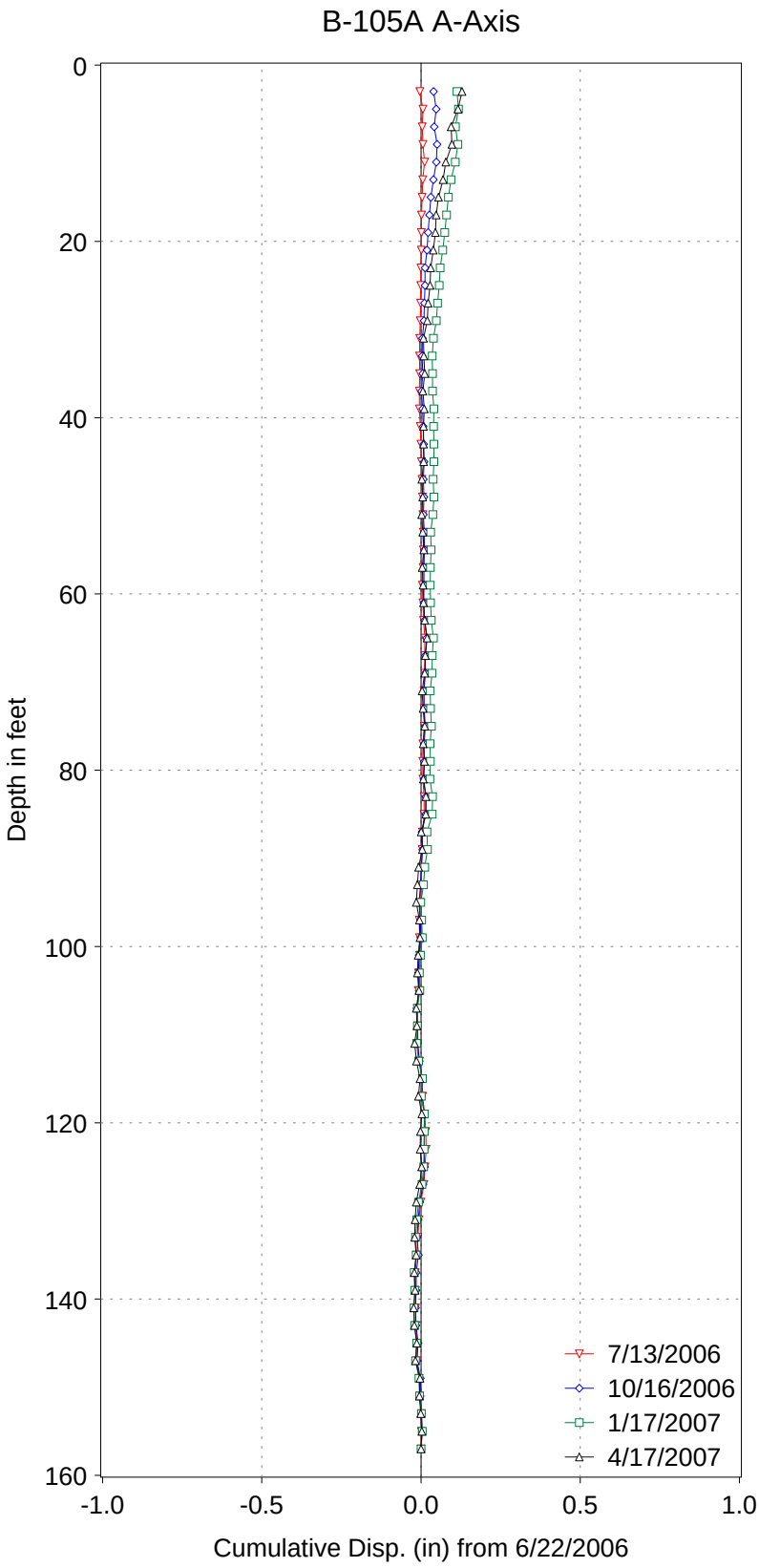
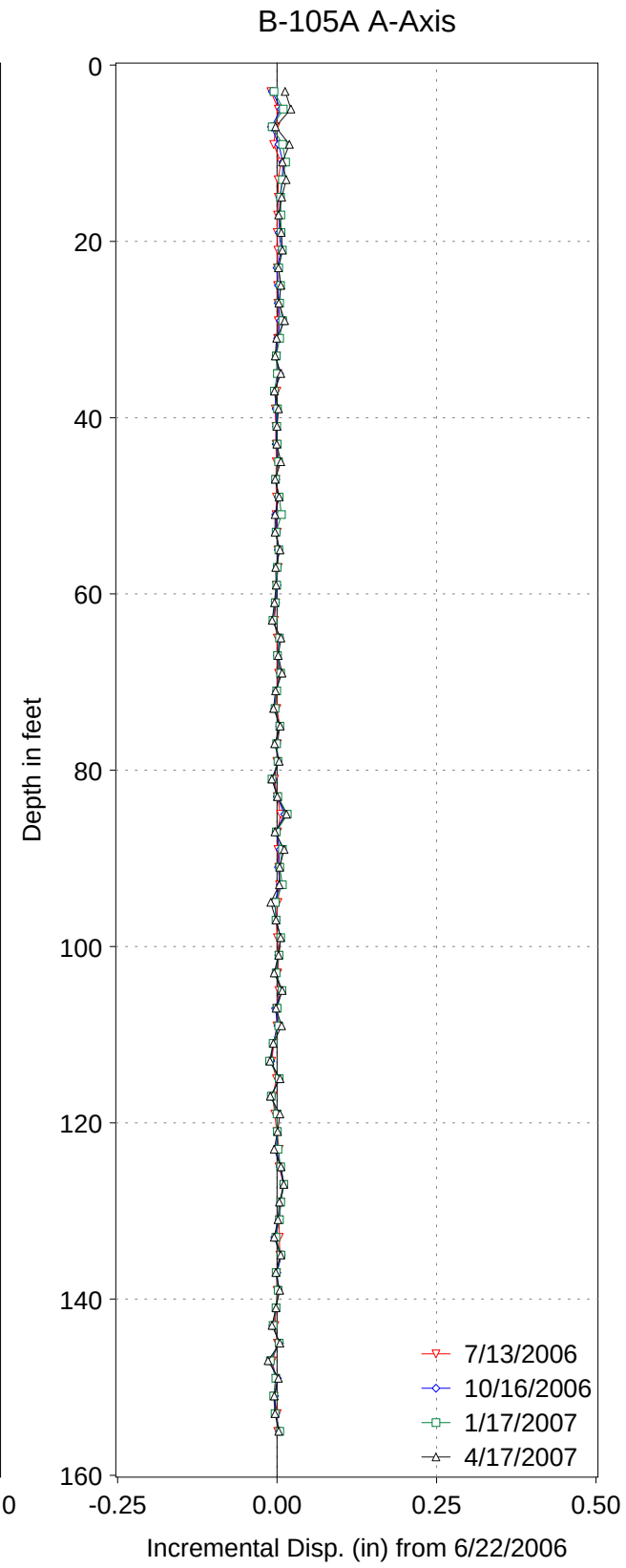

B-303 Time-Displacement A-Axis
47-51 feet
55-57 feet
95-99 feet
Displacement (in)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year

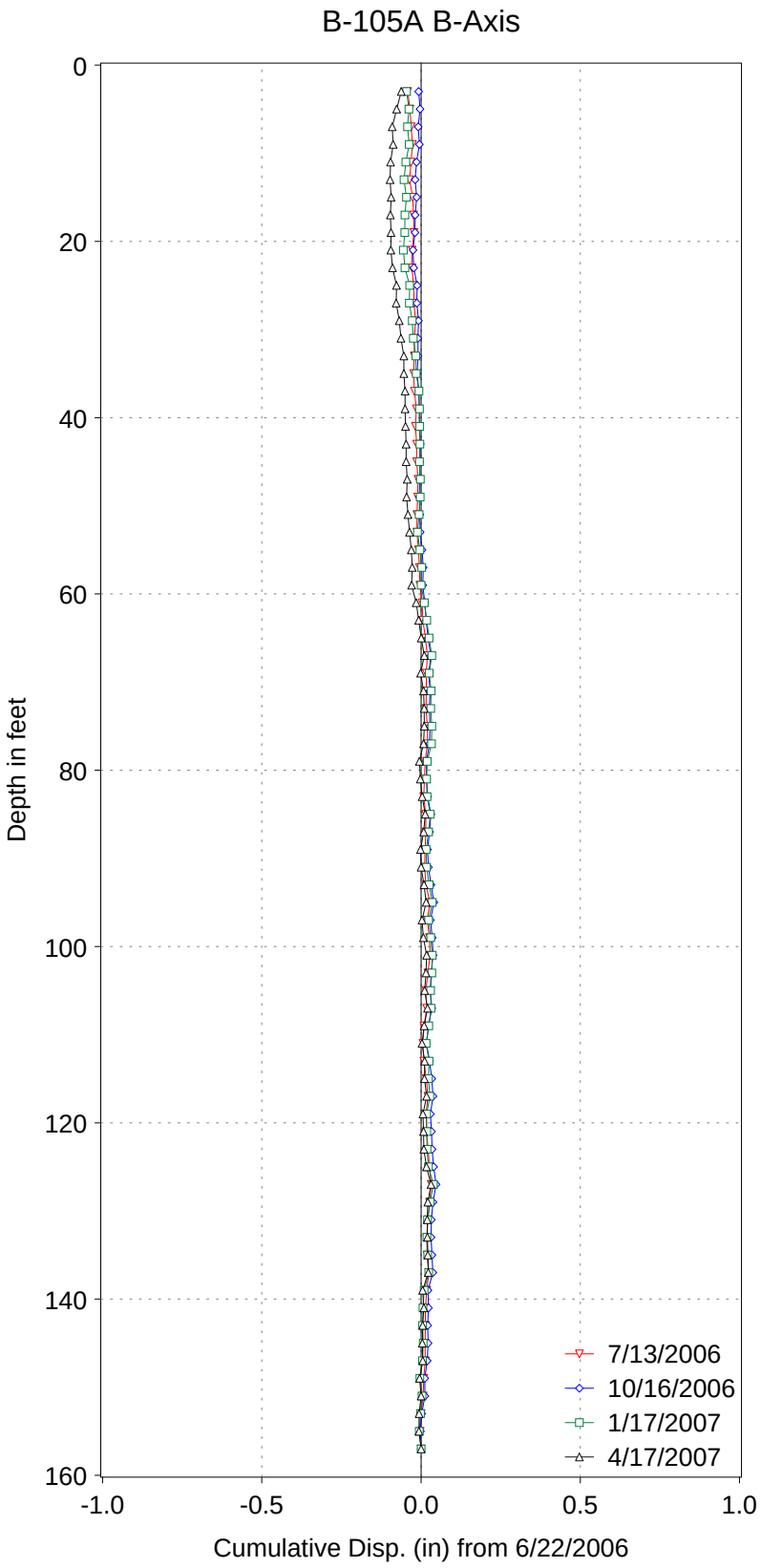
PLATE 21

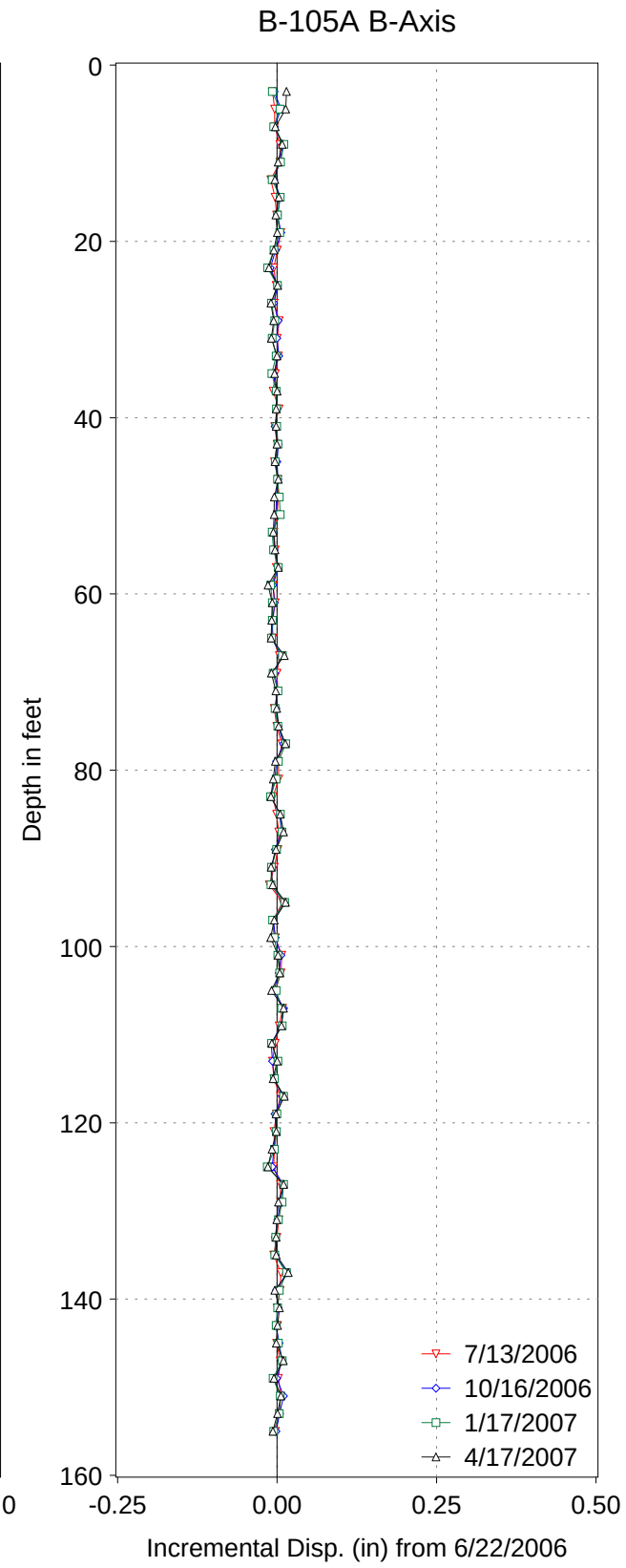




B-105A

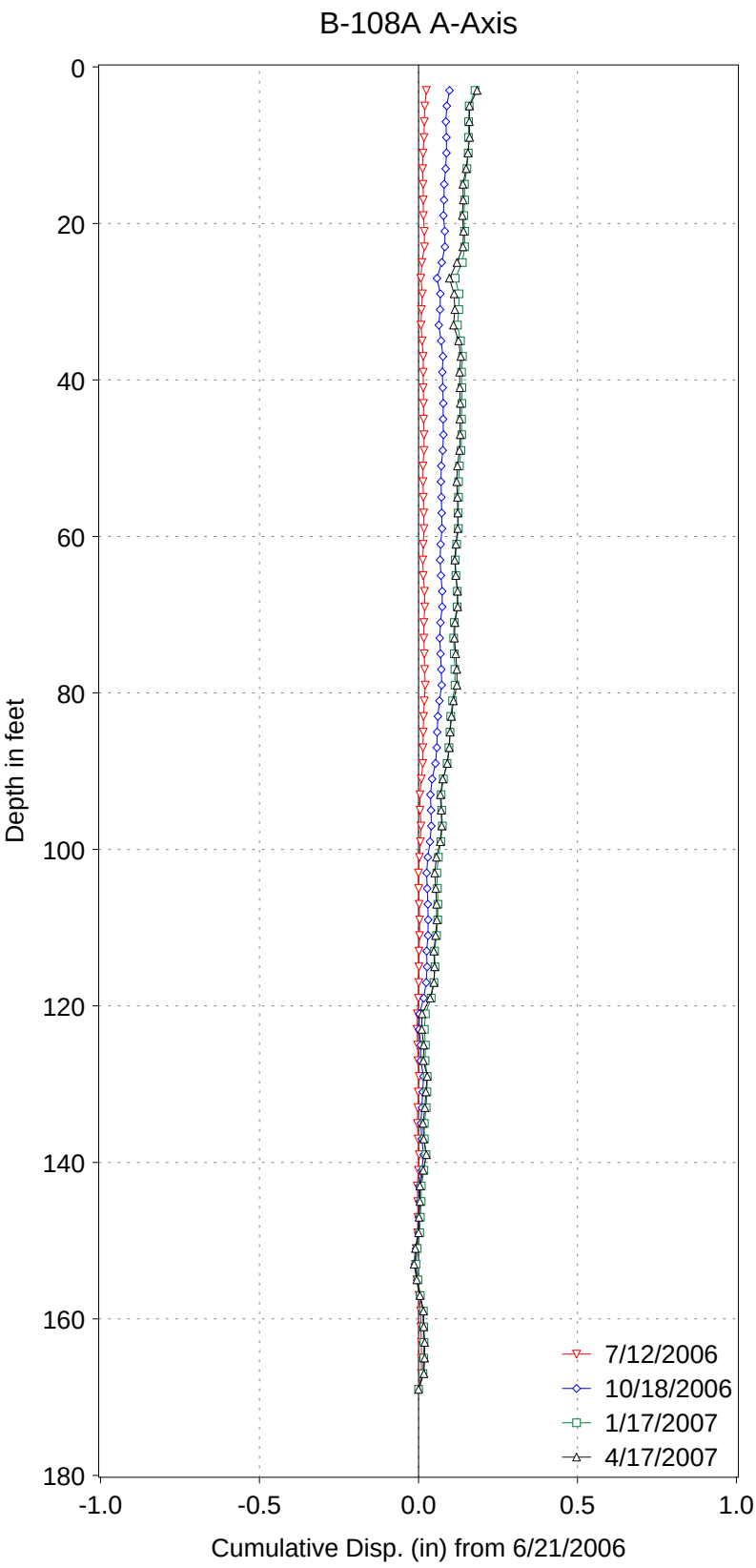
PLATE 22

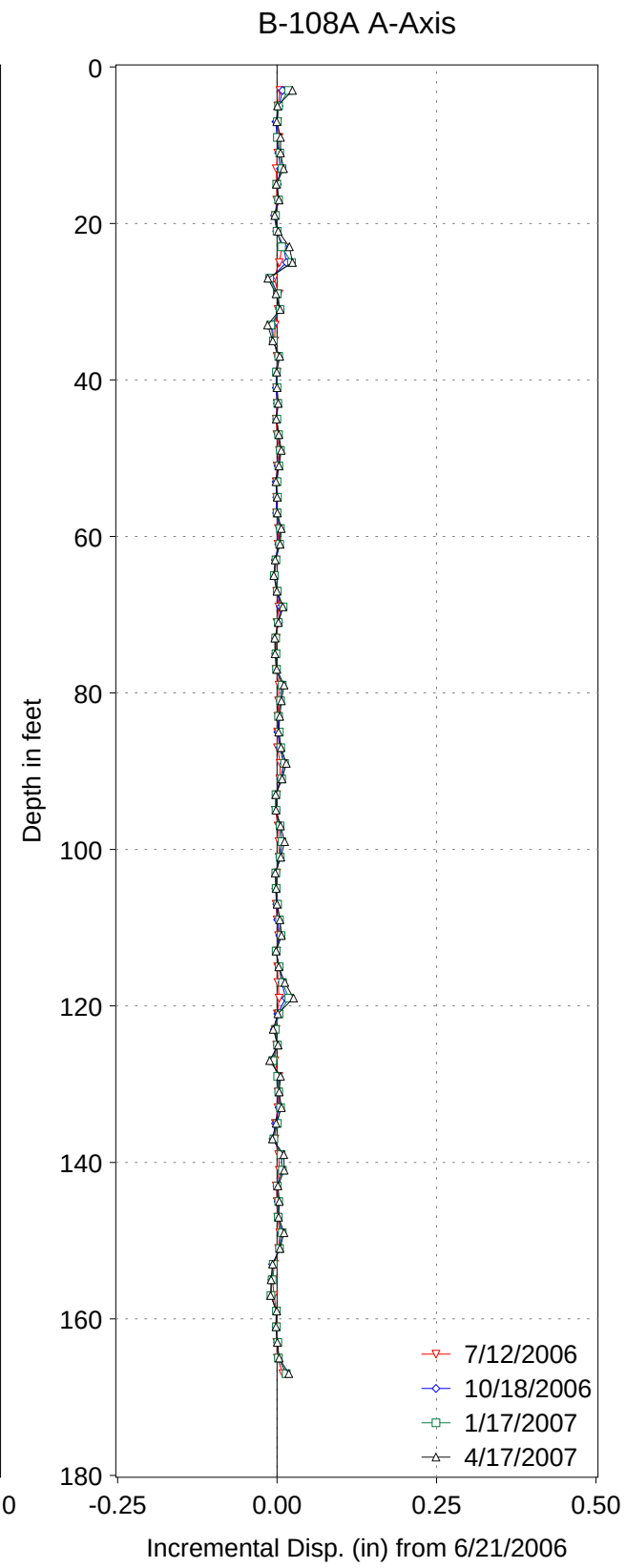




B-105A

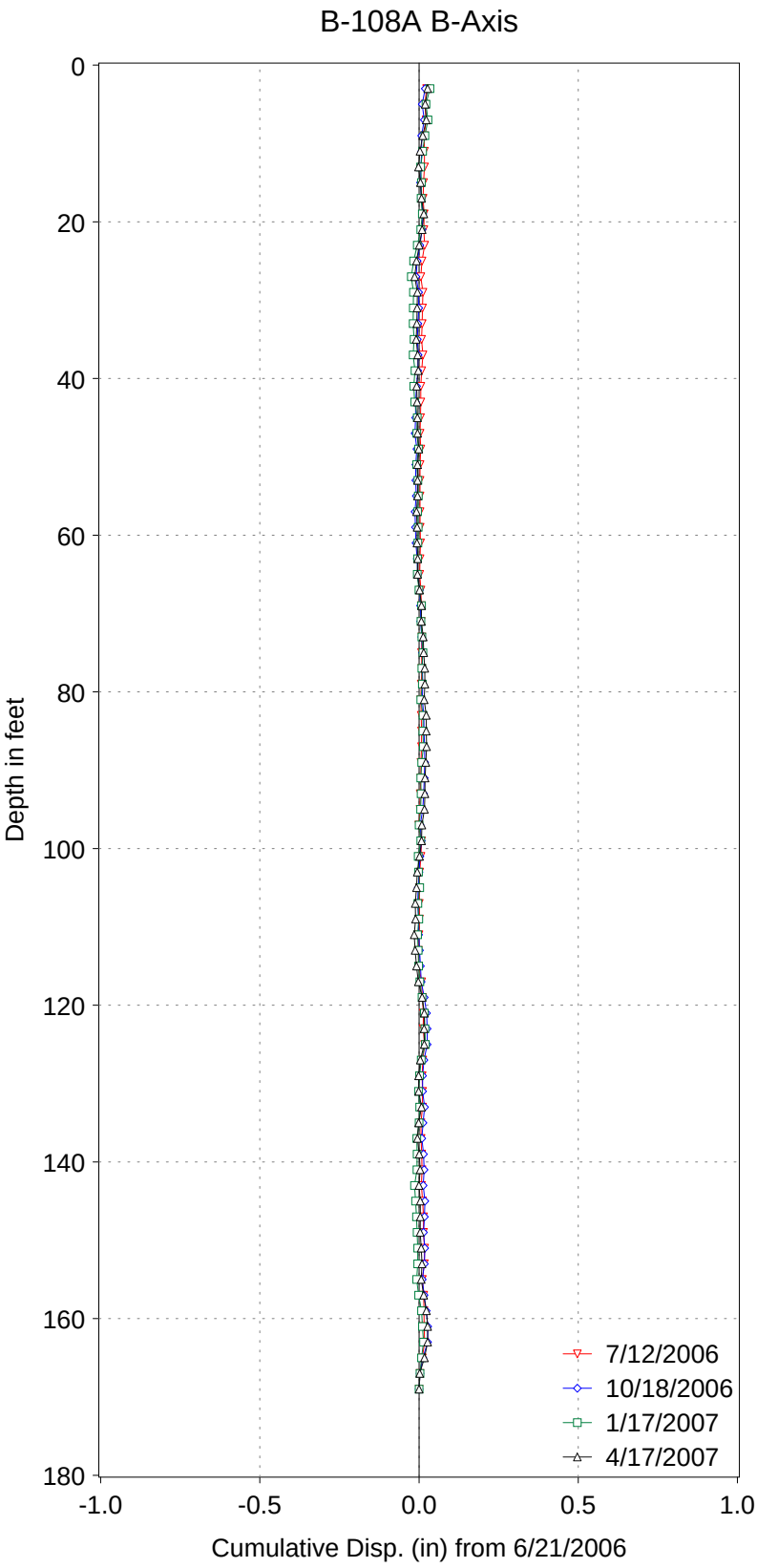
PLATE 23

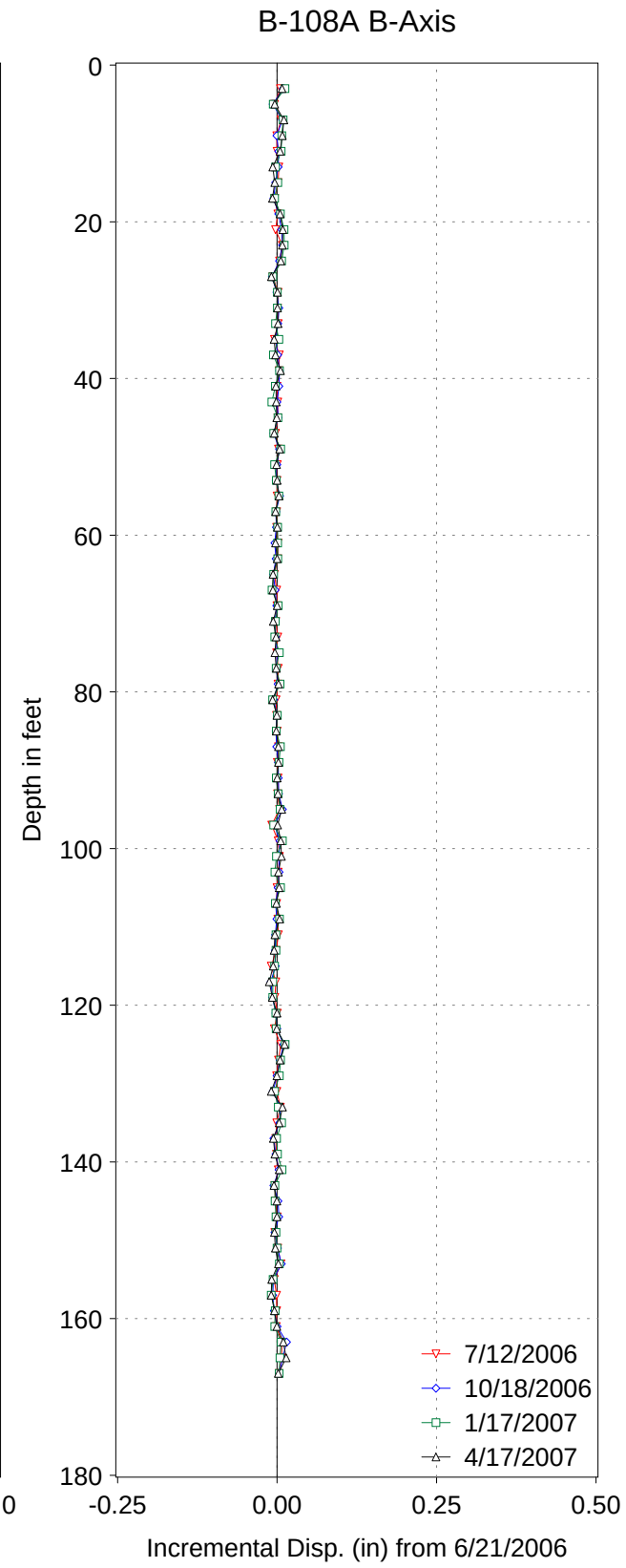




B-108A

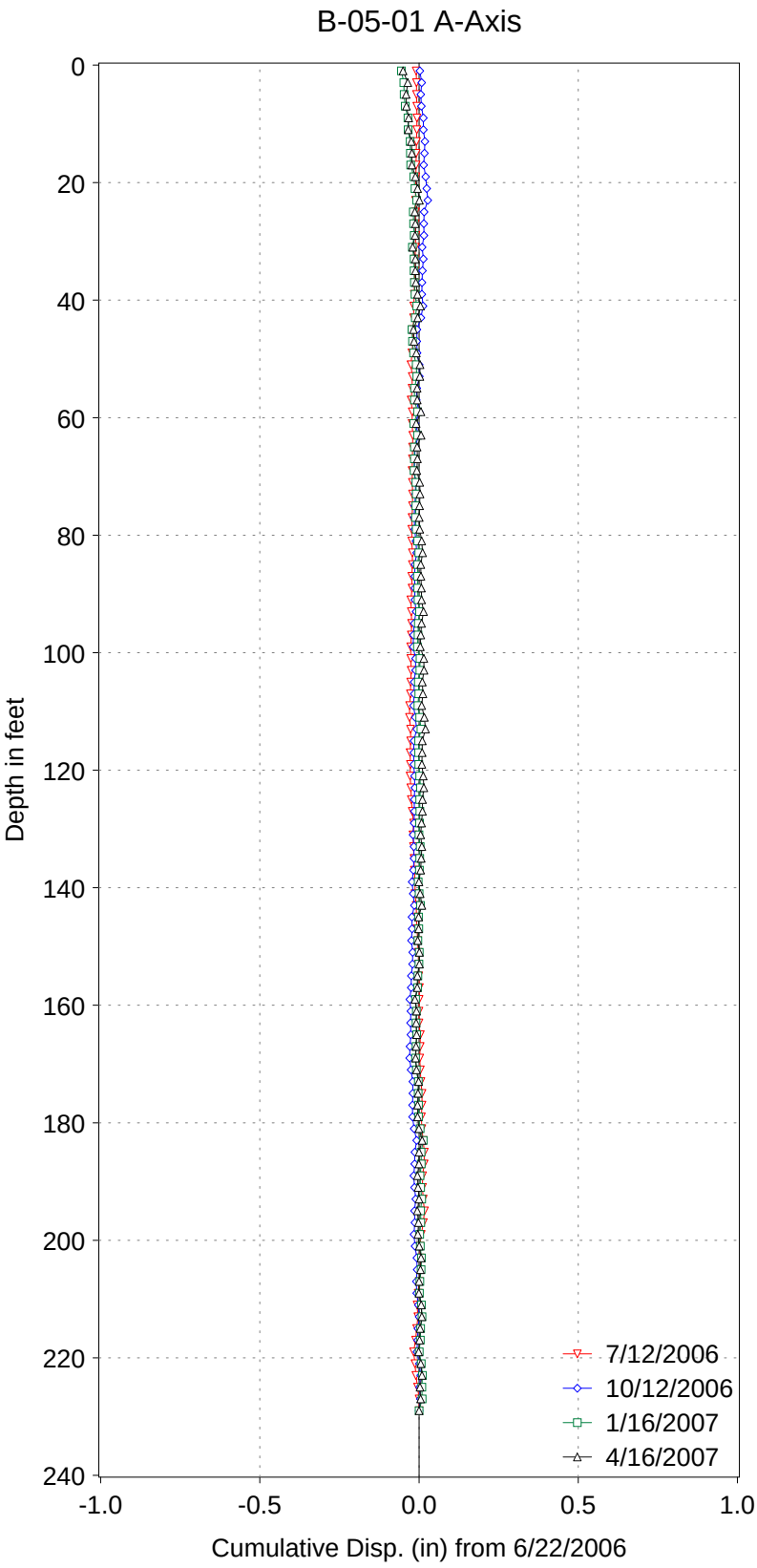
PLATE 24

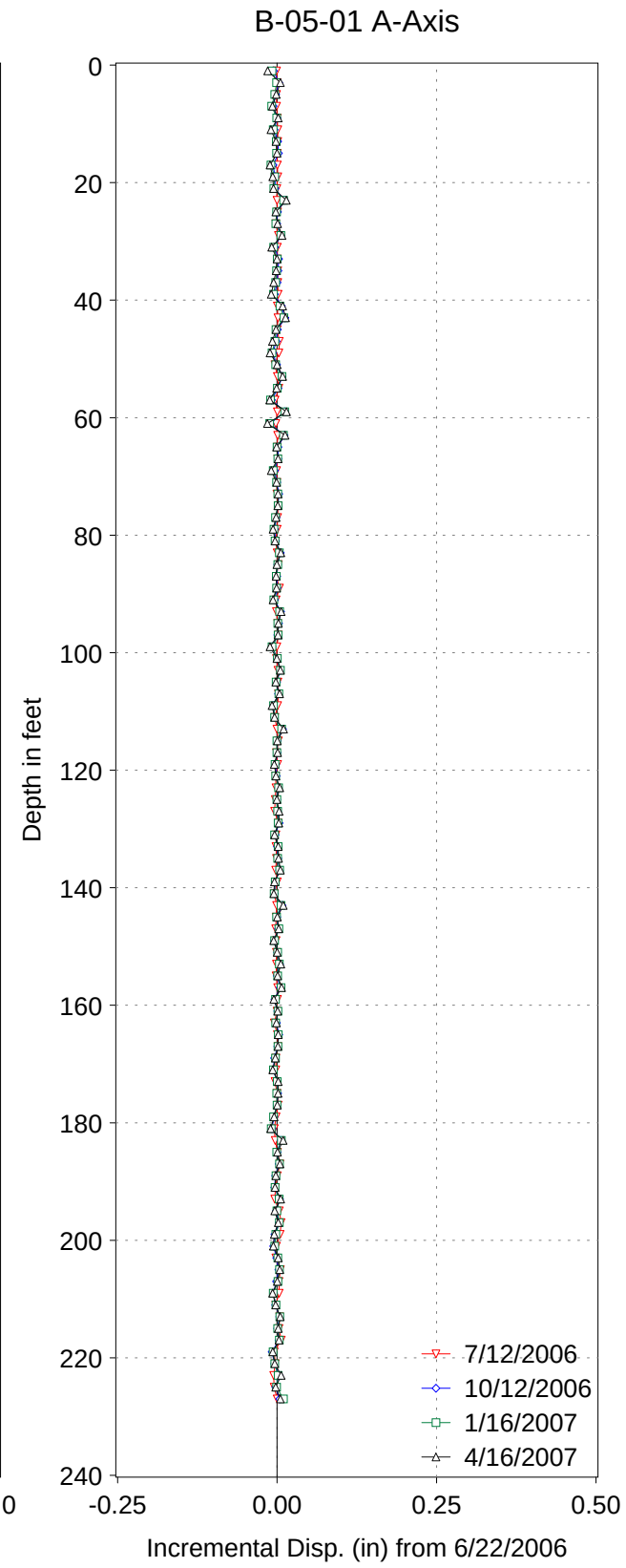




B-108A

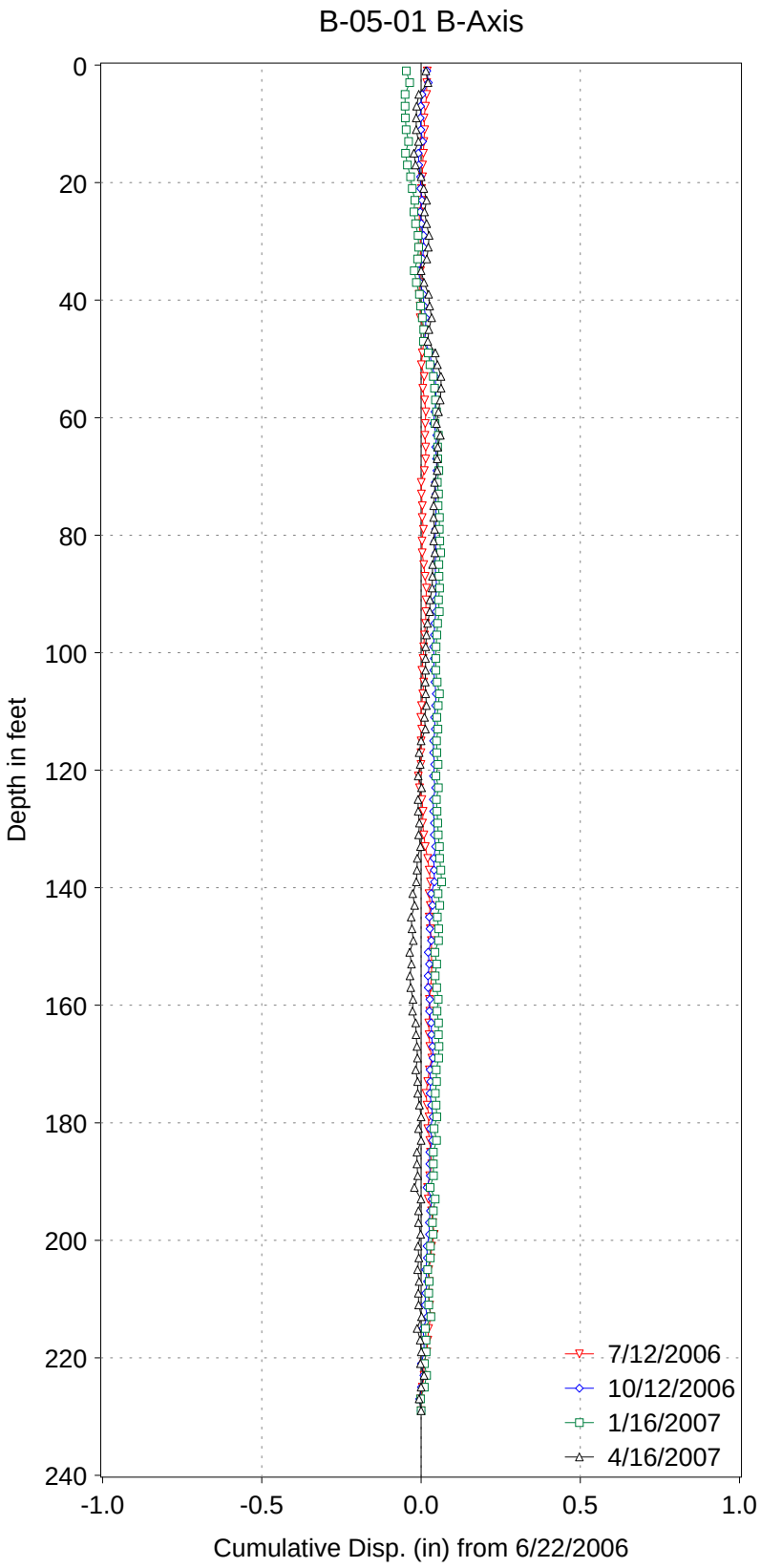
PLATE 25

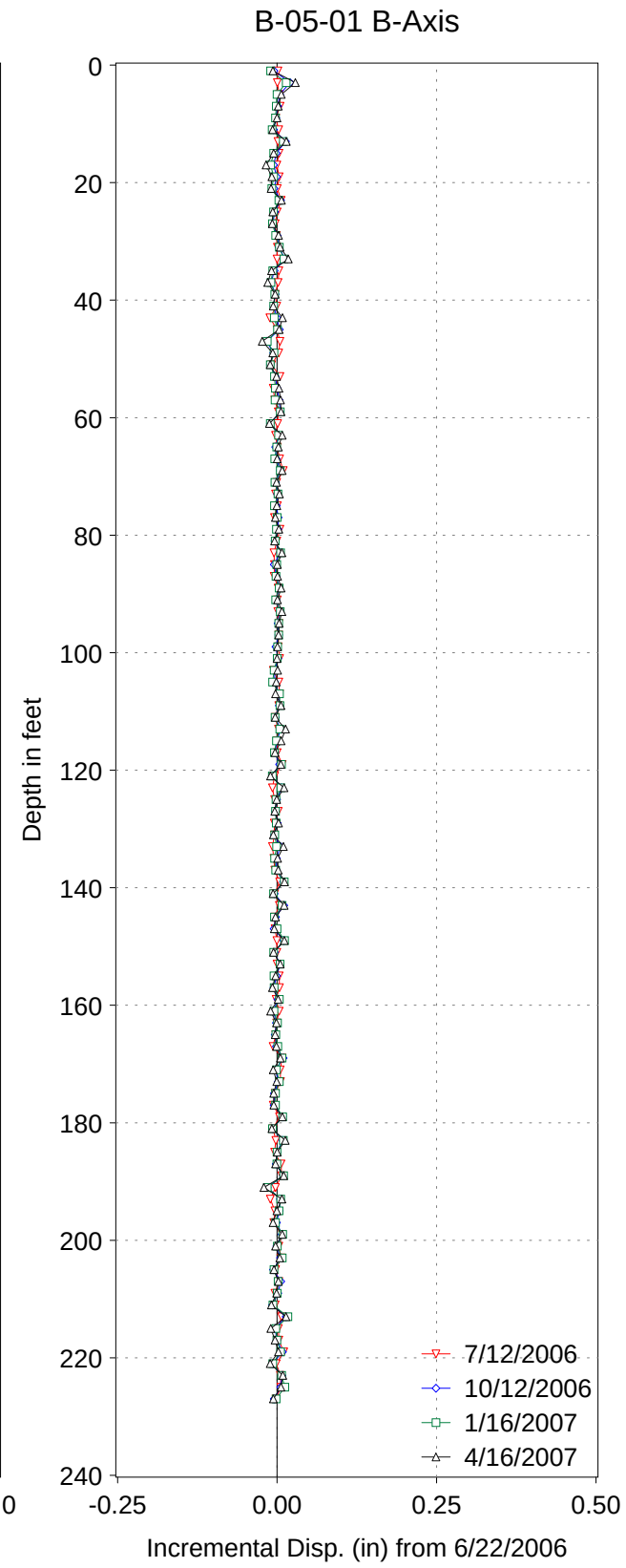




B-05-01

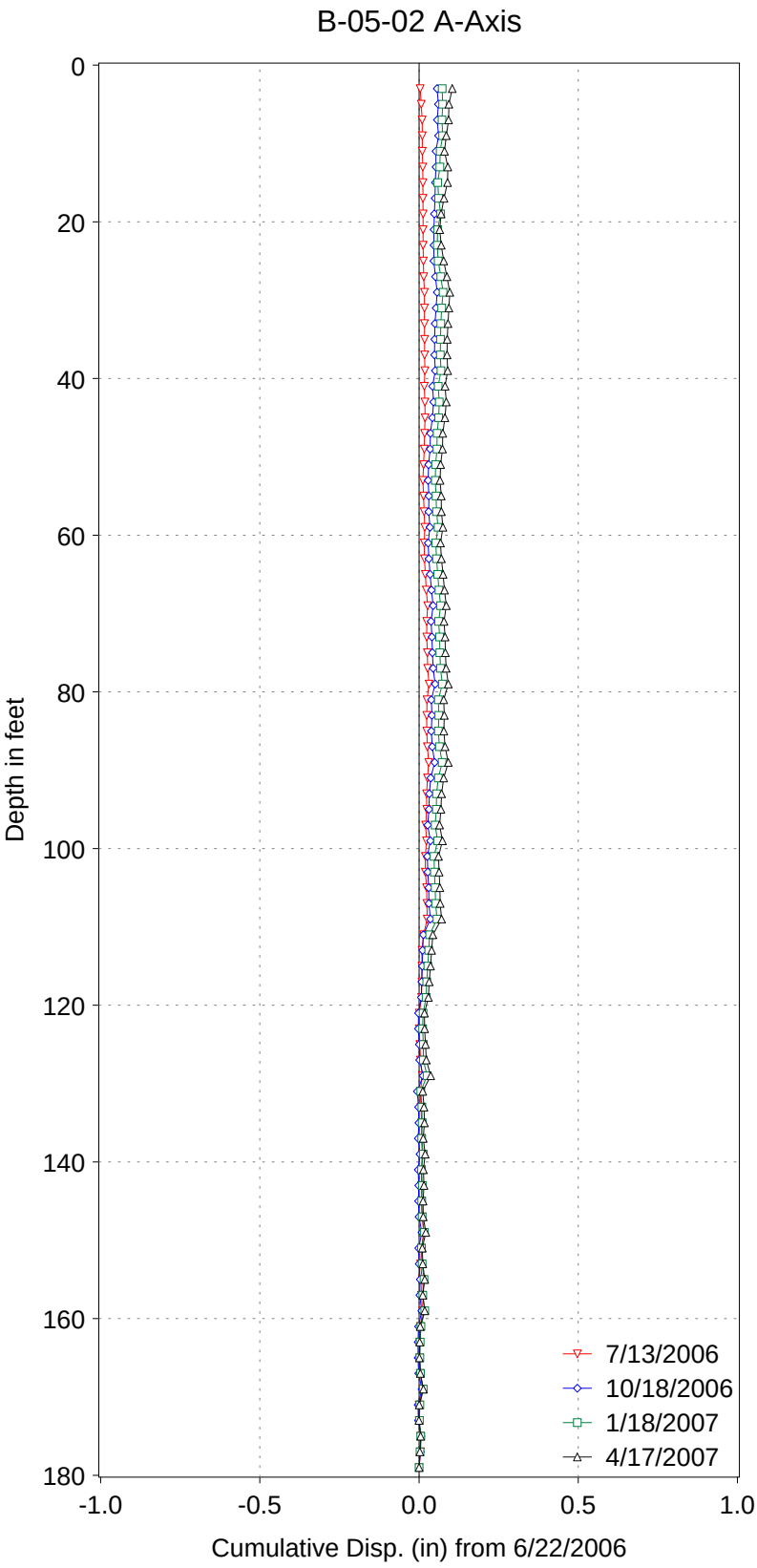
PLATE 26

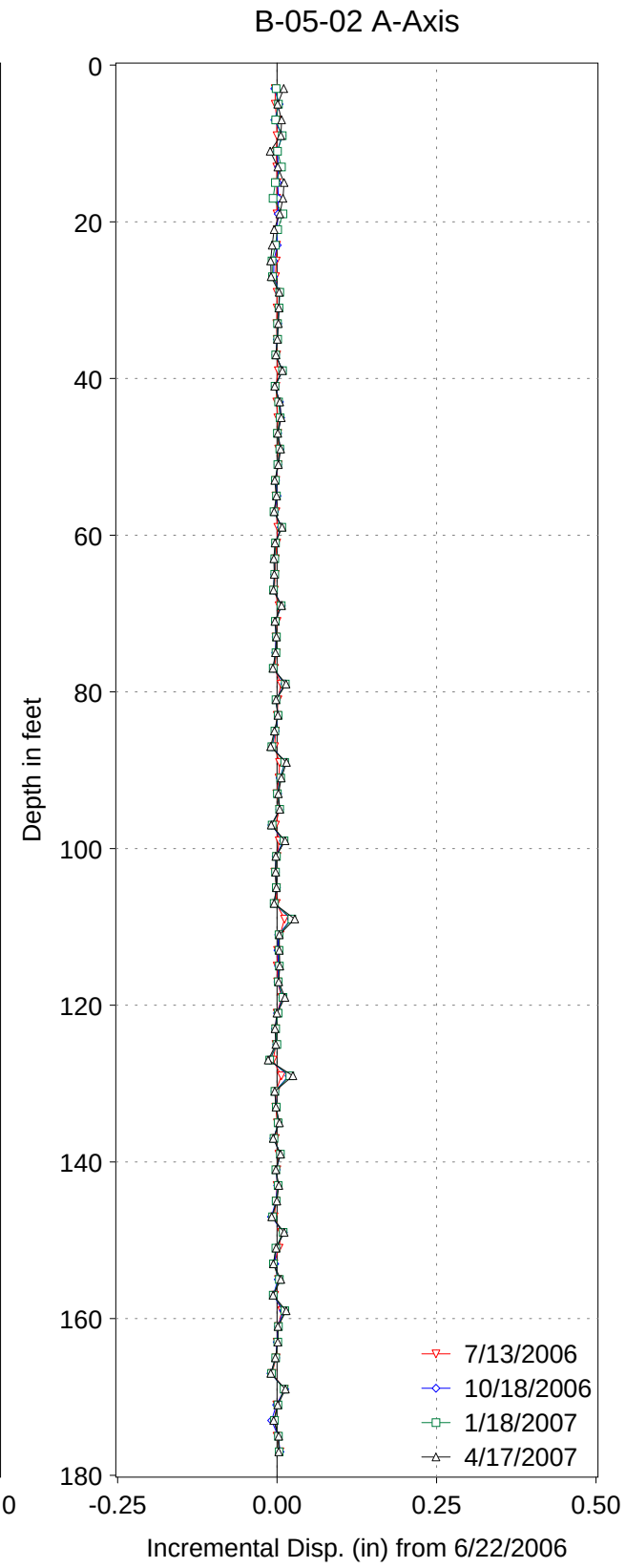




B-05-01

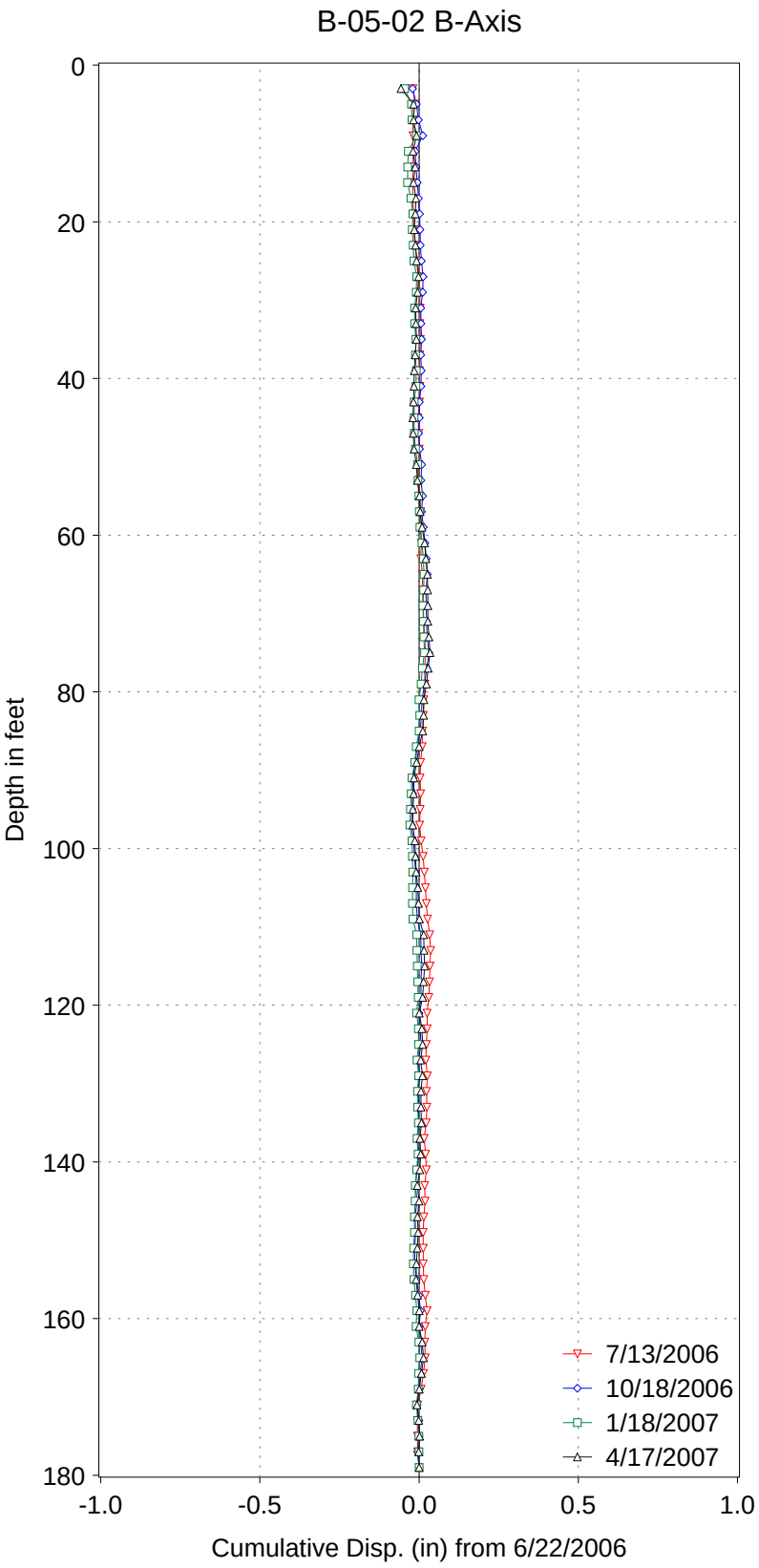
PLATE 27

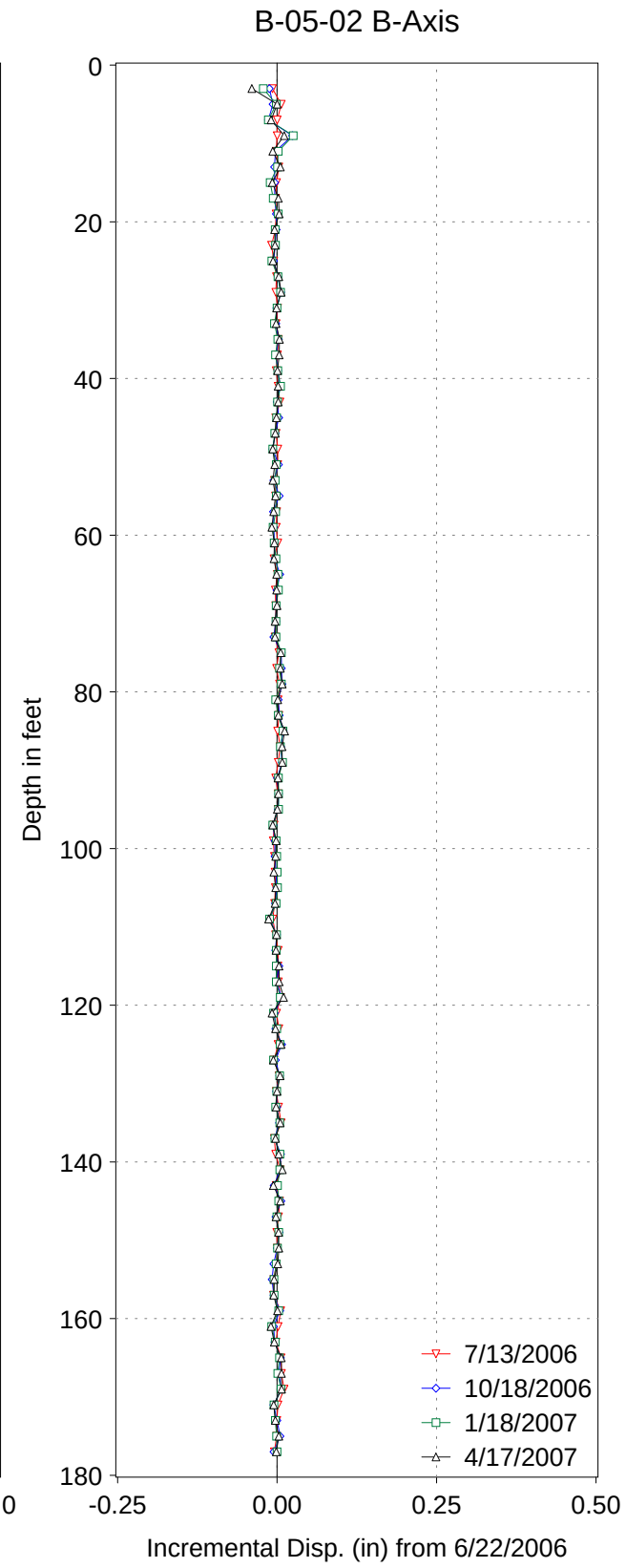




B-05-02

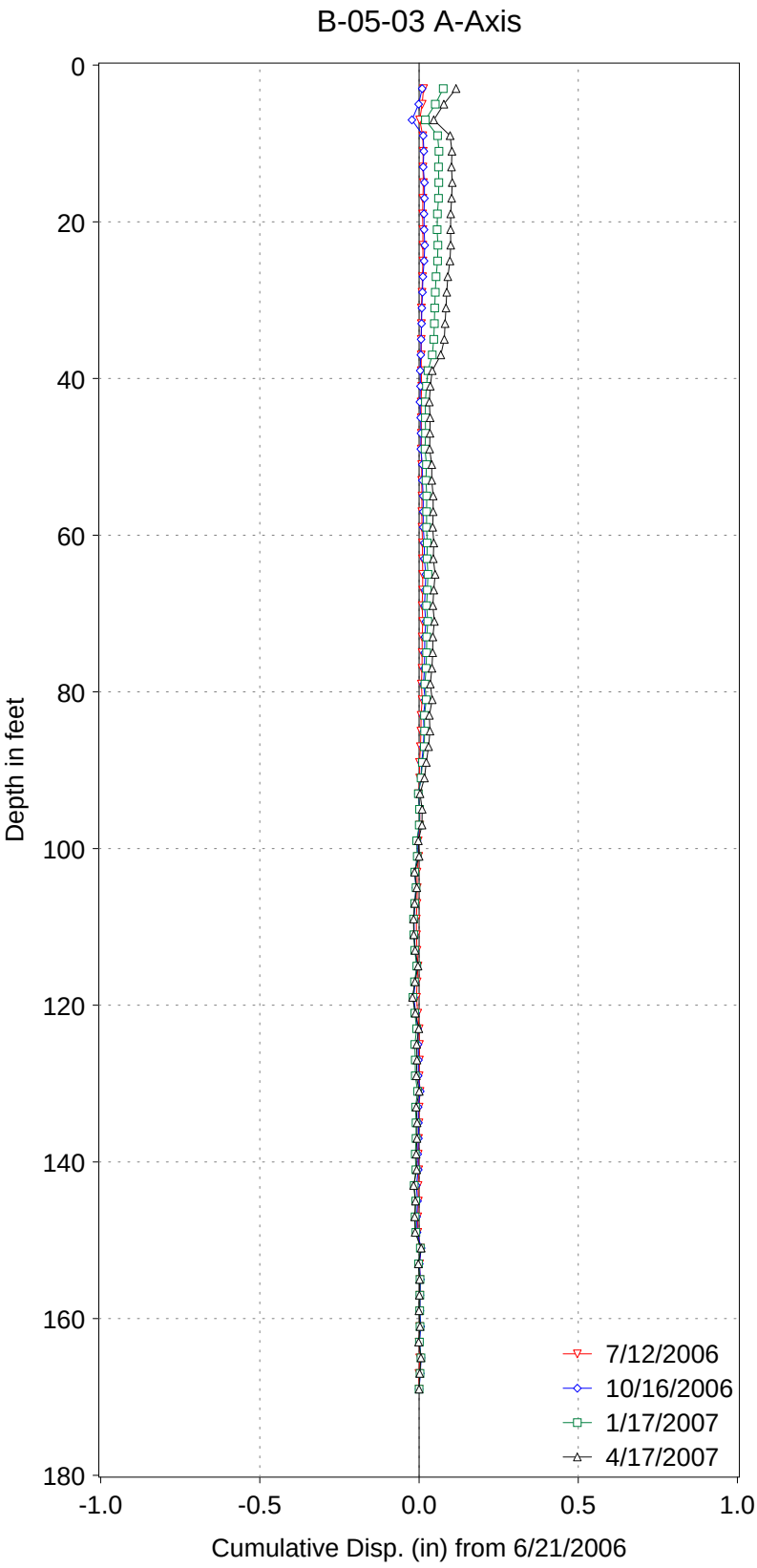
PLATE 28

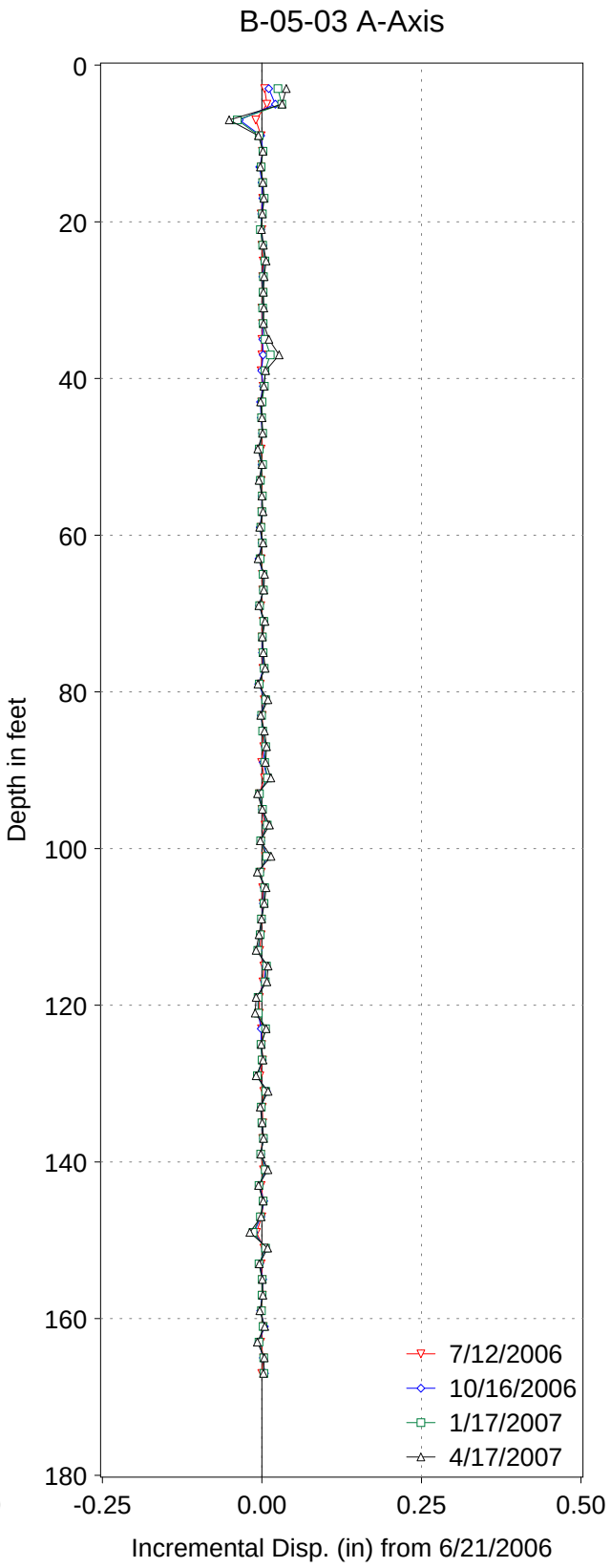




B-05-02

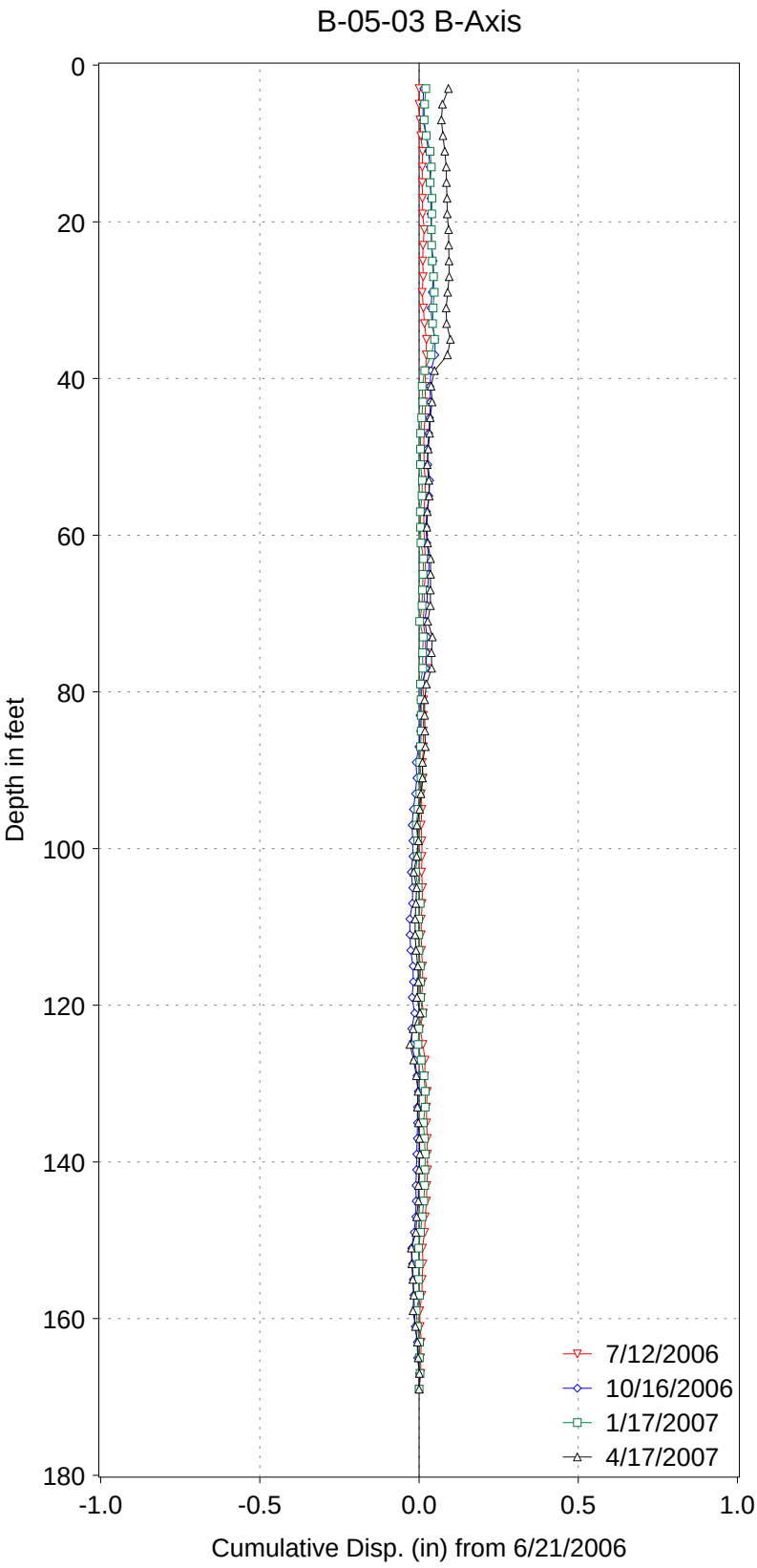
PLATE 29

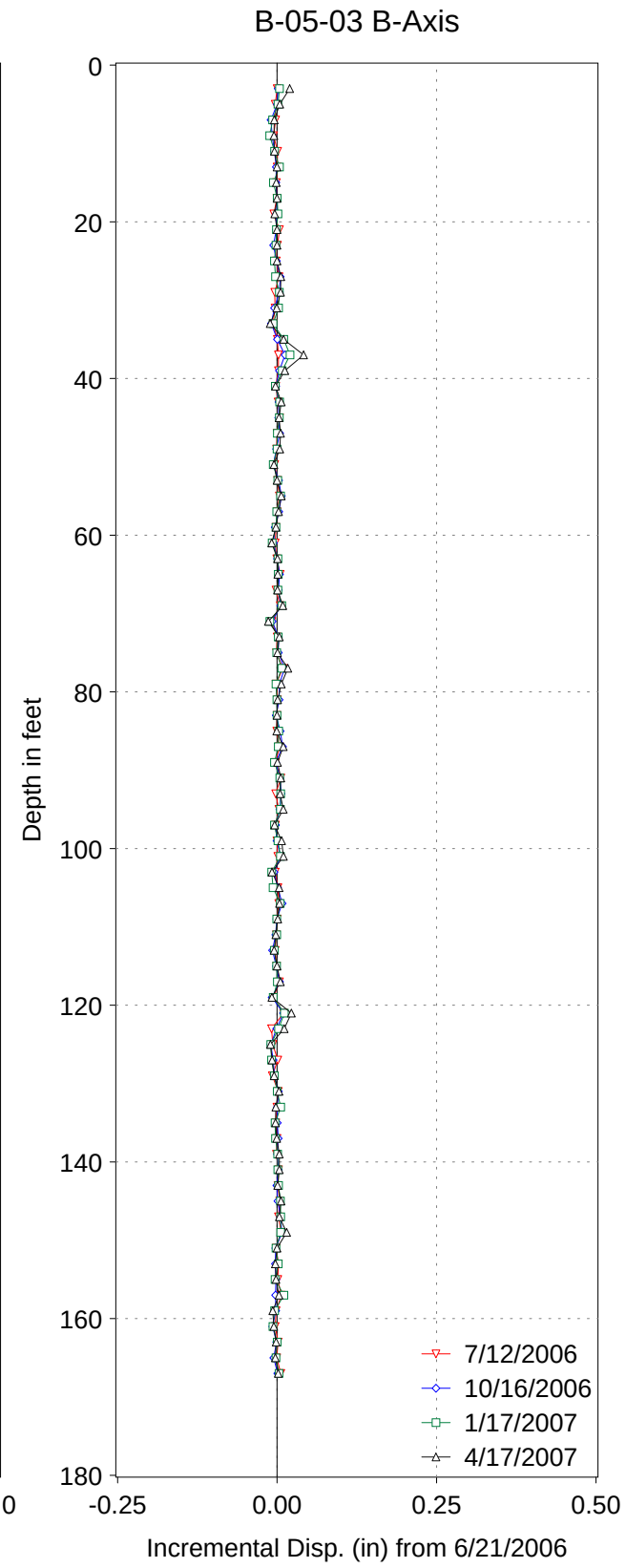




B-05-03

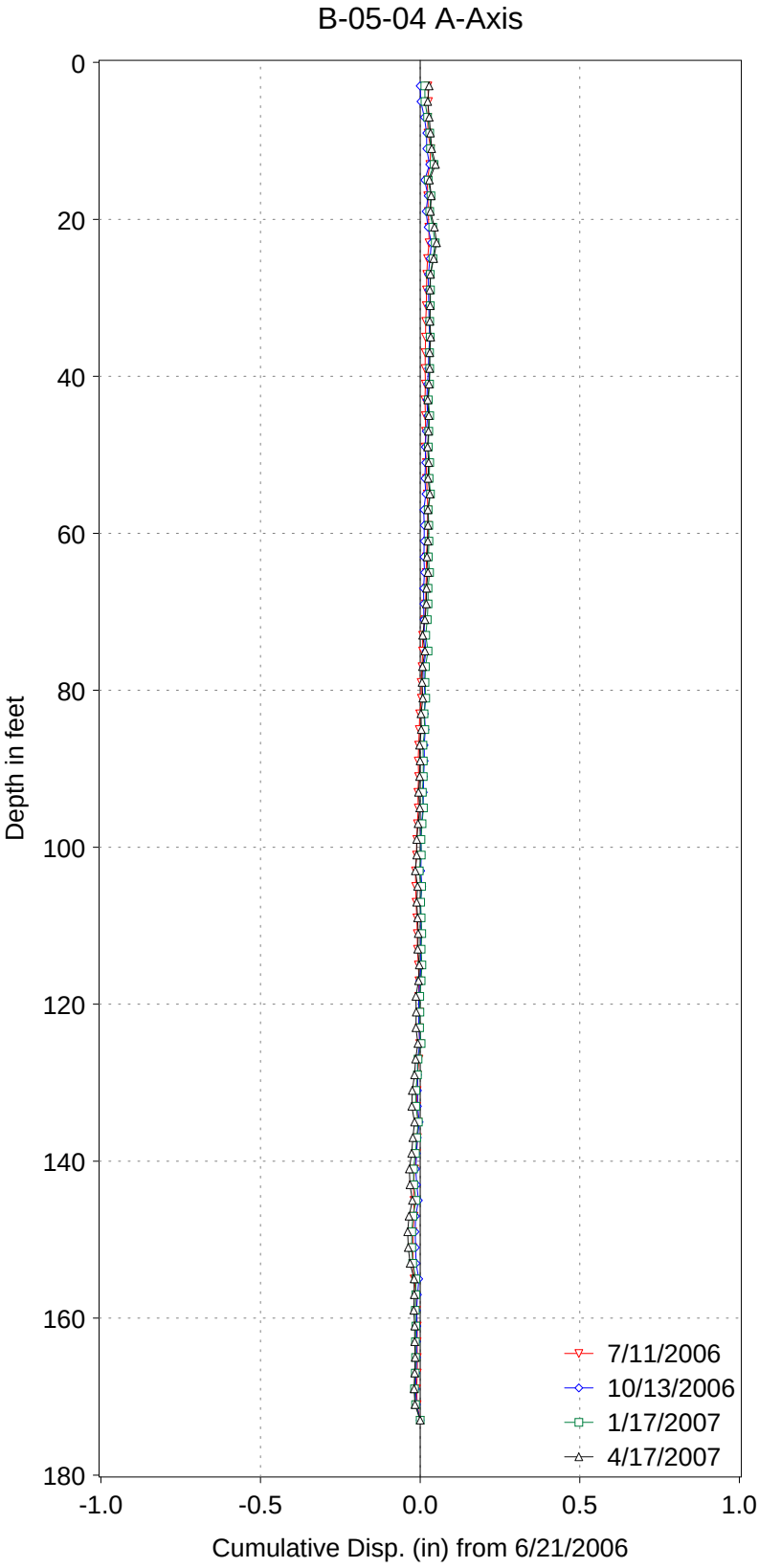
PLATE 30

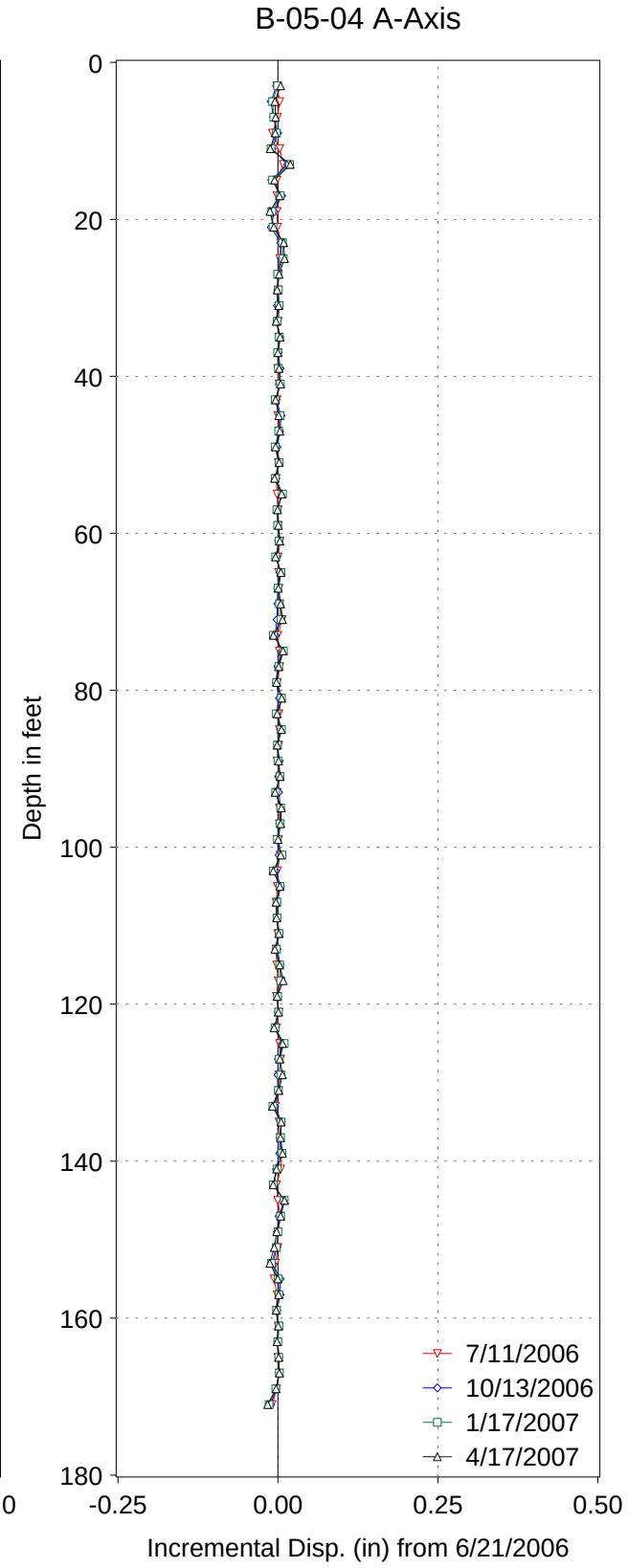




B-05-03

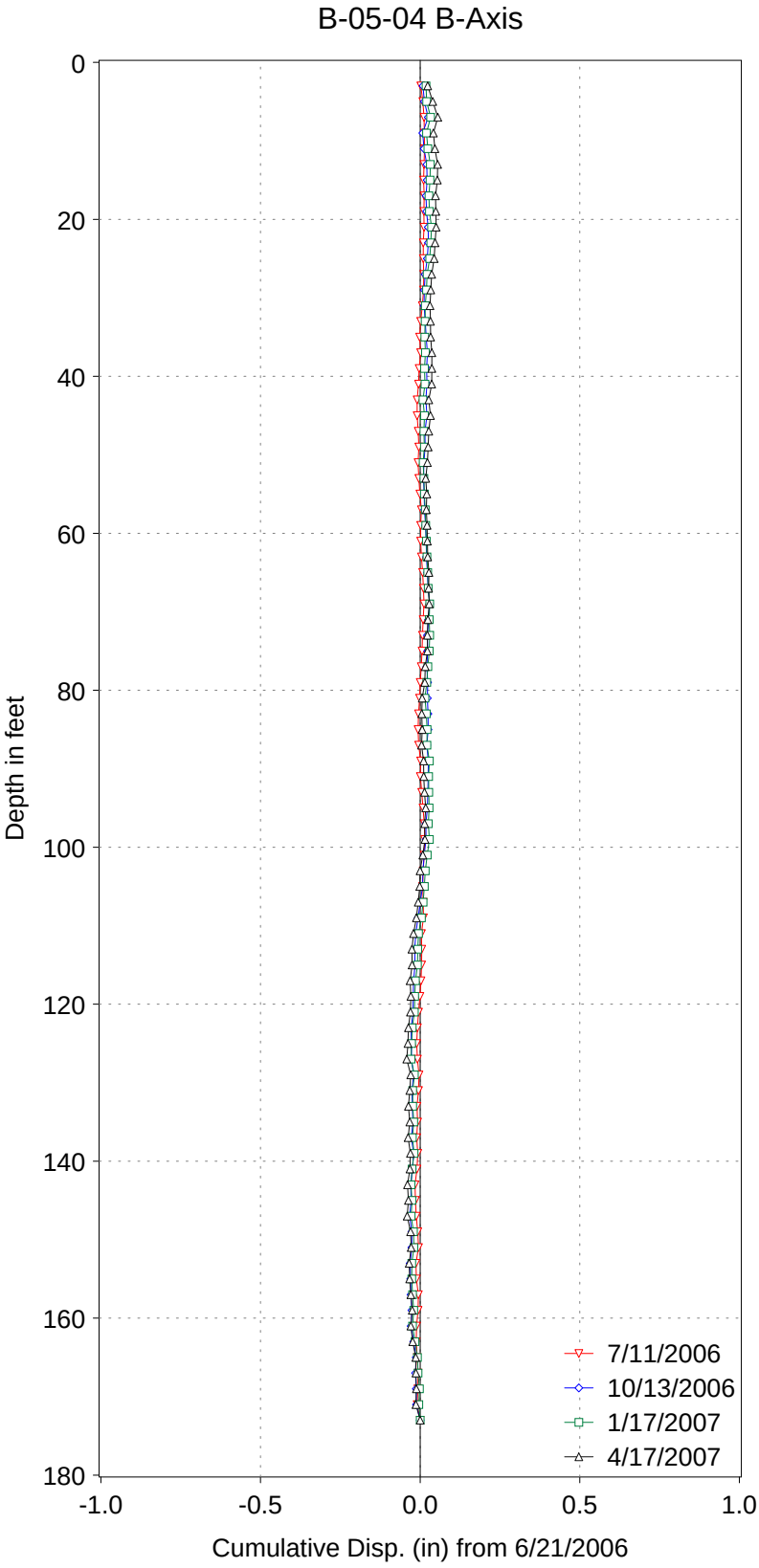
PLATE 31

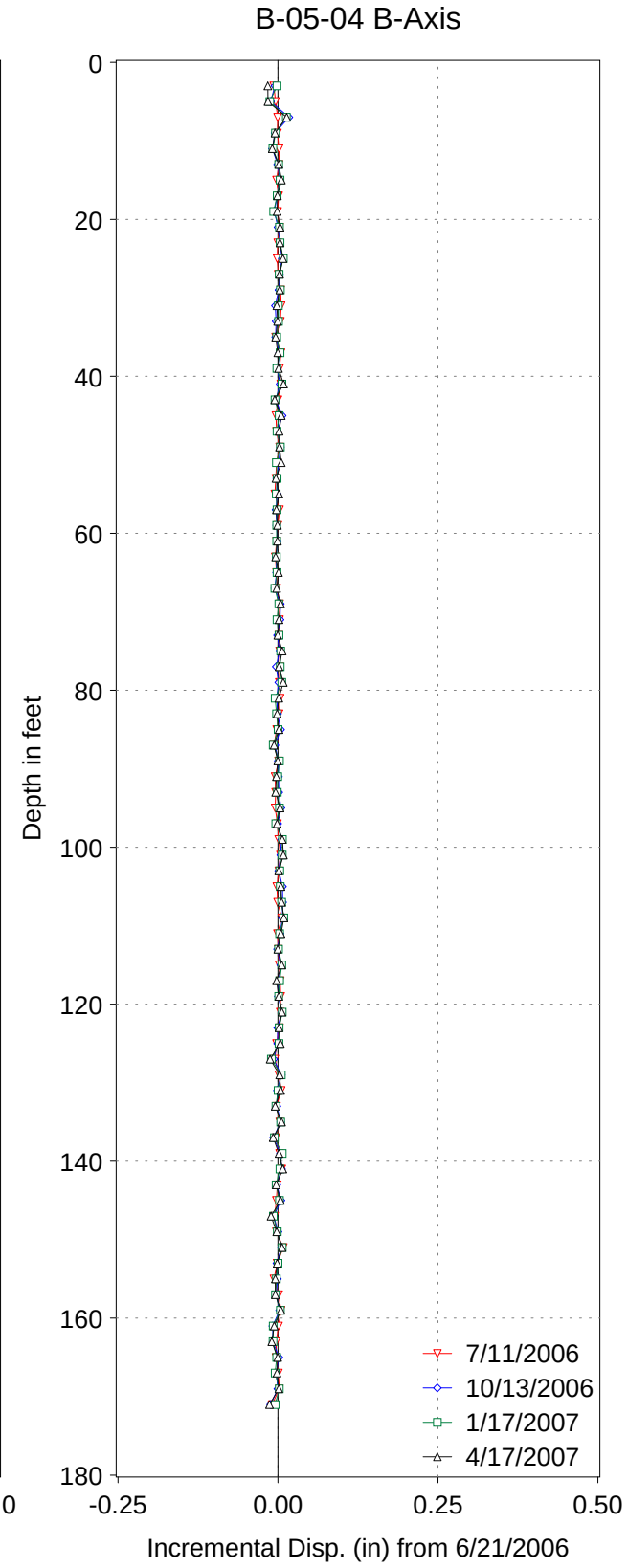




B-05-04

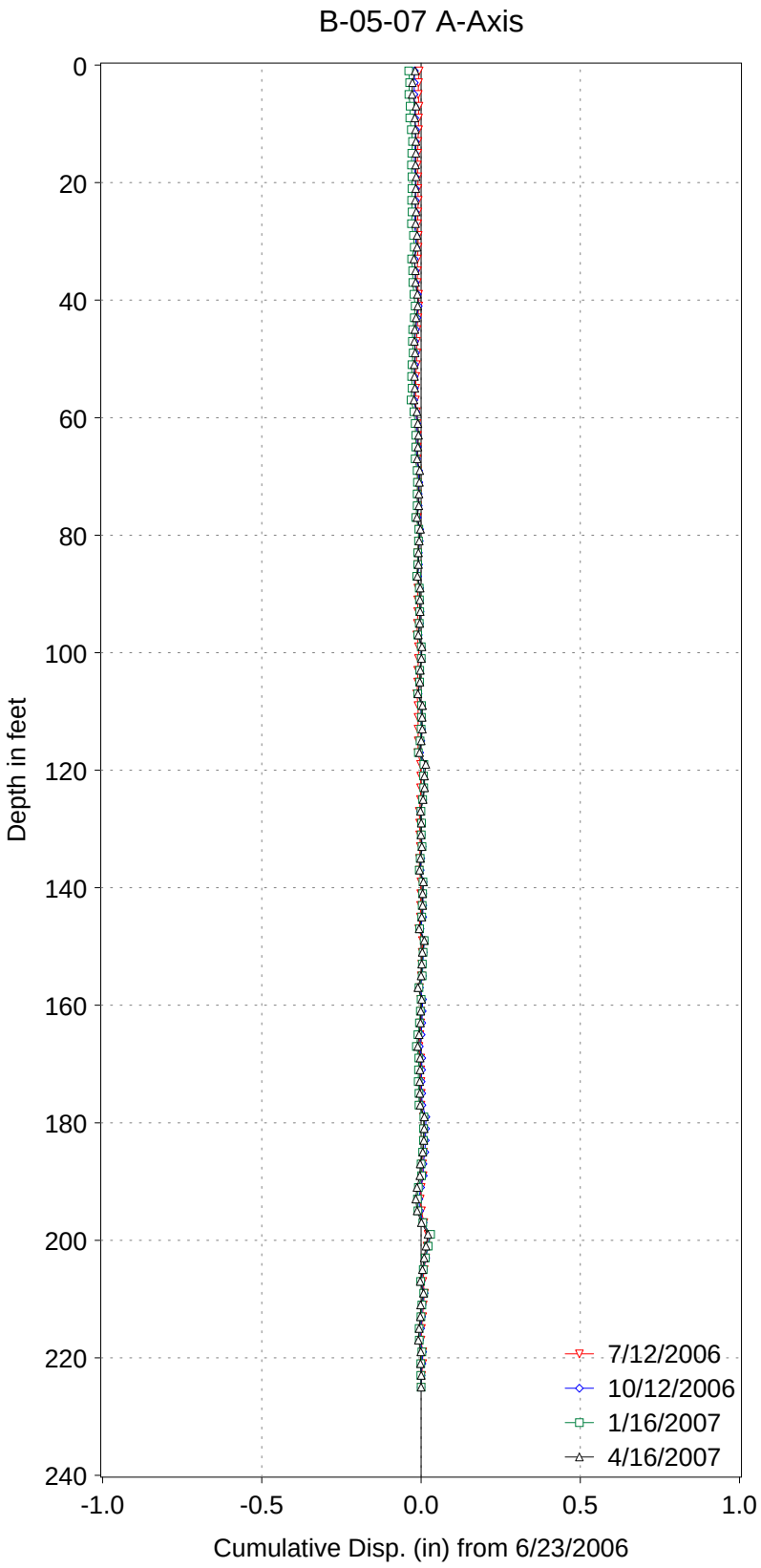
PLATE 32

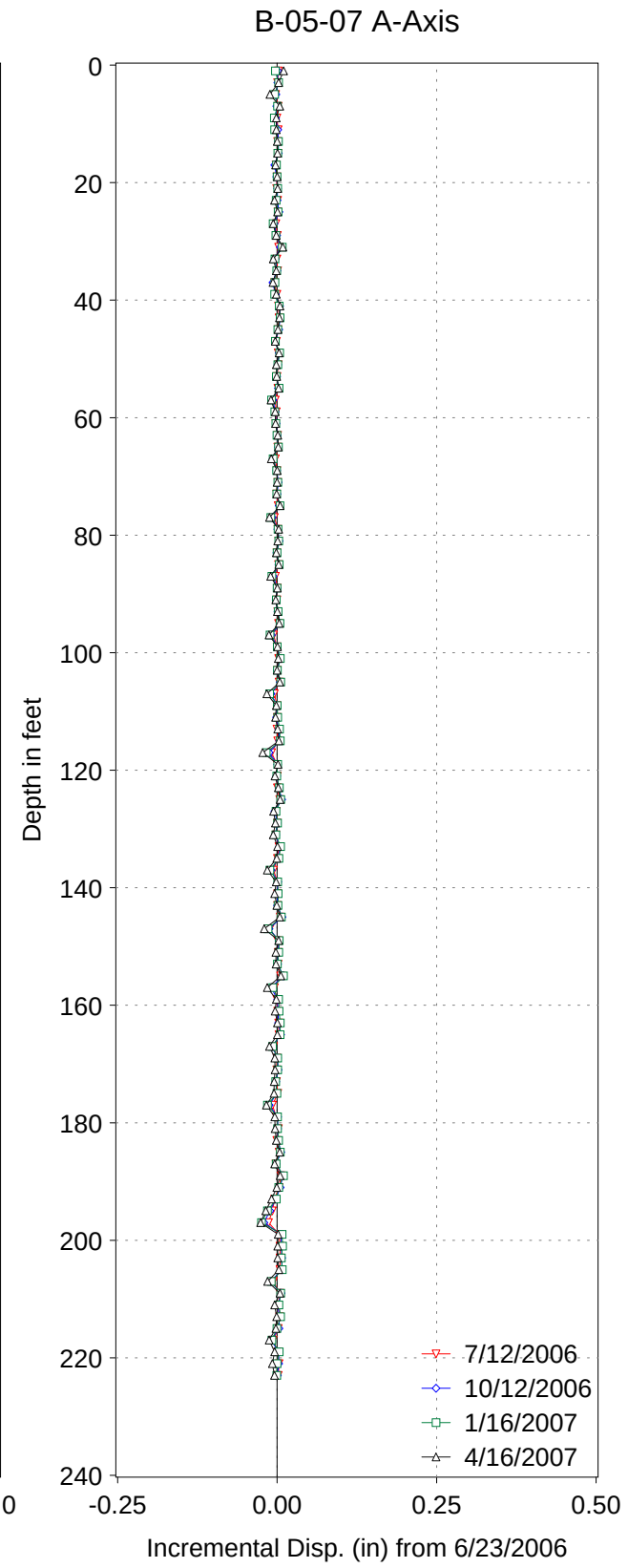




B-05-04

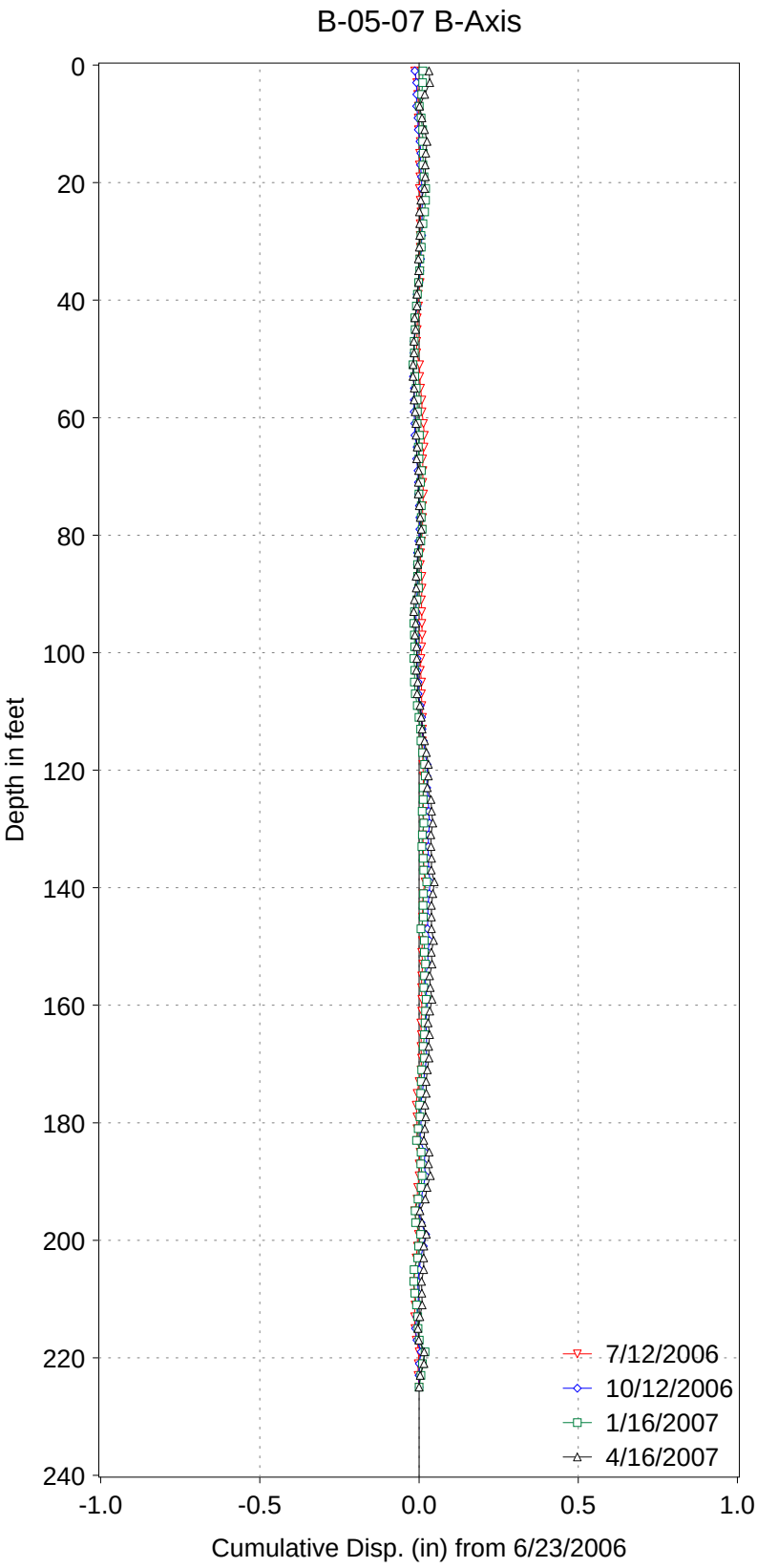
PLATE 33

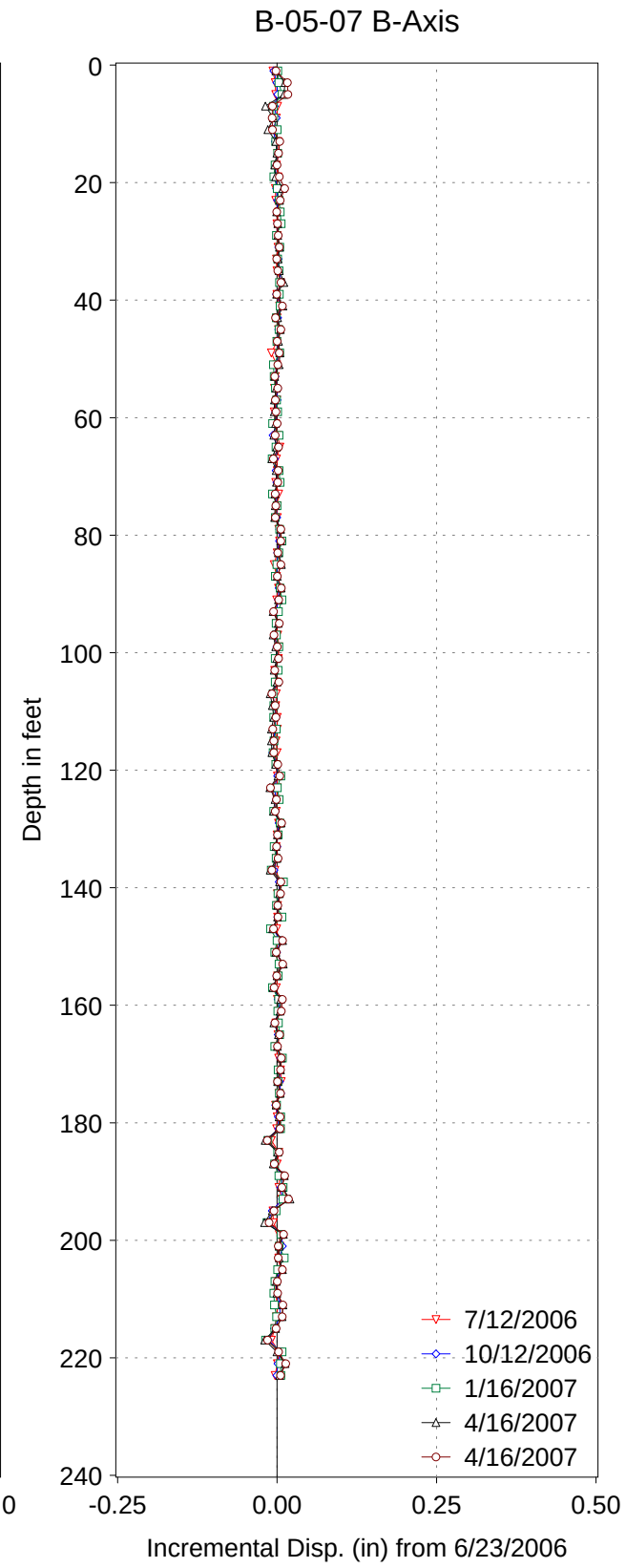




B-05-07

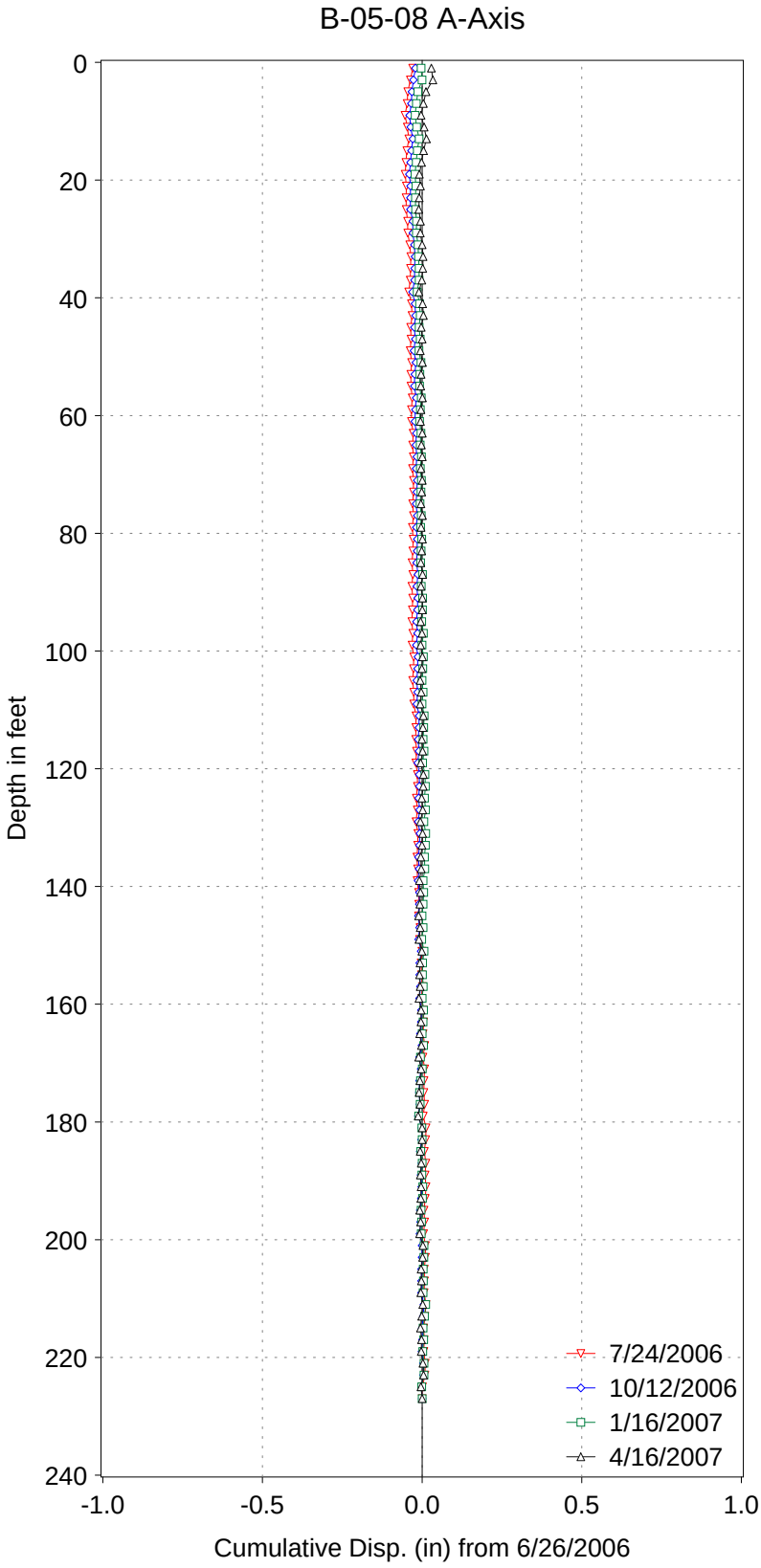
PLATE 34

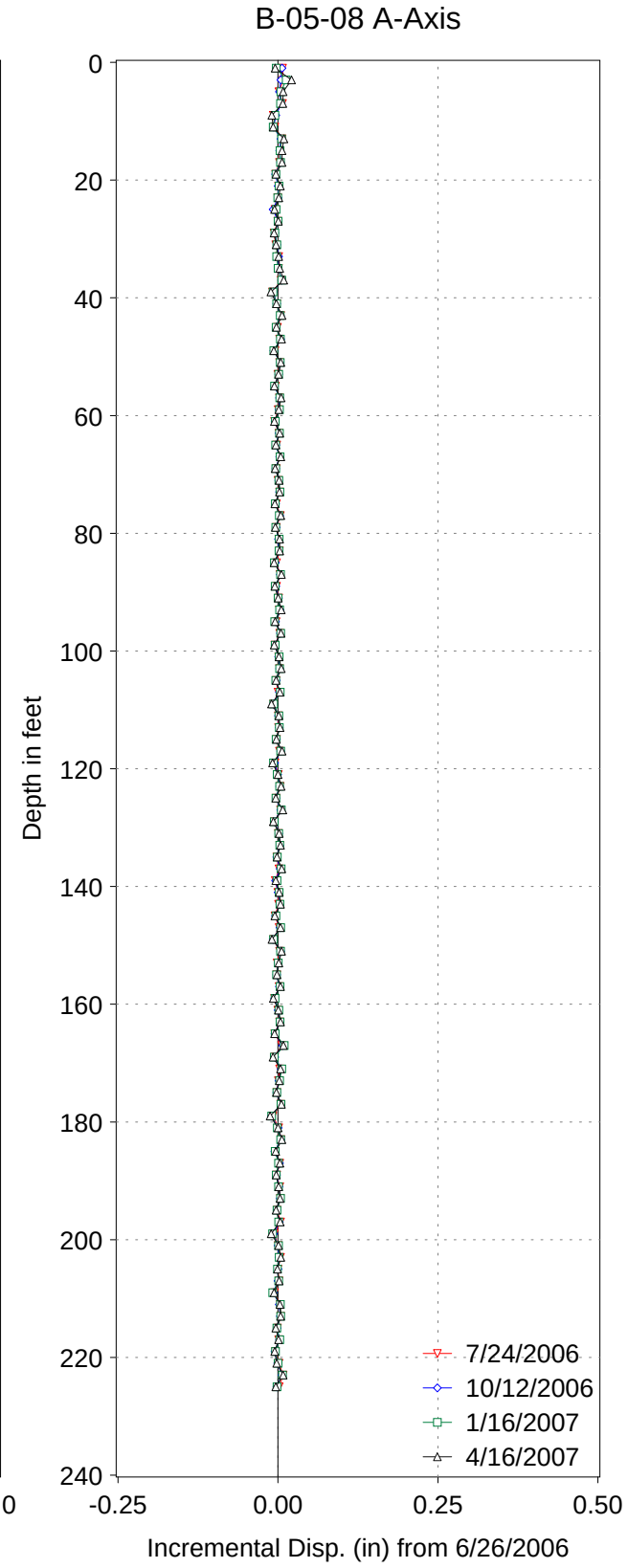




B-05-07

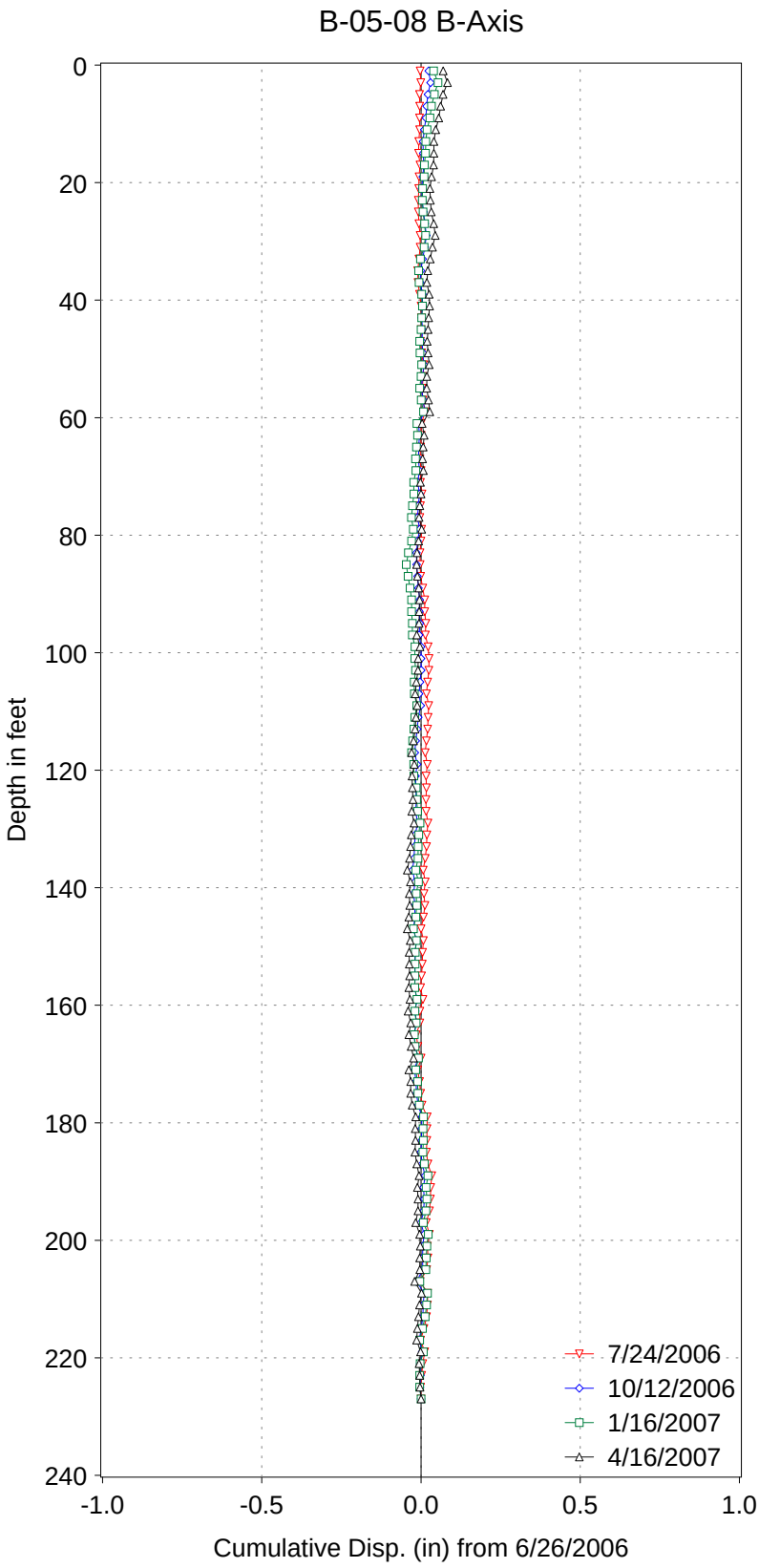
PLATE 35

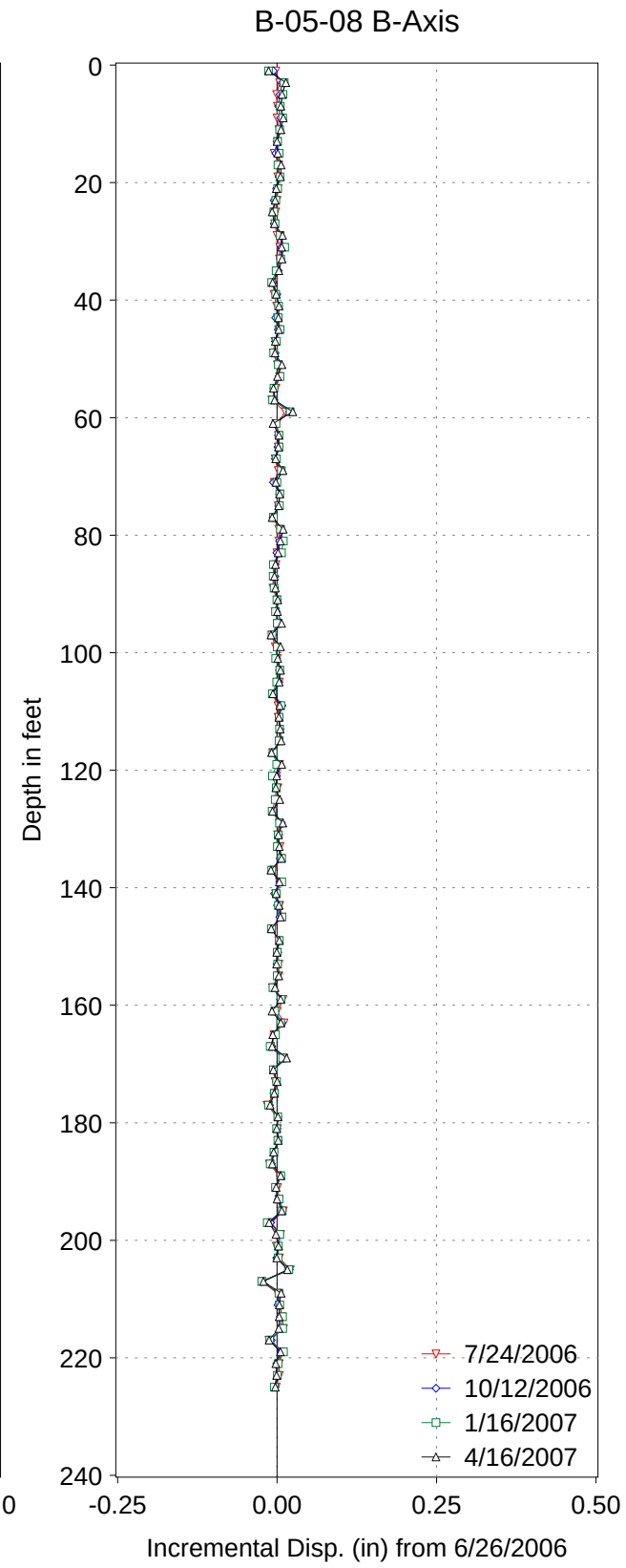




B-05-08

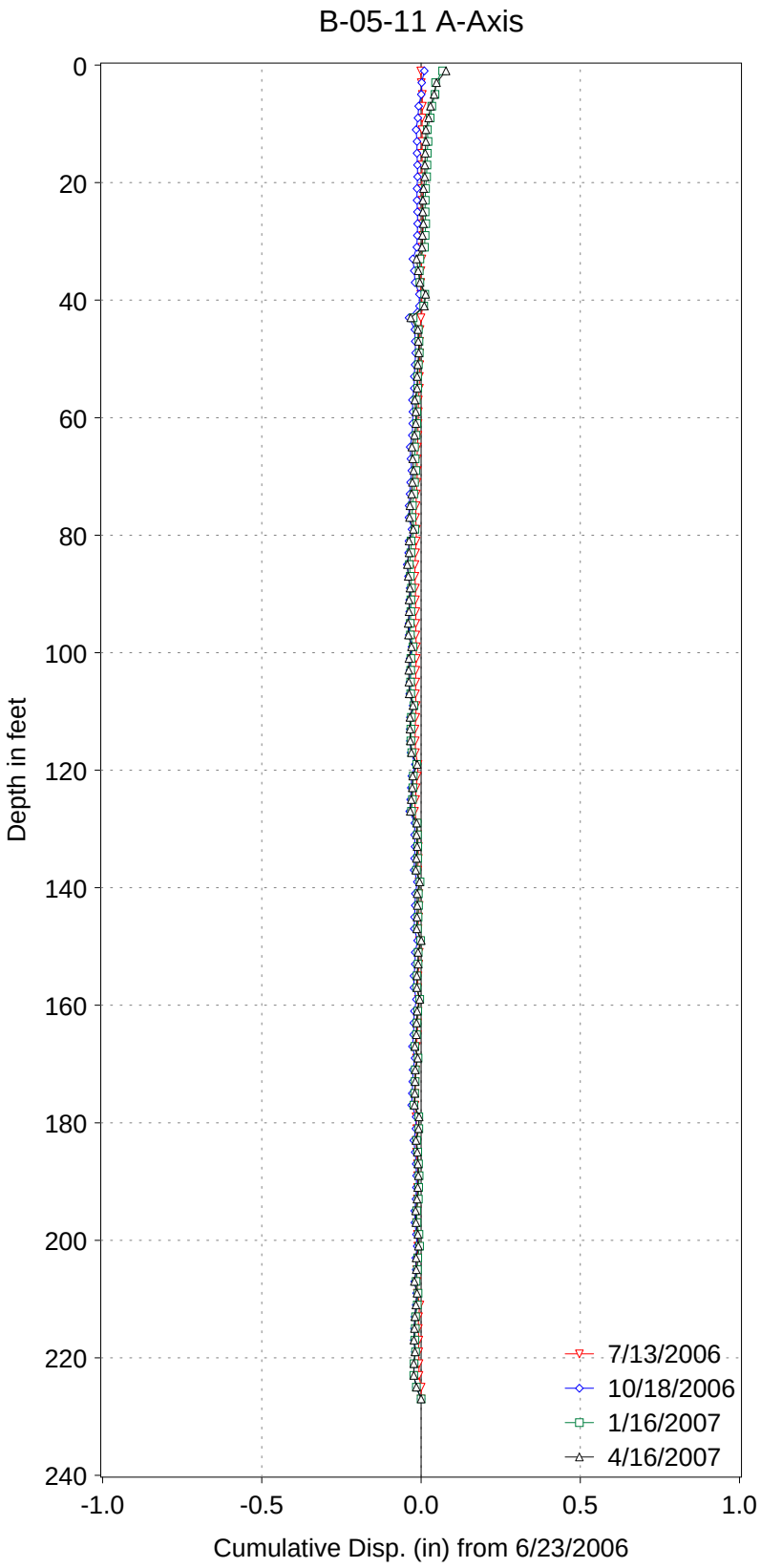
PLATE 36

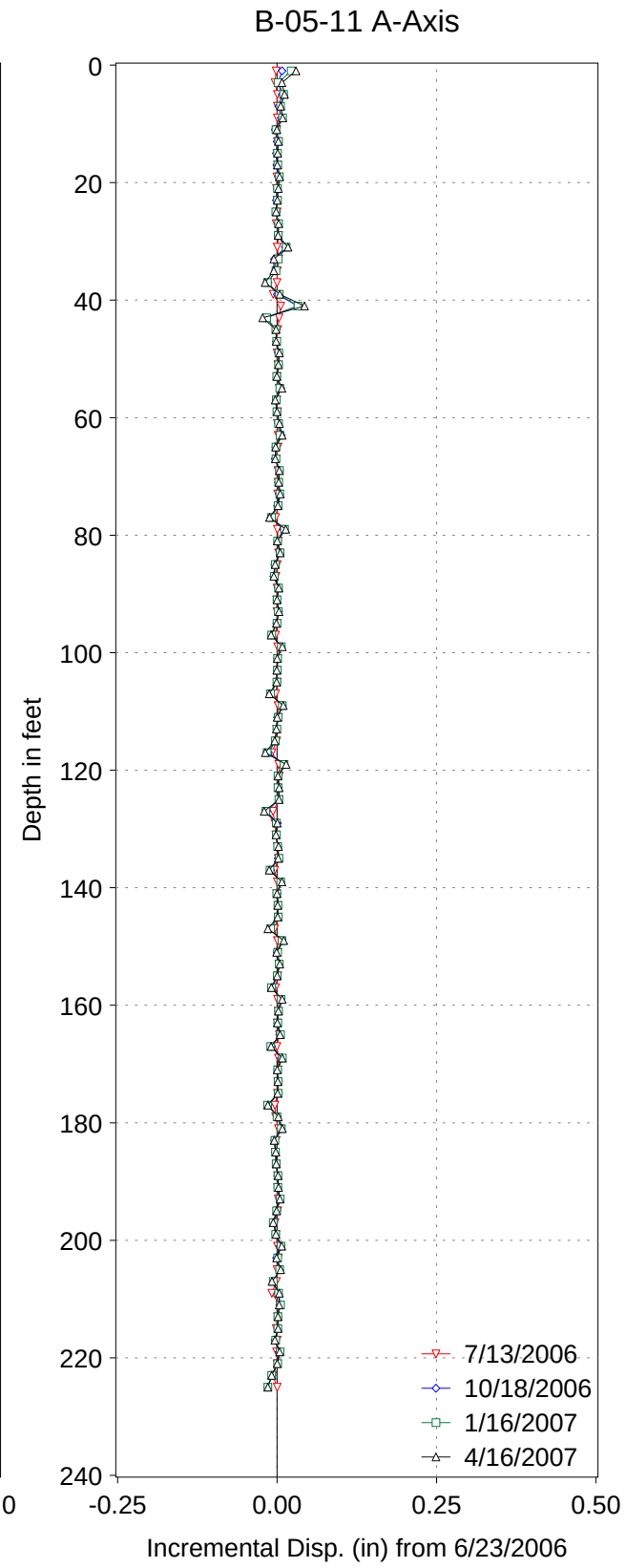




B-05-08

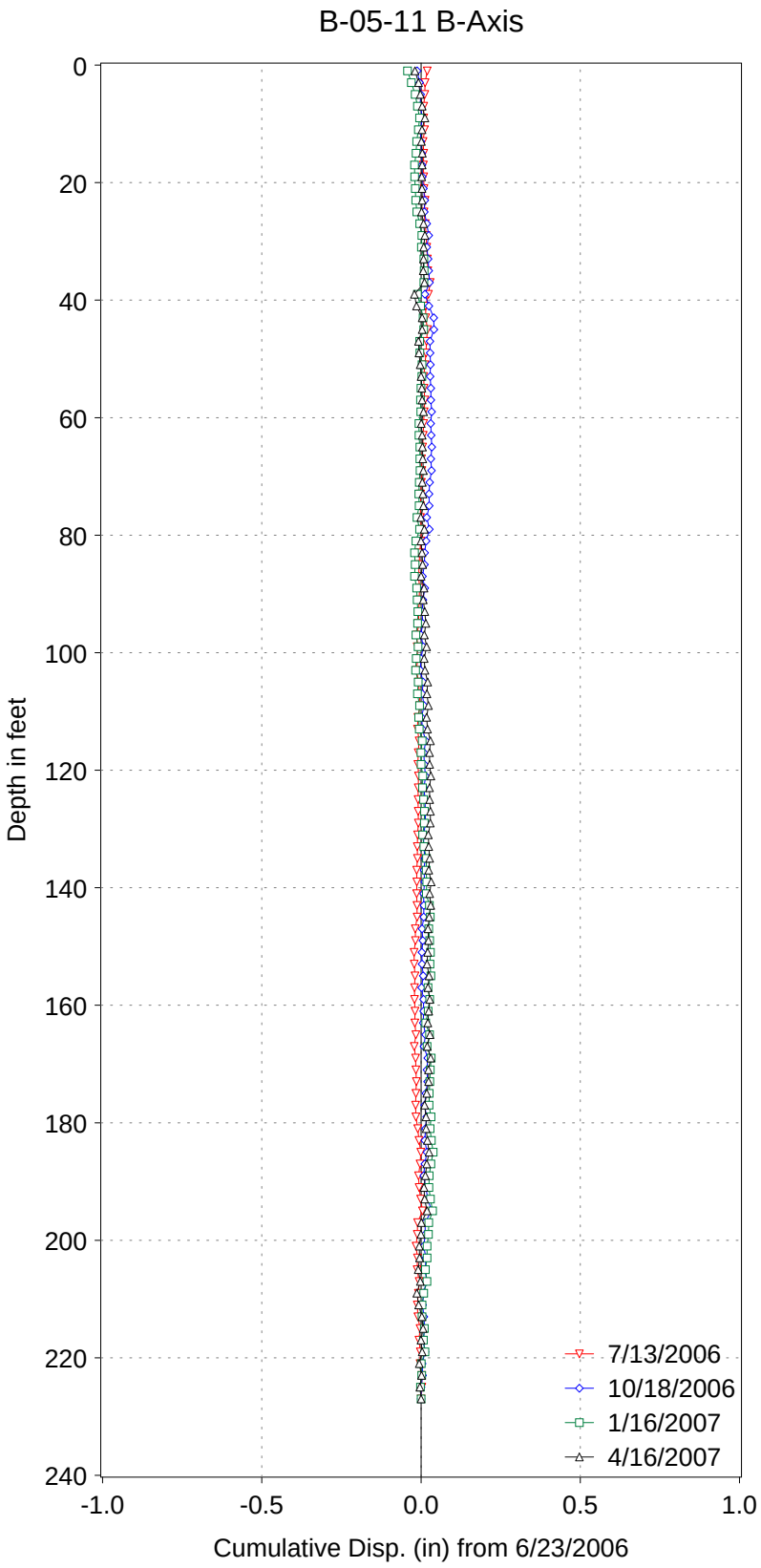
PLATE 37

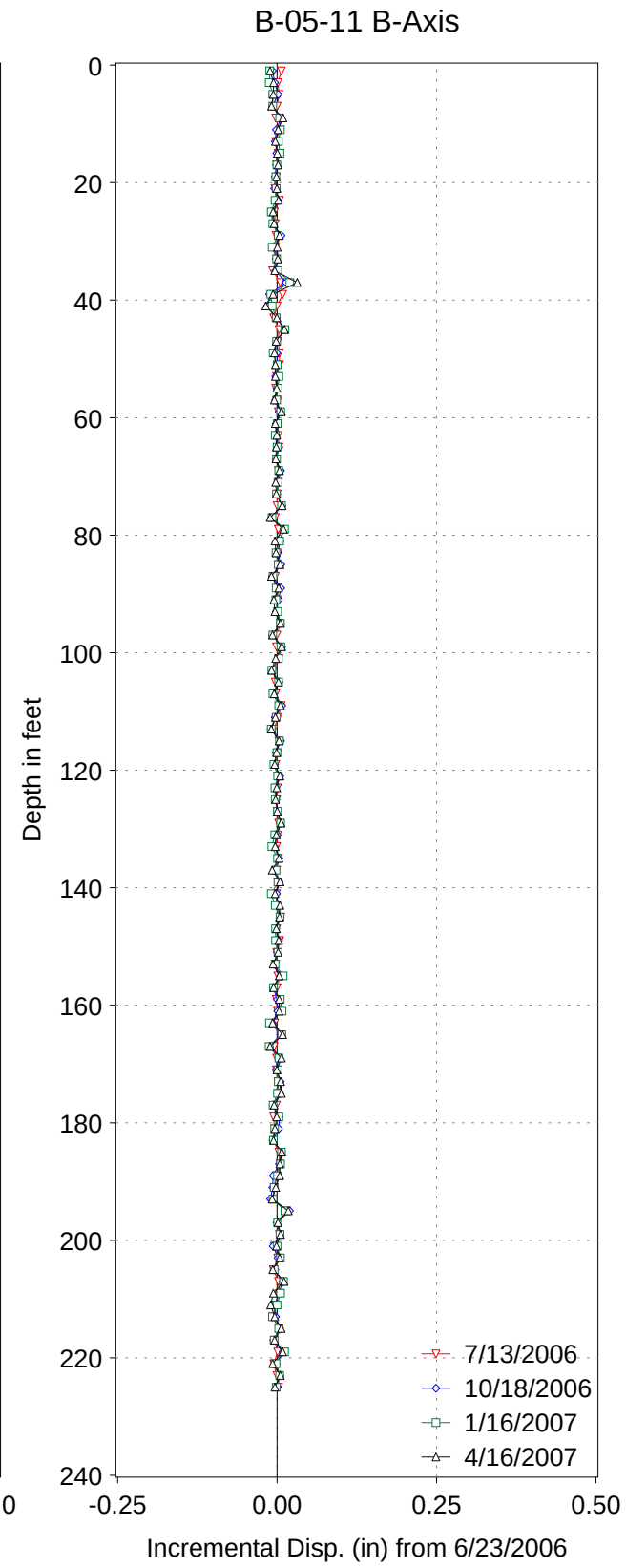




B-05-11

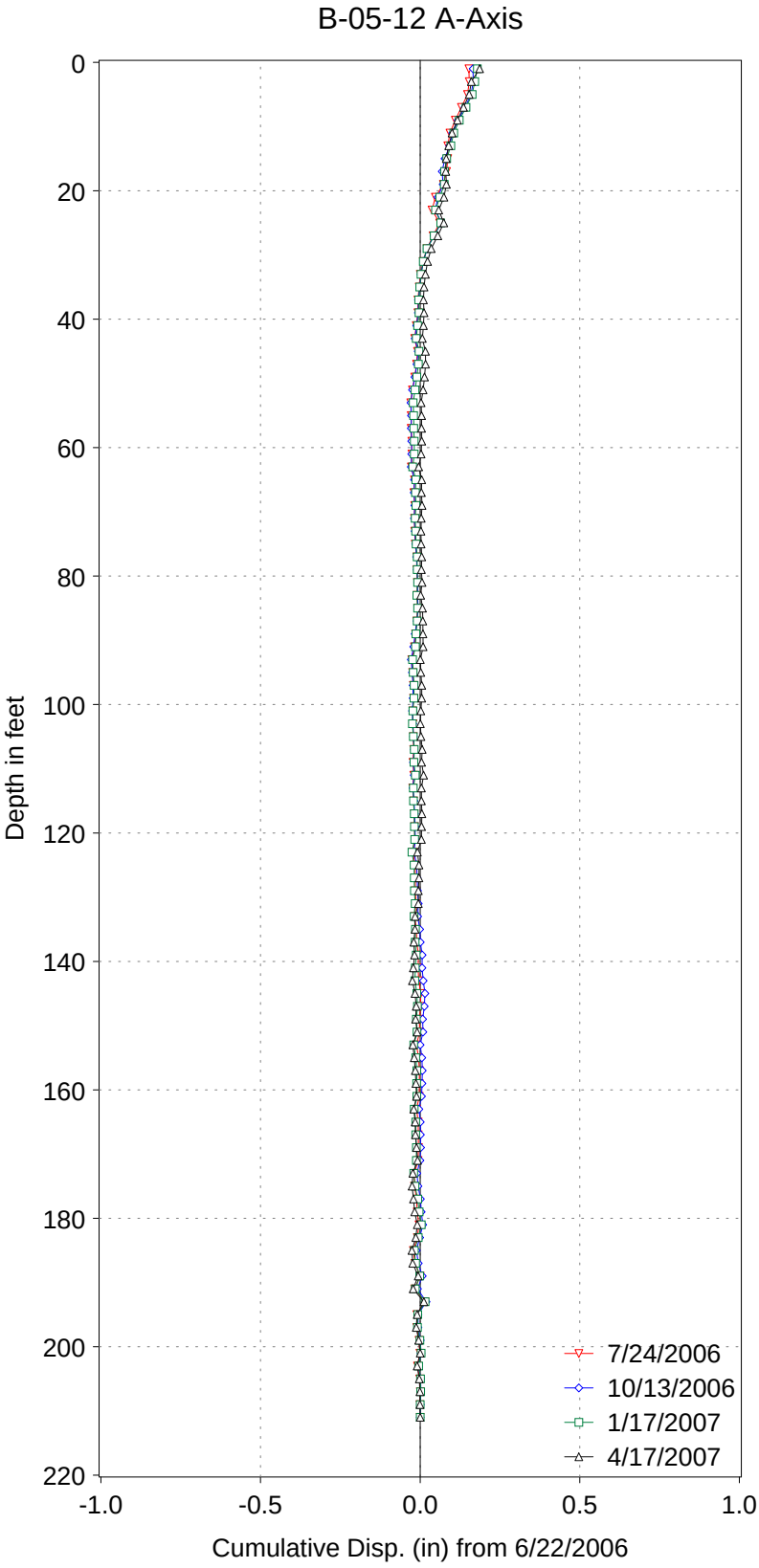
PLATE 38

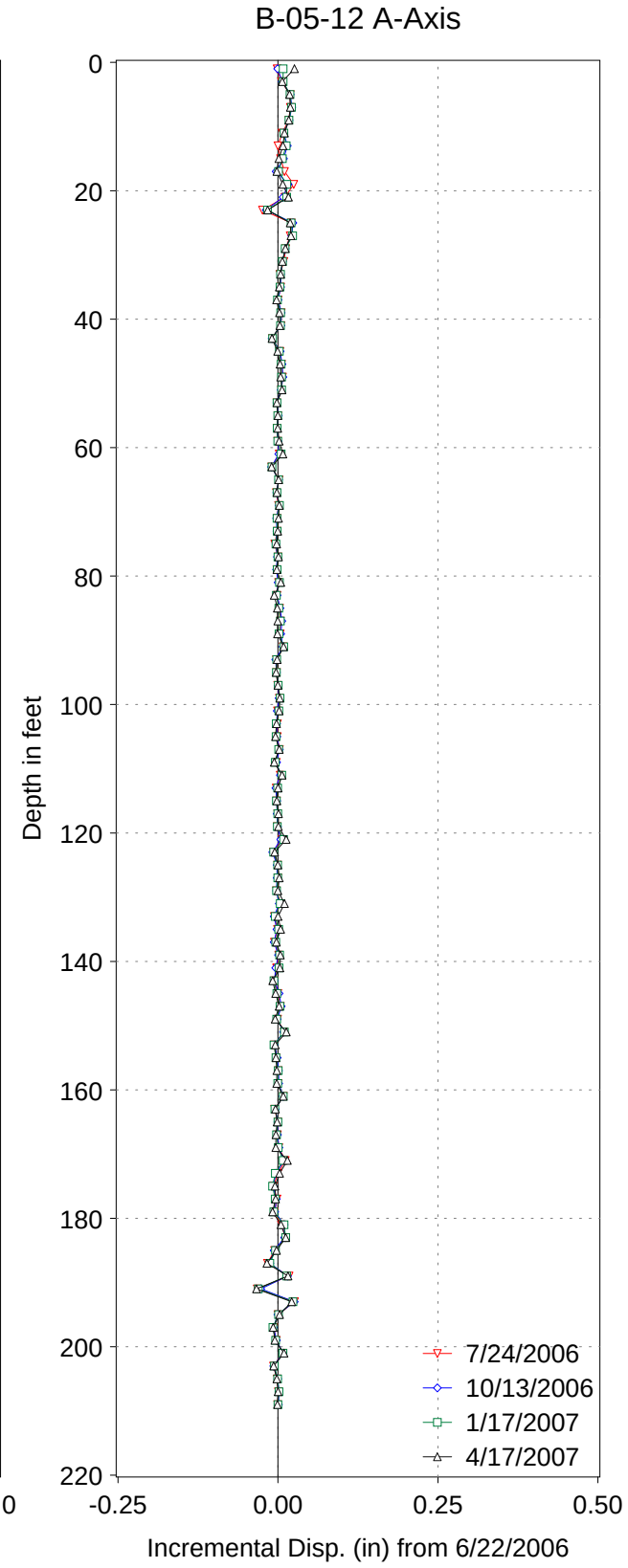




B-05-11

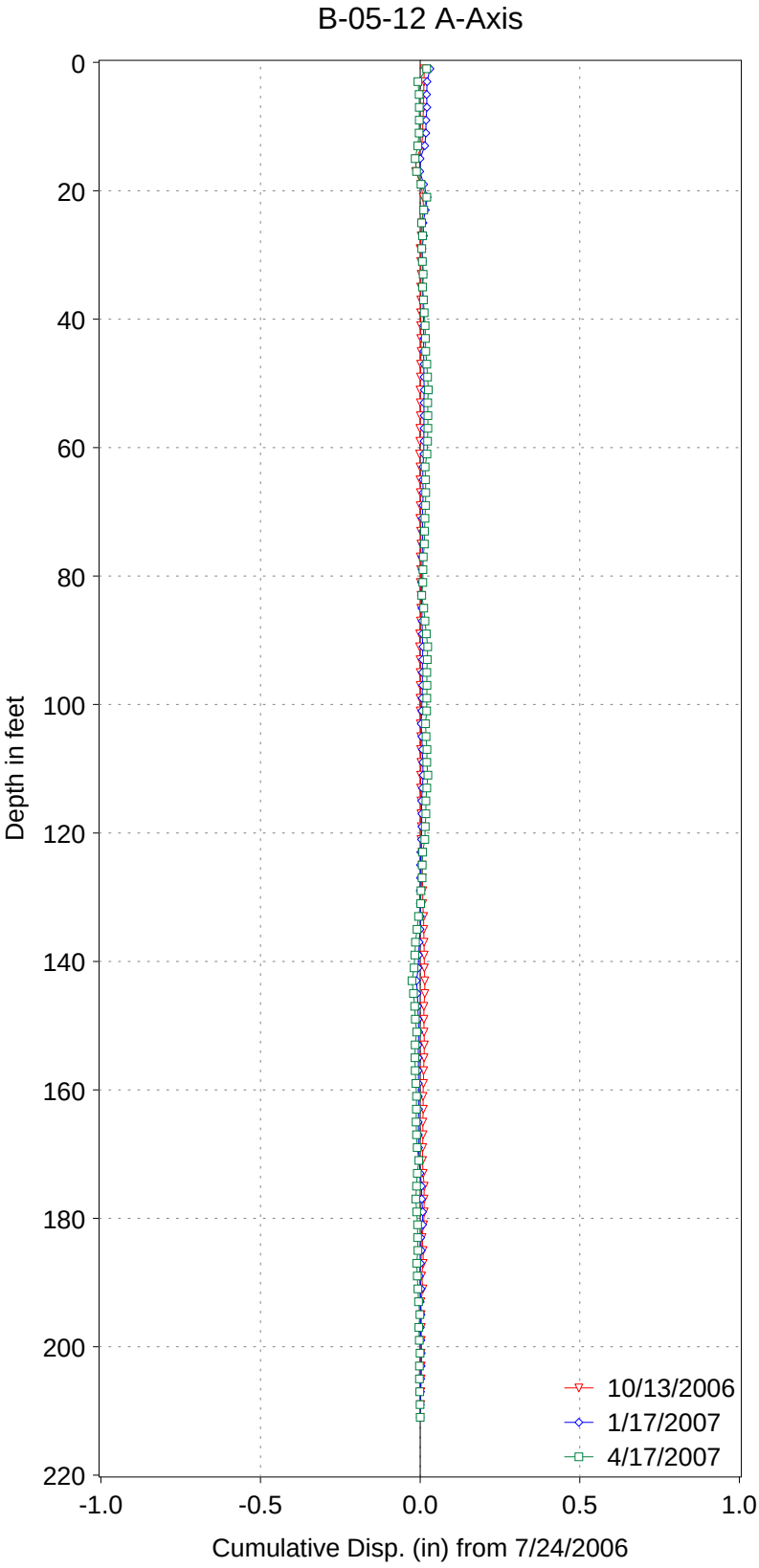
PLATE 39

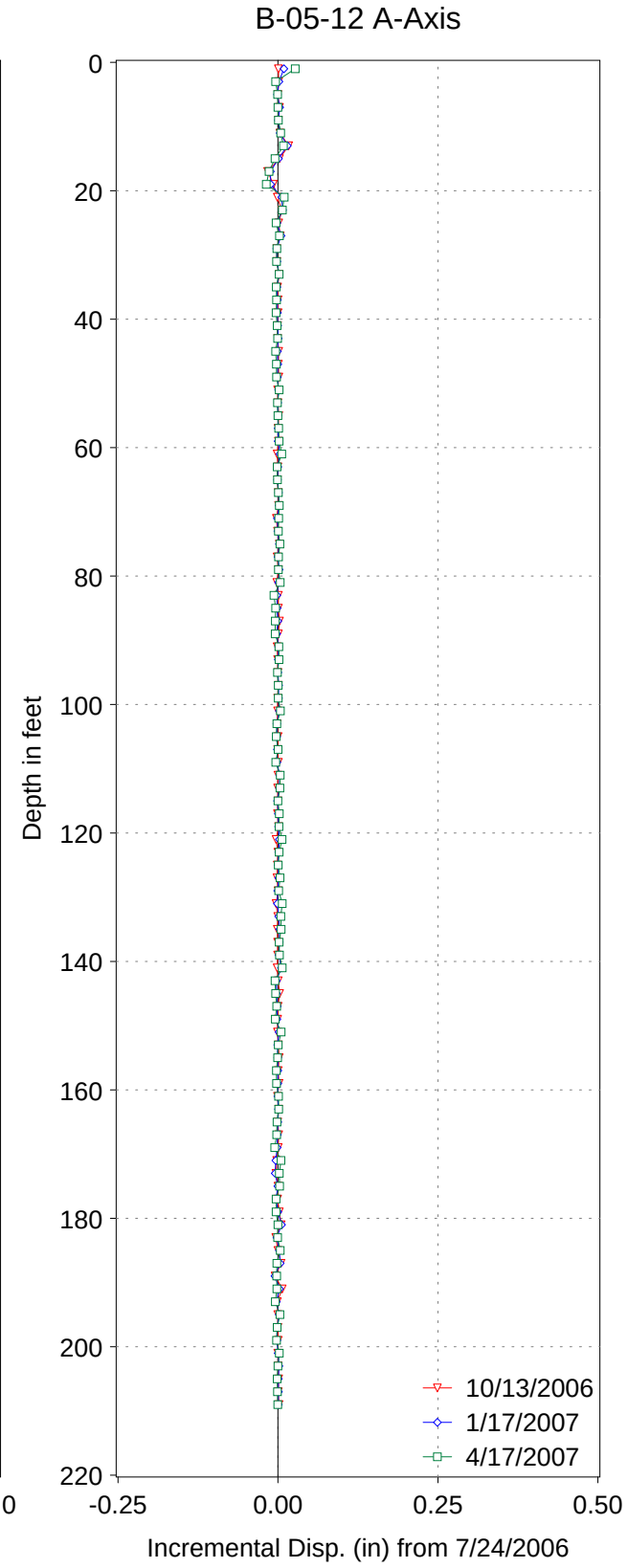




B-05-12

PLATE 40

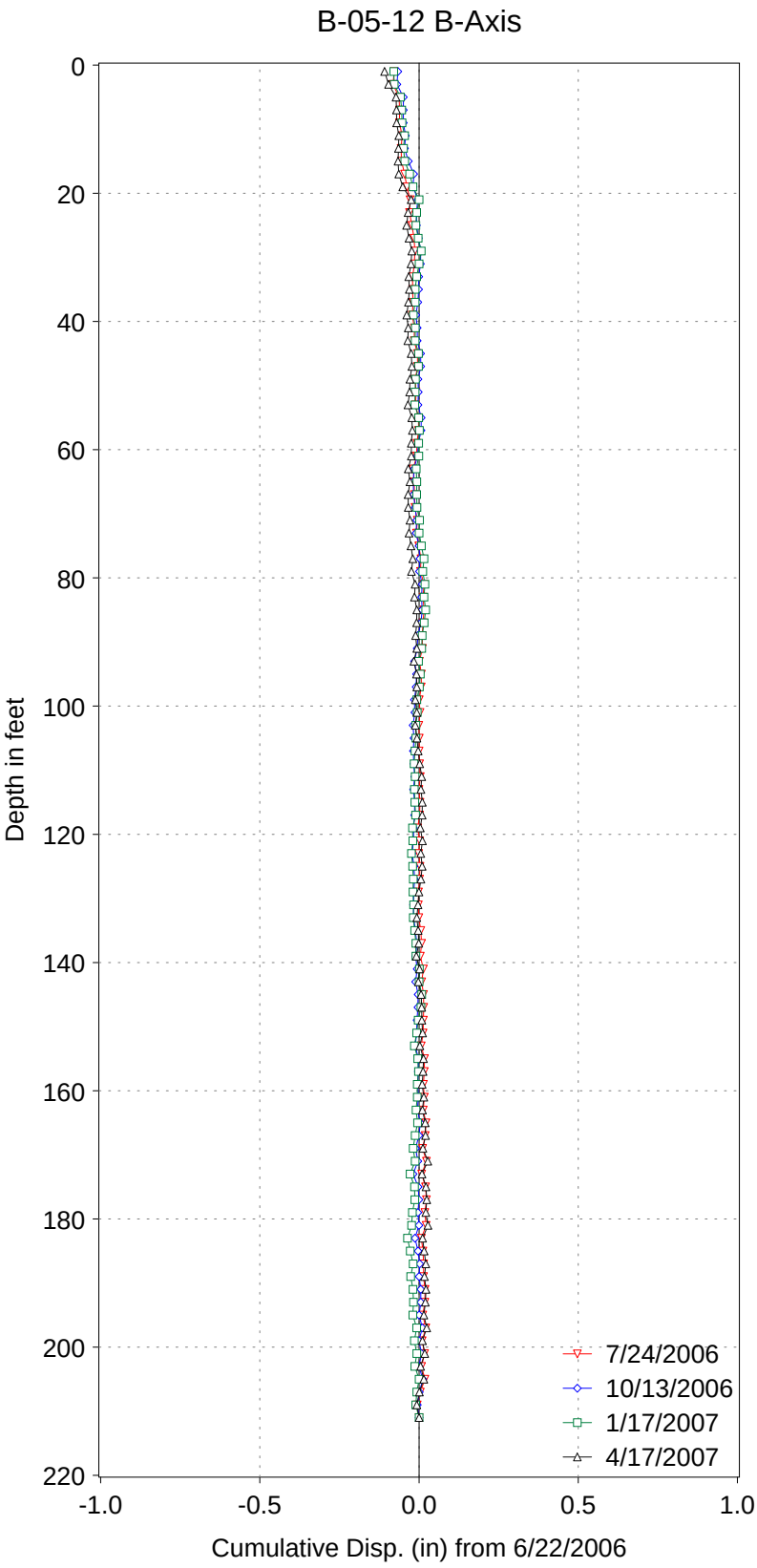


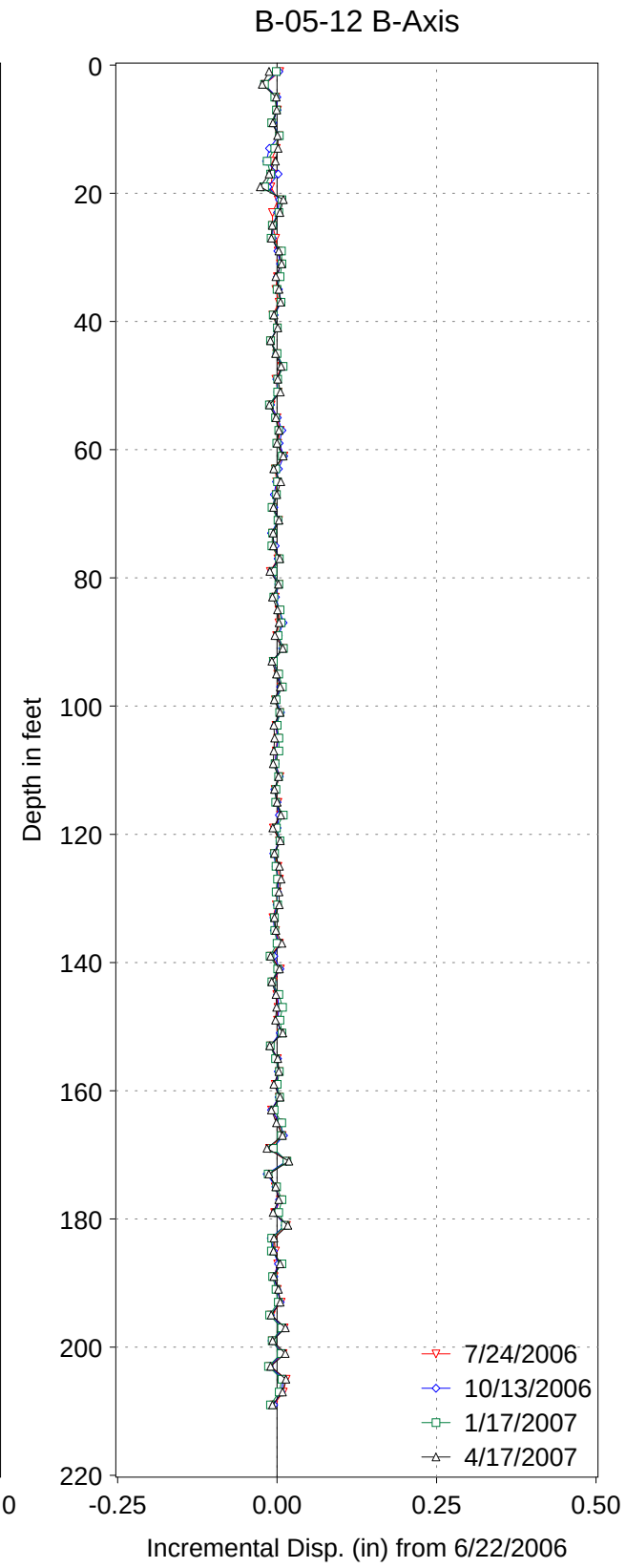


B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

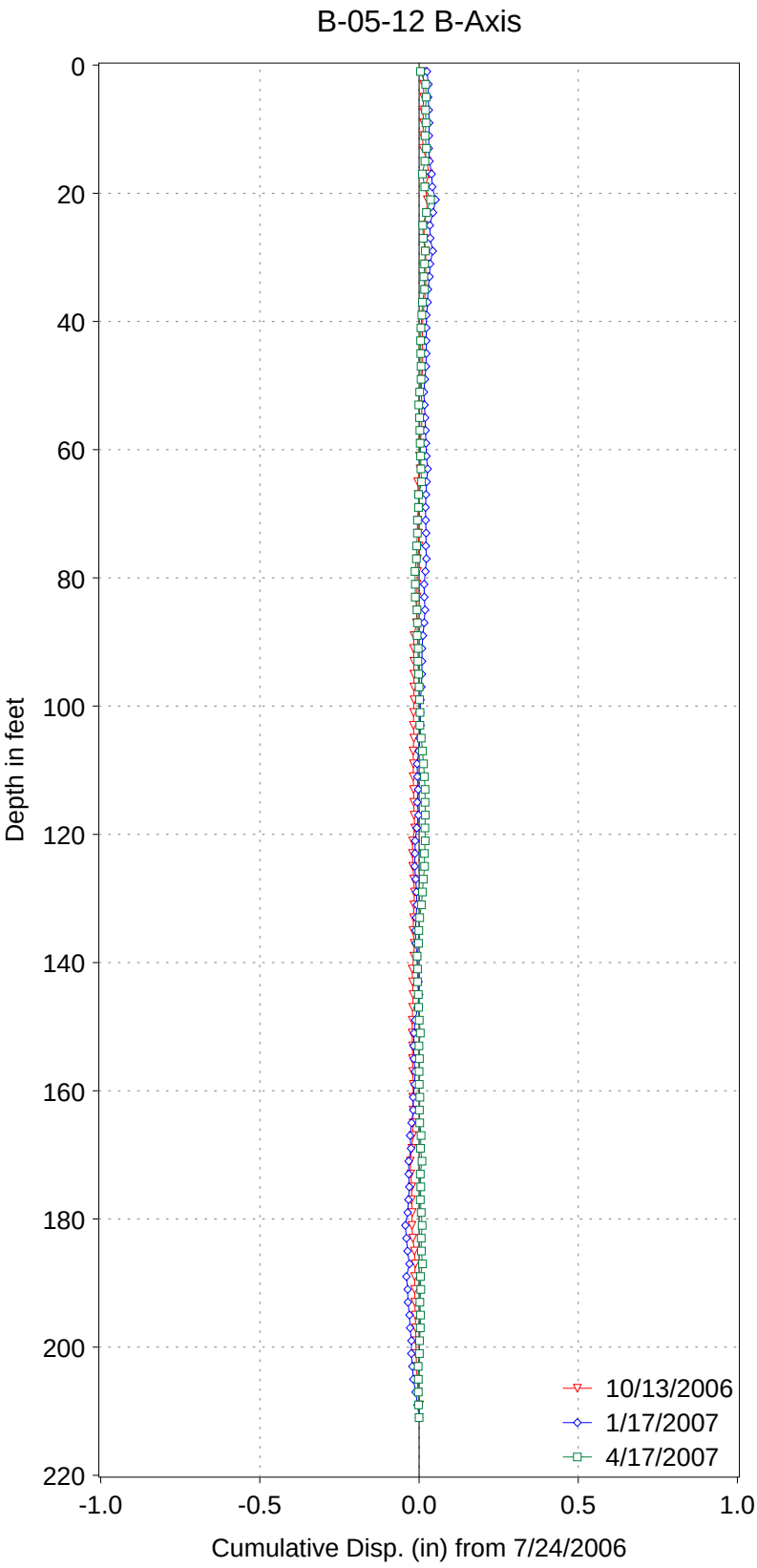
PLATE 40A

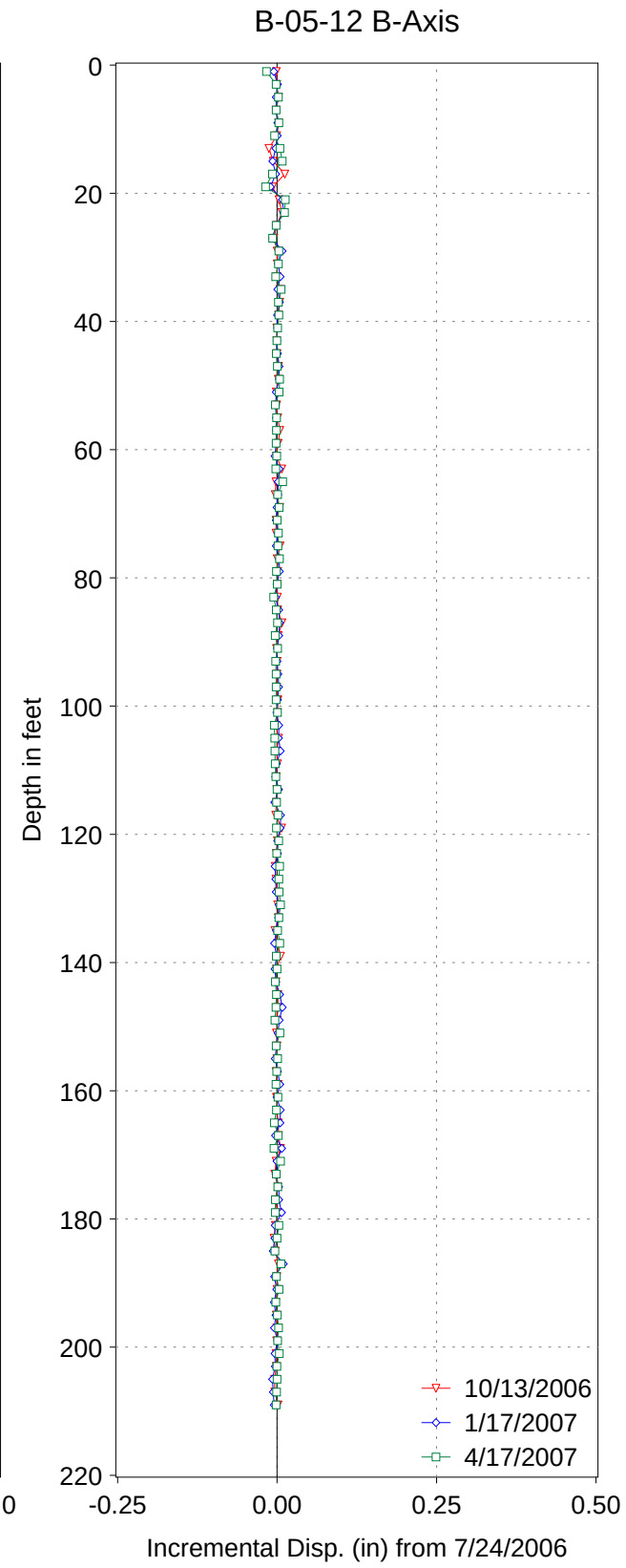




B-05-12

PLATE 41

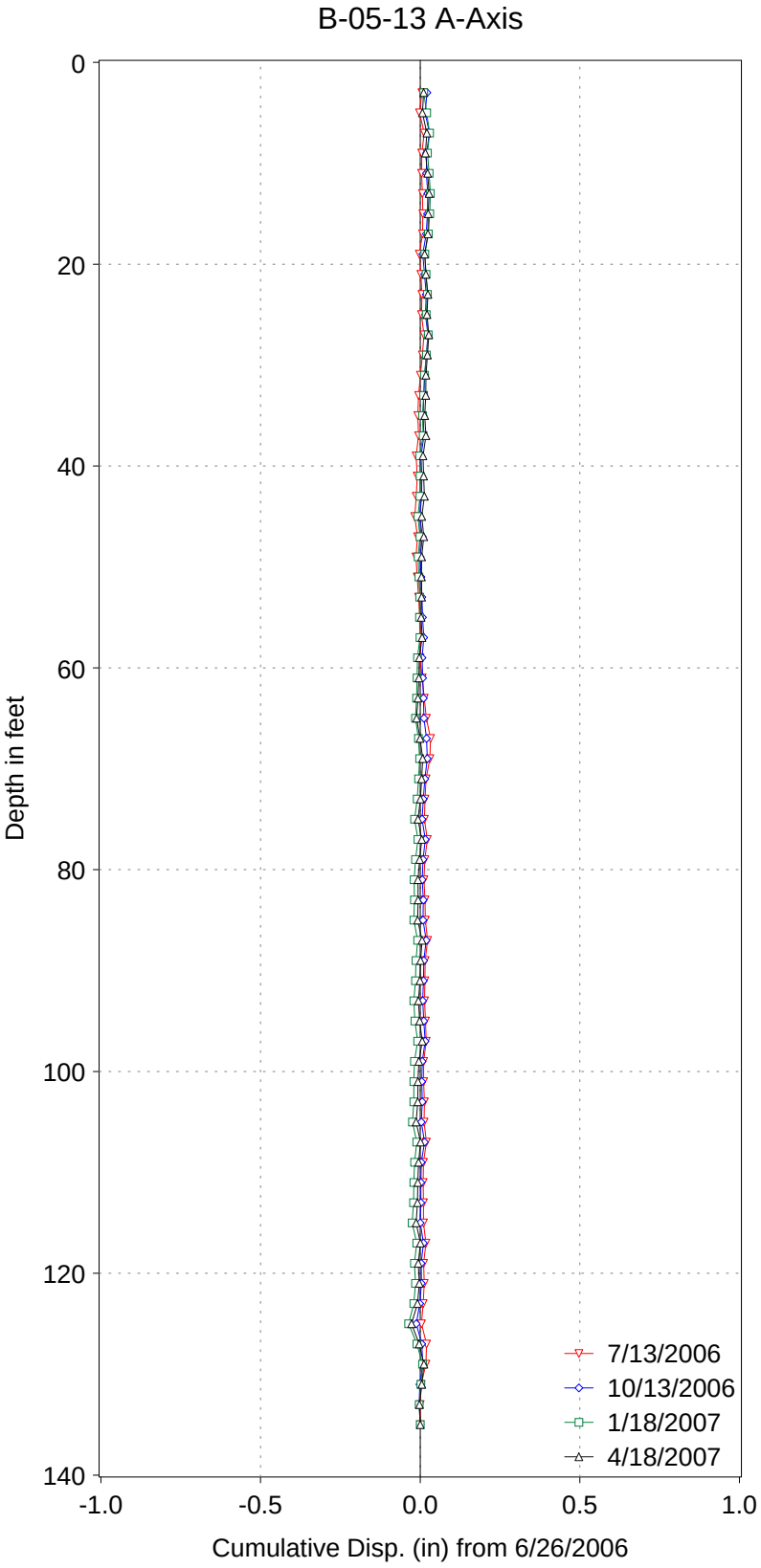


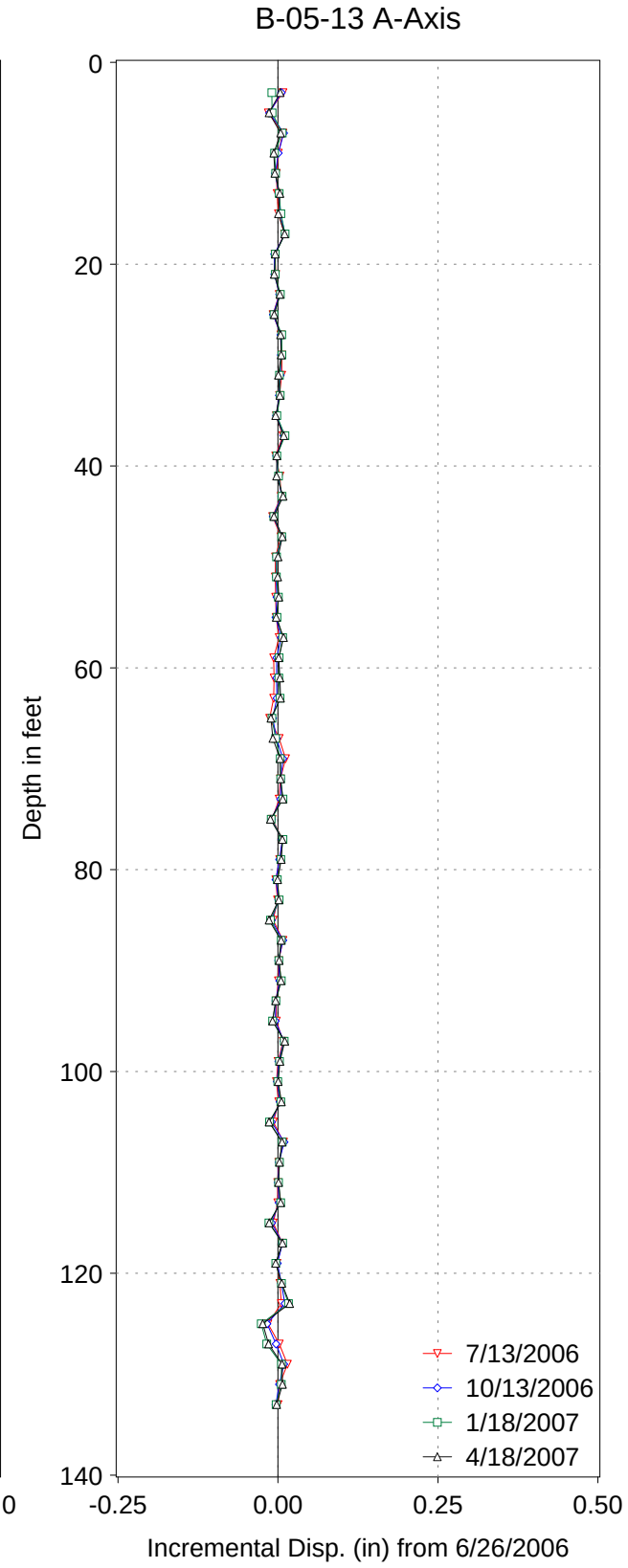


B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

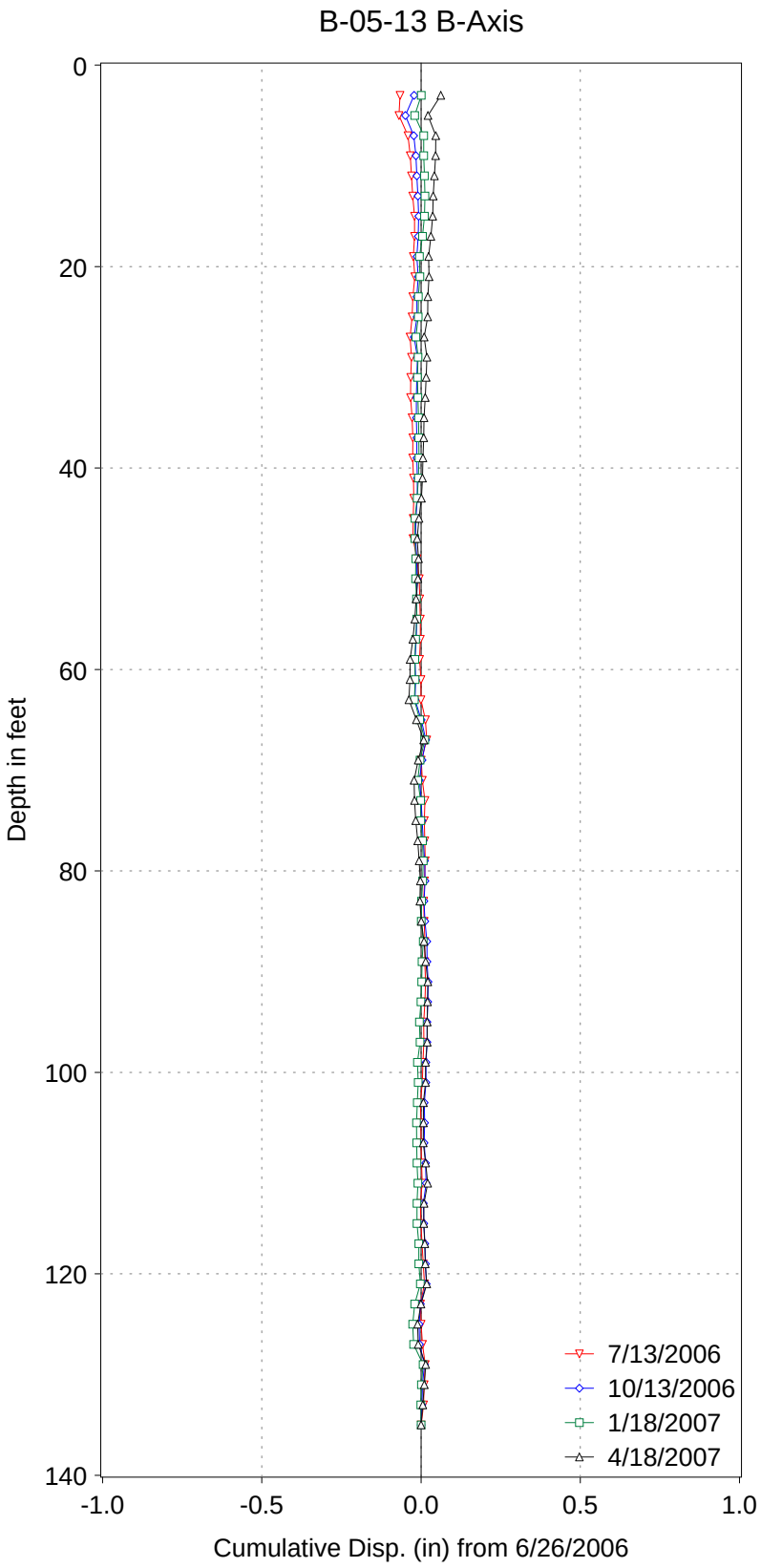
PLATE 41A

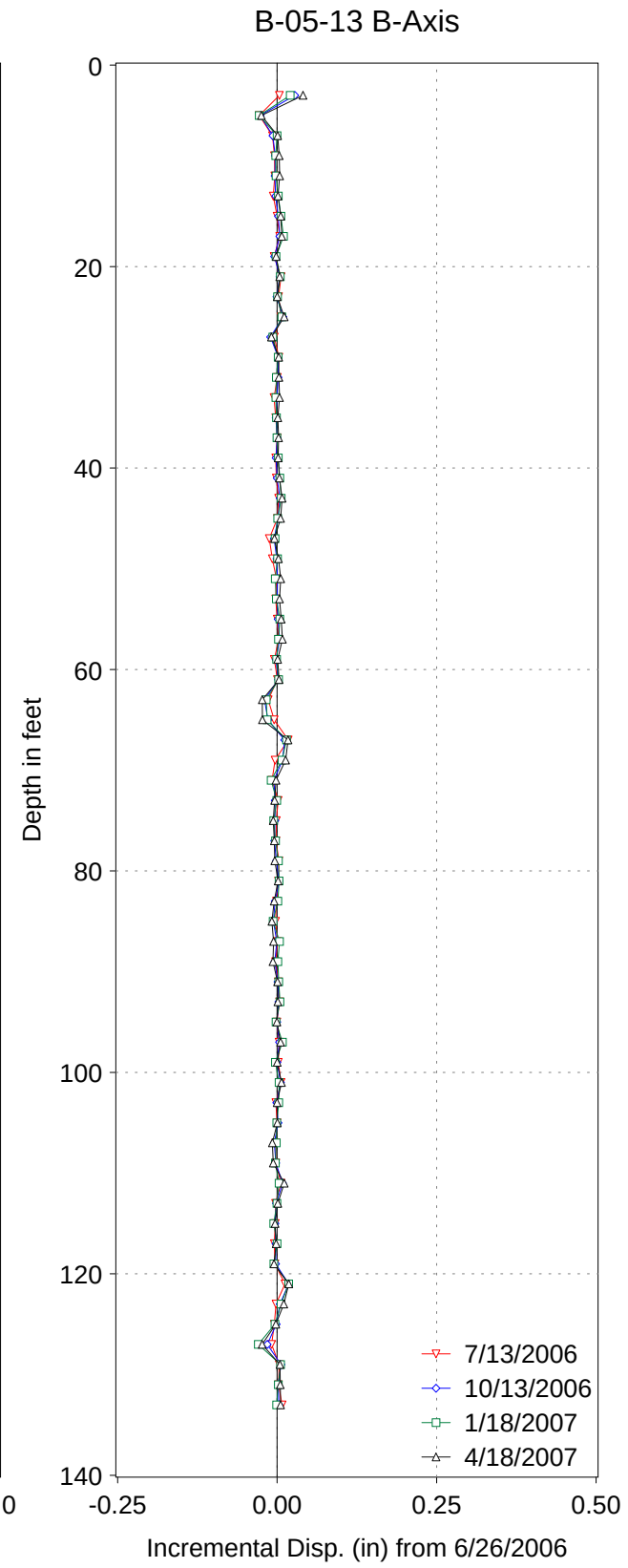




B-05-13

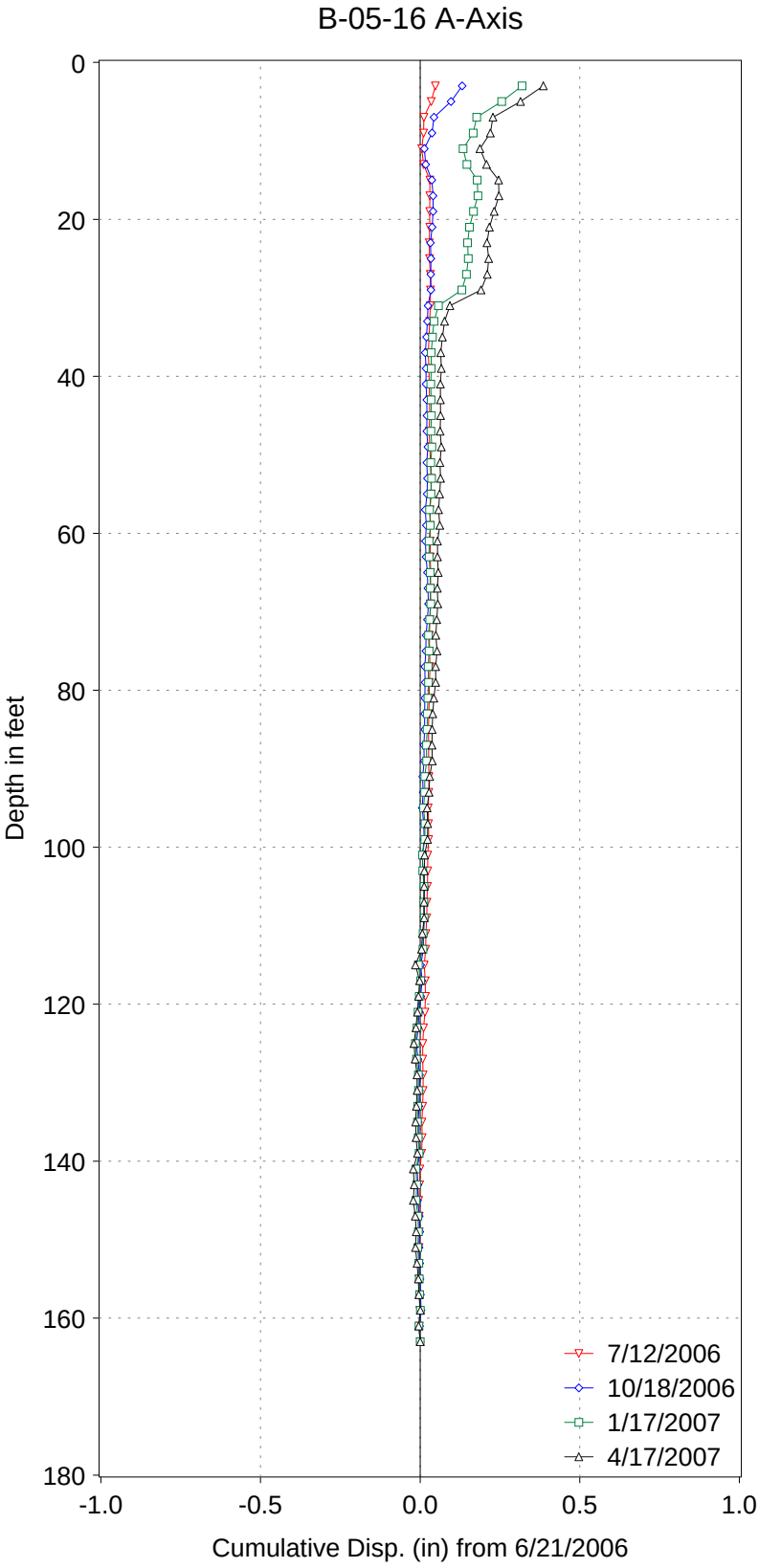
PLATE 42

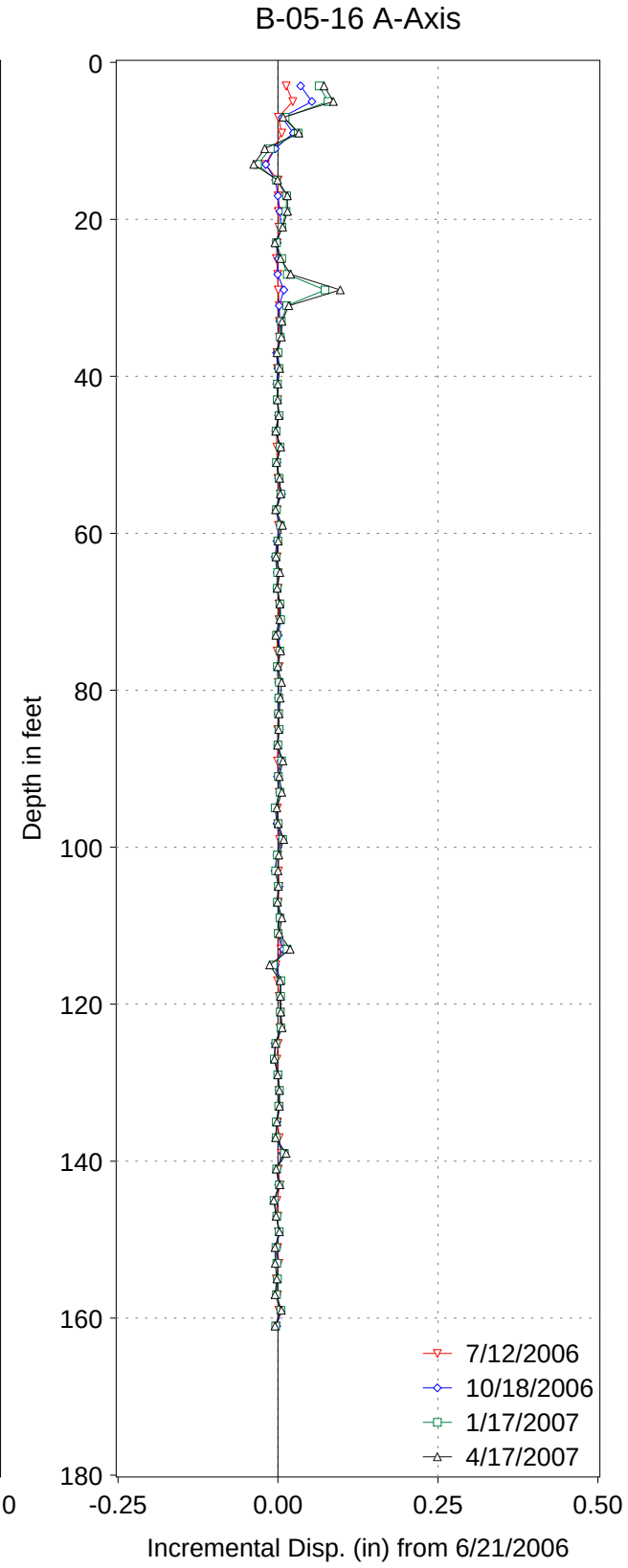




B-05-13

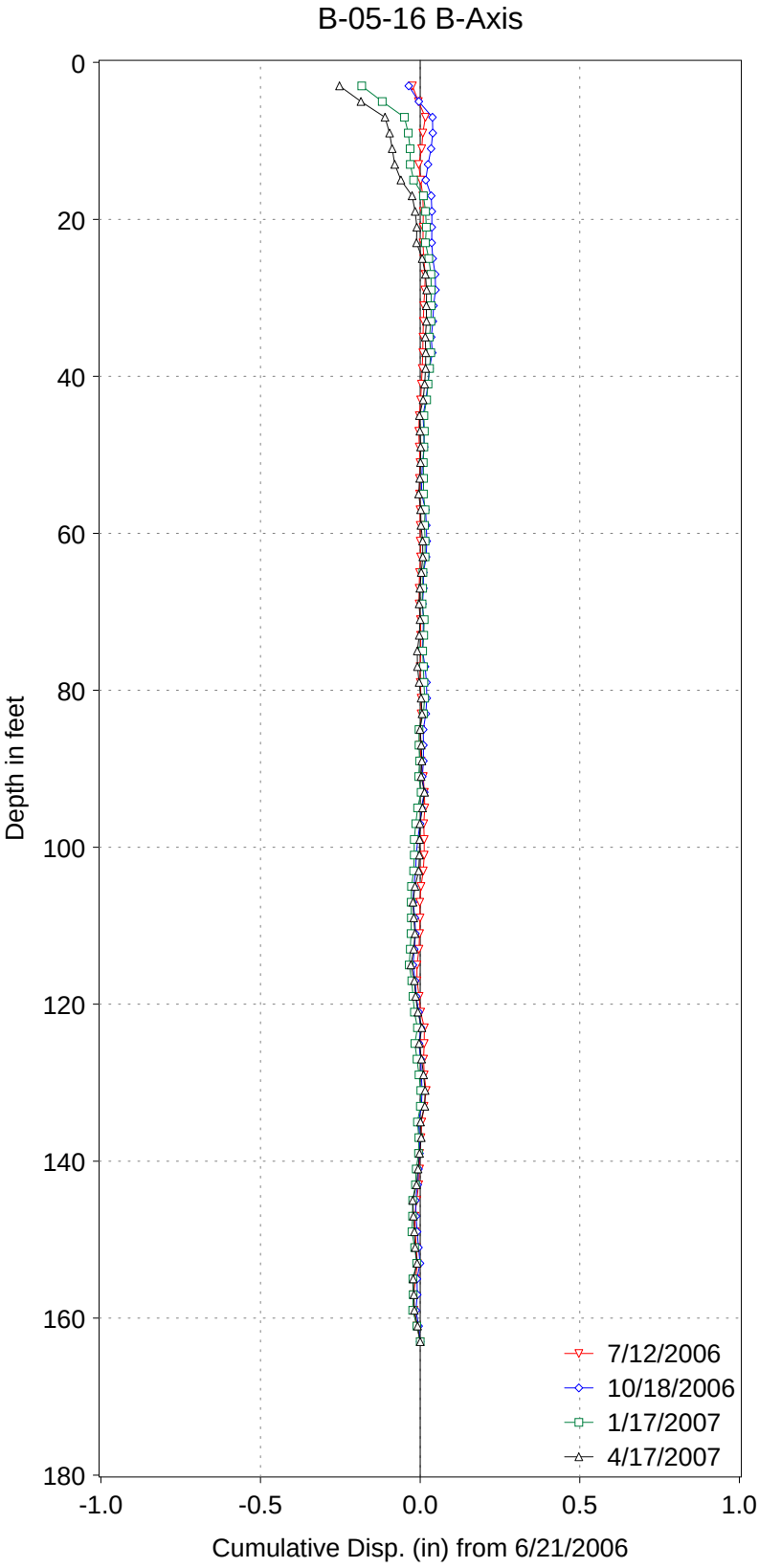
PLATE 43

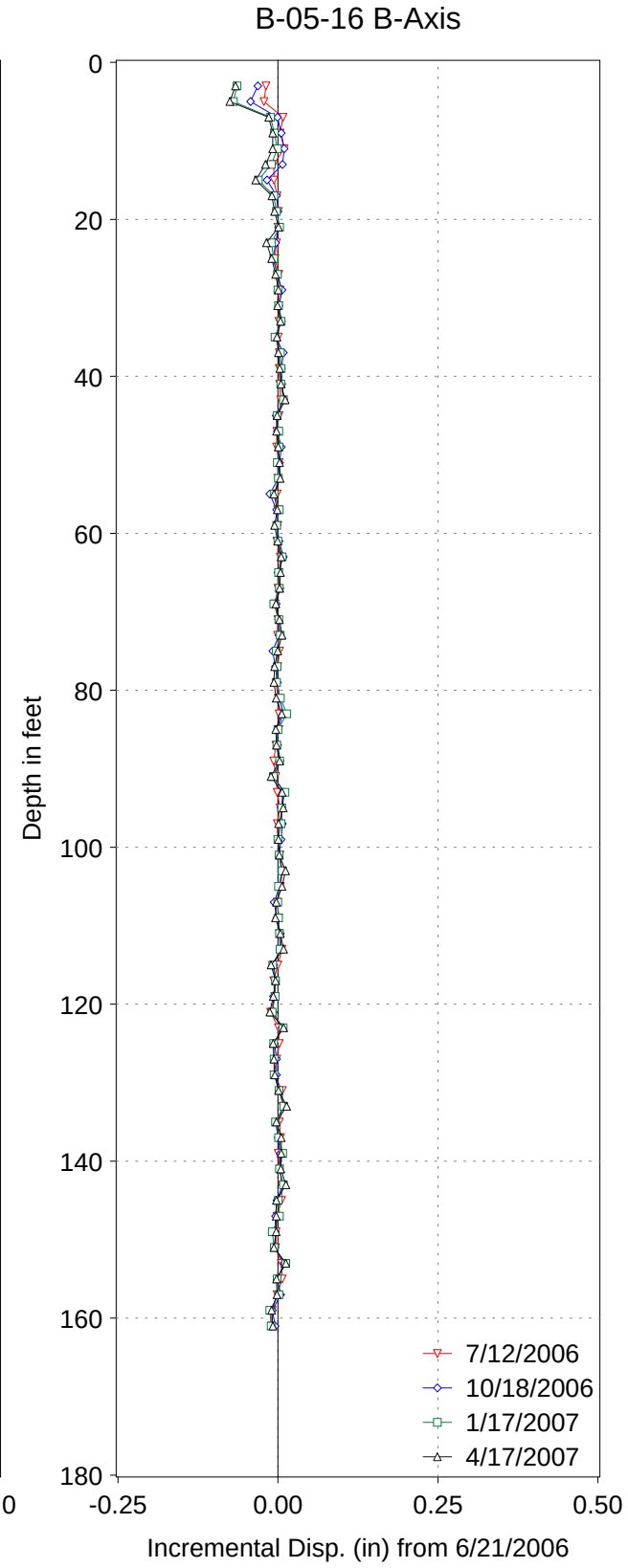




B-05-16

PLATE 44





B-05-16

PLATE 45

B-101 Pneumatic Piezometer Readings

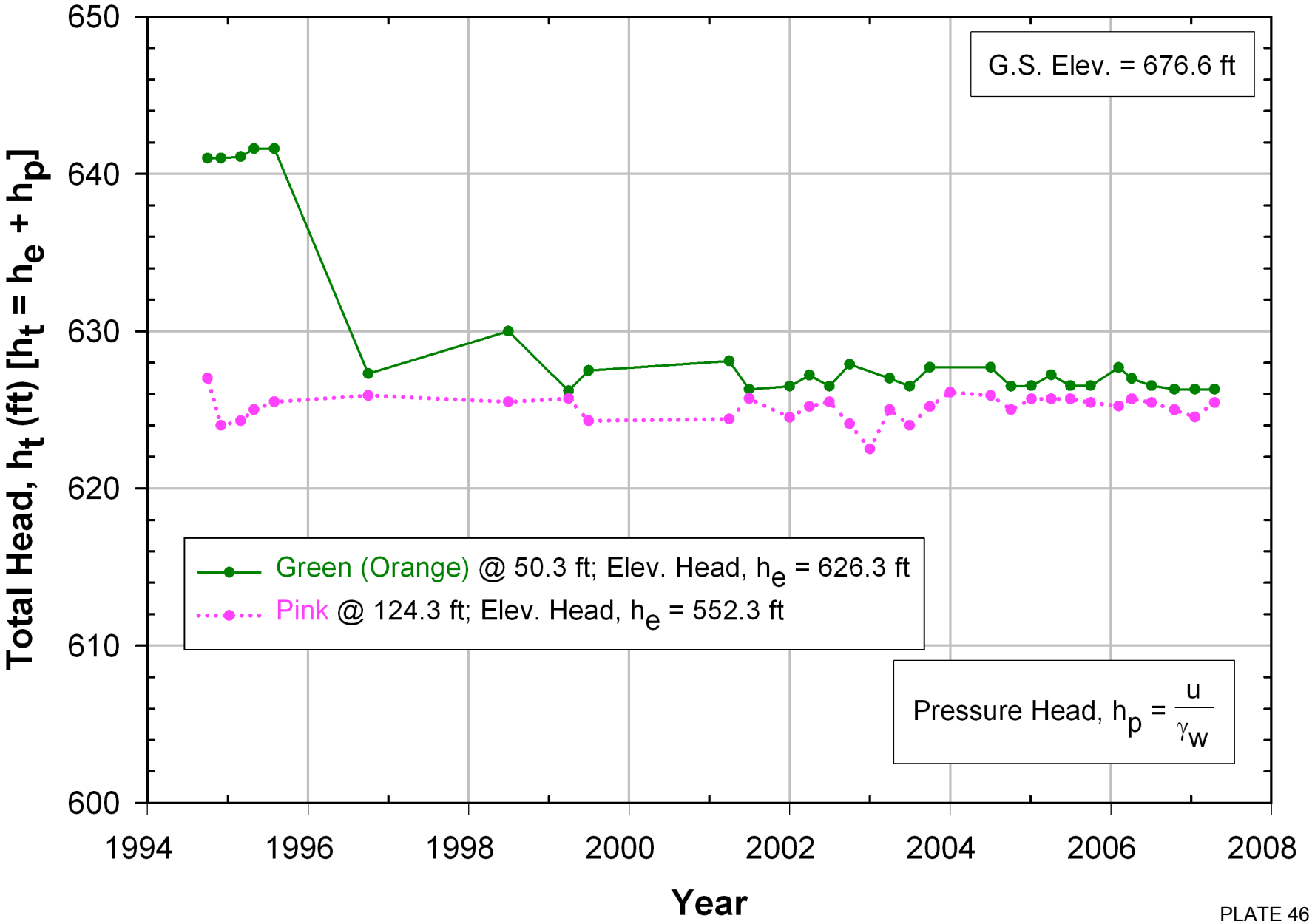


PLATE 46

B-105 Pneumatic Piezometer Readings

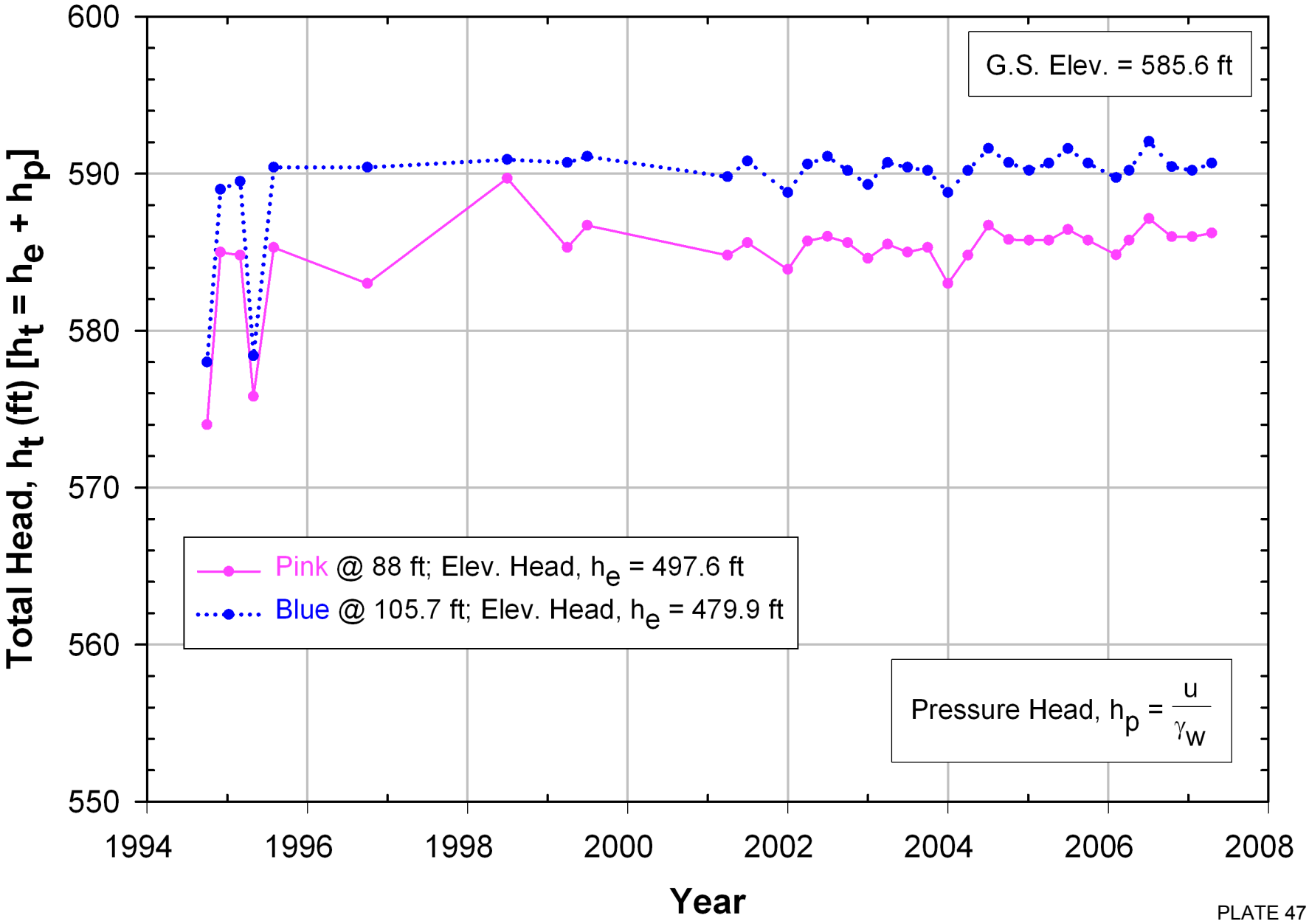


PLATE 47

B-107 Pneumatic Piezometer Readings

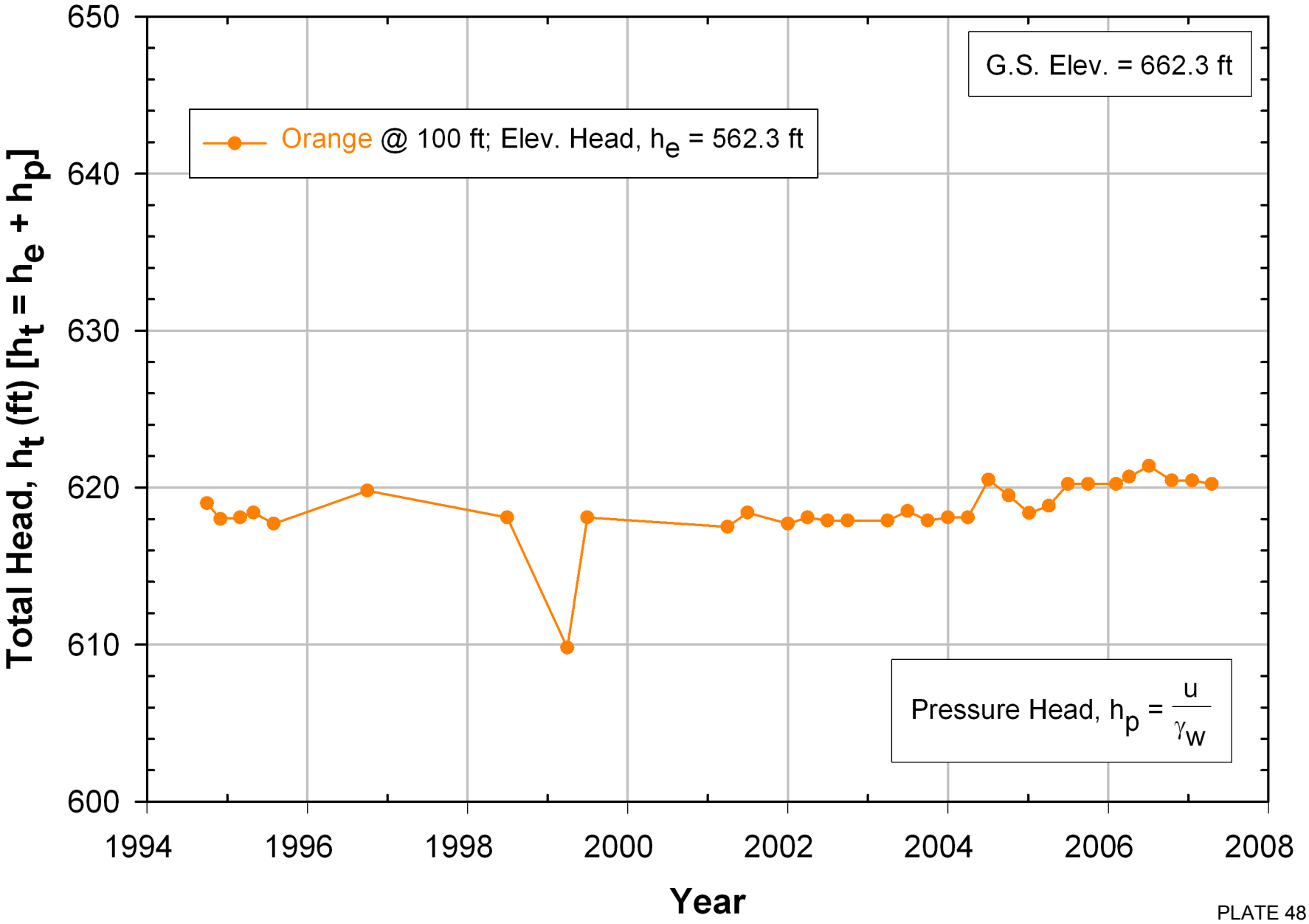


PLATE 48

B-303 Pneumatic Piezometer Readings

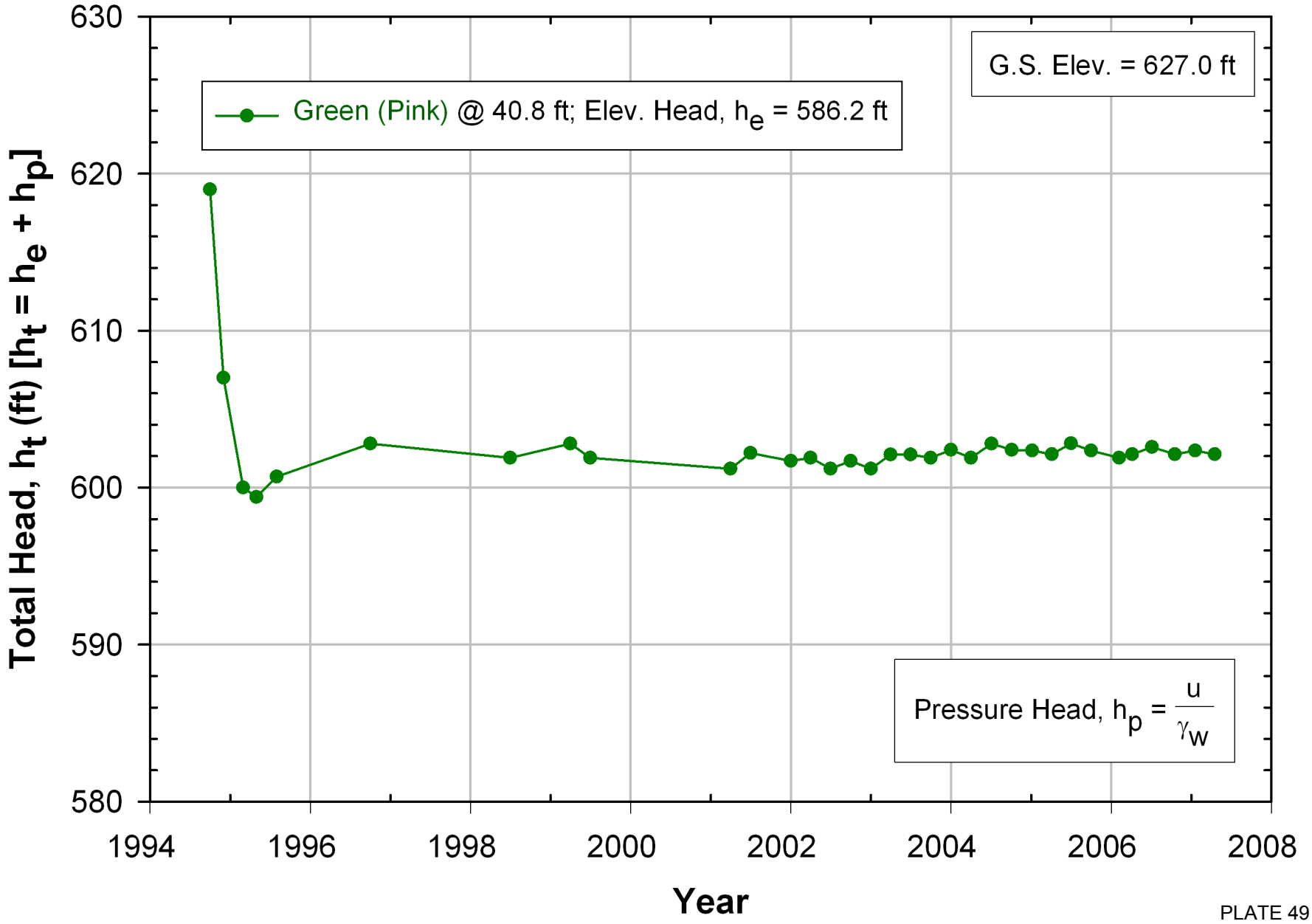


PLATE 49

B-05-01 VW Piezometer Readings

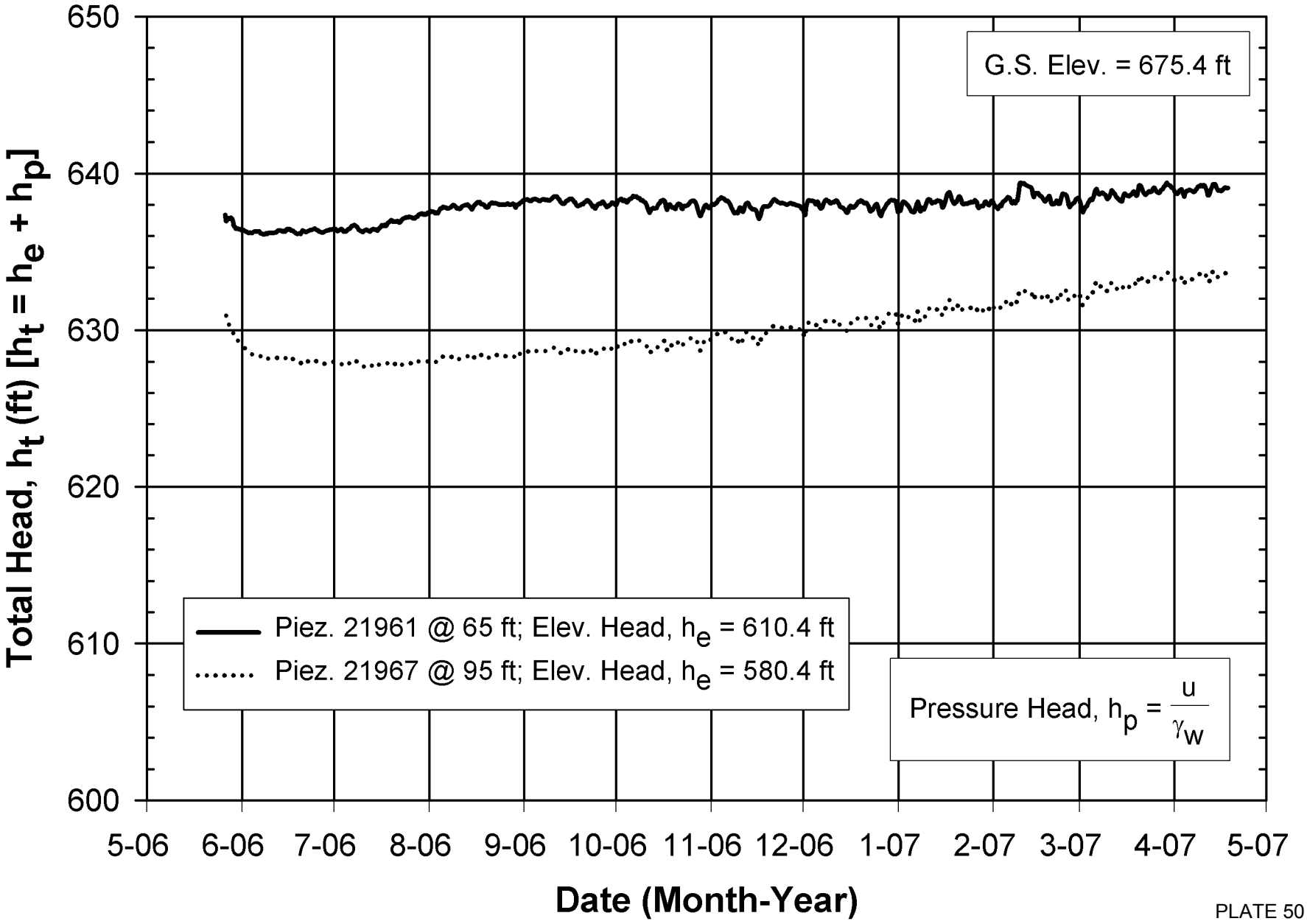


PLATE 50

B-05-02 VW Piezometer Readings

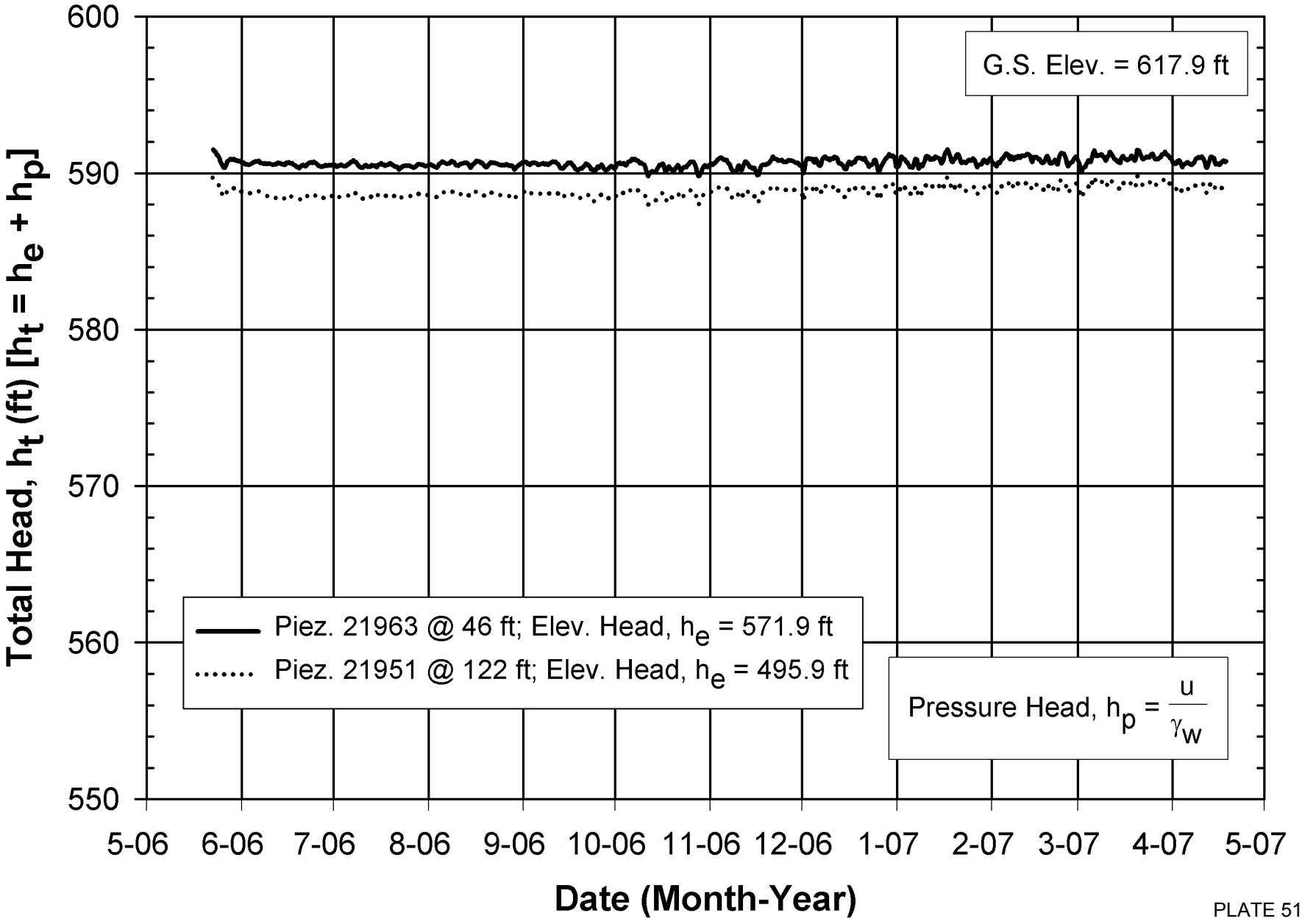


PLATE 51

B-05-03 VW Piezometer Readings

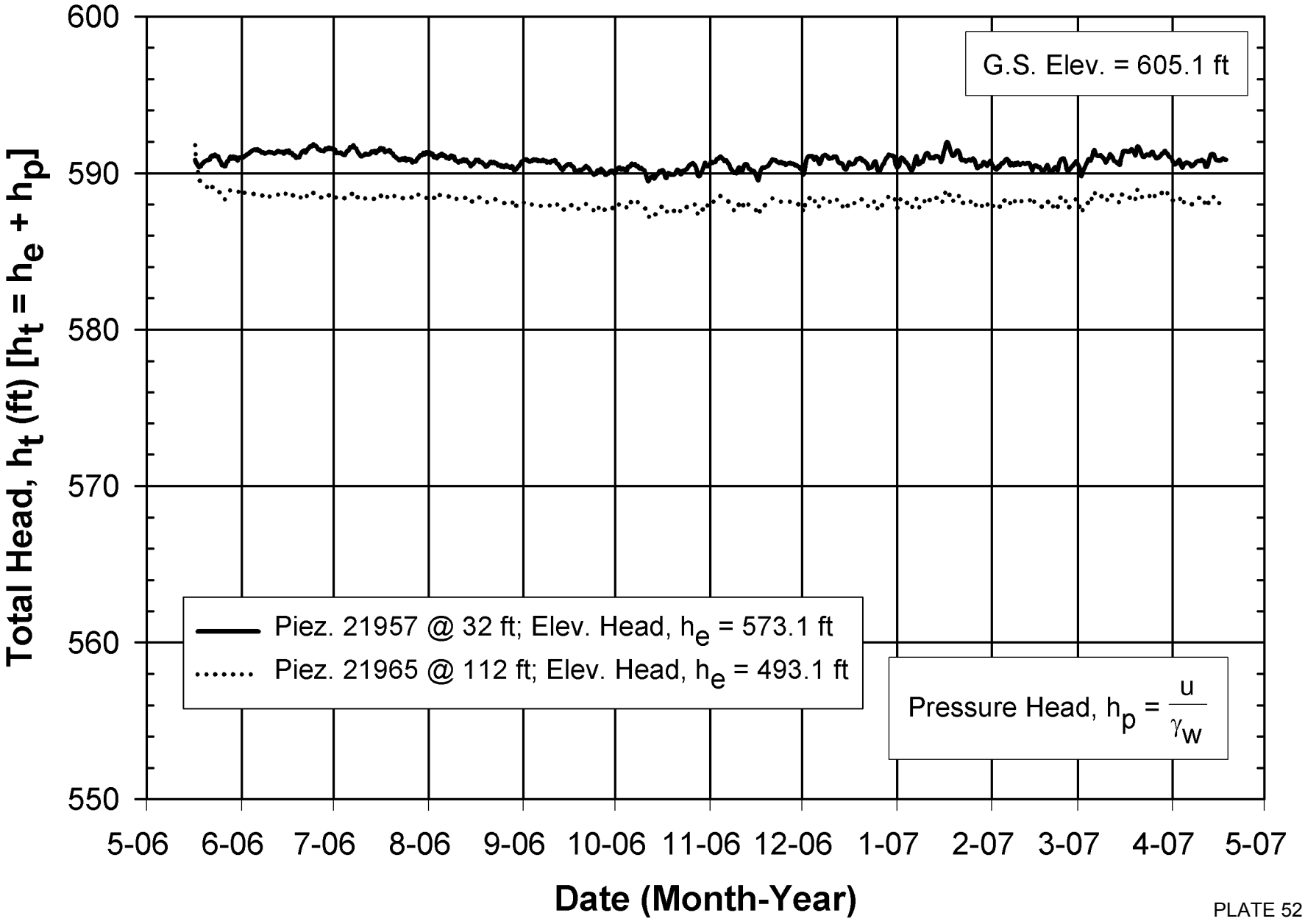


PLATE 52

B-05-04 VW Piezometer Readings

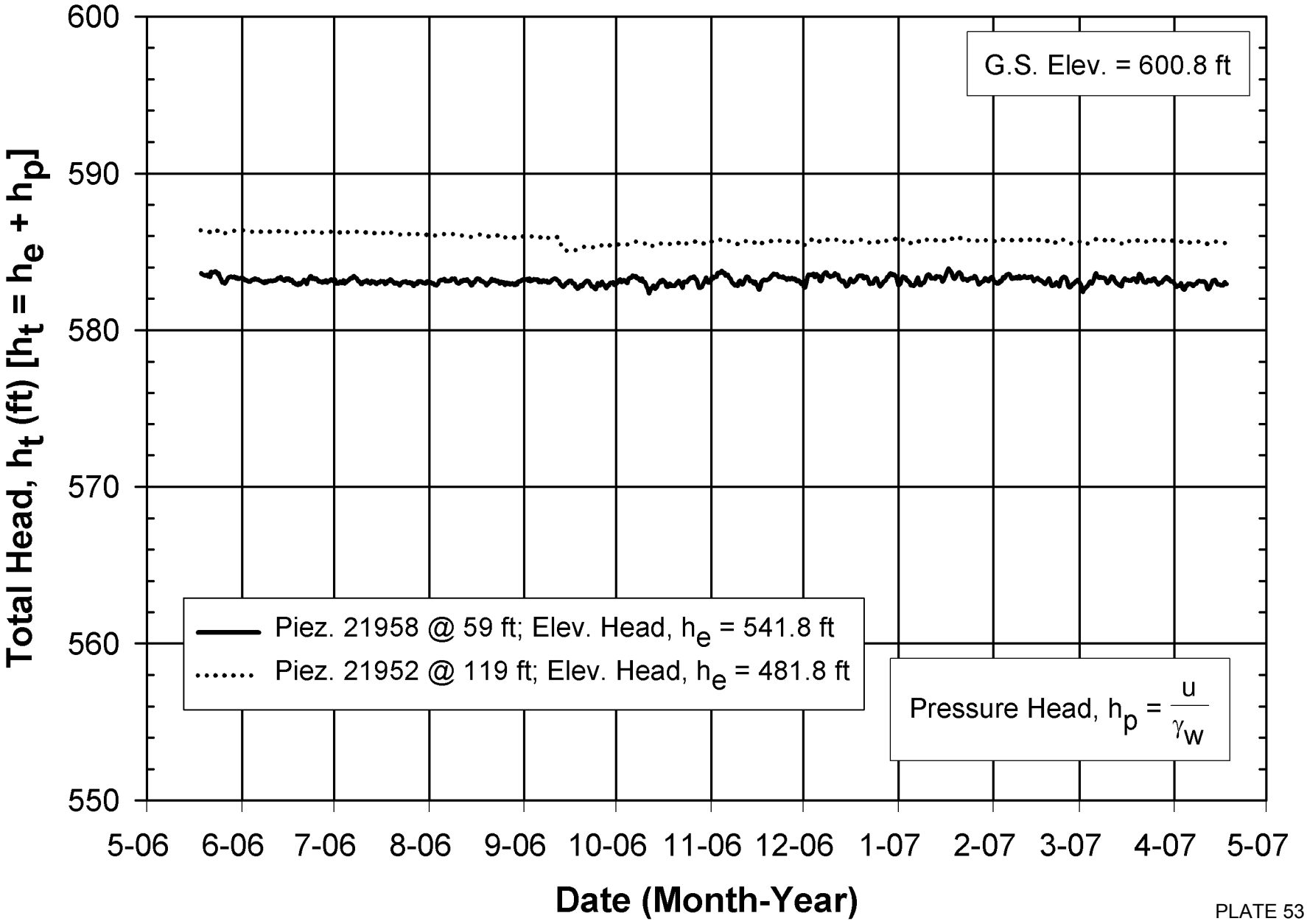


PLATE 53

B-05-07 VW Piezometer Readings

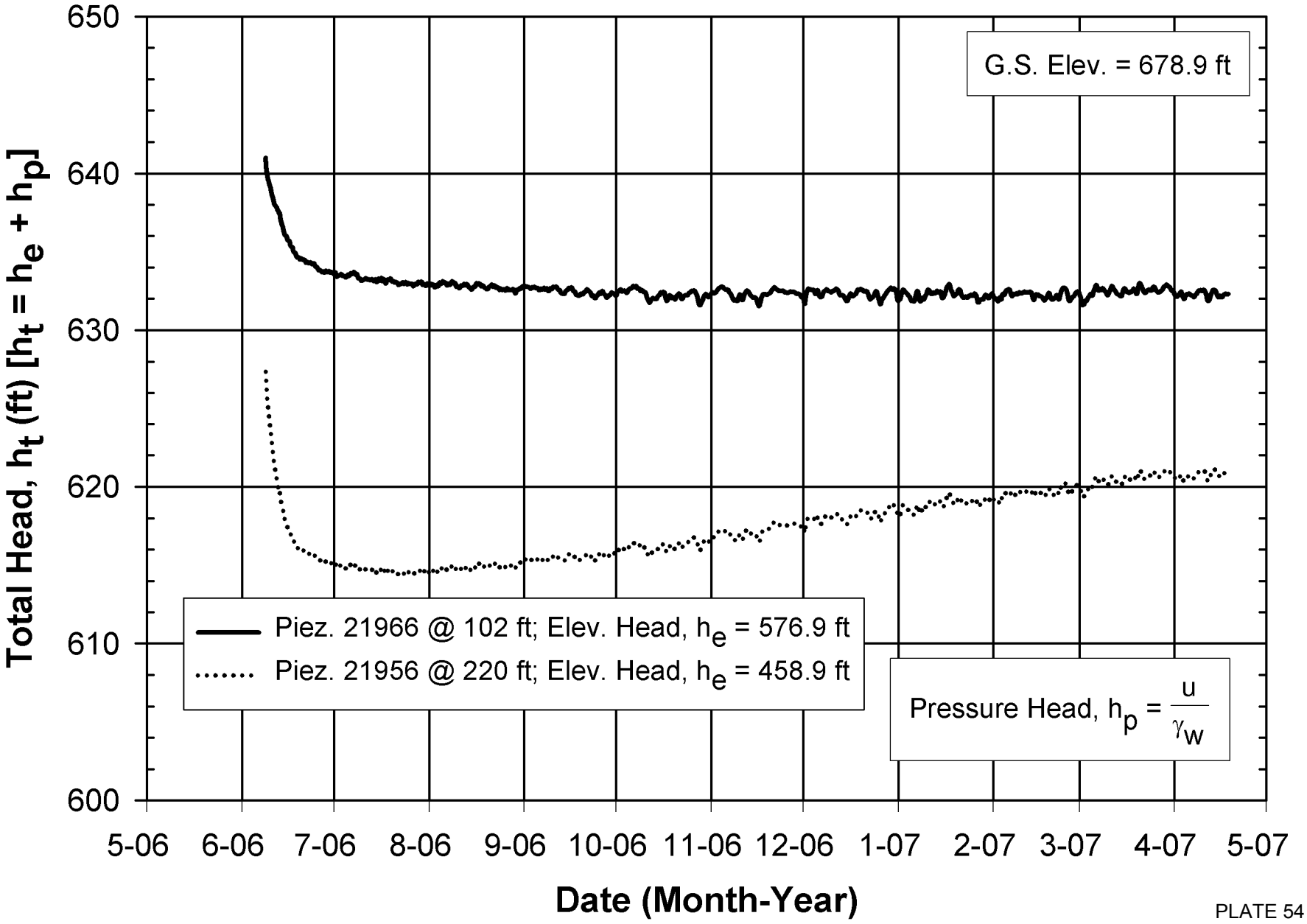


PLATE 54

B-05-08 VW Piezometer Readings

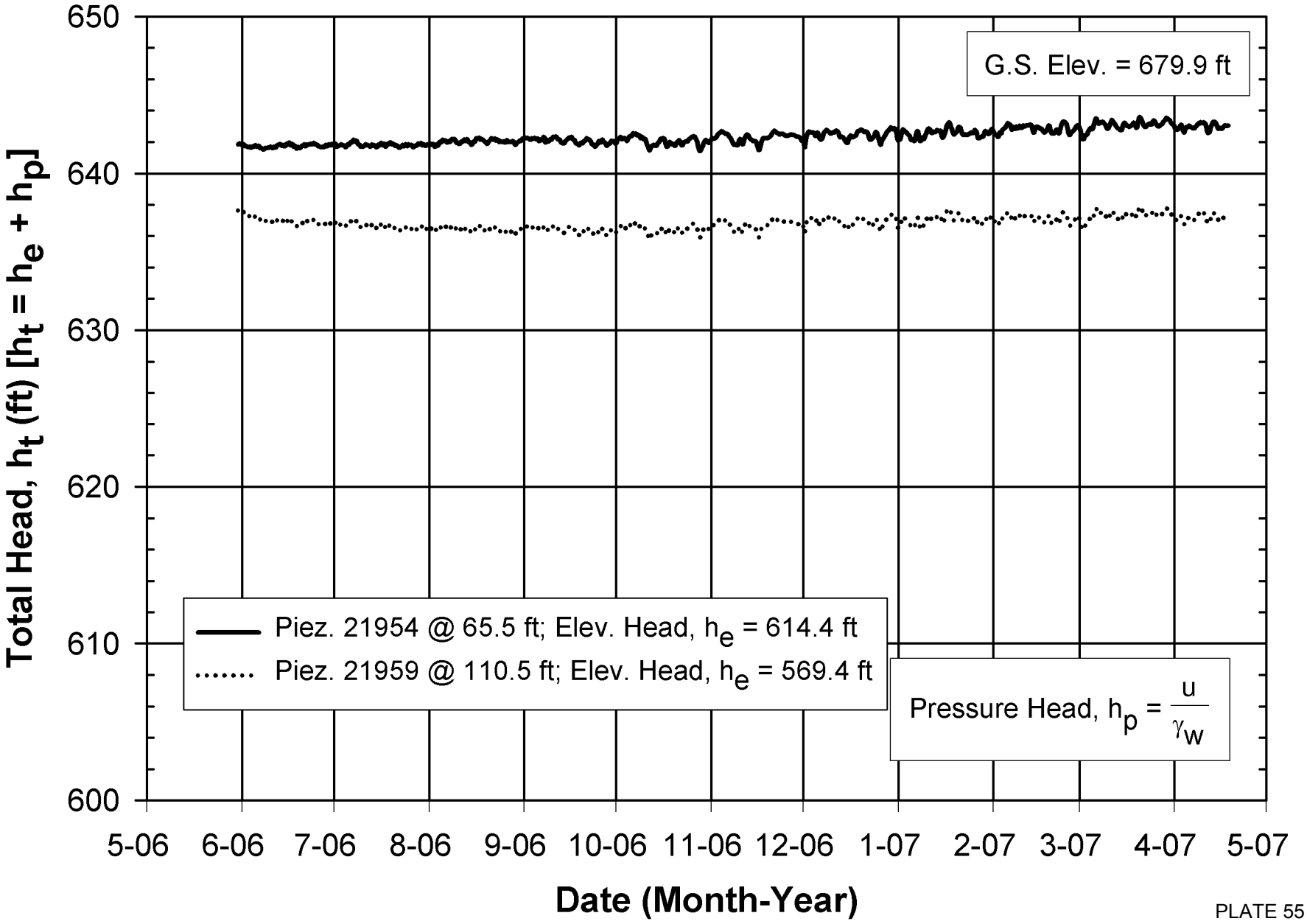


PLATE 55

B-05-11 VW Piezometer Readings

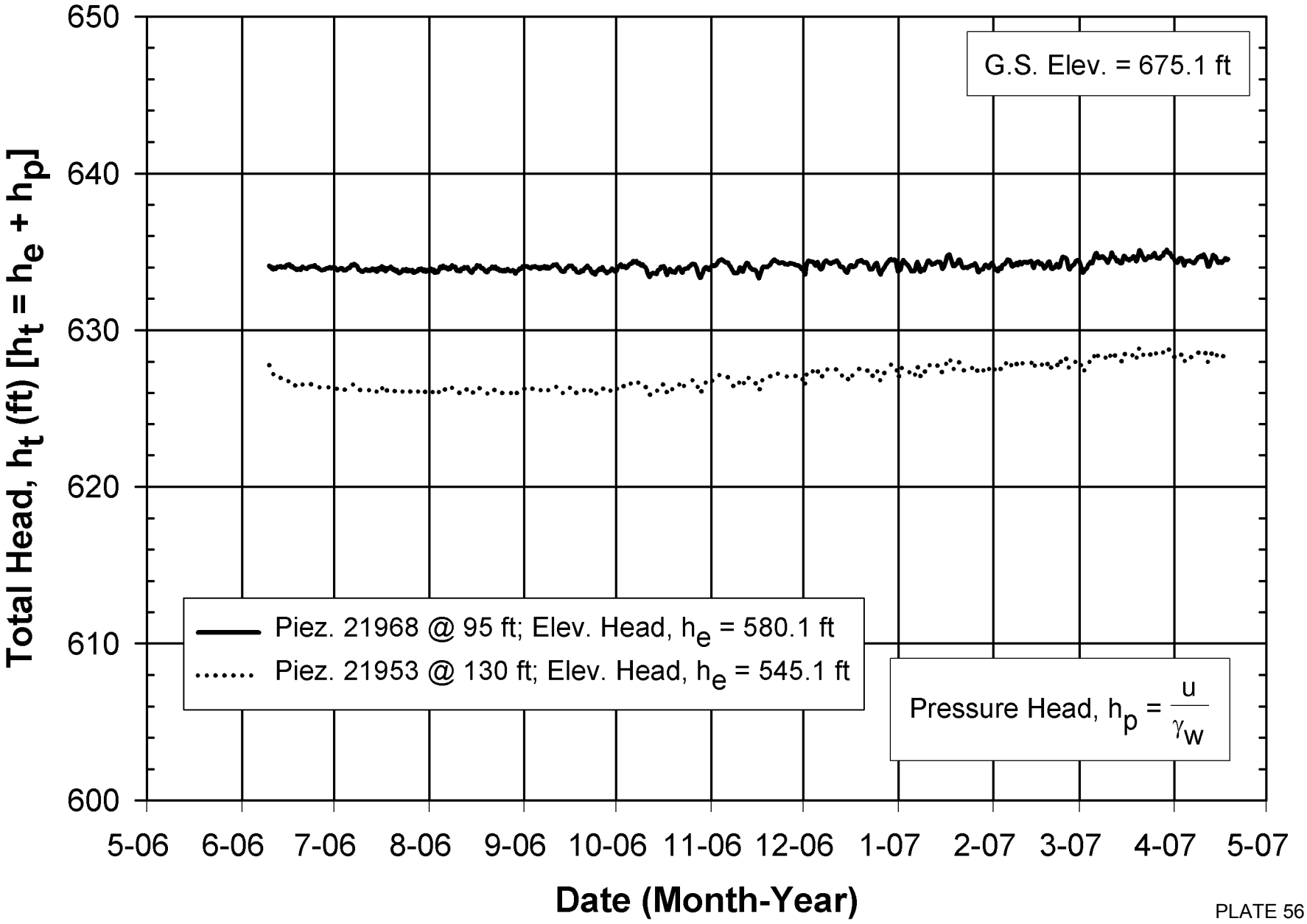


PLATE 56

B-05-12 VW Piezometer Readings

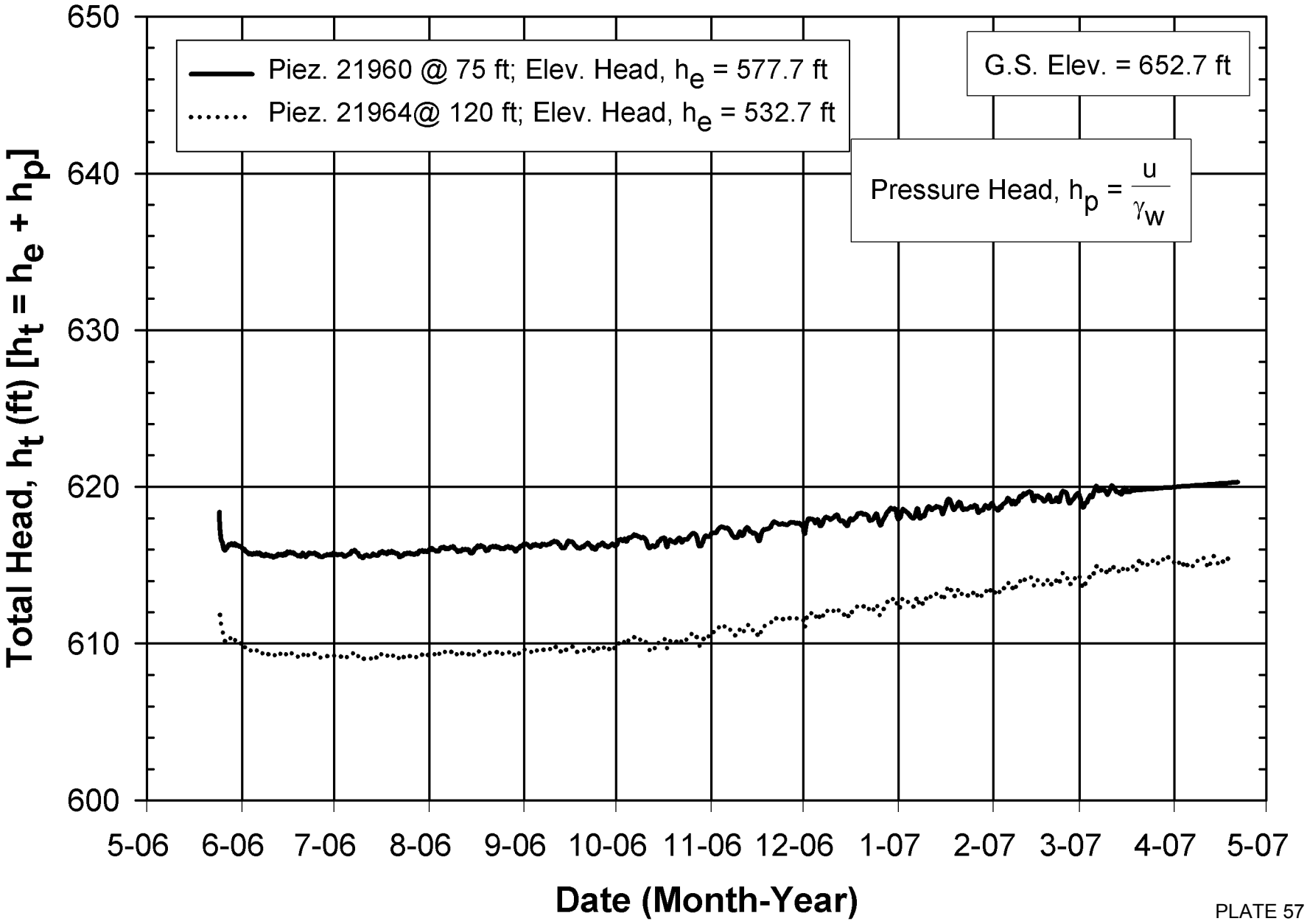


PLATE 57

B-05-13 VW Piezometer Readings

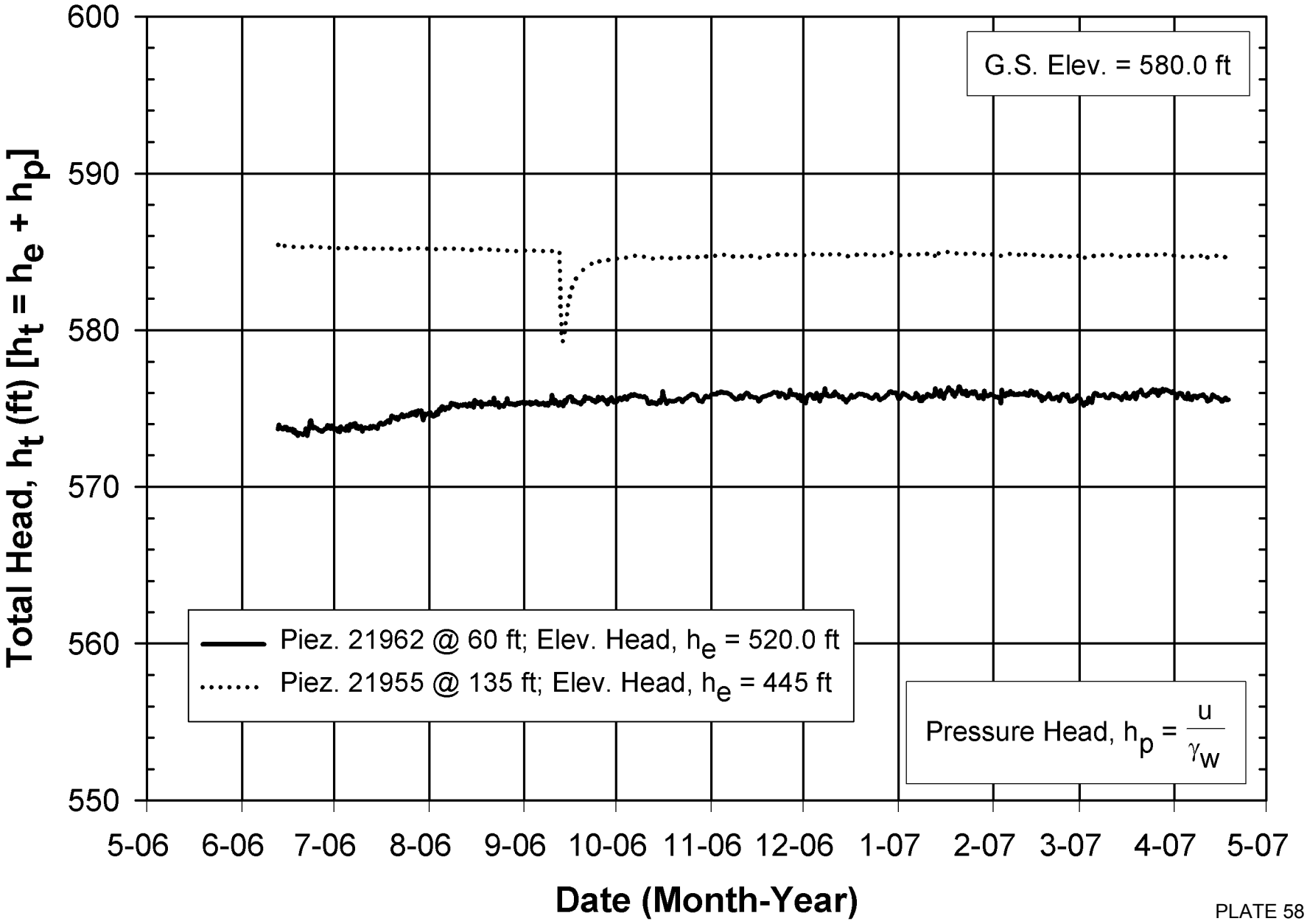


PLATE 58

CALIPERED SURFACE DISTANCE TABLE
CUY-90-15.24

Date	Left Pier Calipered Surface Distance		Center Line Calipered Surface Distance		Right Pier Calipered Surface Distance	
	Present reading	Change (in.)	Present reading	Change (in.)	Present reading	Change (in.)
07/20/00	6.000	--	Not Accessible		4.516	--
10/26/00	5.876	-0.124	Not Accessible		4.294	-0.222
01/29/01	5.929	0.053	Not Accessible		4.385	0.091
04/17/01	Not Accessible		Not Accessible		Not Accessible	
07/19/01	6.043	0.114	Not Accessible		4.312	-0.073
11/08/01	6.250	0.207	Not Accessible		4.469	0.157
01/23/02	6.253	0.003	Not Accessible		4.518	0.049
04/17/02	6.285	0.032	Not Accessible		4.435	-0.083
07/16/02	6.290	0.005	Not Accessible		4.444	0.009
10/15/02	6.333	0.043	Discontinued		4.482	0.038
01/15/03	6.405	0.072			4.473	-0.009
04/17/03	6.333	-0.072			4.482	0.009
07/18/03	6.186	-0.147			4.350	-0.132
10/16/03	6.385	0.199			4.519	0.169
01/08/04	6.124	-0.261			4.594	0.075
04/14/04	6.129	0.005			4.402	-0.193
07/16/04	6.250	0.122			4.277	-0.125
10/27/04	6.375	0.125			4.467	0.190
01/12/05	6.250	-0.125			4.349	-0.118
04/14/05	6.375	0.125			4.372	0.023
07/14/05	6.313	-0.063			4.392	0.020
10/12/05	6.375	0.063			4.358	-0.034
02/01/06	6.438	0.063			4.395	0.037
04/20/06	6.500	0.063			4.430	0.035
07/14/06	6.375	-0.125			4.381	-0.049
10/18/06	6.438	0.063			4.400	0.020
01/19/07	6.500	0.062			4.506	0.106
04/18/07	6.375	-0.125			4.357	-0.150

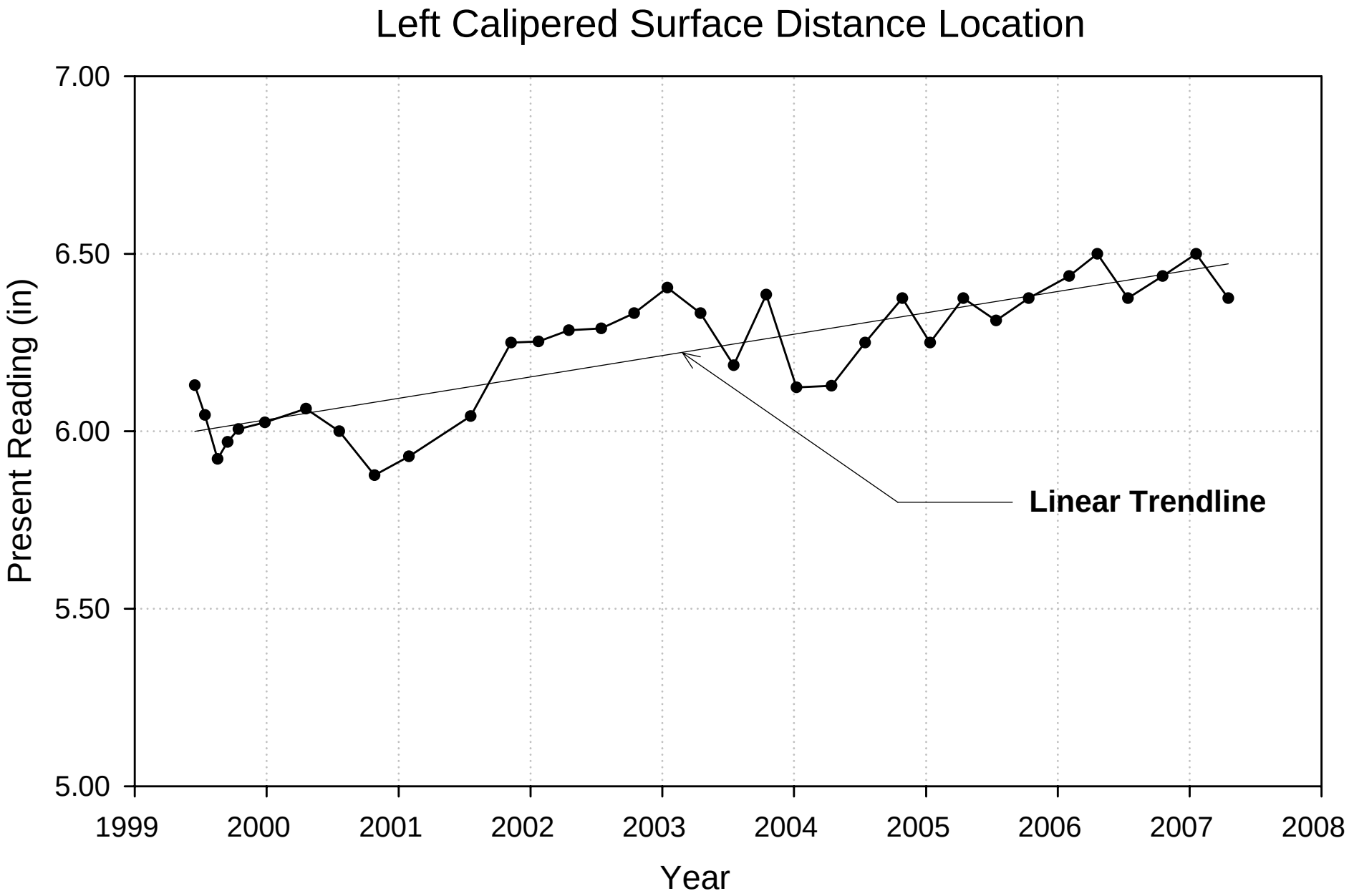

Left Calipered Surface Distance Location
7.00
6.50
6.00
5.50
5.00
Present Reading (in)
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Linear Trendline

PLATE 60

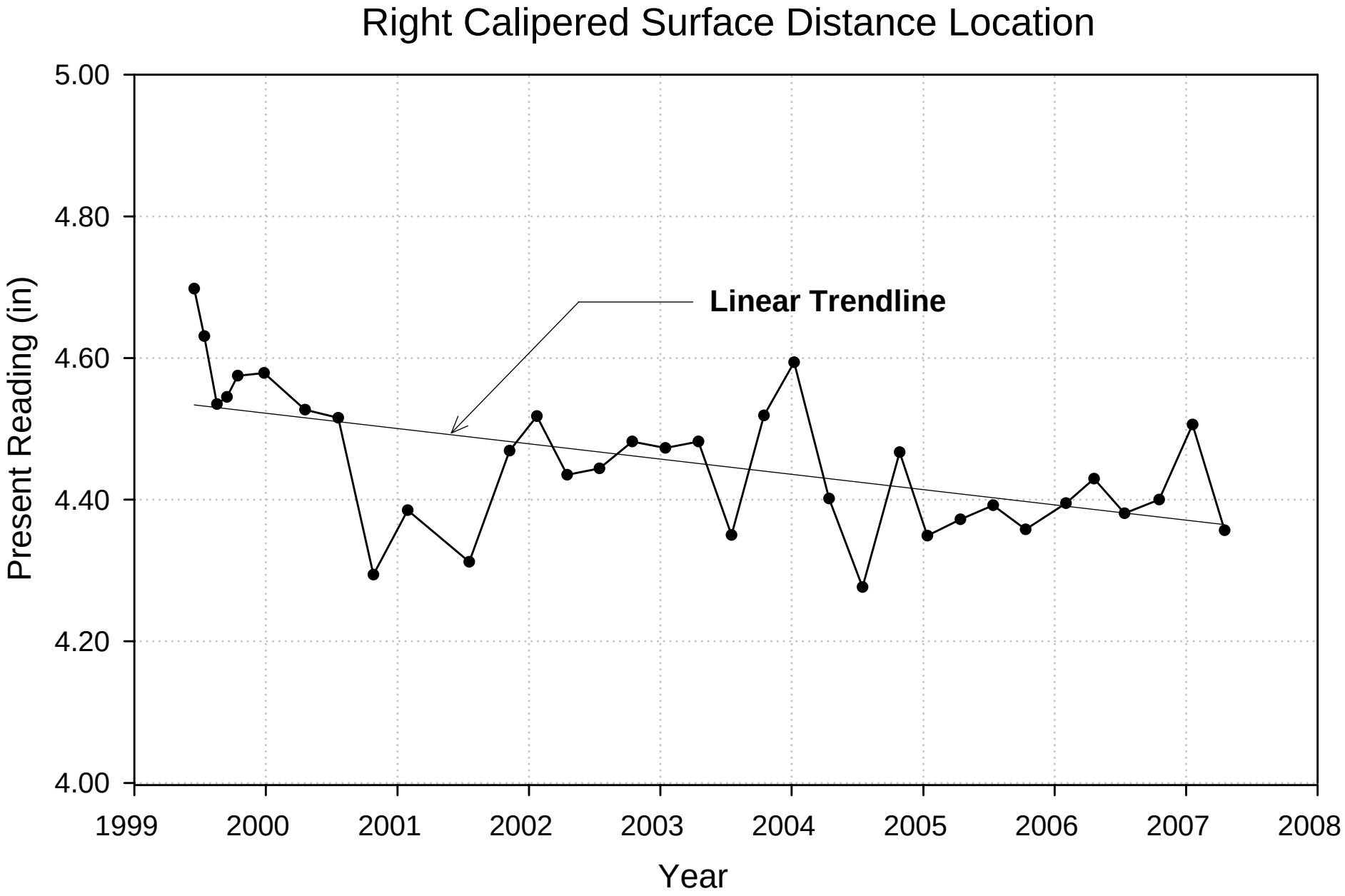

Right Calipered Surface Distance Location
Present Reading (in)
5.00
4.80
4.60
4.40
4.20
4.00
Linear Trendline
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year

PLATE 61

BBCM

BBC&M ENGINEERING, INC. 8555 Sweet Valley Drive, Suite S, Valley View, Ohio 44125-4254
Phone (216) 901-1000 Fax (216) 901-9996

March 16, 2006
Inc_B110 Removal.doc

Mr. Robert B. Parker, P.E.
Ohio Manager/Assistant Vice President
Michael Baker Jr., Inc.
The Halle Building
1228 Euclid Avenue, Suite 1050
Cleveland, Ohio 44115

Re: Excavation and Removal of Inclinometer B-110
CUY-90-15.24 Bridge
Cleveland, Cuyahoga County, Ohio

Dear Mr. Parker:

During field operations associated with the subsurface investigation for the CUY-90-15.24 West Abutment project, BBCM personnel observed the results of recent excavation activities near inclinometer B-110. Inclinometer B-110 is northeast of the existing I-90 bridge alignment as illustrated in Plate 1. **These excavation activities could have a potentially negative impact on the overall stability of the existing I-90 bridge and may accelerate movement of the hillside adjacent to the bridge.**

Cook Paving Construction Co., Inc. vehicles were noted at the site as shown in Plate 2. Approximately 20 feet of material has been excavated adjacent to the Cuyahoga River and has been stockpiled upslope near University Avenue. Plates 3 and 4 illustrate the stockpiled material near University Avenue. Plates 5 and 6 illustrate the excavation area adjacent to the Cuyahoga River. In the process of excavation, it appears the existing inclinometer B-110 has been either destroyed or buried and is now unreadable. Plate 7 illustrates crewmen apparently preparing to pull back the sheetpile wall.

Removing material at the toe of the local slide that is actively occurring near B-110 and placing that material upslope has at least four negative impacts.

1. Resistance at the toe of the local slide has been removed, which is expected to reduce the stability of the local slide in the vicinity of inclinometer B-110;
2. Additional fill has been placed at the top of the hillside adjacent to University Avenue thus adding to the driving force, which is expected to reduce the stability of the local slide in the vicinity of inclinometer B-110;
3. Resistance at the toe of the west bank slope large slide mass beneath the I-90 bridge has been removed and it is expected to reduce the stability and/or increase the creep rate since inclinometer readings indicate the slope is creeping more or less toward inclinometer B-110 as illustrated in Plate 8, which was taken from BBCM's 2005 report

to Richland Engineering; and,

4. Inclinometer B-110 is now unreadable, which negatively impacts BBCM's ability to monitor creep behavior at the toe of the slope northwest of the existing I-90 bridge as there are no other inclinometers in the immediate vicinity.

In addition to the negative impact these activities have on the existing bridge structure, **it could also have a potentially negative impact of the stability of the hillside beneath the proposed near north and far north bridge alignments. BBCM will need updated ground surface topographic information to adequately perform the stability analysis within cross section A-A** as stated in our Revised Cost Proposal, dated February 1, 2006, of Subsurface Investigation/Instrumentation for the West Abutment of the proposed CUY-90-15.24 Bridge.

BBCM wants to emphasize that the excavation activities presented herein **could have a potentially negative impact on the overall stability of the existing I-90 bridge, proposed near north alignment, and proposed far north alignment and these activities may accelerate movement of the hillside.** As such, BBCM recommends advising ODOT of the noted excavation activities as quickly as possible. Furthermore, BBCM requests that the design team keep BBCM informed of any measures ODOT takes, if any, as these excavation activities and any ODOT measures could affect BBCM's recommendations pertaining to Subsurface Investigation/Instrumentation for the West Abutment of the proposed CUY-90-15.24 Bridge.

We appreciate the opportunity to be of service to you and look forward to continued collaboration in the future. Please do not hesitate to call our office should you require further information.

Respectfully submitted,
BBC&M Engineering, Inc.
Cleveland, Ohio

Donald C. Wotring

Donald C. Wotring, Ph.D.
Project Engineer

Peter Lee

Peter S. Lee, Ph.D., P.E.
Senior Project Engineer

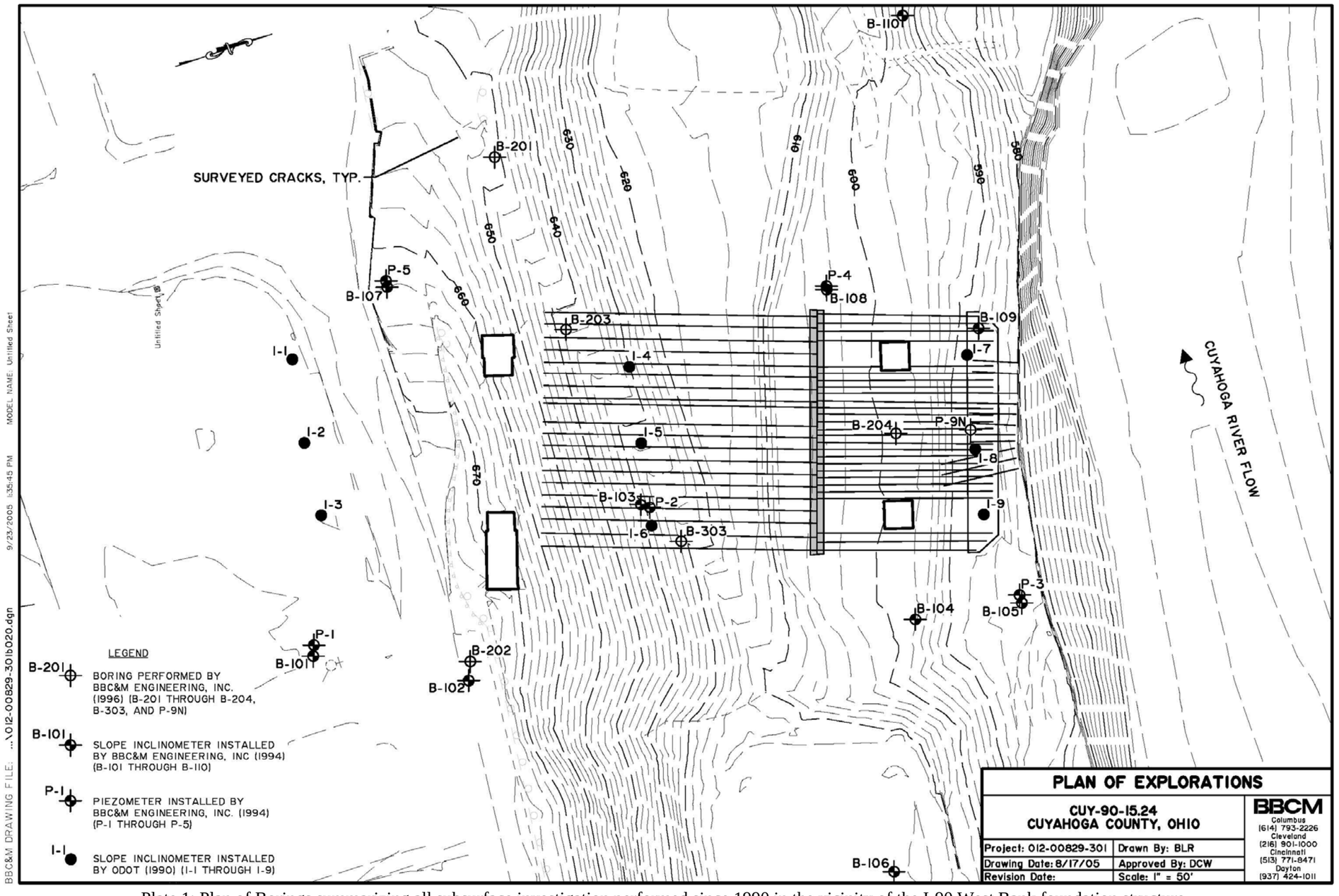


Plate 1: Plan of Borings summarizing all subsurface investigation performed since 1990 in the vicinity of the I-90 West Bank foundation structure.

Plate 2: Looking northwest from University Avenue at crew vehicle (Cook).

Plate 3: View from platform near cold storage warehouse. The stockpile of recently excavated material is located at the top of the hillside near the excavator.

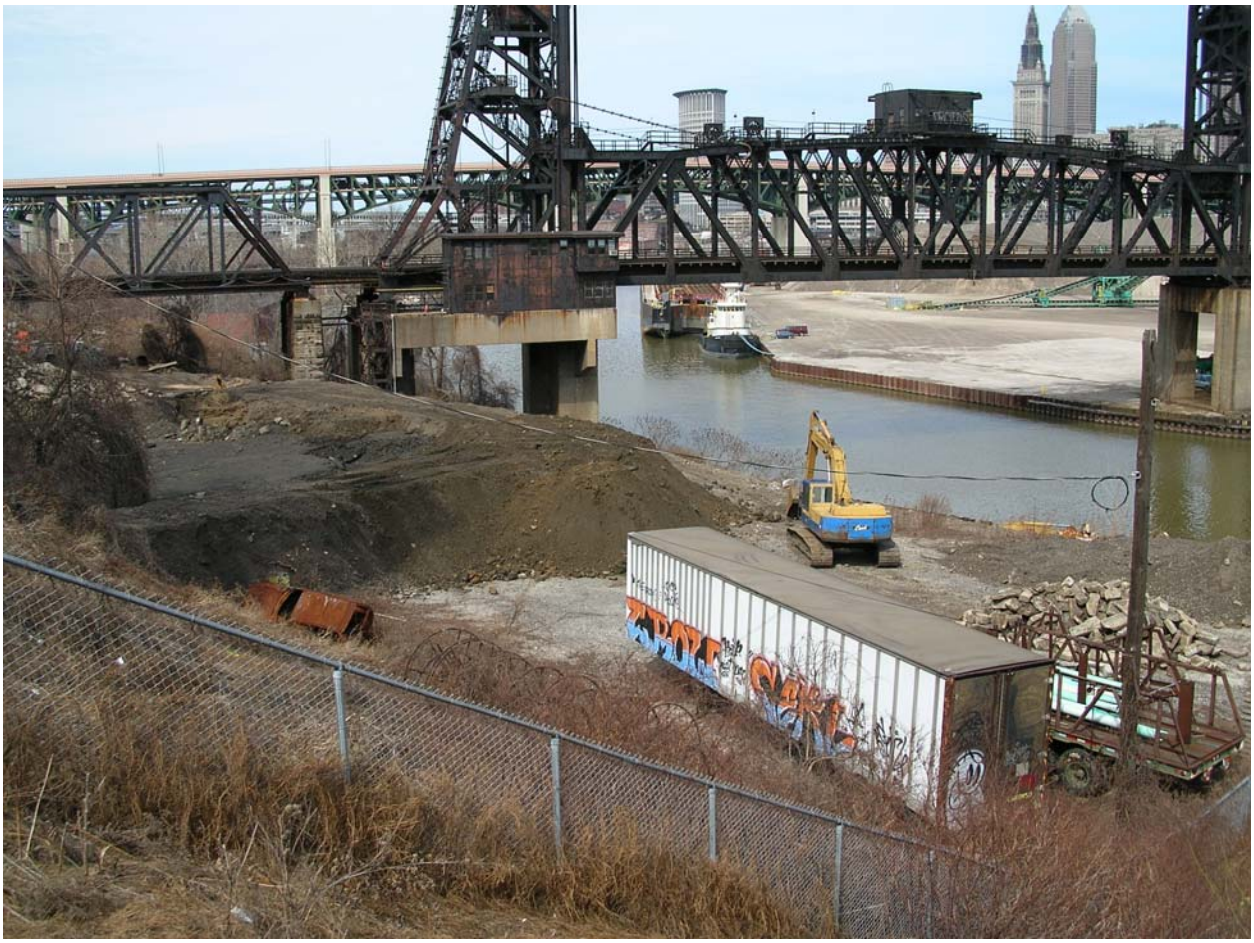


Plate 4: View from University Avenue. Stockpile of recently excavated material stored at the

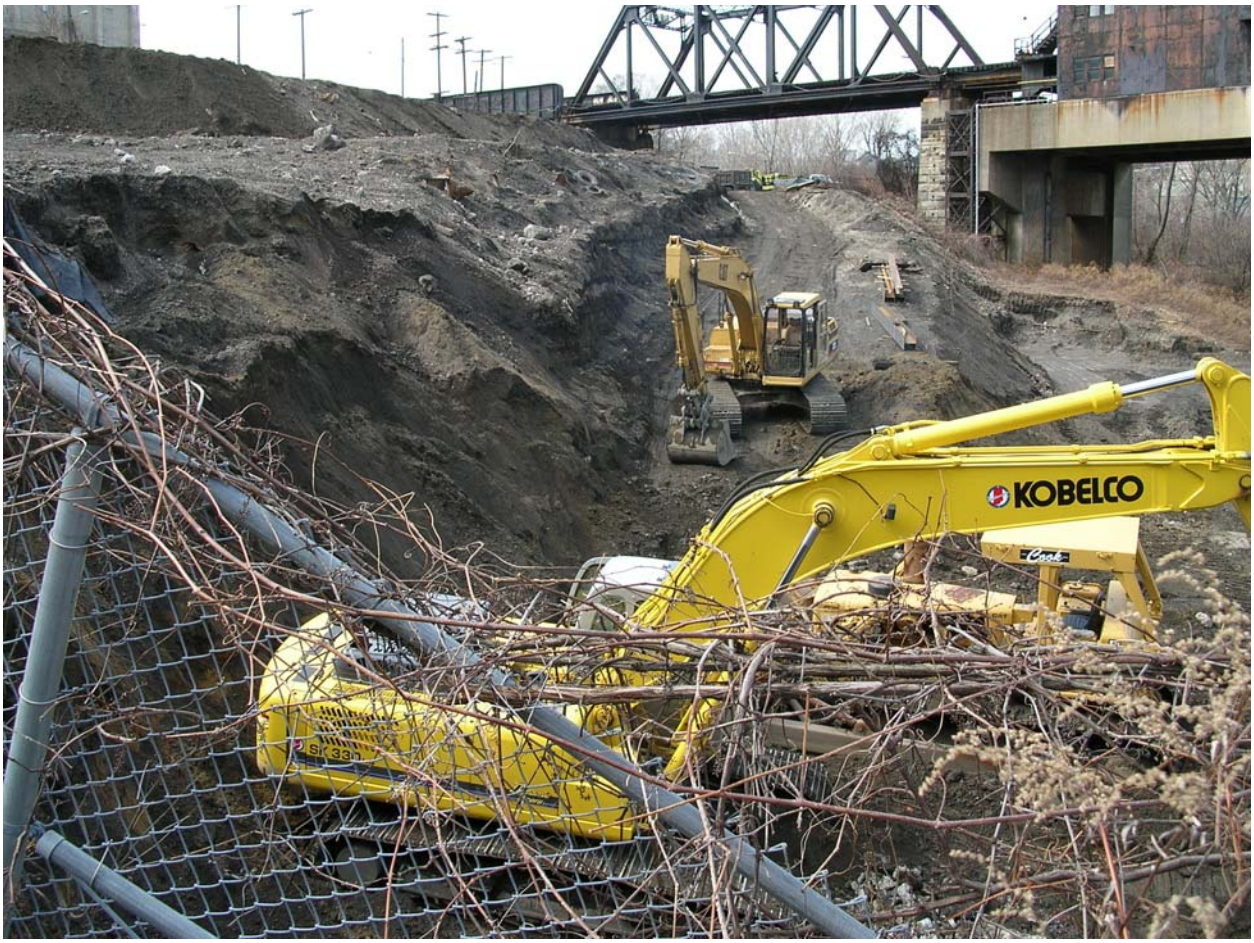


Plate 5: Looking west at area of excavation. Visual observation indicates that approximately 20 feet of material was removed and placed upslope. The stockpile of material is visible at the upper left corner of this picture.

Plate 6: Looking west at excavation area.

Plate 7: Looking northwest at crew apparently preparing to pull back sheet pile wall.

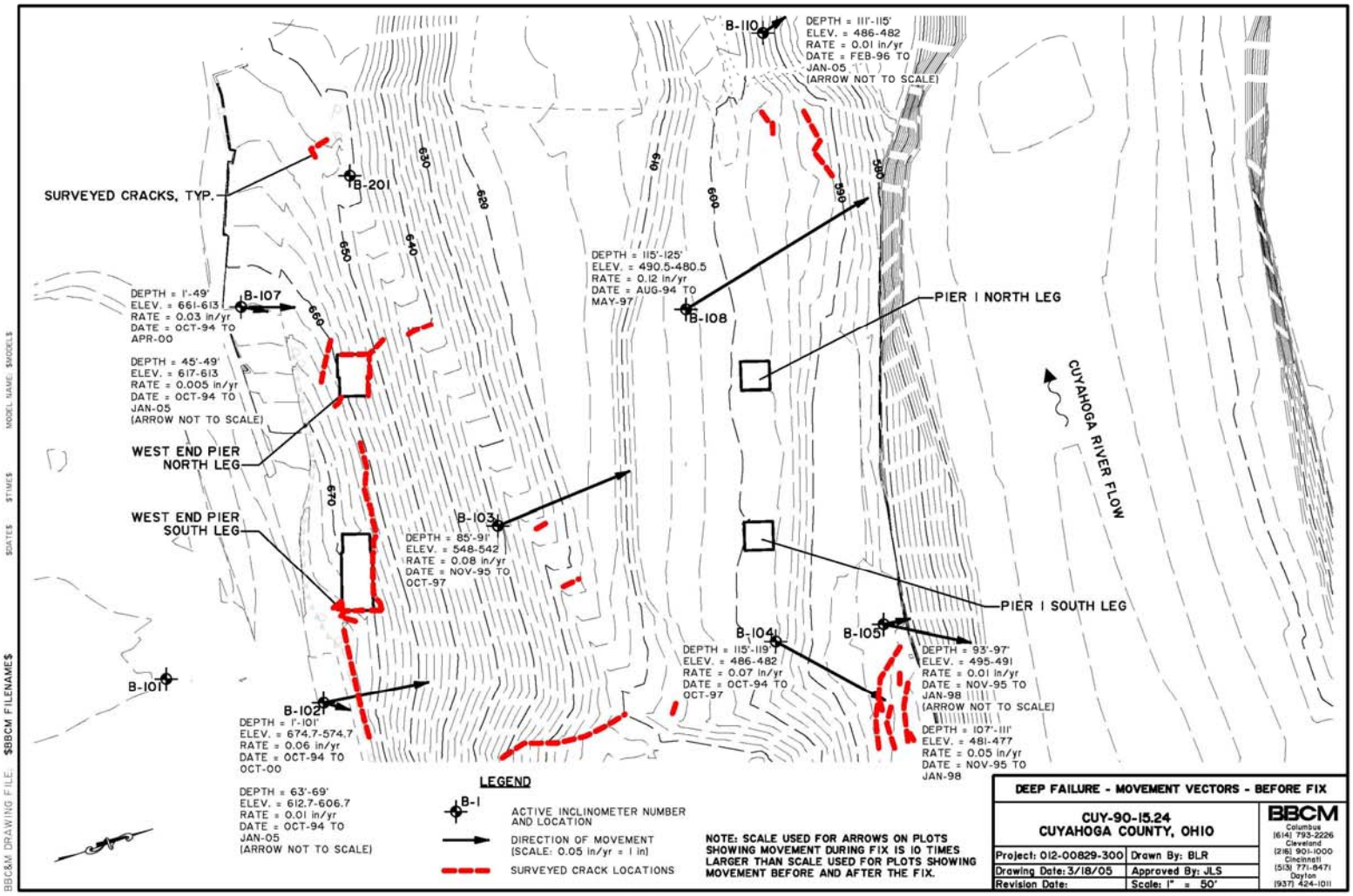


FIGURE 10

Plate 8: Movement vectors associated with the deep failure plane prior to constructing the stabilization structure. This figure was taken from BBCM's 2005 report to Richland Engineering.

PLATE 71

PLATE 72

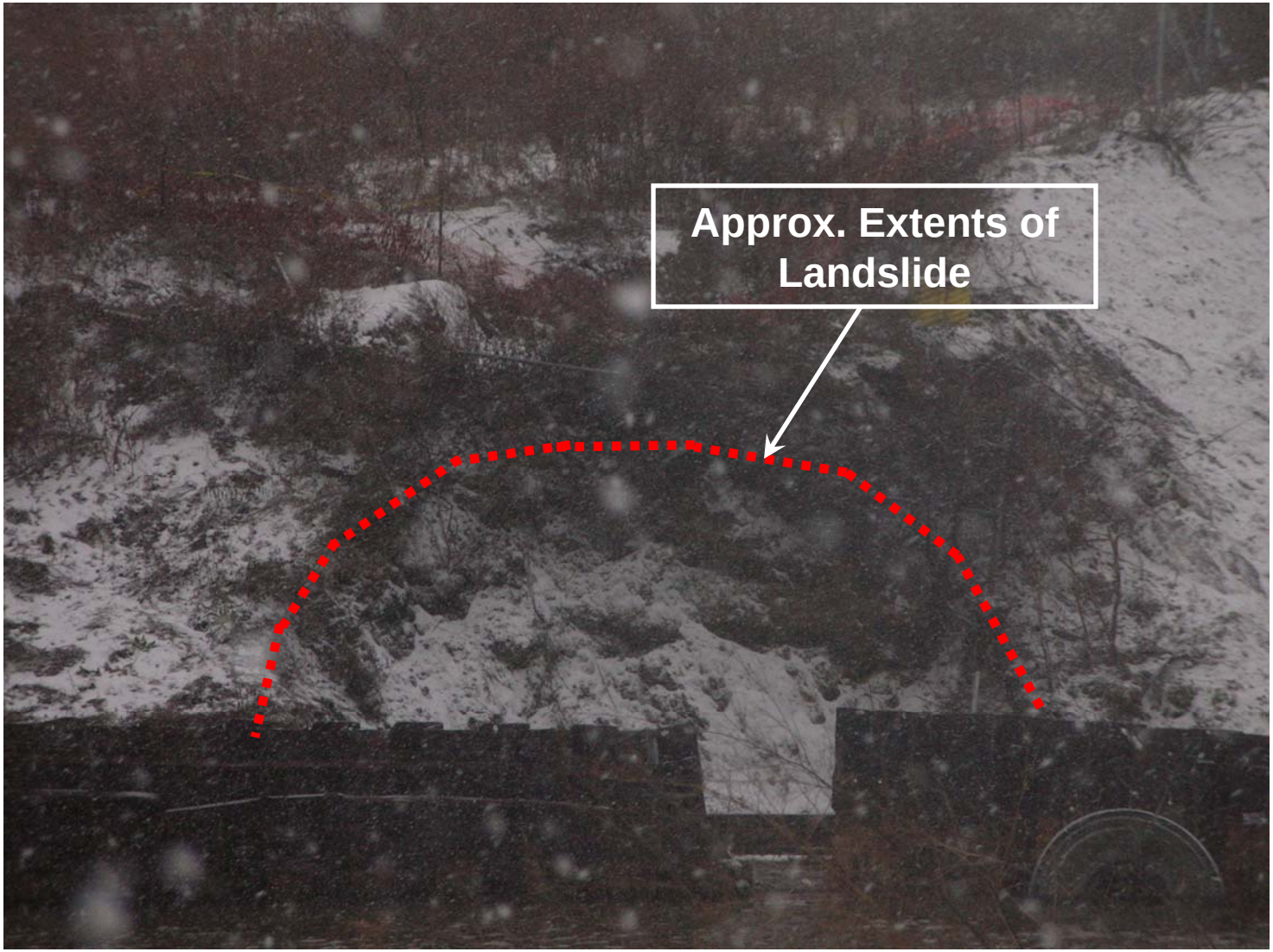


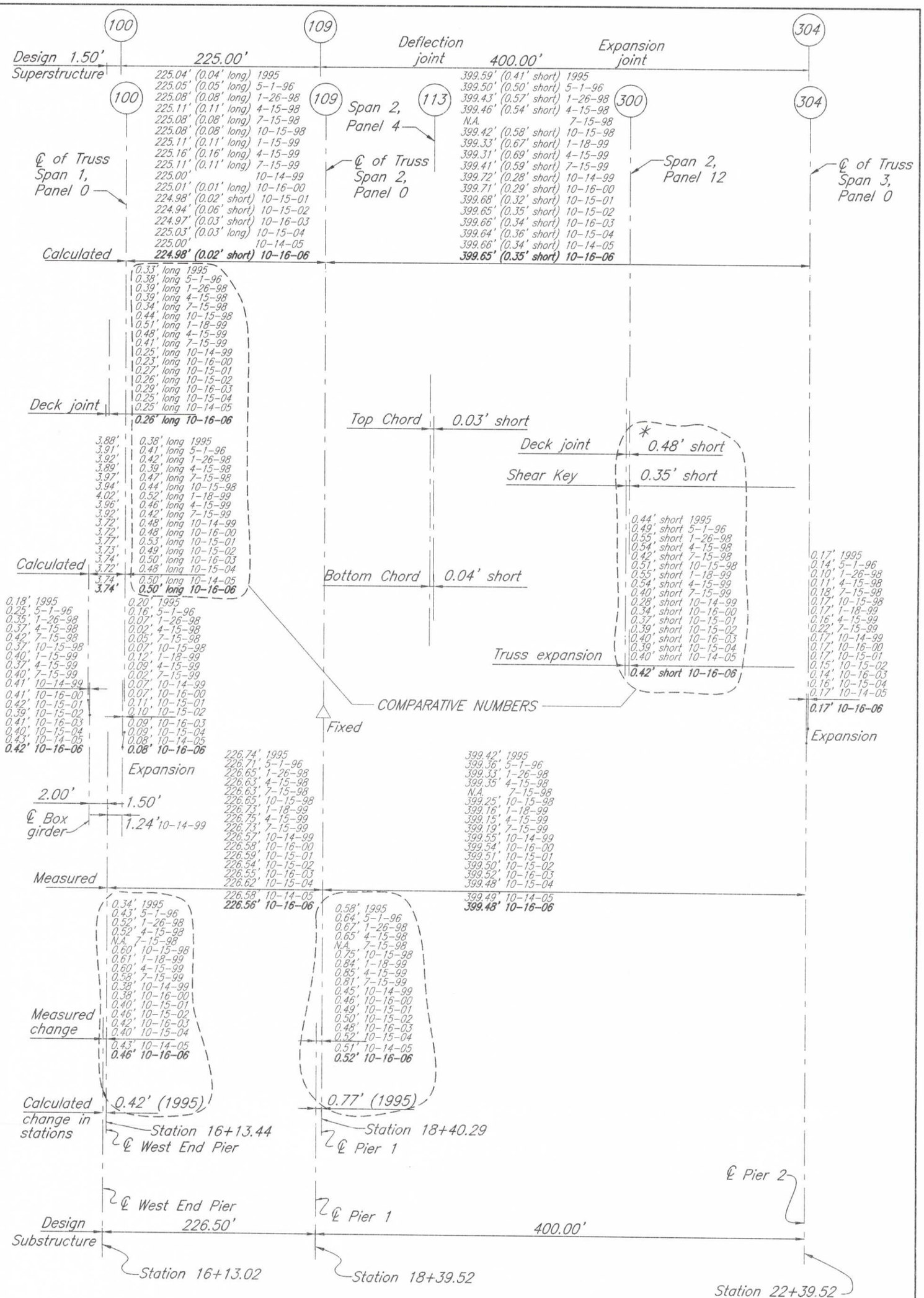
PLATE 73

PLATE 74

PLATE 75

PLATE 76

PLATE 77



*1972 Joint repositioned open 0.21'
1998 Joint closed 0.27'
0.48'

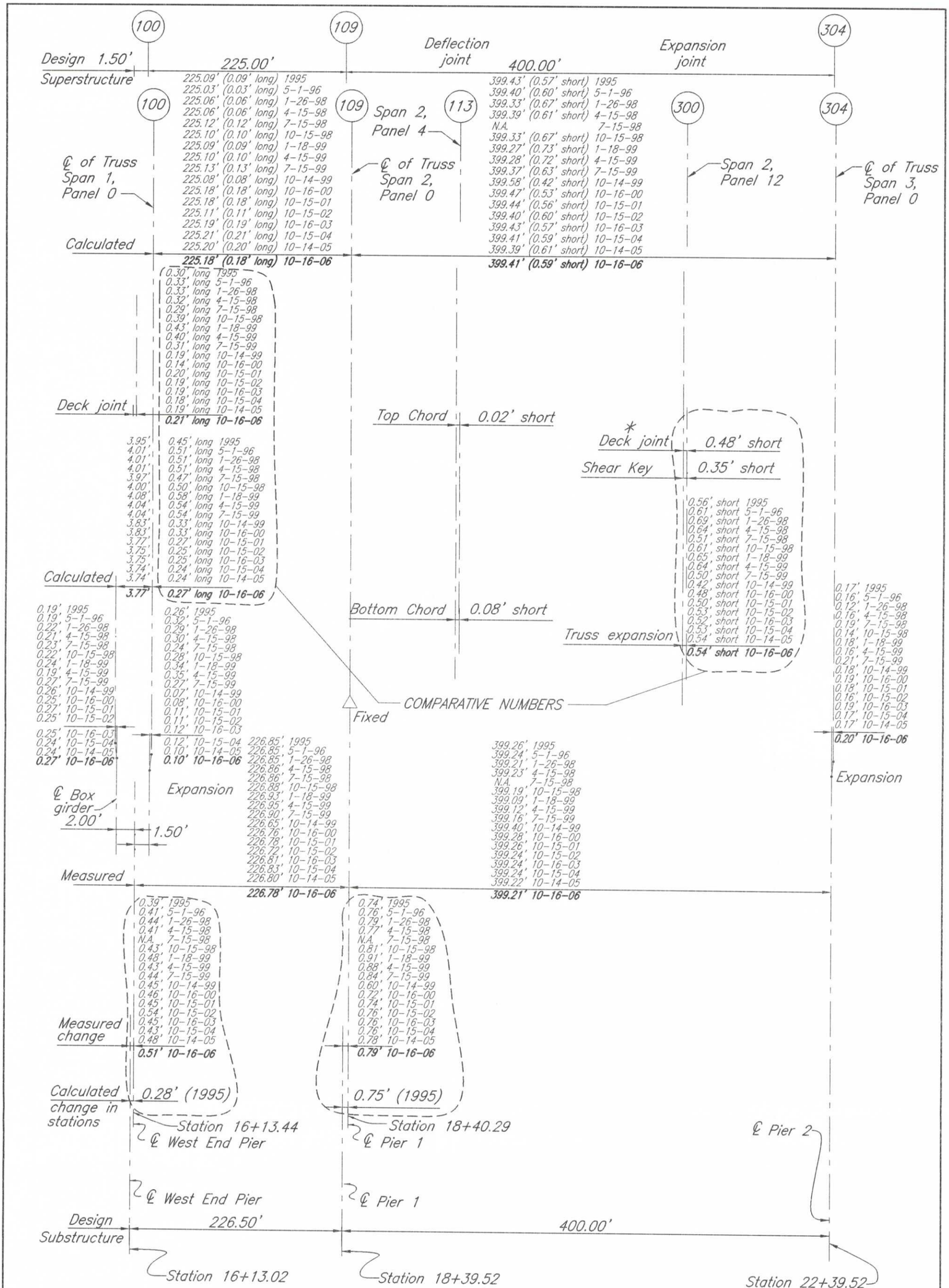
(100) – Panel Number given in Original Construction drawings

Summary of Truss Measurements

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

SCHEMATIC – NORTH TRUSS @ 60° F (10-16-06)
CUY-90-1524

10/31/2006 Measurements CUY90SCH.DWG



* 1972 Joint repositioned open 0.21'
1998 Joint closed 0.27'
0.48'

(100) – Panel Number given in Original Construction drawings

Summary of Truss Measurements

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

SCHEMATIC – SOUTH TRUSS @ 60° F (10-16-06)
CUY-90-1524

10/17/2006 Measurements/CUY90SCH.DWG

RELATIVE SPAN LENGTHS

(Distance between points set on consecutive piers)

	Span 1		Span 2	
	North Truss	South Truss	North Truss	South Truss
1985	215.35	215.30	399.49	399.74
1988	215.47	215.46	399.38	399.57
1989	215.48	215.44	399.36	399.59
1990	215.48	215.45	399.35	399.56
1991	215.48	215.42	399.29	399.57
1992	215.51	215.50	399.30	399.52
1993	215.46	215.49	399.34	399.51
1994	215.47	215.44	399.31	399.52
1995	215.49	215.45	399.34	399.55
5 / 1996	215.46	215.45	399.28	399.53
8 / 1996	215.45	215.46	399.28	399.54
9 / 1997	215.45	215.48	399.29	399.53
1 / 1998	215.40	215.45	399.25	399.50
4 / 1998	215.38	215.46	399.27	399.52
7 /1998	215.35	215.44	¥	¥
10 / 1998	215.40	215.48	399.16	399.47
12 / 1998	215.48	215.53	399.08	399.41
1 / 1999	215.48	215.53	399.08	399.39
4 / 1999	215.51	215.55	399.07	399.41
10 / 1999	215.48	215.50	399.11	399.45
***10/ 1999	215.56	215.66	398.98	399.25
10/2000	215.57	215.77	398.97	399.13
10/2001	215.58	215.79	398.94	399.12
10/2002	215.53	215.73	398.93	399.10
10/2003	215.55	215.82	398.95	399.10
10/2004	215.61	215.84	398.91	399.09
10/2005	215.58	215.81	398.92	399.08
Net Change	-0.00	0.13	-0.07	-0.19
Design	215.25	215.10	399.92	400.29
10/2006	215.55	215.79	398.91	399.06
Change from 10/05 to 10/06	-0.02	-0.02	-0.01	-0.01

¥ Points destroyed during construction. New points set atop of pier 2, first reading taken 10/15/98

Net change is current reading compared to the last compatible reading (10/1999)

*** Bridge relocated

CUY-90-1524
106017

DECK EXPANSION JOINT OPENINGS

Finger Type Joints

Measurements are in inches.

Date	Temp (F)	West End Pier North	West End Pier South	Near Pier 2 North	Near Pier 2 South	Near Pier 4 North	Near Pier 4 South
Expansion Distance		476 feet		650 feet			
Design	60˚	3.25	3.25	3.25	3.25	3.25	3.25
06-01-70	80˚	4.00		0.00		N.A.	
09-19-75	60˚	5.25		2.00		N.A.	
05-08-78	60˚	4.75	5.50	2.00	2.00	3.25	2.50
07-30-81	75˚	5.50	5.50	2.25	2.25	3.25	2.75
06-09-83	70˚	5.00	5.00	1.50	1.50	2.75	2.25
07-31-85	73˚	5.25	4.75	1.50	1.00	2.75	2.25
10-31-88	40˚	7.75	8.38	1.50	0.75	3.81	3.38
11-01-89	50˚	7.75	7.00	1.13	0.63	3.25	3.13
10-26-90	50˚	7.75	7.25	1.00	0.50	3.00	3.00
09-30-91	55˚	7.50	7.00	0.88	0.00	3.00	3.00
10-13-92	60˚	7.25	6.81	0.63	0.00	2.50	2.50
10-01-93	50˚	7.50	7.13	0.75	0.31	2.75	2.63
09-01-94	63˚	7.25	6.38	0.31	0.00	2.88	1.88
09-08-95	60˚	7.00	6.63	0.44	0.00	2.00	1.88
09-05-96	77˚	6.50	6.63	0.38	0.00	1.25	1.00
09-19-97	75˚	6.88	7.00	0.31	0.06	1.68	1.42
09-24-98	69˚	7.63	7.00	0.00	0.00	1.88	1.75
10-14-99	45˚	6.19	5.50	2.38	1.88	3.13	2.75
10-16-00	55˚	6.00	4.88	1.75	1.25	2.56	2.43
04-23-01	70˚	5.50	4.25	1.38	0.63	2.13	1.75
07-16-01	80˚	5.00	3.88	1.00	0.25	1.50	1.25
10-15-01	50˚	6.63	5.63	1.63	1.06	3.25	2.75

Date	Temp (F)	West End Pier		Near Pier 2		Near Pier 4	
		North	South	North	South	North	South
1-15-02	30˚	6.88	6.25	2.13	1.50	3.88	3.50
4-15-02	61˚	6.00	5.25	1.38	0.88	2.50	2.38
7-15-02	76˚	5.13	4.13	1.13	0.50	1.75	1.50
10-17-02	48˚	7.00	6.38	1.75	1.25	3.25	2.88
11-1-02	35˚	7.25	6.13	1.88	1.38	3.63	3.38
1-15-03	7˚	8.13	6.63	2.38	1.88	5.00	4.75
4-15-03	67˚	5.63	4.63	1.25	0.63	2.25	2.00
7-15-03	74˚	5.38	4.38	1.00	0.50	2.00	1.63
10-16-03	46˚	7.00	5.75	1.50	1.13	3.25	3.13
1-15-04	11˚	8.00	6.75	2.00	1.38	4.63	4.00
4-15-04	41˚	6.88	5.75	1.38	0.88	3.50	3.25
7-15-04	67˚	5.63	4.75	1.00	0.50	2.13	1.75
10-15-04	50˚	6.38	5.50	1.25	0.75	3.00	2.75
1-15-05	12˚	7.75	7.00	2.00	1.38	4.63	4.25
4-16-05	47˚	6.50	5.63	1.25	0.75	3.25	2.88
7-16-05	74˚	5.50	4.50	0.75	0.375	1.75	1.63
10-14-05	51˚	6.25	5.50	1.13	0.63	2.81	2.56
1-16-06	26˚	7.63	6.38	1.75	1.13	4.13	3.75
4-14-06	65˚	5.75	4.88	0.75	0.50	2.25	2.00
7-14-06	78˚	5.00	4.00	0.63	0.19	1.63	1.25
10-16-06	50˚	6.50	5.88	1.00	0.75	3.25	3.00
1-15-07	41˚	7.00	6.13	1.13	0.88	3.56	3.38
4-16-07	34˚	7.25	6.38	1.38	0.88	3.75	3.50

N.A. - No measurements available

SEAT ELEVATIONS

POINT NO.	DESCRIPTION	10/17/94	02/26/98	04/15/98	07/15/98	07/22/98	10/15/98	1/19/99	3/5/99	4/15/99	7/15/99	10/14/99	10/16/00	10/15/01	10/15/02	10/16/03	10/14/04	10/14/05	10/16/06
WEST END PIER SOUTH																			
103	ROD IN PIER SEAT	667.18	667.15	667.18	667.18	-	667.14	667.16	-	667.17	667.17	667.16	667.16	667.20	667.17	667.17	667.19	667.15	667.16
401	ROD IN SOUTH FACE	-	677.91	677.93	677.92	-	677.92	677.93	-	677.93	677.92	677.91	677.92	677.94	677.93	677.92	677.94	677.91	677.92
402	ROD IN NORTH FACE	-	670.79	670.81	670.80	-	670.78	670.80	-	670.79	670.80	670.78	670.80	670.83	670.80	670.80	670.81	670.78	670.79
WEST END PIER NORTH																			
	ROD IN PIER SEAT																		
102	Destroyed	667.04	667.03	667.07	667.05	-	667.04	667.03	-	667.04	-	-	-	-	-	-	-	-	-
802	(SET 7/16/99)									-	667.02	667.01	667.01	667.05	667.01	667.02	667.03	667.00	667.01
404	ROD IN NORTH FACE	-	660.83	660.86	660.86	-	660.82	660.88	-	660.84	660.85	660.84	660.84	660.87	660.85	660.84	660.86	660.82	660.83
PIER 1 NORTH																			
	ROD IN PIER SEAT																		
104	Destroyed	626.29	626.33	-	626.38	-	626.32	-	-	-	-	-	-	-	-	-	-	-	-
606	(SET 7/22/98)							626.35	-	626.33	626.34	626.33	626.33	626.34	626.30	626.33	626.34	626.31	626.29
607	(SET 12/29/98)							626.32	-	626.30	626.30	-	-	-	-	-	-	-	-
608	(SET 12/29/98)							626.24	-	626.21	626.21	626.22	626.23	626.23	626.22	626.23	626.23	626.20	626.19
609	(SET 12/29/98)							626.23	-	626.22	626.21	626.21	626.21	-	-	-	-	-	-
903	(SET 10/13/99)											626.30	626.30	626.30	626.33	626.30	626.30	626.27	626.26
902	(SET 10/13/99)											626.25	626.26	626.26	626.25	626.26	626.25	626.23	626.21
308	ROD IN NORTH FACE	-	604.51	-	-	-	604.48	604.51	-	604.55	604.52	604.50	604.50	604.52	604.51	604.51	604.52	604.49	604.48
407	ROD IN SOUTH FACE	-	-	-	-	-	604.25	§	-	604.26	604.28	604.23	604.24	604.27	604.25	604.25	604.26	604.23	604.20
PIER 1 SOUTH																			
	ROD IN PIER SEAT																		
105	Destroyed	626.25	626.27	-	626.34	626.32	626.28	-	-	-	-	-	-	-	-	-	-	-	-
602	(SET 7/22/98)	-	-	-	-	626.29	626.24	626.25	-	626.23	626.23	-	-	-	-	-	-	-	-
603	(SET 12/29/98)							626.26	-	626.25	626.24	-	-	-	-	-	-	-	-
604	(SET 12/29/98)							626.23	-	626.21	626.20	-	-	-	-	-	-	-	-
605	(SET 12/29/98)							626.24	-	626.22	626.21	-	-	-	-	-	-	-	-
901	(SET 10/13/99)											626.22	626.23	626.23	626.22	626.23	626.22	626.20	626.18
900	(SET 10/13/99)											626.21	626.22	626.22	626.21	626.22	626.21	626.19	626.17
306	ROD IN NORTH FACE	-	606.55	-	-	-	606.53	§	-	606.51	606.54	606.50	606.50	606.52	606.51	606.51	606.51	606.49	606.47
305	ROD IN SOUTH FACE	-	607.33	-	-	-	607.33	607.32	-	607.31	607.34	607.29	607.30	607.32	607.31	607.31	607.33	607.30	607.27
PIER 2 NORTH																			
	ROD IN PIER SEAT																		
601	(SET 7/22/98)	-	-	-	-	628.65	628.58	628.66	-	628.62	628.65	628.63	628.64	628.65	628.65	628.64	628.61	628.61	628.58
206	ROD IN SOUTH FACE	-	586.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
610	ROD IN SOUTH FACE	-	-	-	-	-	586.09	586.15	-	-	586.11	586.12	586.14	586.16	586.18	586.17	586.18	586.15	586.17
	(SET 7/22/98)																		
PIER 2 SOUTH																			
600	ROD IN PIER SEAT	-	-	-	-	628.78	628.72	628.77	-	628.76	628.78	628.76	628.78	628.78	628.76	628.77	628.73	628.75	628.72
	(SET 7/22/98)																		
207	ROD IN NORTH FACE	-	586.08	-	-	-	586.07	586.10	-	-	586.16	586.16	586.10	586.11	586.13	586.12	586.13	586.11	586.12
ANCHOR STRUCTURE																			
500	ROD SOUTH END	-	591.00	-	-	591.00	590.97	590.98	591.00	590.99	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
501	ROD CENTER +-	-	590.96	-	-	590.97	590.94	590.96	590.96	590.96	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
502	ROD NORTH END	-	590.98	-	-	590.99	590.97	590.99	590.99	590.99	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
DRILLED SHAFT CAP (SET 3/4/99)																			
700	BRASS DISK NORTH END	-	-	-	-	-	-	-	589.61	589.62	589.66	589.65	589.65	589.66	589.66	589.67	589.68	589.65	589.62
701	BRASS DISK CENTER +-	-	-	-	-	-	-	-	589.66	589.66	589.68	589.68	589.69	589.69	589.69	589.70	589.71	589.68	589.65
702	BRASS DISK SOUTH END	-	-	-	-	-	-	-	589.62	589.62	589.63	589.64	589.65	589.65	589.64	589.66	589.66	589.63	589.60
CONTROL POINT																			
64	PK IN CONC DRIVE	633.37	633.30	-	-	633.31	633.26	633.27	-	633.22	633.23	633.22	633.22	633.23	633.21	633.21	633.22	633.16 ***	633.15 ***

| Calculated from top of concrete using an average rod height
§ Shots were not taken due to heat tent for rock anchor placement procedure.
¥¥ No future shots will be taken due to anchor structure being buried
*** Head of Nail Missing

PIER SEAT COORDINATES

(Reference Point Locations on Top of Piers)

Pier	Direction	B&N 1985*	REL 1988‡	REL 1989‡	REL 1990‡	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 5/96	REL 8/96	REL 9/97	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 3/99	REL 4/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06
WEP North	N	5114.58	5114.53	5114.55	5114.55	5114.58	5114.64	5114.64	5114.65	5114.65	5114.67	5114.67	5114.68	5114.66	5114.65	5114.67	5114.66	5114.64	5114.68	N.A.	N.A.	5114.71	5114.69	5114.66	5114.65	5114.63	5114.67	5114.65	5114.64	5114.66	5114.63
	E	4840.08	4839.58	4839.59	4839.59	4839.59	4839.59	4839.62	4839.62	4839.60	4839.67	4839.67	4839.69	4839.75	4839.77	4839.82	4839.84	4839.83	4839.83	N.A.	N.A.	4839.81	4839.81	4839.85	4839.84	4839.85	4839.88	4839.85	4839.87	4839.90	4839.91
WEP South	N	5033.90	5033.84	5033.85	5033.86	5033.87	5033.96	5033.98	5033.98	5033.96	5033.98	5034.01	5033.96	5033.99	5033.99	5033.98	5033.99	NA	5033.99	N.A.	N.A.	5033.99	5033.96	5033.95	5033.94	5033.94	5033.94	5033.94	5033.95	5033.94	5033.96
	E	4839.62	4839.12	4839.14	4839.14	4839.12	4839.11	4839.14	4839.15	4839.13	4839.15	4839.13	4839.15	4839.16	4839.17	4839.20	4839.22	NA	4839.23	N.A.	N.A.	4839.19	4839.21	4839.22	4839.22	4839.24	4839.26	4839.19	4839.21	4839.25	4839.27
Pier 1 North	N	5124.44	5124.42	5124.40	5124.43	5124.39	5124.46	5124.50	5124.47	5124.44	5124.44	5124.48	5124.46	5124.47	5124.46	5124.46	5124.47	5124.47 £	5124.47	N.A.	N.A.	5124.46	5124.48	5124.42	5124.43	5124.44	5124.43	5124.43	5124.47	5124.45	5124.46
	E	5055.20	5054.83	5054.84	5054.84	5054.85	5054.88	5054.86	5054.86	5054.87	5054.91	5054.90	5054.92	5054.93	5054.94	5054.95	5055.02	5055.09 £	5055.09	N.A.	N.A.	5055.10	5055.07	5055.18	5055.19	5055.21	5055.19	5055.18	5055.25	5055.25	5055.24
Pier 1 South	N	5034.50	5034.49	5034.49	5034.53	5034.45	5034.53	5034.57	5034.55	5034.52	5034.54	5034.56	5034.54	5034.55	5034.54	5034.53	5034.57	5034.55 £	5034.56	N.A.	N.A.	5034.57	5034.56	5034.60	5034.59	5034.61	5034.64	5034.62	5034.65	5034.65	5034.66
	E	5054.91	5054.59	5054.58	5054.60	5054.54	5054.60	5054.62	5054.59	5054.57	5054.60	5054.59	5054.63	5054.61	5054.63	5054.64	5054.70	5054.73 £	5054.76	N.A.	N.A.	5054.74	5054.71	5054.89	5054.99	5055.03	5054.99	5055.00	5055.05	5055.06	5055.06
Pier 2 North	N	5124.60	5124.53	5124.55	5124.57	5124.43	5124.46	5124.45	5124.48	5124.40	5124.40	5124.40	5124.41	5124.37	5124.40	¥	5124.44	5124.42	5124.42	N.A.	N.A.	5124.43	5124.41	5124.40	5124.39	5124.41	5124.39	5124.42	5124.43	5124.41	5124.43
	E	5454.68	5454.21	5454.21	5454.20	5454.14	5454.18	5454.20	5454.18	5454.21	5454.19	5454.19	5454.21	5454.17	5454.21	¥	5454.18	5454.17	5454.17	N.A.	N.A.	5454.17	5454.18	5454.16	5454.16	5454.15	5454.12	5454.13	5454.16	5454.17	5454.15
Pier 2 South	N	5024.98	5024.89	5024.91	5024.91	5024.78	5024.81	5024.81	5024.84	5024.74	5024.76	5024.76	5024.76	5024.75	5024.78	¥	5024.72	5024.73	5024.73	N.A.	N.A.	5024.73	5024.70	5024.71	5024.69	5024.68	5024.73	5024.71	5024.72	5024.73	5024.73
	E	5454.54	5454.04	5454.06	5454.04	5453.99	5454.01	5454.01	5453.99	5454.00	5454.01	5454.00	5454.04	5453.99	5454.03	¥	5454.05	5454.03	5454.03	N.A.	N.A.	5454.03	5454.04	5454.02	5454.00	5454.02	5453.96	5453.98	5454.01	5454.02	5454.00
Anchor Structure North	N													5143.42	5143.42	5143.45	5143.44	NA	5143.44	5143.39	5143.41	5143.43	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
	E													5018.39	5018.44	5018.44	5018.50	NA	5018.54	5018.55	5018.56	5018.52	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure Center	N													5075.81	5075.77	5075.82	5075.81	NA	5075.82	5075.78	5075.80	5075.82	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
	E													5018.37	5018.40	5018.48	5018.48	NA	5018.58	5018.58	5018.59	5018.53	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure South	N													5009.41	5009.36	5009.42	5009.42	NA	5009.42	5009.40	5009.40	5009.41	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
	E													5018.53	5018.56	5018.61	5018.61	NA	5018.75	5018.77	5018.78	5018.71	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Drilled Shaft Cap North	N																			5138.49	5138.50	5138.53	5138.52	5138.49	5138.52	5138.52	5138.52	5138.53	5138.55	5138.55	5138.55
	E																			5109.81	5109.81	5109.78	5109.77	5109.80	5109.80	5109.81	5109.84	5109.82	5109.83	5109.83	5109.84
Drilled Shaft Cap Center	N																			5074.42	5074.41	5074.43	5074.44	5074.40	5074.43	5074.43	5074.45	5074.45	5074.46	5074.47	5074.46
	E																			5109.81	5109.82	5109.79	5109.78	5109.81	5109.81	5109.83	5109.84	5109.84	5109.84	5109.87	5109.86
Drilled Shaft Cap South	N																			5010.31	5010.32	5010.33	5010.33	5010.31	5010.32	5010.33	5010.35	5010.35	5010.36	5010.36	5010.37
	E																			5109.83	5109.83	5109.80	5109.80	5109.83	5109.84	5109.87	5109.89	5109.89	5109.92	5109.92	5109.92

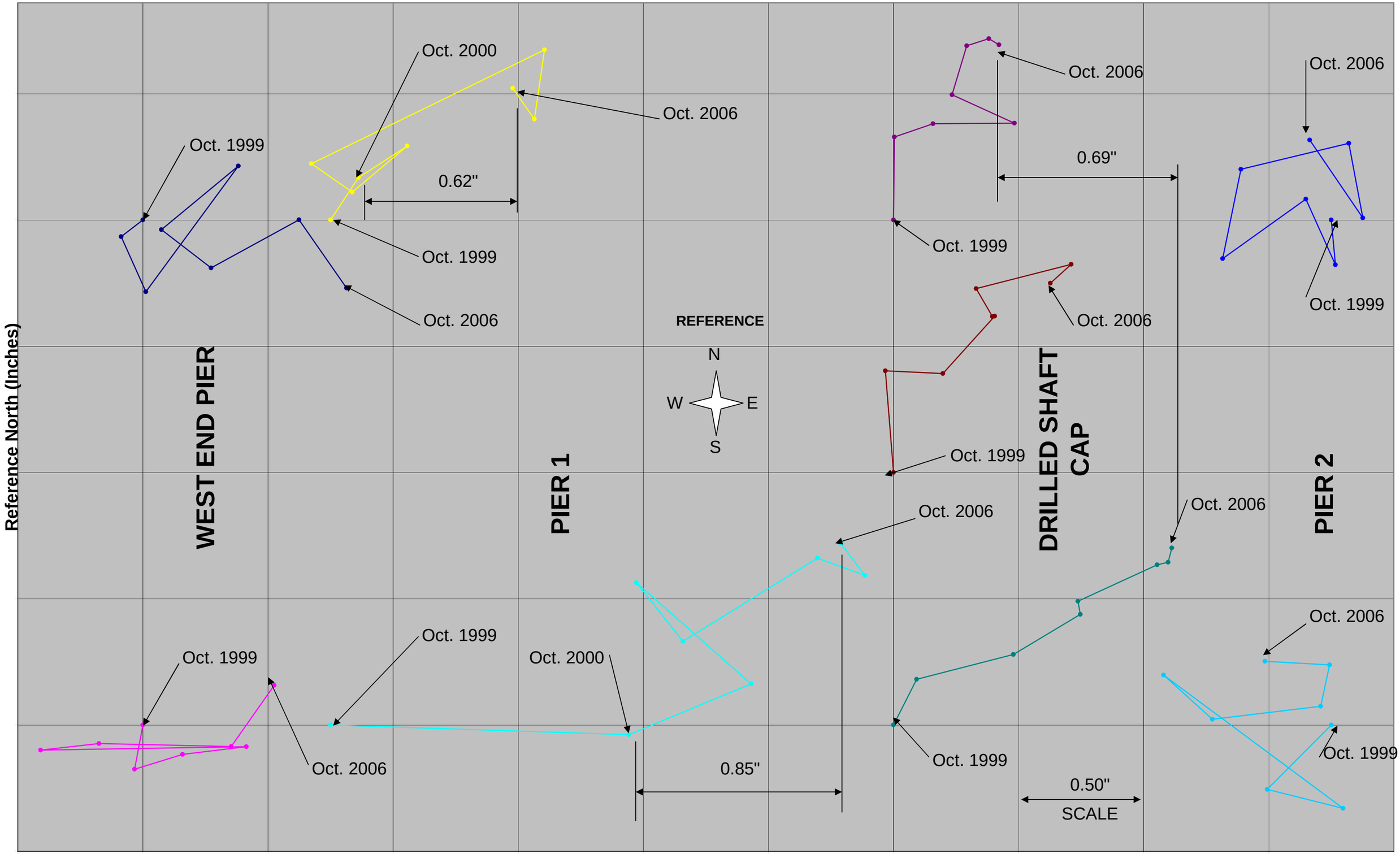
* Monumentation damaged by earth moving operations.

‡ Monuments appear to have been displaced 6" along the bridge.

¥ Points destroyed durning construction. New points set. First reading taken 10/15/98

£ Monumentation removed for new pier caps for jacking procedure. New points set and first readings taken 12/29/98

¥¥ No future shots will be taken due to anchor structure being buried


Reference North (Inches)
WEST END PIER
Oct. 1999
Oct. 2000
Oct. 2006
0.62"
Oct. 1999
Oct. 2006
PIER 1
REFERENCE
N
W
E
S
Oct. 2006
0.69"
Oct. 1999
DRILLED SHAFT CAP
Oct. 2006
Oct. 1999
PIER 2
Oct. 2006
Oct. 1999
Oct. 1999
Oct. 2006
Oct. 1999
Oct. 2000
0.85"
Oct. 2006
Oct. 1999
0.50"
SCALE
Reference East (Inches)
PIER SEAT COORDINATES

DIFFERENTIAL MOVEMENT

(A positive value indicates movement to the north or east.
A negative value indicates movement to the south or west.)

Pier	Point	Direction	85-88 *	88-89 ‡	89-90 ‡	90-91 ‡	91-92	92-93	93-94	94-95	95-5/96	95-8/96	8/96-97	97-1/98	1/98-4/98	4/98-7/98	7/98-10/98	10/98-12/98	10/98-1/99	1/99-3/99	3/99-4/99	1/99-4/99	4/99-7/99	7/99-10/99	10/99-10/00	10/00-10/01	10/01-10/02	10/02-10/03	10/03-10/04	10/04-10/05	10/05-10/06	¤ Net Change
WEP North	50	N	-0.05	0.03	-0.00	0.03	0.06	-0.00	0.00	0.00	0.02	0.00	0.01	-0.02	-0.01	0.02	-0.01	-0.02	0.04	NA	NA	0.03	-0.02	-0.03	-0.01	-0.02	0.04	-0.02	-0.01	0.02	-0.02	0.11
Pier Seat		E	-0.50	0.01	0.01	-0.00	0.00	0.03	-0.00	-0.02	0.07	-0.00	0.02	0.06	0.02	0.05	0.02	-0.01	-0.00	NA	NA	-0.02	0.00	0.03	-0.01	0.01	0.03	-0.03	0.02	0.03	0.02	0.33
WEP South	60	N	-0.05	0.01	0.01	0.01	0.09	0.02	-0.00	-0.02	0.02	0.03	-0.04	0.03	-0.00	-0.01	0.01	NA	0.04	NA	NA	-0.01	-0.03	-0.01	-0.01	0.00	0.00	-0.00	0.00	-0.00	0.02	0.12
Pier Seat		E	-0.50	0.02	0.00	-0.02	-0.02	0.03	0.01	-0.02	0.03	-0.02	0.02	0.01	0.01	0.03	0.02	NA	0.03	NA	NA	-0.04	0.02	0.02	-0.00	0.02	0.02	-0.07	0.02	0.04	0.01	0.14
Pier 1 North	30	N	-0.02	-0.02	0.03	-0.04	0.07	0.04	-0.03	-0.03	0.00	0.04	-0.01	0.00	-0.01	0.00	0.01	-0.01	0.00	NA	NA	-0.01	0.02	-0.06	0.01	0.01	-0.02	0.01	0.04	-0.02	0.01	0.04
Pier Seat		E	-0.37	0.01	0.00	0.01	0.03	-0.02	0.00	0.01	0.04	-0.01	0.01	0.01	0.01	0.02	0.07	0.07	0.00	NA	NA	0.01	-0.02	0.11	0.01	0.02	-0.02	-0.01	0.08	-0.00	-0.01	0.41
Pier 1 South	40	N	-0.01	0.01	0.04	-0.08	0.08	0.04	-0.02	-0.03	0.02	0.02	-0.02	0.01	-0.01	-0.01	0.04	-0.02	0.01	NA	NA	0.01	-0.01	0.04	-0.00	0.02	0.03	-0.02	0.03	-0.01	0.01	0.17
Pier Seat		E	-0.33	-0.00	0.01	-0.06	0.06	0.02	-0.04	-0.01	0.03	-0.02	0.04	-0.02	0.02	0.01	0.06	0.03	0.03	NA	NA	-0.02	-0.03	0.18	0.10	0.04	-0.04	0.02	0.04	0.02	-0.01	0.47
Pier 2 North	10	N	-0.06	0.02	0.02	-0.14	0.02	-0.01	0.02	-0.07	-0.00	0.00	0.01	-0.05	0.03	NA	§	-0.02	0.00	NA	NA	0.01	-0.02	-0.01	-0.01	0.02	-0.02	0.03	0.01	-0.02	0.03	-0.01
Pier Seat		E	-0.47	-0.00	-0.01	-0.05	0.03	0.02	-0.02	0.03	-0.01	-0.01	0.03	-0.04	0.04	NA	§	-0.01	0.00	NA	NA	-0.00	0.02	-0.03	0.00	-0.01	-0.03	0.01	0.04	0.00	-0.02	-0.03
Pier 2 South	20	N	-0.09	0.01	0.00	-0.13	0.03	-0.00	0.03	-0.10	0.01	0.01	-0.00	-0.02	0.03	NA	§	0.01	0.00	NA	NA	-0.00	-0.03	0.01	-0.02	-0.01	0.04	-0.01	0.00	0.01	0.00	0.01
Pier Seat		E	-0.50	0.01	-0.01	-0.05	0.02	0.01	-0.02	0.01	0.01	-0.01	0.03	-0.05	0.04	NA	§	-0.03	0.00	NA	NA	0.00	0.01	-0.02	-0.02	0.03	-0.06	0.02	0.04	0.00	-0.02	-0.06
Anchor Structure	502	N												¥	-0.00	0.03	-0.01	NA	0.02	-0.05	0.01	0.02	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
North		E												¥	0.05	0.01	0.05	NA	0.07	0.01	0.01	-0.04	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure	501	N												¥	-0.04	0.05	-0.00	NA	0.05	-0.03	0.02	0.02	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Center		E												¥	0.03	0.08	0.00	NA	0.07	-0.00	0.01	-0.06	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure	500	N												¥	-0.05	0.06	-0.01	NA	0.03	-0.02	-0.00	0.01	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
South		E												¥	0.03	0.05	-0.00	NA	0.06	0.03	0.01	-0.07	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Drilled Shaft Cap	700	N																		£	0.01	0.03	-0.01	-0.03	0.03	0.00	0.00	0.01	0.02	0.00	-0.00	0.06
North		E																		£	-0.00	-0.03	-0.01	0.03	0.00	0.01	0.03	-0.02	0.00	0.01	0.00	0.03
Drilled Shaft Cap	701	N																		£	-0.00	0.02	0.00	-0.04	0.03	-0.00	0.02	-0.00	0.01	0.01	-0.01	0.05
Center		E																		£	0.01	-0.04	-0.00	0.02	-0.00	0.02	0.02	-0.00	-0.01	0.03	-0.01	0.05
Drilled Shaft Cap	702	N																		£	0.01	0.01	0.01	-0.02	0.02	0.01	0.01	0.00	0.01	0.00	0.00	0.05
South		E																		£	0.01	-0.04	0.00	0.03	0.01	0.03	0.02	-0.00	0.03	0.00	0.00	0.09

* Monumentation damaged by earth moving operations.

‡ Monuments appear to have been displaced 6" along the bridge.

¥ First measurements taken 2/26/98

§ First measurements taken 10/15/98

¤ Net change is initial reading compared to the last compatible reading

£ First measurements taken 3/08/99

¥¥ No future shots will be taken due to anchor structure being buried

PIER SIDE COORDINATES

(Reference Point Locations on Sides of Piers)

Pier	Direction	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 5/96	REL 8/96	REL 1997	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06
WEP North (Inside)	N	5162.58	5162.67	5162.69	5161.99	5162.66	-------	5161.00	5160.98	5160.96	5160.92	5160.94	5160.96	5160.89	5160.93	5160.93	5160.90	5160.89	5160.89	5160.88	5160.86	5160.89	5160.90	5160.90	5160.90
	E	4879.46	4879.32	4879.17	4878.94	4879.23	-------	4884.16	4884.18	4884.26	4884.27	4884.27	4884.22	4884.30	4884.32	4884.29	4884.29	4884.29	4884.30	4884.33	4884.34	4884.29	4884.34	4884.34	4884.35
WEP North (Outside)	N	-------	-------	5184.24	NA	5184.22	-------	5184.04	5184.03	5183.97	5183.98	5183.99	5183.94	5183.99	5184.01	5184.06	5184.06	5184.06	5184.04	5184.04	5184.03	5184.04	5184.03	5183.98	5184.03
	E	-------	-------	4887.48	NA	4887.51	-------	4888.05	4888.09	4888.14	4888.16	4888.19	4888.24	4888.20	4888.19	4888.21	4888.23	4888.23	4888.25	4888.25	4888.28	4888.28	4888.26	4888.26	4888.28
WEP South (Inside)	N	5088.80	5088.86	5088.87	5088.86	5088.85	-------	5076.56	5076.51	5076.53	5076.52	5076.50	5076.49	5076.53	5076.53	5076.49	5076.53	5076.51	5076.45	5076.42	5076.46	5076.45	5076.46	5076.43	5076.46
	E	4854.36	4854.51	4854.43	4854.46	4854.43	-------	4857.97	4857.97	4857.98	4858.01	4858.02	4858.10	4858.02	4858.05	4858.00	4858.02	4858.03	4858.01	4858.02	4858.04	4858.03	4858.04	4858.05	4858.07
WEP South (Outside)	N	-------	-------	5051.47	5051.45	5051.45	-------	5051.41	5051.37	5051.40	5051.38	5051.34	5051.40	NA	5051.37	5051.35	5051.34	5051.33	5051.32	5051.30	5051.33	5051.34	5051.33	5051.34	5051.34
	E	-------	-------	4840.79	4840.84	4840.80	-------	4841.07	4841.08	4841.07	4841.08	4841.07	4841.04	NA	4841.10	4841.08	4841.08	4841.08	4841.08	4841.08	4841.12	4841.07	4841.09	4841.09	4841.11
Pier 1 North (Inside)	N	-------	-------	5087.19	5087.15	5087.09	-------	5086.18	5086.17	5086.17	5086.14	5086.14	5086.16	§	§	5086.13	5086.09	5086.06	5086.08	5086.06	5086.06	5086.05	5086.07	5086.10	5086.08
	E	-------	-------	5093.22	5093.16	5093.17	-------	5095.93	5095.94	5095.94	5096.01	5096.03	5096.01	§	§	5096.16	5096.15	5096.17	5096.16	5096.21	5096.20	5096.19	5096.23	5096.23	5096.22
Pier 1 North (Outside)	N	-------	-------	5100.04	NA	5100.11	5100.12	5100.13	5100.13	5100.12	5100.13	5100.12	5100.06	5100.08	5100.09	5100.12	5100.06	5100.03	5100.09	5100.04	5099.98	5100.01	5099.99	5099.99	5099.99
	E	-------	-------	5098.27	NA	5098.01	5098.03	5098.06	5098.08	5098.08	5098.11	5098.15	5098.22	5098.24	5098.24	5098.24	5098.25	5098.27	5098.30	5098.29	5098.31	5098.32	5098.31	5098.32	5098.33
Pier 1 South (Inside)	N	5014.59	5014.57	5014.66	5014.61	5014.55	5014.59	5014.60	5014.61	5014.62	5014.61	5014.61	5014.56	§	§	5014.59	5014.53	5014.53	5014.54	5014.52	5014.53	5014.55	5014.55	5014.53	5014.56
	E	5068.67	5068.93	5068.70	5068.68	5068.65	5068.68	5068.68	5068.70	5068.67	5068.70	5068.74	5068.78	§	§	5068.84	5068.87	5068.96	5068.94	5068.99	5069.04	5069.04	5069.01	5069.03	5069.02
Pier 1 South (Outside)	N	-------	-------	5001.94	5001.90	5001.87	5001.89	5001.90	5001.87	5001.90	5001.86	5001.86	5001.91	5001.83	5001.84	5001.84	5001.83	5001.80	5001.82	5001.81	5001.81	5001.80	5001.81	5001.83	5001.86
	E	-------	-------	5063.39	5063.42	5063.34	5063.39	5063.41	5063.42	5063.38	5063.43	5063.46	5063.42	5063.56	5063.58	5063.56	5063.61	5063.69	5063.69	5063.70	5063.74	5063.74	5063.76	5063.75	5063.78
Pier 2 North (Inside)	N	4954.01	4953.99	4953.99	4953.97	4953.95	4953.95	4953.97	NA	4953.95	4953.95	¥	4953.96	4953.96	4953.93	4953.93	4953.92	4953.94	4953.96	4953.94	4953.94	4953.95	4953.96	4953.97	4953.98
	E	5469.91	5470.01	5470.04	5469.99	5470.02	5470.03	5470.00	NA	5470.03	5470.03	¥	5469.96	5469.97	5470.05	5470.01	5470.01	5469.99	5469.99	5470.02	5470.00	5469.97	5469.97	5469.98	5469.97
Pier 2 South (Inside)	N	4883.44	4883.44	4883.44	4883.46	4883.38	4883.39	4883.40	NA	4883.31	4883.37	‡	4883.33	4883.40	4883.35	4883.42	4883.44	4883.40	4883.37	4883.34	4883.37	4883.36	4883.35	4883.39	4883.38
	E	5445.32	5445.45	5445.46	5445.41	5445.40	5445.40	5445.36	NA	5445.37	5445.39	‡	5445.45	5445.40	5445.50	5445.35	5445.37	5445.38	5445.41	5445.42	5445.40	5445.39	5445.41	5445.41	5445.40

-------	No reading taken (point not yet set).
NA	Information not available.
¥	Points destroyed during construction. New points set
‡	Unable to shoot points due to rock piles next to piers
§	Shots were not taken due to heat tent for rock anchor placement procedure.

PIER TILT

(The difference between the coordinates of the points set on the pier seat and the points at the ground line using the first year measured as the zero point. A positive value indicates top tilt to the north or east. A negative value indicates top tilt to the south or west.)

Pier	Direction	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 8/96	REL 9/97	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06
WEP North (Inside)	N	=====	-0.03	-0.05	0.66	-0.01	=====	0.03	0.03	0.06	0.06	0.02	0.08	0.07	0.10	0.12	0.10	0.10	0.08	0.14	0.09	0.08	0.09	0.07
	E	=====	0.14	0.32	0.55	0.24	=====	-0.00	-0.02	-0.00	0.04	0.11	0.03	0.00	0.01	0.01	0.04	0.02	0.01	0.03	0.05	0.02	0.04	0.05
WEP North (Outside)	N	=====	-------	=====	NA	0.03	=====	0.02	0.06	0.04	0.05	0.08	0.02	0.03	0.02	-0.00	-0.04	-0.02	-0.04	0.01	-0.02	-0.03	0.04	-0.03
	E	=====	-------	=====	NA	-0.04	=====	-0.02	-0.01	-0.01	0.01	-0.02	0.01	0.02	-0.03	-0.04	-0.01	-0.03	-0.03	-0.03	-0.05	-0.02	0.02	0.01
WEP South (Inside)	N	=====	0.02	0.03	0.04	0.03	=====	0.01	0.02	0.02	0.03	0.05	-0.03	0.01	0.04	-0.02	-0.00	0.03	0.07	0.04	0.04	0.04	0.07	0.06
	E	=====	-0.16	-0.05	-0.08	-0.06	=====	0.02	0.02	0.00	0.02	-0.05	0.02	0.02	0.03	0.02	0.03	0.04	0.05	0.06	-0.01	0.01	0.04	0.04
WEP South (Outside)	N	=====	-------	=====	0.01	-0.01	=====	-0.01	-0.01	0.02	0.03	-0.01	NA	0.02	0.03	0.02	0.02	0.02	0.04	0.01	0.01	0.01	0.01	0.02
	E	=====	-------	=====	-0.05	-0.02	=====	0.01	0.03	0.04	0.07	0.12	NA	0.07	0.05	0.07	0.09	0.08	0.10	0.08	0.06	0.06	0.10	0.10
Pier 1 North (Inside)	N	=====	-------	=====	0.01	0.03	=====	-0.00	0.00	0.02	0.03	0.02	NA	NA	0.04	0.09	0.06	0.06	0.09	0.07	0.09	0.11	0.05	0.08
	E	=====	-------	=====	0.06	0.06	=====	0.01	0.02	-0.04	-0.04	0.04	NA	NA	-0.03	-0.05	0.05	0.06	0.03	0.02	0.01	0.06	0.05	0.05
Pier 1 North (Outside)	N	=====	-------	=====	NA	-0.14	-0.11	-0.13	-0.12	-0.13	-0.13	-0.05	-0.08	-0.09	-0.13	-0.05	-0.08	-0.12	-0.06	-0.02	-0.04	0.02	-0.00	0.01
	E	=====	-------	=====	NA	0.27	0.26	0.25	0.26	0.24	0.22	0.21	0.26	0.26	0.27	0.24	0.33	0.30	0.33	0.30	0.27	0.35	0.35	0.33
Pier 1 South (Inside)	N	=====	0.10	0.05	0.07	0.11	0.09	0.06	0.06	0.07	0.05	0.15	NA	NA	0.12	0.16	0.20	0.18	0.22	0.24	0.21	0.23	0.24	0.23
	E	=====	-0.20	0.05	0.03	0.05	0.04	0.05	0.07	0.06	0.02	0.05	NA	NA	0.03	-0.03	0.05	0.17	0.17	0.08	0.09	0.16	0.16	0.16
Pier 1 South (Outside)	N	=====	-------	=====	0.01	0.02	0.02	0.04	0.02	0.05	0.04	0.02	0.09	0.09	0.10	0.09	0.16	0.14	0.17	0.20	0.19	0.21	0.19	0.16
	E	=====	-------	=====	-0.07	-0.01	-0.06	-0.03	-0.01	-0.04	-0.06	0.04	-0.07	-0.06	-0.06	-0.13	-0.04	0.06	0.10	0.01	0.03	0.05	0.08	0.04
Pier 2 North (Inside)	N	=====	0.04	0.03	0.07	0.03	0.01	NA	-0.01	0.03	NA	=====	0.03	0.06	0.06	0.06	0.03	0.00	0.04	0.02	0.04	0.04	0.01	0.02
	E	=====	-0.07	-0.08	-0.05	-0.04	-0.04	NA	-0.09	-0.05	NA	=====	-0.03	-0.12	-0.08	-0.06	-0.07	-0.07	-0.10	-0.12	-0.08	-0.04	-0.04	-0.05
Pier 2 South (Inside)	N	=====	0.03	0.03	0.04	0.03	0.02	NA	0.10	0.07	NA	=====	-0.00	0.04	-0.03	-0.08	-0.03	-0.02	0.01	0.02	0.01	0.02	0.00	0.02
	E	=====	-0.11	-0.11	-0.08	-0.07	-0.03	NA	-0.05	-0.03	NA	=====	-0.04	-0.14	0.02	0.00	-0.02	-0.08	-0.06	-0.11	-0.07	-0.06	-0.06	-0.07

-------	No reading taken. (Point not set.)
=====	First reading (Point set/reset)
NA	Information Not Available

CHANGE IN PIER TILTS

(The change in tilts are difference between the coordinates and elevations of the points set on the pier seat and side of the pier. The first angle of compatible data is set to zero and compared to the preceding years A positive value indicates top tilt to the north or east. A negative value indicates top tilt to the south or west.)

Pier	Direction	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 8/96	REL 9/97	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06
WEP North (Inside)	N	NA	NA	NA	NA	NA	0.00 º	0.01 º	0.00 º	0.01 º	0.01 º	0.00 º	0.01 º	0.01 º	0.02 º	0.02 º	0.02 º	0.02 º	0.01 º	0.02 º	0.01 º	0.01 º	0.01 º	0.01 º
	E	NA	NA	NA	NA	NA	0.00 º	-0.00 º	-0.00 º	-0.00 º	0.01 º	0.02 º	0.00 º	0.00 º	0.00 º	0.00 º	0.01 º	0.00 º	0.00 º	0.00 º	0.01 º	0.00 º	0.01 º	0.01 º
WEP North (Outside)	N	NA	NA	NA	NA	NA	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	0.01 º	0.00 º	0.00 º	0.00 º	-0.00 º	-0.00 º	-0.00 º	-0.00 º	0.00 º	-0.00 º	-0.00 º	0.00 º	-0.00 º
	E	NA	NA	NA	NA	NA	0.00 º	-0.00 º	-0.00 º	-0.00 º	0.00 º	-0.00 º	0.00 º	0.00 º	-0.00 º	-0.01 º	-0.00 º	-0.00 º	-0.00 º	-0.00 º	-0.01 º	-0.00 º	0.00 º	0.00 º
WEP South (Inside)	N	NA	NA	NA	NA	NA	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	0.01 º	-0.00 º	0.00 º	0.01 º	-0.00 º	-0.00 º	0.00 º	0.01 º	0.00 º	0.00 º	0.00 º	0.01 º	0.01 º
	E	NA	NA	NA	NA	NA	0.00 º	0.01 º	0.01 º	0.00 º	0.01 º	-0.03 º	0.01 º	0.01 º	0.02 º	0.01 º	0.02 º	0.03 º	0.03 º	0.03 º	-0.00 º	0.00 º	0.02 º	0.02 º
WEP South (Outside)	N	NA	NA	NA	NA	NA	0.00 º	-0.01 º	-0.01 º	0.02 º	0.05 º	-0.02 º	NA	0.03 º	0.05 º	0.03 º	0.03 º	0.02 º	0.05 º	0.02 º	0.01 º	0.02 º	0.01 º	0.04 º
	E	NA	NA	NA	NA	NA	0.00 º	0.06 º	0.16 º	0.19 º	0.37 º	0.62 º	NA	0.36 º	0.26 º	0.36 º	0.45 º	0.41 º	0.52 º	0.42 º	0.32 º	0.29 º	0.52 º	0.50 º
Pier 1 North (Inside)	N	NA	NA	NA	0.00 º	0.01 º	0.63 º	0.63 º	0.63 º	0.64 º	0.65 º	0.64 º	NA	NA	0.65 º	0.69 º	0.67 º	0.67 º	0.68 º	0.68 º	0.68 º	0.70 º	0.66 º	0.68 º
	E	NA	NA	NA	NA	NA	0.00 º	0.00 º	0.01 º	-0.02 º	-0.02 º	0.03 º	NA	NA	-0.02 º	-0.03 º	0.03 º	0.03 º	0.02 º	0.01 º	0.01 º	0.03 º	0.03 º	0.03 º
Pier 1 North (Outside)	N	NA	NA	NA	NA	0.00 º	0.03 º	0.01 º	0.02 º	0.00 º	0.01 º	0.11 º	0.06 º	0.05 º	0.01 º	0.10 º	0.06 º	0.02 º	0.09 º	0.14 º	0.11 º	0.18 º	0.16 º	0.16 º
	E	NA	NA	NA	NA	0.00 º	-0.01 º	-0.01 º	-0.00 º	-0.02 º	-0.03 º	-0.03 º	-0.01 º	-0.00 º	0.00 º	-0.02 º	0.03 º	0.02 º	0.03 º	0.01 º	-0.00 º	0.04 º	0.04 º	0.03 º
Pier 1 South (Inside)	N	0.00 º	0.14 º	0.07 º	0.11 º	0.15 º	0.13 º	0.08 º	0.09 º	0.09 º	0.07 º	0.21 º	NA	NA	0.17 º	0.23 º	0.29 º	0.26 º	0.31 º	0.35 º	0.29 º	0.33 º	0.35 º	0.33 º
	E	0.00 º	-0.38 º	0.10 º	0.07 º	0.10 º	0.08 º	0.10 º	0.13 º	0.12 º	0.05 º	0.09 º	NA	NA	0.05 º	-0.06 º	0.10 º	0.33 º	0.32 º	0.15 º	0.18 º	0.31 º	0.32 º	0.31 º
Pier 1 South (Outside)	N	NA	NA	NA	0.00 º	0.01 º	0.01 º	0.02 º	0.00 º	0.03 º	0.02 º	0.01 º	0.06 º	0.06 º	0.07 º	0.06 º	0.11 º	0.10 º	0.12 º	0.14 º	0.13 º	0.15 º	0.13 º	0.11 º
	E	NA	NA	NA	0.00 º	0.16 º	0.03 º	0.11 º	0.16 º	0.08 º	0.03 º	0.29 º	0.01 º	0.04 º	0.03 º	-0.15 º	0.08 º	0.33 º	0.42 º	0.21 º	0.26 º	0.30 º	0.37 º	0.28 º
Pier 2 North (Inside)	N	0.00 º	0.00 º	0.00 º	0.01 º	0.00 º	0.00 º	NA	-0.00 º	0.00 º	NA	0.00 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º
	E	0.00 º	-0.08 º	-0.09 º	-0.05 º	-0.05 º	-0.05 º	NA	-0.10 º	-0.06 º	NA	0.00 º	-0.04 º	-0.15 º	-0.10 º	-0.08 º	-0.09 º	-0.09 º	-0.13 º	-0.15 º	-0.10 º	-0.05 º	-0.06 º	-0.07 º
Pier 2 South (Inside)	N	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	NA	0.01 º	0.01 º	NA	0.00 º	-0.00 º	0.00 º	-0.00 º	-0.01 º	-0.00 º	-0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º
	E	0.00 º	-0.14 º	-0.14 º	-0.10 º	-0.09 º	-0.03 º	NA	-0.06 º	-0.04 º	NA	0.00 º	-0.07 º	-0.20 º	0.00 º	-0.02 º	-0.05 º	-0.13 º	-0.10 º	-0.16 º	-0.12 º	-0.10 º	-0.10 º	-0.11 º

0.00 º	First reading (Tilt set/reset)
NA	Information Not Available

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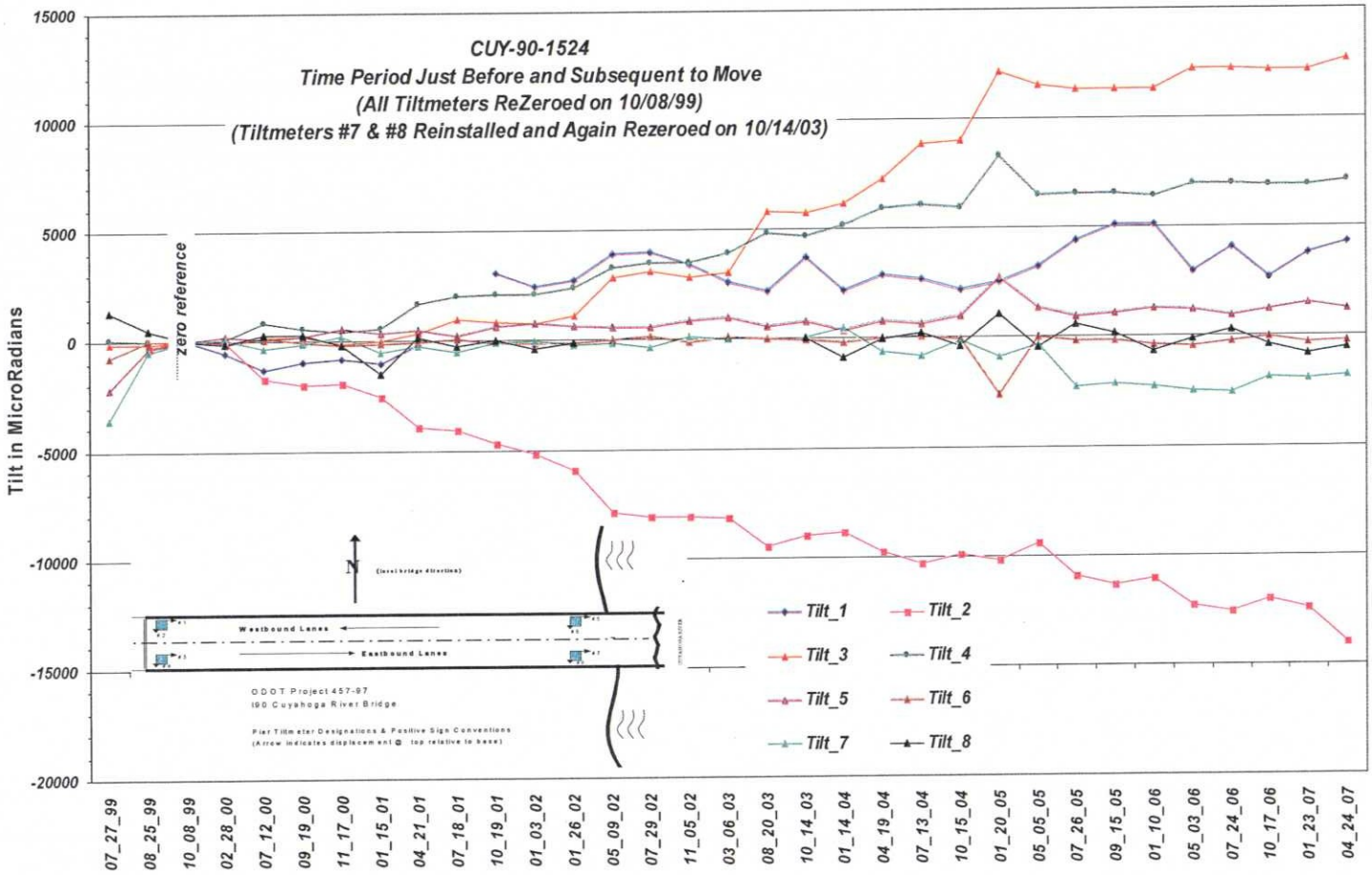
April 24, 2007

Mr. Dean Palmer, P.E.
Richland Engineering Limited
Mansfield, Ohio
(419)524-0074

RE: CUY-90-1524 West End Slope Monitoring

Dear Dean:

Tilimeter readings were taken on April 24, 2007 on CUY-90-1524 for the west abutment and pier 1. The cumulative data are plotted below:



With the exception of tiltmeter #2, which measures "northward" inclination of the northerly west-end abutment, all tiltmeter readings have been relatively stable since early 2005. Readings for tiltmeters #5 through #8, located at pier 1, have actually been reasonably stable almost since the expansion joint re-opening in 1999. Tiltmeter #2, does indicate a continued increase in the "northward" inclination of the northerly west-end abutment. If survey data does not fully corroborate this continued drift, some of it could possibly be attributable to a drift in the circuitry of the instrument.

Feel free to contact me should any questions arise.

Regards,

Art Huckelbridge, D.Eng., P.E.

LONG TERM MONITORING AT CUY-90-15.24 BRIDGE PROJECT

Annual Report for Year 2006-2007

Robert Y. Liang

May 2007

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I. Introduction

This is an Annual Report on the monitoring results of the stabilization structures at the CUY-90-15.24 west end slope for the period between 4/26/2006 and 4/11/2007. The strain gages and slope inclinometers (SI) previously installed in the stabilization structures between 1997 and 1999 have been monitored continuously. Since the beginning of the monitoring, quarterly reports and annual reports have been submitted to document the monitoring results. For the purpose of completeness and for a better perspective, the presentation of the monitored and deduced data in this report covers the period from the beginning of monitoring to the last reading taken in April 2007.

The plane view of the general layout of the stabilization structures is shown in Fig. 1. A total of five tie-beams (#1, #12, #13, #14, and #26) were instrumented with strain gages at both ends of the beams, as shown in Fig. 2. The gage numbering system is indicated in Fig. 2 as well. A total of five driven piles (#1, #17, #18, #19, and #34) were each instrumented with four strain gages near the top of the pile, as shown in Fig. 3. Rock anchors #1, #8, #9, and #17 were each instrumented with a load cell at the anchor head. Finally, drilled shafts #1 and #9 were instrumented with sister-bar type of strain gages. The locations of these strain gages along the length of the drilled shafts and the gage designation numbers are presented in Fig. 4 and Fig. 5 for shaft #1 and shaft #9, respectively. Furthermore, drilled shafts #1, #3, #8, #9, #10, and #17, shown in Fig. 6, were each embedded with slope inclinometer casings for monitoring shafts deflections.

II. Monitoring Results

II.1 Rock Anchors:

The recorded numerical values of load cells at the anchor heads are summarized in Table 1. Also, the load versus time plot for each anchor is shown in Fig. 7. Between 4/2006 and 4/2007, the anchor loads appeared to remain fairly steady.

II.2 Tie-Beams:

The strain readings from the gages in the tie-beams have been converted into axial forces and bending moments at the locations near the driven pile cap side and near the drilled shaft cap side, and they are summarized in Table 2 and Table 3, respectively. The plots of the axial force versus time for five monitored tie-beams are presented in Fig. 8 and Fig. 9 for the drilled shaft cap side and the driven pile cap side, respectively. The average axial forces of all five monitored tie-beams on the pile cap side and the drilled shaft cap side are plotted respectively in Fig. 10. The axial forces appeared to oscillate within a small range.

The major bending moments for each of the five monitored tie-beams are shown in Fig. 11 and Fig. 12 for the pile cap side and drilled shaft cap side, respectively. The average bending moments for all five monitored tie-beams for the drilled shaft side and the pile cap side are shown in Fig. 13. These average bending moments on both sides of the tie-beams appeared to be fairly constant during the past year.

II.3 Driven Piles:

The strain readings from the strain gages on the driven piles have been converted into the bending moments and axial forces for each of the five monitored driven piles and are summarized in Table 4. The axial forces versus time and the major bending moments versus time are plotted in Fig. 14 and Fig. 15, respectively. Since the end of construction (6/1999), the forces and bending moments have shown some increases. However, within the past year, these changes were very small.

II.4 Drilled Shafts:

The bending moments in the drilled shaft #9 at different elevations are shown in Fig. 16. It can be seen that the moments have been increasing over time, especially at the depth of 95 ft below the cap top. However, the rate of change has decreased over the last year. The bending moments in the drilled shaft #1 at different elevations are shown in Fig. 17. Please note that the bending moments shown in Fig. 17 are smaller than those shown in Fig. 16, due to the fact that the moments measured in shaft #9 (Fig. 16) are in the major bending direction, while the moments measured in shaft #1 are not in the major bending direction.

The distribution of bending moments along the depth of the drilled shafts is depicted in Fig. 18 and Fig. 19 for shaft #9 and shaft #1, respectively. Again, keep in mind that the moment direction in shaft #1 and shaft #9 is different, as noted previously in Fig. 6.

II.5 Slope Inclinometer reading:

Four separate inclinometer readings were taken over the last year for all six slope inclinometer casings embedded in the drilled shafts. It is noted that inclinometer casing 9B was blocked and no longer readable. The incremental and cumulative deflection plots in the A-direction (toward river direction) are presented in Figs. 20 to 25. There was no significant movement observed during this monitoring period.

III. Concluding Remark

Based on examinations of the monitored data collected over the last year, the stabilization structures in the slope seemed to experience fairly steady state of forces and moments. There was no observed sudden big jump in the monitored data. Nevertheless, continuing monitoring of these slope stabilization structures, the ground movements, and the behavior of the superstructures, is recommended.

Table 1 Numerical reading of anchor load as a function of time for anchors #1, #8, #9 and #17

Date	Anchor #1 Load, kips	Anchor #8 Load, kips	Anchor #9 Load, kips	Anchor #17 Load, kips	Comment
4/7/1999		560			
4/8/1999	489			499	Anchor Lock off
4/14/1999	460	473	596 (Lock off)	461	
5/7/1999	452	473	572	445	End of construction
7/1/1999	446	468	564	439	
10/1/1999	441	467	560	440	
1/1/2000	439	461	555	424	
4/1/2000	432	453	546	414	
7/1/2000	431	451	521	415	
10/1/2000	431	451	519	416	
1/1/2001	430	455	517	400	
4/1/2001	421	443	513	397	
7/1/2001	422	443	510	399	
10/1/2001	425	445	512	403	
1/1/2002	424	444	511	398	
4/1/2002	421	440	508	386	
7/1/2002	419	439	506	391	
10/1/2002	423	442	508	396	
1/1/2003	423	435	508	389	
4/15/2003	416	427	501	380	
8/7/2003	416	428	503	384	
10/7/2003	418	429	504	387	
12/31/2003	417	426	503	378	
4/13/2004	408	418	494	370	
7/13/2004	409	419	494	374	
10/8/2004	411	422	496	377	
1/7/2005	411	421	495	374	
4/8/2005	407	414	485	366	
7/18/2005	407	415	485	370	
11/12/2005	410	419	489	374	
1/10/2006	409	417	487	369	
4/9/2006	399	411	487	365	
7/19/2006	399	412	487	368	
10/18/2006	407.3	414.8	489.6	371.7	
1/18/2007	405	412	487	366	
4/19/2007	401	406	501	361	

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
1	7/1/1999	-47.1	68.5	551.7	681.8	313.73	10.70	616.75	252.30	375.15	83.06	-40.28	-2.75
	7/15/1999	-70.1	53.8	538.8	666.8	297.33	-8.15	602.80	234.35	360.30	78.72	-40.60	-2.82
	8/15/1999	10.7	114.3	613.7	728.1	366.70	62.50	670.90	312.20	421.20	97.09	-40.43	-2.44
	8/31/1999	12.0	114.3	617.3	732.8	369.10	63.15	675.05	314.65	423.55	97.73	-40.67	-2.44
	9/15/1999	13.1	113.5	619.7	737.5	370.95	63.30	678.60	316.40	425.50	98.22	-40.89	-2.44
	9/30/1999	29.6	122.3	634.4	753.4	384.93	75.95	693.90	332.00	437.85	101.92	-41.07	-2.37
	10/15/1999	34.7	123.9	637.8	757.9	388.58	79.30	697.85	336.25	440.90	102.88	-41.11	-2.34
	10/31/1999	39.8	127.2	646.6	762	393.90	83.50	704.30	343.20	444.60	104.29	-41.26	-2.27
	11/15/1999	62.3	139.3	662.9	780.1	411.15	100.80	721.50	362.60	459.70	108.86	-41.25	-2.18
	11/30/1999	73.7	146.3	670.6	788.6	419.80	110.00	729.60	372.15	467.45	111.15	-41.18	-2.13
	12/15/1999	72.8	143.6	668.9	789.7	418.75	108.20	729.30	370.85	466.65	110.87	-41.28	-2.15
	12/31/1999	88.8	152.1	680.1	802.5	430.88	120.45	741.30	384.45	477.30	114.08	-41.26	-2.08
	3/31/2000	95.3	158.7	682.5	825.2	440.43	127.00	753.85	388.90	491.95	116.61	-41.66	-2.31
	6/30/2000	60.2	138.2	662.7	804.5	416.40	99.20	733.60	361.45	471.35	110.25	-42.16	-2.46
	9/30/2000	50.1	142.5	668.8	795.7	414.28	96.30	732.25	359.45	469.10	109.69	-42.26	-2.46
	1/13/2001	109.5	179.9	712.3	845.5	461.80	144.70	778.90	410.90	512.70	122.27	-42.15	-2.28
	4/20/2001	126.8	283.2	715.3	881.9	501.80	205.00	798.60	421.05	582.55	132.86	-39.45	-3.62
	7/16/2001	68.3	149.8	674.3	837.1	432.38	109.05	755.70	371.30	493.45	114.48	-42.98	-2.74
	10/9/2001	71.4	157.1	685.5	840.8	438.70	114.25	763.15	378.45	498.95	116.15	-43.12	-2.70
	1/9/2002	102.7	177.8	713	872	466.38	140.25	792.50	407.85	524.90	123.48	-43.35	-2.62
	4/12/2002	125.5	192.8	738.6	904.9	490.45	159.15	821.75	432.05	548.85	129.86	-44.04	-2.62
	7/18/2002	62.3	151.8	706.334	859.6	445.01	107.05	782.97	384.32	505.70	117.82	-44.92	-2.72
	10/8/2002	43.7	151.1	711.3	846.7	438.20	97.40	779.00	377.50	498.90	116.02	-45.30	-2.72
	1/8/2003	84.7	180.5	748.5	891.8	476.38	132.60	820.15	416.60	536.15	126.13	-45.69	-2.68
	4/15/2003	96.1	191.9	739.9	989.3	504.30	144.00	864.60	418.00	590.60	133.52	-47.89	-3.87
	7/1/2003	57.4	168	713	959	474.35	112.70	836.00	385.20	563.50	125.59	-48.07	-3.99
	10/7/2003	42.1	166.8	714	946.6	467.38	104.45	830.30	378.05	556.70	123.75	-48.24	-4.00
	12/31/2003	80	197.9	753.9	985.1	504.23	138.95	869.50	416.95	591.50	133.50	-48.55	-3.91
	4/13/2004	92	208.9	760.4	1006.6	516.98	150.45	883.50	426.20	607.75	136.88	-48.72	-4.07
	7/13/2004	14.6	163.9	707.3	954.4	460.05	89.25	830.85	360.95	559.15	121.81	-49.29	-4.44
	10/8/2004	-8.6	233.4	704.6	941	467.60	112.40	822.80	348.00	587.20	123.81	-47.21	-5.36
	1/7/2005	19.5	190.4	746.5	982.5	484.73	104.95	864.50	383.00	586.45	128.34	-50.48	-4.56
	4/8/2005	3.4	397.6	751.6	1003.4	539.00	200.50	877.50	377.50	700.50	142.71	-44.99	-7.24
	7/18/2005	3.1	164.3	709.7	969.6	461.68	83.70	839.65	356.40	566.95	122.24	-50.24	-4.72
	8/26/2005	3.1	157.5	702.5	956.3	454.85	80.30	829.40	352.80	556.90	120.43	-49.78	-4.57
	10/11/2005	3.1	164.2	712.6	960.1	460.00	83.65	836.35	357.85	562.15	121.79	-50.02	-4.58
	1/10/2006	3.1	191.9	742.5	997	483.63	97.50	869.75	372.80	594.45	128.05	-51.32	-4.97
	4/9/2006	3.5	205.3	750.7	1018.8	494.58	104.40	884.75	377.10	612.05	130.95	-51.86	-5.26
	7/19/2006	3.5	166.6	703.7	975.5	462.33	85.05	839.60	353.60	571.05	122.41	-50.15	-4.87
	10/18/2006	3.5	170.2	709	967.5	462.55	86.85	838.25	356.25	568.85	122.47	-49.94	-4.76
	1/18/2007	3.5	209.1	748.7	1013.1	493.60	106.30	880.90	376.10	611.10	130.69	-51.48	-5.26
	4/19/2007	3.5	216.6	743.7	1021.2	496.25	110.05	882.45	373.60	618.90	131.39	-51.33	-5.50

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
12	7/1/1999	374.9	6	549.6	471.8	350.58	190.45	510.70	462.25	238.90	92.82	-21.28	5.00
	7/15/1999	368.6	-3.6	544.2	467.3	344.13	182.50	505.75	456.40	231.85	91.11	-21.48	5.03
	8/15/1999	373.7	0.2	569.4	485.2	357.13	186.95	527.30	471.55	242.70	94.56	-22.62	5.13
	8/31/1999	368.4	-4.7	567	486.2	354.23	181.85	526.60	467.70	240.75	93.79	-22.91	5.08
	9/15/1999	365.9	-9.2	565.3	485.1	351.78	178.35	525.20	465.60	237.95	93.14	-23.05	5.10
	9/30/1999	364.6	-11.7	570.1	487.6	352.65	176.45	528.85	467.35	237.95	93.37	-23.42	5.14
	10/15/1999	361.7	-14.8	569.9	487.4	351.05	173.45	528.65	465.80	236.30	92.95	-23.61	5.14
	10/31/1999	362.8	-13.5	575.6	493.1	354.50	174.65	534.35	469.20	239.80	93.86	-23.91	5.14
	11/15/1999	365.0	-11.5	581.4	498	358.23	176.75	539.70	473.20	243.25	94.85	-24.12	5.15
	11/30/1999	365.6	-11.8	583.7	500.1	359.40	176.90	541.90	474.65	244.15	95.16	-24.26	5.16
	12/15/1999	368.0	-9.2	589.7	504.2	363.18	179.40	546.95	478.85	247.50	96.16	-24.43	5.18
	12/31/1999	369.0	-8	592.9	506.6	365.13	180.50	549.75	480.95	249.30	96.67	-24.54	5.19
	3/31/2000	379.6	7.3	617	524.1	382.00	193.45	570.55	498.30	265.70	101.14	-25.06	5.21
	6/30/2000	376.1	4.4	608.9	519.1	377.13	190.25	564.00	492.50	261.75	99.85	-24.84	5.17
	9/30/2000	360.7	-12.3	588.3	503.5	360.05	174.20	545.90	474.50	245.60	95.33	-24.70	5.13
	1/13/2001	372.1	2.2	618.1	526.1	379.63	187.15	572.10	495.10	264.15	100.51	-25.58	5.17
	4/20/2001	387.6	21	645.8	549.2	400.90	204.30	597.50	516.70	285.10	106.15	-26.13	5.19
	7/16/2001	374.6	6.5	621.5	532.9	383.88	190.55	577.20	498.05	269.70	101.64	-25.70	5.12
	10/9/2001	360.9	-9.4	598.9	515.8	366.55	175.75	557.35	479.90	253.20	97.05	-25.36	5.08
	1/9/2002	363.5	-2.5	611.5	524.5	374.25	180.50	568.00	487.50	261.00	99.09	-25.75	5.07
	4/12/2002	381.7	16.9	642.7	550.5	397.95	199.30	596.60	512.20	283.70	105.37	-26.40	5.12
	7/18/2002	375	10.5	629	544.7	389.80	192.75	586.85	502.00	277.60	103.21	-26.19	5.03
	10/8/2002	357.7	-9.6	599.2	523	367.58	174.05	561.10	478.45	256.70	97.32	-25.72	4.97
	1/8/2003	367.3	6.5	626.7	542.7	385.80	186.90	584.70	497.00	274.60	102.15	-26.44	4.98
	4/15/2003	385.9	27.3	655.3	566.2	408.68	206.60	610.75	520.60	296.75	108.20	-26.86	5.01
	7/1/2003	384.7	26.3	649.2	565.6	406.45	205.50	607.40	516.95	295.95	107.62	-26.71	4.95
	10/7/2003	360.6	3.5	613	539.7	379.20	182.05	576.35	486.80	271.60	100.40	-26.20	4.82
	12/31/2003	372	19.4	636	558.3	396.43	195.70	597.15	504.00	288.85	104.96	-26.68	4.82
	4/13/2004	389.4	39.8	665.5	583.1	419.45	214.60	624.30	527.45	311.45	111.06	-27.23	4.84
	7/13/2004	379.5	27.7	643.3	571.1	405.40	203.60	607.20	511.40	299.40	107.34	-26.82	4.75
	10/8/2004	361.6	10.3	615.2	550.9	384.50	185.95	583.05	488.40	280.60	101.80	-26.39	4.66
	1/7/2005	367.5	16.1	630.6	561.5	393.93	191.80	596.05	499.05	288.80	104.30	-26.87	4.71
	4/8/2005	388.2	35.6	662.3	587.2	418.33	211.90	624.75	525.25	311.40	110.76	-27.44	4.79
	7/18/2005	382.6	26.3	647.7	580.1	409.18	204.45	613.90	515.15	303.20	108.34	-27.21	4.75
	8/26/2005	373.6	15.7	629.8	566.8	396.48	194.65	598.30	501.70	291.25	104.97	-26.83	4.71
	10/11/2005	365.9	6.1	617.8	557.9	386.93	186.00	587.85	491.85	282.00	102.45	-26.71	4.70
	1/10/2006	376.2	17.5	639	572.2	401.23	196.85	605.60	507.60	294.85	106.23	-27.16	4.77
	4/9/2006	393.8	32.7	665.7	594	421.55	213.25	629.85	529.75	313.35	111.61	-27.69	4.85
	7/19/2006	384.2	20.3	646.2	582.7	408.35	202.25	614.45	515.20	301.50	108.12	-27.39	4.79
	10/18/2006	365	-2	614.4	558.2	383.90	181.50	586.30	489.70	278.10	101.65	-26.90	4.74
	1/18/2007	376	9.6	635.9	573.9	398.85	192.80	604.90	505.95	291.75	105.60	-27.39	4.80
	4/19/2007	390.7	24.1	659.3	592.7	416.70	207.40	626.00	525.00	308.40	110.33	-27.82	4.85

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
13	7/1/1999	306.3	72.2	490.8	675.2	386.13	189.25	583.00	398.55	373.70	102.23	-26.17	0.56
	7/15/1999	288.0	53.1	484.2	670.6	373.98	170.55	577.40	386.10	361.85	99.02	-27.04	0.54
	8/15/1999	280.9	61.8	506.3	693.7	385.68	171.35	600.00	393.60	377.75	102.12	-28.49	0.36
	8/31/1999	270.4	52.1	503.1	691.4	379.25	161.25	597.25	386.75	371.75	100.41	-28.98	0.34
	9/15/1999	261.3	43.9	501.2	689.9	374.08	152.60	595.55	381.25	366.90	99.04	-29.44	0.32
	9/30/1999	257.1	40.7	503.1	690.7	372.90	148.90	596.90	380.10	365.70	98.73	-29.77	0.32
	10/15/1999	250.1	33.8	501.2	691	369.03	141.95	596.10	375.65	362.40	97.71	-30.18	0.30
	10/31/1999	251.4	38	507.6	697.6	373.65	144.70	602.60	379.50	367.80	98.93	-30.43	0.26
	11/15/1999	253.9	41.6	512.1	701.9	377.38	147.75	607.00	383.00	371.75	99.92	-30.52	0.25
	11/30/1999	253.5	41.2	513.6	704.4	378.18	147.35	609.00	383.55	372.80	100.13	-30.68	0.24
	12/15/1999	255.8	46.7	519.1	709.3	382.73	151.25	614.20	387.45	378.00	101.33	-30.77	0.21
	12/31/1999	256.7	48.9	522.3	712.4	385.08	152.80	617.35	389.50	380.65	101.96	-30.87	0.20
	3/31/2000	267.5	64.6	542.8	734.2	402.28	166.05	638.50	405.15	399.40	106.51	-31.40	0.13
	6/30/2000	258.9	46.4	531.2	726.1	390.65	152.65	628.65	395.05	386.25	103.43	-31.63	0.20
	9/30/2000	237.1	10.1	504.9	705.9	364.50	123.60	605.40	371.00	358.00	96.51	-32.02	0.29
	1/13/2001	254.0	40.9	535.1	734.6	391.15	147.45	634.85	394.55	387.75	103.56	-32.39	0.15
	4/20/2001	275.4	72.6	561.4	763.7	418.28	174.00	662.55	418.40	418.15	110.75	-32.47	0.01
	7/16/2001	255.3	37.7	534.8	740.9	392.18	146.50	637.85	395.05	389.30	103.84	-32.65	0.13
	10/9/2001	235.7	7.5	510.6	719.6	368.35	121.60	615.10	373.15	363.55	97.53	-32.80	0.22
	1/9/2002	240	18.9	523.3	731	378.30	129.45	627.15	381.65	374.95	100.16	-33.08	0.15
	4/12/2002	263.4	58.5	554.8	763	409.93	160.95	658.90	409.10	410.75	108.54	-33.09	-0.04
	7/18/2002	255.5	40.1	566.1	754.5	404.05	147.80	660.30	410.80	397.30	106.98	-34.06	0.30
	10/8/2002	231.2	3.4	508.7	726.1	367.35	117.30	617.40	369.95	364.75	97.26	-33.24	0.12
	1/8/2003	249.4	38.5	540.1	754.4	395.60	143.95	647.25	394.75	396.45	104.74	-33.45	-0.04
	4/15/2003	276.4	78.5	571.6	784.9	427.85	177.45	678.25	424.00	431.70	113.28	-33.28	-0.17
	7/1/2003	273	69	561.4	779.9	420.83	171.00	670.65	417.20	424.45	111.42	-33.21	-0.16
	10/7/2003	246.6	22.5	524.7	744.6	384.60	134.55	634.65	385.65	383.55	101.83	-33.24	0.05
	12/31/2003	264.8	58.9	552.8	770.1	411.65	161.85	661.45	408.80	414.50	108.99	-33.20	-0.13
	4/13/2004	291.3	97.7	584	803.2	444.05	194.50	693.60	437.65	450.45	117.57	-33.17	-0.29
	7/13/2004	275.5	64.3	556.1	781	419.23	169.90	668.55	415.80	422.65	111.00	-33.14	-0.15
	10/8/2004	252.8	29.9	527.5	755.8	391.50	141.35	641.65	390.15	392.85	103.66	-33.25	-0.06
	1/7/2005	264	50.8	544.5	770.6	407.48	157.40	657.55	404.25	410.70	107.89	-33.24	-0.14
	4/8/2005	289.9	90.7	576	802	439.65	190.30	689.00	432.95	446.35	116.41	-33.14	-0.30
	7/18/2005	277.8	67.7	556.4	787.1	422.25	172.75	671.75	417.10	427.40	111.80	-33.16	-0.23
	8/26/2005	266.7	46.5	539.8	771.9	406.23	156.60	655.85	403.25	409.20	107.56	-33.18	-0.13
	10/11/2005	257.2	33.8	526.8	760.8	394.65	145.50	643.80	392.00	397.30	104.49	-33.12	-0.12
	1/10/2006	269.3	59.9	551.2	780.4	415.20	164.60	665.80	410.25	420.15	109.93	-33.31	-0.22
	4/9/2006	289.9	90	576.3	806.2	440.60	189.95	691.25	433.10	448.10	116.66	-33.32	-0.34
	7/19/2006	277.7	63.9	553.8	787.8	420.80	170.80	670.80	415.75	425.85	111.42	-33.23	-0.23
	10/18/2006	253.3	27.9	523.7	757.8	390.68	140.60	640.75	388.50	392.85	103.44	-33.24	-0.10
	1/18/2007	267.4	54.9	546.5	778.5	411.83	161.15	662.50	406.95	416.70	109.04	-33.32	-0.22
	4/19/2007	289	88.7	575.1	806.8	439.90	188.85	690.95	432.05	447.75	116.47	-33.37	-0.35

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
14	7/1/1999	445.4	53.9	802	298.7	400.00	249.65	550.35	623.70	176.30	105.91	-19.98	10.02
	7/15/1999	440.5	34.4	799.5	280.7	388.78	237.45	540.10	620.00	157.55	102.94	-20.11	10.36
	8/15/1999	455.6	40.8	837.6	284.6	404.65	248.20	561.10	646.60	162.70	107.14	-20.79	10.84
	8/31/1999	452.7	30.7	837.1	274.1	398.65	241.70	555.60	644.90	152.40	105.55	-20.86	11.03
	9/15/1999	448.5	21.7	836.8	266.2	393.30	235.10	551.50	642.65	143.95	104.13	-21.03	11.17
	9/30/1999	447.0	16.1	838.5	260.8	390.60	231.55	549.65	642.75	138.45	103.42	-21.14	11.30
	10/15/1999	446.5	8.8	839.3	255.1	387.43	227.65	547.20	642.90	131.95	102.58	-21.24	11.45
	10/31/1999	450.9	11.7	847.9	257.8	392.08	231.30	552.85	649.40	134.75	103.81	-21.37	11.53
	11/15/1999	455.9	16.1	856.2	259.8	397.00	236.00	558.00	656.05	137.95	105.11	-21.40	11.61
	11/30/1999	456.3	15.5	858.3	259	397.28	235.90	558.65	657.30	137.25	105.19	-21.45	11.65
	12/15/1999	461.3	20.5	865.6	261.7	402.28	240.90	563.65	663.45	141.10	106.51	-21.45	11.70
	12/31/1999	463.4	22.5	871.6	262.9	405.10	242.95	567.25	667.50	142.70	107.26	-21.55	11.76
	3/31/2000	477.8	35.6	903.8	282.7	424.98	256.70	593.25	690.80	159.15	112.52	-22.37	11.91
	6/30/2000	469.2	17.4	889.7	267.4	410.93	243.30	578.55	679.45	142.40	108.80	-22.28	12.03
	9/30/2000	453.5	-23.5	856.8	240.4	381.80	215.00	548.60	655.15	108.45	101.09	-22.17	12.25
	1/13/2001	476.9	5	891.3	257.6	407.70	240.95	574.45	684.10	131.30	107.95	-22.16	12.38
	4/20/2001	494.8	40.8	932.8	281.2	437.40	267.80	607.00	713.80	161.00	115.81	-22.54	12.38
	7/16/2001	475.7	4.9	900.7	255.9	409.30	240.30	578.30	688.20	130.40	108.37	-22.46	12.50
	10/9/2001	459.3	-30.8	870.4	236.8	383.93	214.25	553.60	664.85	103.00	101.65	-22.55	12.59
	1/9/2002	468.8	-18.5	883.7	241.5	393.88	225.15	562.60	676.25	111.50	104.29	-22.43	12.65
	4/12/2002	492.8	22.5	926.5	270.2	428.00	257.65	598.35	709.65	146.35	113.32	-22.64	12.62
	7/18/2002	483.5	3.8	911.9	257.3	414.13	243.65	584.60	697.70	130.55	109.65	-22.66	12.71
	10/8/2002	462.7	-35	875.6	233	384.08	213.85	554.30	669.15	99.00	101.69	-22.63	12.77
	1/8/2003	485.5	2.5	912.6	253.9	413.63	244.00	583.25	699.05	128.20	109.52	-22.55	12.79
	4/15/2003	501.9	612.9	952.7	285.1	588.15	557.40	618.90	727.30	449.00	155.72	-4.09	6.23
	7/1/2003	521.6	28.8	943.4	278.1	442.98	275.20	610.75	732.50	153.45	117.29	-22.30	12.97
	10/7/2003	472.3	-16.5	903.8	247.5	401.78	227.90	575.65	688.05	115.50	106.38	-23.11	12.83
	12/31/2003	495.5	18.6	939.3	268.7	430.53	257.05	604.00	717.40	143.65	113.99	-23.06	12.85
	4/13/2004	504.6	68.9	989	299.2	465.43	286.75	644.10	746.80	184.05	123.23	-23.75	12.61
	7/13/2004	487.3	36.7	961.8	277.7	440.88	262.00	619.75	724.55	157.20	116.73	-23.78	12.71
	10/8/2004	468.9	-0.5	928.8	256.4	413.40	234.20	592.60	698.85	127.95	109.46	-23.82	12.79
	1/7/2005	485.2	21.4	952.7	269.7	432.25	253.30	611.20	718.95	145.55	114.45	-23.79	12.85
	4/8/2005	512.9	68.8	998.7	302.5	470.73	290.85	650.60	755.80	185.65	124.63	-23.91	12.77
	7/18/2005	498.2	40	977.1	286.8	450.53	269.10	631.95	737.65	163.40	119.29	-24.11	12.86
	8/26/2005	486.3	17.1	955.5	271.8	432.68	251.70	613.65	720.90	144.45	114.56	-24.05	12.91
	10/11/2005	478.8	2.4	942.6	263.6	421.85	240.60	603.10	710.70	133.00	111.69	-24.09	12.94
	1/10/2006	497.9	28.2	970.6	280.6	444.33	263.05	625.60	734.25	154.40	117.64	-24.09	12.99
	4/9/2006	519.6	65.1	1008.9	306	474.90	292.35	657.45	764.25	185.55	125.74	-24.26	12.96
	7/19/2006	505.7	73.4	984.2	290.7	463.50	289.55	637.45	744.95	182.05	122.72	-23.12	12.61
	10/18/2006	484	-5.7	946.5	265.8	422.65	239.15	606.15	715.25	130.05	111.91	-24.39	13.11
	1/18/2007	503	21.5	974.4	282.5	445.35	262.25	628.45	738.70	152.00	117.92	-24.34	13.14
	4/19/2007	525.1	60.9	1012.9	309.1	477.00	293.00	661.00	769.00	185.00	126.30	-24.46	13.08

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side)(cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
26	7/1/1999	468.3	92.2	387.7	511.7	364.98	280.25	449.70	428.00	301.95	96.63	-11.26	2.82
	7/15/1999	460.1	81	381.5	505.7	357.08	270.55	443.60	420.80	293.35	94.54	-11.50	2.86
	8/15/1999	482.3	96.1	410.7	526	378.78	289.20	468.35	446.50	311.05	100.29	-11.91	3.03
	8/31/1999	490.3	101.9	422.4	535	387.40	296.10	478.70	456.35	318.45	102.57	-12.14	3.09
	9/15/1999	491.0	101.4	426.3	536.4	388.78	296.20	481.35	458.65	318.90	102.94	-12.30	3.13
	9/30/1999	497.9	106.7	434.7	543.6	395.73	302.30	489.15	466.30	325.15	104.78	-12.42	3.16
	10/15/1999	505.0	112.3	443.2	550.9	402.85	308.65	497.05	474.10	331.60	106.66	-12.52	3.19
	10/31/1999	515.6	118.8	452.5	560.9	411.95	317.20	506.70	484.05	339.85	109.07	-12.59	3.23
	11/15/1999	525.0	128.3	463.4	570.2	421.73	326.65	516.80	494.20	349.25	111.66	-12.64	3.25
	11/30/1999	532.5	134.9	471.5	576.8	428.93	333.70	524.15	502.00	355.85	113.57	-12.66	3.27
	12/15/1999	534.1	138.1	476.5	580.2	432.23	336.10	528.35	505.30	359.15	114.44	-12.78	3.27
	12/31/1999	540.4	144.3	484.4	587.2	439.08	342.35	535.80	512.40	365.75	116.25	-12.86	3.29
	3/31/2000	551.1	156	501.3	602.1	452.63	353.55	551.70	526.20	379.05	119.84	-13.17	3.30
	6/30/2000	533.5	137.3	477.6	577.9	431.58	335.40	527.75	505.55	357.60	114.27	-12.78	3.31
	9/30/2000	539.6	136.8	480.7	575.1	433.05	338.20	527.90	510.15	355.95	114.66	-12.61	3.45
	1/13/2001	571.4	169.7	522.7	611.8	468.90	370.55	567.25	547.05	390.75	124.15	-13.07	3.50
	4/20/2001	580.2	184.8	537.9	624.6	481.88	382.50	581.25	559.05	404.70	127.59	-13.21	3.46
	7/16/2001	555.8	159.1	508	598.6	455.38	357.45	553.30	531.90	378.85	120.57	-13.02	3.43
	10/9/2001	556.2	154.1	506	595.8	453.03	355.15	550.90	531.10	374.95	119.95	-13.01	3.50
	1/9/2002	572	170.3	527.3	614.7	471.08	371.15	571.00	549.65	392.50	124.73	-13.28	3.52
	4/12/2002	584.6	187.7	546.3	632.8	487.85	386.15	589.55	565.45	410.25	129.17	-13.52	3.48
	7/18/2002	559.5	162.1	516.1	606	460.93	360.80	561.05	537.80	384.05	122.04	-13.31	3.44
	10/8/2002	557	154.4	511	599.8	455.55	355.70	555.40	534.00	377.10	120.62	-13.27	3.51
	1/8/2003	591	189.2	552.8	639	493.00	390.10	595.90	571.90	414.10	130.53	-13.68	3.54
	4/15/2003	597.9	204.3	567.5	650.5	505.05	401.10	609.00	582.70	427.40	133.72	-13.82	3.48
	7/1/2003	580.7	184.3	545.4	632.5	485.73	382.50	588.95	563.05	408.40	128.61	-13.72	3.46
	10/7/2003	578.2	176.3	538	627	479.88	377.25	582.50	558.10	401.65	127.06	-13.64	3.50
	12/31/2003	610.3	207.7	572.6	661.6	513.05	409.00	617.10	591.45	434.65	135.84	-13.83	3.51
	4/13/2004	617.1	224.2	589.5	675.7	526.63	420.65	632.60	603.30	449.95	139.43	-14.09	3.44
	7/13/2004	584	186.6	549.1	642.6	490.58	385.30	595.85	566.55	414.60	129.89	-13.99	3.40
	10/8/2004	581.8	181.2	543.7	638.3	486.25	381.50	591.00	562.75	409.75	128.74	-13.92	3.43
	1/7/2005	609.9	209	574.8	669.1	515.70	409.45	621.95	592.35	439.05	136.54	-14.12	3.43
	4/8/2005	617.5	225	590.2	683.9	529.15	421.25	637.05	603.85	454.45	140.10	-14.34	3.35
	7/18/2005	590.4	192.7	554.7	656	498.45	391.55	605.35	572.55	424.35	131.97	-14.21	3.32
	8/26/2005	584.4	183.1	544	647.8	489.83	383.75	595.90	564.20	415.45	129.69	-14.10	3.33
	10/11/2005	589.3	185.9	548.5	652	493.93	387.60	600.25	568.90	418.95	130.78	-14.13	3.36
	1/10/2006	616	216.1	582.8	683.4	524.58	416.05	633.10	599.40	449.75	138.89	-14.42	3.35
	4/9/2006	629	235.4	605.8	701.1	542.83	432.20	653.45	617.40	468.25	143.72	-14.70	3.34
	7/19/2006	595.8	199	563.1	668.3	506.55	397.40	615.70	579.45	433.65	134.12	-14.51	3.27
	10/18/2006	595.6	193	557.4	662.8	502.20	394.30	610.10	576.50	427.90	132.97	-14.34	3.33
	1/18/2007	622.2	223.4	590.2	694.6	532.60	422.80	642.40	606.20	459.00	141.02	-14.59	3.30
	4/19/2007	624.5	231.7	598.4	701.1	538.93	428.10	649.75	611.45	466.40	142.69	-14.73	3.25

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
1	7/1/1999	-115.0	299.7	422.9	109.6	179.30	92.35	266.25	153.95	204.65	47.47	-11.56	-1.14
	7/15/1999	-122.0	289	405.2	95.6	166.95	83.50	250.40	141.60	192.30	44.20	-11.09	-1.14
	8/15/1999	-139.4	265.8	401.5	101.8	157.43	63.20	251.65	131.05	183.80	41.68	-12.52	-1.18
	8/31/1999	-144.1	258.4	394.7	99.6	152.15	57.15	247.15	125.30	179.00	40.28	-12.63	-1.20
	9/15/1999	-144.1	255.9	395.1	102	152.23	55.90	248.55	125.50	178.95	40.30	-12.80	-1.20
	9/30/1999	-141.7	260.4	408.3	112.3	159.83	59.35	260.30	133.30	186.35	42.32	-13.35	-1.19
	10/15/1999	-138.1	275.3	441.9	138.4	179.38	68.60	290.15	151.90	206.85	47.49	-14.72	-1.23
	10/31/1999	-148.1	272.7	430.1	118.5	168.30	62.30	274.30	141.00	195.60	44.56	-14.09	-1.22
	11/15/1999	-142.3	278.9	446.6	134.9	179.53	68.30	290.75	152.15	206.90	47.53	-14.78	-1.23
	11/30/1999	-137.9	284.4	462	150.8	189.83	73.25	306.40	162.05	217.60	50.26	-15.49	-1.24
	12/15/1999	-135.4	290	463.8	152.5	192.73	77.30	308.15	164.20	221.25	51.03	-15.34	-1.28
	12/31/1999	-126.8	301.4	481.4	168.9	206.23	87.30	325.15	177.30	235.15	54.60	-15.81	-1.30
	3/31/2000	-133.9	283.1	455.7	149.6	188.63	74.60	302.65	160.90	216.35	49.94	-15.16	-1.24
	6/30/2000	-157.3	230.6	397.4	119.3	147.50	36.65	258.35	120.05	174.95	39.05	-14.73	-1.23
	9/30/2000	-142.8	237.4	427.4	156.8	169.70	47.30	292.10	142.30	197.10	44.93	-16.27	-1.23
	1/13/2001	-118.2	295.4	511.7	182.5	217.85	88.60	347.10	196.75	238.95	57.68	-17.18	-0.95
	4/20/2001	-128.9	270.9	454	163.4	189.85	71.00	308.70	162.55	217.15	50.27	-15.80	-1.22
	7/16/2001	-146.4	213.9	384.1	133.3	146.23	33.75	258.70	118.85	173.60	38.72	-14.95	-1.23
	10/9/2001	-135.7	237.5	439.4	178.3	179.88	50.90	308.85	151.85	207.90	47.63	-17.14	-1.26
	1/9/2002	-120.2	281.4	483	190.7	208.73	80.60	336.85	181.40	236.05	55.26	-17.03	-1.22
	4/12/2002	-133.2	263.6	441.1	154.2	181.43	65.20	297.65	153.95	208.90	48.04	-15.45	-1.23
	7/18/2002	-158.1	191.2	355.6	118	126.68	16.55	236.80	98.75	154.60	33.54	-14.64	-1.25
	10/7/2002	-149.2	192.4	391.7	156.3	147.80	21.60	274.00	121.25	174.35	39.13	-16.77	-1.19
	1/8/2003	-123.2	268.7	469.3	191.8	201.65	72.75	330.55	173.05	230.25	53.39	-17.13	-1.28
	4/15/2003	-137.5	248.4	427.1	157.1	173.78	55.45	292.10	144.80	202.75	46.01	-15.73	-1.30
	7/1/2003	-159.7	183.9	351.2	124.6	125.00	12.10	237.90	95.75	154.25	33.10	-15.01	-1.31
	10/7/2003	-146.6	206.4	412.6	177.8	162.55	29.90	295.20	133.00	192.10	43.04	-17.63	-1.32
	12/31/2003	-135.4	243.4	450.4	190	187.10	54.00	320.20	157.50	216.70	49.54	-17.69	-1.33
	4/13/2004	-144.6	228.6	422.1	168	168.53	42.00	295.05	138.75	198.30	44.62	-16.82	-1.33
	7/13/2004	-179.1	155.6	334.2	117.5	107.05	-11.75	225.85	77.55	136.55	28.34	-15.79	-1.32
	10/8/2004	-169	170.9	373.7	152.9	132.13	0.95	263.30	102.35	161.90	34.98	-17.44	-1.33
	1/7/2005	-145.5	227.8	440.5	188.2	177.75	41.15	314.35	147.50	208.00	47.06	-18.16	-1.36
	4/8/2005	-159.4	209.2	398.5	148.8	149.28	24.90	273.65	119.55	179.00	39.52	-16.53	-1.33
	7/18/2005	-182.8	141.5	330.3	131.3	105.08	-20.65	230.80	73.75	136.40	27.82	-16.71	-1.40
	8/26/2005	-184	140.7	341.3	131.3	107.33	-21.65	236.30	78.65	136.00	28.42	-17.14	-1.28
	10/11/2005	-174.2	159.1	370.9	131.3	121.78	-7.55	251.10	98.35	145.20	32.24	-17.19	-1.05
	1/10/2006	-152.5	216.4	430.7	131.3	156.48	31.95	281.00	139.10	173.85	41.43	-16.55	-0.78
	4/9/2006	-157.2	206.1	413	131.3	148.30	24.45	272.15	127.90	168.70	39.27	-16.46	-0.91
	7/19/2006	-189.4	135.9	330	131.3	101.95	-26.75	230.65	70.30	133.60	26.99	-17.11	-1.42
	10/18/2006	-170.5	170.2	390.6	131.3	130.40	-0.15	260.95	110.05	150.75	34.53	-17.35	-0.91
	1/18/2007	-145.4	217.2	448.1	131.3	162.80	35.90	289.70	151.35	174.25	43.10	-16.87	-0.51
	4/19/2007	-159.2	203.2	410.4	131.3	146.43	22.00	270.85	125.60	167.25	38.77	-16.54	-0.93

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
12	7/1/1999	356.2	257	201.2	275.1	272.38	306.60	238.15	278.70	266.05	72.12	4.55	0.28
	7/15/1999	353.8	251.6	188.4	273.4	266.80	302.70	230.90	271.10	262.50	70.64	4.77	0.19
	8/15/1999	350.0	242.8	195.3	301.1	272.30	296.40	248.20	272.65	271.95	72.10	3.20	0.02
	8/31/1999	350.2	247.8	201.7	307.9	276.90	299.00	254.80	275.95	277.85	73.31	2.94	-0.04
	9/15/1999	349.8	249.1	203.6	314	279.13	299.45	258.80	276.70	281.55	73.90	2.70	-0.11
	9/30/1999	352.2	256.8	212.1	322.7	285.95	304.50	267.40	282.15	289.75	75.71	2.47	-0.17
	10/15/1999	352.6	257.7	225.5	337.3	293.28	305.15	281.40	289.05	297.50	77.65	1.58	-0.19
	10/31/1999	361.0	268.5	222.6	333.7	296.45	314.75	278.15	291.80	301.10	78.49	2.43	-0.21
	11/15/1999	364.5	273.1	237.1	353.6	307.08	318.80	295.35	300.80	313.35	81.30	1.56	-0.28
	11/30/1999	367.6	276.3	249.1	369.4	315.60	321.95	309.25	308.35	322.85	83.56	0.84	-0.32
	12/15/1999	370.6	280.7	248.5	364.3	316.03	325.65	306.40	309.55	322.50	83.67	1.28	-0.29
	12/31/1999	371.2	282.5	254.8	368.8	319.33	326.85	311.80	313.00	325.65	84.55	1.00	-0.28
	3/31/2000	376.0	289.2	244.7	361.1	317.75	332.60	302.90	310.35	325.15	84.13	1.97	-0.33
	6/30/2000	358.4	247.7	207.4	329.3	285.70	303.05	268.35	282.90	288.50	75.64	2.31	-0.13
	9/30/2000	357.6	235.9	230.1	366.4	297.50	296.75	298.25	293.85	301.15	78.77	-0.10	-0.16
	1/13/2001	382.0	289.5	264.4	384.8	330.18	335.75	324.60	323.20	337.15	87.42	0.74	-0.31
	4/20/2001	382.9	294.9	260.1	378.2	329.03	338.90	319.15	321.50	336.55	87.12	1.31	-0.34
	7/16/2001	352.4	249.4	219.2	330.6	287.90	300.90	274.90	285.80	290.00	76.23	1.73	-0.09
	10/9/2001	357.7	267.9	262.1	382	317.43	312.80	322.05	309.90	324.95	84.04	-0.61	-0.34
	1/9/2002	385.8	301.2	285.1	395.6	341.93	343.50	340.35	335.45	348.40	90.53	0.21	-0.29
	4/12/2002	390.9	310.2	263.2	370.1	333.60	350.55	316.65	327.05	340.15	88.33	2.25	-0.29
	7/18/2002	346.39	265.03	220.4	323.3	288.78	305.71	271.85	283.39	294.17	76.46	2.25	-0.24
	10/7/2002	344.5	265.3	252.4	363.5	306.43	304.90	307.95	298.45	314.40	81.13	-0.20	-0.36
	1/8/2003	385.9	308.5	295.9	394.3	346.15	347.20	345.10	340.90	351.40	91.65	0.14	-0.24
	4/15/2003	392.4	317.3	275.8	371.1	339.15	354.85	323.45	334.10	344.20	89.80	2.09	-0.23
	7/1/2003	360	288.1	238.7	332.8	304.90	324.05	285.75	299.35	310.45	80.73	2.55	-0.25
	10/7/2003	357.1	284.5	277.7	372.1	322.85	320.80	324.90	317.40	328.30	85.48	-0.27	-0.24
	12/31/2003	387.7	318.7	304.1	392.5	350.75	353.20	348.30	345.90	355.60	92.87	0.33	-0.22
	4/13/2004	389.4	324.2	294.9	381.2	347.43	356.80	338.05	342.15	352.70	91.99	1.25	-0.24
	7/13/2004	348	285.8	241	324.8	299.90	316.90	282.90	294.50	305.30	79.40	2.26	-0.24
	10/8/2004	342.4	281.8	269.4	353.1	311.68	312.10	311.25	305.90	317.45	82.52	0.06	-0.26
	1/7/2005	374.1	315.2	302.9	382.8	343.75	344.65	342.85	338.50	349.00	91.01	0.12	-0.24
	4/8/2005	386.7	328.9	284.3	365	341.23	357.80	324.65	335.50	346.95	90.35	2.20	-0.26
	7/18/2005	343.2	285.5	242.4	322.1	298.30	314.35	282.25	292.80	303.80	78.98	2.13	-0.25
	8/26/2005	337	278.7	250.1	331.1	299.23	307.85	290.60	293.55	304.90	79.23	1.15	-0.25
	10/11/2005	338.7	283.6	264.1	348.6	308.75	311.15	306.35	301.40	316.10	81.75	0.32	-0.33
	1/10/2006	371.5	317.4	297	373.5	339.85	344.45	335.25	334.25	345.45	89.98	0.61	-0.25
	4/9/2006	377.4	324.1	290.6	368.2	340.08	350.75	329.40	334.00	346.15	90.04	1.42	-0.27
	7/19/2006	341.9	289.2	238.8	315.3	296.30	315.55	277.05	290.35	302.25	78.45	2.56	-0.27
	10/18/2006	342.7	289.5	274.8	354.5	315.38	316.10	314.65	308.75	322.00	83.50	0.10	-0.30
	1/18/2007	368.4	316.6	305.5	385	343.88	342.50	345.25	336.95	350.80	91.05	-0.18	-0.31
	4/19/2007	370.5	320.9	279.2	353.9	331.13	345.70	316.55	324.85	337.40	87.67	1.94	-0.28

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
13	7/1/1999	177.4	380.2	417.6	236.2	302.85	278.80	326.90	297.50	308.20	80.19	-3.20	-0.24
	7/15/1999	173.8	378	412.7	230.2	298.68	275.90	321.45	293.25	304.10	79.08	-3.03	-0.24
	8/15/1999	172.8	380.2	439.6	252.6	311.30	276.50	346.10	306.20	316.40	82.42	-4.63	-0.23
	8/31/1999	172.6	378	445.8	257.5	313.48	275.30	351.65	309.20	317.75	83.00	-5.07	-0.19
	9/15/1999	170.9	377.2	447.2	261	314.08	274.05	354.10	309.05	319.10	83.16	-5.32	-0.23
	9/30/1999	176.4	380.7	455.9	269.3	320.58	278.55	362.60	316.15	325.00	84.88	-5.59	-0.20
	10/15/1999	176.7	378.9	468.1	279.5	325.80	277.80	373.80	322.40	329.20	86.26	-6.38	-0.15
	10/31/1999	182.4	385.8	502.1	273.8	336.03	284.10	387.95	342.25	329.80	88.97	-6.90	0.28
	11/15/1999	186.8	392.4	482.7	292	338.48	289.60	387.35	334.75	342.20	89.62	-6.50	-0.17
	11/30/1999	189.8	396.8	638.9	305.6	382.78	293.30	472.25	414.35	351.20	101.35	-11.89	1.41
	12/15/1999	193.5	401.1	516.7	302.2	353.38	297.30	409.45	355.10	351.65	93.56	-7.45	0.08
	12/31/1999	194.7	406.1	507.2	308	354.00	300.40	407.60	350.95	357.05	93.73	-7.12	-0.14
	3/31/2000	194.8	409	492.7	298.7	348.80	301.90	395.70	343.75	353.85	92.35	-6.23	-0.23
	6/30/2000	177.7	389.4	467.2	278.7	328.25	283.55	372.95	322.45	334.05	86.91	-5.94	-0.26
	9/30/2000	174.2	385.1	496.7	308	341.00	279.65	402.35	335.45	346.55	90.29	-8.15	-0.25
	1/13/2001	200.0	418.2	530.3	318.6	366.78	309.10	424.45	365.15	368.40	97.11	-7.67	-0.07
	4/20/2001	194.1	416.2	512.8	310.6	358.43	305.15	411.70	353.45	363.40	94.90	-7.08	-0.22
	7/16/2001	166.5	386.2	469	273.8	323.88	276.35	371.40	317.75	330.00	85.75	-6.32	-0.27
	10/9/2001	171.5	389.1	514.8	315.2	347.65	280.30	415.00	343.15	352.15	92.05	-8.95	-0.20
	1/9/2002	193.6	413.6	539.3	324.6	367.78	303.60	431.95	366.45	369.10	97.38	-8.53	-0.06
	4/12/2002	198.8	418.5	509.3	299.2	356.45	308.65	404.25	354.05	358.85	94.38	-6.35	-0.11
	7/18/2002	161.4	379.1	462.4	262.6	316.38	270.25	362.50	311.90	320.85	83.77	-6.13	-0.20
	10/7/2002	155.8	373.6	686.8	301.1	379.33	264.70	493.95	421.30	337.35	100.43	-15.24	1.88
	1/8/2003	193.1	414	547.6	331	371.43	303.55	439.30	370.35	372.50	98.34	-9.02	-0.05
	4/15/2003	195.8	419.9	560.6	305.7	370.50	307.85	433.15	378.20	362.80	98.10	-8.33	0.34
	7/1/2003	172.1	394.8	479.4	273.9	330.05	283.45	376.65	325.75	334.35	87.39	-6.19	-0.19
	10/7/2003	169	389.1	527.1	317.5	350.68	279.05	422.30	348.05	353.30	92.85	-9.52	-0.12
	12/31/2003	196.2	423.2	560.3	334.7	378.60	309.70	447.50	378.25	378.95	100.24	-9.16	-0.02
	4/13/2004	197.9	424.7	546.1	321.7	372.60	311.30	433.90	372.00	373.20	98.65	-8.15	-0.03
	7/13/2004	155.6	383.5	482.7	266.1	321.98	269.55	374.40	319.15	324.80	85.25	-6.97	-0.13
	10/8/2004	152.2	378.4	519	298.6	337.05	265.30	408.80	335.60	338.50	89.24	-9.54	-0.06
	1/7/2005	180.6	410.6	556.1	324.9	368.05	295.60	440.50	368.35	367.75	97.45	-9.63	0.01
	4/8/2005	188.3	419.5	529.1	301	359.48	303.90	415.05	358.70	360.25	95.18	-7.39	-0.03
	7/18/2005	150.7	376.8	482.9	262.2	318.15	263.75	372.55	316.80	319.50	84.24	-7.23	-0.06
	8/26/2005	144.7	373.1	494.1	275.3	321.80	258.90	384.70	319.40	324.20	85.20	-8.36	-0.11
	10/11/2005	146.5	375.2	533.7	291.5	336.73	260.85	412.60	340.10	333.35	89.15	-10.09	0.15
	1/10/2006	176	407.1	548.8	313.5	361.35	291.55	431.15	362.40	360.30	95.67	-9.28	0.05
	4/9/2006	180.6	412.1	538.7	307.8	359.80	296.35	423.25	359.65	359.95	95.26	-8.43	-0.01
	7/19/2006	149.4	377.4	480.1	259.8	316.68	263.40	369.95	314.75	318.60	83.85	-7.08	-0.09
	10/18/2006	155.2	382.8	532.6	304.1	343.68	269.00	418.35	343.90	343.45	90.99	-9.93	0.01
	1/18/2007	179.5	407.9	563.5	330.9	370.45	293.70	447.20	371.50	369.40	98.08	-10.20	0.05
	4/19/2007	182.7	413.5	536	305.6	359.45	298.10	420.80	359.35	359.55	95.17	-8.15	0.00

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
14	7/1/1999	199.5	418.4	473.6	323.8	353.83	308.95	398.70	336.55	371.10	93.68	-5.96	-0.77
	7/15/1999	194.3	414.4	461.1	314.4	346.05	304.35	387.75	327.70	364.40	91.62	-5.54	-0.82
	8/15/1999	191.0	402.1	488.7	347.5	357.33	296.55	418.10	339.85	374.80	94.61	-8.08	-0.78
	8/31/1999	189.5	395.4	496	352.6	358.38	292.45	424.30	342.75	374.00	94.89	-8.76	-0.70
	9/15/1999	186.8	391.6	503.6	359.8	360.45	289.20	431.70	345.20	375.70	95.44	-9.47	-0.68
	9/30/1999	188.5	396.7	516	369	367.55	292.60	442.50	352.25	382.85	97.32	-9.96	-0.69
	10/15/1999	235.3	403	530.4	378.9	386.90	319.15	454.65	382.85	390.95	102.44	-9.01	-0.18
	10/31/1999	202.7	418.5	524.2	371.5	379.23	310.60	447.85	363.45	395.00	100.41	-9.12	-0.71
	11/15/1999	208.9	426.2	548.2	393.2	394.13	317.55	470.70	378.55	409.70	104.35	-10.18	-0.70
	11/30/1999	212.9	429.2	566.6	409.5	404.55	321.05	488.05	389.75	419.35	107.11	-11.10	-0.66
	12/15/1999	216.9	433.5	561.4	403.7	403.88	325.20	482.55	389.15	418.60	106.93	-10.46	-0.66
	12/31/1999	220.7	443.8	566.6	407.4	409.63	332.25	487.00	393.65	425.60	108.46	-10.28	-0.72
	3/31/2000	215.2	438.2	567.9	406.5	406.95	326.70	487.20	391.55	422.35	107.75	-10.67	-0.69
	6/30/2000	191.3	415.8	542.4	380.7	382.55	303.55	461.55	366.85	398.25	101.29	-10.50	-0.70
	6/30/2000	183.3	409.8	571	409.9	393.50	296.55	490.45	377.15	409.85	104.19	-12.89	-0.73
	1/13/2001	215.4	447.2	588.9	421.9	418.35	331.30	505.40	402.15	434.55	110.77	-11.57	-0.73
	4/20/2001	210.2	445.1	586.6	415.7	414.40	327.65	501.15	398.40	430.40	109.72	-11.53	-0.72
	7/16/2001	171.2	413	554.5	377.7	379.10	292.10	466.10	362.85	395.35	100.37	-11.56	-0.73
	10/9/2001	178.5	417.9	596.2	418.8	402.85	298.20	507.50	387.35	418.35	106.66	-13.91	-0.69
	1/9/2002	206.2	445.9	606.4	430	422.13	326.05	518.20	406.30	437.95	111.77	-12.77	-0.71
	4/12/2002	208.6	449.5	584.1	408.1	412.58	329.05	496.10	396.35	428.80	109.24	-11.10	-0.73
	7/18/2002	161.7	410.1	551.9	368.5	373.05	285.90	460.20	356.80	389.30	98.77	-11.58	-0.73
	10/7/2002	160.2	405.5	592.3	407.7	391.43	282.85	500.00	376.25	406.60	103.64	-14.43	-0.68
	1/8/2003	202	449.1	620.2	437.7	427.25	325.55	528.95	411.10	443.40	113.12	-13.52	-0.72
	4/15/2003	205.4	453.6	590	409.8	414.70	329.50	499.90	397.70	431.70	109.80	-11.32	-0.76
	7/1/2003	171.9	426.9	559.5	377.3	383.90	299.40	468.40	365.70	402.10	101.65	-11.23	-0.82
	10/7/2003	172	424.4	600.8	422.4	404.90	298.20	511.60	386.40	423.40	107.21	-14.18	-0.83
	12/31/2003	205.6	461.3	624.2	444.9	434.00	333.45	534.55	414.90	453.10	114.91	-13.36	-0.86
	4/13/2004	204.7	463.4	611.5	433.1	428.18	334.05	522.30	408.10	448.25	113.37	-12.51	-0.90
	7/13/2004	159.6	424.2	566.4	383.7	383.48	291.90	475.05	363.00	403.95	101.53	-12.17	-0.92
	10/8/2004	153	416.8	590.5	409.5	392.45	284.90	500.00	371.75	413.15	103.91	-14.30	-0.93
	1/7/2005	192.8	454.9	627.8	446.9	430.60	323.85	537.35	410.30	450.90	114.01	-14.19	-0.91
	4/8/2005	205.2	467.5	600.9	425.2	424.70	336.35	513.05	403.05	446.35	112.45	-11.74	-0.97
	7/18/2005	154.9	424.1	560.9	385.2	381.28	289.50	473.05	357.90	404.65	100.95	-12.20	-1.05
	8/26/2005	168.3	416.1	569.1	391.2	386.18	292.20	480.15	368.70	403.65	102.25	-12.49	-0.78
	10/11/2005	152.5	418.5	590.5	413.4	393.73	285.50	501.95	371.50	415.95	104.25	-14.38	-1.00
	1/10/2006	190.7	455.4	615	436.7	424.45	323.05	525.85	402.85	446.05	112.38	-13.48	-0.97
	4/9/2006	196.7	460.2	612.3	436.6	426.45	328.45	524.45	404.50	448.40	112.91	-13.03	-0.98
	7/19/2006	159.7	426.1	562.3	382.1	382.55	292.90	472.20	361.00	404.10	101.29	-11.92	-0.97
	10/18/2006	161.9	425.9	600.5	422.5	402.70	293.90	511.50	381.20	424.20	106.62	-14.46	-0.96
	1/18/2007	192.2	454.2	638.5	460	436.23	323.20	549.25	415.35	457.10	115.50	-15.02	-0.94
	4/19/2007	198.7	462.5	611.3	432	426.13	330.60	521.65	405.00	447.25	112.83	-12.70	-0.95

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
26	7/1/1999	222.2	-19.9	305.2	560	266.88	101.15	432.60	263.70	270.05	70.66	-22.03	-0.14
	7/15/1999	207.8	-36.8	294.3	540.9	251.55	85.50	417.60	251.05	252.05	66.60	-22.07	-0.02
	8/15/1999	189.9	-53.4	320.4	546.8	250.93	68.25	433.60	255.15	246.70	66.44	-24.28	0.19
	8/31/1999	184.8	-60	330.2	555.2	252.55	62.40	442.70	257.50	247.60	66.87	-25.27	0.22
	9/15/1999	185.7	-57.2	336.6	558.2	255.83	64.25	447.40	261.15	250.50	67.73	-25.46	0.24
	9/30/1999	187.5	-53.7	349.9	570.1	263.45	66.90	460.00	268.70	258.20	69.75	-26.12	0.24
	10/15/1999	195.3	-50.5	375.2	601.5	280.38	72.40	488.35	285.25	275.50	74.23	-27.64	0.22
	10/31/1999	197.3	-39.9	370.8	589.7	279.48	78.70	480.25	284.05	274.90	74.00	-26.69	0.20
	11/15/1999	202.5	-32.3	385.9	601.1	289.30	85.10	493.50	294.20	284.40	76.60	-27.14	0.22
	11/30/1999	206.5	-27.3	398.1	613.9	297.80	89.60	506.00	302.30	293.30	78.85	-27.67	0.20
	12/15/1999	216.1	-19.5	401.6	620.9	304.78	98.30	511.25	308.85	300.70	80.70	-27.44	0.18
	12/31/1999	223.8	-15	410.7	633.4	313.23	104.40	522.05	317.25	309.20	82.93	-27.76	0.18
	3/31/2000	203.5	-16	395.7	633.5	304.18	93.75	514.60	299.60	308.75	80.54	-27.97	-0.20
	6/30/2000	149.3	-41	371.2	553.8	258.33	54.15	462.50	260.25	256.40	68.40	-27.14	0.09
	6/30/2000	154.3	-22.3	411.5	580.2	280.93	66.00	495.85	282.90	278.95	74.38	-28.57	0.09
	1/13/2001	197.9	7.7	446.8	627.1	319.88	102.80	536.95	322.35	317.40	84.69	-28.85	0.11
	4/20/2001	167.6	1.3	434.9	589.5	298.33	84.45	512.20	301.25	295.40	78.99	-28.43	0.13
	7/16/2001	112.8	-20.6	409.7	555.1	264.25	46.10	482.40	261.25	267.25	69.97	-29.00	-0.13
	10/9/2001	136.9	-5.4	451.7	582.7	291.48	65.75	517.20	294.30	288.65	77.17	-30.00	0.13
	1/9/2002	176.6	9	461.6	618.2	316.35	92.80	539.90	319.10	313.60	83.76	-29.71	0.12
	4/12/2002	158.20	3.40	438	581.00	295.25	80.80	509.70	298.30	292.20	78.17	-28.50	0.14
	7/18/2002	86.10	-23.70	405	503.86	242.87	31.20	454.53	245.65	240.08	64.30	-28.13	0.12
	10/7/2002	96.1	2.90	445.20	562.80	276.75	49.50	504.00	270.65	282.85	73.28	-30.21	-0.27
	1/8/2003	165.9	41.91	480.40	628.48	329.17	103.91	554.44	323.15	335.20	87.16	-29.94	-0.27
	4/15/2003	147.5	33.95	455.30	592.01	307.19	90.73	523.65	301.40	312.98	81.33	-28.77	-0.26
	7/1/2003	88.2	9.66	424.1	577.30	274.82	48.93	500.70	256.15	293.48	72.76	-30.02	-0.84
	10/7/2003	103.5	24.24	466.9	574.34	292.25	63.87	520.62	285.20	299.29	77.38	-30.35	-0.32
	12/31/2003	130.5	44.68	481.6	566.95	305.93	87.59	524.27	306.05	305.81	81.00	-29.02	0.01
	4/13/2004	118.2	42.08	471.6	585.31	304.30	80.14	528.45	294.90	313.69	80.57	-29.79	-0.42
	7/13/2004	49.6	8.40	430.9	548.80	259.43	29.00	489.85	240.25	278.60	68.69	-30.63	-0.86
	10/8/2004	54.7	18.19	457.3	588.15	279.59	36.45	522.72	256.00	303.17	74.03	-32.32	-1.06
	1/7/2005	108.7	42.65	486.4	597.82	308.89	75.67	542.11	297.55	320.23	81.78	-31.00	-0.51
	4/8/2005	91.7	33.99	457.3	601.47	296.12	62.85	529.39	274.50	317.73	78.40	-31.01	-0.97
	7/18/2005	28.7	12.91	432.3	605.33	269.81	20.81	518.82	230.50	309.12	71.44	-33.10	-1.76
	8/26/2005	31.4	16.85	447.8	588.39	271.11	24.13	518.10	239.60	302.62	71.78	-32.83	-1.41
	10/11/2005	43.7	14.58	464.4	588.60	277.82	29.14	526.50	254.05	301.59	73.56	-33.05	-1.06
	1/10/2006	96.3	14.58	483.8	588.60	295.82	55.44	536.20	290.05	301.59	78.32	-31.95	-0.26
	4/9/1906	87.1	29.40	477	588.60	295.52	58.25	532.80	282.05	309.00	78.25	-31.54	-0.60
	7/19/1906	18.4	-2.90	430.9	588.60	258.75	7.75	509.75	224.65	292.85	68.51	-33.36	-1.53
	10/18/1906	61.1	14.58	483.2	588.60	286.87	37.84	535.90	272.15	301.59	75.95	-33.10	-0.66
	1/18/2007	99.2	14.58	505.9	588.60	302.07	56.89	547.25	302.55	301.59	79.98	-32.59	0.02
	4/19/2007	80.5	14.58	477.1	588.60	290.19	47.54	532.85	278.80	301.59	76.83	-32.25	-0.51

Table 4 Pile Forces and Bending Moments

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
1	07/01/99	903.00	42.30	679.00	-	541.43	472.65	679.00	791.00	42.30	456.92	-73.98	99.88
	07/15/99	918.00	48.00	885.00	-	617.00	483.00	885.00	901.50	48.00	520.69	-144.12	113.86
	07/31/00	932.43	51.99	887.34	-	623.92	492.21	887.34	909.89	51.99	526.53	-141.66	114.44
	08/15/99	940.56	34.46	923.00	-	632.67	487.51	923.00	931.78	34.46	533.91	-156.13	119.70
	08/30/99	948.68	31.28	931.09	-	637.02	489.98	931.09	939.89	31.28	537.58	-158.14	121.21
	09/15/99	955.75	27.83	938.36	-	640.65	491.79	938.36	947.06	27.83	540.64	-160.10	122.62
	09/30/99	959.08	23.03	947.01	-	643.04	491.06	947.01	953.05	23.03	542.66	-163.47	124.06
	10/15/99	963.38	18.85	954.86	-	645.70	491.12	954.86	959.12	18.85	544.90	-166.26	125.43
	10/31/99	973.25	5.58	968.30	-	649.04	489.42	968.30	970.78	5.58	547.73	-171.69	128.76
	11/15/99	973.34	1.26	977.48	-	650.69	487.30	977.48	975.41	1.26	549.12	-175.74	129.95
	11/30/99	975.73	-2.84	980.87	-	651.25	486.45	980.87	978.30	-2.84	549.59	-177.26	130.88
	12/15/99	974.96	-2.47	982.11	-	651.53	486.25	982.11	978.54	-2.47	549.83	-177.77	130.87
	12/31/99	974.03	-54.00	984.71		634.91	460.02	984.71	979.37	-54.00	535.80	-188.11	137.85
	03/31/00	964.52	3.86	981.83	-	650.07	484.19	981.83	973.17	3.86	548.59	-178.41	129.31
	06/30/00	977.80	-36.92	980.73	-	640.54	470.44	980.73	979.27	-36.92	540.55	-182.94	135.56
	09/30/00	1009.20	-10.20	1005.99	-	668.33	499.50	1005.99	1007.60	-10.20	564.01	-181.58	135.77
	01/13/01	1014.12	-29.4495	1029.11	-	671.26	492.33	1029.11	1021.61	-29.45	566.48	-192.44	140.21
	04/20/01	1008.27	-18.6852	1022.57	-	670.72	494.79	1022.57	1015.42	-18.69	566.02	-189.21	137.95
	07/10/01	1030.41	-8.36772	1019.56	-	680.53	511.02	1019.56	1024.98	-8.37	574.30	-182.32	137.85
	10/09/01	1054.25	-20.5131	1038.65	-	690.80	516.87	1038.65	1046.45	-20.51	582.96	-187.07	142.33
	01/09/02	1055.96	-29.65	1045.80	-	690.70	513.15	1045.80	1050.88	-29.65	582.88	-190.96	144.14
	04/12/02	1041.9	-24.8188	1040.36	-	685.81	508.54	1040.36	1041.13	-24.82	578.76	-190.66	142.20
	07/19/02	1062.21	-17.26	1035.12	17.14	693.36	522.47	1035.12	1048.67	-17.26	585.12	-183.79	142.20
	10/08/02	1086.38	-30.07	1049.75	-6.63	702.02	528.16	1049.75	1068.06	-30.07	592.43	-187.00	146.49
	01/08/03	1080.45	-42.89	1062.94	0.41	700.17	518.78	1062.94	1071.70	-42.89	590.87	-195.09	148.69
	04/15/03	1059.37	-29.65	1049.86	22.95	693.19	514.86	1049.86	1054.62	-29.65	584.99	-191.81	144.64
	06/01/03	1064.93	-31.16	1053.52	21.00	695.77	516.89	1053.52	1059.23	-31.16	587.16	-192.39	145.46
	08/07/03	1083.86	-27.66	1053.40	9.26	703.20	528.10	1053.40	1068.63	-27.66	593.43	-188.33	146.25
	10/07/03	1095.56	-38.67	1066.64	-0.69	707.84	528.45	1066.64	1081.10	-38.67	597.35	-192.95	149.38
	12/31/03	1100.15	-54.88	1082.97	-0.89	709.41	522.64	1082.97	1091.56	-54.88	598.68	-200.89	152.93
	04/13/04	1080.17	-43.67	1074.07	21.65	703.52	518.25	1074.07	1077.12	-43.67	593.70	-199.27	149.51
	07/13/04	1101.53	-34.89	1072.49	10.76	713.04	533.32	1072.49	1087.01	-34.89	601.74	-193.30	149.66
	10/08/04	1122.82	-45.70	1085.57	-8.86	720.90	538.56	1085.57	1104.19	-45.70	608.36	-196.11	153.40
	01/07/05	1116.60	-58.49	1097.39	-8.94	718.50	529.06	1097.39	1107.00	-58.49	606.34	-203.76	155.48
	04/08/05	1099.01	-52.77	1096.58	5.48	714.28	523.12	1096.58	1097.80	-52.77	602.78	-205.59	153.49
	07/18/05	1116.44	-41.55	1096.58	-2.36	723.82	537.44	1096.58	1106.51	-41.55	610.83	-200.46	153.15
	08/26/05	1128.14	-43.63	1095.73	-10.20	726.75	542.26	1095.73	1111.93	-43.63	613.30	-198.43	154.15
	11/12/05	1127.45	-44.76	1095.72	-9.67	726.14	541.34	1095.72	1111.58	-44.76	612.79	-198.75	154.26
	01/10/06	1129.36	-64.30	1095.72	-19.70	720.26	532.53	1095.72	1112.54	-64.30	607.83	-201.91	156.99
	04/09/06	1114.90	-55.20	1095.72	-1.14	718.47	529.85	1095.72	1105.31	-55.20	606.32	-202.87	154.81
	07/19/06	1130.94	-46.83	1095.72	-9.42	726.61	542.05	1095.72	1113.33	-46.83	613.19	-198.50	154.77
	10/18/06	1154.91	-58.29	1095.72	-27.50	730.78	548.31	1095.72	1125.32	-58.29	616.71	-196.26	157.89
	01/18/07	1139.55	-68.49	1095.72	-21.73	722.26	535.53	1095.72	1117.64	-68.49	609.52	-200.84	158.23
	04/19/07	1125.58	-58.82	1095.72	-8.49	720.83	533.38	1095.72	1110.65	-58.82	608.31	-201.61	156.01

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
17	07/01/99	575.00	589.00	243.00	-	469.00	582.00	243.00	409.00	589.00	395.79	121.54	-24.01
	07/15/99	585.00	602.00	237.00	-	474.67	593.50	237.00	411.00	602.00	400.57	127.81	-25.48
	07/30/99	594.35	611.17	230.68	-	478.73	602.76	230.68	412.52	611.17	404.00	133.40	-26.50
	08/15/99	596.87	611.09	242.58	336.68	446.81	603.98	289.63	419.73	473.89	377.06	112.70	-7.22
	08/31/99	601.58	616.82	241.00	-	486.47	609.20	241.00	421.29	616.82	410.53	132.00	-26.08
	09/15/99	605.96	622.42	240.47	-	489.62	614.19	240.47	423.22	622.42	413.19	133.98	-26.57
	09/30/99	609.62	624.20	240.71	336.98	452.88	616.91	288.85	425.17	480.59	382.18	117.62	-7.39
	10/15/99	612.87	629.40	240.27	336.21	454.69	621.14	288.24	426.57	482.81	383.71	119.35	-7.50
	10/31/99	616.45	631.80	243.11	336.29	456.91	624.13	289.70	429.78	484.05	385.59	119.90	-7.24
	11/15/99	619.54	632.45	245.83	337.79	458.90	626.00	291.81	432.69	485.12	387.27	119.81	-6.99
	11/30/99	623.35	635.58	248.71	340.31	461.99	629.47	294.51	436.03	487.95	389.87	120.09	-6.93
	12/15/99	624.21	637.77	247.77	339.95	462.43	630.99	293.86	435.99	488.86	390.24	120.87	-7.05
	12/31/99	626.60	640.86	249.37	341.45	464.57	633.73	295.41	437.99	491.16	392.05	121.29	-7.09
	03/31/00	634.53	648.30	254.69	346.89	471.10	641.41	300.79	444.61	497.60	397.56	122.12	-7.07
	06/30/00	640.05	652.80	250.99	342.06	471.48	646.43	296.53	445.52	497.43	397.88	125.44	-6.93
	09/30/00	647.16	661.13	247.62	336.78	473.17	654.14	292.20	447.39	498.96	399.31	129.76	-6.88
	01/13/01	654.063	665.1119	256.39	342.22	479.45	659.59	299.31	455.23	503.67	404.61	129.16	-6.46
	04/20/01	654.429	664.7057	260.37	345.47	481.25	659.57	302.92	457.40	505.09	406.12	127.86	-6.36
	07/10/01	661.456	672.0985	256.15	342.75	483.11	666.78	299.45	458.80	507.43	407.70	131.69	-6.49
	10/09/01	668.361	679.0039	251.93	338.20	484.37	673.68	295.06	460.14	508.60	408.76	135.74	-6.46
	01/09/02	671.083	683.4721	252.17	337.92	486.16	677.28	295.04	461.63	510.69	410.27	137.04	-6.55
	04/12/02	669.17	680.02	256.68	342.06	486.98	674.60	299.37	462.93	511.04	410.96	134.52	-6.42
	07/19/02	671.69	683.96	253.27	272.93	470.46	677.83	263.10	462.48	478.44	397.02	148.69	-2.13
	10/08/02	678.60	692.21	247.01	332.37	487.54	685.40	289.69	462.80	512.29	411.44	141.87	-6.60
	01/08/03	678.44	689.32	251.28	334.22	488.31	683.88	292.75	464.86	511.77	412.09	140.22	-6.26
	04/15/03	679.45	692.45	254.73	341.09	491.93	685.95	297.91	467.09	516.77	415.14	139.12	-6.63
	06/01/03	678.76	689.85	256.43	341.09	491.53	684.30	298.76	467.60	515.47	414.80	138.22	-6.39
	08/07/03	682.33	695.54	251.15	336.74	491.44	688.94	293.95	466.74	516.14	414.73	141.61	-6.59
	10/07/03	686.23	700.57	250.14	334.87	492.95	693.40	292.50	468.19	517.72	416.00	143.73	-6.61
	12/31/03	689.48	700.61	257.04	341.05	497.05	695.05	299.04	473.26	520.83	419.46	141.97	-6.35
	04/13/04	689.24	699.88	260.70	346.65	499.12	694.56	303.68	474.97	523.27	421.21	140.14	-6.44
	07/13/04	693.10	667.59	255.46	341.33	489.37	680.34	298.39	474.28	504.46	412.98	136.93	-4.03
	10/08/04	699.03	710.89	250.83	337.39	499.53	704.96	294.11	474.93	524.14	421.56	147.30	-6.56
	01/07/05	699.07	711.46	253.31	339.95	500.95	705.26	296.63	476.19	525.70	422.75	146.50	-6.61
	04/08/05	696.43	708.09	257.94	343.81	501.57	702.26	300.87	477.18	525.95	423.27	143.90	-6.51
	07/18/05	699.56	708.33	253.71	338.36	499.99	703.94	296.04	476.64	523.35	421.94	146.24	-6.23
	08/26/05	702.04	711.17	250.91	335.97	500.02	706.61	293.44	476.47	523.57	421.97	148.13	-6.28
	11/12/05	701.95	699.60	251.68	337.06	497.57	700.78	294.37	476.82	518.33	419.90	145.70	-5.54
	01/10/06	705.16	715.03	253.47	339.58	503.31	710.10	296.53	479.32	527.31	424.75	148.27	-6.40
	04/09/06	703.94	713.04	259.52	343.20	504.93	708.49	301.36	481.73	528.12	426.11	145.96	-6.19
	07/19/06	708.37	716.01	256.84	339.95	505.29	712.19	298.39	482.61	527.98	426.42	148.35	-6.05
	10/18/06	713.29	721.25	251.76	334.02	505.08	717.27	292.89	482.52	527.63	426.24	152.14	-6.02
	01/18/07	712.84	717.96	256.52	336.54	505.96	715.40	296.53	484.68	527.25	426.98	150.17	-5.68
	04/19/07	711.13	716.21	260.62	340.56	507.13	713.67	300.59	485.88	528.38	427.97	148.10	-5.67

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
18	07/01/99	546.00	501.00	248.00	173	367.00	523.50	210.50	397.00	337.00	309.71	112.21	8.00
	07/15/99	557.00	513.00	243.00	229	385.50	535.00	236.00	400.00	371.00	325.32	107.20	3.87
	07/30/99	565.55	519.94	239.54	224.26	387.32	542.75	231.90	402.55	372.10	326.86	111.44	4.06
	08/15/99	567.71	520.14	230.56	232.51	387.73	543.93	231.54	399.14	376.33	327.21	112.00	3.04
	08/31/99	573.72	526.52	247.46	232.87	395.14	550.12	240.17	410.59	379.70	333.46	111.12	4.12
	09/15/99	578.06	532.08	246.65	233.61	397.60	555.07	240.13	412.36	382.85	335.53	112.91	3.94
	09/30/99	582.49	534.97	247.46	234.05	399.74	558.73	240.76	414.98	384.51	337.34	114.00	4.06
	10/15/99	586.68	538.17	247.25	235.23	401.83	562.43	241.24	416.97	386.70	339.11	115.15	4.04
	10/31/99	590.77	539.40	249.37	235.6	403.79	565.09	242.49	420.07	387.50	340.75	115.66	4.34
	11/15/99	592.65	540.65	251.68	237.47	405.61	566.65	244.58	422.17	389.06	342.30	115.47	4.42
	11/30/99	596.63	527.25	254.12	239.69	404.42	561.94	246.91	425.38	383.47	341.29	112.94	5.59
	12/15/99	599.47	545.53	254.12	239.05	409.54	572.50	246.59	426.80	392.29	345.61	116.84	4.60
	12/31/99	601.54	548.45	255.38	239.17	411.14	575.00	247.28	428.46	393.81	346.96	117.49	4.62
	03/31/00	610.32	554.87	262.08	243.60	417.72	582.59	252.84	436.20	399.23	352.51	118.22	4.93
	06/30/00	616.94	539.60	260.98	238.93	414.11	578.27	249.96	438.96	389.26	349.47	117.70	6.63
	09/30/00	625.63	400.76	255.58	232.18	378.54	513.19	243.88	440.61	316.47	319.45	96.55	16.56
	01/13/01	632.372	566.6896	264.44	235.84	424.83	599.53	250.14	448.40	401.26	358.52	125.26	6.29
	04/20/01	632.575	561.5309	268.38	236.21	424.67	597.05	252.29	450.48	398.87	358.38	123.60	6.88
	07/10/01	639.684	569.2893	264.64	234.54	427.04	604.49	249.59	452.16	401.91	360.38	127.23	6.70
	10/09/01	646.508	576.5197	259.81	232.14	428.74	611.51	245.97	453.16	404.33	361.82	131.05	6.51
	01/09/02	650.895	576.8446	259.68	230.92	429.59	613.87	245.30	455.29	403.88	362.53	132.14	6.86
	04/12/02	650.123	570.1017	264.192	232.55	429.24	610.11	248.37	457.16	401.33	362.24	129.69	7.45
	07/19/02	653.45	572.46	260.90	226.38	428.30	612.96	243.64	457.18	399.42	361.44	132.40	7.71
	10/08/02	659.69	581.14	254.65	222.68	429.54	620.41	238.66	457.17	401.91	362.49	136.86	7.37
	01/08/03	657.76	576.89	257.57	224.47	429.17	617.32	241.02	457.67	400.68	362.18	134.91	7.60
	04/15/03	661.78	576.19	262.16	228.04	432.04	618.99	245.10	461.97	402.12	364.60	134.04	7.98
	06/01/03	661.37	572.66	264.07	227.59	431.43	617.02	245.83	462.72	400.13	364.08	133.07	8.35
	08/07/03	665.76	577.29	258.18	222.76	431.00	621.53	240.47	461.97	400.03	363.72	136.61	8.26
	10/07/03	669.26	582.73	256.11	222.56	432.66	625.99	239.33	462.68	402.65	365.13	138.62	8.01
	12/31/03	670.27	581.39	262.53	229.62	435.95	625.83	246.08	466.40	405.51	367.90	136.15	8.12
	04/13/04	669.42	576.64	266.47	232.35	436.22	623.03	249.41	467.94	404.49	368.12	133.95	8.46
	07/13/04	672.95	578.63	261.80	224.79	434.54	625.79	243.29	467.37	401.71	366.71	137.13	8.76
	10/08/04	677.95	587.12	255.42	222.31	435.70	632.53	238.87	466.68	404.72	367.69	141.14	8.27
	01/07/05	677.50	586.02	257.61	226.05	436.80	631.76	241.83	467.56	406.04	368.61	139.80	8.21
	04/08/05	674.17	580.83	263.14	227.80	436.48	627.50	245.47	468.65	404.31	368.35	136.96	8.58
	07/18/05	677.87	580.70	259.40	221.74	434.93	629.29	240.57	468.63	401.22	367.04	139.36	8.99
	08/26/05	679.25	583.30	256.27	219.43	434.56	631.28	237.85	467.76	401.37	366.73	141.05	8.86
	11/12/05	679.13	583.14	256.88	220.08	434.81	631.13	238.48	468.00	401.61	366.93	140.77	8.86
	01/10/06	679.45	587.32	257.33	223.00	436.78	633.39	240.17	468.39	405.16	368.60	140.97	8.43
	04/09/06	679.57	583.14	263.01	226.46	438.05	631.36	244.74	471.29	404.80	369.67	138.61	8.87
	07/19/06	683.27	585.78	260.94	222.31	438.08	634.53	241.63	472.11	404.05	369.69	140.86	9.08
	10/18/06	687.01	592.40	255.09	218.66	438.29	639.70	236.88	471.05	405.53	369.87	144.42	8.74
	01/18/07	685.10	588.58	259.16	221.83	438.67	636.84	240.49	472.13	405.20	370.19	142.10	8.93
	04/19/07	685.18	584.40	264.40	222.96	439.23	634.79	243.68	474.79	403.68	370.67	140.22	9.49

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
19	07/01/99	566.97	586.00	298.00	228.9	419.97	576.49	263.45	432.49	407.45	354.41	112.23	3.34
	07/15/99	580.00	597.00	294.00	224	423.75	588.50	259.00	437.00	410.50	357.60	118.13	3.54
	07/30/99	588.71	606.46	291.38	218.62	426.29	597.59	255.00	440.05	412.54	359.75	122.82	3.67
	08/15/99	591.02	607.35	300.95	227.92	431.81	599.19	264.44	445.99	417.64	364.40	120.01	3.78
	08/31/99	595.94	613.52	300.59	229.63	434.92	604.73	265.11	448.27	421.58	367.03	121.76	3.56
	09/15/99	599.88	617.91	300.67	229.54	437.00	608.90	265.11	450.28	423.73	368.78	123.25	3.54
	09/30/99	603.53	621.65	302.70	229.75	439.41	612.59	266.23	453.12	425.70	370.82	124.18	3.66
	10/15/99	607.51	625.02	302.29	229.71	441.13	616.27	266.00	454.90	427.37	372.27	125.57	3.67
	10/31/99	611.37	627.25	306.07	229.7	443.60	619.31	267.89	458.72	428.48	374.35	125.99	4.03
	11/15/99	613.61	627.78	308.31	232.67	445.59	620.70	270.49	460.96	430.23	376.04	125.55	4.10
	11/30/99	616.29	630.54	313.83	234.7	448.84	623.42	274.27	465.06	432.62	378.78	125.17	4.33
	12/15/99	617.83	631.44	314.03	234.9	449.55	624.64	274.47	465.93	433.17	379.38	125.54	4.37
	12/31/99	619.94	634.20	314.36	236.45	451.24	627.07	275.41	467.15	435.33	380.80	126.08	4.25
	03/31/00	629.45	639.44	320.33	239.74	457.24	634.44	280.03	474.89	439.59	385.86	127.06	4.71
	06/30/00	636.15	643.50	317.81	51.91	412.34	639.83	184.86	476.98	347.71	347.98	163.11	17.25
	09/30/00	646.59	651.99	312.33	231.29	460.55	649.29	271.81	479.46	441.64	388.66	135.33	5.04
	01/13/01	653.454	657.0691	320.21	236.77	466.88	655.26	278.49	486.83	446.92	394.00	135.08	5.32
	04/20/01	651.464	653.2102	324.03	237.42	466.53	652.34	280.72	487.74	445.32	393.71	133.23	5.66
	07/10/01	658.856	661.1717	320.61	235.03	468.92	660.01	277.82	489.74	448.10	395.72	137.02	5.55
	10/09/01	667.346	669.2551	315.37	230.97	470.74	668.30	273.17	491.36	450.11	397.25	141.66	5.50
	01/09/02	670.88	671.7736	315.66	229.71	472.00	671.33	272.68	493.27	450.74	398.32	142.92	5.67
	04/12/02	667.71	665.64	321.06	231.62	471.51	666.68	276.34	494.39	448.63	397.90	139.94	6.10
	07/19/02	673.44	667.87	319.88	227.72	472.23	670.66	273.80	496.66	447.79	398.51	142.28	6.52
	10/08/02	681.93	676.18	313.24	222.91	473.56	679.05	268.07	497.58	449.54	399.64	147.34	6.41
	01/08/03	682.42	673.60	316.88	225.03	474.48	678.01	270.96	499.65	449.32	400.42	145.93	6.71
	04/15/03	686.11	672.95	321.26	228.37	477.17	679.53	274.81	503.69	450.66	402.69	145.10	7.07
	06/01/03	685.30	670.80	322.48	227.84	476.60	678.05	275.16	503.89	449.32	402.21	144.44	7.28
	08/07/03	689.12	675.35	317.28	223.09	476.21	682.23	270.18	503.20	449.22	401.87	147.72	7.20
	10/07/03	694.48	681.03	314.64	222.27	478.11	687.76	268.46	504.56	451.65	403.47	150.32	7.06
	12/31/03	695.94	680.95	322.73	229.34	482.24	688.45	276.03	509.33	455.15	406.96	147.86	7.23
	04/13/04	695.62	676.77	330.77	231.41	483.64	686.19	281.09	513.19	454.09	408.15	145.23	7.88
	07/13/04	700.37	679.61	327.88	224.22	483.02	689.99	276.05	514.13	451.92	407.62	148.40	8.30
	10/08/04	706.18	688.67	321.87	221.22	484.48	697.43	271.54	514.03	454.94	408.86	152.68	7.88
	01/07/05	705.37	688.14	324.72	224.55	485.69	696.75	274.63	515.04	456.35	409.88	151.34	7.83
	04/08/05	702.85	682.86	329.75	226.66	485.53	692.86	278.21	516.30	454.76	409.74	148.66	8.21
	07/18/05	706.50	683.55	327.15	219.55	484.19	695.03	273.35	516.83	451.55	408.61	151.18	8.71
	08/26/05	708.05	686.48	322.81	217.89	483.80	697.26	270.35	515.43	452.18	408.28	153.05	8.44
	11/12/05	707.97	686.27	323.74	218.33	484.08	697.12	271.04	515.85	452.30	408.51	152.76	8.48
	01/10/06	710.04	690.54	324.68	221.62	486.72	700.29	273.15	517.36	456.08	410.74	153.13	8.17
	04/09/06	709.47	686.72	329.75	224.34	487.57	698.10	277.05	519.61	455.53	411.46	150.95	8.55
	07/19/06	714.26	690.38	328.09	220.57	488.32	702.32	274.33	521.17	455.47	412.10	153.44	8.76
	10/18/06	718.93	696.80	321.91	216.75	488.60	707.86	269.33	520.42	456.77	412.33	157.22	8.49
	01/18/07	717.19	692.98	326.63	219.88	489.17	705.08	273.25	521.91	456.43	412.81	154.82	8.73
	04/19/07	716.98	689.52	331.50	221.54	489.89	703.25	276.52	524.24	455.53	413.42	152.99	9.17

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
34	07/01/99	271.75	436.00	261.00	583.00	387.94	353.88	422.00	266.38	509.50	327.38	-24.42	-32.43
	07/15/99	279.00	617.00	253.00	583.00	433.00	448.00	418.00	266.00	600.00	365.41	10.76	-44.56
	07/30/99	282.79	647.00	243.64	585.13	439.64	464.90	414.39	263.22	616.07	371.01	18.11	-47.07
	08/15/99	272.89	690.09	251.16	614.66	457.20	481.49	432.91	262.03	652.38	385.83	17.42	-52.07
	08/31/99	265.66	576.80	245.14	627.09	428.67	421.23	436.12	255.40	601.95	361.76	-5.34	-46.23
	09/15/99	265.08	802.81	242.34	635.26	486.37	533.95	438.80	253.71	719.04	410.45	34.11	-62.07
	09/30/99	260.50	807.40	238.64	642.65	487.30	533.95	440.65	249.57	725.03	411.23	33.45	-63.43
	10/15/99	256.43	811.14	234.46	648.58	487.65	533.79	441.52	245.45	729.86	411.53	33.08	-64.62
	10/31/99	240.47	824.02	221.62	665.31	487.86	532.25	443.47	231.05	744.67	411.70	31.83	-68.52
	11/15/99	241.93	831.45	224.75	676.77	493.73	536.69	450.76	233.34	754.11	416.65	30.81	-69.47
	11/31/99	240.47	835.88	224.26	648.85	487.37	538.18	436.56	232.37	742.37	411.29	36.43	-68.03
	12/15/99	241.41	836.77	222.35	684.04	496.14	539.09	453.20	231.88	760.41	418.69	30.79	-70.51
	12/31/99	242.22	836.08	224.14	684.93	496.84	539.15	454.54	233.18	760.51	419.29	30.34	-70.35
	03/31/00	257.37	828.85	237.38	675.92	499.88	543.11	456.65	247.38	752.38	421.85	31.00	-67.37
	06/30/00	266.43	846.32	225.20	500.93	459.72	556.37	363.06	245.81	673.62	387.96	69.30	-57.07
	09/30/00	257.37	895.02	196.89	705.00	513.57	576.19	450.94	227.13	800.01	433.40	44.90	-76.42
	01/13/01	247.90	856.11	197.37	729.58	507.74	552.01	463.47	222.64	792.84	428.48	31.74	-76.07
	04/20/01	44.66	883.01	212.28	457.21	399.29	463.83	334.74	128.47	670.11	336.96	46.28	-72.25
	07/10/01	-279.94	502.86	204.24	66.21	123.34	111.46	135.22	-37.85	284.53	104.09	-8.52	-43.01
	10/09/01	442.16	725.37	50.98	1199.89	604.60	583.76	625.44	246.57	962.63	510.22	-14.94	-95.52
	01/09/02	263.63	616.73	159.27	765.05	451.17	440.18	462.16	211.45	690.89	380.74	-7.88	-63.96
	04/12/02	67.35	579.97	58.13	501.01	301.61	323.66	279.57	62.74	540.49	254.53	15.81	-63.73
	07/19/02	288.69	941.04	187.83	727.59	536.29	614.86	457.71	238.26	834.31	452.57	56.34	-79.51
	10/08/02	277.15	962.54	162.58	740.98	535.81	619.84	451.78	219.86	851.76	452.17	60.25	-84.29
	01/08/03	256.07	949.53	162.24	758.66	531.62	602.80	460.45	209.15	854.10	448.64	51.04	-86.04
	04/15/03	277.19	928.37	189.53	744.52	534.90	602.78	467.03	233.36	836.45	451.41	48.67	-80.45
	06/01/03	277.96	939.01	184.90	749.68	537.89	608.49	467.29	231.43	844.35	453.93	50.62	-81.76
	08/07/03	288.69	965.09	171.66	750.09	543.88	626.89	460.87	230.17	857.59	458.98	59.52	-83.70
	10/07/03	274.96	978.21	155.53	762.84	542.89	626.58	459.19	215.25	870.53	458.14	60.01	-87.41
	12/31/03	258.26	983.57	156.83	795.22	548.47	620.92	476.03	207.55	889.40	462.86	51.95	-90.96
	04/13/04	281.17	960.30	188.88	781.65	553.00	620.73	485.27	235.03	870.97	466.68	48.57	-84.84
	07/13/04	302.86	991.98	173.93	772.27	560.26	647.42	473.10	238.40	882.12	472.80	62.50	-85.87
	10/08/04	295.63	1004.49	151.19	786.40	559.43	650.06	468.80	223.41	895.45	472.10	64.99	-89.65
	01/07/05	277.35	997.91	148.79	798.02	555.52	637.63	473.41	213.07	897.97	468.80	58.88	-91.36
	04/08/05	286.74	978.21	166.99	788.76	555.17	632.47	477.87	226.86	883.49	468.51	55.43	-87.59
	07/18/05	304.00	1000.02	160.94	783.60	562.14	652.01	472.27	232.47	891.81	474.39	64.44	-87.96
	08/26/05	301.85	1018.4	147.73	791.81	564.94	660.12	469.77	224.79	905.09	476.76	68.24	-90.75
	11/12/05	300.51	1018.3	147.82	793.35	564.99	659.40	470.58	224.16	905.83	476.80	67.70	-90.93
	01/10/06	274.59	1009.41	138.15	808.34	557.62	642.00	473.24	206.37	908.87	470.58	60.50	-93.71
	04/09/06	283.04	986.09	160.45	798.02	556.90	634.57	479.23	221.74	892.06	469.97	55.69	-89.42
	07/19/06	295.67	1009.41	149.73	796.56	562.84	652.54	473.14	222.70	902.98	474.98	64.32	-90.75
	10/18/06	284.79	1030.77	131.20	808.38	563.79	657.78	469.79	207.99	919.58	475.78	67.40	-94.92
	01/18/07	270.29	1012.82	134.82	813.33	557.81	641.55	474.08	202.55	913.08	470.74	60.04	-94.78
	04/19/07	282.35	996.04	153.99	805.37	559.44	639.20	479.68	218.17	900.71	472.11	57.19	-91.05

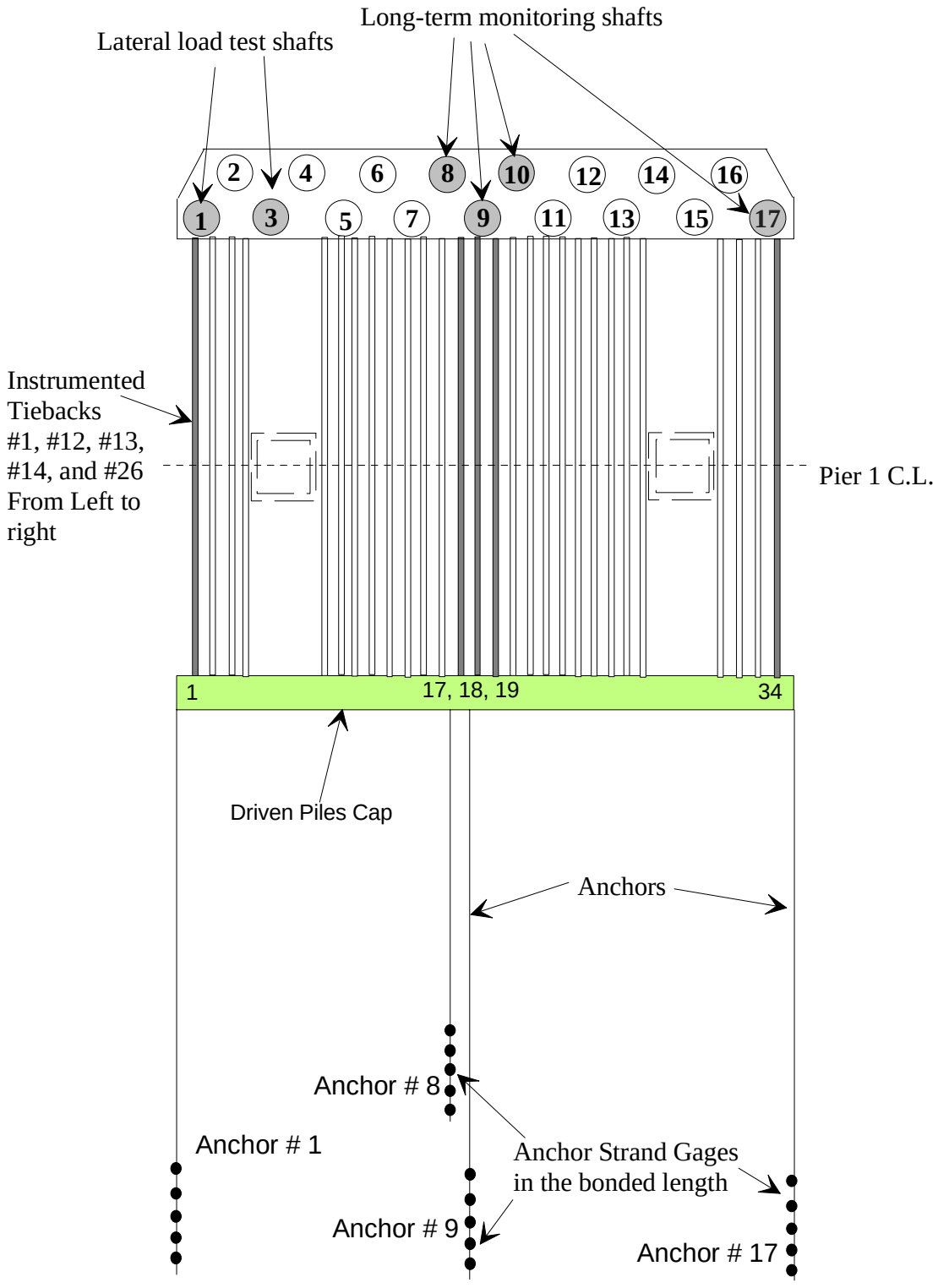


Fig.1 Plan view of the entire stabilization system and the locations of instrumented foundation elements.

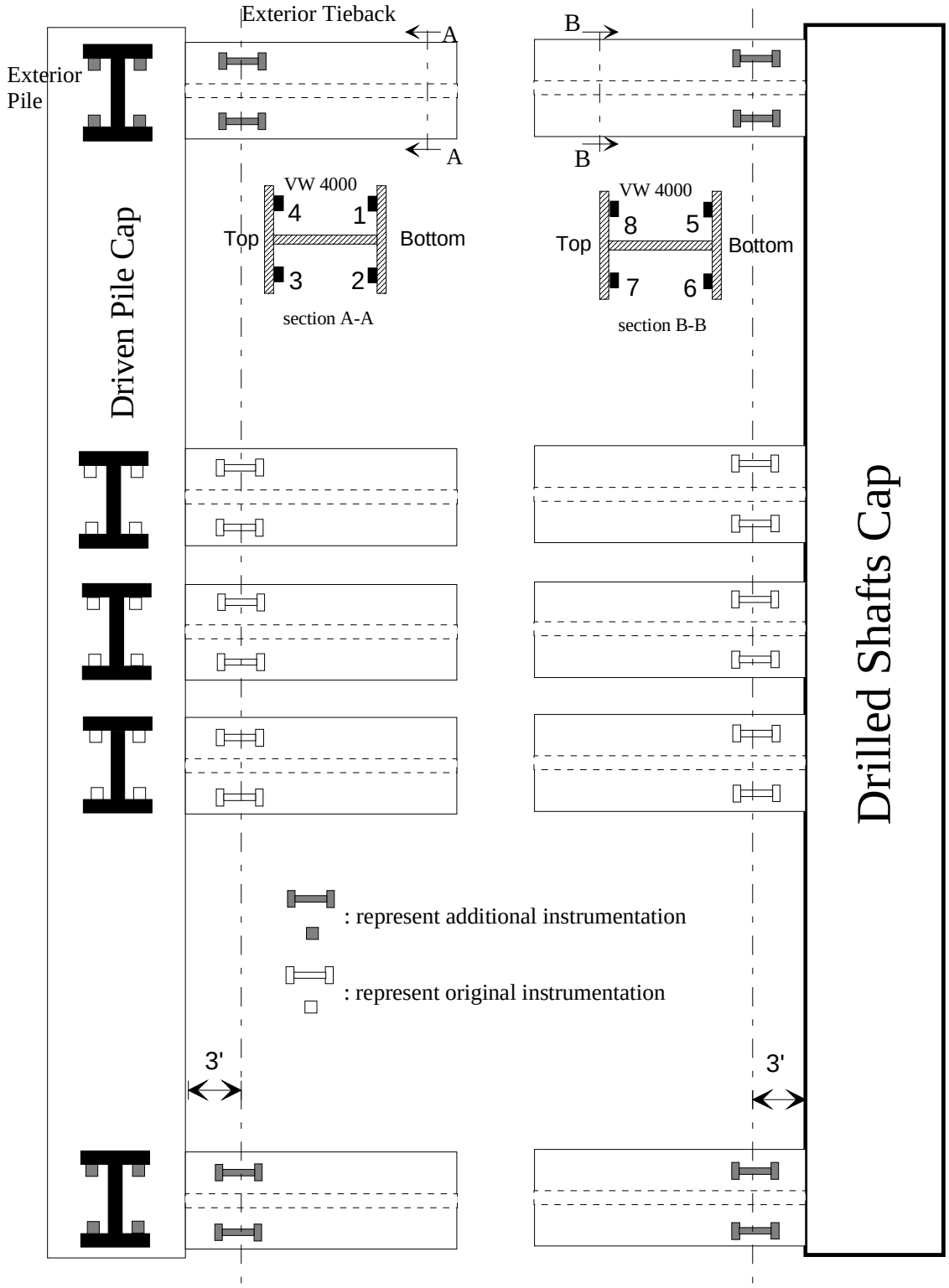


Fig. 2 Instrumentation of tie-beams for long term monitoring

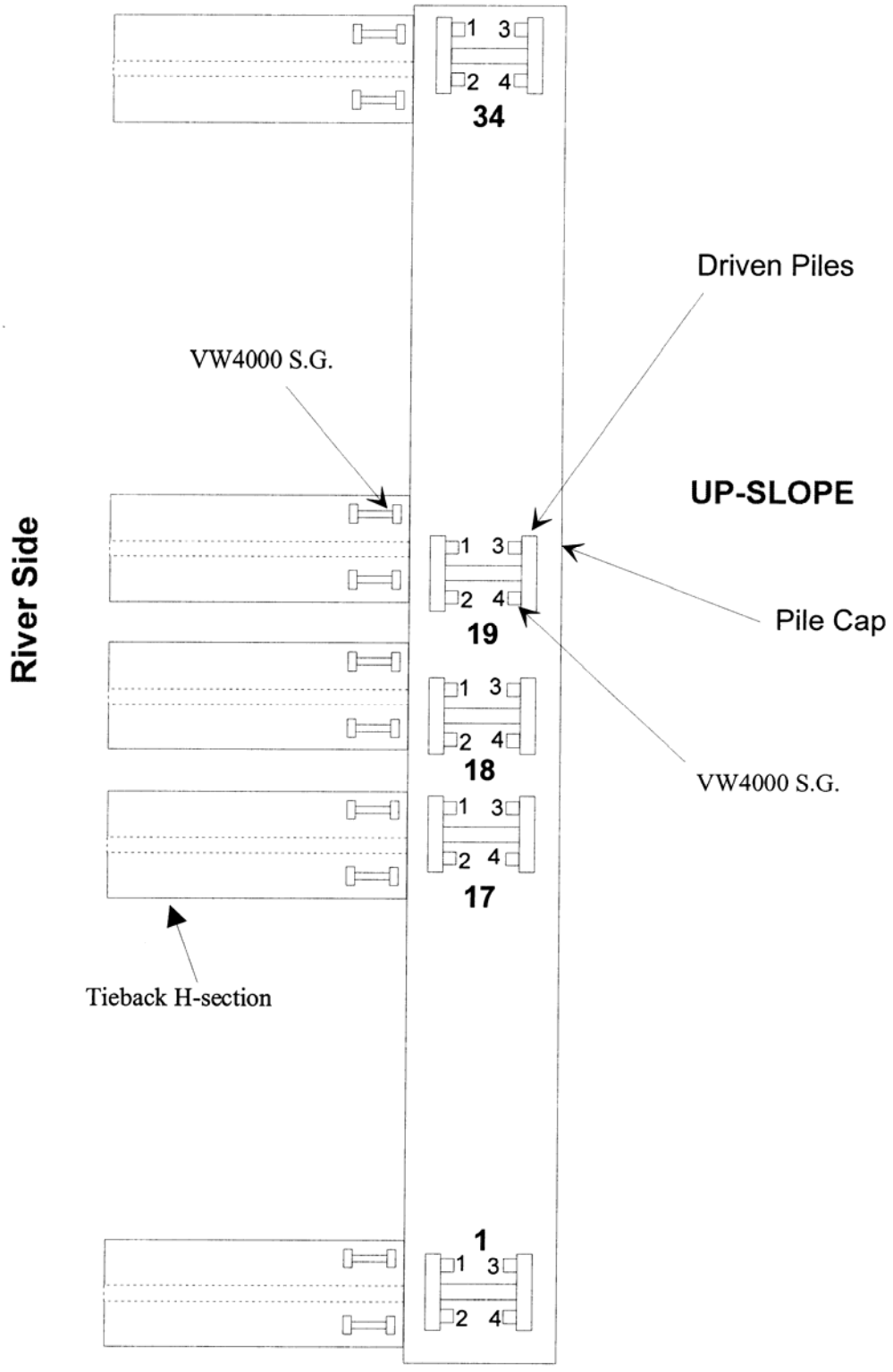


Fig.3 Schematic of gage locations on the driven piles.

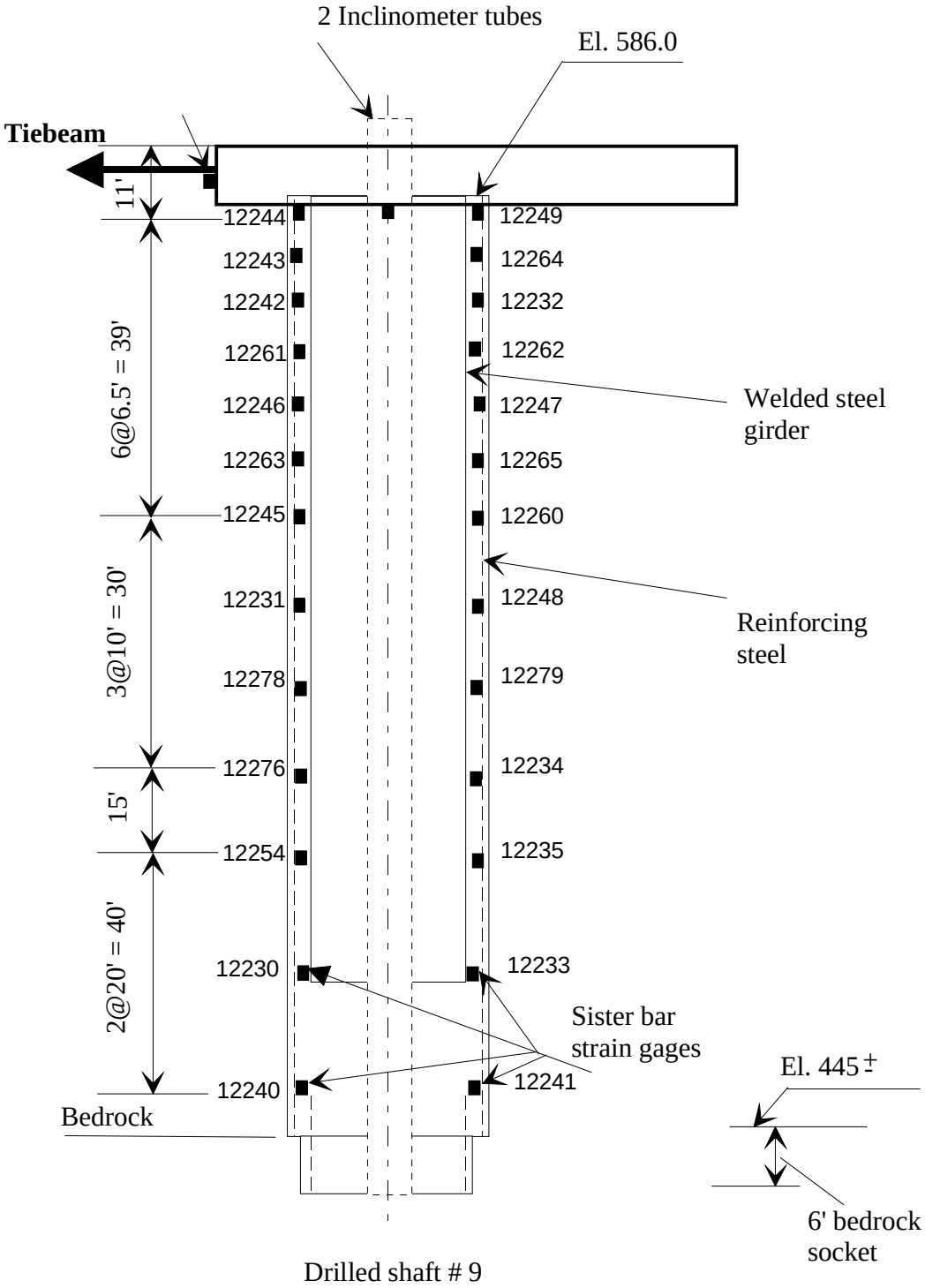


Fig.4 Location and designation of the strain gages in shaft # 9.

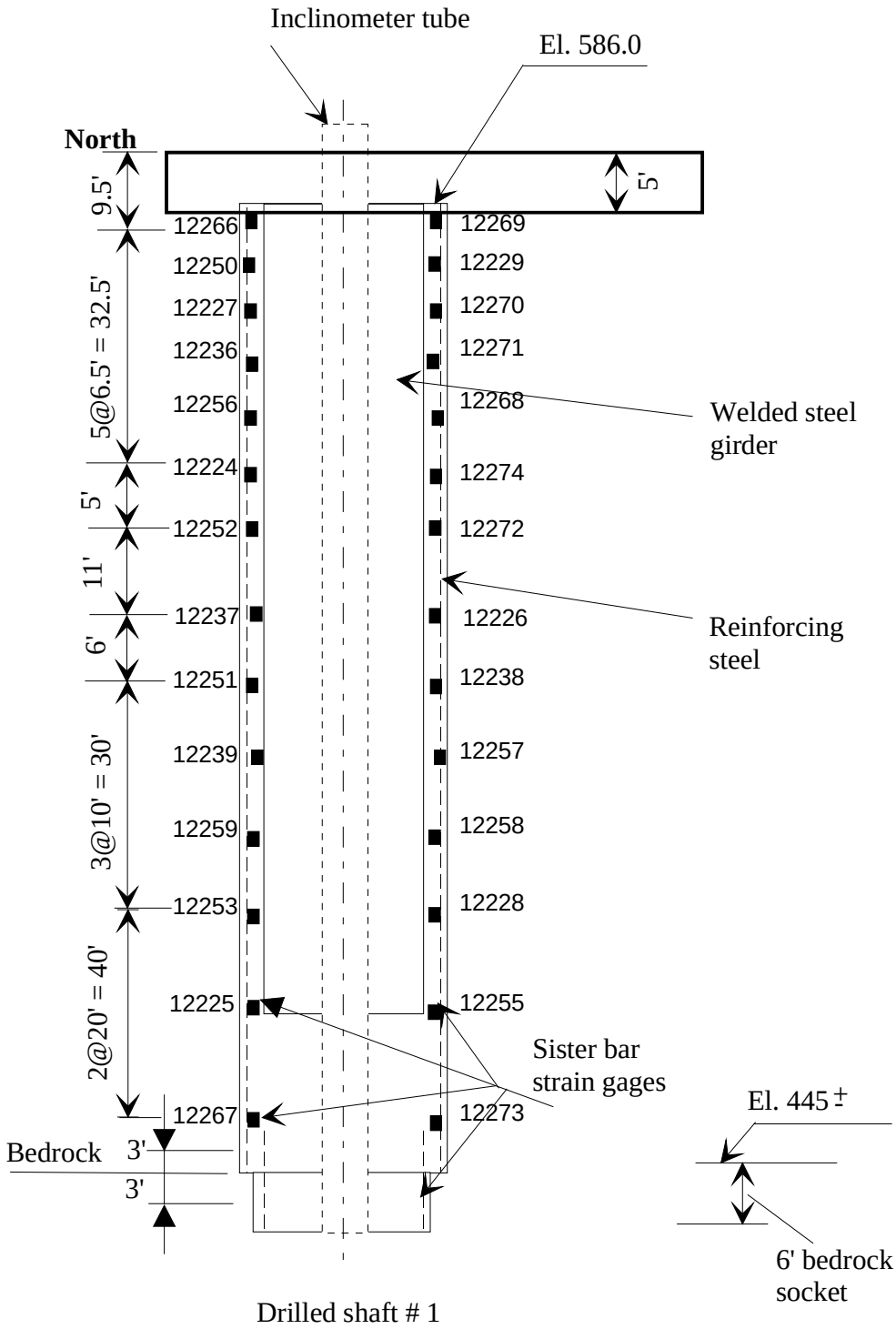


Fig.5: Locations and designations of the strain gages in shaft # 1.

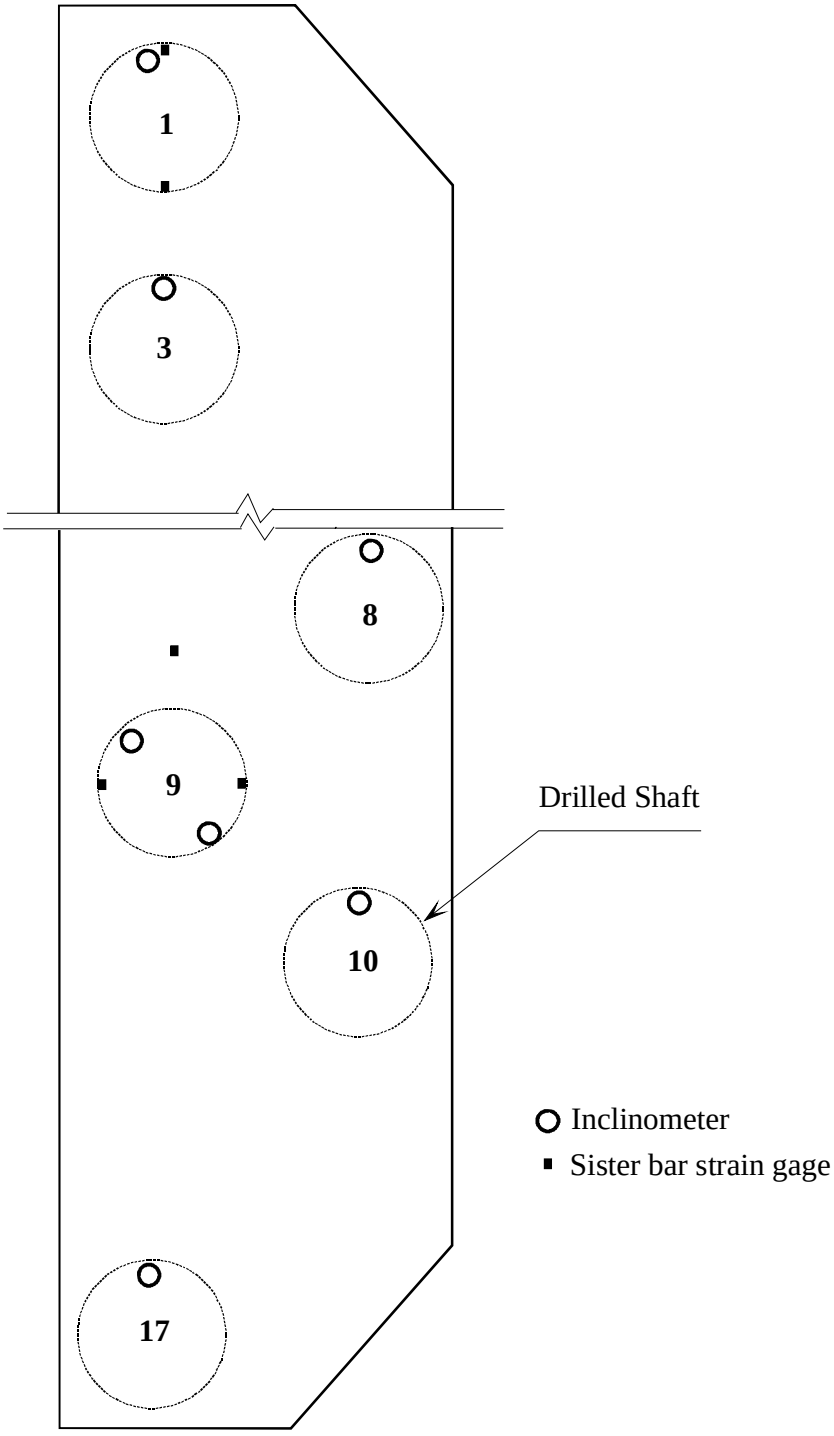


Fig. 6 Location of inclinometers in the drilled shaft cap

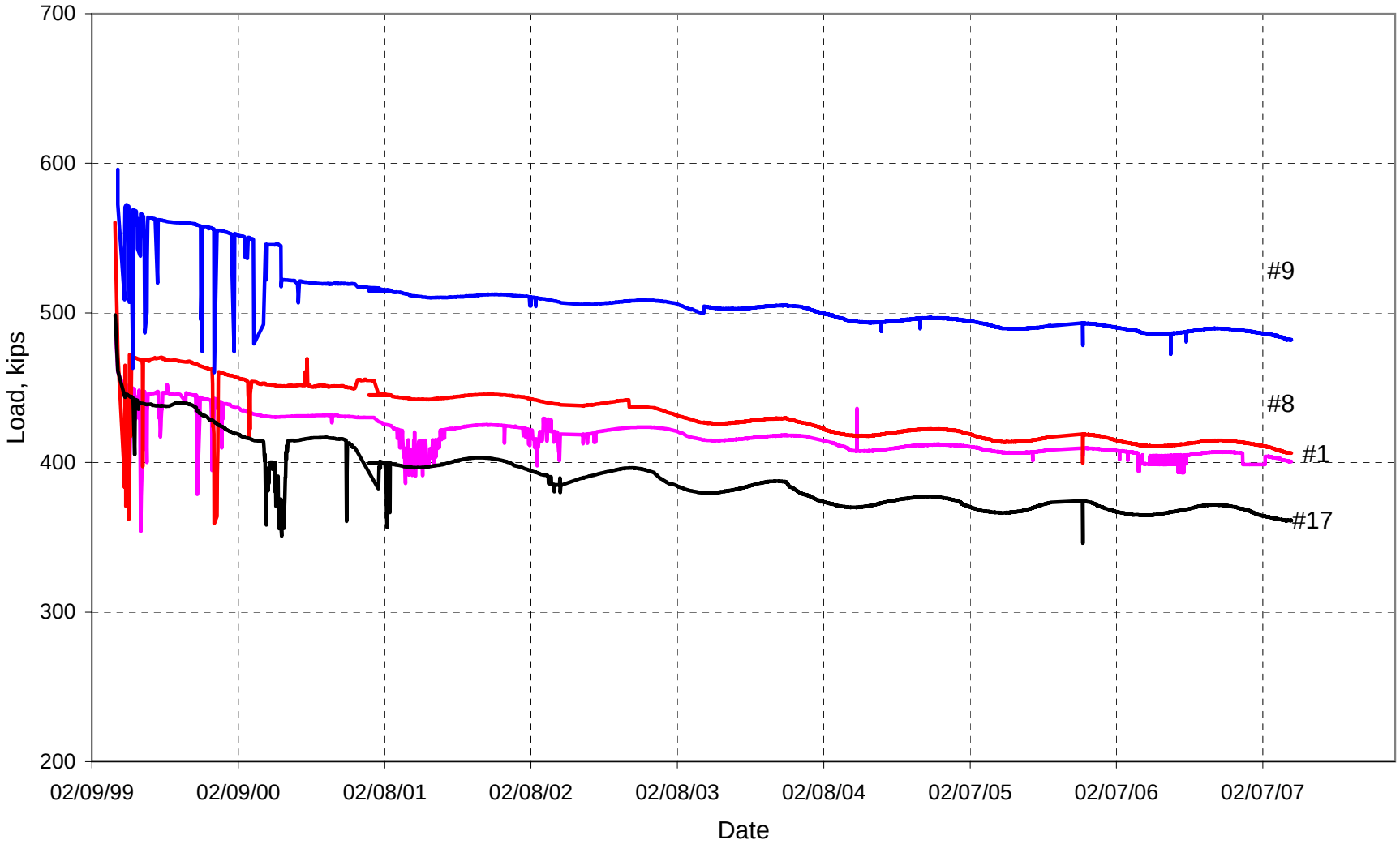


Fig. 7 Anchor load vs. date

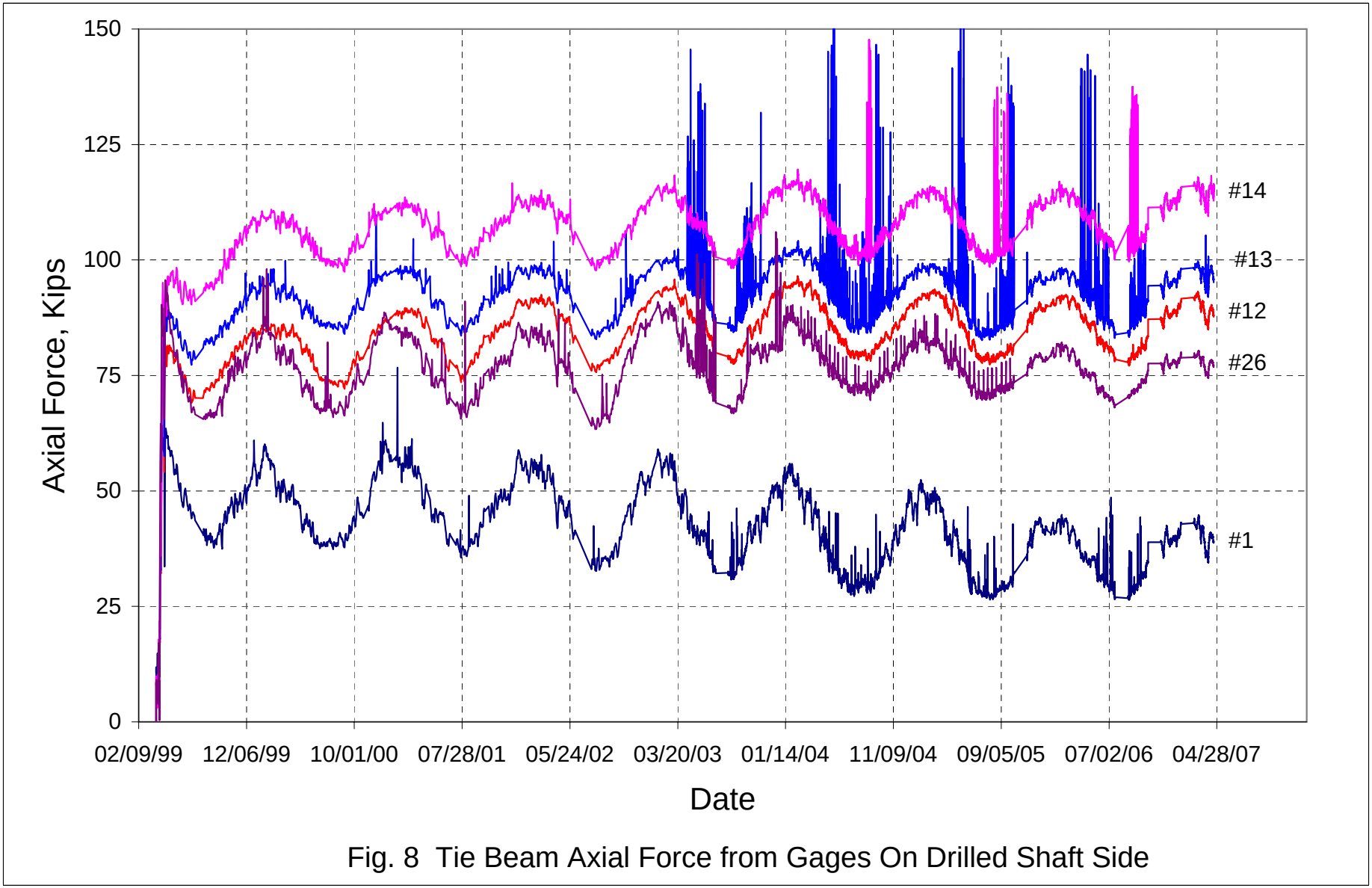


Fig. 8 Tie Beam Axial Force from Gages On Drilled Shaft Side

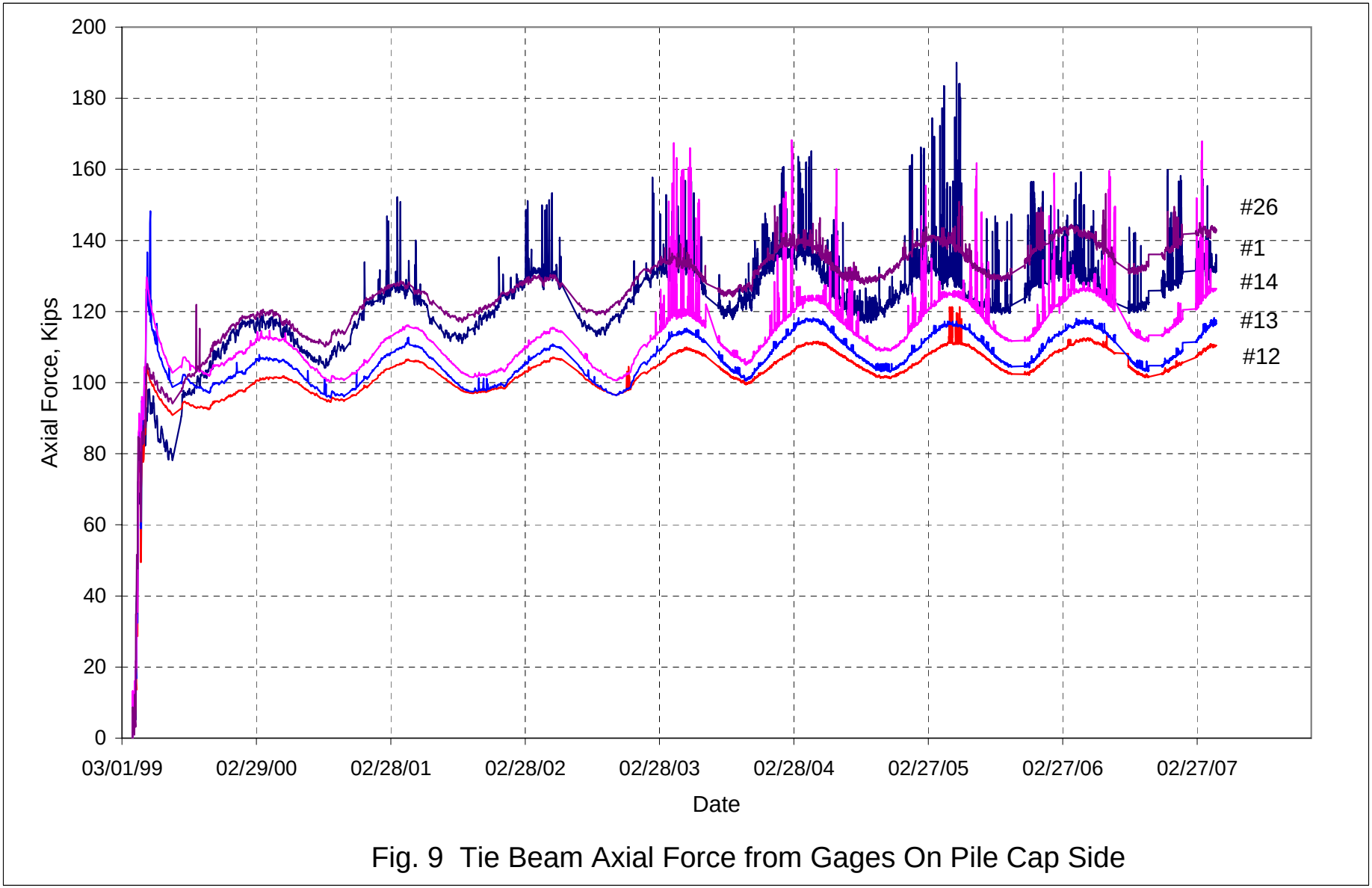


Fig. 9 Tie Beam Axial Force from Gages On Pile Cap Side

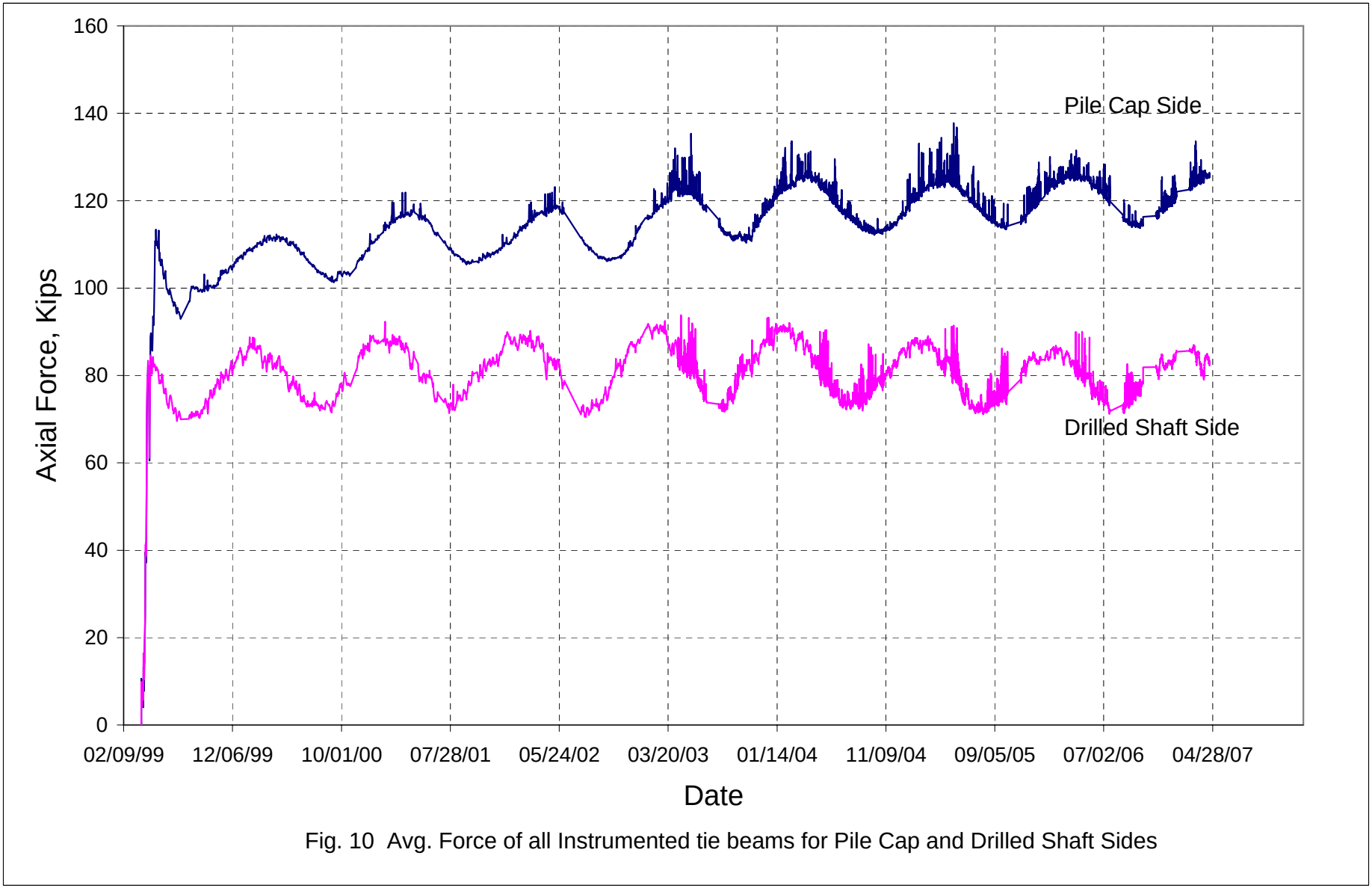


Fig. 10 Avg. Force of all Instrumented tie beams for Pile Cap and Drilled Shaft Sides

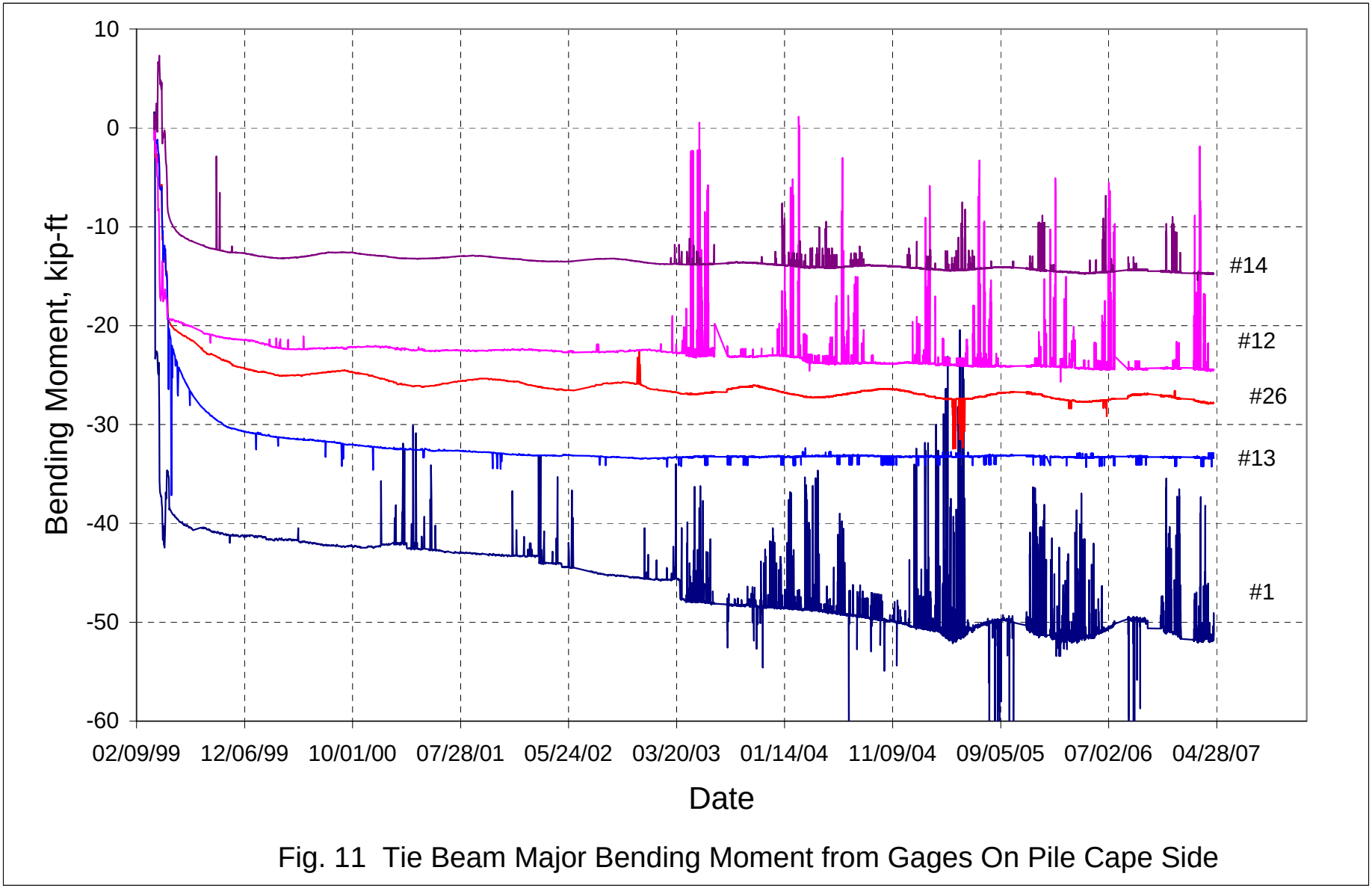


Fig. 11 Tie Beam Major Bending Moment from Gages On Pile Cape Side

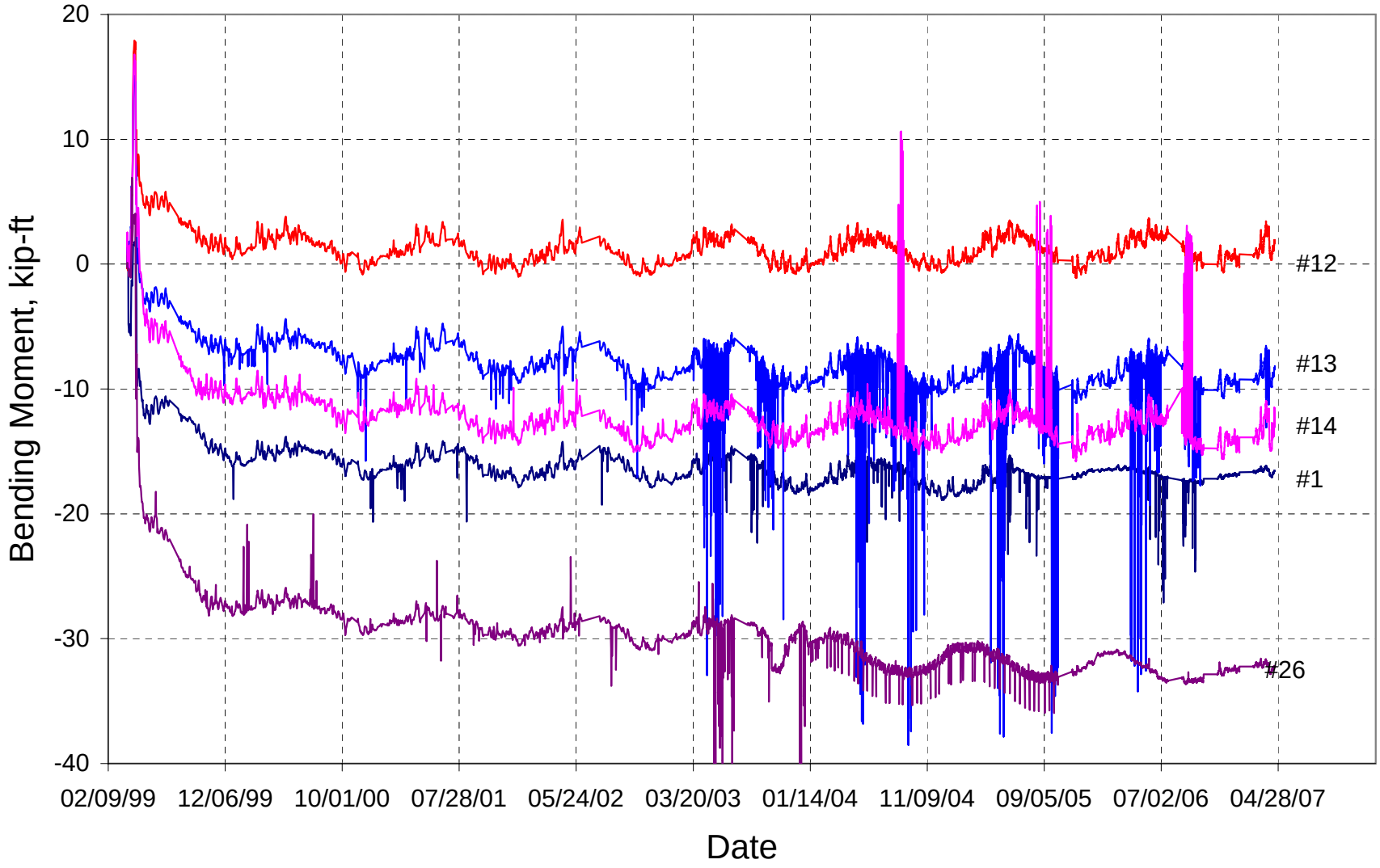


Fig. 12 Tie Beam Major Bending Moment from Gages On Pile Cap Side

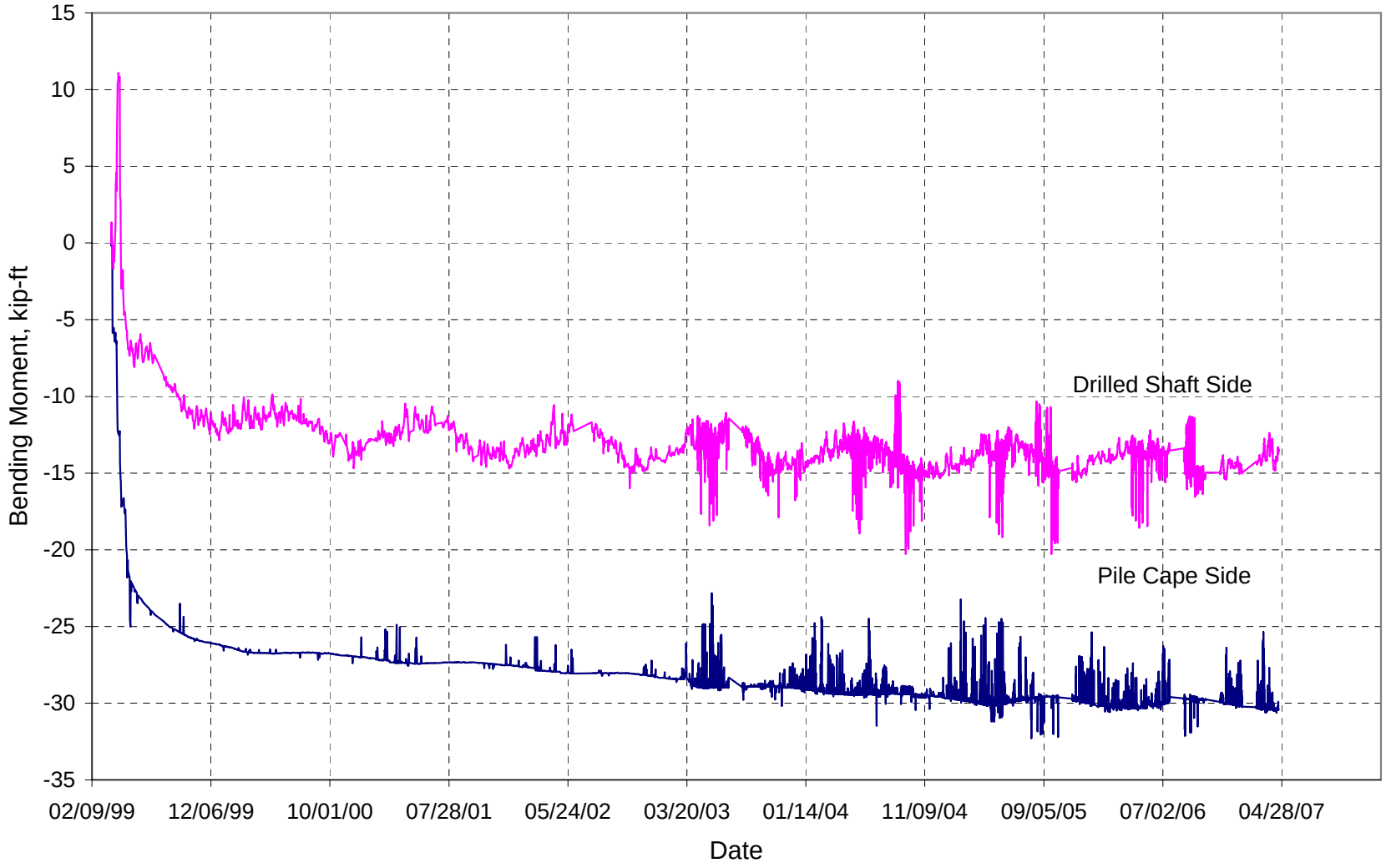


Fig. 13 Tie Beam Avg. Major Bending Moment From Gages for Pile Cap and Drilled Shaft Sides

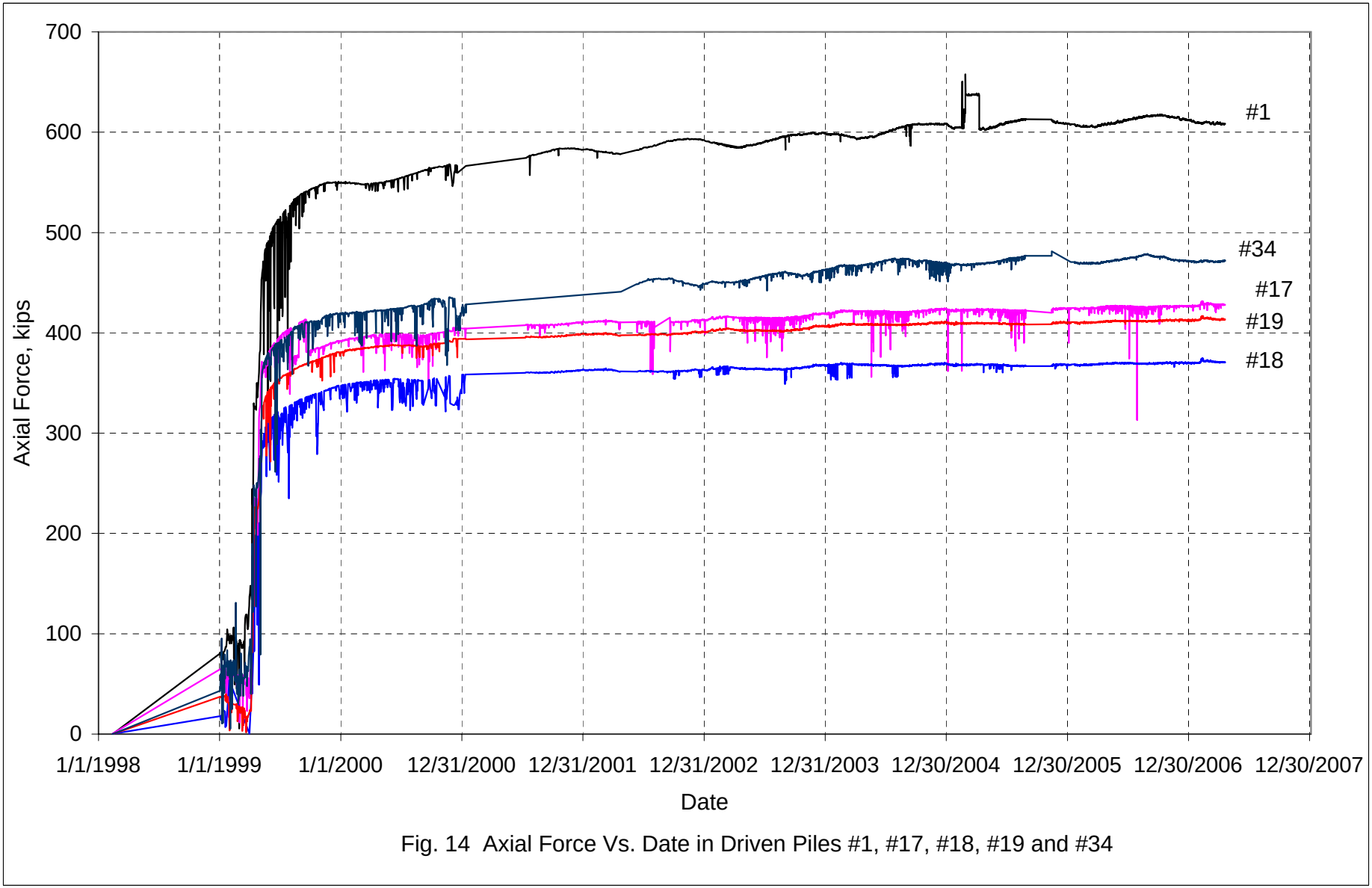


Fig. 14 Axial Force Vs. Date in Driven Piles #1, #17, #18, #19 and #34

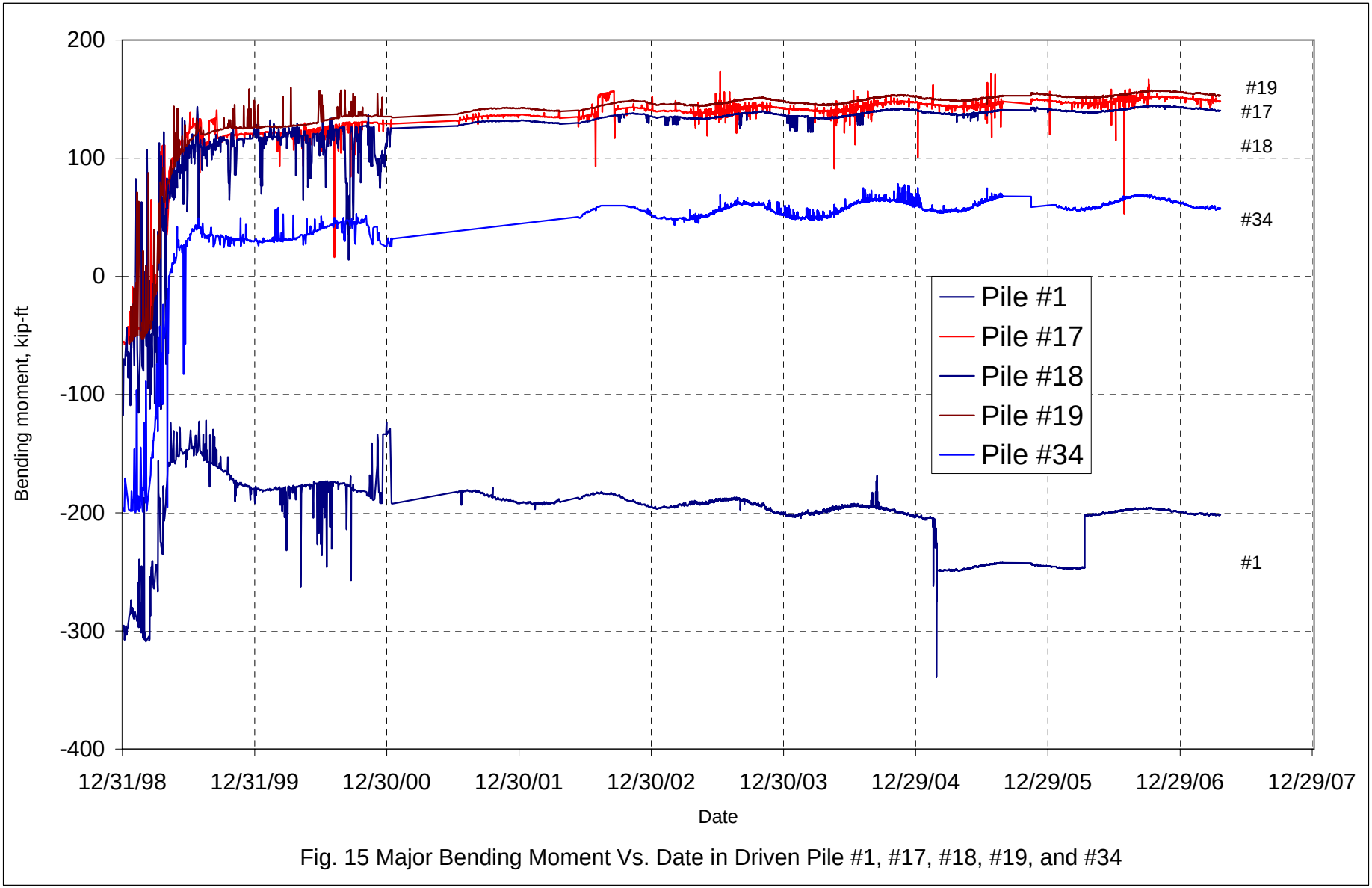


Fig. 15 Major Bending Moment Vs. Date in Driven Pile #1, #17, #18, #19, and #34

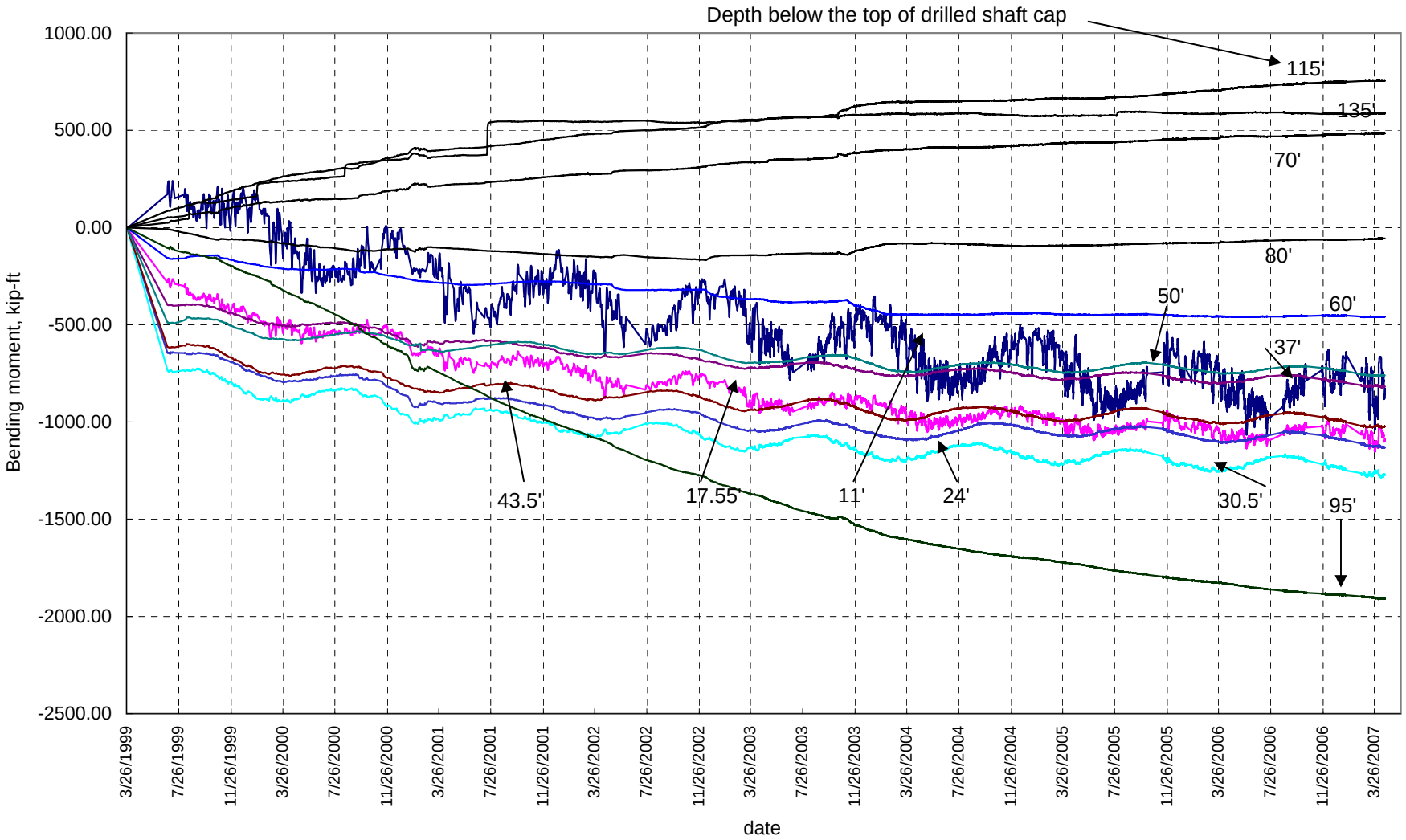


Fig. 16 Shaft #9, Bending moment vs. date in different elevations below the top of cap

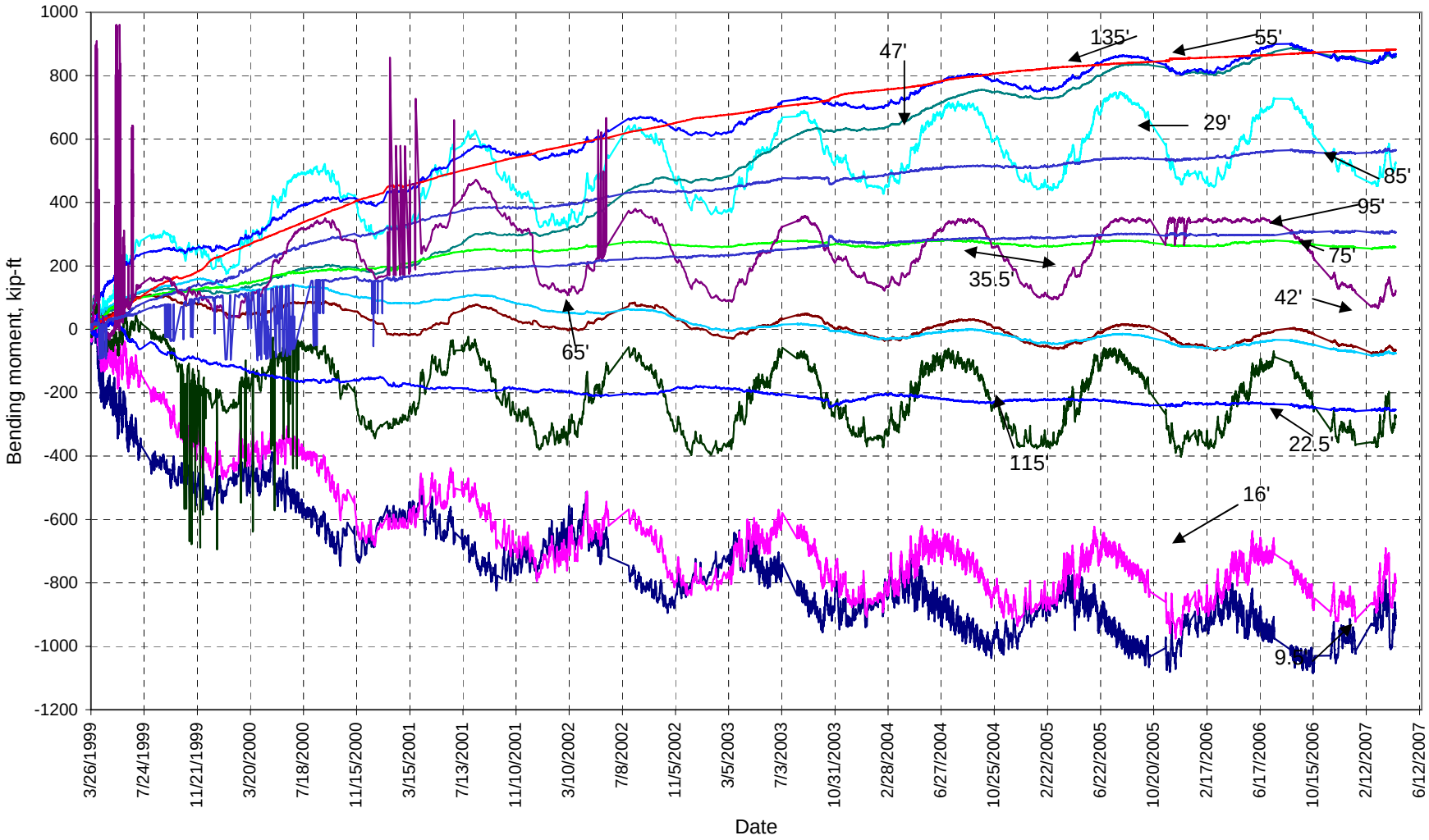


Fig. 17 Shaft #1, Bending moment vs. date in different elevations below the top of cap

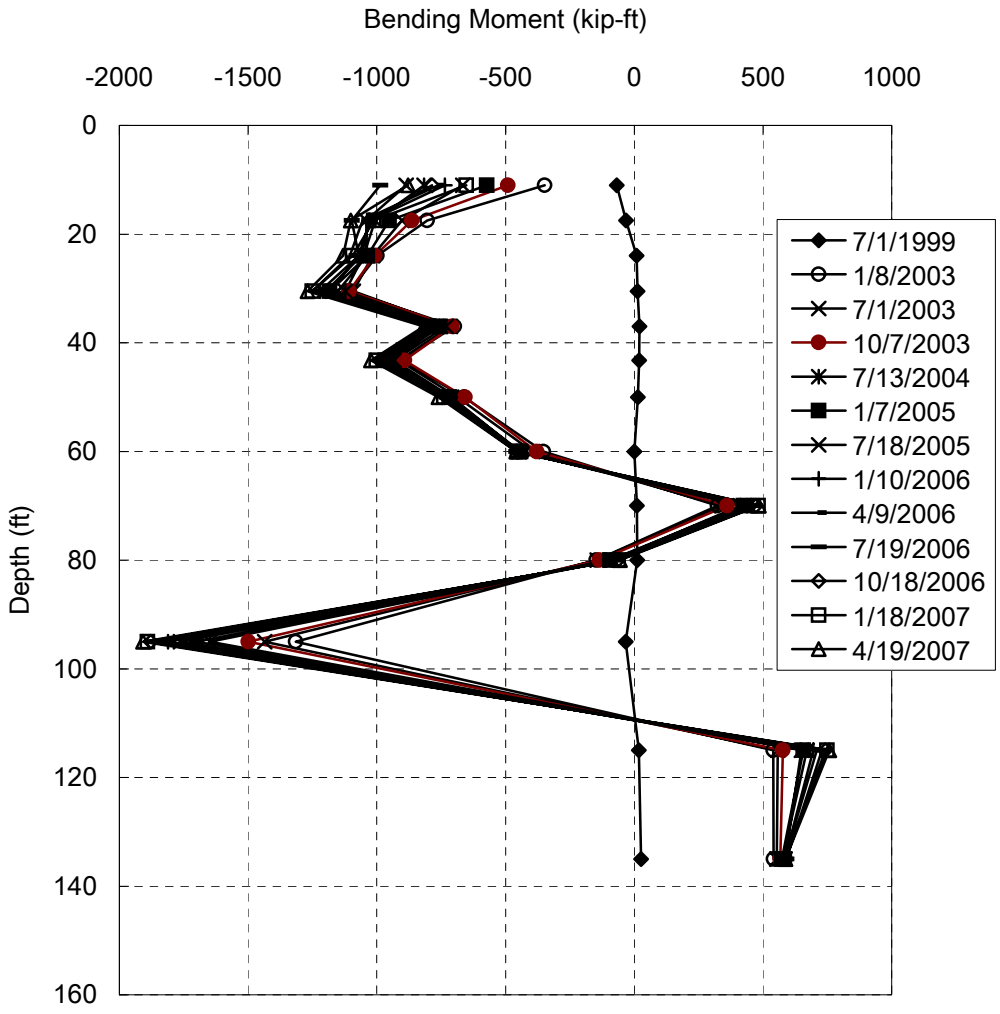


Fig. 18 Shaft #9, Bending Moment vs. Depth After Construction was completed

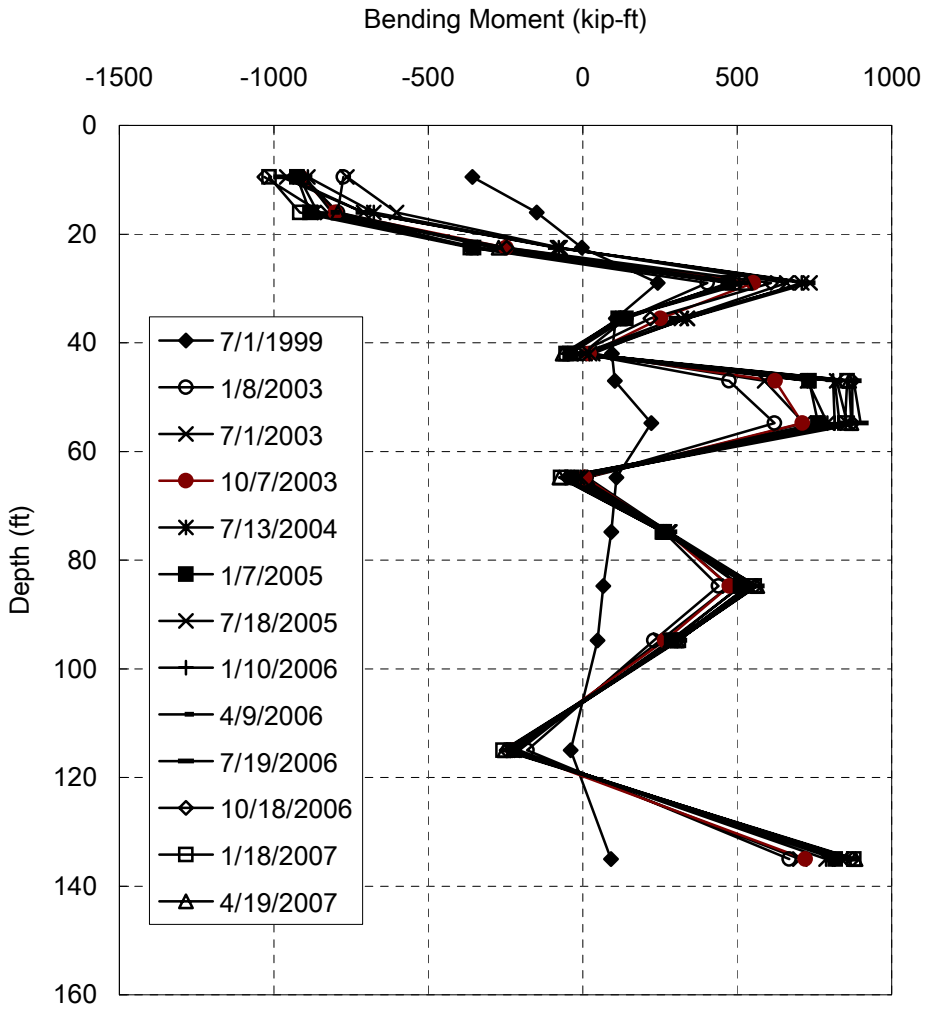


Fig. 19 Shaft #1, Bending Moment vs. Depth After Construction was completed

Fig. 20 Inclinometer #1 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

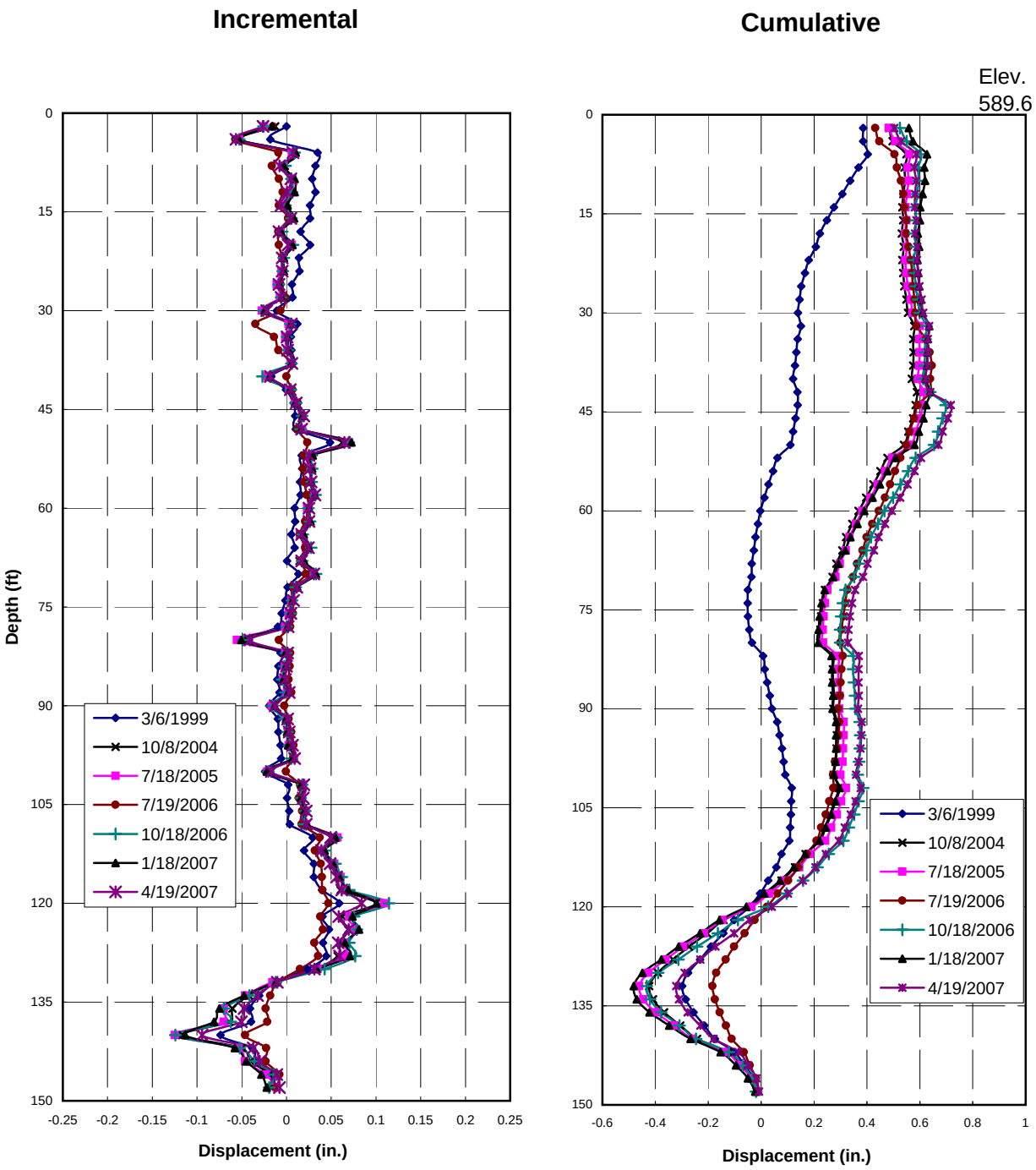


Fig. 21 Inclinometer #3 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

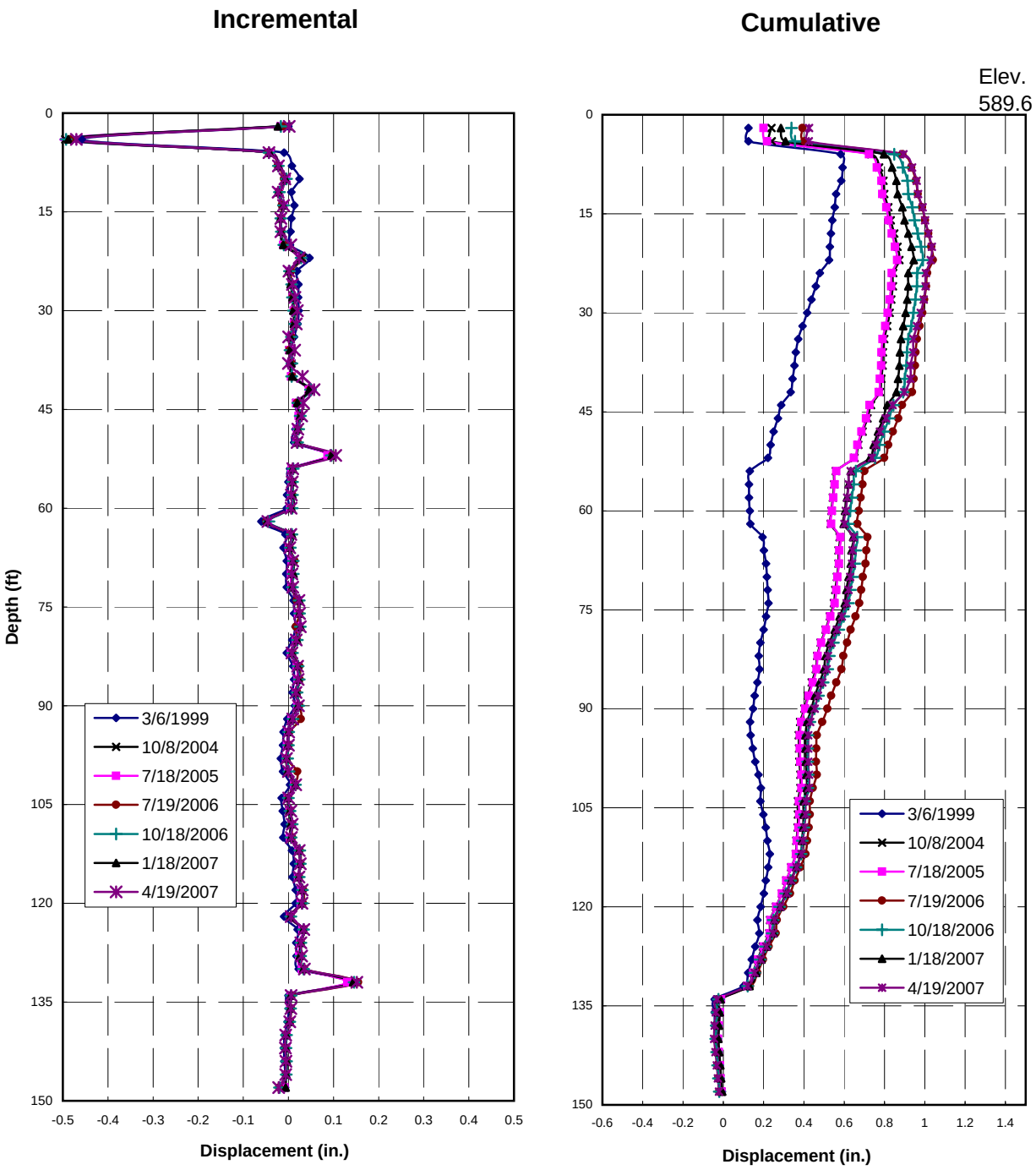


Fig. 22 Inclinometer #8 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

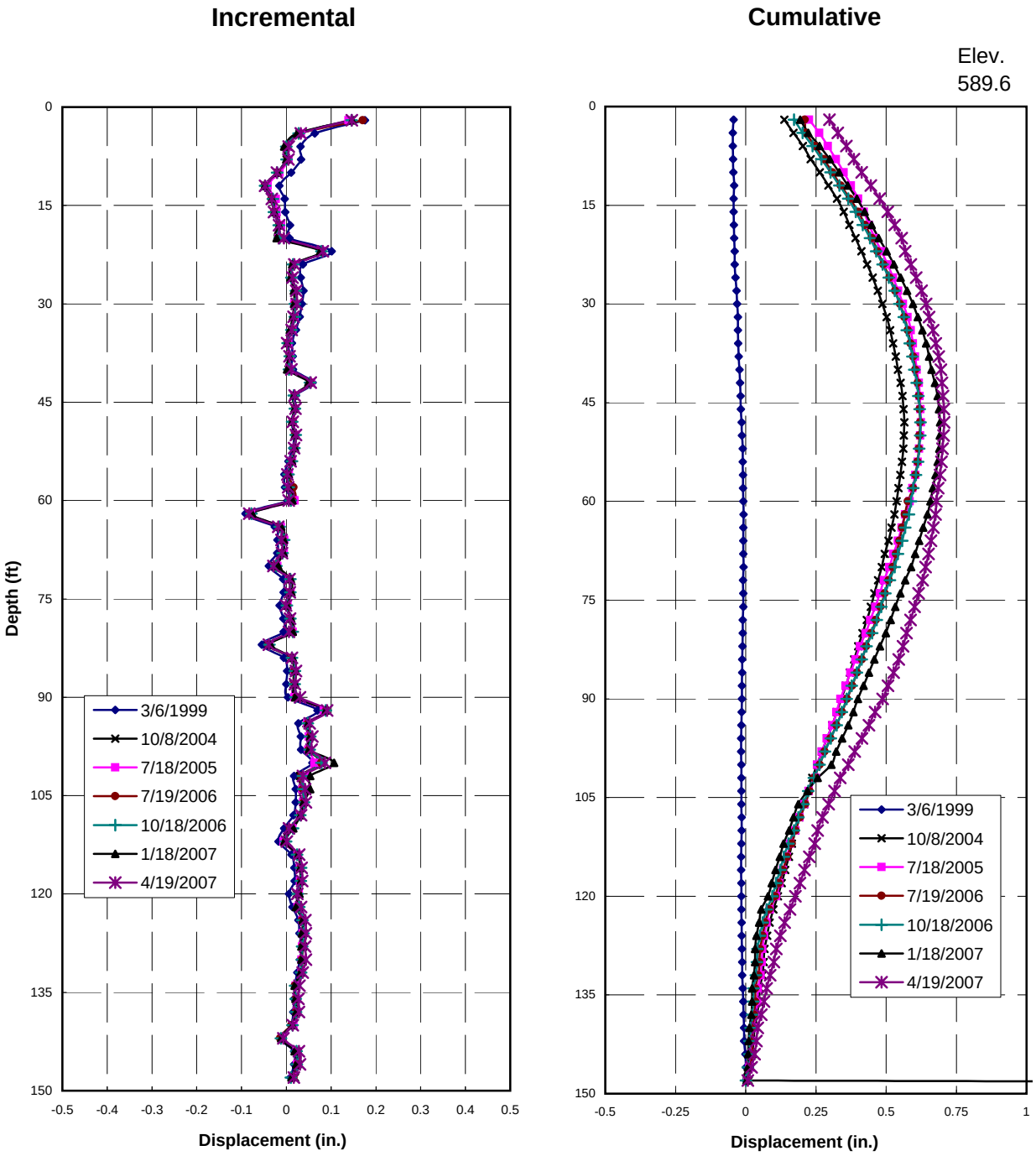


Fig. 23 Inclinometer #9A Displacement in the A+ Direction Downslope (River direction) Base Line 12/11/1998

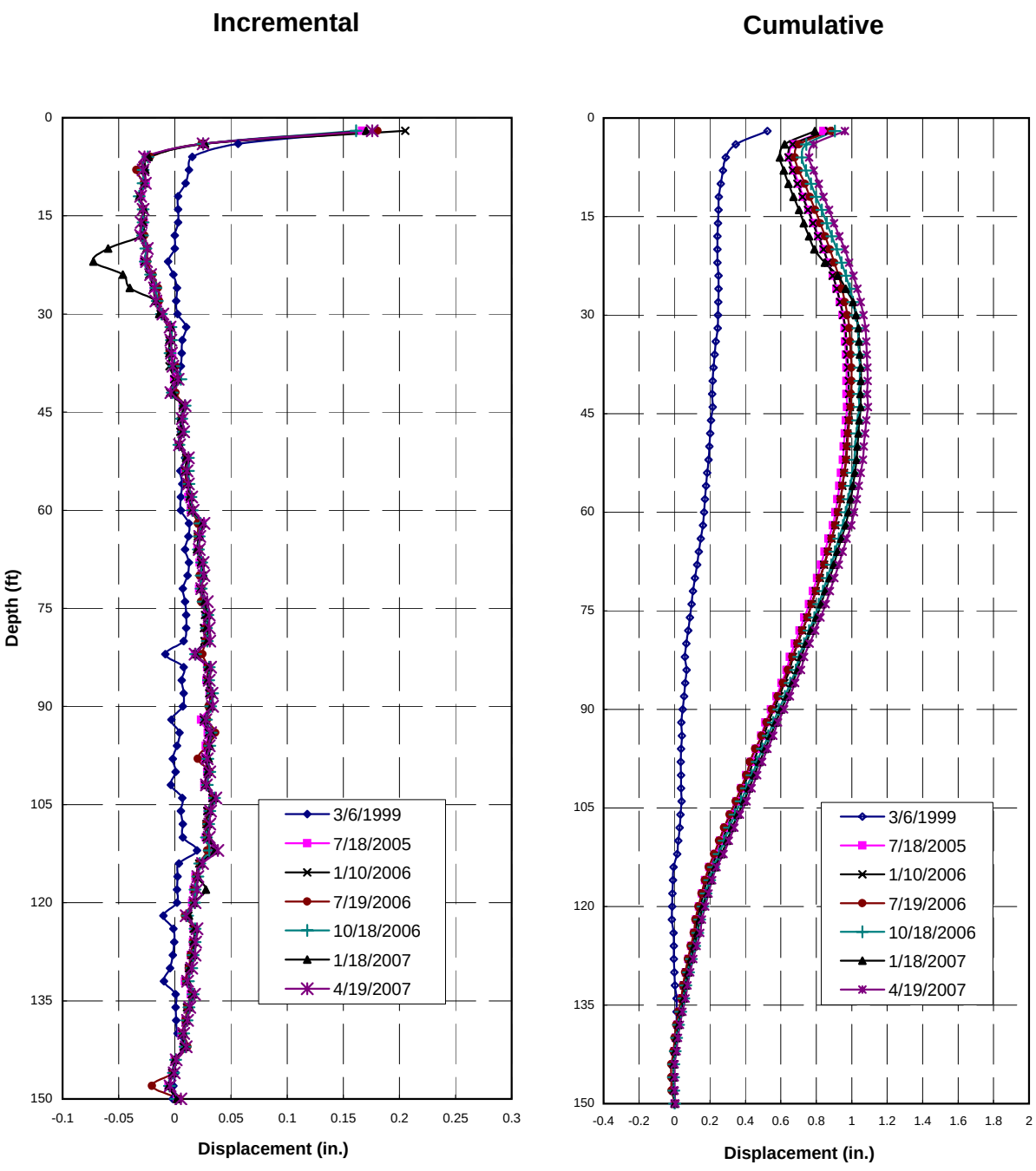


Fig. 24 Inclinometer #10 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

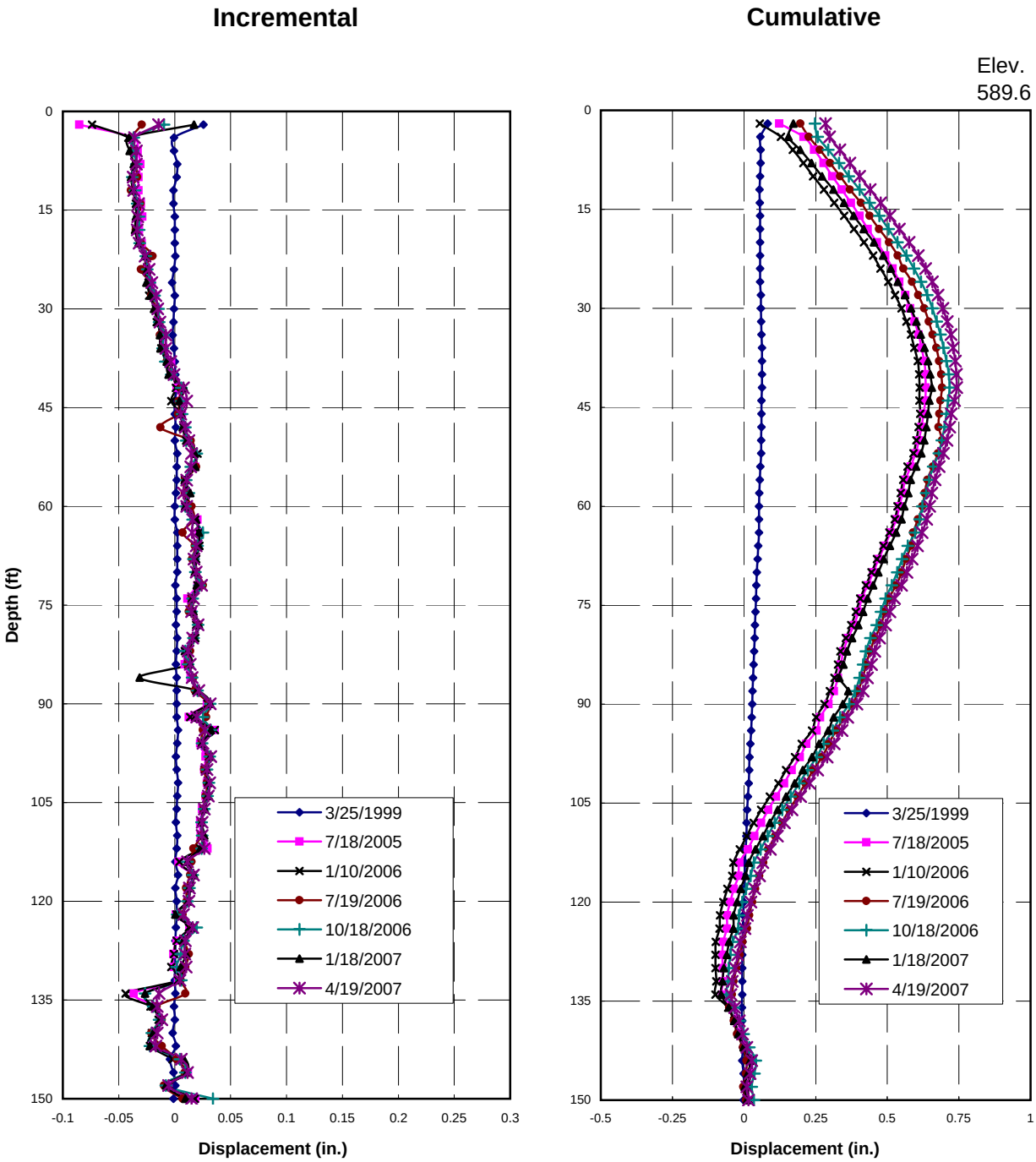
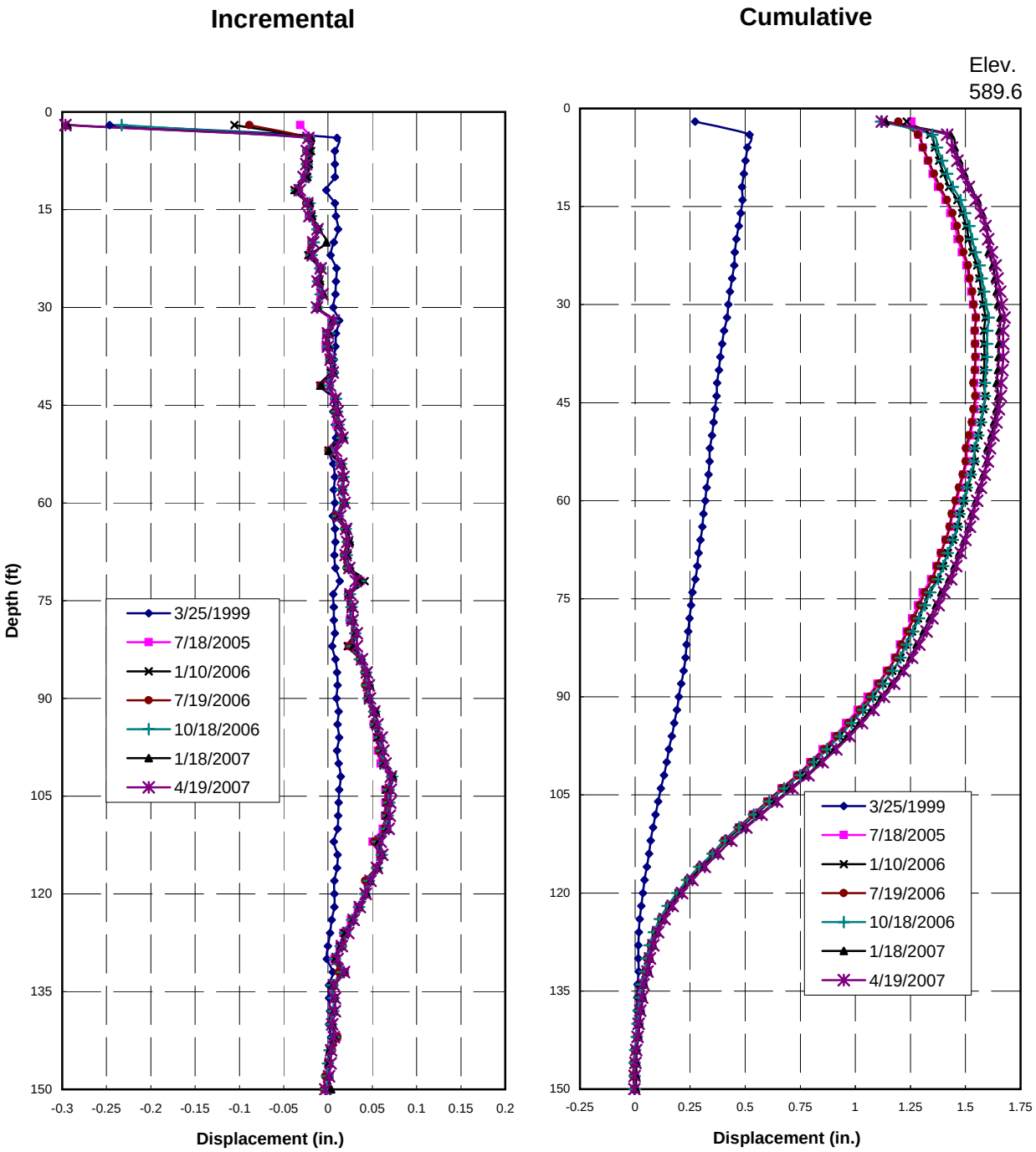


Fig. 25 Inclinometer #17 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998



RICHLAND ENGINEERING LIMITED
29 North Park Street, Mansfield, Ohio 44902-1769 • 419-524-0074 FAX 419-524-1812

106017

August 15, 2007

Ohio Department of Transportation
5500 Transportation Boulevard
Garfield Heights, Ohio 44125-5396

Attn: Mr. Mike Malloy

Re: CUY-90-1524
Central Viaduct
PID No. 20752
Slope and Pier Monitoring Services
Interim Report

Dear Mr. Malloy:

The following is our report on monitoring activity and collected data for the west slope of the Cuyahoga River and Bridge No. CUY-90-1524 west end pier, pier 1, and slope stabilization structure. The last report of data was the annual report submitted June 1, 2007 for data collected through April 2007. This report is for data collected through July 2007.

Enclosed is one CD with the electronic .pdf files of the detailed reports from BBC&M, REL, Dr. Huckelbridge, and Dr. Liang.

The slope monitoring began in 1994. The stabilization structure was constructed and the span 1 superstructure was relocated in 1999. The stabilization structure monitoring began in 1999. Additional slope monitoring north of the existing bridge began in 2006.

BBC&M Engineering, Inc. obtained inclinometer readings, piezometer readings, and calipered crack distances between July 9 through 13, 2007. Seven inclinometers and 6 piezometers installed between 1994 and 1999 continue to be monitored. Three replacement inclinometers, 9 new inclinometers, and 18 new piezometers installed March through June 2006 were also monitored. The older instrumentation continues to indicate movements of the shallow and deep failure planes at consistent rates. The overall rates appear to be slower since 2004. There is a new shallow slide plane appearing in B-107 northwest of the west end pier on University Avenue. The new inclinometers both north and south of the bridge are beginning to indicate shallow and deep failure planes. The older piezometer total head values were slightly higher than in April 2007. The new vibrating wire piezometer values were relatively constant. The calipered crack openings continue

to change at a constant slow rate. There was one small aggregate pile adjacent to the south right of way fence in July 2007. The property owner north of the right of way fence had a contractor repair the failed sheet pile dock wall at the river's edge in Spring 2006. A progressive failure was observed in the small landslide near the north right of way fence adjacent to the river on the southern edge of the large excavation.

Richland Engineering Limited measured expansion joint openings at the west end pier, near pier 2, and near pier 4 on July 16, 2007. The deck expansion joint opening near pier 2 closed with the rise in temperature since April 2007. The closed dimension is typical of past summer observations.

Art Huckelbridge obtained tiltmeter readings at the west end pier and pier 1 on July 13, 2007. The tiltmeters show positions and magnitudes of movement similar to past readings.

Robert Liang monitored instrumentation on July 9 and 11, 2007. The instrumentation readings in the rock anchors, driven piles, tieback beams, drilled shafts, and inclinometers showed no significant change during this quarter.

The next readings are scheduled about October 15, 2007. The project has been authorized for continued monitoring through October 2007.

Please contact us if you have any questions (email reltd@r-e-l.com). Copies of detailed quarterly reports are available upon request.

Very truly yours,

RICHLAND ENGINEERING LIMITED

Dean A. Palmer, P.E.

DAP:dap
cc: Craig Hebebrand, District 12
Youssef Seif, District 12
Tim Keller, Office of Structures
Gene Geiger, Office of Geotechnical Services
Tom Lefchik, FHWA
Steve Pasternack, BBC&M Engineering, Inc., Dublin
Jeff Snyder, BBC&M Engineering, Inc., Valley View
Art Huckelbridge
Robert Liang
Rick Engel, E.L. Robinson Engineering Co.
Bob Parker, Michael Baker, Jr., Inc.

JULY 2007 QUARTERLY REPORT
FIELD MONITORING SERVICES
CUY-90-14.52/15.24
PID #77332
CLEVELAND, OHIO

Report to

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

Prepared by

BBC&M ENGINEERING, INC.
CLEVELAND, OHIO

July 2007

July 26, 2007
012-00946-300

BBCM
SOLUTIONS TO BUILD ON

Mr. Dean A. Palmer, P.E.
Richland Engineering Limited
29 North Park Street
Mansfield, Ohio 44902

Re: CUY-90-14.52/15.24 Bridge (PID No. 77332)
Quarterly Report - Field Monitoring Services
July 2007 (Third Quarter)

Dear Mr. Palmer:

BBC&M Engineering, Inc. (BBCM) has completed the field monitoring services for the July 2007 quarter as part of the CUY-90-14.92/15.24 project. This quarterly report presents our general site observations and the results and evaluation of data collected from all the actively monitored instrumentation (inclinometers, piezometers, and calipered distance locations) installed by BBCM at or near the West Abutment of the existing I-90 Central Viaduct Bridge.

A total of 19 inclinometers, six (6) pneumatic piezometers and 18 vibrating wire (VW) piezometers are actively monitored as part of the project. A Summary Table and Site Plan of Active Instrumentation are submitted as Plates 1 and 2 of the Appendix. Quarterly readings were taken during the period of July 9 through July 13, 2007.

Inclinometers

All the data sets presented in the Appendix have been corrected for measured spiral of the inclinometer casings and for systematic errors such as bias-shift, sensor rotation and depth positioning error, where necessary. The rates of movement were computed using linear regression for the depth ranges shown on the Displacement vs. Time plots in the Appendix.

Active BBCM Inclinometers Installed between 1994 and 1999

No significant changes in the rates of movement have been observed in the shallow or deep failure planes between the April 2007 and July 2007 quarterly readings. In the immediate vicinity of the Pier 1 area, no shallow slip-plane movements have been observed in inclinometers installed before 2000 since completion of construction of the Pier 1 stabilization system. The shallow failure plane upslope from Pier 1 area (B-203 and B-303) continues to move at an average rate of about 0.05 inches per year from 1999 to the present yet appears to have decreased to about a rate of 0.03 inches per year from 2004 to the present. South of the West End Pier (B-102 and B-107), the deep

failure plane continues to move at an average rate of about 0.03 inches per year from 2000 to the present. An additional possible slide plane has been observed in B-107 at a depth of about 25 feet. The relative displacement of this slide plane in the A direction has been added to the Displacement vs. Time plot for B-107 submitted as Plate 18 in the Appendix. The B-101 inclinometer has indicated nominal movement since its installation. In the immediate vicinity and upslope from the Pier 1 area (B-203, B-204 and B-303), the deep failure plane continues to move at an average rate of about 0.06 inches per year from 1999 to the present yet appears to have decreased to about 0.02 inches per year from 2004 to the present.

Inclinometer P-9N indicates the top of the drilled shaft is restrained laterally and that the maximum lateral deflection about 0.90 inches from about 40 to 60 feet below the top of the inclinometer casing.

Active BBCM Inclinometers Installed in 2006

Slide planes have been observed in the following new and replacement inclinometers (refer to the Displacement vs. Time plots, Plates 27, 48 and 49 in the Appendix):

- In B-108A - depths of 23 ft and 119 ft (see Plate 24 in the Appendix);
- In B-05-03 - depth of 35 ft (see Plates 32 and 33 in the Appendix); and,
- In B-05-16 - depths of 3 to 11 ft, 29 ft and 113 ft (see Plate 46 and 47 in the Appendix).

Cantilever displacement has been observed in B-105A to a depth of about 70 feet (see Plates 22 and 23 in the Appendix) similar to that observed in B-105, which is now inactive. This bulkhead at this location may be progressively leaning outwards toward the river. A Displacement vs. Time plot for B-105A has been submitted as Plate 26 in the Appendix.

Additional potential slide planes have been observed in the following new and replacement inclinometers:

- In B-105A, depth of 85 ft (see Plate 22 in the Appendix);
- In B-05-02, depth of 109 ft and 129 ft (see Plate 30 in the Appendix);

Piezometers

Pneumatic Piezometers

The results of the active pneumatic piezometer readings taken on July 9, 2007 are summarized in Table 1 below.

Table 1: Summary of Readings for Active Pneumatic Piezometers – CUY-90-15.24

Piezometer Identifier		Ground Surface Elevation (ft)	Elevation Head, h_e (ft)	Pore Pressure Reading, u (psi)	Total Head, h_t (ft)
B-101 (P-1*)	orange	676.6	626.3	0.0**	626.3**
	pink	676.6	552.3	32.0	626.1
B-105 (P-3*)	pink	585.6	497.6	38.7	586.9
	blue	585.6	479.9	48.2	591.1
B-107 (P-5*)	orange	662.3	562.3	26.0	622.3
B-303 (P-2*)	pink	627.0	586.2	7.2	602.8

*BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers.

**Pneumatic piezometers *cannot* read negative pressure (i.e., a water level below the depth of the pneumatic piezometer). Thus, it is unknown whether this is an accurate pressure reading.

All the piezometers have exhibited slightly higher readings than those recorded in April 2007, except the piezometer at B-101, which continues to exhibit a reading of 0 psi. Note that the piezometers at B-105 continue to indicate an elevated water pressure (i.e. a total head above the ground surface, artesian conditions). Total Head vs. Time plots have been submitted as Plates 50 through 53 in the Appendix of this report.

Vibrating Wire (VW) Piezometers

Table 2 provides a summary of the maximum and minimum values of all the pressure readings taken from April 18, 2007 (end of previous reporting period) to the time when the collected data was downloaded from VW Miniloggers on July 9 or 11, 2007.

Table 2: Summary of Readings for VW Piezometers – CUY-90-14.92

Piezometer Identifier		Time Interval of Readings Reported*	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-01	21961 - 65 ft	4/18/07 to 7/11/07	14.1/13.5	675.4	610.4	12.9/12.4	640.3/638.9
	21967 - 95 ft	4/18/07 to 7/11/07	13.2/13.2	675.4	580.4	23.8/23.1	635.4/633.6
B-05-02	21963 - 46 ft	4/18/07 to 7/9/07	12.2/12.2	617.9	571.9	8.4/7.9	591.3/590.2
	21951 - 122 ft	4/18/07 to 7/9/07	12.2/12.1	617.9	495.9	40.7/40.2	589.7/588.6
B-05-03	21957 - 32 ft	4/18/07 to 7/9/07	12.4/12.0	605.1	573.1	8.0/7.2	591.5/589.7
	21965 - 112 ft	4/18/07 to 7/9/07	12.5/12.5	605.1	493.1	41.6/40.9	589.0/587.6

*Readings generally were taken every 8 hours during the reported time interval.

Table 2: Summary of Readings for VW Piezometers – CUY-90-14.92 (continued)

Piezometer Identifier		Time Interval of Readings Reported*	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-04	21958 - 59 ft	4/18/07 to 7/9/07	12.9/12.9	600.8	541.8	18.0/17.5	583.3/582.3
	21952 - 119 ft	4/18/07 to 7/9/07	13.1/13.1	600.8	481.8	45.1/44.9	585.8/585.4
B-05-07	21966 - 102 ft	4/18/07 to 7/11/07	12.4/12.4	678.9	576.9	24.3/23.8	632.9/631.9
	21956 - 220 ft	4/18/07 to 7/11/07	11.9/11.9	678.9	458.9	70.8/70.2	622.2/620.9
B-05-08	21954 - 65.5 ft	4/18/07 to 7/11/07	12.7/12.7	679.9	614.4	12.7/12.3	643.8/642.8
	21959 - 110.5 ft	4/18/07 to 7/11/07	12.4/12.4	679.9	569.4	29.7/29.1	637.8/636.6
B-05-11	21968 - 95 ft	4/18/07 to 7/11/07**	12.7/12.7	675.1	580.1	23.8/23.5	635.1/634.4
	21953 - 130 ft	4/18/07 to 7/11/07	12.7/12.6	675.1	545.1	36.5/36.0	629.3/628.2
B-05-12	21960 - 75 ft	4/18/07 to 7/11/07	12.9/12.9	652.7	577.7	19.0/18.4	621.4/620.2
	21964 - 120 ft	4/18/07 to 7/11/07	12.8/12.5	652.7	532.7	36.5/35.9	617.0/615.4
B-05-13	21962 - 60 ft	4/18/07 to 7/11/07	12.6/12.6	580.0	520.0	24.5/24.0	576.4/575.4
	21955 - 135 ft	4/18/07 to 7/11/07	12.8/12.8	580.0	445.0	60.7/60.5	585.0/584.6

*Readings generally were taken every 8 hours during the reported time interval.
**VW MiniLogger 21968 did not record any readings from April 29, 2007 to July 10, 2007 most likely due to battery malfunction.

The measured total head values were relatively constant during the current reporting period with a difference between maximum and minimum total head values of no more than 1.8 feet in all of the VW piezometers. Five (5) VW piezometers (21961 and 21967 at B-05-01, 21956 at B-05-07, and 21960 and 21964 at B-05-12) indicated a gradual increase in the pore pressures until about the beginning of May 2007, yet have measured relatively constant pore pressures from May 2007 to July 2007. Total Head vs. Time plots have been submitted as Plates 54 through 62 in the Appendix.

Additional Field Measurements and Observations

The locations of the two calipered locations (left and right) are provided in the Site Plan of Active Instrumentation (Plate 2 of the Appendix). A Calipered Surface Distance Table and Calipered Distance Readings vs. Time plots have been included as Plates 63 through 65 in the Appendix. The left calipered location indicates the gap is continuing to open at a rate of about 0.06 inches per year and the gap at the right calipered location is continuing to close at a rate of about 0.02 inches per year.

In July 2007, a relatively small aggregate pile, less than 30 feet high, was observed at the southeast corner of the property and covered roughly 15 percent of the property currently being used to stockpile aggregate adjacent to the east right-of-way fence.

The large excavation and the repair effort of the bulkhead near the west right-of-way fence appears to be unfinished as of July 2007. Adjacent to the large excavation near the west right-of-way fence (just north of B-05-16), a small landslide was initially observed by BBCM personnel in January 2007. It appears that progressive failure in this landslide area has occurred since the last quarterly readings were taken in April 2007. Settlement of the ground surface has been observed and appears to have progressed farther towards the south and the east. Site photos of the landslide area taken on July 11, 2007 are submitted as Plates 66 through 73 in the Appendix.

Closing

We appreciate being of continued service during this project. Please contact our office if you have any questions or require additional information. The next quarterly readings are scheduled to take place around October 15, 2007.

Sincerely,
BBC&M ENGINEERING, INC.
Cleveland, Ohio

Jeffrey L. Snyder, M.S., P.E.
Staff Engineer

Stephen C. Pasternack, Ph.D., P.E.
Senior Project Engineer

cc: Mr. Robert B. Parker, P.E. (Michael Baker Jr., Inc.)

Submitted: pdf copy submitted to Richland Engineering at reltd@r-e-l.com and Michael Baker Jr., Inc. at BParker@mbakercorp.com
Attachments: Appendix (Plates 1 through 73)

APPENDIX

CUY-90-14.52/15.24 INSTRUMENTATION MONITORING

APPENDIX

Plate No.

General Information

Summary Table of Active Instrumentation.....1
Site Plan of Active Instrumentation.....2

Plots for Active BBCM Inclinometers Installed from 1994 to 1999–CUY-90-15.24

Cumulative and Incremental Displacement versus Depth Plots

B-101 – A and B-Axis.....3-4
B-102 – A and B-Axis.....5-6
B-107 – A and B-Axis.....7-8
B-203 – A and B-Axis.....9-10
B-204 – A and B-Axis.....11-12
B-303 – A and B-Axis.....13-14
P-9N – A and B-Axis.....15-16

Displacement versus Time Plots

B-102 – A-Axis.....17
B-107 – A-Axis.....18
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B-303 – A-Axis.....21

Plots for Replacement Inclinometers Installed by BBCM in 2006 – CUY-90-15.24

Cumulative and Incremental Displacement versus Depth Plots

B-105A – A and B-Axis.....22-23
B-108A – A and B-Axis.....24-25

Displacement versus Time Plots

B-105A – A-Axis.....26
B-108A – A-Axis.....27

Plots for Inclinometers Installed by BBCM in 2006 – CUY-90-14.52

Cumulative and Incremental Displacement versus Depth Plots

B-05-01 – A and B-Axis.....28-29
B-05-02 – A and B-Axis.....30-31
B-05-03 – A and B-Axis.....32-33
B-05-04 – A and B-Axis.....34-35
B-05-07 – A and B-Axis.....36-37
B-05-08 – A and B-Axis.....38-39
B-05-08 – A and B-Axis (reinitialized).....38A-39A

APPENDIX (continued)

Plate No.

B-05-11 – A and B-Axis 40-41
B-05-12 – A and B-Axis 42-43
B-05-12 – A and B-Axis (reinitialized) 42A-43A
B-05-13 – A and B-Axis 44-45
B-05-16 – A and B-Axis 46-47

Displacement versus Time Plots

B-05-03 – A-Axis 48
B-05-16 – A-Axis 49

Plots for Active Pneumatic Piezometers Installed by BBCM in 1994 – CUY-90-15.24

Total Head (h_t) versus Time Plots

B-101 (P-1) 50
B-105 (P-3) 51
B-107 (P-5) 52
B-303 (P-2) 53

Plots for Vibrating Wire (VW) Piezometers Installed by BBCM in 2006 – CUY-90-14.52

Total Head (h_t) versus Time Plots

B-05-01 54
B-05-02 55
B-05-03 56
B-05-04 57
B-05-07 58
B-05-08 59
B-05-11 60
B-05-12 61
B-05-13 62

Calipered Surface Distance Data – CUY-90-15.24

Calipered Surface Distance Table 63
Calipered Distance Readings versus Time Plot - Left Calipered Location 64
Calipered Distance Readings versus Time Plot - Right Calipered Location 65

Large Excavation Adjacent to West Right-of-Way Fence

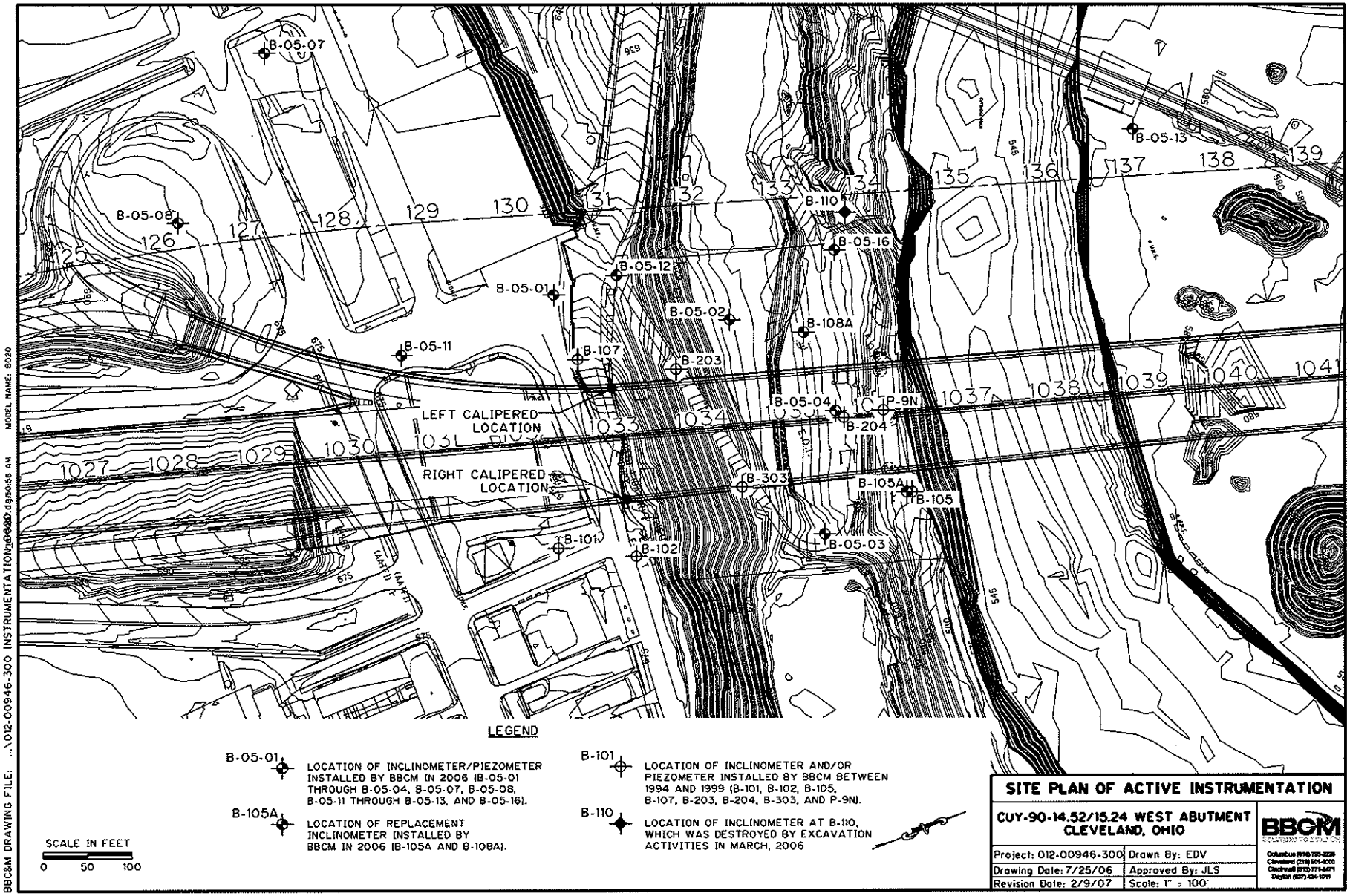
Site Photos of Excavation and Small Landslide Taken on July 11, 2007 66-73

SUMMARY OF ACTIVE INSTRUMENTATION
CUY-90-14.52/15.24

Active Instrumentation	Active Inclinometer ?	Inclinometer Depth (ft)	Active Piezometer?	VW or Pneumatic?	# of Active Piezometers	Piezometer Depth(s) Below Existing G.S. (ft)	Instrumentation Installation Date
B-101	Y	190	Y*	Pneumatic*	2*	50.3, 124.3	Aug-Sep 1994
B-102	Y	224	N	---	---	---	Sep 1994
B-105	N	---	Y*	Pneumatic*	2*	88, 105.7	Aug 1994
B-105A	Y	156	N	---	---	---	May 2006
B-107	Y	210	Y	Pneumatic*	1*	100	Sep 1994
B-108A	Y	168	N	---	---	---	Apr-May 2006
B-203	Y	190	N	---	---	---	Aug 1996
B-204	Y	134	N	---	---	---	Jul 1998
B-303	Y	178	Y**	Pneumatic**	1**	40.8	Aug 1994**, Jul 1998
P-9N	Y	150	N	---	---	---	Feb 1999
B-05-01	Y	228	Y	VW	2	65, 95	Apr-May 2006
B-05-02	Y	178	Y	VW	2	46, 122	Apr-May 2006
B-05-03	Y	168	Y	VW	2	32, 112	Apr-May 2006
B-05-04	Y	172	Y	VW	2	59, 119	Mar-May 2006
B-05-07	Y	224	Y	VW	2	102, 220	Apr-Jun 2006
B-05-08	Y	226	Y	VW	2	65.5, 110.5	Apr-May 2006
B-05-11	Y	226	Y	VW	2	95, 130	Apr-Jun 2006
B-05-12	Y	210	Y	VW	2	75, 120	Apr-May 2006
B-05-13	Y	134	Y	VW	2	60, 135	May-Jun 2006
B-05-16	Y	162	N	---	---	---	Jun 2006

*BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers (i.e. P-1 to B-101, P-3 to B-105, and P-5 to B-107).

**The pneumatic piezometer was actually installed in August 1994 at Boring P-2 in the vicinity of the B-103 inclinometer (now inactive). However, the piezometer has since been renamed to B-303 due to its close proximity to the active inclinometer at B-303, which was installed in July 1998.



BBC&M DRAWING FILE: ...\012-00946-300 INSTRUMENTATION\00800.dgn 8:56 AM MODEL NAME: 8020

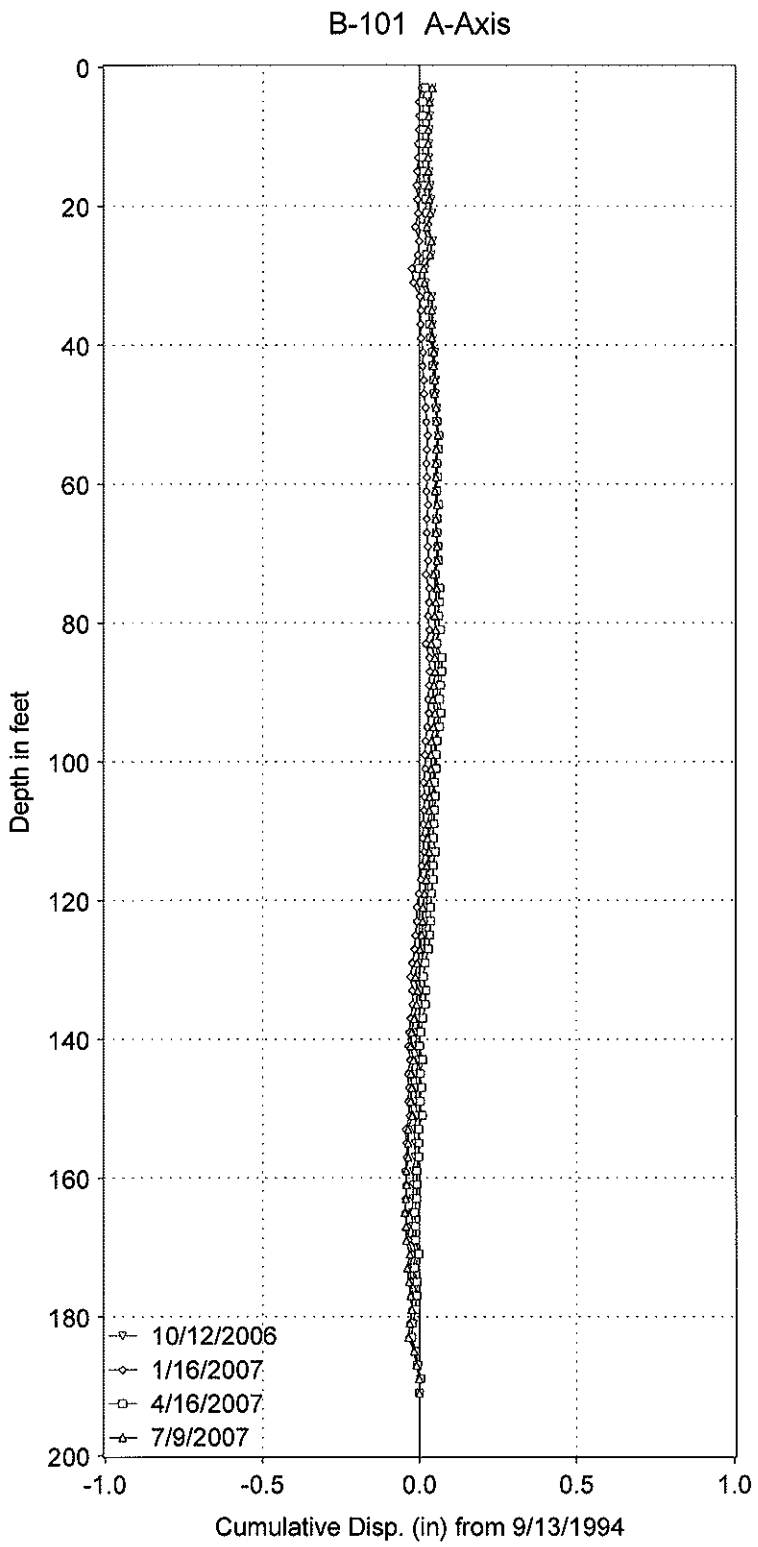
SITE PLAN OF ACTIVE INSTRUMENTATION

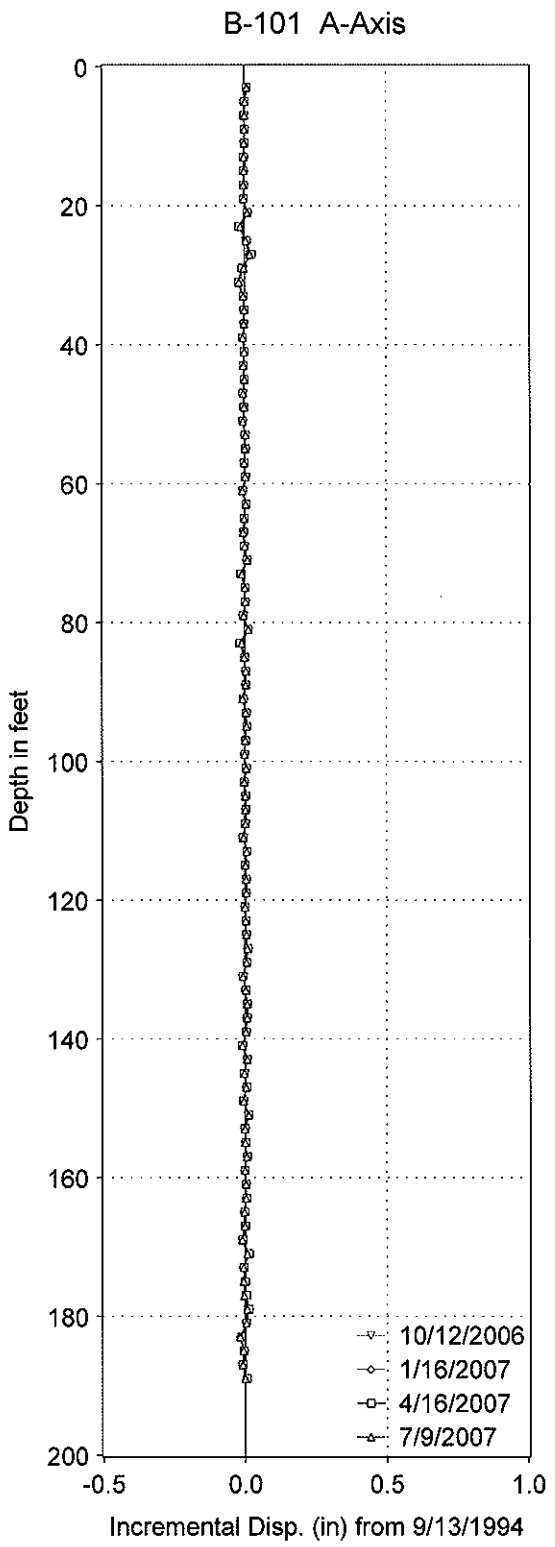
CUY-90-14.52/15.24 WEST ABUTMENT
CLEVELAND, OHIO

Project: 012-00946-300	Drawn By: EDV
Drawing Date: 7/25/06	Approved By: JLS
Revision Date: 2/9/07	Scale: 1" = 100'

BBCM

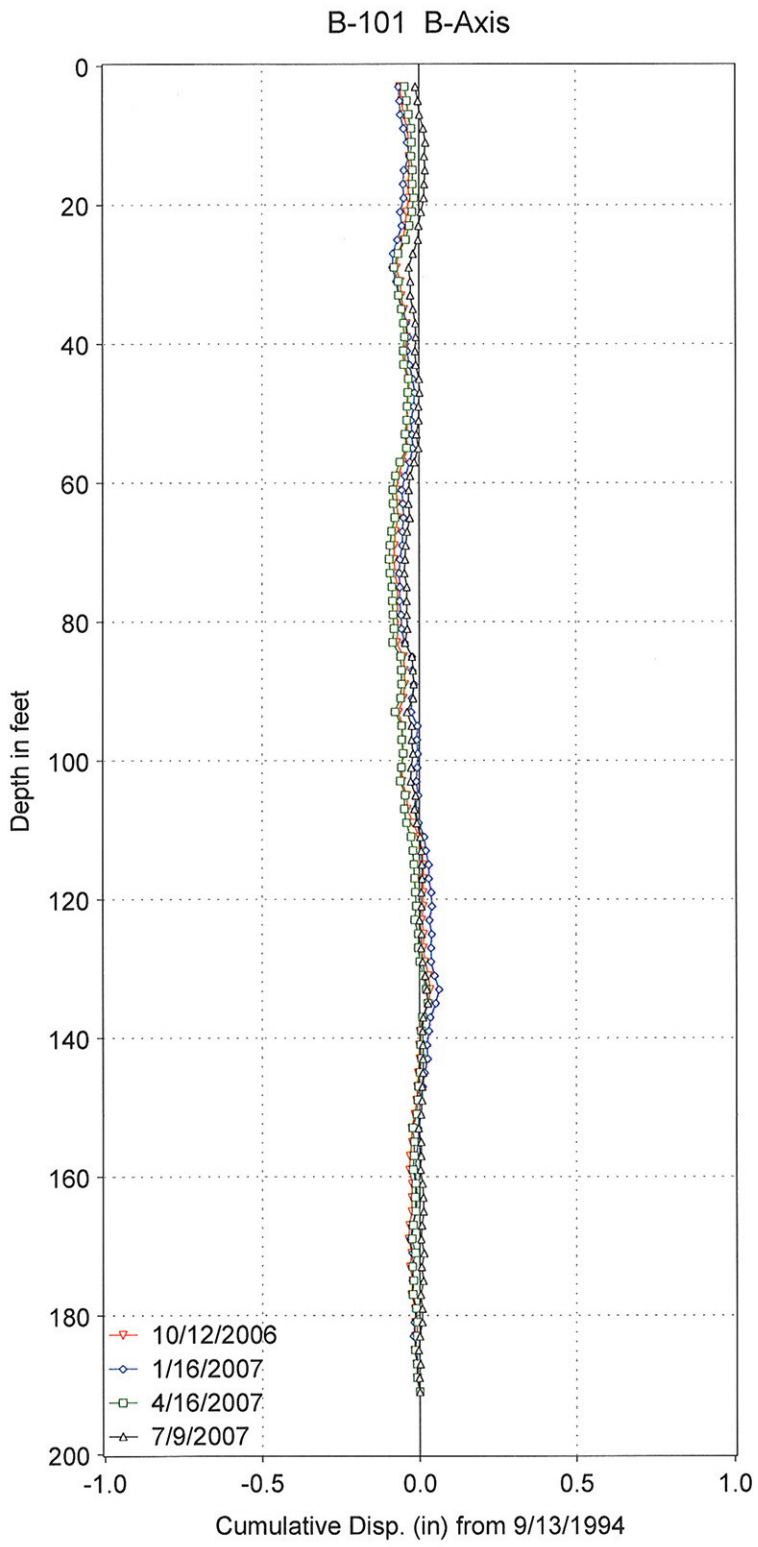
PLATE 2

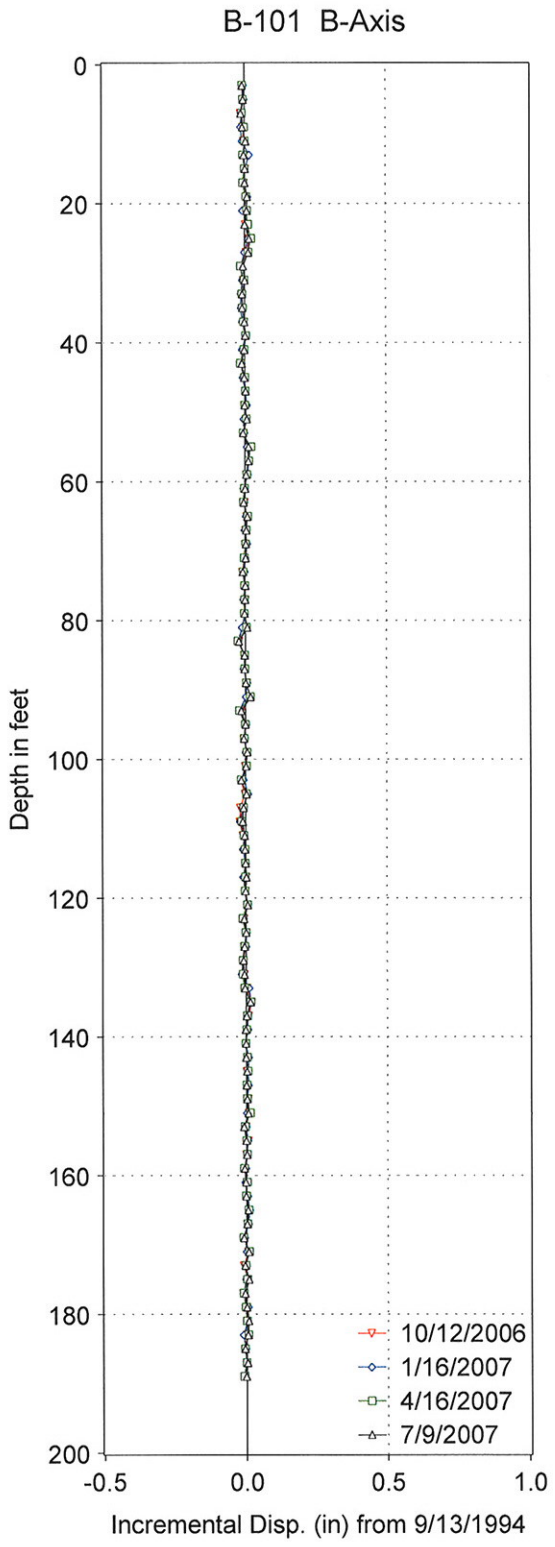




B-101
-Includes readings from the last four quarters.

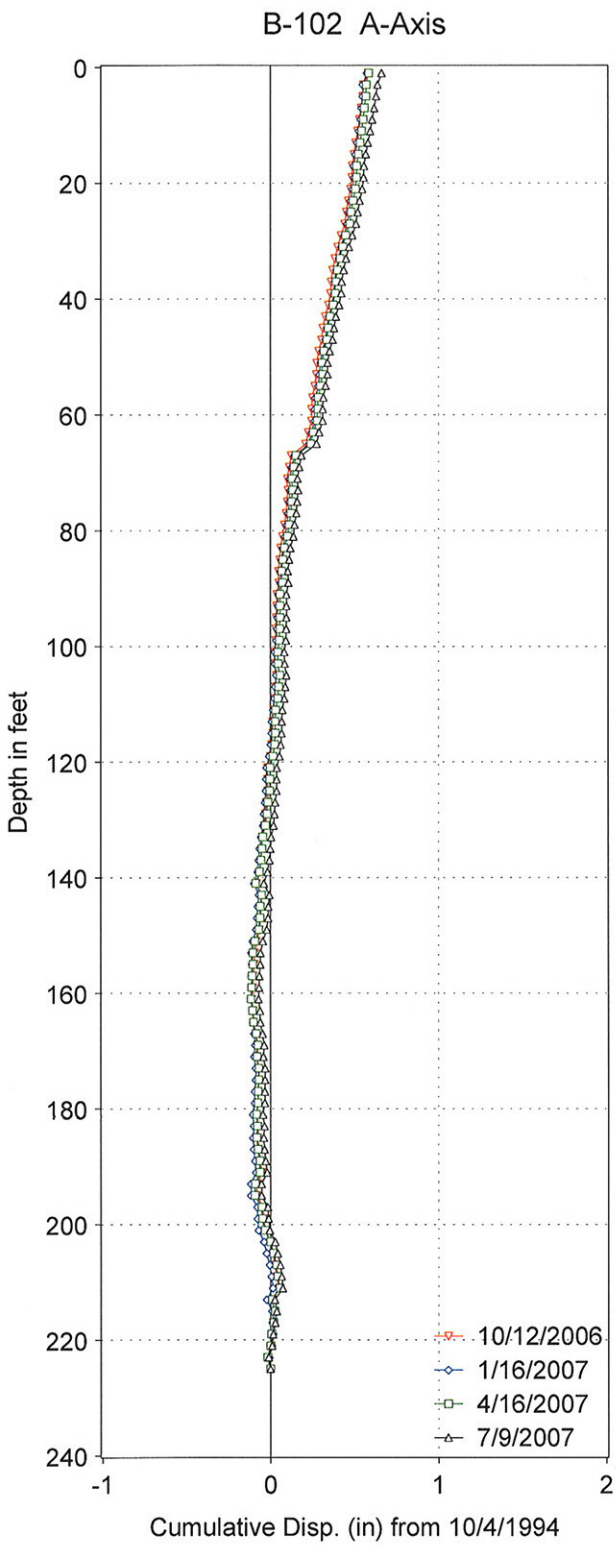
PLATE 3

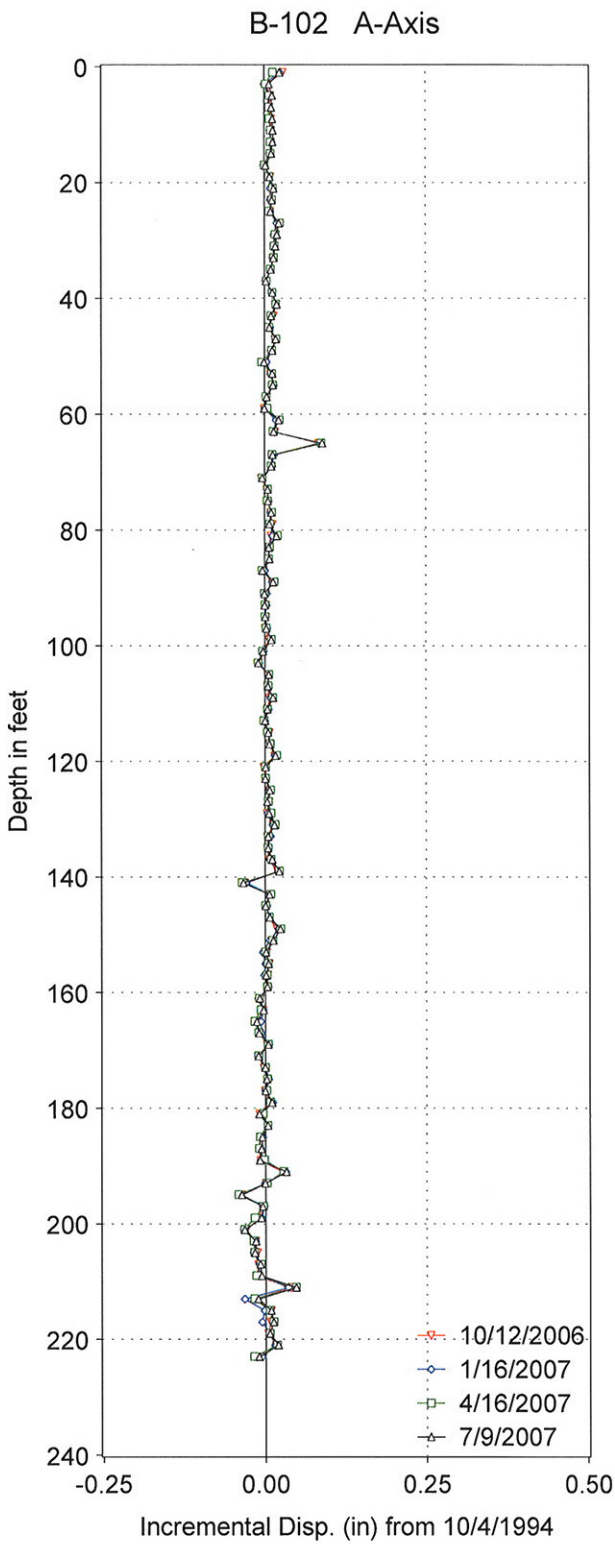




B-101
-Includes readings from the last four quarters.

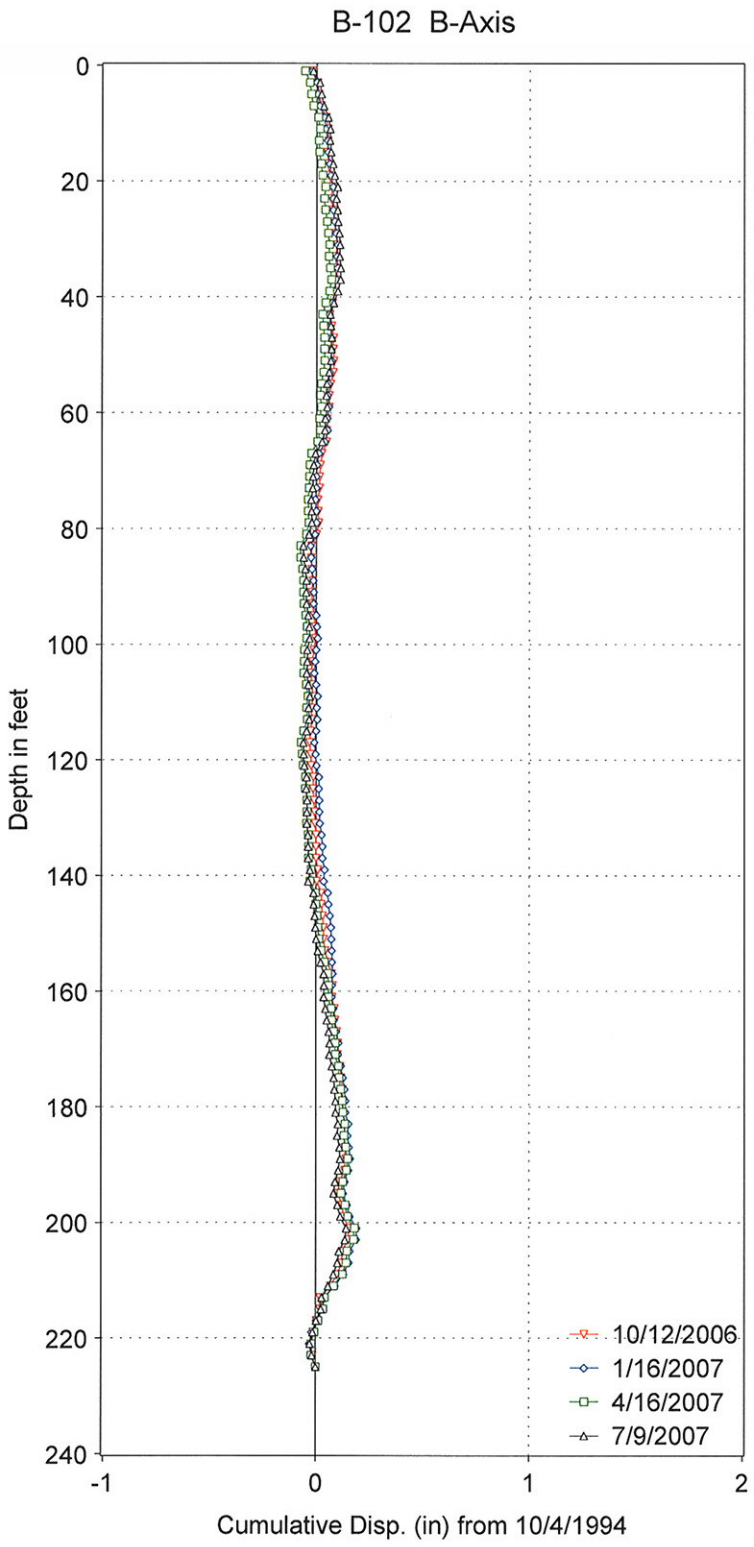
PLATE 4

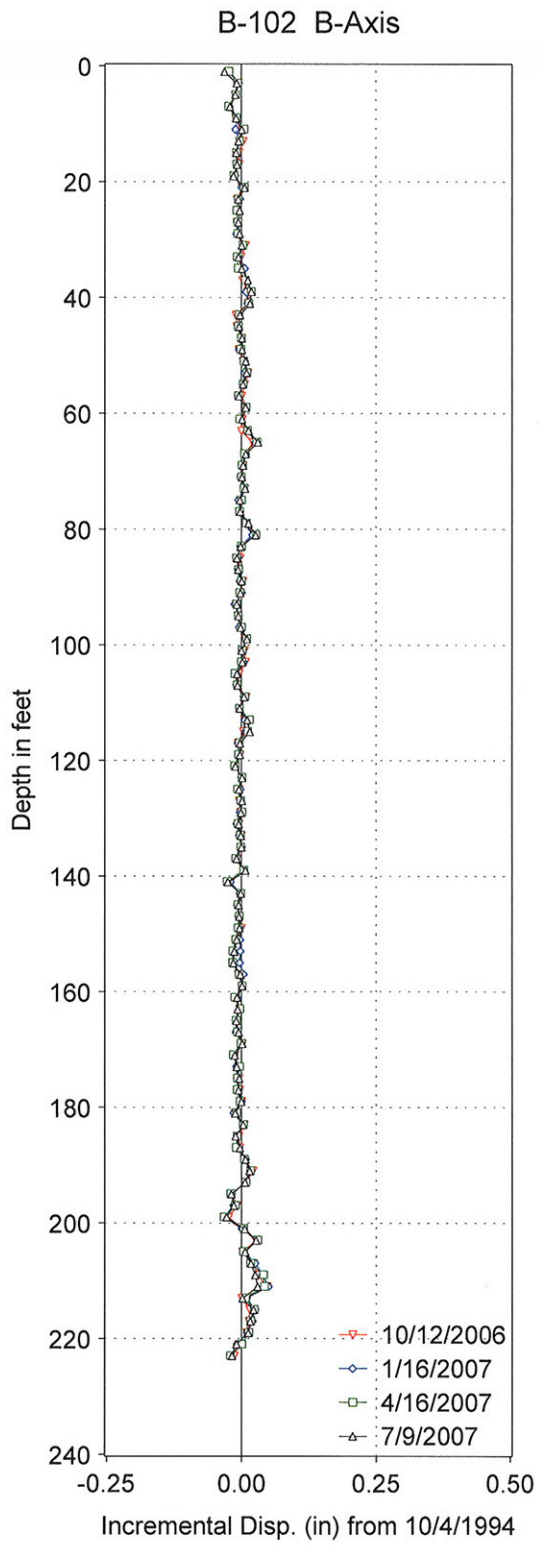




B-102
-Includes readings from the last four quarters.

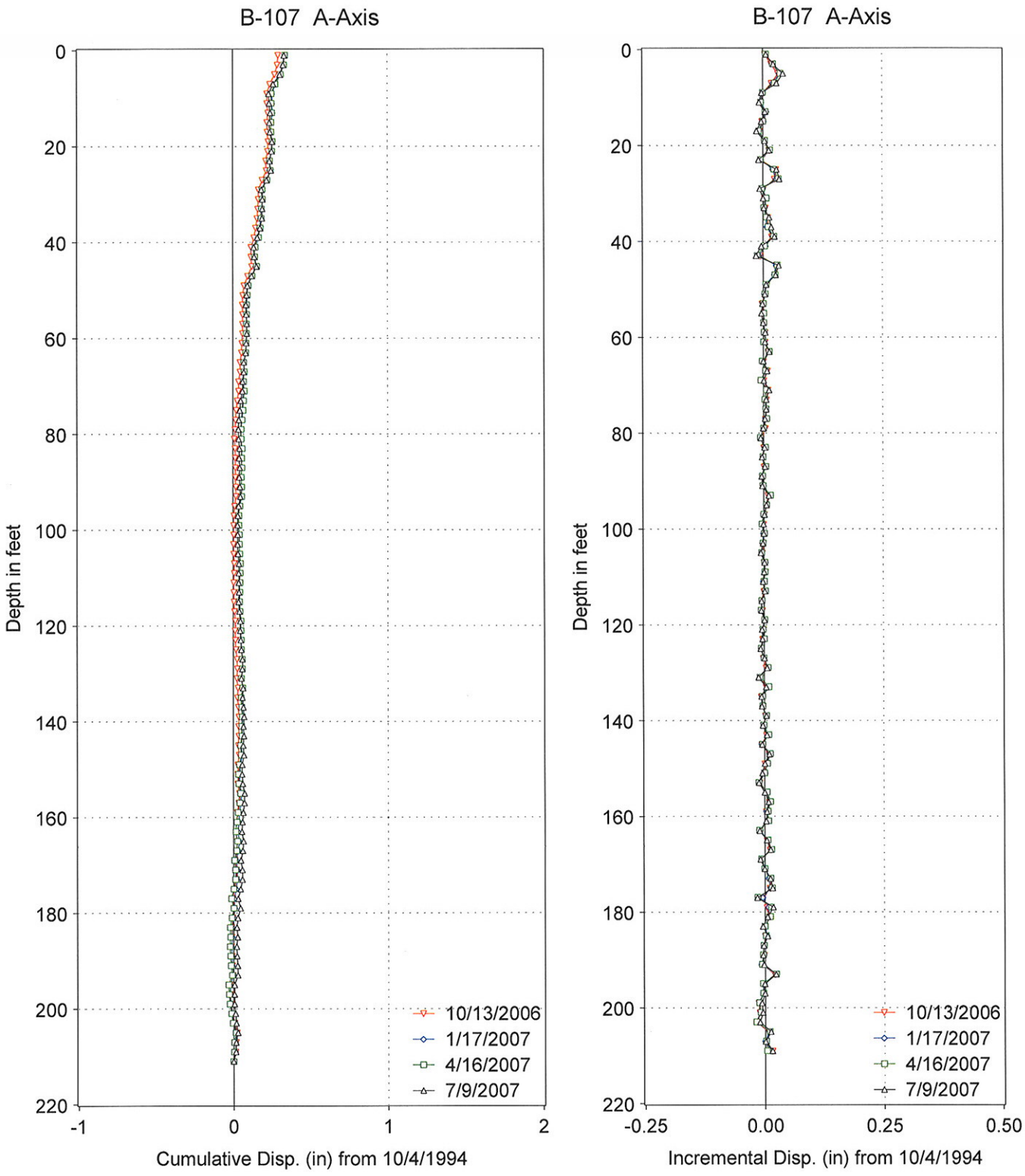
PLATE 5





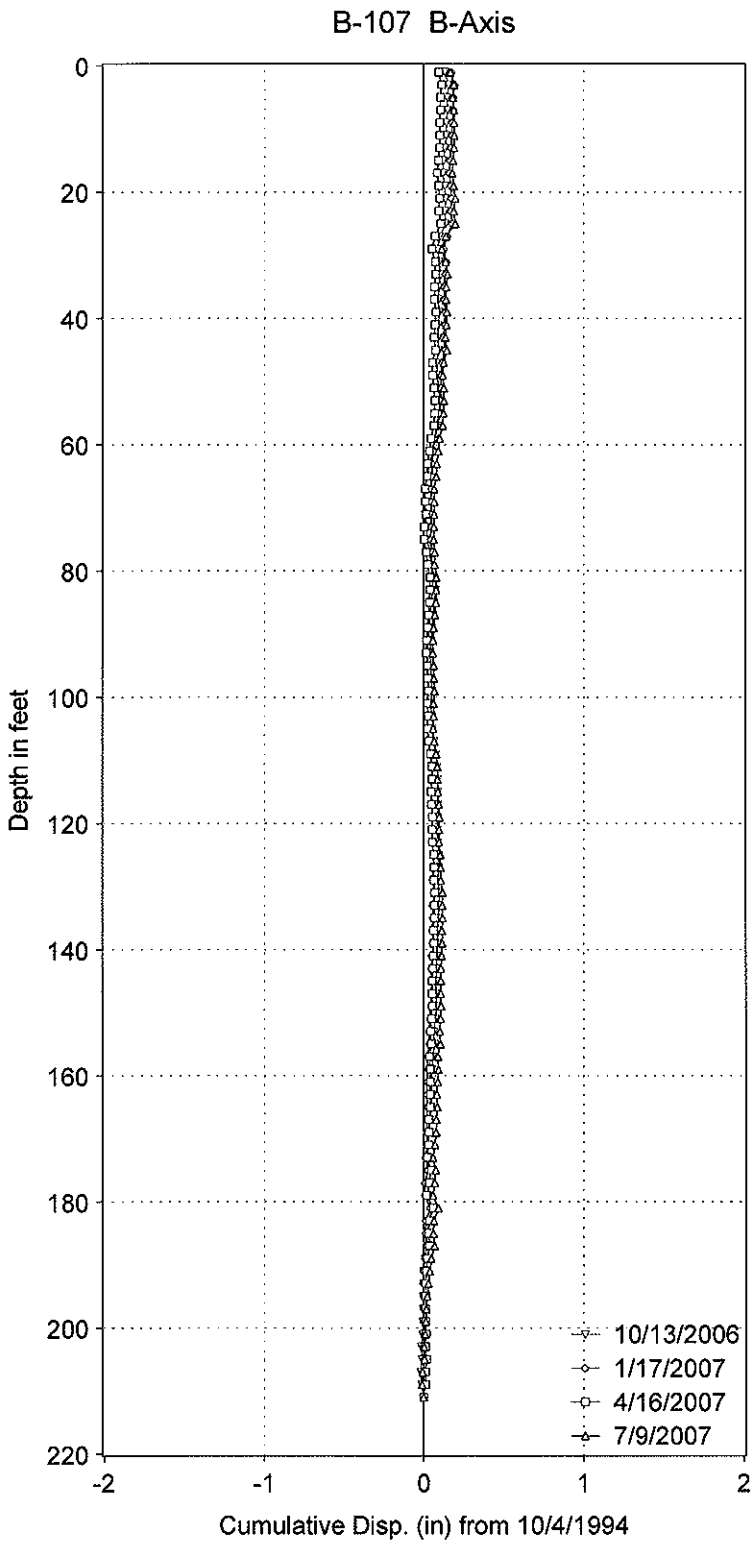
B-102
-Includes readings from the last four quarters.

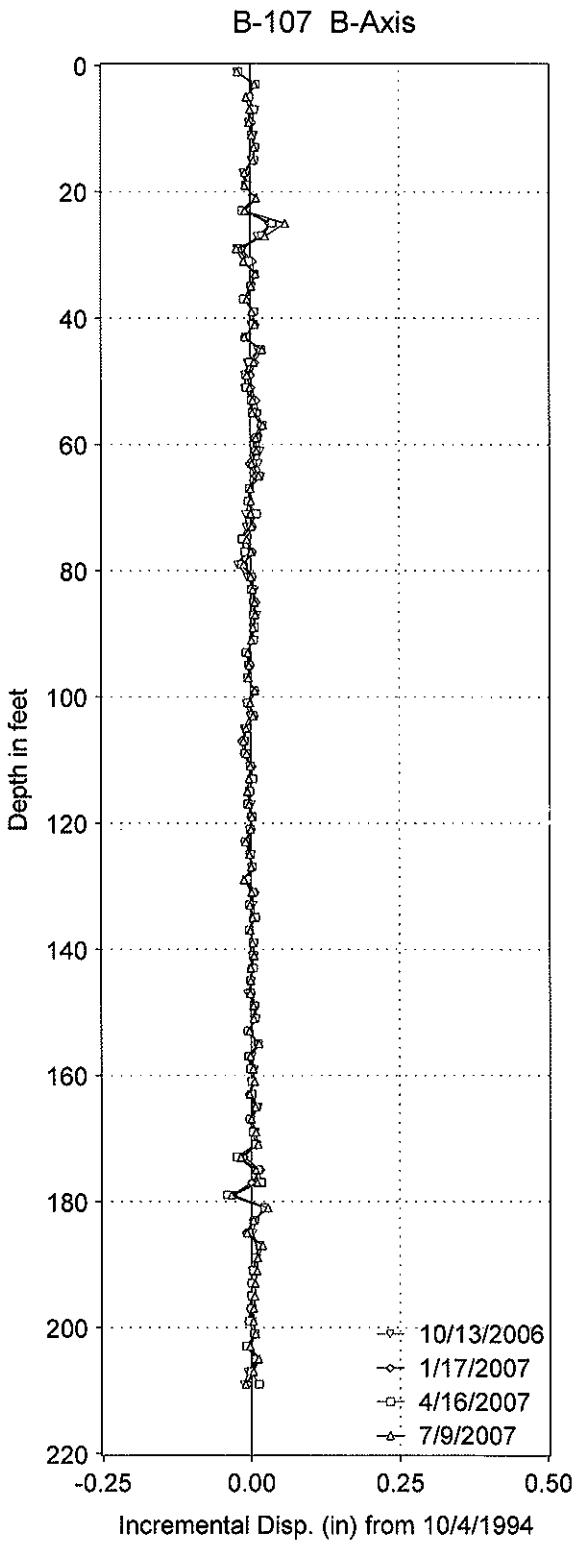
PLATE 6



B-107
-Includes readings from the last four quarters.

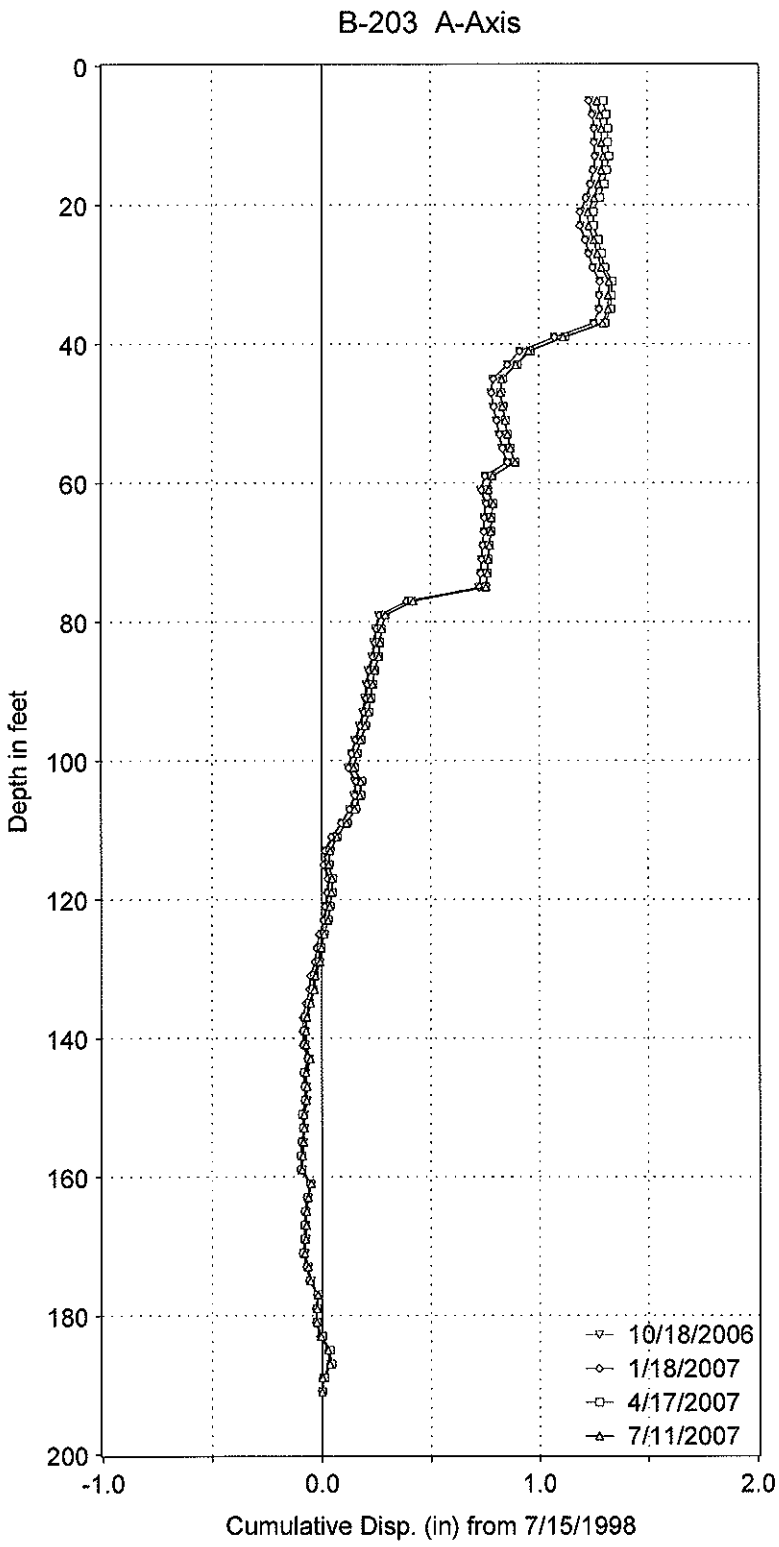
PLATE 7

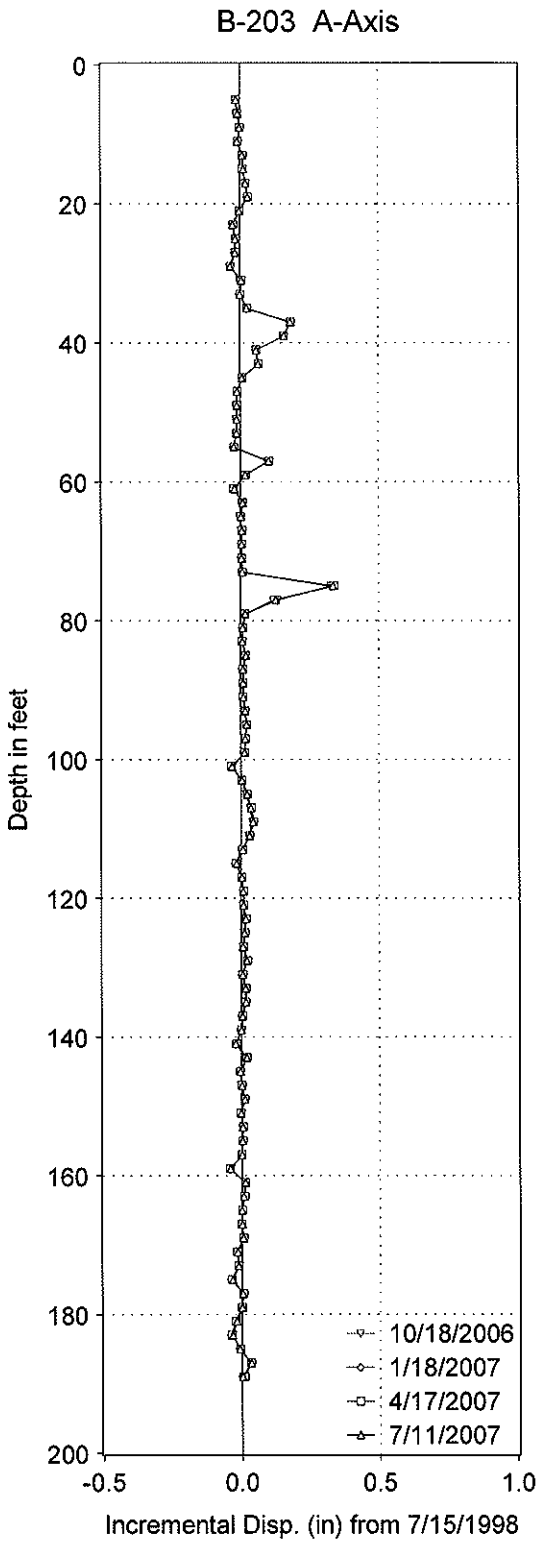




B-107
-Includes readings from the last four quarters.

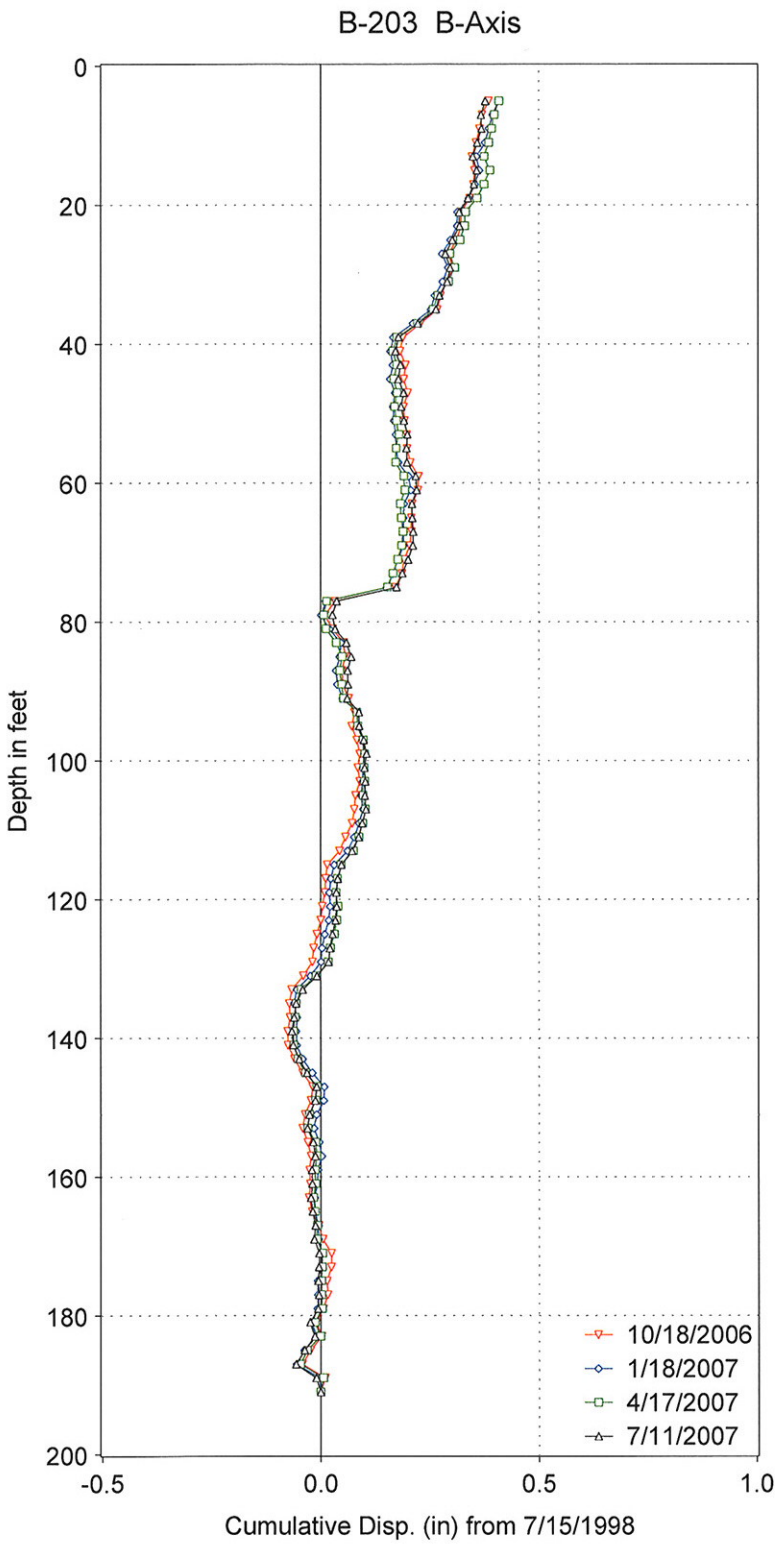
PLATE 8

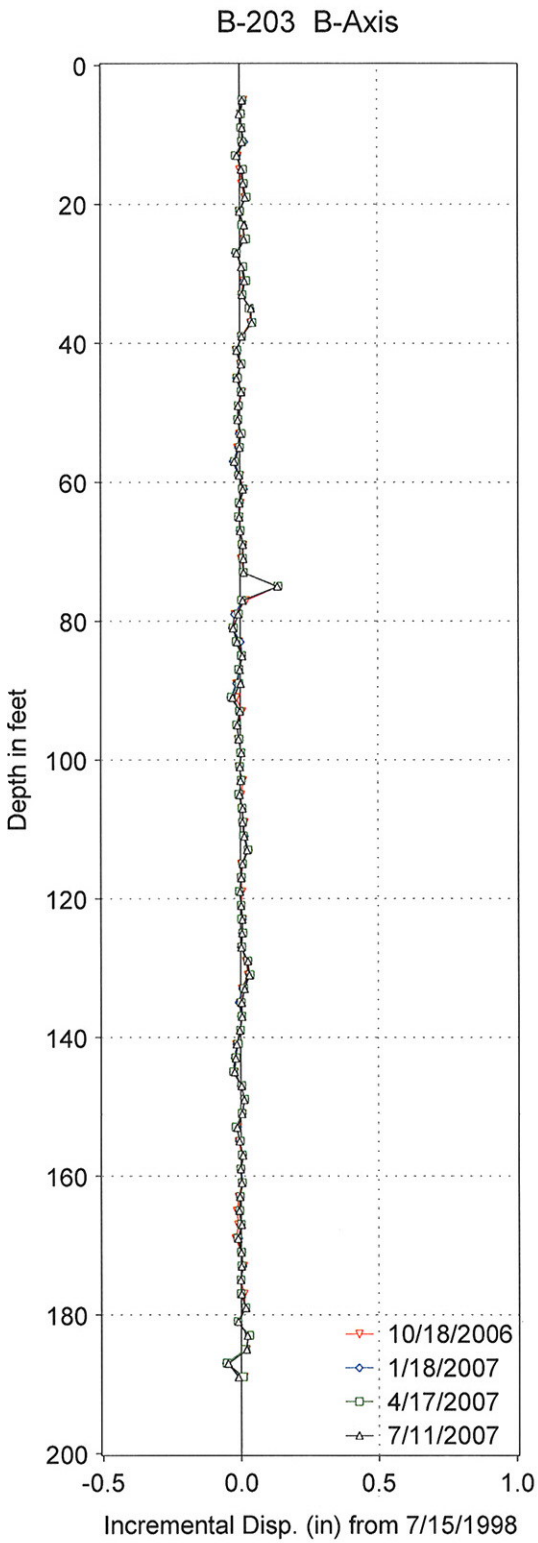




B-203
-Includes readings from the last four quarters.

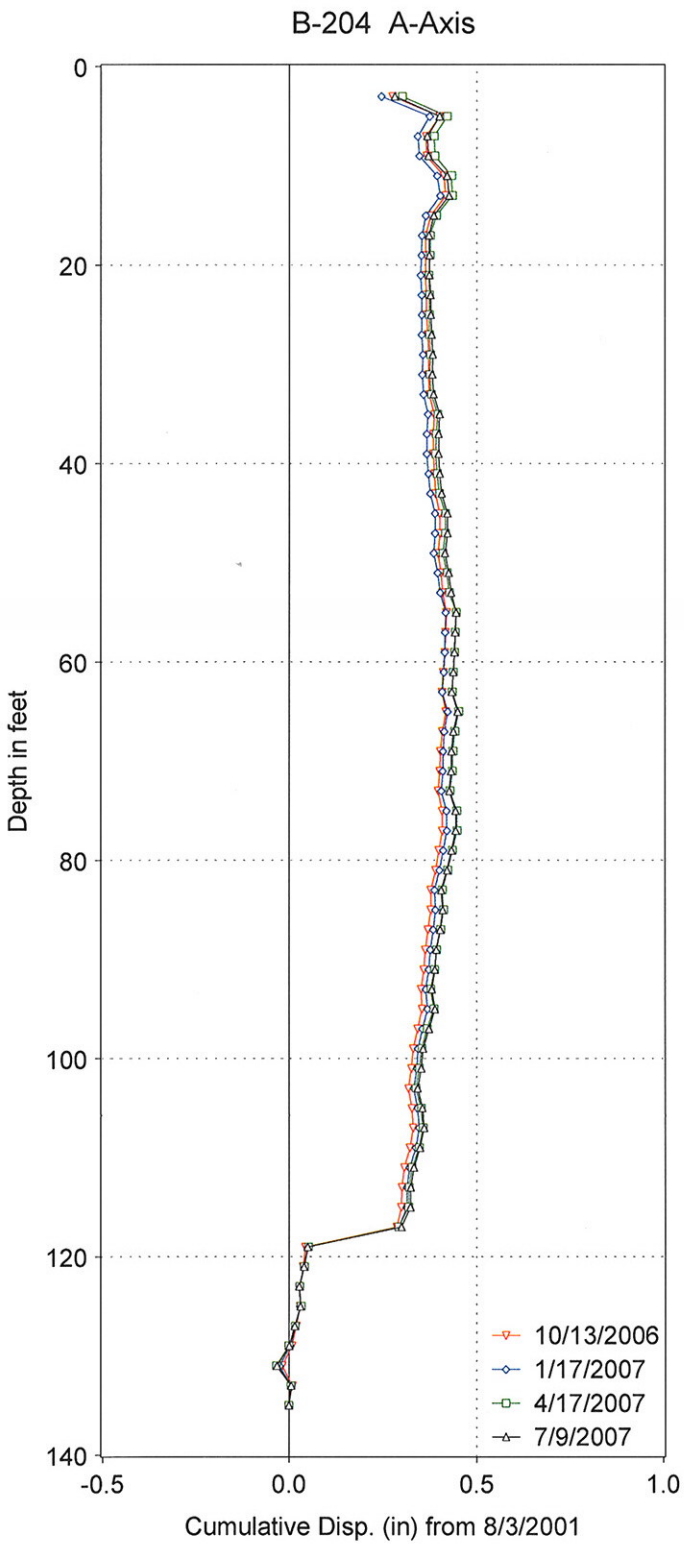
PLATE 9

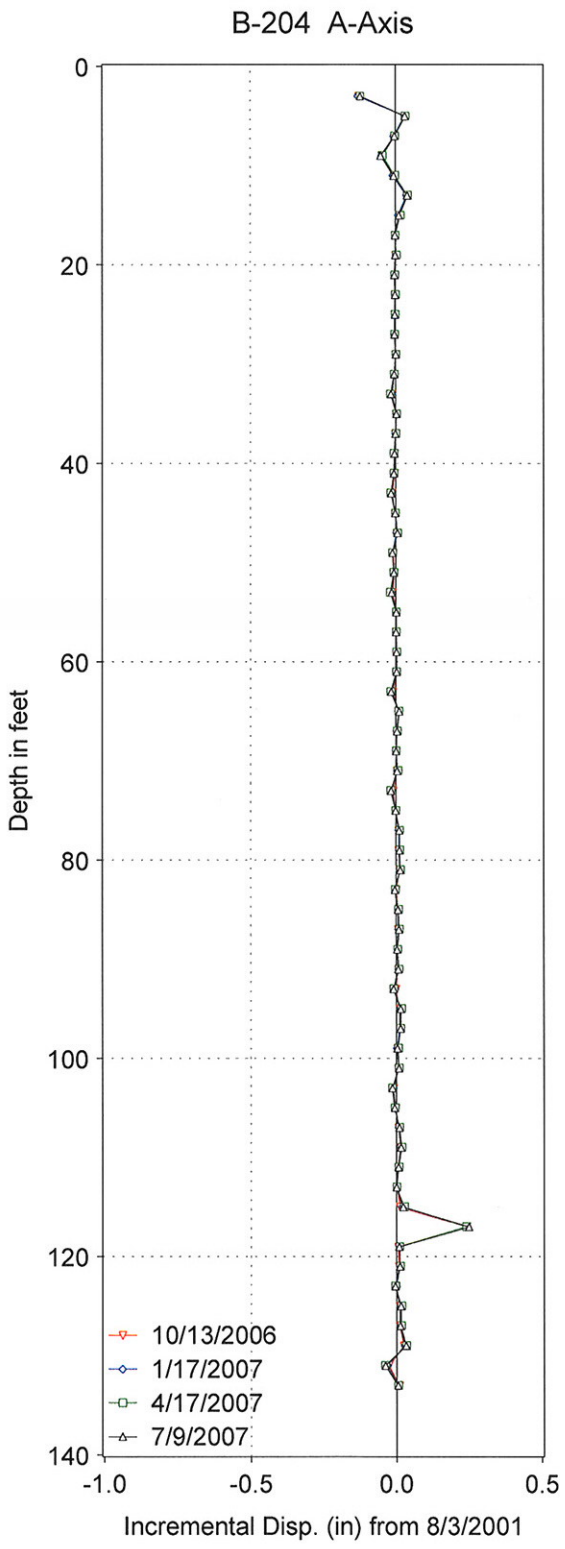




B-203
-Includes readings from the last four quarters.

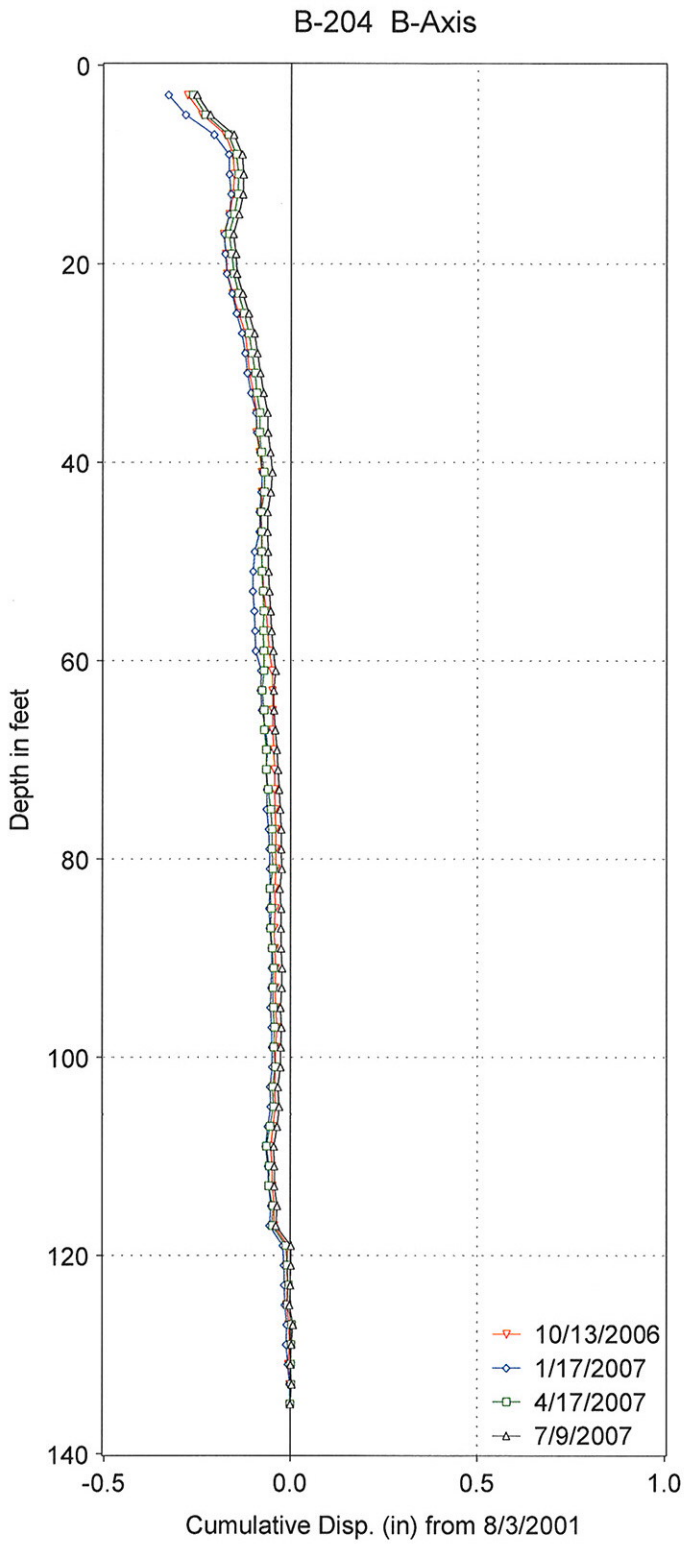
PLATE 10

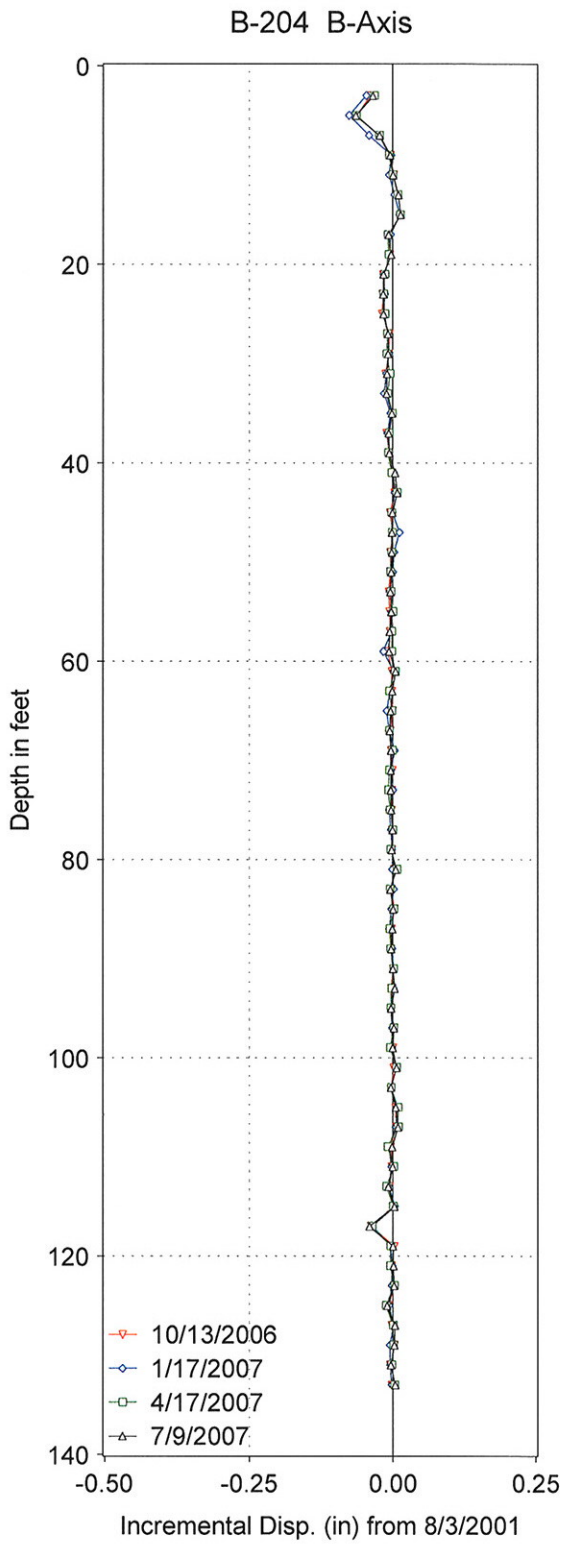




B-204
-Includes readings from the last four quarters.

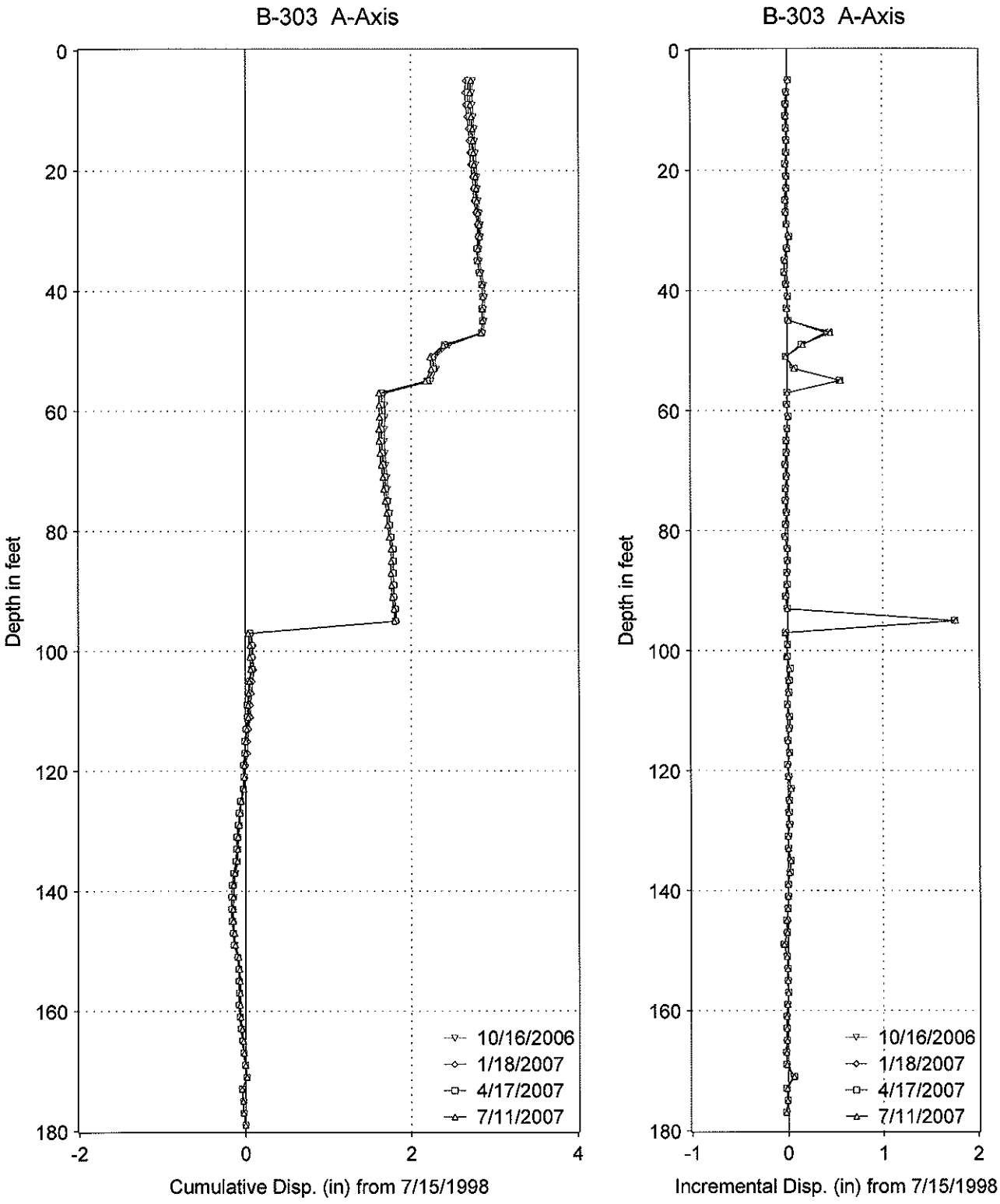
PLATE 11





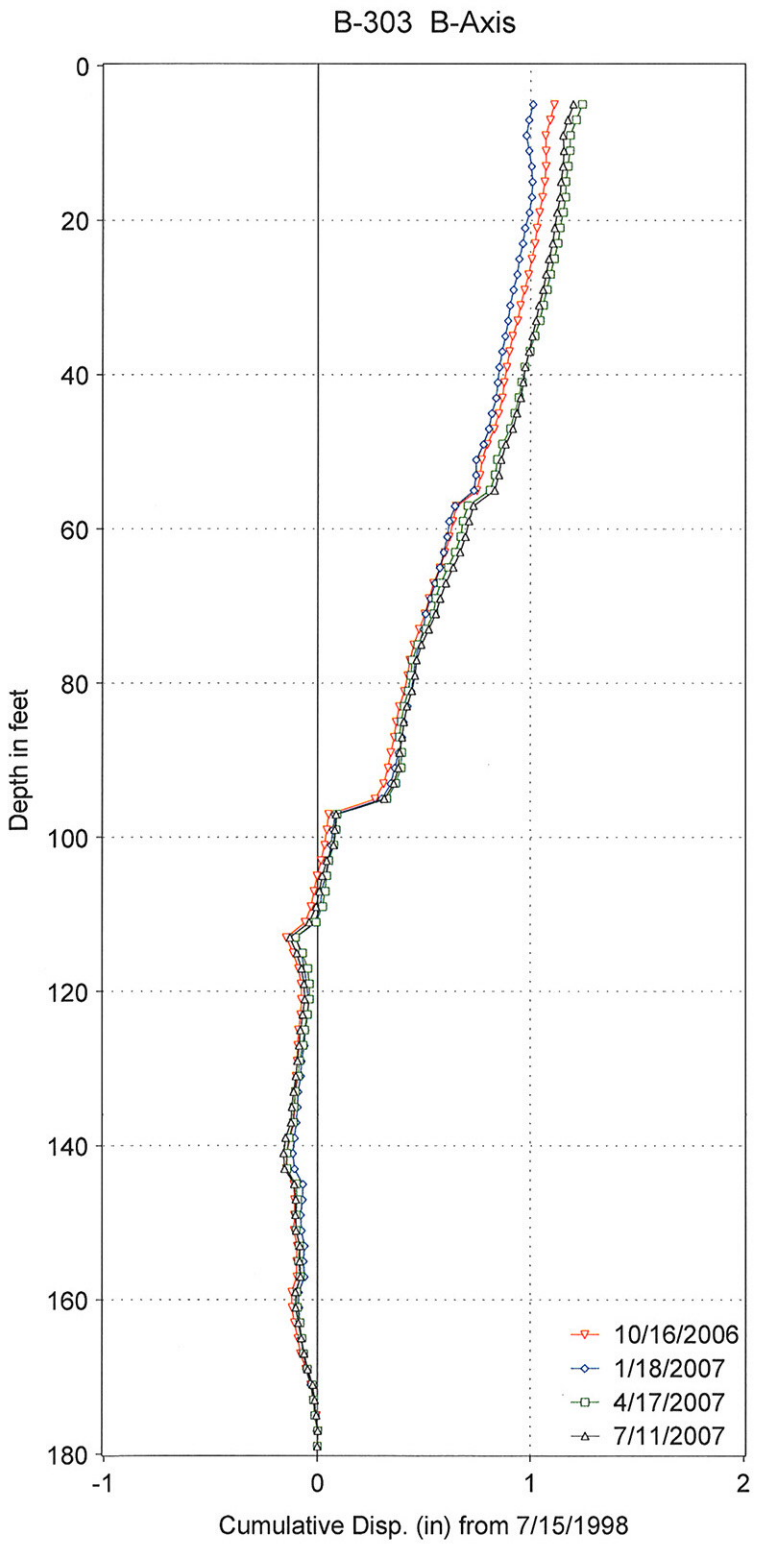
B-204
-Includes readings from the last four quarters.

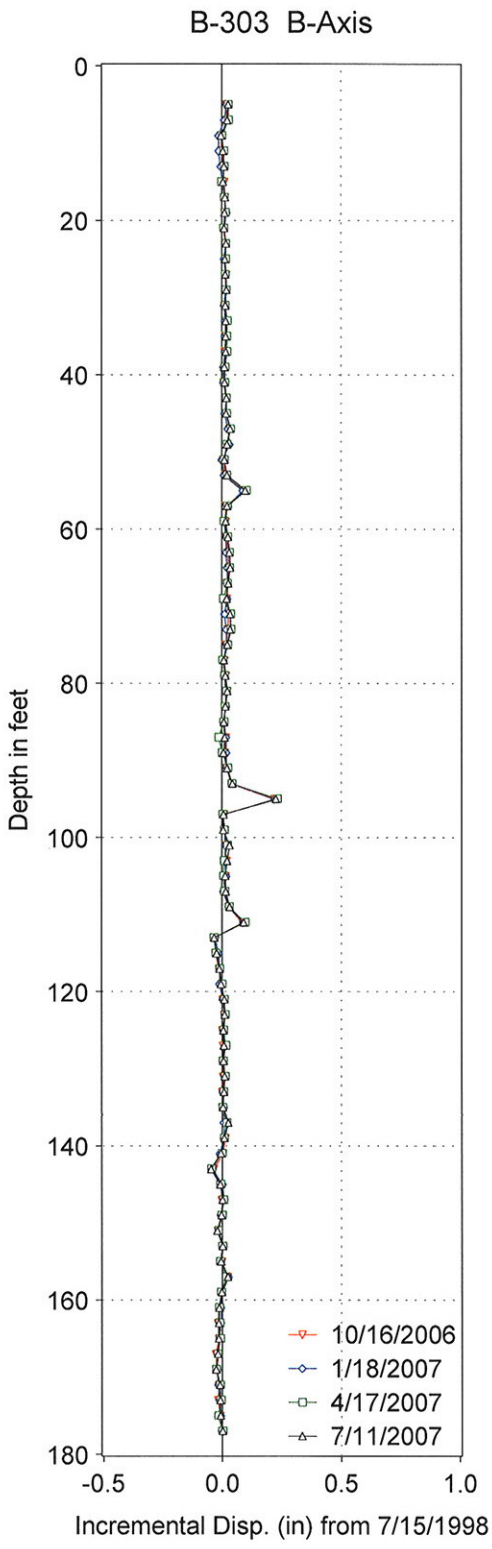
PLATE 12



B-303
-Includes readings from the last four quarters.

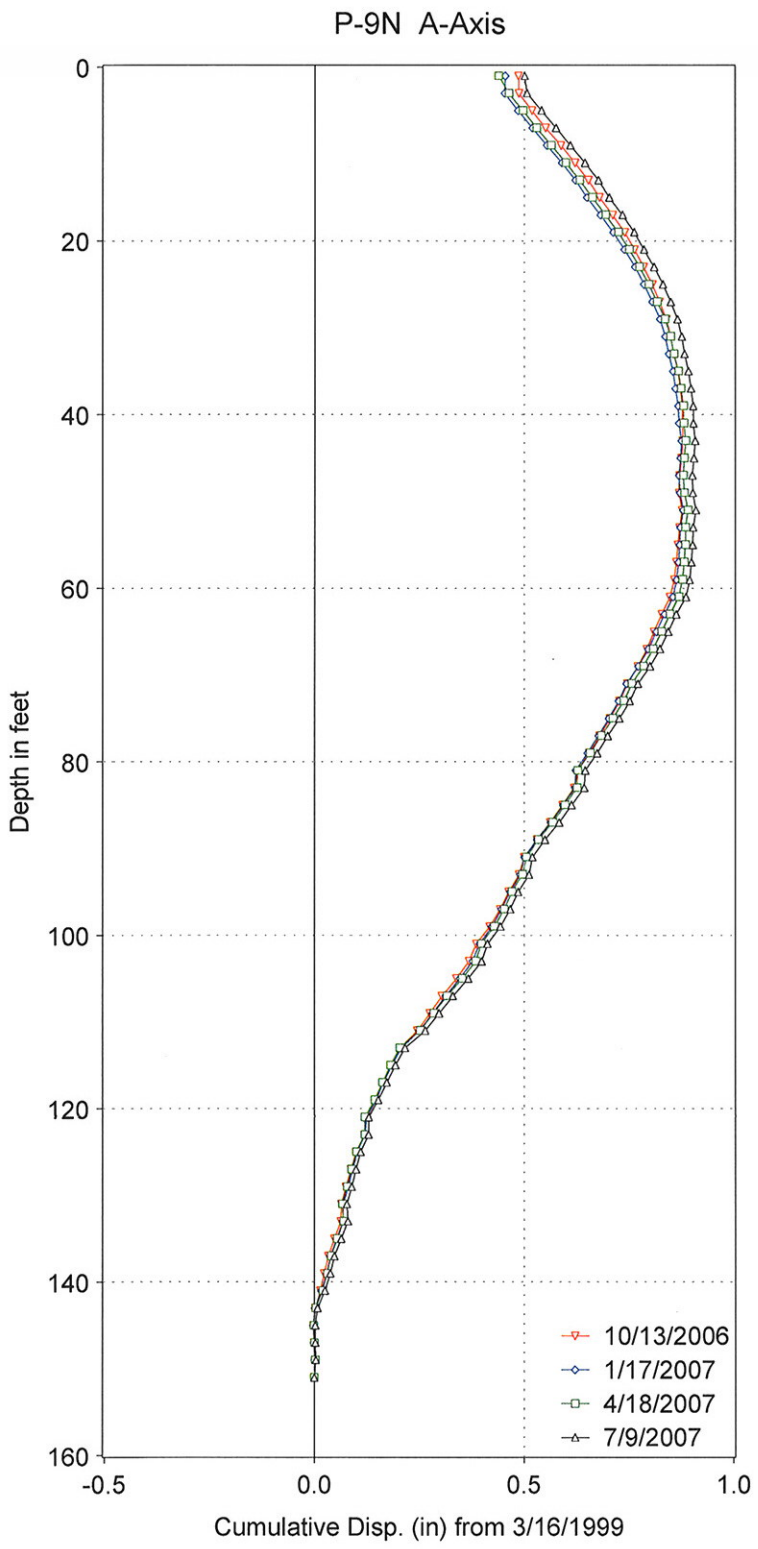
PLATE 13

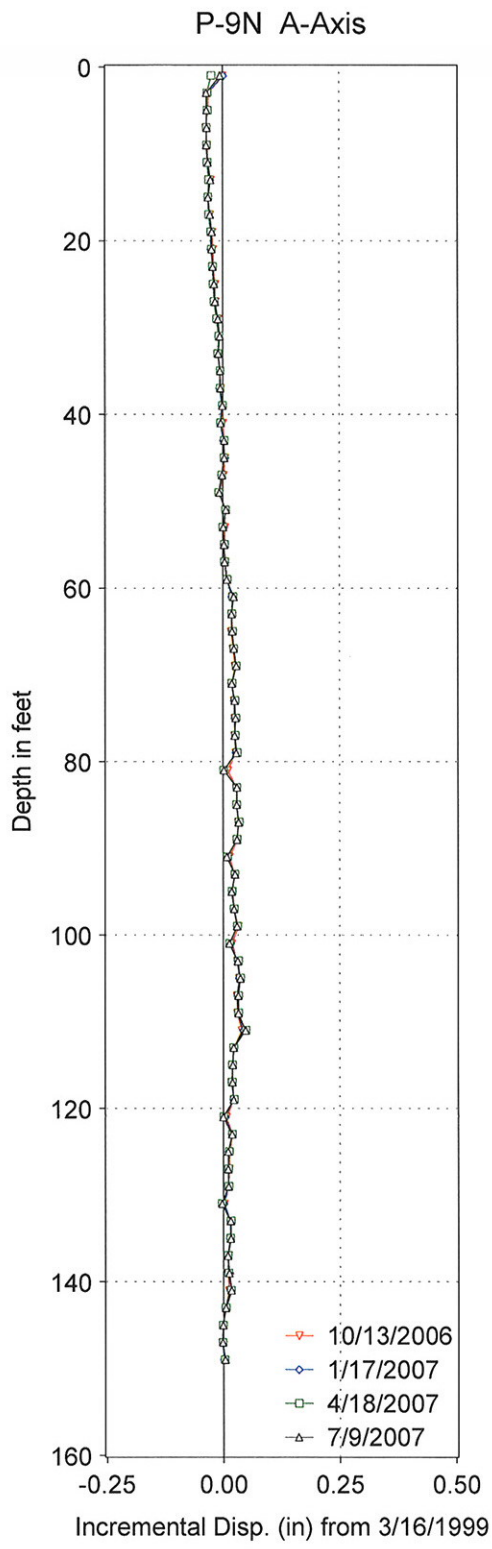




B-303
-Includes readings from the last four quarters.

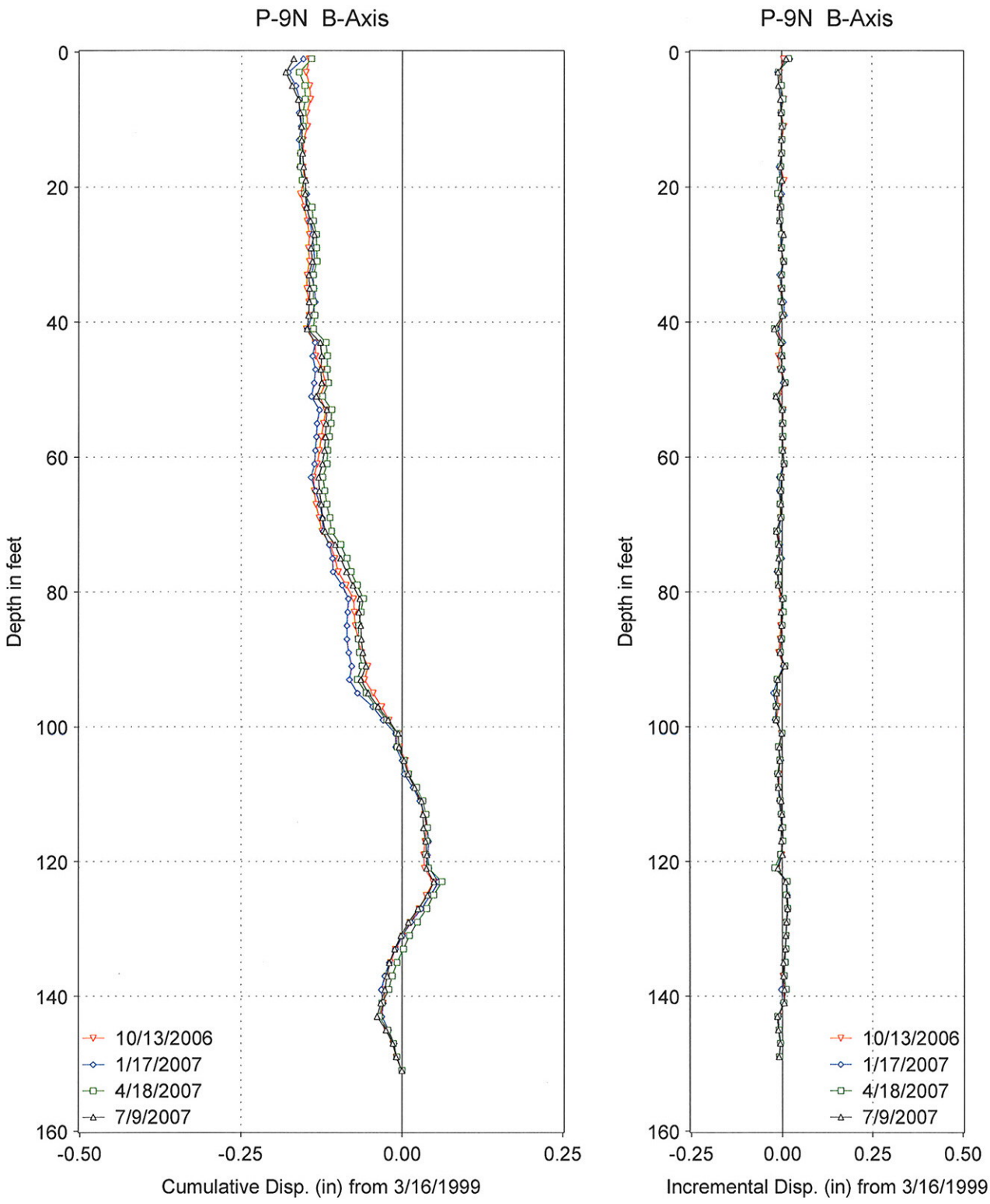
PLATE 14





P-9N
-Includes readings from the last four quarters.

PLATE 15



P-9N

-Includes readings from the last four quarters.

PLATE 16

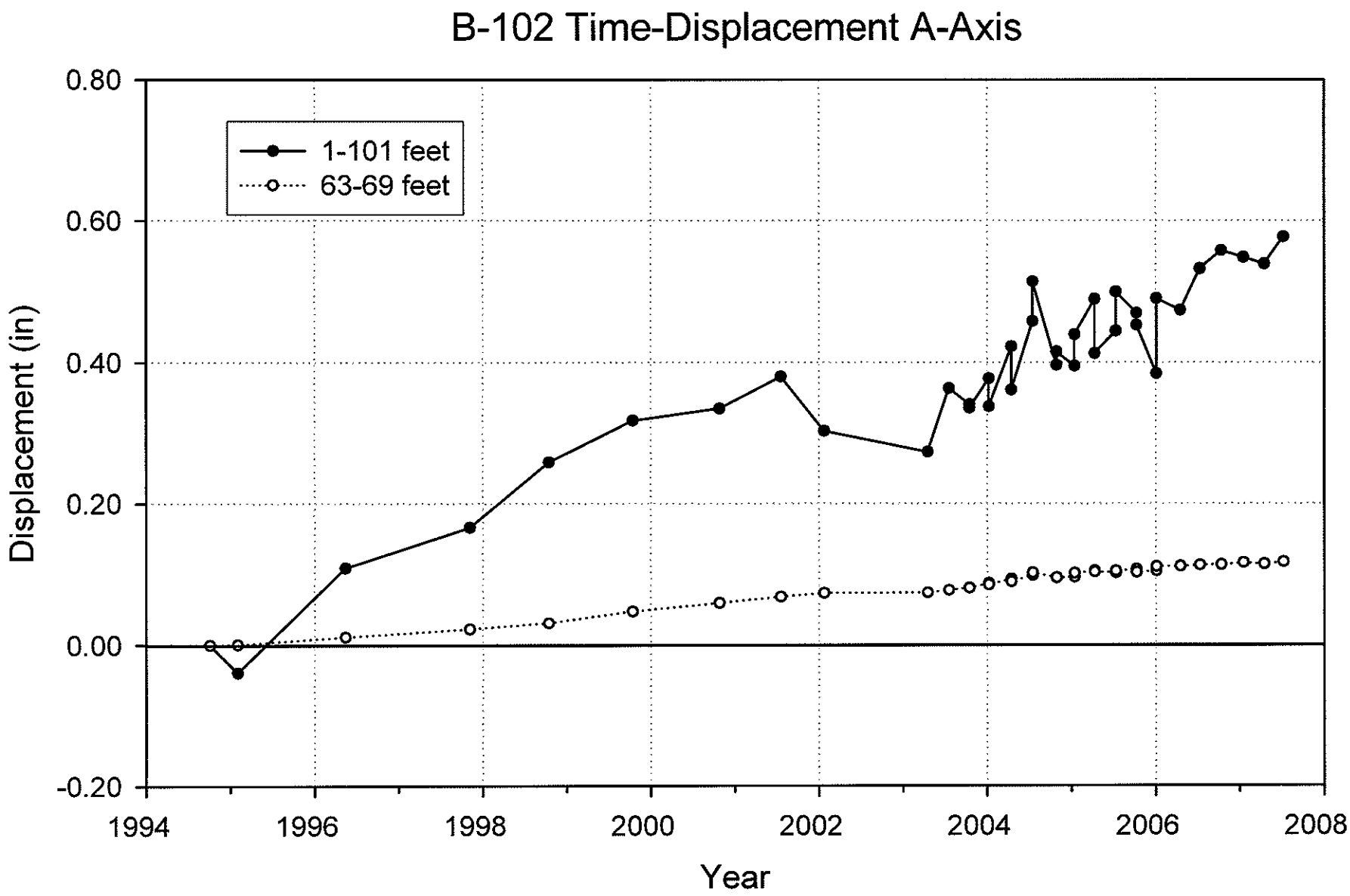

B-102 Time-Displacement A-Axis
1-101 feet
63-69 feet
Displacement (in)
0.80
0.60
0.40
0.20
0.00
-0.20
1994
1996
1998
2000
2002
2004
2006
2008
Year

PLATE 17

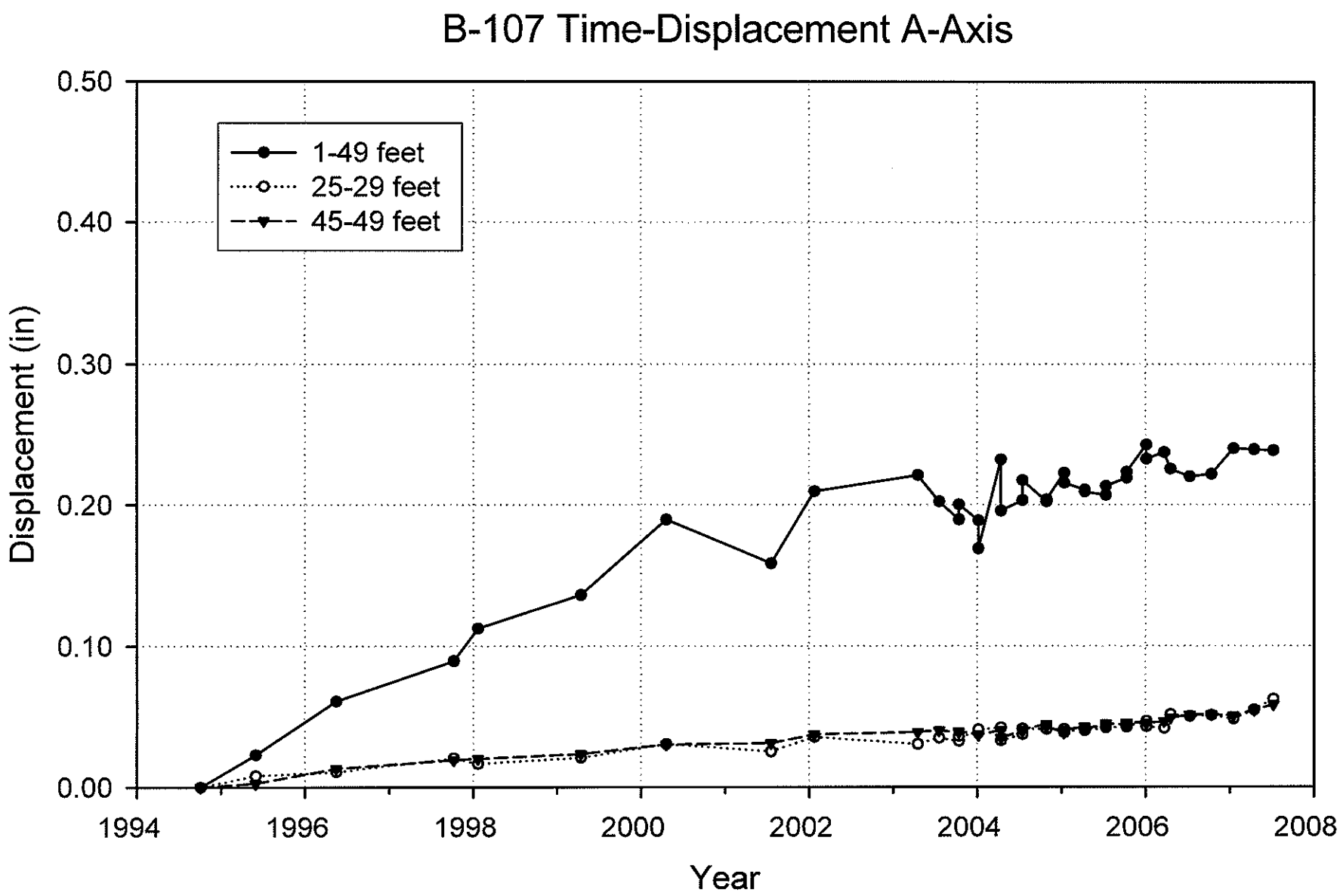

B-107 Time-Displacement A-Axis
1-49 feet
25-29 feet
45-49 feet
Displacement (in)
0.50
0.40
0.30
0.20
0.10
0.00
1994
1996
1998
2000
2002
2004
2006
2008
Year

PLATE 18

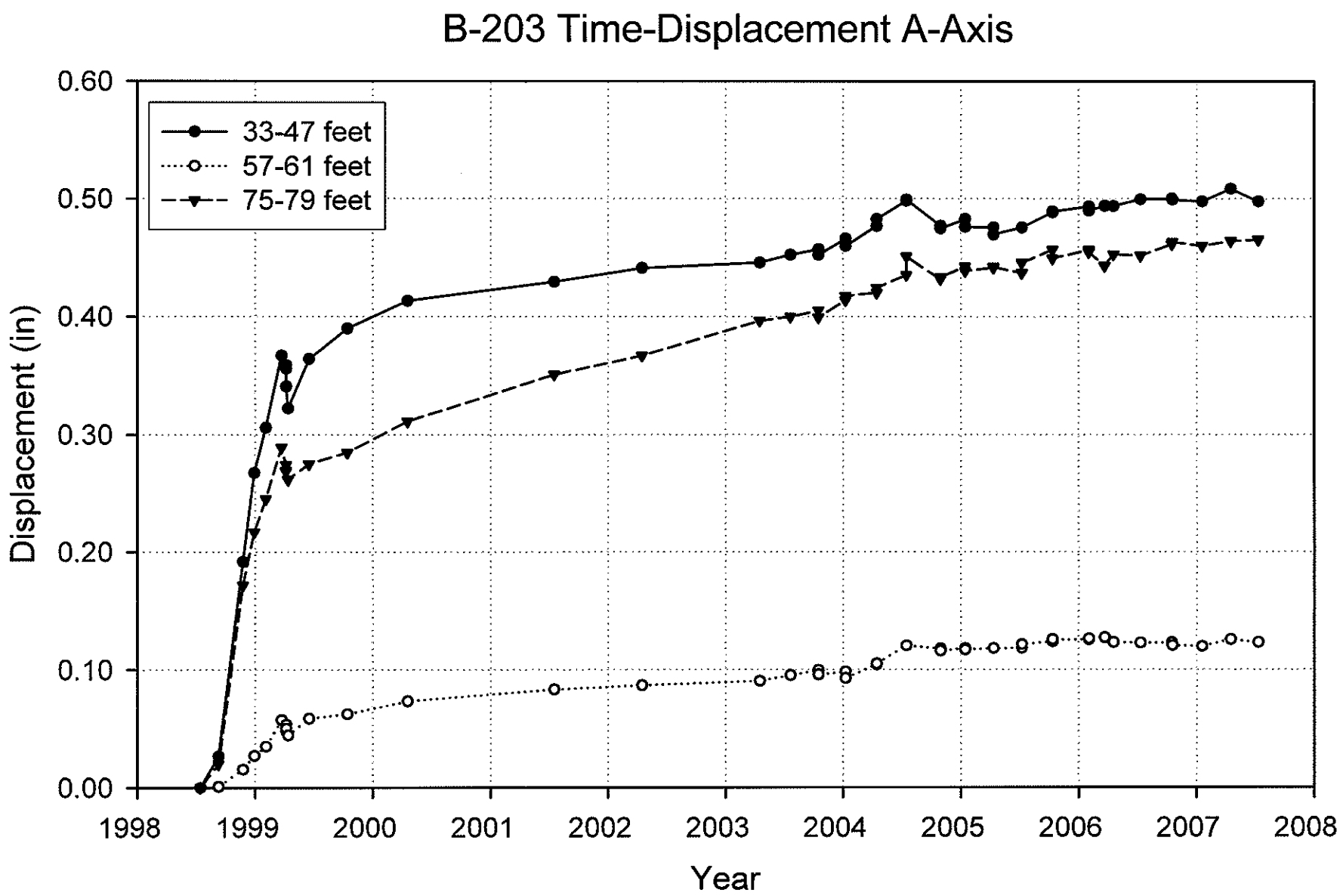

B-203 Time-Displacement A-Axis
33-47 feet
57-61 feet
75-79 feet
Displacement (in)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year

PLATE 19

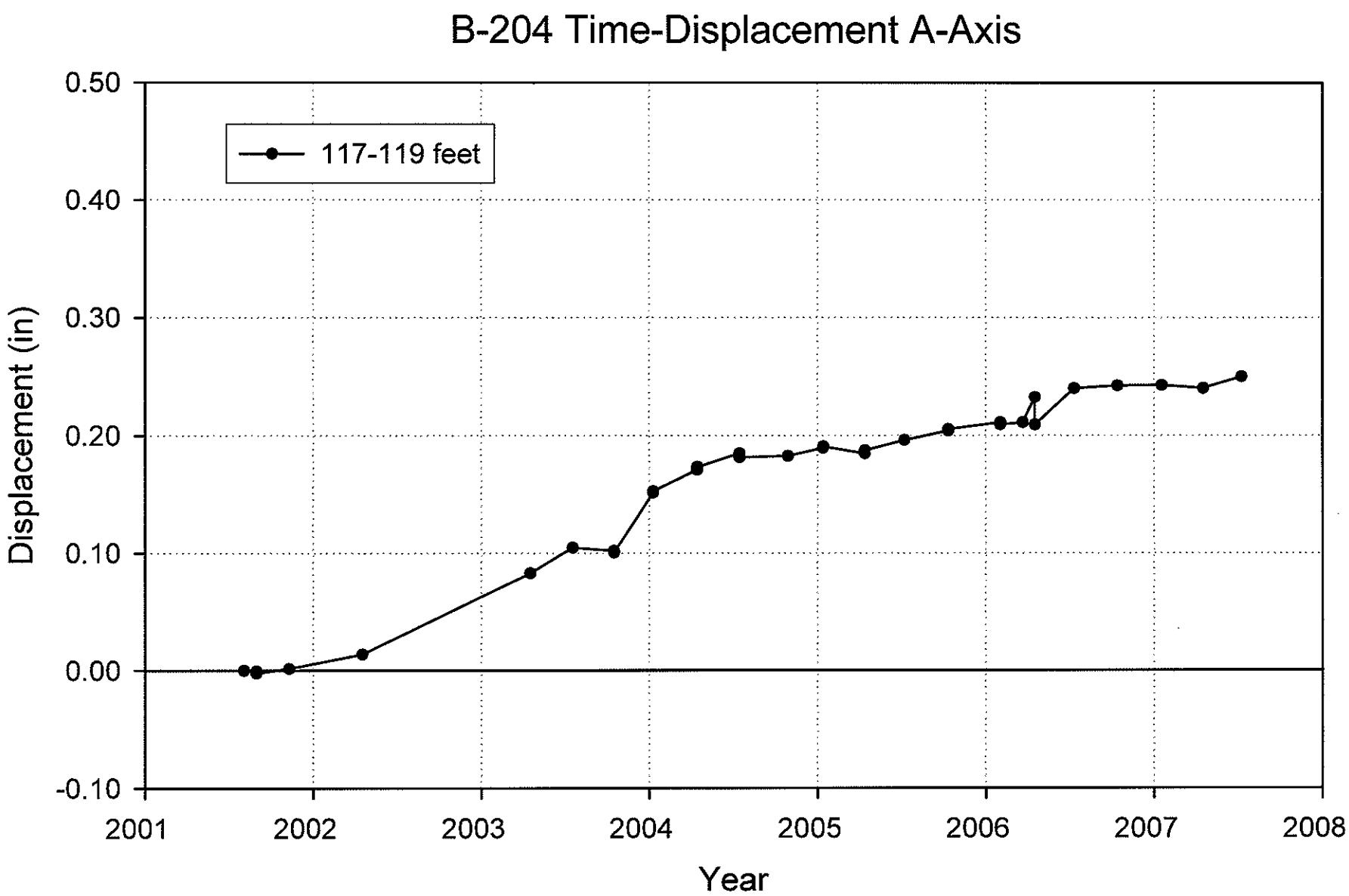

B-204 Time-Displacement A-Axis
117-119 feet
Displacement (in)
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
2001
2002
2003
2004
2005
2006
2007
2008
Year

PLATE 20

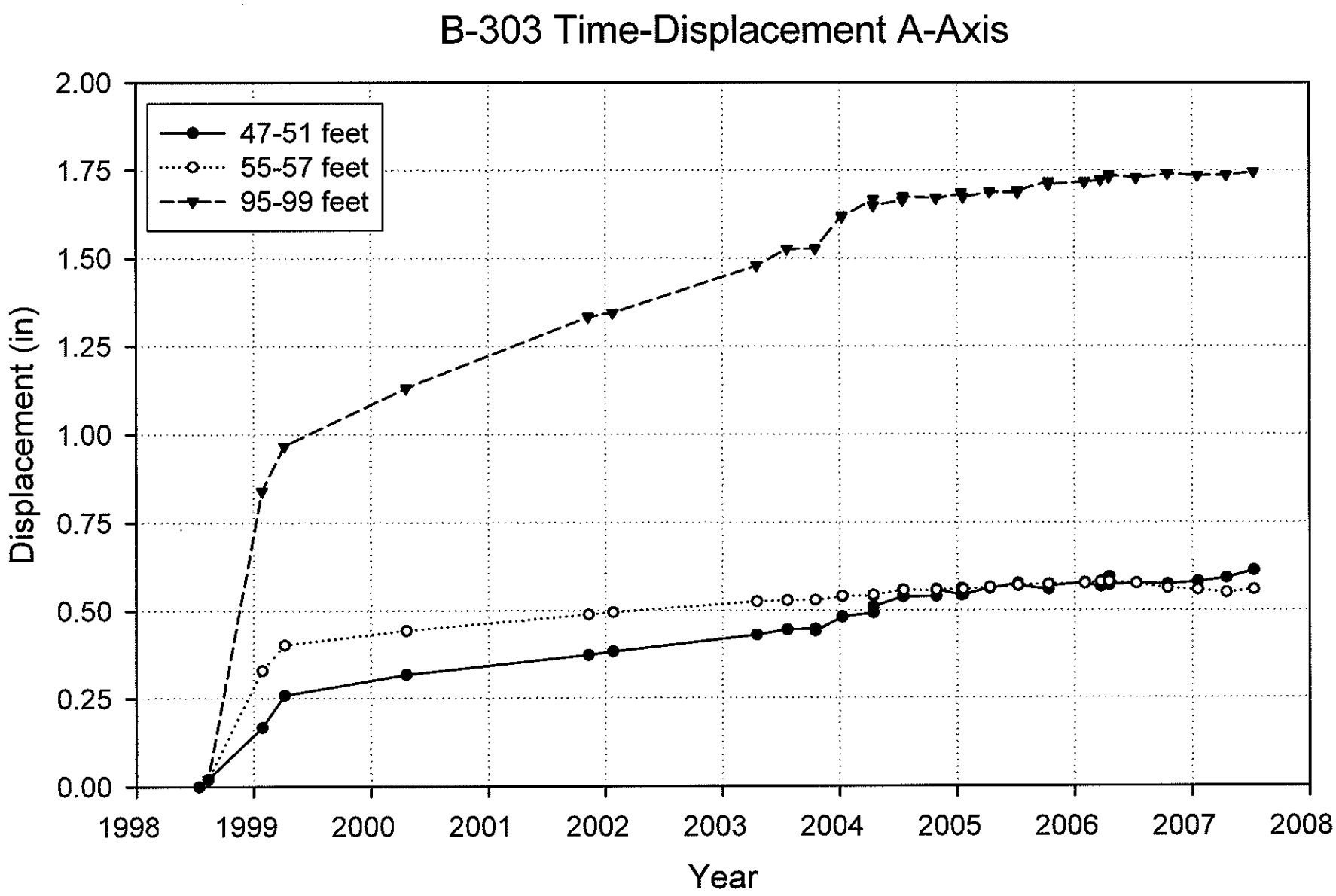
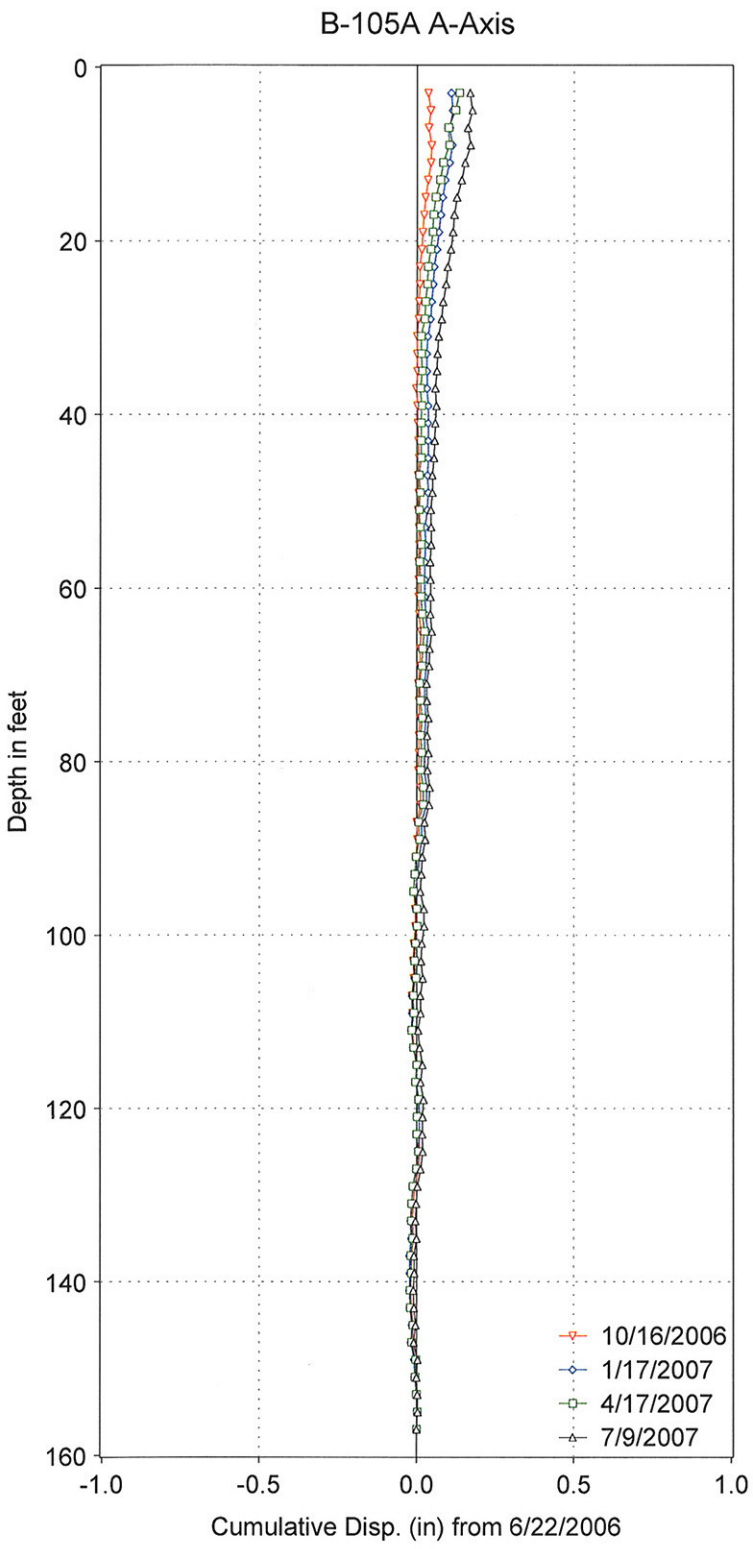
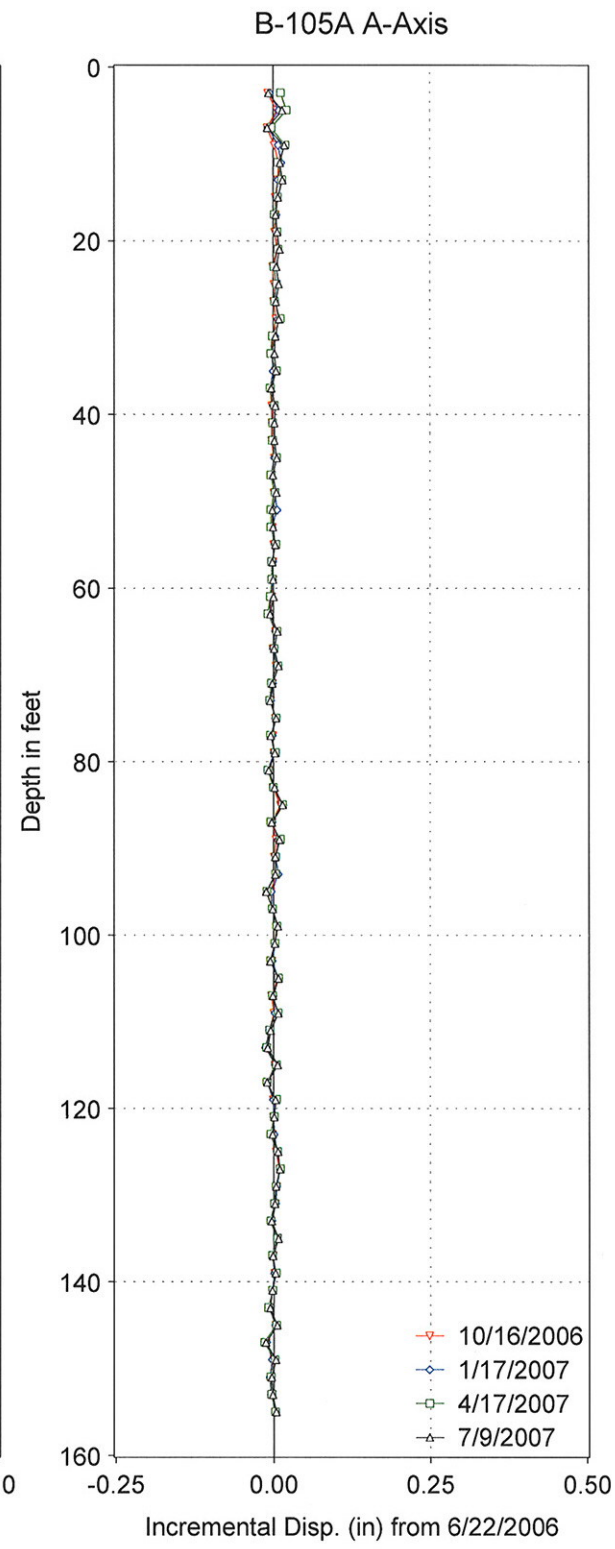

B-303 Time-Displacement A-Axis
47-51 feet
55-57 feet
95-99 feet
Displacement (in)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year

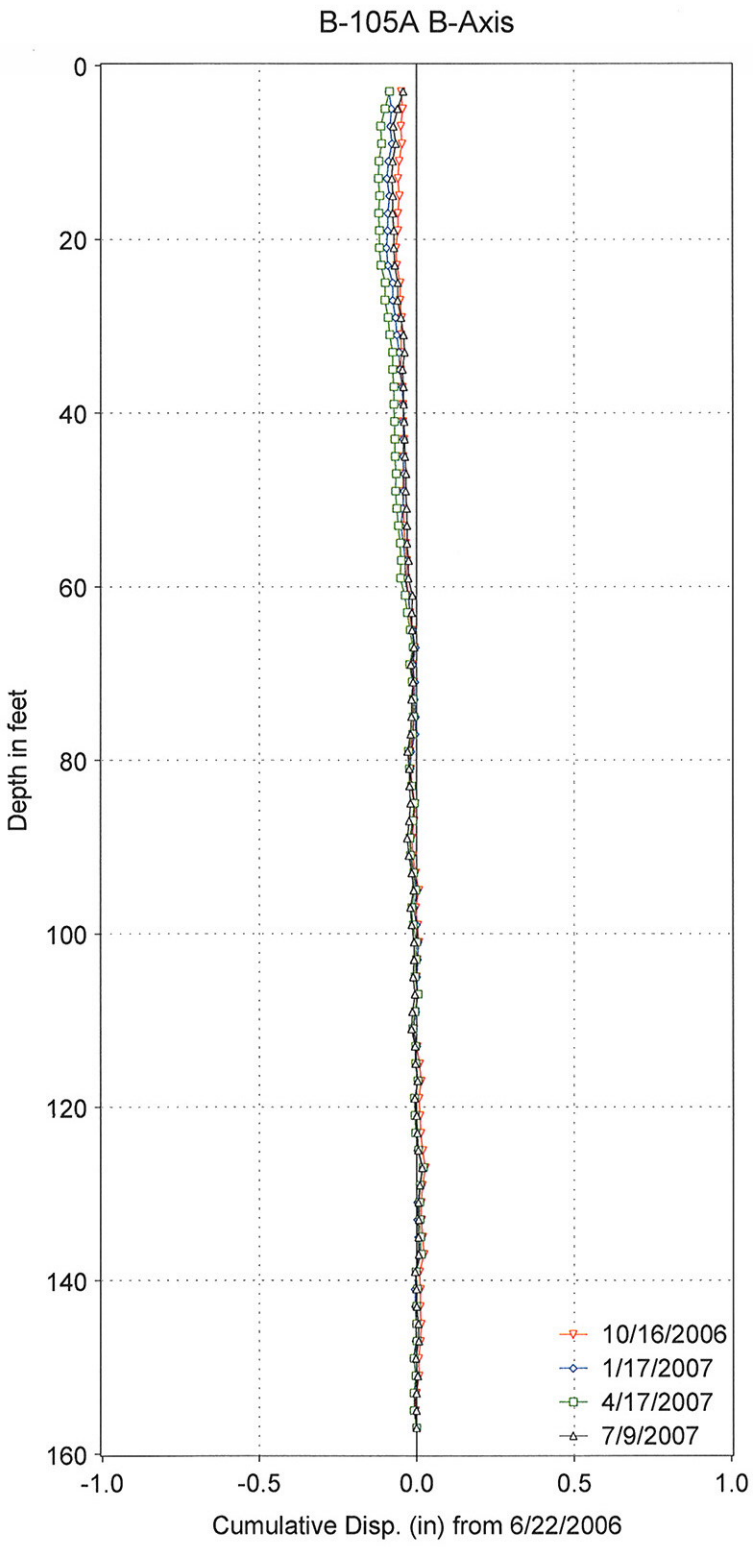
PLATE 21

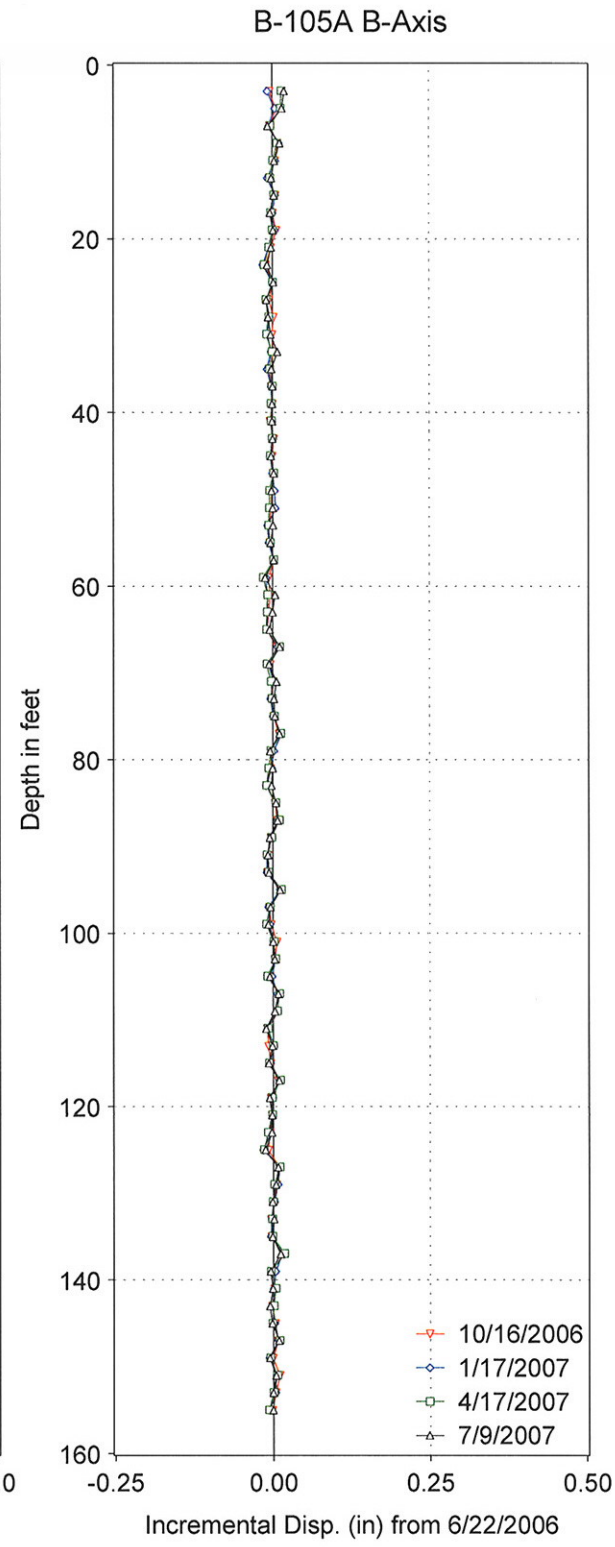




B-105A
-Includes readings from the last four quarters.

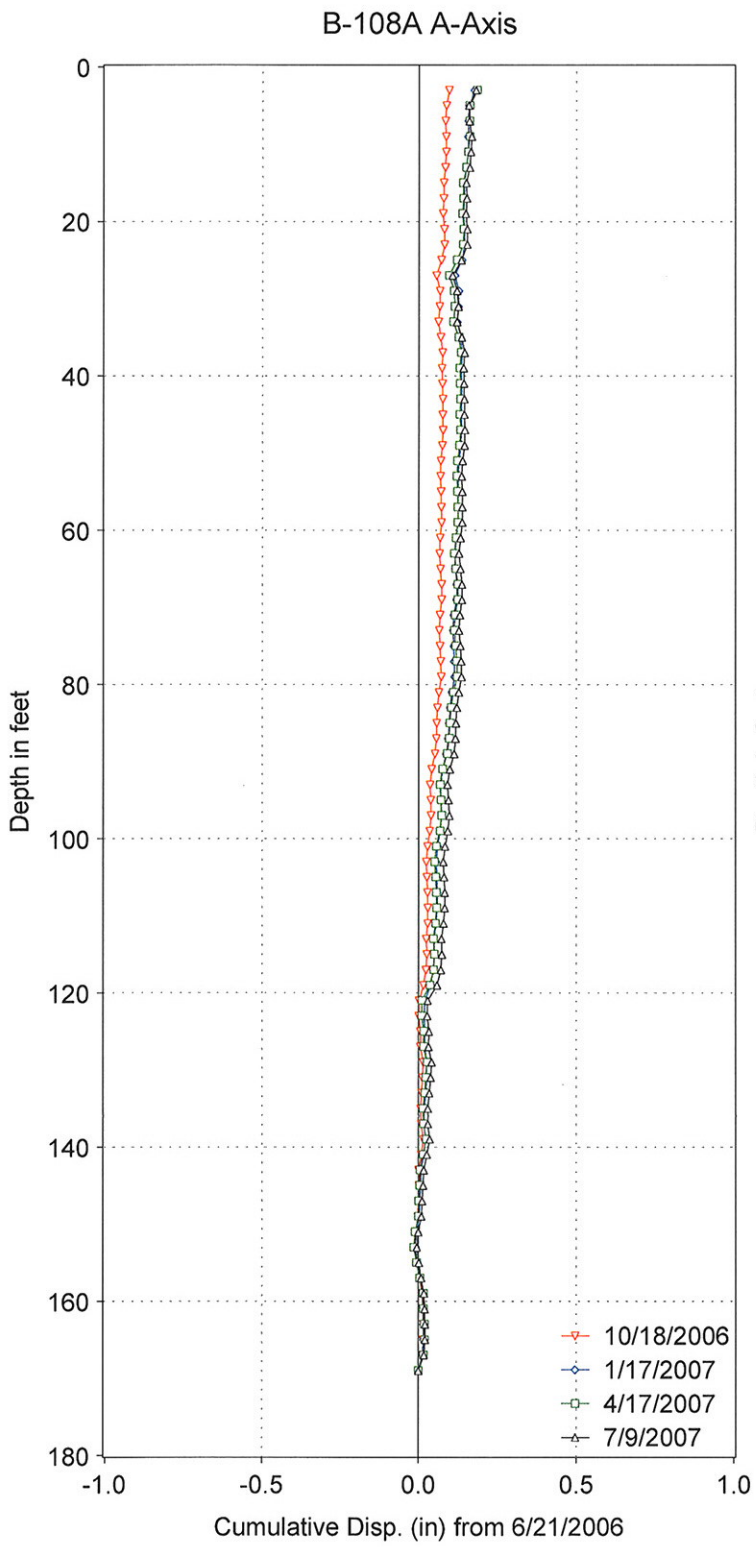
PLATE 22

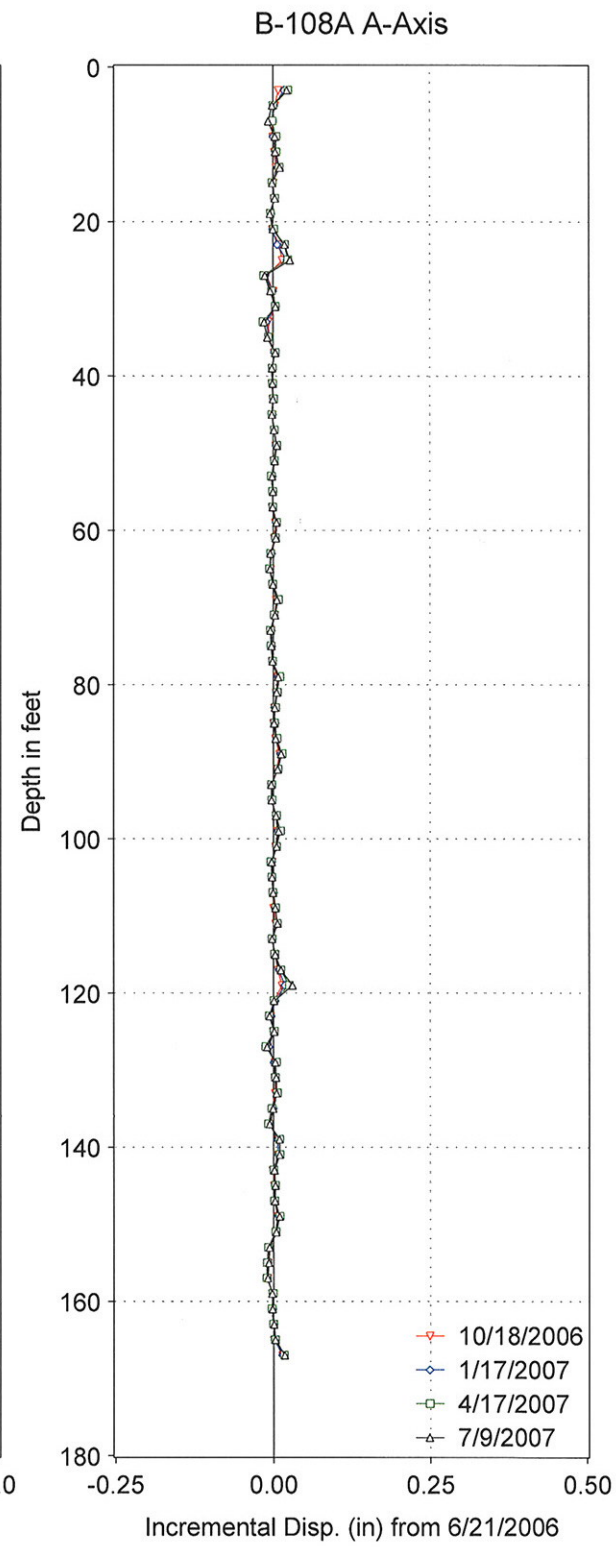




B-105A
-Includes readings from the last four quarters.

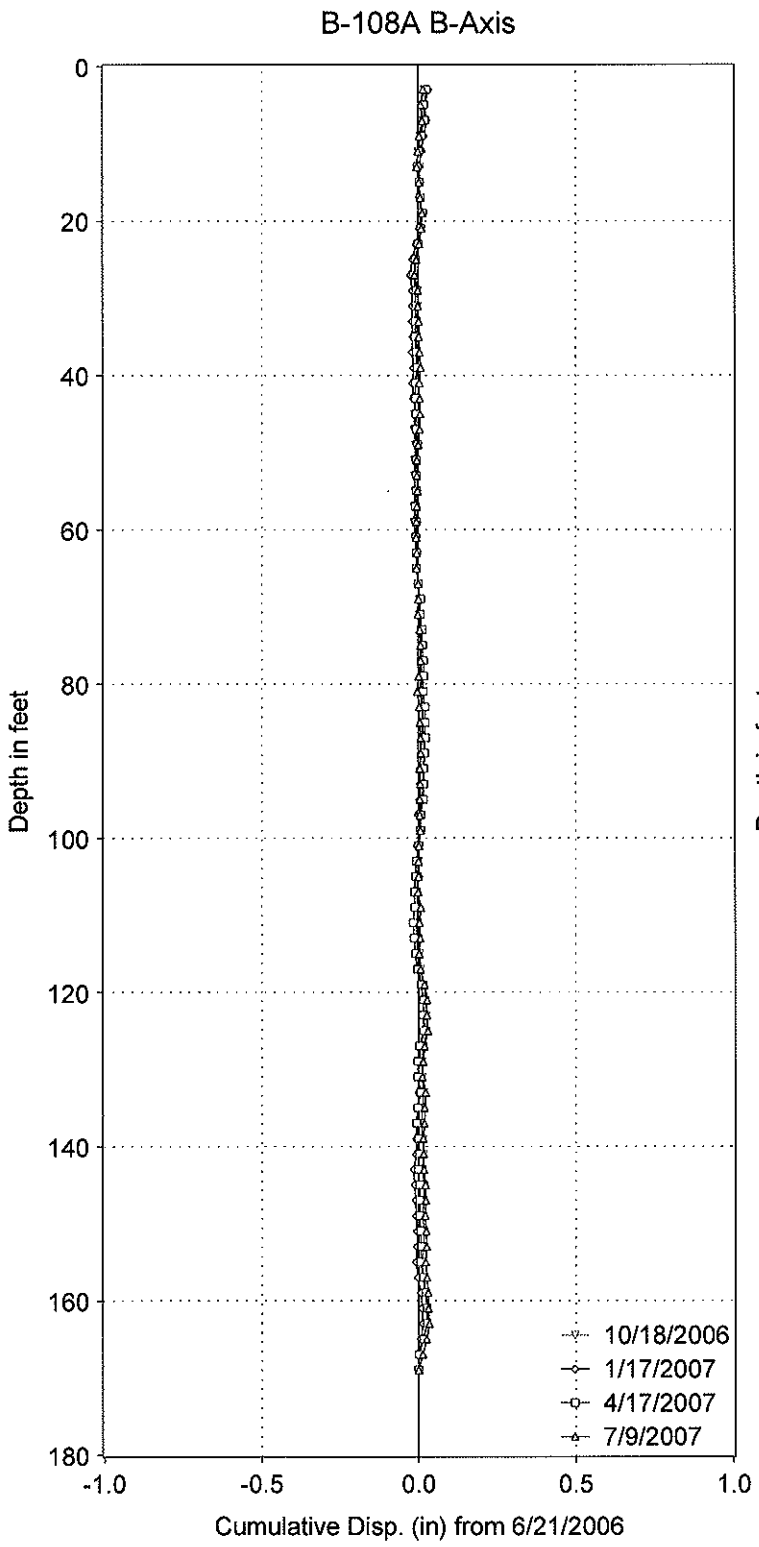
PLATE 23

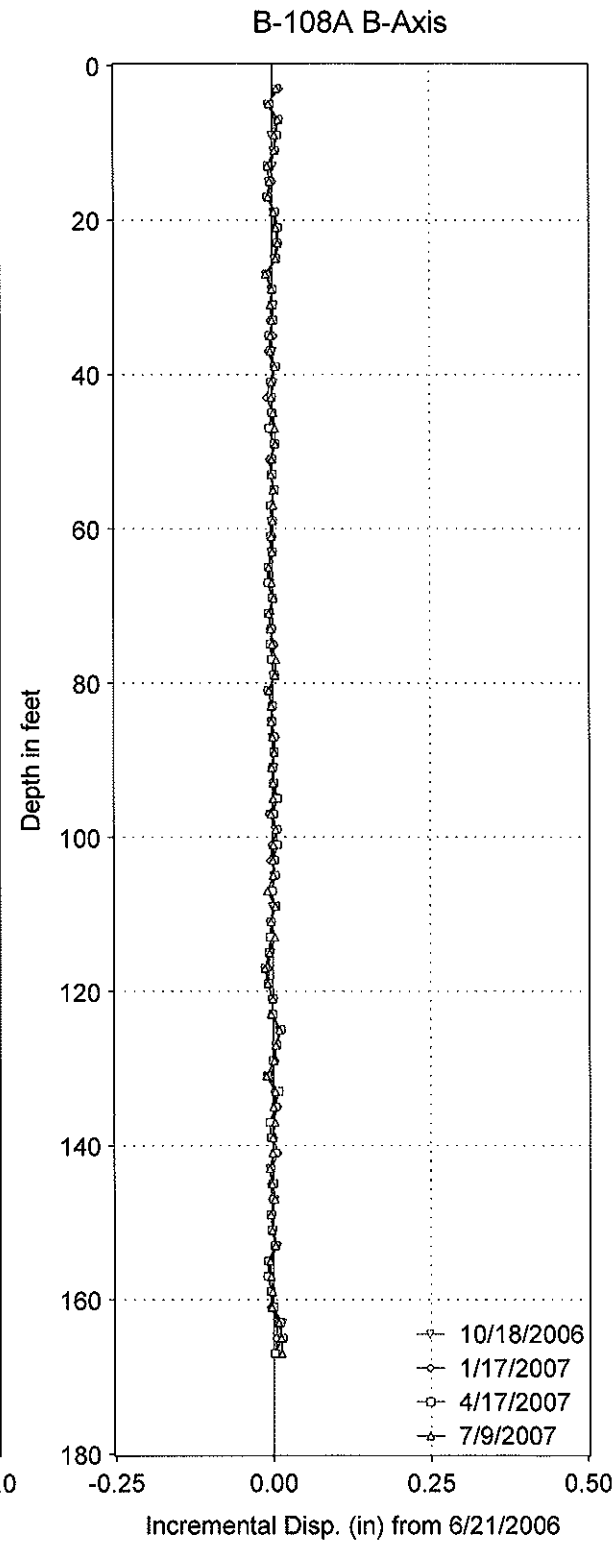




B-108A
-Includes readings from the last four quarters.

PLATE 24





B-108A
-Includes readings from the last four quarters.

PLATE 25

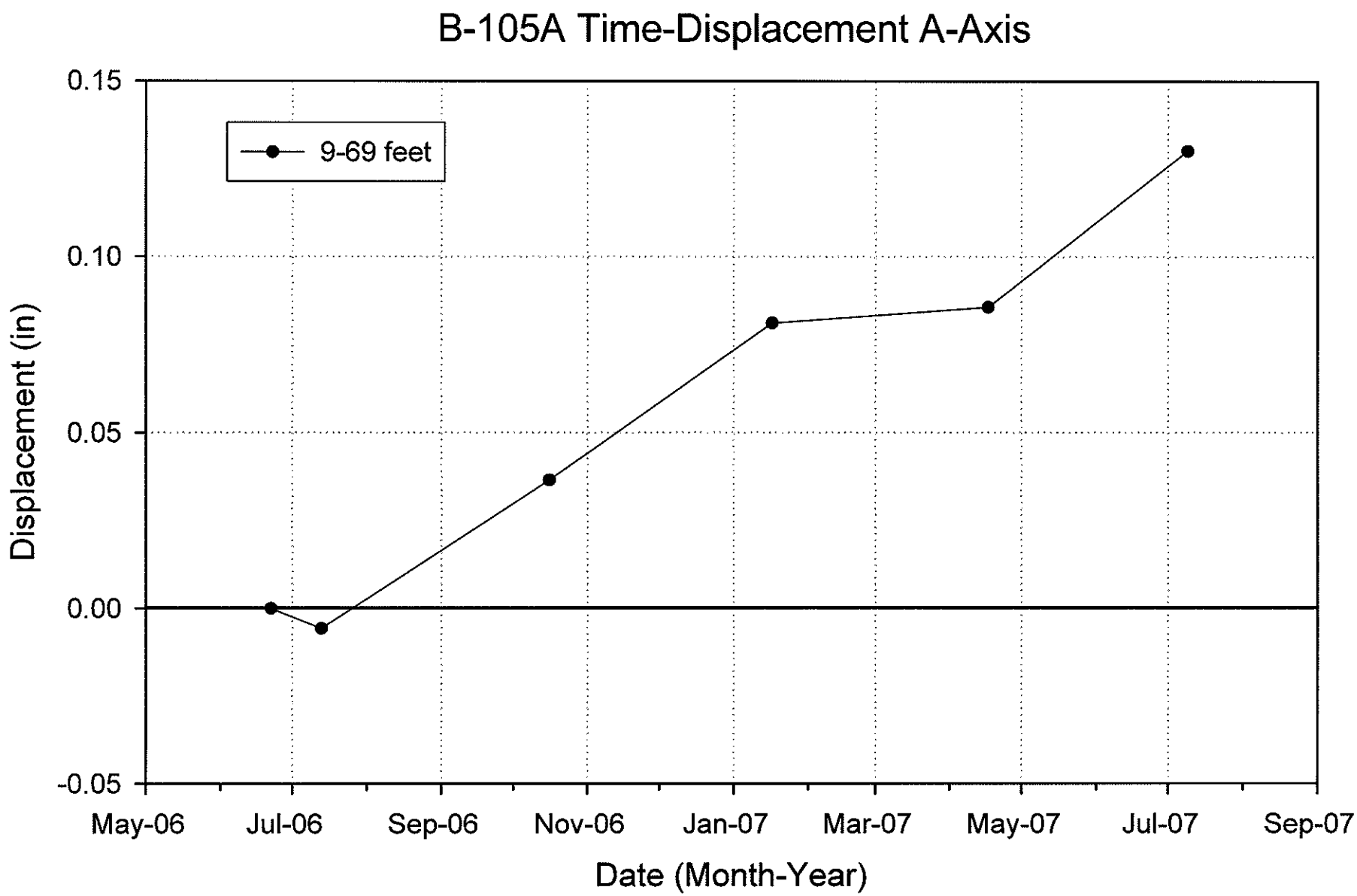

B-105A Time-Displacement A-Axis
9-69 feet
0.15
0.10
0.05
0.00
-0.05
Displacement (in)
May-06
Jul-06
Sep-06
Nov-06
Jan-07
Mar-07
May-07
Jul-07
Sep-07
Date (Month-Year)

PLATE 26

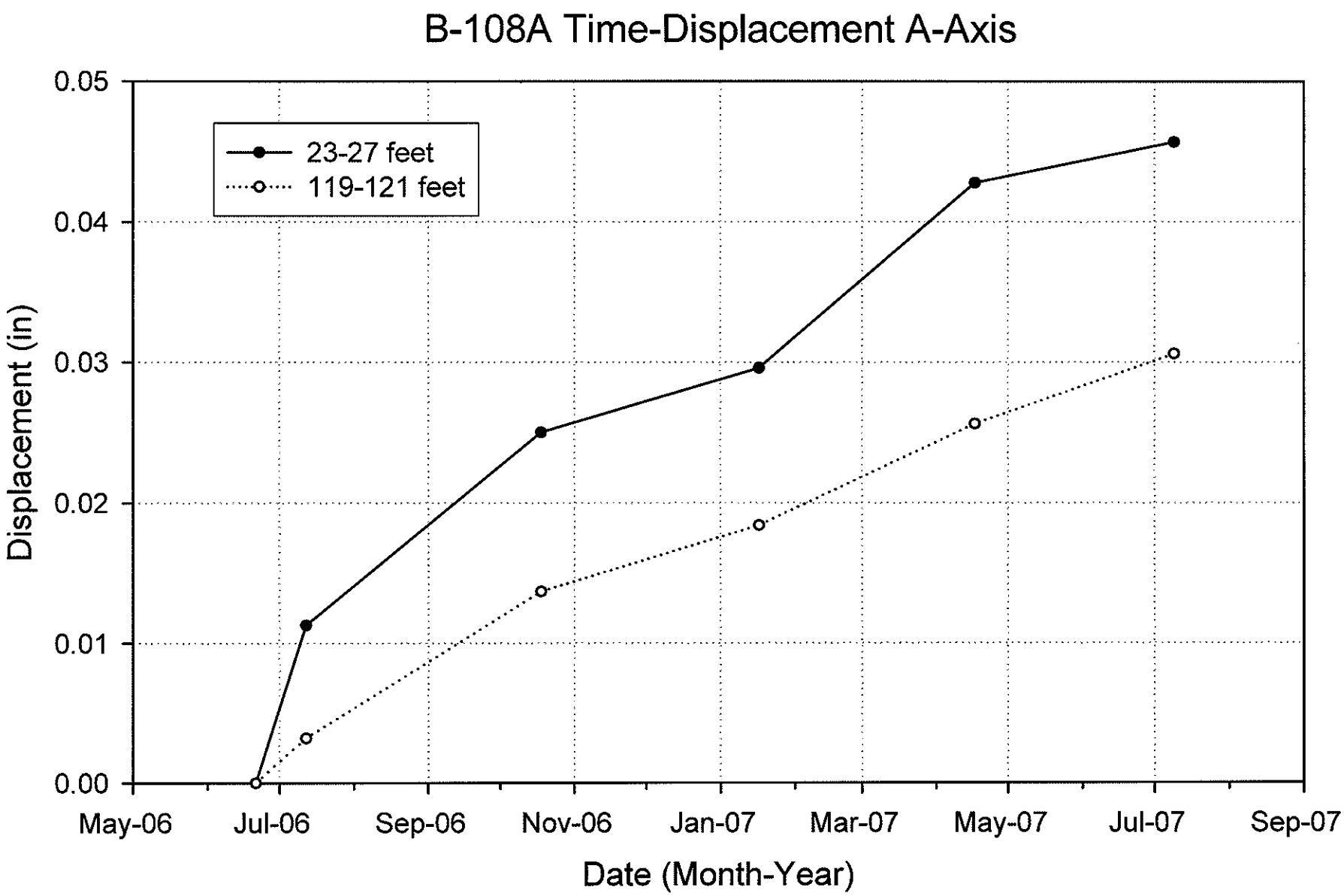
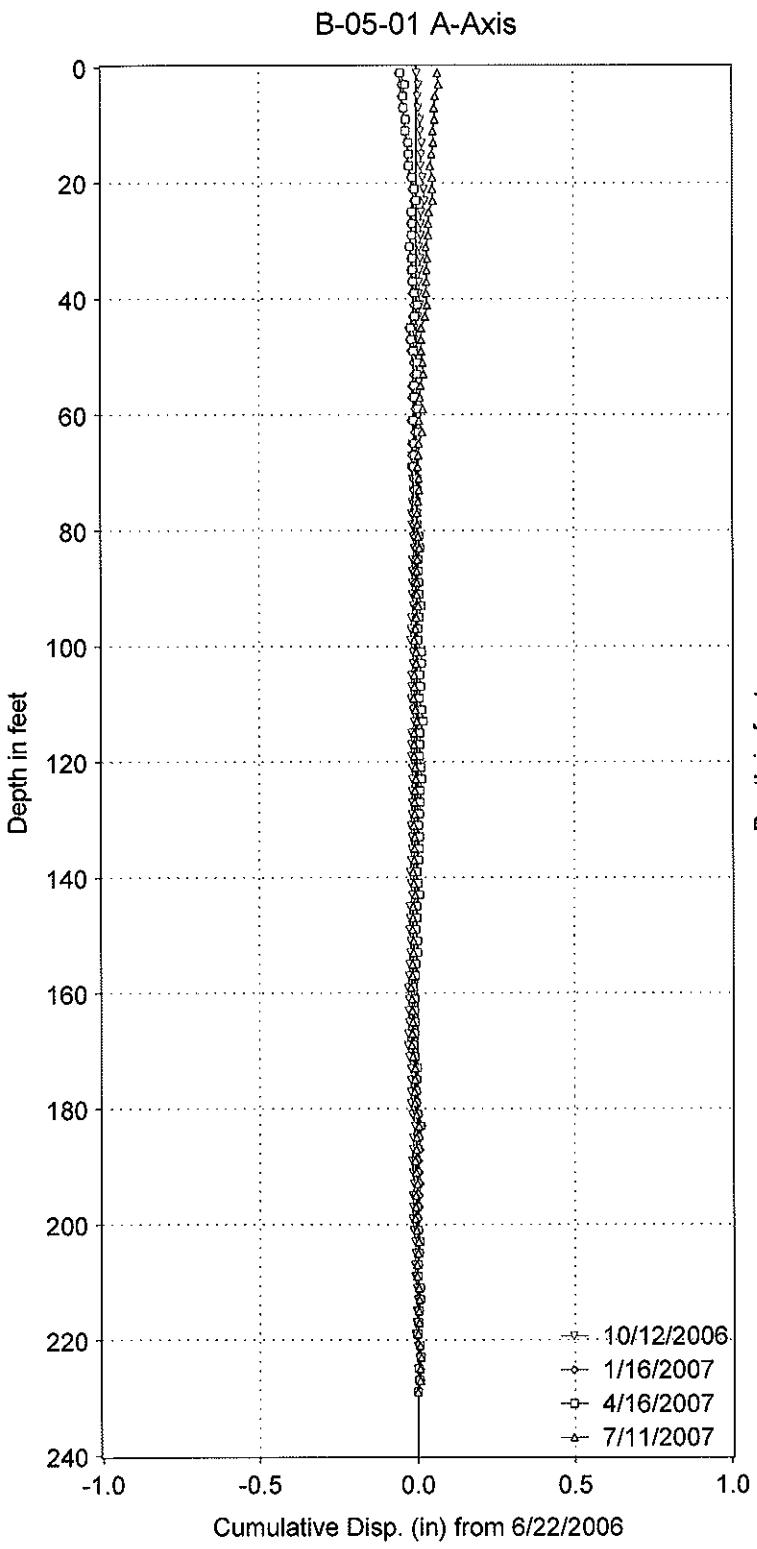
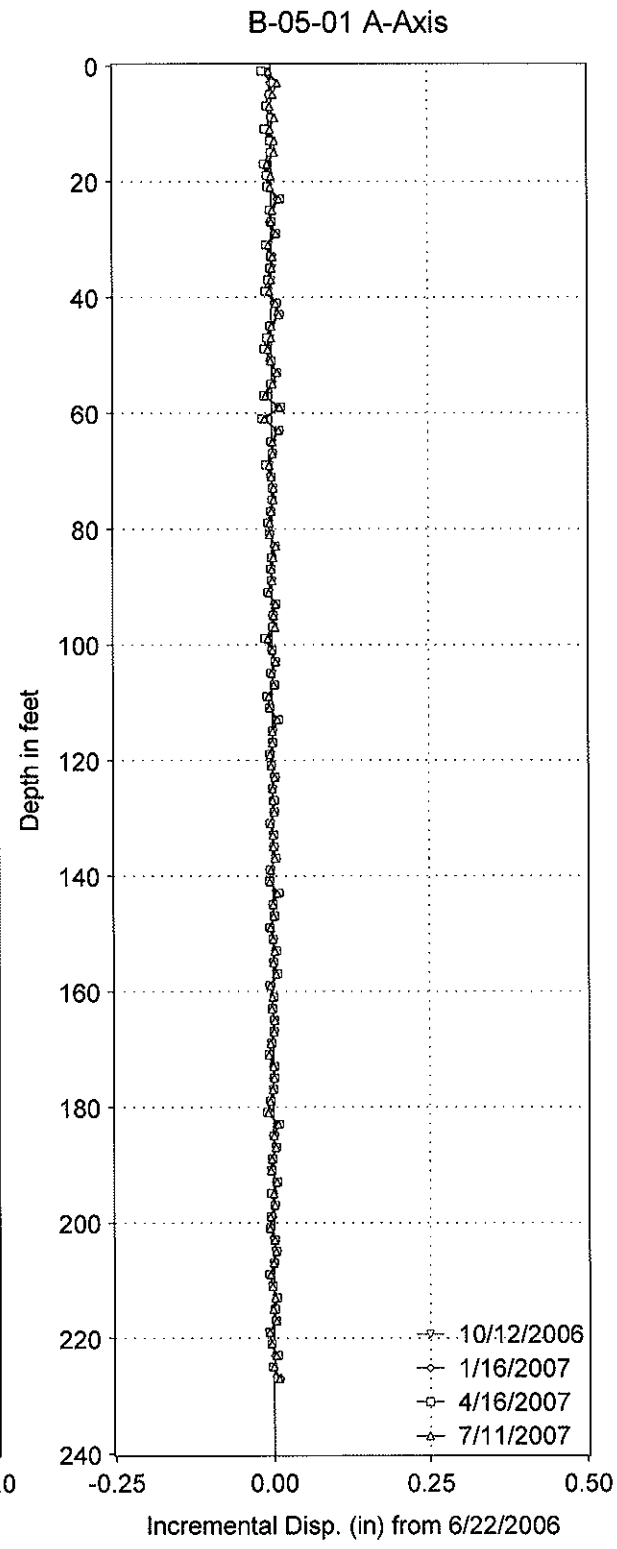

B-108A Time-Displacement A-Axis
23-27 feet
119-121 feet
Displacement (in)
0.05
0.04
0.03
0.02
0.01
0.00
May-06
Jul-06
Sep-06
Nov-06
Jan-07
Mar-07
May-07
Jul-07
Sep-07
Date (Month-Year)

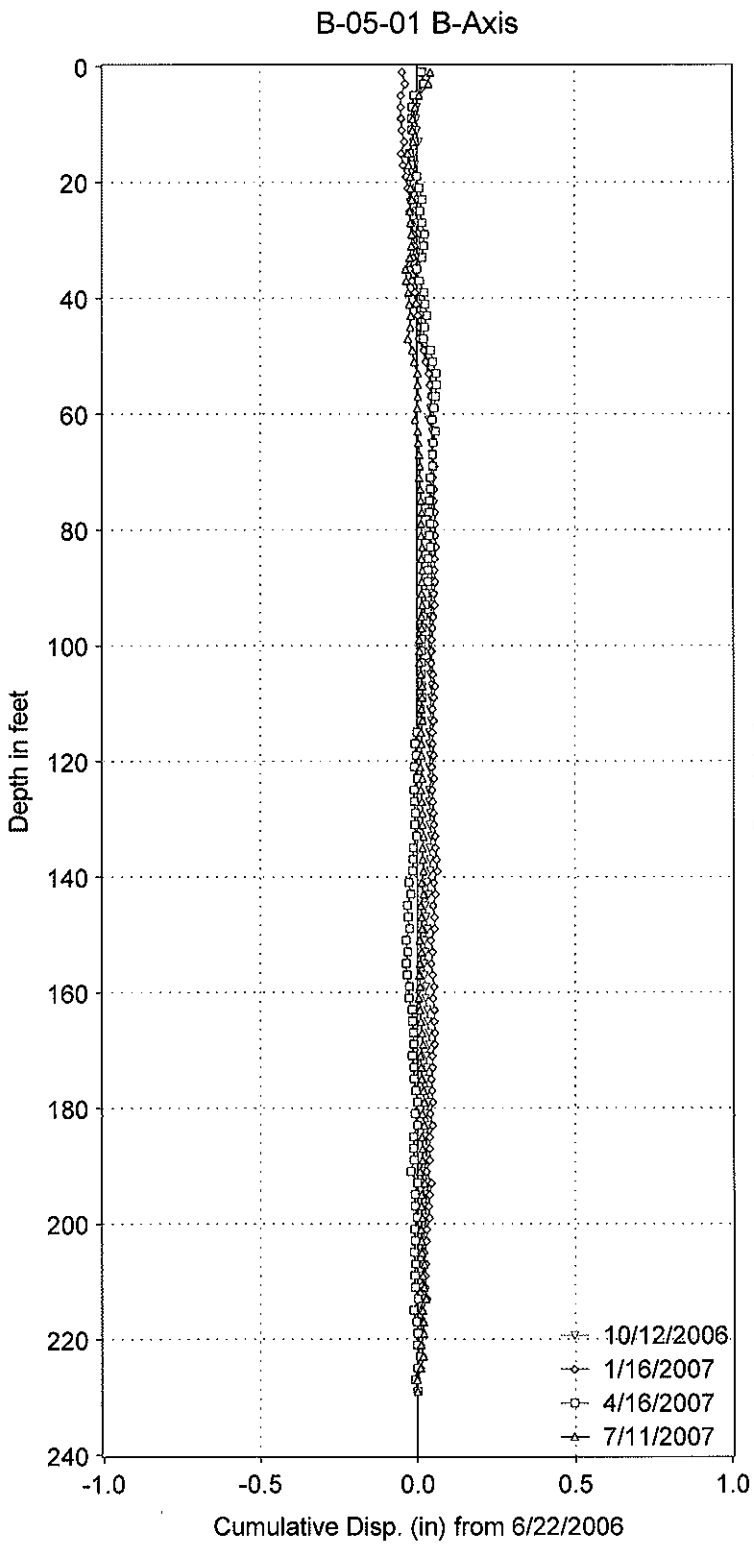
PLATE 27

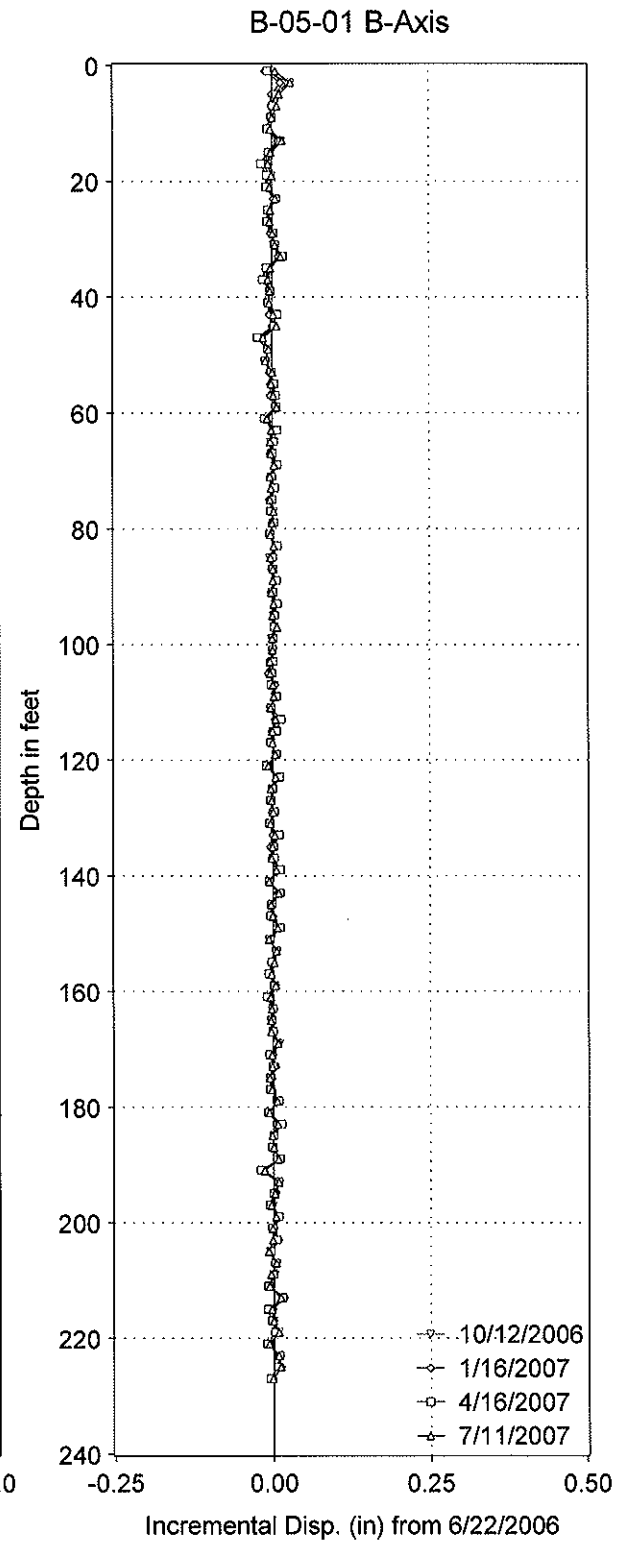




B-05-01
-Includes readings from the last four quarters.

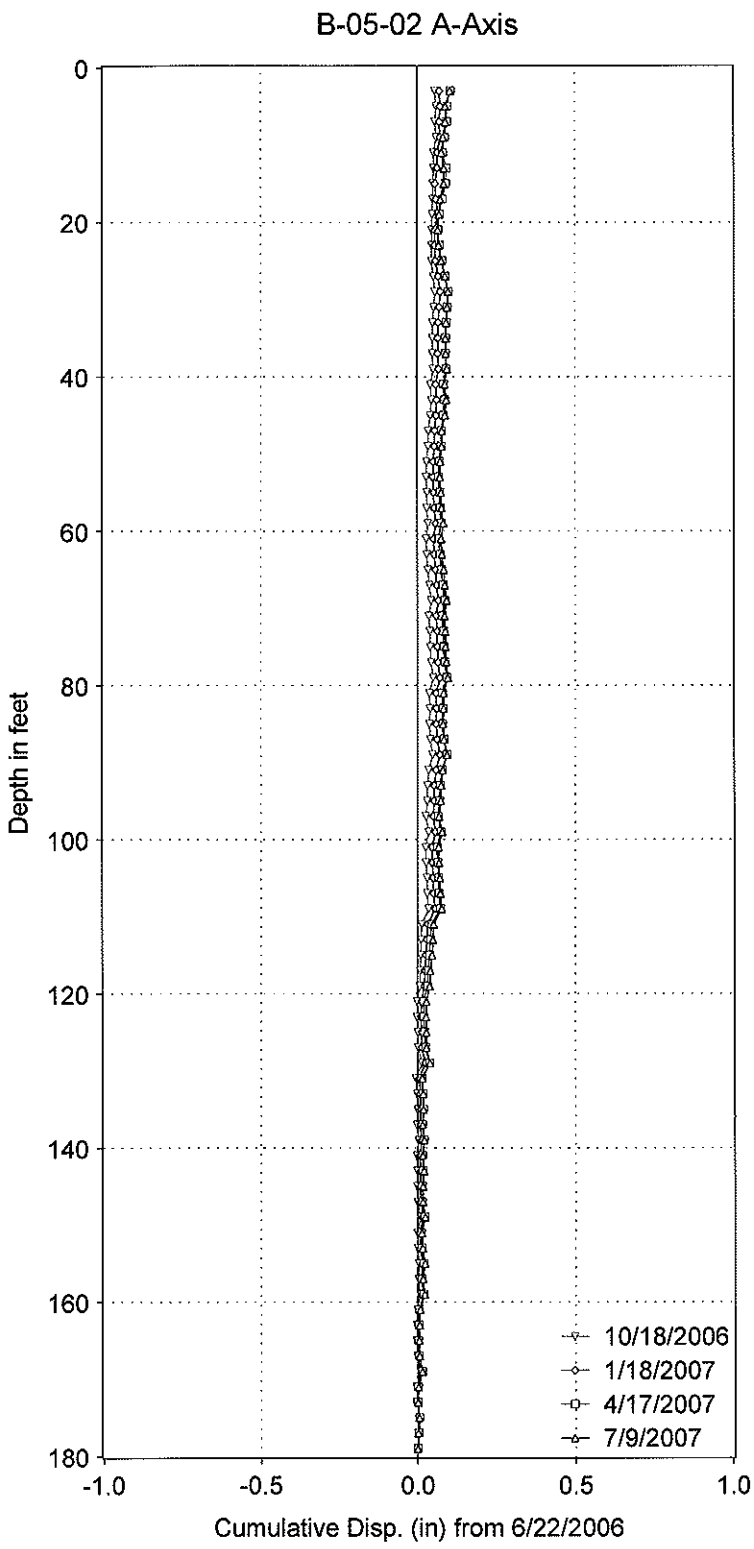
PLATE 28

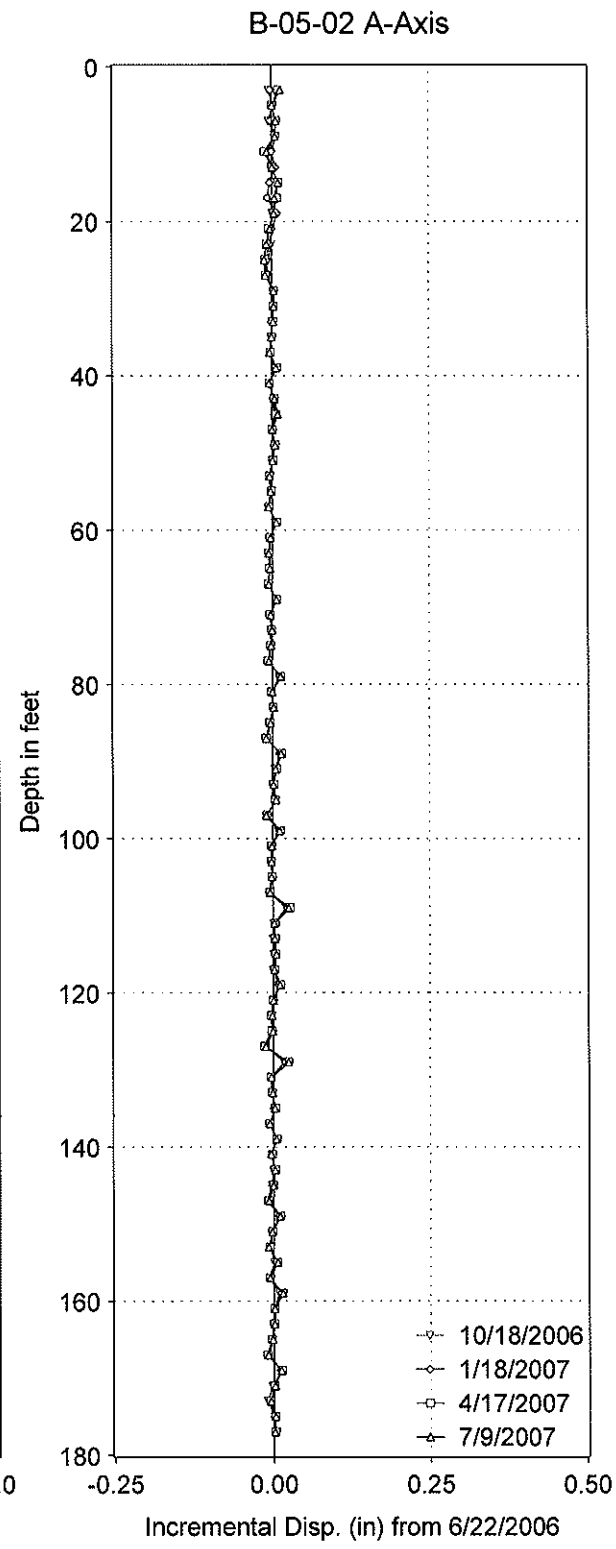




B-05-01
-Includes readings from the last four quarters.

PLATE 29

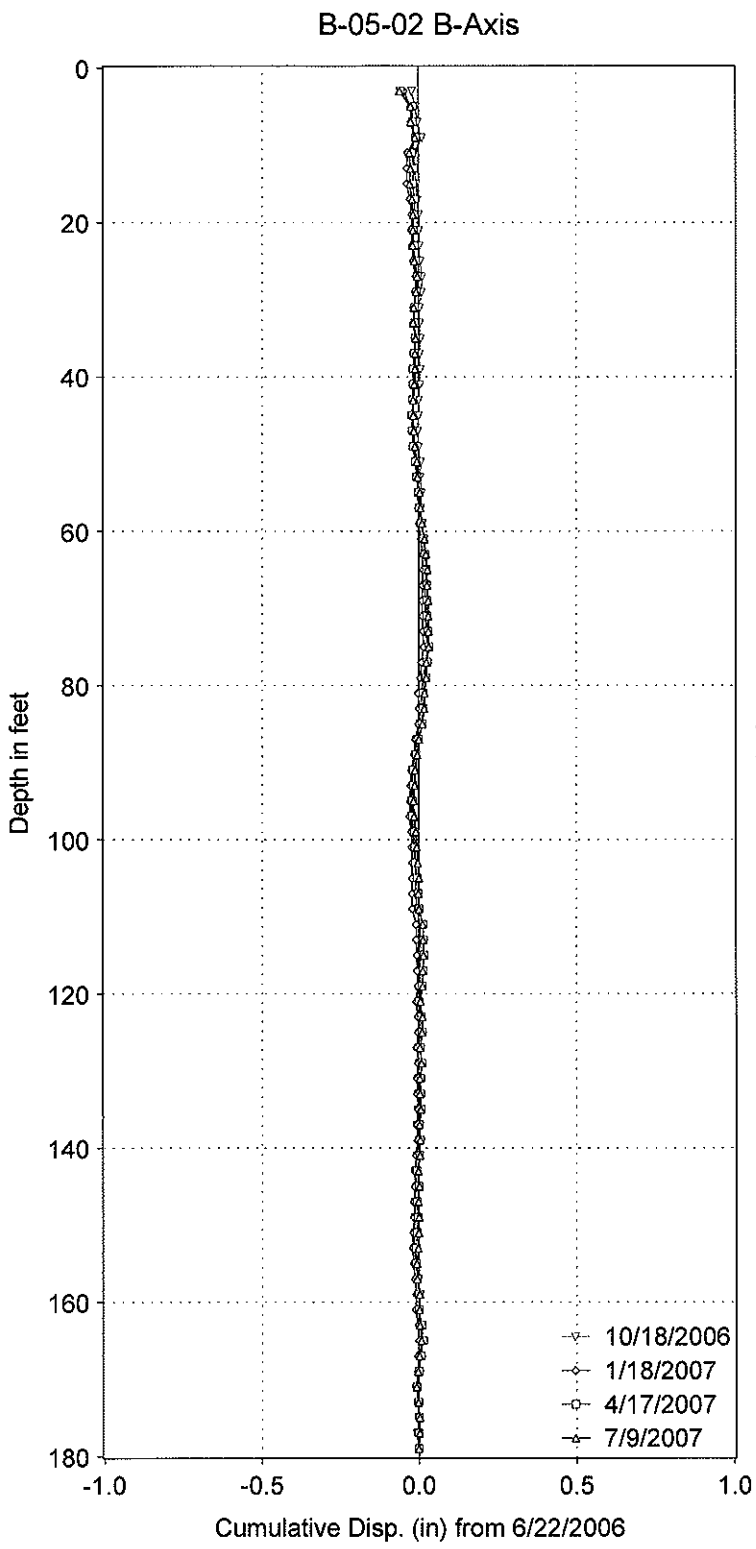


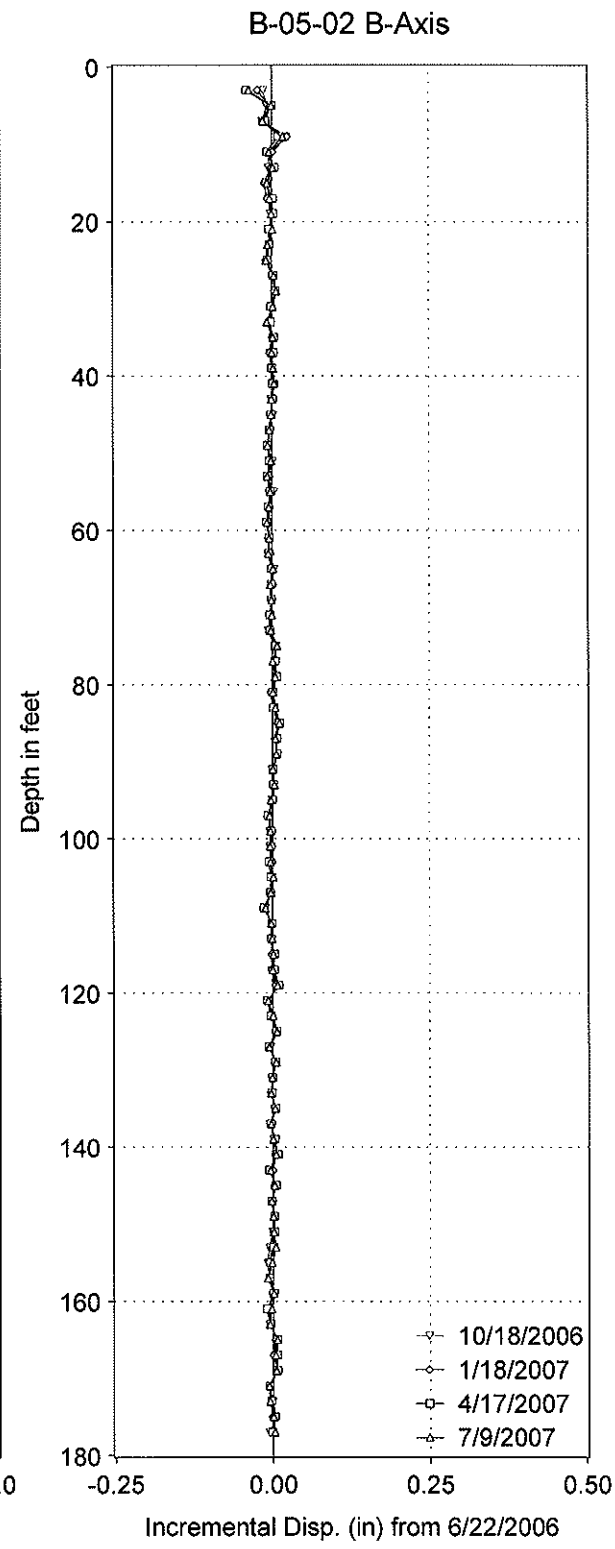


B-05-02

-Includes readings from the last four quarters.

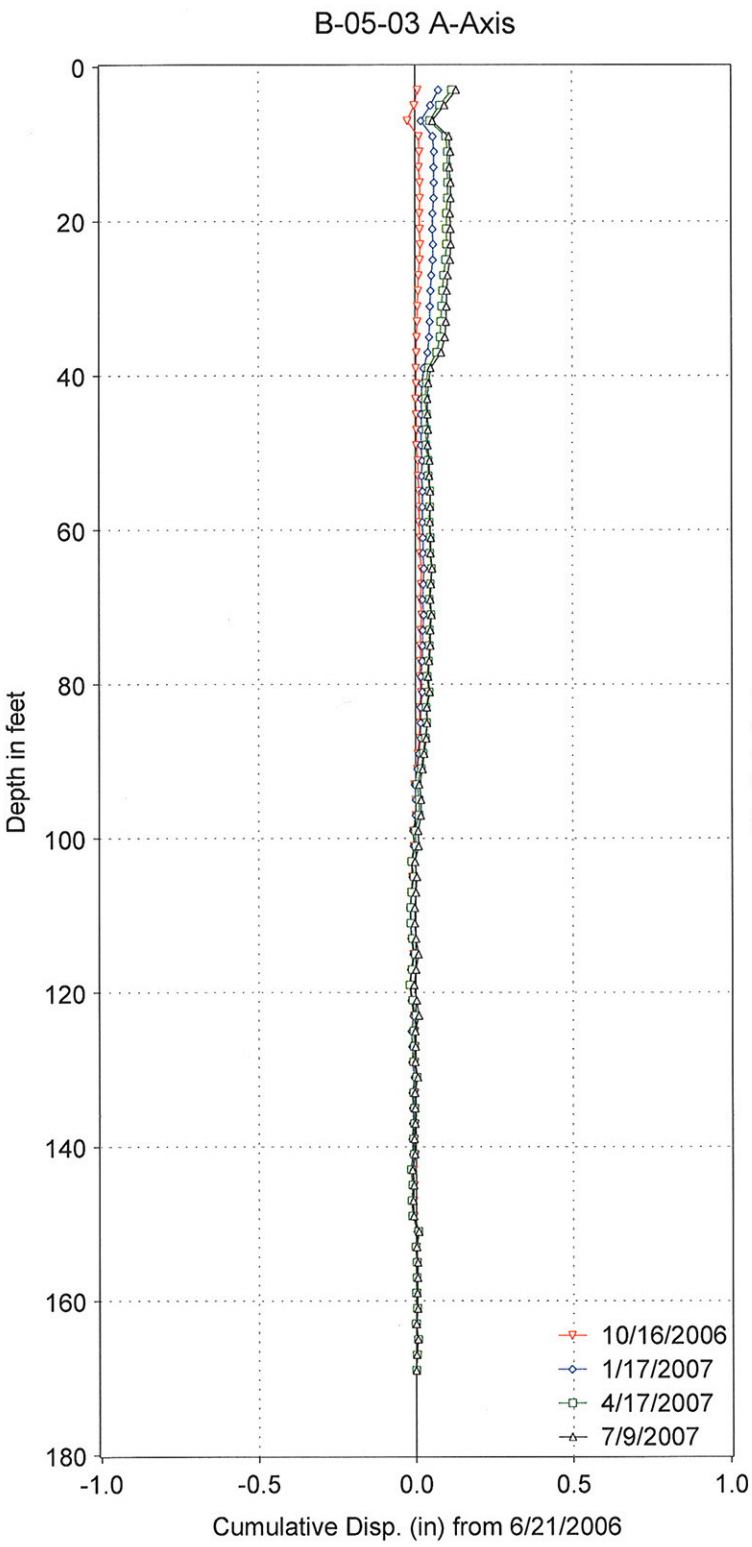
PLATE 30

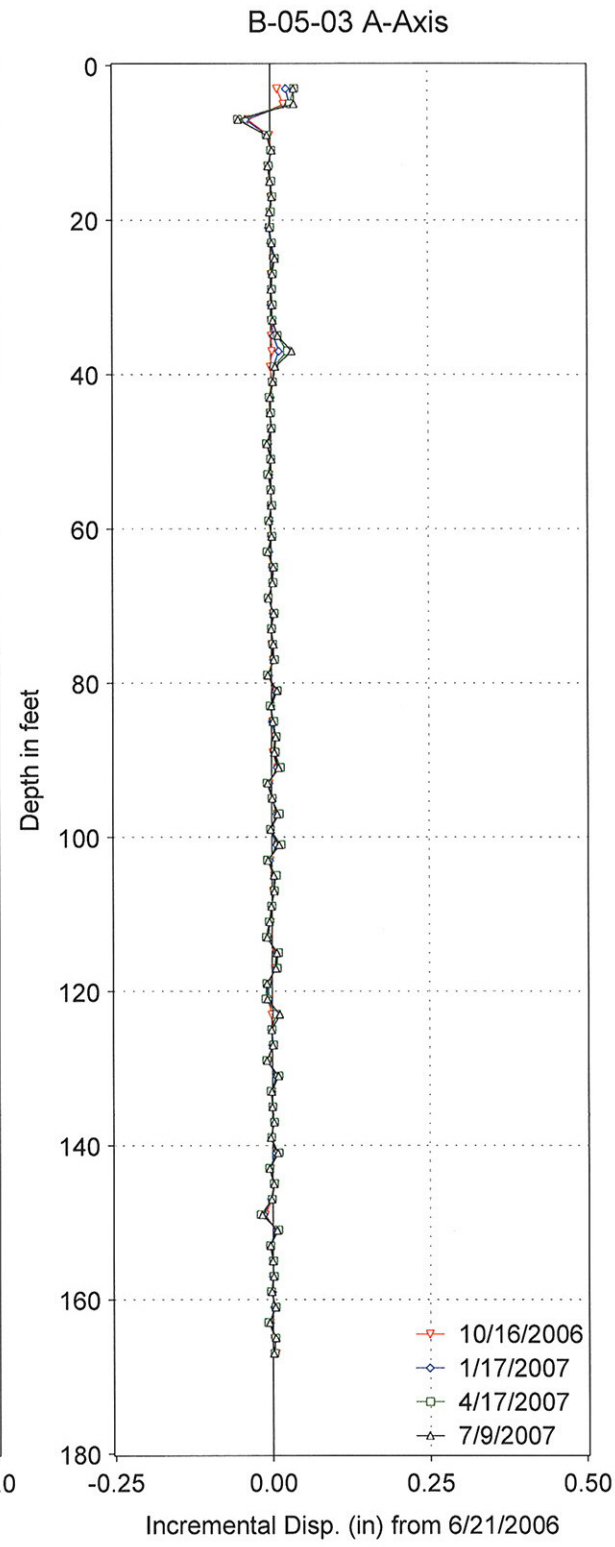




B-05-02
-Includes readings from the last four quarters.

PLATE 31

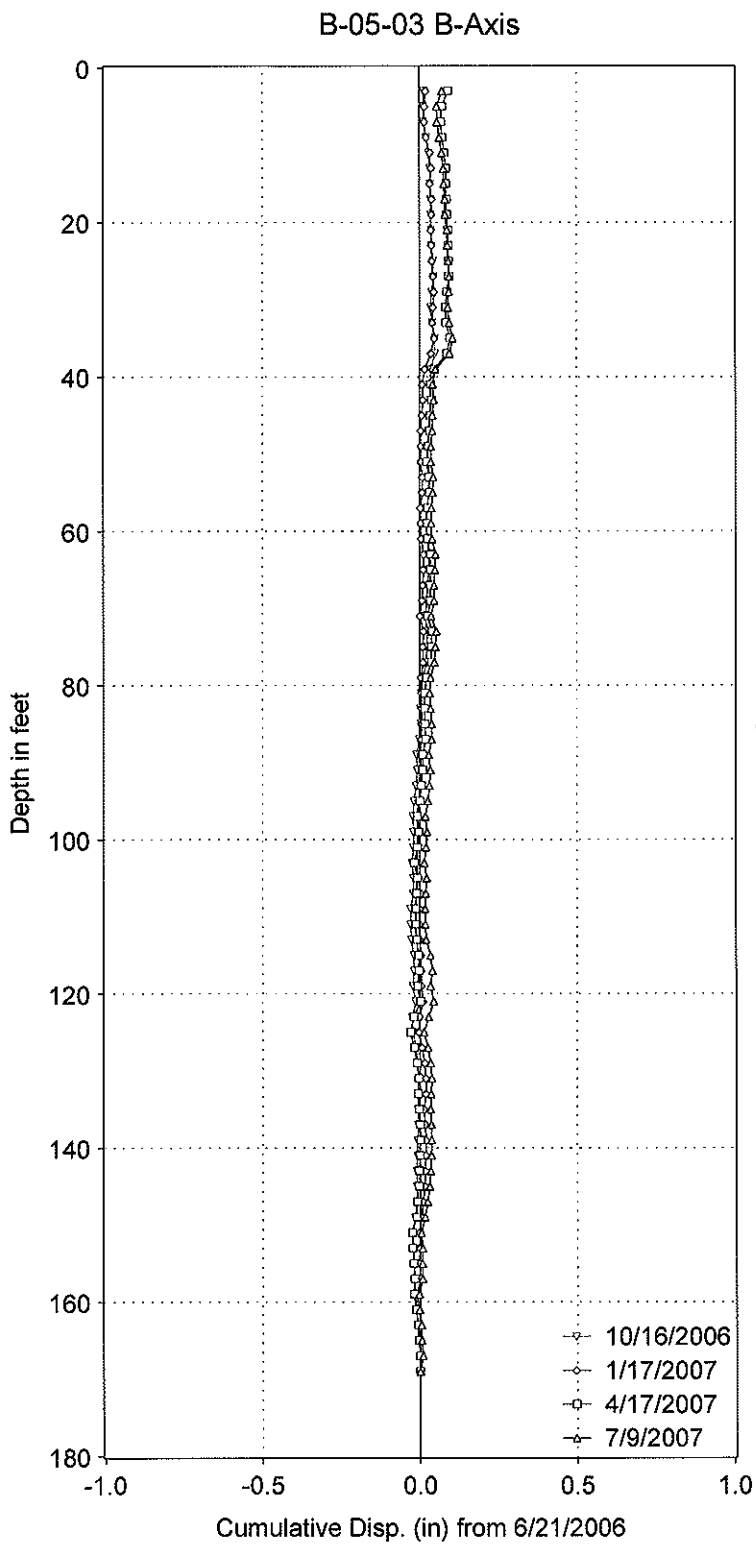


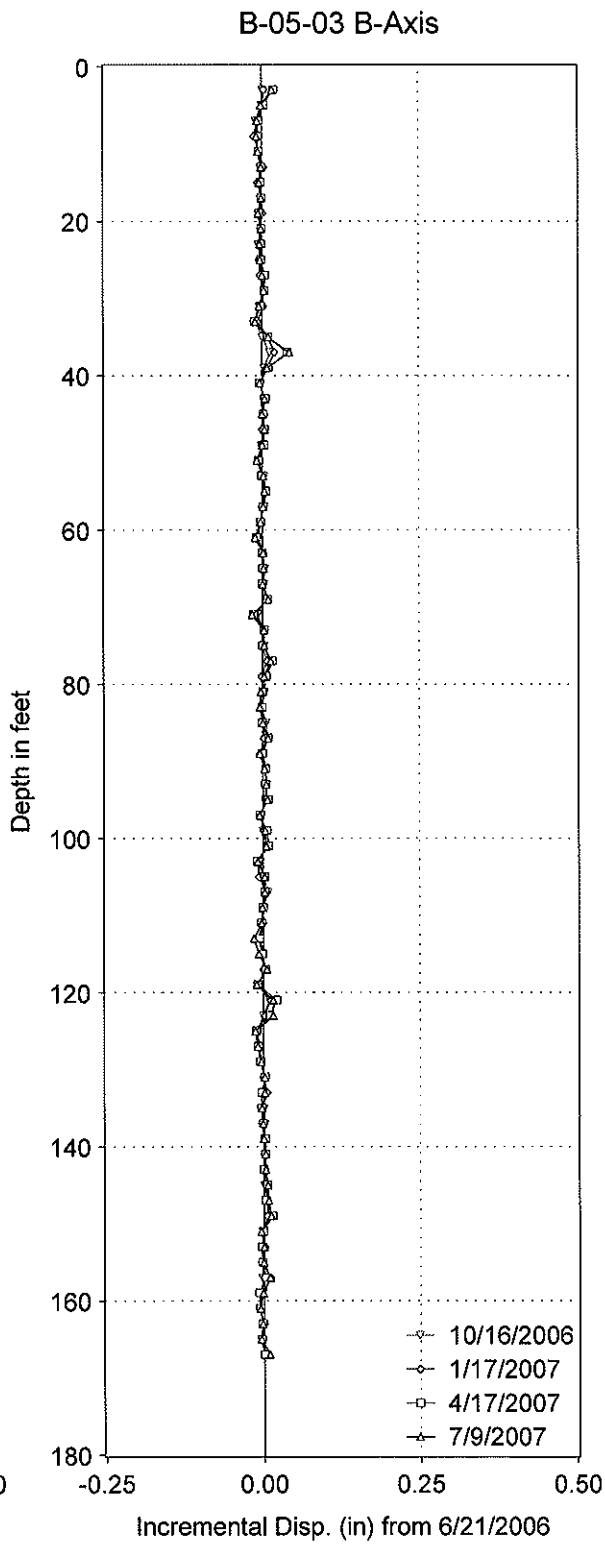


B-05-03

-Includes readings from the last four quarters.

PLATE 32

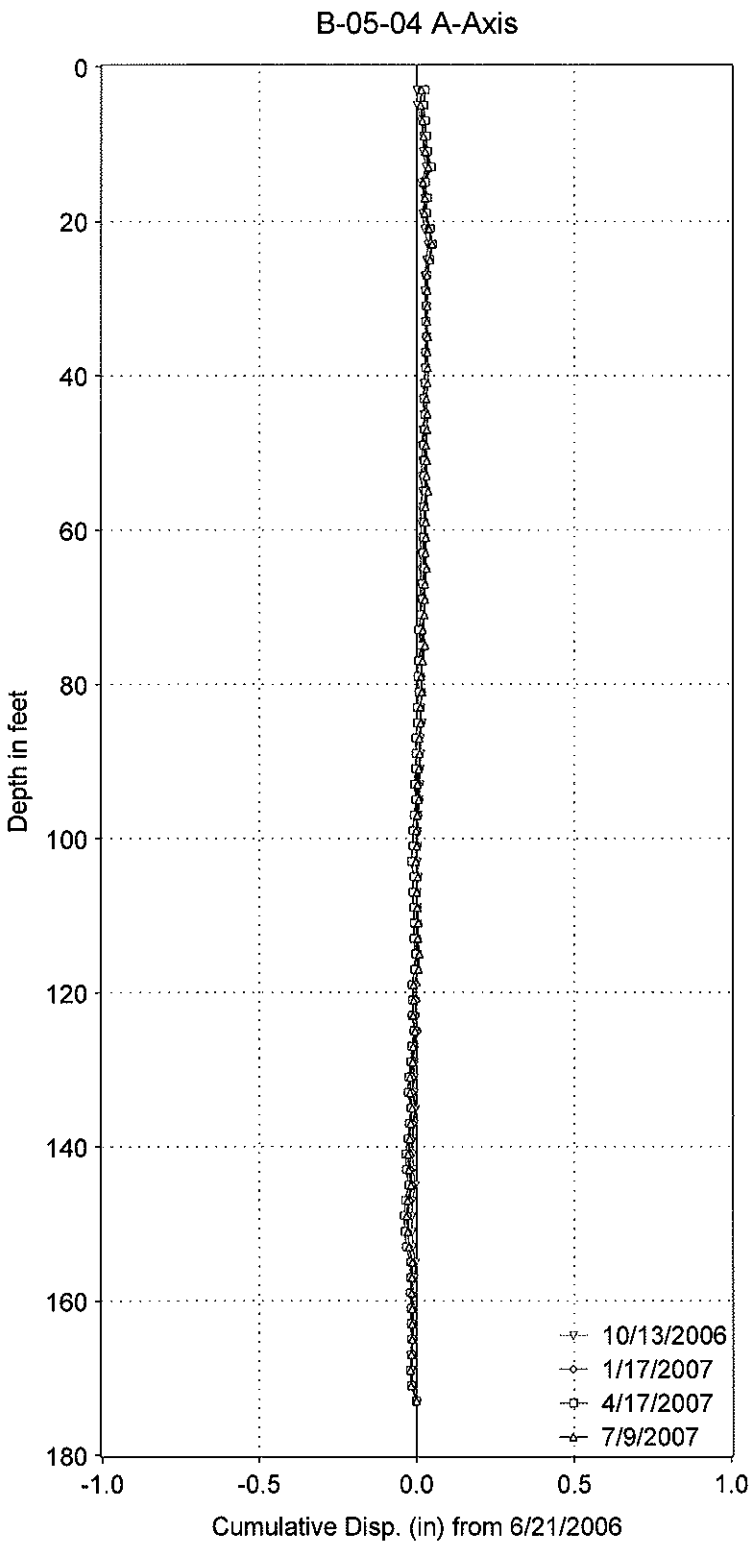


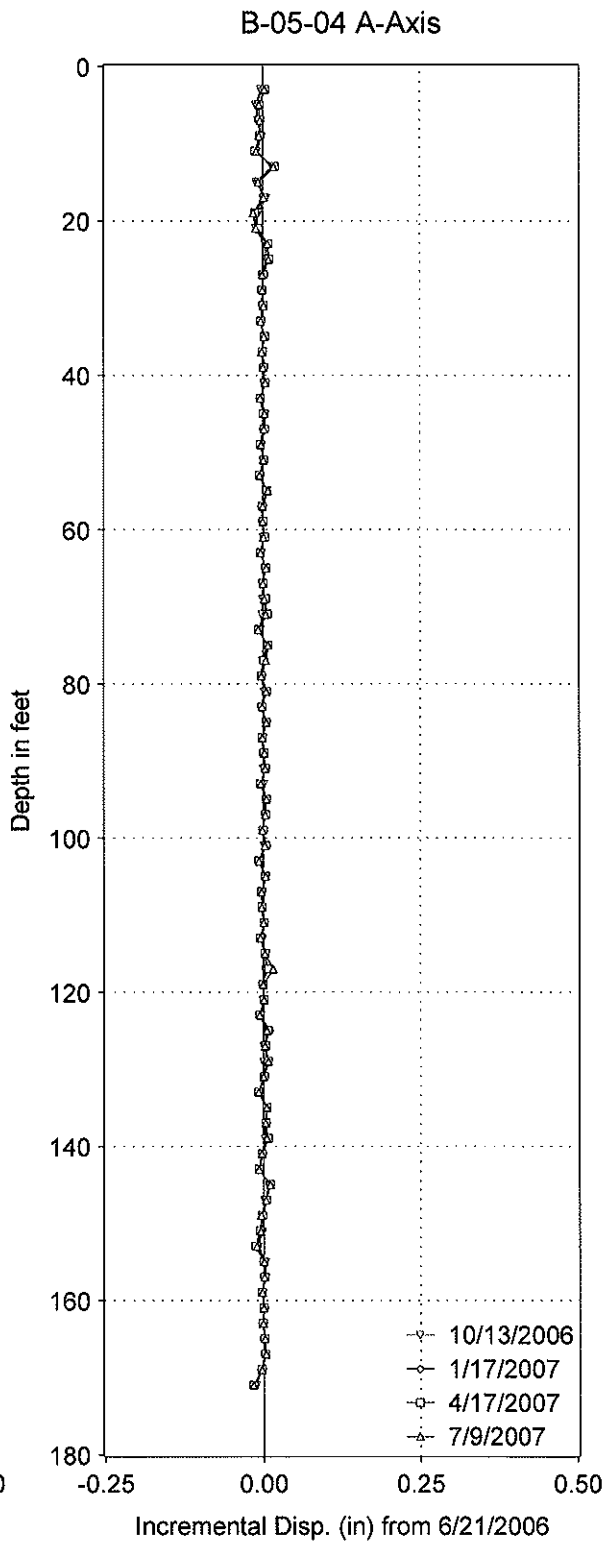


B-05-03

-Includes readings from the last four quarters.

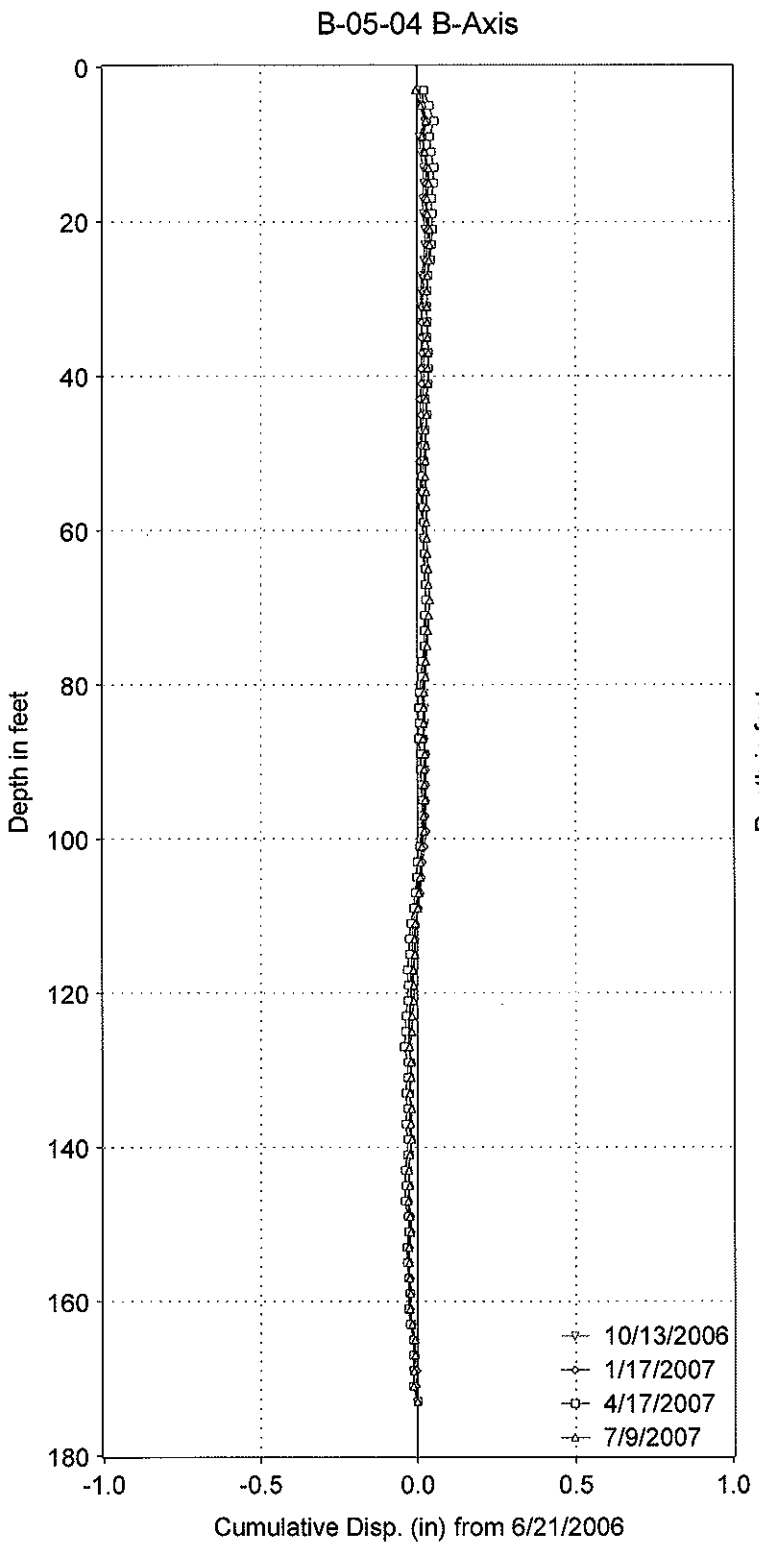
PLATE 33

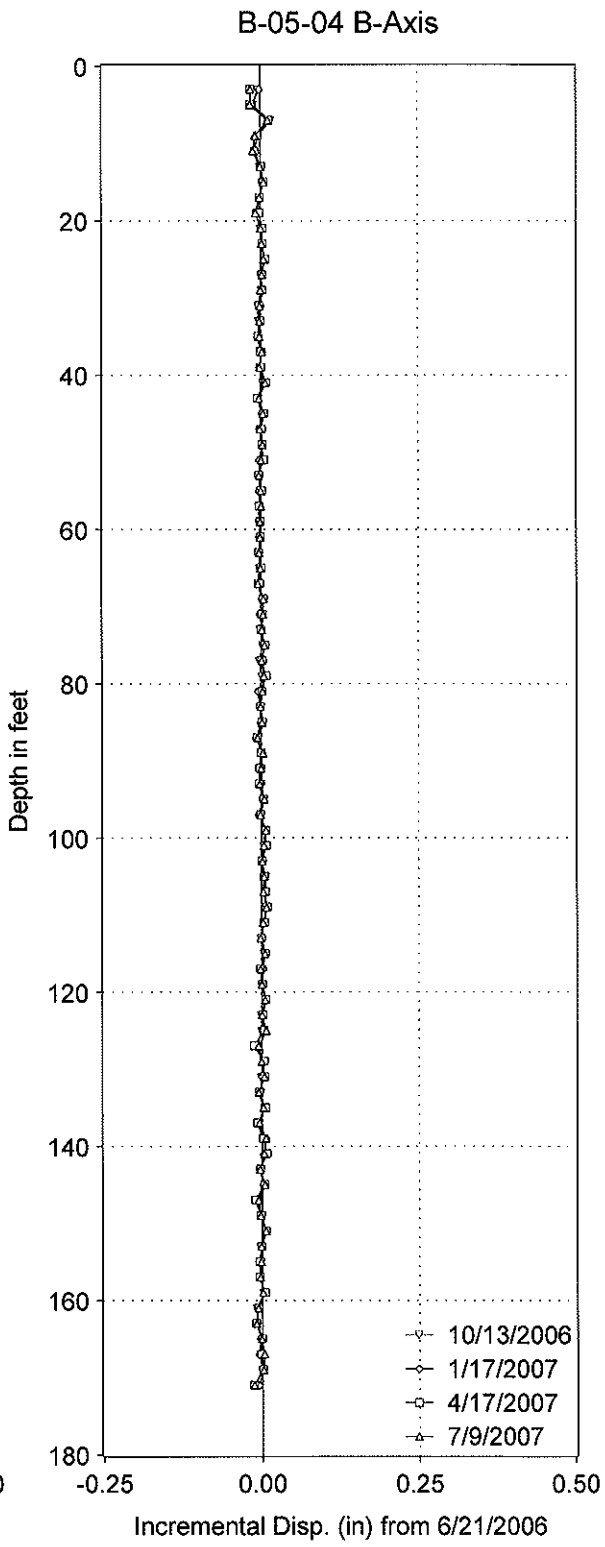




B-05-04
-Includes readings from the last four quarters.

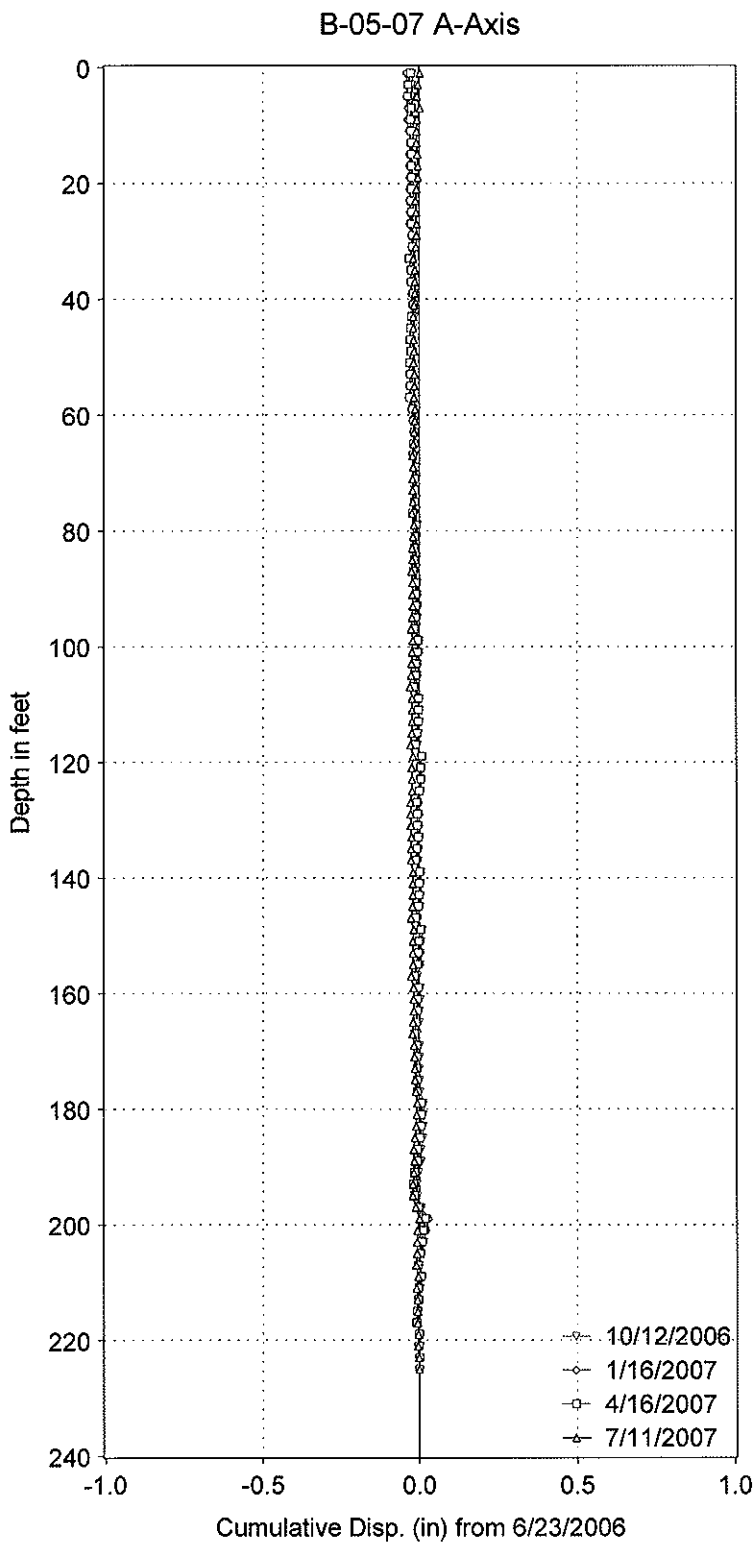
PLATE 34

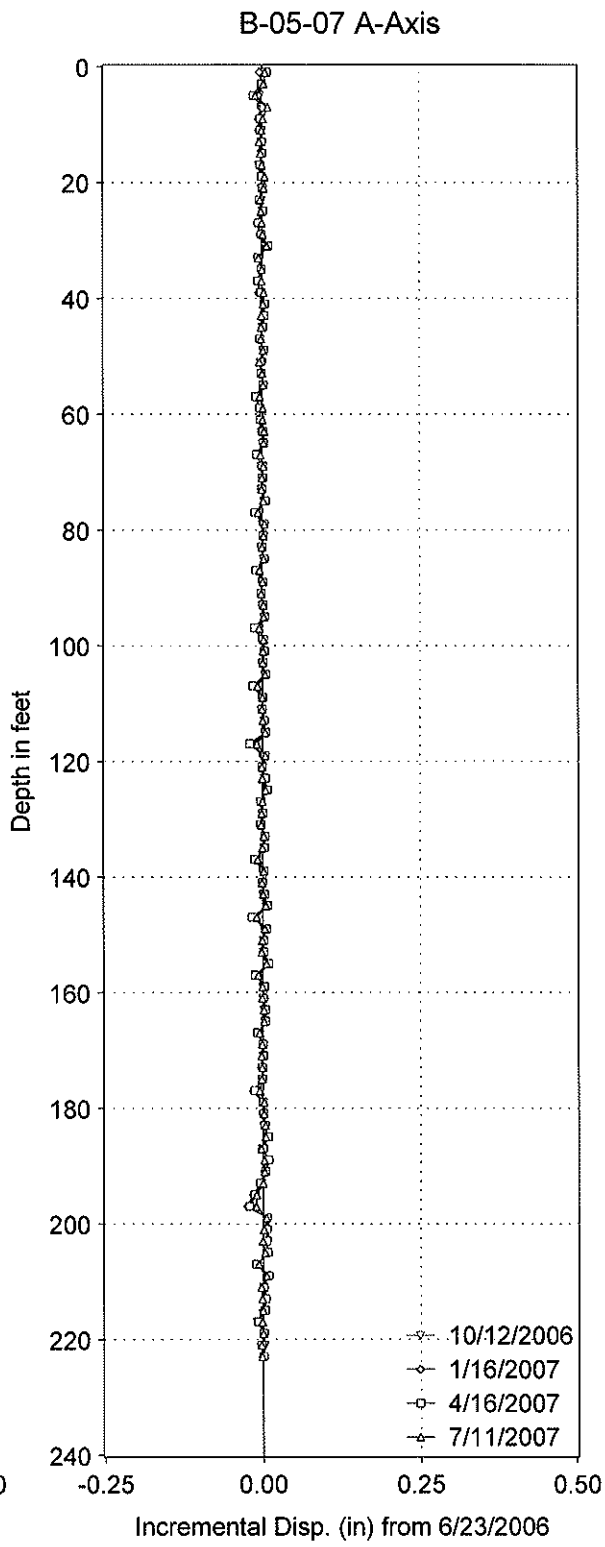




B-05-04
-Includes readings from the last four quarters.

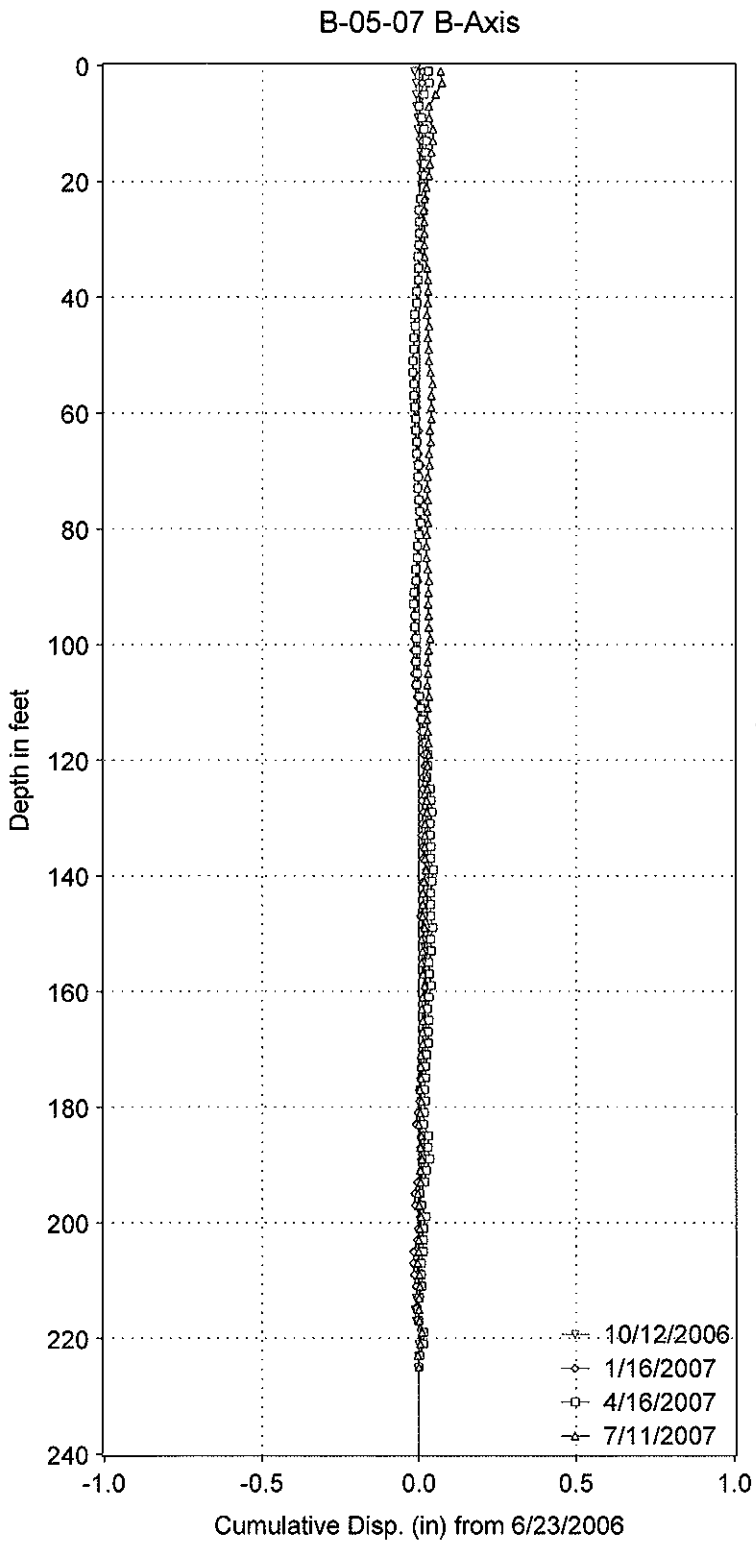
PLATE 35

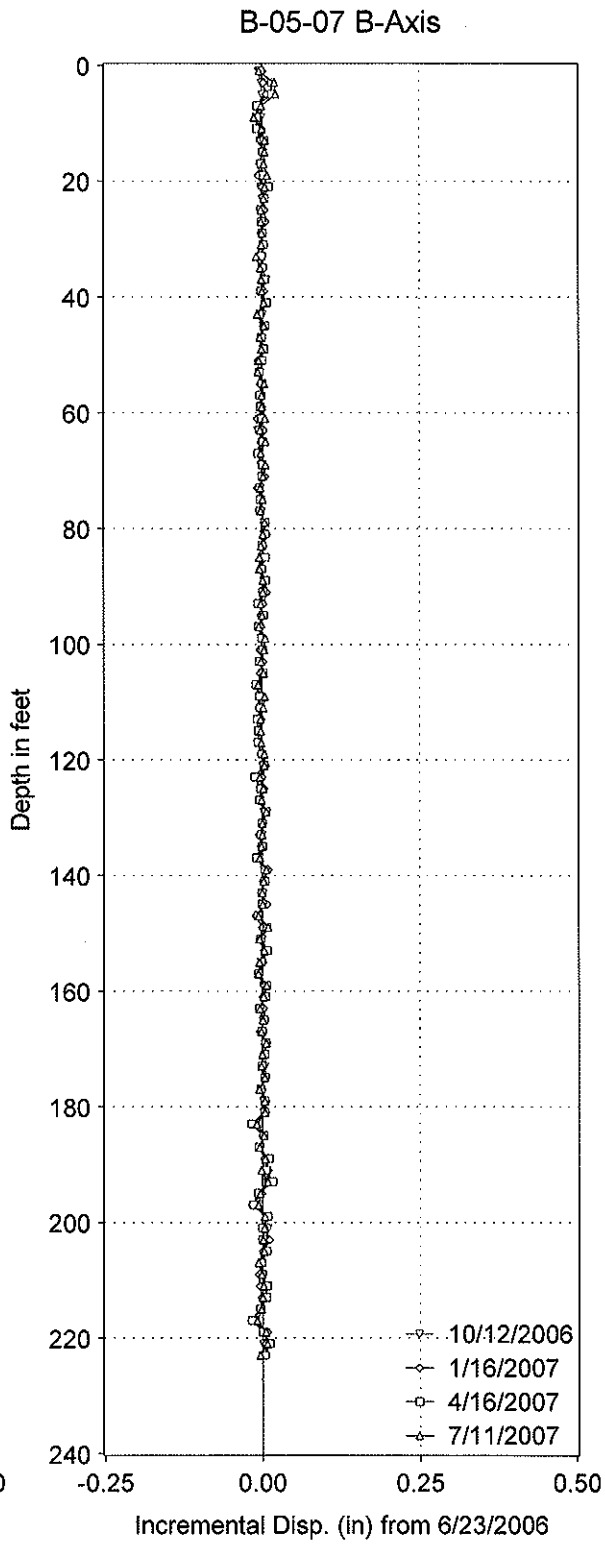




B-05-07
-Includes readings from the last four quarters.

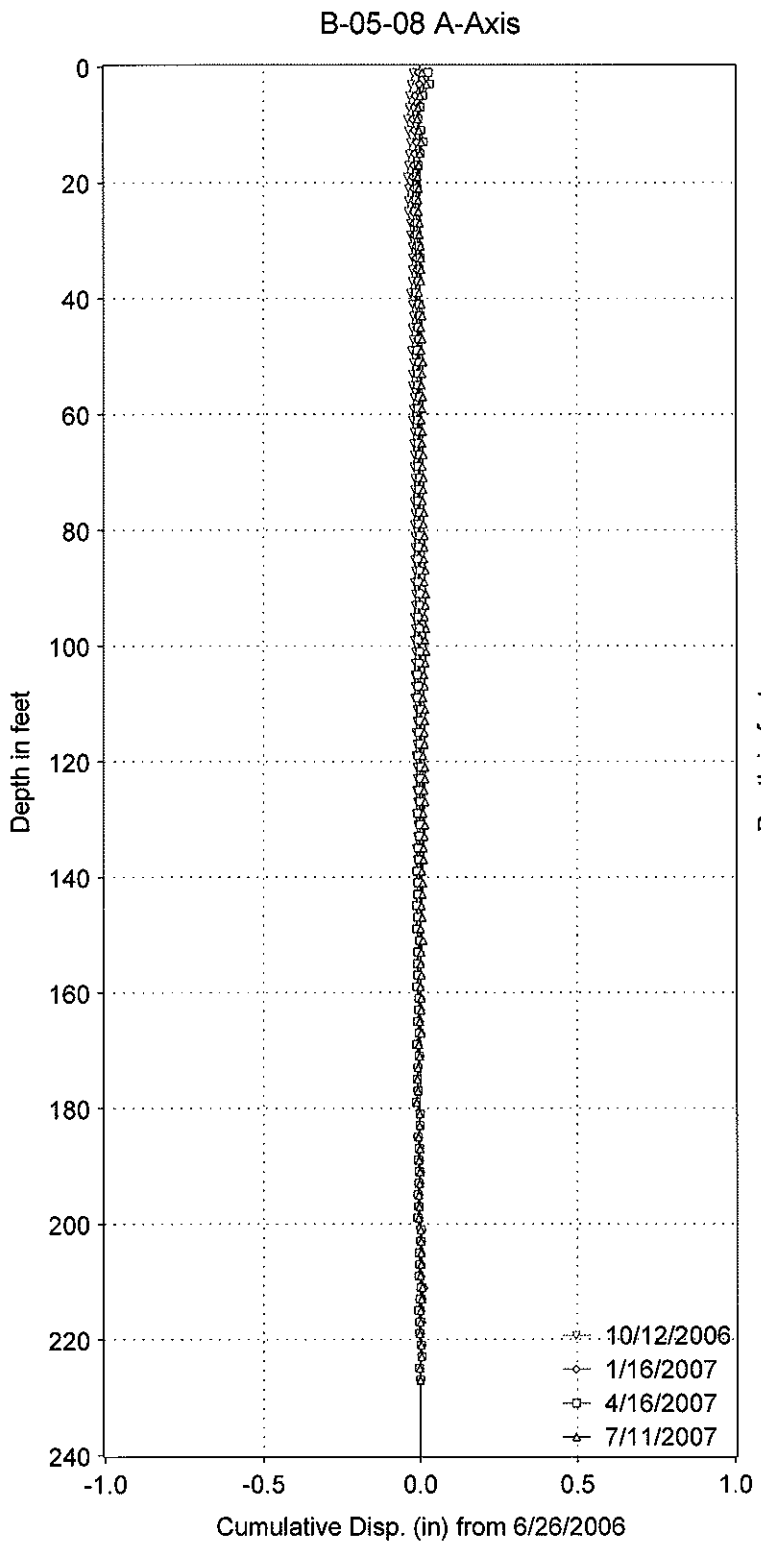
PLATE 36

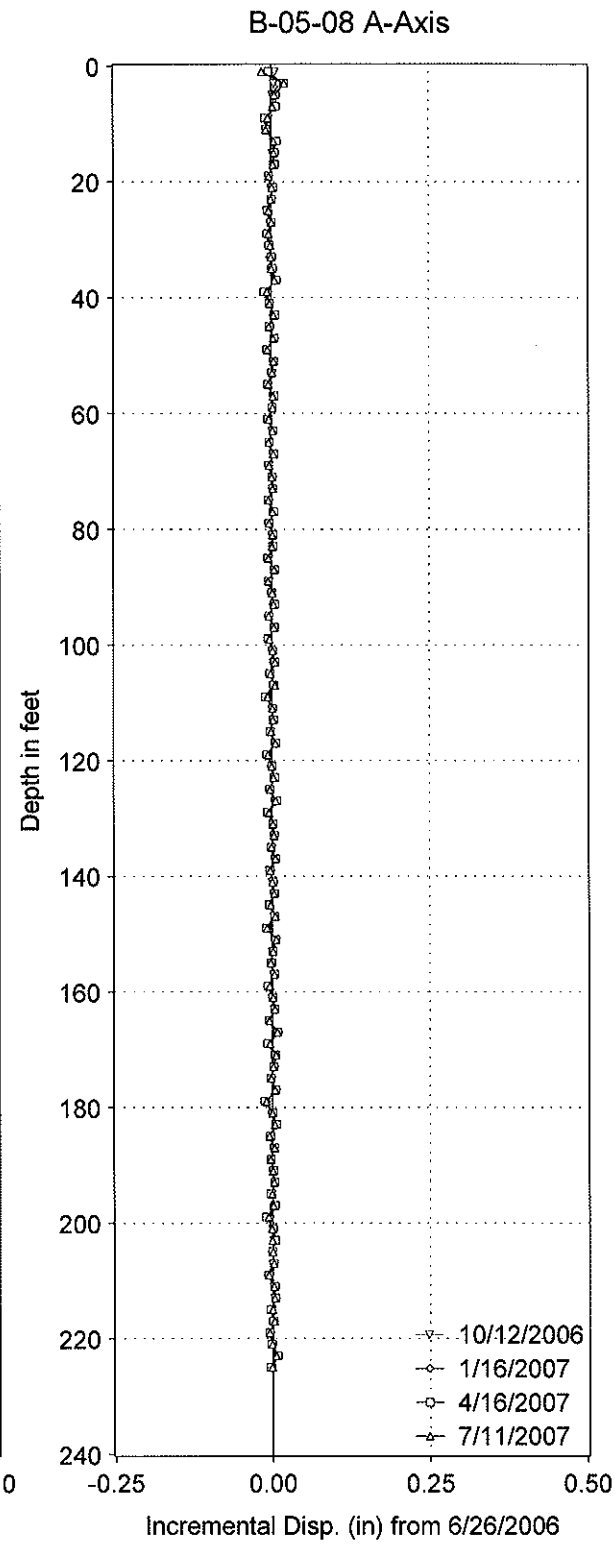




B-05-07
-Includes readings from the last four quarters.

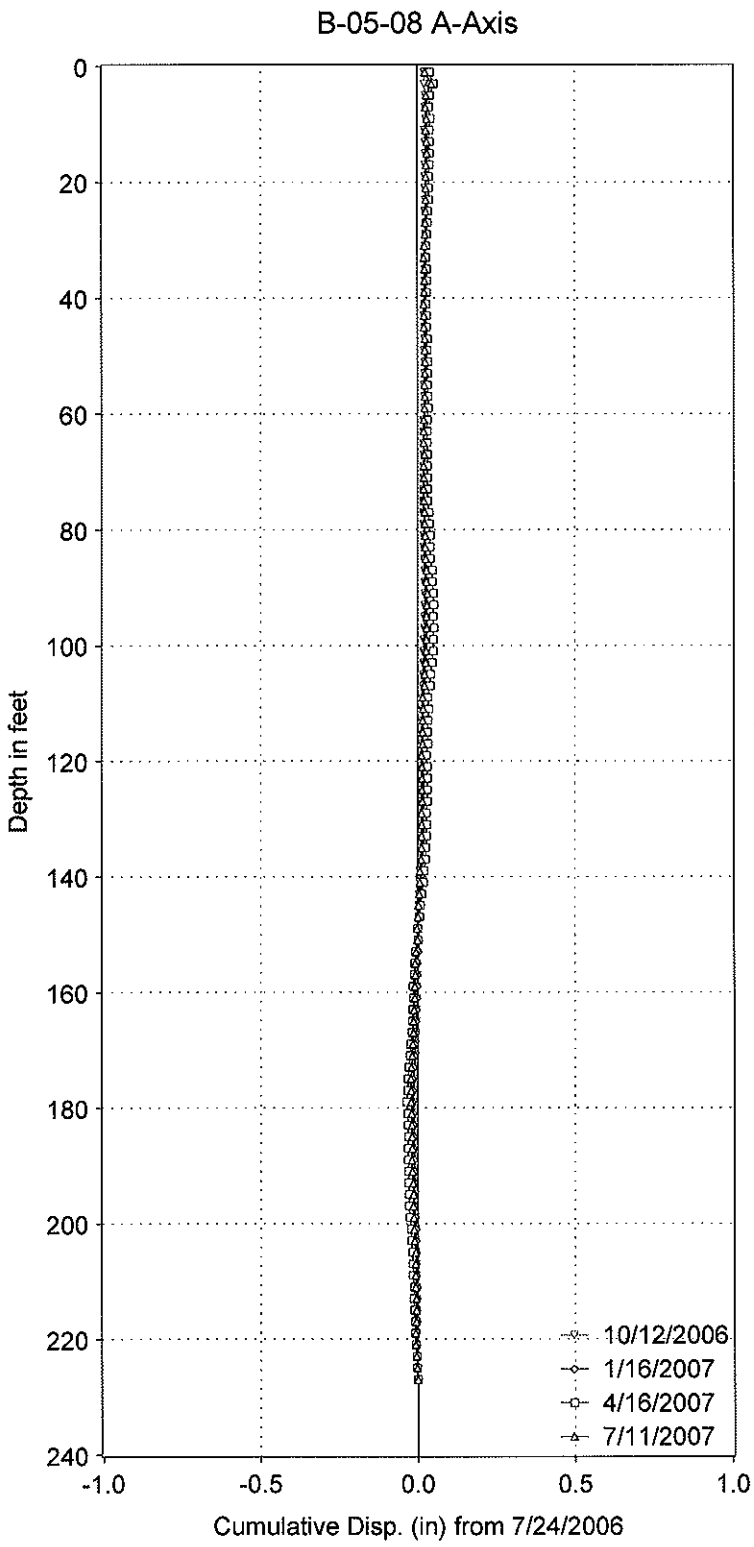
PLATE 37

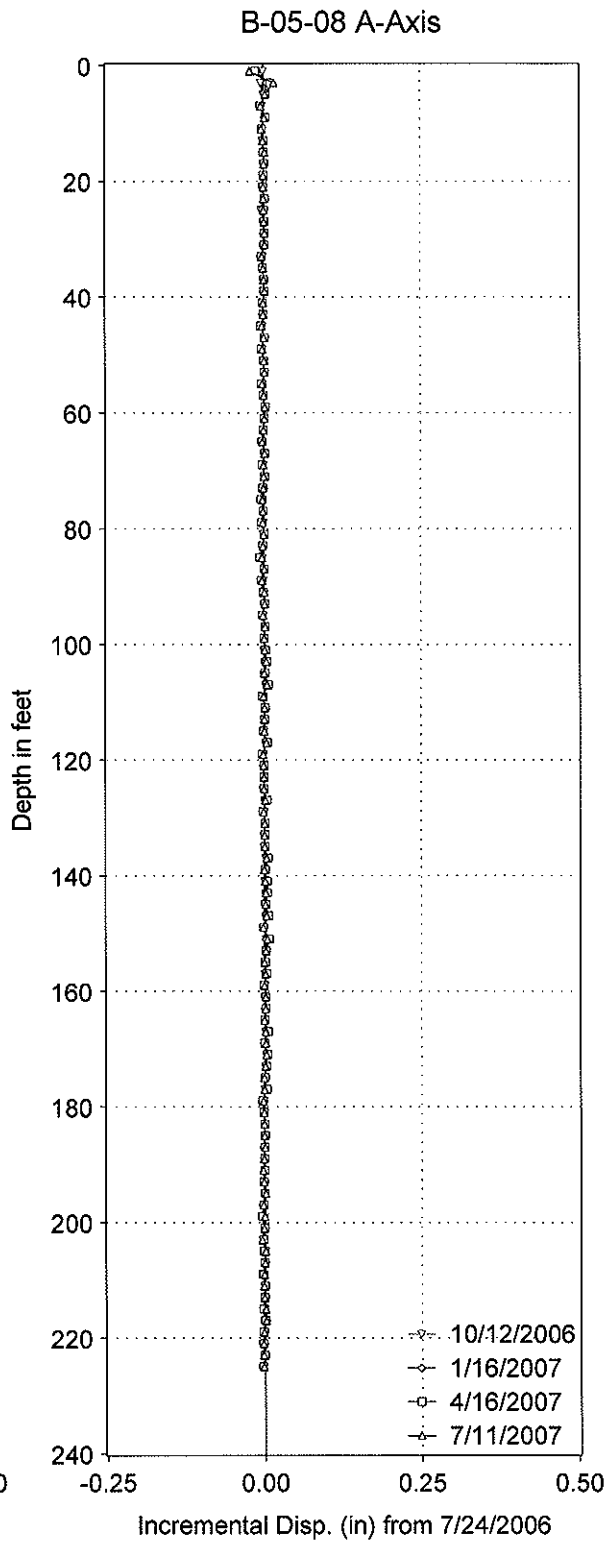




B-05-08
-Includes readings from the last four quarters.

PLATE 38

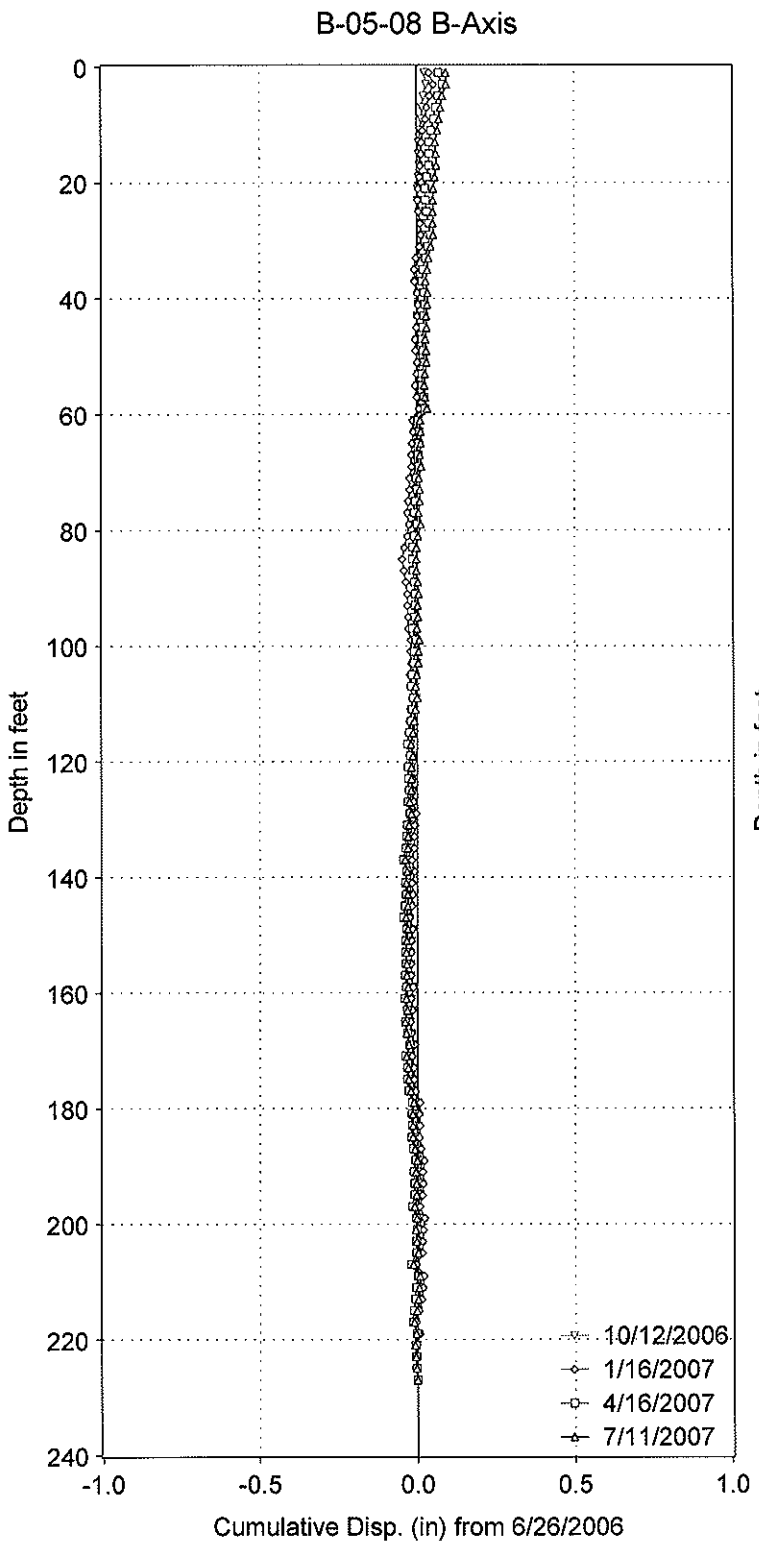


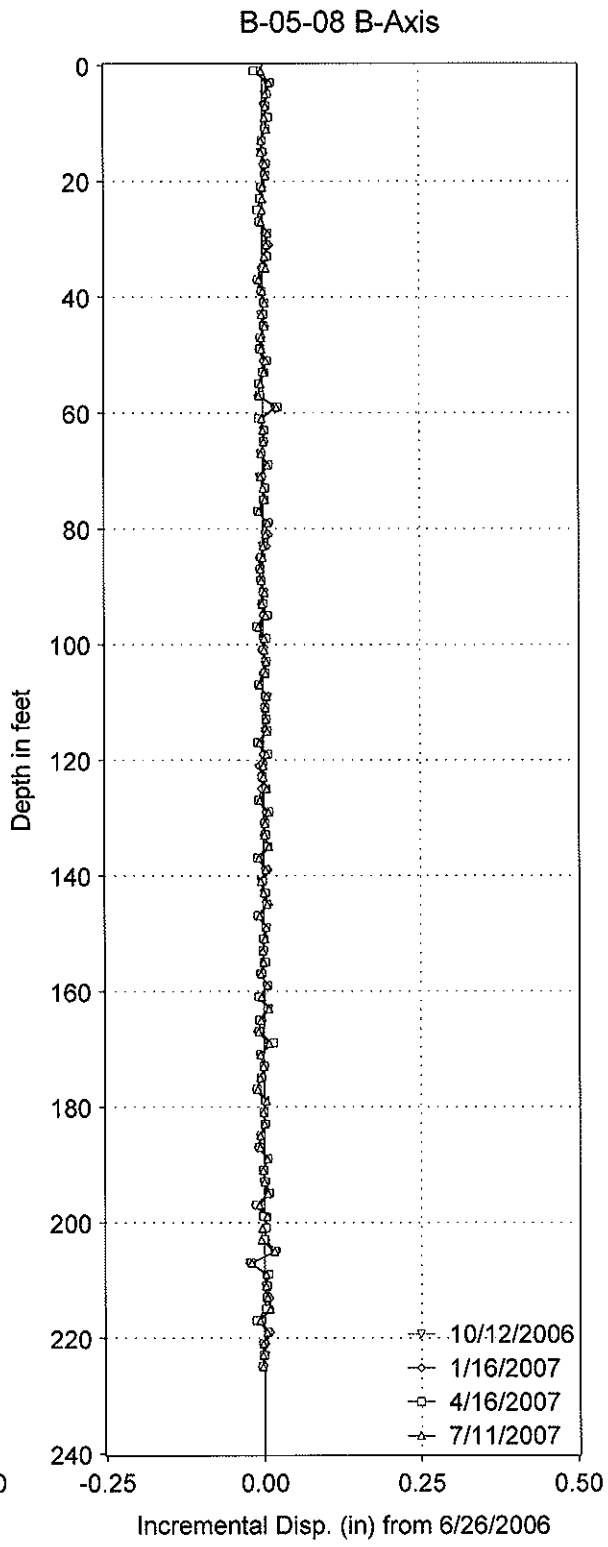


B-05-08

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 26, 2006 reading.

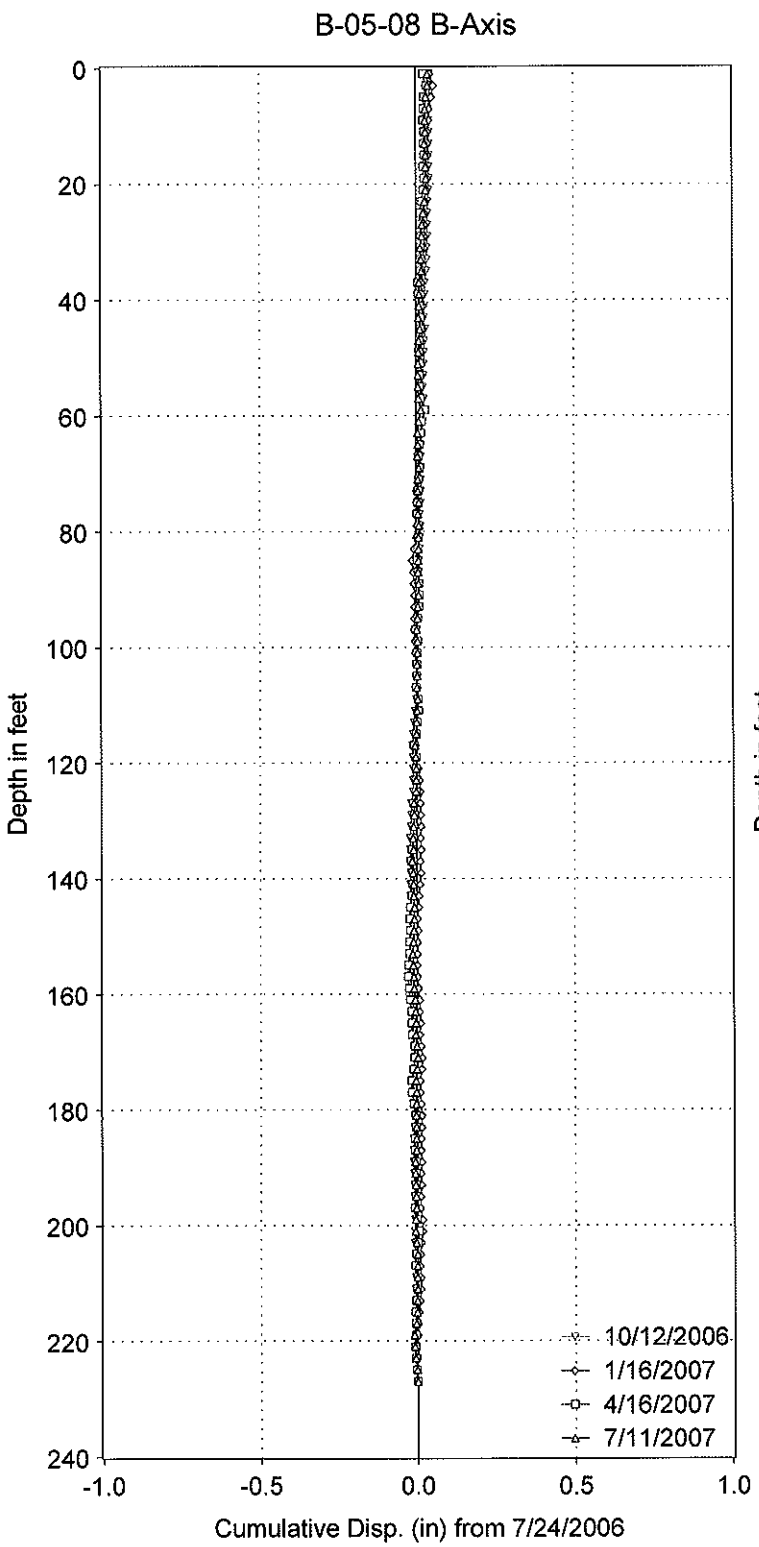
PLATE 38A

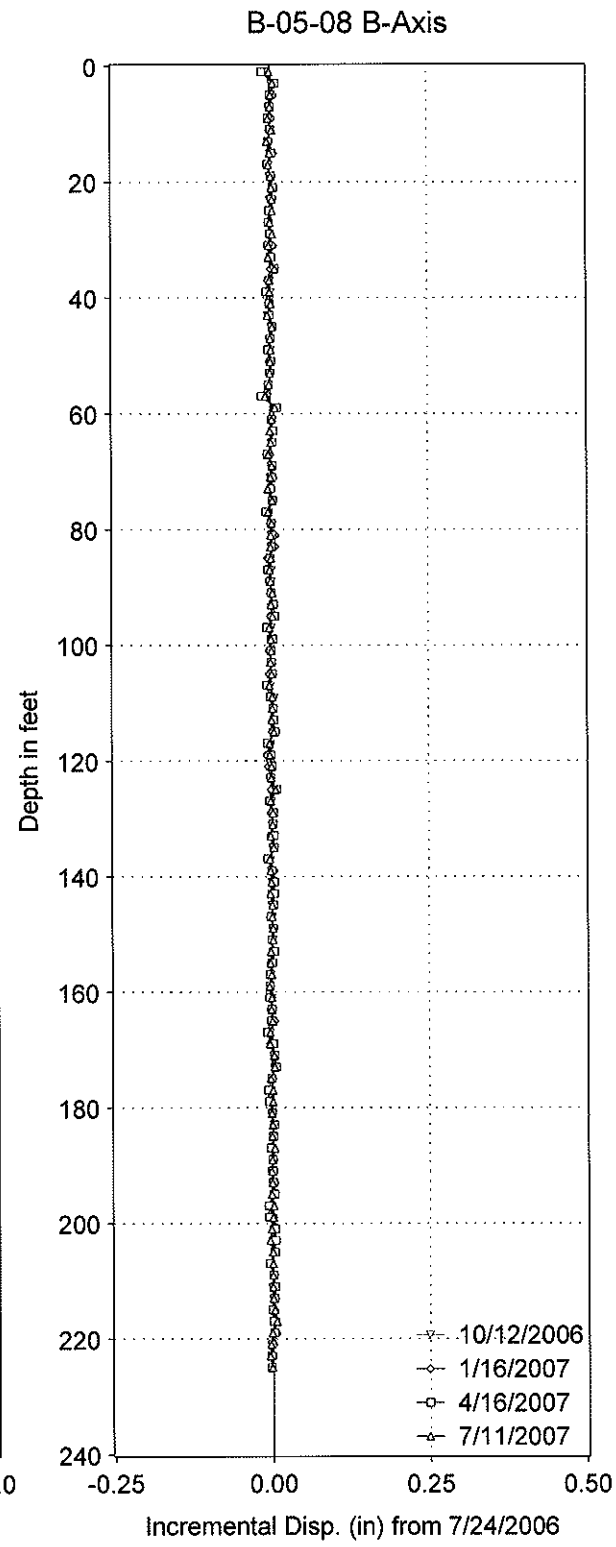




B-05-08
-Includes readings from the last four quarters.

PLATE 39

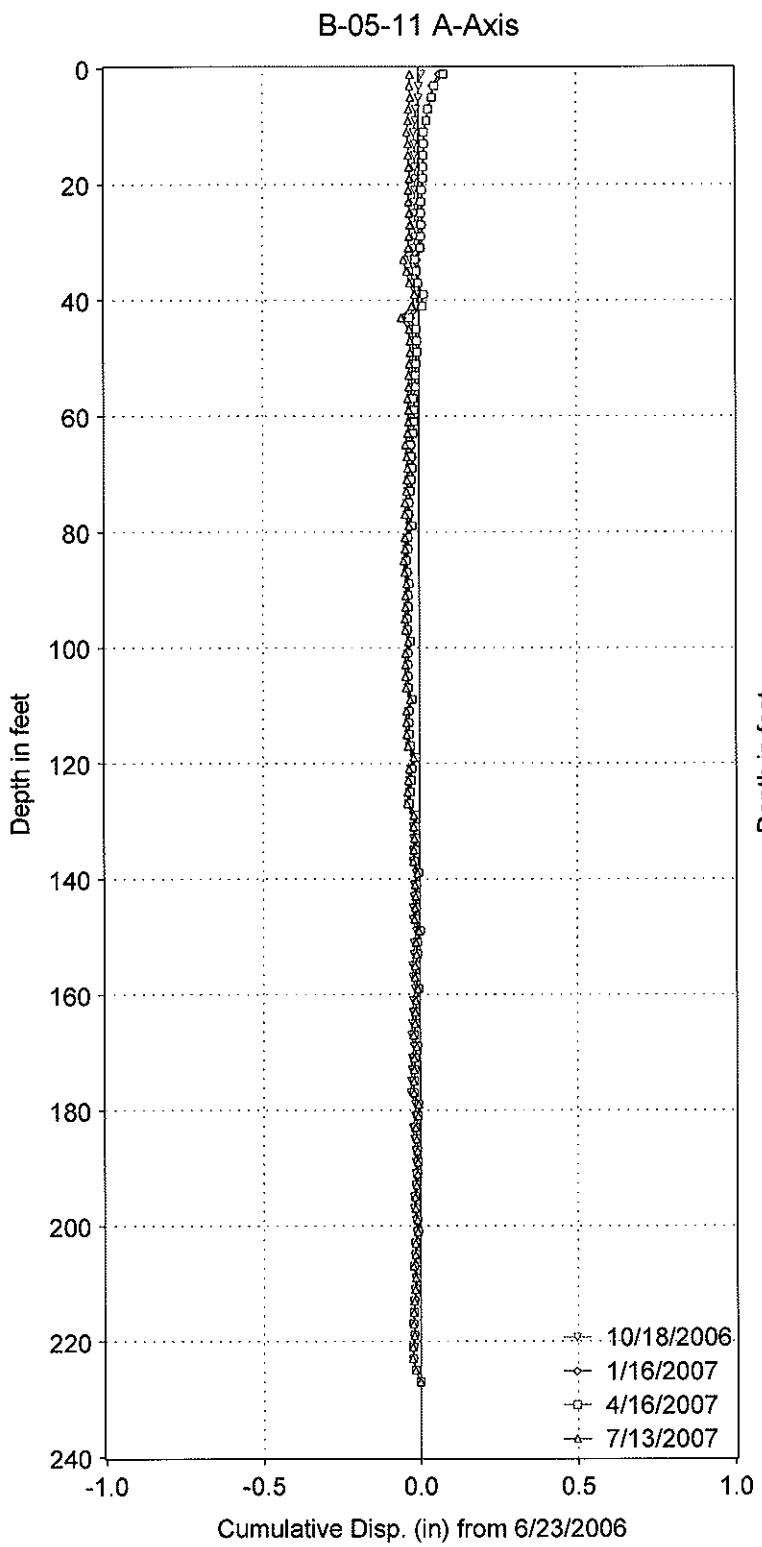


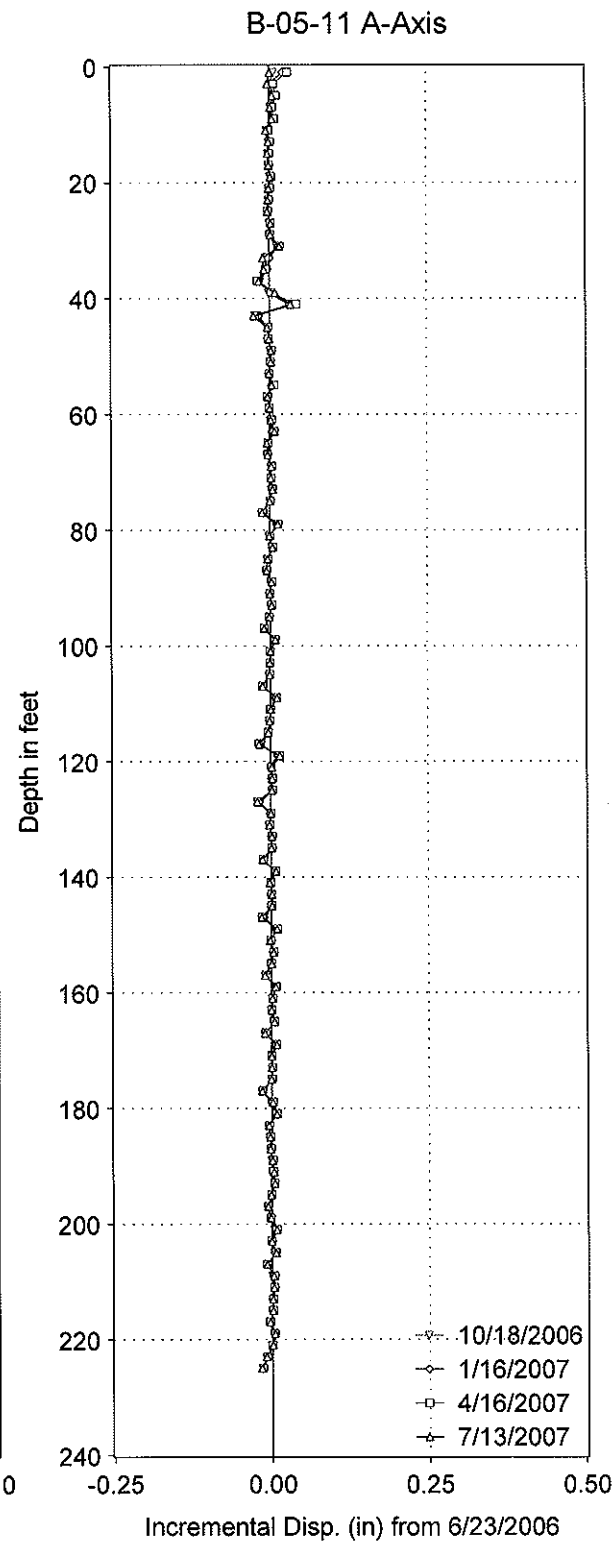


B-05-08

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 26, 2006 reading.

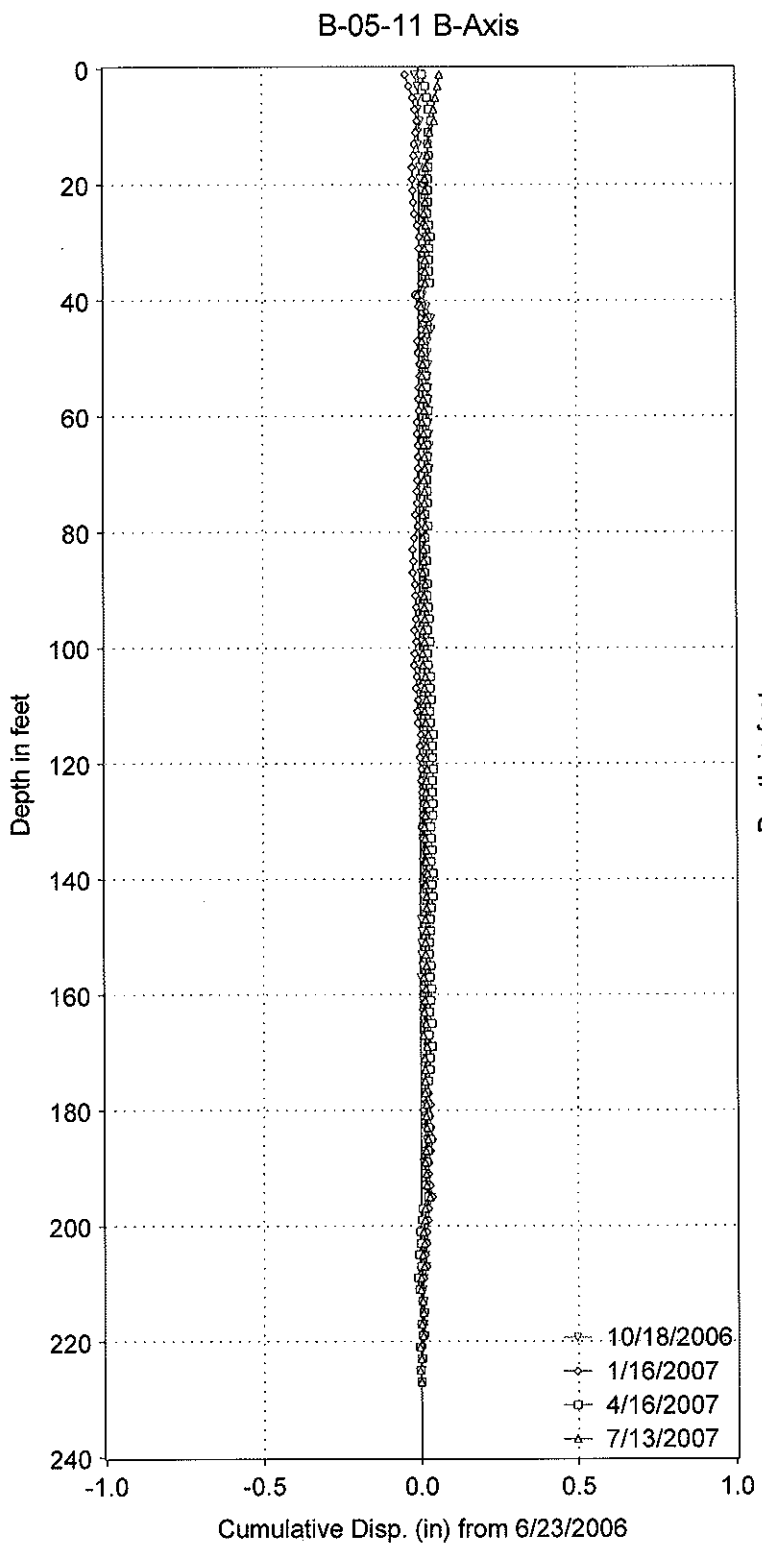
PLATE 39A

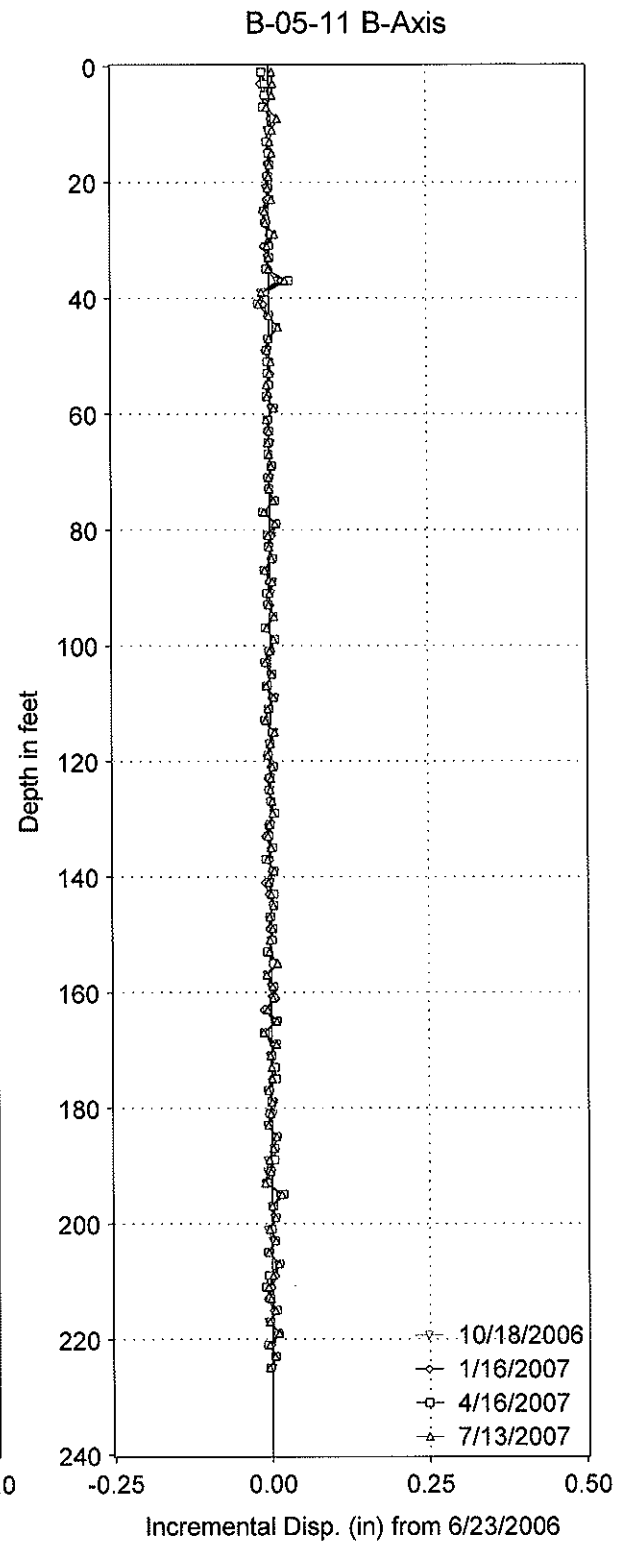




B-05-11
-Includes readings from the last four quarters.

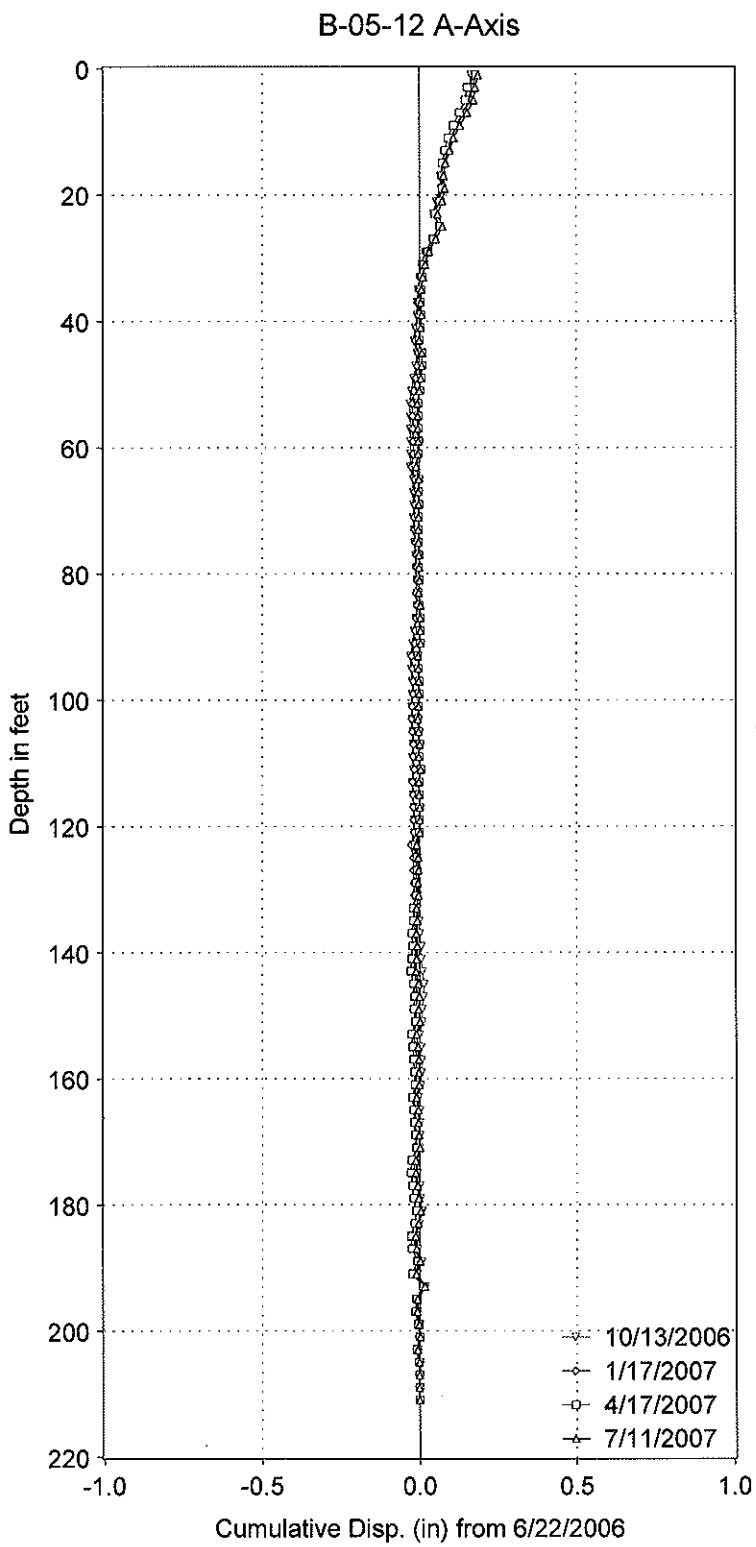
PLATE 40

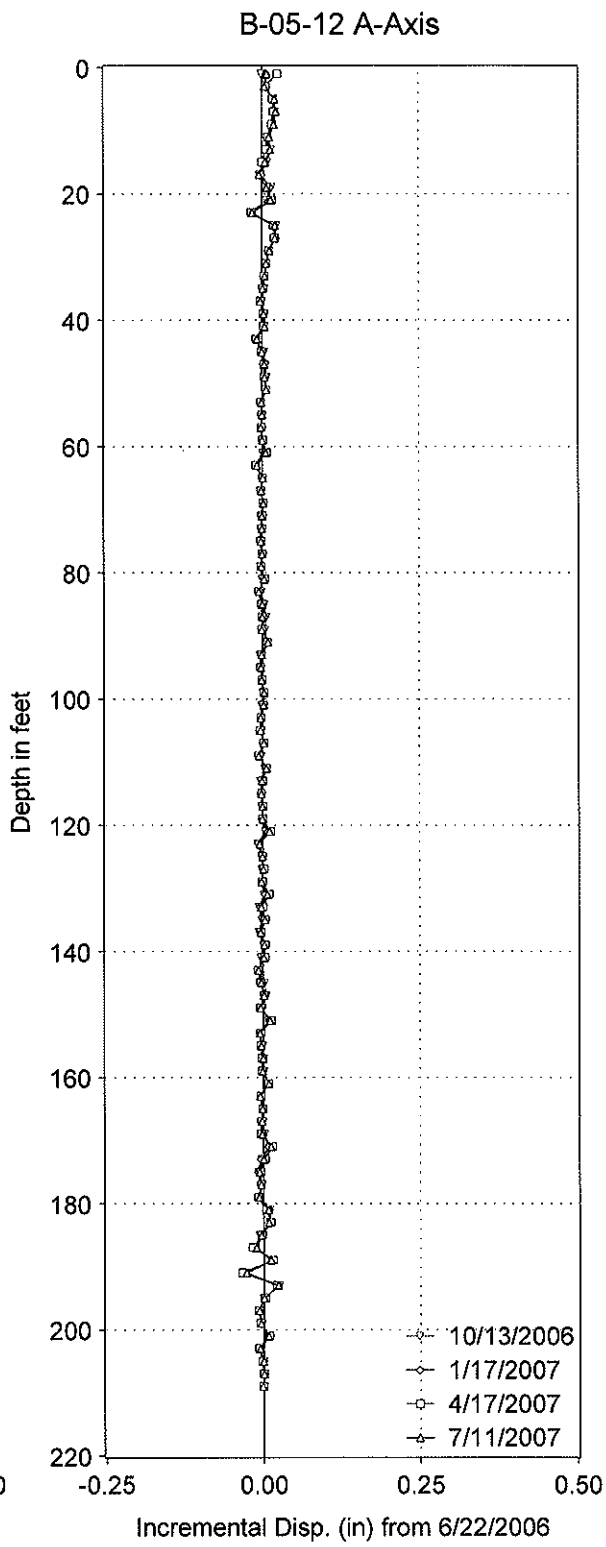




B-05-11
-Includes readings from the last four quarters.

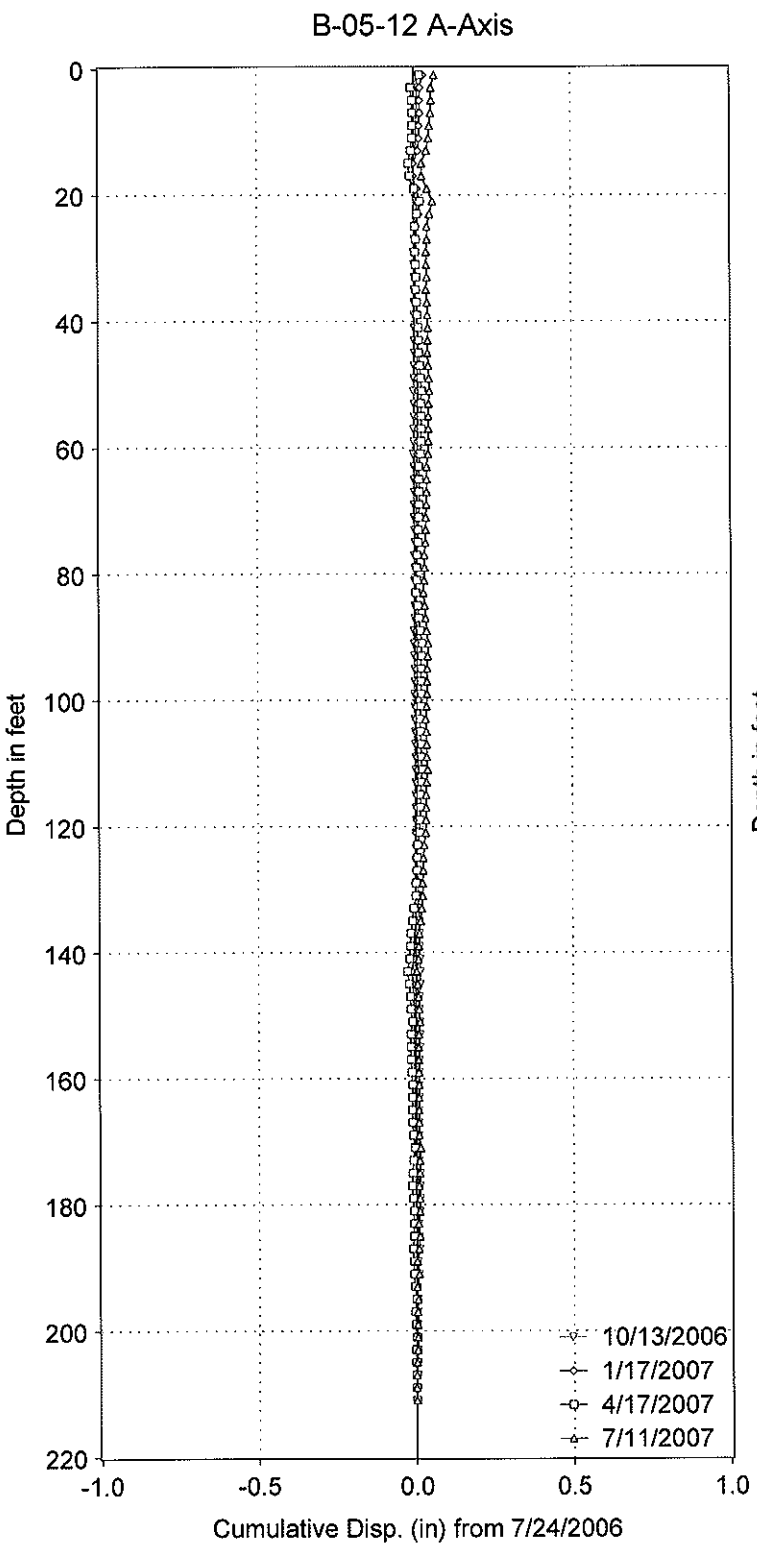
PLATE 41

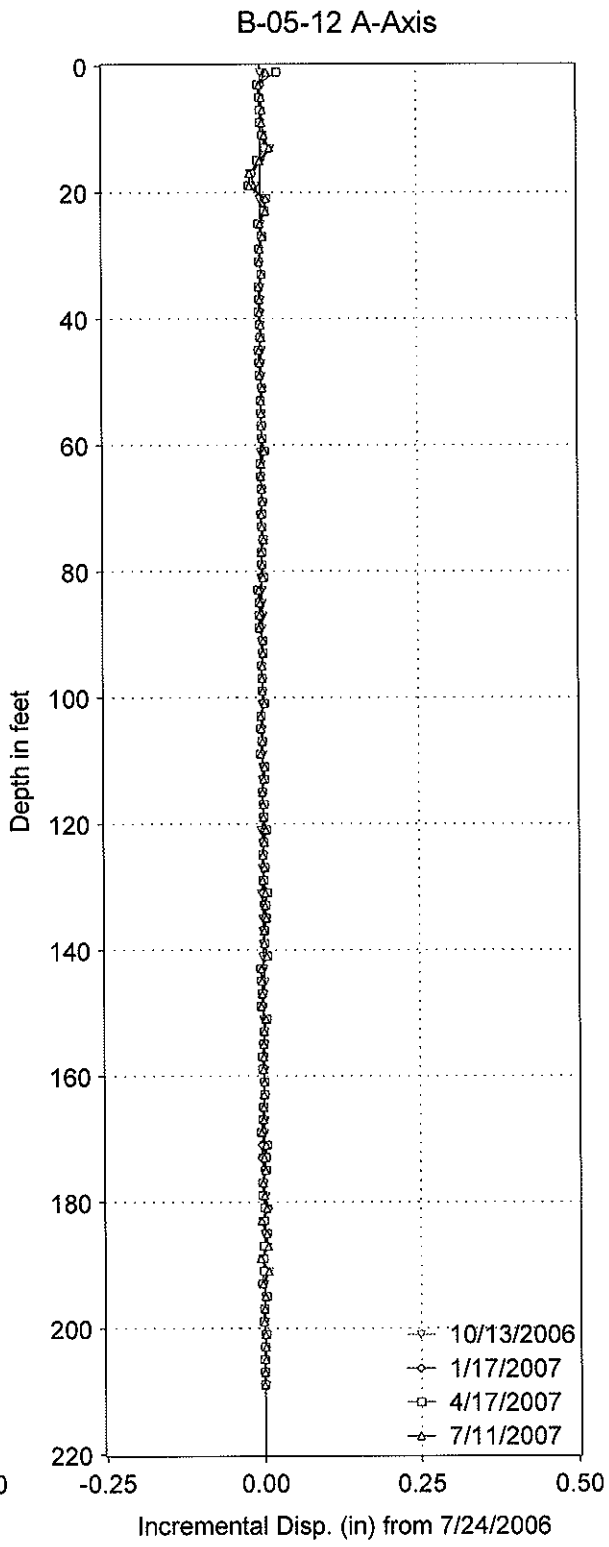




B-05-12
-Includes readings from the last four quarters.

PLATE 42

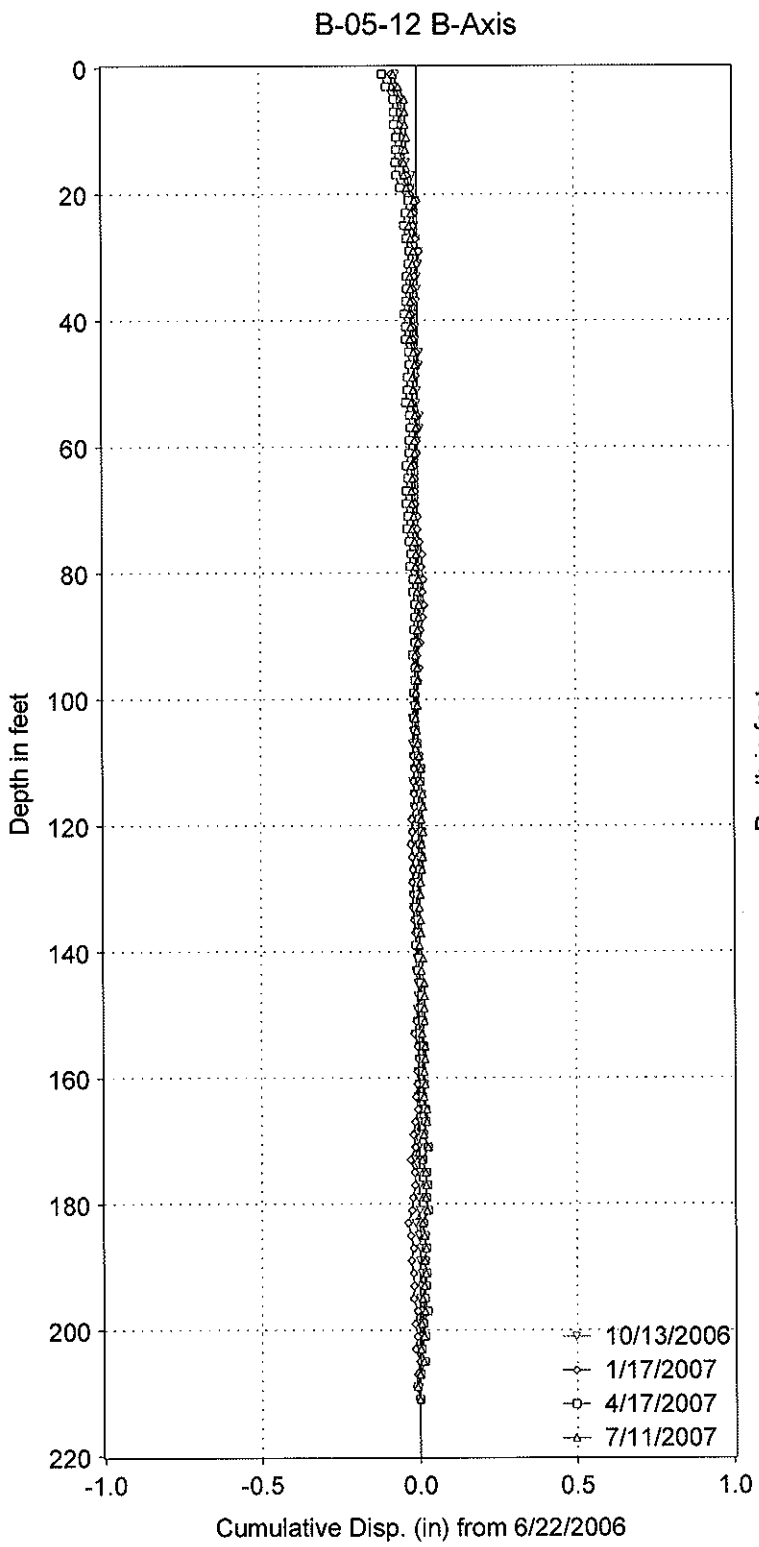


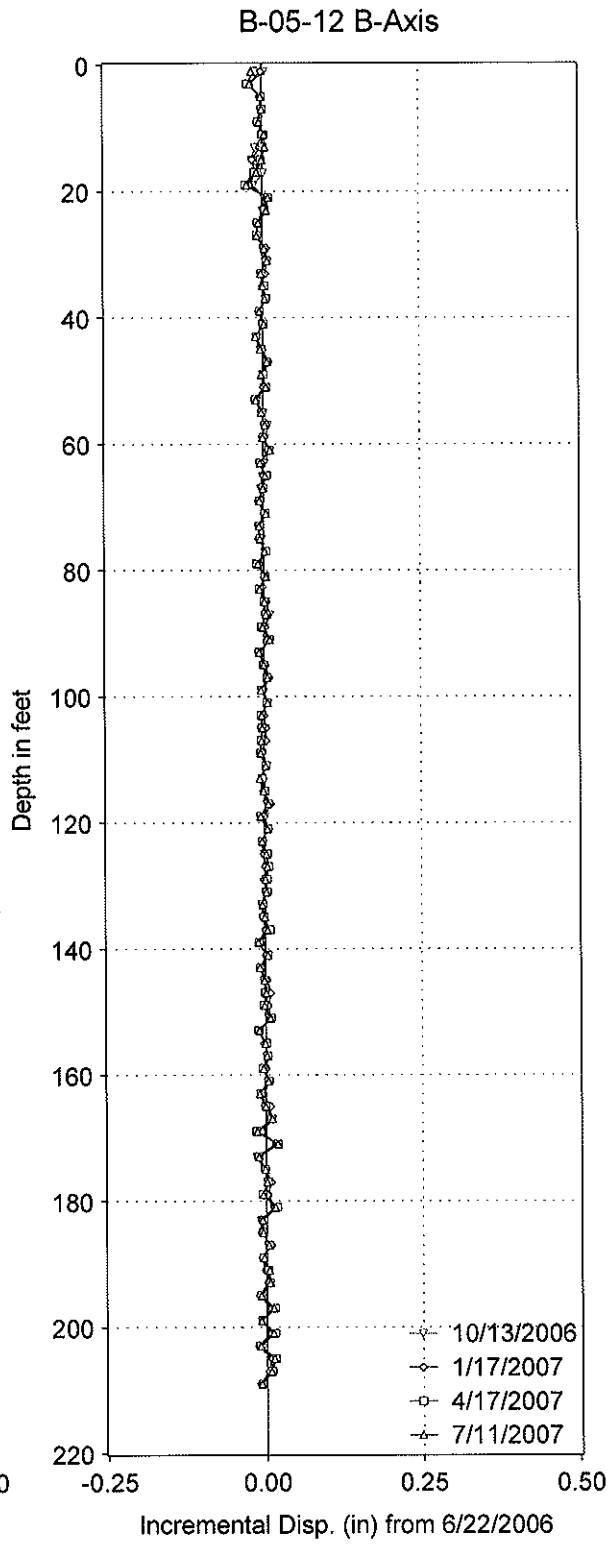


B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

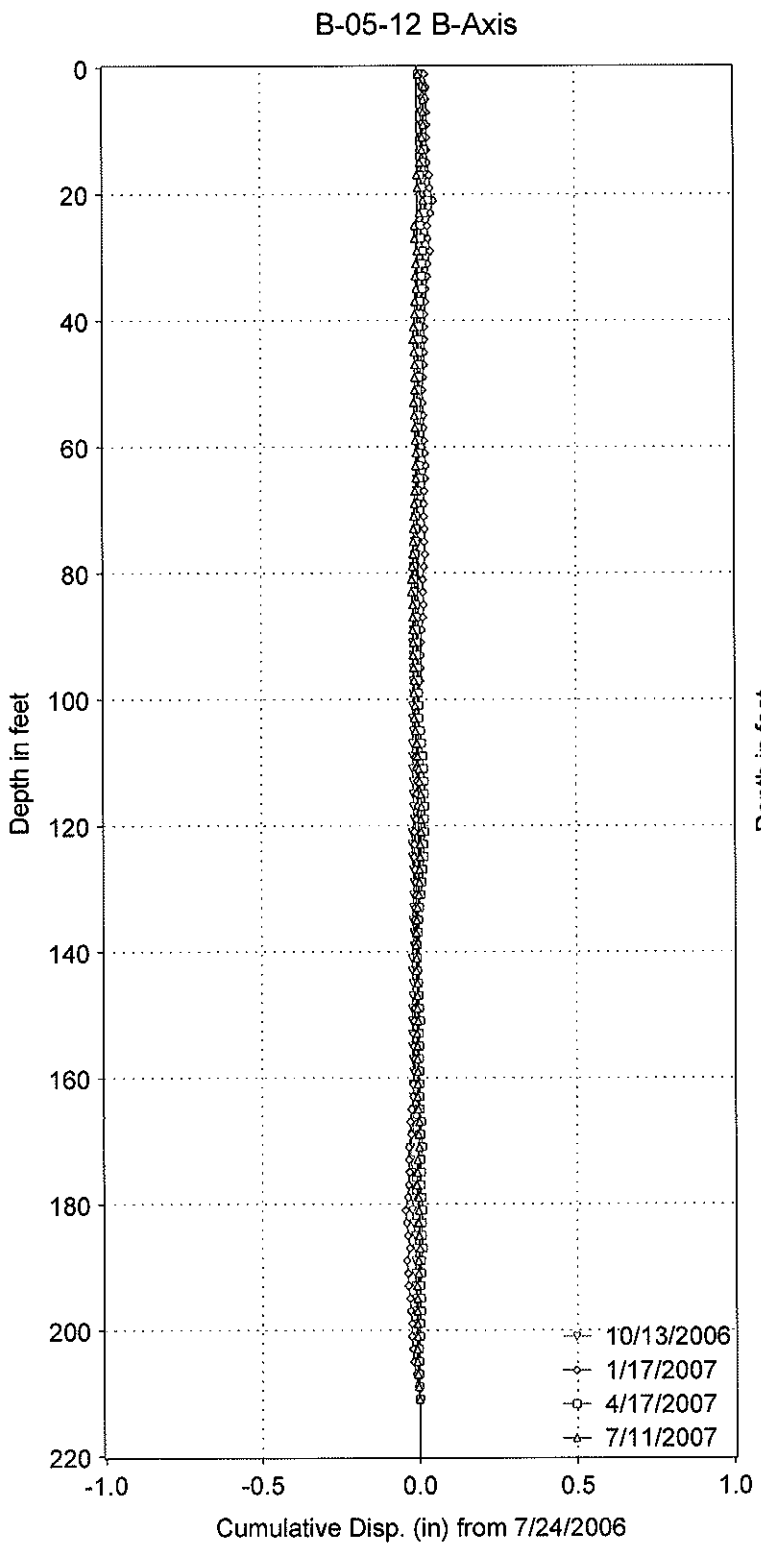
PLATE 42A

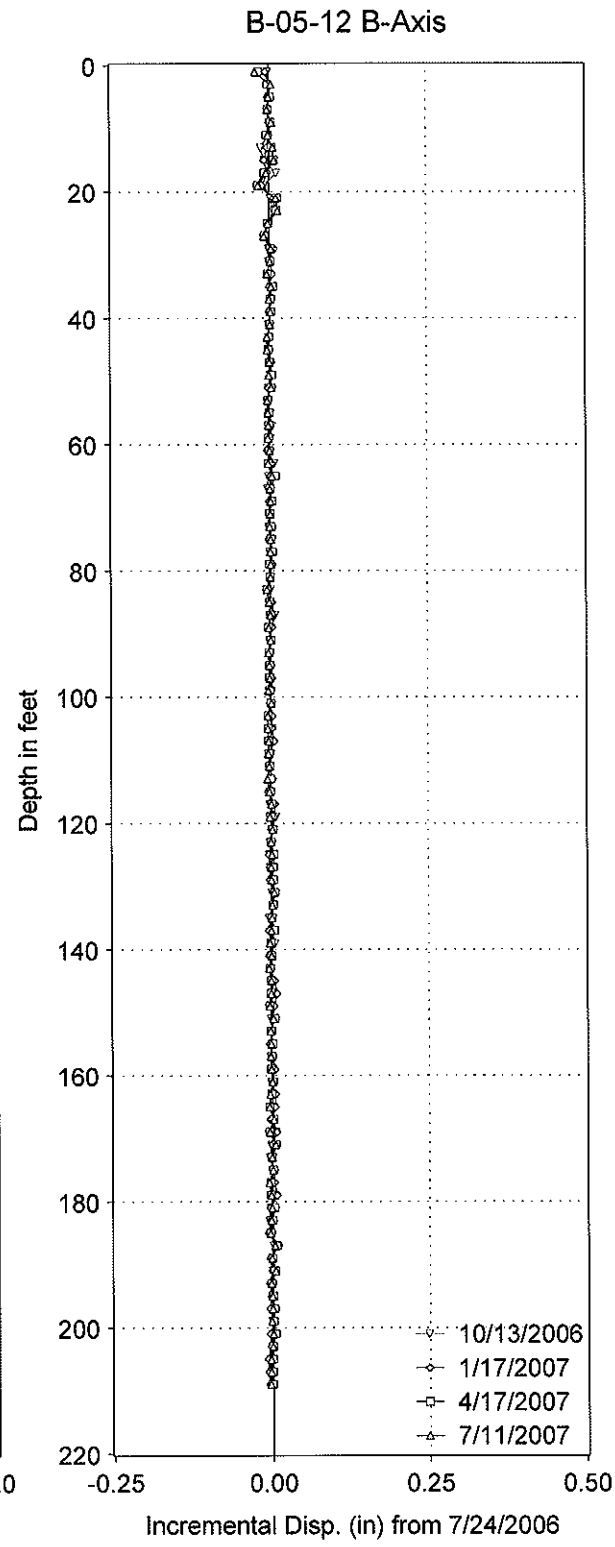




B-05-12
-Includes readings from the last four quarters.

PLATE 43

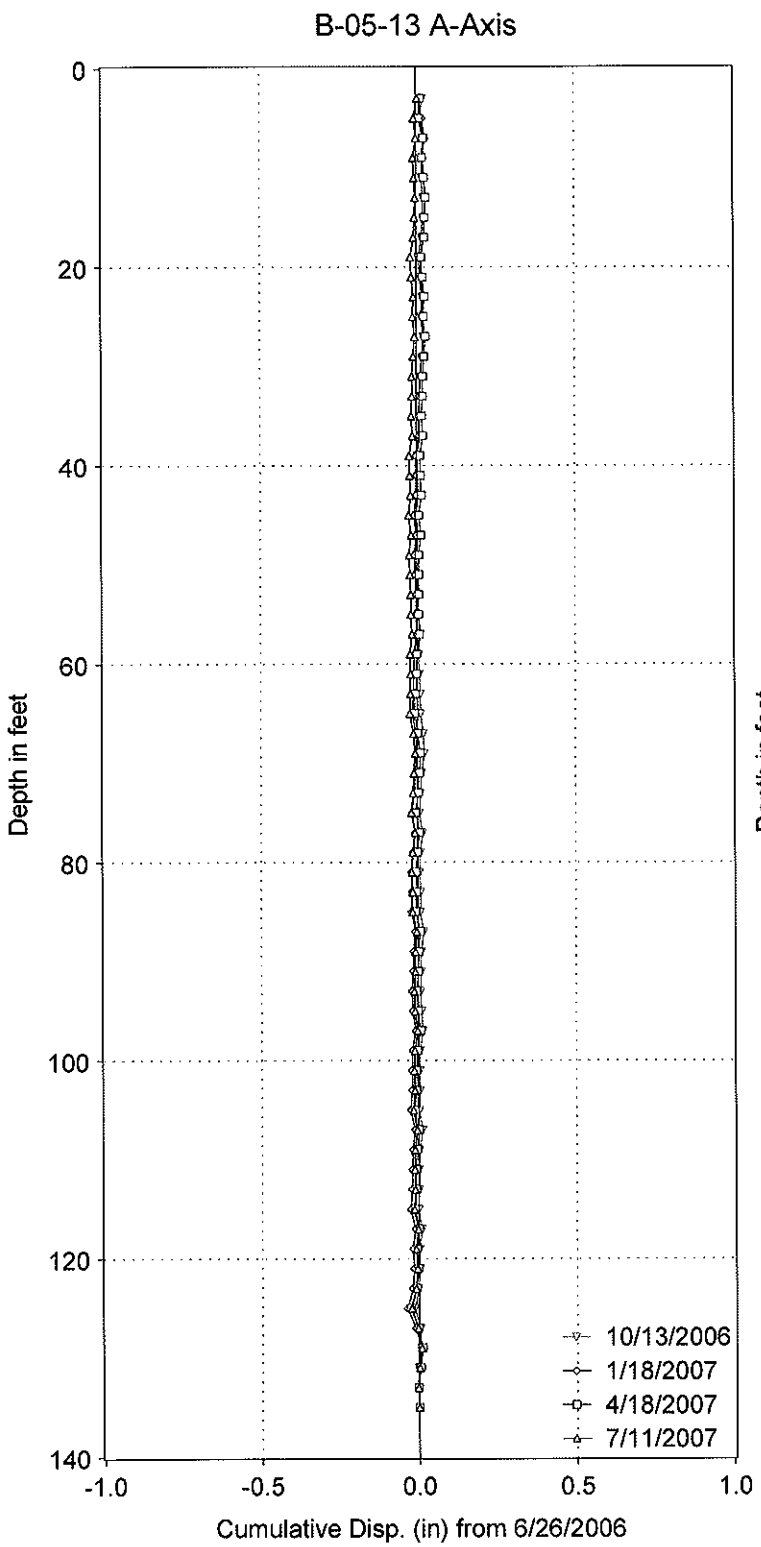


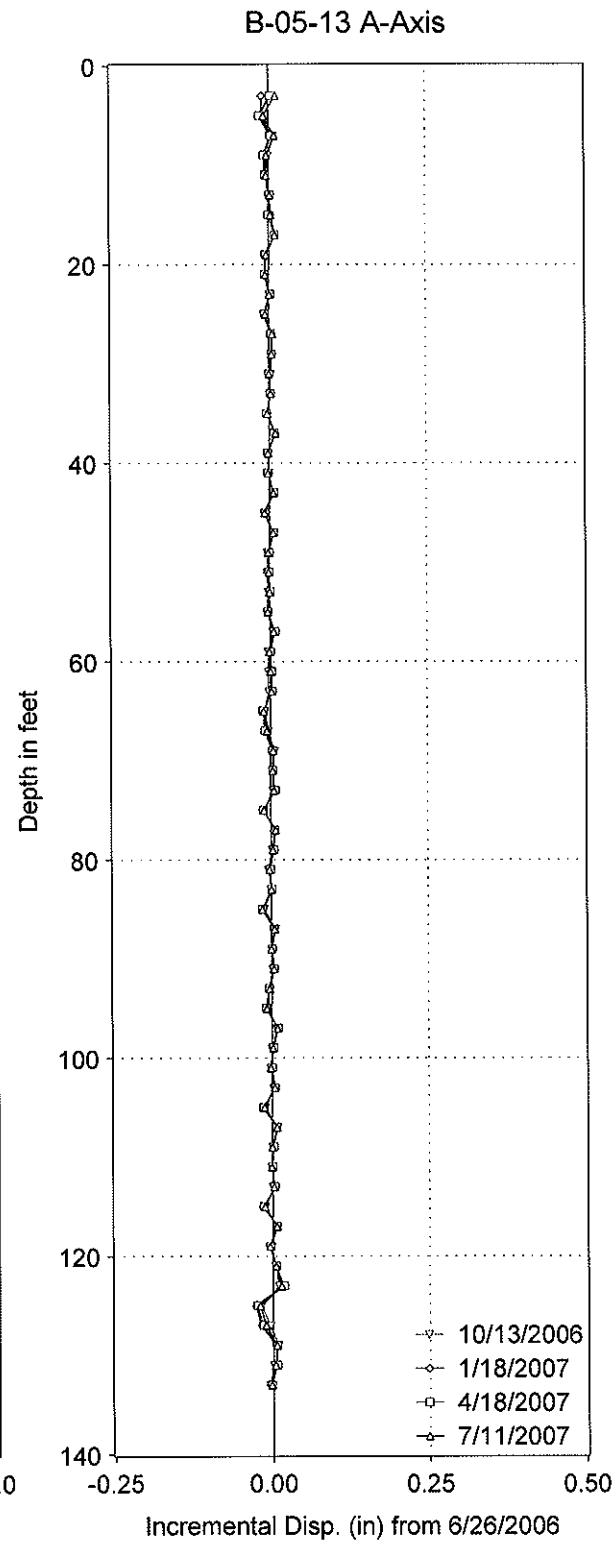


B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

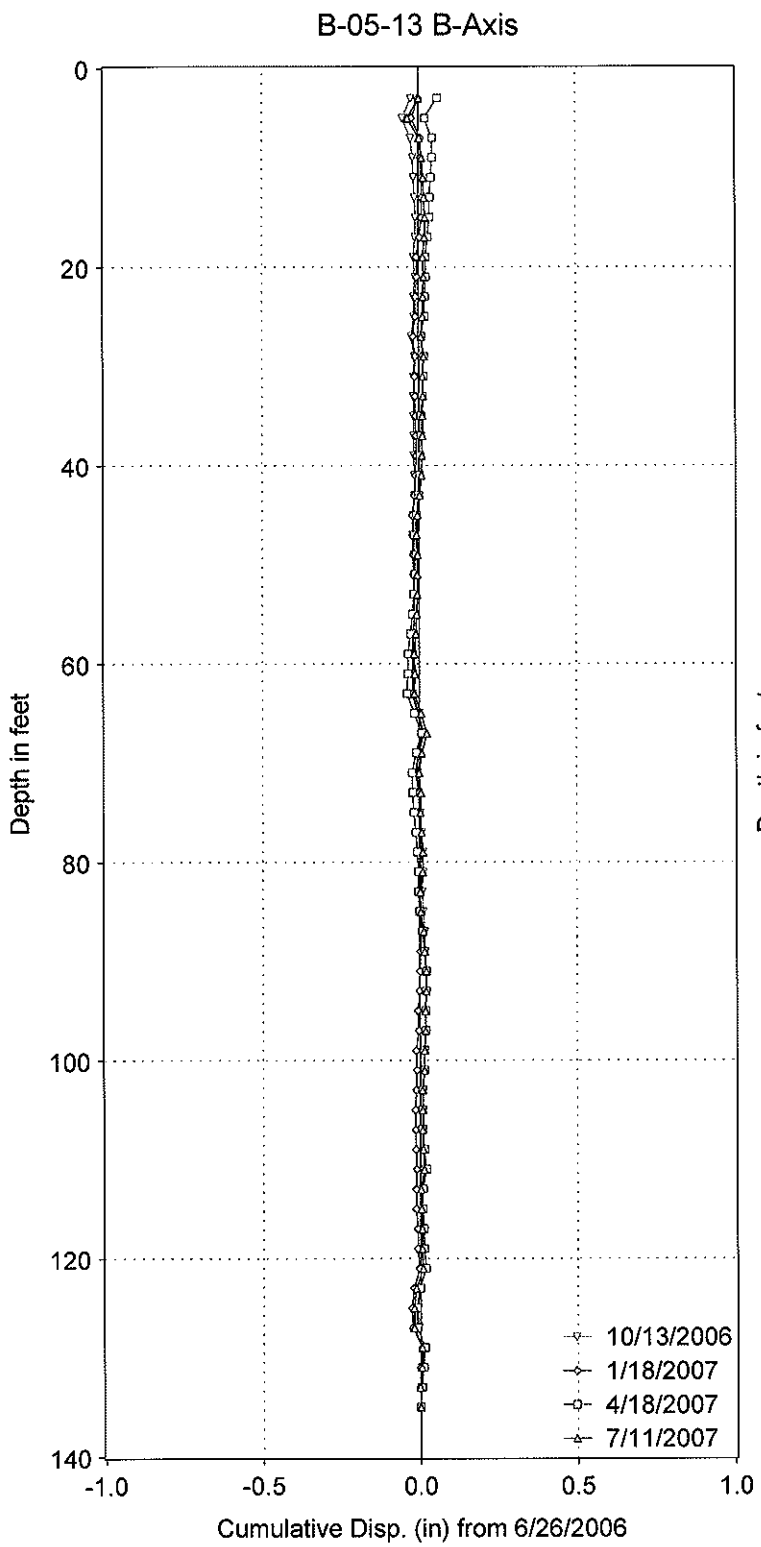
PLATE 43A

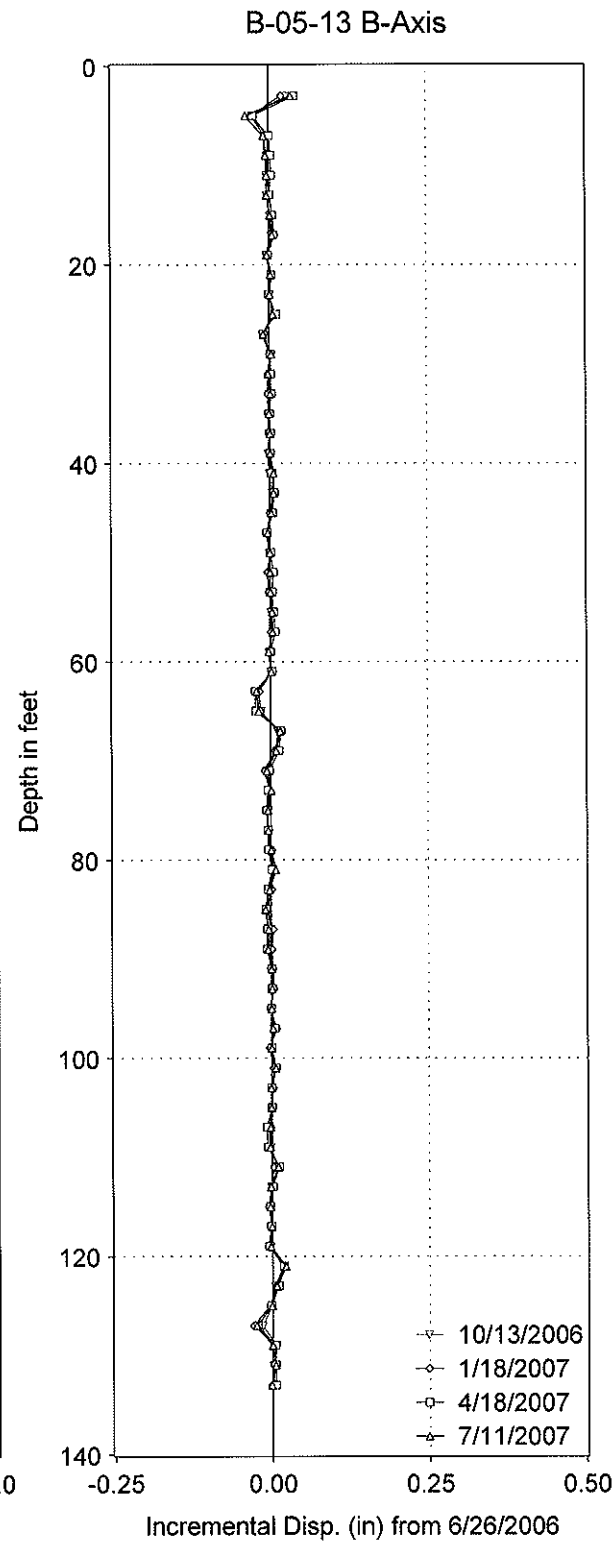




B-05-13
-Includes readings from the last four quarters.

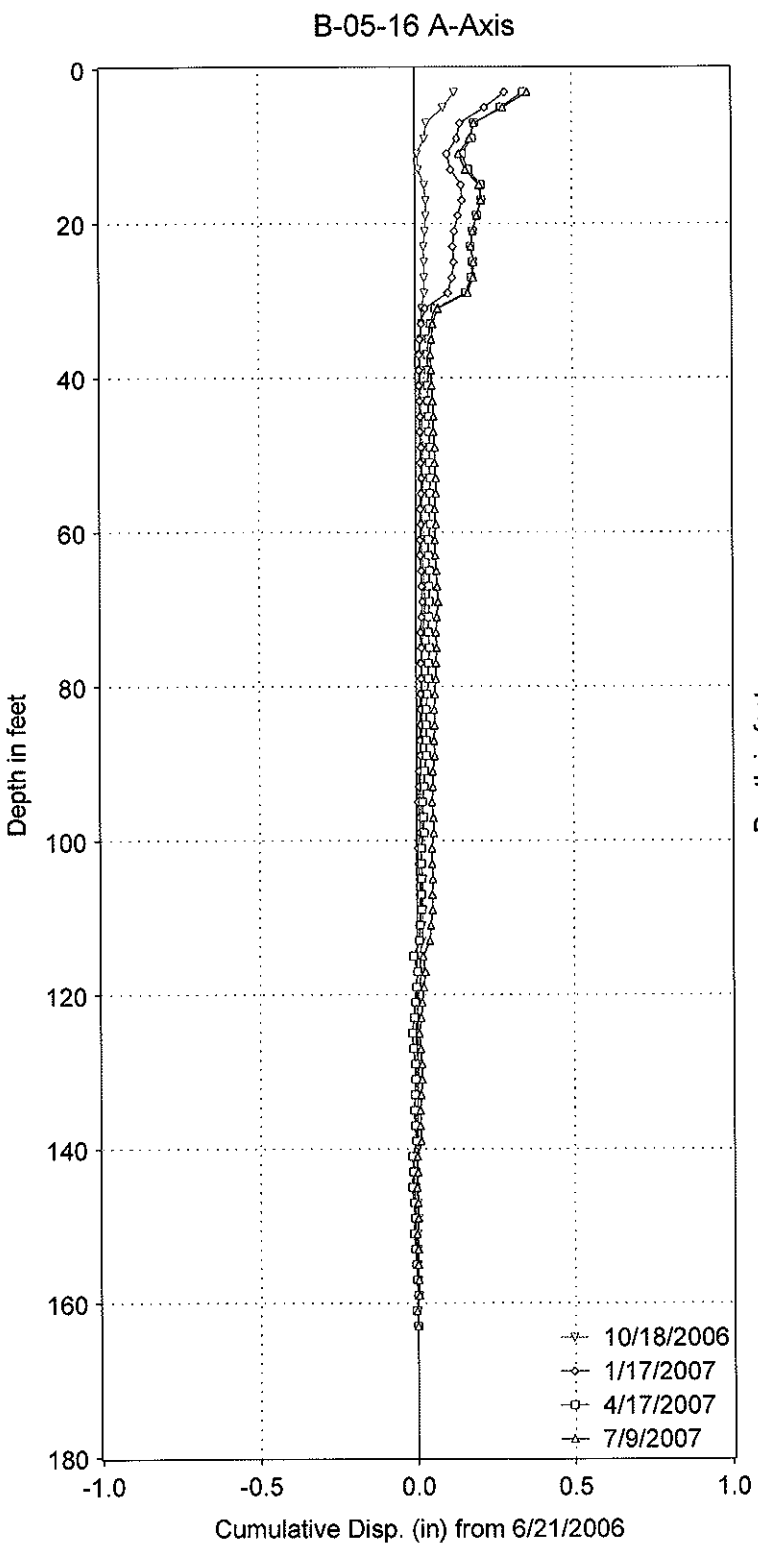
PLATE 44

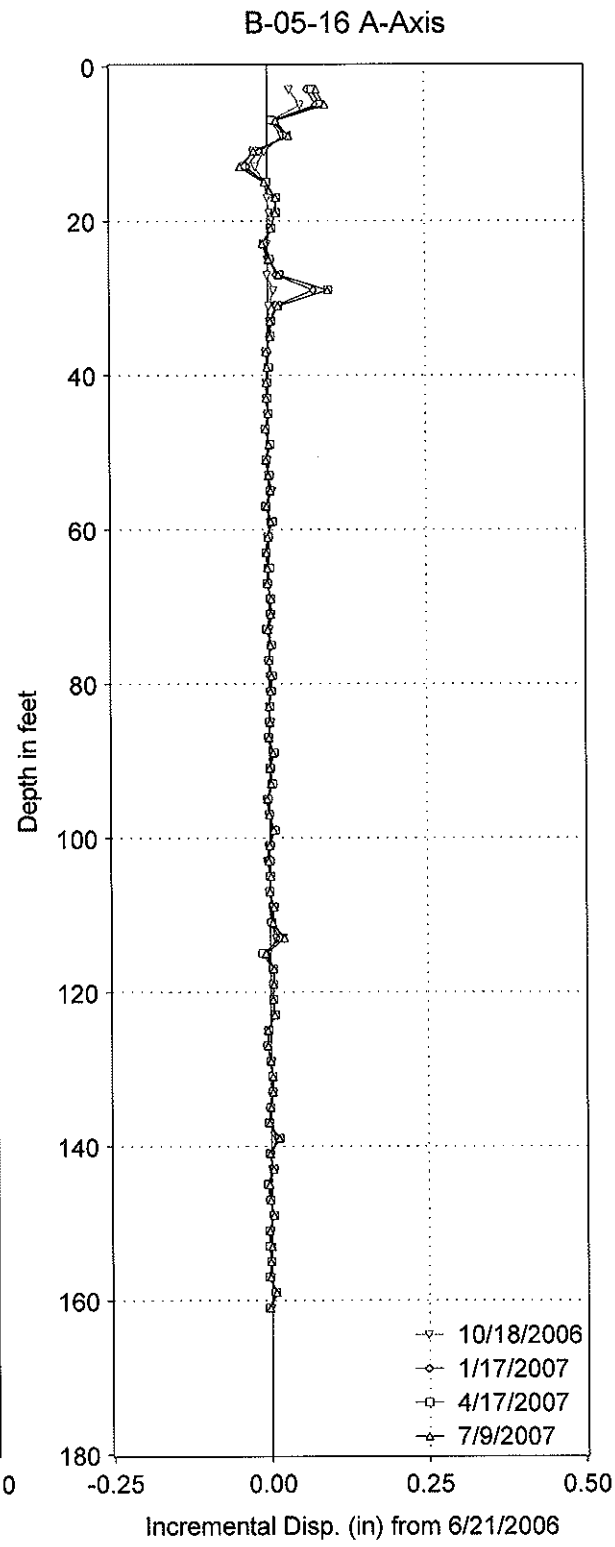




B-05-13
-Includes readings from the last four quarters.

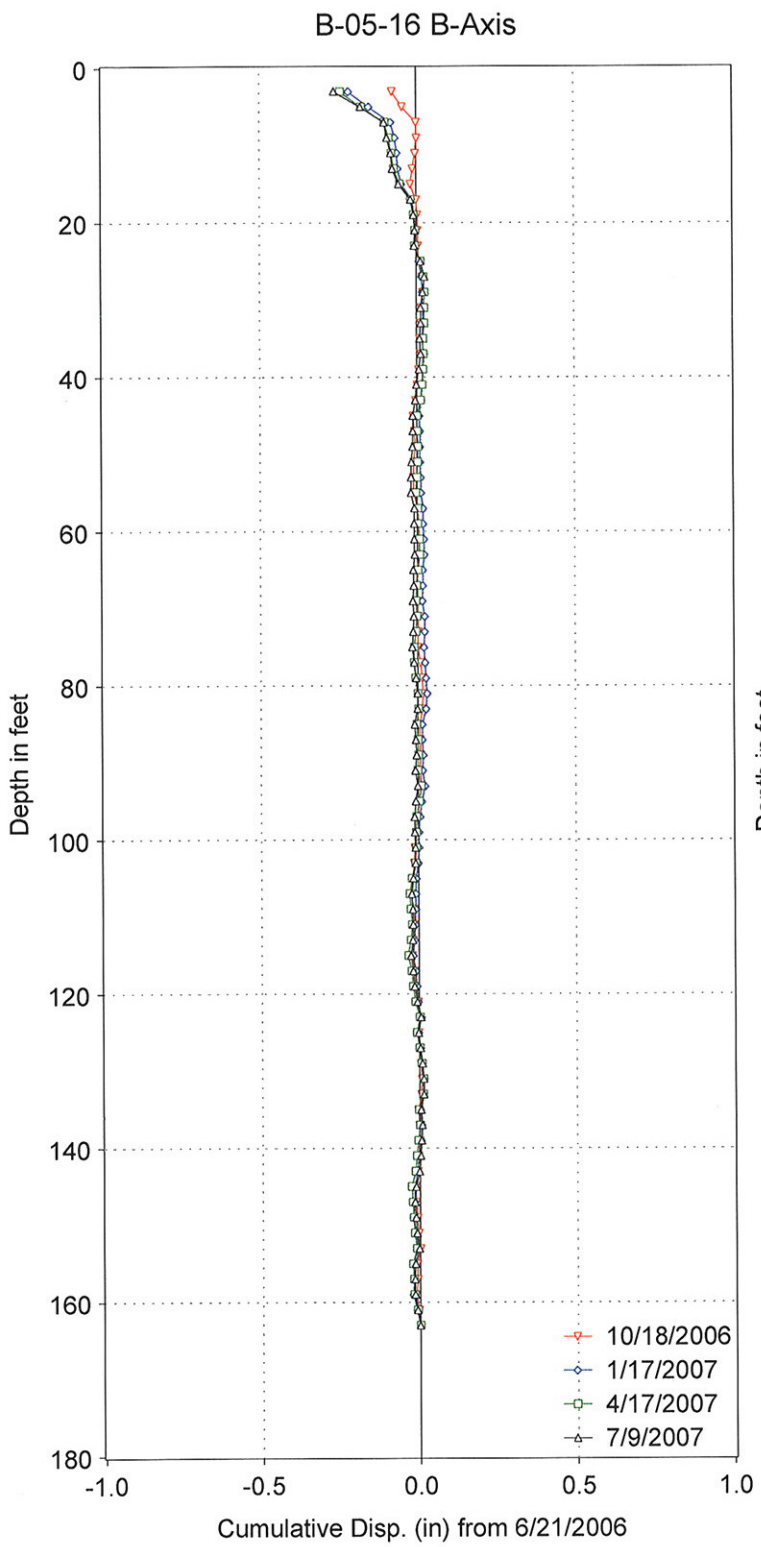
PLATE 45

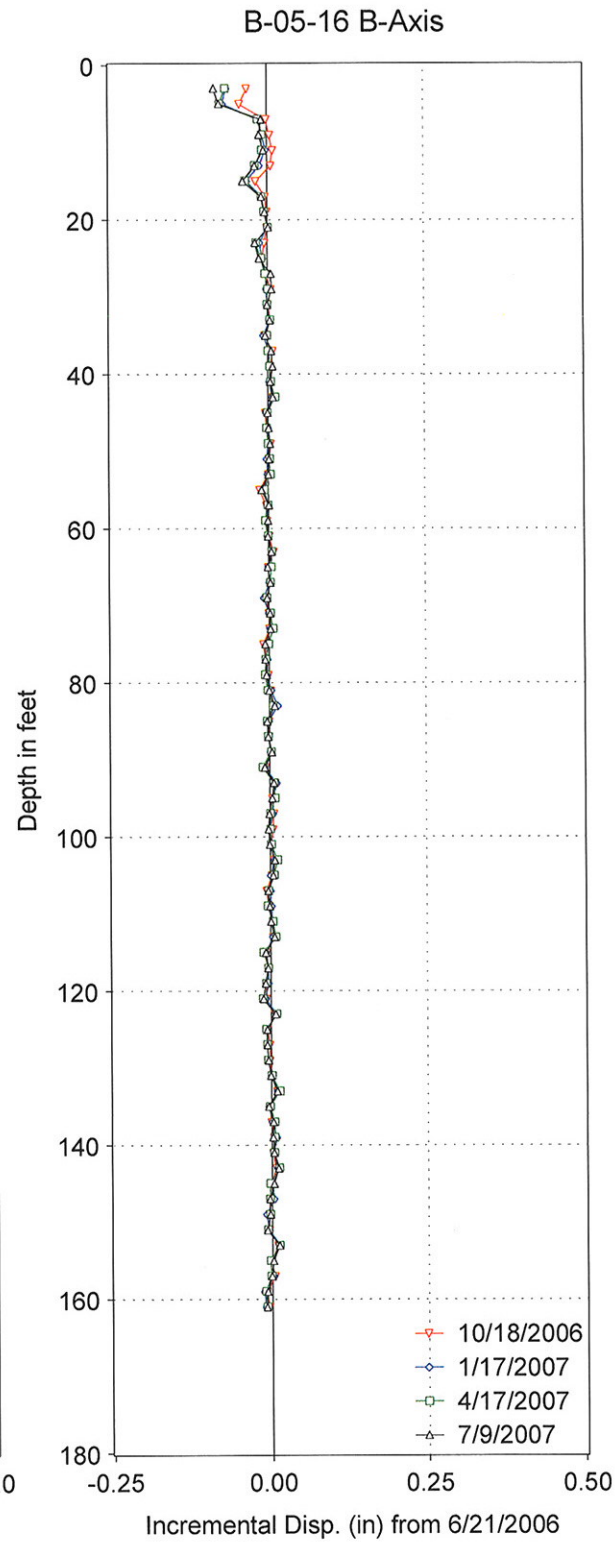




B-05-16
-Includes readings from the last four quarters.

PLATE 46





B-05-16
-Includes readings from the last four quarters.

PLATE 47

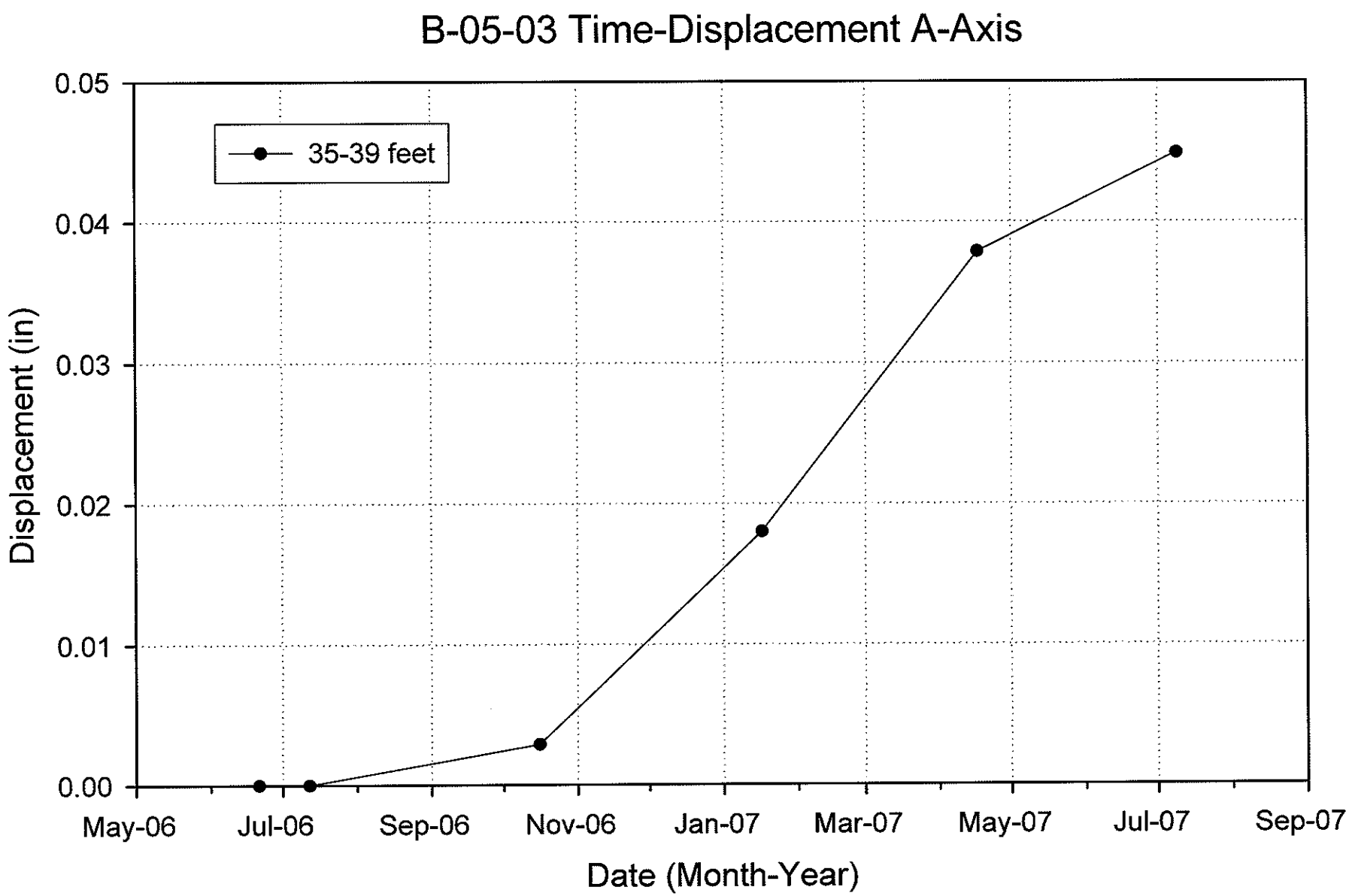

B-05-03 Time-Displacement A-Axis
35-39 feet
Displacement (in)
0.05
0.04
0.03
0.02
0.01
0.00
May-06
Jul-06
Sep-06
Nov-06
Jan-07
Mar-07
May-07
Jul-07
Sep-07
Date (Month-Year)

PLATE 48

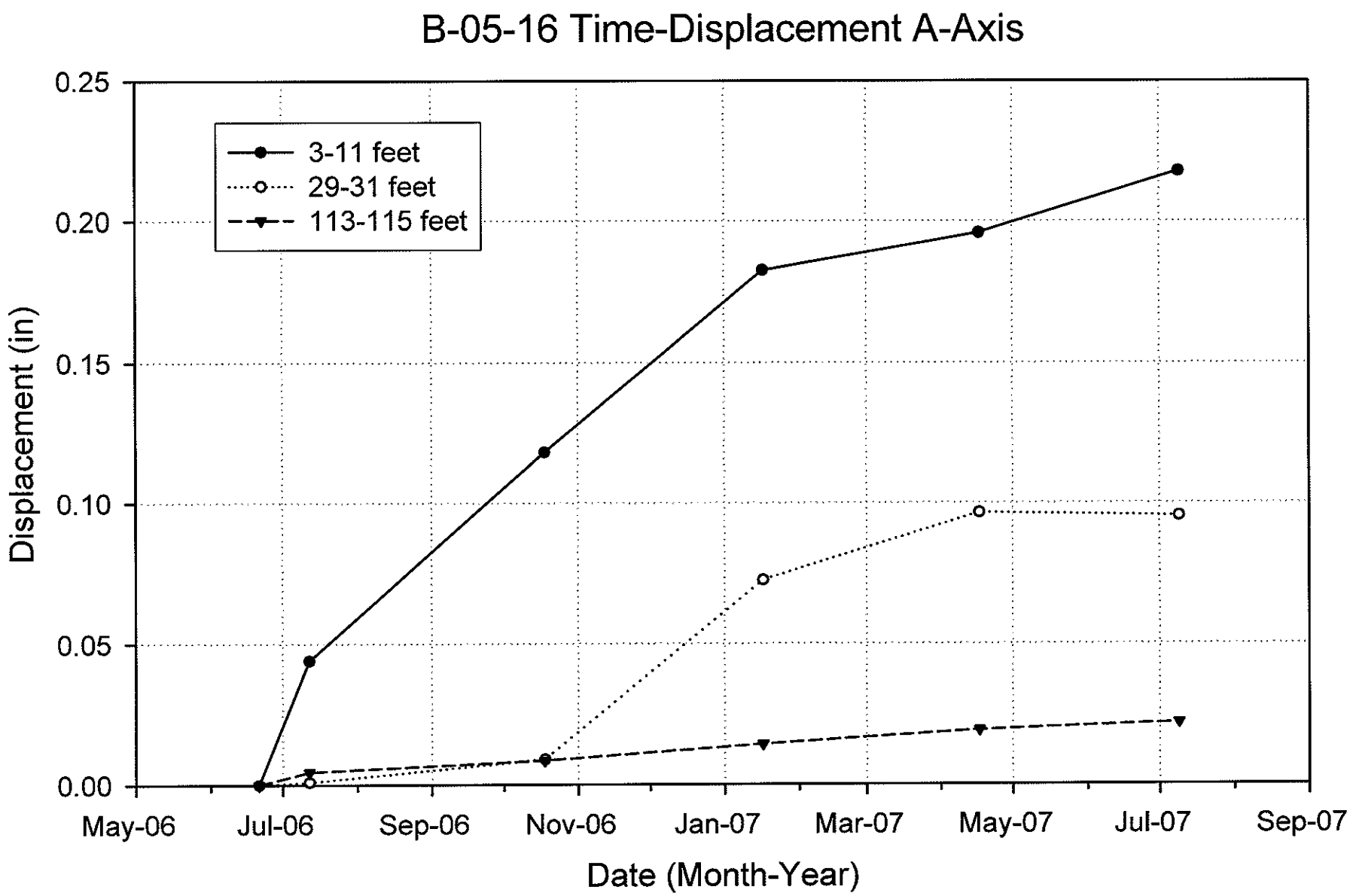

B-05-16 Time-Displacement A-Axis
3-11 feet
29-31 feet
113-115 feet
Displacement (in)
0.25
0.20
0.15
0.10
0.05
0.00
May-06
Jul-06
Sep-06
Nov-06
Jan-07
Mar-07
May-07
Jul-07
Sep-07
Date (Month-Year)

PLATE 49

B-101 (P-1) Pneumatic Piezometer Readings

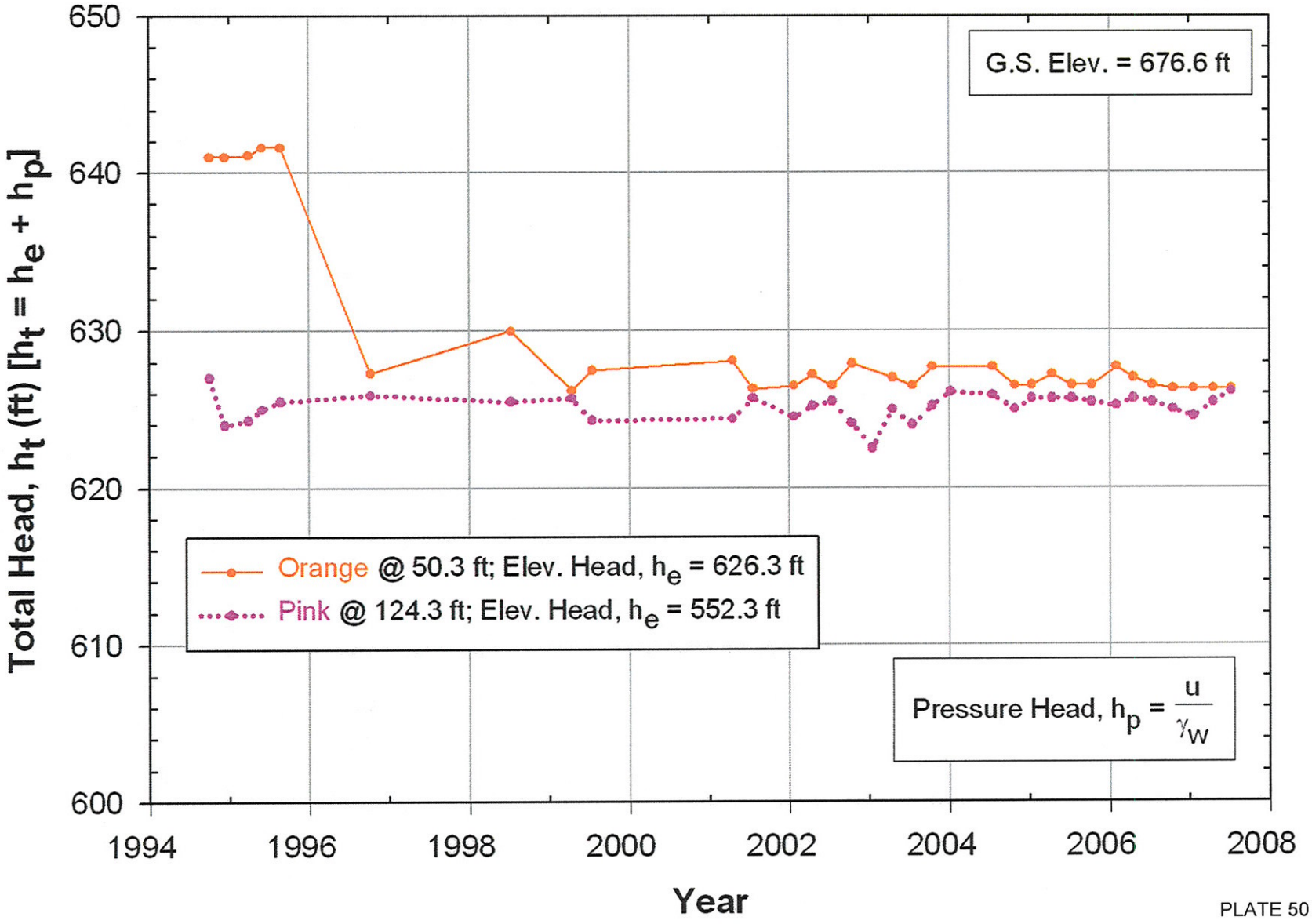


PLATE 50

B-105 (P-3) Pneumatic Piezometer Readings

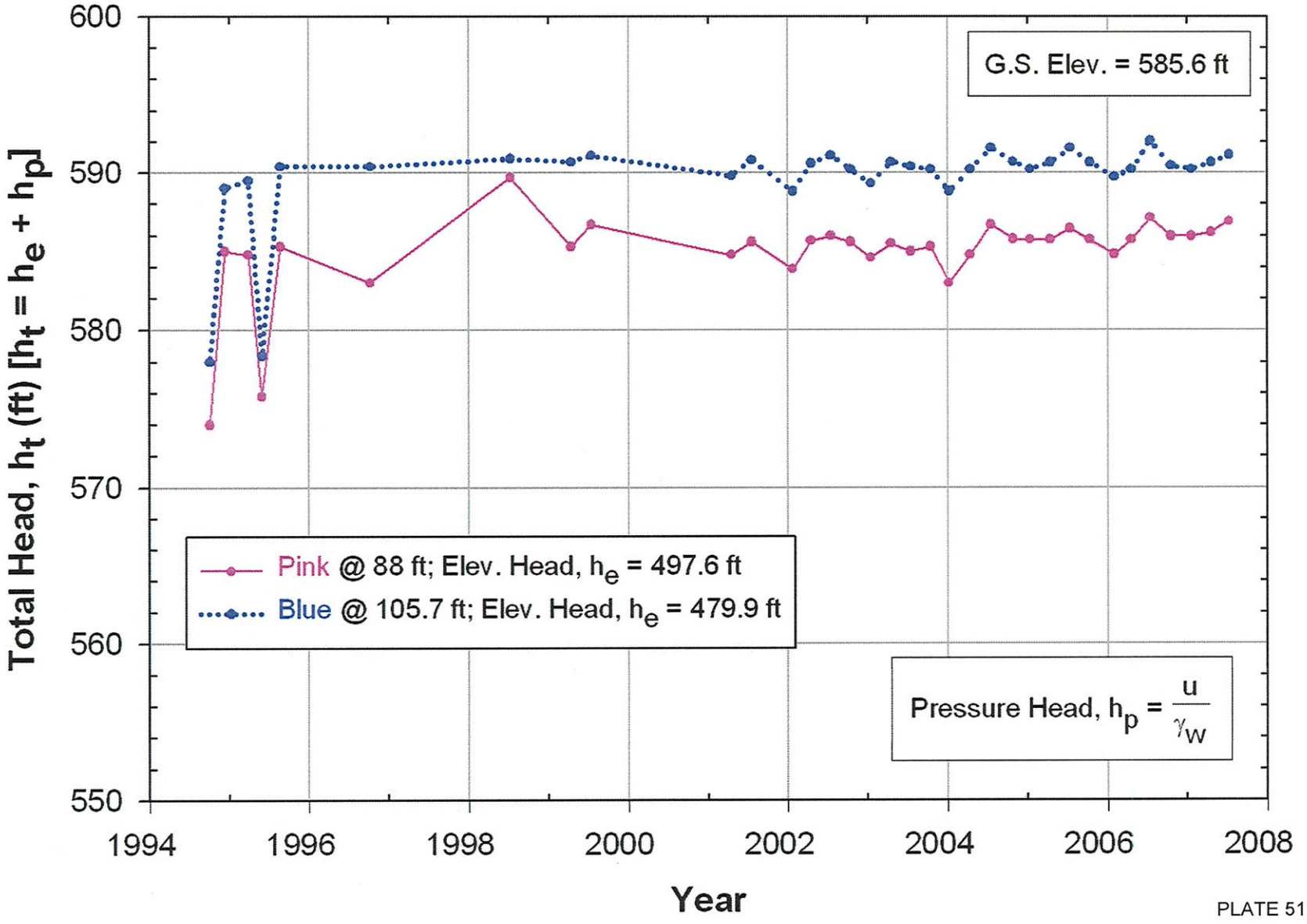


PLATE 51

B-107 (P-5) Pneumatic Piezometer Readings

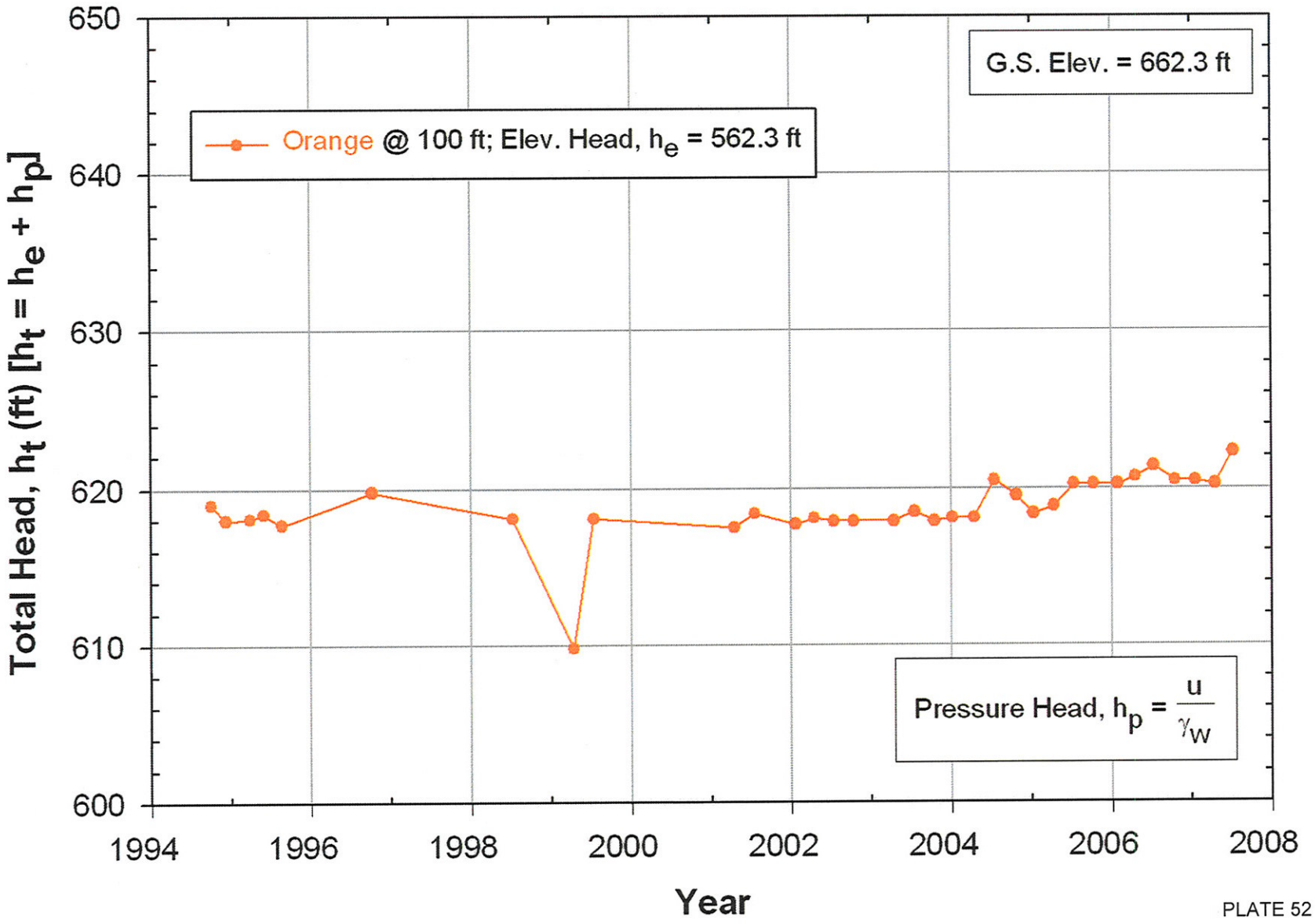


PLATE 52

B-303 (P-2) Pneumatic Piezometer Readings

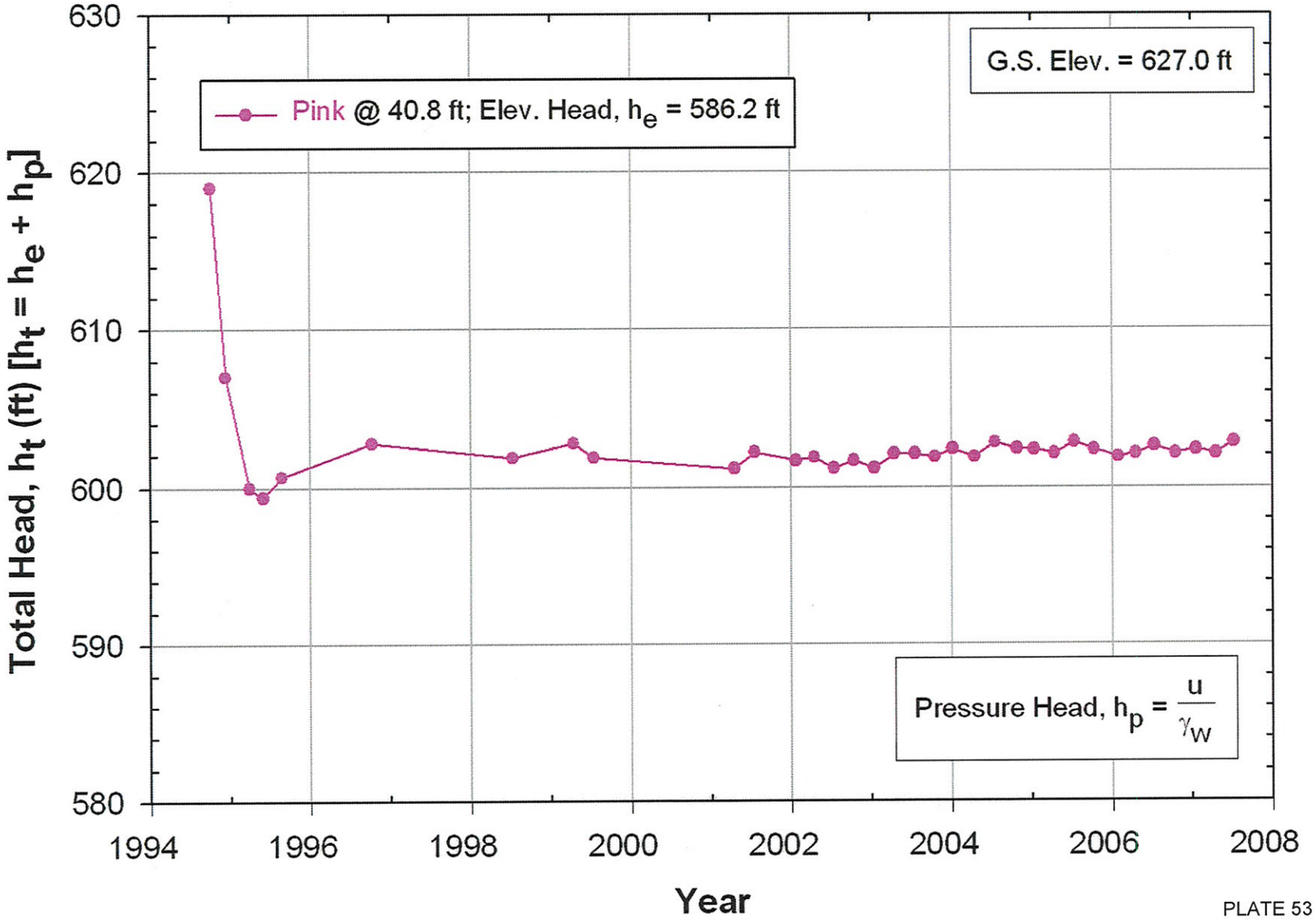


PLATE 53

B-05-01 VW Piezometer Readings

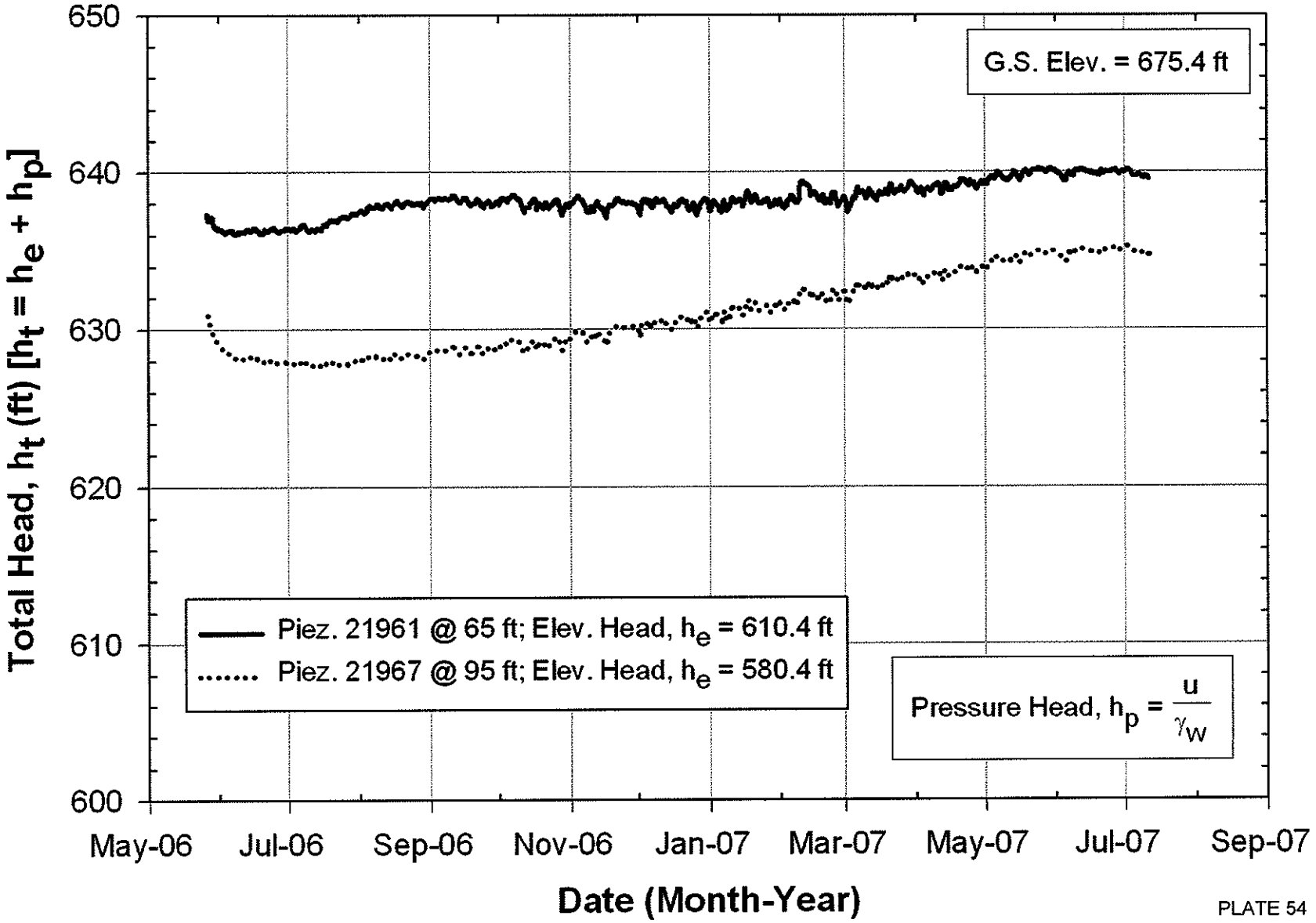


PLATE 54

B-05-02 VW Piezometer Readings

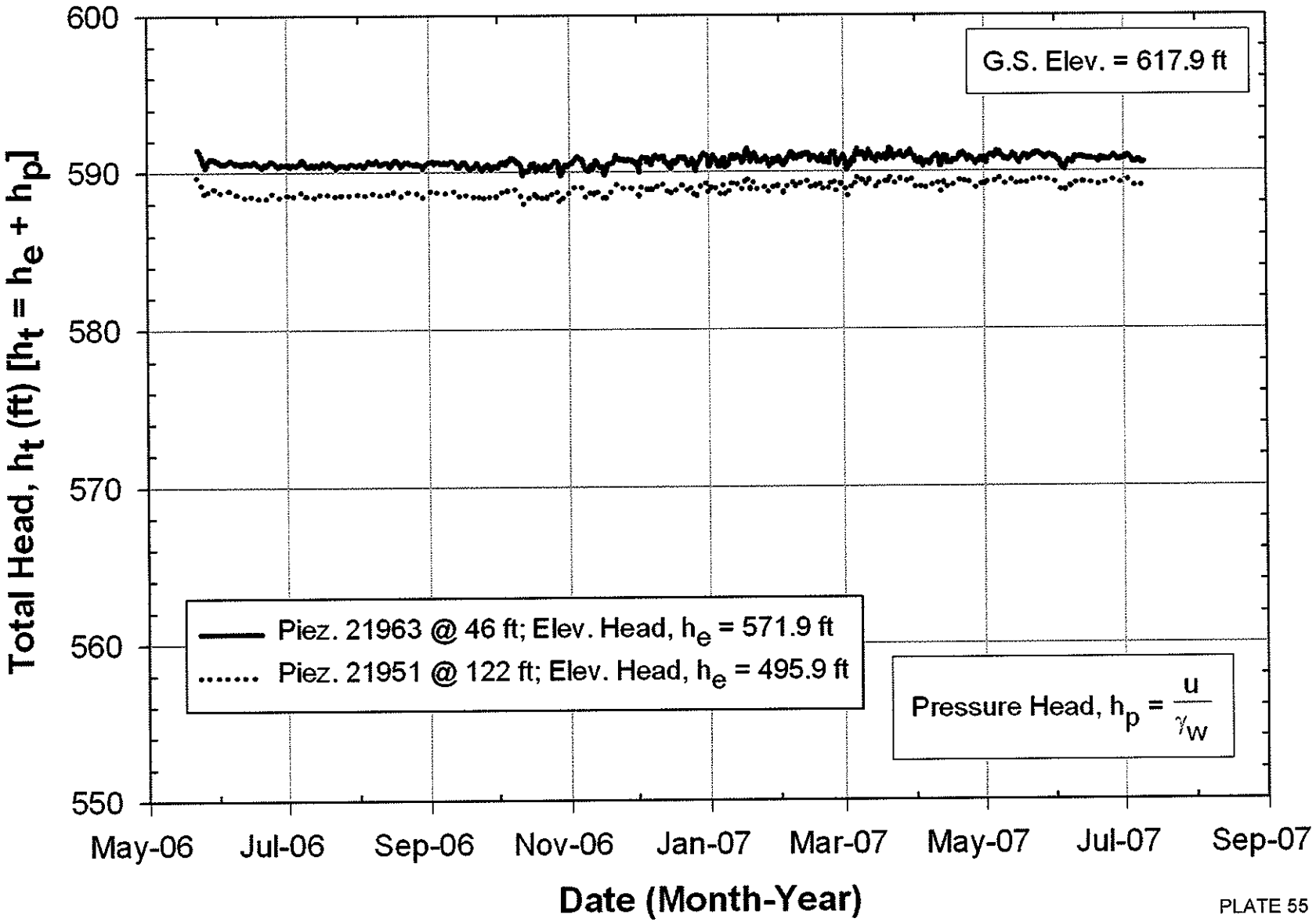


PLATE 55

B-05-03 VW Piezometer Readings

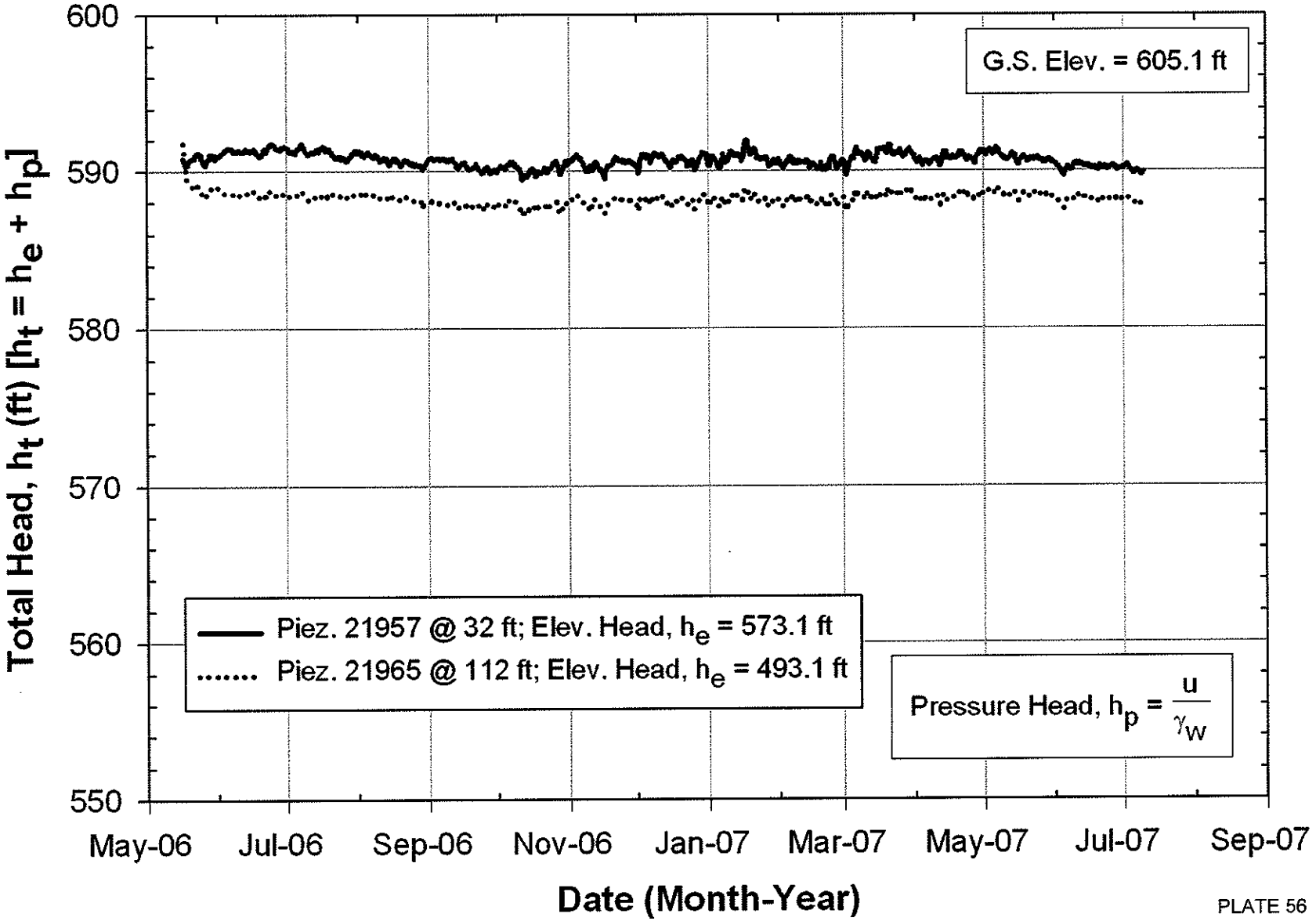


PLATE 56

B-05-04 VW Piezometer Readings

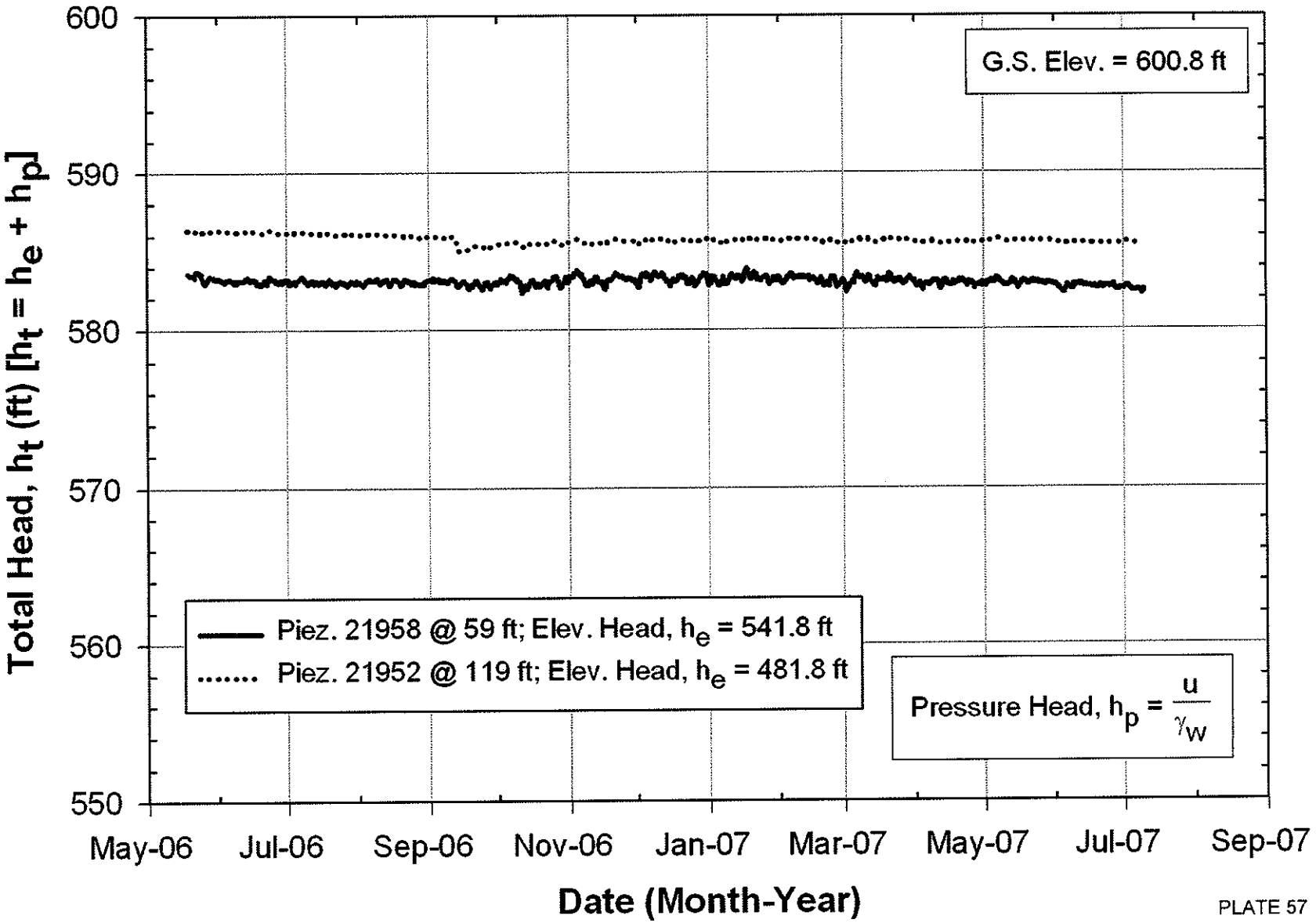


PLATE 57

B-05-07 VW Piezometer Readings

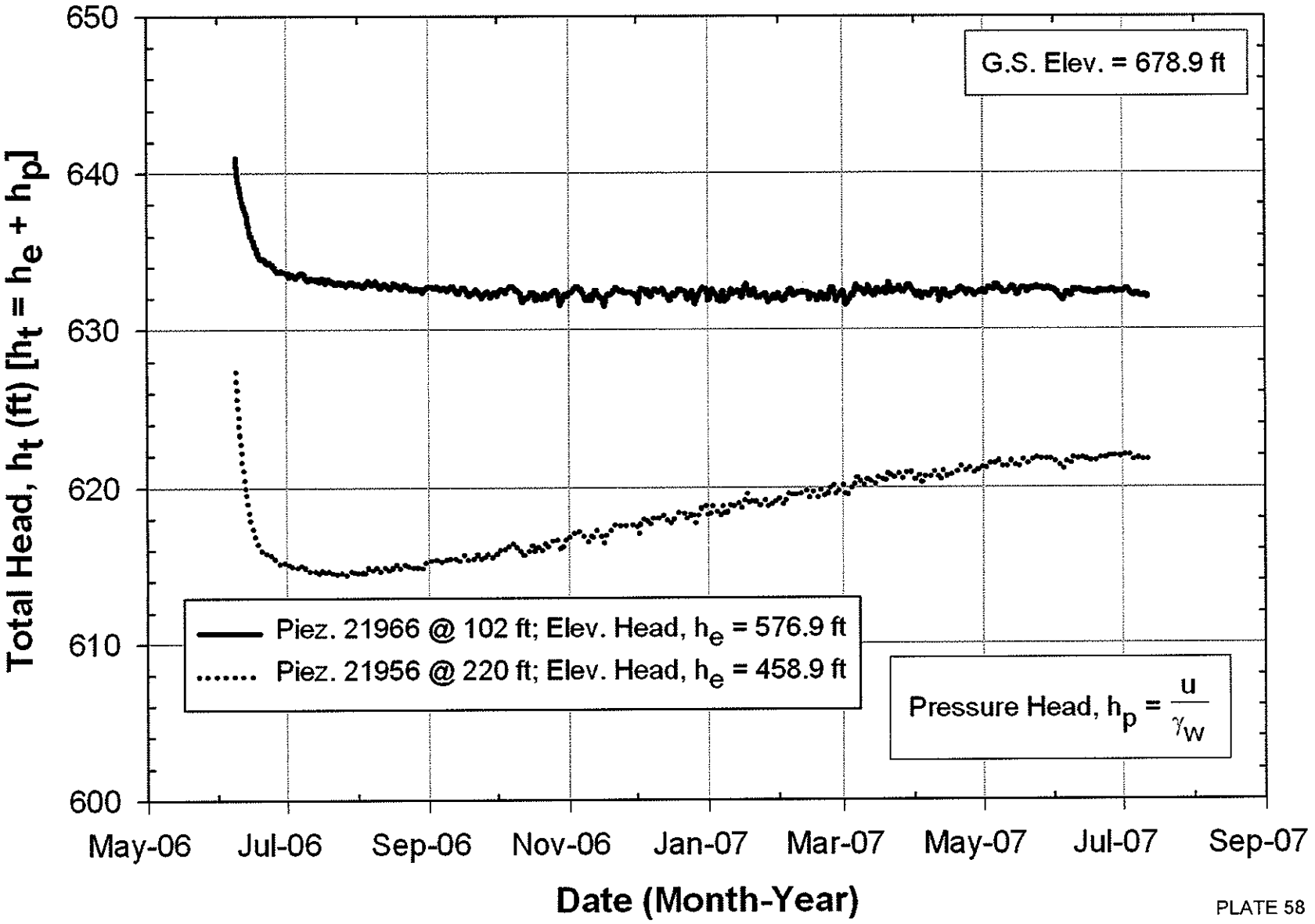


PLATE 58

B-05-08 VW Piezometer Readings

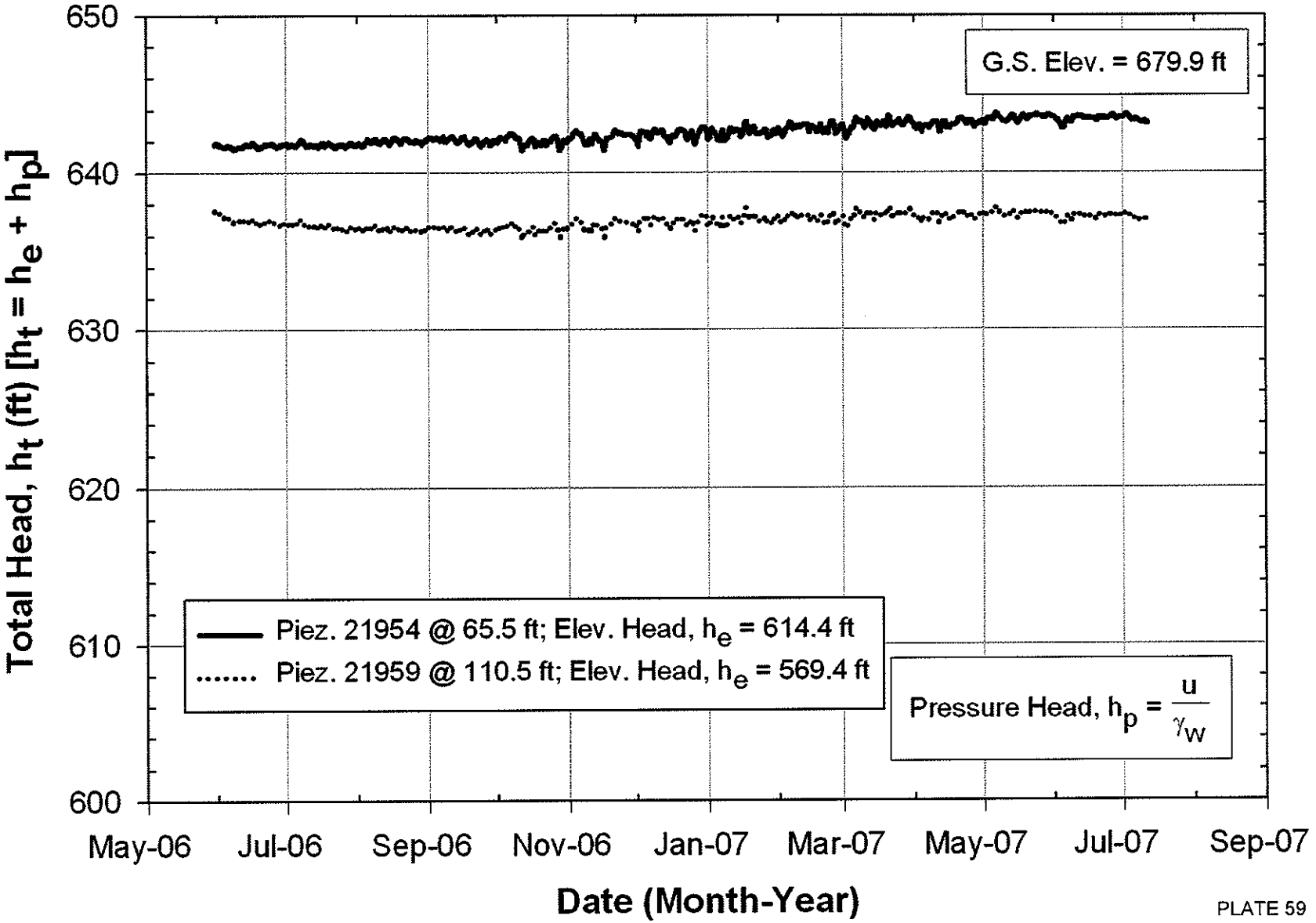


PLATE 59

B-05-11 VW Piezometer Readings

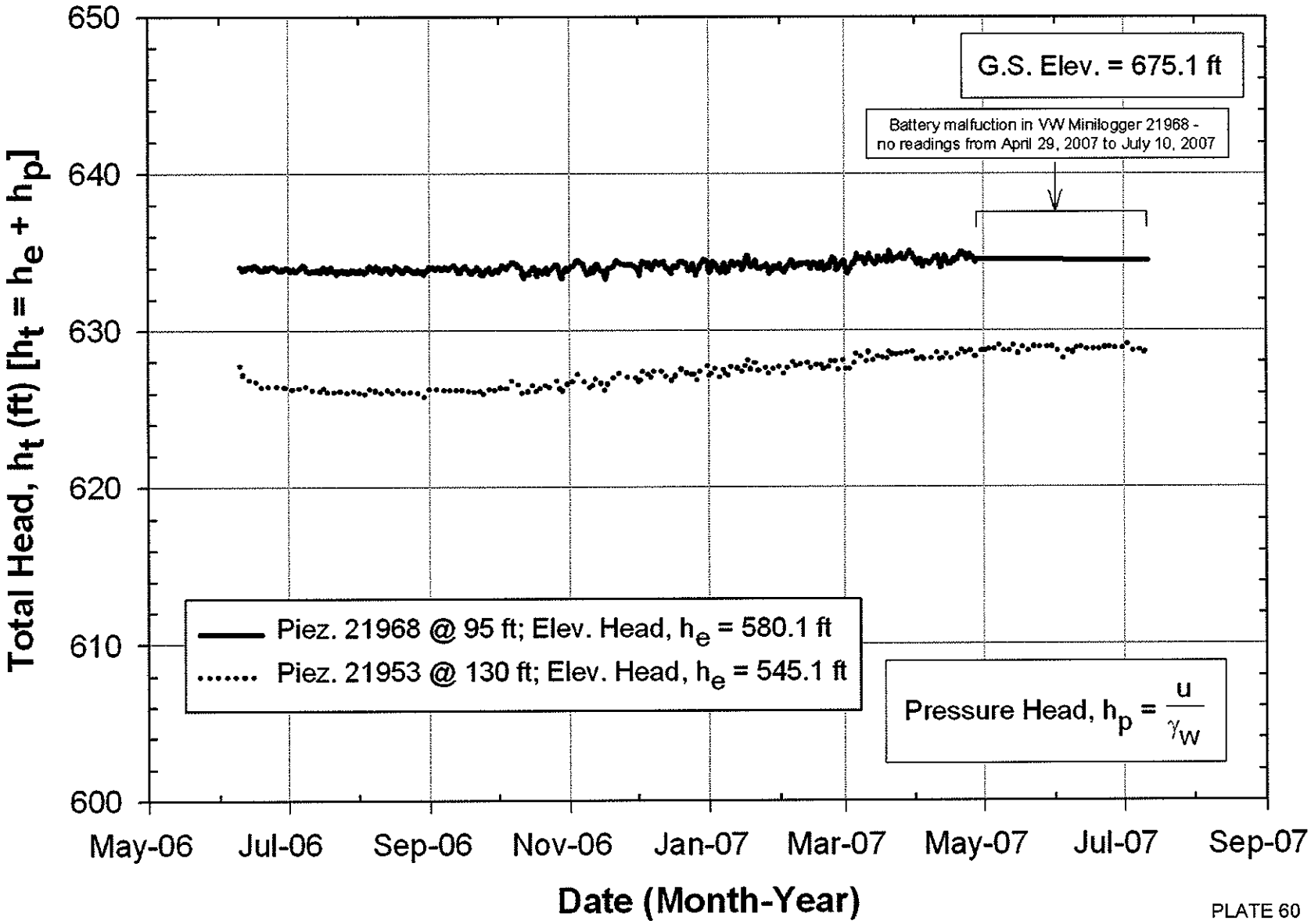


PLATE 60

B-05-12 VW Piezometer Readings

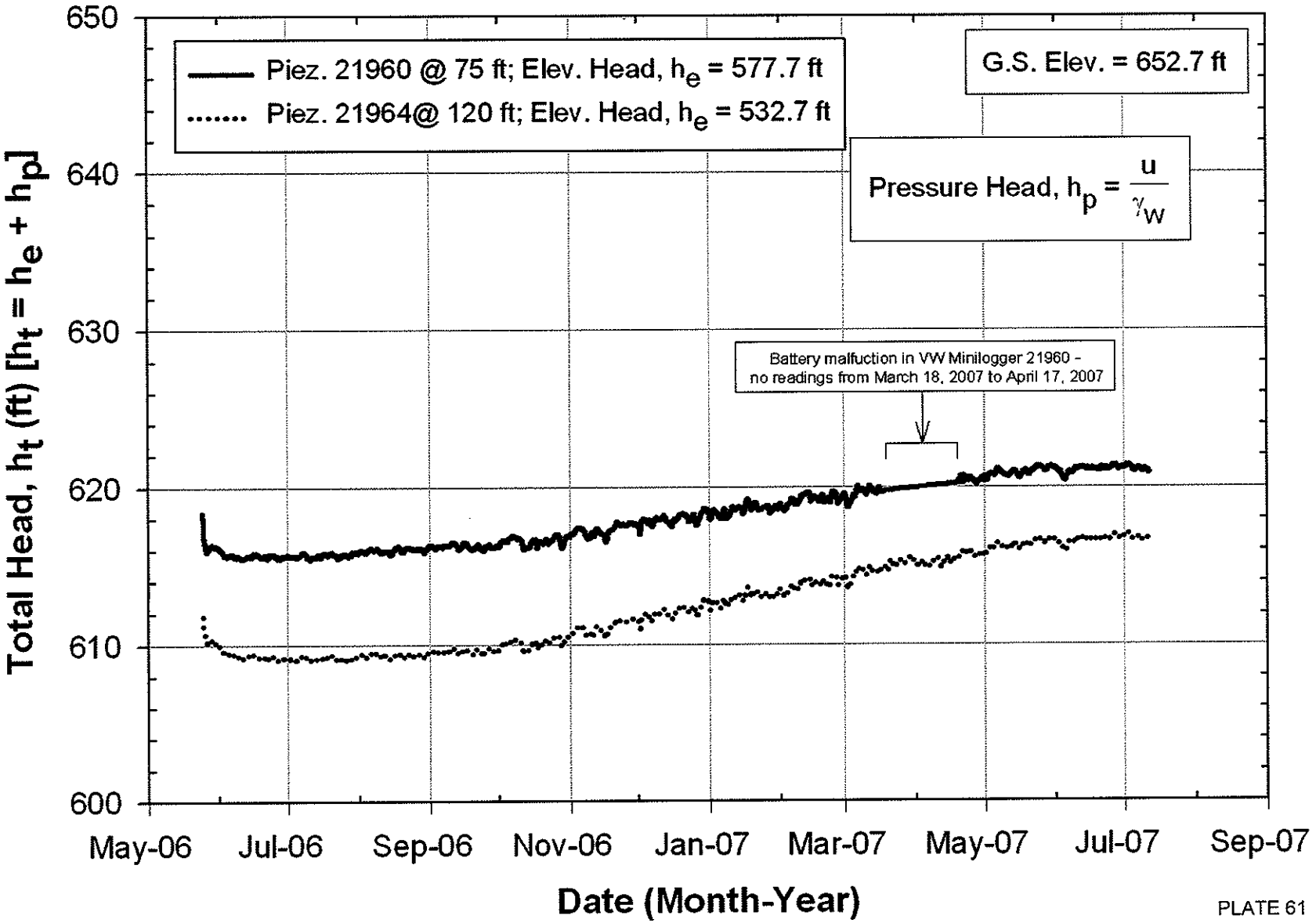


PLATE 61

B-05-13 VW Piezometer Readings

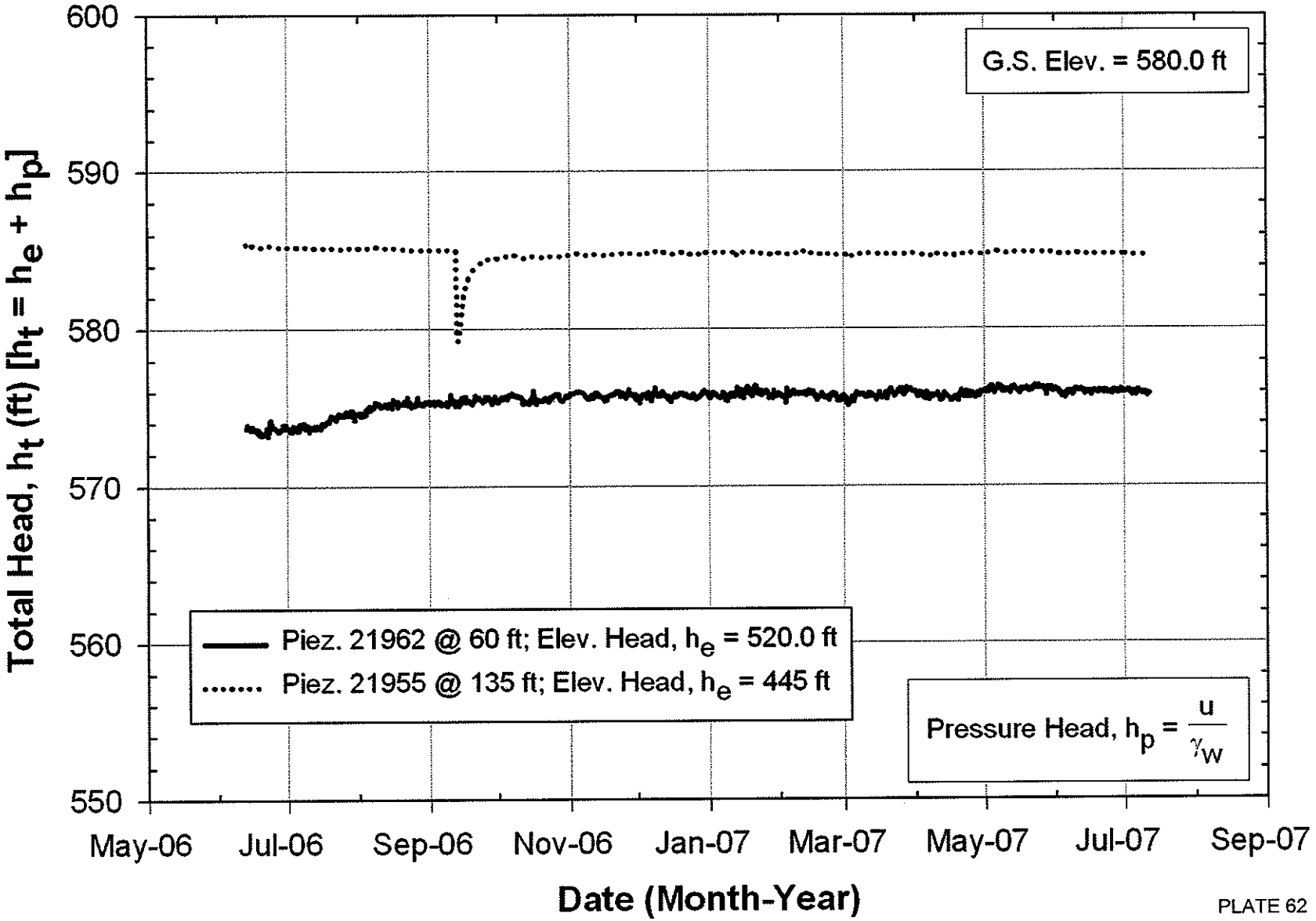


PLATE 62

CALIPERED SURFACE DISTANCE TABLE
CUY-90-15.24

Date	Left Pier Calipered Surface Distance		Center Line Calipered Surface Distance		Right Pier Calipered Surface Distance	
	Present reading	Change (in.)	Present reading	Change (in.)	Present reading	Change (in.)
10/26/00	5.876	--	Not Accessible		4.294	--
01/29/01	5.929	0.053	Not Accessible		4.385	0.091
04/17/01	Not Accessible		Not Accessible		Not Accessible	
07/19/01	6.043	0.114	Not Accessible		4.312	-0.073
11/08/01	6.250	0.207	Not Accessible		4.469	0.157
01/23/02	6.253	0.003	Not Accessible		4.518	0.049
04/17/02	6.285	0.032	Not Accessible		4.435	-0.083
07/16/02	6.290	0.005	Not Accessible		4.444	0.009
10/15/02	6.333	0.043	Discontinued		4.482	0.038
01/15/03	6.405	0.072			4.473	-0.009
04/17/03	6.333	-0.072			4.482	0.009
07/18/03	6.186	-0.147			4.350	-0.132
10/16/03	6.385	0.199			4.519	0.169
01/08/04	6.124	-0.261			4.594	0.075
04/14/04	6.129	0.005			4.402	-0.193
07/16/04	6.250	0.122			4.277	-0.125
10/27/04	6.375	0.125			4.467	0.190
01/12/05	6.250	-0.125			4.349	-0.118
04/14/05	6.375	0.125			4.372	0.023
07/14/05	6.313	-0.063			4.392	0.020
10/12/05	6.375	0.063			4.358	-0.034
02/01/06	6.438	0.063			4.395	0.037
04/20/06	6.500	0.063			4.430	0.035
07/14/06	6.375	-0.125			4.381	-0.049
10/18/06	6.438	0.063			4.400	0.020
01/19/07	6.500	0.062			4.506	0.106
04/18/07	6.375	-0.125			4.357	-0.150
07/11/07	6.438	0.063			4.341	-0.015

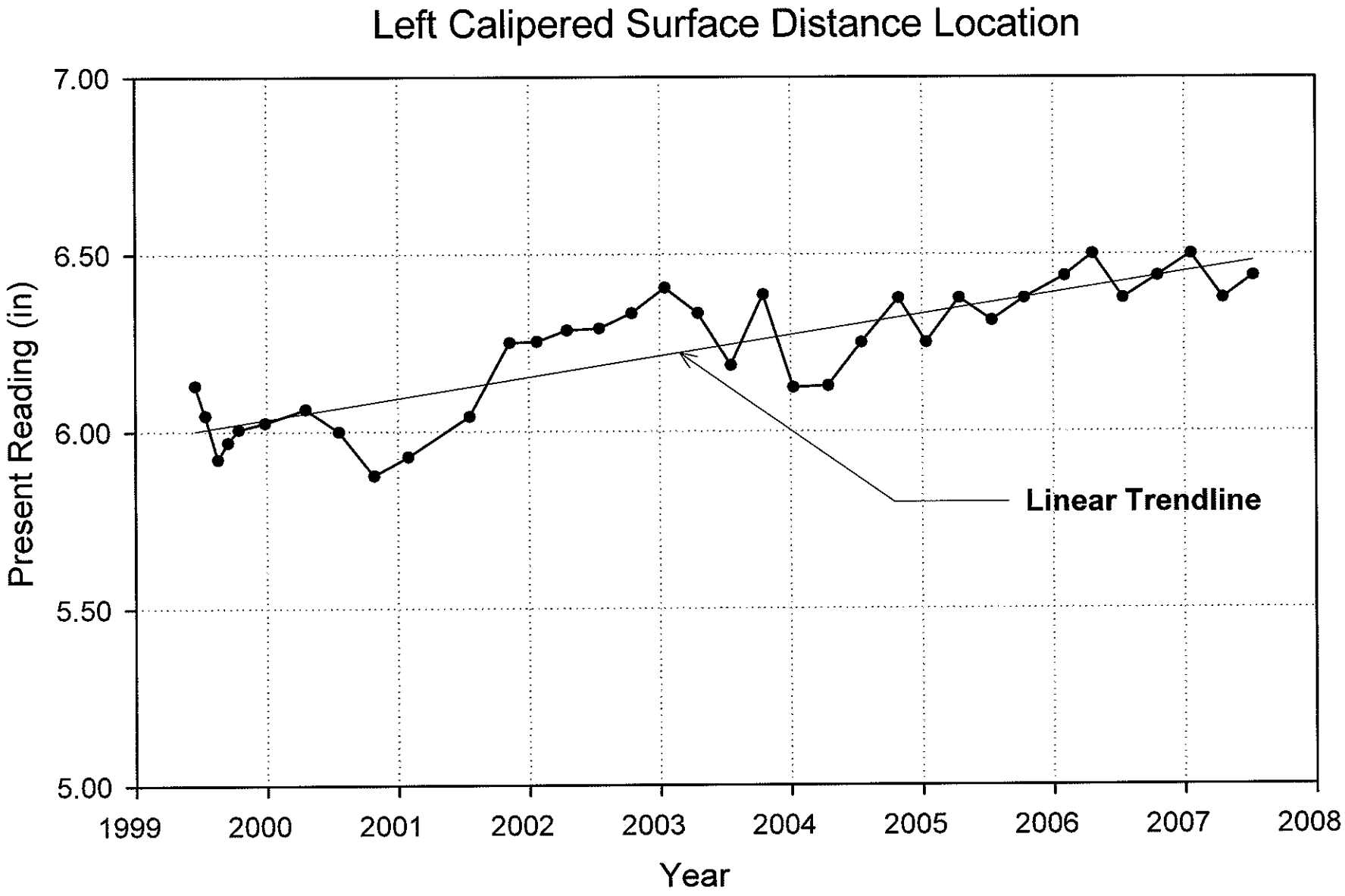

Left Calipered Surface Distance Location
7.00
6.50
6.00
5.50
5.00
Present Reading (in)
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Linear Trendline

PLATE 64

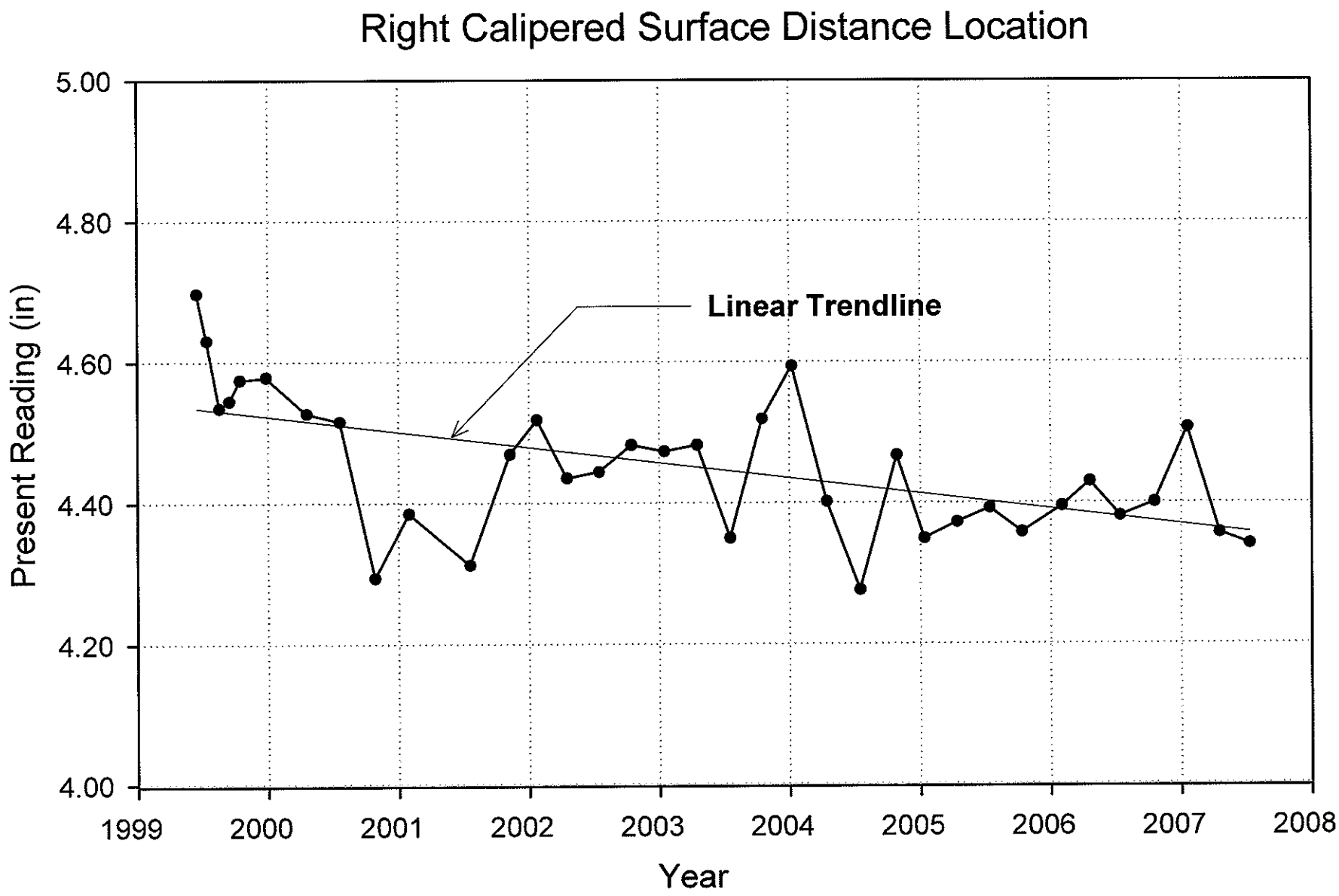

Right Calipered Surface Distance Location
5.00
4.80
4.60
4.40
4.20
4.00
Present Reading (in)
Linear Trendline
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year

PLATE 65

View towards the northwest of the excavation area adjacent to the west right-of-way fence.

PLATE 66

View towards the northwest of the bulkhead in the excavation area adjacent to the west right-of-way fence.

PLATE 67

View towards the west of the excavation area adjacent to the west right-of-way fence.

PLATE 68

View towards the northeast of a large scarp in the landslide area adjacent to the west right-of-way fence.

PLATE 69

View towards the north of a gap in the bulkhead at the east end of the excavation area adjacent to the west right-of-way fence.

PLATE 70

View of a large scarp in the landslide area adjacent to the west right-of-way fence.

PLATE 71

View towards the south of the large excavation area and landslide area. Photo taken from near B-05-13 across the Cuyahoga River.

PLATE 72

View towards the south of the landslide area adjacent to the west right-of-way fence.
Photo taken from near B-05-13 across the Cuyahoga River.

PLATE 73

Richland Engineering Limited 10L07

From: "arthur huckelbridge" <aah4@case.edu>
To: "'Richland Engineering Limited'" <reltd@r-e-l.com>
Sent: Wednesday, July 18, 2007 1:59 PM
Attach: tilts_July'07.ppt
Subject: RE: Gate at I-90 Site

Dean:

Attached is the updated tiltmeter readings from July '07. Tiltmeter #6 indicates a small spike, which I am willing to consider a possibly spurious reading, given no dramatic changes were evident in the other instruments. There is more evidence of kids' presence (increased grafitti, etc.) at pier #1, but no overt evidence, as yet, of vandalism to the instruments. We will watch #6 more closely to see if it reverts to historical trends next quarter. All other instruments are continuing historical trends. Contact me if you have any questions.

Regards,

Art

From: Richland Engineering Limited [mailto:reltd@r-e-l.com]
Sent: Tuesday, June 26, 2007 8:19 AM
To: Arthur Huckelbridge
Subject: Fw: Gate at I-90 Site

Art,

For your information.

Dean Palmer

----- Original Message -----
From: Richland Engineering Limited
To: Jeff Snyder
Cc: arthur.helmicki@uc.edu ; Robert Liang ; Mike Malloy
Sent: Tuesday, June 26, 2007 8:13 AM
Subject: Re: Gate at I-90 Site

Jeff,

District 12 put the new lock on the gate to secure the site. They do not want to copy the key. Contact Mike Malloy at District (216-581-2100) to borrow the key when you need access. You may want to coordinate with Robert Liang who will also need access about the same time. The next quarterly data collection should be around July 15.

Let us know if you have questions.

Thank you,
Dean Palmer

----- Original Message -----
From: Jeff Snyder
To: Richland Engineering Limited
Sent: Monday, June 25, 2007 9:29 AM

Subject: Gate at I-90 Site

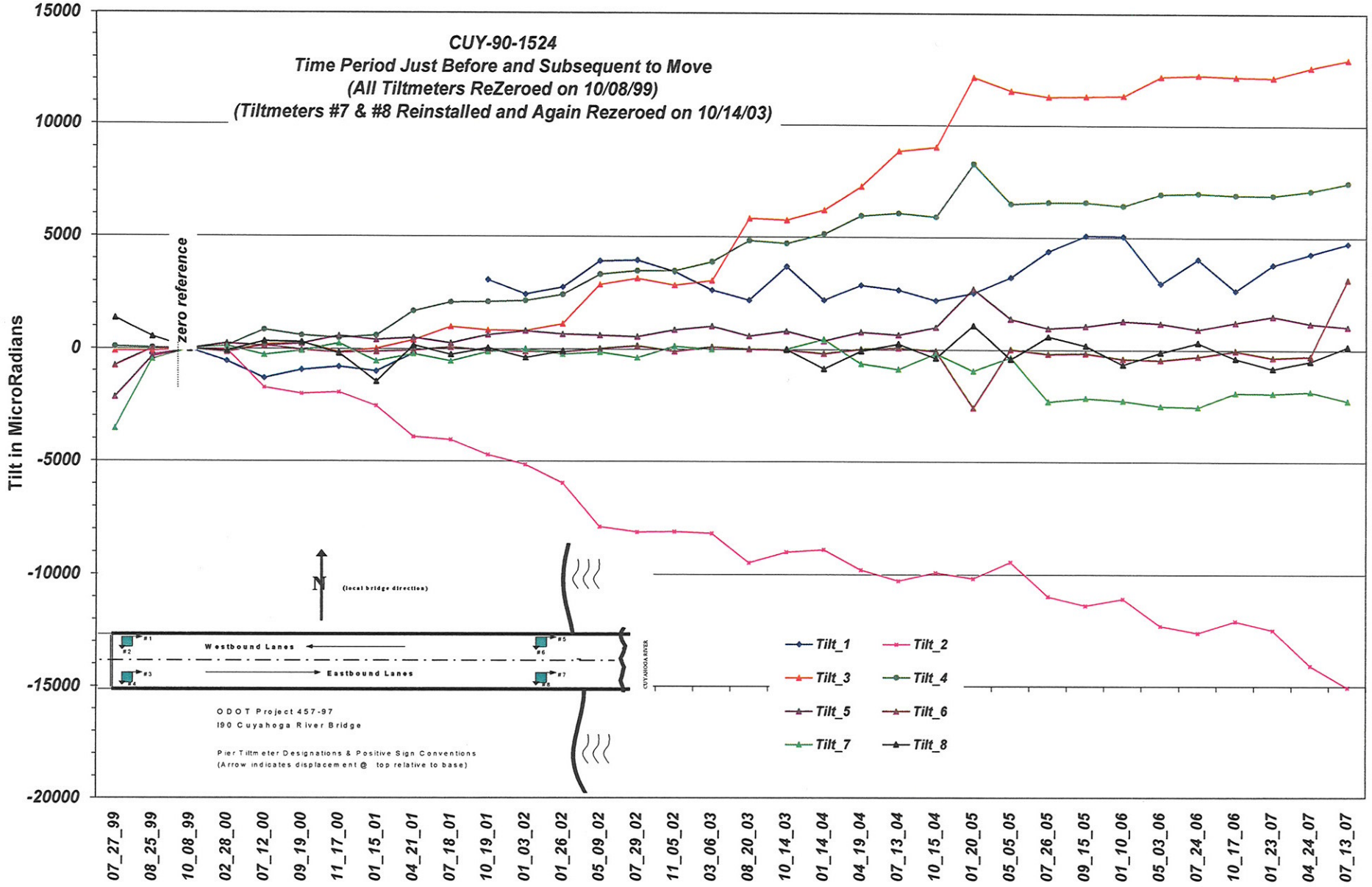
Dean,

I was passing through the site and noticed that a new lock (resembles a bicycle lock) has been placed on the gate to the access road. As we will be taking readings in a few weeks, we need to have a key to that lock. Could you send us a copy at your earliest convenience?

Thanks,
Jeff Snyder
BBC&M Engineering, Inc.
8555 Sweet Valley Drive
Suite S
Valley View, Ohio 44125

Phone 216.901.1000
Fax 216.901.9996
www.BBCM.com

Attention: This e-mail message, including any attachment(s) (collectively the "e-mail"), has been sent by BBC&M Engineering, Inc. and may contain PRIVILEGED AND CONFIDENTIAL INFORMATION. If you are not the intended recipient, then please (i) do not read this e-mail, (ii) do not forward, print, copy or otherwise disseminate this e-mail, (iii) notify us of the error by a reply to this e-mail and (iv) delete this e-mail from your computer. Thank you.


CUY-90-1524
Time Period Just Before and Subsequent to Move
(All Tiltmeters ReZeroed on 10/08/99)
(Tiltmeters #7 & #8 Reinstalled and Again Rezeroed on 10/14/03)
Tilt in MicroRadians
15000
10000
5000
0
-5000
-10000
-15000
-20000
zero reference
07_27_99
08_25_99
10_08_99
02_28_00
07_12_00
09_19_00
11_17_00
01_15_01
04_21_01
07_18_01
10_19_01
01_03_02
01_26_02
05_09_02
07_29_02
11_05_02
03_06_03
08_20_03
10_14_03
01_14_04
04_19_04
07_13_04
10_15_04
01_20_05
05_05_05
07_26_05
09_15_05
01_10_06
05_03_06
07_24_06
10_17_06
01_23_07
04_24_07
07_13_07
Tilt_1
Tilt_2
Tilt_3
Tilt_4
Tilt_5
Tilt_6
Tilt_7
Tilt_8
N
(local bridge direction)
Westbound Lanes
Eastbound Lanes
CUYAHOGA RIVER
ODOT Project 457-97
I90 Cuyahoga River Bridge
Pier Tiltmeter Designations & Positive Sign Conventions
(Arrow indicates displacement @ top relative to base)

Robert Y. Liang, Ph.D., P.E
8441 Timber Tr.
Brecksville, Ohio 44141

Cell Phone: (440) 725-7425
e-mail: RYLIANG@AOL.COM

July 24, 2007

Mr. Dean Palmer, P.E.
Richland Engineering, Ltd.
29 North Park St.
Mansfield, OH 44902

Ref: CUY-90-14.52, PID No. 77332

Dear Mr. Palmer:

Attached please find the processed monitoring data for the stabilization structures for the above referenced project. We went to the project site on July 9 and 11, 2007 to download the data and to take the inclinometer readings. The on-site data logger was maintained and the batteries were replaced with new ones as well. All data acquisition equipment at the site has been functioning well in this period.

The processed data is provided in the attached plots and tables. As indicated by the attached monitoring data, there was no significant change in the readings from all the strain gages and load cells during this monitoring period; i.e., between April 2007 and July 2007. The inclinometer readings of the six casings in the drilled shafts showed no significant movement in this quarter.

If you have any question or concern about the data, please call me at (440) 725-7425. Thank you.

Sincerely,

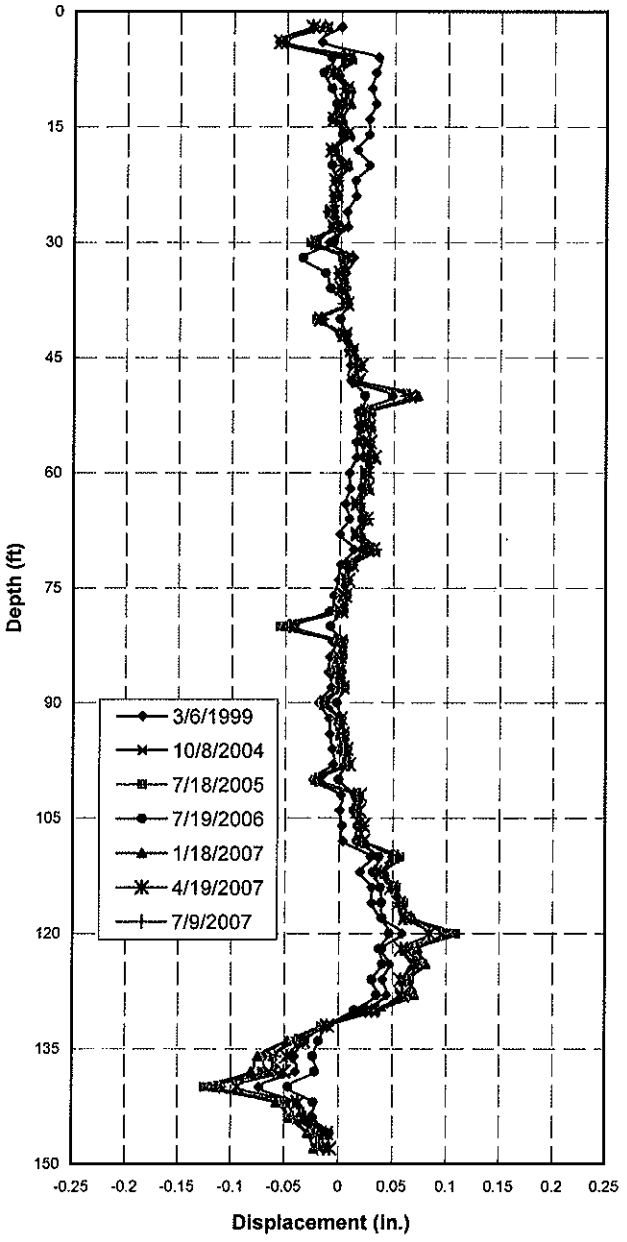
Robert Liang

Robert Liang

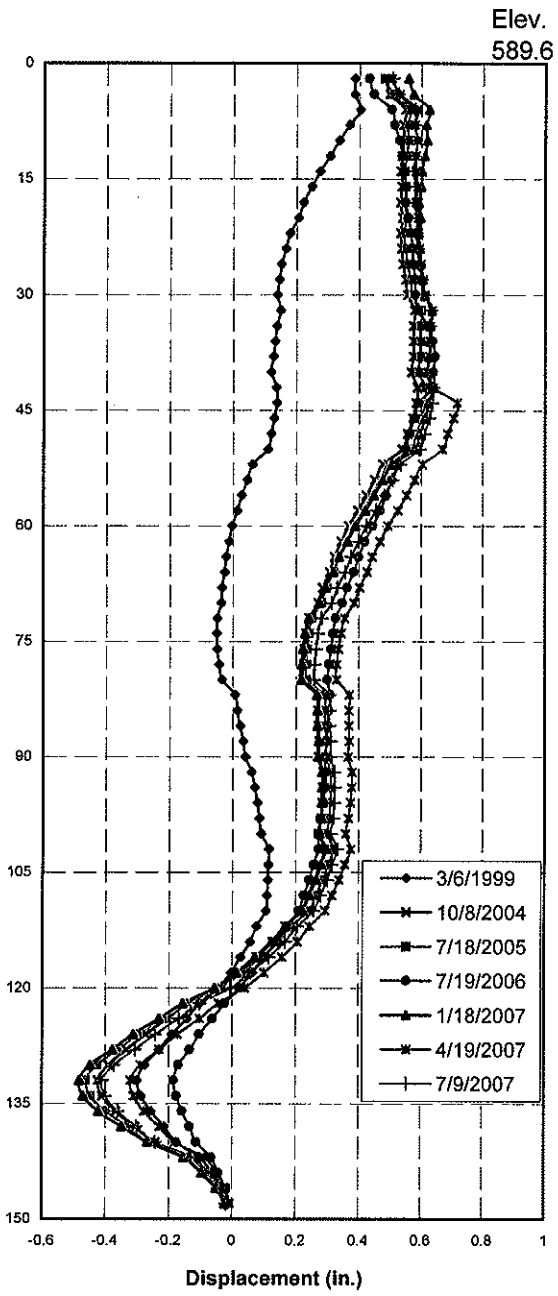
RECEIVED
JUL 26 2007
RICHLAND ENGINEERING LIMITED

Inclinometer #1 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

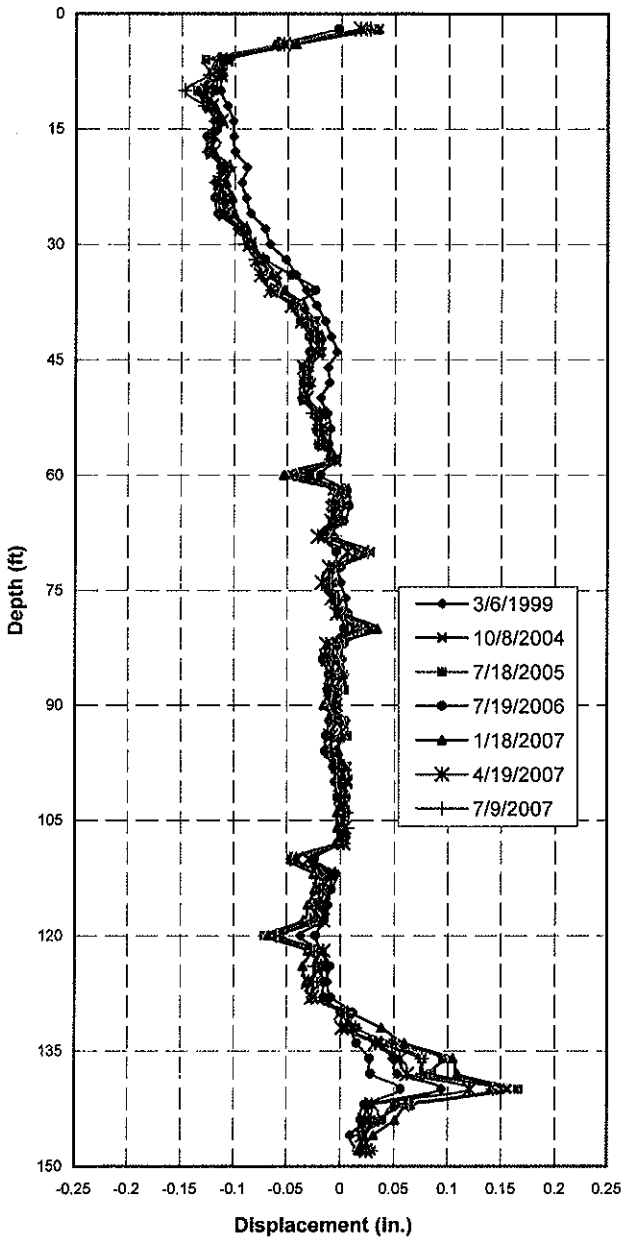


Cumulative

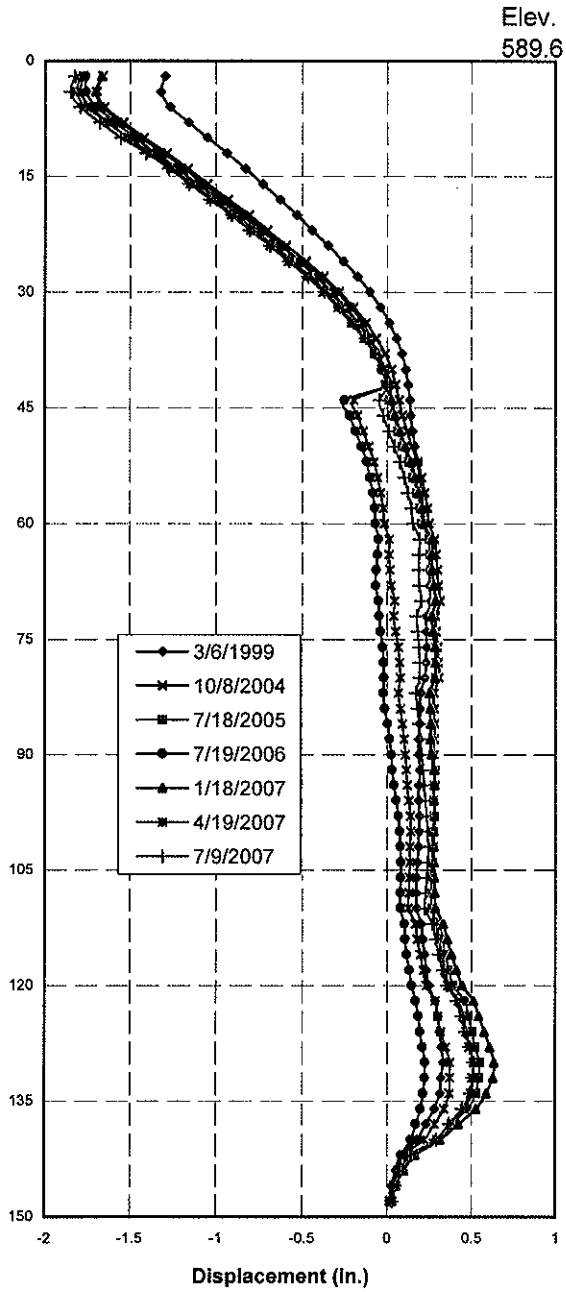


Inclinometer #1 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

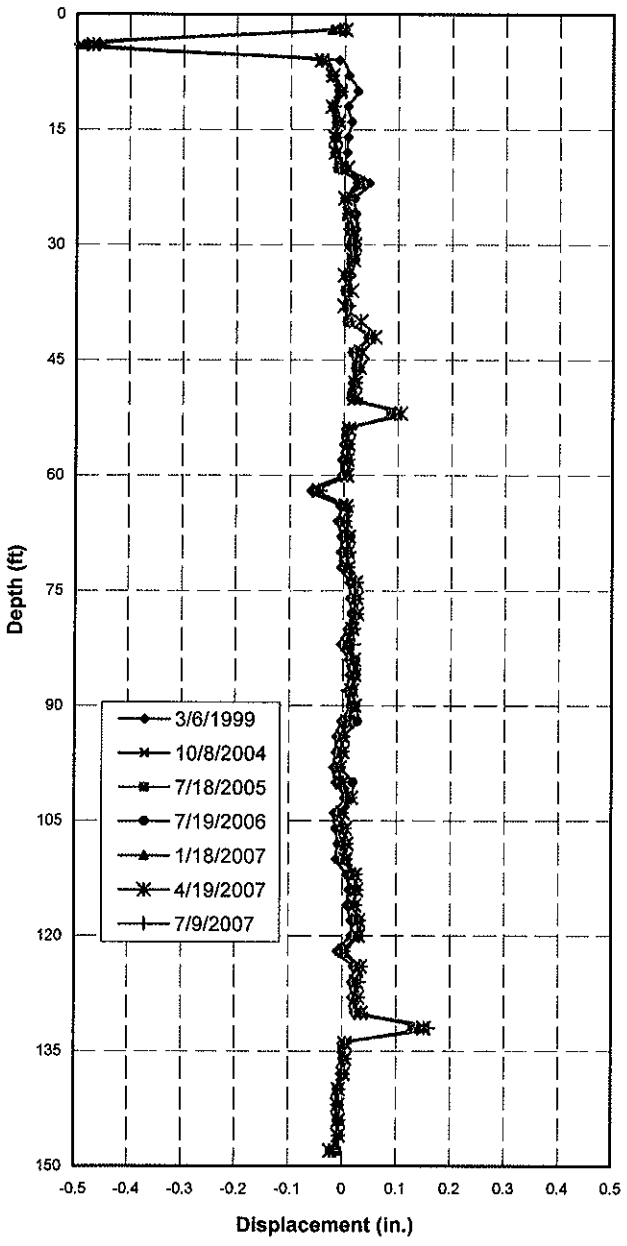


Cumulative

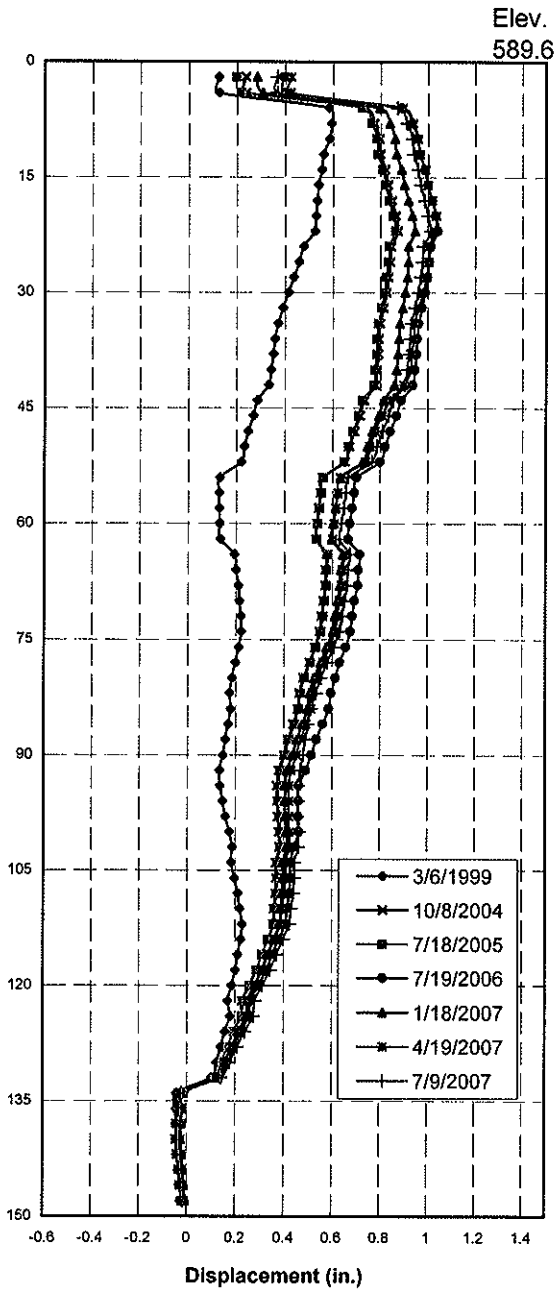


Inclinometer #3 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

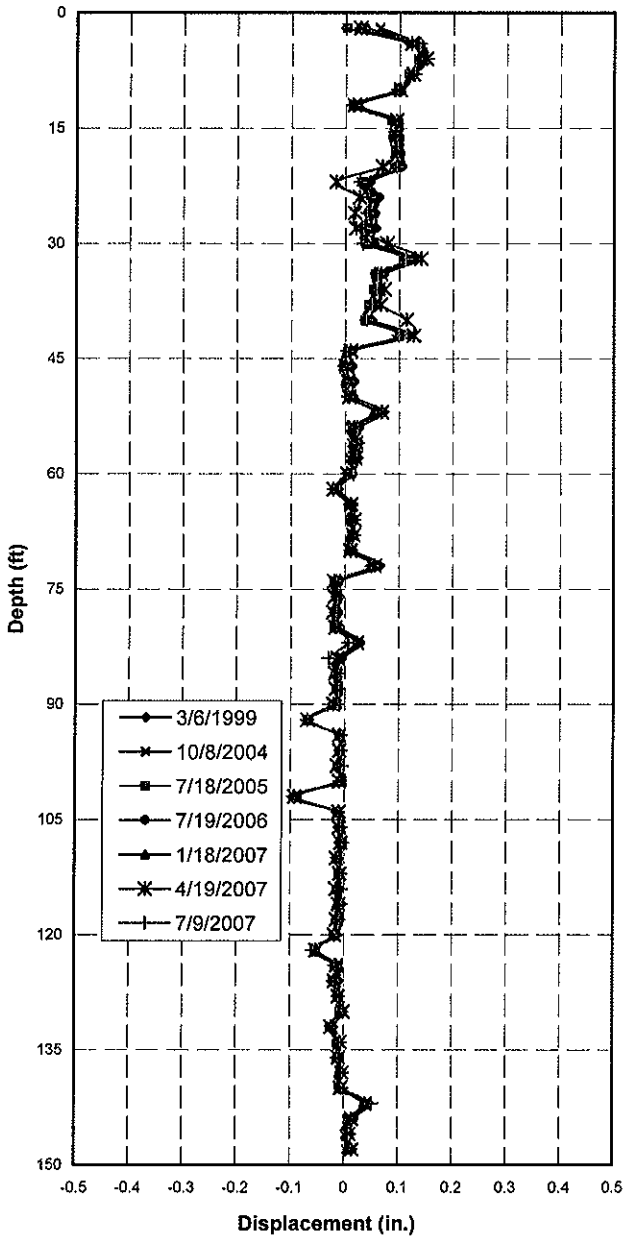


Cumulative

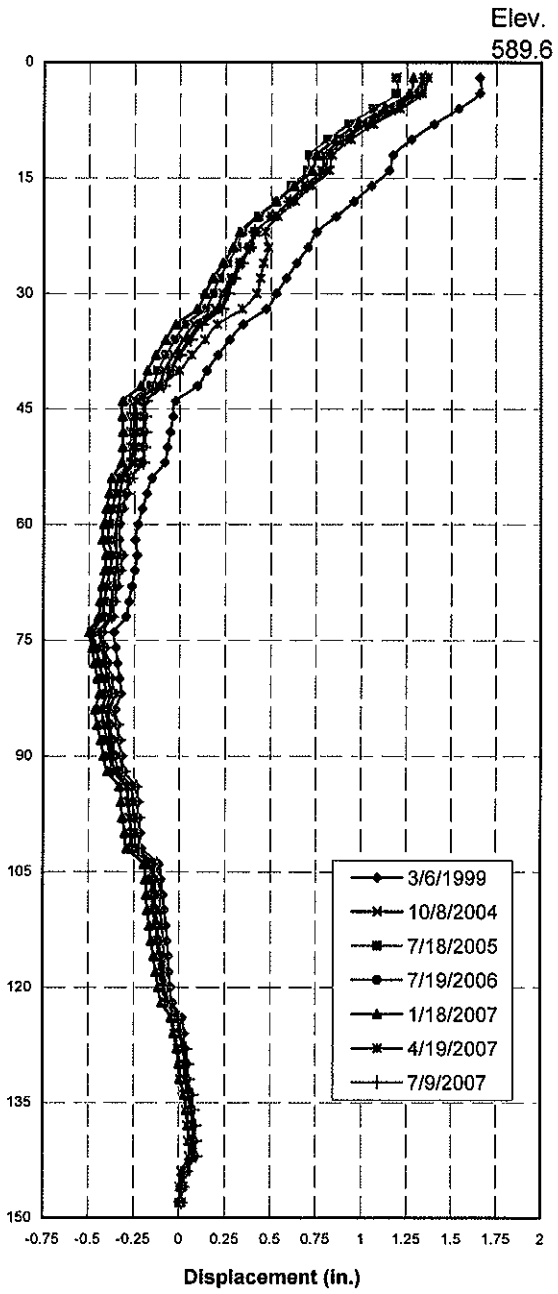


Inclinometer #3 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

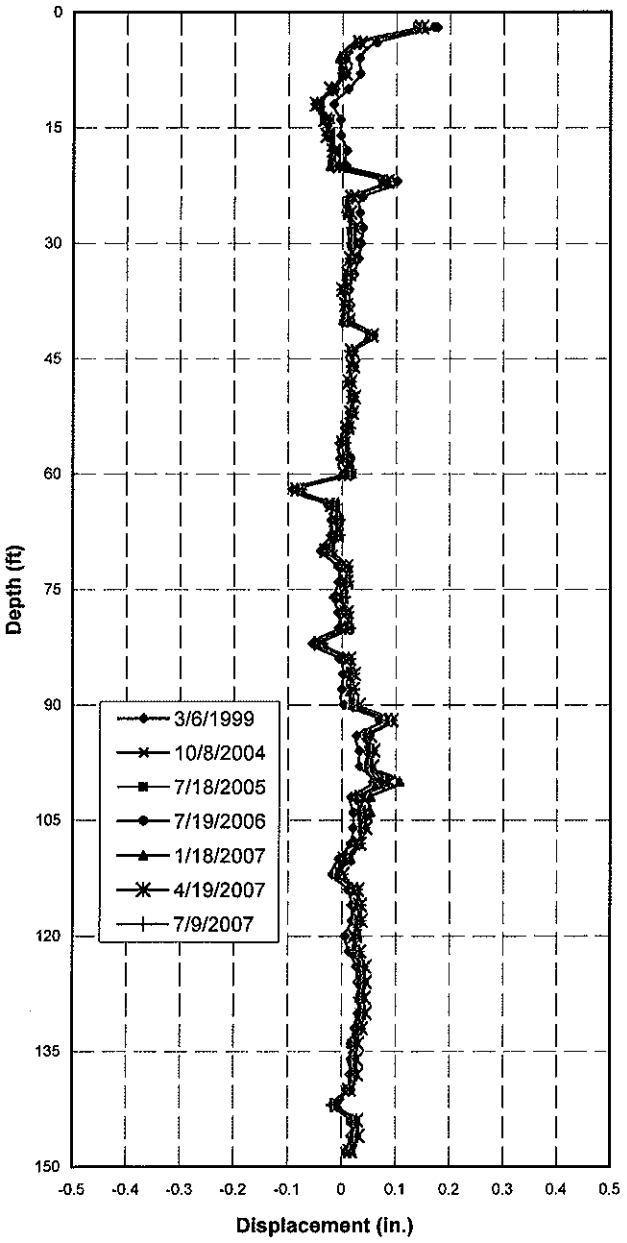


Cumulative

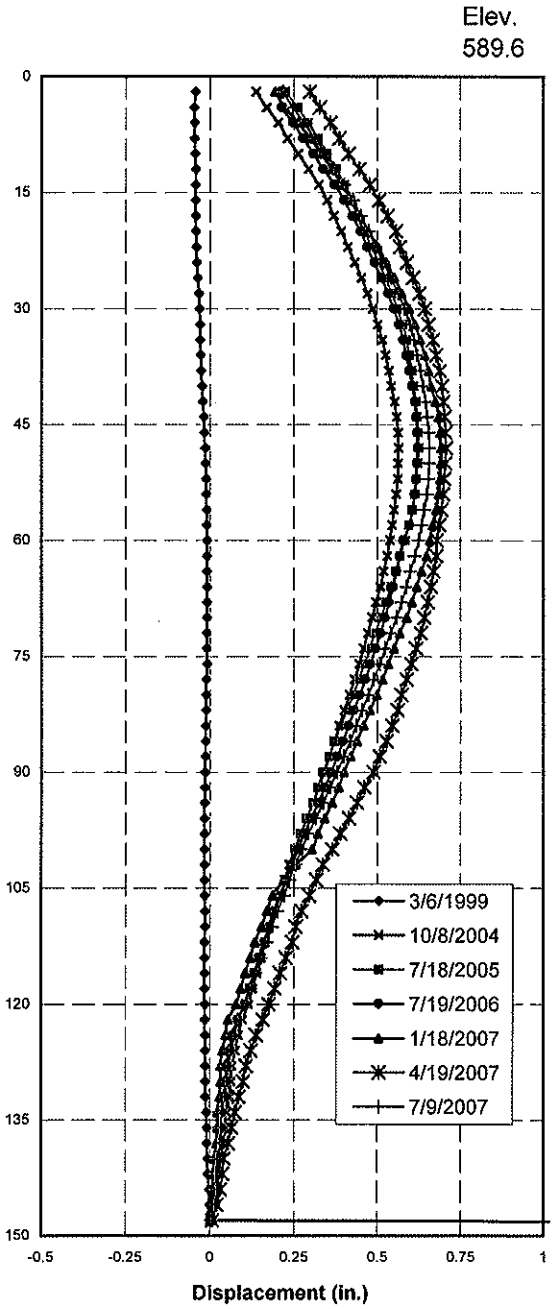


Inclinometer #8 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

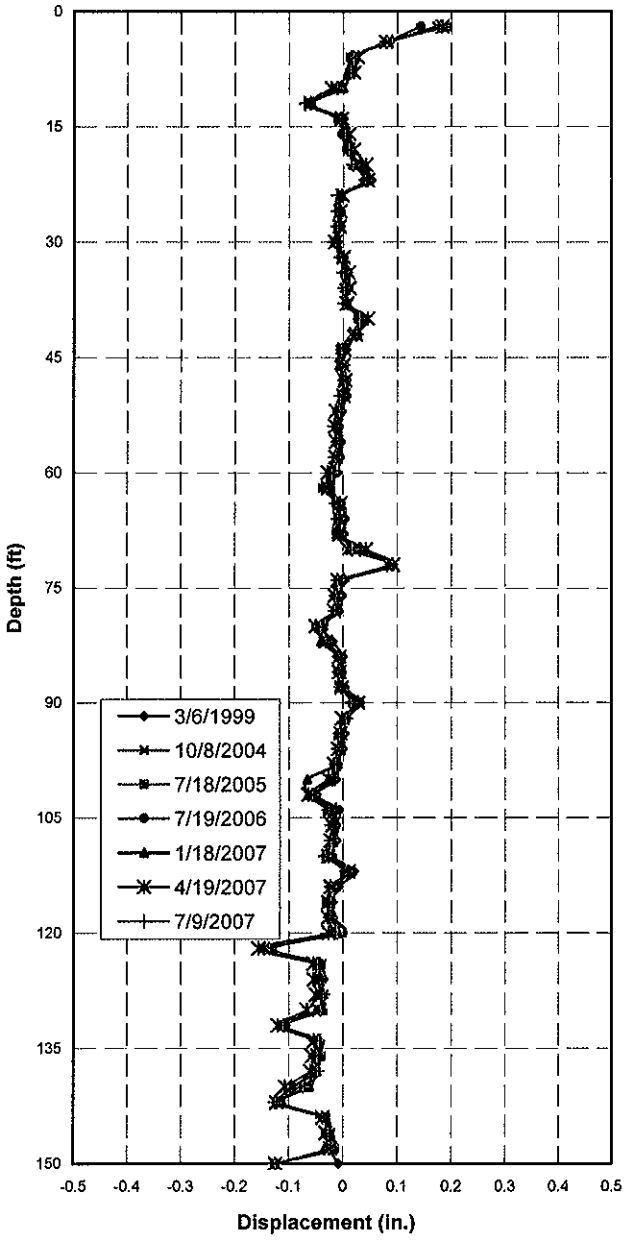


Cumulative

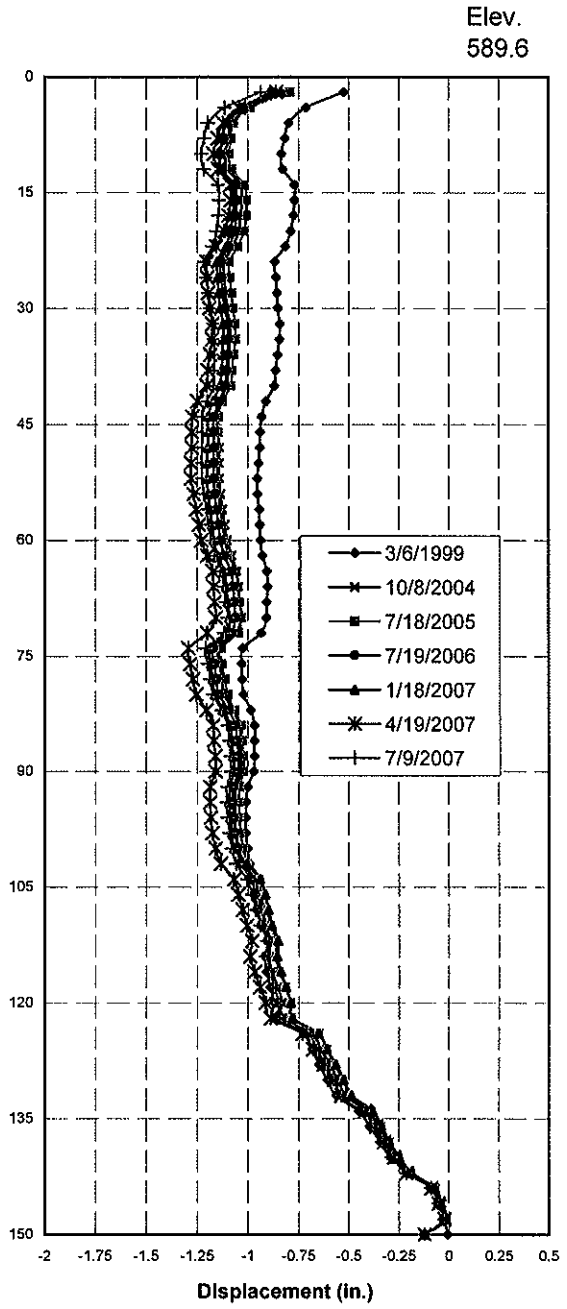


Inclinometer #8 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

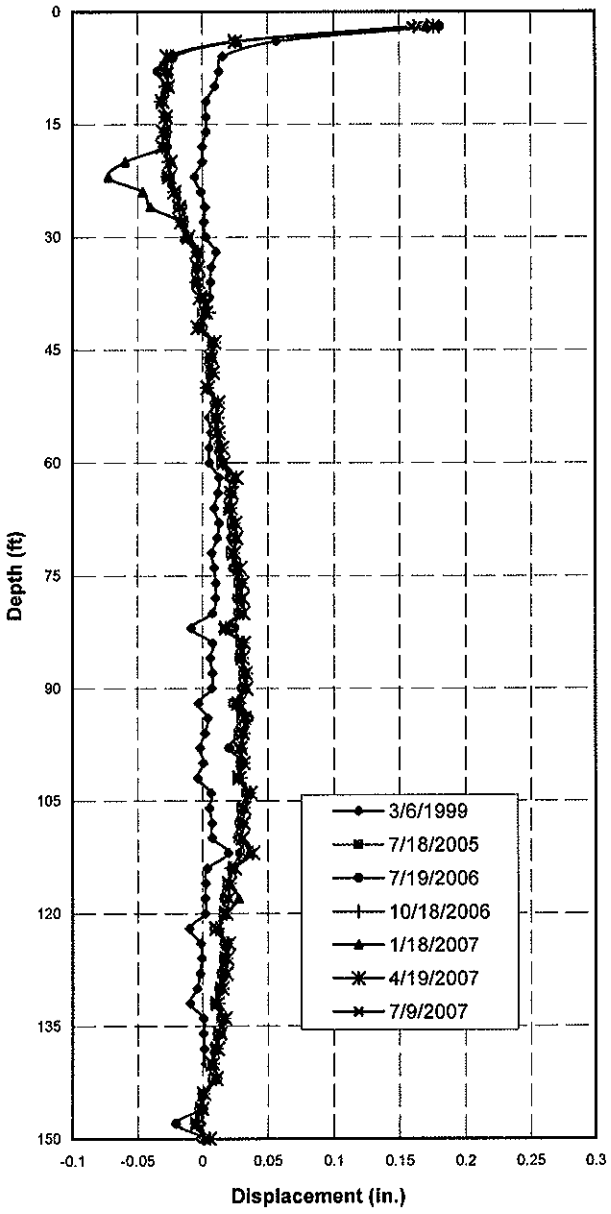


Cumulative



Inclinometer #9A Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



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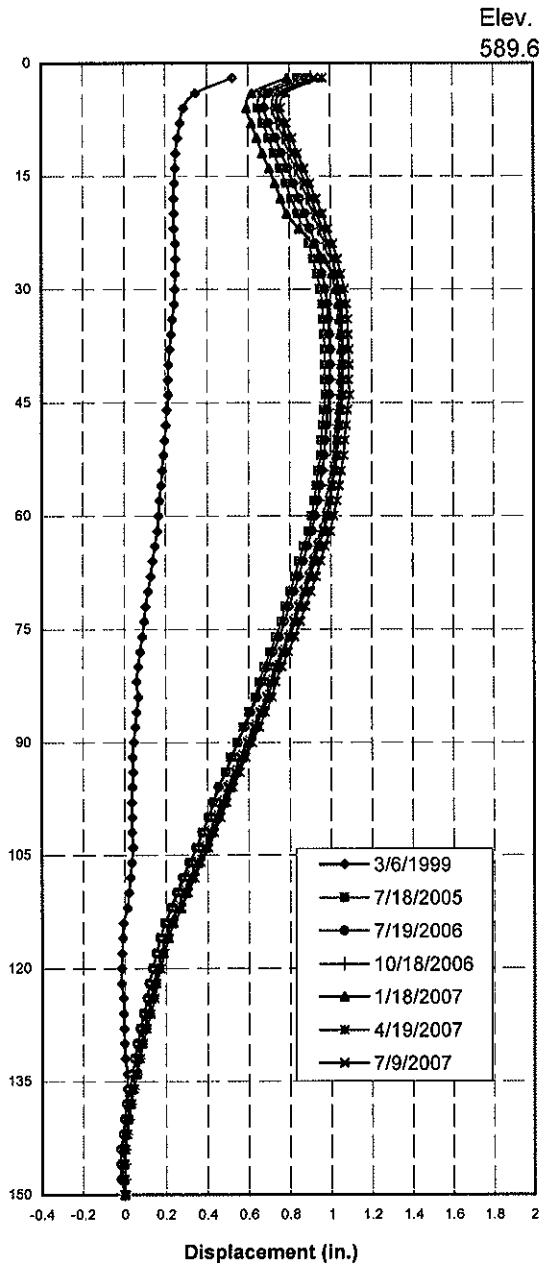
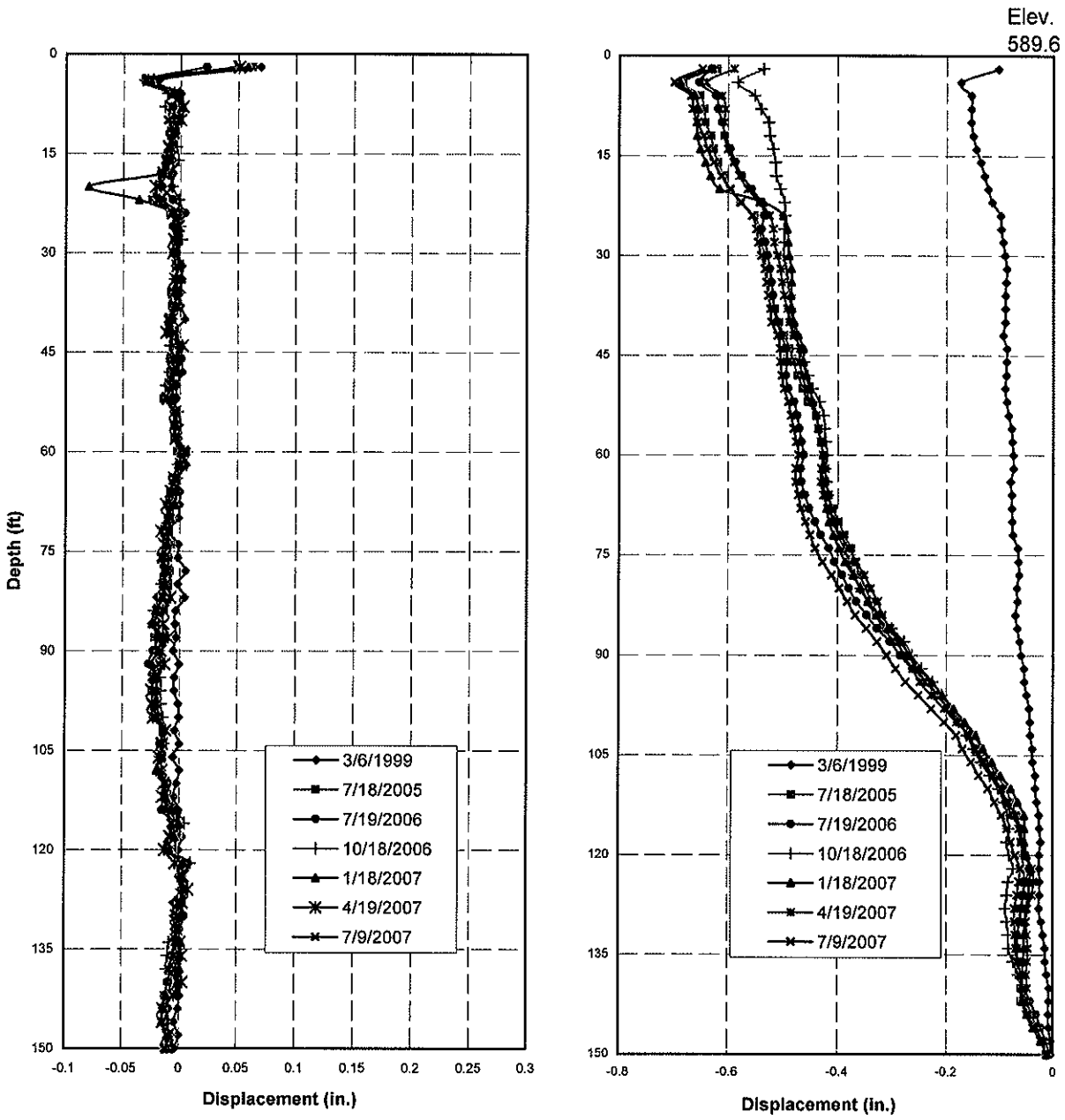
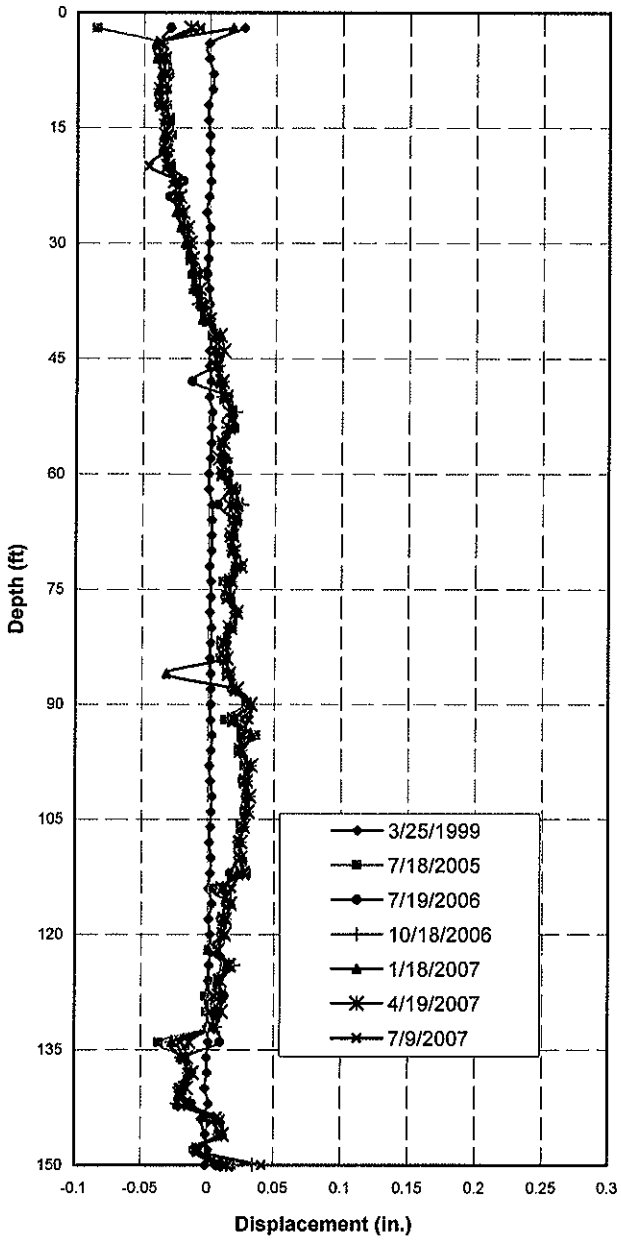


Inclinometer #9A Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

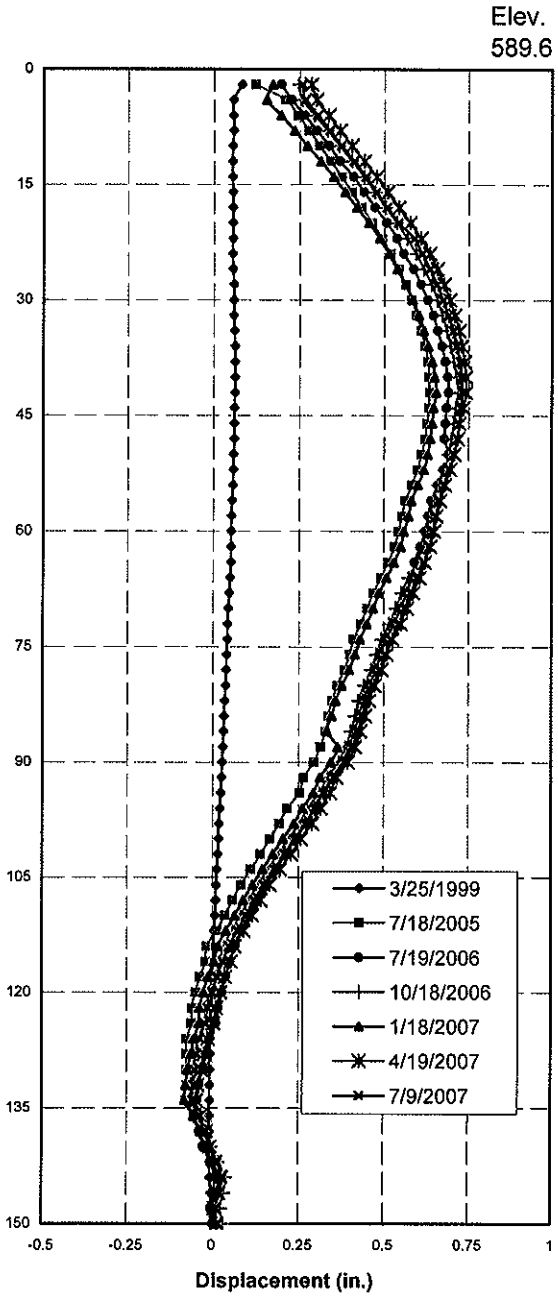


Inclinometer #10 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

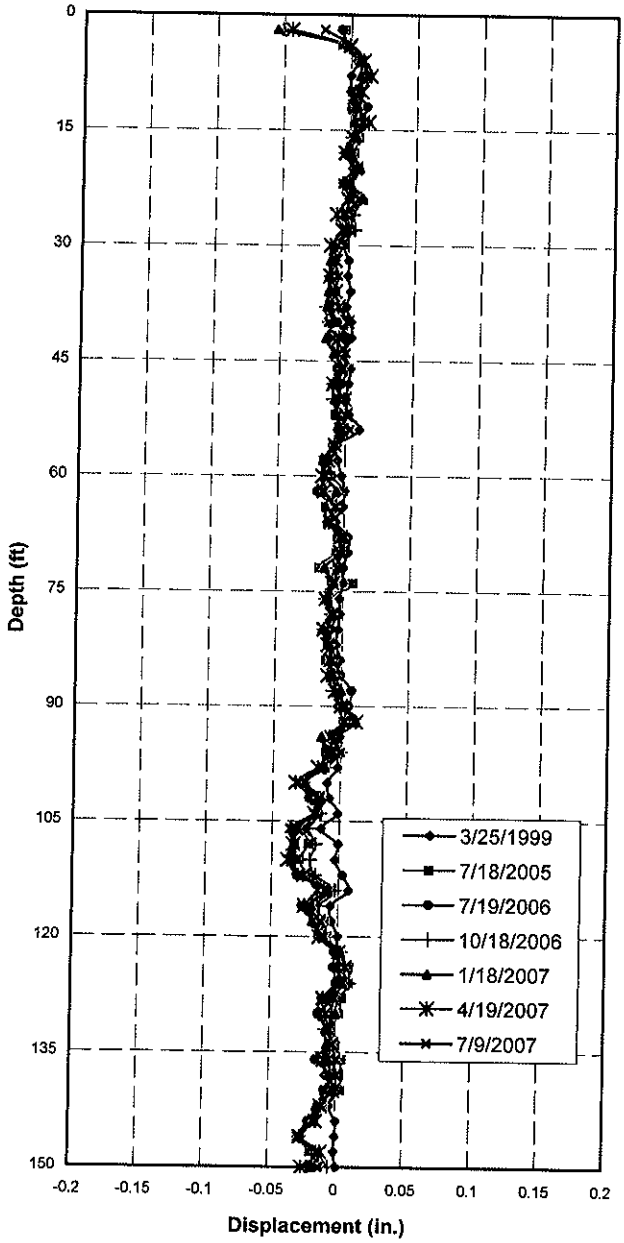


Cumulative

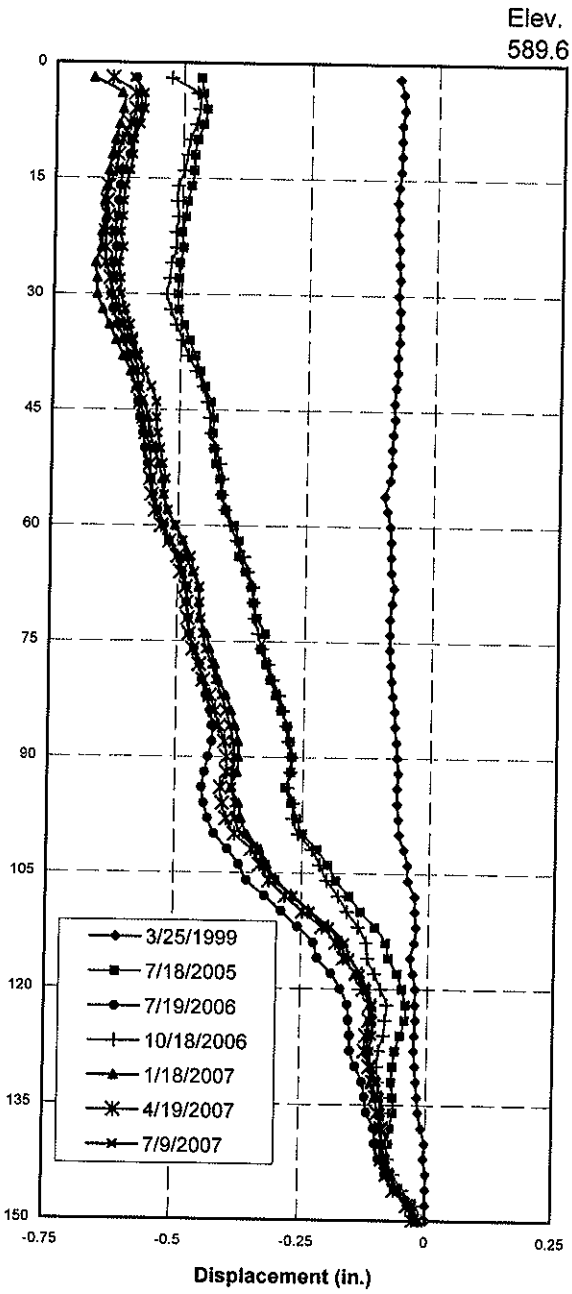


Inclinometer #10 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

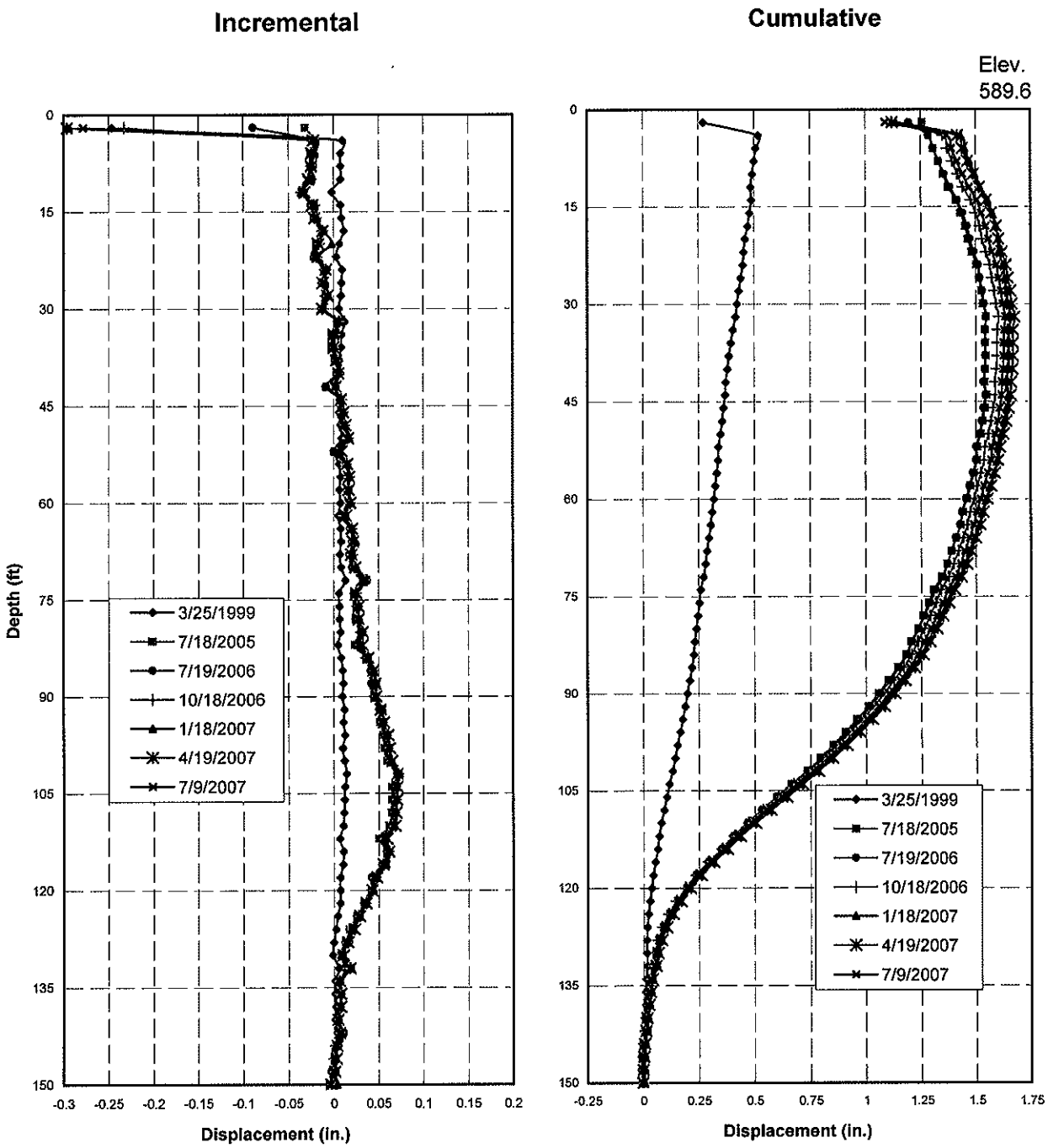
Incremental



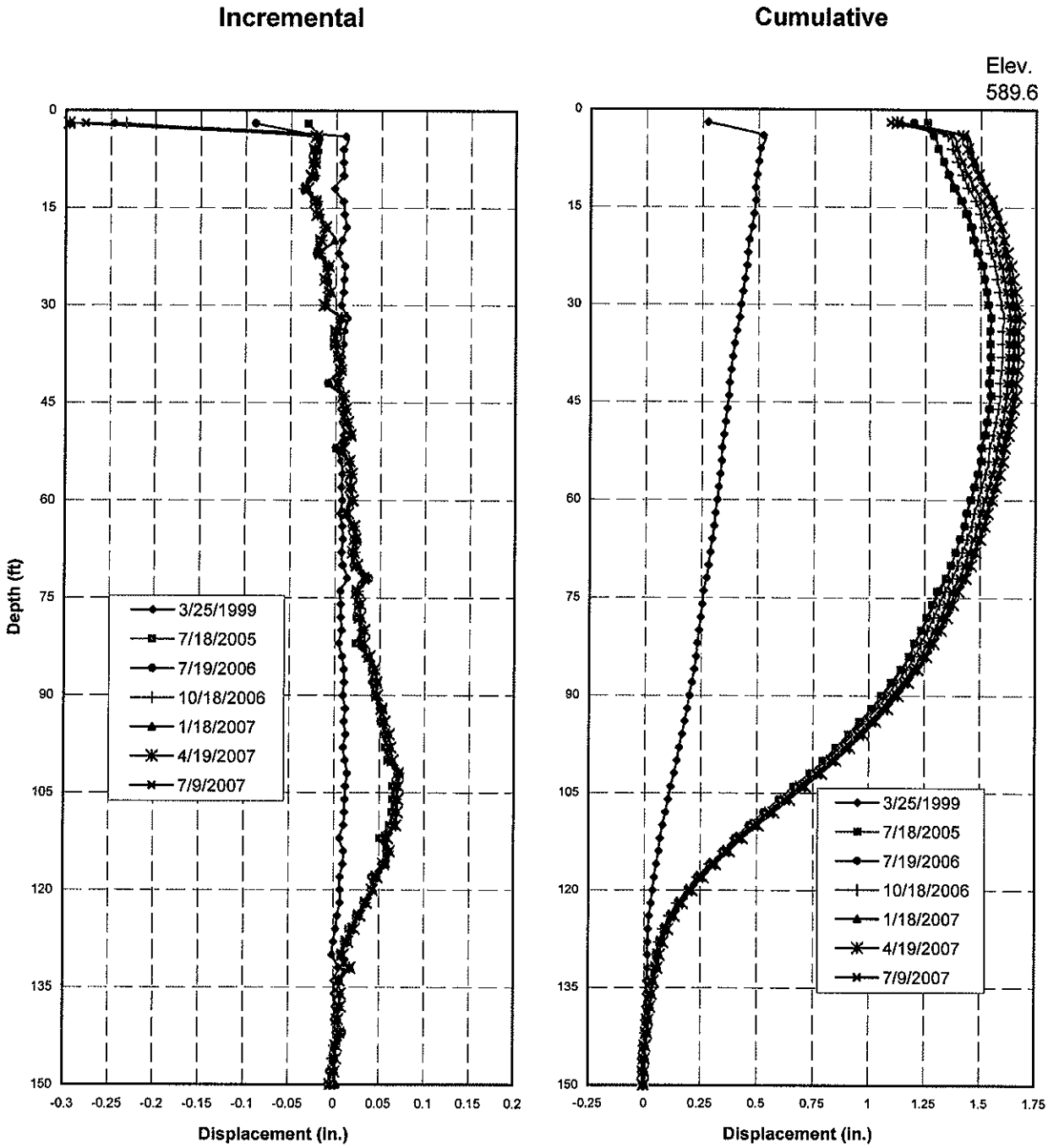
Cumulative



Inclinometer #17 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998



Inclinometer #17 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998



Pile Forces and Bending Moments

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	903.00	42.30	679.00	-	541.43	472.65	679.00	791.00	42.30	456.92	-73.98	99.88
	07/15/99	918.00	48.00	885.00	-	617.00	483.00	885.00	901.50	48.00	520.69	-144.12	113.86
	07/31/00	932.43	51.99	887.34	-	623.92	492.21	887.34	909.89	51.99	526.53	-141.66	114.44
	08/15/99	940.56	34.46	923.00	-	632.67	487.51	923.00	931.78	34.46	533.91	-156.13	119.70
	08/30/99	948.68	31.28	931.09	-	637.02	489.98	931.09	939.89	31.28	537.58	-158.14	121.21
	09/15/99	955.75	27.83	938.36	-	640.65	491.79	938.36	947.06	27.83	540.64	-160.10	122.62
	09/30/99	959.08	23.03	947.01	-	643.04	491.06	947.01	953.05	23.03	542.66	-163.47	124.06
	10/15/99	963.38	18.85	954.86	-	645.70	491.12	954.86	959.12	18.85	544.90	-166.26	125.43
	10/31/99	973.25	5.58	968.30	-	649.04	489.42	968.30	970.78	5.58	547.73	-171.69	128.76
	11/15/99	973.34	1.26	977.48	-	650.69	487.30	977.48	975.41	1.26	549.12	-175.74	129.95
	11/30/99	975.73	-2.84	980.87	-	651.25	486.45	980.87	978.30	-2.84	549.59	-177.26	130.88
	12/15/99	974.96	-2.47	982.11	-	651.53	486.25	982.11	978.54	-2.47	549.83	-177.77	130.87
	12/31/99	974.03	-54.00	984.71		634.91	460.02	984.71	979.37	-54.00	535.80	-188.11	137.85
	03/31/00	964.52	3.86	981.83	-	650.07	484.19	981.83	973.17	3.86	548.59	-178.41	129.31
	06/30/00	977.80	-36.92	980.73	-	640.54	470.44	980.73	979.27	-36.92	540.55	-182.94	135.56
	09/30/00	1009.20	-10.20	1005.99	-	668.33	499.50	1005.99	1007.60	-10.20	564.01	-181.58	135.77
	01/13/01	1014.12	-29.4495	1029.11	-	671.26	492.33	1029.11	1021.61	-29.45	566.48	-192.44	140.21
	04/20/01	1008.27	-18.6852	1022.57	-	670.72	494.79	1022.57	1015.42	-18.69	566.02	-189.21	137.95
	07/10/01	1030.41	-8.36772	1019.56	-	680.53	511.02	1019.56	1024.98	-8.37	574.30	-182.32	137.85
	10/09/01	1054.25	-20.5131	1038.65	-	690.80	516.87	1038.65	1046.45	-20.51	582.96	-187.07	142.33
	01/09/02	1055.96	-29.65	1045.80	-	690.70	513.15	1045.80	1050.88	-29.65	582.88	-190.96	144.14
	04/12/02	1041.9	-24.8188	1040.36	-	685.81	508.54	1040.36	1041.13	-24.82	578.76	-190.66	142.20
1	07/19/02	1062.21	-17.26	1035.12	17.14	693.36	522.47	1035.12	1048.67	-17.26	585.12	-183.79	142.20
	10/08/02	1086.38	-30.07	1049.75	-6.63	702.02	528.16	1049.75	1068.06	-30.07	592.43	-187.00	146.49
	01/08/03	1080.45	-42.89	1062.94	0.41	700.17	518.78	1062.94	1071.70	-42.89	590.87	-195.09	148.69
	04/15/03	1059.37	-29.65	1049.86	22.95	693.19	514.86	1049.86	1054.62	-29.65	584.99	-191.81	144.64
	06/01/03	1064.93	-31.16	1053.52	21.00	695.77	516.89	1053.52	1059.23	-31.16	587.16	-192.39	145.46
	08/07/03	1083.86	-27.66	1053.40	9.26	703.20	528.10	1053.40	1068.63	-27.66	593.43	-188.33	146.25
	10/07/03	1095.56	-38.67	1066.64	-0.69	707.84	528.45	1066.64	1081.10	-38.67	597.35	-192.95	149.38
	12/31/03	1100.15	-54.88	1082.97	-0.89	709.41	522.64	1082.97	1091.56	-54.88	598.68	-200.89	152.93
	04/13/04	1080.17	-43.67	1074.07	21.65	703.52	518.25	1074.07	1077.12	-43.67	593.70	-199.27	149.51
	07/13/04	1101.53	-34.89	1072.49	10.76	713.04	533.32	1072.49	1087.01	-34.89	601.74	-193.30	149.66
	10/08/04	1122.82	-45.70	1085.57	-8.86	720.90	538.56	1085.57	1104.19	-45.70	608.36	-196.11	153.40
	01/07/05	1116.60	-58.49	1097.39	-8.94	718.50	529.06	1097.39	1107.00	-58.49	606.34	-203.76	155.48
	04/08/05	1099.01	-52.77	1096.58	5.48	714.28	523.12	1096.58	1097.80	-52.77	602.78	-205.59	153.49
	07/18/05	1116.44	-41.55	1096.58	-2.36	723.82	537.44	1096.58	1106.51	-41.55	610.83	-200.46	153.15
	08/26/05	1128.14	-43.63	1095.73	-10.20	726.75	542.26	1095.73	1111.93	-43.63	613.30	-198.43	154.15
	11/12/05	1127.45	-44.76	1095.72	-9.67	726.14	541.34	1095.72	1111.58	-44.76	612.79	-198.75	154.26
	01/10/06	1129.36	-64.30	1095.72	-19.70	720.26	532.53	1095.72	1112.54	-64.30	607.83	-201.91	156.99
	04/09/06	1114.90	-55.20	1095.72	-1.14	718.47	529.85	1095.72	1105.31	-55.20	606.32	-202.87	154.81
	07/19/06	1130.94	-46.83	1095.72	-9.42	726.61	542.05	1095.72	1113.33	-46.83	613.19	-198.50	154.77
	10/18/06	1154.91	-58.29	1095.72	-27.50	730.78	548.31	1095.72	1125.32	-58.29	616.71	-196.26	157.89
	01/18/07	1139.55	-68.49	1095.72	-21.73	722.26	535.53	1095.72	1117.64	-68.49	609.52	-200.84	158.23
	04/19/07	1125.58	-58.82	1095.72	-8.49	720.83	533.38	1095.72	1110.65	-58.82	608.31	-201.61	156.01
	07/09/07	1141.38	-47.08	1095.72	-16.09	730.01	547.15	1095.72	1118.55	-47.08	616.05	-196.67	155.50

Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	575.00	589.00	243.00	-	469.00	582.00	243.00	409.00	589.00	395.79	121.54	-24.01
	07/15/99	585.00	602.00	237.00	-	474.67	593.50	237.00	411.00	602.00	400.57	127.81	-25.48
	07/30/99	594.35	611.17	230.68	-	478.73	602.76	230.68	412.52	611.17	404.00	133.40	-26.50
	08/15/99	596.87	611.09	242.58	336.68	446.81	603.98	289.63	419.73	473.89	377.06	112.70	-7.22
	08/31/99	601.58	616.82	241.00	-	486.47	609.20	241.00	421.29	616.82	410.53	132.00	-26.08
	09/15/99	605.96	622.42	240.47	-	489.62	614.19	240.47	423.22	622.42	413.19	133.98	-26.57
	09/30/99	609.62	624.20	240.71	336.98	452.88	616.91	288.85	425.17	480.59	382.18	117.62	-7.39
	10/15/99	612.87	629.40	240.27	336.21	454.69	621.14	288.24	426.57	482.81	383.71	119.35	-7.50
	10/31/99	616.45	631.80	243.11	336.29	456.91	624.13	289.70	429.78	484.05	385.59	119.90	-7.24
	11/15/99	619.54	632.45	245.83	337.79	458.90	626.00	291.81	432.69	485.12	387.27	119.81	-6.99
	11/30/99	623.35	635.58	248.71	340.31	461.99	629.47	294.51	436.03	487.95	389.87	120.09	-6.93
	12/15/99	624.21	637.77	247.77	339.95	462.43	630.99	293.86	435.99	488.86	390.24	120.87	-7.05
	12/31/99	626.60	640.86	249.37	341.45	464.57	633.73	295.41	437.99	491.16	392.05	121.29	-7.09
	03/31/00	634.53	648.30	254.69	346.89	471.10	641.41	300.79	444.61	497.60	397.56	122.12	-7.07
	06/30/00	640.05	652.80	250.99	342.06	471.48	646.43	296.53	445.52	497.43	397.88	125.44	-6.93
	09/30/00	647.16	661.13	247.62	336.78	473.17	654.14	292.20	447.39	498.96	399.31	129.76	-6.88
	01/13/01	654.063	665.1119	256.39	342.22	479.45	659.59	299.31	455.23	503.67	404.61	129.16	-6.46
	04/20/01	654.429	664.7057	260.37	345.47	481.25	659.57	302.92	457.40	505.09	406.12	127.86	-6.36
	07/10/01	661.456	672.0985	256.15	342.75	483.11	666.78	299.45	458.80	507.43	407.70	131.69	-6.49
	10/09/01	668.361	679.0039	251.93	338.20	484.37	673.68	295.06	460.14	508.60	408.76	135.74	-6.46
	01/09/02	671.083	683.4721	252.17	337.92	486.16	677.28	295.04	461.63	510.69	410.27	137.04	-6.55
	04/12/02	669.17	680.02	256.68	342.06	486.98	674.60	299.37	462.93	511.04	410.96	134.52	-6.42
17	07/19/02	671.69	683.96	253.27	272.93	470.46	677.83	263.10	462.48	478.44	397.02	148.69	-2.13
	10/08/02	678.60	692.21	247.01	332.37	487.54	685.40	289.69	462.80	512.29	411.44	141.87	-6.60
	01/08/03	678.44	689.32	251.28	334.22	488.31	683.88	292.75	464.86	511.77	412.09	140.22	-6.26
	04/15/03	679.45	692.45	254.73	341.09	491.93	685.95	297.91	467.09	516.77	415.14	139.12	-6.63
	06/01/03	678.76	689.85	256.43	341.09	491.53	684.30	298.76	467.60	515.47	414.80	138.22	-6.39
	08/07/03	682.33	695.54	251.15	336.74	491.44	688.94	293.95	466.74	516.14	414.73	141.61	-6.59
	10/07/03	686.23	700.57	250.14	334.87	492.95	693.40	292.50	468.19	517.72	416.00	143.73	-6.61
	12/31/03	689.48	700.61	257.04	341.05	497.05	695.05	299.04	473.26	520.83	419.46	141.97	-6.35
	04/13/04	689.24	699.88	260.70	346.65	499.12	694.56	303.68	474.97	523.27	421.21	140.14	-6.44
	07/13/04	693.10	667.59	255.46	341.33	489.37	680.34	298.39	474.28	504.46	412.98	136.93	-4.03
	10/08/04	699.03	710.89	250.83	337.39	499.53	704.96	294.11	474.93	524.14	421.56	147.30	-6.56
	01/07/05	699.07	711.46	253.31	339.95	500.95	705.26	296.63	476.19	525.70	422.75	146.50	-6.61
	04/08/05	696.43	708.09	257.94	343.81	501.57	702.26	300.87	477.18	525.95	423.27	143.90	-6.51
	07/18/05	699.56	708.33	253.71	338.36	499.99	703.94	296.04	476.64	523.35	421.94	146.24	-6.23
	08/26/05	702.04	711.17	250.91	335.97	500.02	706.61	293.44	476.47	523.57	421.97	148.13	-6.28
	11/12/05	701.95	699.60	251.68	337.06	497.57	700.78	294.37	476.82	518.33	419.90	145.70	-5.54
	01/10/06	705.16	715.03	253.47	339.58	503.31	710.10	296.53	479.32	527.31	424.75	148.27	-6.40
	04/09/06	703.94	713.04	259.52	343.20	504.93	708.49	301.36	481.73	528.12	426.11	145.96	-6.19
	07/19/06	708.37	716.01	256.84	339.95	505.29	712.19	298.39	482.61	527.98	426.42	148.35	-6.05
	10/18/06	713.29	721.25	251.76	334.02	505.08	717.27	292.89	482.52	527.63	426.24	152.14	-6.02
	01/18/07	712.84	717.96	256.52	336.54	505.96	715.40	296.53	484.68	527.25	426.98	150.17	-5.68
	04/19/07	711.13	716.21	260.62	340.56	507.13	713.67	300.59	485.88	528.38	427.97	148.10	-5.67
	07/09/07	713.04	716.74	255.22	334.18	504.79	714.89	294.70	484.13	525.46	426.00	150.64	-5.51

Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	546.00	501.00	248.00	173	367.00	523.50	210.50	397.00	337.00	309.71	112.21	8.00
	07/15/99	557.00	513.00	243.00	229	385.50	535.00	236.00	400.00	371.00	325.32	107.20	3.87
	07/30/99	565.55	519.94	239.54	224.26	387.32	542.75	231.90	402.55	372.10	326.86	111.44	4.06
	08/15/99	567.71	520.14	230.56	232.51	387.73	543.93	231.54	399.14	376.33	327.21	112.00	3.04
	08/31/99	573.72	526.52	247.46	232.87	395.14	550.12	240.17	410.59	379.70	333.46	111.12	4.12
	09/15/99	578.06	532.08	246.65	233.61	397.60	555.07	240.13	412.36	382.85	335.53	112.91	3.94
	09/30/99	582.49	534.97	247.46	234.05	399.74	558.73	240.76	414.98	384.51	337.34	114.00	4.06
	10/15/99	586.68	538.17	247.25	235.23	401.83	562.43	241.24	416.97	386.70	339.11	115.15	4.04
	10/31/99	590.77	539.40	249.37	235.6	403.79	565.09	242.49	420.07	387.50	340.75	115.66	4.34
	11/15/99	592.65	540.65	251.68	237.47	405.61	566.65	244.58	422.17	389.06	342.30	115.47	4.42
	11/30/99	596.63	527.25	254.12	239.69	404.42	561.94	246.91	425.38	383.47	341.29	112.94	5.59
	12/15/99	599.47	545.53	254.12	239.05	409.54	572.50	246.59	426.80	392.29	345.61	116.84	4.60
	12/31/99	601.54	548.45	255.38	239.17	411.14	575.00	247.28	428.46	393.81	346.96	117.49	4.62
	03/31/00	610.32	554.87	262.08	243.60	417.72	582.59	252.84	436.20	399.23	352.51	118.22	4.93
	06/30/00	616.94	539.60	260.98	238.93	414.11	578.27	249.96	438.96	389.26	349.47	117.70	6.63
	09/30/00	625.63	400.76	255.58	232.18	378.54	513.19	243.88	440.61	316.47	319.45	96.55	16.56
	01/13/01	632.372	566.6896	264.44	235.84	424.83	599.53	250.14	448.40	401.26	358.52	125.26	6.29
	04/20/01	632.575	561.5309	268.38	236.21	424.67	597.05	252.29	450.48	398.87	358.38	123.60	6.88
	07/10/01	639.684	569.2893	264.64	234.54	427.04	604.49	249.59	452.16	401.91	360.38	127.23	6.70
	10/09/01	646.508	576.5197	259.81	232.14	428.74	611.51	245.97	453.16	404.33	361.82	131.05	6.51
	01/09/02	650.895	576.8446	259.68	230.92	429.59	613.87	245.30	455.29	403.88	362.53	132.14	6.86
	04/12/02	650.123	570.1017	264.192	232.55	429.24	610.11	248.37	457.16	401.33	362.24	129.69	7.45
18	07/19/02	653.45	572.46	260.90	226.38	428.30	612.96	243.64	457.18	399.42	361.44	132.40	7.71
	10/08/02	659.69	581.14	254.65	222.68	429.54	620.41	238.66	457.17	401.91	362.49	136.86	7.37
	01/08/03	657.76	576.89	257.57	224.47	429.17	617.32	241.02	457.67	400.68	362.18	134.91	7.60
	04/15/03	661.78	576.19	262.16	228.04	432.04	618.99	245.10	461.97	402.12	364.60	134.04	7.98
	06/01/03	661.37	572.66	264.07	227.59	431.43	617.02	245.83	462.72	400.13	364.08	133.07	8.35
	08/07/03	665.76	577.29	258.18	222.76	431.00	621.53	240.47	461.97	400.03	363.72	136.61	8.26
	10/07/03	669.26	582.73	256.11	222.56	432.66	625.99	239.33	462.68	402.65	365.13	138.62	8.01
	12/31/03	670.27	581.39	262.53	229.62	435.95	625.83	246.08	466.40	405.51	367.90	136.15	8.12
	04/13/04	669.42	576.64	266.47	232.35	436.22	623.03	249.41	467.94	404.49	368.12	133.95	8.46
	07/13/04	672.95	578.63	261.80	224.79	434.54	625.79	243.29	467.37	401.71	366.71	137.13	8.76
	10/08/04	677.95	587.12	255.42	222.31	435.70	632.53	238.87	466.68	404.72	367.69	141.14	8.27
	01/07/05	677.50	586.02	257.61	226.05	436.80	631.76	241.83	467.56	406.04	368.61	139.80	8.21
	04/08/05	674.17	580.83	263.14	227.80	436.48	627.50	245.47	468.65	404.31	368.35	136.96	8.58
	07/18/05	677.87	580.70	259.40	221.74	434.93	629.29	240.57	468.63	401.22	367.04	139.36	8.99
	08/26/05	679.25	583.30	256.27	219.43	434.56	631.28	237.85	467.76	401.37	366.73	141.05	8.86
	11/12/05	679.13	583.14	256.88	220.08	434.81	631.13	238.48	468.00	401.61	366.93	140.77	8.86
	01/10/06	679.45	587.32	257.33	223.00	436.78	633.39	240.17	468.39	405.16	368.60	140.97	8.43
	04/09/06	679.57	583.14	263.01	226.46	438.05	631.36	244.74	471.29	404.80	369.67	138.61	8.87
	07/19/06	683.27	585.78	260.94	222.31	438.08	634.53	241.63	472.11	404.05	369.69	140.86	9.08
	10/18/06	687.01	592.40	255.09	218.66	438.29	639.70	236.88	471.05	405.53	369.87	144.42	8.74
	01/18/07	685.10	588.58	259.16	221.83	438.67	636.84	240.49	472.13	405.20	370.19	142.10	8.93
	04/19/07	685.18	584.40	264.40	222.96	439.23	634.79	243.68	474.79	403.68	370.67	140.22	9.49
	07/09/07	687.74	584.85	259.24	215.85	436.92	636.29	237.55	473.49	400.35	368.72	142.96	9.76

Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	566.97	586.00	298.00	228.9	419.97	576.49	263.45	432.49	407.45	354.41	112.23	3.34
	07/15/99	580.00	597.00	294.00	224	423.75	588.50	259.00	437.00	410.50	357.60	118.13	3.54
	07/30/99	588.71	606.46	291.38	218.62	426.29	597.59	255.00	440.05	412.54	359.75	122.82	3.67
	08/15/99	591.02	607.35	300.95	227.92	431.81	599.19	264.44	445.99	417.64	364.40	120.01	3.78
	08/31/99	595.94	613.52	300.59	229.63	434.92	604.73	265.11	448.27	421.58	367.03	121.76	3.56
	09/15/99	599.88	617.91	300.67	229.54	437.00	608.90	265.11	450.28	423.73	368.78	123.25	3.54
	09/30/99	603.53	621.65	302.70	229.75	439.41	612.59	266.23	453.12	425.70	370.82	124.18	3.66
	10/15/99	607.51	625.02	302.29	229.71	441.13	616.27	266.00	454.90	427.37	372.27	125.57	3.67
	10/31/99	611.37	627.25	306.07	229.7	443.60	619.31	267.89	458.72	428.48	374.35	125.99	4.03
	11/15/99	613.61	627.78	308.31	232.67	445.59	620.70	270.49	460.96	430.23	376.04	125.55	4.10
	11/30/99	616.29	630.54	313.83	234.7	448.84	623.42	274.27	465.06	432.62	378.78	125.17	4.33
	12/15/99	617.83	631.44	314.03	234.9	449.55	624.64	274.47	465.93	433.17	379.38	125.54	4.37
	12/31/99	619.94	634.20	314.36	236.45	451.24	627.07	275.41	467.15	435.33	380.80	126.08	4.25
	03/31/00	629.45	639.44	320.33	239.74	457.24	634.44	280.03	474.89	439.59	385.86	127.06	4.71
	06/30/00	636.15	643.50	317.81	51.91	412.34	639.83	184.86	476.98	347.71	347.98	163.11	17.25
	09/30/00	646.59	651.99	312.33	231.29	460.55	649.29	271.81	479.46	441.64	388.66	135.33	5.04
	01/13/01	653.454	657.0691	320.21	236.77	466.88	655.26	278.49	486.83	446.92	394.00	135.08	5.32
	04/20/01	651.464	653.2102	324.03	237.42	466.53	652.34	280.72	487.74	445.32	393.71	133.23	5.66
	07/10/01	658.856	661.1717	320.61	235.03	468.92	660.01	277.82	489.74	448.10	395.72	137.02	5.55
	10/09/01	667.346	669.2551	315.37	230.97	470.74	668.30	273.17	491.36	450.11	397.25	141.66	5.50
	01/09/02	670.88	671.7736	315.66	229.71	472.00	671.33	272.68	493.27	450.74	398.32	142.92	5.67
	04/12/02	667.71	665.64	321.06	231.62	471.51	666.68	276.34	494.39	448.63	397.90	139.94	6.10
19	07/19/02	673.44	667.87	319.88	227.72	472.23	670.66	273.80	496.66	447.79	398.51	142.28	6.52
	10/08/02	681.93	676.18	313.24	222.91	473.56	679.05	268.07	497.58	449.54	399.64	147.34	6.41
	01/08/03	682.42	673.60	316.88	225.03	474.48	678.01	270.96	499.65	449.32	400.42	145.93	6.71
	04/15/03	686.11	672.95	321.26	228.37	477.17	679.53	274.81	503.69	450.66	402.69	145.10	7.07
	06/01/03	685.30	670.80	322.48	227.84	476.60	678.05	275.16	503.89	449.32	402.21	144.44	7.28
	08/07/03	689.12	675.35	317.28	223.09	476.21	682.23	270.18	503.20	449.22	401.87	147.72	7.20
	10/07/03	694.48	681.03	314.64	222.27	478.11	687.76	268.46	504.56	451.65	403.47	150.32	7.06
	12/31/03	695.94	680.95	322.73	229.34	482.24	688.45	276.03	509.33	455.15	406.96	147.86	7.23
	04/13/04	695.62	676.77	330.77	231.41	483.64	686.19	281.09	513.19	454.09	408.15	145.23	7.88
	07/13/04	700.37	679.61	327.88	224.22	483.02	689.99	276.05	514.13	451.92	407.62	148.40	8.30
	10/08/04	706.18	688.67	321.87	221.22	484.48	697.43	271.54	514.03	454.94	408.86	152.68	7.88
	01/07/05	705.37	688.14	324.72	224.55	485.69	696.75	274.63	515.04	456.35	409.88	151.34	7.83
	04/08/05	702.85	682.86	329.75	226.66	485.53	692.86	278.21	516.30	454.76	409.74	148.66	8.21
	07/18/05	706.50	683.55	327.15	219.55	484.19	695.03	273.35	516.83	451.55	408.61	151.18	8.71
	08/26/05	708.05	686.48	322.81	217.89	483.80	697.26	270.35	515.43	452.18	408.28	153.05	8.44
	11/12/05	707.97	686.27	323.74	218.33	484.08	697.12	271.04	515.85	452.30	408.51	152.76	8.48
	01/10/06	710.04	690.54	324.68	221.62	486.72	700.29	273.15	517.36	456.08	410.74	153.13	8.17
	04/09/06	709.47	686.72	329.75	224.34	487.57	698.10	277.05	519.61	455.53	411.46	150.95	8.55
	07/19/06	714.26	690.38	328.09	220.57	488.32	702.32	274.33	521.17	455.47	412.10	153.44	8.76
	10/18/06	718.93	696.80	321.91	216.75	488.60	707.86	269.33	520.42	456.77	412.33	157.22	8.49
	01/18/07	717.19	692.98	326.63	219.88	489.17	705.08	273.25	521.91	456.43	412.81	154.82	8.73
	04/19/07	716.98	689.52	331.50	221.54	489.89	703.25	276.52	524.24	455.53	413.42	152.99	9.17
	07/09/07	720.64	690.13	327.60	214.47	488.21	705.39	271.04	524.12	452.30	412.00	155.72	9.58

Pile Forces and Bending Moments (cont'd)

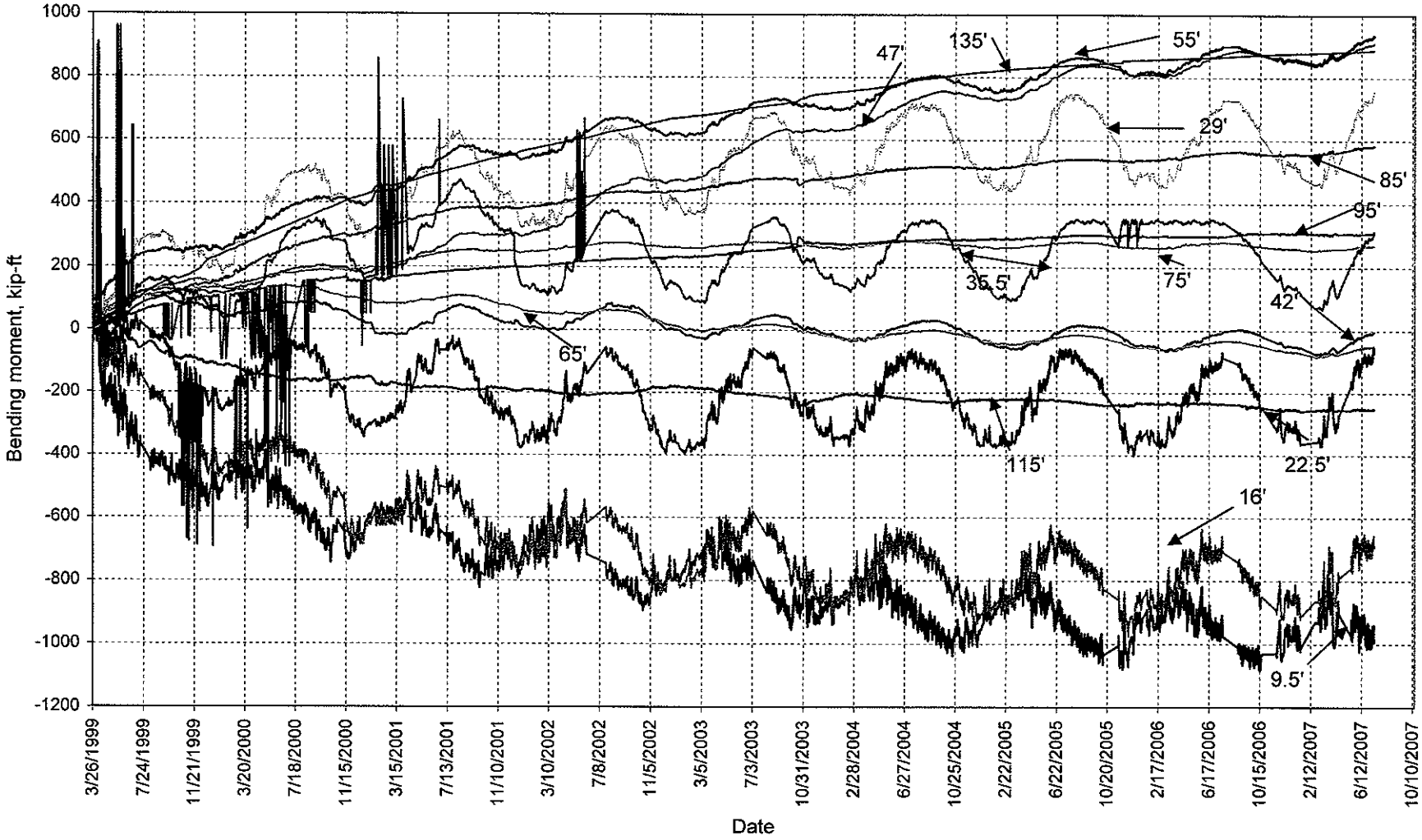
Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	271.75	436.00	261.00	583.00	387.94	353.88	422.00	266.38	509.50	327.38	-24.42	-32.43
	07/15/99	279.00	617.00	253.00	583.00	433.00	448.00	418.00	266.00	600.00	365.41	10.76	-44.56
	07/30/99	282.79	647.00	243.64	585.13	439.64	464.90	414.39	263.22	616.07	371.01	18.11	-47.07
	08/15/99	272.89	690.09	251.16	614.66	457.20	481.49	432.91	262.03	652.38	385.83	17.42	-52.07
	08/31/99	265.66	576.80	245.14	627.09	428.67	421.23	436.12	255.40	601.95	361.76	-5.34	-46.23
	09/15/99	265.08	802.81	242.34	635.26	486.37	533.95	438.80	253.71	719.04	410.45	34.11	-62.07
	09/30/99	260.50	807.40	238.64	642.65	487.30	533.95	440.65	249.57	725.03	411.23	33.45	-63.43
	10/15/99	256.43	811.14	234.46	648.58	487.65	533.79	441.52	245.45	729.86	411.53	33.08	-64.62
	10/31/99	240.47	824.02	221.62	665.31	487.86	532.25	443.47	231.05	744.67	411.70	31.83	-68.52
	11/15/99	241.93	831.45	224.75	676.77	493.73	536.69	450.76	233.34	754.11	416.65	30.81	-69.47
	11/31/99	240.47	835.88	224.26	648.85	487.37	538.18	436.56	232.37	742.37	411.29	36.43	-68.03
	12/15/99	241.41	836.77	222.35	684.04	496.14	539.09	453.20	231.88	760.41	418.69	30.79	-70.51
	12/31/99	242.22	836.08	224.14	684.93	496.84	539.15	454.54	233.18	760.51	419.29	30.34	-70.35
	03/31/00	257.37	828.85	237.38	675.92	499.88	543.11	456.65	247.38	752.38	421.85	31.00	-67.37
	06/30/00	266.43	846.32	225.20	500.93	459.72	556.37	363.06	245.81	673.62	387.96	69.30	-57.07
	09/30/00	257.37	895.02	196.89	705.00	513.57	576.19	450.94	227.13	800.01	433.40	44.90	-76.42
	01/13/01	247.90	856.11	197.37	729.58	507.74	552.01	463.47	222.64	792.84	428.48	31.74	-76.07
	04/20/01	44.66	883.01	212.28	457.21	399.29	463.83	334.74	128.47	670.11	336.96	46.28	-72.25
	07/10/01	-279.94	502.86	204.24	66.21	123.34	111.46	135.22	-37.85	284.53	104.09	-8.52	-43.01
	10/09/01	442.16	725.37	50.98	1199.89	604.60	583.76	625.44	246.57	962.63	510.22	-14.94	-95.52
	01/09/02	263.63	616.73	159.27	765.05	451.17	440.18	462.16	211.45	690.89	380.74	-7.88	-63.96
	04/12/02	67.35	579.97	58.13	501.01	301.61	323.66	279.57	62.74	540.49	254.53	15.81	-63.73
34	07/19/02	288.69	941.04	187.83	727.59	536.29	614.86	457.71	238.26	834.31	452.57	56.34	-79.51
	10/08/02	277.15	962.54	162.58	740.98	535.81	619.84	451.78	219.86	851.76	452.17	60.25	-84.29
	01/08/03	256.07	949.53	162.24	758.66	531.62	602.80	460.45	209.15	854.10	448.64	51.04	-86.04
	04/15/03	277.19	928.37	189.53	744.52	534.90	602.78	467.03	233.36	836.45	451.41	48.67	-80.45
	06/01/03	277.96	939.01	184.90	749.68	537.89	608.49	467.29	231.43	844.35	453.93	50.62	-81.76
	08/07/03	288.69	965.09	171.66	750.09	543.88	626.89	460.87	230.17	857.59	458.98	59.52	-83.70
	10/07/03	274.96	978.21	155.53	762.84	542.89	626.58	459.19	215.25	870.53	458.14	60.01	-87.41
	12/31/03	258.26	983.57	156.83	795.22	548.47	620.92	476.03	207.55	889.40	462.86	51.95	-90.96
	04/13/04	281.17	960.30	188.88	781.65	553.00	620.73	485.27	235.03	870.97	466.68	48.57	-84.84
	07/13/04	302.86	991.98	173.93	772.27	560.26	647.42	473.10	238.40	882.12	472.80	62.50	-85.87
	10/08/04	295.63	1004.49	151.19	786.40	559.43	650.06	468.80	223.41	895.45	472.10	64.99	-89.65
	01/07/05	277.35	997.91	148.79	798.02	555.52	637.63	473.41	213.07	897.97	468.80	58.88	-91.36
	04/08/05	286.74	978.21	166.99	788.76	555.17	632.47	477.87	226.86	883.49	468.51	55.43	-87.59
	07/18/05	304.00	1000.02	160.94	783.60	562.14	652.01	472.27	232.47	891.81	474.39	64.44	-87.96
	08/26/05	301.85	1018.4	147.73	791.81	564.94	660.12	469.77	224.79	905.09	476.76	68.24	-90.75
	11/12/05	300.51	1018.3	147.82	793.35	564.99	659.40	470.58	224.16	905.83	476.80	67.70	-90.93
	01/10/06	274.59	1009.41	138.15	808.34	557.62	642.00	473.24	206.37	908.87	470.58	60.50	-93.71
	04/09/06	283.04	986.09	160.45	798.02	556.90	634.57	479.23	221.74	892.06	469.97	55.69	-89.42
	07/19/06	295.67	1009.41	149.73	796.56	562.84	652.54	473.14	222.70	902.98	474.98	64.32	-90.75
	10/18/06	284.79	1030.77	131.20	808.38	563.79	657.78	469.79	207.99	919.58	475.78	67.40	-94.92
	01/18/07	270.29	1012.82	134.82	813.33	557.81	641.55	474.08	202.55	913.08	470.74	60.04	-94.78
	04/19/07	282.35	996.04	153.99	805.37	559.44	639.20	479.68	218.17	900.71	472.11	57.19	-91.05
	07/09/07	306.44	1014.48	154.64	795.38	567.74	660.46	475.01	230.54	904.93	479.11	66.49	-89.96

Shaft 1: Bending moment along shaft, kip-ft

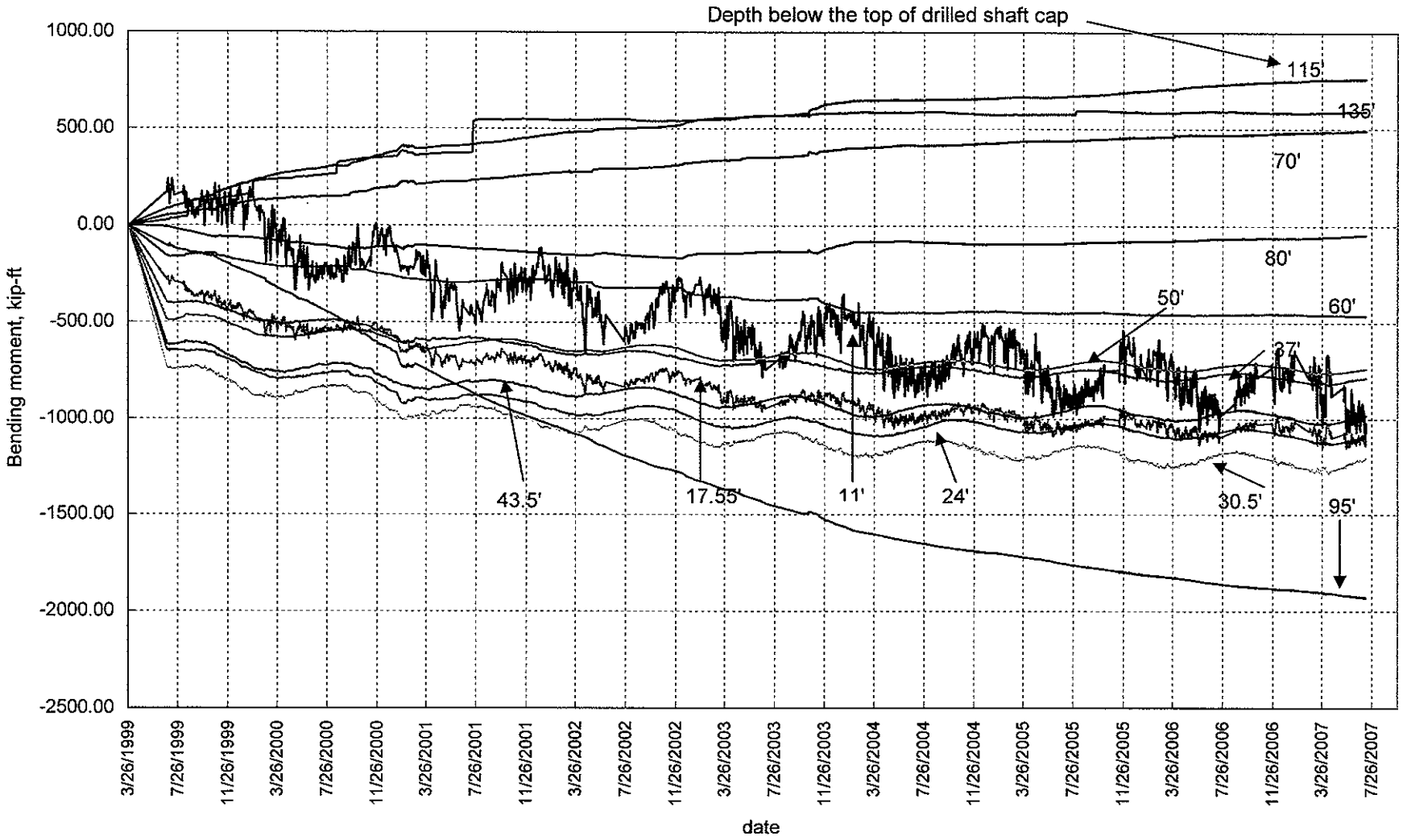
Depth, ft / Date	9.5	16	22.5	29	35.5	42	47	54.8	64.8	74.8	84.8	94.8	115	135
7/1/1999	-357.65	-148.91	-2.99	242.13	107.23	94.27	103.67	221.87	109.32	92.67	66.77	48.25	-38.94	91.57
1/8/2003	-774.82	-792.9	-360.63	403.12	139.71	-1.79	473.87	620.31	11.19	262.65	439.51	230.65	-179.6	668.9
4/15/2003	-657.74	-650	-232.57	481.71	156.43	-14.02	517.65	659.68	2.44	268.91	457.85	238.57	-192.49	684.79
7/1/2003	-763.24	-602.42	-72.91	660.28	319.17	32.14	588.57	715.87	14.21	278.09	474.99	251.23	-206	702.94
8/7/2003	-817.04	-638.73	-81.08	678	343.79	44.44	615.09	726.92	17.44	279.15	477.58	254.31	-210.32	708.78
10/7/2003	-913.81	-801.08	-248.05	552.54	251.84	20.93	623.3	710.92	6.8	271.9	474.43	265.38	-225.46	720.58
12/31/2003	-870.9	-838.68	-322.24	476.14	168.18	-13.93	630.87	701.76	-19.51	263.35	479.49	275.24	-220.96	748.57
4/13/2004	-831.87	-777.37	-255.87	514.98	175.37	-24.83	659.66	727.03	-27.47	269.67	495.81	277.88	-211.65	763.52
7/13/2004	-889.99	-676.85	-77.13	709.38	338.24	22.05	727.23	792.27	-5.75	281.7	512.3	283.5	-221.34	787.54
10/8/2004	-983.05	-812	-201.66	636.33	293	16.71	752.87	793.14	-7.37	272.19	514.89	286.68	-231.1	803.15
1/7/2005	-925.21	-882.29	-353.38	471.75	139.59	-39.87	733.05	761.38	-34.6	264.1	510.62	288.64	-223.06	817.18
4/8/2005	-775.03	-726	-235.05	530.47	150.69	-53.27	749.88	786.67	-40.37	267.3	525.48	290.73	-219.8	828.14
7/18/2005	-957.73	-709.43	-81.75	735.77	338.65	7.97	821.52	856.49	-16.82	278.53	538.72	298.79	-226.87	837.24
8/26/2005	-1005.57	-755.34	-117.03	721.71	336.36	13.6	835.13	860.64	-16.18	278.76	539.43	301.65	-233.64	840.82
10/11/2005	-1033.08	-827.24	-199.79	654.9	284.17	7.2946	833.72	848.04	-26.29	273.5	537.36	299.33	-240.08	843.25
1/10/2006	-918.83	-858.03	-339.71	489.13	122.55	-48.55	810.18	815.92	-54.94	262.93	536.1	298.82	-234.11	855.77
4/9/2006	-901.14	-812	-289.67	510.35	123.88	-55.75	815.9	831.32	-58.19	267.19	540.25	311.97	-239.53	860
7/19/2006	-975.46	-709.09	-86.84	727.21	303.99	-3.19	876.46	899.71	-33.29	280.02	563.21	306.55	-235.87	865.96
10/18/2006	-1030.45	-848.40	-245.88	609.17	218.59	-17.57	872.05	872.96	-49.65	267.05	557.80	306.95	-246.77	873.58
1/18/2007	-1015.18	-915.62	-363.79	485.63	115.44	-53.84	856.23	849.07	-71.01	257.71	555.06	310.45	-258.05	878.10
4/19/2007	-904.71	-791.93	-272.27	527.72	122.40	-65.28	862.30	869.52	-74.95	259.50	564.85	305.74	-254.07	882.60
7/11/2007	-990.93	-694.73	-72.44	749.91	312.39	-2.99	910.88	934.53	-49.88	269.47	582.93	306.29	-251.96	888.31

Shaft 9: Bending moment along shaft, kip-ft

Depth, ft / Date	11	17.5	24	30.5	37	43.25	50	60	70	80	95	115	135
7/1/1999	-67.89	-31.81	8.56	12.84	20.8	19.57	14.07	0.61	9.79	11.62	-33.33	18.35	26.3
1/8/2003	-347.44	-803.74	-998.93	-1106.33	-698.39	-903.77	-661.43	-353.18	324.27	-148.11	-1315.52	540.06	541.35
4/15/2003	-592.31	-919.8	-1050.61	-1133.34	-723.59	-939.66	-696.63	-369.12	336.59	-143.51	-1378.77	555.2	549.67
7/1/2003	-666.55	-902.38	-1016.77	-1090.93	-713.88	-914.42	-686.74	-395.16	340.01	-144.29	-1435.98	557.09	553.5
8/7/2003	-687.84	-917.2	-1003.18	-1072.98	-695.58	-886.87	-664.36	-384.64	352	-133.3	-1462.27	566.15	565.69
10/7/2003	-490.45	-863.81	-1007.81	-1107.14	-708.81	-891.63	-656.83	-378.93	360.91	-134.77	-1498.83	577.44	567.18
12/31/2003	-514.68	-913.27	-1054.9	-1163.2	-741.63	-949.18	-697.72	-421.12	390.01	-101.42	-1555.5	633.83	579.35
4/13/2004	-604.44	-966.22	-1090.5	-1188	-761.54	-987.22	-743.54	-446.54	402.54	-82.56	-1609.1	644.77	582.97
7/13/2004	-817.01	-1007.24	-1051.35	-1122.59	-730.91	-933.53	-709.92	-447.66	411.36	-83.06	-1648.19	649.1	585.94
10/8/2004	-674.74	-949.72	-1005.93	-1128.49	-732.6	-927.74	-697.54	-445.16	413.37	-90.78	-1677.71	652.24	581.64
1/7/2005	-572.76	-951.94	-1036.44	-1183	-760.9	-966.49	-718.51	-441.27	424.15	-94.18	-1699.91	657.05	573.07
4/8/2005	-773.86	-1039.72	-1072.89	-1200.56	-775.89	-989.82	-743.85	-446.59	435.56	-92.57	-1726.57	664.45	574.55
7/18/2005	-885.57	-1041.08	-1038.29	-1152.24	-752.36	-948.63	-719.09	-449.39	438.06	-89.12	-1762.02	670.82	576.24
8/26/2005	-835.5	-1020.01	-1028.45	-1146.98	-746.96	-933.35	-702.48	-447.31	442.02	-86.41	-1773.96	672.92	595.07
10/11/2005	-749.53	-997.4	-1026.45	-1157.47	-750.11	-932.26	-695.29	-445.61	446.57	-84.01	-1786.07	677.93	594.21
1/10/2006	-735.54	-1025.94	-1070.26	-1220.95	-784.71	-983.06	-728.35	-455.6	455.8	-79.41	-1811.1	694.94	585.21
4/9/2006	-761.63	-1055.46	-1104.66	-1250.13	-799.79	-1009.4	-750.25	-456.86	465.33	-75.95	-1830.39	709.25	584.13
7/19/2006	-986.65	-1097.57	-1069.44	-1182.51	-765.49	-967.32	-726.98	-458.20	468.35	-67.36	-1860.26	728.74	591.17
10/18/2006	-785.55	-1028.56	-1059.04	-1198.03	-770.44	-962.79	-714.95	-455.21	472.24	-63.08	-1878.38	742.33	587.52
1/18/2007	-652.26	-1012.08	-1093.82	-1249.92	-798.31	-1001.31	-738.72	-453.20	481.92	-62.15	-1891.06	749.16	583.45
4/19/2007	-878.81	-1101.41	-1131.14	-1269.03	-817.30	-1023.35	-760.98	-458.74	484.61	-55.95	-1908.23	757.20	587.07
7/11/2007	-1020.68	-1113.23	-1096.67	-1211.04	-787.54	-982.11	-738.79	-463.61	490.76	-47.79	-1930.33	760.68	591.55



Shaft #1, Bending moment vs. date in different elevations below the top of cap



Shaft #9, Bending moment vs. date in different elevations below the top of cap

Tie Beam Forces and Bending Moments (Driven Pile Cap side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	-47.1	68.5	551.7	681.8	313.73	10.70	616.75	252.30	375.15	83.06	-40.28	-2.75
	7/15/1999	-70.1	53.8	538.8	666.8	297.33	-8.15	602.80	234.35	360.30	78.72	-40.60	-2.82
	8/15/1999	10.7	114.3	613.7	728.1	366.70	62.50	670.90	312.20	421.20	97.09	-40.43	-2.44
	8/31/1999	12.0	114.3	617.3	732.8	369.10	63.15	675.05	314.65	423.55	97.73	-40.67	-2.44
	9/15/1999	13.1	113.5	619.7	737.5	370.95	63.30	678.60	316.40	425.50	98.22	-40.89	-2.44
	9/30/1999	29.6	122.3	634.4	753.4	384.93	75.95	693.90	332.00	437.85	101.92	-41.07	-2.37
	10/15/1999	34.7	123.9	637.8	757.9	388.58	79.30	697.85	336.25	440.90	102.88	-41.11	-2.34
	10/31/1999	39.8	127.2	646.6	762	393.90	83.50	704.30	343.20	444.60	104.29	-41.26	-2.27
	11/15/1999	62.3	139.3	662.9	780.1	411.15	100.80	721.50	362.60	459.70	108.86	-41.25	-2.18
	11/30/1999	73.7	146.3	670.6	788.6	419.80	110.00	729.60	372.15	467.45	111.15	-41.18	-2.13
	12/15/1999	72.8	143.6	668.9	789.7	418.75	108.20	729.30	370.85	466.65	110.87	-41.28	-2.15
	12/31/1999	88.8	152.1	680.1	802.5	430.88	120.45	741.30	384.45	477.30	114.08	-41.26	-2.08
	3/31/2000	95.3	158.7	682.5	825.2	440.43	127.00	753.85	388.90	491.95	116.61	-41.66	-2.31
	6/30/2000	60.2	138.2	662.7	804.5	416.40	99.20	733.60	361.45	471.35	110.25	-42.16	-2.46
	9/30/2000	50.1	142.5	668.8	795.7	414.28	96.30	732.25	359.45	469.10	109.69	-42.26	-2.46
	1/13/2001	109.5	179.9	712.3	845.5	461.80	144.70	778.90	410.90	512.70	122.27	-42.15	-2.28
	4/20/2001	126.8	283.2	715.3	881.9	501.80	205.00	798.60	421.05	582.55	132.86	-39.45	-3.62
	7/16/2001	68.3	149.8	674.3	837.1	432.38	109.05	755.70	371.30	493.45	114.48	-42.98	-2.74
	10/9/2001	71.4	157.1	685.5	840.8	438.70	114.25	763.15	378.45	498.95	116.15	-43.12	-2.70
	1/9/2002	102.7	177.8	713	872	466.38	140.25	792.50	407.85	524.90	123.48	-43.35	-2.62
	4/12/2002	125.5	192.8	738.6	904.9	490.45	159.15	821.75	432.05	548.85	129.86	-44.04	-2.62
1	7/18/2002	62.3	151.8	706.334	859.6	445.01	107.05	782.97	384.32	505.70	117.82	-44.92	-2.72
	10/8/2002	43.7	151.1	711.3	846.7	438.20	97.40	779.00	377.50	498.90	116.02	-45.30	-2.72
	1/8/2003	84.7	180.5	748.5	891.8	476.38	132.60	820.15	416.60	536.15	126.13	-45.69	-2.68
	4/15/2003	96.1	191.9	739.9	989.3	504.30	144.00	864.60	418.00	590.60	133.52	-47.89	-3.87
	7/1/2003	57.4	168	713	959	474.35	112.70	836.00	385.20	563.50	125.59	-48.07	-3.99
	10/7/2003	42.1	166.8	714	946.6	467.38	104.45	830.30	378.05	556.70	123.75	-48.24	-4.00
	12/31/2003	80	197.9	753.9	985.1	504.23	138.95	869.50	416.95	591.50	133.50	-48.55	-3.91
	4/13/2004	92	208.9	760.4	1006.6	516.98	150.45	883.50	426.20	607.75	136.88	-48.72	-4.07
	7/13/2004	14.6	163.9	707.3	954.4	460.05	89.25	830.85	360.95	559.15	121.81	-49.29	-4.44
	10/8/2004	-8.6	233.4	704.6	941	467.60	112.40	822.80	348.00	587.20	123.81	-47.21	-5.36
	1/7/2005	19.5	190.4	746.5	982.5	484.73	104.95	864.50	383.00	586.45	128.34	-50.48	-4.56
	4/8/2005	3.4	397.6	751.6	1003.4	539.00	200.50	877.50	377.50	700.50	142.71	-44.99	-7.24
	7/18/2005	3.1	164.3	709.7	969.6	461.68	83.70	839.65	356.40	566.95	122.24	-50.24	-4.72
	8/26/2005	3.1	157.5	702.5	956.3	454.85	80.30	829.40	352.80	556.90	120.43	-49.78	-4.57
	10/11/2005	3.1	164.2	712.6	960.1	460.00	83.65	836.35	357.85	562.15	121.79	-50.02	-4.58
	1/10/2006	3.1	191.9	742.5	997	483.63	97.50	869.75	372.80	594.45	128.05	-51.32	-4.97
	4/9/2006	3.5	205.3	750.7	1018.8	494.58	104.40	884.75	377.10	612.05	130.95	-51.86	-5.26
	7/19/2006	3.5	166.6	703.7	975.5	462.33	85.05	839.60	353.60	571.05	122.41	-50.15	-4.87
	10/18/2006	3.5	170.2	709	967.5	462.55	86.85	838.25	356.25	568.85	122.47	-49.94	-4.76
	1/18/2007	3.5	209.1	748.7	1013.1	493.60	106.30	880.90	376.10	611.10	130.69	-51.48	-5.26
	4/19/2007	3.5	216.6	743.7	1021.2	496.25	110.05	882.45	373.60	618.90	131.39	-51.33	-5.50
	7/11/2007	3.5	169.6	700.9	981.6	463.90	86.55	841.25	352.20	575.60	122.83	-50.16	-5.00

Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	374.9	6	549.6	471.8	350.58	190.45	510.70	462.25	238.90	92.82	-21.28	5.00
	7/15/1999	368.6	-3.6	544.2	467.3	344.13	182.50	505.75	456.40	231.85	91.11	-21.48	5.03
	8/15/1999	373.7	0.2	569.4	485.2	357.13	186.95	527.30	471.55	242.70	94.56	-22.62	5.13
	8/31/1999	368.4	-4.7	567	486.2	354.23	181.85	526.60	467.70	240.75	93.79	-22.91	5.08
	9/15/1999	365.9	-9.2	565.3	485.1	351.78	178.35	525.20	465.60	237.95	93.14	-23.05	5.10
	9/30/1999	364.6	-11.7	570.1	487.6	352.65	176.45	528.85	467.35	237.95	93.37	-23.42	5.14
	10/15/1999	361.7	-14.8	569.9	487.4	351.05	173.45	528.65	465.80	236.30	92.95	-23.61	5.14
	10/31/1999	362.8	-13.5	575.6	493.1	354.50	174.65	534.35	469.20	239.80	93.86	-23.91	5.14
	11/15/1999	365.0	-11.5	581.4	498	358.23	176.75	539.70	473.20	243.25	94.85	-24.12	5.15
	11/30/1999	365.6	-11.8	583.7	500.1	359.40	176.90	541.90	474.65	244.15	95.16	-24.26	5.16
	12/15/1999	368.0	-9.2	589.7	504.2	363.18	179.40	546.95	478.85	247.50	96.16	-24.43	5.18
	12/31/1999	369.0	-8	592.9	506.6	365.13	180.50	549.75	480.95	249.30	96.67	-24.54	5.19
	3/31/2000	379.6	7.3	617	524.1	382.00	193.45	570.55	498.30	265.70	101.14	-25.06	5.21
	6/30/2000	376.1	4.4	608.9	519.1	377.13	190.25	564.00	492.50	261.75	99.85	-24.84	5.17
	9/30/2000	360.7	-12.3	588.3	503.5	360.05	174.20	545.90	474.50	245.60	95.33	-24.70	5.13
	1/13/2001	372.1	2.2	618.1	526.1	379.63	187.15	572.10	495.10	264.15	100.51	-25.58	5.17
	4/20/2001	387.6	21	645.8	549.2	400.90	204.30	597.50	516.70	285.10	106.15	-26.13	5.19
	7/16/2001	374.6	6.5	621.5	532.9	383.88	190.55	577.20	498.05	269.70	101.64	-25.70	5.12
	10/9/2001	360.9	-9.4	598.9	515.8	366.55	175.75	557.35	479.90	253.20	97.05	-25.36	5.08
	1/9/2002	363.5	-2.5	611.5	524.5	374.25	180.50	568.00	487.50	261.00	99.09	-25.75	5.07
	4/12/2002	381.7	16.9	642.7	550.5	397.95	199.30	596.60	512.20	283.70	105.37	-26.40	5.12
12	7/18/2002	375	10.5	629	544.7	389.80	192.75	586.85	502.00	277.60	103.21	-26.19	5.03
	10/8/2002	357.7	-9.6	599.2	523	367.58	174.05	561.10	478.45	256.70	97.32	-25.72	4.97
	1/8/2003	367.3	6.5	626.7	542.7	385.80	186.90	584.70	497.00	274.60	102.15	-26.44	4.98
	4/15/2003	385.9	27.3	655.3	566.2	408.68	206.60	610.75	520.60	296.75	108.20	-26.86	5.01
	7/1/2003	384.7	26.3	649.2	565.6	406.45	205.50	607.40	516.95	295.95	107.62	-26.71	4.95
	10/7/2003	360.6	3.5	613	539.7	379.20	182.05	576.35	486.80	271.60	100.40	-26.20	4.82
	12/31/2003	372	19.4	636	558.3	396.43	195.70	597.15	504.00	288.85	104.96	-26.68	4.82
	4/13/2004	389.4	39.8	665.5	583.1	419.45	214.60	624.30	527.45	311.45	111.06	-27.23	4.84
	7/13/2004	379.5	27.7	643.3	571.1	405.40	203.60	607.20	511.40	299.40	107.34	-26.82	4.75
	10/8/2004	361.6	10.3	615.2	550.9	384.50	185.95	583.05	488.40	280.60	101.80	-26.39	4.66
	1/7/2005	367.5	16.1	630.6	561.5	393.93	191.80	596.05	499.05	288.80	104.30	-26.87	4.71
	4/8/2005	388.2	35.6	662.3	587.2	418.33	211.90	624.75	525.25	311.40	110.76	-27.44	4.79
	7/18/2005	382.6	26.3	647.7	580.1	409.18	204.45	613.90	515.15	303.20	108.34	-27.21	4.75
	8/26/2005	373.6	15.7	629.8	566.8	396.48	194.65	598.30	501.70	291.25	104.97	-26.83	4.71
	10/11/2005	365.9	6.1	617.8	557.9	386.93	186.00	587.85	491.85	282.00	102.45	-26.71	4.70
	1/10/2006	376.2	17.5	639	572.2	401.23	196.85	605.60	507.60	294.85	106.23	-27.16	4.77
	4/9/2006	393.8	32.7	665.7	594	421.55	213.25	629.85	529.75	313.35	111.61	-27.69	4.85
	7/19/2006	384.2	20.3	646.2	582.7	408.35	202.25	614.45	515.20	301.50	108.12	-27.39	4.79
	10/18/2006	365	-2	614.4	558.2	383.90	181.50	586.30	489.70	278.10	101.65	-26.90	4.74
	1/18/2007	376	9.6	635.9	573.9	398.85	192.80	604.90	505.95	291.75	105.60	-27.39	4.80
	4/19/2007	390.7	24.1	659.3	592.7	416.70	207.40	626.00	525.00	308.40	110.33	-27.82	4.85
	7/11/2007	384.1	15	644.6	584.6	407.08	199.55	614.60	514.35	299.80	107.78	-27.58	4.81

Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	306.3	72.2	490.8	675.2	386.13	189.25	583.00	398.55	373.70	102.23	-26.17	0.56
	7/15/1999	288.0	53.1	484.2	670.6	373.98	170.55	577.40	386.10	361.85	99.02	-27.04	0.54
	8/15/1999	280.9	61.8	506.3	693.7	385.68	171.35	600.00	393.60	377.75	102.12	-28.49	0.36
	8/31/1999	270.4	52.1	503.1	691.4	379.25	161.25	597.25	386.75	371.75	100.41	-28.98	0.34
	9/15/1999	261.3	43.9	501.2	689.9	374.08	152.60	595.55	381.25	366.90	99.04	-29.44	0.32
	9/30/1999	257.1	40.7	503.1	690.7	372.90	148.90	596.90	380.10	365.70	98.73	-29.77	0.32
	10/15/1999	250.1	33.8	501.2	691	369.03	141.95	596.10	375.65	362.40	97.71	-30.18	0.30
	10/31/1999	251.4	38	507.6	697.6	373.65	144.70	602.60	379.50	367.80	98.93	-30.43	0.26
	11/15/1999	253.9	41.6	512.1	701.9	377.38	147.75	607.00	383.00	371.75	99.92	-30.52	0.25
	11/30/1999	253.5	41.2	513.6	704.4	378.18	147.35	609.00	383.55	372.80	100.13	-30.68	0.24
	12/15/1999	255.8	46.7	519.1	709.3	382.73	151.25	614.20	387.45	378.00	101.33	-30.77	0.21
	12/31/1999	256.7	48.9	522.3	712.4	385.08	152.80	617.35	389.50	380.65	101.96	-30.87	0.20
	3/31/2000	267.5	64.6	542.8	734.2	402.28	166.05	638.50	405.15	399.40	106.51	-31.40	0.13
	6/30/2000	258.9	46.4	531.2	726.1	390.65	152.65	628.65	395.05	386.25	103.43	-31.63	0.20
	9/30/2000	237.1	10.1	504.9	705.9	364.50	123.60	605.40	371.00	358.00	96.51	-32.02	0.29
	1/13/2001	254.0	40.9	535.1	734.6	391.15	147.45	634.85	394.55	387.75	103.56	-32.39	0.15
	4/20/2001	275.4	72.6	561.4	763.7	418.28	174.00	662.55	418.40	418.15	110.75	-32.47	0.01
	7/16/2001	255.3	37.7	534.8	740.9	392.18	146.50	637.85	395.05	389.30	103.84	-32.65	0.13
	10/9/2001	235.7	7.5	510.6	719.6	368.35	121.60	615.10	373.15	363.55	97.53	-32.80	0.22
	1/9/2002	240	18.9	523.3	731	378.30	129.45	627.15	381.65	374.95	100.16	-33.08	0.15
	4/12/2002	263.4	58.5	554.8	763	409.93	160.95	658.90	409.10	410.75	108.54	-33.09	-0.04
13	7/18/2002	255.5	40.1	566.1	754.5	404.05	147.80	660.30	410.80	397.30	106.98	-34.06	0.30
	10/8/2002	231.2	3.4	508.7	726.1	367.35	117.30	617.40	369.95	364.75	97.26	-33.24	0.12
	1/8/2003	249.4	38.5	540.1	754.4	395.60	143.95	647.25	394.75	396.45	104.74	-33.45	-0.04
	4/15/2003	276.4	78.5	571.6	784.9	427.85	177.45	678.25	424.00	431.70	113.28	-33.28	-0.17
	7/1/2003	273	69	561.4	779.9	420.83	171.00	670.65	417.20	424.45	111.42	-33.21	-0.16
	10/7/2003	246.6	22.5	524.7	744.6	384.60	134.55	634.65	385.65	383.55	101.83	-33.24	0.05
	12/31/2003	264.8	58.9	552.8	770.1	411.65	161.85	661.45	408.80	414.50	108.99	-33.20	-0.13
	4/13/2004	291.3	97.7	584	803.2	444.05	194.50	693.60	437.65	450.45	117.57	-33.17	-0.29
	7/13/2004	275.5	64.3	556.1	781	419.23	169.90	668.55	415.80	422.65	111.00	-33.14	-0.15
	10/8/2004	252.8	29.9	527.5	755.8	391.50	141.35	641.65	390.15	392.85	103.66	-33.25	-0.06
	1/7/2005	264	50.8	544.5	770.6	407.48	157.40	657.55	404.25	410.70	107.89	-33.24	-0.14
	4/8/2005	289.9	90.7	576	802	439.65	190.30	689.00	432.95	446.35	116.41	-33.14	-0.30
	7/18/2005	277.8	67.7	556.4	787.1	422.25	172.75	671.75	417.10	427.40	111.80	-33.16	-0.23
	8/26/2005	266.7	46.5	539.8	771.9	406.23	156.60	655.85	403.25	409.20	107.56	-33.18	-0.13
	10/11/2005	257.2	33.8	526.8	760.8	394.65	145.50	643.80	392.00	397.30	104.49	-33.12	-0.12
	1/10/2006	269.3	59.9	551.2	780.4	415.20	164.60	665.80	410.25	420.15	109.93	-33.31	-0.22
	4/9/2006	289.9	90	576.3	806.2	440.60	189.95	691.25	433.10	448.10	116.66	-33.32	-0.34
	7/19/2006	277.7	63.9	553.8	787.8	420.80	170.80	670.80	415.75	425.85	111.42	-33.23	-0.23
	10/18/2006	253.3	27.9	523.7	757.8	390.68	140.60	640.75	388.50	392.85	103.44	-33.24	-0.10
	1/18/2007	267.4	54.9	546.5	778.5	411.83	161.15	662.50	406.95	416.70	109.04	-33.32	-0.22
	4/19/2007	289	88.7	575.1	806.8	439.90	188.85	690.95	432.05	447.75	116.47	-33.37	-0.35
	7/11/2007	280	67	558	793.6	424.65	173.50	675.80	419.00	430.30	112.43	-33.38	-0.25

Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	445.4	53.9	802	298.7	400.00	249.65	550.35	623.70	176.30	105.91	-19.98	10.02
	7/15/1999	440.5	34.4	799.5	280.7	388.78	237.45	540.10	620.00	157.55	102.94	-20.11	10.36
	8/15/1999	455.6	40.8	837.6	284.6	404.65	248.20	561.10	646.60	162.70	107.14	-20.79	10.84
	8/31/1999	452.7	30.7	837.1	274.1	398.65	241.70	555.60	644.90	152.40	105.55	-20.86	11.03
	9/15/1999	448.5	21.7	836.8	266.2	393.30	235.10	551.50	642.65	143.95	104.13	-21.03	11.17
	9/30/1999	447.0	16.1	838.5	260.8	390.60	231.55	549.65	642.75	138.45	103.42	-21.14	11.30
	10/15/1999	446.5	8.8	839.3	255.1	387.43	227.65	547.20	642.90	131.95	102.58	-21.24	11.45
	10/31/1999	450.9	11.7	847.9	257.8	392.08	231.30	552.85	649.40	134.75	103.81	-21.37	11.53
	11/15/1999	455.9	16.1	856.2	259.8	397.00	236.00	558.00	656.05	137.95	105.11	-21.40	11.61
	11/30/1999	456.3	15.5	858.3	259	397.28	235.90	558.65	657.30	137.25	105.19	-21.45	11.65
	12/15/1999	461.3	20.5	865.6	261.7	402.28	240.90	563.65	663.45	141.10	106.51	-21.45	11.70
	12/31/1999	463.4	22.5	871.6	262.9	405.10	242.95	567.25	667.50	142.70	107.26	-21.55	11.76
	3/31/2000	477.8	35.6	903.8	282.7	424.98	256.70	593.25	690.80	159.15	112.52	-22.37	11.91
	6/30/2000	469.2	17.4	889.7	267.4	410.93	243.30	578.55	679.45	142.40	108.80	-22.28	12.03
	9/30/2000	453.5	-23.5	856.8	240.4	381.80	215.00	548.60	655.15	108.45	101.09	-22.17	12.25
	1/13/2001	476.9	5	891.3	257.6	407.70	240.95	574.45	684.10	131.30	107.95	-22.16	12.38
	4/20/2001	494.8	40.8	932.8	281.2	437.40	267.80	607.00	713.80	161.00	115.81	-22.54	12.38
	7/16/2001	475.7	4.9	900.7	255.9	409.30	240.30	578.30	688.20	130.40	108.37	-22.46	12.50
	10/9/2001	459.3	-30.8	870.4	236.8	383.93	214.25	553.60	664.85	103.00	101.65	-22.55	12.59
	1/9/2002	468.8	-18.5	883.7	241.5	393.88	225.15	562.60	676.25	111.50	104.29	-22.43	12.65
	4/12/2002	492.8	22.5	926.5	270.2	428.00	257.65	598.35	709.65	146.35	113.32	-22.64	12.62
14	7/18/2002	483.5	3.8	911.9	257.3	414.13	243.65	584.60	697.70	130.55	109.65	-22.66	12.71
	10/8/2002	462.7	-35	875.6	233	384.08	213.85	554.30	669.15	99.00	101.69	-22.63	12.77
	1/8/2003	485.5	2.5	912.6	253.9	413.63	244.00	583.25	699.05	128.20	109.52	-22.55	12.79
	4/15/2003	501.9	612.9	952.7	285.1	588.15	557.40	618.90	727.30	449.00	155.72	-4.09	6.23
	7/1/2003	521.6	28.8	943.4	278.1	442.98	275.20	610.75	732.50	153.45	117.29	-22.30	12.97
	10/7/2003	472.3	-16.5	903.8	247.5	401.78	227.90	575.65	688.05	115.50	106.38	-23.11	12.83
	12/31/2003	495.5	18.6	939.3	268.7	430.53	257.05	604.00	717.40	143.65	113.99	-23.06	12.85
	4/13/2004	504.6	68.9	989	299.2	465.43	286.75	644.10	746.80	184.05	123.23	-23.75	12.61
	7/13/2004	487.3	36.7	961.8	277.7	440.88	262.00	619.75	724.55	157.20	116.73	-23.78	12.71
	10/8/2004	468.9	-0.5	928.8	256.4	413.40	234.20	592.60	698.85	127.95	109.46	-23.82	12.79
	1/7/2005	485.2	21.4	952.7	269.7	432.25	253.30	611.20	718.95	145.55	114.45	-23.79	12.85
	4/8/2005	512.9	68.8	998.7	302.5	470.73	290.85	650.60	755.80	185.65	124.63	-23.91	12.77
	7/18/2005	498.2	40	977.1	286.8	450.53	269.10	631.95	737.65	163.40	119.29	-24.11	12.86
	8/26/2005	486.3	17.1	955.5	271.8	432.68	251.70	613.65	720.90	144.45	114.56	-24.05	12.91
	10/11/2005	478.8	2.4	942.6	263.6	421.85	240.60	603.10	710.70	133.00	111.69	-24.09	12.94
	1/10/2006	497.9	28.2	970.6	280.6	444.33	263.05	625.60	734.25	154.40	117.64	-24.09	12.99
	4/9/2006	519.6	65.1	1008.9	306	474.90	292.35	657.45	764.25	185.55	125.74	-24.26	12.96
	7/19/2006	505.7	73.4	984.2	290.7	463.50	289.55	637.45	744.95	182.05	122.72	-23.12	12.61
	10/18/2006	484	-5.7	946.5	265.8	422.65	239.15	606.15	715.25	130.05	111.91	-24.39	13.11
	1/18/2007	503	21.5	974.4	282.5	445.35	262.25	628.45	738.70	152.00	117.92	-24.34	13.14
	4/19/2007	525.1	60.9	1012.9	309.1	477.00	293.00	661.00	769.00	185.00	126.30	-24.46	13.08
	7/11/2007	533.8	36.8	994.5	295.1	465.05	285.30	644.80	764.15	165.95	123.13	-23.89	13.40

Tie Beam Forces and Bending Moments (Driven Pile Cap side)(cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	468.3	92.2	387.7	511.7	364.98	280.25	449.70	428.00	301.95	96.63	-11.26	2.82
	7/15/1999	460.1	81	381.5	505.7	357.08	270.55	443.60	420.80	293.35	94.54	-11.50	2.86
	8/15/1999	482.3	96.1	410.7	526	378.78	289.20	468.35	446.50	311.05	100.29	-11.91	3.03
	8/31/1999	490.3	101.9	422.4	535	387.40	296.10	478.70	456.35	318.45	102.57	-12.14	3.09
	9/15/1999	491.0	101.4	426.3	536.4	388.78	296.20	481.35	458.65	318.90	102.94	-12.30	3.13
	9/30/1999	497.9	106.7	434.7	543.6	395.73	302.30	489.15	466.30	325.15	104.78	-12.42	3.16
	10/15/1999	505.0	112.3	443.2	550.9	402.85	308.65	497.05	474.10	331.60	106.66	-12.52	3.19
	10/31/1999	515.6	118.8	452.5	560.9	411.95	317.20	506.70	484.05	339.85	109.07	-12.59	3.23
	11/15/1999	525.0	128.3	463.4	570.2	421.73	326.65	516.80	494.20	349.25	111.66	-12.64	3.25
	11/30/1999	532.5	134.9	471.5	576.8	428.93	333.70	524.15	502.00	355.85	113.57	-12.66	3.27
	12/15/1999	534.1	138.1	476.5	580.2	432.23	336.10	528.35	505.30	359.15	114.44	-12.78	3.27
	12/31/1999	540.4	144.3	484.4	587.2	439.08	342.35	535.80	512.40	365.75	116.25	-12.86	3.29
	3/31/2000	551.1	156	501.3	602.1	452.63	353.55	551.70	526.20	379.05	119.84	-13.17	3.30
	6/30/2000	533.5	137.3	477.6	577.9	431.58	335.40	527.75	505.55	357.60	114.27	-12.78	3.31
	9/30/2000	539.6	136.8	480.7	575.1	433.05	338.20	527.90	510.15	355.95	114.66	-12.61	3.45
	1/13/2001	571.4	169.7	522.7	611.8	468.90	370.55	567.25	547.05	390.75	124.15	-13.07	3.50
	4/20/2001	580.2	184.8	537.9	624.6	481.88	382.50	581.25	559.05	404.70	127.59	-13.21	3.46
	7/16/2001	555.8	159.1	508	598.6	455.38	357.45	553.30	531.90	378.85	120.57	-13.02	3.43
	10/9/2001	556.2	154.1	506	595.8	453.03	355.15	550.90	531.10	374.95	119.95	-13.01	3.50
	1/9/2002	572	170.3	527.3	614.7	471.08	371.15	571.00	549.65	392.50	124.73	-13.28	3.52
	4/12/2002	584.6	187.7	546.3	632.8	487.85	386.15	589.55	565.45	410.25	129.17	-13.52	3.48
26	7/18/2002	559.5	162.1	516.1	606	460.93	360.80	561.05	537.80	384.05	122.04	-13.31	3.44
	10/8/2002	557	154.4	511	599.8	455.55	355.70	555.40	534.00	377.10	120.62	-13.27	3.51
	1/8/2003	591	189.2	552.8	639	493.00	390.10	595.90	571.90	414.10	130.53	-13.68	3.54
	4/15/2003	597.9	204.3	567.5	650.5	505.05	401.10	609.00	582.70	427.40	133.72	-13.82	3.48
	7/1/2003	580.7	184.3	545.4	632.5	485.73	382.50	588.95	563.05	408.40	128.61	-13.72	3.46
	10/7/2003	578.2	176.3	538	627	479.88	377.25	582.50	558.10	401.65	127.06	-13.64	3.50
	12/31/2003	610.3	207.7	572.6	661.6	513.05	409.00	617.10	591.45	434.65	135.84	-13.83	3.51
	4/13/2004	617.1	224.2	589.5	675.7	526.63	420.65	632.60	603.30	449.95	139.43	-14.09	3.44
	7/13/2004	584	186.6	549.1	642.6	490.58	385.30	595.85	566.55	414.60	129.89	-13.99	3.40
	10/8/2004	581.8	181.2	543.7	638.3	486.25	381.50	591.00	562.75	409.75	128.74	-13.92	3.43
	1/7/2005	609.9	209	574.8	669.1	515.70	409.45	621.95	592.35	439.05	136.54	-14.12	3.43
	4/8/2005	617.5	225	590.2	683.9	529.15	421.25	637.05	603.85	454.45	140.10	-14.34	3.35
	7/18/2005	590.4	192.7	554.7	656	498.45	391.55	605.35	572.55	424.35	131.97	-14.21	3.32
	8/26/2005	584.4	183.1	544	647.8	489.83	383.75	595.90	564.20	415.45	129.69	-14.10	3.33
	10/11/2005	589.3	185.9	548.5	652	493.93	387.60	600.25	568.90	418.95	130.78	-14.13	3.36
	1/10/2006	616	216.1	582.8	683.4	524.58	416.05	633.10	599.40	449.75	138.89	-14.42	3.35
	4/9/2006	629	235.4	605.8	701.1	542.83	432.20	653.45	617.40	468.25	143.72	-14.70	3.34
	7/19/2006	595.8	199	563.1	668.3	506.55	397.40	615.70	579.45	433.65	134.12	-14.51	3.27
	10/18/2006	595.6	193	557.4	662.8	502.20	394.30	610.10	576.50	427.90	132.97	-14.34	3.33
	1/18/2007	622.2	223.4	590.2	694.6	532.60	422.80	642.40	606.20	459.00	141.02	-14.59	3.30
	4/19/2007	624.5	231.7	598.4	701.1	538.93	428.10	649.75	611.45	466.40	142.69	-14.73	3.25
	7/11/2007	594.6	199.2	561.5	670.8	506.53	396.90	616.15	578.05	435.00	134.11	-14.57	3.20

Tie Beam Forces and Bending Moments (Drilled Shaft side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force (Kip)	Moment(x) (Kip-ft)	Moment(y) (Kip-ft)
	7/1/1999	-115.0	299.7	422.9	109.6	179.30	92.35	266.25	153.95	204.65	47.47	-11.56	-1.14
	7/15/1999	-122.0	289	405.2	95.6	166.95	83.50	250.40	141.60	192.30	44.20	-11.09	-1.14
	8/15/1999	-139.4	265.8	401.5	101.8	157.43	63.20	251.65	131.05	183.80	41.68	-12.52	-1.18
	8/31/1999	-144.1	258.4	394.7	99.6	152.15	57.15	247.15	125.30	179.00	40.28	-12.63	-1.20
	9/15/1999	-144.1	255.9	395.1	102	152.23	55.90	248.55	125.50	178.95	40.30	-12.80	-1.20
	9/30/1999	-141.7	260.4	408.3	112.3	159.83	59.35	260.30	133.30	186.35	42.32	-13.35	-1.19
	10/15/1999	-138.1	275.3	441.9	138.4	179.38	68.60	290.15	151.90	206.85	47.49	-14.72	-1.23
	10/31/1999	-148.1	272.7	430.1	118.5	168.30	62.30	274.30	141.00	195.60	44.56	-14.09	-1.22
	11/15/1999	-142.3	278.9	446.6	134.9	179.53	68.30	290.75	152.15	206.90	47.53	-14.78	-1.23
	11/30/1999	-137.9	284.4	462	150.8	189.83	73.25	306.40	162.05	217.60	50.26	-15.49	-1.24
	12/15/1999	-135.4	290	463.8	152.5	192.73	77.30	308.15	164.20	221.25	51.03	-15.34	-1.28
	12/31/1999	-126.8	301.4	481.4	168.9	206.23	87.30	325.15	177.30	235.15	54.60	-15.81	-1.30
	3/31/2000	-133.9	283.1	455.7	149.6	188.63	74.60	302.65	160.90	216.35	49.94	-15.16	-1.24
	6/30/2000	-157.3	230.6	397.4	119.3	147.50	36.65	258.35	120.05	174.95	39.05	-14.73	-1.23
	9/30/2000	-142.8	237.4	427.4	156.8	169.70	47.30	292.10	142.30	197.10	44.93	-16.27	-1.23
	1/13/2001	-118.2	295.4	511.7	182.5	217.85	88.60	347.10	196.75	238.95	57.68	-17.18	-0.95
	4/20/2001	-128.9	270.9	454	163.4	189.85	71.00	308.70	162.55	217.15	50.27	-15.80	-1.22
	7/16/2001	-146.4	213.9	384.1	133.3	146.23	33.75	258.70	118.85	173.60	38.72	-14.95	-1.23
	10/9/2001	-135.7	237.5	439.4	178.3	179.88	50.90	308.85	151.85	207.90	47.63	-17.14	-1.26
	1/9/2002	-120.2	281.4	483	190.7	208.73	80.60	336.85	181.40	236.05	55.26	-17.03	-1.22
	4/12/2002	-133.2	263.6	441.1	154.2	181.43	65.20	297.65	153.95	208.90	48.04	-15.45	-1.23
1	7/18/2002	-158.1	191.2	355.6	118	126.68	16.55	236.80	98.75	154.60	33.54	-14.64	-1.25
	10/7/2002	-149.2	192.4	391.7	156.3	147.80	21.60	274.00	121.25	174.35	39.13	-16.77	-1.19
	1/8/2003	-123.2	268.7	469.3	191.8	201.65	72.75	330.55	173.05	230.25	53.39	-17.13	-1.28
	4/15/2003	-137.5	248.4	427.1	157.1	173.78	55.45	292.10	144.80	202.75	46.01	-15.73	-1.30
	7/1/2003	-159.7	183.9	351.2	124.6	125.00	12.10	237.90	95.75	154.25	33.10	-15.01	-1.31
	10/7/2003	-146.6	206.4	412.6	177.8	162.55	29.90	295.20	133.00	192.10	43.04	-17.63	-1.32
	12/31/2003	-135.4	243.4	450.4	190	187.10	54.00	320.20	157.50	216.70	49.54	-17.69	-1.33
	4/13/2004	-144.6	228.6	422.1	168	168.53	42.00	295.05	138.75	198.30	44.62	-16.82	-1.33
	7/13/2004	-179.1	155.6	334.2	117.5	107.05	-11.75	225.85	77.55	136.55	28.34	-15.79	-1.32
	10/8/2004	-169	170.9	373.7	152.9	132.13	0.95	263.30	102.35	161.90	34.98	-17.44	-1.33
	1/7/2005	-145.5	227.8	440.5	188.2	177.75	41.15	314.35	147.50	208.00	47.06	-18.16	-1.36
	4/8/2005	-159.4	209.2	398.5	148.8	149.28	24.90	273.65	119.55	179.00	39.52	-16.53	-1.33
	7/18/2005	-182.8	141.5	330.3	131.3	105.08	-20.65	230.80	73.75	136.40	27.82	-16.71	-1.40
	8/26/2005	-184	140.7	341.3	131.3	107.33	-21.65	236.30	78.65	136.00	28.42	-17.14	-1.28
	10/11/2005	-174.2	159.1	370.9	131.3	121.78	-7.55	251.10	98.35	145.20	32.24	-17.19	-1.05
	1/10/2006	-152.5	216.4	430.7	131.3	156.48	31.95	281.00	139.10	173.85	41.43	-16.55	-0.78
	4/9/2006	-157.2	206.1	413	131.3	148.30	24.45	272.15	127.90	168.70	39.27	-16.46	-0.91
	7/19/2006	-189.4	135.9	330	131.3	101.95	-26.75	230.65	70.30	133.60	26.99	-17.11	-1.42
	10/18/2006	-170.5	170.2	390.6	131.3	130.40	-0.15	260.95	110.05	150.75	34.53	-17.35	-0.91
	1/18/2007	-145.4	217.2	448.1	131.3	162.80	35.90	289.70	151.35	174.25	43.10	-16.87	-0.51
	4/19/2007	-159.2	203.2	410.4	131.3	146.43	22.00	270.85	125.60	167.25	38.77	-16.54	-0.93
	7/11/2007	-192.9	128.3	318.7	131.3	96.35	-32.30	225.00	62.90	129.80	25.51	-17.10	-1.50

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	356.2	257	201.2	275.1	272.38	306.60	238.15	278.70	266.05	72.12	4.55	0.28
	7/15/1999	353.8	251.6	188.4	273.4	266.80	302.70	230.90	271.10	262.50	70.64	4.77	0.19
	8/15/1999	350.0	242.8	195.3	301.1	272.30	296.40	248.20	272.65	271.95	72.10	3.20	0.02
	8/31/1999	350.2	247.8	201.7	307.9	276.90	299.00	254.80	275.95	277.85	73.31	2.94	-0.04
	9/15/1999	349.8	249.1	203.6	314	279.13	299.45	258.80	276.70	281.55	73.90	2.70	-0.11
	9/30/1999	352.2	256.8	212.1	322.7	285.95	304.50	267.40	282.15	289.75	75.71	2.47	-0.17
	10/15/1999	352.6	257.7	225.5	337.3	293.28	305.15	281.40	289.05	297.50	77.65	1.58	-0.19
	10/31/1999	361.0	268.5	222.6	333.7	296.45	314.75	278.15	291.80	301.10	78.49	2.43	-0.21
	11/15/1999	364.5	273.1	237.1	353.6	307.08	318.80	295.35	300.80	313.35	81.30	1.56	-0.28
	11/30/1999	367.6	276.3	249.1	369.4	315.60	321.95	309.25	308.35	322.85	83.56	0.84	-0.32
	12/15/1999	370.6	280.7	248.5	364.3	316.03	325.65	306.40	309.55	322.50	83.67	1.28	-0.29
	12/31/1999	371.2	282.5	254.8	368.8	319.33	326.85	311.80	313.00	325.65	84.55	1.00	-0.28
	3/31/2000	376.0	289.2	244.7	361.1	317.75	332.60	302.90	310.35	325.15	84.13	1.97	-0.33
	6/30/2000	358.4	247.7	207.4	329.3	285.70	303.05	268.35	282.90	288.50	75.64	2.31	-0.13
	9/30/2000	357.6	235.9	230.1	366.4	297.50	296.75	298.25	293.85	301.15	78.77	-0.10	-0.16
	1/13/2001	382.0	289.5	264.4	384.8	330.18	335.75	324.60	323.20	337.15	87.42	0.74	-0.31
	4/20/2001	382.9	294.9	260.1	378.2	329.03	338.90	319.15	321.50	336.55	87.12	1.31	-0.34
	7/16/2001	352.4	249.4	219.2	330.6	287.90	300.90	274.90	285.80	290.00	76.23	1.73	-0.09
	10/9/2001	357.7	267.9	262.1	382	317.43	312.80	322.05	309.90	324.95	84.04	-0.61	-0.34
	1/9/2002	385.8	301.2	285.1	395.6	341.93	343.50	340.35	335.45	348.40	90.53	0.21	-0.29
	4/12/2002	390.9	310.2	263.2	370.1	333.60	350.55	316.65	327.05	340.15	88.33	2.25	-0.29
12	7/18/2002	346.39	265.03	220.4	323.3	288.78	305.71	271.85	283.39	294.17	76.46	2.25	-0.24
	10/7/2002	344.5	265.3	252.4	363.5	306.43	304.90	307.95	298.45	314.40	81.13	-0.20	-0.36
	1/8/2003	385.9	308.5	295.9	394.3	346.15	347.20	345.10	340.90	351.40	91.65	0.14	-0.24
	4/15/2003	392.4	317.3	275.8	371.1	339.15	354.85	323.45	334.10	344.20	89.80	2.09	-0.23
	7/1/2003	360	288.1	238.7	332.8	304.90	324.05	285.75	299.35	310.45	80.73	2.55	-0.25
	10/7/2003	357.1	284.5	277.7	372.1	322.85	320.80	324.90	317.40	328.30	85.48	-0.27	-0.24
	12/31/2003	387.7	318.7	304.1	392.5	350.75	353.20	348.30	345.90	355.60	92.87	0.33	-0.22
	4/13/2004	389.4	324.2	294.9	381.2	347.43	356.80	338.05	342.15	352.70	91.99	1.25	-0.24
	7/13/2004	348	285.8	241	324.8	299.90	316.90	282.90	294.50	305.30	79.40	2.26	-0.24
	10/8/2004	342.4	281.8	269.4	353.1	311.68	312.10	311.25	305.90	317.45	82.52	0.06	-0.26
	1/7/2005	374.1	315.2	302.9	382.8	343.75	344.65	342.85	338.50	349.00	91.01	0.12	-0.24
	4/8/2005	386.7	328.9	284.3	365	341.23	357.80	324.65	335.50	346.95	90.35	2.20	-0.26
	7/18/2005	343.2	285.5	242.4	322.1	298.30	314.35	282.25	292.80	303.80	78.98	2.13	-0.25
	8/26/2005	337	278.7	250.1	331.1	299.23	307.85	290.60	293.55	304.90	79.23	1.15	-0.25
	10/11/2005	338.7	283.6	264.1	348.6	308.75	311.15	306.35	301.40	316.10	81.75	0.32	-0.33
	1/10/2006	371.5	317.4	297	373.5	339.85	344.45	335.25	334.25	345.45	89.98	0.61	-0.25
	4/9/2006	377.4	324.1	290.6	368.2	340.08	350.75	329.40	334.00	346.15	90.04	1.42	-0.27
	7/19/2006	341.9	289.2	238.8	315.3	296.30	315.55	277.05	290.35	302.25	78.45	2.56	-0.27
	10/18/2006	342.7	289.5	274.8	354.5	315.38	316.10	314.65	308.75	322.00	83.50	0.10	-0.30
	1/18/2007	368.4	316.6	305.5	385	343.88	342.50	345.25	336.95	350.80	91.05	-0.18	-0.31
	4/19/2007	370.5	320.9	279.2	353.9	331.13	345.70	316.55	324.85	337.40	87.67	1.94	-0.28
	7/11/2007	326.6	278.1	219	294	279.43	302.35	256.50	272.80	286.05	73.98	3.05	-0.30

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	177.4	380.2	417.6	236.2	302.85	278.80	326.90	297.50	308.20	80.19	-3.20	-0.24
	7/15/1999	173.8	378	412.7	230.2	298.68	275.90	321.45	293.25	304.10	79.08	-3.03	-0.24
	8/15/1999	172.8	380.2	439.6	252.6	311.30	276.50	346.10	306.20	316.40	82.42	-4.63	-0.23
	8/31/1999	172.6	378	445.8	257.5	313.48	275.30	351.65	309.20	317.75	83.00	-5.07	-0.19
	9/15/1999	170.9	377.2	447.2	261	314.08	274.05	354.10	309.05	319.10	83.16	-5.32	-0.23
	9/30/1999	176.4	380.7	455.9	269.3	320.58	278.55	362.60	316.15	325.00	84.88	-5.59	-0.20
	10/15/1999	176.7	378.9	468.1	279.5	325.80	277.80	373.80	322.40	329.20	86.26	-6.38	-0.15
	10/31/1999	182.4	385.8	502.1	273.8	336.03	284.10	387.95	342.25	329.80	88.97	-6.90	0.28
	11/15/1999	186.8	392.4	482.7	292	338.48	289.60	387.35	334.75	342.20	89.62	-6.50	-0.17
	11/30/1999	189.8	396.8	638.9	305.6	382.78	293.30	472.25	414.35	351.20	101.35	-11.89	1.41
	12/15/1999	193.5	401.1	516.7	302.2	353.38	297.30	409.45	355.10	351.65	93.56	-7.45	0.08
	12/31/1999	194.7	406.1	507.2	308	354.00	300.40	407.60	350.95	357.05	93.73	-7.12	-0.14
	3/31/2000	194.8	409	492.7	298.7	348.80	301.90	395.70	343.75	353.85	92.35	-6.23	-0.23
	6/30/2000	177.7	389.4	467.2	278.7	328.25	283.55	372.95	322.45	334.05	86.91	-5.94	-0.26
	9/30/2000	174.2	385.1	496.7	308	341.00	279.65	402.35	335.45	346.55	90.29	-8.15	-0.25
	1/13/2001	200.0	418.2	530.3	318.6	366.78	309.10	424.45	365.15	368.40	97.11	-7.67	-0.07
	4/20/2001	194.1	416.2	512.8	310.6	358.43	305.15	411.70	353.45	363.40	94.90	-7.08	-0.22
	7/16/2001	166.5	386.2	469	273.8	323.88	276.35	371.40	317.75	330.00	85.75	-6.32	-0.27
	10/9/2001	171.5	389.1	514.8	315.2	347.65	280.30	415.00	343.15	352.15	92.05	-8.95	-0.20
	1/9/2002	193.6	413.6	539.3	324.6	367.78	303.60	431.95	366.45	369.10	97.38	-8.53	-0.06
	4/12/2002	198.8	418.5	509.3	299.2	356.45	308.65	404.25	354.05	358.85	94.38	-6.35	-0.11
13	7/18/2002	161.4	379.1	462.4	262.6	316.38	270.25	362.50	311.90	320.85	83.77	-6.13	-0.20
	10/7/2002	155.8	373.6	686.8	301.1	379.33	264.70	493.95	421.30	337.35	100.43	-15.24	1.88
	1/8/2003	193.1	414	547.6	331	371.43	303.55	439.30	370.35	372.50	98.34	-9.02	-0.05
	4/15/2003	195.8	419.9	560.6	305.7	370.50	307.85	433.15	378.20	362.80	98.10	-8.33	0.34
	7/1/2003	172.1	394.8	479.4	273.9	330.05	283.45	376.65	325.75	334.35	87.39	-6.19	-0.19
	10/7/2003	169	389.1	527.1	317.5	350.68	279.05	422.30	348.05	353.30	92.85	-9.52	-0.12
	12/31/2003	196.2	423.2	560.3	334.7	378.60	309.70	447.50	378.25	378.95	100.24	-9.16	-0.02
	4/13/2004	197.9	424.7	546.1	321.7	372.60	311.30	433.90	372.00	373.20	98.65	-8.15	-0.03
	7/13/2004	155.6	383.5	482.7	266.1	321.98	269.55	374.40	319.15	324.80	85.25	-6.97	-0.13
	10/8/2004	152.2	378.4	519	298.6	337.05	265.30	408.80	335.60	338.50	89.24	-9.54	-0.06
	1/7/2005	180.6	410.6	556.1	324.9	368.05	295.60	440.50	368.35	367.75	97.45	-9.63	0.01
	4/8/2005	188.3	419.5	529.1	301	359.48	303.90	415.05	358.70	360.25	95.18	-7.39	-0.03
	7/18/2005	150.7	376.8	482.9	262.2	318.15	263.75	372.55	316.80	319.50	84.24	-7.23	-0.06
	8/26/2005	144.7	373.1	494.1	275.3	321.80	258.90	384.70	319.40	324.20	85.20	-8.36	-0.11
	10/11/2005	146.5	375.2	533.7	291.5	336.73	260.85	412.60	340.10	333.35	89.15	-10.09	0.15
	1/10/2006	176	407.1	548.8	313.5	361.35	291.55	431.15	362.40	360.30	95.67	-9.28	0.05
	4/9/2006	180.6	412.1	538.7	307.8	359.80	296.35	423.25	359.65	359.95	95.26	-8.43	-0.01
	7/19/2006	149.4	377.4	480.1	259.8	316.68	263.40	369.95	314.75	318.60	83.85	-7.08	-0.09
	10/18/2006	155.2	382.8	532.6	304.1	343.68	269.00	418.35	343.90	343.45	90.99	-9.93	0.01
	1/18/2007	179.5	407.9	563.5	330.9	370.45	293.70	447.20	371.50	369.40	98.08	-10.20	0.05
	4/19/2007	182.7	413.5	536	305.6	359.45	298.10	420.80	359.35	359.55	95.17	-8.15	0.00
	7/11/2007	146.1	373.2	467.5	250.6	309.35	259.65	359.05	306.80	311.90	81.91	-6.61	-0.11

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	199.5	418.4	473.6	323.8	353.83	308.95	398.70	336.55	371.10	93.68	-5.96	-0.77
	7/15/1999	194.3	414.4	461.1	314.4	346.05	304.35	387.75	327.70	364.40	91.62	-5.54	-0.82
	8/15/1999	191.0	402.1	488.7	347.5	357.33	296.55	418.10	339.85	374.80	94.61	-8.08	-0.78
	8/31/1999	189.5	395.4	496	352.6	358.38	292.45	424.30	342.75	374.00	94.89	-8.76	-0.70
	9/15/1999	186.8	391.6	503.6	359.8	360.45	289.20	431.70	345.20	375.70	95.44	-9.47	-0.68
	9/30/1999	188.5	396.7	516	369	367.55	292.60	442.50	352.25	382.85	97.32	-9.96	-0.69
	10/15/1999	235.3	403	530.4	378.9	386.90	319.15	454.65	382.85	390.95	102.44	-9.01	-0.18
	10/31/1999	202.7	418.5	524.2	371.5	379.23	310.60	447.85	363.45	395.00	100.41	-9.12	-0.71
	11/15/1999	208.9	426.2	548.2	393.2	394.13	317.55	470.70	378.55	409.70	104.35	-10.18	-0.70
	11/30/1999	212.9	429.2	566.6	409.5	404.55	321.05	488.05	389.75	419.35	107.11	-11.10	-0.66
	12/15/1999	216.9	433.5	561.4	403.7	403.88	325.20	482.55	389.15	418.60	106.93	-10.46	-0.66
	12/31/1999	220.7	443.8	566.6	407.4	409.63	332.25	487.00	393.65	425.60	108.46	-10.28	-0.72
	3/31/2000	215.2	438.2	567.9	406.5	406.95	326.70	487.20	391.55	422.35	107.75	-10.67	-0.69
	6/30/2000	191.3	415.8	542.4	380.7	382.55	303.55	461.55	366.85	398.25	101.29	-10.50	-0.70
	6/30/2000	183.3	409.8	571	409.9	393.50	296.55	490.45	377.15	409.85	104.19	-12.89	-0.73
	1/13/2001	215.4	447.2	588.9	421.9	418.35	331.30	505.40	402.15	434.55	110.77	-11.57	-0.73
	4/20/2001	210.2	445.1	586.6	415.7	414.40	327.65	501.15	398.40	430.40	109.72	-11.53	-0.72
	7/16/2001	171.2	413	554.5	377.7	379.10	292.10	466.10	362.85	395.35	100.37	-11.56	-0.73
	10/9/2001	178.5	417.9	596.2	418.8	402.85	298.20	507.50	387.35	418.35	106.66	-13.91	-0.69
	1/9/2002	206.2	445.9	606.4	430	422.13	326.05	518.20	406.30	437.95	111.77	-12.77	-0.71
	4/12/2002	208.6	449.5	584.1	408.1	412.58	329.05	496.10	396.35	428.80	109.24	-11.10	-0.73
14	7/18/2002	161.7	410.1	551.9	368.5	373.05	285.90	460.20	356.80	389.30	98.77	-11.58	-0.73
	10/7/2002	160.2	405.5	592.3	407.7	391.43	282.85	500.00	376.25	406.60	103.64	-14.43	-0.68
	1/8/2003	202	449.1	620.2	437.7	427.25	325.55	528.95	411.10	443.40	113.12	-13.52	-0.72
	4/15/2003	205.4	453.6	590	409.8	414.70	329.50	499.90	397.70	431.70	109.80	-11.32	-0.76
	7/1/2003	171.9	426.9	559.5	377.3	383.90	299.40	468.40	365.70	402.10	101.65	-11.23	-0.82
	10/7/2003	172	424.4	600.8	422.4	404.90	298.20	511.60	386.40	423.40	107.21	-14.18	-0.83
	12/31/2003	205.6	461.3	624.2	444.9	434.00	333.45	534.55	414.90	453.10	114.91	-13.36	-0.86
	4/13/2004	204.7	463.4	611.5	433.1	428.18	334.05	522.30	408.10	448.25	113.37	-12.51	-0.90
	7/13/2004	159.6	424.2	566.4	383.7	383.48	291.90	475.05	363.00	403.95	101.53	-12.17	-0.92
	10/8/2004	153	416.8	590.5	409.5	392.45	284.90	500.00	371.75	413.15	103.91	-14.30	-0.93
	1/7/2005	192.8	454.9	627.8	446.9	430.60	323.85	537.35	410.30	450.90	114.01	-14.19	-0.91
	4/8/2005	205.2	467.5	600.9	425.2	424.70	336.35	513.05	403.05	446.35	112.45	-11.74	-0.97
	7/18/2005	154.9	424.1	560.9	385.2	381.28	289.50	473.05	357.90	404.65	100.95	-12.20	-1.05
	8/26/2005	168.3	416.1	569.1	391.2	386.18	292.20	480.15	368.70	403.65	102.25	-12.49	-0.78
	10/11/2005	152.5	418.5	590.5	413.4	393.73	285.50	501.95	371.50	415.95	104.25	-14.38	-1.00
	1/10/2006	190.7	455.4	615	436.7	424.45	323.05	525.85	402.85	446.05	112.38	-13.48	-0.97
	4/9/2006	196.7	460.2	612.3	436.6	426.45	328.45	524.45	404.50	448.40	112.91	-13.03	-0.98
	7/19/2006	159.7	426.1	562.3	382.1	382.55	292.90	472.20	361.00	404.10	101.29	-11.92	-0.97
	10/18/2006	161.9	425.9	600.5	422.5	402.70	293.90	511.50	381.20	424.20	106.62	-14.46	-0.96
	1/18/2007	192.2	454.2	638.5	460	436.23	323.20	549.25	415.35	457.10	115.50	-15.02	-0.94
	4/19/2007	198.7	462.5	611.3	432	426.13	330.60	521.65	405.00	447.25	112.83	-12.70	-0.95
	7/11/2007	149.8	419.9	567.4	379.8	379.23	284.85	473.60	358.60	399.85	100.41	-12.54	-0.92

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	222.2	-19.9	305.2	560	266.88	101.15	432.60	263.70	270.05	70.66	-22.03	-0.14
	7/15/1999	207.8	-36.8	294.3	540.9	251.55	85.50	417.60	251.05	252.05	66.60	-22.07	-0.02
	8/15/1999	189.9	-53.4	320.4	546.8	250.93	68.25	433.60	255.15	246.70	66.44	-24.28	0.19
	8/31/1999	184.8	-60	330.2	555.2	252.55	62.40	442.70	257.50	247.60	66.87	-25.27	0.22
	9/15/1999	185.7	-57.2	336.6	558.2	255.83	64.25	447.40	261.15	250.50	67.73	-25.46	0.24
	9/30/1999	187.5	-53.7	349.9	570.1	263.45	66.90	460.00	268.70	258.20	69.75	-26.12	0.24
	10/15/1999	195.3	-50.5	375.2	601.5	280.38	72.40	488.35	285.25	275.50	74.23	-27.64	0.22
	10/31/1999	197.3	-39.9	370.8	589.7	279.48	78.70	480.25	284.05	274.90	74.00	-26.69	0.20
	11/15/1999	202.5	-32.3	385.9	601.1	289.30	85.10	493.50	294.20	284.40	76.60	-27.14	0.22
	11/30/1999	206.5	-27.3	398.1	613.9	297.80	89.60	506.00	302.30	293.30	78.85	-27.67	0.20
	12/15/1999	216.1	-19.5	401.6	620.9	304.78	98.30	511.25	308.85	300.70	80.70	-27.44	0.18
	12/31/1999	223.8	-15	410.7	633.4	313.23	104.40	522.05	317.25	309.20	82.93	-27.76	0.18
	3/31/2000	203.5	-16	395.7	633.5	304.18	93.75	514.60	299.60	308.75	80.54	-27.97	-0.20
	6/30/2000	149.3	-41	371.2	553.8	258.33	54.15	462.50	260.25	256.40	68.40	-27.14	0.09
	6/30/2000	154.3	-22.3	411.5	580.2	280.93	66.00	495.85	282.90	278.95	74.38	-28.57	0.09
	1/13/2001	197.9	7.7	446.8	627.1	319.88	102.80	536.95	322.35	317.40	84.69	-28.85	0.11
	4/20/2001	167.6	1.3	434.9	589.5	298.33	84.45	512.20	301.25	295.40	78.99	-28.43	0.13
	7/16/2001	112.8	-20.6	409.7	555.1	264.25	46.10	482.40	261.25	267.25	69.97	-29.00	-0.13
	10/9/2001	136.9	-5.4	451.7	582.7	291.48	65.75	517.20	294.30	288.65	77.17	-30.00	0.13
	1/9/2002	176.6	9	461.6	618.2	316.35	92.80	539.90	319.10	313.60	83.76	-29.71	0.12
	4/12/2002	158.20	3.40	438	581.00	295.25	80.80	509.70	298.30	292.20	78.17	-28.50	0.14
26	7/18/2002	86.10	-23.70	405	503.86	242.87	31.20	454.53	245.65	240.08	64.30	-28.13	0.12
	10/7/2002	96.1	2.90	445.20	562.80	276.75	49.50	504.00	270.65	282.85	73.28	-30.21	-0.27
	1/8/2003	165.9	41.91	480.40	628.48	329.17	103.91	554.44	323.15	335.20	87.16	-29.94	-0.27
	4/15/2003	147.5	33.95	455.30	592.01	307.19	90.73	523.65	301.40	312.98	81.33	-28.77	-0.26
	7/1/2003	88.2	9.66	424.1	577.30	274.82	48.93	500.70	256.15	293.48	72.76	-30.02	-0.84
	10/7/2003	103.5	24.24	466.9	574.34	292.25	63.87	520.62	285.20	299.29	77.38	-30.35	-0.32
	12/31/2003	130.5	44.68	481.6	566.95	305.93	87.59	524.27	306.05	305.81	81.00	-29.02	0.01
	4/13/2004	118.2	42.08	471.6	585.31	304.30	80.14	528.45	294.90	313.69	80.57	-29.79	-0.42
	7/13/2004	49.6	8.40	430.9	548.80	259.43	29.00	489.85	240.25	278.60	68.69	-30.63	-0.86
	10/8/2004	54.7	18.19	457.3	588.15	279.59	36.45	522.72	256.00	303.17	74.03	-32.32	-1.06
	1/7/2005	108.7	42.65	486.4	597.82	308.89	75.67	542.11	297.55	320.23	81.78	-31.00	-0.51
	4/8/2005	91.7	33.99	457.3	601.47	296.12	62.85	529.39	274.50	317.73	78.40	-31.01	-0.97
	7/18/2005	28.7	12.91	432.3	605.33	269.81	20.81	518.82	230.50	309.12	71.44	-33.10	-1.76
	8/26/2005	31.4	16.85	447.8	588.39	271.11	24.13	518.10	239.60	302.62	71.78	-32.83	-1.41
	10/11/2005	43.7	14.58	464.4	588.60	277.82	29.14	526.50	254.05	301.59	73.56	-33.05	-1.06
	1/10/2006	96.3	14.58	483.8	588.60	295.82	55.44	536.20	290.05	301.59	78.32	-31.95	-0.26
	4/9/1906	87.1	29.40	477	588.60	295.52	58.25	532.80	282.05	309.00	78.25	-31.54	-0.60
	7/19/1906	18.4	-2.90	430.9	588.60	258.75	7.75	509.75	224.65	292.85	68.51	-33.36	-1.53
	10/18/1906	61.1	14.58	483.2	588.60	286.87	37.84	535.90	272.15	301.59	75.95	-33.10	-0.66
	1/18/2007	99.2	14.58	505.9	588.60	302.07	56.89	547.25	302.55	301.59	79.98	-32.59	0.02
	4/19/2007	80.5	14.58	477.1	588.60	290.19	47.54	532.85	278.80	301.59	76.83	-32.25	-0.51
	7/11/2007	11.2	14.5768	431.3	588.5957	261.42	12.89	509.95	221.25	301.59	69.22	-33.03	-1.80

Numerical reading of anchor load as a function of time for anchors #1, #8, #9 and #17

Date	Anchor #1 Load, kips	Anchor #8 Load, kips	Anchor #9 Load, kips	Anchor #17 Load, kips	Comment
4/7/1999		560			
4/8/1999	489			499	Anchor Lock off
4/14/1999	460	473	596 (Lock off)	461	
5/7/1999	452	473	572	445	End of construction
7/1/1999	446	468	564	439	
10/1/1999	441	467	560	440	
1/1/2000	439	461	555	424	
4/1/2000	432	453	546	414	
7/1/2000	431	451	521	415	
10/1/2000	431	451	519	416	
1/1/2001	430	455	517	400	
4/1/2001	421	443	513	397	
7/1/2001	422	443	510	399	
10/1/2001	425	445	512	403	
1/1/2002	424	444	511	398	
4/1/2002	421	440	508	386	
7/1/2002	419	439	506	391	
10/1/2002	423	442	508	396	
1/1/2003	423	435	508	389	
4/15/2003	416	427	501	380	
8/7/2003	416	428	503	384	
10/7/2003	418	429	504	387	
12/31/2003	417	426	503	378	
4/13/2004	408	418	494	370	
7/13/2004	409	419	494	374	
10/8/2004	411	422	496	377	
1/7/2005	411	421	495	374	
4/8/2005	407	414	485	366	
7/18/2005	407	415	485	370	
11/12/2005	410	419	489	374	
1/10/2006	409	417	487	369	
4/9/2006	399	411	487	365	
7/19/2006	399	412	487	368	
10/18/2006	407.3	414.8	489.6	371.7	
1/18/2007	405	412	487	366	
4/19/2007	401	406	501	361	
7/9/2007	401	408	502	365	

RICHLAND ENGINEERING LIMITED
29 North Park Street, Mansfield, Ohio 44902-1769 • 419-524-0074 FAX 419-524-1812

106017

November 23, 2007

Ohio Department of Transportation
5500 Transportation Boulevard
Garfield Heights, Ohio 44125-5396

Attn: Mr. Mike Malloy

Re: CUY-90-1524
Central Viaduct
PID No. 20752
Slope and Pier Monitoring Services
Interim Report

Dear Mr. Malloy:

The following is our report on monitoring activity and collected data for the west slope of the Cuyahoga River and Bridge No. CUY-90-1524 west end pier, pier 1, and slope stabilization structure. The last report of data was the interim report submitted August 15, 2007 for data collected through July 2007. This report is for data collected through October 2007.

Enclosed is one CD with the electronic .pdf files of the detailed reports from BBC&M, REL, Dr. Huckelbridge, and Dr. Liang.

The slope monitoring began in 1994. The stabilization structure was constructed and the span 1 superstructure was relocated in 1999. The stabilization structure monitoring began in 1999. Additional slope monitoring north of the existing bridge began in 2006.

BBC&M Engineering, Inc. obtained inclinometer readings, piezometer readings, and calipered crack distances between October 10 through 22, 2007. Seven inclinometers and 6 piezometers installed between 1994 and 1999 continue to be monitored. Three replacement inclinometers, 9 new inclinometers, and 18 new piezometers installed March through June 2006 were also monitored. The older instrumentation continues to indicate movements of the shallow and deep failure planes at consistent rates. The overall rates appear to be slower since 2004. The new inclinometers both north and south of the bridge are indicating shallow and deep failure planes. The older piezometer total head values were slightly lower than in July 2007. The new vibrating wire piezometer values were relatively constant. The calipered crack openings continue to change at a constant slow rate. There was one small aggregate pile adjacent to the south right of way fence in October 2007. The property

owner north of the right of way fence had a contractor repair the failed sheet pile dock wall at the river's edge in Spring 2006. A progressive failure continues in the small landslide near the north right of way fence adjacent to the river on the southern edge of the large excavation.

Richland Engineering Limited measured expansion joint openings at the west end pier, near pier 2, and near pier 4 on October 15, 2007. The deck expansion joint opening near pier 2 opened 1/4" with the 14 degree drop in temperature since July 2007. The joint opening dimension is typical of past Fall observations. Substructure elevations; relative span 1 ans 2 lengths; and pier monument coordinates were measured on October 15 and 16, 2007. No significant change in locations from previous data was noted.

Art Huckelbridge obtained tiltmeter readings at the west end pier and pier 1 on October 19, 2007. The tiltmeters show positions and magnitudes of movement similar to past readings.

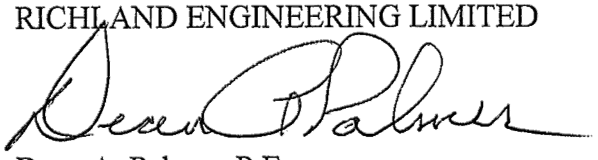
Robert Liang monitored instrumentation on October 19 and 20, 2007. The instrumentation readings in the rock anchors, driven piles, tieback beams, drilled shafts, and inclinometers showed no significant change during this quarter.

The next readings are scheduled about January 15, 2008. Authorization to proceed with the next year's monitoring will be requested.

Please contact us if you have any questions (email reltd@r-e-l.com). Copies of detailed quarterly reports are available upon request.

Very truly yours,

RICHLAND ENGINEERING LIMITED



Dean A. Palmer, P.E.

DAP:dap
cc: Craig Hebebrand, District 12
Youssef Seif, District 12
Tim Keller, Office of Structures
Gene Geiger, Office of Geotechnical Services
Tom Lefchik, FHWA
Steve Pasternack, BBC&M Engineering, Inc., Dublin
Jeff Snyder, BBC&M Engineering, Inc., Valley View
Art Huckelbridge
Robert Liang
Rick Engel, E.L. Robinson Engineering Co.
Bob Parker, Michael Baker, Jr., Inc.

OCTOBER 2007 QUARTERLY REPORT
FIELD MONITORING SERVICES
CUY-90-14.52/15.24
PID #77332
CLEVELAND, OHIO

Report to

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

Prepared by

BBC&M ENGINEERING, INC.
CLEVELAND, OHIO

November 2007

November 9, 2007
012-00946-300

BBCM
SOLUTIONS TO BUILD ON

Mr. Dean A. Palmer, P.E.
Richland Engineering Limited
29 North Park Street
Mansfield, Ohio 44902

Re: CUY-90-14.52/15.24 Bridge (PID No. 77332)
Quarterly Report - Field Monitoring Services
October 2007 (Fourth Quarter)

Dear Mr. Palmer:

BBC&M Engineering, Inc. (BBCM) has completed the field monitoring services for the October 2007 quarter as part of the CUY-90-14.92/15.24 project. This quarterly report presents our general site observations and the results and evaluation of data collected from all the actively monitored instrumentation (inclinometers, piezometers and calipered distance locations) installed by BBCM at or near the West Abutment of the existing I-90 Central Viaduct Bridge.

A total of 19 inclinometers, six (6) pneumatic piezometers and 18 vibrating wire (VW) piezometers are actively monitored as part of the project. A Summary Table and Site Plan of Active Instrumentation are submitted as Plates 1 and 2 of the Appendix. Quarterly readings were taken during the period of October 10 through October 22, 2007.

Inclinometers

All the data sets presented in the Appendix have been corrected for measured spiral of the inclinometer casings and for systematic errors such as bias-shift, sensor rotation and depth positioning error, where necessary. The rates of movement were computed using linear regression for the depth ranges shown on the Displacement vs. Time plots in the Appendix.

Active BBCM Inclinometers Installed between 1994 and 1999

No significant changes in the rates of movement have been observed in the shallow or deep failure planes between the July 2007 and October 2007 quarterly readings. In the immediate vicinity of the Pier 1 area, no shallow slip-plane movements have been observed in inclinometers installed before 2000 since completion of construction of the Pier 1 stabilization system. The shallow failure plane upslope from the Pier 1 area (B-203 and B-303) continues to move at an average rate of about 0.05 inches per year from 1999 to the present yet appears to have decreased to about a rate of 0.03 inches

per year from 2004 to the present. South of the West End Pier (B-102 and B-107), the deep failure plane continues to move at an average rate of about 0.03 inches per year from 2000 to the present. The B-101 inclinometer has indicated nominal movement since its installation. In the immediate vicinity and upslope from the Pier 1 area (B-203, B-204 and B-303), the deep failure plane is moving at an average rate of about 0.05 inches per year from 1999 to the present. This is a slight decrease from the rate of movement of 0.06 inches per year as reported in the July 2007 Quarterly Monitoring Report. Additionally, from 2004 to the present, the rate of movement appears to have decreased to about 0.02 inches per year.

Inclinometer P-9N indicates the top of the drilled shaft is restrained laterally and that the maximum lateral deflection is about 0.93 inches from about 40 to 60 feet below the top of the inclinometer casing.

Active BBCM Inclinometers Installed in 2006

Slide planes have been observed in the following new and replacement inclinometers (refer to the Displacement vs. Time plots, Plates 27, 48 and 49 in the Appendix):

- In B-108A - depths of 23 ft and 119 ft (see Plate 24 in the Appendix);
- In B-05-03 - depth of 35 ft (see Plates 32 and 33 in the Appendix); and,
- In B-05-16 - depths of 3 to 11 ft, 29 ft and 113 ft (see Plate 46 and 47 in the Appendix).

Cantilever displacement has been observed in B-105A to a depth of about 70 feet (see Plates 22 and 23 in the Appendix) similar to that observed in B-105, which is now inactive. The bulkhead at this location may be progressively leaning outwards toward the river. A Displacement vs. Time plot for B-105A has been submitted as Plate 26 in the Appendix.

Additional <u>potential</u> slide planes have been observed in some of the new and replacement inclinometers for which additional readings are needed to verify they are actual slide planes. These potential slide planes are listed as follows:

- In B-105A, depth of 85 ft (see Plate 22 in the Appendix);
- In B-05-02, depth of 109 ft and 129 ft (see Plate 30 in the Appendix);
- In B-05-04, depth of 117 ft (see Plate 34 in the Appendix). This depth is identical with the depth of movement observed in the adjacent B-204 inclinometer (see Plates 11 and 12 in the Appendix).

<u>Piezometers</u>

Pneumatic Piezometers

The results of the active pneumatic piezometer readings taken on October 10 and October 12, 2007 are summarized in Table 1 below.

Table 1: Summary of Readings for Active Pneumatic Piezometers – CUY-90-15.24

Piezometer Identifier		Ground Surface Elevation (ft)	Elevation Head, h_e (ft)	Pore Pressure Reading, u (psi)	Total Head, h_t (ft)
B-101 (P-1*)	orange	676.6	626.3	0.0**	626.3**
	pink	676.6	552.3	31.8	625.7
B-105 (P-3*)	pink	585.6	497.6	38.4	586.2
	blue	585.6	479.9	48.0	590.7
B-107 (P-5*)	orange	662.3	562.3	25.2	620.5
B-303 (P-2*)	pink	627.0	586.2	7.0	602.4

*BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers.

**Pneumatic piezometers *cannot* read negative pressure (i.e., a water level below the depth of the pneumatic piezometer). Thus, it is unknown whether this is an accurate pressure reading.

All the piezometers have exhibited slightly lower readings than those recorded in July 2007, except the B-101 orange piezometer, which continues to exhibit a reading of 0 psi. Note that the piezometers at B-105 continue to indicate elevated water pressures (i.e. a total head above the ground surface, artesian conditions). Total Head vs. Time plots have been submitted as Plates 50 through 53 in the Appendix of this report.

Vibrating Wire (VW) Piezometers

Table 2 provides a summary of the maximum and minimum values of all the pressure readings taken from July 9 or July 11, 2007 (end of previous reporting period) to the time when the collected data was last downloaded from VW Miniloggers between October 10 and October 22, 2007.

Table 2: Summary of Readings for VW Piezometers – CUY-90-14.92

Piezometer Identifier		Time Interval of Readings Reported [1]	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-01	21961 - 65 ft	7/11/07 to 10/12/07	13.5/9.7	675.4	610.4	12.9/12.3	640.2/638.9
	21967 - 95 ft	7/11/07 to 10/12/07	13.2/13.2	675.4	580.4	23.9/23.5	635.6/634.7
B-05-02	21963 - 46 ft	7/9/07 to 10/10/07	12.2/12.1	617.9	571.9	8.3/7.9	591.0/590.2
	21951 - 122 ft	7/9/07 to 10/10/07	12.2/12.1	617.9	495.9	40.6/40.2	589.5/588.7
B-05-03	21957 - 32 ft	7/9/07 to 10/10/07	12.0/11.8	605.1	573.1	7.8/7.1	591.2/589.6
	21965 - 112 ft	7/9/07 to 10/10/07	12.5/12.5	605.1	493.1	41.4/41.0	588.7/587.7

1 - Readings generally were taken every 8 hours during the reported time interval.

Table 2: Summary of Readings for VW Piezometers – CUY-90-14.92 (continued)

Piezometer Identifier		Time Interval of Readings Reported [1]	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-04	21958 - 59 ft	7/9/07 to 10/10/07[2]	12.9/12.9	600.8	541.8	17.6/17.6	582.4/582.4
	21952 - 119 ft	7/9/07 to 10/10/07	13.1/13.0	600.8	481.8	45.0/44.8	585.5/585.2
B-05-07	21966 - 102 ft	7/11/07 to 10/16/07	12.4/12.4	678.9	576.9	24.2/23.8	632.7/631.9
	21956 - 220 ft	7/11/07 to 10/16/07	11.9/11.9	678.9	458.9	71.1/70.5	623.0/621.7
B-05-08	21954 - 65.5 ft	7/11/07 to 10/16/07	12.7/12.7	679.9	614.4	12.6/12.3	643.6/642.7
	21959 - 110.5 ft	7/11/07 to 10/16/07	12.4/12.4	679.9	569.4	29.6/29.2	637.7/636.9
B-05-11	21968 - 95 ft	7/11/07 to 10/12/07[3]	13.0/12.7	675.1	580.1	23.6/23.6	634.5/634.5
	21953 - 130 ft	7/11/07 to 10/22/07[4]	12.8/12.2	675.1	545.1	36.5/36.1	629.3/628.5
B-05-12	21960 - 75 ft	7/11/07 to 10/12/07	12.9/12.9	652.7	577.7	19.0/18.7	621.6/620.9
	21964 - 120 ft	7/11/07 to 10/12/07	12.5/12.5	652.7	532.7	36.7/36.3	617.5/616.5
B-05-13	21962 - 60 ft	7/11/07 to 10/16/07	12.6/12.5	580.0	520.0	24.5/24.0	576.5/575.5
	21955 - 135 ft	7/11/07 to 10/16/07	12.8/12.8	580.0	445.0	60.6/60.4	584.7/584.4

1 - Readings generally were taken every 8 hours during the reported time interval.
2 - VW Minilogger 21958 did not record any readings from July 10, 2007 to October 9, 2007 (almost the entire time interval) most likely due to battery malfunction.
3 - The 21968 VW Minilogger was flooded with the Minilogger box completely full of water. Readings were not recorded from July 12, 2007 to October 11, 2007 (almost the entire time interval). This is the 2nd consecutive reporting period that this Minilogger has malfunctioned. Since April 2007, readings have only been recorded at the time of download. The primary cause of the malfunction is not yet known.
4 - The 21953 VW Minilogger was also flooded with the Minilogger box completely full of water. Readings were not recorded from August 5, 2007 to October 11, 2007. On October 12, 2007 when readings were first attempted to be downloaded, the Minilogger was unresponsive even after the water was emptied from the box, the box was wiped dry and the batteries were replaced. On October 22, 2007, the box was responsive and readings were able to be downloaded. It is likely the Minilogger malfunctioned due to the flooding of the box.

The measured total head values were relatively constant during the current reporting period with a difference between maximum and minimum total head values of no more than 1.3 feet in all of the VW piezometers. Six (6) VW piezometers (21961 and 21967 at B-05-01, 21956 at B-05-07, 21953 at B-05-11 and 21960 and 21964 at B-05-12) indicated a gradual increase in the pore pressures until about the beginning of May 2007, yet have measured relatively constant pore pressures from May 2007 to October 2007. Total Head vs. Time plots have been submitted as Plates 54 through 62 in the Appendix.

As discussed in the footnotes of Table 2 and on the Total Head vs. Time plots (see Plates 57, 60 and 61 of the Appendix) some of the VW Miniloggers temporarily malfunctioned during the current and previous reporting periods causing scheduled readings to be missed. The cause(s) of the temporary malfunctions may be attributed to faulty batteries, flooding of some of the VW Minilogger boxes with water, or some other unknown cause(s). Reasonable precautions are taken by BBCM to attempt to protect the Minilogger boxes from water damage; however, during heavy rain events, only the installation of a water tight box to house the Miniloggers will provide adequate protection. BBCM recommends the replacement of the 21968 VW Minilogger at B-05-11 as it has failed to take any scheduled readings during two (2) consecutive reporting periods. The other VW Miniloggers which have failed to take scheduled readings at one time or another (21958 at B-05-04, 21953 at B-05-11 and 21960 at B-05-12) may need to be replaced eventually but appear to be currently functioning properly.

Additional Field Measurements and Observations

The locations of the two calipered locations (left and right) are provided in the Site Plan of Active Instrumentation (Plate 2 of the Appendix). A Calipered Surface Distance Table and Calipered Distance Readings vs. Time plots have been included as Plates 63 through 65 in the Appendix. The left calipered location indicates the gap is continuing to open at a rate of about 0.06 inches per year and the gap at the right calipered location is continuing to close at a rate of about 0.02 inches per year.

In October 2007, a relatively small aggregate pile, roughly 20 to 30 feet high, was observed near the east right-of-way fence and covered roughly 10 to 15 percent of the property currently being used to stockpile aggregate adjacent to the east right-of-way fence.

The large excavation and the repair effort of the bulkhead near the west right-of-way fence appear to be unfinished as of October 2007. Adjacent to the large excavation near the west right-of-way fence (just north of B-05-16), a small landslide was initially observed by BBCM personnel in January 2007. It appears that progressive failure in this landslide area has occurred since the last quarterly readings were taken in July 2007. The scarps have been observed to have increased in depth. Site photos of the landslide area taken on October 10 and October 16, 2007 are submitted as Plates 66 through 73 in the Appendix.

Closing

BBCM will need to submit a modification to our contract for the additional cost of replacing the 21968 VW Minilogger at B-05-11. We appreciate being of continued service during this project. Please contact our office if you have any questions or require additional information. The next quarterly readings are scheduled to take place around January 15, 2008.

Sincerely,
BBC&M ENGINEERING, INC.
Cleveland, Ohio

Jeffrey L. Snyder, M.S., P.E.
Staff Engineer

Stephen C. Pasternack, Ph.D., P.E.
Senior Project Engineer

cc: Mr. Robert B. Parker, P.E. (Michael Baker Jr., Inc.)

Submitted: pdf copy submitted to Richland Engineering at reltd@r-e-l.com and Michael Baker Jr., Inc. at BParker@mbakercorp.com
Attachments: Appendix (Plates 1 through 73)

APPENDIX

CUY-90-14.52/15.24 INSTRUMENTATION MONITORING

APPENDIX

Plate No.

General Information

Summary Table of Active Instrumentation 1
Site Plan of Active Instrumentation 2

Plots for Active BBCM Inclinometers Installed from 1994 to 1999 – CUY-90-15.24

Cumulative and Incremental Displacement versus Depth Plots
B-101 – A and B-Axis 3-4
B-102 – A and B-Axis 5-6
B-107 – A and B-Axis 7-8
B-203 – A and B-Axis 9-10
B-204 – A and B-Axis 11-12
B-303 – A and B-Axis 13-14
P-9N – A and B-Axis 15-16

Displacement versus Time Plots
B-102 – A-Axis 17
B-107 – A-Axis 18
B-203 – A-Axis 19
B-204 – A-Axis 20
B-303 – A-Axis 21

Plots for Replacement Inclinometers Installed by BBCM in 2006 – CUY-90-15.24

Cumulative and Incremental Displacement versus Depth Plots
B-105A – A and B-Axis 22-23
B-108A – A and B-Axis 24-25

Displacement versus Time Plots
B-105A – A-Axis 26
B-108A – A-Axis 27

Plots for Inclinometers Installed by BBCM in 2006 – CUY-90-14.52

Cumulative and Incremental Displacement versus Depth Plots
B-05-01 – A and B-Axis 28-29
B-05-02 – A and B-Axis 30-31
B-05-03 – A and B-Axis 32-33
B-05-04 – A and B-Axis 34-35
B-05-07 – A and B-Axis 36-37
B-05-08 – A and B-Axis 38-39
B-05-08 – A and B-Axis (reinitialized) 38A-39A

APPENDIX (continued)

Plate No.

B-05-11 – A and B-Axis 40-41
B-05-12 – A and B-Axis 42-43
B-05-12 – A and B-Axis (reinitialized) 42A-43A
B-05-13 – A and B-Axis 44-45
B-05-16 – A and B-Axis 46-47

Displacement versus Time Plots

B-05-03 – A-Axis 48
B-05-16 – A-Axis 49

Plots for Active Pneumatic Piezometers Installed by BBCM in 1994 – CUY-90-15.24

Total Head (h_t) versus Time Plots

B-101 (P-1) 50
B-105 (P-3) 51
B-107 (P-5) 52
B-303 (P-2) 53

Plots for Vibrating Wire (VW) Piezometers Installed by BBCM in 2006 – CUY-90-14.52

Total Head (h_t) versus Time Plots

B-05-01 54
B-05-02 55
B-05-03 56
B-05-04 57
B-05-07 58
B-05-08 59
B-05-11 60
B-05-12 61
B-05-13 62

Calipered Surface Distance Data – CUY-90-15.24

Calipered Surface Distance Table 63
Calipered Distance Readings versus Time Plot - Left Calipered Location 64
Calipered Distance Readings versus Time Plot - Right Calipered Location 65

Large Excavation Adjacent to West Right-of-Way Fence

Site Photos of Excavation and Small Landslide Taken on October 10 and October 16, 2007 66-73

SUMMARY OF ACTIVE INSTRUMENTATION
CUY-90-14.52/15.24

Active Instrumentation	Active Inclinometer ?	Inclinometer Depth (ft)	Active Piezometer?	VW or Pneumatic?	# of Active Piezometers	Piezometer Depth(s) Below Existing G.S. (ft)	Instrumentation Installation Date
B-101	Y	190	Y*	Pneumatic*	2*	50.3, 124.3	Aug-Sep 1994
B-102	Y	224	N	---	---	---	Sep 1994
B-105	N	---	Y*	Pneumatic*	2*	88, 105.7	Aug 1994
B-105A	Y	156	N	---	---	---	May 2006
B-107	Y	210	Y	Pneumatic*	1*	100	Sep 1994
B-108A	Y	168	N	---	---	---	Apr-May 2006
B-203	Y	190	N	---	---	---	Aug 1996
B-204	Y	134	N	---	---	---	Jul 1998
B-303	Y	178	Y**	Pneumatic**	1**	40.8	Aug 1994**, Jul 1998
P-9N	Y	150	N	---	---	---	Feb 1999
B-05-01	Y	228	Y	VW	2	65, 95	Apr-May 2006
B-05-02	Y	178	Y	VW	2	46, 122	Apr-May 2006
B-05-03	Y	168	Y	VW	2	32, 112	Apr-May 2006
B-05-04	Y	172	Y	VW	2	59, 119	Mar-May 2006
B-05-07	Y	224	Y	VW	2	102, 220	Apr-Jun 2006
B-05-08	Y	226	Y	VW	2	65.5, 110.5	Apr-May 2006
B-05-11	Y	226	Y	VW	2	95, 130	Apr-Jun 2006
B-05-12	Y	210	Y	VW	2	75, 120	Apr-May 2006
B-05-13	Y	134	Y	VW	2	60, 135	May-Jun 2006
B-05-16	Y	162	N	---	---	---	Jun 2006

*BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers (i.e. P-1 to B-101, P-3 to B-105, and P-5 to B-107).

**The pneumatic piezometer was actually installed in August 1994 at Boring P-2 in the vicinity of the B-103 inclinometer (now inactive). However, the piezometer has since been renamed to B-303 due to its close proximity to the active inclinometer at B-303, which was installed in July 1998.

B-05-07
B-05-13
B-05-08
B-110
B-05-16
B-05-12
B-05-01
B-05-02
B-108A
B-05-11
B-107
B-203
LEFT CALIPERED LOCATION
B-05-04
P-9N
B-204
RIGHT CALIPERED LOCATION
B-303
B-105AU
B-105
B-101
B-102
B-05-03

LEGEND

B-05-01 — LOCATION OF INCLINOMETER/PIEZOMETER INSTALLED BY BBCM IN 2006 (B-05-01 THROUGH B-05-04, B-05-07, B-05-08, B-05-11 THROUGH B-05-13, AND B-05-16).

B-105A — LOCATION OF REPLACEMENT INCLINOMETER INSTALLED BY BBCM IN 2006 (B-105A AND B-108A).

B-101 — LOCATION OF INCLINOMETER AND/OR PIEZOMETER INSTALLED BY BBCM BETWEEN 1994 AND 1999 (B-101, B-102, B-105, B-107, B-203, B-204, B-303, AND P-9N).

B-110 — LOCATION OF INCLINOMETER AT B-110, WHICH WAS DESTROYED BY EXCAVATION ACTIVITIES IN MARCH, 2006

SCALE IN FEET
0 50 100

SITE PLAN OF ACTIVE INSTRUMENTATION

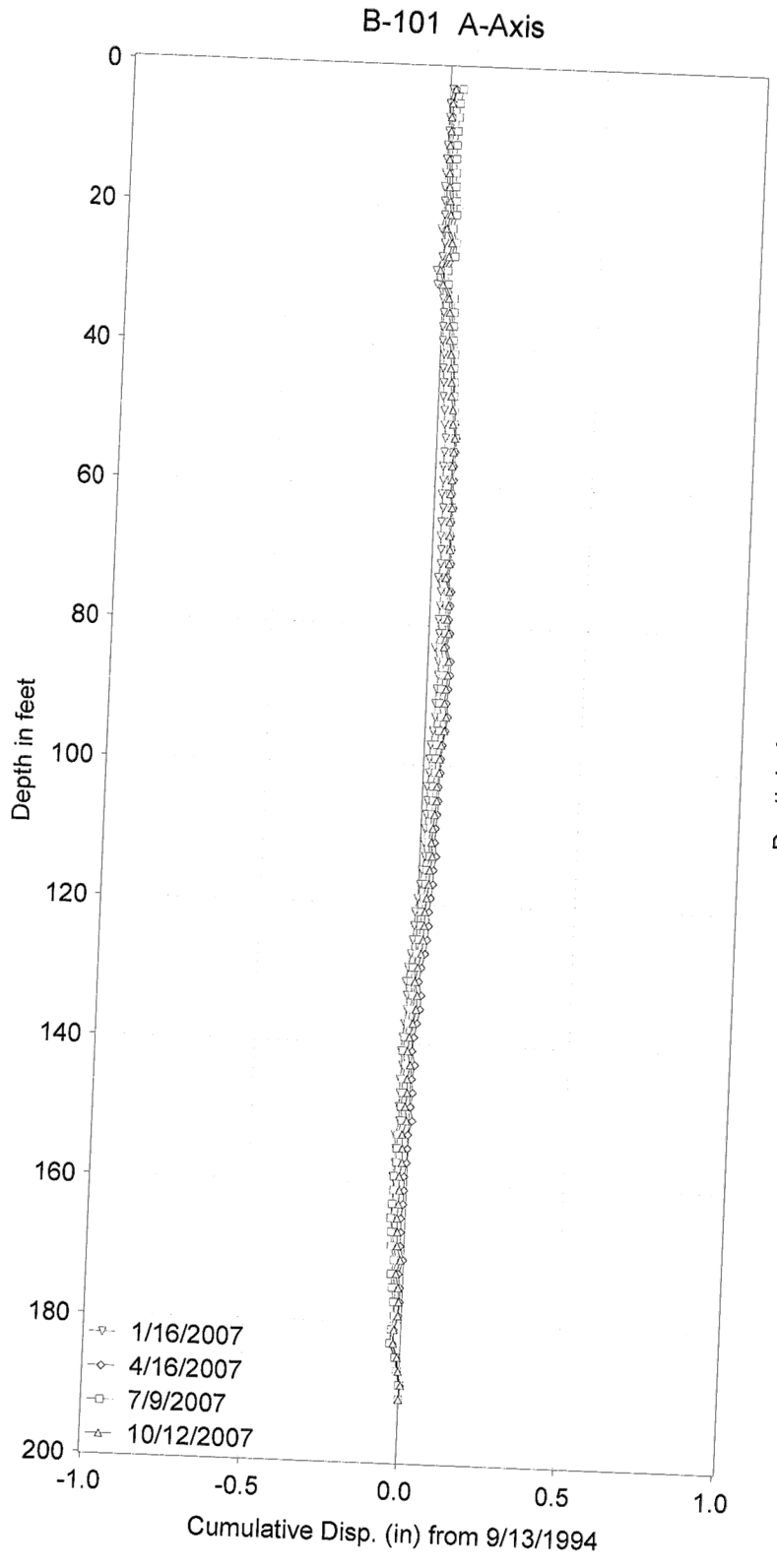
CUY-90-14.52/15.24 WEST ABUTMENT CLEVELAND, OHIO

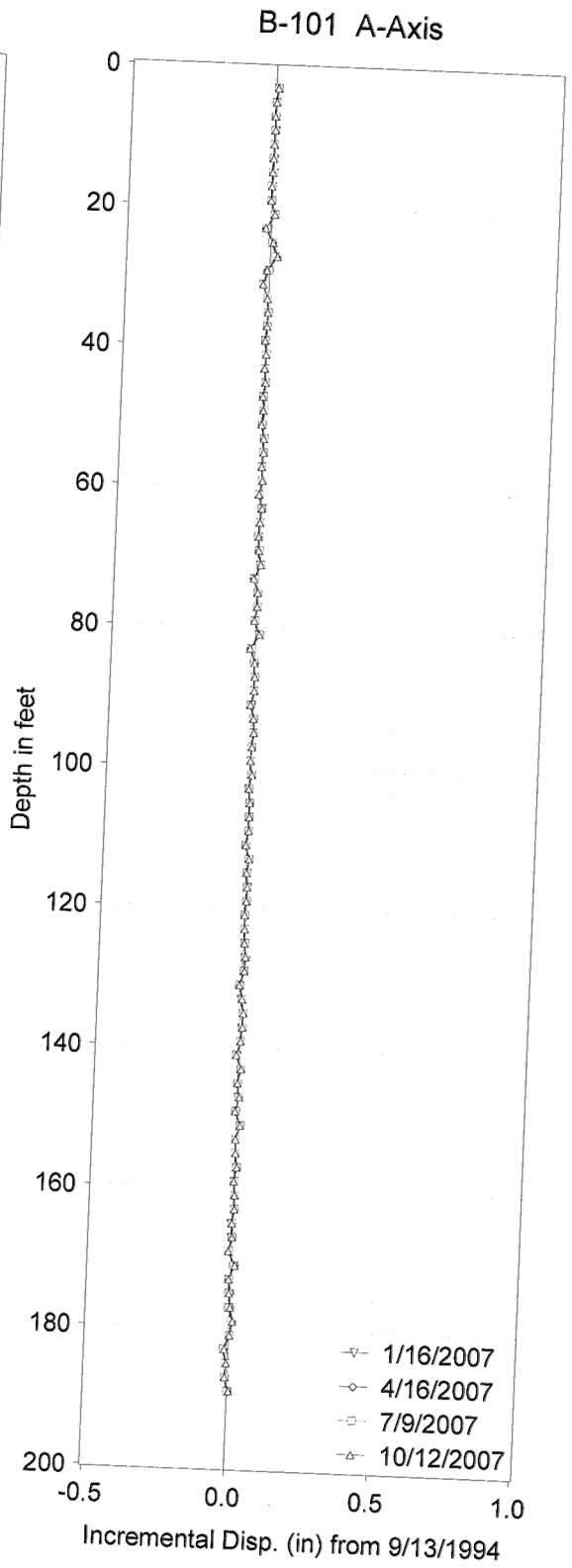
Project: 012-00946-300	Drawn By: EDV
Drawing Date: 7/25/06	Approved By: JLS
Revision Date: 2/9/07	Scale: 1" = 100'

BBCM
Solutions To Build On
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

PLATE 2

MODEL NAME: B020
BBC&M DRAWING FILE: ...\012-00946-300 INSTRUMENTATION-B020.dgn 10:56 AM

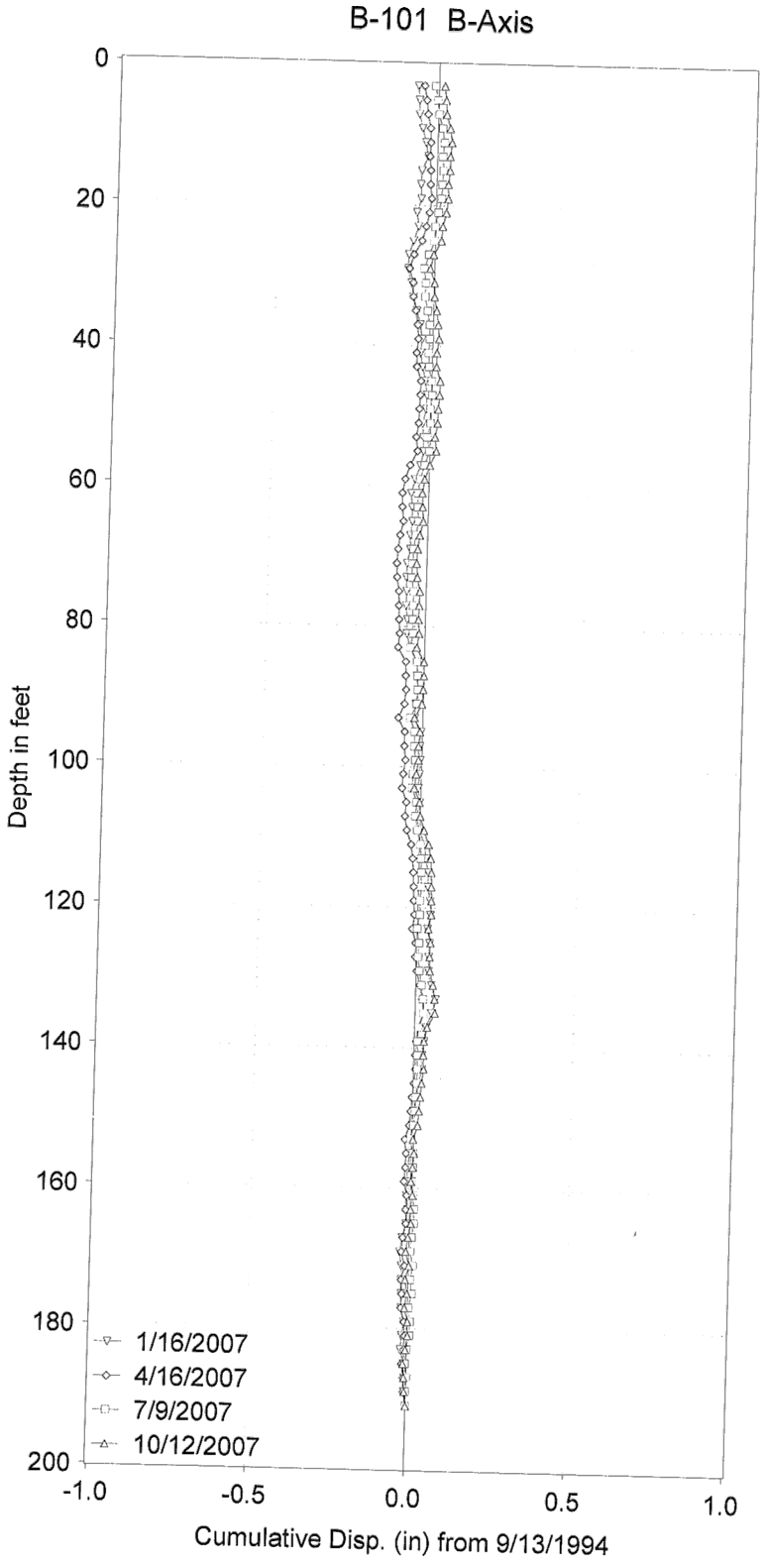


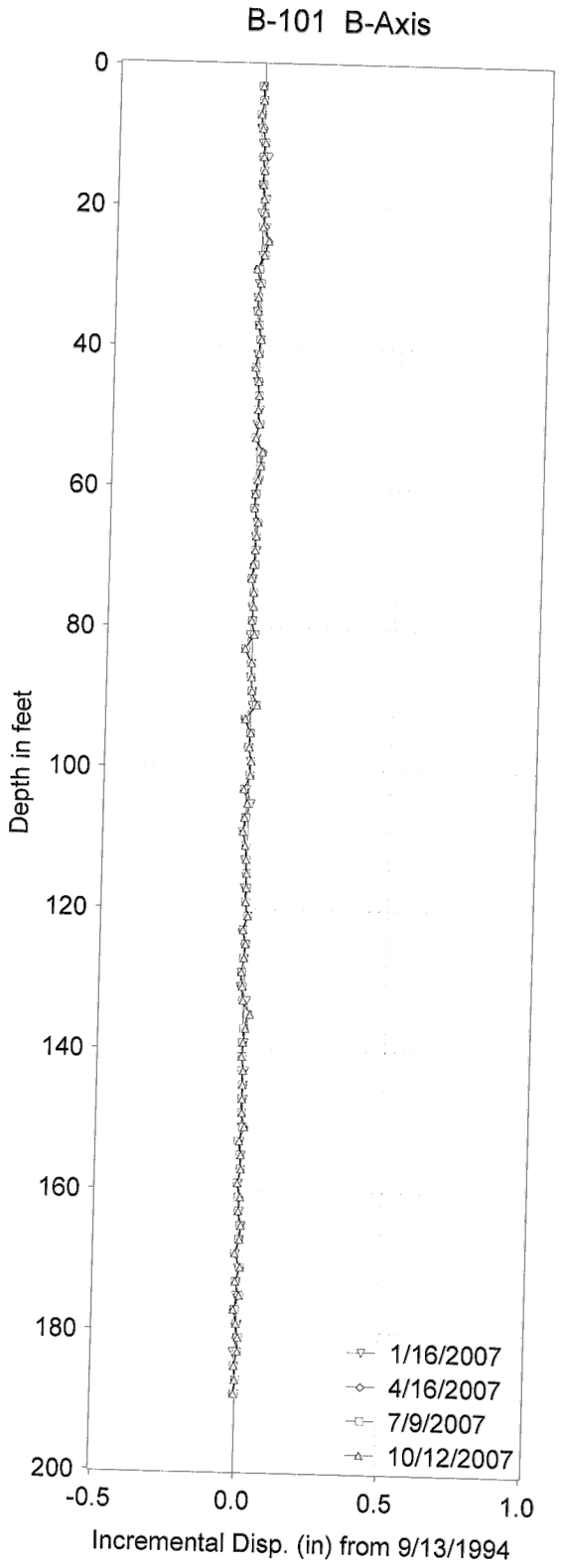


B-101

-Includes readings from the last four quarters.

PLATE 3

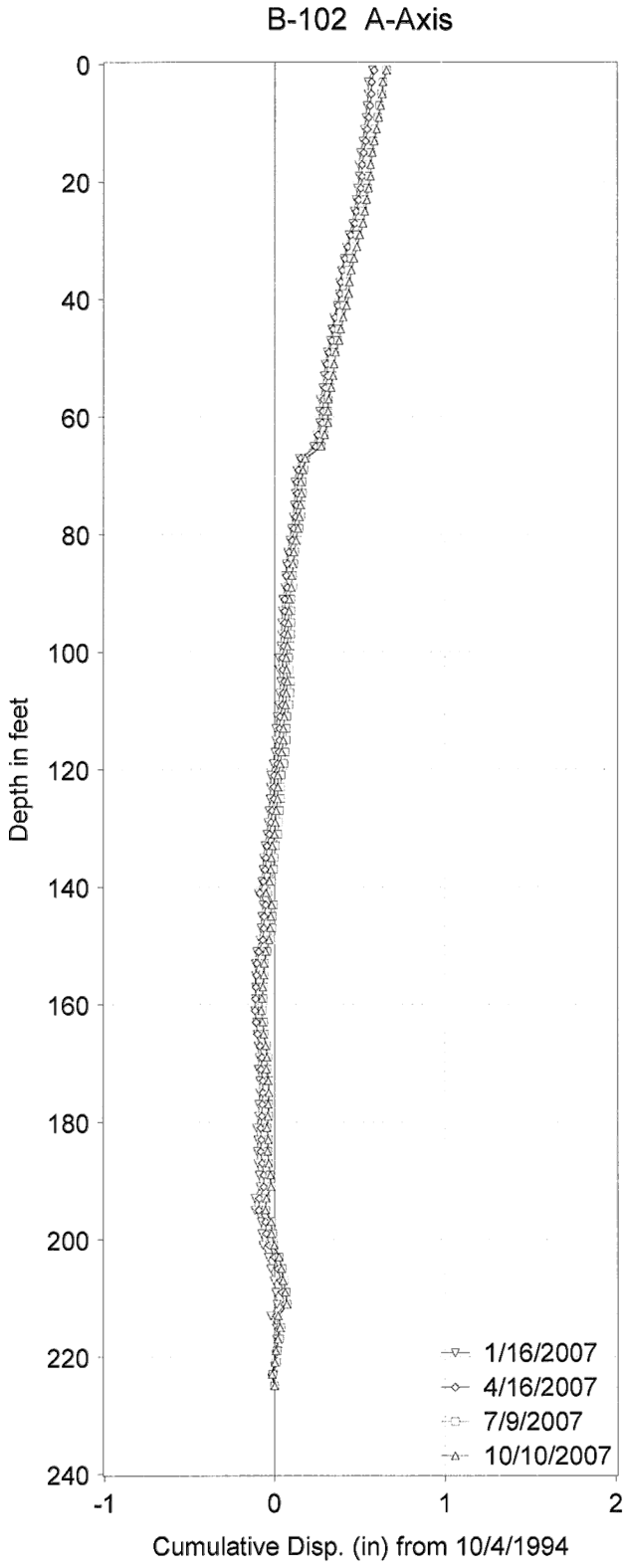


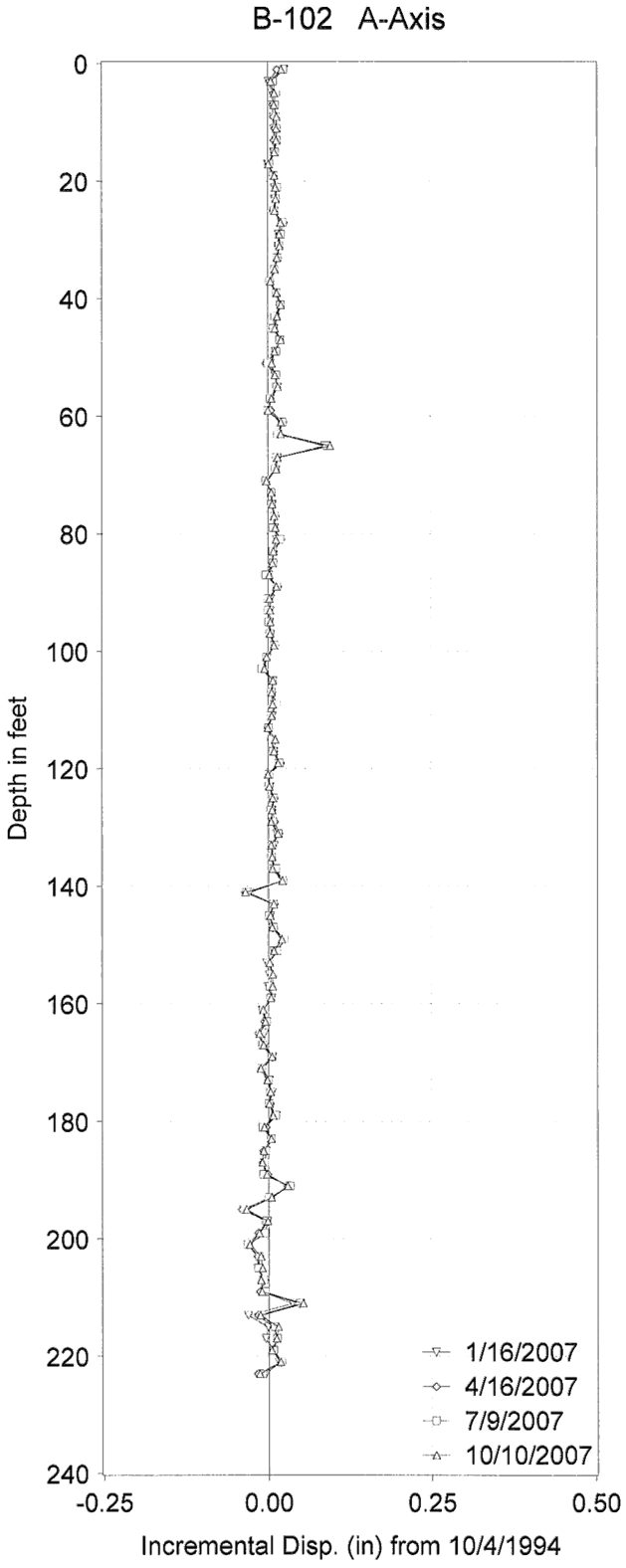


B-101

-Includes readings from the last four quarters.

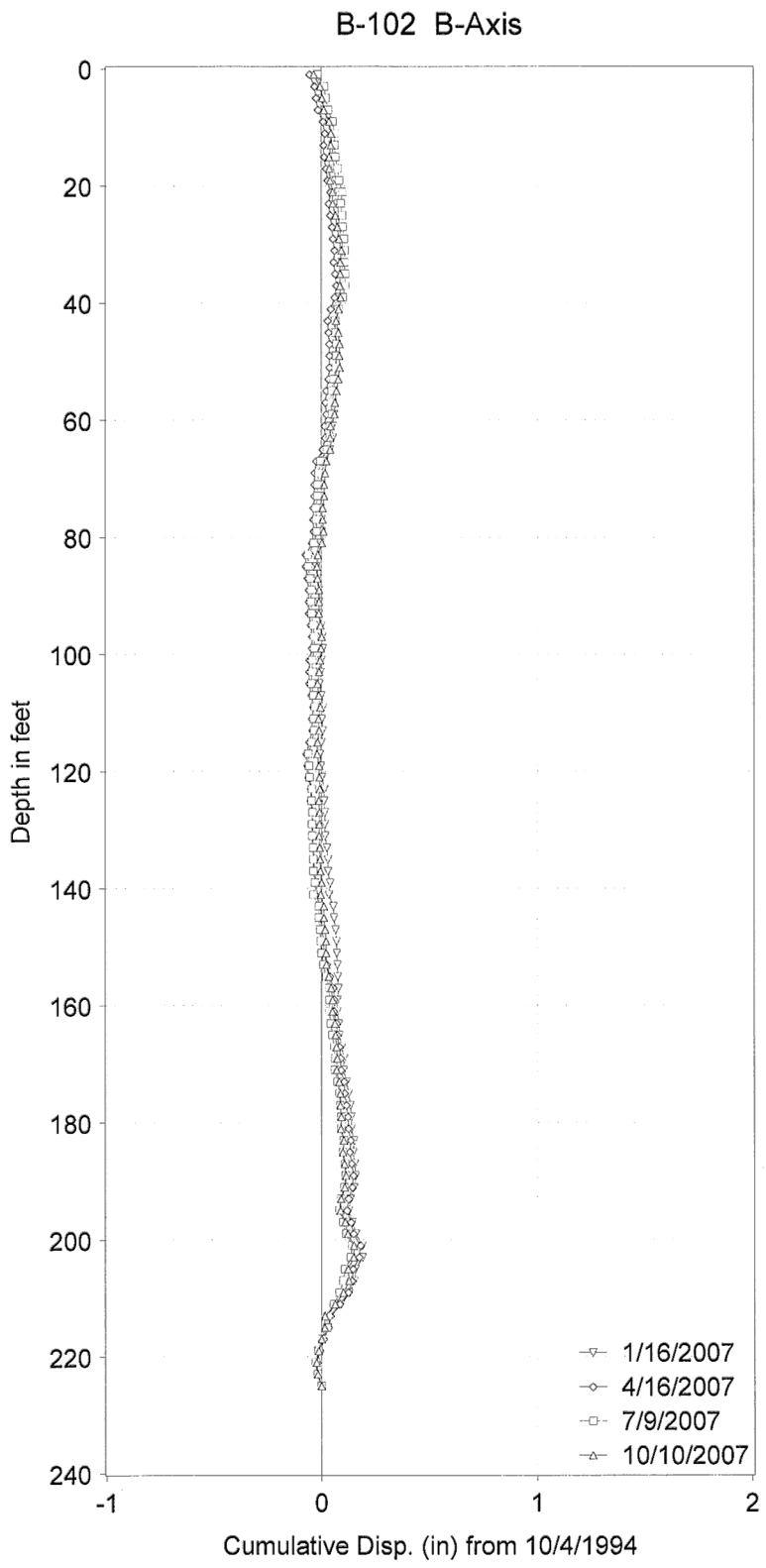
PLATE 4

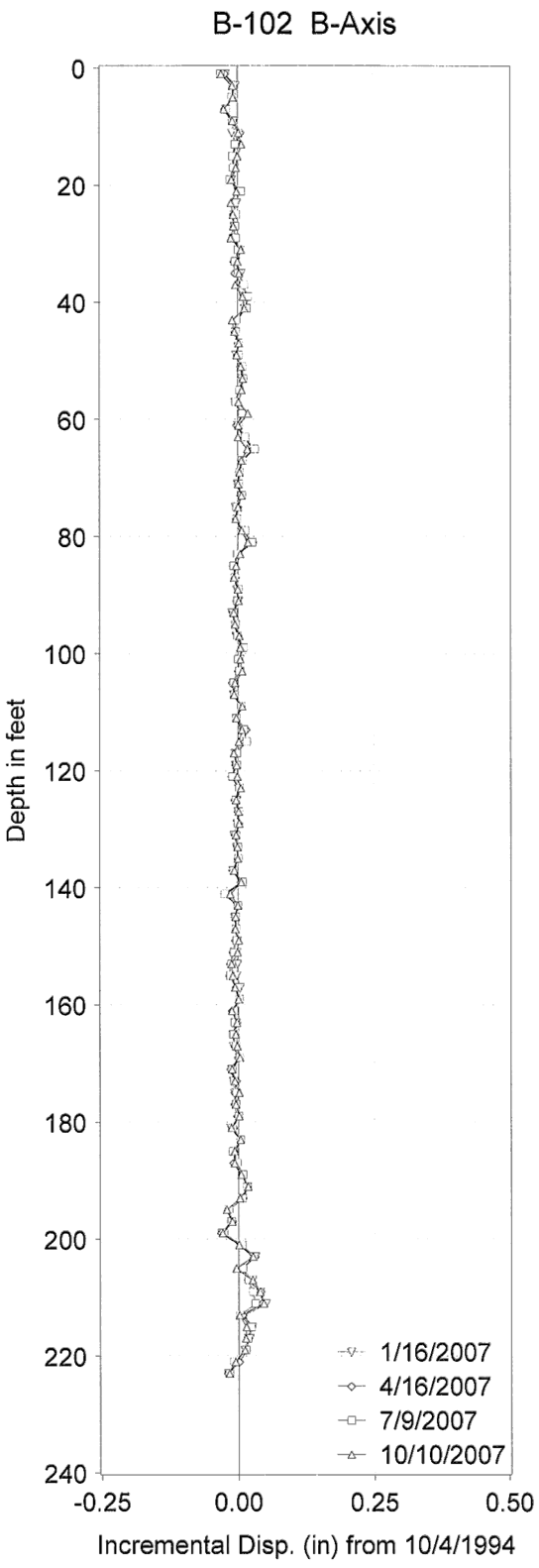




B-102
-Includes readings from the last four quarters.

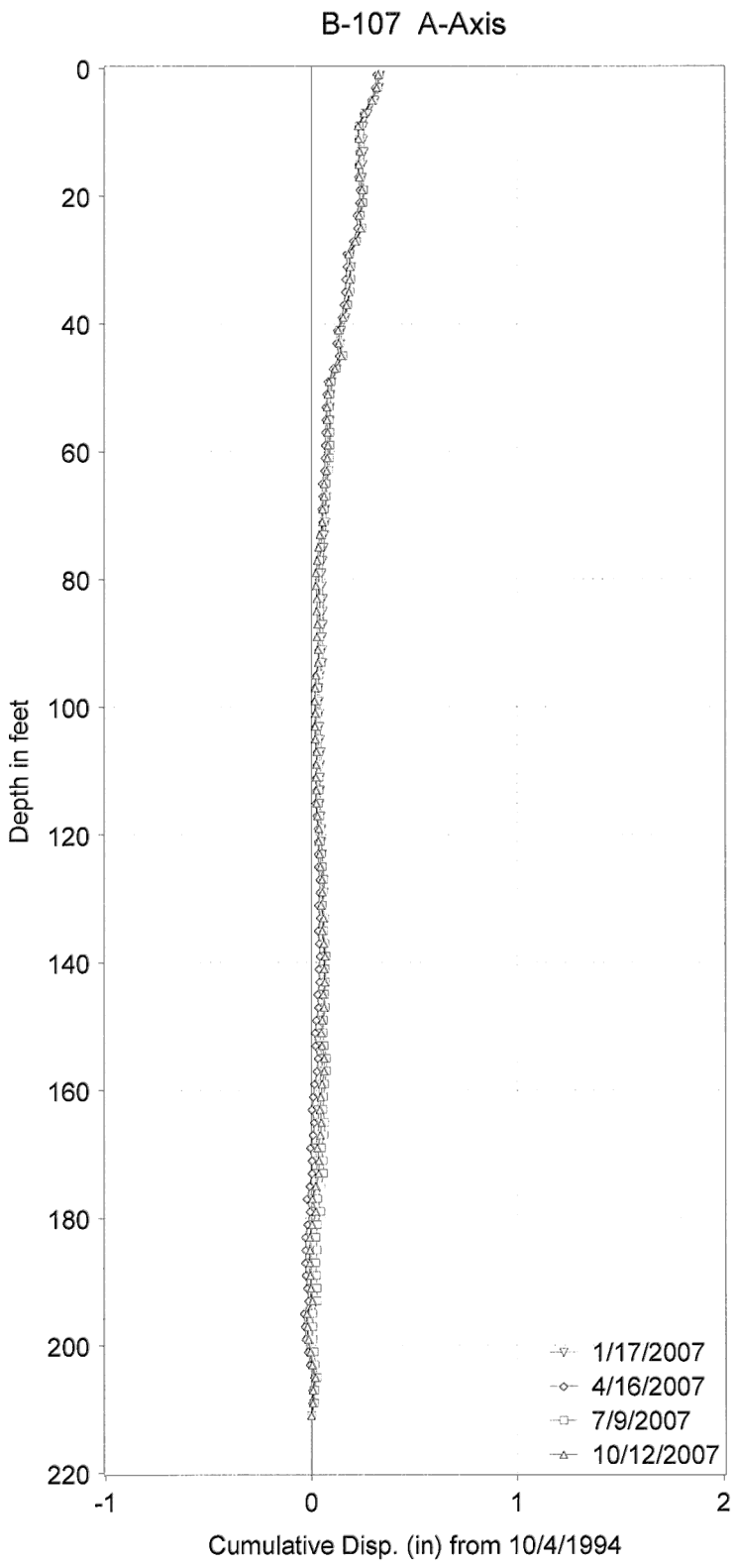
PLATE 5

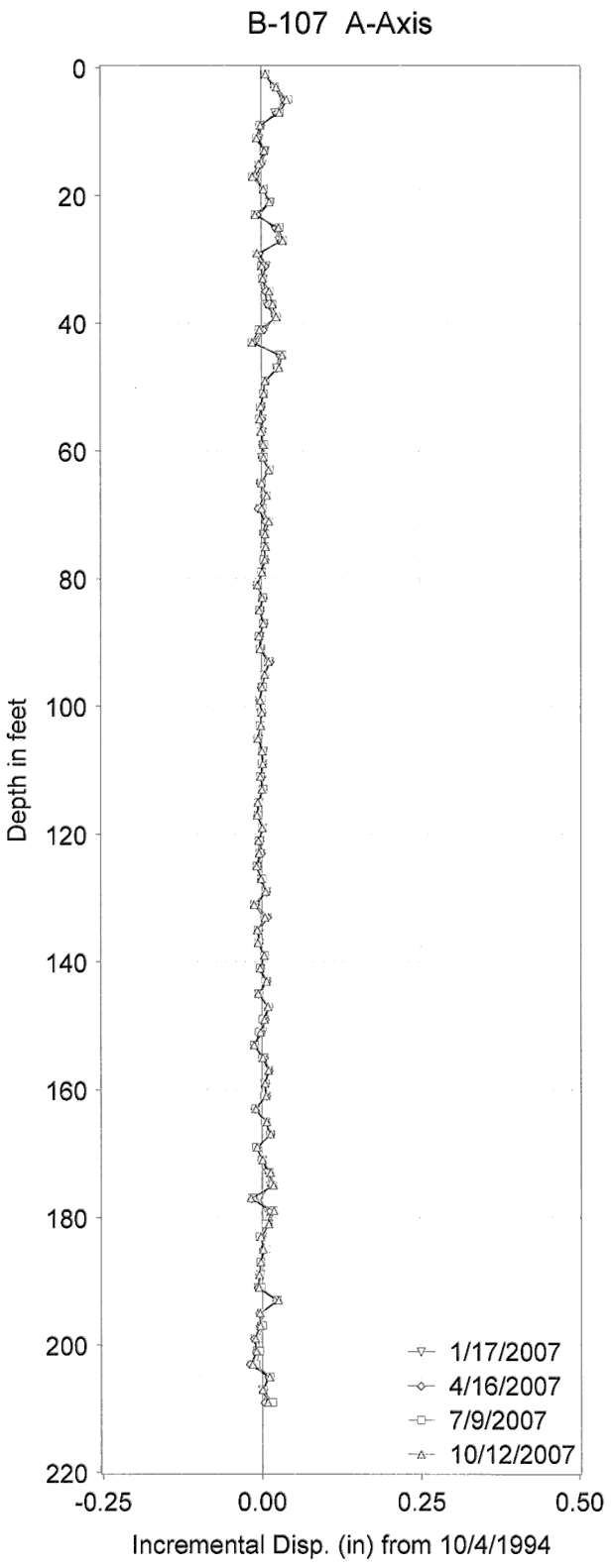




B-102
-Includes readings from the last four quarters.

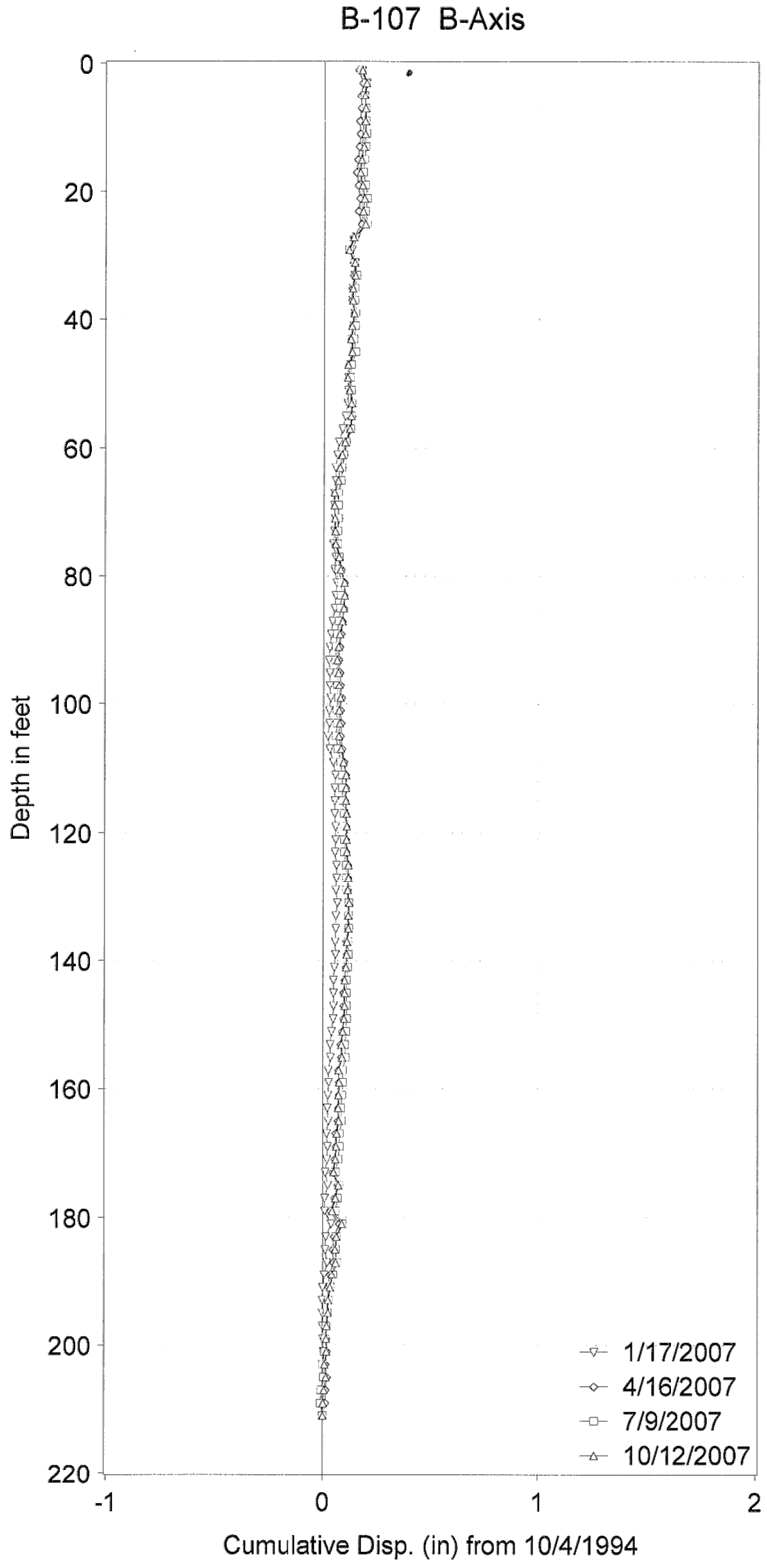
PLATE 6

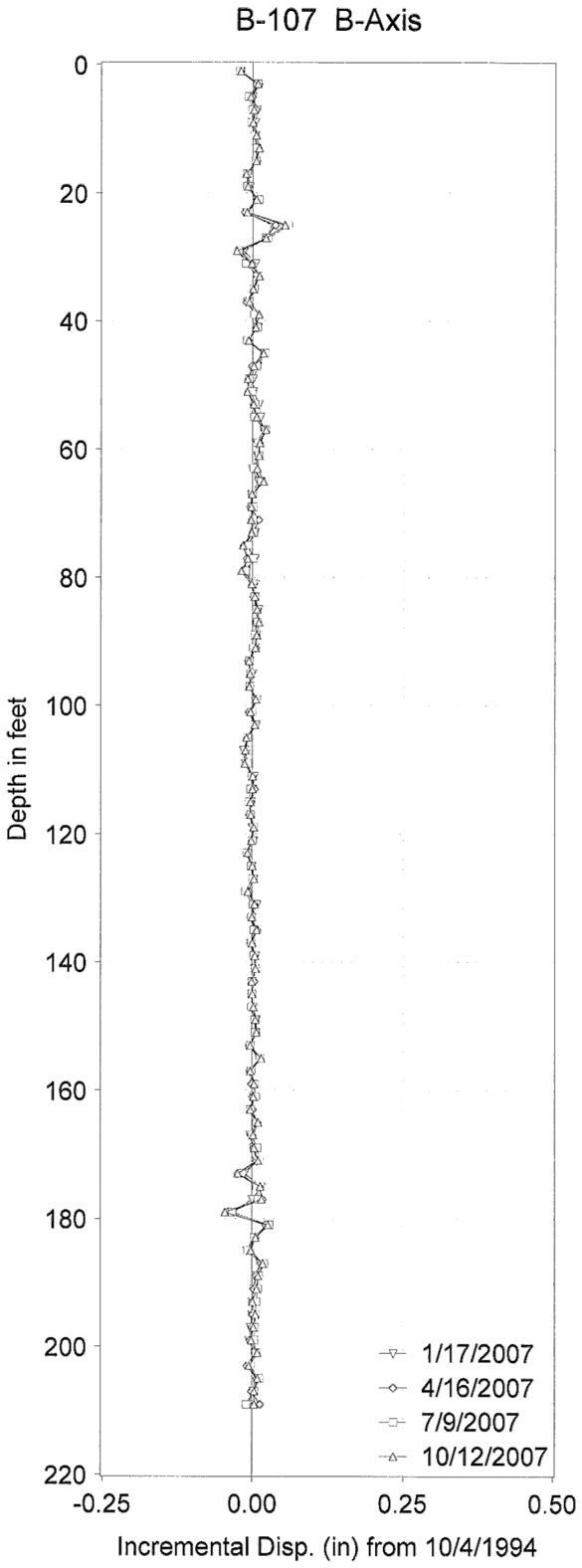




B-107
-Includes readings from the last four quarters.

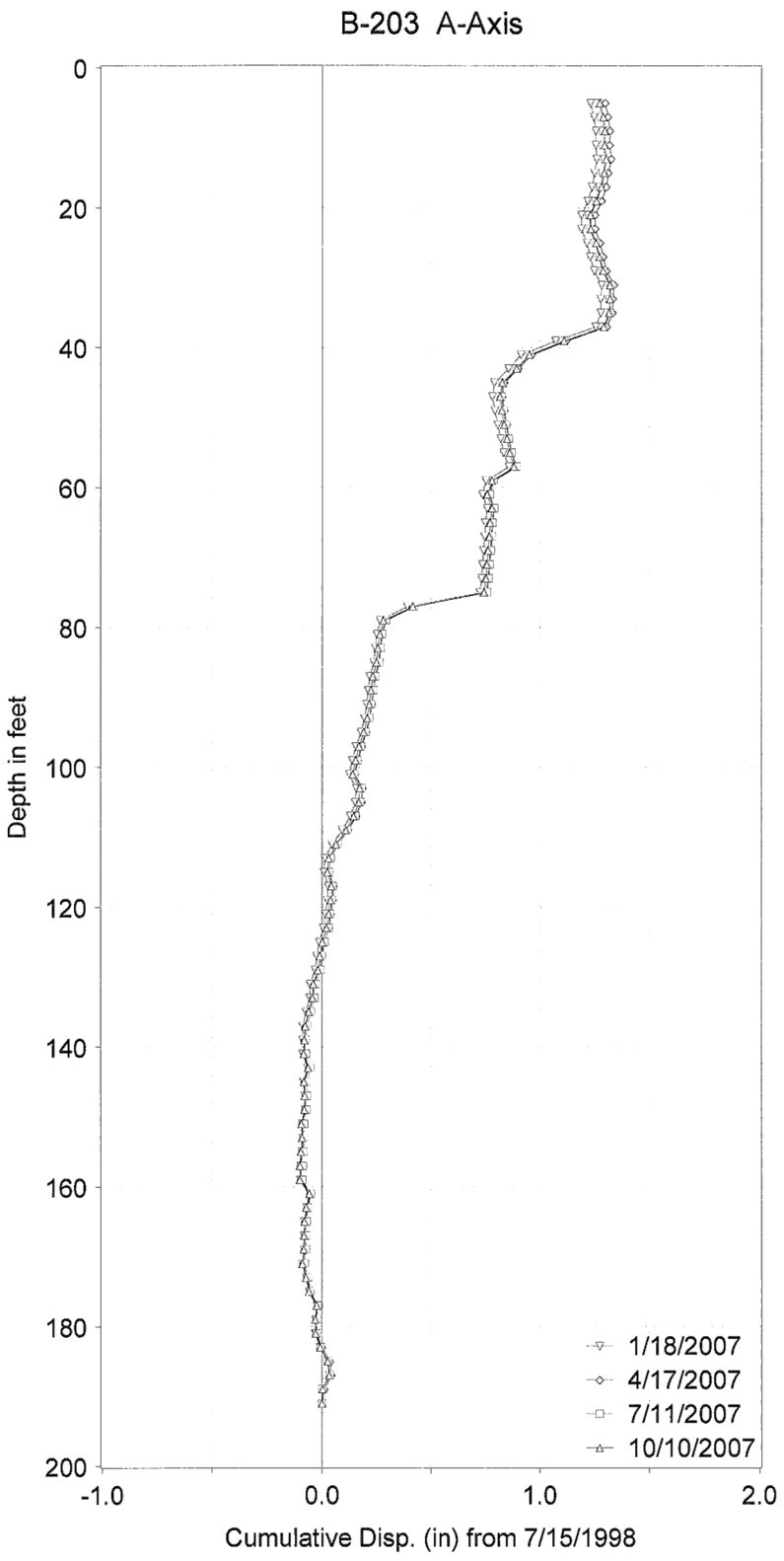
PLATE 7

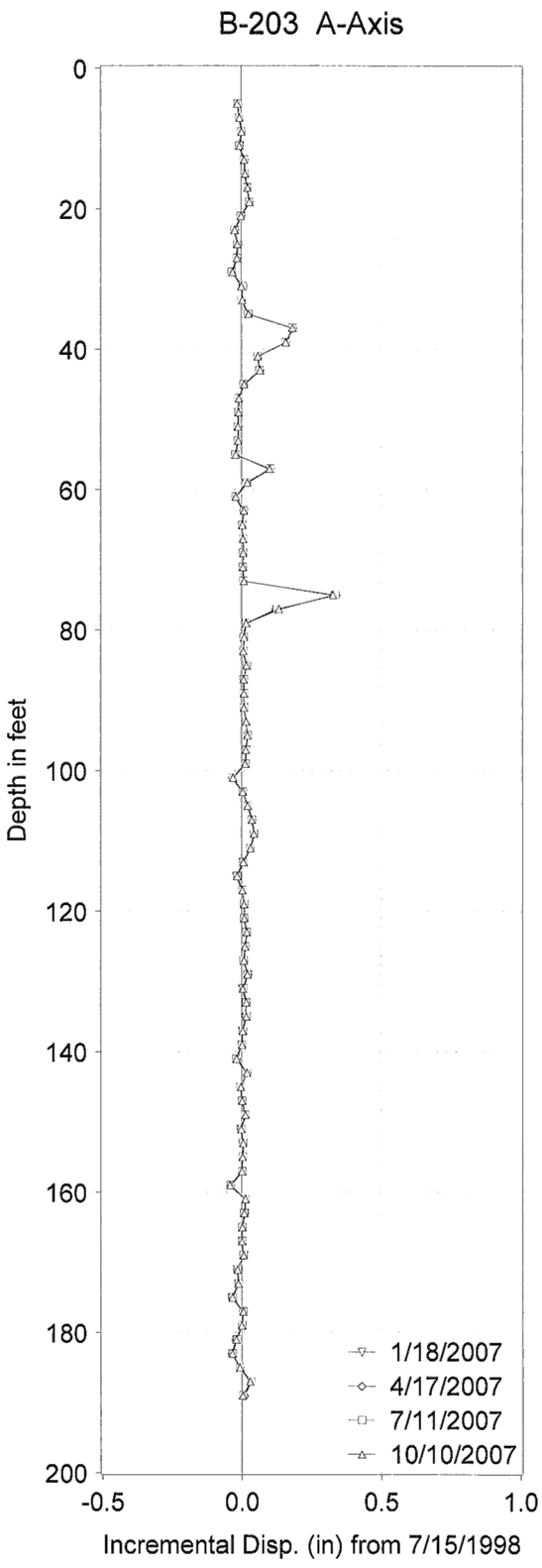




B-107
-Includes readings from the last four quarters.

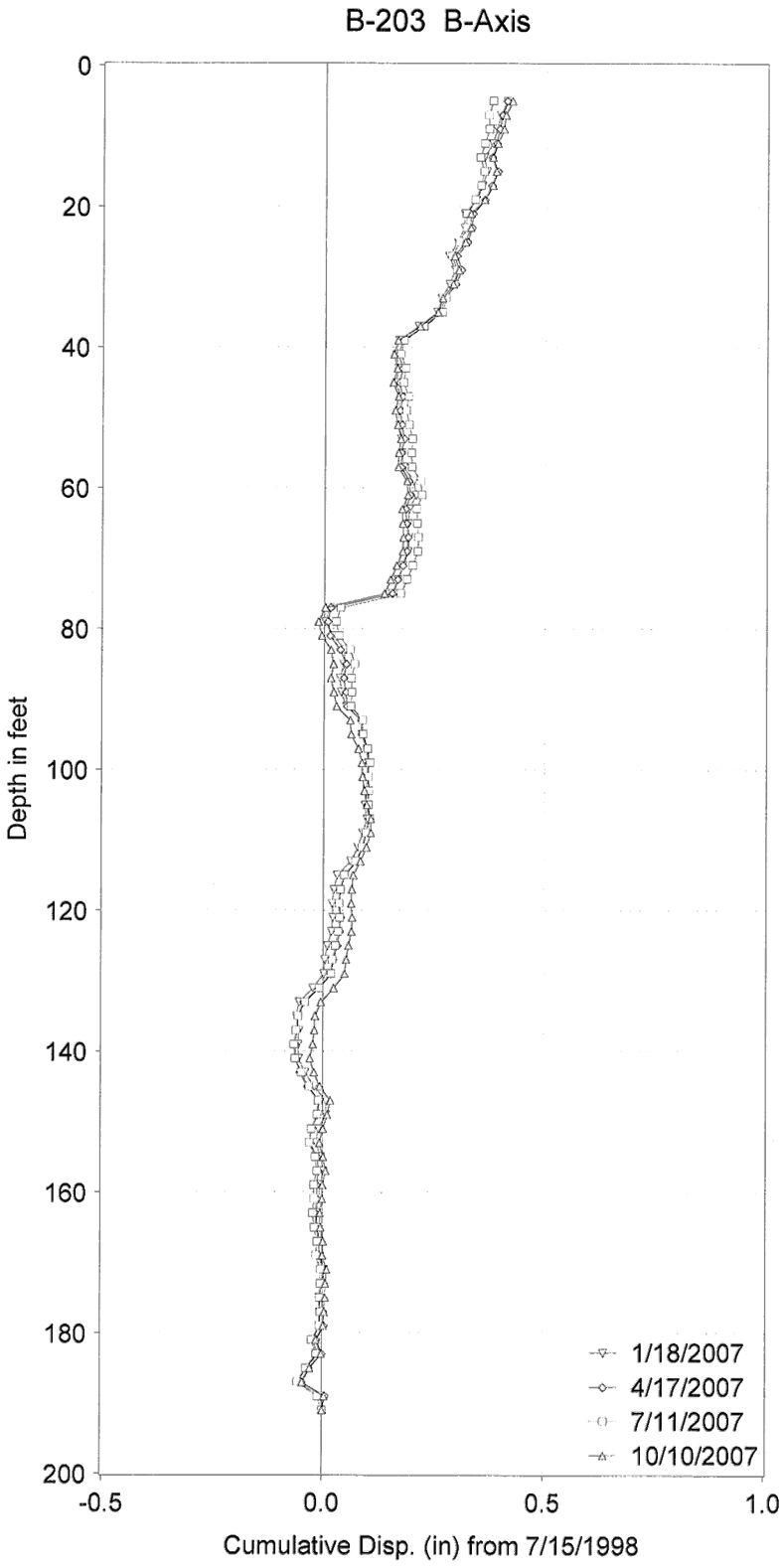
PLATE 8

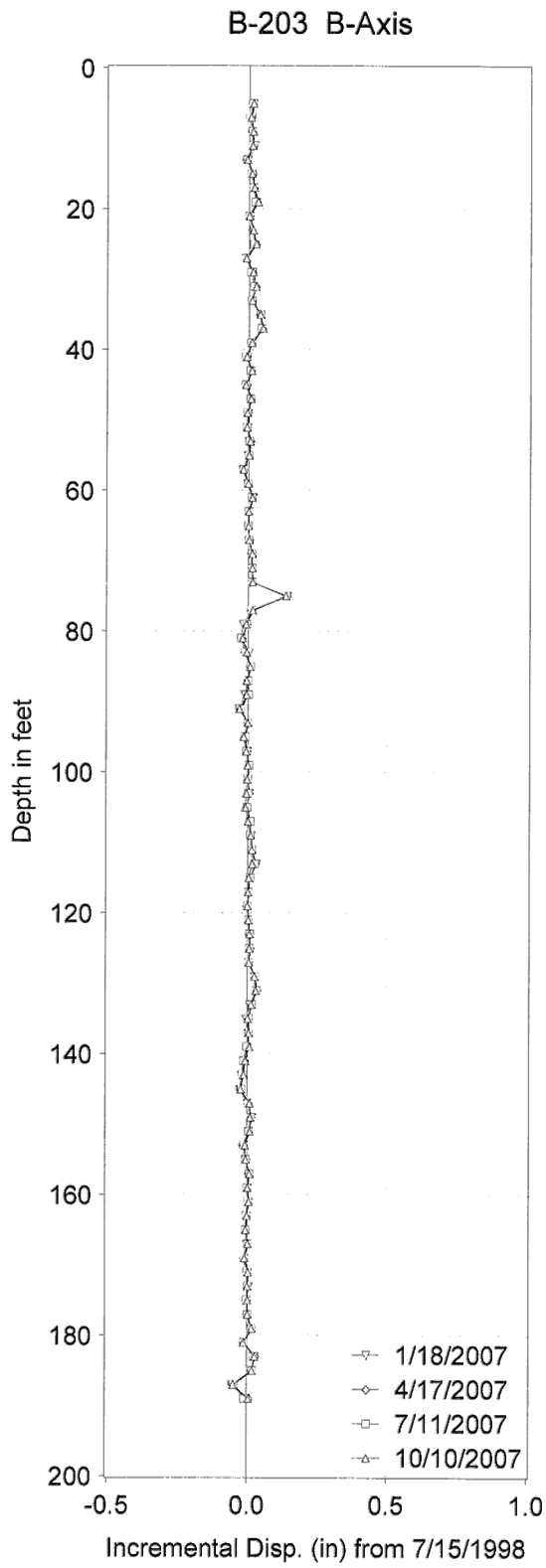




B-203
-Includes readings from the last four quarters.

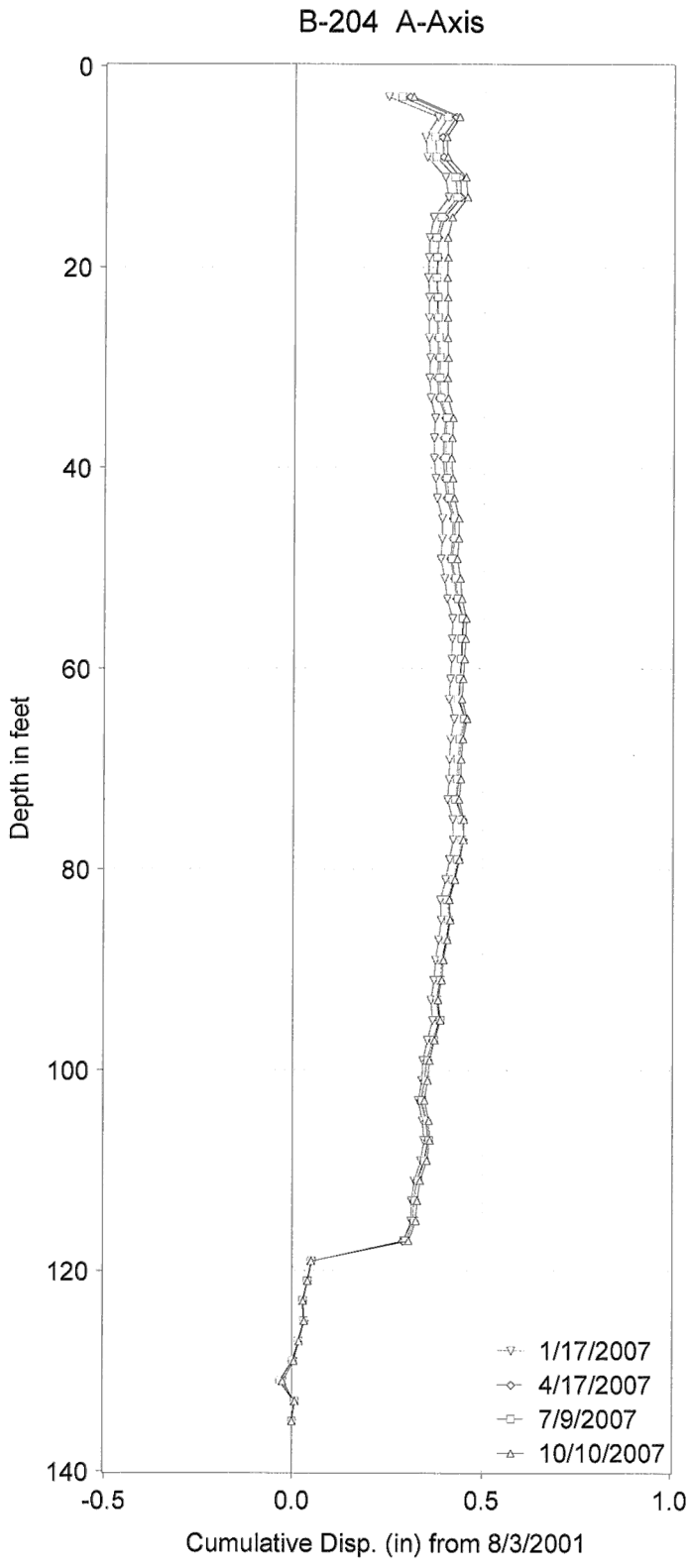
PLATE 9

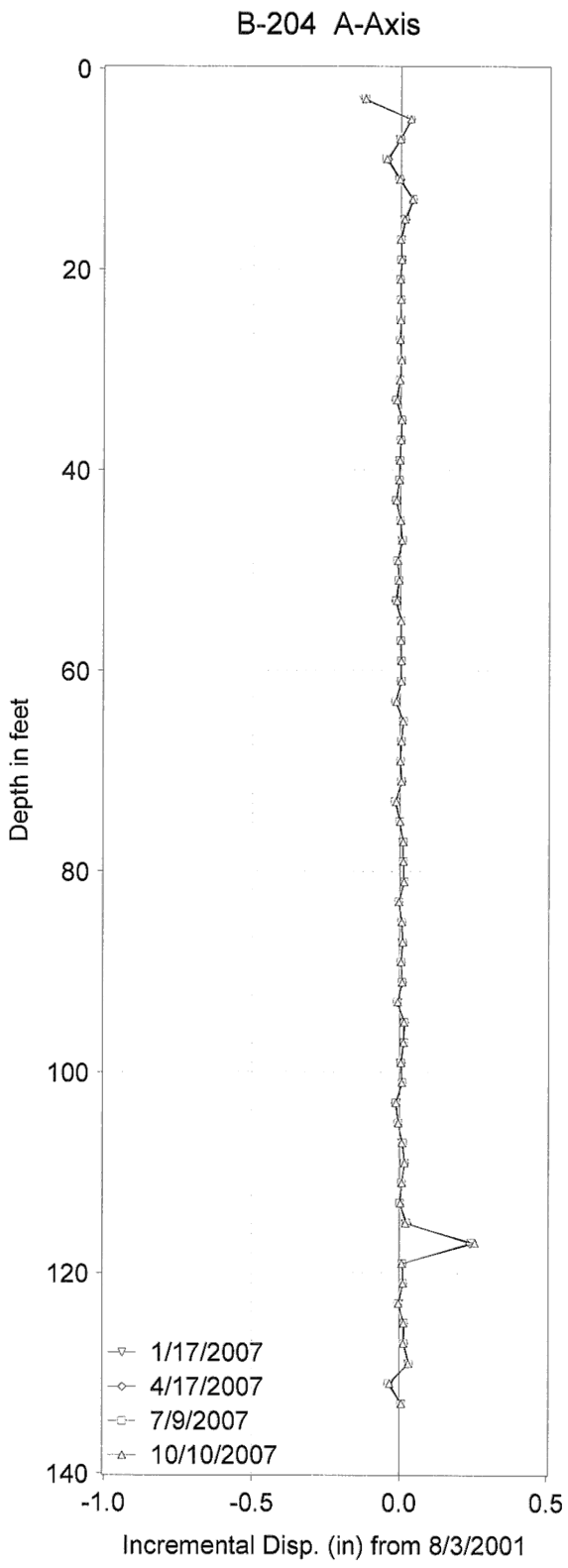




B-203
-Includes readings from the last four quarters.

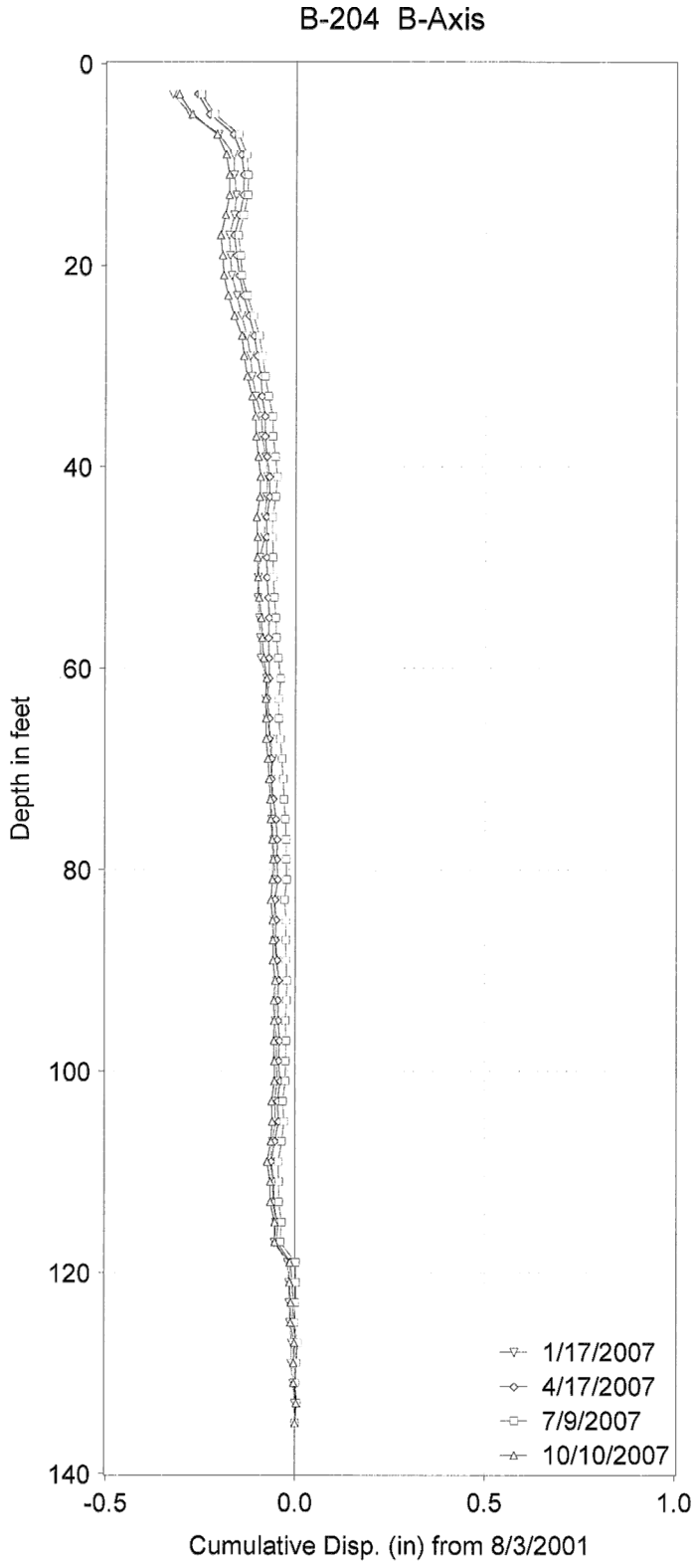
PLATE 10

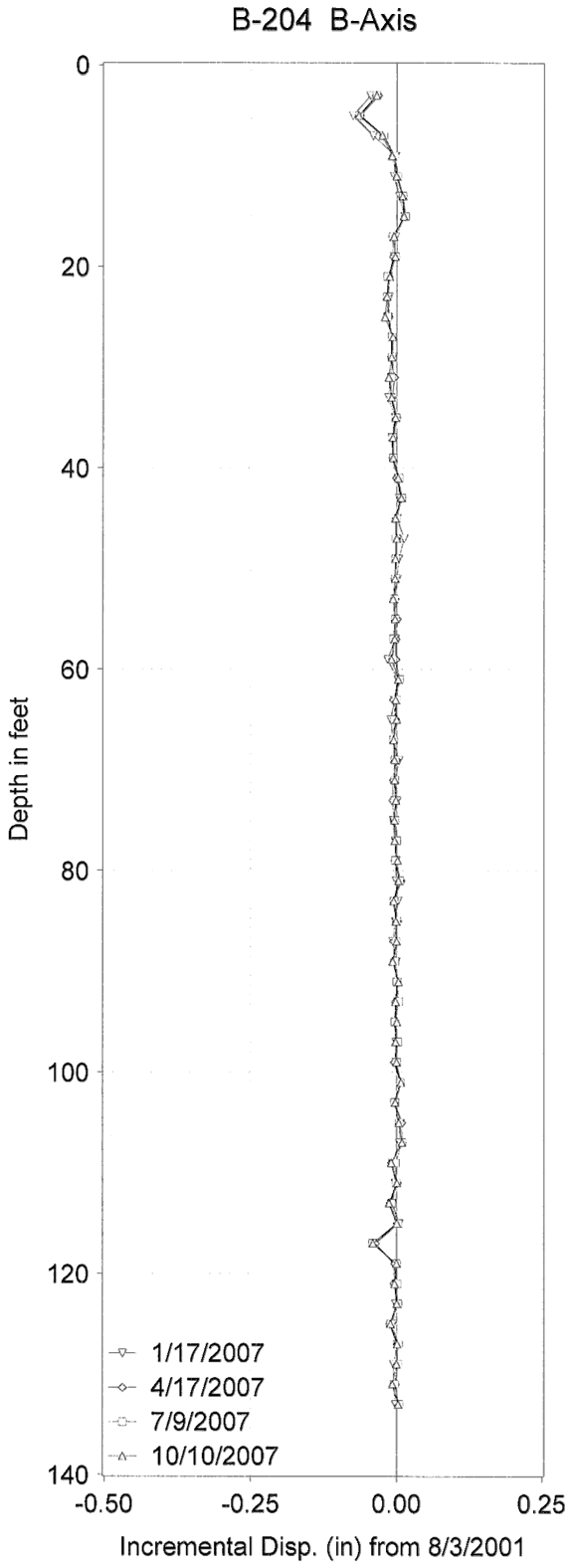




B-204
-Includes readings from the last four quarters.

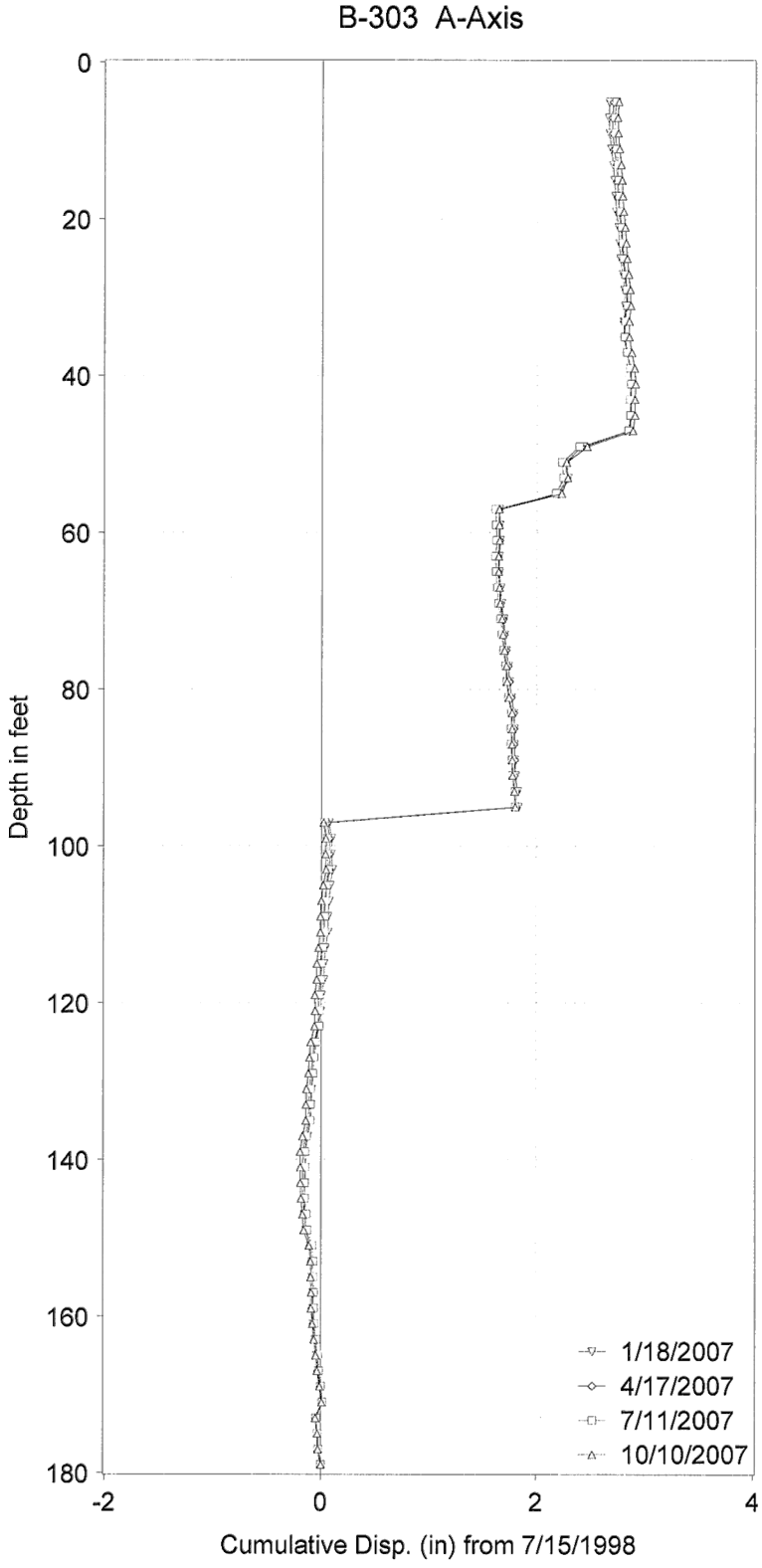
PLATE 11

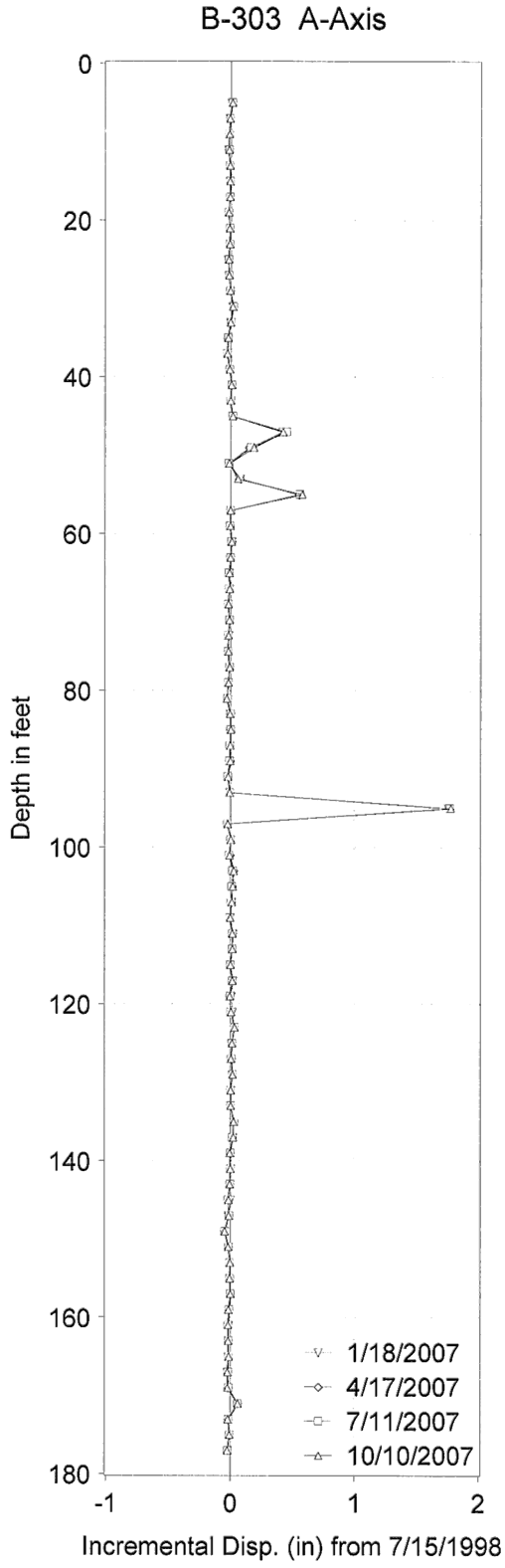




B-204
-Includes readings from the last four quarters.

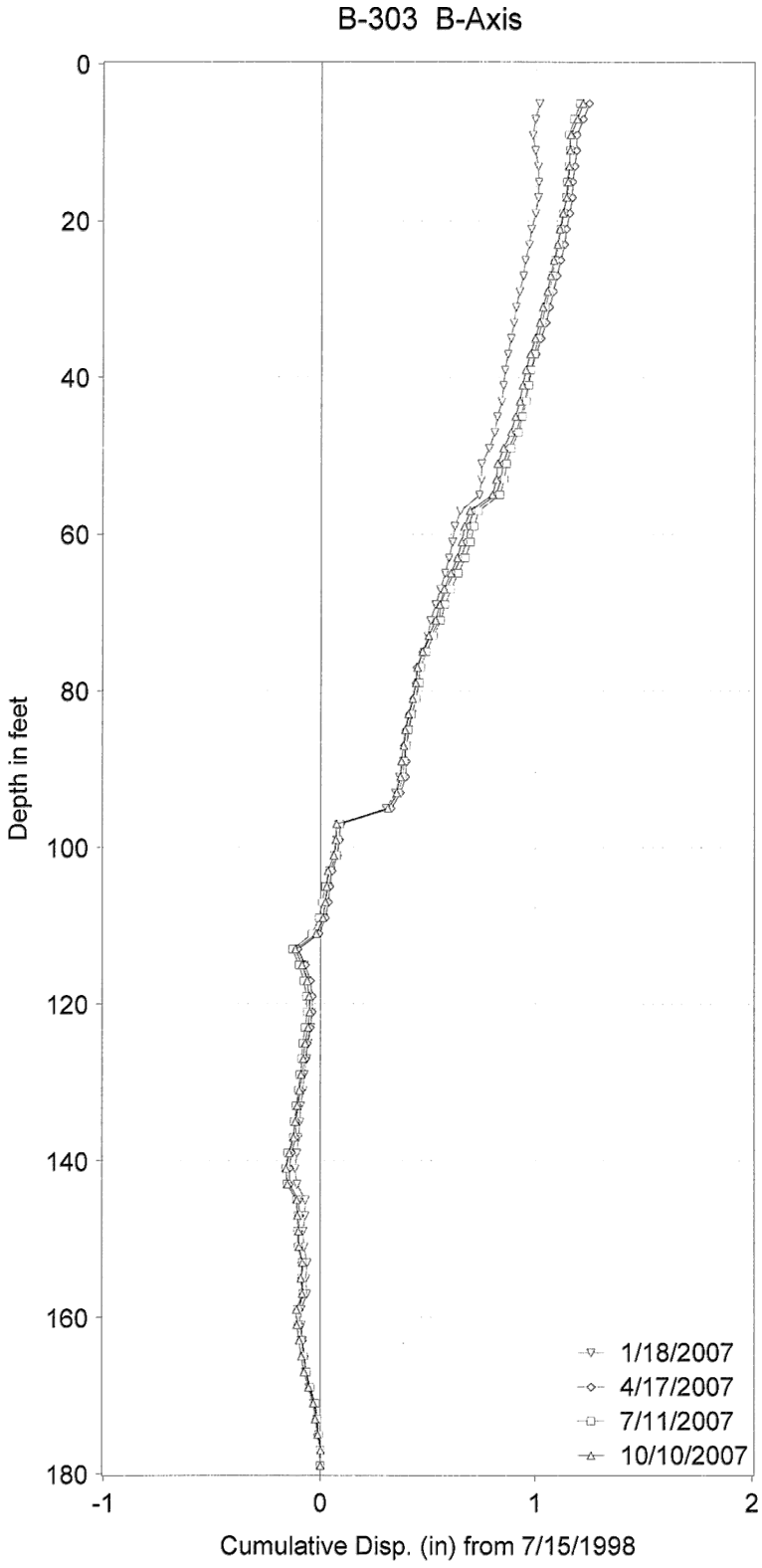
PLATE 12

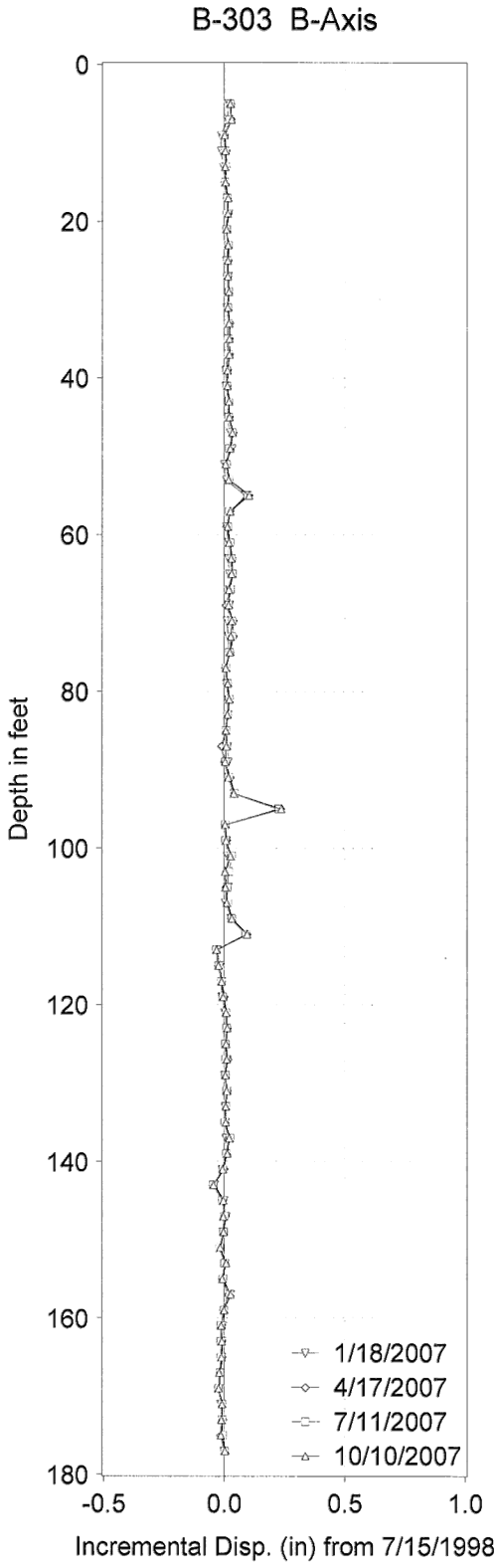




B-303
-Includes readings from the last four quarters.

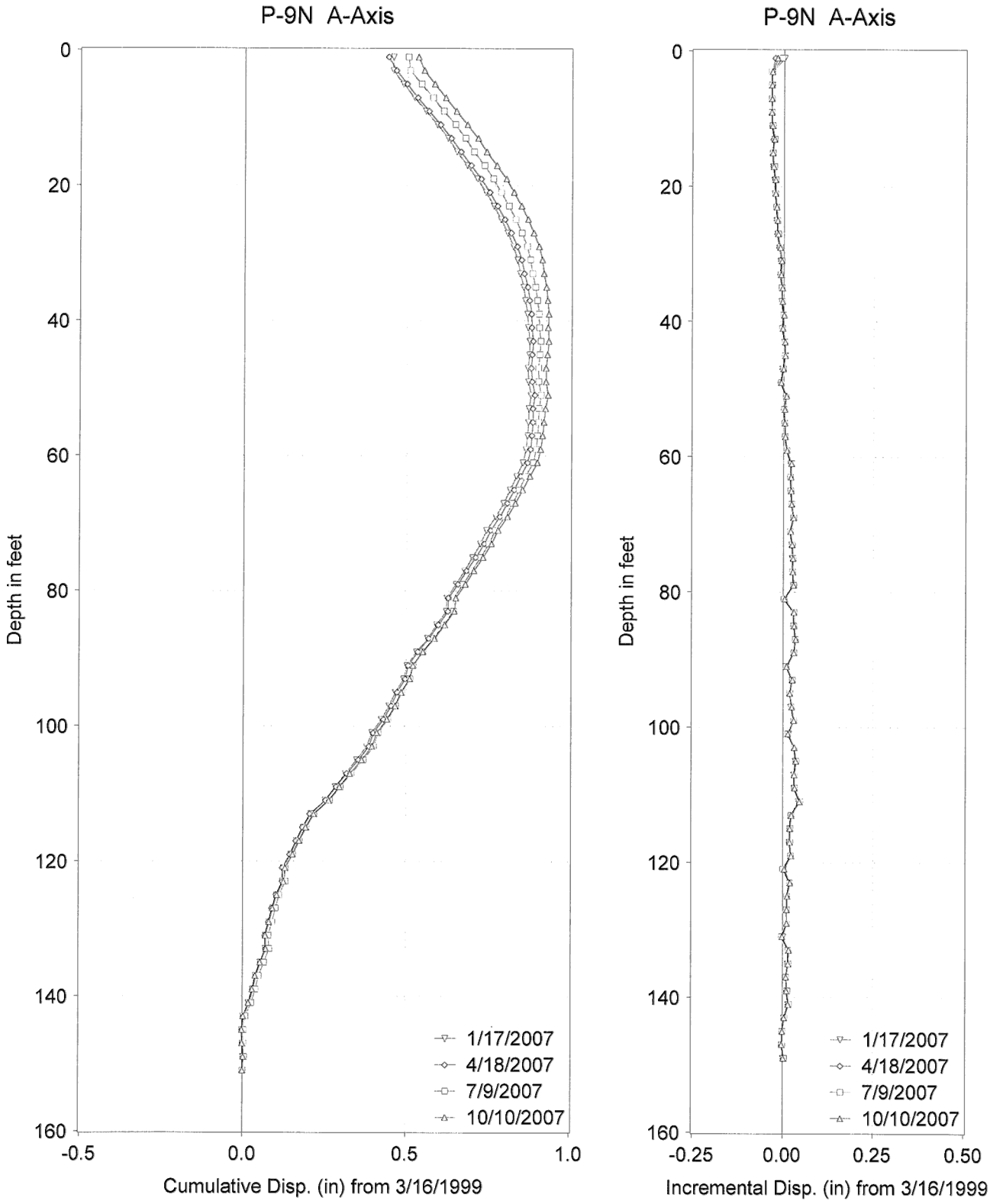
PLATE 13





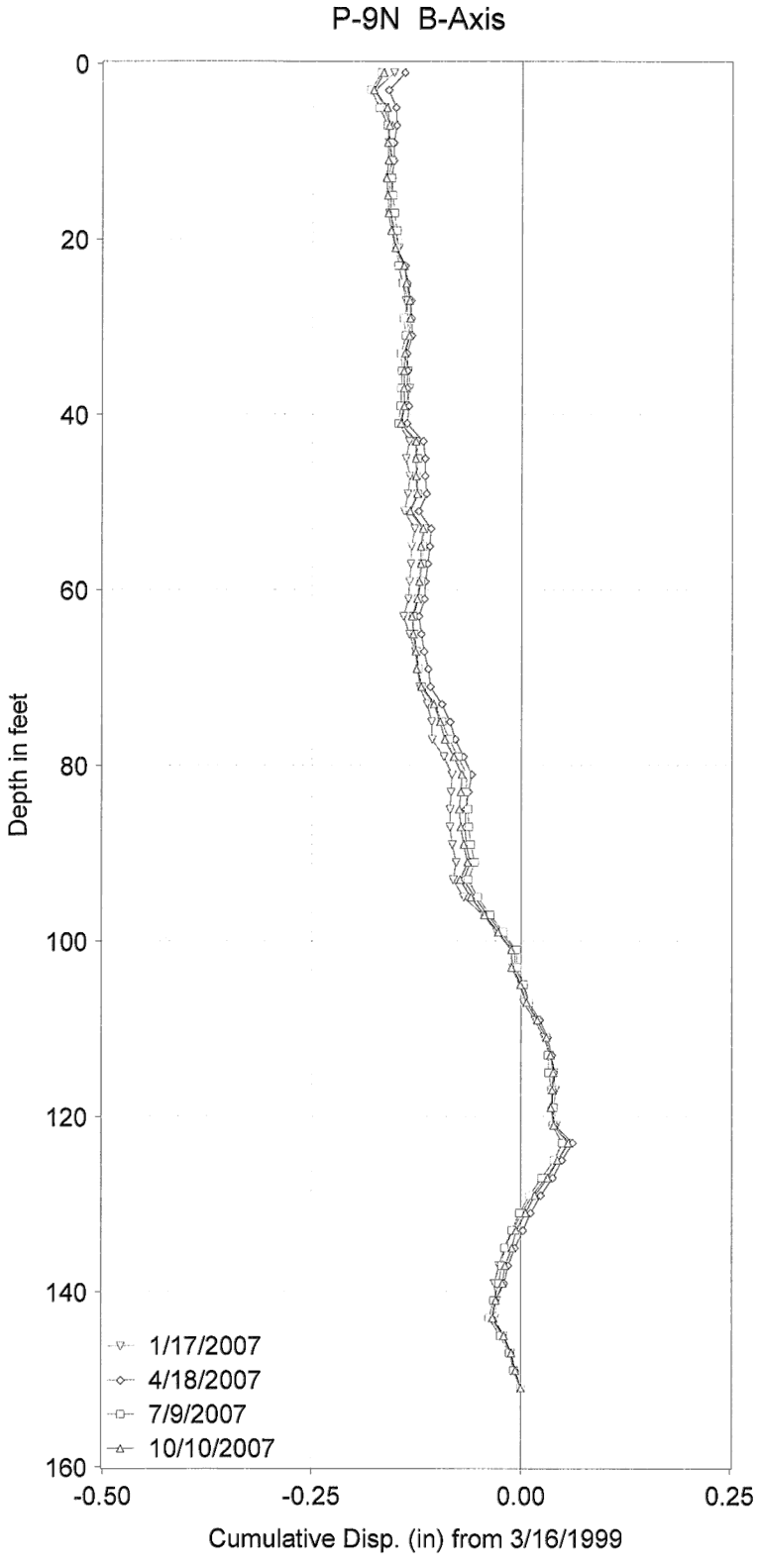
B-303
-Includes readings from the last four quarters.

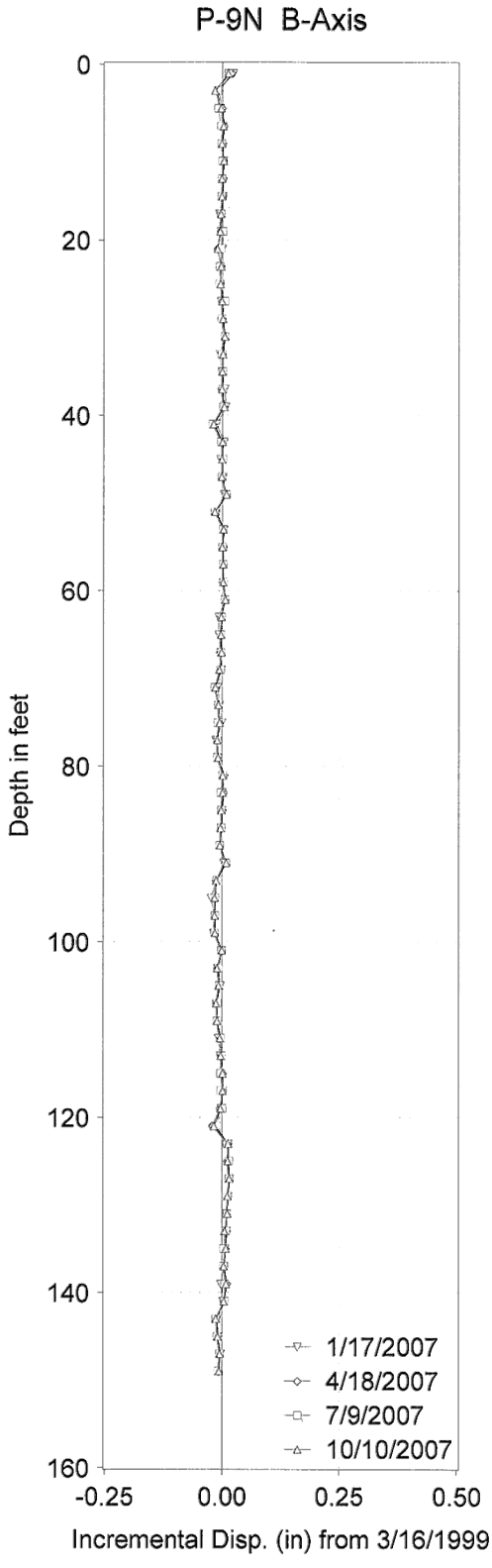
PLATE 14



P-9N
-Includes readings from the last four quarters.

PLATE 15





P-9N

-Includes readings from the last four quarters.

PLATE 16

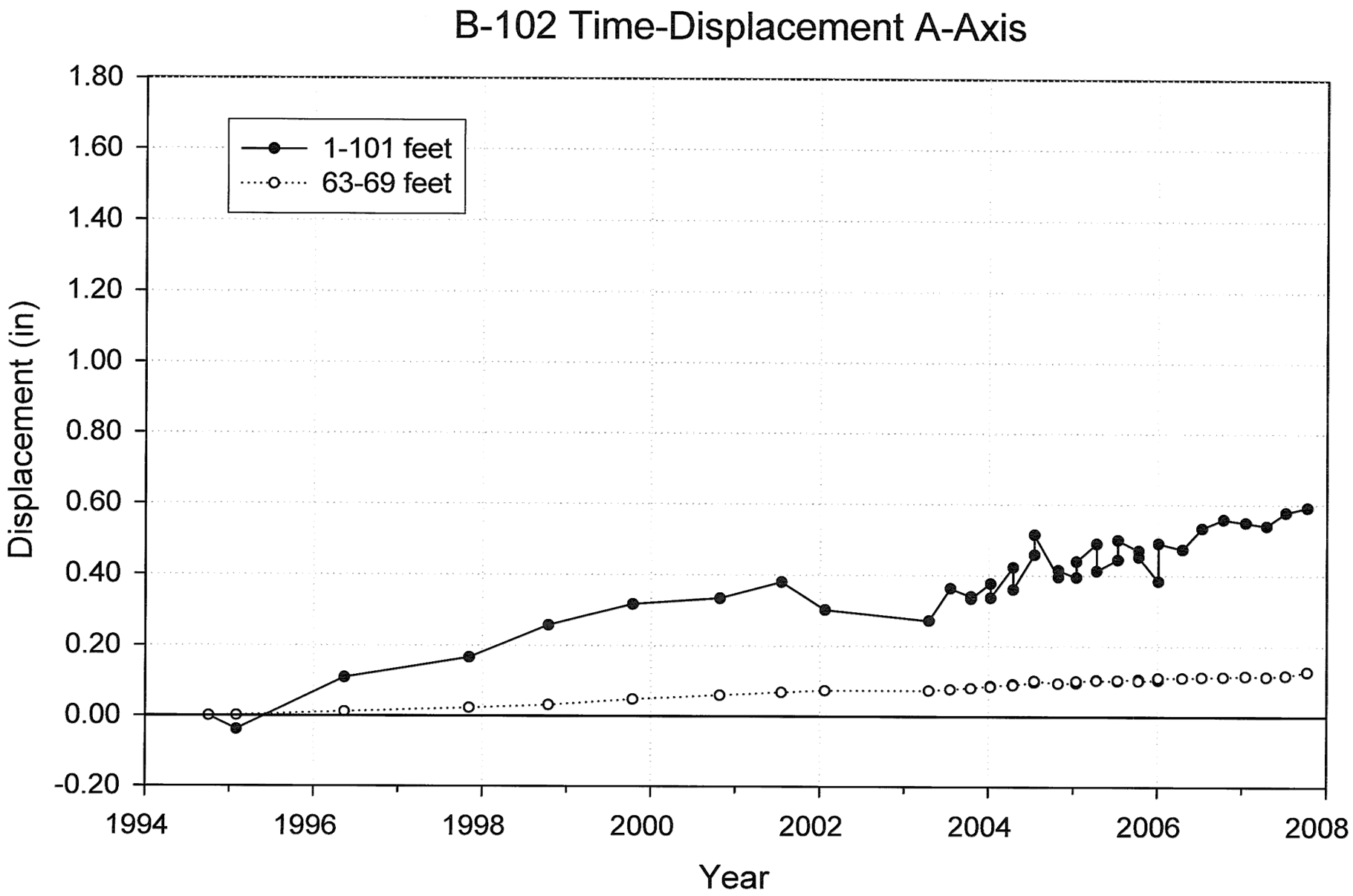

B-102 Time-Displacement A-Axis
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Displacement (in)
1-101 feet
63-69 feet
1994
1996
1998
2000
2002
2004
2006
2008
Year

PLATE 17

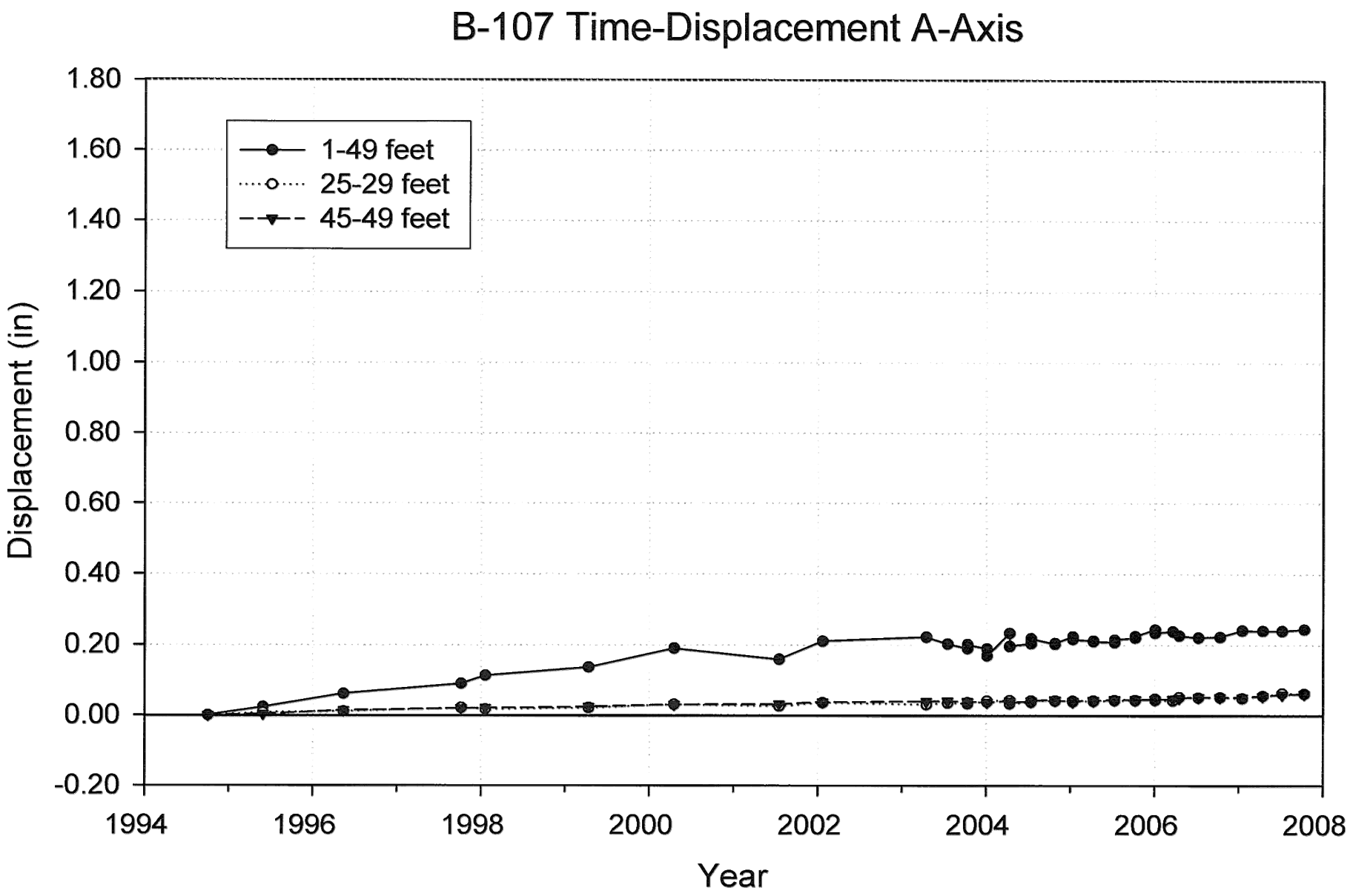

B-107 Time-Displacement A-Axis
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Displacement (in)
1-49 feet
25-29 feet
45-49 feet
1994
1996
1998
2000
2002
2004
2006
2008
Year

PLATE 18

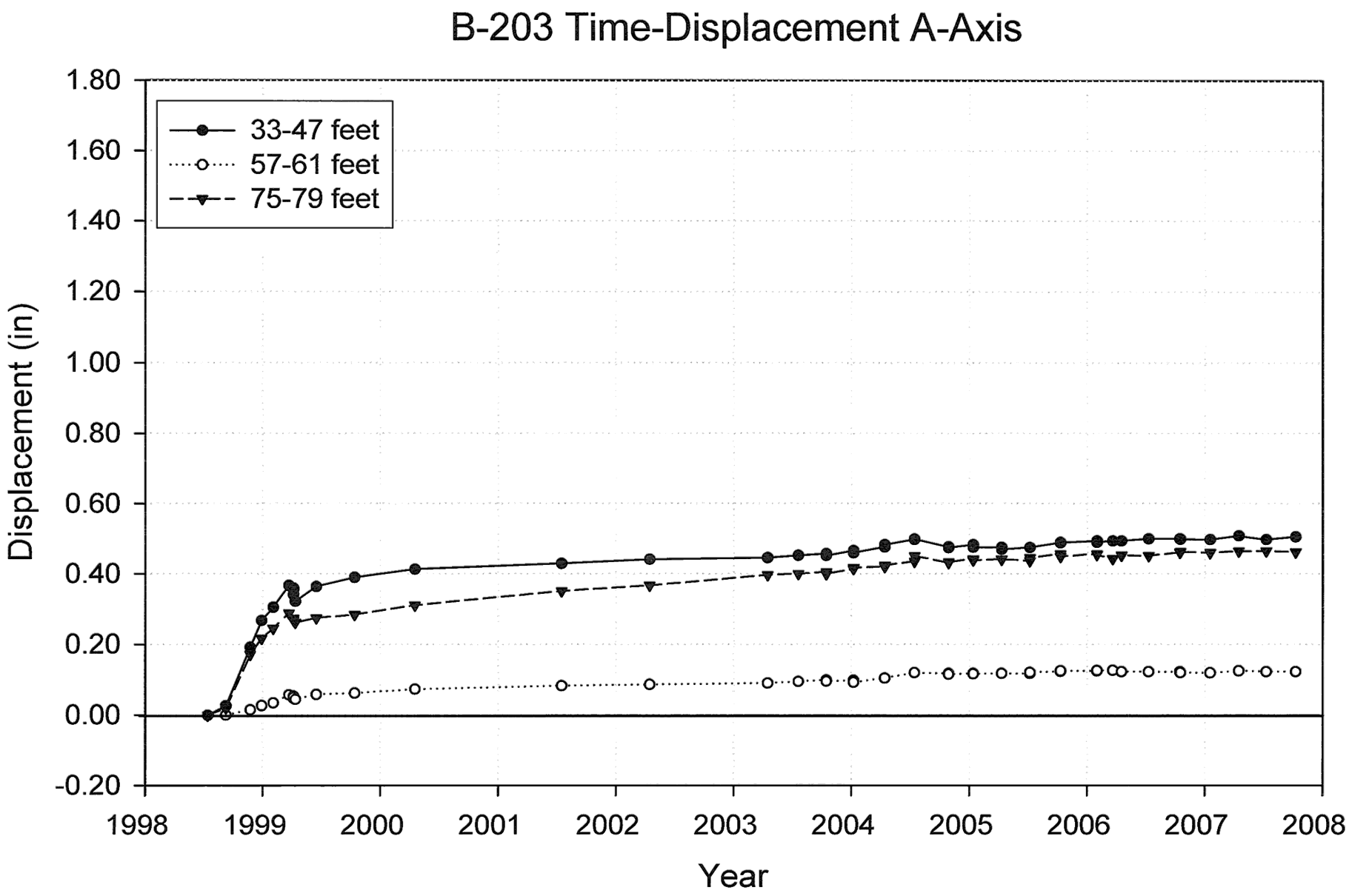

B-203 Time-Displacement A-Axis
33-47 feet
57-61 feet
75-79 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year

PLATE 19

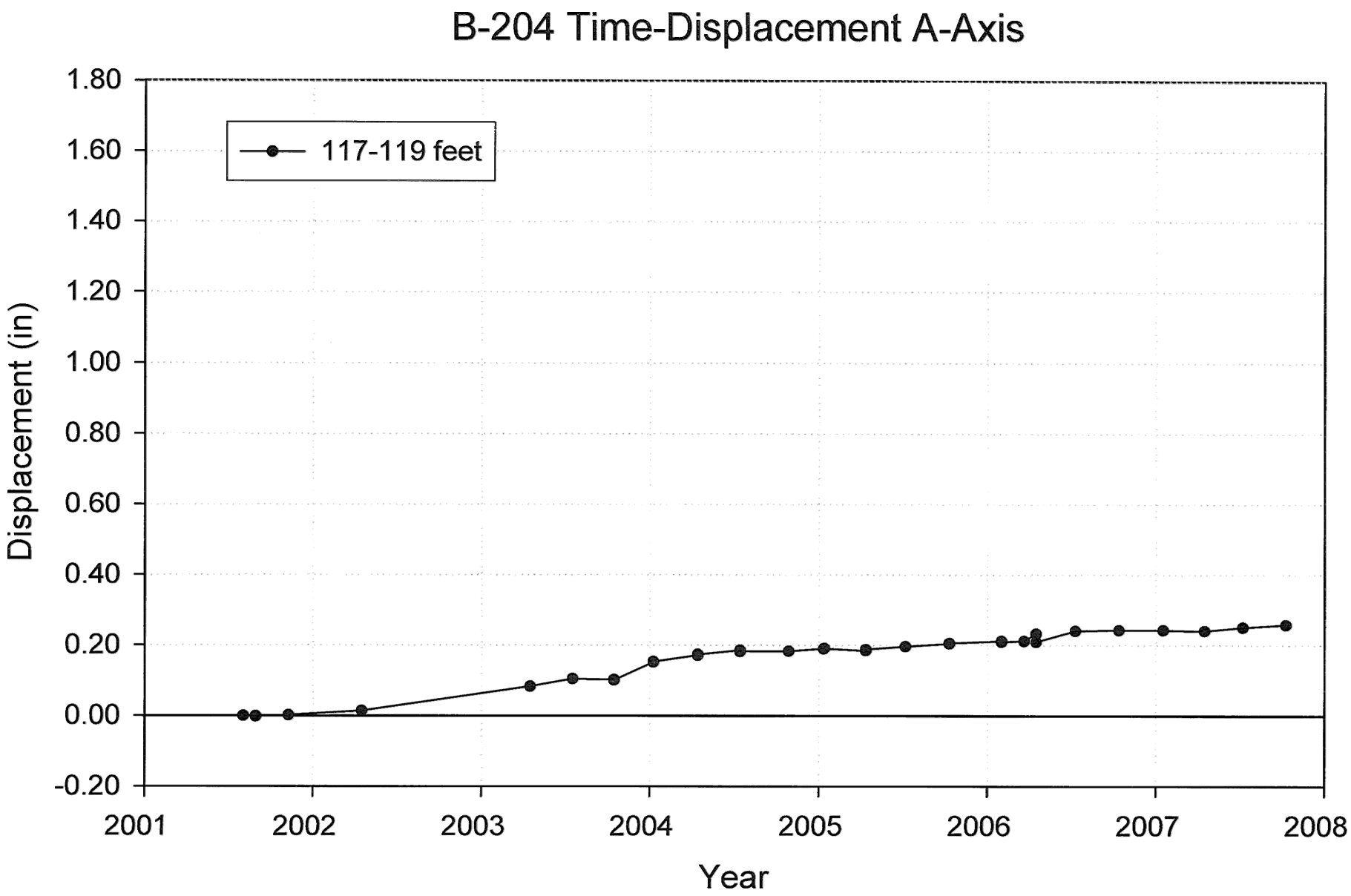

B-204 Time-Displacement A-Axis
117-119 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
2001
2002
2003
2004
2005
2006
2007
2008
Year

PLATE 20

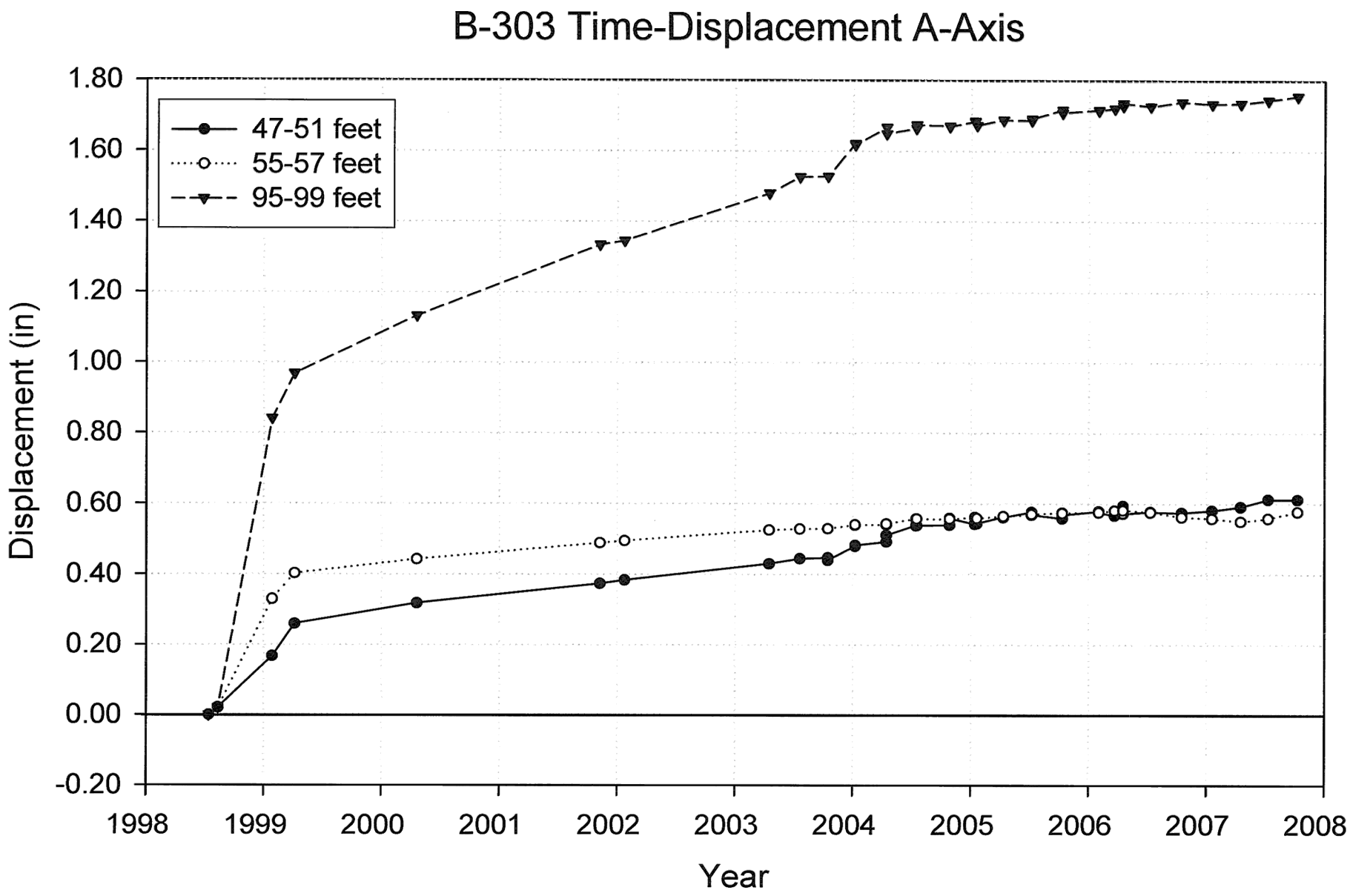
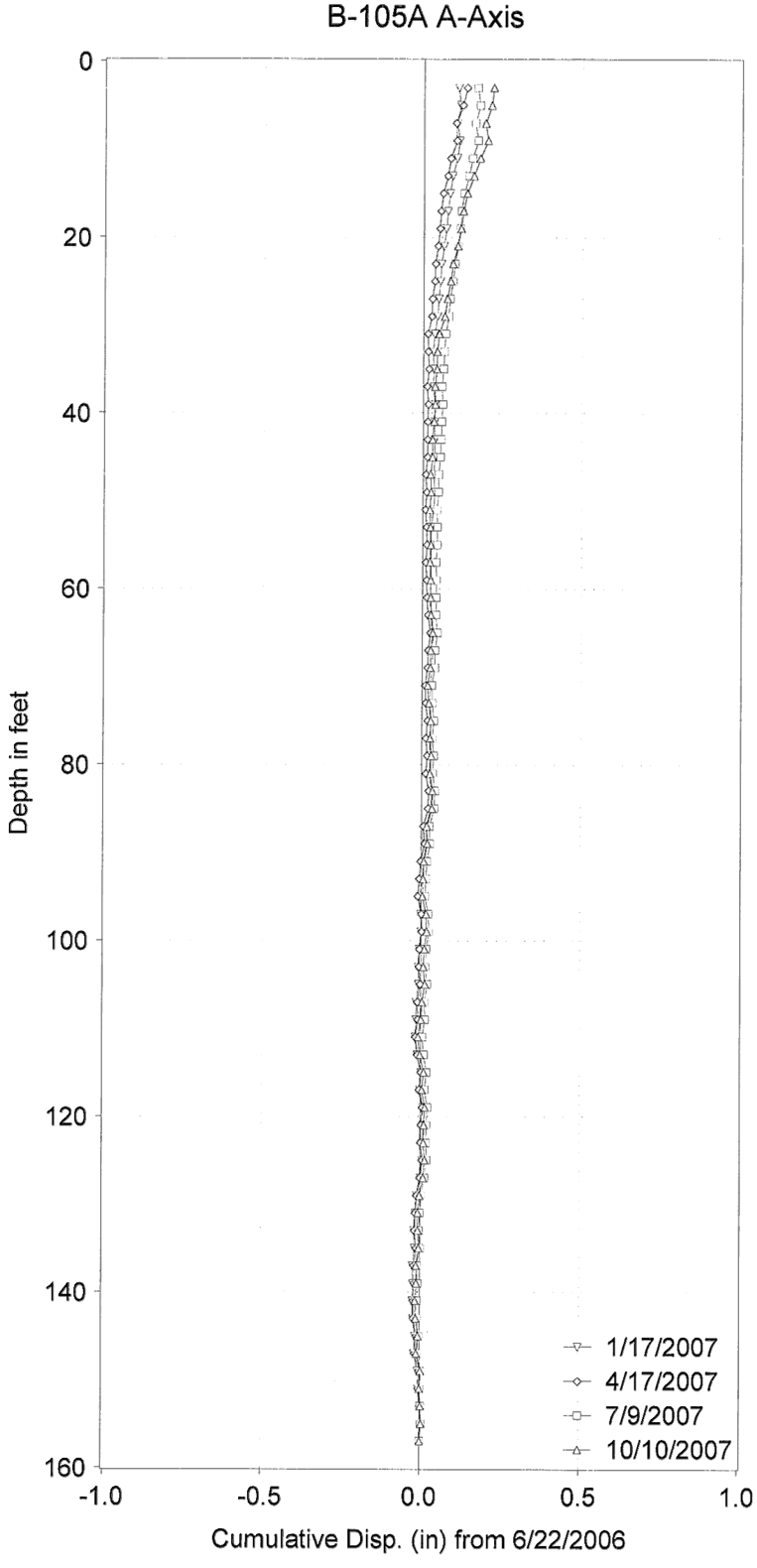
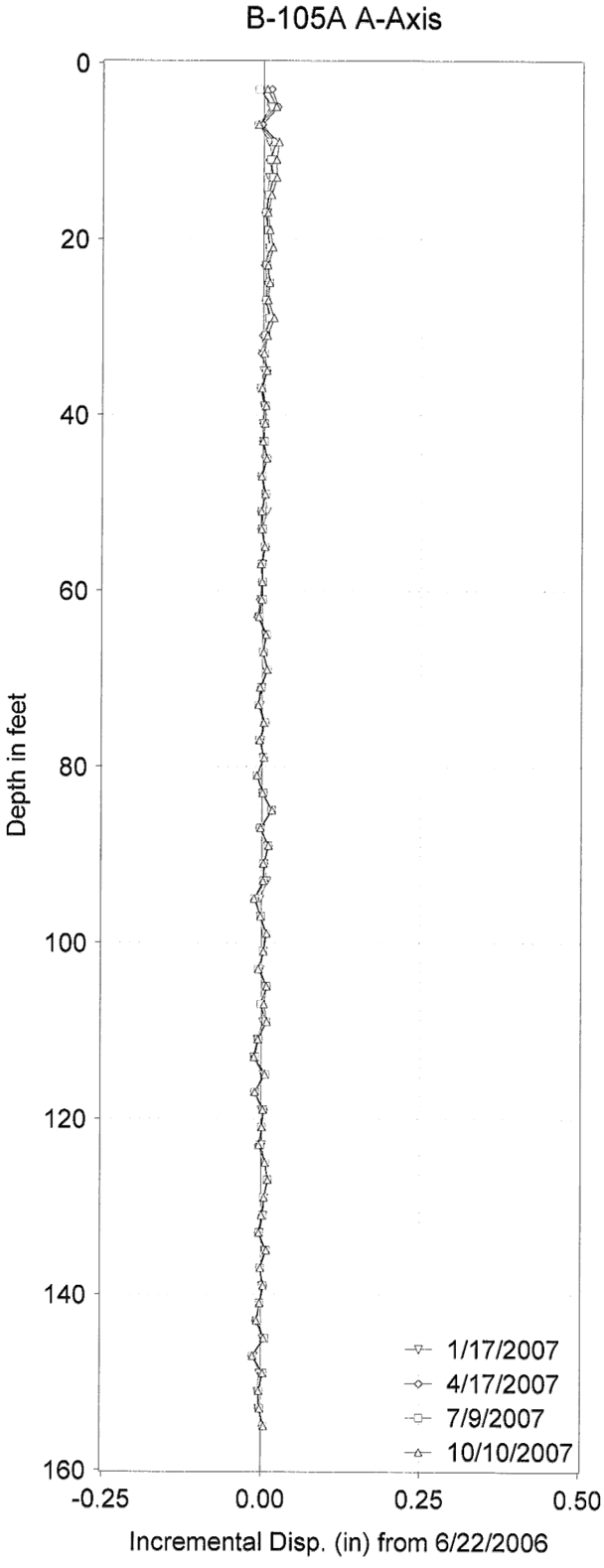

B-303 Time-Displacement A-Axis
47-51 feet
55-57 feet
95-99 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year

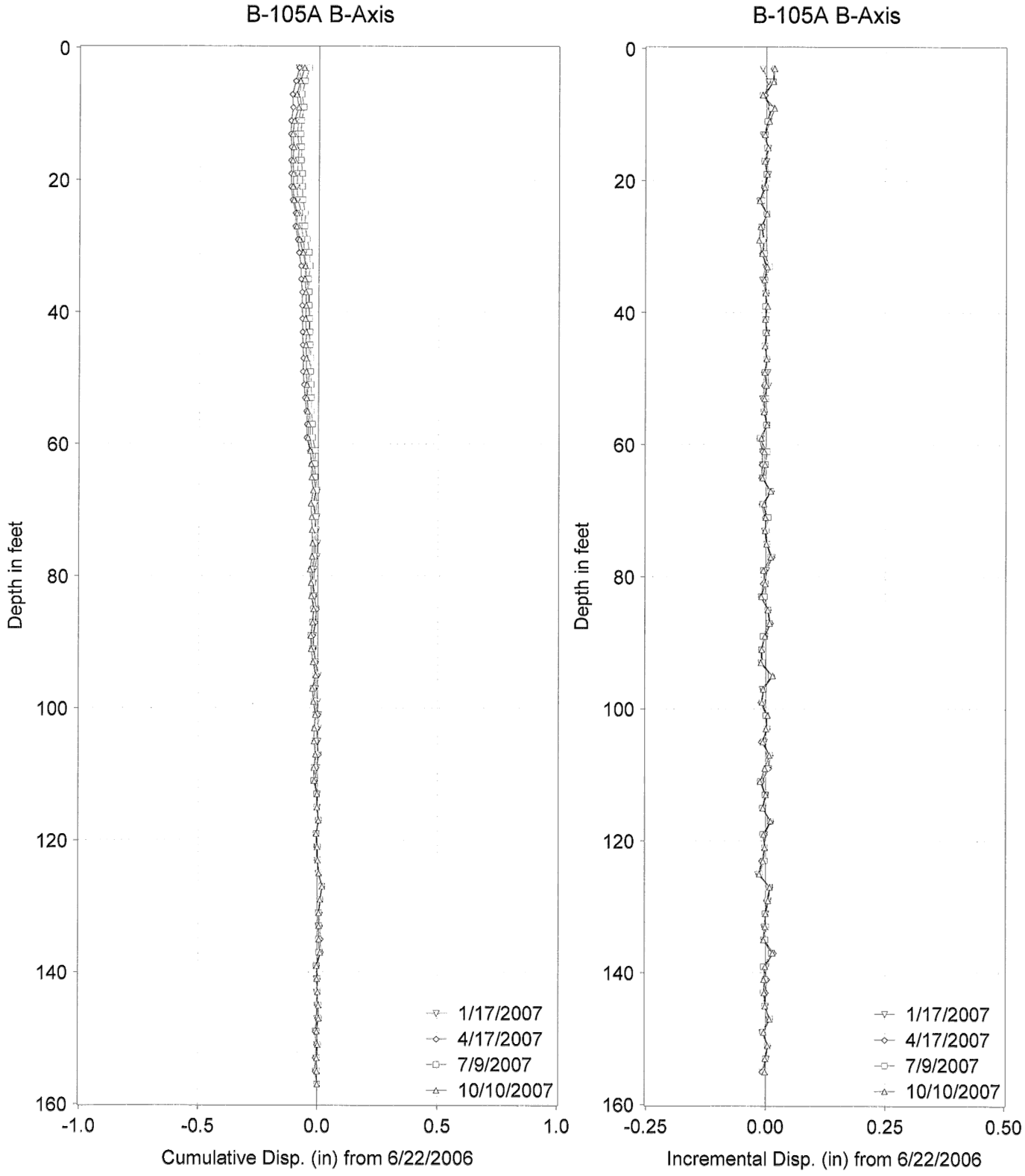
PLATE 21





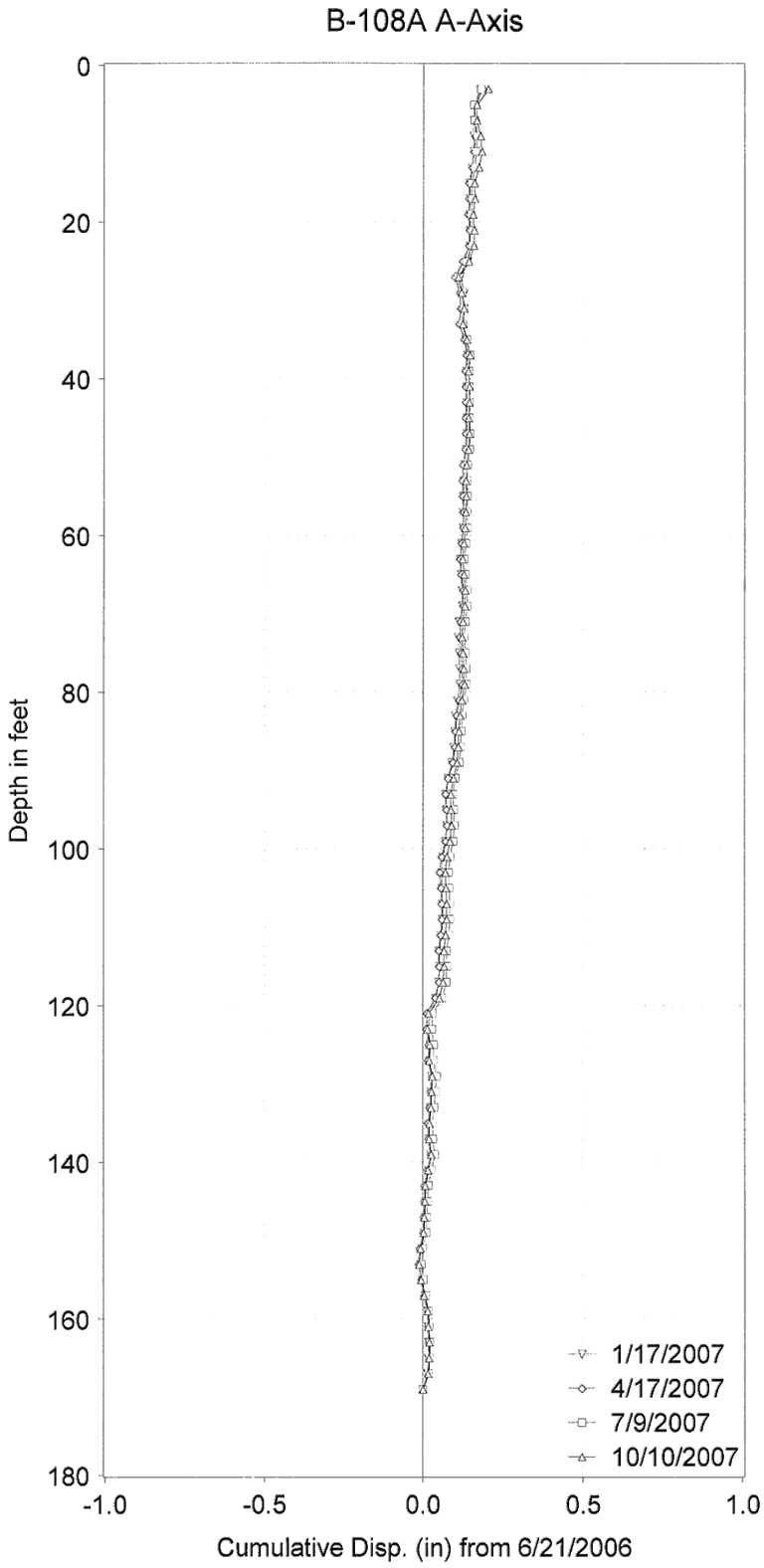
B-105A
-Includes readings from the last four quarters.

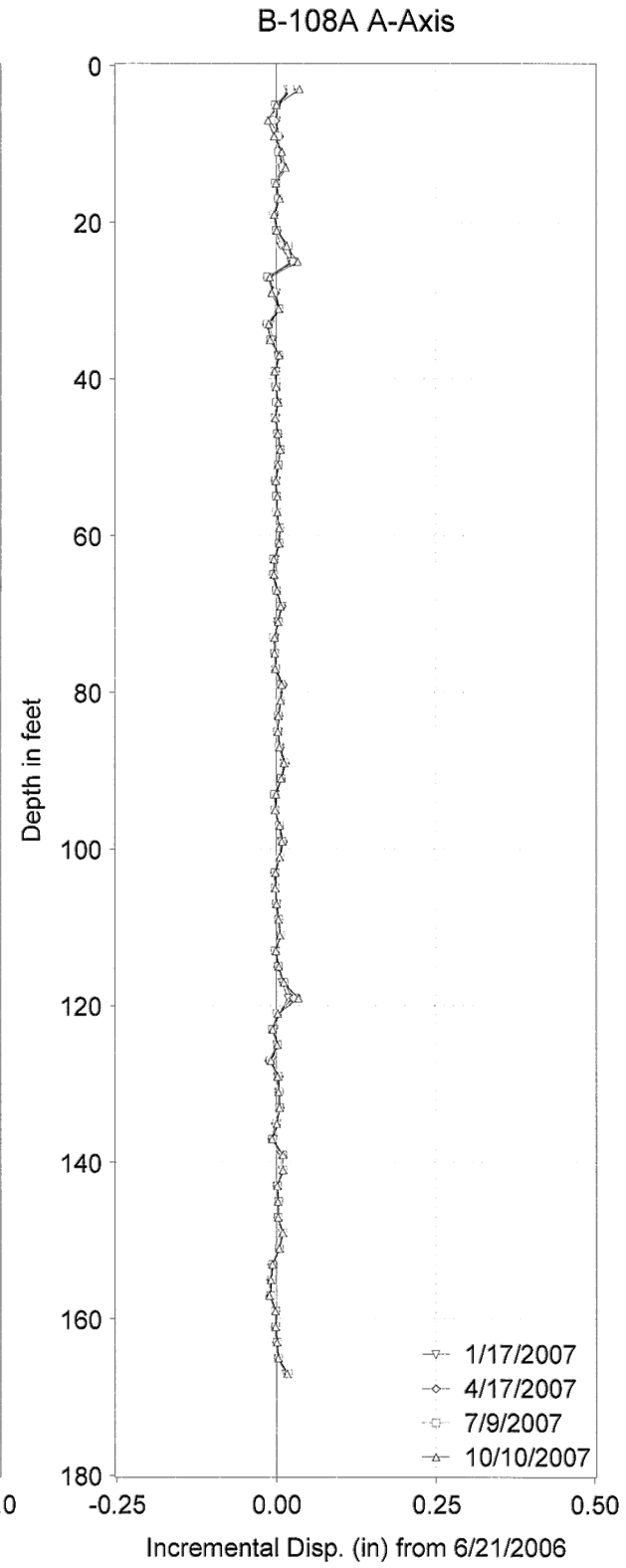
PLATE 22



B-105A
-Includes readings from the last four quarters.

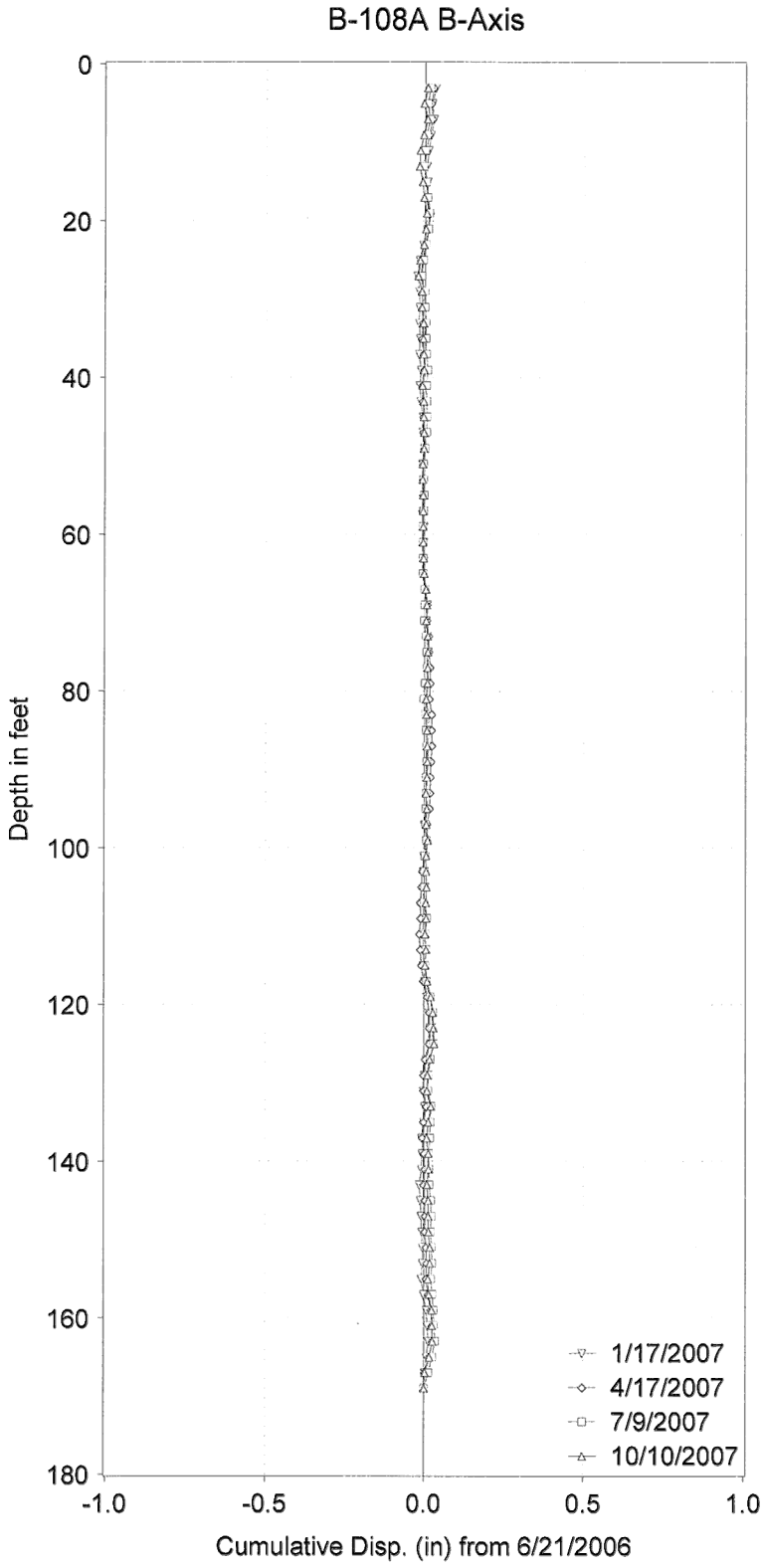
PLATE 23

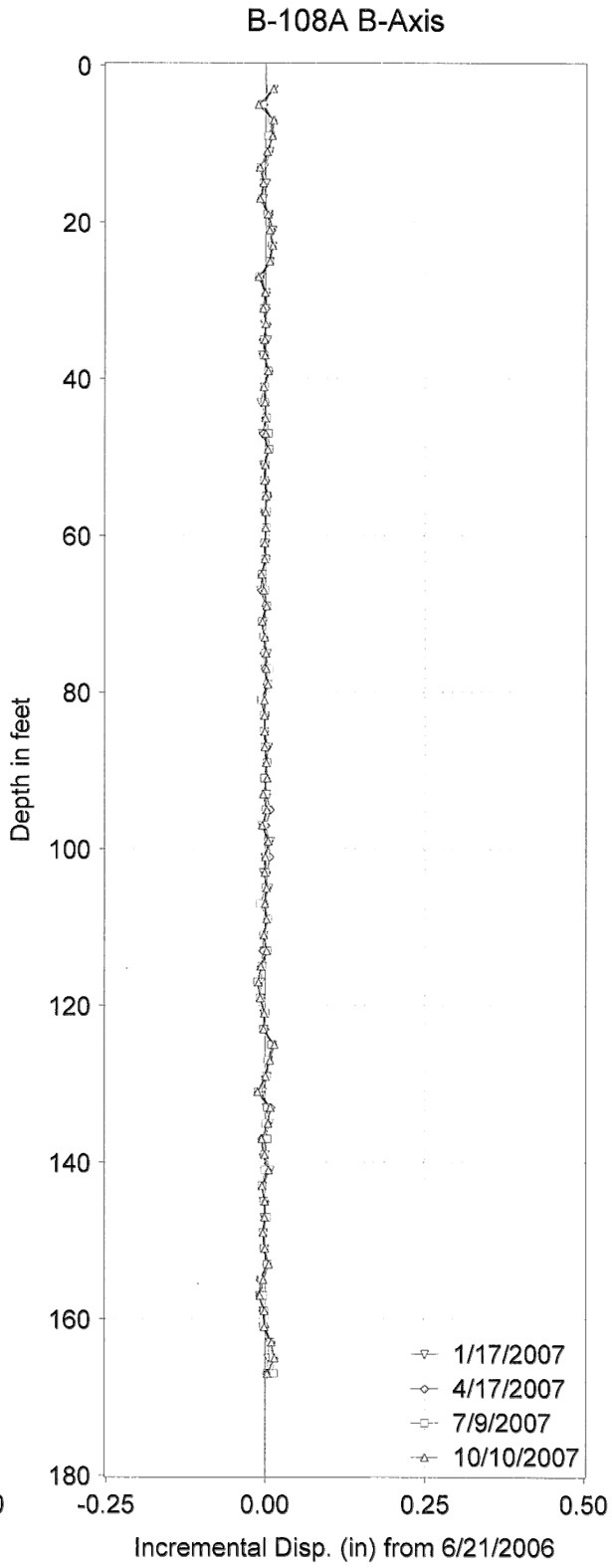




B-108A
-Includes readings from the last four quarters.

PLATE 24





B-108A
-Includes readings from the last four quarters.

PLATE 25

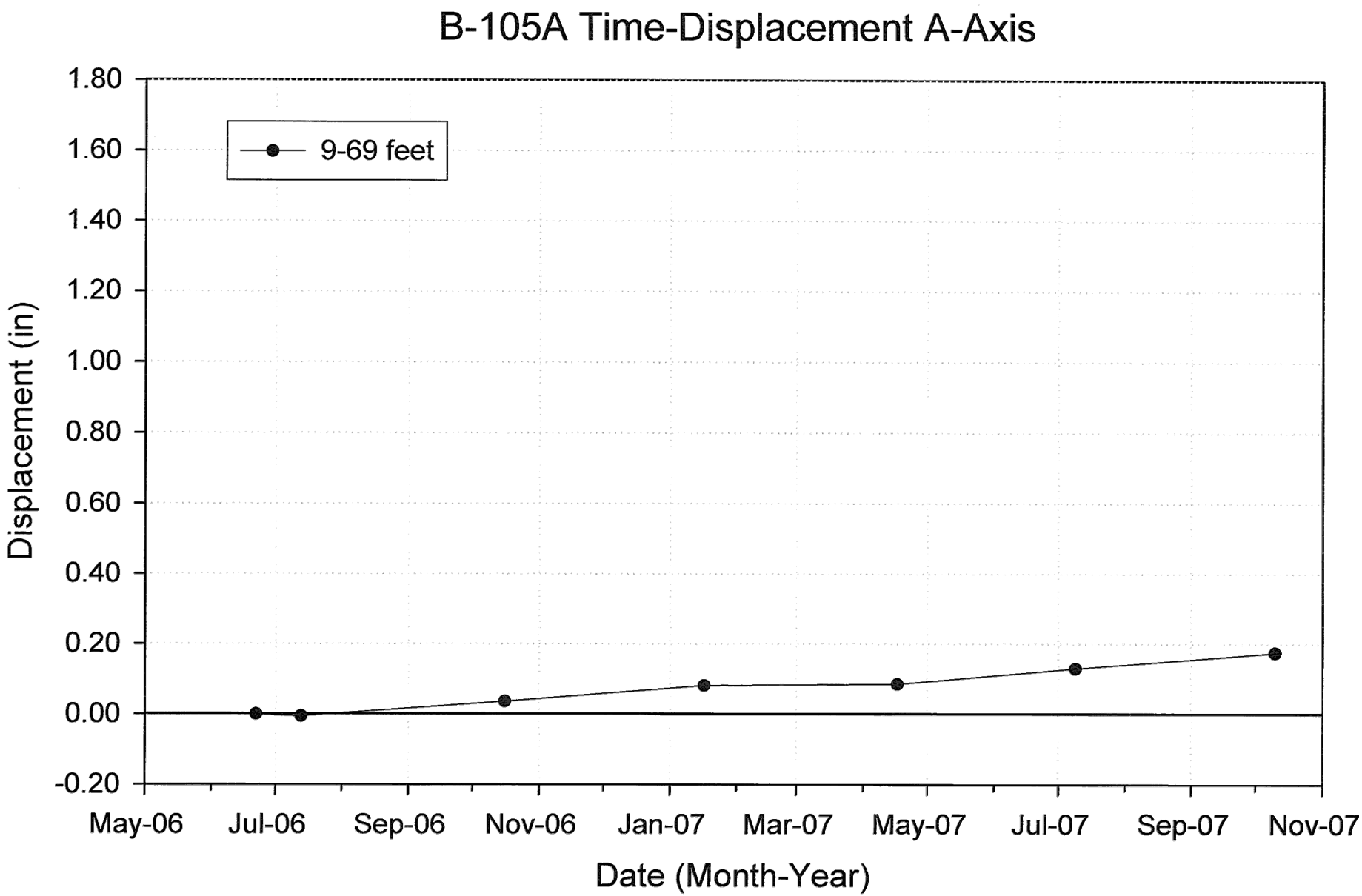

B-105A Time-Displacement A-Axis
9-69 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Jul-06
Sep-06
Nov-06
Jan-07
Mar-07
May-07
Jul-07
Sep-07
Nov-07
Date (Month-Year)

PLATE 26

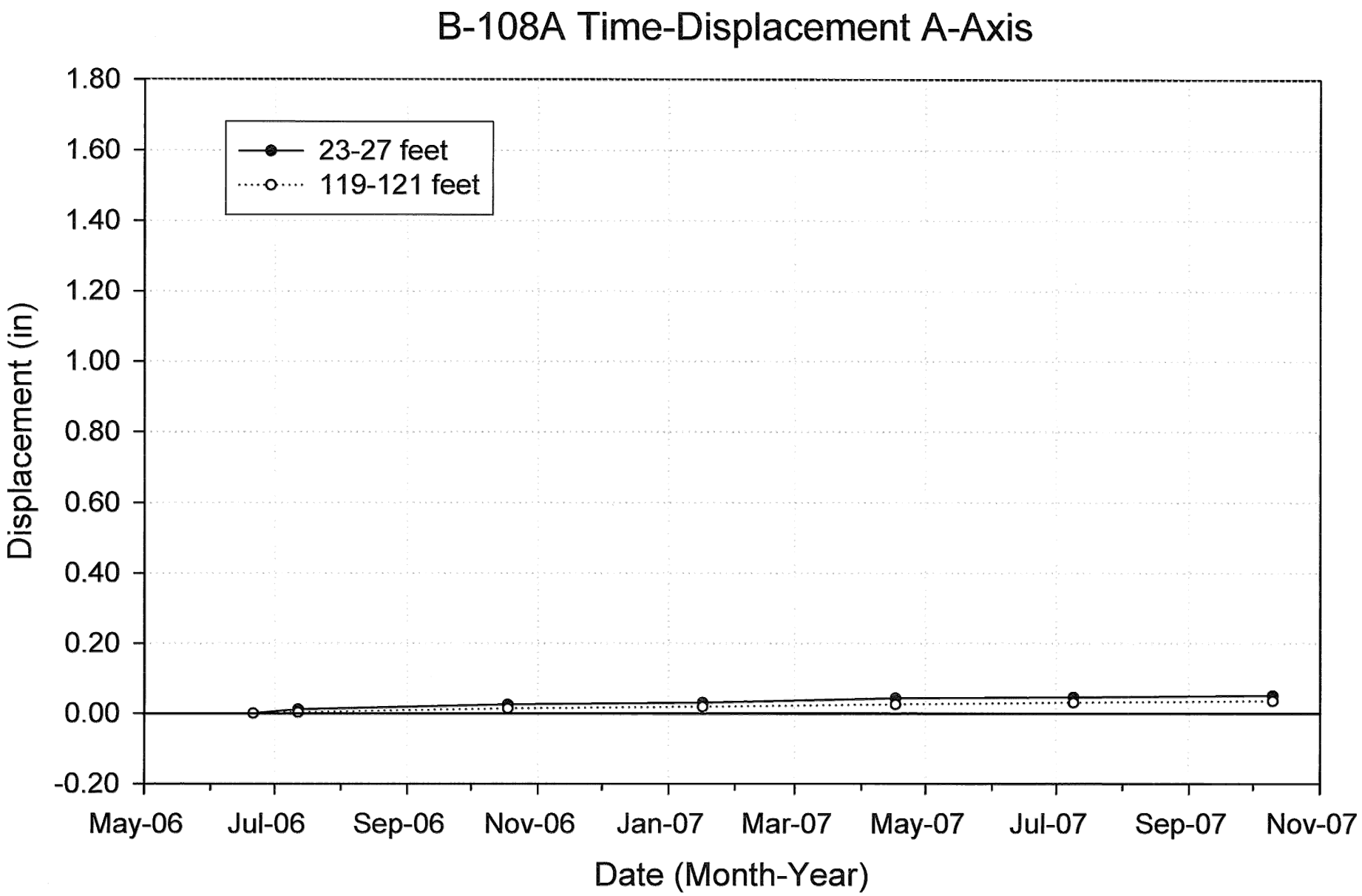
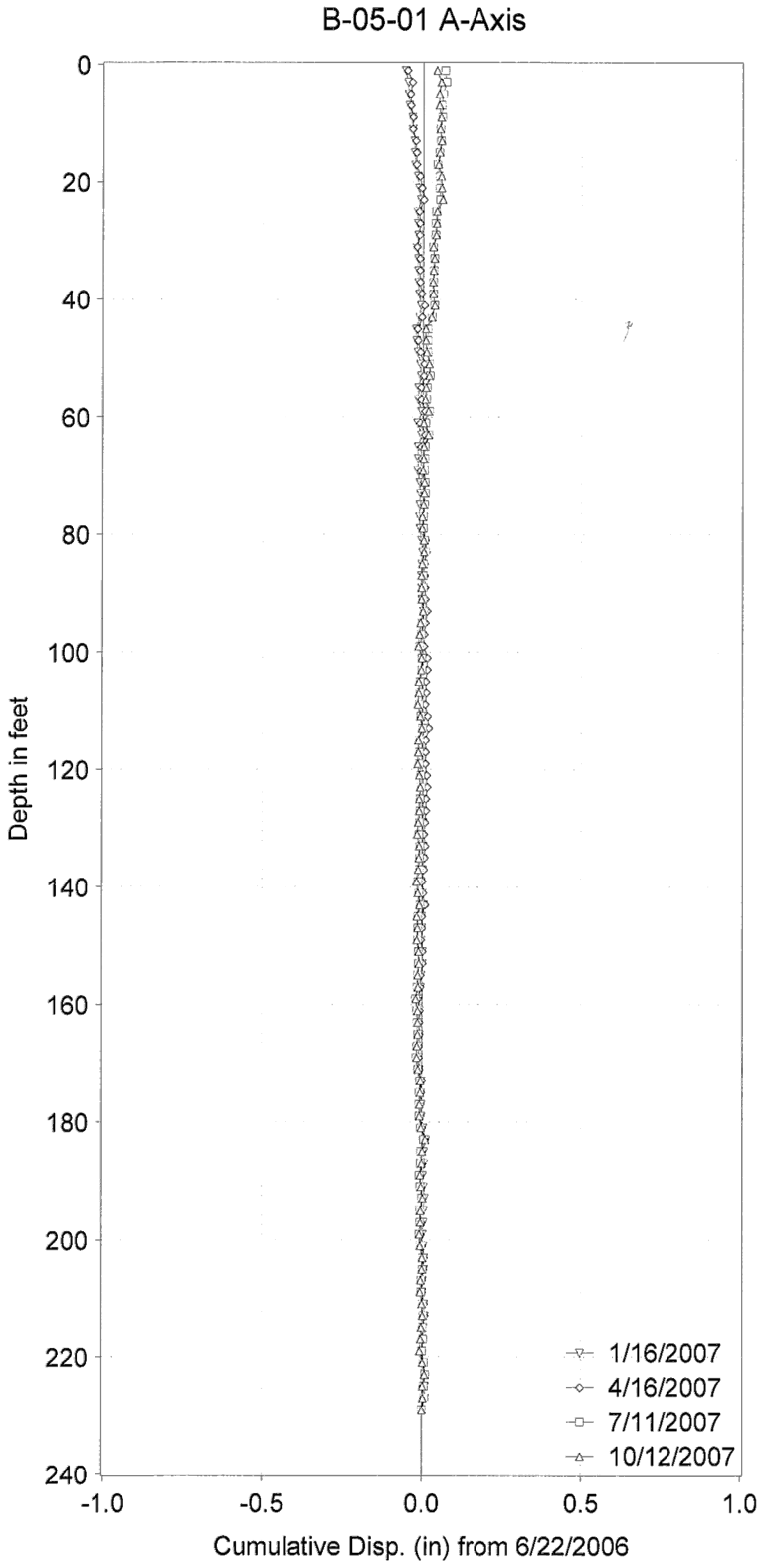
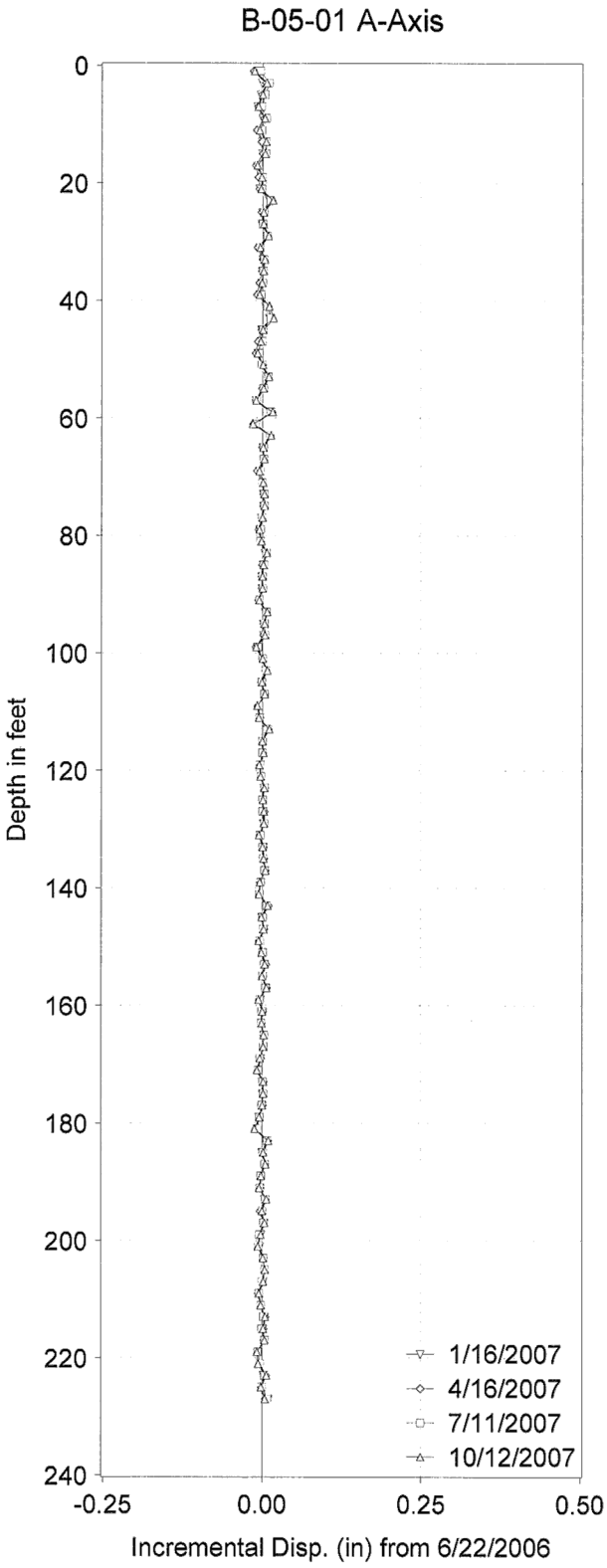

B-108A Time-Displacement A-Axis
23-27 feet
119-121 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Jul-06
Sep-06
Nov-06
Jan-07
Mar-07
May-07
Jul-07
Sep-07
Nov-07
Date (Month-Year)

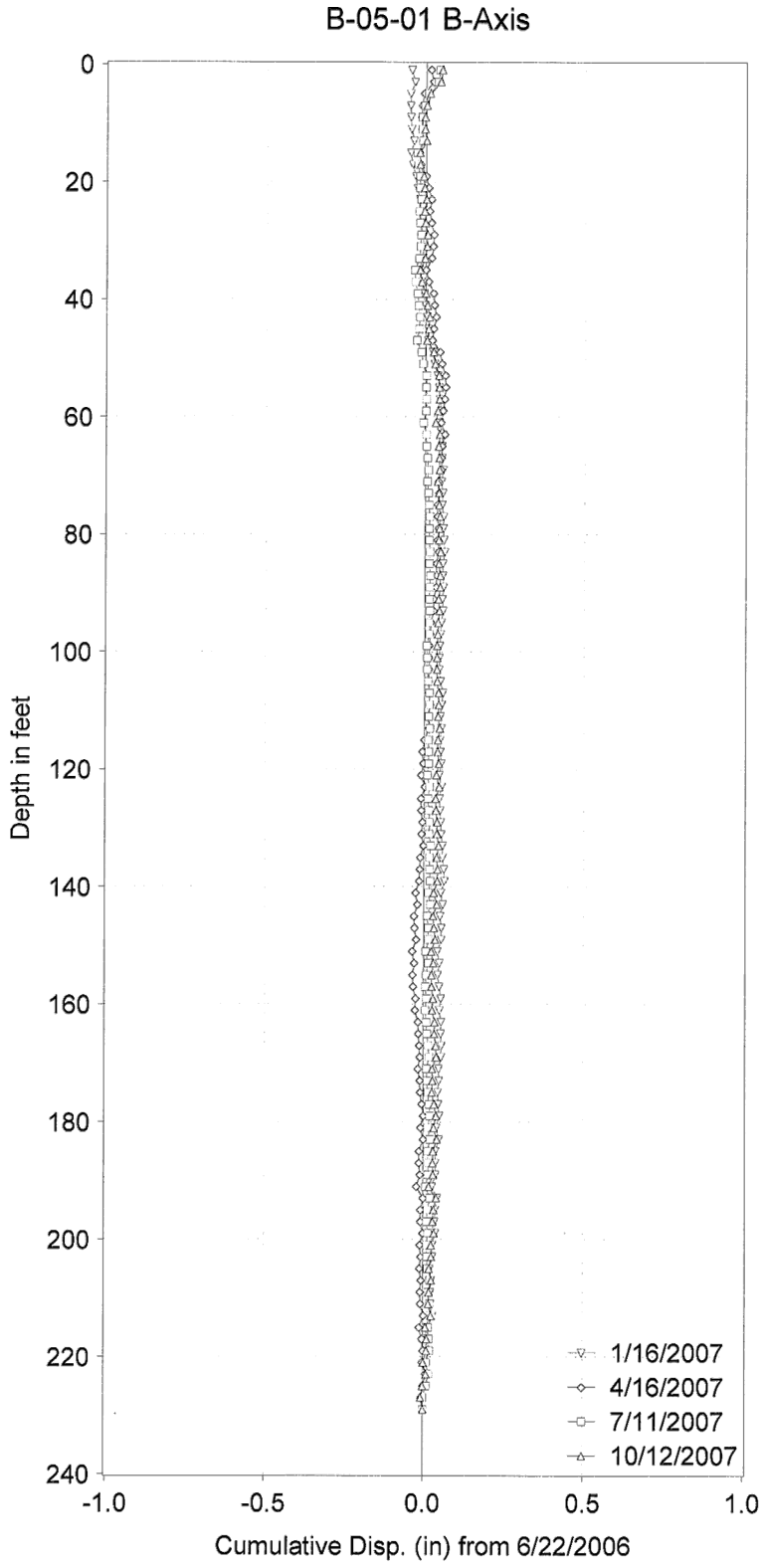
PLATE 27

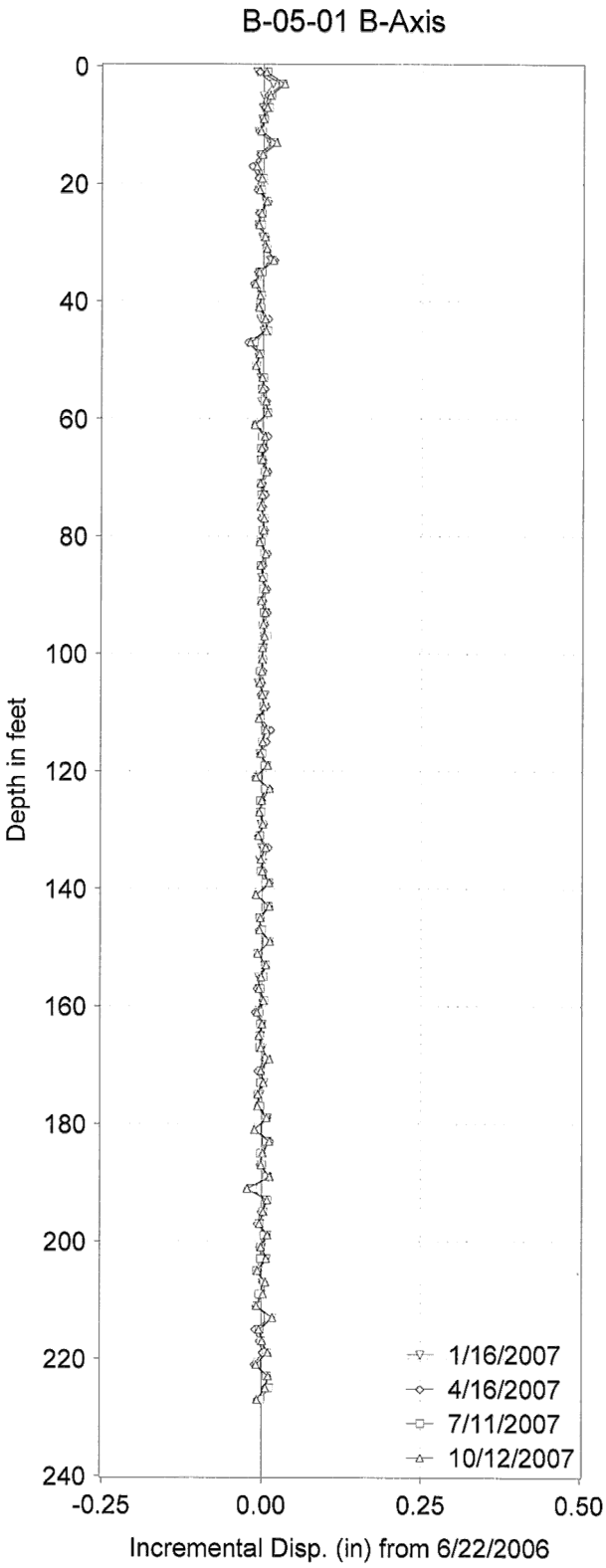




B-05-01
-Includes readings from the last four quarters.

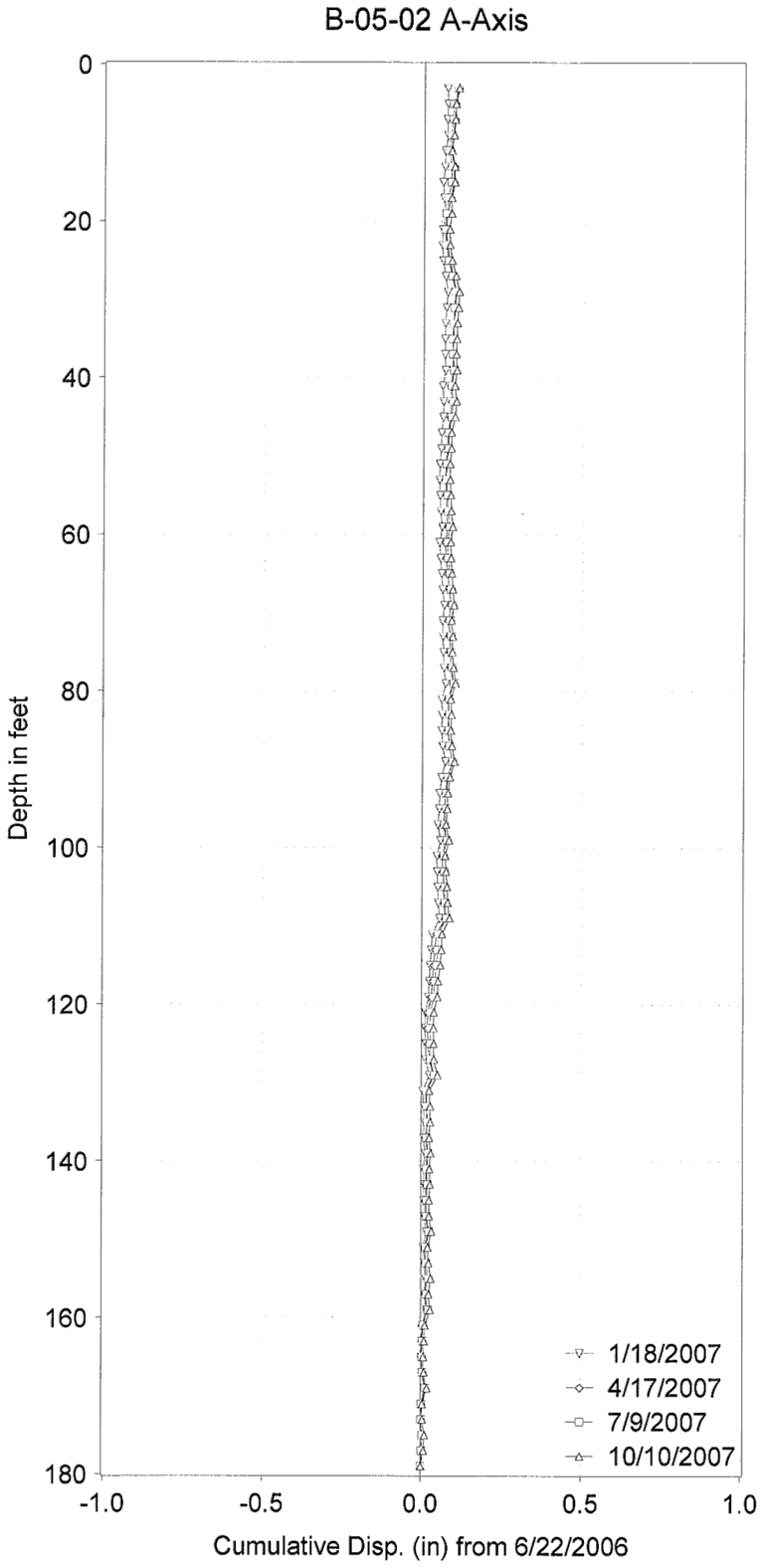
PLATE 28

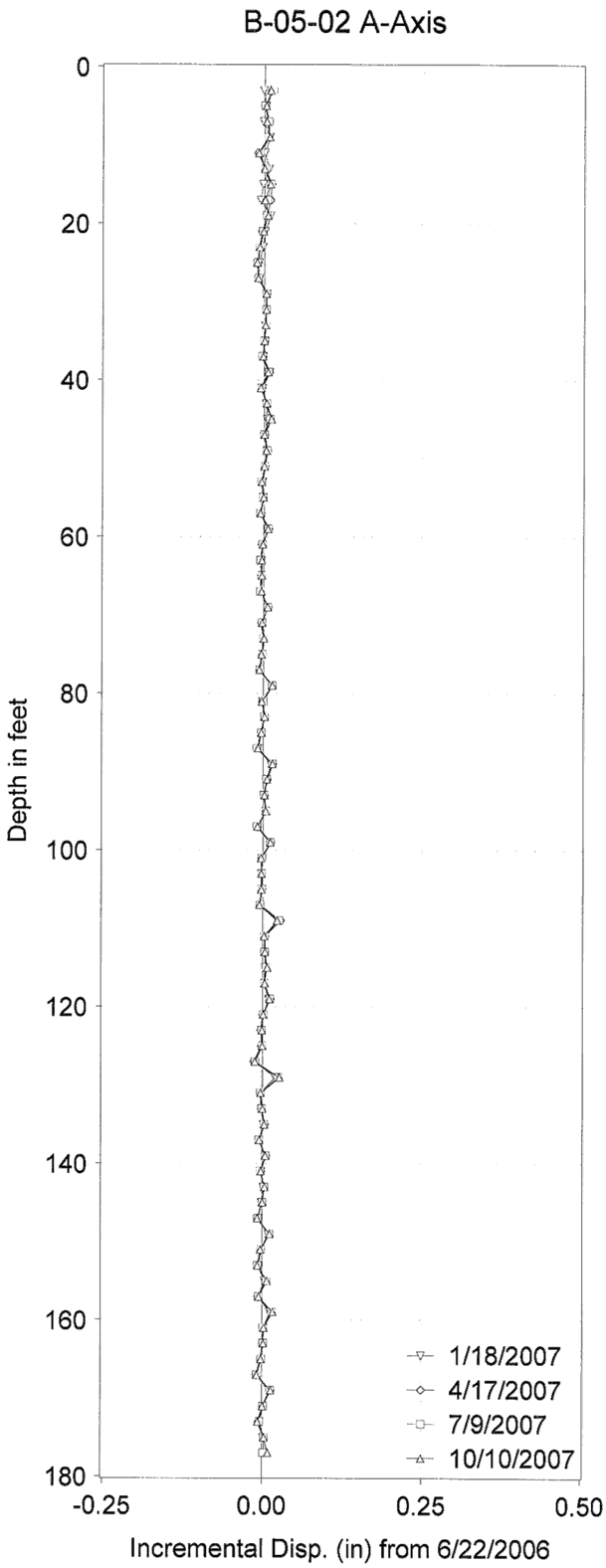




B-05-01
-Includes readings from the last four quarters.

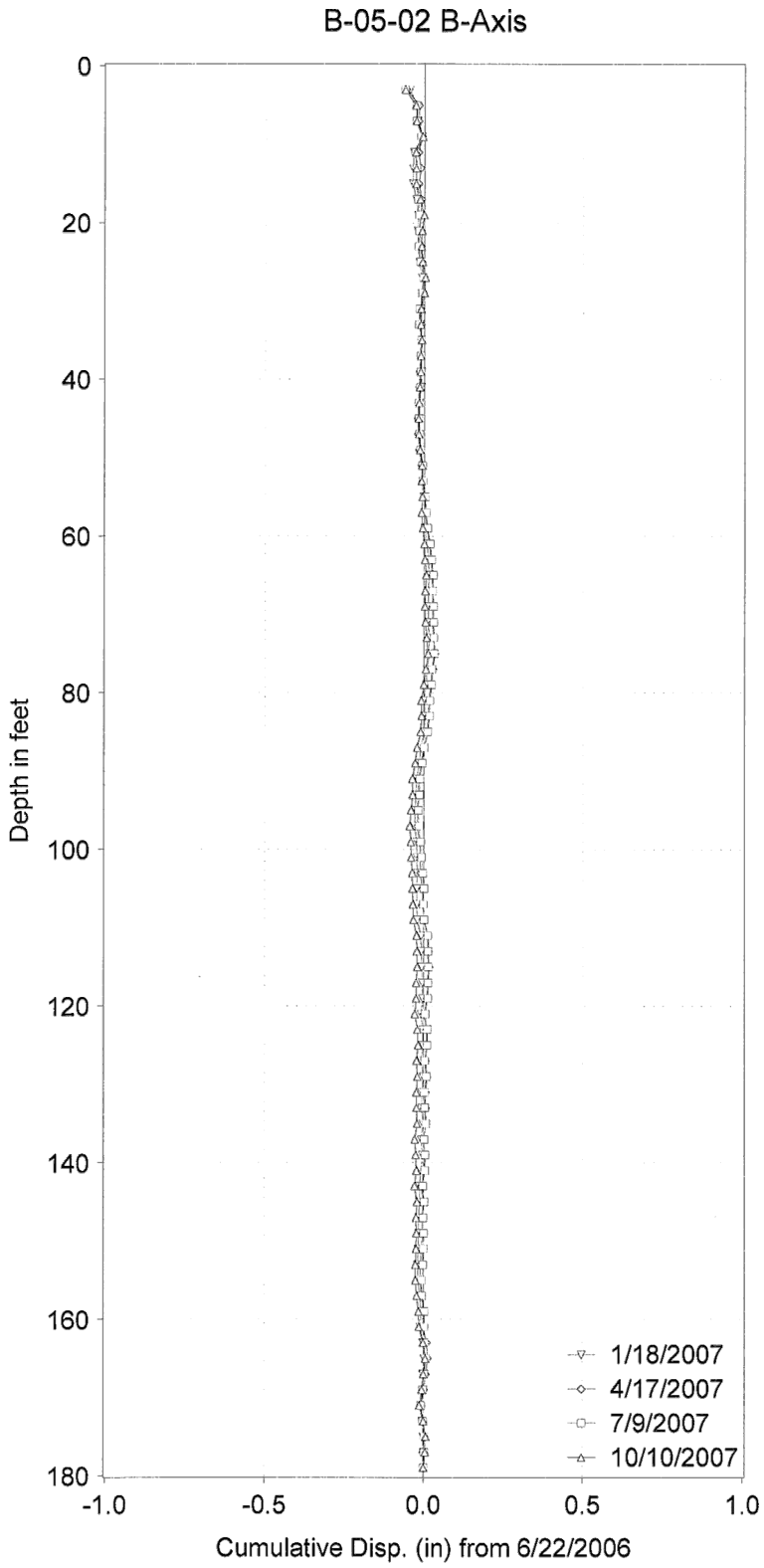
PLATE 29

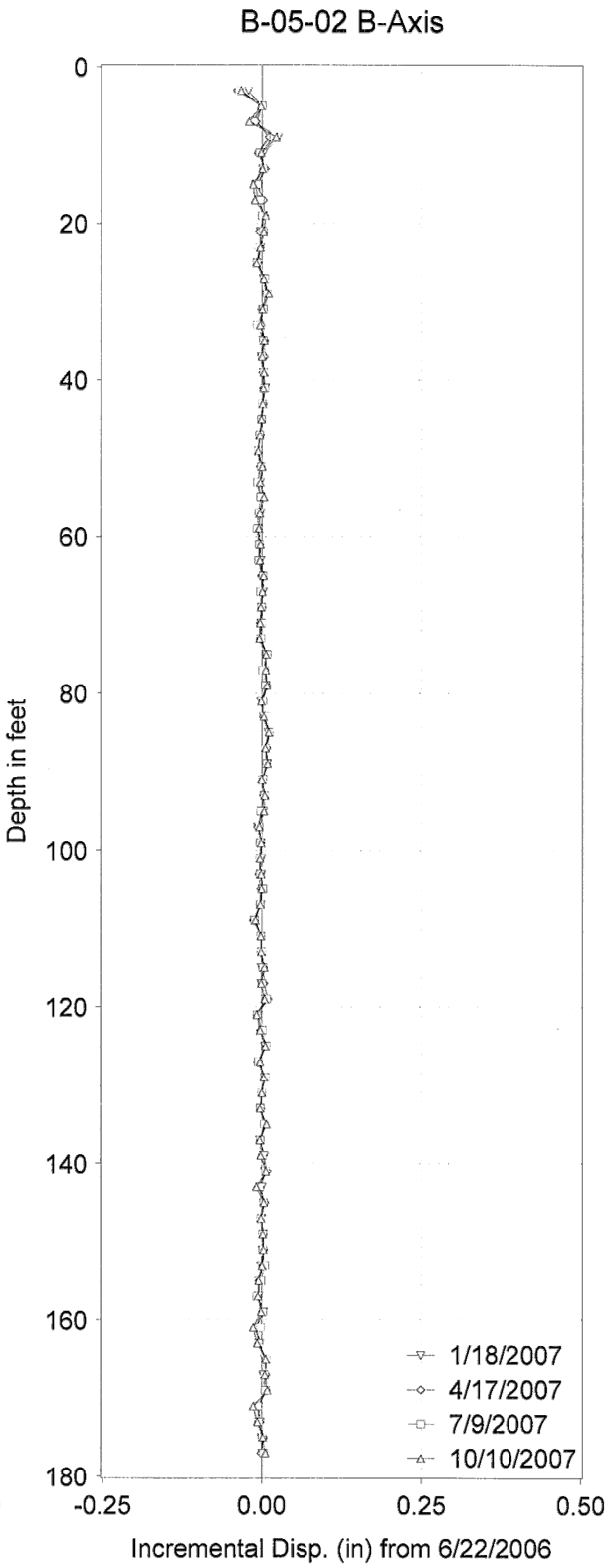




B-05-02
-Includes readings from the last four quarters.

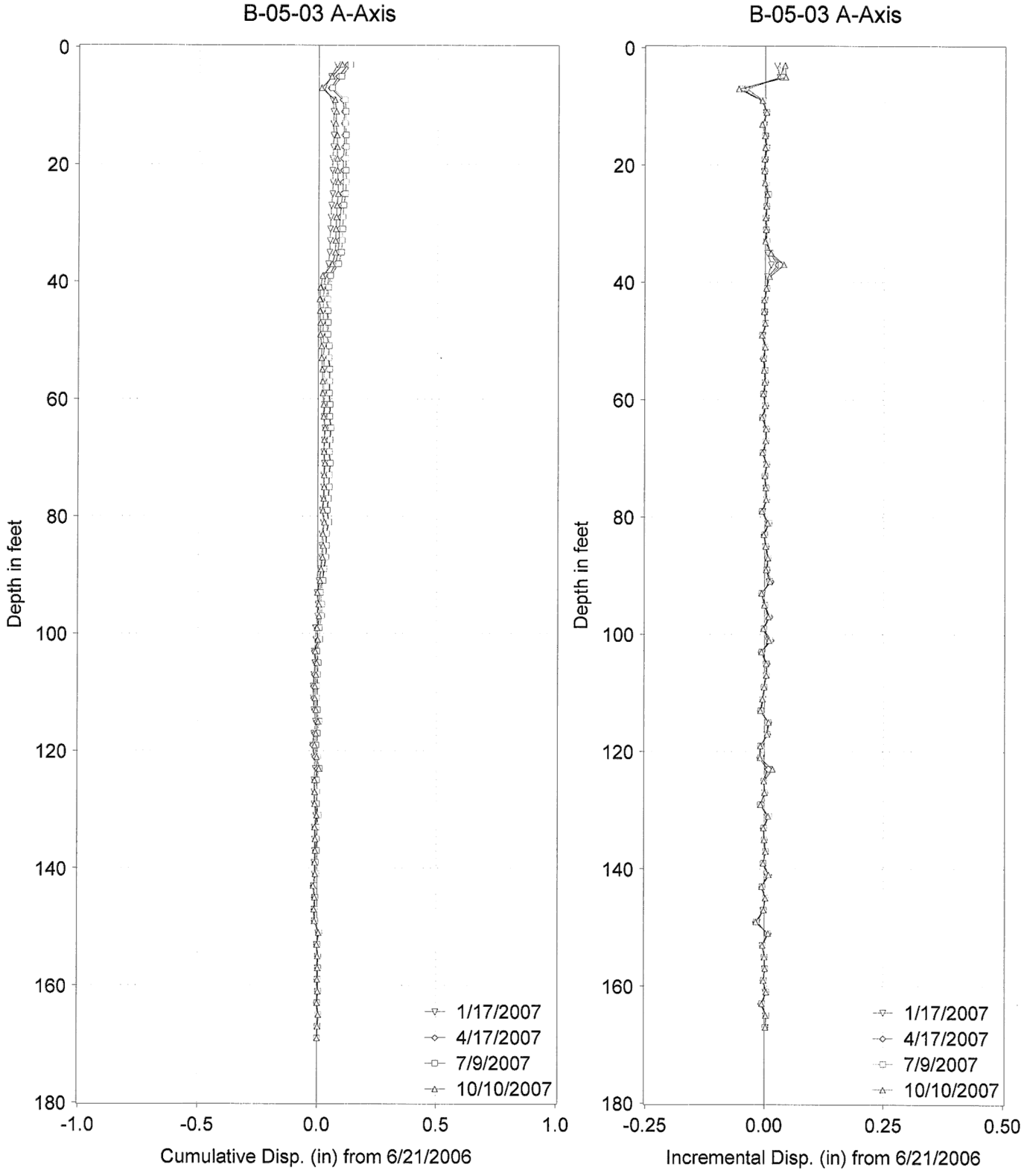
PLATE 30





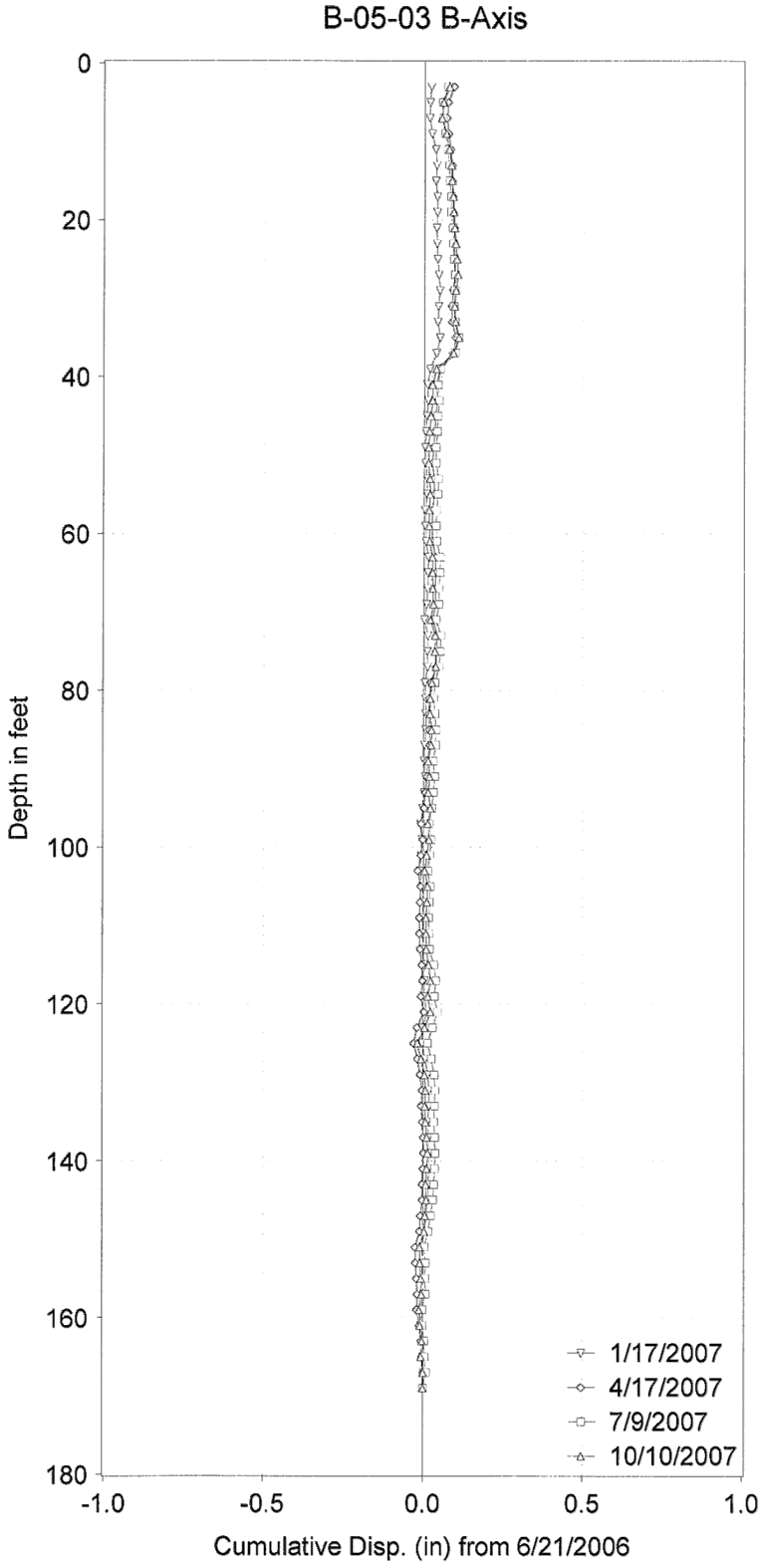
B-05-02
-Includes readings from the last four quarters.

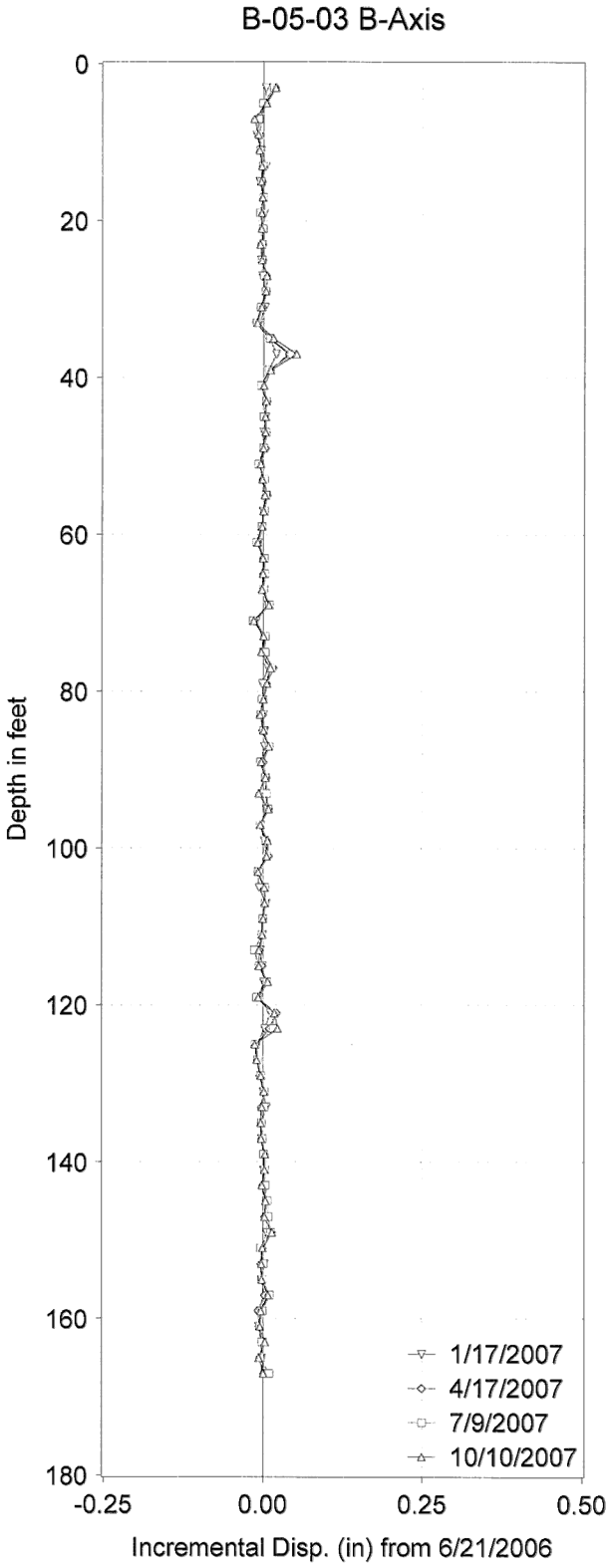
PLATE 31



B-05-03
-Includes readings from the last four quarters.

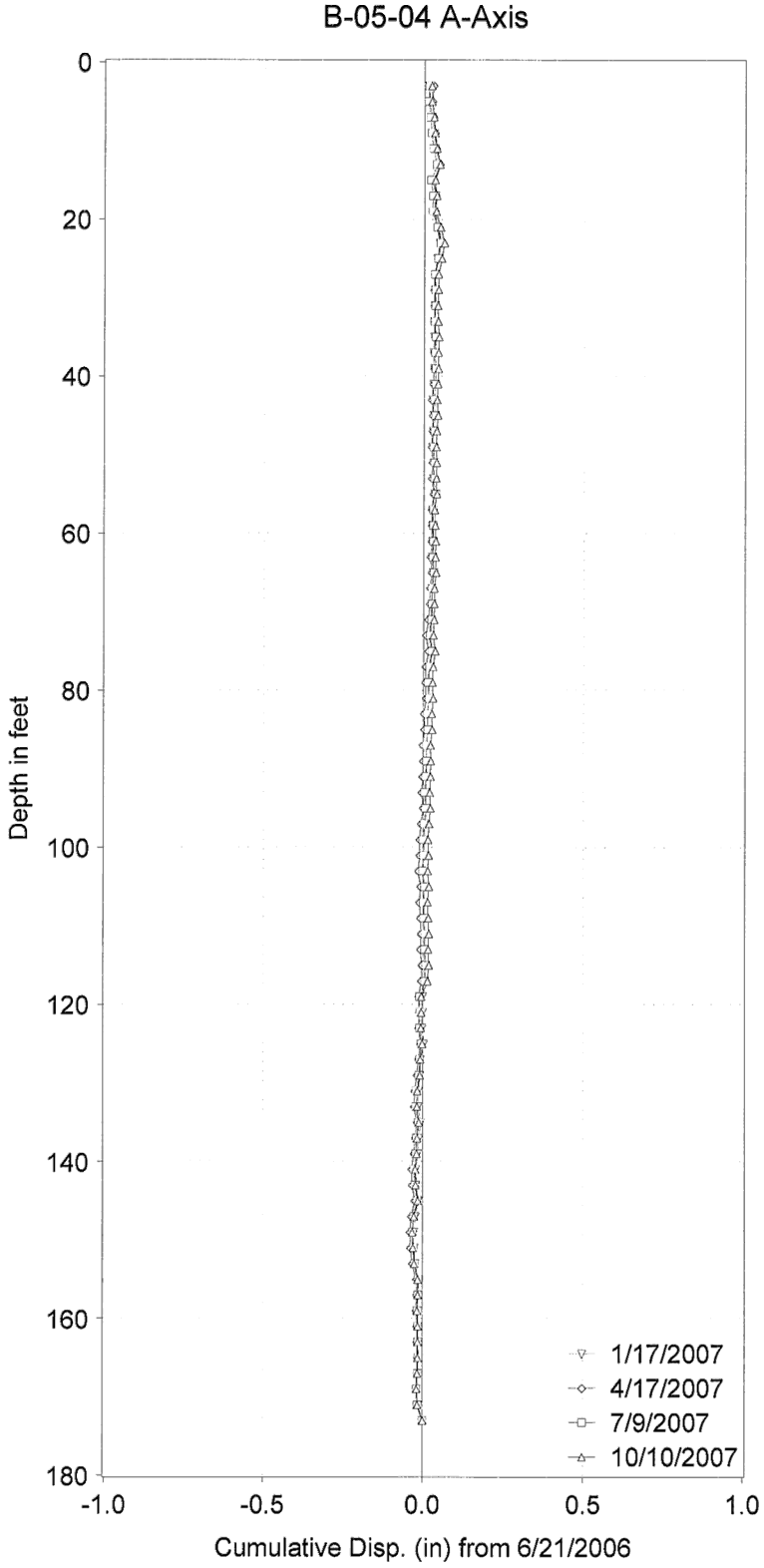
PLATE 32

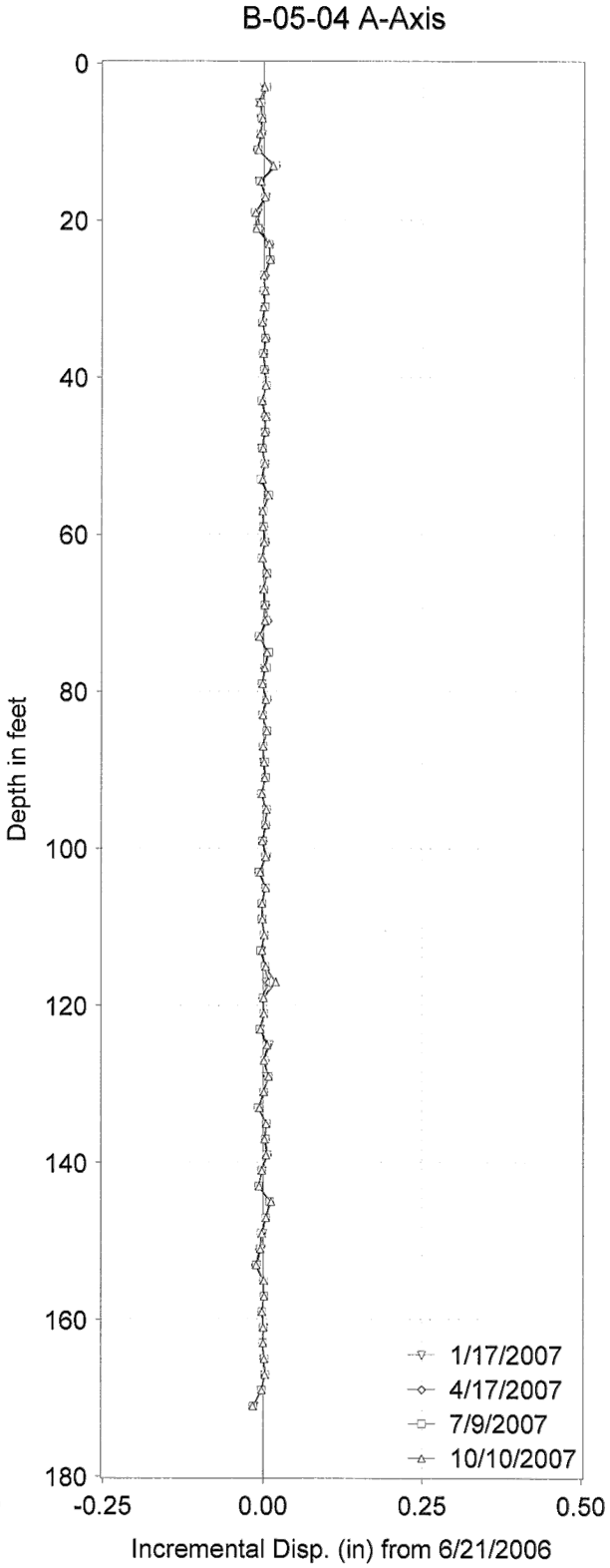




B-05-03
-Includes readings from the last four quarters.

PLATE 33

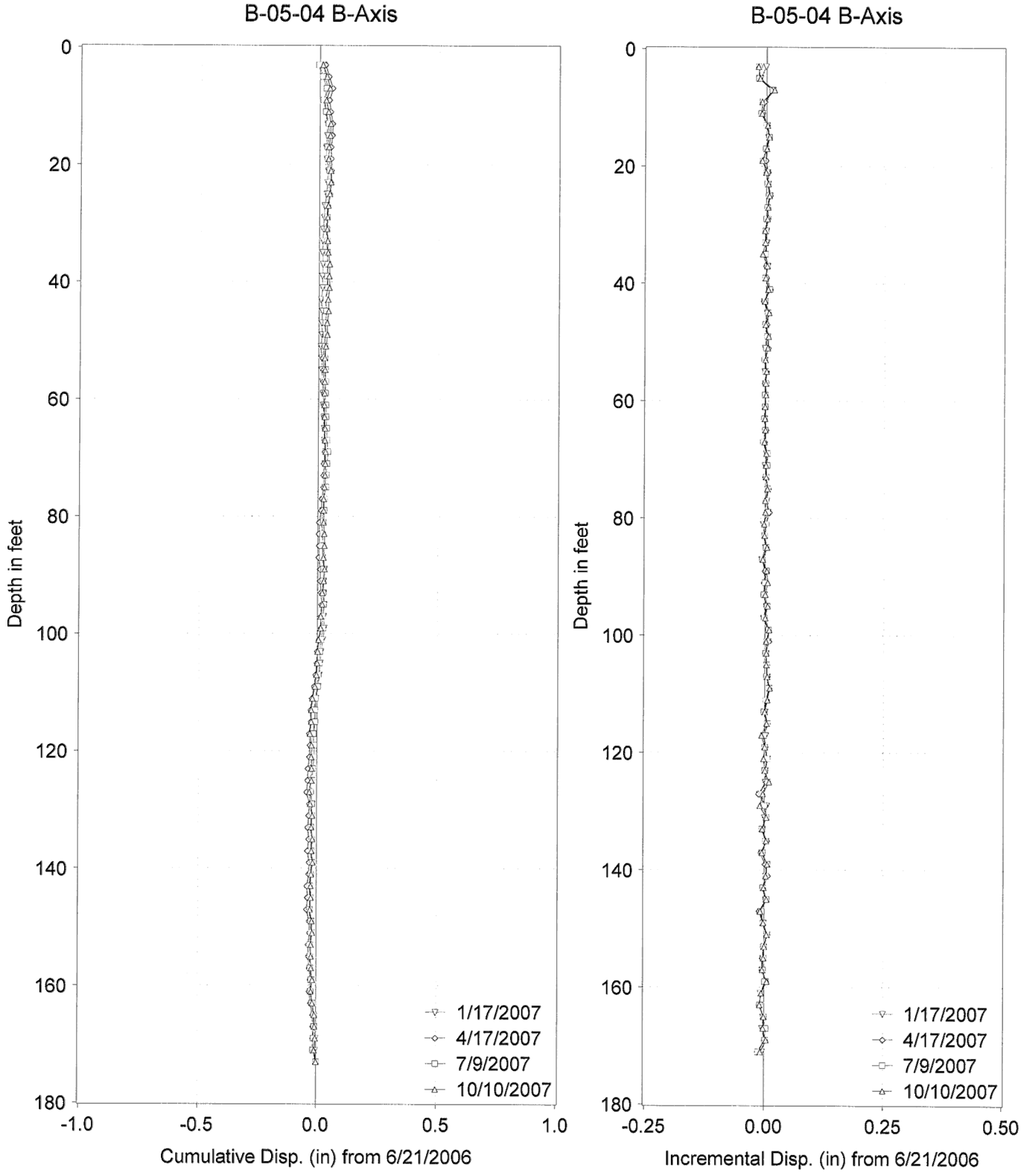




B-05-04

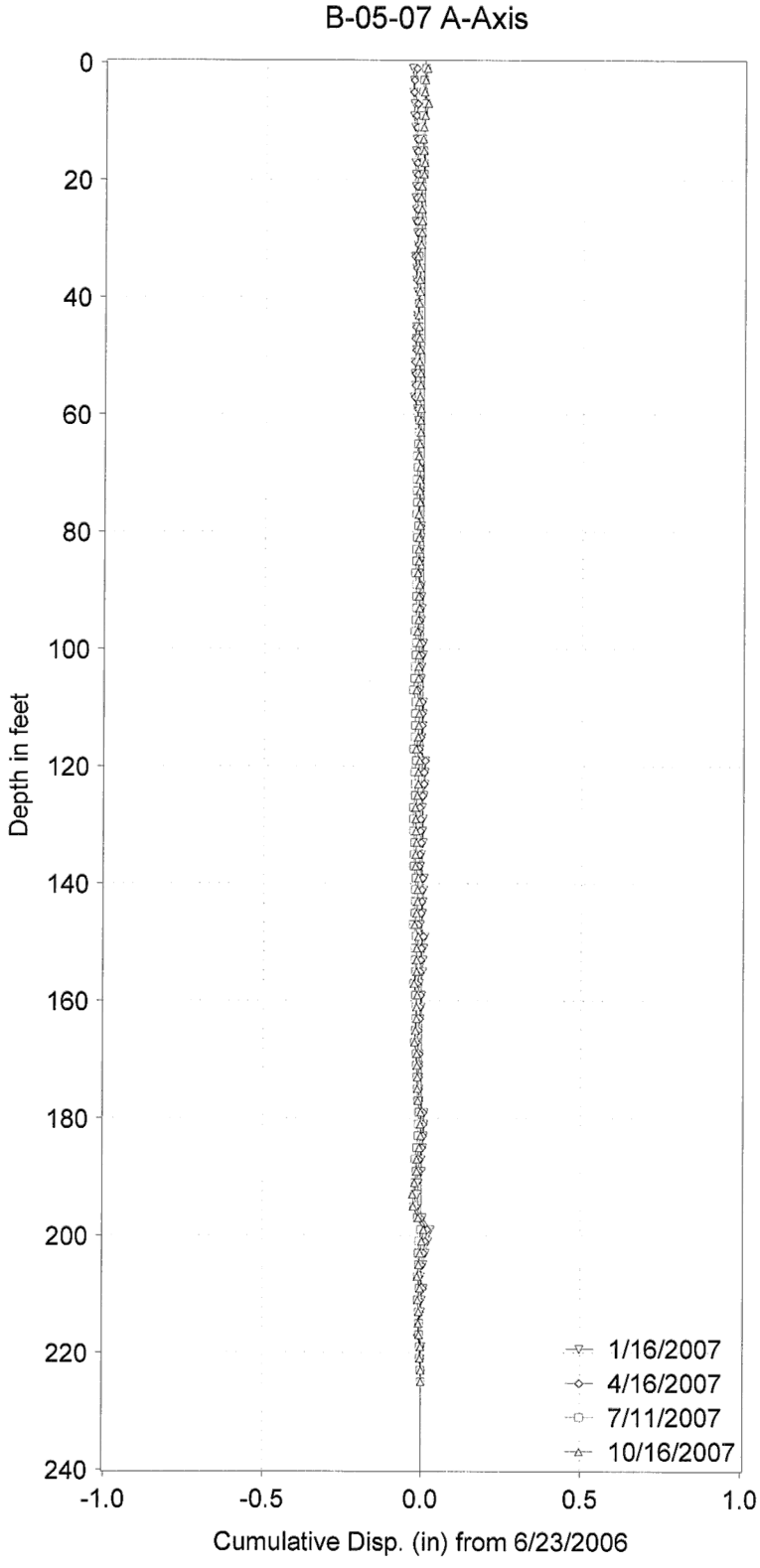
-Includes readings from the last four quarters.

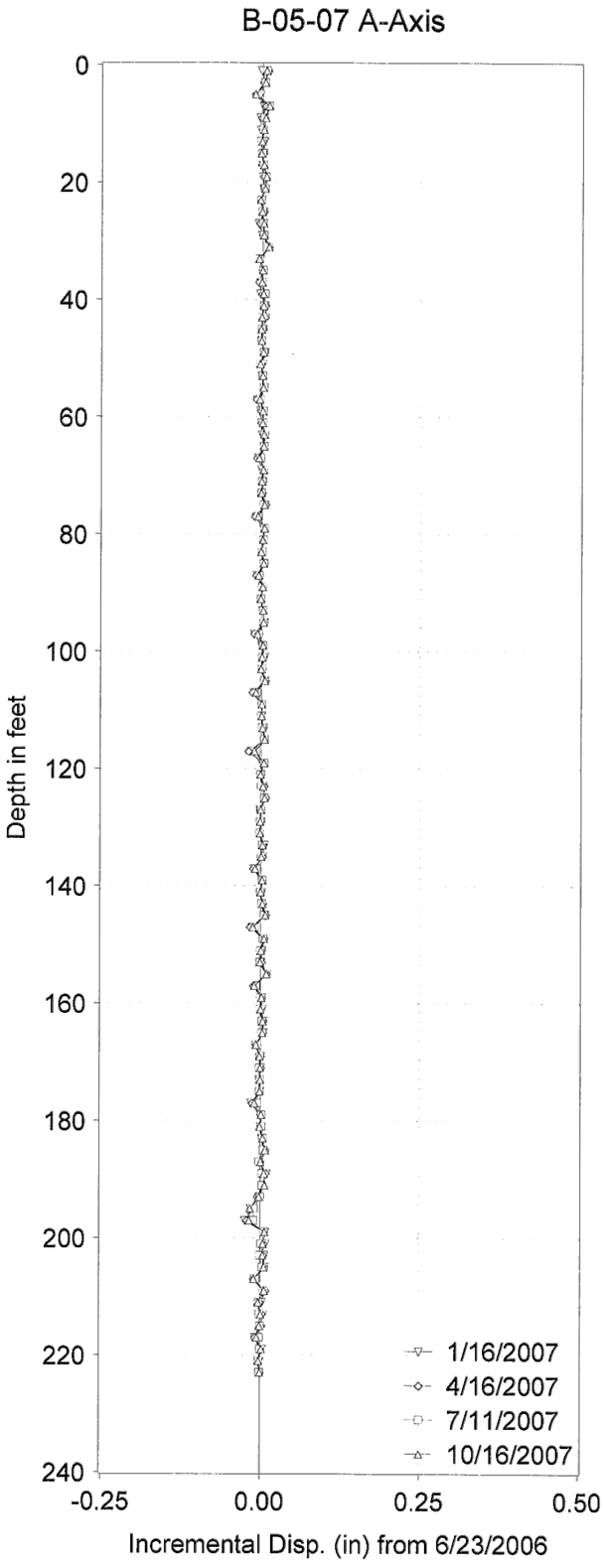
PLATE 34



B-05-04
-Includes readings from the last four quarters.

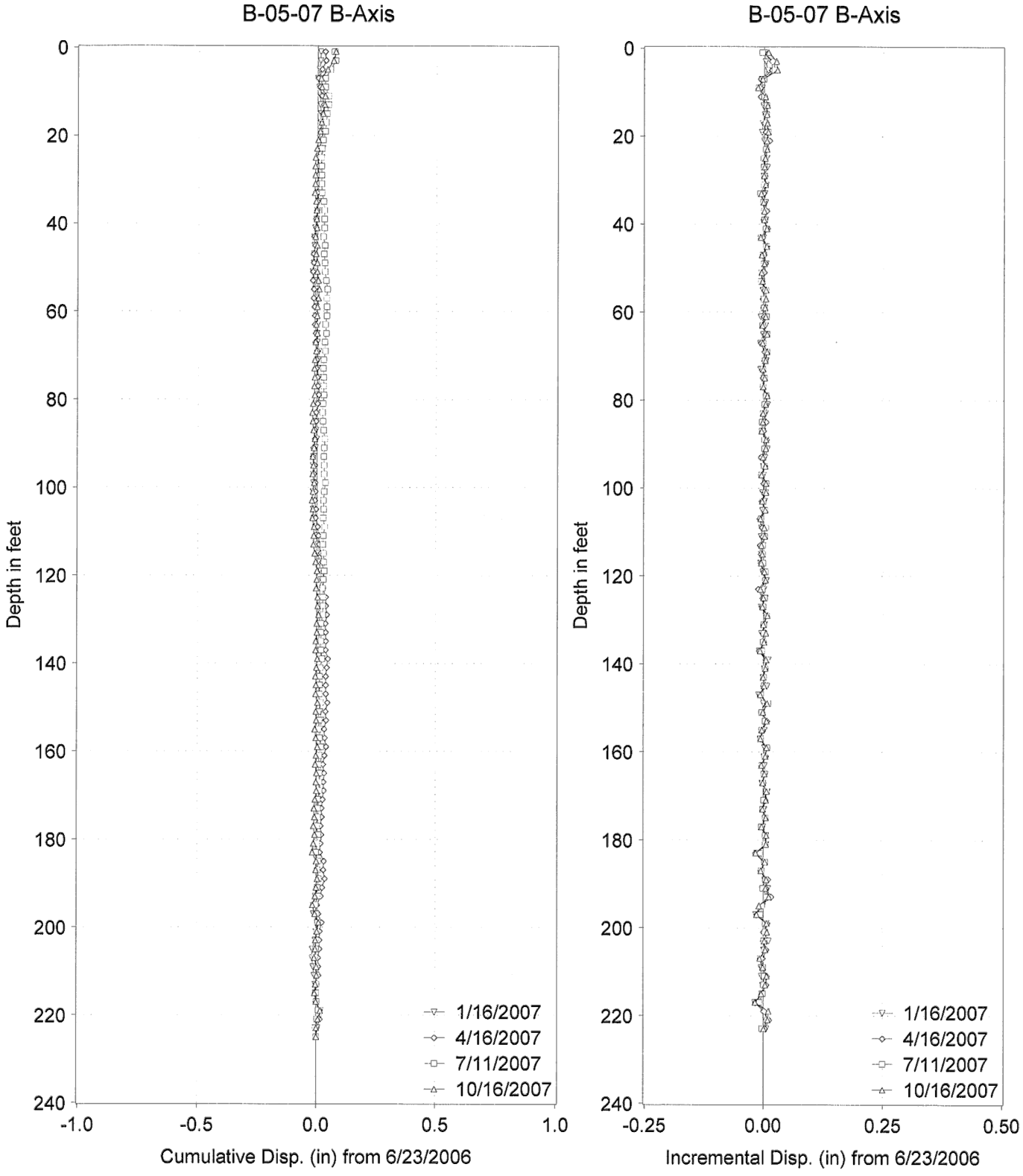
PLATE 35





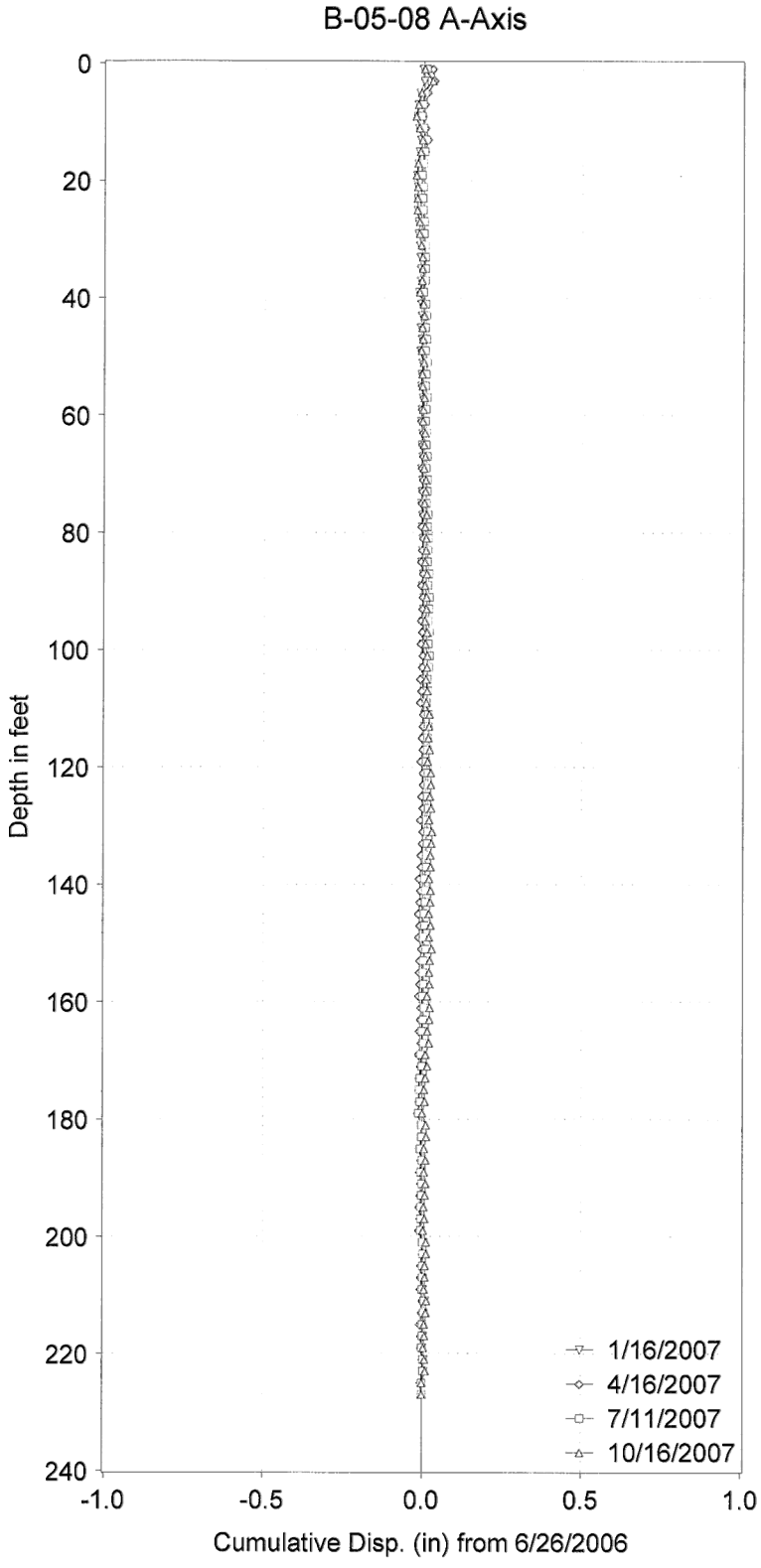
B-05-07
-Includes readings from the last four quarters.

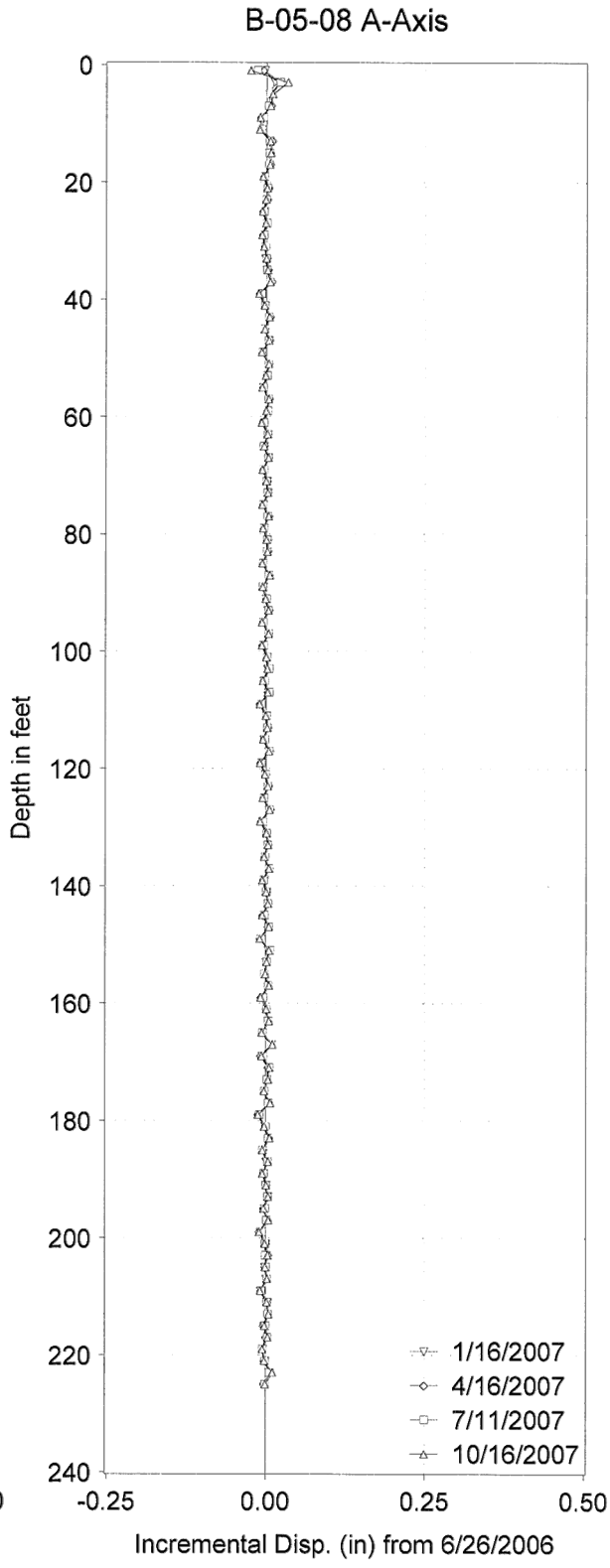
PLATE 36



B-05-07
-Includes readings from the last four quarters.

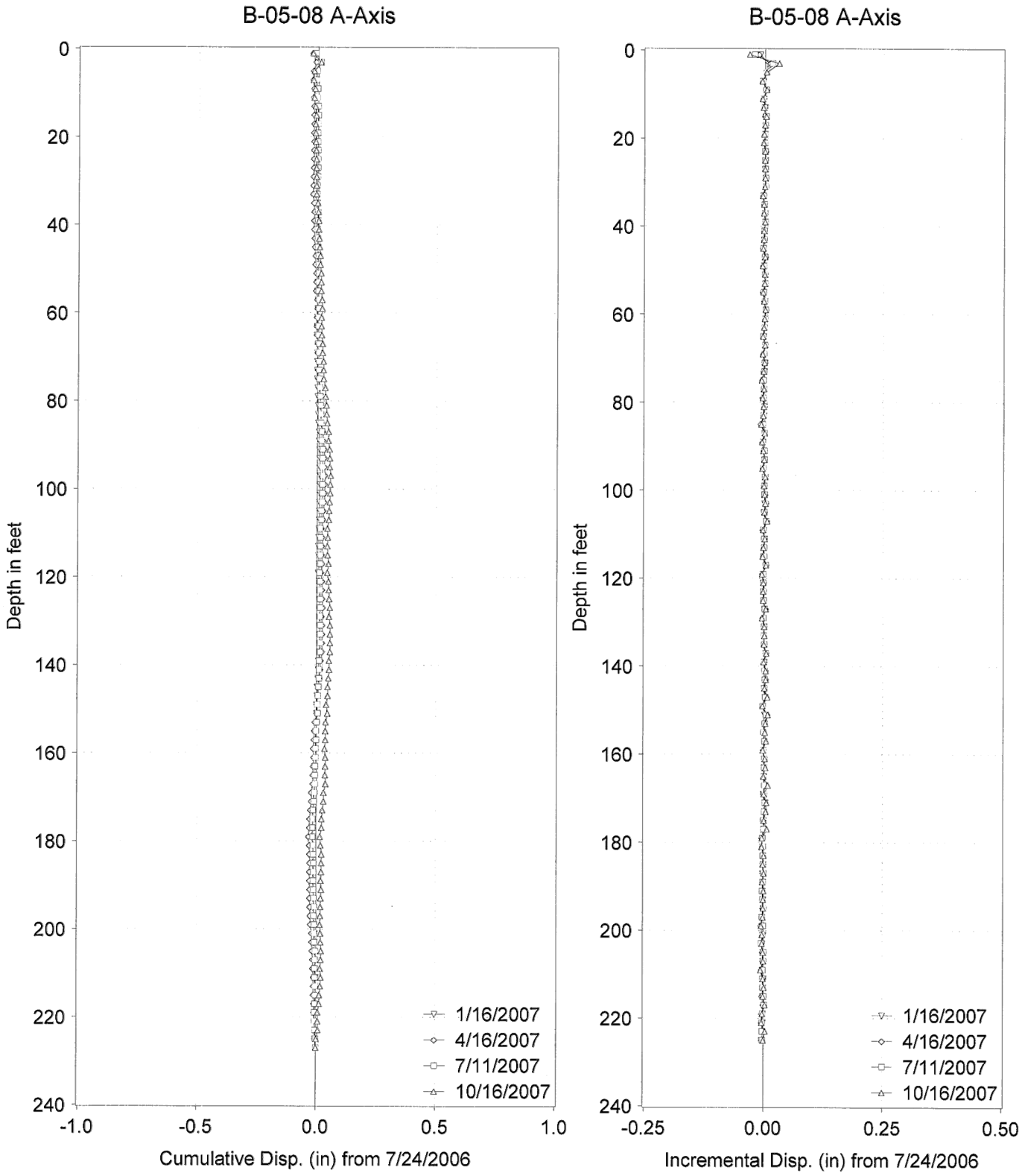
PLATE 37





B-05-08
-Includes readings from the last four quarters.

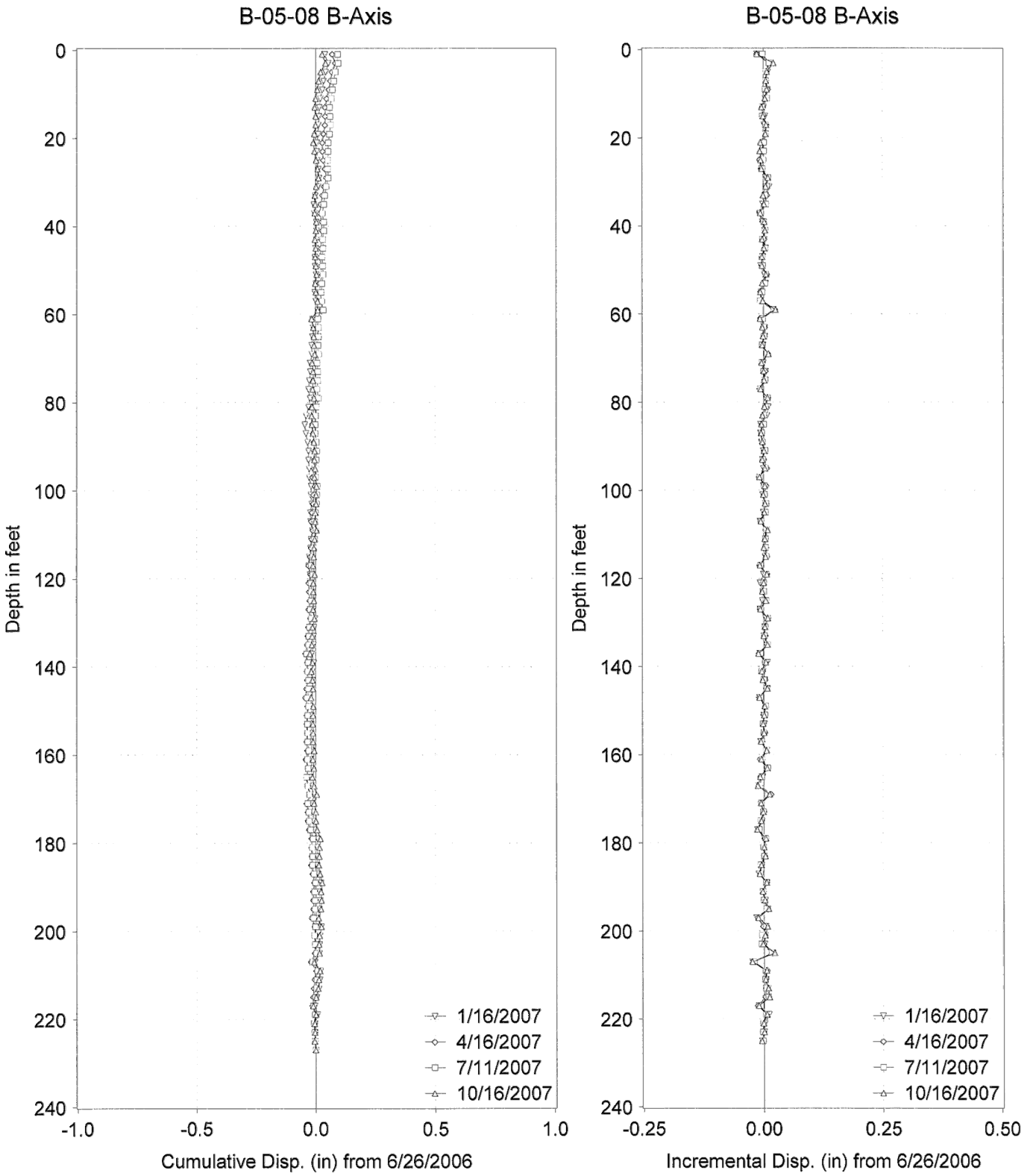
PLATE 38



B-05-08

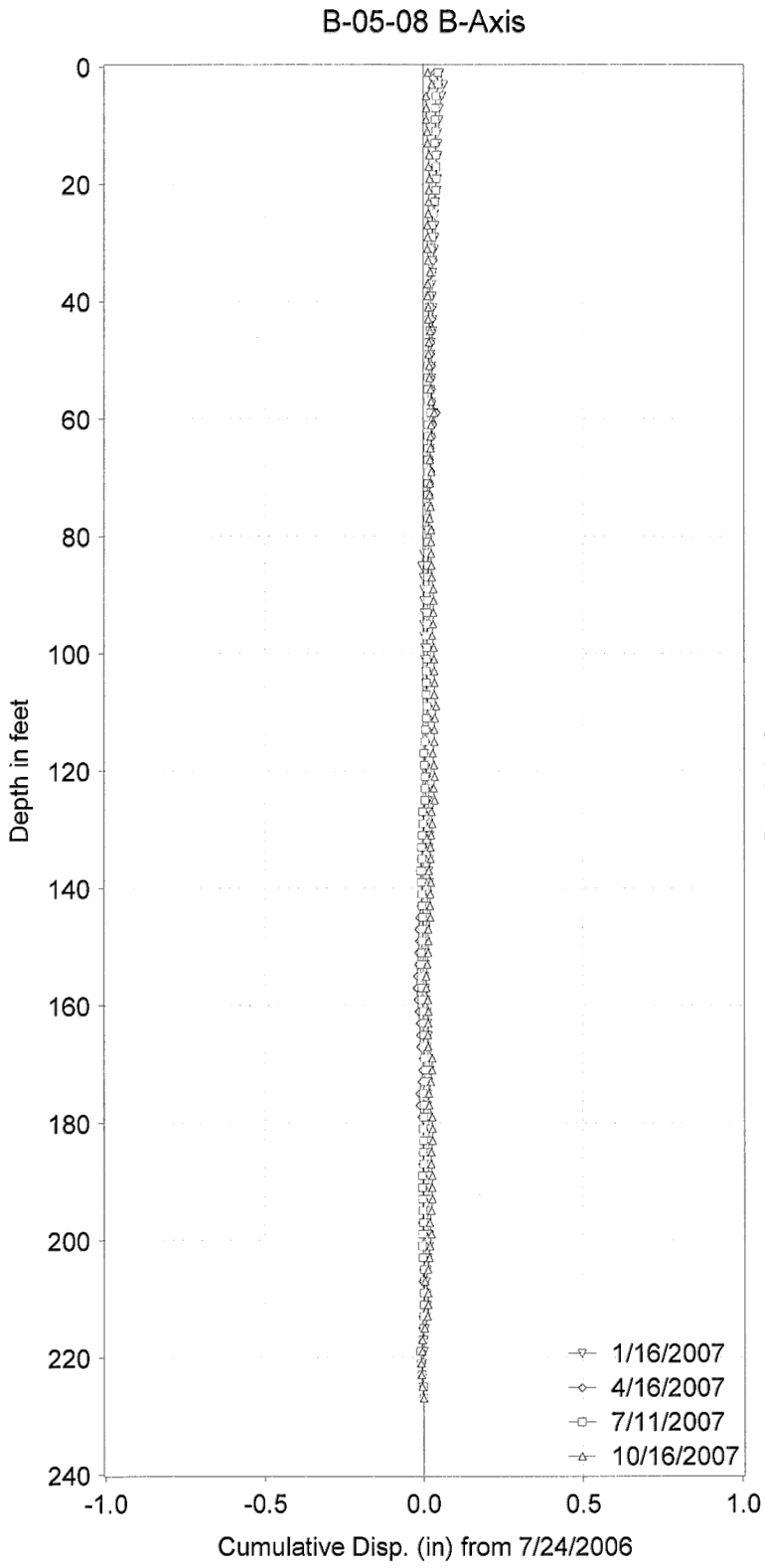
-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 26, 2006 reading.

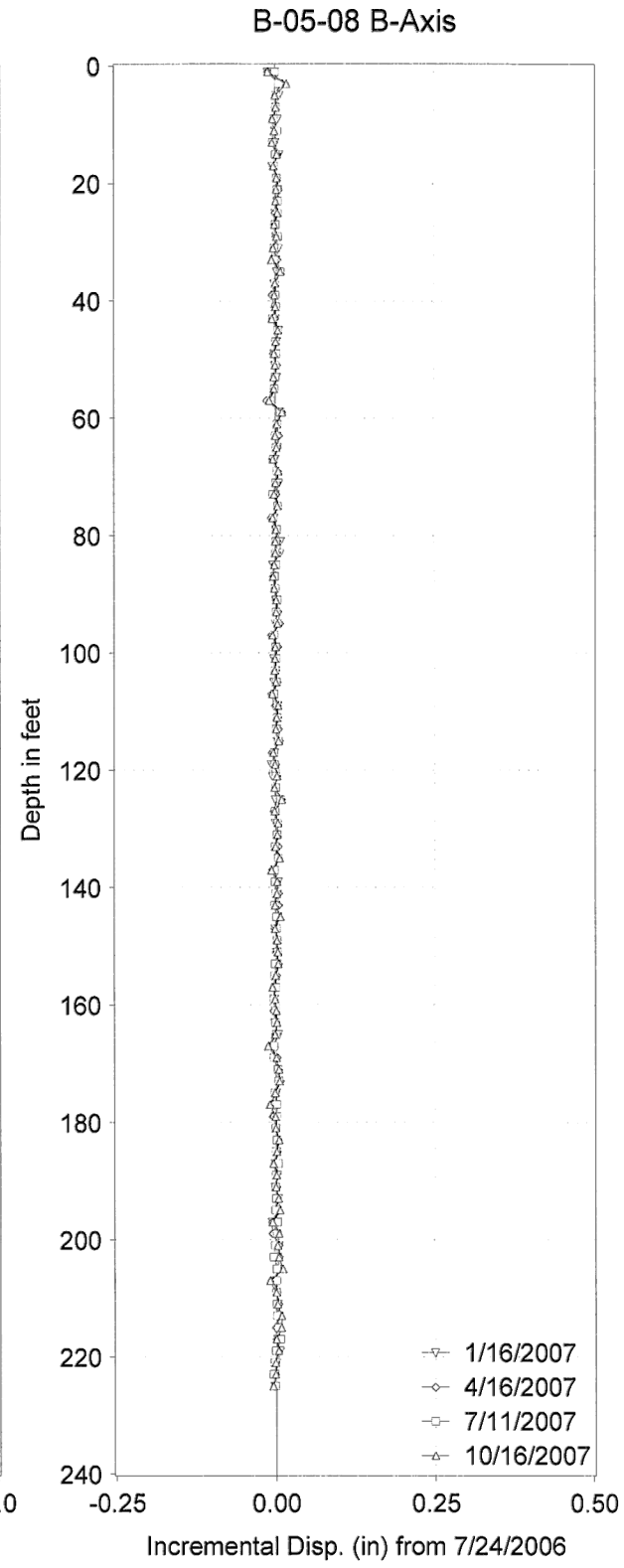
PLATE 38A



B-05-08
-Includes readings from the last four quarters.

PLATE 39

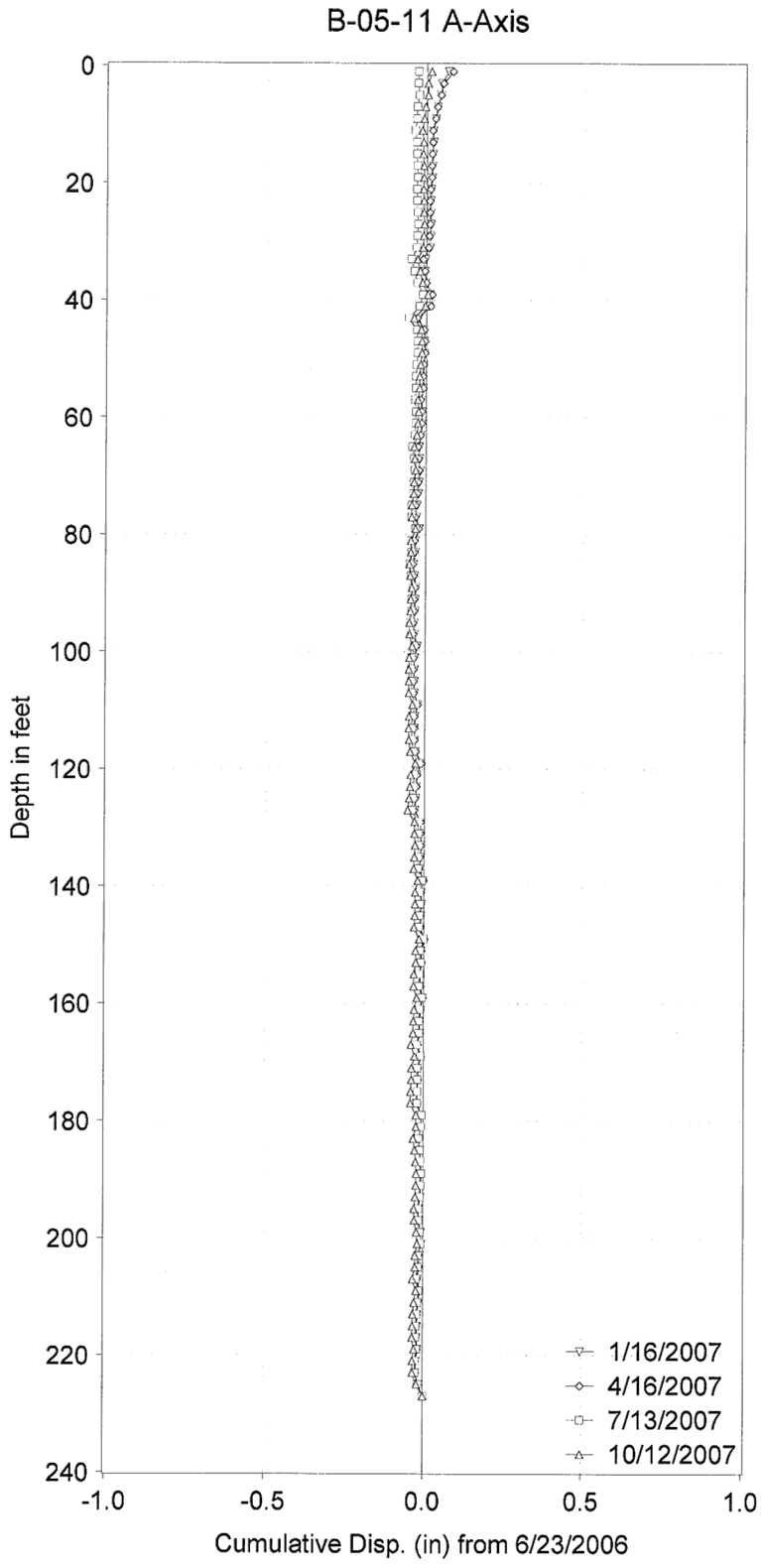


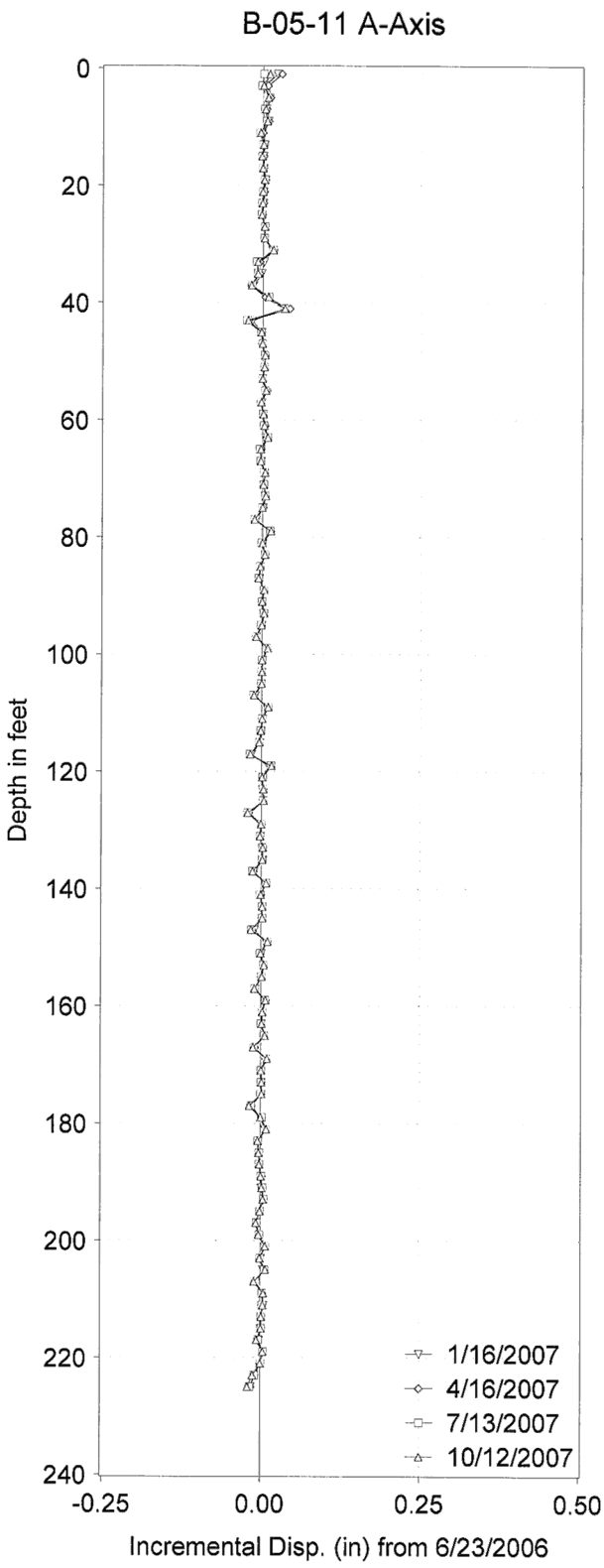


B-05-08

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 26, 2006 reading.

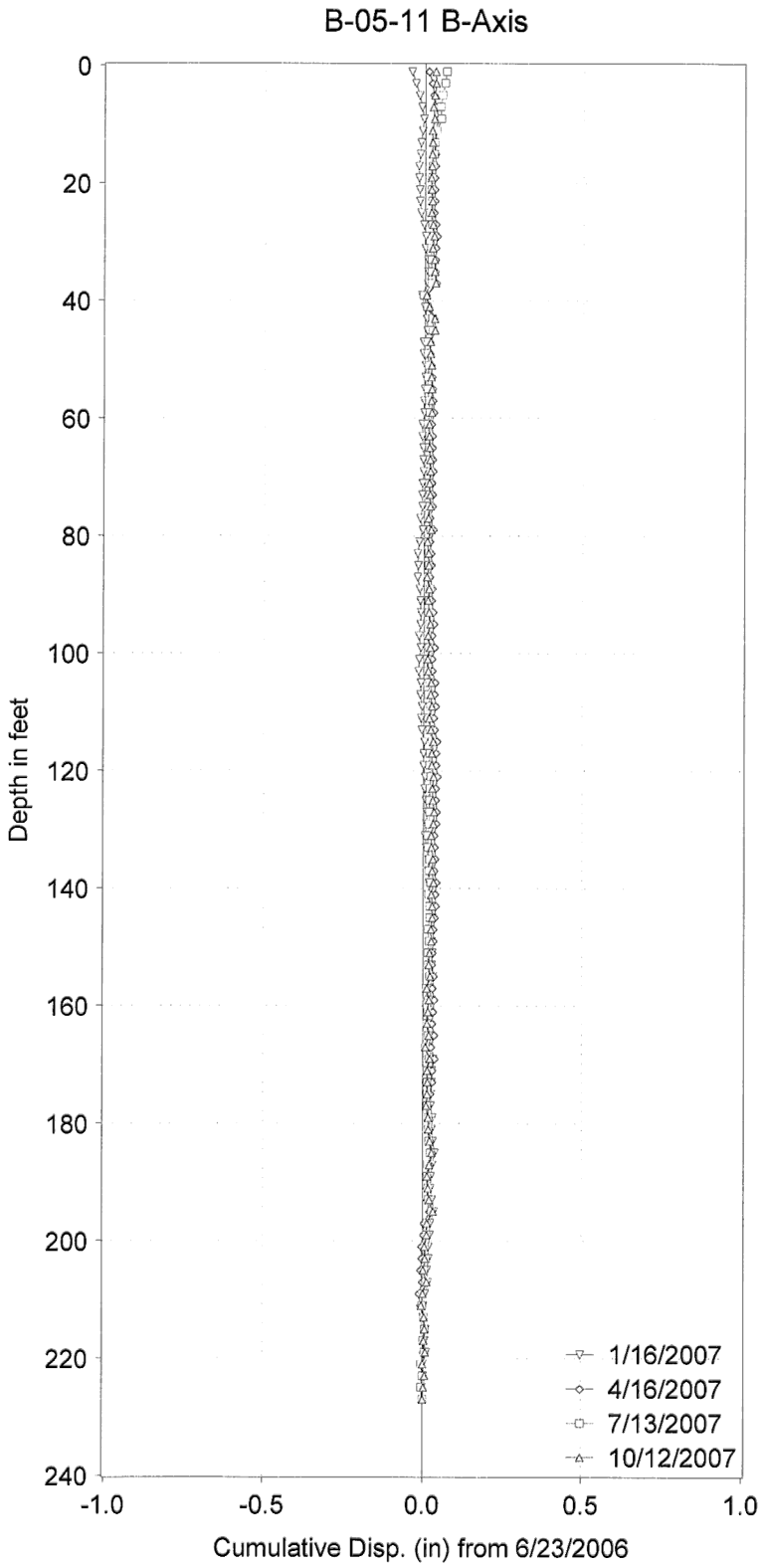
PLATE 39A

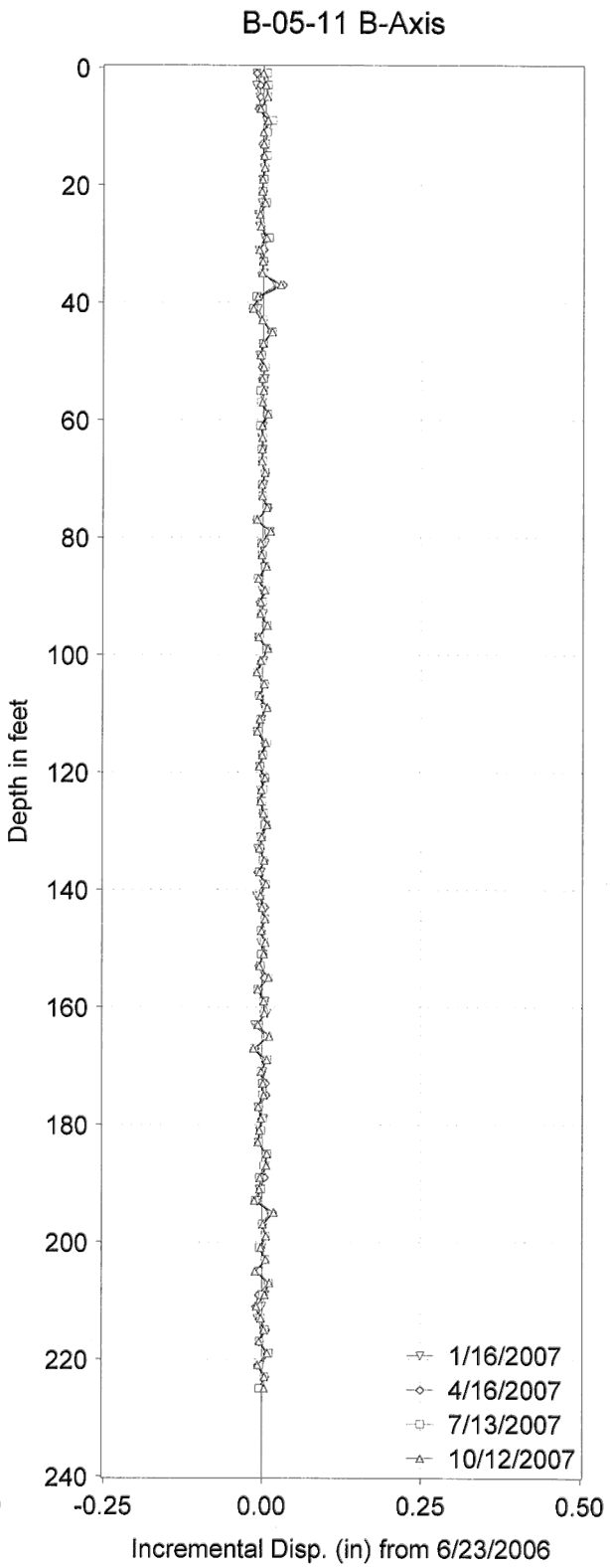




B-05-11
-Includes readings from the last four quarters.

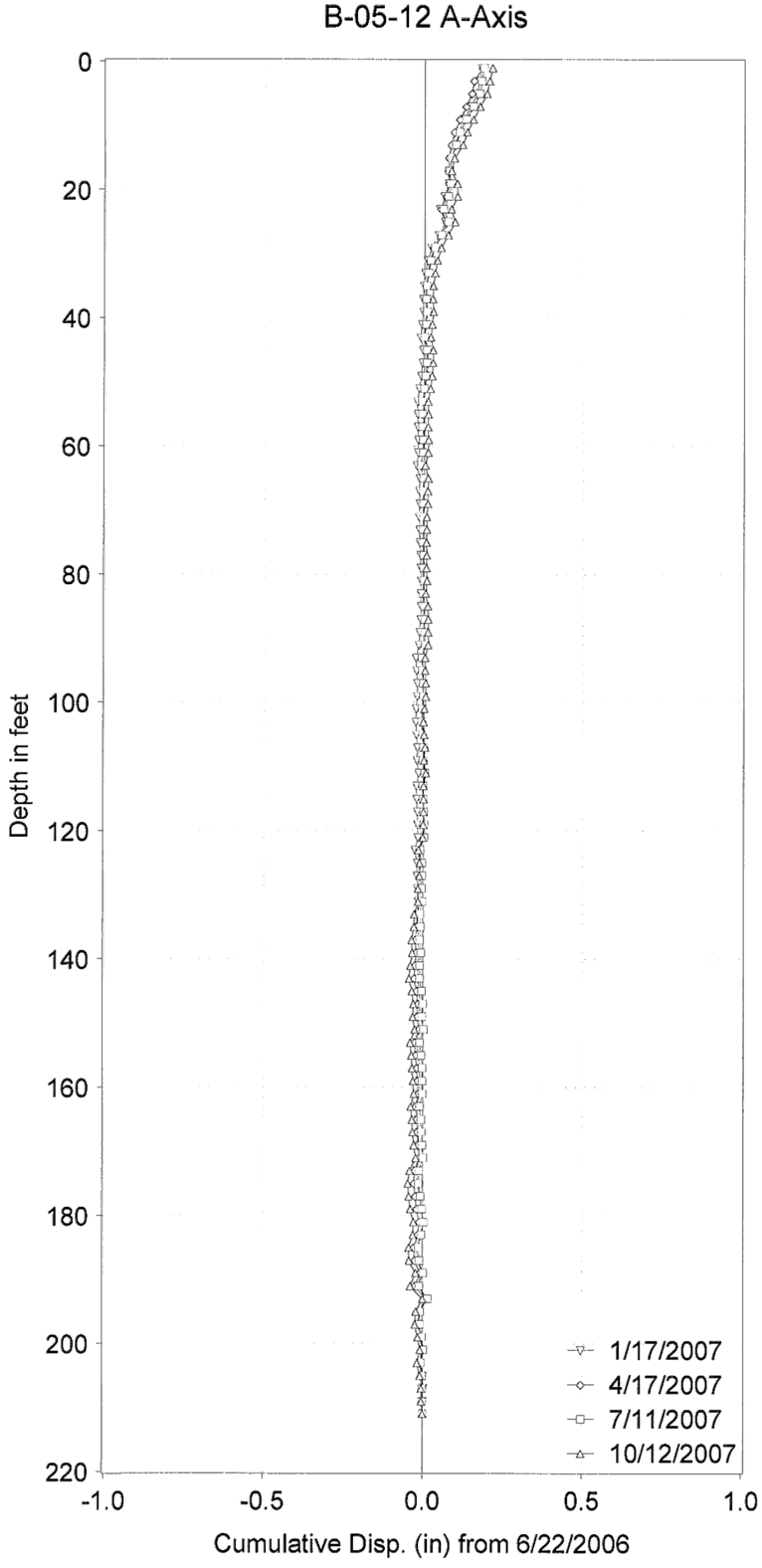
PLATE 40

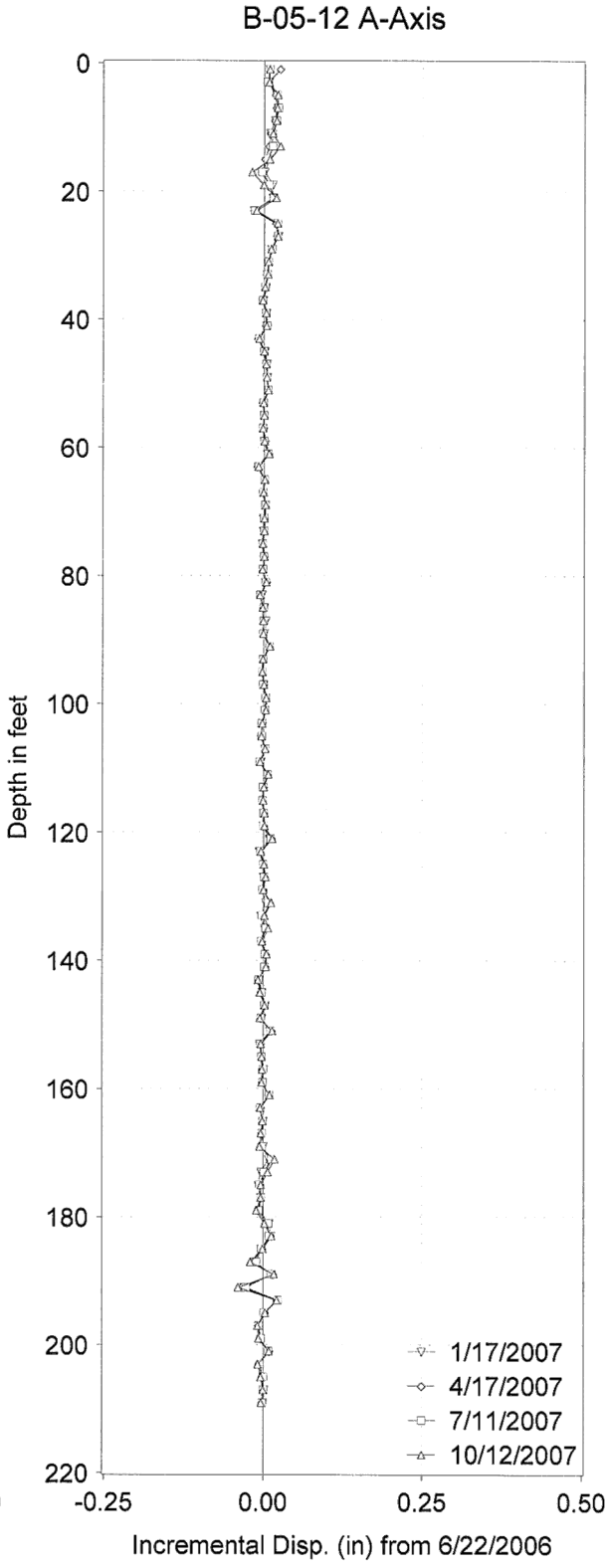




B-05-11
-Includes readings from the last four quarters.

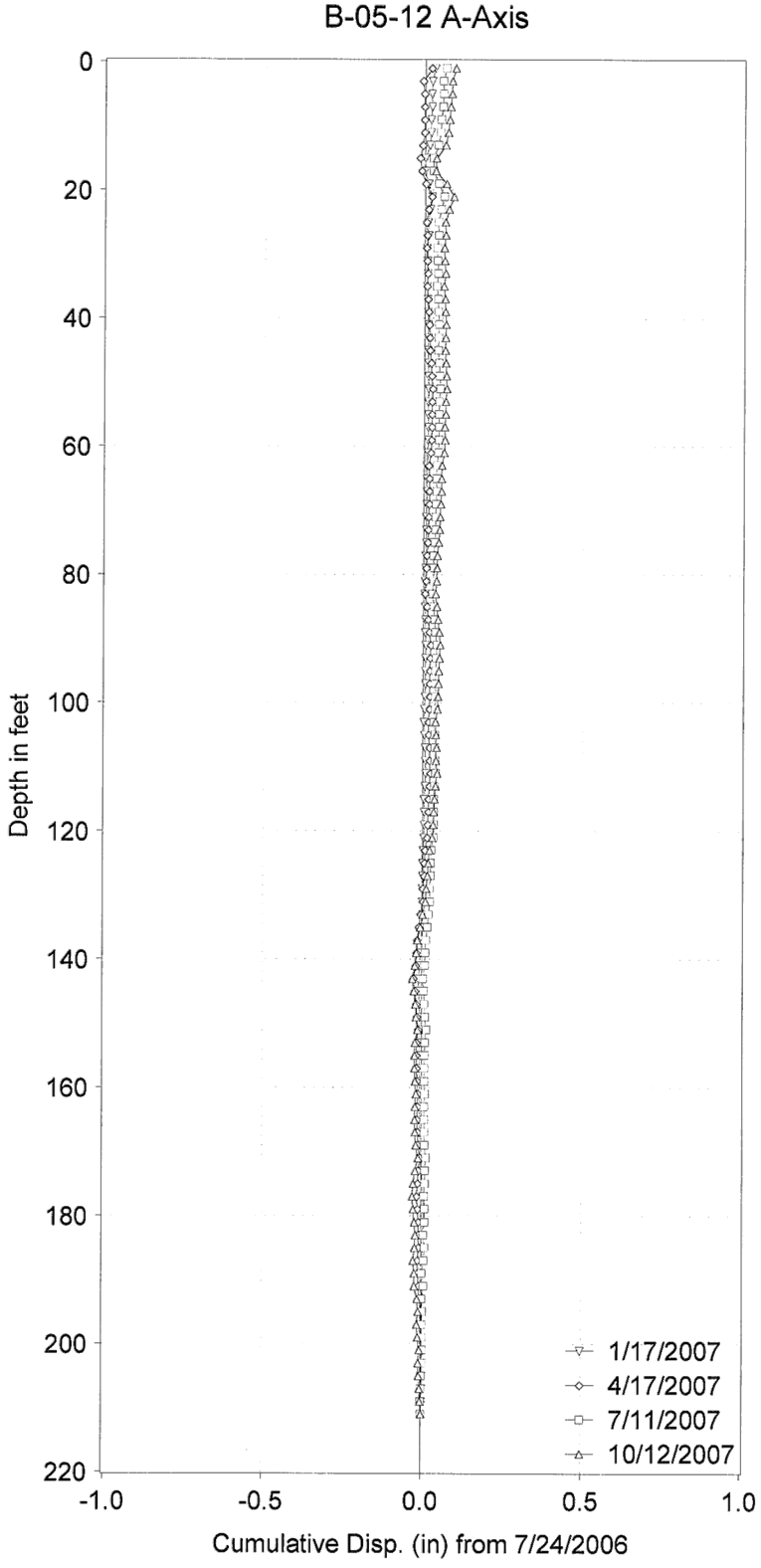
PLATE 41

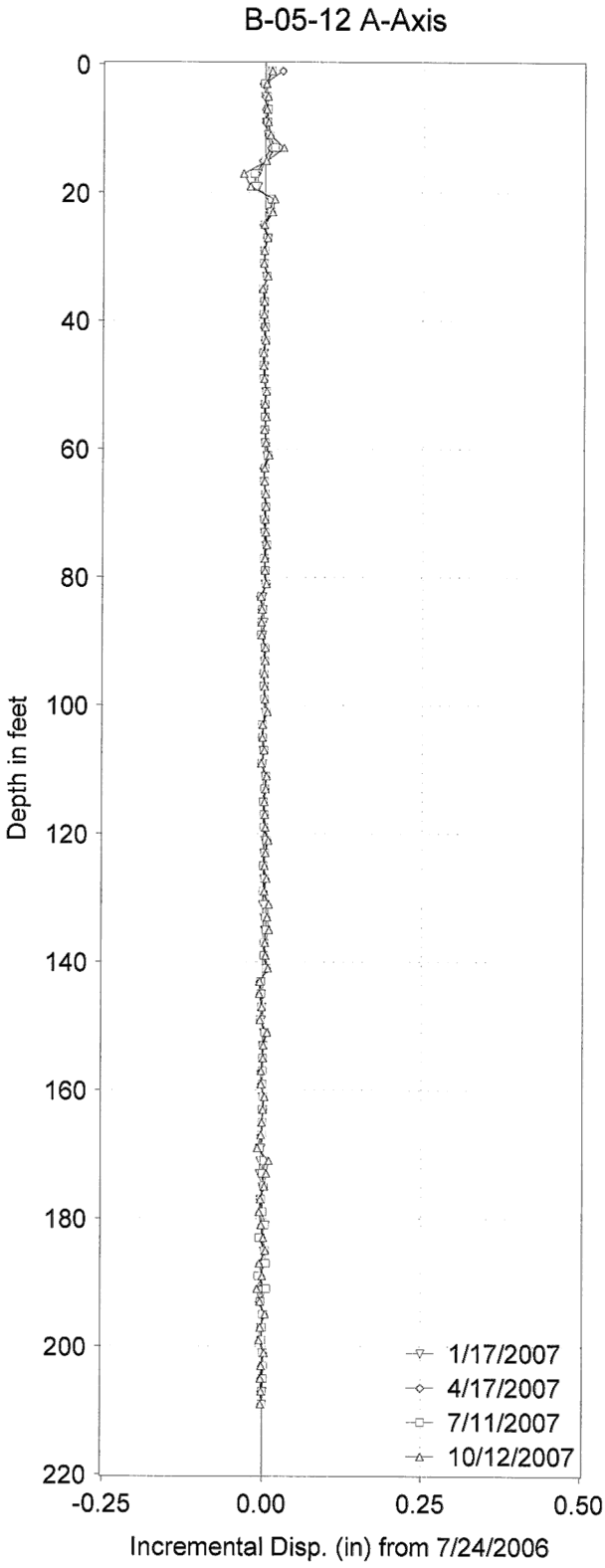




B-05-12
-Includes readings from the last four quarters.

PLATE 42

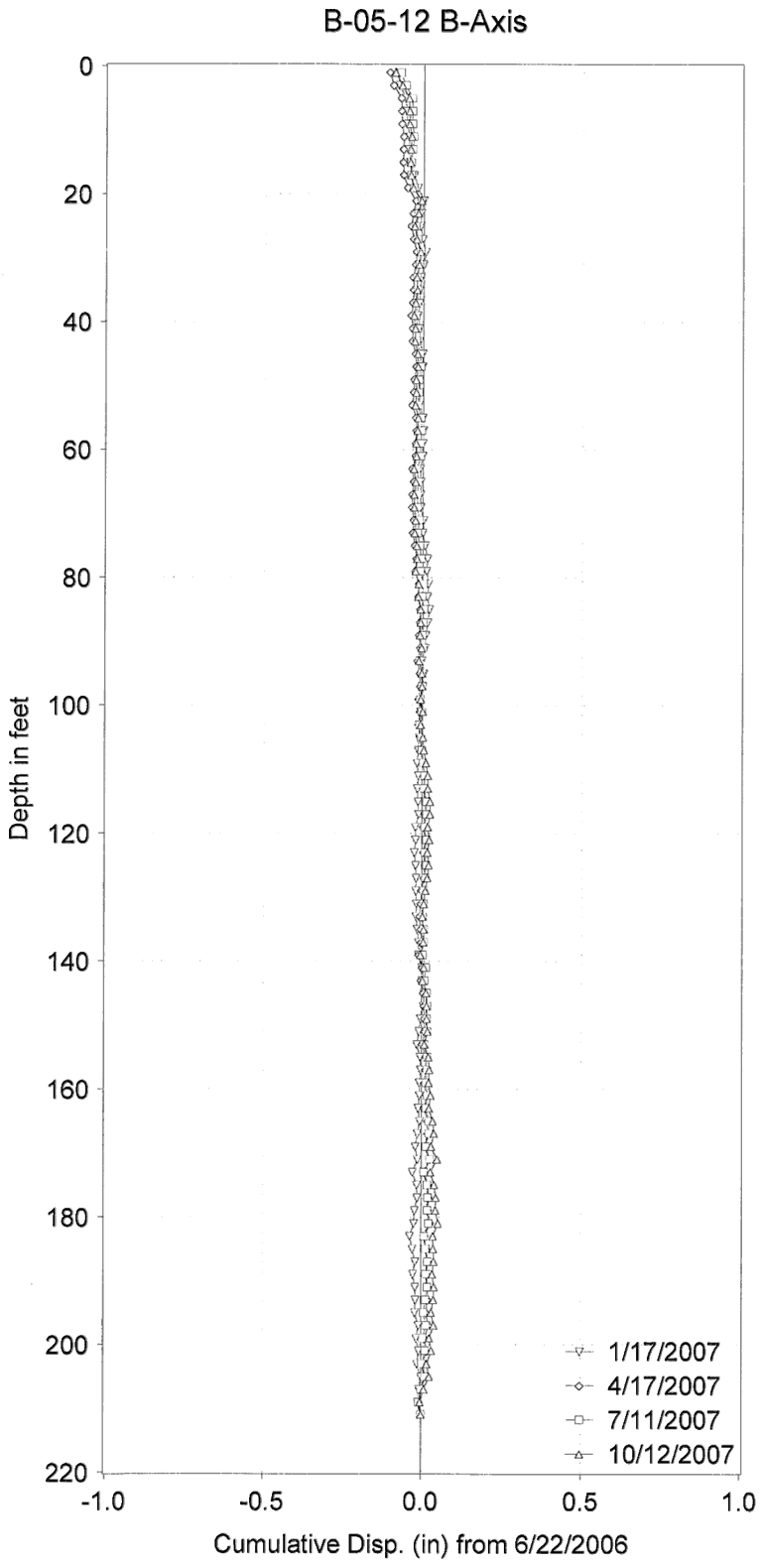


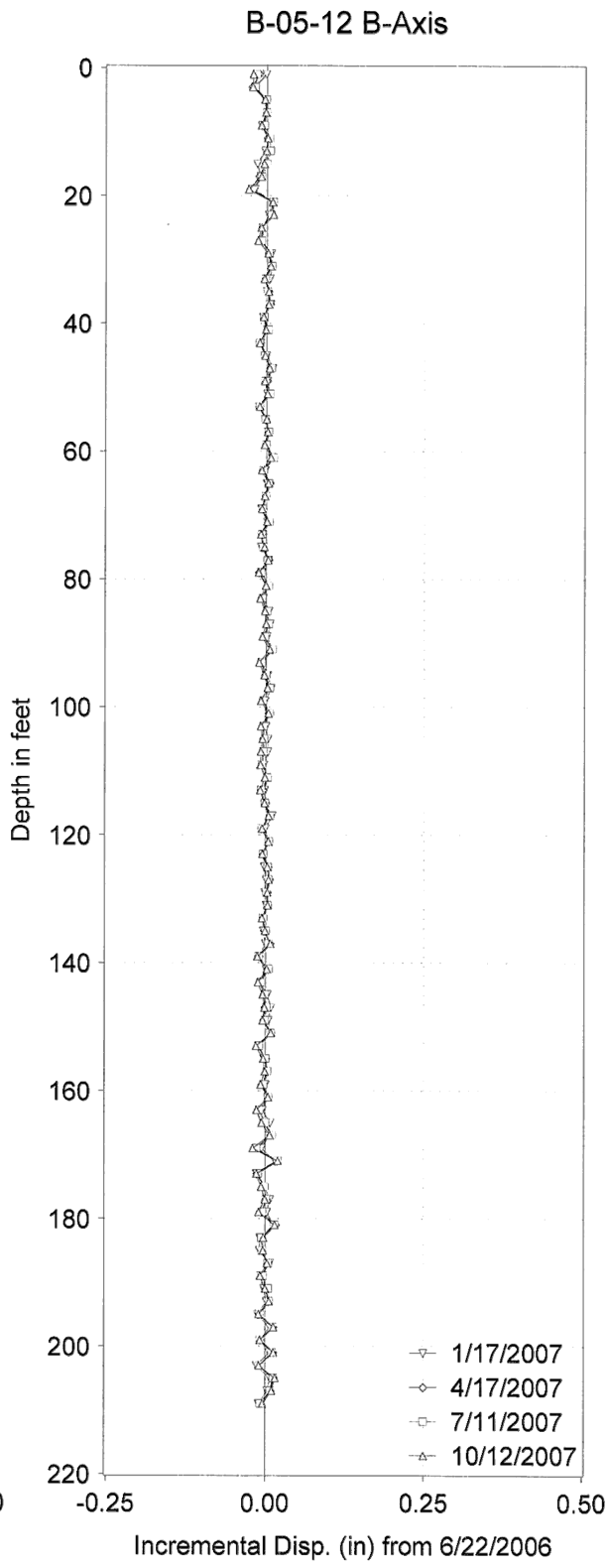


B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

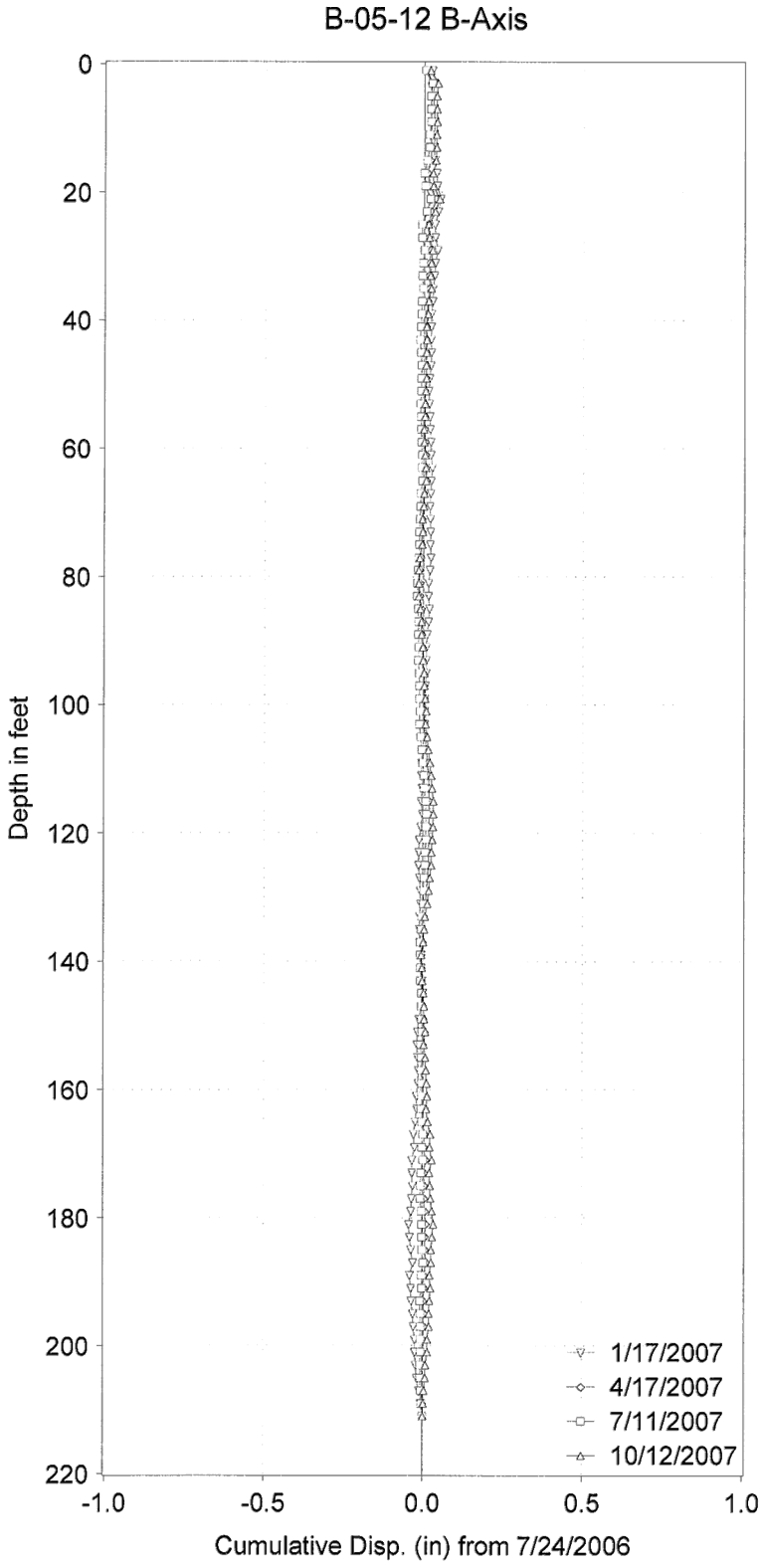
PLATE 42A

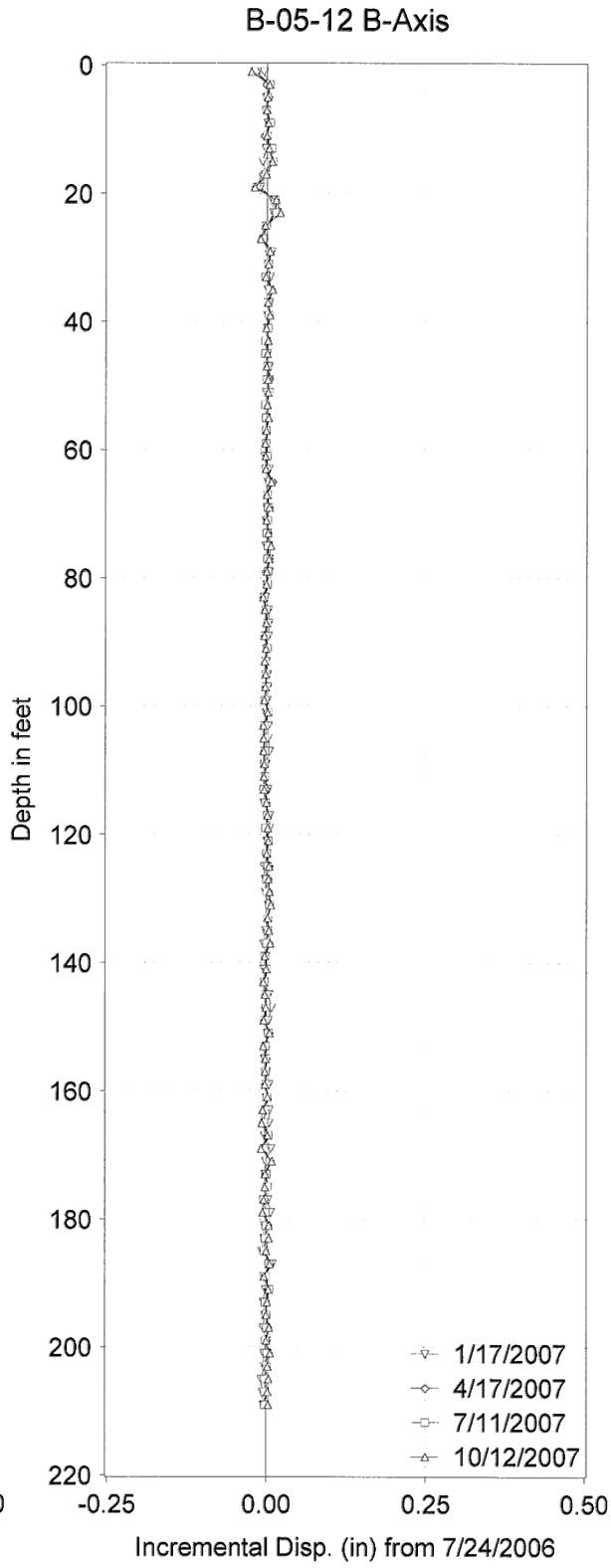




B-05-12
-Includes readings from the last four quarters.

PLATE 43

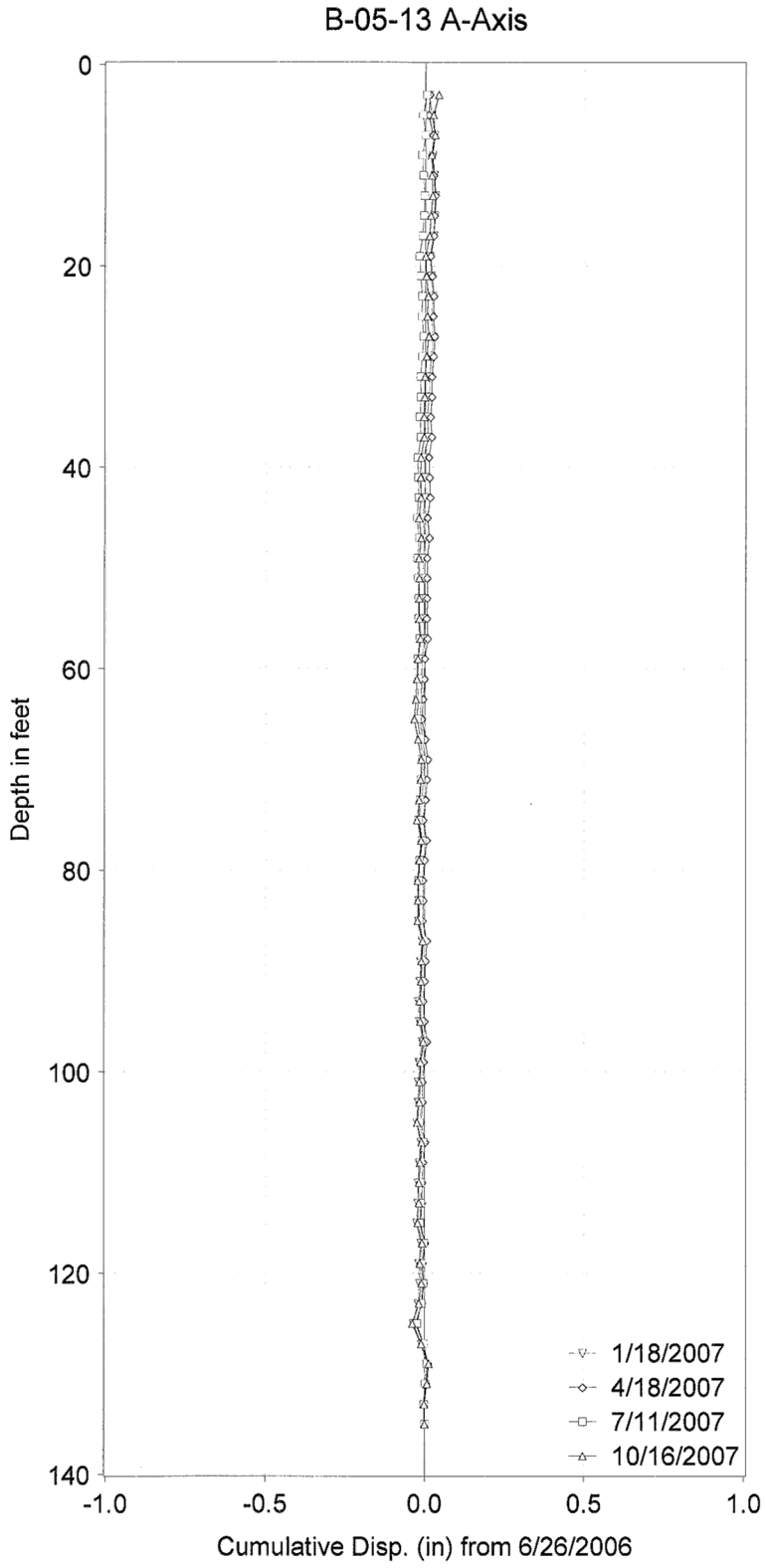


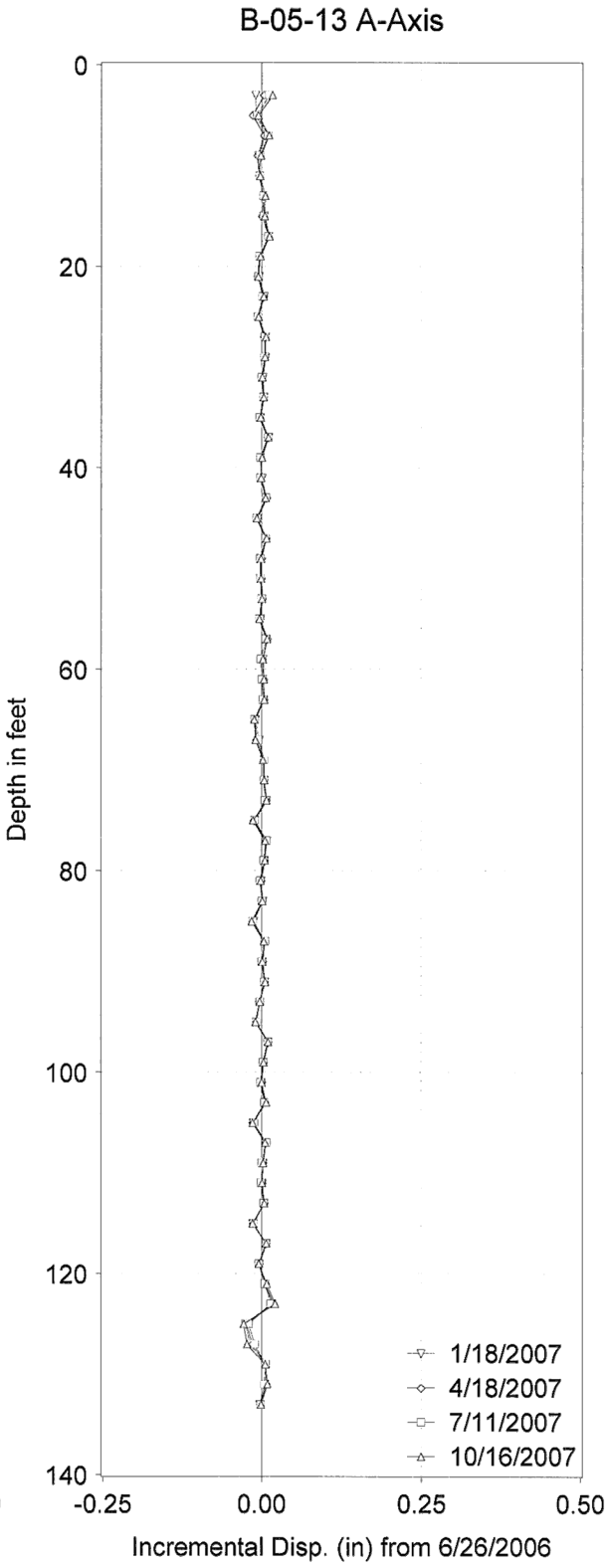


B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

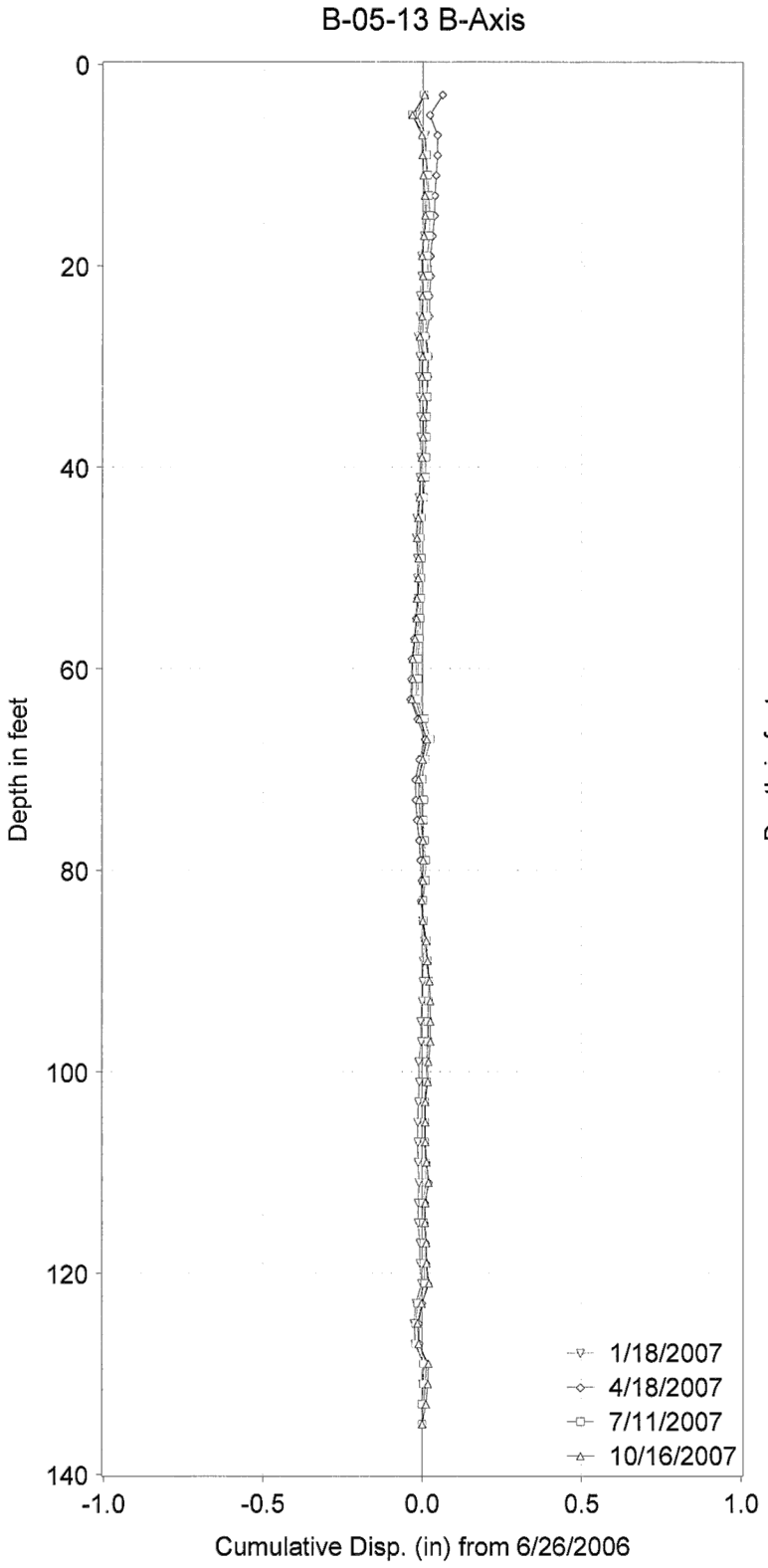
PLATE 43A

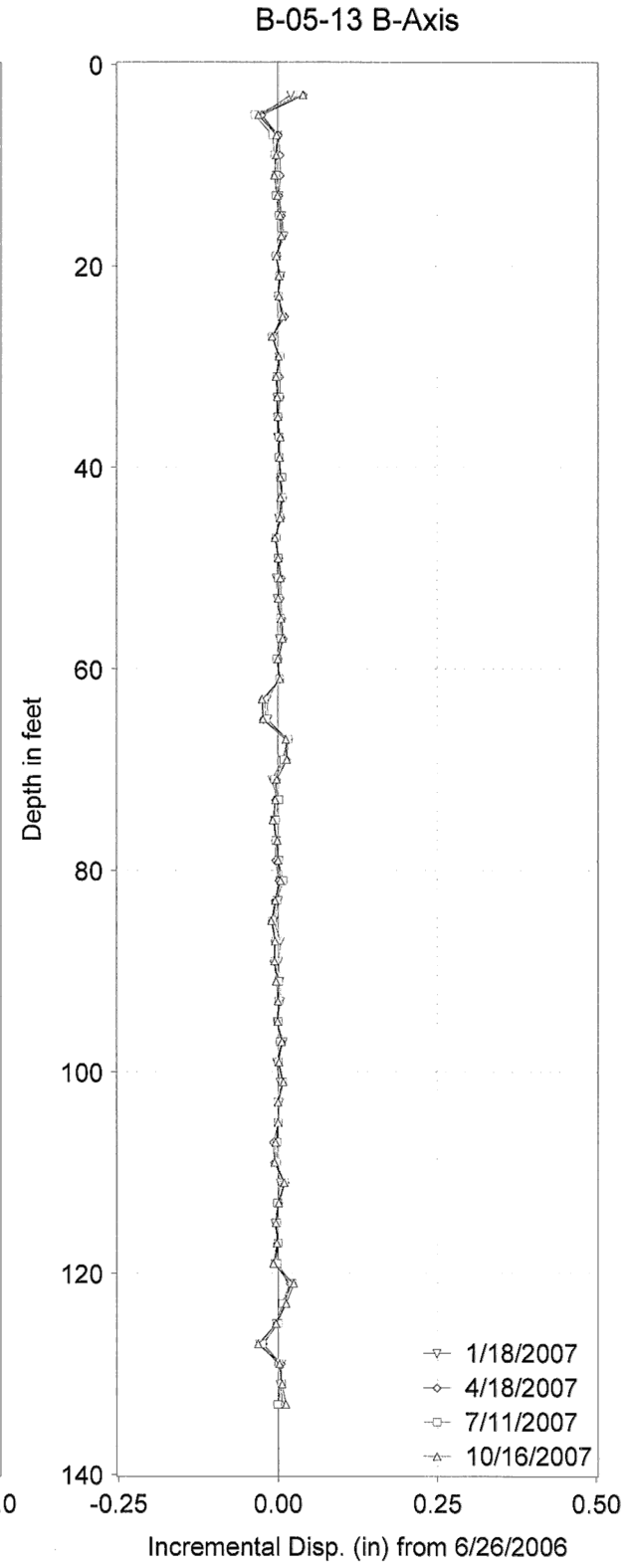




B-05-13
-Includes readings from the last four quarters.

PLATE 44

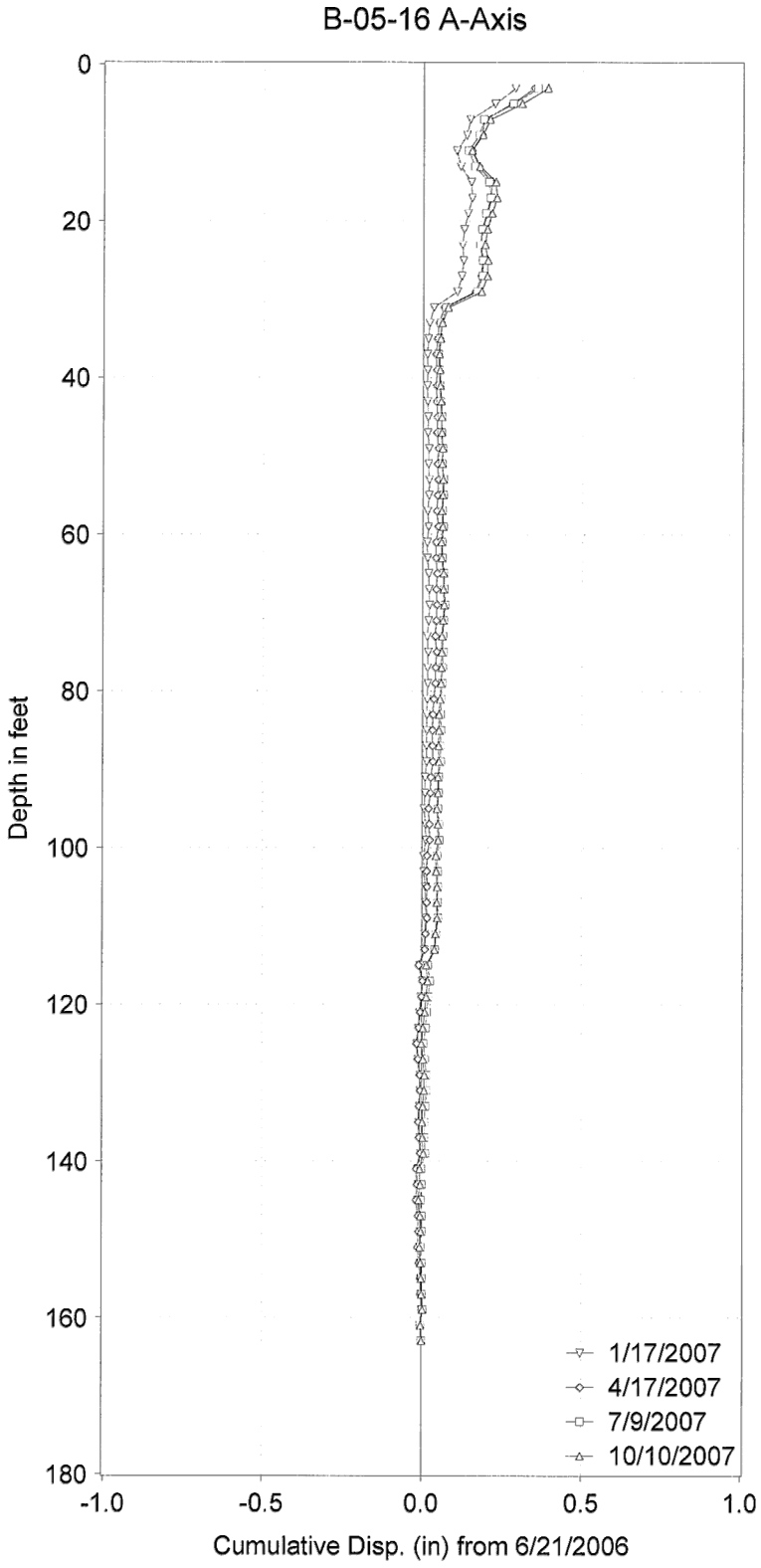


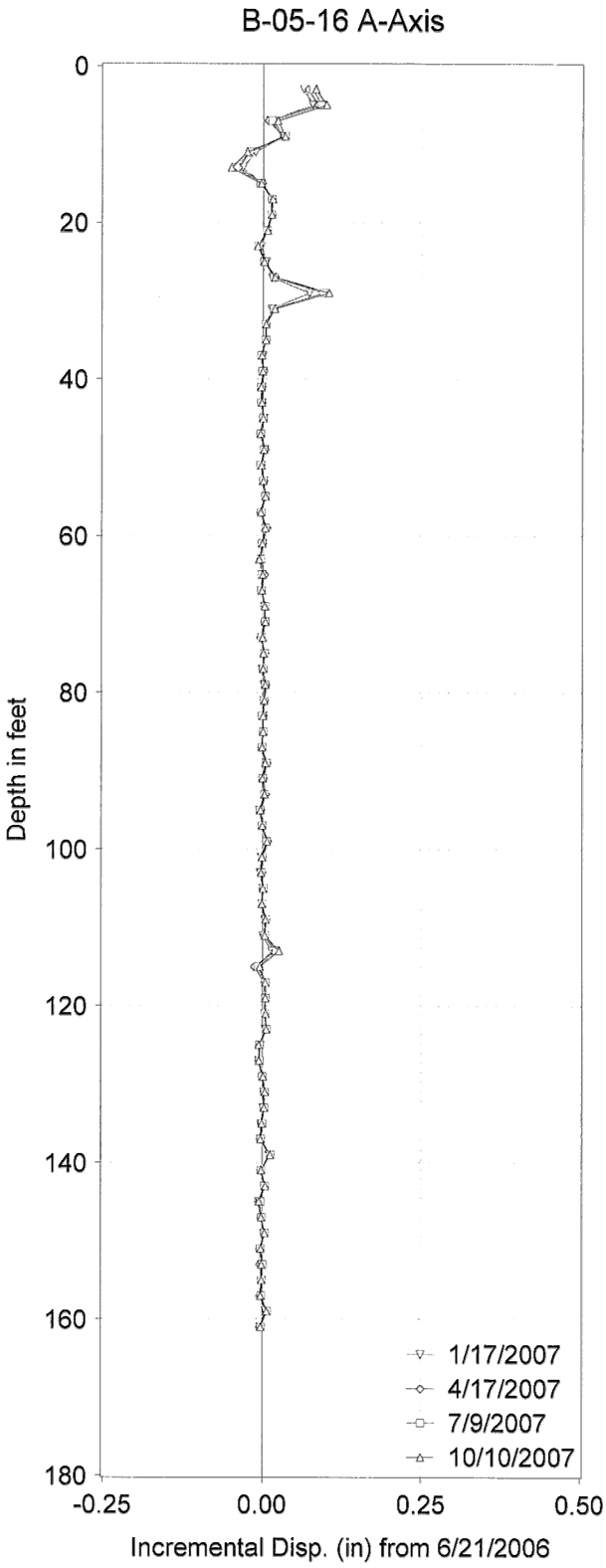


B-05-13

-Includes readings from the last four quarters.

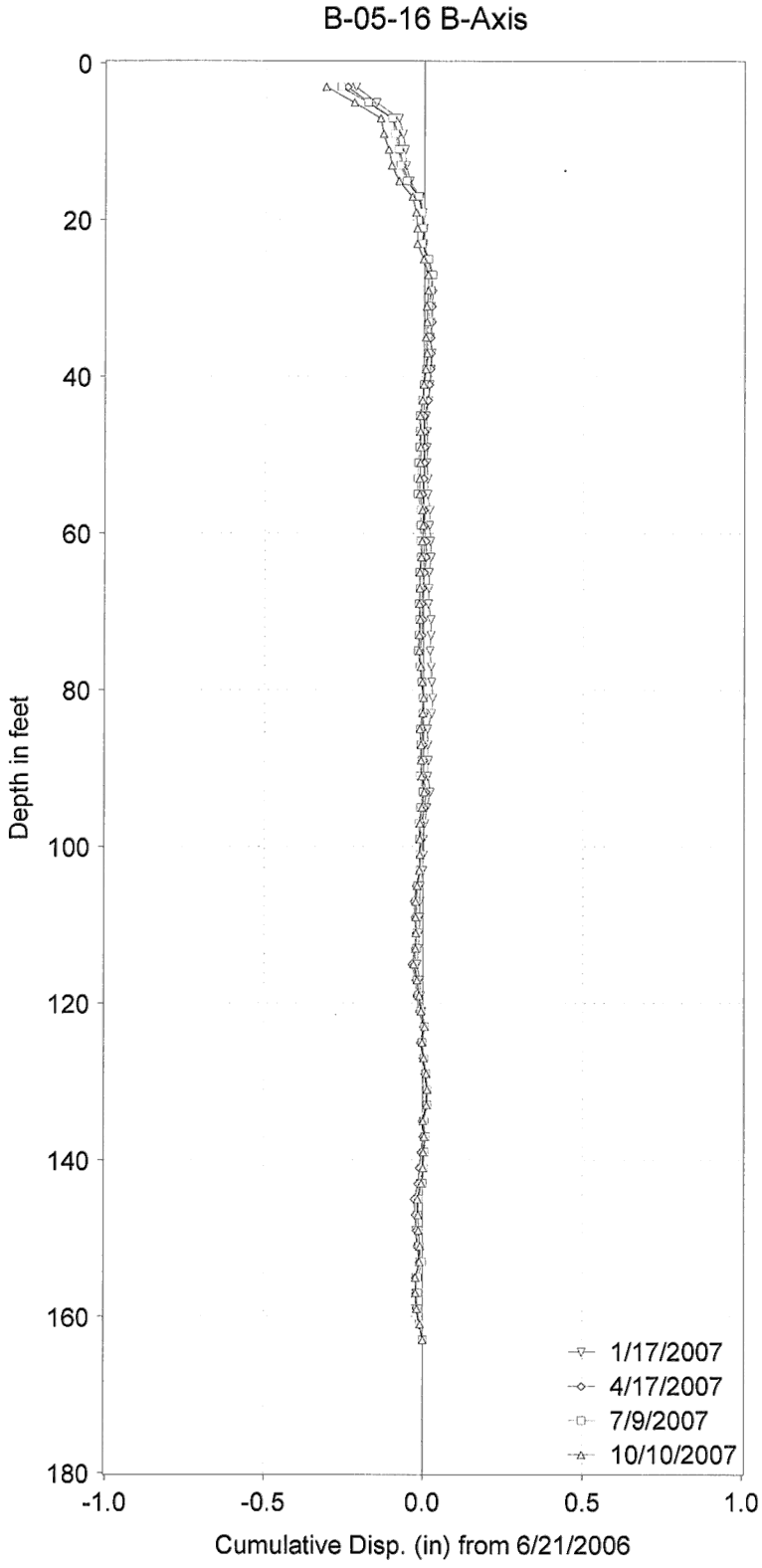
PLATE 45

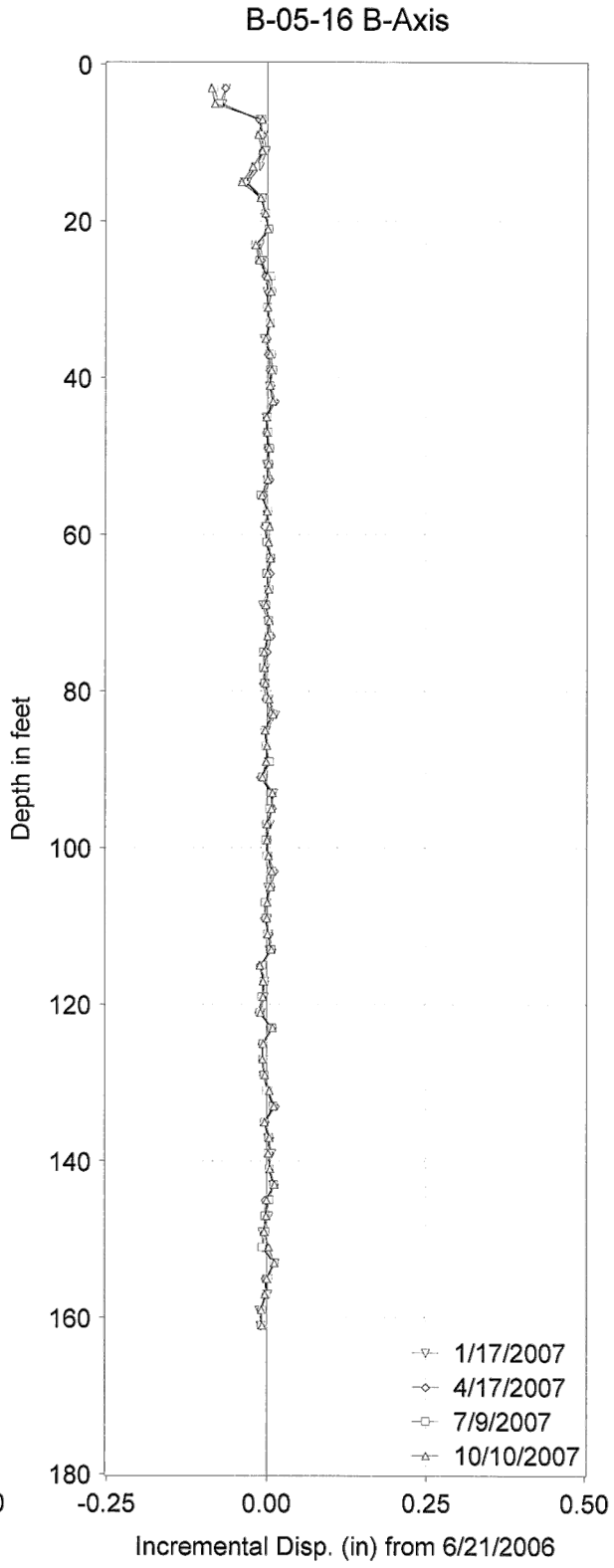




B-05-16
-Includes readings from the last four quarters.

PLATE 46





B-05-16
-Includes readings from the last four quarters.

PLATE 47

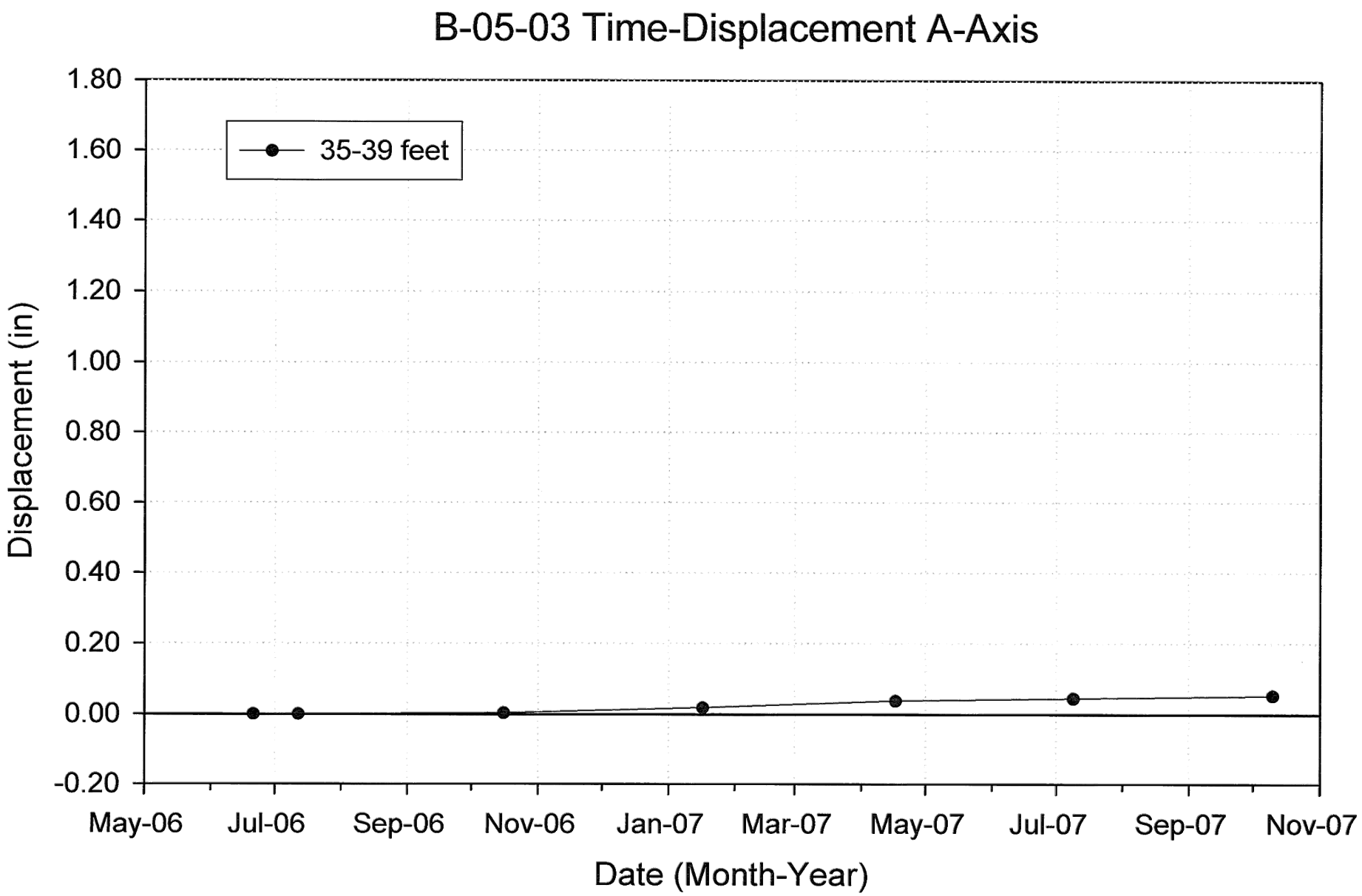

B-05-03 Time-Displacement A-Axis
35-39 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Jul-06
Sep-06
Nov-06
Jan-07
Mar-07
May-07
Jul-07
Sep-07
Nov-07
Date (Month-Year)

PLATE 48

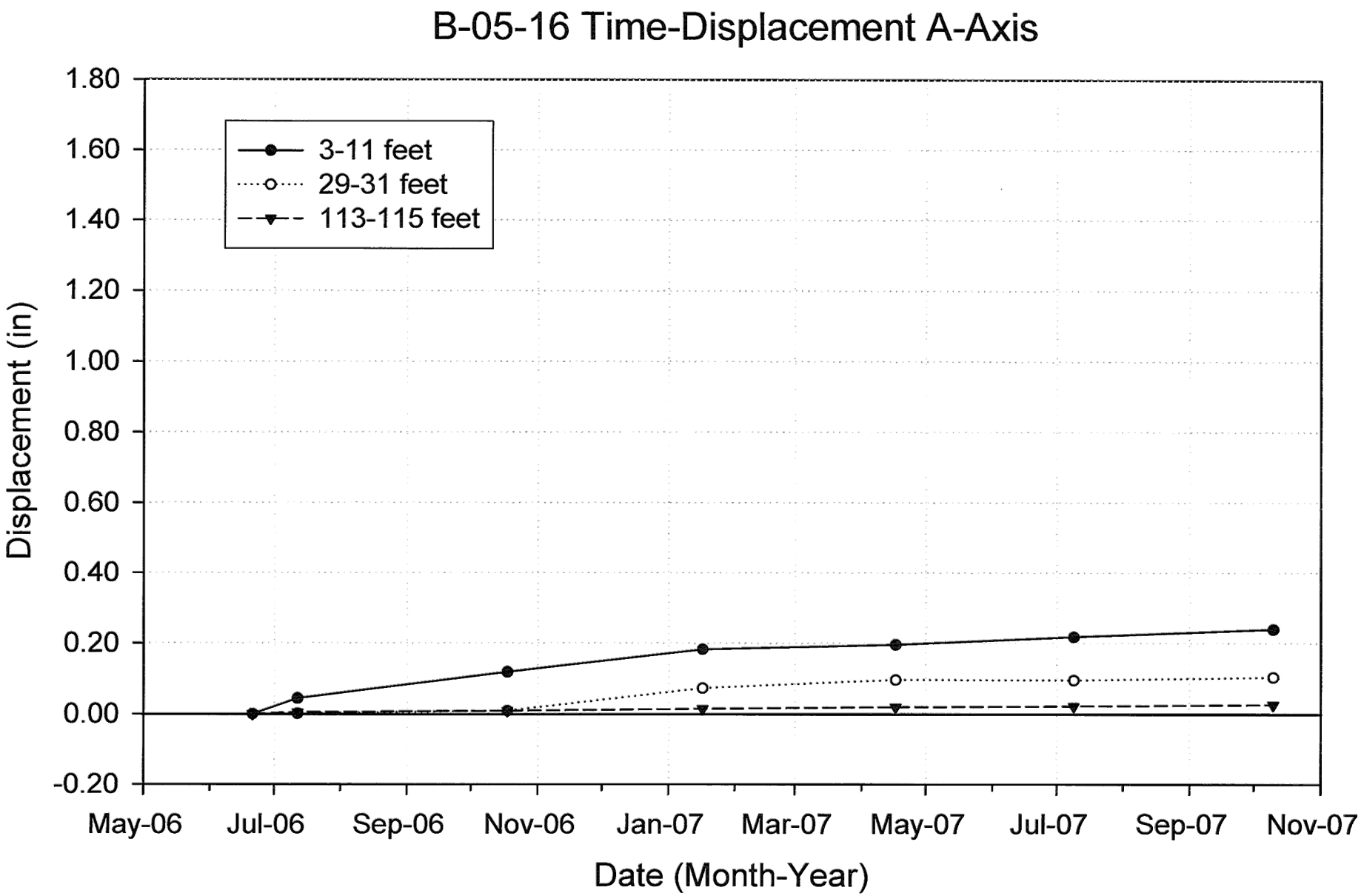

B-05-16 Time-Displacement A-Axis
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Displacement (in)
3-11 feet
29-31 feet
113-115 feet
May-06
Jul-06
Sep-06
Nov-06
Jan-07
Mar-07
May-07
Jul-07
Sep-07
Nov-07
Date (Month-Year)

PLATE 49

B-101 (P-1) Pneumatic Piezometer Readings

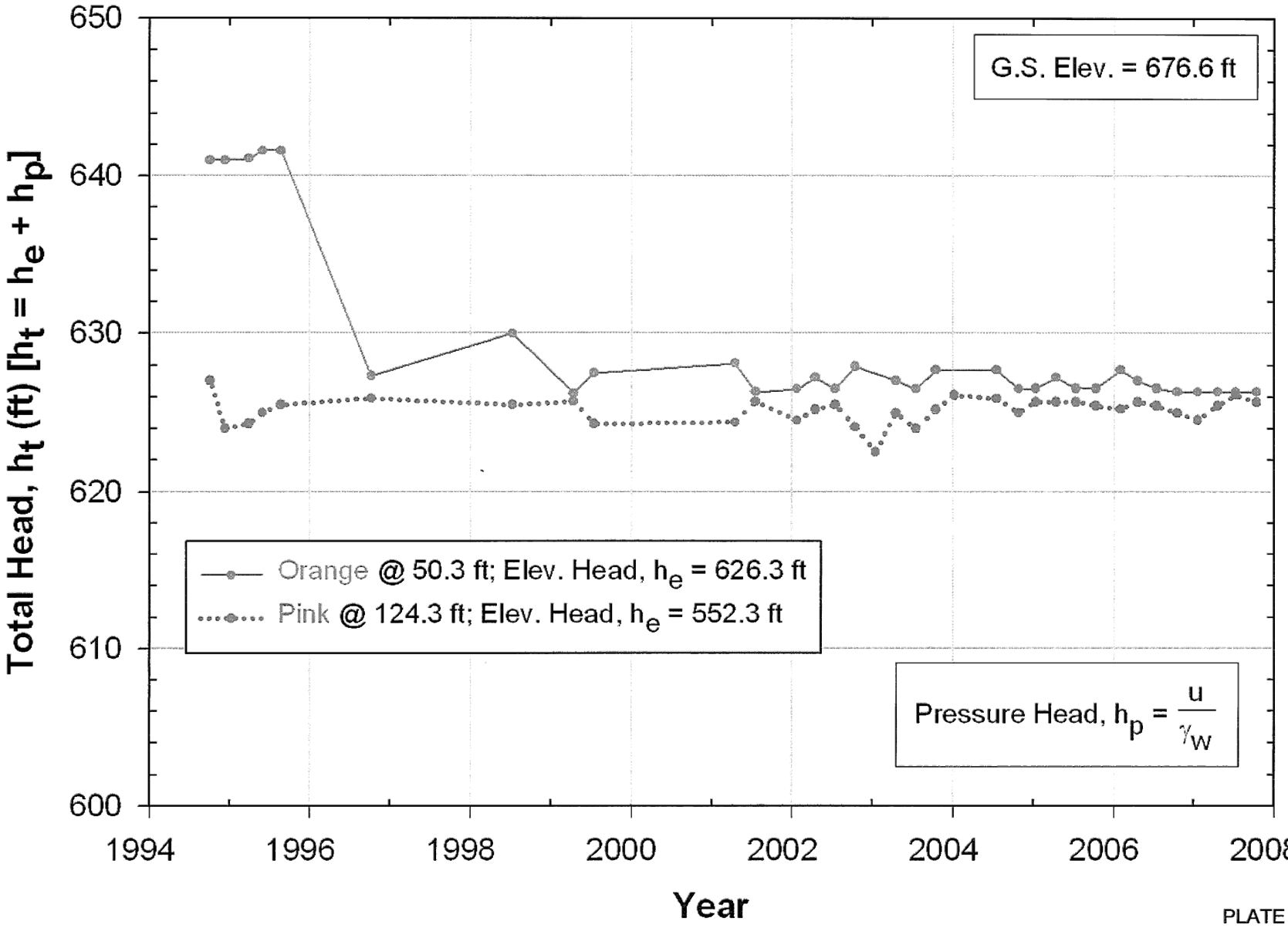


PLATE 50

B-105 (P-3) Pneumatic Piezometer Readings

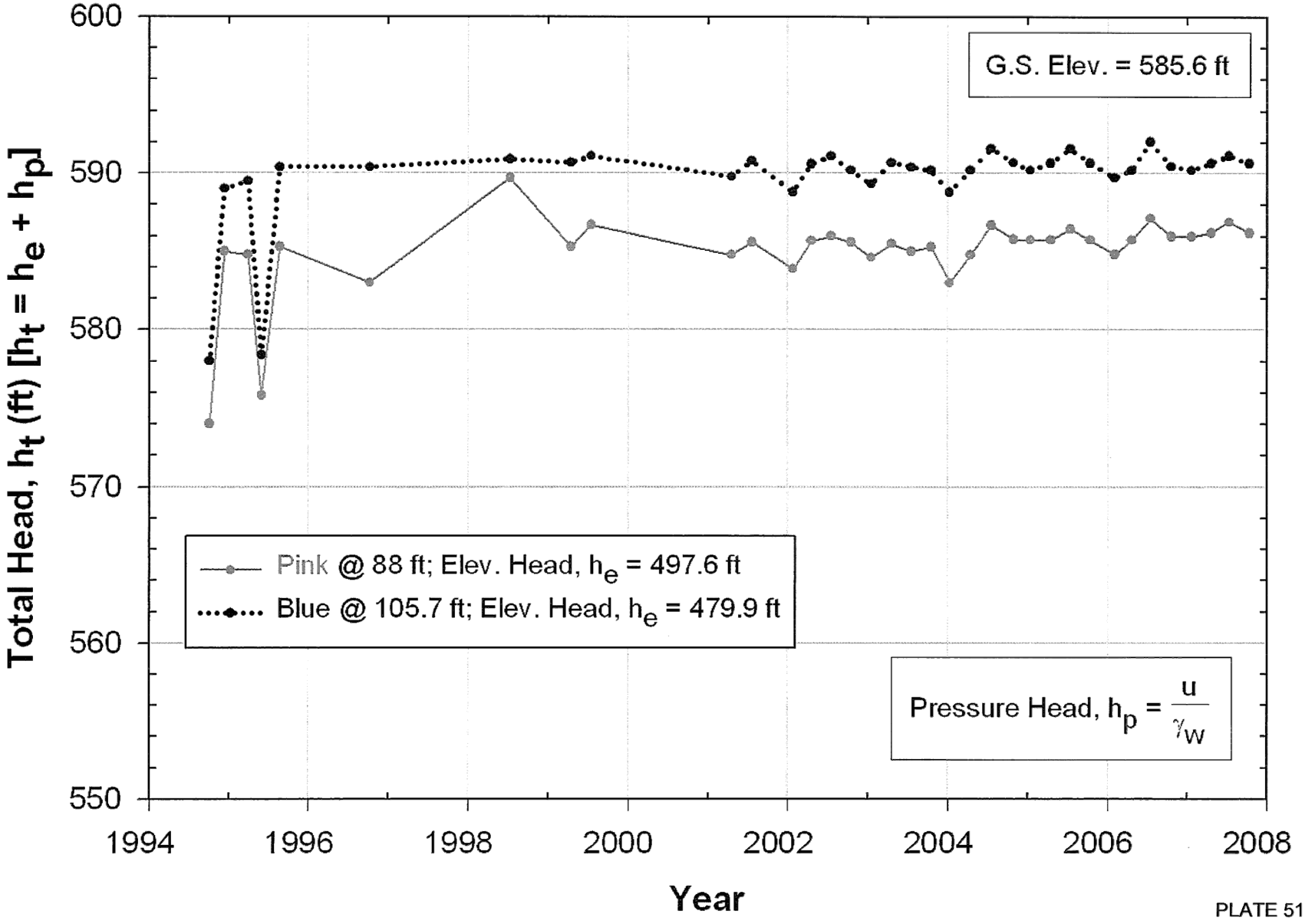


PLATE 51

B-107 (P-5) Pneumatic Piezometer Readings

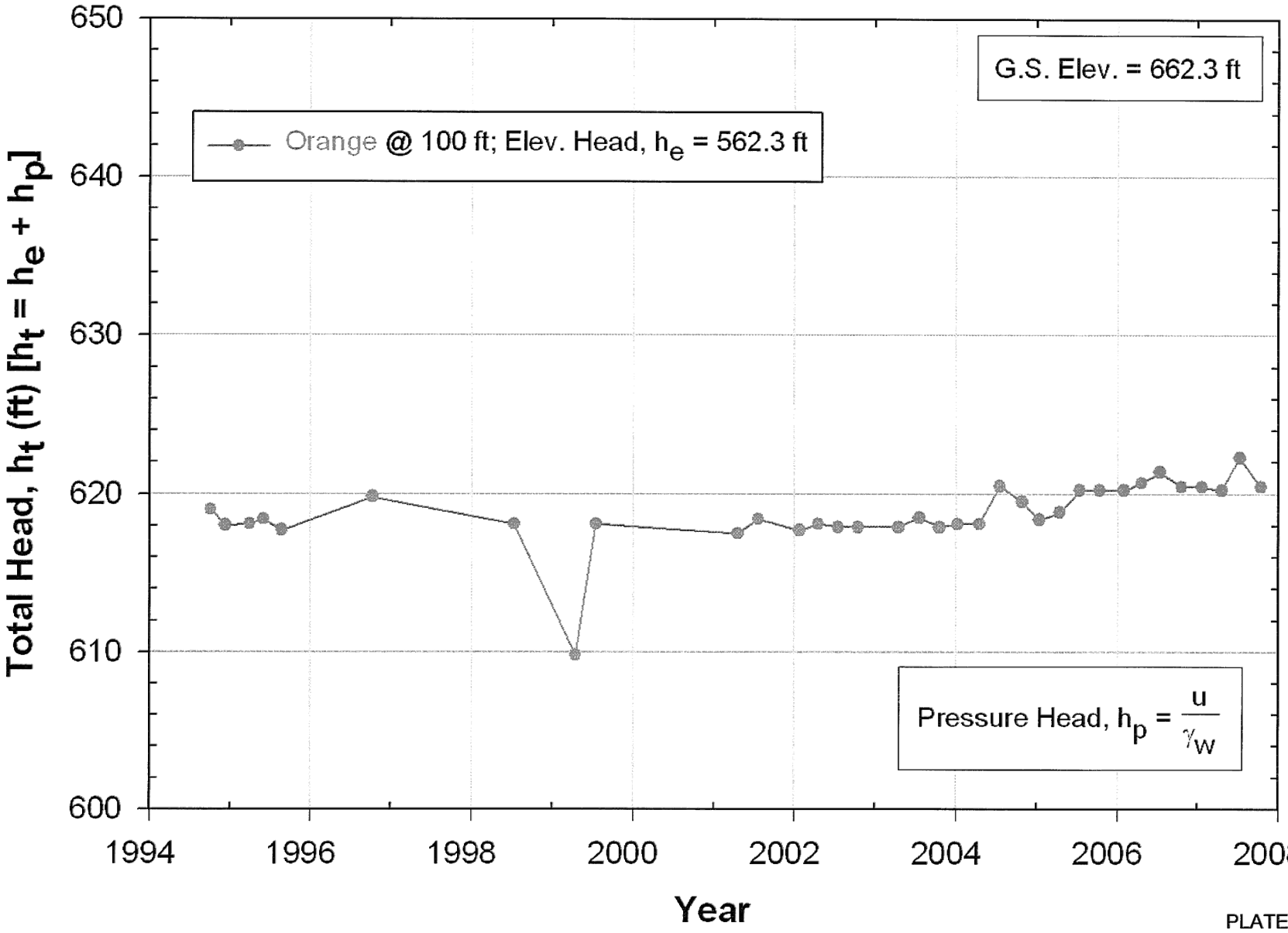


PLATE 52

B-303 (P-2) Pneumatic Piezometer Readings

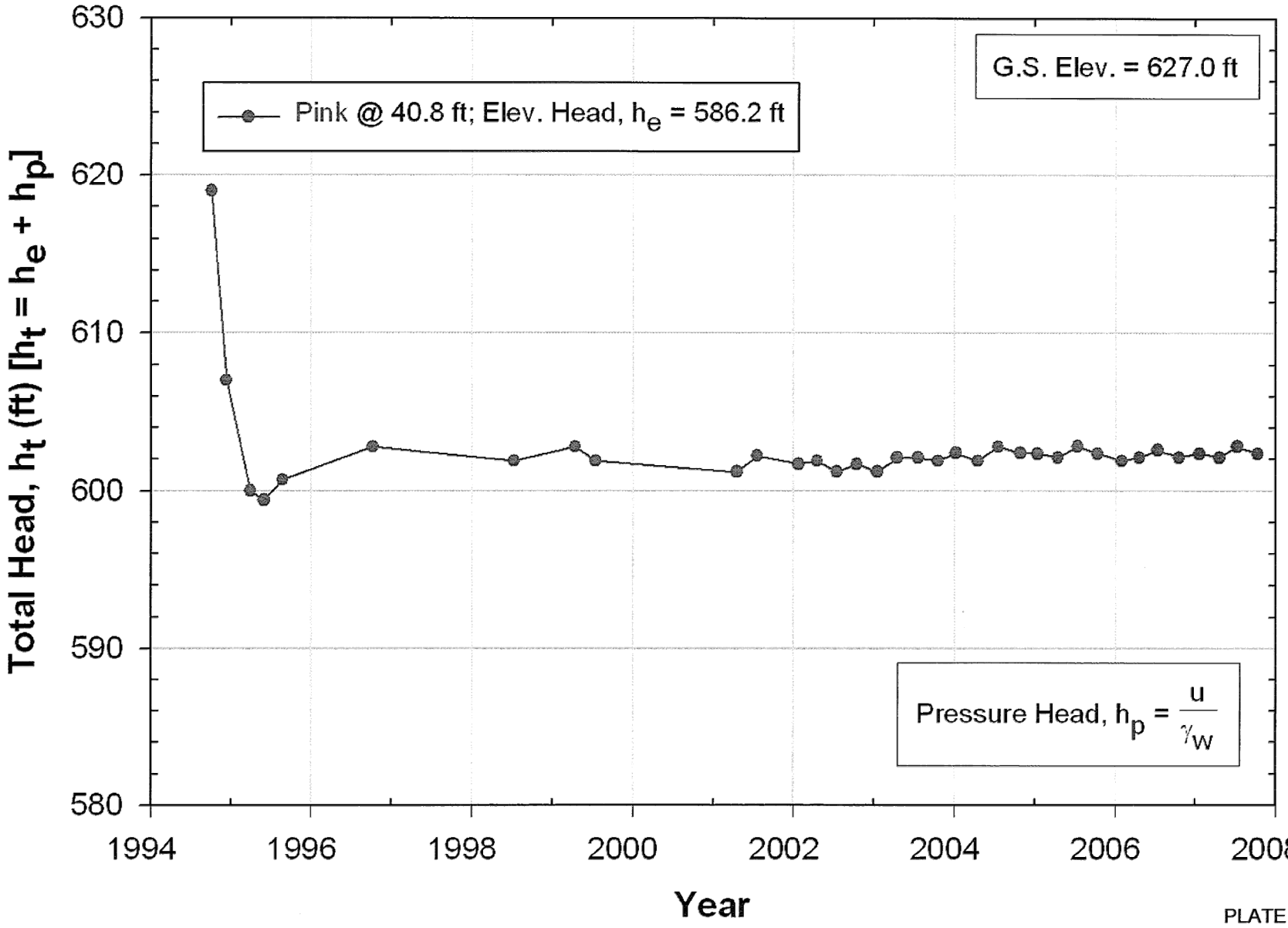


PLATE 53

B-05-01 VW Piezometer Readings

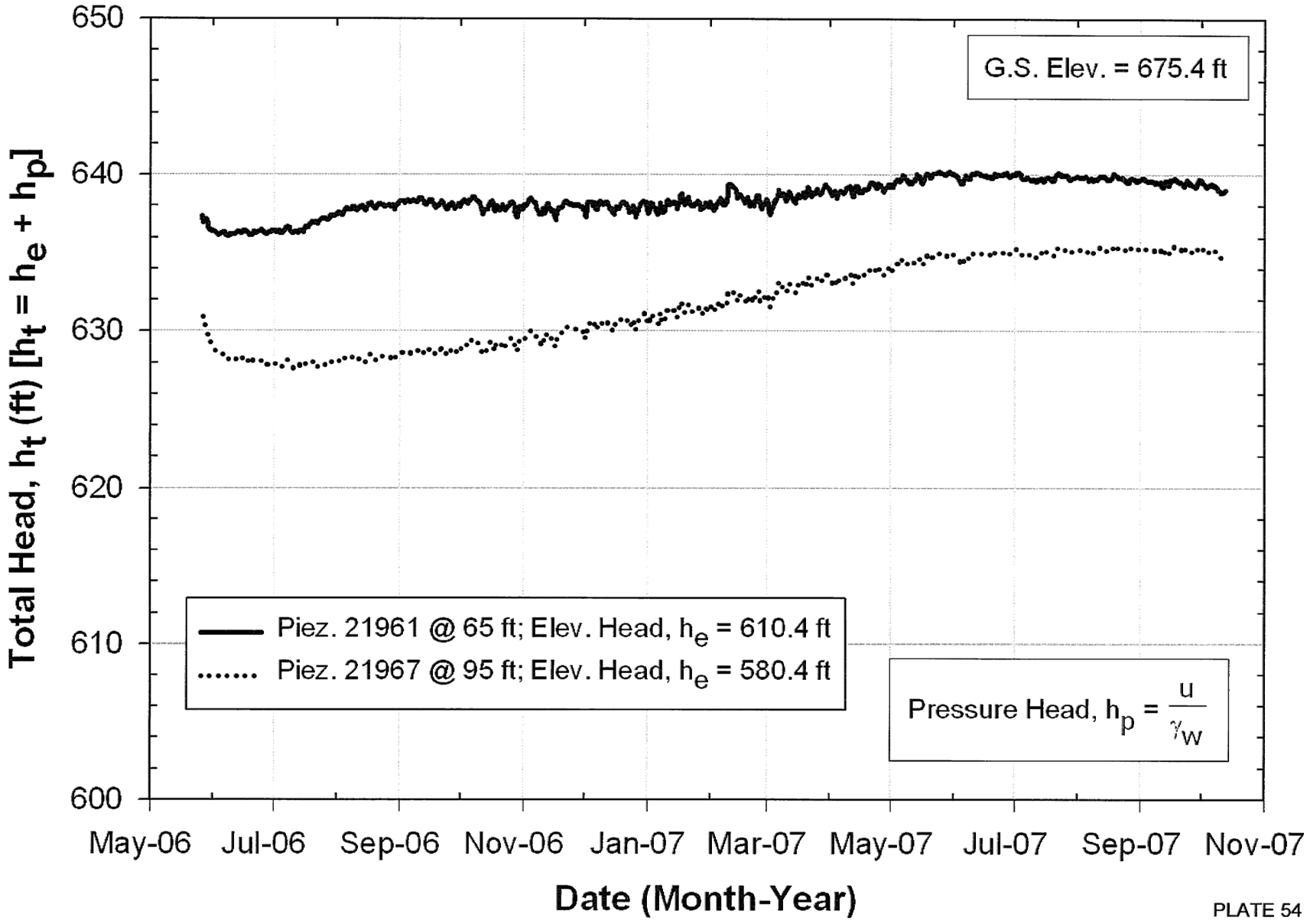


PLATE 54

B-05-02 VW Piezometer Readings

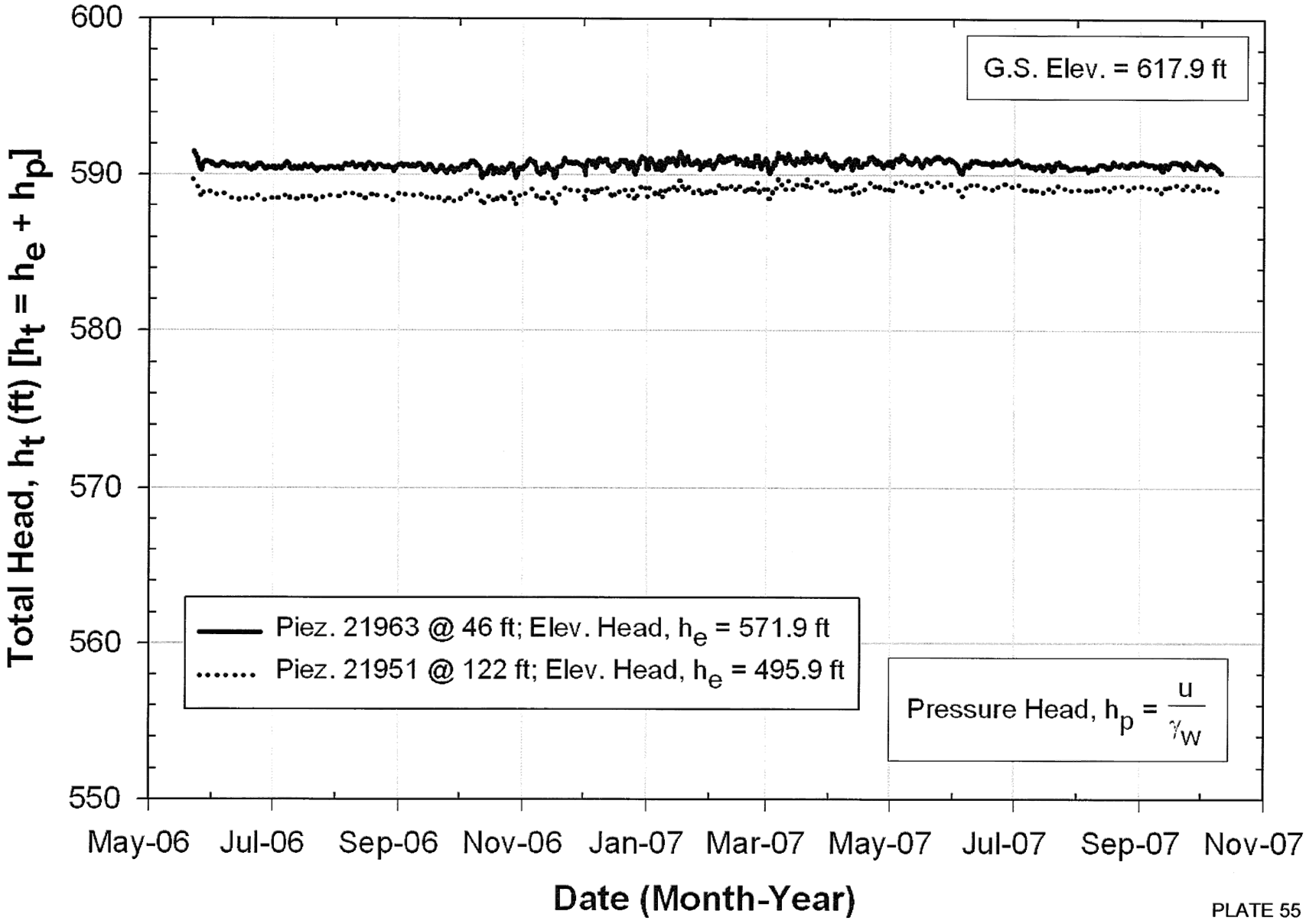


PLATE 55

B-05-03 VW Piezometer Readings

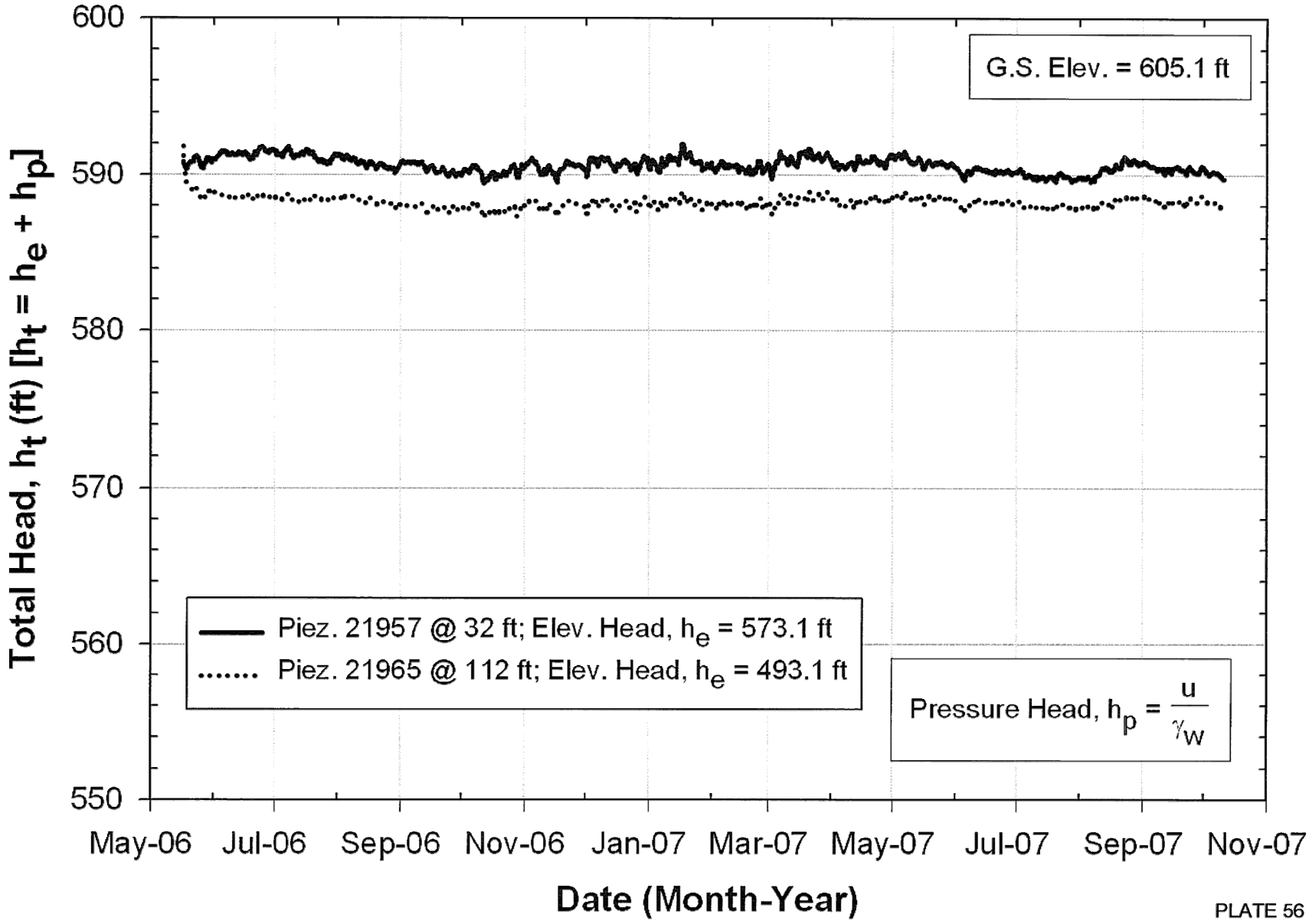


PLATE 56

B-05-04 VW Piezometer Readings

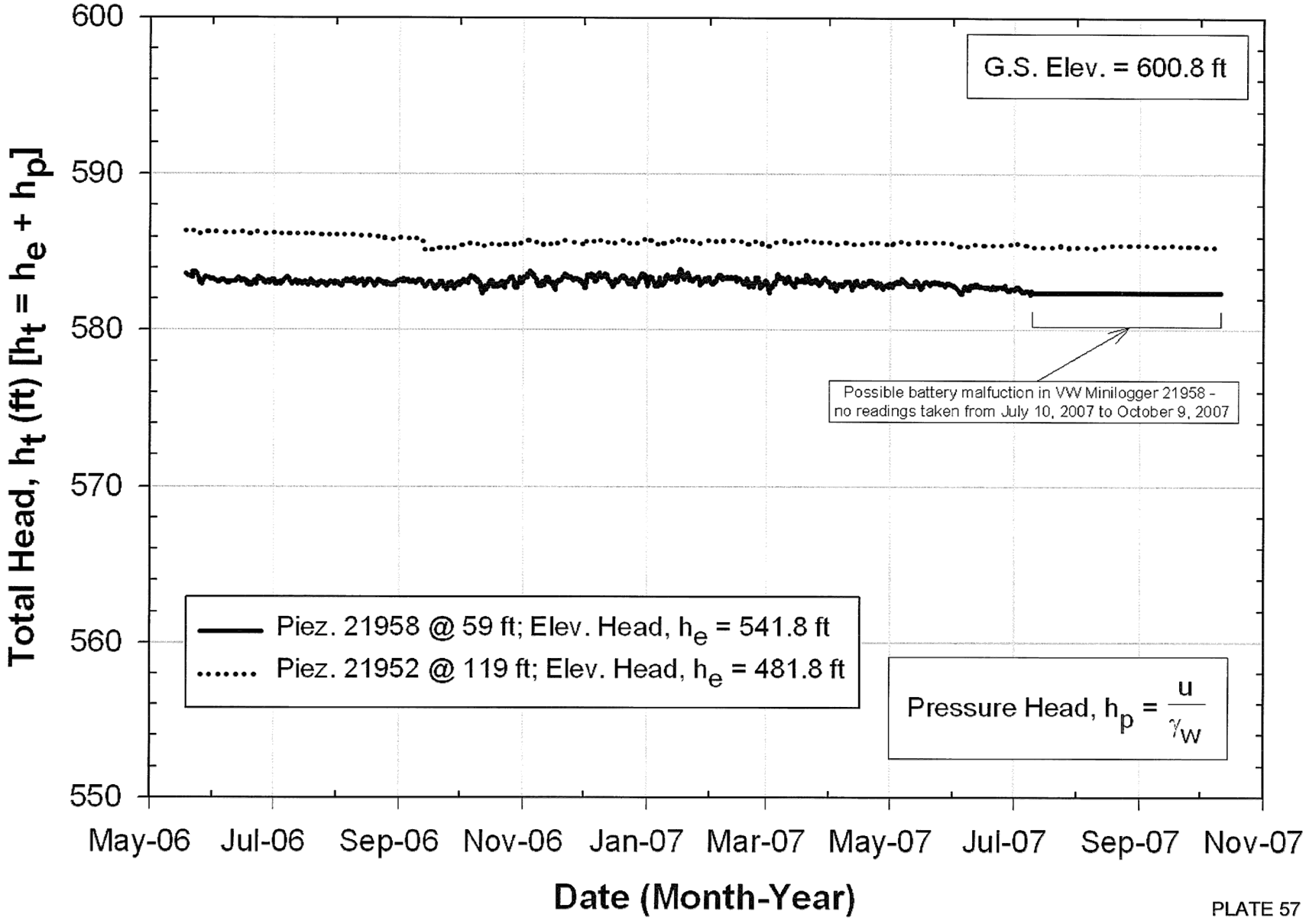


PLATE 57

B-05-07 VW Piezometer Readings

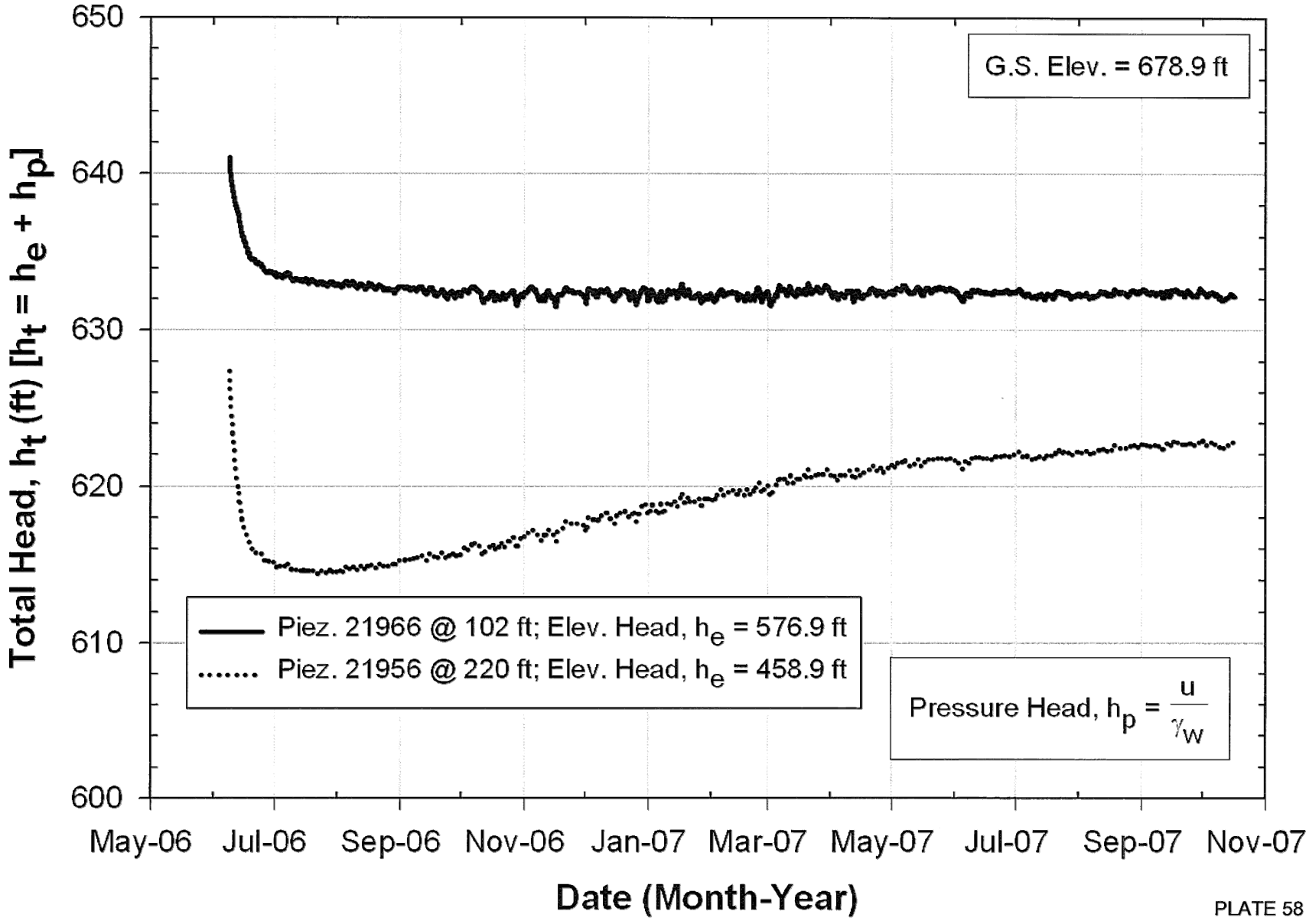


PLATE 58

B-05-08 VW Piezometer Readings

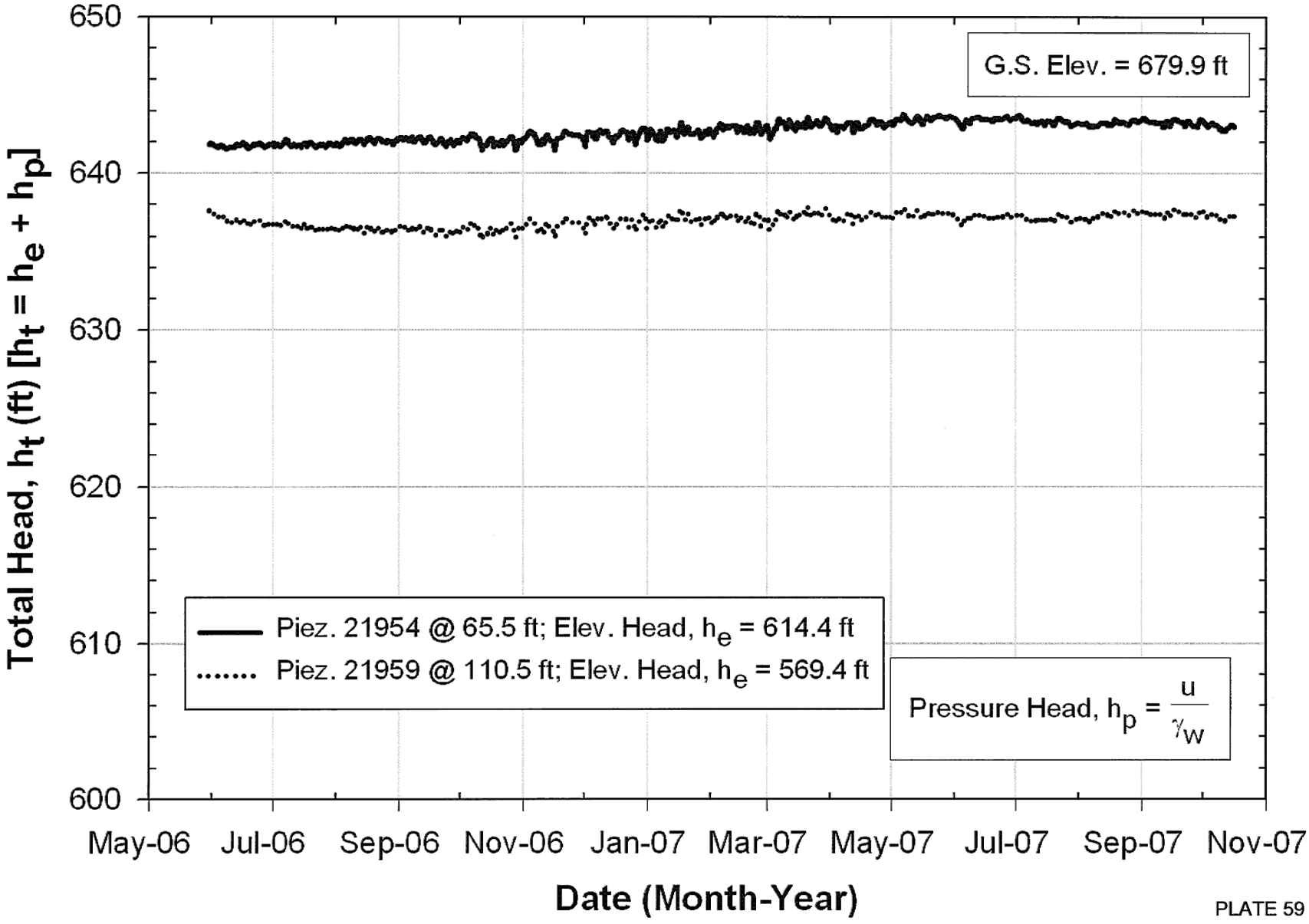


PLATE 59

B-05-11 VW Piezometer Readings

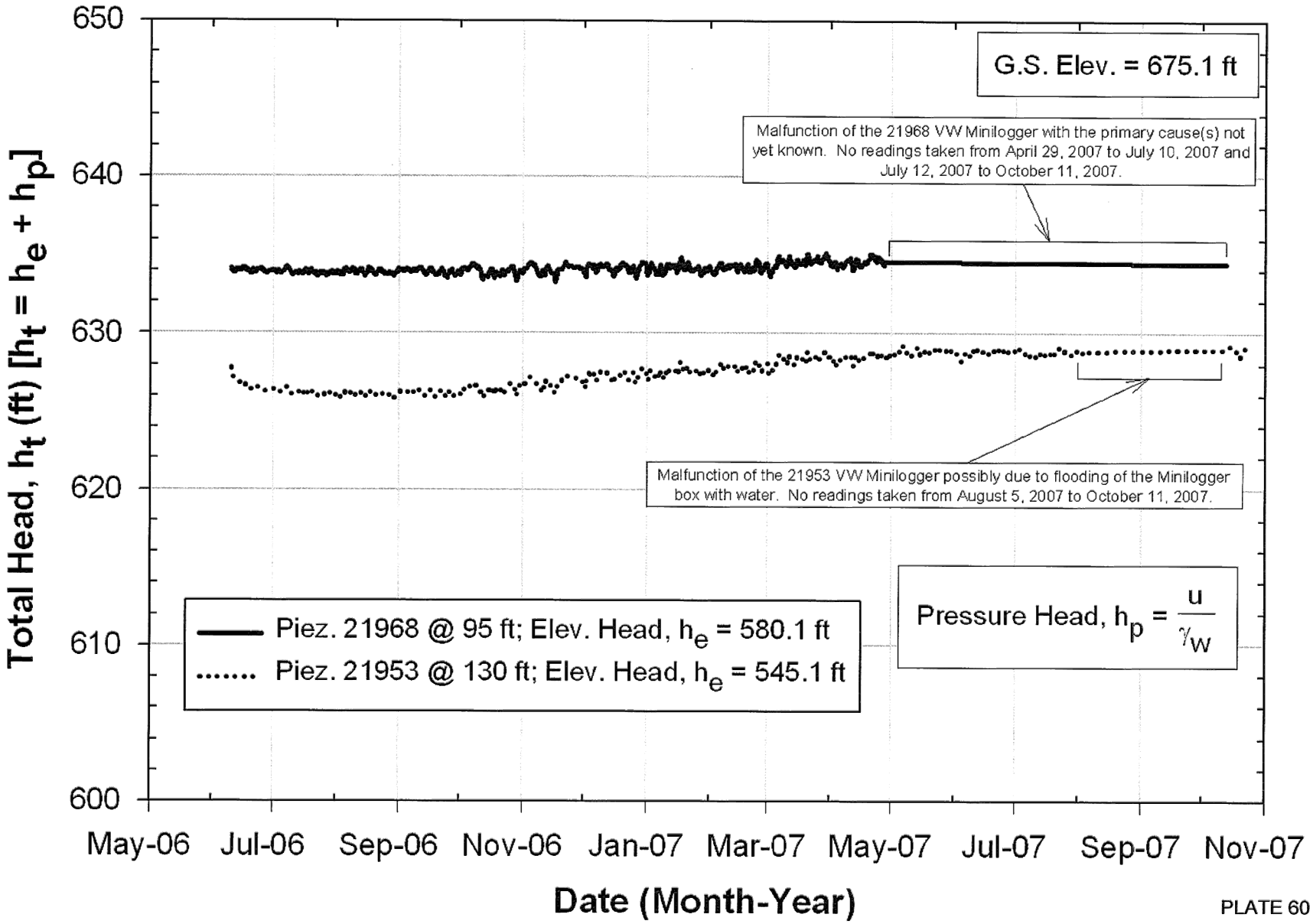


PLATE 60

B-05-12 VW Piezometer Readings

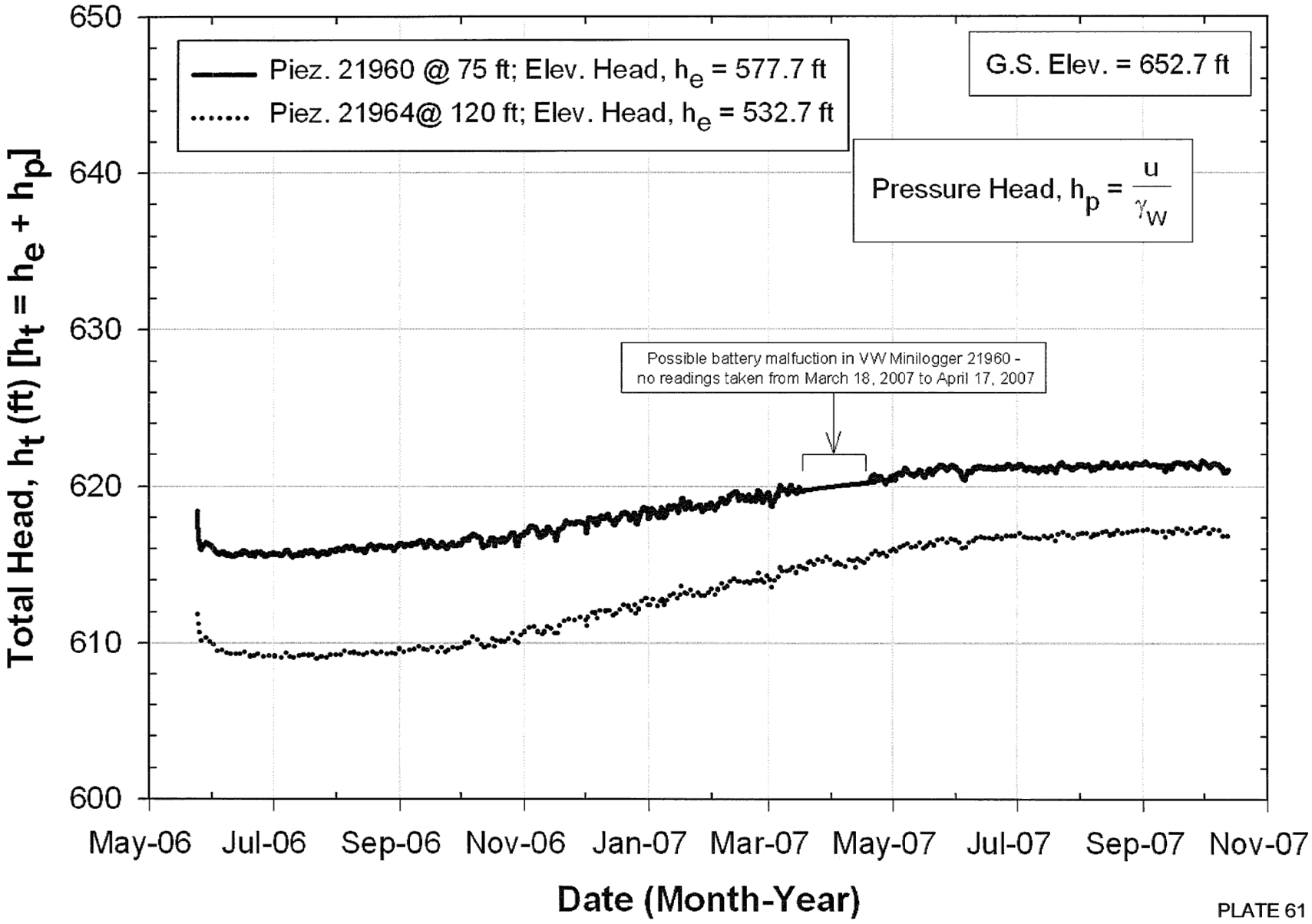


PLATE 61

B-05-13 VW Piezometer Readings

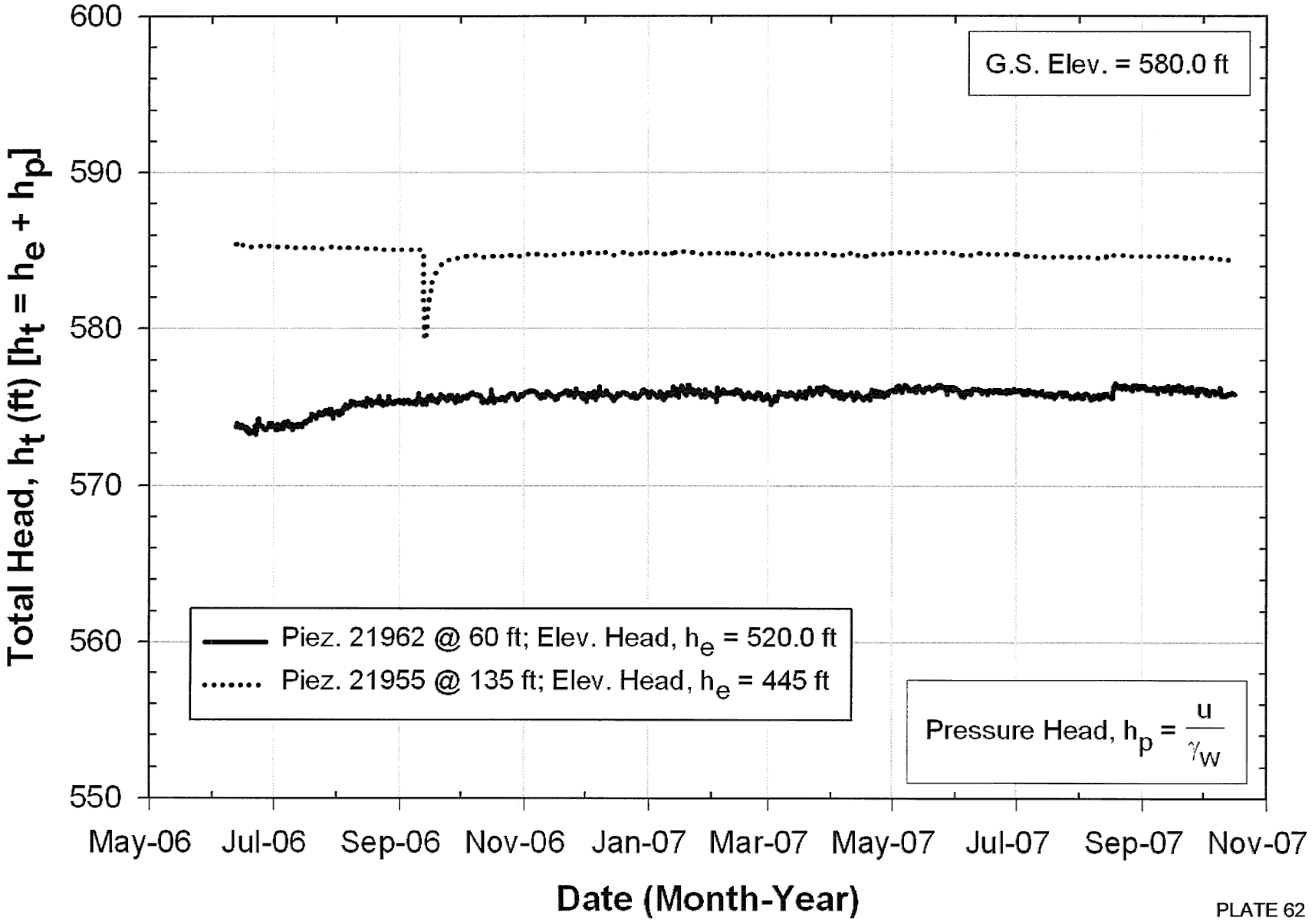


PLATE 62

CALIPERED SURFACE DISTANCE TABLE
CUY-90-15.24

Date	Left Pier Calipered Surface Distance		Center Line Calipered Surface Distance		Right Pier Calipered Surface Distance	
	Present reading	Change (in.)	Present reading	Change (in.)	Present reading	Change (in.)
01/29/01	5.929	--	Not Accessible		4.385	--
04/17/01	Not Accessible		Not Accessible		Not Accessible	
07/19/01	6.043	0.114	Not Accessible		4.312	-0.073
11/08/01	6.250	0.207	Not Accessible		4.469	0.157
01/23/02	6.253	0.003	Not Accessible		4.518	0.049
04/17/02	6.285	0.032	Not Accessible		4.435	-0.083
07/16/02	6.290	0.005	Not Accessible		4.444	0.009
10/15/02	6.333	0.043	Discontinued		4.482	0.038
01/15/03	6.405	0.072			4.473	-0.009
04/17/03	6.333	-0.072			4.482	0.009
07/18/03	6.186	-0.147			4.350	-0.132
10/16/03	6.385	0.199			4.519	0.169
01/08/04	6.124	-0.261			4.594	0.075
04/14/04	6.129	0.005			4.402	-0.193
07/16/04	6.250	0.122			4.277	-0.125
10/27/04	6.375	0.125			4.467	0.190
01/12/05	6.250	-0.125			4.349	-0.118
04/14/05	6.375	0.125			4.372	0.023
07/14/05	6.313	-0.063			4.392	0.020
10/12/05	6.375	0.063			4.358	-0.034
02/01/06	6.438	0.063			4.395	0.037
04/20/06	6.500	0.063			4.430	0.035
07/14/06	6.375	-0.125			4.381	-0.049
10/18/06	6.438	0.063			4.400	0.020
01/19/07	6.500	0.062			4.506	0.106
04/18/07	6.375	-0.125			4.357	-0.150
07/11/07	6.438	0.063			4.341	-0.015
10/12/07	6.438	0.000			4.384	0.043

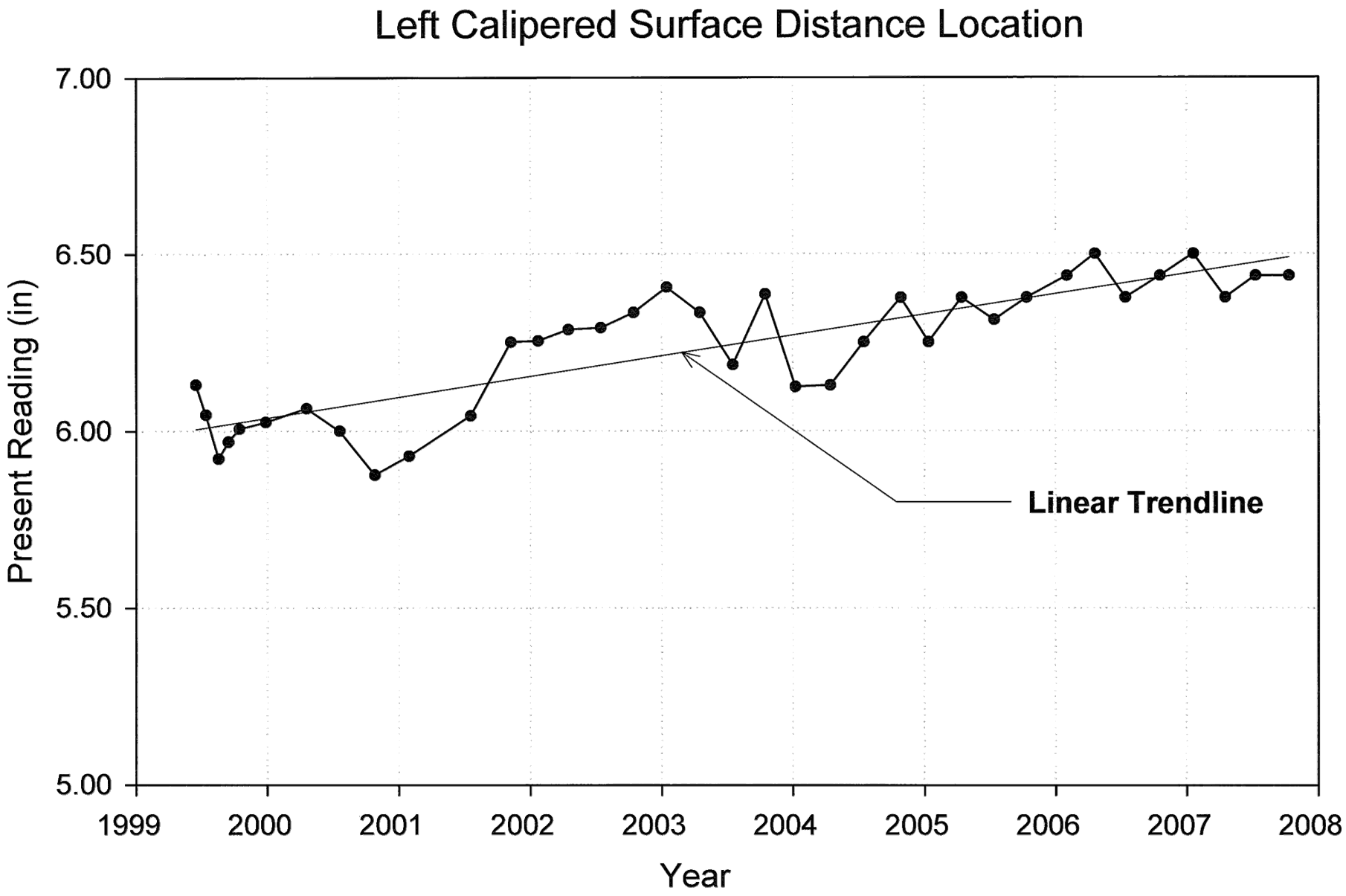

Left Calipered Surface Distance Location
7.00
6.50
6.00
5.50
5.00
Present Reading (in)
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Linear Trendline

PLATE 64

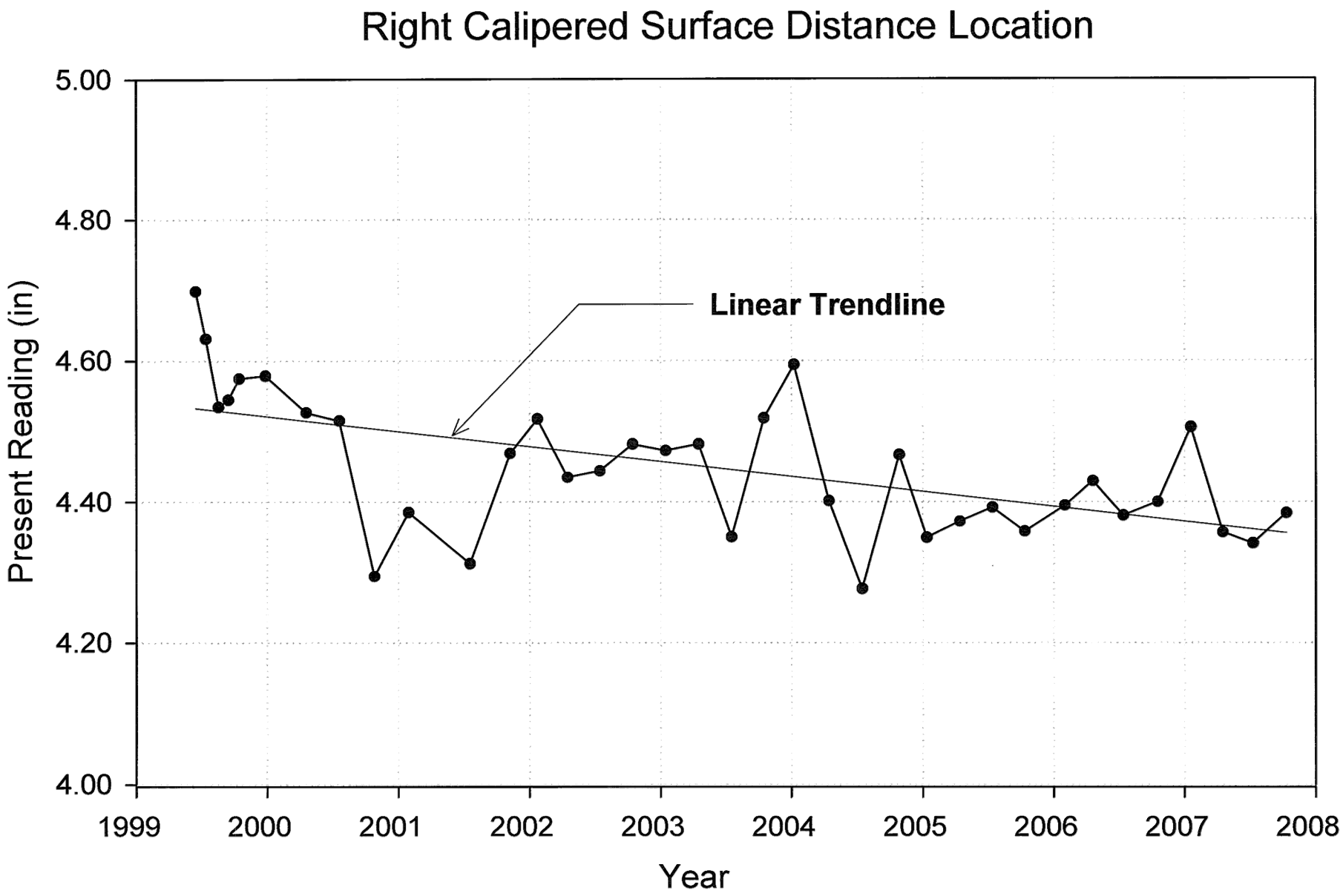

Right Calipered Surface Distance Location
5.00
4.80
4.60
4.40
4.20
4.00
Present Reading (in)
Linear Trendline
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year

PLATE 65

View towards the northwest of the excavation area adjacent to the west right-of-way fence.

PLATE 66

View towards the west of the excavation backslope adjacent to the west right-of-way fence.

PLATE 67

View towards the northwest of the bulkhead in the excavation area adjacent to the west right-of-way fence.

PLATE 68

View towards the north-northwest of the bulkhead in the excavation area adjacent to the west right-of-way fence.

PLATE 69

View of a large scarp in the landslide area adjacent to the west right-of-way fence.

PLATE 70

View of another large scarp in the landslide area adjacent to the west right-of-way fence.

PLATE 71

View towards the southeast of the large excavation area and landslide area. Photo taken from near B-05-13 across the Cuyahoga River.

PLATE 72

Close-up view towards the southeast of the landslide area adjacent to the west right-of-way fence. Photo taken from near B-05-13 across the Cuyahoga River.

PLATE 73

~~100106~~
100017

Richland Engineering Limited

From: "arthur huckelbridge" <aah4@case.edu>
To: "'Richland Engineering Limited'" <reltd@r-e-l.com>
Sent: Friday, October 19, 2007 4:13 PM
Attach: tilts_10_19_07.ppt; IN07_012.doc
Subject: RE: CUY-90-1524 Central Viaduct Monitoring

Dean:

No dramatic changes to report on the data collected today (10_19_07). Tiltmeter 6 did return to "normal", so I suspect last quarter's "odd" reading was just an electronic hiccup. At the west abutment, tiltmeter 2 continues it's northbound journey, tiltmeter 3 it's eastbound journey and tiltmeter 4 it's southbound journey. Pier 1 appears to be holding it's own. Let me know if you have any questions.

Regards,

Art

From: Richland Engineering Limited [mailto:reltd@r-e-l.com]
Sent: Tuesday, October 09, 2007 11:24 AM
To: Arthur Huckelbridge; Robert Liang; Jeff Snyder
Subject: CUY-90-1524 Central Viaduct Monitoring

A reminder that the quarterly data collection should occur about 10/15/07. Jason Burgholder and our inspection crew are at the bridge every day performing the annual inspection through the end of next week. They have the key to the gate.

Thank you,
Dean Palmer

Richland Engineering Limited
Mansfield, Ohio
(419)524-0074

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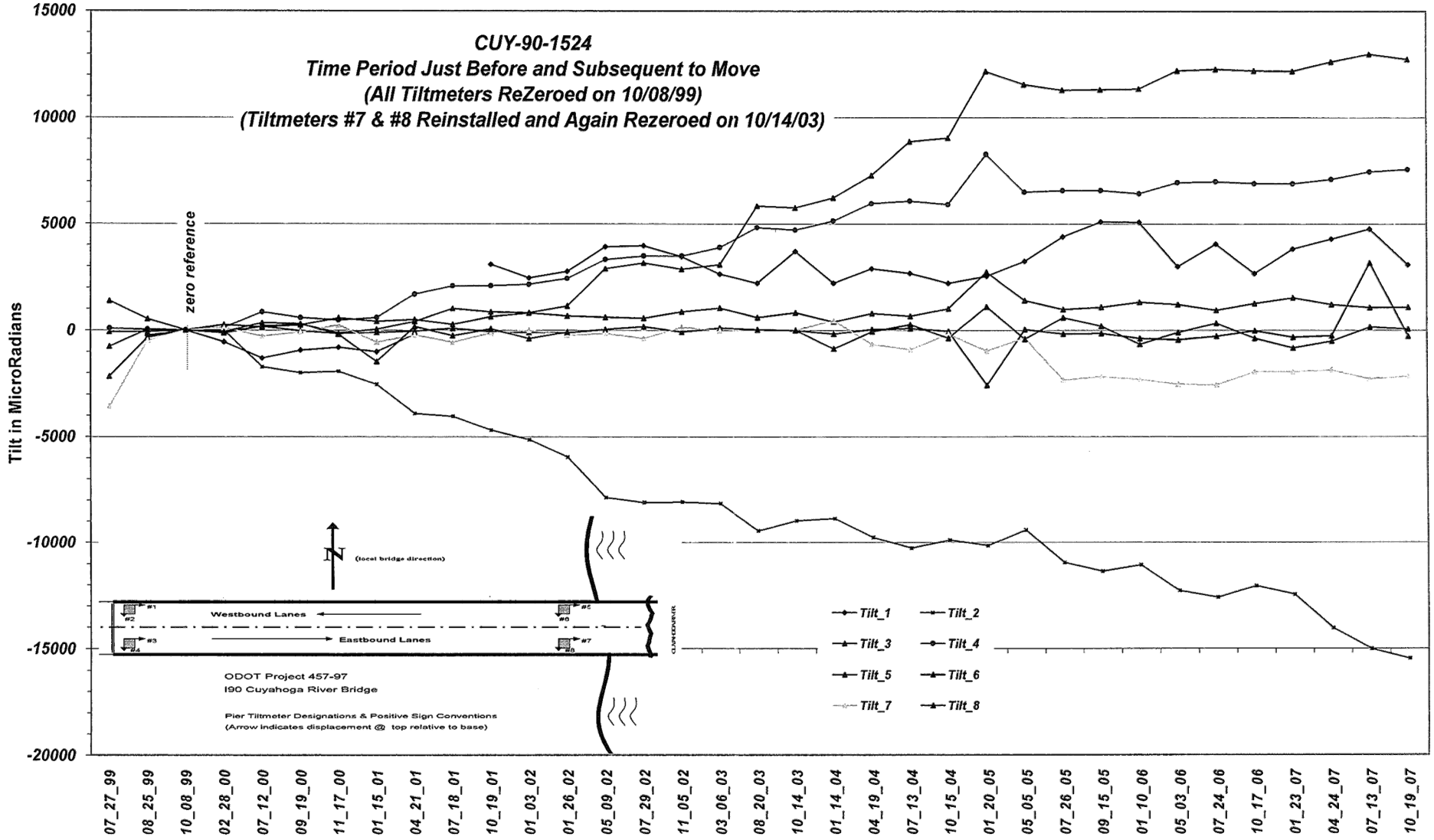

CUY-90-1524
Time Period Just Before and Subsequent to Move
(All Tiltmeters ReZeroed on 10/08/99)
(Tiltmeters #7 & #8 Reinstalled and Again Rezeroed on 10/14/03)
Tilt in MicroRadians
zero reference
15000
10000
5000
0
-5000
-10000
-15000
-20000
07_27_99
08_25_99
10_08_99
02_28_00
07_12_00
09_19_00
11_17_00
01_15_01
04_21_01
07_18_01
10_19_01
01_03_02
01_26_02
05_09_02
07_29_02
11_05_02
03_06_03
08_20_03
10_14_03
01_14_04
04_19_04
07_13_04
10_15_04
01_20_05
05_05_05
07_26_05
09_15_05
01_10_06
05_03_06
07_24_06
10_17_06
01_23_07
04_24_07
07_13_07
10_19_07
Tilt_1
Tilt_2
Tilt_3
Tilt_4
Tilt_5
Tilt_6
Tilt_7
Tilt_8
N
(local bridge direction)
Westbound Lanes
Eastbound Lanes
#1
#2
#3
#4
#5
#6
#7
#8
ODOT Project 457-97
I90 Cuyahoga River Bridge
Pier Tiltmeter Designations & Positive Sign Conventions
(Arrow indicates displacement @ top relative to base)

Robert Y. Liang, Ph.D., P.E
8441 Timber Tr.
Brecksville, Ohio 44141

Cell Phone: (440) 725-7425
e-mail: RYLIANG@AOL.COM

November 2, 2007

Mr. Dean Palmer, P.E.
Richland Engineering, Ltd.
29 North Park St.
Mansfield, OH 44902

Ref: CUY-90-14.52, PID No. 77332

Dear Mr. Palmer:

I have enclosed the monitoring data for the stabilization structures at the referenced project site. The inclinometer reading and strain data was taken on October 19 and 20. Also, the batteries were replaced and on-site data logger was maintained.

During this monitoring period, the data compiled and summarized in the attached tables indicate no significant change. The inclinometer readings of the six casings in the drilled shafts also show no significant additional movement during this quarter.

Please call me at (440) 725-7425, if you have any question. Thank you.

Sincerely,

Robert Liang
Robert Liang

Pile Forces and Bending Moments

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
1	07/01/99	903.00	42.30	679.00	-	541.43	472.65	679.00	791.00	42.30	456.92	-73.98	99.88
	07/15/99	918.00	48.00	885.00	-	617.00	483.00	885.00	901.50	48.00	520.69	-144.12	113.86
	07/31/00	932.43	51.99	887.34	-	623.92	492.21	887.34	909.89	51.99	526.53	-141.66	114.44
	08/15/99	940.56	34.46	923.00	-	632.67	487.51	923.00	931.78	34.46	533.91	-156.13	119.70
	08/30/99	948.68	31.28	931.09	-	637.02	489.98	931.09	939.89	31.28	537.58	-158.14	121.21
	09/15/99	955.75	27.83	938.36	-	640.65	491.79	938.36	947.06	27.83	540.64	-160.10	122.62
	09/30/99	959.08	23.03	947.01	-	643.04	491.06	947.01	953.05	23.03	542.66	-163.47	124.06
	10/15/99	963.38	18.85	954.86	-	645.70	491.12	954.86	959.12	18.85	544.90	-166.26	125.43
	10/31/99	973.25	5.58	968.30	-	649.04	489.42	968.30	970.78	5.58	547.73	-171.69	128.76
	11/15/99	973.34	1.26	977.48	-	650.69	487.30	977.48	975.41	1.26	549.12	-175.74	129.95
	11/30/99	975.73	-2.84	980.87	-	651.25	486.45	980.87	978.30	-2.84	549.59	-177.26	130.88
	12/15/99	974.96	-2.47	982.11	-	651.53	486.25	982.11	978.54	-2.47	549.83	-177.77	130.87
	12/31/99	974.03	-54.00	984.71		634.91	460.02	984.71	979.37	-54.00	535.80	-188.11	137.85
	03/31/00	964.52	3.86	981.83	-	650.07	484.19	981.83	973.17	3.86	548.59	-178.41	129.31
	06/30/00	977.80	-36.92	980.73	-	640.54	470.44	980.73	979.27	-36.92	540.55	-182.94	135.56
	09/30/00	1009.20	-10.20	1005.99	-	668.33	499.50	1005.99	1007.60	-10.20	564.01	-181.58	135.77
	01/13/01	1014.12	-29.4495	1029.11	-	671.26	492.33	1029.11	1021.61	-29.45	566.48	-192.44	140.21
	04/20/01	1008.27	-18.6852	1022.57	-	670.72	494.79	1022.57	1015.42	-18.69	566.02	-189.21	137.95
	07/10/01	1030.41	-8.36772	1019.56	-	680.53	511.02	1019.56	1024.98	-8.37	574.30	-182.32	137.85
	10/09/01	1054.25	-20.5131	1038.65	-	690.80	516.87	1038.65	1046.45	-20.51	582.96	-187.07	142.33
	01/09/02	1055.96	-29.65	1045.80	-	690.70	513.15	1045.80	1050.88	-29.65	582.88	-190.96	144.14
	04/12/02	1041.9	-24.8188	1040.36	-	685.81	508.54	1040.36	1041.13	-24.82	578.76	-190.66	142.20
	07/19/02	1062.21	-17.26	1035.12	17.14	693.36	522.47	1035.12	1048.67	-17.26	585.12	-183.79	142.20
	10/08/02	1086.38	-30.07	1049.75	-6.63	702.02	528.16	1049.75	1068.06	-30.07	592.43	-187.00	146.49
	01/08/03	1080.45	-42.89	1062.94	0.41	700.17	518.78	1062.94	1071.70	-42.89	590.87	-195.09	148.69
	04/15/03	1059.37	-29.65	1049.86	22.95	693.19	514.86	1049.86	1054.62	-29.65	584.99	-191.81	144.64
	06/01/03	1064.93	-31.16	1053.52	21.00	695.77	516.89	1053.52	1059.23	-31.16	587.16	-192.39	145.46
	08/07/03	1083.86	-27.66	1053.40	9.26	703.20	528.10	1053.40	1068.63	-27.66	593.43	-188.33	146.25
	10/07/03	1095.56	-38.67	1066.64	-0.69	707.84	528.45	1066.64	1081.10	-38.67	597.35	-192.95	149.38
	12/31/03	1100.15	-54.88	1082.97	-0.89	709.41	522.64	1082.97	1091.56	-54.88	598.68	-200.89	152.93
	04/13/04	1080.17	-43.67	1074.07	21.65	703.52	518.25	1074.07	1077.12	-43.67	593.70	-199.27	149.51
	07/13/04	1101.53	-34.89	1072.49	10.76	713.04	533.32	1072.49	1087.01	-34.89	601.74	-193.30	149.66
	10/08/04	1122.82	-45.70	1085.57	-8.86	720.90	538.56	1085.57	1104.19	-45.70	608.36	-196.11	153.40
	01/07/05	1116.60	-58.49	1097.39	-8.94	718.50	529.06	1097.39	1107.00	-58.49	606.34	-203.76	155.48
	04/08/05	1099.01	-52.77	1096.58	5.48	714.28	523.12	1096.58	1097.80	-52.77	602.78	-205.59	153.49
	07/18/05	1116.44	-41.55	1096.58	-2.36	723.82	537.44	1096.58	1106.51	-41.55	610.83	-200.46	153.15
	08/26/05	1128.14	-43.63	1095.73	-10.20	726.75	542.26	1095.73	1111.93	-43.63	613.30	-198.43	154.15
	11/12/05	1127.45	-44.76	1095.72	-9.67	726.14	541.34	1095.72	1111.58	-44.76	612.79	-198.75	154.26
	01/10/06	1129.36	-64.30	1095.72	-19.70	720.26	532.53	1095.72	1112.54	-64.30	607.83	-201.91	156.99
	04/09/06	1114.90	-55.20	1095.72	-1.14	718.47	529.85	1095.72	1105.31	-55.20	606.32	-202.87	154.81
	07/19/06	1130.94	-46.83	1095.72	-9.42	726.61	542.05	1095.72	1113.33	-46.83	613.19	-198.50	154.77
	10/18/06	1154.91	-58.29	1095.72	-27.50	730.78	548.31	1095.72	1125.32	-58.29	616.71	-196.26	157.89
	01/18/07	1139.55	-68.49	1095.72	-21.73	722.26	535.53	1095.72	1117.64	-68.49	609.52	-200.84	158.23
	04/19/07	1125.58	-58.82	1095.72	-8.49	720.83	533.38	1095.72	1110.65	-58.82	608.31	-201.61	156.01
	07/09/07	1141.38	-47.08	1095.72	-16.09	730.01	547.15	1095.72	1118.55	-47.08	616.05	-196.67	155.50
	10/20/07	1161.81	-62.03	1095.72	-36.23	731.84	549.89	1095.72	1128.77	-62.03	617.60	-195.69	158.85

Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
17	07/01/99	575.00	589.00	243.00	-	469.00	582.00	243.00	409.00	589.00	395.79	121.54	-24.01
	07/15/99	585.00	602.00	237.00	-	474.67	593.50	237.00	411.00	602.00	400.57	127.81	-25.48
	07/30/99	594.35	611.17	230.68	-	478.73	602.76	230.68	412.52	611.17	404.00	133.40	-26.50
	08/15/99	596.87	611.09	242.58	336.68	446.81	603.98	289.63	419.73	473.89	377.06	112.70	-7.22
	08/31/99	601.58	616.82	241.00	-	486.47	609.20	241.00	421.29	616.82	410.53	132.00	-26.08
	09/15/99	605.96	622.42	240.47	-	489.62	614.19	240.47	423.22	622.42	413.19	133.98	-26.57
	09/30/99	609.62	624.20	240.71	336.98	452.88	616.91	288.85	425.17	480.59	382.18	117.62	-7.39
	10/15/99	612.87	629.40	240.27	336.21	454.69	621.14	288.24	426.57	482.81	383.71	119.35	-7.50
	10/31/99	616.45	631.80	243.11	336.29	456.91	624.13	289.70	429.78	484.05	385.59	119.90	-7.24
	11/15/99	619.54	632.45	245.83	337.79	458.90	626.00	291.81	432.69	485.12	387.27	119.81	-6.99
	11/30/99	623.35	635.58	248.71	340.31	461.99	629.47	294.51	436.03	487.95	389.87	120.09	-6.93
	12/15/99	624.21	637.77	247.77	339.95	462.43	630.99	293.86	435.99	488.86	390.24	120.87	-7.05
	12/31/99	626.60	640.86	249.37	341.45	464.57	633.73	295.41	437.99	491.16	392.05	121.29	-7.09
	03/31/00	634.53	648.30	254.69	346.89	471.10	641.41	300.79	444.61	497.60	397.56	122.12	-7.07
	06/30/00	640.05	652.80	250.99	342.06	471.48	646.43	296.53	445.52	497.43	397.88	125.44	-6.93
	09/30/00	647.16	661.13	247.62	336.78	473.17	654.14	292.20	447.39	498.96	399.31	129.76	-6.88
	01/13/01	654.063	665.1119	256.39	342.22	479.45	659.59	299.31	455.23	503.67	404.61	129.16	-6.46
	04/20/01	654.429	664.7057	260.37	345.47	481.25	659.57	302.92	457.40	505.09	406.12	127.86	-6.36
	07/10/01	661.456	672.0985	256.15	342.75	483.11	666.78	299.45	458.80	507.43	407.70	131.69	-6.49
	10/09/01	668.361	679.0039	251.93	338.20	484.37	673.68	295.06	460.14	508.60	408.76	135.74	-6.46
	01/09/02	671.083	683.4721	252.17	337.92	486.16	677.28	295.04	461.63	510.69	410.27	137.04	-6.55
	04/12/02	669.17	680.02	256.68	342.06	486.98	674.60	299.37	462.93	511.04	410.96	134.52	-6.42
	07/19/02	671.69	683.96	253.27	272.93	470.46	677.83	263.10	462.48	478.44	397.02	148.69	-2.13
	10/08/02	678.60	692.21	247.01	332.37	487.54	685.40	289.69	462.80	512.29	411.44	141.87	-6.60
	01/08/03	678.44	689.32	251.28	334.22	488.31	683.88	292.75	464.86	511.77	412.09	140.22	-6.26
	04/15/03	679.45	692.45	254.73	341.09	491.93	685.95	297.91	467.09	516.77	415.14	139.12	-6.63
	06/01/03	678.76	689.85	256.43	341.09	491.53	684.30	298.76	467.60	515.47	414.80	138.22	-6.39
	08/07/03	682.33	695.54	251.15	336.74	491.44	688.94	293.95	466.74	516.14	414.73	141.61	-6.59
	10/07/03	686.23	700.57	250.14	334.87	492.95	693.40	292.50	468.19	517.72	416.00	143.73	-6.61
	12/31/03	689.48	700.61	257.04	341.05	497.05	695.05	299.04	473.26	520.83	419.46	141.97	-6.35
	04/13/04	689.24	699.88	260.70	346.65	499.12	694.56	303.68	474.97	523.27	421.21	140.14	-6.44
	07/13/04	693.10	667.59	255.46	341.33	489.37	680.34	298.39	474.28	504.46	412.98	136.93	-4.03
	10/08/04	699.03	710.89	250.83	337.39	499.53	704.96	294.11	474.93	524.14	421.56	147.30	-6.56
	01/07/05	699.07	711.46	253.31	339.95	500.95	705.26	296.63	476.19	525.70	422.75	146.50	-6.61
	04/08/05	696.43	708.09	257.94	343.81	501.57	702.26	300.87	477.18	525.95	423.27	143.90	-6.51
	07/18/05	699.56	708.33	253.71	338.36	499.99	703.94	296.04	476.64	523.35	421.94	146.24	-6.23
	08/26/05	702.04	711.17	250.91	335.97	500.02	706.61	293.44	476.47	523.57	421.97	148.13	-6.28
	11/12/05	701.95	699.60	251.68	337.06	497.57	700.78	294.37	476.82	518.33	419.90	145.70	-5.54
	01/10/06	705.16	715.03	253.47	339.58	503.31	710.10	296.53	479.32	527.31	424.75	148.27	-6.40
	04/09/06	703.94	713.04	259.52	343.20	504.93	708.49	301.36	481.73	528.12	426.11	145.96	-6.19
	07/19/06	708.37	716.01	256.84	339.95	505.29	712.19	298.39	482.61	527.98	426.42	148.35	-6.05
	10/18/06	713.29	721.25	251.76	334.02	505.08	717.27	292.89	482.52	527.63	426.24	152.14	-6.02
	01/18/07	712.84	717.96	256.52	336.54	505.96	715.40	296.53	484.68	527.25	426.98	150.17	-5.68
	04/19/07	711.13	716.21	260.62	340.56	507.13	713.67	300.59	485.88	528.38	427.97	148.10	-5.67
	07/09/07	713.04	716.74	255.22	334.18	504.79	714.89	294.70	484.13	525.46	426.00	150.64	-5.51
	10/20/07	715.97	721.74	250.87	329.51	504.52	718.85	290.19	483.42	525.62	425.77	153.68	-5.63

Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
18	07/01/99	546.00	501.00	248.00	173	367.00	523.50	210.50	397.00	337.00	309.71	112.21	8.00
	07/15/99	557.00	513.00	243.00	229	385.50	535.00	236.00	400.00	371.00	325.32	107.20	3.87
	07/30/99	565.55	519.94	239.54	224.26	387.32	542.75	231.90	402.55	372.10	326.86	111.44	4.06
	08/15/99	567.71	520.14	230.56	232.51	387.73	543.93	231.54	399.14	376.33	327.21	112.00	3.04
	08/31/99	573.72	526.52	247.46	232.87	395.14	550.12	240.17	410.59	379.70	333.46	111.12	4.12
	09/15/99	578.06	532.08	246.65	233.61	397.60	555.07	240.13	412.36	382.85	335.53	112.91	3.94
	09/30/99	582.49	534.97	247.46	234.05	399.74	558.73	240.76	414.98	384.51	337.34	114.00	4.06
	10/15/99	586.68	538.17	247.25	235.23	401.83	562.43	241.24	416.97	386.70	339.11	115.15	4.04
	10/31/99	590.77	539.40	249.37	235.6	403.79	565.09	242.49	420.07	387.50	340.75	115.66	4.34
	11/15/99	592.65	540.65	251.68	237.47	405.61	566.65	244.58	422.17	389.06	342.30	115.47	4.42
	11/30/99	596.63	527.25	254.12	239.69	404.42	561.94	246.91	425.38	383.47	341.29	112.94	5.59
	12/15/99	599.47	545.53	254.12	239.05	409.54	572.50	246.59	426.80	392.29	345.61	116.84	4.60
	12/31/99	601.54	548.45	255.38	239.17	411.14	575.00	247.28	428.46	393.81	346.96	117.49	4.62
	03/31/00	610.32	554.87	262.08	243.60	417.72	582.59	252.84	436.20	399.23	352.51	118.22	4.93
	06/30/00	616.94	539.60	260.98	238.93	414.11	578.27	249.96	438.96	389.26	349.47	117.70	6.63
	09/30/00	625.63	400.76	255.58	232.18	378.54	513.19	243.88	440.61	316.47	319.45	96.55	16.56
	01/13/01	632.372	566.6896	264.44	235.84	424.83	599.53	250.14	448.40	401.26	358.52	125.26	6.29
	04/20/01	632.575	561.5309	268.38	236.21	424.67	597.05	252.29	450.48	398.87	358.38	123.60	6.88
	07/10/01	639.684	569.2893	264.64	234.54	427.04	604.49	249.59	452.16	401.91	360.38	127.23	6.70
	10/09/01	646.508	576.5197	259.81	232.14	428.74	611.51	245.97	453.16	404.33	361.82	131.05	6.51
	01/09/02	650.895	576.8446	259.68	230.92	429.59	613.87	245.30	455.29	403.88	362.53	132.14	6.86
	04/12/02	650.123	570.1017	264.192	232.55	429.24	610.11	248.37	457.16	401.33	362.24	129.69	7.45
	07/19/02	653.45	572.46	260.90	226.38	428.30	612.96	243.64	457.18	399.42	361.44	132.40	7.71
	10/08/02	659.69	581.14	254.65	222.68	429.54	620.41	238.66	457.17	401.91	362.49	136.86	7.37
	01/08/03	657.76	576.89	257.57	224.47	429.17	617.32	241.02	457.67	400.68	362.18	134.91	7.60
	04/15/03	661.78	576.19	262.16	228.04	432.04	618.99	245.10	461.97	402.12	364.60	134.04	7.98
	06/01/03	661.37	572.66	264.07	227.59	431.43	617.02	245.83	462.72	400.13	364.08	133.07	8.35
	08/07/03	665.76	577.29	258.18	222.76	431.00	621.53	240.47	461.97	400.03	363.72	136.61	8.26
	10/07/03	669.26	582.73	256.11	222.56	432.66	625.99	239.33	462.68	402.65	365.13	138.62	8.01
	12/31/03	670.27	581.39	262.53	229.62	435.95	625.83	246.08	466.40	405.51	367.90	136.15	8.12
	04/13/04	669.42	576.64	266.47	232.35	436.22	623.03	249.41	467.94	404.49	368.12	133.95	8.46
	07/13/04	672.95	578.63	261.80	224.79	434.54	625.79	243.29	467.37	401.71	366.71	137.13	8.76
	10/08/04	677.95	587.12	255.42	222.31	435.70	632.53	238.87	466.68	404.72	367.69	141.14	8.27
	01/07/05	677.50	586.02	257.61	226.05	436.80	631.76	241.83	467.56	406.04	368.61	139.80	8.21
	04/08/05	674.17	580.83	263.14	227.80	436.48	627.50	245.47	468.65	404.31	368.35	136.96	8.58
	07/18/05	677.87	580.70	259.40	221.74	434.93	629.29	240.57	468.63	401.22	367.04	139.36	8.99
	08/26/05	679.25	583.30	256.27	219.43	434.56	631.28	237.85	467.76	401.37	366.73	141.05	8.86
	11/12/05	679.13	583.14	256.88	220.08	434.81	631.13	238.48	468.00	401.61	366.93	140.77	8.86
	01/10/06	679.45	587.32	257.33	223.00	436.78	633.39	240.17	468.39	405.16	368.60	140.97	8.43
	04/09/06	679.57	583.14	263.01	226.46	438.05	631.36	244.74	471.29	404.80	369.67	138.61	8.87
	07/19/06	683.27	585.78	260.94	222.31	438.08	634.53	241.63	472.11	404.05	369.69	140.86	9.08
	10/18/06	687.01	592.40	255.09	218.66	438.29	639.70	236.88	471.05	405.53	369.87	144.42	8.74
	01/18/07	685.10	588.58	259.16	221.83	438.67	636.84	240.49	472.13	405.20	370.19	142.10	8.93
	04/19/07	685.18	584.40	264.40	222.96	439.23	634.79	243.68	474.79	403.68	370.67	140.22	9.49
	07/09/07	687.74	584.85	259.24	215.85	436.92	636.29	237.55	473.49	400.35	368.72	142.96	9.76
	10/20/07	690.01	591.22	253.79	213.46	437.12	640.62	233.63	471.90	402.34	368.89	145.91	9.28

Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
19	07/01/99	566.97	586.00	298.00	228.9	419.97	576.49	263.45	432.49	407.45	354.41	112.23	3.34
	07/15/99	580.00	597.00	294.00	224	423.75	588.50	259.00	437.00	410.50	357.60	118.13	3.54
	07/30/99	588.71	606.46	291.38	218.62	426.29	597.59	255.00	440.05	412.54	359.75	122.82	3.67
	08/15/99	591.02	607.35	300.95	227.92	431.81	599.19	264.44	445.99	417.64	364.40	120.01	3.78
	08/31/99	595.94	613.52	300.59	229.63	434.92	604.73	265.11	448.27	421.58	367.03	121.76	3.56
	09/15/99	599.88	617.91	300.67	229.54	437.00	608.90	265.11	450.28	423.73	368.78	123.25	3.54
	09/30/99	603.53	621.65	302.70	229.75	439.41	612.59	266.23	453.12	425.70	370.82	124.18	3.66
	10/15/99	607.51	625.02	302.29	229.71	441.13	616.27	266.00	454.90	427.37	372.27	125.57	3.67
	10/31/99	611.37	627.25	306.07	229.7	443.60	619.31	267.89	458.72	428.48	374.35	125.99	4.03
	11/15/99	613.61	627.78	308.31	232.67	445.59	620.70	270.49	460.96	430.23	376.04	125.55	4.10
	11/30/99	616.29	630.54	313.83	234.7	448.84	623.42	274.27	465.06	432.62	378.78	125.17	4.33
	12/15/99	617.83	631.44	314.03	234.9	449.55	624.64	274.47	465.93	433.17	379.38	125.54	4.37
	12/31/99	619.94	634.20	314.36	236.45	451.24	627.07	275.41	467.15	435.33	380.80	126.08	4.25
	03/31/00	629.45	639.44	320.33	239.74	457.24	634.44	280.03	474.89	439.59	385.86	127.06	4.71
	06/30/00	636.15	643.50	317.81	51.91	412.34	639.83	184.86	476.98	347.71	347.98	163.11	17.25
	09/30/00	646.59	651.99	312.33	231.29	460.55	649.29	271.81	479.46	441.64	388.66	135.33	5.04
	01/13/01	653.454	657.0691	320.21	236.77	466.88	655.26	278.49	486.83	446.92	394.00	135.08	5.32
	04/20/01	651.464	653.2102	324.03	237.42	466.53	652.34	280.72	487.74	445.32	393.71	133.23	5.66
	07/10/01	658.856	661.1717	320.61	235.03	468.92	660.01	277.82	489.74	448.10	395.72	137.02	5.55
	10/09/01	667.346	669.2551	315.37	230.97	470.74	668.30	273.17	491.36	450.11	397.25	141.66	5.50
	01/09/02	670.88	671.7736	315.66	229.71	472.00	671.33	272.68	493.27	450.74	398.32	142.92	5.67
	04/12/02	667.71	665.64	321.06	231.62	471.51	666.68	276.34	494.39	448.63	397.90	139.94	6.10
	07/19/02	673.44	667.87	319.88	227.72	472.23	670.66	273.80	496.66	447.79	398.51	142.28	6.52
	10/08/02	681.93	676.18	313.24	222.91	473.56	679.05	268.07	497.58	449.54	399.64	147.34	6.41
	01/08/03	682.42	673.60	316.88	225.03	474.48	678.01	270.96	499.65	449.32	400.42	145.93	6.71
	04/15/03	686.11	672.95	321.26	228.37	477.17	679.53	274.81	503.69	450.66	402.69	145.10	7.07
	06/01/03	685.30	670.80	322.48	227.84	476.60	678.05	275.16	503.89	449.32	402.21	144.44	7.28
	08/07/03	689.12	675.35	317.28	223.09	476.21	682.23	270.18	503.20	449.22	401.87	147.72	7.20
	10/07/03	694.48	681.03	314.64	222.27	478.11	687.76	268.46	504.56	451.65	403.47	150.32	7.06
	12/31/03	695.94	680.95	322.73	229.34	482.24	688.45	276.03	509.33	455.15	406.96	147.86	7.23
	04/13/04	695.62	676.77	330.77	231.41	483.64	686.19	281.09	513.19	454.09	408.15	145.23	7.88
	07/13/04	700.37	679.61	327.88	224.22	483.02	689.99	276.05	514.13	451.92	407.62	148.40	8.30
	10/08/04	706.18	688.67	321.87	221.22	484.48	697.43	271.54	514.03	454.94	408.86	152.68	7.88
	01/07/05	705.37	688.14	324.72	224.55	485.69	696.75	274.63	515.04	456.35	409.88	151.34	7.83
	04/08/05	702.85	682.86	329.75	226.66	485.53	692.86	278.21	516.30	454.76	409.74	148.66	8.21
	07/18/05	706.50	683.55	327.15	219.55	484.19	695.03	273.35	516.83	451.55	408.61	151.18	8.71
	08/26/05	708.05	686.48	322.81	217.89	483.80	697.26	270.35	515.43	452.18	408.28	153.05	8.44
	11/12/05	707.97	686.27	323.74	218.33	484.08	697.12	271.04	515.85	452.30	408.51	152.76	8.48
	01/10/06	710.04	690.54	324.68	221.62	486.72	700.29	273.15	517.36	456.08	410.74	153.13	8.17
	04/09/06	709.47	686.72	329.75	224.34	487.57	698.10	277.05	519.61	455.53	411.46	150.95	8.55
	07/19/06	714.26	690.38	328.09	220.57	488.32	702.32	274.33	521.17	455.47	412.10	153.44	8.76
	10/18/06	718.93	696.80	321.91	216.75	488.60	707.86	269.33	520.42	456.77	412.33	157.22	8.49
	01/18/07	717.19	692.98	326.63	219.88	489.17	705.08	273.25	521.91	456.43	412.81	154.82	8.73
	04/19/07	716.98	689.52	331.50	221.54	489.89	703.25	276.52	524.24	455.53	413.42	152.99	9.17
	07/09/07	720.64	690.13	327.60	214.47	488.21	705.39	271.04	524.12	452.30	412.00	155.72	9.58
	10/20/07	723.97	695.70	321.18	211.96	488.20	709.83	266.57	522.58	453.83	411.99	158.92	9.17

Pile Forces and Bending Moments (cont'd)

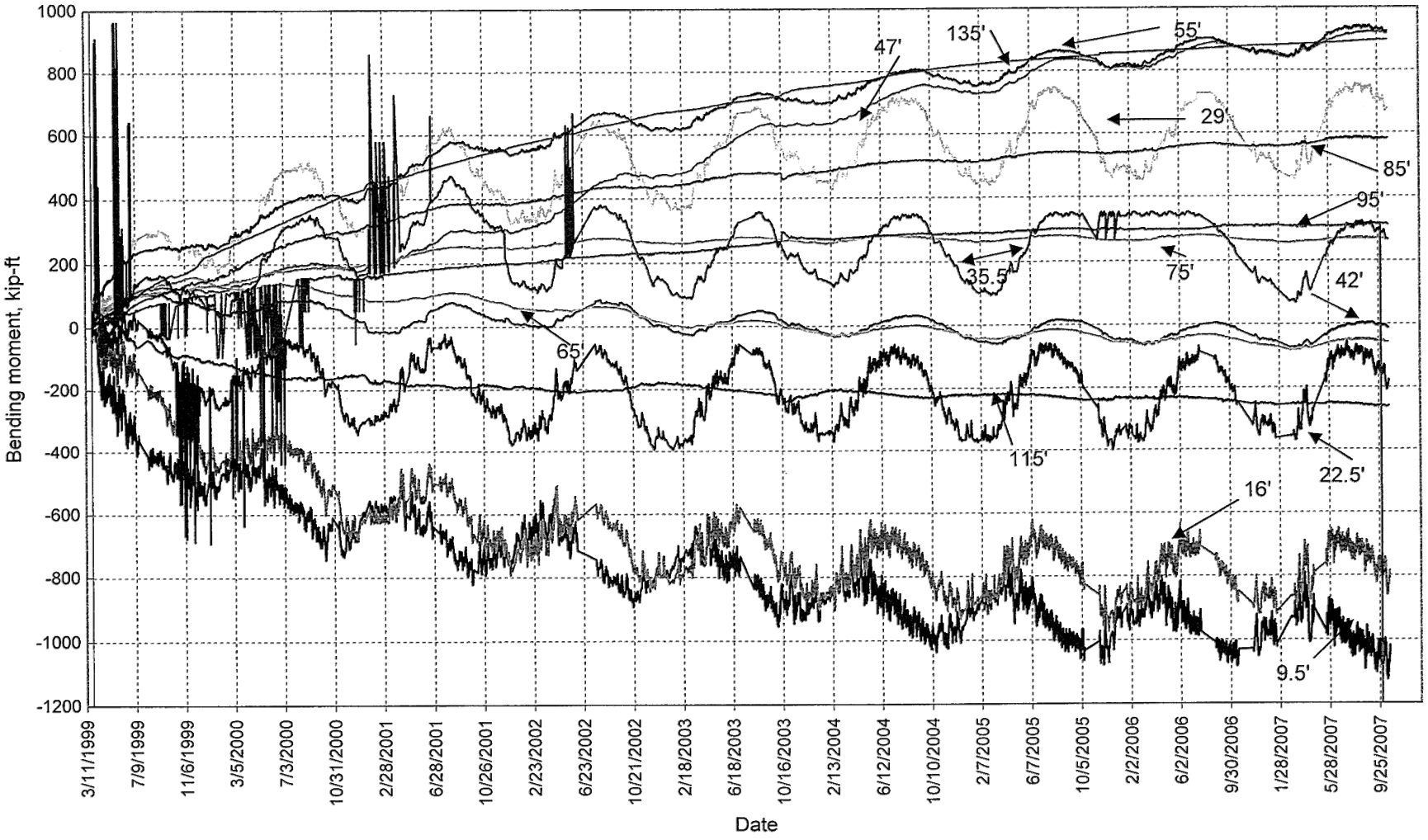
Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
34	07/01/99	271.75	436.00	261.00	583.00	387.94	353.88	422.00	266.38	509.50	327.38	-24.42	-32.43
	07/15/99	279.00	617.00	253.00	583.00	433.00	448.00	418.00	266.00	600.00	365.41	10.76	-44.56
	07/30/99	282.79	647.00	243.64	585.13	439.64	464.90	414.39	263.22	616.07	371.01	18.11	-47.07
	08/15/99	272.89	690.09	251.16	614.66	457.20	481.49	432.91	262.03	652.38	385.83	17.42	-52.07
	08/31/99	265.66	576.80	245.14	627.09	428.67	421.23	436.12	255.40	601.95	361.76	-5.34	-46.23
	09/15/99	265.08	802.81	242.34	635.26	486.37	533.95	438.80	253.71	719.04	410.45	34.11	-62.07
	09/30/99	260.50	807.40	238.64	642.65	487.30	533.95	440.65	249.57	725.03	411.23	33.45	-63.43
	10/15/99	256.43	811.14	234.46	648.58	487.65	533.79	441.52	245.45	729.86	411.53	33.08	-64.62
	10/31/99	240.47	824.02	221.62	665.31	487.86	532.25	443.47	231.05	744.67	411.70	31.83	-68.52
	11/15/99	241.93	831.45	224.75	676.77	493.73	536.69	450.76	233.34	754.11	416.65	30.81	-69.47
	11/31/99	240.47	835.88	224.26	648.85	487.37	538.18	436.56	232.37	742.37	411.29	36.43	-68.03
	12/15/99	241.41	836.77	222.35	684.04	496.14	539.09	453.20	231.88	760.41	418.69	30.79	-70.51
	12/31/99	242.22	836.08	224.14	684.93	496.84	539.15	454.54	233.18	760.51	419.29	30.34	-70.35
	03/31/00	257.37	828.85	237.38	675.92	499.88	543.11	456.65	247.38	752.38	421.85	31.00	-67.37
	06/30/00	266.43	846.32	225.20	500.93	459.72	556.37	363.06	245.81	673.62	387.96	69.30	-57.07
	09/30/00	257.37	895.02	196.89	705.00	513.57	576.19	450.94	227.13	800.01	433.40	44.90	-76.42
	01/13/01	247.90	856.11	197.37	729.58	507.74	552.01	463.47	222.64	792.84	428.48	31.74	-76.07
	04/20/01	44.66	883.01	212.28	457.21	399.29	463.83	334.74	128.47	670.11	336.96	46.28	-72.25
	07/10/01	-279.94	502.86	204.24	66.21	123.34	111.46	135.22	-37.85	284.53	104.09	-8.52	-43.01
	10/09/01	442.16	725.37	50.98	1199.89	604.60	583.76	625.44	246.57	962.63	510.22	-14.94	-95.52
	01/09/02	263.63	616.73	159.27	765.05	451.17	440.18	462.16	211.45	690.89	380.74	-7.88	-63.96
	04/12/02	67.35	579.97	58.13	501.01	301.61	323.66	279.57	62.74	540.49	254.53	15.81	-63.73
	07/19/02	288.69	941.04	187.83	727.59	536.29	614.86	457.71	238.26	834.31	452.57	56.34	-79.51
	10/08/02	277.15	962.54	162.58	740.98	535.81	619.84	451.78	219.86	851.76	452.17	60.25	-84.29
	01/08/03	256.07	949.53	162.24	758.66	531.62	602.80	460.45	209.15	854.10	448.64	51.04	-86.04
	04/15/03	277.19	928.37	189.53	744.52	534.90	602.78	467.03	233.36	836.45	451.41	48.67	-80.45
	06/01/03	277.96	939.01	184.90	749.68	537.89	608.49	467.29	231.43	844.35	453.93	50.62	-81.76
	08/07/03	288.69	965.09	171.66	750.09	543.88	626.89	460.87	230.17	857.59	458.98	59.52	-83.70
	10/07/03	274.96	978.21	155.53	762.84	542.89	626.58	459.19	215.25	870.53	458.14	60.01	-87.41
	12/31/03	258.26	983.57	156.83	795.22	548.47	620.92	476.03	207.55	889.40	462.86	51.95	-90.96
	04/13/04	281.17	960.30	188.88	781.65	553.00	620.73	485.27	235.03	870.97	466.68	48.57	-84.84
	07/13/04	302.86	991.98	173.93	772.27	560.26	647.42	473.10	238.40	882.12	472.80	62.50	-85.87
	10/08/04	295.63	1004.49	151.19	786.40	559.43	650.06	468.80	223.41	895.45	472.10	64.99	-89.65
	01/07/05	277.35	997.91	148.79	798.02	555.52	637.63	473.41	213.07	897.97	468.80	58.88	-91.36
	04/08/05	286.74	978.21	166.99	788.76	555.17	632.47	477.87	226.86	883.49	468.51	55.43	-87.59
	07/18/05	304.00	1000.02	160.94	783.60	562.14	652.01	472.27	232.47	891.81	474.39	64.44	-87.96
	08/26/05	301.85	1018.4	147.73	791.81	564.94	660.12	469.77	224.79	905.09	476.76	68.24	-90.75
	11/12/05	300.51	1018.3	147.82	793.35	564.99	659.40	470.58	224.16	905.83	476.80	67.70	-90.93
	01/10/06	274.59	1009.41	138.15	808.34	557.62	642.00	473.24	206.37	908.87	470.58	60.50	-93.71
	04/09/06	283.04	986.09	160.45	798.02	556.90	634.57	479.23	221.74	892.06	469.97	55.69	-89.42
	07/19/06	295.67	1009.41	149.73	796.56	562.84	652.54	473.14	222.70	902.98	474.98	64.32	-90.75
	10/18/06	284.79	1030.77	131.20	808.38	563.79	657.78	469.79	207.99	919.58	475.78	67.40	-94.92
	01/18/07	270.29	1012.82	134.82	813.33	557.81	641.55	474.08	202.55	913.08	470.74	60.04	-94.78
	04/19/07	282.35	996.04	153.99	805.37	559.44	639.20	479.68	218.17	900.71	472.11	57.19	-91.05
	07/09/07	306.44	1014.48	154.64	795.38	567.74	660.46	475.01	230.54	904.93	479.11	66.49	-89.96
	10/20/07	290.51	1037.35	126.69	809.72	566.07	663.93	468.21	208.60	923.54	477.71	70.17	-95.37

Shaft 1: Bending moment along shaft, kip-ft

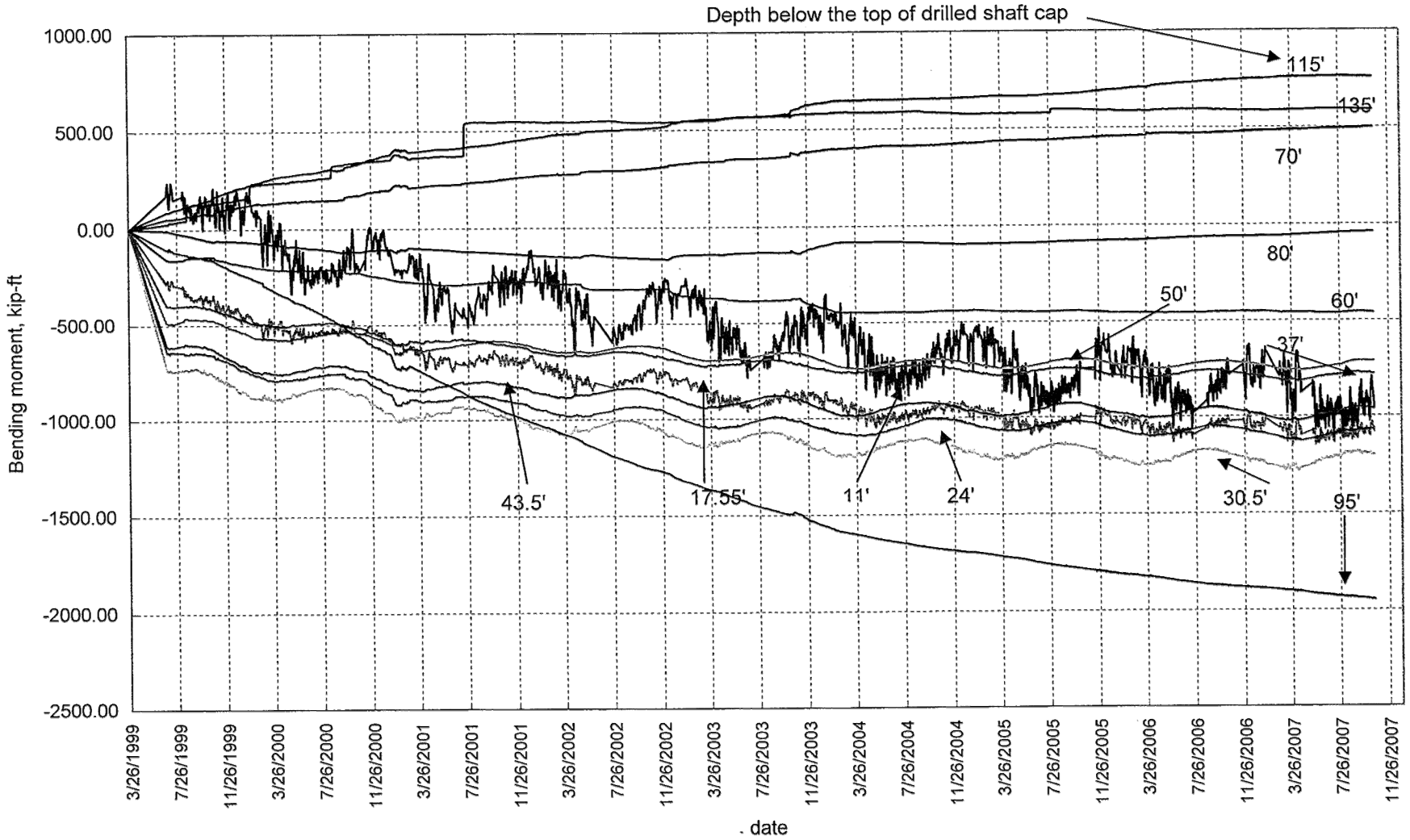
Depth, ft / Date	9.5	16	22.5	29	35.5	42	47	54.8	64.8	74.8	84.8	94.8	115	135
7/1/1999	-357.65	-148.91	-2.99	242.13	107.23	94.27	103.67	221.87	109.32	92.67	66.77	48.25	-38.94	91.57
1/8/2003	-774.82	-792.9	-360.63	403.12	139.71	-1.79	473.87	620.31	11.19	262.65	439.51	230.65	-179.6	668.9
4/15/2003	-657.74	-650	-232.57	481.71	156.43	-14.02	517.65	659.68	2.44	268.91	457.85	238.57	-192.49	684.79
7/1/2003	-763.24	-602.42	-72.91	660.28	319.17	32.14	588.57	715.87	14.21	278.09	474.99	251.23	-206	702.94
8/7/2003	-817.04	-638.73	-81.08	678	343.79	44.44	615.09	726.92	17.44	279.15	477.58	254.31	-210.32	708.78
10/7/2003	-913.81	-801.08	-248.05	552.54	251.84	20.93	623.3	710.92	6.8	271.9	474.43	265.38	-225.46	720.58
12/31/2003	-870.9	-838.68	-322.24	476.14	168.18	-13.93	630.87	701.76	-19.51	263.35	479.49	275.24	-220.96	748.57
4/13/2004	-831.87	-777.37	-255.87	514.98	175.37	-24.83	659.66	727.03	-27.47	269.67	495.81	277.88	-211.65	763.52
7/13/2004	-889.99	-676.85	-77.13	709.38	338.24	22.05	727.23	792.27	-5.75	281.7	512.3	283.5	-221.34	787.54
10/8/2004	-983.05	-812	-201.66	636.33	293	16.71	752.87	793.14	-7.37	272.19	514.89	286.68	-231.1	803.15
1/7/2005	-925.21	-882.29	-353.38	471.75	139.59	-39.87	733.05	761.38	-34.6	264.1	510.62	288.64	-223.06	817.18
4/8/2005	-775.03	-726	-235.05	530.47	150.69	-53.27	749.88	786.67	-40.37	267.3	525.48	290.73	-219.8	828.14
7/18/2005	-957.73	-709.43	-81.75	735.77	338.65	7.97	821.52	856.49	-16.82	278.53	538.72	298.79	-226.87	837.24
8/26/2005	-1005.57	-755.34	-117.03	721.71	336.36	13.6	835.13	860.64	-16.18	278.76	539.43	301.65	-233.64	840.82
10/11/2005	-1033.08	-827.24	-199.79	654.9	284.17	7.2946	833.72	848.04	-26.29	273.5	537.36	299.33	-240.08	843.25
1/10/2006	-918.83	-858.03	-339.71	489.13	122.55	-48.55	810.18	815.92	-54.94	262.93	536.1	298.82	-234.11	855.77
4/9/2006	-901.14	-812	-289.67	510.35	123.88	-55.75	815.9	831.32	-58.19	267.19	540.25	311.97	-239.53	860
7/19/2006	-975.46	-709.09	-86.84	727.21	303.99	-3.19	876.46	899.71	-33.29	280.02	563.21	306.55	-235.87	865.96
10/18/2006	-1030.45	-848.40	-245.88	609.17	218.59	-17.57	872.05	872.96	-49.65	267.05	557.80	306.95	-246.77	873.58
1/18/2007	-1015.18	-915.62	-363.79	485.63	115.44	-53.84	856.23	849.07	-71.01	257.71	555.06	310.45	-258.05	878.10
4/19/2007	-904.71	-791.93	-272.27	527.72	122.40	-65.28	862.30	869.52	-74.95	259.50	564.85	305.74	-254.07	882.60
7/11/2007	-990.93	-694.73	-72.44	749.91	312.39	-2.99	910.88	934.53	-49.88	269.47	582.93	306.29	-251.96	888.31
10/20/2007	-1018.74	-786.18	-177.53	678.23	265.08	-13.72	915.47	922.26	-57.70	265.45	581.36	309.85	-259.55	895.13

Shaft 9: Bending moment along shaft, kip-ft

Depth, ft / Date	11	17.5	24	30.5	37	43.25	50	60	70	80	95	115	135
7/1/1999	-67.89	-31.81	8.56	12.84	20.8	19.57	14.07	0.61	9.79	11.62	-33.33	18.35	26.3
1/8/2003	-347.44	-803.74	-998.93	-1106.33	-698.39	-903.77	-661.43	-353.18	324.27	-148.11	-1315.52	540.06	541.35
4/15/2003	-592.31	-919.8	-1050.61	-1133.34	-723.59	-939.66	-696.63	-369.12	336.59	-143.51	-1378.77	555.2	549.67
7/1/2003	-666.55	-902.38	-1016.77	-1090.93	-713.88	-914.42	-686.74	-395.16	340.01	-144.29	-1435.98	557.09	553.5
8/7/2003	-687.84	-917.2	-1003.18	-1072.98	-695.58	-886.87	-664.36	-384.64	352	-133.3	-1462.27	566.15	565.69
10/7/2003	-490.45	-863.81	-1007.81	-1107.14	-708.81	-891.63	-656.83	-378.93	360.91	-134.77	-1498.83	577.44	567.18
12/31/2003	-514.68	-913.27	-1054.9	-1163.2	-741.63	-949.18	-697.72	-421.12	390.01	-101.42	-1555.5	633.83	579.35
4/13/2004	-604.44	-966.22	-1090.5	-1188	-761.54	-987.22	-743.54	-446.54	402.54	-82.56	-1609.1	644.77	582.97
7/13/2004	-817.01	-1007.24	-1051.35	-1122.59	-730.91	-933.53	-709.92	-447.66	411.36	-83.06	-1648.19	649.1	585.94
10/8/2004	-674.74	-949.72	-1005.93	-1128.49	-732.6	-927.74	-697.54	-445.16	413.37	-90.78	-1677.71	652.24	581.64
1/7/2005	-572.76	-951.94	-1036.44	-1183	-760.9	-966.49	-718.51	-441.27	424.15	-94.18	-1699.91	657.05	573.07
4/8/2005	-773.86	-1039.72	-1072.89	-1200.56	-775.89	-989.82	-743.85	-446.59	435.56	-92.57	-1726.57	664.45	574.55
7/18/2005	-885.57	-1041.08	-1038.29	-1152.24	-752.36	-948.63	-719.09	-449.39	438.06	-89.12	-1762.02	670.82	576.24
8/26/2005	-835.5	-1020.01	-1028.45	-1146.98	-746.96	-933.35	-702.48	-447.31	442.02	-86.41	-1773.96	672.92	595.07
10/11/2005	-749.53	-997.4	-1026.45	-1157.47	-750.11	-932.26	-695.29	-445.61	446.57	-84.01	-1786.07	677.93	594.21
1/10/2006	-735.54	-1025.94	-1070.26	-1220.95	-784.71	-983.06	-728.35	-455.6	455.8	-79.41	-1811.1	694.94	585.21
4/9/2006	-761.63	-1055.46	-1104.66	-1250.13	-799.79	-1009.4	-750.25	-456.86	465.33	-75.95	-1830.39	709.25	584.13
7/19/2006	-986.65	-1097.57	-1069.44	-1182.51	-765.49	-967.32	-726.98	-458.20	468.35	-67.36	-1860.26	728.74	591.17
10/18/2006	-785.55	-1028.56	-1059.04	-1198.03	-770.44	-962.79	-714.95	-455.21	472.24	-63.08	-1878.38	742.33	587.52
1/18/2007	-652.26	-1012.08	-1093.82	-1249.92	-798.31	-1001.31	-738.72	-453.20	481.92	-62.15	-1891.06	749.16	583.45
4/19/2007	-878.81	-1101.41	-1131.14	-1269.03	-817.30	-1023.35	-760.98	-458.74	484.61	-55.95	-1908.23	757.20	587.07
7/11/2007	-1020.68	-1113.23	-1096.67	-1211.04	-787.54	-982.11	-738.79	-463.61	490.76	-47.79	-1930.33	760.68	591.55
10/20/2007	-959.39	-1084.45	-1073.44	-1199.41	-780.45	-961.01	-714.61	-460.69	495.15	-40.84	-1949.93	755.58	587.47



Shaft #1, Bending moment vs. date in different elevations below the top of cap



Shaft #9, Bending moment vs. date in different elevations below the top of cap

Tie Beam Forces and Bending Moments (Driven Pile Cap side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
1	7/1/1999	-47.1	68.5	551.7	681.8	313.73	10.70	616.75	252.30	375.15	83.06	-40.28	-2.75
	7/15/1999	-70.1	53.8	538.8	666.8	297.33	-8.15	602.80	234.35	360.30	78.72	-40.60	-2.82
	8/15/1999	10.7	114.3	613.7	728.1	366.70	62.50	670.90	312.20	421.20	97.09	-40.43	-2.44
	8/31/1999	12.0	114.3	617.3	732.8	369.10	63.15	675.05	314.65	423.55	97.73	-40.67	-2.44
	9/15/1999	13.1	113.5	619.7	737.5	370.95	63.30	678.60	316.40	425.50	98.22	-40.89	-2.44
	9/30/1999	29.6	122.3	634.4	753.4	384.93	75.95	693.90	332.00	437.85	101.92	-41.07	-2.37
	10/15/1999	34.7	123.9	637.8	757.9	388.58	79.30	697.85	336.25	440.90	102.88	-41.11	-2.34
	10/31/1999	39.8	127.2	646.6	762	393.90	83.50	704.30	343.20	444.60	104.29	-41.26	-2.27
	11/15/1999	62.3	139.3	662.9	780.1	411.15	100.80	721.50	362.60	459.70	108.86	-41.25	-2.18
	11/30/1999	73.7	146.3	670.6	788.6	419.80	110.00	729.60	372.15	467.45	111.15	-41.18	-2.13
	12/15/1999	72.8	143.6	668.9	789.7	418.75	108.20	729.30	370.85	466.65	110.87	-41.28	-2.15
	12/31/1999	88.8	152.1	680.1	802.5	430.88	120.45	741.30	384.45	477.30	114.08	-41.26	-2.08
	3/31/2000	95.3	158.7	682.5	825.2	440.43	127.00	753.85	388.90	491.95	116.61	-41.66	-2.31
	6/30/2000	60.2	138.2	662.7	804.5	416.40	99.20	733.60	361.45	471.35	110.25	-42.16	-2.46
	9/30/2000	50.1	142.5	668.8	795.7	414.28	96.30	732.25	359.45	469.10	109.69	-42.26	-2.46
	1/13/2001	109.5	179.9	712.3	845.5	461.80	144.70	778.90	410.90	512.70	122.27	-42.15	-2.28
	4/20/2001	126.8	283.2	715.3	881.9	501.80	205.00	798.60	421.05	582.55	132.86	-39.45	-3.62
	7/16/2001	68.3	149.8	674.3	837.1	432.38	109.05	755.70	371.30	493.45	114.48	-42.98	-2.74
	10/9/2001	71.4	157.1	685.5	840.8	438.70	114.25	763.15	378.45	498.95	116.15	-43.12	-2.70
	1/9/2002	102.7	177.8	713	872	466.38	140.25	792.50	407.85	524.90	123.48	-43.35	-2.62
	4/12/2002	125.5	192.8	738.6	904.9	490.45	159.15	821.75	432.05	548.85	129.86	-44.04	-2.62
	7/18/2002	62.3	151.8	706.334	859.6	445.01	107.05	782.97	384.32	505.70	117.82	-44.92	-2.72
	10/8/2002	43.7	151.1	711.3	846.7	438.20	97.40	779.00	377.50	498.90	116.02	-45.30	-2.72
	1/8/2003	84.7	180.5	748.5	891.8	476.38	132.60	820.15	416.60	536.15	126.13	-45.69	-2.68
	4/15/2003	96.1	191.9	739.9	989.3	504.30	144.00	864.60	418.00	590.60	133.52	-47.89	-3.87
	7/1/2003	57.4	168	713	959	474.35	112.70	836.00	385.20	563.50	125.59	-48.07	-3.99
	10/7/2003	42.1	166.8	714	946.6	467.38	104.45	830.30	378.05	556.70	123.75	-48.24	-4.00
	12/31/2003	80	197.9	753.9	985.1	504.23	138.95	869.50	416.95	591.50	133.50	-48.55	-3.91
	4/13/2004	92	208.9	760.4	1006.6	516.98	150.45	883.50	426.20	607.75	136.88	-48.72	-4.07
	7/13/2004	14.6	163.9	707.3	954.4	460.05	89.25	830.85	360.95	559.15	121.81	-49.29	-4.44
	10/8/2004	-8.6	233.4	704.6	941	467.60	112.40	822.80	348.00	587.20	123.81	-47.21	-5.36
	1/7/2005	19.5	190.4	746.5	982.5	484.73	104.95	864.50	383.00	586.45	128.34	-50.48	-4.56
	4/8/2005	3.4	397.6	751.6	1003.4	539.00	200.50	877.50	377.50	700.50	142.71	-44.99	-7.24
	7/18/2005	3.1	164.3	709.7	969.6	461.68	83.70	839.65	356.40	566.95	122.24	-50.24	-4.72
	8/26/2005	3.1	157.5	702.5	956.3	454.85	80.30	829.40	352.80	556.90	120.43	-49.78	-4.57
	10/11/2005	3.1	164.2	712.6	960.1	460.00	83.65	836.35	357.85	562.15	121.79	-50.02	-4.58
	1/10/2006	3.1	191.9	742.5	997	483.63	97.50	869.75	372.80	594.45	128.05	-51.32	-4.97
	4/9/2006	3.5	205.3	750.7	1018.8	494.58	104.40	884.75	377.10	612.05	130.95	-51.86	-5.26
	7/19/2006	3.5	166.6	703.7	975.5	462.33	85.05	839.60	353.60	571.05	122.41	-50.15	-4.87
	10/18/2006	3.5	170.2	709	967.5	462.55	86.85	838.25	356.25	568.85	122.47	-49.94	-4.76
	1/18/2007	3.5	209.1	748.7	1013.1	493.60	106.30	880.90	376.10	611.10	130.69	-51.48	-5.26
	4/19/2007	3.5	216.6	743.7	1021.2	496.25	110.05	882.45	373.60	618.90	131.39	-51.33	-5.50
	7/11/2007	3.5	169.6	700.9	981.6	463.90	86.55	841.25	352.20	575.60	122.83	-50.16	-5.00
	10/20/2007	3.5	163.4	696	963.7	456.65	83.45	829.85	349.75	563.55	120.91	-49.60	-4.79

Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
12	7/1/1999	374.9	6	549.6	471.8	350.58	190.45	510.70	462.25	238.90	92.82	-21.28	5.00
	7/15/1999	368.6	-3.6	544.2	467.3	344.13	182.50	505.75	456.40	231.85	91.11	-21.48	5.03
	8/15/1999	373.7	0.2	569.4	485.2	357.13	186.95	527.30	471.55	242.70	94.56	-22.62	5.13
	8/31/1999	368.4	-4.7	567	486.2	354.23	181.85	526.60	467.70	240.75	93.79	-22.91	5.08
	9/15/1999	365.9	-9.2	565.3	485.1	351.78	178.35	525.20	465.60	237.95	93.14	-23.05	5.10
	9/30/1999	364.6	-11.7	570.1	487.6	352.65	176.45	528.85	467.35	237.95	93.37	-23.42	5.14
	10/15/1999	361.7	-14.8	569.9	487.4	351.05	173.45	528.65	465.80	236.30	92.95	-23.61	5.14
	10/31/1999	362.8	-13.5	575.6	493.1	354.50	174.65	534.35	469.20	239.80	93.86	-23.91	5.14
	11/15/1999	365.0	-11.5	581.4	498	358.23	176.75	539.70	473.20	243.25	94.85	-24.12	5.15
	11/30/1999	365.6	-11.8	583.7	500.1	359.40	176.90	541.90	474.65	244.15	95.16	-24.26	5.16
	12/15/1999	368.0	-9.2	589.7	504.2	363.18	179.40	546.95	478.85	247.50	96.16	-24.43	5.18
	12/31/1999	369.0	-8	592.9	506.6	365.13	180.50	549.75	480.95	249.30	96.67	-24.54	5.19
	3/31/2000	379.6	7.3	617	524.1	382.00	193.45	570.55	498.30	265.70	101.14	-25.06	5.21
	6/30/2000	376.1	4.4	608.9	519.1	377.13	190.25	564.00	492.50	261.75	99.85	-24.84	5.17
	9/30/2000	360.7	-12.3	588.3	503.5	360.05	174.20	545.90	474.50	245.60	95.33	-24.70	5.13
	1/13/2001	372.1	2.2	618.1	526.1	379.63	187.15	572.10	495.10	264.15	100.51	-25.58	5.17
	4/20/2001	387.6	21	645.8	549.2	400.90	204.30	597.50	516.70	285.10	106.15	-26.13	5.19
	7/16/2001	374.6	6.5	621.5	532.9	383.88	190.55	577.20	498.05	269.70	101.64	-25.70	5.12
	10/9/2001	360.9	-9.4	598.9	515.8	366.55	175.75	557.35	479.90	253.20	97.05	-25.36	5.08
	1/9/2002	363.5	-2.5	611.5	524.5	374.25	180.50	568.00	487.50	261.00	99.09	-25.75	5.07
	4/12/2002	381.7	16.9	642.7	550.5	397.95	199.30	596.60	512.20	283.70	105.37	-26.40	5.12
	7/18/2002	375	10.5	629	544.7	389.80	192.75	586.85	502.00	277.60	103.21	-26.19	5.03
	10/8/2002	357.7	-9.6	599.2	523	367.58	174.05	561.10	478.45	256.70	97.32	-25.72	4.97
	1/8/2003	367.3	6.5	626.7	542.7	385.80	186.90	584.70	497.00	274.60	102.15	-26.44	4.98
	4/15/2003	385.9	27.3	655.3	566.2	408.68	206.60	610.75	520.60	296.75	108.20	-26.86	5.01
	7/1/2003	384.7	26.3	649.2	565.6	406.45	205.50	607.40	516.95	295.95	107.62	-26.71	4.95
	10/7/2003	360.6	3.5	613	539.7	379.20	182.05	576.35	486.80	271.60	100.40	-26.20	4.82
	12/31/2003	372	19.4	636	558.3	396.43	195.70	597.15	504.00	288.85	104.96	-26.68	4.82
	4/13/2004	389.4	39.8	665.5	583.1	419.45	214.60	624.30	527.45	311.45	111.06	-27.23	4.84
	7/13/2004	379.5	27.7	643.3	571.1	405.40	203.60	607.20	511.40	299.40	107.34	-26.82	4.75
	10/8/2004	361.6	10.3	615.2	550.9	384.50	185.95	583.05	488.40	280.60	101.80	-26.39	4.66
	1/7/2005	367.5	16.1	630.6	561.5	393.93	191.80	596.05	499.05	288.80	104.30	-26.87	4.71
	4/8/2005	388.2	35.6	662.3	587.2	418.33	211.90	624.75	525.25	311.40	110.76	-27.44	4.79
	7/18/2005	382.6	26.3	647.7	580.1	409.18	204.45	613.90	515.15	303.20	108.34	-27.21	4.75
	8/26/2005	373.6	15.7	629.8	566.8	396.48	194.65	598.30	501.70	291.25	104.97	-26.83	4.71
	10/11/2005	365.9	6.1	617.8	557.9	386.93	186.00	587.85	491.85	282.00	102.45	-26.71	4.70
	1/10/2006	376.2	17.5	639	572.2	401.23	196.85	605.60	507.60	294.85	106.23	-27.16	4.77
	4/9/2006	393.8	32.7	665.7	594	421.55	213.25	629.85	529.75	313.35	111.61	-27.69	4.85
	7/19/2006	384.2	20.3	646.2	582.7	408.35	202.25	614.45	515.20	301.50	108.12	-27.39	4.79
	10/18/2006	365	-2	614.4	558.2	383.90	181.50	586.30	489.70	278.10	101.65	-26.90	4.74
	1/18/2007	376	9.6	635.9	573.9	398.85	192.80	604.90	505.95	291.75	105.60	-27.39	4.80
	4/19/2007	390.7	24.1	659.3	592.7	416.70	207.40	626.00	525.00	308.40	110.33	-27.82	4.85
	7/11/2007	384.1	15	644.6	584.6	407.08	199.55	614.60	514.35	299.80	107.78	-27.58	4.81
	10/20/2007	363.7	-9.6	611.5	560.6	381.55	177.05	586.05	487.60	275.50	101.02	-27.18	4.75

Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
13	7/1/1999	306.3	72.2	490.8	675.2	386.13	189.25	583.00	398.55	373.70	102.23	-26.17	0.56
	7/15/1999	288.0	53.1	484.2	670.6	373.98	170.55	577.40	386.10	361.85	99.02	-27.04	0.54
	8/15/1999	280.9	61.8	506.3	693.7	385.68	171.35	600.00	393.60	377.75	102.12	-28.49	0.36
	8/31/1999	270.4	52.1	503.1	691.4	379.25	161.25	597.25	386.75	371.75	100.41	-28.98	0.34
	9/15/1999	261.3	43.9	501.2	689.9	374.08	152.60	595.55	381.25	366.90	99.04	-29.44	0.32
	9/30/1999	257.1	40.7	503.1	690.7	372.90	148.90	596.90	380.10	365.70	98.73	-29.77	0.32
	10/15/1999	250.1	33.8	501.2	691	369.03	141.95	596.10	375.65	362.40	97.71	-30.18	0.30
	10/31/1999	251.4	38	507.6	697.6	373.65	144.70	602.60	379.50	367.80	98.93	-30.43	0.26
	11/15/1999	253.9	41.6	512.1	701.9	377.38	147.75	607.00	383.00	371.75	99.92	-30.52	0.25
	11/30/1999	253.5	41.2	513.6	704.4	378.18	147.35	609.00	383.55	372.80	100.13	-30.68	0.24
	12/15/1999	255.8	46.7	519.1	709.3	382.73	151.25	614.20	387.45	378.00	101.33	-30.77	0.21
	12/31/1999	256.7	48.9	522.3	712.4	385.08	152.80	617.35	389.50	380.65	101.96	-30.87	0.20
	3/31/2000	267.5	64.6	542.8	734.2	402.28	166.05	638.50	405.15	399.40	106.51	-31.40	0.13
	6/30/2000	258.9	46.4	531.2	726.1	390.65	152.65	628.65	395.05	386.25	103.43	-31.63	0.20
	9/30/2000	237.1	10.1	504.9	705.9	364.50	123.60	605.40	371.00	358.00	96.51	-32.02	0.29
	1/13/2001	254.0	40.9	535.1	734.6	391.15	147.45	634.85	394.55	387.75	103.56	-32.39	0.15
	4/20/2001	275.4	72.6	561.4	763.7	418.28	174.00	662.55	418.40	418.15	110.75	-32.47	0.01
	7/16/2001	255.3	37.7	534.8	740.9	392.18	146.50	637.85	395.05	389.30	103.84	-32.65	0.13
	10/9/2001	235.7	7.5	510.6	719.6	368.35	121.60	615.10	373.15	363.55	97.53	-32.80	0.22
	1/9/2002	240	18.9	523.3	731	378.30	129.45	627.15	381.65	374.95	100.16	-33.08	0.15
	4/12/2002	263.4	58.5	554.8	763	409.93	160.95	658.90	409.10	410.75	108.54	-33.09	-0.04
	7/18/2002	255.5	40.1	566.1	754.5	404.05	147.80	660.30	410.80	397.30	106.98	-34.06	0.30
	10/8/2002	231.2	3.4	508.7	726.1	367.35	117.30	617.40	369.95	364.75	97.26	-33.24	0.12
	1/8/2003	249.4	38.5	540.1	754.4	395.60	143.95	647.25	394.75	396.45	104.74	-33.45	-0.04
	4/15/2003	276.4	78.5	571.6	784.9	427.85	177.45	678.25	424.00	431.70	113.28	-33.28	-0.17
	7/1/2003	273	69	561.4	779.9	420.83	171.00	670.65	417.20	424.45	111.42	-33.21	-0.16
	10/7/2003	246.6	22.5	524.7	744.6	384.60	134.55	634.65	385.65	383.55	101.83	-33.24	0.05
	12/31/2003	264.8	58.9	552.8	770.1	411.65	161.85	661.45	408.80	414.50	108.99	-33.20	-0.13
	4/13/2004	291.3	97.7	584	803.2	444.05	194.50	693.60	437.65	450.45	117.57	-33.17	-0.29
	7/13/2004	275.5	64.3	556.1	781	419.23	169.90	668.55	415.80	422.65	111.00	-33.14	-0.15
	10/8/2004	252.8	29.9	527.5	755.8	391.50	141.35	641.65	390.15	392.85	103.66	-33.25	-0.06
	1/7/2005	264	50.8	544.5	770.6	407.48	157.40	657.55	404.25	410.70	107.89	-33.24	-0.14
	4/8/2005	289.9	90.7	576	802	439.65	190.30	689.00	432.95	446.35	116.41	-33.14	-0.30
	7/18/2005	277.8	67.7	556.4	787.1	422.25	172.75	671.75	417.10	427.40	111.80	-33.16	-0.23
	8/26/2005	266.7	46.5	539.8	771.9	406.23	156.60	655.85	403.25	409.20	107.56	-33.18	-0.13
	10/11/2005	257.2	33.8	526.8	760.8	394.65	145.50	643.80	392.00	397.30	104.49	-33.12	-0.12
	1/10/2006	269.3	59.9	551.2	780.4	415.20	164.60	665.80	410.25	420.15	109.93	-33.31	-0.22
	4/9/2006	289.9	90	576.3	806.2	440.60	189.95	691.25	433.10	448.10	116.66	-33.32	-0.34
	7/19/2006	277.7	63.9	553.8	787.8	420.80	170.80	670.80	415.75	425.85	111.42	-33.23	-0.23
	10/18/2006	253.3	27.9	523.7	757.8	390.68	140.60	640.75	388.50	392.85	103.44	-33.24	-0.10
	1/18/2007	267.4	54.9	546.5	778.5	411.83	161.15	662.50	406.95	416.70	109.04	-33.32	-0.22
	4/19/2007	289	88.7	575.1	806.8	439.90	188.85	690.95	432.05	447.75	116.47	-33.37	-0.35
	7/11/2007	280	67	558	793.6	424.65	173.50	675.80	419.00	430.30	112.43	-33.38	-0.25
	10/20/2007	255.4	29.1	525	763.8	393.33	142.25	644.40	390.20	396.45	104.14	-33.37	-0.14

Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
14	7/1/1999	445.4	53.9	802	298.7	400.00	249.65	550.35	623.70	176.30	105.91	-19.98	10.02
	7/15/1999	440.5	34.4	799.5	280.7	388.78	237.45	540.10	620.00	157.55	102.94	-20.11	10.36
	8/15/1999	455.6	40.8	837.6	284.6	404.65	248.20	561.10	646.60	162.70	107.14	-20.79	10.84
	8/31/1999	452.7	30.7	837.1	274.1	398.65	241.70	555.60	644.90	152.40	105.55	-20.86	11.03
	9/15/1999	448.5	21.7	836.8	266.2	393.30	235.10	551.50	642.65	143.95	104.13	-21.03	11.17
	9/30/1999	447.0	16.1	838.5	260.8	390.60	231.55	549.65	642.75	138.45	103.42	-21.14	11.30
	10/15/1999	446.5	8.8	839.3	255.1	387.43	227.65	547.20	642.90	131.95	102.58	-21.24	11.45
	10/31/1999	450.9	11.7	847.9	257.8	392.08	231.30	552.85	649.40	134.75	103.81	-21.37	11.53
	11/15/1999	455.9	16.1	856.2	259.8	397.00	236.00	558.00	656.05	137.95	105.11	-21.40	11.61
	11/30/1999	456.3	15.5	858.3	259	397.28	235.90	558.65	657.30	137.25	105.19	-21.45	11.65
	12/15/1999	461.3	20.5	865.6	261.7	402.28	240.90	563.65	663.45	141.10	106.51	-21.45	11.70
	12/31/1999	463.4	22.5	871.6	262.9	405.10	242.95	567.25	667.50	142.70	107.26	-21.55	11.76
	3/31/2000	477.8	35.6	903.8	282.7	424.98	256.70	593.25	690.80	159.15	112.52	-22.37	11.91
	6/30/2000	469.2	17.4	889.7	267.4	410.93	243.30	578.55	679.45	142.40	108.80	-22.28	12.03
	9/30/2000	453.5	-23.5	856.8	240.4	381.80	215.00	548.60	655.15	108.45	101.09	-22.17	12.25
	1/13/2001	476.9	5	891.3	257.6	407.70	240.95	574.45	684.10	131.30	107.95	-22.16	12.38
	4/20/2001	494.8	40.8	932.8	281.2	437.40	267.80	607.00	713.80	161.00	115.81	-22.54	12.38
	7/16/2001	475.7	4.9	900.7	255.9	409.30	240.30	578.30	688.20	130.40	108.37	-22.46	12.50
	10/9/2001	459.3	-30.8	870.4	236.8	383.93	214.25	553.60	664.85	103.00	101.65	-22.55	12.59
	1/9/2002	468.8	-18.5	883.7	241.5	393.88	225.15	562.60	676.25	111.50	104.29	-22.43	12.65
	4/12/2002	492.8	22.5	926.5	270.2	428.00	257.65	598.35	709.65	146.35	113.32	-22.64	12.62
	7/18/2002	483.5	3.8	911.9	257.3	414.13	243.65	584.60	697.70	130.55	109.65	-22.66	12.71
	10/8/2002	462.7	-35	875.6	233	384.08	213.85	554.30	669.15	99.00	101.69	-22.63	12.77
	1/8/2003	485.5	2.5	912.6	253.9	413.63	244.00	583.25	699.05	128.20	109.52	-22.55	12.79
	4/15/2003	501.9	612.9	952.7	285.1	588.15	557.40	618.90	727.30	449.00	155.72	-4.09	6.23
	7/1/2003	521.6	28.8	943.4	278.1	442.98	275.20	610.75	732.50	153.45	117.29	-22.30	12.97
	10/7/2003	472.3	-16.5	903.8	247.5	401.78	227.90	575.65	688.05	115.50	106.38	-23.11	12.83
	12/31/2003	495.5	18.6	939.3	268.7	430.53	257.05	604.00	717.40	143.65	113.99	-23.06	12.85
	4/13/2004	504.6	68.9	989	299.2	465.43	286.75	644.10	746.80	184.05	123.23	-23.75	12.61
	7/13/2004	487.3	36.7	961.8	277.7	440.88	262.00	619.75	724.55	157.20	116.73	-23.78	12.71
	10/8/2004	468.9	-0.5	928.8	256.4	413.40	234.20	592.60	698.85	127.95	109.46	-23.82	12.79
	1/7/2005	485.2	21.4	952.7	269.7	432.25	253.30	611.20	718.95	145.55	114.45	-23.79	12.85
	4/8/2005	512.9	68.8	998.7	302.5	470.73	290.85	650.60	755.80	185.65	124.63	-23.91	12.77
	7/18/2005	498.2	40	977.1	286.8	450.53	269.10	631.95	737.65	163.40	119.29	-24.11	12.86
	8/26/2005	486.3	17.1	955.5	271.8	432.68	251.70	613.65	720.90	144.45	114.56	-24.05	12.91
	10/11/2005	478.8	2.4	942.6	263.6	421.85	240.60	603.10	710.70	133.00	111.69	-24.09	12.94
	1/10/2006	497.9	28.2	970.6	280.6	444.33	263.05	625.60	734.25	154.40	117.64	-24.09	12.99
	4/9/2006	519.6	65.1	1008.9	306	474.90	292.35	657.45	764.25	185.55	125.74	-24.26	12.96
	7/19/2006	505.7	73.4	984.2	290.7	463.50	289.55	637.45	744.95	182.05	122.72	-23.12	12.61
	10/18/2006	484	-5.7	946.5	265.8	422.65	239.15	606.15	715.25	130.05	111.91	-24.39	13.11
	1/18/2007	503	21.5	974.4	282.5	445.35	262.25	628.45	738.70	152.00	117.92	-24.34	13.14
	4/19/2007	525.1	60.9	1012.9	309.1	477.00	293.00	661.00	769.00	185.00	126.30	-24.46	13.08
	7/11/2007	533.8	36.8	994.5	295.1	465.05	285.30	644.80	764.15	165.95	123.13	-23.89	13.40
	10/20/2007	487.8	-9.1	953.8	269.9	425.60	239.35	611.85	720.80	130.40	112.69	-24.76	13.23

Tie Beam Forces and Bending Moments (Driven Pile Cap side)(cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
26	7/1/1999	468.3	92.2	387.7	511.7	364.98	280.25	449.70	428.00	301.95	96.63	-11.26	2.82
	7/15/1999	460.1	81	381.5	505.7	357.08	270.55	443.60	420.80	293.35	94.54	-11.50	2.86
	8/15/1999	482.3	96.1	410.7	526	378.78	289.20	468.35	446.50	311.05	100.29	-11.91	3.03
	8/31/1999	490.3	101.9	422.4	535	387.40	296.10	478.70	456.35	318.45	102.57	-12.14	3.09
	9/15/1999	491.0	101.4	426.3	536.4	388.78	296.20	481.35	458.65	318.90	102.94	-12.30	3.13
	9/30/1999	497.9	106.7	434.7	543.6	395.73	302.30	489.15	466.30	325.15	104.78	-12.42	3.16
	10/15/1999	505.0	112.3	443.2	550.9	402.85	308.65	497.05	474.10	331.60	106.66	-12.52	3.19
	10/31/1999	515.6	118.8	452.5	560.9	411.95	317.20	506.70	484.05	339.85	109.07	-12.59	3.23
	11/15/1999	525.0	128.3	463.4	570.2	421.73	326.65	516.80	494.20	349.25	111.66	-12.64	3.25
	11/30/1999	532.5	134.9	471.5	576.8	428.93	333.70	524.15	502.00	355.85	113.57	-12.66	3.27
	12/15/1999	534.1	138.1	476.5	580.2	432.23	336.10	528.35	505.30	359.15	114.44	-12.78	3.27
	12/31/1999	540.4	144.3	484.4	587.2	439.08	342.35	535.80	512.40	365.75	116.25	-12.86	3.29
	3/31/2000	551.1	156	501.3	602.1	452.63	353.55	551.70	526.20	379.05	119.84	-13.17	3.30
	6/30/2000	533.5	137.3	477.6	577.9	431.58	335.40	527.75	505.55	357.60	114.27	-12.78	3.31
	9/30/2000	539.6	136.8	480.7	575.1	433.05	338.20	527.90	510.15	355.95	114.66	-12.61	3.45
	1/13/2001	571.4	169.7	522.7	611.8	468.90	370.55	567.25	547.05	390.75	124.15	-13.07	3.50
	4/20/2001	580.2	184.8	537.9	624.6	481.88	382.50	581.25	559.05	404.70	127.59	-13.21	3.46
	7/16/2001	555.8	159.1	508	598.6	455.38	357.45	553.30	531.90	378.85	120.57	-13.02	3.43
	10/9/2001	556.2	154.1	506	595.8	453.03	355.15	550.90	531.10	374.95	119.95	-13.01	3.50
	1/9/2002	572	170.3	527.3	614.7	471.08	371.15	571.00	549.65	392.50	124.73	-13.28	3.52
	4/12/2002	584.6	187.7	546.3	632.8	487.85	386.15	589.55	565.45	410.25	129.17	-13.52	3.48
	7/18/2002	559.5	162.1	516.1	606	460.93	360.80	561.05	537.80	384.05	122.04	-13.31	3.44
	10/8/2002	557	154.4	511	599.8	455.55	355.70	555.40	534.00	377.10	120.62	-13.27	3.51
	1/8/2003	591	189.2	552.8	639	493.00	390.10	595.90	571.90	414.10	130.53	-13.68	3.54
	4/15/2003	597.9	204.3	567.5	650.5	505.05	401.10	609.00	582.70	427.40	133.72	-13.82	3.48
	7/1/2003	580.7	184.3	545.4	632.5	485.73	382.50	588.95	563.05	408.40	128.61	-13.72	3.46
	10/7/2003	578.2	176.3	538	627	479.88	377.25	582.50	558.10	401.65	127.06	-13.64	3.50
	12/31/2003	610.3	207.7	572.6	661.6	513.05	409.00	617.10	591.45	434.65	135.84	-13.83	3.51
	4/13/2004	617.1	224.2	589.5	675.7	526.63	420.65	632.60	603.30	449.95	139.43	-14.09	3.44
	7/13/2004	584	186.6	549.1	642.6	490.58	385.30	595.85	566.55	414.60	129.89	-13.99	3.40
	10/8/2004	581.8	181.2	543.7	638.3	486.25	381.50	591.00	562.75	409.75	128.74	-13.92	3.43
	1/7/2005	609.9	209	574.8	669.1	515.70	409.45	621.95	592.35	439.05	136.54	-14.12	3.43
	4/8/2005	617.5	225	590.2	683.9	529.15	421.25	637.05	603.85	454.45	140.10	-14.34	3.35
	7/18/2005	590.4	192.7	554.7	656	498.45	391.55	605.35	572.55	424.35	131.97	-14.21	3.32
	8/26/2005	584.4	183.1	544	647.8	489.83	383.75	595.90	564.20	415.45	129.69	-14.10	3.33
	10/11/2005	589.3	185.9	548.5	652	493.93	387.60	600.25	568.90	418.95	130.78	-14.13	3.36
	1/10/2006	616	216.1	582.8	683.4	524.58	416.05	633.10	599.40	449.75	138.89	-14.42	3.35
	4/9/2006	629	235.4	605.8	701.1	542.83	432.20	653.45	617.40	468.25	143.72	-14.70	3.34
	7/19/2006	595.8	199	563.1	668.3	506.55	397.40	615.70	579.45	433.65	134.12	-14.51	3.27
	10/18/2006	595.6	193	557.4	662.8	502.20	394.30	610.10	576.50	427.90	132.97	-14.34	3.33
	1/18/2007	622.2	223.4	590.2	694.6	532.60	422.80	642.40	606.20	459.00	141.02	-14.59	3.30
	4/19/2007	624.5	231.7	598.4	701.1	538.93	428.10	649.75	611.45	466.40	142.69	-14.73	3.25
	7/11/2007	594.6	199.2	561.5	670.8	506.53	396.90	616.15	578.05	435.00	134.11	-14.57	3.20
	10/20/2007	588.7	187	550.3	661.8	496.95	387.85	606.05	569.50	424.40	131.58	-14.50	3.25

Tie Beam Forces and Bending Moments (Drilled Shaft side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
1	7/1/1999	-115.0	299.7	422.9	109.6	179.30	92.35	266.25	153.95	204.65	47.47	-11.56	-1.14
	7/15/1999	-122.0	289	405.2	95.6	166.95	83.50	250.40	141.60	192.30	44.20	-11.09	-1.14
	8/15/1999	-139.4	265.8	401.5	101.8	157.43	63.20	251.65	131.05	183.80	41.68	-12.52	-1.18
	8/31/1999	-144.1	258.4	394.7	99.6	152.15	57.15	247.15	125.30	179.00	40.28	-12.63	-1.20
	9/15/1999	-144.1	255.9	395.1	102	152.23	55.90	248.55	125.50	178.95	40.30	-12.80	-1.20
	9/30/1999	-141.7	260.4	408.3	112.3	159.83	59.35	260.30	133.30	186.35	42.32	-13.35	-1.19
	10/15/1999	-138.1	275.3	441.9	138.4	179.38	68.60	290.15	151.90	206.85	47.49	-14.72	-1.23
	10/31/1999	-148.1	272.7	430.1	118.5	168.30	62.30	274.30	141.00	195.60	44.56	-14.09	-1.22
	11/15/1999	-142.3	278.9	446.6	134.9	179.53	68.30	290.75	152.15	206.90	47.53	-14.78	-1.23
	11/30/1999	-137.9	284.4	462	150.8	189.83	73.25	306.40	162.05	217.60	50.26	-15.49	-1.24
	12/15/1999	-135.4	290	463.8	152.5	192.73	77.30	308.15	164.20	221.25	51.03	-15.34	-1.28
	12/31/1999	-126.8	301.4	481.4	168.9	206.23	87.30	325.15	177.30	235.15	54.60	-15.81	-1.30
	3/31/2000	-133.9	283.1	455.7	149.6	188.63	74.60	302.65	160.90	216.35	49.94	-15.16	-1.24
	6/30/2000	-157.3	230.6	397.4	119.3	147.50	36.65	258.35	120.05	174.95	39.05	-14.73	-1.23
	9/30/2000	-142.8	237.4	427.4	156.8	169.70	47.30	292.10	142.30	197.10	44.93	-16.27	-1.23
	1/13/2001	-118.2	295.4	511.7	182.5	217.85	88.60	347.10	196.75	238.95	57.68	-17.18	-0.95
	4/20/2001	-128.9	270.9	454	163.4	189.85	71.00	308.70	162.55	217.15	50.27	-15.80	-1.22
	7/16/2001	-146.4	213.9	384.1	133.3	146.23	33.75	258.70	118.85	173.60	38.72	-14.95	-1.23
	10/9/2001	-135.7	237.5	439.4	178.3	179.88	50.90	308.85	151.85	207.90	47.63	-17.14	-1.26
	1/9/2002	-120.2	281.4	483	190.7	208.73	80.60	336.85	181.40	236.05	55.26	-17.03	-1.22
	4/12/2002	-133.2	263.6	441.1	154.2	181.43	65.20	297.65	153.95	208.90	48.04	-15.45	-1.23
	7/18/2002	-158.1	191.2	355.6	118	126.68	16.55	236.80	98.75	154.60	33.54	-14.64	-1.25
	10/7/2002	-149.2	192.4	391.7	156.3	147.80	21.60	274.00	121.25	174.35	39.13	-16.77	-1.19
	1/8/2003	-123.2	268.7	469.3	191.8	201.65	72.75	330.55	173.05	230.25	53.39	-17.13	-1.28
	4/15/2003	-137.5	248.4	427.1	157.1	173.78	55.45	292.10	144.80	202.75	46.01	-15.73	-1.30
	7/1/2003	-159.7	183.9	351.2	124.6	125.00	12.10	237.90	95.75	154.25	33.10	-15.01	-1.31
	10/7/2003	-146.6	206.4	412.6	177.8	162.55	29.90	295.20	133.00	192.10	43.04	-17.63	-1.32
	12/31/2003	-135.4	243.4	450.4	190	187.10	54.00	320.20	157.50	216.70	49.54	-17.69	-1.33
	4/13/2004	-144.6	228.6	422.1	168	168.53	42.00	295.05	138.75	198.30	44.62	-16.82	-1.33
	7/13/2004	-179.1	155.6	334.2	117.5	107.05	-11.75	225.85	77.55	136.55	28.34	-15.79	-1.32
	10/8/2004	-169	170.9	373.7	152.9	132.13	0.95	263.30	102.35	161.90	34.98	-17.44	-1.33
	1/7/2005	-145.5	227.8	440.5	188.2	177.75	41.15	314.35	147.50	208.00	47.06	-18.16	-1.36
	4/8/2005	-159.4	209.2	398.5	148.8	149.28	24.90	273.65	119.55	179.00	39.52	-16.53	-1.33
	7/18/2005	-182.8	141.5	330.3	131.3	105.08	-20.65	230.80	73.75	136.40	27.82	-16.71	-1.40
	8/26/2005	-184	140.7	341.3	131.3	107.33	-21.65	236.30	78.65	136.00	28.42	-17.14	-1.28
	10/11/2005	-174.2	159.1	370.9	131.3	121.78	-7.55	251.10	98.35	145.20	32.24	-17.19	-1.05
	1/10/2006	-152.5	216.4	430.7	131.3	156.48	31.95	281.00	139.10	173.85	41.43	-16.55	-0.78
	4/9/2006	-157.2	206.1	413	131.3	148.30	24.45	272.15	127.90	168.70	39.27	-16.46	-0.91
	7/19/2006	-189.4	135.9	330	131.3	101.95	-26.75	230.65	70.30	133.60	26.99	-17.11	-1.42
	10/18/2006	-170.5	170.2	390.6	131.3	130.40	-0.15	260.95	110.05	150.75	34.53	-17.35	-0.91
	1/18/2007	-145.4	217.2	448.1	131.3	162.80	35.90	289.70	151.35	174.25	43.10	-16.87	-0.51
	4/19/2007	-159.2	203.2	410.4	131.3	146.43	22.00	270.85	125.60	167.25	38.77	-16.54	-0.93
	7/11/2007	-192.9	128.3	318.7	131.3	96.35	-32.30	225.00	62.90	129.80	25.51	-17.10	-1.50
	10/20/2007	-183.2	145.9	358.7	131.3	113.18	-18.65	245.00	87.75	138.60	29.97	-17.52	-1.14

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
12	7/1/1999	356.2	257	201.2	275.1	272.38	306.60	238.15	278.70	266.05	72.12	4.55	0.28
	7/15/1999	353.8	251.6	188.4	273.4	266.80	302.70	230.90	271.10	262.50	70.64	4.77	0.19
	8/15/1999	350.0	242.8	195.3	301.1	272.30	296.40	248.20	272.65	271.95	72.10	3.20	0.02
	8/31/1999	350.2	247.8	201.7	307.9	276.90	299.00	254.80	275.95	277.85	73.31	2.94	-0.04
	9/15/1999	349.8	249.1	203.6	314	279.13	299.45	258.80	276.70	281.55	73.90	2.70	-0.11
	9/30/1999	352.2	256.8	212.1	322.7	285.95	304.50	267.40	282.15	289.75	75.71	2.47	-0.17
	10/15/1999	352.6	257.7	225.5	337.3	293.28	305.15	281.40	289.05	297.50	77.65	1.58	-0.19
	10/31/1999	361.0	268.5	222.6	333.7	296.45	314.75	278.15	291.80	301.10	78.49	2.43	-0.21
	11/15/1999	364.5	273.1	237.1	353.6	307.08	318.80	295.35	300.80	313.35	81.30	1.56	-0.28
	11/30/1999	367.6	276.3	249.1	369.4	315.60	321.95	309.25	308.35	322.85	83.56	0.84	-0.32
	12/15/1999	370.6	280.7	248.5	364.3	316.03	325.65	306.40	309.55	322.50	83.67	1.28	-0.29
	12/31/1999	371.2	282.5	254.8	368.8	319.33	326.85	311.80	313.00	325.65	84.55	1.00	-0.28
	3/31/2000	376.0	289.2	244.7	361.1	317.75	332.60	302.90	310.35	325.15	84.13	1.97	-0.33
	6/30/2000	358.4	247.7	207.4	329.3	285.70	303.05	268.35	282.90	288.50	75.64	2.31	-0.13
	9/30/2000	357.6	235.9	230.1	366.4	297.50	296.75	298.25	293.85	301.15	78.77	-0.10	-0.16
	1/13/2001	382.0	289.5	264.4	384.8	330.18	335.75	324.60	323.20	337.15	87.42	0.74	-0.31
	4/20/2001	382.9	294.9	260.1	378.2	329.03	338.90	319.15	321.50	336.55	87.12	1.31	-0.34
	7/16/2001	352.4	249.4	219.2	330.6	287.90	300.90	274.90	285.80	290.00	76.23	1.73	-0.09
	10/9/2001	357.7	267.9	262.1	382	317.43	312.80	322.05	309.90	324.95	84.04	-0.61	-0.34
	1/9/2002	385.8	301.2	285.1	395.6	341.93	343.50	340.35	335.45	348.40	90.53	0.21	-0.29
	4/12/2002	390.9	310.2	263.2	370.1	333.60	350.55	316.65	327.05	340.15	88.33	2.25	-0.29
	7/18/2002	346.39	265.03	220.4	323.3	288.78	305.71	271.85	283.39	294.17	76.46	2.25	-0.24
	10/7/2002	344.5	265.3	252.4	363.5	306.43	304.90	307.95	298.45	314.40	81.13	-0.20	-0.36
	1/8/2003	385.9	308.5	295.9	394.3	346.15	347.20	345.10	340.90	351.40	91.65	0.14	-0.24
	4/15/2003	392.4	317.3	275.8	371.1	339.15	354.85	323.45	334.10	344.20	89.80	2.09	-0.23
	7/1/2003	360	288.1	238.7	332.8	304.90	324.05	285.75	299.35	310.45	80.73	2.55	-0.25
	10/7/2003	357.1	284.5	277.7	372.1	322.85	320.80	324.90	317.40	328.30	85.48	-0.27	-0.24
	12/31/2003	387.7	318.7	304.1	392.5	350.75	353.20	348.30	345.90	355.60	92.87	0.33	-0.22
	4/13/2004	389.4	324.2	294.9	381.2	347.43	356.80	338.05	342.15	352.70	91.99	1.25	-0.24
	7/13/2004	348	285.8	241	324.8	299.90	316.90	282.90	294.50	305.30	79.40	2.26	-0.24
	10/8/2004	342.4	281.8	269.4	353.1	311.68	312.10	311.25	305.90	317.45	82.52	0.06	-0.26
	1/7/2005	374.1	315.2	302.9	382.8	343.75	344.65	342.85	338.50	349.00	91.01	0.12	-0.24
	4/8/2005	386.7	328.9	284.3	365	341.23	357.80	324.65	335.50	346.95	90.35	2.20	-0.26
	7/18/2005	343.2	285.5	242.4	322.1	298.30	314.35	282.25	292.80	303.80	78.98	2.13	-0.25
	8/26/2005	337	278.7	250.1	331.1	299.23	307.85	290.60	293.55	304.90	79.23	1.15	-0.25
	10/11/2005	338.7	283.6	264.1	348.6	308.75	311.15	306.35	301.40	316.10	81.75	0.32	-0.33
	1/10/2006	371.5	317.4	297	373.5	339.85	344.45	335.25	334.25	345.45	89.98	0.61	-0.25
	4/9/2006	377.4	324.1	290.6	368.2	340.08	350.75	329.40	334.00	346.15	90.04	1.42	-0.27
	7/19/2006	341.9	289.2	238.8	315.3	296.30	315.55	277.05	290.35	302.25	78.45	2.56	-0.27
	10/18/2006	342.7	289.5	274.8	354.5	315.38	316.10	314.65	308.75	322.00	83.50	0.10	-0.30
	1/18/2007	368.4	316.6	305.5	385	343.88	342.50	345.25	336.95	350.80	91.05	-0.18	-0.31
	4/19/2007	370.5	320.9	279.2	353.9	331.13	345.70	316.55	324.85	337.40	87.67	1.94	-0.28
	7/11/2007	326.6	278.1	219	294	279.43	302.35	256.50	272.80	286.05	73.98	3.05	-0.30
	10/20/2007	325.9	278.3	243.8	321.7	292.43	302.10	282.75	284.85	300.00	77.43	1.29	-0.34

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
13	7/1/1999	177.4	380.2	417.6	236.2	302.85	278.80	326.90	297.50	308.20	80.19	-3.20	-0.24
	7/15/1999	173.8	378	412.7	230.2	298.68	275.90	321.45	293.25	304.10	79.08	-3.03	-0.24
	8/15/1999	172.8	380.2	439.6	252.6	311.30	276.50	346.10	306.20	316.40	82.42	-4.63	-0.23
	8/31/1999	172.6	378	445.8	257.5	313.48	275.30	351.65	309.20	317.75	83.00	-5.07	-0.19
	9/15/1999	170.9	377.2	447.2	261	314.08	274.05	354.10	309.05	319.10	83.16	-5.32	-0.23
	9/30/1999	176.4	380.7	455.9	269.3	320.58	278.55	362.60	316.15	325.00	84.88	-5.59	-0.20
	10/15/1999	176.7	378.9	468.1	279.5	325.80	277.80	373.80	322.40	329.20	86.26	-6.38	-0.15
	10/31/1999	182.4	385.8	502.1	273.8	336.03	284.10	387.95	342.25	329.80	88.97	-6.90	0.28
	11/15/1999	186.8	392.4	482.7	292	338.48	289.60	387.35	334.75	342.20	89.62	-6.50	-0.17
	11/30/1999	189.8	396.8	638.9	305.6	382.78	293.30	472.25	414.35	351.20	101.35	-11.89	1.41
	12/15/1999	193.5	401.1	516.7	302.2	353.38	297.30	409.45	355.10	351.65	93.56	-7.45	0.08
	12/31/1999	194.7	406.1	507.2	308	354.00	300.40	407.60	350.95	357.05	93.73	-7.12	-0.14
	3/31/2000	194.8	409	492.7	298.7	348.80	301.90	395.70	343.75	353.85	92.35	-6.23	-0.23
	6/30/2000	177.7	389.4	467.2	278.7	328.25	283.55	372.95	322.45	334.05	86.91	-5.94	-0.26
	9/30/2000	174.2	385.1	496.7	308	341.00	279.65	402.35	335.45	346.55	90.29	-8.15	-0.25
	1/13/2001	200.0	418.2	530.3	318.6	366.78	309.10	424.45	365.15	368.40	97.11	-7.67	-0.07
	4/20/2001	194.1	416.2	512.8	310.6	358.43	305.15	411.70	353.45	363.40	94.90	-7.08	-0.22
	7/16/2001	166.5	386.2	469	273.8	323.88	276.35	371.40	317.75	330.00	85.75	-6.32	-0.27
	10/9/2001	171.5	389.1	514.8	315.2	347.65	280.30	415.00	343.15	352.15	92.05	-8.95	-0.20
	1/9/2002	193.6	413.6	539.3	324.6	367.78	303.60	431.95	366.45	369.10	97.38	-8.53	-0.06
	4/12/2002	198.8	418.5	509.3	299.2	356.45	308.65	404.25	354.05	358.85	94.38	-6.35	-0.11
	7/18/2002	161.4	379.1	462.4	262.6	316.38	270.25	362.50	311.90	320.85	83.77	-6.13	-0.20
	10/7/2002	155.8	373.6	686.8	301.1	379.33	264.70	493.95	421.30	337.35	100.43	-15.24	1.88
	1/8/2003	193.1	414	547.6	331	371.43	303.55	439.30	370.35	372.50	98.34	-9.02	-0.05
	4/15/2003	195.8	419.9	560.6	305.7	370.50	307.85	433.15	378.20	362.80	98.10	-8.33	0.34
	7/1/2003	172.1	394.8	479.4	273.9	330.05	283.45	376.65	325.75	334.35	87.39	-6.19	-0.19
	10/7/2003	169	389.1	527.1	317.5	350.68	279.05	422.30	348.05	353.30	92.85	-9.52	-0.12
	12/31/2003	196.2	423.2	560.3	334.7	378.60	309.70	447.50	378.25	378.95	100.24	-9.16	-0.02
	4/13/2004	197.9	424.7	546.1	321.7	372.60	311.30	433.90	372.00	373.20	98.65	-8.15	-0.03
	7/13/2004	155.6	383.5	482.7	266.1	321.98	269.55	374.40	319.15	324.80	85.25	-6.97	-0.13
	10/8/2004	152.2	378.4	519	298.6	337.05	265.30	408.80	335.60	338.50	89.24	-9.54	-0.06
	1/7/2005	180.6	410.6	556.1	324.9	368.05	295.60	440.50	368.35	367.75	97.45	-9.63	0.01
	4/8/2005	188.3	419.5	529.1	301	359.48	303.90	415.05	358.70	360.25	95.18	-7.39	-0.03
	7/18/2005	150.7	376.8	482.9	262.2	318.15	263.75	372.55	316.80	319.50	84.24	-7.23	-0.06
	8/26/2005	144.7	373.1	494.1	275.3	321.80	258.90	384.70	319.40	324.20	85.20	-8.36	-0.11
	10/11/2005	146.5	375.2	533.7	291.5	336.73	260.85	412.60	340.10	333.35	89.15	-10.09	0.15
	1/10/2006	176	407.1	548.8	313.5	361.35	291.55	431.15	362.40	360.30	95.67	-9.28	0.05
	4/9/2006	180.6	412.1	538.7	307.8	359.80	296.35	423.25	359.65	359.95	95.26	-8.43	-0.01
	7/19/2006	149.4	377.4	480.1	259.8	316.68	263.40	369.95	314.75	318.60	83.85	-7.08	-0.09
	10/18/2006	155.2	382.8	532.6	304.1	343.68	269.00	418.35	343.90	343.45	90.99	-9.93	0.01
	1/18/2007	179.5	407.9	563.5	330.9	370.45	293.70	447.20	371.50	369.40	98.08	-10.20	0.05
	4/19/2007	182.7	413.5	536	305.6	359.45	298.10	420.80	359.35	359.55	95.17	-8.15	0.00
	7/11/2007	146.1	373.2	467.5	250.6	309.35	259.65	359.05	306.80	311.90	81.91	-6.61	-0.11
	10/20/2007	144.3	373.6	638.9	278.5	358.83	258.95	458.70	391.60	326.05	95.01	-13.28	1.47

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
14	7/1/1999	199.5	418.4	473.6	323.8	353.83	308.95	398.70	336.55	371.10	93.68	-5.96	-0.77
	7/15/1999	194.3	414.4	461.1	314.4	346.05	304.35	387.75	327.70	364.40	91.62	-5.54	-0.82
	8/15/1999	191.0	402.1	488.7	347.5	357.33	296.55	418.10	339.85	374.80	94.61	-8.08	-0.78
	8/31/1999	189.5	395.4	496	352.6	358.38	292.45	424.30	342.75	374.00	94.89	-8.76	-0.70
	9/15/1999	186.8	391.6	503.6	359.8	360.45	289.20	431.70	345.20	375.70	95.44	-9.47	-0.68
	9/30/1999	188.5	396.7	516	369	367.55	292.60	442.50	352.25	382.85	97.32	-9.96	-0.69
	10/15/1999	235.3	403	530.4	378.9	386.90	319.15	454.65	382.85	390.95	102.44	-9.01	-0.18
	10/31/1999	202.7	418.5	524.2	371.5	379.23	310.60	447.85	363.45	395.00	100.41	-9.12	-0.71
	11/15/1999	208.9	426.2	548.2	393.2	394.13	317.55	470.70	378.55	409.70	104.35	-10.18	-0.70
	11/30/1999	212.9	429.2	566.6	409.5	404.55	321.05	488.05	389.75	419.35	107.11	-11.10	-0.66
	12/15/1999	216.9	433.5	561.4	403.7	403.88	325.20	482.55	389.15	418.60	106.93	-10.46	-0.66
	12/31/1999	220.7	443.8	566.6	407.4	409.63	332.25	487.00	393.65	425.60	108.46	-10.28	-0.72
	3/31/2000	215.2	438.2	567.9	406.5	406.95	326.70	487.20	391.55	422.35	107.75	-10.67	-0.69
	6/30/2000	191.3	415.8	542.4	380.7	382.55	303.55	461.55	366.85	398.25	101.29	-10.50	-0.70
	6/30/2000	183.3	409.8	571	409.9	393.50	296.55	490.45	377.15	409.85	104.19	-12.89	-0.73
	1/13/2001	215.4	447.2	588.9	421.9	418.35	331.30	505.40	402.15	434.55	110.77	-11.57	-0.73
	4/20/2001	210.2	445.1	586.6	415.7	414.40	327.65	501.15	398.40	430.40	109.72	-11.53	-0.72
	7/16/2001	171.2	413	554.5	377.7	379.10	292.10	466.10	362.85	395.35	100.37	-11.56	-0.73
	10/9/2001	178.5	417.9	596.2	418.8	402.85	298.20	507.50	387.35	418.35	106.66	-13.91	-0.69
	1/9/2002	206.2	445.9	606.4	430	422.13	326.05	518.20	406.30	437.95	111.77	-12.77	-0.71
	4/12/2002	208.6	449.5	584.1	408.1	412.58	329.05	496.10	396.35	428.80	109.24	-11.10	-0.73
	7/18/2002	161.7	410.1	551.9	368.5	373.05	285.90	460.20	356.80	389.30	98.77	-11.58	-0.73
	10/7/2002	160.2	405.5	592.3	407.7	391.43	282.85	500.00	376.25	406.60	103.64	-14.43	-0.68
	1/8/2003	202	449.1	620.2	437.7	427.25	325.55	528.95	411.10	443.40	113.12	-13.52	-0.72
	4/15/2003	205.4	453.6	590	409.8	414.70	329.50	499.90	397.70	431.70	109.80	-11.32	-0.76
	7/1/2003	171.9	426.9	559.5	377.3	383.90	299.40	468.40	365.70	402.10	101.65	-11.23	-0.82
	10/7/2003	172	424.4	600.8	422.4	404.90	298.20	511.60	386.40	423.40	107.21	-14.18	-0.83
	12/31/2003	205.6	461.3	624.2	444.9	434.00	333.45	534.55	414.90	453.10	114.91	-13.36	-0.86
	4/13/2004	204.7	463.4	611.5	433.1	428.18	334.05	522.30	408.10	448.25	113.37	-12.51	-0.90
	7/13/2004	159.6	424.2	566.4	383.7	383.48	291.90	475.05	363.00	403.95	101.53	-12.17	-0.92
	10/8/2004	153	416.8	590.5	409.5	392.45	284.90	500.00	371.75	413.15	103.91	-14.30	-0.93
	1/7/2005	192.8	454.9	627.8	446.9	430.60	323.85	537.35	410.30	450.90	114.01	-14.19	-0.91
	4/8/2005	205.2	467.5	600.9	425.2	424.70	336.35	513.05	403.05	446.35	112.45	-11.74	-0.97
	7/18/2005	154.9	424.1	560.9	385.2	381.28	289.50	473.05	357.90	404.65	100.95	-12.20	-1.05
	8/26/2005	168.3	416.1	569.1	391.2	386.18	292.20	480.15	368.70	403.65	102.25	-12.49	-0.78
	10/11/2005	152.5	418.5	590.5	413.4	393.73	285.50	501.95	371.50	415.95	104.25	-14.38	-1.00
	1/10/2006	190.7	455.4	615	436.7	424.45	323.05	525.85	402.85	446.05	112.38	-13.48	-0.97
	4/9/2006	196.7	460.2	612.3	436.6	426.45	328.45	524.45	404.50	448.40	112.91	-13.03	-0.98
	7/19/2006	159.7	426.1	562.3	382.1	382.55	292.90	472.20	361.00	404.10	101.29	-11.92	-0.97
	10/18/2006	161.9	425.9	600.5	422.5	402.70	293.90	511.50	381.20	424.20	106.62	-14.46	-0.96
	1/18/2007	192.2	454.2	638.5	460	436.23	323.20	549.25	415.35	457.10	115.50	-15.02	-0.94
	4/19/2007	198.7	462.5	611.3	432	426.13	330.60	521.65	405.00	447.25	112.83	-12.70	-0.95
	7/11/2007	149.8	419.9	567.4	379.8	379.23	284.85	473.60	358.60	399.85	100.41	-12.54	-0.92
	10/20/2007	208.9	417	590.1	409	406.25	312.95	499.55	399.50	413.00	107.56	-12.40	-0.30

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

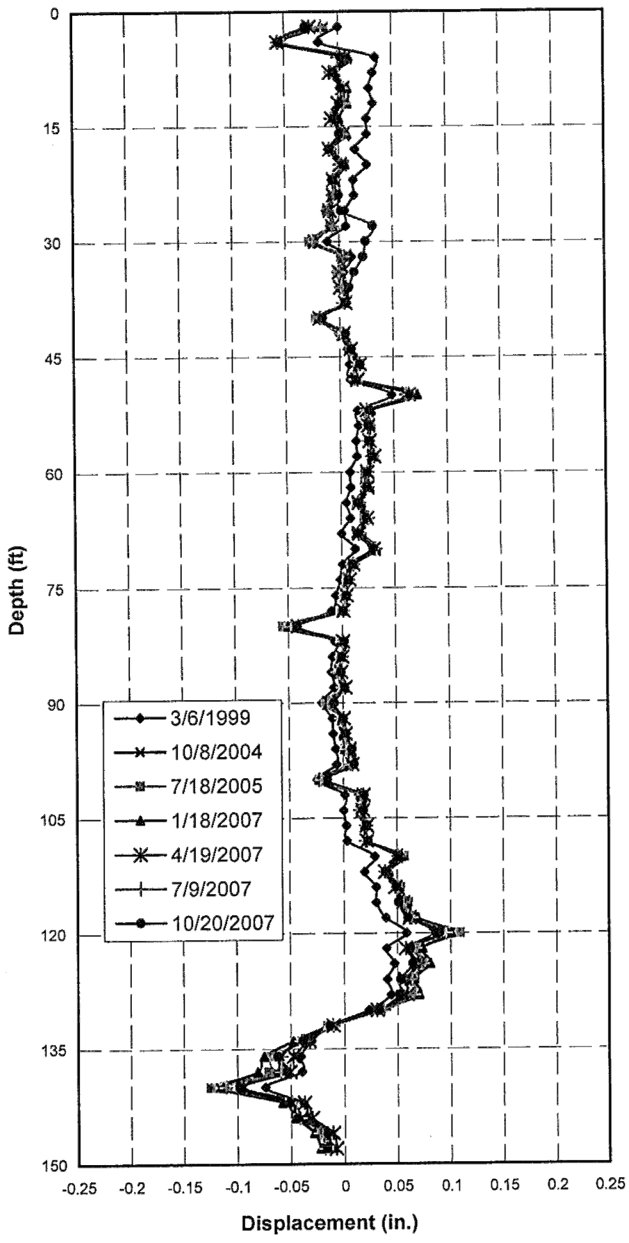
Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
26	7/1/1999	222.2	-19.9	305.2	560	266.88	101.15	432.60	263.70	270.05	70.66	-22.03	-0.14
	7/15/1999	207.8	-36.8	294.3	540.9	251.55	85.50	417.60	251.05	252.05	66.60	-22.07	-0.02
	8/15/1999	189.9	-53.4	320.4	546.8	250.93	68.25	433.60	255.15	246.70	66.44	-24.28	0.19
	8/31/1999	184.8	-60	330.2	555.2	252.55	62.40	442.70	257.50	247.60	66.87	-25.27	0.22
	9/15/1999	185.7	-57.2	336.6	558.2	255.83	64.25	447.40	261.15	250.50	67.73	-25.46	0.24
	9/30/1999	187.5	-53.7	349.9	570.1	263.45	66.90	460.00	268.70	258.20	69.75	-26.12	0.24
	10/15/1999	195.3	-50.5	375.2	601.5	280.38	72.40	488.35	285.25	275.50	74.23	-27.64	0.22
	10/31/1999	197.3	-39.9	370.8	589.7	279.48	78.70	480.25	284.05	274.90	74.00	-26.69	0.20
	11/15/1999	202.5	-32.3	385.9	601.1	289.30	85.10	493.50	294.20	284.40	76.60	-27.14	0.22
	11/30/1999	206.5	-27.3	398.1	613.9	297.80	89.60	506.00	302.30	293.30	78.85	-27.67	0.20
	12/15/1999	216.1	-19.5	401.6	620.9	304.78	98.30	511.25	308.85	300.70	80.70	-27.44	0.18
	12/31/1999	223.8	-15	410.7	633.4	313.23	104.40	522.05	317.25	309.20	82.93	-27.76	0.18
	3/31/2000	203.5	-16	395.7	633.5	304.18	93.75	514.60	299.60	308.75	80.54	-27.97	-0.20
	6/30/2000	149.3	-41	371.2	553.8	258.33	54.15	462.50	260.25	256.40	68.40	-27.14	0.09
	6/30/2000	154.3	-22.3	411.5	580.2	280.93	66.00	495.85	282.90	278.95	74.38	-28.57	0.09
	1/13/2001	197.9	7.7	446.8	627.1	319.88	102.80	536.95	322.35	317.40	84.69	-28.85	0.11
	4/20/2001	167.6	1.3	434.9	589.5	298.33	84.45	512.20	301.25	295.40	78.99	-28.43	0.13
	7/16/2001	112.8	-20.6	409.7	555.1	264.25	46.10	482.40	261.25	267.25	69.97	-29.00	-0.13
	10/9/2001	136.9	-5.4	451.7	582.7	291.48	65.75	517.20	294.30	288.65	77.17	-30.00	0.13
	1/9/2002	176.6	9	461.6	618.2	316.35	92.80	539.90	319.10	313.60	83.76	-29.71	0.12
	4/12/2002	158.20	3.40	438	581.00	295.25	80.80	509.70	298.30	292.20	78.17	-28.50	0.14
	7/18/2002	86.10	-23.70	405	503.86	242.87	31.20	454.53	245.65	240.08	64.30	-28.13	0.12
	10/7/2002	96.1	2.90	445.20	562.80	276.75	49.50	504.00	270.65	282.85	73.28	-30.21	-0.27
	1/8/2003	165.9	41.91	480.40	628.48	329.17	103.91	554.44	323.15	335.20	87.16	-29.94	-0.27
	4/15/2003	147.5	33.95	455.30	592.01	307.19	90.73	523.65	301.40	312.98	81.33	-28.77	-0.26
	7/1/2003	88.2	9.66	424.1	577.30	274.82	48.93	500.70	256.15	293.48	72.76	-30.02	-0.84
	10/7/2003	103.5	24.24	466.9	574.34	292.25	63.87	520.62	285.20	299.29	77.38	-30.35	-0.32
	12/31/2003	130.5	44.68	481.6	566.95	305.93	87.59	524.27	306.05	305.81	81.00	-29.02	0.01
	4/13/2004	118.2	42.08	471.6	585.31	304.30	80.14	528.45	294.90	313.69	80.57	-29.79	-0.42
	7/13/2004	49.6	8.40	430.9	548.80	259.43	29.00	489.85	240.25	278.60	68.69	-30.63	-0.86
	10/8/2004	54.7	18.19	457.3	588.15	279.59	36.45	522.72	256.00	303.17	74.03	-32.32	-1.06
	1/7/2005	108.7	42.65	486.4	597.82	308.89	75.67	542.11	297.55	320.23	81.78	-31.00	-0.51
	4/8/2005	91.7	33.99	457.3	601.47	296.12	62.85	529.39	274.50	317.73	78.40	-31.01	-0.97
	7/18/2005	28.7	12.91	432.3	605.33	269.81	20.81	518.82	230.50	309.12	71.44	-33.10	-1.76
	8/26/2005	31.4	16.85	447.8	588.39	271.11	24.13	518.10	239.60	302.62	71.78	-32.83	-1.41
	10/11/2005	43.7	14.58	464.4	588.60	277.82	29.14	526.50	254.05	301.59	73.56	-33.05	-1.06
	1/10/2006	96.3	14.58	483.8	588.60	295.82	55.44	536.20	290.05	301.59	78.32	-31.95	-0.26
	4/9/1906	87.1	29.40	477	588.60	295.52	58.25	532.80	282.05	309.00	78.25	-31.54	-0.60
	7/19/1906	18.4	-2.90	430.9	588.60	258.75	7.75	509.75	224.65	292.85	68.51	-33.36	-1.53
	10/18/1906	61.1	14.58	483.2	588.60	286.87	37.84	535.90	272.15	301.59	75.95	-33.10	-0.66
	1/18/2007	99.2	14.58	505.9	588.60	302.07	56.89	547.25	302.55	301.59	79.98	-32.59	0.02
	4/19/2007	80.5	14.58	477.1	588.60	290.19	47.54	532.85	278.80	301.59	76.83	-32.25	-0.51
	7/11/2007	11.2	14.5768	431.3	588.5957	261.42	12.89	509.95	221.25	301.59	69.22	-33.03	-1.80
	10/20/2007	19.8	14.5768	455.1	588.5957	269.52	17.19	521.85	237.45	301.59	71.36	-33.54	-1.44

Numerical reading of anchor load as a function of time for anchors #1, #8, #9 and #17

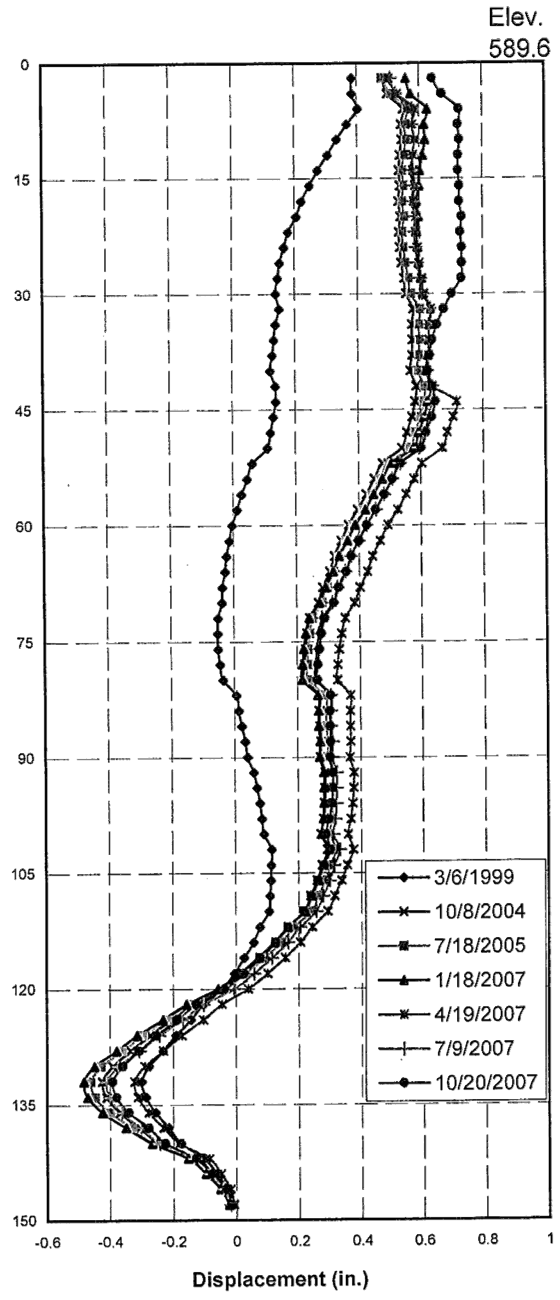
Date	Anchor #1 Load, kips	Anchor #8 Load, kips	Anchor #9 Load, kips	Anchor #17 Load, kips	Comment
4/7/1999		560			
4/8/1999	489			499	Anchor Lock off
4/14/1999	460	473	596 (Lock off)	461	
5/7/1999	452	473	572	445	End of construction
7/1/1999	446	468	564	439	
10/1/1999	441	467	560	440	
1/1/2000	439	461	555	424	
4/1/2000	432	453	546	414	
7/1/2000	431	451	521	415	
10/1/2000	431	451	519	416	
1/1/2001	430	455	517	400	
4/1/2001	421	443	513	397	
7/1/2001	422	443	510	399	
10/1/2001	425	445	512	403	
1/1/2002	424	444	511	398	
4/1/2002	421	440	508	386	
7/1/2002	419	439	506	391	
10/1/2002	423	442	508	396	
1/1/2003	423	435	508	389	
4/15/2003	416	427	501	380	
8/7/2003	416	428	503	384	
10/7/2003	418	429	504	387	
12/31/2003	417	426	503	378	
4/13/2004	408	418	494	370	
7/13/2004	409	419	494	374	
10/8/2004	411	422	496	377	
1/7/2005	411	421	495	374	
4/8/2005	407	414	485	366	
7/18/2005	407	415	485	370	
11/12/2005	410	419	489	374	
1/10/2006	409	417	487	369	
4/9/2006	399	411	487	365	
7/19/2006	399	412	487	368	
10/18/2006	407.3	414.8	489.6	371.7	
1/18/2007	405	412	487	366	
4/19/2007	401	406	501	361	
7/9/2007	401	408	502	365	
10/20/2007	404	411	506	369	

Inclinometer #1 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

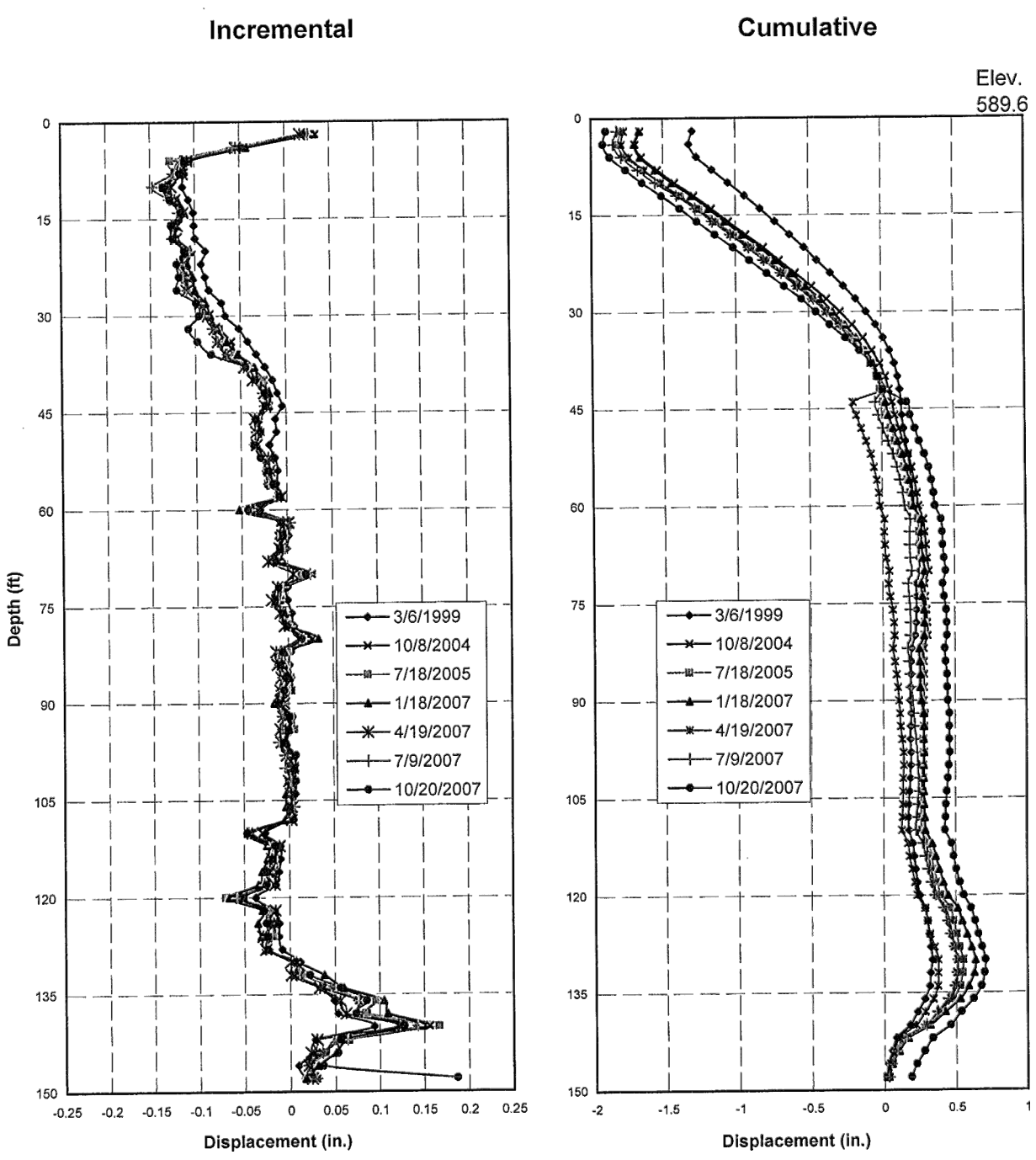
Incremental



Cumulative

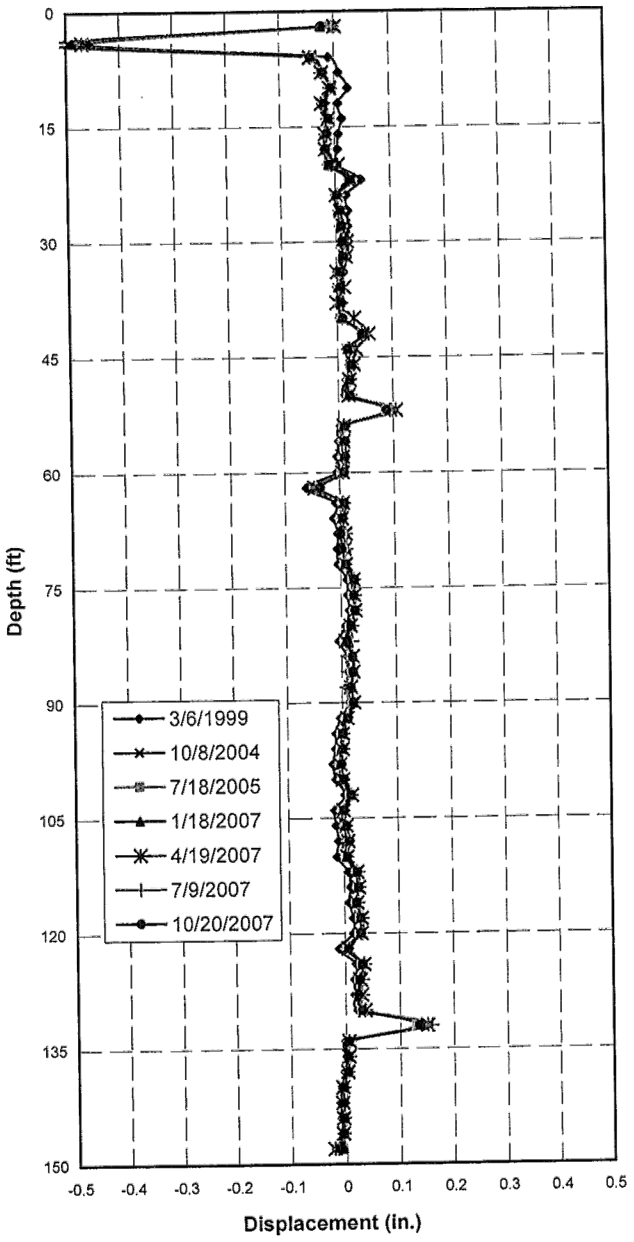


Inclinometer #1 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998



Inclinometer #3 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



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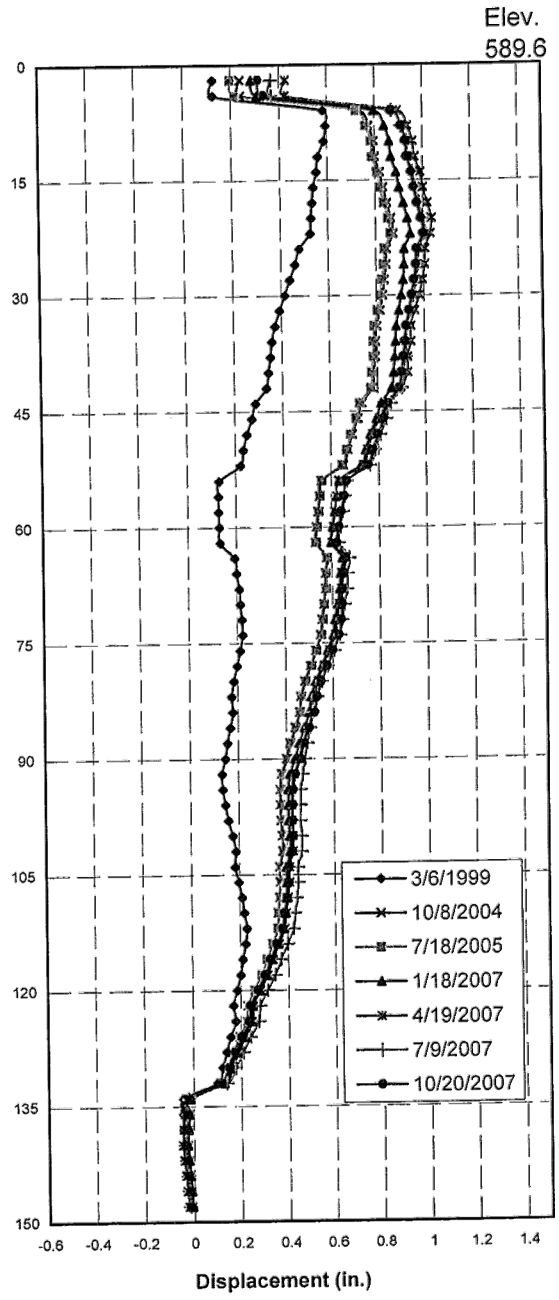
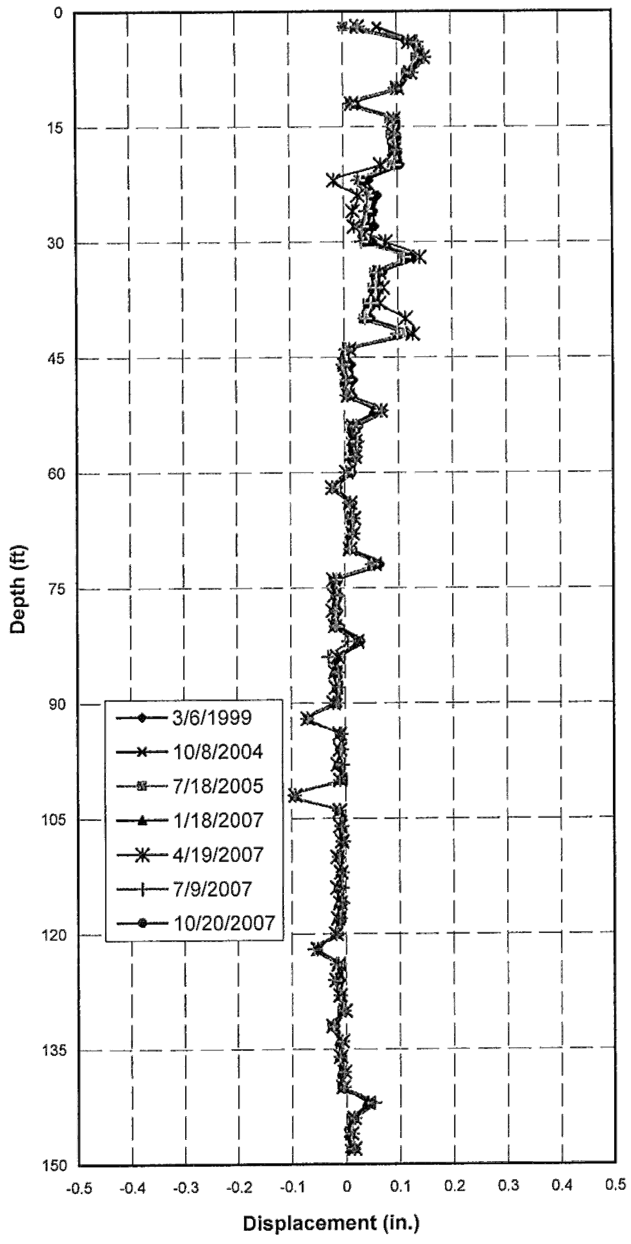


Inclinometer #3 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



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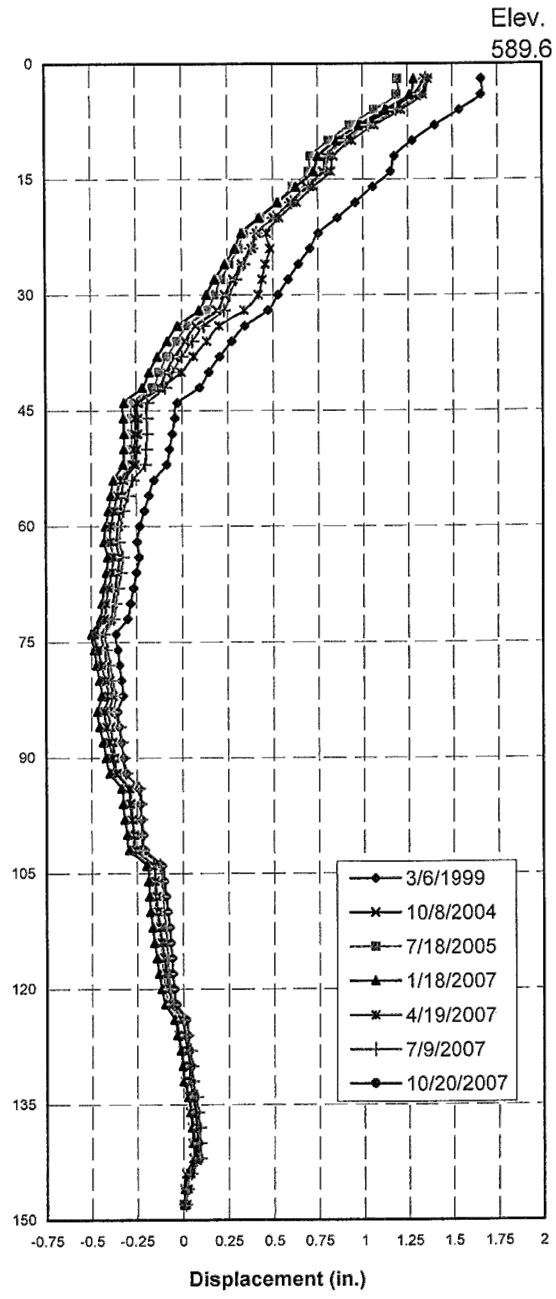
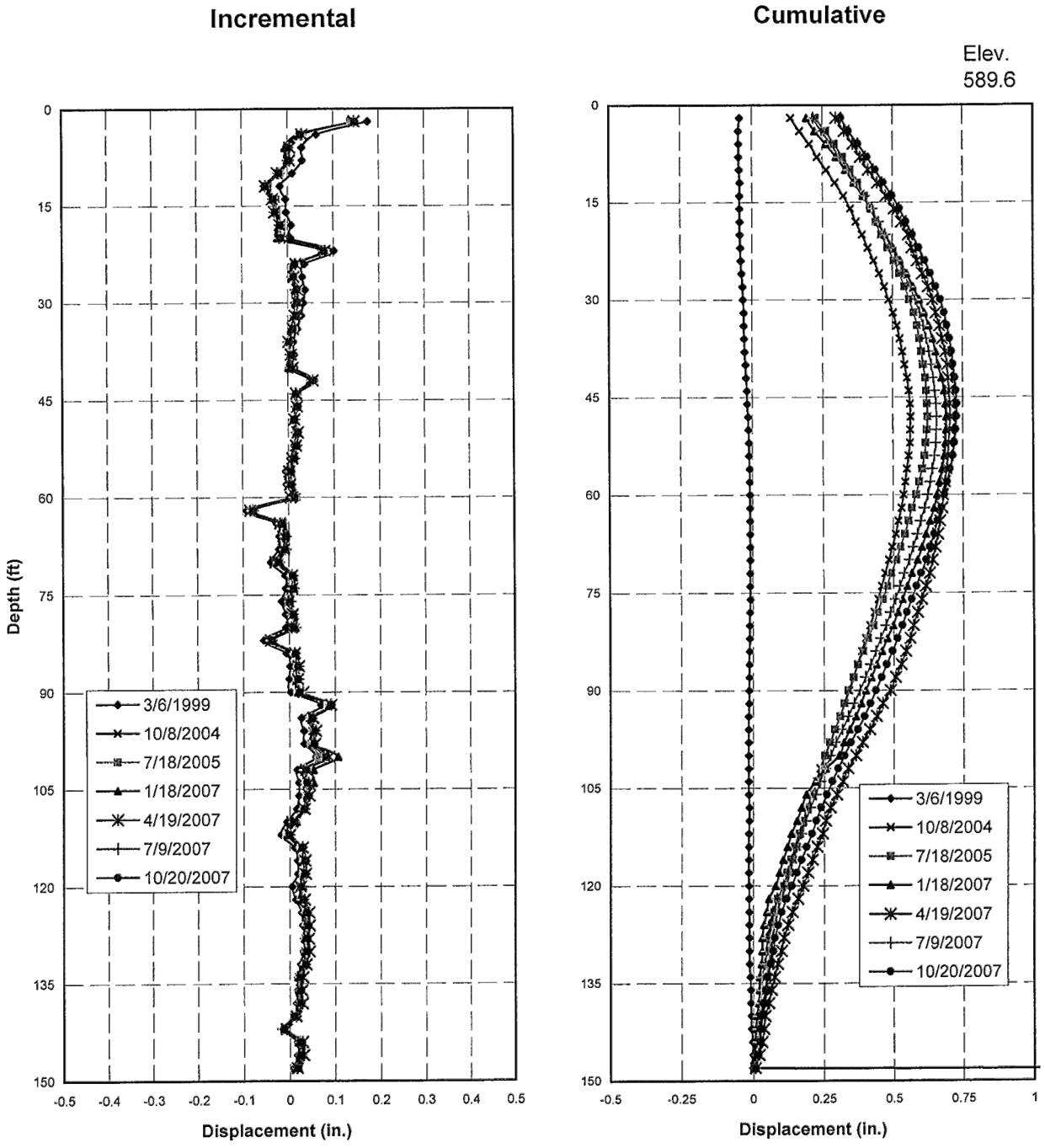
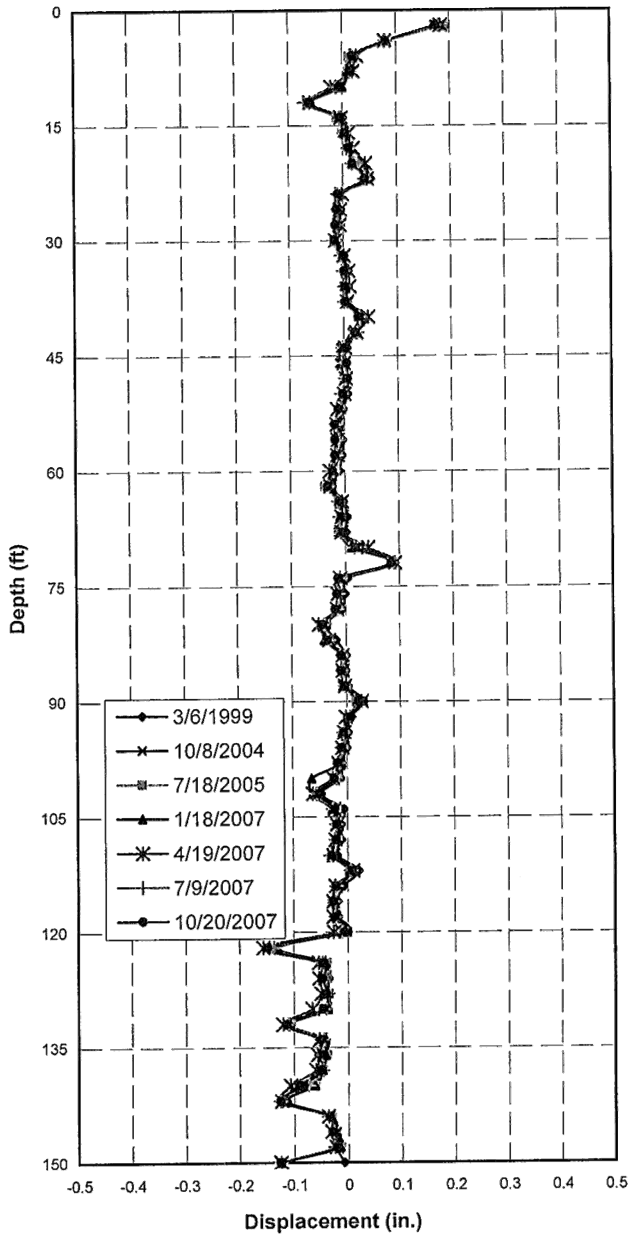


Inclinometer #8 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998



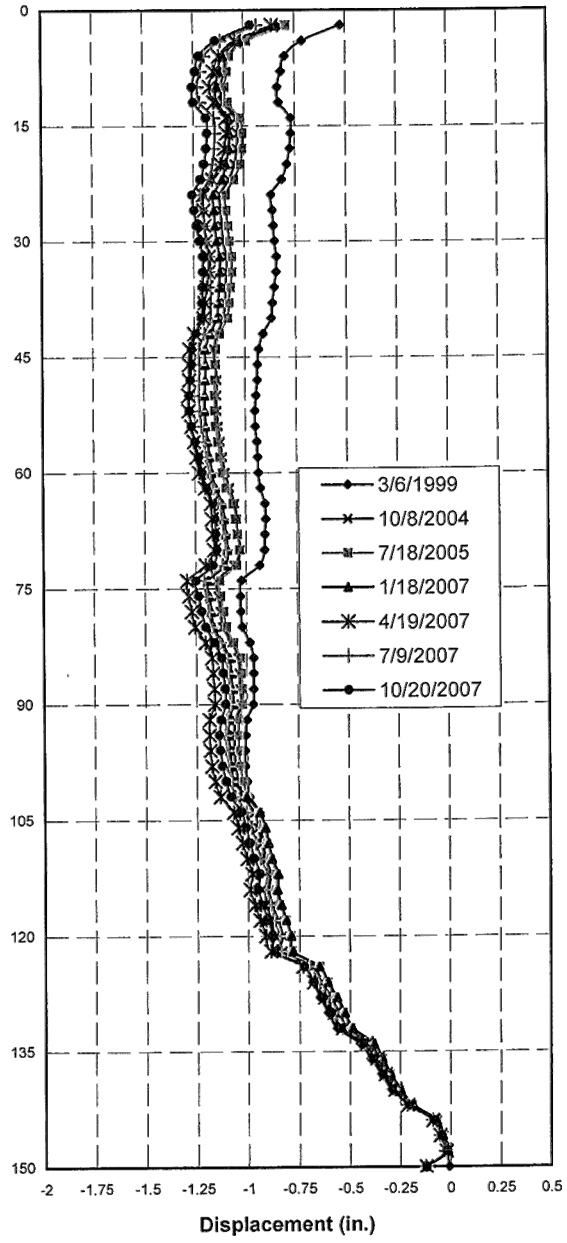
Inclinometer #8 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



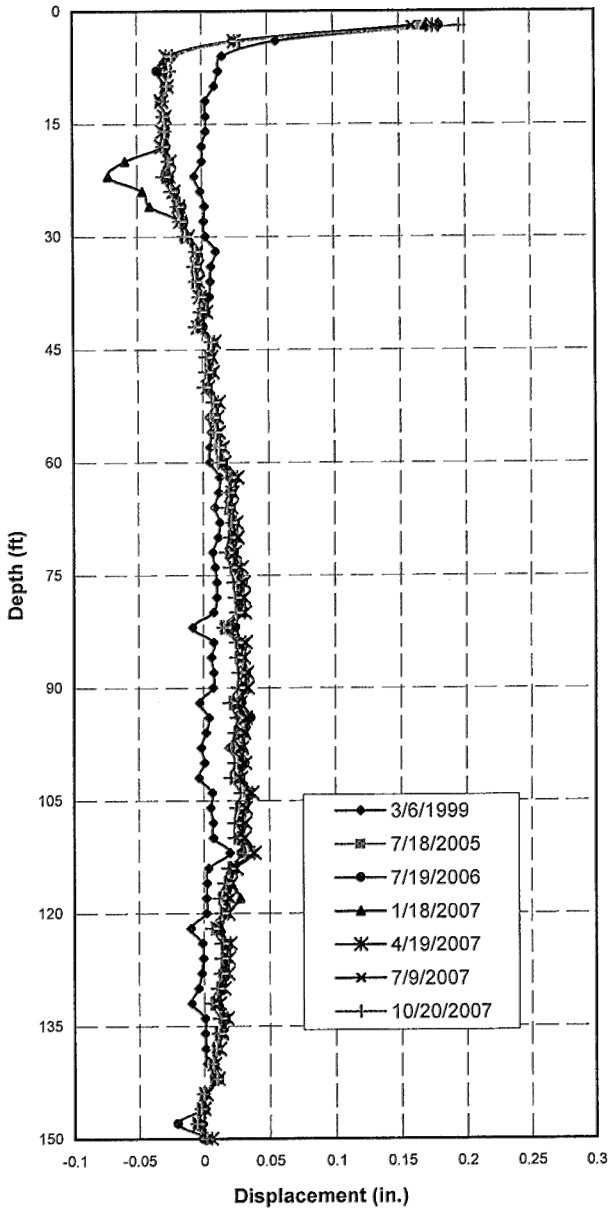
Cumulative

Elev.
589.6

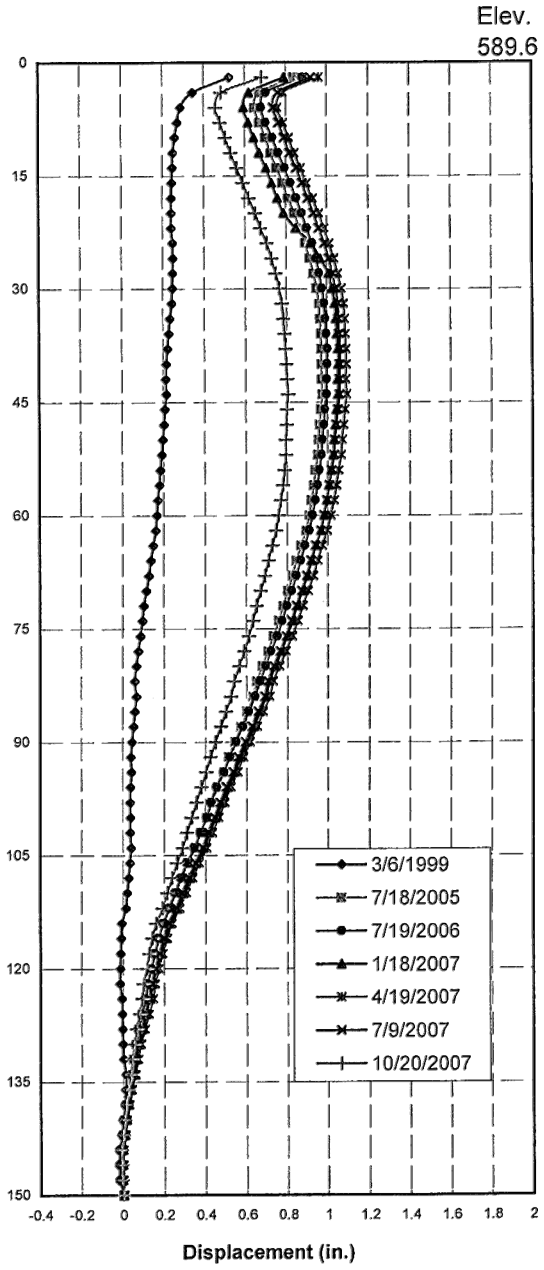


Inclinometer #9A Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

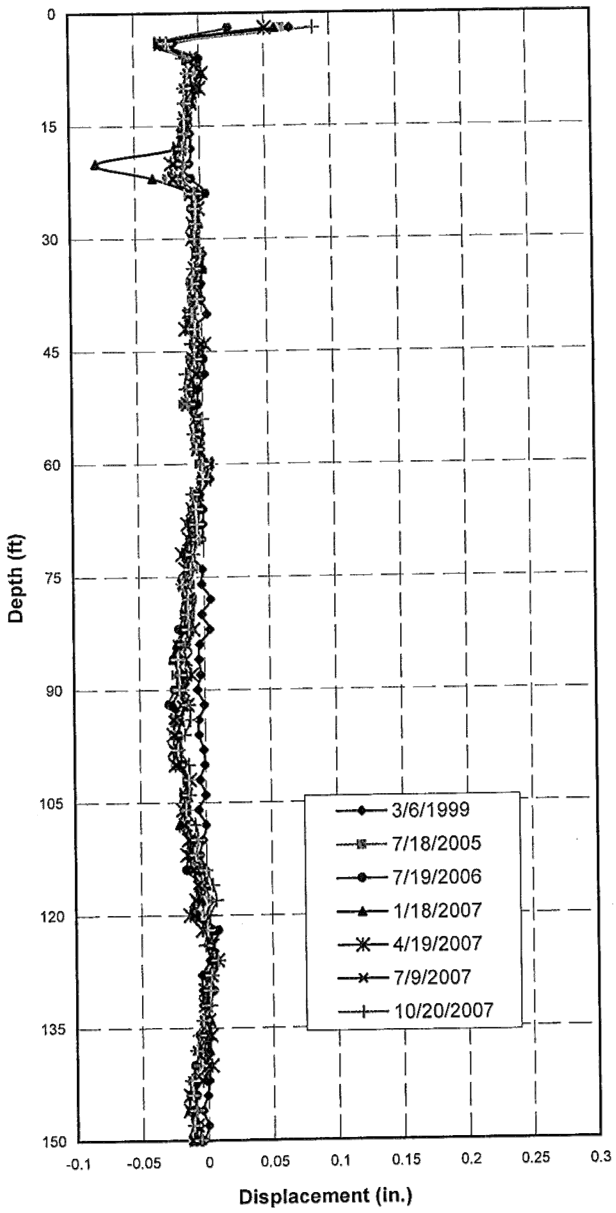


Cumulative

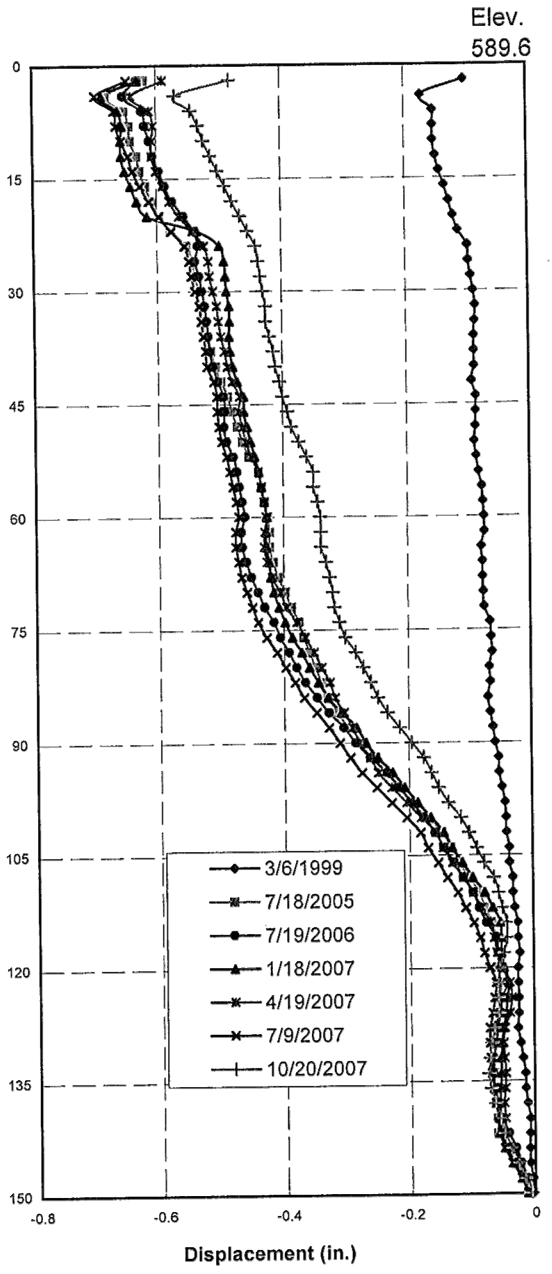


Inclinometer #9A Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

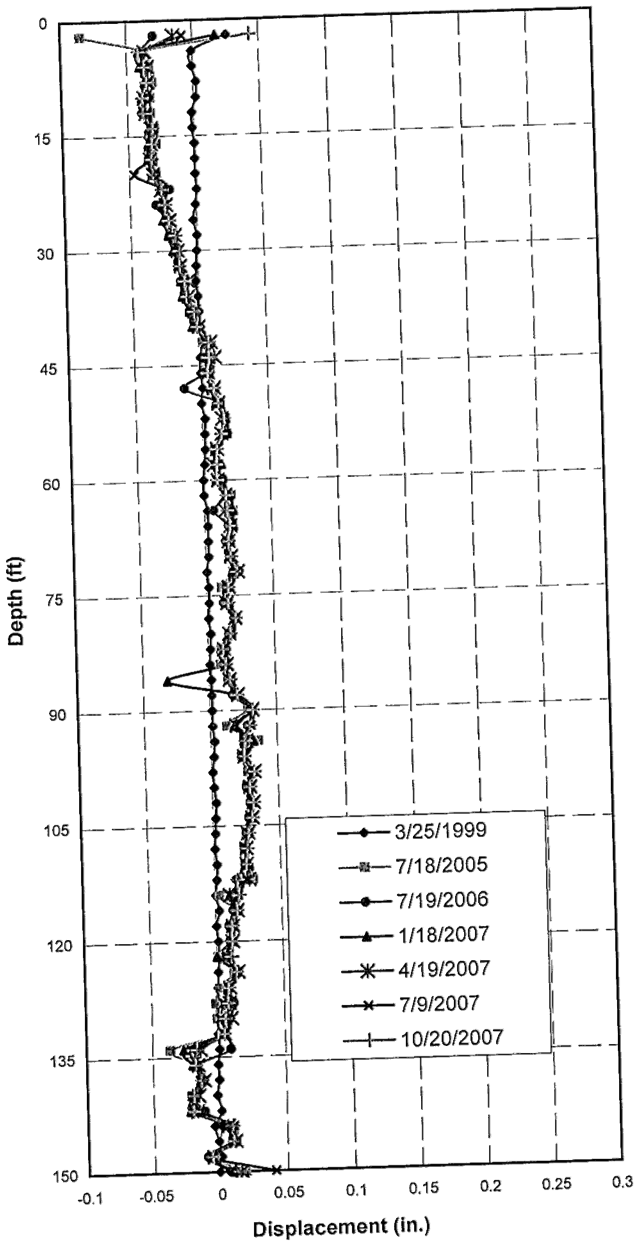


Cumulative

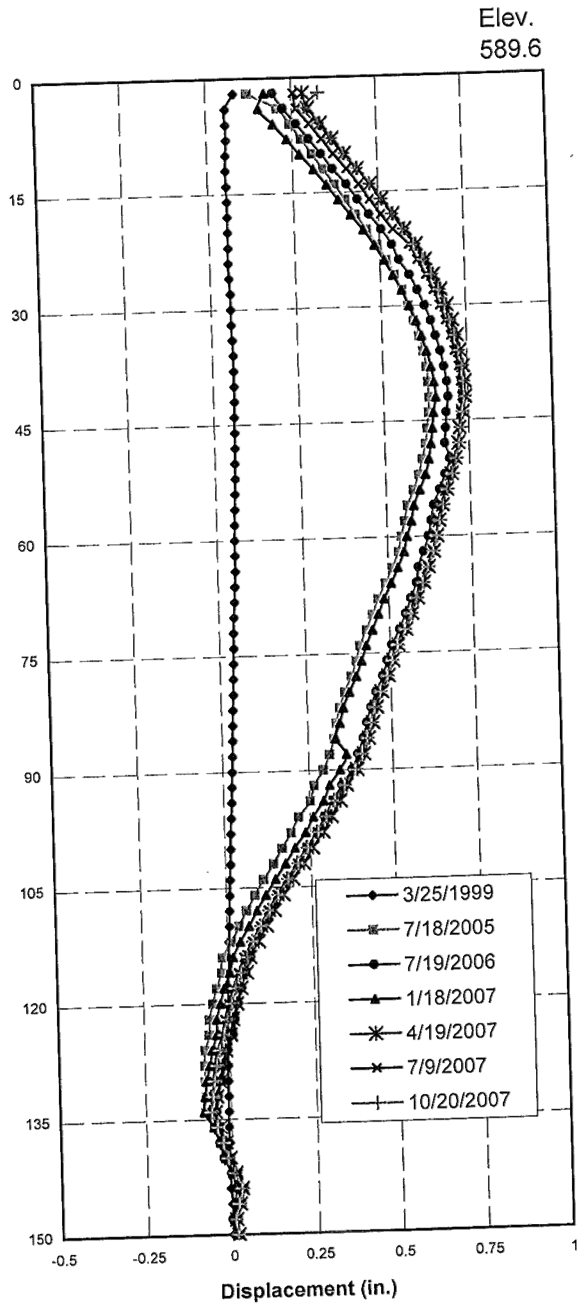


Inclinometer #10 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

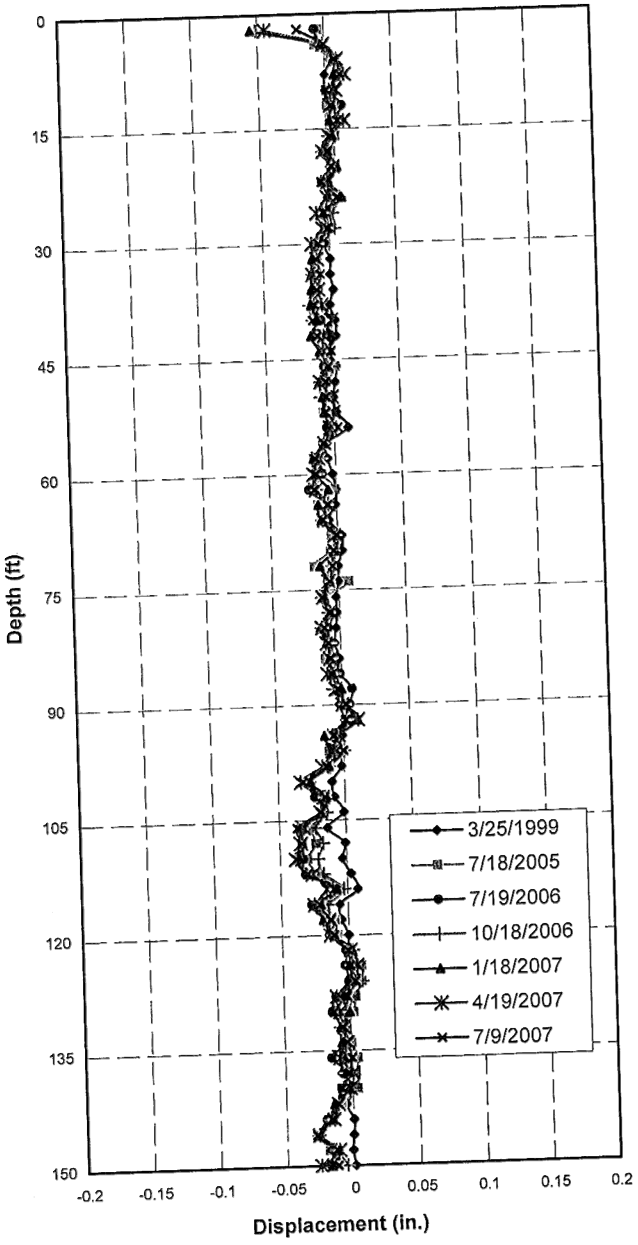


Cumulative

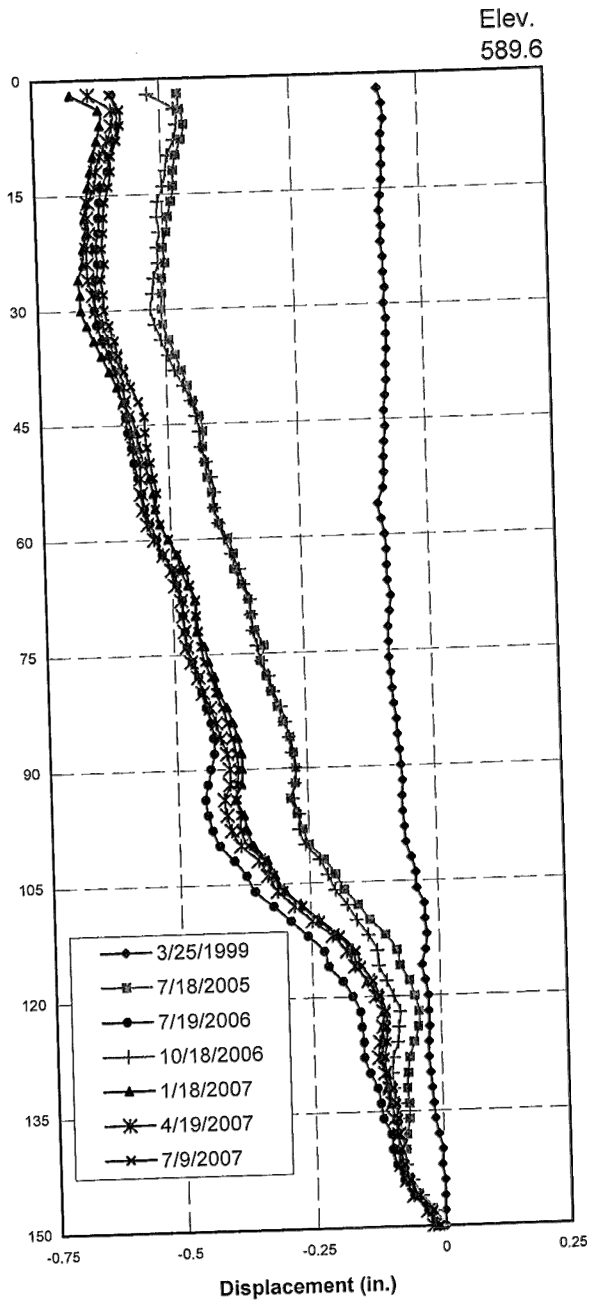


Inclinometer #10 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

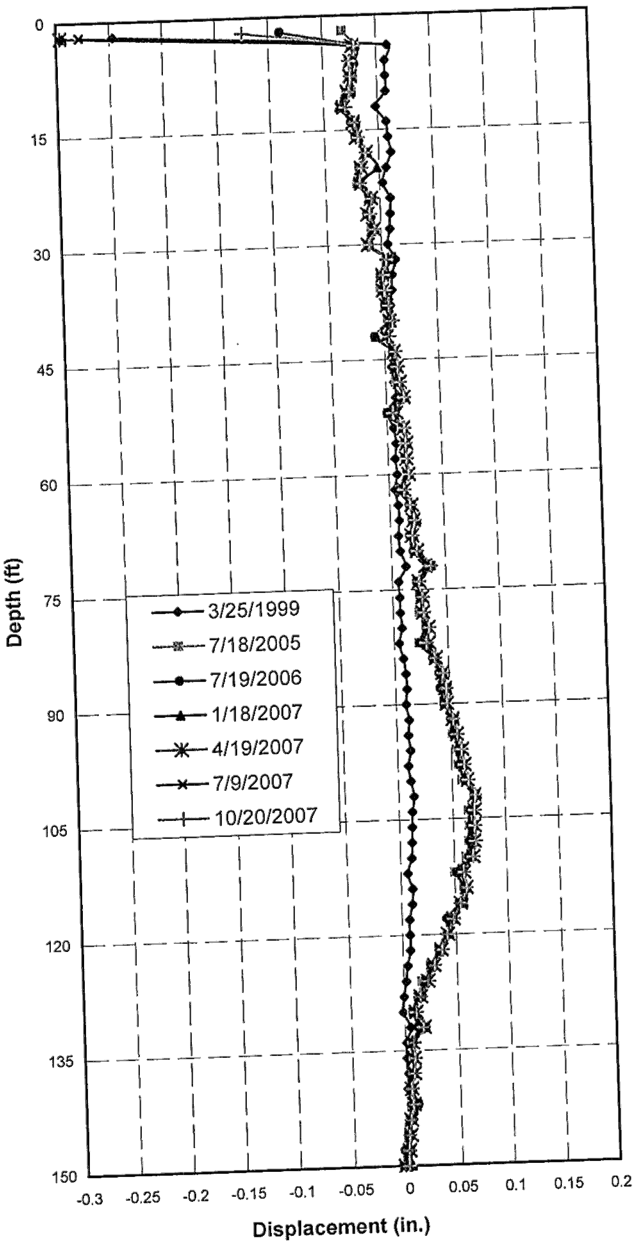


Cumulative

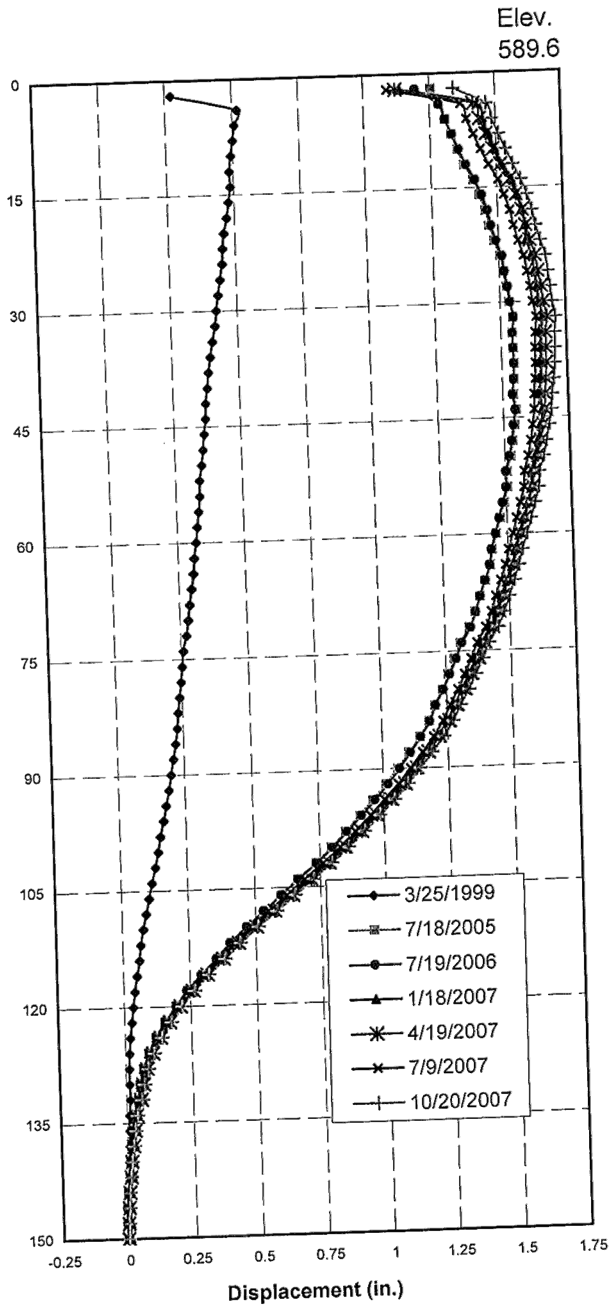


Inclinometer #17 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

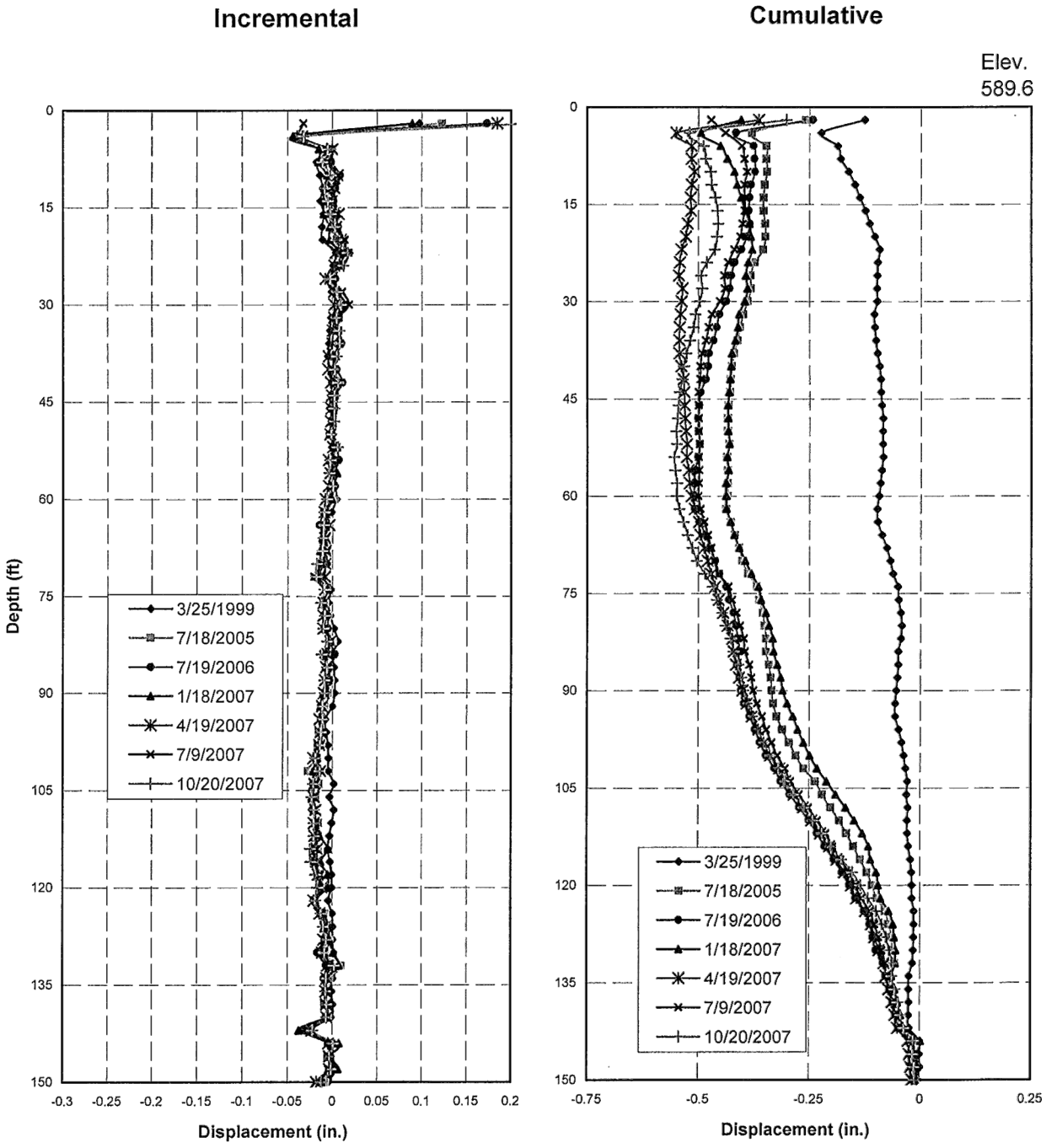
Incremental



Cumulative



Inclinometer #17 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998



RICHLAND ENGINEERING LIMITED
29 North Park Street, Mansfield, Ohio 44902-1769 • 419-524-0074 FAX 419-524-1812

106017

February 29, 2008

Ohio Department of Transportation
5500 Transportation Boulevard
Garfield Heights, Ohio 44125-5396

Attn: Mr. Mike Malloy

Re: CUY-90-1524
Central Viaduct
PID No. 20752
Slope and Pier Monitoring Services
Interim Report

Dear Mr. Malloy:

The following is our report on monitoring activity and collected data for the west slope of the Cuyahoga River and Bridge No. CUY-90-1524 west end pier, pier 1, and slope stabilization structure. The last report of data was the interim report submitted November 23, 2007 for data collected through October 2007. This report is for data collected through January 2008.

Enclosed is one CD with the electronic .pdf files of the detailed reports from BBC&M, REL, Dr. Huckelbridge, and Dr. Liang.

The slope monitoring began in 1994. The stabilization structure was constructed and the span 1 superstructure was relocated in 1999. The stabilization structure monitoring began in 1999. Additional slope monitoring north of the existing bridge began in 2006.

BBC&M Engineering, Inc. obtained inclinometer readings, piezometer readings, and calipered crack distances between January 8 through 16, 2008. Seven inclinometers and 6 piezometers installed between 1994 and 1999 continue to be monitored. Three replacement inclinometers, 9 new inclinometers, and 18 new piezometers installed March through June 2006 were also monitored. The inclinometers installed before 2000 continue to indicate movements of the shallow and deep failure planes at consistent rates. The overall rates appear to be slower since 2004. The inclinometers installed in 2006 both north and south of the bridge are indicating shallow and deep failure planes. There is an increased rate of movement in the surface near the failed steel dockwall north of the bridge. The piezometers installed before 2000 total head values were slightly different than in October 2007. The new vibrating wire piezometer values were relatively constant. Four of the 9

automatic recording devices for the piezometers have malfunctioned. Readings were taken manually. The calipered crack openings continue to change at a constant slow rate. There was one small aggregate pile adjacent to the south right of way fence in January 2008. The property owner north of the right of way fence had a contractor repair the failed sheet pile dock wall at the river's edge in Spring 2006. A progressive failure continues in the small landslide near the north right of way fence adjacent to the river on the southern edge of the large excavation.

Richland Engineering Limited measured expansion joint openings at the west end pier, near pier 2, and near pier 4 on January 15, 2008. The deck expansion joint opening near pier 2 opened 1/2" at the north curb and 1/4" at the south curb with the 37 degree drop in temperature since October 2007. The north curb opening dimension is typical of past January observations. The south curb joint opening dimension is somewhat less than past January observations.

Art Huckelbridge obtained tiltmeter readings at the west end pier and pier 1 on January 21, 2008. The tiltmeters show positions and magnitudes of movement similar to past readings.

Robert Liang monitored instrumentation on January 7 and 8, 2008. The instrumentation readings in the rock anchors, driven piles, tieback beams, drilled shafts, and inclinometers showed no significant change during this quarter.

The next readings are scheduled about April 15, 2008. Data collection and monitoring has been authorized through 2008.

Please contact us if you have any questions (email reltd@r-e-l.com). Copies of detailed quarterly reports are available upon request.

Very truly yours,

RICHLAND ENGINEERING LIMITED

Dean A. Palmer, P.E.

DAP:dap
cc: Craig Hebebrand, District 12
Youssef Seif, District 12
Jeff Leake, District 12
Tim Keller, Office of Structures
Gene Geiger, Office of Geotechnical Services
Tom Lefchik, FHWA
Steve Pasternack, BBC&M Engineering, Inc., Dublin
Jeff Snyder, BBC&M Engineering, Inc., Valley View
Art Huckelbridge
Robert Liang
Rick Engel, E.L. Robinson Engineering Co.
Bob Parker, Michael Baker, Jr., Inc.

CUY-90-1524
106017

DECK EXPANSION JOINT OPENINGS

Finger Type Joints

Measurements are in inches.

Date	Temp (F)	West End Pier North	West End Pier South	Near Pier 2 North	Near Pier 2 South	Near Pier 4 North	Near Pier 4 South
Expansion Distance		476 feet		650 feet			
Design	60°	3.25	3.25	3.25	3.25	3.25	3.25
06-01-70	80°	4.00		0.00		N.A.	
09-19-75	60°	5.25		2.00		N.A.	
05-08-78	60°	4.75	5.50	2.00	2.00	3.25	2.50
07-30-81	75°	5.50	5.50	2.25	2.25	3.25	2.75
06-09-83	70°	5.00	5.00	1.50	1.50	2.75	2.25
07-31-85	73°	5.25	4.75	1.50	1.00	2.75	2.25
10-31-88	40°	7.75	8.38	1.50	0.75	3.81	3.38
11-01-89	50°	7.75	7.00	1.13	0.63	3.25	3.13
10-26-90	50°	7.75	7.25	1.00	0.50	3.00	3.00
09-30-91	55°	7.50	7.00	0.88	0.00	3.00	3.00
10-13-92	60°	7.25	6.81	0.63	0.00	2.50	2.50
10-01-93	50°	7.50	7.13	0.75	0.31	2.75	2.63
09-01-94	63°	7.25	6.38	0.31	0.00	2.88	1.88
09-08-95	60°	7.00	6.63	0.44	0.00	2.00	1.88
09-05-96	77°	6.50	6.63	0.38	0.00	1.25	1.00
09-19-97	75°	6.88	7.00	0.31	0.06	1.68	1.42
09-24-98	69°	7.63	7.00	0.00	0.00	1.88	1.75
10-14-99	45°	6.19	5.50	2.38	1.88	3.13	2.75
10-16-00	55°	6.00	4.88	1.75	1.25	2.56	2.43
04-23-01	70°	5.50	4.25	1.38	0.63	2.13	1.75
07-16-01	80°	5.00	3.88	1.00	0.25	1.50	1.25
10-15-01	50°	6.63	5.63	1.63	1.06	3.25	2.75

Date	Temp (F)	West End Pier		Near Pier 2		Near Pier 4	
		North	South	North	South	North	South
1-15-02	30°	6.88	6.25	2.13	1.50	3.88	3.50
4-15-02	61°	6.00	5.25	1.38	0.88	2.50	2.38
7-15-02	76°	5.13	4.13	1.13	0.50	1.75	1.50
10-17-02	48°	7.00	6.38	1.75	1.25	3.25	2.88
11-1-02	35°	7.25	6.13	1.88	1.38	3.63	3.38
1-15-03	7°	8.13	6.63	2.38	1.88	5.00	4.75
4-15-03	67°	5.63	4.63	1.25	0.63	2.25	2.00
7-15-03	74°	5.38	4.38	1.00	0.50	2.00	1.63
10-16-03	46°	7.00	5.75	1.50	1.13	3.25	3.13
1-15-04	11°	8.00	6.75	2.00	1.38	4.63	4.00
4-15-04	41°	6.88	5.75	1.38	0.88	3.50	3.25
7-15-04	67°	5.63	4.75	1.00	0.50	2.13	1.75
10-15-04	50°	6.38	5.50	1.25	0.75	3.00	2.75
1-15-05	12°	7.75	7.00	2.00	1.38	4.63	4.25
4-16-05	47°	6.50	5.63	1.25	0.75	3.25	2.88
7-16-05	74°	5.50	4.50	0.75	0.375	1.75	1.63
10-14-05	51°	6.25	5.50	1.13	0.63	2.81	2.56
1-16-06	26°	7.63	6.38	1.75	1.13	4.13	3.75
4-14-06	65°	5.75	4.88	0.75	0.50	2.25	2.00
7-14-06	78°	5.00	4.00	0.63	0.19	1.63	1.25
10-16-06	50°	6.50	5.88	1.00	0.75	3.25	3.00
1-15-07	41°	7.00	6.13	1.13	0.88	3.56	3.38
4-16-07	34°	7.25	6.38	1.38	0.88	3.75	3.50
7-16-07	70°	5.38	4.75	0.88	0.25	2.13	1.63
10-15-07	56°	6.38	5.50	1.13	0.75	2.88	2.69
1-15-08	19°	7.63	6.63	1.63	1.00	4.13	4.00

N.A. - No measurements available

JANUARY 2008 QUARTERLY REPORT
FIELD MONITORING SERVICES
CUY-90-14.52/15.24
PID #77332
CLEVELAND, OHIO

Report to

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

Prepared by

BBC&M ENGINEERING, INC.
CLEVELAND, OHIO

February 2008

February 8, 2008
012-00946-300

Mr. Dean A. Palmer, P.E.
Richland Engineering Limited
29 North Park Street
Mansfield, Ohio 44902

Re: CUY-90-14.52/15.24 Bridge (PID No. 77332)
Quarterly Report - Field Monitoring Services
January 2008 (First Quarter)

Dear Mr. Palmer:

BBC&M Engineering, Inc. (BBCM) has completed the field monitoring services for the January 2008 quarter as part of the CUY-90-14.92/15.24 project. This quarterly report presents our general site observations and the results and evaluation of data collected from all the actively monitored instrumentation (inclinometers, piezometers and calipered distance locations) installed by BBCM at or near the West Abutment of the existing I-90 Central Viaduct Bridge.

A total of 19 inclinometers, six (6) pneumatic piezometers and 18 vibrating wire (VW) piezometers are actively monitored as part of the project. A Summary Table and Site Plan of Active Instrumentation are submitted as Plates 1 and 2 of the Appendix. Quarterly readings were taken during the period of January 8 through January 16, 2008.

Inclinometers

All the data sets presented in the Appendix have been corrected for measured spiral of the inclinometer casings and for systematic errors such as bias-shift, sensor rotation and depth positioning error, where necessary. The rates of movement were computed using linear regression for the depth ranges shown on the Displacement vs. Time plots in the Appendix.

Active BBCM Inclinometers Installed between 1994 and 1999

For the active inclinometers installed before 2000, no significant changes in the rates of movement have been observed in the shallow or deep failure planes between the October 2007 and January 2008 quarterly readings. In the immediate vicinity of the Pier 1 area, no shallow slip-plane movements have been observed in inclinometers installed before 2000 since completion of construction of the Pier 1 stabilization system. The shallow failure plane upslope from the Pier 1 area (B-203 and B-303) continues to move at an average rate of about 0.05 inches per year from 1999 to the present yet appears to have decreased to a rate of about 0.03 inches per year from 2004 to the present.

8555 Sweet Valley Dr., Ste. S • Valley View, OH 44125-4210 • Phone 216.901.1000 • Fax 216. 901.9996

South of the West End Pier (B-102 and B-107), the deep failure plane continues to move at an average rate of about 0.03 inches per year from 2000 to the present. The B-101 inclinometer has indicated nominal movement since its installation. In the immediate vicinity and upslope from the Pier 1 area (B-203, B-204 and B-303), the deep failure plane continues to move at an average rate of about 0.05 inches per year from 1999 to the present yet appears to have decreased to a rate of about 0.02 inches per year from 2004 to the present.

Inclinometer P-9N indicates the top of the drilled shaft is restrained laterally and that the maximum lateral deflection is about 0.94 inches from about 40 to 60 feet below the top of the inclinometer casing.

Active BBCM Inclinometers Installed in 2006

Slide planes have been observed in the following new and replacement inclinometers (refer to the Displacement vs. Time plots, Plates 27, 48 and 49 in the Appendix):

- In B-108A - depths of 23 ft and 119 ft (see Plate 24 in the Appendix);
- In B-05-03 - depth of 35 ft and newly observed depth of 123 ft (see Plates 32 and 33 in the Appendix); and,
- In B-05-16 - depths of 3 to 11 ft, 29 ft and 113 ft (see Plates 46 and 47 in the Appendix).

Cantilever displacement has been observed in B-105A to a depth of about 70 feet (see Plates 22 and 23 in the Appendix) similar to that observed in B-105, which is now inactive. The bulkhead at this location may be progressively leaning outwards toward the river. **A significant relative displacement of about 0.3 inches has occurred between October 2007 and January 2008 indicating the bulkhead may be leaning outwards at an increased rate.** A Displacement vs. Time plot for B-105A has been submitted as Plate 26 in the Appendix.

Additional <u>potential</u> slide planes have been observed in some of the new and replacement inclinometers for which additional readings are needed to verify they are actual slide planes. These potential slide planes are listed as follows:

- In B-105A, depth of 85 ft (see Plate 22 in the Appendix);
- In B-05-02, depth of 109 ft and 129 ft (see Plate 30 in the Appendix);
- In B-05-04, depth of 117 ft (see Plate 34 in the Appendix). This depth is identical with the depth of movement observed in the adjacent B-204 inclinometer (see Plates 11 and 12 in the Appendix).

Piezometers

Pneumatic Piezometers

The results of the active pneumatic piezometer readings taken on January 8 and January 9, 2008 are summarized in Table 1 below.

Table 1: Summary of Readings for Active Pneumatic Piezometers – CUY-90-15.24

Piezometer Identifier		Ground Surface Elevation (ft)	Elevation Head, h_e (ft)	Pore Pressure Reading, u (psi)	Total Head, h_t (ft)
B-101 (P-1*)	orange	676.6	626.3	0.9	628.4
	pink	676.6	552.3	31.9	625.9
B-105 (P-3*)	pink	585.6	497.6	38.1	585.5
	blue	585.6	479.9	47.6	589.7
B-107 (P-5*)	orange	662.3	562.3	25.5	621.1
B-303 (P-2*)	pink	627.0	586.2	6.9	602.1

*BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers.

The piezometers at B-101 and B-107 have exhibited slightly higher readings than those recorded in October 2007, whereas the piezometers at B-105 and B-303 have exhibited slightly lower readings. Note that the piezometer B-105 blue continues to indicate an elevated water pressure (i.e. a total head above the ground surface, artesian conditions). The piezometer B-105 pink has indicated an elevated water pressure in the past several readings. However, the current reading indicates the total head at that depth is just slightly below the existing ground surface. Total Head vs. Time plots have been submitted as Plates 50 through 53 in the Appendix of this report.

Vibrating Wire (VW) Piezometers

Table 2 provides a summary of the maximum and minimum values of all the pressure readings taken from October 2007 (end of previous reporting period) to the time when the collected data was last downloaded from VW Miniloggers between January 8 and January 15, 2008.

Table 2: Summary of Readings for VW Piezometers – CUY-90-14.92

Piezometer Identifier		Time Interval of Readings Reported [1]	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-01	21961 - 65 ft	1/16/08[2]	13.6[2]	675.4	610.4	12.1[2]	639.1[2]
	21967 - 95 ft	1/16/08[2]	13.1[2]	675.4	580.4	23.5[2]	635.4[2]
B-05-02	21963 - 46 ft	10/10/07 to 1/9/08	12.2/7.9	617.9	571.9	8.4/7.7	591.3/589.8
	21951 - 122 ft	10/10/07 to 1/9/08	12.2/12.1	617.9	495.9	40.7/40.1	589.8/588.3
B-05-03	21957 - 32 ft	10/10/07 to 1/9/08	12.3/11.9	605.1	573.1	8.2/7.0	592.0/589.4
	21965 - 112 ft	10/10/07 to 1/9/08	12.5/12.5	605.1	493.1	41.6/40.9	589.0/587.4
B-05-04	21958 - 59 ft	10/10/07 to 1/9/08	12.9/12.9	600.8	541.8	18.0/17.5	583.4/582.1
	21952 - 119 ft	10/10/07 to 1/9/08	13.1/13.0	600.8	481.8	44.9/44.7	585.5/585.1
B-05-07	21966 - 102 ft	10/16/07 to 1/8/08	12.4/12.4	678.9	576.9	24.2/23.6	632.8/631.3
	21956 - 220 ft	10/16/07 to 1/8/08	11.9/11.9	678.9	458.9	71.4/70.7	623.8/622.1
B-05-08	21954 - 65.5 ft	10/16/07 to 1/8/08	12.7/12.6	679.9	614.4	12.6/11.9	643.4/641.9
	21959 - 110.5 ft	10/16/07 to 1/8/08	12.4/12.4	679.9	569.4	29.8/29.1	638.3/636.7
B-05-11	21968 - 95 ft	1/16/08[2]	12.7[2]	675.1	580.1	23.4[2]	634.9[2]
	21953 - 130 ft	10/22/07 to 1/8/08	12.8/12.6	675.1	545.1	36.8/36.1	630.0/628.5
B-05-12	21960 - 75 ft	1/16/08[2]	12.8[2]	652.7	577.7	18.8[2]	621.7[2]
	21964 - 120 ft	10/12/07 to 1/8/08	12.5/12.5	652.7	532.7	37.0/36.3	618.0/616.4
B-05-13	21962 - 60 ft	10/16/07 to 1/8/08	12.6/7.3	580.0	520.0	24.3/23.8	576.0/575.0
	21955 - 135 ft	10/16/07 to 1/8/08	12.8/12.8	580.0	445.0	60.4/60.3	584.5/584.1

1 - Readings generally were taken every 8 hours during the reported time interval.

2 - The VW Minilogger was unresponsive even after the batteries were replaced and the box allowed to dry out (where applicable). A manual reading was taken instead. The 21961 and 21967 VW Minilogger boxes were flooded with the boxes completely full of water at the time of the first attempted download on January 8, 2008. The 21968 VW Minilogger box was not flooded at this time, but it was flooded in October 2007. The 21960 VW Minilogger has never been flooded.

The measured total head values were relatively constant during the current reporting period with a difference between maximum and minimum total head values of no more than 2.6 feet in all of the VW piezometers where readings were recorded at regular

intervals (see footnote 2 in Table 2). Six (6) VW piezometers (21961 and 21967 at B-05-01, 21956 at B-05-07, 21953 at B-05-11 and 21960 and 21964 at B-05-12) indicated a gradual increase in the pore pressures until about the beginning of May 2007, yet have measured relatively constant or very slightly increasing pore pressures from May 2007 to January 2008. Total Head vs. Time plots have been submitted as Plates 54 through 62 in the Appendix.

As discussed in footnote 2 of Table 2 and on the Total Head vs. Time plots (see Plates 54, 60 and 61 of the Appendix), four (4) VW Miniloggers were unresponsive at the time of download. Instead, manual readings were taken with a portable VW Data Recorder at these four (4) piezometers. These VW Miniloggers may no longer be functional due to either flooding of the VW Minilogger boxes with water or some other unknown cause(s). Reasonable precautions are taken by BBCM to attempt to protect the Minilogger boxes from water damage; however, during heavy rain events, only the installation of a water tight box to house the Miniloggers will provide adequate protection. BBCM recommends the replacement of the four (4) nonfunctioning VW Miniloggers (21961 and 21967 at B-05-01, 21968 at B-05-11 and 21960 at B-05-12. The other VW Miniloggers which have failed to take scheduled readings at one time or another (21958 at B-05-04 and 21953 at B-05-11) may need to be replaced eventually but appear to be currently functioning properly.

Additional Field Measurements and Observations

The two calipered surface distance locations (left and right) are provided in the Site Plan of Active Instrumentation (Plate 2 of the Appendix). A Calipered Surface Distance Table and Calipered Distance Readings vs. Time plots have been included as Plates 63 through 65 in the Appendix. The left calipered location indicates the gap is continuing to open at a rate of about 0.06 inches per year and the gap at the right calipered location is continuing to close at a rate of about 0.02 inches per year.

In January 2008, a relatively small aggregate pile, roughly 15 to 20 feet high, was observed near the east right-of-way fence and covered roughly less than 10 percent of the property currently being used to stockpile aggregate adjacent to the east right-of-way fence.

The large excavation and the repair effort of the bulkhead near the west right-of-way fence appear to be unfinished as of January 2008. Adjacent to the large excavation near the west right-of-way fence (just north of B-05-16), a small landslide was initially observed by BBCM personnel in January 2007 (see Plate 2 in the Appendix for the approximate landslide location). It appears that progressive failure in this landslide area has occurred since the last quarterly readings were taken in October 2007. The scarps have been observed to have increased in depth. The fence in the landslide area has been torn apart by the movements at some locations and has almost completely tipped over on its side. Site photos of the landslide area taken on January 8 and January 9, 2008 are submitted as Plates 66 through 72 in the Appendix.

Ruhlin Construction was onsite repairing the gusset plates on the I-90 Central Viaduct Bridge while BBCM personnel were taking readings on January 8, 9 and 16, 2008.

Closing

We appreciate being of continued service during this project. Please contact our office if you have any questions or require additional information. The next quarterly readings are scheduled to take place around April 15, 2008.

Sincerely,
BBC&M ENGINEERING, INC.
Cleveland, Ohio

Jeffrey L. Snyder, P.E.
Project Engineer

Stephen C. Pasternack, P.E.
Senior Project Engineer

cc: Mr. Robert B. Parker, P.E. (Michael Baker Jr., Inc.)

Submitted: pdf copy submitted to Richland Engineering at reltd@r-e-l.com and Michael Baker Jr., Inc. via their ftp site
Attachments: Appendix (Plates 1 through 72)

APPENDIX

CUY-90-14.52/15.24 INSTRUMENTATION MONITORING

APPENDIX

Plate No.

General Information

Summary Table of Active Instrumentation 1
Site Plan of Active Instrumentation 2

Plots for Active BBCM Inclinometers Installed from 1994 to 1999 – CUY-90-15.24

Cumulative and Incremental Displacement versus Depth Plots
B-101 – A and B-Axis 3-4
B-102 – A and B-Axis 5-6
B-107 – A and B-Axis 7-8
B-203 – A and B-Axis 9-10
B-204 – A and B-Axis 11-12
B-303 – A and B-Axis 13-14
P-9N – A and B-Axis 15-16

Displacement versus Time Plots
B-102 – A-Axis 17
B-107 – A-Axis 18
B-203 – A-Axis 19
B-204 – A-Axis 20
B-303 – A-Axis 21

Plots for Replacement Inclinometers Installed by BBCM in 2006 – CUY-90-15.24

Cumulative and Incremental Displacement versus Depth Plots
B-105A – A and B-Axis 22-23
B-108A – A and B-Axis 24-25

Displacement versus Time Plots
B-105A – A-Axis 26
B-108A – A-Axis 27

Plots for Inclinometers Installed by BBCM in 2006 – CUY-90-14.52

Cumulative and Incremental Displacement versus Depth Plots
B-05-01 – A and B-Axis 28-29
B-05-02 – A and B-Axis 30-31
B-05-03 – A and B-Axis 32-33
B-05-04 – A and B-Axis 34-35
B-05-07 – A and B-Axis 36-37
B-05-08 – A and B-Axis 38-39
B-05-08 – A and B-Axis (reinitialized) 38A-39A

APPENDIX (continued)

Plate No.

B-05-11 – A and B-Axis 40-41
B-05-12 – A and B-Axis 42-43
B-05-12 – A and B-Axis (reinitialized) 42A-43A
B-05-13 – A and B-Axis 44-45
B-05-16 – A and B-Axis 46-47

Displacement versus Time Plots

B-05-03 – A-Axis 48
B-05-16 – A-Axis 49

Plots for Active Pneumatic Piezometers Installed by BBCM in 1994 – CUY-90-15.24

Total Head (h_t) versus Time Plots

B-101 (P-1) 50
B-105 (P-3) 51
B-107 (P-5) 52
B-303 (P-2) 53

Plots for Vibrating Wire (VW) Piezometers Installed by BBCM in 2006 – CUY-90-14.52

Total Head (h_t) versus Time Plots

B-05-01 54
B-05-02 55
B-05-03 56
B-05-04 57
B-05-07 58
B-05-08 59
B-05-11 60
B-05-12 61
B-05-13 62

Calipered Surface Distance Data – CUY-90-15.24

Calipered Surface Distance Table 63
Calipered Distance Readings versus Time Plot - Left Calipered Location 64
Calipered Distance Readings versus Time Plot - Right Calipered Location 65

Large Excavation Adjacent to West Right-of-Way Fence

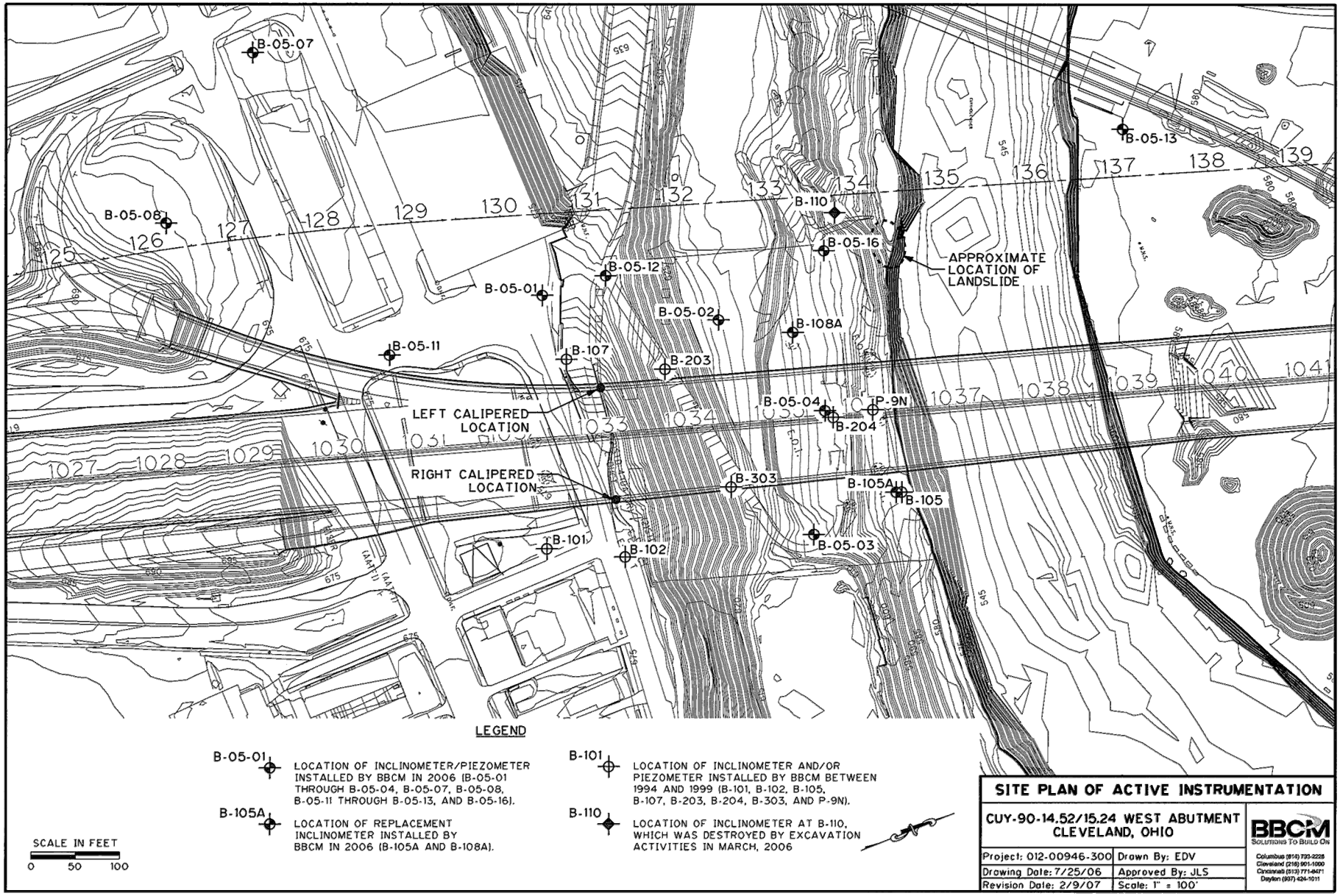
Site Photos of Excavation and Small Landslide Taken on January 8 and January 9, 2008 66-72

SUMMARY OF ACTIVE INSTRUMENTATION
CUY-90-14.52/15.24

Active Instrumentation	Active Inclinometer ?	Inclinometer Depth (ft)	Active Piezometer?	VW or Pneumatic?	# of Active Piezometers	Piezometer Depth(s) Below Existing G.S. (ft)	Instrumentation Installation Date
B-101	Y	190	Y*	Pneumatic*	2*	50.3, 124.3	Aug-Sep 1994
B-102	Y	224	N	---	---	---	Sep 1994
B-105	N	---	Y*	Pneumatic*	2*	88, 105.7	Aug 1994
B-105A	Y	156	N	---	---	---	May 2006
B-107	Y	210	Y	Pneumatic*	1*	100	Sep 1994
B-108A	Y	168	N	---	---	---	Apr-May 2006
B-203	Y	190	N	---	---	---	Aug 1996
B-204	Y	134	N	---	---	---	Jul 1998
B-303	Y	178	Y**	Pneumatic**	1**	40.8	Aug 1994**, Jul 1998
P-9N	Y	150	N	---	---	---	Feb 1999
B-05-01	Y	228	Y	VW	2	65, 95	Apr-May 2006
B-05-02	Y	178	Y	VW	2	46, 122	Apr-May 2006
B-05-03	Y	168	Y	VW	2	32, 112	Apr-May 2006
B-05-04	Y	172	Y	VW	2	59, 119	Mar-May 2006
B-05-07	Y	224	Y	VW	2	102, 220	Apr-Jun 2006
B-05-08	Y	224	Y	VW	2	65.5, 110.5	Apr-May 2006
B-05-11	Y	226	Y	VW	2	95, 130	Apr-Jun 2006
B-05-12	Y	210	Y	VW	2	75, 120	Apr-May 2006
B-05-13	Y	134	Y	VW	2	60, 135	May-Jun 2006
B-05-16	Y	162	N	---	---	---	Jun 2006

*BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers (i.e. P-1 to B-101, P-3 to B-105, and P-5 to B-107).

**The pneumatic piezometer was actually installed in August 1994 at Boring P-2 in the vicinity of the B-103 inclinometer (now inactive). However, the piezometer has since been renamed to B-303 due to its close proximity to the active inclinometer at B-303, which was installed in July 1998.



LEGEND

B-05-01 — LOCATION OF INCLINOMETER/PIEZOMETER INSTALLED BY BBCM IN 2006 (B-05-01 THROUGH B-05-04, B-05-07, B-05-08, B-05-11 THROUGH B-05-13, AND B-05-16).

B-105A — LOCATION OF REPLACEMENT INCLINOMETER INSTALLED BY BBCM IN 2006 (B-105A AND B-108A).

B-101 — LOCATION OF INCLINOMETER AND/OR PIEZOMETER INSTALLED BY BBCM BETWEEN 1994 AND 1999 (B-101, B-102, B-105, B-107, B-203, B-204, B-303, AND P-9N).

B-110 — LOCATION OF INCLINOMETER AT B-110, WHICH WAS DESTROYED BY EXCAVATION ACTIVITIES IN MARCH, 2006

SCALE IN FEET
0 50 100

SITE PLAN OF ACTIVE INSTRUMENTATION

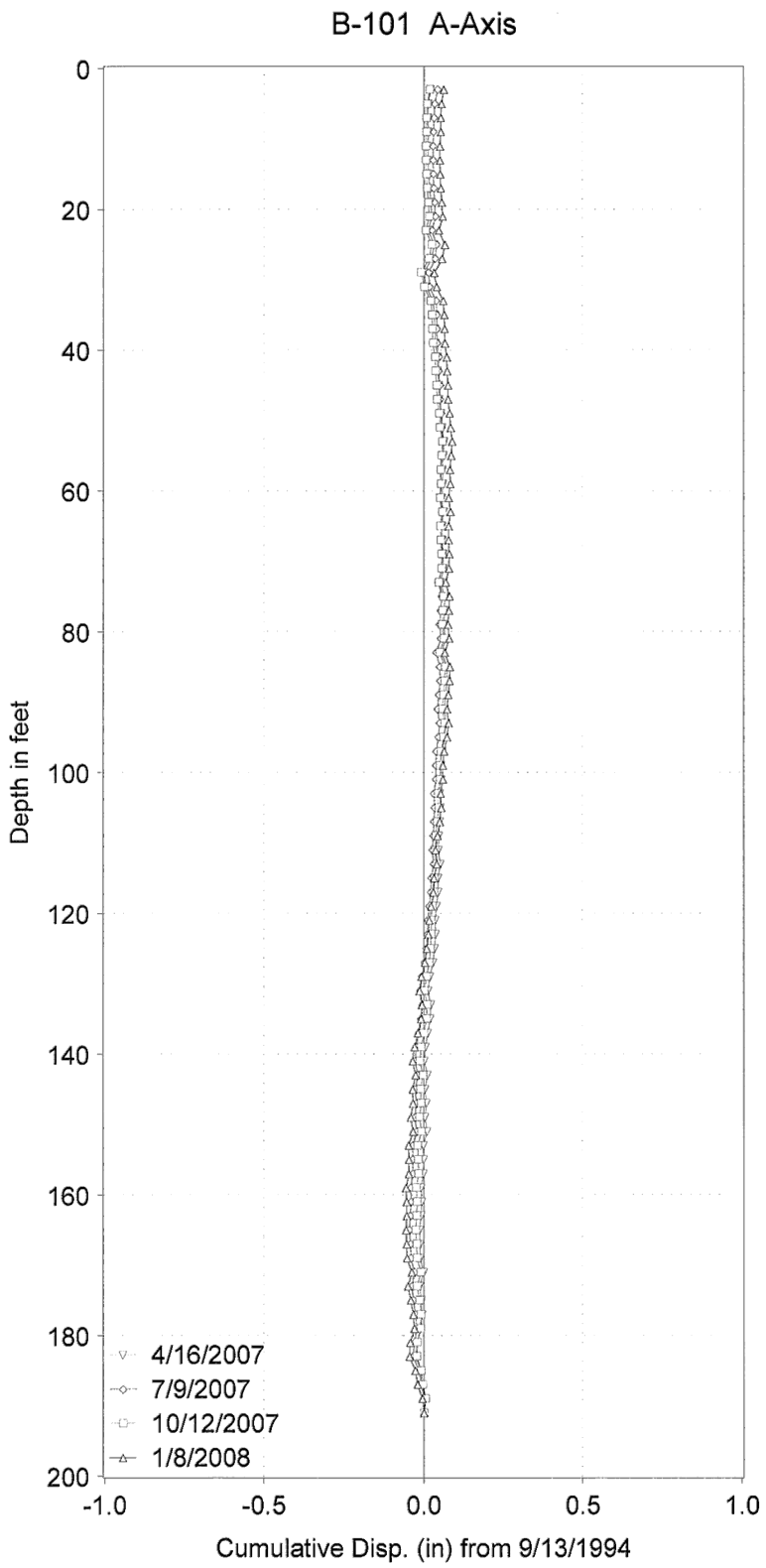
CUY-90-14.52/15.24 WEST ABUTMENT
CLEVELAND, OHIO

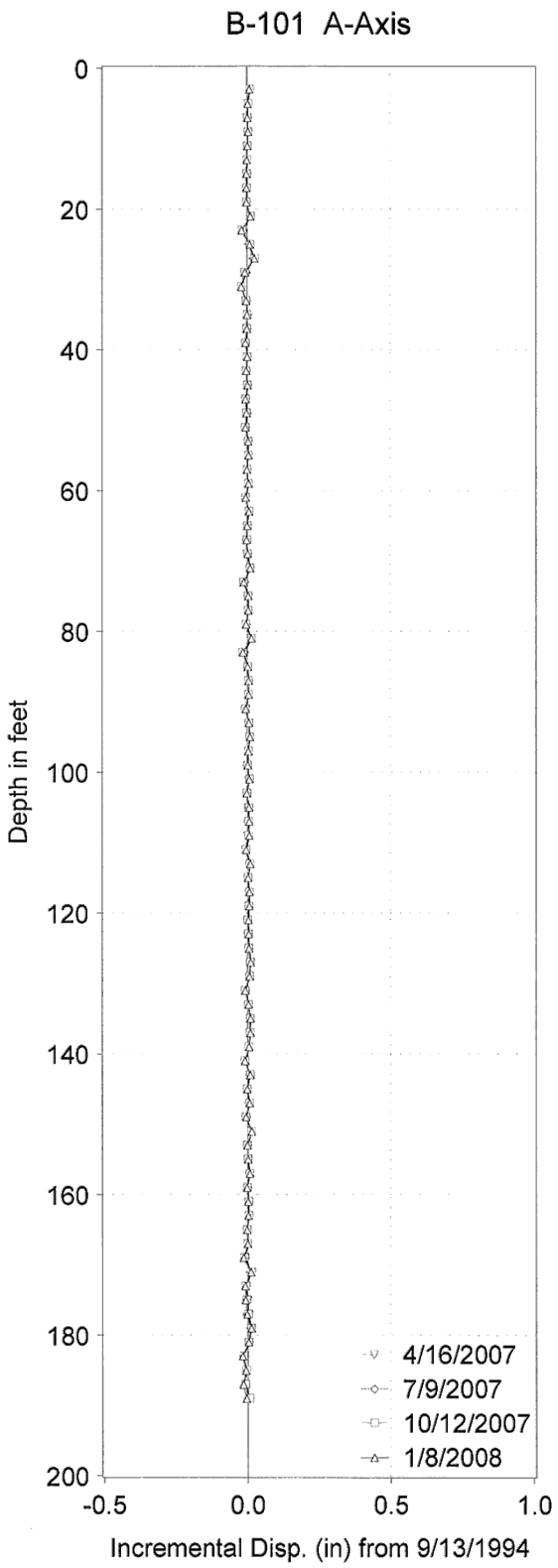
Project: 012-00946-300	Drawn By: EDV
Drawing Date: 7/25/06	Approved By: JLS
Revision Date: 2/9/07	Scale: 1" = 100'

BBCM
SOLUTIONS TO BUILD ON
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-6471
Dayton (937) 424-1011

BBC&M DRAWING FILE: $BBCM FILENAME$ $DATE$ $TIME$ MODEL NAME: $MODEL$

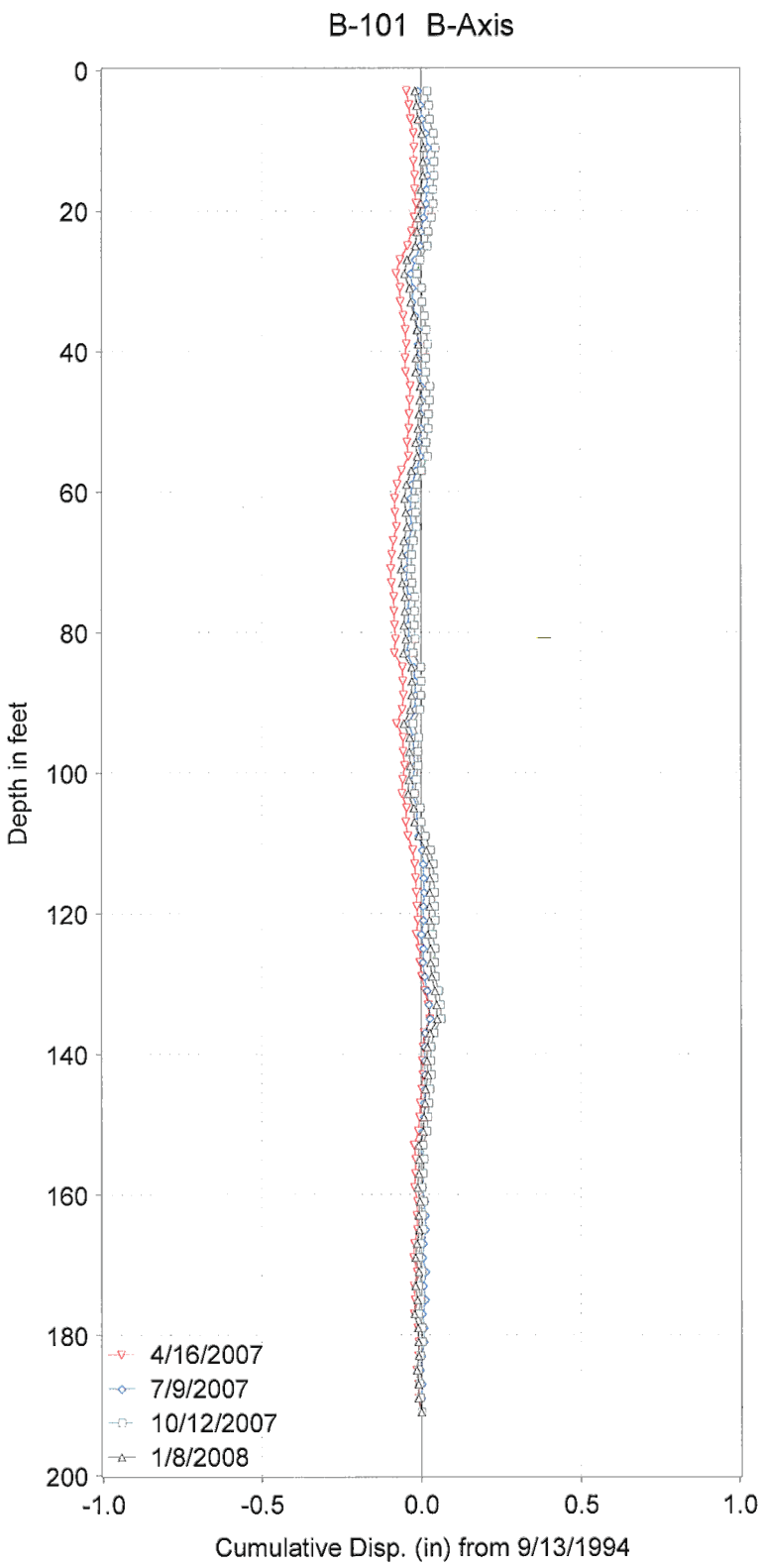
PLATE 2

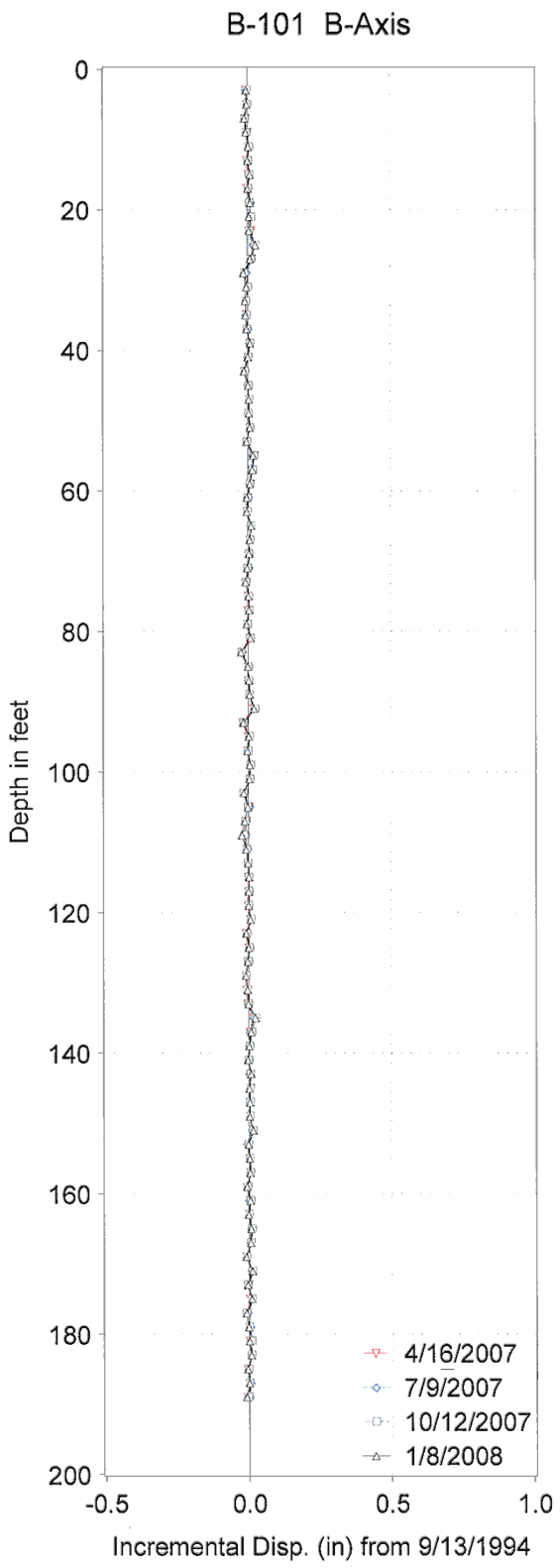




B-101
-Includes readings from the last four quarters.

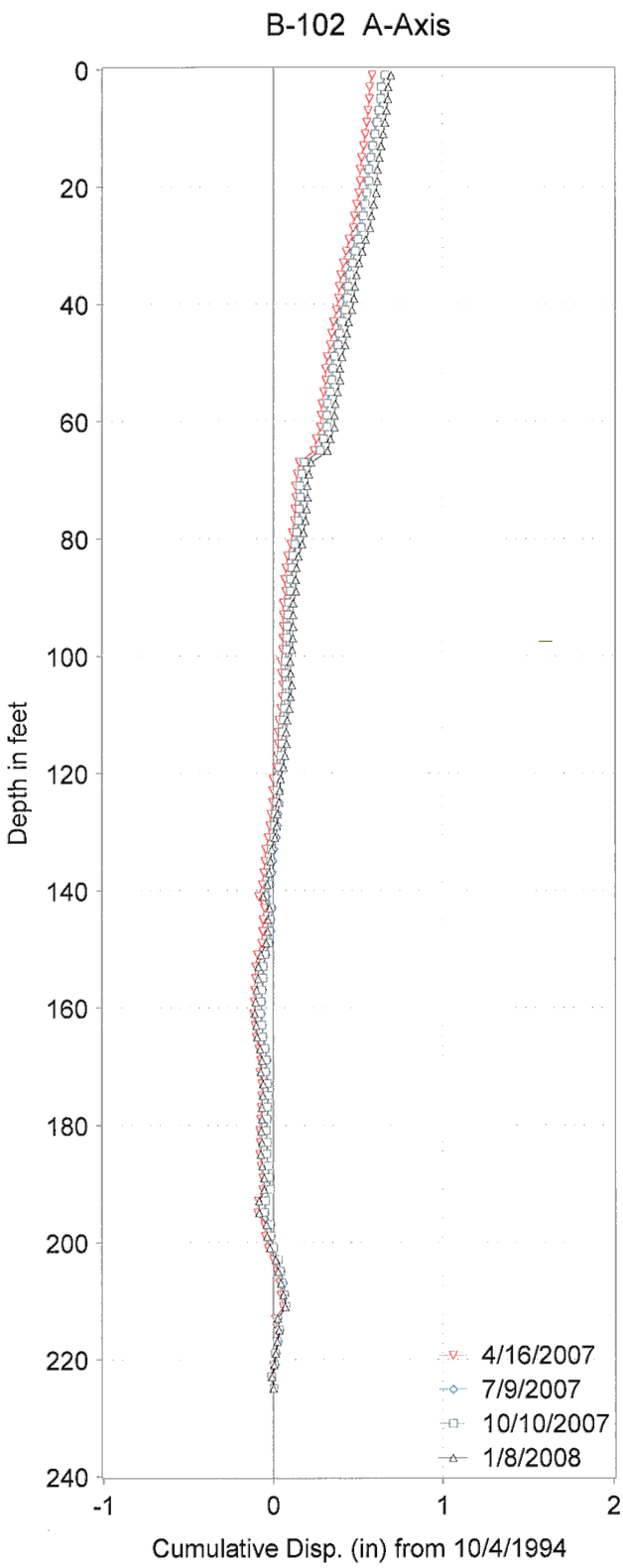
PLATE 3

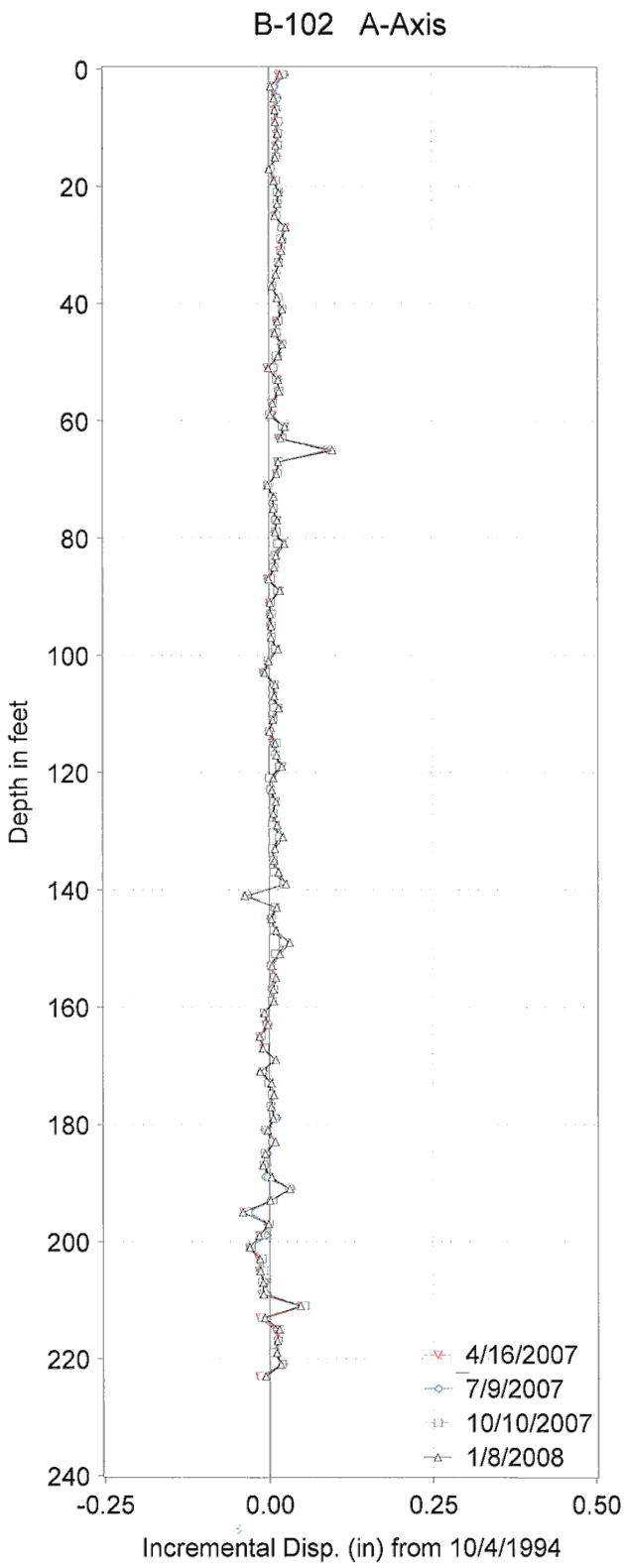




B-101
-Includes readings from the last four quarters.

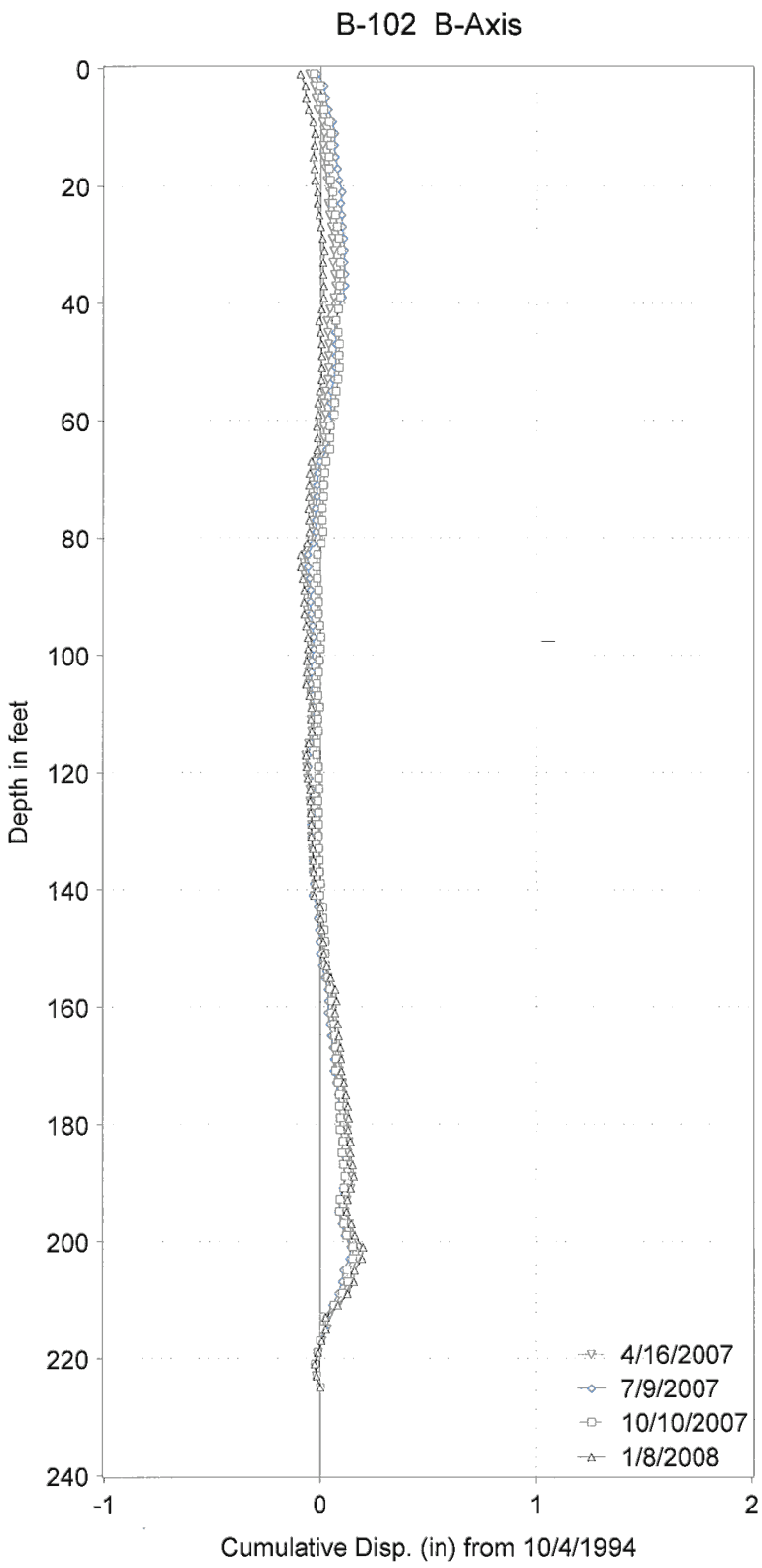
PLATE 4

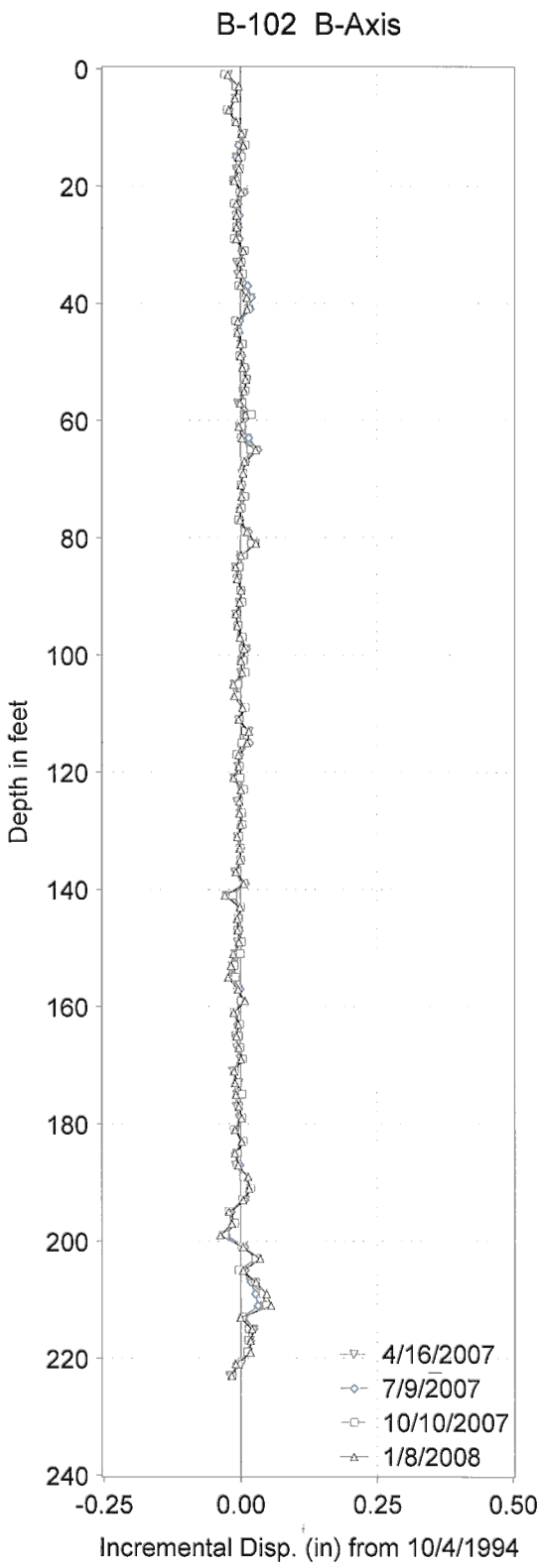




B-102
-Includes readings from the last four quarters.

PLATE 5





B-102
-Includes readings from the last four quarters.

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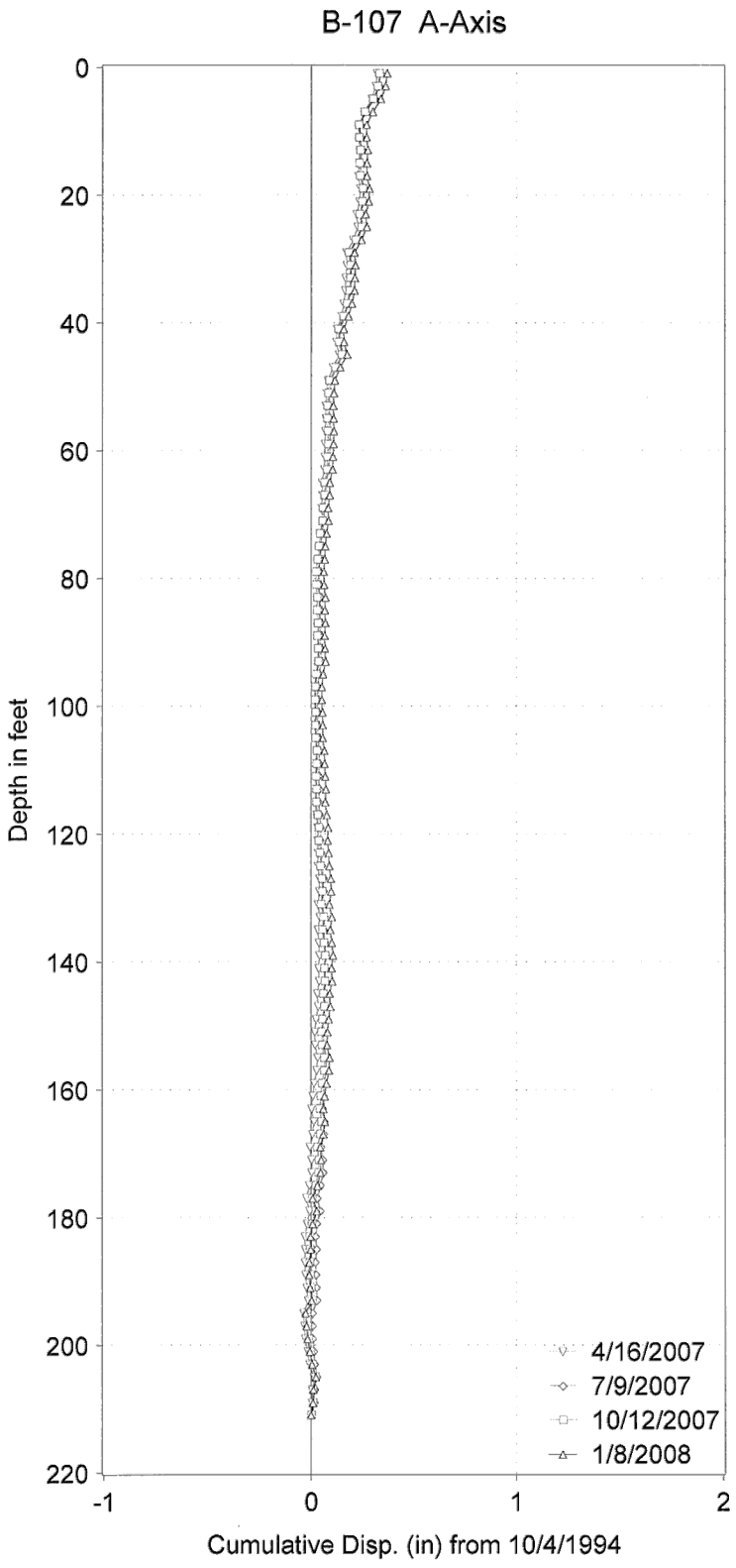
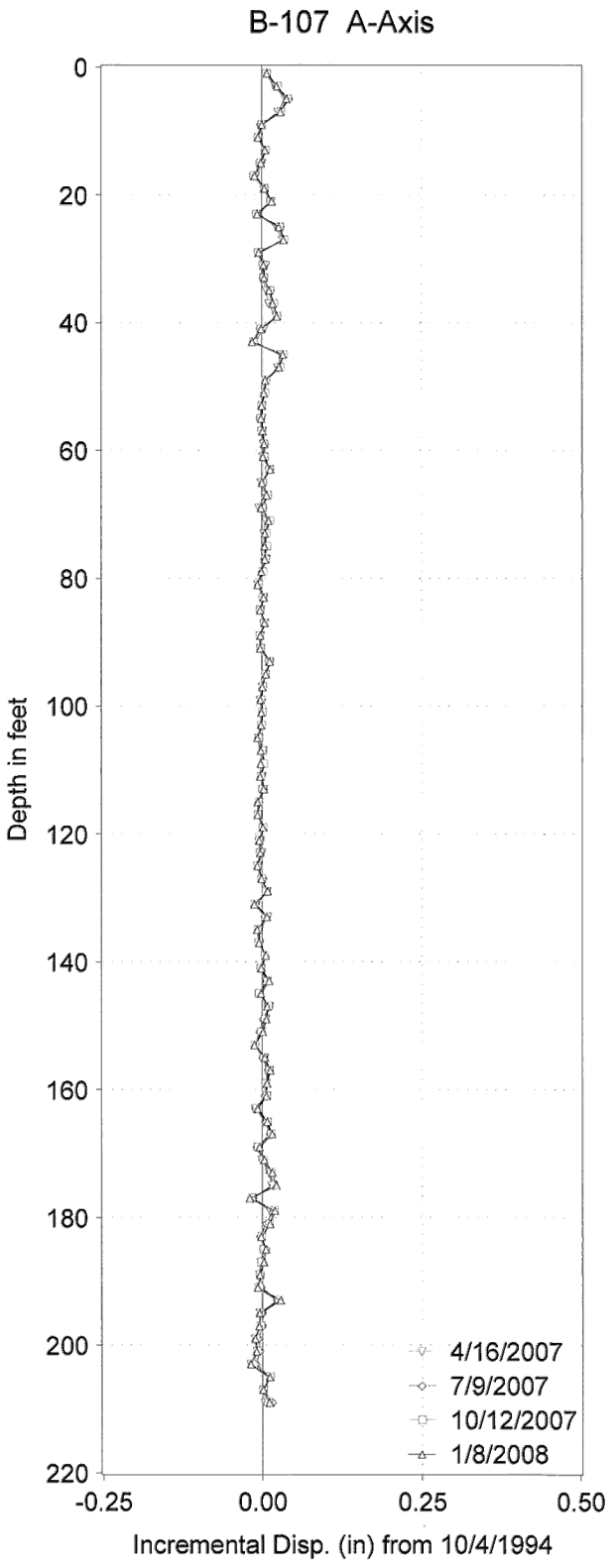
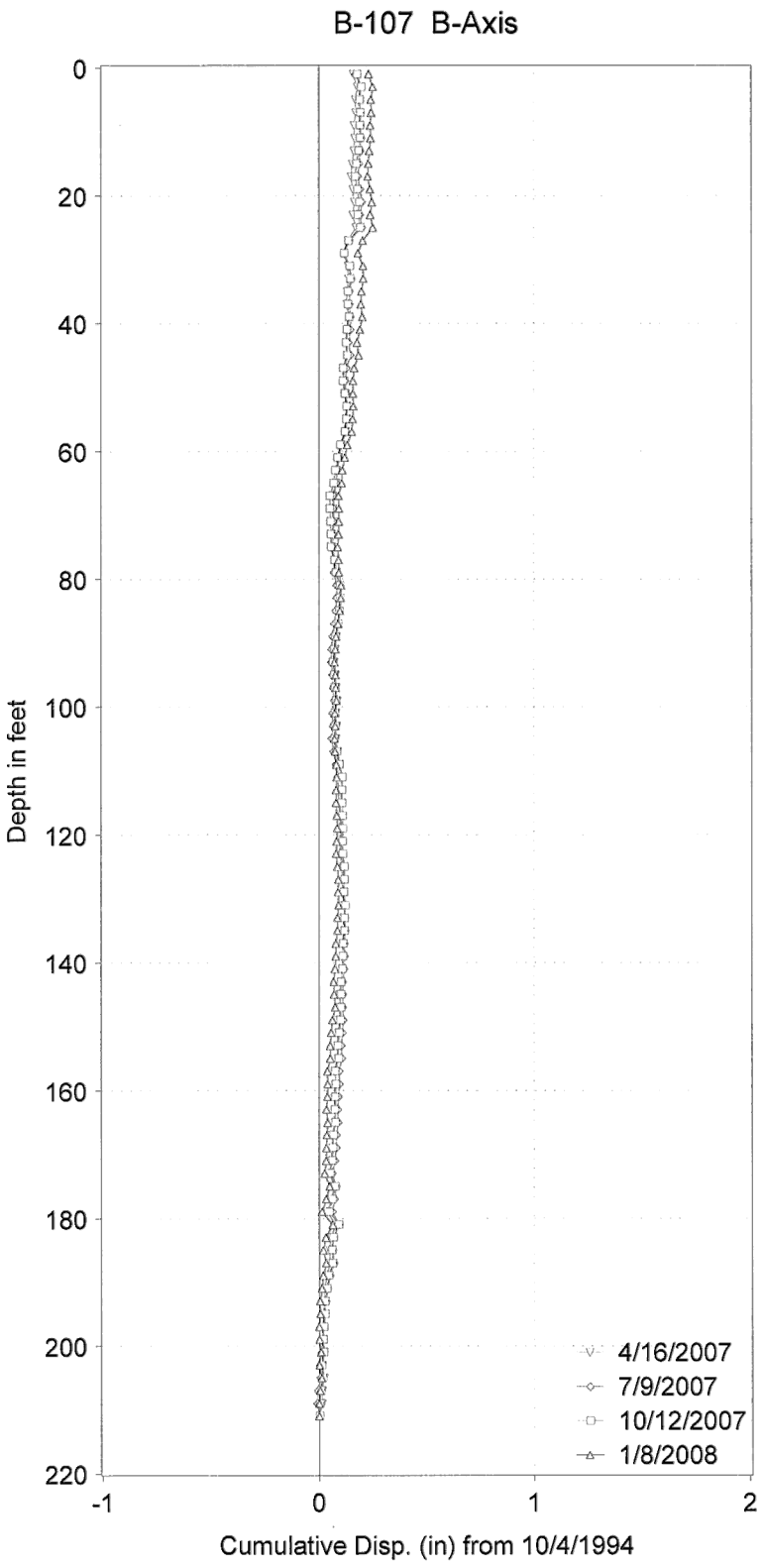
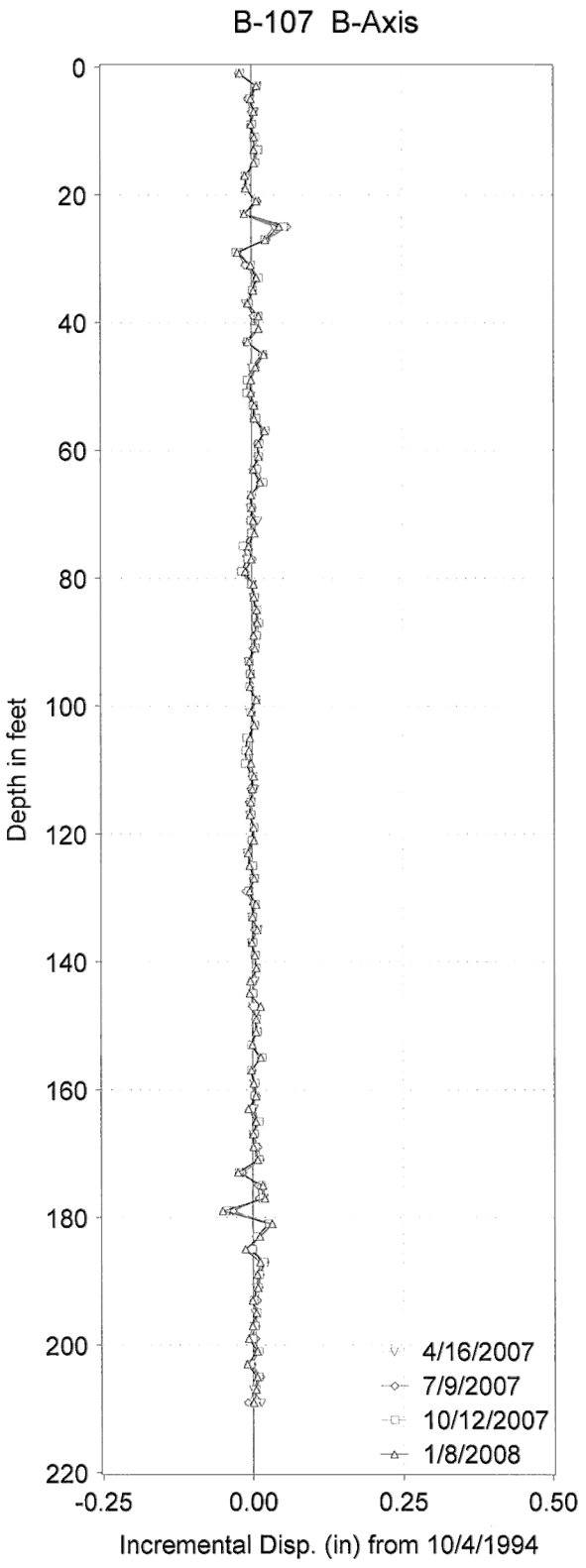




B-107
-Includes readings from the last four quarters.

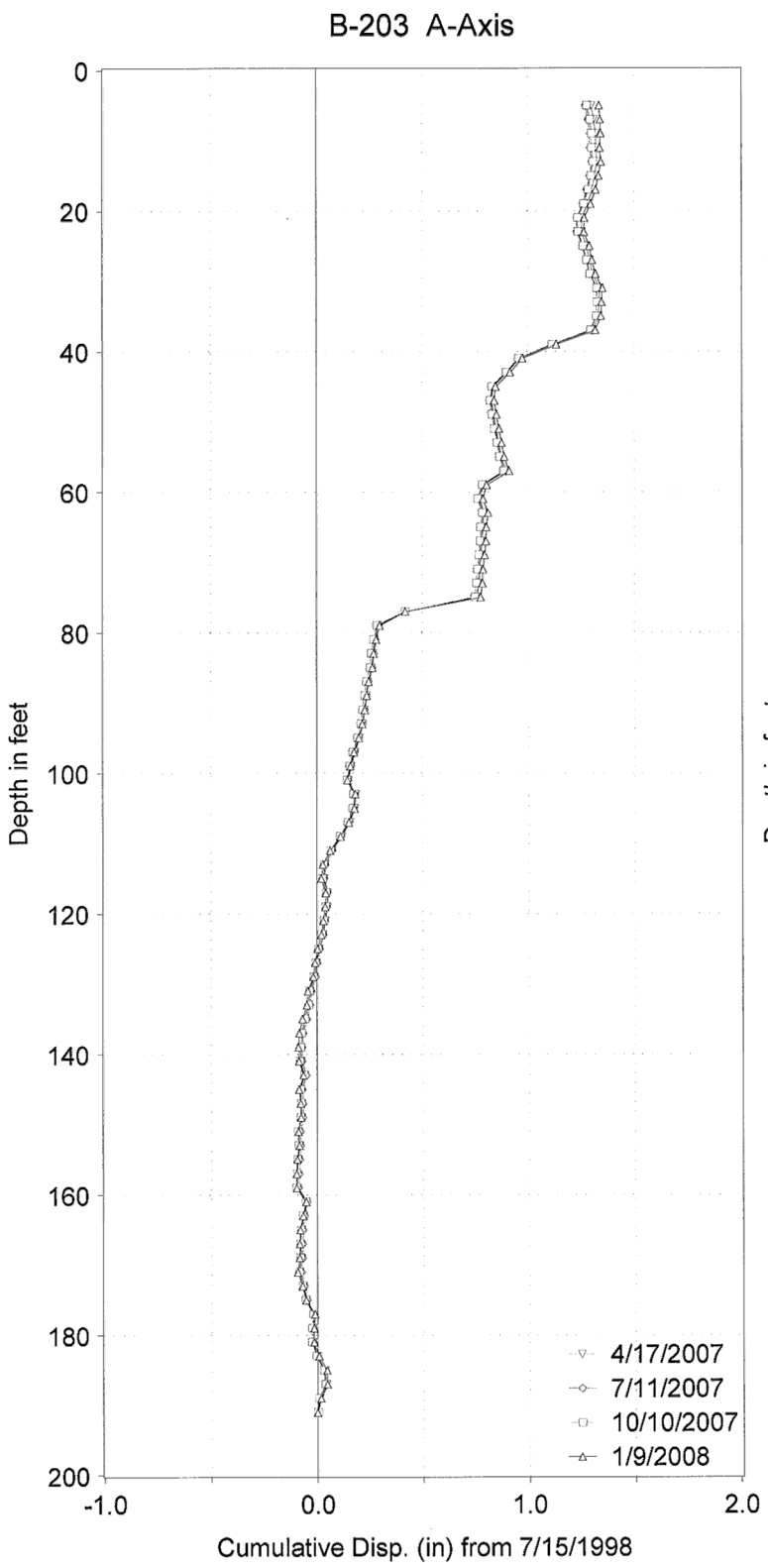
PLATE 7

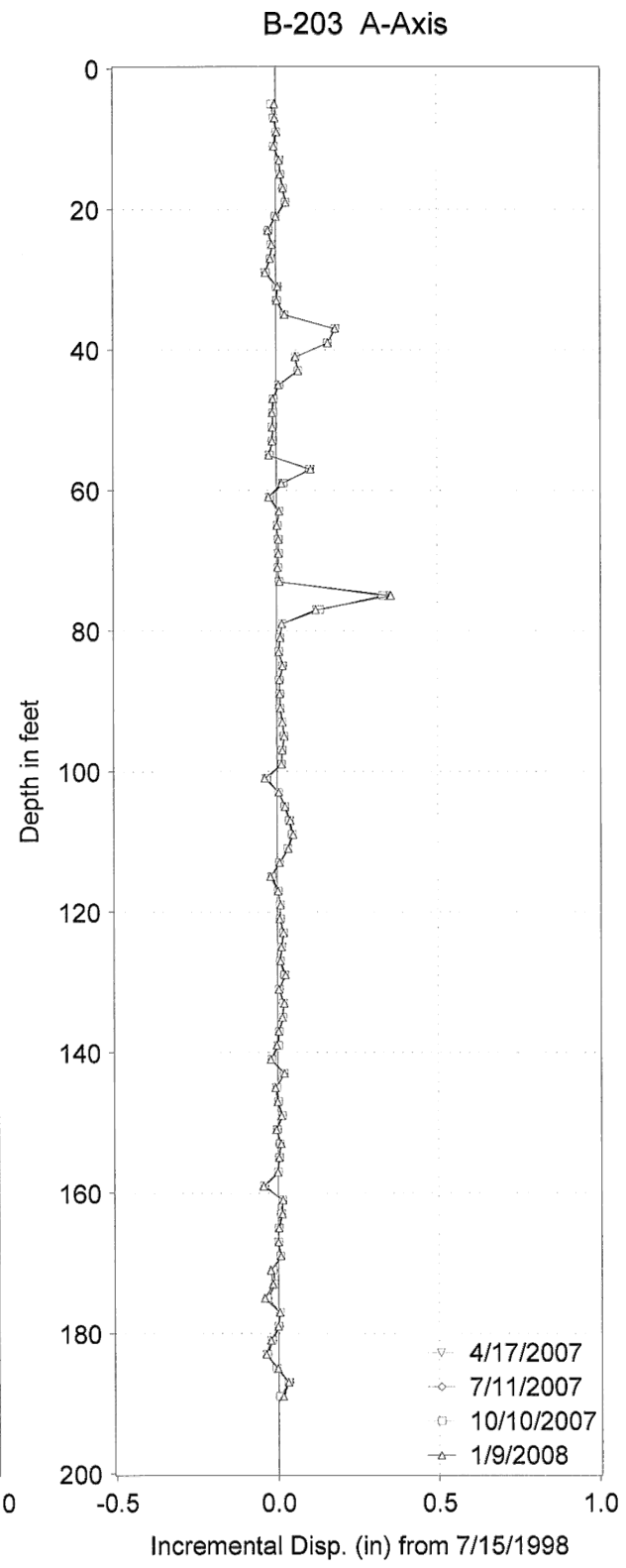




B-107
-Includes readings from the last four quarters.

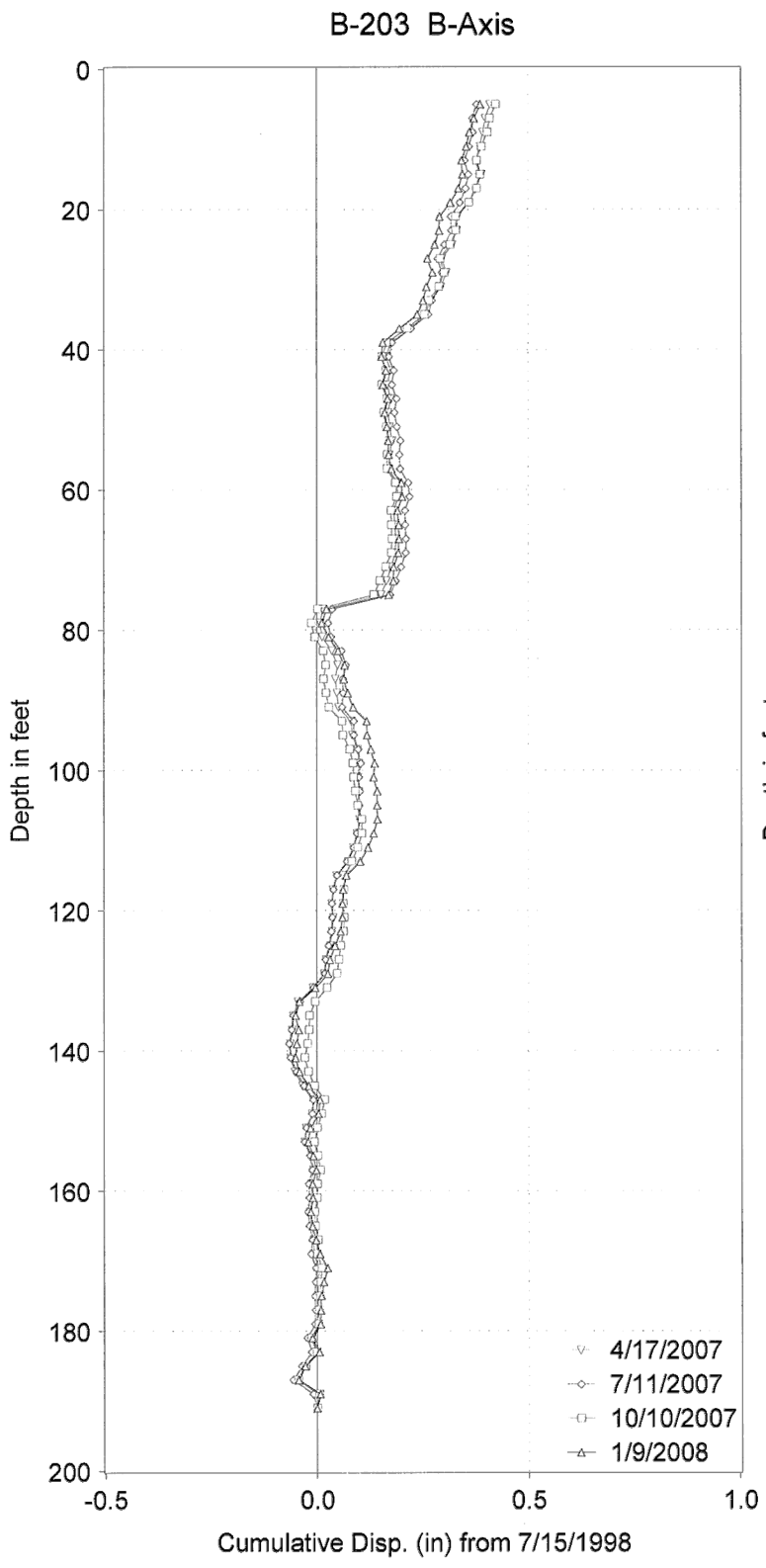
PLATE 8

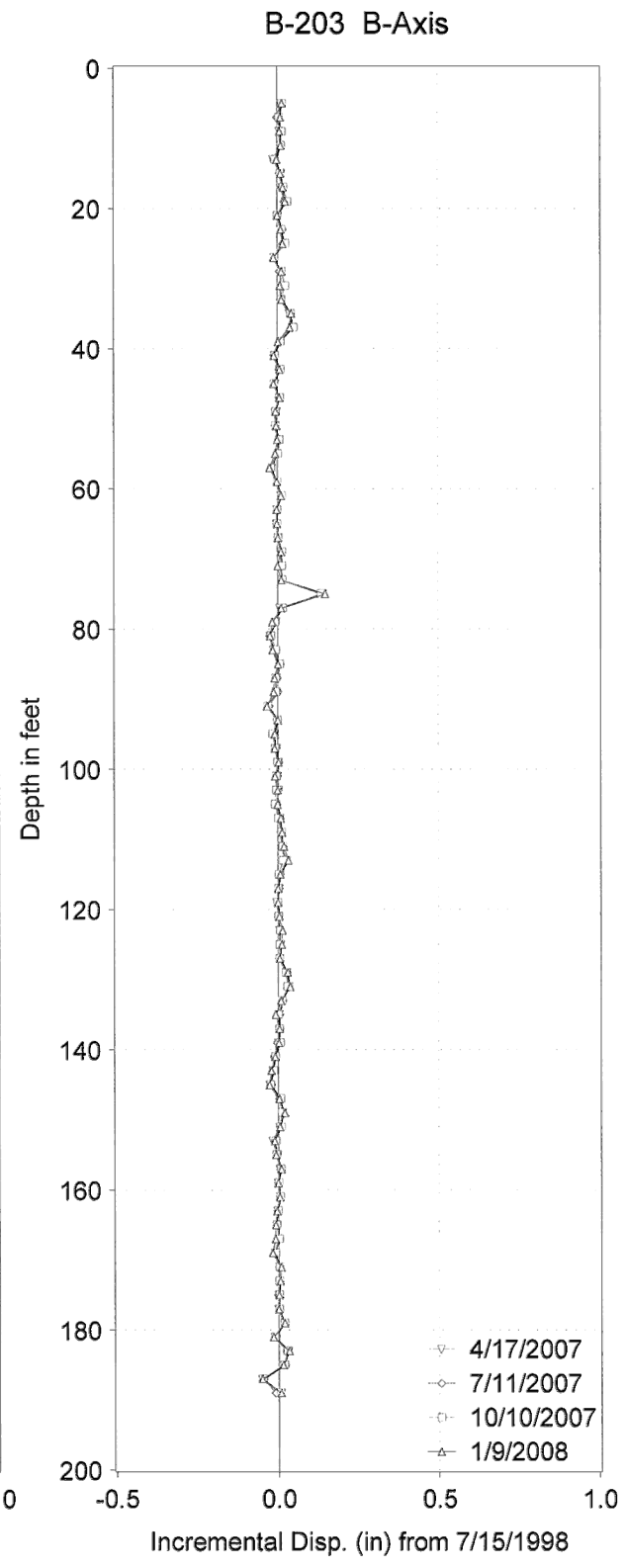




B-203
-Includes readings from the last four quarters.

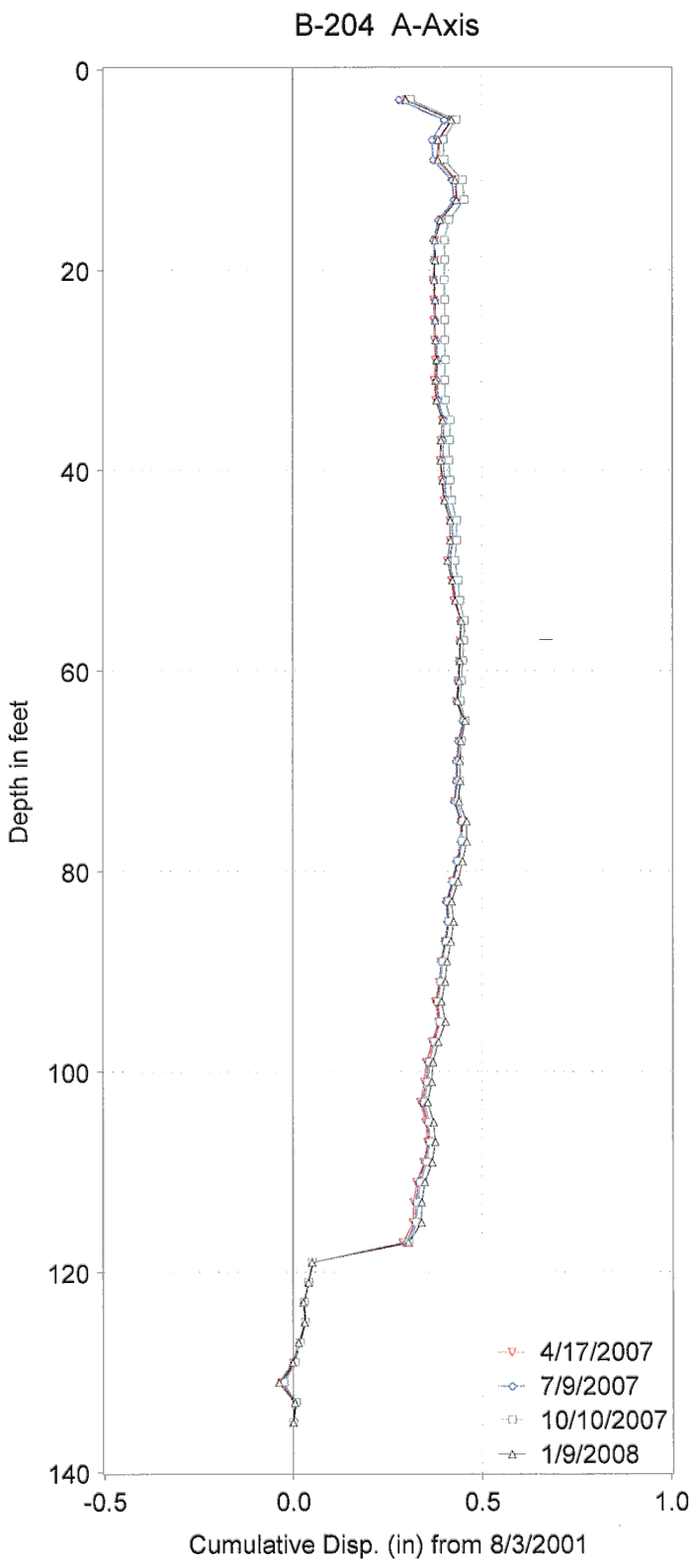
PLATE 9

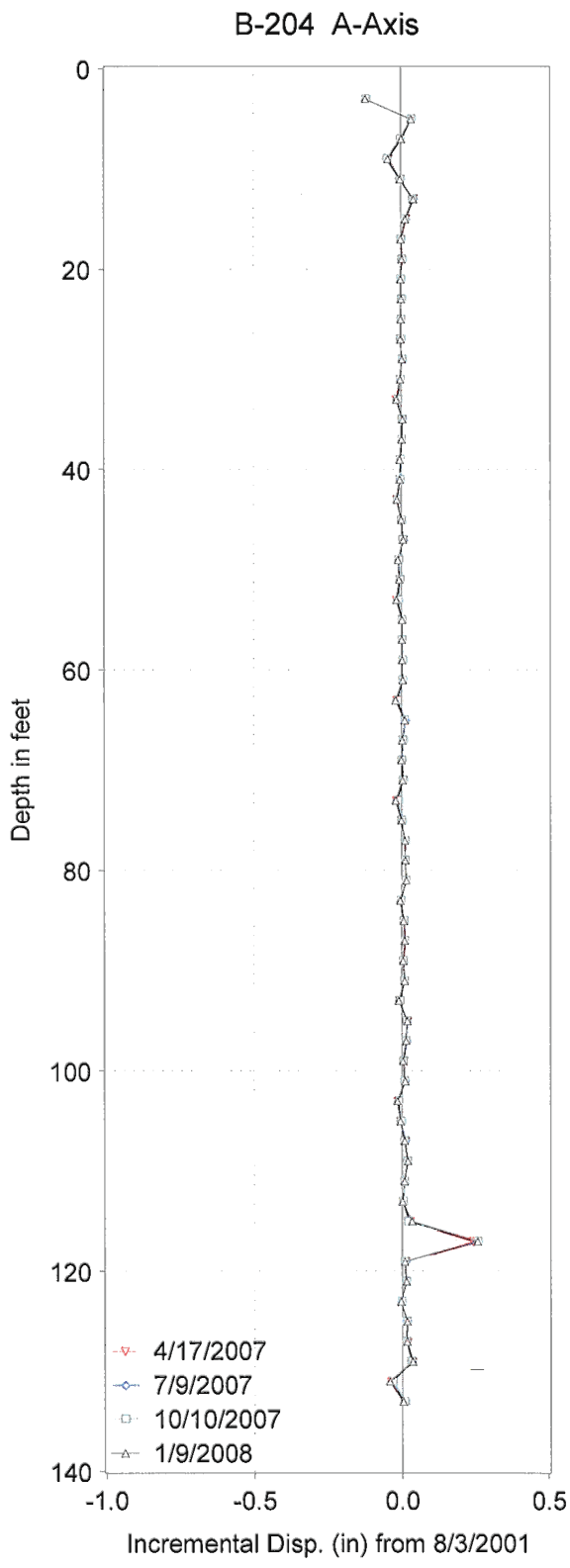




B-203
-Includes readings from the last four quarters.

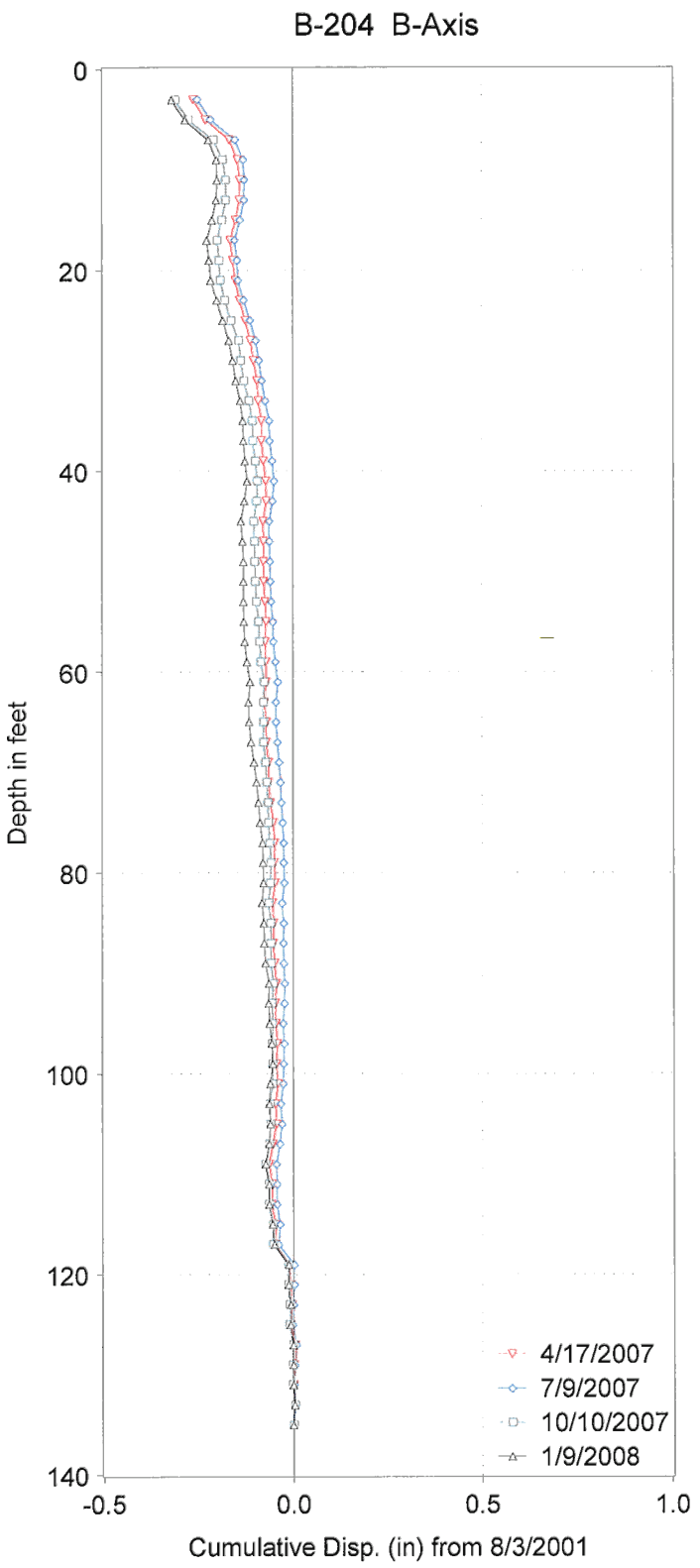
PLATE 10

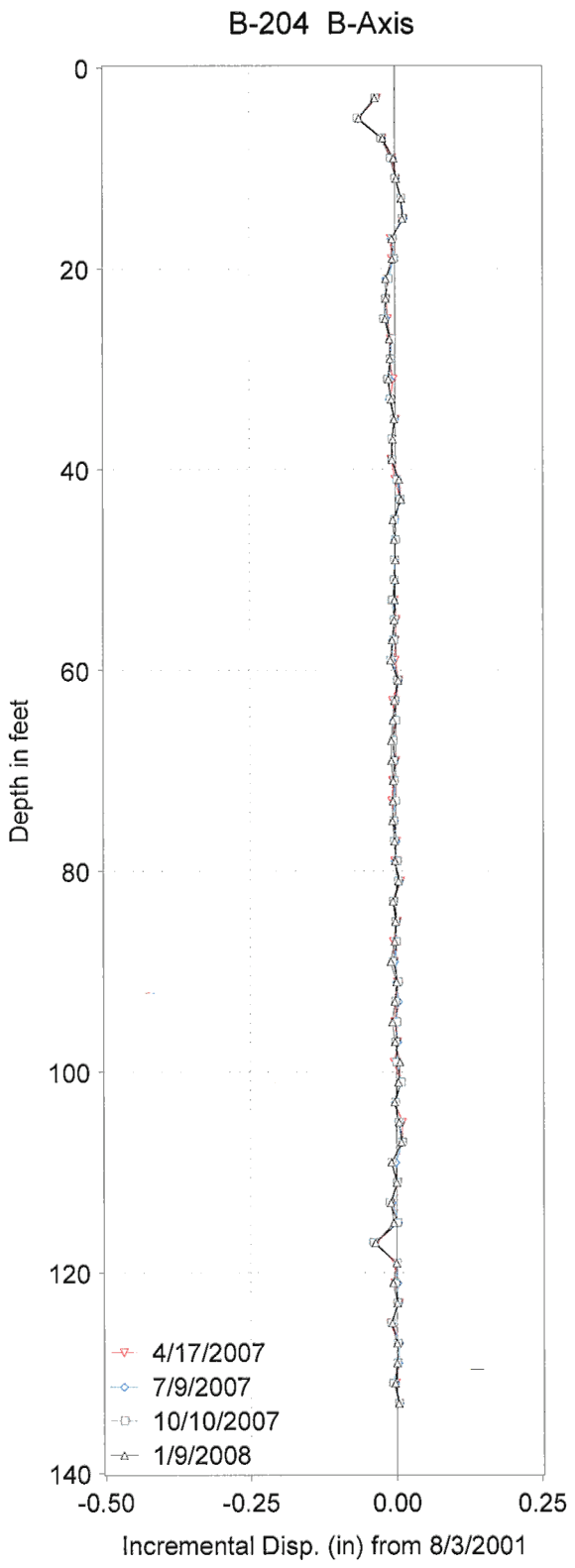




B-204
-Includes readings from the last four quarters.

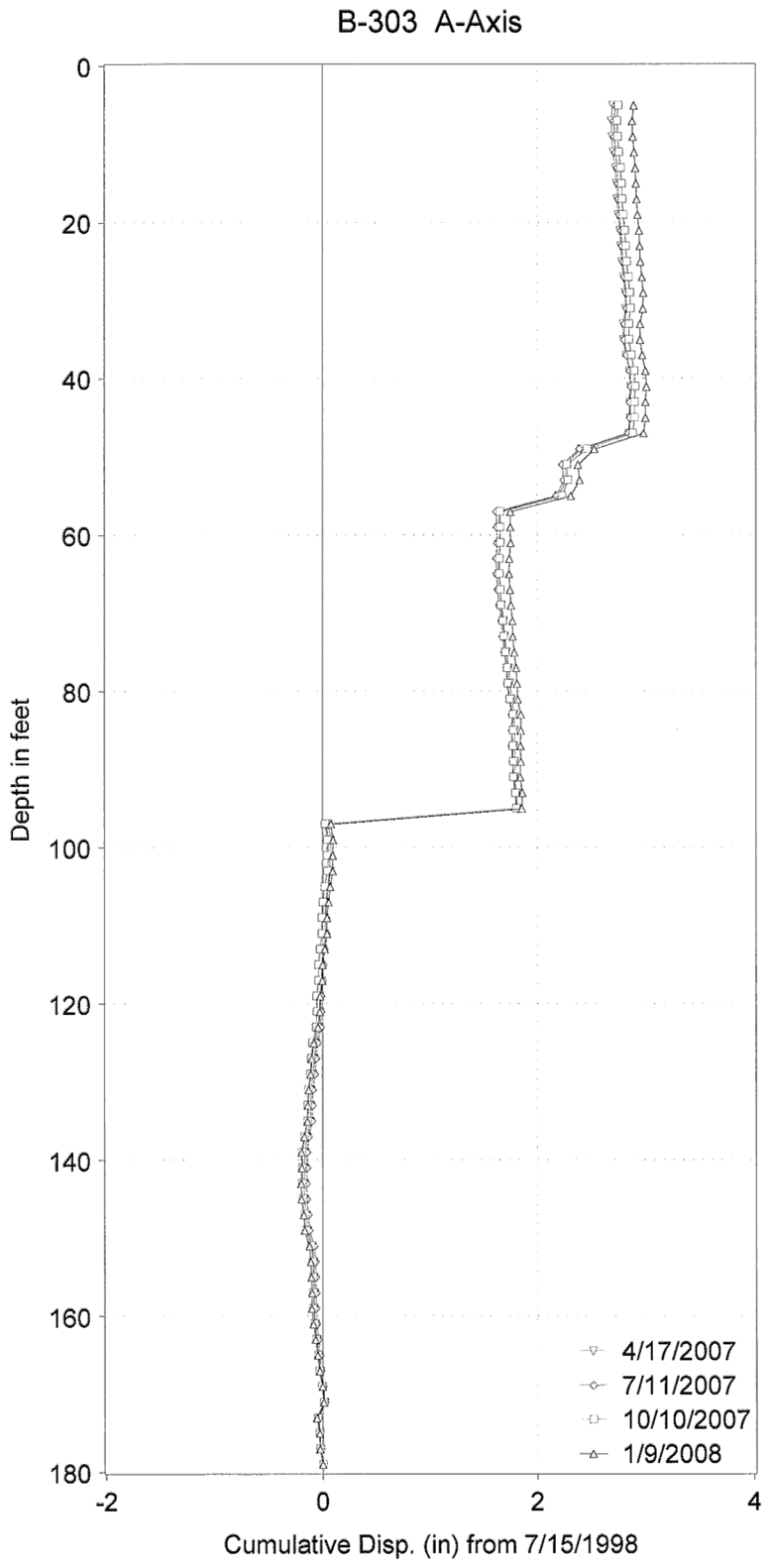
PLATE 11

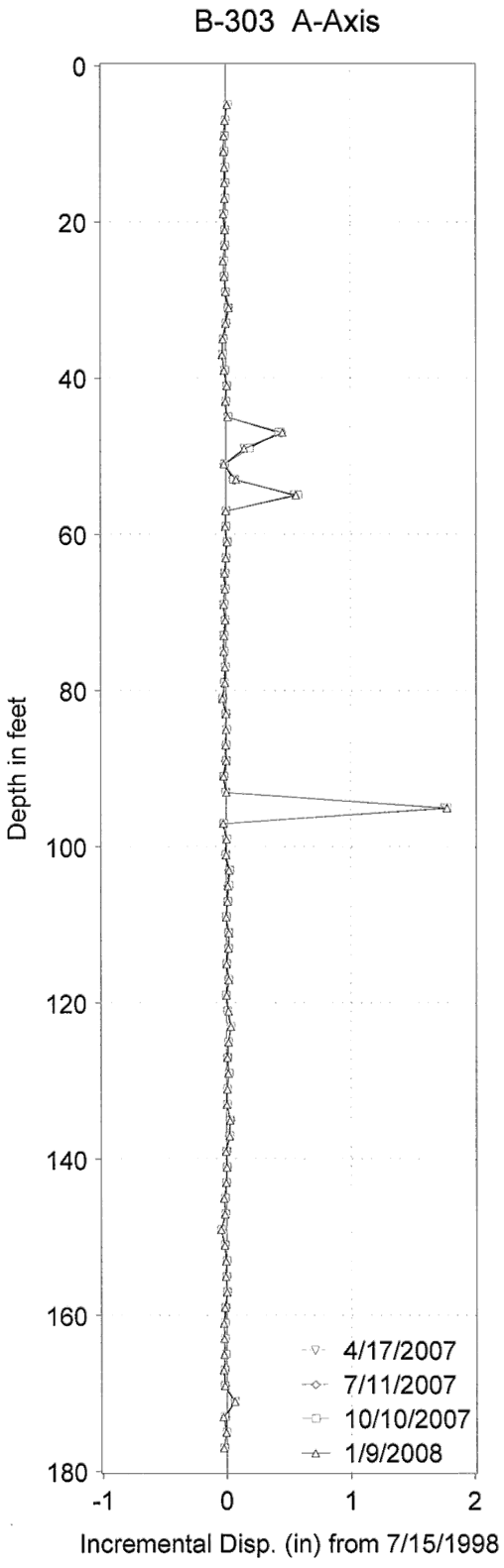




B-204
-Includes readings from the last four quarters.

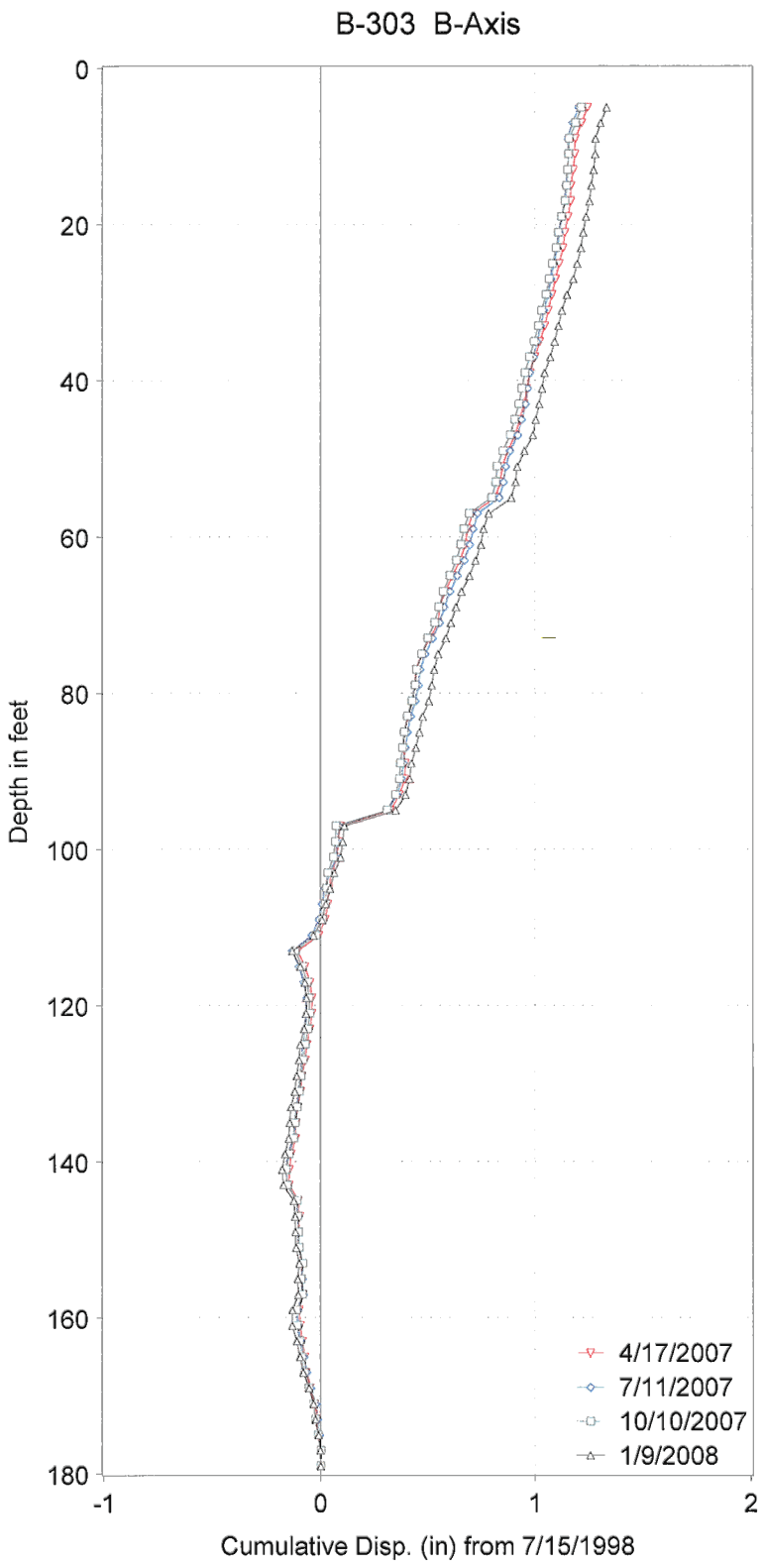
PLATE 12

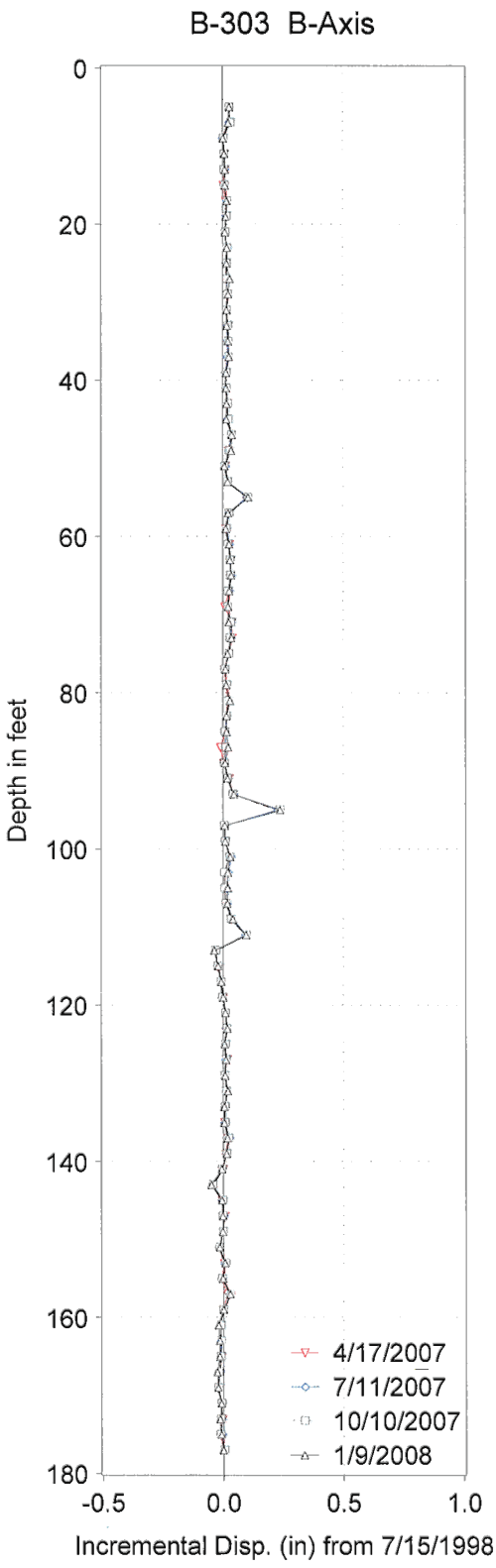




B-303
-Includes readings from the last four quarters.

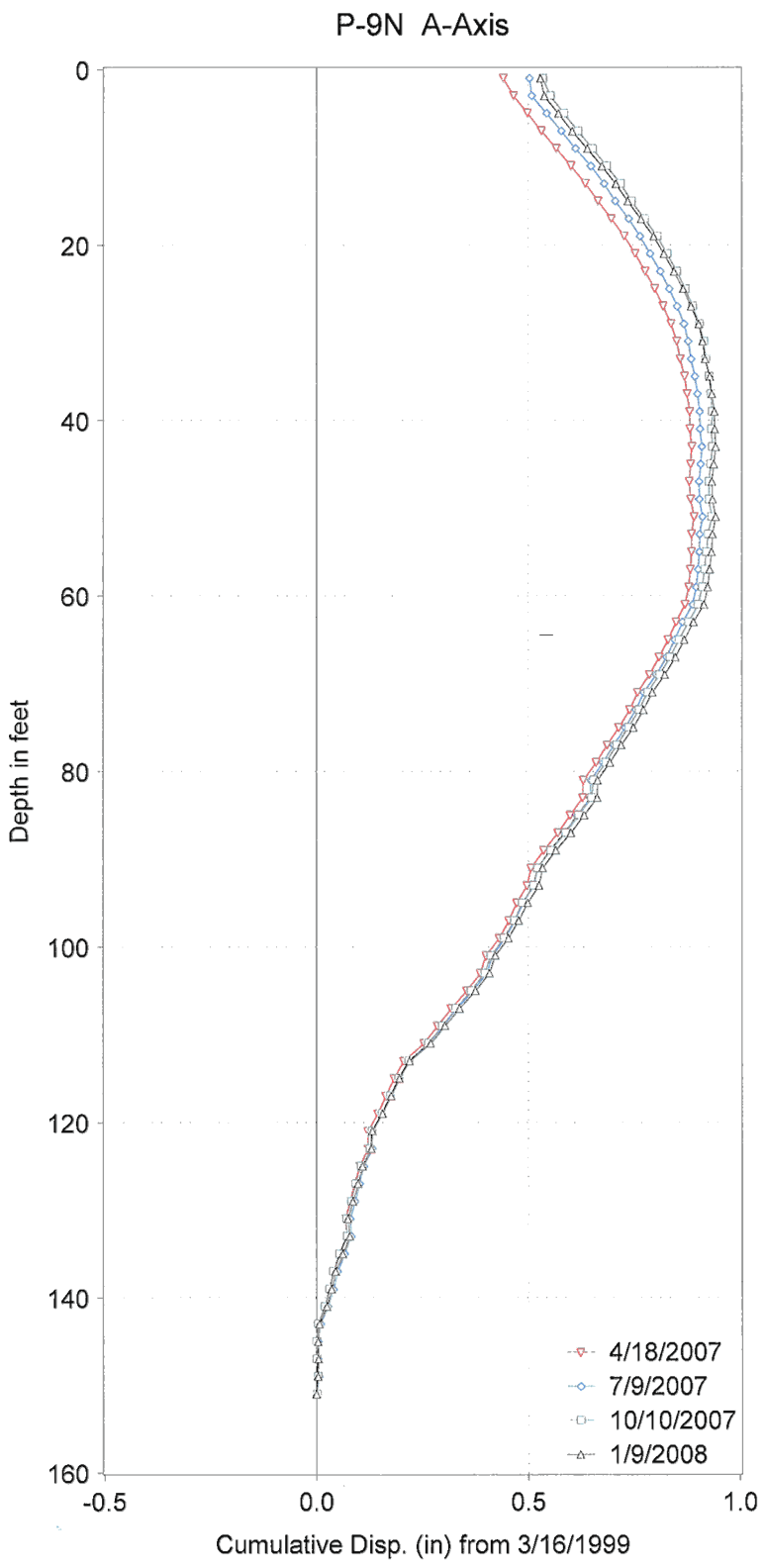
PLATE 13

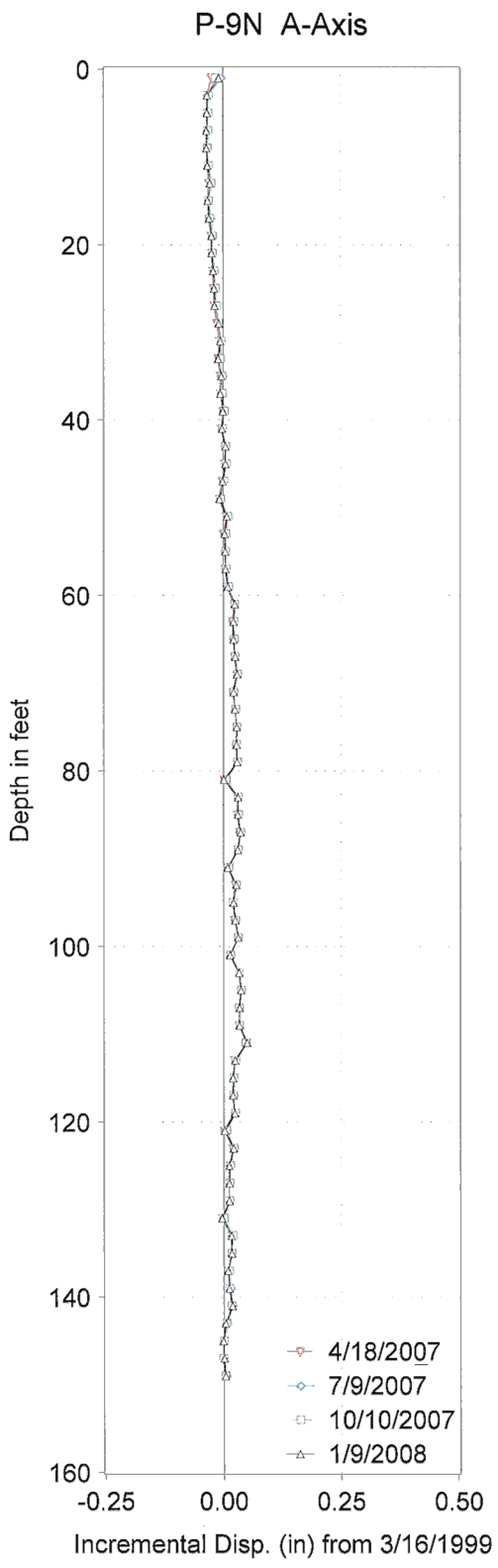




B-303
-Includes readings from the last four quarters.

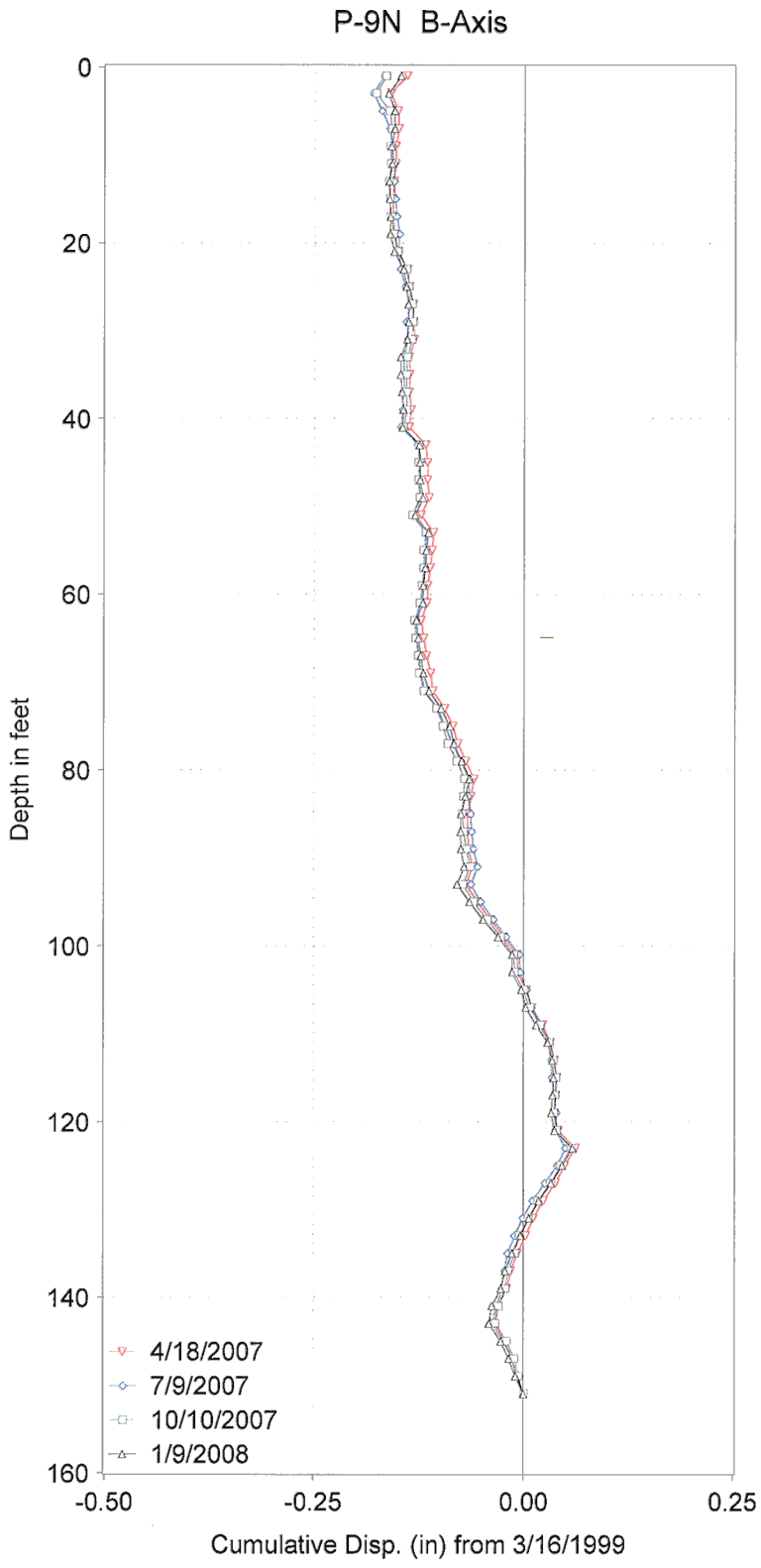
PLATE 14

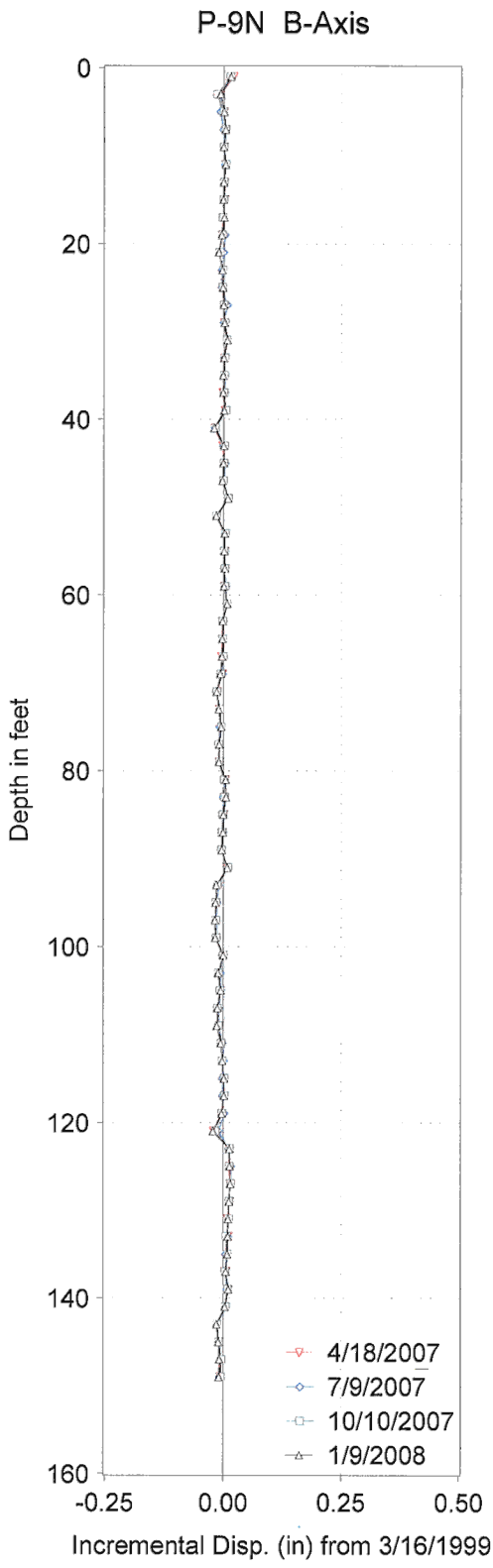




P-9N
-Includes readings from the last four quarters.

PLATE 15





P-9N

-Includes readings from the last four quarters.

PLATE 16

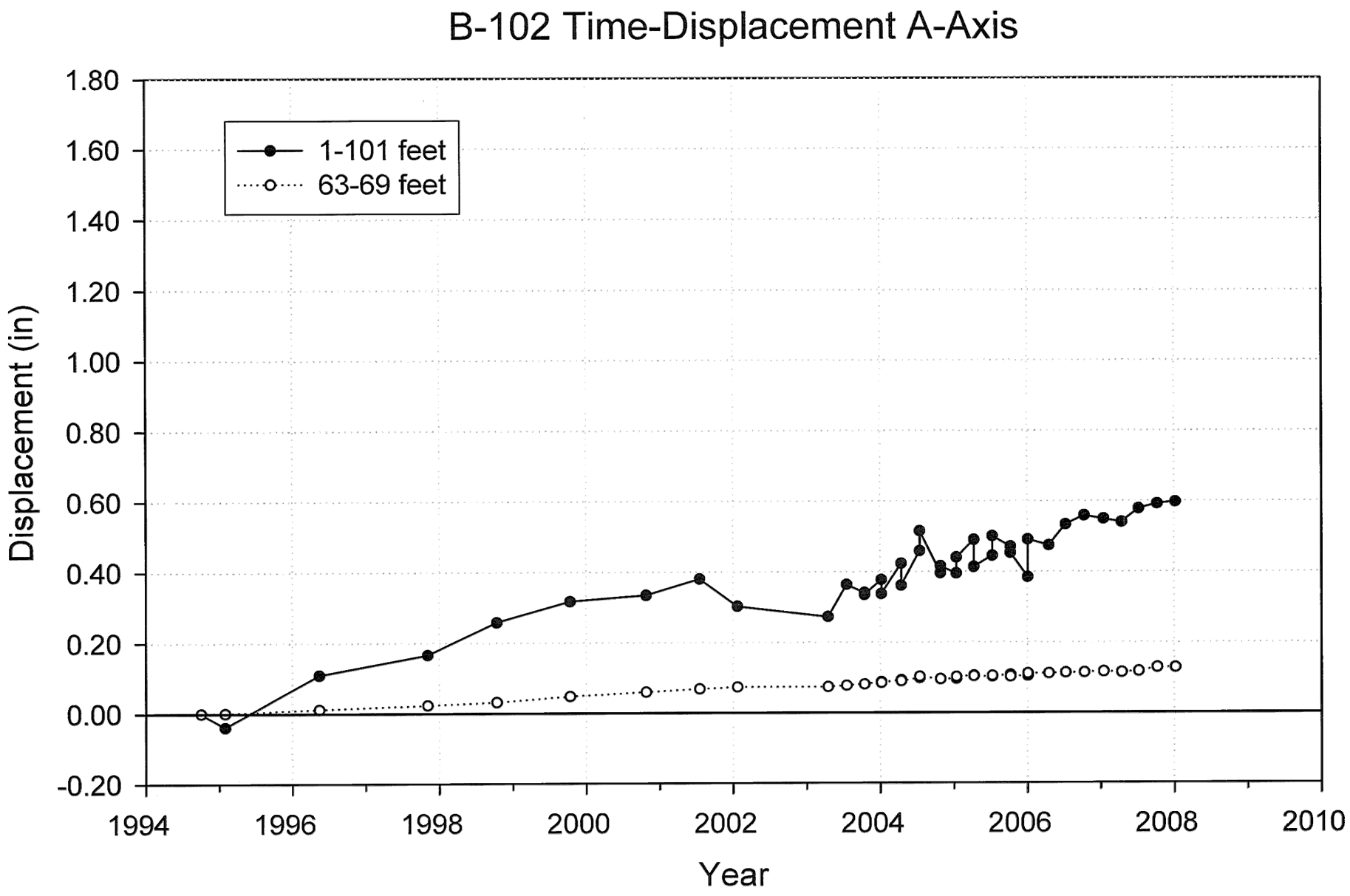

B-102 Time-Displacement A-Axis
1-101 feet
63-69 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 17

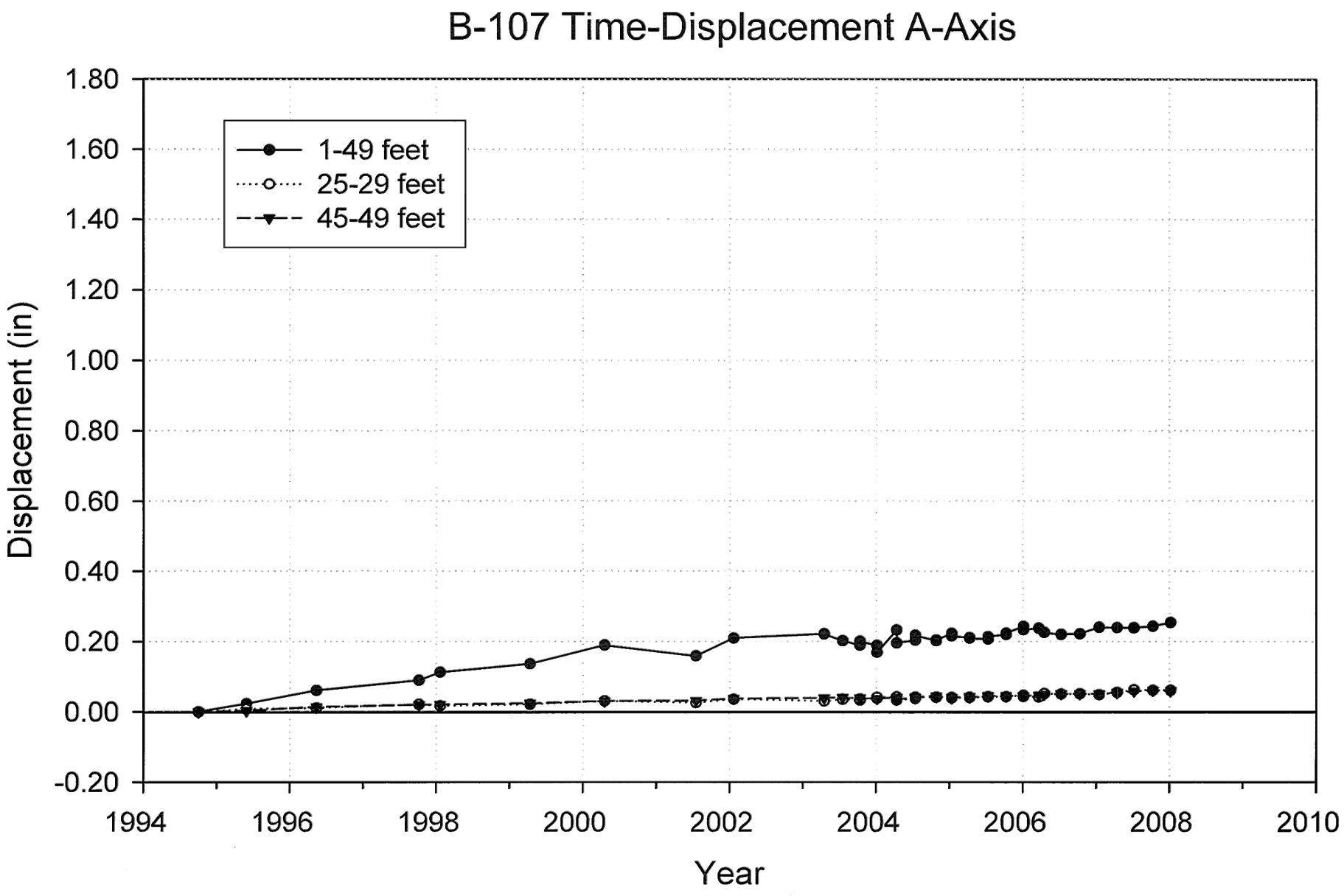

B-107 Time-Displacement A-Axis
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Displacement (in)
1-49 feet
25-29 feet
45-49 feet
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 18

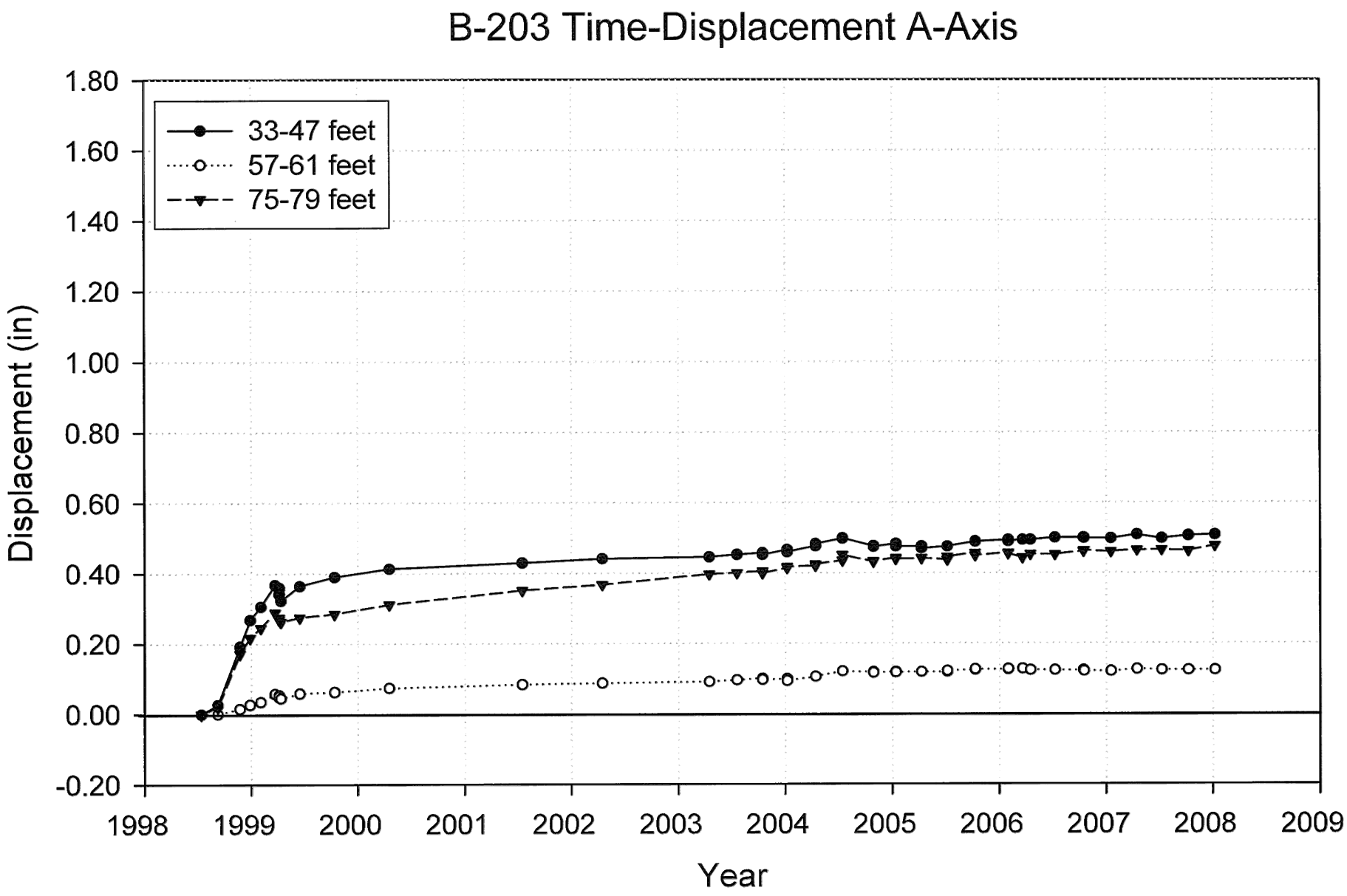

B-203 Time-Displacement A-Axis
33-47 feet
57-61 feet
75-79 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

PLATE 19

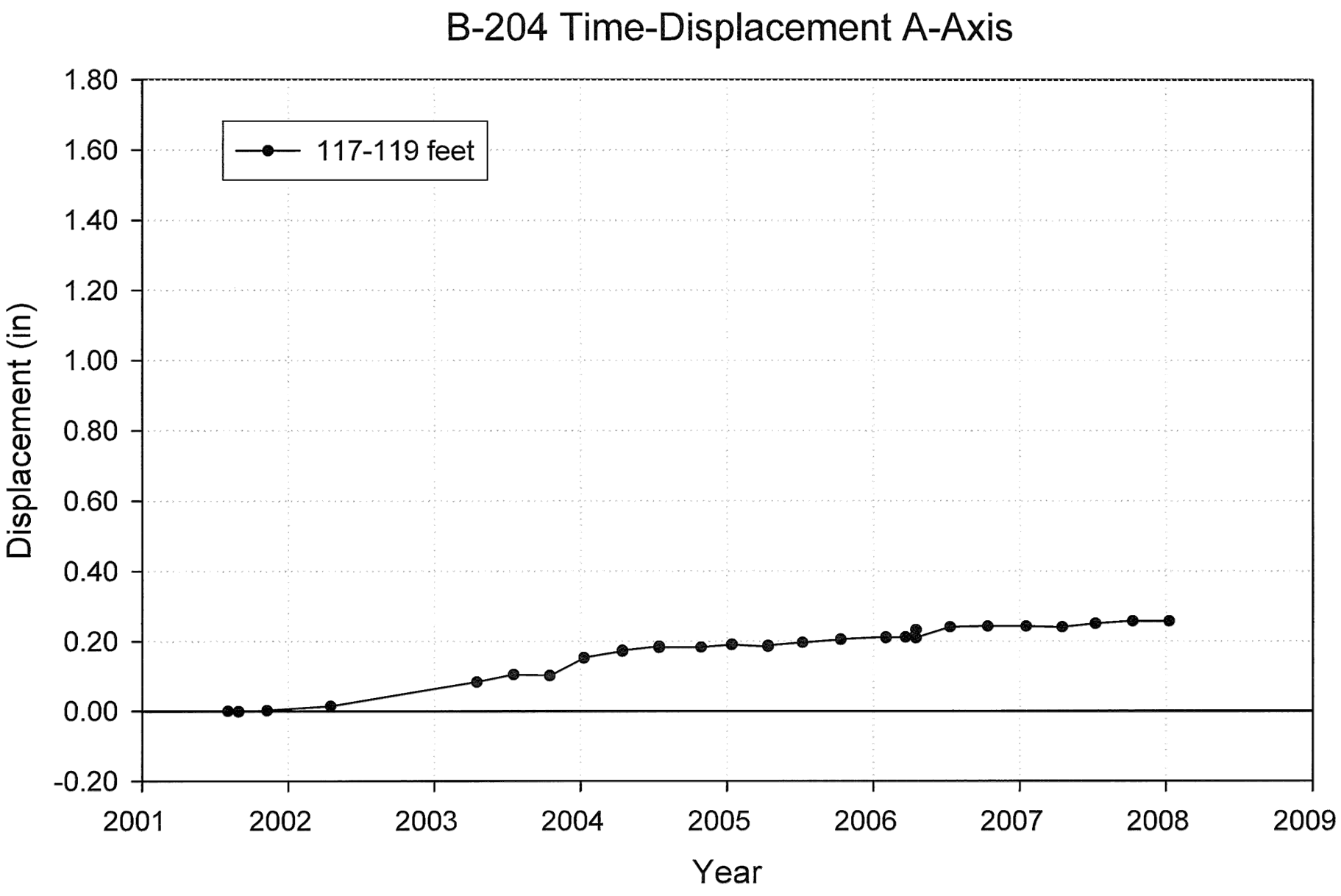

B-204 Time-Displacement A-Axis
117-119 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

PLATE 20

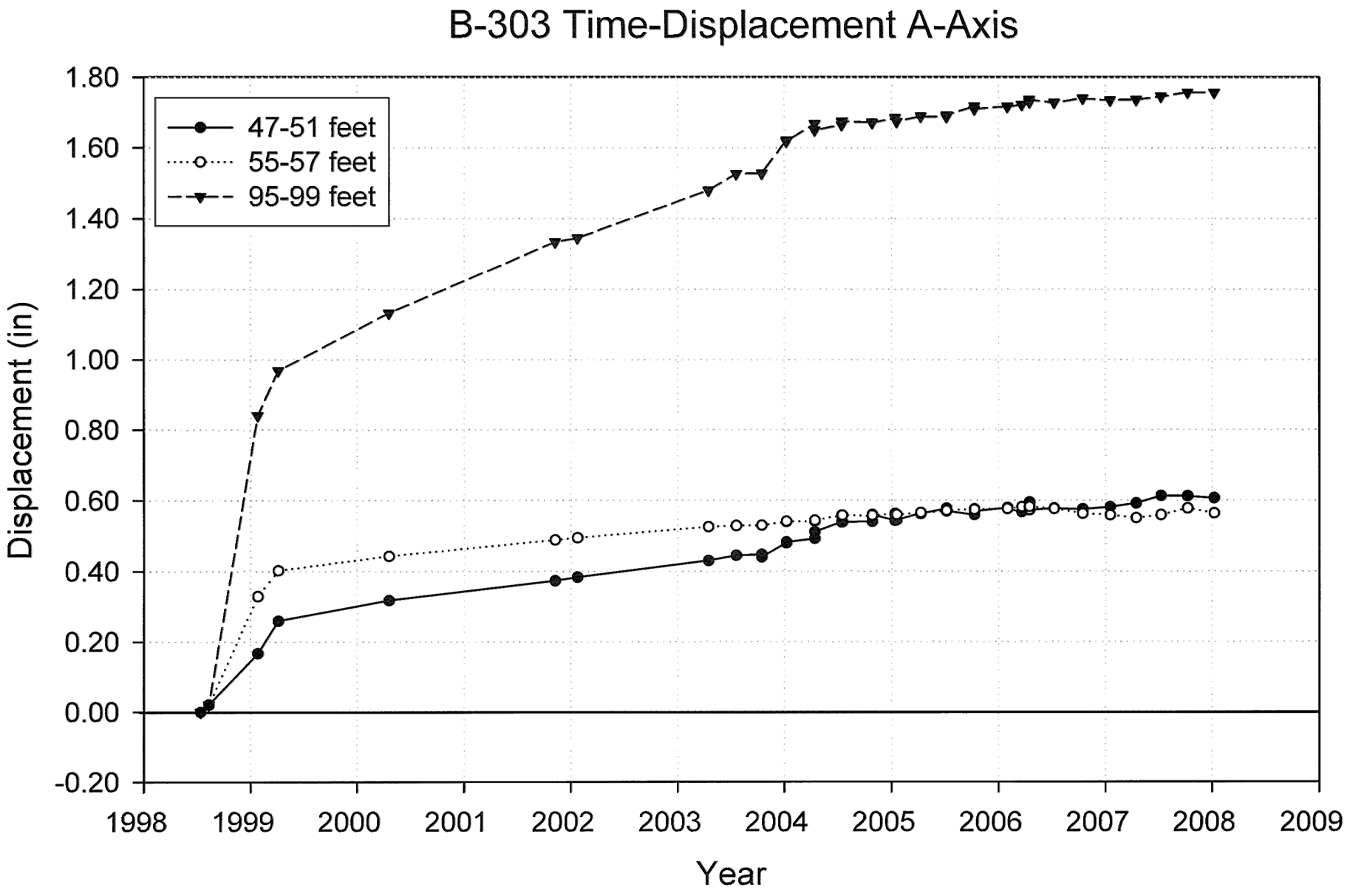
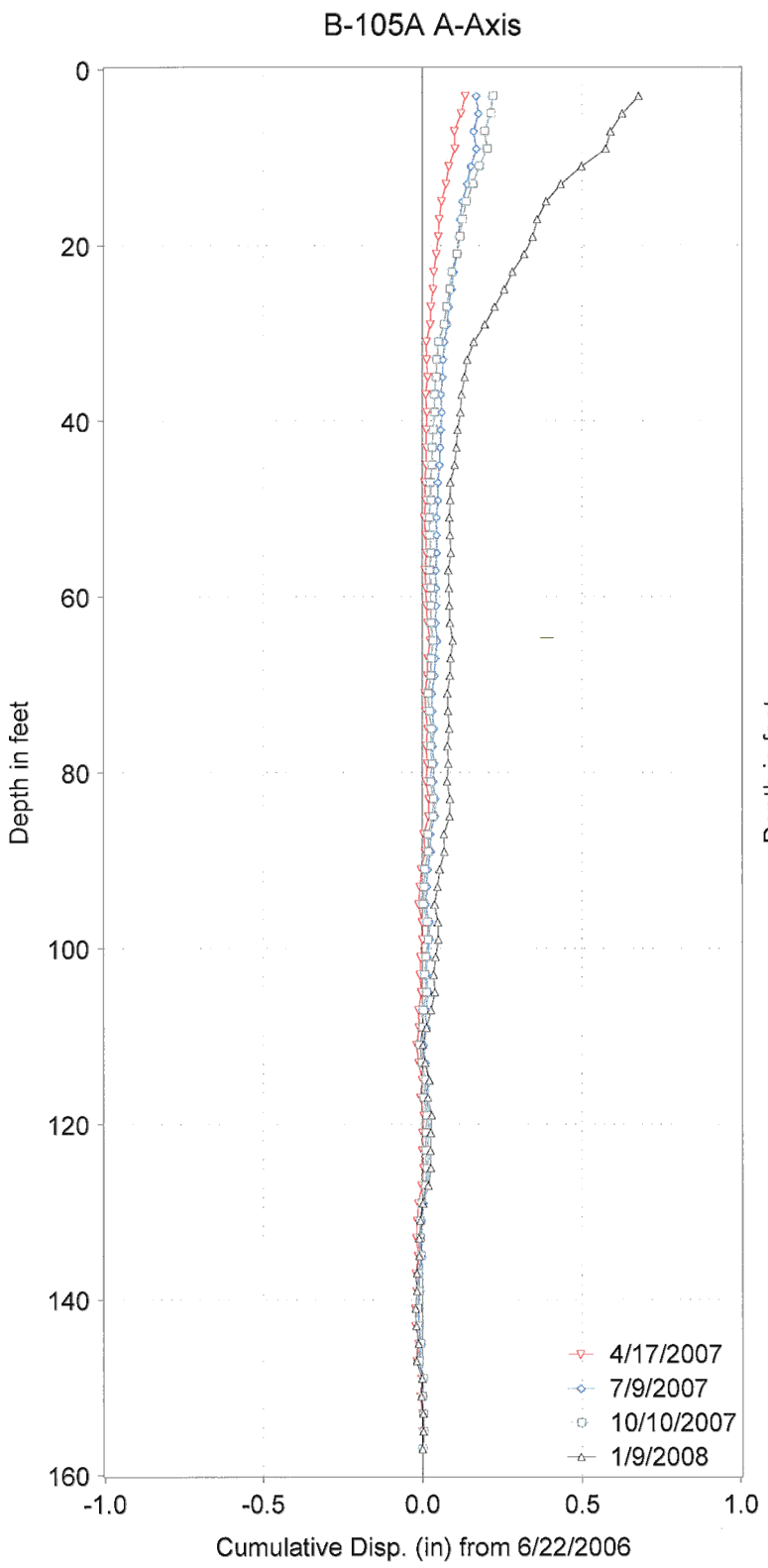
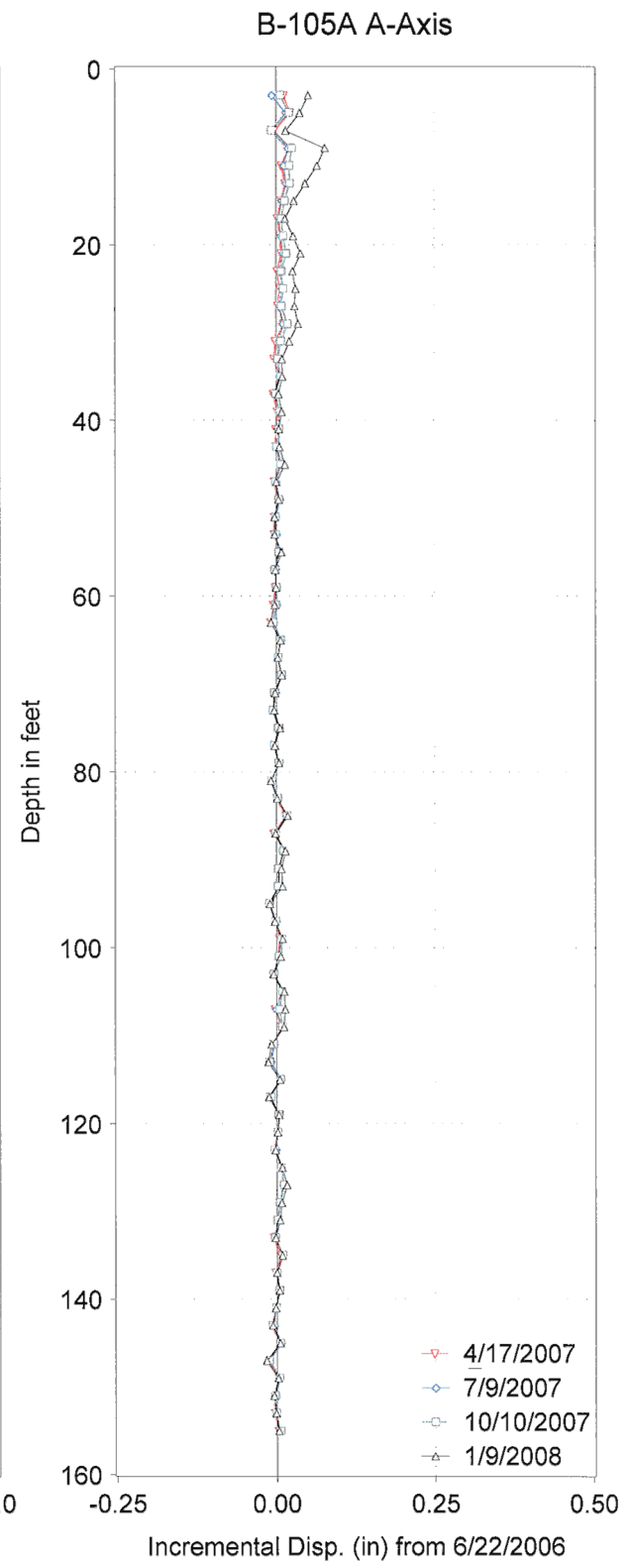

B-303 Time-Displacement A-Axis
47-51 feet
55-57 feet
95-99 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

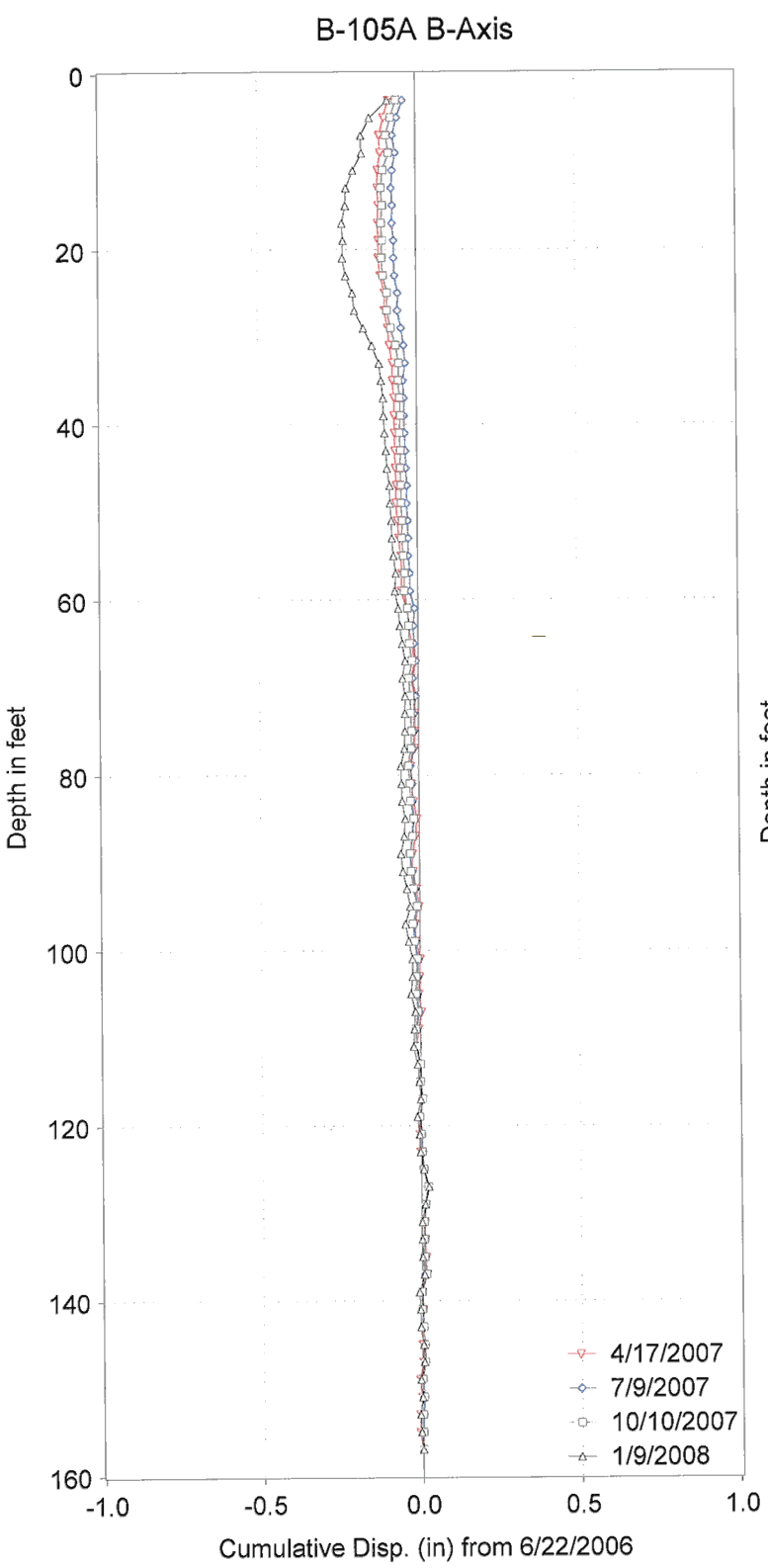
PLATE 21

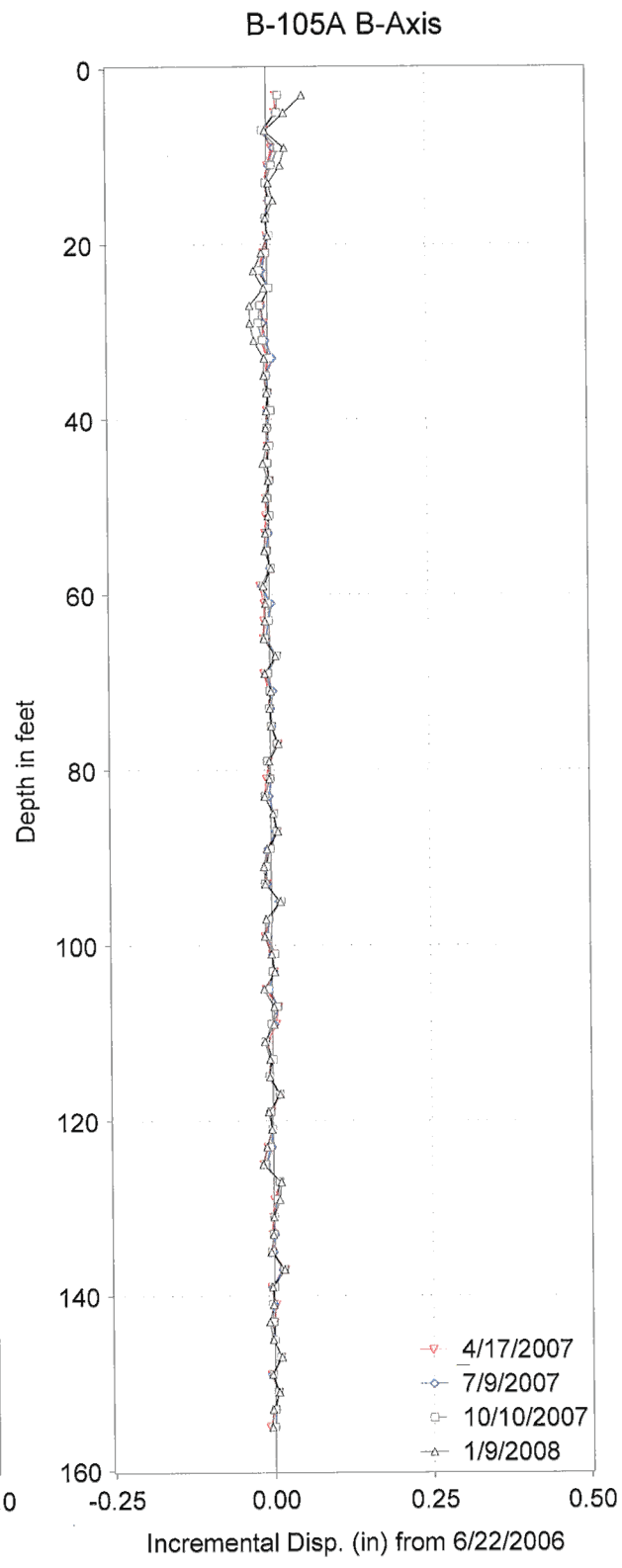




B-105A
-Includes readings from the last four quarters.

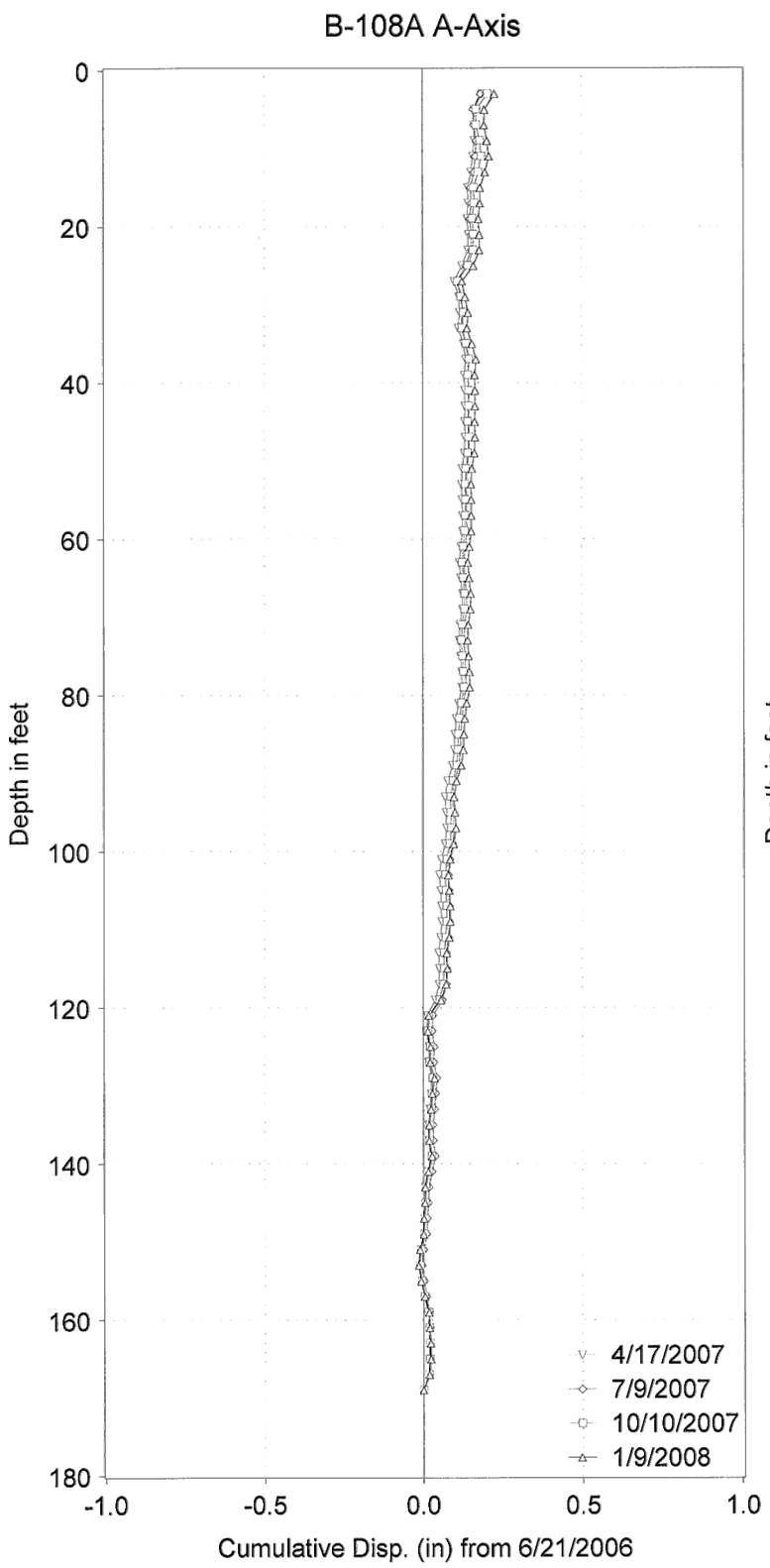
PLATE 22

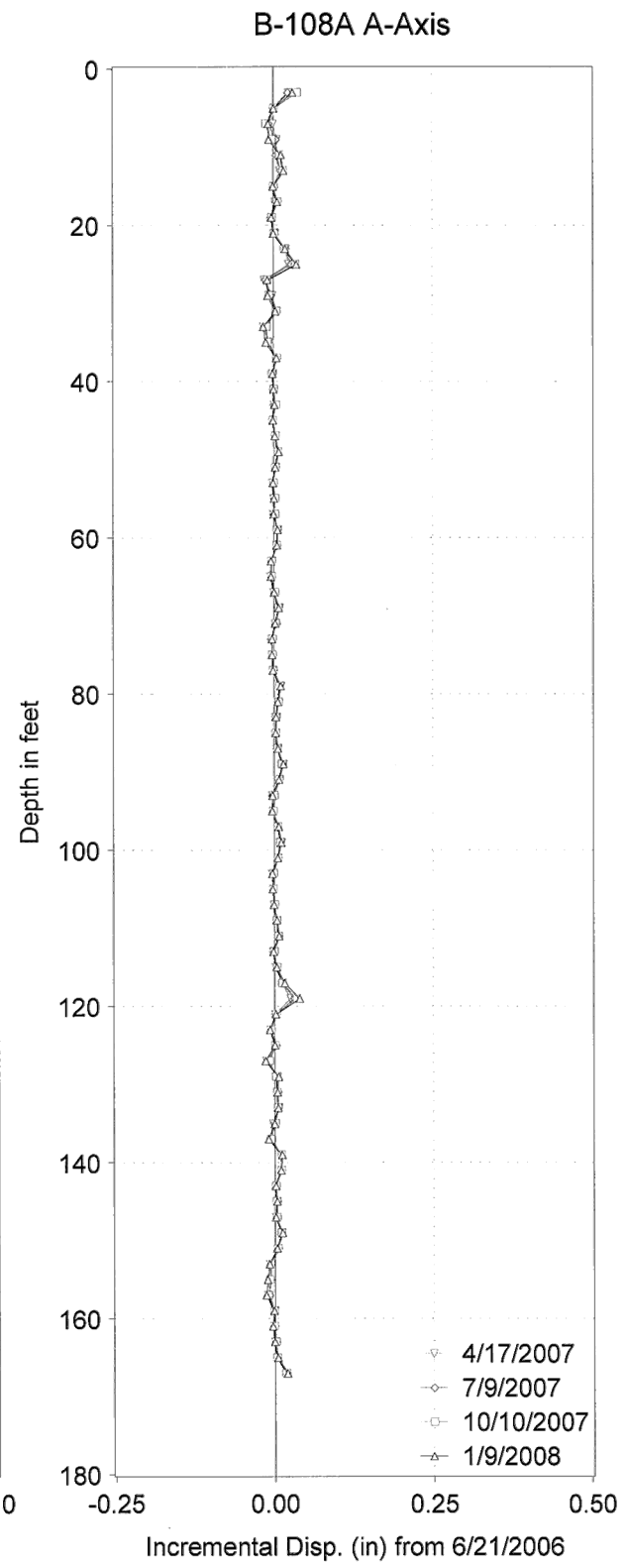




B-105A
-Includes readings from the last four quarters.

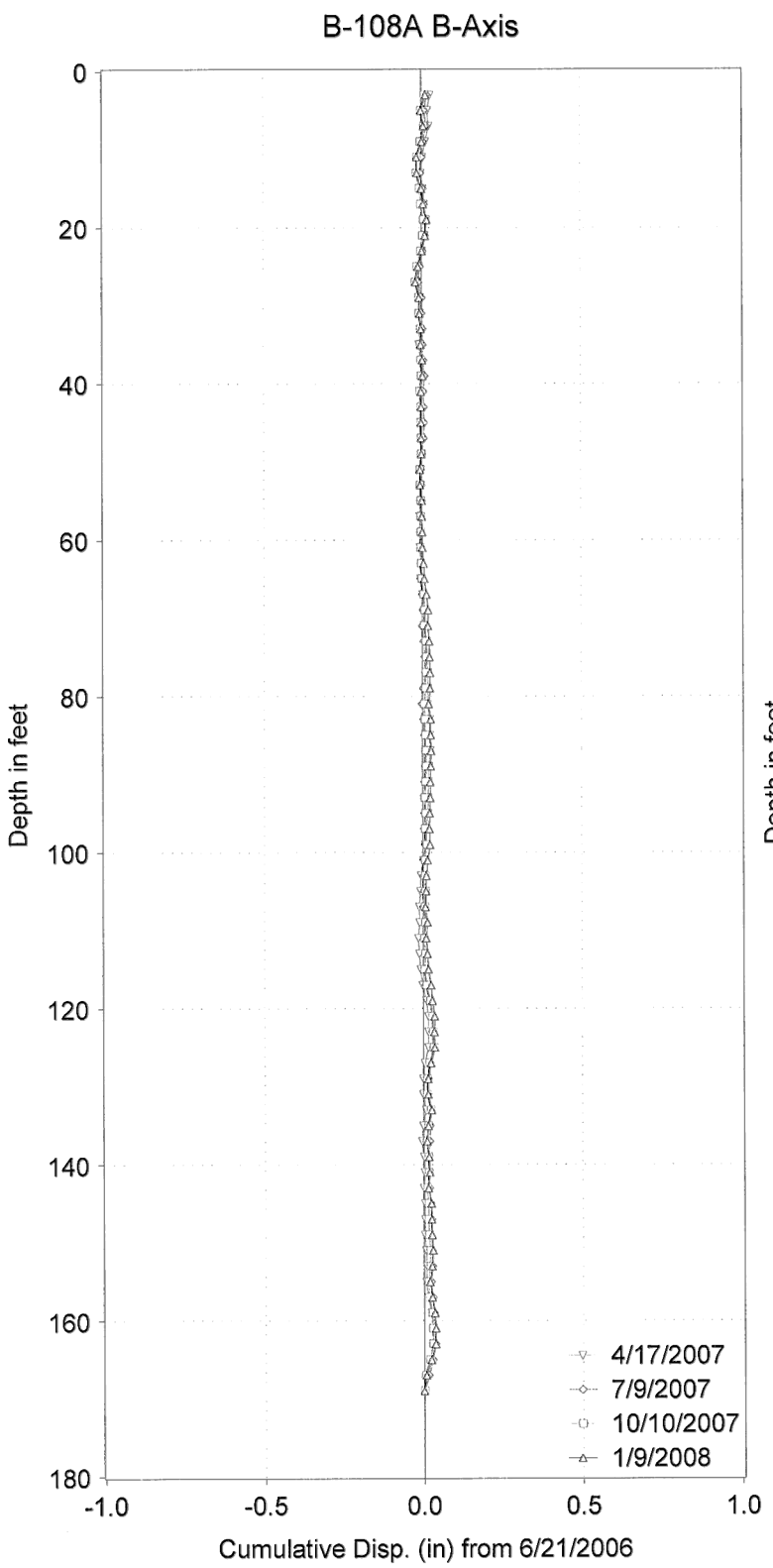
PLATE 23

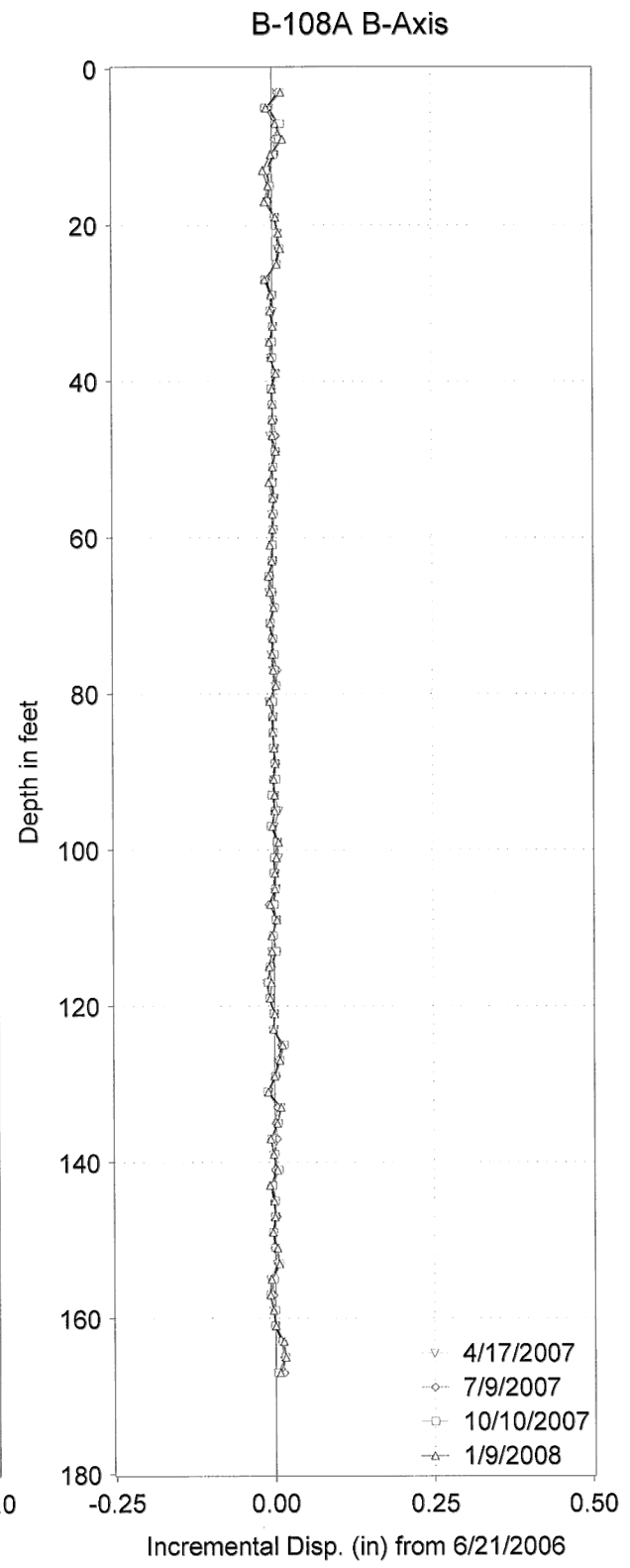




B-108A
-Includes readings from the last four quarters.

PLATE 24





B-108A
-Includes readings from the last four quarters.

PLATE 25

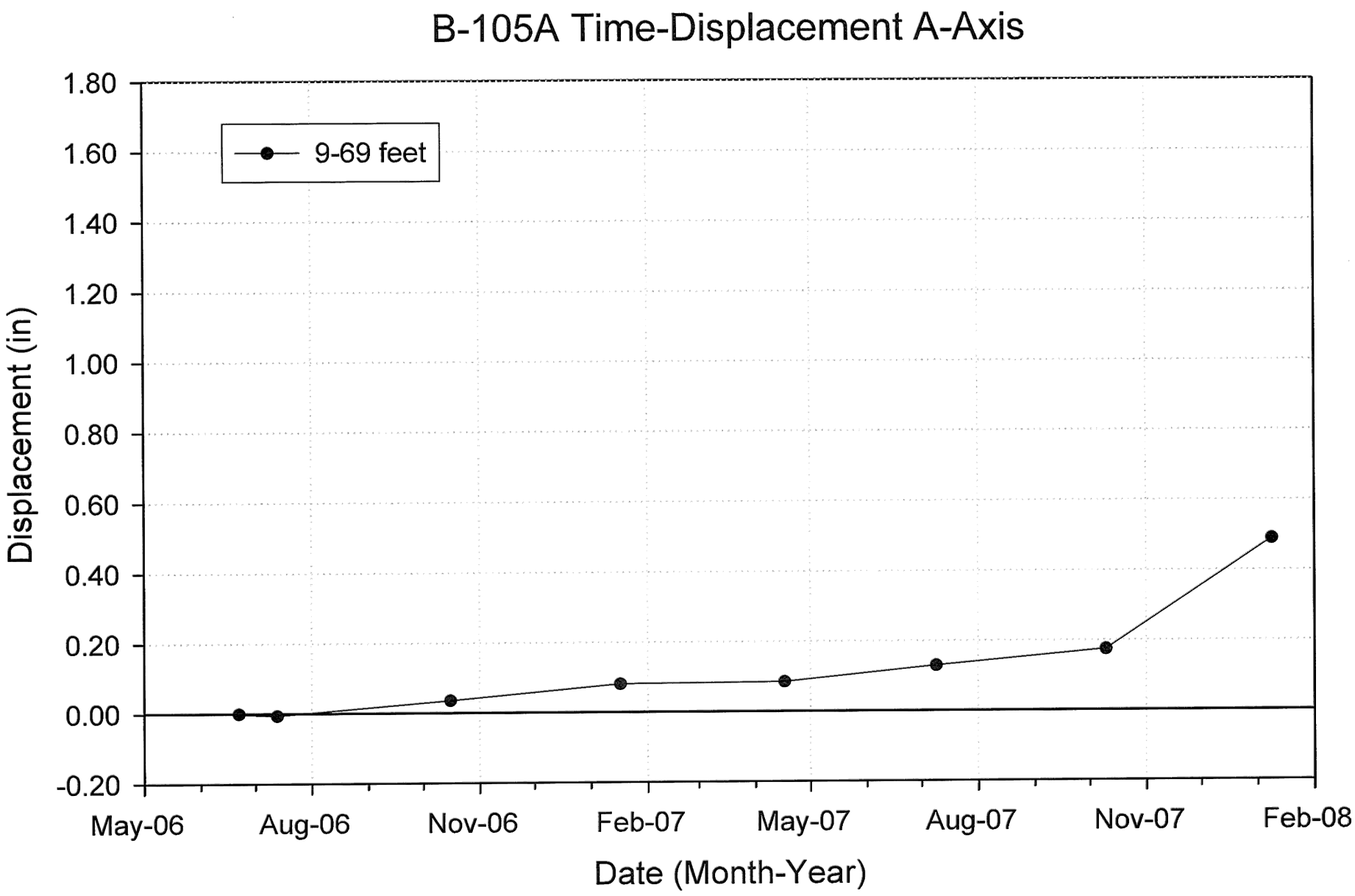

B-105A Time-Displacement A-Axis
9-69 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Aug-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
Date (Month-Year)

PLATE 26

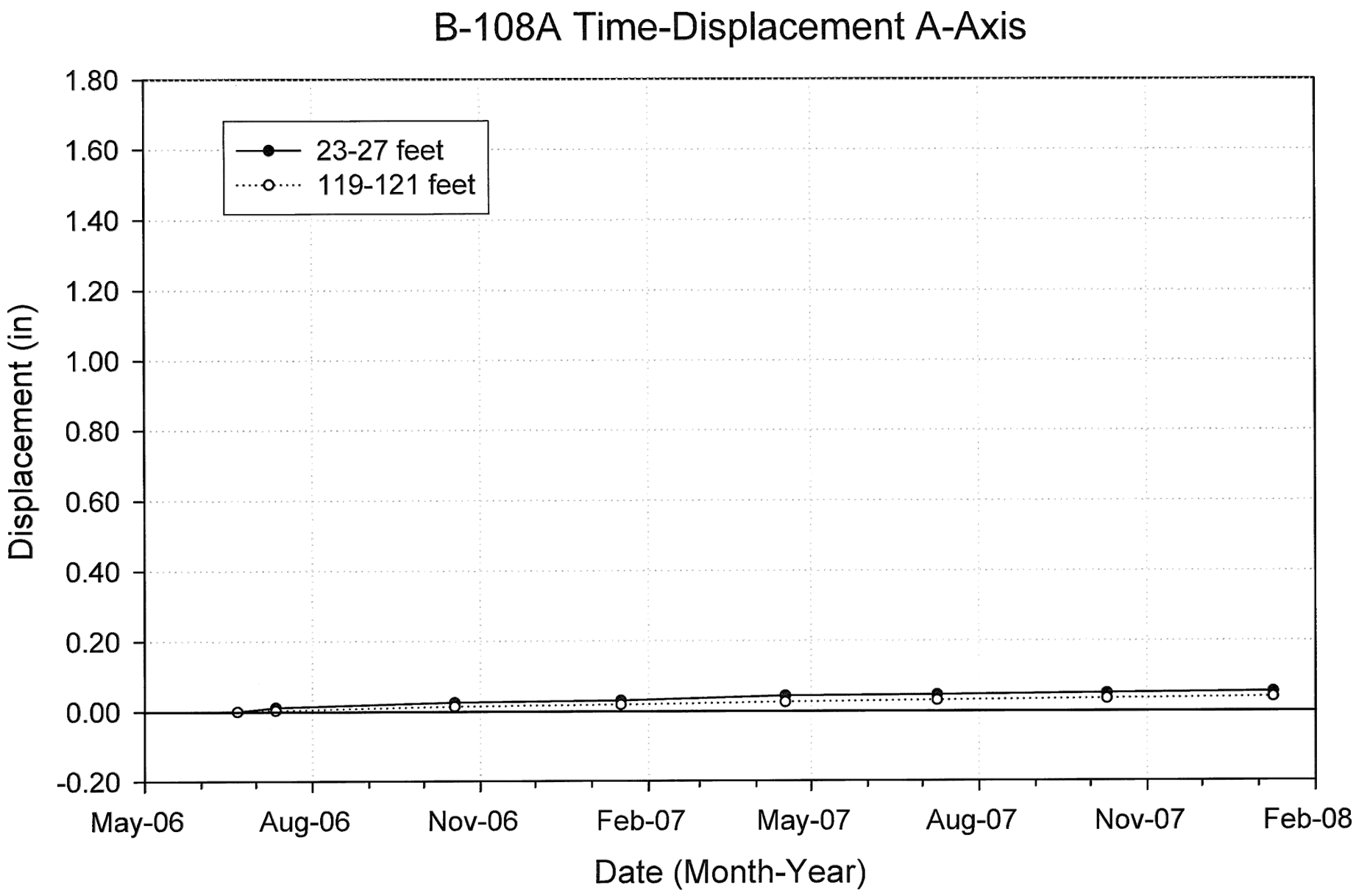
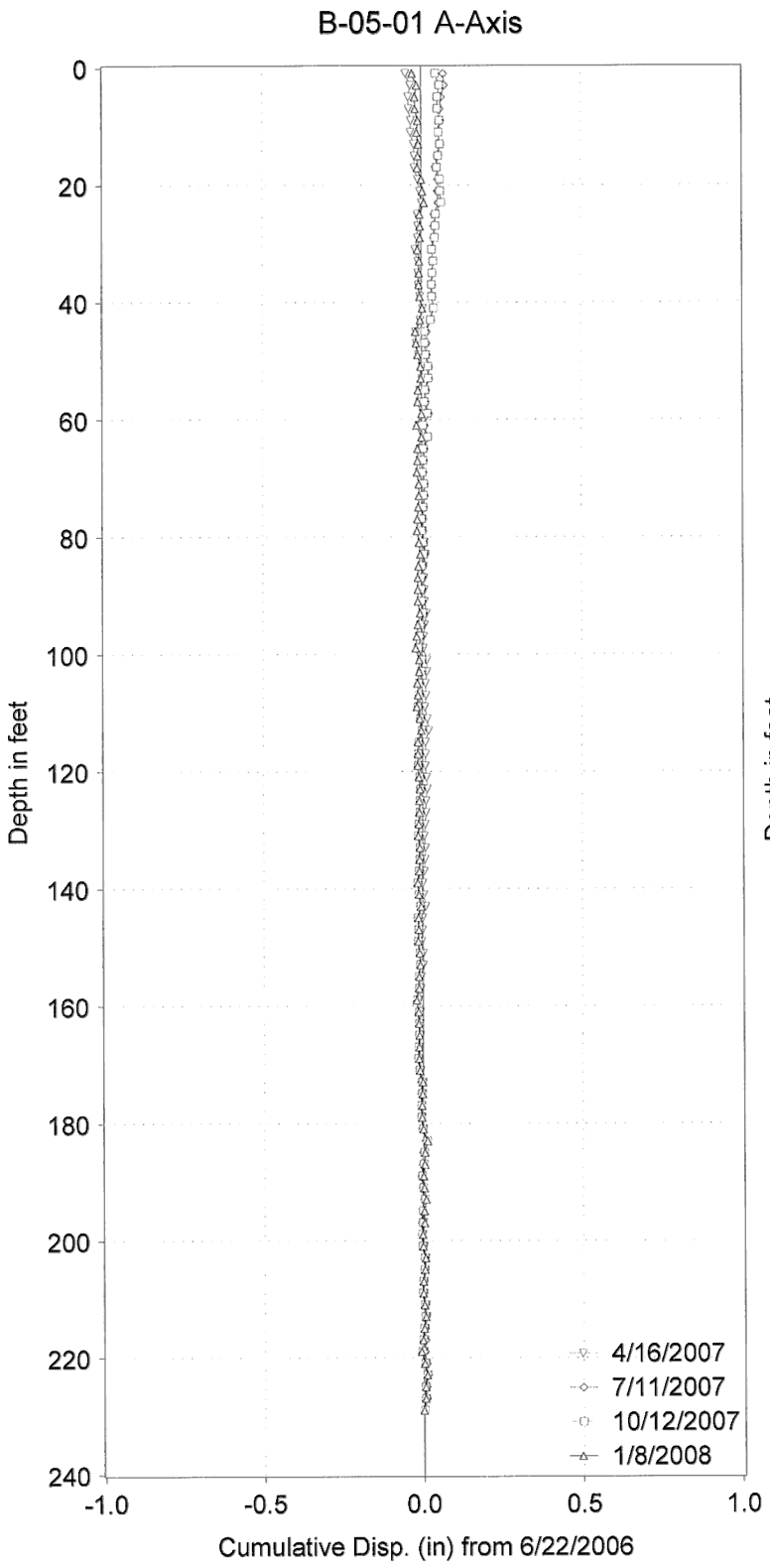
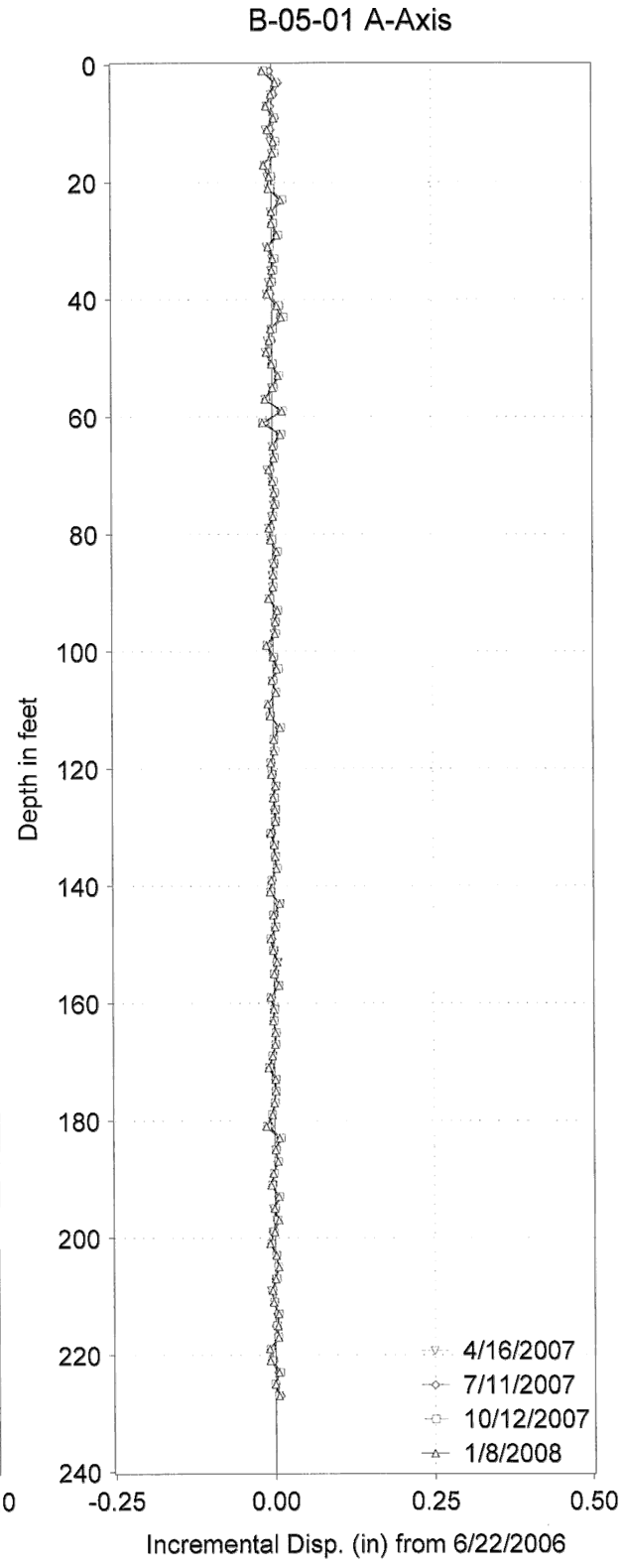

B-108A Time-Displacement A-Axis
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Displacement (in)
23-27 feet
119-121 feet
May-06
Aug-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
Date (Month-Year)

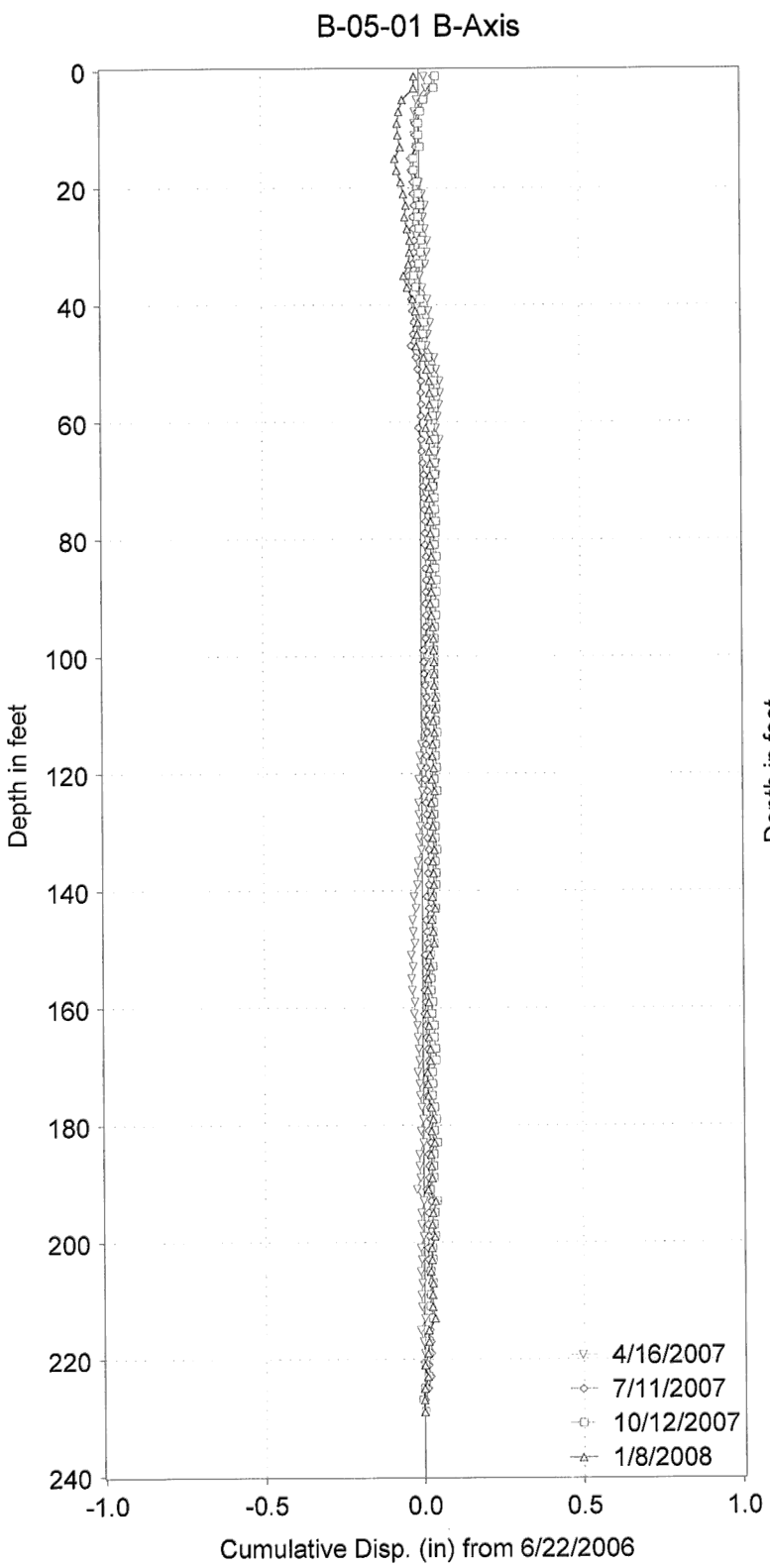
PLATE 27

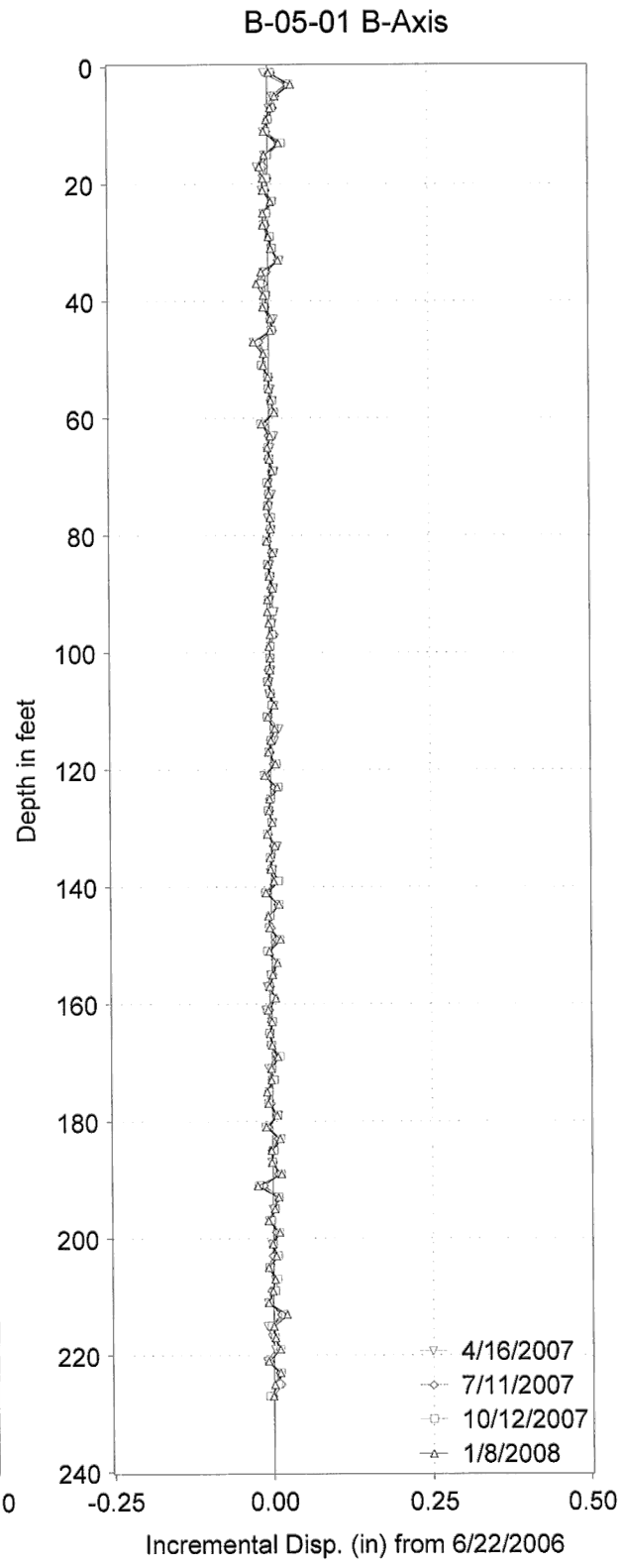




B-05-01
-Includes readings from the last four quarters.

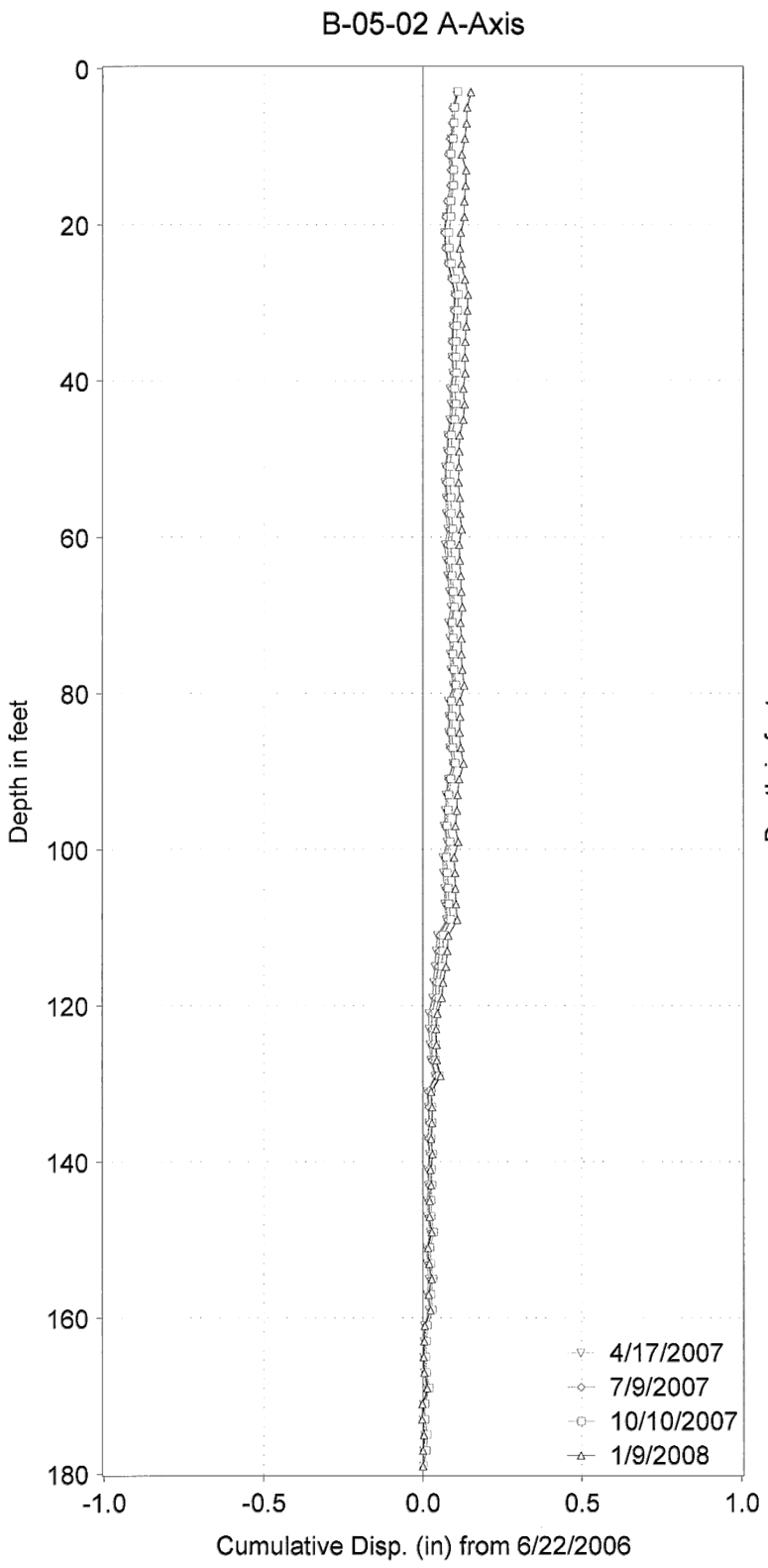
PLATE 28

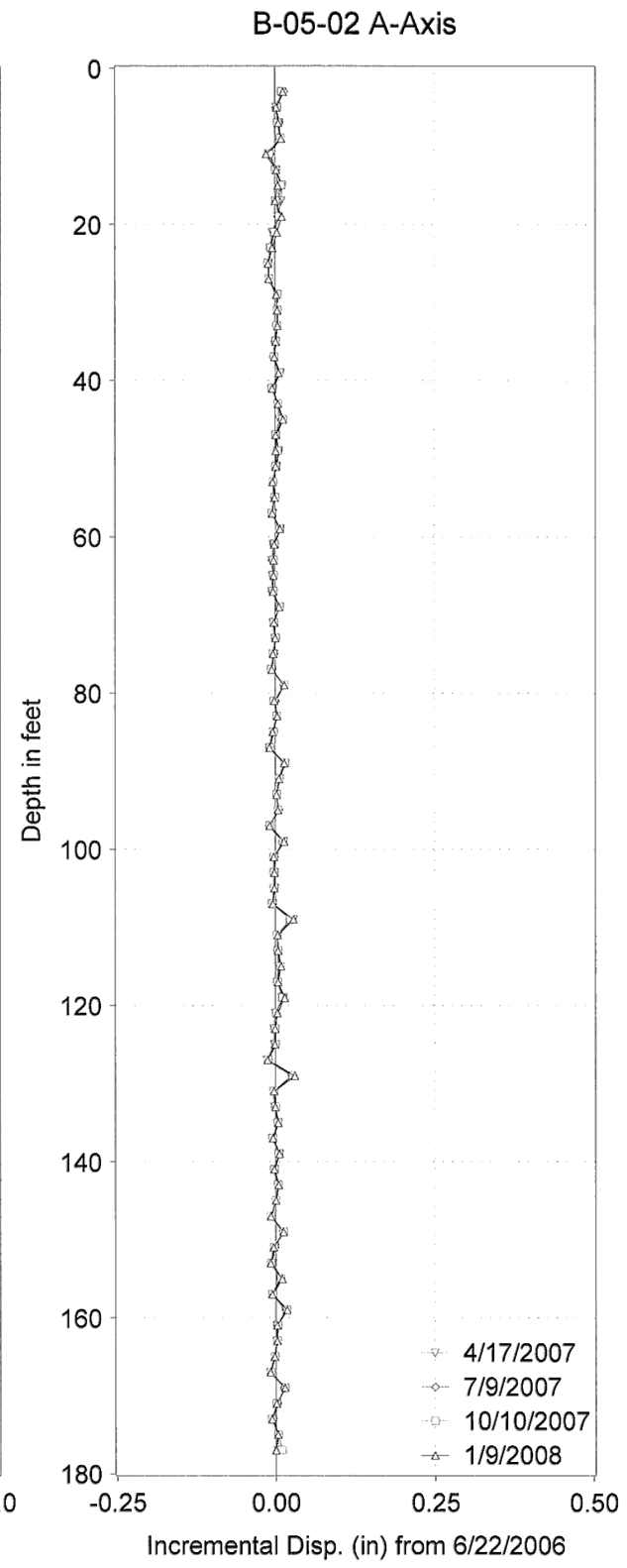




B-05-01
-Includes readings from the last four quarters.

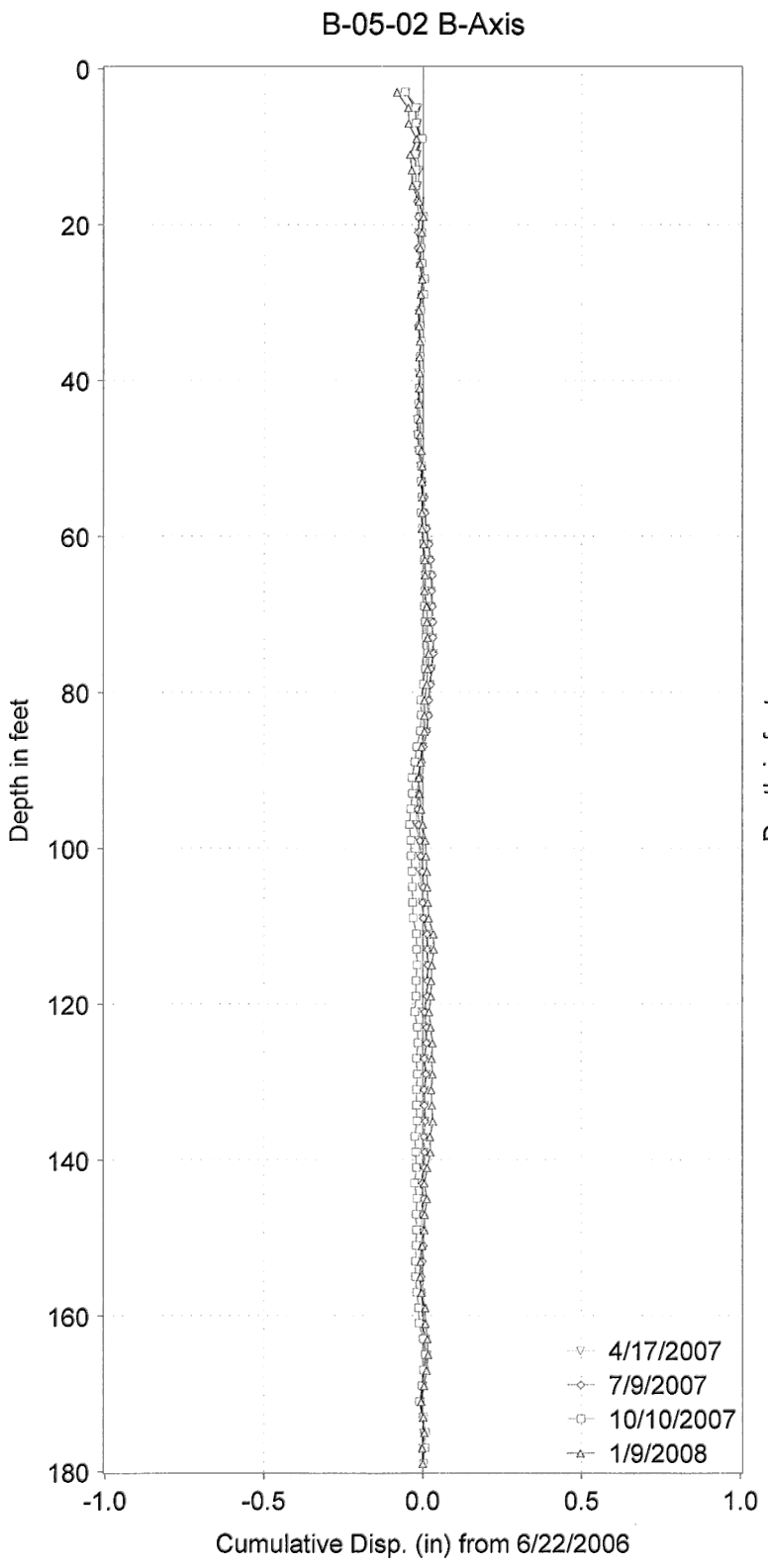
PLATE 29

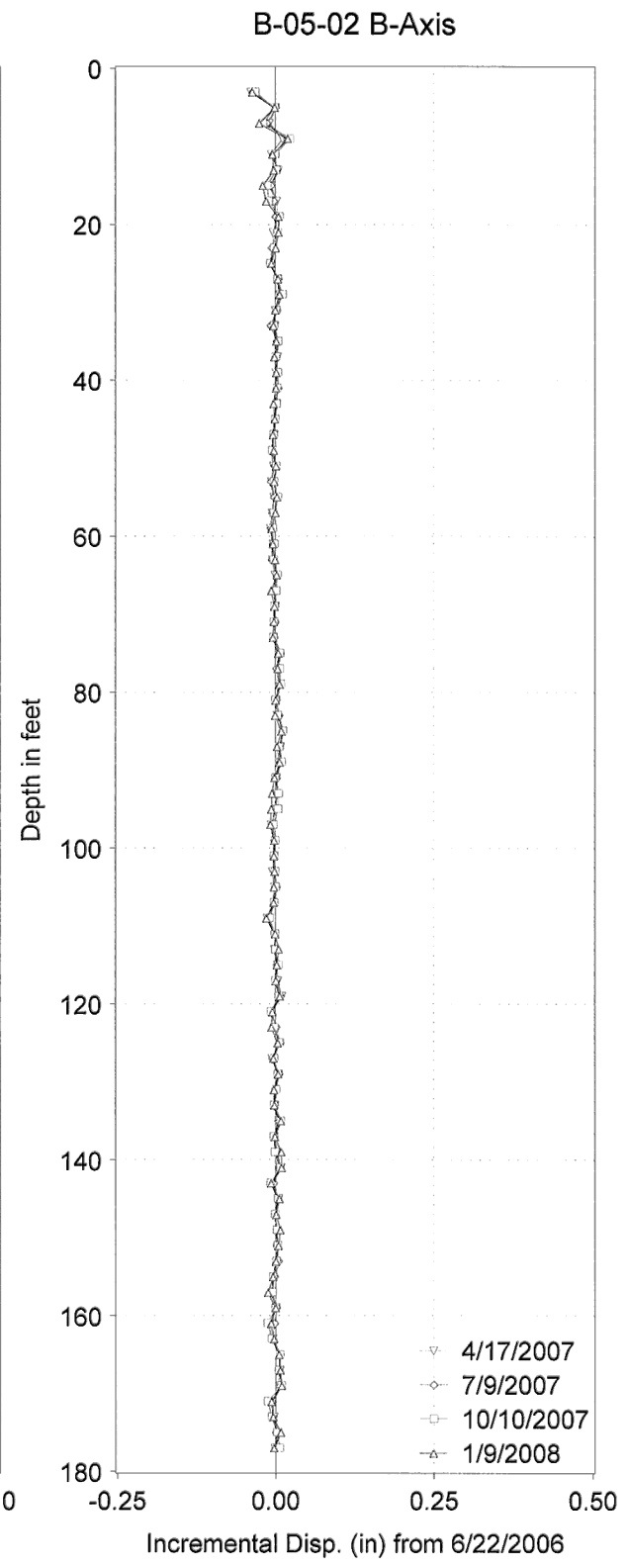




B-05-02
-Includes readings from the last four quarters.

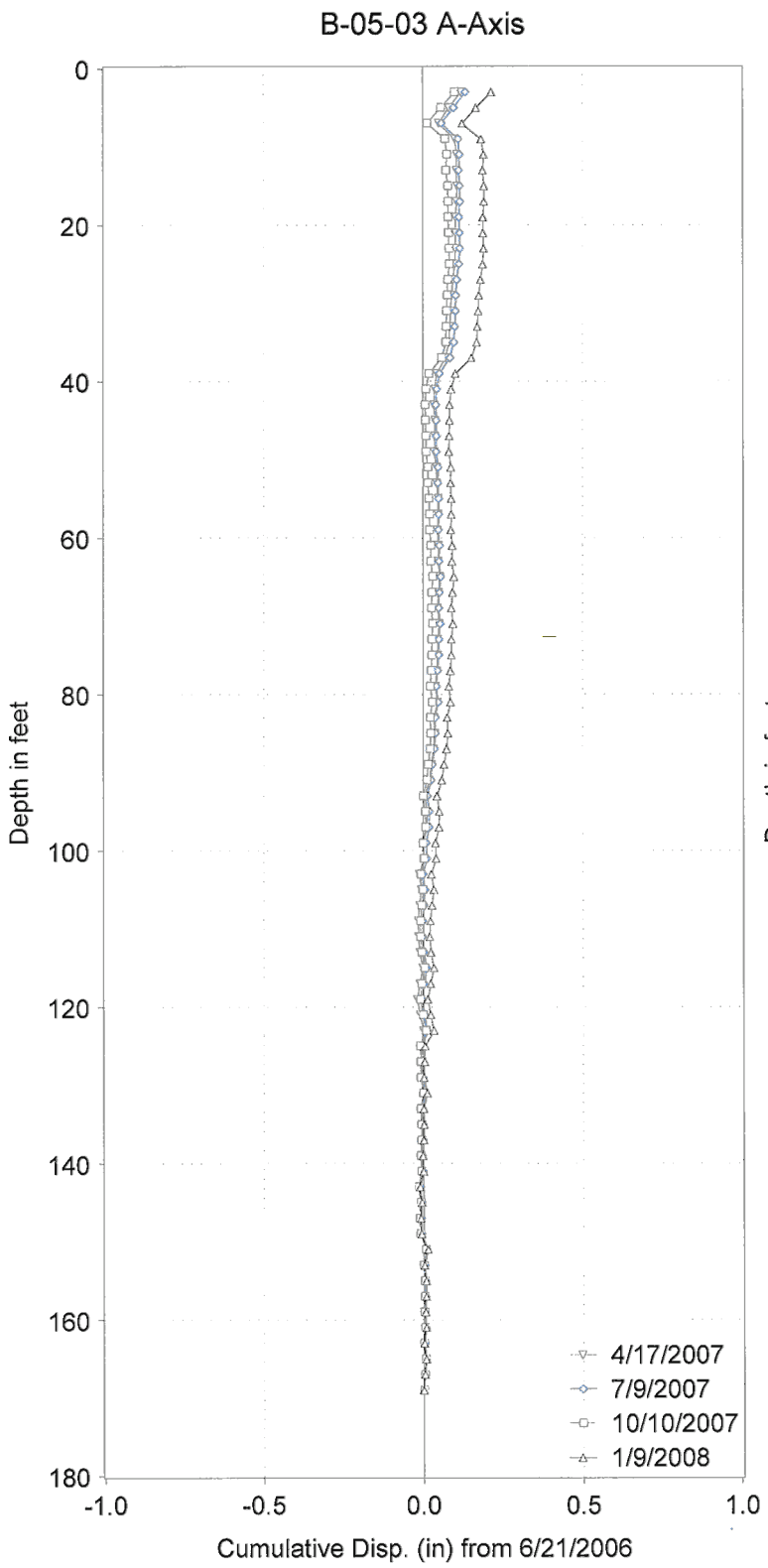
PLATE 30

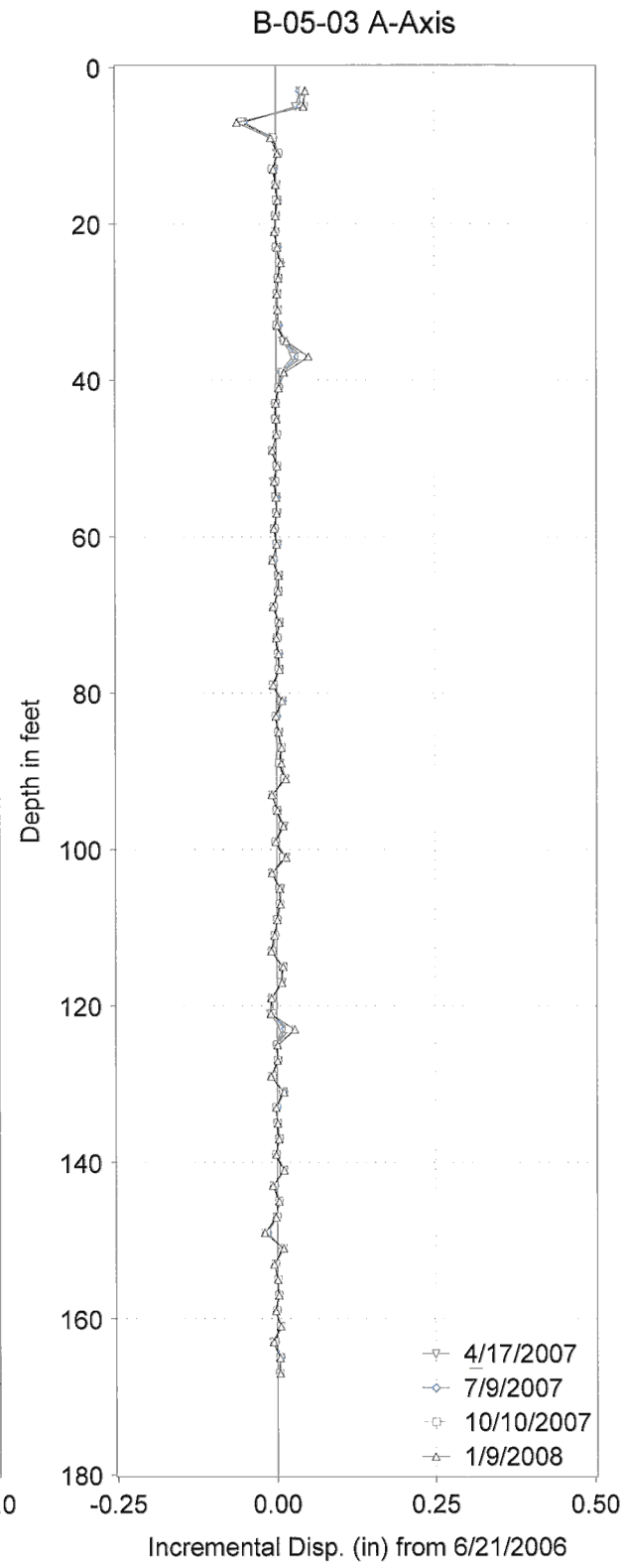




B-05-02
-Includes readings from the last four quarters.

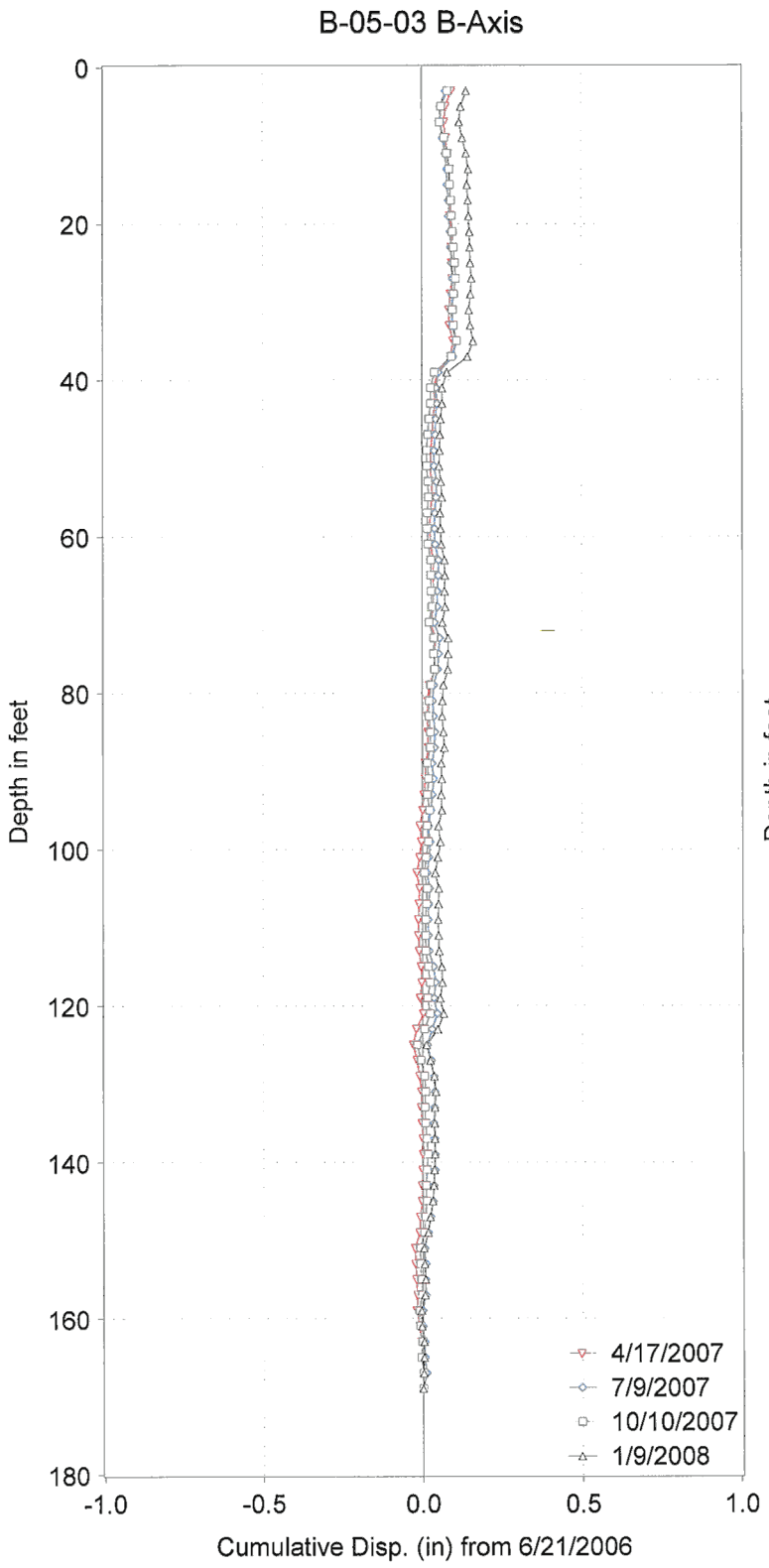
PLATE 31

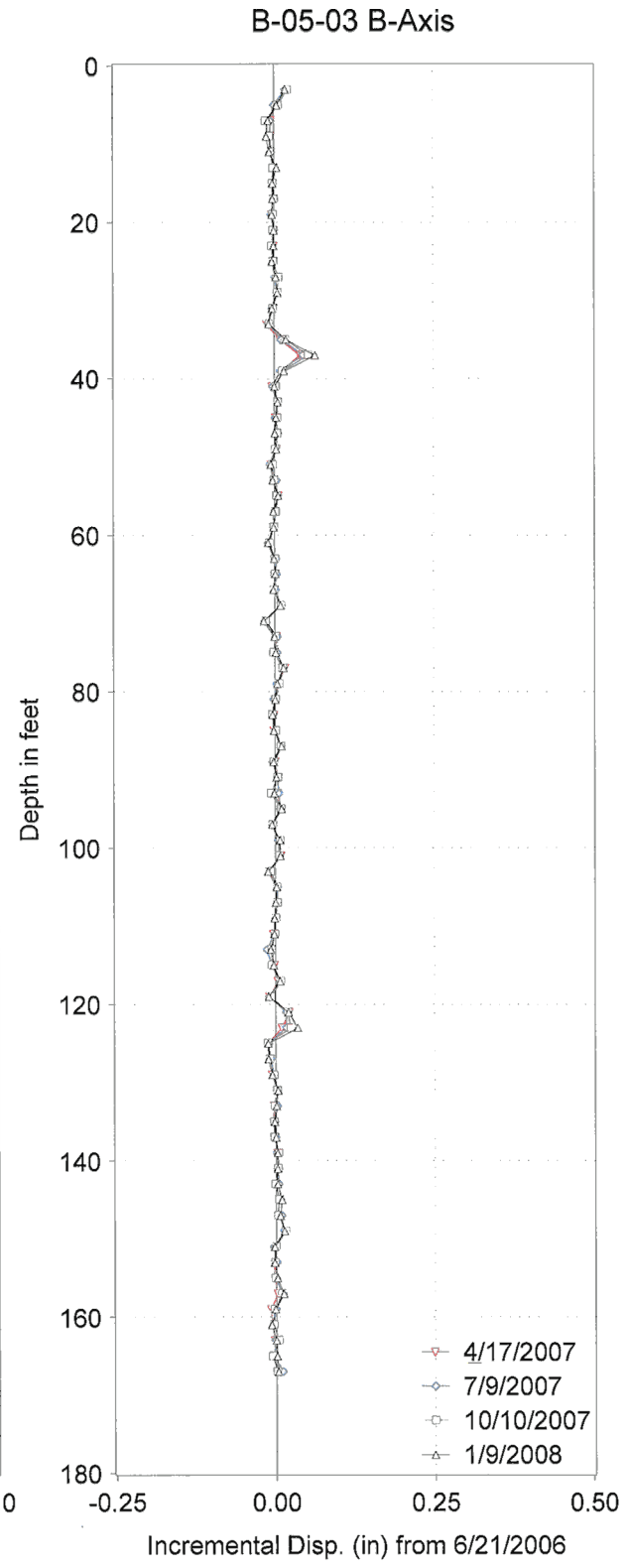




B-05-03
-Includes readings from the last four quarters.

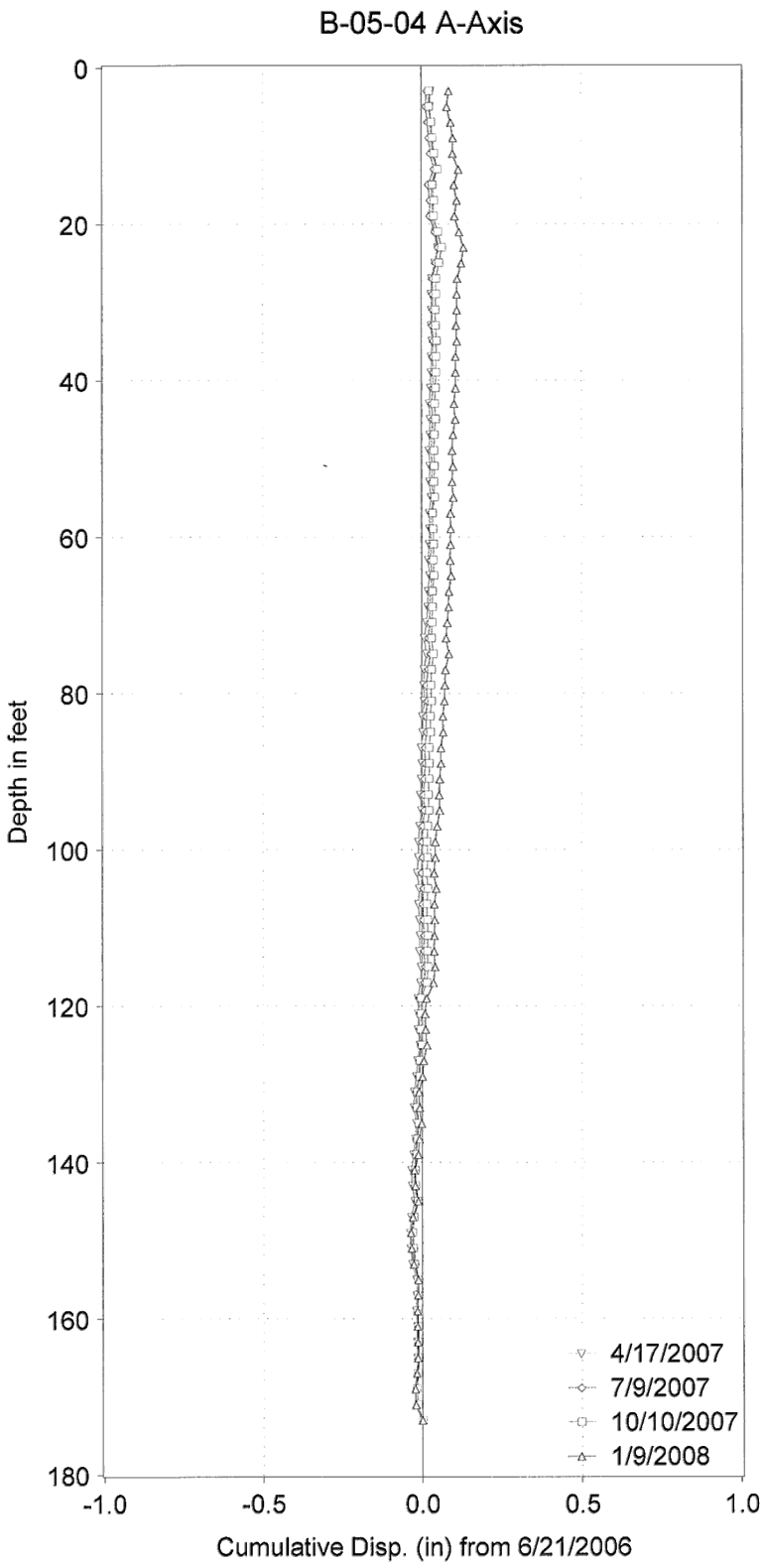
PLATE 32

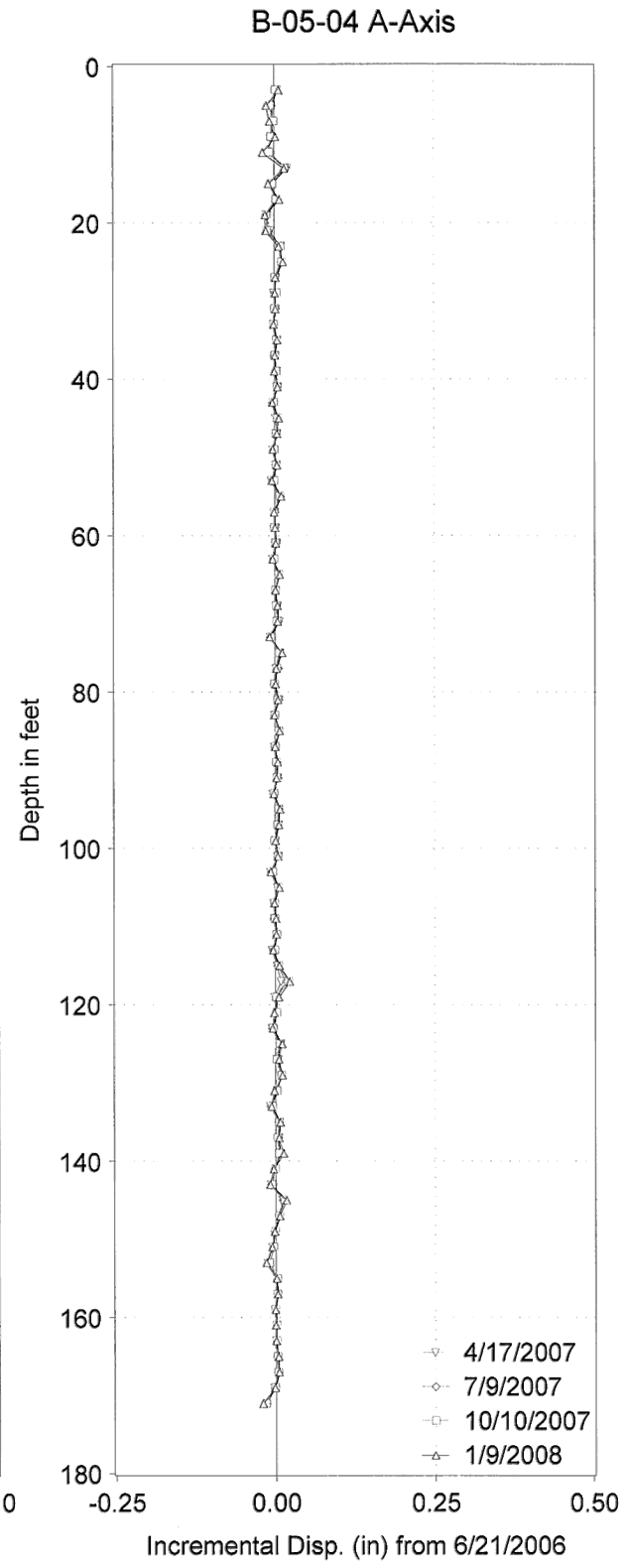




B-05-03
-Includes readings from the last four quarters.

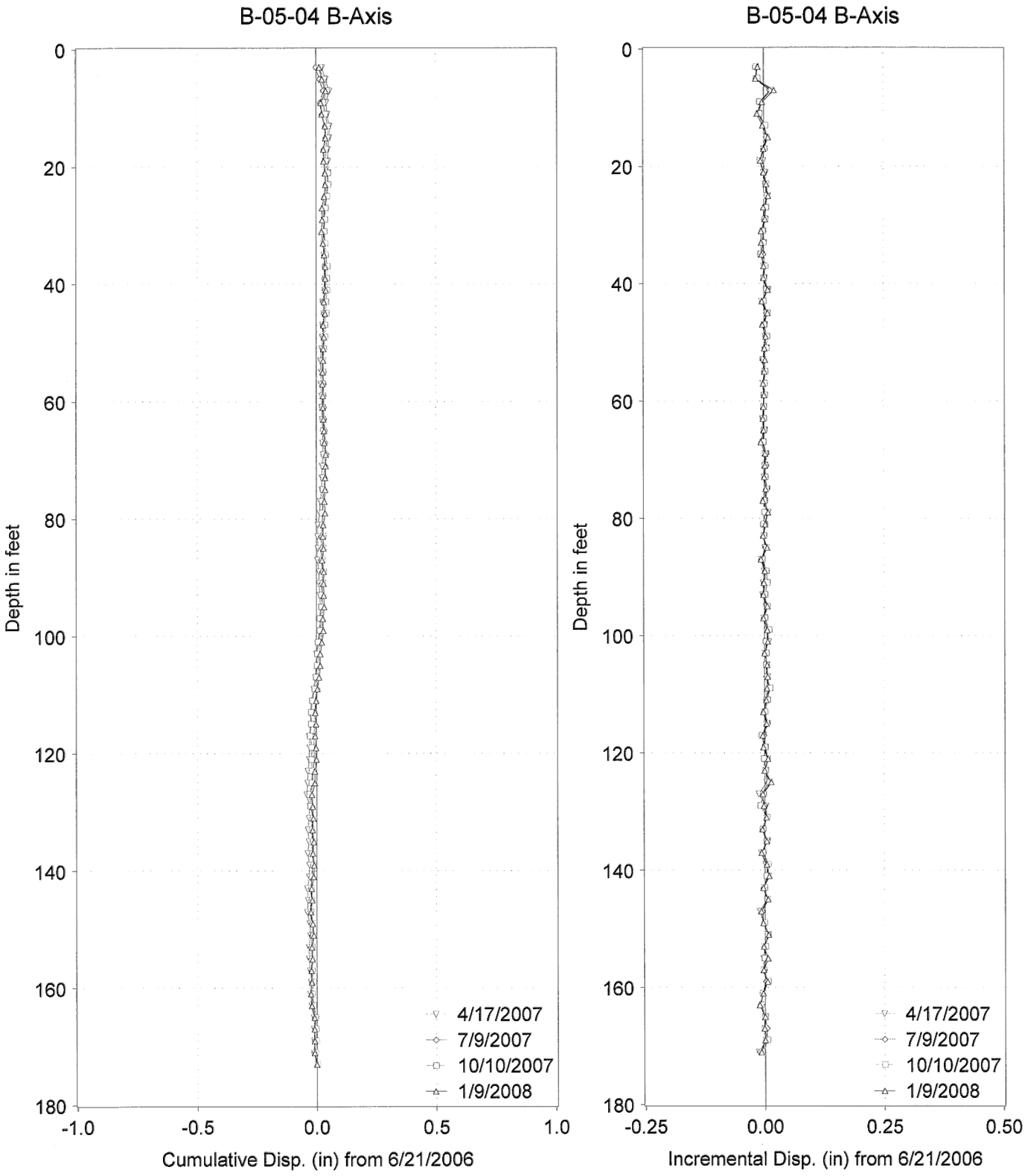
PLATE 33





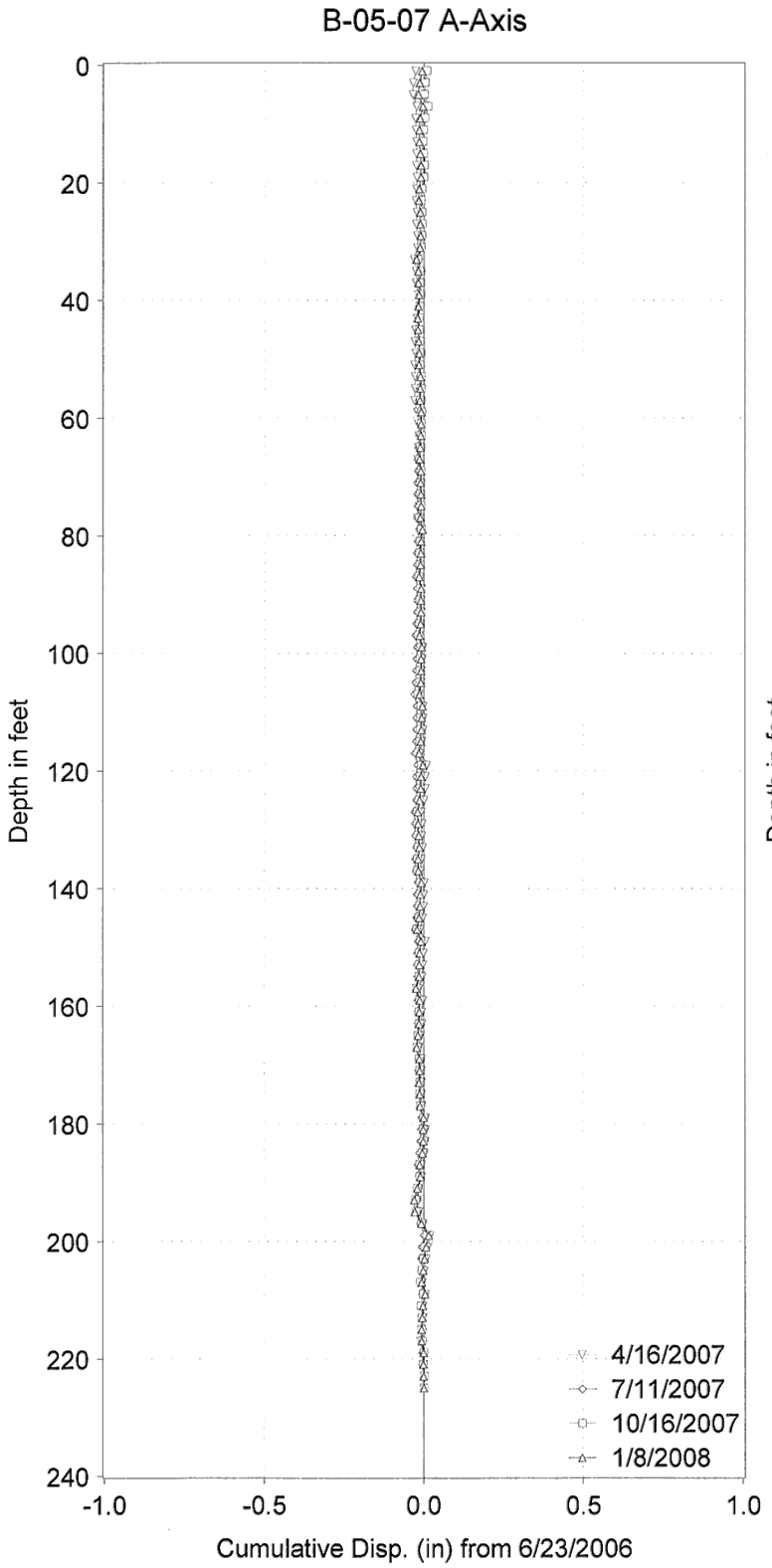
B-05-04
-Includes readings from the last four quarters.

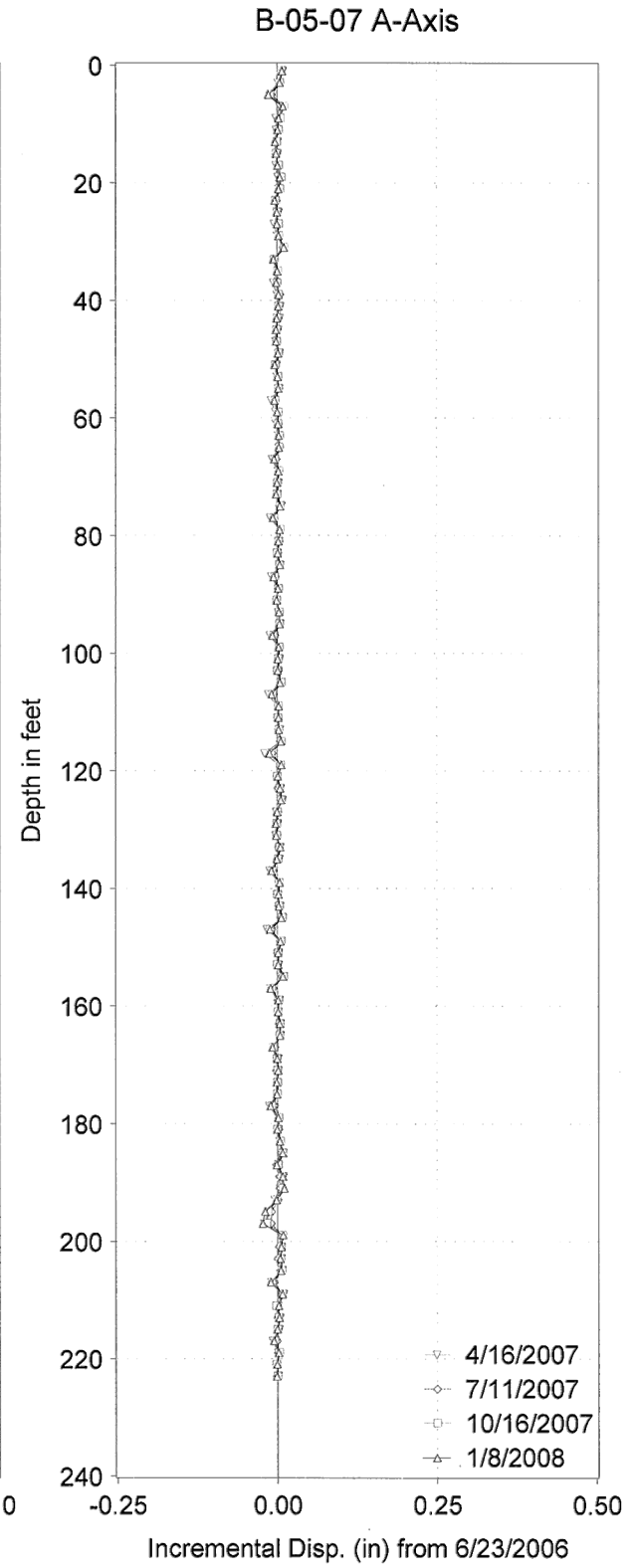
PLATE 34



B-05-04
-Includes readings from the last four quarters.

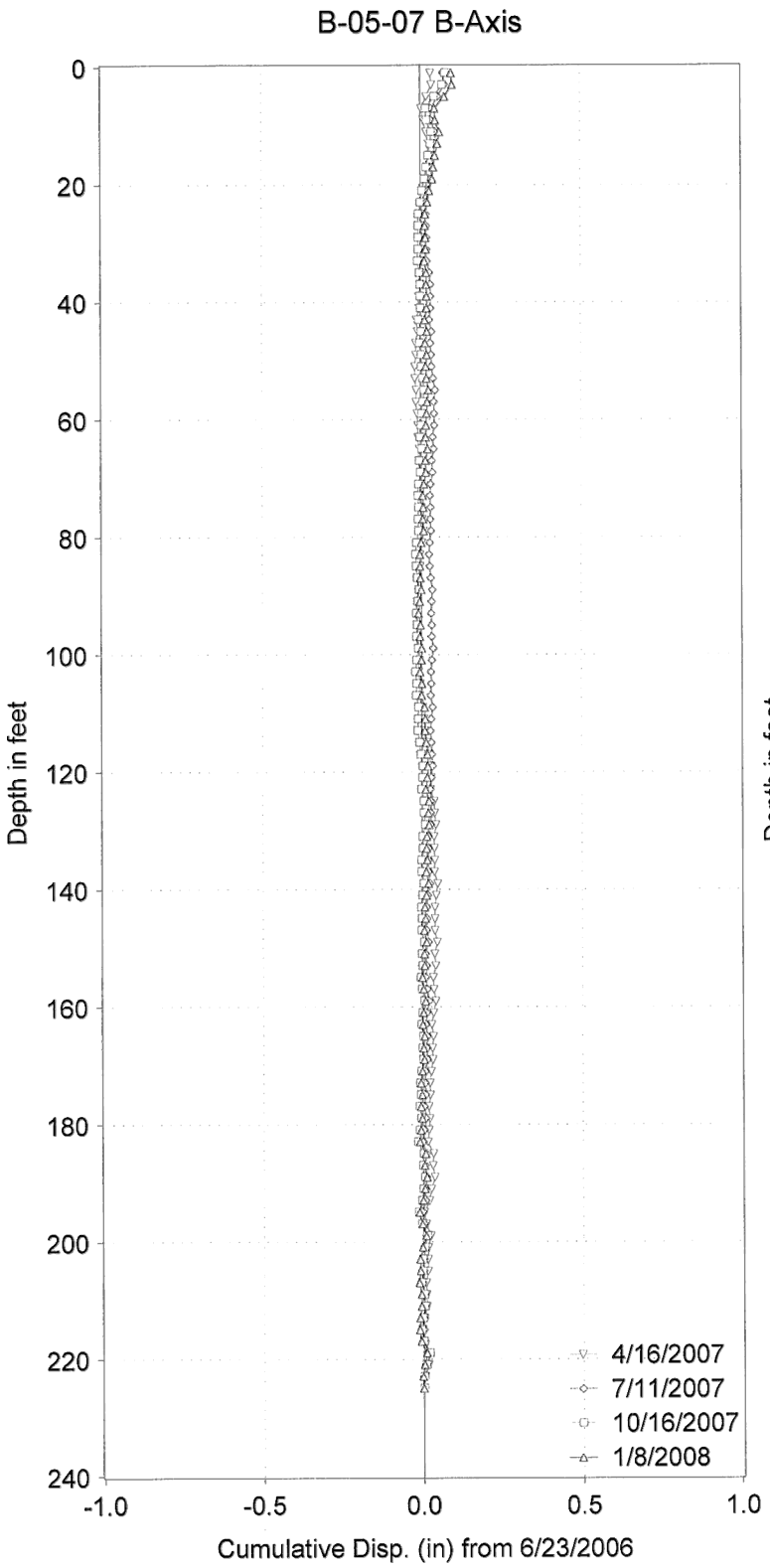
PLATE 35

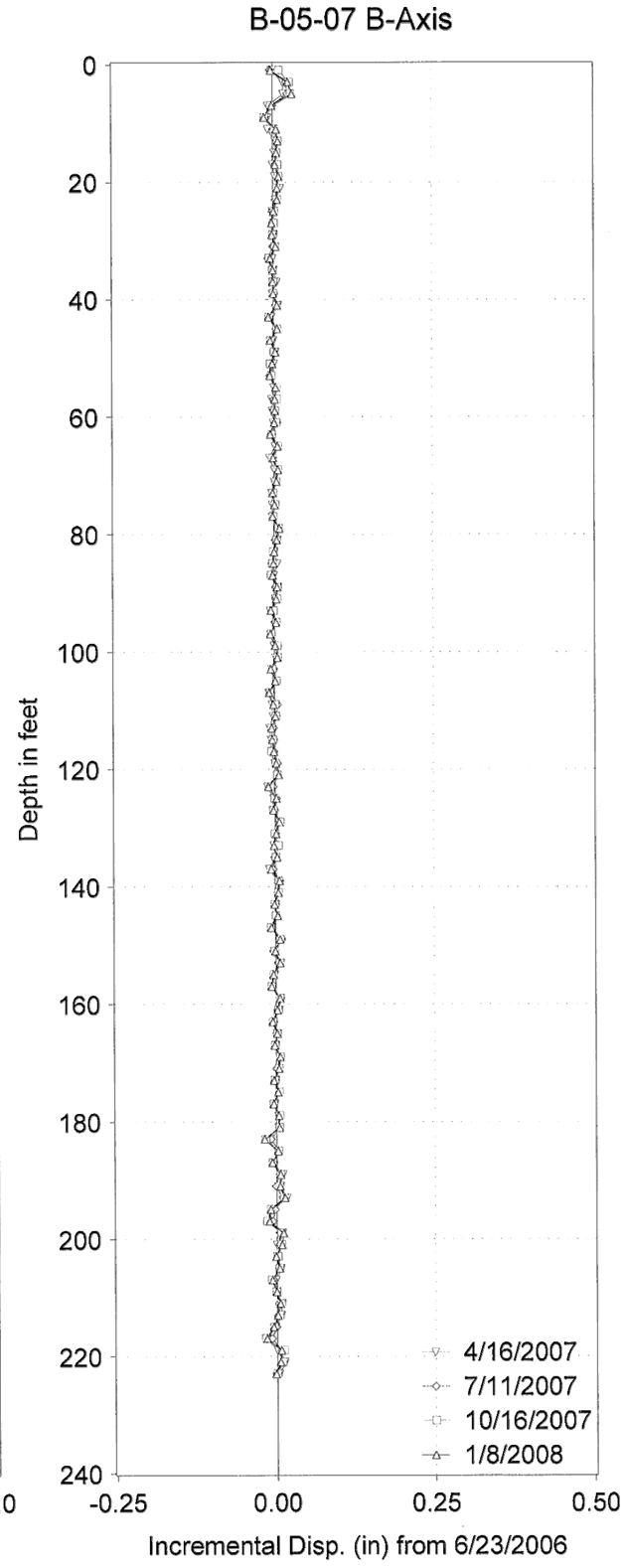




B-05-07
-Includes readings from the last four quarters.

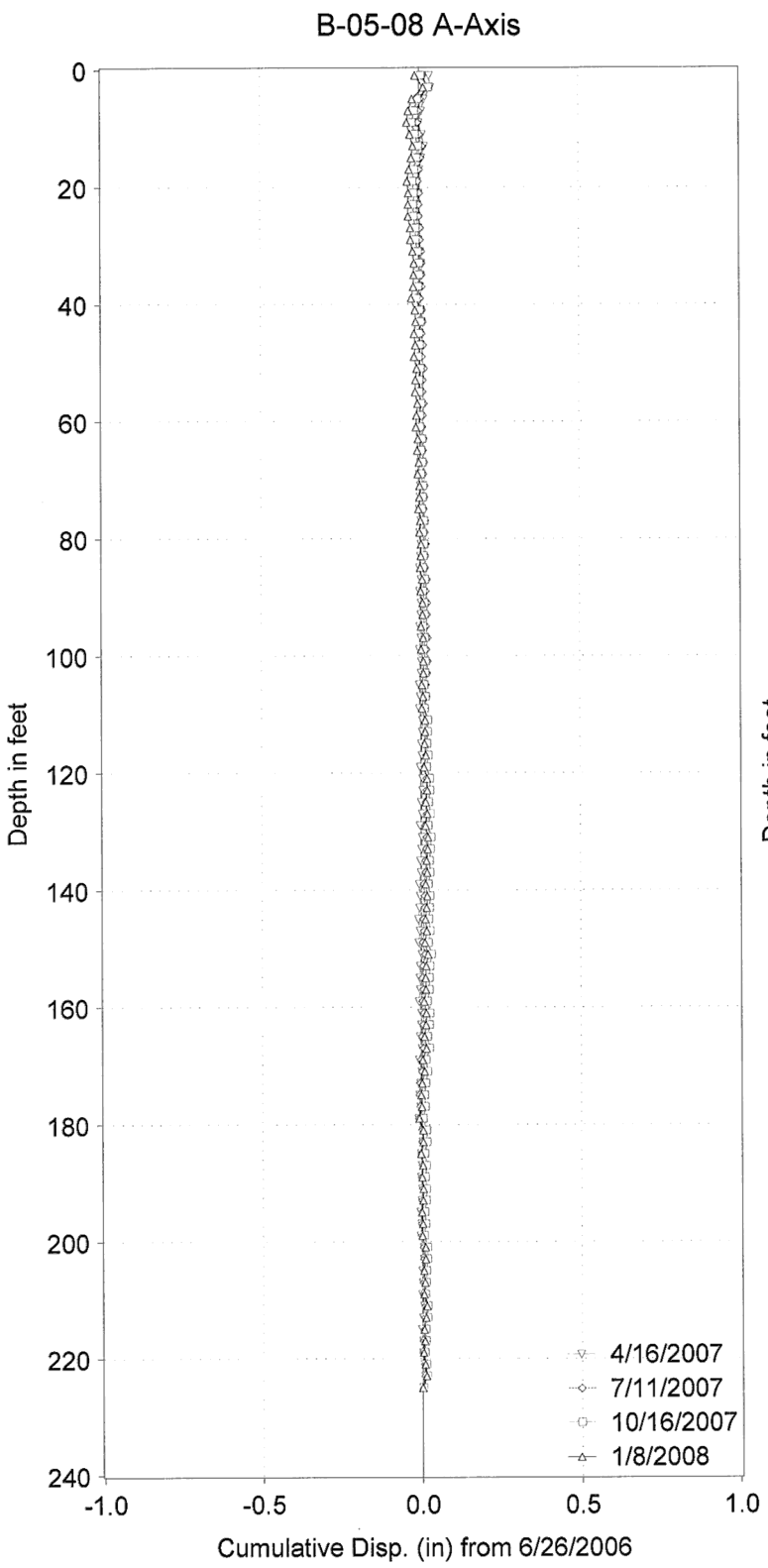
PLATE 36

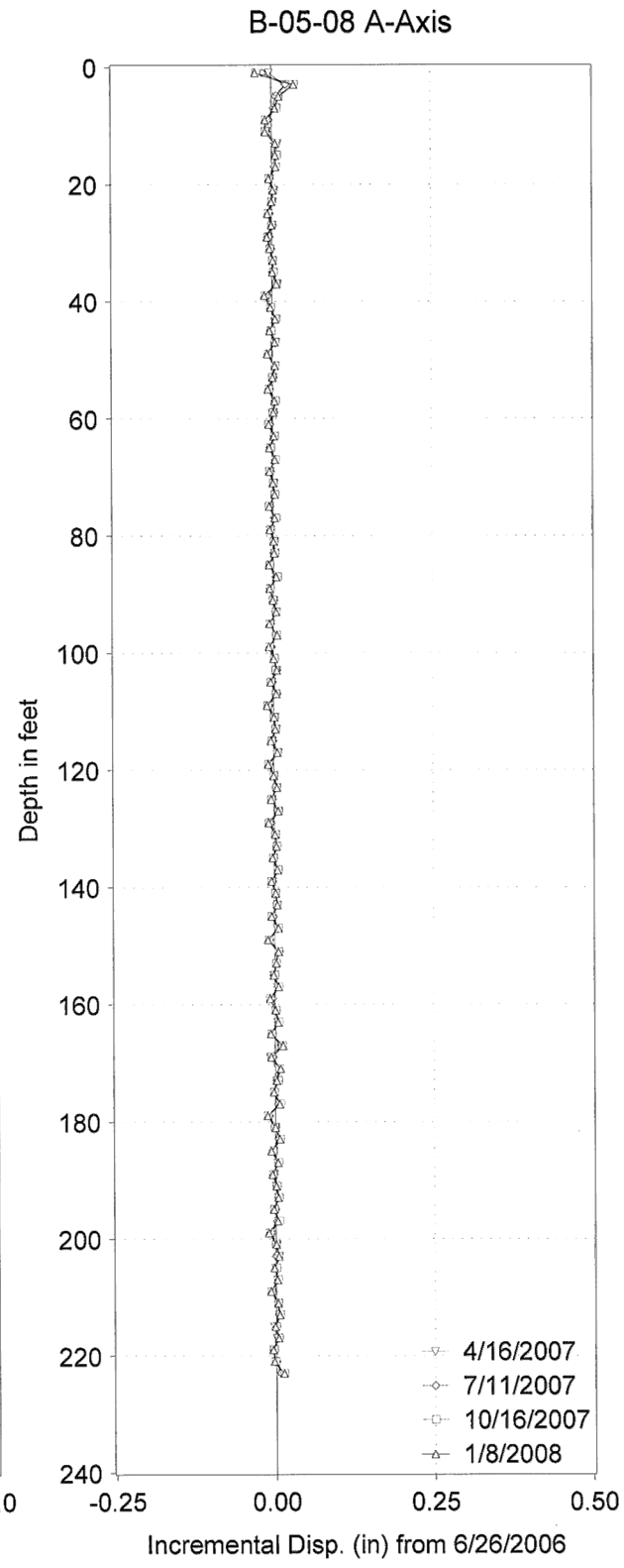




B-05-07
-Includes readings from the last four quarters.

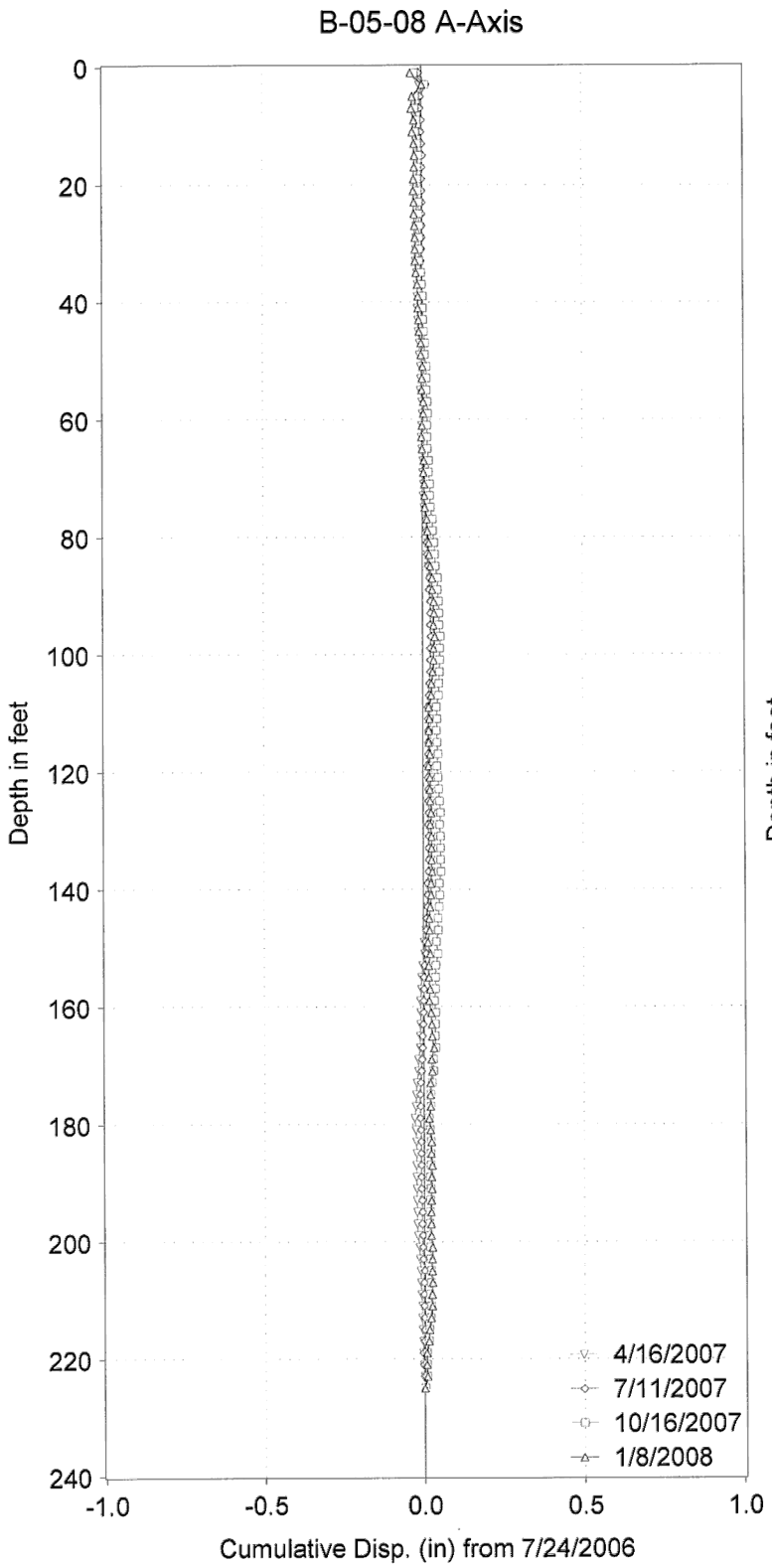
PLATE 37

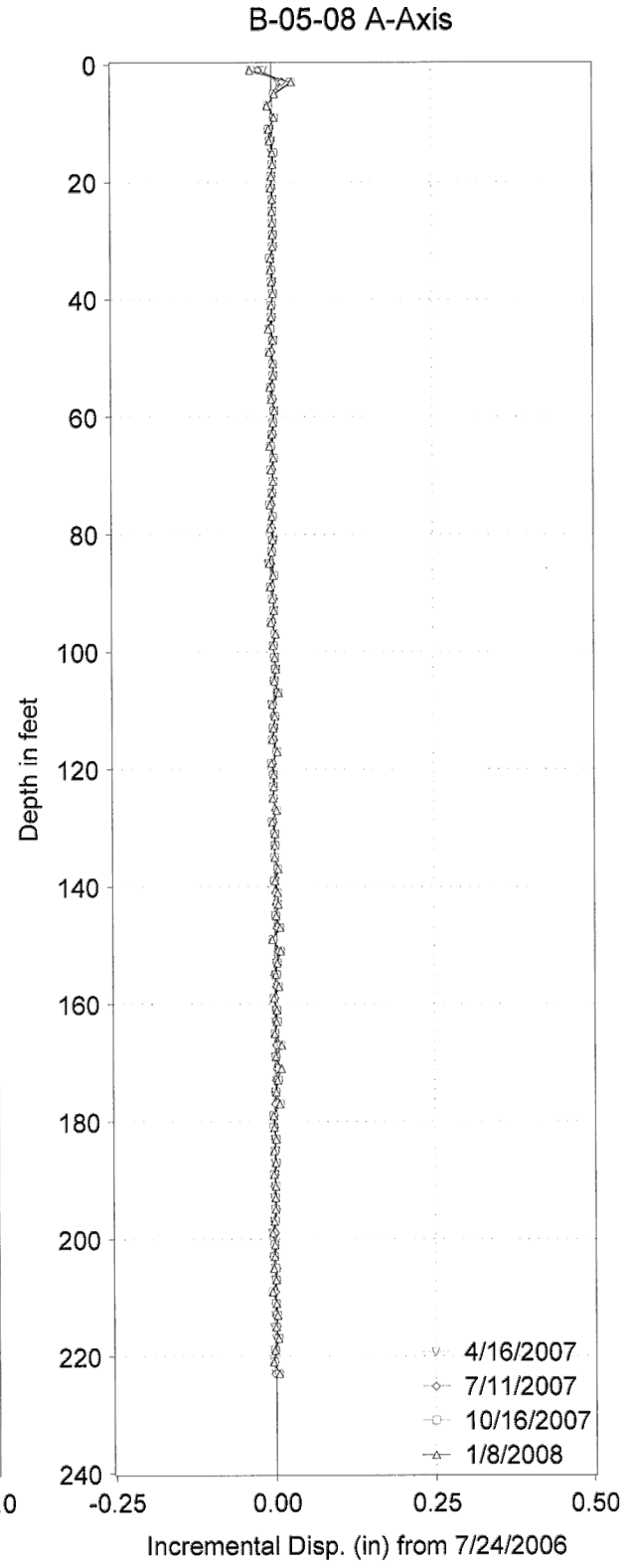




B-05-08
-Includes readings from the last four quarters.

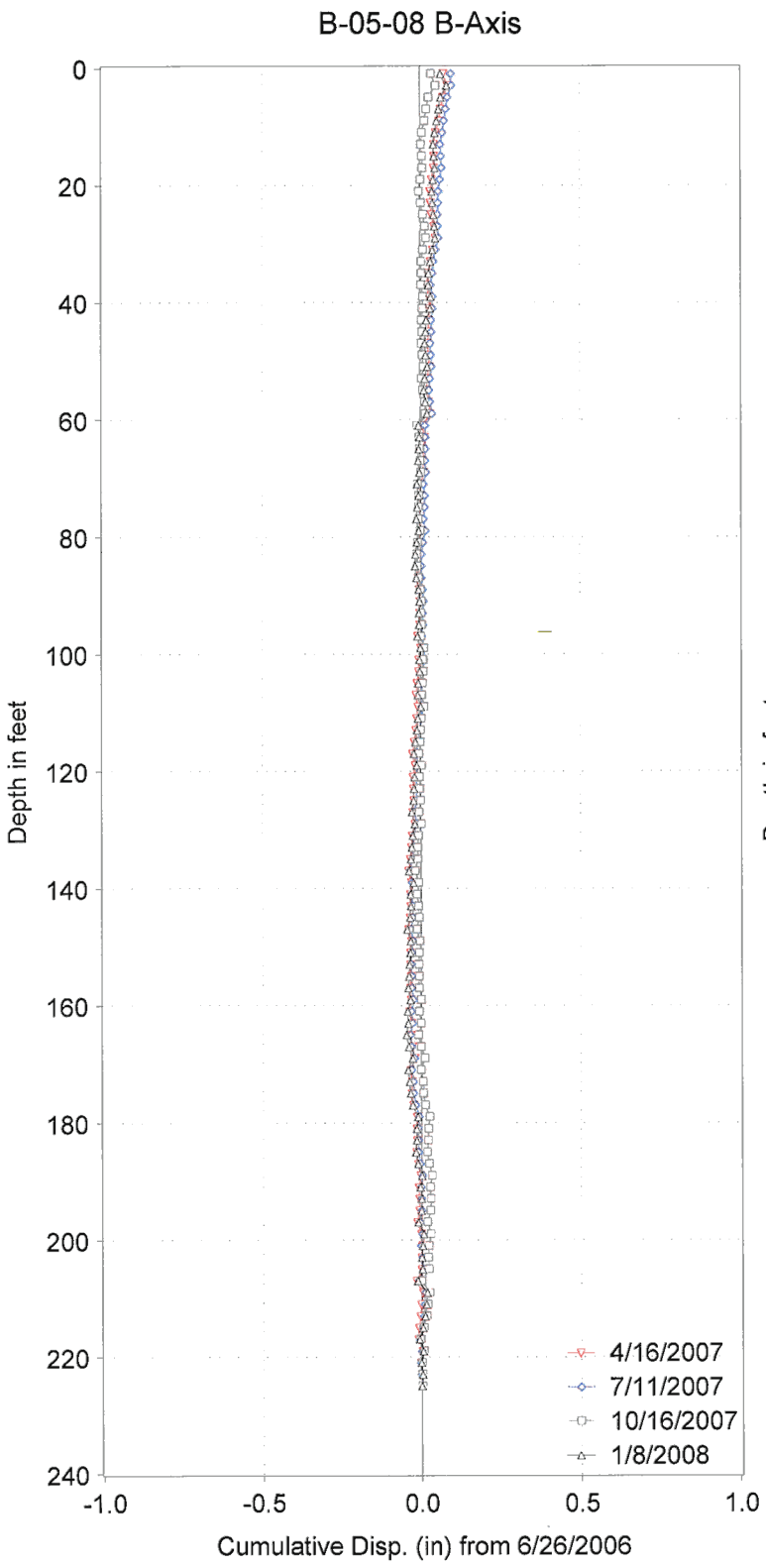
PLATE 38

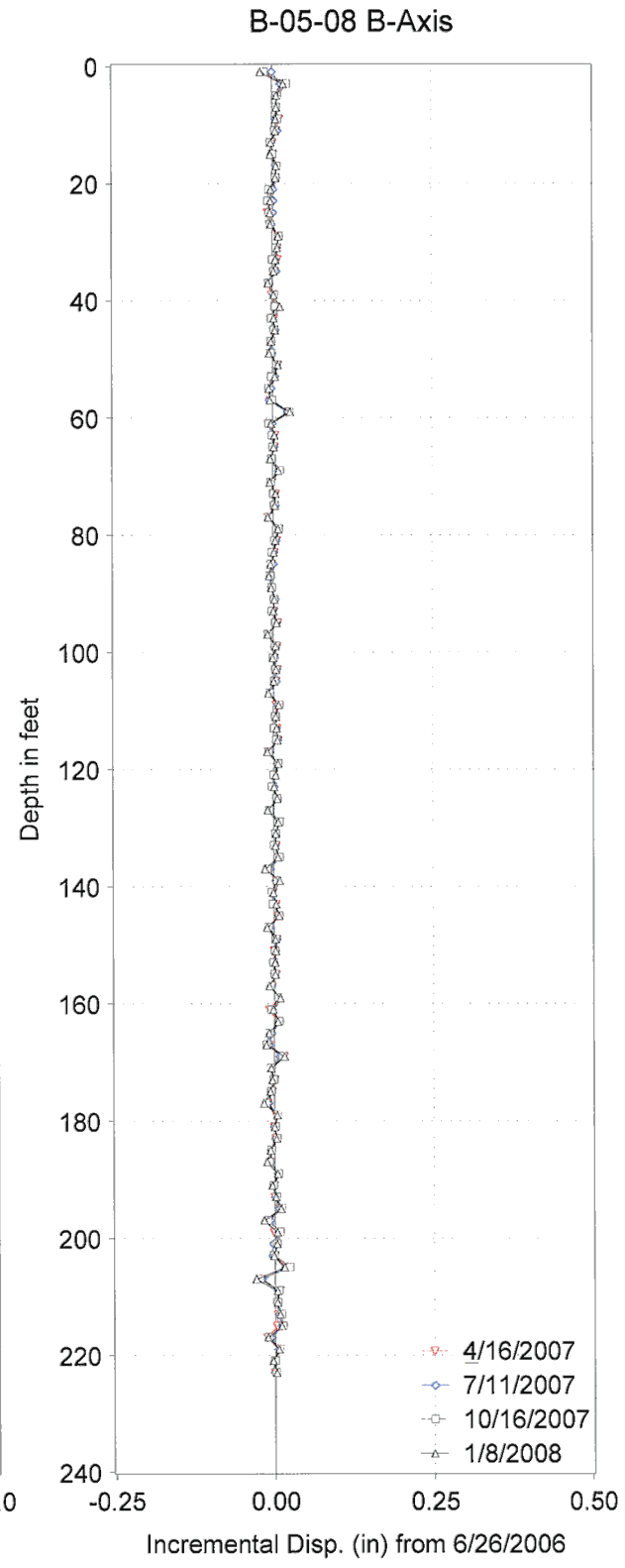




B-05-08
-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 26, 2006 reading.

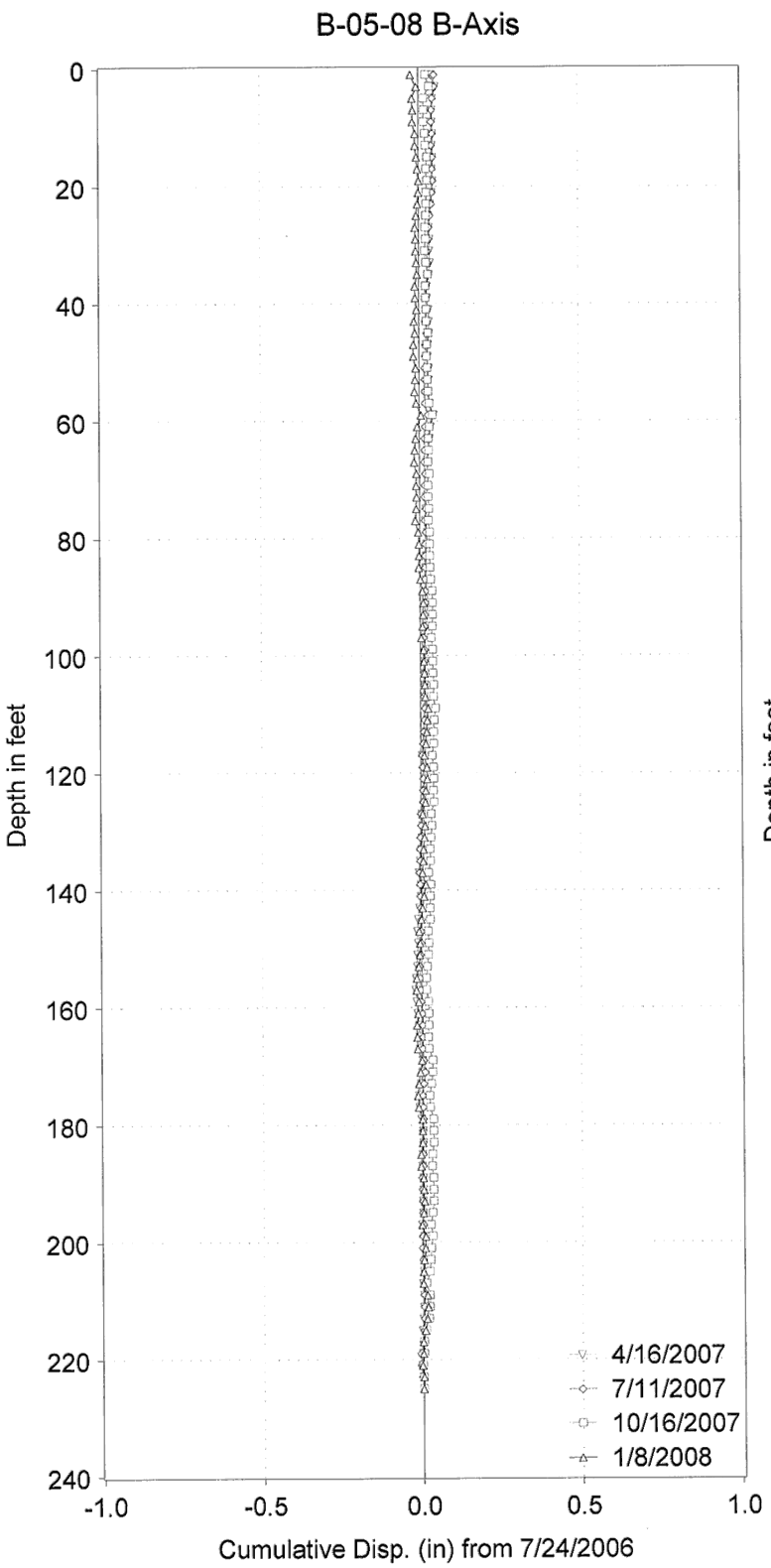
PLATE 38A

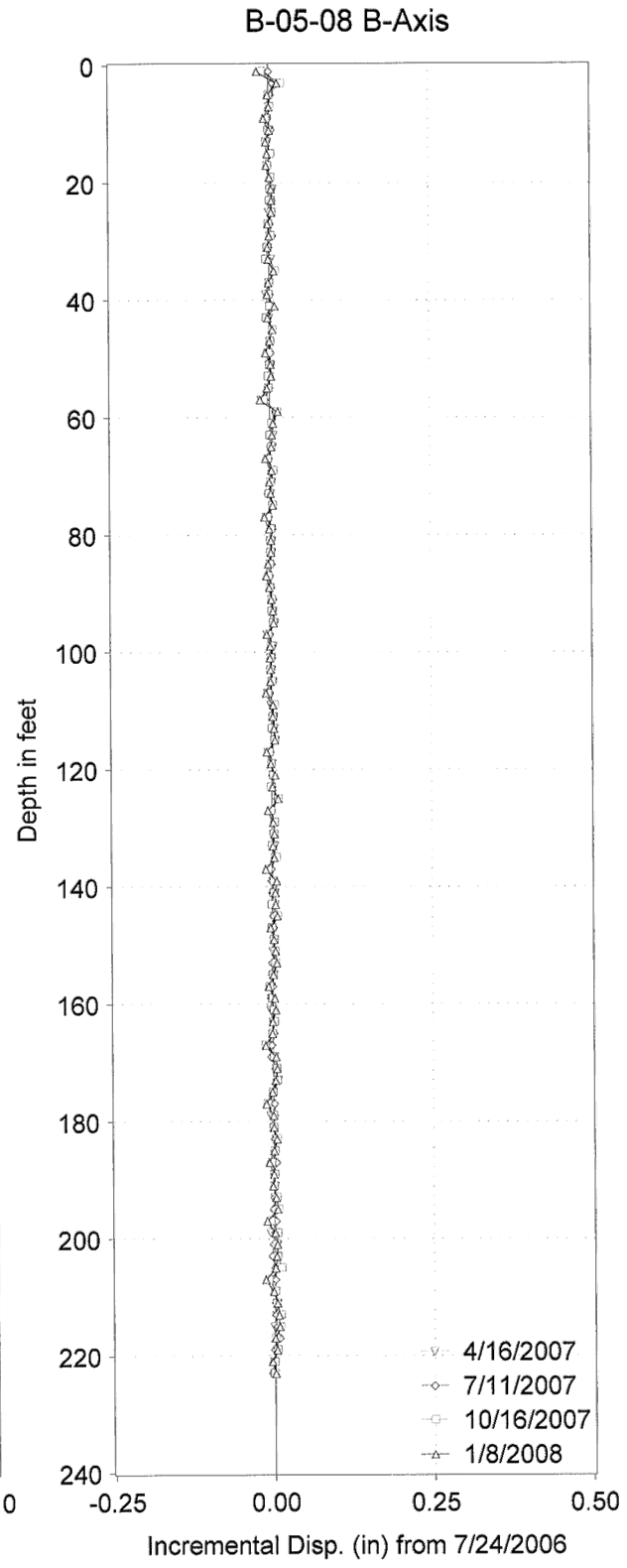




B-05-08
-Includes readings from the last four quarters.

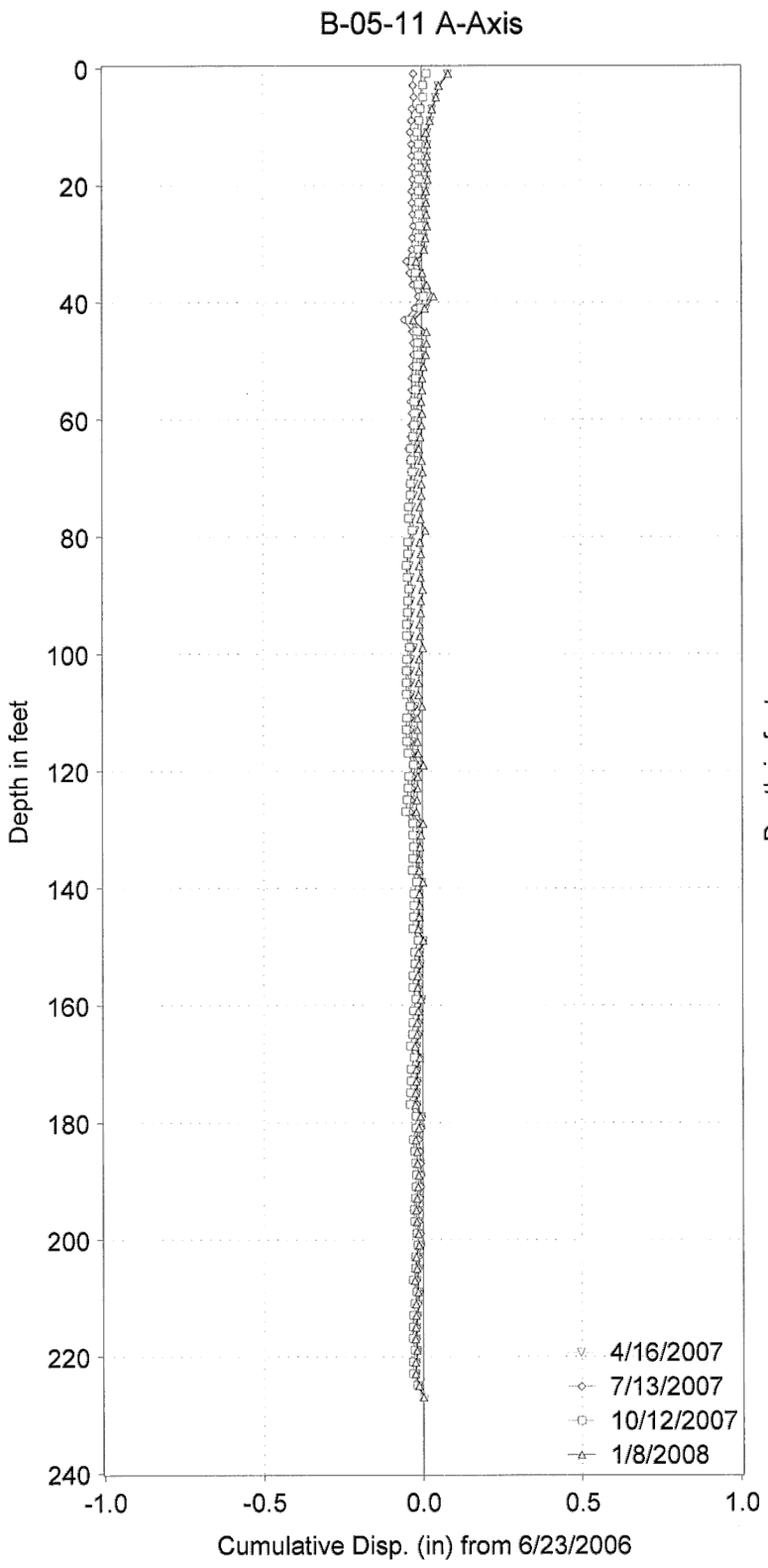
PLATE 39

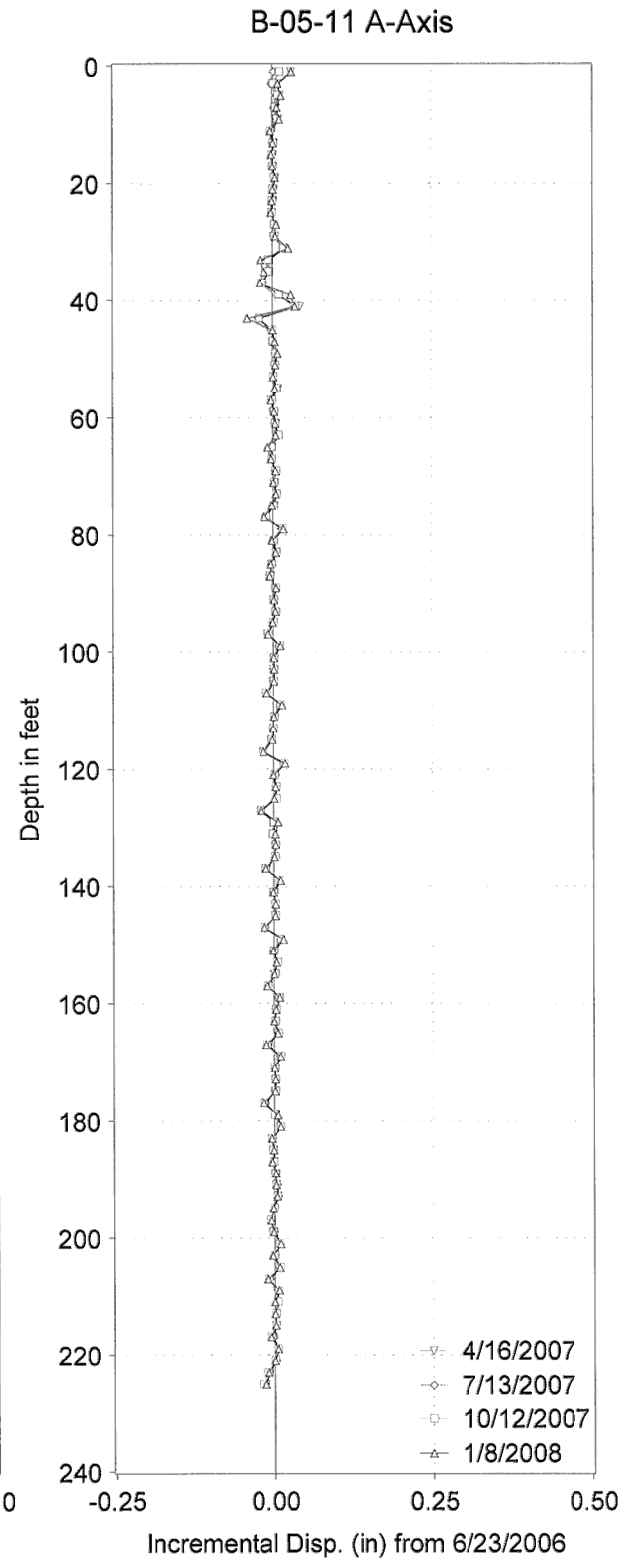




B-05-08
-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 26, 2006 reading.

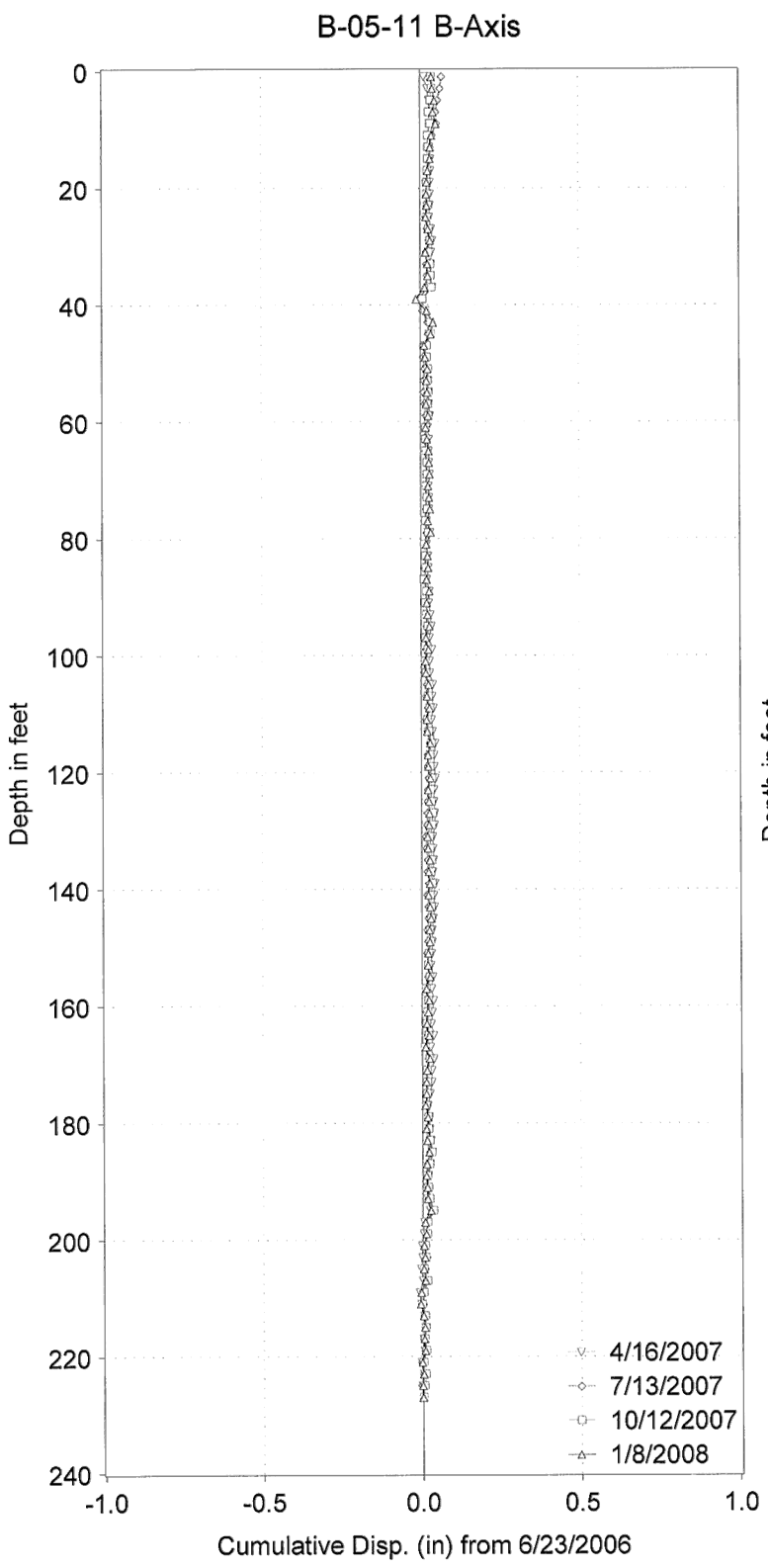
PLATE 39A

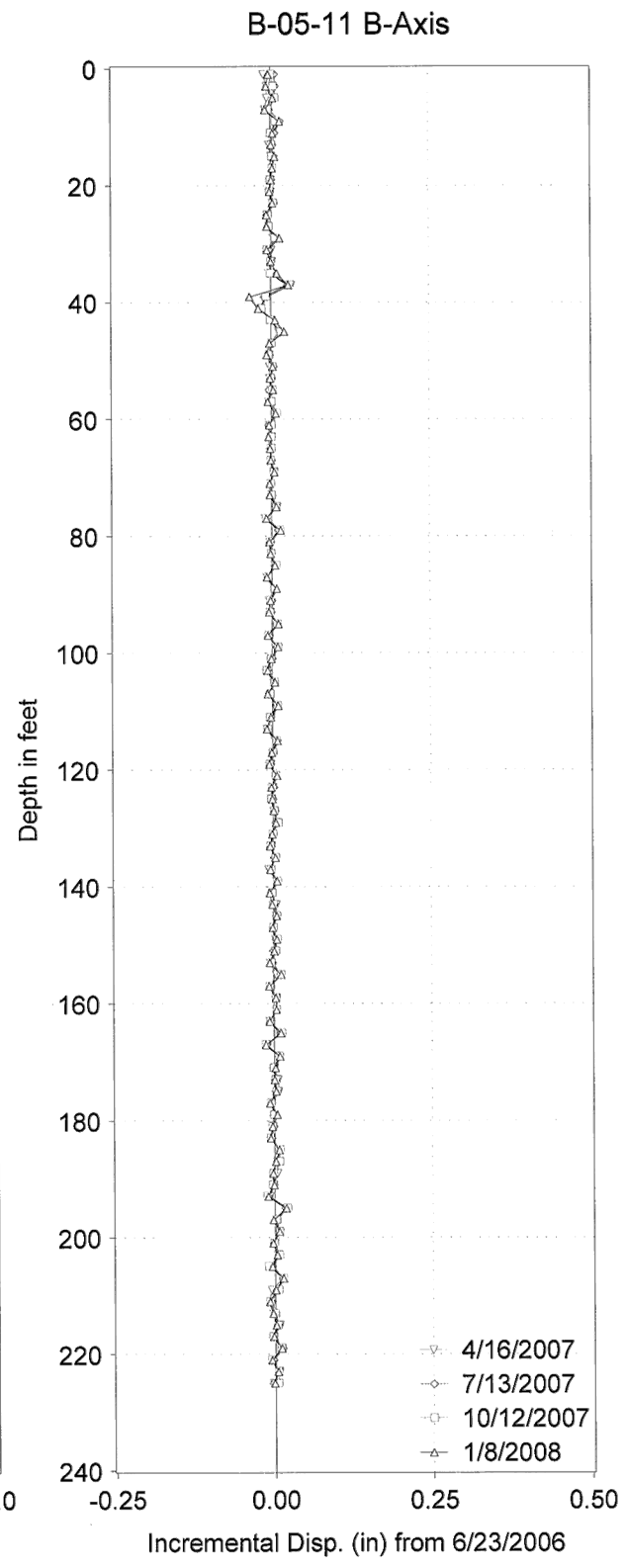




B-05-11
-Includes readings from the last four quarters.

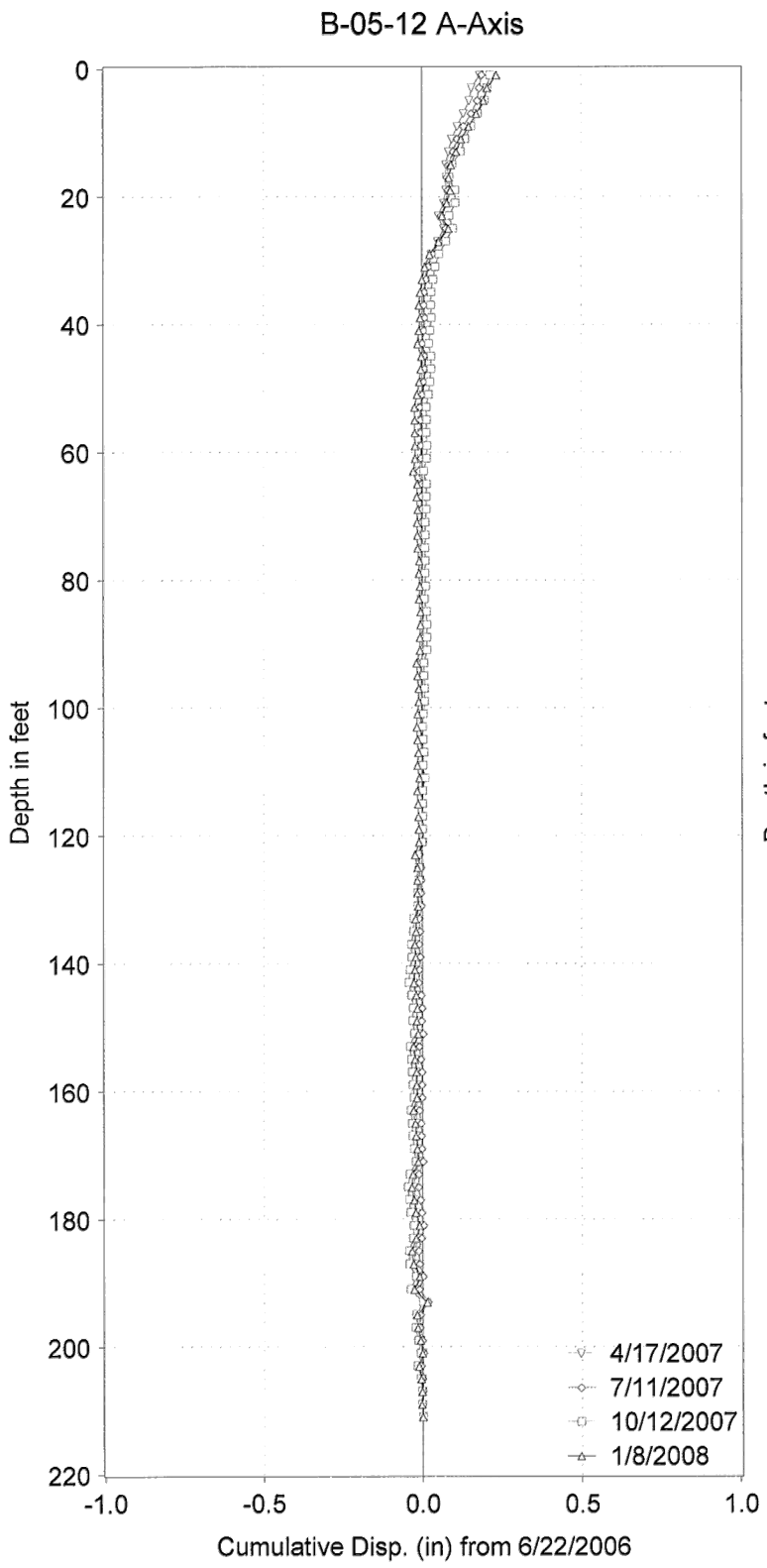
PLATE 40

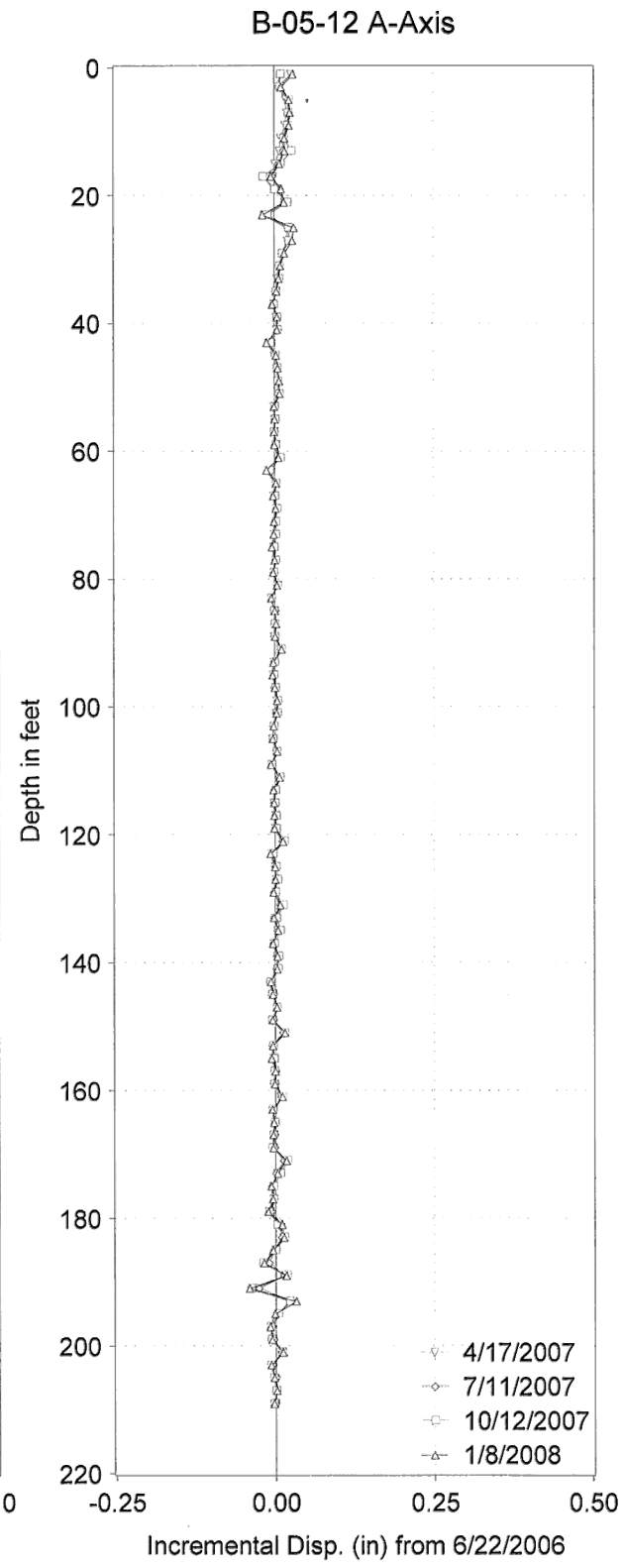




B-05-11
-Includes readings from the last four quarters.

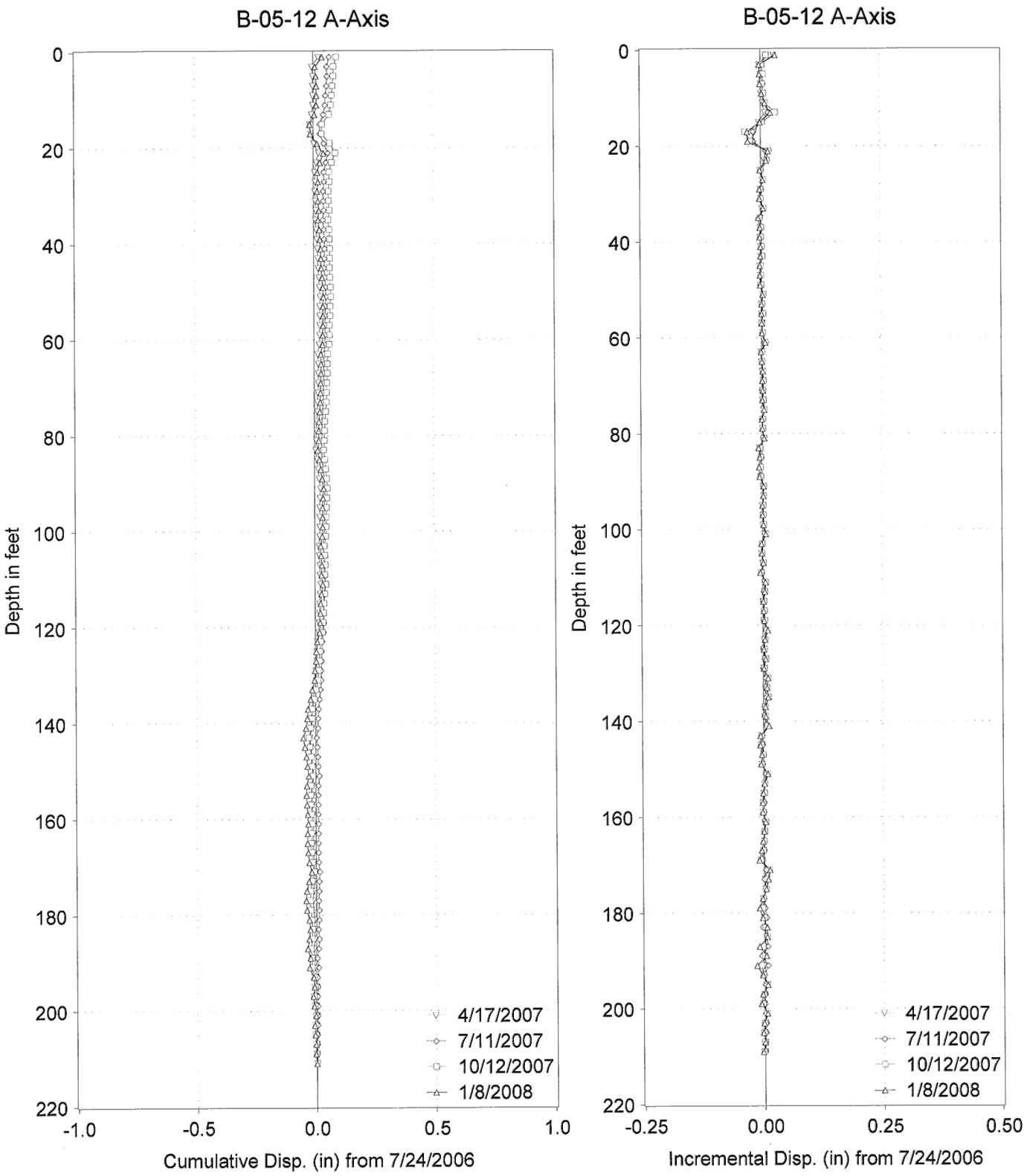
PLATE 41





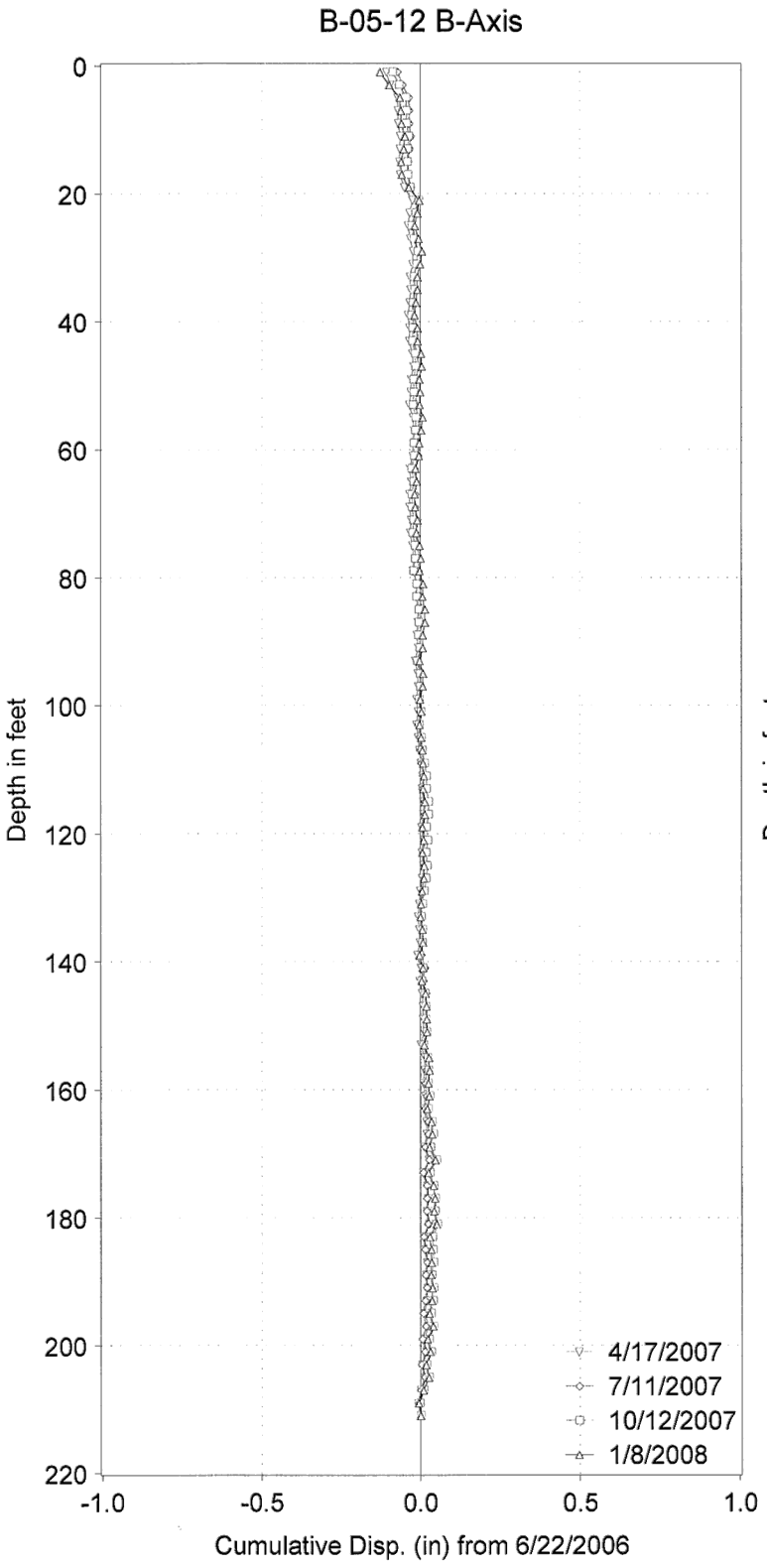
B-05-12
-Includes readings from the last four quarters.

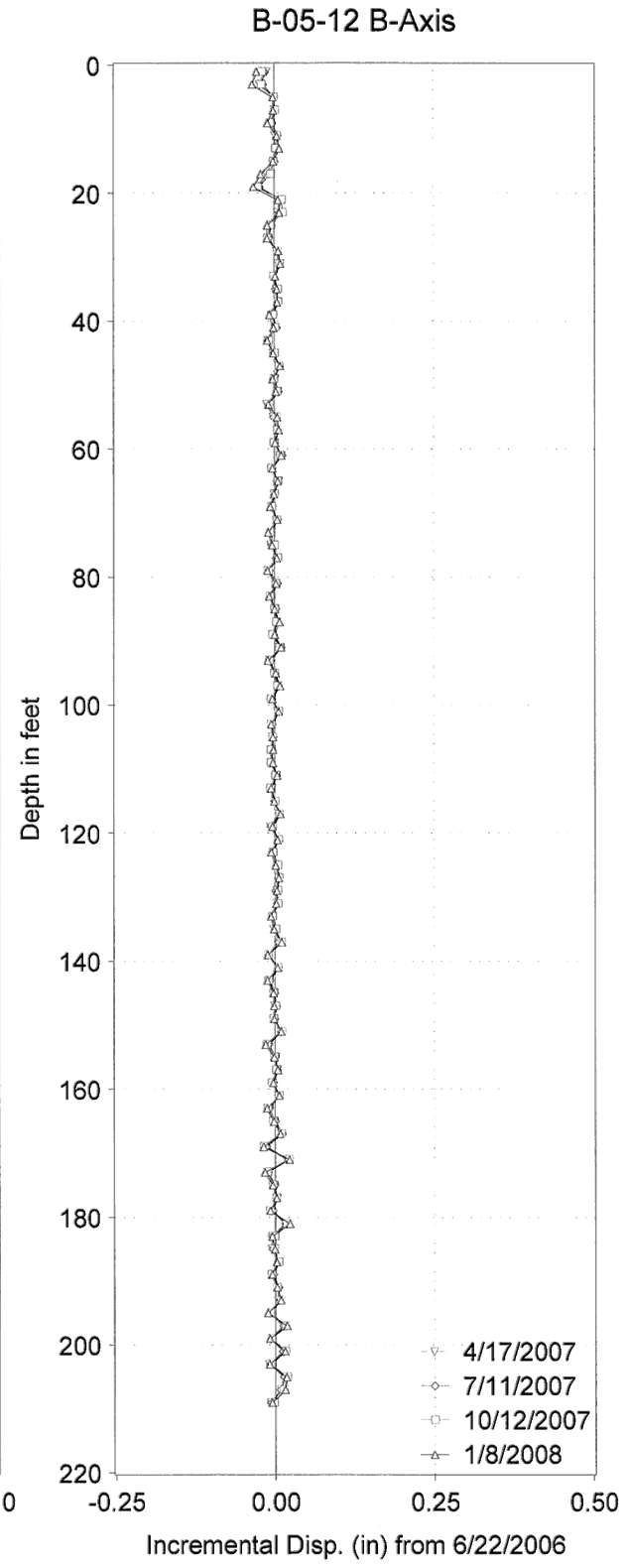
PLATE 42



B-05-12
-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

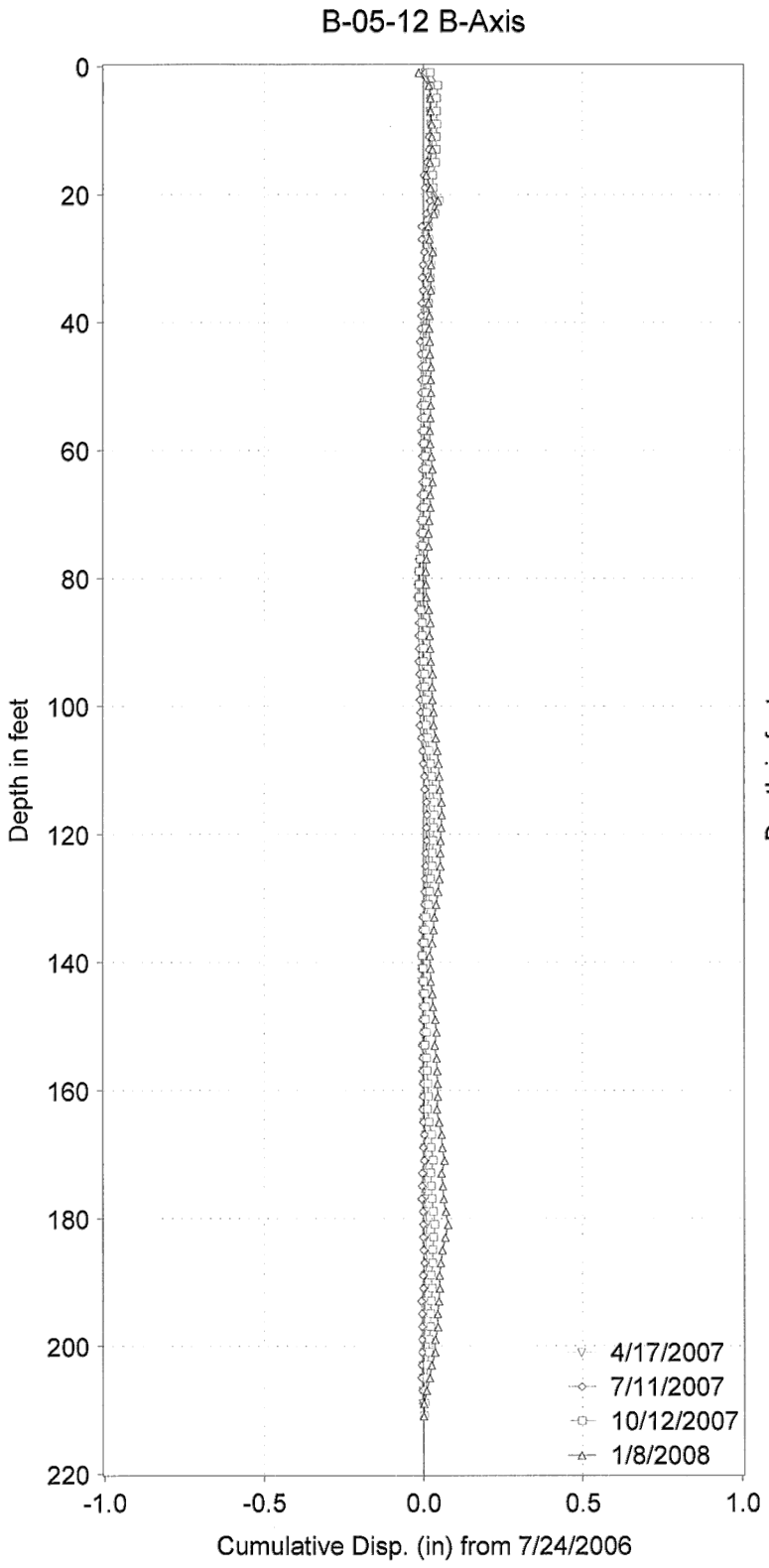
PLATE 42A

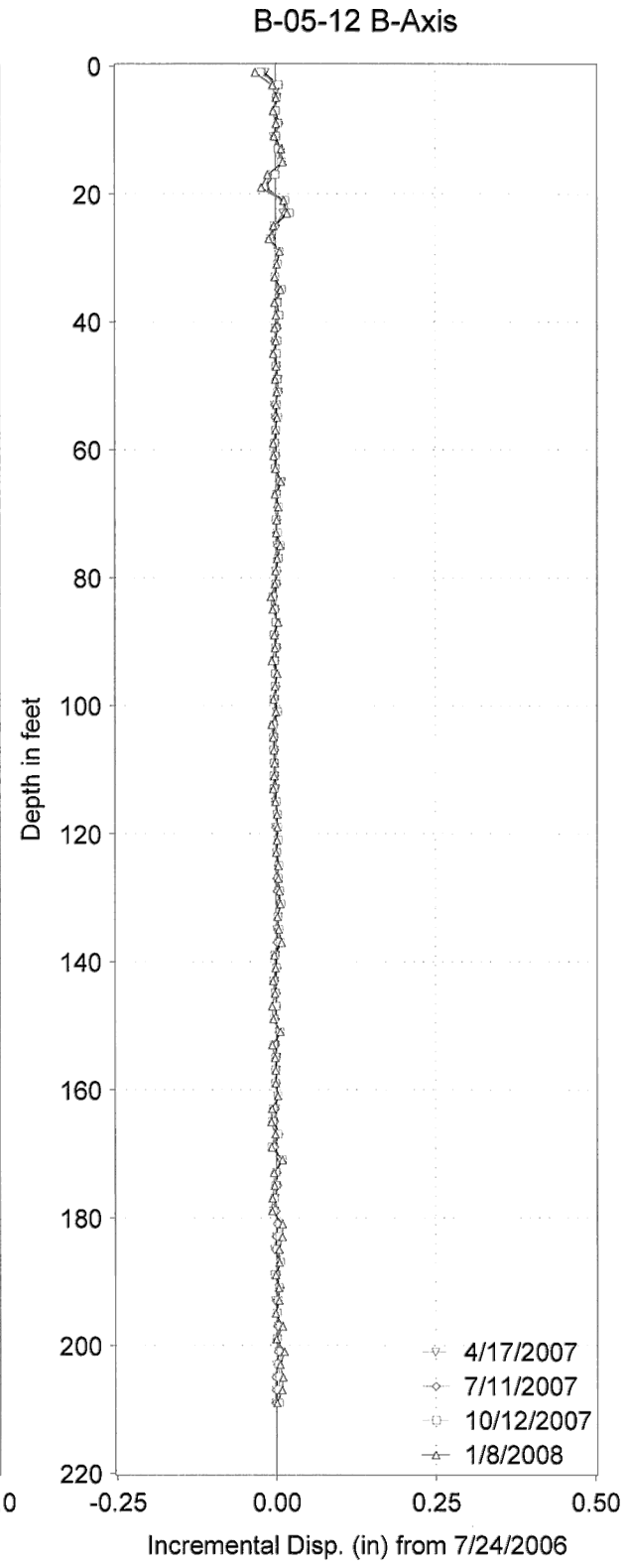




B-05-12
-Includes readings from the last four quarters.

PLATE 43

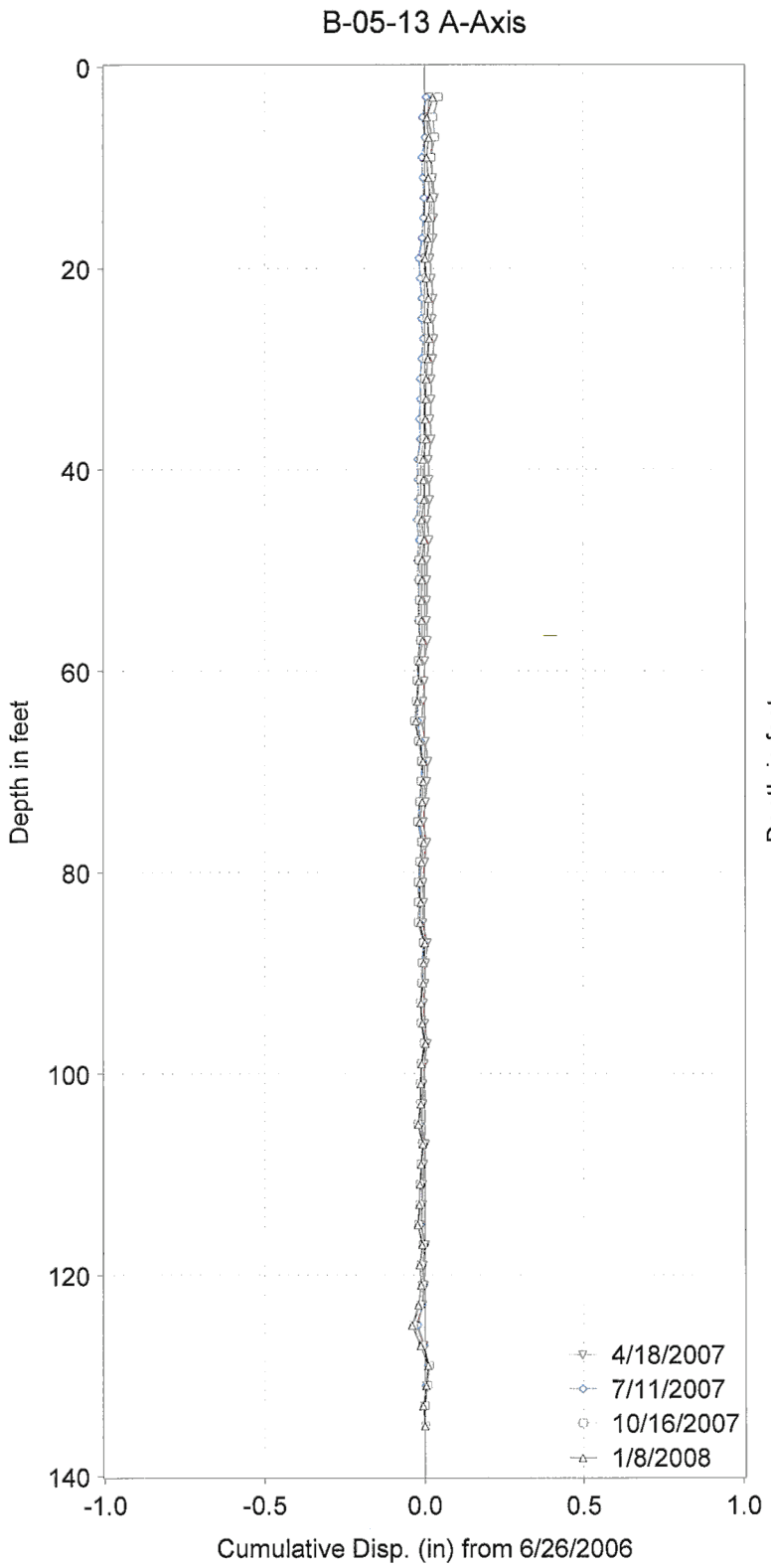


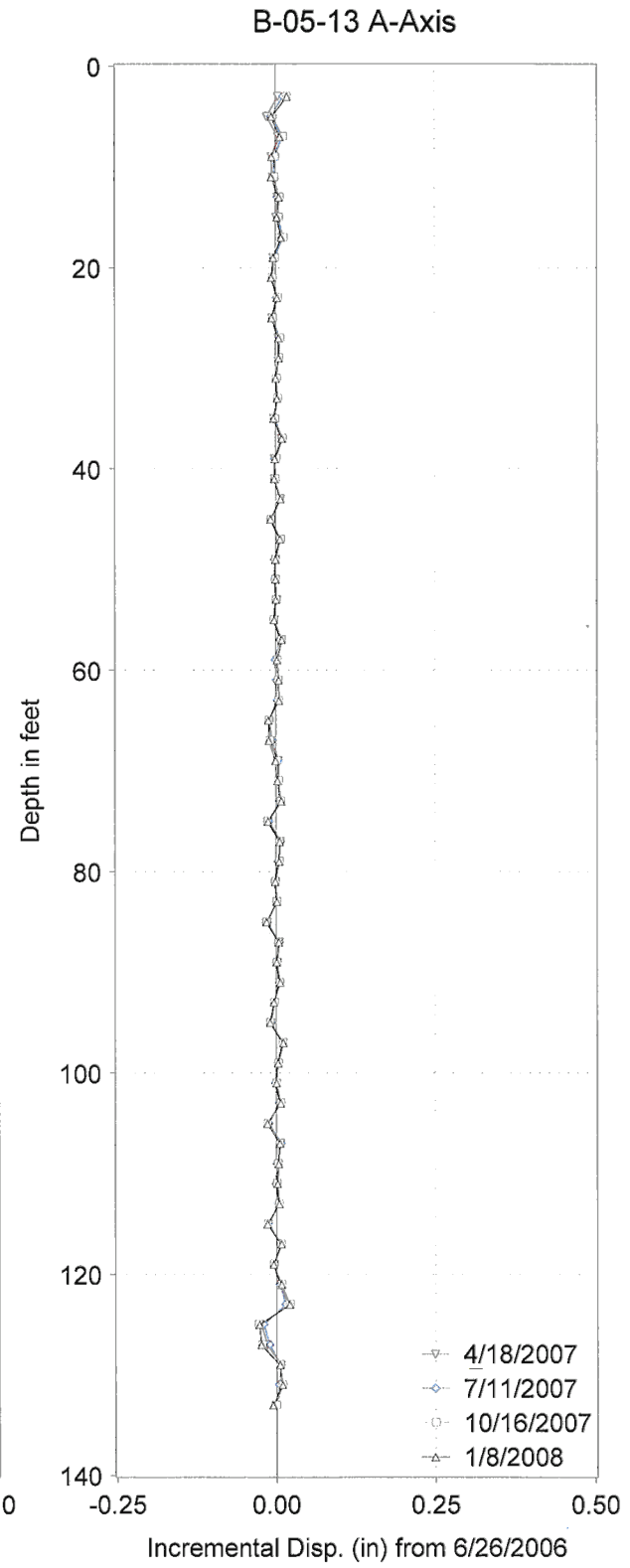


B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

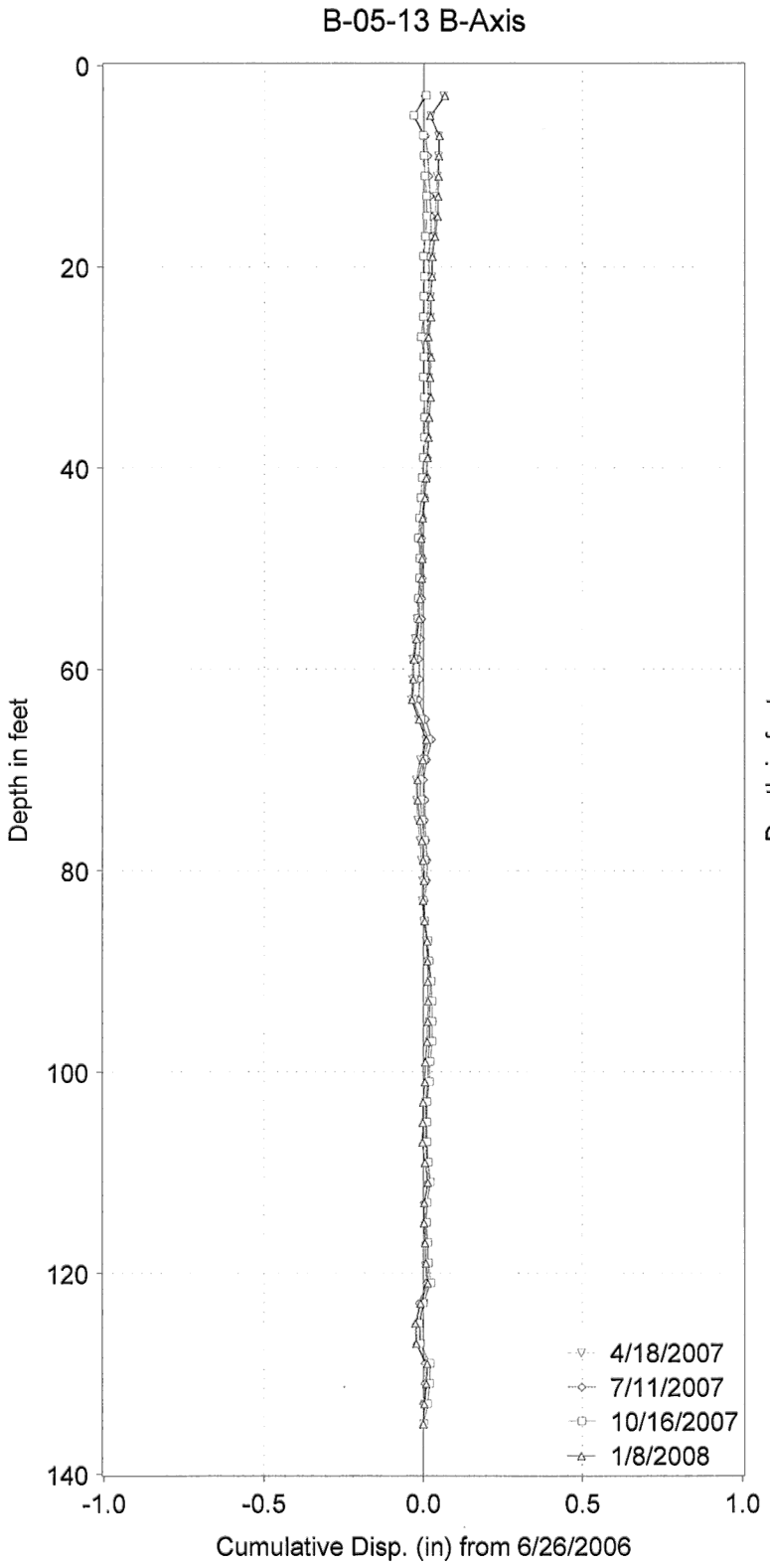
PLATE 43A

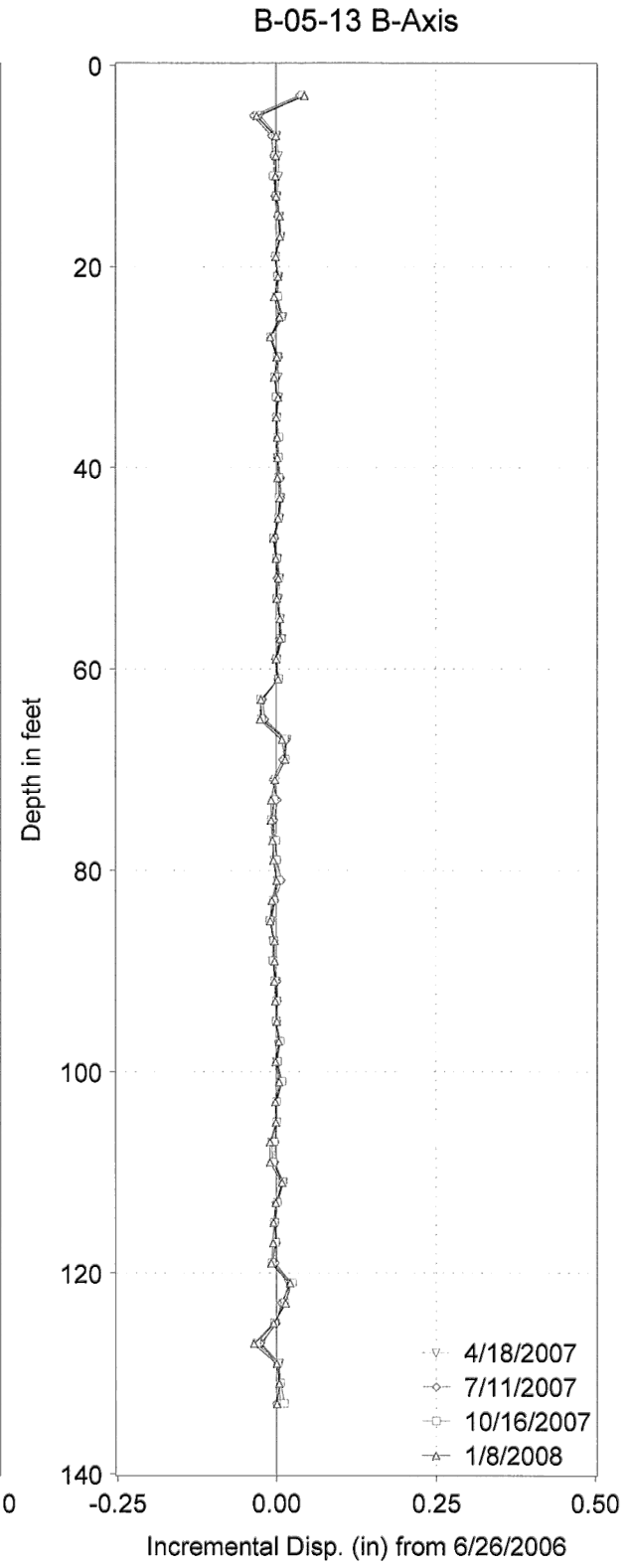




B-05-13
-Includes readings from the last four quarters.

PLATE 44

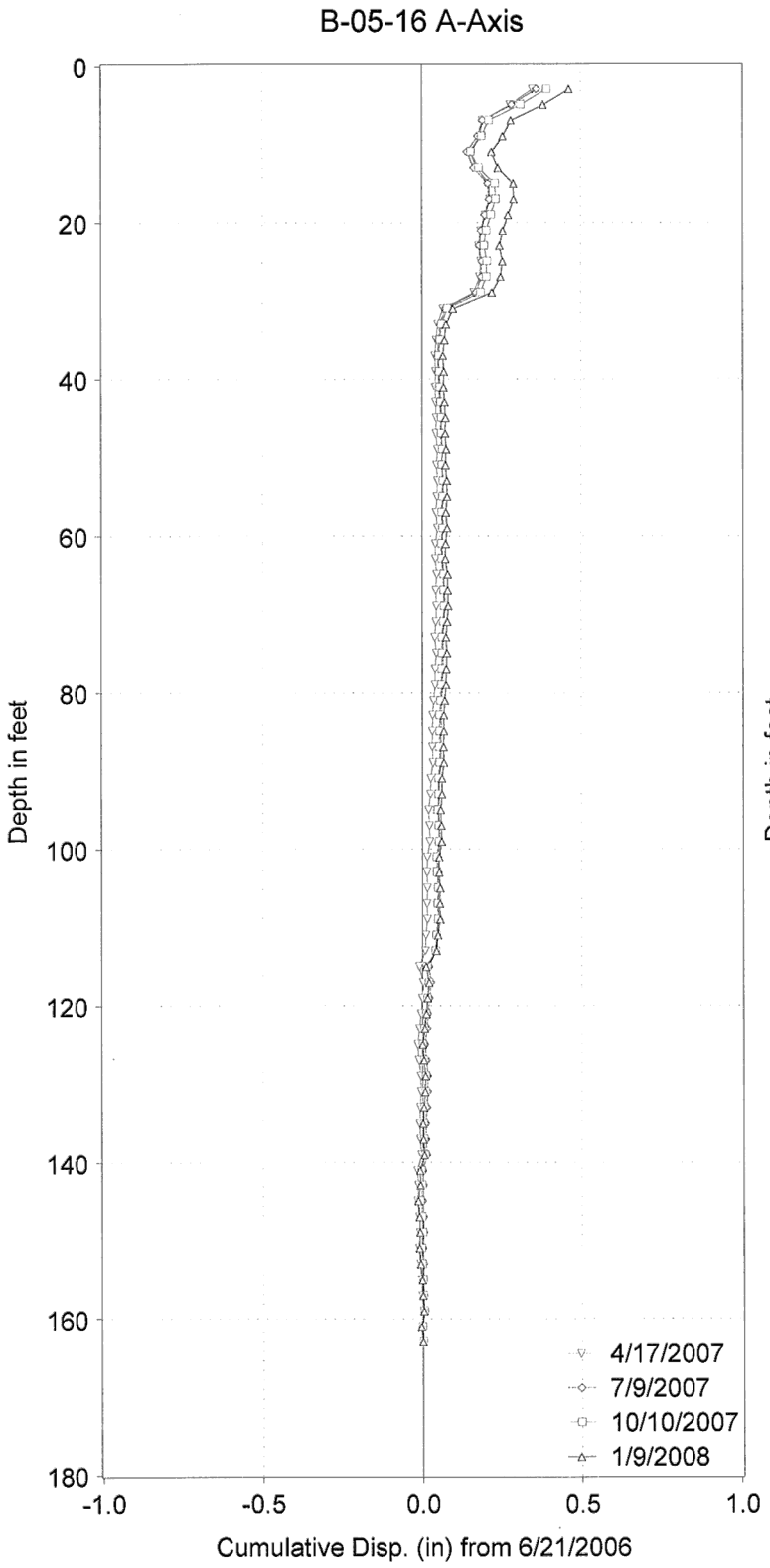


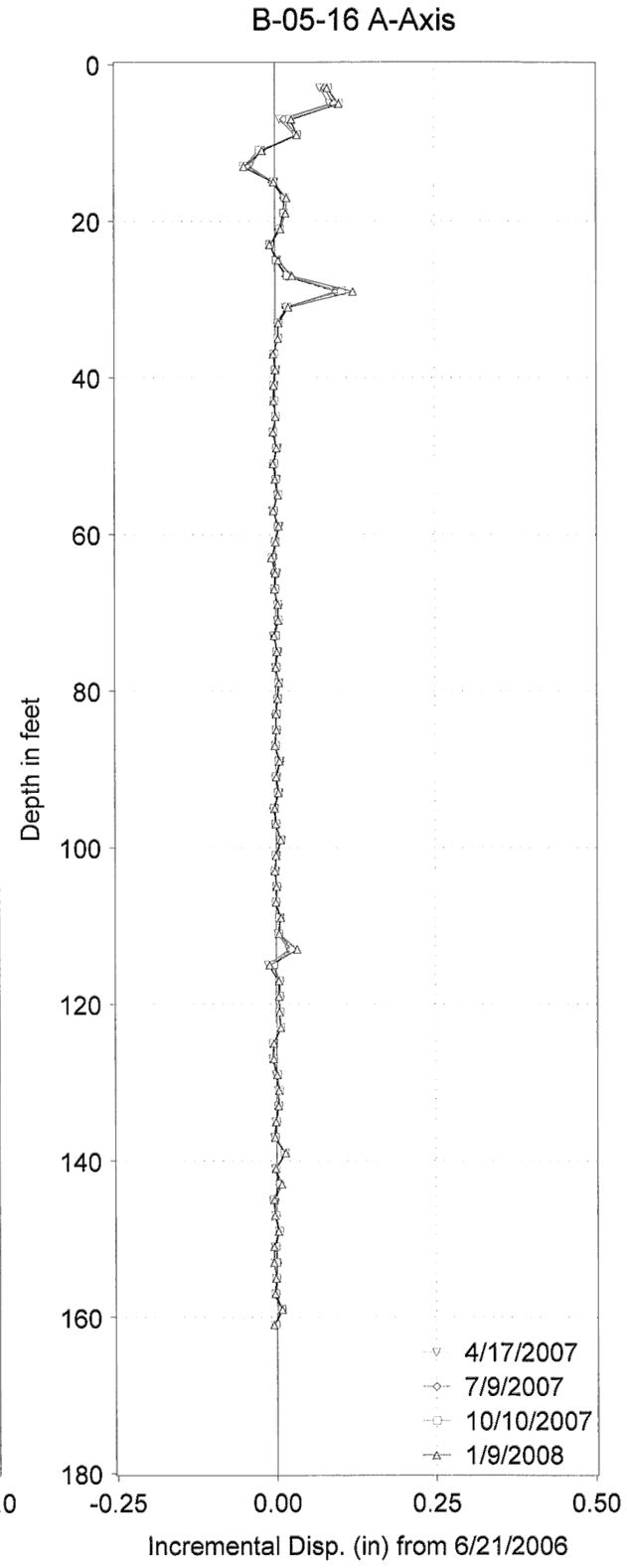


B-05-13

-Includes readings from the last four quarters.

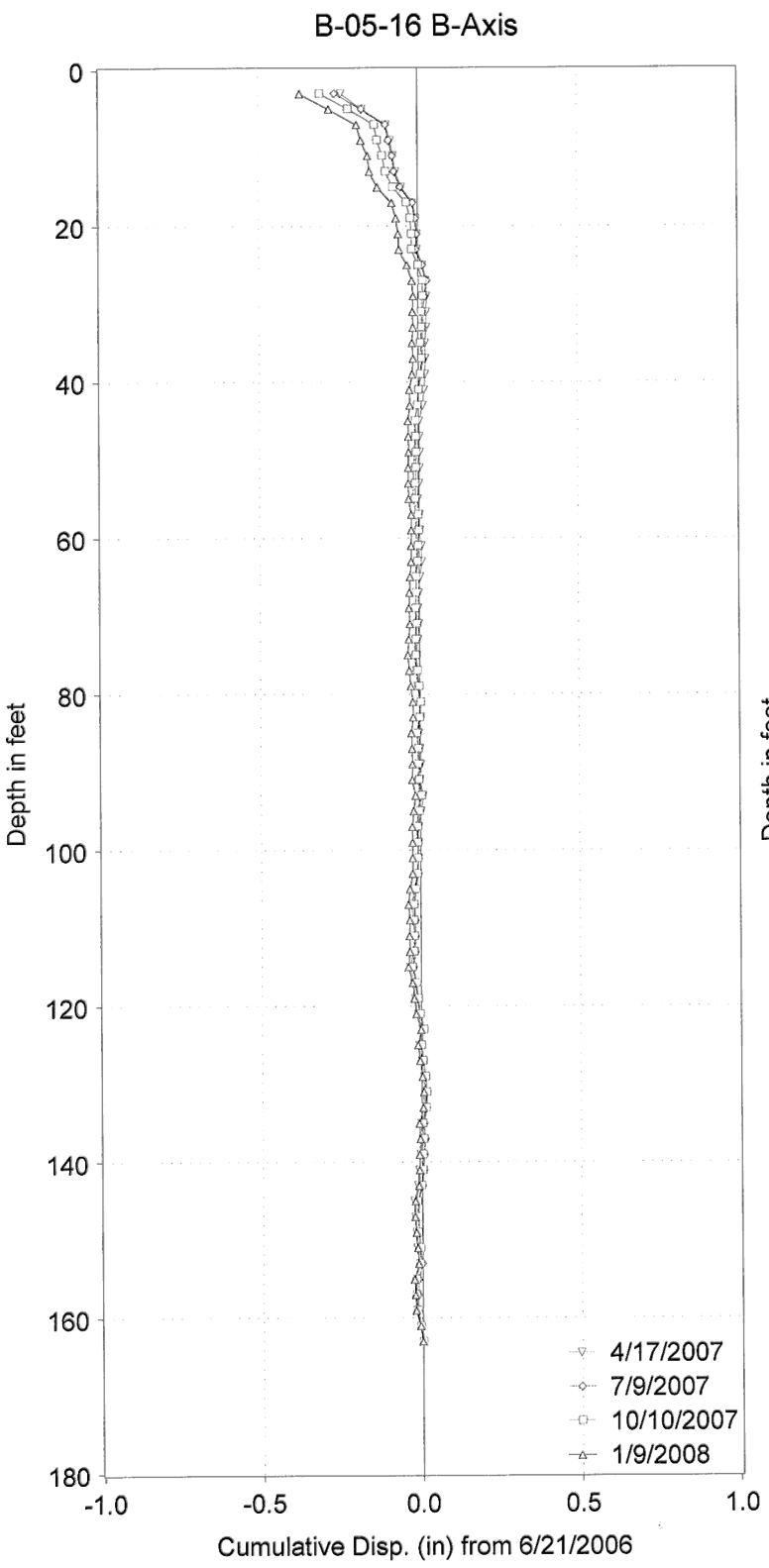
PLATE 45

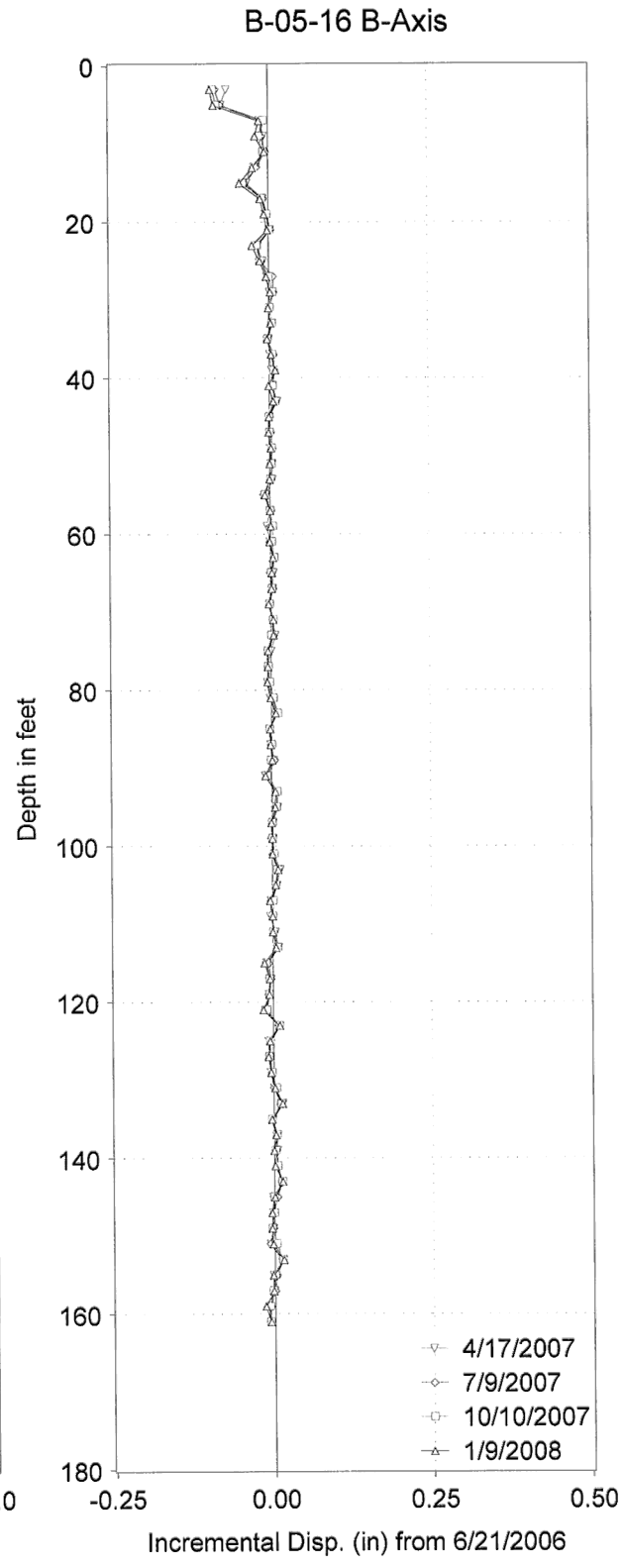




B-05-16
-Includes readings from the last four quarters.

PLATE 46





B-05-16
-Includes readings from the last four quarters.

PLATE 47

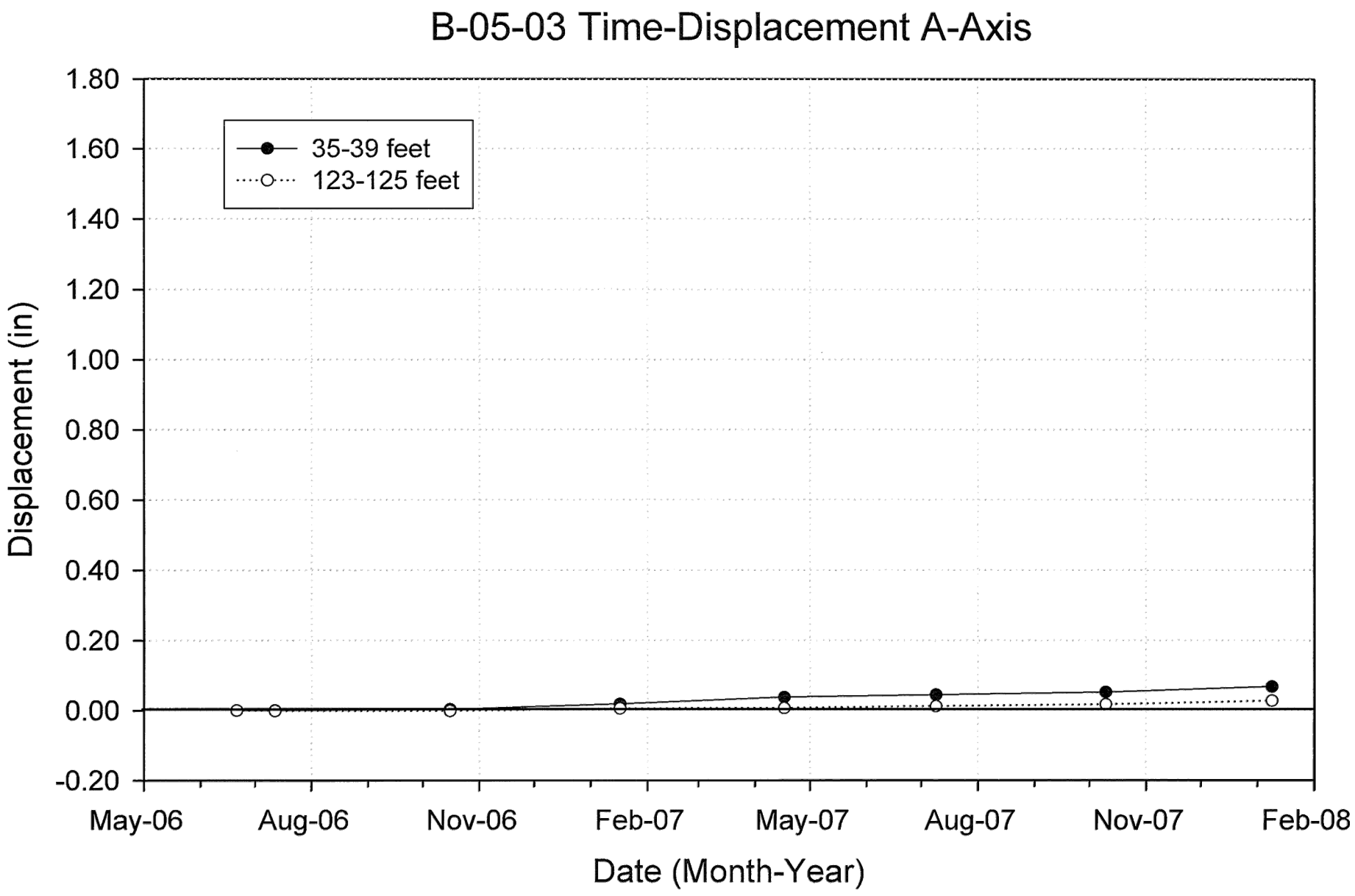

B-05-03 Time-Displacement A-Axis
35-39 feet
123-125 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Aug-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
Date (Month-Year)

PLATE 48

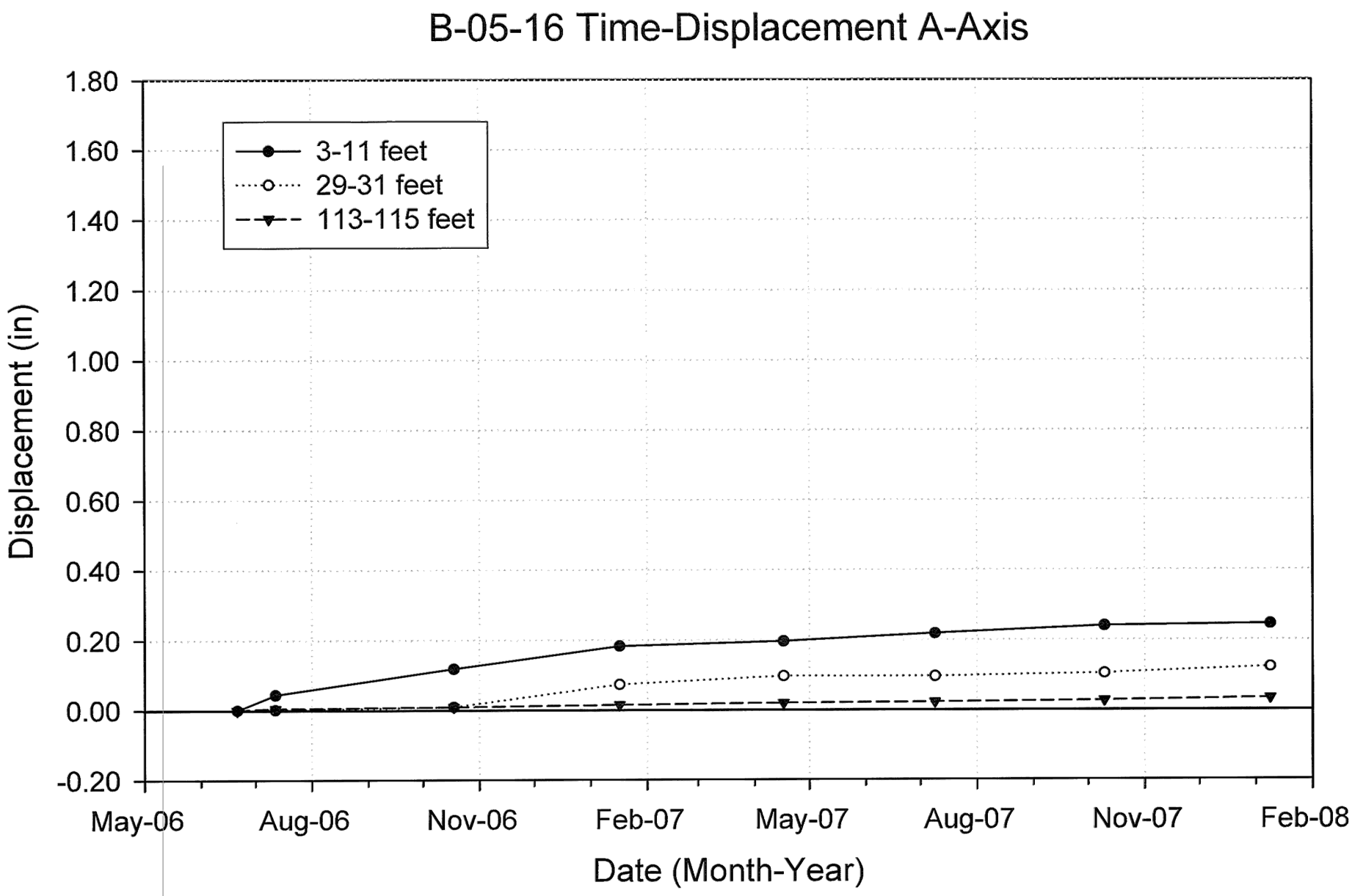

B-05-16 Time-Displacement A-Axis
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Displacement (in)
3-11 feet
29-31 feet
113-115 feet
May-06
Aug-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
Date (Month-Year)

PLATE 49

B-101 (P-1) Pneumatic Piezometer Readings

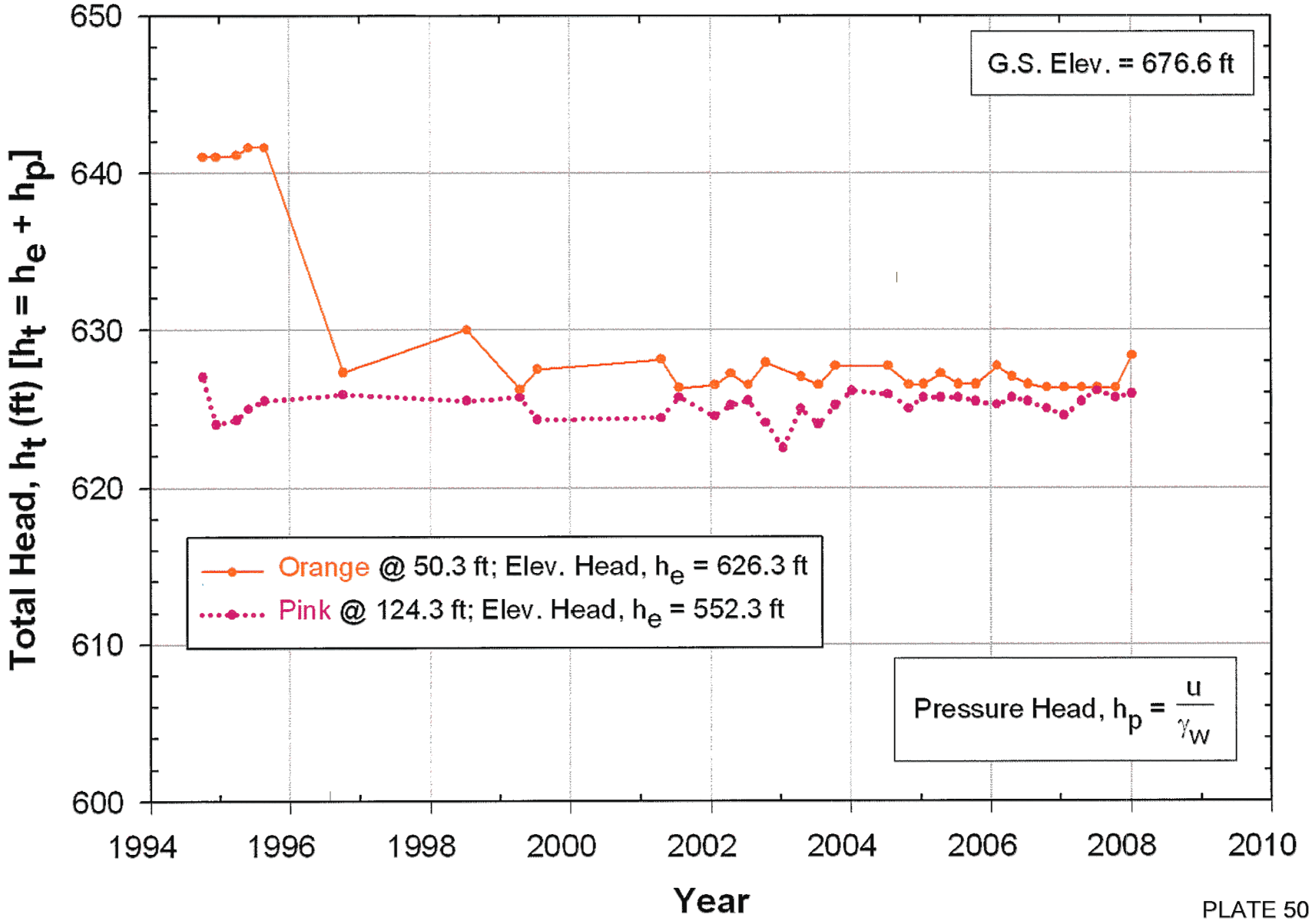


PLATE 50

B-105 (P-3) Pneumatic Piezometer Readings

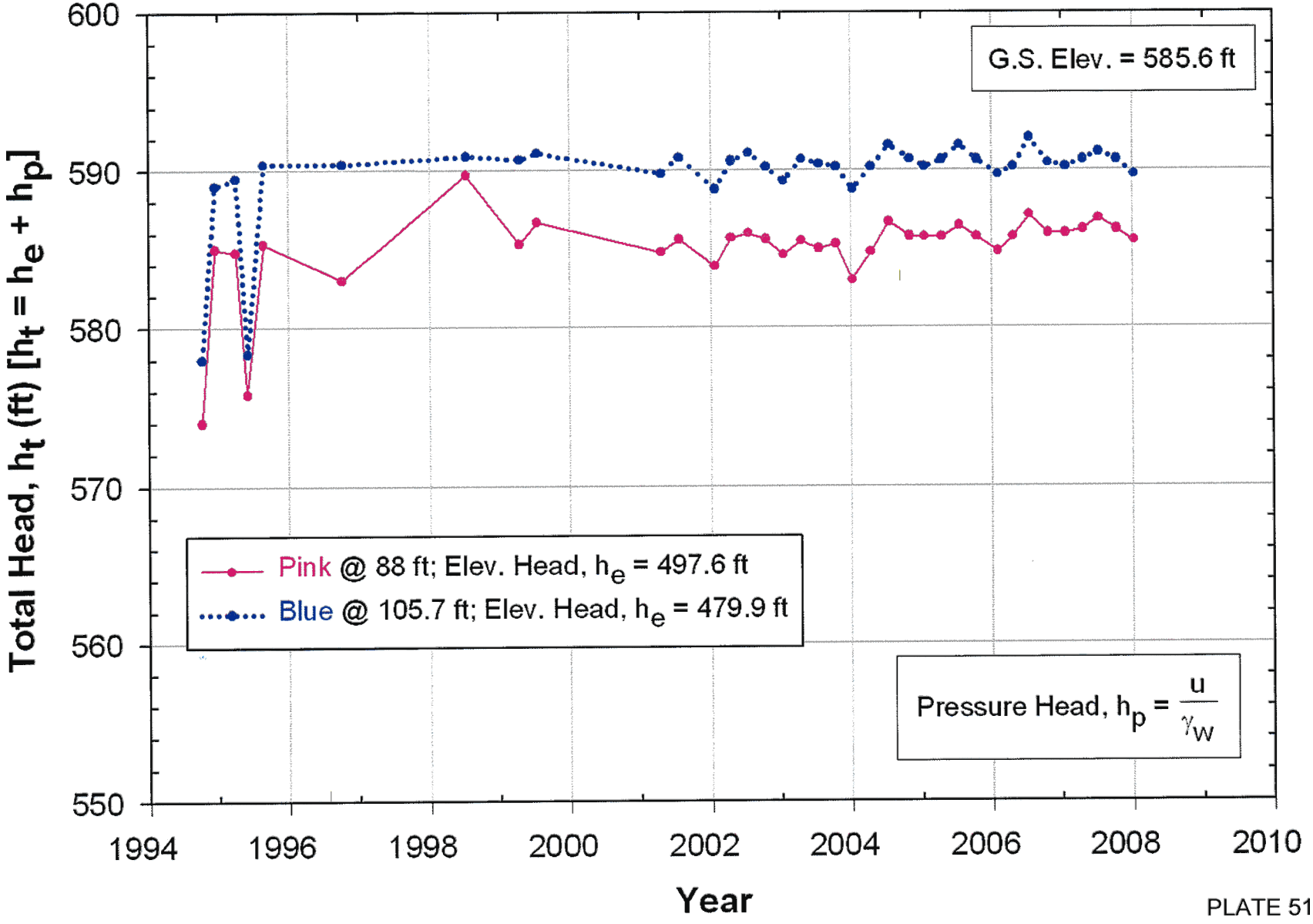


PLATE 51

B-107 (P-5) Pneumatic Piezometer Readings

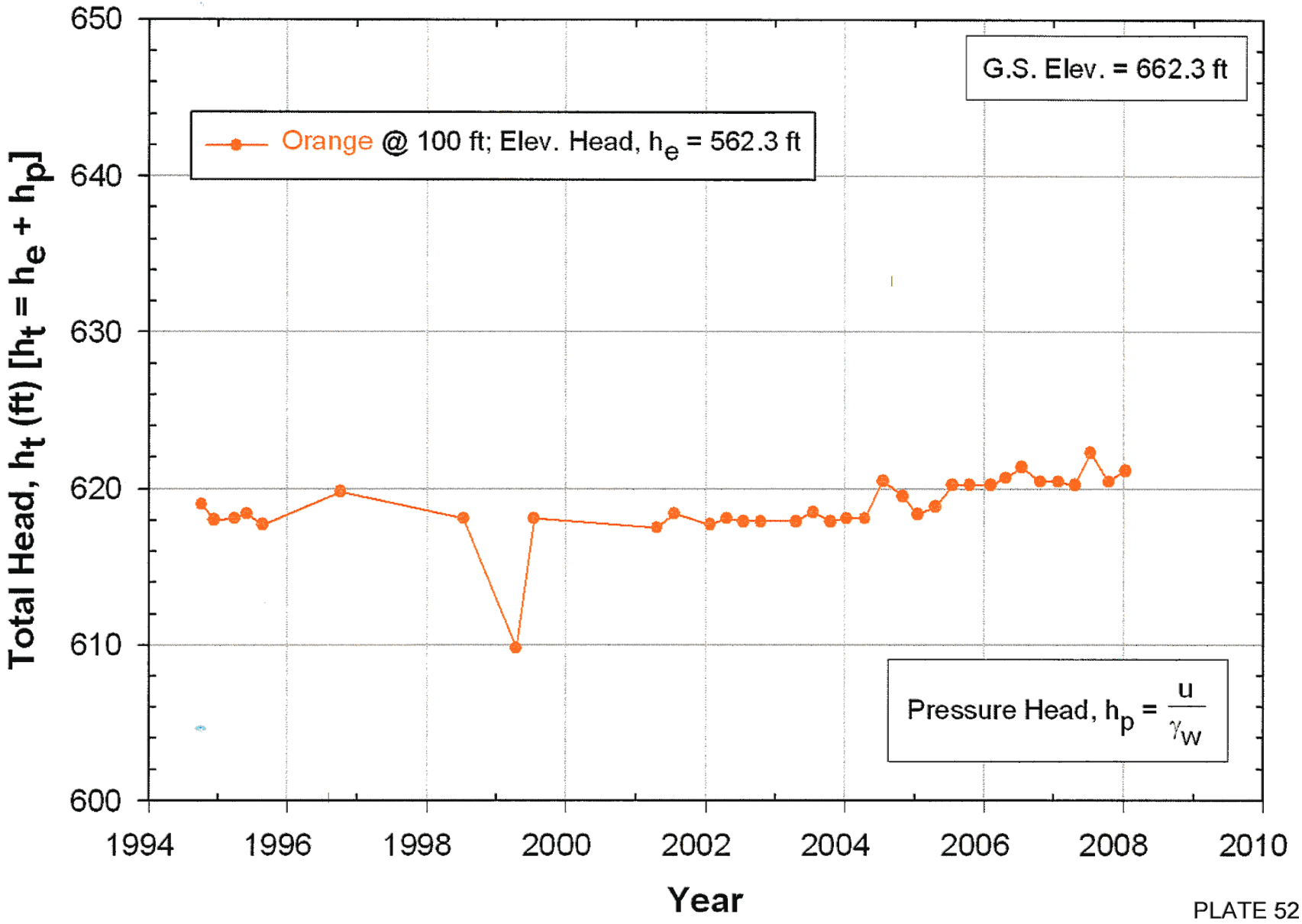


PLATE 52

B-303 (P-2) Pneumatic Piezometer Readings

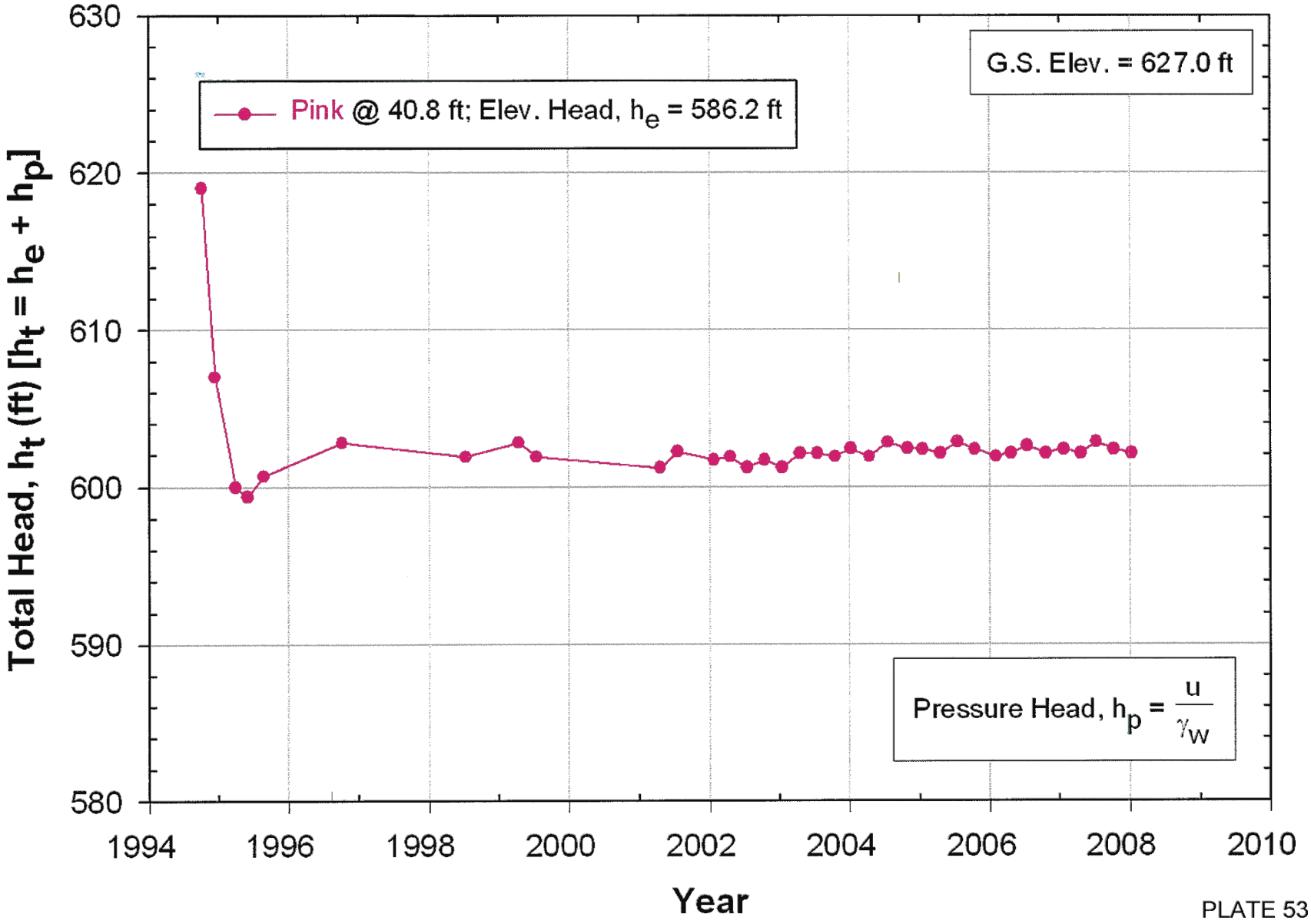


PLATE 53

B-05-01 VW Piezometer Readings

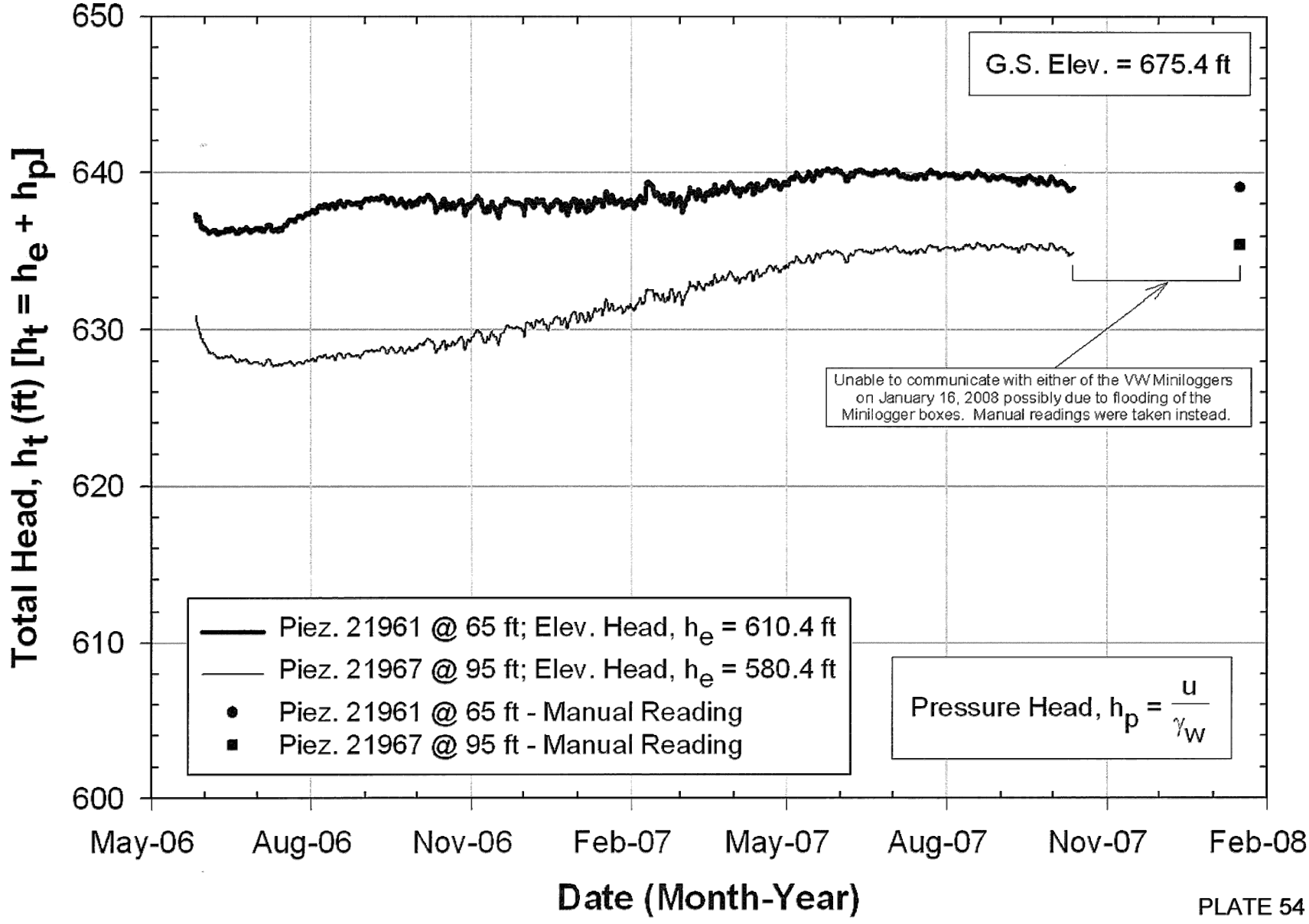


PLATE 54

B-05-02 VW Piezometer Readings

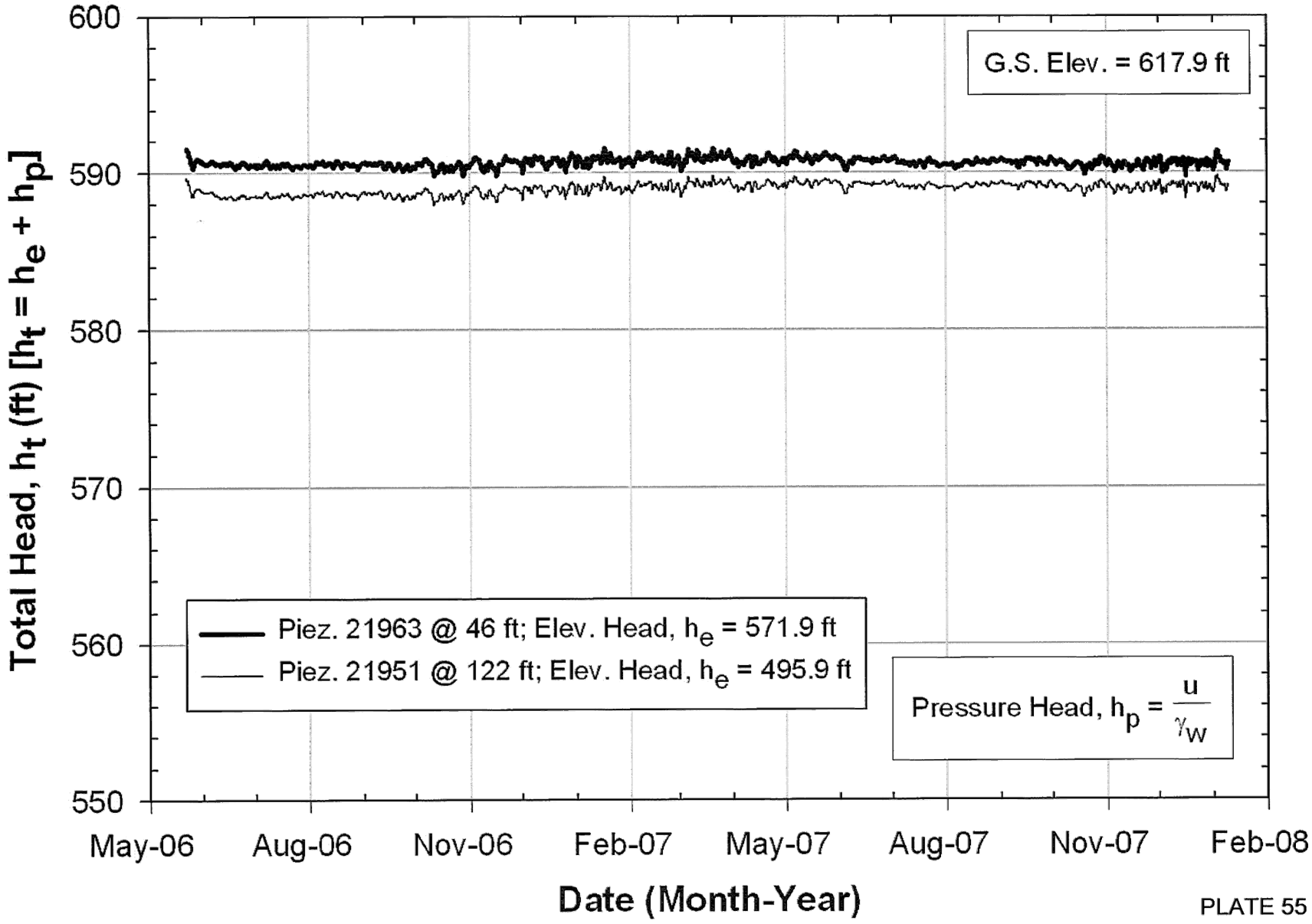


PLATE 55

B-05-03 VW Piezometer Readings

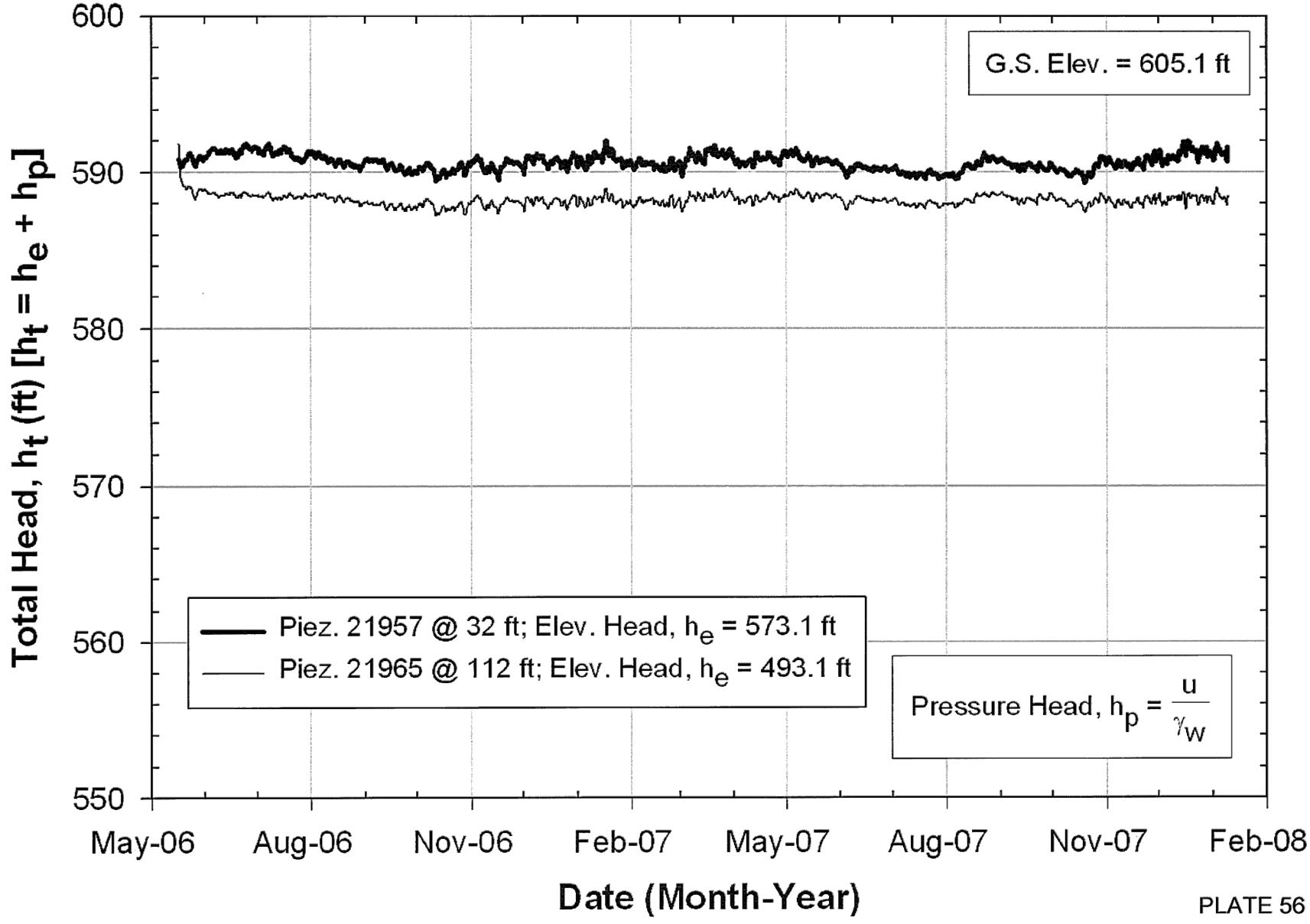


PLATE 56

B-05-04 VW Piezometer Readings

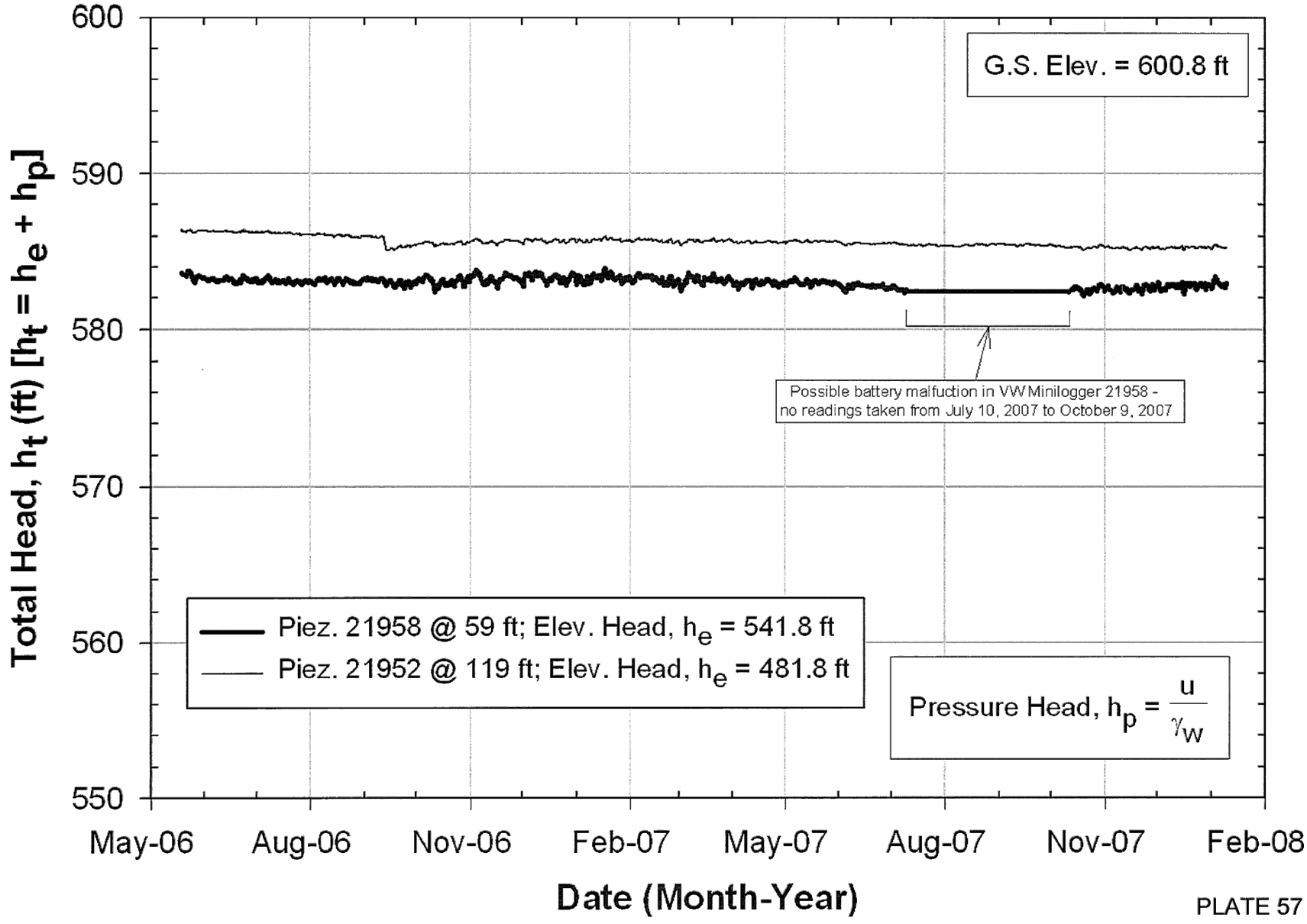


PLATE 57

B-05-07 VW Piezometer Readings

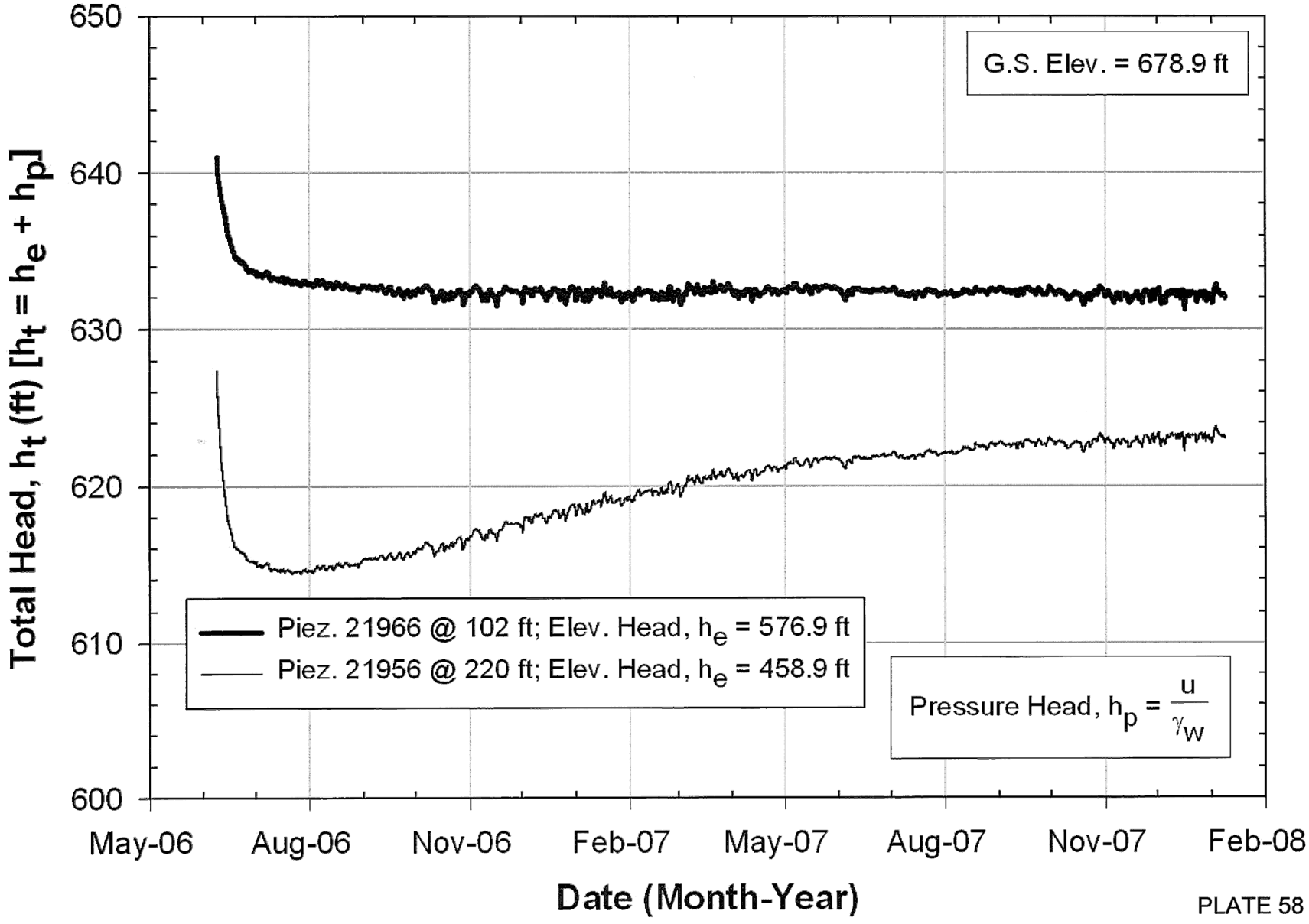


PLATE 58

B-05-08 VW Piezometer Readings

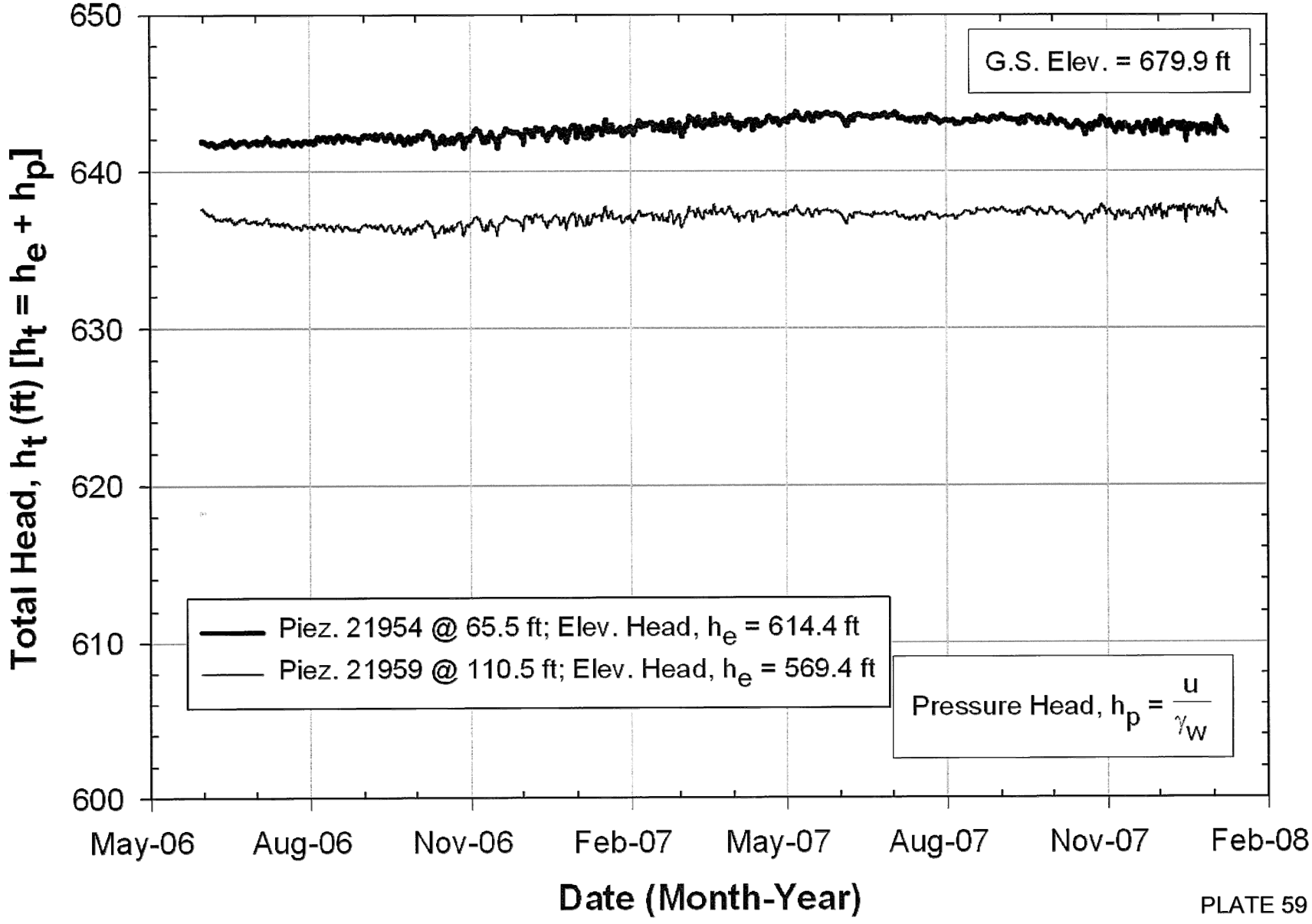


PLATE 59

B-05-11 VW Piezometer Readings

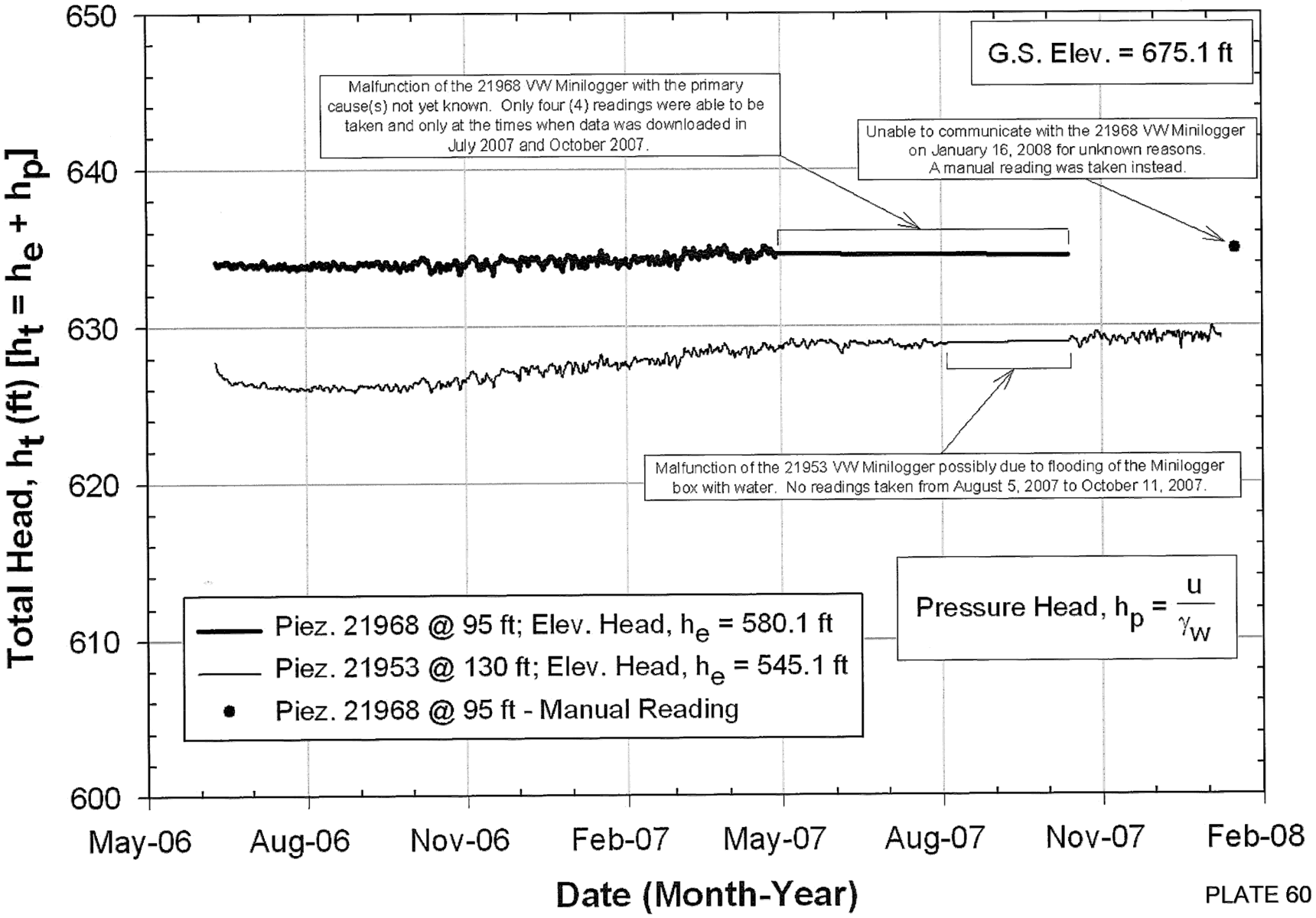


PLATE 60

B-05-12 VW Piezometer Readings

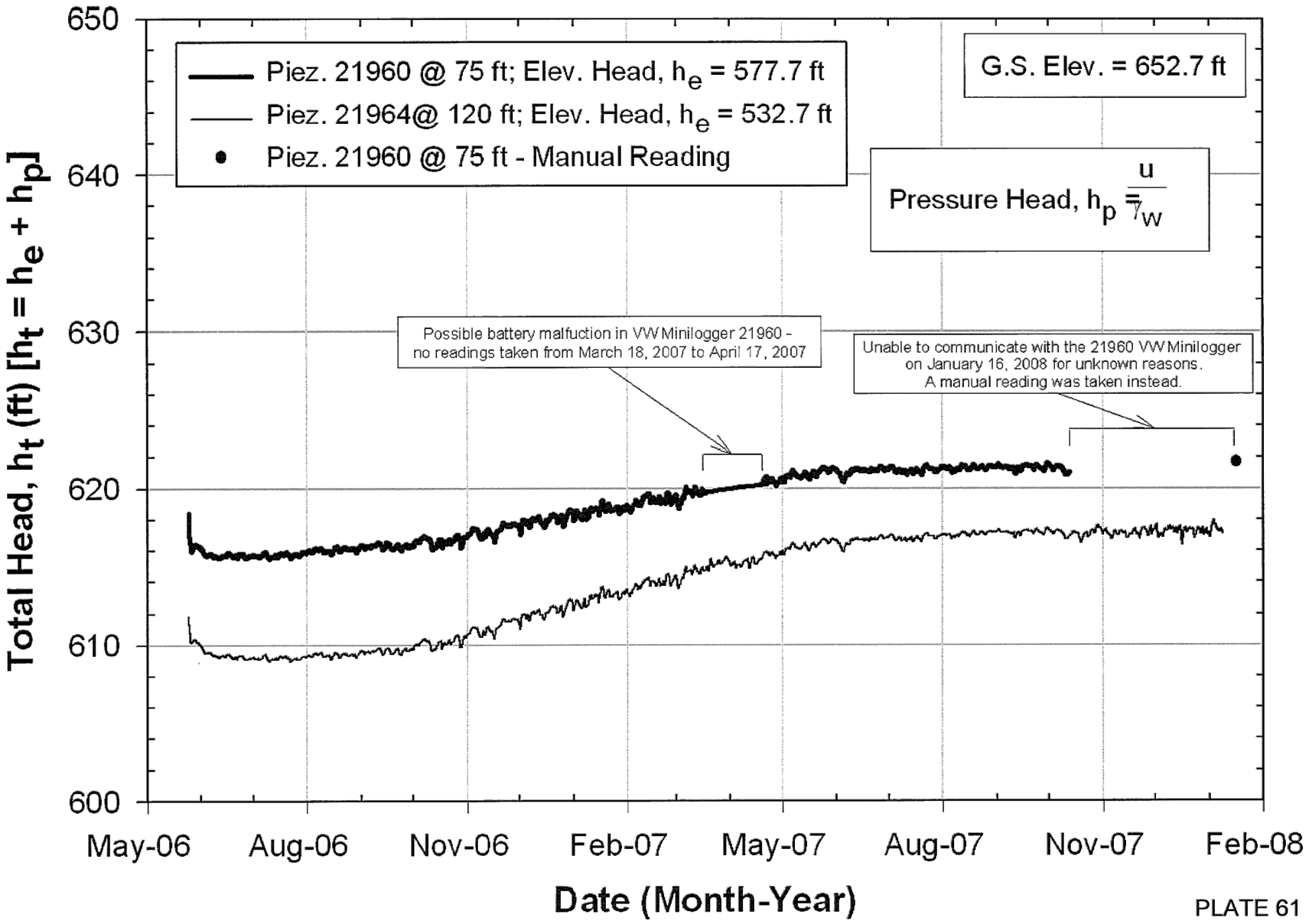


PLATE 61

B-05-13 VW Piezometer Readings

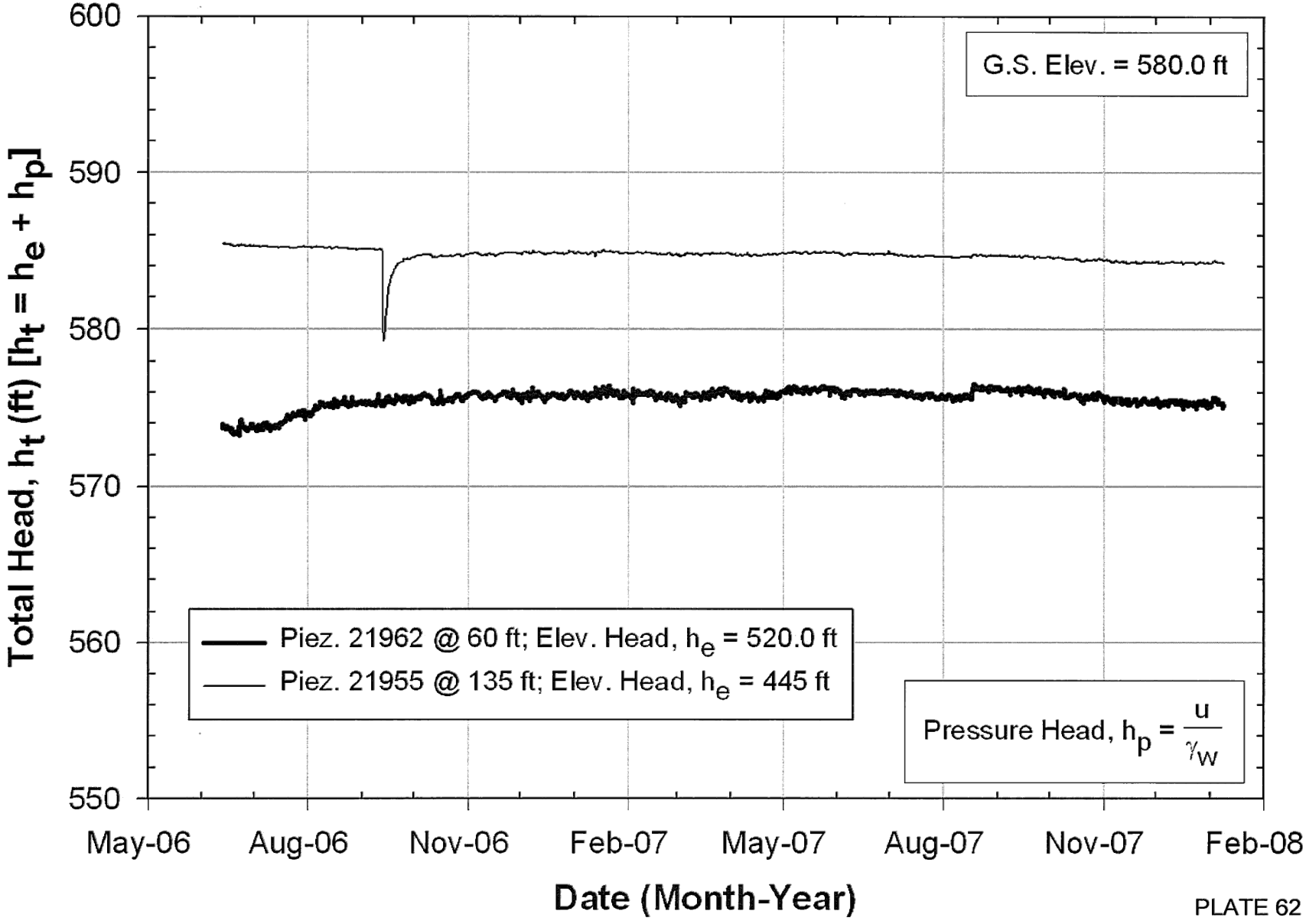


PLATE 62

CALIPERED SURFACE DISTANCE TABLE
CUY-90-15.24

Date	Left Pier Calipered Surface Distance		Center Line Calipered Surface Distance		Right Pier Calipered Surface Distance	
	Present reading	Change (in.)	Present reading	Change (in.)	Present reading	Change (in.)
04/17/01	Not Accessible		Not Accessible		Not Accessible	
07/19/01	6.043	--	Not Accessible		4.312	--
11/08/01	6.250	0.207	Not Accessible		4.469	0.157
01/23/02	6.253	0.003	Not Accessible		4.518	0.049
04/17/02	6.285	0.032	Not Accessible		4.435	-0.083
07/16/02	6.290	0.005	Not Accessible		4.444	0.009
10/15/02	6.333	0.043	Discontinued		4.482	0.038
01/15/03	6.405	0.072			4.473	-0.009
04/17/03	6.333	-0.072			4.482	0.009
07/18/03	6.186	-0.147			4.350	-0.132
10/16/03	6.385	0.199			4.519	0.169
01/08/04	6.124	-0.261			4.594	0.075
04/14/04	6.129	0.005			4.402	-0.193
07/16/04	6.250	0.122			4.277	-0.125
10/27/04	6.375	0.125			4.467	0.190
01/12/05	6.250	-0.125			4.349	-0.118
04/14/05	6.375	0.125			4.372	0.023
07/14/05	6.313	-0.063			4.392	0.020
10/12/05	6.375	0.063			4.358	-0.034
02/01/06	6.438	0.063			4.395	0.037
04/20/06	6.500	0.063			4.430	0.035
07/14/06	6.375	-0.125			4.381	-0.049
10/18/06	6.438	0.063			4.400	0.020
01/19/07	6.500	0.062			4.506	0.106
04/18/07	6.375	-0.125			4.357	-0.150
07/11/07	6.438	0.063			4.341	-0.015
10/12/07	6.438	0.000			4.384	0.043
01/08/08	6.469	0.031			4.349	-0.036

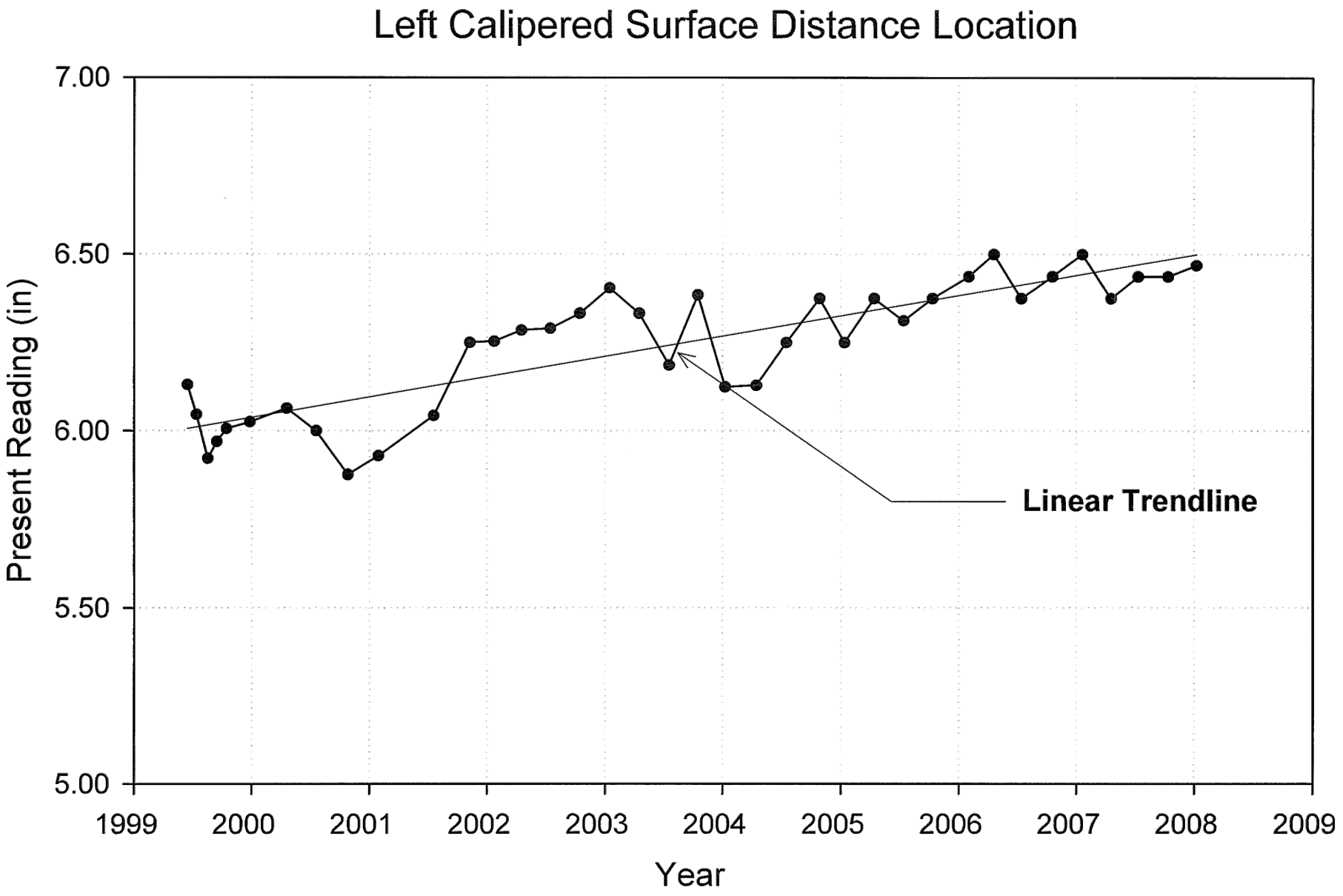

Left Calipered Surface Distance Location
7.00
6.50
6.00
5.50
5.00
Present Reading (in)
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year
Linear Trendline

PLATE 64

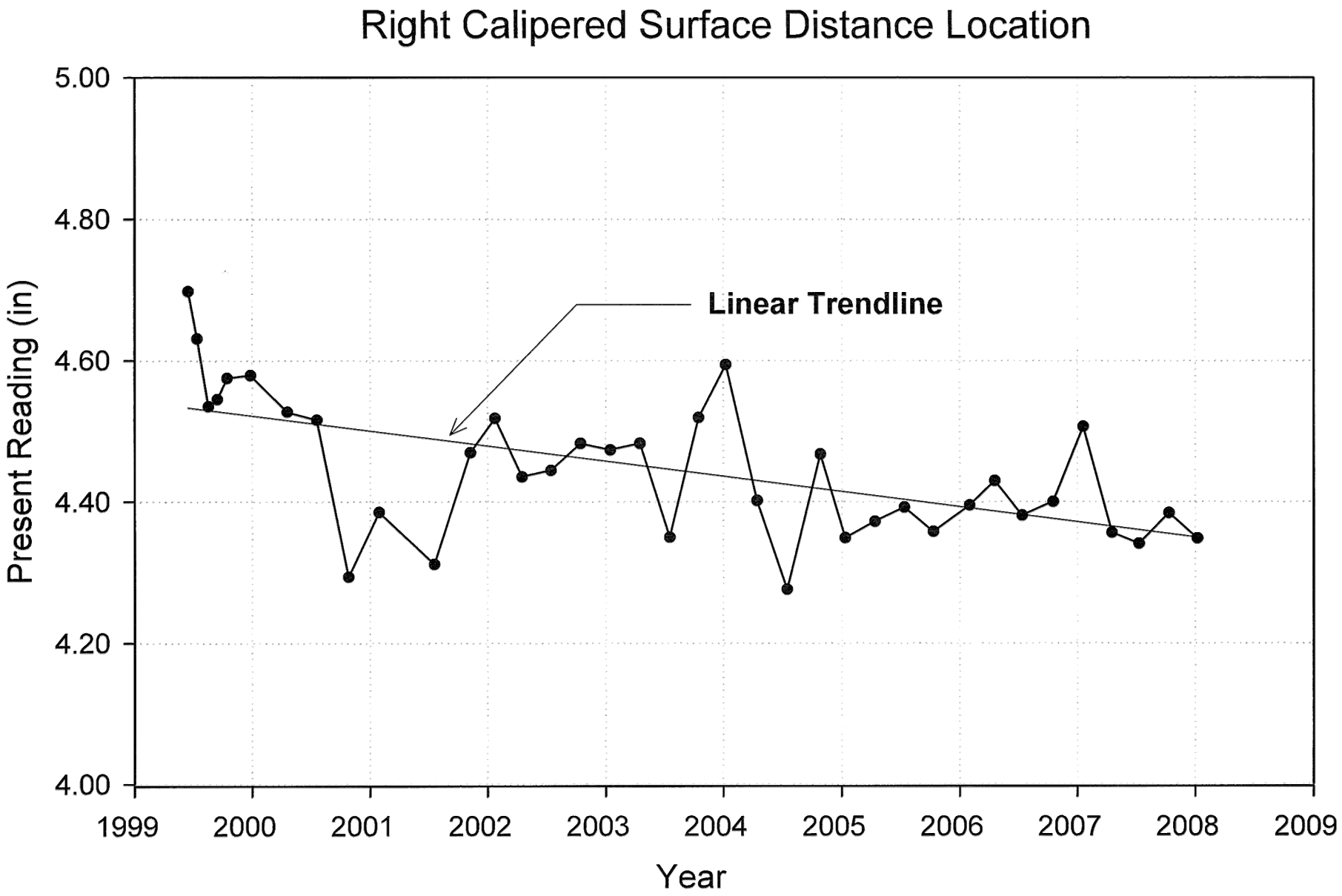
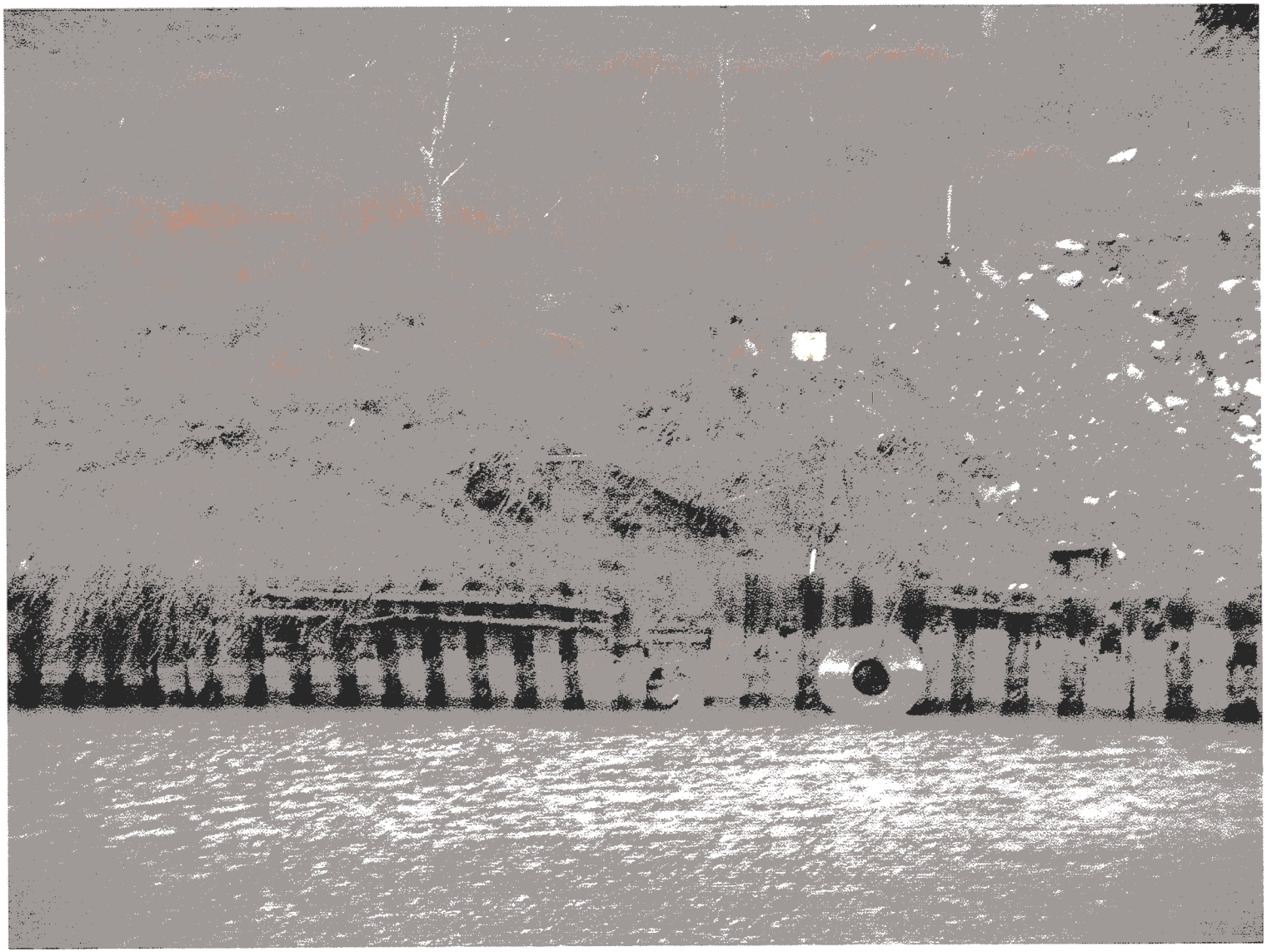

Right Calipered Surface Distance Location
5.00
4.80
4.60
4.40
4.20
4.00
Present Reading (in)
Linear Trendline
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

PLATE 65

View towards the southeast of the large excavation area and landslide area. Photo taken from near B-05-13 across the Cuyahoga River.

PLATE 66



Close-up view towards the southeast of the landslide area adjacent to the west right-of-way fence. Photo taken from near B-05-13 across the Cuyahoga River.

PLATE 67

View towards the north-northwest of the bulkhead in the excavation area adjacent to the west right-of-way fence.

PLATE 68

View towards the east of a large scarp within the landslide area and the tipped over fence.

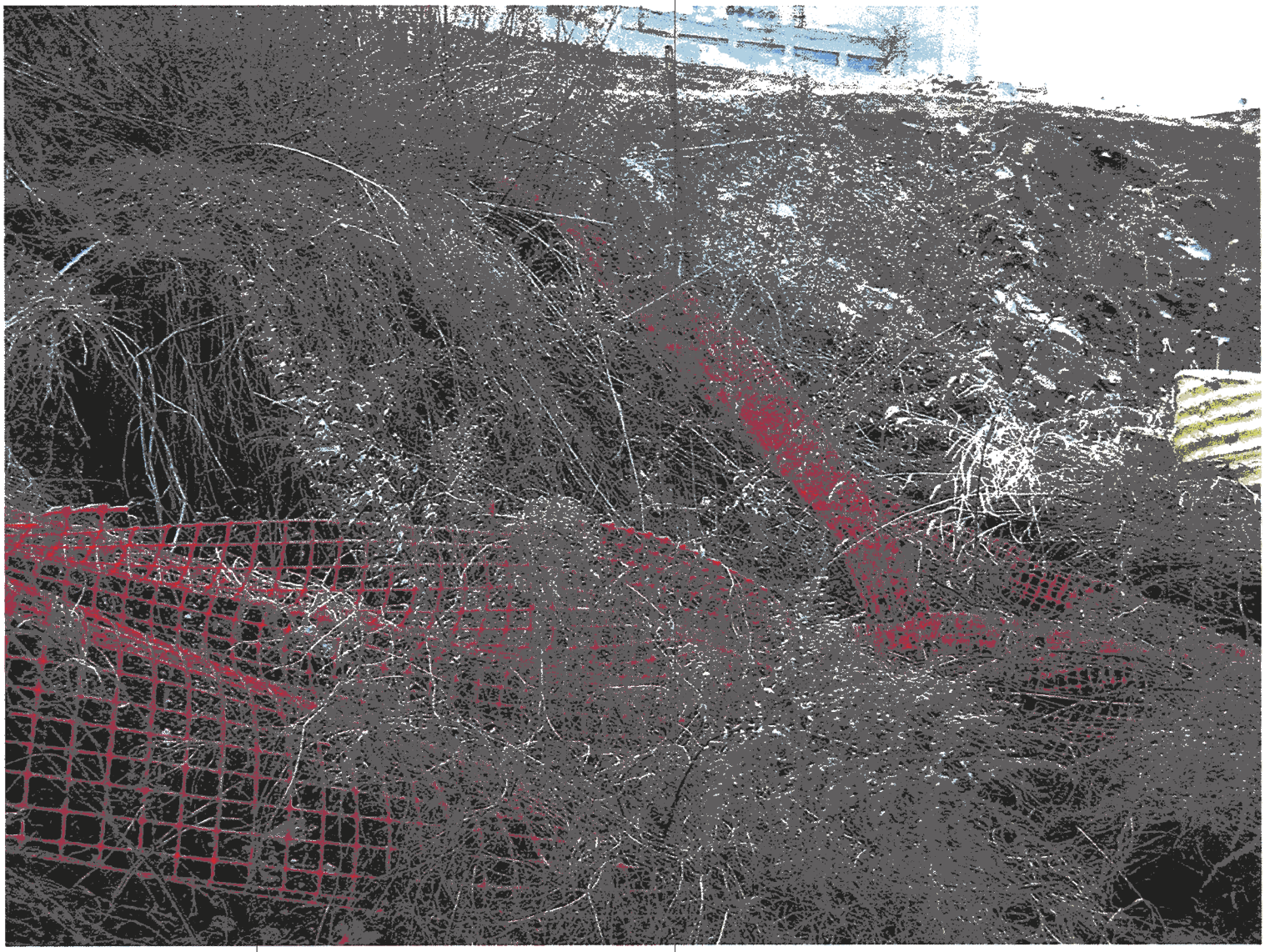
PLATE 69

View towards the northeast of a large scarp within the landslide area.

PLATE 70

View towards the east of large scarps within the landslide area and the tipped over fence.

PLATE 71



View towards the southwest of the multiple scarps within the landslide area.

PLATE 72

~~100109~~

106017

Richland Engineering Limited

From: "arthur huckelbridge" <aah4@case.edu>
To: "'Richland Engineering Limited'" <reltd@r-e-l.com>
Sent: Monday, January 21, 2008 3:57 PM
Attach: Tiltmeters_Jan08.ppt
Subject: RE: CUY-90-1524 West End Slope Monitoring

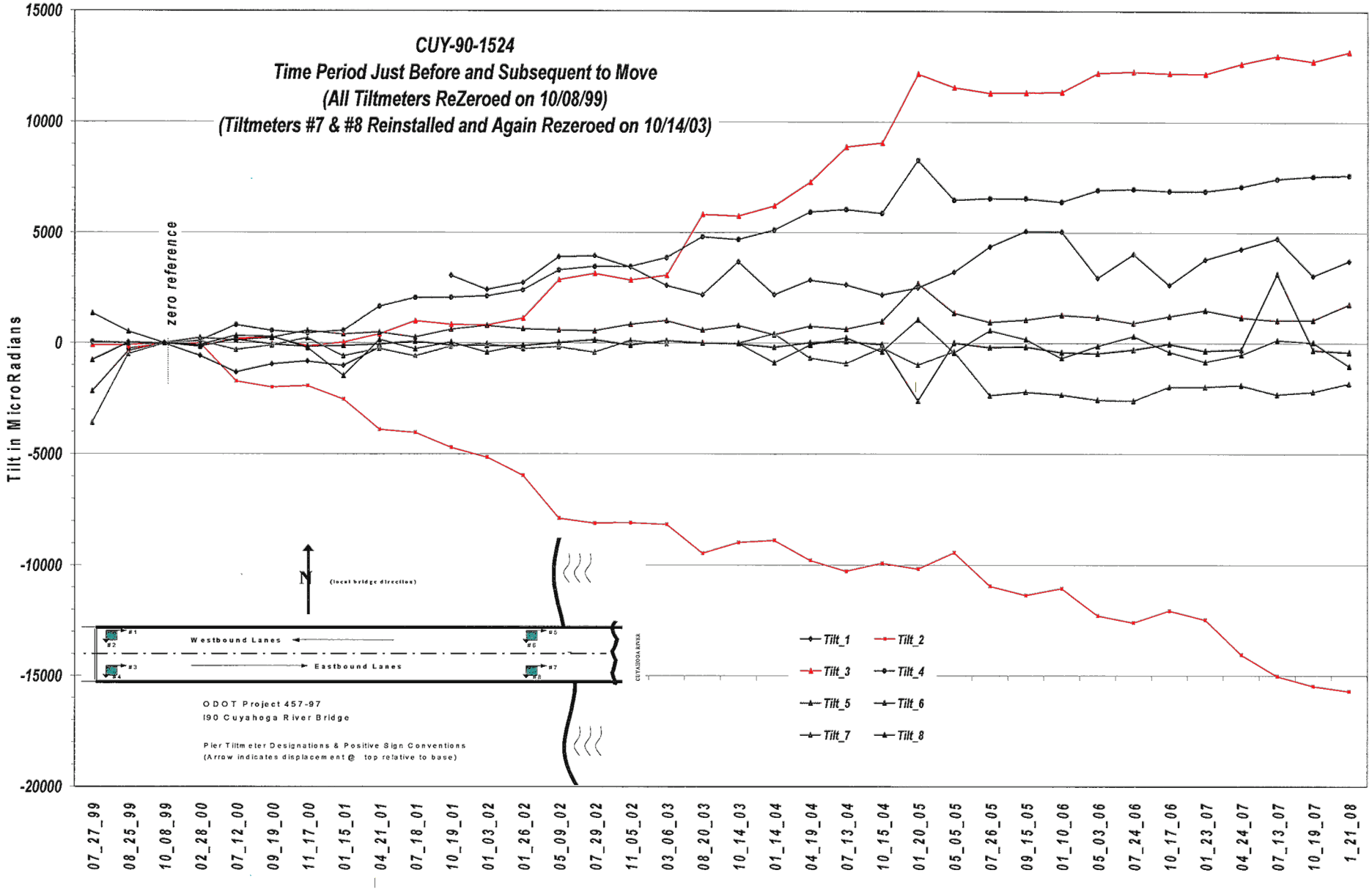
Dean:

Updated innerbelt bridge tiltmeter readings are attached. There were no startling developments to report in the readings. Gusset plate reinforcement was underway during my visit today.

Let me know if any questions arise.

Regards,

Art



Tiltmeter Readings Through January 21, 2008

106017

Robert Y. Liang, Ph.D., P.E
8441 Timber Tr.
Brecksville, Ohio 44141

Cell Phone: (440) 725-7425
e-mail: RYLIANG@AOL.COM

January 24, 2008

Mr. Dean Palmer, P.E.
Richland Engineering, Ltd.
29 North Park St.
Mansfield, OH 44902

Ref: CUY-90-14.52, PID No. 77332

Dear Mr. Palmer:

The monitoring data for the stabilization structures at the referenced project site for the last three months are enclosed. The inclinometer reading and strain data were taken on January 7 and 8, 2008. Also, the batteries were replaced and the on-site data logger was maintained.

As can be seen from the enclosed data, there was no significant change in the strain reading during this past quarter. Furthermore, the inclinometer reading of the six casings in the drilled shafts did not exhibit significant additional movement.

Please call me at (440) 725-7425, if you have any question. Thank you.

Sincerely,

Robert Liang

Robert Liang

RECEIVED
JAN 28 2008
RICHLAND ENGINEERING LIMITED

Tie Beam Forces and Bending Moments (Driven Pile Cap side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	-47.1	68.5	551.7	681.8	313.73	10.70	616.75	252.30	375.15	83.06	-40.28	-2.75
	7/15/1999	-70.1	53.8	538.8	666.8	297.33	-8.15	602.80	234.35	360.30	78.72	-40.60	-2.82
	8/15/1999	10.7	114.3	613.7	728.1	366.70	62.50	670.90	312.20	421.20	97.09	-40.43	-2.44
	8/31/1999	12.0	114.3	617.3	732.8	369.10	63.15	675.05	314.65	423.55	97.73	-40.67	-2.44
	9/15/1999	13.1	113.5	619.7	737.5	370.95	63.30	678.60	316.40	425.50	98.22	-40.89	-2.44
	9/30/1999	29.6	122.3	634.4	753.4	384.93	75.95	693.90	332.00	437.85	101.92	-41.07	-2.37
	10/15/1999	34.7	123.9	637.8	757.9	388.58	79.30	697.85	336.25	440.90	102.88	-41.11	-2.34
	10/31/1999	39.8	127.2	646.6	762	393.90	83.50	704.30	343.20	444.60	104.29	-41.26	-2.27
	11/15/1999	62.3	139.3	662.9	780.1	411.15	100.80	721.50	362.60	459.70	108.86	-41.25	-2.18
	11/30/1999	73.7	146.3	670.6	788.6	419.80	110.00	729.60	372.15	467.45	111.15	-41.18	-2.13
	12/15/1999	72.8	143.6	668.9	789.7	418.75	108.20	729.30	370.85	466.65	110.87	-41.28	-2.15
	12/31/1999	88.8	152.1	680.1	802.5	430.88	120.45	741.30	384.45	477.30	114.08	-41.26	-2.08
	3/31/2000	95.3	158.7	682.5	825.2	440.43	127.00	753.85	388.90	491.95	116.61	-41.66	-2.31
	6/30/2000	60.2	138.2	662.7	804.5	416.40	99.20	733.60	361.45	471.35	110.25	-42.16	-2.46
	9/30/2000	50.1	142.5	668.8	795.7	414.28	96.30	732.25	359.45	469.10	109.69	-42.26	-2.46
	1/13/2001	109.5	179.9	712.3	845.5	461.80	144.70	778.90	410.90	512.70	122.27	-42.15	-2.28
	4/20/2001	126.8	283.2	715.3	881.9	501.80	205.00	798.60	421.05	582.55	132.86	-39.45	-3.62
	7/16/2001	68.3	149.8	674.3	837.1	432.38	109.05	755.70	371.30	493.45	114.48	-42.98	-2.74
	10/9/2001	71.4	157.1	685.5	840.8	438.70	114.25	763.15	378.45	498.95	116.15	-43.12	-2.70
	1/9/2002	102.7	177.8	713	872	466.38	140.25	792.50	407.85	524.90	123.48	-43.35	-2.62
	4/12/2002	125.5	192.8	738.6	904.9	490.45	159.15	821.75	432.05	548.85	129.86	-44.04	-2.62
	7/18/2002	62.3	151.8	706.334	859.6	445.01	107.05	782.97	384.32	505.70	117.82	-44.92	-2.72
1	10/8/2002	43.7	151.1	711.3	846.7	438.20	97.40	779.00	377.50	498.90	116.02	-45.30	-2.72
	1/8/2003	84.7	180.5	748.5	891.8	476.38	132.60	820.15	416.60	536.15	126.13	-45.69	-2.68
	4/15/2003	96.1	191.9	739.9	989.3	504.30	144.00	864.60	418.00	590.60	133.52	-47.89	-3.87
	7/1/2003	57.4	168	713	959	474.35	112.70	836.00	385.20	563.50	125.59	-48.07	-3.99
	10/7/2003	42.1	166.8	714	946.6	467.38	104.45	830.30	378.05	556.70	123.75	-48.24	-4.00
	12/31/2003	80	197.9	753.9	985.1	504.23	138.95	869.50	416.95	591.50	133.50	-48.55	-3.91
	4/13/2004	92	208.9	760.4	1006.6	516.98	150.45	883.50	426.20	607.75	136.88	-48.72	-4.07
	7/13/2004	14.6	163.9	707.3	954.4	460.05	89.25	830.85	360.95	559.15	121.81	-49.29	-4.44
	10/8/2004	-8.6	233.4	704.6	941	467.60	112.40	822.80	348.00	587.20	123.81	-47.21	-5.36
	1/7/2005	19.5	190.4	746.5	982.5	484.73	104.95	864.50	383.00	586.45	128.34	-50.48	-4.56
	4/8/2005	3.4	397.6	751.6	1003.4	539.00	200.50	877.50	377.50	700.50	142.71	-44.99	-7.24
	7/18/2005	3.1	164.3	709.7	969.6	461.68	83.70	839.65	356.40	566.95	122.24	-50.24	-4.72
	8/26/2005	3.1	157.5	702.5	956.3	454.85	80.30	829.40	352.80	556.90	120.43	-49.78	-4.57
	10/11/2005	3.1	164.2	712.6	960.1	460.00	83.65	836.35	357.85	562.15	121.79	-50.02	-4.58
	1/10/2006	3.1	191.9	742.5	997	483.63	97.50	869.75	372.80	594.45	128.05	-51.32	-4.97
	4/9/2006	3.5	205.3	750.7	1018.8	494.58	104.40	884.75	377.10	612.05	130.95	-51.86	-5.26
	7/19/2006	3.5	166.6	703.7	975.5	462.33	85.05	839.60	353.60	571.05	122.41	-50.15	-4.87
	10/18/2006	3.5	170.2	709	967.5	462.55	86.85	838.25	356.25	568.85	122.47	-49.94	-4.76
	1/18/2007	3.5	209.1	748.7	1013.1	493.60	106.30	880.90	376.10	611.10	130.69	-51.48	-5.26
	4/19/2007	3.5	216.6	743.7	1021.2	496.25	110.05	882.45	373.60	618.90	131.39	-51.33	-5.50
	7/11/2007	3.5	169.6	700.9	981.6	463.90	86.55	841.25	352.20	575.60	122.83	-50.16	-5.00
	10/20/2007	3.5	163.4	696	963.7	456.65	83.45	829.85	349.75	563.55	120.91	-49.60	-4.79
	1/7/2008	3.5	193.1	730.4	1002.9	482.48	98.30	866.65	366.95	598.00	127.74	-51.06	-5.18

Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	374.9	6	549.6	471.8	350.58	190.45	510.70	462.25	238.90	92.82	-21.28	5.00
	7/15/1999	368.6	-3.6	544.2	467.3	344.13	182.50	505.75	456.40	231.85	91.11	-21.48	5.03
	8/15/1999	373.7	0.2	569.4	485.2	357.13	186.95	527.30	471.55	242.70	94.56	-22.62	5.13
	8/31/1999	368.4	-4.7	567	486.2	354.23	181.85	526.60	467.70	240.75	93.79	-22.91	5.08
	9/15/1999	365.9	-9.2	565.3	485.1	351.78	178.35	525.20	465.60	237.95	93.14	-23.05	5.10
	9/30/1999	364.6	-11.7	570.1	487.6	352.65	176.45	528.85	467.35	237.95	93.37	-23.42	5.14
	10/15/1999	361.7	-14.8	569.9	487.4	351.05	173.45	528.65	465.80	236.30	92.95	-23.61	5.14
	10/31/1999	362.8	-13.5	575.6	493.1	354.50	174.65	534.35	469.20	239.80	93.86	-23.91	5.14
	11/15/1999	365.0	-11.5	581.4	498	358.23	176.75	539.70	473.20	243.25	94.85	-24.12	5.15
	11/30/1999	365.6	-11.8	583.7	500.1	359.40	176.90	541.90	474.65	244.15	95.16	-24.26	5.16
	12/15/1999	368.0	-9.2	589.7	504.2	363.18	179.40	546.95	478.85	247.50	96.16	-24.43	5.18
	12/31/1999	369.0	-8	592.9	506.6	365.13	180.50	549.75	480.95	249.30	96.67	-24.54	5.19
	3/31/2000	379.6	7.3	617	524.1	382.00	193.45	570.55	498.30	265.70	101.14	-25.06	5.21
	6/30/2000	376.1	4.4	608.9	519.1	377.13	190.25	564.00	492.50	261.75	99.85	-24.84	5.17
	9/30/2000	360.7	-12.3	588.3	503.5	360.05	174.20	545.90	474.50	245.60	95.33	-24.70	5.13
	1/13/2001	372.1	2.2	618.1	526.1	379.63	187.15	572.10	495.10	264.15	100.51	-25.58	5.17
	4/20/2001	387.6	21	645.8	549.2	400.90	204.30	597.50	516.70	285.10	106.15	-26.13	5.19
	7/16/2001	374.6	6.5	621.5	532.9	383.88	190.55	577.20	498.05	269.70	101.64	-25.70	5.12
	10/9/2001	360.9	-9.4	598.9	515.8	366.55	175.75	557.35	479.90	253.20	97.05	-25.36	5.08
	1/9/2002	363.5	-2.5	611.5	524.5	374.25	180.50	568.00	487.50	261.00	99.09	-25.75	5.07
	4/12/2002	381.7	16.9	642.7	550.5	397.95	199.30	596.60	512.20	283.70	105.37	-26.40	5.12
	7/18/2002	375	10.5	629	544.7	389.80	192.75	586.85	502.00	277.60	103.21	-26.19	5.03
12	10/8/2002	357.7	-9.6	599.2	523	367.58	174.05	561.10	478.45	256.70	97.32	-25.72	4.97
	1/8/2003	367.3	6.5	626.7	542.7	385.80	186.90	584.70	497.00	274.60	102.15	-26.44	4.98
	4/15/2003	385.9	27.3	655.3	566.2	408.68	206.60	610.75	520.60	296.75	108.20	-26.86	5.01
	7/1/2003	384.7	26.3	649.2	565.6	406.45	205.50	607.40	516.95	295.95	107.62	-26.71	4.95
	10/7/2003	360.6	3.5	613	539.7	379.20	182.05	576.35	486.80	271.60	100.40	-26.20	4.82
	12/31/2003	372	19.4	636	558.3	396.43	195.70	597.15	504.00	288.85	104.96	-26.68	4.82
	4/13/2004	389.4	39.8	665.5	583.1	419.45	214.60	624.30	527.45	311.45	111.06	-27.23	4.84
	7/13/2004	379.5	27.7	643.3	571.1	405.40	203.60	607.20	511.40	299.40	107.34	-26.82	4.75
	10/8/2004	361.6	10.3	615.2	550.9	384.50	185.95	583.05	488.40	280.60	101.80	-26.39	4.66
	1/7/2005	367.5	16.1	630.6	561.5	393.93	191.80	596.05	499.05	288.80	104.30	-26.87	4.71
	4/8/2005	388.2	35.6	662.3	587.2	418.33	211.90	624.75	525.25	311.40	110.76	-27.44	4.79
	7/18/2005	382.6	26.3	647.7	580.1	409.18	204.45	613.90	515.15	303.20	108.34	-27.21	4.75
	8/26/2005	373.6	15.7	629.8	566.8	396.48	194.65	598.30	501.70	291.25	104.97	-26.83	4.71
	10/11/2005	365.9	6.1	617.8	557.9	386.93	186.00	587.85	491.85	282.00	102.45	-26.71	4.70
	1/10/2006	376.2	17.5	639	572.2	401.23	196.85	605.60	507.60	294.85	106.23	-27.16	4.77
	4/9/2006	393.8	32.7	665.7	594	421.55	213.25	629.85	529.75	313.35	111.61	-27.69	4.85
	7/19/2006	384.2	20.3	646.2	582.7	408.35	202.25	614.45	515.20	301.50	108.12	-27.39	4.79
	10/18/2006	365	-2	614.4	558.2	383.90	181.50	586.30	489.70	278.10	101.65	-26.90	4.74
	1/18/2007	376	9.6	635.9	573.9	398.85	192.80	604.90	505.95	291.75	105.60	-27.39	4.80
	4/19/2007	390.7	24.1	659.3	592.7	416.70	207.40	626.00	525.00	308.40	110.33	-27.82	4.85
	7/11/2007	384.1	15	644.6	584.6	407.08	199.55	614.60	514.35	299.80	107.78	-27.58	4.81
	10/20/2007	363.7	-9.6	611.5	560.6	381.55	177.05	586.05	487.60	275.50	101.02	-27.18	4.75
	1/7/2008	371.2	-2.9	625.1	569.7	390.78	184.15	597.40	498.15	283.40	103.47	-27.46	4.81

Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	306.3	72.2	490.8	675.2	386.13	189.25	583.00	398.55	373.70	102.23	-26.17	0.56
	7/15/1999	288.0	53.1	484.2	670.6	373.98	170.55	577.40	386.10	361.85	99.02	-27.04	0.54
	8/15/1999	280.9	61.8	506.3	693.7	385.68	171.35	600.00	393.60	377.75	102.12	-28.49	0.36
	8/31/1999	270.4	52.1	503.1	691.4	379.25	161.25	597.25	386.75	371.75	100.41	-28.98	0.34
	9/15/1999	261.3	43.9	501.2	689.9	374.08	152.60	595.55	381.25	366.90	99.04	-29.44	0.32
	9/30/1999	257.1	40.7	503.1	690.7	372.90	148.90	596.90	380.10	365.70	98.73	-29.77	0.32
	10/15/1999	250.1	33.8	501.2	691	369.03	141.95	596.10	375.65	362.40	97.71	-30.18	0.30
	10/31/1999	251.4	38	507.6	697.6	373.65	144.70	602.60	379.50	367.80	98.93	-30.43	0.26
	11/15/1999	253.9	41.6	512.1	701.9	377.38	147.75	607.00	383.00	371.75	99.92	-30.52	0.25
	11/30/1999	253.5	41.2	513.6	704.4	378.18	147.35	609.00	383.55	372.80	100.13	-30.68	0.24
	12/15/1999	255.8	46.7	519.1	709.3	382.73	151.25	614.20	387.45	378.00	101.33	-30.77	0.21
	12/31/1999	256.7	48.9	522.3	712.4	385.08	152.80	617.35	389.50	380.65	101.96	-30.87	0.20
	3/31/2000	267.5	64.6	542.8	734.2	402.28	166.05	638.50	405.15	399.40	106.51	-31.40	0.13
	6/30/2000	258.9	46.4	531.2	726.1	390.65	152.65	628.65	395.05	386.25	103.43	-31.63	0.20
	9/30/2000	237.1	10.1	504.9	705.9	364.50	123.60	605.40	371.00	358.00	96.51	-32.02	0.29
	1/13/2001	254.0	40.9	535.1	734.6	391.15	147.45	634.85	394.55	387.75	103.56	-32.39	0.15
	4/20/2001	275.4	72.6	561.4	763.7	418.28	174.00	662.55	418.40	418.15	110.75	-32.47	0.01
	7/16/2001	255.3	37.7	534.8	740.9	392.18	146.50	637.85	395.05	389.30	103.84	-32.65	0.13
	10/9/2001	235.7	7.5	510.6	719.6	368.35	121.60	615.10	373.15	363.55	97.53	-32.80	0.22
	1/9/2002	240	18.9	523.3	731	378.30	129.45	627.15	381.65	374.95	100.16	-33.08	0.15
	4/12/2002	263.4	58.5	554.8	763	409.93	160.95	658.90	409.10	410.75	108.54	-33.09	-0.04
	7/18/2002	255.5	40.1	566.1	754.5	404.05	147.80	660.30	410.80	397.30	106.98	-34.06	0.30
13	10/8/2002	231.2	3.4	508.7	726.1	367.35	117.30	617.40	369.95	364.75	97.26	-33.24	0.12
	1/8/2003	249.4	38.5	540.1	754.4	395.60	143.95	647.25	394.75	396.45	104.74	-33.45	-0.04
	4/15/2003	276.4	78.5	571.6	784.9	427.85	177.45	678.25	424.00	431.70	113.28	-33.28	-0.17
	7/1/2003	273	69	561.4	779.9	420.83	171.00	670.65	417.20	424.45	111.42	-33.21	-0.16
	10/7/2003	246.6	22.5	524.7	744.6	384.60	134.55	634.65	385.65	383.55	101.83	-33.24	0.05
	12/31/2003	264.8	58.9	552.8	770.1	411.65	161.85	661.45	408.80	414.50	108.99	-33.20	-0.13
	4/13/2004	291.3	97.7	584	803.2	444.05	194.50	693.60	437.65	450.45	117.57	-33.17	-0.29
	7/13/2004	275.5	64.3	556.1	781	419.23	169.90	668.55	415.80	422.65	111.00	-33.14	-0.15
	10/8/2004	252.8	29.9	527.5	755.8	391.50	141.35	641.65	390.15	392.85	103.66	-33.25	-0.06
	1/7/2005	264	50.8	544.5	770.6	407.48	157.40	657.55	404.25	410.70	107.89	-33.24	-0.14
	4/8/2005	289.9	90.7	576	802	439.65	190.30	689.00	432.95	446.35	116.41	-33.14	-0.30
	7/18/2005	277.8	67.7	556.4	787.1	422.25	172.75	671.75	417.10	427.40	111.80	-33.16	-0.23
	8/26/2005	266.7	46.5	539.8	771.9	406.23	156.60	655.85	403.25	409.20	107.56	-33.18	-0.13
	10/11/2005	257.2	33.8	526.8	760.8	394.65	145.50	643.80	392.00	397.30	104.49	-33.12	-0.12
	1/10/2006	269.3	59.9	551.2	780.4	415.20	164.60	665.80	410.25	420.15	109.93	-33.31	-0.22
	4/9/2006	289.9	90	576.3	806.2	440.60	189.95	691.25	433.10	448.10	116.66	-33.32	-0.34
	7/19/2006	277.7	63.9	553.8	787.8	420.80	170.80	670.80	415.75	425.85	111.42	-33.23	-0.23
	10/18/2006	253.3	27.9	523.7	757.8	390.68	140.60	640.75	388.50	392.85	103.44	-33.24	-0.10
	1/18/2007	267.4	54.9	546.5	778.5	411.83	161.15	662.50	406.95	416.70	109.04	-33.32	-0.22
	4/19/2007	289	88.7	575.1	806.8	439.90	188.85	690.95	432.05	447.75	116.47	-33.37	-0.35
	7/11/2007	280	67	558	793.6	424.65	173.50	675.80	419.00	430.30	112.43	-33.38	-0.25
	10/20/2007	255.4	29.1	525	763.8	393.33	142.25	644.40	390.20	396.45	104.14	-33.37	-0.14
	1/7/2008	265.4	49.2	542.8	778	408.85	157.30	660.40	404.10	413.60	108.25	-33.44	-0.21

Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	445.4	53.9	802	298.7	400.00	249.65	550.35	623.70	176.30	105.91	-19.98	10.02
	7/15/1999	440.5	34.4	799.5	280.7	388.78	237.45	540.10	620.00	157.55	102.94	-20.11	10.36
	8/15/1999	455.6	40.8	837.6	284.6	404.65	248.20	561.10	646.60	162.70	107.14	-20.79	10.84
	8/31/1999	452.7	30.7	837.1	274.1	398.65	241.70	555.60	644.90	152.40	105.55	-20.86	11.03
	9/15/1999	448.5	21.7	836.8	266.2	393.30	235.10	551.50	642.65	143.95	104.13	-21.03	11.17
	9/30/1999	447.0	16.1	838.5	260.8	390.60	231.55	549.65	642.75	138.45	103.42	-21.14	11.30
	10/15/1999	446.5	8.8	839.3	255.1	387.43	227.65	547.20	642.90	131.95	102.58	-21.24	11.45
	10/31/1999	450.9	11.7	847.9	257.8	392.08	231.30	552.85	649.40	134.75	103.81	-21.37	11.53
	11/15/1999	455.9	16.1	856.2	259.8	397.00	236.00	558.00	656.05	137.95	105.11	-21.40	11.61
	11/30/1999	456.3	15.5	858.3	259	397.28	235.90	558.65	657.30	137.25	105.19	-21.45	11.65
	12/15/1999	461.3	20.5	865.6	261.7	402.28	240.90	563.65	663.45	141.10	106.51	-21.45	11.70
	12/31/1999	463.4	22.5	871.6	262.9	405.10	242.95	567.25	667.50	142.70	107.26	-21.55	11.76
	3/31/2000	477.8	35.6	903.8	282.7	424.98	256.70	593.25	690.80	159.15	112.52	-22.37	11.91
	6/30/2000	469.2	17.4	889.7	267.4	410.93	243.30	578.55	679.45	142.40	108.80	-22.28	12.03
	9/30/2000	453.5	-23.5	856.8	240.4	381.80	215.00	548.60	655.15	108.45	101.09	-22.17	12.25
	1/13/2001	476.9	5	891.3	257.6	407.70	240.95	574.45	684.10	131.30	107.95	-22.16	12.38
	4/20/2001	494.8	40.8	932.8	281.2	437.40	267.80	607.00	713.80	161.00	115.81	-22.54	12.38
	7/16/2001	475.7	4.9	900.7	255.9	409.30	240.30	578.30	688.20	130.40	108.37	-22.46	12.50
	10/9/2001	459.3	-30.8	870.4	236.8	383.93	214.25	553.60	664.85	103.00	101.65	-22.55	12.59
	1/9/2002	468.8	-18.5	883.7	241.5	393.88	225.15	562.60	676.25	111.50	104.29	-22.43	12.65
	4/12/2002	492.8	22.5	926.5	270.2	428.00	257.65	598.35	709.65	146.35	113.32	-22.64	12.62
	7/18/2002	483.5	3.8	911.9	257.3	414.13	243.65	584.60	697.70	130.55	109.65	-22.66	12.71
14	10/8/2002	462.7	-35	875.6	233	384.08	213.85	554.30	669.15	99.00	101.69	-22.63	12.77
	1/8/2003	485.5	2.5	912.6	253.9	413.63	244.00	583.25	699.05	128.20	109.52	-22.55	12.79
	4/15/2003	501.9	612.9	952.7	285.1	588.15	557.40	618.90	727.30	449.00	155.72	-4.09	6.23
	7/1/2003	521.6	28.8	943.4	278.1	442.98	275.20	610.75	732.50	153.45	117.29	-22.30	12.97
	10/7/2003	472.3	-16.5	903.8	247.5	401.78	227.90	575.65	688.05	115.50	106.38	-23.11	12.83
	12/31/2003	495.5	18.6	939.3	268.7	430.53	257.05	604.00	717.40	143.65	113.99	-23.06	12.85
	4/13/2004	504.6	68.9	989	299.2	465.43	286.75	644.10	746.80	184.05	123.23	-23.75	12.61
	7/13/2004	487.3	36.7	961.8	277.7	440.88	262.00	619.75	724.55	157.20	116.73	-23.78	12.71
	10/8/2004	468.9	-0.5	928.8	256.4	413.40	234.20	592.60	698.85	127.95	109.46	-23.82	12.79
	1/7/2005	485.2	21.4	952.7	269.7	432.25	253.30	611.20	718.95	145.55	114.45	-23.79	12.85
	4/8/2005	512.9	68.8	998.7	302.5	470.73	290.85	650.60	755.80	185.65	124.63	-23.91	12.77
	7/18/2005	498.2	40	977.1	286.8	450.53	269.10	631.95	737.65	163.40	119.29	-24.11	12.86
	8/26/2005	486.3	17.1	955.5	271.8	432.68	251.70	613.65	720.90	144.45	114.56	-24.05	12.91
	10/11/2005	478.8	2.4	942.6	263.6	421.85	240.60	603.10	710.70	133.00	111.69	-24.09	12.94
	1/10/2006	497.9	28.2	970.6	280.6	444.33	263.05	625.60	734.25	154.40	117.64	-24.09	12.99
	4/9/2006	519.6	65.1	1008.9	306	474.90	292.35	657.45	764.25	185.55	125.74	-24.26	12.96
	7/19/2006	505.7	73.4	984.2	290.7	463.50	289.55	637.45	744.95	182.05	122.72	-23.12	12.61
	10/18/2006	484	-5.7	946.5	265.8	422.65	239.15	606.15	715.25	130.05	111.91	-24.39	13.11
	1/18/2007	503	21.5	974.4	282.5	445.35	262.25	628.45	738.70	152.00	117.92	-24.34	13.14
	4/19/2007	525.1	60.9	1012.9	309.1	477.00	293.00	661.00	769.00	185.00	126.30	-24.46	13.08
	7/11/2007	533.8	36.8	994.5	295.1	465.05	285.30	644.80	764.15	165.95	123.13	-23.89	13.40
	10/20/2007	487.8	-9.1	953.8	269.9	425.60	239.35	611.85	720.80	130.40	112.69	-24.76	13.23
	1/7/2008	504.2	11.4	976	284.1	443.93	257.80	630.05	740.10	147.75	117.54	-24.74	13.27

Tie Beam Forces and Bending Moments (Driven Pile Cap side)(cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
26	7/1/1999	468.3	92.2	387.7	511.7	364.98	280.25	449.70	428.00	301.95	96.63	-11.26	2.82
	7/15/1999	460.1	81	381.5	505.7	357.08	270.55	443.60	420.80	293.35	94.54	-11.50	2.86
	8/15/1999	482.3	96.1	410.7	526	378.78	289.20	468.35	446.50	311.05	100.29	-11.91	3.03
	8/31/1999	490.3	101.9	422.4	535	387.40	296.10	478.70	456.35	318.45	102.57	-12.14	3.09
	9/15/1999	491.0	101.4	426.3	536.4	388.78	296.20	481.35	458.65	318.90	102.94	-12.30	3.13
	9/30/1999	497.9	106.7	434.7	543.6	395.73	302.30	489.15	466.30	325.15	104.78	-12.42	3.16
	10/15/1999	505.0	112.3	443.2	550.9	402.85	308.65	497.05	474.10	331.60	106.66	-12.52	3.19
	10/31/1999	515.6	118.8	452.5	560.9	411.95	317.20	506.70	484.05	339.85	109.07	-12.59	3.23
	11/15/1999	525.0	128.3	463.4	570.2	421.73	326.65	516.80	494.20	349.25	111.66	-12.64	3.25
	11/30/1999	532.5	134.9	471.5	576.8	428.93	333.70	524.15	502.00	355.85	113.57	-12.66	3.27
	12/15/1999	534.1	138.1	476.5	580.2	432.23	336.10	528.35	505.30	359.15	114.44	-12.78	3.27
	12/31/1999	540.4	144.3	484.4	587.2	439.08	342.35	535.80	512.40	365.75	116.25	-12.86	3.29
	3/31/2000	551.1	156	501.3	602.1	452.63	353.55	551.70	526.20	379.05	119.84	-13.17	3.30
	6/30/2000	533.5	137.3	477.6	577.9	431.58	335.40	527.75	505.55	357.60	114.27	-12.78	3.31
	9/30/2000	539.6	136.8	480.7	575.1	433.05	338.20	527.90	510.15	355.95	114.66	-12.61	3.45
	1/13/2001	571.4	169.7	522.7	611.8	468.90	370.55	567.25	547.05	390.75	124.15	-13.07	3.50
	4/20/2001	580.2	184.8	537.9	624.6	481.88	382.50	581.25	559.05	404.70	127.59	-13.21	3.46
	7/16/2001	555.8	159.1	508	598.6	455.38	357.45	553.30	531.90	378.85	120.57	-13.02	3.43
	10/9/2001	556.2	154.1	506	595.8	453.03	355.15	550.90	531.10	374.95	119.95	-13.01	3.50
	1/9/2002	572	170.3	527.3	614.7	471.08	371.15	571.00	549.65	392.50	124.73	-13.28	3.52
	4/12/2002	584.6	187.7	546.3	632.8	487.85	386.15	589.55	565.45	410.25	129.17	-13.52	3.48
	7/18/2002	559.5	162.1	516.1	606	460.93	360.80	561.05	537.80	384.05	122.04	-13.31	3.44
	10/8/2002	557	154.4	511	599.8	455.55	355.70	555.40	534.00	377.10	120.62	-13.27	3.51
	1/8/2003	591	189.2	552.8	639	493.00	390.10	595.90	571.90	414.10	130.53	-13.68	3.54
	4/15/2003	597.9	204.3	567.5	650.5	505.05	401.10	609.00	582.70	427.40	133.72	-13.82	3.48
	7/1/2003	580.7	184.3	545.4	632.5	485.73	382.50	588.95	563.05	408.40	128.61	-13.72	3.46
	10/7/2003	578.2	176.3	538	627	479.88	377.25	582.50	558.10	401.65	127.06	-13.64	3.50
	12/31/2003	610.3	207.7	572.6	661.6	513.05	409.00	617.10	591.45	434.65	135.84	-13.83	3.51
	4/13/2004	617.1	224.2	589.5	675.7	526.63	420.65	632.60	603.30	449.95	139.43	-14.09	3.44
	7/13/2004	584	186.6	549.1	642.6	490.58	385.30	595.85	566.55	414.60	129.89	-13.99	3.40
	10/8/2004	581.8	181.2	543.7	638.3	486.25	381.50	591.00	562.75	409.75	128.74	-13.92	3.43
	1/7/2005	609.9	209	574.8	669.1	515.70	409.45	621.95	592.35	439.05	136.54	-14.12	3.43
	4/8/2005	617.5	225	590.2	683.9	529.15	421.25	637.05	603.85	454.45	140.10	-14.34	3.35
	7/18/2005	590.4	192.7	554.7	656	498.45	391.55	605.35	572.55	424.35	131.97	-14.21	3.32
	8/26/2005	584.4	183.1	544	647.8	489.83	383.75	595.90	564.20	415.45	129.69	-14.10	3.33
	10/11/2005	589.3	185.9	548.5	652	493.93	387.60	600.25	568.90	418.95	130.78	-14.13	3.36
	1/10/2006	616	216.1	582.8	683.4	524.58	416.05	633.10	599.40	449.75	138.89	-14.42	3.35
	4/9/2006	629	235.4	605.8	701.1	542.83	432.20	653.45	617.40	468.25	143.72	-14.70	3.34
	7/19/2006	595.8	199	563.1	668.3	506.55	397.40	615.70	579.45	433.65	134.12	-14.51	3.27
	10/18/2006	595.6	193	557.4	662.8	502.20	394.30	610.10	576.50	427.90	132.97	-14.34	3.33
	1/18/2007	622.2	223.4	590.2	694.6	532.60	422.80	642.40	606.20	459.00	141.02	-14.59	3.30
	4/19/2007	624.5	231.7	598.4	701.1	538.93	428.10	649.75	611.45	466.40	142.69	-14.73	3.25
	7/11/2007	594.6	199.2	561.5	670.8	506.53	396.90	616.15	578.05	435.00	134.11	-14.57	3.20
	10/20/2007	588.7	187	550.3	661.8	496.95	387.85	606.05	569.50	424.40	131.58	-14.50	3.25
	1/7/2008	619.8	219.6	589.6	697.1	531.53	419.70	643.35	604.70	458.35	140.73	-14.86	3.28

Tie Beam Forces and Bending Moments (Drilled Shaft side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	-115.0	299.7	422.9	109.6	179.30	92.35	266.25	153.95	204.65	47.47	-11.56	-1.14
	7/15/1999	-122.0	289	405.2	95.6	166.95	83.50	250.40	141.60	192.30	44.20	-11.09	-1.14
	8/15/1999	-139.4	265.8	401.5	101.8	157.43	63.20	251.65	131.05	183.80	41.68	-12.52	-1.18
	8/31/1999	-144.1	258.4	394.7	99.6	152.15	57.15	247.15	125.30	179.00	40.28	-12.63	-1.20
	9/15/1999	-144.1	255.9	395.1	102	152.23	55.90	248.55	125.50	178.95	40.30	-12.80	-1.20
	9/30/1999	-141.7	260.4	408.3	112.3	159.83	59.35	260.30	133.30	186.35	42.32	-13.35	-1.19
	10/15/1999	-138.1	275.3	441.9	138.4	179.38	68.60	290.15	151.90	206.85	47.49	-14.72	-1.23
	10/31/1999	-148.1	272.7	430.1	118.5	168.30	62.30	274.30	141.00	195.60	44.56	-14.09	-1.22
	11/15/1999	-142.3	278.9	446.6	134.9	179.53	68.30	290.75	152.15	206.90	47.53	-14.78	-1.23
	11/30/1999	-137.9	284.4	462	150.8	189.83	73.25	306.40	162.05	217.60	50.26	-15.49	-1.24
	12/15/1999	-135.4	290	463.8	152.5	192.73	77.30	308.15	164.20	221.25	51.03	-15.34	-1.28
	12/31/1999	-126.8	301.4	481.4	168.9	206.23	87.30	325.15	177.30	235.15	54.60	-15.81	-1.30
	3/31/2000	-133.9	283.1	455.7	149.6	188.63	74.60	302.65	160.90	216.35	49.94	-15.16	-1.24
	6/30/2000	-157.3	230.6	397.4	119.3	147.50	36.65	258.35	120.05	174.95	39.05	-14.73	-1.23
	9/30/2000	-142.8	237.4	427.4	156.8	169.70	47.30	292.10	142.30	197.10	44.93	-16.27	-1.23
	1/13/2001	-118.2	295.4	511.7	182.5	217.85	88.60	347.10	196.75	238.95	57.68	-17.18	-0.95
	4/20/2001	-128.9	270.9	454	163.4	189.85	71.00	308.70	162.55	217.15	50.27	-15.80	-1.22
	7/16/2001	-146.4	213.9	384.1	133.3	146.23	33.75	258.70	118.85	173.60	38.72	-14.95	-1.23
	10/9/2001	-135.7	237.5	439.4	178.3	179.88	50.90	308.85	151.85	207.90	47.63	-17.14	-1.26
	1/9/2002	-120.2	281.4	483	190.7	208.73	80.60	336.85	181.40	236.05	55.26	-17.03	-1.22
	4/12/2002	-133.2	263.6	441.1	154.2	181.43	65.20	297.65	153.95	208.90	48.04	-15.45	-1.23
	7/18/2002	-158.1	191.2	355.6	118	126.68	16.55	236.80	98.75	154.60	33.54	-14.64	-1.25
1	10/7/2002	-149.2	192.4	391.7	156.3	147.80	21.60	274.00	121.25	174.35	39.13	-16.77	-1.19
	1/8/2003	-123.2	268.7	469.3	191.8	201.65	72.75	330.55	173.05	230.25	53.39	-17.13	-1.28
	4/15/2003	-137.5	248.4	427.1	157.1	173.78	55.45	292.10	144.80	202.75	46.01	-15.73	-1.30
	7/1/2003	-159.7	183.9	351.2	124.6	125.00	12.10	237.90	95.75	154.25	33.10	-15.01	-1.31
	10/7/2003	-146.6	206.4	412.6	177.8	162.55	29.90	295.20	133.00	192.10	43.04	-17.63	-1.32
	12/31/2003	-135.4	243.4	450.4	190	187.10	54.00	320.20	157.50	216.70	49.54	-17.69	-1.33
	4/13/2004	-144.6	228.6	422.1	168	168.53	42.00	295.05	138.75	198.30	44.62	-16.82	-1.33
	7/13/2004	-179.1	155.6	334.2	117.5	107.05	-11.75	225.85	77.55	136.55	28.34	-15.79	-1.32
	10/8/2004	-169	170.9	373.7	152.9	132.13	0.95	263.30	102.35	161.90	34.98	-17.44	-1.33
	1/7/2005	-145.5	227.8	440.5	188.2	177.75	41.15	314.35	147.50	208.00	47.06	-18.16	-1.36
	4/8/2005	-159.4	209.2	398.5	148.8	149.28	24.90	273.65	119.55	179.00	39.52	-16.53	-1.33
	7/18/2005	-182.8	141.5	330.3	131.3	105.08	-20.65	230.80	73.75	136.40	27.82	-16.71	-1.40
	8/26/2005	-184	140.7	341.3	131.3	107.33	-21.65	236.30	78.65	136.00	28.42	-17.14	-1.28
	10/11/2005	-174.2	159.1	370.9	131.3	121.78	-7.55	251.10	98.35	145.20	32.24	-17.19	-1.05
	1/10/2006	-152.5	216.4	430.7	131.3	156.48	31.95	281.00	139.10	173.85	41.43	-16.55	-0.78
	4/9/2006	-157.2	206.1	413	131.3	148.30	24.45	272.15	127.90	168.70	39.27	-16.46	-0.91
	7/19/2006	-189.4	135.9	330	131.3	101.95	-26.75	230.65	70.30	133.60	26.99	-17.11	-1.42
	10/18/2006	-170.5	170.2	390.6	131.3	130.40	-0.15	260.95	110.05	150.75	34.53	-17.35	-0.91
	1/18/2007	-145.4	217.2	448.1	131.3	162.80	35.90	289.70	151.35	174.25	43.10	-16.87	-0.51
	4/19/2007	-159.2	203.2	410.4	131.3	146.43	22.00	270.85	125.60	167.25	38.77	-16.54	-0.93
	7/11/2007	-192.9	128.3	318.7	131.3	96.35	-32.30	225.00	62.90	129.80	25.51	-17.10	-1.50
	10/20/2007	-183.2	145.9	358.7	131.3	113.18	-18.65	245.00	87.75	138.60	29.97	-17.52	-1.14
	1/7/2008	-155.6	207.5	426.7	131.3	152.48	25.95	279.00	135.55	169.40	40.37	-16.82	-0.76

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	356.2	257	201.2	275.1	272.38	306.60	238.15	278.70	266.05	72.12	4.55	0.28
	7/15/1999	353.8	251.6	188.4	273.4	266.80	302.70	230.90	271.10	262.50	70.64	4.77	0.19
	8/15/1999	350.0	242.8	195.3	301.1	272.30	296.40	248.20	272.65	271.95	72.10	3.20	0.02
	8/31/1999	350.2	247.8	201.7	307.9	276.90	299.00	254.80	275.95	277.85	73.31	2.94	-0.04
	9/15/1999	349.8	249.1	203.6	314	279.13	299.45	258.80	276.70	281.55	73.90	2.70	-0.11
	9/30/1999	352.2	256.8	212.1	322.7	285.95	304.50	267.40	282.15	289.75	75.71	2.47	-0.17
	10/15/1999	352.6	257.7	225.5	337.3	293.28	305.15	281.40	289.05	297.50	77.65	1.58	-0.19
	10/31/1999	361.0	268.5	222.6	333.7	296.45	314.75	278.15	291.80	301.10	78.49	2.43	-0.21
	11/15/1999	364.5	273.1	237.1	353.6	307.08	318.80	295.35	300.80	313.35	81.30	1.56	-0.28
	11/30/1999	367.6	276.3	249.1	369.4	315.60	321.95	309.25	308.35	322.85	83.56	0.84	-0.32
	12/15/1999	370.6	280.7	248.5	364.3	316.03	325.65	306.40	309.55	322.50	83.67	1.28	-0.29
	12/31/1999	371.2	282.5	254.8	368.8	319.33	326.85	311.80	313.00	325.65	84.55	1.00	-0.28
	3/31/2000	376.0	289.2	244.7	361.1	317.75	332.60	302.90	310.35	325.15	84.13	1.97	-0.33
	6/30/2000	358.4	247.7	207.4	329.3	285.70	303.05	268.35	282.90	288.50	75.64	2.31	-0.13
	9/30/2000	357.6	235.9	230.1	366.4	297.50	296.75	298.25	293.85	301.15	78.77	-0.10	-0.16
	1/13/2001	382.0	289.5	264.4	384.8	330.18	335.75	324.60	323.20	337.15	87.42	0.74	-0.31
	4/20/2001	382.9	294.9	260.1	378.2	329.03	338.90	319.15	321.50	336.55	87.12	1.31	-0.34
	7/16/2001	352.4	249.4	219.2	330.6	287.90	300.90	274.90	285.80	290.00	76.23	1.73	-0.09
	10/9/2001	357.7	267.9	262.1	382	317.43	312.80	322.05	309.90	324.95	84.04	-0.61	-0.34
	1/9/2002	385.8	301.2	285.1	395.6	341.93	343.50	340.35	335.45	348.40	90.53	0.21	-0.29
	4/12/2002	390.9	310.2	263.2	370.1	333.60	350.55	316.65	327.05	340.15	88.33	2.25	-0.29
	7/18/2002	346.39	265.03	220.4	323.3	288.78	305.71	271.85	283.39	294.17	76.46	2.25	-0.24
12	10/7/2002	344.5	265.3	252.4	363.5	306.43	304.90	307.95	298.45	314.40	81.13	-0.20	-0.36
	1/8/2003	385.9	308.5	295.9	394.3	346.15	347.20	345.10	340.90	351.40	91.65	0.14	-0.24
	4/15/2003	392.4	317.3	275.8	371.1	339.15	354.85	323.45	334.10	344.20	89.80	2.09	-0.23
	7/1/2003	360	288.1	238.7	332.8	304.90	324.05	285.75	299.35	310.45	80.73	2.55	-0.25
	10/7/2003	357.1	284.5	277.7	372.1	322.85	320.80	324.90	317.40	328.30	85.48	-0.27	-0.24
	12/31/2003	387.7	318.7	304.1	392.5	350.75	353.20	348.30	345.90	355.60	92.87	0.33	-0.22
	4/13/2004	389.4	324.2	294.9	381.2	347.43	356.80	338.05	342.15	352.70	91.99	1.25	-0.24
	7/13/2004	348	285.8	241	324.8	299.90	316.90	282.90	294.50	305.30	79.40	2.26	-0.24
	10/8/2004	342.4	281.8	269.4	353.1	311.68	312.10	311.25	305.90	317.45	82.52	0.06	-0.26
	1/7/2005	374.1	315.2	302.9	382.8	343.75	344.65	342.85	338.50	349.00	91.01	0.12	-0.24
	4/8/2005	386.7	328.9	284.3	365	341.23	357.80	324.65	335.50	346.95	90.35	2.20	-0.26
	7/18/2005	343.2	285.5	242.4	322.1	298.30	314.35	282.25	292.80	303.80	78.98	2.13	-0.25
	8/26/2005	337	278.7	250.1	331.1	299.23	307.85	290.60	293.55	304.90	79.23	1.15	-0.25
	10/11/2005	338.7	283.6	264.1	348.6	308.75	311.15	306.35	301.40	316.10	81.75	0.32	-0.33
	1/10/2006	371.5	317.4	297	373.5	339.85	344.45	335.25	334.25	345.45	89.98	0.61	-0.25
	4/9/2006	377.4	324.1	290.6	368.2	340.08	350.75	329.40	334.00	346.15	90.04	1.42	-0.27
	7/19/2006	341.9	289.2	238.8	315.3	296.30	315.55	277.05	290.35	302.25	78.45	2.56	-0.27
	10/18/2006	342.7	289.5	274.8	354.5	315.38	316.10	314.65	308.75	322.00	83.50	0.10	-0.30
	1/18/2007	368.4	316.6	305.5	385	343.88	342.50	345.25	336.95	350.80	91.05	-0.18	-0.31
	4/19/2007	370.5	320.9	279.2	353.9	331.13	345.70	316.55	324.85	337.40	87.67	1.94	-0.28
	7/11/2007	326.6	278.1	219	294	279.43	302.35	256.50	272.80	286.05	73.98	3.05	-0.30
	10/20/2007	325.9	278.3	243.8	321.7	292.43	302.10	282.75	284.85	300.00	77.43	1.29	-0.34
	1/7/2008	359.2	310.2	282.8	353	326.30	334.70	317.90	321.00	331.60	86.39	1.12	-0.24

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	177.4	380.2	417.6	236.2	302.85	278.80	326.90	297.50	308.20	80.19	-3.20	-0.24
	7/15/1999	173.8	378	412.7	230.2	298.68	275.90	321.45	293.25	304.10	79.08	-3.03	-0.24
	8/15/1999	172.8	380.2	439.6	252.6	311.30	276.50	346.10	306.20	316.40	82.42	-4.63	-0.23
	8/31/1999	172.6	378	445.8	257.5	313.48	275.30	351.65	309.20	317.75	83.00	-5.07	-0.19
	9/15/1999	170.9	377.2	447.2	261	314.08	274.05	354.10	309.05	319.10	83.16	-5.32	-0.23
	9/30/1999	176.4	380.7	455.9	269.3	320.58	278.55	362.60	316.15	325.00	84.88	-5.59	-0.20
	10/15/1999	176.7	378.9	468.1	279.5	325.80	277.80	373.80	322.40	329.20	86.26	-6.38	-0.15
	10/31/1999	182.4	385.8	502.1	273.8	336.03	284.10	387.95	342.25	329.80	88.97	-6.90	0.28
	11/15/1999	186.8	392.4	482.7	292	338.48	289.60	387.35	334.75	342.20	89.62	-6.50	-0.17
	11/30/1999	189.8	396.8	638.9	305.6	382.78	293.30	472.25	414.35	351.20	101.35	-11.89	1.41
	12/15/1999	193.5	401.1	516.7	302.2	353.38	297.30	409.45	355.10	351.65	93.56	-7.45	0.08
	12/31/1999	194.7	406.1	507.2	308	354.00	300.40	407.60	350.95	357.05	93.73	-7.12	-0.14
	3/31/2000	194.8	409	492.7	298.7	348.80	301.90	395.70	343.75	353.85	92.35	-6.23	-0.23
	6/30/2000	177.7	389.4	467.2	278.7	328.25	283.55	372.95	322.45	334.05	86.91	-5.94	-0.26
	9/30/2000	174.2	385.1	496.7	308	341.00	279.65	402.35	335.45	346.55	90.29	-8.15	-0.25
	1/13/2001	200.0	418.2	530.3	318.6	366.78	309.10	424.45	365.15	368.40	97.11	-7.67	-0.07
	4/20/2001	194.1	416.2	512.8	310.6	358.43	305.15	411.70	353.45	363.40	94.90	-7.08	-0.22
	7/16/2001	166.5	386.2	469	273.8	323.88	276.35	371.40	317.75	330.00	85.75	-6.32	-0.27
	10/9/2001	171.5	389.1	514.8	315.2	347.65	280.30	415.00	343.15	352.15	92.05	-8.95	-0.20
	1/9/2002	193.6	413.6	539.3	324.6	367.78	303.60	431.95	366.45	369.10	97.38	-8.53	-0.06
	4/12/2002	198.8	418.5	509.3	299.2	356.45	308.65	404.25	354.05	358.85	94.38	-6.35	-0.11
	7/18/2002	161.4	379.1	462.4	262.6	316.38	270.25	362.50	311.90	320.85	83.77	-6.13	-0.20
13	10/7/2002	155.8	373.6	686.8	301.1	379.33	264.70	493.95	421.30	337.35	100.43	-15.24	1.88
	1/8/2003	193.1	414	547.6	331	371.43	303.55	439.30	370.35	372.50	98.34	-9.02	-0.05
	4/15/2003	195.8	419.9	560.6	305.7	370.50	307.85	433.15	378.20	362.80	98.10	-8.33	0.34
	7/1/2003	172.1	394.8	479.4	273.9	330.05	283.45	376.65	325.75	334.35	87.39	-6.19	-0.19
	10/7/2003	169	389.1	527.1	317.5	350.68	279.05	422.30	348.05	353.30	92.85	-9.52	-0.12
	12/31/2003	196.2	423.2	560.3	334.7	378.60	309.70	447.50	378.25	378.95	100.24	-9.16	-0.02
	4/13/2004	197.9	424.7	546.1	321.7	372.60	311.30	433.90	372.00	373.20	98.65	-8.15	-0.03
	7/13/2004	155.6	383.5	482.7	266.1	321.98	269.55	374.40	319.15	324.80	85.25	-6.97	-0.13
	10/8/2004	152.2	378.4	519	298.6	337.05	265.30	408.80	335.60	338.50	89.24	-9.54	-0.06
	1/7/2005	180.6	410.6	556.1	324.9	368.05	295.60	440.50	368.35	367.75	97.45	-9.63	0.01
	4/8/2005	188.3	419.5	529.1	301	359.48	303.90	415.05	358.70	360.25	95.18	-7.39	-0.03
	7/18/2005	150.7	376.8	482.9	262.2	318.15	263.75	372.55	316.80	319.50	84.24	-7.23	-0.06
	8/26/2005	144.7	373.1	494.1	275.3	321.80	258.90	384.70	319.40	324.20	85.20	-8.36	-0.11
	10/11/2005	146.5	375.2	533.7	291.5	336.73	260.85	412.60	340.10	333.35	89.15	-10.09	0.15
	1/10/2006	176	407.1	548.8	313.5	361.35	291.55	431.15	362.40	360.30	95.67	-9.28	0.05
	4/9/2006	180.6	412.1	538.7	307.8	359.80	296.35	423.25	359.65	359.95	95.26	-8.43	-0.01
	7/19/2006	149.4	377.4	480.1	259.8	316.68	263.40	369.95	314.75	318.60	83.85	-7.08	-0.09
	10/18/2006	155.2	382.8	532.6	304.1	343.68	269.00	418.35	343.90	343.45	90.99	-9.93	0.01
	1/18/2007	179.5	407.9	563.5	330.9	370.45	293.70	447.20	371.50	369.40	98.08	-10.20	0.05
	4/19/2007	182.7	413.5	536	305.6	359.45	298.10	420.80	359.35	359.55	95.17	-8.15	0.00
	7/11/2007	146.1	373.2	467.5	250.6	309.35	259.65	359.05	306.80	311.90	81.91	-6.61	-0.11
	10/20/2007	144.3	373.6	638.9	278.5	358.83	258.95	458.70	391.60	326.05	95.01	-13.28	1.47
	1/7/2008	179.2	408.8	548	312	362.00	294.00	430.00	363.60	360.40	95.85	-9.04	0.07

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	199.5	418.4	473.6	323.8	353.83	308.95	398.70	336.55	371.10	93.68	-5.96	-0.77
	7/15/1999	194.3	414.4	461.1	314.4	346.05	304.35	387.75	327.70	364.40	91.62	-5.54	-0.82
	8/15/1999	191.0	402.1	488.7	347.5	357.33	296.55	418.10	339.85	374.80	94.61	-8.08	-0.78
	8/31/1999	189.5	395.4	496	352.6	358.38	292.45	424.30	342.75	374.00	94.89	-8.76	-0.70
	9/15/1999	186.8	391.6	503.6	359.8	360.45	289.20	431.70	345.20	375.70	95.44	-9.47	-0.68
	9/30/1999	188.5	396.7	516	369	367.55	292.60	442.50	352.25	382.85	97.32	-9.96	-0.69
	10/15/1999	235.3	403	530.4	378.9	386.90	319.15	454.65	382.85	390.95	102.44	-9.01	-0.18
	10/31/1999	202.7	418.5	524.2	371.5	379.23	310.60	447.85	363.45	395.00	100.41	-9.12	-0.71
	11/15/1999	208.9	426.2	548.2	393.2	394.13	317.55	470.70	378.55	409.70	104.35	-10.18	-0.70
	11/30/1999	212.9	429.2	566.6	409.5	404.55	321.05	488.05	389.75	419.35	107.11	-11.10	-0.66
	12/15/1999	216.9	433.5	561.4	403.7	403.88	325.20	482.55	389.15	418.60	106.93	-10.46	-0.66
	12/31/1999	220.7	443.8	566.6	407.4	409.63	332.25	487.00	393.65	425.60	108.46	-10.28	-0.72
	3/31/2000	215.2	438.2	567.9	406.5	406.95	326.70	487.20	391.55	422.35	107.75	-10.67	-0.69
	6/30/2000	191.3	415.8	542.4	380.7	382.55	303.55	461.55	366.85	398.25	101.29	-10.50	-0.70
	6/30/2000	183.3	409.8	571	409.9	393.50	296.55	490.45	377.15	409.85	104.19	-12.89	-0.73
	1/13/2001	215.4	447.2	588.9	421.9	418.35	331.30	505.40	402.15	434.55	110.77	-11.57	-0.73
	4/20/2001	210.2	445.1	586.6	415.7	414.40	327.65	501.15	398.40	430.40	109.72	-11.53	-0.72
	7/16/2001	171.2	413	554.5	377.7	379.10	292.10	466.10	362.85	395.35	100.37	-11.56	-0.73
	10/9/2001	178.5	417.9	596.2	418.8	402.85	298.20	507.50	387.35	418.35	106.66	-13.91	-0.69
	1/9/2002	206.2	445.9	606.4	430	422.13	326.05	518.20	406.30	437.95	111.77	-12.77	-0.71
	4/12/2002	208.6	449.5	584.1	408.1	412.58	329.05	496.10	396.35	428.80	109.24	-11.10	-0.73
	7/18/2002	161.7	410.1	551.9	368.5	373.05	285.90	460.20	356.80	389.30	98.77	-11.58	-0.73
14	10/7/2002	160.2	405.5	592.3	407.7	391.43	282.85	500.00	376.25	406.60	103.64	-14.43	-0.68
	1/8/2003	202	449.1	620.2	437.7	427.25	325.55	528.95	411.10	443.40	113.12	-13.52	-0.72
	4/15/2003	205.4	453.6	590	409.8	414.70	329.50	499.90	397.70	431.70	109.80	-11.32	-0.76
	7/1/2003	171.9	426.9	559.5	377.3	383.90	299.40	468.40	365.70	402.10	101.65	-11.23	-0.82
	10/7/2003	172	424.4	600.8	422.4	404.90	298.20	511.60	386.40	423.40	107.21	-14.18	-0.83
	12/31/2003	205.6	461.3	624.2	444.9	434.00	333.45	534.55	414.90	453.10	114.91	-13.36	-0.86
	4/13/2004	204.7	463.4	611.5	433.1	428.18	334.05	522.30	408.10	448.25	113.37	-12.51	-0.90
	7/13/2004	159.6	424.2	566.4	383.7	383.48	291.90	475.05	363.00	403.95	101.53	-12.17	-0.92
	10/8/2004	153	416.8	590.5	409.5	392.45	284.90	500.00	371.75	413.15	103.91	-14.30	-0.93
	1/7/2005	192.8	454.9	627.8	446.9	430.60	323.85	537.35	410.30	450.90	114.01	-14.19	-0.91
	4/8/2005	205.2	467.5	600.9	425.2	424.70	336.35	513.05	403.05	446.35	112.45	-11.74	-0.97
	7/18/2005	154.9	424.1	560.9	385.2	381.28	289.50	473.05	357.90	404.65	100.95	-12.20	-1.05
	8/26/2005	168.3	416.1	569.1	391.2	386.18	292.20	480.15	368.70	403.65	102.25	-12.49	-0.78
	10/11/2005	152.5	418.5	590.5	413.4	393.73	285.50	501.95	371.50	415.95	104.25	-14.38	-1.00
	1/10/2006	190.7	455.4	615	436.7	424.45	323.05	525.85	402.85	446.05	112.38	-13.48	-0.97
	4/9/2006	196.7	460.2	612.3	436.6	426.45	328.45	524.45	404.50	448.40	112.91	-13.03	-0.98
	7/19/2006	159.7	426.1	562.3	382.1	382.55	292.90	472.20	361.00	404.10	101.29	-11.92	-0.97
	10/18/2006	161.9	425.9	600.5	422.5	402.70	293.90	511.50	381.20	424.20	106.62	-14.46	-0.96
	1/18/2007	192.2	454.2	638.5	460	436.23	323.20	549.25	415.35	457.10	115.50	-15.02	-0.94
	4/19/2007	198.7	462.5	611.3	432	426.13	330.60	521.65	405.00	447.25	112.83	-12.70	-0.95
	7/11/2007	149.8	419.9	567.4	379.8	379.23	284.85	473.60	358.60	399.85	100.41	-12.54	-0.92
	10/20/2007	208.9	417	590.1	409	406.25	312.95	499.55	399.50	413.00	107.56	-12.40	-0.30
	1/7/2008	194.6	460.1	617.4	439.8	427.98	327.35	528.60	406.00	449.95	113.31	-13.37	-0.98

Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	222.2	-19.9	305.2	560	266.88	101.15	432.60	263.70	270.05	70.66	-22.03	-0.14
	7/15/1999	207.8	-36.8	294.3	540.9	251.55	85.50	417.60	251.05	252.05	66.60	-22.07	-0.02
	8/15/1999	189.9	-53.4	320.4	546.8	250.93	68.25	433.60	255.15	246.70	66.44	-24.28	0.19
	8/31/1999	184.8	-60	330.2	555.2	252.55	62.40	442.70	257.50	247.60	66.87	-25.27	0.22
	9/15/1999	185.7	-57.2	336.6	558.2	255.83	64.25	447.40	261.15	250.50	67.73	-25.46	0.24
	9/30/1999	187.5	-53.7	349.9	570.1	263.45	66.90	460.00	268.70	258.20	69.75	-26.12	0.24
	10/15/1999	195.3	-50.5	375.2	601.5	280.38	72.40	488.35	285.25	275.50	74.23	-27.64	0.22
	10/31/1999	197.3	-39.9	370.8	589.7	279.48	78.70	480.25	284.05	274.90	74.00	-26.69	0.20
	11/15/1999	202.5	-32.3	385.9	601.1	289.30	85.10	493.50	294.20	284.40	76.60	-27.14	0.22
	11/30/1999	206.5	-27.3	398.1	613.9	297.80	89.60	506.00	302.30	293.30	78.85	-27.67	0.20
	12/15/1999	216.1	-19.5	401.6	620.9	304.78	98.30	511.25	308.85	300.70	80.70	-27.44	0.18
	12/31/1999	223.8	-15	410.7	633.4	313.23	104.40	522.05	317.25	309.20	82.93	-27.76	0.18
	3/31/2000	203.5	-16	395.7	633.5	304.18	93.75	514.60	299.60	308.75	80.54	-27.97	-0.20
	6/30/2000	149.3	-41	371.2	553.8	258.33	54.15	462.50	260.25	256.40	68.40	-27.14	0.09
	6/30/2000	154.3	-22.3	411.5	580.2	280.93	66.00	495.85	282.90	278.95	74.38	-28.57	0.09
	1/13/2001	197.9	7.7	446.8	627.1	319.88	102.80	536.95	322.35	317.40	84.69	-28.85	0.11
	4/20/2001	167.6	1.3	434.9	589.5	298.33	84.45	512.20	301.25	295.40	78.99	-28.43	0.13
	7/16/2001	112.8	-20.6	409.7	555.1	264.25	46.10	482.40	261.25	267.25	69.97	-29.00	-0.13
	10/9/2001	136.9	-5.4	451.7	582.7	291.48	65.75	517.20	294.30	288.65	77.17	-30.00	0.13
	1/9/2002	176.6	9	461.6	618.2	316.35	92.80	539.90	319.10	313.60	83.76	-29.71	0.12
	4/12/2002	158.20	3.40	438	581.00	295.25	80.80	509.70	298.30	292.20	78.17	-28.50	0.14
	7/18/2002	86.10	-23.70	405	503.86	242.87	31.20	454.53	245.65	240.08	64.30	-28.13	0.12
26	10/7/2002	96.1	2.90	445.20	562.80	276.75	49.50	504.00	270.65	282.85	73.28	-30.21	-0.27
	1/8/2003	165.9	41.91	480.40	628.48	329.17	103.91	554.44	323.15	335.20	87.16	-29.94	-0.27
	4/15/2003	147.5	33.95	455.30	592.01	307.19	90.73	523.65	301.40	312.98	81.33	-28.77	-0.26
	7/1/2003	88.2	9.66	424.1	577.30	274.82	48.93	500.70	256.15	293.48	72.76	-30.02	-0.84
	10/7/2003	103.5	24.24	466.9	574.34	292.25	63.87	520.62	285.20	299.29	77.38	-30.35	-0.32
	12/31/2003	130.5	44.68	481.6	566.95	305.93	87.59	524.27	306.05	305.81	81.00	-29.02	0.01
	4/13/2004	118.2	42.08	471.6	585.31	304.30	80.14	528.45	294.90	313.69	80.57	-29.79	-0.42
	7/13/2004	49.6	8.40	430.9	548.80	259.43	29.00	489.85	240.25	278.60	68.69	-30.63	-0.86
	10/8/2004	54.7	18.19	457.3	588.15	279.59	36.45	522.72	256.00	303.17	74.03	-32.32	-1.06
	1/7/2005	108.7	42.65	486.4	597.82	308.89	75.67	542.11	297.55	320.23	81.78	-31.00	-0.51
	4/8/2005	91.7	33.99	457.3	601.47	296.12	62.85	529.39	274.50	317.73	78.40	-31.01	-0.97
	7/18/2005	28.7	12.91	432.3	605.33	269.81	20.81	518.82	230.50	309.12	71.44	-33.10	-1.76
	8/26/2005	31.4	16.85	447.8	588.39	271.11	24.13	518.10	239.60	302.62	71.78	-32.83	-1.41
	10/11/2005	43.7	14.58	464.4	588.60	277.82	29.14	526.50	254.05	301.59	73.56	-33.05	-1.06
	1/10/2006	96.3	14.58	483.8	588.60	295.82	55.44	536.20	290.05	301.59	78.32	-31.95	-0.26
	4/9/1906	87.1	29.40	477	588.60	295.52	58.25	532.80	282.05	309.00	78.25	-31.54	-0.60
	7/19/1906	18.4	-2.90	430.9	588.60	258.75	7.75	509.75	224.65	292.85	68.51	-33.36	-1.53
	10/18/1906	61.1	14.58	483.2	588.60	286.87	37.84	535.90	272.15	301.59	75.95	-33.10	-0.66
	1/18/2007	99.2	14.58	505.9	588.60	302.07	56.89	547.25	302.55	301.59	79.98	-32.59	0.02
	4/19/2007	80.5	14.58	477.1	588.60	290.19	47.54	532.85	278.80	301.59	76.83	-32.25	-0.51
	7/11/2007	11.2	14.5768	431.3	588.5957	261.42	12.89	509.95	221.25	301.59	69.22	-33.03	-1.80
	10/20/2007	19.8	14.5768	455.1	588.5957	269.52	17.19	521.85	237.45	301.59	71.36	-33.54	-1.44
	1/7/2008	82.9	14.5768	489.6	588.5957	293.92	48.74	539.10	286.25	301.59	77.82	-32.59	-0.34

Numerical reading of anchor load as a function of time for anchors #1, #8, #9 and #17

Date	Anchor #1 Load, kips	Anchor #8 Load, kips	Anchor #9 Load, kips	Anchor #17 Load, kips	Comment
4/7/1999		560			
4/8/1999	489			499	Anchor Lock off
4/14/1999	460	473	596 (Lock off)	461	
5/7/1999	452	473	572	445	End of construction
7/1/1999	446	468	564	439	
10/1/1999	441	467	560	440	
1/1/2000	439	461	555	424	
4/1/2000	432	453	546	414	
7/1/2000	431	451	521	415	
10/1/2000	431	451	519	416	
1/1/2001	430	455	517	400	
4/1/2001	421	443	513	397	
7/1/2001	422	443	510	399	
10/1/2001	425	445	512	403	
1/1/2002	424	444	511	398	
4/1/2002	421	440	508	386	
7/1/2002	419	439	506	391	
10/1/2002	423	442	508	396	
1/1/2003	423	435	508	389	
4/15/2003	416	427	501	380	
8/7/2003	416	428	503	384	
10/7/2003	418	429	504	387	
12/31/2003	417	426	503	378	
4/13/2004	408	418	494	370	
7/13/2004	409	419	494	374	
10/8/2004	411	422	496	377	
1/7/2005	411	421	495	374	
4/8/2005	407	414	485	366	
7/18/2005	407	415	485	370	
11/12/2005	410	419	489	374	
1/10/2006	409	417	487	369	
4/9/2006	399	411	487	365	
7/19/2006	399	412	487	368	
10/18/2006	407.3	414.8	489.6	371.7	
1/18/2007	405	412	487	366	
4/19/2007	401	406	501	361	
7/9/2007	401	408	502	365	
10/20/2007	404	411	506	369	
1/7/2008	403	410	504	364	

Pile Forces and Bending Moments

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	903.00	42.30	679.00	-	541.43	472.65	679.00	791.00	42.30	456.92	-73.98	99.88
	07/15/99	918.00	48.00	885.00	-	617.00	483.00	885.00	901.50	48.00	520.69	-144.12	113.86
	07/31/00	932.43	51.99	887.34	-	623.92	492.21	887.34	909.89	51.99	526.53	-141.66	114.44
	08/15/99	940.56	34.46	923.00	-	632.67	487.51	923.00	931.78	34.46	533.91	-156.13	119.70
	08/30/99	948.68	31.28	931.09	-	637.02	489.98	931.09	939.89	31.28	537.58	-158.14	121.21
	09/15/99	955.75	27.83	938.36	-	640.65	491.79	938.36	947.06	27.83	540.64	-160.10	122.62
	09/30/99	959.08	23.03	947.01	-	643.04	491.06	947.01	953.05	23.03	542.66	-163.47	124.06
	10/15/99	963.38	18.85	954.86	-	645.70	491.12	954.86	959.12	18.85	544.90	-166.26	125.43
	10/31/99	973.25	5.58	968.30	-	649.04	489.42	968.30	970.78	5.58	547.73	-171.69	128.76
	11/15/99	973.34	1.26	977.48	-	650.69	487.30	977.48	975.41	1.26	549.12	-175.74	129.95
	11/30/99	975.73	-2.84	980.87	-	651.25	486.45	980.87	978.30	-2.84	549.59	-177.26	130.88
	12/15/99	974.96	-2.47	982.11	-	651.53	486.25	982.11	978.54	-2.47	549.83	-177.77	130.87
	12/31/99	974.03	-54.00	984.71		634.91	460.02	984.71	979.37	-54.00	535.80	-188.11	137.85
	03/31/00	964.52	3.86	981.83	-	650.07	484.19	981.83	973.17	3.86	548.59	-178.41	129.31
	06/30/00	977.80	-36.92	980.73	-	640.54	470.44	980.73	979.27	-36.92	540.55	-182.94	135.56
	09/30/00	1009.20	-10.20	1005.99	-	668.33	499.50	1005.99	1007.60	-10.20	564.01	-181.58	135.77
	01/13/01	1014.12	-29.4495	1029.11	-	671.26	492.33	1029.11	1021.61	-29.45	566.48	-192.44	140.21
	04/20/01	1008.27	-18.6852	1022.57	-	670.72	494.79	1022.57	1015.42	-18.69	566.02	-189.21	137.95
	07/10/01	1030.41	-8.36772	1019.56	-	680.53	511.02	1019.56	1024.98	-8.37	574.30	-182.32	137.85
	10/09/01	1054.25	-20.5131	1038.65	-	690.80	516.87	1038.65	1046.45	-20.51	582.96	-187.07	142.33
	01/09/02	1055.96	-29.65	1045.80	-	690.70	513.15	1045.80	1050.88	-29.65	582.88	-190.96	144.14
	04/12/02	1041.9	-24.8188	1040.36	-	685.81	508.54	1040.36	1041.13	-24.82	578.76	-190.66	142.20
	07/19/02	1062.21	-17.26	1035.12	17.14	693.36	522.47	1035.12	1048.67	-17.26	585.12	-183.79	142.20
1	10/08/02	1086.38	-30.07	1049.75	-6.63	702.02	528.16	1049.75	1068.06	-30.07	592.43	-187.00	146.49
	01/08/03	1080.45	-42.89	1062.94	0.41	700.17	518.78	1062.94	1071.70	-42.89	590.87	-195.09	148.69
	04/15/03	1059.37	-29.65	1049.86	22.95	693.19	514.86	1049.86	1054.62	-29.65	584.99	-191.81	144.64
	06/01/03	1064.93	-31.16	1053.52	21.00	695.77	516.89	1053.52	1059.23	-31.16	587.16	-192.39	145.46
	08/07/03	1083.86	-27.66	1053.40	9.26	703.20	528.10	1053.40	1068.63	-27.66	593.43	-188.33	146.25
	10/07/03	1095.56	-38.67	1066.64	-0.69	707.84	528.45	1066.64	1081.10	-38.67	597.35	-192.95	149.38
	12/31/03	1100.15	-54.88	1082.97	-0.89	709.41	522.64	1082.97	1091.56	-54.88	598.68	-200.89	152.93
	04/13/04	1080.17	-43.67	1074.07	21.65	703.52	518.25	1074.07	1077.12	-43.67	593.70	-199.27	149.51
	07/13/04	1101.53	-34.89	1072.49	10.76	713.04	533.32	1072.49	1087.01	-34.89	601.74	-193.30	149.66
	10/08/04	1122.82	-45.70	1085.57	-8.86	720.90	538.56	1085.57	1104.19	-45.70	608.36	-196.11	153.40
	01/07/05	1116.60	-58.49	1097.39	-8.94	718.50	529.06	1097.39	1107.00	-58.49	606.34	-203.76	155.48
	04/08/05	1099.01	-52.77	1096.58	5.48	714.28	523.12	1096.58	1097.80	-52.77	602.78	-205.59	153.49
	07/18/05	1116.44	-41.55	1096.58	-2.36	723.82	537.44	1096.58	1106.51	-41.55	610.83	-200.46	153.15
	08/26/05	1128.14	-43.63	1095.73	-10.20	726.75	542.26	1095.73	1111.93	-43.63	613.30	-198.43	154.15
	11/12/05	1127.45	-44.76	1095.72	-9.67	726.14	541.34	1095.72	1111.58	-44.76	612.79	-198.75	154.26
	01/10/06	1129.36	-64.30	1095.72	-19.70	720.26	532.53	1095.72	1112.54	-64.30	607.83	-201.91	156.99
	04/09/06	1114.90	-55.20	1095.72	-1.14	718.47	529.85	1095.72	1105.31	-55.20	606.32	-202.87	154.81
	07/19/06	1130.94	-46.83	1095.72	-9.42	726.61	542.05	1095.72	1113.33	-46.83	613.19	-198.50	154.77
	10/18/06	1154.91	-58.29	1095.72	-27.50	730.78	548.31	1095.72	1125.32	-58.29	616.71	-196.26	157.89
	01/18/07	1139.55	-68.49	1095.72	-21.73	722.26	535.53	1095.72	1117.64	-68.49	609.52	-200.84	158.23
	04/19/07	1125.58	-58.82	1095.72	-8.49	720.83	533.38	1095.72	1110.65	-58.82	608.31	-201.61	156.01
	07/09/07	1141.38	-47.08	1095.72	-16.09	730.01	547.15	1095.72	1118.55	-47.08	616.05	-196.67	155.50
	10/20/07	1161.81	-62.03	1095.72	-36.23	731.84	549.89	1095.72	1128.77	-62.03	617.60	-195.69	158.85
	01/07/08	1155.60	-68.08	1095.72	-28.03	727.75	543.76	1095.72	1125.66	-68.08	614.15	-197.89	159.24

Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	575.00	589.00	243.00	-	469.00	582.00	243.00	409.00	589.00	395.79	121.54	-24.01
	07/15/99	585.00	602.00	237.00	-	474.67	593.50	237.00	411.00	602.00	400.57	127.81	-25.48
	07/30/99	594.35	611.17	230.68	-	478.73	602.76	230.68	412.52	611.17	404.00	133.40	-26.50
	08/15/99	596.87	611.09	242.58	336.68	446.81	603.98	289.63	419.73	473.89	377.06	112.70	-7.22
	08/31/99	601.58	616.82	241.00	-	486.47	609.20	241.00	421.29	616.82	410.53	132.00	-26.08
	09/15/99	605.96	622.42	240.47	-	489.62	614.19	240.47	423.22	622.42	413.19	133.98	-26.57
	09/30/99	609.62	624.20	240.71	336.98	452.88	616.91	288.85	425.17	480.59	382.18	117.62	-7.39
	10/15/99	612.87	629.40	240.27	336.21	454.69	621.14	288.24	426.57	482.81	383.71	119.35	-7.50
	10/31/99	616.45	631.80	243.11	336.29	456.91	624.13	289.70	429.78	484.05	385.59	119.90	-7.24
	11/15/99	619.54	632.45	245.83	337.79	458.90	626.00	291.81	432.69	485.12	387.27	119.81	-6.99
	11/30/99	623.35	635.58	248.71	340.31	461.99	629.47	294.51	436.03	487.95	389.87	120.09	-6.93
	12/15/99	624.21	637.77	247.77	339.95	462.43	630.99	293.86	435.99	488.86	390.24	120.87	-7.05
	12/31/99	626.60	640.86	249.37	341.45	464.57	633.73	295.41	437.99	491.16	392.05	121.29	-7.09
	03/31/00	634.53	648.30	254.69	346.89	471.10	641.41	300.79	444.61	497.60	397.56	122.12	-7.07
	06/30/00	640.05	652.80	250.99	342.06	471.48	646.43	296.53	445.52	497.43	397.88	125.44	-6.93
	09/30/00	647.16	661.13	247.62	336.78	473.17	654.14	292.20	447.39	498.96	399.31	129.76	-6.88
	01/13/01	654.063	665.1119	256.39	342.22	479.45	659.59	299.31	455.23	503.67	404.61	129.16	-6.46
	04/20/01	654.429	664.7057	260.37	345.47	481.25	659.57	302.92	457.40	505.09	406.12	127.86	-6.36
	07/10/01	661.456	672.0985	256.15	342.75	483.11	666.78	299.45	458.80	507.43	407.70	131.69	-6.49
	10/09/01	668.361	679.0039	251.93	338.20	484.37	673.68	295.06	460.14	508.60	408.76	135.74	-6.46
	01/09/02	671.083	683.4721	252.17	337.92	486.16	677.28	295.04	461.63	510.69	410.27	137.04	-6.55
	04/12/02	669.17	680.02	256.68	342.06	486.98	674.60	299.37	462.93	511.04	410.96	134.52	-6.42
	07/19/02	671.69	683.96	253.27	272.93	470.46	677.83	263.10	462.48	478.44	397.02	148.69	-2.13
17	10/08/02	678.60	692.21	247.01	332.37	487.54	685.40	289.69	462.80	512.29	411.44	141.87	-6.60
	01/08/03	678.44	689.32	251.28	334.22	488.31	683.88	292.75	464.86	511.77	412.09	140.22	-6.26
	04/15/03	679.45	692.45	254.73	341.09	491.93	685.95	297.91	467.09	516.77	415.14	139.12	-6.63
	06/01/03	678.76	689.85	256.43	341.09	491.53	684.30	298.76	467.60	515.47	414.80	138.22	-6.39
	08/07/03	682.33	695.54	251.15	336.74	491.44	688.94	293.95	466.74	516.14	414.73	141.61	-6.59
	10/07/03	686.23	700.57	250.14	334.87	492.95	693.40	292.50	468.19	517.72	416.00	143.73	-6.61
	12/31/03	689.48	700.61	257.04	341.05	497.05	695.05	299.04	473.26	520.83	419.46	141.97	-6.35
	04/13/04	689.24	699.88	260.70	346.65	499.12	694.56	303.68	474.97	523.27	421.21	140.14	-6.44
	07/13/04	693.10	667.59	255.46	341.33	489.37	680.34	298.39	474.28	504.46	412.98	136.93	-4.03
	10/08/04	699.03	710.89	250.83	337.39	499.53	704.96	294.11	474.93	524.14	421.56	147.30	-6.56
	01/07/05	699.07	711.46	253.31	339.95	500.95	705.26	296.63	476.19	525.70	422.75	146.50	-6.61
	04/08/05	696.43	708.09	257.94	343.81	501.57	702.26	300.87	477.18	525.95	423.27	143.90	-6.51
	07/18/05	699.56	708.33	253.71	338.36	499.99	703.94	296.04	476.64	523.35	421.94	146.24	-6.23
	08/26/05	702.04	711.17	250.91	335.97	500.02	706.61	293.44	476.47	523.57	421.97	148.13	-6.28
	11/12/05	701.95	699.60	251.68	337.06	497.57	700.78	294.37	476.82	518.33	419.90	145.70	-5.54
	01/10/06	705.16	715.03	253.47	339.58	503.31	710.10	296.53	479.32	527.31	424.75	148.27	-6.40
	04/09/06	703.94	713.04	259.52	343.20	504.93	708.49	301.36	481.73	528.12	426.11	145.96	-6.19
	07/19/06	708.37	716.01	256.84	339.95	505.29	712.19	298.39	482.61	527.98	426.42	148.35	-6.05
	10/18/06	713.29	721.25	251.76	334.02	505.08	717.27	292.89	482.52	527.63	426.24	152.14	-6.02
	01/18/07	712.84	717.96	256.52	336.54	505.96	715.40	296.53	484.68	527.25	426.98	150.17	-5.68
	04/19/07	711.13	716.21	260.62	340.56	507.13	713.67	300.59	485.88	528.38	427.97	148.10	-5.67
	07/09/07	713.04	716.74	255.22	334.18	504.79	714.89	294.70	484.13	525.46	426.00	150.64	-5.51
	10/20/07	715.97	721.74	250.87	329.51	504.52	718.85	290.19	483.42	525.62	425.77	153.68	-5.63
	01/07/08	719.26	723.93	256.47	335.12	508.69	721.59	295.79	487.87	529.52	429.29	152.65	-5.56

Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	546.00	501.00	248.00	173	367.00	523.50	210.50	397.00	337.00	309.71	112.21	8.00
	07/15/99	557.00	513.00	243.00	229	385.50	535.00	236.00	400.00	371.00	325.32	107.20	3.87
	07/30/99	565.55	519.94	239.54	224.26	387.32	542.75	231.90	402.55	372.10	326.86	111.44	4.06
	08/15/99	567.71	520.14	230.56	232.51	387.73	543.93	231.54	399.14	376.33	327.21	112.00	3.04
	08/31/99	573.72	526.52	247.46	232.87	395.14	550.12	240.17	410.59	379.70	333.46	111.12	4.12
	09/15/99	578.06	532.08	246.65	233.61	397.60	555.07	240.13	412.36	382.85	335.53	112.91	3.94
	09/30/99	582.49	534.97	247.46	234.05	399.74	558.73	240.76	414.98	384.51	337.34	114.00	4.06
	10/15/99	586.68	538.17	247.25	235.23	401.83	562.43	241.24	416.97	386.70	339.11	115.15	4.04
	10/31/99	590.77	539.40	249.37	235.6	403.79	565.09	242.49	420.07	387.50	340.75	115.66	4.34
	11/15/99	592.65	540.65	251.68	237.47	405.61	566.65	244.58	422.17	389.06	342.30	115.47	4.42
	11/30/99	596.63	527.25	254.12	239.69	404.42	561.94	246.91	425.38	383.47	341.29	112.94	5.59
	12/15/99	599.47	545.53	254.12	239.05	409.54	572.50	246.59	426.80	392.29	345.61	116.84	4.60
	12/31/99	601.54	548.45	255.38	239.17	411.14	575.00	247.28	428.46	393.81	346.96	117.49	4.62
	03/31/00	610.32	554.87	262.08	243.60	417.72	582.59	252.84	436.20	399.23	352.51	118.22	4.93
	06/30/00	616.94	539.60	260.98	238.93	414.11	578.27	249.96	438.96	389.26	349.47	117.70	6.63
	09/30/00	625.63	400.76	255.58	232.18	378.54	513.19	243.88	440.61	316.47	319.45	96.55	16.56
	01/13/01	632.372	566.6896	264.44	235.84	424.83	599.53	250.14	448.40	401.26	358.52	125.26	6.29
	04/20/01	632.575	561.5309	268.38	236.21	424.67	597.05	252.29	450.48	398.87	358.38	123.60	6.88
	07/10/01	639.684	569.2893	264.64	234.54	427.04	604.49	249.59	452.16	401.91	360.38	127.23	6.70
	10/09/01	646.508	576.5197	259.81	232.14	428.74	611.51	245.97	453.16	404.33	361.82	131.05	6.51
	01/09/02	650.895	576.8446	259.68	230.92	429.59	613.87	245.30	455.29	403.88	362.53	132.14	6.86
	04/12/02	650.123	570.1017	264.192	232.55	429.24	610.11	248.37	457.16	401.33	362.24	129.69	7.45
	07/19/02	653.45	572.46	260.90	226.38	428.30	612.96	243.64	457.18	399.42	361.44	132.40	7.71
18	10/08/02	659.69	581.14	254.65	222.68	429.54	620.41	238.66	457.17	401.91	362.49	136.86	7.37
	01/08/03	657.76	576.89	257.57	224.47	429.17	617.32	241.02	457.67	400.68	362.18	134.91	7.60
	04/15/03	661.78	576.19	262.16	228.04	432.04	618.99	245.10	461.97	402.12	364.60	134.04	7.98
	06/01/03	661.37	572.66	264.07	227.59	431.43	617.02	245.83	462.72	400.13	364.08	133.07	8.35
	08/07/03	665.76	577.29	258.18	222.76	431.00	621.53	240.47	461.97	400.03	363.72	136.61	8.26
	10/07/03	669.26	582.73	256.11	222.56	432.66	625.99	239.33	462.68	402.65	365.13	138.62	8.01
	12/31/03	670.27	581.39	262.53	229.62	435.95	625.83	246.08	466.40	405.51	367.90	136.15	8.12
	04/13/04	669.42	576.64	266.47	232.35	436.22	623.03	249.41	467.94	404.49	368.12	133.95	8.46
	07/13/04	672.95	578.63	261.80	224.79	434.54	625.79	243.29	467.37	401.71	366.71	137.13	8.76
	10/08/04	677.95	587.12	255.42	222.31	435.70	632.53	238.87	466.68	404.72	367.69	141.14	8.27
	01/07/05	677.50	586.02	257.61	226.05	436.80	631.76	241.83	467.56	406.04	368.61	139.80	8.21
	04/08/05	674.17	580.83	263.14	227.80	436.48	627.50	245.47	468.65	404.31	368.35	136.96	8.58
	07/18/05	677.87	580.70	259.40	221.74	434.93	629.29	240.57	468.63	401.22	367.04	139.36	8.99
	08/26/05	679.25	583.30	256.27	219.43	434.56	631.28	237.85	467.76	401.37	366.73	141.05	8.86
	11/12/05	679.13	583.14	256.88	220.08	434.81	631.13	238.48	468.00	401.61	366.93	140.77	8.86
	01/10/06	679.45	587.32	257.33	223.00	436.78	633.39	240.17	468.39	405.16	368.60	140.97	8.43
	04/09/06	679.57	583.14	263.01	226.46	438.05	631.36	244.74	471.29	404.80	369.67	138.61	8.87
	07/19/06	683.27	585.78	260.94	222.31	438.08	634.53	241.63	472.11	404.05	369.69	140.86	9.08
	10/18/06	687.01	592.40	255.09	218.66	438.29	639.70	236.88	471.05	405.53	369.87	144.42	8.74
	01/18/07	685.10	588.58	259.16	221.83	438.67	636.84	240.49	472.13	405.20	370.19	142.10	8.93
	04/19/07	685.18	584.40	264.40	222.96	439.23	634.79	243.68	474.79	403.68	370.67	140.22	9.49
	07/09/07	687.74	584.85	259.24	215.85	436.92	636.29	237.55	473.49	400.35	368.72	142.96	9.76
	10/20/07	690.01	591.22	253.79	213.46	437.12	640.62	233.63	471.90	402.34	368.89	145.91	9.28
	01/07/08	691.80	593.86	258.30	218.94	440.73	642.83	238.62	475.05	406.40	371.93	144.91	9.16

Pile Forces and Bending Moments (cont'd)

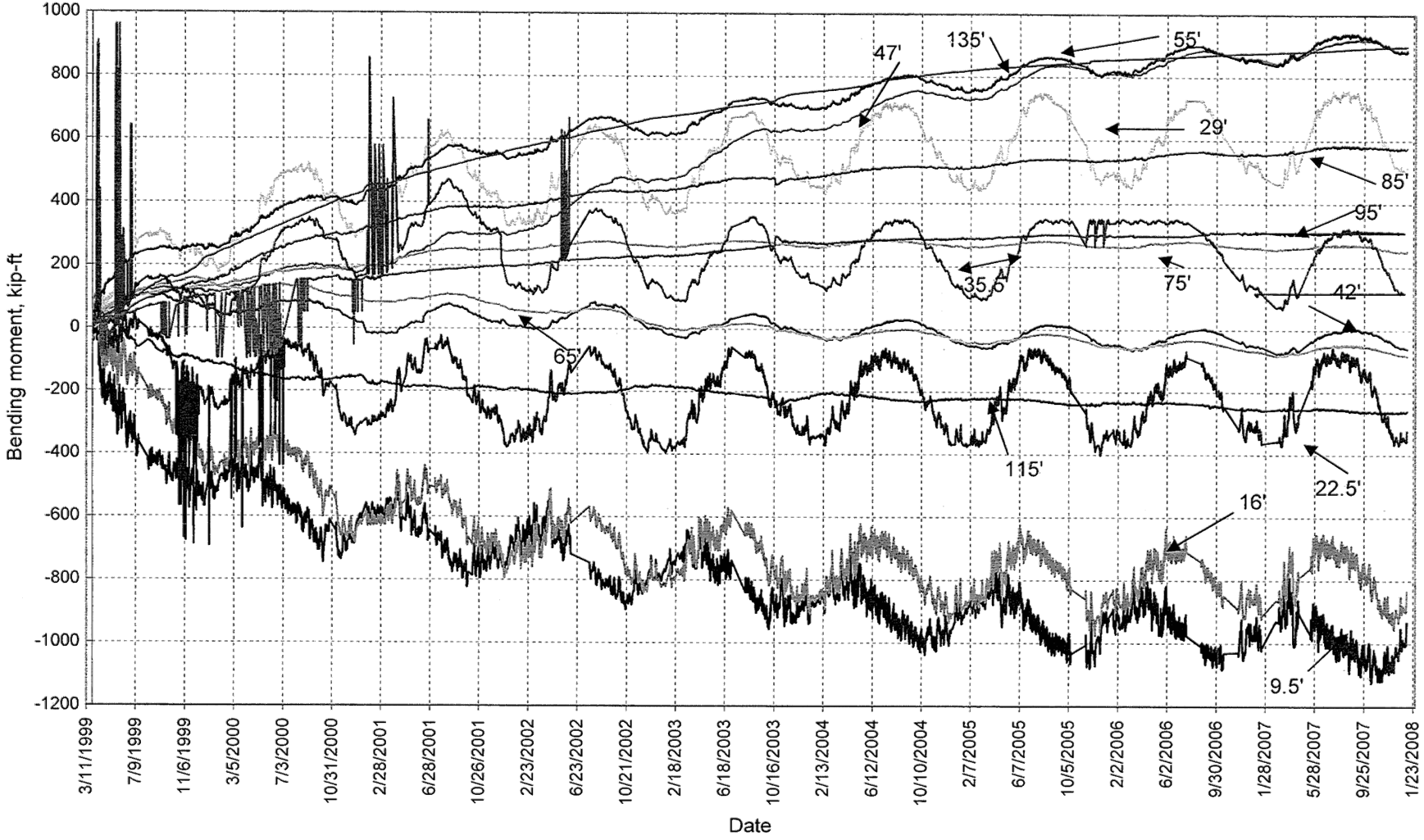
Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	566.97	586.00	298.00	228.9	419.97	576.49	263.45	432.49	407.45	354.41	112.23	3.34
	07/15/99	580.00	597.00	294.00	224	423.75	588.50	259.00	437.00	410.50	357.60	118.13	3.54
	07/30/99	588.71	606.46	291.38	218.62	426.29	597.59	255.00	440.05	412.54	359.75	122.82	3.67
	08/15/99	591.02	607.35	300.95	227.92	431.81	599.19	264.44	445.99	417.64	364.40	120.01	3.78
	08/31/99	595.94	613.52	300.59	229.63	434.92	604.73	265.11	448.27	421.58	367.03	121.76	3.56
	09/15/99	599.88	617.91	300.67	229.54	437.00	608.90	265.11	450.28	423.73	368.78	123.25	3.54
	09/30/99	603.53	621.65	302.70	229.75	439.41	612.59	266.23	453.12	425.70	370.82	124.18	3.66
	10/15/99	607.51	625.02	302.29	229.71	441.13	616.27	266.00	454.90	427.37	372.27	125.57	3.67
	10/31/99	611.37	627.25	306.07	229.7	443.60	619.31	267.89	458.72	428.48	374.35	125.99	4.03
	11/15/99	613.61	627.78	308.31	232.67	445.59	620.70	270.49	460.96	430.23	376.04	125.55	4.10
	11/30/99	616.29	630.54	313.83	234.7	448.84	623.42	274.27	465.06	432.62	378.78	125.17	4.33
	12/15/99	617.83	631.44	314.03	234.9	449.55	624.64	274.47	465.93	433.17	379.38	125.54	4.37
	12/31/99	619.94	634.20	314.36	236.45	451.24	627.07	275.41	467.15	435.33	380.80	126.08	4.25
	03/31/00	629.45	639.44	320.33	239.74	457.24	634.44	280.03	474.89	439.59	385.86	127.06	4.71
	06/30/00	636.15	643.50	317.81	51.91	412.34	639.83	184.86	476.98	347.71	347.98	163.11	17.25
	09/30/00	646.59	651.99	312.33	231.29	460.55	649.29	271.81	479.46	441.64	388.66	135.33	5.04
	01/13/01	653.454	657.0691	320.21	236.77	466.88	655.26	278.49	486.83	446.92	394.00	135.08	5.32
	04/20/01	651.464	653.2102	324.03	237.42	466.53	652.34	280.72	487.74	445.32	393.71	133.23	5.66
	07/10/01	658.856	661.1717	320.61	235.03	468.92	660.01	277.82	489.74	448.10	395.72	137.02	5.55
	10/09/01	667.346	669.2551	315.37	230.97	470.74	668.30	273.17	491.36	450.11	397.25	141.66	5.50
	01/09/02	670.88	671.7736	315.66	229.71	472.00	671.33	272.68	493.27	450.74	398.32	142.92	5.67
	04/12/02	667.71	665.64	321.06	231.62	471.51	666.68	276.34	494.39	448.63	397.90	139.94	6.10
	07/19/02	673.44	667.87	319.88	227.72	472.23	670.66	273.80	496.66	447.79	398.51	142.28	6.52
19	10/08/02	681.93	676.18	313.24	222.91	473.56	679.05	268.07	497.58	449.54	399.64	147.34	6.41
	01/08/03	682.42	673.60	316.88	225.03	474.48	678.01	270.96	499.65	449.32	400.42	145.93	6.71
	04/15/03	686.11	672.95	321.26	228.37	477.17	679.53	274.81	503.69	450.66	402.69	145.10	7.07
	06/01/03	685.30	670.80	322.48	227.84	476.60	678.05	275.16	503.89	449.32	402.21	144.44	7.28
	08/07/03	689.12	675.35	317.28	223.09	476.21	682.23	270.18	503.20	449.22	401.87	147.72	7.20
	10/07/03	694.48	681.03	314.64	222.27	478.11	687.76	268.46	504.56	451.65	403.47	150.32	7.06
	12/31/03	695.94	680.95	322.73	229.34	482.24	688.45	276.03	509.33	455.15	406.96	147.86	7.23
	04/13/04	695.62	676.77	330.77	231.41	483.64	686.19	281.09	513.19	454.09	408.15	145.23	7.88
	07/13/04	700.37	679.61	327.88	224.22	483.02	689.99	276.05	514.13	451.92	407.62	148.40	8.30
	10/08/04	706.18	688.67	321.87	221.22	484.48	697.43	271.54	514.03	454.94	408.86	152.68	7.88
	01/07/05	705.37	688.14	324.72	224.55	485.69	696.75	274.63	515.04	456.35	409.88	151.34	7.83
	04/08/05	702.85	682.86	329.75	226.66	485.53	692.86	278.21	516.30	454.76	409.74	148.66	8.21
	07/18/05	706.50	683.55	327.15	219.55	484.19	695.03	273.35	516.83	451.55	408.61	151.18	8.71
	08/26/05	708.05	686.48	322.81	217.89	483.80	697.26	270.35	515.43	452.18	408.28	153.05	8.44
	11/12/05	707.97	686.27	323.74	218.33	484.08	697.12	271.04	515.85	452.30	408.51	152.76	8.48
	01/10/06	710.04	690.54	324.68	221.62	486.72	700.29	273.15	517.36	456.08	410.74	153.13	8.17
	04/09/06	709.47	686.72	329.75	224.34	487.57	698.10	277.05	519.61	455.53	411.46	150.95	8.55
	07/19/06	714.26	690.38	328.09	220.57	488.32	702.32	274.33	521.17	455.47	412.10	153.44	8.76
	10/18/06	718.93	696.80	321.91	216.75	488.60	707.86	269.33	520.42	456.77	412.33	157.22	8.49
	01/18/07	717.19	692.98	326.63	219.88	489.17	705.08	273.25	521.91	456.43	412.81	154.82	8.73
	04/19/07	716.98	689.52	331.50	221.54	489.89	703.25	276.52	524.24	455.53	413.42	152.99	9.17
	07/09/07	720.64	690.13	327.60	214.47	488.21	705.39	271.04	524.12	452.30	412.00	155.72	9.58
	10/20/07	723.97	695.70	321.18	211.96	488.20	709.83	266.57	522.58	453.83	411.99	158.92	9.17
	01/07/08	725.43	698.46	326.71	217.89	492.12	711.95	272.30	526.07	458.17	415.30	157.62	9.06

Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
34	07/01/99	271.75	436.00	261.00	583.00	387.94	353.88	422.00	266.38	509.50	327.38	-24.42	-32.43
	07/15/99	279.00	617.00	253.00	583.00	433.00	448.00	418.00	266.00	600.00	365.41	10.76	-44.56
	07/30/99	282.79	647.00	243.64	585.13	439.64	464.90	414.39	263.22	616.07	371.01	18.11	-47.07
	08/15/99	272.89	690.09	251.16	614.66	457.20	481.49	432.91	262.03	652.38	385.83	17.42	-52.07
	08/31/99	265.66	576.80	245.14	627.09	428.67	421.23	436.12	255.40	601.95	361.76	-5.34	-46.23
	09/15/99	265.08	802.81	242.34	635.26	486.37	533.95	438.80	253.71	719.04	410.45	34.11	-62.07
	09/30/99	260.50	807.40	238.64	642.65	487.30	533.95	440.65	249.57	725.03	411.23	33.45	-63.43
	10/15/99	256.43	811.14	234.46	648.58	487.65	533.79	441.52	245.45	729.86	411.53	33.08	-64.62
	10/31/99	240.47	824.02	221.62	665.31	487.86	532.25	443.47	231.05	744.67	411.70	31.83	-68.52
	11/15/99	241.93	831.45	224.75	676.77	493.73	536.69	450.76	233.34	754.11	416.65	30.81	-69.47
	11/31/99	240.47	835.88	224.26	648.85	487.37	538.18	436.56	232.37	742.37	411.29	36.43	-68.03
	12/15/99	241.41	836.77	222.35	684.04	496.14	539.09	453.20	231.88	760.41	418.69	30.79	-70.51
	12/31/99	242.22	836.08	224.14	684.93	496.84	539.15	454.54	233.18	760.51	419.29	30.34	-70.35
	03/31/00	257.37	828.85	237.38	675.92	499.88	543.11	456.65	247.38	752.38	421.85	31.00	-67.37
	06/30/00	266.43	846.32	225.20	500.93	459.72	556.37	363.06	245.81	673.62	387.96	69.30	-57.07
	09/30/00	257.37	895.02	196.89	705.00	513.57	576.19	450.94	227.13	800.01	433.40	44.90	-76.42
	01/13/01	247.90	856.11	197.37	729.58	507.74	552.01	463.47	222.64	792.84	428.48	31.74	-76.07
	04/20/01	44.66	883.01	212.28	457.21	399.29	463.83	334.74	128.47	670.11	336.96	46.28	-72.25
	07/10/01	-279.94	502.86	204.24	66.21	123.34	111.46	135.22	-37.85	284.53	104.09	-8.52	-43.01
	10/09/01	442.16	725.37	50.98	1199.89	604.60	583.76	625.44	246.57	962.63	510.22	-14.94	-95.52
	01/09/02	263.63	616.73	159.27	765.05	451.17	440.18	462.16	211.45	690.89	380.74	-7.88	-63.96
	04/12/02	67.35	579.97	58.13	501.01	301.61	323.66	279.57	62.74	540.49	254.53	15.81	-63.73
	07/19/02	288.69	941.04	187.83	727.59	536.29	614.86	457.71	238.26	834.31	452.57	56.34	-79.51
	10/08/02	277.15	962.54	162.58	740.98	535.81	619.84	451.78	219.86	851.76	452.17	60.25	-84.29
	01/08/03	256.07	949.53	162.24	758.66	531.62	602.80	460.45	209.15	854.10	448.64	51.04	-86.04
	04/15/03	277.19	928.37	189.53	744.52	534.90	602.78	467.03	233.36	836.45	451.41	48.67	-80.45
	06/01/03	277.96	939.01	184.90	749.68	537.89	608.49	467.29	231.43	844.35	453.93	50.62	-81.76
	08/07/03	288.69	965.09	171.66	750.09	543.88	626.89	460.87	230.17	857.59	458.98	59.52	-83.70
	10/07/03	274.96	978.21	155.53	762.84	542.89	626.58	459.19	215.25	870.53	458.14	60.01	-87.41
	12/31/03	258.26	983.57	156.83	795.22	548.47	620.92	476.03	207.55	889.40	462.86	51.95	-90.96
	04/13/04	281.17	960.30	188.88	781.65	553.00	620.73	485.27	235.03	870.97	466.68	48.57	-84.84
	07/13/04	302.86	991.98	173.93	772.27	560.26	647.42	473.10	238.40	882.12	472.80	62.50	-85.87
	10/08/04	295.63	1004.49	151.19	786.40	559.43	650.06	468.80	223.41	895.45	472.10	64.99	-89.65
	01/07/05	277.35	997.91	148.79	798.02	555.52	637.63	473.41	213.07	897.97	468.80	58.88	-91.36
	04/08/05	286.74	978.21	166.99	788.76	555.17	632.47	477.87	226.86	883.49	468.51	55.43	-87.59
	07/18/05	304.00	1000.02	160.94	783.60	562.14	652.01	472.27	232.47	891.81	474.39	64.44	-87.96
	08/26/05	301.85	1018.4	147.73	791.81	564.94	660.12	469.77	224.79	905.09	476.76	68.24	-90.75
	11/12/05	300.51	1018.3	147.82	793.35	564.99	659.40	470.58	224.16	905.83	476.80	67.70	-90.93
	01/10/06	274.59	1009.41	138.15	808.34	557.62	642.00	473.24	206.37	908.87	470.58	60.50	-93.71
	04/09/06	283.04	986.09	160.45	798.02	556.90	634.57	479.23	221.74	892.06	469.97	55.69	-89.42
	07/19/06	295.67	1009.41	149.73	796.56	562.84	652.54	473.14	222.70	902.98	474.98	64.32	-90.75
	10/18/06	284.79	1030.77	131.20	808.38	563.79	657.78	469.79	207.99	919.58	475.78	67.40	-94.92
	01/18/07	270.29	1012.82	134.82	813.33	557.81	641.55	474.08	202.55	913.08	470.74	60.04	-94.78
	04/19/07	282.35	996.04	153.99	805.37	559.44	639.20	479.68	218.17	900.71	472.11	57.19	-91.05
	07/09/07	306.44	1014.48	154.64	795.38	567.74	660.46	475.01	230.54	904.93	479.11	66.49	-89.96
	10/20/07	290.51	1037.35	126.69	809.72	566.07	663.93	468.21	208.60	923.54	477.71	70.17	-95.37
	01/07/08	274.06	1024.92	128.89	820.48	562.09	649.49	474.69	201.48	922.70	474.35	62.67	-96.21

Shaft 1: Bending moment along shaft, kip-ft

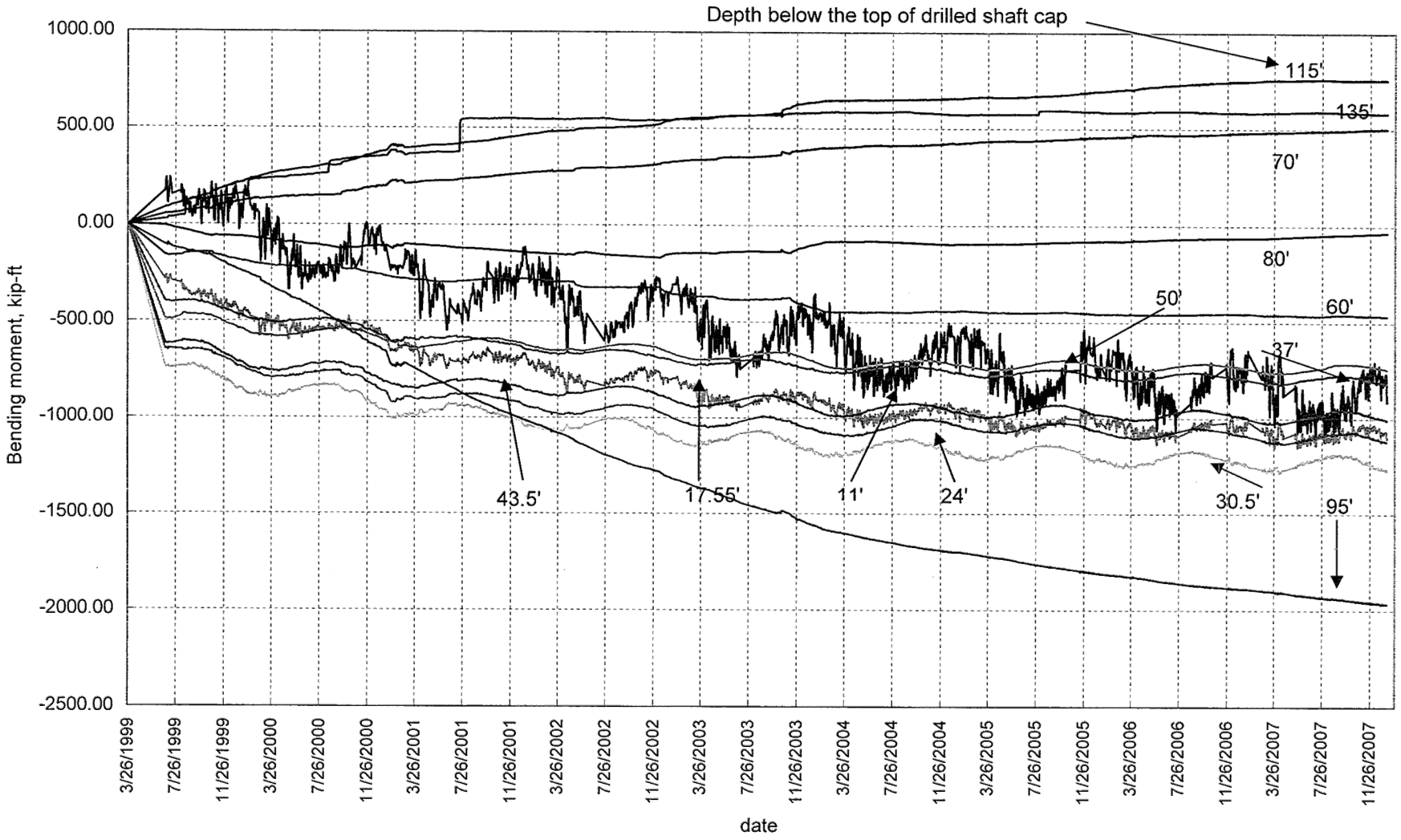
Depth, ft / Date	9.5	16	22.5	29	35.5	42	47	54.8	64.8	74.8	84.8	94.8	115	135
7/1/1999	-357.65	-148.91	-2.99	242.13	107.23	94.27	103.67	221.87	109.32	92.67	66.77	48.25	-38.94	91.57
1/8/2003	-774.82	-792.9	-360.63	403.12	139.71	-1.79	473.87	620.31	11.19	262.65	439.51	230.65	-179.6	668.9
4/15/2003	-657.74	-650	-232.57	481.71	156.43	-14.02	517.65	659.68	2.44	268.91	457.85	238.57	-192.49	684.79
7/1/2003	-763.24	-602.42	-72.91	660.28	319.17	32.14	588.57	715.87	14.21	278.09	474.99	251.23	-206	702.94
8/7/2003	-817.04	-638.73	-81.08	678	343.79	44.44	615.09	726.92	17.44	279.15	477.58	254.31	-210.32	708.78
10/7/2003	-913.81	-801.08	-248.05	552.54	251.84	20.93	623.3	710.92	6.8	271.9	474.43	265.38	-225.46	720.58
12/31/2003	-870.9	-838.68	-322.24	476.14	168.18	-13.93	630.87	701.76	-19.51	263.35	479.49	275.24	-220.96	748.57
4/13/2004	-831.87	-777.37	-255.87	514.98	175.37	-24.83	659.66	727.03	-27.47	269.67	495.81	277.88	-211.65	763.52
7/13/2004	-889.99	-676.85	-77.13	709.38	338.24	22.05	727.23	792.27	-5.75	281.7	512.3	283.5	-221.34	787.54
10/8/2004	-983.05	-812	-201.66	636.33	293	16.71	752.87	793.14	-7.37	272.19	514.89	286.68	-231.1	803.15
1/7/2005	-925.21	-882.29	-353.38	471.75	139.59	-39.87	733.05	761.38	-34.6	264.1	510.62	288.64	-223.06	817.18
4/8/2005	-775.03	-726	-235.05	530.47	150.69	-53.27	749.88	786.67	-40.37	267.3	525.48	290.73	-219.8	828.14
7/18/2005	-957.73	-709.43	-81.75	735.77	338.65	7.97	821.52	856.49	-16.82	278.53	538.72	298.79	-226.87	837.24
8/26/2005	-1005.57	-755.34	-117.03	721.71	336.36	13.6	835.13	860.64	-16.18	278.76	539.43	301.65	-233.64	840.82
10/11/2005	-1033.08	-827.24	-199.79	654.9	284.17	7.2946	833.72	848.04	-26.29	273.5	537.36	299.33	-240.08	843.25
1/10/2006	-918.83	-858.03	-339.71	489.13	122.55	-48.55	810.18	815.92	-54.94	262.93	536.1	298.82	-234.11	855.77
4/9/2006	-901.14	-812	-289.67	510.35	123.88	-55.75	815.9	831.32	-58.19	267.19	540.25	311.97	-239.53	860
7/19/2006	-975.46	-709.09	-86.84	727.21	303.99	-3.19	876.46	899.71	-33.29	280.02	563.21	306.55	-235.87	865.96
10/18/2006	-1030.45	-848.40	-245.88	609.17	218.59	-17.57	872.05	872.96	-49.65	267.05	557.80	306.95	-246.77	873.58
1/18/2007	-1015.18	-915.62	-363.79	485.63	115.44	-53.84	856.23	849.07	-71.01	257.71	555.06	310.45	-258.05	878.10
4/19/2007	-904.71	-791.93	-272.27	527.72	122.40	-65.28	862.30	869.52	-74.95	259.50	564.85	305.74	-254.07	882.60
7/11/2007	-990.93	-694.73	-72.44	749.91	312.39	-2.99	910.88	934.53	-49.88	269.47	582.93	306.29	-251.96	888.31
10/20/2007	-1018.74	-786.18	-177.53	678.23	265.08	-13.72	915.47	922.26	-57.70	265.45	581.36	309.85	-259.55	895.13
1/7/2008	-932.03	-833.86	-321.36	513.46	112.58	-59.96	880.84	888.07	-82.44	252.01	576.25	309.48	-259.33	899.85



Shaft #1, Bending moment vs. date in different elevations below the top of cap

Shaft 9: Bending moment along shaft, kip-ft

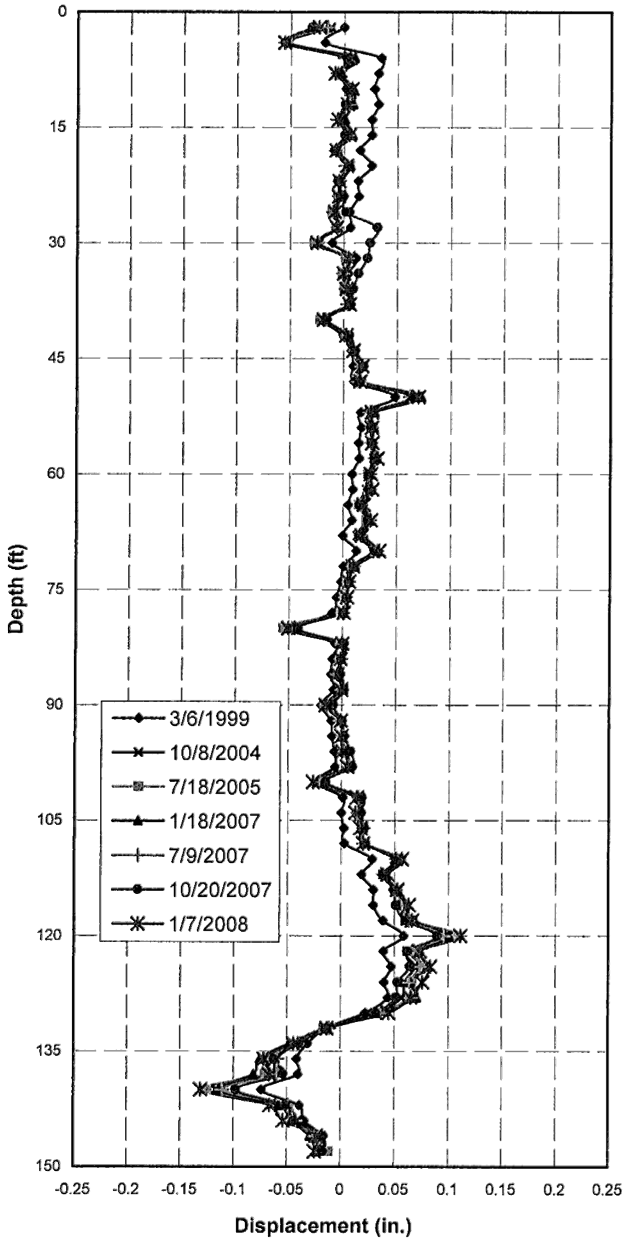
Depth, ft / Date	11	17.5	24	30.5	37	43.25	50	60	70	80	95	115	135
7/1/1999	-67.89	-31.81	8.56	12.84	20.8	19.57	14.07	0.61	9.79	11.62	-33.33	18.35	26.3
1/8/2003	-347.44	-803.74	-998.93	-1106.33	-698.39	-903.77	-661.43	-353.18	324.27	-148.11	-1315.52	540.06	541.35
4/15/2003	-592.31	-919.8	-1050.61	-1133.34	-723.59	-939.66	-696.63	-369.12	336.59	-143.51	-1378.77	555.2	549.67
7/1/2003	-666.55	-902.38	-1016.77	-1090.93	-713.88	-914.42	-686.74	-395.16	340.01	-144.29	-1435.98	557.09	553.5
8/7/2003	-687.84	-917.2	-1003.18	-1072.98	-695.58	-886.87	-664.36	-384.64	352	-133.3	-1462.27	566.15	565.69
10/7/2003	-490.45	-863.81	-1007.81	-1107.14	-708.81	-891.63	-656.83	-378.93	360.91	-134.77	-1498.83	577.44	567.18
12/31/2003	-514.68	-913.27	-1054.9	-1163.2	-741.63	-949.18	-697.72	-421.12	390.01	-101.42	-1555.5	633.83	579.35
4/13/2004	-604.44	-966.22	-1090.5	-1188	-761.54	-987.22	-743.54	-446.54	402.54	-82.56	-1609.1	644.77	582.97
7/13/2004	-817.01	-1007.24	-1051.35	-1122.59	-730.91	-933.53	-709.92	-447.66	411.36	-83.06	-1648.19	649.1	585.94
10/8/2004	-674.74	-949.72	-1005.93	-1128.49	-732.6	-927.74	-697.54	-445.16	413.37	-90.78	-1677.71	652.24	581.64
1/7/2005	-572.76	-951.94	-1036.44	-1183	-760.9	-966.49	-718.51	-441.27	424.15	-94.18	-1699.91	657.05	573.07
4/8/2005	-773.86	-1039.72	-1072.89	-1200.56	-775.89	-989.82	-743.85	-446.59	435.56	-92.57	-1726.57	664.45	574.55
7/18/2005	-885.57	-1041.08	-1038.29	-1152.24	-752.36	-948.63	-719.09	-449.39	438.06	-89.12	-1762.02	670.82	576.24
8/26/2005	-835.5	-1020.01	-1028.45	-1146.98	-746.96	-933.35	-702.48	-447.31	442.02	-86.41	-1773.96	672.92	595.07
10/11/2005	-749.53	-997.4	-1026.45	-1157.47	-750.11	-932.26	-695.29	-445.61	446.57	-84.01	-1786.07	677.93	594.21
1/10/2006	-735.54	-1025.94	-1070.26	-1220.95	-784.71	-983.06	-728.35	-455.6	455.8	-79.41	-1811.1	694.94	585.21
4/9/2006	-761.63	-1055.46	-1104.66	-1250.13	-799.79	-1009.4	-750.25	-456.86	465.33	-75.95	-1830.39	709.25	584.13
7/19/2006	-986.65	-1097.57	-1069.44	-1182.51	-765.49	-967.32	-726.98	-458.20	468.35	-67.36	-1860.26	728.74	591.17
10/18/2006	-785.55	-1028.56	-1059.04	-1198.03	-770.44	-962.79	-714.95	-455.21	472.24	-63.08	-1878.38	742.33	587.52
1/18/2007	-652.26	-1012.08	-1093.82	-1249.92	-798.31	-1001.31	-738.72	-453.20	481.92	-62.15	-1891.06	749.16	583.45
4/19/2007	-878.81	-1101.41	-1131.14	-1269.03	-817.30	-1023.35	-760.98	-458.74	484.61	-55.95	-1908.23	757.20	587.07
7/11/2007	-1020.68	-1113.23	-1096.67	-1211.04	-787.54	-982.11	-738.79	-463.61	490.76	-47.79	-1930.33	760.68	591.55
10/20/2007	-959.39	-1084.45	-1073.44	-1199.41	-780.45	-961.01	-714.61	-460.69	495.15	-40.84	-1949.93	755.58	587.47
1/7/2008	-913.31	-1106.23	-1119.18	-1262.45	-816.00	-1007.26	-741.89	-466.44	500.87	-33.08	-1965.87	755.43	582.76



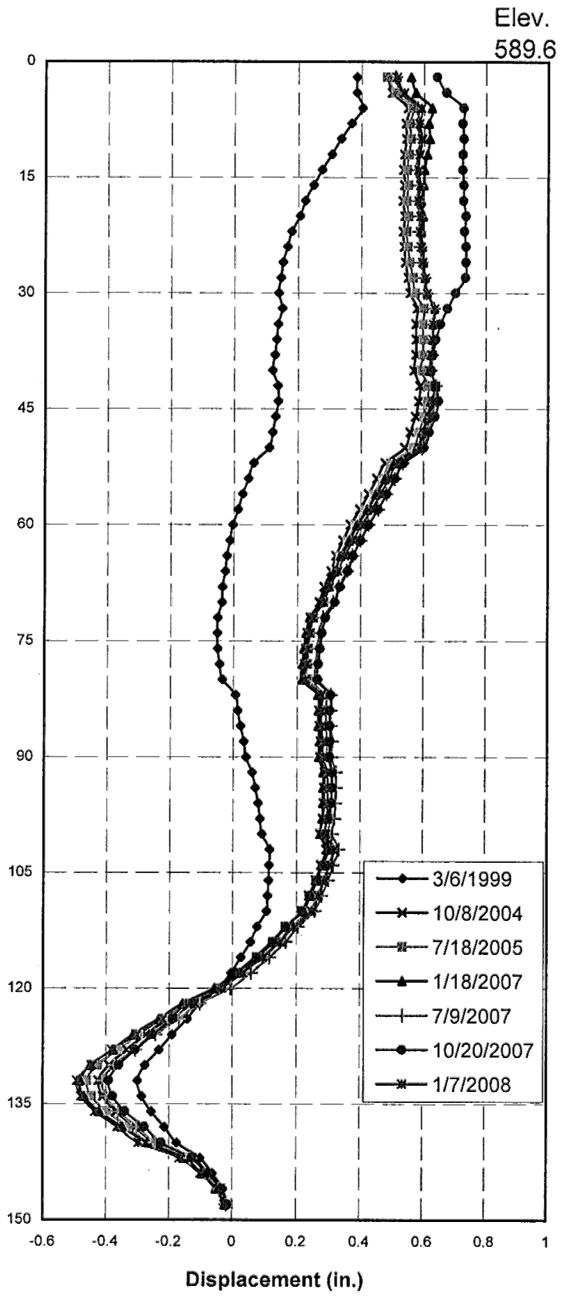
Shaft #9, Bending moment vs. date in different elevations below the top of cap

Inclinometer #1 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

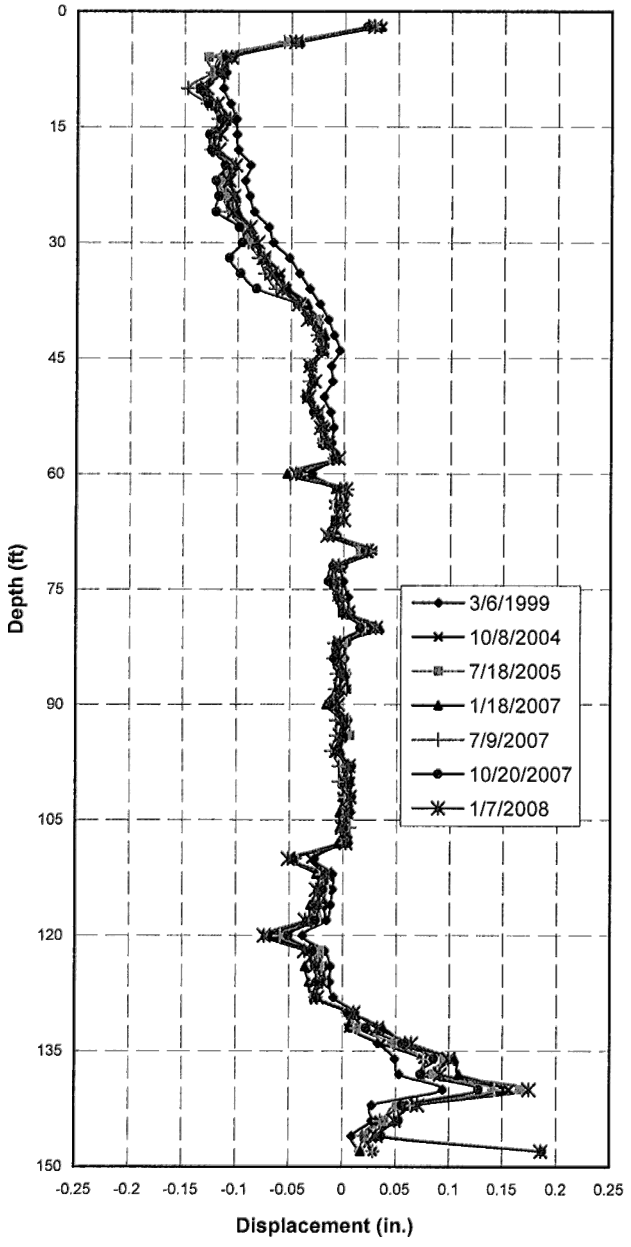


Cumulative

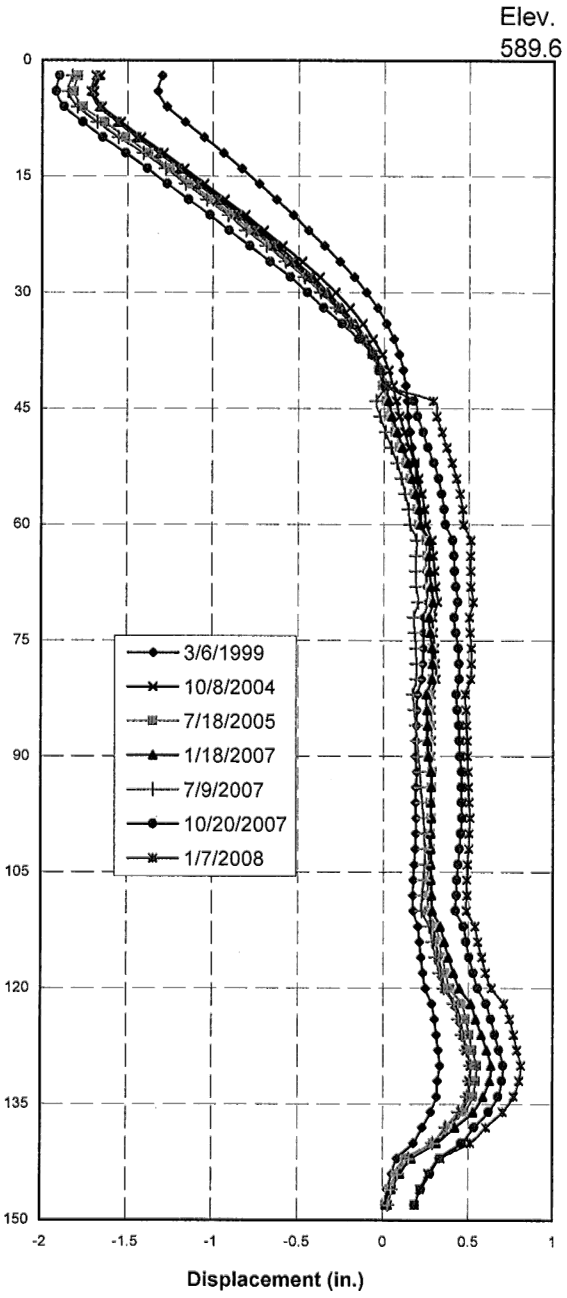


Inclinometer #1 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

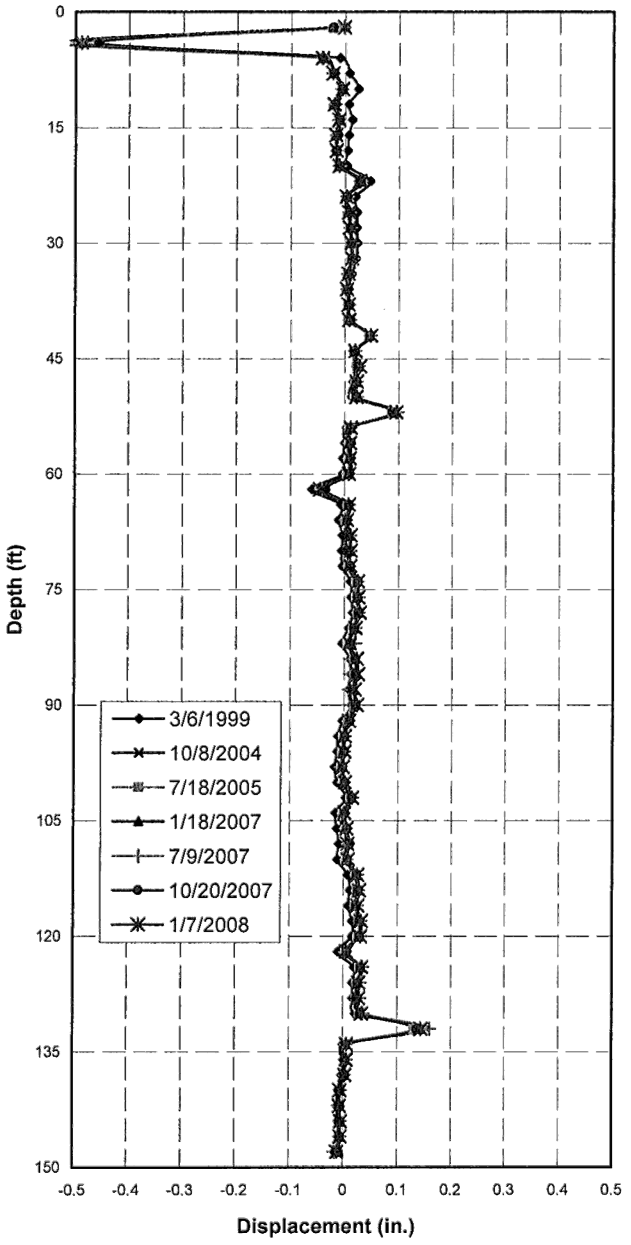


Cumulative

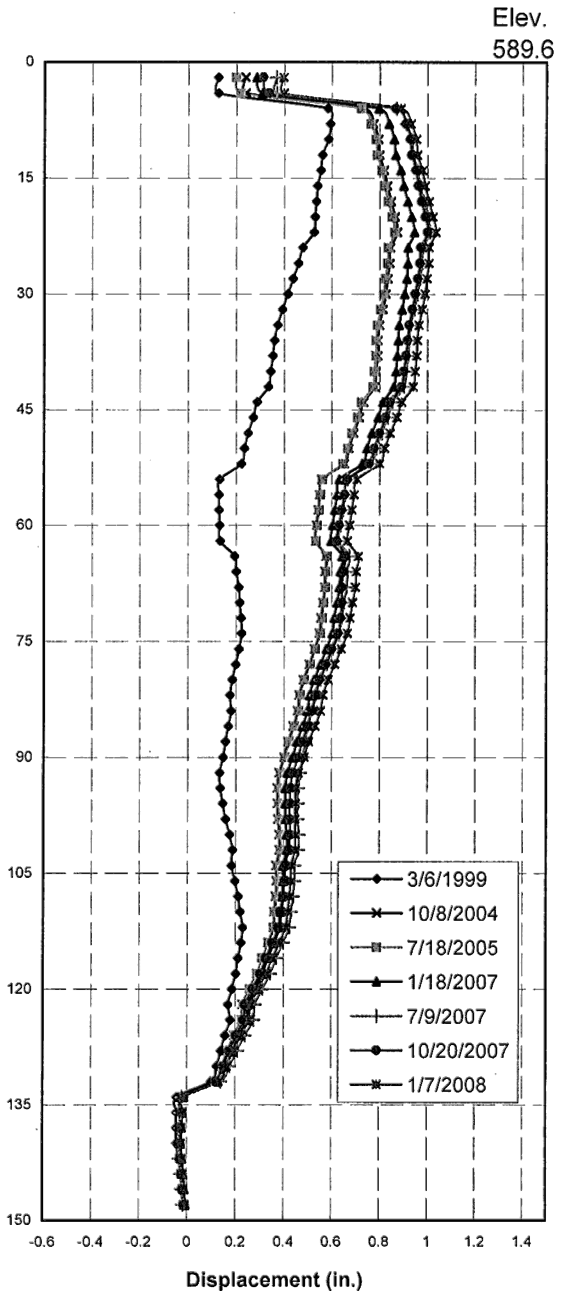


Inclinometer #3 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

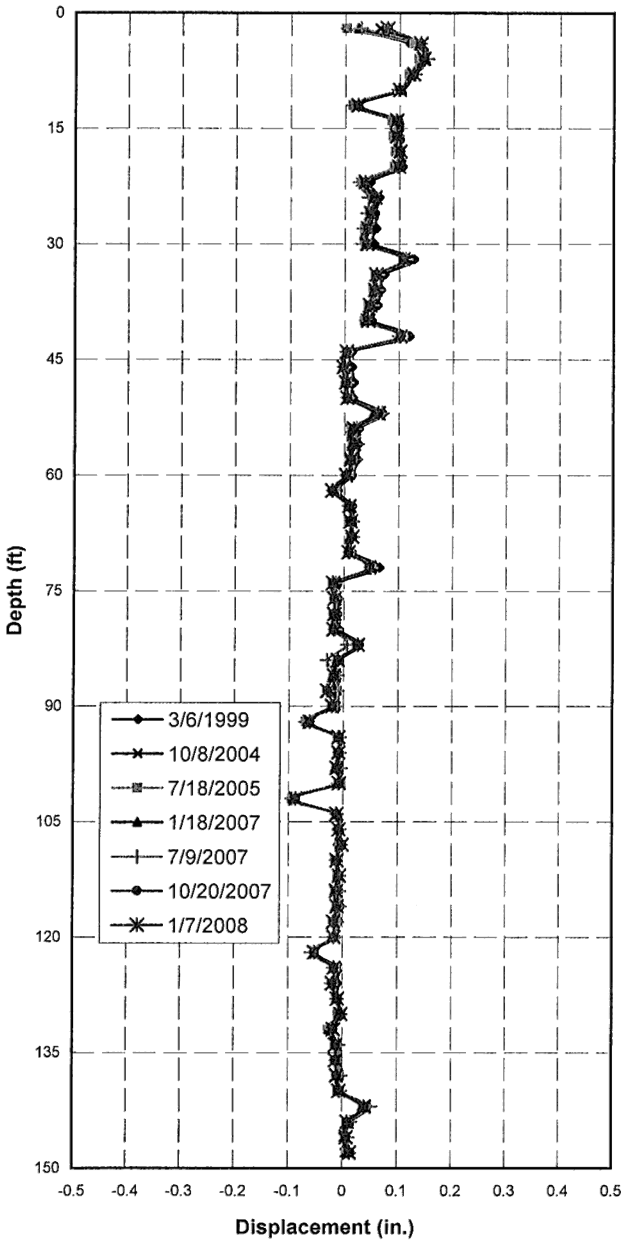


Cumulative

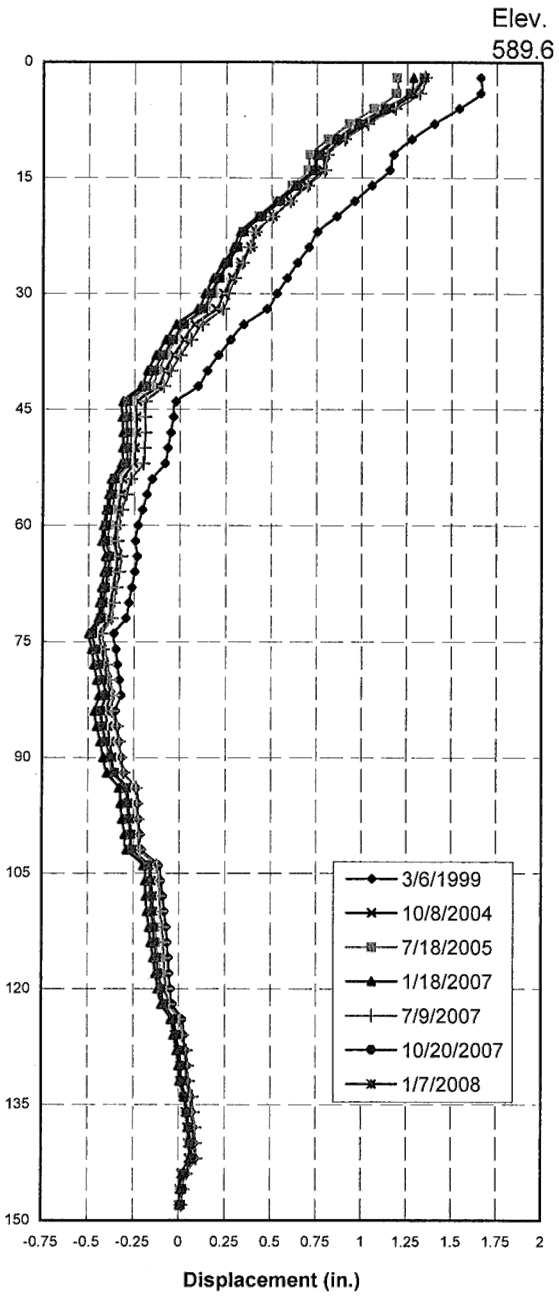


Inclinometer #3 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

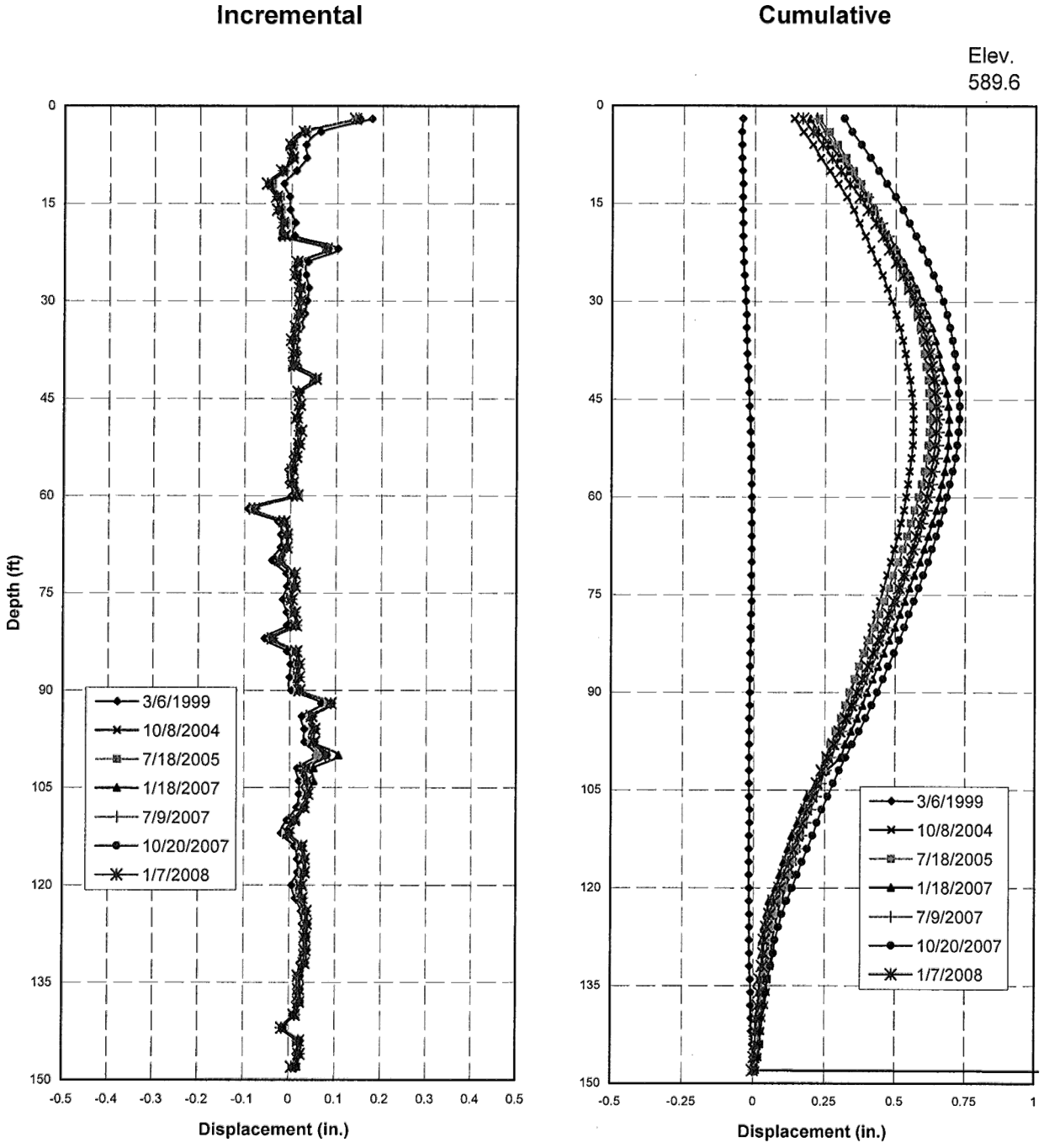
Incremental



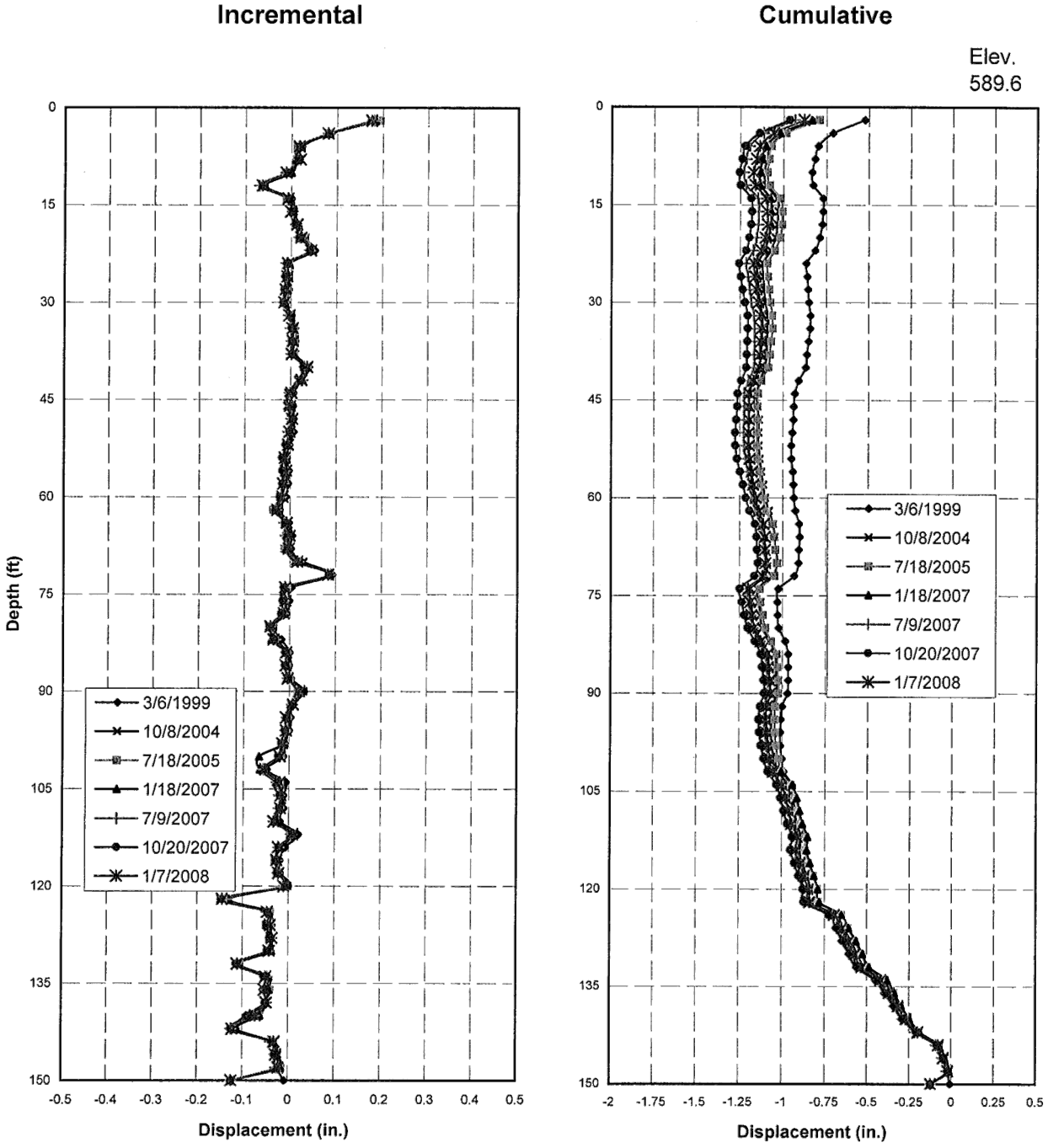
Cumulative



Inclinometer #8 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

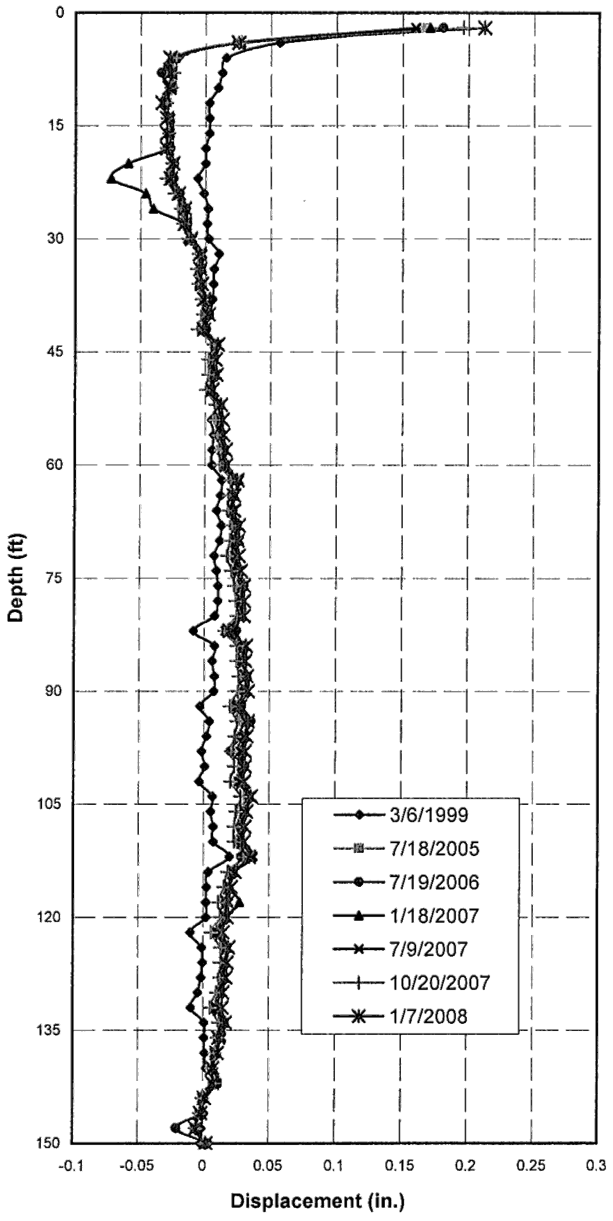


Inclinometer #8 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

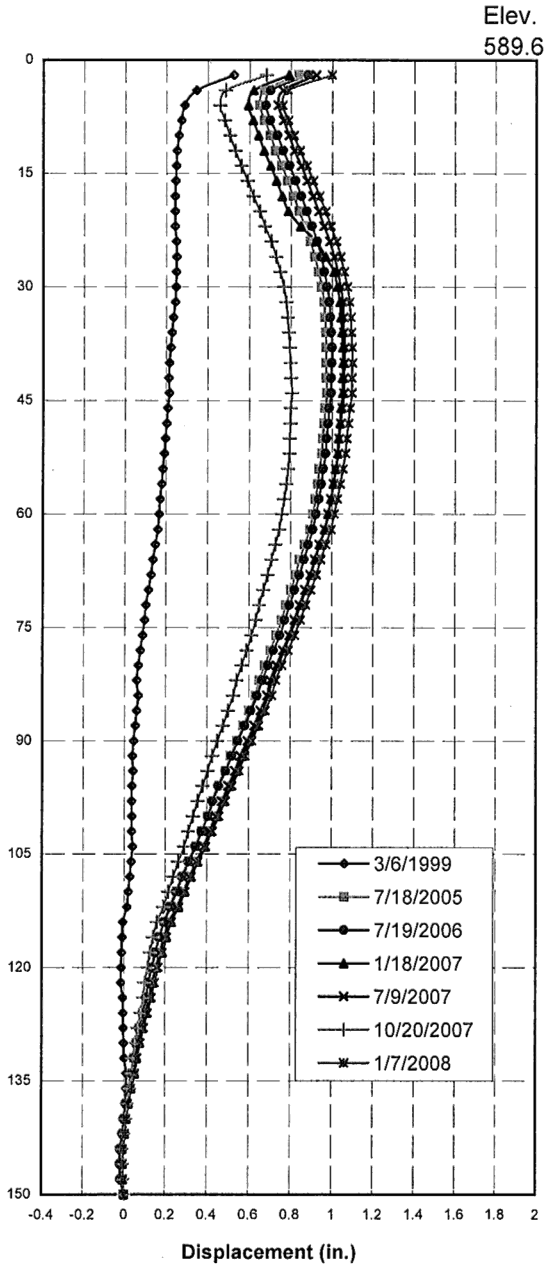


Inclinometer #9A Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

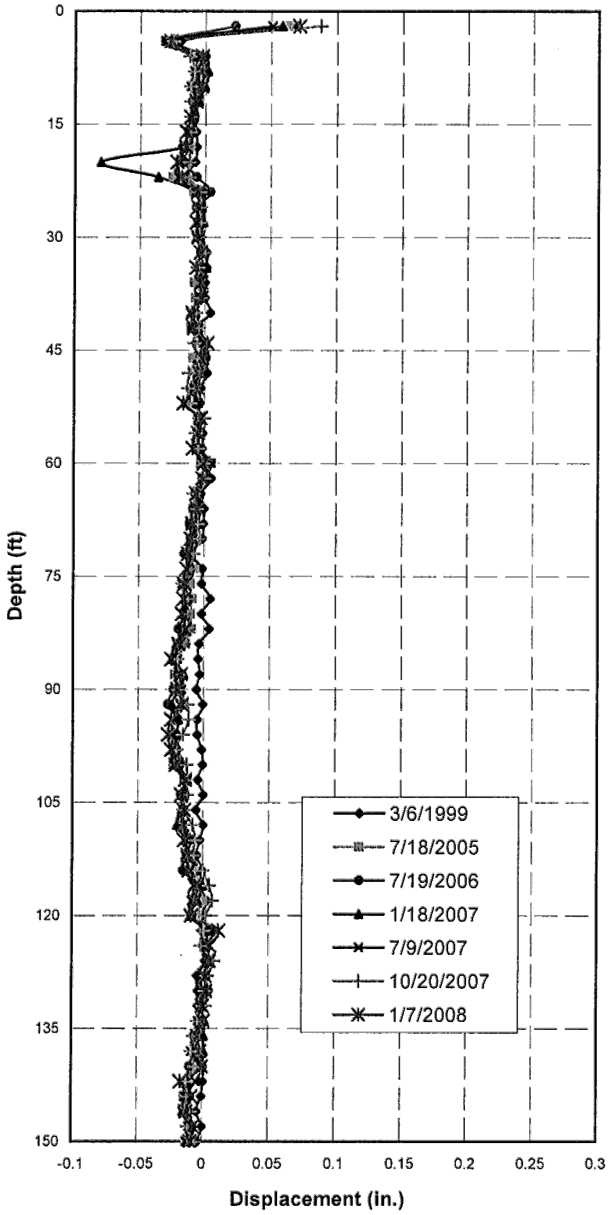


Cumulative

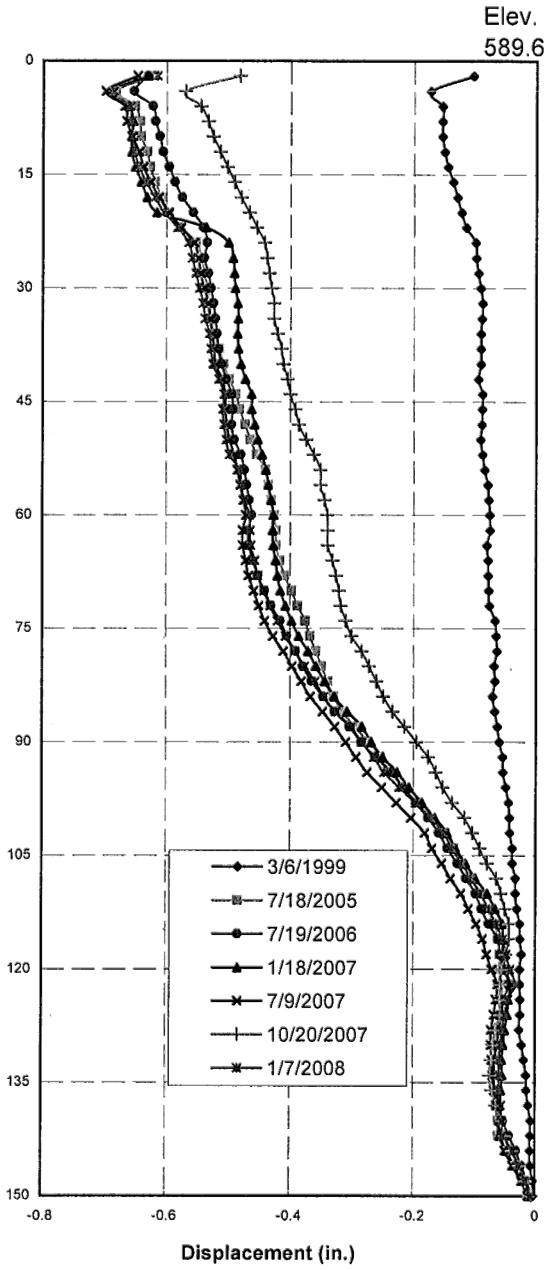


Inclinometer #9A Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

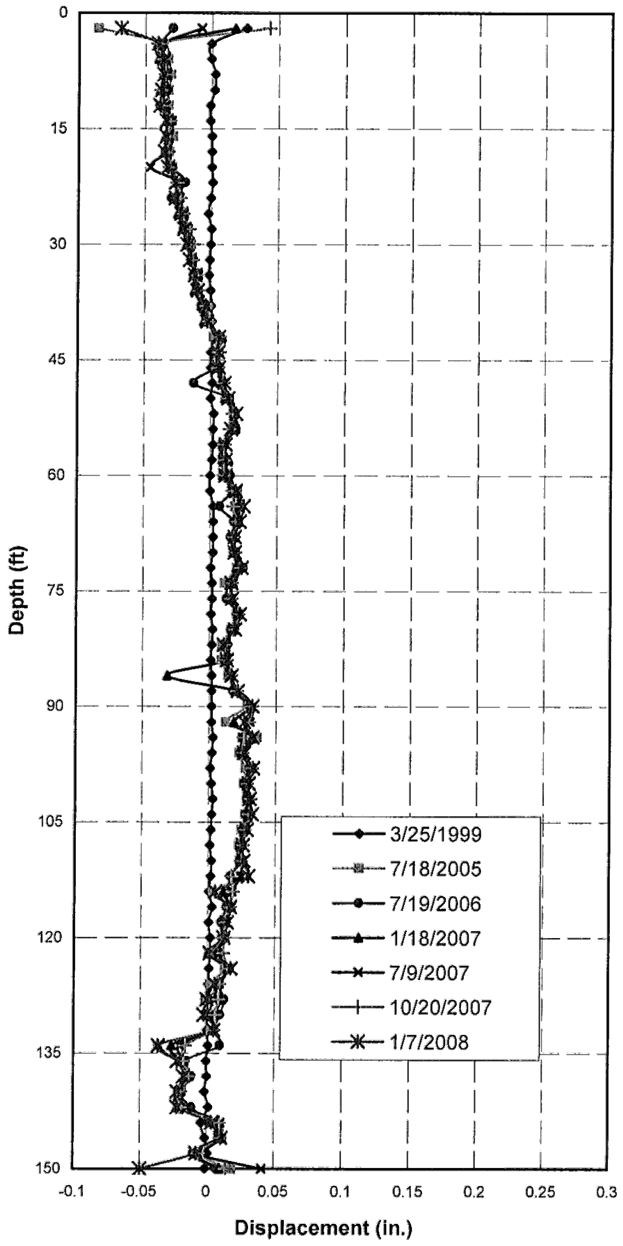


Cumulative



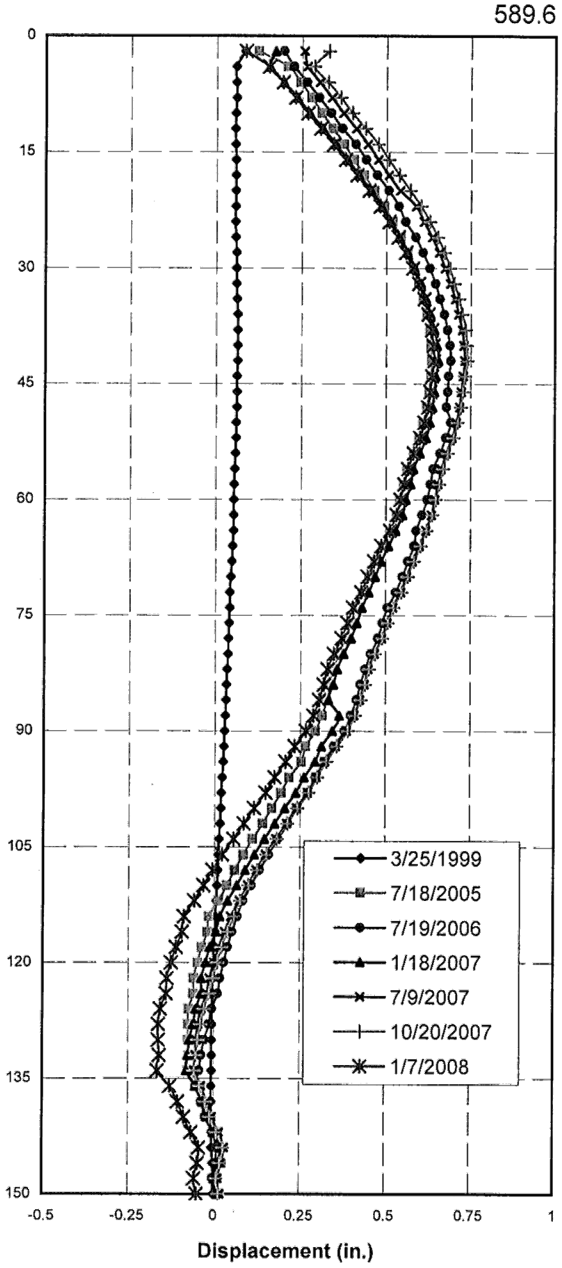
Inclinometer #10 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

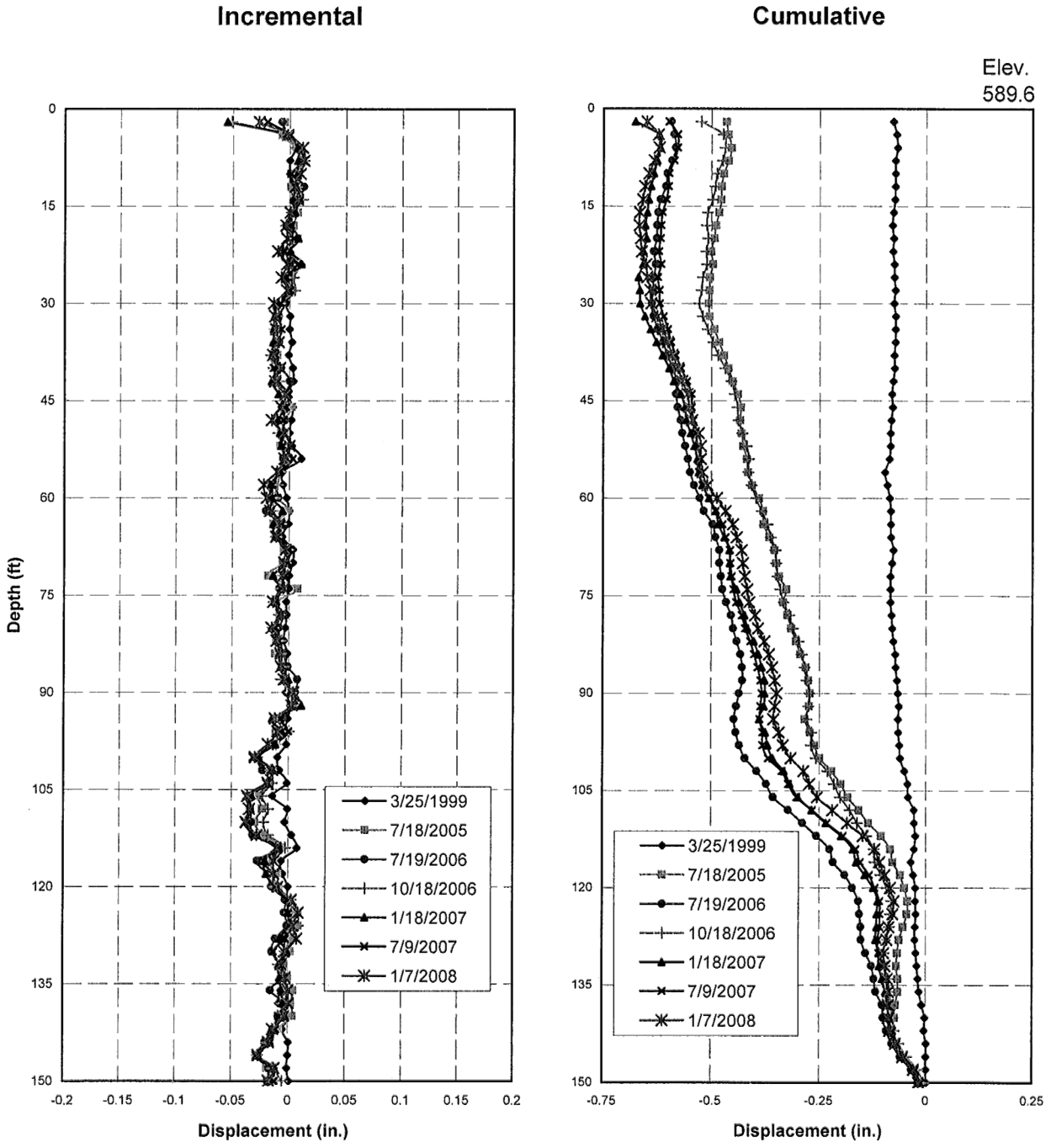


Cumulative

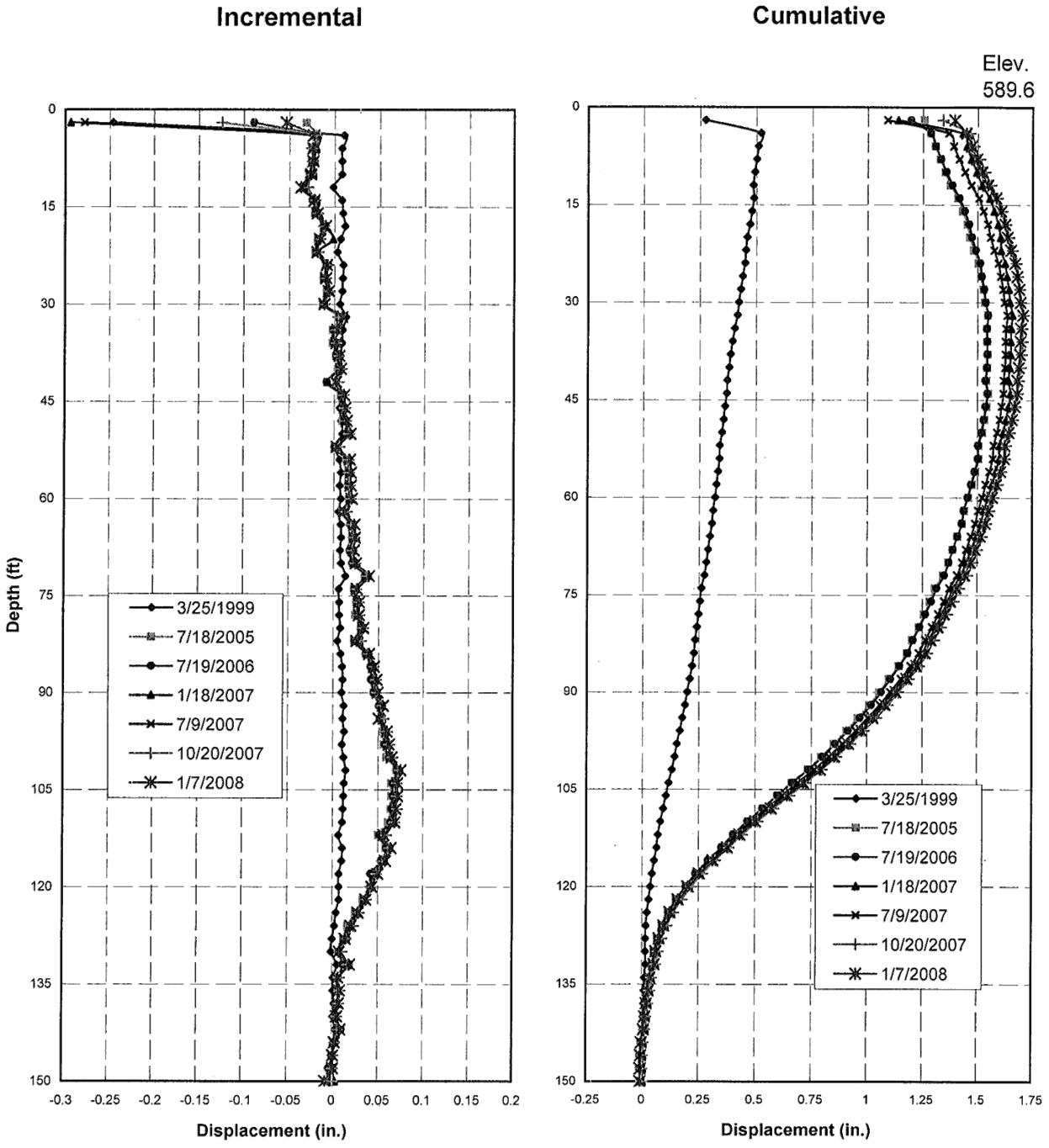
Elev.
589.6



Inclinometer #10 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

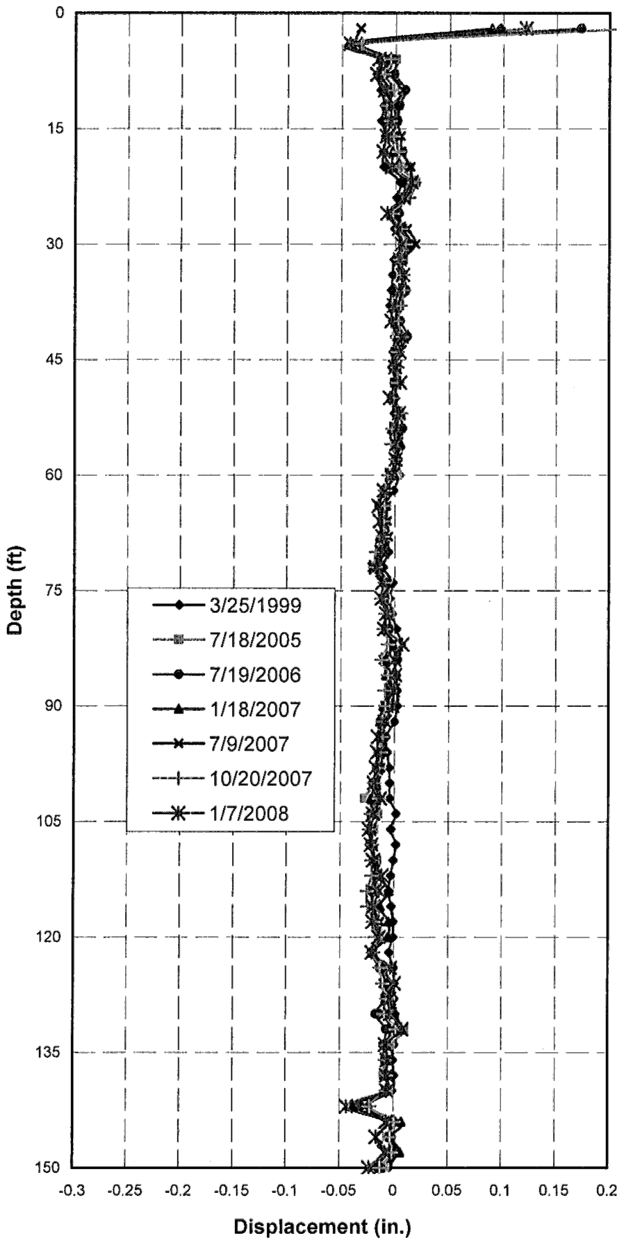


Inclinometer #17 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

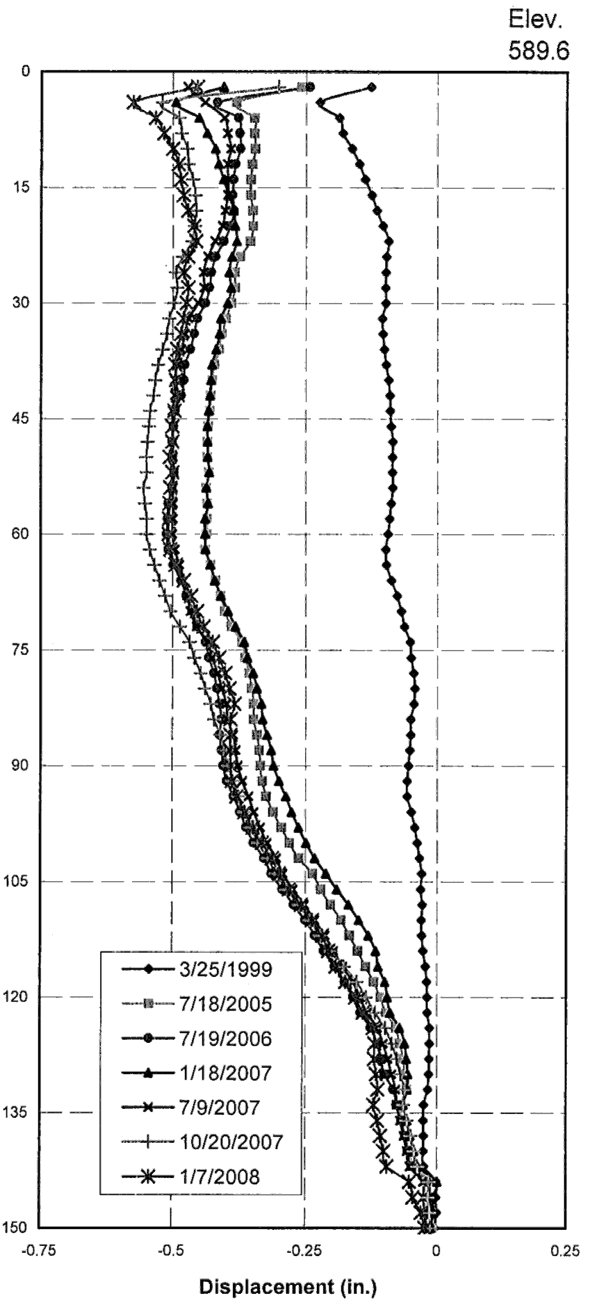


Inclinometer #17 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



Cumulative



CUY-90-1524
Central Viaduct
PID No. 77332

Monitoring Services
Annual Report

July 2, 2008

RICHLAND ENGINEERING LIMITED
29 North Park Street, Mansfield, Ohio 44902-1769 • 419-524-0074 FAX 419-524-1812

106017

July 2, 2008

Ohio Department of Transportation
5500 Transportation Boulevard
Garfield Heights, Ohio 44125

Attn: Mr. Michael Malloy, P.E.

Re: CUY-90-1524
Central Viaduct
PID No. 77332
Monitoring Services
Annual Report

Dear Mr. Malloy:

Enclosed are two (2) copies of the following information:

- BBC&M Engineering, Inc.'s Annual Report dated May 2008 with information on the inclinometer readings taken through April 2008.
- Richland Engineering Limited schematic drawings of span 1 and 2, north and south truss measurements; relative span lengths; deck expansion joint openings; seat elevations; tabulations of pier location data; and plots of pier location data through October 2007.
- A. Huckelbridge tiltmeter data for pier 1 and the west end pier from July 27, 1999 through June 7, 2008.
- R. Liang annual instrumentation monitoring report dated May 2008.
- CD containing electronic files of the letter and annual report in .pdf format.

Note: For discussion, North is assumed to the left, perpendicular to the local centerline of bridge, toward Lake Erie.

The rock anchors were tensioned in April 1999 which put the stabilization structure in service. Site grading work was completed in May 1999. The span 1 superstructure was relocated in August 1999.

A study entitled "West End Slope and Substructure Evaluation," May 2005, was prepared by Richland Engineering Limited, BBC&M Engineering, Inc., Arthur Huckelbridge, and Robert Liang. The study was prepared for ODOT and evaluated the suitability of the existing west end pier, pier 1, west end slope, and slope stabilization structure for reuse in a rehabilitated structure.

The last annual report was dated June 1, 2007, for data collected through April 2007.

We have the following observations on the data collected:

1. No shallow failure plane movement has been observed in the immediate vicinity of pier 1 since the pier stabilization structure was constructed. Shallow failure planes are evident in data from inclinometers B-203 and B-303. B-203 and B-303 are located upslope of pier 1 and show an average rate of movement at the shallow failure plane of 0.045 inches per year. The average rate of movement of the shallow failure plane appears to have decreased to about 0.025 inches per year from 2004 to the present. The shallow failure plane is evident just outside the stabilization structure in inclinometers B-05-03 and B-108A, moving at an average rate of about 0.055 inches per year. Inclinometer B-05-16 to the north of pier 1 near the adjacent property bulkhead excavation shows a shallow failure plane moving at an average rate of 0.26 inches per year.

2. A deep failure plane is evident in data from inclinometers B-203, B-204, and B-303. B-203 and B-303 are located upslope of pier 1 and B-204 is located between the pier 1 legs. The average rate of movement at the deep failure plane in the area of pier 1 is 0.05 inches per year from 1999 to the present. The average rate of movement of the deep failure plane in the immediate vicinity and upslope from the pier 1 area appears to have decreased to about 0.02 inches per year from 2004 to the present.

3. A significant displacement of about 0.7 inches occurred at the top of inclinometer B105A southeast of the stabilization structure, between October 2007 and April 2008. The cantilever displacement may indicate the bulkhead is leaning to the river. Or construction equipment activity in the area during the same time period may have affected the inclinometer.

4. Inclinometer B-101, at the top of the slope west of the west end pier, has shown no significant movement since it was installed.

5. Pneumatic piezometer readings have shown no significant change from previous readings. The maximum change in water elevation during the past year occurred in B-105 blue and varied by 1.4 feet. Piezometers B-105 pink and B-105 blue continue to indicate an elevated water pressure.

6. New vibrating wire piezometers were installed in offset boreholes at B-05-01 through B-05-04, B-05-07, B-05-08 and B-05-11 through B-05-13, between May and June 2006. Two

piezometers were installed at each of the nine locations. The piezometers have shown stable pore pressures.

7. The Calipered Crack Distance measurements at the top of the concrete slope protection by the west end pier show no significant change. The measurements are showing an average movement of 0.06 inches per year since 1999.

8. One small aggregate pile was observed during each of the quarterly visits at the site in the area adjacent to the south right-of-way fence.

9. BBC&M personnel observed a small landslide appearing in January 2007 located at the north right of way line on the west side of the river. The landslide is near the excavation performed for the dock wall repair on the adjacent property. The failure has progressed.

10. Comparing October 2007 survey measurements with October 2000 data, it appears that the west end pier and pier 1 have moved toward the river with the span 1 distance showing little change and the span 2 distance decreasing about 0.8 inches.

11. The position of the north and south west end pier legs have moved toward the river approximately 1.1 inches and 0.8 inches, respectively, since October 2000.

12. The position of the top of each of the north and south legs of pier 1 appear to have moved toward the river approximately 0.6 inches and 0.8 inches, respectively, since October 2000.

13. The drilled shaft structure appears to be rotating with the south end moving ahead of the north end about 0.5 inches since October 2000.

14. There has been no significant change in the pier seat elevations.

15. In 1999, truss span 1 and 75% of span 2 were relocated to the west by approximately 3 inches to reopen the expansion joint in span 2. Since the relocation, maximum expansion joint openings have been measured of 2.38 inches at the north curb and 1.88 inches at the south curb. During the past year the openings varied from 0.88 inch to 1.63 inches at the north curb and 0.25 inch to 1.00 inch at the south curb for steel temperatures ranging between 19° and 70°F. It appears that about 0.6 inches of expansion opening has been lost since October 2000.

16. Tiltmeter readings on the west end pier and pier 1 have been steady for the past few years. There appears to be a systematic drift in the readings for tiltmeters #2 and 3 which may be electrical in nature. Duplicate tiltmeters should be installed at these locations to improve the data.

17. The instrumentation readings in the rock anchors, driven piles, and tieback beams have been steady. The instrumentation readings in the drilled shafts have shown a continued increase in

bending moments, although at a slower rate of increase. Inclinometers in the drilled shafts are showing some decreased deflection.

18. The 17 rock anchors are made up of 16 strands of 0.6 inch diameter 270 ksi steel material. The anchors were initially tensioned to ±10% of the design load. Actual measured values in the 4 anchors being monitored were 490 kips to 600 kips at lock-off. After initial losses the anchors had a gradual reduction in load on the order of 3% to 9% in the first year. Present load levels in the anchors being monitored are 359 kips to 497 kips. The rock anchor loads continue to decrease at a slow rate.

19. The 34 anchor structure piles are HP 14x89 steel piles. Actual measured values in the 5 piles being monitored were 373 kips to 474 kips for piles #17, 18, 19, and 34 with pile #1 measured at 610 kips. There is significant bending (up to 200 kip-ft.) in some of the piles at the gage locations. The gages are located at the top of the pile. The pile loads have increased very slowly since the stabilization structure was loaded.

20. The tiebacks that are being monitored between the anchor structure and the drilled shaft structure are W8x35 rolled steel sections. Actual measured values in the 5 tiebacks being monitored were 109 kips to 144 kips at the anchor structure end, and 34 to 111 kips at the drilled shaft structure end. There is significant bending (up to 52 kip-ft.) in the tiebacks at the gage locations at the ends of the tiebacks. There is less bending in the tiebacks at the drilled shaft structure end. The tieback loads increased with time for the first year, but have become steady over the past seven years. The tieback forces oscillate through one cycle in a year due to the seasonal change in temperature. The tieback forces are up to 15 kips higher during the winter than in the summer months.

21. There are seventeen 72 inch diameter reinforced concrete filled drilled shafts in the drilled shaft structure. Actual moments measured in the drilled shafts were a maximum of 2,000 kip-feet at a depth of 95 feet in Shaft #9. The moments in the drilled shafts have been increasing with time. It appears that the rate of increase may be slowing.

22. Dr. Liang has been monitoring 7 inclinometers in 6 of the drilled shafts. The inclinometers indicate a gradual change in the deflection of the shafts with deflection at the top varying from 0.1 to 1.1 inches and the maximum deflection below the top of the shaft at 1.6 inches in the longitudinal direction. The shaft deflections have decreased in the past year.

We have the following comments regarding the evaluation and monitoring data:

1. There is movement at the shallow failure plane within the influence of the stabilization structure, but it is moving at a slower rate than the adjacent soil mass. The movement is at an average rate of about 0.045 inches per year since 1999. This rate appears to have decreased to about 0.025 inches per year from 2004 to the present.

2. There is movement at the deep failure plane within the influence of the stabilization structure, but it is also moving at a slower rate than the adjacent soil mass. The average rate of movement at the deep failure plane outside the influence of the stabilization structure is about 0.05 inches per year. The average rate of movement within the area of the stabilization structure is about 0.02 inches per year.

3. The tops of the west end pier and pier 1 legs have moved toward the river and closed the span 2 expansion joint about 0.6 inches since October 2000.

4. The pier 1 and truss superstructure instrumentation performed in 2005 for the "West End Slope and Substructure Evaluation Study" showed that the tops of the pier 1 legs are moving west and east with expansion and contraction movement of the steel superstructure. The movement and horizontal thrust in the superstructure varies with temperature.

5. The substructure stabilization structure was originally designed using "LPILE" computer software to calculate forces and member design loads. The Contractor was given loads and designed the rock anchors, anchor structure and tiebacks to resist those loads.

   Under a separate ODOT sponsored research project Dr. Robert Liang prepared a finite element analysis of the stabilization structure as it was being constructed ("Long Term Monitoring at CUY-90-1524 Bridge Project," December 31, 1999).

   The original design loads, the finite element analysis (FEA), and the range of measured values are compared in the attached table.

   a. Rock anchor loads are less than design and FEA values and generally continue to decrease at a slow rate.

   b. The loads in the piles are higher than expected. The anchor structure pile gages are located near the top of the piles in an area of localized bending. The combined axial load and bending may have exceeded the 36 ksi yield value of the steel. However, the piles will redistribute the load in the redundant system through yielding before failure would occur.

   c. The axial tension in the tiebacks is less than the design load and slightly higher than the loads calculated by FEA. Again, combined axial loads and bending may approach yield at isolated locations, but the members would not fail.

   d. The moment in the piles and tiebacks and the bending in the drilled shafts indicates a rotation of the anchor structure concrete cap about the transverse axis of the cap.

   e. The drilled shaft measured moments and deflections are well below the design values. The increasing moments measured in the drilled shafts indicate increased bending in the shafts.

The bending is expected as the soil mass lateral loading is gradually transferred to the drilled shafts. The rate of moment increase appears to be decreasing.

6. The stabilization structure is currently performing adequately with only some minor concern for the high loads in the anchor structure piles. The stabilization structure has slowed the rate of creep movement in the soil mass within its influence.

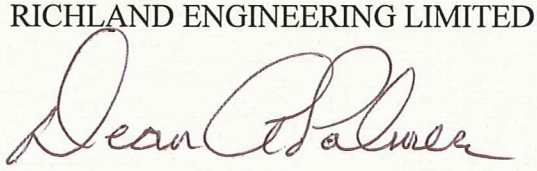
7. Loading and pressures within the stabilization structure and the influenced soil mass are continuing to increase at a slow rate. The rate of change of moment in the drilled shafts has slowed. The stabilization structure was designed with the concept that the structure and soil mass would reach equilibrium at some time in the future when loads and deflections would remain constant. However, the "West End Slope and Substructure Evaluation Study" has suggested that the stabilization structure may have a finite life. The creep movement at the failure planes has historically moved at a very slow rate. The data collected over the past 9 years indicates that there is still movement at the failure planes, but within the last few years this movement appears to be slowing.

The next readings are scheduled about July 15, 2008. The monitoring will continue by the same parties under the agreement between ODOT and Michael Baker Jr., Inc.

Please contact us if you have any questions.

Very truly yours,

RICHLAND ENGINEERING LIMITED



Dean A. Palmer, P.E.

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Steve Pasternack, BBC&M Inc., w/enc.
Art Huckelbridge, w/enc.
Robert Liang, w/enc.
Bob Parker, Michael Baker Jr., Inc., w/enc.
Rick Engel, E.L. Robinson Engineering Co., w/enc.

COMPARISON OF MEMBER LOADS
DESIGN VALUES AND MEASURED VALUES
CUY-90-1524 SLOPE STABILIZATION STRUCTURE

MEMBER	DESIGN	FINITE ELEMENT ANALYSIS	January 2001 MEASURED	January 2002 MEASURED	April 2003 MEASURED	April 2004 MEASURED	April 2005 MEASURED	April 2006 MEASURED	April 2007 MEASURED	May 2008 MEASURED
Rock Anchors	550 kips	550 kips	430 to 530 kips	400 to 510 kips	380 to 501 kips	370 to 494 kips	366 to 494 kips	365 to 487 kips	361 to 501 kips	359 to 497 kips
Anchor Structure Piles										
Axial Load	279 kips	310 kips	358 to 566 kips	362 to 583 kips	365 to 585 kips	368 to 594 kips	368 to 603 kips	370 to 606 kips	371 to 608 kips	373 to 610 kips
Moment	None	80 kip-feet	32 to 192 kip-feet	8 to 191 kip-feet	49 to 192 kip-feet	49 to 199 kip-feet	55 to 206 kip-feet	56 to 203 kip-feet	57 to 202 kip-feet	59 to 200 kip-feet
Tiebacks										
Axial Load - Anchor End	192 kips	100 kips	101 to 124 kips	99 to 124 kips	108 to 134 kips	111 to 139 kips	111 to 143 kips	112 to 144 kips	110 to 143 kips	109 to 144 kips
Axial Load - Drilled Shaft End	192 kips	100 kips	58 to 111 kips	55 to 112 kips	46 to 110 kips	45 to 113 kips	40 to 112 kips	39 to 113 kips	39 to 113 kips	34 to 111 kips
Moment - Anchor End	None	80 kip-feet	13 to 42 kip-feet	13 to 43 kip-feet	14 to 48 kip-feet	14 to 49 kip-feet	14 to 45 kip-feet	15 to 52 kip-feet	15 to 51 kip-feet	15 to 52 kip-feet
Moment - Drilled Shaft End	None	80 kip-feet	1 to 29 kip-feet	1 to 30 kip-feet	2 to 29 kip-feet	1 to 30 kip-feet	2 to 31 kip-feet	1 to 32 kip-feet	2 to 32 kip-feet	2 to 33 kip-feet
Drilled Shafts										
Deflection at Top	2.0 inch	0.4 inch	0.2 inch	-0.2 to 0.6 inch	-0.1 to 0.7 inch	0.1 to 1.1 inch	0.1 to 1.0 inch	0.2 to 1.2 inch	0.3 to 1.1 inch	0.1 to 1.1 inch
Maximum Deflection Below Top	4.0 inch	0.1 inch	0.4 inch	1.0 inch	1.3 inch	1.5 inch	1.5 inch	1.6 inch	1.65 inch	1.6 inch
Maximum Moment	3,141 kip-feet	800 kip-feet	1,000 kip-feet	1,045 kip-feet	1,400 kip-feet	1,600 kip-feet	1,700 kip-feet	1,800 kip-feet	1,900 kip-feet	2,000 kip-feet
Maximum Axial Force	458 kips	420 kips	1,100 kips	2,382 kips	3,000 kips	3,250 kips	----	----	----	----

2007-2008 ANNUAL REPORT
FIELD MONITORING SERVICES
CUY-90-14.52/15.24
PID #77332
CLEVELAND, OHIO

Report to

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

Prepared by

BBC&M ENGINEERING, INC.
CLEVELAND, OHIO

May 2008

May 2, 2008
012-00946-300

BBCM
SOLUTIONS TO BUILD ON

Mr. Dean A. Palmer, P.E.
Richland Engineering Limited
29 North Park Street
Mansfield, Ohio 44902

Re: CUY-90-14.52/15.24 Bridge
2007-2008 Annual Report - Field Monitoring Services
PID No. 77332

Dear Mr. Palmer:

In accordance with our proposal dated February 1, 2006, BBC&M Engineering, Inc. (BBCM) has completed the field monitoring services during the period of July 2007 through April 2008 as part of the CUY-90-14.52/15.24 project. Quarterly reports were submitted to Richland Engineering Limited in July 2007, November 2007, and February 2008 for quarterly readings taken in July 2007, October 2007, and January 2008, respectively. A quarterly report was not submitted summarizing the data obtained in April 2008 per your instructions via an e-mail dated March 31, 2008. This annual report summarizes the data obtained from all the actively monitored instrumentation (inclinometers, piezometers, and calipered distance locations), discussions of observations of the data, and general site observations.

We appreciate being of continued service during this project. The next quarterly readings are scheduled to take place around July 15, 2008. Please contact our office if you have any questions or require additional information.

Sincerely,
BBC&M ENGINEERING, INC.
Cleveland, Ohio

Jeffrey L. Snyder, P.E.
Project Engineer

Stephen C. Pasternack, P.E.
Senior Project Engineer

JLS/jls

cc: Mr. Robert B. Parker, P.E. (Michael Baker Jr., Inc.)
Submitted: 2 hard copies (1 bound, 1 unbound) and 1 pdf copy on CD to Richland Engineering Limited, 1 pdf copy to Michael Baker Jr., Inc. via their ftp site

8555 Sweet Valley Dr., Ste. S • Valley View, OH 44125-4210 • Phone 216.901.1000 • Fax 216.901.9996

EXECUTIVE SUMMARY

Quarterly readings were taken at the new and remaining active inclinometers and piezometers in July 2007, October 2007, January 2008 and April 2008.

Inclinometers

In general, there are observed movements that correspond to two major slide planes, termed the shallow and deep failure planes.

In the immediate vicinity of the Pier 1 area, no shallow slip-plane movements have been observed since completion of construction of the Pier 1 stabilization system. The shallow failure plane upslope from the Pier 1 area (B-203 and B-303) is moving at an average rate of about 0.045 inches per year from April 1999 to the present yet appears to have decreased to a rate of about 0.025 inches per year from 2004 to the present. In the vicinity of Pier 1 just outside of the stabilization system (B-05-03 and B-108A), the shallow failure plane is moving at an average rate of about 0.055 inches per year. Well outside the Pier 1 area (B-05-16), the shallow failure plane is moving at an average rate of 0.26 inches per year. This higher rate of movement in B-05-16 is most likely due to the close proximity of this inclinometer to the open excavation adjacent to the west right-of-way fence.

South of the West End Pier, the deep failure plane is moving at an average rate of about 0.03 inches per year. The B-101 inclinometer has indicated nominal movement since its installation. In the Pier 1 area (B-203, B-204 and B-303), the deep failure plane is moving at an average rate of about 0.05 inches per year from April 1999 (August 2001 in B-204) to the present. From 2004 to the present, the average rate of movement of the deep failure plane appears to have decreased. Including the rates of movements from the inclinometers installed in 2006 (B-05-03, B-05-04 and B-108A), the average rate of movement of the deep failure plane in the Pier 1 area is about 0.02 inches per year from 2004 to the present. Well outside the Pier 1 area (B-05-16), the deep failure plane is also moving at an average rate of about 0.02 inches per year.

Cantilever displacement has been observed in B-105A to a depth of about 60 to 70 feet similar to that observed in B-105 (now inactive). **A significant relative displacement of about two-thirds (2/3) of an inch has occurred between October 2007 and April 2008 indicating the bulkhead may be leaning outwards at a significantly increased rate. Prior to October 2007, the cantilever displacement in B-105A was occurring at a rate of about 0.16 inches per year. Since October 2007, this cantilever displacement rate has significantly increased to about 1.27 inches per year.**

Other potential slope movements (not yet developed enough to be called definitive slide planes) have been observed in some of the new and replacement inclinometers, which are listed as follows:

- In B-105A, depth of 85 feet and 110 feet; and,
- In B-05-02 at depths of 109 and 129 feet.

Distinct and consistent movement has not been observed in the inclinometers at B-05-01, B-05-07, B-05-08, B-05-11, B-05-12 and B-05-13. However, displacements may not yet be evident within the time period between the baseline and the current readings. Multiple readings over a period of a few years are likely needed to measure definitive displacement trends.

Pneumatic Piezometers

The readings for the pneumatic piezometers were similar between the four (4) quarters. The B-105 blue piezometer indicated an elevated water pressure with the total head ranging from 4.1 to 5.5 feet above the existing ground surface. Additionally, the B-105 pink piezometer indicated an elevated total head ranging from 0.1 feet below to 1.3 feet above the existing ground surface.

Vibrating Wire (VW) Piezometers

The measured total head values were relatively constant over the last four (4) quarters with a difference between maximum and minimum total head values of no more than 3.4 feet in all of the VW Piezometers. Six (6) VW piezometers indicated a gradual increase in pore pressures until about the beginning of May 2007 upon which the measured pore pressures have since been relatively constant or a decreased rate of pore pressure increase has been observed. Six (6) of the VW Miniloggers have been unresponsive most likely due to the flooding of the Minilogger boxes or other unknown cause(s).

Additional Field Observations

BBCM personnel observed evidence of a potential small landslide during the January 2007 quarterly readings that may have occurred after the quarterly readings were taken in October 2006. This small landslide area is located near the west right-of-way fence just north of B-05-16, adjacent to the river and on the eastern edge of the large excavation. It appears that progressive failure in this landslide area has occurred between January 2007 and April 2008.

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1.0 INTRODUCTION

This Annual Report presents the results and evaluation of data collected from July 2007 to April 2008 in instrumentation installed by BBC&M Engineering, Inc. (BBCM) at or near the West Abutment of the existing I-90 Central Viaduct Bridge.

Of the 14 inclinometers and 12 pneumatic piezometers installed by BBCM between 1994 and 1999, seven (7) inclinometers (B-101, B-102, B-107, B-203, B-204, B-303 and P-9N) and six (6) pneumatic piezometers at B-101 and B-105 (2 piezometers each), as well as B-107 and B-303 are still actively monitored. This active instrumentation is associated with the CUY-90-15.24 project. During the period of March through June 2006, BBCM installed 12 new inclinometers (including 3 replacement inclinometers) and 18 vibrating wire (VW) piezometers. These newly installed inclinometers and piezometers are associated with the CUY-90-14.52 Innerbelt project. A Summary Table and Site Plan of Active Instrumentation are submitted as Plates 1 and 2 of the Appendix. Quarterly readings were taken at the new and remaining active inclinometers and piezometers in July 2007, October 2007, January 2008 and April 2008.

1.1 New and Replacement Inclinometers

The inclinometers B-105A, B-108A and B-05-16, installed between April 2006 and June 2006, are replacement inclinometers for B-105, B-108 and B-110, respectively. The B-110 inclinometer was destroyed by excavation activities adjacent to the west right-of-way fence (see Plate 2 in the Appendix for the location of B-110) in mid-March 2006. These excavation activities are associated with the repair effort of the failed bulkhead in this area. This repair effort appears to be unfinished as of April 2008. The B-105 and B-108 inclinometers became unreadable due to excessive displacements at the observed slide planes. Baseline (initial) readings were taken at these replacement inclinometers in June 2006. New inclinometers were also installed at B-05-01 through B-05-04, B-05-07, B-05-08 and B-05-11 through B-05-13, between April 2006 and June 2006. Baseline readings were taken at these new inclinometers in June 2006.

1.2 New Piezometers

New VW piezometers were installed in offset boreholes at B-05-01 through B-05-04, B-05-07, B-05-08 and B-05-11 through B-05-13, between May and June 2006. Two (2) VW piezometers were installed at each of the nine (9) locations. Readings are automatically taken generally every eight (8) hours and stored in portable data collectors called VW Miniloggers. Five (5) of the VW Miniloggers are currently unresponsive and one (1) VW Minilogger has been unresponsive in the past but some readings were able to be downloaded in April 2008. These Miniloggers may have been damaged by flooding of the Minilogger boxes or are not functioning due to some other unknown cause(s). Manual readings, which represent the pore pressures at the time of reading, have been taken at the unresponsive VW Miniloggers.

2.0 DISCUSSION OF INSTRUMENTATION DATA

2.1 Inclinometers

Spiral (twist) measurements were performed in January 2005 on the 10 inclinometers that were active at the time. Spiral measurements were also performed in June 2006 on the 12 new/replacement inclinometers. All the data sets presented in the Appendix have been corrected to account for the measured spiral of the inclinometer casings.

The Cumulative and Incremental Displacement vs. Depth plots in the Appendix show one reading from each of the previous four quarters. Additionally, the Displacement vs. Time plots include at least one reading from each year since the baseline readings.

Lateral deflections from slope inclinometer measurements contain both random and systematic errors. Durham Geo Slope Indicator Company provides typical displacement accuracy threshold for slope inclinometer measurements as follows:

1) Ordinary precision of ± 0.3 inches per 100 ft of casing using standard installation procedures;
2) Higher Precision of ± 0.1 inches per 100 ft of casing with careful survey practices and error correction during data reduction; and,
3) Highest Precision of ± 0.05 inches per 100 ft of casing with careful survey and data selection from redundant data sets and excellent casing installation.

BBCM considers the inclinometer measured displacement data presented herein to have a precision in the range of ± 0.1 to ± 0.2 inches per 100 ft. **Hence, any measured displacement (especially along deep failure planes) on the order of about 0.1 inches could be due to data precision errors and not actual field movements.** The actual estimated rates of slope movement in active inclinometers generally range from about 0.01 inches per year to 0.26 inches per year on the two slide planes.

The rates of movement were computed using linear regression for the depth ranges shown on the Displacement vs. Time plots in the Appendix. The rates of movement are discussed in more detail in Sections 2.1.2 of this report. Linear regression provided a best-fit match through the data points on each of the Displacement vs. Time curves. The time period for the linear regression (see the time periods presented in Tables 1a and 1b in Section 2.1.2) was chosen based on a visual observation of each curve at the time when the rate was believed to have last changed significantly (typically in 1999 or 2000 just after the end of construction of the Pier 1 stabilization system). Some of the inclinometers indicate a somewhat decreased rate of movement since 2004, which is subsequently discussed. Linear regression, therefore, was also performed on the data in some of the inclinometers over a time period from 2004 to the present (see Tables 1a and 1b). The 95% confidence interval of the regression of each analyzed slide plane from 1999 or 2000 to the present falls within the range of the expected precision of the inclinometer measurements (about 0.1 inches per 100 ft). However, as the decreased rate has been consistent for a period of nearly four (4) years, it is likely that the rates of

movements have generally decreased from 2004 to the present in the inclinometers installed before 2000. The decreased rate of movement likely indicates that greater load is being transferred from the creeping soil mass to the stabilization system. Note that short term increases in the rates of movements have been observed in some of the new inclinometers (i.e., B-105A and B-05-16, subsequently discussed) outside of the stabilization area.

In general, there are observed movements that correspond to two major slide planes, termed the shallow and deep failure planes. In some of the inclinometers, multiple slide planes may be observed within the shallow or deep failure zones (i.e. B-203, B-303 and B-05-16). In such cases, the multiple slide planes have been grouped together and referred to as part of either the shallow or deep failure plane, whichever is deemed more appropriate. Consequently, the magnitude and rate of movements subsequently discussed are the summation of the relative movements of the individual slide planes within either the shallow or deep failure plane. This summation is performed in an attempt to quantify the total relative soil movement that would be transferred to a pier or the stabilization structure.

2.1.1 Systematic Error Correction

Systematic errors are correctable errors observed in inclinometer data and are caused by one or more of the following factors: sensor bias-shift, rotation (sensor alignment shift), sensitivity drift, depth positioning error (DPE), and casing inclination/curvature. The data presented in this report have been analyzed and corrected for bias-shift, rotation and DPE, where necessary.

A large surficial displacement in the upper 20 feet that was observed in the B-05-12 inclinometer between the initial reading in June 2006 and the second reading in July 2006 appears to have been caused by DPE (see Plates 42A and 43A in the Appendix). There have been minimal displacements observed in the upper 20 feet of this inclinometer since the July 2006 reading and nearby inclinometers (i.e. B-107 and B-05-02) have not indicated a similar displacement thus indicating this displacement is not likely real. The Cumulative and Incremental Displacement vs. Depth plot shown on Plates 42 and 43 have been reinitialized to the July 2007 reading to eliminate this surficial displacement.

2.1.2 Summary of Observed Movements

Tables 1a and 1b below summarize the average rates of movement for the shallow and deep failure planes and the various time ranges chosen for each active inclinometer where consistent movements have been observed. The time ranges shown in these tables extend to the last set of readings taken within each respective inclinometer. The inclinometers where movements have been observed have been divided into five (5) categories based on location as follows: 1) the immediate vicinity of the Pier 1 area, which includes the inclinometers within the Pier 1 stabilization system (B-204, B-05-04); 2) vicinity of Pier 1, which includes inclinometers just outside of the Pier 1 stabilization

system (B-05-03, B-108A); 3) upslope from Pier 1 (B-203, B-303); 4) south of the West End Pier (B-102 and B-107); and, 5) well outside the Pier 1 area (B-05-16).

In the inclinometers installed before 2000, the rates of movements from 1999 to the present for the shallow and deep failure planes have either remained the same or decreased slightly compared to the rates reported in BBCM's 2006-2007 Annual Report dated May 4, 2007. The rates of movements last significantly changed in these older inclinometers around 1999 shortly after construction of the stabilization system was completed. Rates of movements for the new and replacement inclinometers installed in 2006 were not reported in the 2006-2007 Annual Report as there was not enough data in these inclinometers yet to determine general trends of movements.

As indicated in Tables 1a and 1b, the rates of movements appear to have generally decreased from 2004 to the present in the inclinometers installed before 2000 in the Pier 1 area. These decreased rates of movements for the deep failure plane are generally similar to the rates of movements observed on the deep failure plane in the new and replacement inclinometers installed in 2006 in the Pier 1 area. However, the two (2) inclinometers (B-05-03 and B-108A) in the Pier 1 area indicate the shallow failure plane just outside of the Pier 1 stabilization system is currently moving at an average rate just slightly higher than observed in the older inclinometers from 1999 to the present. No shallow slip-plane movements have been observed in the inclinometers within the Pier 1 stabilization system (B-204 and B-05-04) since completion of construction of the stabilization system.

The complexity of the depths, locations, and orientations of the shallow and deep movements in the inclinometers indicates that there are likely multiple deep and shallow failure planes at the site.

Table 1a: Average Rate of Movement in Inclinometers – Shallow Failure Plane

Inclinometer	Location	Time Range (1999-2008)	Avg. Rate of Movement (in/yr)	Time Range (2004[1]-2008)	Avg. Rate of Movement (in/yr)
B-203	Upslope from Pier 1	Apr-99 to Apr-08	0.03	Oct-04 to Apr-08	0.015
B-303	Upslope from Pier 1	Apr-99 to Apr-08	0.06	Jan-04 to Apr-08	0.035
Avg. Rate of Movement – Upslope from Pier 1			**0.045**		**0.025**
B-05-03	Vicinity of Pier 1	N/A	N/A	Jun-06 to Apr-08	0.075
B-108A	Vicinity of Pier 1	N/A	N/A	Jun-06 to Apr-08	0.03
Avg. Rate of Movement – Vicinity of Pier 1			**N/A**		**0.055**
B-05-16	Well Outside Pier 1 Area	N/A	N/A	Jun-06 to Apr-08	0.26

1 Time range of 2006-2008 for new inclinometers installed in 2006.

Table 1b: Average Rate of Movement in Inclinometers – Deep Failure Plane

Inclinometer	Location	Time Range (1999[1]-2008)	Avg. Rate of Movement (in/yr)	Time Range (2004[2]-2008)	Avg. Rate of Movement (in/yr)
B-102	South of West End Pier	Oct-99 to Apr-08	0.04	N/A[3]	N/A[3]
B-107	South of West End Pier	Apr-00 to Apr-08	0.015	N/A[3]	N/A[3]
Avg. Rate of Movement – South of West End Pier			**0.03**		**N/A**
B-204	Immediate Vicinity of Pier 1 Area	Aug-01[4] to Apr-08	0.04	Jan-04 to Apr-08	0.025
B-05-04	Immediate Vicinity of Pier 1 Area	N/A	N/A	Jun-06 to Apr-08	0.015
B-05-03	Vicinity of Pier 1	N/A	N/A	Jun-06 to Apr-08	0.03
B-108A	Vicinity of Pier 1	N/A	N/A	Jun-06 to Apr-08	0.025
B-203	Upslope from Pier 1	Apr-99 to Apr-08	0.025	Oct-04 to Apr-08	0.01
B-303	Upslope from Pier 1	Apr-99 to Apr-08	0.08	Jan-04 to Apr-08	0.03
Avg. Rate of Movement – Pier 1 Area			**0.05**		**0.02**
B-05-16	Well Outside Pier 1 Area	N/A	N/A	Jun-06 to Apr-08	0.02

1 The time period generally begins in 1999 or early 2000 (i.e., B-107).
2 Time range of 2006-2008 for new inclinometers installed in 2006.
3 Change of rate not observed in these inclinometers from 2004 to the present.
4 Inclinometer reinitialized on the shown date, which does not necessarily indicate the date when a significant change in the rate of movement occurred

Additional Observations in Active Inclinometers Installed between 1994 and 1999

The B-101 inclinometer has indicated nominal movement since its installation. The inclinometer at P-9N (installed in one of the drilled shafts) indicates the top of the drilled shaft is restrained laterally and that the maximum lateral deflection is about 0.94 inches and occurs approximately 40 to 60 feet below the top of the inclinometer casing.

Additional Observations in Active Inclinometers Installed in 2006

The deep-seated displacement at 120 feet in B-108A (see Table 1b) is nearly identical with the depth of the observed slide plane in the inactive inclinometer at B-108, which is located about 10 feet away from B-108A. Also, the rate of movement of this deep-seated displacement in B-108A (0.025 in/yr) is comparable to the rate of movement last observed in B-108 (0.03 in/yr) before it was inactivated.

In B-05-16, the deep-seated displacement at 113 feet listed in Table 1b is within five (5) feet of the depth of the observed slide plane in the now destroyed B-110 inclinometer. The rate of movement of this deep-seated displacement in B-05-16 (0.02 in/yr) is slightly higher than the rate of movement last observed in B-110 (0.01 in/yr). The rates of movement of the shallow slide planes in B-05-16 combine to be about 0.26 inches per year, which is significantly higher than the rates of movements observed in the shallow slide plane in other inclinometers at the site. These higher rates of shallow movement in B-05-16 are expected due to its close proximity to the open excavation in the vicinity of the removed B-110 inclinometer. Scarps, tension cracks and ground settlement have been observed in the area downslope of the inclinometer, which is discussed in more in detail in Section 3.3.

Cantilever displacement has been observed in B-105A to a depth of about 60 to 70 feet (see Plates 22 and 23 in the Appendix) similar to that observed in B-105, which is now inactive. The bulkhead at this location may be progressively leaning outwards toward the Cuyahoga River. **A significant relative displacement of about two-thirds (2/3) of an inch has occurred between October 2007 and April 2008 indicating the bulkhead may be leaning outwards at a significantly increased rate. Prior to October 2007, the cantilever displacement in B-105A was occurring at a rate of about 0.16 inches per year. Since October 2007, this cantilever displacement rate has significantly increased to about 1.27 inches per year.** A Displacement vs. Time plot for B-105A has been submitted as Plate 26 in the Appendix.

The deep-seated displacement at 117 feet in B-05-04 listed in Table 1b is identical with the depth of the observed slide plane in the B-204 inclinometer, which is located less than 10 feet away from B-05-04. The movement rate of this displacement in B-05-04 (0.015 in/yr) is slightly lower than the rate of movement observed in B-204 (0.025 in/yr).

In addition to the observed slide planes in the new and replacement inclinometers reported in Tables 1a and 1b, potential slope movements (not yet developed enough to be called definitive slide planes) have been observed in other inclinometers, which are listed as follows:

- In B-105A, depth of 85 feet and 110 feet (see Plate 22 in the Appendix); and,
- In B-05-02 at depths of 109 and 129 feet (see Plate 30 in the Appendix).

Additional readings are needed in these inclinometers to evaluate whether these potential slide planes are true displacements.

Other apparent movements in the new and replacement inclinometers are generally inconsistent from reading to reading or are unrealistic (i.e., movement upslope) and may be caused by systematic and/or random errors. Distinct and consistent movement has not been observed in the inclinometers at B-05-01, B-05-07, B-05-08, B-05-11, B-05-12 and B-05-13. Based on the relatively slow rates of movement of the slide planes observed at the site over the past several years, observed displacements may not yet be evident within the time period between the baseline and current readings, which

have been taken over a 22-month period. Multiple readings over a period of a few years may be needed to measure definitive displacement trends.

2.2 Piezometers

Tables 2 and 3 provided in the following sections present a summary of the measured total head (h_t) for each pneumatic or VW piezometer. Additionally, plots of Total Head vs. Time are provided in the Appendix. The total head (h_t) is calculated using the following equations:

$$h_t = h_e + h_p$$
$$h_p = u/\gamma_w$$

where h_e is the elevation head (elevation where the piezometer was installed), h_p is the pressure head, u is the pore pressure reading, and γ_w is the unit weight of water. The pore pressure readings (u) are measured and recorded in units of pounds per square inch (psi). The remaining variables of these equations (h_e, h_p, h_t, and γ_w) are in units of feet and pounds requiring u to be converted to pounds per square foot (psf).

2.2.1 Pneumatic Piezometers

The results of the active pneumatic piezometer readings taken over the last four (4) quarters are summarized in Table 2. Pneumatic piezometers are identified both by boring number and ribbon color to specify the location and depth of the instrumentation.

Table 2: Summary of Readings for Active Pneumatic Piezometers – CUY-90-15.24

Piezometer Identifier		Ground Surface Elevation (ft)	Elevation Head, h_e (ft)	Pore Pressure Readings (u) and Computed Total Head (h_t) Values				
				Piezo. Data	July 9, 2007	October 10 or 12, 2007	January 8 or 9, 2008	April 14, 16 or 17, 2008
B-101 (P-1[1])	orange	676.6	626.3	u (psi)	0.0[2]	0.0[2]	0.9	0.6
				h_t (ft)	626.3	626.3	628.4	627.7
	pink	676.6	552.3	u (psi)	32.0	31.8	31.9	32.0
				h_t (ft)	626.1	625.7	625.9	626.1
B-105 (P-3[1])	pink	585.6	497.6	u (psi)	38.7	38.4	38.1	38.6
				h_t (ft)	586.9	586.2	585.5	586.7
	blue	585.6	479.9	u (psi)	48.2	48.0	47.6	48.0
				h_t (ft)	591.1	590.7	589.7	590.7
B-107 (P-5[1])	orange	662.3	562.3	u (psi)	26.0	25.2	25.5	26.1
				h_t (ft)	622.3	620.5	621.1	622.5
B-303 (P-2[1])	pink	627.0	586.2	u (psi)	7.2	7.0	6.9	6.9
				h_t (ft)	602.8	602.4	602.1	602.1

1 BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers.
2 Pneumatic piezometers *cannot* read negative pressure (i.e., a water level below the depth of the pneumatic piezometer). Thus, it is unknown whether this is an accurate pressure reading.

The readings for the pneumatic piezometers were similar between the four (4) quarters. The maximum change in total head occurred at B-101 orange, which varied by as much as 2.1 feet (or more, see Note 2 of Table 2).

The B-105 blue piezometer indicated an elevated water pressure (i.e., a total head above the ground surface, artesian conditions) with the total head ranging from 4.1 to 5.5 feet above the existing ground surface. Additionally, the B-105 pink piezometer indicated an elevated total head ranging from 0.1 feet below to 1.3 feet above the existing ground surface. It is possible that the elevated water pressure in B-105 may be attributed to either a thin silt seam sandwiched between fairly thick clay layers located near the base of the piles supporting Pier 1, or the percolation of natural gas out of the underlying Devonian Ohio Shale. Elevated pore pressures can have a detrimental effect on slope stability and may increase the rate of slope creep.

Total Head vs. Time plots, which provide the measured total head from 1994 to the present, have been submitted as Plates 51 through 54 in the Appendix of this report.

2.2.2 Vibrating Wire (VW) Piezometers

The VW piezometers have been placed at various depths with two (2) piezometers at each of the nine (9) offset boring locations. The VW piezometers were installed on 1¼-inch PVC pipe encased in grout with a cable attached to the VW piezometer. Each cable runs up through the PVC pipe and is attached to a MiniLogger, which stores the pore pressure data. A flush mount protective cover was installed at each offset boring location to house the two (2) MiniLoggers. Readings are taken by Miniloggers generally every 8 hours; however, this time interval can be adjusted upon request.

Table 3 provides a summary of the maximum and minimum values of all the pressure readings taken over the last four (4) quarters which includes data collected between April 18, 2007 and the time when the collected data was last downloaded from VW Miniloggers between April 14, 2008 and April 23, 2008. The data was also downloaded from the VW Miniloggers each quarter prior to April 2008 over the annual reporting period including in July 2007, October 2007 and January 2008. The VW piezometers are identified by boring number, MiniLogger serial number, and depth the piezometer was installed. The VW piezometers also measure the ground temperature around the piezometer. The maximum and minimum temperature readings are also provided in Table 3.

Table 3: Summary of Readings for VW Piezometers – CUY-90-14.52

Piezometer Identifier		Time Interval of Readings Reported[1]	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-01	21961 - 65 ft	4/18/07 to 4/23/08[2]	14.1/9.7	675.4	610.4	13.0/12.3	640.4/638.9
	21967 - 95 ft	4/18/07 to 4/23/08[2]	13.2/13.1	675.4	580.4	24.4/23.1	636.7/633.6
B-05-02	21963 - 46 ft	4/18/07 to 4/16/08	12.3/7.9	617.9	571.9	8.7/7.7	591.9/589.8
	21951 - 122 ft	4/18/07 to 4/16/08	12.2/12.1	617.9	495.9	40.8/40.0	590.1/588.3
B-05-03	21957 - 32 ft	4/18/07 to 4/23/08[2]	12.4/11.8	605.1	573.1	8.3/7.0	592.4/589.4
	21965 - 112 ft	4/18/07 to 4/23/08[2]	12.5/12.4	605.1	493.1	41.6/40.9	589.1/587.4
B-05-04	21958 - 59 ft	4/18/07 to 4/16/08[3]	12.9/12.9	600.8	541.8	18.1/17.5	583.7/582.1
	21952 - 119 ft	4/18/07 to 4/16/08	13.1/13.0	600.8	481.8	45.1/44.7	585.8/585.0
B-05-07	21966 - 102 ft	4/18/07 to 4/14/08	12.4/12.4	678.9	576.9	24.4/23.6	633.3/631.3
	21956 - 220 ft	4/18/07 to 4/14/08	11.9/11.9	678.9	458.9	71.7/70.2	624.3/620.9
B-05-08	21954 - 65.5 ft	4/18/07 to 4/14/08	12.7/12.6	679.9	614.4	13.0/11.9	644.3/641.9
	21959 - 110.5 ft	4/18/07 to 4/14/08	12.4/12.4	679.9	569.4	30.0/29.1	638.6/636.6
B-05-11	21968 - 95 ft	4/18/07 to 4/23/08[2]	13.0/12.6	675.1	580.1	24.1/23.5	635.6/634.4
	21953 - 130 ft	4/18/07 to 4/14/08[4]	12.8/10.9	675.1	545.1	36.9/36.0	630.3/628.2
B-05-12	21960 - 75 ft	4/18/07 to 4/23/08[5]	12.9/12.1	652.7	577.7	19.2/18.4	622.1/620.2
	21964 - 120 ft	4/18/07 to 4/14/08	12.8/12.5	652.7	532.7	37.1/35.9	618.3/615.4
B-05-13	21962 - 60 ft	4/18/07 to 4/17/08	12.6/7.3	580.0	520.0	24.5/23.6	576.5/574.5
	21955 - 135 ft	4/18/07 to 4/17/08	12.8/12.8	580.0	445.0	60.7/60.2	585.0/584.0

1 Readings generally were taken every 8 hours during the reported time interval.
2 The VW Minilogger box was unresponsive due to flooding of the Minilogger box. Manual readings are currently being taken. Communication was able to be reestablished with 21961 VW Minilogger in April 2008 after communication failure occurred in January 2008. Readings were able to be downloaded though many scheduled readings were missed between October 2007 and April 2008.
3 VW Minilogger did not record readings from July 10, 2007 to October 9, 2007, possible battery malfunction.
4 VW Minilogger did not record readings from August 5, 2007 to October 11, 2007, possible flooding of the box.
5 The VW Minilogger box is unresponsive with the primary cause(s) unknown as it has never been flooded.

Three (3) VW Miniloggers (21967 at B-05-01, 21968 at B-05-11 and 21960 at B-05-12) were unresponsive at the times of download in January 2008 and April 2008. One (1) VW Minilogger (21961 at B-05-01) was unresponsive at the time of download in January 2008, however, communication was able to be reestablished in April 2008 and readings were downloaded. Many scheduled readings were missed in 21961 between the October 2007 and April 2008 downloads (see Plate 55 in the Appendix). An additional two (2) VW Miniloggers (21957 and 21965 at B-05-03) were unresponsive at the time of download in April 2008. Refer to the footnotes of Table 3 and the Total Head vs. Time plots provided on Plates 55, 57, 61 and 62 of the Appendix for additional comments regarding these nonfunctioning Miniloggers. Manual readings were taken with a portable VW Data Recorder at these six (6) piezometers.

The nonresponsive VW Miniloggers may no longer be functional due to either flooding of the VW Minilogger boxes with water or some other unknown cause(s). All of the nonfunctioning VW Miniloggers except the 21960 VW Minilogger at B-05-12 have been flooded at one time or another. Reasonable precautions are taken by BBCM to attempt to protect the Minilogger boxes from water damage. However, during heavy rain events, only the installation of free-draining street boxes to house the Miniloggers or placing the Miniloggers in secure boxes above ground will greatly minimize water infiltration and damage. BBCM recommends the replacement of these six (6) nonfunctioning VW Miniloggers. The other VW Miniloggers which have failed to take scheduled readings at one time or another (21958 at B-05-04, 21953 at B-05-11) may need to be replaced eventually but appear to be currently functioning properly.

General Observations in VW Piezometers

The measured total head values were relatively constant over the last four (4) quarters with a difference between maximum and minimum total head values of no more than 3.4 feet in all of the VW Piezometers.

Six (6) VW piezometers (21961 and 21967 at B-05-01, 21956 at B-05-07, 21953 at B-05-11, and 21960 and 21964 at B-05-12) indicated a gradual increase in pore pressures until about the beginning of May 2007 upon which the measured pore pressures have since been relatively constant or a noticeably decreased rate of pore pressure increase has been observed (i.e., 21956 at B-05-07). In 21961 and 21967 at B-05-01, and 21960 at B-05-12, the VW Miniloggers were unresponsive at the times of download in January 2008 and April 2008 (discussed previously, see footnotes of Table 3), thus the trend can only be observed in these piezometers until October 2007 or November 2007.

In the 21955 piezometer in B-05-13, the total head over the reporting period was as high as 5.0 feet above the existing ground surface at Elevation 580 (see Table 3) indicating that there is an elevated water pressure (i.e., total head above the ground surface, artesian conditions) at this location similar to that observed in the pneumatic piezometers at B-105 previously discussed. During drilling of Boring B-05-13, gas pockets were encountered during rock coring, which leads us to believe the elevated water pressure observed in the 21955 piezometer may be mostly attributed to

percolation of natural gas out of the underlying Devonian Ohio Shale into the sandy silt layer where the piezometer was installed. This sandy silt layer is sandwiched between the shale bedrock below and clay above that could confine the natural gas to the sandy silt due to the low permeability of clays.

Total Head vs. Time plots have been submitted as Plates 55 through 63 in the Appendix of this report.

3.0 ADDITIONAL FIELD MEASUREMENTS AND OBSERVATIONS

3.1 Calipered Surface Distance Locations

The left and right calipered locations (see the Site Plan of Active Instrumentation, Plate 2 in the Appendix), which have been monitored since June 1999, are located just east and west of the I-90 Bridge centerline, respectively. Initially, three (3) locations were monitored, which included a center calipered location. However, the center calipered location became inaccessible in August 1999. A Calipered Surface Distance Table and Calipered Distance Readings vs. Time plots have been included as Plates 64 through 66 in the Appendix.

Close inspection of the data in the plots indicates the possibility of general movement trends at the calipered locations. The data is somewhat oscillatory, which is likely due to the seasonal temperature fluctuations affecting the concrete combined with human measurement error. In the data plots, linear trendlines were added to estimate the average rate of separation/closure per year. The left calipered location indicates the gap is continuing to open at a rate of about 0.06 inches per year, which is equivalent to the rate reported in the 2006-2007 Annual Report for Field Monitoring Services, dated May 4, 2007. The right calipered location indicates the gap is closing at a rate of about 0.02 inches per year, which is also equivalent to the rate reported in the 2006-2007 Annual Report. The movements are relatively small (½ of an inch or less since June 1999) and are sensitive to the interpretation of the center of the nails. Thus it is inconclusive that these movements have been caused by the observed slope movements. Additionally, the right calipered location has been oscillating above and below a distance of about 4.4 inches since late 2000 indicating that there might not be a trend (see Plate 66 of the Appendix). Continued observation of these calipered locations is needed in order to adequately determine if judgment error and weather conditions are the main cause of the observed trends or if they are indeed caused by slope movements.

3.2 Stockpiling of Aggregate Adjacent to East Right-of-Way Fence

The property adjacent to the east right-of-way fence is currently being used to stockpile aggregate. One (1) relatively small aggregate pile ranging roughly from 15 to 30 feet high covering less than roughly 15 percent of the property was observed during each of the quarterly visits to the site. In July 2007, an aggregate pile was observed near the southeast corner of the property. In October 2007, January 2008 and April 2008, an

aggregate pile was observed near the west end of the property. Stockpiling of large aggregate piles could have a significant impact on slope movements at the site.

3.3 Excavation Activities Adjacent to West Right-of-Way Fence

As previously discussed, a large excavation near the west right-of-way fence was first observed by BBCM personnel in mid-March 2006. The excavation was performed apparently in an effort to repair the failed bulkhead. As of April 2008, the repair effort appears to be unfinished as the bulkhead does not appear to be fully repaired and the large excavation has not yet been backfilled.

In January 2007, BBCM personnel observed evidence of a potential small landslide that may have occurred after the quarterly readings were taken in October 2006. This small landslide area is located near the west right-of-way fence just north of B-05-16, adjacent to the river and on the eastern edge of the large excavation (see Plate 2 in the Appendix for the approximate landslide location). It appears that progressive failure in this landslide area has occurred between January 2007 and April 2008. Apparent settlement of the ground surface has been observed and the failure appears to have progressed farther towards the south and east. The scarps seem to have increased in depth and the fence in the landslide area has been torn apart by the movements at some locations and has almost completely tipped over on its side. Note that relatively large shallow displacements have been observed in the B-05-16 inclinometer (see Table 1a in Section 2.1.2 and Plates 46 and 47 in the Appendix). Pictures of this landslide location were taken during each quarter since January 2007. Site photos of this small landslide taken from near B-05-13 across the Cuyahoga River each quarter since January 2007 have been submitted as Plates 67 through 80 in the Appendix. Additional site photos of the landslide area taken on April 17, 2008 have been submitted as Plates 81 through 85 in the Appendix.

3.4 Additional Site Observations

The small sinkhole (1'-2' in dia.) in the pavement near B-05-12 on University Road, first observed by BBCM personnel in March 2006, has been partially covered by a jersey wall since January 2007. It does not appear that the sinkhole has grown in size since January 2007.

APPENDIX

CUY-90-14.52/15.24 INSTRUMENTATION MONITORING

SUMMARY OF ACTIVE INSTRUMENTATION
CUY-90-14.52/15.24

Active Instrumentation	Active Inclinometer ?	Inclinometer Depth (ft)	Active Piezometer?	VW or Pneumatic?	# of Active Piezometers	Piezometer Depth(s) Below Existing G.S. (ft)	Instrumentation Installation Date	G.S. Elevation (ft)
B-101	Y	190	Y[1]	Pneumatic[1]	2 [1]	50.3, 124.3	Aug-Sep 1994	676.6 (676.6[3])
B-102	Y	224	N	---	---	---	Sep 1994	675.7
B-105	N	---	Y[1]	Pneumatic[1]	2 [1]	88, 105.7	Aug 1994	585.4 (585.6[3])
B-105A	Y	156	N	---	---	---	May 2006	585.7
B-107	Y	210	Y[1]	Pneumatic[1]	1 [1]	100	Sep 1994	662.7 (662.3[3])
B-108A	Y	168	N	---	---	---	Apr-May 2006	603.0
B-203	Y	190	N	---	---	---	Aug 1996	638.0
B-204	Y	134	N	---	---	---	Jul 1998	599.0
B-303	Y	178	Y[2]	Pneumatic[2]	1 [2]	40.8	Aug 1994[2], Jul 1998	622.0 (627.0[3])
P-9N	Y	150	N	---	---	---	Feb 1999	588.0
B-05-01	Y	228	Y	VW	2	65, 95	Apr-May 2006	675.4
B-05-02	Y	178	Y	VW	2	46, 122	Apr-May 2006	617.9
B-05-03	Y	168	Y	VW	2	32, 112	Apr-May 2006	605.1
B-05-04	Y	172	Y	VW	2	59, 119	Mar-May 2006	600.8
B-05-07	Y	224	Y	VW	2	102, 220	Apr-Jun 2006	678.9
B-05-08	Y	224	Y	VW	2	65.5, 110.5	Apr-May 2006	679.9
B-05-11	Y	226	Y	VW	2	95, 130	Apr-Jun 2006	675.1
B-05-12	Y	210	Y	VW	2	75, 120	Apr-May 2006	652.7
B-05-13	Y	134	Y	VW	2	60, 135	May-Jun 2006	580.0
B-05-16	Y	162	N	---	---	---	Jun 2006	598.5

1 BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers (i.e. P-1 to B-101, P-3 to B-105, and P-5 to B-107).

2 The pneumatic piezometer was actually installed in August 1994 at Boring P-2 in the vicinity of the B-103 inclinometer (now inactive). However, the piezometer has since been renamed to B-303 due to its close proximity to the active inclinometer at B-303, which was installed in July 1998.

3 Elevation in parenthesis refers to the ground surface (G.S.) elevation of the P boring location where the pneumatic piezometer was installed.

B-05-07
B-05-08
B-05-01
B-05-11
B-05-12
B-05-02
B-107
B-203
B-108A
B-110
B-05-16
B-05-13
APPROXIMATE LOCATION OF LANDSLIDE
LEFT CALIPERED LOCATION
RIGHT CALIPERED LOCATION
B-05-04
P-9N
B-204
B-303
B-105A
B-105
B-05-03
B-101
B-102
CUYAHOGA RIVER
(AATT)
RAILROAD

MODEL NAME: $MODEL$
$TIME$
$DATE$
BBC&M DRAWING FILE: $BBCM FILENAME$

LEGEND

B-05-01 — LOCATION OF INCLINOMETER/PIEZOMETER INSTALLED BY BBCM IN 2006 (B-05-01 THROUGH B-05-04, B-05-07, B-05-08, B-05-11 THROUGH B-05-13, AND B-05-16).

B-105A — LOCATION OF REPLACEMENT INCLINOMETER INSTALLED BY BBCM IN 2006 (B-105A AND B-108A).

B-101 — LOCATION OF INCLINOMETER AND/OR PIEZOMETER INSTALLED BY BBCM BETWEEN 1994 AND 1999 (B-101, B-102, B-105, B-107, B-203, B-204, B-303, AND P-9N).

B-110 — LOCATION OF INCLINOMETER AT B-110, WHICH WAS DESTROYED BY EXCAVATION ACTIVITIES IN MARCH, 2006

SCALE IN FEET
0 50 100

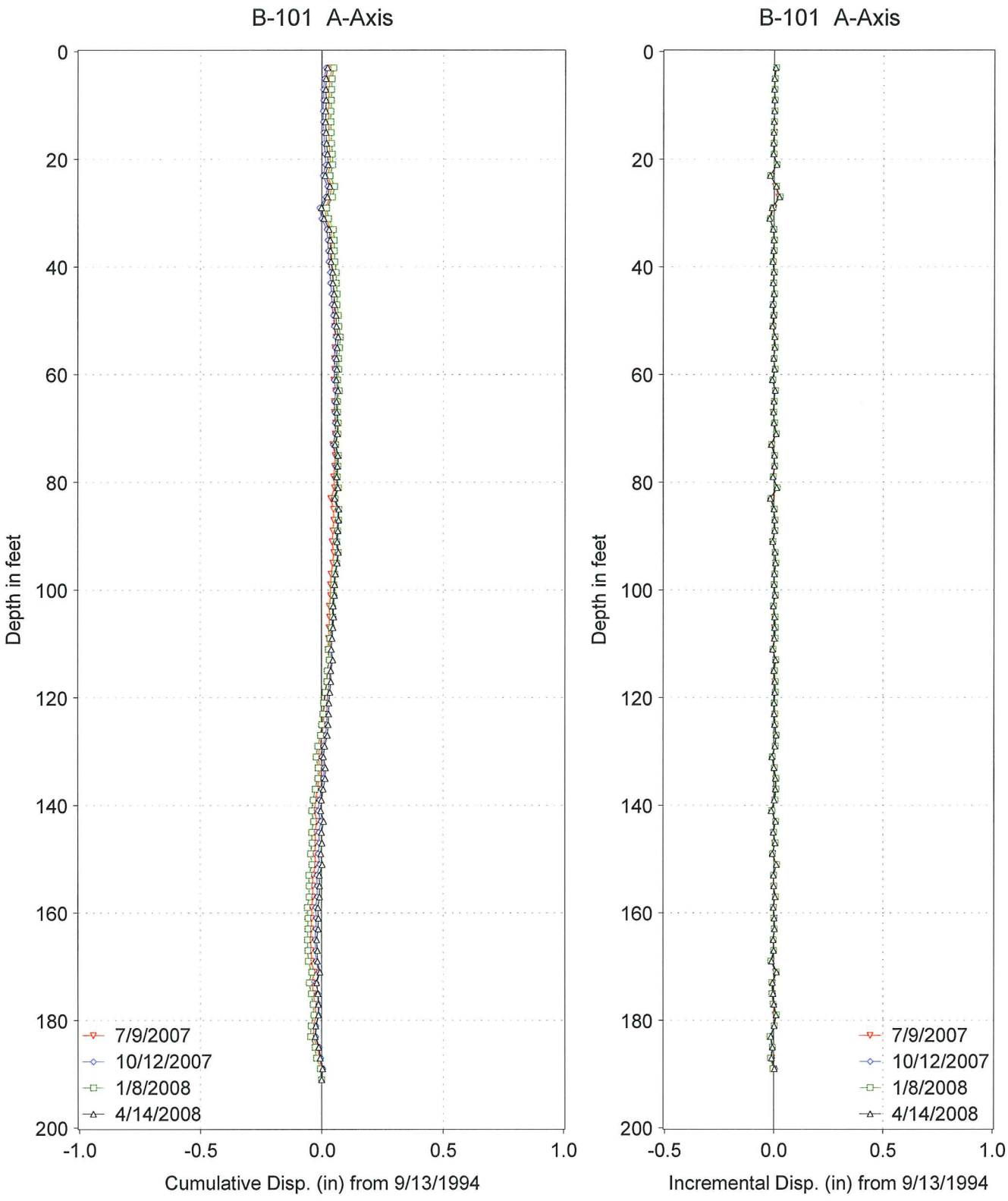
SITE PLAN OF ACTIVE INSTRUMENTATION

CUY-90-14.52/15.24 WEST ABUTMENT CLEVELAND, OHIO

Project: 012-00946-300	Drawn By: EDV
Drawing Date: 7/25/06	Approved By: JLS
Revision Date: 2/9/07	Scale: 1" = 100'

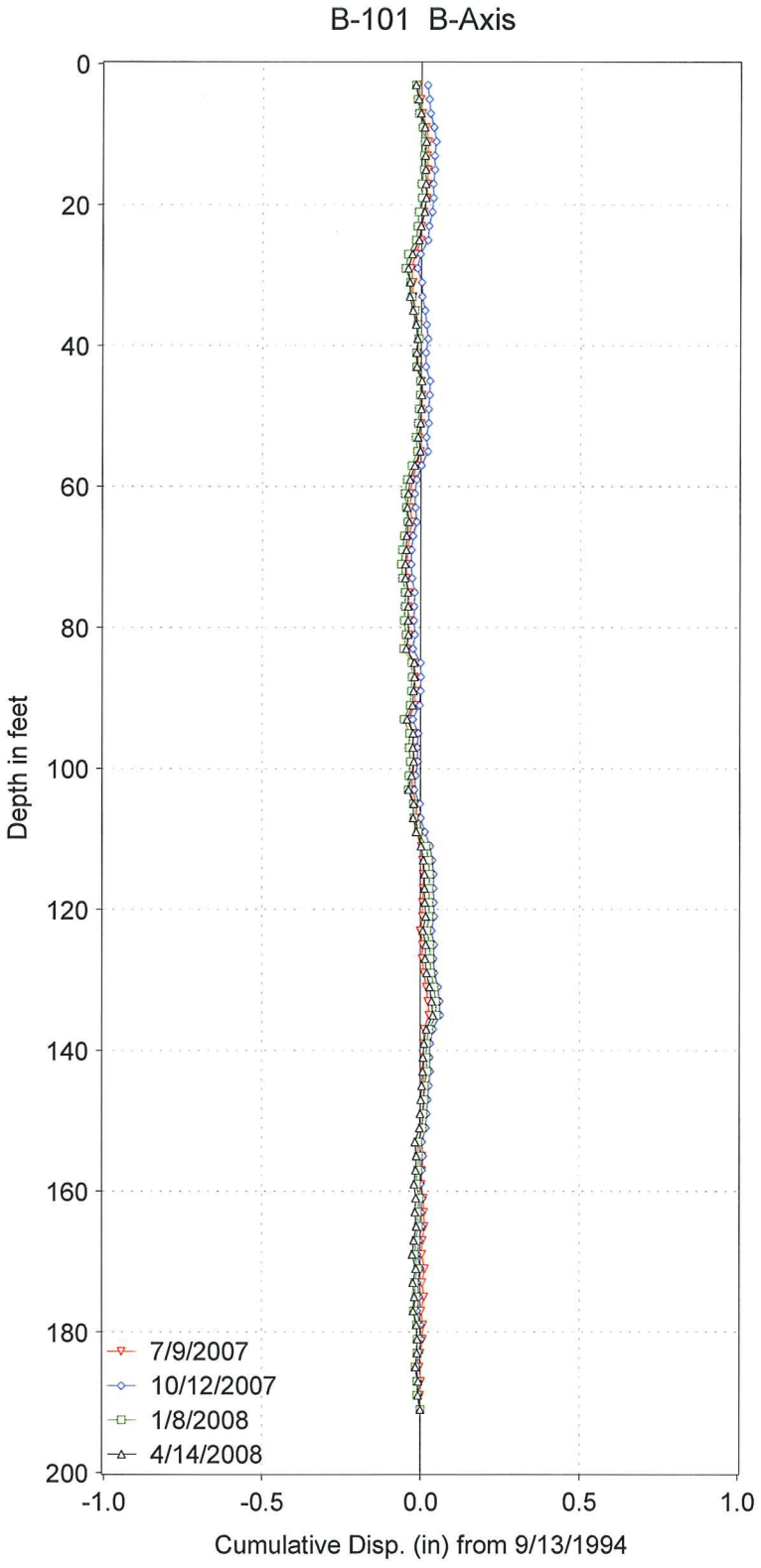
BBC&M
SOLUTIONS TO BUILD ON
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

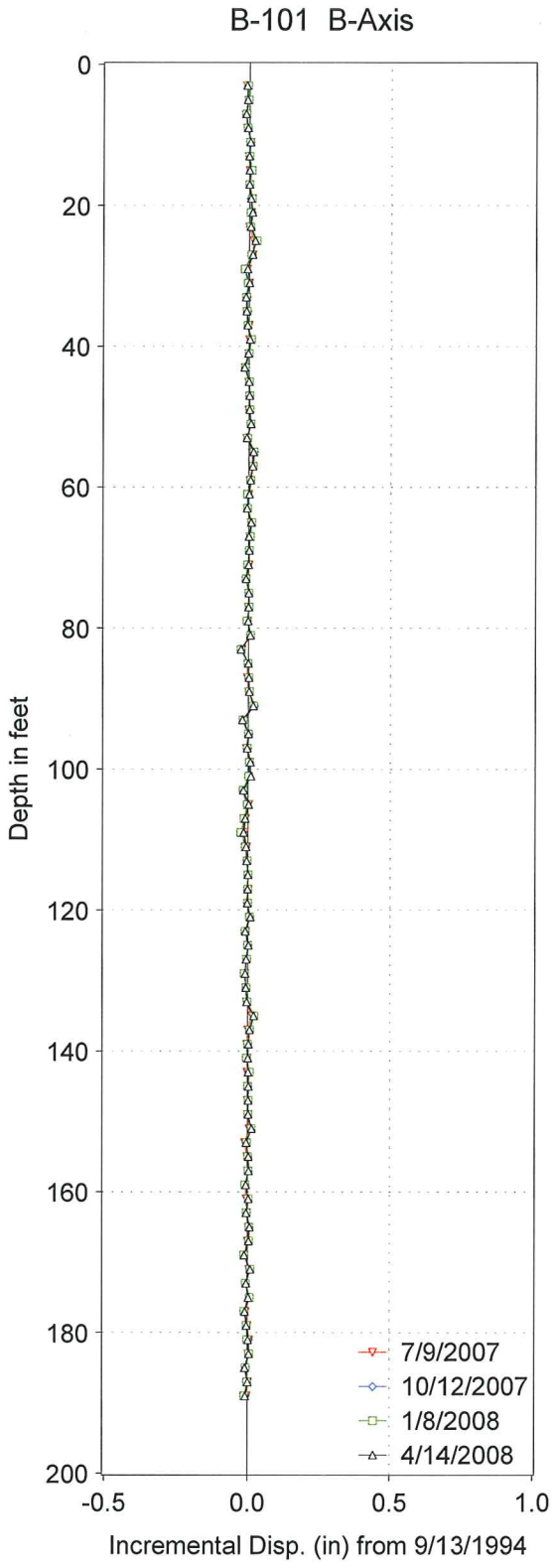
PLATE 2



B-101
-Includes readings from the last four quarters.

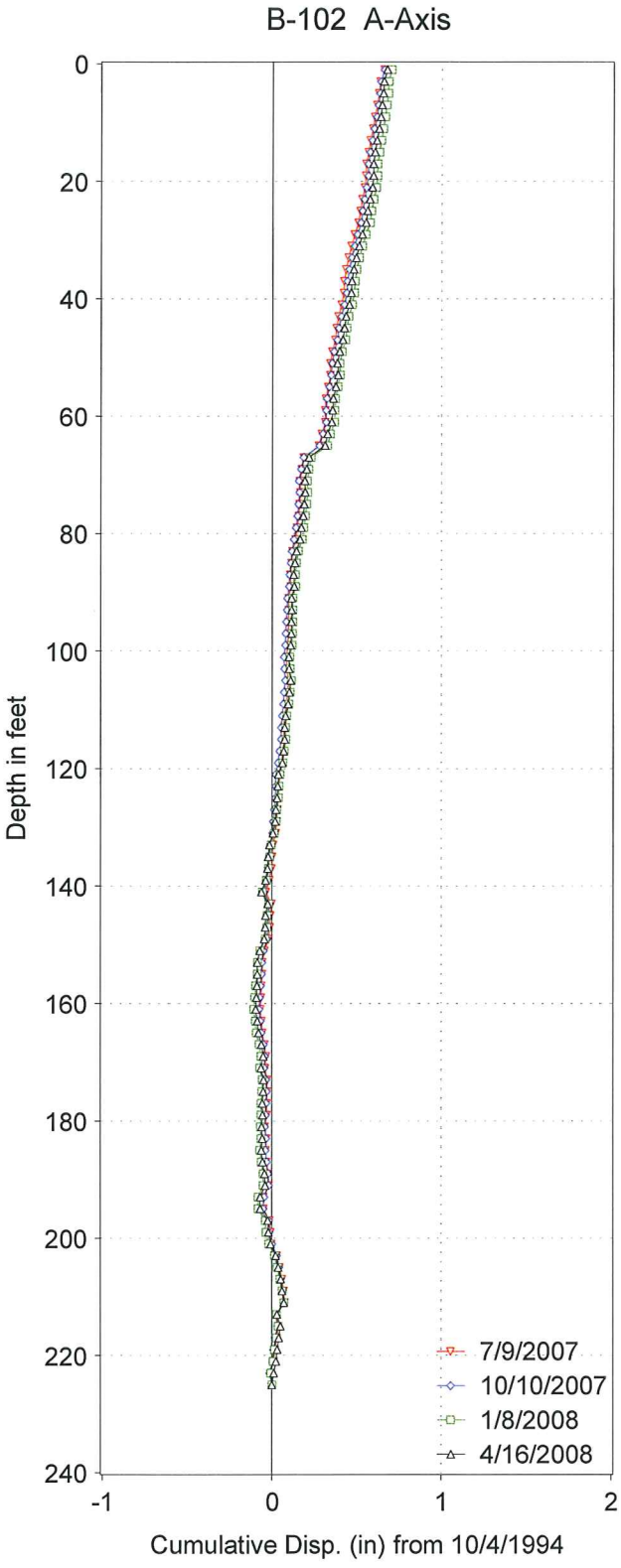
PLATE 3

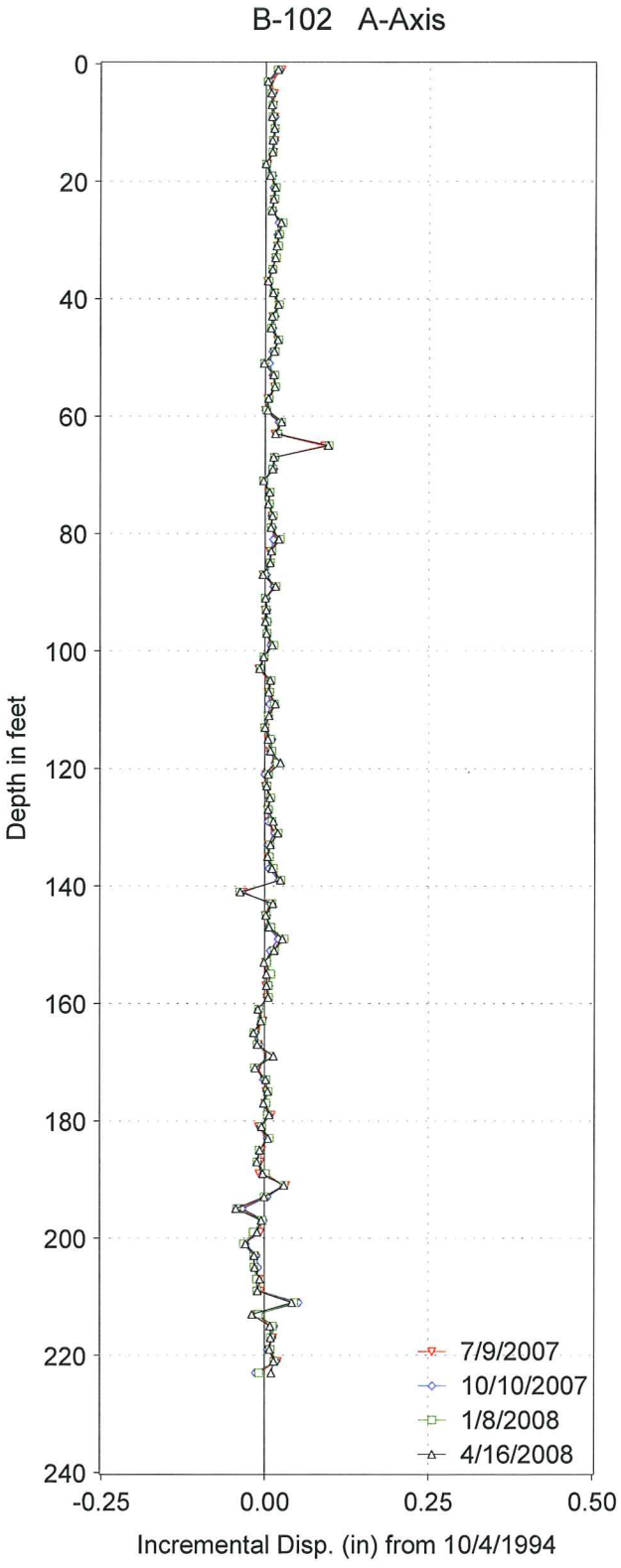




B-101
-Includes readings from the last four quarters.

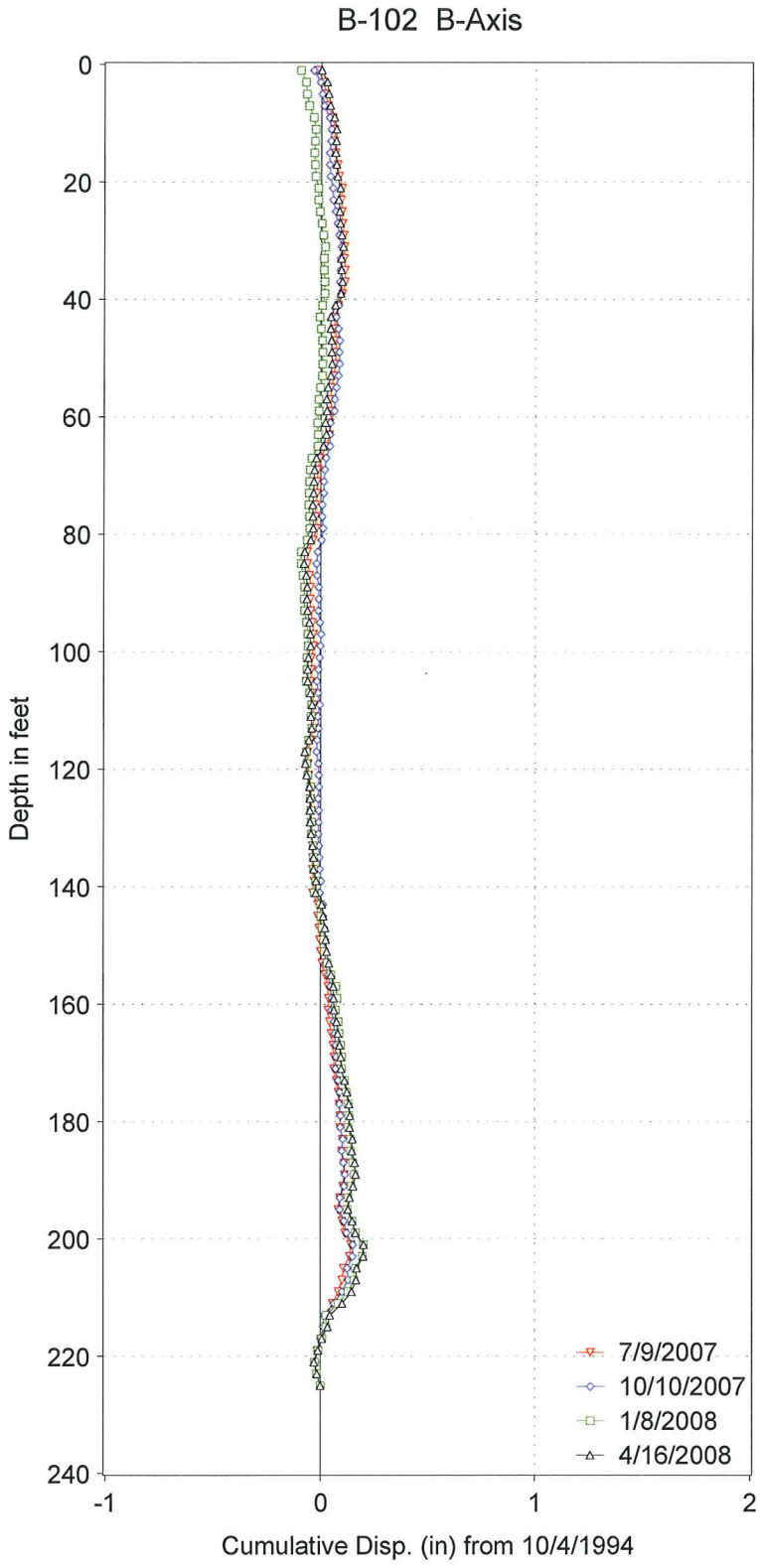
PLATE 4

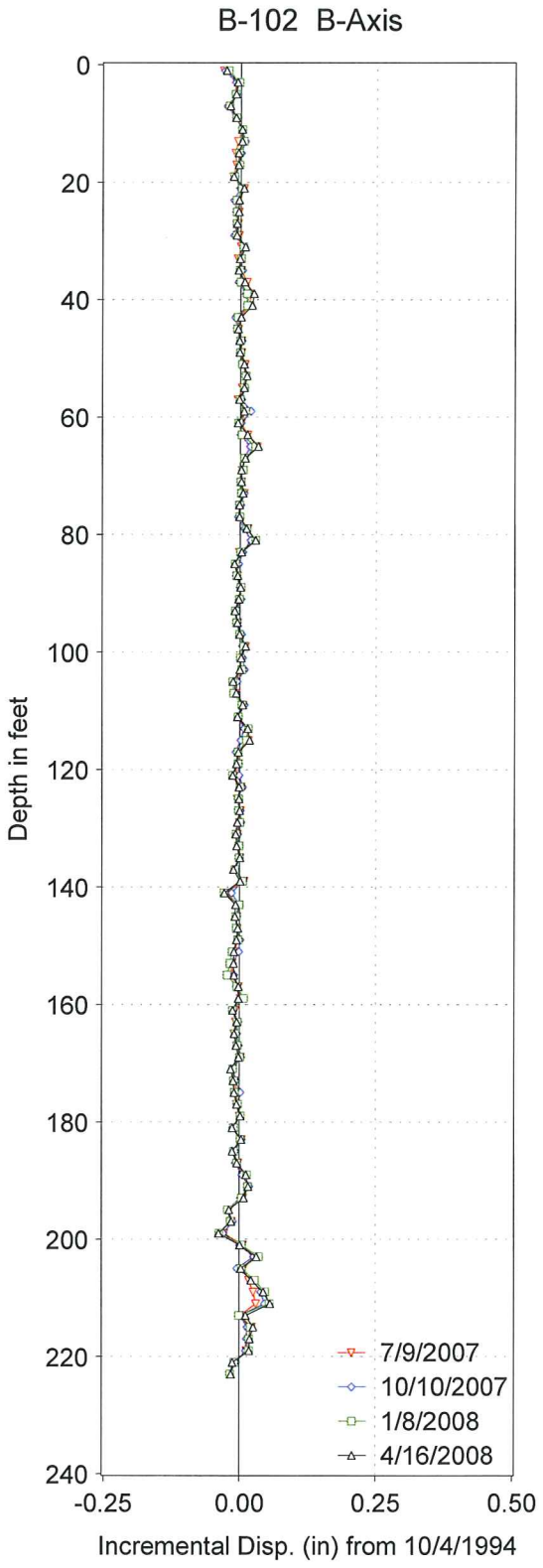




B-102
-Includes readings from the last four quarters.

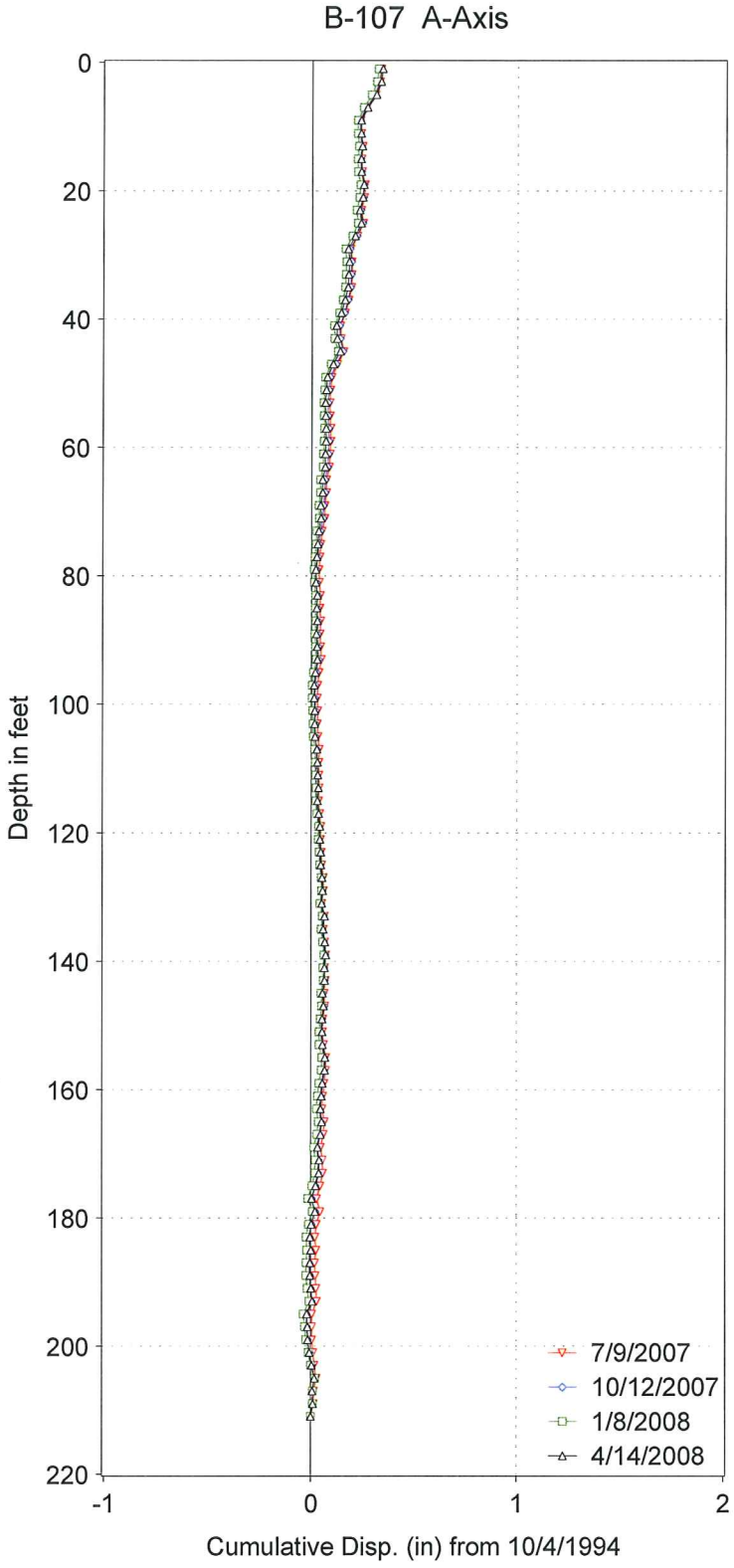
PLATE 5

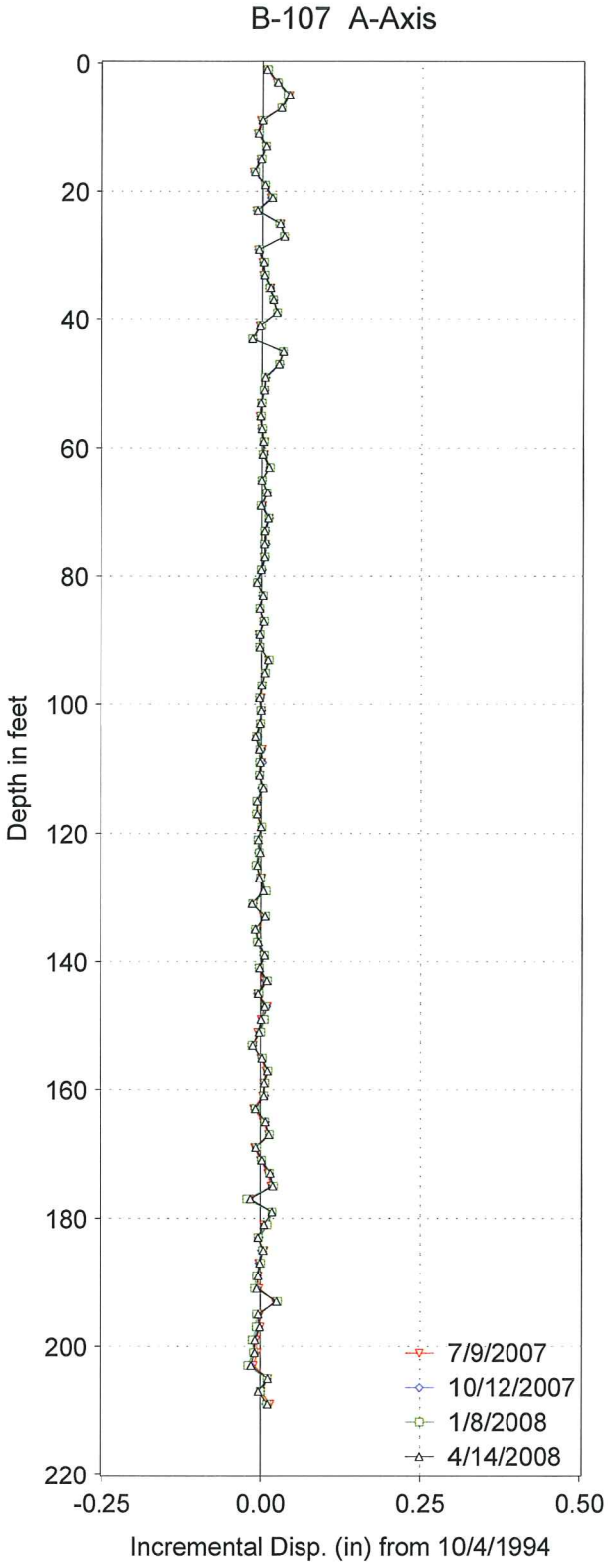




B-102
-Includes readings from the last four quarters.

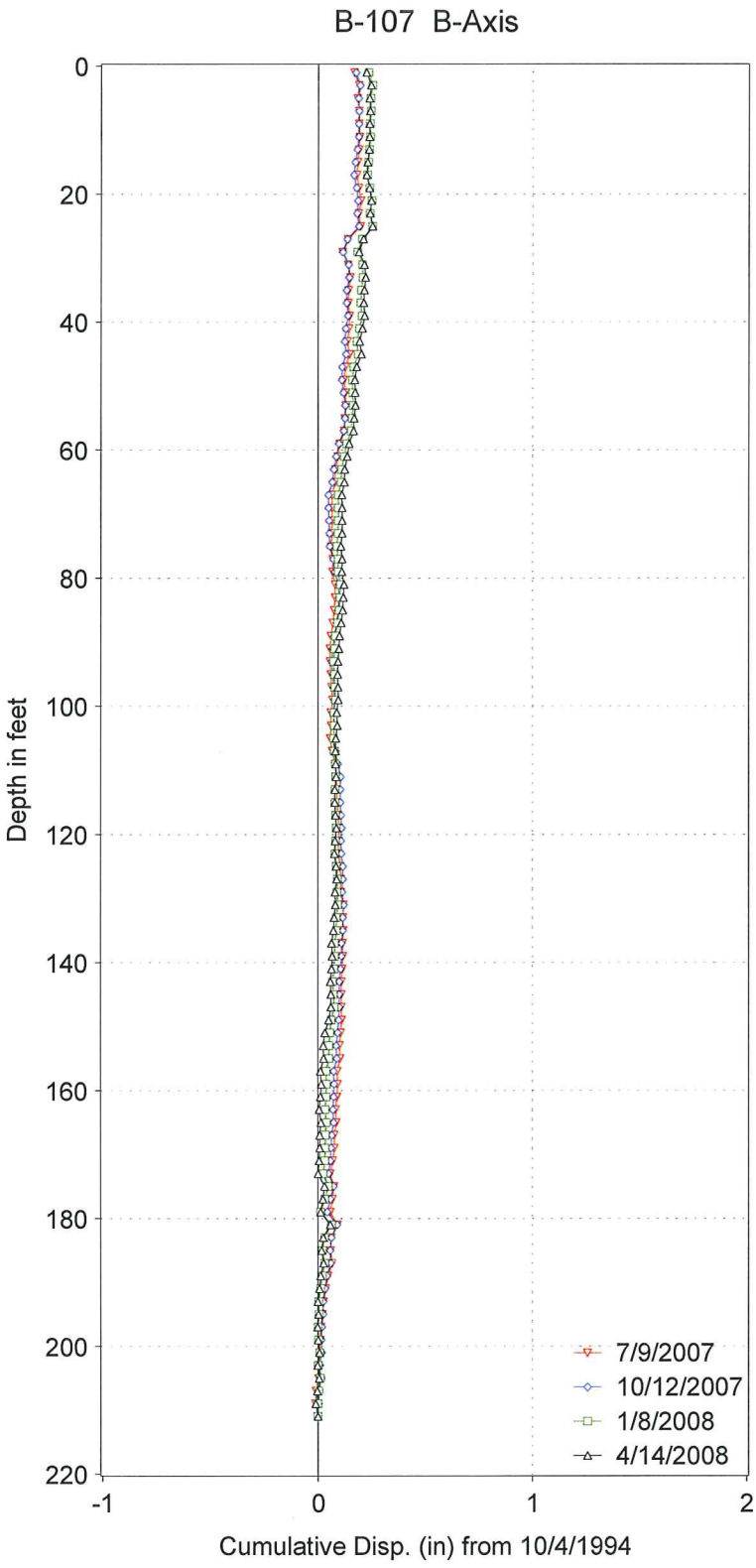
PLATE 6

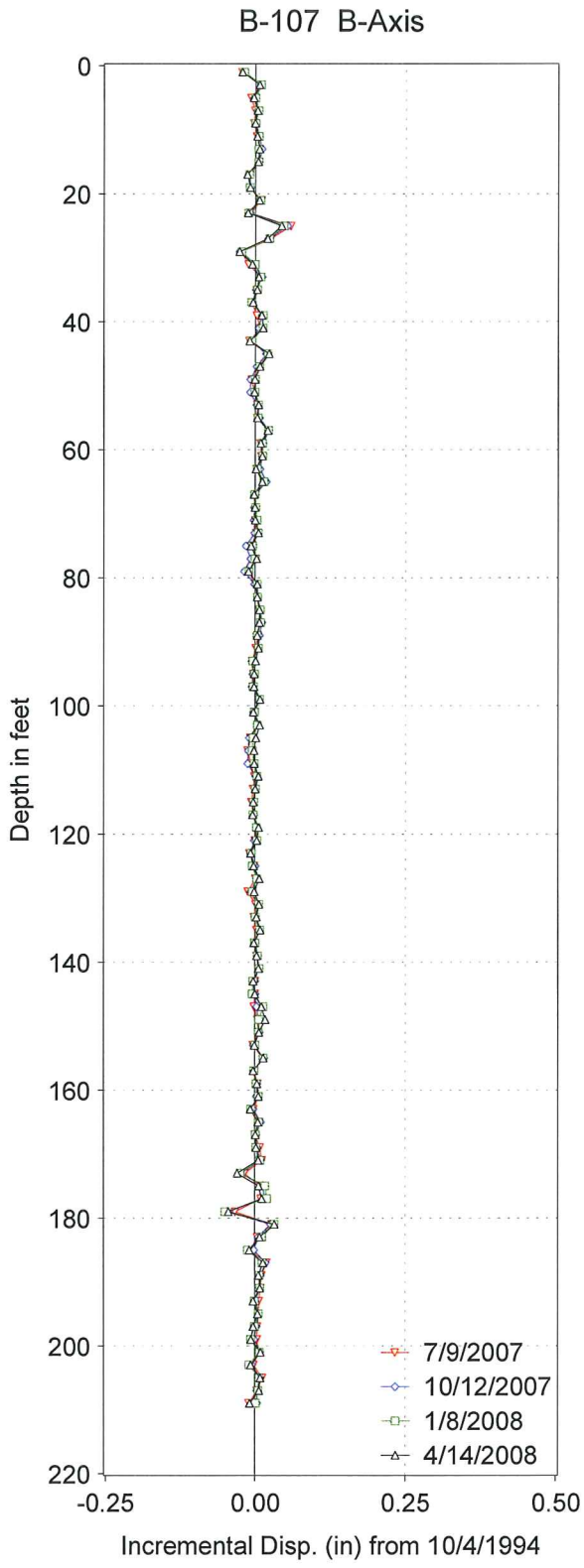




B-107
-Includes readings from the last four quarters.

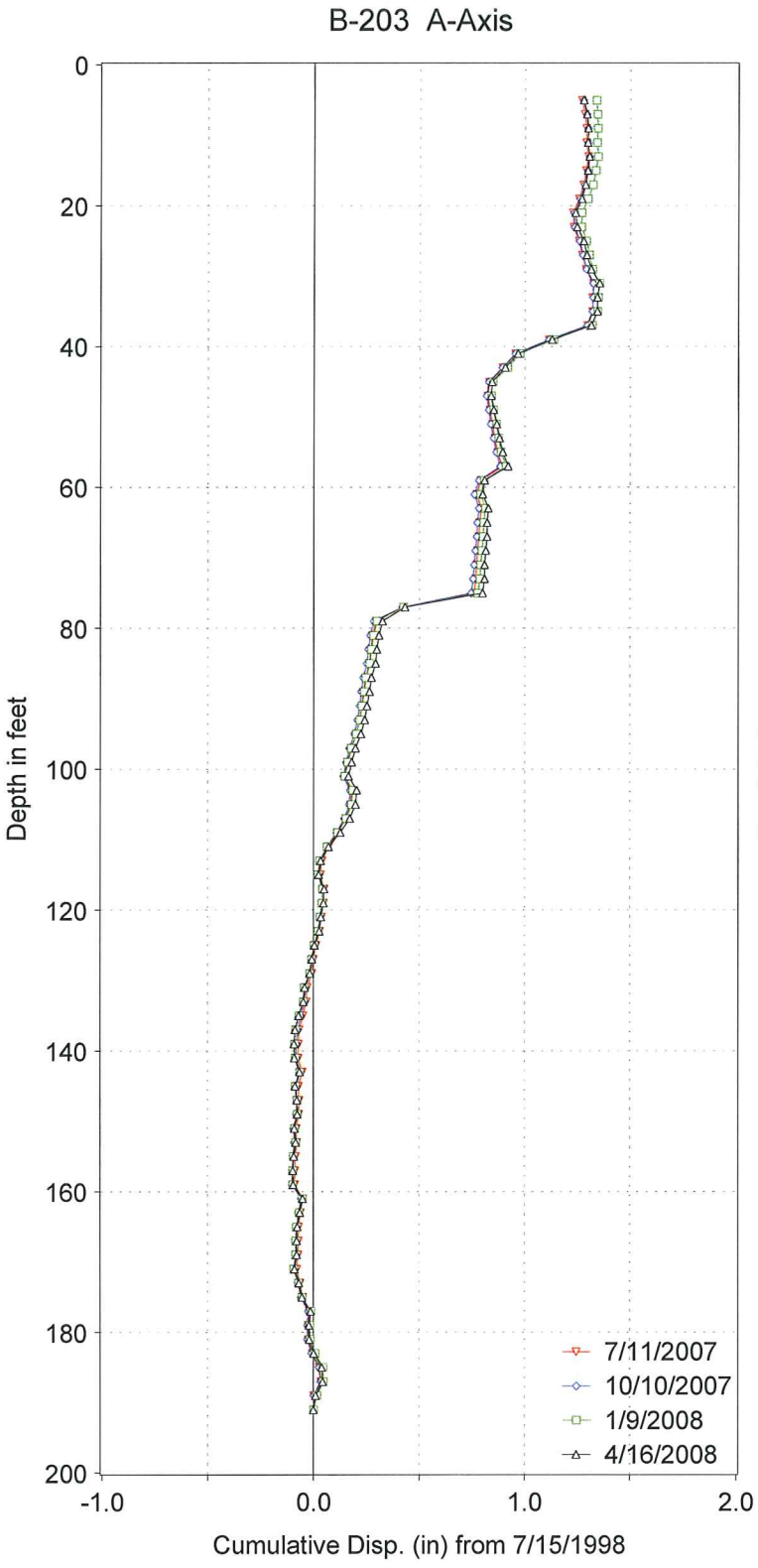
PLATE 7

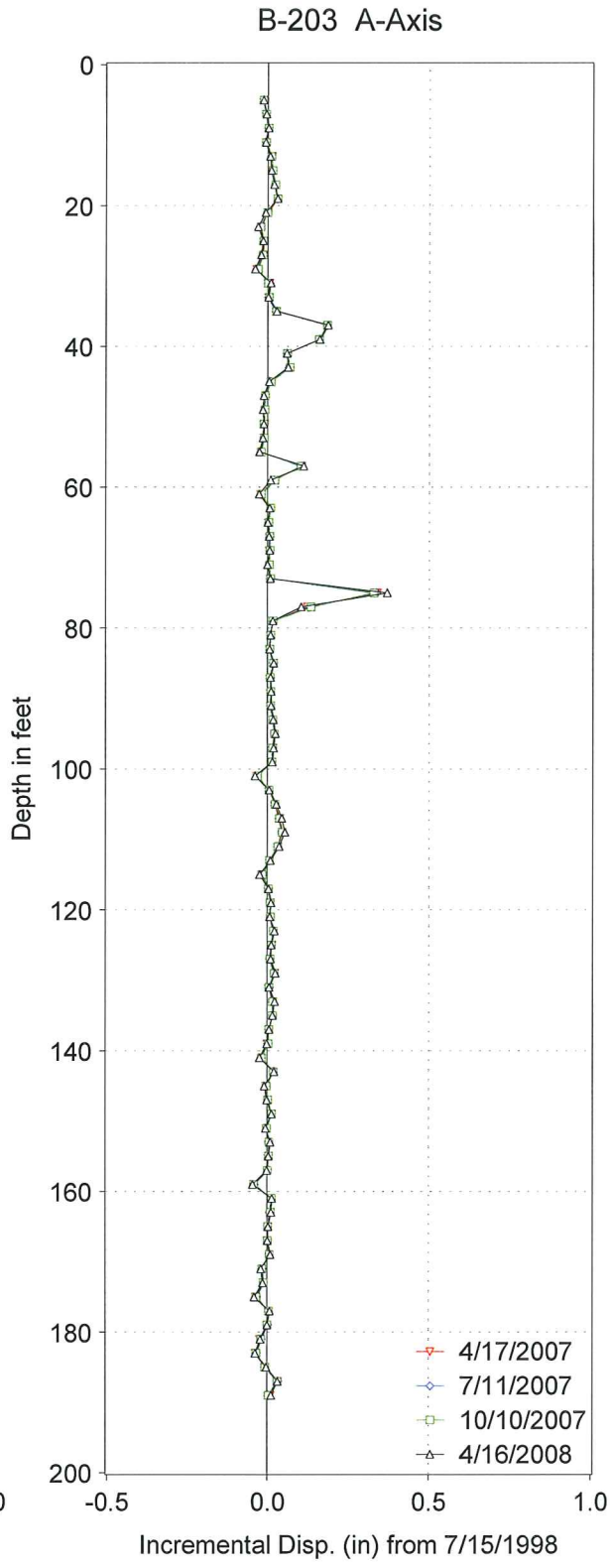




B-107
-Includes readings from the last four quarters.

PLATE 8

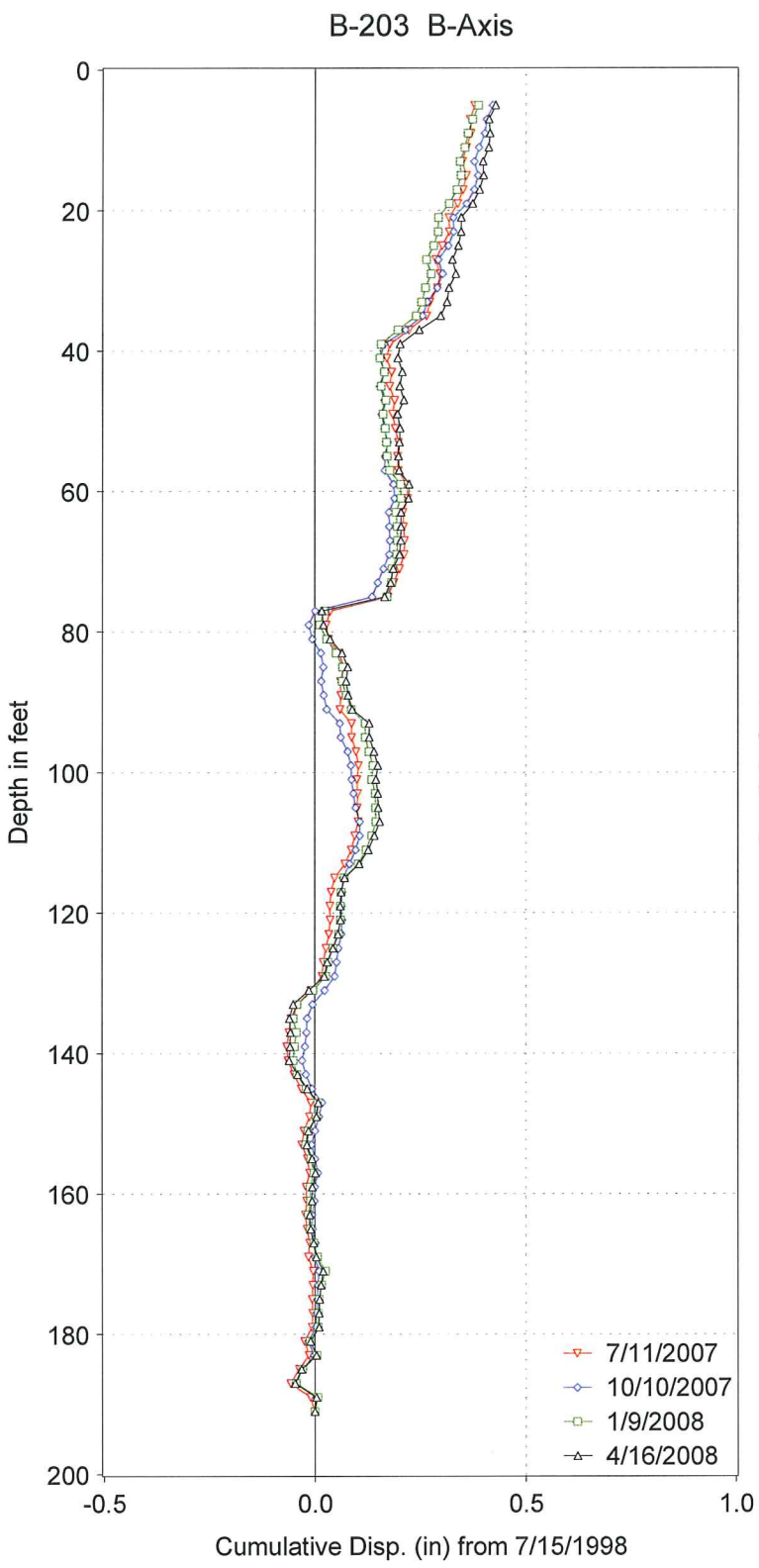


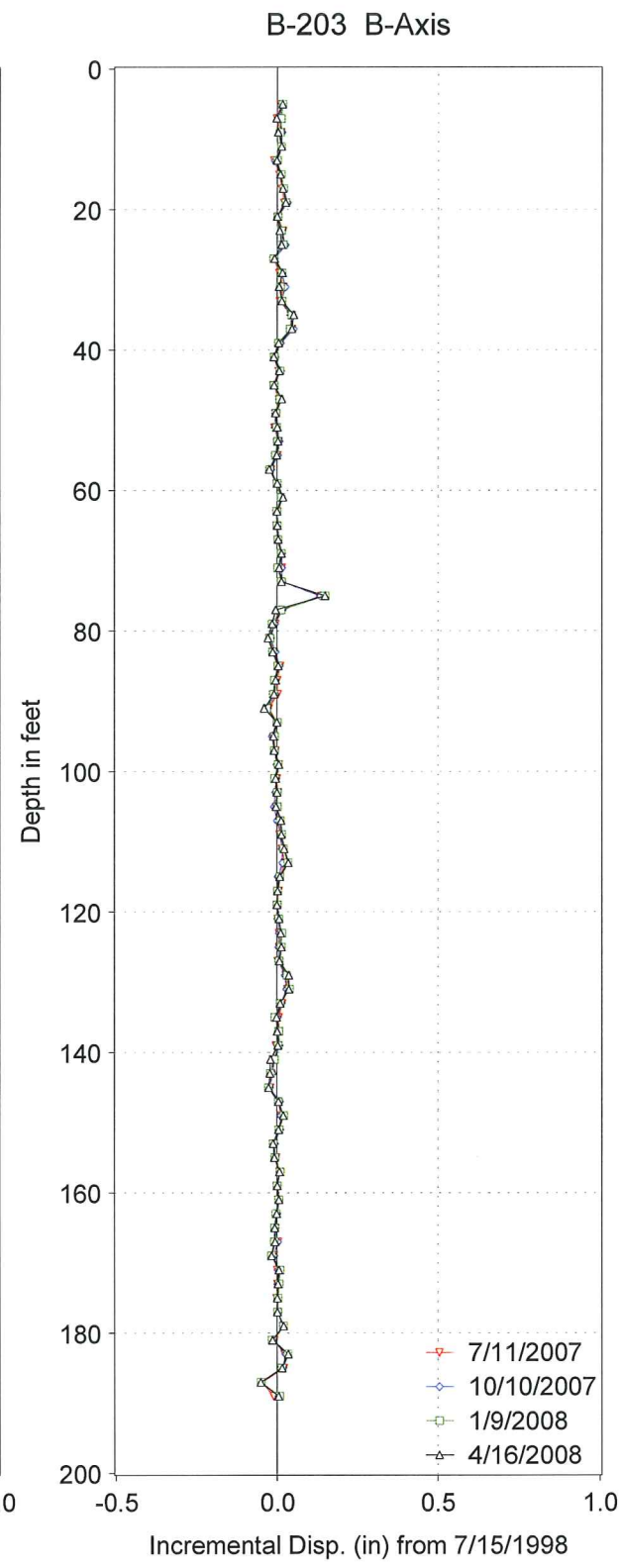


B-203

-Includes readings from the last four quarters.

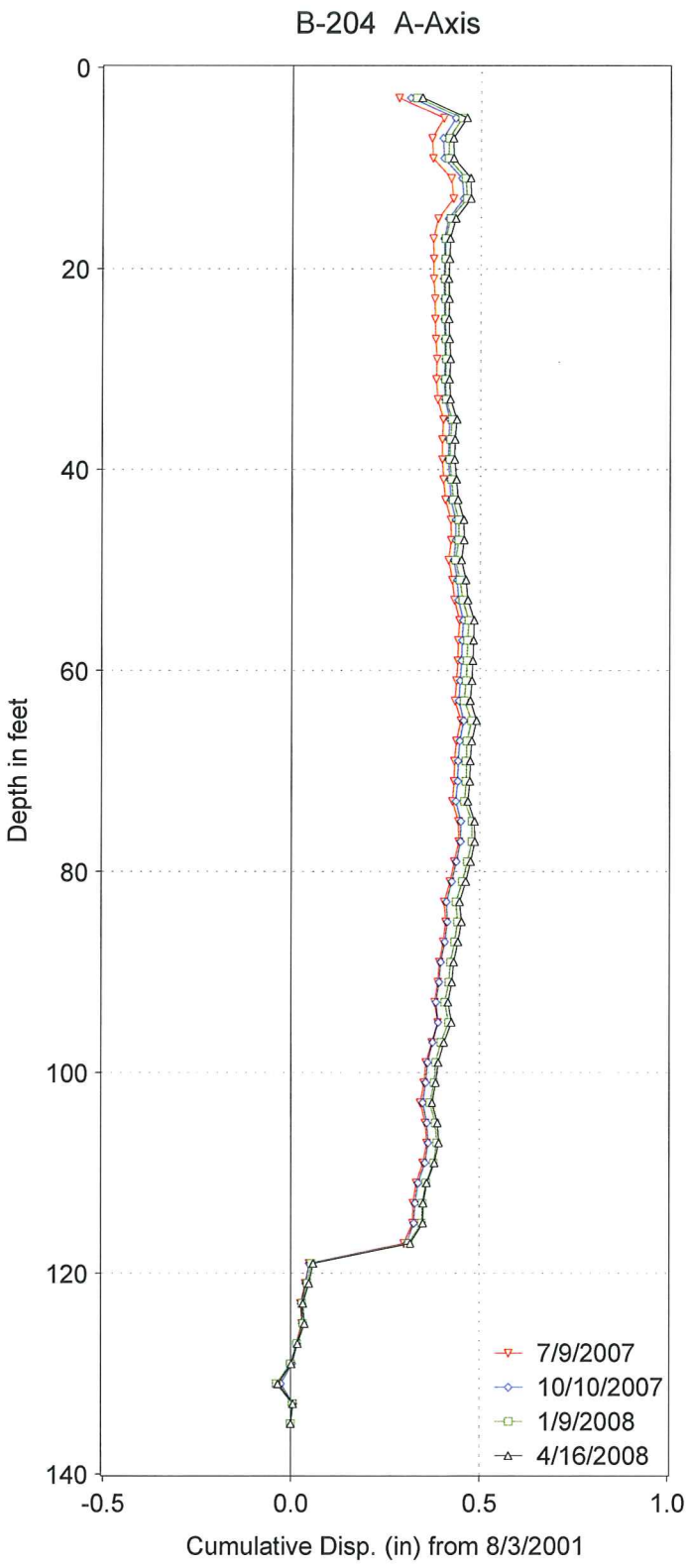
PLATE 9

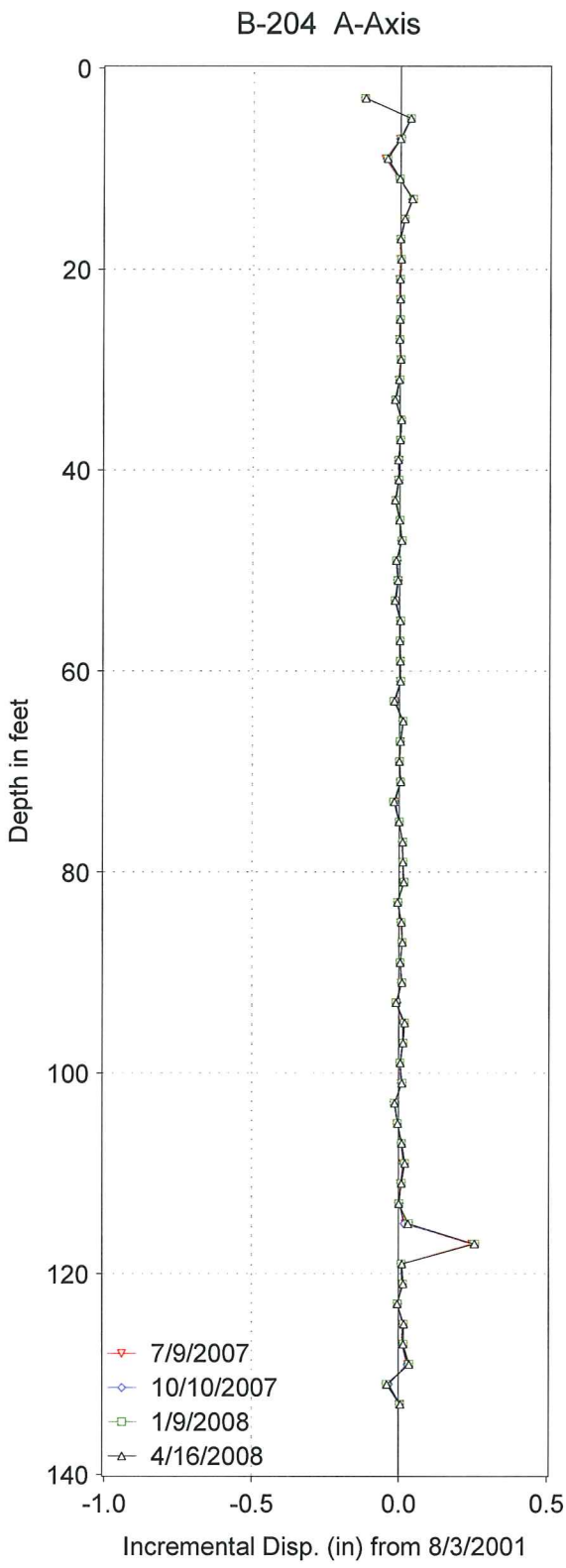




B-203
-Includes readings from the last four quarters.

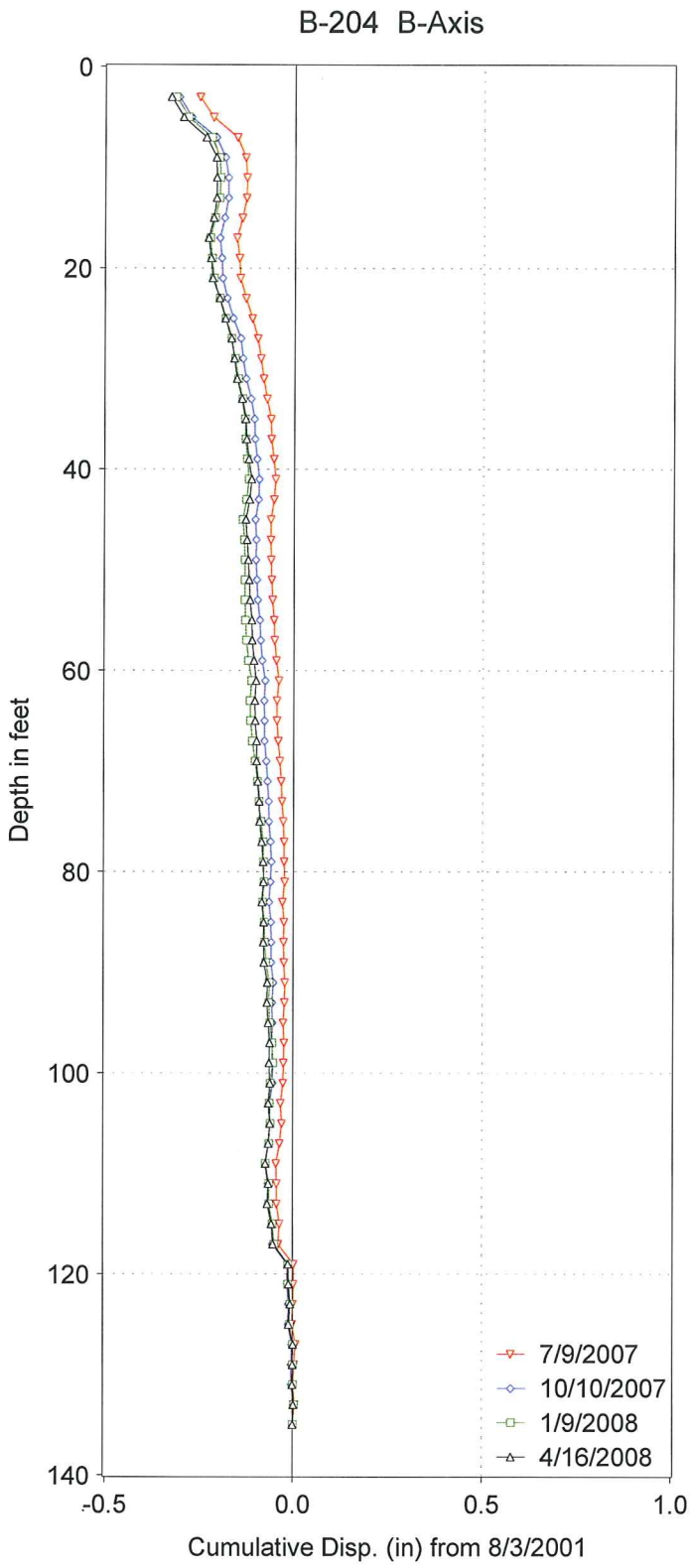
PLATE 10

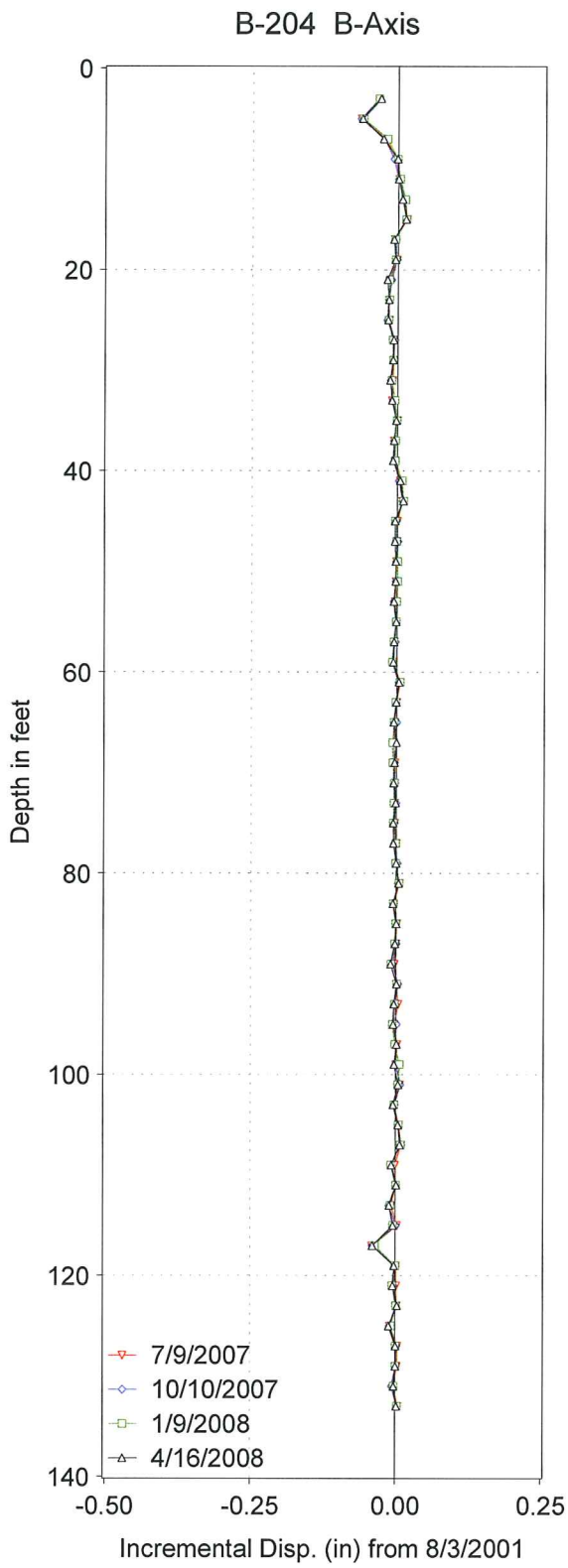




B-204
-Includes readings from the last four quarters.

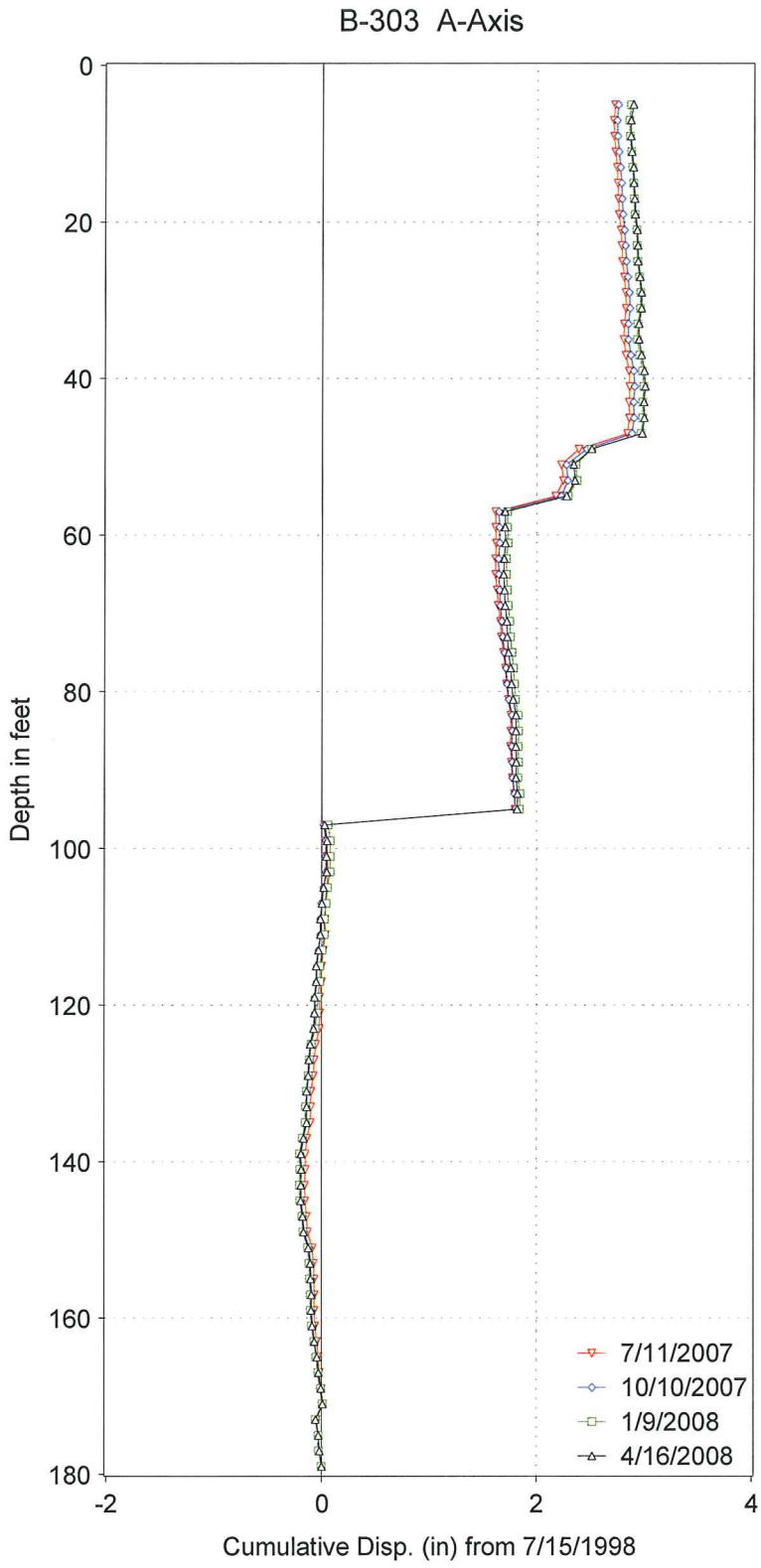
PLATE 11

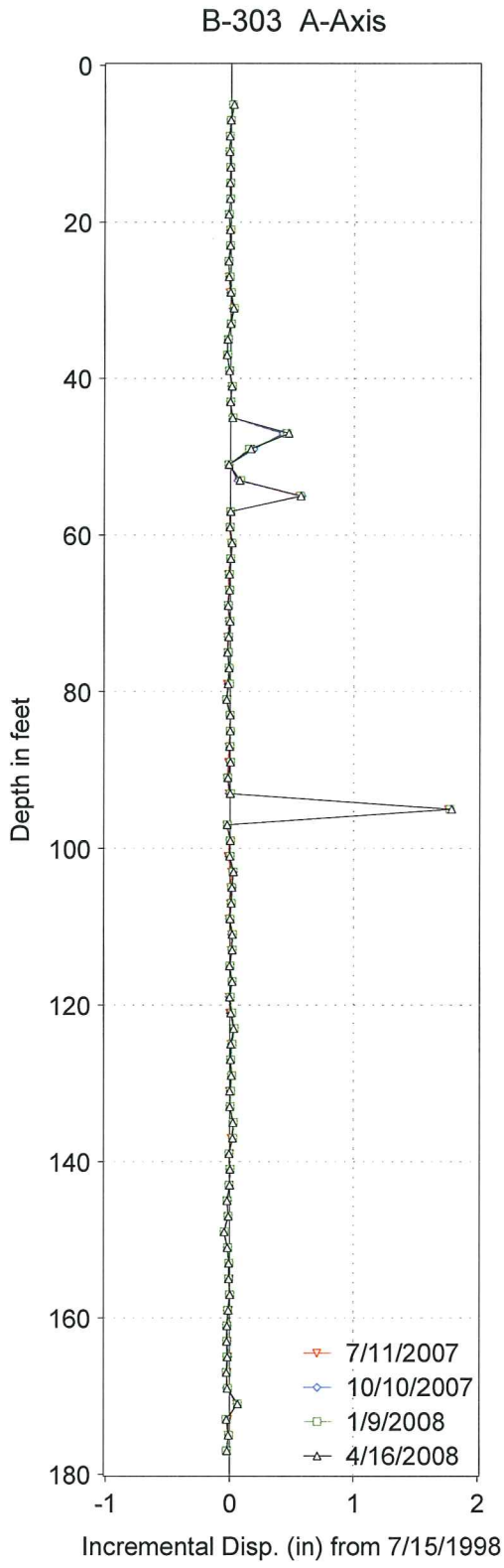




B-204
-Includes readings from the last four quarters.

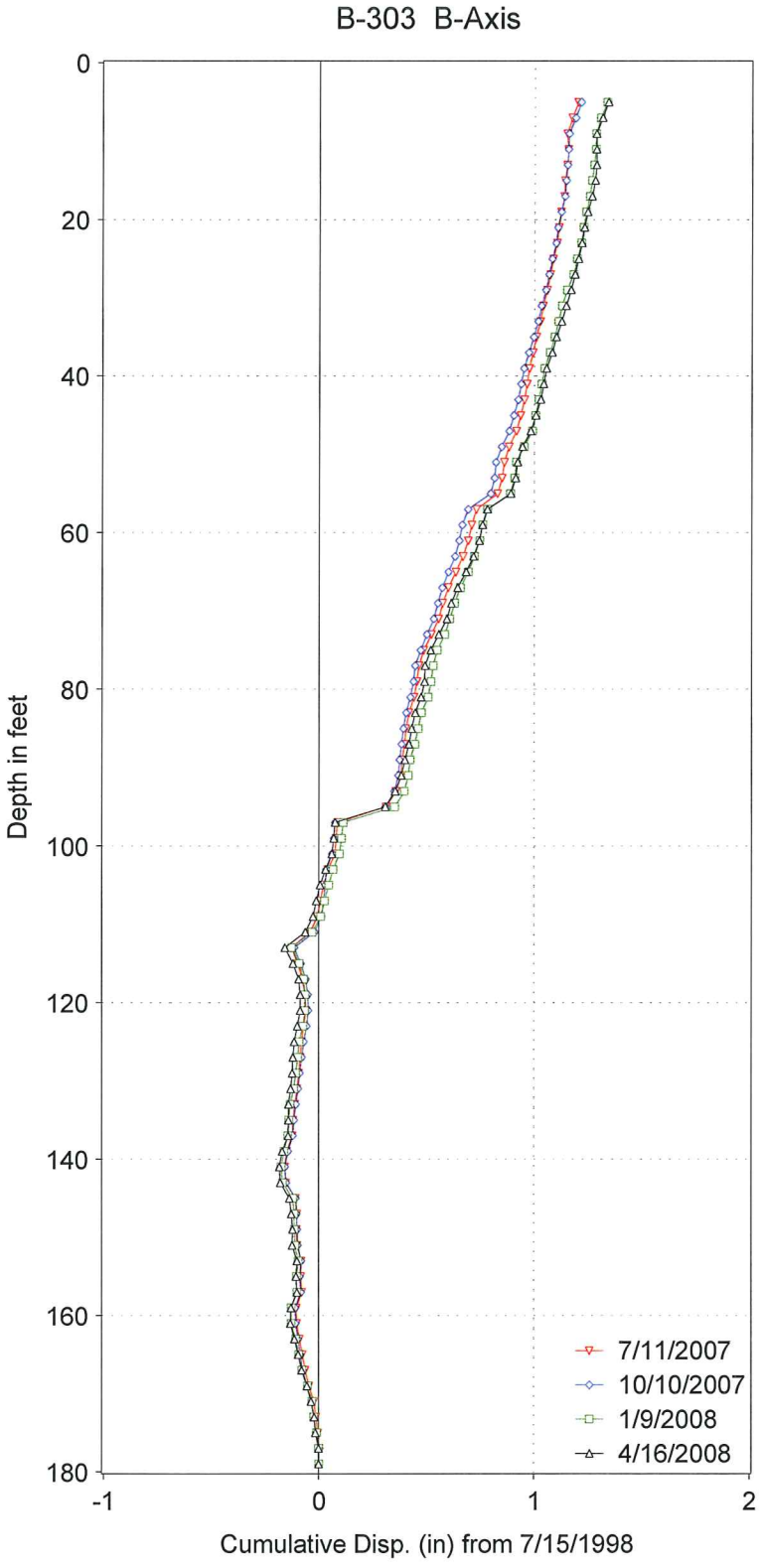
PLATE 12

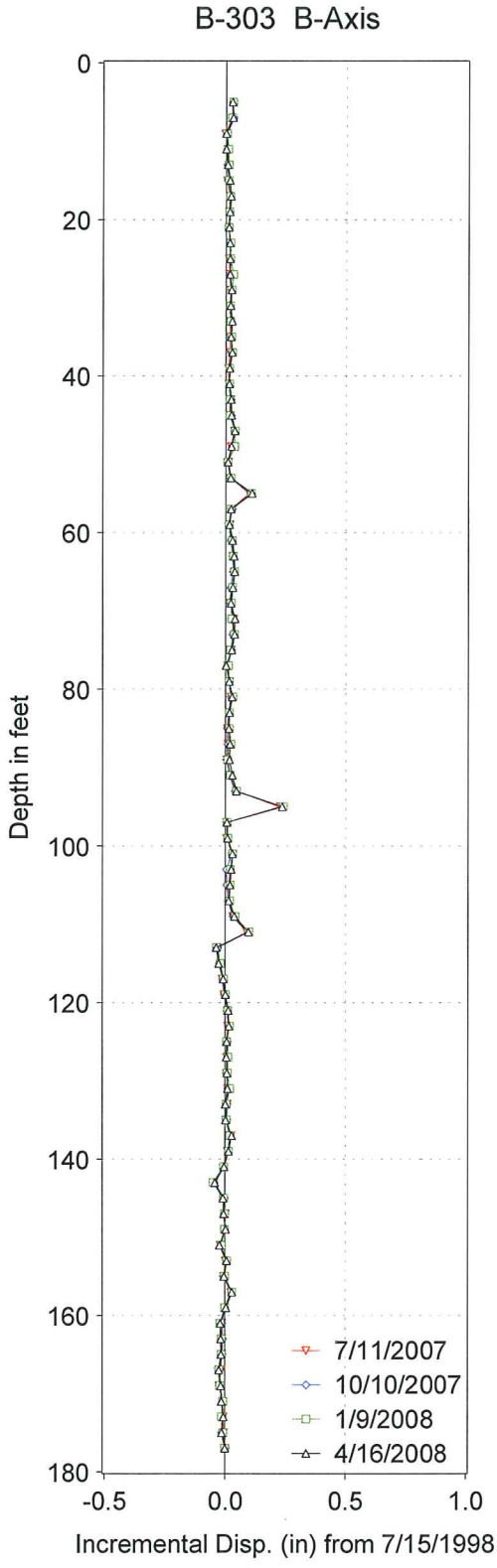




B-303
-Includes readings from the last four quarters.

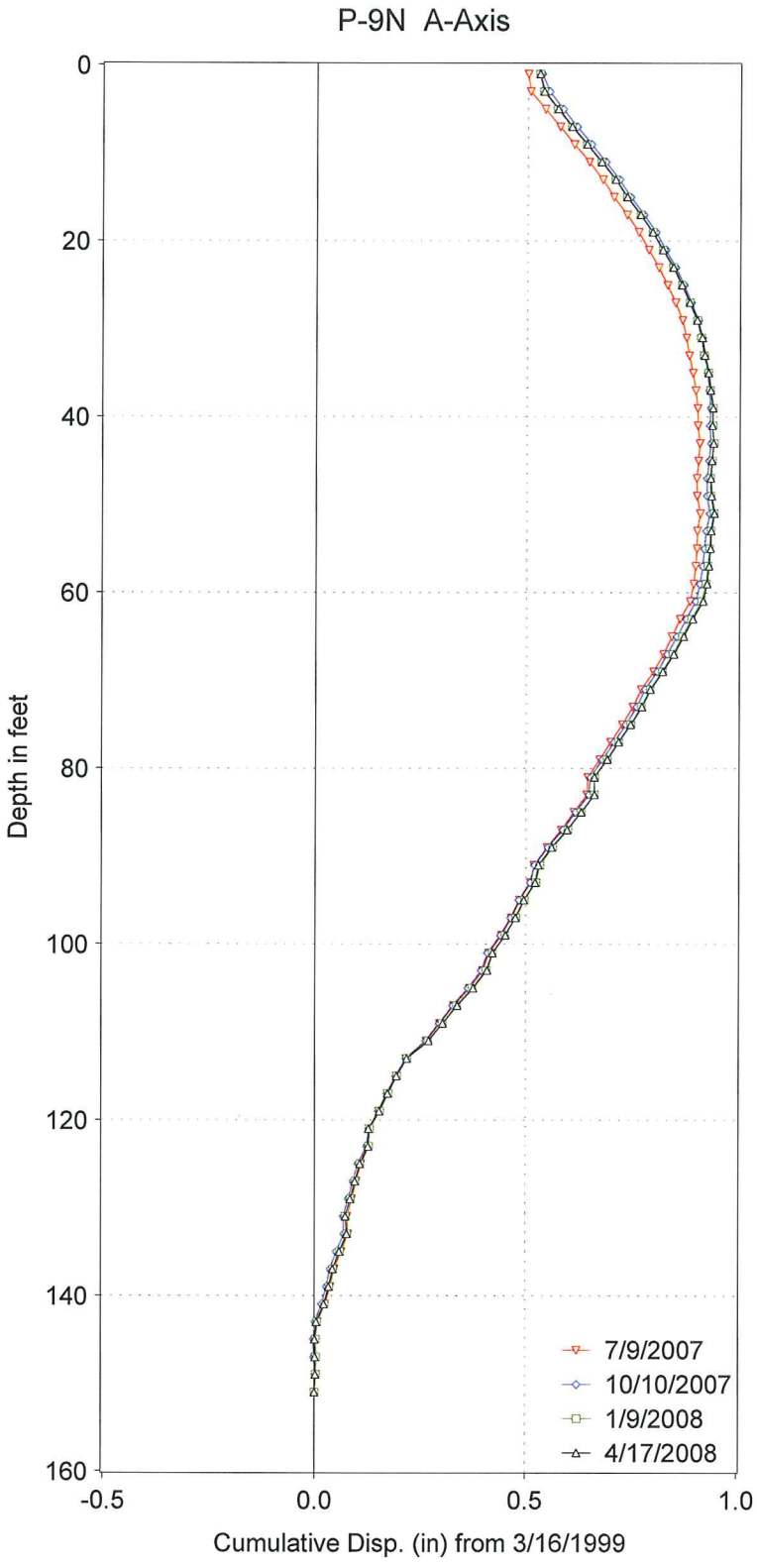
PLATE 13

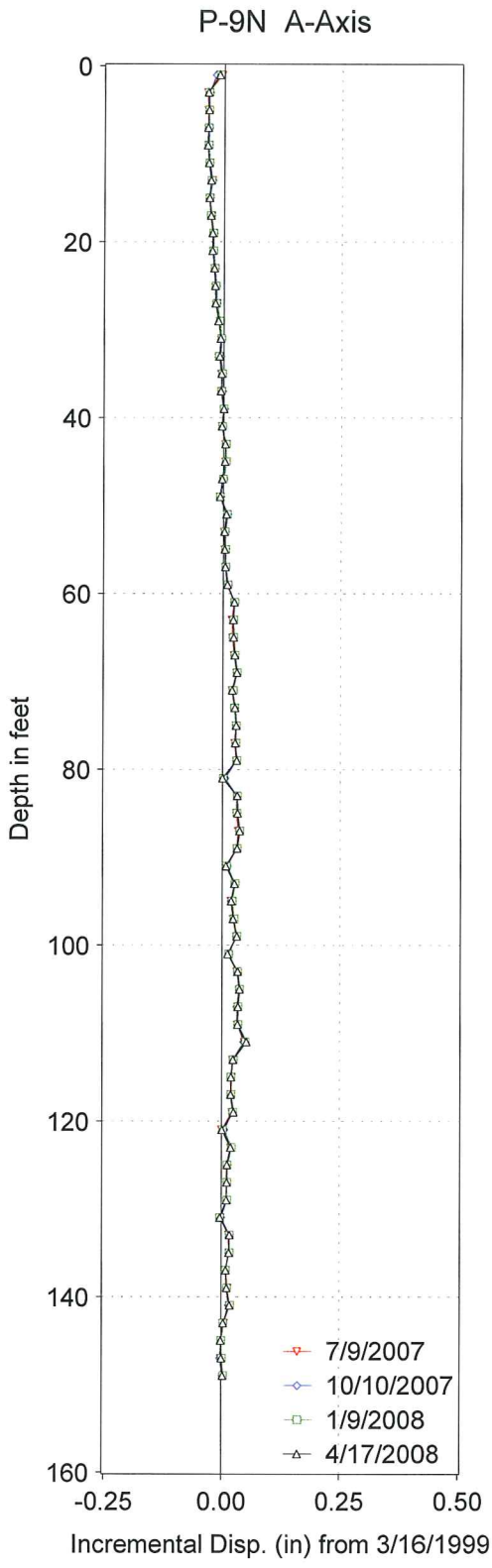




B-303
-Includes readings from the last four quarters.

PLATE 14

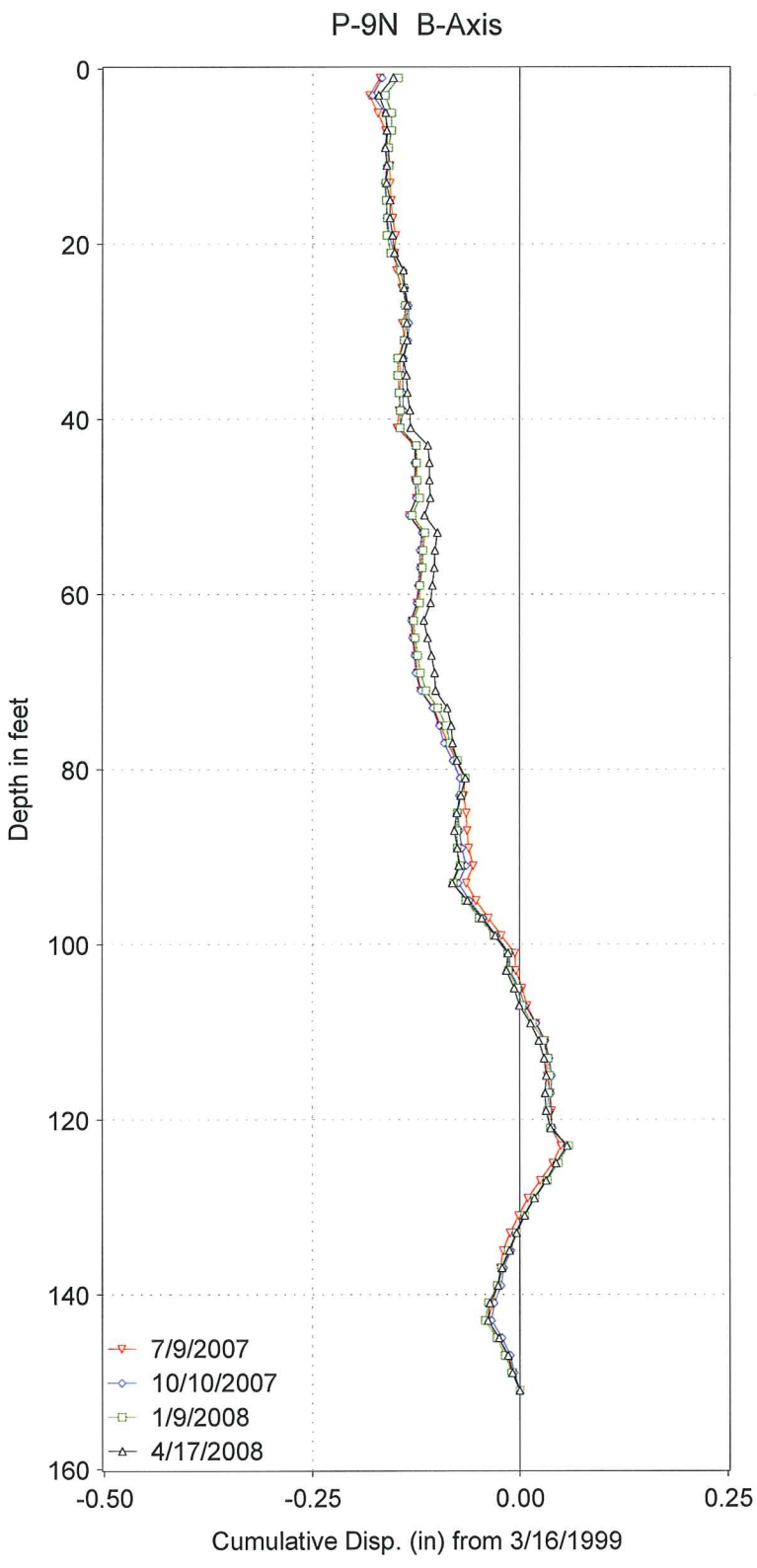


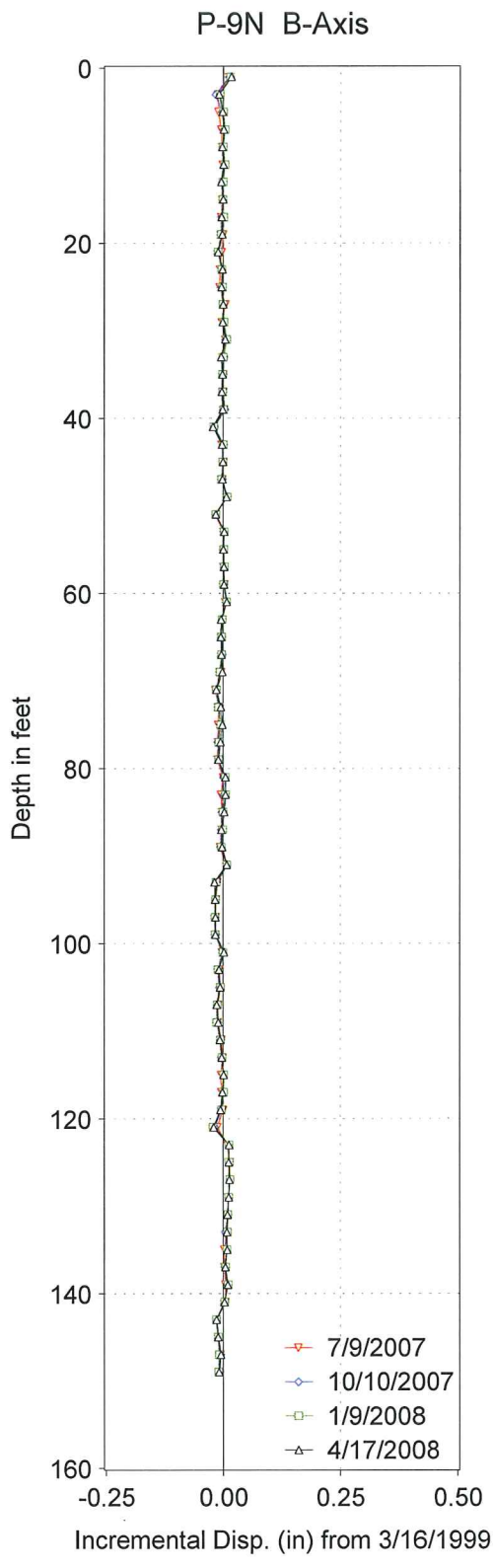


P-9N

-Includes readings from the last four quarters.

PLATE 15





P-9N

-Includes readings from the last four quarters.

PLATE 16

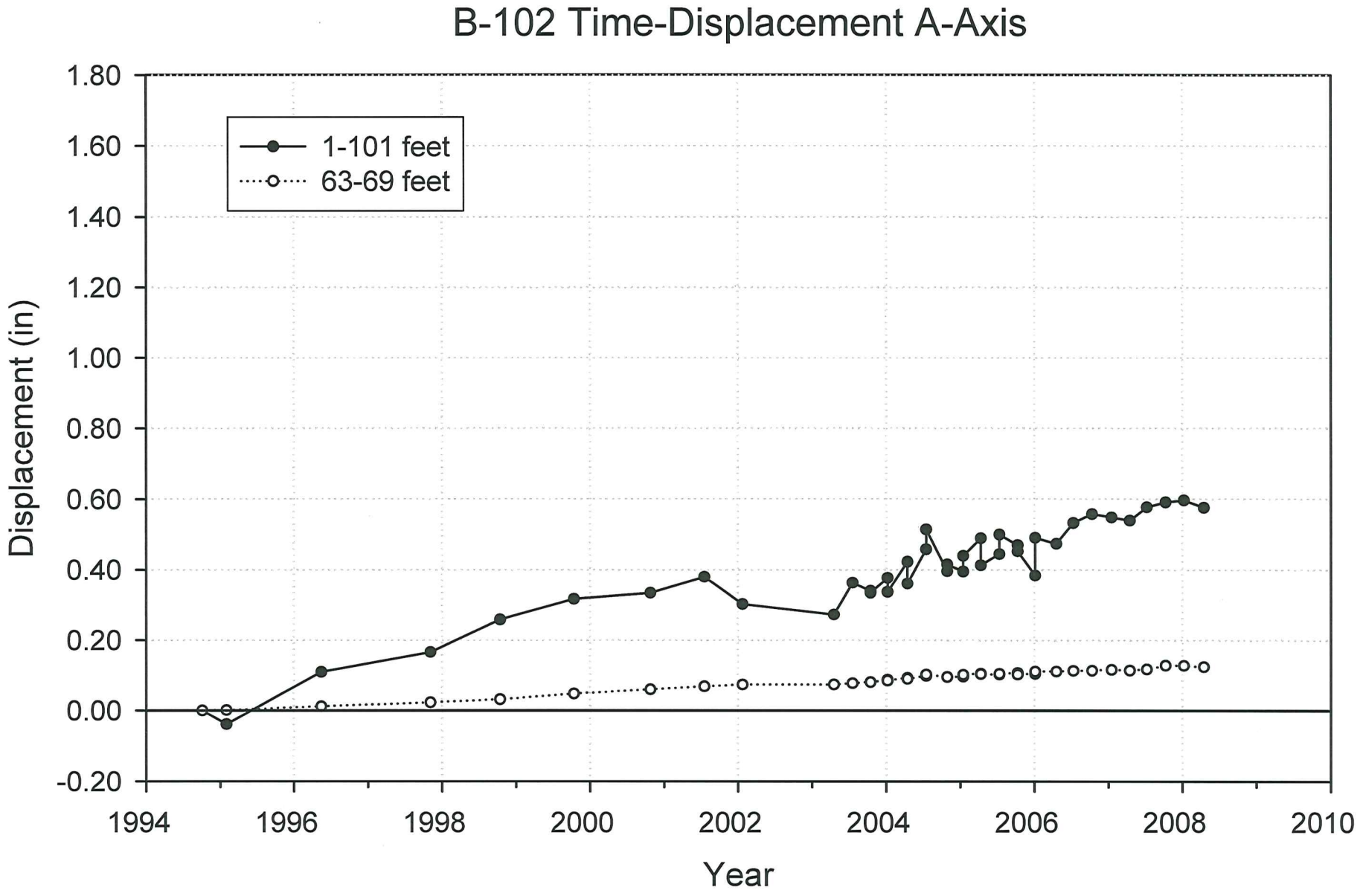

B-102 Time-Displacement A-Axis
1-101 feet
63-69 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 17

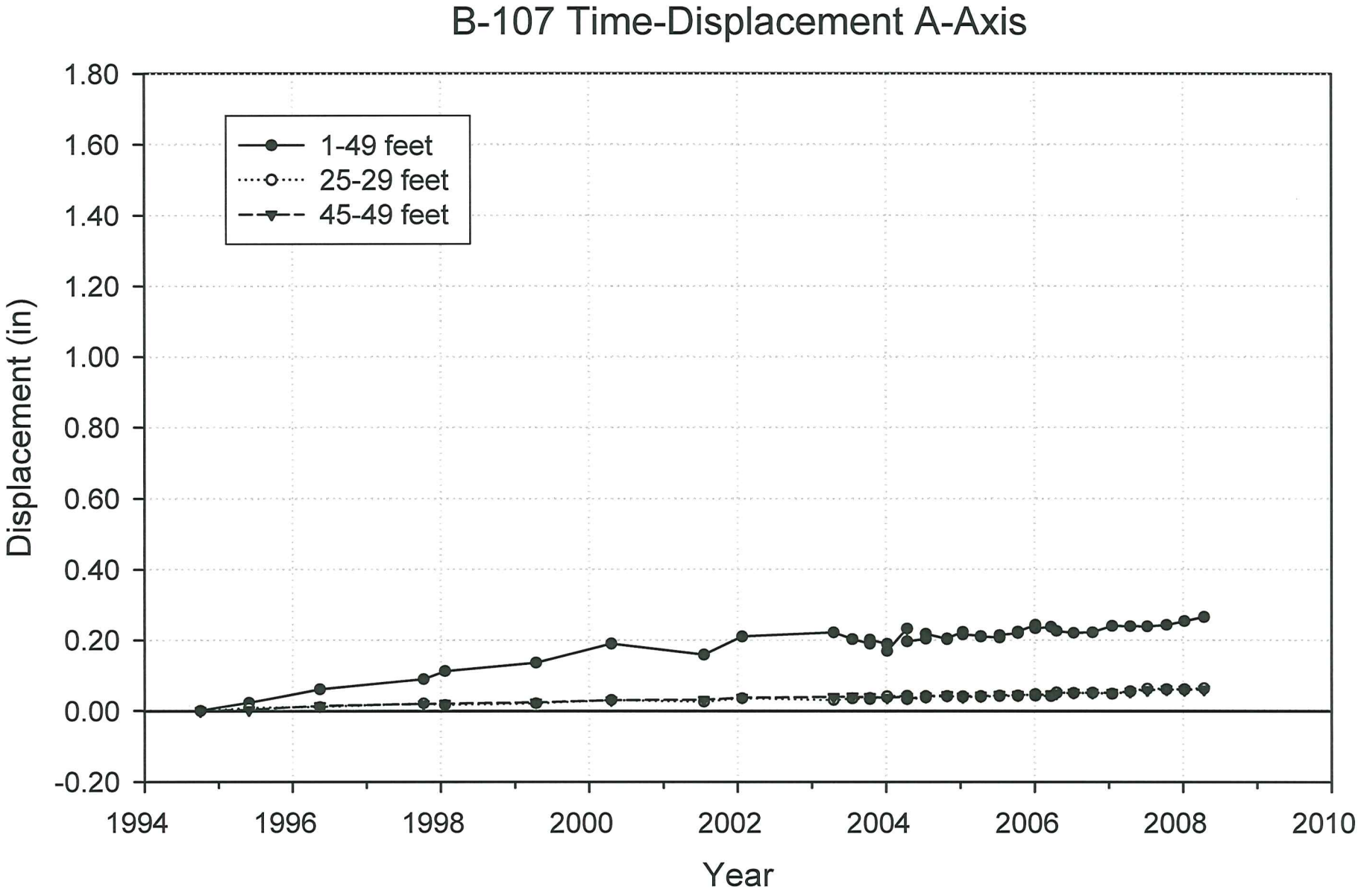

B-107 Time-Displacement A-Axis
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Displacement (in)
1-49 feet
25-29 feet
45-49 feet
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 18

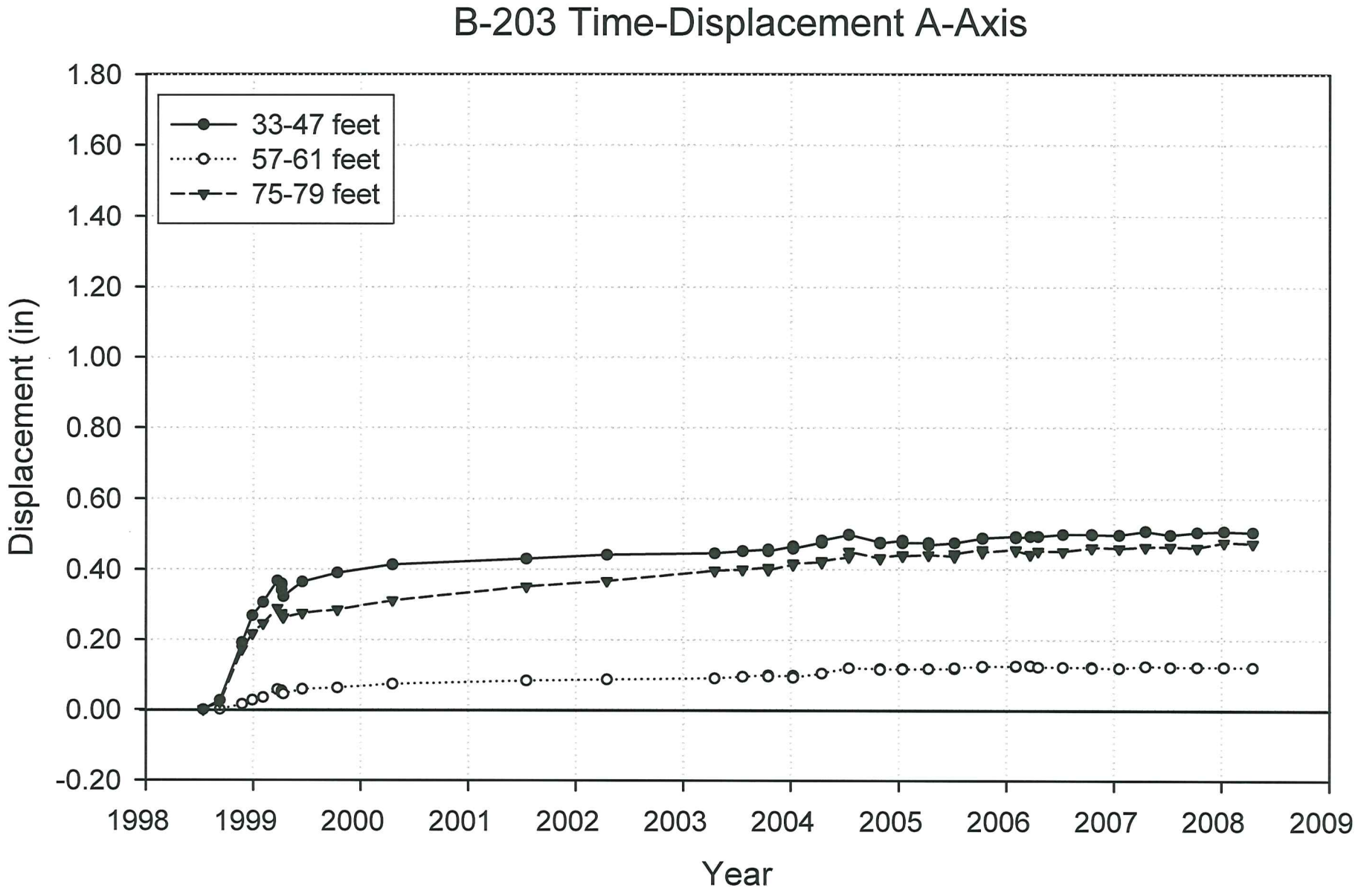

B-203 Time-Displacement A-Axis
33-47 feet
57-61 feet
75-79 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

PLATE 19

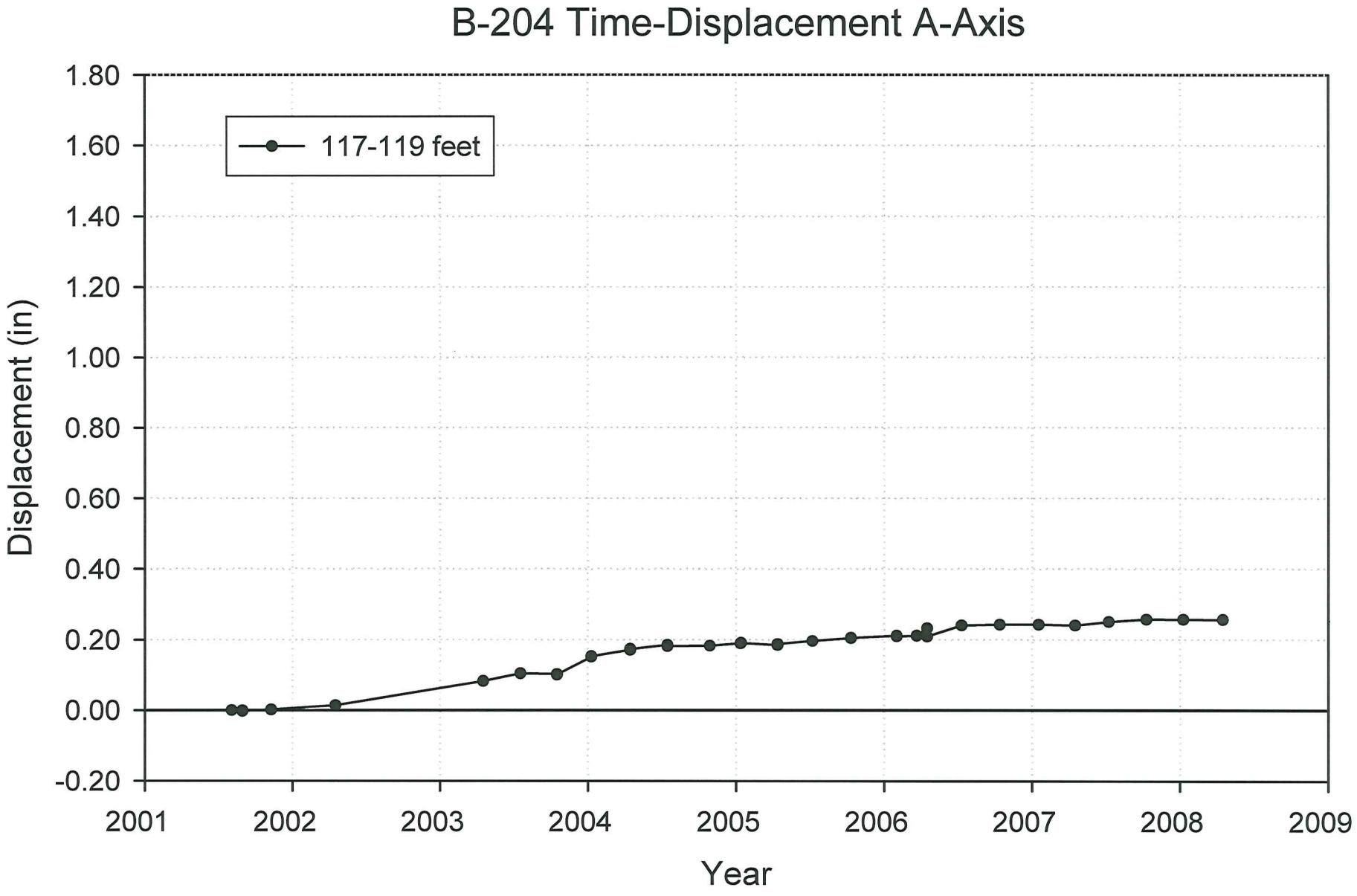

B-204 Time-Displacement A-Axis
117-119 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

PLATE 20

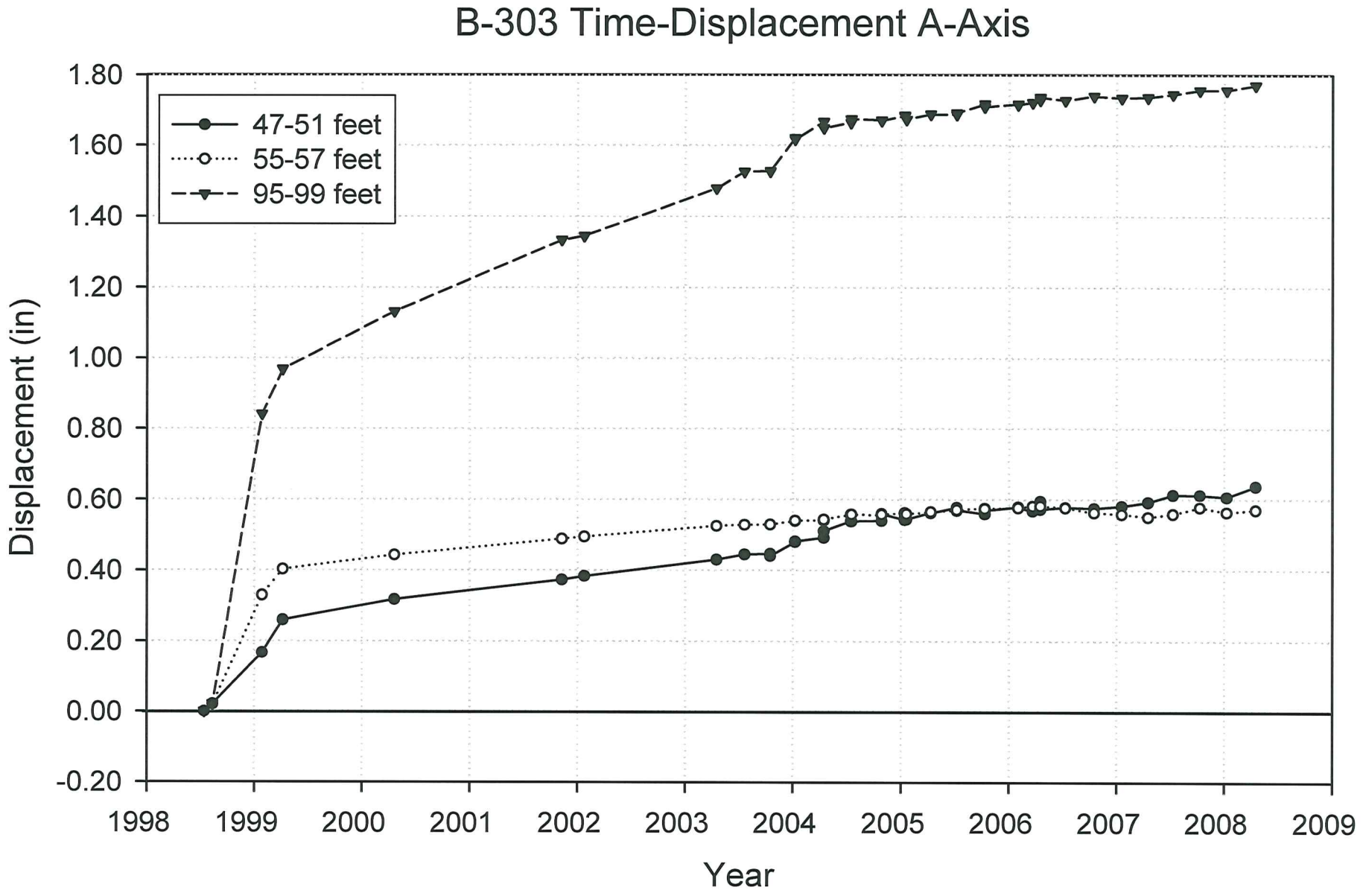
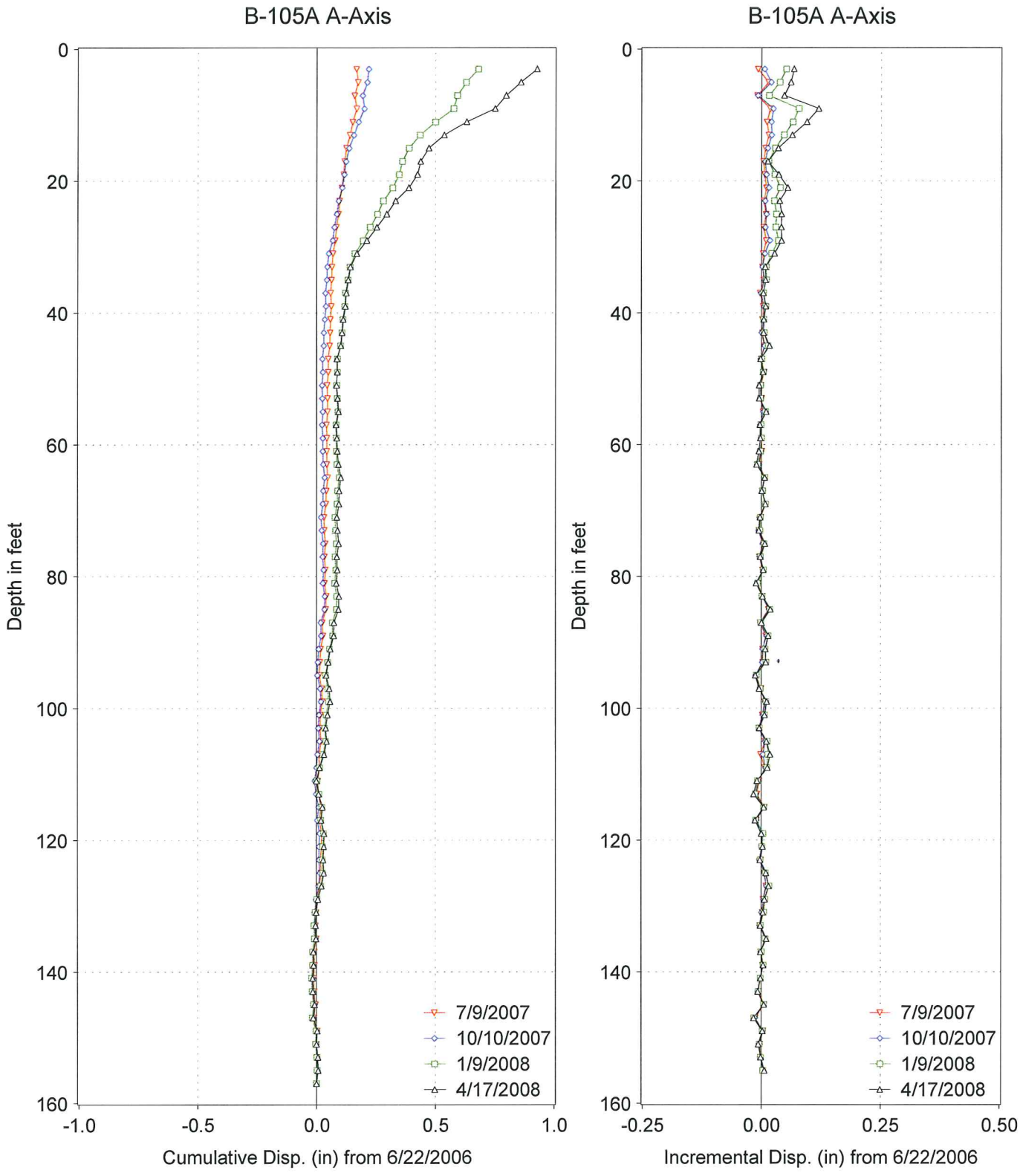
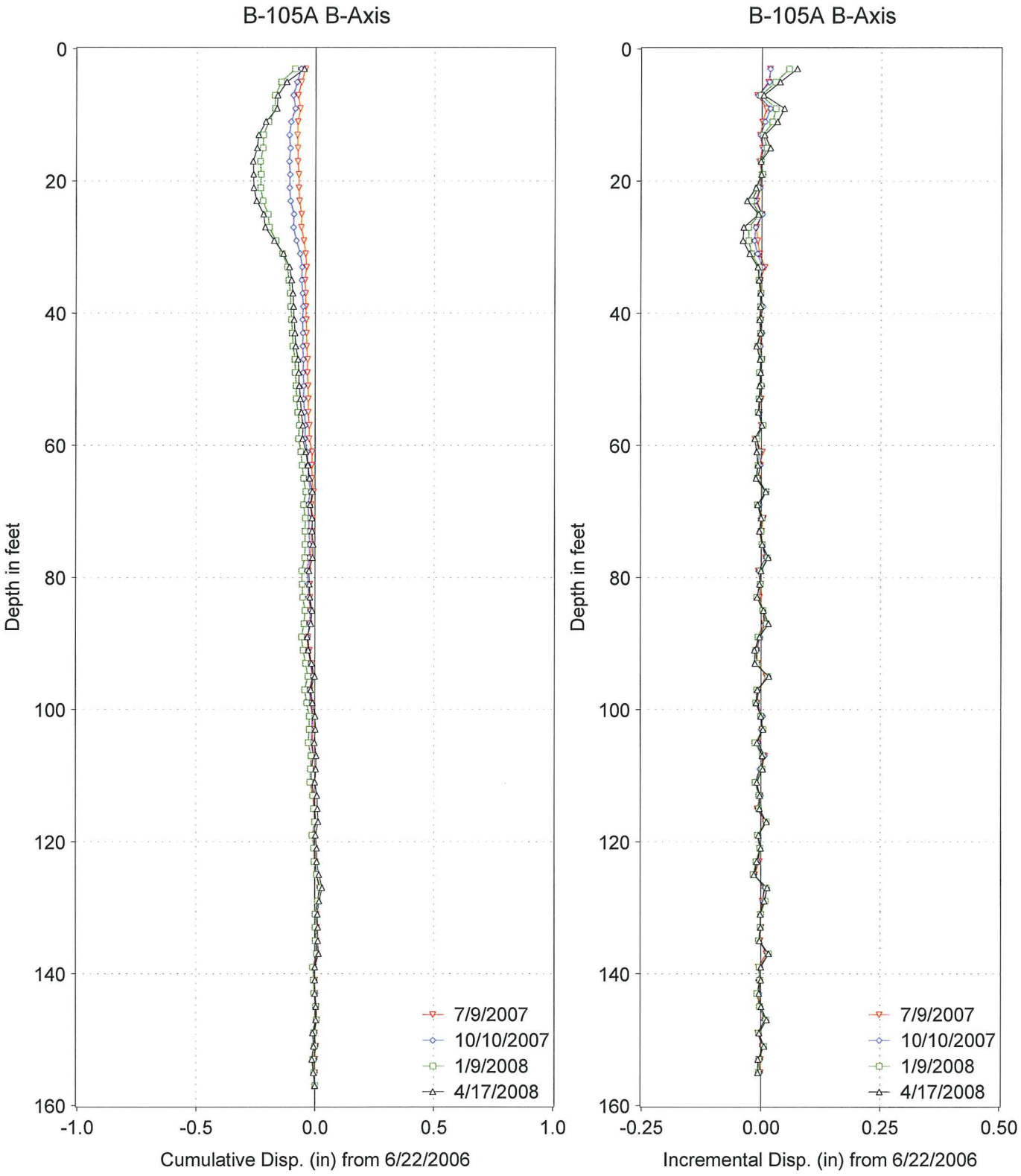

B-303 Time-Displacement A-Axis
47-51 feet
55-57 feet
95-99 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

PLATE 21



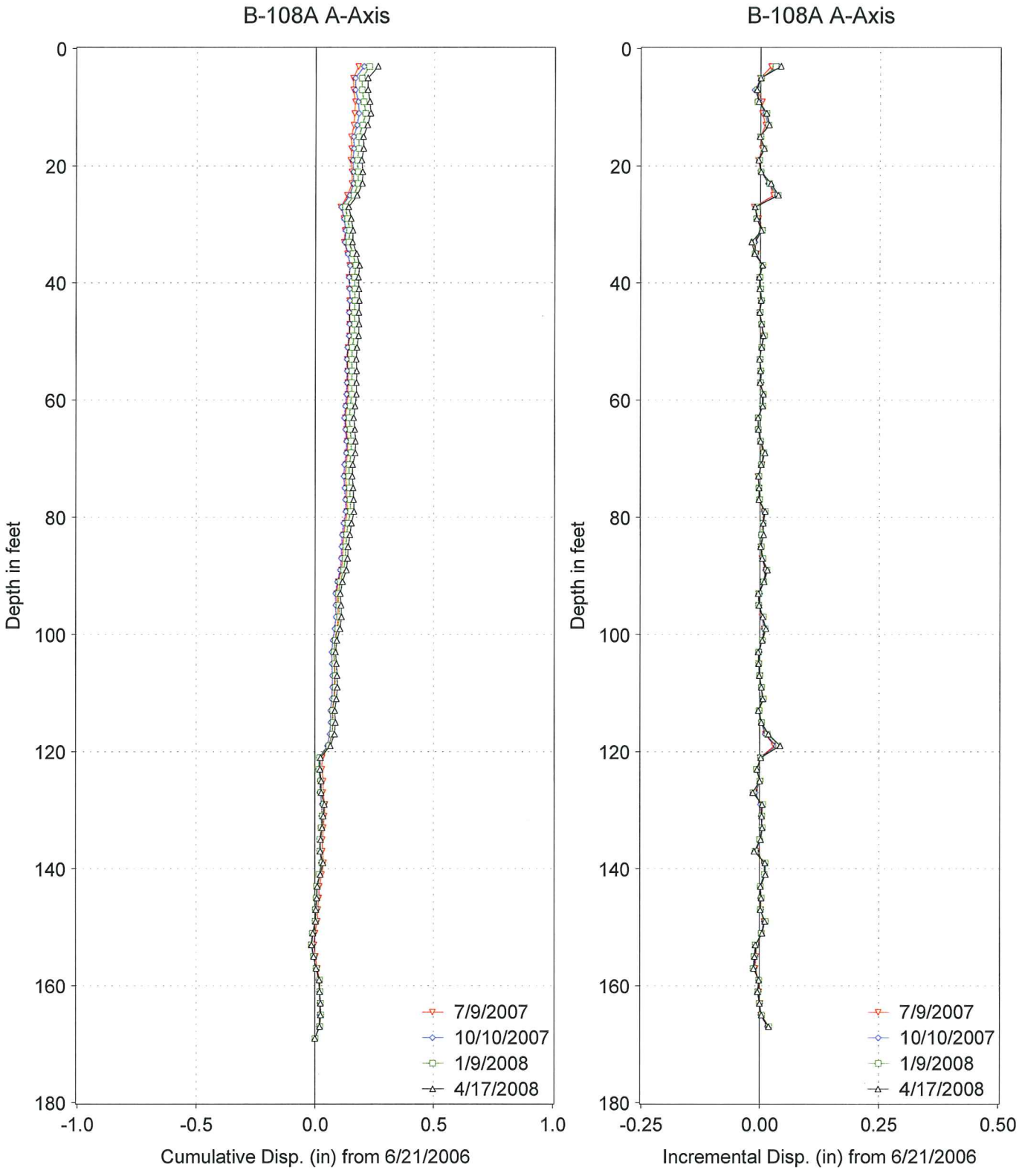
B-105A
-Includes readings from the last four quarters.

PLATE 22



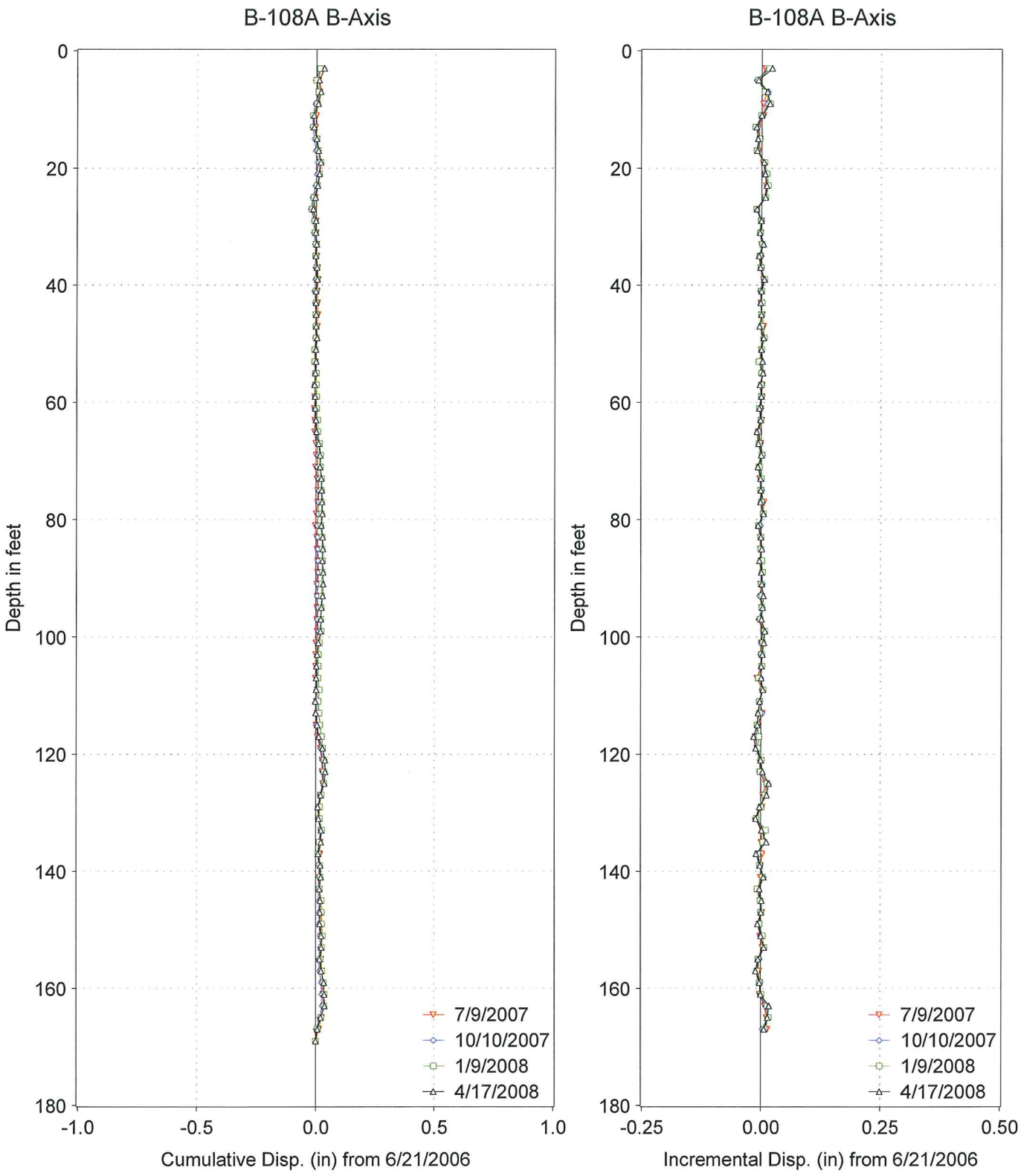
B-105A
-Includes readings from the last four quarters.

PLATE 23



B-108A
-Includes readings from the last four quarters.

PLATE 24



B-108A
-Includes readings from the last four quarters.

PLATE 25

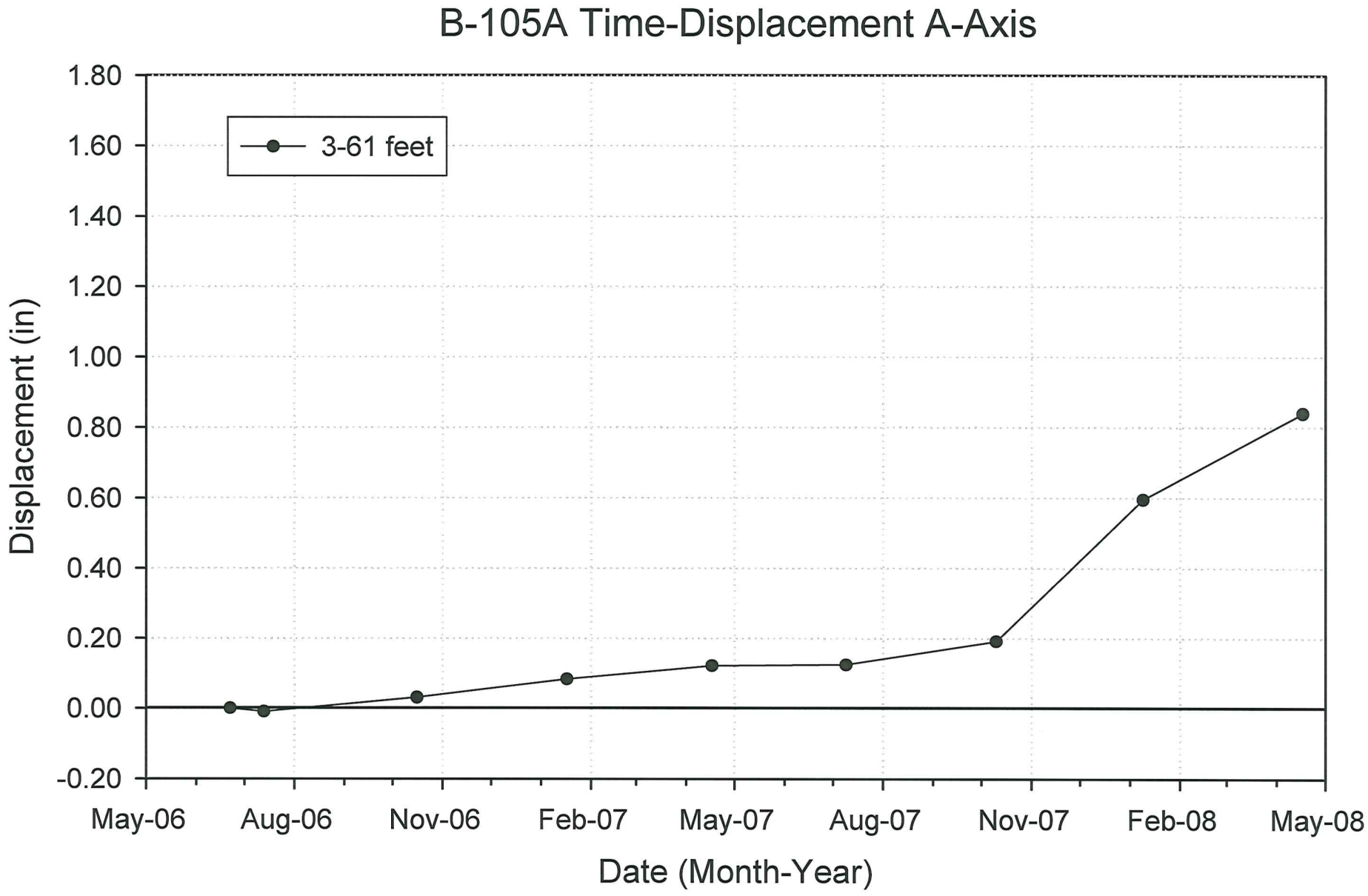

B-105A Time-Displacement A-Axis
3-61 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Aug-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
May-08
Date (Month-Year)

PLATE 26

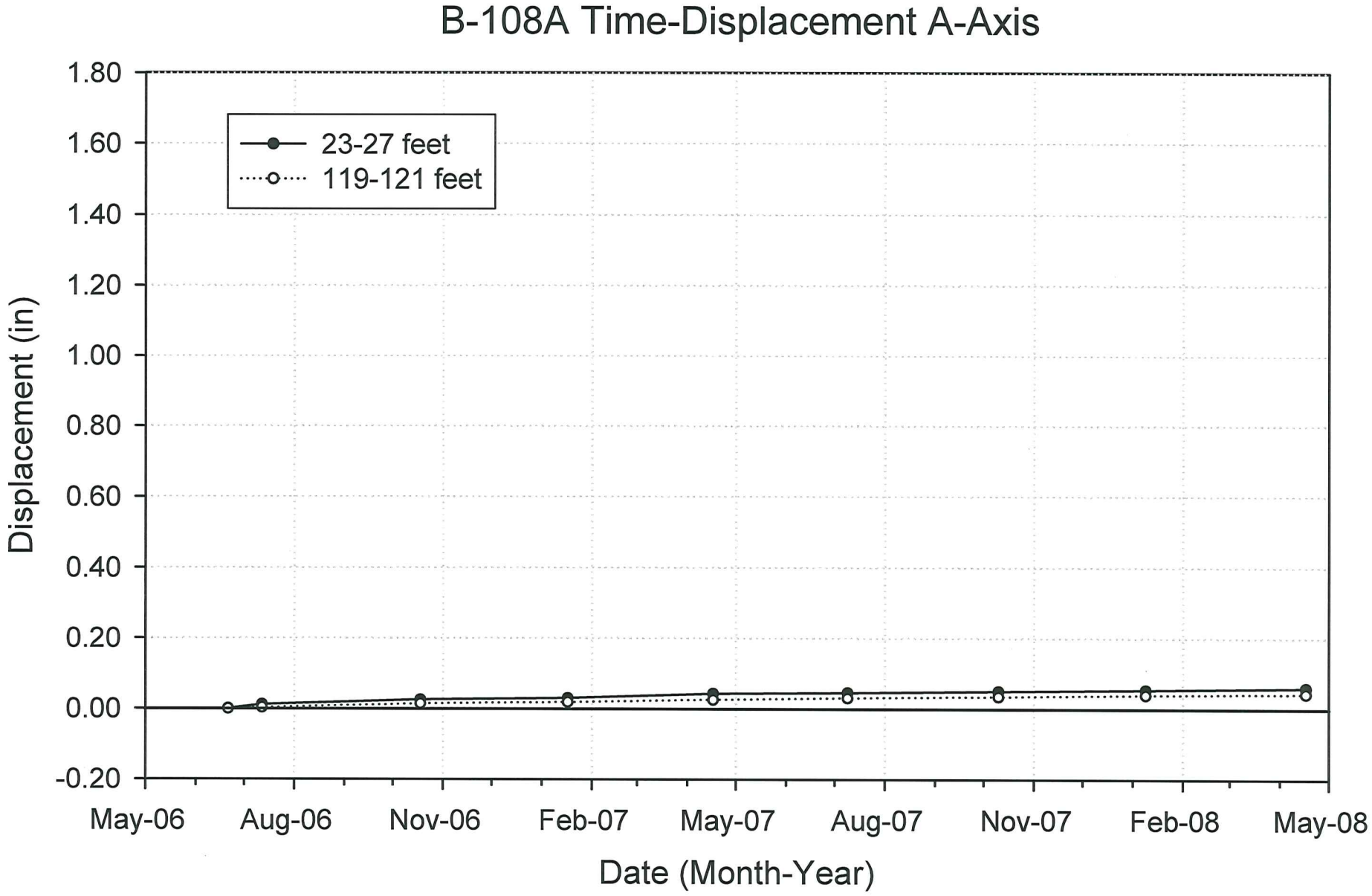
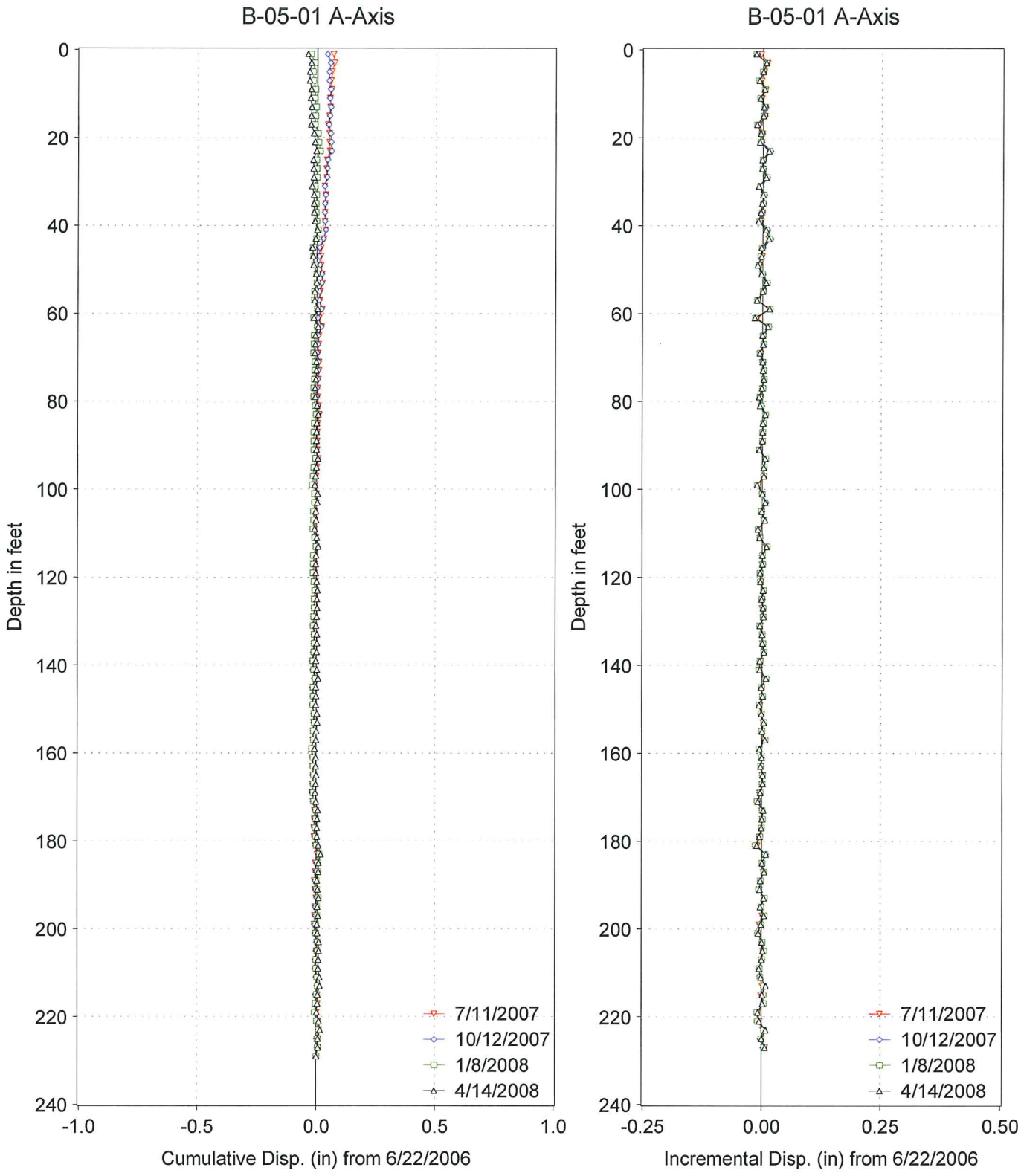
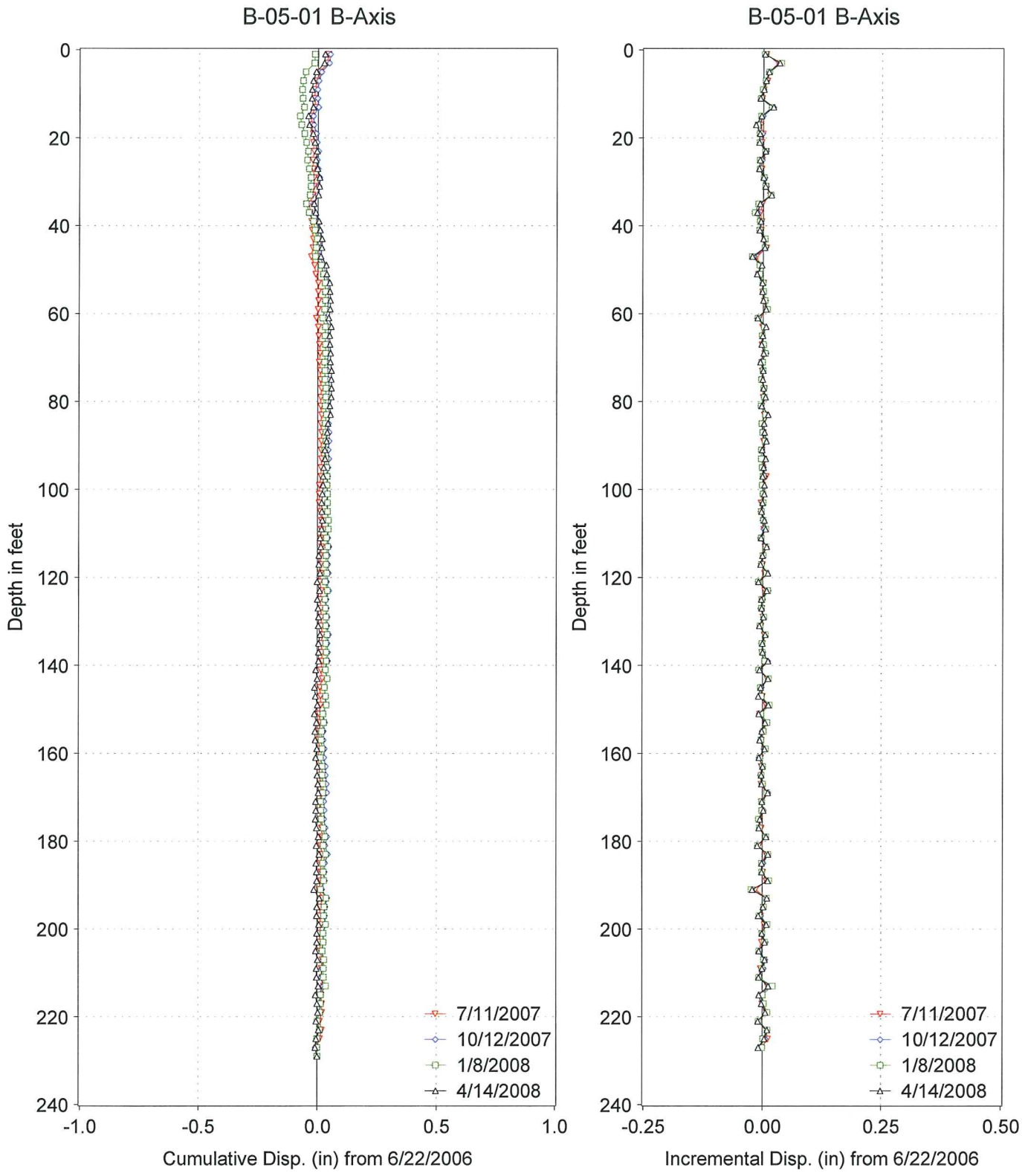

B-108A Time-Displacement A-Axis
23-27 feet
119-121 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Aug-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
May-08
Date (Month-Year)

PLATE 27



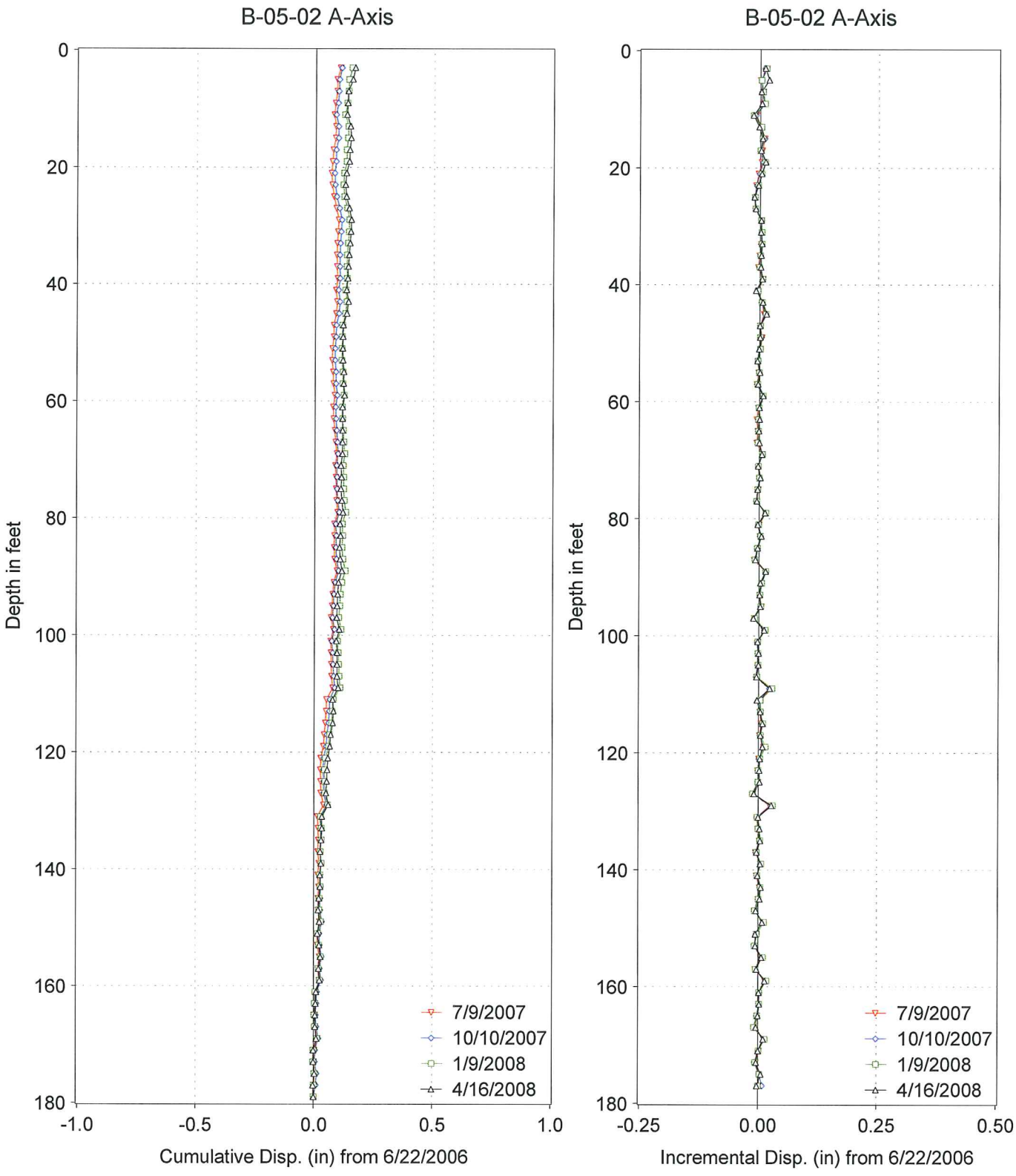
B-05-01
-Includes readings from the last four quarters.

PLATE 28



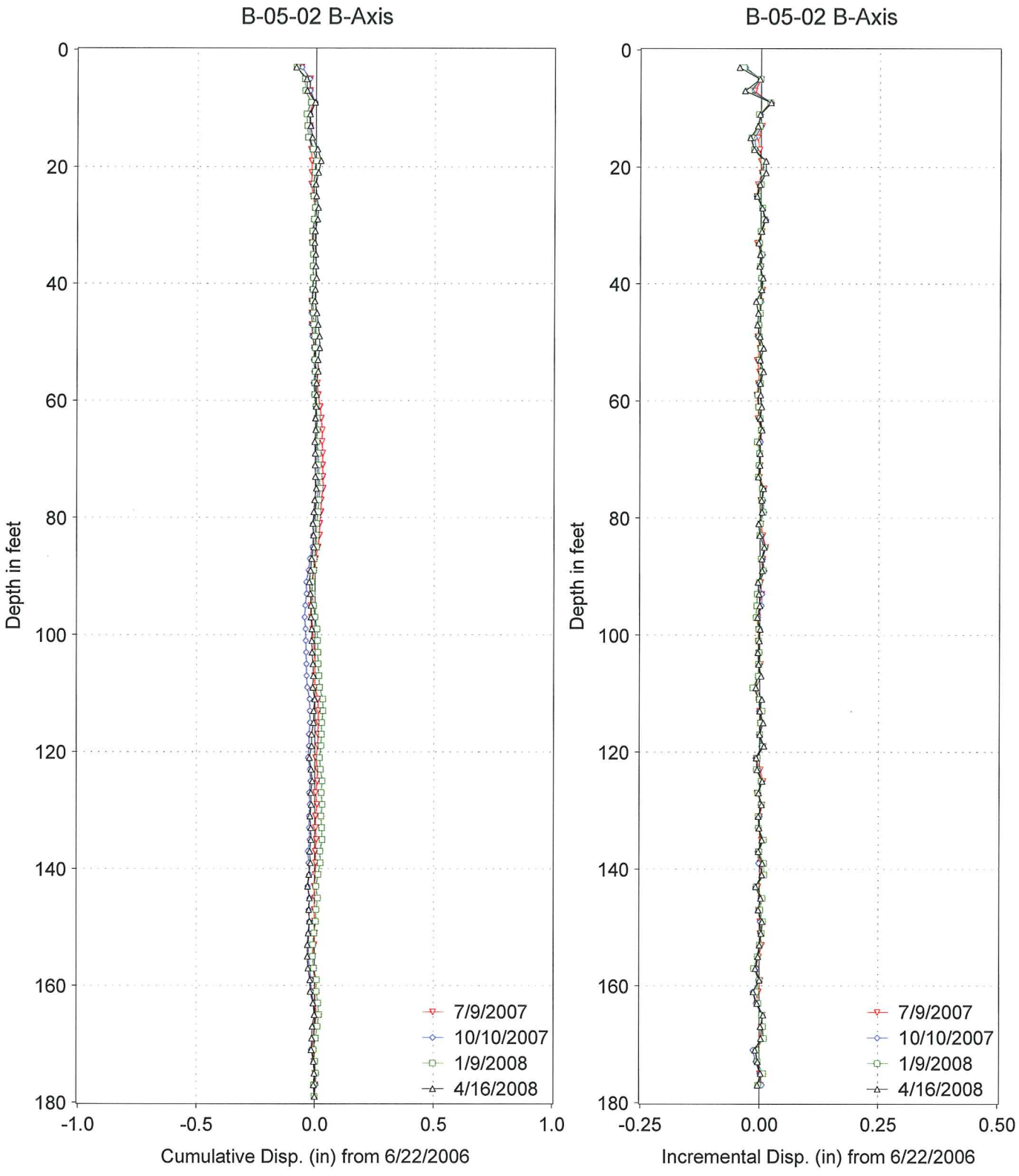
B-05-01
-Includes readings from the last four quarters.

PLATE 29



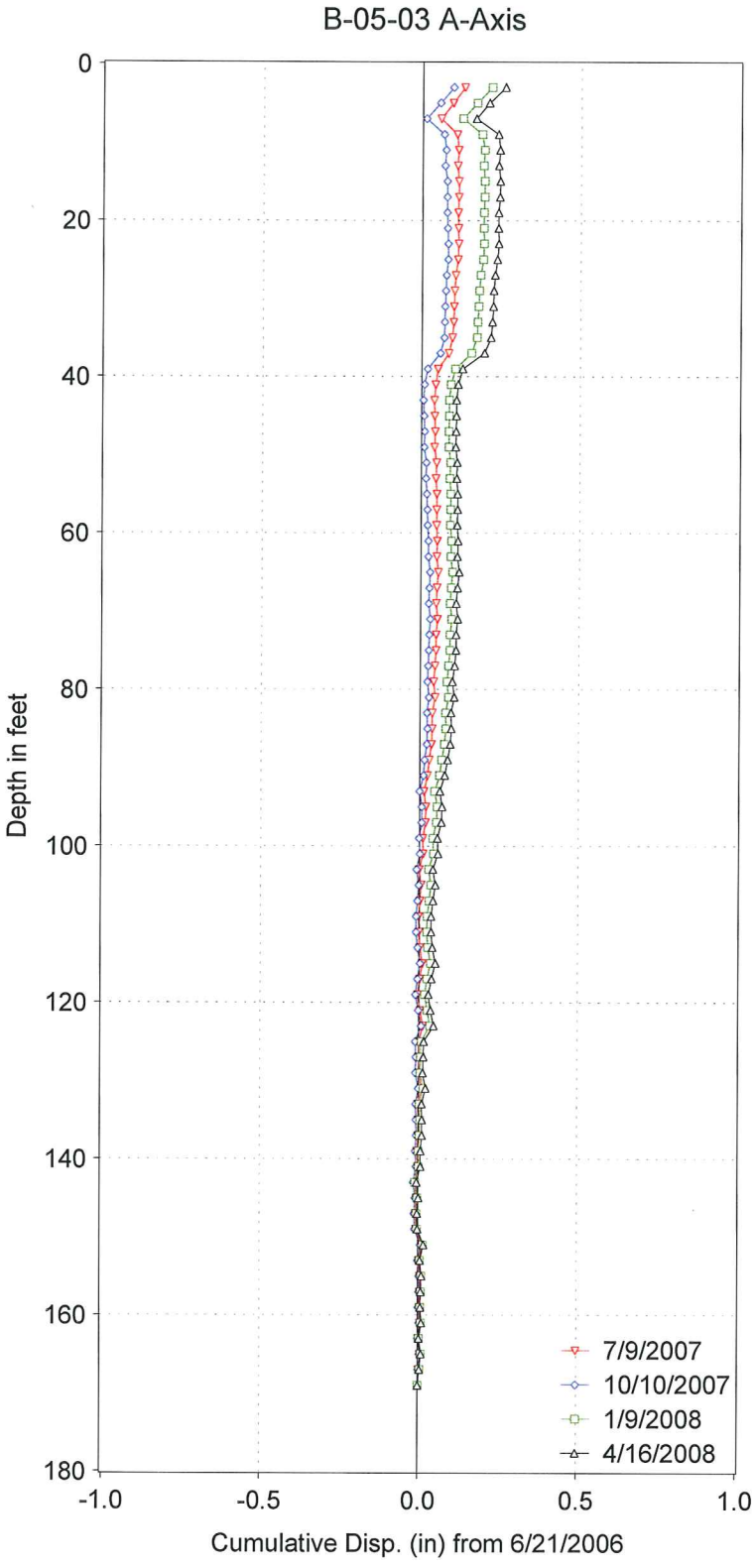
B-05-02
-Includes readings from the last four quarters.

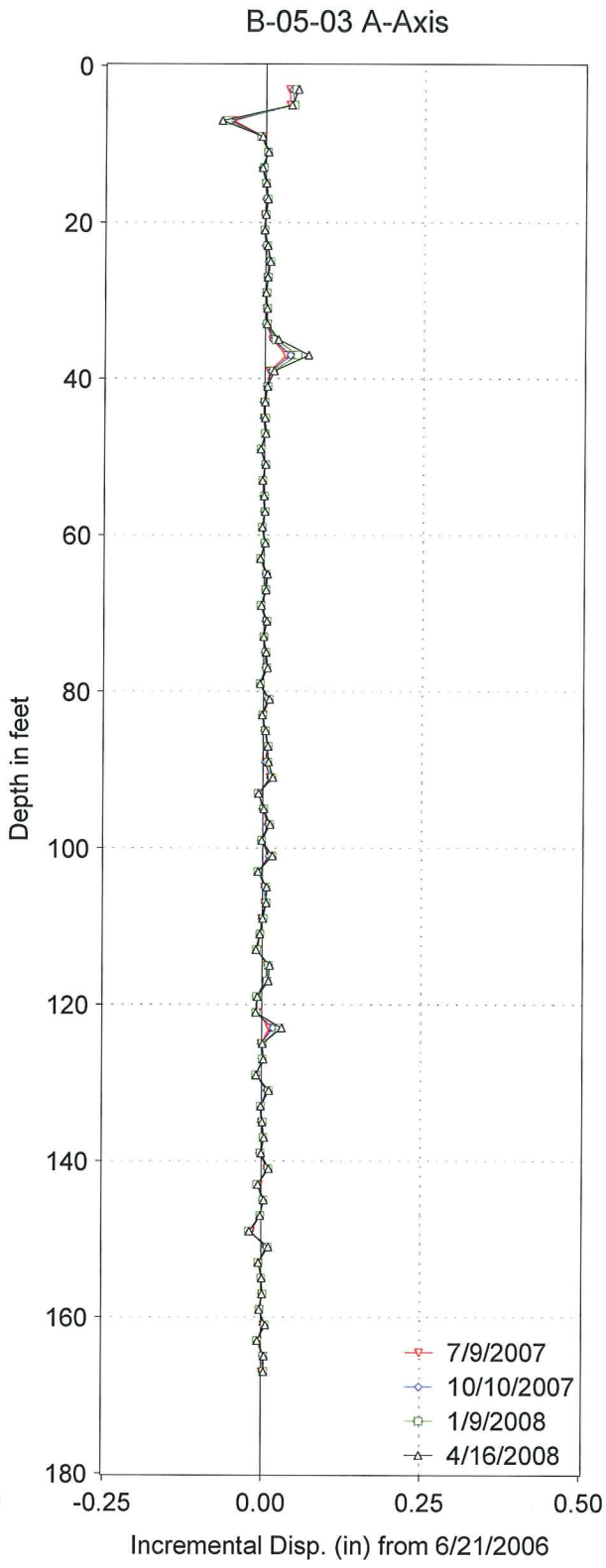
PLATE 30



B-05-02
-Includes readings from the last four quarters.

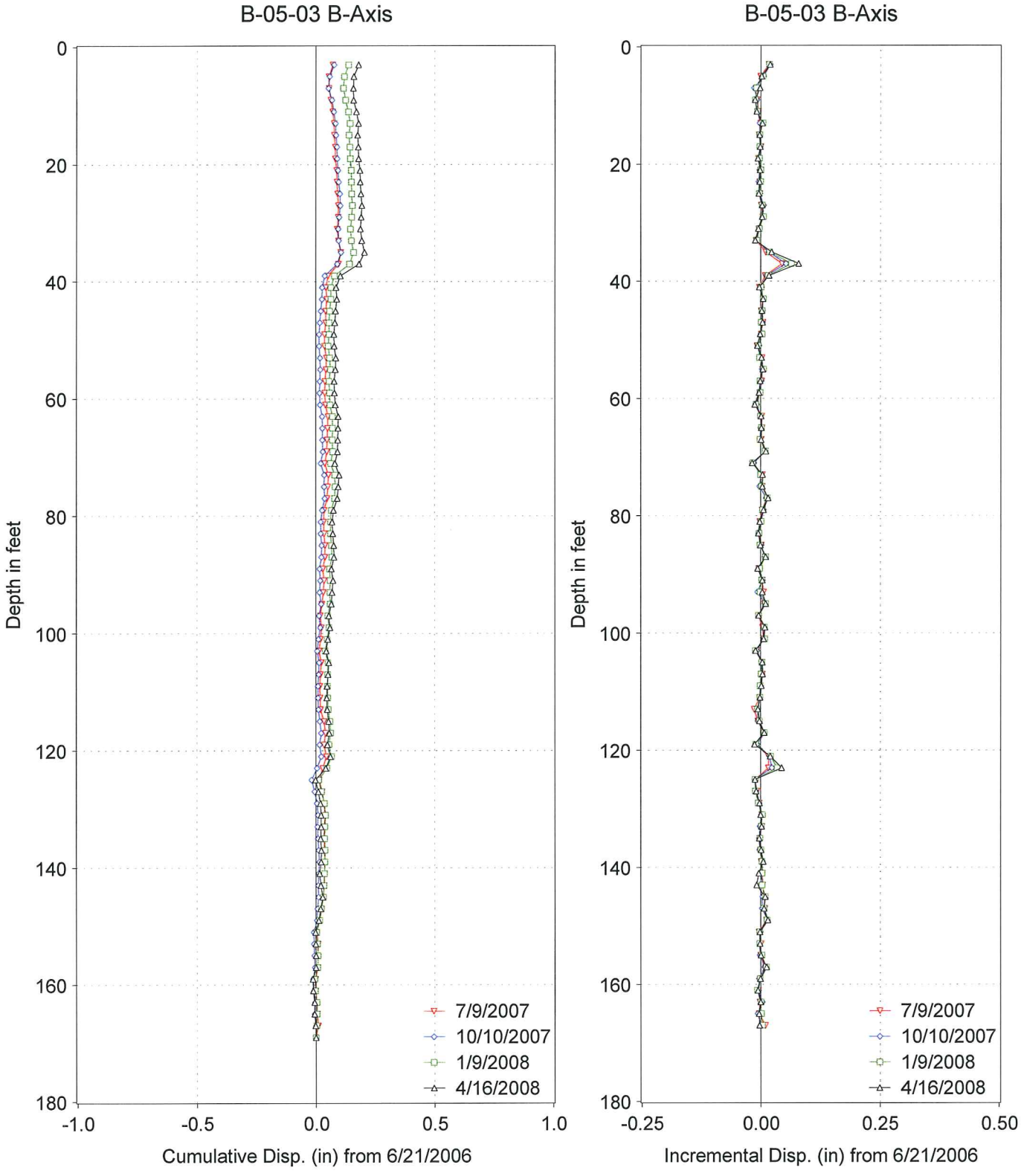
PLATE 31





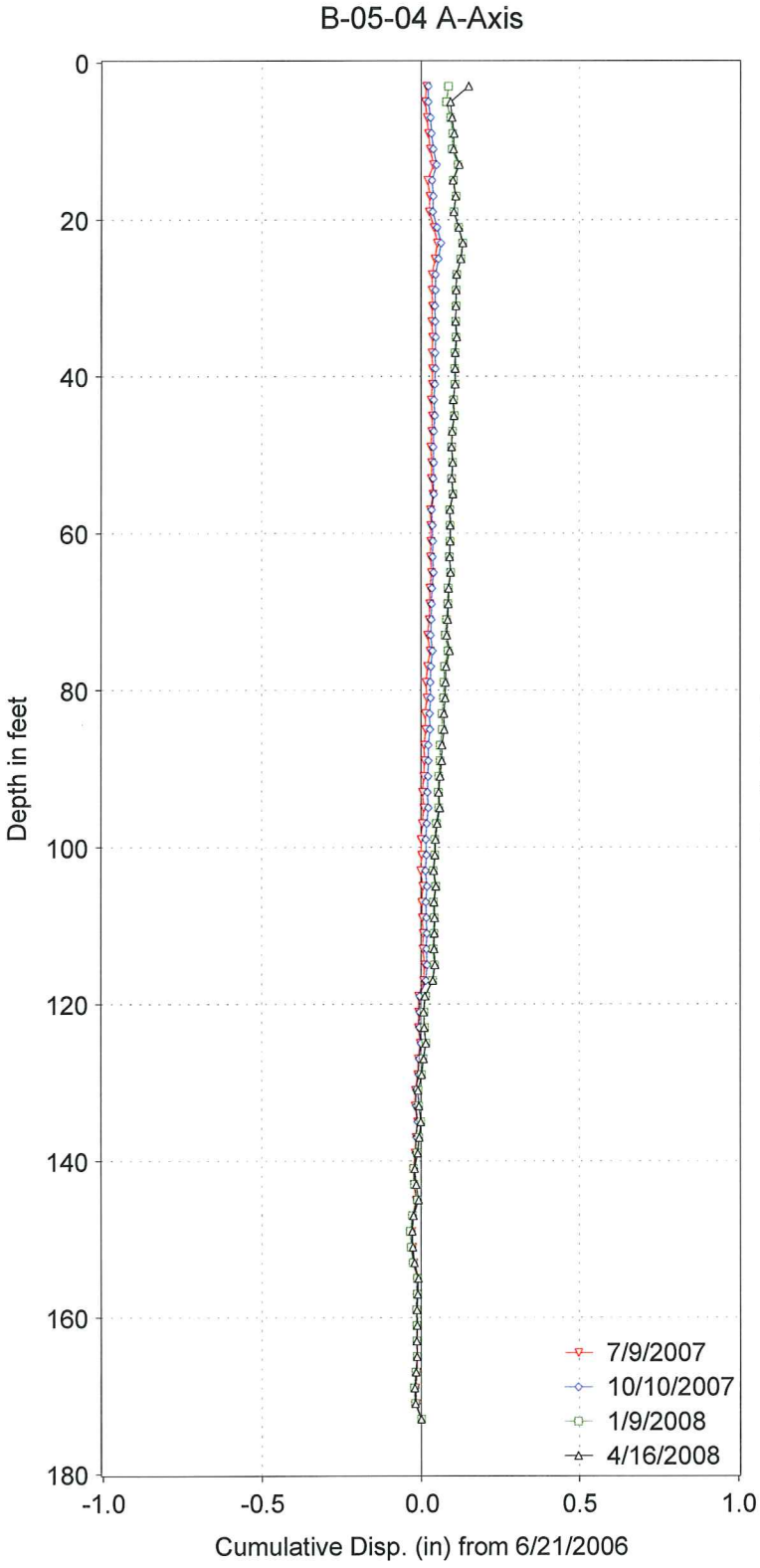
B-05-03
-Includes readings from the last four quarters.

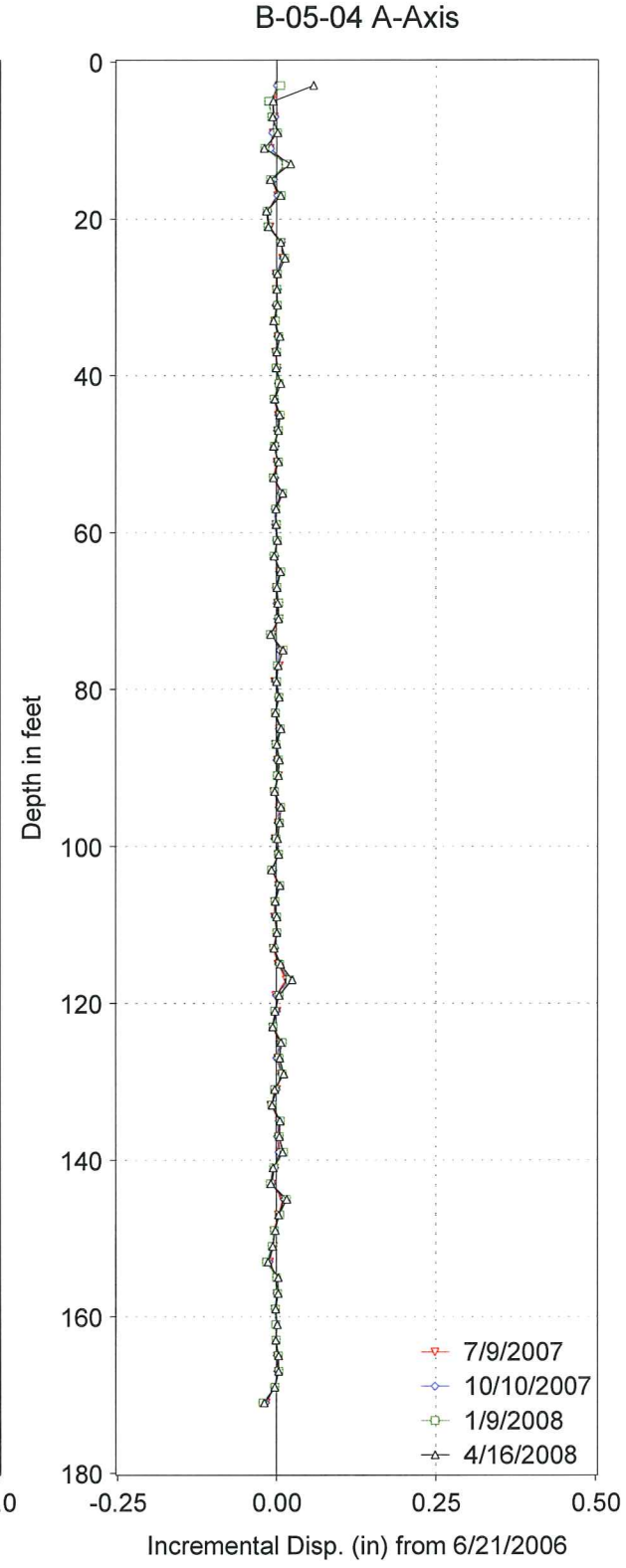
PLATE 32



B-05-03
-Includes readings from the last four quarters.

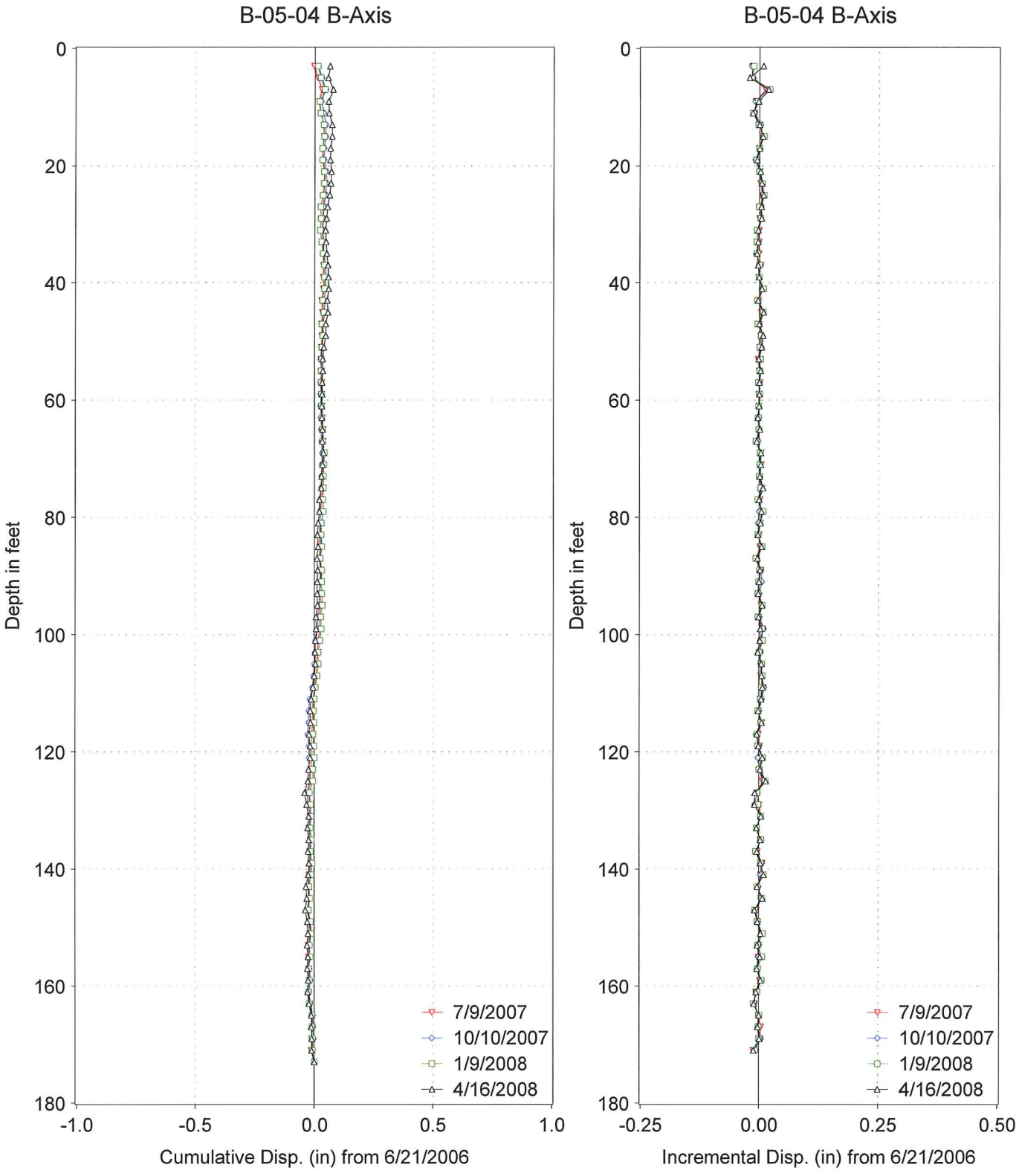
PLATE 33





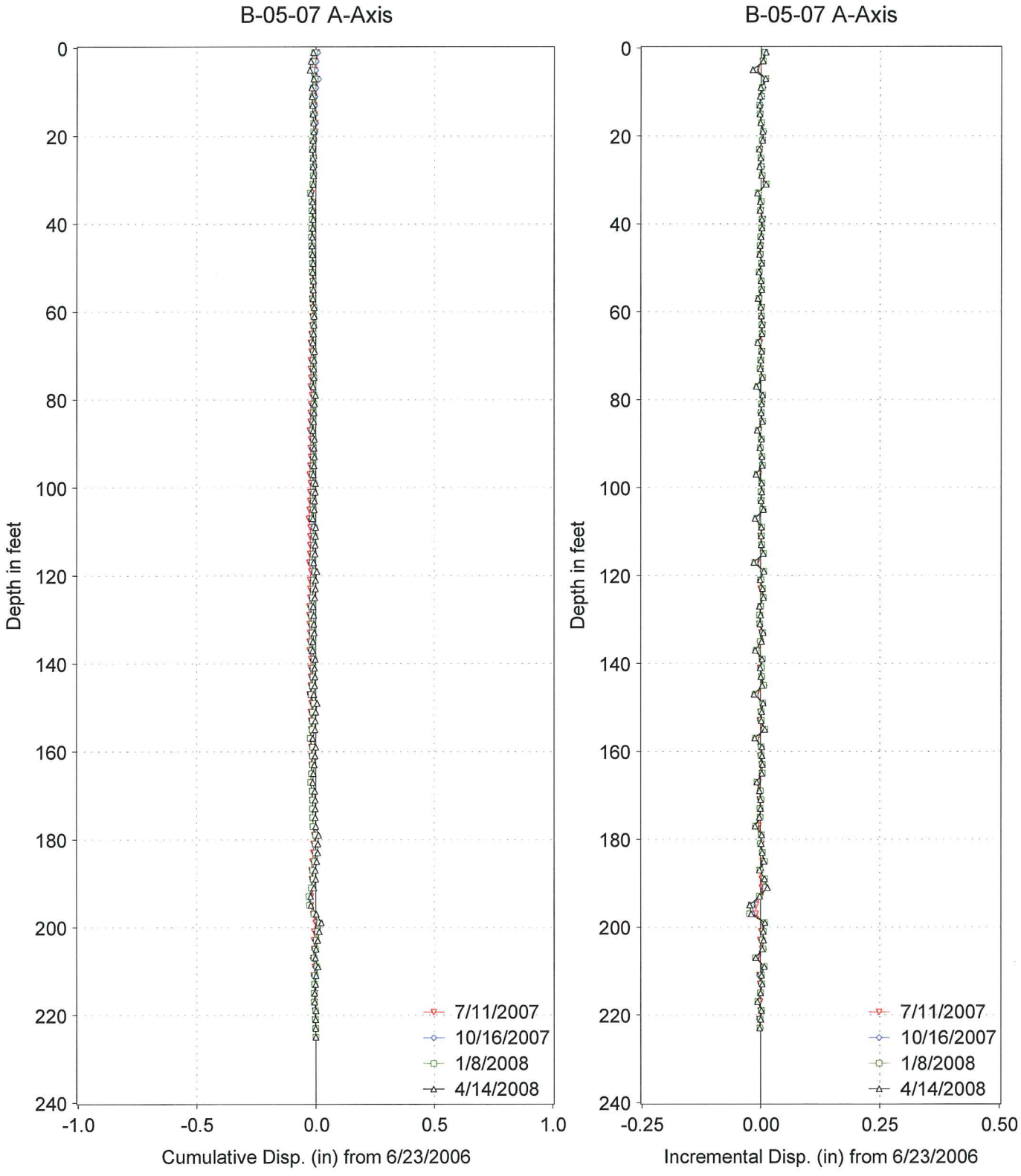
B-05-04
-Includes readings from the last four quarters.

PLATE 34



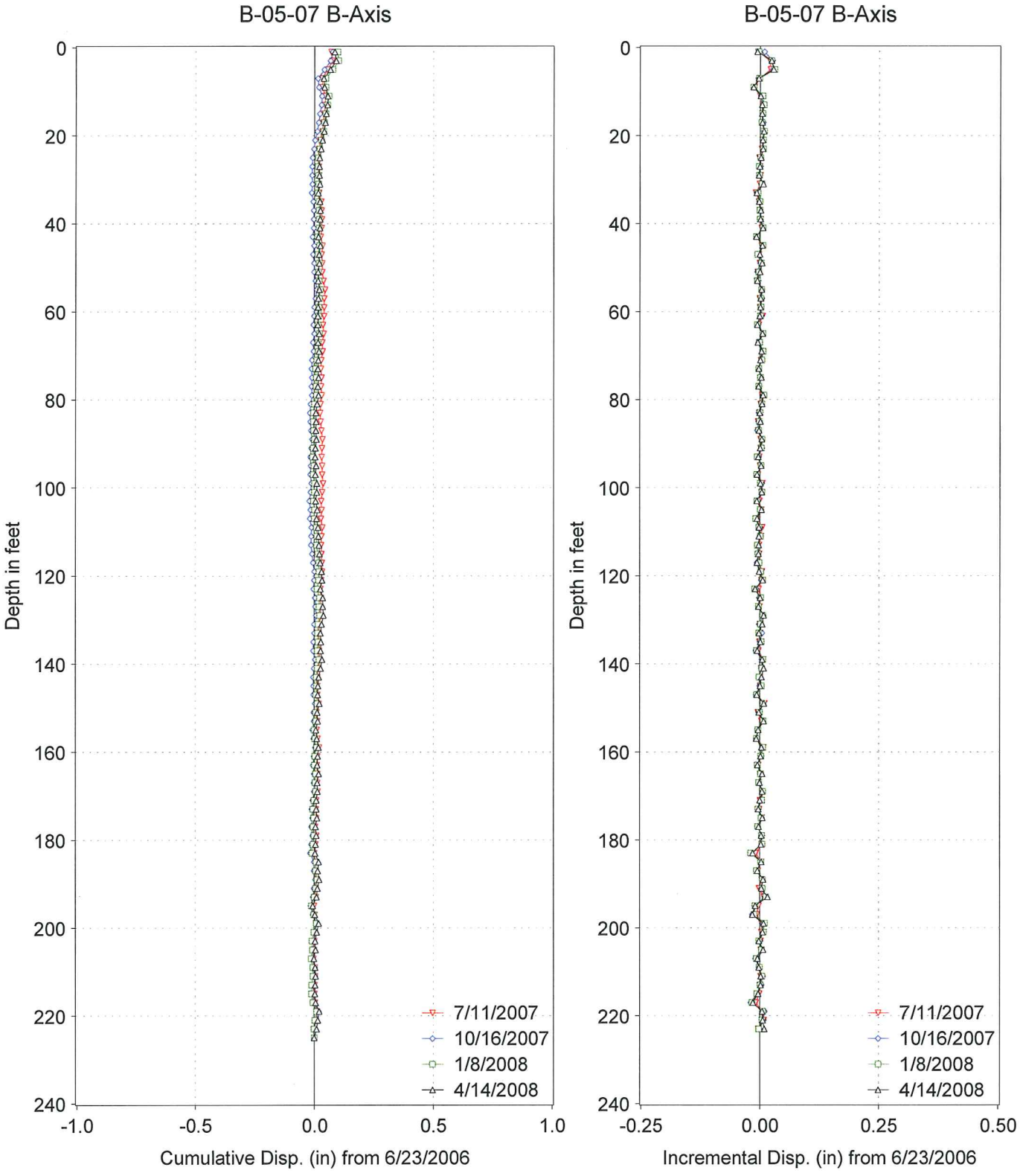
B-05-04
-Includes readings from the last four quarters.

PLATE 35



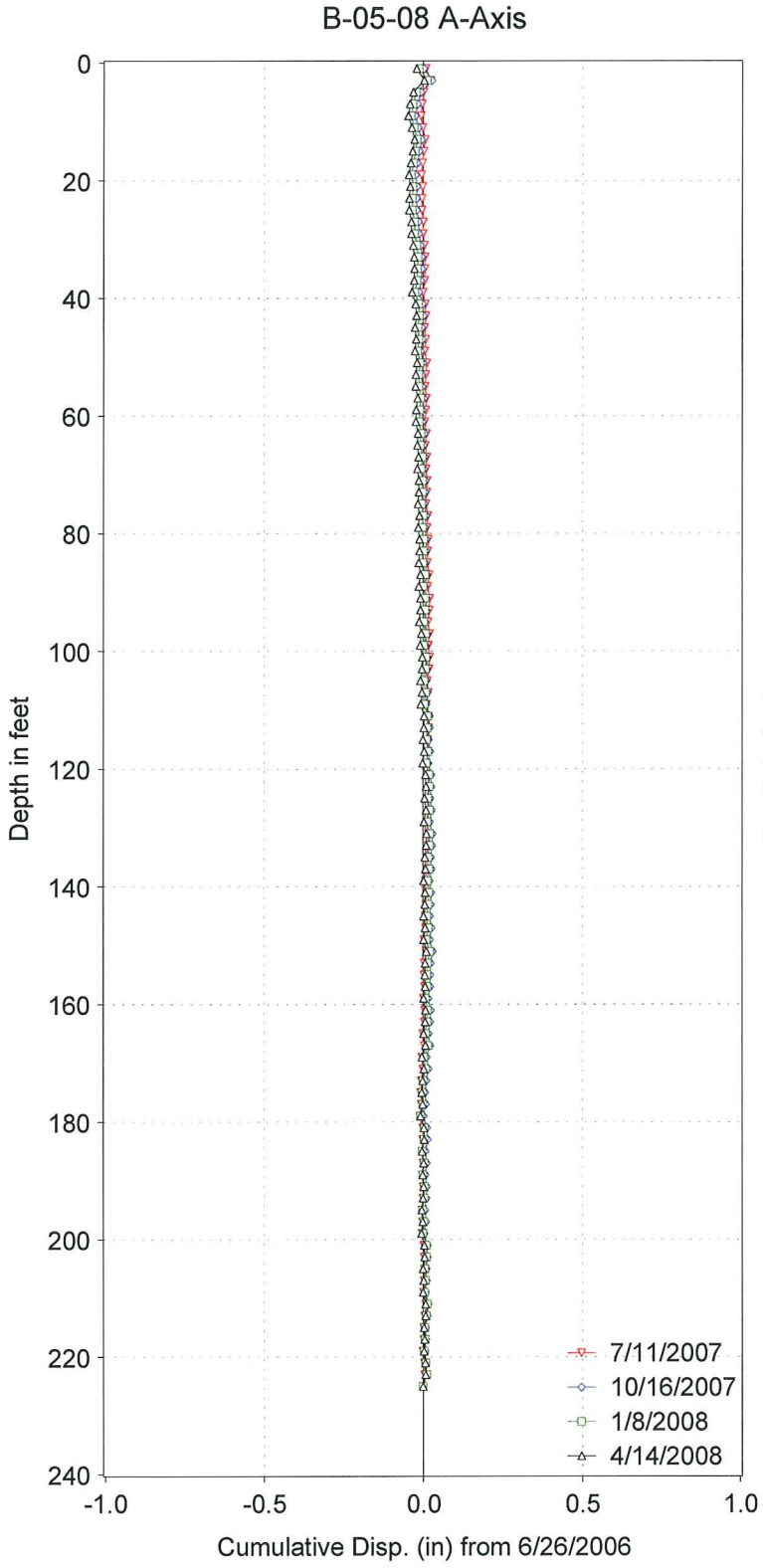
B-05-07
-Includes readings from the last four quarters.

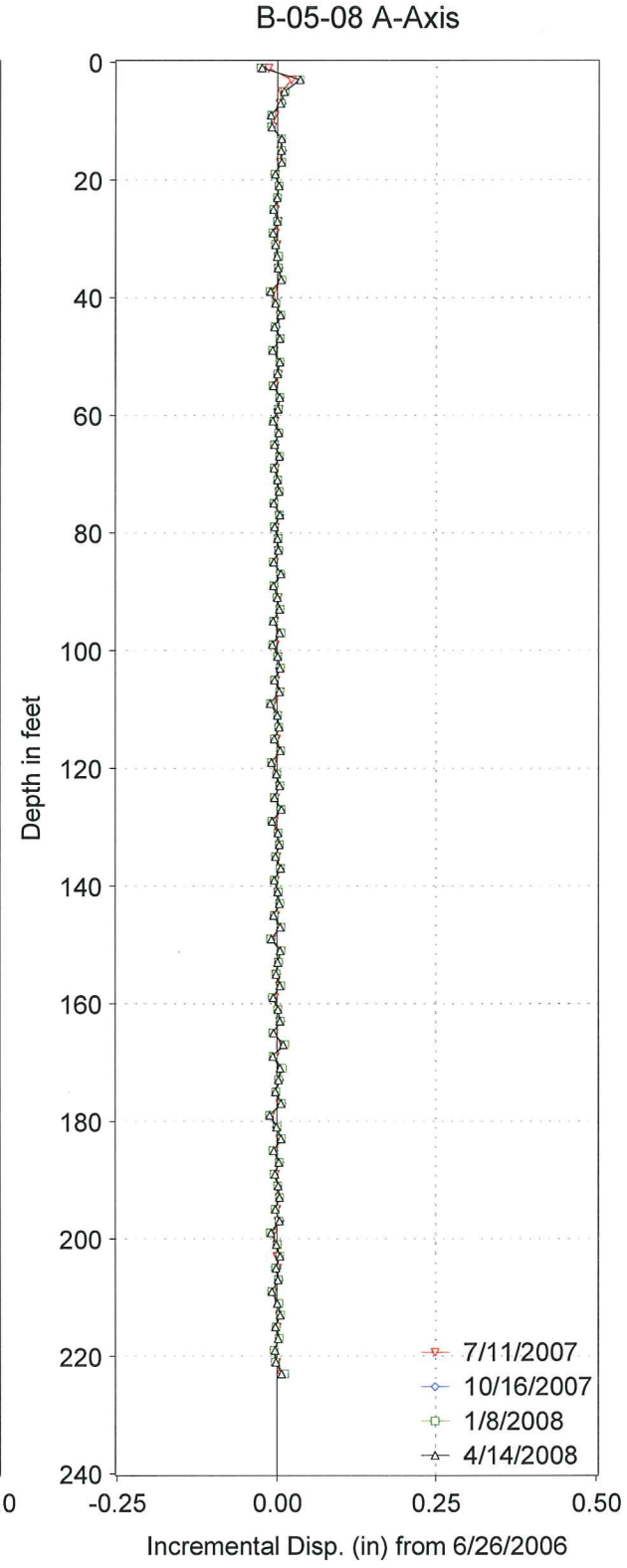
PLATE 36



B-05-07
-Includes readings from the last four quarters.

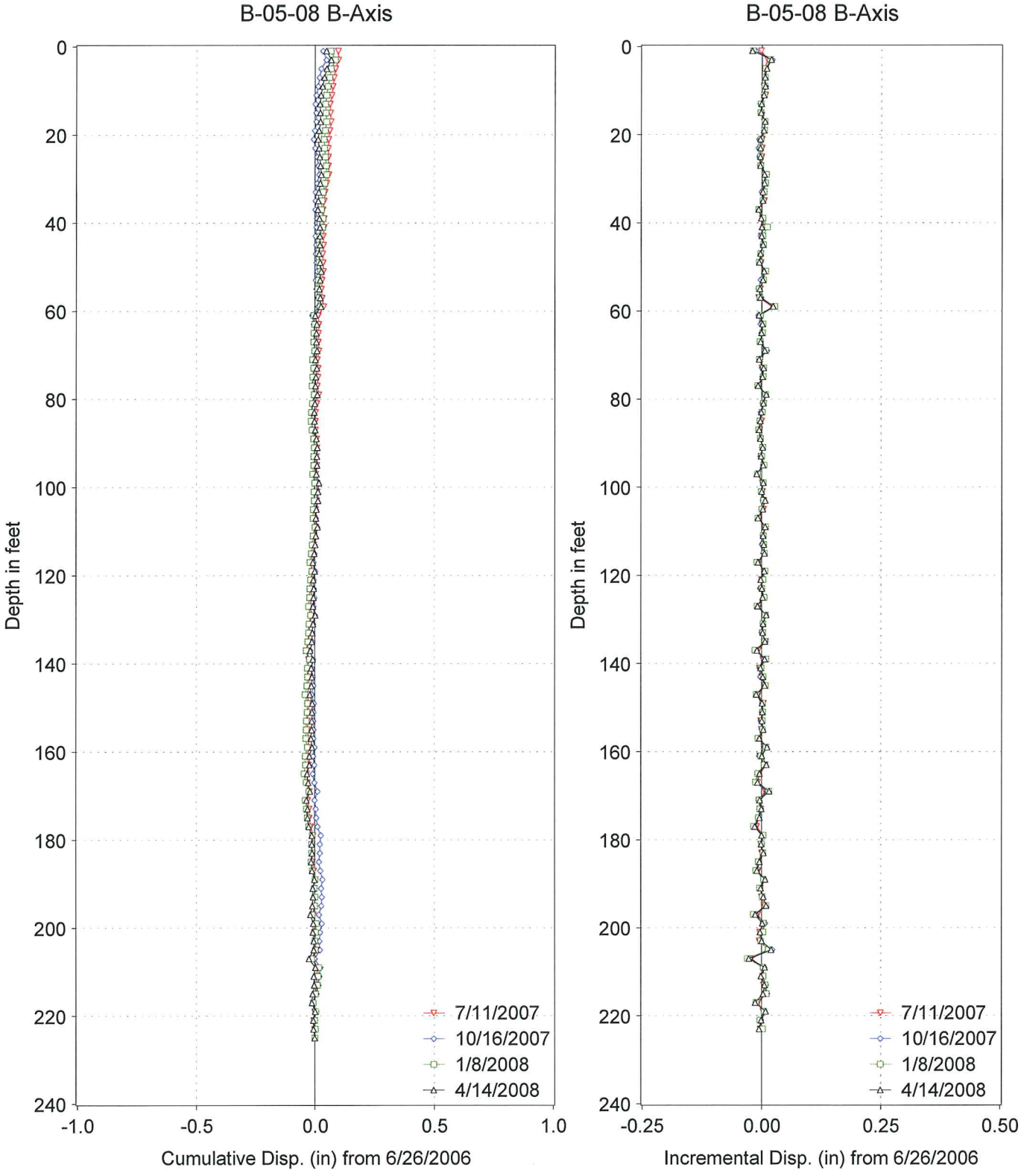
PLATE 37





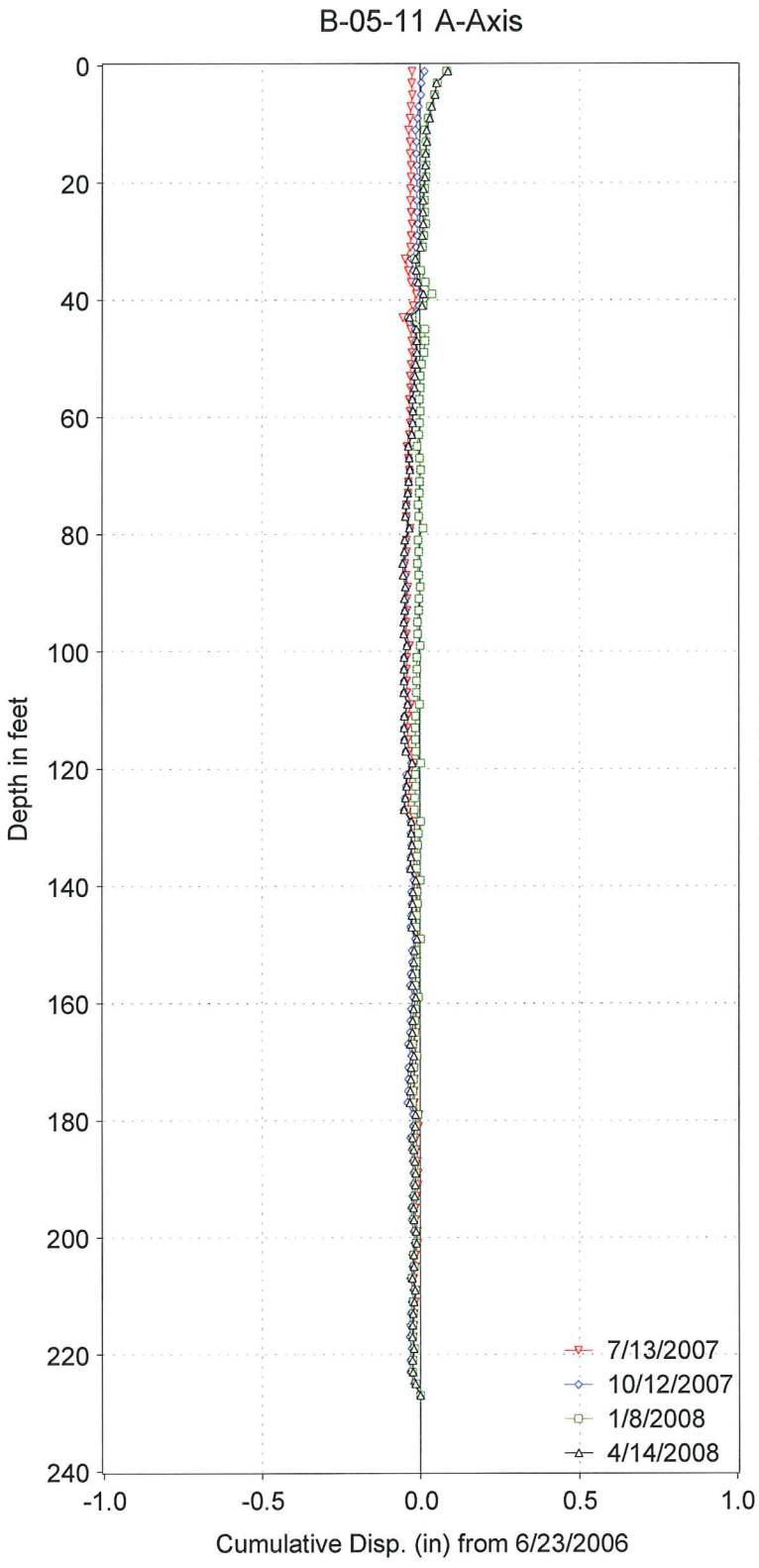
B-05-08
-Includes readings from the last four quarters.

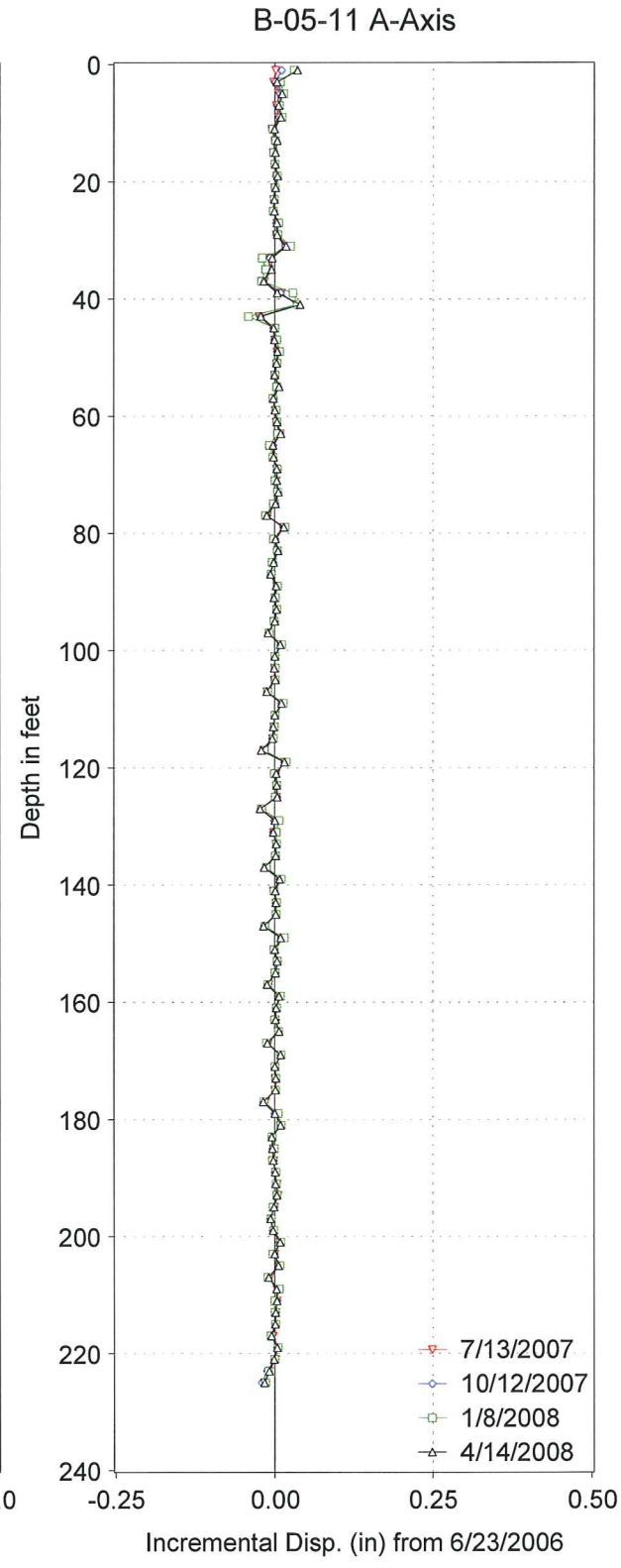
PLATE 38



B-05-08
-Includes readings from the last four quarters.

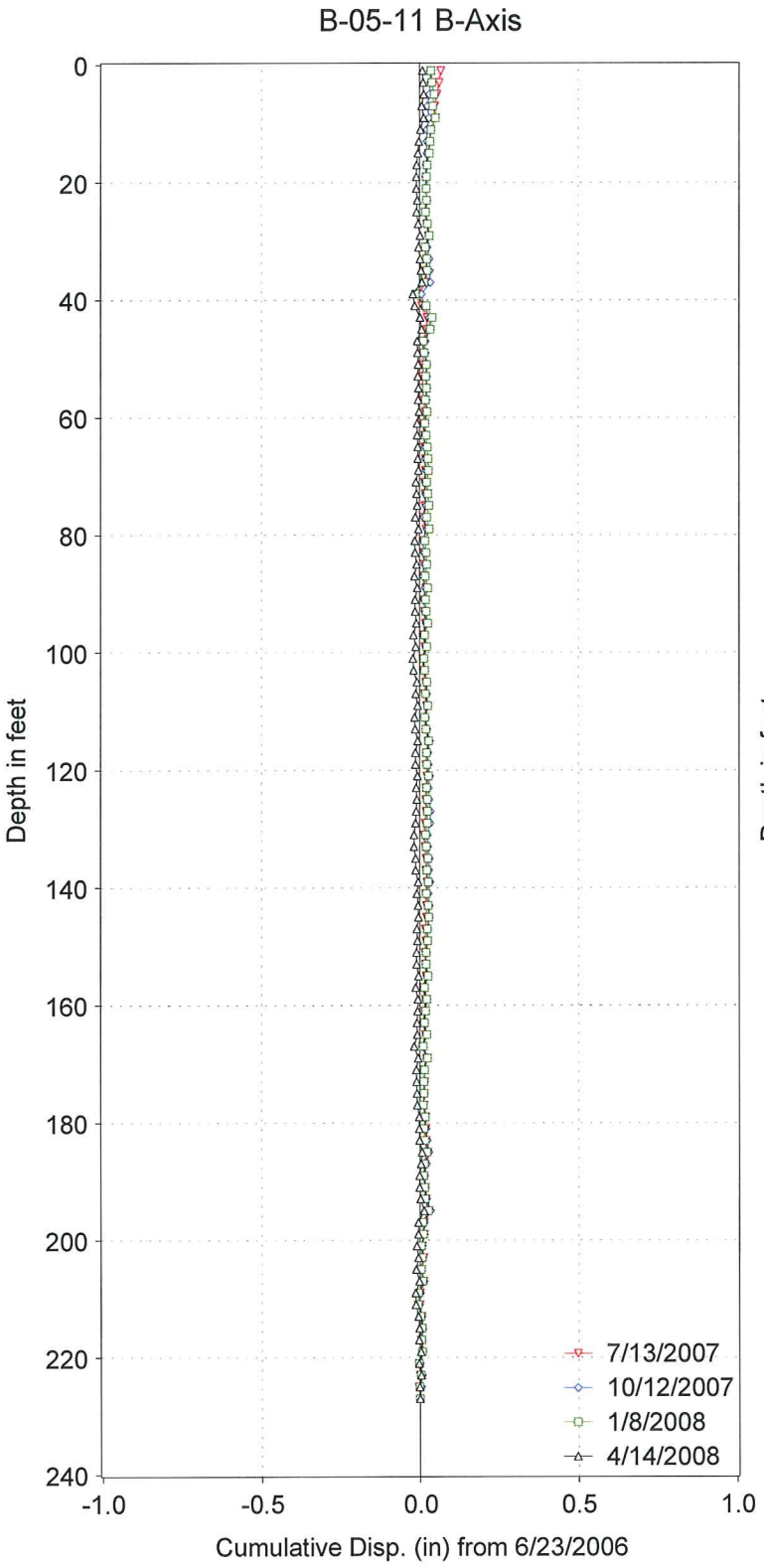
PLATE 39

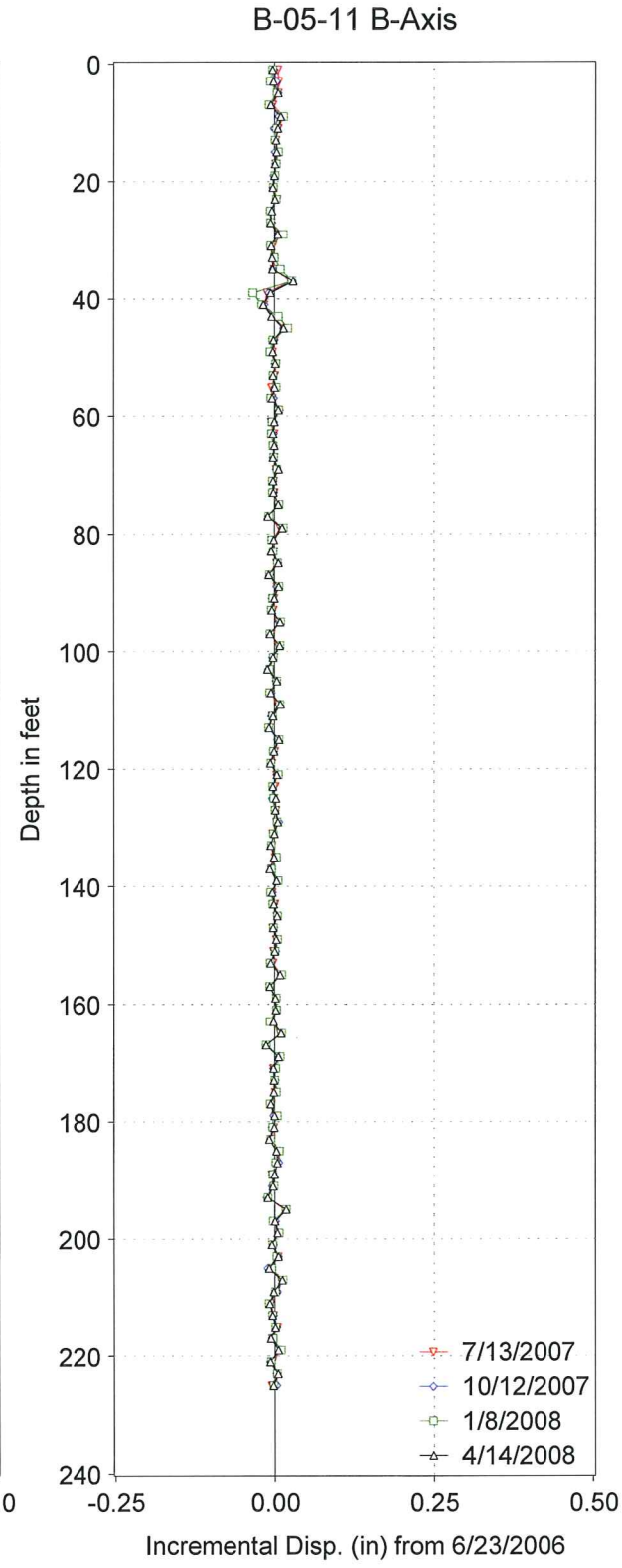




B-05-11
-Includes readings from the last four quarters.

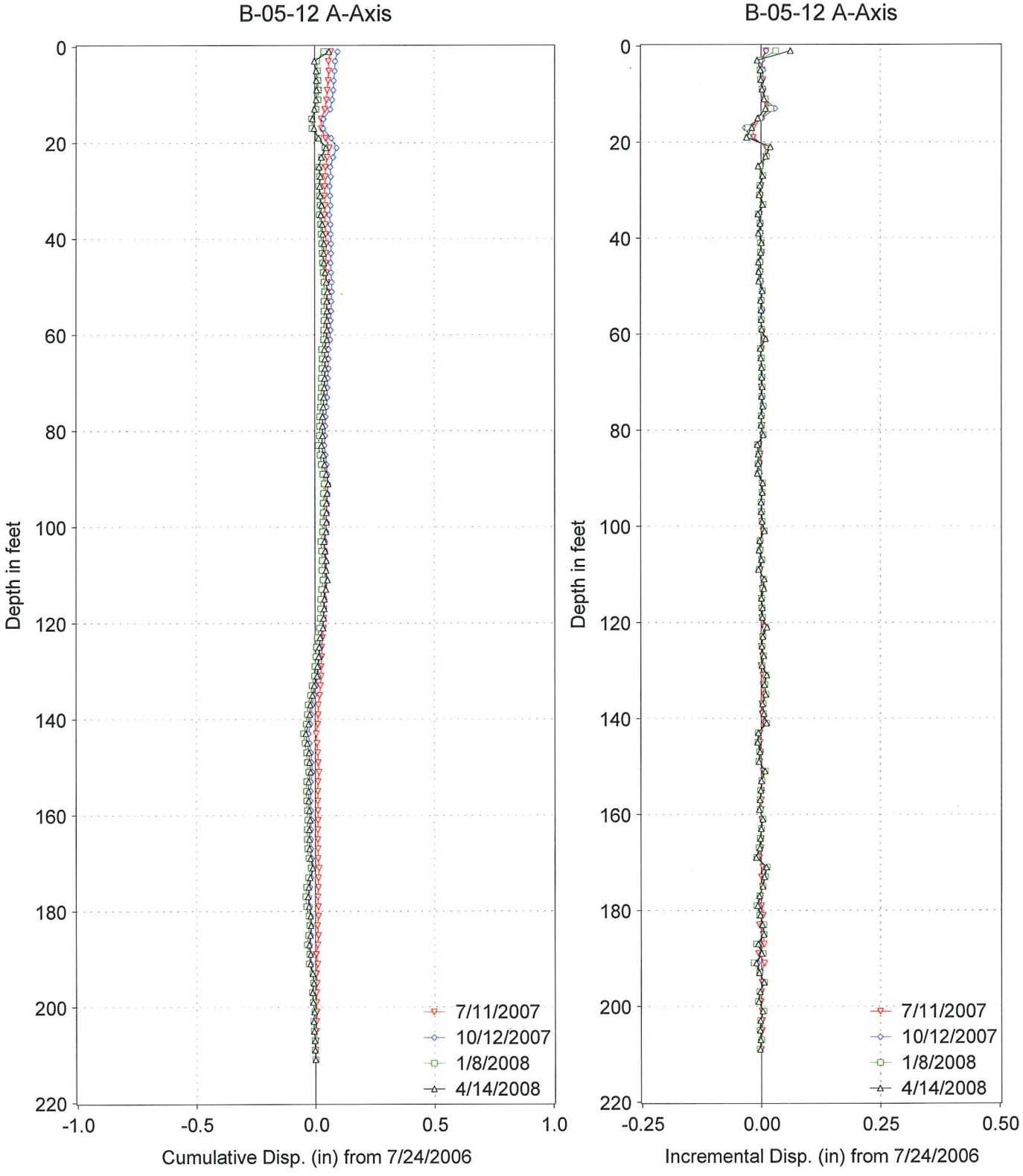
PLATE 40





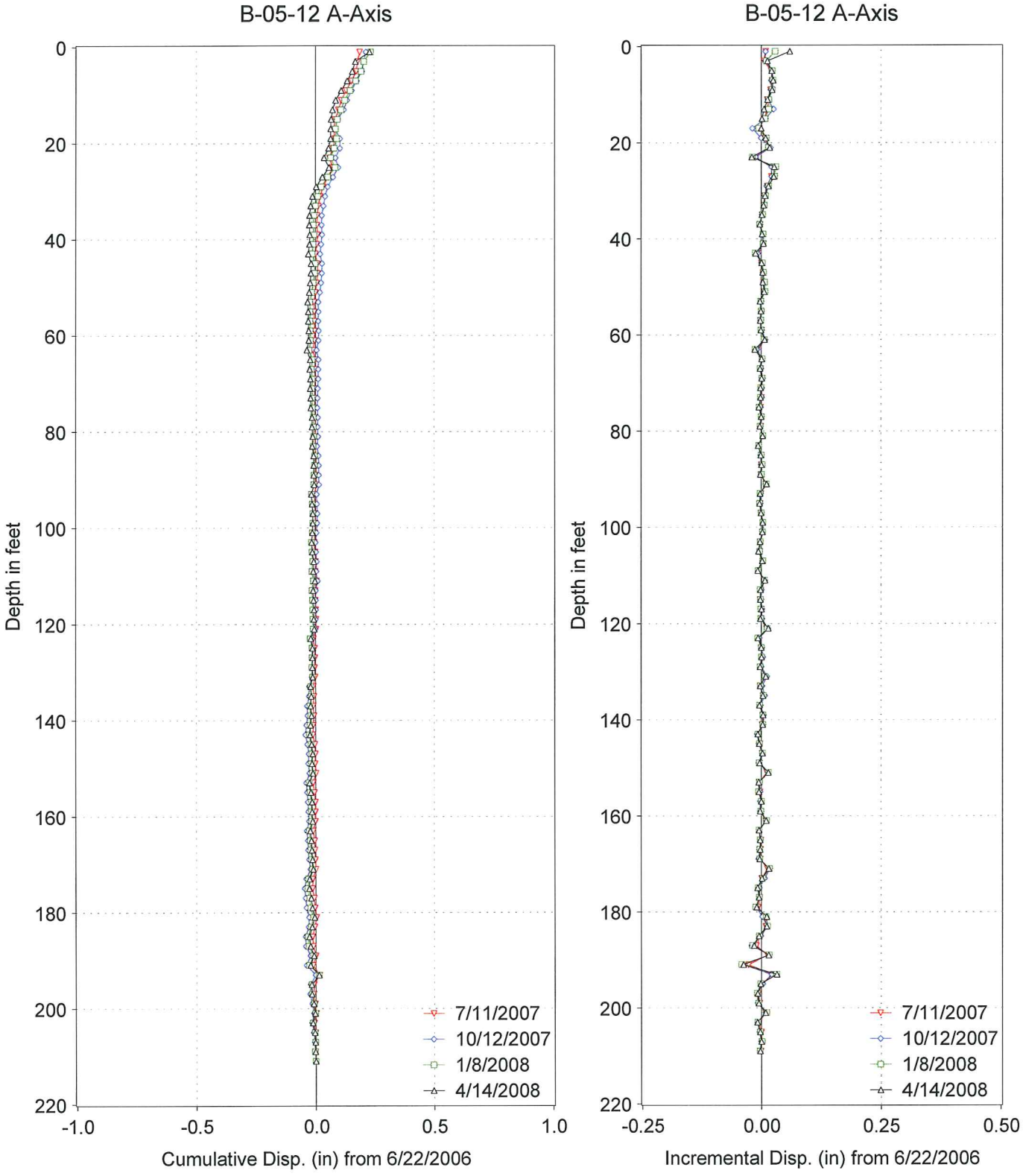
B-05-11
-Includes readings from the last four quarters.

PLATE 41



B-05-12
-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

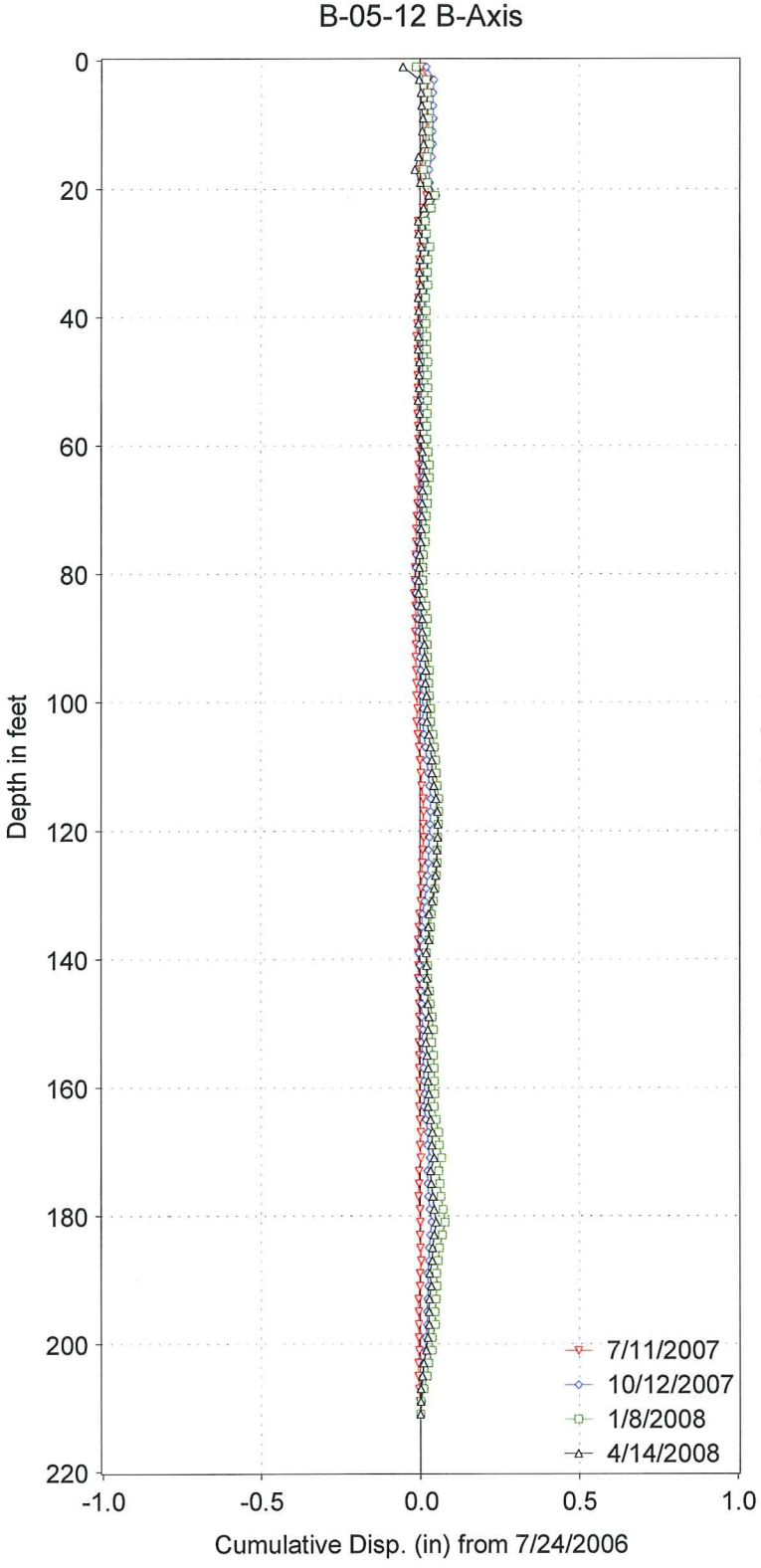
PLATE 42

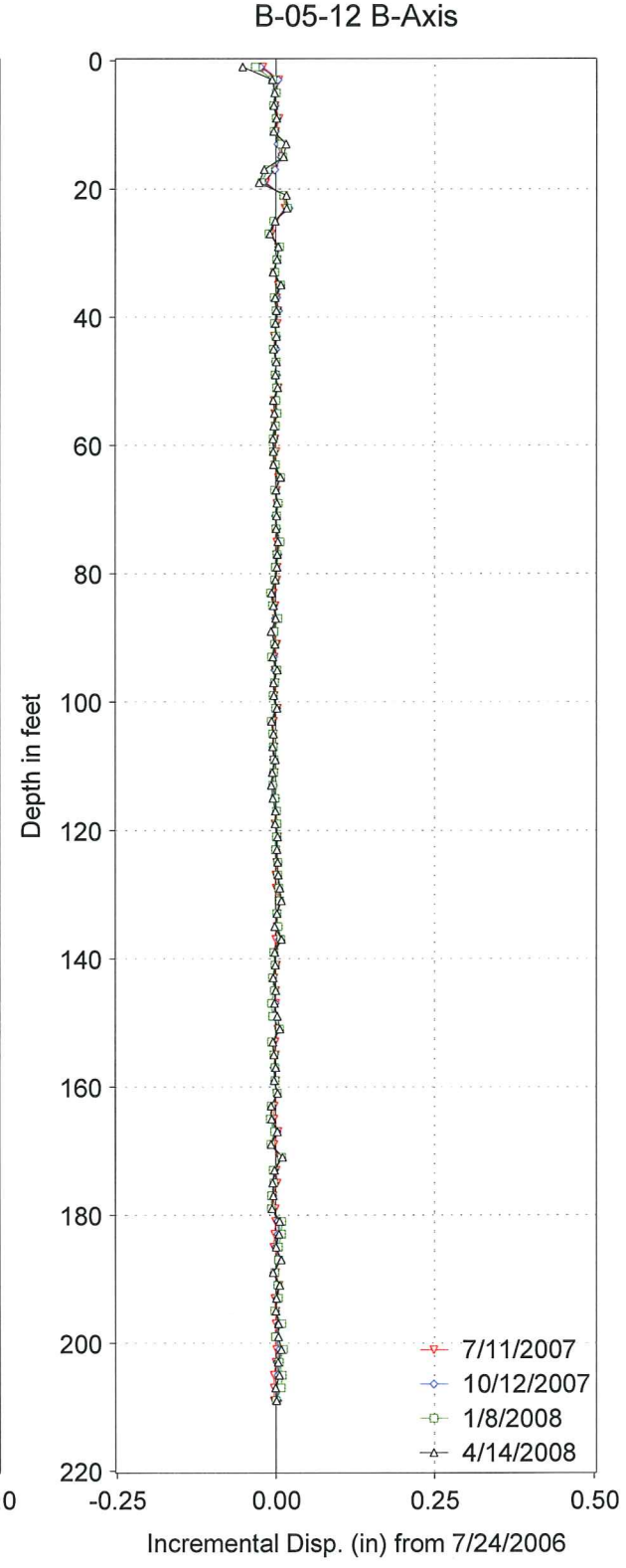


B-05-12

-Data presented using the initial (baseline) reading from June 2006.

PLATE 42A

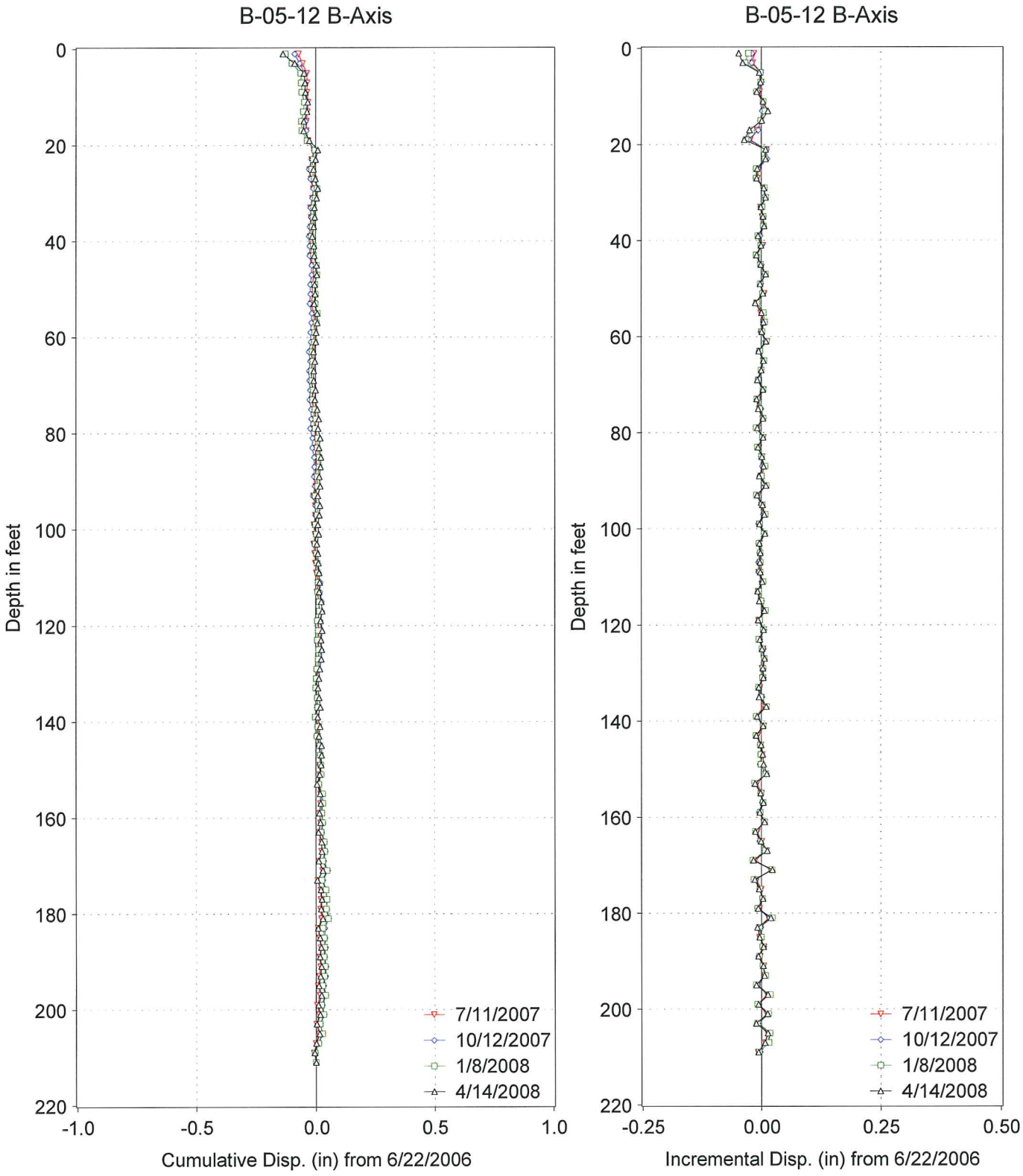




B-05-12

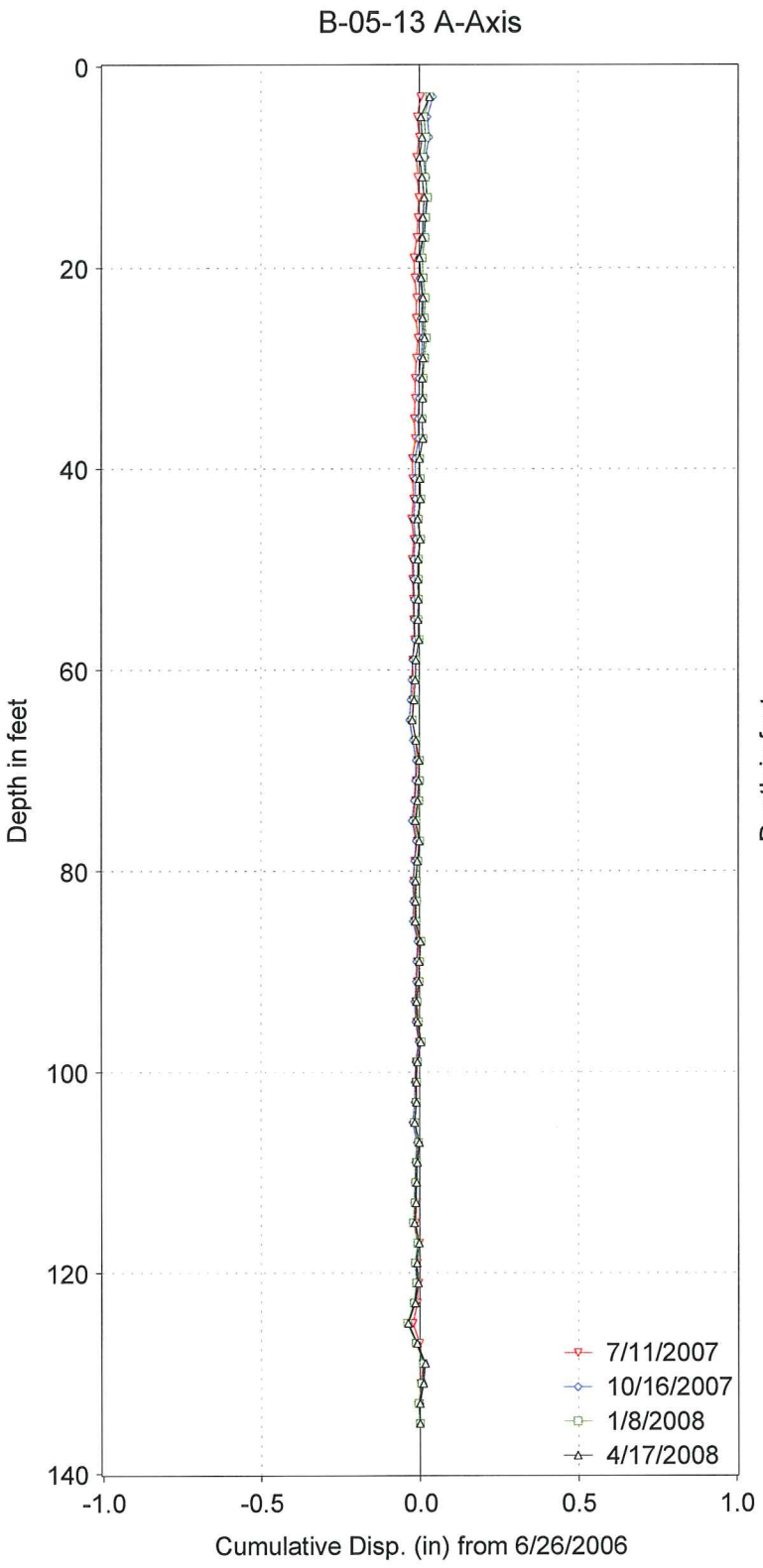
-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

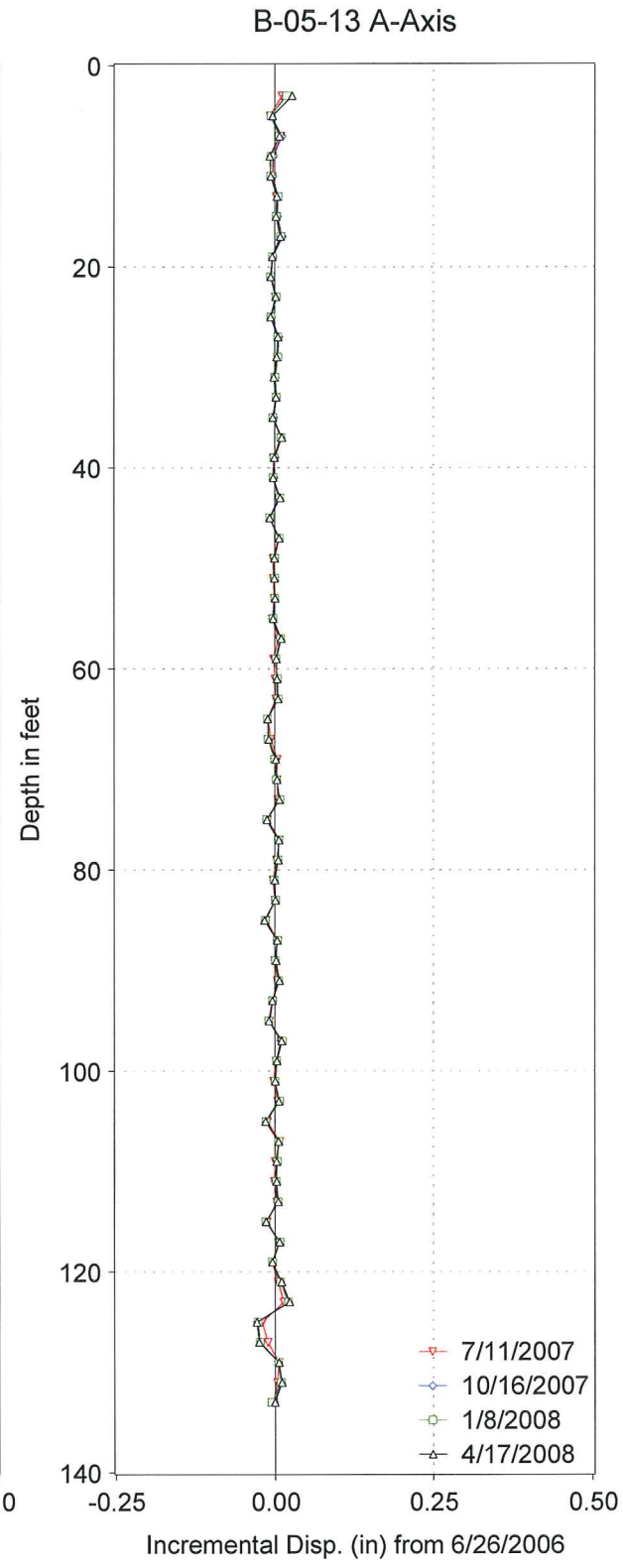
PLATE 43



B-05-12
-Data presented using the initial (baseline) reading from June 2006.

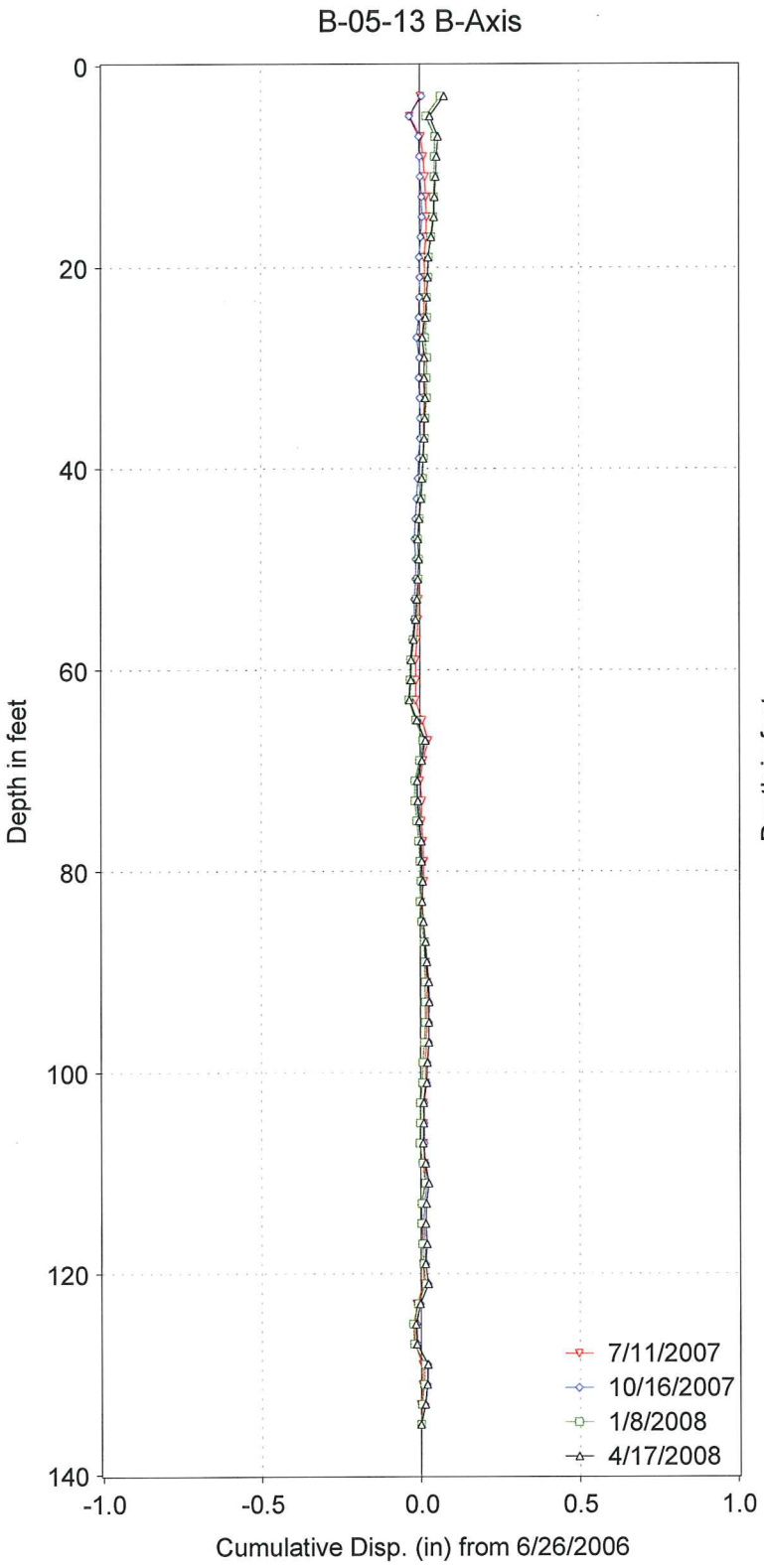
PLATE 43A

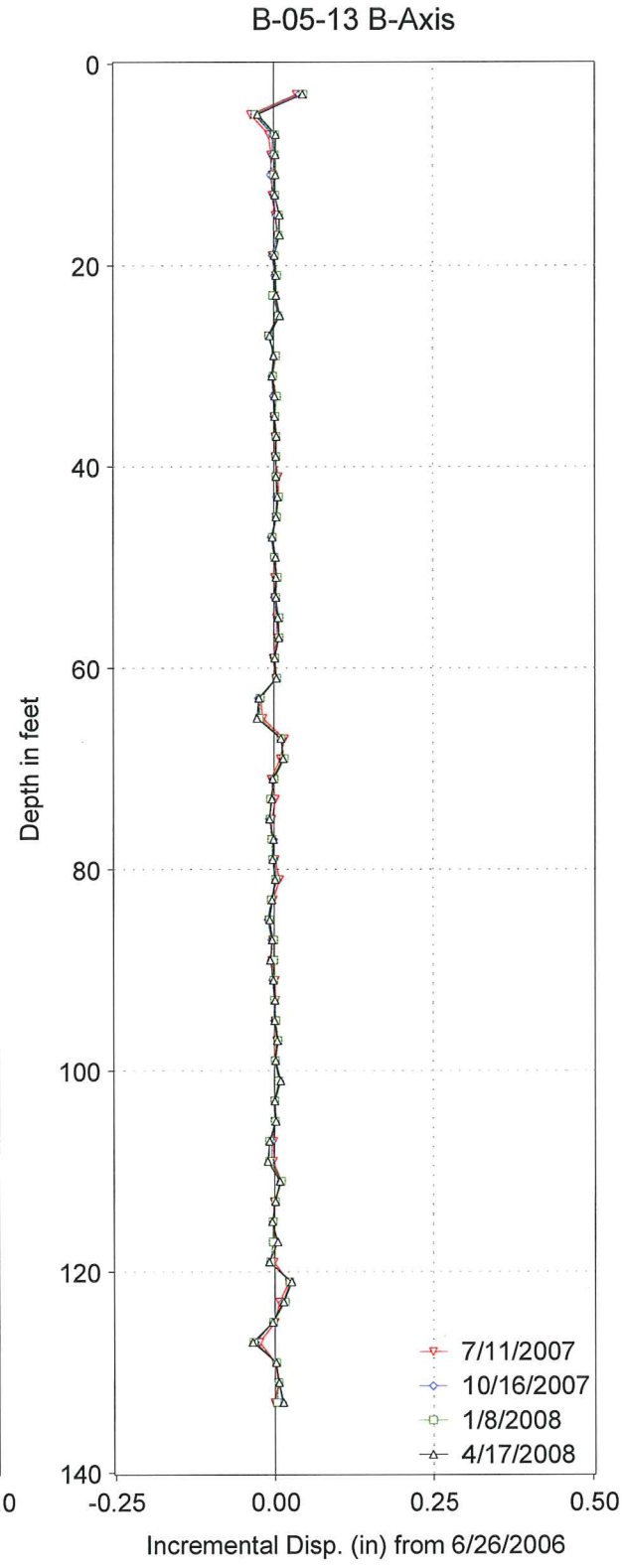




B-05-13
-Includes readings from the last four quarters.

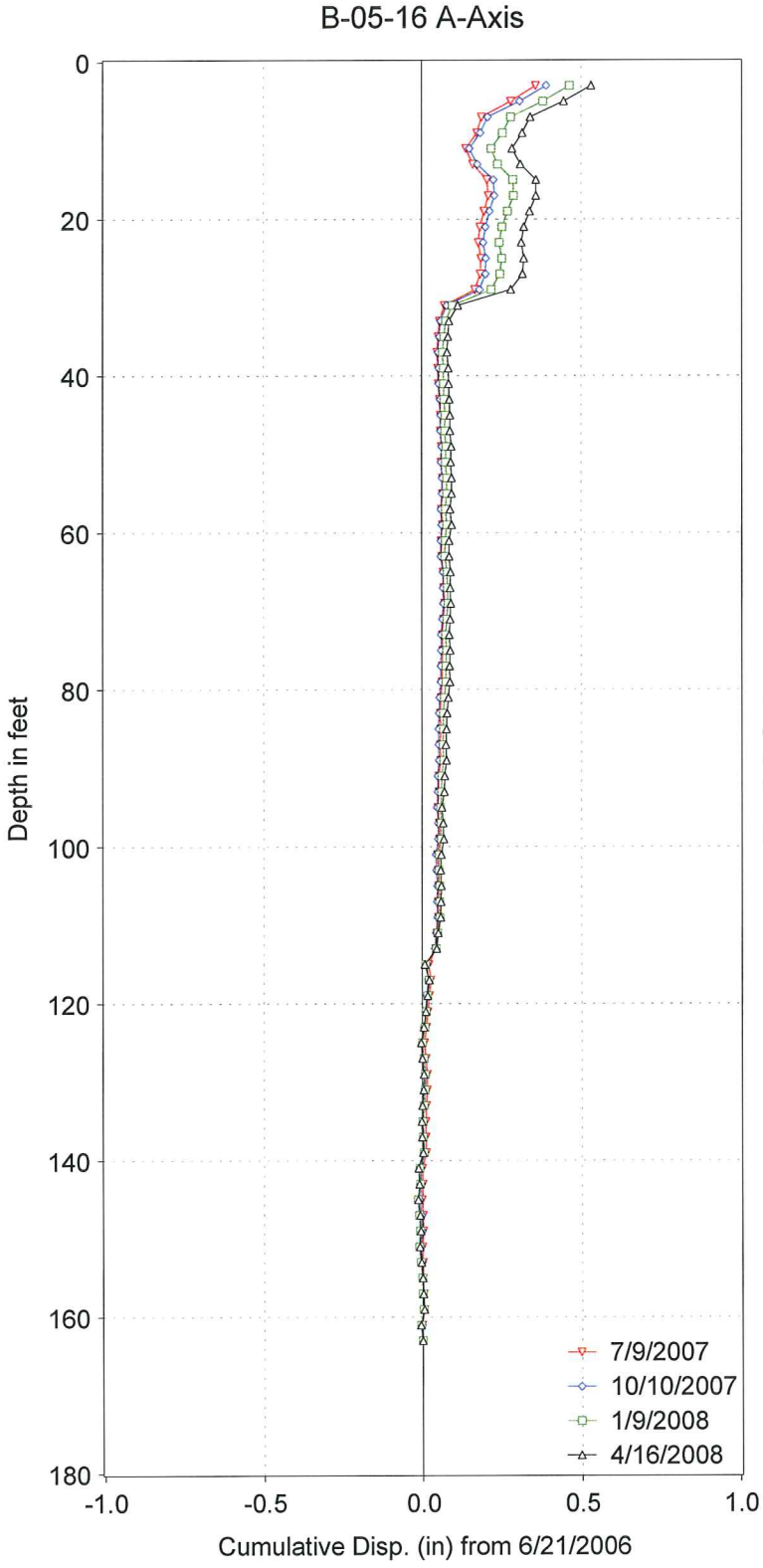
PLATE 44

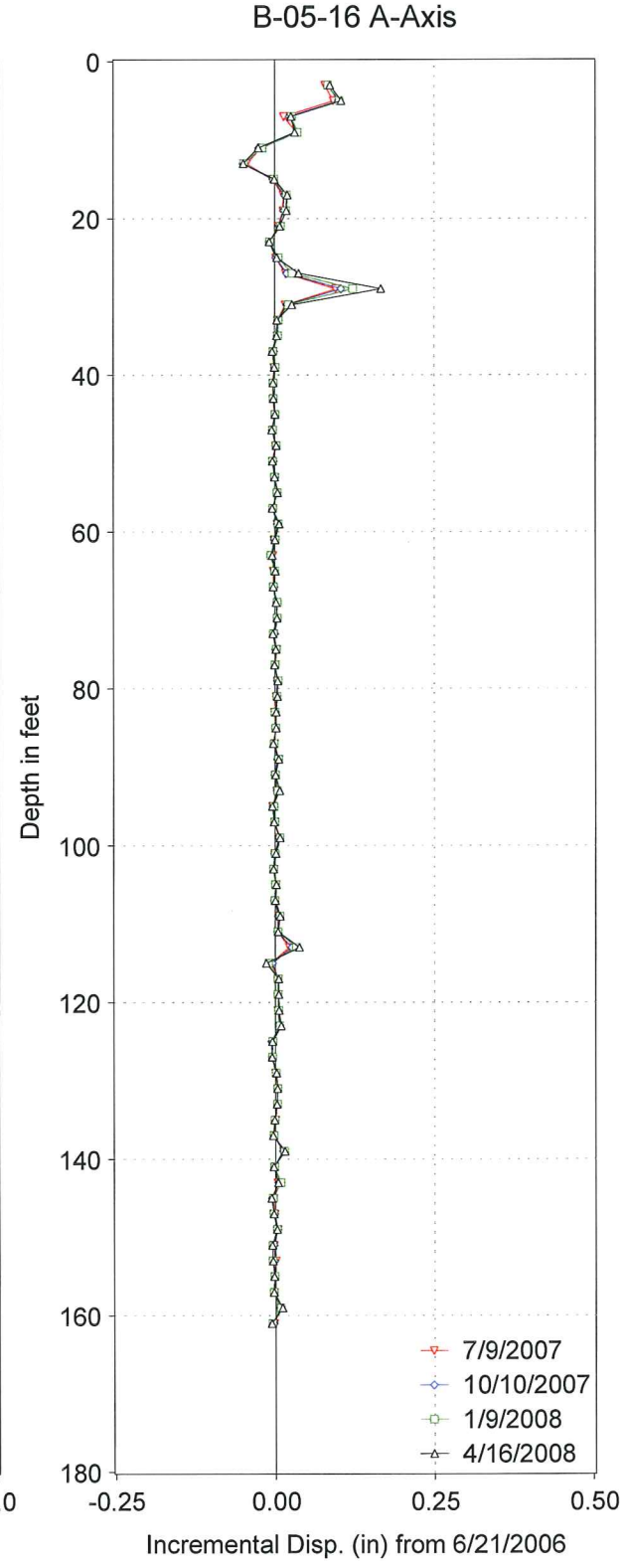




B-05-13
-Includes readings from the last four quarters.

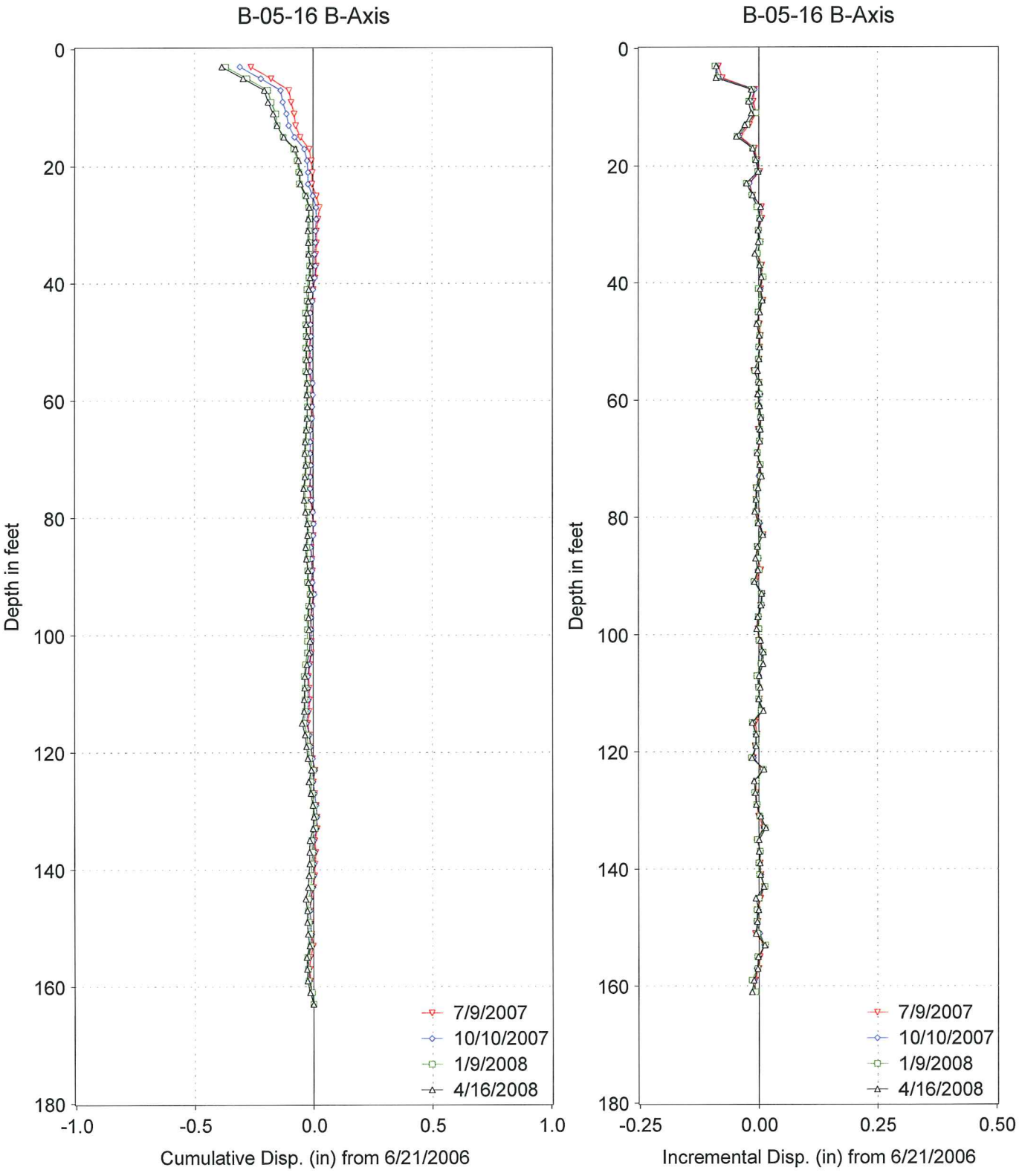
PLATE 45





B-05-16
-Includes readings from the last four quarters.

PLATE 46



B-05-16
-Includes readings from the last four quarters.

PLATE 47

B-05-03 Time-Displacement A-Axis

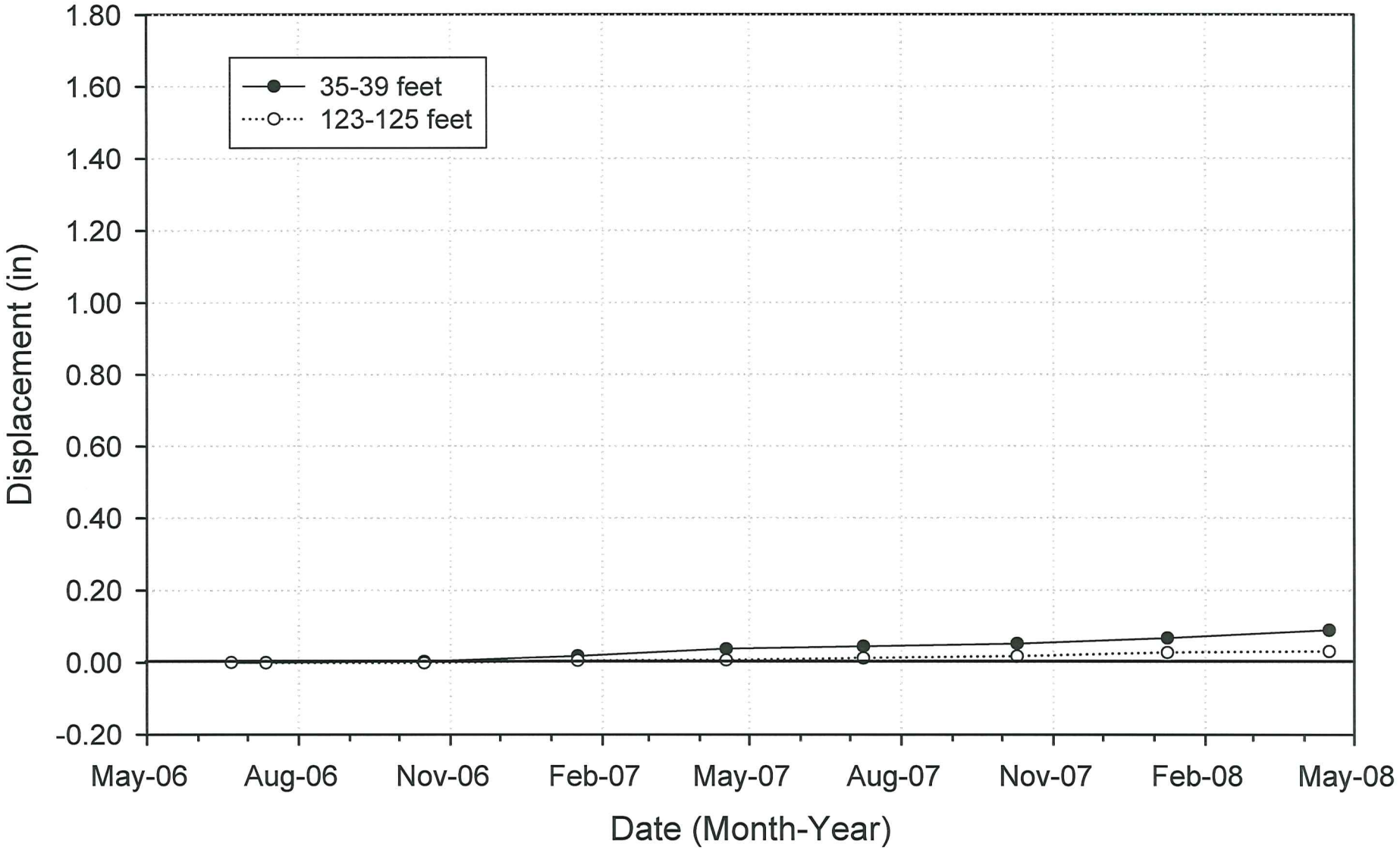


PLATE 48

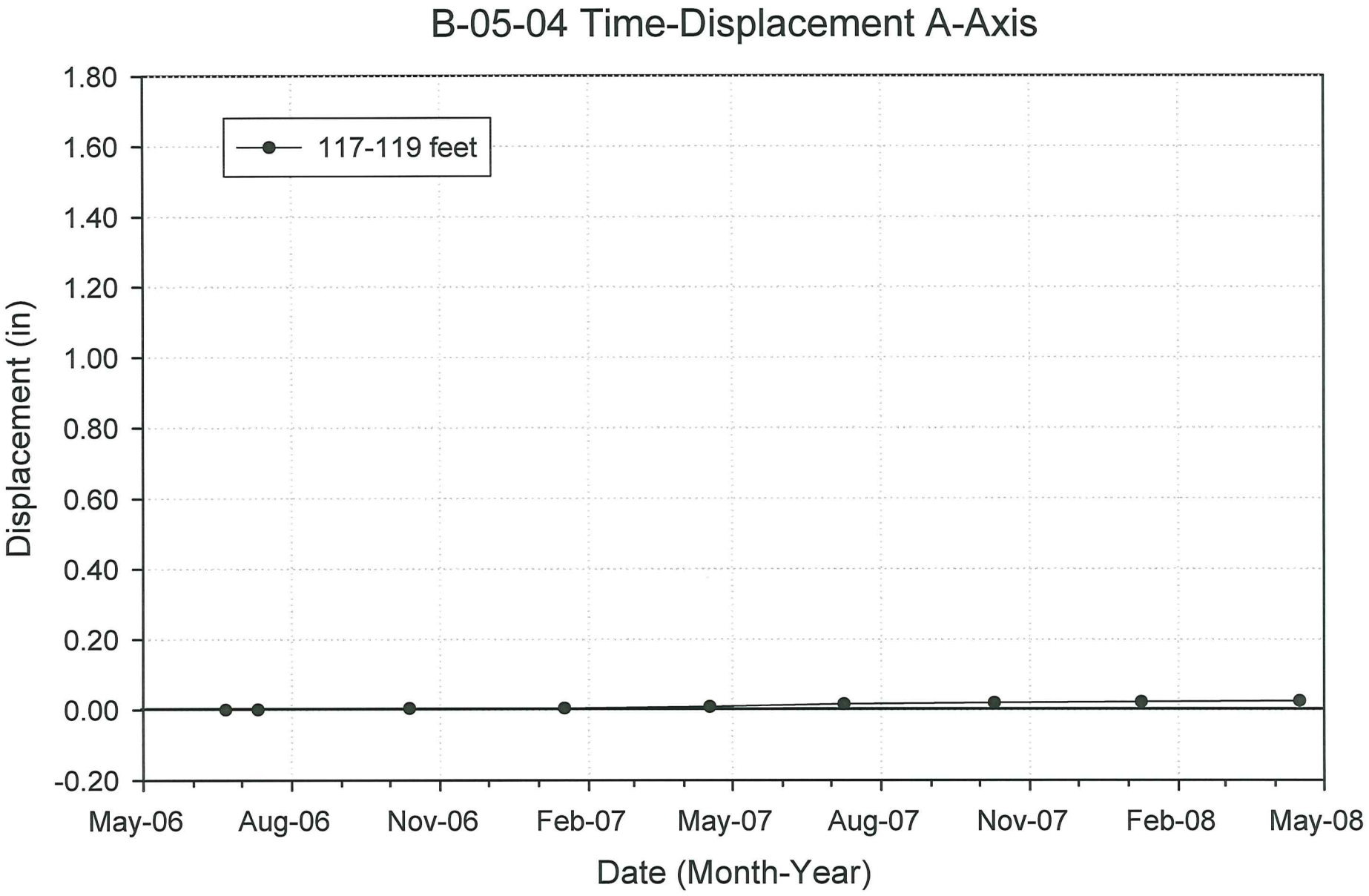

B-05-04 Time-Displacement A-Axis
117-119 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Aug-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
May-08
Date (Month-Year)

PLATE 49

B-05-16 Time-Displacement A-Axis

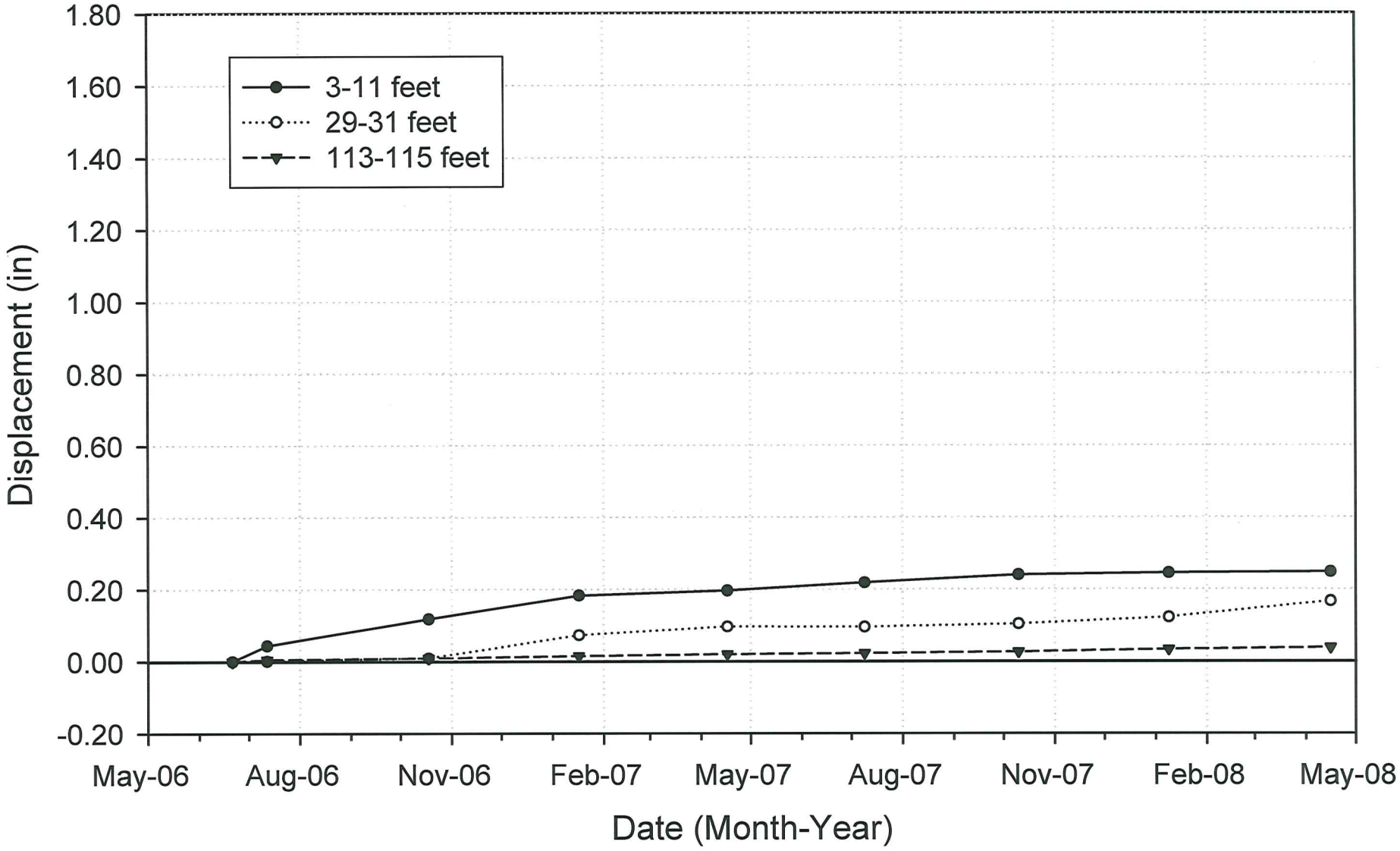


PLATE 50

B-101 (P-1) Pneumatic Piezometer Readings

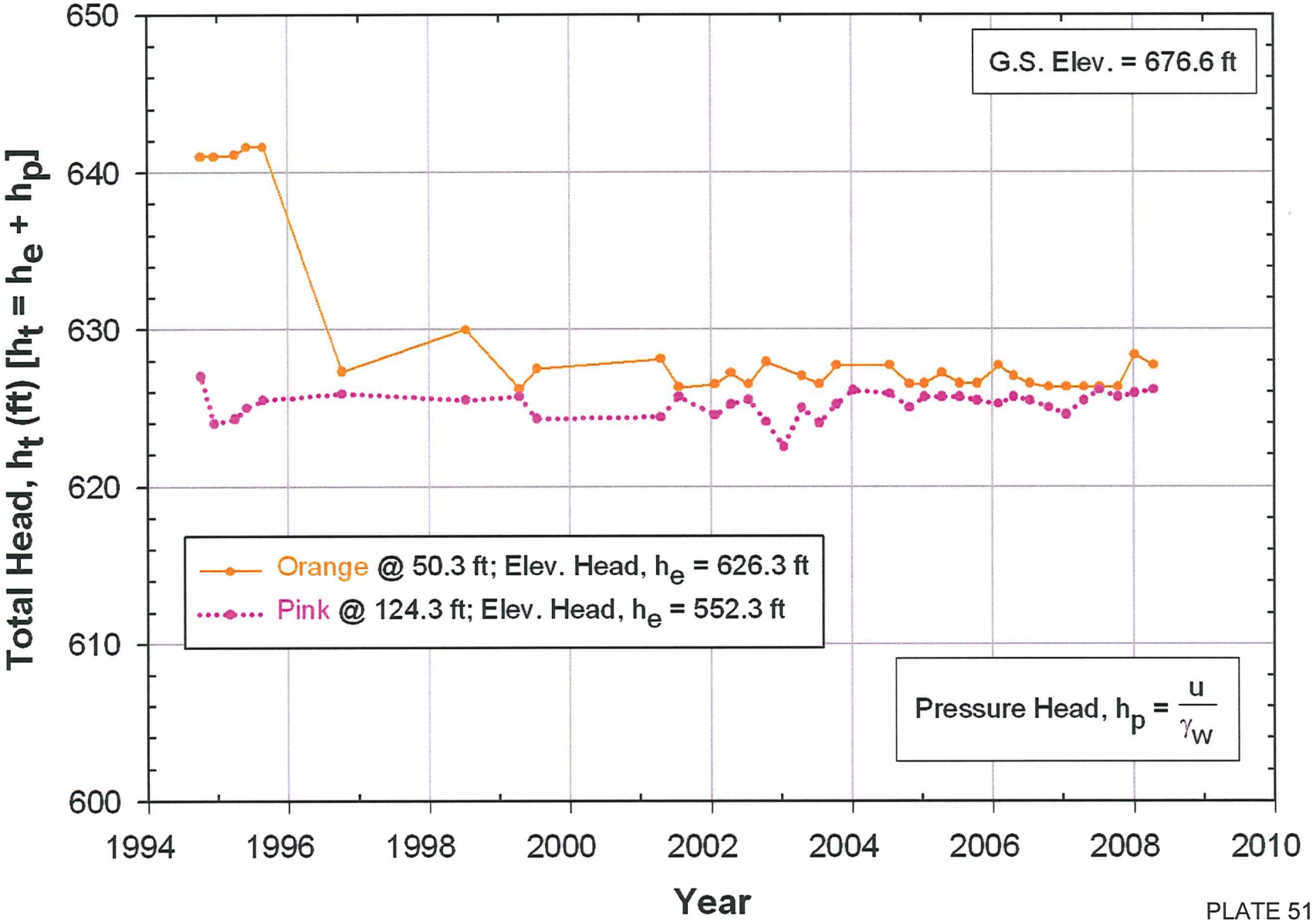


PLATE 51

B-105 (P-3) Pneumatic Piezometer Readings

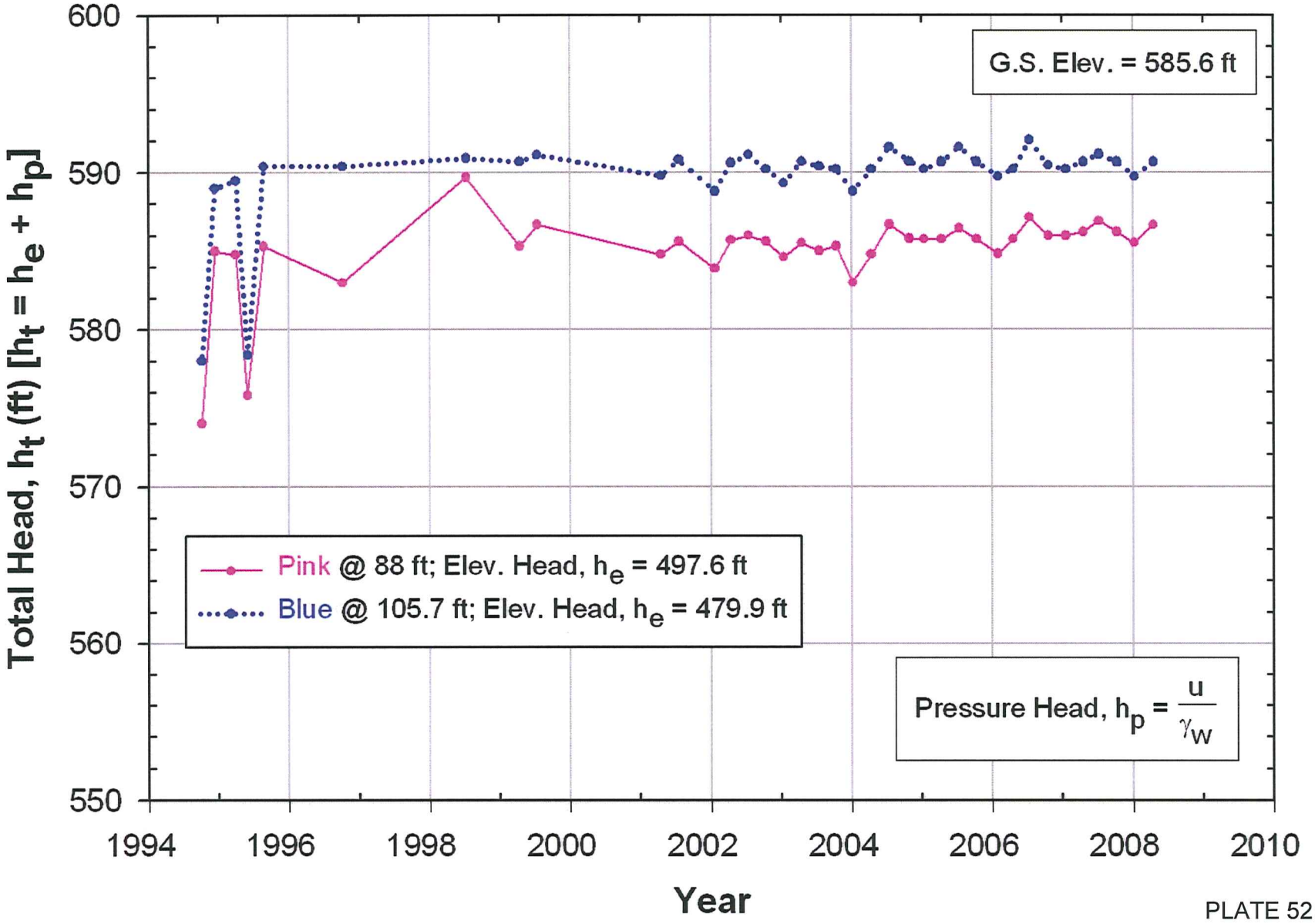


PLATE 52

B-107 (P-5) Pneumatic Piezometer Readings

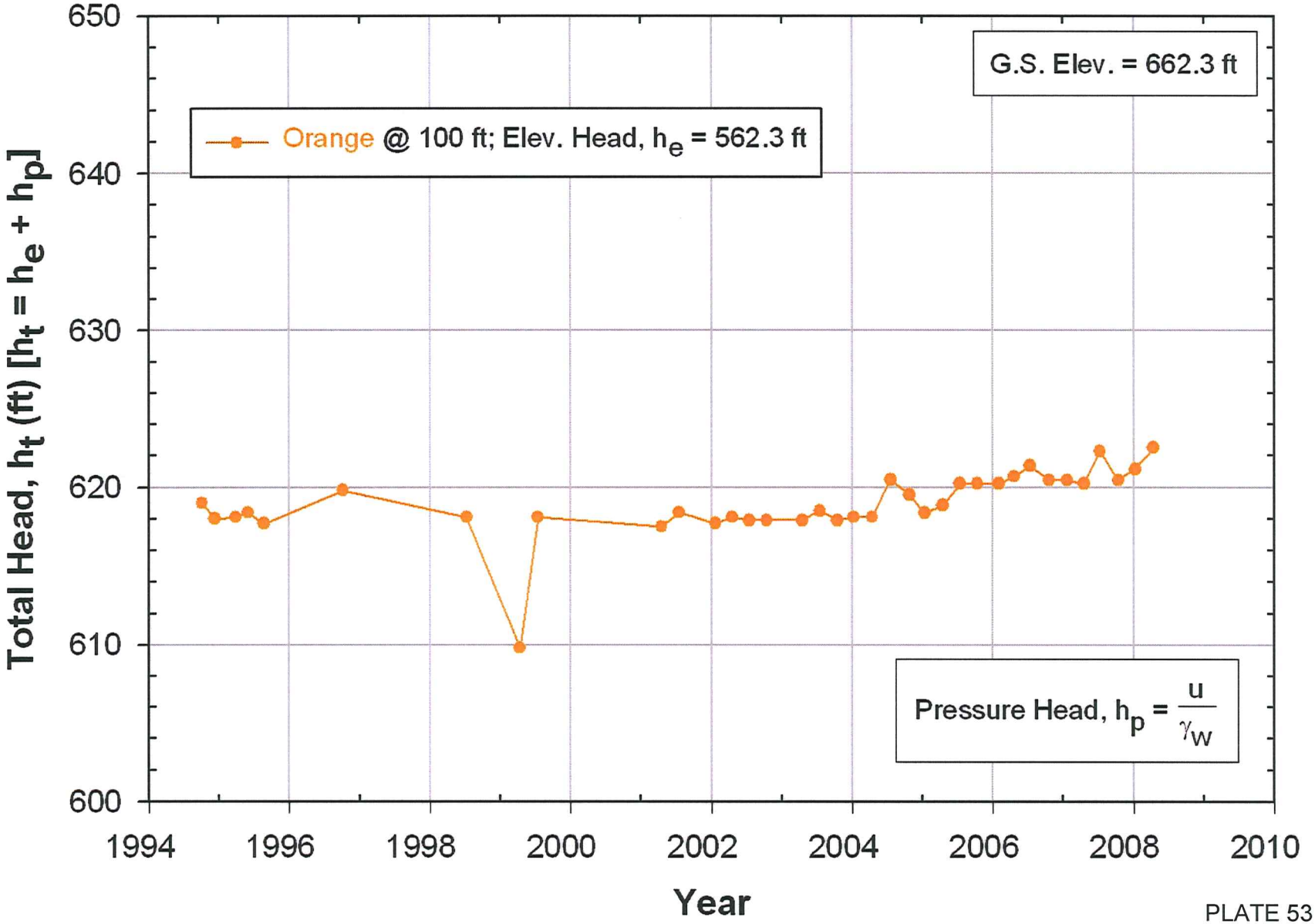


PLATE 53

B-303 (P-2) Pneumatic Piezometer Readings

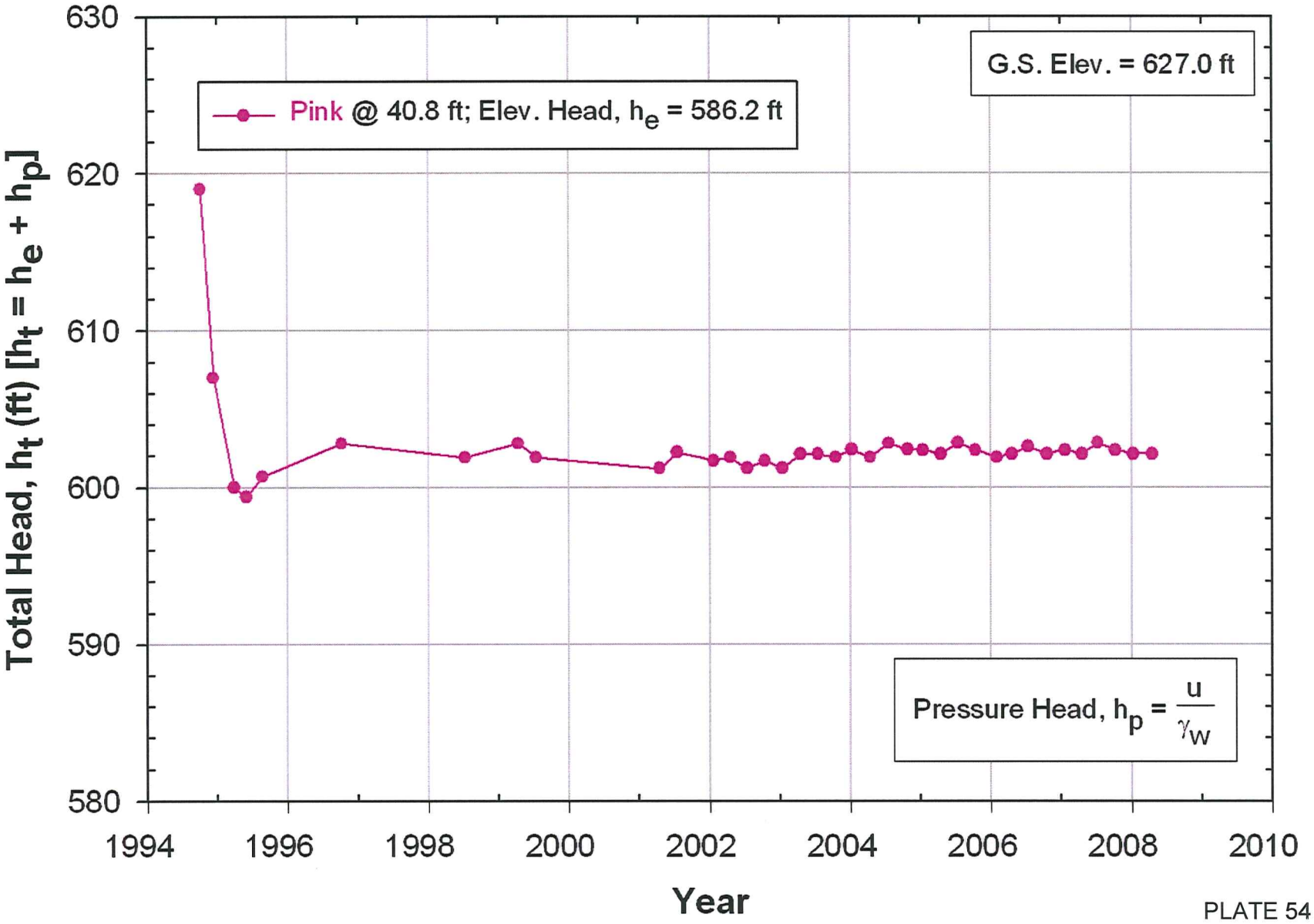


PLATE 54

B-05-01 VW Piezometer Readings

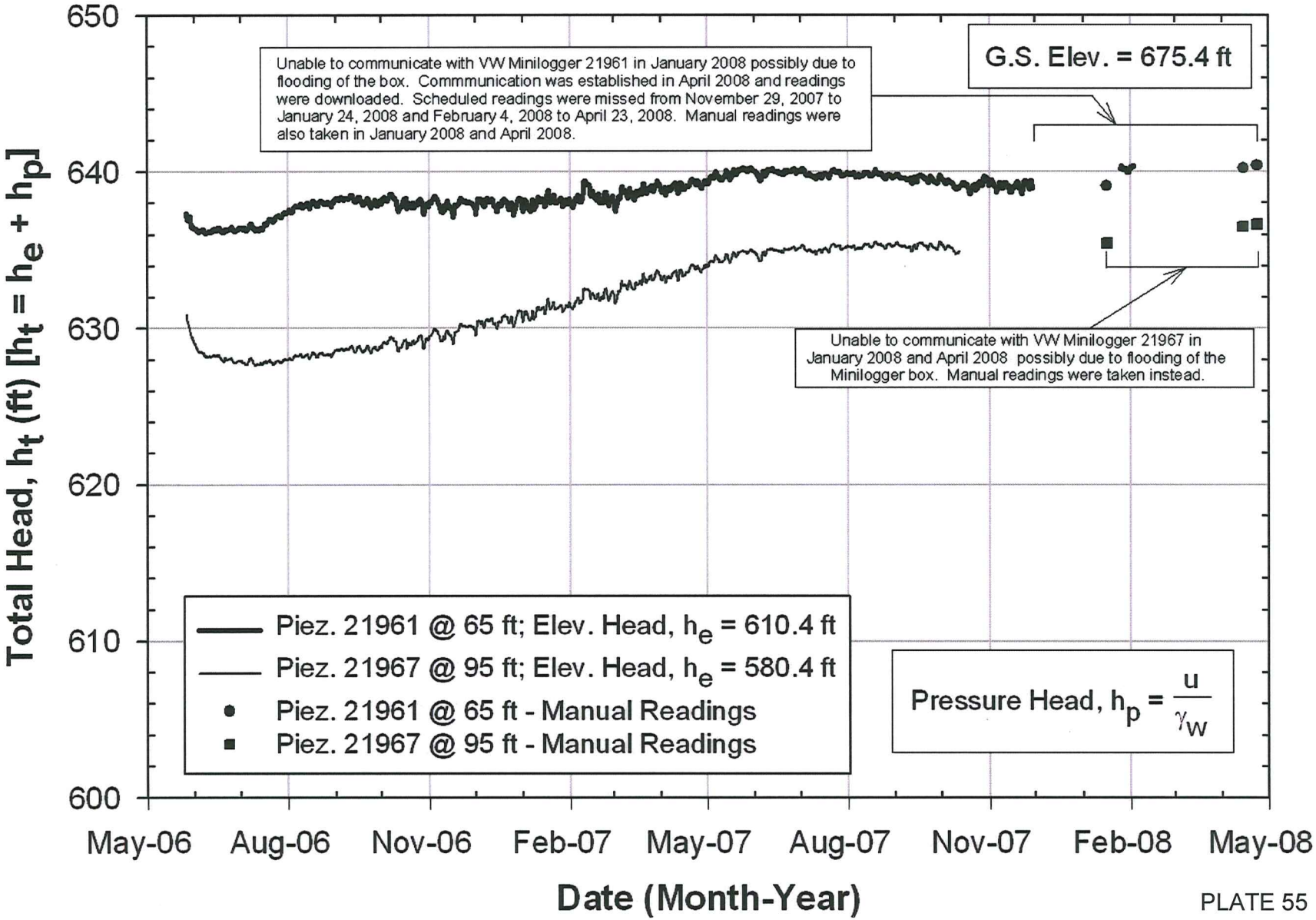


PLATE 55

B-05-02 VW Piezometer Readings

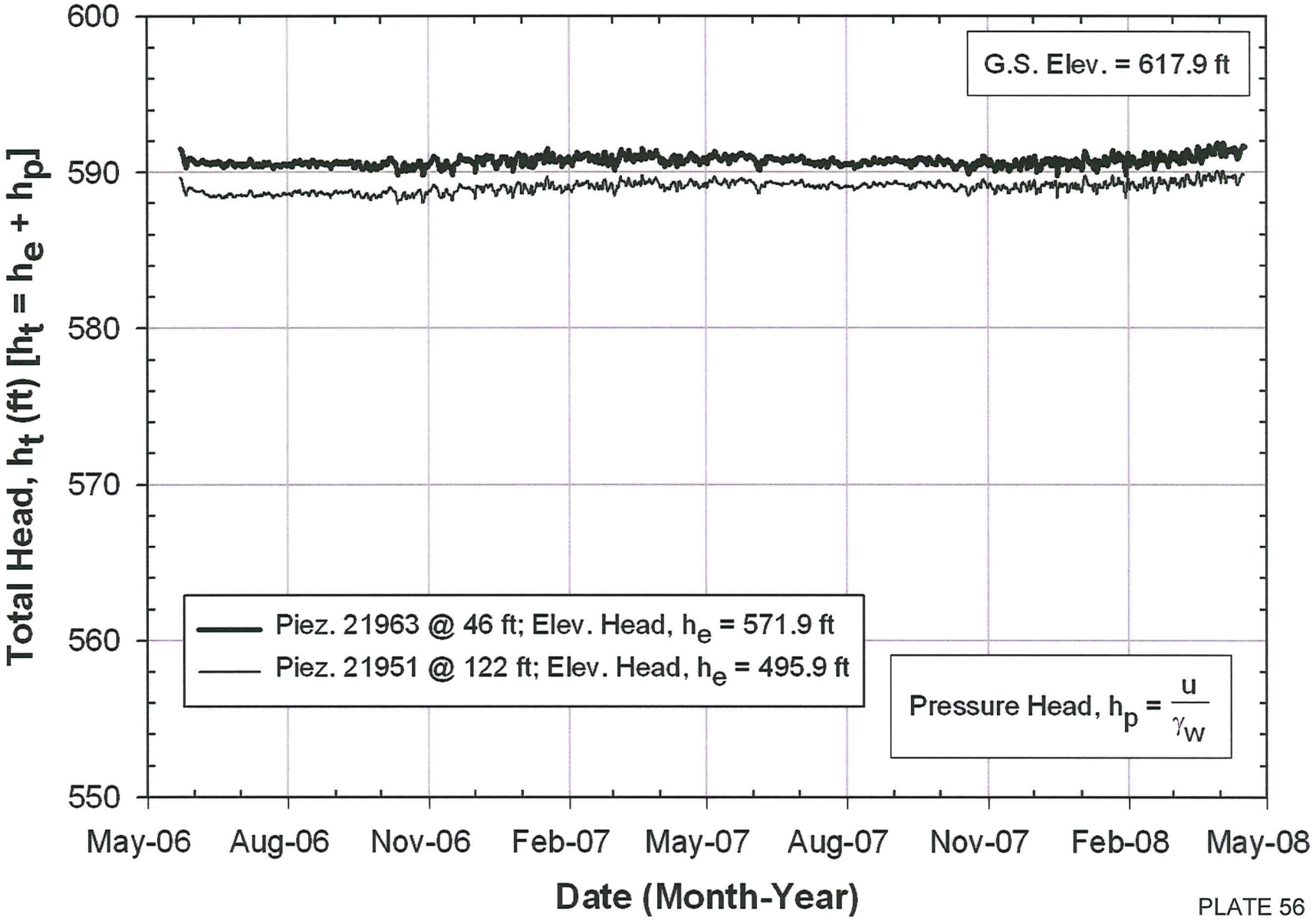


PLATE 56

B-05-03 VW Piezometer Readings

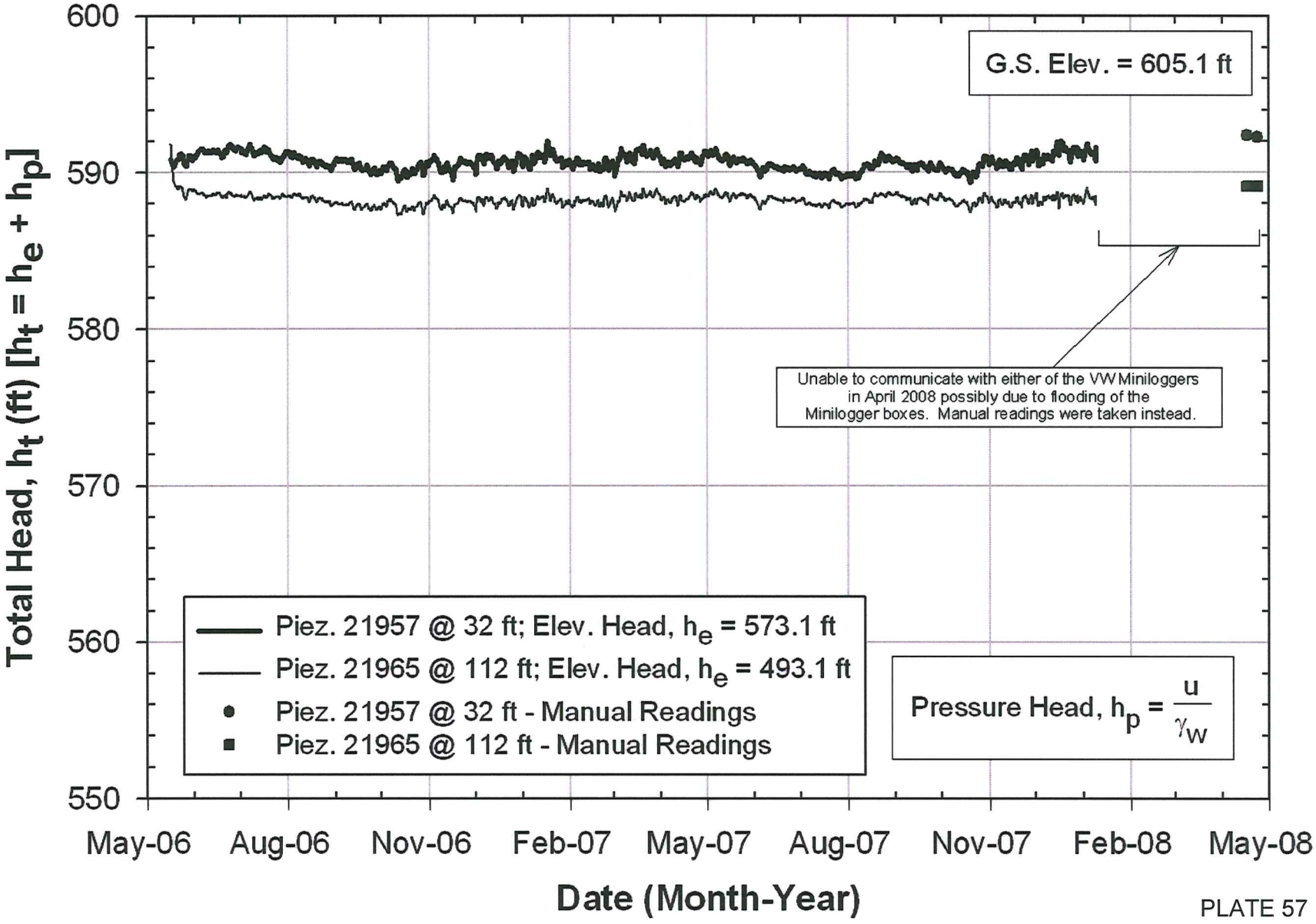


PLATE 57

B-05-04 VW Piezometer Readings

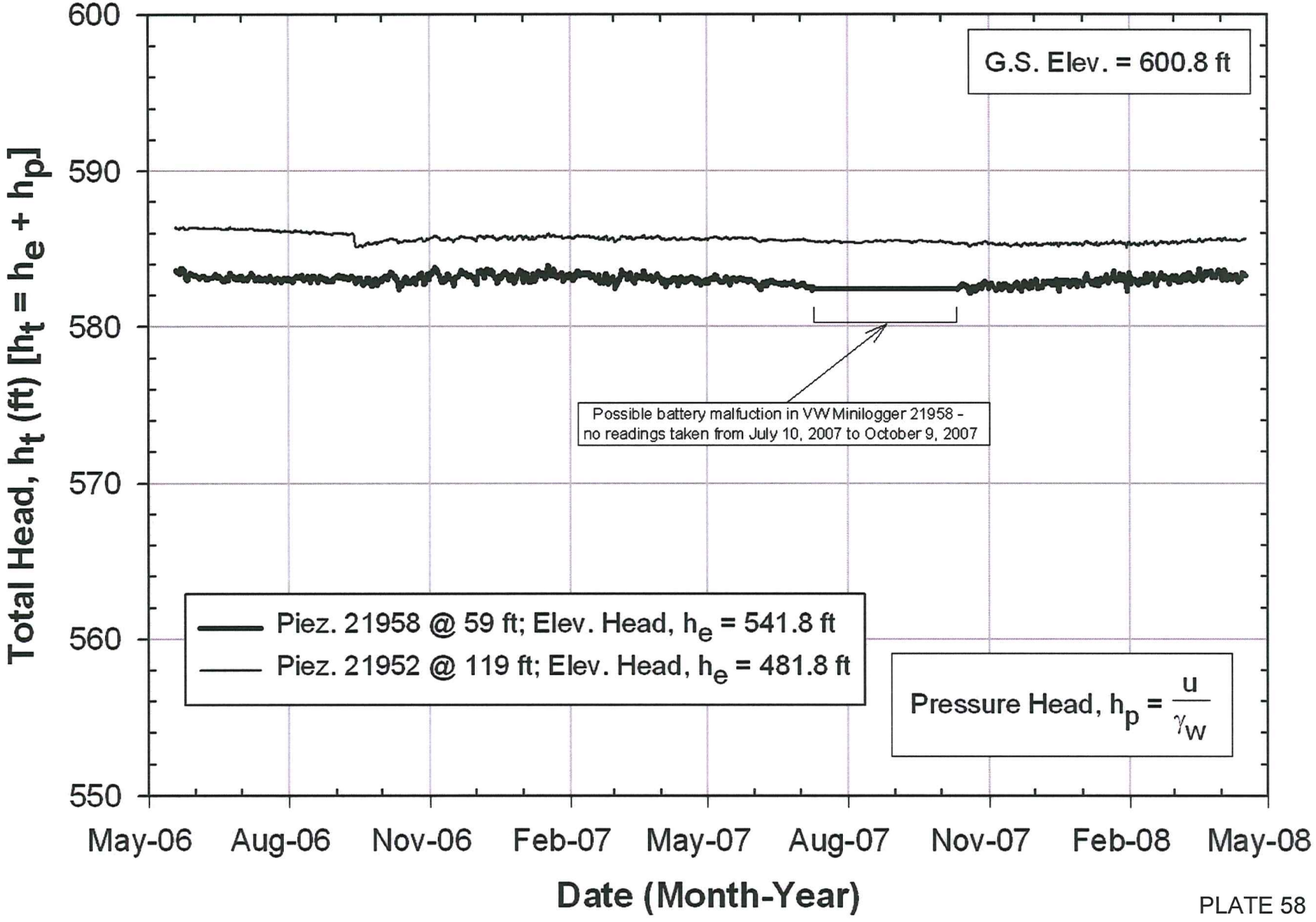


PLATE 58

B-05-07 VW Piezometer Readings

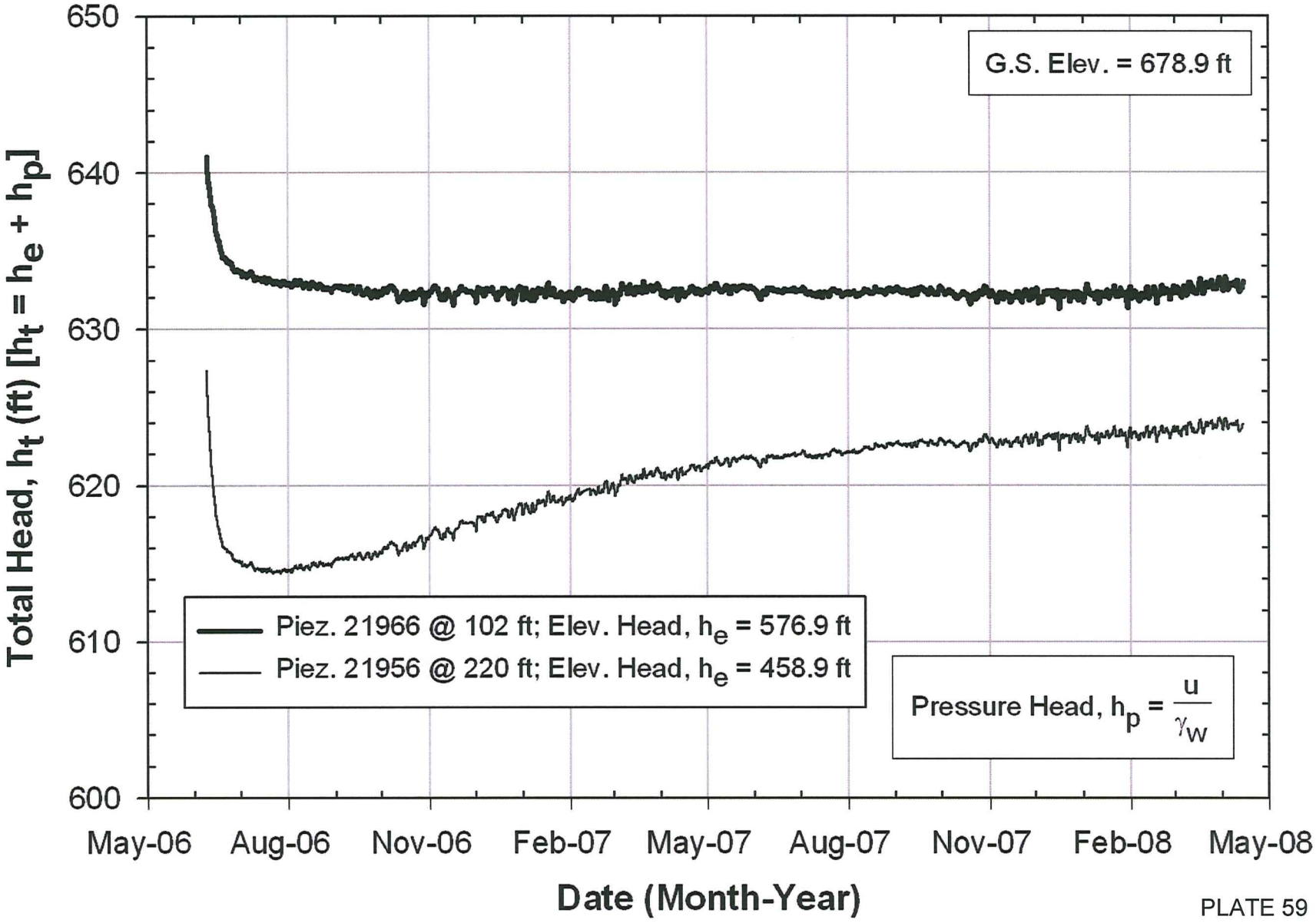


PLATE 59

B-05-08 VW Piezometer Readings

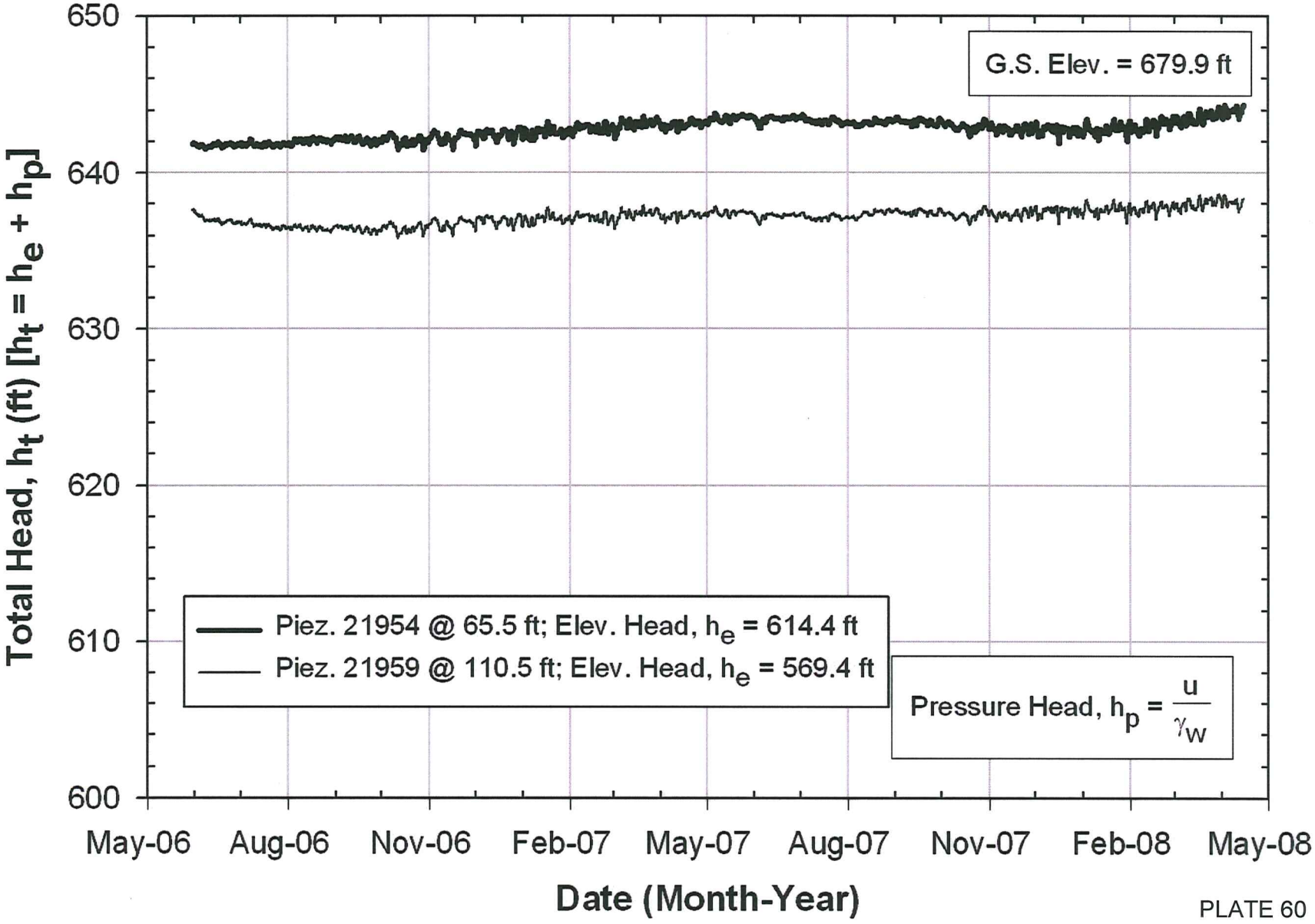


PLATE 60

B-05-11 VW Piezometer Readings

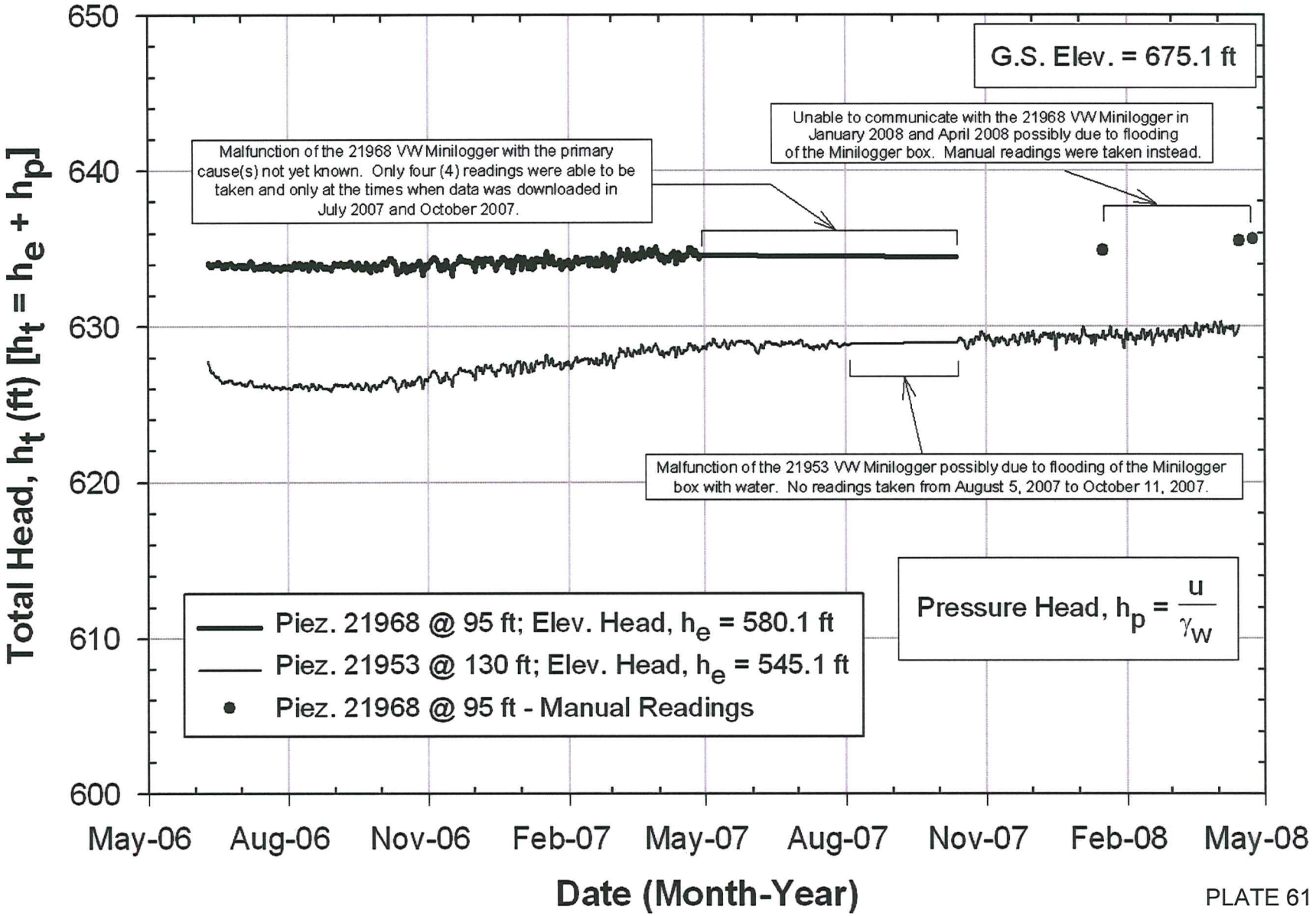


PLATE 61

B-05-12 VW Piezometer Readings

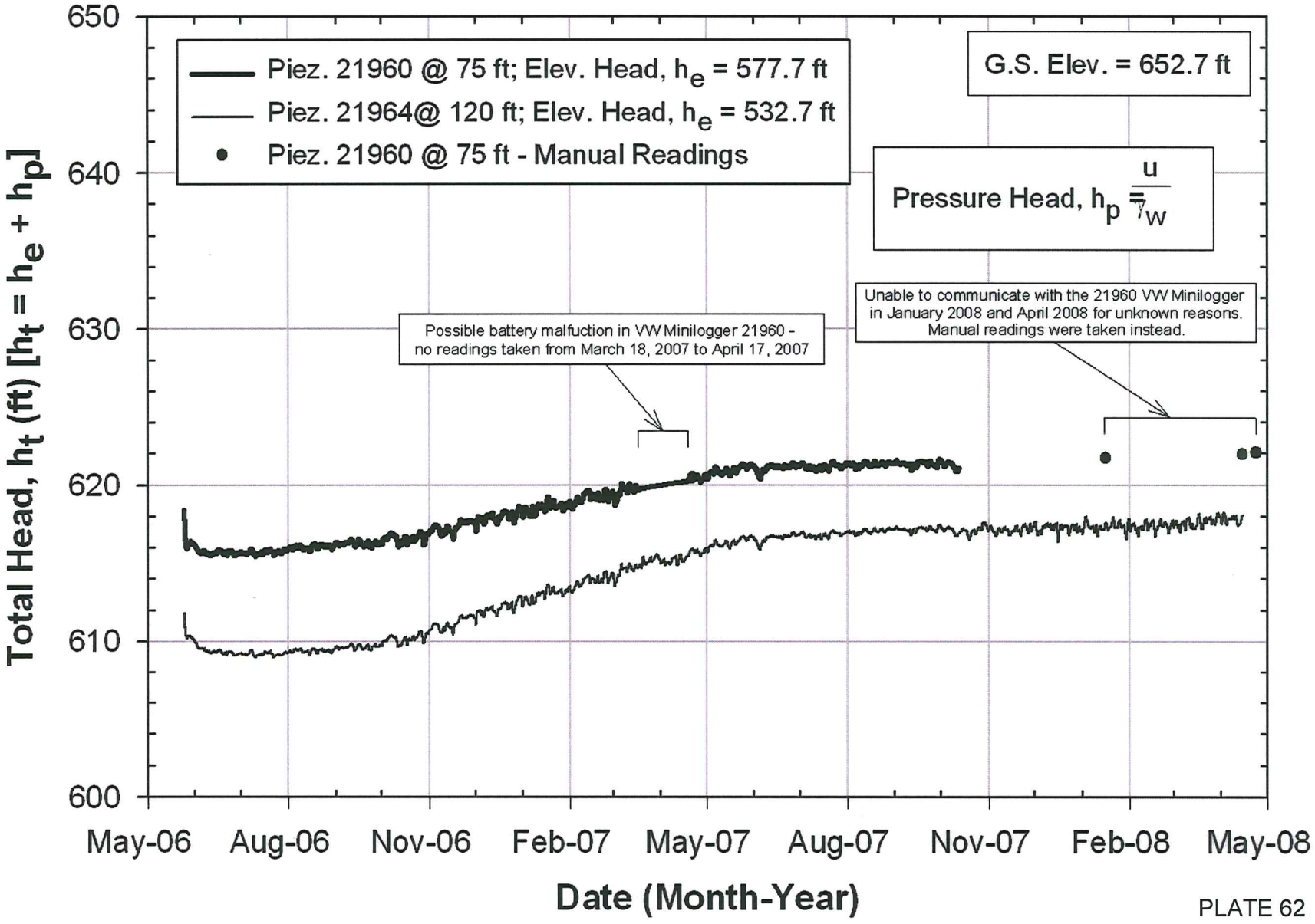


PLATE 62

B-05-13 VW Piezometer Readings

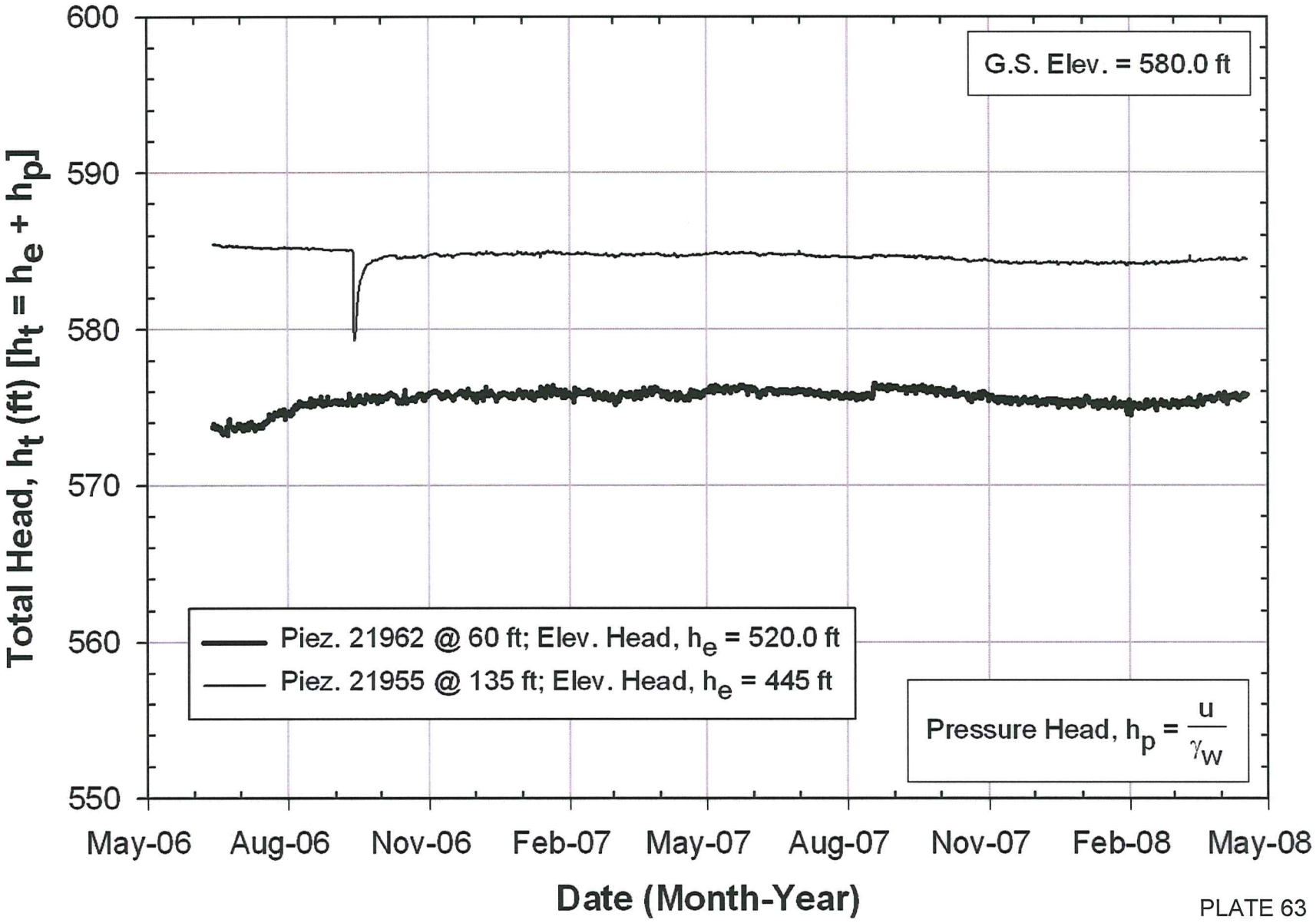


PLATE 63

CALIPERED SURFACE DISTANCE TABLE
CUY-90-15.24

Date	Left Pier Calipered Surface Distance		Center Line Calipered Surface Distance		Right Pier Calipered Surface Distance	
	Present reading	Change (in.)	Present reading	Change (in.)	Present reading	Change (in.)
07/19/01	6.043	--	Not Accessible		4.312	--
11/08/01	6.250	0.207	Not Accessible		4.469	0.157
01/23/02	6.253	0.003	Not Accessible		4.518	0.049
04/17/02	6.285	0.032	Not Accessible		4.435	-0.083
07/16/02	6.290	0.005	Not Accessible		4.444	0.009
10/15/02	6.333	0.043	Discontinued		4.482	0.038
01/15/03	6.405	0.072			4.473	-0.009
04/17/03	6.333	-0.072			4.482	0.009
07/18/03	6.186	-0.147			4.350	-0.132
10/16/03	6.385	0.199			4.519	0.169
01/08/04	6.124	-0.261			4.594	0.075
04/14/04	6.129	0.005			4.402	-0.193
07/16/04	6.250	0.122			4.277	-0.125
10/27/04	6.375	0.125			4.467	0.190
01/12/05	6.250	-0.125			4.349	-0.118
04/14/05	6.375	0.125			4.372	0.023
07/14/05	6.313	-0.063			4.392	0.020
10/12/05	6.375	0.063			4.358	-0.034
02/01/06	6.438	0.063			4.395	0.037
04/20/06	6.500	0.063			4.430	0.035
07/14/06	6.375	-0.125			4.381	-0.049
10/18/06	6.438	0.063			4.400	0.020
01/19/07	6.500	0.062			4.506	0.106
04/18/07	6.375	-0.125			4.357	-0.150
07/11/07	6.438	0.063			4.341	-0.015
10/12/07	6.438	0.000			4.384	0.043
01/08/08	6.469	0.031			4.349	-0.036
04/14/08	6.500	0.031			4.410	0.062

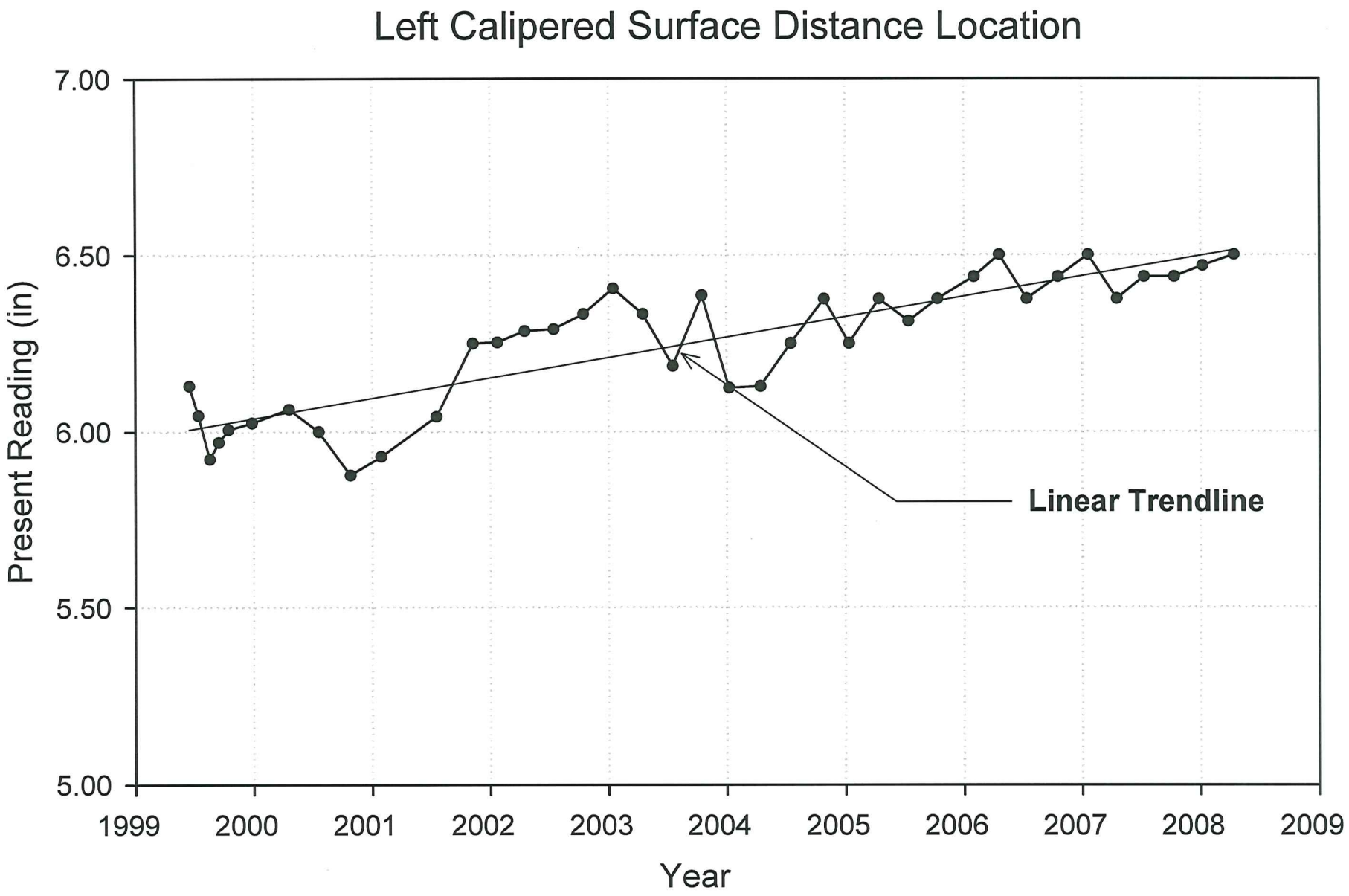

Left Calipered Surface Distance Location
7.00
6.50
6.00
5.50
5.00
Present Reading (in)
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year
Linear Trendline

PLATE 65

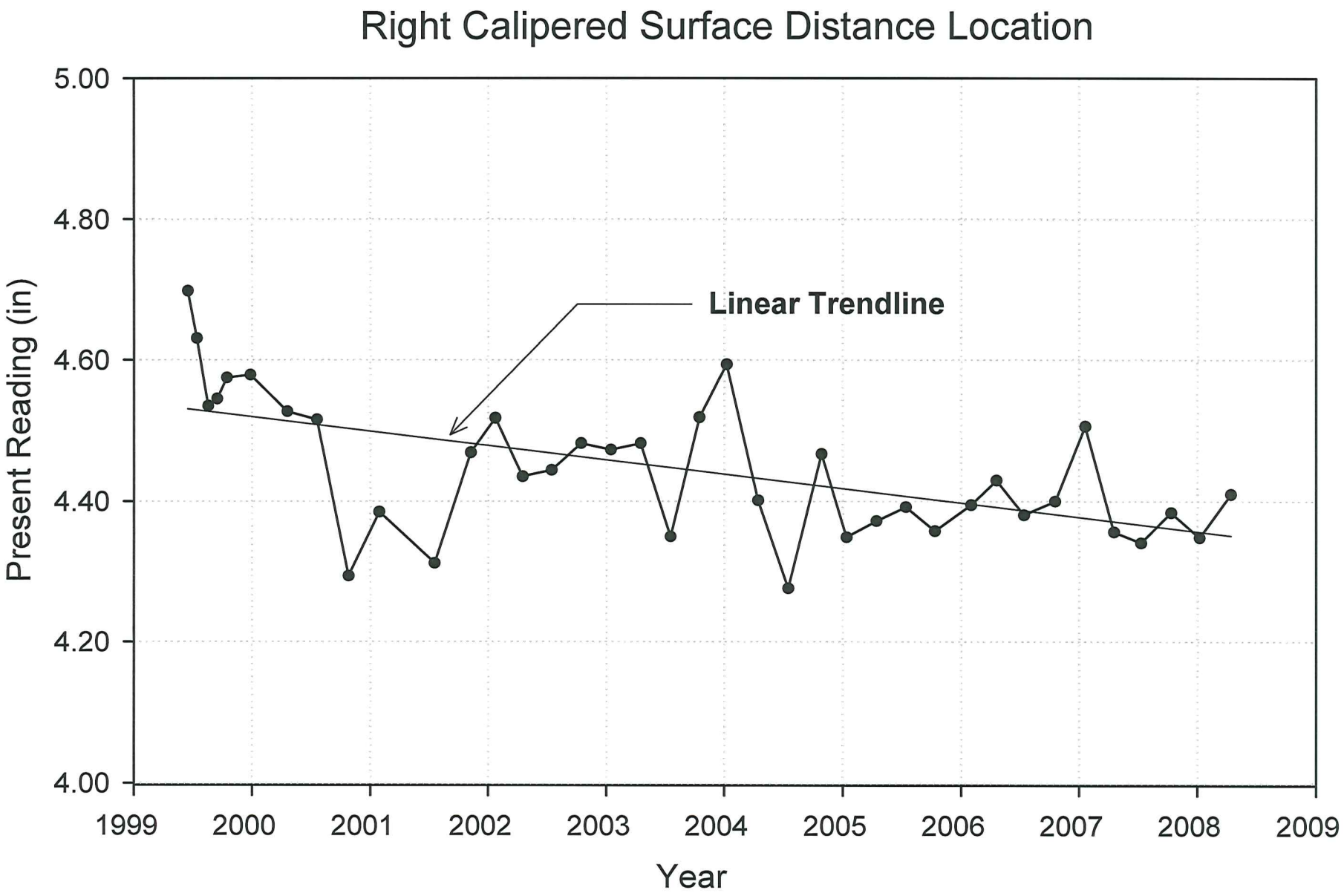

Right Calipered Surface Distance Location
5.00
4.80
4.60
4.40
4.20
4.00
Present Reading (in)
Linear Trendline
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

PLATE 66

View of the large excavation area and landslide area. Photo taken from near B-05-13 on January 19, 2007.

PLATE 67

Close-up view of the landslide area adjacent to excavation. Photo taken from near B-05-13 on January 19, 2007.

PLATE 68

View of the large excavation area and landslide area. Photo taken from near B-05-13 on February 22, 2007.

PLATE 69

Close-up view of the landslide area adjacent to excavation. Photo taken from near B-05-13 on February 22, 2007.

PLATE 70

View of part of the large excavation area and landslide area. Photo taken from near B-05-13 on April 17, 2007.

PLATE 71

Close-up view of the landslide area adjacent to excavation. Photo taken from near B-05-13 on April 17, 2007.

PLATE 72

View of the large excavation area and landslide area. Photo taken from near B-05-13 on July 11, 2007.

PLATE 73

Close-up view of the landslide area adjacent to excavation. Photo taken from near B-05-13 on July 11, 2007.

PLATE 74

View of the large excavation area and landslide area. Photo taken from near B-05-13 on October 16, 2007.

PLATE 75

Close-up view of the landslide area adjacent to excavation. Photo taken from near B-05-13 on October 16, 2007.

PLATE 76

View of the large excavation area and landslide area. Photo taken from near B-05-13 on January 8, 2008.

PLATE 77

Close-up view of the landslide area adjacent to excavation. Photo taken from near B-05-13 on January 8, 2008.

PLATE 78

View of the large excavation area and landslide area. Photo taken from near B-05-13 on April 17, 2008.

PLATE 79

Close-up view of the landslide area adjacent to excavation. Photo taken from near B-05-13 on April 17, 2008.

PLATE 80

View towards the west-northwest of the bulkhead in the excavation area adjacent to the west right-of-way fence. Photo taken on April 17, 2008.

PLATE 81

View towards the east of a large scarp within the landslide area and the tipped over fence.
Photo taken on April 17, 2008.

PLATE 82

View towards the east of the large scarp within the landslide area and the tipped over fence.
Photo taken on April 17, 2008.

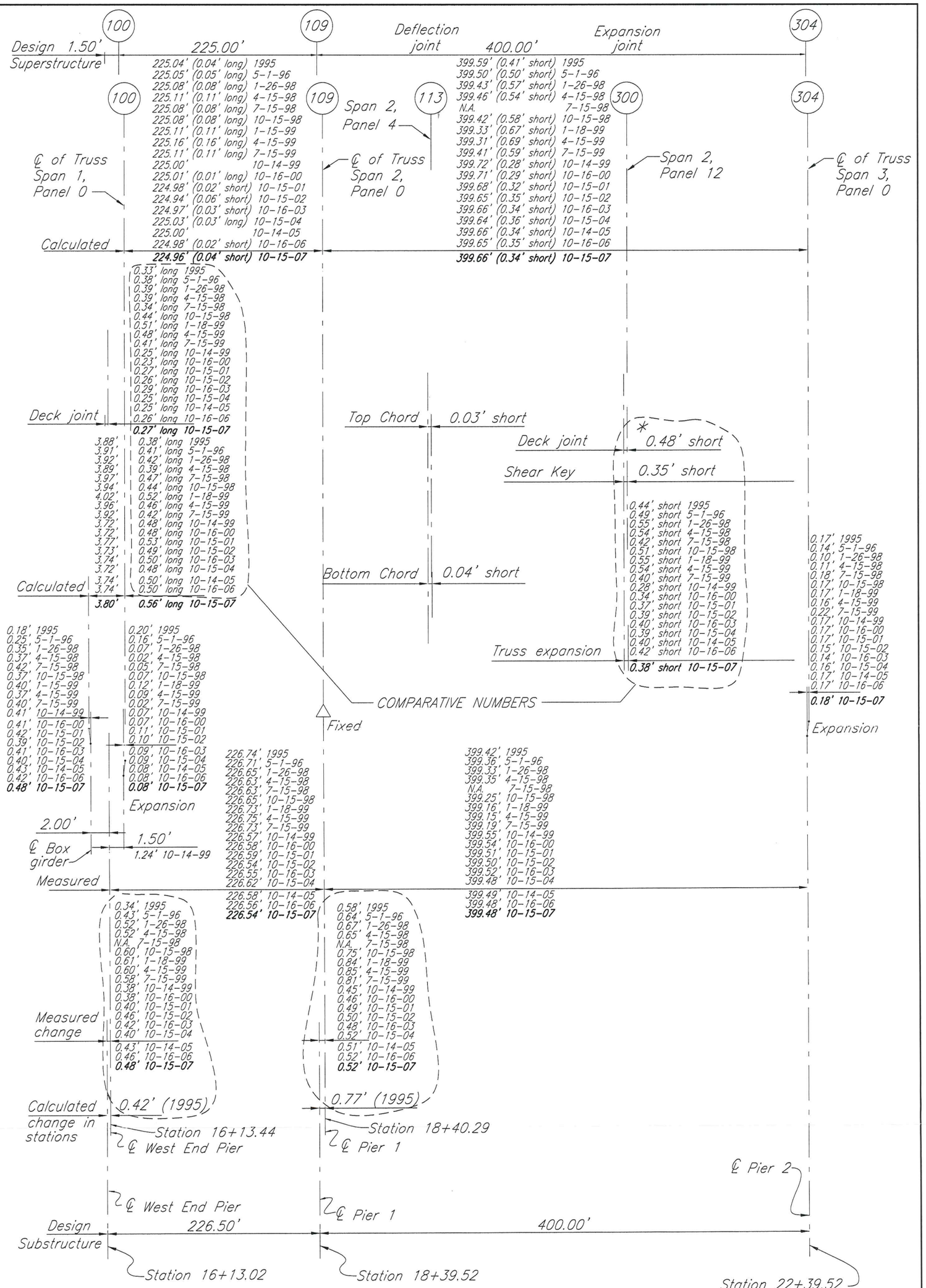
PLATE 83

View towards the east-northeast of multiple scarps within the landslide area. Photo taken on April 17, 2008.

PLATE 84

View towards the east-southeast of the multiple scarps within the landslide area.
Photo taken on April 17, 2008.

PLATE 85



* 1972 Joint repositioned open 0.21'
1998 Joint closed 0.27'
0.48'

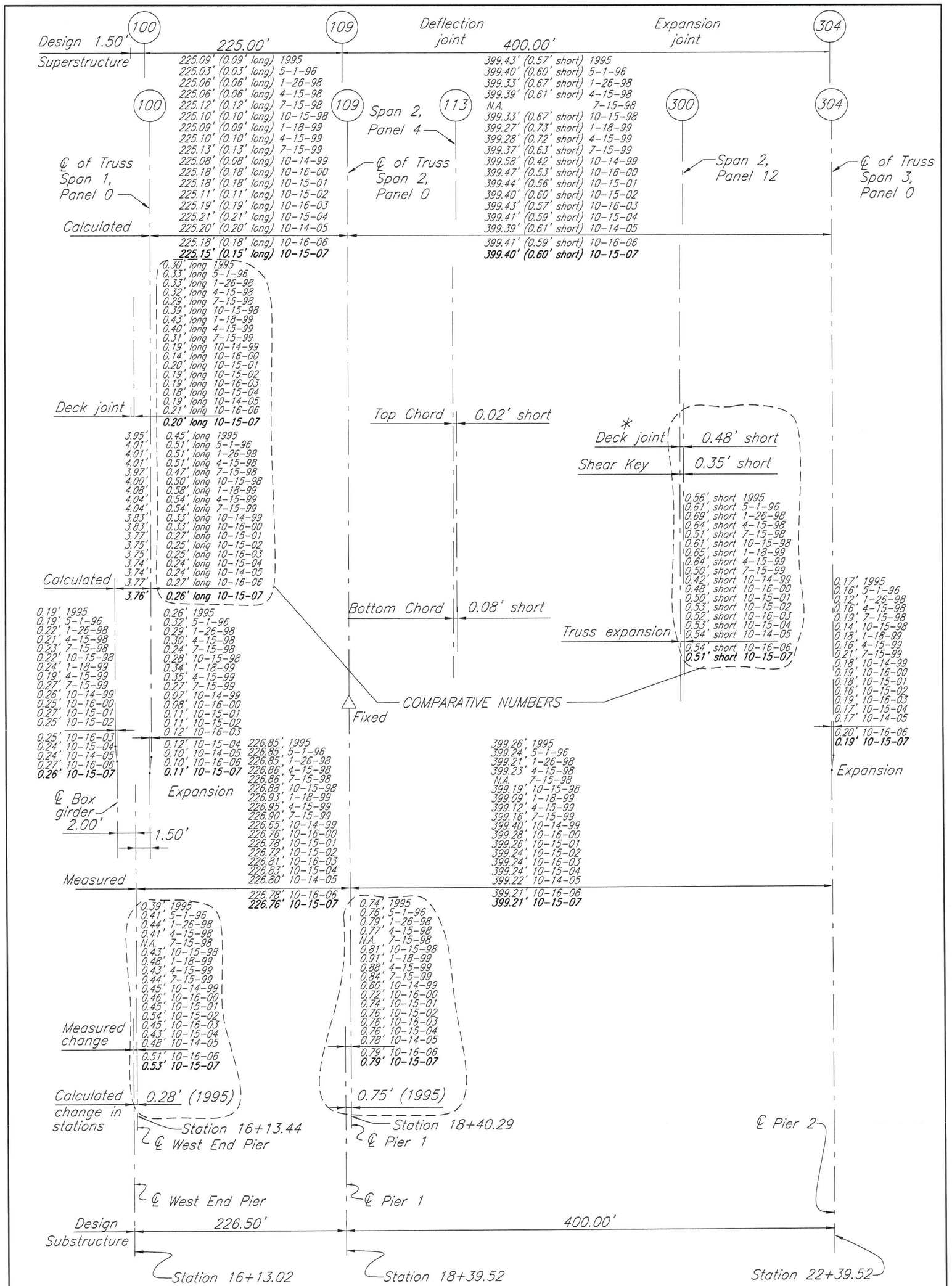
(100) – Panel Number given in Original Construction drawings

Summary of Truss Measurements

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

SCHEMATIC – NORTH TRUSS @ 60° F (10–15–07)
CUY–90–1524

10/30/2007 Measurements/Cuy/SR90SCH.DWG



*1972 Joint repositioned open 0.21'
1998 Joint closed 0.27'
0.48'

(100) – Panel Number given in Original Construction drawings

Summary of Truss Measurements

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

SCHEMATIC – SOUTH TRUSS @ 60° F (10-15-07)
CUY-90-1524

10/01/2007 Measurements/Cuy90S02XL.DWG

RELATIVE SPAN LENGTHS

(Distance between points set on consecutive piers)

	Span 1		Span 2	
	North Truss	South Truss	North Truss	South Truss
1985	215.35	215.30	399.49	399.74
1988	215.47	215.46	399.38	399.57
1989	215.48	215.44	399.36	399.59
1990	215.48	215.45	399.35	399.56
1991	215.48	215.42	399.29	399.57
1992	215.51	215.50	399.30	399.52
1993	215.46	215.49	399.34	399.51
1994	215.47	215.44	399.31	399.52
1995	215.49	215.45	399.34	399.55
5 / 1996	215.46	215.45	399.28	399.53
8 / 1996	215.45	215.46	399.28	399.54
9 / 1997	215.45	215.48	399.29	399.53
1 / 1998	215.40	215.45	399.25	399.50
4 / 1998	215.38	215.46	399.27	399.52
7 /1998	215.35	215.44	¥	¥
10 / 1998	215.40	215.48	399.16	399.47
12 / 1998	215.48	215.53	399.08	399.41
1 / 1999	215.48	215.53	399.08	399.39
4 / 1999	215.51	215.55	399.07	399.41
10 / 1999	215.48	215.50	399.11	399.45
***10/ 1999	215.56	215.66	398.98	399.25
10/2000	215.57	215.77	398.97	399.13
10/2001	215.58	215.79	398.94	399.12
10/2002	215.53	215.73	398.93	399.10
10/2003	215.55	215.82	398.95	399.10
10/2004	215.61	215.84	398.91	399.09
10/2005	215.58	215.81	398.92	399.08
10/2006	215.55	215.79	398.91	399.06
Net Change	-0.03	0.11	-0.07	-0.19
Design	215.25	215.10	399.92	400.29
10/2007	215.53	215.77	398.91	399.06
Change from 10/06 to 10/07	-0.02	-0.02	0.00	0.00

¥ Points destroyed during construction. New points set atop of pier 2, first reading taken 10/15/98

Net change is current reading compared to the last compatible reading (10/1999)

*** Bridge relocated

CUY-90-1524
106017

DECK EXPANSION JOINT OPENINGS

Finger Type Joints

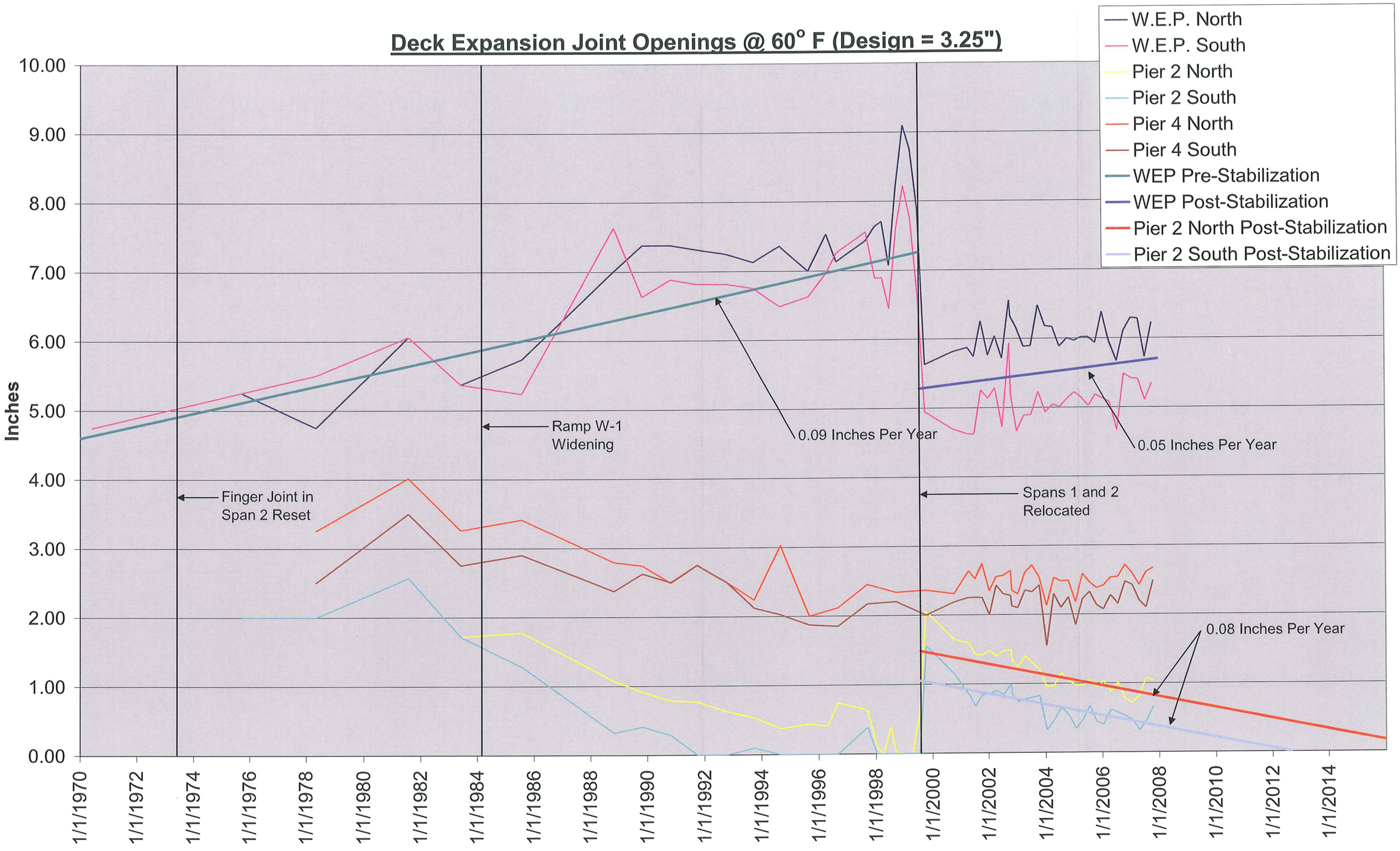
Measurements are in inches.

Date	Temp (F)	West End Pier North	West End Pier South	Near Pier 2 North	Near Pier 2 South	Near Pier 4 North	Near Pier 4 South
Expansion Distance		476 feet		650 feet			
Design	60°	3.25	3.25	3.25	3.25	3.25	3.25
06-01-70	80°	4.00		0.00		N.A.	
09-19-75	60°	5.25		2.00		N.A.	
05-08-78	60°	4.75	5.50	2.00	2.00	3.25	2.50
07-30-81	75°	5.50	5.50	2.25	2.25	3.25	2.75
06-09-83	70°	5.00	5.00	1.50	1.50	2.75	2.25
07-31-85	73°	5.25	4.75	1.50	1.00	2.75	2.25
10-31-88	40°	7.75	8.38	1.50	0.75	3.81	3.38
11-01-89	50°	7.75	7.00	1.13	0.63	3.25	3.13
10-26-90	50°	7.75	7.25	1.00	0.50	3.00	3.00
09-30-91	55°	7.50	7.00	0.88	0.00	3.00	3.00
10-13-92	60°	7.25	6.81	0.63	0.00	2.50	2.50
10-01-93	50°	7.50	7.13	0.75	0.31	2.75	2.63
09-01-94	63°	7.25	6.38	0.31	0.00	2.88	1.88
09-08-95	60°	7.00	6.63	0.44	0.00	2.00	1.88
09-05-96	77°	6.50	6.63	0.38	0.00	1.25	1.00
09-19-97	75°	6.88	7.00	0.31	0.06	1.68	1.42
09-24-98	69°	7.63	7.00	0.00	0.00	1.88	1.75
10-14-99	45°	6.19	5.50	2.38	1.88	3.13	2.75
10-16-00	55°	6.00	4.88	1.75	1.25	2.56	2.43
04-23-01	70°	5.50	4.25	1.38	0.63	2.13	1.75
07-16-01	80°	5.00	3.88	1.00	0.25	1.50	1.25
10-15-01	50°	6.63	5.63	1.63	1.06	3.25	2.75

Date	Temp (F)	West End Pier		Near Pier 2		Near Pier 4	
		North	South	North	South	North	South
1-15-02	30°	6.88	6.25	2.13	1.50	3.88	3.50
4-15-02	61°	6.00	5.25	1.38	0.88	2.50	2.38
7-15-02	76°	5.13	4.13	1.13	0.50	1.75	1.50
10-17-02	48°	7.00	6.38	1.75	1.25	3.25	2.88
11-1-02	35°	7.25	6.13	1.88	1.38	3.63	3.38
1-15-03	7°	8.13	6.63	2.38	1.88	5.00	4.75
4-15-03	67°	5.63	4.63	1.25	0.63	2.25	2.00
7-15-03	74°	5.38	4.38	1.00	0.50	2.00	1.63
10-16-03	46°	7.00	5.75	1.50	1.13	3.25	3.13
1-15-04	11°	8.00	6.75	2.00	1.38	4.63	4.00
4-15-04	41°	6.88	5.75	1.38	0.88	3.50	3.25
7-15-04	67°	5.63	4.75	1.00	0.50	2.13	1.75
10-15-04	50°	6.38	5.50	1.25	0.75	3.00	2.75
1-15-05	12°	7.75	7.00	2.00	1.38	4.63	4.25
4-16-05	47°	6.50	5.63	1.25	0.75	3.25	2.88
7-16-05	74°	5.50	4.50	0.75	0.375	1.75	1.63
10-14-05	51°	6.25	5.50	1.13	0.63	2.81	2.56
1-16-06	26°	7.63	6.38	1.75	1.13	4.13	3.75
4-14-06	65°	5.75	4.88	0.75	0.50	2.25	2.00
7-14-06	78°	5.00	4.00	0.63	0.19	1.63	1.25
10-16-06	50°	6.50	5.88	1.00	0.75	3.25	3.00
1-15-07	41°	7.00	6.13	1.13	0.88	3.56	3.38
4-16-07	34°	7.25	6.38	1.38	0.88	3.75	3.50
7-16-07	70°	5.38	4.75	0.88	0.25	2.13	1.63
10-15-07	56°	6.38	5.50	1.13	0.75	2.88	2.69
1-15-08	19°	7.63	6.63	1.63	1.00	4.13	4.00
4-15-08	41°	7.13	6.25	1.44	0.88	3.75	3.19

N.A. - No measurements available

Deck Expansion Joint Openings @ 60° F (Design = 3.25")



SEAT ELEVATIONS

POINT NO.	DESCRIPTION	10/17/94	02/26/98	04/15/98	07/15/98	07/22/98	10/15/98	1/19/99	3/5/99	4/15/99	7/15/99	10/14/99	10/16/00	10/15/01	10/15/02	10/16/03	10/14/04	10/14/05	10/16/06	10/15/07
WEST END PIER SOUTH																				
103	ROD IN PIER SEAT	667.18	667.15	667.18	667.18	-	667.14	667.16	-	667.17	667.17	667.16	667.16	667.20	667.17	667.17	667.19	667.15	667.16	667.16
401	ROD IN SOUTH FACE	-	677.91	677.93	677.92	-	677.92	677.93	-	677.93	677.92	677.91	677.92	677.94	677.93	677.92	677.94	677.91	677.92	677.91
402	ROD IN NORTH FACE	-	670.79	670.81	670.80	-	670.78	670.80	-	670.79	670.80	670.78	670.80	670.83	670.80	670.80	670.81	670.78	670.79	670.79
WEST END PIER NORTH																				
	ROD IN PIER SEAT																			
102	Destroyed	667.04	667.03	667.07	667.05	-	667.04	667.03	-	667.04	-	-	-	-	-	-	-	-	-	-
802	(SET 7/16/99)									-	667.02	667.01	667.01	667.05	667.01	667.02	667.03	667.00	667.01	667.01
404	ROD IN NORTH FACE	-	660.83	660.86	660.86	-	660.82	660.88	-	660.84	660.85	660.84	660.84	660.87	660.85	660.84	660.86	660.82	660.83	660.83
PIER 1 NORTH																				
	ROD IN PIER SEAT																			
104	Destroyed	626.29	626.33	-	626.38	-	626.32	-	-	-	-	-	-	-	-	-	-	-	-	-
606	(SET 7/22/98)							626.35	-	626.33	626.34	626.33	626.33	626.34	626.30	626.33	626.34	626.31	626.29	626.34
607	(SET 12/29/98)							626.32	-	626.30	626.30	-	-	-	-	-	-	-	-	-
608	(SET 12/29/98)							626.24	-	626.21	626.21	626.22	626.23	626.23	626.22	626.23	626.23	626.20	626.19	626.23
609	(SET 12/29/98)							626.23	-	626.22	626.21	626.21	626.21	-	-	-	-	-	-	-
903	(SET 10/13/99)											626.30	626.30	626.30	626.33	626.30	626.30	626.27	626.26	626.31
902	(SET 10/13/99)											626.25	626.26	626.26	626.25	626.26	626.25	626.23	626.21	626.26
308	ROD IN NORTH FACE	-	604.51	-	-	-	604.48	604.51	-	604.55	604.52	604.50	604.50	604.52	604.51	604.51	604.52	604.49	604.48	604.52
407	ROD IN SOUTH FACE	-	-	-	-	-	604.25	§	-	604.26	604.28	604.23	604.24	604.27	604.25	604.25	604.26	604.23	604.20	604.26
PIER 1 SOUTH																				
	ROD IN PIER SEAT																			
105	Destroyed	626.25	626.27	-	626.34	626.32	626.28	-	-	-	-	-	-	-	-	-	-	-	-	-
602	(SET 7/22/98)	-	-	-	-	626.29	626.24	626.25	-	626.23	626.23	-	-	-	-	-	-	-	-	-
603	(SET 12/29/98)							626.26	-	626.25	626.24	-	-	-	-	-	-	-	-	-
604	(SET 12/29/98)							626.23	-	626.21	626.20	-	-	-	-	-	-	-	-	-
605	(SET 12/29/98)							626.24	-	626.22	626.21	-	-	-	-	-	-	-	-	-
901	(SET 10/13/99)											626.22	626.23	626.23	626.22	626.23	626.22	626.20	626.18	626.23
900	(SET 10/13/99)											626.21	626.22	626.22	626.21	626.22	626.21	626.19	626.17	626.22
306	ROD IN NORTH FACE	-	606.55	-	-	-	606.53	§	-	606.51	606.54	606.50	606.50	606.52	606.51	606.51	606.51	606.49	606.47	-
305	ROD IN SOUTH FACE	-	607.33	-	-	-	607.33	607.32	-	607.31	607.34	607.29	607.30	607.32	607.31	607.31	607.33	607.30	607.27	607.31
PIER 2 NORTH																				
	ROD IN PIER SEAT																			
601	(SET 7/22/98)	-	-	-	-	628.65	628.58	628.66	-	628.62	628.65	628.63	628.64	628.65	628.65	628.64	628.61	628.61	628.58	628.68
206	ROD IN SOUTH FACE	-	586.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
610	ROD IN SOUTH FACE (SET 7/22/98)	-	-	-	-	-	586.09	586.15	-	-	586.11	586.12	586.14	586.16	586.18	586.17	586.18	586.15	586.17	586.16
PIER 2 SOUTH																				
600	ROD IN PIER SEAT (SET 7/22/98)	-	-	-	-	628.78	628.72	628.77	-	628.76	628.78	628.76	628.78	628.78	628.76	628.77	628.73	628.75	628.72	628.79
207	ROD IN NORTH FACE	-	586.08	-	-	-	586.07	586.10	-	-	586.16	586.16	586.10	586.11	586.13	586.12	586.13	586.11	586.12	586.11
ANCHOR STRUCTURE																				
500	ROD SOUTH END	-	591.00	-	-	591.00	590.97	590.98	591.00	590.99	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
501	ROD CENTER +-	-	590.96	-	-	590.97	590.94	590.96	590.96	590.96	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
502	ROD NORTH END	-	590.98	-	-	590.99	590.97	590.99	590.99	590.99	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
DRILLED SHAFT CAP (SET 3/4/99)																				
700	BRASS DISK NORTH END	-	-	-	-	-	-	-	589.61	589.62	589.66	589.65	589.65	589.66	589.66	589.67	589.68	589.65	589.62	589.68
701	BRASS DISK CENTER +-	-	-	-	-	-	-	-	589.66	589.66	589.68	589.68	589.69	589.69	589.69	589.70	589.71	589.68	589.65	589.71
702	BRASS DISK SOUTH END	-	-	-	-	-	-	-	589.62	589.62	589.63	589.64	589.65	589.65	589.64	589.66	589.66	589.63	589.60	589.66
CONTROL POINT																				
64	PK IN CONC DRIVE	633.37	633.30	-	-	633.31	633.26	633.27	-	633.22	633.23	633.22	633.22	633.23	633.21	633.21	633.22	633.16 ***	633.15 ***	633.17 ***

| Calculated from top of concrete using an average rod height
§ Shots were not taken due to heat tent for rock anchor placement procedure.
¥¥ No future shots will be taken due to anchor structure being buried
*** Head of Nail Missing

PIER SEAT COORDINATES

(Reference Point Locations on Top of Piers)

Pier	Direction	B&N 1985*	REL 1988‡	REL 1989‡	REL 1990‡	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 5/96	REL 8/96	REL 9/97	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 3/99	REL 4/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06	REL 10/07
WEP North	N	5114.58	5114.53	5114.55	5114.55	5114.58	5114.64	5114.64	5114.65	5114.65	5114.67	5114.67	5114.68	5114.66	5114.65	5114.67	5114.66	5114.64	5114.68	N.A.	N.A.	5114.71	5114.69	5114.66	5114.65	5114.63	5114.67	5114.65	5114.64	5114.66	5114.63	5114.65
	E	4840.08	4839.58	4839.59	4839.59	4839.59	4839.59	4839.62	4839.62	4839.60	4839.67	4839.67	4839.69	4839.75	4839.77	4839.82	4839.84	4839.83	4839.83	N.A.	N.A.	4839.81	4839.81	4839.85	4839.84	4839.85	4839.88	4839.85	4839.87	4839.90	4839.91	4839.93
WEP South	N	5033.90	5033.84	5033.85	5033.86	5033.87	5033.96	5033.98	5033.98	5033.96	5033.98	5034.01	5033.96	5033.99	5033.99	5033.98	5033.99	NA	5033.99	N.A.	N.A.	5033.99	5033.96	5033.95	5033.94	5033.94	5033.94	5033.94	5033.95	5033.94	5033.96	5033.94
	E	4839.62	4839.12	4839.14	4839.14	4839.12	4839.11	4839.14	4839.15	4839.13	4839.15	4839.13	4839.15	4839.16	4839.17	4839.20	4839.22	NA	4839.23	N.A.	N.A.	4839.19	4839.21	4839.22	4839.22	4839.24	4839.26	4839.19	4839.21	4839.25	4839.27	4839.29
Pier 1 North	N	5124.44	5124.42	5124.40	5124.43	5124.39	5124.46	5124.50	5124.47	5124.44	5124.44	5124.48	5124.46	5124.47	5124.46	5124.46	5124.47	5124.47 £	5124.47	N.A.	N.A.	5124.46	5124.48	5124.42	5124.43	5124.44	5124.43	5124.43	5124.47	5124.45	5124.46	5124.47
	E	5055.20	5054.83	5054.84	5054.84	5054.85	5054.88	5054.86	5054.86	5054.87	5054.91	5054.90	5054.92	5054.93	5054.94	5054.95	5055.02	5055.09 £	5055.09	N.A.	N.A.	5055.10	5055.07	5055.18	5055.19	5055.21	5055.19	5055.18	5055.25	5055.25	5055.24	5055.24
Pier 1 South	N	5034.50	5034.49	5034.49	5034.53	5034.45	5034.53	5034.57	5034.55	5034.52	5034.54	5034.56	5034.54	5034.55	5034.54	5034.53	5034.57	5034.55 £	5034.56	N.A.	N.A.	5034.57	5034.56	5034.60	5034.59	5034.61	5034.64	5034.62	5034.65	5034.65	5034.66	5034.64
	E	5054.91	5054.59	5054.58	5054.60	5054.54	5054.60	5054.62	5054.59	5054.57	5054.60	5054.59	5054.63	5054.61	5054.63	5054.64	5054.70	5054.73 £	5054.76	N.A.	N.A.	5054.74	5054.71	5054.89	5054.99	5055.03	5054.99	5055.00	5055.05	5055.06	5055.06	5055.06
Pier 2 North	N	5124.60	5124.53	5124.55	5124.57	5124.43	5124.46	5124.45	5124.48	5124.40	5124.40	5124.40	5124.41	5124.37	5124.40	¥	5124.44	5124.42	5124.42	N.A.	N.A.	5124.43	5124.41	5124.40	5124.39	5124.41	5124.39	5124.42	5124.43	5124.41	5124.43	5124.44
	E	5454.68	5454.21	5454.21	5454.20	5454.14	5454.18	5454.20	5454.18	5454.21	5454.19	5454.19	5454.21	5454.17	5454.21	¥	5454.18	5454.17	5454.17	N.A.	N.A.	5454.17	5454.18	5454.16	5454.16	5454.15	5454.12	5454.13	5454.16	5454.17	5454.15	5454.14
Pier 2 South	N	5024.98	5024.89	5024.91	5024.91	5024.78	5024.81	5024.81	5024.84	5024.74	5024.76	5024.76	5024.76	5024.75	5024.78	¥	5024.72	5024.73	5024.73	N.A.	N.A.	5024.73	5024.70	5024.71	5024.69	5024.68	5024.73	5024.71	5024.72	5024.73	5024.73	5024.73
	E	5454.54	5454.04	5454.06	5454.04	5453.99	5454.01	5454.01	5453.99	5454.00	5454.01	5454.00	5454.04	5453.99	5454.03	¥	5454.05	5454.03	5454.03	N.A.	N.A.	5454.03	5454.04	5454.02	5454.00	5454.02	5453.96	5453.98	5454.01	5454.02	5454.00	5454.00
Anchor Structure	N													5143.42	5143.42	5143.45	5143.44	NA	5143.44	5143.39	5143.41	5143.43	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
North	E													5018.39	5018.44	5018.44	5018.50	NA	5018.54	5018.55	5018.56	5018.52	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure	N													5075.81	5075.77	5075.82	5075.81	NA	5075.82	5075.78	5075.80	5075.82	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Center	E													5018.37	5018.40	5018.48	5018.48	NA	5018.58	5018.58	5018.59	5018.53	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure	N													5009.41	5009.36	5009.42	5009.42	NA	5009.42	5009.40	5009.40	5009.41	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
South	E													5018.53	5018.56	5018.61	5018.61	NA	5018.75	5018.77	5018.78	5018.71	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Drilled Shaft Cap	N																			5138.49	5138.50	5138.53	5138.52	5138.49	5138.52	5138.52	5138.52	5138.53	5138.55	5138.55	5138.55	5138.56
North	E																			5109.81	5109.81	5109.78	5109.77	5109.80	5109.80	5109.81	5109.84	5109.82	5109.83	5109.83	5109.84	5109.85
Drilled Shaft Cap	N																			5074.42	5074.41	5074.43	5074.44	5074.40	5074.43	5074.43	5074.45	5074.45	5074.46	5074.47	5074.46	5074.48
Center	E																			5109.81	5109.82	5109.79	5109.78	5109.81	5109.81	5109.83	5109.84	5109.84	5109.84	5109.87	5109.86	5109.87
Drilled Shaft Cap	N																			5010.31	5010.32	5010.33	5010.33	5010.31	5010.32	5010.33	5010.35	5010.35	5010.36	5010.36	5010.37	5010.37
South	E																			5109.83	5109.83	5109.80	5109.80	5109.83	5109.84	5109.87	5109.89	5109.89	5109.92	5109.92	5109.92	5109.93

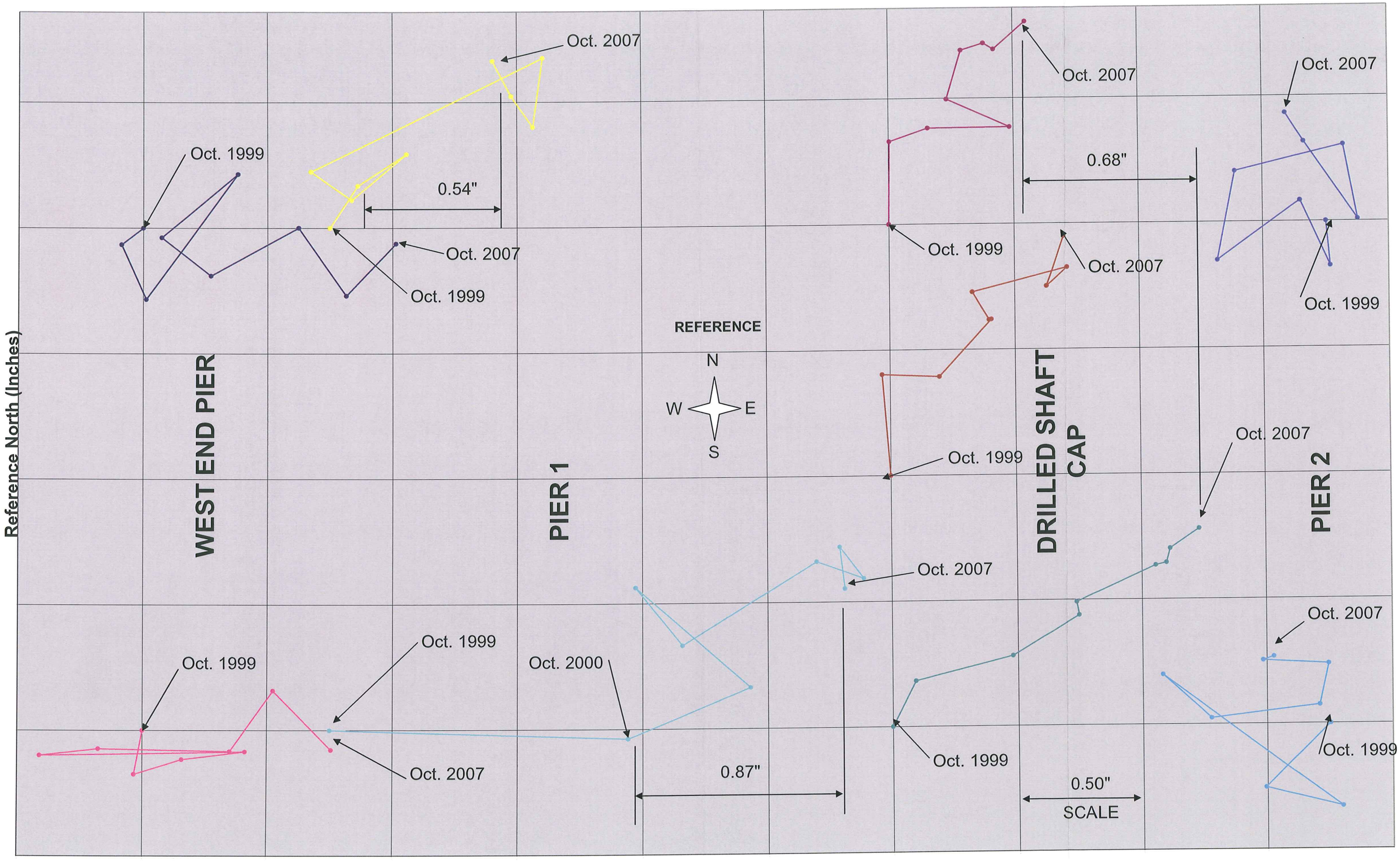
* Monumentation damaged by earth moving operations.

‡ Monuments appear to have been displaced 6" along the bridge.

¥ Points destroyed durning construction. New points set. First reading taken 10/15/98

£ Monumentation removed for new pier caps for jacking procedure. New points set and first readings taken 12/29/98

¥¥ No future shots will be taken due to anchor structure being buried



PIER SEAT COORDINATES

DIFFERENTIAL MOVEMENT

(A positive value indicates movement to the north or east.
A negative value indicates movement to the south or west.)

Pier	Point	Direction	85-88 *	88-89 ‡	89-90 ‡	90-91 ‡	91-92	92-93	93-94	94-95	95-5/96	95-8/96	8/96-97	97-1/98	1/98-4/98	4/98-7/98	7/98-10/98	10/98-12/98	10/98-1/99	1/99-3/99	3/99-4/99	1/99-4/99	4/99-7/99	7/99-10/99	10/99-10/00	10/00-10/01	10/01-10/02	10/02-10/03	10/03-10/04	10/04-10/05	10/05-10/06	10/06-10/07	¤ Net Change
WEP North	50	N	-0.05	0.03	-0.00	0.03	0.06	-0.00	0.00	0.00	0.02	0.00	0.01	-0.02	-0.01	0.02	-0.01	-0.02	0.04	NA	NA	0.03	-0.02	-0.03	-0.01	-0.02	0.04	-0.02	-0.01	0.02	-0.02	0.02	0.12
Pier Seat		E	-0.50	0.01	0.01	-0.00	0.00	0.03	-0.00	-0.02	0.07	-0.00	0.02	0.06	0.02	0.05	0.02	-0.01	-0.00	NA	NA	-0.02	0.00	0.03	-0.01	0.01	0.03	-0.03	0.02	0.03	0.02	0.02	0.35
WEP South	60	N	-0.05	0.01	0.01	0.01	0.09	0.02	-0.00	-0.02	0.02	0.03	-0.04	0.03	-0.00	-0.01	0.01	NA	0.04	NA	NA	-0.01	-0.03	-0.01	-0.01	0.00	0.00	-0.00	0.00	-0.00	0.02	-0.02	0.10
Pier Seat		E	-0.50	0.02	0.00	-0.02	-0.02	0.03	0.01	-0.02	0.03	-0.02	0.02	0.01	0.01	0.03	0.02	NA	0.03	NA	NA	-0.04	0.02	0.02	-0.00	0.02	0.02	-0.07	0.02	0.04	0.01	0.02	0.16
Pier 1 North	30	N	-0.02	-0.02	0.03	-0.04	0.07	0.04	-0.03	-0.03	0.00	0.04	-0.01	0.00	-0.01	0.00	0.01	-0.01	0.00	NA	NA	-0.01	0.02	-0.06	0.01	0.01	-0.02	0.01	0.04	-0.02	0.01	0.01	0.05
Pier Seat		E	-0.37	0.01	0.00	0.01	0.03	-0.02	0.00	0.01	0.04	-0.01	0.01	0.01	0.01	0.02	0.07	0.07	0.00	NA	NA	0.01	-0.02	0.11	0.01	0.02	-0.02	-0.01	0.08	-0.00	-0.01	-0.01	0.41
Pier 1 South	40	N	-0.01	0.01	0.04	-0.08	0.08	0.04	-0.02	-0.03	0.02	0.02	-0.02	0.01	-0.01	-0.01	0.04	-0.02	0.01	NA	NA	0.01	-0.01	0.04	-0.00	0.02	0.03	-0.02	0.03	-0.01	0.01	-0.01	0.15
Pier Seat		E	-0.33	-0.00	0.01	-0.06	0.06	0.02	-0.04	-0.01	0.03	-0.02	0.04	-0.02	0.02	0.01	0.06	0.03	0.03	NA	NA	-0.02	-0.03	0.18	0.10	0.04	-0.04	0.02	0.04	0.02	-0.01	0.00	0.47
Pier 2 North	10	N	-0.06	0.02	0.02	-0.14	0.02	-0.01	0.02	-0.07	-0.00	0.00	0.01	-0.05	0.03	NA	§	-0.02	0.00	NA	NA	0.01	-0.02	-0.01	-0.01	0.02	-0.02	0.03	0.01	-0.02	0.03	0.01	-0.00
Pier Seat		E	-0.47	-0.00	-0.01	-0.05	0.03	0.02	-0.02	0.03	-0.01	-0.01	0.03	-0.04	0.04	NA	§	-0.01	0.00	NA	NA	-0.00	0.02	-0.03	0.00	-0.01	-0.03	0.01	0.04	0.00	-0.02	-0.01	-0.04
Pier 2 South	20	N	-0.09	0.01	0.00	-0.13	0.03	-0.00	0.03	-0.10	0.01	0.01	-0.00	-0.02	0.03	NA	§	0.01	0.00	NA	NA	-0.00	-0.03	0.01	-0.02	-0.01	0.04	-0.01	0.00	0.01	0.00	0.00	0.01
Pier Seat		E	-0.50	0.01	-0.01	-0.05	0.02	0.01	-0.02	0.01	0.01	-0.01	0.03	-0.05	0.04	NA	§	-0.03	0.00	NA	NA	0.00	0.01	-0.02	-0.02	0.03	-0.06	0.02	0.04	0.00	-0.02	0.00	-0.05
Anchor Structure	502	N												¥	-0.00	0.03	-0.01	NA	0.02	-0.05	0.01	0.02	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
North		E												¥	0.05	0.01	0.05	NA	0.07	0.01	0.01	-0.04	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure	501	N												¥	-0.04	0.05	-0.00	NA	0.05	-0.03	0.02	0.02	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Center		E												¥	0.03	0.08	0.00	NA	0.07	-0.00	0.01	-0.06	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure	500	N												¥	-0.05	0.06	-0.01	NA	0.03	-0.02	-0.00	0.01	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
South		E												¥	0.03	0.05	-0.00	NA	0.06	0.03	0.01	-0.07	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Drilled Shaft Cap	700	N																		£	0.01	0.03	-0.01	-0.03	0.03	0.00	0.00	0.01	0.02	0.00	-0.00	0.01	0.07
North		E																		£	-0.00	-0.03	-0.01	0.03	0.00	0.01	0.03	-0.02	0.00	0.01	0.00	0.01	0.04
Drilled Shaft Cap	701	N																		£	-0.00	0.02	0.00	-0.04	0.03	-0.00	0.02	-0.00	0.01	0.01	-0.01	0.02	0.06
Center		E																		£	0.01	-0.04	-0.00	0.02	-0.00	0.02	0.02	-0.00	-0.01	0.03	-0.01	0.01	0.05
Drilled Shaft Cap	702	N																		£	0.01	0.01	0.01	-0.02	0.02	0.01	0.01	0.00	0.01	0.00	0.00	0.01	0.06
South		E																		£	0.01	-0.04	0.00	0.03	0.01	0.03	0.02	-0.00	0.03	0.00	0.00	0.01	0.10

* Monumentation damaged by earth moving operations.
‡ Monuments appear to have been displaced 6" along the bridge.
¥ First measurements taken 2/26/98
§ First measurements taken 10/15/98
¤ Net change is initial reading compared to the last compatible reading
£ First measurements taken 3/08/99
¥¥ No future shots will be taken due to anchor structure being buried

PIER SIDE COORDINATES

(Reference Point Locations on Sides of Piers)

Pier	Direction	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 5/96	REL 8/96	REL 1997	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06	REL 10/07
WEP North (Inside)	N	5162.58	5162.67	5162.69	5161.99	5162.66	-------	5161.00	5160.98	5160.96	5160.92	5160.94	5160.96	5160.89	5160.93	5160.93	5160.90	5160.89	5160.89	5160.88	5160.86	5160.89	5160.90	5160.90	5160.90	5160.91
	E	4879.46	4879.32	4879.17	4878.94	4879.23	-------	4884.16	4884.18	4884.26	4884.27	4884.27	4884.22	4884.30	4884.32	4884.29	4884.29	4884.29	4884.30	4884.33	4884.34	4884.29	4884.34	4884.34	4884.35	4884.38
WEP North (Outside)	N	-------	-------	5184.24	NA	5184.22	-------	5184.04	5184.03	5183.97	5183.98	5183.99	5183.94	5183.99	5184.01	5184.06	5184.06	5184.06	5184.04	5184.04	5184.03	5184.04	5184.03	5183.98	5184.03	5184.03
	E	-------	-------	4887.48	NA	4887.51	-------	4888.05	4888.09	4888.14	4888.16	4888.19	4888.24	4888.20	4888.19	4888.21	4888.23	4888.23	4888.25	4888.25	4888.28	4888.28	4888.26	4888.26	4888.28	4888.29
WEP South (Inside)	N	5088.80	5088.86	5088.87	5088.86	5088.85	-------	5076.56	5076.51	5076.53	5076.52	5076.50	5076.49	5076.53	5076.53	5076.49	5076.53	5076.51	5076.45	5076.42	5076.46	5076.45	5076.46	5076.43	5076.46	5076.46
	E	4854.36	4854.51	4854.43	4854.46	4854.43	-------	4857.97	4857.97	4857.98	4858.01	4858.02	4858.10	4858.02	4858.05	4858.00	4858.02	4858.03	4858.01	4858.02	4858.04	4858.03	4858.04	4858.05	4858.07	4858.08
WEP South (Outside)	N	-------	-------	5051.47	5051.45	5051.45	-------	5051.41	5051.37	5051.40	5051.38	5051.34	5051.40	NA	5051.37	5051.35	5051.34	5051.33	5051.32	5051.30	5051.33	5051.34	5051.33	5051.34	5051.34	5051.36
	E	-------	-------	4840.79	4840.84	4840.80	-------	4841.07	4841.08	4841.07	4841.08	4841.07	4841.04	NA	4841.10	4841.08	4841.08	4841.08	4841.08	4841.08	4841.12	4841.07	4841.09	4841.09	4841.11	4841.13
Pier 1 North (Inside)	N	-------	-------	5087.19	5087.15	5087.09	-------	5086.18	5086.17	5086.17	5086.14	5086.14	5086.16	§	§	5086.13	5086.09	5086.06	5086.08	5086.06	5086.06	5086.05	5086.07	5086.10	5086.08	5086.09
	E	-------	-------	5093.22	5093.16	5093.17	-------	5095.93	5095.94	5095.94	5096.01	5096.03	5096.01	§	§	5096.16	5096.15	5096.17	5096.16	5096.21	5096.20	5096.19	5096.23	5096.23	5096.22	5096.26
Pier 1 North (Outside)	N	-------	-------	5100.04	NA	5100.11	5100.12	5100.13	5100.13	5100.12	5100.13	5100.12	5100.06	5100.08	5100.09	5100.12	5100.06	5100.03	5100.09	5100.04	5099.98	5100.01	5099.99	5099.99	5099.99	5100.00
	E	-------	-------	5098.27	NA	5098.01	5098.03	5098.06	5098.08	5098.08	5098.11	5098.15	5098.22	5098.24	5098.24	5098.24	5098.25	5098.27	5098.30	5098.29	5098.31	5098.32	5098.31	5098.32	5098.33	5098.34
Pier 1 South (Inside)	N	5014.59	5014.57	5014.66	5014.61	5014.55	5014.59	5014.60	5014.61	5014.62	5014.61	5014.61	5014.56	§	§	5014.59	5014.53	5014.53	5014.54	5014.52	5014.53	5014.55	5014.55	5014.53	5014.56	5014.52
	E	5068.67	5068.93	5068.70	5068.68	5068.65	5068.68	5068.68	5068.70	5068.67	5068.70	5068.74	5068.78	§	§	5068.84	5068.87	5068.96	5068.94	5068.99	5069.04	5069.04	5069.01	5069.03	5069.02	5069.05
Pier 1 South (Outside)	N	-------	-------	5001.94	5001.90	5001.87	5001.89	5001.90	5001.87	5001.90	5001.86	5001.86	5001.91	5001.83	5001.84	5001.84	5001.83	5001.80	5001.82	5001.81	5001.81	5001.80	5001.81	5001.83	5001.86	5001.85
	E	-------	-------	5063.39	5063.42	5063.34	5063.39	5063.41	5063.42	5063.38	5063.43	5063.46	5063.42	5063.56	5063.58	5063.56	5063.61	5063.69	5063.69	5063.70	5063.74	5063.74	5063.76	5063.75	5063.78	5063.78
Pier 2 North (Inside)	N	4954.01	4953.99	4953.99	4953.97	4953.95	4953.95	4953.97	NA	4953.95	4953.95	¥	4953.96	4953.96	4953.93	4953.93	4953.92	4953.94	4953.96	4953.94	4953.94	4953.95	4953.96	4953.97	4953.98	4953.98
	E	5469.91	5470.01	5470.04	5469.99	5470.02	5470.03	5470.00	NA	5470.03	5470.03	¥	5469.96	5469.97	5470.05	5470.01	5470.01	5469.99	5469.99	5470.02	5470.00	5469.97	5469.97	5469.98	5469.97	5469.99
Pier 2 South (Inside)	N	4883.44	4883.44	4883.44	4883.46	4883.38	4883.39	4883.40	NA	4883.31	4883.37	‡	4883.33	4883.40	4883.35	4883.42	4883.44	4883.40	4883.37	4883.34	4883.37	4883.36	4883.35	4883.39	4883.38	4883.38
	E	5445.32	5445.45	5445.46	5445.41	5445.40	5445.40	5445.36	NA	5445.37	5445.39	‡	5445.45	5445.40	5445.50	5445.35	5445.37	5445.38	5445.41	5445.42	5445.40	5445.39	5445.41	5445.41	5445.40	5445.40

------- No reading taken (point not yet set).

NA Information not available.

¥ Points destroyed during construction. New points set

‡ Unable to shoot points due to rock piles next to piers

§ Shots were not taken due to heat tent for rock anchor placement procedure.

PIER TILT

(The difference between the coordinates of the points set on the pier seat and the points at the ground line using the first year measured as the zero point. A positive value indicates top tilt to the north or east. A negative value indicates top tilt to the south or west.)

Pier	Direction	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 8/96	REL 9/97	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06	REL 10/07
WEP North (Inside)	N	=====	-0.03	-0.05	0.66	-0.01	=====	0.03	0.03	0.06	0.06	0.02	0.08	0.07	0.10	0.12	0.10	0.10	0.08	0.14	0.09	0.08	0.09	0.07	0.07
	E	=====	0.14	0.32	0.55	0.24	=====	-0.00	-0.02	-0.00	0.04	0.11	0.03	0.00	0.01	0.01	0.04	0.02	0.01	0.03	0.05	0.02	0.04	0.05	0.04
WEP North (Outside)	N	=====	-------	=====	NA	0.03	=====	0.02	0.06	0.04	0.05	0.08	0.02	0.03	0.02	-0.00	-0.04	-0.02	-0.04	0.01	-0.02	-0.03	0.04	-0.03	-0.02
	E	=====	-------	=====	NA	-0.04	=====	-0.02	-0.01	-0.01	0.01	-0.02	0.01	0.02	-0.03	-0.04	-0.01	-0.03	-0.03	-0.03	-0.05	-0.02	0.02	0.01	0.02
WEP South (Inside)	N	=====	0.02	0.03	0.04	0.03	=====	0.01	0.02	0.02	0.03	0.05	-0.03	0.01	0.04	-0.02	-0.00	0.03	0.07	0.04	0.04	0.04	0.07	0.06	0.04
	E	=====	-0.16	-0.05	-0.08	-0.06	=====	0.02	0.02	0.00	0.02	-0.05	0.02	0.02	0.03	0.02	0.03	0.04	0.05	0.06	-0.01	0.01	0.04	0.04	0.04
WEP South (Outside)	N	=====	-------	=====	0.01	-0.01	=====	-0.01	-0.01	0.02	0.03	-0.01	NA	0.02	0.03	0.02	0.02	0.02	0.04	0.01	0.01	0.01	0.01	0.02	-0.02
	E	=====	-------	=====	-0.05	-0.02	=====	0.01	0.03	0.04	0.07	0.12	NA	0.07	0.05	0.07	0.09	0.08	0.10	0.08	0.06	0.06	0.10	0.10	0.10
Pier 1 North (Inside)	N	=====	-------	=====	0.01	0.03	=====	-0.00	0.00	0.02	0.03	0.02	NA	NA	0.04	0.09	0.06	0.06	0.09	0.07	0.09	0.11	0.05	0.08	0.09
	E	=====	-------	=====	0.06	0.06	=====	0.01	0.02	-0.04	-0.04	0.04	NA	NA	-0.03	-0.05	0.05	0.06	0.03	0.02	0.01	0.06	0.05	0.05	0.01
Pier 1 North (Outside)	N	=====	-------	=====	NA	-0.14	-0.11	-0.13	-0.12	-0.13	-0.13	-0.05	-0.08	-0.09	-0.13	-0.05	-0.08	-0.12	-0.06	-0.02	-0.04	0.02	-0.00	0.01	0.01
	E	=====	-------	=====	NA	0.27	0.26	0.25	0.26	0.24	0.22	0.21	0.26	0.26	0.27	0.24	0.33	0.30	0.33	0.30	0.27	0.35	0.35	0.33	0.31
Pier 1 South (Inside)	N	=====	0.10	0.05	0.07	0.11	0.09	0.06	0.06	0.07	0.05	0.15	NA	NA	0.12	0.16	0.20	0.18	0.22	0.24	0.21	0.23	0.24	0.23	0.26
	E	=====	-0.20	0.05	0.03	0.05	0.04	0.05	0.07	0.06	0.02	0.05	NA	NA	0.03	-0.03	0.05	0.17	0.17	0.08	0.09	0.16	0.16	0.16	0.14
Pier 1 South (Outside)	N	=====	-------	=====	0.01	0.02	0.02	0.04	0.02	0.05	0.04	0.02	0.09	0.09	0.10	0.09	0.16	0.14	0.17	0.20	0.19	0.21	0.19	0.16	0.17
	E	=====	-------	=====	-0.07	-0.01	-0.06	-0.03	-0.01	-0.04	-0.06	0.04	-0.07	-0.06	-0.06	-0.13	-0.04	0.06	0.10	0.01	0.03	0.05	0.08	0.04	0.04
Pier 2 North (Inside)	N	=====	0.04	0.03	0.07	0.03	0.01	NA	-0.01	0.03	NA	=====	0.03	0.06	0.06	0.06	0.03	0.00	0.04	0.02	0.04	0.04	0.01	0.02	0.03
	E	=====	-0.07	-0.08	-0.05	-0.04	-0.04	NA	-0.09	-0.05	NA	=====	-0.03	-0.12	-0.08	-0.06	-0.07	-0.07	-0.10	-0.12	-0.08	-0.04	-0.04	-0.05	-0.08
Pier 2 South (Inside)	N	=====	0.03	0.03	0.04	0.03	0.02	NA	0.10	0.07	NA	=====	-0.00	0.04	-0.03	-0.08	-0.03	-0.02	0.01	0.02	0.01	0.02	0.00	0.02	0.01
	E	=====	-0.11	-0.11	-0.08	-0.07	-0.03	NA	-0.05	-0.03	NA	=====	-0.04	-0.14	0.02	0.00	-0.02	-0.08	-0.06	-0.11	-0.07	-0.06	-0.06	-0.07	-0.07

------- No reading taken. (Point not set.)
===== First reading (Point set/reset)
NA Information Not Available

CHANGE IN PIER TILTS

(The change in tilts are difference between the coordinates and elevations of the points set on the pier seat and side of the pier. The first angle of compatible data is set to zero and compared to the preceding years A positive value indicates top tilt to the north or east. A negative value indicates top tilt to the south or west.)

Pier	Direction	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 8/96	REL 9/97	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06	REL 10/07
WEP North (Inside)	N	NA	NA	NA	NA	NA	0.00 º	0.01 º	0.00 º	0.01 º	0.01 º	0.00 º	0.01 º	0.01 º	0.02 º	0.02 º	0.02 º	0.02 º	0.01 º	0.02 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º
	E	NA	NA	NA	NA	NA	0.00 º	-0.00 º	-0.00 º	-0.00 º	0.01 º	0.02 º	0.00 º	0.00 º	0.00 º	0.00 º	0.01 º	0.00 º	0.00 º	0.00 º	0.01 º	0.00 º	0.01 º	0.01 º	0.01 º
WEP North (Outside)	N	NA	NA	NA	NA	NA	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	0.01 º	0.00 º	0.00 º	0.00 º	-0.00 º	-0.00 º	-0.00 º	-0.00 º	0.00 º	-0.00 º	-0.00 º	0.00 º	-0.00 º	-0.00 º
	E	NA	NA	NA	NA	NA	0.00 º	-0.00 º	-0.00 º	-0.00 º	0.00 º	-0.00 º	0.00 º	0.00 º	-0.00 º	-0.01 º	-0.00 º	-0.00 º	-0.00 º	-0.00 º	-0.01 º	-0.00 º	0.00 º	0.00 º	0.00 º
WEP South (Inside)	N	NA	NA	NA	NA	NA	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	0.01 º	-0.00 º	0.00 º	0.01 º	-0.00 º	-0.00 º	0.00 º	0.01 º	0.00 º	0.00 º	0.00 º	0.01 º	0.01 º	0.00 º
	E	NA	NA	NA	NA	NA	0.00 º	0.01 º	0.01 º	0.00 º	0.01 º	-0.03 º	0.01 º	0.01 º	0.02 º	0.01 º	0.02 º	0.03 º	0.03 º	0.03 º	-0.00 º	0.00 º	0.02 º	0.02 º	0.02 º
WEP South (Outside)	N	NA	NA	NA	NA	NA	0.00 º	-0.01 º	-0.01 º	0.02 º	0.05 º	-0.02 º	NA	0.03 º	0.05 º	0.03 º	0.03 º	0.02 º	0.05 º	0.02 º	0.01 º	0.02 º	0.01 º	0.04 º	-0.03 º
	E	NA	NA	NA	NA	NA	0.00 º	0.06 º	0.16 º	0.19 º	0.37 º	0.62 º	NA	0.36 º	0.26 º	0.36 º	0.45 º	0.41 º	0.52 º	0.42 º	0.32 º	0.29 º	0.52 º	0.50 º	0.52 º
Pier 1 North (Inside)	N	NA	NA	NA	0.00 º	0.01 º	0.63 º	0.63 º	0.63 º	0.64 º	0.65 º	0.64 º	NA	NA	0.65 º	0.69 º	0.67 º	0.67 º	0.68 º	0.68 º	0.68 º	0.70 º	0.66 º	0.68 º	0.69 º
	E	NA	NA	NA	NA	NA	0.00 º	0.00 º	0.01 º	-0.02 º	-0.02 º	0.03 º	NA	NA	-0.02 º	-0.03 º	0.03 º	0.03 º	0.02 º	0.01 º	0.01 º	0.03 º	0.03 º	0.03 º	0.00 º
Pier 1 North (Outside)	N	NA	NA	NA	NA	0.00 º	0.03 º	0.01 º	0.02 º	0.00 º	0.01 º	0.11 º	0.06 º	0.05 º	0.01 º	0.10 º	0.06 º	0.02 º	0.09 º	0.14 º	0.11 º	0.18 º	0.16 º	0.16 º	0.17 º
	E	NA	NA	NA	NA	0.00 º	-0.01 º	-0.01 º	-0.00 º	-0.02 º	-0.03 º	-0.03 º	-0.01 º	-0.00 º	0.00 º	-0.02 º	0.03 º	0.02 º	0.03 º	0.01 º	-0.00 º	0.04 º	0.04 º	0.03 º	0.02 º
Pier 1 South (Inside)	N	0.00 º	0.14 º	0.07 º	0.11 º	0.15 º	0.13 º	0.08 º	0.09 º	0.09 º	0.07 º	0.21 º	NA	NA	0.17 º	0.23 º	0.29 º	0.26 º	0.31 º	0.35 º	0.29 º	0.33 º	0.35 º	0.33 º	0.37 º
	E	0.00 º	-0.38 º	0.10 º	0.07 º	0.10 º	0.08 º	0.10 º	0.13 º	0.12 º	0.05 º	0.09 º	NA	NA	0.05 º	-0.06 º	0.10 º	0.33 º	0.32 º	0.15 º	0.18 º	0.31 º	0.32 º	0.31 º	0.27 º
Pier 1 South (Outside)	N	NA	NA	NA	0.00 º	0.01 º	0.01 º	0.02 º	0.00 º	0.03 º	0.02 º	0.01 º	0.06 º	0.06 º	0.07 º	0.06 º	0.11 º	0.10 º	0.12 º	0.14 º	0.13 º	0.15 º	0.13 º	0.11 º	0.12 º
	E	NA	NA	NA	0.00 º	0.16 º	0.03 º	0.11 º	0.16 º	0.08 º	0.03 º	0.29 º	0.01 º	0.04 º	0.03 º	-0.15 º	0.08 º	0.33 º	0.42 º	0.21 º	0.26 º	0.30 º	0.37 º	0.28 º	0.28 º
Pier 2 North (Inside)	N	0.00 º	0.00 º	0.00 º	0.01 º	0.00 º	0.00 º	NA	-0.00 º	0.00 º	NA	0.00 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º	0.01 º
	E	0.00 º	-0.08 º	-0.09 º	-0.05 º	-0.05 º	-0.05 º	NA	-0.10 º	-0.06 º	NA	0.00 º	-0.04 º	-0.15 º	-0.10 º	-0.08 º	-0.09 º	-0.09 º	-0.13 º	-0.15 º	-0.10 º	-0.05 º	-0.06 º	-0.07 º	-0.10 º
Pier 2 South (Inside)	N	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	NA	0.01 º	0.01 º	NA	0.00 º	-0.00 º	0.00 º	-0.00 º	-0.01 º	-0.00 º	-0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º	0.00 º
	E	0.00 º	-0.14 º	-0.14 º	-0.10 º	-0.09 º	-0.03 º	NA	-0.06 º	-0.04 º	NA	0.00 º	-0.07 º	-0.20 º	0.00 º	-0.02 º	-0.05 º	-0.13 º	-0.10 º	-0.16 º	-0.12 º	-0.10 º	-0.10 º	-0.11 º	-0.11 º

0.00 º	First reading (Tilt set/reset)
NA	Information Not Available

Richland Engineering Limited 10L017

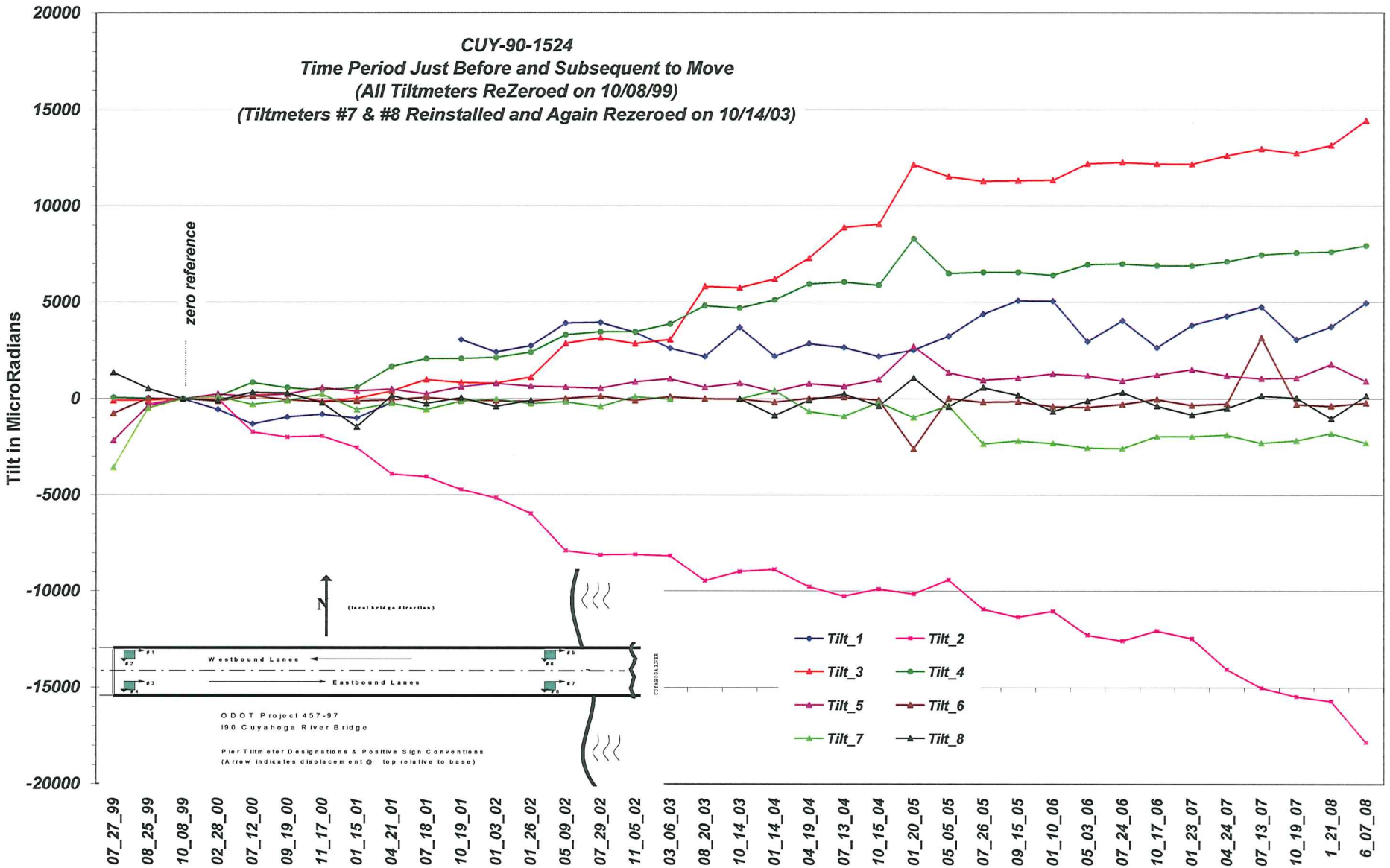
From: "arthur huckelbridge" <aah4@case.edu>
To: "'Richland Engineering Limited'" <reltd@r-e-l.com>
Sent: Monday, June 09, 2008 8:44 AM
Attach: tilts thru May 08.ppt
Subject: RE: Central Viaduct Monitoring

Dean:

I did finally get tiltmeter readings and they are attached. The drift in tiltmeters 2 and 3 continues in the same trend; the others are holding pretty steady, particularly over the past three years. The total accumulated change in tilt of around .015 radians recorded by tiltmeters 2 and 3 over the past 9 years would imply actual displacements of the west abutment at the level of the bridge deck ("northward" for tiltmeter 2 on the northern pier and "eastward" for tiltmeter 3 on the southern pier) of several inches, which I presume are not apparent in that magnitude. I can only conclude that some of this recorded drift must be electrical in nature, which makes interpretation of that data problematic.

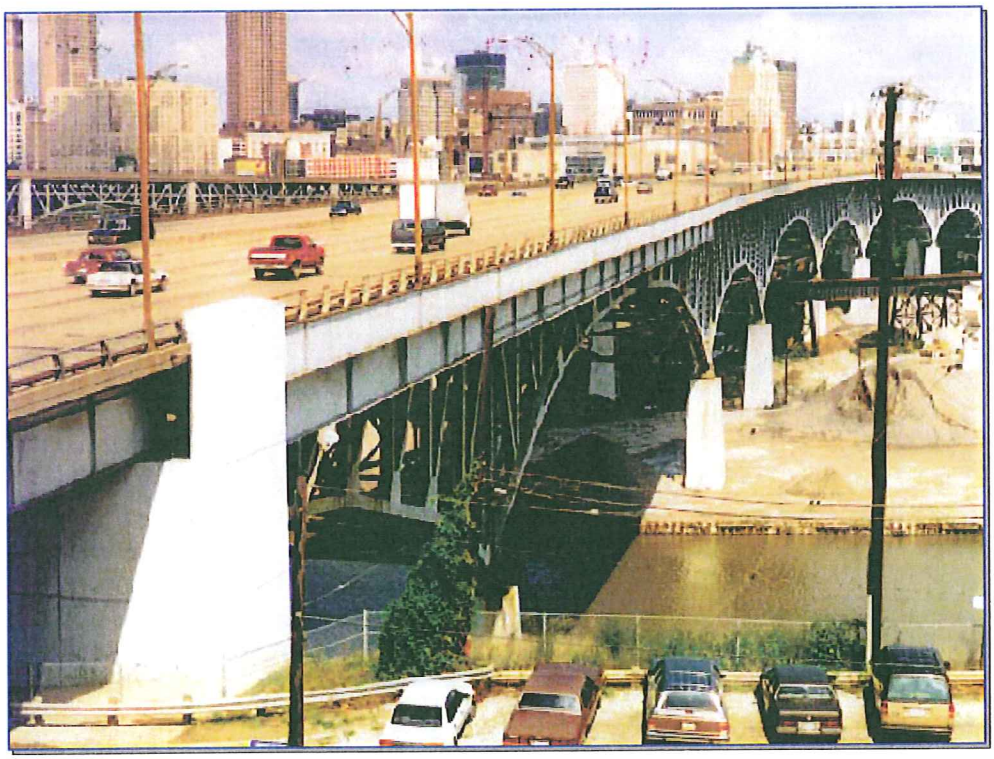
Let me know if you have questions. Is there enough concern about the west abutment movement to consider installing "backup" tiltmeters, particularly for 2 & 3 ?

Art


CUY-90-1524
Time Period Just Before and Subsequent to Move
(All Tiltmeters ReZeroed on 10/08/99)
(Tiltmeters #7 & #8 Reinstalled and Again Rezeroed on 10/14/03)
Tilt in MicroRadians
zero reference
20000
15000
10000
5000
0
-5000
-10000
-15000
-20000
07_27_99
08_25_99
10_08_99
02_28_00
07_12_00
09_19_00
11_17_00
01_15_01
04_21_01
07_18_01
10_19_01
01_03_02
01_26_02
05_09_02
07_29_02
11_05_02
03_06_03
08_20_03
10_14_03
01_14_04
04_19_04
07_13_04
10_15_04
01_20_05
05_05_05
07_26_05
09_15_05
01_10_06
05_03_06
07_24_06
10_17_06
01_23_07
04_24_07
07_13_07
10_19_07
1_21_08
6_07_08
Tilt_1
Tilt_2
Tilt_3
Tilt_4
Tilt_5
Tilt_6
Tilt_7
Tilt_8
N
(local bridge direction)
Westbound Lanes
Eastbound Lanes
#1
#2
#3
#4
#5
#6
#7
#8
ODOT Project 457-97
I90 Cuyahoga River Bridge
Pier Tiltmeter Designations & Positive Sign Conventions
(Arrow indicates displacement @ top relative to base)

LONG TERM MONITORING AT CUY-90-15.24 BRIDGE PROJECT

Annual Report for Year 2007-2008



Robert Y. Liang

May 2008

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I. Introduction

This is an Annual Report on the monitoring results of the stabilization structures at the CUY-90-15.24 west end slope for the period between 4/11/2007 and 5/13/2008. The strain gages and slope inclinometers (SI) previously installed in the stabilization structures between 1997 and 1999 have been monitored continuously. Since the beginning of the monitoring, quarterly reports and annual reports have been submitted to document the monitoring results. For the purpose of completeness and for a better perspective, the presentation of the monitored and deduced data in this report covers the period from the beginning of monitoring to the last reading taken in May 2008.

The plane view of the general layout of the stabilization structures is shown in Fig. 1. A total of five tie-beams (#1, #12, #13, #14, and #26) were instrumented with strain gages at both ends of the beams, as shown in Fig. 2. The gage numbering system is indicated in Fig. 2 as well. A total of five driven piles (#1, #17, #18, #19, and #34) were each instrumented with four strain gages near the top of the pile, as shown in Fig. 3. Rock anchors #1, #8, #9, and #17 were each instrumented with a load cell at the anchor head. Finally, drilled shafts #1 and #9 were instrumented with sister-bar type of strain gages. The locations of these strain gages along the length of the drilled shafts and the gage designation numbers are presented in Fig. 4 and Fig. 5 for shaft #9 and shaft #1, respectively. Furthermore, drilled shafts #1, #3, #8, #9, #10, and #17, shown in Fig. 6, were each embedded with slope inclinometer casings for monitoring shafts deflections.

II. Monitoring Results

II.1 Rock Anchors:

The recorded numerical values of load cells at the anchor heads are summarized in Table 1. Also, the load versus time plot for each anchor is shown in Fig. 7. Between 4/2007 and 5/2008, the anchor loads for all monitored anchors (except for anchor #9) appeared to exhibit slight decrease from a long-term perspective. However, the rate of decrease was very small.

II.2 Tie-Beams:

The strain readings from the gages in the tie-beams have been converted into axial forces and bending moments at the locations near the driven pile cap side and near the drilled shaft cap side, and they are summarized in Table 2 and Table 3, respectively. The plots of the axial force versus time for five monitored tie-beams are presented in Fig. 8 and Fig. 9 for the drilled shaft cap side and the driven pile cap side, respectively. The average axial forces of all five monitored tie-beams on the pile cap side and the drilled shaft cap side are plotted respectively in Fig. 10. The average axial forces of the five tie-beams appeared to oscillate within a small range.

The major bending moments for each of the five monitored tie-beams are shown in Fig. 11 and Fig. 12 for the pile cap side and drilled shaft cap side, respectively. The average bending moments for all five monitored tie-beams for the drilled shaft side and the pile cap side are shown in Fig. 13. These average bending moments on both sides of the tie-beams appeared to be fairly constant during the past year.

II.3 Driven Piles:

The strain readings from the strain gages on the driven piles are converted into the bending moments and axial forces for each of the five monitored driven piles and are summarized in Table 4. The axial forces versus time and the major bending moments versus time for each monitored pile are plotted in Fig. 14 and Fig. 15, respectively. Within the past year, there was little change in the axial force and bending moment in the driven piles.

II.4 Drilled Shafts:

The bending moments in the drilled shaft #9 at different elevations are shown in Fig. 16. It can be seen that the moments have been increasing over time, especially at the depth of 95 ft below the cap top. However, the rate of change has remained constant. The bending moments in the drilled shaft #1 at different elevations are shown in Fig. 17. Please note that the bending moments shown in Fig. 17 are smaller than those shown in Fig. 16, due to the fact that the moments measured in shaft #9 (Fig. 16) are in the major bending direction, while the moments measured in shaft #1 are in the direction 90° from the major bending direction.

The distribution of bending moments along the depth of the drilled shafts is depicted in Fig. 18 and Fig. 19 for shaft #9 and shaft #1, respectively. Again, keep in mind that the moment direction in shaft #1 and shaft #9 is different, as noted previously in Fig. 16.

II.5 Slope Inclinometer reading:

Four separate inclinometer readings were taken over the last year for all six slope inclinometer casings embedded in the drilled shafts. It is noted that inclinometer casing 9B was blocked and no longer readable. The incremental and cumulative deflection plots for each inclinometer casing in the A-direction (toward river direction) are presented in Figs. 20 to 25. There was no significant movement during this monitoring period.

III. Concluding Remark

Based on examinations of the monitored data collected over the last year, the stabilization structures in the slope seemed to experience fairly steady state of forces and moments. There was no observed sudden big jump in the monitored data. It should be noted that the bending moment at the drilled shaft # 9 near 95 ft below the ground is very high and continue to show a slow rate of increase. Also, the axial forces in the driven piles, although remained steady, are near the design geotechnical axial capacity of the piles. Therefore, continuing monitoring of these slope stabilization structures, the ground movements, and the behavior of the superstructures, is recommended.

Table 1 Numerical reading of anchor load as a function of time for anchors #1, #8, #9 and #17

Date	Anchor #1 Load, kips	Anchor #8 Load, kips	Anchor #9 Load, kips	Anchor #17 Load, kips	Comment
4/7/1999		560			
4/8/1999	489			499	Anchor Lock off
4/14/1999	460	473	596 (Lock off)	461	
5/7/1999	452	473	572	445	End of construction
7/1/1999	446	468	564	439	
10/1/1999	441	467	560	440	
1/1/2000	439	461	555	424	
4/1/2000	432	453	546	414	
7/1/2000	431	451	521	415	
10/1/2000	431	451	519	416	
1/1/2001	430	455	517	400	
4/1/2001	421	443	513	397	
7/1/2001	422	443	510	399	
10/1/2001	425	445	512	403	
1/1/2002	424	444	511	398	
4/1/2002	421	440	508	386	
7/1/2002	419	439	506	391	
10/1/2002	423	442	508	396	
1/1/2003	423	435	508	389	
4/15/2003	416	427	501	380	
8/7/2003	416	428	503	384	
10/7/2003	418	429	504	387	
12/31/2003	417	426	503	378	
4/13/2004	408	418	494	370	
7/13/2004	409	419	494	374	
10/8/2004	411	422	496	377	
1/7/2005	411	421	495	374	
4/8/2005	407	414	485	366	
7/18/2005	407	415	485	370	
11/12/2005	410	419	489	374	
1/10/2006	409	417	487	369	
4/9/2006	399	411	487	365	
7/19/2006	399	412	487	368	
10/18/2006	407.3	414.8	489.6	371.7	
1/18/2007	405	412	487	366	
4/19/2007	401	406	501	361	
7/9/2007	401	408	502	365	
10/20/2007	404	411	506	369	
1/7/2008	403	410	504	364	
5/13/2008	397	403	497	359	

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
1	7/1/1999	-47.1	68.5	551.7	681.8	313.73	10.70	616.75	252.30	375.15	83.06	-40.28	-2.75
	7/15/1999	-70.1	53.8	538.8	666.8	297.33	-8.15	602.80	234.35	360.30	78.72	-40.60	-2.82
	8/15/1999	10.7	114.3	613.7	728.1	366.70	62.50	670.90	312.20	421.20	97.09	-40.43	-2.44
	8/31/1999	12.0	114.3	617.3	732.8	369.10	63.15	675.05	314.65	423.55	97.73	-40.67	-2.44
	9/15/1999	13.1	113.5	619.7	737.5	370.95	63.30	678.60	316.40	425.50	98.22	-40.89	-2.44
	9/30/1999	29.6	122.3	634.4	753.4	384.93	75.95	693.90	332.00	437.85	101.92	-41.07	-2.37
	10/15/1999	34.7	123.9	637.8	757.9	388.58	79.30	697.85	336.25	440.90	102.88	-41.11	-2.34
	10/31/1999	39.8	127.2	646.6	762	393.90	83.50	704.30	343.20	444.60	104.29	-41.26	-2.27
	11/15/1999	62.3	139.3	662.9	780.1	411.15	100.80	721.50	362.60	459.70	108.86	-41.25	-2.18
	11/30/1999	73.7	146.3	670.6	788.6	419.80	110.00	729.60	372.15	467.45	111.15	-41.18	-2.13
	12/15/1999	72.8	143.6	668.9	789.7	418.75	108.20	729.30	370.85	466.65	110.87	-41.28	-2.15
	12/31/1999	88.8	152.1	680.1	802.5	430.88	120.45	741.30	384.45	477.30	114.08	-41.26	-2.08
	3/31/2000	95.3	158.7	682.5	825.2	440.43	127.00	753.85	388.90	491.95	116.61	-41.66	-2.31
	6/30/2000	60.2	138.2	662.7	804.5	416.40	99.20	733.60	361.45	471.35	110.25	-42.16	-2.46
	9/30/2000	50.1	142.5	668.8	795.7	414.28	96.30	732.25	359.45	469.10	109.69	-42.26	-2.46
	1/13/2001	109.5	179.9	712.3	845.5	461.80	144.70	778.90	410.90	512.70	122.27	-42.15	-2.28
	4/20/2001	126.8	283.2	715.3	881.9	501.80	205.00	798.60	421.05	582.55	132.86	-39.45	-3.62
	7/16/2001	68.3	149.8	674.3	837.1	432.38	109.05	755.70	371.30	493.45	114.48	-42.98	-2.74
	10/9/2001	71.4	157.1	685.5	840.8	438.70	114.25	763.15	378.45	498.95	116.15	-43.12	-2.70
	1/9/2002	102.7	177.8	713	872	466.38	140.25	792.50	407.85	524.90	123.48	-43.35	-2.62
	4/12/2002	125.5	192.8	738.6	904.9	490.45	159.15	821.75	432.05	548.85	129.86	-44.04	-2.62
	7/18/2002	62.3	151.8	706.334	859.6	445.01	107.05	782.97	384.32	505.70	117.82	-44.92	-2.72
	10/8/2002	43.7	151.1	711.3	846.7	438.20	97.40	779.00	377.50	498.90	116.02	-45.30	-2.72
	1/8/2003	84.7	180.5	748.5	891.8	476.38	132.60	820.15	416.60	536.15	126.13	-45.69	-2.68
	4/15/2003	96.1	191.9	739.9	989.3	504.30	144.00	864.60	418.00	590.60	133.52	-47.89	-3.87
	7/1/2003	57.4	168	713	959	474.35	112.70	836.00	385.20	563.50	125.59	-48.07	-3.99
	10/7/2003	42.1	166.8	714	946.6	467.38	104.45	830.30	378.05	556.70	123.75	-48.24	-4.00
	12/31/2003	80	197.9	753.9	985.1	504.23	138.95	869.50	416.95	591.50	133.50	-48.55	-3.91
	4/13/2004	92	208.9	760.4	1006.6	516.98	150.45	883.50	426.20	607.75	136.88	-48.72	-4.07
	7/13/2004	14.6	163.9	707.3	954.4	460.05	89.25	830.85	360.95	559.15	121.81	-49.29	-4.44
	10/8/2004	-8.6	233.4	704.6	941	467.60	112.40	822.80	348.00	587.20	123.81	-47.21	-5.36
	1/7/2005	19.5	190.4	746.5	982.5	484.73	104.95	864.50	383.00	586.45	128.34	-50.48	-4.56
	4/8/2005	3.4	397.6	751.6	1003.4	539.00	200.50	877.50	377.50	700.50	142.71	-44.99	-7.24
	7/18/2005	3.1	164.3	709.7	969.6	461.68	83.70	839.65	356.40	566.95	122.24	-50.24	-4.72
	8/26/2005	3.1	157.5	702.5	956.3	454.85	80.30	829.40	352.80	556.90	120.43	-49.78	-4.57
	10/11/2005	3.1	164.2	712.6	960.1	460.00	83.65	836.35	357.85	562.15	121.79	-50.02	-4.58
	1/10/2006	3.1	191.9	742.5	997	483.63	97.50	869.75	372.80	594.45	128.05	-51.32	-4.97
	4/9/2006	3.5	205.3	750.7	1018.8	494.58	104.40	884.75	377.10	612.05	130.95	-51.86	-5.26
	7/19/2006	3.5	166.6	703.7	975.5	462.33	85.05	839.60	353.60	571.05	122.41	-50.15	-4.87
	10/18/2006	3.5	170.2	709	967.5	462.55	86.85	838.25	356.25	568.85	122.47	-49.94	-4.76
	1/18/2007	3.5	209.1	748.7	1013.1	493.60	106.30	880.90	376.10	611.10	130.69	-51.48	-5.26
	4/19/2007	3.5	216.6	743.7	1021.2	496.25	110.05	882.45	373.60	618.90	131.39	-51.33	-5.50
	7/11/2007	3.5	169.6	700.9	981.6	463.90	86.55	841.25	352.20	575.60	122.83	-50.16	-5.00
	10/20/2007	3.5	163.4	696	963.7	456.65	83.45	829.85	349.75	563.55	120.91	-49.60	-4.79
	1/7/2008	3.5	193.1	730.4	1002.9	482.48	98.30	866.65	366.95	598.00	127.74	-51.06	-5.18
	5/13/2008	3.5	202	734.4	1020.9	490.20	102.75	877.65	368.95	611.45	129.79	-51.50	-5.43

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
12	7/1/1999	374.9	6	549.6	471.8	350.58	190.45	510.70	462.25	238.90	92.82	-21.28	5.00
	7/15/1999	368.6	-3.6	544.2	467.3	344.13	182.50	505.75	456.40	231.85	91.11	-21.48	5.03
	8/15/1999	373.7	0.2	569.4	485.2	357.13	186.95	527.30	471.55	242.70	94.56	-22.62	5.13
	8/31/1999	368.4	-4.7	567	486.2	354.23	181.85	526.60	467.70	240.75	93.79	-22.91	5.08
	9/15/1999	365.9	-9.2	565.3	485.1	351.78	178.35	525.20	465.60	237.95	93.14	-23.05	5.10
	9/30/1999	364.6	-11.7	570.1	487.6	352.65	176.45	528.85	467.35	237.95	93.37	-23.42	5.14
	10/15/1999	361.7	-14.8	569.9	487.4	351.05	173.45	528.65	465.80	236.30	92.95	-23.61	5.14
	10/31/1999	362.8	-13.5	575.6	493.1	354.50	174.65	534.35	469.20	239.80	93.86	-23.91	5.14
	11/15/1999	365.0	-11.5	581.4	498	358.23	176.75	539.70	473.20	243.25	94.85	-24.12	5.15
	11/30/1999	365.6	-11.8	583.7	500.1	359.40	176.90	541.90	474.65	244.15	95.16	-24.26	5.16
	12/15/1999	368.0	-9.2	589.7	504.2	363.18	179.40	546.95	478.85	247.50	96.16	-24.43	5.18
	12/31/1999	369.0	-8	592.9	506.6	365.13	180.50	549.75	480.95	249.30	96.67	-24.54	5.19
	3/31/2000	379.6	7.3	617	524.1	382.00	193.45	570.55	498.30	265.70	101.14	-25.06	5.21
	6/30/2000	376.1	4.4	608.9	519.1	377.13	190.25	564.00	492.50	261.75	99.85	-24.84	5.17
	9/30/2000	360.7	-12.3	588.3	503.5	360.05	174.20	545.90	474.50	245.60	95.33	-24.70	5.13
	1/13/2001	372.1	2.2	618.1	526.1	379.63	187.15	572.10	495.10	264.15	100.51	-25.58	5.17
	4/20/2001	387.6	21	645.8	549.2	400.90	204.30	597.50	516.70	285.10	106.15	-26.13	5.19
	7/16/2001	374.6	6.5	621.5	532.9	383.88	190.55	577.20	498.05	269.70	101.64	-25.70	5.12
	10/9/2001	360.9	-9.4	598.9	515.8	366.55	175.75	557.35	479.90	253.20	97.05	-25.36	5.08
	1/9/2002	363.5	-2.5	611.5	524.5	374.25	180.50	568.00	487.50	261.00	99.09	-25.75	5.07
	4/12/2002	381.7	16.9	642.7	550.5	397.95	199.30	596.60	512.20	283.70	105.37	-26.40	5.12
	7/18/2002	375	10.5	629	544.7	389.80	192.75	586.85	502.00	277.60	103.21	-26.19	5.03
	10/8/2002	357.7	-9.6	599.2	523	367.58	174.05	561.10	478.45	256.70	97.32	-25.72	4.97
	1/8/2003	367.3	6.5	626.7	542.7	385.80	186.90	584.70	497.00	274.60	102.15	-26.44	4.98
	4/15/2003	385.9	27.3	655.3	566.2	408.68	206.60	610.75	520.60	296.75	108.20	-26.86	5.01
	7/1/2003	384.7	26.3	649.2	565.6	406.45	205.50	607.40	516.95	295.95	107.62	-26.71	4.95
	10/7/2003	360.6	3.5	613	539.7	379.20	182.05	576.35	486.80	271.60	100.40	-26.20	4.82
	12/31/2003	372	19.4	636	558.3	396.43	195.70	597.15	504.00	288.85	104.96	-26.68	4.82
	4/13/2004	389.4	39.8	665.5	583.1	419.45	214.60	624.30	527.45	311.45	111.06	-27.23	4.84
	7/13/2004	379.5	27.7	643.3	571.1	405.40	203.60	607.20	511.40	299.40	107.34	-26.82	4.75
	10/8/2004	361.6	10.3	615.2	550.9	384.50	185.95	583.05	488.40	280.60	101.80	-26.39	4.66
	1/7/2005	367.5	16.1	630.6	561.5	393.93	191.80	596.05	499.05	288.80	104.30	-26.87	4.71
	4/8/2005	388.2	35.6	662.3	587.2	418.33	211.90	624.75	525.25	311.40	110.76	-27.44	4.79
	7/18/2005	382.6	26.3	647.7	580.1	409.18	204.45	613.90	515.15	303.20	108.34	-27.21	4.75
	8/26/2005	373.6	15.7	629.8	566.8	396.48	194.65	598.30	501.70	291.25	104.97	-26.83	4.71
	10/11/2005	365.9	6.1	617.8	557.9	386.93	186.00	587.85	491.85	282.00	102.45	-26.71	4.70
	1/10/2006	376.2	17.5	639	572.2	401.23	196.85	605.60	507.60	294.85	106.23	-27.16	4.77
	4/9/2006	393.8	32.7	665.7	594	421.55	213.25	629.85	529.75	313.35	111.61	-27.69	4.85
	7/19/2006	384.2	20.3	646.2	582.7	408.35	202.25	614.45	515.20	301.50	108.12	-27.39	4.79
	10/18/2006	365	-2	614.4	558.2	383.90	181.50	586.30	489.70	278.10	101.65	-26.90	4.74
	1/18/2007	376	9.6	635.9	573.9	398.85	192.80	604.90	505.95	291.75	105.60	-27.39	4.80
	4/19/2007	390.7	24.1	659.3	592.7	416.70	207.40	626.00	525.00	308.40	110.33	-27.82	4.85
	7/11/2007	384.1	15	644.6	584.6	407.08	199.55	614.60	514.35	299.80	107.78	-27.58	4.81
	10/20/2007	363.7	-9.6	611.5	560.6	381.55	177.05	586.05	487.60	275.50	101.02	-27.18	4.75
	1/7/2008	371.2	-2.9	625.1	569.7	390.78	184.15	597.40	498.15	283.40	103.47	-27.46	4.81
	5/13/2008	391.2	11.9	651.1	592.9	411.78	201.55	622.00	521.15	302.40	109.03	-27.94	4.90

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
13	7/1/1999	306.3	72.2	490.8	675.2	386.13	189.25	583.00	398.55	373.70	102.23	-26.17	0.56
	7/15/1999	288.0	53.1	484.2	670.6	373.98	170.55	577.40	386.10	361.85	99.02	-27.04	0.54
	8/15/1999	280.9	61.8	506.3	693.7	385.68	171.35	600.00	393.60	377.75	102.12	-28.49	0.36
	8/31/1999	270.4	52.1	503.1	691.4	379.25	161.25	597.25	386.75	371.75	100.41	-28.98	0.34
	9/15/1999	261.3	43.9	501.2	689.9	374.08	152.60	595.55	381.25	366.90	99.04	-29.44	0.32
	9/30/1999	257.1	40.7	503.1	690.7	372.90	148.90	596.90	380.10	365.70	98.73	-29.77	0.32
	10/15/1999	250.1	33.8	501.2	691	369.03	141.95	596.10	375.65	362.40	97.71	-30.18	0.30
	10/31/1999	251.4	38	507.6	697.6	373.65	144.70	602.60	379.50	367.80	98.93	-30.43	0.26
	11/15/1999	253.9	41.6	512.1	701.9	377.38	147.75	607.00	383.00	371.75	99.92	-30.52	0.25
	11/30/1999	253.5	41.2	513.6	704.4	378.18	147.35	609.00	383.55	372.80	100.13	-30.68	0.24
	12/15/1999	255.8	46.7	519.1	709.3	382.73	151.25	614.20	387.45	378.00	101.33	-30.77	0.21
	12/31/1999	256.7	48.9	522.3	712.4	385.08	152.80	617.35	389.50	380.65	101.96	-30.87	0.20
	3/31/2000	267.5	64.6	542.8	734.2	402.28	166.05	638.50	405.15	399.40	106.51	-31.40	0.13
	6/30/2000	258.9	46.4	531.2	726.1	390.65	152.65	628.65	395.05	386.25	103.43	-31.63	0.20
	9/30/2000	237.1	10.1	504.9	705.9	364.50	123.60	605.40	371.00	358.00	96.51	-32.02	0.29
	1/13/2001	254.0	40.9	535.1	734.6	391.15	147.45	634.85	394.55	387.75	103.56	-32.39	0.15
	4/20/2001	275.4	72.6	561.4	763.7	418.28	174.00	662.55	418.40	418.15	110.75	-32.47	0.01
	7/16/2001	255.3	37.7	534.8	740.9	392.18	146.50	637.85	395.05	389.30	103.84	-32.65	0.13
	10/9/2001	235.7	7.5	510.6	719.6	368.35	121.60	615.10	373.15	363.55	97.53	-32.80	0.22
	1/9/2002	240	18.9	523.3	731	378.30	129.45	627.15	381.65	374.95	100.16	-33.08	0.15
	4/12/2002	263.4	58.5	554.8	763	409.93	160.95	658.90	409.10	410.75	108.54	-33.09	-0.04
	7/18/2002	255.5	40.1	566.1	754.5	404.05	147.80	660.30	410.80	397.30	106.98	-34.06	0.30
	10/8/2002	231.2	3.4	508.7	726.1	367.35	117.30	617.40	369.95	364.75	97.26	-33.24	0.12
	1/8/2003	249.4	38.5	540.1	754.4	395.60	143.95	647.25	394.75	396.45	104.74	-33.45	-0.04
	4/15/2003	276.4	78.5	571.6	784.9	427.85	177.45	678.25	424.00	431.70	113.28	-33.28	-0.17
	7/1/2003	273	69	561.4	779.9	420.83	171.00	670.65	417.20	424.45	111.42	-33.21	-0.16
	10/7/2003	246.6	22.5	524.7	744.6	384.60	134.55	634.65	385.65	383.55	101.83	-33.24	0.05
	12/31/2003	264.8	58.9	552.8	770.1	411.65	161.85	661.45	408.80	414.50	108.99	-33.20	-0.13
	4/13/2004	291.3	97.7	584	803.2	444.05	194.50	693.60	437.65	450.45	117.57	-33.17	-0.29
	7/13/2004	275.5	64.3	556.1	781	419.23	169.90	668.55	415.80	422.65	111.00	-33.14	-0.15
	10/8/2004	252.8	29.9	527.5	755.8	391.50	141.35	641.65	390.15	392.85	103.66	-33.25	-0.06
	1/7/2005	264	50.8	544.5	770.6	407.48	157.40	657.55	404.25	410.70	107.89	-33.24	-0.14
	4/8/2005	289.9	90.7	576	802	439.65	190.30	689.00	432.95	446.35	116.41	-33.14	-0.30
	7/18/2005	277.8	67.7	556.4	787.1	422.25	172.75	671.75	417.10	427.40	111.80	-33.16	-0.23
	8/26/2005	266.7	46.5	539.8	771.9	406.23	156.60	655.85	403.25	409.20	107.56	-33.18	-0.13
	10/11/2005	257.2	33.8	526.8	760.8	394.65	145.50	643.80	392.00	397.30	104.49	-33.12	-0.12
	1/10/2006	269.3	59.9	551.2	780.4	415.20	164.60	665.80	410.25	420.15	109.93	-33.31	-0.22
	4/9/2006	289.9	90	576.3	806.2	440.60	189.95	691.25	433.10	448.10	116.66	-33.32	-0.34
	7/19/2006	277.7	63.9	553.8	787.8	420.80	170.80	670.80	415.75	425.85	111.42	-33.23	-0.23
	10/18/2006	253.3	27.9	523.7	757.8	390.68	140.60	640.75	388.50	392.85	103.44	-33.24	-0.10
	1/18/2007	267.4	54.9	546.5	778.5	411.83	161.15	662.50	406.95	416.70	109.04	-33.32	-0.22
	4/19/2007	289	88.7	575.1	806.8	439.90	188.85	690.95	432.05	447.75	116.47	-33.37	-0.35
	7/11/2007	280	67	558	793.6	424.65	173.50	675.80	419.00	430.30	112.43	-33.38	-0.25
	10/20/2007	255.4	29.1	525	763.8	393.33	142.25	644.40	390.20	396.45	104.14	-33.37	-0.14
	1/7/2008	265.4	49.2	542.8	778	408.85	157.30	660.40	404.10	413.60	108.25	-33.44	-0.21
	5/13/2008	288	84.3	573.8	809.8	438.98	186.15	691.80	430.90	447.05	116.23	-33.60	-0.36

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
14	7/1/1999	445.4	53.9	802	298.7	400.00	249.65	550.35	623.70	176.30	105.91	-19.98	10.02
	7/15/1999	440.5	34.4	799.5	280.7	388.78	237.45	540.10	620.00	157.55	102.94	-20.11	10.36
	8/15/1999	455.6	40.8	837.6	284.6	404.65	248.20	561.10	646.60	162.70	107.14	-20.79	10.84
	8/31/1999	452.7	30.7	837.1	274.1	398.65	241.70	555.60	644.90	152.40	105.55	-20.86	11.03
	9/15/1999	448.5	21.7	836.8	266.2	393.30	235.10	551.50	642.65	143.95	104.13	-21.03	11.17
	9/30/1999	447.0	16.1	838.5	260.8	390.60	231.55	549.65	642.75	138.45	103.42	-21.14	11.30
	10/15/1999	446.5	8.8	839.3	255.1	387.43	227.65	547.20	642.90	131.95	102.58	-21.24	11.45
	10/31/1999	450.9	11.7	847.9	257.8	392.08	231.30	552.85	649.40	134.75	103.81	-21.37	11.53
	11/15/1999	455.9	16.1	856.2	259.8	397.00	236.00	558.00	656.05	137.95	105.11	-21.40	11.61
	11/30/1999	456.3	15.5	858.3	259	397.28	235.90	558.65	657.30	137.25	105.19	-21.45	11.65
	12/15/1999	461.3	20.5	865.6	261.7	402.28	240.90	563.65	663.45	141.10	106.51	-21.45	11.70
	12/31/1999	463.4	22.5	871.6	262.9	405.10	242.95	567.25	667.50	142.70	107.26	-21.55	11.76
	3/31/2000	477.8	35.6	903.8	282.7	424.98	256.70	593.25	690.80	159.15	112.52	-22.37	11.91
	6/30/2000	469.2	17.4	889.7	267.4	410.93	243.30	578.55	679.45	142.40	108.80	-22.28	12.03
	9/30/2000	453.5	-23.5	856.8	240.4	381.80	215.00	548.60	655.15	108.45	101.09	-22.17	12.25
	1/13/2001	476.9	5	891.3	257.6	407.70	240.95	574.45	684.10	131.30	107.95	-22.16	12.38
	4/20/2001	494.8	40.8	932.8	281.2	437.40	267.80	607.00	713.80	161.00	115.81	-22.54	12.38
	7/16/2001	475.7	4.9	900.7	255.9	409.30	240.30	578.30	688.20	130.40	108.37	-22.46	12.50
	10/9/2001	459.3	-30.8	870.4	236.8	383.93	214.25	553.60	664.85	103.00	101.65	-22.55	12.59
	1/9/2002	468.8	-18.5	883.7	241.5	393.88	225.15	562.60	676.25	111.50	104.29	-22.43	12.65
	4/12/2002	492.8	22.5	926.5	270.2	428.00	257.65	598.35	709.65	146.35	113.32	-22.64	12.62
	7/18/2002	483.5	3.8	911.9	257.3	414.13	243.65	584.60	697.70	130.55	109.65	-22.66	12.71
	10/8/2002	462.7	-35	875.6	233	384.08	213.85	554.30	669.15	99.00	101.69	-22.63	12.77
	1/8/2003	485.5	2.5	912.6	253.9	413.63	244.00	583.25	699.05	128.20	109.52	-22.55	12.79
	4/15/2003	501.9	612.9	952.7	285.1	588.15	557.40	618.90	727.30	449.00	155.72	-4.09	6.23
	7/1/2003	521.6	28.8	943.4	278.1	442.98	275.20	610.75	732.50	153.45	117.29	-22.30	12.97
	10/7/2003	472.3	-16.5	903.8	247.5	401.78	227.90	575.65	688.05	115.50	106.38	-23.11	12.83
	12/31/2003	495.5	18.6	939.3	268.7	430.53	257.05	604.00	717.40	143.65	113.99	-23.06	12.85
	4/13/2004	504.6	68.9	989	299.2	465.43	286.75	644.10	746.80	184.05	123.23	-23.75	12.61
	7/13/2004	487.3	36.7	961.8	277.7	440.88	262.00	619.75	724.55	157.20	116.73	-23.78	12.71
	10/8/2004	468.9	-0.5	928.8	256.4	413.40	234.20	592.60	698.85	127.95	109.46	-23.82	12.79
	1/7/2005	485.2	21.4	952.7	269.7	432.25	253.30	611.20	718.95	145.55	114.45	-23.79	12.85
	4/8/2005	512.9	68.8	998.7	302.5	470.73	290.85	650.60	755.80	185.65	124.63	-23.91	12.77
	7/18/2005	498.2	40	977.1	286.8	450.53	269.10	631.95	737.65	163.40	119.29	-24.11	12.86
	8/26/2005	486.3	17.1	955.5	271.8	432.68	251.70	613.65	720.90	144.45	114.56	-24.05	12.91
	10/11/2005	478.8	2.4	942.6	263.6	421.85	240.60	603.10	710.70	133.00	111.69	-24.09	12.94
	1/10/2006	497.9	28.2	970.6	280.6	444.33	263.05	625.60	734.25	154.40	117.64	-24.09	12.99
	4/9/2006	519.6	65.1	1008.9	306	474.90	292.35	657.45	764.25	185.55	125.74	-24.26	12.96
	7/19/2006	505.7	73.4	984.2	290.7	463.50	289.55	637.45	744.95	182.05	122.72	-23.12	12.61
	10/18/2006	484	-5.7	946.5	265.8	422.65	239.15	606.15	715.25	130.05	111.91	-24.39	13.11
	1/18/2007	503	21.5	974.4	282.5	445.35	262.25	628.45	738.70	152.00	117.92	-24.34	13.14
	4/19/2007	525.1	60.9	1012.9	309.1	477.00	293.00	661.00	769.00	185.00	126.30	-24.46	13.08
	7/11/2007	533.8	36.8	994.5	295.1	465.05	285.30	644.80	764.15	165.95	123.13	-23.89	13.40
	10/20/2007	487.8	-9.1	953.8	269.9	425.60	239.35	611.85	720.80	130.40	112.69	-24.76	13.23
	1/7/2008	504.2	11.4	976	284.1	443.93	257.80	630.05	740.10	147.75	117.54	-24.74	13.27
	5/13/2008	552.9	52.7	1019.4	315.4	485.10	302.80	667.40	786.15	184.05	128.44	-24.23	13.49

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
26	7/1/1999	468.3	92.2	387.7	511.7	364.98	280.25	449.70	428.00	301.95	96.63	-11.26	2.82
	7/15/1999	460.1	81	381.5	505.7	357.08	270.55	443.60	420.80	293.35	94.54	-11.50	2.86
	8/15/1999	482.3	96.1	410.7	526	378.78	289.20	468.35	446.50	311.05	100.29	-11.91	3.03
	8/31/1999	490.3	101.9	422.4	535	387.40	296.10	478.70	456.35	318.45	102.57	-12.14	3.09
	9/15/1999	491.0	101.4	426.3	536.4	388.78	296.20	481.35	458.65	318.90	102.94	-12.30	3.13
	9/30/1999	497.9	106.7	434.7	543.6	395.73	302.30	489.15	466.30	325.15	104.78	-12.42	3.16
	10/15/1999	505.0	112.3	443.2	550.9	402.85	308.65	497.05	474.10	331.60	106.66	-12.52	3.19
	10/31/1999	515.6	118.8	452.5	560.9	411.95	317.20	506.70	484.05	339.85	109.07	-12.59	3.23
	11/15/1999	525.0	128.3	463.4	570.2	421.73	326.65	516.80	494.20	349.25	111.66	-12.64	3.25
	11/30/1999	532.5	134.9	471.5	576.8	428.93	333.70	524.15	502.00	355.85	113.57	-12.66	3.27
	12/15/1999	534.1	138.1	476.5	580.2	432.23	336.10	528.35	505.30	359.15	114.44	-12.78	3.27
	12/31/1999	540.4	144.3	484.4	587.2	439.08	342.35	535.80	512.40	365.75	116.25	-12.86	3.29
	3/31/2000	551.1	156	501.3	602.1	452.63	353.55	551.70	526.20	379.05	119.84	-13.17	3.30
	6/30/2000	533.5	137.3	477.6	577.9	431.58	335.40	527.75	505.55	357.60	114.27	-12.78	3.31
	9/30/2000	539.6	136.8	480.7	575.1	433.05	338.20	527.90	510.15	355.95	114.66	-12.61	3.45
	1/13/2001	571.4	169.7	522.7	611.8	468.90	370.55	567.25	547.05	390.75	124.15	-13.07	3.50
	4/20/2001	580.2	184.8	537.9	624.6	481.88	382.50	581.25	559.05	404.70	127.59	-13.21	3.46
	7/16/2001	555.8	159.1	508	598.6	455.38	357.45	553.30	531.90	378.85	120.57	-13.02	3.43
	10/9/2001	556.2	154.1	506	595.8	453.03	355.15	550.90	531.10	374.95	119.95	-13.01	3.50
	1/9/2002	572	170.3	527.3	614.7	471.08	371.15	571.00	549.65	392.50	124.73	-13.28	3.52
	4/12/2002	584.6	187.7	546.3	632.8	487.85	386.15	589.55	565.45	410.25	129.17	-13.52	3.48
	7/18/2002	559.5	162.1	516.1	606	460.93	360.80	561.05	537.80	384.05	122.04	-13.31	3.44
	10/8/2002	557	154.4	511	599.8	455.55	355.70	555.40	534.00	377.10	120.62	-13.27	3.51
	1/8/2003	591	189.2	552.8	639	493.00	390.10	595.90	571.90	414.10	130.53	-13.68	3.54
	4/15/2003	597.9	204.3	567.5	650.5	505.05	401.10	609.00	582.70	427.40	133.72	-13.82	3.48
	7/1/2003	580.7	184.3	545.4	632.5	485.73	382.50	588.95	563.05	408.40	128.61	-13.72	3.46
	10/7/2003	578.2	176.3	538	627	479.88	377.25	582.50	558.10	401.65	127.06	-13.64	3.50
	12/31/2003	610.3	207.7	572.6	661.6	513.05	409.00	617.10	591.45	434.65	135.84	-13.83	3.51
	4/13/2004	617.1	224.2	589.5	675.7	526.63	420.65	632.60	603.30	449.95	139.43	-14.09	3.44
	7/13/2004	584	186.6	549.1	642.6	490.58	385.30	595.85	566.55	414.60	129.89	-13.99	3.40
	10/8/2004	581.8	181.2	543.7	638.3	486.25	381.50	591.00	562.75	409.75	128.74	-13.92	3.43
	1/7/2005	609.9	209	574.8	669.1	515.70	409.45	621.95	592.35	439.05	136.54	-14.12	3.43
	4/8/2005	617.5	225	590.2	683.9	529.15	421.25	637.05	603.85	454.45	140.10	-14.34	3.35
	7/18/2005	590.4	192.7	554.7	656	498.45	391.55	605.35	572.55	424.35	131.97	-14.21	3.32
	8/26/2005	584.4	183.1	544	647.8	489.83	383.75	595.90	564.20	415.45	129.69	-14.10	3.33
	10/11/2005	589.3	185.9	548.5	652	493.93	387.60	600.25	568.90	418.95	130.78	-14.13	3.36
	1/10/2006	616	216.1	582.8	683.4	524.58	416.05	633.10	599.40	449.75	138.89	-14.42	3.35
	4/9/2006	629	235.4	605.8	701.1	542.83	432.20	653.45	617.40	468.25	143.72	-14.70	3.34
	7/19/2006	595.8	199	563.1	668.3	506.55	397.40	615.70	579.45	433.65	134.12	-14.51	3.27
	10/18/2006	595.6	193	557.4	662.8	502.20	394.30	610.10	576.50	427.90	132.97	-14.34	3.33
	1/18/2007	622.2	223.4	590.2	694.6	532.60	422.80	642.40	606.20	459.00	141.02	-14.59	3.30
	4/19/2007	624.5	231.7	598.4	701.1	538.93	428.10	649.75	611.45	466.40	142.69	-14.73	3.25
	7/11/2007	594.6	199.2	561.5	670.8	506.53	396.90	616.15	578.05	435.00	134.11	-14.57	3.20
	10/20/2007	588.7	187	550.3	661.8	496.95	387.85	606.05	569.50	424.40	131.58	-14.50	3.25
	1/7/2008	619.8	219.6	589.6	697.1	531.53	419.70	643.35	604.70	458.35	140.73	-14.86	3.28
	5/13/2008	626.5	234.4	601.8	708.8	542.88	430.45	655.30	614.15	471.60	143.74	-14.94	3.19

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
1	7/1/1999	-115.0	299.7	422.9	109.6	179.30	92.35	266.25	153.95	204.65	47.47	-11.56	-1.14
	7/15/1999	-122.0	289	405.2	95.6	166.95	83.50	250.40	141.60	192.30	44.20	-11.09	-1.14
	8/15/1999	-139.4	265.8	401.5	101.8	157.43	63.20	251.65	131.05	183.80	41.68	-12.52	-1.18
	8/31/1999	-144.1	258.4	394.7	99.6	152.15	57.15	247.15	125.30	179.00	40.28	-12.63	-1.20
	9/15/1999	-144.1	255.9	395.1	102	152.23	55.90	248.55	125.50	178.95	40.30	-12.80	-1.20
	9/30/1999	-141.7	260.4	408.3	112.3	159.83	59.35	260.30	133.30	186.35	42.32	-13.35	-1.19
	10/15/1999	-138.1	275.3	441.9	138.4	179.38	68.60	290.15	151.90	206.85	47.49	-14.72	-1.23
	10/31/1999	-148.1	272.7	430.1	118.5	168.30	62.30	274.30	141.00	195.60	44.56	-14.09	-1.22
	11/15/1999	-142.3	278.9	446.6	134.9	179.53	68.30	290.75	152.15	206.90	47.53	-14.78	-1.23
	11/30/1999	-137.9	284.4	462	150.8	189.83	73.25	306.40	162.05	217.60	50.26	-15.49	-1.24
	12/15/1999	-135.4	290	463.8	152.5	192.73	77.30	308.15	164.20	221.25	51.03	-15.34	-1.28
	12/31/1999	-126.8	301.4	481.4	168.9	206.23	87.30	325.15	177.30	235.15	54.60	-15.81	-1.30
	3/31/2000	-133.9	283.1	455.7	149.6	188.63	74.60	302.65	160.90	216.35	49.94	-15.16	-1.24
	6/30/2000	-157.3	230.6	397.4	119.3	147.50	36.65	258.35	120.05	174.95	39.05	-14.73	-1.23
	9/30/2000	-142.8	237.4	427.4	156.8	169.70	47.30	292.10	142.30	197.10	44.93	-16.27	-1.23
	1/13/2001	-118.2	295.4	511.7	182.5	217.85	88.60	347.10	196.75	238.95	57.68	-17.18	-0.95
	4/20/2001	-128.9	270.9	454	163.4	189.85	71.00	308.70	162.55	217.15	50.27	-15.80	-1.22
	7/16/2001	-146.4	213.9	384.1	133.3	146.23	33.75	258.70	118.85	173.60	38.72	-14.95	-1.23
	10/9/2001	-135.7	237.5	439.4	178.3	179.88	50.90	308.85	151.85	207.90	47.63	-17.14	-1.26
	1/9/2002	-120.2	281.4	483	190.7	208.73	80.60	336.85	181.40	236.05	55.26	-17.03	-1.22
	4/12/2002	-133.2	263.6	441.1	154.2	181.43	65.20	297.65	153.95	208.90	48.04	-15.45	-1.23
	7/18/2002	-158.1	191.2	355.6	118	126.68	16.55	236.80	98.75	154.60	33.54	-14.64	-1.25
	10/7/2002	-149.2	192.4	391.7	156.3	147.80	21.60	274.00	121.25	174.35	39.13	-16.77	-1.19
	1/8/2003	-123.2	268.7	469.3	191.8	201.65	72.75	330.55	173.05	230.25	53.39	-17.13	-1.28
	4/15/2003	-137.5	248.4	427.1	157.1	173.78	55.45	292.10	144.80	202.75	46.01	-15.73	-1.30
	7/1/2003	-159.7	183.9	351.2	124.6	125.00	12.10	237.90	95.75	154.25	33.10	-15.01	-1.31
	10/7/2003	-146.6	206.4	412.6	177.8	162.55	29.90	295.20	133.00	192.10	43.04	-17.63	-1.32
	12/31/2003	-135.4	243.4	450.4	190	187.10	54.00	320.20	157.50	216.70	49.54	-17.69	-1.33
	4/13/2004	-144.6	228.6	422.1	168	168.53	42.00	295.05	138.75	198.30	44.62	-16.82	-1.33
	7/13/2004	-179.1	155.6	334.2	117.5	107.05	-11.75	225.85	77.55	136.55	28.34	-15.79	-1.32
	10/8/2004	-169	170.9	373.7	152.9	132.13	0.95	263.30	102.35	161.90	34.98	-17.44	-1.33
	1/7/2005	-145.5	227.8	440.5	188.2	177.75	41.15	314.35	147.50	208.00	47.06	-18.16	-1.36
	4/8/2005	-159.4	209.2	398.5	148.8	149.28	24.90	273.65	119.55	179.00	39.52	-16.53	-1.33
	7/18/2005	-182.8	141.5	330.3	131.3	105.08	-20.65	230.80	73.75	136.40	27.82	-16.71	-1.40
	8/26/2005	-184	140.7	341.3	131.3	107.33	-21.65	236.30	78.65	136.00	28.42	-17.14	-1.28
	10/11/2005	-174.2	159.1	370.9	131.3	121.78	-7.55	251.10	98.35	145.20	32.24	-17.19	-1.05
	1/10/2006	-152.5	216.4	430.7	131.3	156.48	31.95	281.00	139.10	173.85	41.43	-16.55	-0.78
	4/9/2006	-157.2	206.1	413	131.3	148.30	24.45	272.15	127.90	168.70	39.27	-16.46	-0.91
	7/19/2006	-189.4	135.9	330	131.3	101.95	-26.75	230.65	70.30	133.60	26.99	-17.11	-1.42
	10/18/2006	-170.5	170.2	390.6	131.3	130.40	-0.15	260.95	110.05	150.75	34.53	-17.35	-0.91
	1/18/2007	-145.4	217.2	448.1	131.3	162.80	35.90	289.70	151.35	174.25	43.10	-16.87	-0.51
	4/19/2007	-159.2	203.2	410.4	131.3	146.43	22.00	270.85	125.60	167.25	38.77	-16.54	-0.93
	7/11/2007	-192.9	128.3	318.7	131.3	96.35	-32.30	225.00	62.90	129.80	25.51	-17.10	-1.50
	10/20/2007	-183.2	145.9	358.7	131.3	113.18	-18.65	245.00	87.75	138.60	29.97	-17.52	-1.14
	1/7/2008	-155.6	207.5	426.7	131.3	152.48	25.95	279.00	135.55	169.40	40.37	-16.82	-0.76
	5/13/2008	-172.3	169.8	384.1	131.3	128.23	-1.25	257.70	105.90	150.55	33.95	-17.21	-1.00

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
12	7/1/1999	356.2	257	201.2	275.1	272.38	306.60	238.15	278.70	266.05	72.12	4.55	0.28
	7/15/1999	353.8	251.6	188.4	273.4	266.80	302.70	230.90	271.10	262.50	70.64	4.77	0.19
	8/15/1999	350.0	242.8	195.3	301.1	272.30	296.40	248.20	272.65	271.95	72.10	3.20	0.02
	8/31/1999	350.2	247.8	201.7	307.9	276.90	299.00	254.80	275.95	277.85	73.31	2.94	-0.04
	9/15/1999	349.8	249.1	203.6	314	279.13	299.45	258.80	276.70	281.55	73.90	2.70	-0.11
	9/30/1999	352.2	256.8	212.1	322.7	285.95	304.50	267.40	282.15	289.75	75.71	2.47	-0.17
	10/15/1999	352.6	257.7	225.5	337.3	293.28	305.15	281.40	289.05	297.50	77.65	1.58	-0.19
	10/31/1999	361.0	268.5	222.6	333.7	296.45	314.75	278.15	291.80	301.10	78.49	2.43	-0.21
	11/15/1999	364.5	273.1	237.1	353.6	307.08	318.80	295.35	300.80	313.35	81.30	1.56	-0.28
	11/30/1999	367.6	276.3	249.1	369.4	315.60	321.95	309.25	308.35	322.85	83.56	0.84	-0.32
	12/15/1999	370.6	280.7	248.5	364.3	316.03	325.65	306.40	309.55	322.50	83.67	1.28	-0.29
	12/31/1999	371.2	282.5	254.8	368.8	319.33	326.85	311.80	313.00	325.65	84.55	1.00	-0.28
	3/31/2000	376.0	289.2	244.7	361.1	317.75	332.60	302.90	310.35	325.15	84.13	1.97	-0.33
	6/30/2000	358.4	247.7	207.4	329.3	285.70	303.05	268.35	282.90	288.50	75.64	2.31	-0.13
	9/30/2000	357.6	235.9	230.1	366.4	297.50	296.75	298.25	293.85	301.15	78.77	-0.10	-0.16
	1/13/2001	382.0	289.5	264.4	384.8	330.18	335.75	324.60	323.20	337.15	87.42	0.74	-0.31
	4/20/2001	382.9	294.9	260.1	378.2	329.03	338.90	319.15	321.50	336.55	87.12	1.31	-0.34
	7/16/2001	352.4	249.4	219.2	330.6	287.90	300.90	274.90	285.80	290.00	76.23	1.73	-0.09
	10/9/2001	357.7	267.9	262.1	382	317.43	312.80	322.05	309.90	324.95	84.04	-0.61	-0.34
	1/9/2002	385.8	301.2	285.1	395.6	341.93	343.50	340.35	335.45	348.40	90.53	0.21	-0.29
	4/12/2002	390.9	310.2	263.2	370.1	333.60	350.55	316.65	327.05	340.15	88.33	2.25	-0.29
	7/18/2002	346.39	265.03	220.4	323.3	288.78	305.71	271.85	283.39	294.17	76.46	2.25	-0.24
	10/7/2002	344.5	265.3	252.4	363.5	306.43	304.90	307.95	298.45	314.40	81.13	-0.20	-0.36
	1/8/2003	385.9	308.5	295.9	394.3	346.15	347.20	345.10	340.90	351.40	91.65	0.14	-0.24
	4/15/2003	392.4	317.3	275.8	371.1	339.15	354.85	323.45	334.10	344.20	89.80	2.09	-0.23
	7/1/2003	360	288.1	238.7	332.8	304.90	324.05	285.75	299.35	310.45	80.73	2.55	-0.25
	10/7/2003	357.1	284.5	277.7	372.1	322.85	320.80	324.90	317.40	328.30	85.48	-0.27	-0.24
	12/31/2003	387.7	318.7	304.1	392.5	350.75	353.20	348.30	345.90	355.60	92.87	0.33	-0.22
	4/13/2004	389.4	324.2	294.9	381.2	347.43	356.80	338.05	342.15	352.70	91.99	1.25	-0.24
	7/13/2004	348	285.8	241	324.8	299.90	316.90	282.90	294.50	305.30	79.40	2.26	-0.24
	10/8/2004	342.4	281.8	269.4	353.1	311.68	312.10	311.25	305.90	317.45	82.52	0.06	-0.26
	1/7/2005	374.1	315.2	302.9	382.8	343.75	344.65	342.85	338.50	349.00	91.01	0.12	-0.24
	4/8/2005	386.7	328.9	284.3	365	341.23	357.80	324.65	335.50	346.95	90.35	2.20	-0.26
	7/18/2005	343.2	285.5	242.4	322.1	298.30	314.35	282.25	292.80	303.80	78.98	2.13	-0.25
	8/26/2005	337	278.7	250.1	331.1	299.23	307.85	290.60	293.55	304.90	79.23	1.15	-0.25
	10/11/2005	338.7	283.6	264.1	348.6	308.75	311.15	306.35	301.40	316.10	81.75	0.32	-0.33
	1/10/2006	371.5	317.4	297	373.5	339.85	344.45	335.25	334.25	345.45	89.98	0.61	-0.25
	4/9/2006	377.4	324.1	290.6	368.2	340.08	350.75	329.40	334.00	346.15	90.04	1.42	-0.27
	7/19/2006	341.9	289.2	238.8	315.3	296.30	315.55	277.05	290.35	302.25	78.45	2.56	-0.27
	10/18/2006	342.7	289.5	274.8	354.5	315.38	316.10	314.65	308.75	322.00	83.50	0.10	-0.30
	1/18/2007	368.4	316.6	305.5	385	343.88	342.50	345.25	336.95	350.80	91.05	-0.18	-0.31
	4/19/2007	370.5	320.9	279.2	353.9	331.13	345.70	316.55	324.85	337.40	87.67	1.94	-0.28
	7/11/2007	326.6	278.1	219	294	279.43	302.35	256.50	272.80	286.05	73.98	3.05	-0.30
	10/20/2007	325.9	278.3	243.8	321.7	292.43	302.10	282.75	284.85	300.00	77.43	1.29	-0.34
	1/7/2008	359.2	310.2	282.8	353	326.30	334.70	317.90	321.00	331.60	86.39	1.12	-0.24
	5/13/2008	350.7	304.4	260.9	335.9	312.98	327.55	298.40	305.80	320.15	82.87	1.94	-0.32

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
13	7/1/1999	177.4	380.2	417.6	236.2	302.85	278.80	326.90	297.50	308.20	80.19	-3.20	-0.24
	7/15/1999	173.8	378	412.7	230.2	298.68	275.90	321.45	293.25	304.10	79.08	-3.03	-0.24
	8/15/1999	172.8	380.2	439.6	252.6	311.30	276.50	346.10	306.20	316.40	82.42	-4.63	-0.23
	8/31/1999	172.6	378	445.8	257.5	313.48	275.30	351.65	309.20	317.75	83.00	-5.07	-0.19
	9/15/1999	170.9	377.2	447.2	261	314.08	274.05	354.10	309.05	319.10	83.16	-5.32	-0.23
	9/30/1999	176.4	380.7	455.9	269.3	320.58	278.55	362.60	316.15	325.00	84.88	-5.59	-0.20
	10/15/1999	176.7	378.9	468.1	279.5	325.80	277.80	373.80	322.40	329.20	86.26	-6.38	-0.15
	10/31/1999	182.4	385.8	502.1	273.8	336.03	284.10	387.95	342.25	329.80	88.97	-6.90	0.28
	11/15/1999	186.8	392.4	482.7	292	338.48	289.60	387.35	334.75	342.20	89.62	-6.50	-0.17
	11/30/1999	189.8	396.8	638.9	305.6	382.78	293.30	472.25	414.35	351.20	101.35	-11.89	1.41
	12/15/1999	193.5	401.1	516.7	302.2	353.38	297.30	409.45	355.10	351.65	93.56	-7.45	0.08
	12/31/1999	194.7	406.1	507.2	308	354.00	300.40	407.60	350.95	357.05	93.73	-7.12	-0.14
	3/31/2000	194.8	409	492.7	298.7	348.80	301.90	395.70	343.75	353.85	92.35	-6.23	-0.23
	6/30/2000	177.7	389.4	467.2	278.7	328.25	283.55	372.95	322.45	334.05	86.91	-5.94	-0.26
	9/30/2000	174.2	385.1	496.7	308	341.00	279.65	402.35	335.45	346.55	90.29	-8.15	-0.25
	1/13/2001	200.0	418.2	530.3	318.6	366.78	309.10	424.45	365.15	368.40	97.11	-7.67	-0.07
	4/20/2001	194.1	416.2	512.8	310.6	358.43	305.15	411.70	353.45	363.40	94.90	-7.08	-0.22
	7/16/2001	166.5	386.2	469	273.8	323.88	276.35	371.40	317.75	330.00	85.75	-6.32	-0.27
	10/9/2001	171.5	389.1	514.8	315.2	347.65	280.30	415.00	343.15	352.15	92.05	-8.95	-0.20
	1/9/2002	193.6	413.6	539.3	324.6	367.78	303.60	431.95	366.45	369.10	97.38	-8.53	-0.06
	4/12/2002	198.8	418.5	509.3	299.2	356.45	308.65	404.25	354.05	358.85	94.38	-6.35	-0.11
	7/18/2002	161.4	379.1	462.4	262.6	316.38	270.25	362.50	311.90	320.85	83.77	-6.13	-0.20
	10/7/2002	155.8	373.6	686.8	301.1	379.33	264.70	493.95	421.30	337.35	100.43	-15.24	1.88
	1/8/2003	193.1	414	547.6	331	371.43	303.55	439.30	370.35	372.50	98.34	-9.02	-0.05
	4/15/2003	195.8	419.9	560.6	305.7	370.50	307.85	433.15	378.20	362.80	98.10	-8.33	0.34
	7/1/2003	172.1	394.8	479.4	273.9	330.05	283.45	376.65	325.75	334.35	87.39	-6.19	-0.19
	10/7/2003	169	389.1	527.1	317.5	350.68	279.05	422.30	348.05	353.30	92.85	-9.52	-0.12
	12/31/2003	196.2	423.2	560.3	334.7	378.60	309.70	447.50	378.25	378.95	100.24	-9.16	-0.02
	4/13/2004	197.9	424.7	546.1	321.7	372.60	311.30	433.90	372.00	373.20	98.65	-8.15	-0.03
	7/13/2004	155.6	383.5	482.7	266.1	321.98	269.55	374.40	319.15	324.80	85.25	-6.97	-0.13
	10/8/2004	152.2	378.4	519	298.6	337.05	265.30	408.80	335.60	338.50	89.24	-9.54	-0.06
	1/7/2005	180.6	410.6	556.1	324.9	368.05	295.60	440.50	368.35	367.75	97.45	-9.63	0.01
	4/8/2005	188.3	419.5	529.1	301	359.48	303.90	415.05	358.70	360.25	95.18	-7.39	-0.03
	7/18/2005	150.7	376.8	482.9	262.2	318.15	263.75	372.55	316.80	319.50	84.24	-7.23	-0.06
	8/26/2005	144.7	373.1	494.1	275.3	321.80	258.90	384.70	319.40	324.20	85.20	-8.36	-0.11
	10/11/2005	146.5	375.2	533.7	291.5	336.73	260.85	412.60	340.10	333.35	89.15	-10.09	0.15
	1/10/2006	176	407.1	548.8	313.5	361.35	291.55	431.15	362.40	360.30	95.67	-9.28	0.05
	4/9/2006	180.6	412.1	538.7	307.8	359.80	296.35	423.25	359.65	359.95	95.26	-8.43	-0.01
	7/19/2006	149.4	377.4	480.1	259.8	316.68	263.40	369.95	314.75	318.60	83.85	-7.08	-0.09
	10/18/2006	155.2	382.8	532.6	304.1	343.68	269.00	418.35	343.90	343.45	90.99	-9.93	0.01
	1/18/2007	179.5	407.9	563.5	330.9	370.45	293.70	447.20	371.50	369.40	98.08	-10.20	0.05
	4/19/2007	182.7	413.5	536	305.6	359.45	298.10	420.80	359.35	359.55	95.17	-8.15	0.00
	7/11/2007	146.1	373.2	467.5	250.6	309.35	259.65	359.05	306.80	311.90	81.91	-6.61	-0.11
	10/20/2007	144.3	373.6	638.9	278.5	358.83	258.95	458.70	391.60	326.05	95.01	-13.28	1.47
	1/7/2008	179.2	408.8	548	312	362.00	294.00	430.00	363.60	360.40	95.85	-9.04	0.07
	5/13/2008	172.4	404	523.9	297.4	349.43	288.20	410.65	348.15	350.70	92.52	-8.14	-0.06

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
14	7/1/1999	199.5	418.4	473.6	323.8	353.83	308.95	398.70	336.55	371.10	93.68	-5.96	-0.77
	7/15/1999	194.3	414.4	461.1	314.4	346.05	304.35	387.75	327.70	364.40	91.62	-5.54	-0.82
	8/15/1999	191.0	402.1	488.7	347.5	357.33	296.55	418.10	339.85	374.80	94.61	-8.08	-0.78
	8/31/1999	189.5	395.4	496	352.6	358.38	292.45	424.30	342.75	374.00	94.89	-8.76	-0.70
	9/15/1999	186.8	391.6	503.6	359.8	360.45	289.20	431.70	345.20	375.70	95.44	-9.47	-0.68
	9/30/1999	188.5	396.7	516	369	367.55	292.60	442.50	352.25	382.85	97.32	-9.96	-0.69
	10/15/1999	235.3	403	530.4	378.9	386.90	319.15	454.65	382.85	390.95	102.44	-9.01	-0.18
	10/31/1999	202.7	418.5	524.2	371.5	379.23	310.60	447.85	363.45	395.00	100.41	-9.12	-0.71
	11/15/1999	208.9	426.2	548.2	393.2	394.13	317.55	470.70	378.55	409.70	104.35	-10.18	-0.70
	11/30/1999	212.9	429.2	566.6	409.5	404.55	321.05	488.05	389.75	419.35	107.11	-11.10	-0.66
	12/15/1999	216.9	433.5	561.4	403.7	403.88	325.20	482.55	389.15	418.60	106.93	-10.46	-0.66
	12/31/1999	220.7	443.8	566.6	407.4	409.63	332.25	487.00	393.65	425.60	108.46	-10.28	-0.72
	3/31/2000	215.2	438.2	567.9	406.5	406.95	326.70	487.20	391.55	422.35	107.75	-10.67	-0.69
	6/30/2000	191.3	415.8	542.4	380.7	382.55	303.55	461.55	366.85	398.25	101.29	-10.50	-0.70
	6/30/2000	183.3	409.8	571	409.9	393.50	296.55	490.45	377.15	409.85	104.19	-12.89	-0.73
	1/13/2001	215.4	447.2	588.9	421.9	418.35	331.30	505.40	402.15	434.55	110.77	-11.57	-0.73
	4/20/2001	210.2	445.1	586.6	415.7	414.40	327.65	501.15	398.40	430.40	109.72	-11.53	-0.72
	7/16/2001	171.2	413	554.5	377.7	379.10	292.10	466.10	362.85	395.35	100.37	-11.56	-0.73
	10/9/2001	178.5	417.9	596.2	418.8	402.85	298.20	507.50	387.35	418.35	106.66	-13.91	-0.69
	1/9/2002	206.2	445.9	606.4	430	422.13	326.05	518.20	406.30	437.95	111.77	-12.77	-0.71
	4/12/2002	208.6	449.5	584.1	408.1	412.58	329.05	496.10	396.35	428.80	109.24	-11.10	-0.73
	7/18/2002	161.7	410.1	551.9	368.5	373.05	285.90	460.20	356.80	389.30	98.77	-11.58	-0.73
	10/7/2002	160.2	405.5	592.3	407.7	391.43	282.85	500.00	376.25	406.60	103.64	-14.43	-0.68
	1/8/2003	202	449.1	620.2	437.7	427.25	325.55	528.95	411.10	443.40	113.12	-13.52	-0.72
	4/15/2003	205.4	453.6	590	409.8	414.70	329.50	499.90	397.70	431.70	109.80	-11.32	-0.76
	7/1/2003	171.9	426.9	559.5	377.3	383.90	299.40	468.40	365.70	402.10	101.65	-11.23	-0.82
	10/7/2003	172	424.4	600.8	422.4	404.90	298.20	511.60	386.40	423.40	107.21	-14.18	-0.83
	12/31/2003	205.6	461.3	624.2	444.9	434.00	333.45	534.55	414.90	453.10	114.91	-13.36	-0.86
	4/13/2004	204.7	463.4	611.5	433.1	428.18	334.05	522.30	408.10	448.25	113.37	-12.51	-0.90
	7/13/2004	159.6	424.2	566.4	383.7	383.48	291.90	475.05	363.00	403.95	101.53	-12.17	-0.92
	10/8/2004	153	416.8	590.5	409.5	392.45	284.90	500.00	371.75	413.15	103.91	-14.30	-0.93
	1/7/2005	192.8	454.9	627.8	446.9	430.60	323.85	537.35	410.30	450.90	114.01	-14.19	-0.91
	4/8/2005	205.2	467.5	600.9	425.2	424.70	336.35	513.05	403.05	446.35	112.45	-11.74	-0.97
	7/18/2005	154.9	424.1	560.9	385.2	381.28	289.50	473.05	357.90	404.65	100.95	-12.20	-1.05
	8/26/2005	168.3	416.1	569.1	391.2	386.18	292.20	480.15	368.70	403.65	102.25	-12.49	-0.78
	10/11/2005	152.5	418.5	590.5	413.4	393.73	285.50	501.95	371.50	415.95	104.25	-14.38	-1.00
	1/10/2006	190.7	455.4	615	436.7	424.45	323.05	525.85	402.85	446.05	112.38	-13.48	-0.97
	4/9/2006	196.7	460.2	612.3	436.6	426.45	328.45	524.45	404.50	448.40	112.91	-13.03	-0.98
	7/19/2006	159.7	426.1	562.3	382.1	382.55	292.90	472.20	361.00	404.10	101.29	-11.92	-0.97
	10/18/2006	161.9	425.9	600.5	422.5	402.70	293.90	511.50	381.20	424.20	106.62	-14.46	-0.96
	1/18/2007	192.2	454.2	638.5	460	436.23	323.20	549.25	415.35	457.10	115.50	-15.02	-0.94
	4/19/2007	198.7	462.5	611.3	432	426.13	330.60	521.65	405.00	447.25	112.83	-12.70	-0.95
	7/11/2007	149.8	419.9	567.4	379.8	379.23	284.85	473.60	358.60	399.85	100.41	-12.54	-0.92
	10/20/2007	208.9	417	590.1	409	406.25	312.95	499.55	399.50	413.00	107.56	-12.40	-0.30
	1/7/2008	194.6	460.1	617.4	439.8	427.98	327.35	528.60	406.00	449.95	113.31	-13.37	-0.98
	5/13/2008	188	455	606	431.7	420.18	321.50	518.85	397.00	443.35	111.25	-13.12	-1.04

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
26	7/1/1999	222.2	-19.9	305.2	560	266.88	101.15	432.60	263.70	270.05	70.66	-22.03	-0.14
	7/15/1999	207.8	-36.8	294.3	540.9	251.55	85.50	417.60	251.05	252.05	66.60	-22.07	-0.02
	8/15/1999	189.9	-53.4	320.4	546.8	250.93	68.25	433.60	255.15	246.70	66.44	-24.28	0.19
	8/31/1999	184.8	-60	330.2	555.2	252.55	62.40	442.70	257.50	247.60	66.87	-25.27	0.22
	9/15/1999	185.7	-57.2	336.6	558.2	255.83	64.25	447.40	261.15	250.50	67.73	-25.46	0.24
	9/30/1999	187.5	-53.7	349.9	570.1	263.45	66.90	460.00	268.70	258.20	69.75	-26.12	0.24
	10/15/1999	195.3	-50.5	375.2	601.5	280.38	72.40	488.35	285.25	275.50	74.23	-27.64	0.22
	10/31/1999	197.3	-39.9	370.8	589.7	279.48	78.70	480.25	284.05	274.90	74.00	-26.69	0.20
	11/15/1999	202.5	-32.3	385.9	601.1	289.30	85.10	493.50	294.20	284.40	76.60	-27.14	0.22
	11/30/1999	206.5	-27.3	398.1	613.9	297.80	89.60	506.00	302.30	293.30	78.85	-27.67	0.20
	12/15/1999	216.1	-19.5	401.6	620.9	304.78	98.30	511.25	308.85	300.70	80.70	-27.44	0.18
	12/31/1999	223.8	-15	410.7	633.4	313.23	104.40	522.05	317.25	309.20	82.93	-27.76	0.18
	3/31/2000	203.5	-16	395.7	633.5	304.18	93.75	514.60	299.60	308.75	80.54	-27.97	-0.20
	6/30/2000	149.3	-41	371.2	553.8	258.33	54.15	462.50	260.25	256.40	68.40	-27.14	0.09
	6/30/2000	154.3	-22.3	411.5	580.2	280.93	66.00	495.85	282.90	278.95	74.38	-28.57	0.09
	1/13/2001	197.9	7.7	446.8	627.1	319.88	102.80	536.95	322.35	317.40	84.69	-28.85	0.11
	4/20/2001	167.6	1.3	434.9	589.5	298.33	84.45	512.20	301.25	295.40	78.99	-28.43	0.13
	7/16/2001	112.8	-20.6	409.7	555.1	264.25	46.10	482.40	261.25	267.25	69.97	-29.00	-0.13
	10/9/2001	136.9	-5.4	451.7	582.7	291.48	65.75	517.20	294.30	288.65	77.17	-30.00	0.13
	1/9/2002	176.6	9	461.6	618.2	316.35	92.80	539.90	319.10	313.60	83.76	-29.71	0.12
	4/12/2002	158.20	3.40	438	581.00	295.25	80.80	509.70	298.30	292.20	78.17	-28.50	0.14
	7/18/2002	86.10	-23.70	405	503.86	242.87	31.20	454.53	245.65	240.08	64.30	-28.13	0.12
	10/7/2002	96.1	2.90	445.20	562.80	276.75	49.50	504.00	270.65	282.85	73.28	-30.21	-0.27
	1/8/2003	165.9	41.91	480.40	628.48	329.17	103.91	554.44	323.15	335.20	87.16	-29.94	-0.27
	4/15/2003	147.5	33.95	455.30	592.01	307.19	90.73	523.65	301.40	312.98	81.33	-28.77	-0.26
	7/1/2003	88.2	9.66	424.1	577.30	274.82	48.93	500.70	256.15	293.48	72.76	-30.02	-0.84
	10/7/2003	103.5	24.24	466.9	574.34	292.25	63.87	520.62	285.20	299.29	77.38	-30.35	-0.32
	12/31/2003	130.5	44.68	481.6	566.95	305.93	87.59	524.27	306.05	305.81	81.00	-29.02	0.01
	4/13/2004	118.2	42.08	471.6	585.31	304.30	80.14	528.45	294.90	313.69	80.57	-29.79	-0.42
	7/13/2004	49.6	8.40	430.9	548.80	259.43	29.00	489.85	240.25	278.60	68.69	-30.63	-0.86
	10/8/2004	54.7	18.19	457.3	588.15	279.59	36.45	522.72	256.00	303.17	74.03	-32.32	-1.06
	1/7/2005	108.7	42.65	486.4	597.82	308.89	75.67	542.11	297.55	320.23	81.78	-31.00	-0.51
	4/8/2005	91.7	33.99	457.3	601.47	296.12	62.85	529.39	274.50	317.73	78.40	-31.01	-0.97
	7/18/2005	28.7	12.91	432.3	605.33	269.81	20.81	518.82	230.50	309.12	71.44	-33.10	-1.76
	8/26/2005	31.4	16.85	447.8	588.39	271.11	24.13	518.10	239.60	302.62	71.78	-32.83	-1.41
	10/11/2005	43.7	14.58	464.4	588.60	277.82	29.14	526.50	254.05	301.59	73.56	-33.05	-1.06
	1/10/2006	96.3	14.58	483.8	588.60	295.82	55.44	536.20	290.05	301.59	78.32	-31.95	-0.26
	4/9/1906	87.1	29.40	477	588.60	295.52	58.25	532.80	282.05	309.00	78.25	-31.54	-0.60
	7/19/1906	18.4	-2.90	430.9	588.60	258.75	7.75	509.75	224.65	292.85	68.51	-33.36	-1.53
	10/18/1906	61.1	14.58	483.2	588.60	286.87	37.84	535.90	272.15	301.59	75.95	-33.10	-0.66
	1/18/2007	99.2	14.58	505.9	588.60	302.07	56.89	547.25	302.55	301.59	79.98	-32.59	0.02
	4/19/2007	80.5	14.58	477.1	588.60	290.19	47.54	532.85	278.80	301.59	76.83	-32.25	-0.51
	7/11/2007	11.2	14.5768	431.3	588.5957	261.42	12.89	509.95	221.25	301.59	69.22	-33.03	-1.80
	10/20/2007	19.8	14.5768	455.1	588.5957	269.52	17.19	521.85	237.45	301.59	71.36	-33.54	-1.44
	1/7/2008	82.9	14.5768	489.6	588.5957	293.92	48.74	539.10	286.25	301.59	77.82	-32.59	-0.34
	5/13/2008	44.3	14.5768	472.2	588.5957	279.92	29.44	530.40	258.25	301.59	74.11	-33.29	-0.97

Table 4 Pile Forces and Bending Moments

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
1	07/01/99	903.00	42.30	679.00	-	541.43	472.65	679.00	791.00	42.30	456.92	-73.98	99.88
	07/15/99	918.00	48.00	885.00	-	617.00	483.00	885.00	901.50	48.00	520.69	-144.12	113.86
	07/31/00	932.43	51.99	887.34	-	623.92	492.21	887.34	909.89	51.99	526.53	-141.66	114.44
	08/15/99	940.56	34.46	923.00	-	632.67	487.51	923.00	931.78	34.46	533.91	-156.13	119.70
	08/30/99	948.68	31.28	931.09	-	637.02	489.98	931.09	939.89	31.28	537.58	-158.14	121.21
	09/15/99	955.75	27.83	938.36	-	640.65	491.79	938.36	947.06	27.83	540.64	-160.10	122.62
	09/30/99	959.08	23.03	947.01	-	643.04	491.06	947.01	953.05	23.03	542.66	-163.47	124.06
	10/15/99	963.38	18.85	954.86	-	645.70	491.12	954.86	959.12	18.85	544.90	-166.26	125.43
	10/31/99	973.25	5.58	968.30	-	649.04	489.42	968.30	970.78	5.58	547.73	-171.69	128.76
	11/15/99	973.34	1.26	977.48	-	650.69	487.30	977.48	975.41	1.26	549.12	-175.74	129.95
	11/30/99	975.73	-2.84	980.87	-	651.25	486.45	980.87	978.30	-2.84	549.59	-177.26	130.88
	12/15/99	974.96	-2.47	982.11	-	651.53	486.25	982.11	978.54	-2.47	549.83	-177.77	130.87
	12/31/99	974.03	-54.00	984.71		634.91	460.02	984.71	979.37	-54.00	535.80	-188.11	137.85
	03/31/00	964.52	3.86	981.83	-	650.07	484.19	981.83	973.17	3.86	548.59	-178.41	129.31
	06/30/00	977.80	-36.92	980.73	-	640.54	470.44	980.73	979.27	-36.92	540.55	-182.94	135.56
	09/30/00	1009.20	-10.20	1005.99	-	668.33	499.50	1005.99	1007.60	-10.20	564.01	-181.58	135.77
	01/13/01	1014.12	-29.4495	1029.11	-	671.26	492.33	1029.11	1021.61	-29.45	566.48	-192.44	140.21
	04/20/01	1008.27	-18.6852	1022.57	-	670.72	494.79	1022.57	1015.42	-18.69	566.02	-189.21	137.95
	07/10/01	1030.41	-8.36772	1019.56	-	680.53	511.02	1019.56	1024.98	-8.37	574.30	-182.32	137.85
	10/09/01	1054.25	-20.5131	1038.65	-	690.80	516.87	1038.65	1046.45	-20.51	582.96	-187.07	142.33
	01/09/02	1055.96	-29.65	1045.80	-	690.70	513.15	1045.80	1050.88	-29.65	582.88	-190.96	144.14
	04/12/02	1041.9	-24.8188	1040.36	-	685.81	508.54	1040.36	1041.13	-24.82	578.76	-190.66	142.20
	07/19/02	1062.21	-17.26	1035.12	17.14	693.36	522.47	1035.12	1048.67	-17.26	585.12	-183.79	142.20
	10/08/02	1086.38	-30.07	1049.75	-6.63	702.02	528.16	1049.75	1068.06	-30.07	592.43	-187.00	146.49
	01/08/03	1080.45	-42.89	1062.94	0.41	700.17	518.78	1062.94	1071.70	-42.89	590.87	-195.09	148.69
	04/15/03	1059.37	-29.65	1049.86	22.95	693.19	514.86	1049.86	1054.62	-29.65	584.99	-191.81	144.64
	06/01/03	1064.93	-31.16	1053.52	21.00	695.77	516.89	1053.52	1059.23	-31.16	587.16	-192.39	145.46
	08/07/03	1083.86	-27.66	1053.40	9.26	703.20	528.10	1053.40	1068.63	-27.66	593.43	-188.33	146.25
	10/07/03	1095.56	-38.67	1066.64	-0.69	707.84	528.45	1066.64	1081.10	-38.67	597.35	-192.95	149.38
	12/31/03	1100.15	-54.88	1082.97	-0.89	709.41	522.64	1082.97	1091.56	-54.88	598.68	-200.89	152.93
	04/13/04	1080.17	-43.67	1074.07	21.65	703.52	518.25	1074.07	1077.12	-43.67	593.70	-199.27	149.51
	07/13/04	1101.53	-34.89	1072.49	10.76	713.04	533.32	1072.49	1087.01	-34.89	601.74	-193.30	149.66
	10/08/04	1122.82	-45.70	1085.57	-8.86	720.90	538.56	1085.57	1104.19	-45.70	608.36	-196.11	153.40
	01/07/05	1116.60	-58.49	1097.39	-8.94	718.50	529.06	1097.39	1107.00	-58.49	606.34	-203.76	155.48
	04/08/05	1099.01	-52.77	1096.58	5.48	714.28	523.12	1096.58	1097.80	-52.77	602.78	-205.59	153.49
	07/18/05	1116.44	-41.55	1096.58	-2.36	723.82	537.44	1096.58	1106.51	-41.55	610.83	-200.46	153.15
	08/26/05	1128.14	-43.63	1095.73	-10.20	726.75	542.26	1095.73	1111.93	-43.63	613.30	-198.43	154.15
	11/12/05	1127.45	-44.76	1095.72	-9.67	726.14	541.34	1095.72	1111.58	-44.76	612.79	-198.75	154.26
	01/10/06	1129.36	-64.30	1095.72	-19.70	720.26	532.53	1095.72	1112.54	-64.30	607.83	-201.91	156.99
	04/09/06	1114.90	-55.20	1095.72	-1.14	718.47	529.85	1095.72	1105.31	-55.20	606.32	-202.87	154.81
	07/19/06	1130.94	-46.83	1095.72	-9.42	726.61	542.05	1095.72	1113.33	-46.83	613.19	-198.50	154.77
	10/18/06	1154.91	-58.29	1095.72	-27.50	730.78	548.31	1095.72	1125.32	-58.29	616.71	-196.26	157.89
	01/18/07	1139.55	-68.49	1095.72	-21.73	722.26	535.53	1095.72	1117.64	-68.49	609.52	-200.84	158.23
	04/19/07	1125.58	-58.82	1095.72	-8.49	720.83	533.38	1095.72	1110.65	-58.82	608.31	-201.61	156.01
	07/09/07	1141.38	-47.08	1095.72	-16.09	730.01	547.15	1095.72	1118.55	-47.08	616.05	-196.67	155.50
	10/20/07	1161.81	-62.03	1095.72	-36.23	731.84	549.89	1095.72	1128.77	-62.03	617.60	-195.69	158.85
	01/07/08	1155.60	-68.08	1095.72	-28.03	727.75	543.76	1095.72	1125.66	-68.08	614.15	-197.89	159.24
	05/13/08	1132.20	-59.14	1095.72	-1.83	722.93	536.53	1095.72	1113.96	-59.14	610.08	-200.48	156.49

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
17	07/01/99	575.00	589.00	243.00	-	469.00	582.00	243.00	409.00	589.00	395.79	121.54	-24.01
	07/15/99	585.00	602.00	237.00	-	474.67	593.50	237.00	411.00	602.00	400.57	127.81	-25.48
	07/30/99	594.35	611.17	230.68	-	478.73	602.76	230.68	412.52	611.17	404.00	133.40	-26.50
	08/15/99	596.87	611.09	242.58	336.68	446.81	603.98	289.63	419.73	473.89	377.06	112.70	-7.22
	08/31/99	601.58	616.82	241.00	-	486.47	609.20	241.00	421.29	616.82	410.53	132.00	-26.08
	09/15/99	605.96	622.42	240.47	-	489.62	614.19	240.47	423.22	622.42	413.19	133.98	-26.57
	09/30/99	609.62	624.20	240.71	336.98	452.88	616.91	288.85	425.17	480.59	382.18	117.62	-7.39
	10/15/99	612.87	629.40	240.27	336.21	454.69	621.14	288.24	426.57	482.81	383.71	119.35	-7.50
	10/31/99	616.45	631.80	243.11	336.29	456.91	624.13	289.70	429.78	484.05	385.59	119.90	-7.24
	11/15/99	619.54	632.45	245.83	337.79	458.90	626.00	291.81	432.69	485.12	387.27	119.81	-6.99
	11/30/99	623.35	635.58	248.71	340.31	461.99	629.47	294.51	436.03	487.95	389.87	120.09	-6.93
	12/15/99	624.21	637.77	247.77	339.95	462.43	630.99	293.86	435.99	488.86	390.24	120.87	-7.05
	12/31/99	626.60	640.86	249.37	341.45	464.57	633.73	295.41	437.99	491.16	392.05	121.29	-7.09
	03/31/00	634.53	648.30	254.69	346.89	471.10	641.41	300.79	444.61	497.60	397.56	122.12	-7.07
	06/30/00	640.05	652.80	250.99	342.06	471.48	646.43	296.53	445.52	497.43	397.88	125.44	-6.93
	09/30/00	647.16	661.13	247.62	336.78	473.17	654.14	292.20	447.39	498.96	399.31	129.76	-6.88
	01/13/01	654.063	665.1119	256.39	342.22	479.45	659.59	299.31	455.23	503.67	404.61	129.16	-6.46
	04/20/01	654.429	664.7057	260.37	345.47	481.25	659.57	302.92	457.40	505.09	406.12	127.86	-6.36
	07/10/01	661.456	672.0985	256.15	342.75	483.11	666.78	299.45	458.80	507.43	407.70	131.69	-6.49
	10/09/01	668.361	679.0039	251.93	338.20	484.37	673.68	295.06	460.14	508.60	408.76	135.74	-6.46
	01/09/02	671.083	683.4721	252.17	337.92	486.16	677.28	295.04	461.63	510.69	410.27	137.04	-6.55
	04/12/02	669.17	680.02	256.68	342.06	486.98	674.60	299.37	462.93	511.04	410.96	134.52	-6.42
	07/19/02	671.69	683.96	253.27	272.93	470.46	677.83	263.10	462.48	478.44	397.02	148.69	-2.13
	10/08/02	678.60	692.21	247.01	332.37	487.54	685.40	289.69	462.80	512.29	411.44	141.87	-6.60
	01/08/03	678.44	689.32	251.28	334.22	488.31	683.88	292.75	464.86	511.77	412.09	140.22	-6.26
	04/15/03	679.45	692.45	254.73	341.09	491.93	685.95	297.91	467.09	516.77	415.14	139.12	-6.63
	06/01/03	678.76	689.85	256.43	341.09	491.53	684.30	298.76	467.60	515.47	414.80	138.22	-6.39
	08/07/03	682.33	695.54	251.15	336.74	491.44	688.94	293.95	466.74	516.14	414.73	141.61	-6.59
	10/07/03	686.23	700.57	250.14	334.87	492.95	693.40	292.50	468.19	517.72	416.00	143.73	-6.61
	12/31/03	689.48	700.61	257.04	341.05	497.05	695.05	299.04	473.26	520.83	419.46	141.97	-6.35
	04/13/04	689.24	699.88	260.70	346.65	499.12	694.56	303.68	474.97	523.27	421.21	140.14	-6.44
	07/13/04	693.10	667.59	255.46	341.33	489.37	680.34	298.39	474.28	504.46	412.98	136.93	-4.03
	10/08/04	699.03	710.89	250.83	337.39	499.53	704.96	294.11	474.93	524.14	421.56	147.30	-6.56
	01/07/05	699.07	711.46	253.31	339.95	500.95	705.26	296.63	476.19	525.70	422.75	146.50	-6.61
	04/08/05	696.43	708.09	257.94	343.81	501.57	702.26	300.87	477.18	525.95	423.27	143.90	-6.51
	07/18/05	699.56	708.33	253.71	338.36	499.99	703.94	296.04	476.64	523.35	421.94	146.24	-6.23
	08/26/05	702.04	711.17	250.91	335.97	500.02	706.61	293.44	476.47	523.57	421.97	148.13	-6.28
	11/12/05	701.95	699.60	251.68	337.06	497.57	700.78	294.37	476.82	518.33	419.90	145.70	-5.54
	01/10/06	705.16	715.03	253.47	339.58	503.31	710.10	296.53	479.32	527.31	424.75	148.27	-6.40
	04/09/06	703.94	713.04	259.52	343.20	504.93	708.49	301.36	481.73	528.12	426.11	145.96	-6.19
	07/19/06	708.37	716.01	256.84	339.95	505.29	712.19	298.39	482.61	527.98	426.42	148.35	-6.05
	10/18/06	713.29	721.25	251.76	334.02	505.08	717.27	292.89	482.52	527.63	426.24	152.14	-6.02
	01/18/07	712.84	717.96	256.52	336.54	505.96	715.40	296.53	484.68	527.25	426.98	150.17	-5.68
	04/19/07	711.13	716.21	260.62	340.56	507.13	713.67	300.59	485.88	528.38	427.97	148.10	-5.67
	07/09/07	713.04	716.74	255.22	334.18	504.79	714.89	294.70	484.13	525.46	426.00	150.64	-5.51
	10/20/07	715.97	721.74	250.87	329.51	504.52	718.85	290.19	483.42	525.62	425.77	153.68	-5.63
	01/07/08	719.26	723.93	256.47	335.12	508.69	721.59	295.79	487.87	529.52	429.29	152.65	-5.56
	05/13/08	718.36	721.65	263.34	341.25	511.15	720.01	302.29	490.85	531.45	431.36	149.76	-5.42

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
18	07/01/99	546.00	501.00	248.00	173	367.00	523.50	210.50	397.00	337.00	309.71	112.21	8.00
	07/15/99	557.00	513.00	243.00	229	385.50	535.00	236.00	400.00	371.00	325.32	107.20	3.87
	07/30/99	565.55	519.94	239.54	224.26	387.32	542.75	231.90	402.55	372.10	326.86	111.44	4.06
	08/15/99	567.71	520.14	230.56	232.51	387.73	543.93	231.54	399.14	376.33	327.21	112.00	3.04
	08/31/99	573.72	526.52	247.46	232.87	395.14	550.12	240.17	410.59	379.70	333.46	111.12	4.12
	09/15/99	578.06	532.08	246.65	233.61	397.60	555.07	240.13	412.36	382.85	335.53	112.91	3.94
	09/30/99	582.49	534.97	247.46	234.05	399.74	558.73	240.76	414.98	384.51	337.34	114.00	4.06
	10/15/99	586.68	538.17	247.25	235.23	401.83	562.43	241.24	416.97	386.70	339.11	115.15	4.04
	10/31/99	590.77	539.40	249.37	235.6	403.79	565.09	242.49	420.07	387.50	340.75	115.66	4.34
	11/15/99	592.65	540.65	251.68	237.47	405.61	566.65	244.58	422.17	389.06	342.30	115.47	4.42
	11/30/99	596.63	527.25	254.12	239.69	404.42	561.94	246.91	425.38	383.47	341.29	112.94	5.59
	12/15/99	599.47	545.53	254.12	239.05	409.54	572.50	246.59	426.80	392.29	345.61	116.84	4.60
	12/31/99	601.54	548.45	255.38	239.17	411.14	575.00	247.28	428.46	393.81	346.96	117.49	4.62
	03/31/00	610.32	554.87	262.08	243.60	417.72	582.59	252.84	436.20	399.23	352.51	118.22	4.93
	06/30/00	616.94	539.60	260.98	238.93	414.11	578.27	249.96	438.96	389.26	349.47	117.70	6.63
	09/30/00	625.63	400.76	255.58	232.18	378.54	513.19	243.88	440.61	316.47	319.45	96.55	16.56
	01/13/01	632.372	566.6896	264.44	235.84	424.83	599.53	250.14	448.40	401.26	358.52	125.26	6.29
	04/20/01	632.575	561.5309	268.38	236.21	424.67	597.05	252.29	450.48	398.87	358.38	123.60	6.88
	07/10/01	639.684	569.2893	264.64	234.54	427.04	604.49	249.59	452.16	401.91	360.38	127.23	6.70
	10/09/01	646.508	576.5197	259.81	232.14	428.74	611.51	245.97	453.16	404.33	361.82	131.05	6.51
	01/09/02	650.895	576.8446	259.68	230.92	429.59	613.87	245.30	455.29	403.88	362.53	132.14	6.86
	04/12/02	650.123	570.1017	264.192	232.55	429.24	610.11	248.37	457.16	401.33	362.24	129.69	7.45
	07/19/02	653.45	572.46	260.90	226.38	428.30	612.96	243.64	457.18	399.42	361.44	132.40	7.71
	10/08/02	659.69	581.14	254.65	222.68	429.54	620.41	238.66	457.17	401.91	362.49	136.86	7.37
	01/08/03	657.76	576.89	257.57	224.47	429.17	617.32	241.02	457.67	400.68	362.18	134.91	7.60
	04/15/03	661.78	576.19	262.16	228.04	432.04	618.99	245.10	461.97	402.12	364.60	134.04	7.98
	06/01/03	661.37	572.66	264.07	227.59	431.43	617.02	245.83	462.72	400.13	364.08	133.07	8.35
	08/07/03	665.76	577.29	258.18	222.76	431.00	621.53	240.47	461.97	400.03	363.72	136.61	8.26
	10/07/03	669.26	582.73	256.11	222.56	432.66	625.99	239.33	462.68	402.65	365.13	138.62	8.01
	12/31/03	670.27	581.39	262.53	229.62	435.95	625.83	246.08	466.40	405.51	367.90	136.15	8.12
	04/13/04	669.42	576.64	266.47	232.35	436.22	623.03	249.41	467.94	404.49	368.12	133.95	8.46
	07/13/04	672.95	578.63	261.80	224.79	434.54	625.79	243.29	467.37	401.71	366.71	137.13	8.76
	10/08/04	677.95	587.12	255.42	222.31	435.70	632.53	238.87	466.68	404.72	367.69	141.14	8.27
	01/07/05	677.50	586.02	257.61	226.05	436.80	631.76	241.83	467.56	406.04	368.61	139.80	8.21
	04/08/05	674.17	580.83	263.14	227.80	436.48	627.50	245.47	468.65	404.31	368.35	136.96	8.58
	07/18/05	677.87	580.70	259.40	221.74	434.93	629.29	240.57	468.63	401.22	367.04	139.36	8.99
	08/26/05	679.25	583.30	256.27	219.43	434.56	631.28	237.85	467.76	401.37	366.73	141.05	8.86
	11/12/05	679.13	583.14	256.88	220.08	434.81	631.13	238.48	468.00	401.61	366.93	140.77	8.86
	01/10/06	679.45	587.32	257.33	223.00	436.78	633.39	240.17	468.39	405.16	368.60	140.97	8.43
	04/09/06	679.57	583.14	263.01	226.46	438.05	631.36	244.74	471.29	404.80	369.67	138.61	8.87
	07/19/06	683.27	585.78	260.94	222.31	438.08	634.53	241.63	472.11	404.05	369.69	140.86	9.08
	10/18/06	687.01	592.40	255.09	218.66	438.29	639.70	236.88	471.05	405.53	369.87	144.42	8.74
	01/18/07	685.10	588.58	259.16	221.83	438.67	636.84	240.49	472.13	405.20	370.19	142.10	8.93
	04/19/07	685.18	584.40	264.40	222.96	439.23	634.79	243.68	474.79	403.68	370.67	140.22	9.49
	07/09/07	687.74	584.85	259.24	215.85	436.92	636.29	237.55	473.49	400.35	368.72	142.96	9.76
	10/20/07	690.01	591.22	253.79	213.46	437.12	640.62	233.63	471.90	402.34	368.89	145.91	9.28
	01/07/08	691.80	593.86	258.30	218.94	440.73	642.83	238.62	475.05	406.40	371.93	144.91	9.16
	05/13/08	691.68	588.34	265.05	222.19	441.81	640.01	243.62	478.36	405.27	372.85	142.11	9.75

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
19	07/01/99	566.97	586.00	298.00	228.9	419.97	576.49	263.45	432.49	407.45	354.41	112.23	3.34
	07/15/99	580.00	597.00	294.00	224	423.75	588.50	259.00	437.00	410.50	357.60	118.13	3.54
	07/30/99	588.71	606.46	291.38	218.62	426.29	597.59	255.00	440.05	412.54	359.75	122.82	3.67
	08/15/99	591.02	607.35	300.95	227.92	431.81	599.19	264.44	445.99	417.64	364.40	120.01	3.78
	08/31/99	595.94	613.52	300.59	229.63	434.92	604.73	265.11	448.27	421.58	367.03	121.76	3.56
	09/15/99	599.88	617.91	300.67	229.54	437.00	608.90	265.11	450.28	423.73	368.78	123.25	3.54
	09/30/99	603.53	621.65	302.70	229.75	439.41	612.59	266.23	453.12	425.70	370.82	124.18	3.66
	10/15/99	607.51	625.02	302.29	229.71	441.13	616.27	266.00	454.90	427.37	372.27	125.57	3.67
	10/31/99	611.37	627.25	306.07	229.7	443.60	619.31	267.89	458.72	428.48	374.35	125.99	4.03
	11/15/99	613.61	627.78	308.31	232.67	445.59	620.70	270.49	460.96	430.23	376.04	125.55	4.10
	11/30/99	616.29	630.54	313.83	234.7	448.84	623.42	274.27	465.06	432.62	378.78	125.17	4.33
	12/15/99	617.83	631.44	314.03	234.9	449.55	624.64	274.47	465.93	433.17	379.38	125.54	4.37
	12/31/99	619.94	634.20	314.36	236.45	451.24	627.07	275.41	467.15	435.33	380.80	126.08	4.25
	03/31/00	629.45	639.44	320.33	239.74	457.24	634.44	280.03	474.89	439.59	385.86	127.06	4.71
	06/30/00	636.15	643.50	317.81	51.91	412.34	639.83	184.86	476.98	347.71	347.98	163.11	17.25
	09/30/00	646.59	651.99	312.33	231.29	460.55	649.29	271.81	479.46	441.64	388.66	135.33	5.04
	01/13/01	653.454	657.0691	320.21	236.77	466.88	655.26	278.49	486.83	446.92	394.00	135.08	5.32
	04/20/01	651.464	653.2102	324.03	237.42	466.53	652.34	280.72	487.74	445.32	393.71	133.23	5.66
	07/10/01	658.856	661.1717	320.61	235.03	468.92	660.01	277.82	489.74	448.10	395.72	137.02	5.55
	10/09/01	667.346	669.2551	315.37	230.97	470.74	668.30	273.17	491.36	450.11	397.25	141.66	5.50
	01/09/02	670.88	671.7736	315.66	229.71	472.00	671.33	272.68	493.27	450.74	398.32	142.92	5.67
	04/12/02	667.71	665.64	321.06	231.62	471.51	666.68	276.34	494.39	448.63	397.90	139.94	6.10
	07/19/02	673.44	667.87	319.88	227.72	472.23	670.66	273.80	496.66	447.79	398.51	142.28	6.52
	10/08/02	681.93	676.18	313.24	222.91	473.56	679.05	268.07	497.58	449.54	399.64	147.34	6.41
	01/08/03	682.42	673.60	316.88	225.03	474.48	678.01	270.96	499.65	449.32	400.42	145.93	6.71
	04/15/03	686.11	672.95	321.26	228.37	477.17	679.53	274.81	503.69	450.66	402.69	145.10	7.07
	06/01/03	685.30	670.80	322.48	227.84	476.60	678.05	275.16	503.89	449.32	402.21	144.44	7.28
	08/07/03	689.12	675.35	317.28	223.09	476.21	682.23	270.18	503.20	449.22	401.87	147.72	7.20
	10/07/03	694.48	681.03	314.64	222.27	478.11	687.76	268.46	504.56	451.65	403.47	150.32	7.06
	12/31/03	695.94	680.95	322.73	229.34	482.24	688.45	276.03	509.33	455.15	406.96	147.86	7.23
	04/13/04	695.62	676.77	330.77	231.41	483.64	686.19	281.09	513.19	454.09	408.15	145.23	7.88
	07/13/04	700.37	679.61	327.88	224.22	483.02	689.99	276.05	514.13	451.92	407.62	148.40	8.30
	10/08/04	706.18	688.67	321.87	221.22	484.48	697.43	271.54	514.03	454.94	408.86	152.68	7.88
	01/07/05	705.37	688.14	324.72	224.55	485.69	696.75	274.63	515.04	456.35	409.88	151.34	7.83
	04/08/05	702.85	682.86	329.75	226.66	485.53	692.86	278.21	516.30	454.76	409.74	148.66	8.21
	07/18/05	706.50	683.55	327.15	219.55	484.19	695.03	273.35	516.83	451.55	408.61	151.18	8.71
	08/26/05	708.05	686.48	322.81	217.89	483.80	697.26	270.35	515.43	452.18	408.28	153.05	8.44
	11/12/05	707.97	686.27	323.74	218.33	484.08	697.12	271.04	515.85	452.30	408.51	152.76	8.48
	01/10/06	710.04	690.54	324.68	221.62	486.72	700.29	273.15	517.36	456.08	410.74	153.13	8.17
	04/09/06	709.47	686.72	329.75	224.34	487.57	698.10	277.05	519.61	455.53	411.46	150.95	8.55
	07/19/06	714.26	690.38	328.09	220.57	488.32	702.32	274.33	521.17	455.47	412.10	153.44	8.76
	10/18/06	718.93	696.80	321.91	216.75	488.60	707.86	269.33	520.42	456.77	412.33	157.22	8.49
	01/18/07	717.19	692.98	326.63	219.88	489.17	705.08	273.25	521.91	456.43	412.81	154.82	8.73
	04/19/07	716.98	689.52	331.50	221.54	489.89	703.25	276.52	524.24	455.53	413.42	152.99	9.17
	07/09/07	720.64	690.13	327.60	214.47	488.21	705.39	271.04	524.12	452.30	412.00	155.72	9.58
	10/20/07	723.97	695.70	321.18	211.96	488.20	709.83	266.57	522.58	453.83	411.99	158.92	9.17
	01/07/08	725.43	698.46	326.71	217.89	492.12	711.95	272.30	526.07	458.17	415.30	157.62	9.06
	05/13/08	724.66	694.64	333.98	221.14	493.60	709.65	277.56	529.32	457.89	416.55	154.91	9.53

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
34	07/01/99	271.75	436.00	261.00	583.00	387.94	353.88	422.00	266.38	509.50	327.38	-24.42	-32.43
	07/15/99	279.00	617.00	253.00	583.00	433.00	448.00	418.00	266.00	600.00	365.41	10.76	-44.56
	07/30/99	282.79	647.00	243.64	585.13	439.64	464.90	414.39	263.22	616.07	371.01	18.11	-47.07
	08/15/99	272.89	690.09	251.16	614.66	457.20	481.49	432.91	262.03	652.38	385.83	17.42	-52.07
	08/31/99	265.66	576.80	245.14	627.09	428.67	421.23	436.12	255.40	601.95	361.76	-5.34	-46.23
	09/15/99	265.08	802.81	242.34	635.26	486.37	533.95	438.80	253.71	719.04	410.45	34.11	-62.07
	09/30/99	260.50	807.40	238.64	642.65	487.30	533.95	440.65	249.57	725.03	411.23	33.45	-63.43
	10/15/99	256.43	811.14	234.46	648.58	487.65	533.79	441.52	245.45	729.86	411.53	33.08	-64.62
	10/31/99	240.47	824.02	221.62	665.31	487.86	532.25	443.47	231.05	744.67	411.70	31.83	-68.52
	11/15/99	241.93	831.45	224.75	676.77	493.73	536.69	450.76	233.34	754.11	416.65	30.81	-69.47
	11/31/99	240.47	835.88	224.26	648.85	487.37	538.18	436.56	232.37	742.37	411.29	36.43	-68.03
	12/15/99	241.41	836.77	222.35	684.04	496.14	539.09	453.20	231.88	760.41	418.69	30.79	-70.51
	12/31/99	242.22	836.08	224.14	684.93	496.84	539.15	454.54	233.18	760.51	419.29	30.34	-70.35
	03/31/00	257.37	828.85	237.38	675.92	499.88	543.11	456.65	247.38	752.38	421.85	31.00	-67.37
	06/30/00	266.43	846.32	225.20	500.93	459.72	556.37	363.06	245.81	673.62	387.96	69.30	-57.07
	09/30/00	257.37	895.02	196.89	705.00	513.57	576.19	450.94	227.13	800.01	433.40	44.90	-76.42
	01/13/01	247.90	856.11	197.37	729.58	507.74	552.01	463.47	222.64	792.84	428.48	31.74	-76.07
	04/20/01	44.66	883.01	212.28	457.21	399.29	463.83	334.74	128.47	670.11	336.96	46.28	-72.25
	07/10/01	-279.94	502.86	204.24	66.21	123.34	111.46	135.22	-37.85	284.53	104.09	-8.52	-43.01
	10/09/01	442.16	725.37	50.98	1199.89	604.60	583.76	625.44	246.57	962.63	510.22	-14.94	-95.52
	01/09/02	263.63	616.73	159.27	765.05	451.17	440.18	462.16	211.45	690.89	380.74	-7.88	-63.96
	04/12/02	67.35	579.97	58.13	501.01	301.61	323.66	279.57	62.74	540.49	254.53	15.81	-63.73
	07/19/02	288.69	941.04	187.83	727.59	536.29	614.86	457.71	238.26	834.31	452.57	56.34	-79.51
	10/08/02	277.15	962.54	162.58	740.98	535.81	619.84	451.78	219.86	851.76	452.17	60.25	-84.29
	01/08/03	256.07	949.53	162.24	758.66	531.62	602.80	460.45	209.15	854.10	448.64	51.04	-86.04
	04/15/03	277.19	928.37	189.53	744.52	534.90	602.78	467.03	233.36	836.45	451.41	48.67	-80.45
	06/01/03	277.96	939.01	184.90	749.68	537.89	608.49	467.29	231.43	844.35	453.93	50.62	-81.76
	08/07/03	288.69	965.09	171.66	750.09	543.88	626.89	460.87	230.17	857.59	458.98	59.52	-83.70
	10/07/03	274.96	978.21	155.53	762.84	542.89	626.58	459.19	215.25	870.53	458.14	60.01	-87.41
	12/31/03	258.26	983.57	156.83	795.22	548.47	620.92	476.03	207.55	889.40	462.86	51.95	-90.96
	04/13/04	281.17	960.30	188.88	781.65	553.00	620.73	485.27	235.03	870.97	466.68	48.57	-84.84
	07/13/04	302.86	991.98	173.93	772.27	560.26	647.42	473.10	238.40	882.12	472.80	62.50	-85.87
	10/08/04	295.63	1004.49	151.19	786.40	559.43	650.06	468.80	223.41	895.45	472.10	64.99	-89.65
	01/07/05	277.35	997.91	148.79	798.02	555.52	637.63	473.41	213.07	897.97	468.80	58.88	-91.36
	04/08/05	286.74	978.21	166.99	788.76	555.17	632.47	477.87	226.86	883.49	468.51	55.43	-87.59
	07/18/05	304.00	1000.02	160.94	783.60	562.14	652.01	472.27	232.47	891.81	474.39	64.44	-87.96
	08/26/05	301.85	1018.4	147.73	791.81	564.94	660.12	469.77	224.79	905.09	476.76	68.24	-90.75
	11/12/05	300.51	1018.3	147.82	793.35	564.99	659.40	470.58	224.16	905.83	476.80	67.70	-90.93
	01/10/06	274.59	1009.41	138.15	808.34	557.62	642.00	473.24	206.37	908.87	470.58	60.50	-93.71
	04/09/06	283.04	986.09	160.45	798.02	556.90	634.57	479.23	221.74	892.06	469.97	55.69	-89.42
	07/19/06	295.67	1009.41	149.73	796.56	562.84	652.54	473.14	222.70	902.98	474.98	64.32	-90.75
	10/18/06	284.79	1030.77	131.20	808.38	563.79	657.78	469.79	207.99	919.58	475.78	67.40	-94.92
	01/18/07	270.29	1012.82	134.82	813.33	557.81	641.55	474.08	202.55	913.08	470.74	60.04	-94.78
	04/19/07	282.35	996.04	153.99	805.37	559.44	639.20	479.68	218.17	900.71	472.11	57.19	-91.05
	07/09/07	306.44	1014.48	154.64	795.38	567.74	660.46	475.01	230.54	904.93	479.11	66.49	-89.96
	10/20/07	290.51	1037.35	126.69	809.72	566.07	663.93	468.21	208.60	923.54	477.71	70.17	-95.37
	01/07/08	274.06	1024.92	128.89	820.48	562.09	649.49	474.69	201.48	922.70	474.35	62.67	-96.21
	05/13/08	283.81	1003.11	149.48	810.90	561.83	643.46	480.19	216.65	907.00	474.12	58.54	-92.09

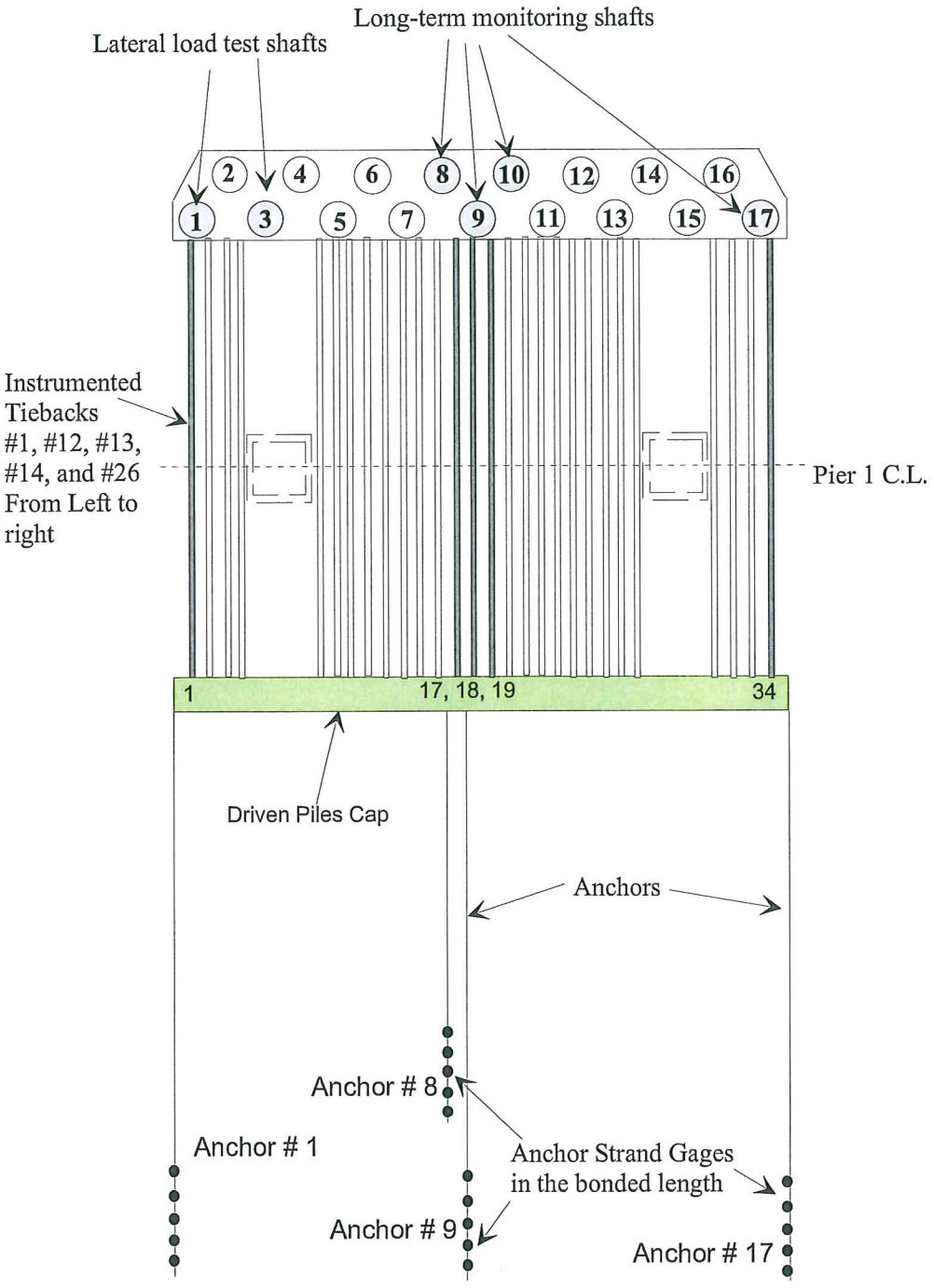


Fig.1 Plan view of the entire stabilization system and the locations of instrumented foundation elements.

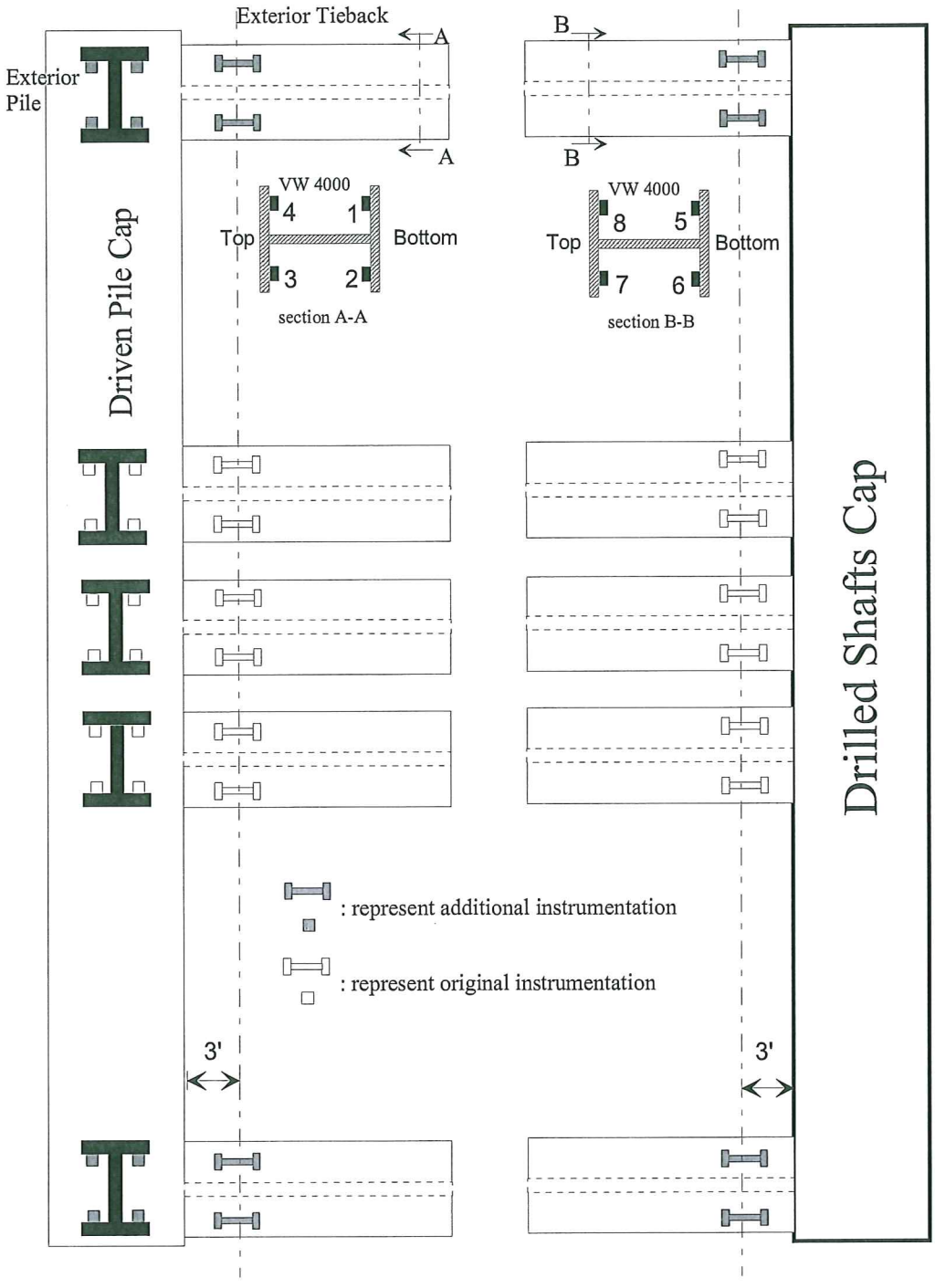


Fig. 2 Instrumentation of tie-beams for long term monitoring

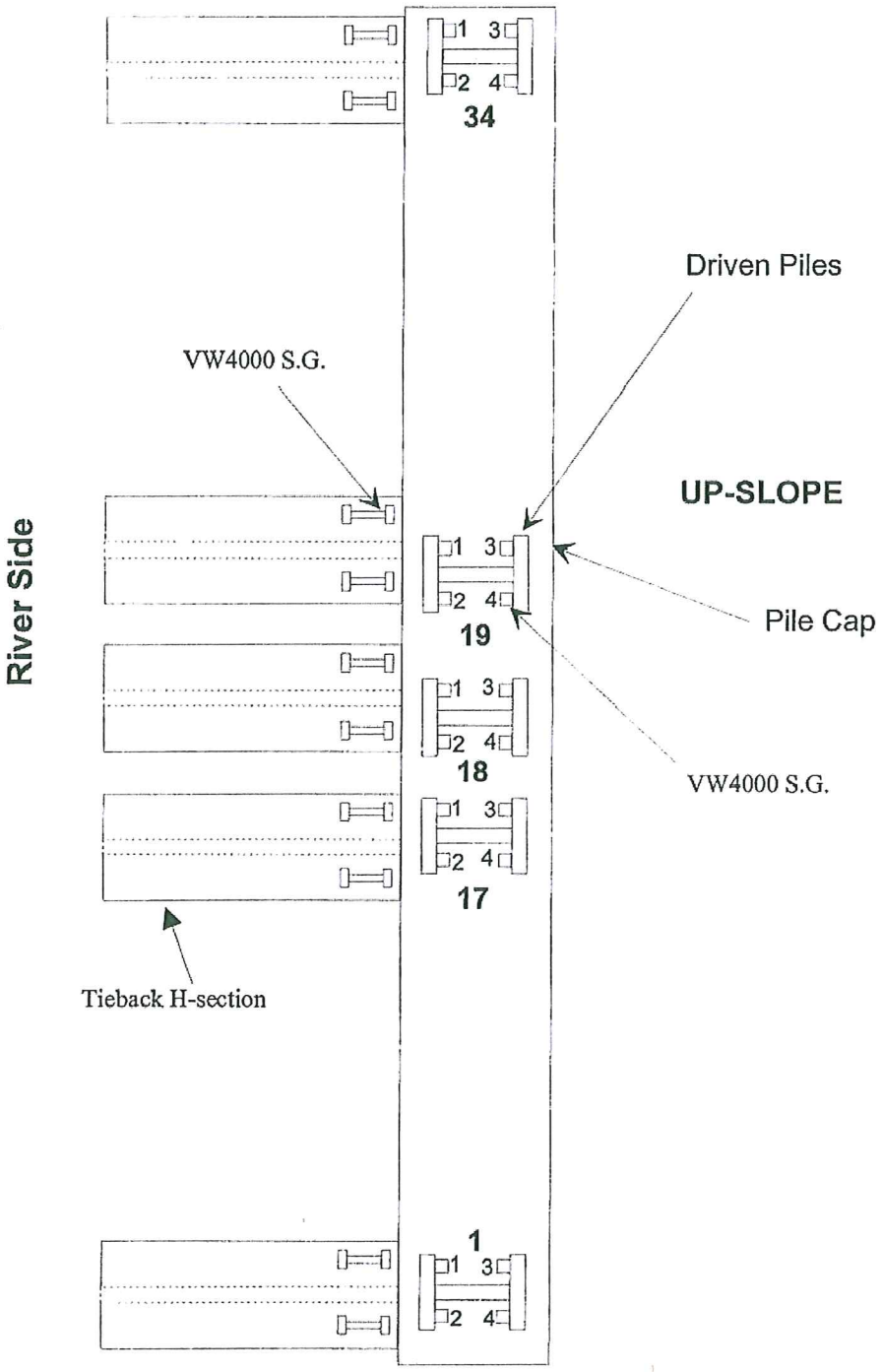


Fig.3 Schematic of gage locations on the driven piles.

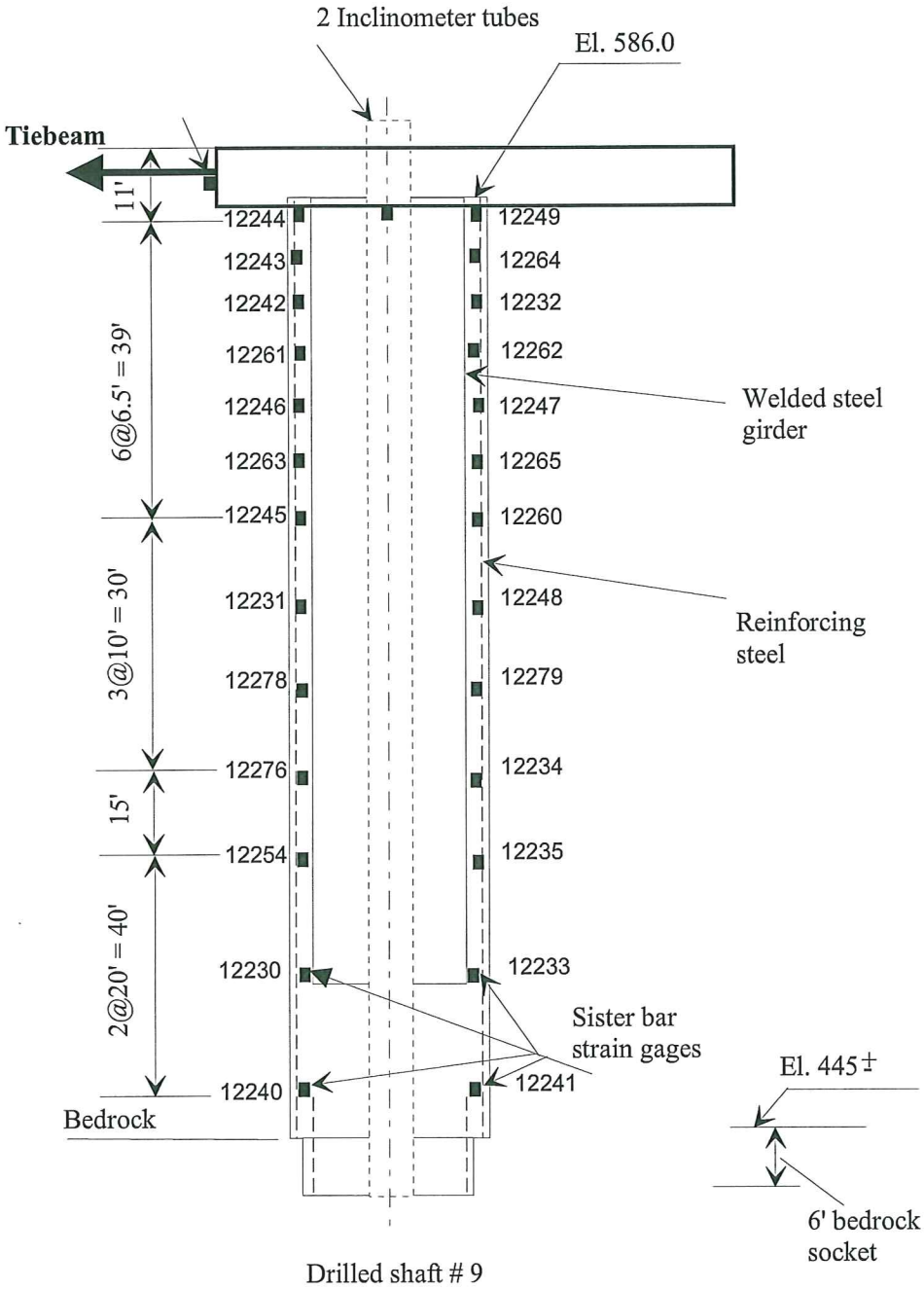


Fig.4 Location and designation of the strain gages in shaft # 9.

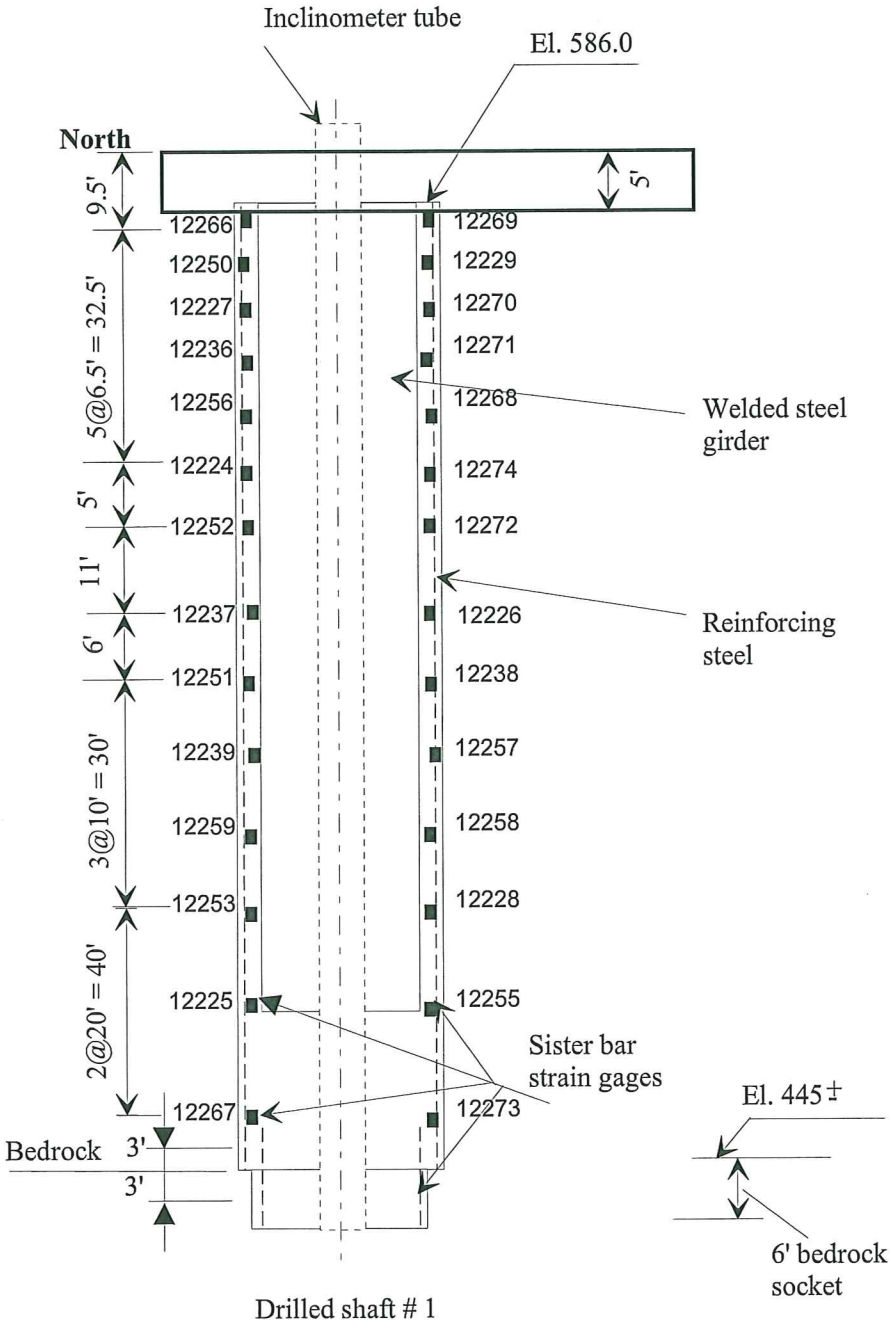


Fig.5: Locations and designations of the strain gages in shaft # 1.

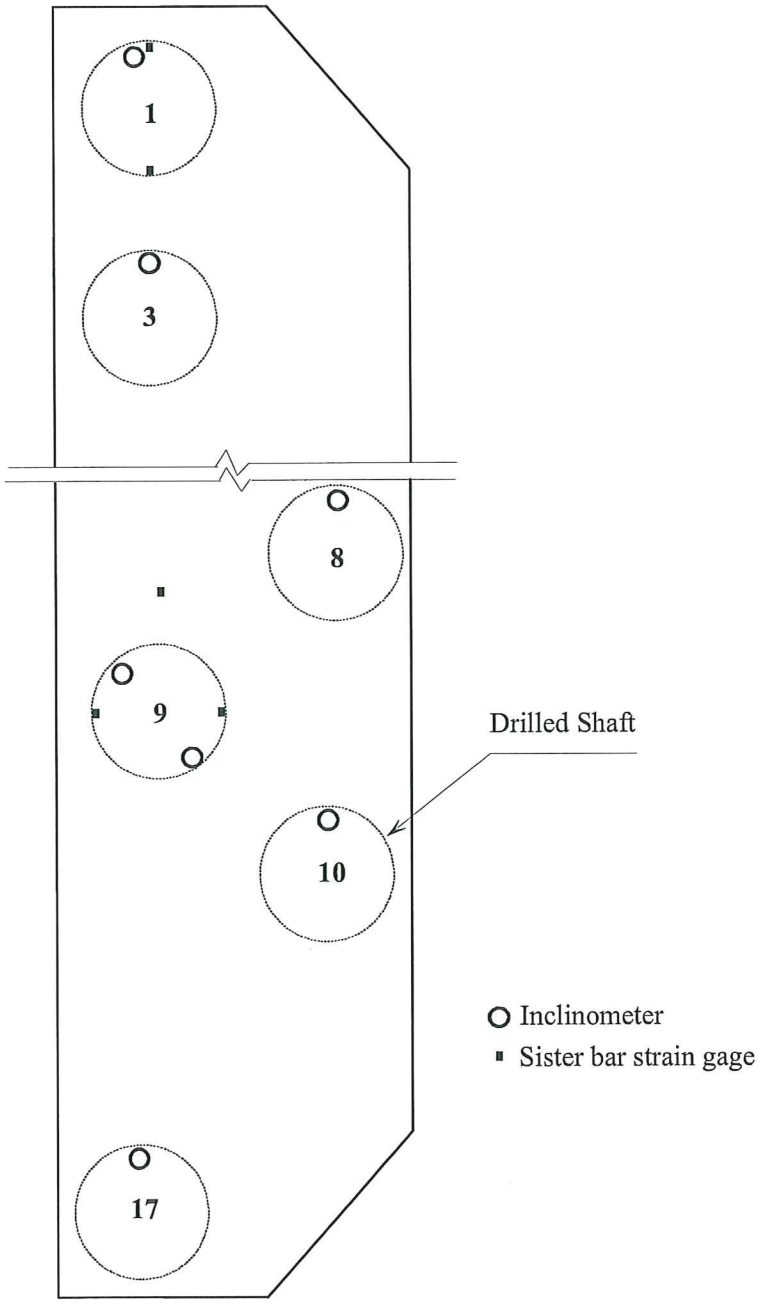


Fig. 6 Location of inclinometers in the drilled shaft cap

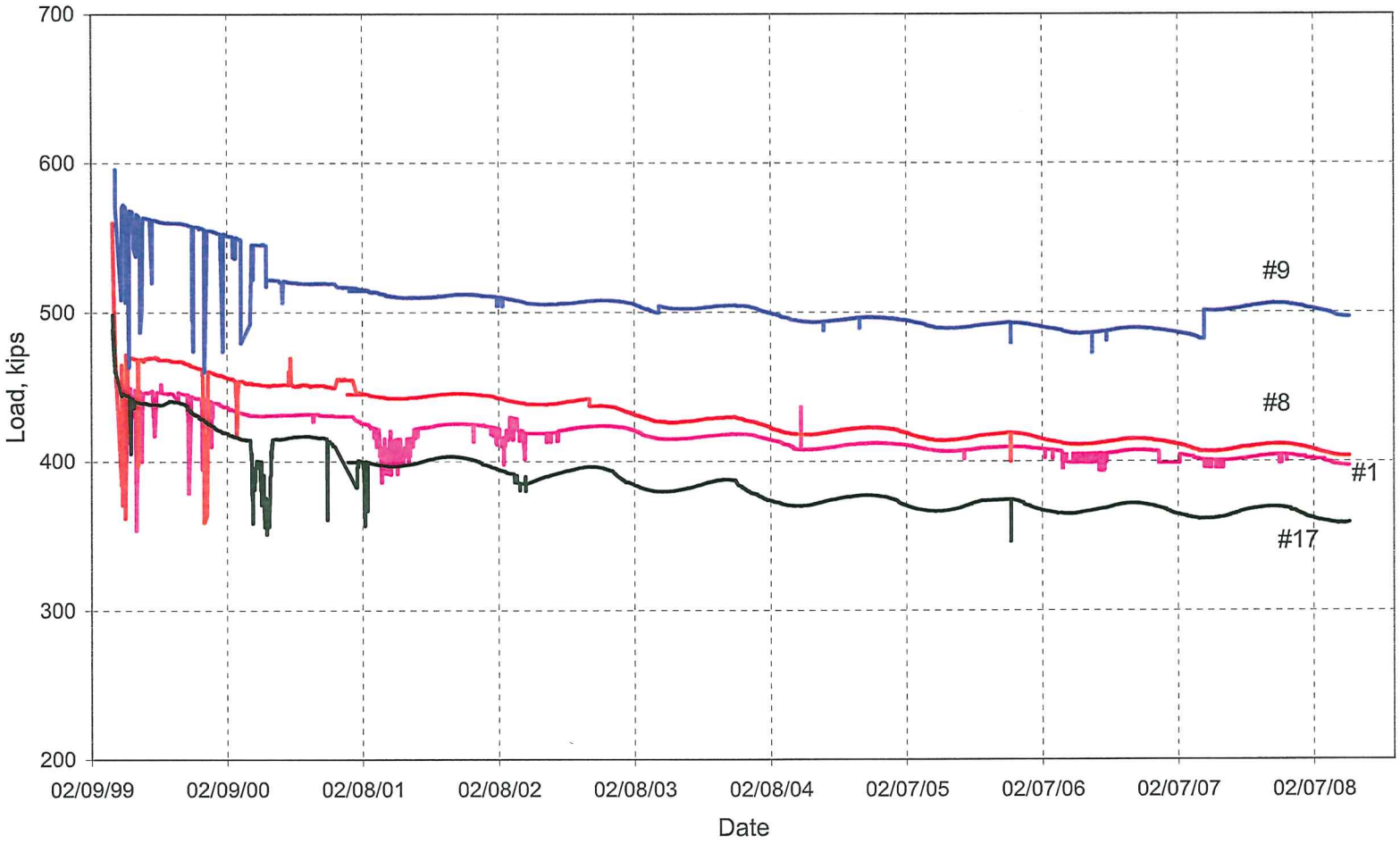


Fig. 7 Anchor load vs. date

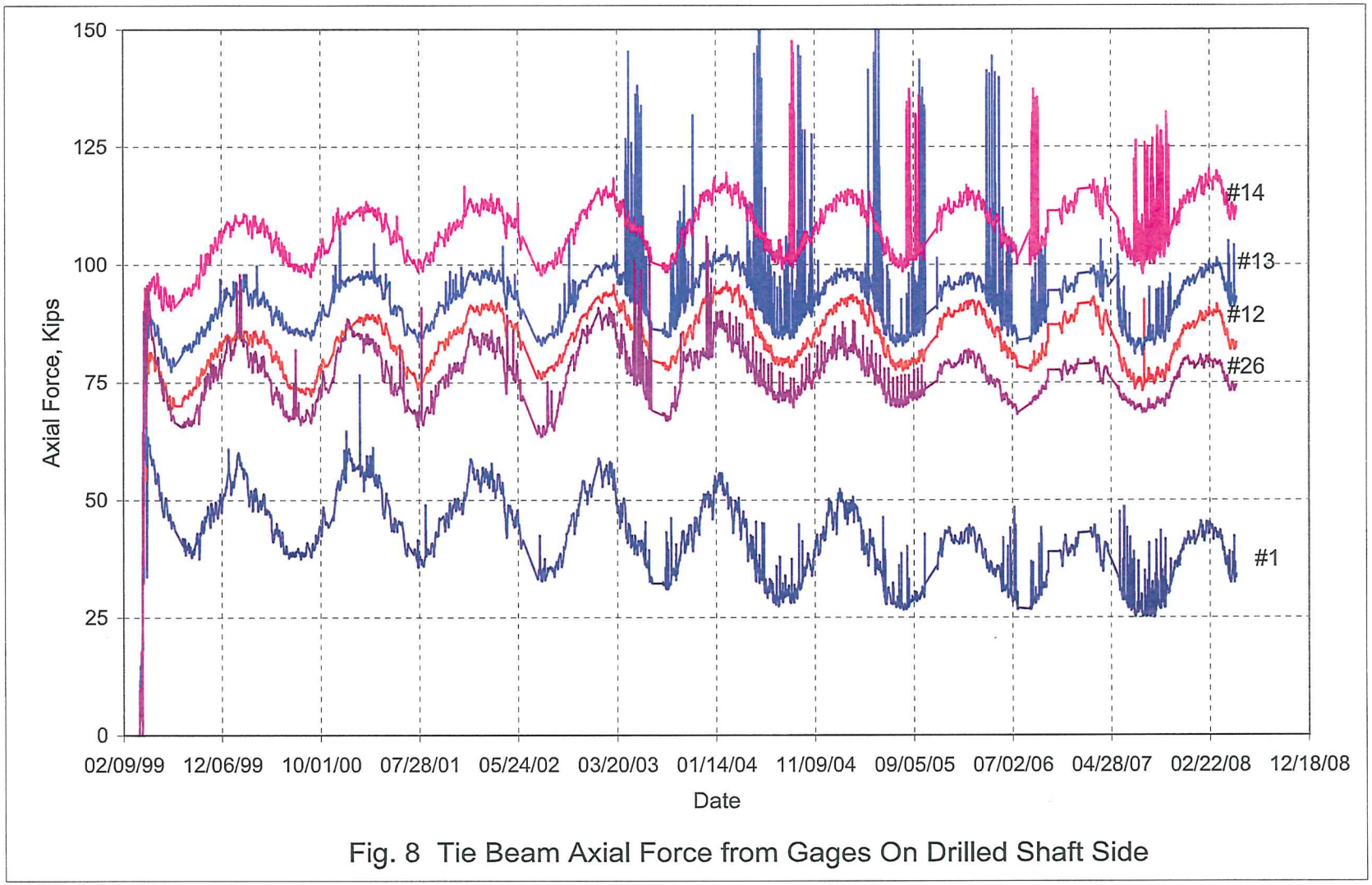


Fig. 8 Tie Beam Axial Force from Gages On Drilled Shaft Side

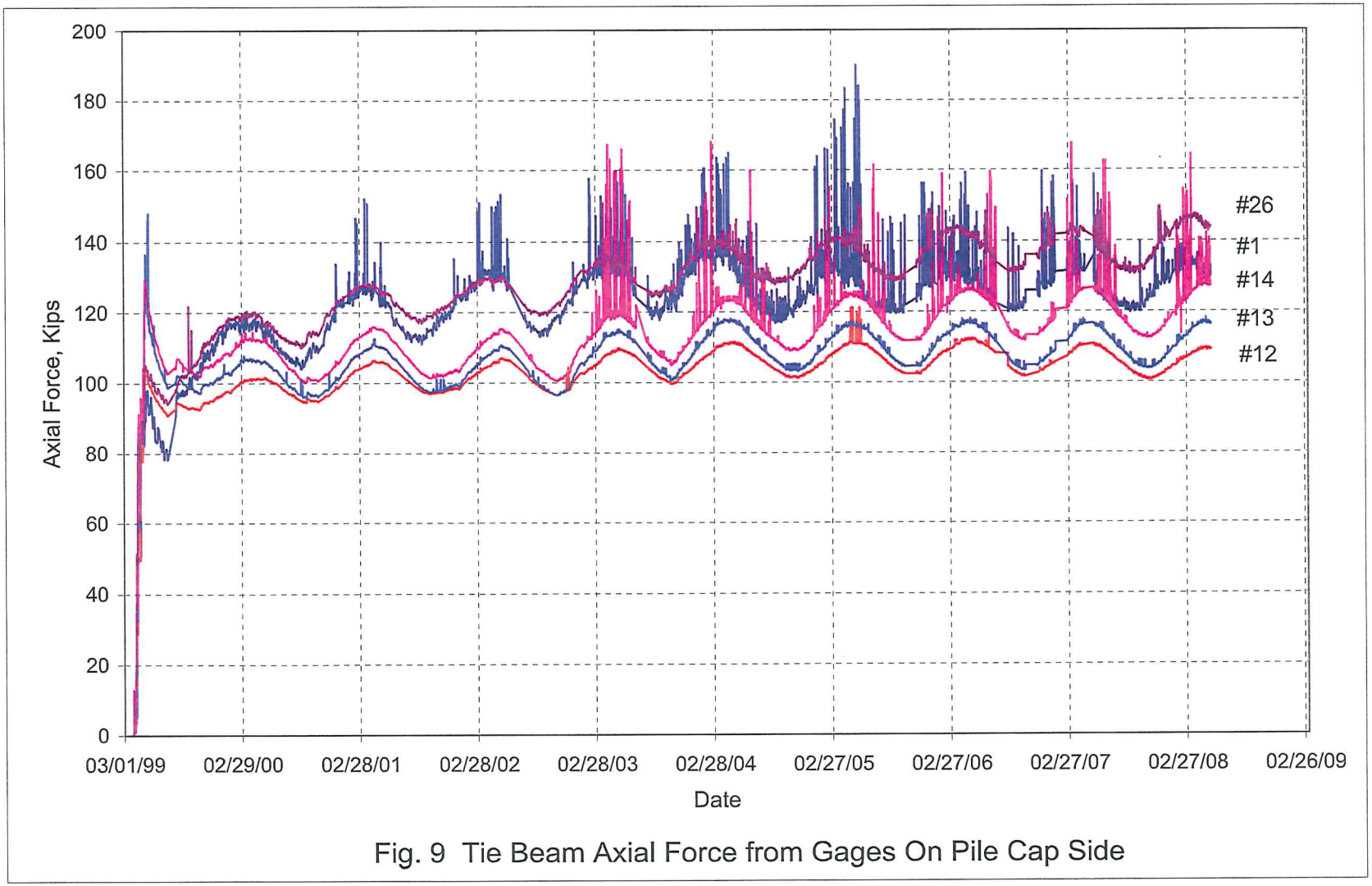


Fig. 9 Tie Beam Axial Force from Gages On Pile Cap Side

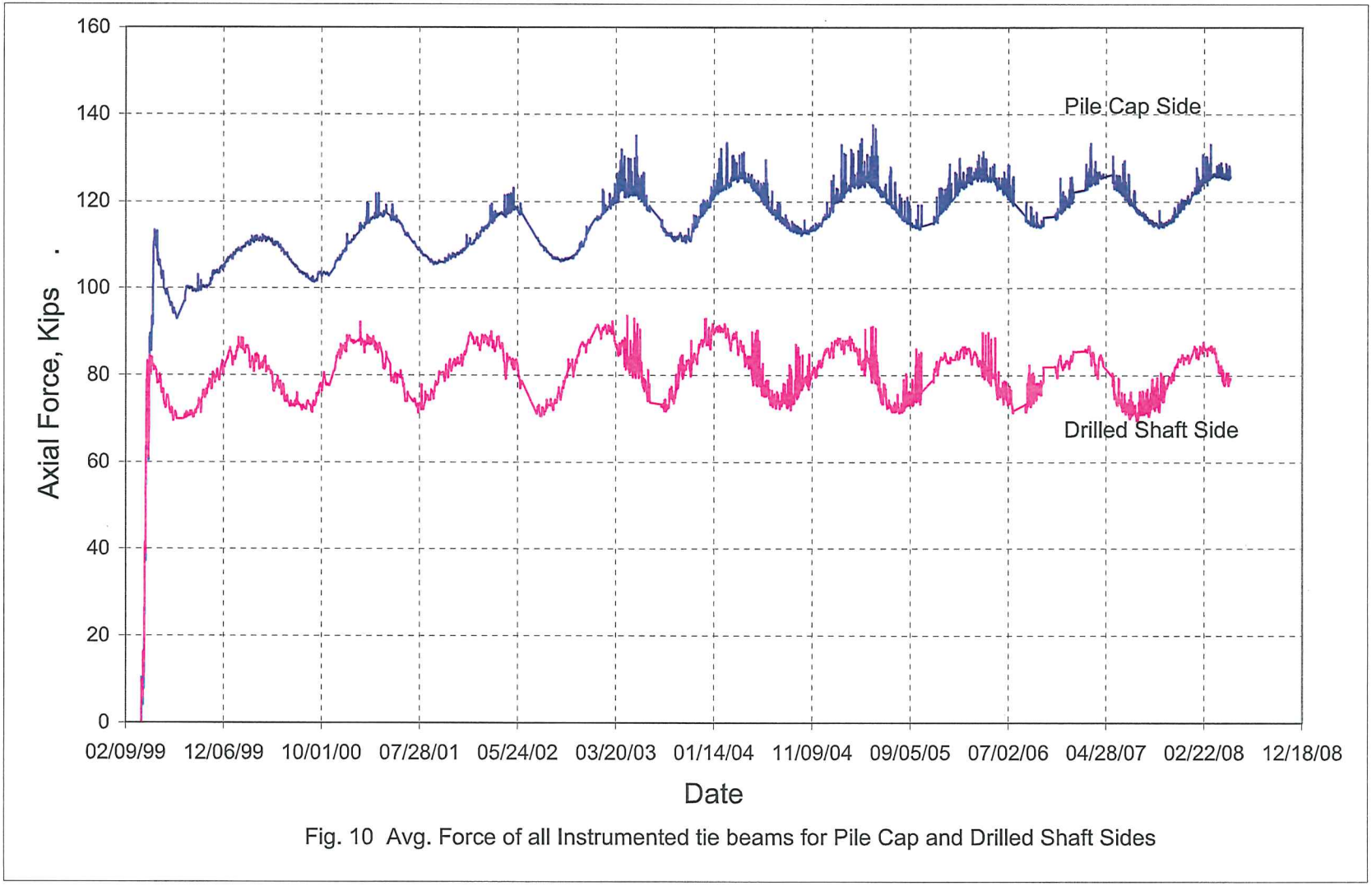


Fig. 10 Avg. Force of all Instrumented tie beams for Pile Cap and Drilled Shaft Sides

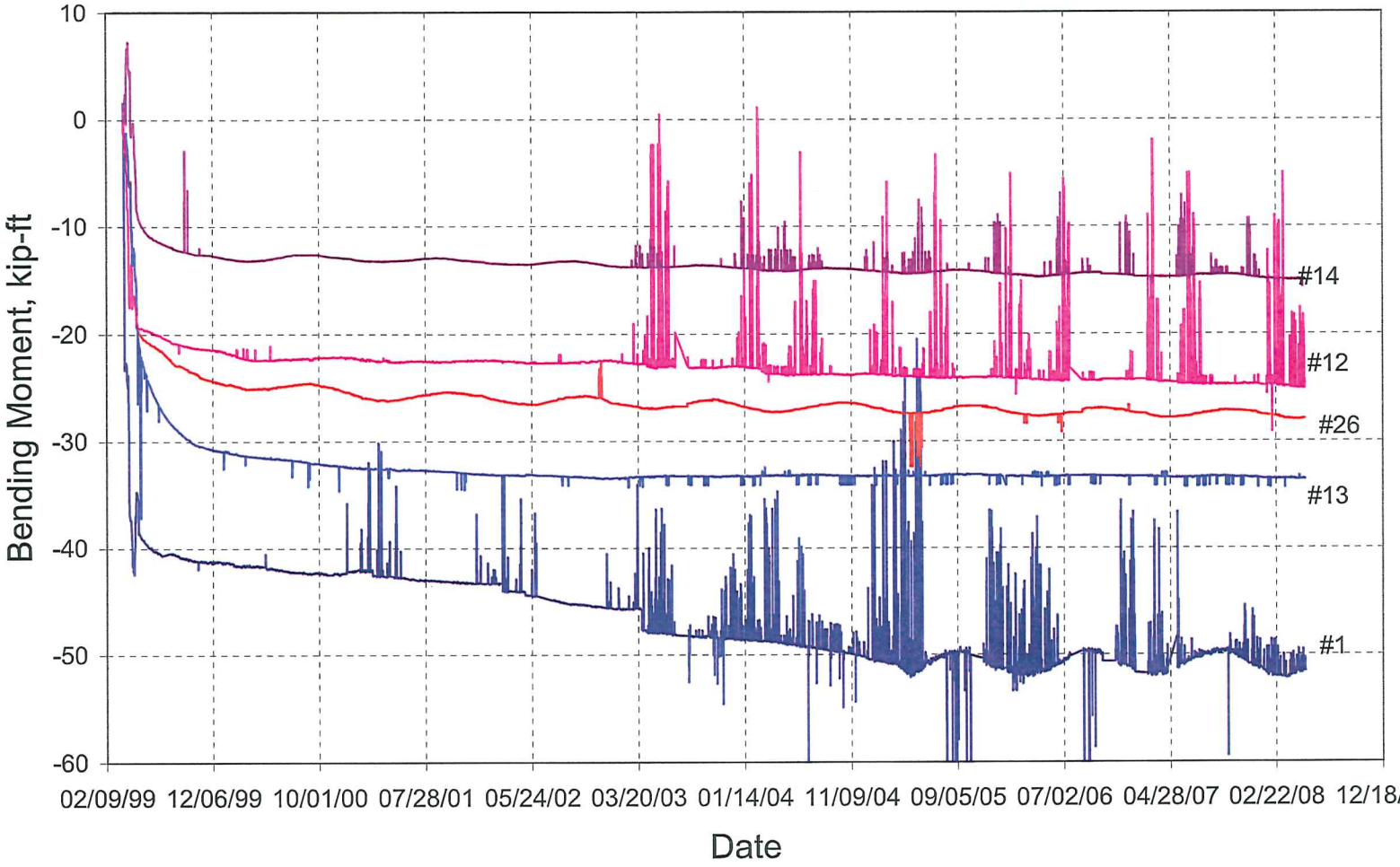


Fig. 11 Tie Beam Major Bending Moment from Gages On Pile Cape Side

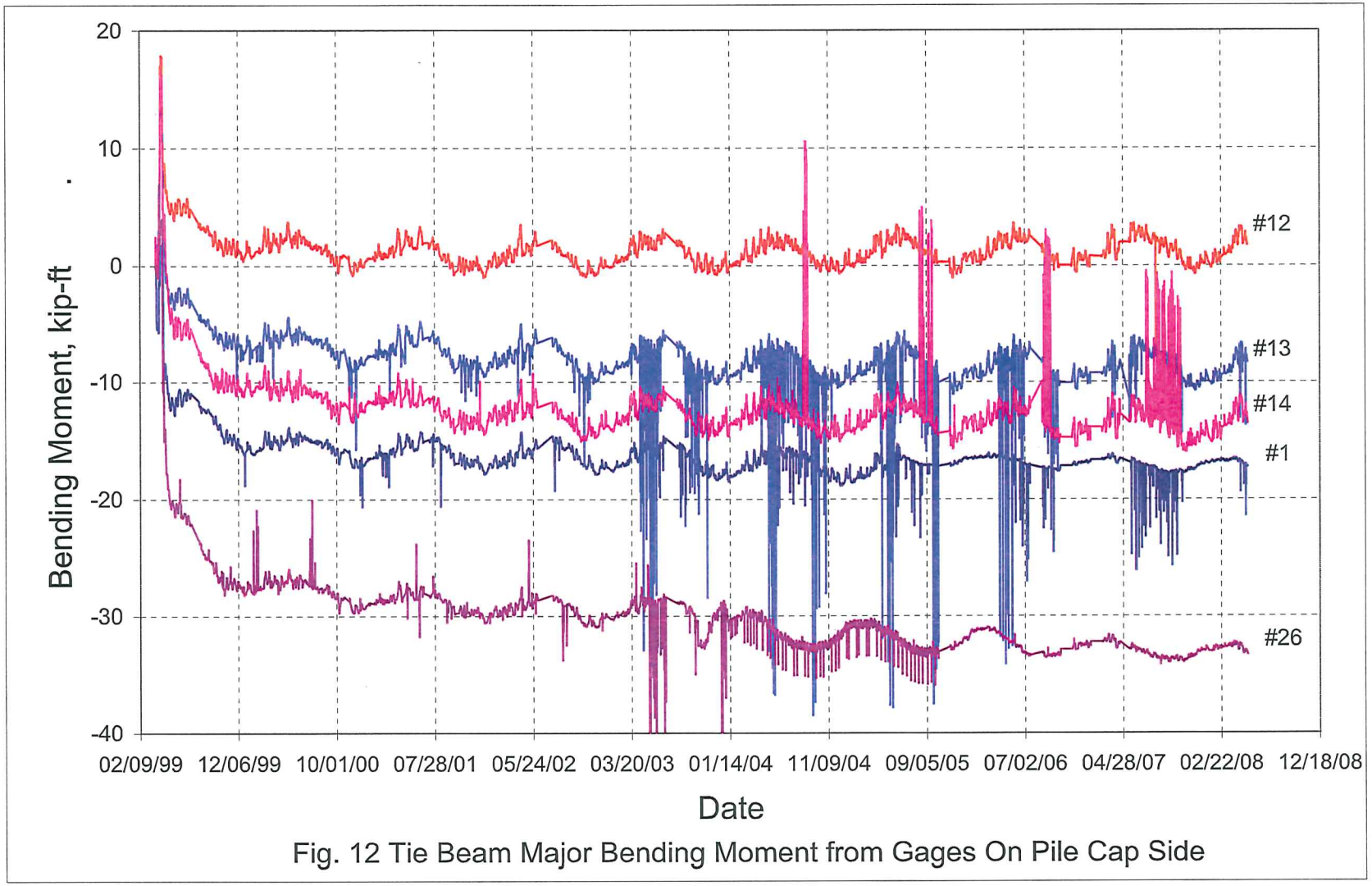


Fig. 12 Tie Beam Major Bending Moment from Gages On Pile Cap Side

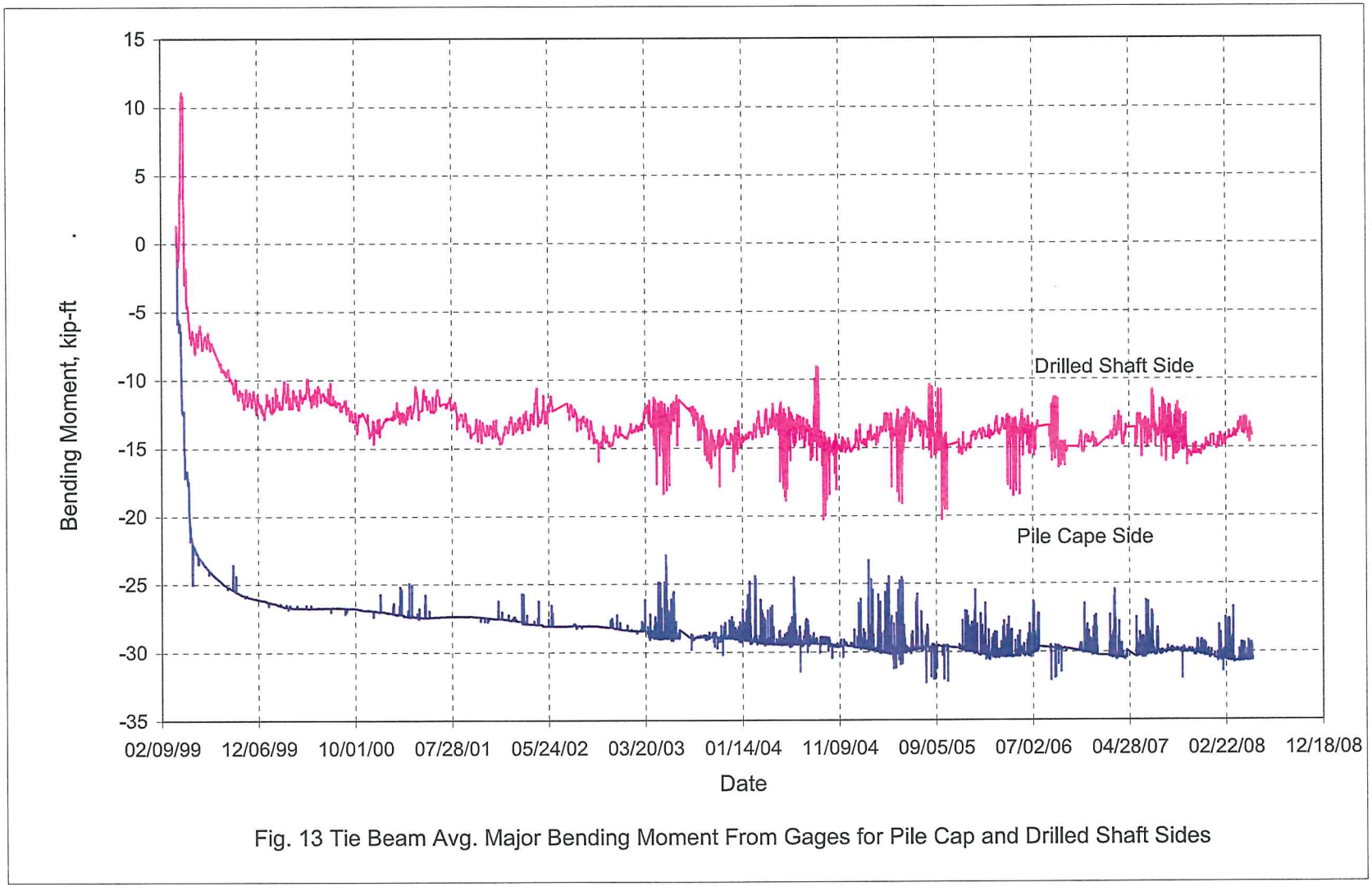


Fig. 13 Tie Beam Avg. Major Bending Moment From Gages for Pile Cap and Drilled Shaft Sides

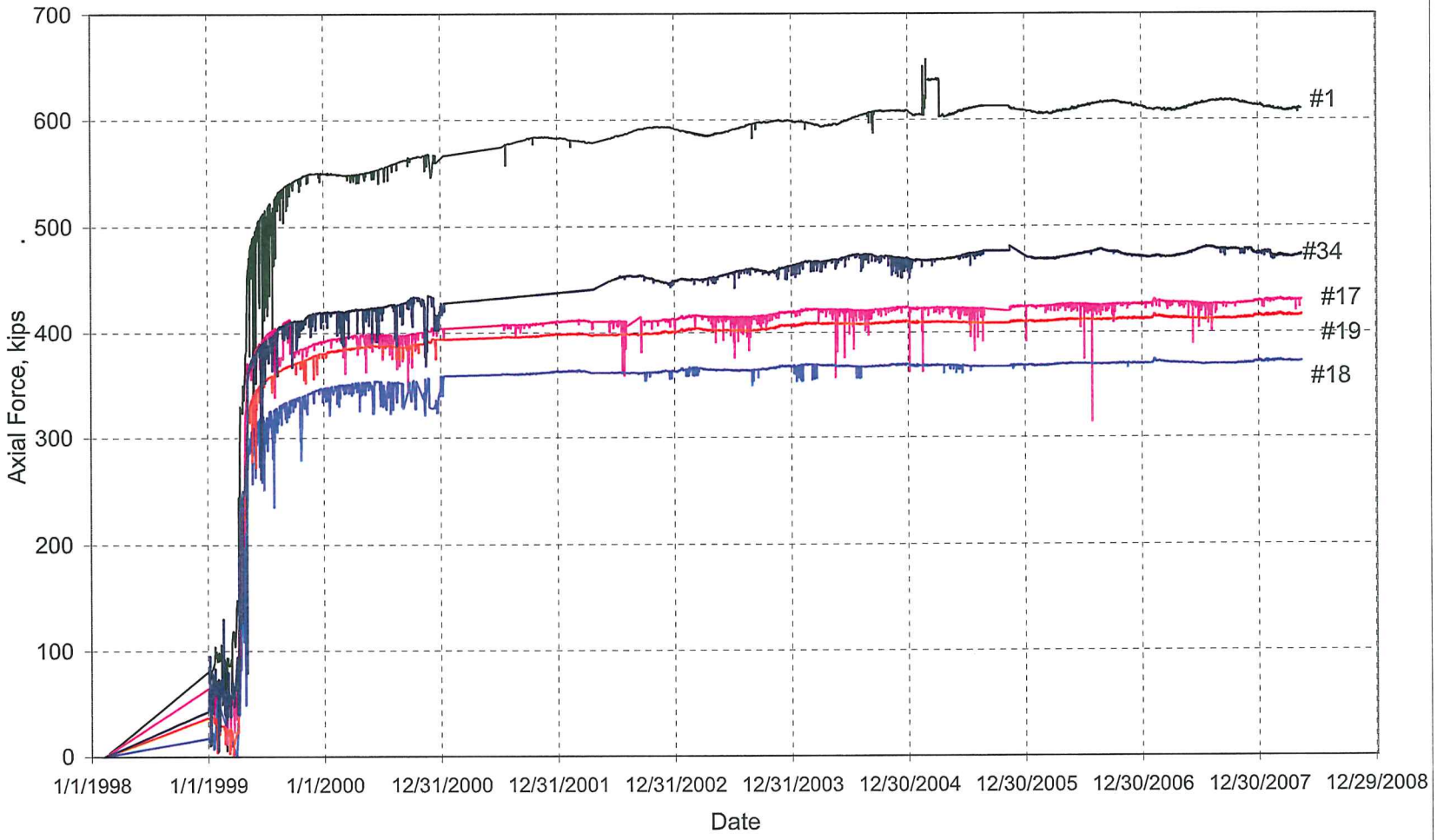


Fig. 14 Axial Force Vs. Date in Driven Piles #1, #17, #18, #19 and #34

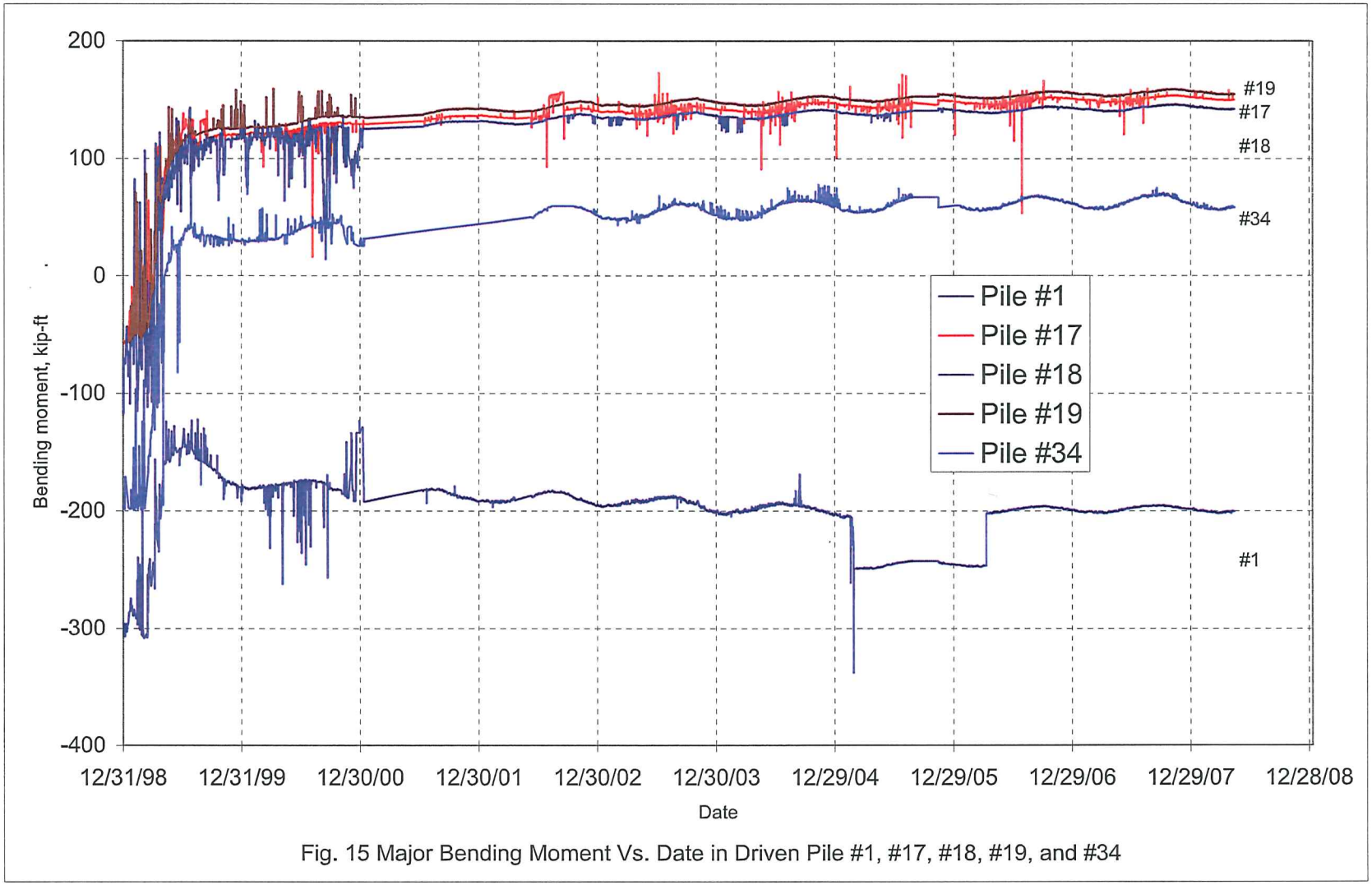


Fig. 15 Major Bending Moment Vs. Date in Driven Pile #1, #17, #18, #19, and #34

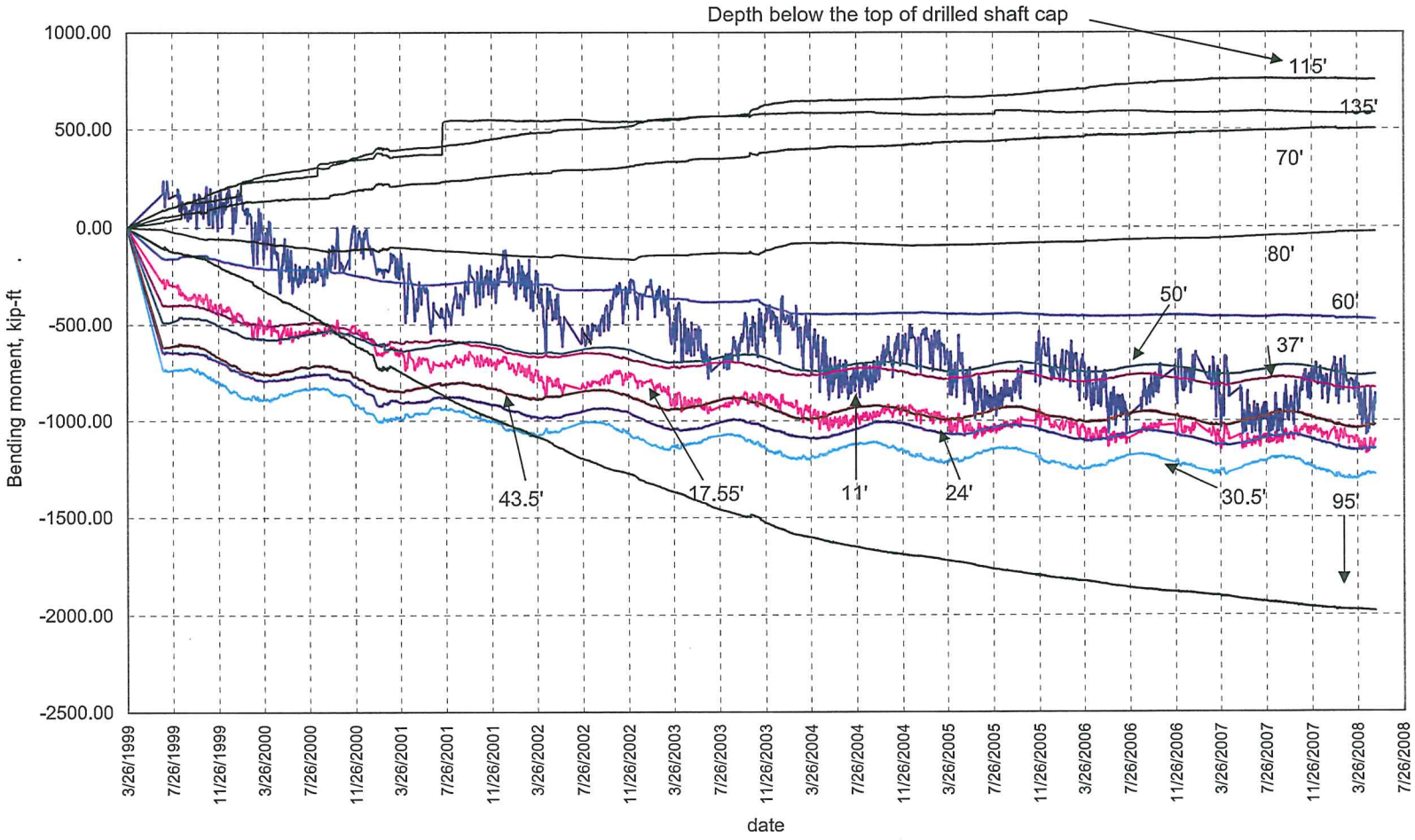


Fig. 16 Shaft #9, Bending moment vs. date in different elevations below the top of cap

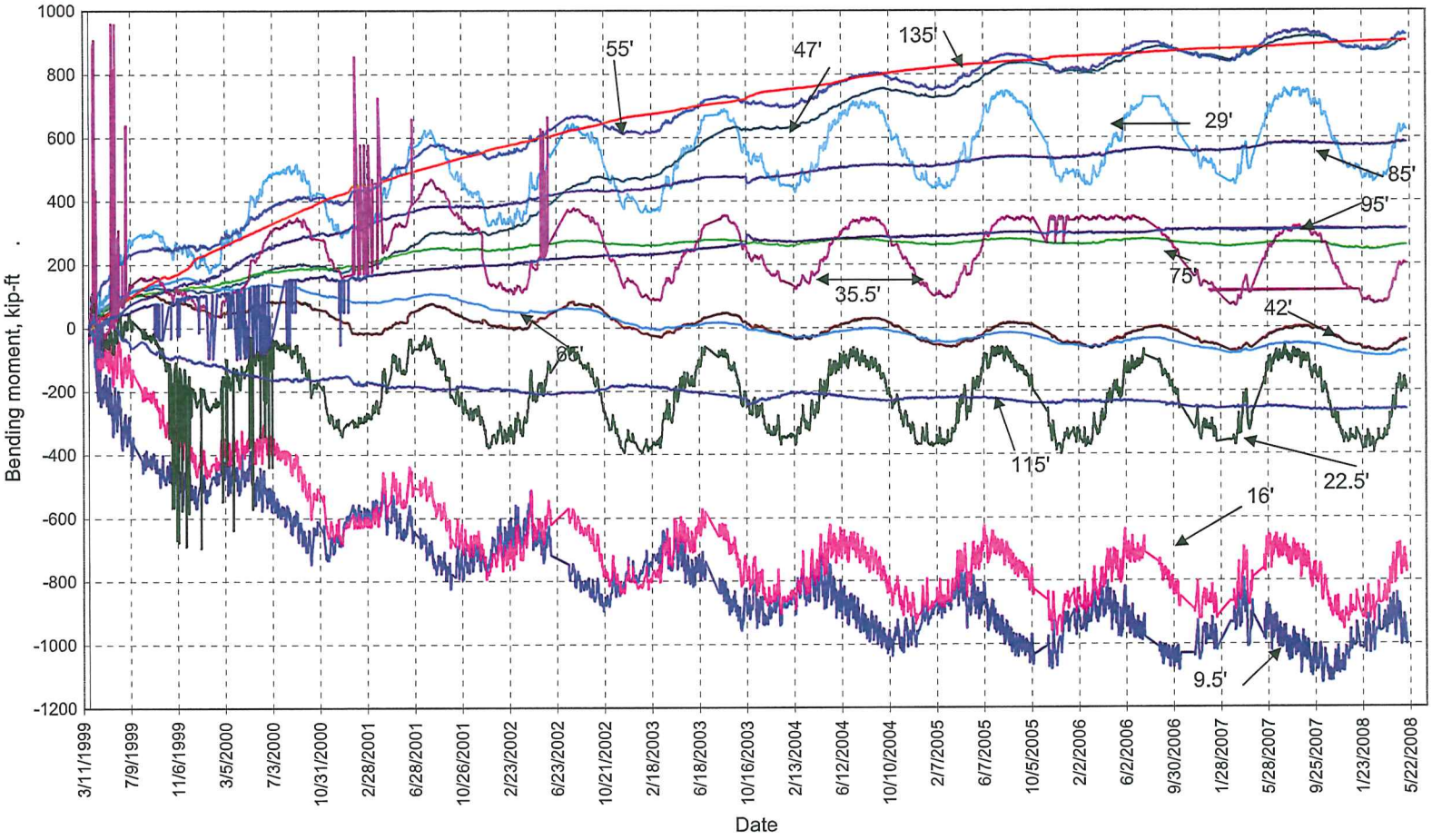


Fig. 17 Shaft #1, Bending moment vs. date in different elevations below the top of cap

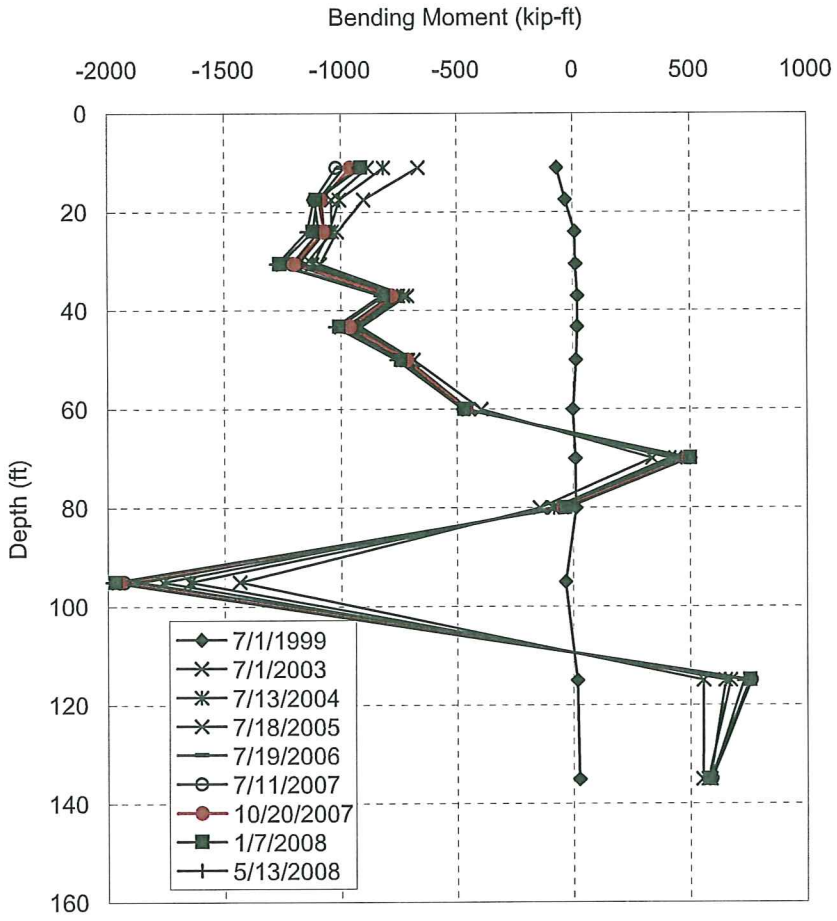


Fig. 18 Shaft #9, Bending Moment vs. Depth After Construction was completed

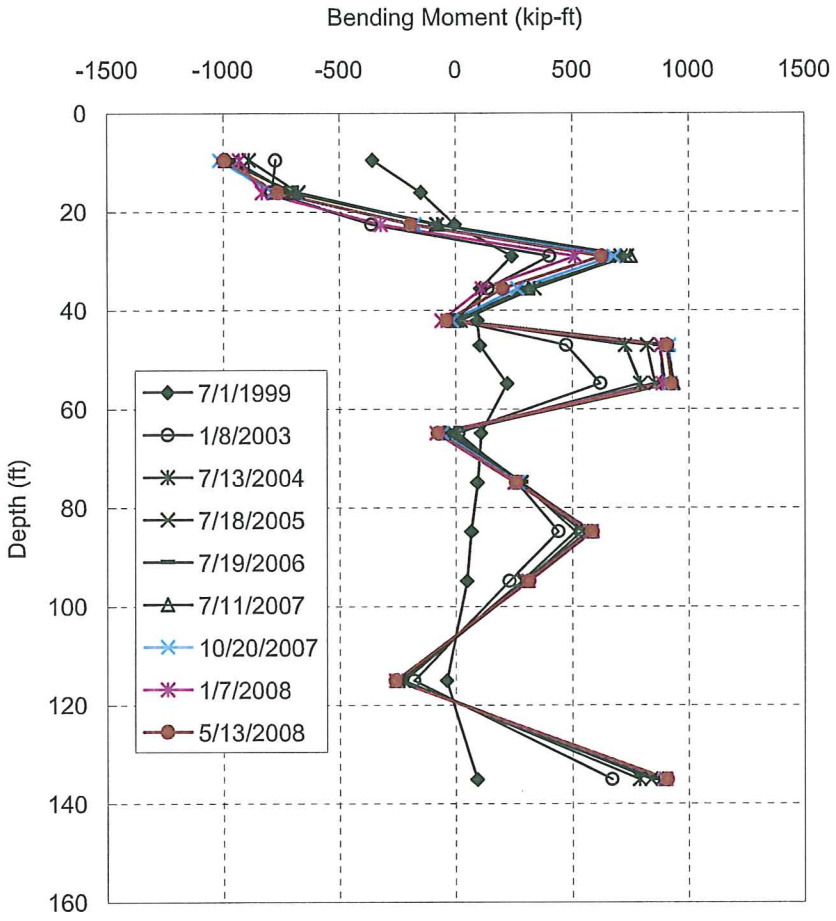


Fig. 19 Shaft #1, Bending Moment vs. Depth After Construction was completed

Fig. 20 Inclinometer #1 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

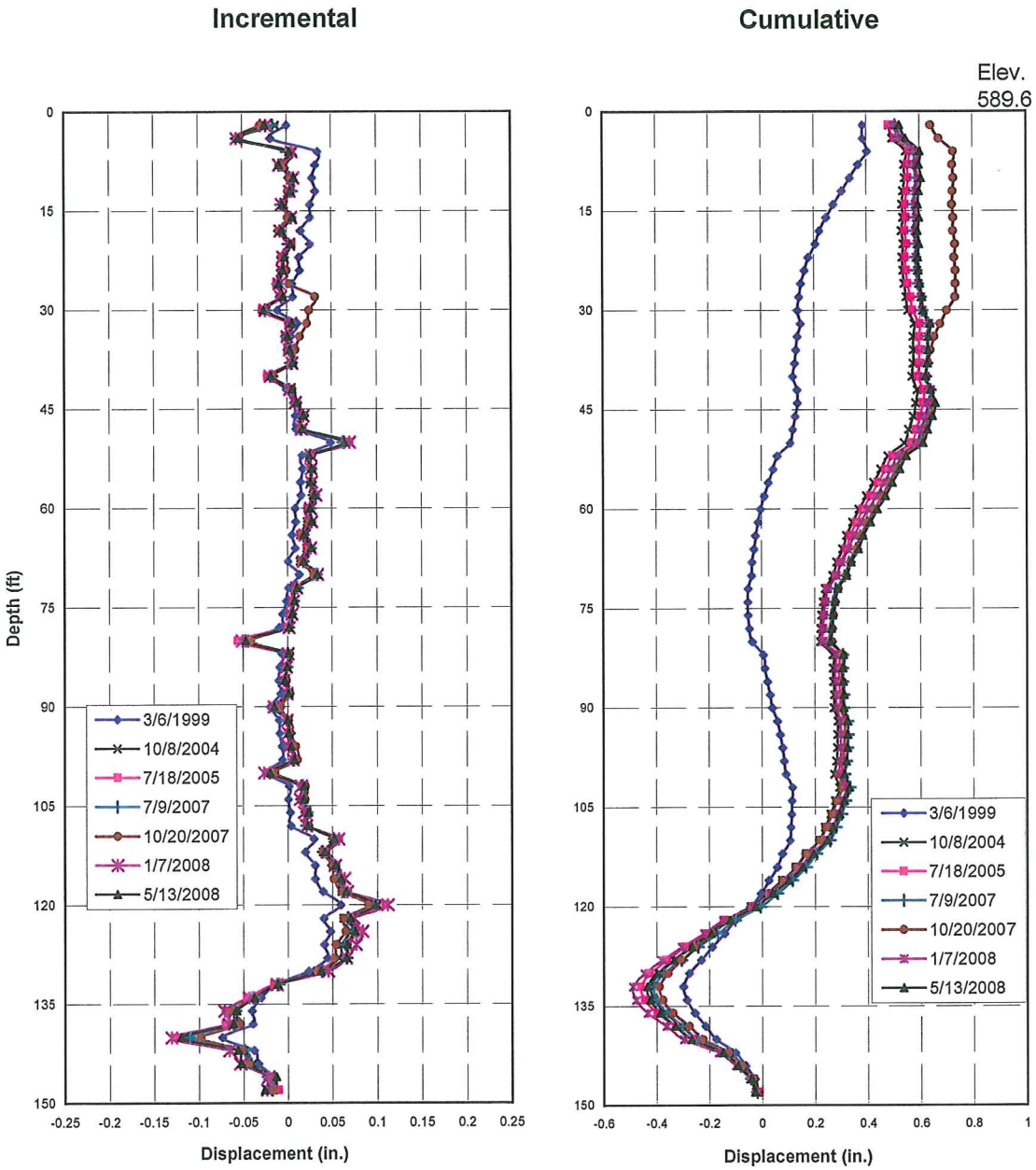


Fig. 21 Inclinometer #3 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

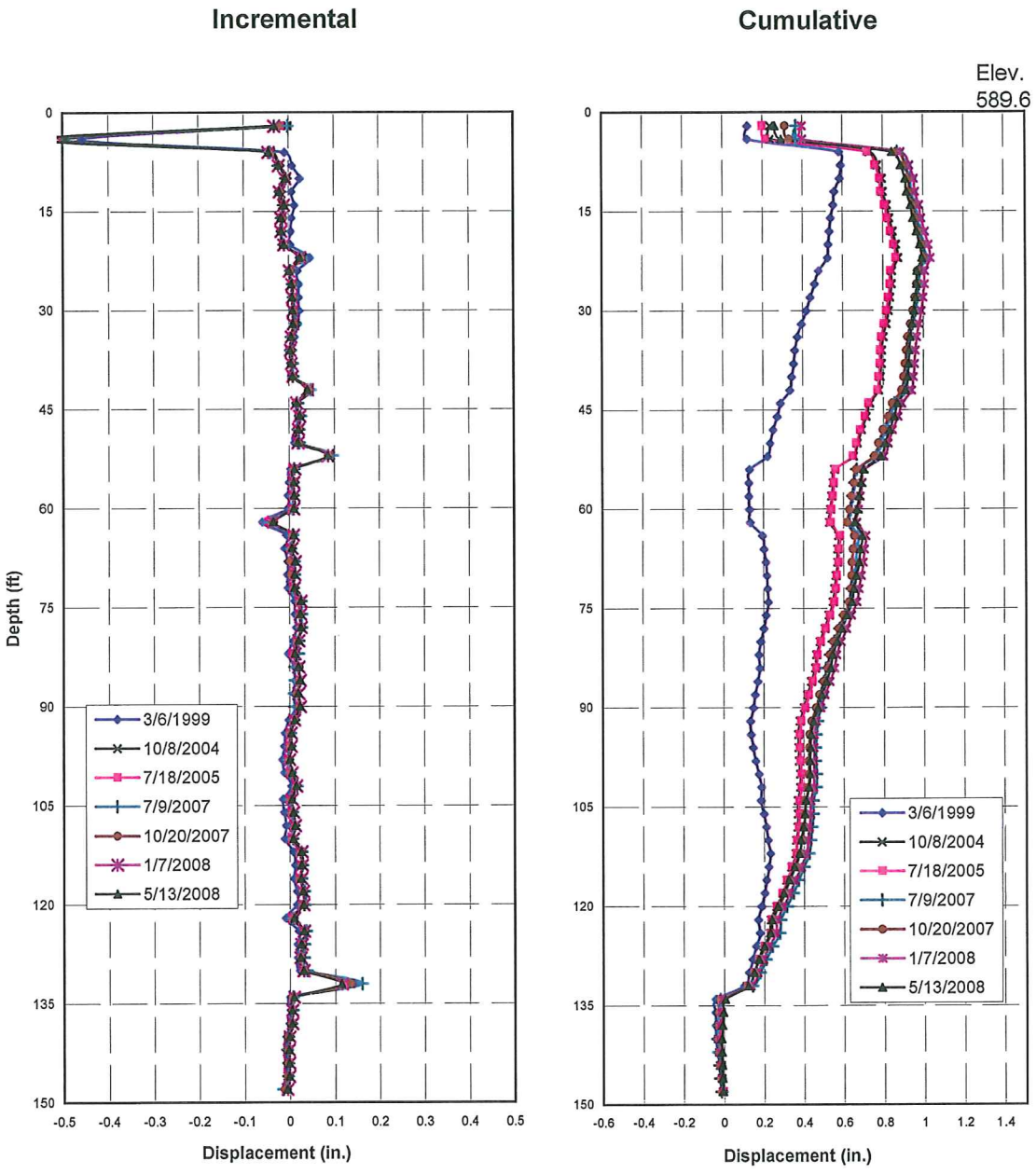


Fig. 22 Inclinometer #8 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

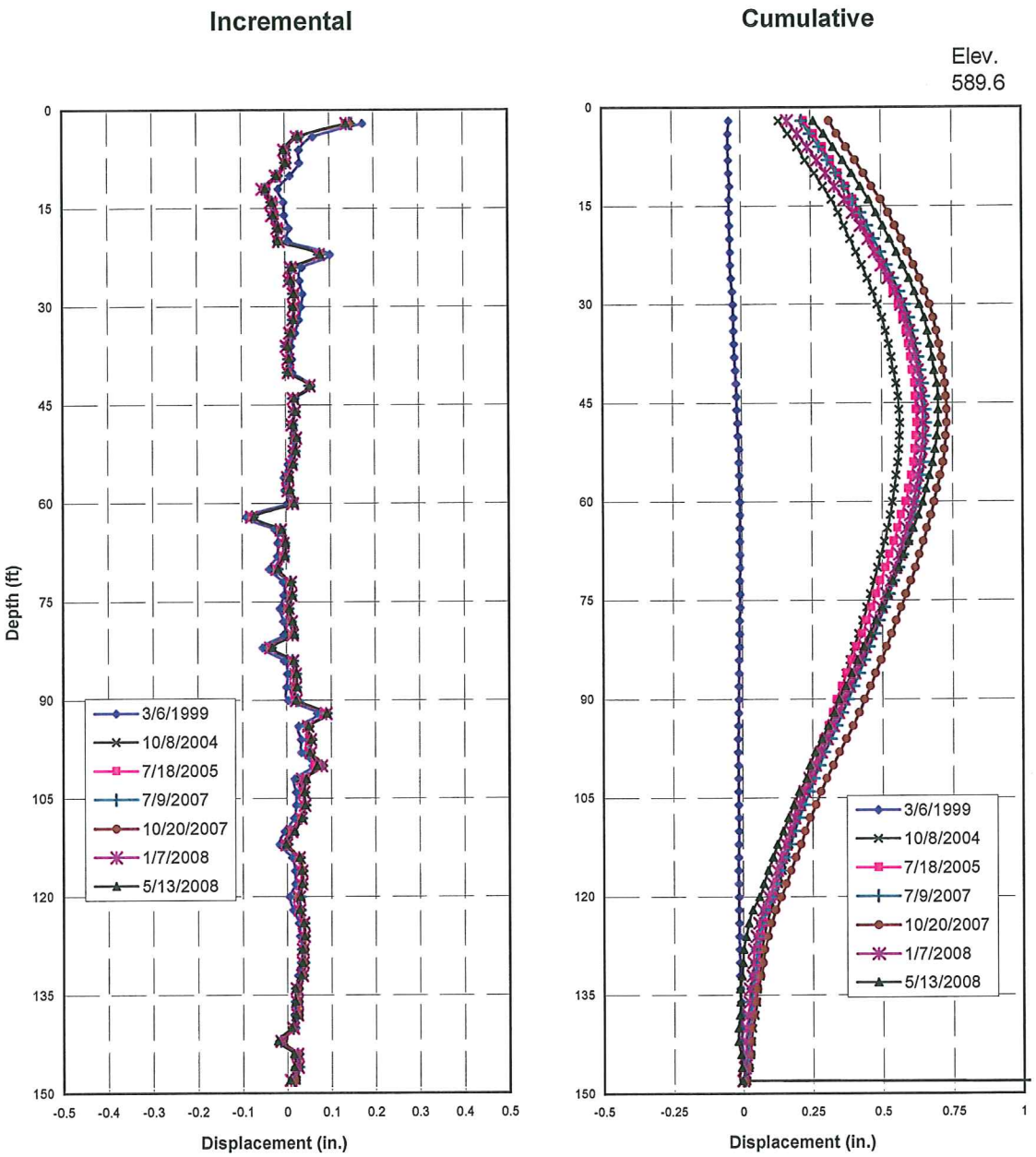


Fig. 23 Inclinometer #9A Displacement in the A+ Direction Downslope (River direction) Base Line 12/11/1998

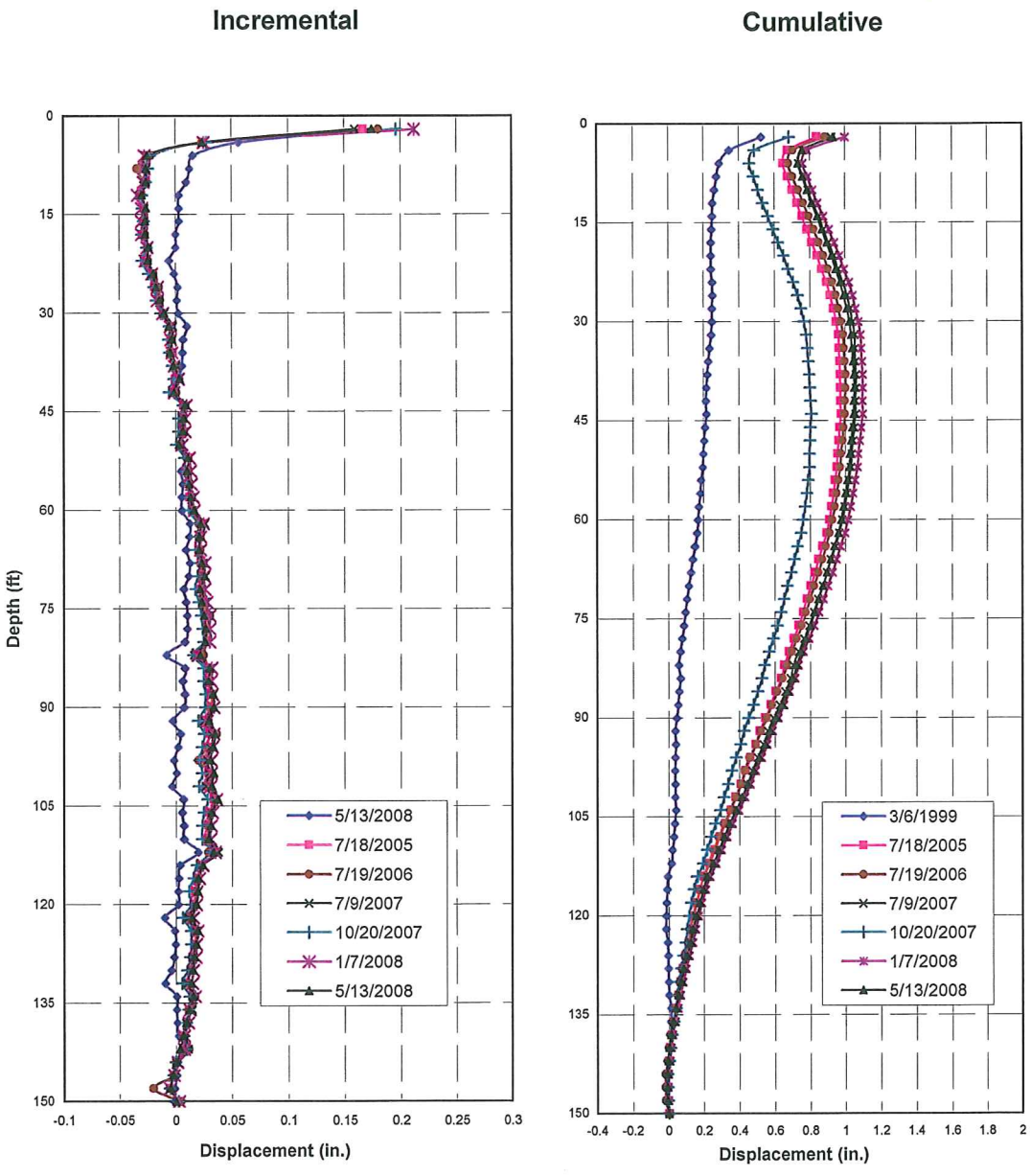


Fig. 24 Inclinometer #10 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

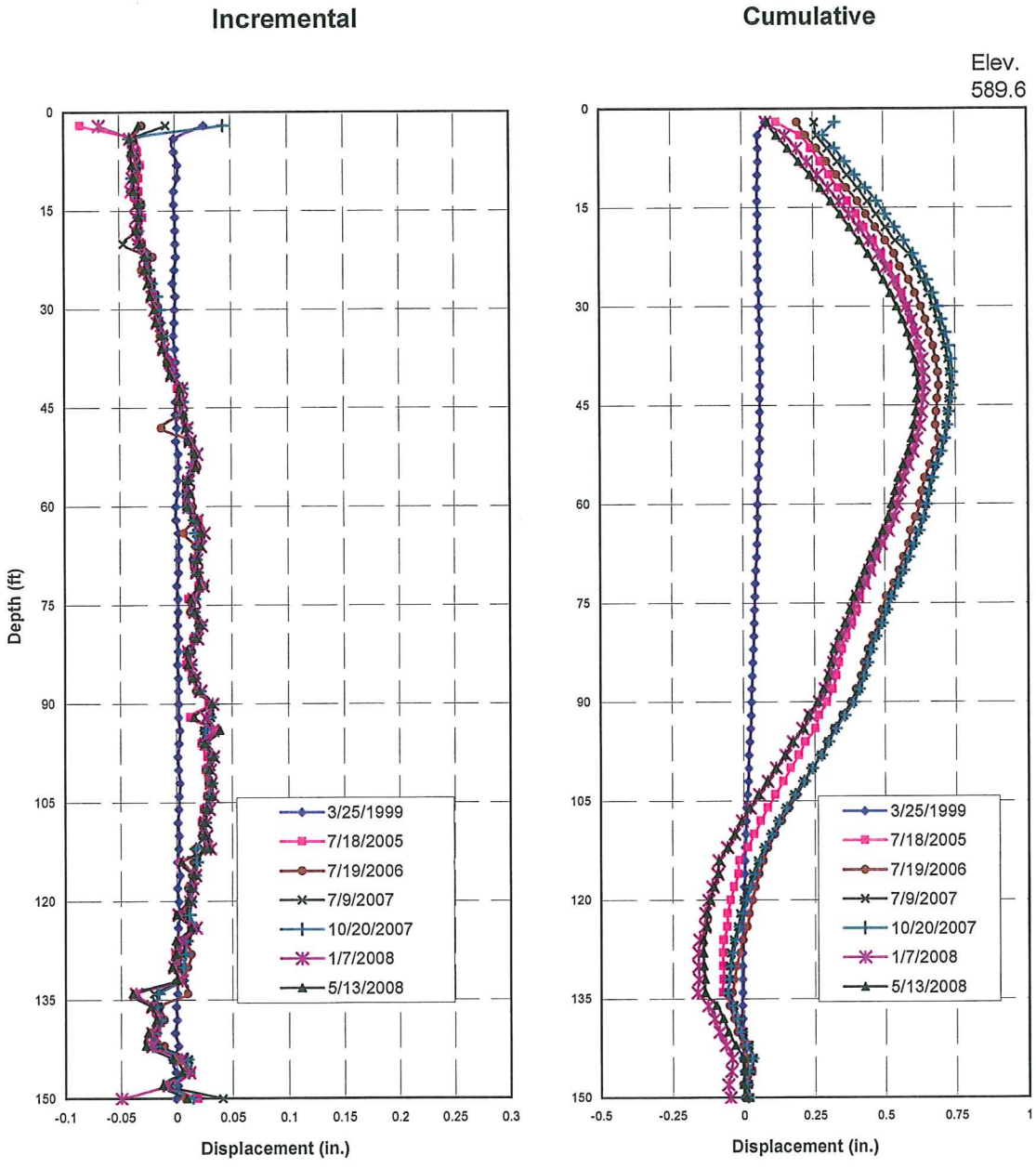
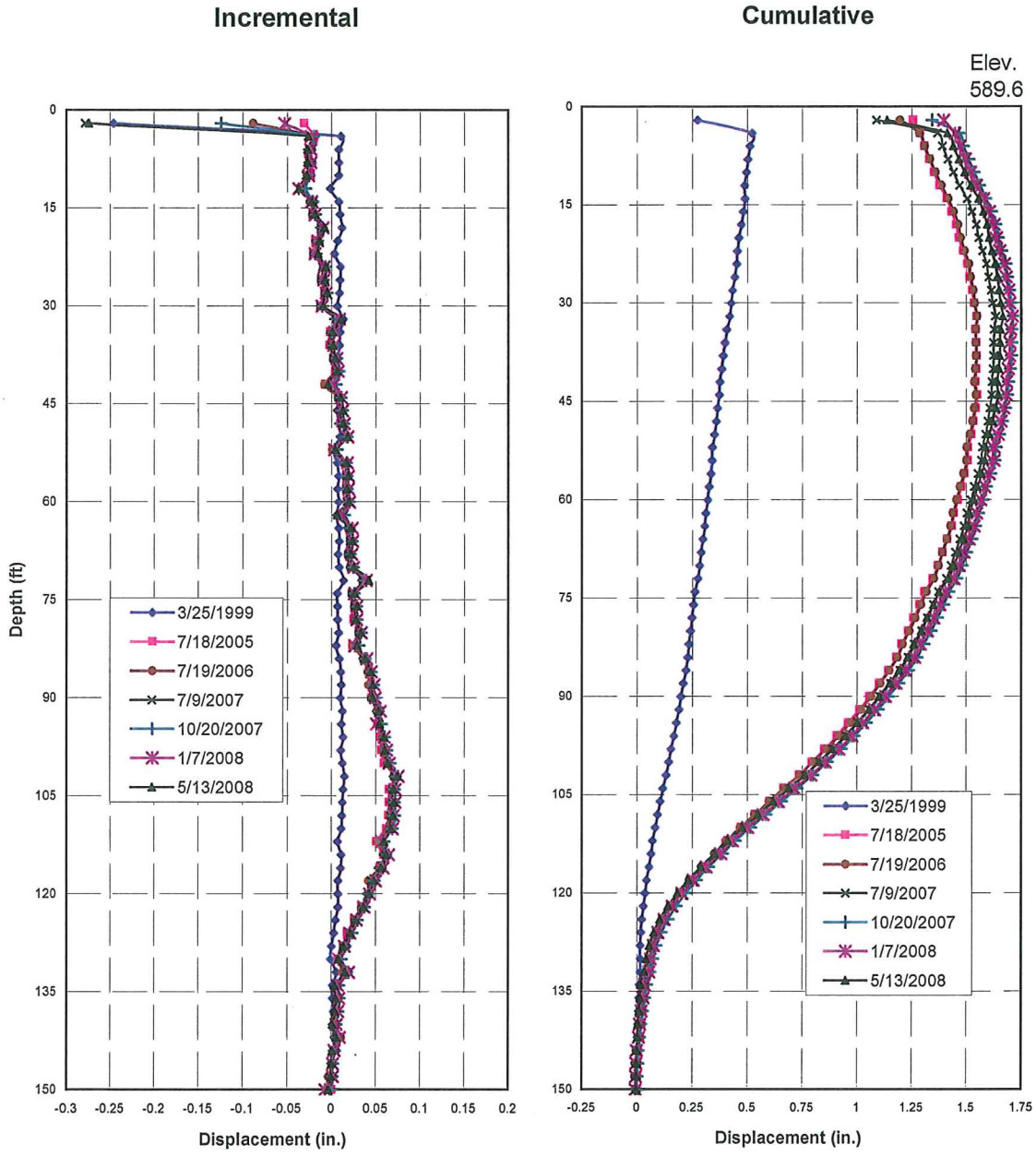


Fig. 25 Inclinometer #17 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998



RICHLAND ENGINEERING LIMITED
29 North Park Street, Mansfield, Ohio 44902-1769 • 419-524-0074 FAX 419-524-1812

106017

August 19, 2008

Ohio Department of Transportation
5500 Transportation Boulevard
Garfield Heights, Ohio 44125-5396

Attn: Mr. Mike Malloy

Re: CUY-90-1524
Central Viaduct
PID No. 20752
Slope and Pier Monitoring Services
Interim Report

Dear Mr. Malloy:

The following is our report on monitoring activity and collected data for the west slope of the Cuyahoga River and Bridge No. CUY-90-1524 west end pier, pier 1, and slope stabilization structure. The last report of data was the annual report submitted July 2, 2008 for data collected through April 2008. This report is for data collected through July 2008.

Enclosed is one CD with the electronic .pdf files of the detailed reports from BBC&M, REL, Dr. Huckelbridge, and Dr. Liang.

The slope monitoring began in 1994. The stabilization structure was constructed and the span 1 superstructure was relocated in 1999. The stabilization structure monitoring began in 1999. Additional slope monitoring north of the existing bridge began in 2006.

BBC&M Engineering, Inc. obtained inclinometer readings, piezometer readings, and calipered crack distances between July 14 through 16, 2008. A total of 19 inclinometers, 6 pneumatic piezometers and 18 vibrating wire (VW) piezometers are actively monitored as part of the project. There was a small but noticeable increase in the rates of movement observed in the inclinometers at B-05-03, B05-04, B-204 and B-303 between the April 2008 and July 2008 quarterly readings. In the other inclinometers, no significant changes in the rates of movement have been observed in the shallow or deep failure planes. All of the pneumatic piezometers exhibited either the same or slightly higher readings than those recorded in April 2008. The piezometers at B-105 continue to indicate elevated water pressures (i.e., a total head above the ground surface, artesian conditions). The measured total head values were relatively constant during the current reporting period with a difference between maximum and minimum total have values of no more than 1.1 feet in all of the VW piezometers where readings were recorded at regular intervals. The 21955 piezometer in B-05-13 continues to indicate an elevated water pressure similar to that observed in the pneumatic piezometers at B-105.

The left calipered location indicates the gap is continuing to open and the gap at the right calipered surface distance location is continuing to close. The right calipered location has been oscillating since late 2000 indicating that there might not be a trend. In July 2008, a moderate size aggregate pile, roughly 25 to 30 feet high, was observed near the east right-of-way fence and covered roughly less than 40 percent of the property currently being used to stockpile aggregate adjacent to the east right-of-way fence. The small landslide adjacent to the large excavation near the west right-of-way fence does not appear to have experienced a significant change since the quarterly readings were last taken in April 2008.

Richland Engineering Limited measured expansion joint openings at the west end pier, near pier 2, and near pier 4 on July 16, 2008. The deck expansion joint opening near pier 2 was closed at the south curb at 84˚F. This is the first time the joint has been observed to be closed since truss span 1 was relocated in 1999.

Art Huckelbridge obtained tiltmeter readings at the west end pier and pier 1 on July 23, 2008. The tiltmeters show positions and magnitudes of movement similar to past readings.

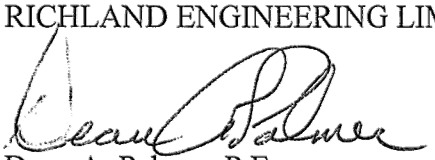
Robert Liang monitored instrumentation on July 28 and 29, 2008. The instrumentation readings in the rock anchors, driven piles, tieback beams, drilled shafts, and inclinometers showed no significant change during this quarter.

The next readings are scheduled about October 15, 2008. Data collection and monitoring has been authorized through 2008.

Please contact us if you have any questions (email reltd@r-e-l.com). Copies of detailed quarterly reports are available upon request.

Very truly yours,

RICHLAND ENGINEERING LIMITED



Dean A. Palmer, P.E.

DAP:dap
cc: Craig Hebebrand, District 12
Youssef Seif, District 12
Jeff Leake, District 12
Tim Keller, Office of Structures
Gene Geiger, Office of Geotechnical Services
Tom Lefchik, FHWA
Steve Pasternack, BBC&M Engineering, Inc., Dublin
Jeff Snyder, BBC&M Engineering, Inc., Valley View
Art Huckelbridge
Robert Liang
Rick Engel, E.L. Robinson Engineering Co.
Bob Parker, Michael Baker, Jr., Inc.

JULY 2008 QUARTERLY REPORT
FIELD MONITORING SERVICES
CUY-90-14.52/15.24
PID #77332
CLEVELAND, OHIO

Report to

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

Prepared by

BBC&M ENGINEERING, INC.
CLEVELAND, OHIO

August 2008

August 5, 2008
012-00946-300

Mr. Dean A. Palmer, P.E.
Richland Engineering Limited
29 North Park Street
Mansfield, Ohio 44902

Re: CUY-90-14.52/15.24 Bridge (PID No. 77332)
Quarterly Report - Field Monitoring Services
July 2008 (Third Quarter)

Dear Mr. Palmer:

BBC&M Engineering, Inc. (BBCM) has completed the field monitoring services for the July 2008 quarter as part of the CUY-90-14.92/15.24 project. This quarterly report presents our general site observations and the results and evaluation of data collected from all the actively monitored instrumentation (inclinometers, piezometers and calipered distance locations) installed by BBCM at or near the West Abutment of the existing I-90 Central Viaduct Bridge.

A total of 19 inclinometers, six (6) pneumatic piezometers and 18 vibrating wire (VW) piezometers are actively monitored as part of the project. A Summary Table and Site Plan of Active Instrumentation are submitted as Plates 1 and 2 of the Appendix. Quarterly readings were taken during the period of July 14 through July 16, 2008.

Inclinometers

All the data sets presented in the Appendix have been corrected for measured spiral of the inclinometer casings and for systematic errors such as bias-shift, sensor rotation and depth positioning error, where necessary. The rates of movement were computed using linear regression for the depth ranges shown on the Displacement vs. Time plots in the Appendix.

There was a small but noticeable increase in the rates of movement observed in the inclinometers at B-05-03, B-05-04, B-204 and B-303 between the April 2008 and July 2008 quarterly readings. In the other inclinometers, no significant changes in the rates of movement have been observed in the shallow or deep failure planes.

Shallow Failure Plane

No shallow slip-plane movements have been observed in the inclinometers within the Pier 1 stabilization system (B-204 and B-05-04) since completion of construction of the stabilization system. In the vicinity of Pier 1 just outside of the stabilization system (B-

05-03 and B-108A), the shallow failure plane is moving at an average rate of about 0.06 inches per year (in/yr) from 2006 to the present. This is a slight increase from the rate of 0.055 in/yr as reported in the 2007-2008 Annual Monitoring Report, dated May 2, 2008. Upslope from Pier 1 (B-203 and B-303), the shallow failure plane continues to move at an average rate of about 0.025 in/yr from 2004 to the present. Well outside the Pier 1 Area (B-05-16), the shallow failure planes are cumulatively moving at an average rate of about 0.24 in/yr from 2006 to the present. This is a slight decrease from the rate of 0.26 in/yr as reported in the 2007-2008 Annual Monitoring Report. Additionally, the cumulative rate of the shallow movements in B-05-16 has decreased to about 0.15 in/yr from January 2007 to the present.

Deep Failure Plane

South of the West End Pier (B-102 and B-107), the deep failure plane continues to move at an average rate of about 0.03 in/yr from around 2000 to the present. In the Pier 1 area (B-203, B-204, B-303, B-108A, B-05-03 and B-05-04), the deep failure plane is moving at an average rate of about 0.025 in/yr from 2004 (or 2006 for new or replacement inclinometers) to the present. This is a slight increase from the rate of movement of 0.02 in/yr as reported in the 2007-2008 Annual Monitoring Report. Well outside the Pier 1 area (B-05-16), the deep failure plane continues to move at an average rate of 0.02 in/yr.

Additional Observations in Active Inclinometers Installed between 1994 and 1999

The B-101 inclinometer has indicated nominal movement since its installation. The inclinometer at P-9N (installed in one of the drilled shafts) indicates the top of the drilled shaft is restrained laterally and that the maximum lateral deflection is about 0.97 inches and occurs approximately 40 to 60 feet below the top of the inclinometer casing.

Additional Observations in Active Inclinometers Installed in 2006

The cantilever displacement continually observed in B-105A to a depth of about 60 to 70 feet (see Plates 22 and 23 in the Appendix) is moving at a rate of about 1.06 in/yr. This is a decrease from the rate of movement of 1.27 in/yr as reported in the 2007-2008 Annual Monitoring Report but the current rate of movement is still significantly higher than the rate of 0.16 in/yr observed from June 2006 to October 2007. The bulkhead at this location may be progressively leaning outwards toward the Cuyahoga River. A Displacement vs. Time plot for B-105A has been submitted as Plate 26 in the Appendix. Additionally, a photo of the bulkhead adjacent to B-105A has been submitted as Plate 67 in the Appendix. It appears that there may be a bulge in the bulkhead in the vicinity of B-105A.

Potential slope movements (not yet developed enough to be called definitive slide planes) have been observed in some of the inclinometers, which are listed as follows:

- In B-105A, depth of 85 feet and 110 feet (see Plate 22 in the Appendix); and,
- In B-05-02, depth of 109 ft and 129 ft (see Plate 30 in the Appendix).

Additional readings are needed in these inclinometers to evaluate whether these potential slide planes are true displacements.

Piezometers

Pneumatic Piezometers

The results of the active pneumatic piezometer readings taken between July 14 and July 16, 2008 are summarized in Table 1 below.

Table 1: Summary of Readings for Active Pneumatic Piezometers – CUY-90-15.24

Piezometer Identifier		Ground Surface Elevation (ft)	Elevation Head, h_e (ft)	Pore Pressure Reading, u (psi)	Total Head, h_t (ft)
B-101 (P-1[1])	orange	676.6	626.3	0.9	628.4
	pink	676.6	552.3	32.5	627.3
B-105 (P-3[1])	pink	585.6	497.6	39.1	587.8
	blue	585.6	479.9	48.2	591.1
B-107 (P-5[1])	orange	662.3	562.3	26.1	622.5
B-303 (P-2[1])	pink	627.0	586.2	6.9	602.1

1 – BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers.

All of the piezometers exhibited either the same or slightly higher readings than those recorded in April 2008. Note that the piezometers at B-105 continue to indicate elevated water pressures (i.e., a total head above the ground surface, artesian conditions). Total Head vs. Time plots have been submitted as Plates 51 through 54 in the Appendix of this report.

Vibrating Wire (VW) Piezometers

Table 2 provides a summary of the maximum and minimum values of all the pressure readings taken from April 2008 (end of previous reporting period) to the time when the collected data was last downloaded from VW Miniloggers between July 14 and July 16, 2008.

Table 2: Summary of Readings for VW Piezometers – CUY-90-14.92

Piezometer Identifier		Time Interval of Readings Reported [1]	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-01	21961 - 65 ft	7/14/08[2]	13.2[2]	675.4	610.4	12.9[2]	640.1[2]
	21967 - 95 ft	7/14/08[2]	13.1[2]	675.4	580.4	24.2[2]	636.4[2]
B-05-02	21963 - 46 ft	4/16/08 to 7/15/08	12.3/12.2	617.9	571.9	8.6/8.1	591.7/590.6
	21951 - 122 ft	4/16/08 to 7/15/08	12.2/12.1	617.9	495.9	40.8/40.3	590.0/589.0
B-05-03	21957 - 32 ft	7/15/08[2]	11.5[2]	605.1	573.1	8.4[2]	592.4[2]
	21965 - 112 ft	7/15/08[2]	12.4[2]	605.1	493.1	41.8[2]	589.5[2]
B-05-04	21958 - 59 ft	4/16/08 to 7/15/08	12.9/12.8	600.8	541.8	18.1/17.7	583.5/582.7
	21952 - 119 ft	4/16/08 to 7/15/08	13.0/13.0	600.8	481.8	45.0/44.9	585.7/585.4
B-05-07	21966 - 102 ft	4/14/08 to 7/14/08	12.4/11.6	678.9	576.9	24.5/24.0	633.4/632.3
	21956 - 220 ft	4/14/08 to 7/14/08	11.9/11.9	678.9	458.9	71.7/71.3	624.4/623.3
B-05-08	21954 - 65.5 ft	4/14/08 to 7/14/08	12.7/12.6	679.9	614.4	13.1/12.7	644.7/643.7
	21959 - 110.5 ft	4/14/08 to 7/14/08	12.4/12.4	679.9	569.4	29.9/29.4	638.4/637.3
B-05-11	21968 - 95 ft	7/14/08[2]	12.7[2]	675.1	580.1	23.9[2]	635.3[2]
	21953 - 130 ft	4/14/08 to 7/14/08[3]	12.5/7.8[3]	675.1	545.1	36.9/36.6[3]	630.3/629.6[3]
B-05-12	21960 - 75 ft	7/15/08[2]	12.8[2]	652.7	577.7	19.1[2]	621.8[2]
	21964 - 120 ft	4/14/08 to 7/15/08	12.5/12.4	652.7	532.7	37.1/36.7	618.3/617.3
B-05-13	21962 - 60 ft	4/17/08 to 7/16/08	12.6/12.6	580.0	520.0	24.3/24.0	576.1/575.4
	21955 - 135 ft	4/17/08 to 7/16/08	12.8/12.8	580.0	445.0	60.5/60.4	584.6/584.4

1 – Readings generally were taken every 8 hours during the reported time interval.
2 – Only one (1) manual reading was taken at the time of data collection during the July 2008 quarterly readings due to Minilogger issues. For additional details, see the Total Head vs. Time plot for the specific Minilogger in the Appendix.
3 – Malfunction of Minilogger resulting in several scheduled readings being missed during the reported time interval.

The measured total head values were relatively constant during the current reporting period with a difference between maximum and minimum total head values of no more than 1.1 feet in all of the VW piezometers where readings were recorded at regular

intervals (see footnotes in Table 2). Total Head vs. Time plots have been submitted as Plates 55 through 63 in the Appendix.

The 21955 piezometer in B-05-13 continues to indicate an elevated water pressure (i.e., a total head above the ground surface, artesian conditions) similar to that observed in the pneumatic piezometers at B-105 previously discussed.

In six (6) of the VW piezometers, only one (1) manual reading was taken at the time of data collection during the July 2008 quarterly readings due to malfunctioning VW Miniloggers (21961 and 21967 at B-05-01, 21957 and 21965 at B-05-03, 21968 at B-05-11 and 21960 at B-05-12). New VW Miniloggers will need to be installed to replace these six (6) malfunctioning Miniloggers in order for regular readings to be taken in the VW piezometers during the quarter. Additionally, as noted in Table 2, several scheduled readings were missed during the reported time interval in the 21953 Minilogger at B-05-11. This Minilogger, which was flooded several months ago, is recommended to be replaced.

Additional Field Measurements and Observations

The two calipered surface distance locations (left and right) are provided in the Site Plan of Active Instrumentation (Plate 2 of the Appendix). A Calipered Surface Distance Table and Calipered Distance Readings vs. Time plots have been included as Plates 64 through 66 in the Appendix. The left calipered location indicates the gap is continuing to open at a rate of about 0.06 in/yr and the gap at the right calipered location is continuing to close at a rate of about 0.02 in/yr. The right calipered location has been oscillating above and below a distance of about 4.4 inches since late 2000 indicating that there might not be a trend.

In July 2008, a moderate size aggregate pile, roughly 25 to 30 feet high, was observed near the east right-of-way fence and covered roughly less than 40 percent of the property currently being used to stockpile aggregate adjacent to the east right-of-way fence.

The large excavation and the repair effort of the bulkhead near the west right-of-way fence appear to be unfinished as of July 2008. The small landslide adjacent to the large excavation near the west right-of-way fence (just north of B-05-16, see Plate 2 in the Appendix for the approximate landslide location) does not appear to have experienced a significant change since the quarterly readings were last taken in April 2008. However, the area was covered heavily with vegetation during the site visit making it difficult to see the scarps. For this reason, site photos of the landslide area were not taken during these current quarterly readings.

Closing

We appreciate being of continued service during this project. Please contact our office if you have any questions or require additional information. The next quarterly readings are scheduled to take place around October 15, 2008.

Sincerely,
BBC&M ENGINEERING, INC.
Cleveland, Ohio

Jeffrey L. Snyder, P.E.
Project Engineer

Stephen C. Pasternack, P.E.
Senior Project Engineer

cc: Mr. Robert B. Parker, P.E. (Michael Baker Jr., Inc.)

Submitted: pdf copy submitted to Richland Engineering at reltd@r-e-l.com and Michael Baker Jr., Inc. via their ftp site
Attachments: Appendix (Plates 1 through 67)

APPENDIX

CUY-90-14.52/15.24 INSTRUMENTATION MONITORING

APPENDIX

Plate No.

General Information

Summary Table of Active Instrumentation.....1
Site Plan of Active Instrumentation.....2

Plots for Active BBCM Inclinometers Installed from 1994 to 1999–CUY-90-15.24

Cumulative and Incremental Displacement versus Depth Plots

B-101 – A and B-Axis.....3-4
B-102 – A and B-Axis.....5-6
B-107 – A and B-Axis.....7-8
B-203 – A and B-Axis.....9-10
B-204 – A and B-Axis.....11-12
B-303 – A and B-Axis.....13-14
P-9N – A and B-Axis.....15-16

Displacement versus Time Plots

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B-107 – A-Axis.....18
B-203 – A-Axis.....19
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Plots for Replacement Inclinometers Installed by BBCM in 2006 – CUY-90-15.24

Cumulative and Incremental Displacement versus Depth Plots

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B-108A – A and B-Axis.....24-25

Displacement versus Time Plots

B-105A – A-Axis.....26
B-108A – A-Axis.....27

Plots for Inclinometers Installed by BBCM in 2006 – CUY-90-14.52

Cumulative and Incremental Displacement versus Depth Plots

B-05-01 – A and B-Axis.....28-29
B-05-02 – A and B-Axis.....30-31
B-05-03 – A and B-Axis.....32-33
B-05-04 – A and B-Axis.....34-35
B-05-07 – A and B-Axis.....36-37
B-05-08 – A and B-Axis.....38-39
B-05-11 – A and B-Axis.....40-41

APPENDIX (continued)

Plate No.

B-05-12 – A and B-Axis 42-43
B-05-13 – A and B-Axis 44-45
B-05-16 – A and B-Axis 46-47

Displacement versus Time Plots

B-05-03 – A-Axis 48
B-05-04 – A-Axis 49
B-05-16 – A-Axis 50

Plots for Active Pneumatic Piezometers Installed by BBCM in 1994 – CUY-90-15.24

Total Head (h_t) versus Time Plots

B-101 (P-1) 51
B-105 (P-3) 52
B-107 (P-5) 53
B-303 (P-2) 54

Plots for Vibrating Wire (VW) Piezometers Installed by BBCM in 2006 – CUY-90-14.52

Total Head (h_t) versus Time Plots

B-05-01 55
B-05-02 56
B-05-03 57
B-05-04 58
B-05-07 59
B-05-08 60
B-05-11 61
B-05-12 62
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Calipered Surface Distance Data – CUY-90-15.24

Calipered Surface Distance Table 64
Calipered Distance Readings versus Time Plot - Left Calipered Location 65
Calipered Distance Readings versus Time Plot - Right Calipered Location 66

Cuyahoga River Bulkhead Adjacent to B-105A

Site Photo of Bulkhead Adjacent to B-105A – Taken on 7/16/08 67

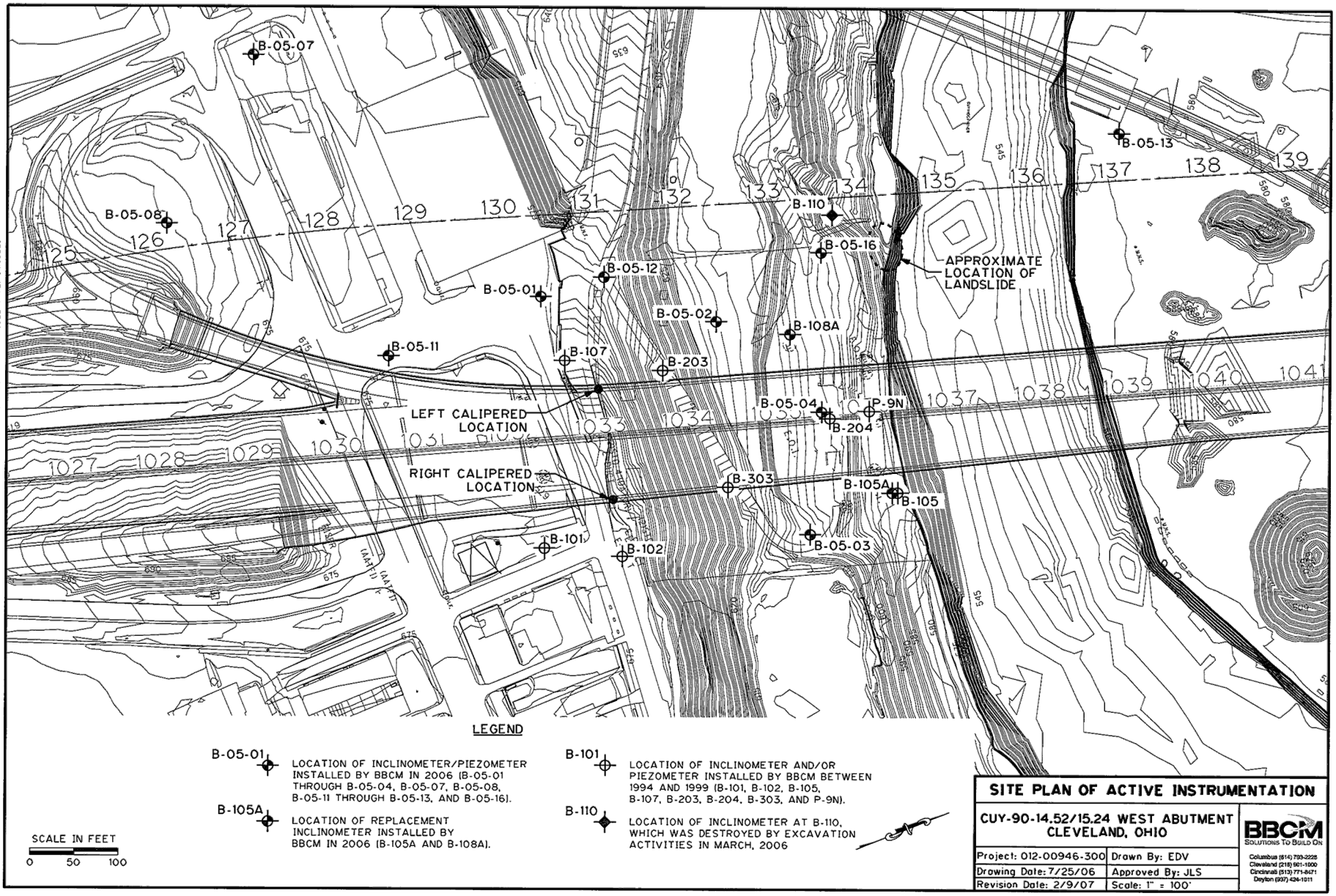
SUMMARY OF ACTIVE INSTRUMENTATION
CUY-90-14.52/15.24

Active Instrumentation	Active Inclinometer ?	Inclinometer Depth (ft)	Active Piezometer?	VW or Pneumatic?	# of Active Piezometers	Piezometer Depth(s) Below Existing G.S. (ft)	Instrumentation Installation Date	G.S. Elevation (ft)
B-101	Y	190	Y[1]	Pneumatic[1]	2 [1]	50.3, 124.3	Aug-Sep 1994	676.6 (676.6[3])
B-102	Y	224	N	---	---	---	Sep 1994	675.7
B-105	N	---	Y[1]	Pneumatic[1]	2 [1]	88, 105.7	Aug 1994	585.4 (585.6[3])
B-105A	Y	156	N	---	---	---	May 2006	585.7
B-107	Y	210	Y[1]	Pneumatic[1]	1 [1]	100	Sep 1994	662.7 (662.3[3])
B-108A	Y	168	N	---	---	---	Apr-May 2006	603.0
B-203	Y	190	N	---	---	---	Aug 1996	638.0
B-204	Y	134	N	---	---	---	Jul 1998	599.0
B-303	Y	178	Y[2]	Pneumatic[2]	1 [2]	40.8	Aug 1994[2], Jul 1998	622.0 (627.0[3])
P-9N	Y	148	N	---	---	---	Feb 1999	588.0
B-05-01	Y	228	Y	VW	2	65, 95	Apr-May 2006	675.4
B-05-02	Y	176	Y	VW	2	46, 122	Apr-May 2006	617.9
B-05-03	Y	168	Y	VW	2	32, 112	Apr-May 2006	605.1
B-05-04	Y	172	Y	VW	2	59, 119	Mar-May 2006	600.8
B-05-07	Y	224	Y	VW	2	102, 220	Apr-Jun 2006	678.9
B-05-08	Y	224	Y	VW	2	65.5, 110.5	Apr-May 2006	679.9
B-05-11	Y	226	Y	VW	2	95, 130	Apr-Jun 2006	675.1
B-05-12	Y	210	Y	VW	2	75, 120	Apr-May 2006	652.7
B-05-13	Y	134	Y	VW	2	60, 135	May-Jun 2006	580.0
B-05-16	Y	162	N	---	---	---	Jun 2006	598.5

1 BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers (i.e. P-1 to B-101, P-3 to B-105, and P-5 to B-107).

2 The pneumatic piezometer was actually installed in August 1994 at Boring P-2 in the vicinity of the B-103 inclinometer (now inactive). However, the piezometer has since been renamed to B-303 due to its close proximity to the active inclinometer at B-303, which was installed in July 1998.

3 Elevation in parenthesis refers to the ground surface (G.S.) elevation of the P boring location where the pneumatic piezometer was installed.



LEGEND

B-05-01 — LOCATION OF INCLINOMETER/PIEZOMETER INSTALLED BY BBCM IN 2006 (B-05-01 THROUGH B-05-04, B-05-07, B-05-08, B-05-11 THROUGH B-05-13, AND B-05-16).

B-105A — LOCATION OF REPLACEMENT INCLINOMETER INSTALLED BY BBCM IN 2006 (B-105A AND B-108A).

B-101 — LOCATION OF INCLINOMETER AND/OR PIEZOMETER INSTALLED BY BBCM BETWEEN 1994 AND 1999 (B-101, B-102, B-105, B-107, B-203, B-204, B-303, AND P-9N).

B-110 — LOCATION OF INCLINOMETER AT B-110, WHICH WAS DESTROYED BY EXCAVATION ACTIVITIES IN MARCH, 2006

SITE PLAN OF ACTIVE INSTRUMENTATION

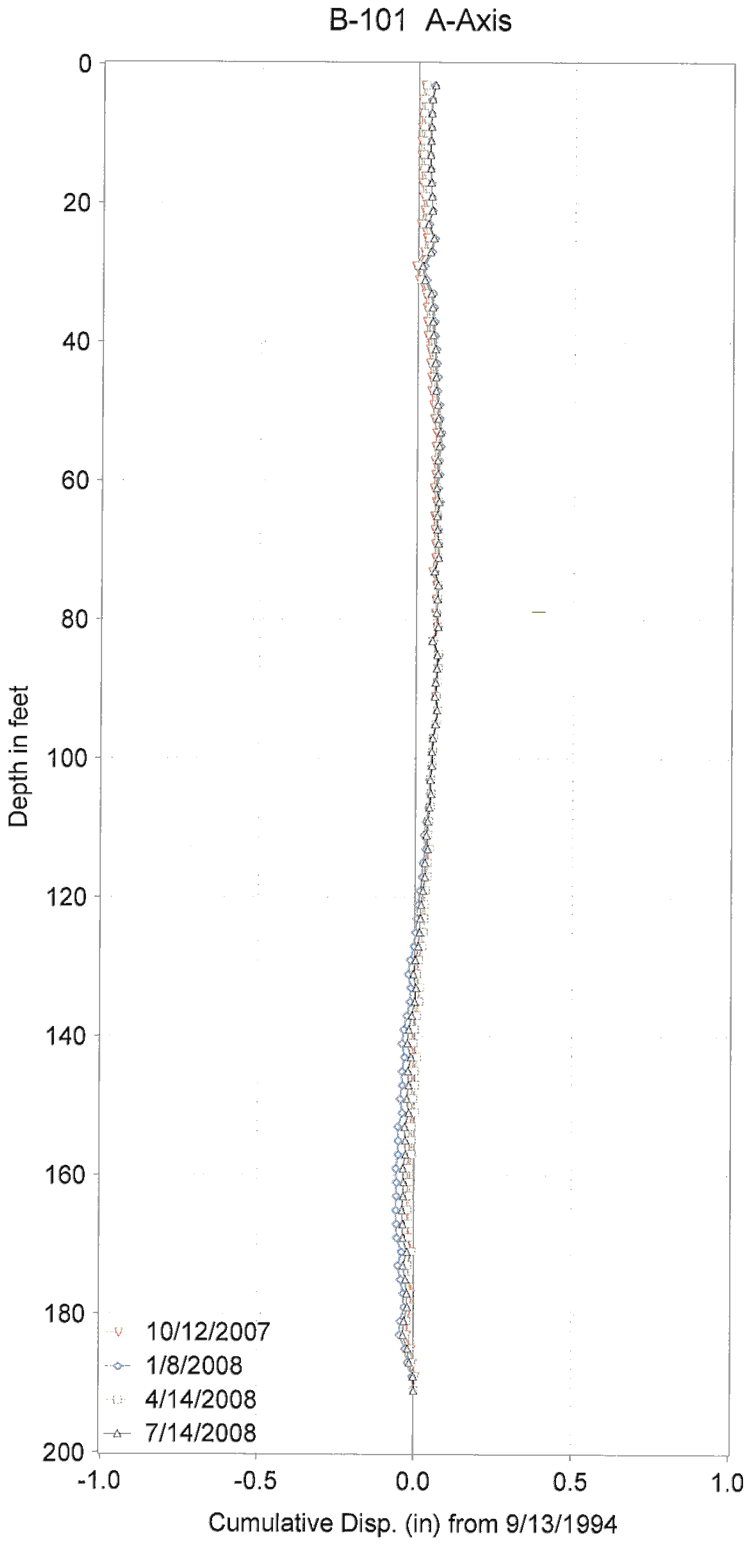
CUY-90-14.52/15.24 WEST ABUTMENT
CLEVELAND, OHIO

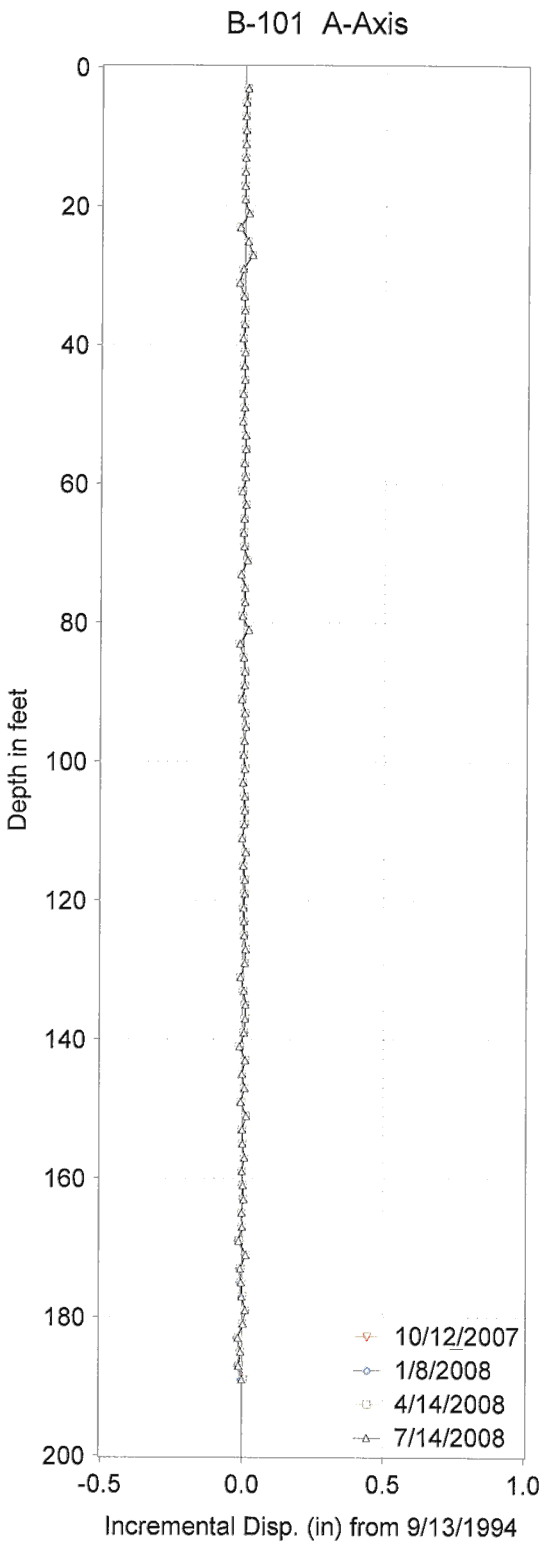
Project: 012-00946-300	Drawn By: EDV
Drawing Date: 7/25/06	Approved By: JLS
Revision Date: 2/9/07	Scale: 1" = 100'

BBCM
SOLUTIONS TO BUILD ON
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 434-1011

BBC&M DRAWING FILE: $BBCM FILENAME$ $DATE$ $TIME$ MODEL NAME: $MODEL$

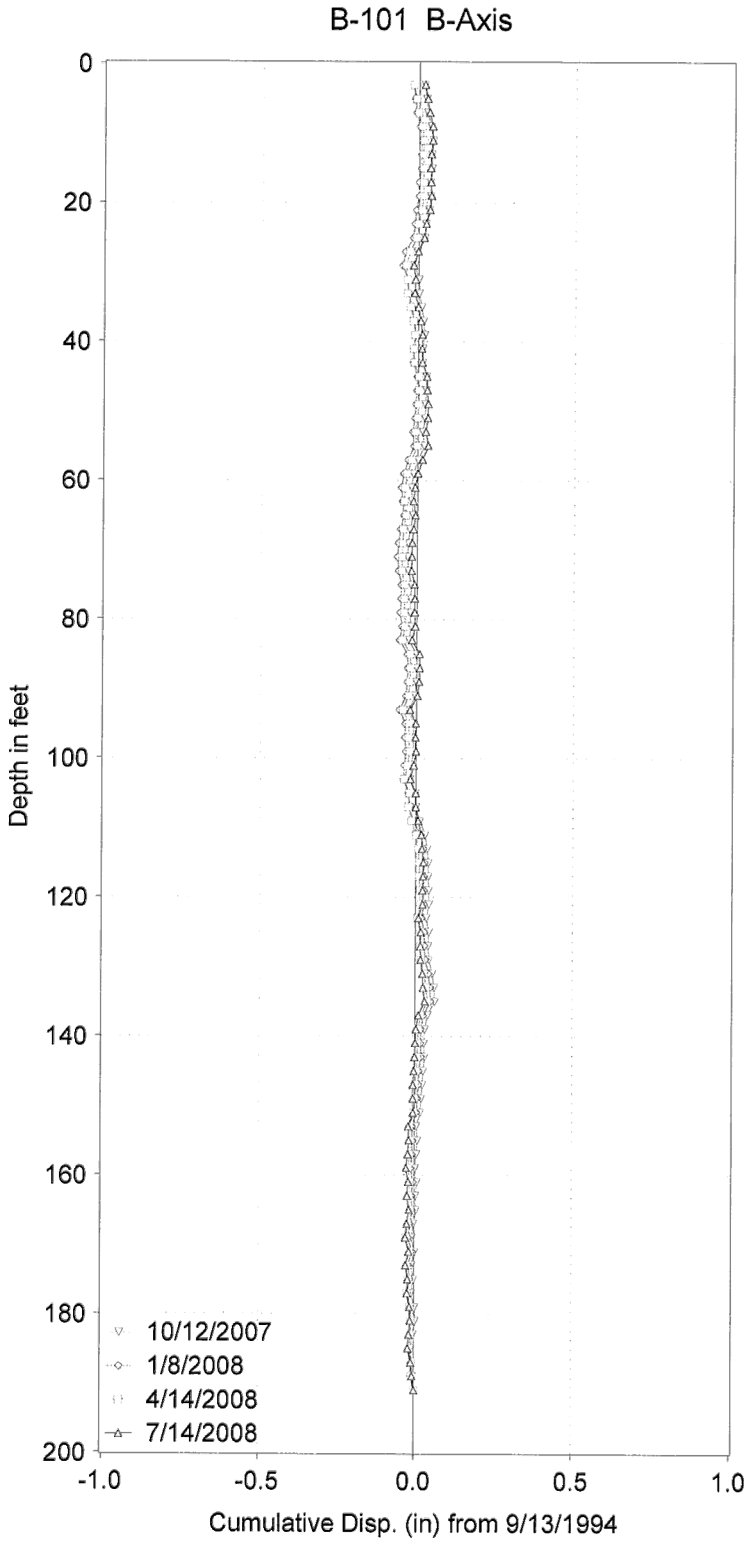
PLATE 2

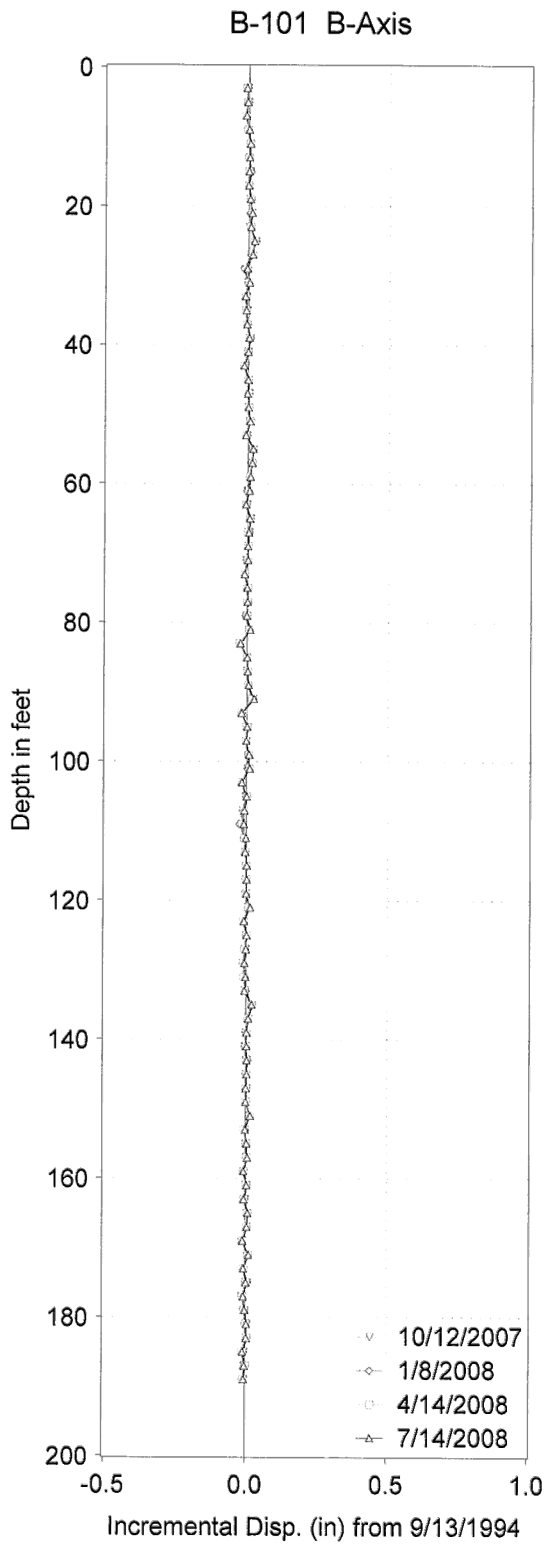




B-101
-Includes readings from the last four quarters.

PLATE 3





B-101
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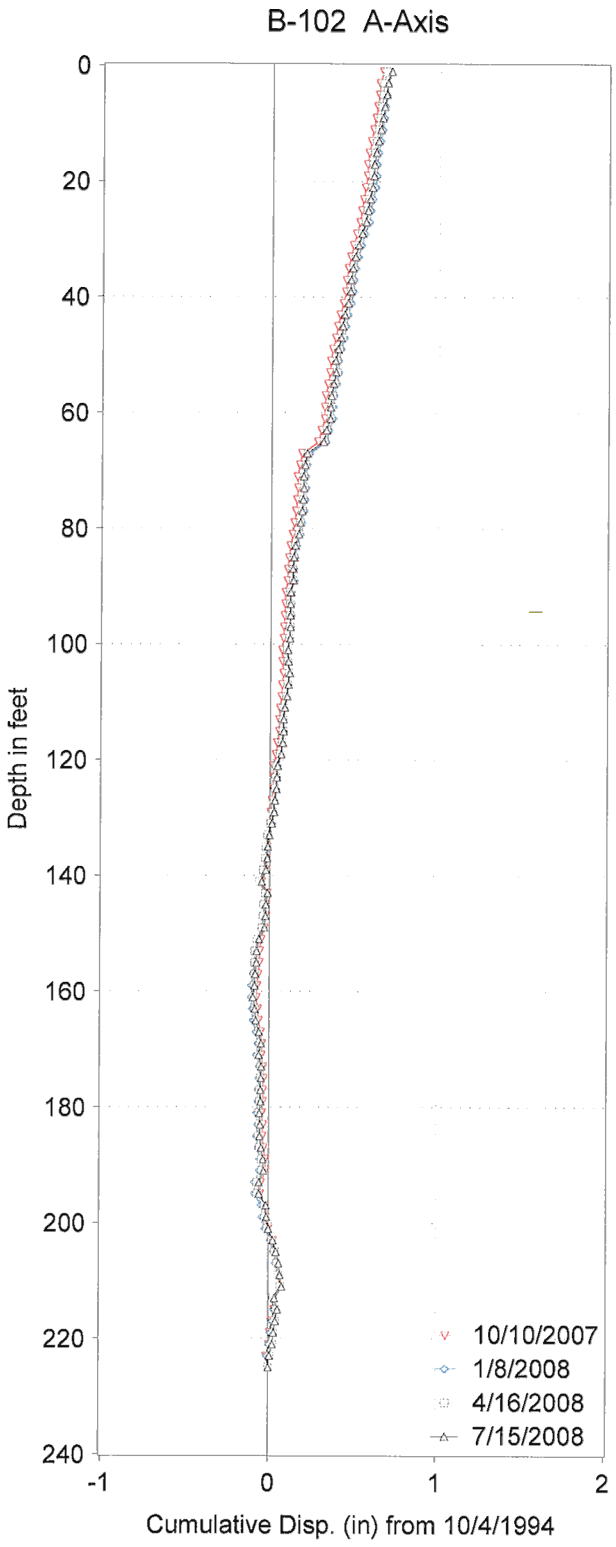
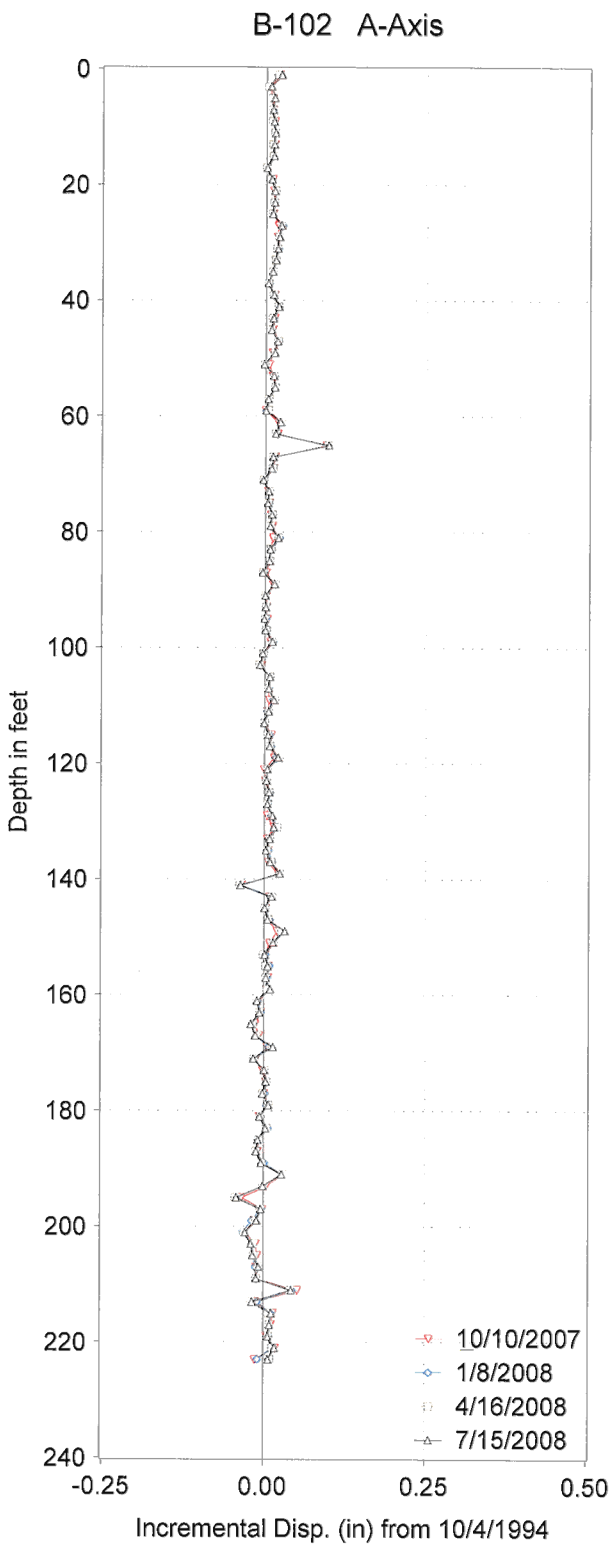
PLATE 4





B-102
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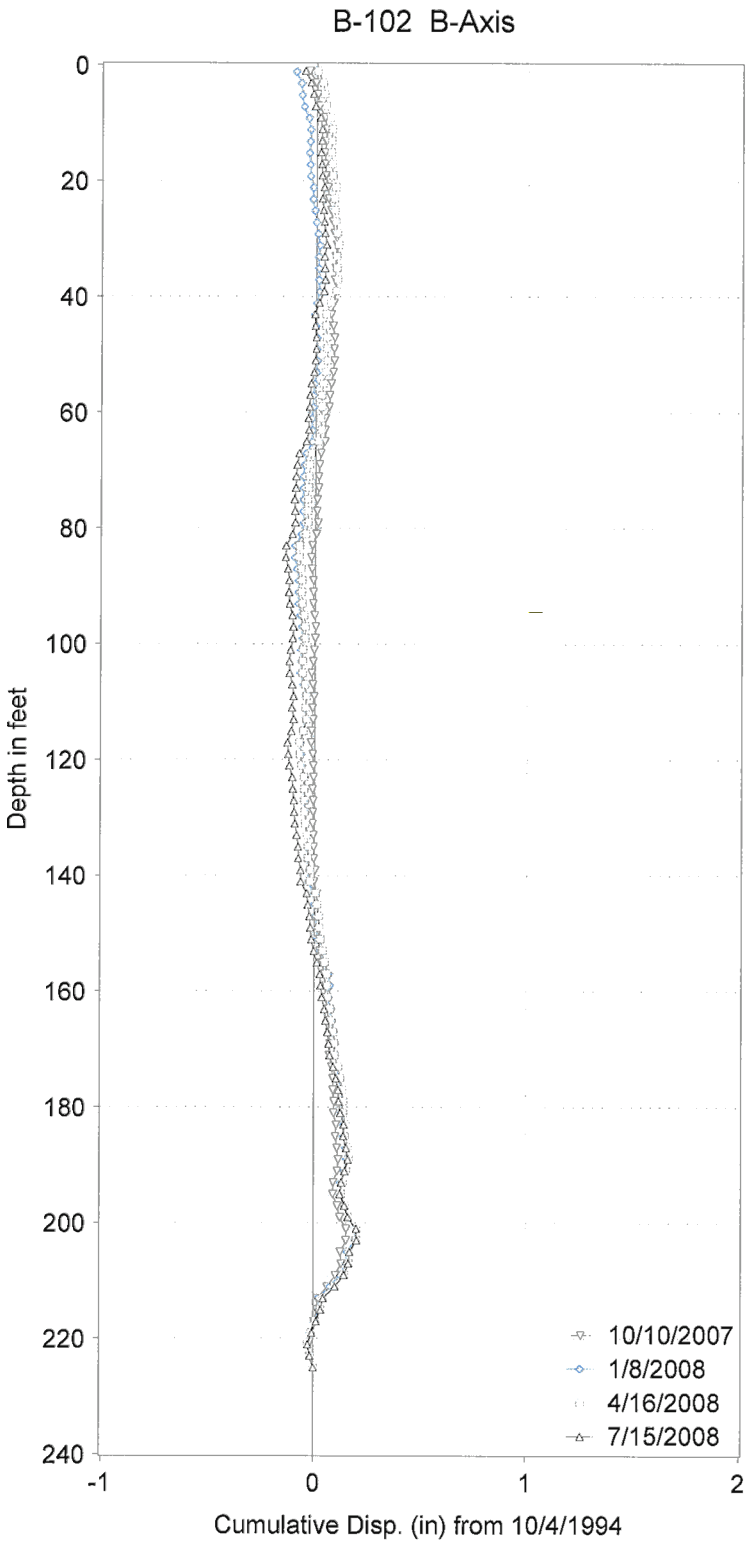
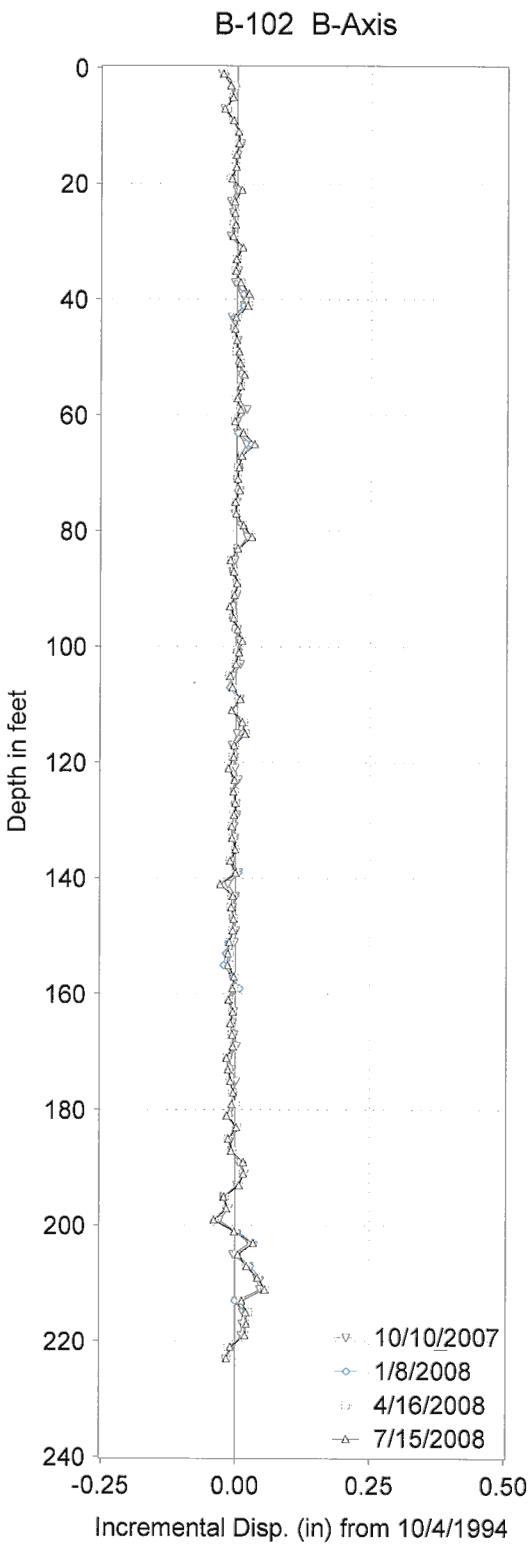
PLATE 5





B-102
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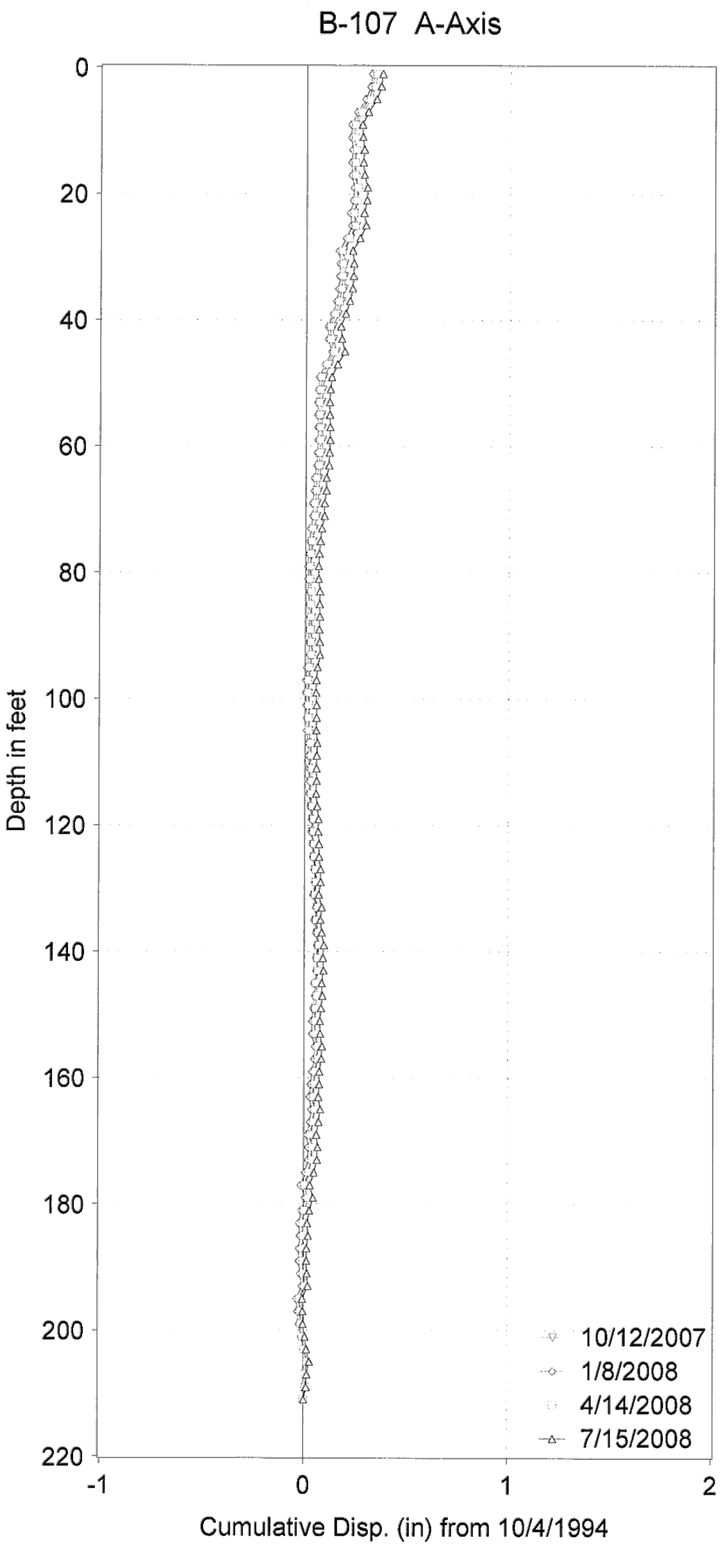
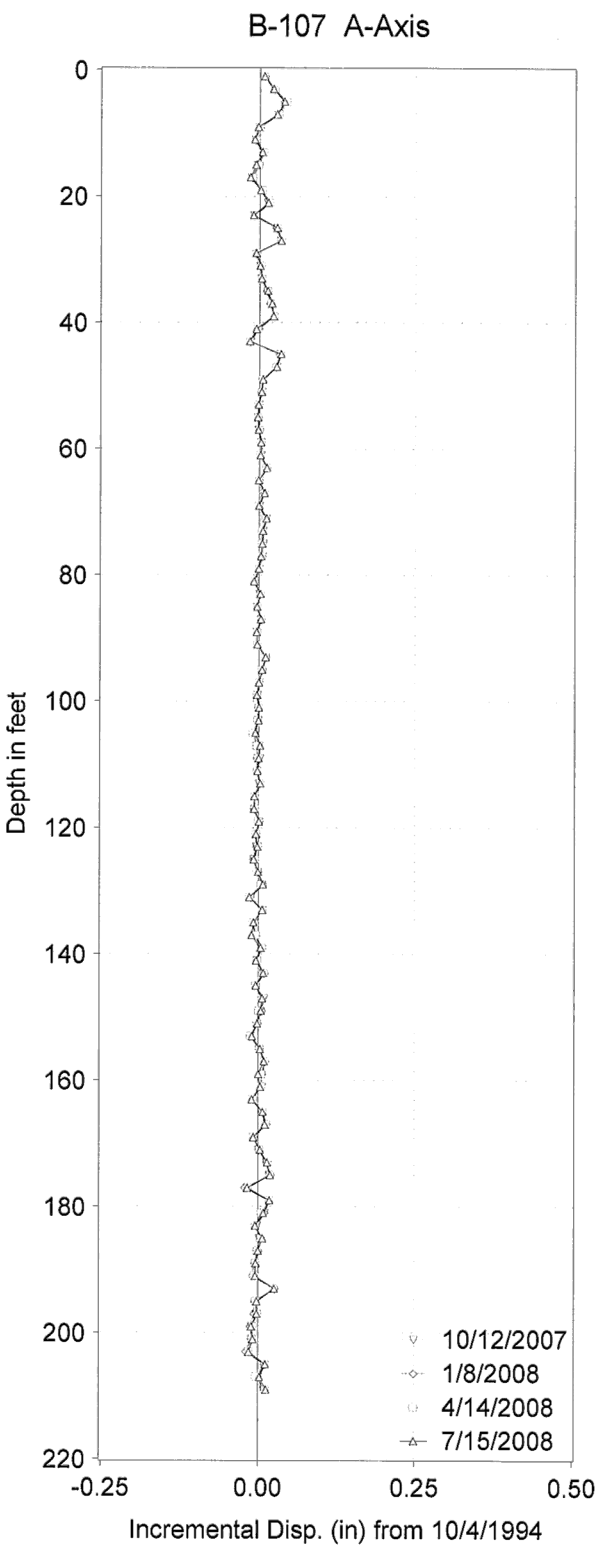
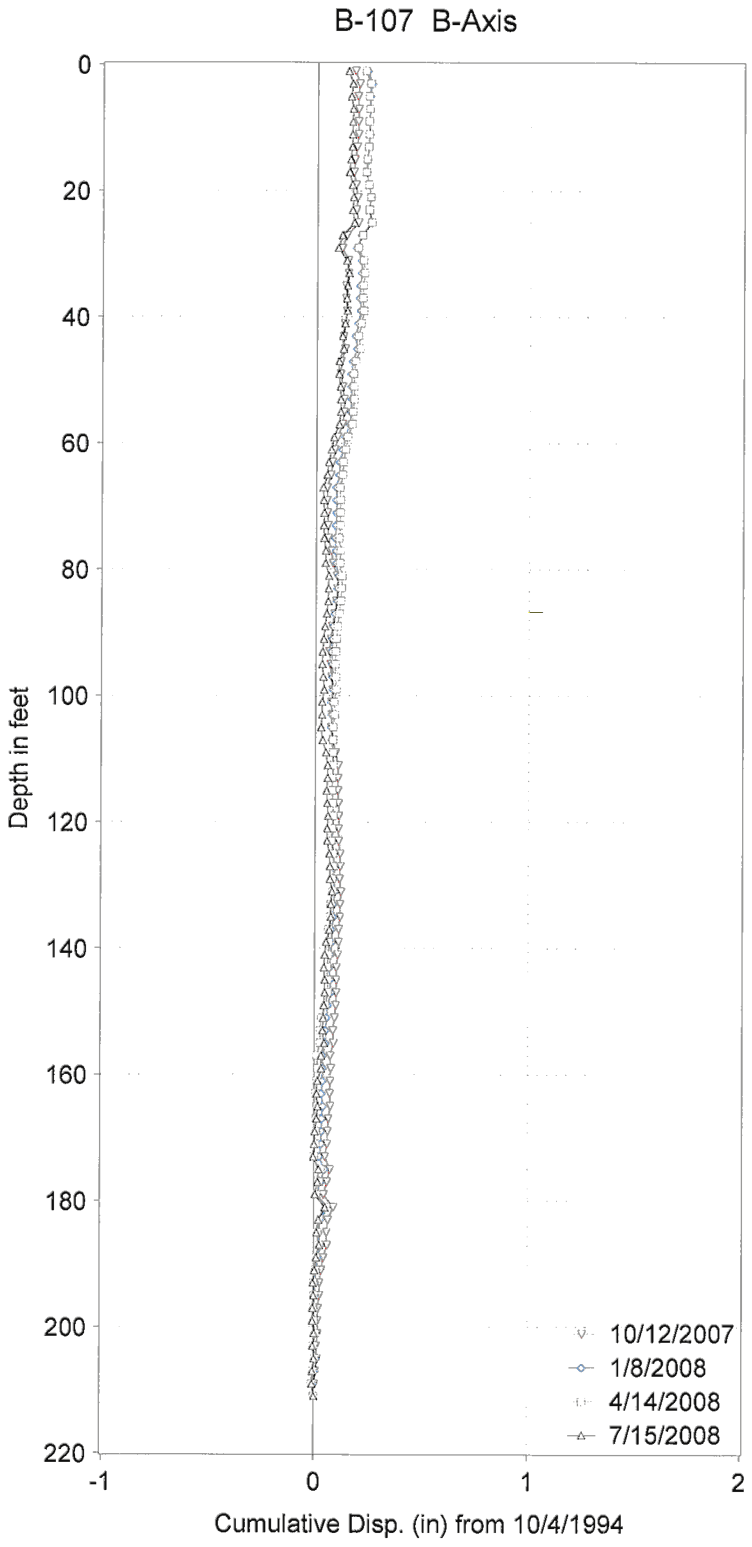
PLATE 6

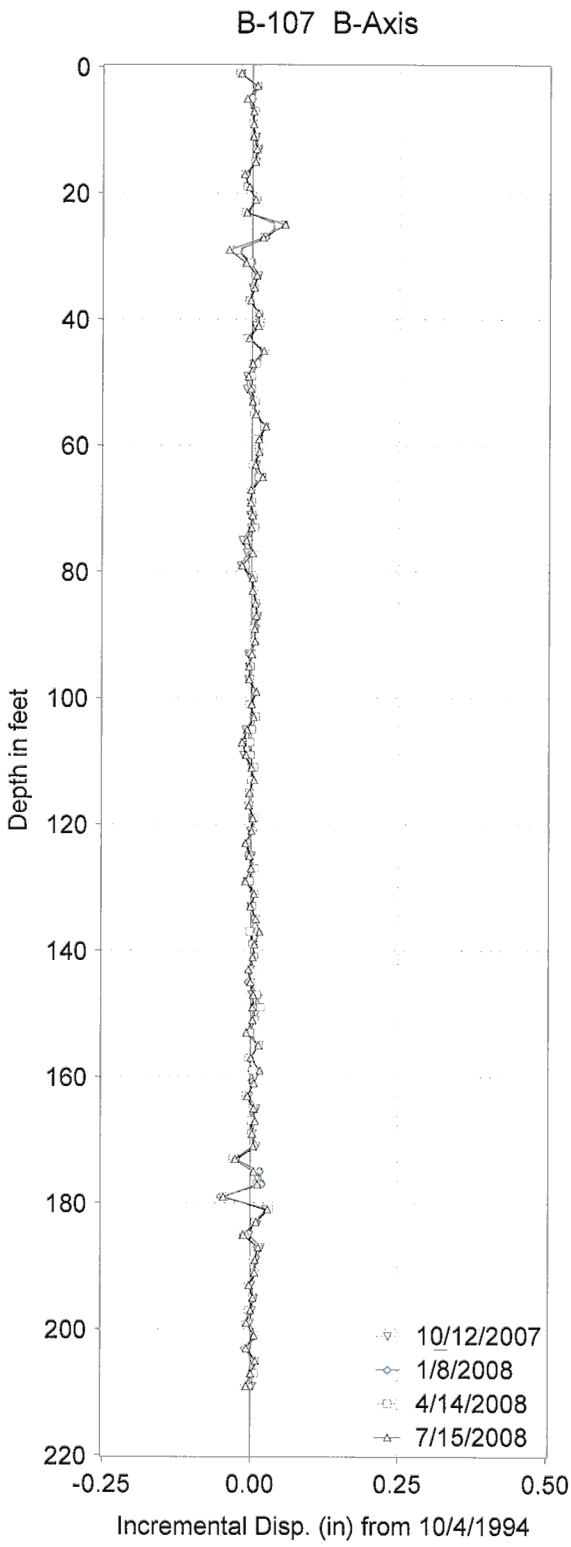




B-107
-Includes readings from the last four quarters.

PLATE 7





B-107
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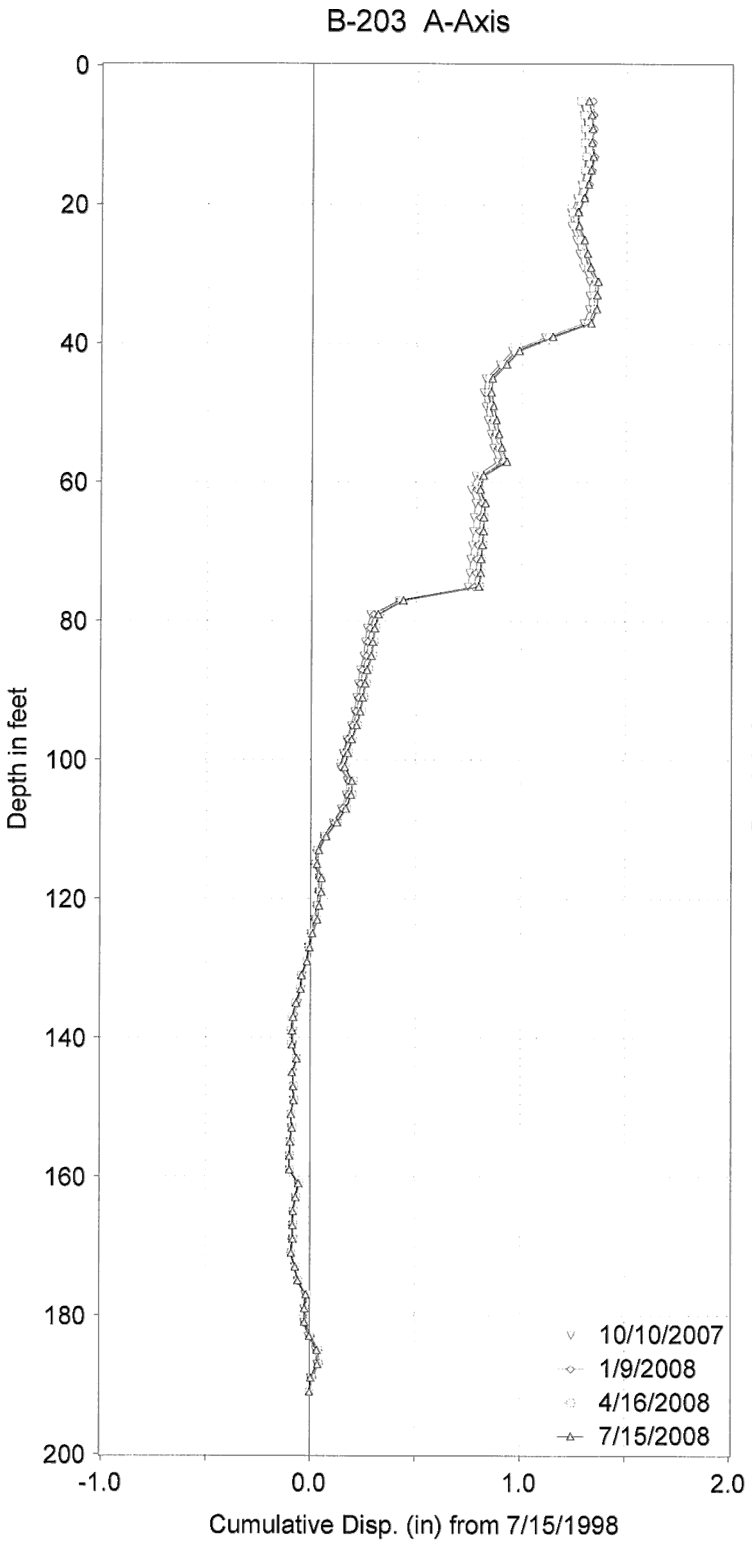
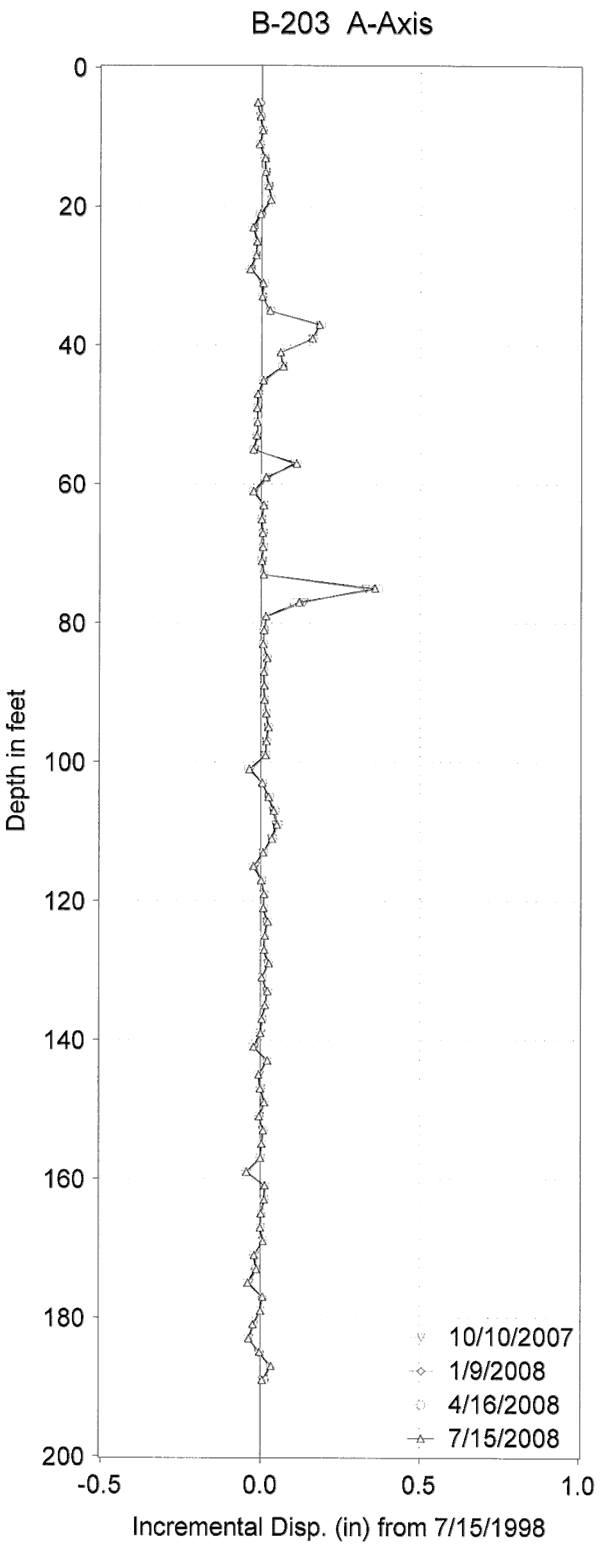
PLATE 8





B-203
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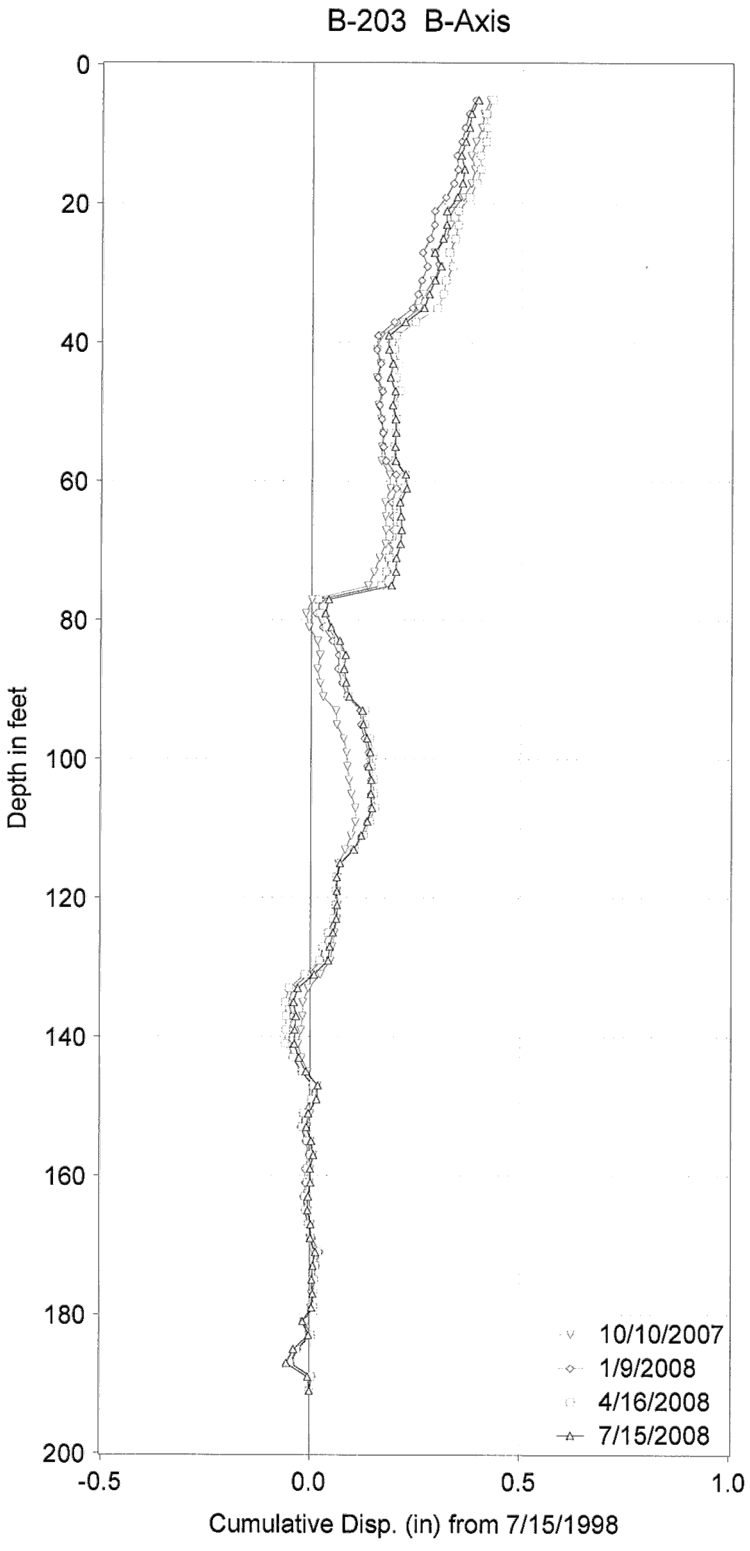
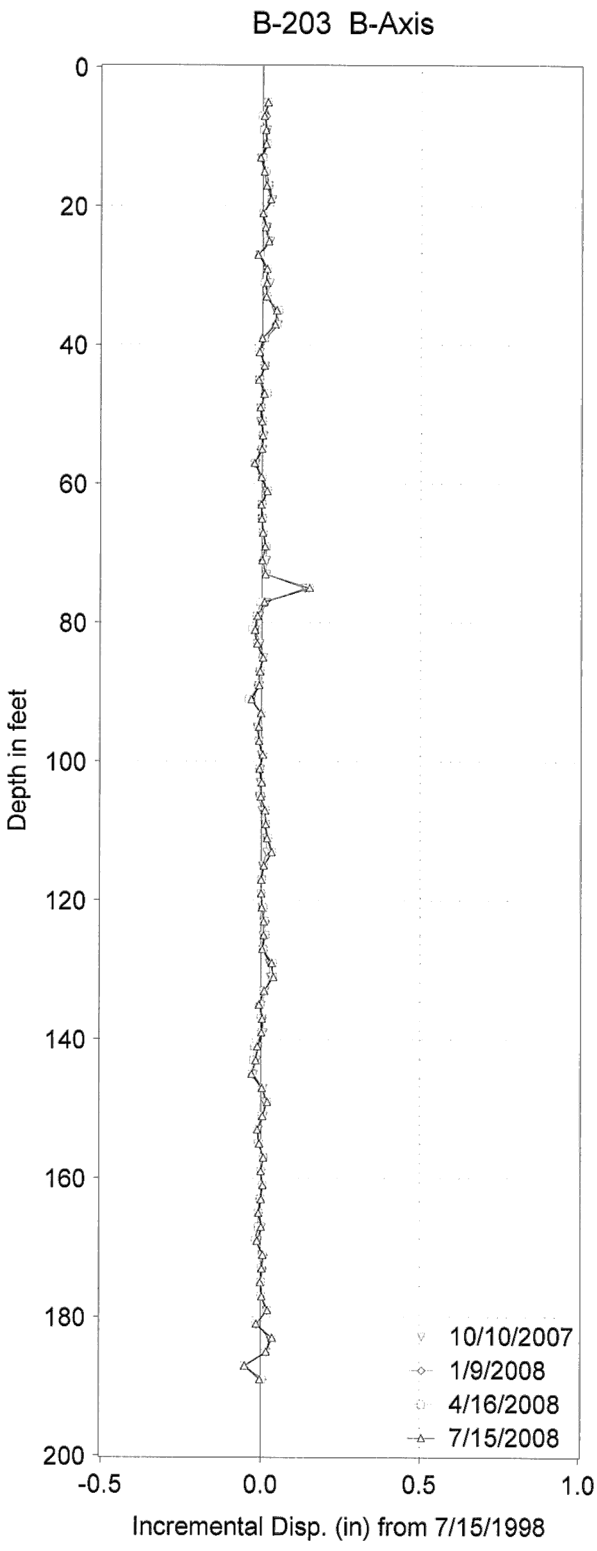
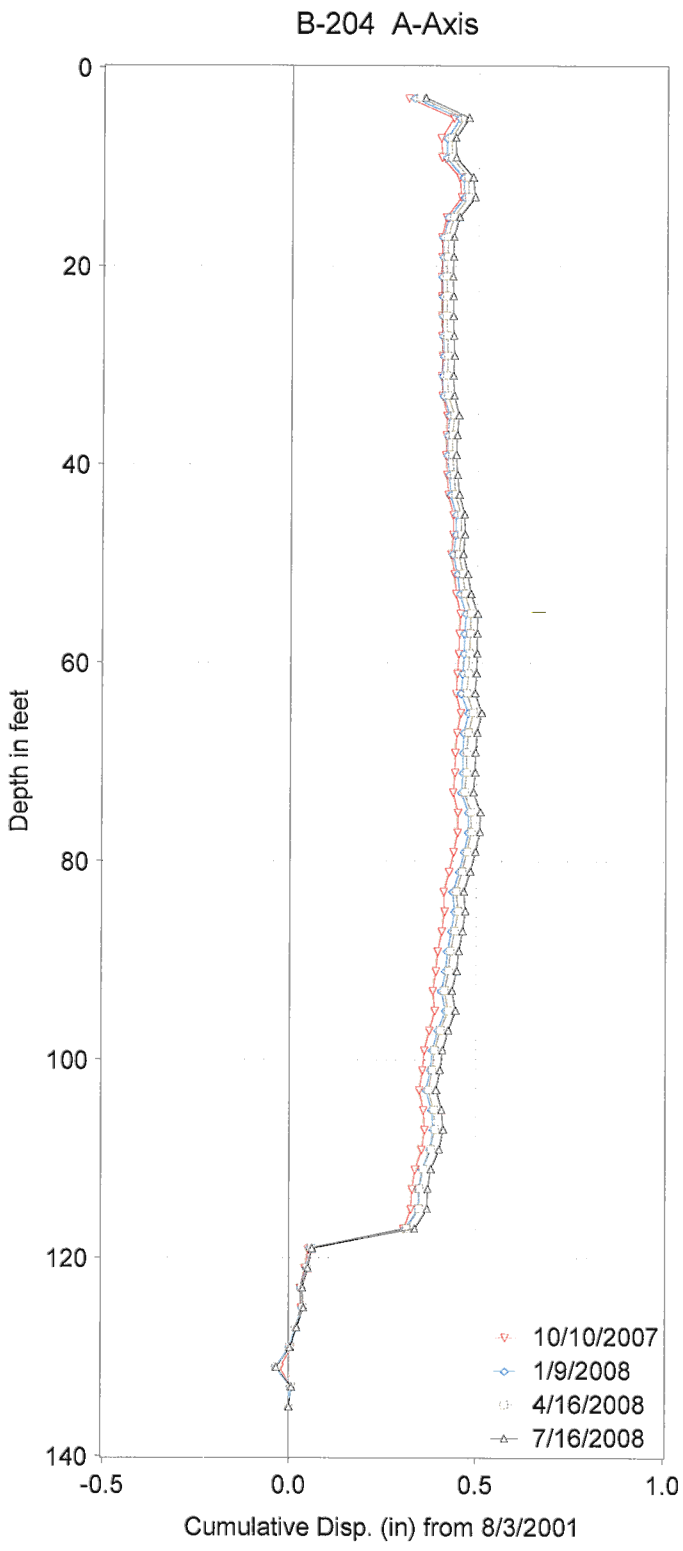
PLATE 9

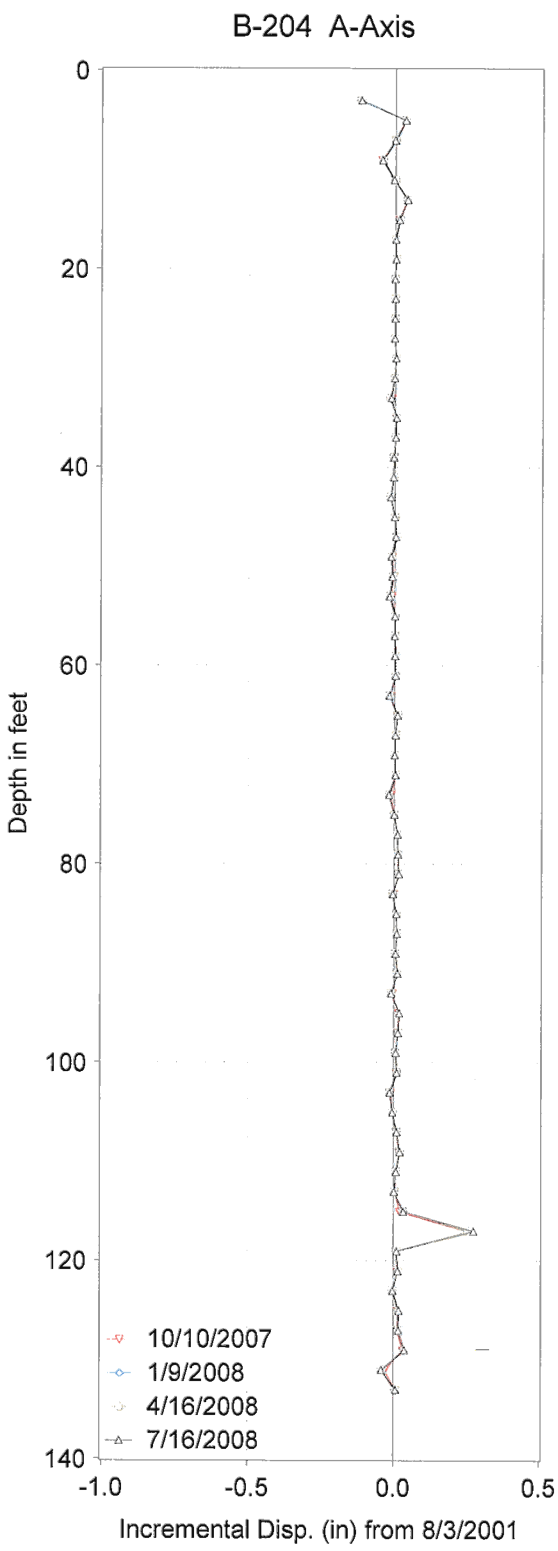




B-203
-Includes readings from the last four quarters.

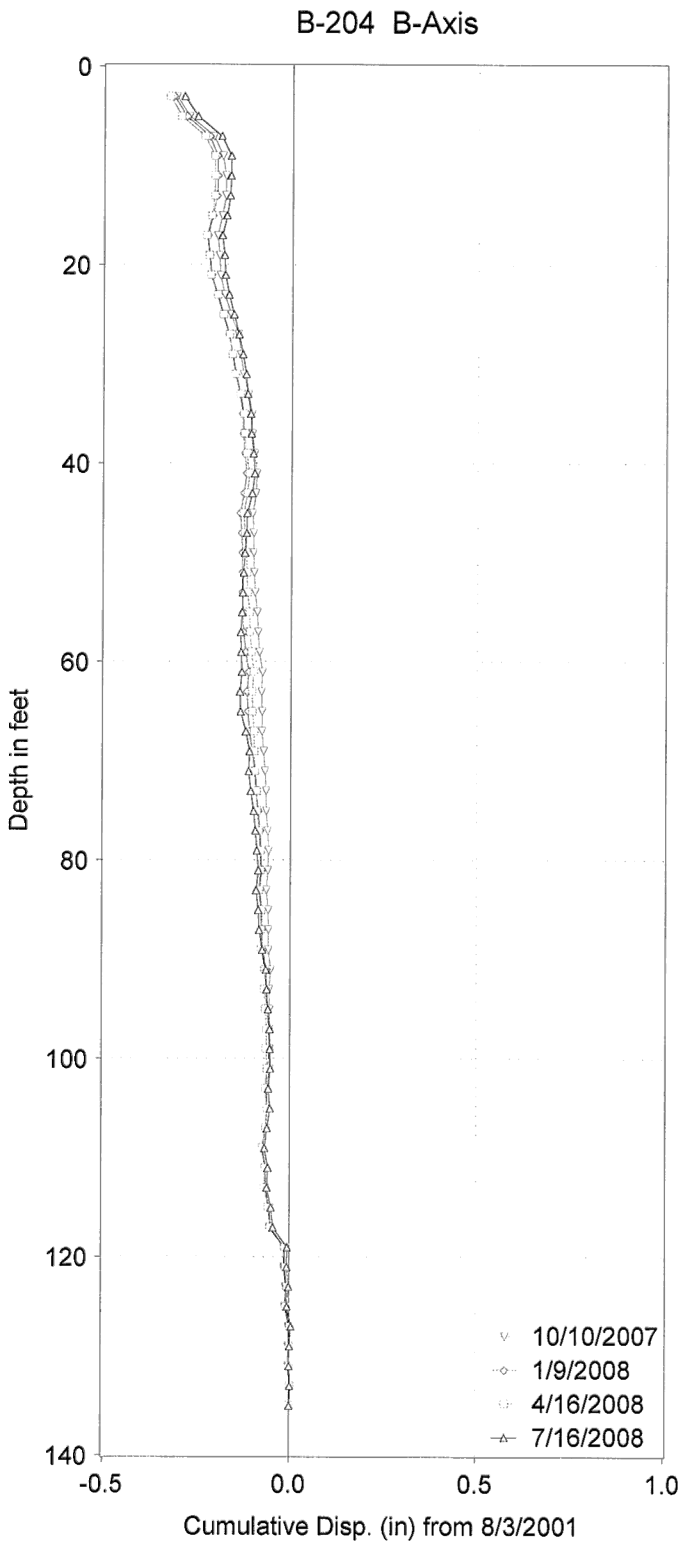
PLATE 10

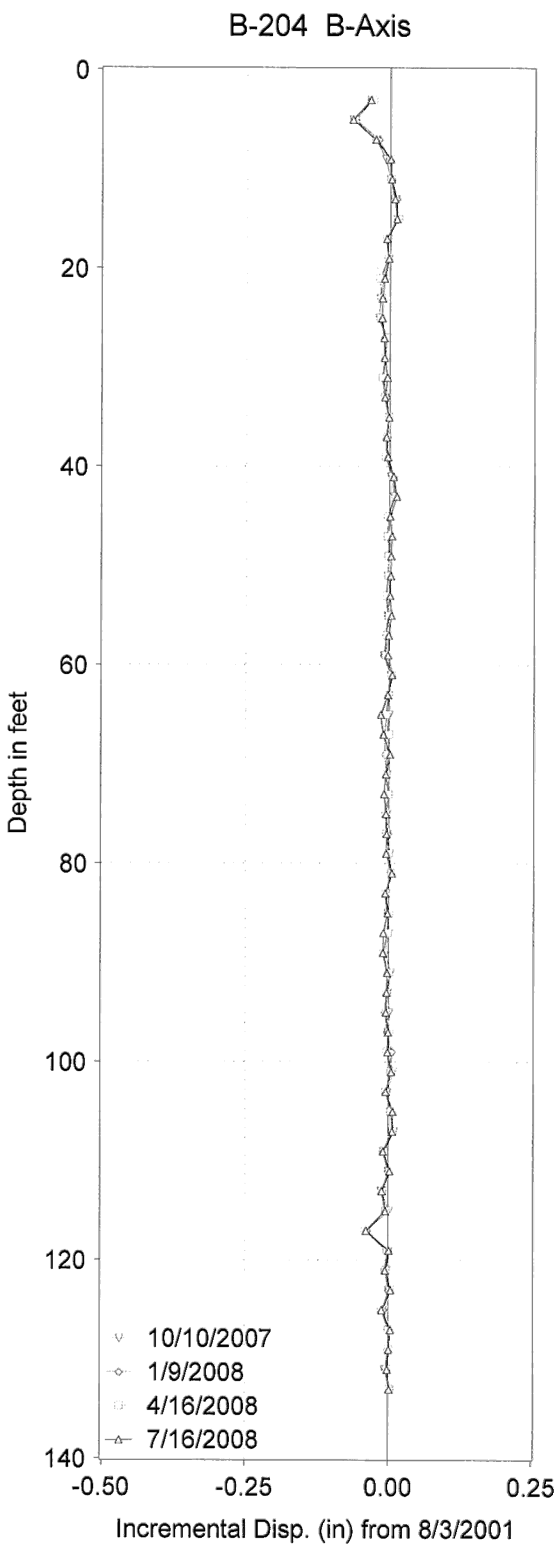




B-204
-Includes readings from the last four quarters.

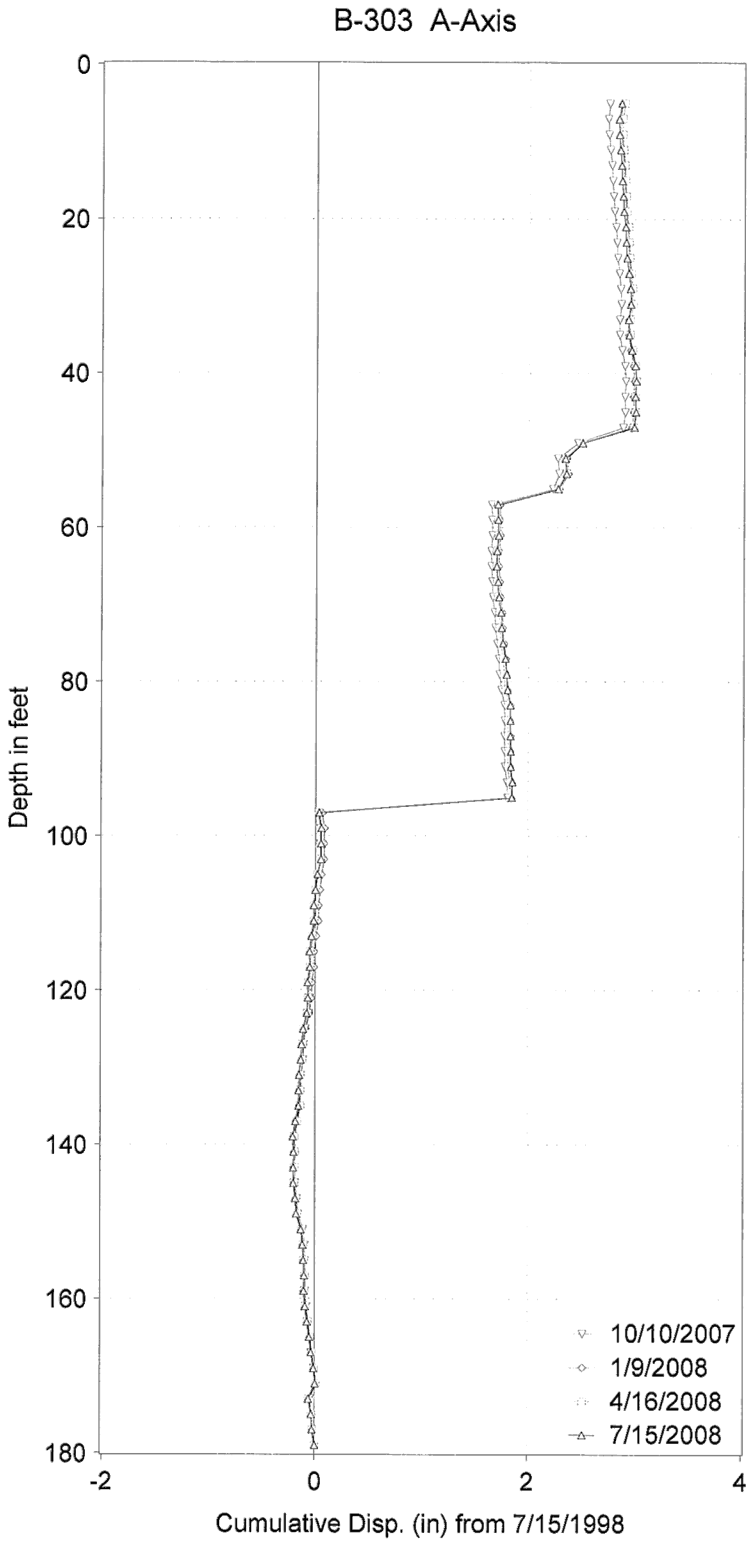
PLATE 11

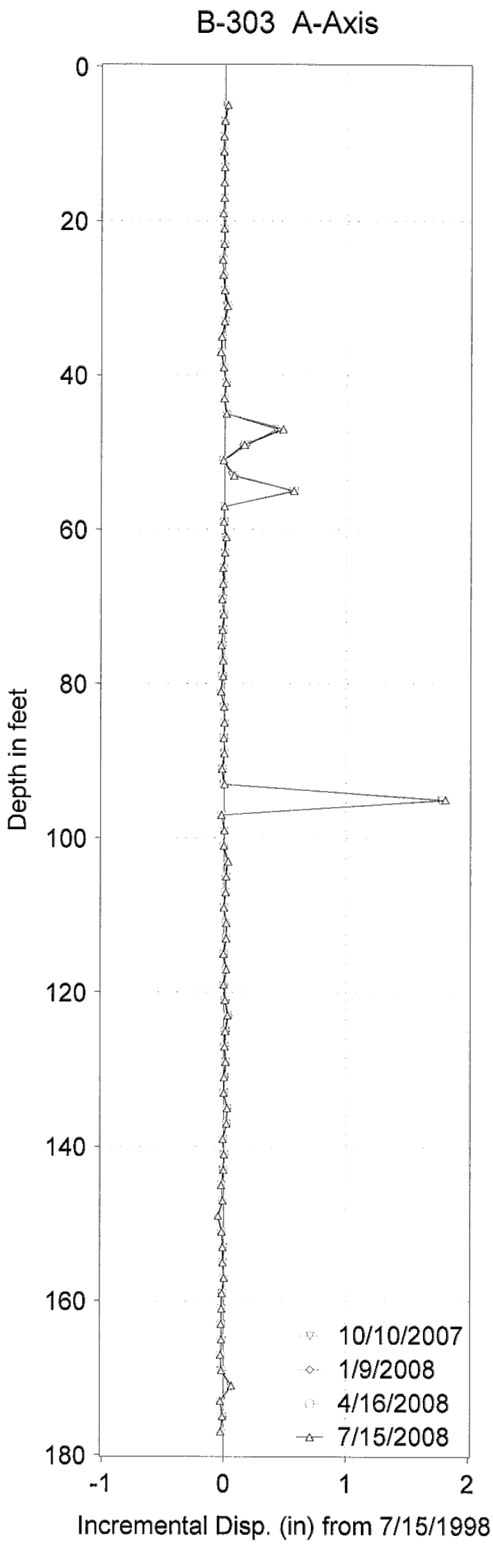




B-204
-Includes readings from the last four quarters.

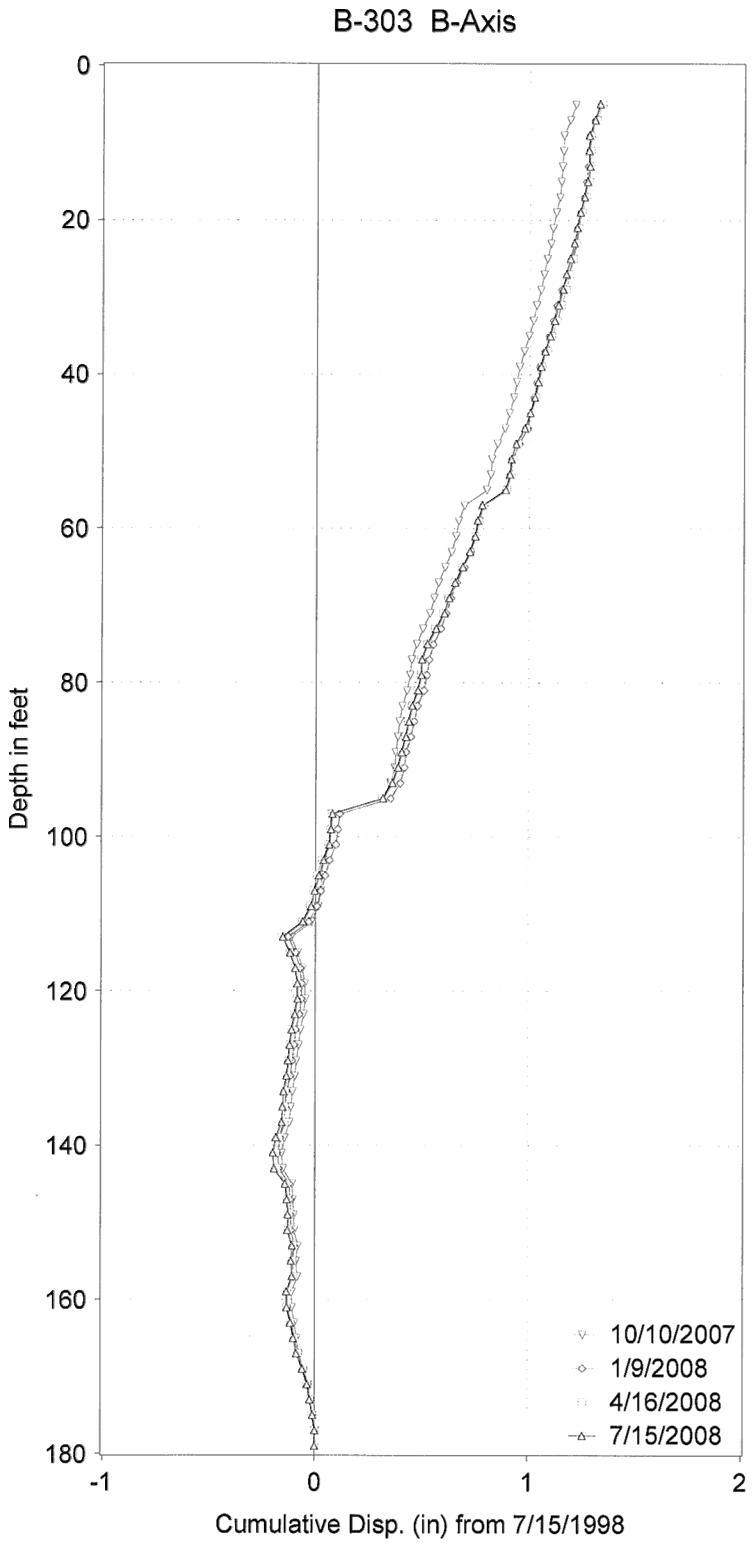
PLATE 12

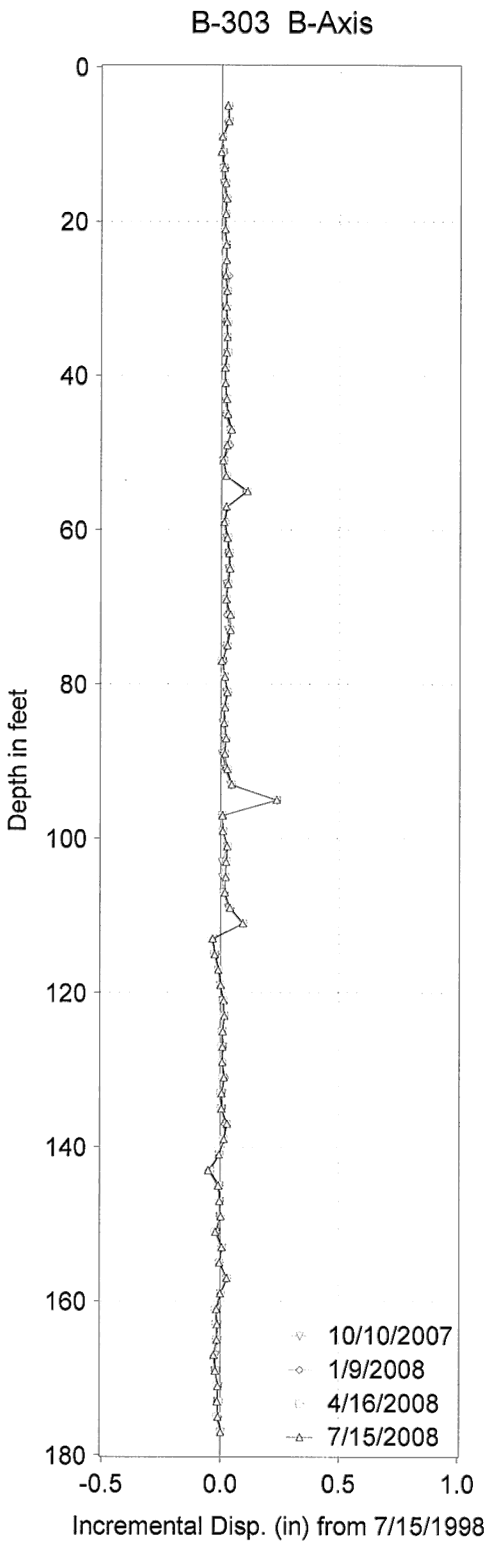




B-303
-Includes readings from the last four quarters.

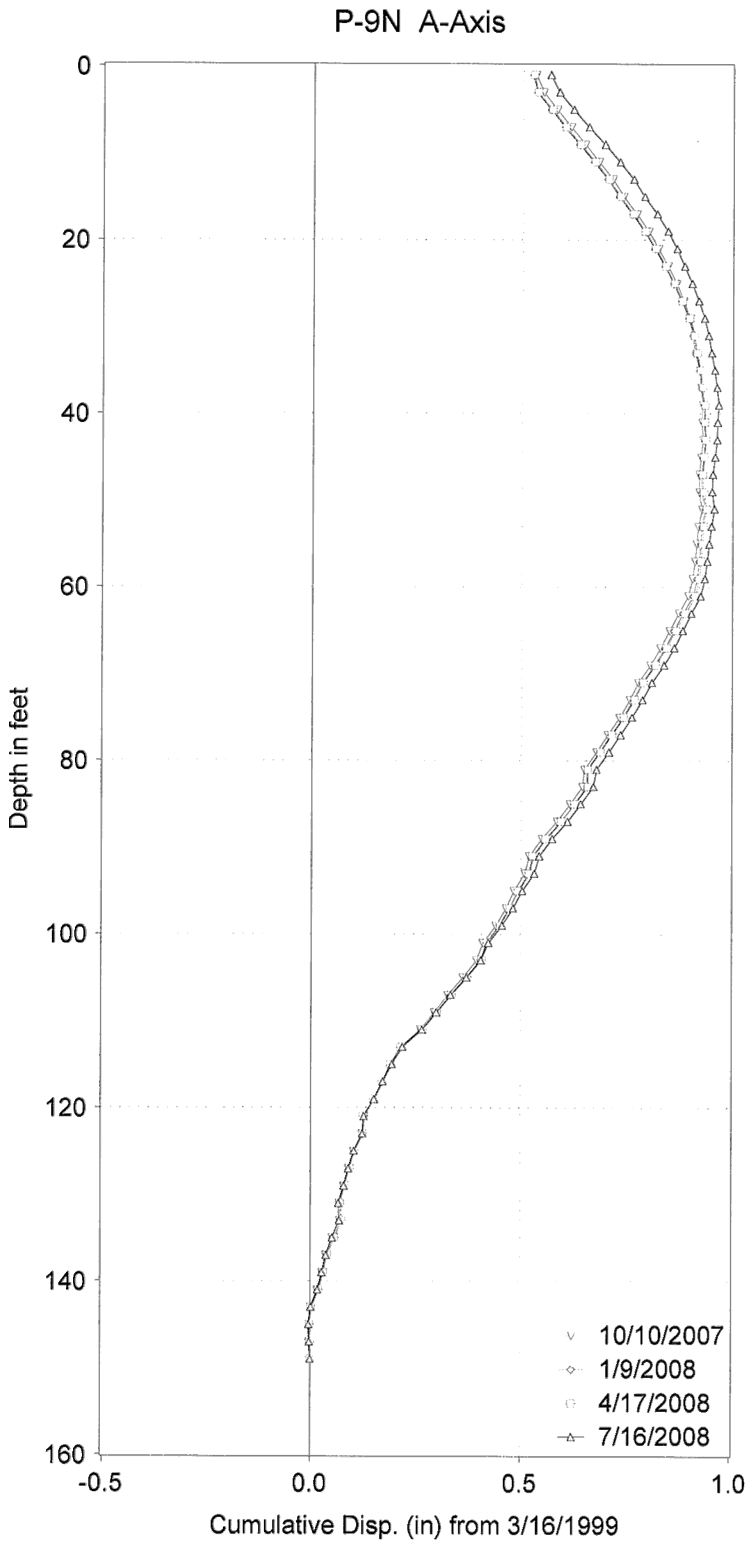
PLATE 13

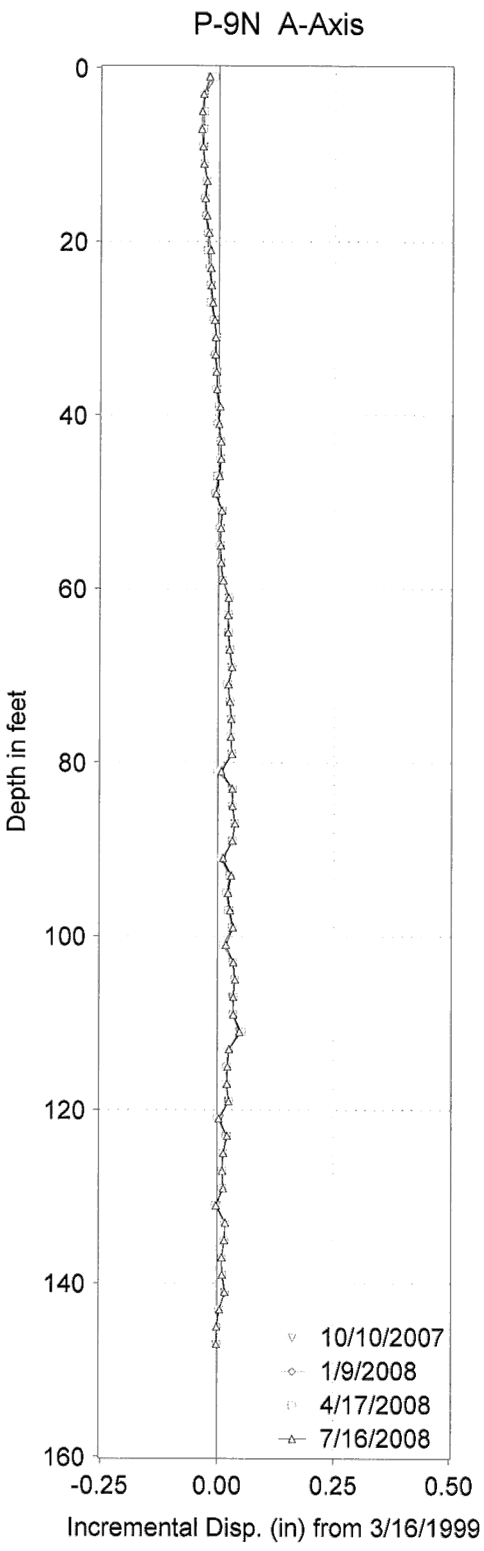




B-303
-Includes readings from the last four quarters.

PLATE 14

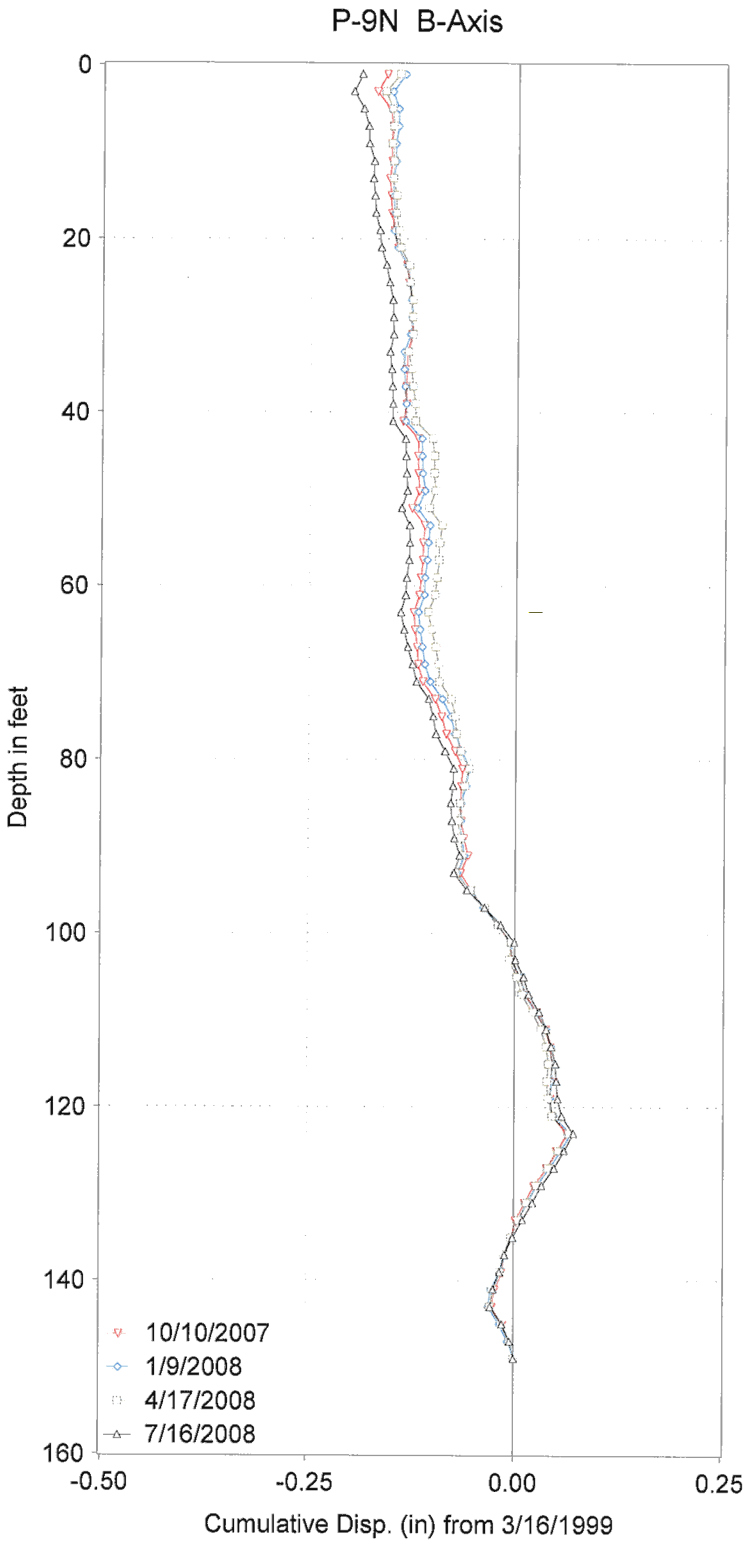


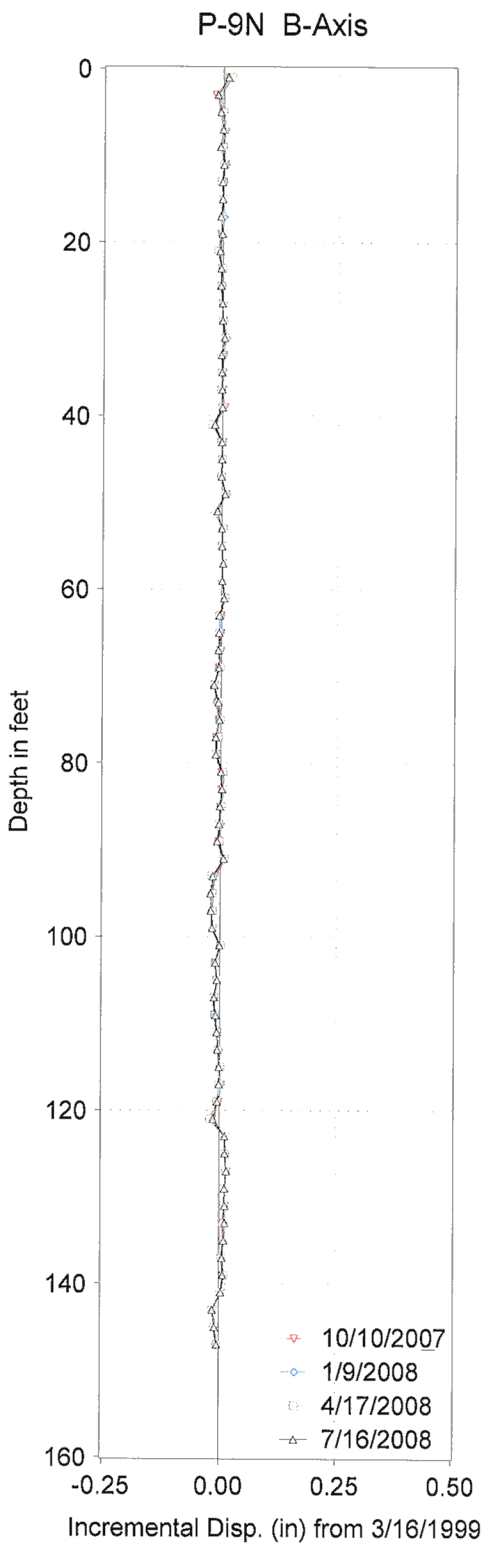


P-9N

-Includes readings from the last four quarters.

PLATE 15





P-9N
-Includes readings from the last four quarters.

PLATE 16

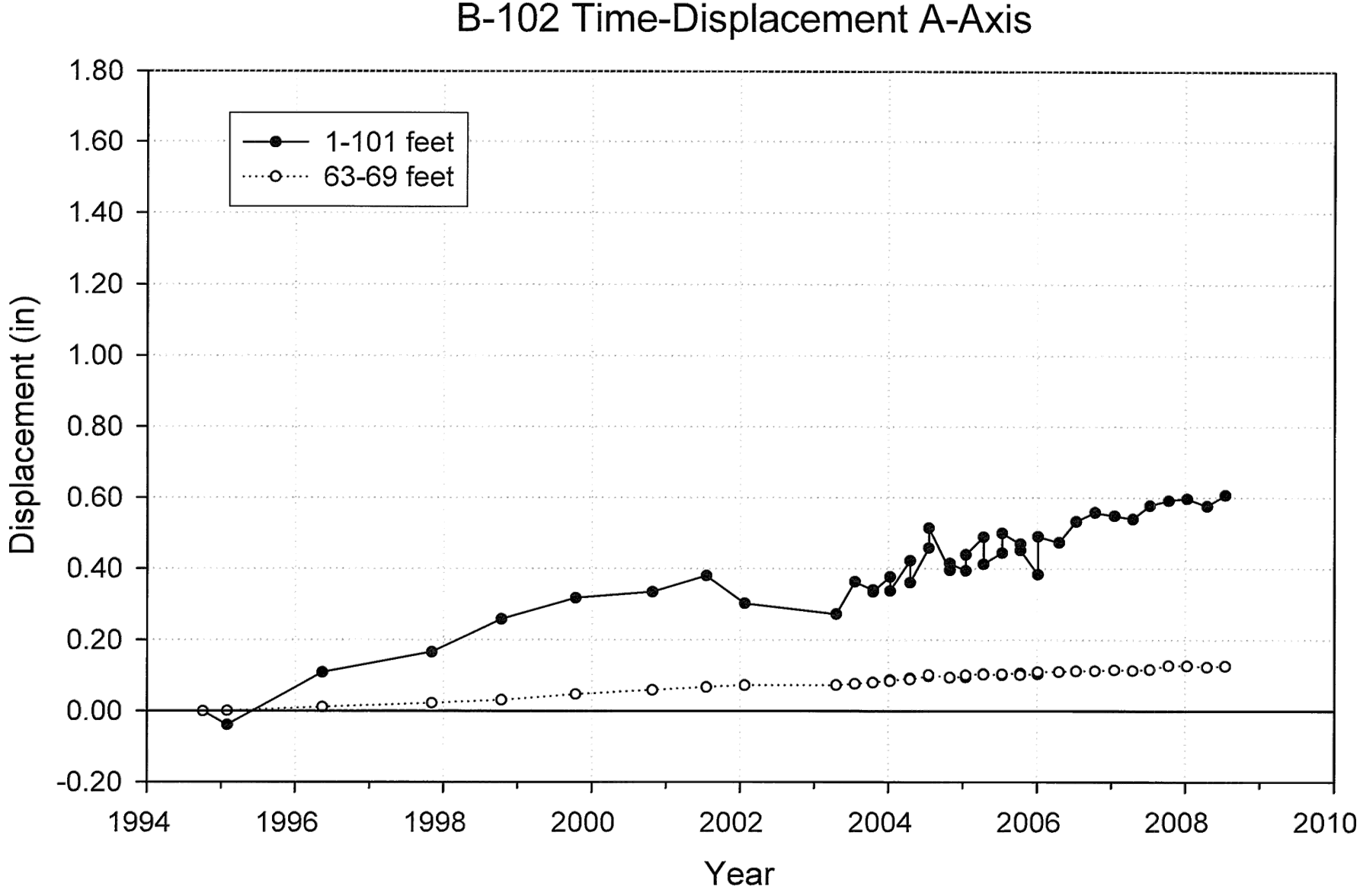

B-102 Time-Displacement A-Axis
1-101 feet
63-69 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 17

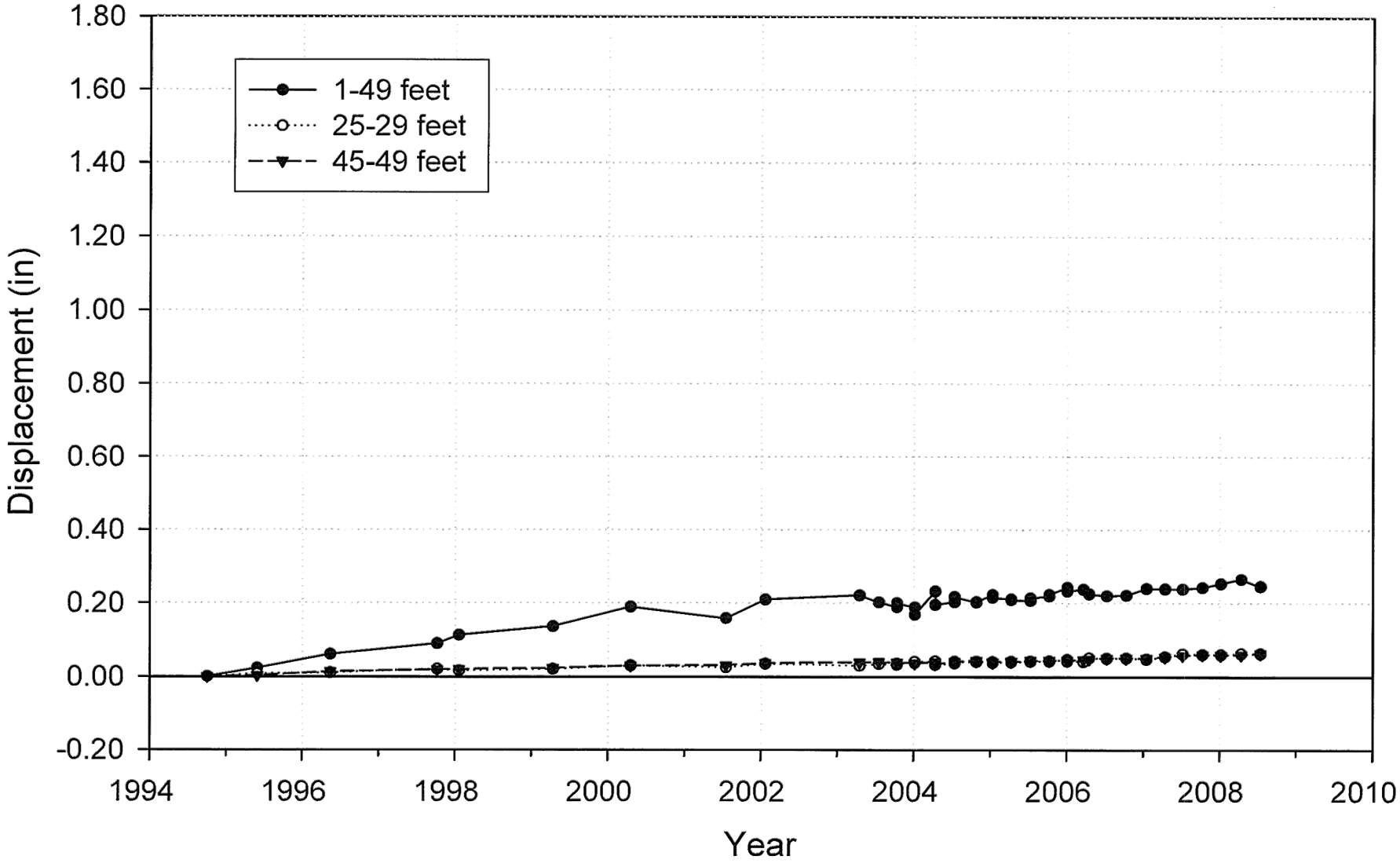

B-107 Time-Displacement A-Axis
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Displacement (in)
1-49 feet
25-29 feet
45-49 feet
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 18

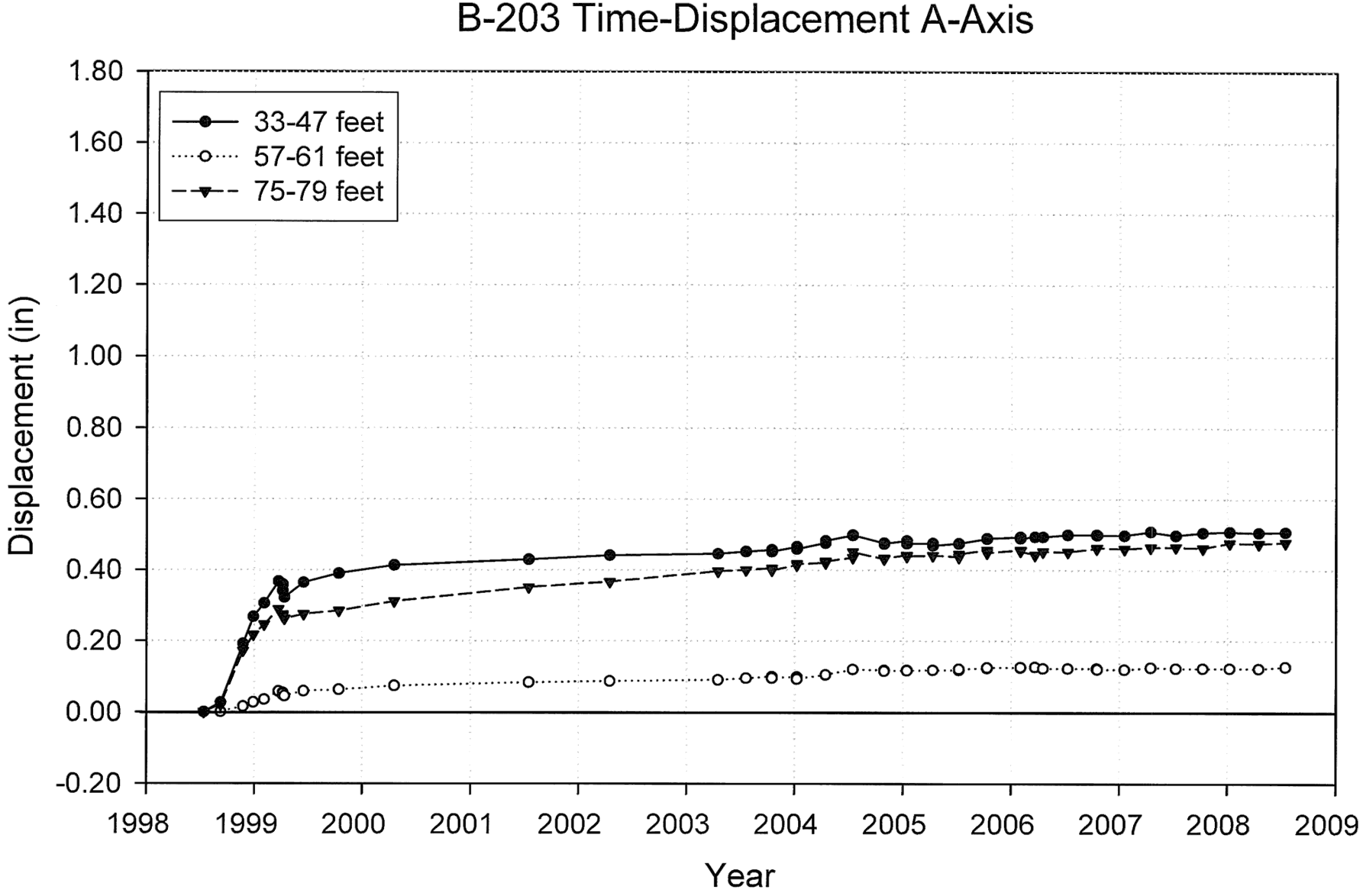

B-203 Time-Displacement A-Axis
33-47 feet
57-61 feet
75-79 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

PLATE 19

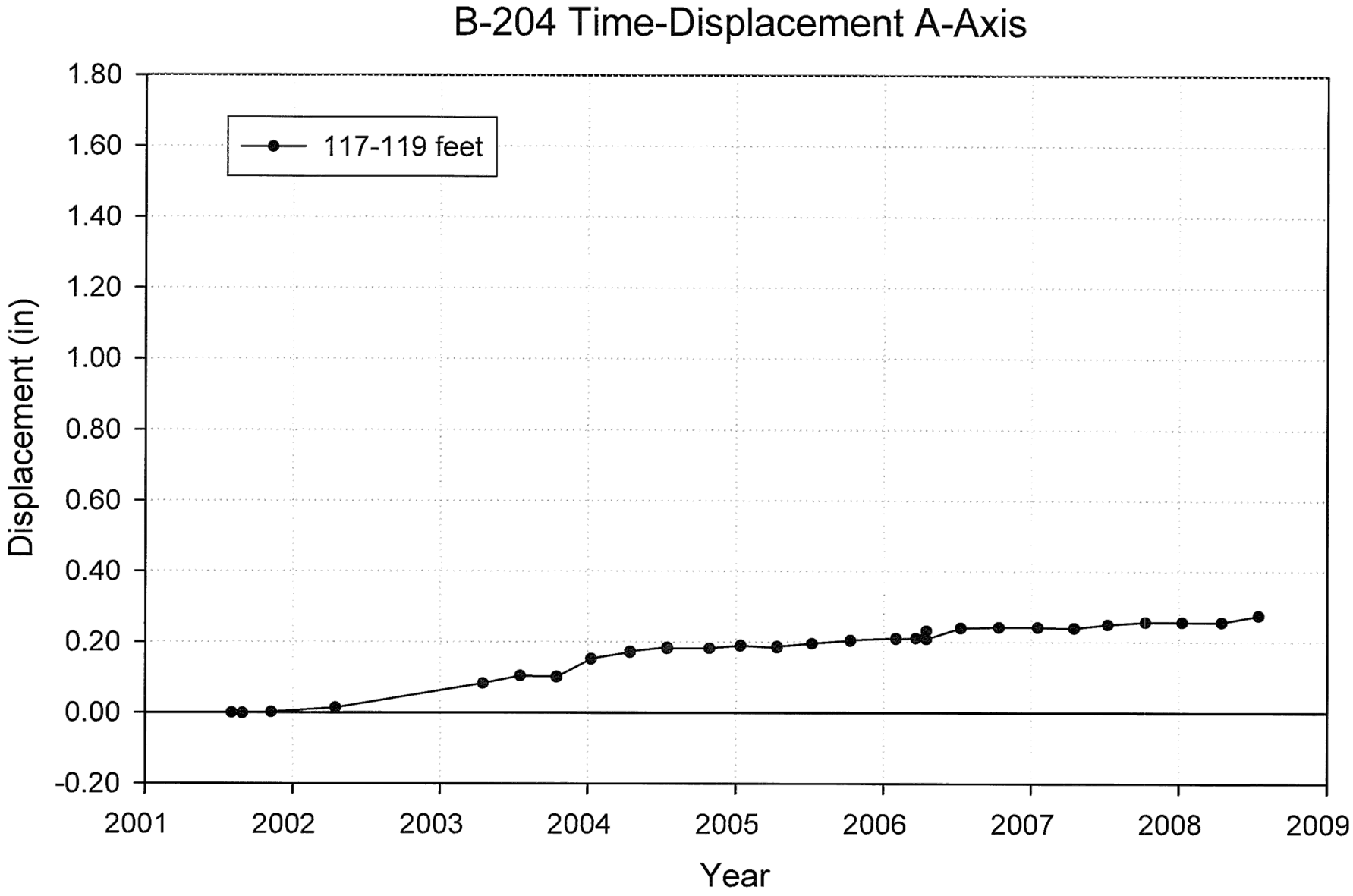

B-204 Time-Displacement A-Axis
117-119 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

PLATE 20

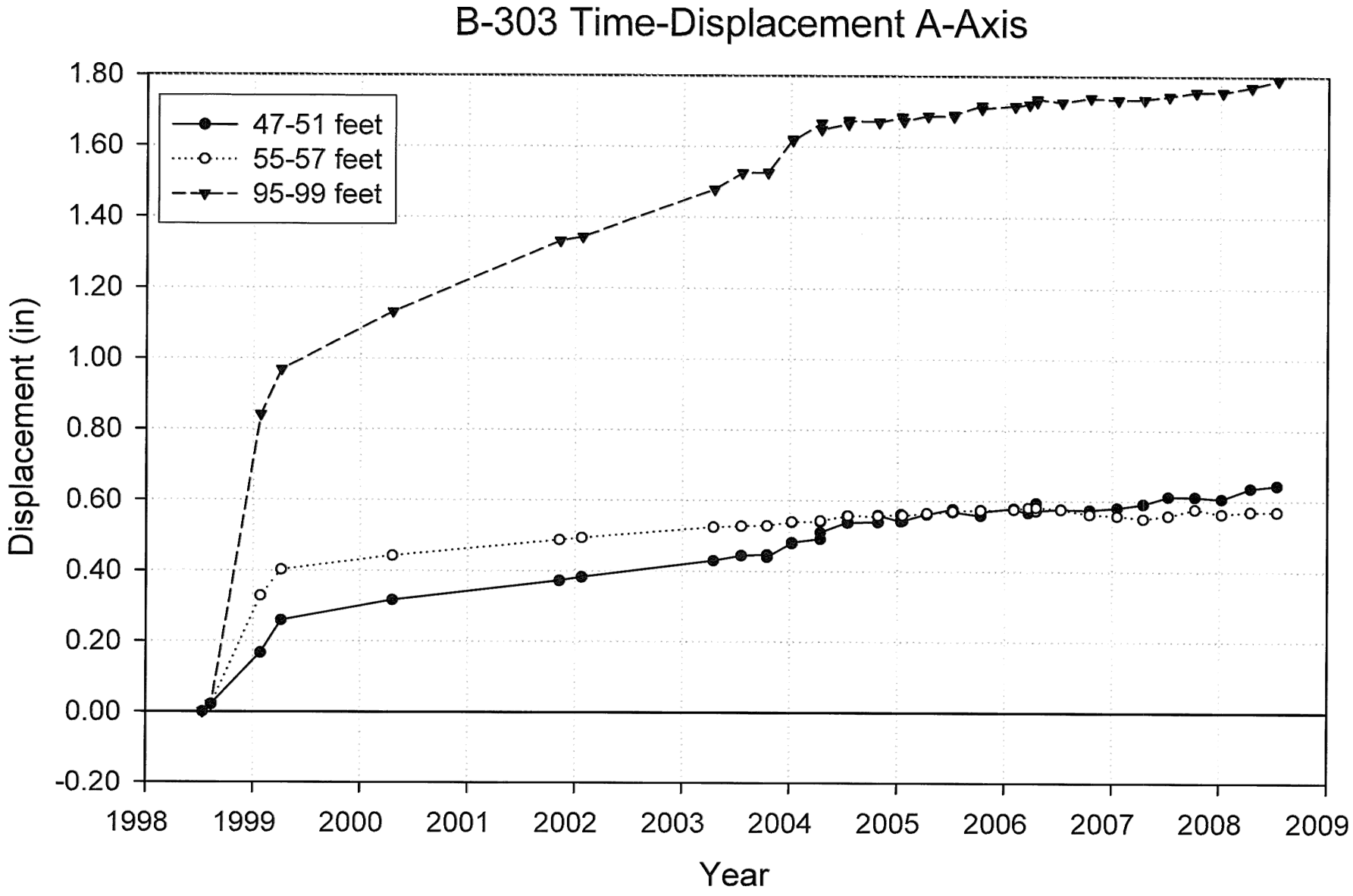
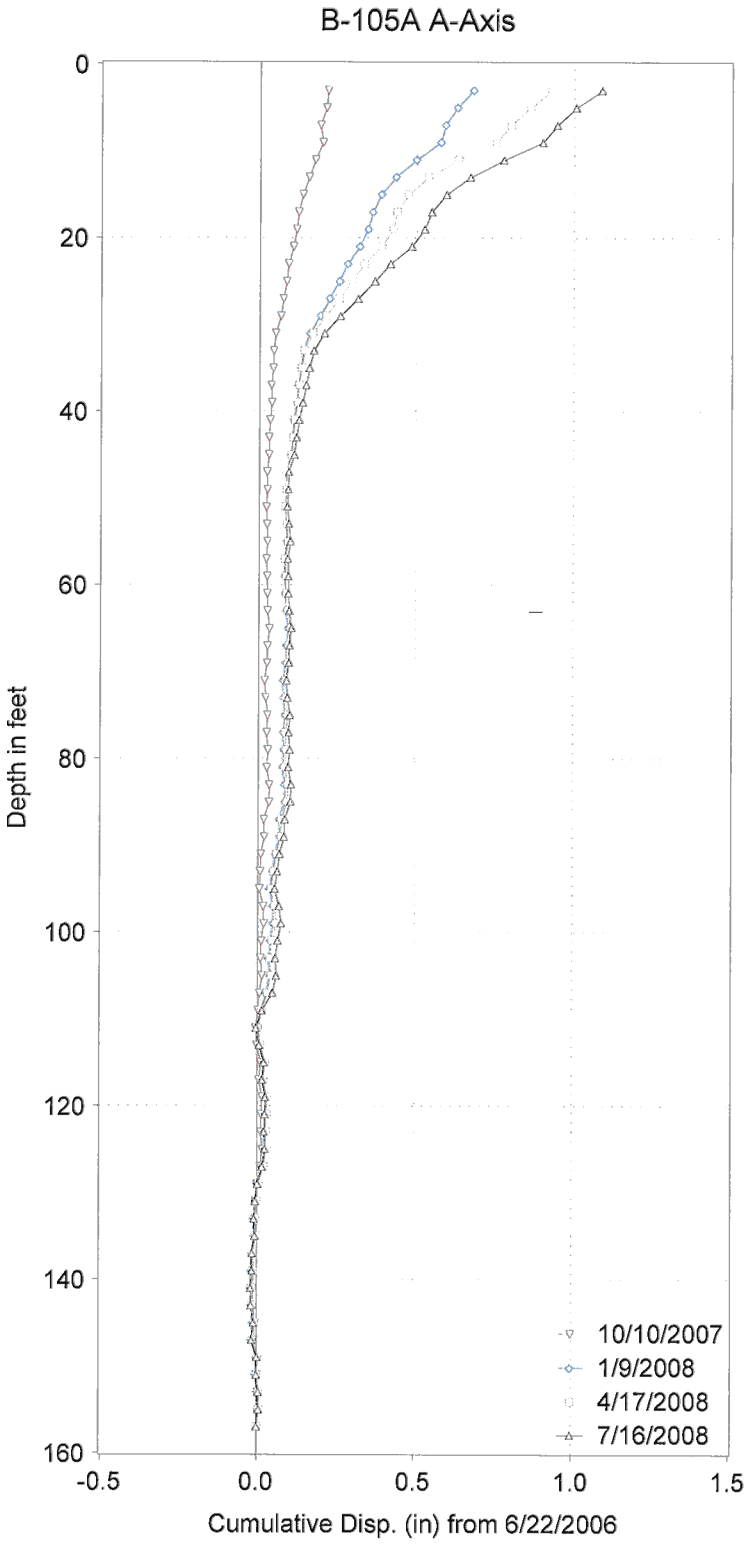
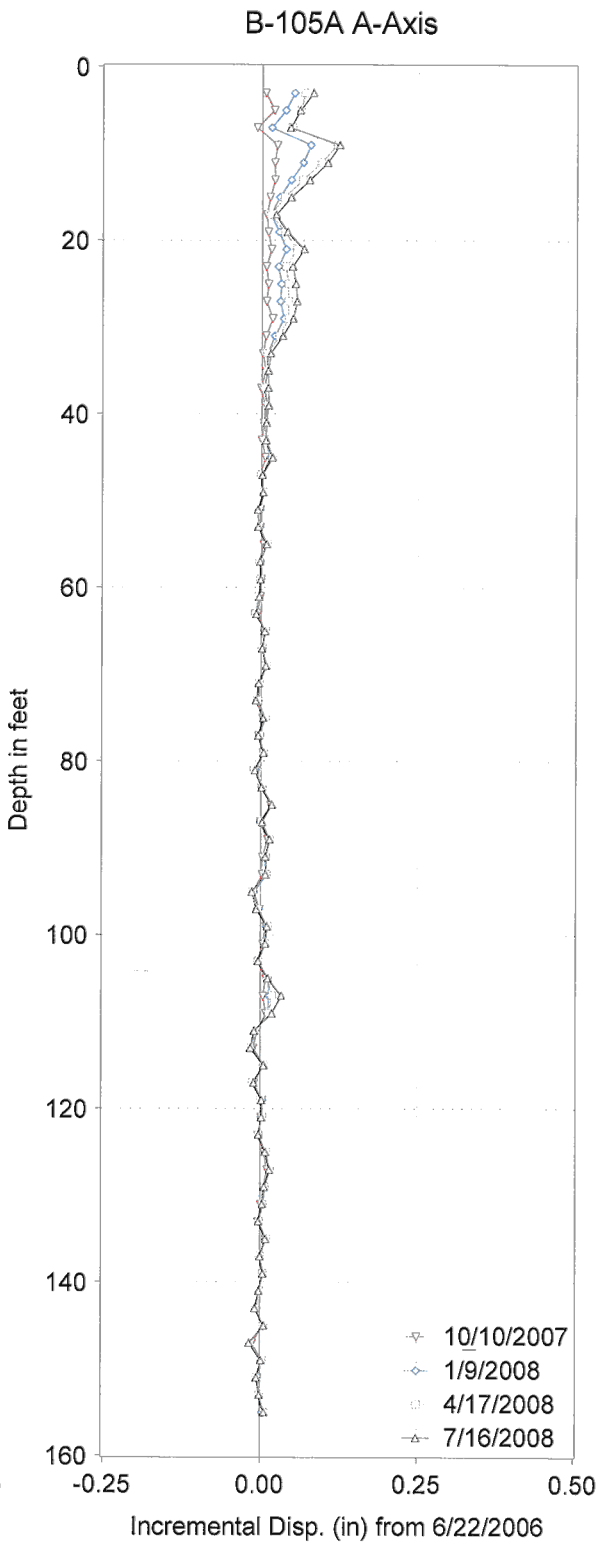

B-303 Time-Displacement A-Axis
47-51 feet
55-57 feet
95-99 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

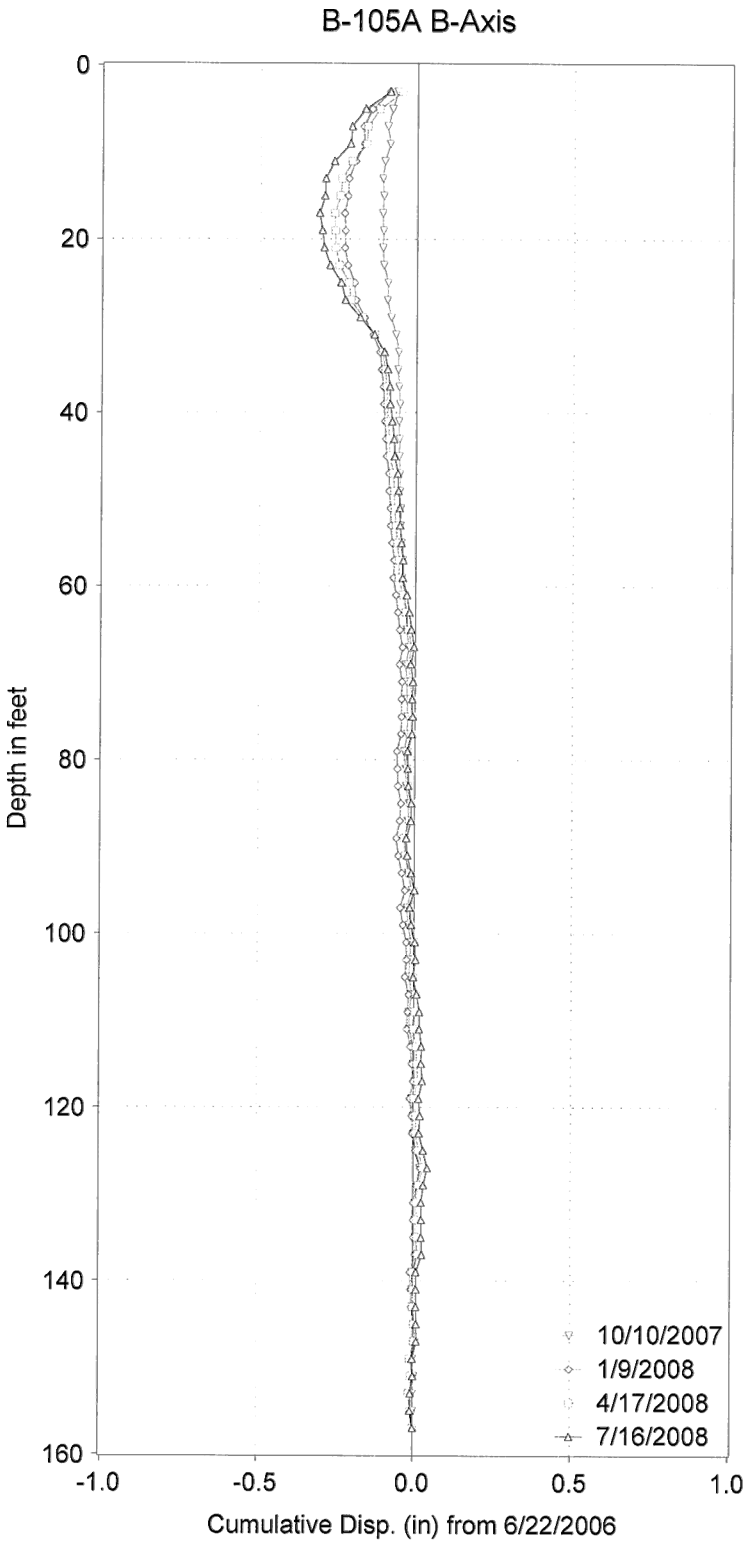
PLATE 21

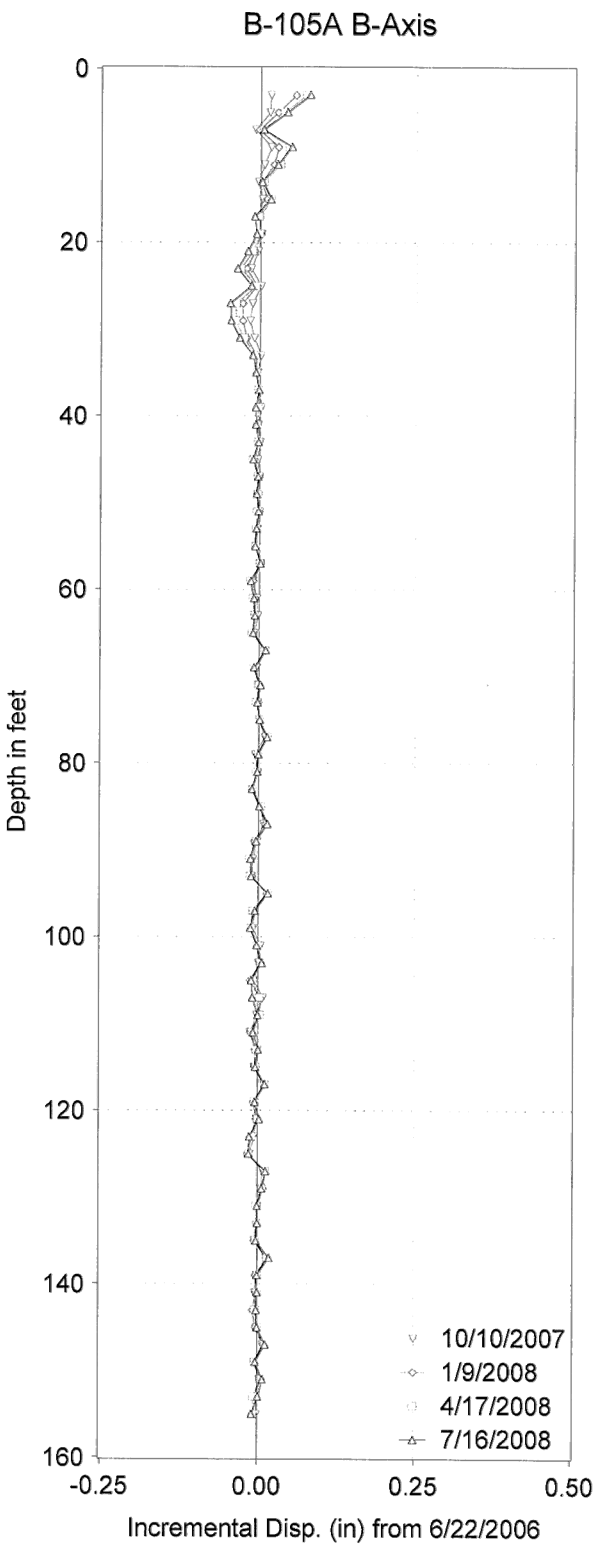




B-105A
-Includes readings from the last four quarters.

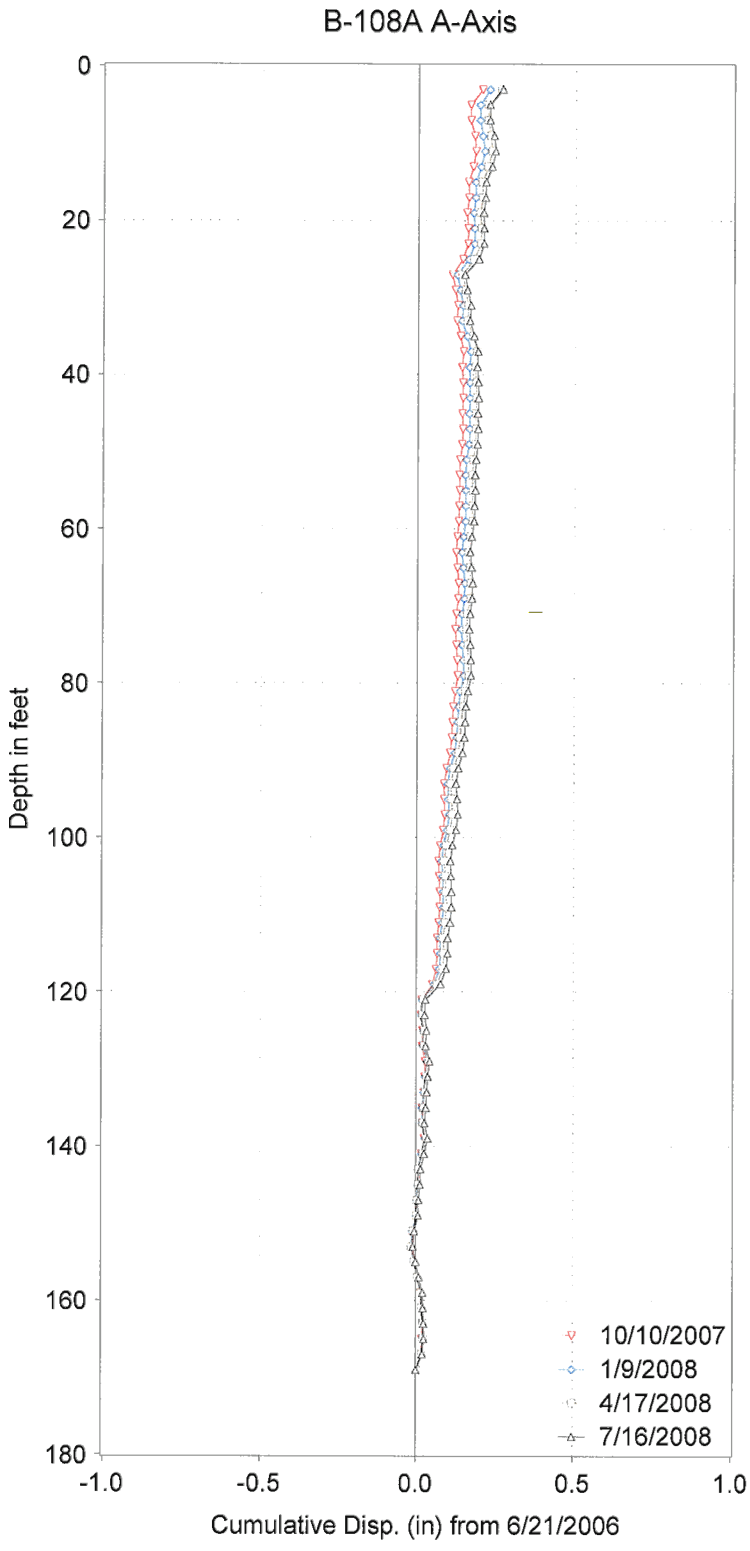
PLATE 22

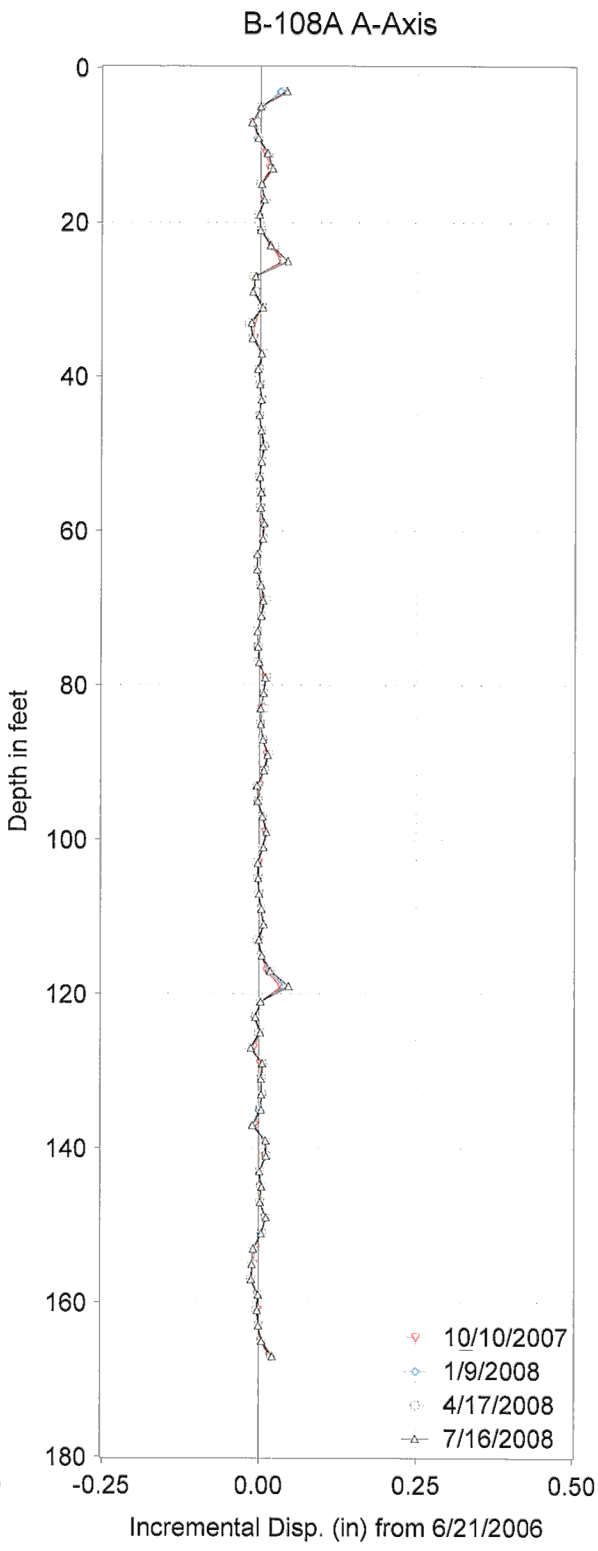




B-105A
-Includes readings from the last four quarters.

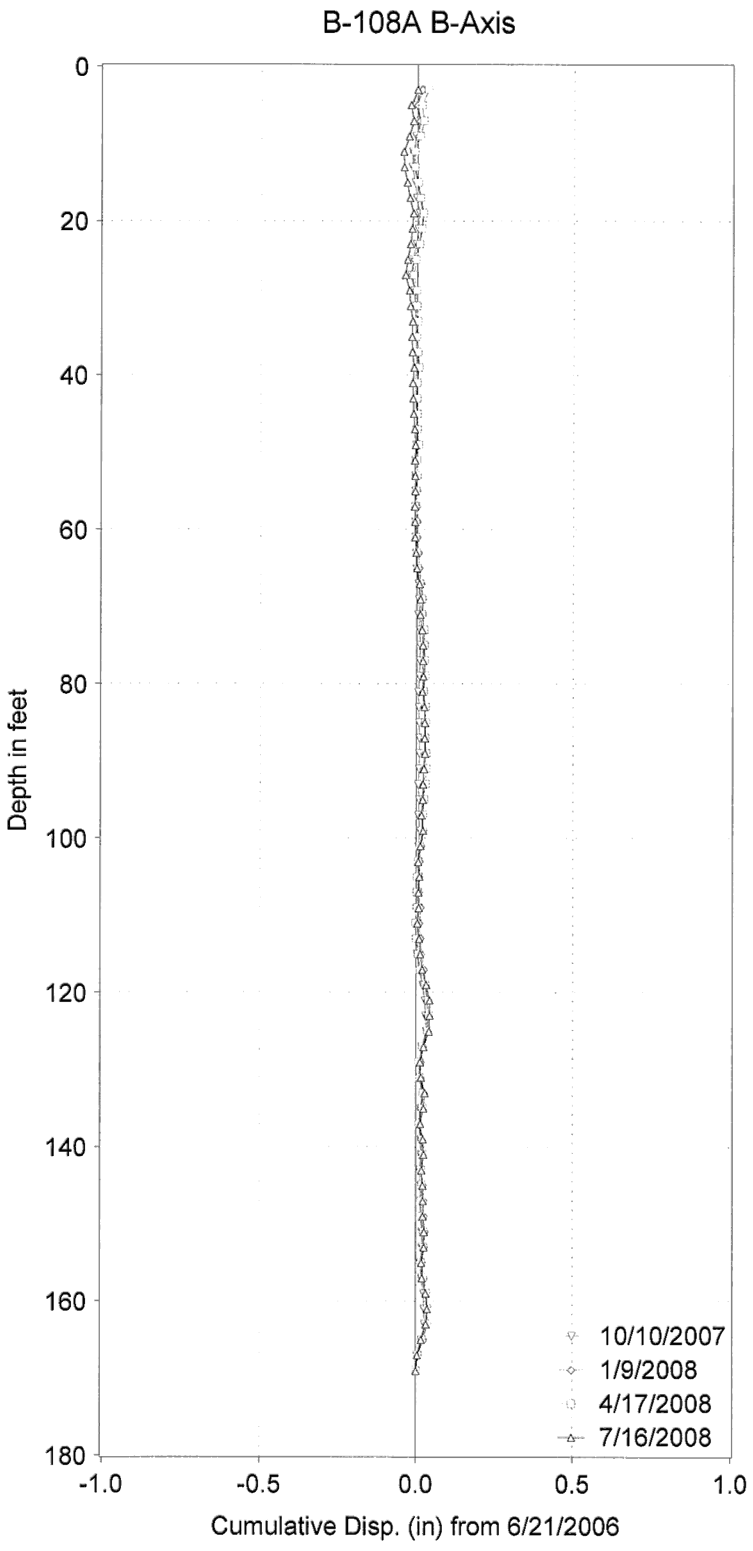
PLATE 23

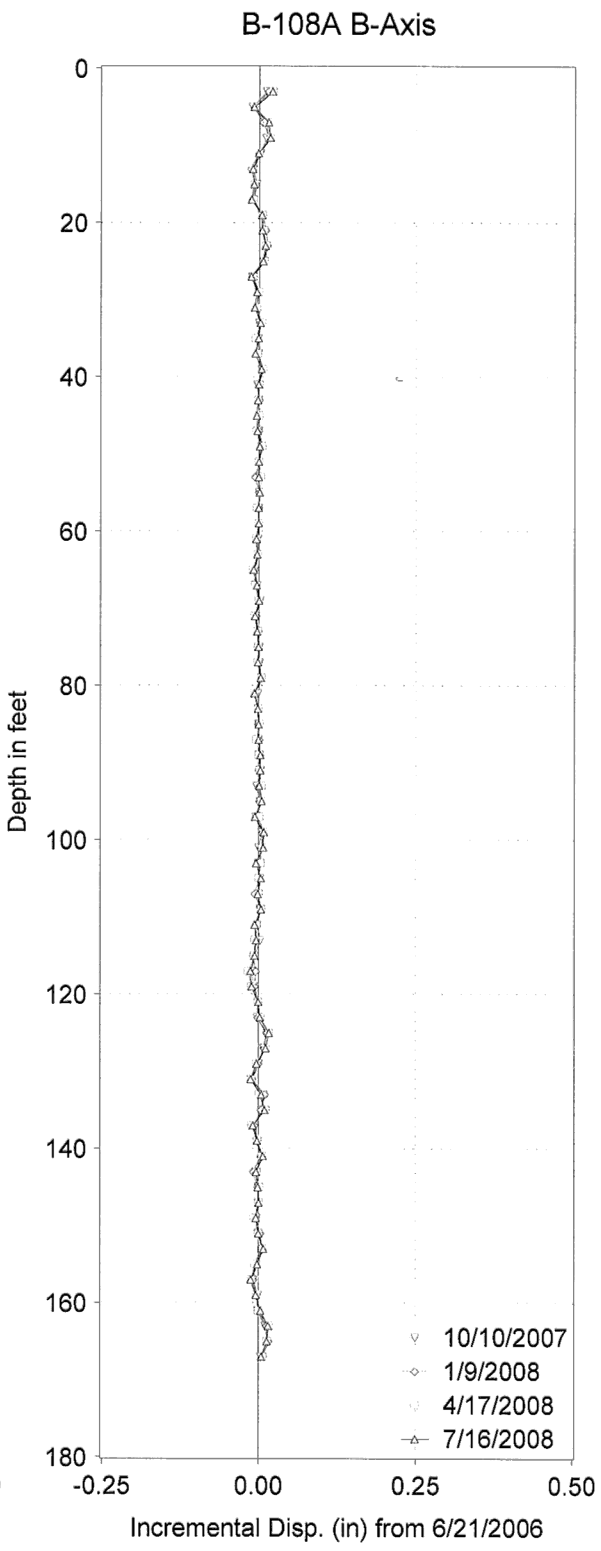




B-108A
-Includes readings from the last four quarters.

PLATE 24





B-108A
-Includes readings from the last four quarters.

PLATE 25

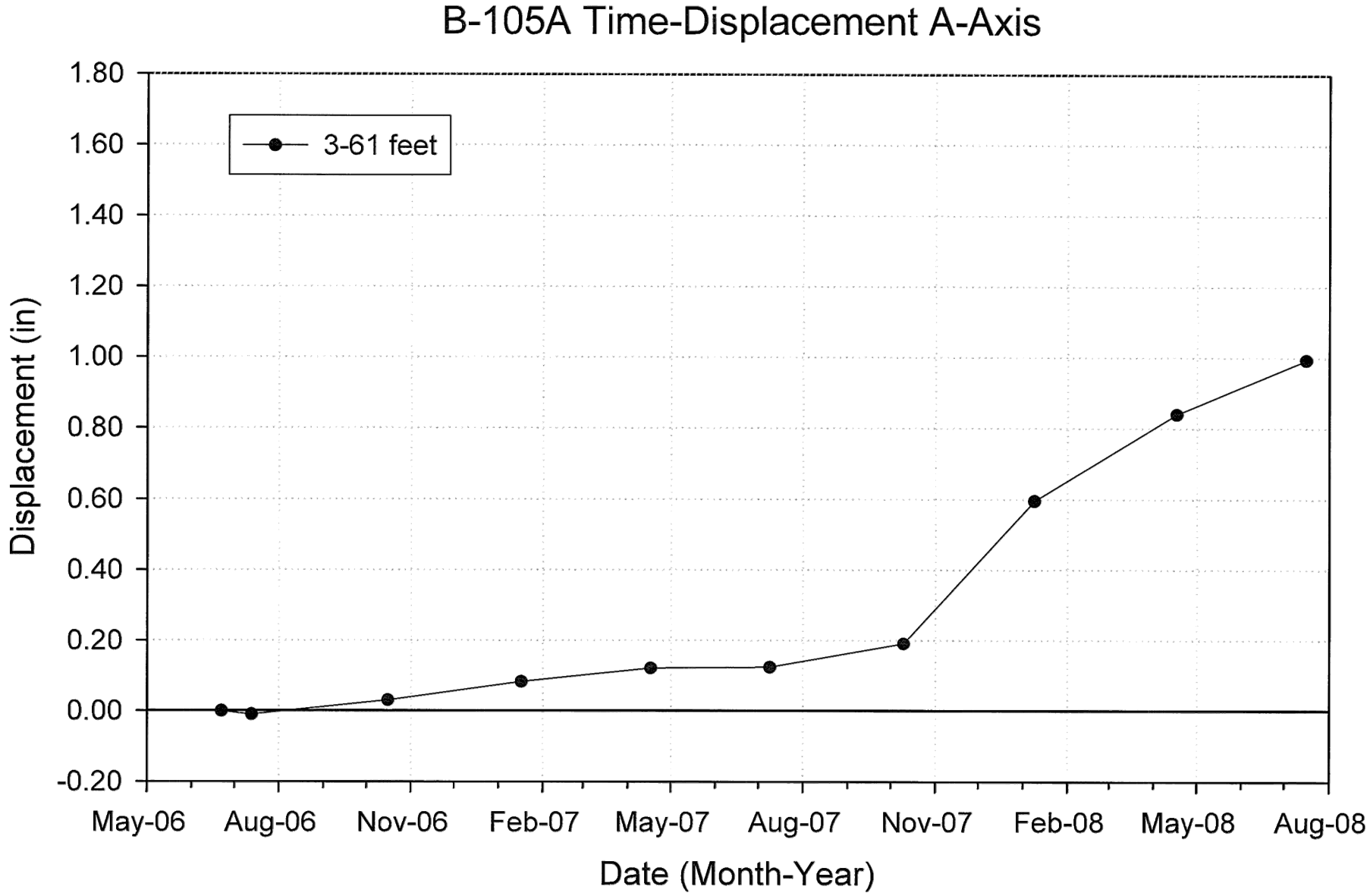

B-105A Time-Displacement A-Axis
3-61 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Aug-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
May-08
Aug-08
Date (Month-Year)

PLATE 26

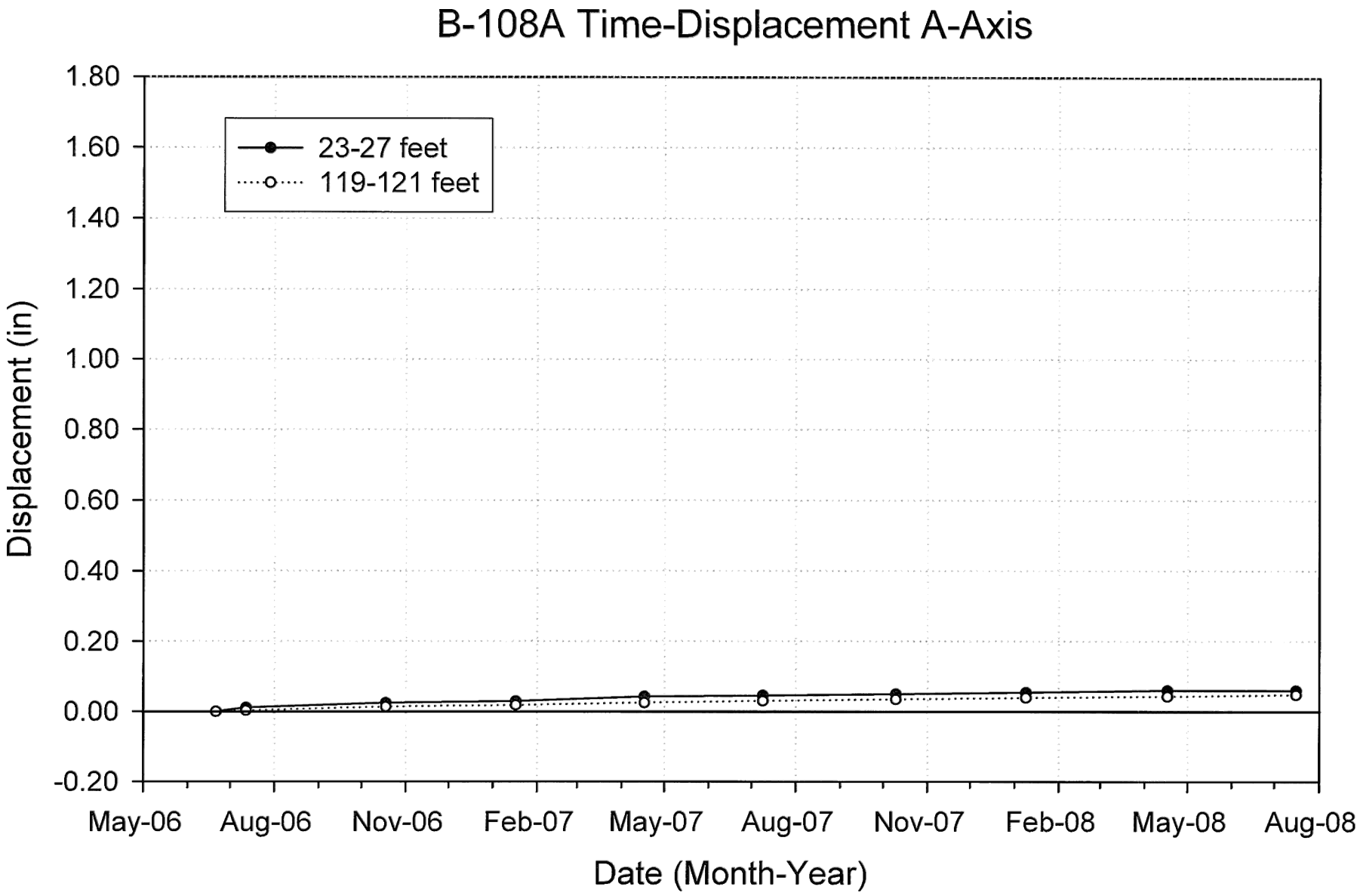
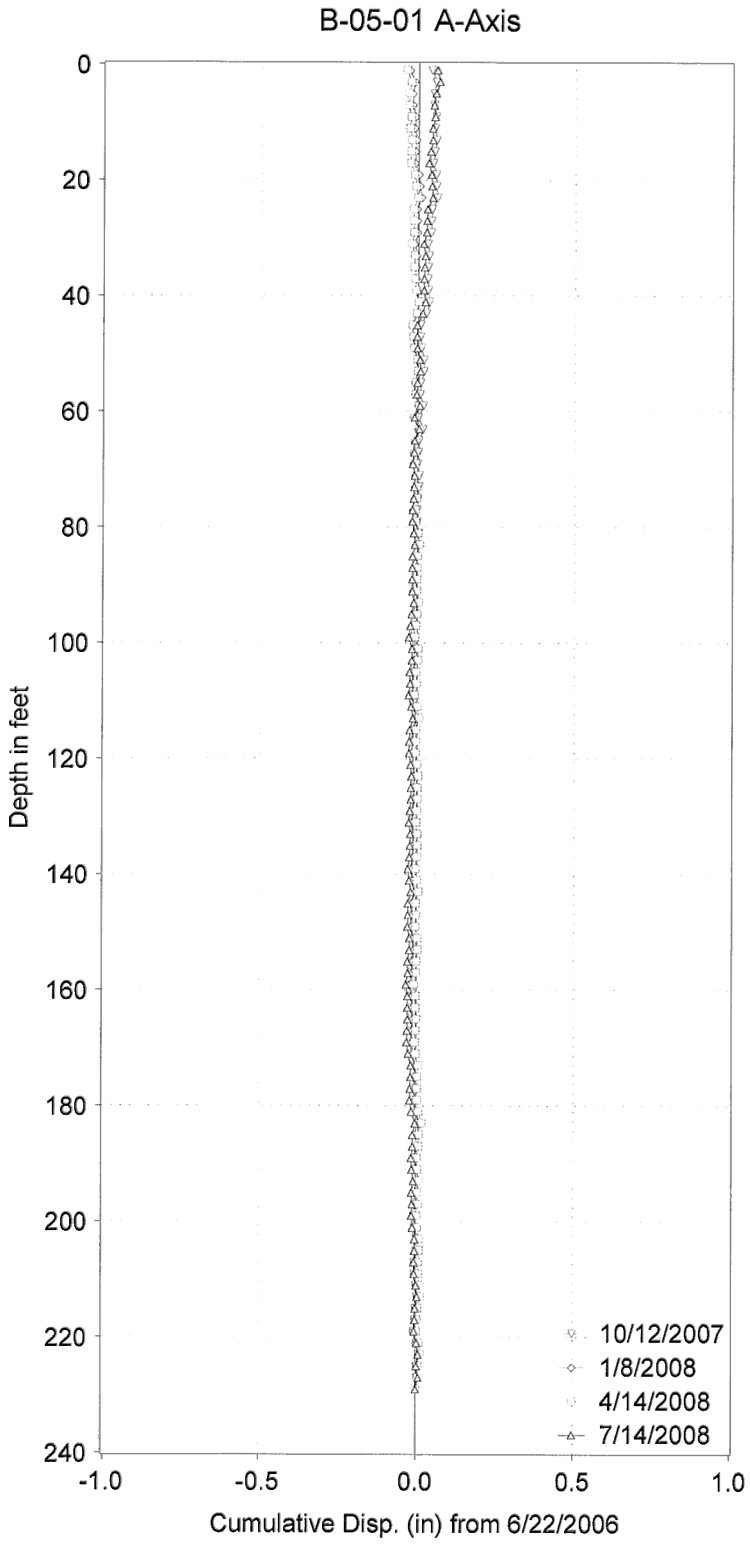
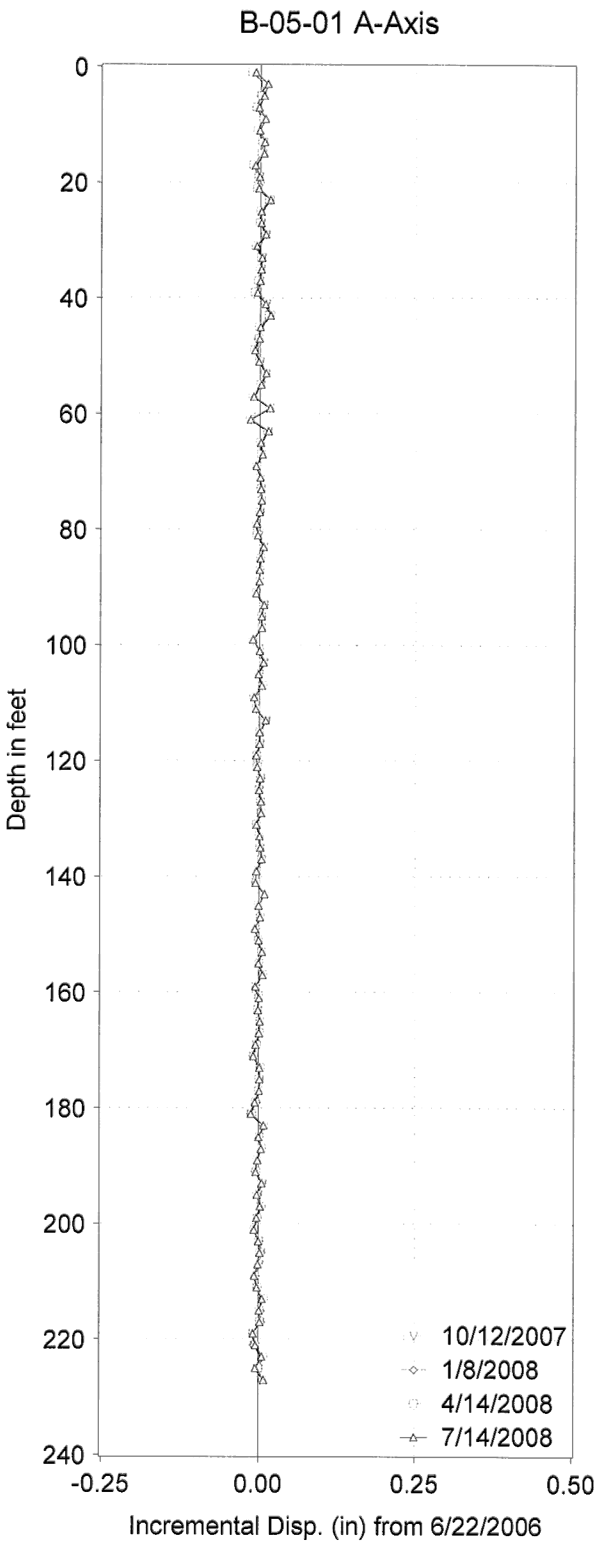

B-108A Time-Displacement A-Axis
23-27 feet
119-121 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Aug-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
May-08
Aug-08
Date (Month-Year)

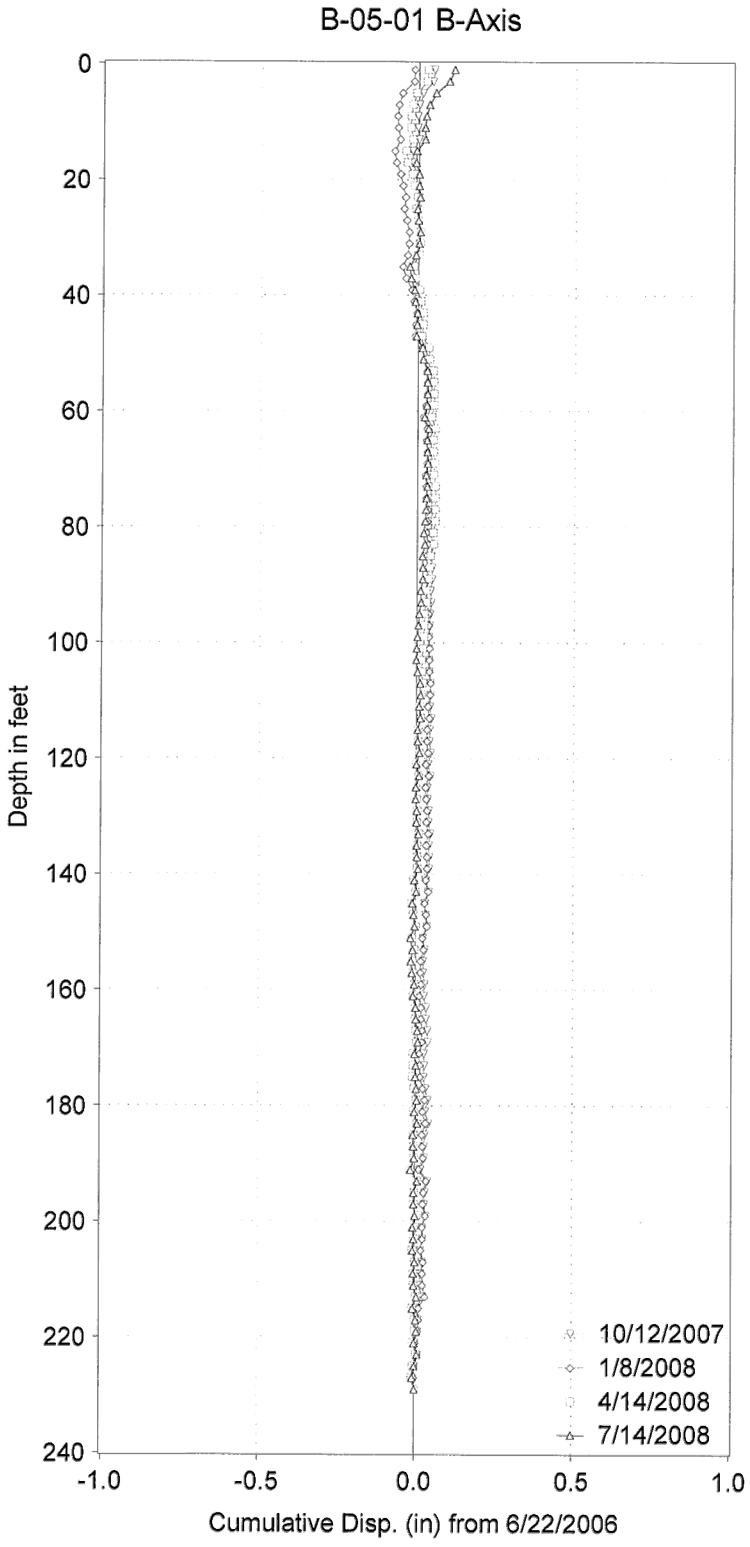
PLATE 27

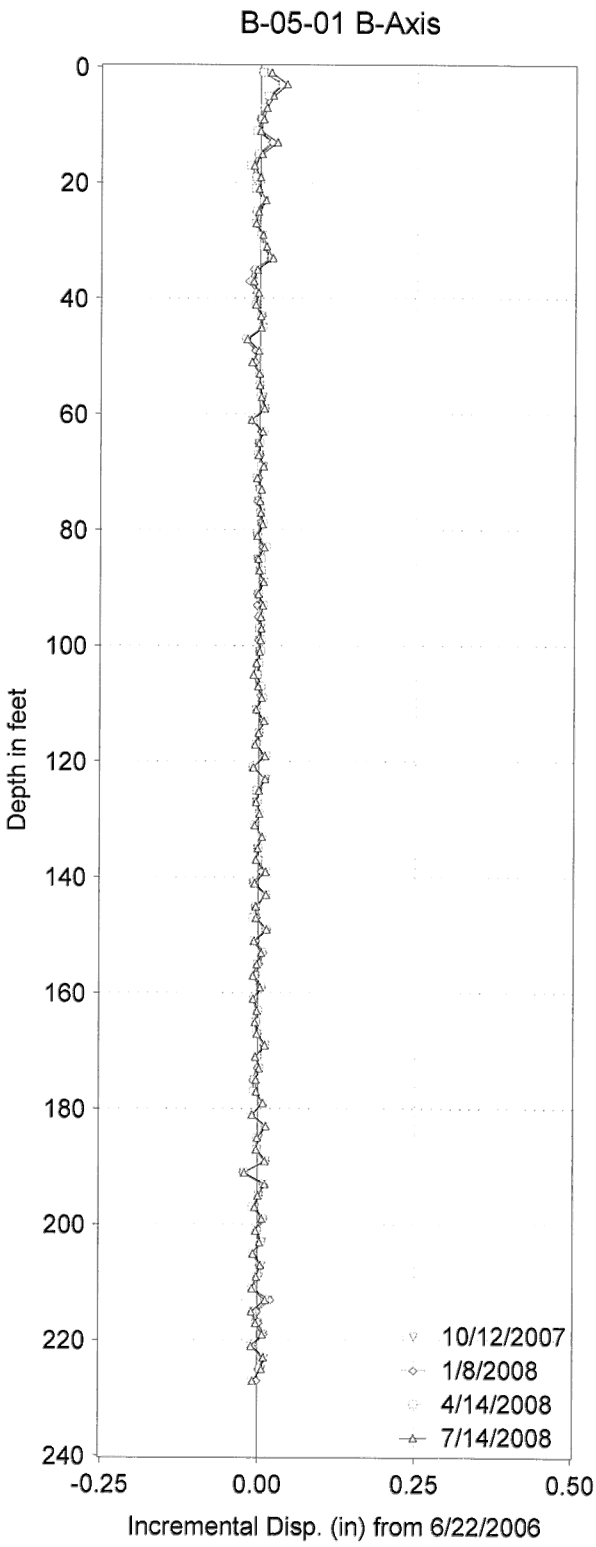




B-05-01
-Includes readings from the last four quarters.

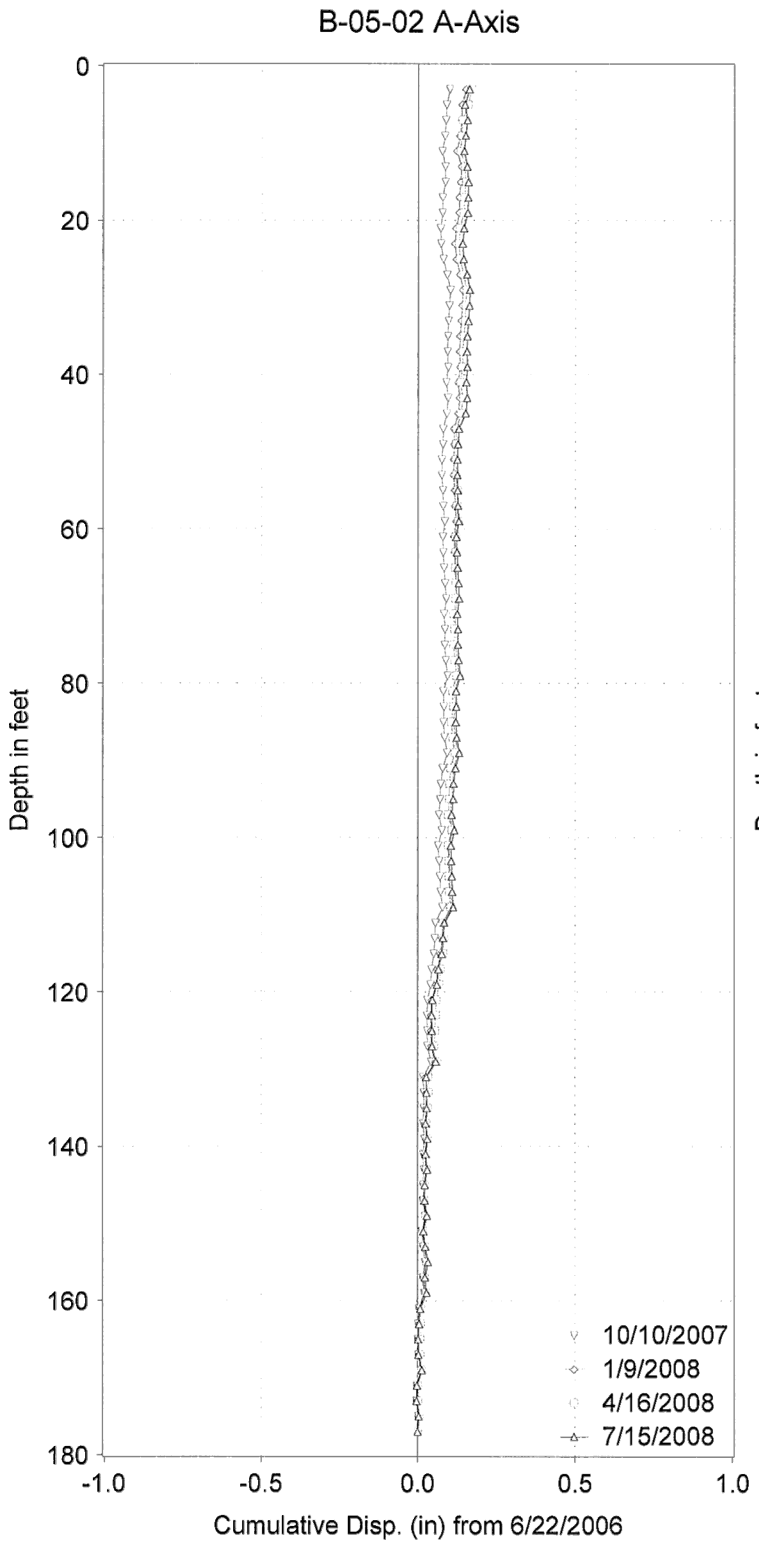
PLATE 28

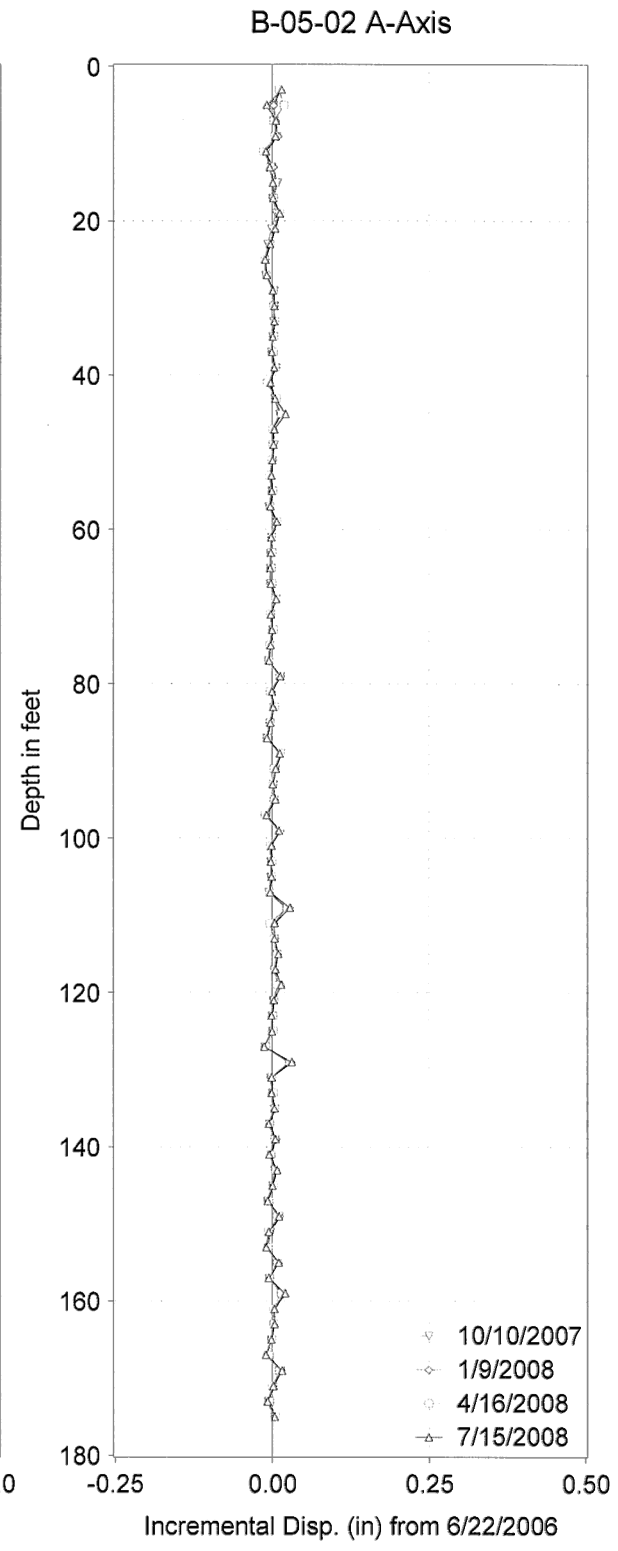




B-05-01
-Includes readings from the last four quarters.

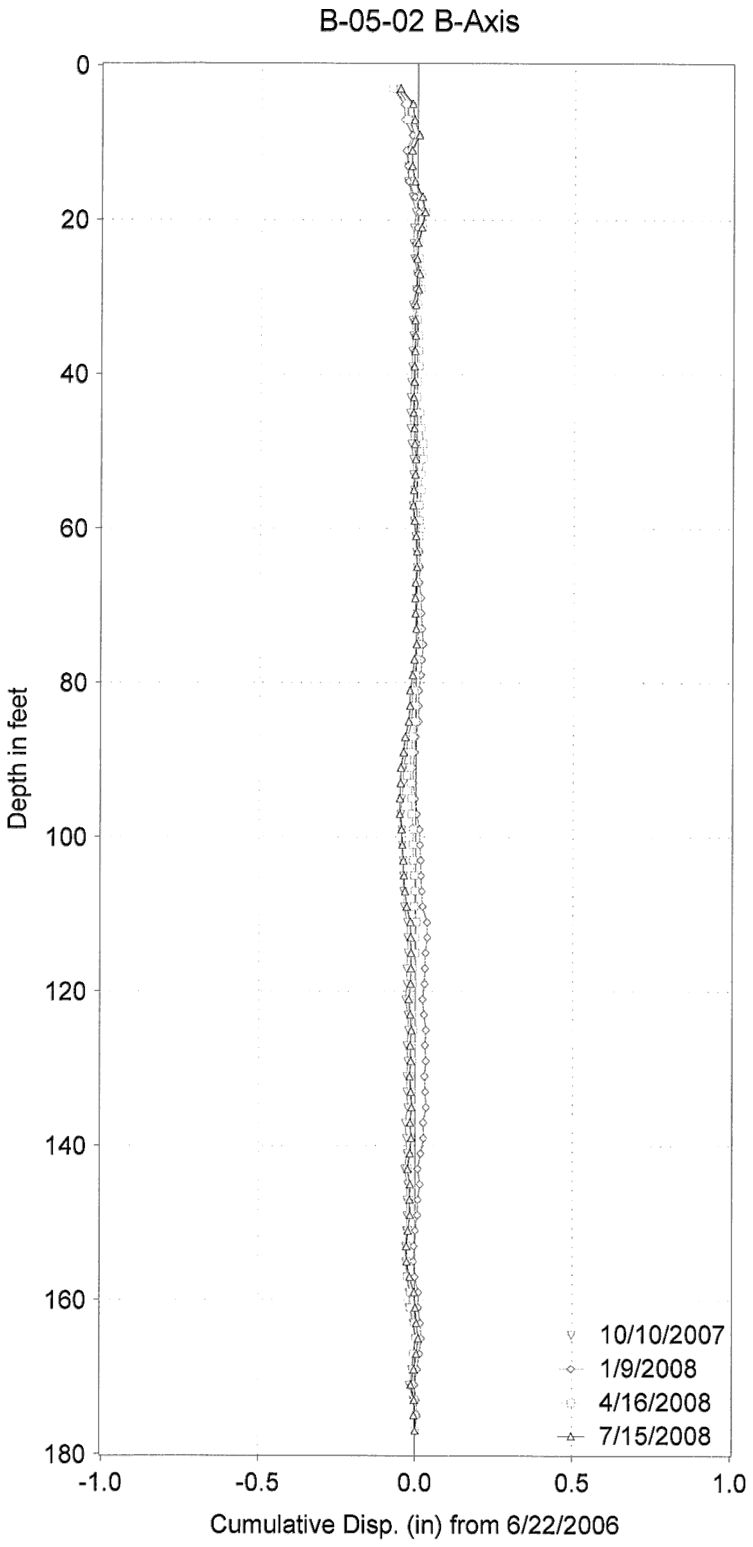
PLATE 29

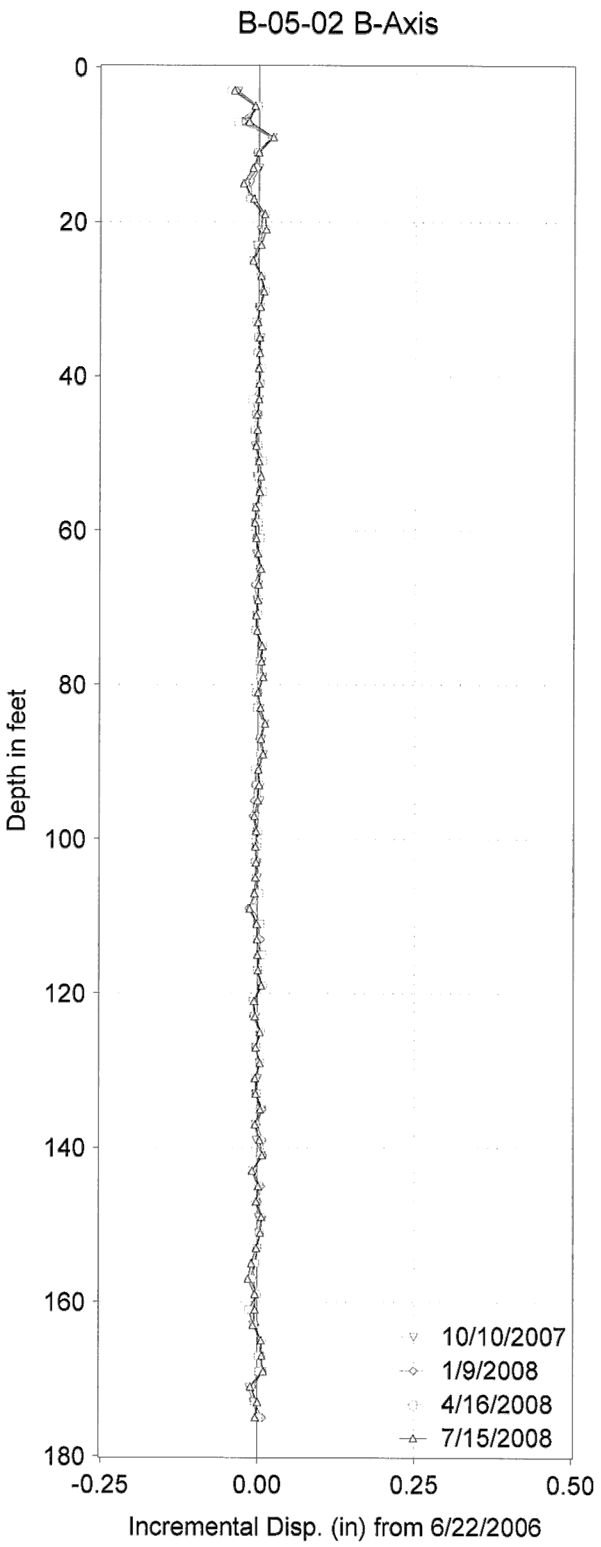




B-05-02
-Includes readings from the last four quarters.

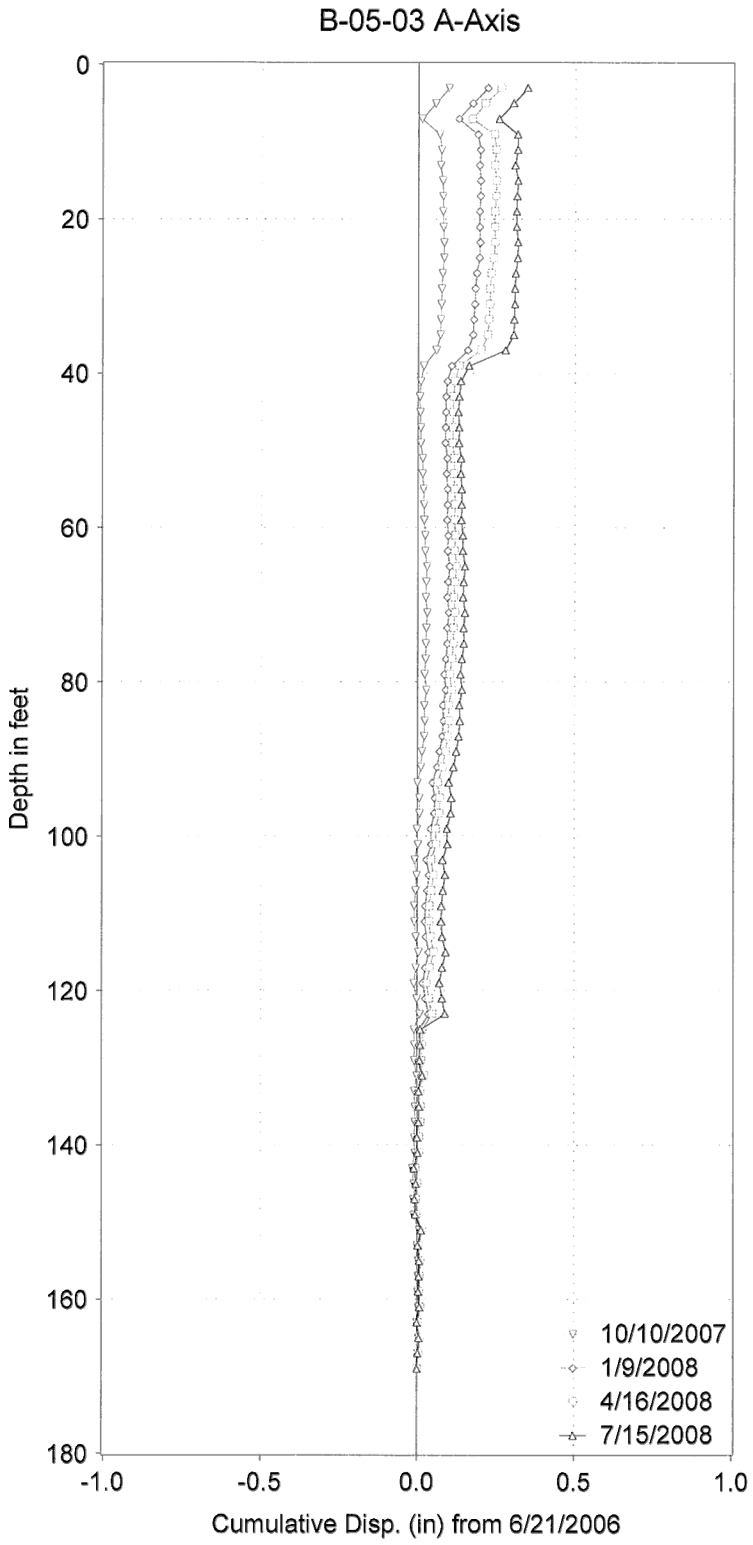
PLATE 30

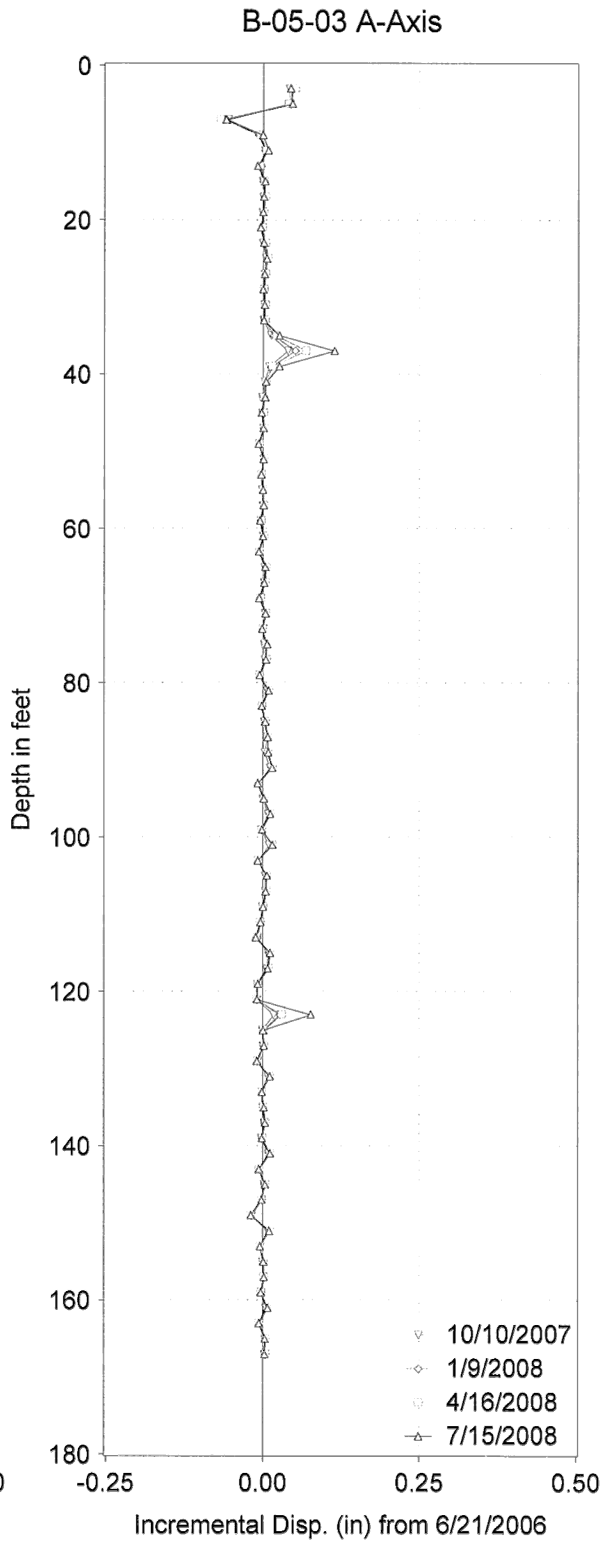




B-05-02
-Includes readings from the last four quarters.

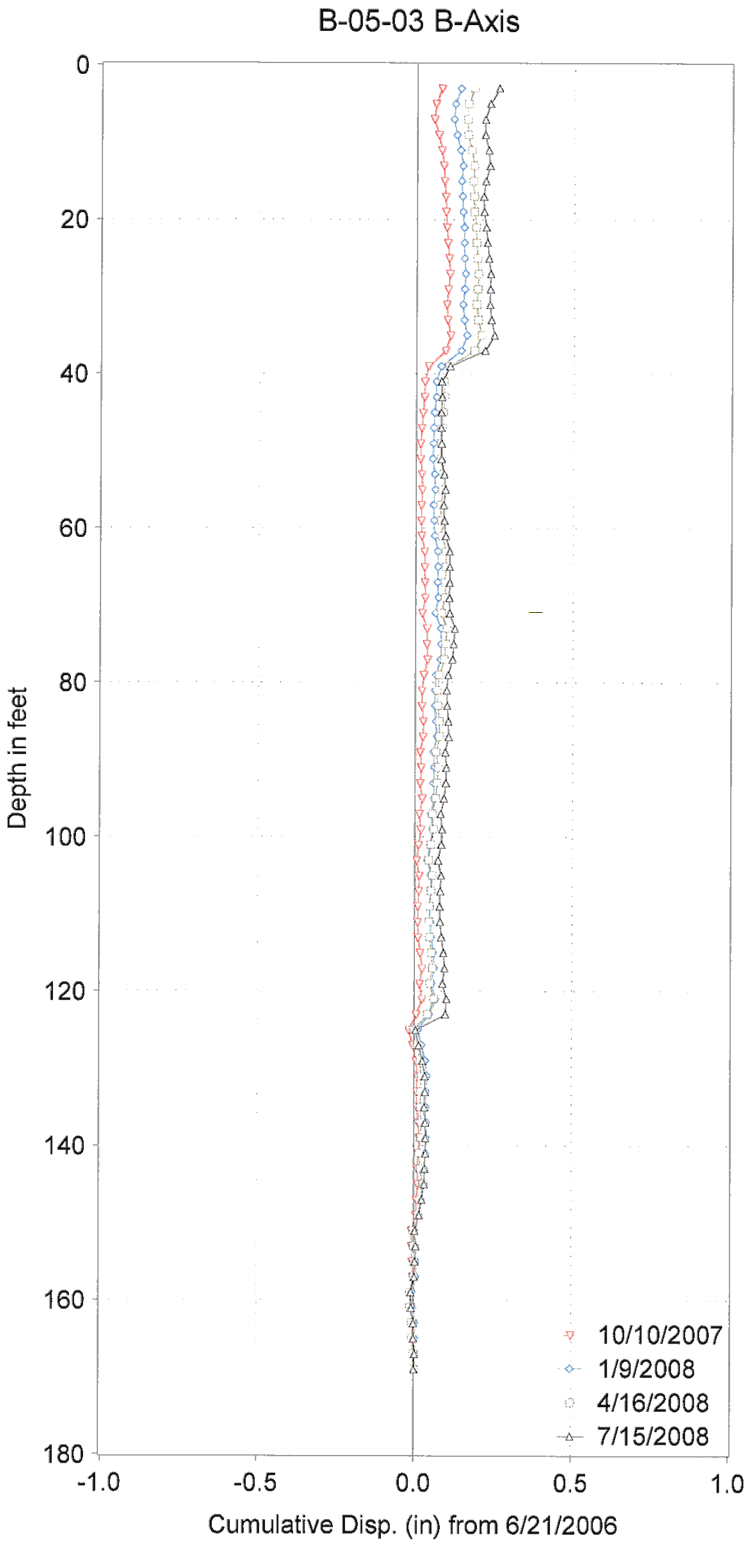
PLATE 31

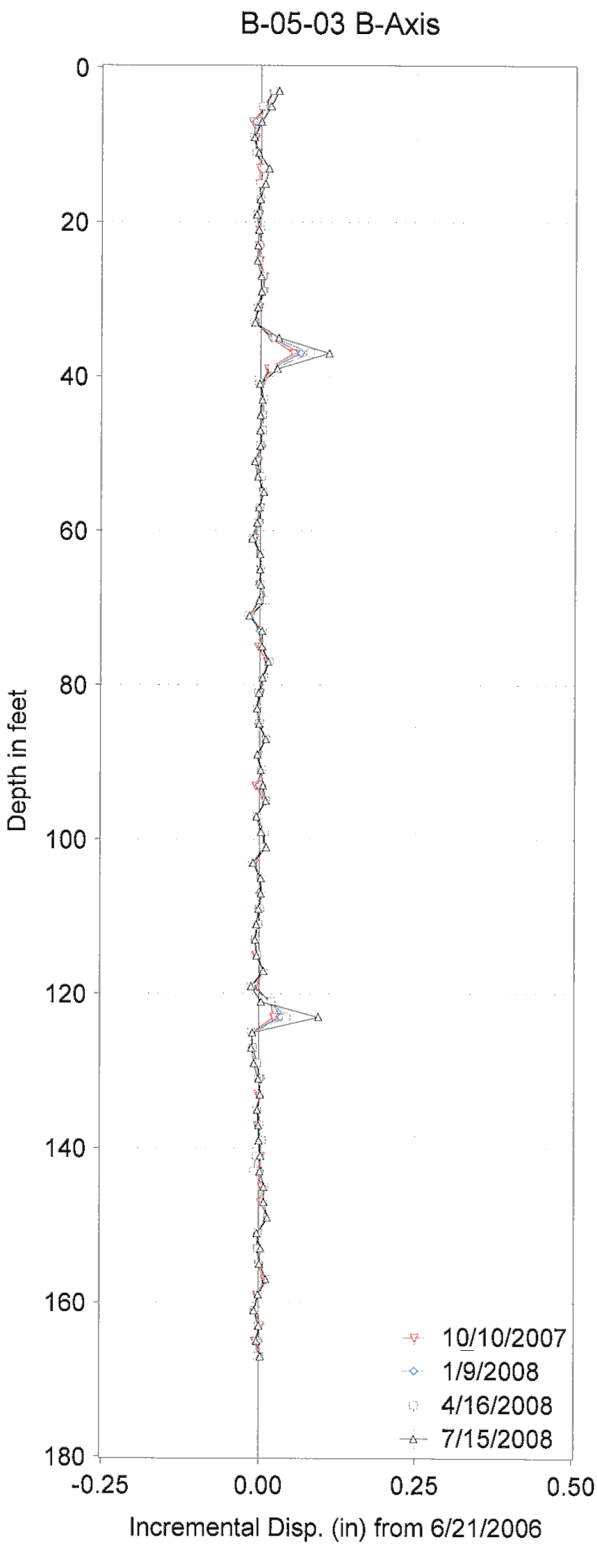




B-05-03
-Includes readings from the last four quarters.

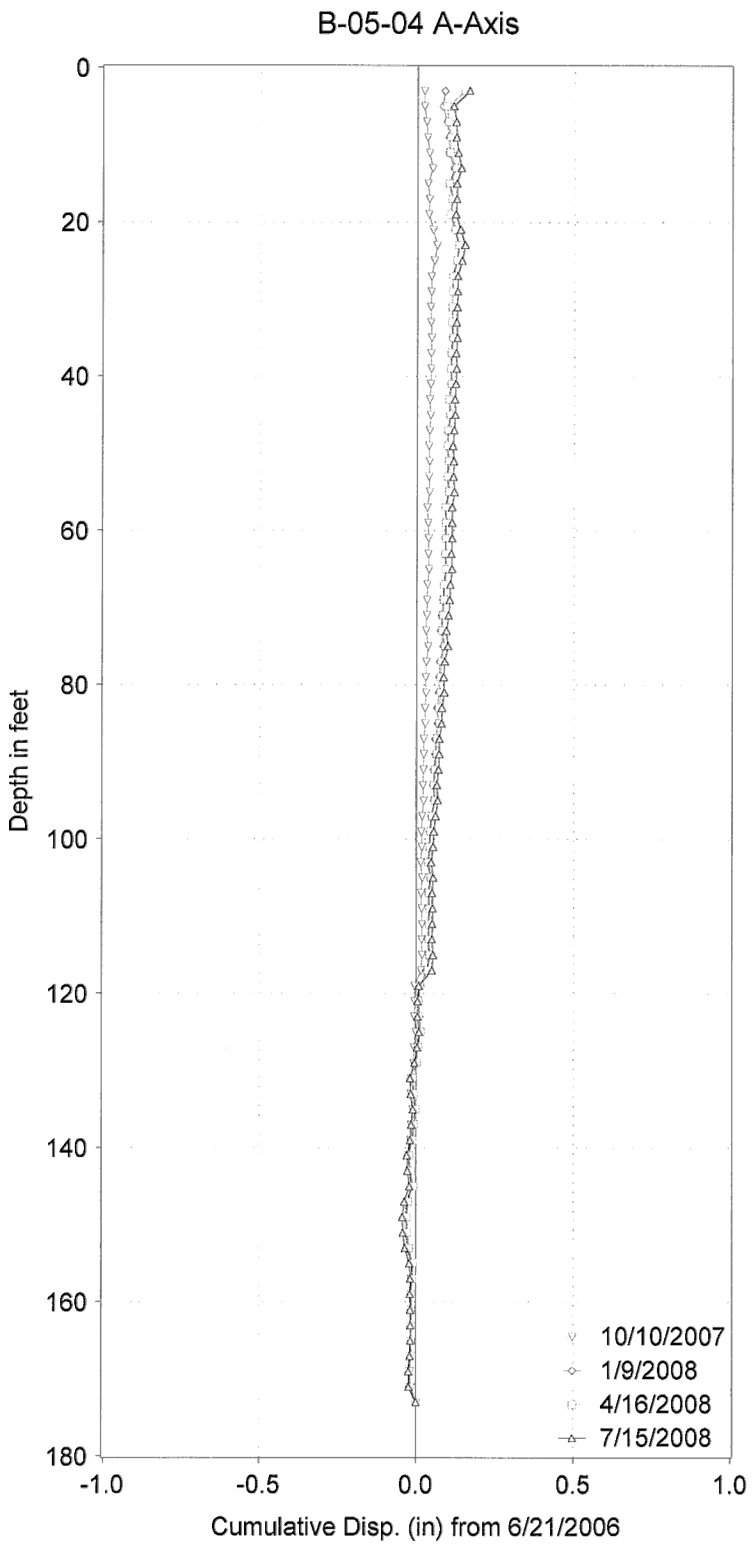
PLATE 32

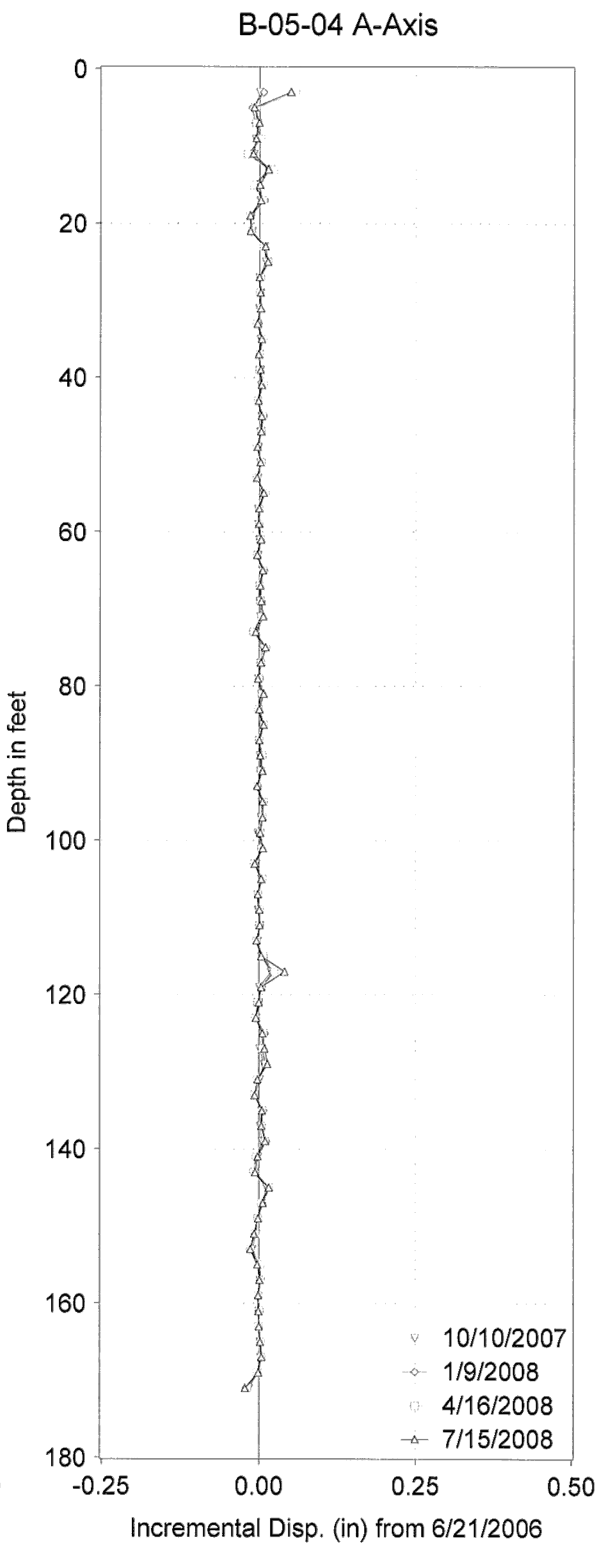




B-05-03
-Includes readings from the last four quarters.

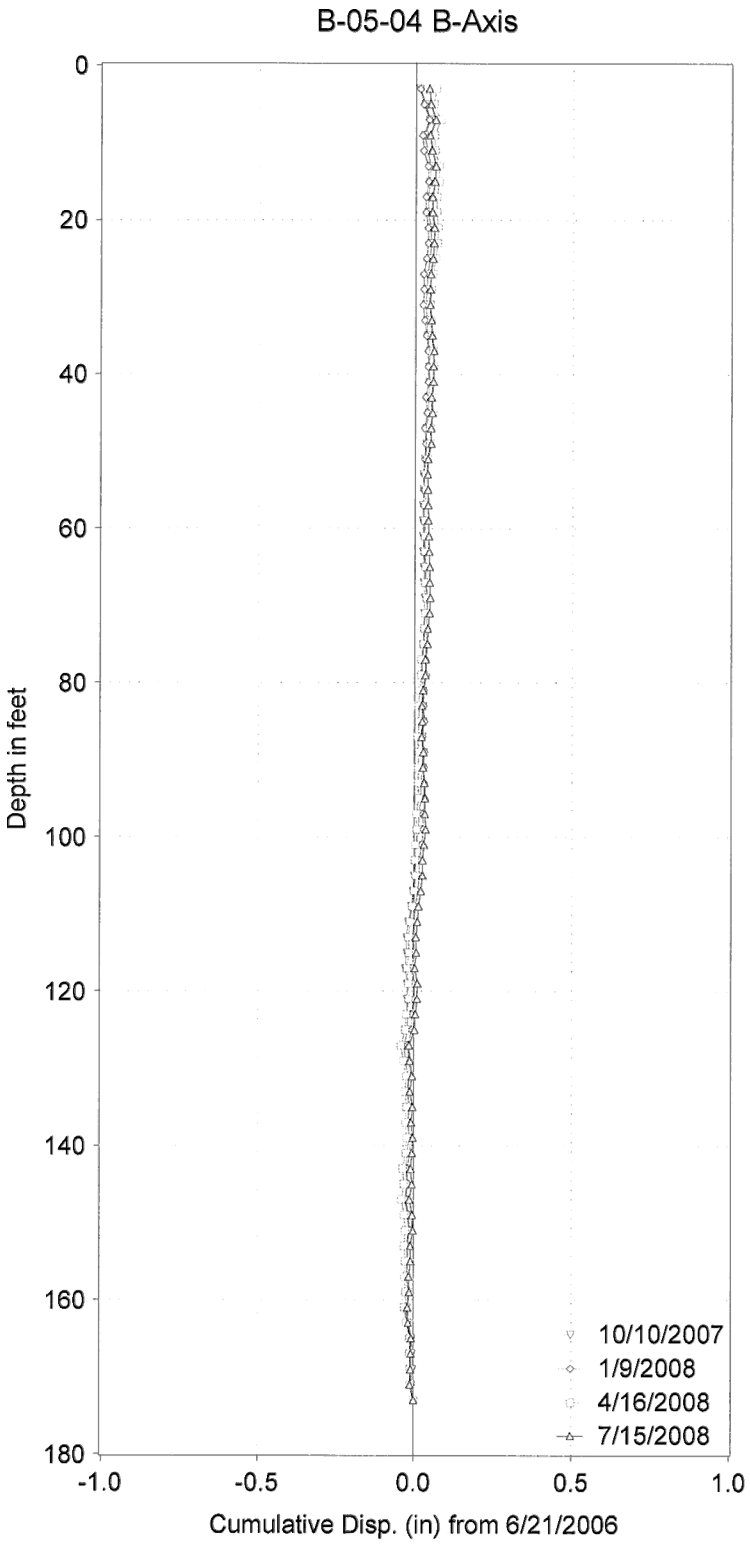
PLATE 33

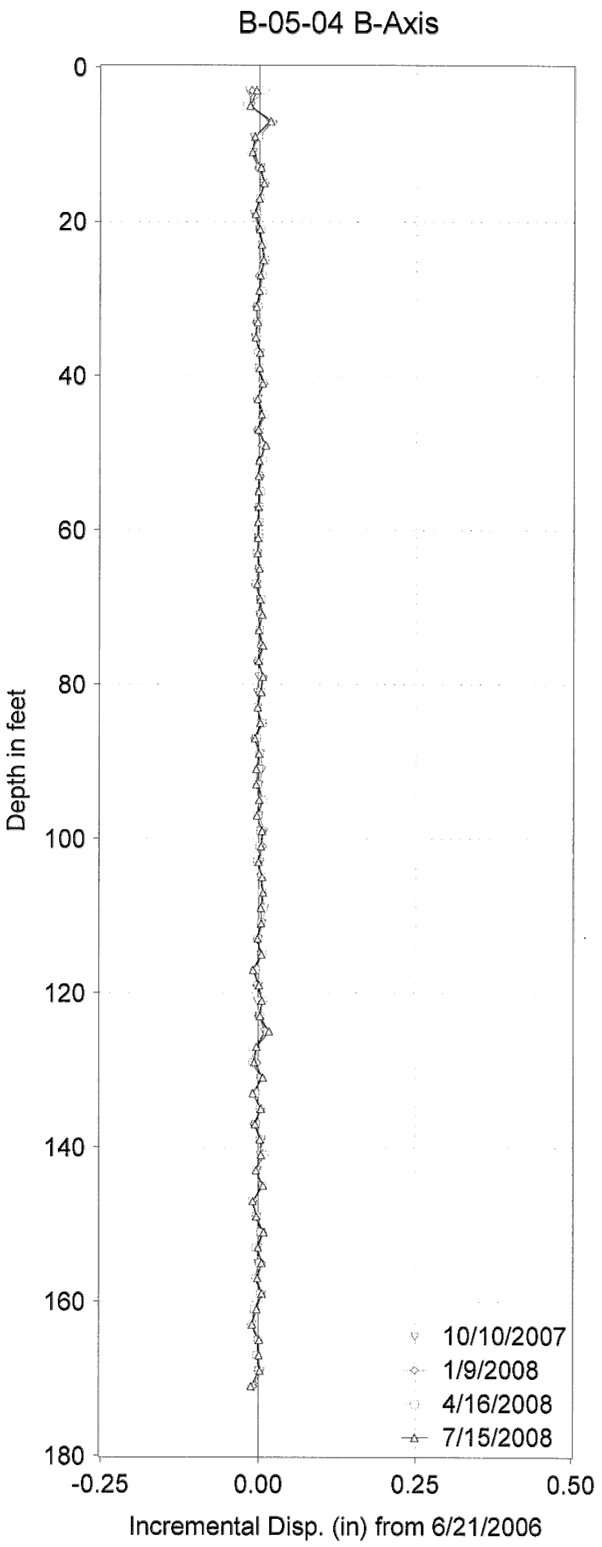




B-05-04
-Includes readings from the last four quarters.

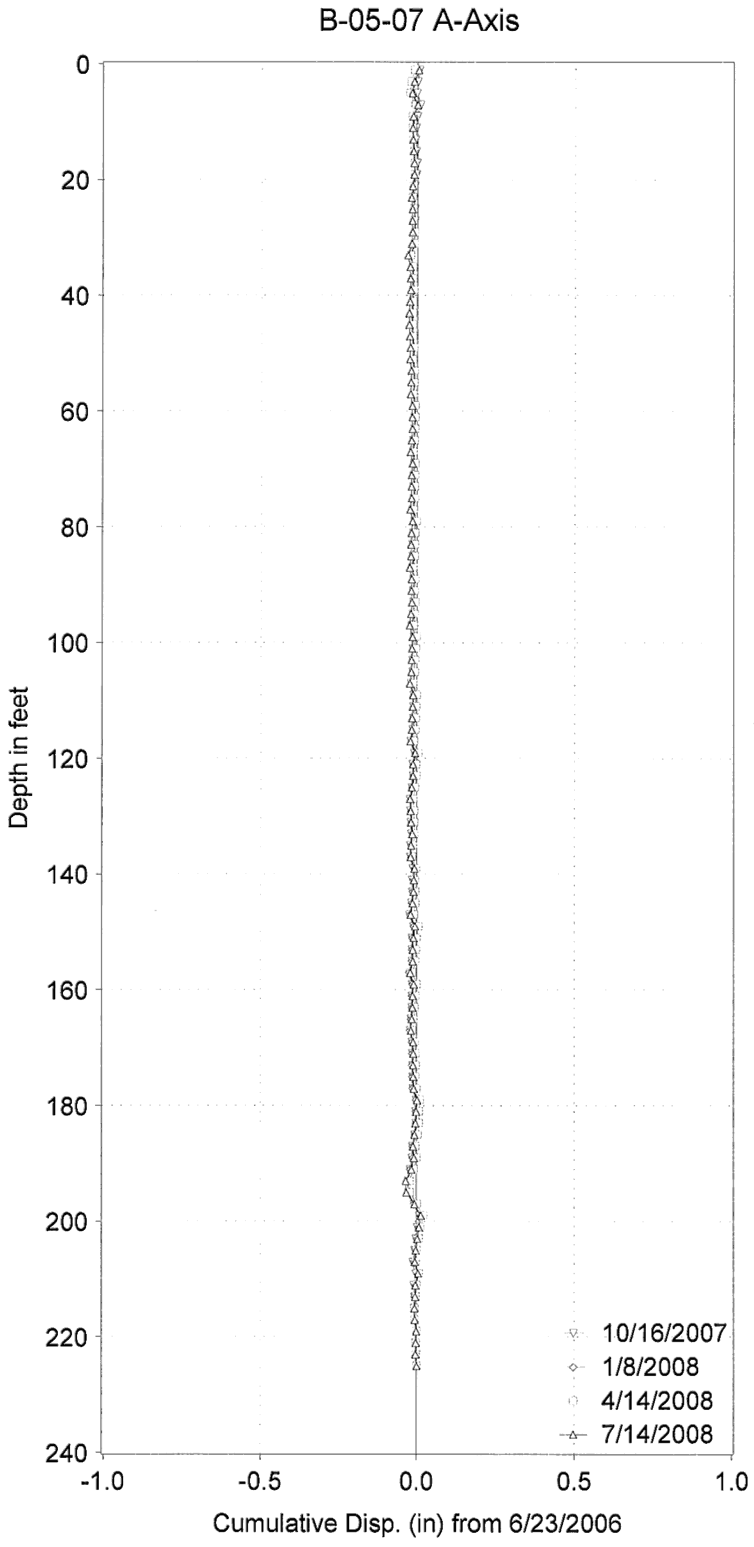
PLATE 34

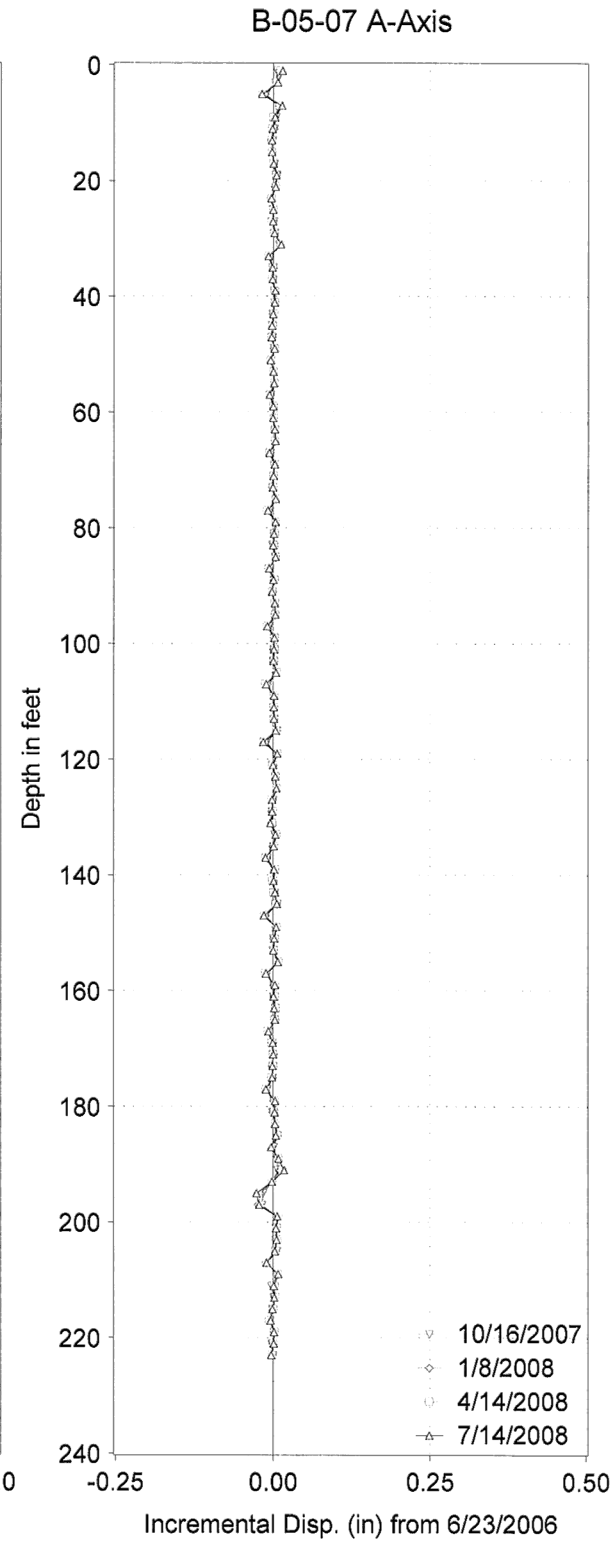




B-05-04
-Includes readings from the last four quarters.

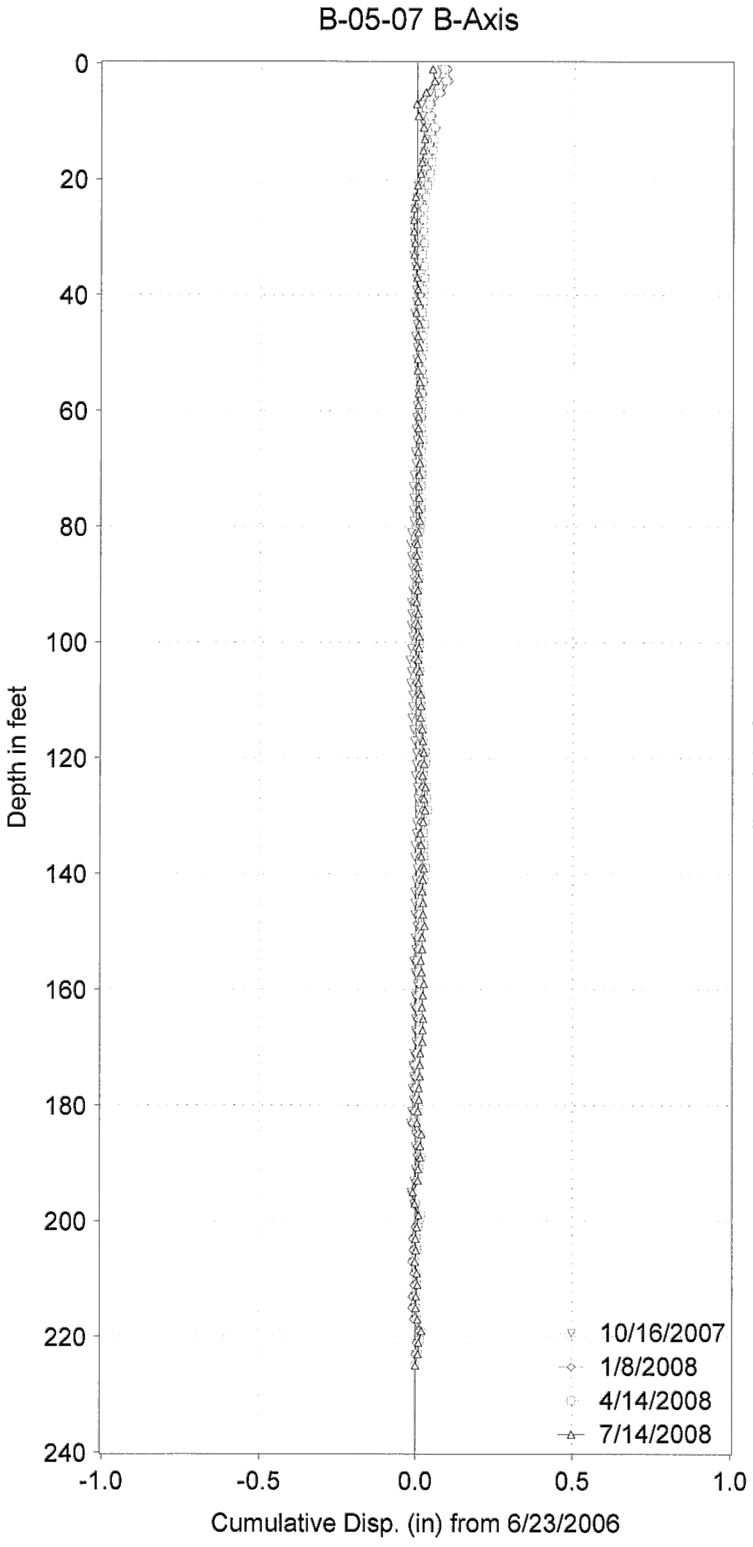
PLATE 35

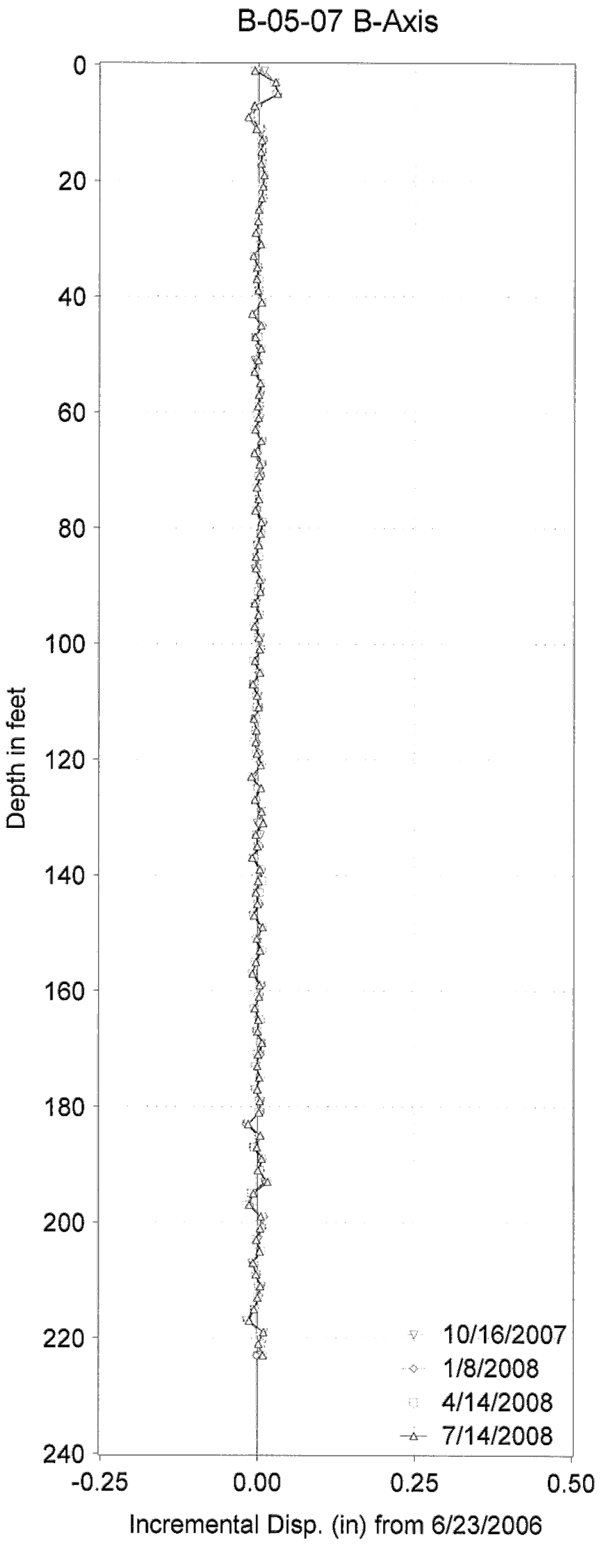




B-05-07
-Includes readings from the last four quarters.

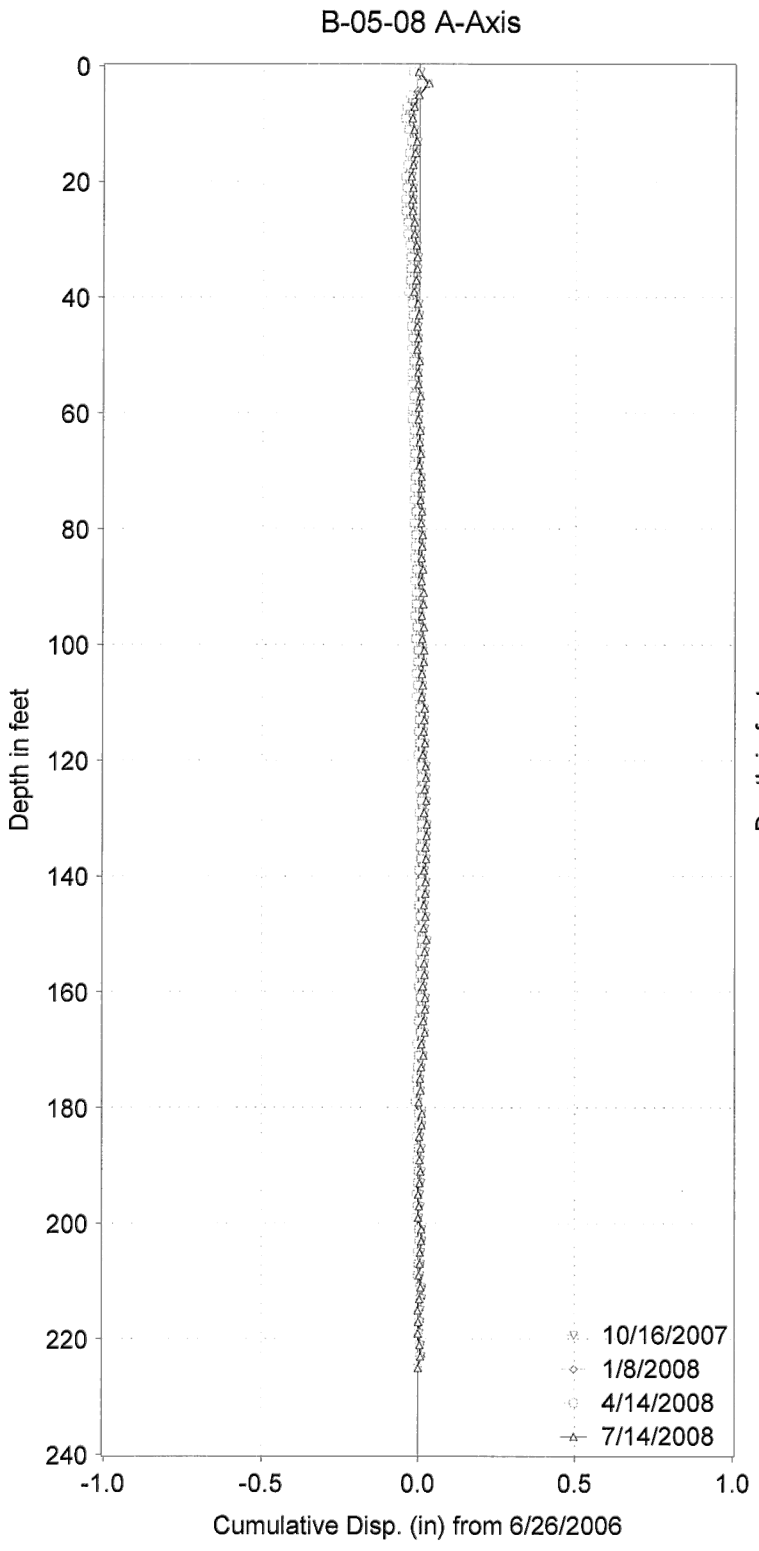
PLATE 36

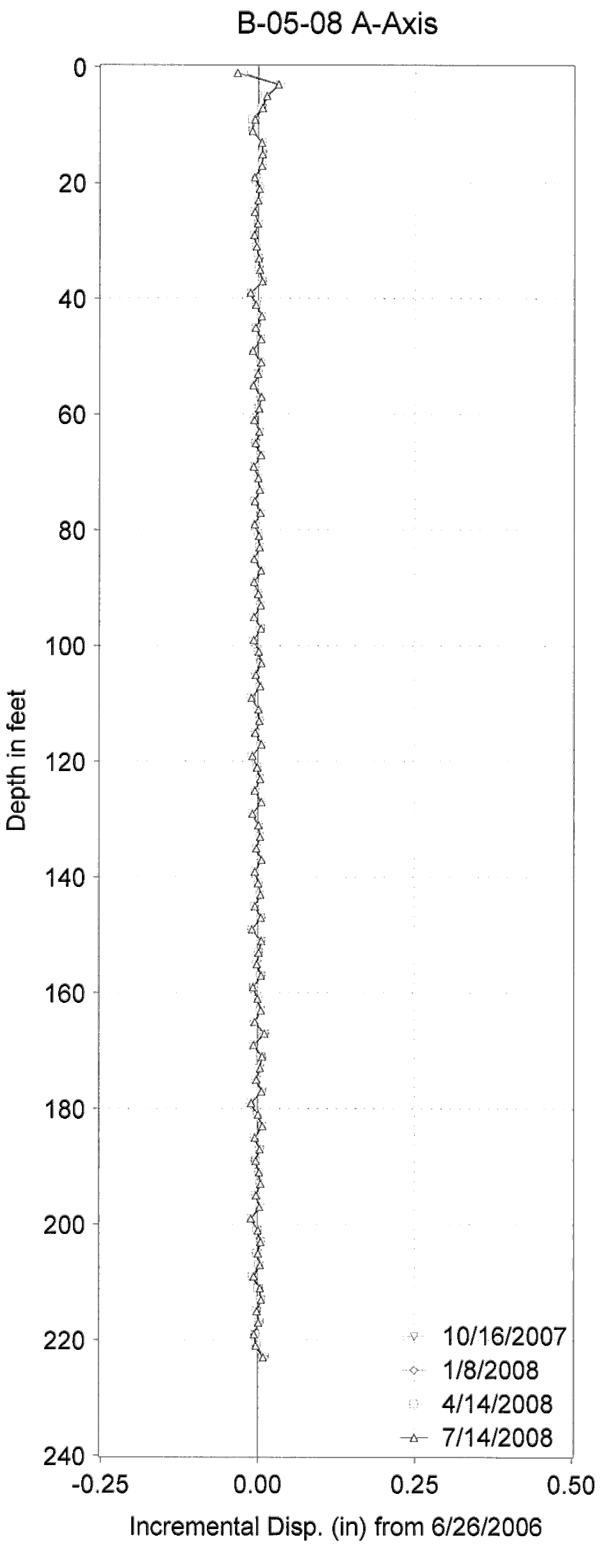




B-05-07
-Includes readings from the last four quarters.

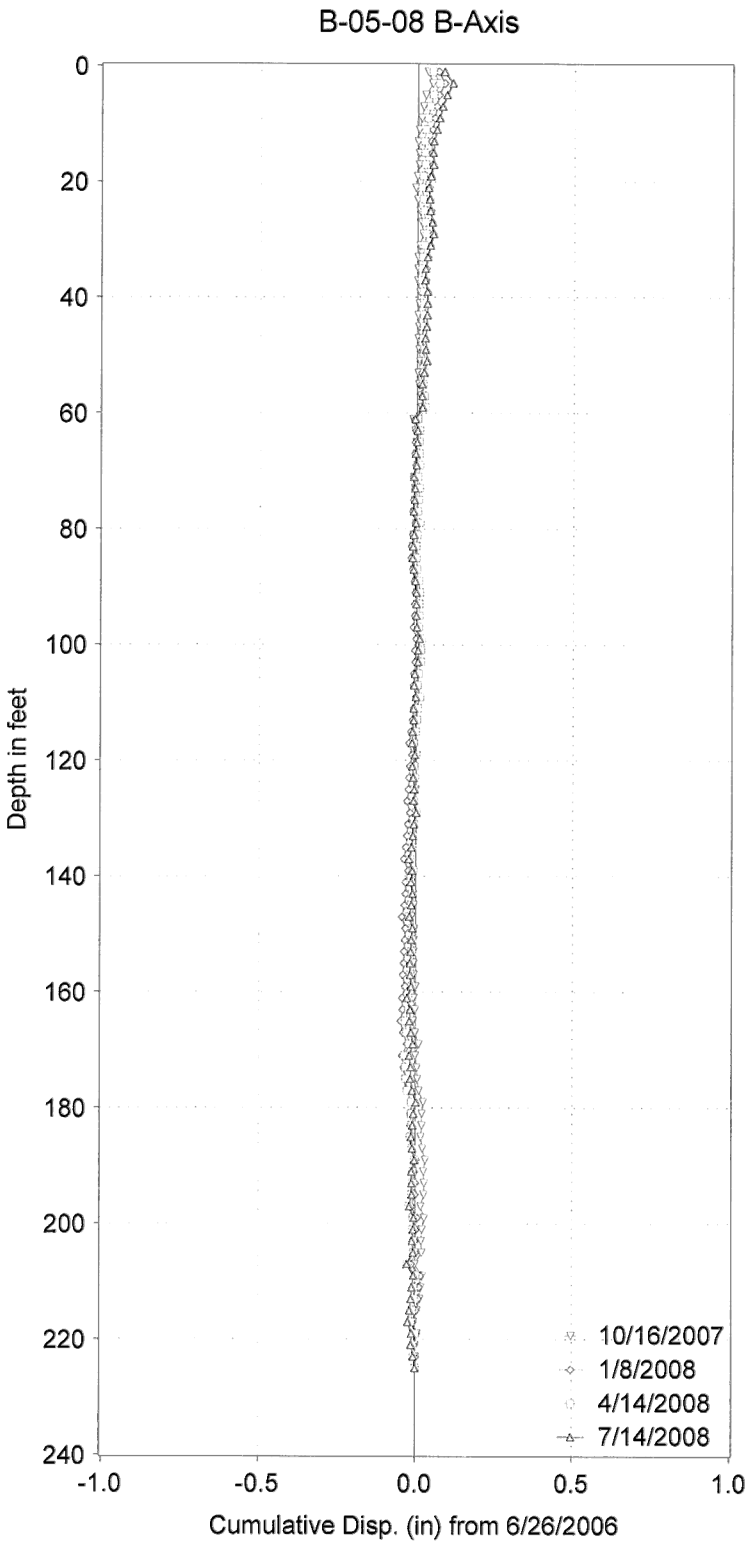
PLATE 37

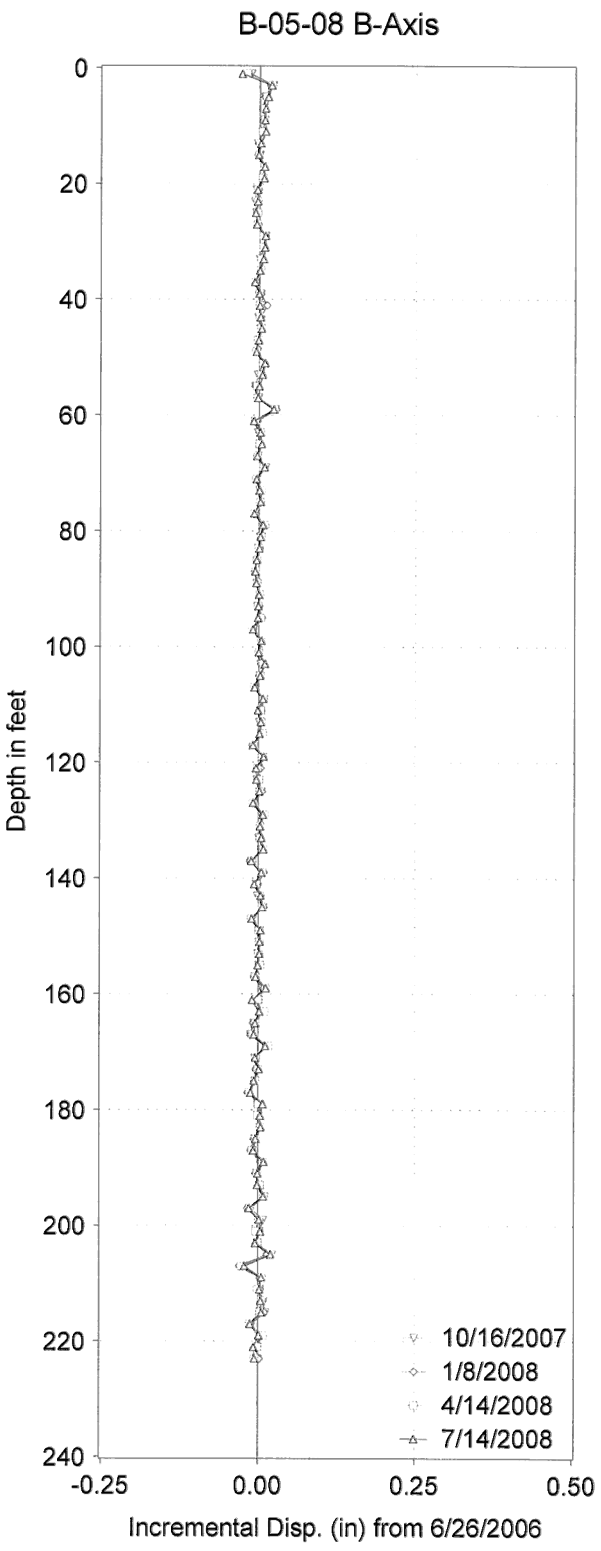




B-05-08
-Includes readings from the last four quarters.

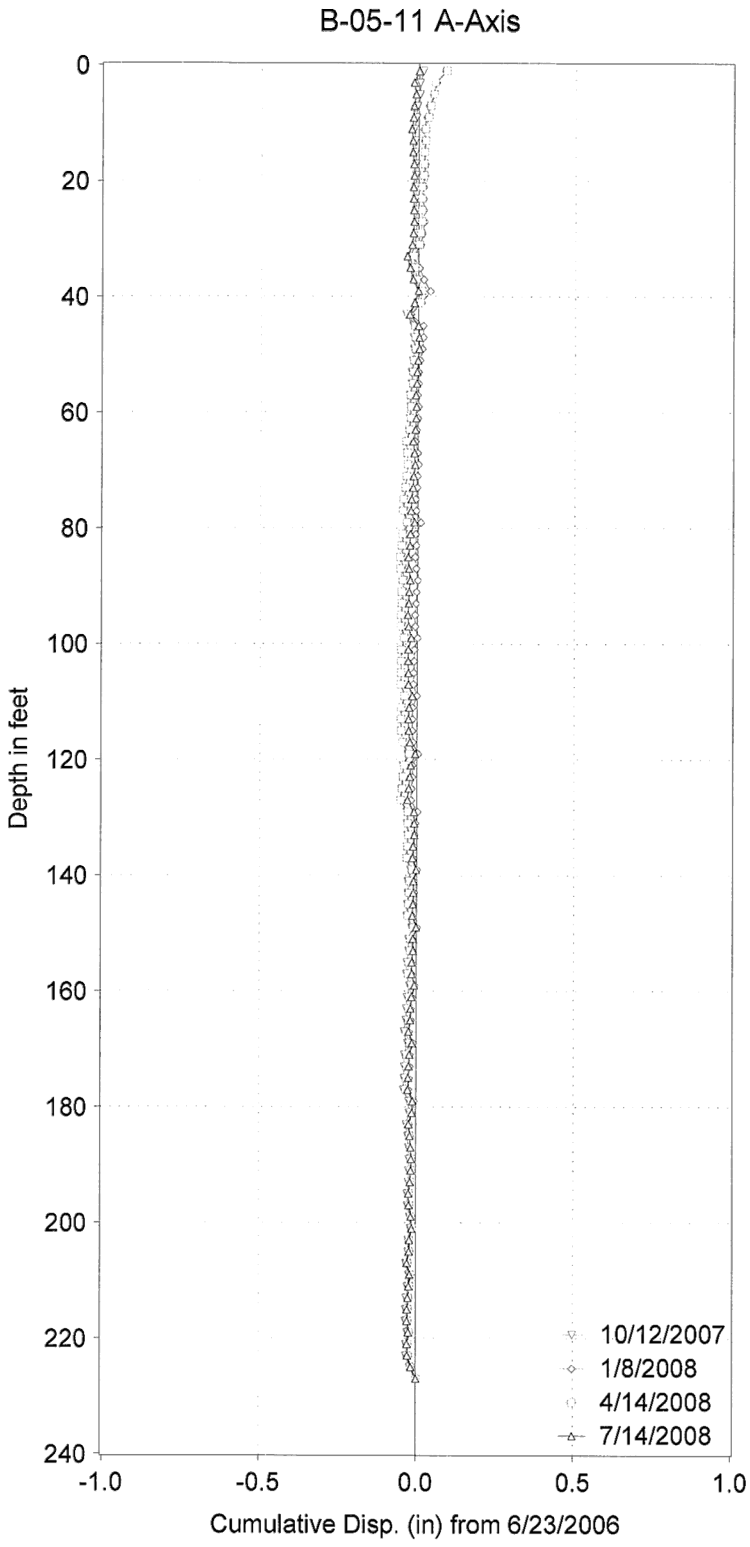
PLATE 38

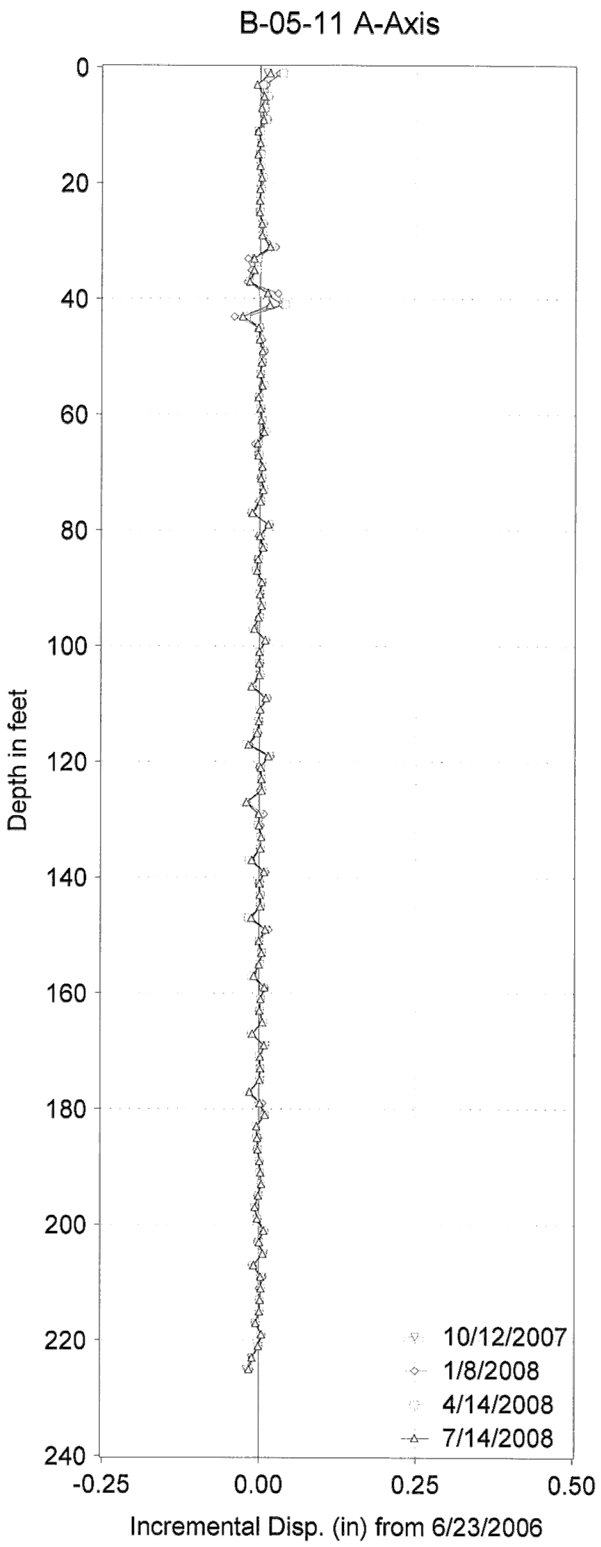




B-05-08
-Includes readings from the last four quarters.

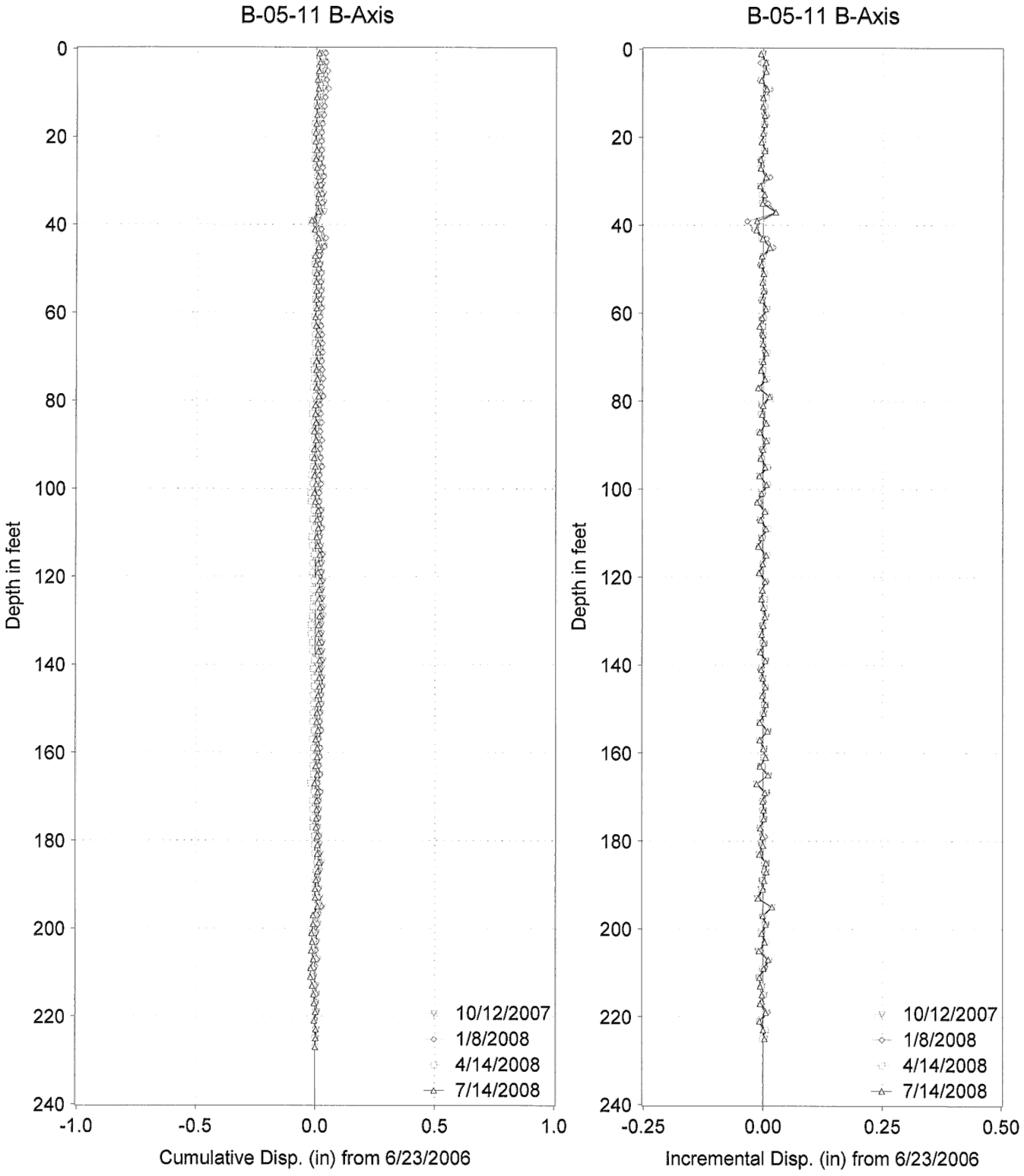
PLATE 39





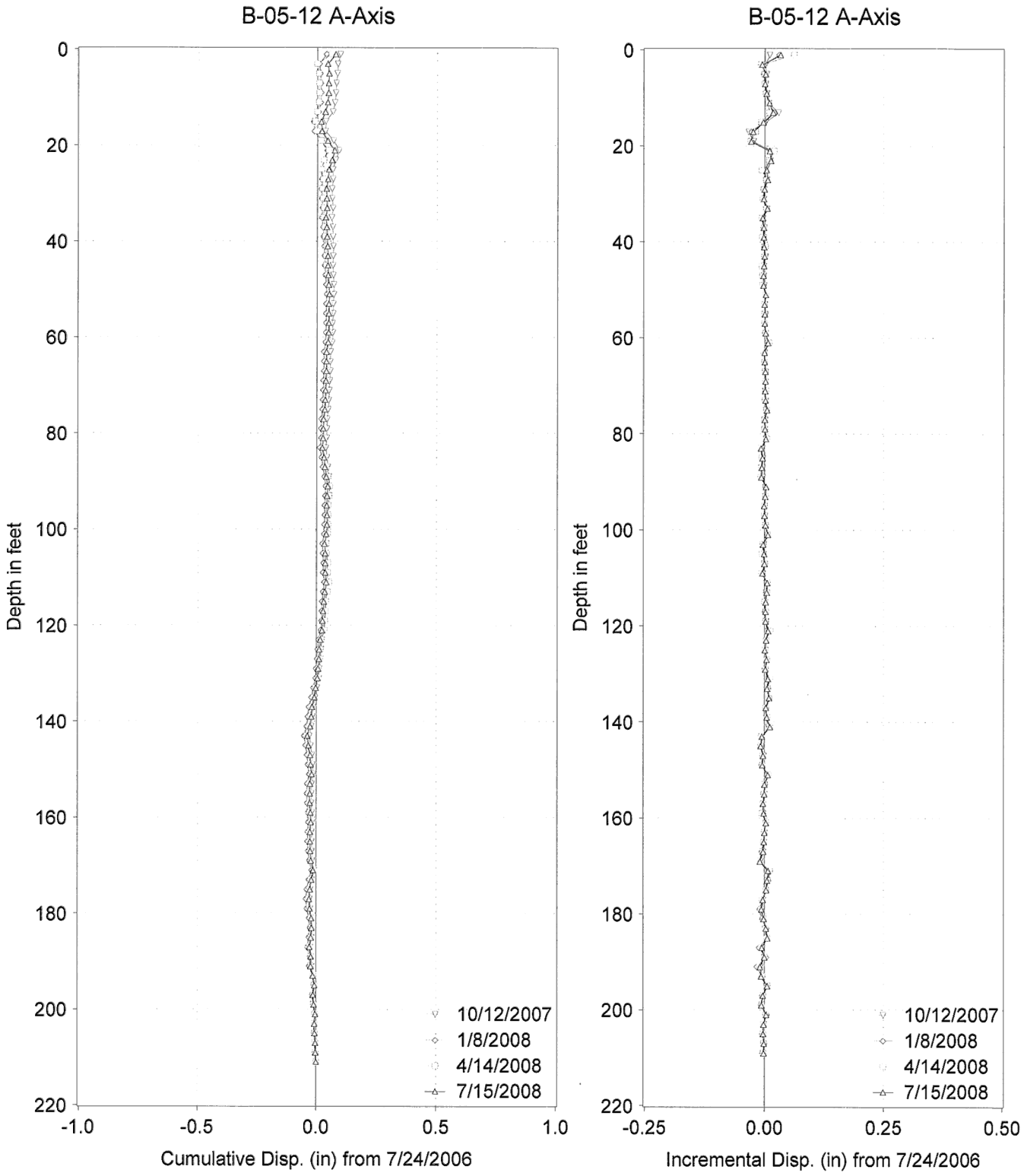
B-05-11
-Includes readings from the last four quarters.

PLATE 40



B-05-11
-Includes readings from the last four quarters.

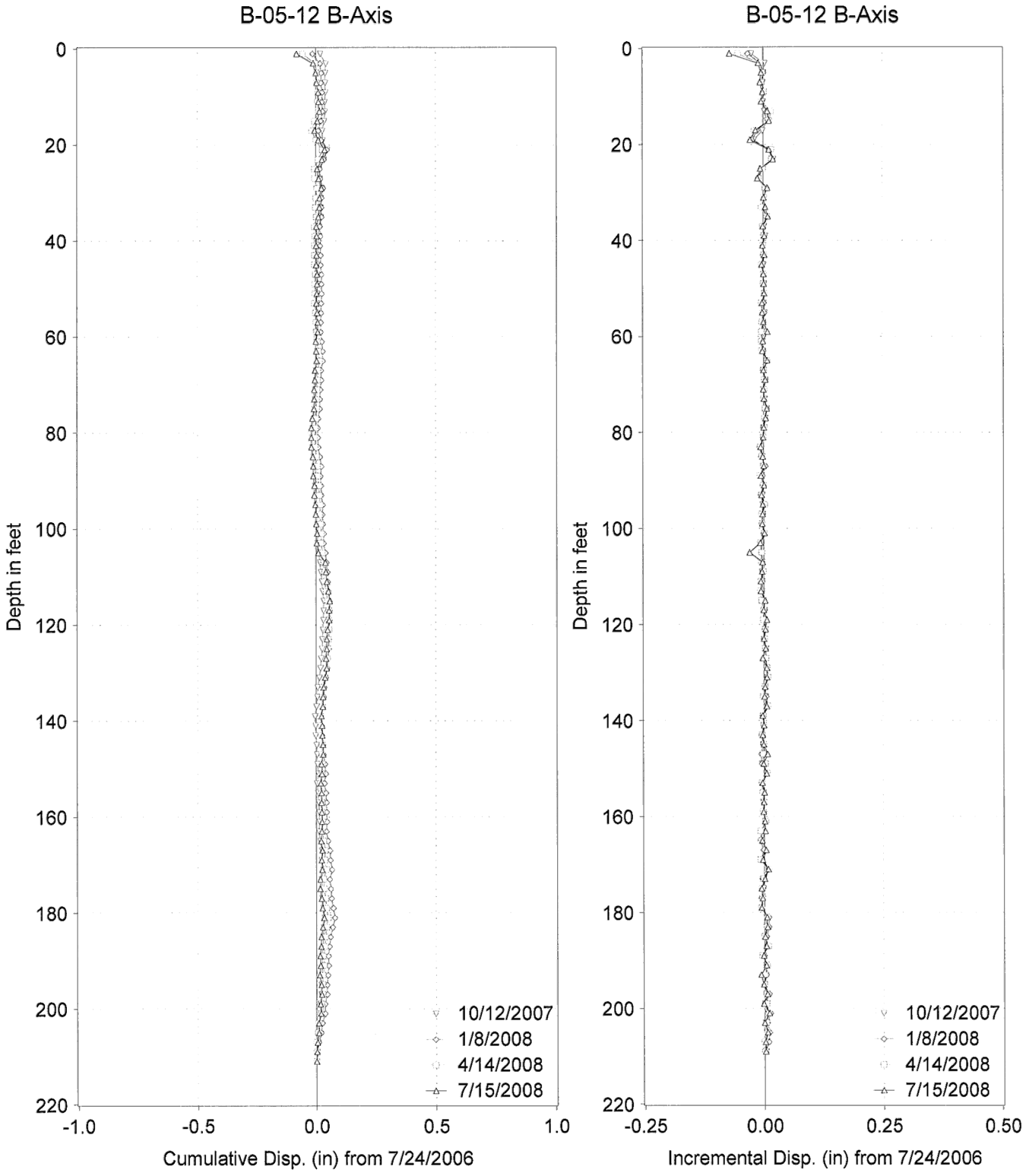
PLATE 41



B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

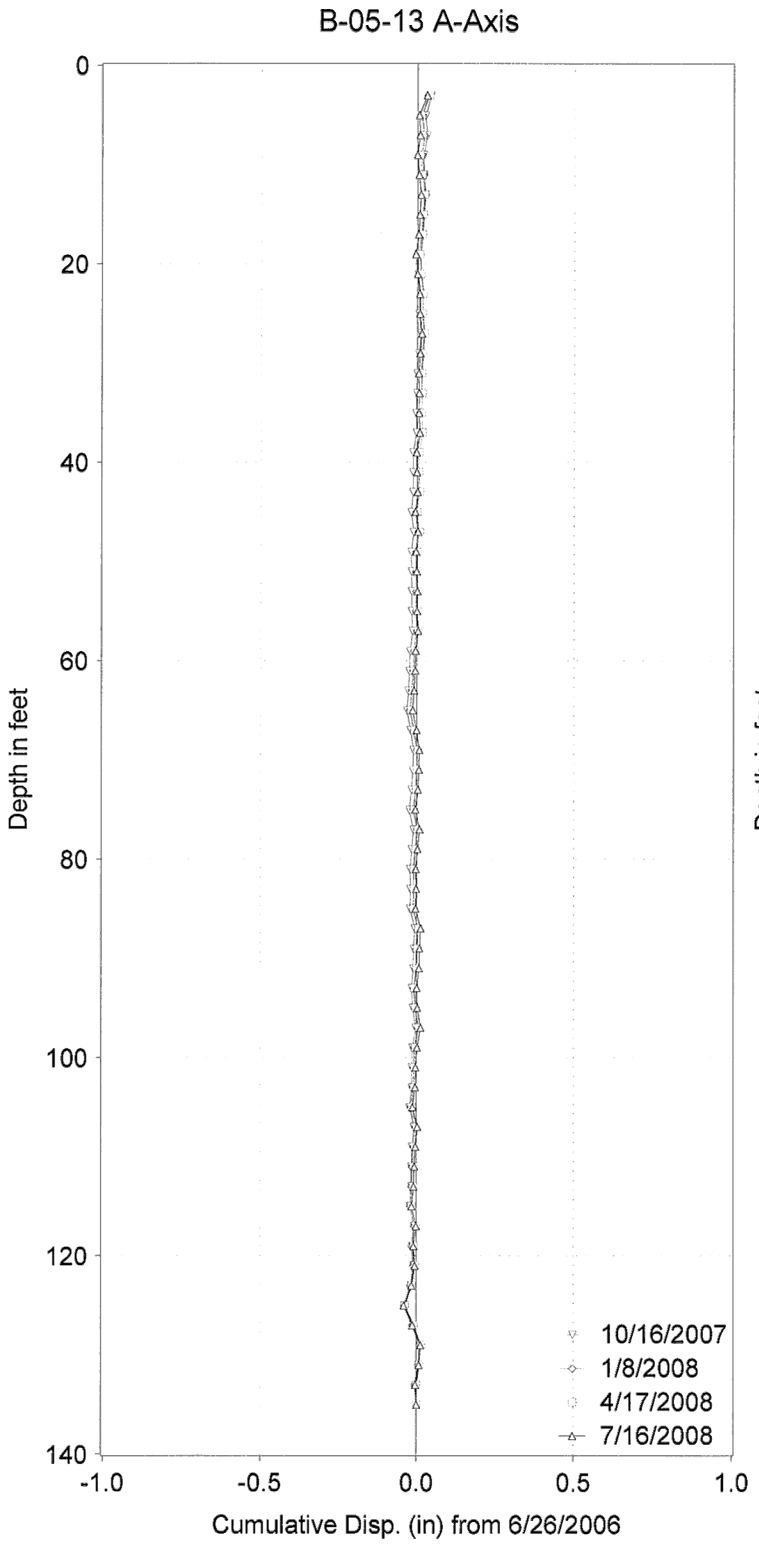
PLATE 42

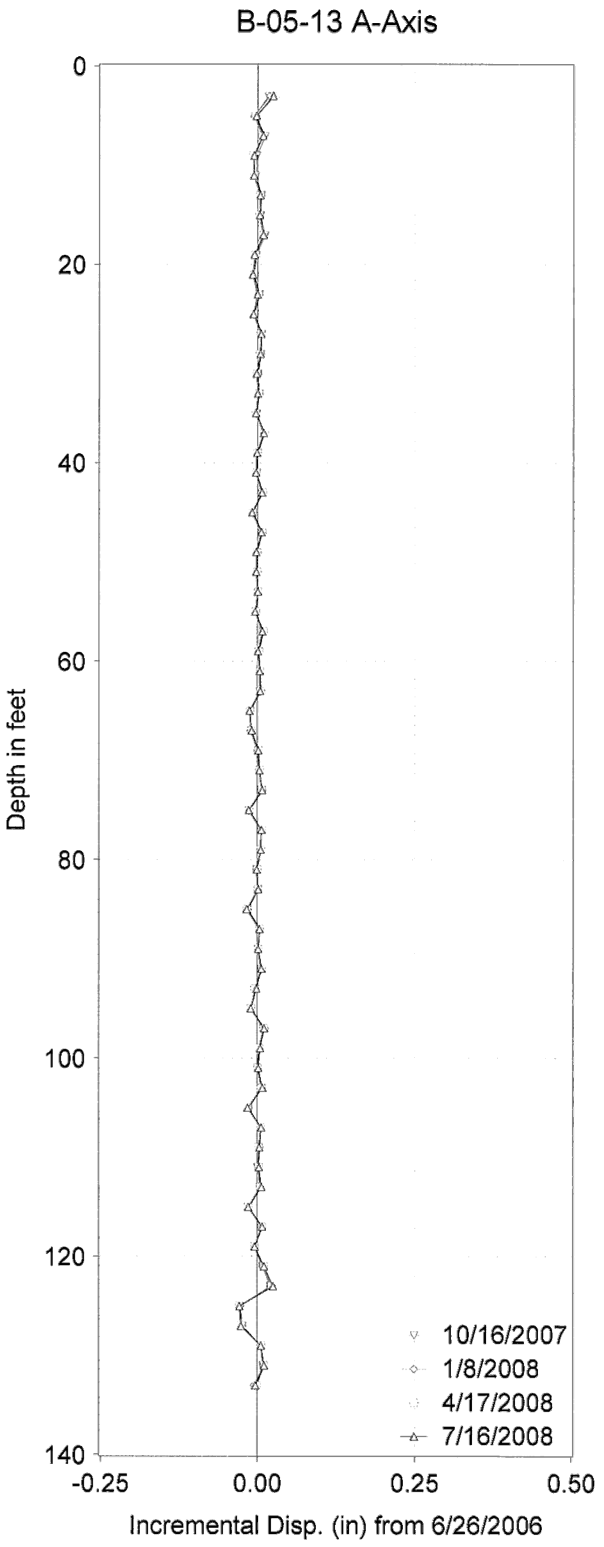


B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

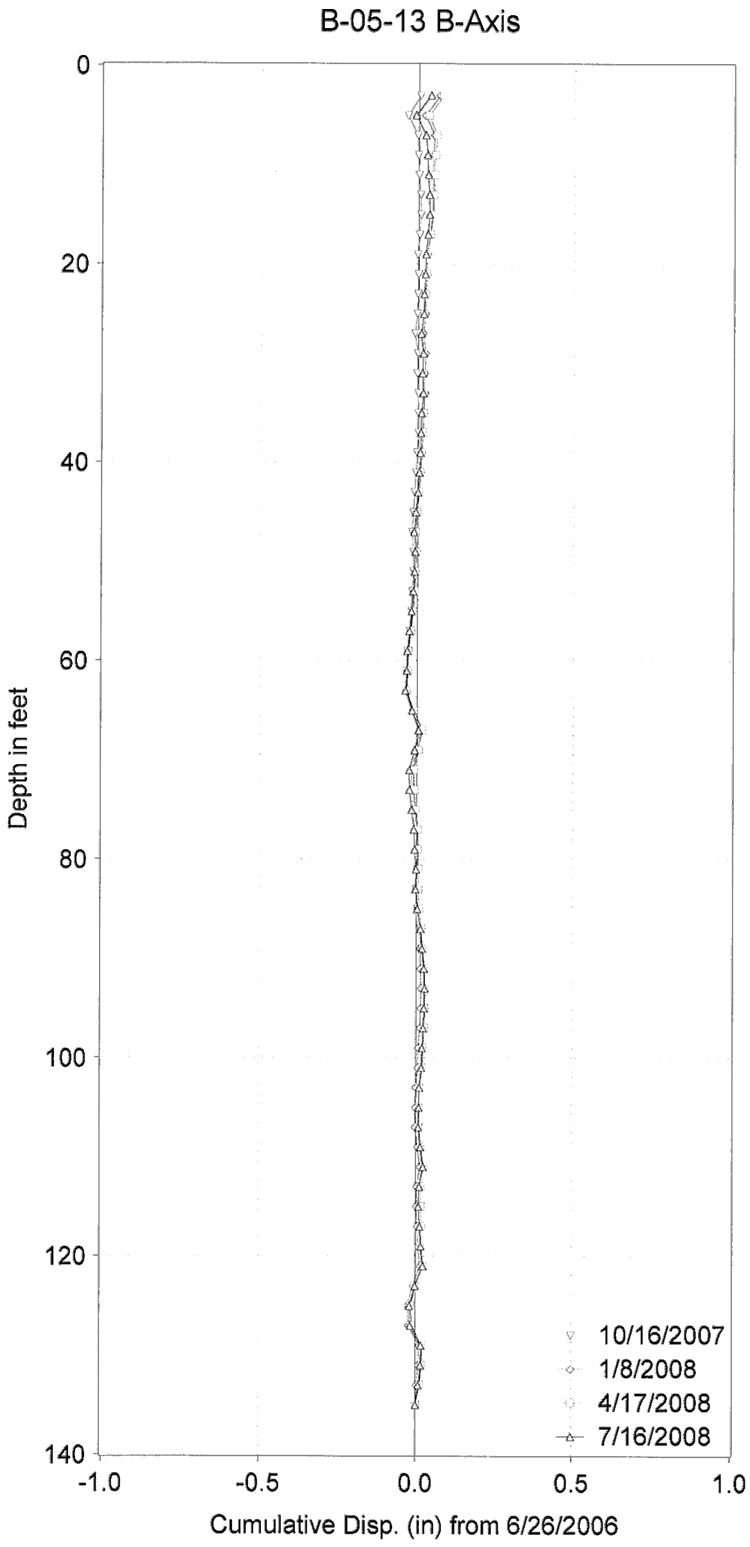
PLATE 43

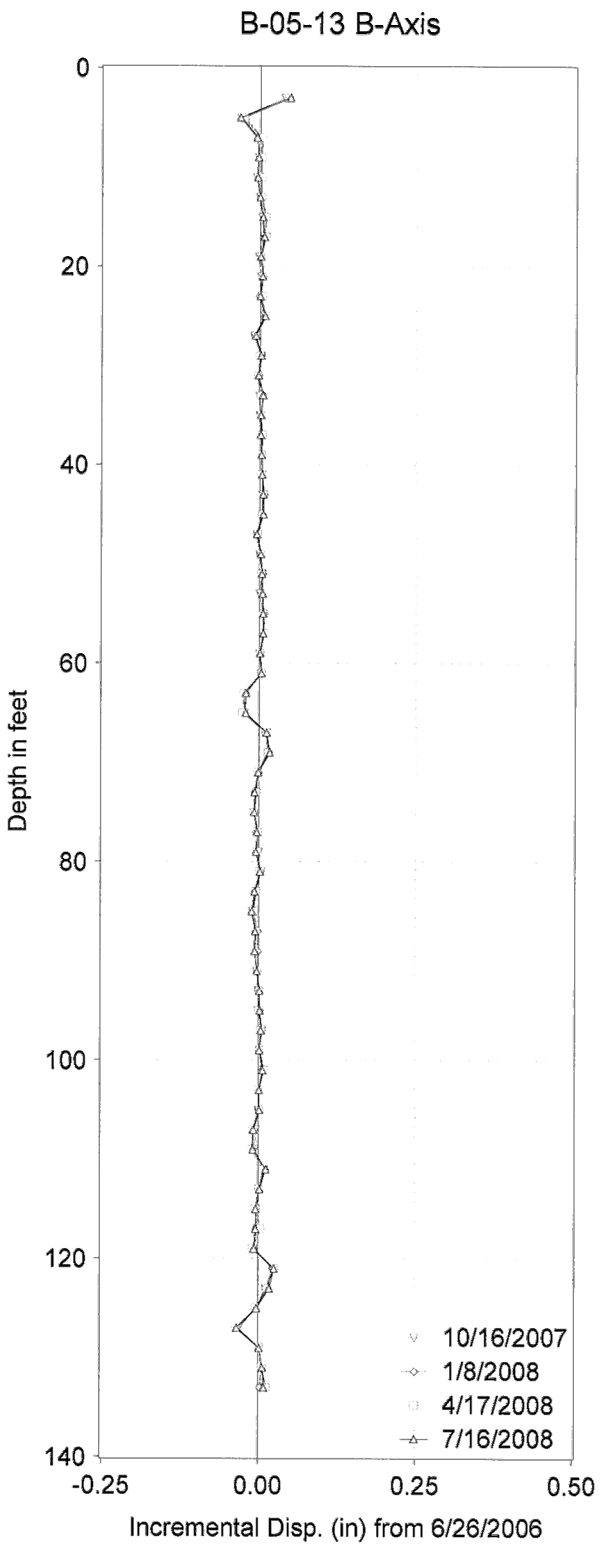




B-05-13
-Includes readings from the last four quarters.

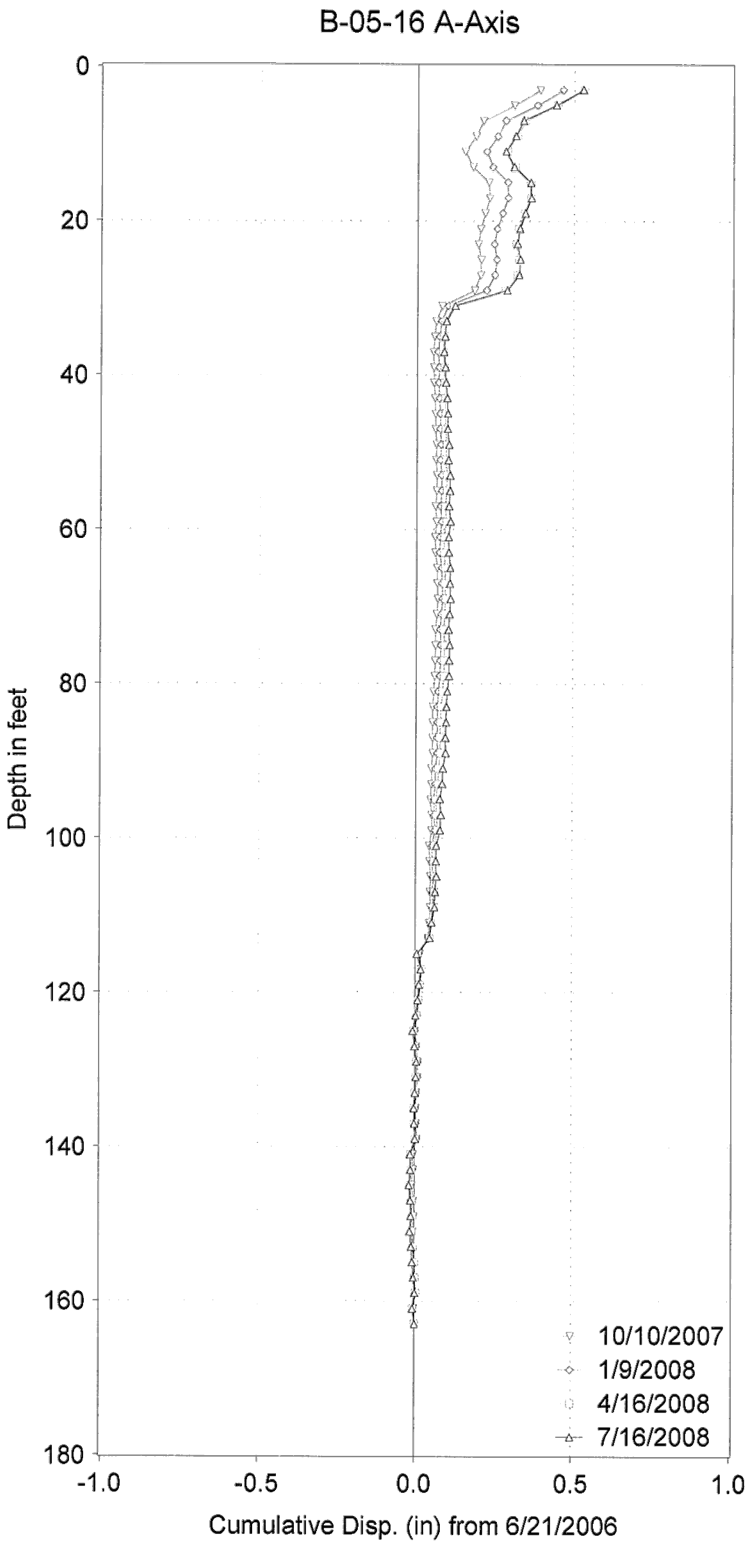
PLATE 44

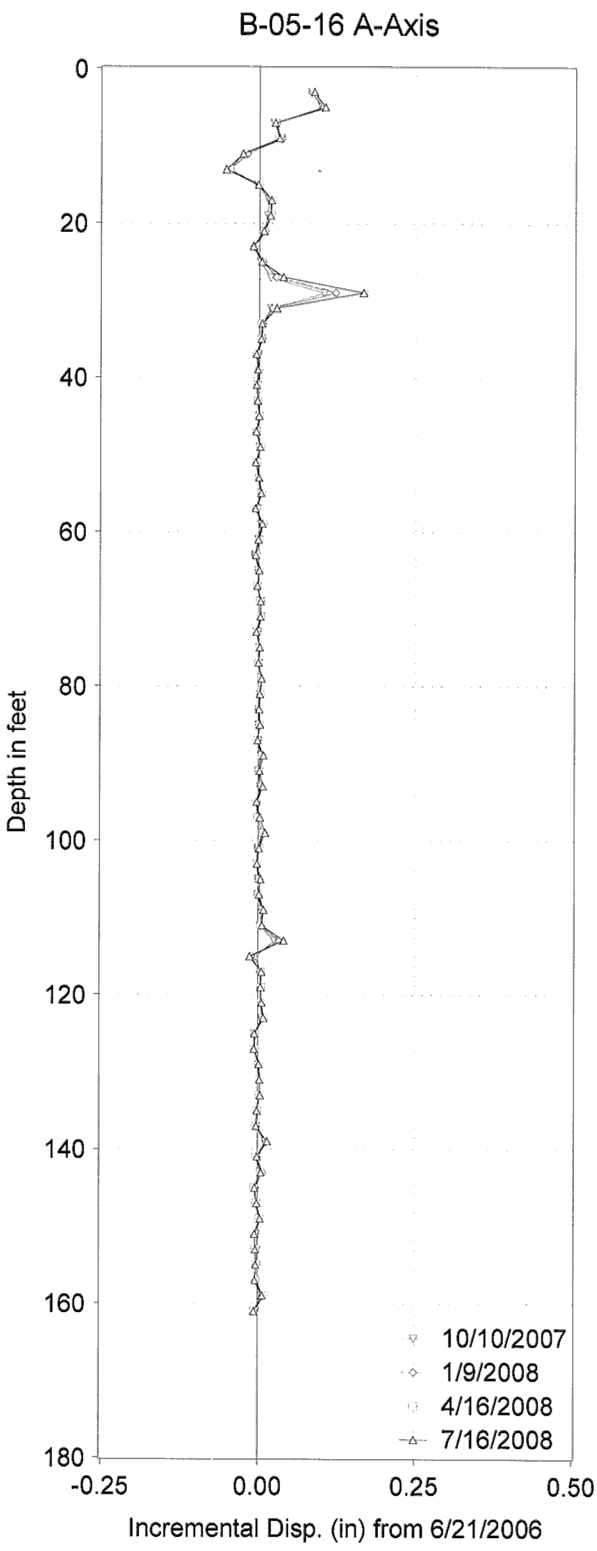




B-05-13
-Includes readings from the last four quarters.

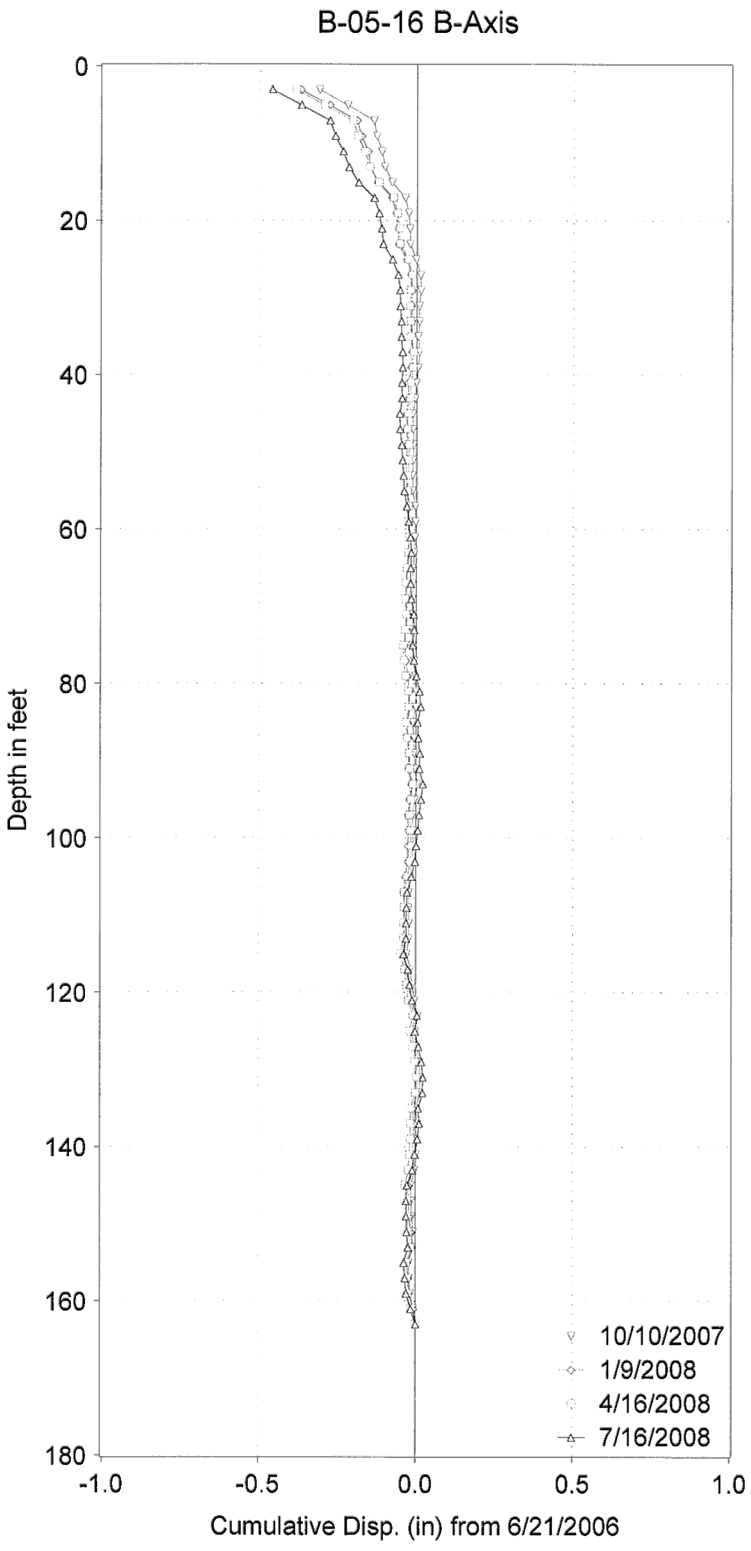
PLATE 45

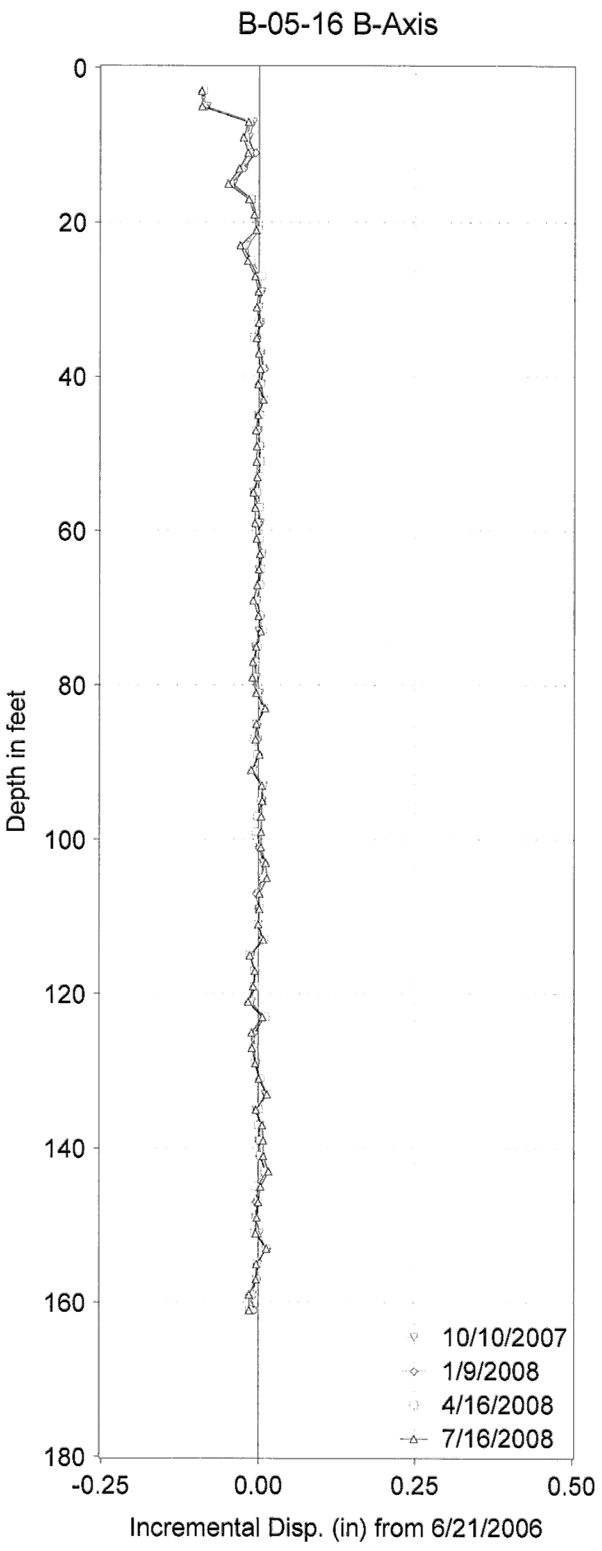




B-05-16
-Includes readings from the last four quarters.

PLATE 46





B-05-16
-Includes readings from the last four quarters.

PLATE 47

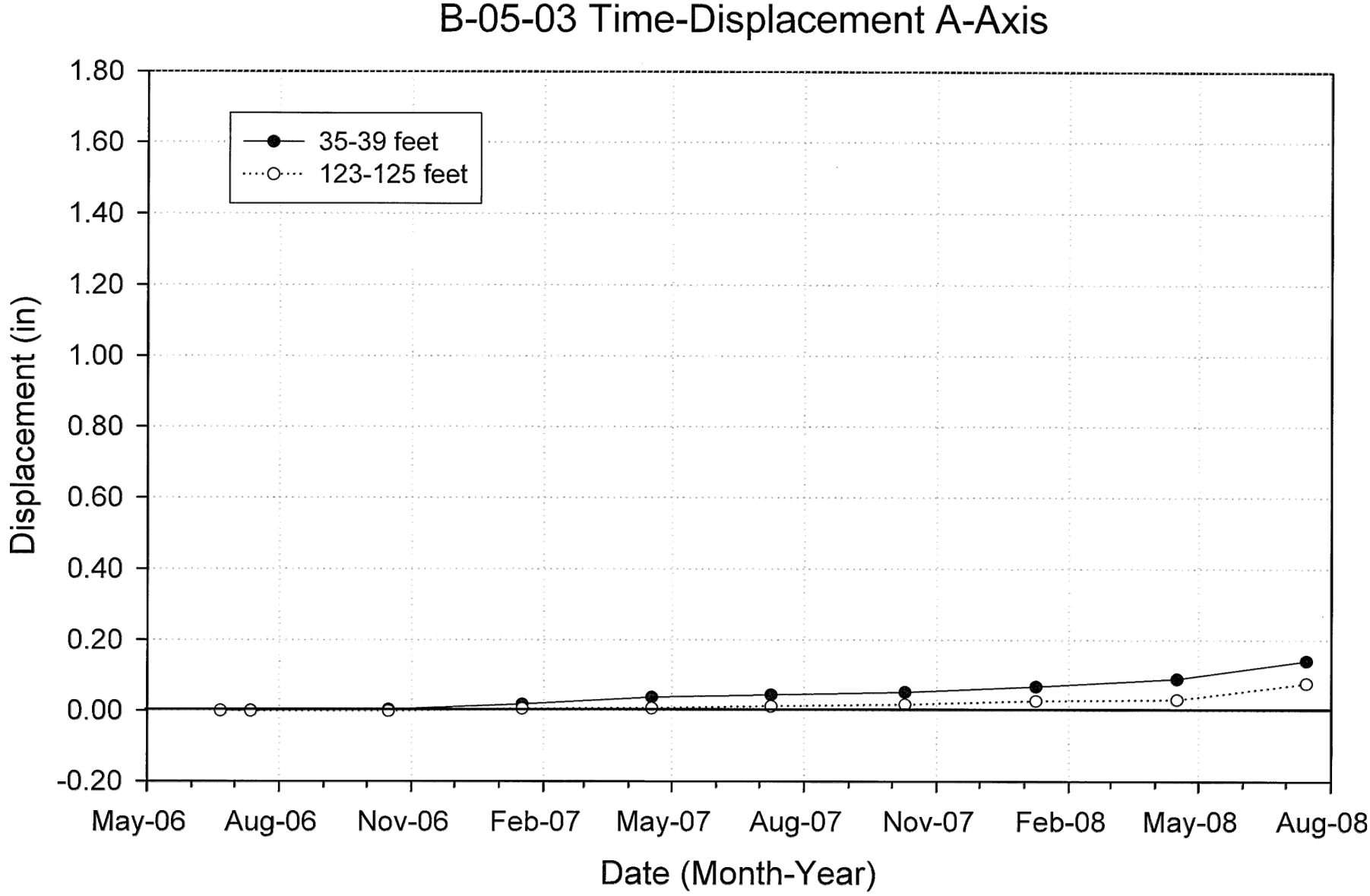

B-05-03 Time-Displacement A-Axis
35-39 feet
123-125 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Aug-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
May-08
Aug-08
Date (Month-Year)

PLATE 48

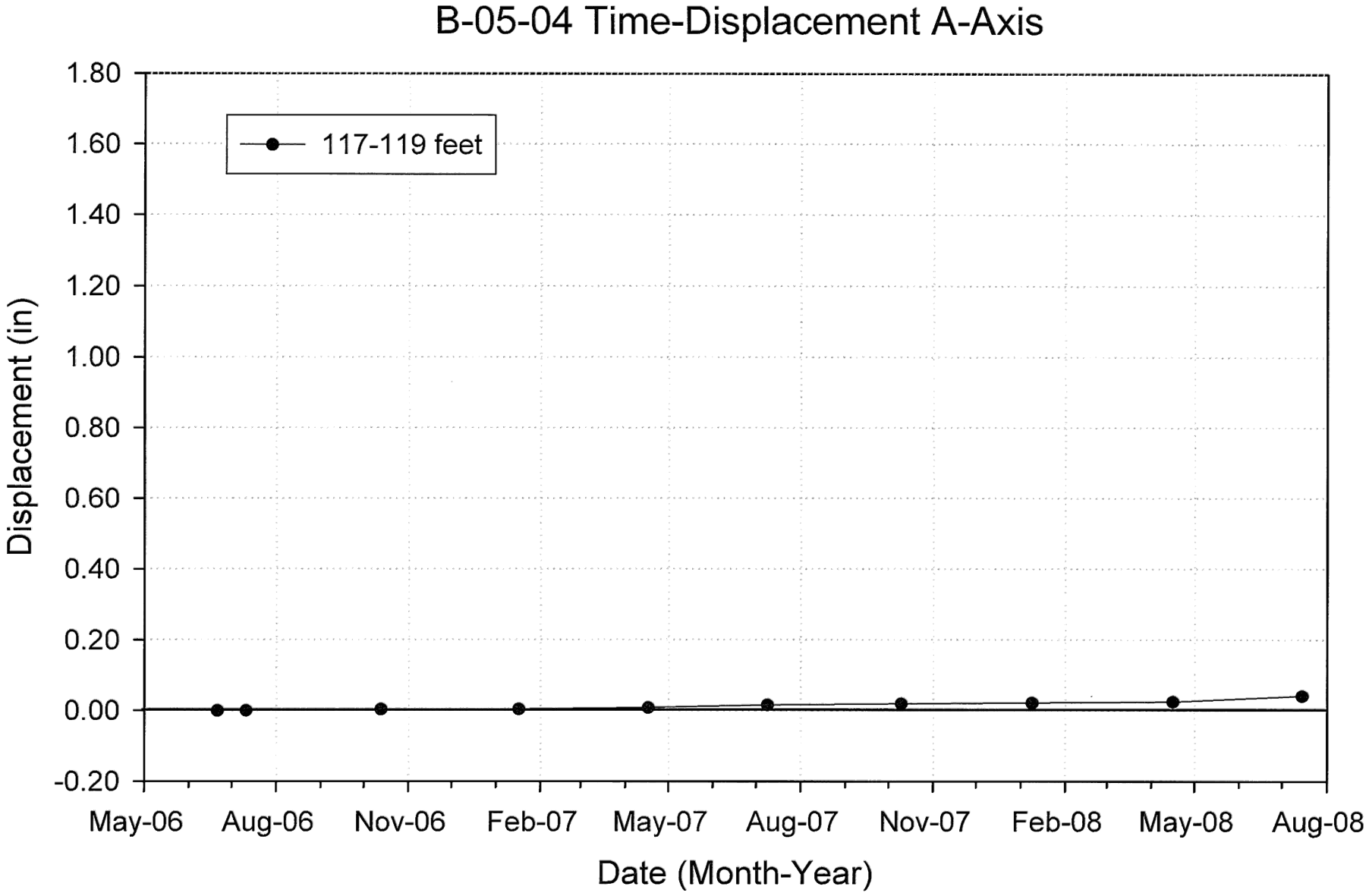

B-05-04 Time-Displacement A-Axis
117-119 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Aug-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
May-08
Aug-08
Date (Month-Year)

PLATE 49

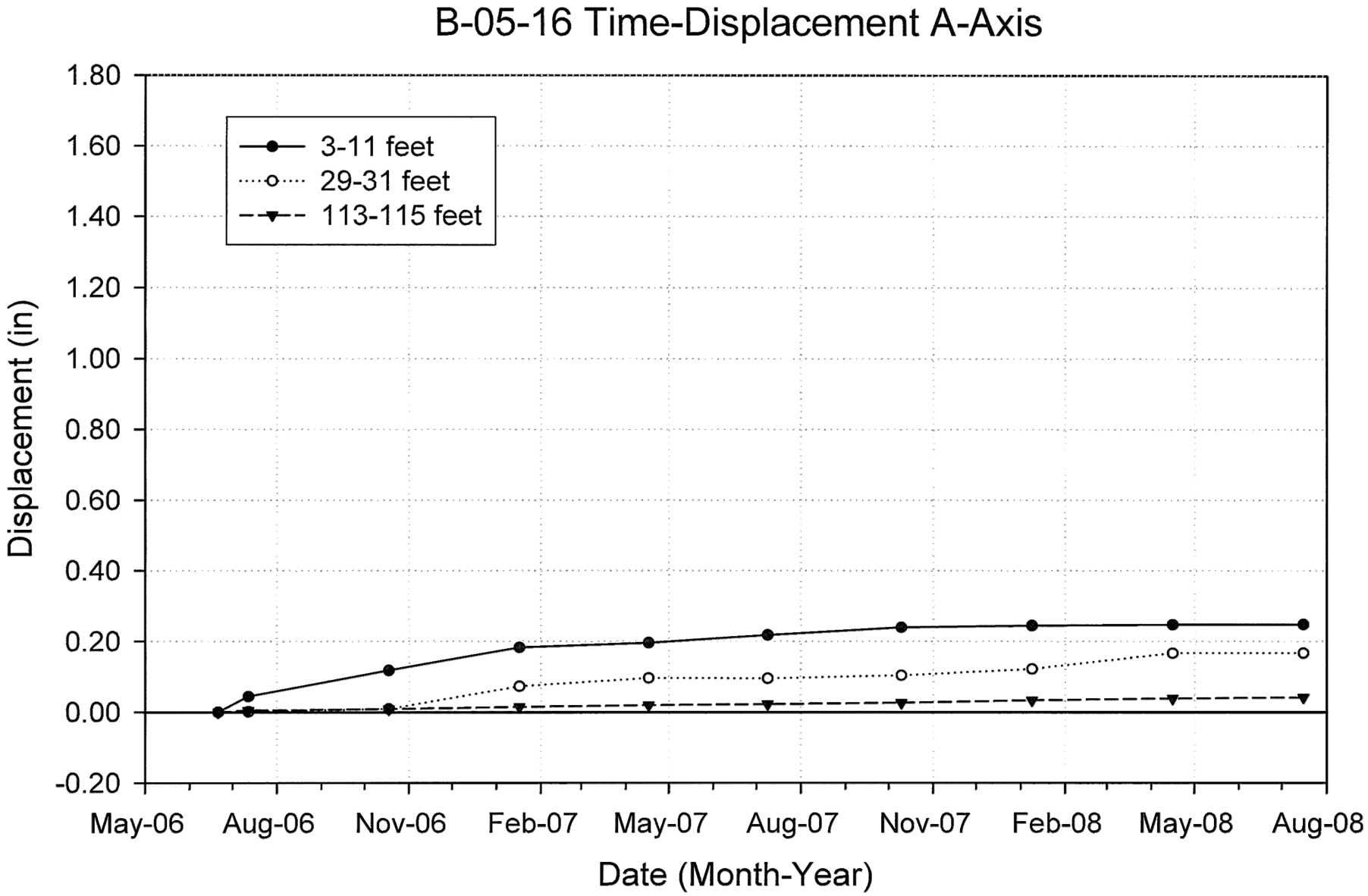

B-05-16 Time-Displacement A-Axis
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Displacement (in)
3-11 feet
29-31 feet
113-115 feet
May-06
Aug-06
Nov-06
Feb-07
May-07
Aug-07
Nov-07
Feb-08
May-08
Aug-08
Date (Month-Year)

PLATE 50

B-101 (P-1) Pneumatic Piezometer Readings

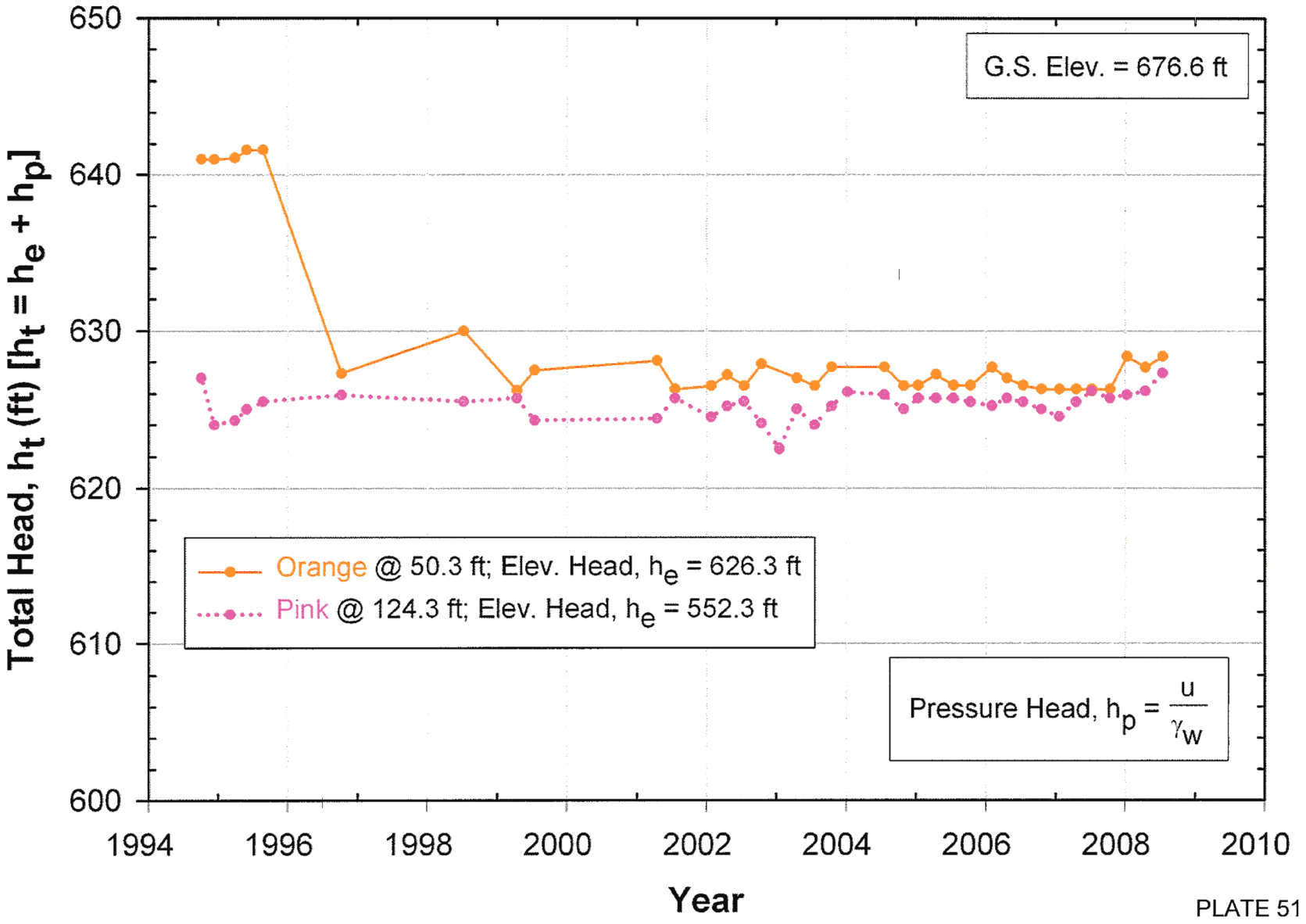


PLATE 51

B-105 (P-3) Pneumatic Piezometer Readings

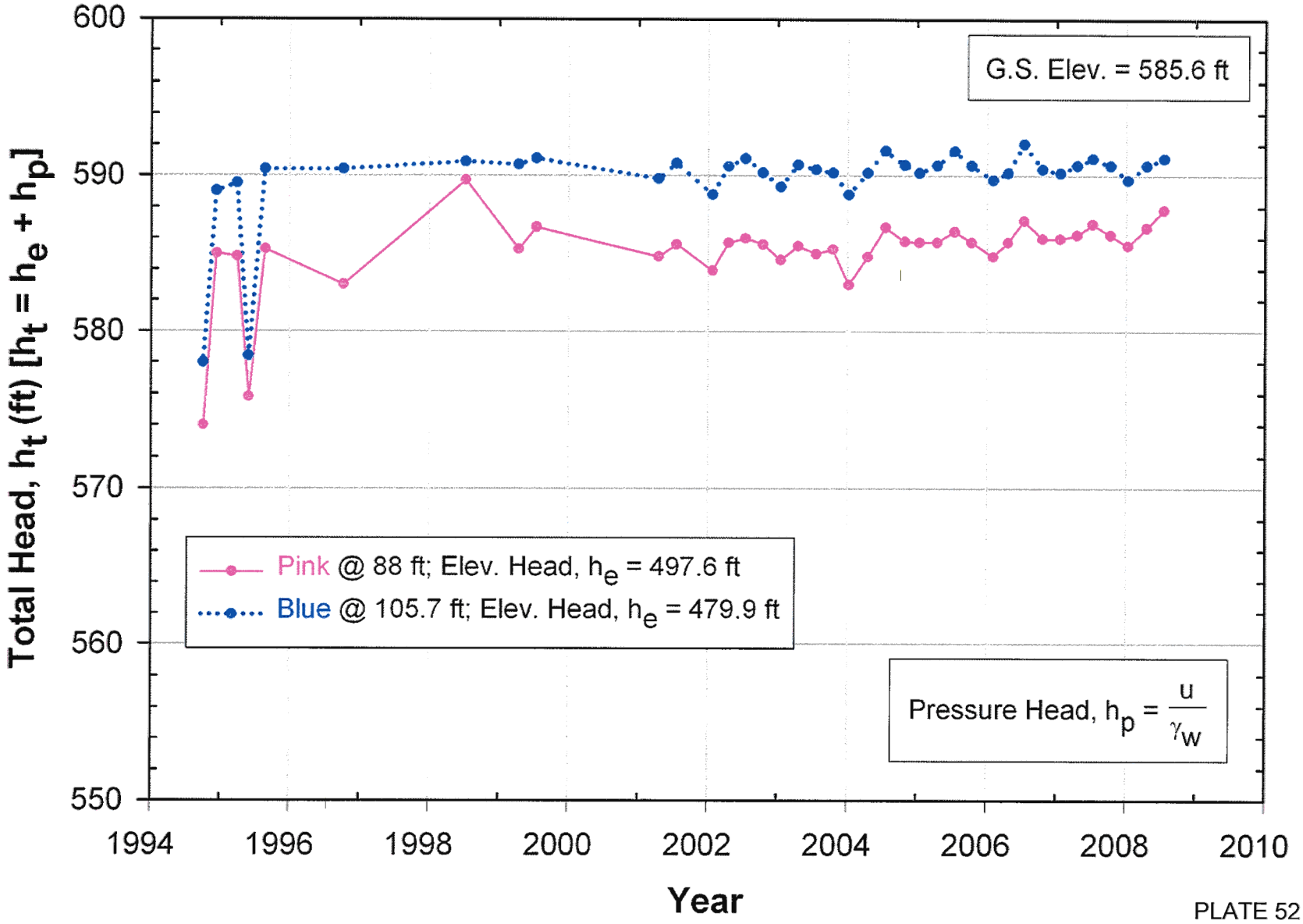


PLATE 52

B-107 (P-5) Pneumatic Piezometer Readings

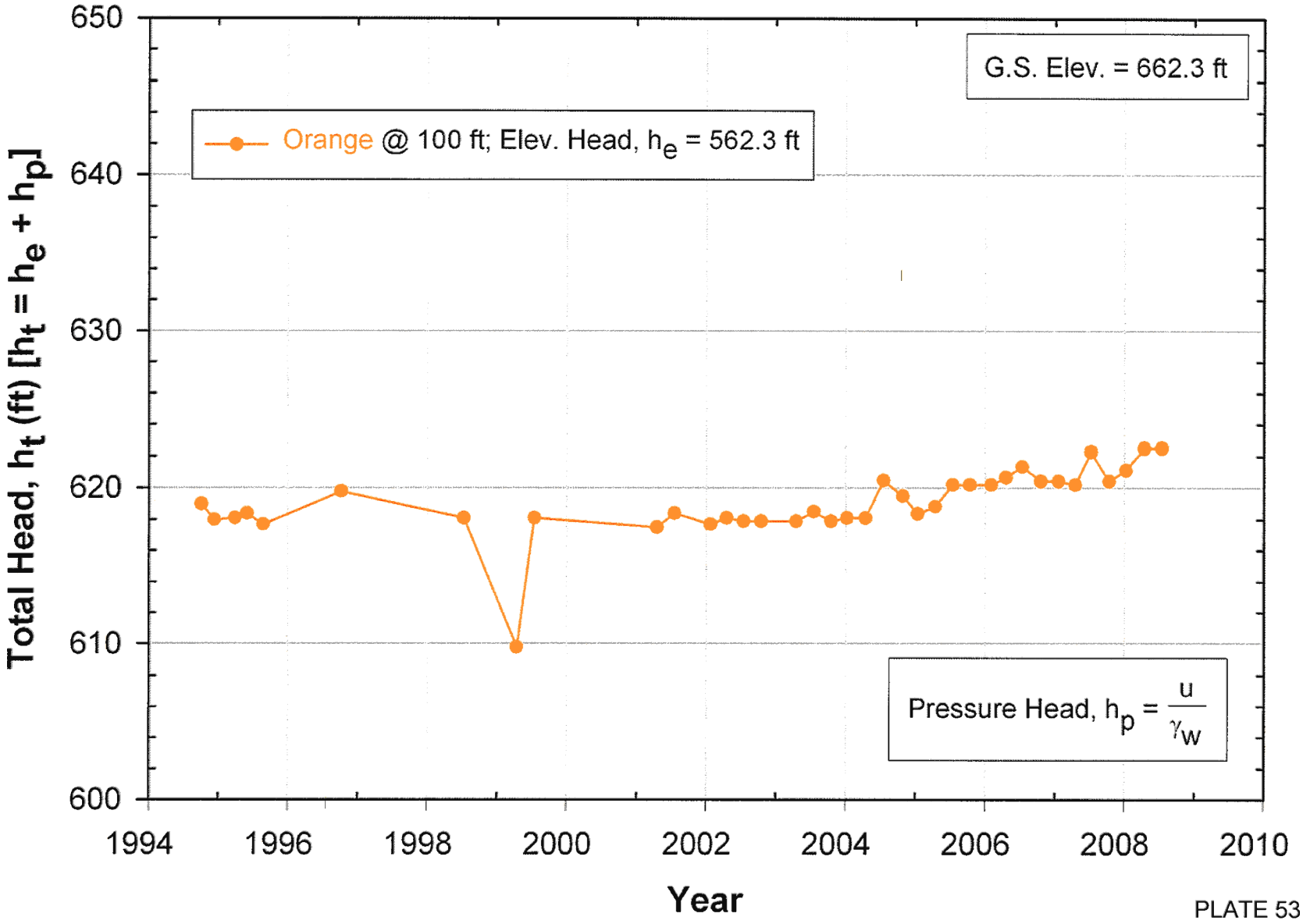


PLATE 53

B-303 (P-2) Pneumatic Piezometer Readings

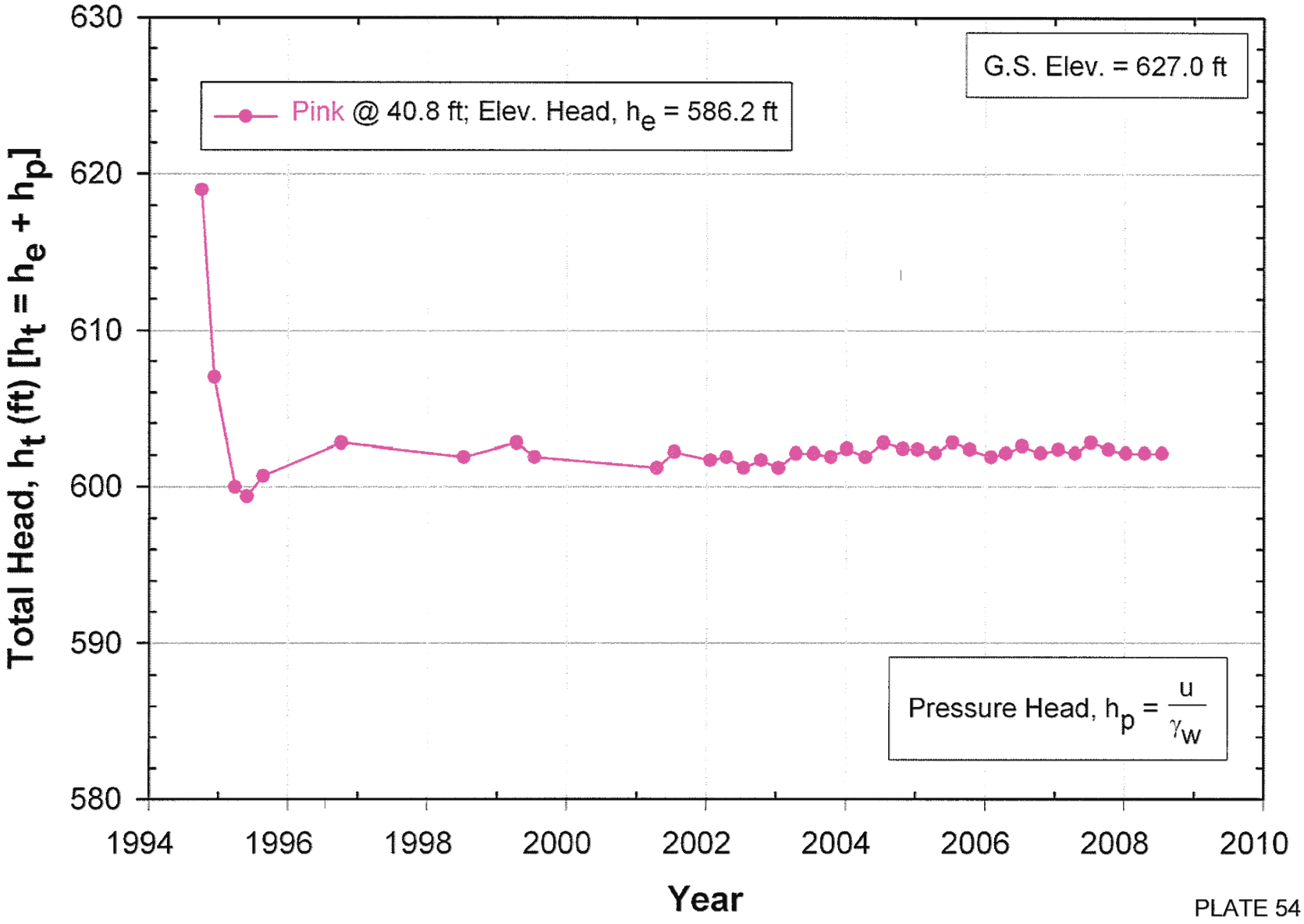


PLATE 54

B-05-01 VW Piezometer Readings

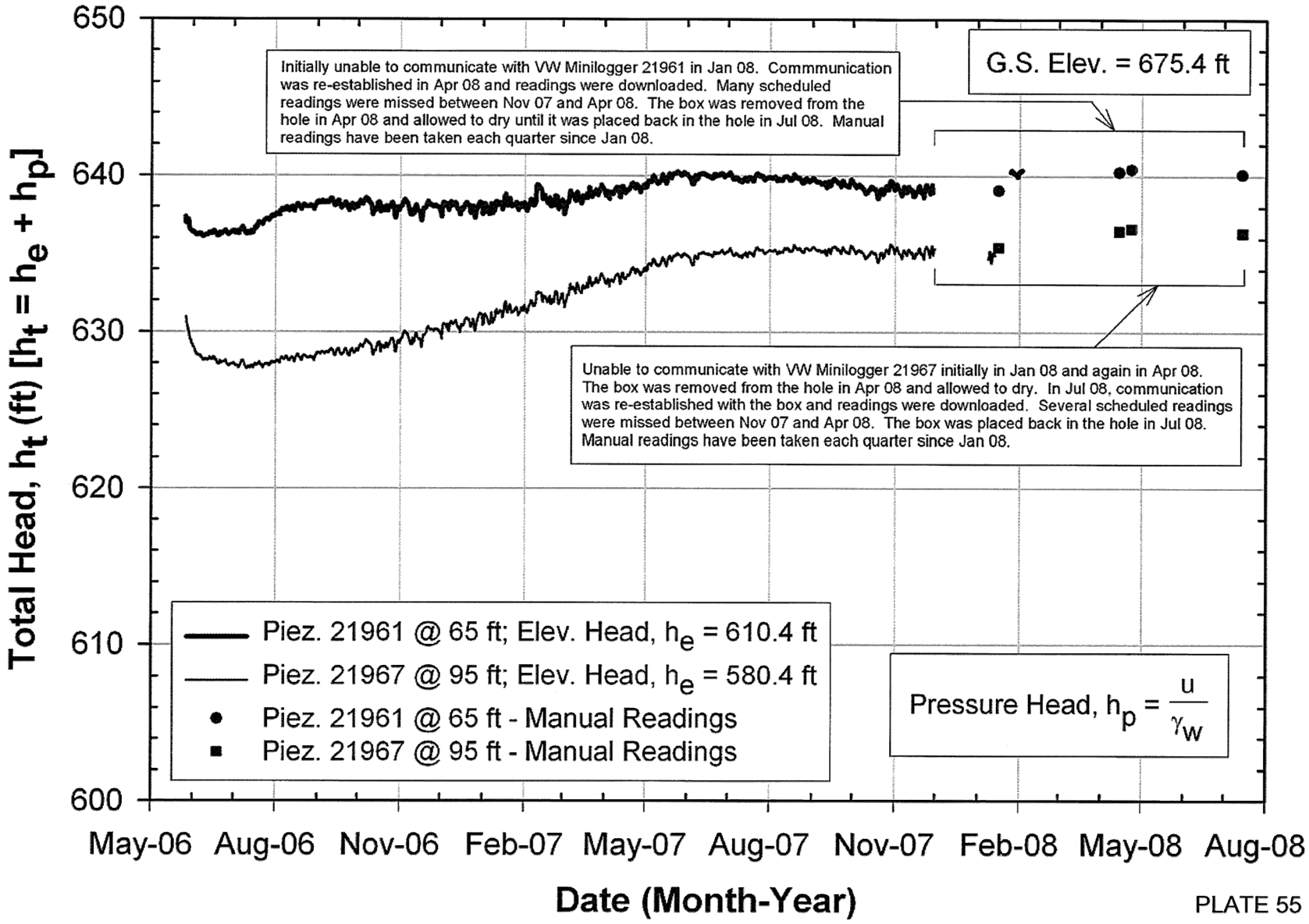


PLATE 55

B-05-02 VW Piezometer Readings

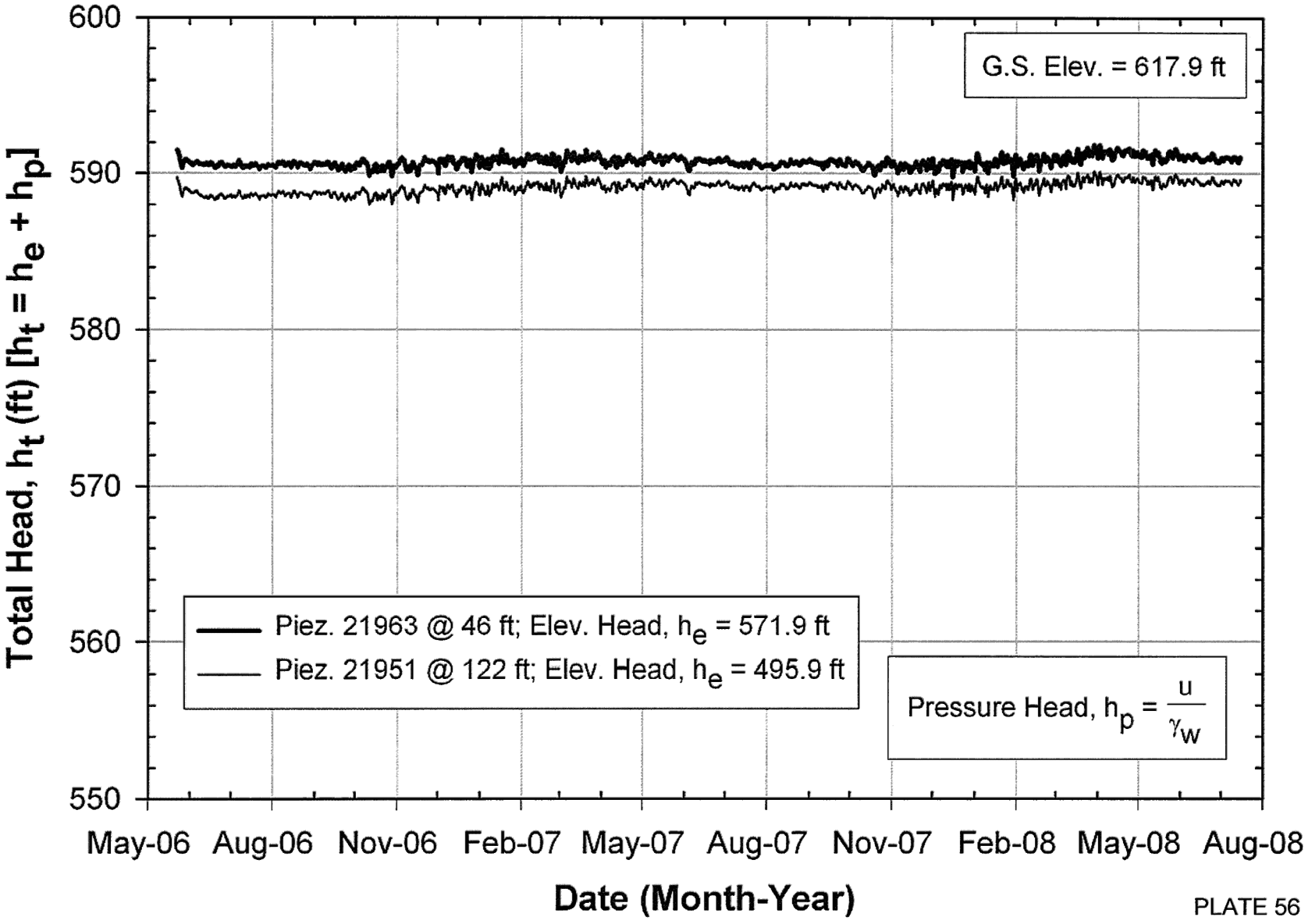


PLATE 56

B-05-03 VW Piezometer Readings

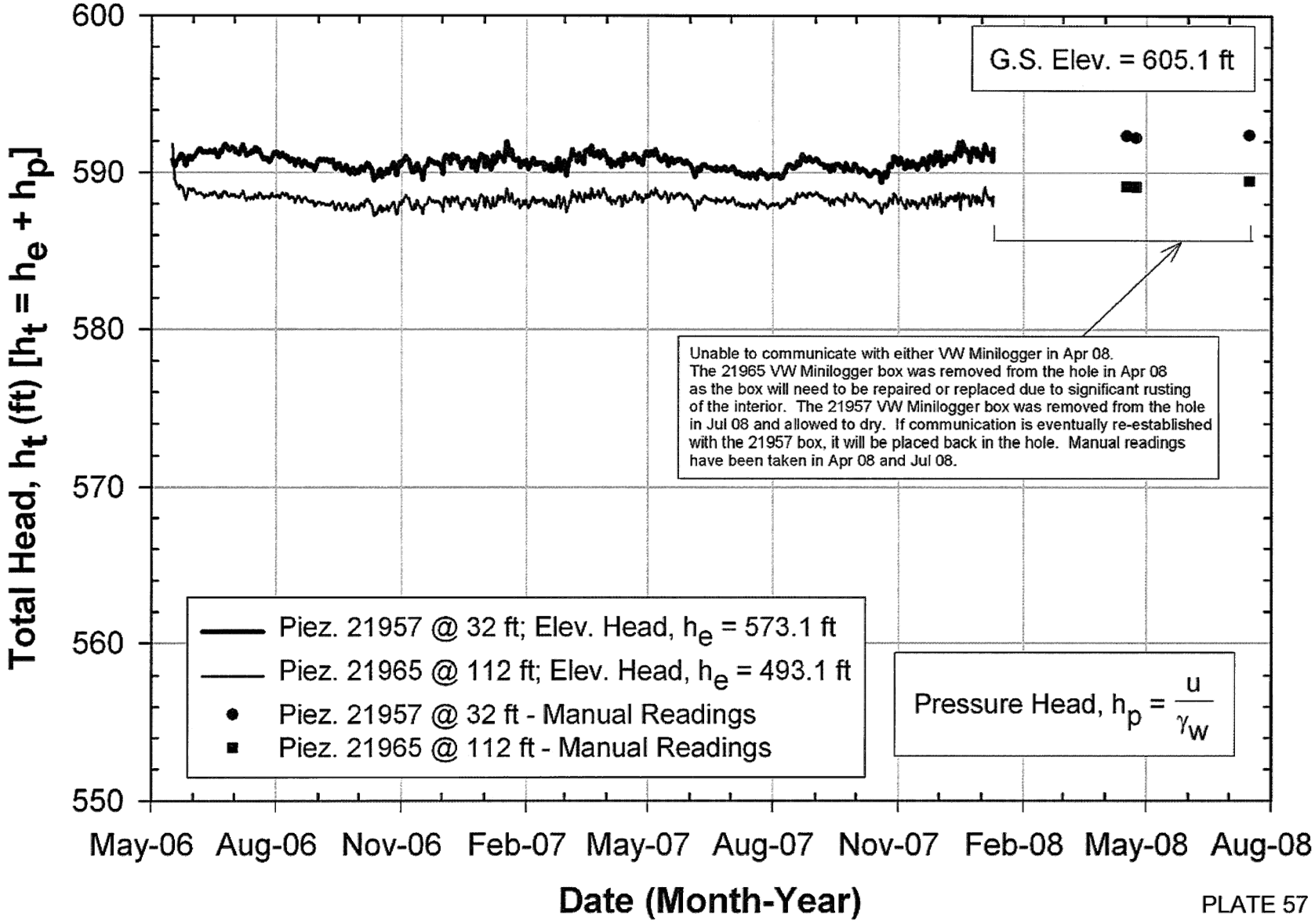


PLATE 57

B-05-04 VW Piezometer Readings

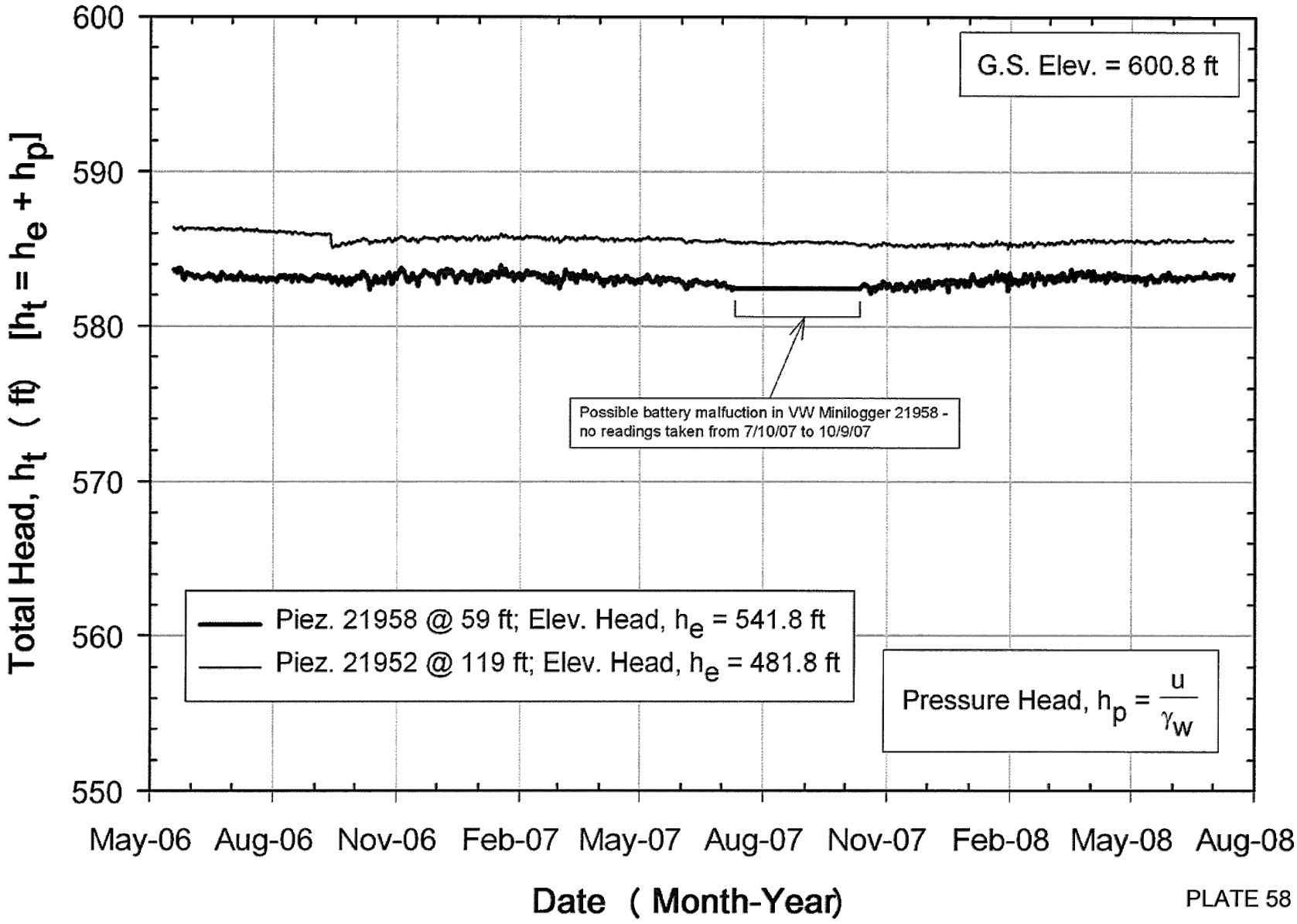


PLATE 58

B-05-07 VW Piezometer Readings

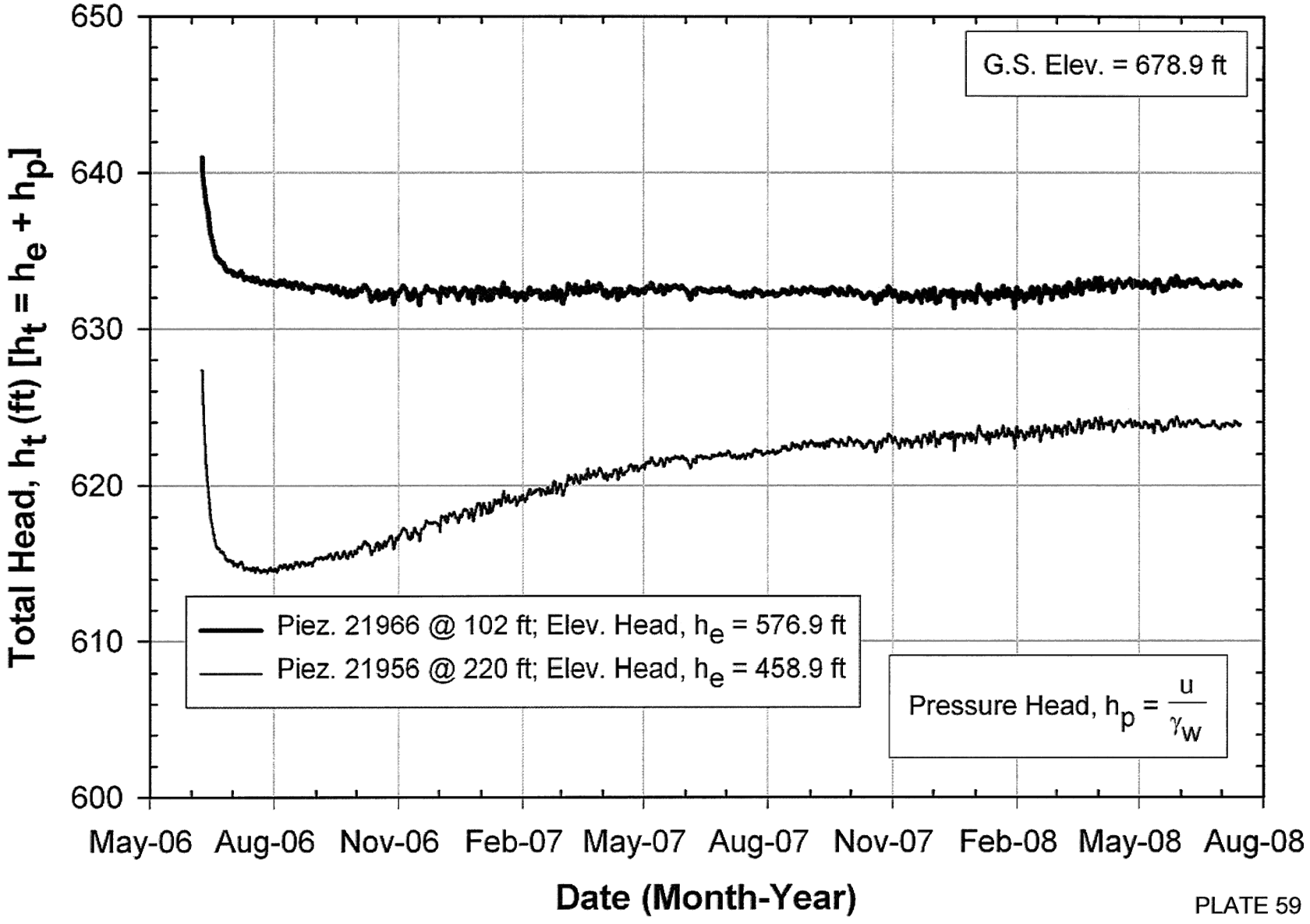


PLATE 59

B-05-08 VW Piezometer Readings

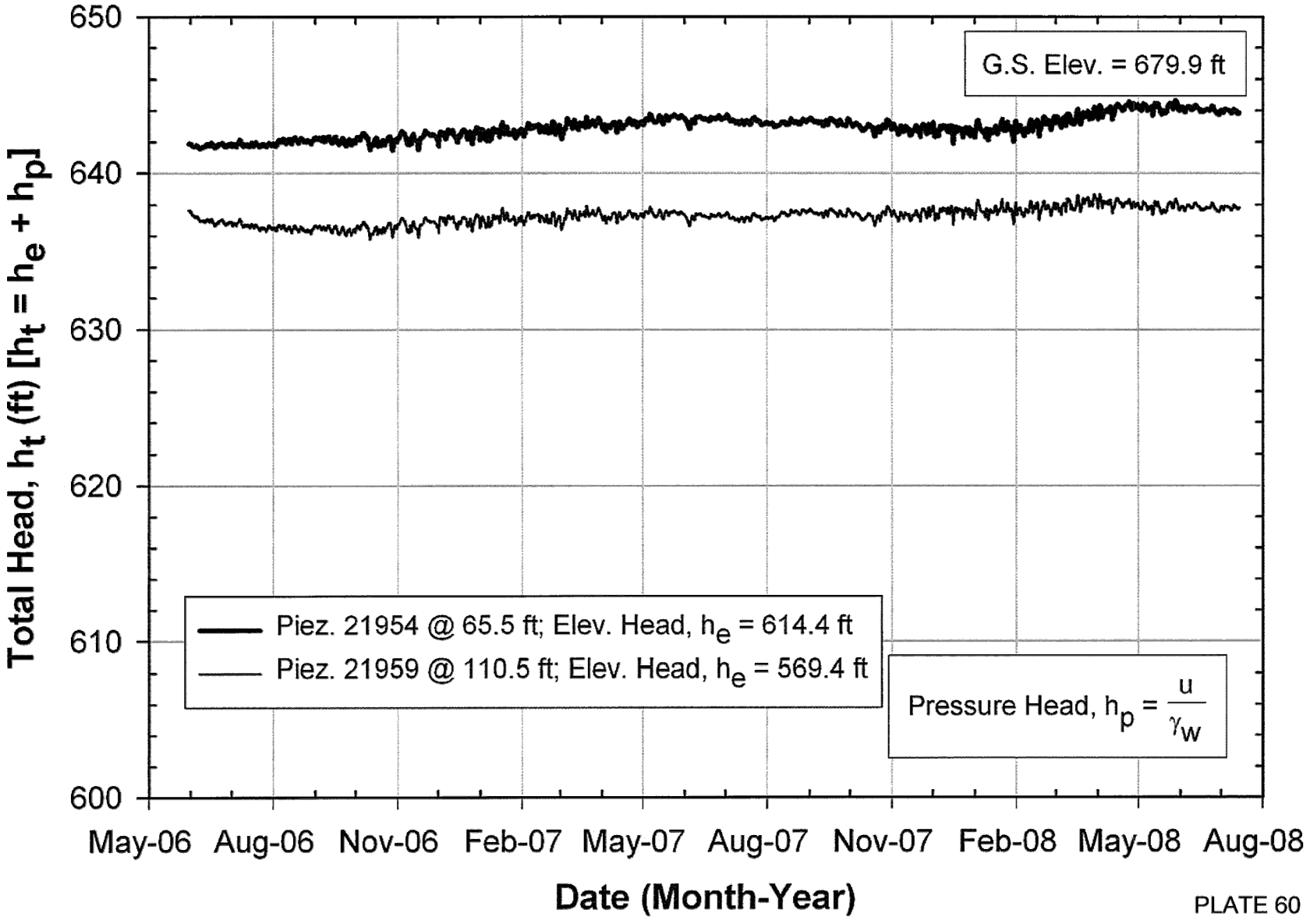


PLATE 60

B-05-11 VW Piezometer Readings

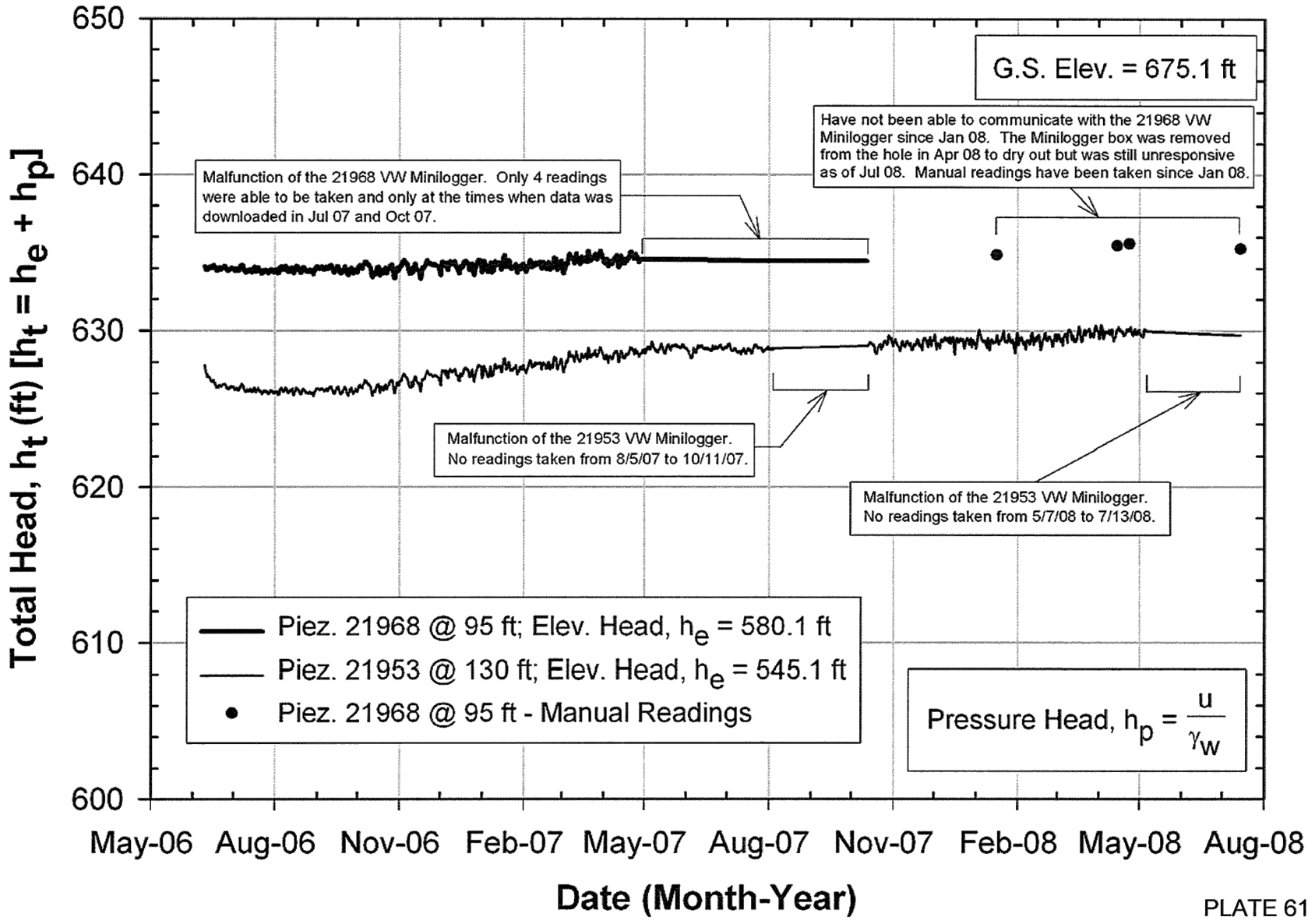


PLATE 61

B-05-12 VW Piezometer Readings

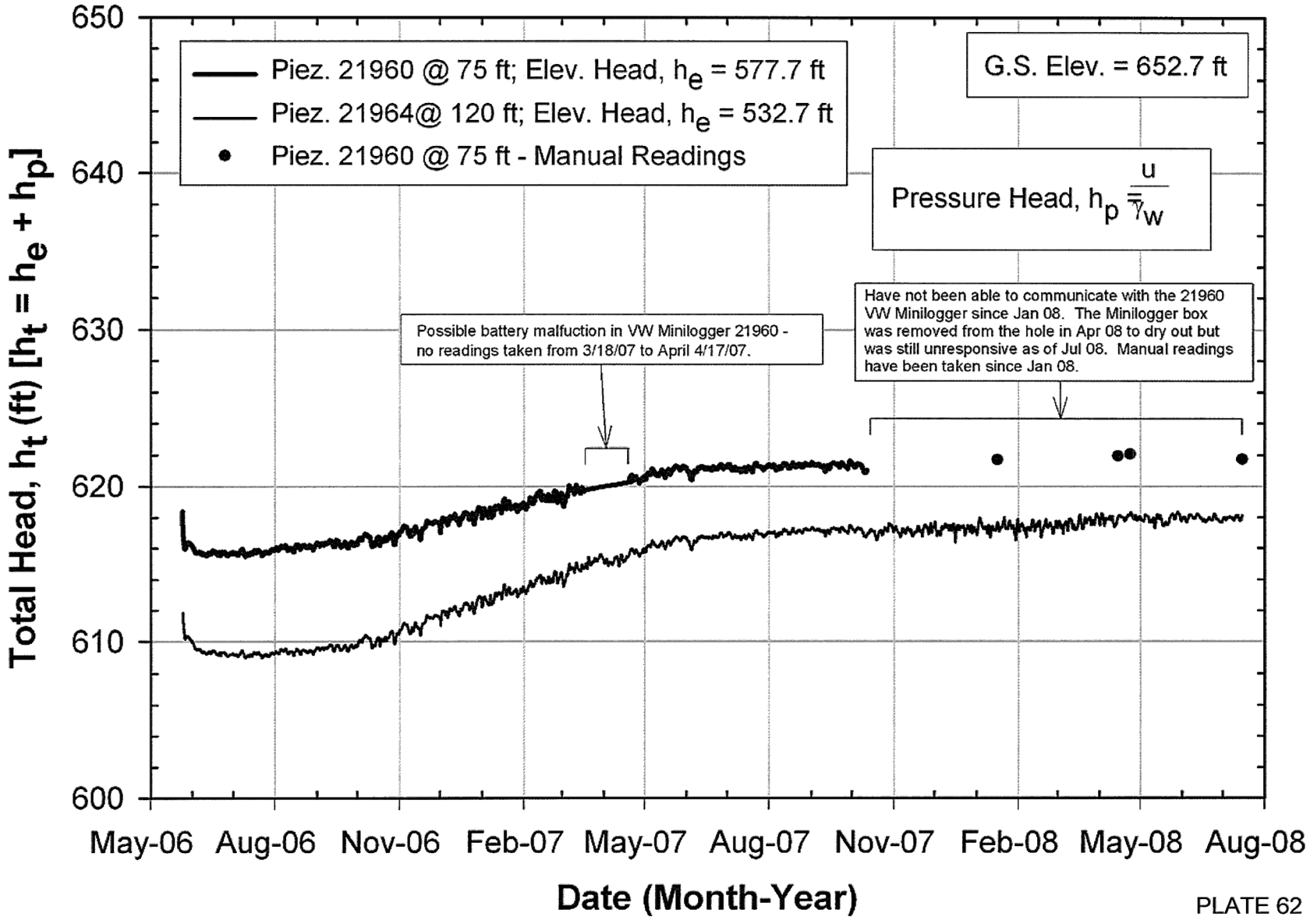


PLATE 62

B-05-13 VW Piezometer Readings

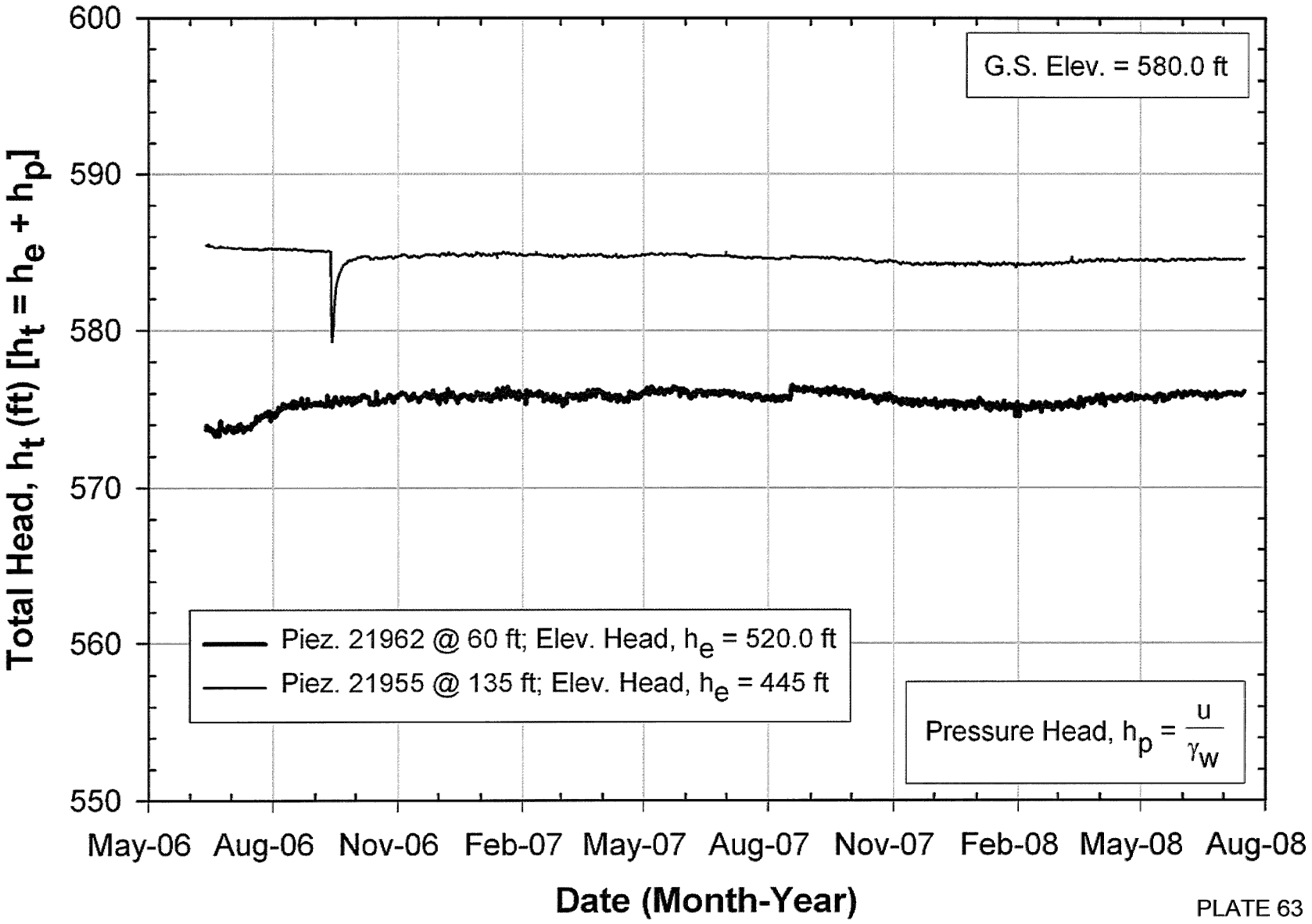


PLATE 63

CALIPERED SURFACE DISTANCE TABLE
CUY-90-15.24

Date	Left Pier Calipered Surface Distance		Center Line Calipered Surface Distance		Right Pier Calipered Surface Distance	
	Present reading	Change (in.)	Present reading	Change (in.)	Present reading	Change (in.)
11/08/01	6.250	--	Not Accessible		4.469	--
01/23/02	6.253	0.003	Not Accessible		4.518	0.049
04/17/02	6.285	0.032	Not Accessible		4.435	-0.083
07/16/02	6.290	0.005	Not Accessible		4.444	0.009
10/15/02	6.333	0.043	Discontinued		4.482	0.038
01/15/03	6.405	0.072			4.473	-0.009
04/17/03	6.333	-0.072			4.482	0.009
07/18/03	6.186	-0.147			4.350	-0.132
10/16/03	6.385	0.199			4.519	0.169
01/08/04	6.124	-0.261			4.594	0.075
04/14/04	6.129	0.005			4.402	-0.193
07/16/04	6.250	0.122			4.277	-0.125
10/27/04	6.375	0.125			4.467	0.190
01/12/05	6.250	-0.125			4.349	-0.118
04/14/05	6.375	0.125			4.372	0.023
07/14/05	6.313	-0.063			4.392	0.020
10/12/05	6.375	0.063			4.358	-0.034
02/01/06	6.438	0.063			4.395	0.037
04/20/06	6.500	0.063			4.430	0.035
07/14/06	6.375	-0.125			4.381	-0.049
10/18/06	6.438	0.063			4.400	0.020
01/19/07	6.500	0.062			4.506	0.106
04/18/07	6.375	-0.125			4.357	-0.150
07/11/07	6.438	0.063			4.341	-0.015
10/12/07	6.438	0.000			4.384	0.043
01/08/08	6.469	0.031			4.349	-0.036
04/14/08	6.500	0.031			4.410	0.062
07/14/08	6.500	0.000			4.410	0.000

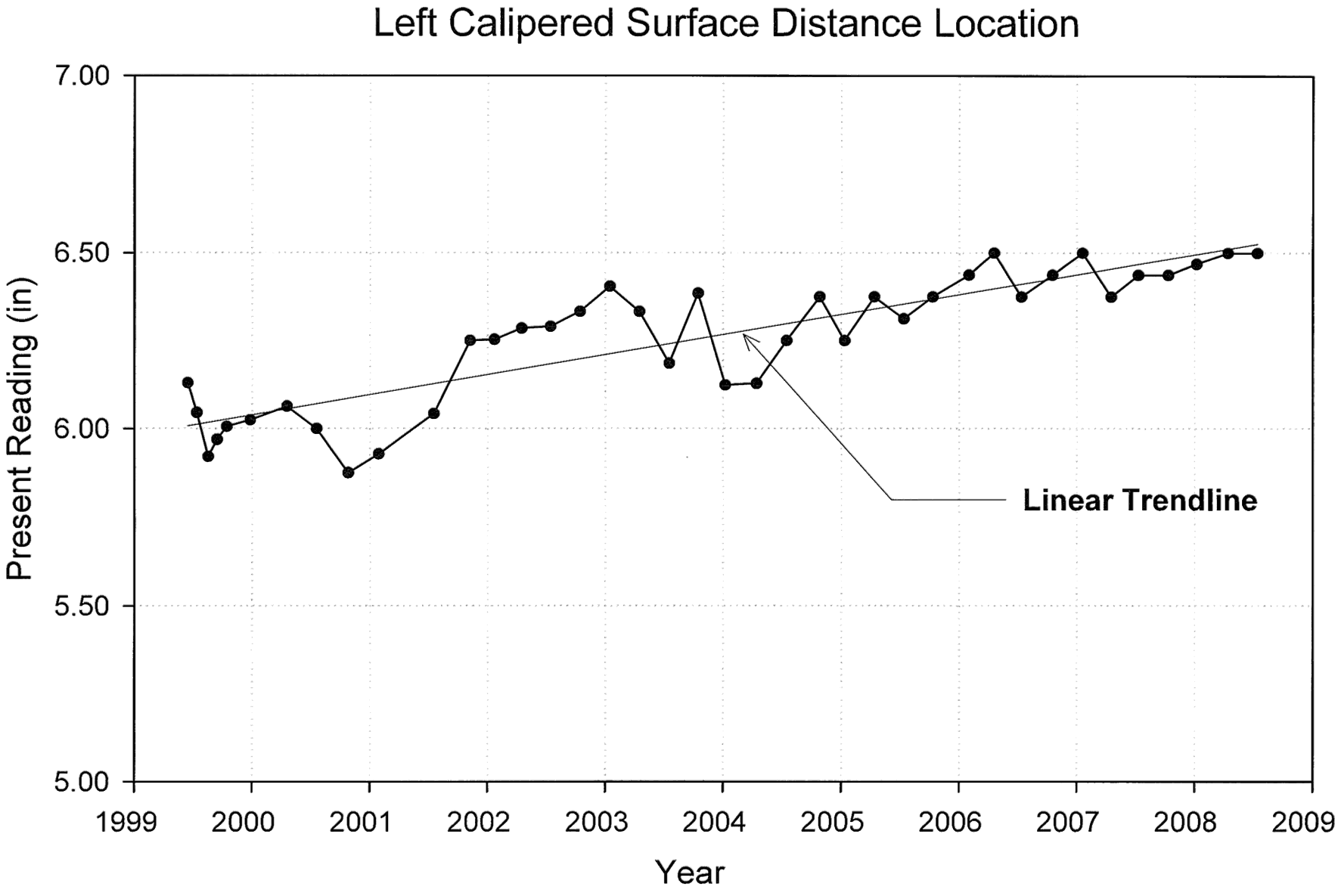

Left Calipered Surface Distance Location
7.00
6.50
6.00
5.50
5.00
Present Reading (in)
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year
Linear Trendline

PLATE 65

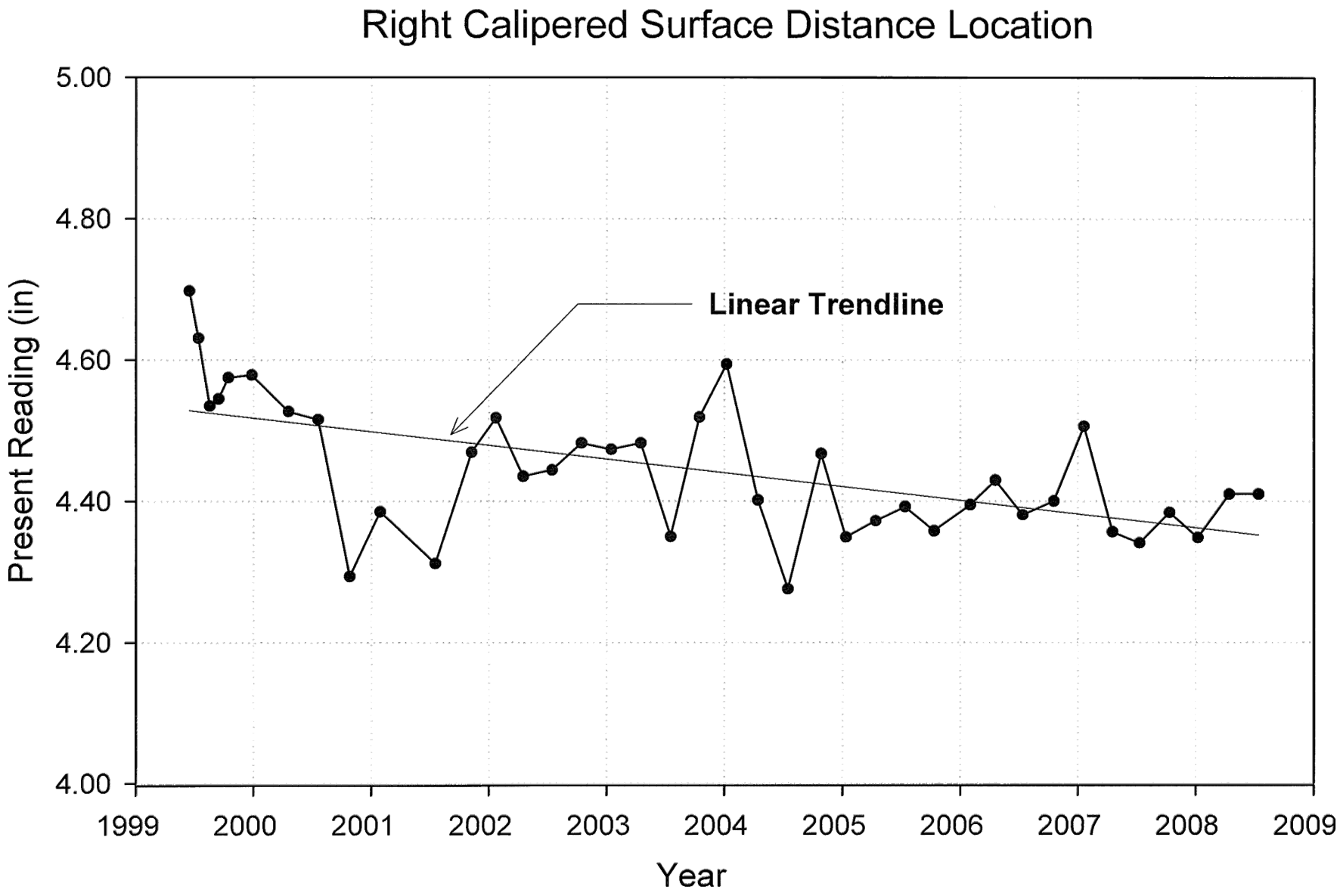

Right Calipered Surface Distance Location
5.00
4.80
4.60
4.40
4.20
4.00
Present Reading (in)
Linear Trendline
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

PLATE 66

View towards the east (upriver) of the bulkhead adjacent to B-105A. Photo taken on July 16, 2008.

PLATE 67

CUY-90-1524
106017

DECK EXPANSION JOINT OPENINGS

Finger Type Joints
Measurements are in inches.

Date	Temp (F)	West End Pier North	West End Pier South	Near Pier 2 North	Near Pier 2 South	Near Pier 4 North	Near Pier 4 South
Expansion Distance		476 feet		650 feet			
Design	60°	3.25	3.25	3.25	3.25	3.25	3.25
06-01-70	80°	4.00		0.00		N.A.	
09-19-75	60°	5.25		2.00		N.A.	
05-08-78	60°	4.75	5.50	2.00	2.00	3.25	2.50
07-30-81	75°	5.50	5.50	2.25	2.25	3.25	2.75
06-09-83	70°	5.00	5.00	1.50	1.50	2.75	2.25
07-31-85	73°	5.25	4.75	1.50	1.00	2.75	2.25
10-31-88	40°	7.75	8.38	1.50	0.75	3.81	3.38
11-01-89	50°	7.75	7.00	1.13	0.63	3.25	3.13
10-26-90	50°	7.75	7.25	1.00	0.50	3.00	3.00
09-30-91	55°	7.50	7.00	0.88	0.00	3.00	3.00
10-13-92	60°	7.25	6.81	0.63	0.00	2.50	2.50
10-01-93	50°	7.50	7.13	0.75	0.31	2.75	2.63
09-01-94	63°	7.25	6.38	0.31	0.00	2.88	1.88
09-08-95	60°	7.00	6.63	0.44	0.00	2.00	1.88
09-05-96	77°	6.50	6.63	0.38	0.00	1.25	1.00
09-19-97	75°	6.88	7.00	0.31	0.06	1.68	1.42
09-24-98	69°	7.63	7.00	0.00	0.00	1.88	1.75
10-14-99	45°	6.19	5.50	2.38	1.88	3.13	2.75
10-16-00	55°	6.00	4.88	1.75	1.25	2.56	2.43
04-23-01	70°	5.50	4.25	1.38	0.63	2.13	1.75
07-16-01	80°	5.00	3.88	1.00	0.25	1.50	1.25

Date	Temp (F)	West End Pier		Near Pier 2		Near Pier 4	
		North	South	North	South	North	South
10-15-01	50°	6.63	5.63	1.63	1.06	3.25	2.75
1-15-02	30°	6.88	6.25	2.13	1.50	3.88	3.50
4-15-02	61°	6.00	5.25	1.38	0.88	2.50	2.38
7-15-02	76°	5.13	4.13	1.13	0.50	1.75	1.50
10-17-02	48°	7.00	6.38	1.75	1.25	3.25	2.88
11-1-02	35°	7.25	6.13	1.88	1.38	3.63	3.38
1-15-03	7°	8.13	6.63	2.38	1.88	5.00	4.75
4-15-03	67°	5.63	4.63	1.25	0.63	2.25	2.00
7-15-03	74°	5.38	4.38	1.00	0.50	2.00	1.63
10-16-03	46°	7.00	5.75	1.50	1.13	3.25	3.13
1-15-04	11°	8.00	6.75	2.00	1.38	4.63	4.00
4-15-04	41°	6.88	5.75	1.38	0.88	3.50	3.25
7-15-04	67°	5.63	4.75	1.00	0.50	2.13	1.75
10-15-04	50°	6.38	5.50	1.25	0.75	3.00	2.75
1-15-05	12°	7.75	7.00	2.00	1.38	4.63	4.25
4-16-05	47°	6.50	5.63	1.25	0.75	3.25	2.88
7-16-05	74°	5.50	4.50	0.75	0.375	1.75	1.63
10-14-05	51°	6.25	5.50	1.13	0.63	2.81	2.56
1-16-06	26°	7.63	6.38	1.75	1.13	4.13	3.75
4-14-06	65°	5.75	4.88	0.75	0.50	2.25	2.00
7-14-06	78°	5.00	4.00	0.63	0.19	1.63	1.25
10-16-06	50°	6.50	5.88	1.00	0.75	3.25	3.00
1-15-07	41°	7.00	6.13	1.13	0.88	3.56	3.38
4-16-07	34°	7.25	6.38	1.38	0.88	3.75	3.50
7-16-07	70°	5.38	4.75	0.88	0.25	2.13	1.63
10-15-07	56°	6.38	5.50	1.13	0.75	2.88	2.69

Date	Temp (F)	West End Pier North	West End Pier South	Near Pier 2 North	Near Pier 2 South	Near Pier 4 North	Near Pier 4 South
1-15-08	19°	7.63	6.63	1.63	1.00	4.13	4.00
4-15-08	41°	7.13	6.25	1.44	0.88	3.75	3.19
7-16-08	83°	4.75	4.00	0.50	0.00	1.13	0.81

N.A. - No measurements available

Richland Engineering Limited 106017

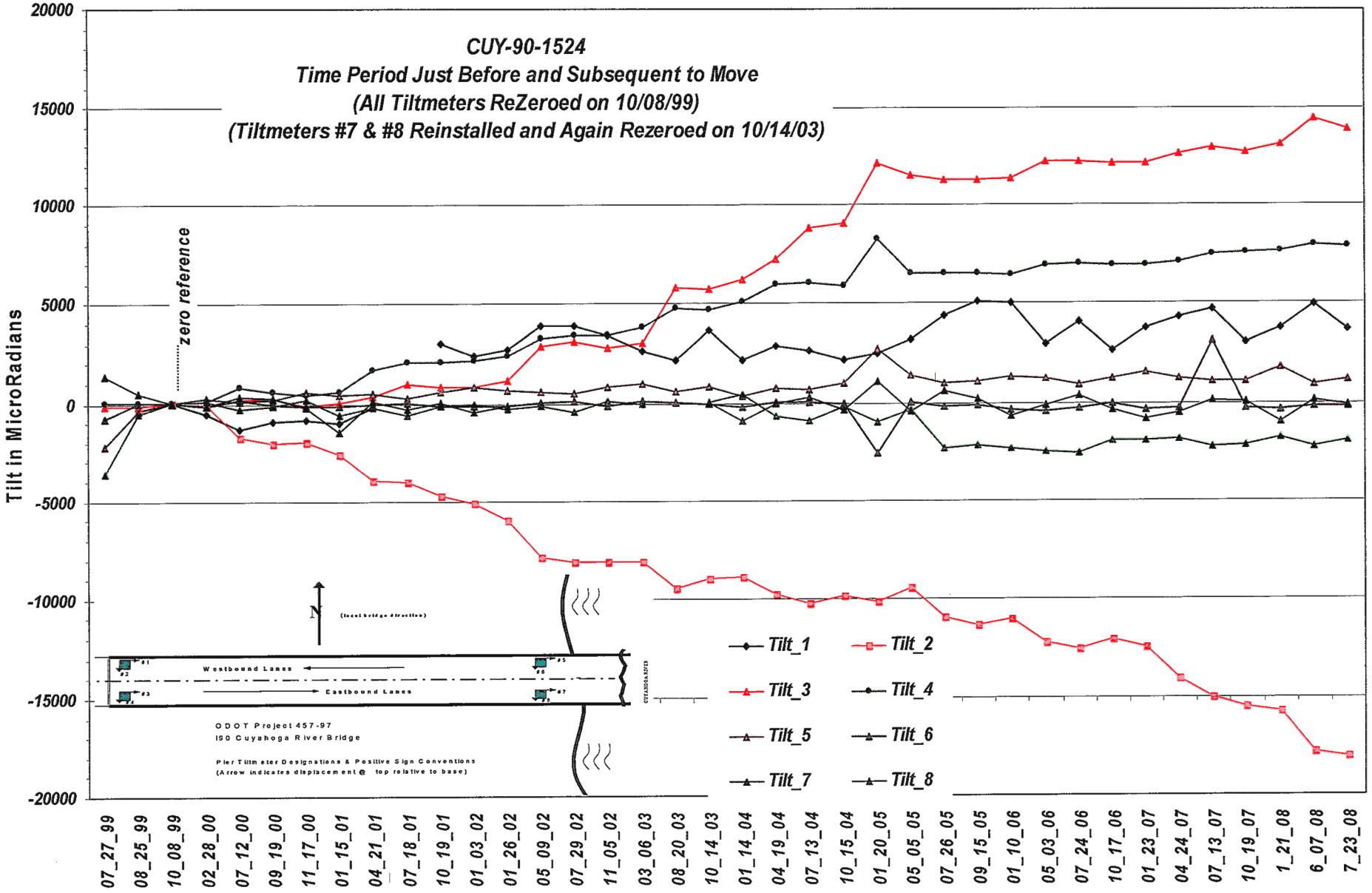
From: "arthur huckelbridge" <aah4@case.edu>
To: <reltd@r-e-l.com>
Sent: Thursday, July 24, 2008 11:55 AM
Attach: Tilts 7_23_08.ppt
Subject: Innerbelt bridge monitoring July 08

Dean:

Attached are updated tiltmeter readings taken on July 23, 2008. Nothing remarkable to report. Let me know if you have questions.

Art

Arthur A. Huckelbridge, Jr., D.Eng., P.E.
Department of Civil Engineering
Case School of Engineering
Case Western Reserve University
Cleveland, OH 44106-7201
off: (216) 368 2474
cell: (216) 534 9141
hm: (216) 321 1844
fax: (216) 368 5229



Tiltmeter Readings Through 7/23/2008

Robert Y. Liang, Ph.D., P.E
8441 Timber Tr.
Brecksville, Ohio 44141

Cell Phone: (440) 725-7425
e-mail: RYLIANG@AOL.COM

August 7, 2008

Mr. Dean Palmer, P.E.
Richland Engineering, Ltd.
29 North Park St.
Mansfield, OH 44902

Ref: CUY-90-14.52, PID No. 77332

Dear Mr. Palmer:

The monitoring data for the stabilization structures at the referenced project site for the last three months (April, May, and June) are enclosed. The inclinometer reading and strain data were taken on July 28 and July 29, 2008. Also, we replaced the old batteries and performed maintenance on the data logger during our site visit.

From the enclosed data sheets and plotted figures, there is no significant change during this monitoring period. The inclinometer reading of the six casings in the drilled shafts did not show significant movement in this period.

Please call me at (440) 725-7425, if you have any question. Thank you.

Sincerely,

Robert Liang

Robert Liang

RECEIVED
AUG 11 2008
RICHLAND ENGINEERING LIMITED

Table 1 Numerical reading of anchor load as a function of time for anchors #1, #8, #9 and #17

Date	Anchor # 1 Load, kips	Anchor # 8 Load, kips	Anchor # 9 Load, kips	Anchor # 17 Load, kips	Comment
4/7/1999		560			
4/8/1999	489			499	Anchor Lock off
4/14/1999	460	473	596 (Lock off)	461	
5/7/1999	452	473	572	445	End of construction
7/1/1999	446	468	564	439	
10/1/1999	441	467	560	440	
1/1/2000	439	461	555	424	
4/1/2000	432	453	546	414	
7/1/2000	431	451	521	415	
10/1/2000	431	451	519	416	
1/1/2001	430	455	517	400	
4/1/2001	421	443	513	397	
7/1/2001	422	443	510	399	
10/1/2001	425	445	512	403	
1/1/2002	424	444	511	398	
4/1/2002	421	440	508	386	
7/1/2002	419	439	506	391	
10/1/2002	423	442	508	396	
1/1/2003	423	435	508	389	
4/15/2003	416	427	501	380	
8/7/2003	416	428	503	384	
10/7/2003	418	429	504	387	
12/31/2003	417	426	503	378	
4/13/2004	408	418	494	370	
7/13/2004	409	419	494	374	
10/8/2004	411	422	496	377	
1/7/2005	411	421	495	374	
4/8/2005	407	414	485	366	
7/18/2005	407	415	485	370	
11/12/2005	410	419	489	374	
1/10/2006	409	417	487	369	
4/9/2006	399	411	487	365	
7/19/2006	399	412	487	368	
10/18/2006	407.3	414.8	489.6	371.7	
1/18/2007	405	412	487	366	
4/19/2007	401	406	501	361	
7/9/2007	401	408	502	365	
10/20/2007	404	411	506	369	
1/7/2008	403	410	504	364	
5/13/2008	397	403	497	359	
7/29/2008	398	403	500	363	

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	-47.1	68.5	551.7	681.8	313.73	10.70	616.75	252.30	375.15	83.06	-40.28	-2.75
	7/15/1999	-70.1	53.8	538.8	666.8	297.33	-8.15	602.80	234.35	360.30	78.72	-40.60	-2.82
	8/15/1999	10.7	114.3	613.7	728.1	366.70	62.50	670.90	312.20	421.20	97.09	-40.43	-2.44
	8/31/1999	12.0	114.3	617.3	732.8	369.10	63.15	675.05	314.65	423.55	97.73	-40.67	-2.44
	9/15/1999	13.1	113.5	619.7	737.5	370.95	63.30	678.60	316.40	425.50	98.22	-40.89	-2.44
	9/30/1999	29.6	122.3	634.4	753.4	384.93	75.95	693.90	332.00	437.85	101.92	-41.07	-2.37
	10/15/1999	34.7	123.9	637.8	757.9	388.58	79.30	697.85	336.25	440.90	102.88	-41.11	-2.34
	10/31/1999	39.8	127.2	646.6	762	393.90	83.50	704.30	343.20	444.60	104.29	-41.26	-2.27
	11/15/1999	62.3	139.3	662.9	780.1	411.15	100.80	721.50	362.60	459.70	108.86	-41.25	-2.18
	11/30/1999	73.7	146.3	670.6	788.6	419.80	110.00	729.60	372.15	467.45	111.15	-41.18	-2.13
	12/15/1999	72.8	143.6	668.9	789.7	418.75	108.20	729.30	370.85	466.65	110.87	-41.28	-2.15
	12/31/1999	88.8	152.1	680.1	802.5	430.88	120.45	741.30	384.45	477.30	114.08	-41.26	-2.08
	3/31/2000	95.3	158.7	682.5	825.2	440.43	127.00	753.85	388.90	491.95	116.61	-41.66	-2.31
	6/30/2000	60.2	138.2	662.7	804.5	416.40	99.20	733.60	361.45	471.35	110.25	-42.16	-2.46
	9/30/2000	50.1	142.5	668.8	795.7	414.28	96.30	732.25	359.45	469.10	109.69	-42.26	-2.46
	1/13/2001	109.5	179.9	712.3	845.5	461.80	144.70	778.90	410.90	512.70	122.27	-42.15	-2.28
	4/20/2001	126.8	283.2	715.3	881.9	501.80	205.00	798.60	421.05	582.55	132.86	-39.45	-3.62
	7/16/2001	68.3	149.8	674.3	837.1	432.38	109.05	755.70	371.30	493.45	114.48	-42.98	-2.74
	10/9/2001	71.4	157.1	685.5	840.8	438.70	114.25	763.15	378.45	498.95	116.15	-43.12	-2.70
	1/9/2002	102.7	177.8	713	872	466.38	140.25	792.50	407.85	524.90	123.48	-43.35	-2.62
	4/12/2002	125.5	192.8	738.6	904.9	490.45	159.15	821.75	432.05	548.85	129.86	-44.04	-2.62
	7/18/2002	62.3	151.8	706.334	859.6	445.01	107.05	782.97	384.32	505.70	117.82	-44.92	-2.72
	10/8/2002	43.7	151.1	711.3	846.7	438.20	97.40	779.00	377.50	498.90	116.02	-45.30	-2.72
1	1/8/2003	84.7	180.5	748.5	891.8	476.38	132.60	820.15	416.60	536.15	126.13	-45.69	-2.68
	4/15/2003	96.1	191.9	739.9	989.3	504.30	144.00	864.60	418.00	590.60	133.52	-47.89	-3.87
	7/1/2003	57.4	168	713	959	474.35	112.70	836.00	385.20	563.50	125.59	-48.07	-3.99
	10/7/2003	42.1	166.8	714	946.6	467.38	104.45	830.30	378.05	556.70	123.75	-48.24	-4.00
	12/31/2003	80	197.9	753.9	985.1	504.23	138.95	869.50	416.95	591.50	133.50	-48.55	-3.91
	4/13/2004	92	208.9	760.4	1006.6	516.98	150.45	883.50	426.20	607.75	136.88	-48.72	-4.07
	7/13/2004	14.6	163.9	707.3	954.4	460.05	89.25	830.85	360.95	559.15	121.81	-49.29	-4.44
	10/8/2004	-8.6	233.4	704.6	941	467.60	112.40	822.80	348.00	587.20	123.81	-47.21	-5.36
	1/7/2005	19.5	190.4	746.5	982.5	484.73	104.95	864.50	383.00	586.45	128.34	-50.48	-4.56
	4/8/2005	3.4	397.6	751.6	1003.4	539.00	200.50	877.50	377.50	700.50	142.71	-44.99	-7.24
	7/18/2005	3.1	164.3	709.7	969.6	461.68	83.70	839.65	356.40	566.95	122.24	-50.24	-4.72
	8/26/2005	3.1	157.5	702.5	956.3	454.85	80.30	829.40	352.80	556.90	120.43	-49.78	-4.57
	10/11/2005	3.1	164.2	712.6	960.1	460.00	83.65	836.35	357.85	562.15	121.79	-50.02	-4.58
	1/10/2006	3.1	191.9	742.5	997	483.63	97.50	869.75	372.80	594.45	128.05	-51.32	-4.97
	4/9/2006	3.5	205.3	750.7	1018.8	494.58	104.40	884.75	377.10	612.05	130.95	-51.86	-5.26
	7/19/2006	3.5	166.6	703.7	975.5	462.33	85.05	839.60	353.60	571.05	122.41	-50.15	-4.87
	10/18/2006	3.5	170.2	709	967.5	462.55	86.85	838.25	356.25	568.85	122.47	-49.94	-4.76
	1/18/2007	3.5	209.1	748.7	1013.1	493.60	106.30	880.90	376.10	611.10	130.69	-51.48	-5.26
	4/19/2007	3.5	216.6	743.7	1021.2	496.25	110.05	882.45	373.60	618.90	131.39	-51.33	-5.50
	7/11/2007	3.5	169.6	700.9	981.6	463.90	86.55	841.25	352.20	575.60	122.83	-50.16	-5.00
	10/20/2007	3.5	163.4	696	963.7	456.65	83.45	829.85	349.75	563.55	120.91	-49.60	-4.79
	1/7/2008	3.5	193.1	730.4	1002.9	482.48	98.30	866.65	366.95	598.00	127.74	-51.06	-5.18
	5/13/2008	3.5	202.2	733	1019.1	489.45	102.85	876.05	368.25	610.65	129.59	-51.39	-5.43
	7/29/2008	3.5	171.2	699.7	981.8	464.05	87.35	840.75	351.60	576.50	122.87	-50.07	-5.04

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	374.9	6	549.6	471.8	350.58	190.45	510.70	462.25	238.90	92.82	-21.28	5.00
	7/15/1999	368.6	-3.6	544.2	467.3	344.13	182.50	505.75	456.40	231.85	91.11	-21.48	5.03
	8/15/1999	373.7	0.2	569.4	485.2	357.13	186.95	527.30	471.55	242.70	94.56	-22.62	5.13
	8/31/1999	368.4	-4.7	567	486.2	354.23	181.85	526.60	467.70	240.75	93.79	-22.91	5.08
	9/15/1999	365.9	-9.2	565.3	485.1	351.78	178.35	525.20	465.60	237.95	93.14	-23.05	5.10
	9/30/1999	364.6	-11.7	570.1	487.6	352.65	176.45	528.85	467.35	237.95	93.37	-23.42	5.14
	10/15/1999	361.7	-14.8	569.9	487.4	351.05	173.45	528.65	465.80	236.30	92.95	-23.61	5.14
	10/31/1999	362.8	-13.5	575.6	493.1	354.50	174.65	534.35	469.20	239.80	93.86	-23.91	5.14
	11/15/1999	365.0	-11.5	581.4	498	358.23	176.75	539.70	473.20	243.25	94.85	-24.12	5.15
	11/30/1999	365.6	-11.8	583.7	500.1	359.40	176.90	541.90	474.65	244.15	95.16	-24.26	5.16
	12/15/1999	368.0	-9.2	589.7	504.2	363.18	179.40	546.95	478.85	247.50	96.16	-24.43	5.18
	12/31/1999	369.0	-8	592.9	506.6	365.13	180.50	549.75	480.95	249.30	96.67	-24.54	5.19
	3/31/2000	379.6	7.3	617	524.1	382.00	193.45	570.55	498.30	265.70	101.14	-25.06	5.21
	6/30/2000	376.1	4.4	608.9	519.1	377.13	190.25	564.00	492.50	261.75	99.85	-24.84	5.17
	9/30/2000	360.7	-12.3	588.3	503.5	360.05	174.20	545.90	474.50	245.60	95.33	-24.70	5.13
	1/13/2001	372.1	2.2	618.1	526.1	379.63	187.15	572.10	495.10	264.15	100.51	-25.58	5.17
	4/20/2001	387.6	21	645.8	549.2	400.90	204.30	597.50	516.70	285.10	106.15	-26.13	5.19
	7/16/2001	374.6	6.5	621.5	532.9	383.88	190.55	577.20	498.05	269.70	101.64	-25.70	5.12
	10/9/2001	360.9	-9.4	598.9	515.8	366.55	175.75	557.35	479.90	253.20	97.05	-25.36	5.08
	1/9/2002	363.5	-2.5	611.5	524.5	374.25	180.50	568.00	487.50	261.00	99.09	-25.75	5.07
	4/12/2002	381.7	16.9	642.7	550.5	397.95	199.30	596.60	512.20	283.70	105.37	-26.40	5.12
	7/18/2002	375	10.5	629	544.7	389.80	192.75	586.85	502.00	277.60	103.21	-26.19	5.03
	10/8/2002	357.7	-9.6	599.2	523	367.58	174.05	561.10	478.45	256.70	97.32	-25.72	4.97
12	1/8/2003	367.3	6.5	626.7	542.7	385.80	186.90	584.70	497.00	274.60	102.15	-26.44	4.98
	4/15/2003	385.9	27.3	655.3	566.2	408.68	206.60	610.75	520.60	296.75	108.20	-26.86	5.01
	7/1/2003	384.7	26.3	649.2	565.6	406.45	205.50	607.40	516.95	295.95	107.62	-26.71	4.95
	10/7/2003	360.6	3.5	613	539.7	379.20	182.05	576.35	486.80	271.60	100.40	-26.20	4.82
	12/31/2003	372	19.4	636	558.3	396.43	195.70	597.15	504.00	288.85	104.96	-26.68	4.82
	4/13/2004	389.4	39.8	665.5	583.1	419.45	214.60	624.30	527.45	311.45	111.06	-27.23	4.84
	7/13/2004	379.5	27.7	643.3	571.1	405.40	203.60	607.20	511.40	299.40	107.34	-26.82	4.75
	10/8/2004	361.6	10.3	615.2	550.9	384.50	185.95	583.05	488.40	280.60	101.80	-26.39	4.66
	1/7/2005	367.5	16.1	630.6	561.5	393.93	191.80	596.05	499.05	288.80	104.30	-26.87	4.71
	4/8/2005	388.2	35.6	662.3	587.2	418.33	211.90	624.75	525.25	311.40	110.76	-27.44	4.79
	7/18/2005	382.6	26.3	647.7	580.1	409.18	204.45	613.90	515.15	303.20	108.34	-27.21	4.75
	8/26/2005	373.6	15.7	629.8	566.8	396.48	194.65	598.30	501.70	291.25	104.97	-26.83	4.71
	10/11/2005	365.9	6.1	617.8	557.9	386.93	186.00	587.85	491.85	282.00	102.45	-26.71	4.70
	1/10/2006	376.2	17.5	639	572.2	401.23	196.85	605.60	507.60	294.85	106.23	-27.16	4.77
	4/9/2006	393.8	32.7	665.7	594	421.55	213.25	629.85	529.75	313.35	111.61	-27.69	4.85
	7/19/2006	384.2	20.3	646.2	582.7	408.35	202.25	614.45	515.20	301.50	108.12	-27.39	4.79
	10/18/2006	365	-2	614.4	558.2	383.90	181.50	586.30	489.70	278.10	101.65	-26.90	4.74
	1/18/2007	376	9.6	635.9	573.9	398.85	192.80	604.90	505.95	291.75	105.60	-27.39	4.80
	4/19/2007	390.7	24.1	659.3	592.7	416.70	207.40	626.00	525.00	308.40	110.33	-27.82	4.85
	7/11/2007	384.1	15	644.6	584.6	407.08	199.55	614.60	514.35	299.80	107.78	-27.58	4.81
	10/20/2007	363.7	-9.6	611.5	560.6	381.55	177.05	586.05	487.60	275.50	101.02	-27.18	4.75
	1/7/2008	371.2	-2.9	625.1	569.7	390.78	184.15	597.40	498.15	283.40	103.47	-27.46	4.81
	5/13/2008	390.8	11.5	650.8	592.6	411.43	201.15	621.70	520.80	302.05	108.93	-27.95	4.90
	7/29/2008	379.9	-2.5	629.3	579.9	396.65	188.70	604.60	504.60	288.70	105.02	-27.64	4.84

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	306.3	72.2	490.8	675.2	386.13	189.25	583.00	398.55	373.70	102.23	-26.17	0.56
	7/15/1999	288.0	53.1	484.2	670.6	373.98	170.55	577.40	386.10	361.85	99.02	-27.04	0.54
	8/15/1999	280.9	61.8	506.3	693.7	385.68	171.35	600.00	393.60	377.75	102.12	-28.49	0.36
	8/31/1999	270.4	52.1	503.1	691.4	379.25	161.25	597.25	386.75	371.75	100.41	-28.98	0.34
	9/15/1999	261.3	43.9	501.2	689.9	374.08	152.60	595.55	381.25	366.90	99.04	-29.44	0.32
	9/30/1999	257.1	40.7	503.1	690.7	372.90	148.90	596.90	380.10	365.70	98.73	-29.77	0.32
	10/15/1999	250.1	33.8	501.2	691	369.03	141.95	596.10	375.65	362.40	97.71	-30.18	0.30
	10/31/1999	251.4	38	507.6	697.6	373.65	144.70	602.60	379.50	367.80	98.93	-30.43	0.26
	11/15/1999	253.9	41.6	512.1	701.9	377.38	147.75	607.00	383.00	371.75	99.92	-30.52	0.25
	11/30/1999	253.5	41.2	513.6	704.4	378.18	147.35	609.00	383.55	372.80	100.13	-30.68	0.24
	12/15/1999	255.8	46.7	519.1	709.3	382.73	151.25	614.20	387.45	378.00	101.33	-30.77	0.21
	12/31/1999	256.7	48.9	522.3	712.4	385.08	152.80	617.35	389.50	380.65	101.96	-30.87	0.20
	3/31/2000	267.5	64.6	542.8	734.2	402.28	166.05	638.50	405.15	399.40	106.51	-31.40	0.13
	6/30/2000	258.9	46.4	531.2	726.1	390.65	152.65	628.65	395.05	386.25	103.43	-31.63	0.20
	9/30/2000	237.1	10.1	504.9	705.9	364.50	123.60	605.40	371.00	358.00	96.51	-32.02	0.29
	1/13/2001	254.0	40.9	535.1	734.6	391.15	147.45	634.85	394.55	387.75	103.56	-32.39	0.15
	4/20/2001	275.4	72.6	561.4	763.7	418.28	174.00	662.55	418.40	418.15	110.75	-32.47	0.01
	7/16/2001	255.3	37.7	534.8	740.9	392.18	146.50	637.85	395.05	389.30	103.84	-32.65	0.13
	10/9/2001	235.7	7.5	510.6	719.6	368.35	121.60	615.10	373.15	363.55	97.53	-32.80	0.22
	1/9/2002	240	18.9	523.3	731	378.30	129.45	627.15	381.65	374.95	100.16	-33.08	0.15
	4/12/2002	263.4	58.5	554.8	763	409.93	160.95	658.90	409.10	410.75	108.54	-33.09	-0.04
	7/18/2002	255.5	40.1	566.1	754.5	404.05	147.80	660.30	410.80	397.30	106.98	-34.06	0.30
	10/8/2002	231.2	3.4	508.7	726.1	367.35	117.30	617.40	369.95	364.75	97.26	-33.24	0.12
13	1/8/2003	249.4	38.5	540.1	754.4	395.60	143.95	647.25	394.75	396.45	104.74	-33.45	-0.04
	4/15/2003	276.4	78.5	571.6	784.9	427.85	177.45	678.25	424.00	431.70	113.28	-33.28	-0.17
	7/1/2003	273	69	561.4	779.9	420.83	171.00	670.65	417.20	424.45	111.42	-33.21	-0.16
	10/7/2003	246.6	22.5	524.7	744.6	384.60	134.55	634.65	385.65	383.55	101.83	-33.24	0.05
	12/31/2003	264.8	58.9	552.8	770.1	411.65	161.85	661.45	408.80	414.50	108.99	-33.20	-0.13
	4/13/2004	291.3	97.7	584	803.2	444.05	194.50	693.60	437.65	450.45	117.57	-33.17	-0.29
	7/13/2004	275.5	64.3	556.1	781	419.23	169.90	668.55	415.80	422.65	111.00	-33.14	-0.15
	10/8/2004	252.8	29.9	527.5	755.8	391.50	141.35	641.65	390.15	392.85	103.66	-33.25	-0.06
	1/7/2005	264	50.8	544.5	770.6	407.48	157.40	657.55	404.25	410.70	107.89	-33.24	-0.14
	4/8/2005	289.9	90.7	576	802	439.65	190.30	689.00	432.95	446.35	116.41	-33.14	-0.30
	7/18/2005	277.8	67.7	556.4	787.1	422.25	172.75	671.75	417.10	427.40	111.80	-33.16	-0.23
	8/26/2005	266.7	46.5	539.8	771.9	406.23	156.60	655.85	403.25	409.20	107.56	-33.18	-0.13
	10/11/2005	257.2	33.8	526.8	760.8	394.65	145.50	643.80	392.00	397.30	104.49	-33.12	-0.12
	1/10/2006	269.3	59.9	551.2	780.4	415.20	164.60	665.80	410.25	420.15	109.93	-33.31	-0.22
	4/9/2006	289.9	90	576.3	806.2	440.60	189.95	691.25	433.10	448.10	116.66	-33.32	-0.34
	7/19/2006	277.7	63.9	553.8	787.8	420.80	170.80	670.80	415.75	425.85	111.42	-33.23	-0.23
	10/18/2006	253.3	27.9	523.7	757.8	390.68	140.60	640.75	388.50	392.85	103.44	-33.24	-0.10
	1/18/2007	267.4	54.9	546.5	778.5	411.83	161.15	662.50	406.95	416.70	109.04	-33.32	-0.22
	4/19/2007	289	88.7	575.1	806.8	439.90	188.85	690.95	432.05	447.75	116.47	-33.37	-0.35
	7/11/2007	280	67	558	793.6	424.65	173.50	675.80	419.00	430.30	112.43	-33.38	-0.25
	10/20/2007	255.4	29.1	525	763.8	393.33	142.25	644.40	390.20	396.45	104.14	-33.37	-0.14
	1/7/2008	265.4	49.2	542.8	778	408.85	157.30	660.40	404.10	413.60	108.25	-33.44	-0.21
	5/13/2008	290.2	83.3	573.8	809.3	439.15	186.75	691.55	432.00	446.30	116.27	-33.55	-0.32
	7/29/2008	274	55.1	548.5	787.7	416.33	164.55	668.10	411.25	421.40	110.23	-33.47	-0.23

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	445.4	53.9	802	298.7	400.00	249.65	550.35	623.70	176.30	105.91	-19.98	10.02
	7/15/1999	440.5	34.4	799.5	280.7	388.78	237.45	540.10	620.00	157.55	102.94	-20.11	10.36
	8/15/1999	455.6	40.8	837.6	284.6	404.65	248.20	561.10	646.60	162.70	107.14	-20.79	10.84
	8/31/1999	452.7	30.7	837.1	274.1	398.65	241.70	555.60	644.90	152.40	105.55	-20.86	11.03
	9/15/1999	448.5	21.7	836.8	266.2	393.30	235.10	551.50	642.65	143.95	104.13	-21.03	11.17
	9/30/1999	447.0	16.1	838.5	260.8	390.60	231.55	549.65	642.75	138.45	103.42	-21.14	11.30
	10/15/1999	446.5	8.8	839.3	255.1	387.43	227.65	547.20	642.90	131.95	102.58	-21.24	11.45
	10/31/1999	450.9	11.7	847.9	257.8	392.08	231.30	552.85	649.40	134.75	103.81	-21.37	11.53
	11/15/1999	455.9	16.1	856.2	259.8	397.00	236.00	558.00	656.05	137.95	105.11	-21.40	11.61
	11/30/1999	456.3	15.5	858.3	259	397.28	235.90	558.65	657.30	137.25	105.19	-21.45	11.65
	12/15/1999	461.3	20.5	865.6	261.7	402.28	240.90	563.65	663.45	141.10	106.51	-21.45	11.70
	12/31/1999	463.4	22.5	871.6	262.9	405.10	242.95	567.25	667.50	142.70	107.26	-21.55	11.76
	3/31/2000	477.8	35.6	903.8	282.7	424.98	256.70	593.25	690.80	159.15	112.52	-22.37	11.91
	6/30/2000	469.2	17.4	889.7	267.4	410.93	243.30	578.55	679.45	142.40	108.80	-22.28	12.03
	9/30/2000	453.5	-23.5	856.8	240.4	381.80	215.00	548.60	655.15	108.45	101.09	-22.17	12.25
	1/13/2001	476.9	5	891.3	257.6	407.70	240.95	574.45	684.10	131.30	107.95	-22.16	12.38
	4/20/2001	494.8	40.8	932.8	281.2	437.40	267.80	607.00	713.80	161.00	115.81	-22.54	12.38
	7/16/2001	475.7	4.9	900.7	255.9	409.30	240.30	578.30	688.20	130.40	108.37	-22.46	12.50
	10/9/2001	459.3	-30.8	870.4	236.8	383.93	214.25	553.60	664.85	103.00	101.65	-22.55	12.59
	1/9/2002	468.8	-18.5	883.7	241.5	393.88	225.15	562.60	676.25	111.50	104.29	-22.43	12.65
	4/12/2002	492.8	22.5	926.5	270.2	428.00	257.65	598.35	709.65	146.35	113.32	-22.64	12.62
	7/18/2002	483.5	3.8	911.9	257.3	414.13	243.65	584.60	697.70	130.55	109.65	-22.66	12.71
	10/8/2002	462.7	-35	875.6	233	384.08	213.85	554.30	669.15	99.00	101.69	-22.63	12.77
14	1/8/2003	485.5	2.5	912.6	253.9	413.63	244.00	583.25	699.05	128.20	109.52	-22.55	12.79
	4/15/2003	501.9	612.9	952.7	285.1	588.15	557.40	618.90	727.30	449.00	155.72	-4.09	6.23
	7/1/2003	521.6	28.8	943.4	278.1	442.98	275.20	610.75	732.50	153.45	117.29	-22.30	12.97
	10/7/2003	472.3	-16.5	903.8	247.5	401.78	227.90	575.65	688.05	115.50	106.38	-23.11	12.83
	12/31/2003	495.5	18.6	939.3	268.7	430.53	257.05	604.00	717.40	143.65	113.99	-23.06	12.85
	4/13/2004	504.6	68.9	989	299.2	465.43	286.75	644.10	746.80	184.05	123.23	-23.75	12.61
	7/13/2004	487.3	36.7	961.8	277.7	440.88	262.00	619.75	724.55	157.20	116.73	-23.78	12.71
	10/8/2004	468.9	-0.5	928.8	256.4	413.40	234.20	592.60	698.85	127.95	109.46	-23.82	12.79
	1/7/2005	485.2	21.4	952.7	269.7	432.25	253.30	611.20	718.95	145.55	114.45	-23.79	12.85
	4/8/2005	512.9	68.8	998.7	302.5	470.73	290.85	650.60	755.80	185.65	124.63	-23.91	12.77
	7/18/2005	498.2	40	977.1	286.8	450.53	269.10	631.95	737.65	163.40	119.29	-24.11	12.86
	8/26/2005	486.3	17.1	955.5	271.8	432.68	251.70	613.65	720.90	144.45	114.56	-24.05	12.91
	10/11/2005	478.8	2.4	942.6	263.6	421.85	240.60	603.10	710.70	133.00	111.69	-24.09	12.94
	1/10/2006	497.9	28.2	970.6	280.6	444.33	263.05	625.60	734.25	154.40	117.64	-24.09	12.99
	4/9/2006	519.6	65.1	1008.9	306	474.90	292.35	657.45	764.25	185.55	125.74	-24.26	12.96
	7/19/2006	505.7	73.4	984.2	290.7	463.50	289.55	637.45	744.95	182.05	122.72	-23.12	12.61
	10/18/2006	484	-5.7	946.5	265.8	422.65	239.15	606.15	715.25	130.05	111.91	-24.39	13.11
	1/18/2007	503	21.5	974.4	282.5	445.35	262.25	628.45	738.70	152.00	117.92	-24.34	13.14
	4/19/2007	525.1	60.9	1012.9	309.1	477.00	293.00	661.00	769.00	185.00	126.30	-24.46	13.08
	7/11/2007	533.8	36.8	994.5	295.1	465.05	285.30	644.80	764.15	165.95	123.13	-23.89	13.40
	10/20/2007	487.8	-9.1	953.8	269.9	425.60	239.35	611.85	720.80	130.40	112.69	-24.76	13.23
	1/7/2008	504.2	11.4	976	284.1	443.93	257.80	630.05	740.10	147.75	117.54	-24.74	13.27
	5/13/2008	552.9	52.7	1019.4	315.4	485.10	302.80	667.40	786.15	184.05	128.44	-24.23	13.49
	7/29/2008	533.4	17.1	989.1	295.9	458.88	275.25	642.50	761.25	156.50	121.50	-24.41	13.55

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side)(cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	468.3	92.2	387.7	511.7	364.98	280.25	449.70	428.00	301.95	96.63	-11.26	2.82
	7/15/1999	460.1	81	381.5	505.7	357.08	270.55	443.60	420.80	293.35	94.54	-11.50	2.86
	8/15/1999	482.3	96.1	410.7	526	378.78	289.20	468.35	446.50	311.05	100.29	-11.91	3.03
	8/31/1999	490.3	101.9	422.4	535	387.40	296.10	478.70	456.35	318.45	102.57	-12.14	3.09
	9/15/1999	491.0	101.4	426.3	536.4	388.78	296.20	481.35	458.65	318.90	102.94	-12.30	3.13
	9/30/1999	497.9	106.7	434.7	543.6	395.73	302.30	489.15	466.30	325.15	104.78	-12.42	3.16
	10/15/1999	505.0	112.3	443.2	550.9	402.85	308.65	497.05	474.10	331.60	106.66	-12.52	3.19
	10/31/1999	515.6	118.8	452.5	560.9	411.95	317.20	506.70	484.05	339.85	109.07	-12.59	3.23
	11/15/1999	525.0	128.3	463.4	570.2	421.73	326.65	516.80	494.20	349.25	111.66	-12.64	3.25
	11/30/1999	532.5	134.9	471.5	576.8	428.93	333.70	524.15	502.00	355.85	113.57	-12.66	3.27
	12/15/1999	534.1	138.1	476.5	580.2	432.23	336.10	528.35	505.30	359.15	114.44	-12.78	3.27
	12/31/1999	540.4	144.3	484.4	587.2	439.08	342.35	535.80	512.40	365.75	116.25	-12.86	3.29
	3/31/2000	551.1	156	501.3	602.1	452.63	353.55	551.70	526.20	379.05	119.84	-13.17	3.30
	6/30/2000	533.5	137.3	477.6	577.9	431.58	335.40	527.75	505.55	357.60	114.27	-12.78	3.31
	9/30/2000	539.6	136.8	480.7	575.1	433.05	338.20	527.90	510.15	355.95	114.66	-12.61	3.45
	1/13/2001	571.4	169.7	522.7	611.8	468.90	370.55	567.25	547.05	390.75	124.15	-13.07	3.50
	4/20/2001	580.2	184.8	537.9	624.6	481.88	382.50	581.25	559.05	404.70	127.59	-13.21	3.46
	7/16/2001	555.8	159.1	508	598.6	455.38	357.45	553.30	531.90	378.85	120.57	-13.02	3.43
	10/9/2001	556.2	154.1	506	595.8	453.03	355.15	550.90	531.10	374.95	119.95	-13.01	3.50
	1/9/2002	572	170.3	527.3	614.7	471.08	371.15	571.00	549.65	392.50	124.73	-13.28	3.52
	4/12/2002	584.6	187.7	546.3	632.8	487.85	386.15	589.55	565.45	410.25	129.17	-13.52	3.48
	7/18/2002	559.5	162.1	516.1	606	460.93	360.80	561.05	537.80	384.05	122.04	-13.31	3.44
	10/8/2002	557	154.4	511	599.8	455.55	355.70	555.40	534.00	377.10	120.62	-13.27	3.51
26	1/8/2003	591	189.2	552.8	639	493.00	390.10	595.90	571.90	414.10	130.53	-13.68	3.54
	4/15/2003	597.9	204.3	567.5	650.5	505.05	401.10	609.00	582.70	427.40	133.72	-13.82	3.48
	7/1/2003	580.7	184.3	545.4	632.5	485.73	382.50	588.95	563.05	408.40	128.61	-13.72	3.46
	10/7/2003	578.2	176.3	538	627	479.88	377.25	582.50	558.10	401.65	127.06	-13.64	3.50
	12/31/2003	610.3	207.7	572.6	661.6	513.05	409.00	617.10	591.45	434.65	135.84	-13.83	3.51
	4/13/2004	617.1	224.2	589.5	675.7	526.63	420.65	632.60	603.30	449.95	139.43	-14.09	3.44
	7/13/2004	584	186.6	549.1	642.6	490.58	385.30	595.85	566.55	414.60	129.89	-13.99	3.40
	10/8/2004	581.8	181.2	543.7	638.3	486.25	381.50	591.00	562.75	409.75	128.74	-13.92	3.43
	1/7/2005	609.9	209	574.8	669.1	515.70	409.45	621.95	592.35	439.05	136.54	-14.12	3.43
	4/8/2005	617.5	225	590.2	683.9	529.15	421.25	637.05	603.85	454.45	140.10	-14.34	3.35
	7/18/2005	590.4	192.7	554.7	656	498.45	391.55	605.35	572.55	424.35	131.97	-14.21	3.32
	8/26/2005	584.4	183.1	544	647.8	489.83	383.75	595.90	564.20	415.45	129.69	-14.10	3.33
	10/11/2005	589.3	185.9	548.5	652	493.93	387.60	600.25	568.90	418.95	130.78	-14.13	3.36
	1/10/2006	616	216.1	582.8	683.4	524.58	416.05	633.10	599.40	449.75	138.89	-14.42	3.35
	4/9/2006	629	235.4	605.8	701.1	542.83	432.20	653.45	617.40	468.25	143.72	-14.70	3.34
	7/19/2006	595.8	199	563.1	668.3	506.55	397.40	615.70	579.45	433.65	134.12	-14.51	3.27
	10/18/2006	595.6	193	557.4	662.8	502.20	394.30	610.10	576.50	427.90	132.97	-14.34	3.33
	1/18/2007	622.2	223.4	590.2	694.6	532.60	422.80	642.40	606.20	459.00	141.02	-14.59	3.30
	4/19/2007	624.5	231.7	598.4	701.1	538.93	428.10	649.75	611.45	466.40	142.69	-14.73	3.25
	7/11/2007	594.6	199.2	561.5	670.8	506.53	396.90	616.15	578.05	435.00	134.11	-14.57	3.20
	10/20/2007	588.7	187	550.3	661.8	496.95	387.85	606.05	569.50	424.40	131.58	-14.50	3.25
	1/7/2008	619.8	219.6	589.6	697.1	531.53	419.70	643.35	604.70	458.35	140.73	-14.86	3.28
	5/13/2008	624.3	232.4	600.5	707.3	541.13	428.35	653.90	612.40	469.85	143.27	-14.99	3.19
	7/29/2008	600.8	202.7	568.1	681.9	513.38	401.75	625.00	584.45	442.30	135.93	-14.84	3.18

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	-115.0	299.7	422.9	109.6	179.30	92.35	266.25	153.95	204.65	47.47	-11.56	-1.14
	7/15/1999	-122.0	289	405.2	95.6	166.95	83.50	250.40	141.60	192.30	44.20	-11.09	-1.14
	8/15/1999	-139.4	265.8	401.5	101.8	157.43	63.20	251.65	131.05	183.80	41.68	-12.52	-1.18
	8/31/1999	-144.1	258.4	394.7	99.6	152.15	57.15	247.15	125.30	179.00	40.28	-12.63	-1.20
	9/15/1999	-144.1	255.9	395.1	102	152.23	55.90	248.55	125.50	178.95	40.30	-12.80	-1.20
	9/30/1999	-141.7	260.4	408.3	112.3	159.83	59.35	260.30	133.30	186.35	42.32	-13.35	-1.19
	10/15/1999	-138.1	275.3	441.9	138.4	179.38	68.60	290.15	151.90	206.85	47.49	-14.72	-1.23
	10/31/1999	-148.1	272.7	430.1	118.5	168.30	62.30	274.30	141.00	195.60	44.56	-14.09	-1.22
	11/15/1999	-142.3	278.9	446.6	134.9	179.53	68.30	290.75	152.15	206.90	47.53	-14.78	-1.23
	11/30/1999	-137.9	284.4	462	150.8	189.83	73.25	306.40	162.05	217.60	50.26	-15.49	-1.24
	12/15/1999	-135.4	290	463.8	152.5	192.73	77.30	308.15	164.20	221.25	51.03	-15.34	-1.28
	12/31/1999	-126.8	301.4	481.4	168.9	206.23	87.30	325.15	177.30	235.15	54.60	-15.81	-1.30
	3/31/2000	-133.9	283.1	455.7	149.6	188.63	74.60	302.65	160.90	216.35	49.94	-15.16	-1.24
	6/30/2000	-157.3	230.6	397.4	119.3	147.50	36.65	258.35	120.05	174.95	39.05	-14.73	-1.23
	9/30/2000	-142.8	237.4	427.4	156.8	169.70	47.30	292.10	142.30	197.10	44.93	-16.27	-1.23
	1/13/2001	-118.2	295.4	511.7	182.5	217.85	88.60	347.10	196.75	238.95	57.68	-17.18	-0.95
	4/20/2001	-128.9	270.9	454	163.4	189.85	71.00	308.70	162.55	217.15	50.27	-15.80	-1.22
	7/16/2001	-146.4	213.9	384.1	133.3	146.23	33.75	258.70	118.85	173.60	38.72	-14.95	-1.23
	10/9/2001	-135.7	237.5	439.4	178.3	179.88	50.90	308.85	151.85	207.90	47.63	-17.14	-1.26
	1/9/2002	-120.2	281.4	483	190.7	208.73	80.60	336.85	181.40	236.05	55.26	-17.03	-1.22
	4/12/2002	-133.2	263.6	441.1	154.2	181.43	65.20	297.65	153.95	208.90	48.04	-15.45	-1.23
	7/18/2002	-158.1	191.2	355.6	118	126.68	16.55	236.80	98.75	154.60	33.54	-14.64	-1.25
	10/7/2002	-149.2	192.4	391.7	156.3	147.80	21.60	274.00	121.25	174.35	39.13	-16.77	-1.19
1	1/8/2003	-123.2	268.7	469.3	191.8	201.65	72.75	330.55	173.05	230.25	53.39	-17.13	-1.28
	4/15/2003	-137.5	248.4	427.1	157.1	173.78	55.45	292.10	144.80	202.75	46.01	-15.73	-1.30
	7/1/2003	-159.7	183.9	351.2	124.6	125.00	12.10	237.90	95.75	154.25	33.10	-15.01	-1.31
	10/7/2003	-146.6	206.4	412.6	177.8	162.55	29.90	295.20	133.00	192.10	43.04	-17.63	-1.32
	12/31/2003	-135.4	243.4	450.4	190	187.10	54.00	320.20	157.50	216.70	49.54	-17.69	-1.33
	4/13/2004	-144.6	228.6	422.1	168	168.53	42.00	295.05	138.75	198.30	44.62	-16.82	-1.33
	7/13/2004	-179.1	155.6	334.2	117.5	107.05	-11.75	225.85	77.55	136.55	28.34	-15.79	-1.32
	10/8/2004	-169	170.9	373.7	152.9	132.13	0.95	263.30	102.35	161.90	34.98	-17.44	-1.33
	1/7/2005	-145.5	227.8	440.5	188.2	177.75	41.15	314.35	147.50	208.00	47.06	-18.16	-1.36
	4/8/2005	-159.4	209.2	398.5	148.8	149.28	24.90	273.65	119.55	179.00	39.52	-16.53	-1.33
	7/18/2005	-182.8	141.5	330.3	131.3	105.08	-20.65	230.80	73.75	136.40	27.82	-16.71	-1.40
	8/26/2005	-184	140.7	341.3	131.3	107.33	-21.65	236.30	78.65	136.00	28.42	-17.14	-1.28
	10/11/2005	-174.2	159.1	370.9	131.3	121.78	-7.55	251.10	98.35	145.20	32.24	-17.19	-1.05
	1/10/2006	-152.5	216.4	430.7	131.3	156.48	31.95	281.00	139.10	173.85	41.43	-16.55	-0.78
	4/9/2006	-157.2	206.1	413	131.3	148.30	24.45	272.15	127.90	168.70	39.27	-16.46	-0.91
	7/19/2006	-189.4	135.9	330	131.3	101.95	-26.75	230.65	70.30	133.60	26.99	-17.11	-1.42
	10/18/2006	-170.5	170.2	390.6	131.3	130.40	-0.15	260.95	110.05	150.75	34.53	-17.35	-0.91
	1/18/2007	-145.4	217.2	448.1	131.3	162.80	35.90	289.70	151.35	174.25	43.10	-16.87	-0.51
	4/19/2007	-159.2	203.2	410.4	131.3	146.43	22.00	270.85	125.60	167.25	38.77	-16.54	-0.93
	7/11/2007	-192.9	128.3	318.7	131.3	96.35	-32.30	225.00	62.90	129.80	25.51	-17.10	-1.50
	10/20/2007	-183.2	145.9	358.7	131.3	113.18	-18.65	245.00	87.75	138.60	29.97	-17.52	-1.14
	1/7/2008	-155.6	207.5	426.7	131.3	152.48	25.95	279.00	135.55	169.40	40.37	-16.82	-0.76
	5/13/2008	-172.2	170	384.2	131.3	128.33	-1.10	257.75	106.00	150.65	33.98	-17.20	-1.00
	7/29/2008	-197.5	120	328.1	131.3	95.48	-38.75	229.70	65.30	125.65	25.28	-17.84	-1.35

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	356.2	257	201.2	275.1	272.38	306.60	238.15	278.70	266.05	72.12	4.55	0.28
	7/15/1999	353.8	251.6	188.4	273.4	266.80	302.70	230.90	271.10	262.50	70.64	4.77	0.19
	8/15/1999	350.0	242.8	195.3	301.1	272.30	296.40	248.20	272.65	271.95	72.10	3.20	0.02
	8/31/1999	350.2	247.8	201.7	307.9	276.90	299.00	254.80	275.95	277.85	73.31	2.94	-0.04
	9/15/1999	349.8	249.1	203.6	314	279.13	299.45	258.80	276.70	281.55	73.90	2.70	-0.11
	9/30/1999	352.2	256.8	212.1	322.7	285.95	304.50	267.40	282.15	289.75	75.71	2.47	-0.17
	10/15/1999	352.6	257.7	225.5	337.3	293.28	305.15	281.40	289.05	297.50	77.65	1.58	-0.19
	10/31/1999	361.0	268.5	222.6	333.7	296.45	314.75	278.15	291.80	301.10	78.49	2.43	-0.21
	11/15/1999	364.5	273.1	237.1	353.6	307.08	318.80	295.35	300.80	313.35	81.30	1.56	-0.28
	11/30/1999	367.6	276.3	249.1	369.4	315.60	321.95	309.25	308.35	322.85	83.56	0.84	-0.32
	12/15/1999	370.6	280.7	248.5	364.3	316.03	325.65	306.40	309.55	322.50	83.67	1.28	-0.29
	12/31/1999	371.2	282.5	254.8	368.8	319.33	326.85	311.80	313.00	325.65	84.55	1.00	-0.28
	3/31/2000	376.0	289.2	244.7	361.1	317.75	332.60	302.90	310.35	325.15	84.13	1.97	-0.33
	6/30/2000	358.4	247.7	207.4	329.3	285.70	303.05	268.35	282.90	288.50	75.64	2.31	-0.13
	9/30/2000	357.6	235.9	230.1	366.4	297.50	296.75	298.25	293.85	301.15	78.77	-0.10	-0.16
	1/13/2001	382.0	289.5	264.4	384.8	330.18	335.75	324.60	323.20	337.15	87.42	0.74	-0.31
	4/20/2001	382.9	294.9	260.1	378.2	329.03	338.90	319.15	321.50	336.55	87.12	1.31	-0.34
	7/16/2001	352.4	249.4	219.2	330.6	287.90	300.90	274.90	285.80	290.00	76.23	1.73	-0.09
	10/9/2001	357.7	267.9	262.1	382	317.43	312.80	322.05	309.90	324.95	84.04	-0.61	-0.34
	1/9/2002	385.8	301.2	285.1	395.6	341.93	343.50	340.35	335.45	348.40	90.53	0.21	-0.29
	4/12/2002	390.9	310.2	263.2	370.1	333.60	350.55	316.65	327.05	340.15	88.33	2.25	-0.29
	7/18/2002	346.39	265.03	220.4	323.3	288.78	305.71	271.85	283.39	294.17	76.46	2.25	-0.24
	10/7/2002	344.5	265.3	252.4	363.5	306.43	304.90	307.95	298.45	314.40	81.13	-0.20	-0.36
12	1/8/2003	385.9	308.5	295.9	394.3	346.15	347.20	345.10	340.90	351.40	91.65	0.14	-0.24
	4/15/2003	392.4	317.3	275.8	371.1	339.15	354.85	323.45	334.10	344.20	89.80	2.09	-0.23
	7/1/2003	360	288.1	238.7	332.8	304.90	324.05	285.75	299.35	310.45	80.73	2.55	-0.25
	10/7/2003	357.1	284.5	277.7	372.1	322.85	320.80	324.90	317.40	328.30	85.48	-0.27	-0.24
	12/31/2003	387.7	318.7	304.1	392.5	350.75	353.20	348.30	345.90	355.60	92.87	0.33	-0.22
	4/13/2004	389.4	324.2	294.9	381.2	347.43	356.80	338.05	342.15	352.70	91.99	1.25	-0.24
	7/13/2004	348	285.8	241	324.8	299.90	316.90	282.90	294.50	305.30	79.40	2.26	-0.24
	10/8/2004	342.4	281.8	269.4	353.1	311.68	312.10	311.25	305.90	317.45	82.52	0.06	-0.26
	1/7/2005	374.1	315.2	302.9	382.8	343.75	344.65	342.85	338.50	349.00	91.01	0.12	-0.24
	4/8/2005	386.7	328.9	284.3	365	341.23	357.80	324.65	335.50	346.95	90.35	2.20	-0.26
	7/18/2005	343.2	285.5	242.4	322.1	298.30	314.35	282.25	292.80	303.80	78.98	2.13	-0.25
	8/26/2005	337	278.7	250.1	331.1	299.23	307.85	290.60	293.55	304.90	79.23	1.15	-0.25
	10/11/2005	338.7	283.6	264.1	348.6	308.75	311.15	306.35	301.40	316.10	81.75	0.32	-0.33
	1/10/2006	371.5	317.4	297	373.5	339.85	344.45	335.25	334.25	345.45	89.98	0.61	-0.25
	4/9/2006	377.4	324.1	290.6	368.2	340.08	350.75	329.40	334.00	346.15	90.04	1.42	-0.27
	7/19/2006	341.9	289.2	238.8	315.3	296.30	315.55	277.05	290.35	302.25	78.45	2.56	-0.27
	10/18/2006	342.7	289.5	274.8	354.5	315.38	316.10	314.65	308.75	322.00	83.50	0.10	-0.30
	1/18/2007	368.4	316.6	305.5	385	343.88	342.50	345.25	336.95	350.80	91.05	-0.18	-0.31
	4/19/2007	370.5	320.9	279.2	353.9	331.13	345.70	316.55	324.85	337.40	87.67	1.94	-0.28
	7/11/2007	326.6	278.1	219	294	279.43	302.35	256.50	272.80	286.05	73.98	3.05	-0.30
	10/20/2007	325.9	278.3	243.8	321.7	292.43	302.10	282.75	284.85	300.00	77.43	1.29	-0.34
	1/7/2008	359.2	310.2	282.8	353	326.30	334.70	317.90	321.00	331.60	86.39	1.12	-0.24
	5/13/2008	350.5	304.1	260.9	335.4	312.73	327.30	298.15	305.70	319.75	82.80	1.94	-0.31
	7/29/2008	325.9	281.2	234.5	305.4	286.75	303.55	269.95	280.20	293.30	75.92	2.23	-0.29

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	177.4	380.2	417.6	236.2	302.85	278.80	326.90	297.50	308.20	80.19	-3.20	-0.24
	7/15/1999	173.8	378	412.7	230.2	298.68	275.90	321.45	293.25	304.10	79.08	-3.03	-0.24
	8/15/1999	172.8	380.2	439.6	252.6	311.30	276.50	346.10	306.20	316.40	82.42	-4.63	-0.23
	8/31/1999	172.6	378	445.8	257.5	313.48	275.30	351.65	309.20	317.75	83.00	-5.07	-0.19
	9/15/1999	170.9	377.2	447.2	261	314.08	274.05	354.10	309.05	319.10	83.16	-5.32	-0.23
	9/30/1999	176.4	380.7	455.9	269.3	320.58	278.55	362.60	316.15	325.00	84.88	-5.59	-0.20
	10/15/1999	176.7	378.9	468.1	279.5	325.80	277.80	373.80	322.40	329.20	86.26	-6.38	-0.15
	10/31/1999	182.4	385.8	502.1	273.8	336.03	284.10	387.95	342.25	329.80	88.97	-6.90	0.28
	11/15/1999	186.8	392.4	482.7	292	338.48	289.60	387.35	334.75	342.20	89.62	-6.50	-0.17
	11/30/1999	189.8	396.8	638.9	305.6	382.78	293.30	472.25	414.35	351.20	101.35	-11.89	1.41
	12/15/1999	193.5	401.1	516.7	302.2	353.38	297.30	409.45	355.10	351.65	93.56	-7.45	0.08
	12/31/1999	194.7	406.1	507.2	308	354.00	300.40	407.60	350.95	357.05	93.73	-7.12	-0.14
	3/31/2000	194.8	409	492.7	298.7	348.80	301.90	395.70	343.75	353.85	92.35	-6.23	-0.23
	6/30/2000	177.7	389.4	467.2	278.7	328.25	283.55	372.95	322.45	334.05	86.91	-5.94	-0.26
	9/30/2000	174.2	385.1	496.7	308	341.00	279.65	402.35	335.45	346.55	90.29	-8.15	-0.25
	1/13/2001	200.0	418.2	530.3	318.6	366.78	309.10	424.45	365.15	368.40	97.11	-7.67	-0.07
	4/20/2001	194.1	416.2	512.8	310.6	358.43	305.15	411.70	353.45	363.40	94.90	-7.08	-0.22
	7/16/2001	166.5	386.2	469	273.8	323.88	276.35	371.40	317.75	330.00	85.75	-6.32	-0.27
	10/9/2001	171.5	389.1	514.8	315.2	347.65	280.30	415.00	343.15	352.15	92.05	-8.95	-0.20
	1/9/2002	193.6	413.6	539.3	324.6	367.78	303.60	431.95	366.45	369.10	97.38	-8.53	-0.06
	4/12/2002	198.8	418.5	509.3	299.2	356.45	308.65	404.25	354.05	358.85	94.38	-6.35	-0.11
	7/18/2002	161.4	379.1	462.4	262.6	316.38	270.25	362.50	311.90	320.85	83.77	-6.13	-0.20
	10/7/2002	155.8	373.6	686.8	301.1	379.33	264.70	493.95	421.30	337.35	100.43	-15.24	1.88
13	1/8/2003	193.1	414	547.6	331	371.43	303.55	439.30	370.35	372.50	98.34	-9.02	-0.05
	4/15/2003	195.8	419.9	560.6	305.7	370.50	307.85	433.15	378.20	362.80	98.10	-8.33	0.34
	7/1/2003	172.1	394.8	479.4	273.9	330.05	283.45	376.65	325.75	334.35	87.39	-6.19	-0.19
	10/7/2003	169	389.1	527.1	317.5	350.68	279.05	422.30	348.05	353.30	92.85	-9.52	-0.12
	12/31/2003	196.2	423.2	560.3	334.7	378.60	309.70	447.50	378.25	378.95	100.24	-9.16	-0.02
	4/13/2004	197.9	424.7	546.1	321.7	372.60	311.30	433.90	372.00	373.20	98.65	-8.15	-0.03
	7/13/2004	155.6	383.5	482.7	266.1	321.98	269.55	374.40	319.15	324.80	85.25	-6.97	-0.13
	10/8/2004	152.2	378.4	519	298.6	337.05	265.30	408.80	335.60	338.50	89.24	-9.54	-0.06
	1/7/2005	180.6	410.6	556.1	324.9	368.05	295.60	440.50	368.35	367.75	97.45	-9.63	0.01
	4/8/2005	188.3	419.5	529.1	301	359.48	303.90	415.05	358.70	360.25	95.18	-7.39	-0.03
	7/18/2005	150.7	376.8	482.9	262.2	318.15	263.75	372.55	316.80	319.50	84.24	-7.23	-0.06
	8/26/2005	144.7	373.1	494.1	275.3	321.80	258.90	384.70	319.40	324.20	85.20	-8.36	-0.11
	10/11/2005	146.5	375.2	533.7	291.5	336.73	260.85	412.60	340.10	333.35	89.15	-10.09	0.15
	1/10/2006	176	407.1	548.8	313.5	361.35	291.55	431.15	362.40	360.30	95.67	-9.28	0.05
	4/9/2006	180.6	412.1	538.7	307.8	359.80	296.35	423.25	359.65	359.95	95.26	-8.43	-0.01
	7/19/2006	149.4	377.4	480.1	259.8	316.68	263.40	369.95	314.75	318.60	83.85	-7.08	-0.09
	10/18/2006	155.2	382.8	532.6	304.1	343.68	269.00	418.35	343.90	343.45	90.99	-9.93	0.01
	1/18/2007	179.5	407.9	563.5	330.9	370.45	293.70	447.20	371.50	369.40	98.08	-10.20	0.05
	4/19/2007	182.7	413.5	536	305.6	359.45	298.10	420.80	359.35	359.55	95.17	-8.15	0.00
	7/11/2007	146.1	373.2	467.5	250.6	309.35	259.65	359.05	306.80	311.90	81.91	-6.61	-0.11
	10/20/2007	144.3	373.6	638.9	278.5	358.83	258.95	458.70	391.60	326.05	95.01	-13.28	1.47
	1/7/2008	179.2	408.8	548	312	362.00	294.00	430.00	363.60	360.40	95.85	-9.04	0.07
	5/13/2008	172.2	403.9	523.7	297.2	349.25	288.05	410.45	347.95	350.55	92.47	-8.13	-0.06
	7/29/2008	149.7	380.4	489.1	265	321.05	265.05	377.05	319.40	322.70	85.00	-7.44	-0.07

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	199.5	418.4	473.6	323.8	353.83	308.95	398.70	336.55	371.10	93.68	-5.96	-0.77
	7/15/1999	194.3	414.4	461.1	314.4	346.05	304.35	387.75	327.70	364.40	91.62	-5.54	-0.82
	8/15/1999	191.0	402.1	488.7	347.5	357.33	296.55	418.10	339.85	374.80	94.61	-8.08	-0.78
	8/31/1999	189.5	395.4	496	352.6	358.38	292.45	424.30	342.75	374.00	94.89	-8.76	-0.70
	9/15/1999	186.8	391.6	503.6	359.8	360.45	289.20	431.70	345.20	375.70	95.44	-9.47	-0.68
	9/30/1999	188.5	396.7	516	369	367.55	292.60	442.50	352.25	382.85	97.32	-9.96	-0.69
	10/15/1999	235.3	403	530.4	378.9	386.90	319.15	454.65	382.85	390.95	102.44	-9.01	-0.18
	10/31/1999	202.7	418.5	524.2	371.5	379.23	310.60	447.85	363.45	395.00	100.41	-9.12	-0.71
	11/15/1999	208.9	426.2	548.2	393.2	394.13	317.55	470.70	378.55	409.70	104.35	-10.18	-0.70
	11/30/1999	212.9	429.2	566.6	409.5	404.55	321.05	488.05	389.75	419.35	107.11	-11.10	-0.66
	12/15/1999	216.9	433.5	561.4	403.7	403.88	325.20	482.55	389.15	418.60	106.93	-10.46	-0.66
	12/31/1999	220.7	443.8	566.6	407.4	409.63	332.25	487.00	393.65	425.60	108.46	-10.28	-0.72
	3/31/2000	215.2	438.2	567.9	406.5	406.95	326.70	487.20	391.55	422.35	107.75	-10.67	-0.69
	6/30/2000	191.3	415.8	542.4	380.7	382.55	303.55	461.55	366.85	398.25	101.29	-10.50	-0.70
	6/30/2000	183.3	409.8	571	409.9	393.50	296.55	490.45	377.15	409.85	104.19	-12.89	-0.73
	1/13/2001	215.4	447.2	588.9	421.9	418.35	331.30	505.40	402.15	434.55	110.77	-11.57	-0.73
	4/20/2001	210.2	445.1	586.6	415.7	414.40	327.65	501.15	398.40	430.40	109.72	-11.53	-0.72
	7/16/2001	171.2	413	554.5	377.7	379.10	292.10	466.10	362.85	395.35	100.37	-11.56	-0.73
	10/9/2001	178.5	417.9	596.2	418.8	402.85	298.20	507.50	387.35	418.35	106.66	-13.91	-0.69
	1/9/2002	206.2	445.9	606.4	430	422.13	326.05	518.20	406.30	437.95	111.77	-12.77	-0.71
	4/12/2002	208.6	449.5	584.1	408.1	412.58	329.05	496.10	396.35	428.80	109.24	-11.10	-0.73
	7/18/2002	161.7	410.1	551.9	368.5	373.05	285.90	460.20	356.80	389.30	98.77	-11.58	-0.73
	10/7/2002	160.2	405.5	592.3	407.7	391.43	282.85	500.00	376.25	406.60	103.64	-14.43	-0.68
14	1/8/2003	202	449.1	620.2	437.7	427.25	325.55	528.95	411.10	443.40	113.12	-13.52	-0.72
	4/15/2003	205.4	453.6	590	409.8	414.70	329.50	499.90	397.70	431.70	109.80	-11.32	-0.76
	7/1/2003	171.9	426.9	559.5	377.3	383.90	299.40	468.40	365.70	402.10	101.65	-11.23	-0.82
	10/7/2003	172	424.4	600.8	422.4	404.90	298.20	511.60	386.40	423.40	107.21	-14.18	-0.83
	12/31/2003	205.6	461.3	624.2	444.9	434.00	333.45	534.55	414.90	453.10	114.91	-13.36	-0.86
	4/13/2004	204.7	463.4	611.5	433.1	428.18	334.05	522.30	408.10	448.25	113.37	-12.51	-0.90
	7/13/2004	159.6	424.2	566.4	383.7	383.48	291.90	475.05	363.00	403.95	101.53	-12.17	-0.92
	10/8/2004	153	416.8	590.5	409.5	392.45	284.90	500.00	371.75	413.15	103.91	-14.30	-0.93
	1/7/2005	192.8	454.9	627.8	446.9	430.60	323.85	537.35	410.30	450.90	114.01	-14.19	-0.91
	4/8/2005	205.2	467.5	600.9	425.2	424.70	336.35	513.05	403.05	446.35	112.45	-11.74	-0.97
	7/18/2005	154.9	424.1	560.9	385.2	381.28	289.50	473.05	357.90	404.65	100.95	-12.20	-1.05
	8/26/2005	168.3	416.1	569.1	391.2	386.18	292.20	480.15	368.70	403.65	102.25	-12.49	-0.78
	10/11/2005	152.5	418.5	590.5	413.4	393.73	285.50	501.95	371.50	415.95	104.25	-14.38	-1.00
	1/10/2006	190.7	455.4	615	436.7	424.45	323.05	525.85	402.85	446.05	112.38	-13.48	-0.97
	4/9/2006	196.7	460.2	612.3	436.6	426.45	328.45	524.45	404.50	448.40	112.91	-13.03	-0.98
	7/19/2006	159.7	426.1	562.3	382.1	382.55	292.90	472.20	361.00	404.10	101.29	-11.92	-0.97
	10/18/2006	161.9	425.9	600.5	422.5	402.70	293.90	511.50	381.20	424.20	106.62	-14.46	-0.96
	1/18/2007	192.2	454.2	638.5	460	436.23	323.20	549.25	415.35	457.10	115.50	-15.02	-0.94
	4/19/2007	198.7	462.5	611.3	432	426.13	330.60	521.65	405.00	447.25	112.83	-12.70	-0.95
	7/11/2007	149.8	419.9	567.4	379.8	379.23	284.85	473.60	358.60	399.85	100.41	-12.54	-0.92
	10/20/2007	208.9	417	590.1	409	406.25	312.95	499.55	399.50	413.00	107.56	-12.40	-0.30
	1/7/2008	194.6	460.1	617.4	439.8	427.98	327.35	528.60	406.00	449.95	113.31	-13.37	-0.98
	5/13/2008	188	455	606	431.7	420.18	321.50	518.85	397.00	443.35	111.25	-13.12	-1.04
	7/29/2008	155	428.4	572.6	394	387.50	291.70	483.30	363.80	411.20	102.60	-12.73	-1.06

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	222.2	-19.9	305.2	560	266.88	101.15	432.60	263.70	270.05	70.66	-22.03	-0.14
	7/15/1999	207.8	-36.8	294.3	540.9	251.55	85.50	417.60	251.05	252.05	66.60	-22.07	-0.02
	8/15/1999	189.9	-53.4	320.4	546.8	250.93	68.25	433.60	255.15	246.70	66.44	-24.28	0.19
	8/31/1999	184.8	-60	330.2	555.2	252.55	62.40	442.70	257.50	247.60	66.87	-25.27	0.22
	9/15/1999	185.7	-57.2	336.6	558.2	255.83	64.25	447.40	261.15	250.50	67.73	-25.46	0.24
	9/30/1999	187.5	-53.7	349.9	570.1	263.45	66.90	460.00	268.70	258.20	69.75	-26.12	0.24
	10/15/1999	195.3	-50.5	375.2	601.5	280.38	72.40	488.35	285.25	275.50	74.23	-27.64	0.22
	10/31/1999	197.3	-39.9	370.8	589.7	279.48	78.70	480.25	284.05	274.90	74.00	-26.69	0.20
	11/15/1999	202.5	-32.3	385.9	601.1	289.30	85.10	493.50	294.20	284.40	76.60	-27.14	0.22
	11/30/1999	206.5	-27.3	398.1	613.9	297.80	89.60	506.00	302.30	293.30	78.85	-27.67	0.20
	12/15/1999	216.1	-19.5	401.6	620.9	304.78	98.30	511.25	308.85	300.70	80.70	-27.44	0.18
	12/31/1999	223.8	-15	410.7	633.4	313.23	104.40	522.05	317.25	309.20	82.93	-27.76	0.18
	3/31/2000	203.5	-16	395.7	633.5	304.18	93.75	514.60	299.60	308.75	80.54	-27.97	-0.20
	6/30/2000	149.3	-41	371.2	553.8	258.33	54.15	462.50	260.25	256.40	68.40	-27.14	0.09
	6/30/2000	154.3	-22.3	411.5	580.2	280.93	66.00	495.85	282.90	278.95	74.38	-28.57	0.09
	1/13/2001	197.9	7.7	446.8	627.1	319.88	102.80	536.95	322.35	317.40	84.69	-28.85	0.11
	4/20/2001	167.6	1.3	434.9	589.5	298.33	84.45	512.20	301.25	295.40	78.99	-28.43	0.13
	7/16/2001	112.8	-20.6	409.7	555.1	264.25	46.10	482.40	261.25	267.25	69.97	-29.00	-0.13
	10/9/2001	136.9	-5.4	451.7	582.7	291.48	65.75	517.20	294.30	288.65	77.17	-30.00	0.13
	1/9/2002	176.6	9	461.6	618.2	316.35	92.80	539.90	319.10	313.60	83.76	-29.71	0.12
	4/12/2002	158.20	3.40	438	581.00	295.25	80.80	509.70	298.30	292.20	78.17	-28.50	0.14
	7/18/2002	86.10	-23.70	405	503.86	242.87	31.20	454.53	245.65	240.08	64.30	-28.13	0.12
	10/7/2002	96.1	2.90	445.20	562.80	276.75	49.50	504.00	270.65	282.85	73.28	-30.21	-0.27
26	1/8/2003	165.9	41.91	480.40	628.48	329.17	103.91	554.44	323.15	335.20	87.16	-29.94	-0.27
	4/15/2003	147.5	33.95	455.30	592.01	307.19	90.73	523.65	301.40	312.98	81.33	-28.77	-0.26
	7/1/2003	88.2	9.66	424.1	577.30	274.82	48.93	500.70	256.15	293.48	72.76	-30.02	-0.84
	10/7/2003	103.5	24.24	466.9	574.34	292.25	63.87	520.62	285.20	299.29	77.38	-30.35	-0.32
	12/31/2003	130.5	44.68	481.6	566.95	305.93	87.59	524.27	306.05	305.81	81.00	-29.02	0.01
	4/13/2004	118.2	42.08	471.6	585.31	304.30	80.14	528.45	294.90	313.69	80.57	-29.79	-0.42
	7/13/2004	49.6	8.40	430.9	548.80	259.43	29.00	489.85	240.25	278.60	68.69	-30.63	-0.86
	10/8/2004	54.7	18.19	457.3	588.15	279.59	36.45	522.72	256.00	303.17	74.03	-32.32	-1.06
	1/7/2005	108.7	42.65	486.4	597.82	308.89	75.67	542.11	297.55	320.23	81.78	-31.00	-0.51
	4/8/2005	91.7	33.99	457.3	601.47	296.12	62.85	529.39	274.50	317.73	78.40	-31.01	-0.97
	7/18/2005	28.7	12.91	432.3	605.33	269.81	20.81	518.82	230.50	309.12	71.44	-33.10	-1.76
	8/26/2005	31.4	16.85	447.8	588.39	271.11	24.13	518.10	239.60	302.62	71.78	-32.83	-1.41
	10/11/2005	43.7	14.58	464.4	588.60	277.82	29.14	526.50	254.05	301.59	73.56	-33.05	-1.06
	1/10/2006	96.3	14.58	483.8	588.60	295.82	55.44	536.20	290.05	301.59	78.32	-31.95	-0.26
	4/9/1906	87.1	29.40	477	588.60	295.52	58.25	532.80	282.05	309.00	78.25	-31.54	-0.60
	7/19/1906	18.4	-2.90	430.9	588.60	258.75	7.75	509.75	224.65	292.85	68.51	-33.36	-1.53
	10/18/1906	61.1	14.58	483.2	588.60	286.87	37.84	535.90	272.15	301.59	75.95	-33.10	-0.66
	1/18/2007	99.2	14.58	505.9	588.60	302.07	56.89	547.25	302.55	301.59	79.98	-32.59	0.02
	4/19/2007	80.5	14.58	477.1	588.60	290.19	47.54	532.85	278.80	301.59	76.83	-32.25	-0.51
	7/11/2007	11.2	14.5768	431.3	588.5957	261.42	12.89	509.95	221.25	301.59	69.22	-33.03	-1.80
	10/20/2007	19.8	14.5768	455.1	588.5957	269.52	17.19	521.85	237.45	301.59	71.36	-33.54	-1.44
	1/7/2008	82.9	14.5768	489.6	588.5957	293.92	48.74	539.10	286.25	301.59	77.82	-32.59	-0.34
	5/13/2008	44.6	14.5768	468.8	588.5957	279.14	48.74	539.10	286.25	301.59	77.82	-32.59	-0.34
	7/29/2008	0.2	14.5768	442.8	588.5957	261.54	48.74	539.10	286.25	301.59	77.82	-32.59	-0.34

Table 4 Pile Forces and Bending Moments

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	903.00	42.30	679.00	-	541.43	472.65	679.00	791.00	42.30	456.92	-73.98	99.88
	07/15/99	918.00	48.00	885.00	-	617.00	483.00	885.00	901.50	48.00	520.69	-144.12	113.86
	07/31/00	932.43	51.99	887.34	-	623.92	492.21	887.34	909.89	51.99	526.53	-141.66	114.44
	08/15/99	940.56	34.46	923.00	-	632.67	487.51	923.00	931.78	34.46	533.91	-156.13	119.70
	08/30/99	948.68	31.28	931.09	-	637.02	489.98	931.09	939.89	31.28	537.58	-158.14	121.21
	09/15/99	955.75	27.83	938.36	-	640.65	491.79	938.36	947.06	27.83	540.64	-160.10	122.62
	09/30/99	959.08	23.03	947.01	-	643.04	491.06	947.01	953.05	23.03	542.66	-163.47	124.06
	10/15/99	963.38	18.85	954.86	-	645.70	491.12	954.86	959.12	18.85	544.90	-166.26	125.43
	10/31/99	973.25	5.58	968.30	-	649.04	489.42	968.30	970.78	5.58	547.73	-171.69	128.76
	11/15/99	973.34	1.26	977.48	-	650.69	487.30	977.48	975.41	1.26	549.12	-175.74	129.95
	11/30/99	975.73	-2.84	980.87	-	651.25	486.45	980.87	978.30	-2.84	549.59	-177.26	130.88
	12/15/99	974.96	-2.47	982.11	-	651.53	486.25	982.11	978.54	-2.47	549.83	-177.77	130.87
	12/31/99	974.03	-54.00	984.71		634.91	460.02	984.71	979.37	-54.00	535.80	-188.11	137.85
	03/31/00	964.52	3.86	981.83	-	650.07	484.19	981.83	973.17	3.86	548.59	-178.41	129.31
	06/30/00	977.80	-36.92	980.73	-	640.54	470.44	980.73	979.27	-36.92	540.55	-182.94	135.56
	09/30/00	1009.20	-10.20	1005.99	-	668.33	499.50	1005.99	1007.60	-10.20	564.01	-181.58	135.77
	01/13/01	1014.12	-29.4495	1029.11	-	671.26	492.33	1029.11	1021.61	-29.45	566.48	-192.44	140.21
	04/20/01	1008.27	-18.6852	1022.57	-	670.72	494.79	1022.57	1015.42	-18.69	566.02	-189.21	137.95
	07/10/01	1030.41	-8.36772	1019.56	-	680.53	511.02	1019.56	1024.98	-8.37	574.30	-182.32	137.85
	10/09/01	1054.25	-20.5131	1038.65	-	690.80	516.87	1038.65	1046.45	-20.51	582.96	-187.07	142.33
	01/09/02	1055.96	-29.65	1045.80	-	690.70	513.15	1045.80	1050.88	-29.65	582.88	-190.96	144.14
	04/12/02	1041.9	-24.8188	1040.36	-	685.81	508.54	1040.36	1041.13	-24.82	578.76	-190.66	142.20
	07/19/02	1062.21	-17.26	1035.12	17.14	693.36	522.47	1035.12	1048.67	-17.26	585.12	-183.79	142.20
	10/08/02	1086.38	-30.07	1049.75	-6.63	702.02	528.16	1049.75	1068.06	-30.07	592.43	-187.00	146.49
1	01/08/03	1080.45	-42.89	1062.94	0.41	700.17	518.78	1062.94	1071.70	-42.89	590.87	-195.09	148.69
	04/15/03	1059.37	-29.65	1049.86	22.95	693.19	514.86	1049.86	1054.62	-29.65	584.99	-191.81	144.64
	06/01/03	1064.93	-31.16	1053.52	21.00	695.77	516.89	1053.52	1059.23	-31.16	587.16	-192.39	145.46
	08/07/03	1083.86	-27.66	1053.40	9.26	703.20	528.10	1053.40	1068.63	-27.66	593.43	-188.33	146.25
	10/07/03	1095.56	-38.67	1066.64	-0.69	707.84	528.45	1066.64	1081.10	-38.67	597.35	-192.95	149.38
	12/31/03	1100.15	-54.88	1082.97	-0.89	709.41	522.64	1082.97	1091.56	-54.88	598.68	-200.89	152.93
	04/13/04	1080.17	-43.67	1074.07	21.65	703.52	518.25	1074.07	1077.12	-43.67	593.70	-199.27	149.51
	07/13/04	1101.53	-34.89	1072.49	10.76	713.04	533.32	1072.49	1087.01	-34.89	601.74	-193.30	149.66
	10/08/04	1122.82	-45.70	1085.57	-8.86	720.90	538.56	1085.57	1104.19	-45.70	608.36	-196.11	153.40
	01/07/05	1116.60	-58.49	1097.39	-8.94	718.50	529.06	1097.39	1107.00	-58.49	606.34	-203.76	155.48
	04/08/05	1099.01	-52.77	1096.58	5.48	714.28	523.12	1096.58	1097.80	-52.77	602.78	-205.59	153.49
	07/18/05	1116.44	-41.55	1096.58	-2.36	723.82	537.44	1096.58	1106.51	-41.55	610.83	-200.46	153.15
	08/26/05	1128.14	-43.63	1095.73	-10.20	726.75	542.26	1095.73	1111.93	-43.63	613.30	-198.43	154.15
	11/12/05	1127.45	-44.76	1095.72	-9.67	726.14	541.34	1095.72	1111.58	-44.76	612.79	-198.75	154.26
	01/10/06	1129.36	-64.30	1095.72	-19.70	720.26	532.53	1095.72	1112.54	-64.30	607.83	-201.91	156.99
	04/09/06	1114.90	-55.20	1095.72	-1.14	718.47	529.85	1095.72	1105.31	-55.20	606.32	-202.87	154.81
	07/19/06	1130.94	-46.83	1095.72	-9.42	726.61	542.05	1095.72	1113.33	-46.83	613.19	-198.50	154.77
	10/18/06	1154.91	-58.29	1095.72	-27.50	730.78	548.31	1095.72	1125.32	-58.29	616.71	-196.26	157.89
	01/18/07	1139.55	-68.49	1095.72	-21.73	722.26	535.53	1095.72	1117.64	-68.49	609.52	-200.84	158.23
	04/19/07	1125.58	-58.82	1095.72	-8.49	720.83	533.38	1095.72	1110.65	-58.82	608.31	-201.61	156.01
	07/09/07	1141.38	-47.08	1095.72	-16.09	730.01	547.15	1095.72	1118.55	-47.08	616.05	-196.67	155.50
	10/20/07	1161.81	-62.03	1095.72	-36.23	731.84	549.89	1095.72	1128.77	-62.03	617.60	-195.69	158.85
	01/07/08	1155.60	-68.08	1095.72	-28.03	727.75	543.76	1095.72	1125.66	-68.08	614.15	-197.89	159.24
	05/13/08	1100.48	-46.92	1095.72	7.39	716.43	526.78	1095.72	1098.10	-46.92	604.59	-203.97	152.75
	07/29/08	1116.32	-42.12	1095.72	-2.07	723.31	537.10	1095.72	1106.02	-42.12	610.40	-200.27	153.16

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	575.00	589.00	243.00	-	469.00	582.00	243.00	409.00	589.00	395.79	121.54	-24.01
	07/15/99	585.00	602.00	237.00	-	474.67	593.50	237.00	411.00	602.00	400.57	127.81	-25.48
	07/30/99	594.35	611.17	230.68	-	478.73	602.76	230.68	412.52	611.17	404.00	133.40	-26.50
	08/15/99	596.87	611.09	242.58	336.68	446.81	603.98	289.63	419.73	473.89	377.06	112.70	-7.22
	08/31/99	601.58	616.82	241.00	-	486.47	609.20	241.00	421.29	616.82	410.53	132.00	-26.08
	09/15/99	605.96	622.42	240.47	-	489.62	614.19	240.47	423.22	622.42	413.19	133.98	-26.57
	09/30/99	609.62	624.20	240.71	336.98	452.88	616.91	288.85	425.17	480.59	382.18	117.62	-7.39
	10/15/99	612.87	629.40	240.27	336.21	454.69	621.14	288.24	426.57	482.81	383.71	119.35	-7.50
	10/31/99	616.45	631.80	243.11	336.29	456.91	624.13	289.70	429.78	484.05	385.59	119.90	-7.24
	11/15/99	619.54	632.45	245.83	337.79	458.90	626.00	291.81	432.69	485.12	387.27	119.81	-6.99
	11/30/99	623.35	635.58	248.71	340.31	461.99	629.47	294.51	436.03	487.95	389.87	120.09	-6.93
	12/15/99	624.21	637.77	247.77	339.95	462.43	630.99	293.86	435.99	488.86	390.24	120.87	-7.05
	12/31/99	626.60	640.86	249.37	341.45	464.57	633.73	295.41	437.99	491.16	392.05	121.29	-7.09
	03/31/00	634.53	648.30	254.69	346.89	471.10	641.41	300.79	444.61	497.60	397.56	122.12	-7.07
	06/30/00	640.05	652.80	250.99	342.06	471.48	646.43	296.53	445.52	497.43	397.88	125.44	-6.93
	09/30/00	647.16	661.13	247.62	336.78	473.17	654.14	292.20	447.39	498.96	399.31	129.76	-6.88
	01/13/01	654.063	665.1119	256.39	342.22	479.45	659.59	299.31	455.23	503.67	404.61	129.16	-6.46
	04/20/01	654.429	664.7057	260.37	345.47	481.25	659.57	302.92	457.40	505.09	406.12	127.86	-6.36
	07/10/01	661.456	672.0985	256.15	342.75	483.11	666.78	299.45	458.80	507.43	407.70	131.69	-6.49
	10/09/01	668.361	679.0039	251.93	338.20	484.37	673.68	295.06	460.14	508.60	408.76	135.74	-6.46
	01/09/02	671.083	683.4721	252.17	337.92	486.16	677.28	295.04	461.63	510.69	410.27	137.04	-6.55
	04/12/02	669.17	680.02	256.68	342.06	486.98	674.60	299.37	462.93	511.04	410.96	134.52	-6.42
	07/19/02	671.69	683.96	253.27	272.93	470.46	677.83	263.10	462.48	478.44	397.02	148.69	-2.13
	10/08/02	678.60	692.21	247.01	332.37	487.54	685.40	289.69	462.80	512.29	411.44	141.87	-6.60
17	01/08/03	678.44	689.32	251.28	334.22	488.31	683.88	292.75	464.86	511.77	412.09	140.22	-6.26
	04/15/03	679.45	692.45	254.73	341.09	491.93	685.95	297.91	467.09	516.77	415.14	139.12	-6.63
	06/01/03	678.76	689.85	256.43	341.09	491.53	684.30	298.76	467.60	515.47	414.80	138.22	-6.39
	08/07/03	682.33	695.54	251.15	336.74	491.44	688.94	293.95	466.74	516.14	414.73	141.61	-6.59
	10/07/03	686.23	700.57	250.14	334.87	492.95	693.40	292.50	468.19	517.72	416.00	143.73	-6.61
	12/31/03	689.48	700.61	257.04	341.05	497.05	695.05	299.04	473.26	520.83	419.46	141.97	-6.35
	04/13/04	689.24	699.88	260.70	346.65	499.12	694.56	303.68	474.97	523.27	421.21	140.14	-6.44
	07/13/04	693.10	667.59	255.46	341.33	489.37	680.34	298.39	474.28	504.46	412.98	136.93	-4.03
	10/08/04	699.03	710.89	250.83	337.39	499.53	704.96	294.11	474.93	524.14	421.56	147.30	-6.56
	01/07/05	699.07	711.46	253.31	339.95	500.95	705.26	296.63	476.19	525.70	422.75	146.50	-6.61
	04/08/05	696.43	708.09	257.94	343.81	501.57	702.26	300.87	477.18	525.95	423.27	143.90	-6.51
	07/18/05	699.56	708.33	253.71	338.36	499.99	703.94	296.04	476.64	523.35	421.94	146.24	-6.23
	08/26/05	702.04	711.17	250.91	335.97	500.02	706.61	293.44	476.47	523.57	421.97	148.13	-6.28
	11/12/05	701.95	699.60	251.68	337.06	497.57	700.78	294.37	476.82	518.33	419.90	145.70	-5.54
	01/10/06	705.16	715.03	253.47	339.58	503.31	710.10	296.53	479.32	527.31	424.75	148.27	-6.40
	04/09/06	703.94	713.04	259.52	343.20	504.93	708.49	301.36	481.73	528.12	426.11	145.96	-6.19
	07/19/06	708.37	716.01	256.84	339.95	505.29	712.19	298.39	482.61	527.98	426.42	148.35	-6.05
	10/18/06	713.29	721.25	251.76	334.02	505.08	717.27	292.89	482.52	527.63	426.24	152.14	-6.02
	01/18/07	712.84	717.96	256.52	336.54	505.96	715.40	296.53	484.68	527.25	426.98	150.17	-5.68
	04/19/07	711.13	716.21	260.62	340.56	507.13	713.67	300.59	485.88	528.38	427.97	148.10	-5.67
	07/09/07	713.04	716.74	255.22	334.18	504.79	714.89	294.70	484.13	525.46	426.00	150.64	-5.51
	10/20/07	715.97	721.74	250.87	329.51	504.52	718.85	290.19	483.42	525.62	425.77	153.68	-5.63
	01/07/08	719.26	723.93	256.47	335.12	508.69	721.59	295.79	487.87	529.52	429.29	152.65	-5.56
	05/13/08	696.51	707.19	257.94	343.56	501.30	701.85	300.75	477.22	525.38	423.05	143.80	-6.42
	07/29/08	699.96	696.80	254.77	339.30	497.71	698.38	297.03	477.37	518.05	420.01	143.89	-5.43

Table 4 Pile Forces and Bending Moments (cont'd)

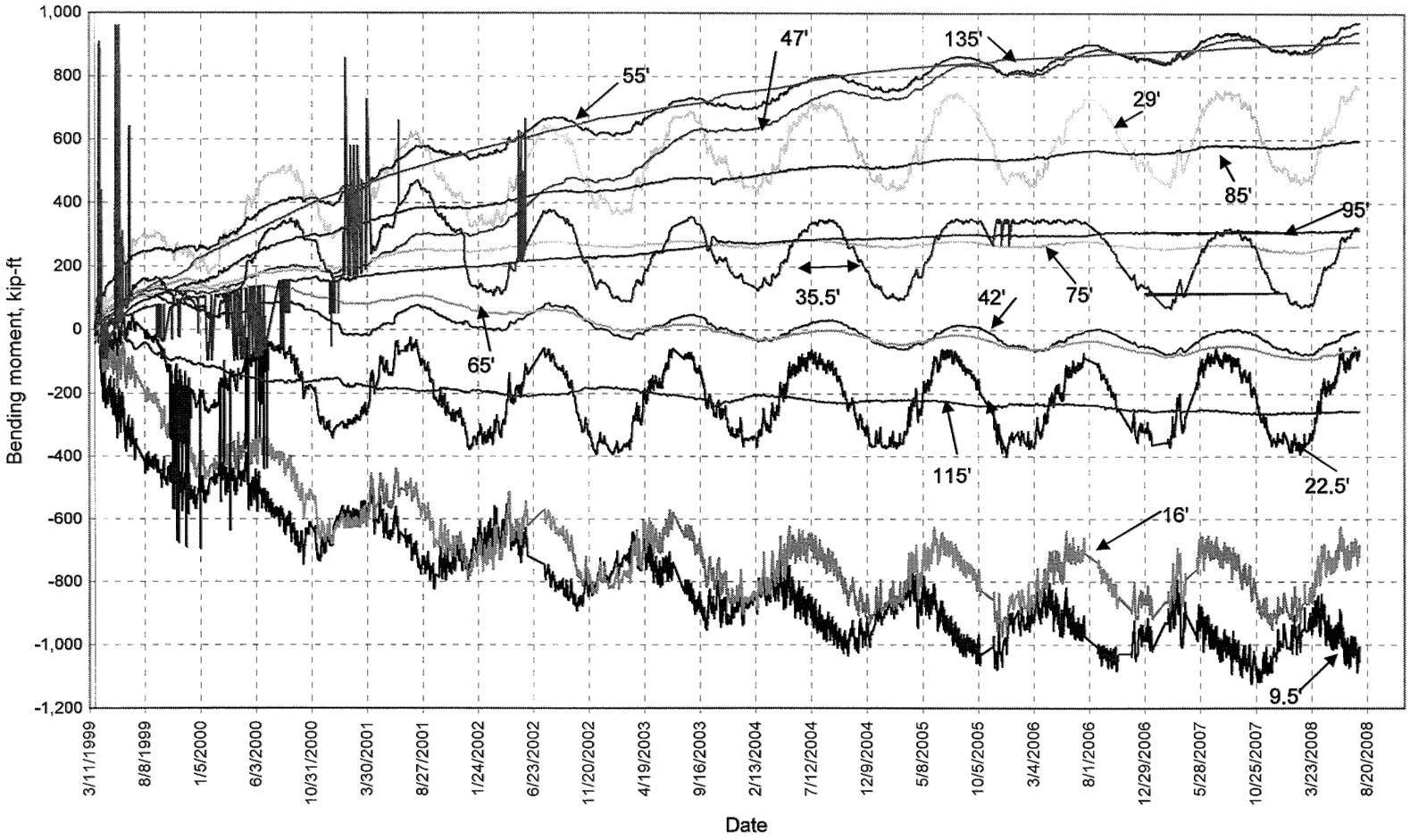
Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	546.00	501.00	248.00	173	367.00	523.50	210.50	397.00	337.00	309.71	112.21	8.00
	07/15/99	557.00	513.00	243.00	229	385.50	535.00	236.00	400.00	371.00	325.32	107.20	3.87
	07/30/99	565.55	519.94	239.54	224.26	387.32	542.75	231.90	402.55	372.10	326.86	111.44	4.06
	08/15/99	567.71	520.14	230.56	232.51	387.73	543.93	231.54	399.14	376.33	327.21	112.00	3.04
	08/31/99	573.72	526.52	247.46	232.87	395.14	550.12	240.17	410.59	379.70	333.46	111.12	4.12
	09/15/99	578.06	532.08	246.65	233.61	397.60	555.07	240.13	412.36	382.85	335.53	112.91	3.94
	09/30/99	582.49	534.97	247.46	234.05	399.74	558.73	240.76	414.98	384.51	337.34	114.00	4.06
	10/15/99	586.68	538.17	247.25	235.23	401.83	562.43	241.24	416.97	386.70	339.11	115.15	4.04
	10/31/99	590.77	539.40	249.37	235.6	403.79	565.09	242.49	420.07	387.50	340.75	115.66	4.34
	11/15/99	592.65	540.65	251.68	237.47	405.61	566.65	244.58	422.17	389.06	342.30	115.47	4.42
	11/30/99	596.63	527.25	254.12	239.69	404.42	561.94	246.91	425.38	383.47	341.29	112.94	5.59
	12/15/99	599.47	545.53	254.12	239.05	409.54	572.50	246.59	426.80	392.29	345.61	116.84	4.60
	12/31/99	601.54	548.45	255.38	239.17	411.14	575.00	247.28	428.46	393.81	346.96	117.49	4.62
	03/31/00	610.32	554.87	262.08	243.60	417.72	582.59	252.84	436.20	399.23	352.51	118.22	4.93
	06/30/00	616.94	539.60	260.98	238.93	414.11	578.27	249.96	438.96	389.26	349.47	117.70	6.63
	09/30/00	625.63	400.76	255.58	232.18	378.54	513.19	243.88	440.61	316.47	319.45	96.55	16.56
	01/13/01	632.372	566.6896	264.44	235.84	424.83	599.53	250.14	448.40	401.26	358.52	125.26	6.29
	04/20/01	632.575	561.5309	268.38	236.21	424.67	597.05	252.29	450.48	398.87	358.38	123.60	6.88
	07/10/01	639.684	569.2893	264.64	234.54	427.04	604.49	249.59	452.16	401.91	360.38	127.23	6.70
	10/09/01	646.508	576.5197	259.81	232.14	428.74	611.51	245.97	453.16	404.33	361.82	131.05	6.51
	01/09/02	650.895	576.8446	259.68	230.92	429.59	613.87	245.30	455.29	403.88	362.53	132.14	6.86
	04/12/02	650.123	570.1017	264.192	232.55	429.24	610.11	248.37	457.16	401.33	362.24	129.69	7.45
	07/19/02	653.45	572.46	260.90	226.38	428.30	612.96	243.64	457.18	399.42	361.44	132.40	7.71
	10/08/02	659.69	581.14	254.65	222.68	429.54	620.41	238.66	457.17	401.91	362.49	136.86	7.37
18	01/08/03	657.76	576.89	257.57	224.47	429.17	617.32	241.02	457.67	400.68	362.18	134.91	7.60
	04/15/03	661.78	576.19	262.16	228.04	432.04	618.99	245.10	461.97	402.12	364.60	134.04	7.98
	06/01/03	661.37	572.66	264.07	227.59	431.43	617.02	245.83	462.72	400.13	364.08	133.07	8.35
	08/07/03	665.76	577.29	258.18	222.76	431.00	621.53	240.47	461.97	400.03	363.72	136.61	8.26
	10/07/03	669.26	582.73	256.11	222.56	432.66	625.99	239.33	462.68	402.65	365.13	138.62	8.01
	12/31/03	670.27	581.39	262.53	229.62	435.95	625.83	246.08	466.40	405.51	367.90	136.15	8.12
	04/13/04	669.42	576.64	266.47	232.35	436.22	623.03	249.41	467.94	404.49	368.12	133.95	8.46
	07/13/04	672.95	578.63	261.80	224.79	434.54	625.79	243.29	467.37	401.71	366.71	137.13	8.76
	10/08/04	677.95	587.12	255.42	222.31	435.70	632.53	238.87	466.68	404.72	367.69	141.14	8.27
	01/07/05	677.50	586.02	257.61	226.05	436.80	631.76	241.83	467.56	406.04	368.61	139.80	8.21
	04/08/05	674.17	580.83	263.14	227.80	436.48	627.50	245.47	468.65	404.31	368.35	136.96	8.58
	07/18/05	677.87	580.70	259.40	221.74	434.93	629.29	240.57	468.63	401.22	367.04	139.36	8.99
	08/26/05	679.25	583.30	256.27	219.43	434.56	631.28	237.85	467.76	401.37	366.73	141.05	8.86
	11/12/05	679.13	583.14	256.88	220.08	434.81	631.13	238.48	468.00	401.61	366.93	140.77	8.86
	01/10/06	679.45	587.32	257.33	223.00	436.78	633.39	240.17	468.39	405.16	368.60	140.97	8.43
	04/09/06	679.57	583.14	263.01	226.46	438.05	631.36	244.74	471.29	404.80	369.67	138.61	8.87
	07/19/06	683.27	585.78	260.94	222.31	438.08	634.53	241.63	472.11	404.05	369.69	140.86	9.08
	10/18/06	687.01	592.40	255.09	218.66	438.29	639.70	236.88	471.05	405.53	369.87	144.42	8.74
	01/18/07	685.10	588.58	259.16	221.83	438.67	636.84	240.49	472.13	405.20	370.19	142.10	8.93
	04/19/07	685.18	584.40	264.40	222.96	439.23	634.79	243.68	474.79	403.68	370.67	140.22	9.49
	07/09/07	687.74	584.85	259.24	215.85	436.92	636.29	237.55	473.49	400.35	368.72	142.96	9.76
	10/20/07	690.01	591.22	253.79	213.46	437.12	640.62	233.63	471.90	402.34	368.89	145.91	9.28
	01/07/08	691.80	593.86	258.30	218.94	440.73	642.83	238.62	475.05	406.40	371.93	144.91	9.16
	05/13/08	675.23	578.71	263.42	226.74	436.03	626.97	245.08	469.32	402.73	367.96	136.91	8.88
	07/29/08	678.03	580.70	259.97	222.03	435.18	629.37	241.00	469.00	401.37	367.25	139.23	9.02

Table 4 Pile Forces and Bending Moments (cont'd)

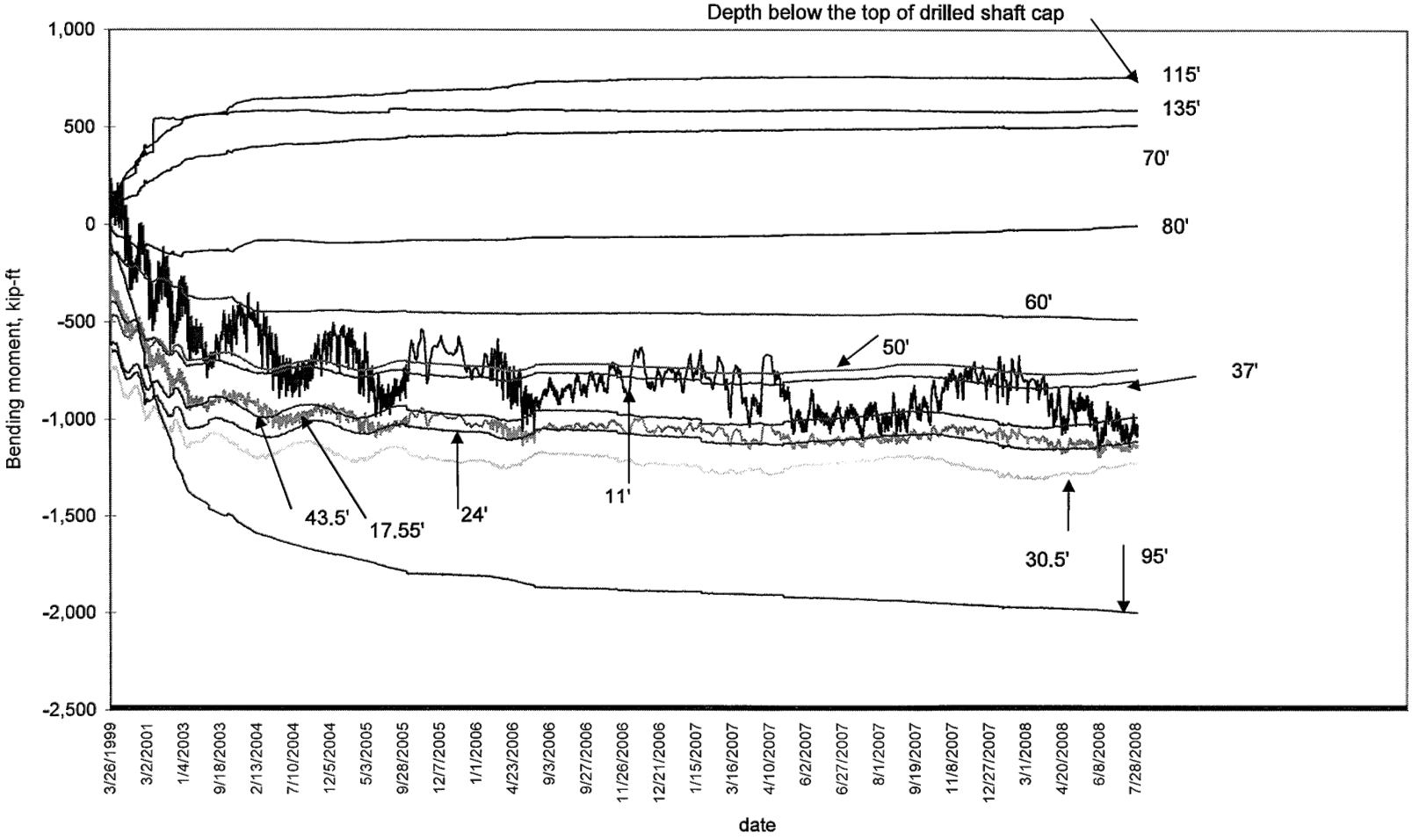
Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	566.97	586.00	298.00	228.9	419.97	576.49	263.45	432.49	407.45	354.41	112.23	3.34
	07/15/99	580.00	597.00	294.00	224	423.75	588.50	259.00	437.00	410.50	357.60	118.13	3.54
	07/30/99	588.71	606.46	291.38	218.62	426.29	597.59	255.00	440.05	412.54	359.75	122.82	3.67
	08/15/99	591.02	607.35	300.95	227.92	431.81	599.19	264.44	445.99	417.64	364.40	120.01	3.78
	08/31/99	595.94	613.52	300.59	229.63	434.92	604.73	265.11	448.27	421.58	367.03	121.76	3.56
	09/15/99	599.88	617.91	300.67	229.54	437.00	608.90	265.11	450.28	423.73	368.78	123.25	3.54
	09/30/99	603.53	621.65	302.70	229.75	439.41	612.59	266.23	453.12	425.70	370.82	124.18	3.66
	10/15/99	607.51	625.02	302.29	229.71	441.13	616.27	266.00	454.90	427.37	372.27	125.57	3.67
	10/31/99	611.37	627.25	306.07	229.7	443.60	619.31	267.89	458.72	428.48	374.35	125.99	4.03
	11/15/99	613.61	627.78	308.31	232.67	445.59	620.70	270.49	460.96	430.23	376.04	125.55	4.10
	11/30/99	616.29	630.54	313.83	234.7	448.84	623.42	274.27	465.06	432.62	378.78	125.17	4.33
	12/15/99	617.83	631.44	314.03	234.9	449.55	624.64	274.47	465.93	433.17	379.38	125.54	4.37
	12/31/99	619.94	634.20	314.36	236.45	451.24	627.07	275.41	467.15	435.33	380.80	126.08	4.25
	03/31/00	629.45	639.44	320.33	239.74	457.24	634.44	280.03	474.89	439.59	385.86	127.06	4.71
	06/30/00	636.15	643.50	317.81	51.91	412.34	639.83	184.86	476.98	347.71	347.98	163.11	17.25
	09/30/00	646.59	651.99	312.33	231.29	460.55	649.29	271.81	479.46	441.64	388.66	135.33	5.04
	01/13/01	653.454	657.0691	320.21	236.77	466.88	655.26	278.49	486.83	446.92	394.00	135.08	5.32
	04/20/01	651.464	653.2102	324.03	237.42	466.53	652.34	280.72	487.74	445.32	393.71	133.23	5.66
	07/10/01	658.856	661.1717	320.61	235.03	468.92	660.01	277.82	489.74	448.10	395.72	137.02	5.55
	10/09/01	667.346	669.2551	315.37	230.97	470.74	668.30	273.17	491.36	450.11	397.25	141.66	5.50
	01/09/02	670.88	671.7736	315.66	229.71	472.00	671.33	272.68	493.27	450.74	398.32	142.92	5.67
	04/12/02	667.71	665.64	321.06	231.62	471.51	666.68	276.34	494.39	448.63	397.90	139.94	6.10
	07/19/02	673.44	667.87	319.88	227.72	472.23	670.66	273.80	496.66	447.79	398.51	142.28	6.52
	10/08/02	681.93	676.18	313.24	222.91	473.56	679.05	268.07	497.58	449.54	399.64	147.34	6.41
19	01/08/03	682.42	673.60	316.88	225.03	474.48	678.01	270.96	499.65	449.32	400.42	145.93	6.71
	04/15/03	686.11	672.95	321.26	228.37	477.17	679.53	274.81	503.69	450.66	402.69	145.10	7.07
	06/01/03	685.30	670.80	322.48	227.84	476.60	678.05	275.16	503.89	449.32	402.21	144.44	7.28
	08/07/03	689.12	675.35	317.28	223.09	476.21	682.23	270.18	503.20	449.22	401.87	147.72	7.20
	10/07/03	694.48	681.03	314.64	222.27	478.11	687.76	268.46	504.56	451.65	403.47	150.32	7.06
	12/31/03	695.94	680.95	322.73	229.34	482.24	688.45	276.03	509.33	455.15	406.96	147.86	7.23
	04/13/04	695.62	676.77	330.77	231.41	483.64	686.19	281.09	513.19	454.09	408.15	145.23	7.88
	07/13/04	700.37	679.61	327.88	224.22	483.02	689.99	276.05	514.13	451.92	407.62	148.40	8.30
	10/08/04	706.18	688.67	321.87	221.22	484.48	697.43	271.54	514.03	454.94	408.86	152.68	7.88
	01/07/05	705.37	688.14	324.72	224.55	485.69	696.75	274.63	515.04	456.35	409.88	151.34	7.83
	04/08/05	702.85	682.86	329.75	226.66	485.53	692.86	278.21	516.30	454.76	409.74	148.66	8.21
	07/18/05	706.50	683.55	327.15	219.55	484.19	695.03	273.35	516.83	451.55	408.61	151.18	8.71
	08/26/05	708.05	686.48	322.81	217.89	483.80	697.26	270.35	515.43	452.18	408.28	153.05	8.44
	11/12/05	707.97	686.27	323.74	218.33	484.08	697.12	271.04	515.85	452.30	408.51	152.76	8.48
	01/10/06	710.04	690.54	324.68	221.62	486.72	700.29	273.15	517.36	456.08	410.74	153.13	8.17
	04/09/06	709.47	686.72	329.75	224.34	487.57	698.10	277.05	519.61	455.53	411.46	150.95	8.55
	07/19/06	714.26	690.38	328.09	220.57	488.32	702.32	274.33	521.17	455.47	412.10	153.44	8.76
	10/18/06	718.93	696.80	321.91	216.75	488.60	707.86	269.33	520.42	456.77	412.33	157.22	8.49
	01/18/07	717.19	692.98	326.63	219.88	489.17	705.08	273.25	521.91	456.43	412.81	154.82	8.73
	04/19/07	716.98	689.52	331.50	221.54	489.89	703.25	276.52	524.24	455.53	413.42	152.99	9.17
	07/09/07	720.64	690.13	327.60	214.47	488.21	705.39	271.04	524.12	452.30	412.00	155.72	9.58
	10/20/07	723.97	695.70	321.18	211.96	488.20	709.83	266.57	522.58	453.83	411.99	158.92	9.17
	01/07/08	725.43	698.46	326.71	217.89	492.12	711.95	272.30	526.07	458.17	415.30	157.62	9.06
	05/13/08	703.58	681.44	330.20	225.12	485.08	692.51	277.66	516.89	453.28	409.36	148.73	8.49
	7/29/2008	706.585	683.7565	327.56	220.079	484.50	695.17	273.82	517.07	451.92	408.87	151.06	8.69

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	271.75	436.00	261.00	583.00	387.94	353.88	422.00	266.38	509.50	327.38	-24.42	-32.43
	07/15/99	279.00	617.00	253.00	583.00	433.00	448.00	418.00	266.00	600.00	365.41	10.76	-44.56
	07/30/99	282.79	647.00	243.64	585.13	439.64	464.90	414.39	263.22	616.07	371.01	18.11	-47.07
	08/15/99	272.89	690.09	251.16	614.66	457.20	481.49	432.91	262.03	652.38	385.83	17.42	-52.07
	08/31/99	265.66	576.80	245.14	627.09	428.67	421.23	436.12	255.40	601.95	361.76	-5.34	-46.23
	09/15/99	265.08	802.81	242.34	635.26	486.37	533.95	438.80	253.71	719.04	410.45	34.11	-62.07
	09/30/99	260.50	807.40	238.64	642.65	487.30	533.95	440.65	249.57	725.03	411.23	33.45	-63.43
	10/15/99	256.43	811.14	234.46	648.58	487.65	533.79	441.52	245.45	729.86	411.53	33.08	-64.62
	10/31/99	240.47	824.02	221.62	665.31	487.86	532.25	443.47	231.05	744.67	411.70	31.83	-68.52
	11/15/99	241.93	831.45	224.75	676.77	493.73	536.69	450.76	233.34	754.11	416.65	30.81	-69.47
	11/31/99	240.47	835.88	224.26	648.85	487.37	538.18	436.56	232.37	742.37	411.29	36.43	-68.03
	12/15/99	241.41	836.77	222.35	684.04	496.14	539.09	453.20	231.88	760.41	418.69	30.79	-70.51
	12/31/99	242.22	836.08	224.14	684.93	496.84	539.15	454.54	233.18	760.51	419.29	30.34	-70.35
	03/31/00	257.37	828.85	237.38	675.92	499.88	543.11	456.65	247.38	752.38	421.85	31.00	-67.37
	06/30/00	266.43	846.32	225.20	500.93	459.72	556.37	363.06	245.81	673.62	387.96	69.30	-57.07
	09/30/00	257.37	895.02	196.89	705.00	513.57	576.19	450.94	227.13	800.01	433.40	44.90	-76.42
	01/13/01	247.90	856.11	197.37	729.58	507.74	552.01	463.47	222.64	792.84	428.48	31.74	-76.07
	04/20/01	44.66	883.01	212.28	457.21	399.29	463.83	334.74	128.47	670.11	336.96	46.28	-72.25
	07/10/01	-279.94	502.86	204.24	66.21	123.34	111.46	135.22	-37.85	284.53	104.09	-8.52	-43.01
	10/09/01	442.16	725.37	50.98	1199.89	604.60	583.76	625.44	246.57	962.63	510.22	-14.94	-95.52
	01/09/02	263.63	616.73	159.27	765.05	451.17	440.18	462.16	211.45	690.89	380.74	-7.88	-63.96
	04/12/02	67.35	579.97	58.13	501.01	301.61	323.66	279.57	62.74	540.49	254.53	15.81	-63.73
	07/19/02	288.69	941.04	187.83	727.59	536.29	614.86	457.71	238.26	834.31	452.57	56.34	-79.51
	10/08/02	277.15	962.54	162.58	740.98	535.81	619.84	451.78	219.86	851.76	452.17	60.25	-84.29
34	01/08/03	256.07	949.53	162.24	758.66	531.62	602.80	460.45	209.15	854.10	448.64	51.04	-86.04
	04/15/03	277.19	928.37	189.53	744.52	534.90	602.78	467.03	233.36	836.45	451.41	48.67	-80.45
	06/01/03	277.96	939.01	184.90	749.68	537.89	608.49	467.29	231.43	844.35	453.93	50.62	-81.76
	08/07/03	288.69	965.09	171.66	750.09	543.88	626.89	460.87	230.17	857.59	458.98	59.52	-83.70
	10/07/03	274.96	978.21	155.53	762.84	542.89	626.58	459.19	215.25	870.53	458.14	60.01	-87.41
	12/31/03	258.26	983.57	156.83	795.22	548.47	620.92	476.03	207.55	889.40	462.86	51.95	-90.96
	04/13/04	281.17	960.30	188.88	781.65	553.00	620.73	485.27	235.03	870.97	466.68	48.57	-84.84
	07/13/04	302.86	991.98	173.93	772.27	560.26	647.42	473.10	238.40	882.12	472.80	62.50	-85.87
	10/08/04	295.63	1004.49	151.19	786.40	559.43	650.06	468.80	223.41	895.45	472.10	64.99	-89.65
	01/07/05	277.35	997.91	148.79	798.02	555.52	637.63	473.41	213.07	897.97	468.80	58.88	-91.36
	04/08/05	286.74	978.21	166.99	788.76	555.17	632.47	477.87	226.86	883.49	468.51	55.43	-87.59
	07/18/05	304.00	1000.02	160.94	783.60	562.14	652.01	472.27	232.47	891.81	474.39	64.44	-87.96
	08/26/05	301.85	1018.4	147.73	791.81	564.94	660.12	469.77	224.79	905.09	476.76	68.24	-90.75
	11/12/05	300.51	1018.3	147.82	793.35	564.99	659.40	470.58	224.16	905.83	476.80	67.70	-90.93
	01/10/06	274.59	1009.41	138.15	808.34	557.62	642.00	473.24	206.37	908.87	470.58	60.50	-93.71
	04/09/06	283.04	986.09	160.45	798.02	556.90	634.57	479.23	221.74	892.06	469.97	55.69	-89.42
	07/19/06	295.67	1009.41	149.73	796.56	562.84	652.54	473.14	222.70	902.98	474.98	64.32	-90.75
	10/18/06	284.79	1030.77	131.20	808.38	563.79	657.78	469.79	207.99	919.58	475.78	67.40	-94.92
	01/18/07	270.29	1012.82	134.82	813.33	557.81	641.55	474.08	202.55	913.08	470.74	60.04	-94.78
	04/19/07	282.35	996.04	153.99	805.37	559.44	639.20	479.68	218.17	900.71	472.11	57.19	-91.05
	07/09/07	306.44	1014.48	154.64	795.38	567.74	660.46	475.01	230.54	904.93	479.11	66.49	-89.96
	10/20/07	290.51	1037.35	126.69	809.72	566.07	663.93	468.21	208.60	923.54	477.71	70.17	-95.37
	01/07/08	274.06	1024.92	128.89	820.48	562.09	649.49	474.69	201.48	922.70	474.35	62.67	-96.21
	05/13/08	292.26	978.90	169.79	784.94	556.47	635.58	477.37	231.03	881.92	469.61	56.72	-86.83
	07/29/08	302.98	1000.19	160.94	784.58	562.17	651.59	472.76	231.96	892.38	474.42	64.11	-88.10



Shaft #1, Bending moment vs. date in different elevations below the top of cap



Shaft #9, Bending moment vs. date in different elevations below the top of cap

Shaft 1: Bending moment along shaft, kip-ft

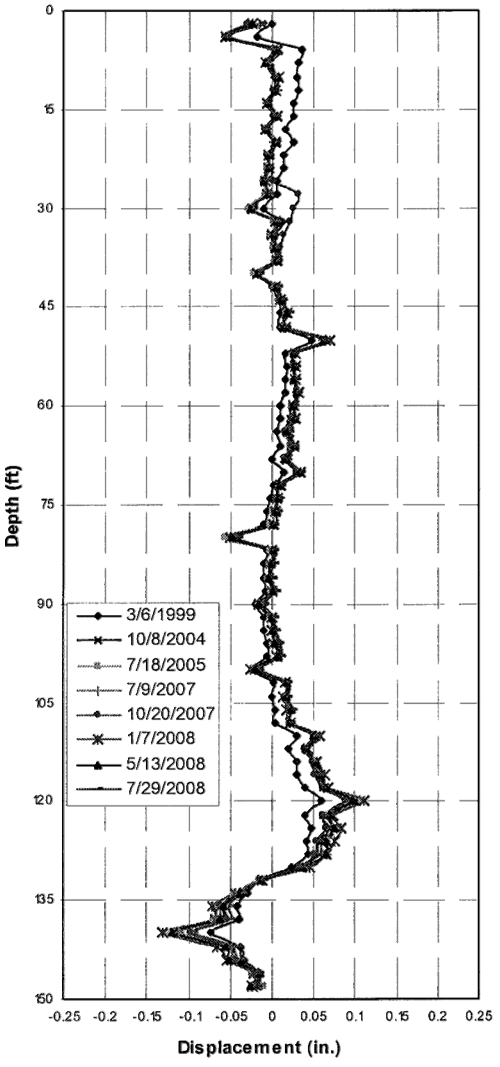
Depth, ft / Date	9.5	16	22.5	29	35.5	42	47	54.8	64.8	74.8	84.8	94.8	115	135
7/1/1999	-357.65	-148.91	-2.99	242.13	107.23	94.27	103.67	221.87	109.32	92.67	66.77	48.25	-38.94	91.57
1/8/2003	-774.82	-792.9	-360.63	403.12	139.71	-1.79	473.87	620.31	11.19	262.65	439.51	230.65	-179.6	668.9
4/15/2003	-657.74	-650	-232.57	481.71	156.43	-14.02	517.65	659.68	2.44	268.91	457.85	238.57	-192.49	684.79
7/1/2003	-763.24	-602.42	-72.91	660.28	319.17	32.14	588.57	715.87	14.21	278.09	474.99	251.23	-206	702.94
8/7/2003	-817.04	-638.73	-81.08	678	343.79	44.44	615.09	726.92	17.44	279.15	477.58	254.31	-210.32	708.78
10/7/2003	-913.81	-801.08	-248.05	552.54	251.84	20.93	623.3	710.92	6.8	271.9	474.43	265.38	-225.46	720.58
12/31/2003	-870.9	-838.68	-322.24	476.14	168.18	-13.93	630.87	701.76	-19.51	263.35	479.49	275.24	-220.96	748.57
4/13/2004	-831.87	-777.37	-255.87	514.98	175.37	-24.83	659.66	727.03	-27.47	269.67	495.81	277.88	-211.65	763.52
7/13/2004	-889.99	-676.85	-77.13	709.38	338.24	22.05	727.23	792.27	-5.75	281.7	512.3	283.5	-221.34	787.54
10/8/2004	-983.05	-812	-201.66	636.33	293	16.71	752.87	793.14	-7.37	272.19	514.89	286.68	-231.1	803.15
1/7/2005	-925.21	-882.29	-353.38	471.75	139.59	-39.87	733.05	761.38	-34.6	264.1	510.62	288.64	-223.06	817.18
4/8/2005	-775.03	-726	-235.05	530.47	150.69	-53.27	749.88	786.67	-40.37	267.3	525.48	290.73	-219.8	828.14
7/18/2005	-957.73	-709.43	-81.75	735.77	338.65	7.97	821.52	856.49	-16.82	278.53	538.72	298.79	-226.87	837.24
8/26/2005	-1005.57	-755.34	-117.03	721.71	336.36	13.6	835.13	860.64	-16.18	278.76	539.43	301.65	-233.64	840.82
10/11/2005	-1033.08	-827.24	-199.79	654.9	284.17	7.2946	833.72	848.04	-26.29	273.5	537.36	299.33	-240.08	843.25
1/10/2006	-918.83	-858.03	-339.71	489.13	122.55	-48.55	810.18	815.92	-54.94	262.93	536.1	298.82	-234.11	855.77
4/9/2006	-901.14	-812	-289.67	510.35	123.88	-55.75	815.9	831.32	-58.19	267.19	540.25	311.97	-239.53	860
7/19/2006	-975.46	-709.09	-86.84	727.21	303.99	-3.19	876.46	899.71	-33.29	280.02	563.21	306.55	-235.87	865.96
10/18/2006	-1030.45	-848.40	-245.88	609.17	218.59	-17.57	872.05	872.96	-49.65	267.05	557.80	306.95	-246.77	873.58
1/18/2007	-1015.18	-915.62	-363.79	485.63	115.44	-53.84	856.23	849.07	-71.01	257.71	555.06	310.45	-258.05	878.10
4/19/2007	-904.71	-791.93	-272.27	527.72	122.40	-65.28	862.30	869.52	-74.95	259.50	564.85	305.74	-254.07	882.60
7/11/2007	-990.93	-694.73	-72.44	749.91	312.39	-2.99	910.88	934.53	-49.88	269.47	582.93	306.29	-251.96	888.31
10/20/2007	-1018.74	-786.18	-177.53	678.23	265.08	-13.72	915.47	922.26	-57.70	265.45	581.36	309.85	-259.55	895.13
1/7/2008	-932.03	-833.86	-321.36	513.46	112.58	-59.96	880.84	888.07	-82.44	252.01	576.25	309.48	-259.33	899.85
5/13/2008	-996.59	-767.07	-192.33	624.95	201.21	-38.80	905.64	926.40	-76.11	259.32	583.95	312.62	-259.90	906.34
7/29/2008	-1053.77	-718.38	-76.47	765.95	324.25	-0.78	940.74	969.80	-60.05	264.41	595.70	316.01	-256.75	910.18

Shaft 9: Bending moment along shaft, kip-ft

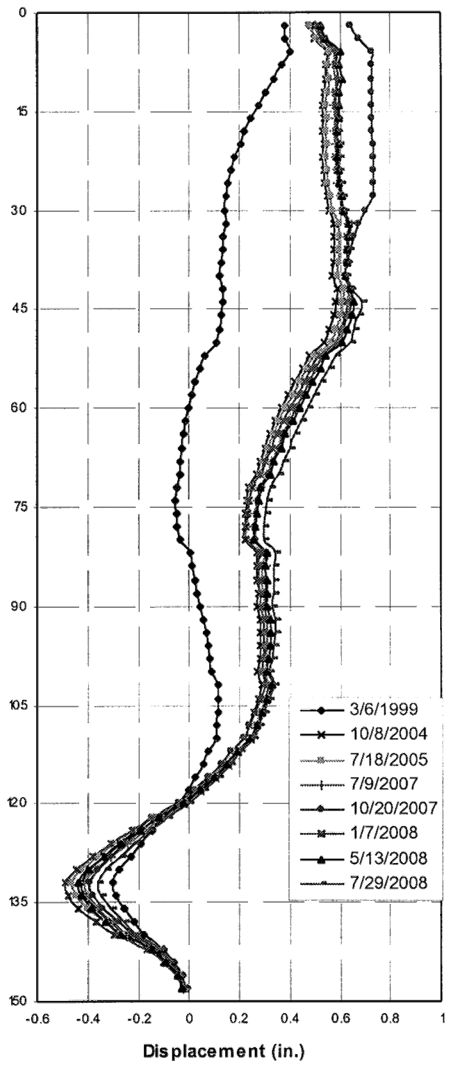
Depth, ft / Date	11	17.5	24	30.5	37	43.25	50	60	70	80	95	115	135
7/1/1999	-67.89	-31.81	8.56	12.84	20.8	19.57	14.07	0.61	9.79	11.62	-33.33	18.35	26.3
1/8/2003	-347.44	-803.74	-998.93	-1106.33	-698.39	-903.77	-661.43	-353.18	324.27	-148.11	-1315.52	540.06	541.35
4/15/2003	-592.31	-919.8	-1050.61	-1133.34	-723.59	-939.66	-696.63	-369.12	336.59	-143.51	-1378.77	555.2	549.67
7/1/2003	-666.55	-902.38	-1016.77	-1090.93	-713.88	-914.42	-686.74	-395.16	340.01	-144.29	-1435.98	557.09	553.5
8/7/2003	-687.84	-917.2	-1003.18	-1072.98	-695.58	-886.87	-664.36	-384.64	352	-133.3	-1462.27	566.15	565.69
10/7/2003	-490.45	-863.81	-1007.81	-1107.14	-708.81	-891.63	-656.83	-378.93	360.91	-134.77	-1498.83	577.44	567.18
12/31/2003	-514.68	-913.27	-1054.9	-1163.2	-741.63	-949.18	-697.72	-421.12	390.01	-101.42	-1555.5	633.83	579.35
4/13/2004	-604.44	-966.22	-1090.5	-1188	-761.54	-987.22	-743.54	-446.54	402.54	-82.56	-1609.1	644.77	582.97
7/13/2004	-817.01	-1007.24	-1051.35	-1122.59	-730.91	-933.53	-709.92	-447.66	411.36	-83.06	-1648.19	649.1	585.94
10/8/2004	-674.74	-949.72	-1005.93	-1128.49	-732.6	-927.74	-697.54	-445.16	413.37	-90.78	-1677.71	652.24	581.64
1/7/2005	-572.76	-951.94	-1036.44	-1183	-760.9	-966.49	-718.51	-441.27	424.15	-94.18	-1699.91	657.05	573.07
4/8/2005	-773.86	-1039.72	-1072.89	-1200.56	-775.89	-989.82	-743.85	-446.59	435.56	-92.57	-1726.57	664.45	574.55
7/18/2005	-885.57	-1041.08	-1038.29	-1152.24	-752.36	-948.63	-719.09	-449.39	438.06	-89.12	-1762.02	670.82	576.24
8/26/2005	-835.5	-1020.01	-1028.45	-1146.98	-746.96	-933.35	-702.48	-447.31	442.02	-86.41	-1773.96	672.92	595.07
10/11/2005	-749.53	-997.4	-1026.45	-1157.47	-750.11	-932.26	-695.29	-445.61	446.57	-84.01	-1786.07	677.93	594.21
1/10/2006	-735.54	-1025.94	-1070.26	-1220.95	-784.71	-983.06	-728.35	-455.6	455.8	-79.41	-1811.1	694.94	585.21
4/9/2006	-761.63	-1055.46	-1104.66	-1250.13	-799.79	-1009.4	-750.25	-456.86	465.33	-75.95	-1830.39	709.25	584.13
7/19/2006	-986.65	-1097.57	-1069.44	-1182.51	-765.49	-967.32	-726.98	-458.20	468.35	-67.36	-1860.26	728.74	591.17
10/18/2006	-785.55	-1028.56	-1059.04	-1198.03	-770.44	-962.79	-714.95	-455.21	472.24	-63.08	-1878.38	742.33	587.52
1/18/2007	-652.26	-1012.08	-1093.82	-1249.92	-798.31	-1001.31	-738.72	-453.20	481.92	-62.15	-1891.06	749.16	583.45
4/19/2007	-878.81	-1101.41	-1131.14	-1269.03	-817.30	-1023.35	-760.98	-458.74	484.61	-55.95	-1908.23	757.20	587.07
7/11/2007	-1020.68	-1113.23	-1096.67	-1211.04	-787.54	-982.11	-738.79	-463.61	490.76	-47.79	-1930.33	760.68	591.55
10/20/2007	-959.39	-1084.45	-1073.44	-1199.41	-780.45	-961.01	-714.61	-460.69	495.15	-40.84	-1949.93	755.58	587.47
1/7/2008	-913.31	-1106.23	-1119.18	-1262.45	-816.00	-1007.26	-741.89	-466.44	500.87	-33.08	-1965.87	755.43	582.76
5/13/2008	-919.37	-1116.30	-1144.79	-1275.67	-828.86	-1025.45	-760.98	-473.48	501.61	-23.44	-1981.23	753.14	584.24
7/29/2008	-1028.17	-1130.81	-1113.35	-1223.79	-801.01	-987.62	-739.09	-483.79	512.25	-5.89	-2001.20	757.38	590.22

Inclinometer #1 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

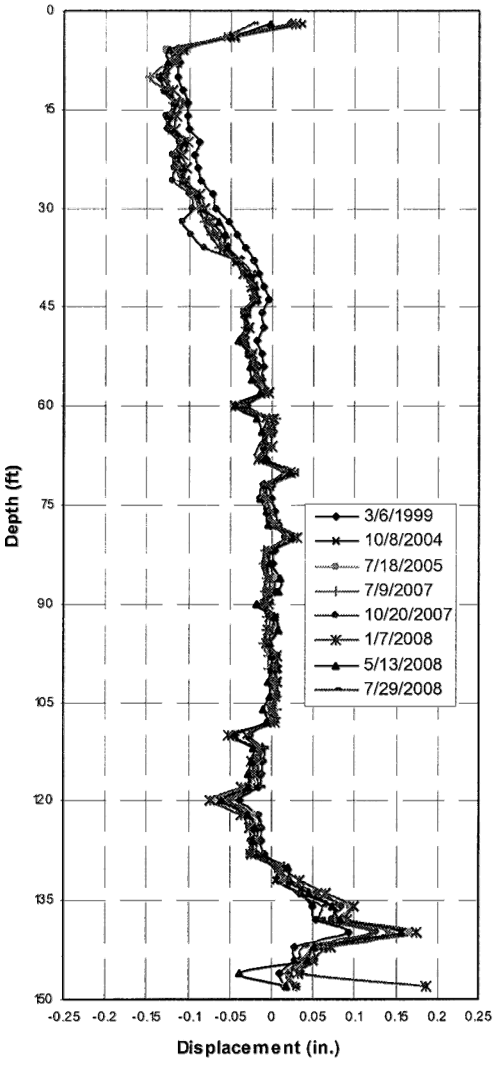


Cumulative



Inclinometer #1 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



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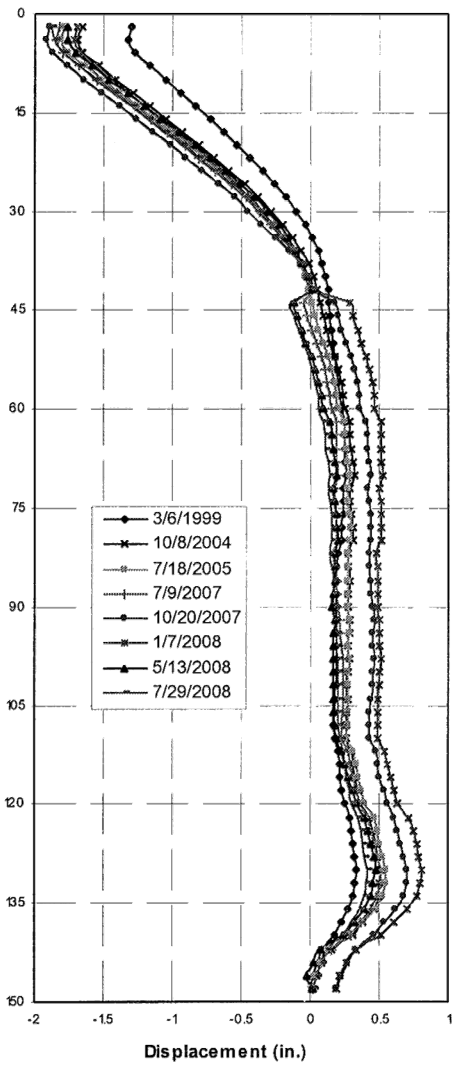
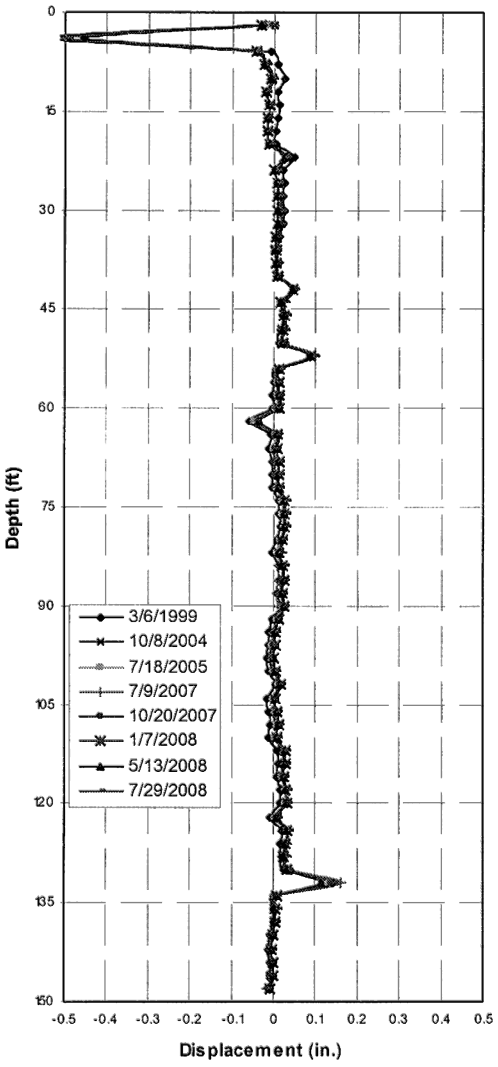


Inclinometer #3 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental



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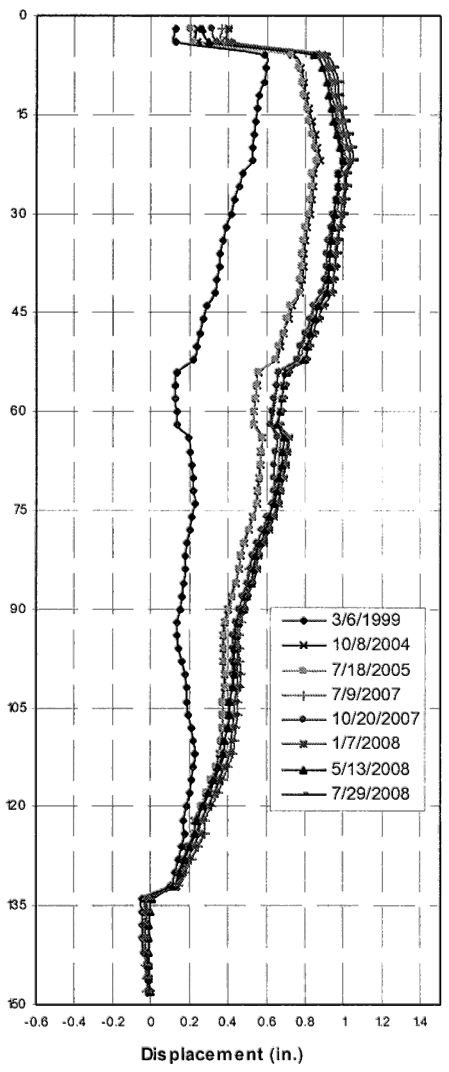
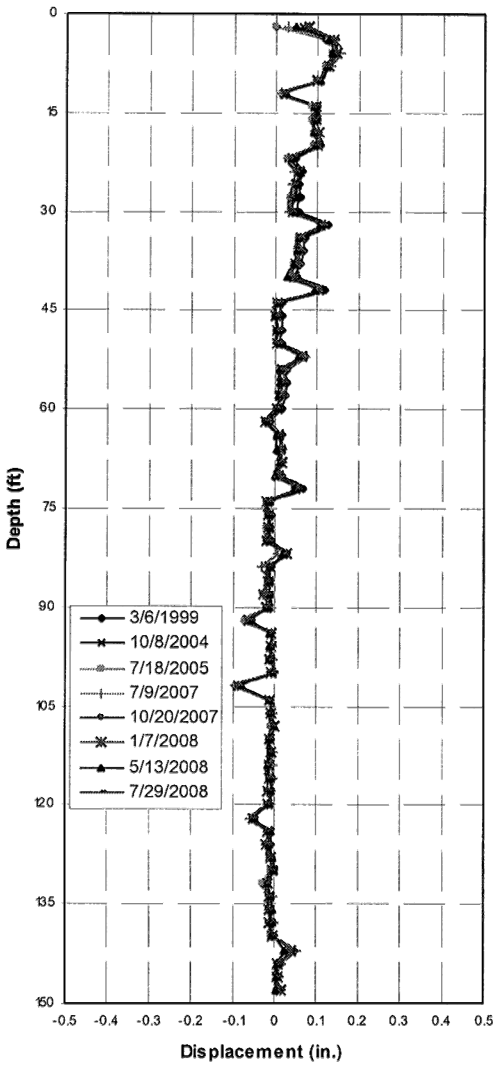
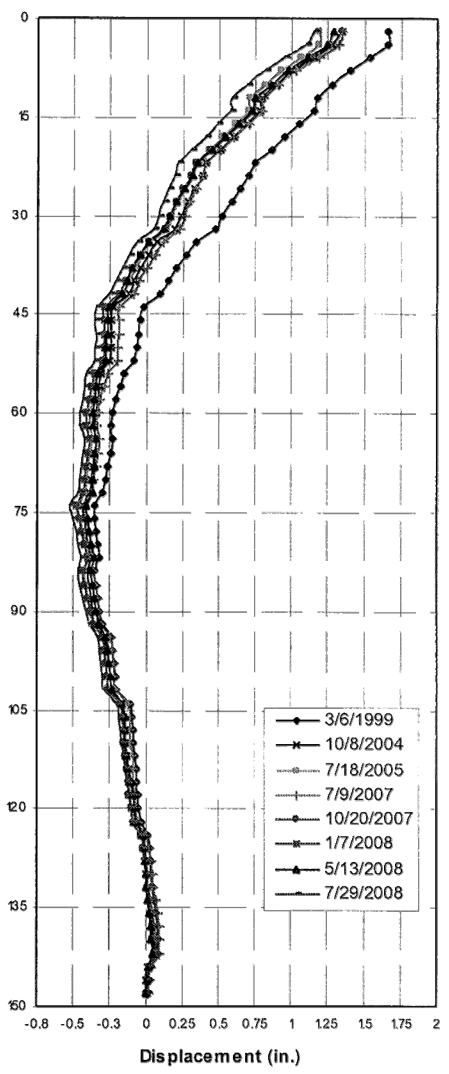


Inclinometer #3 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

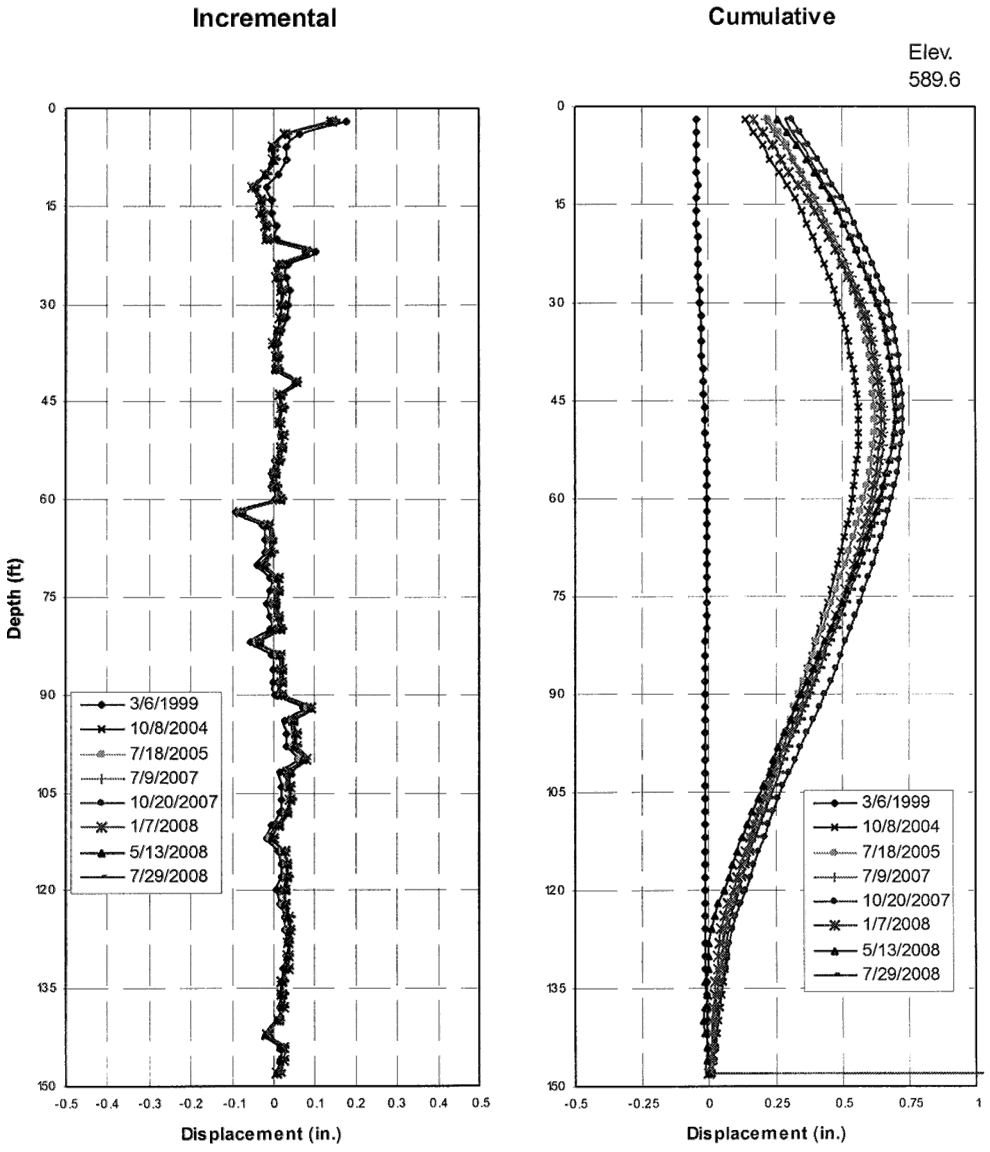
Incremental



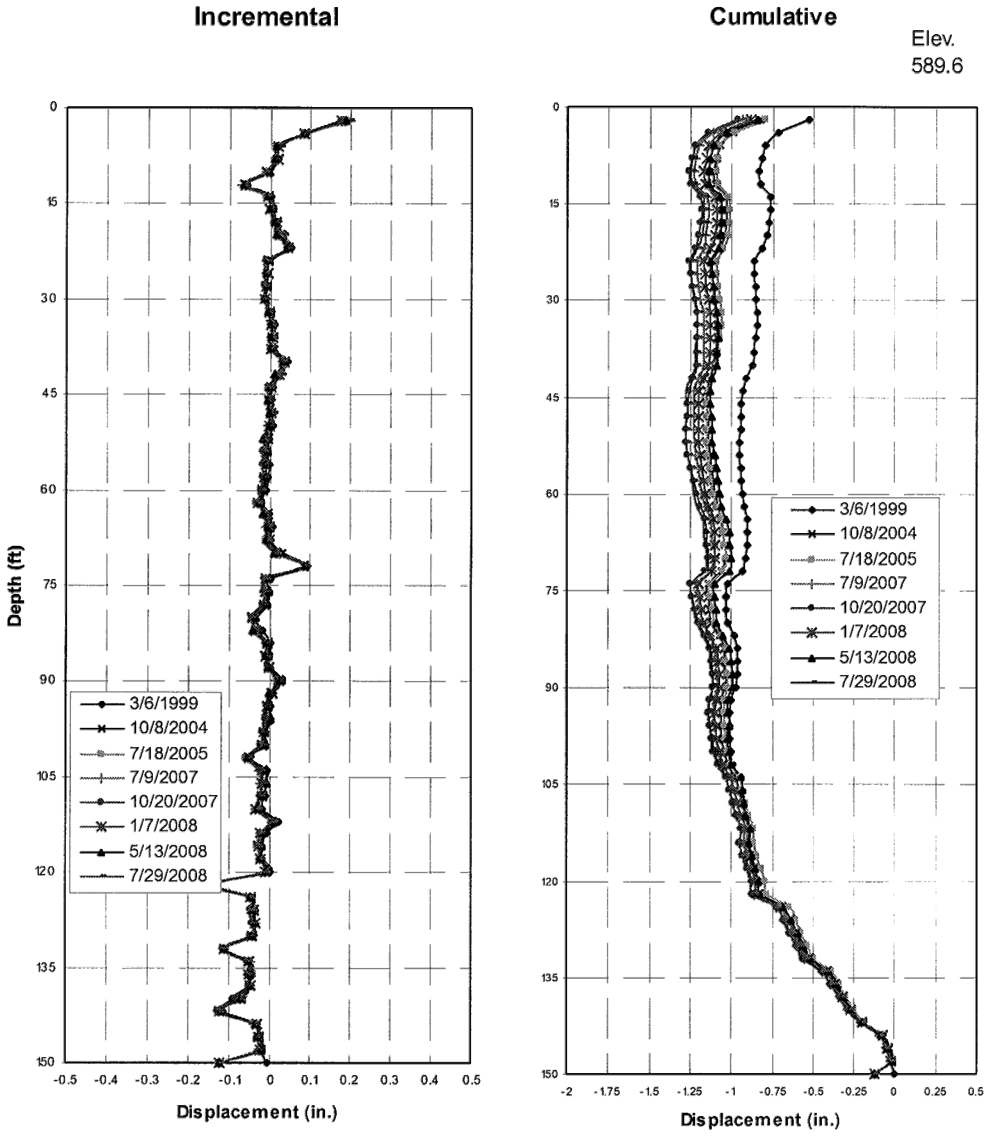
Cumulative



Inclinometer #8 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

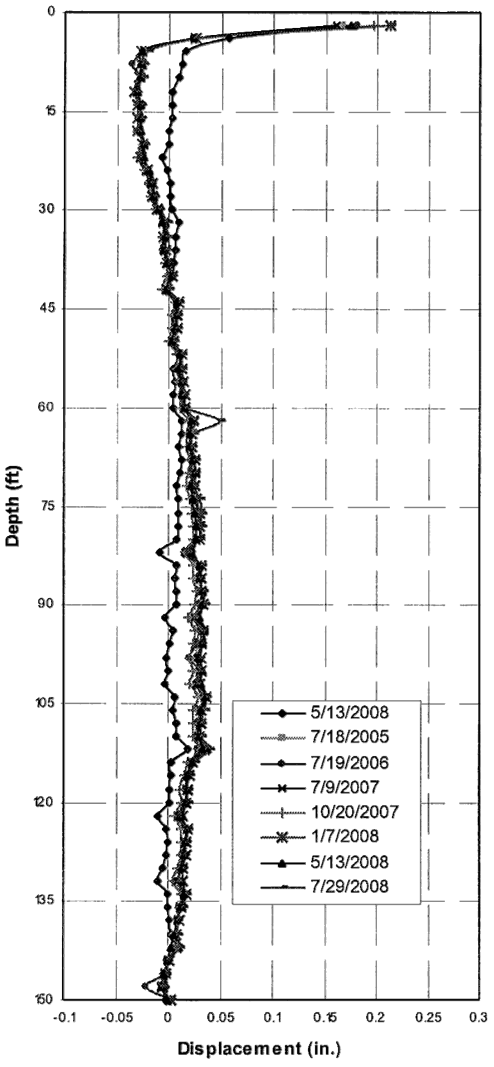


Inclinometer #8 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

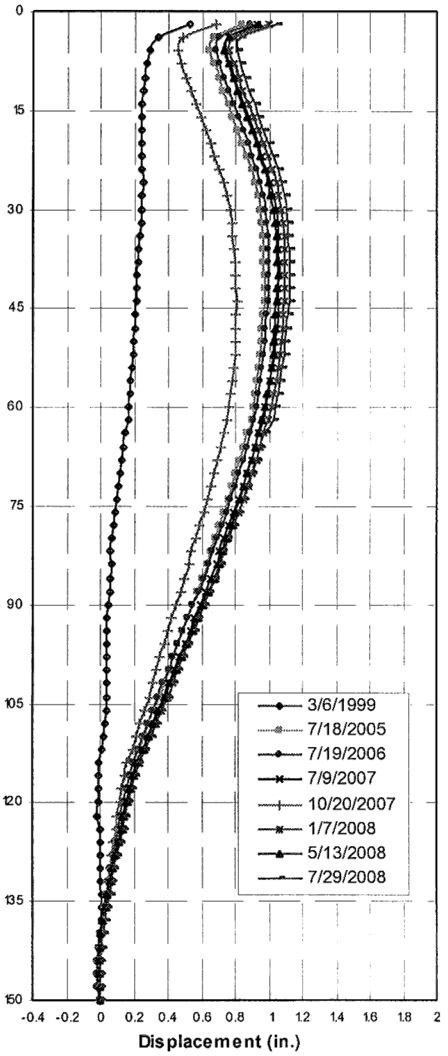


Inclinometer #9A Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

Incremental

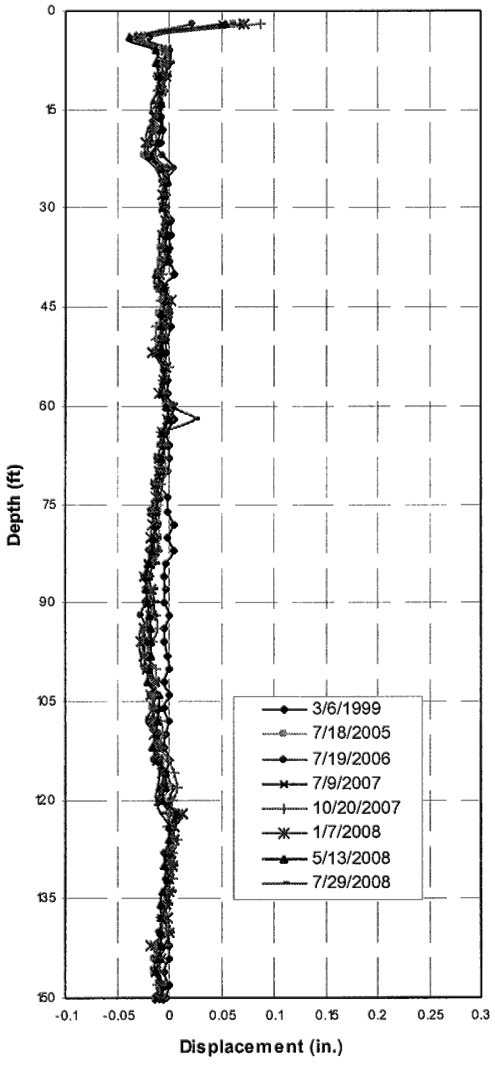


Cumulative

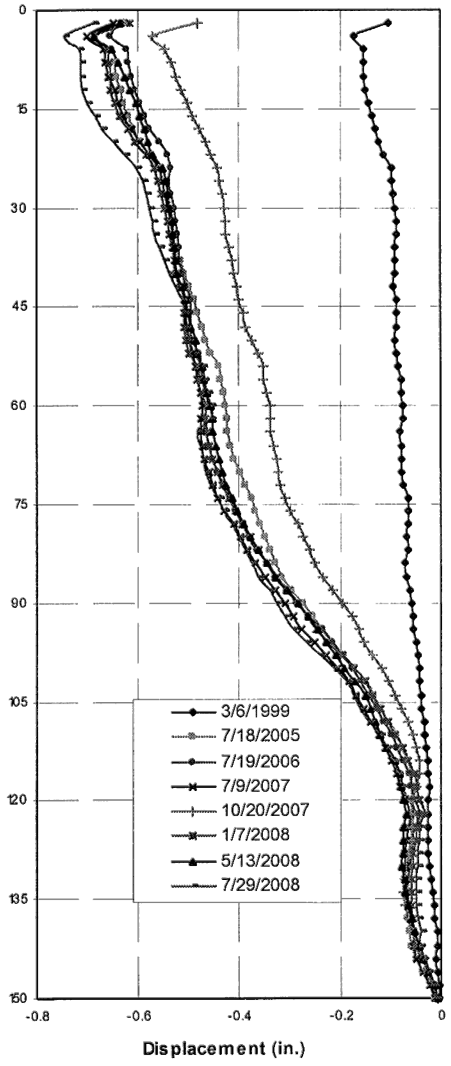


Inclinometer #9A Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

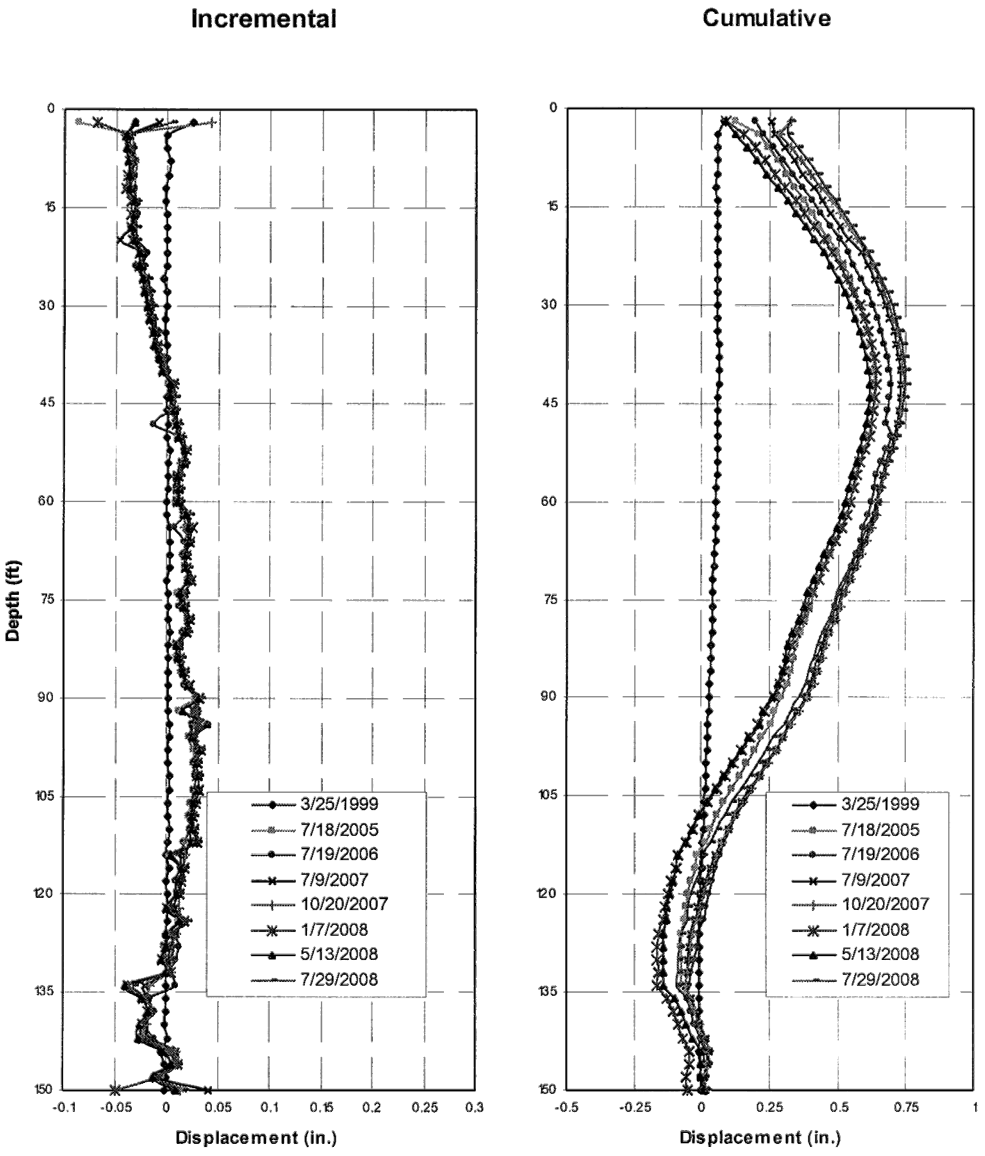
Incremental



Cumulative

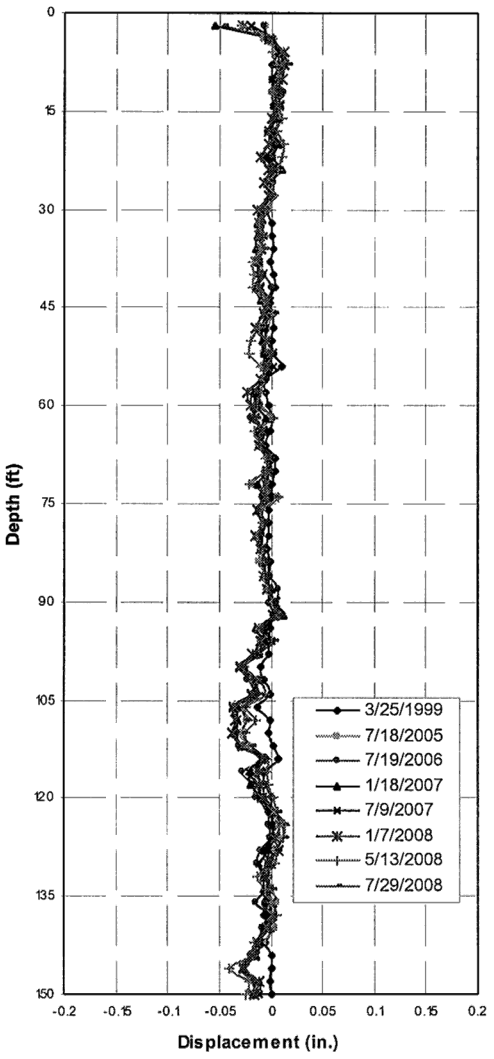


Inclinometer #10 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998

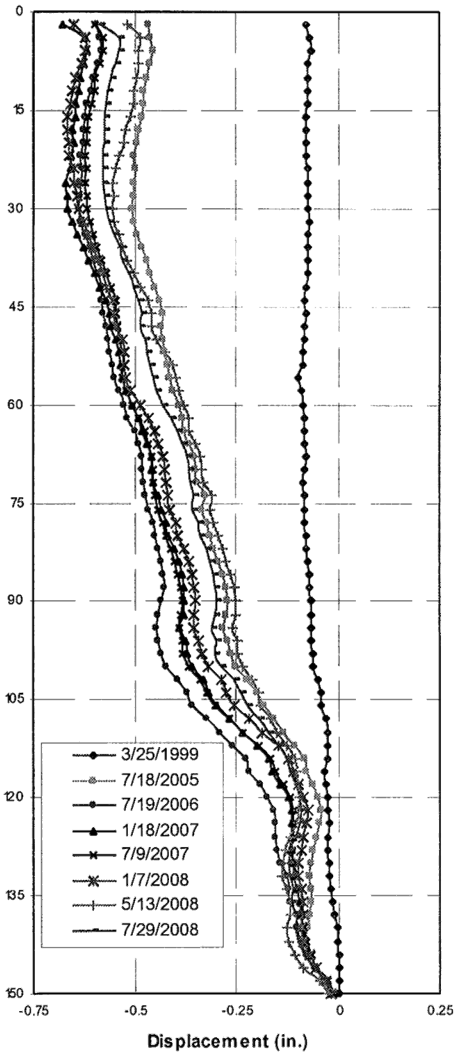


Inclinometer #10 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998

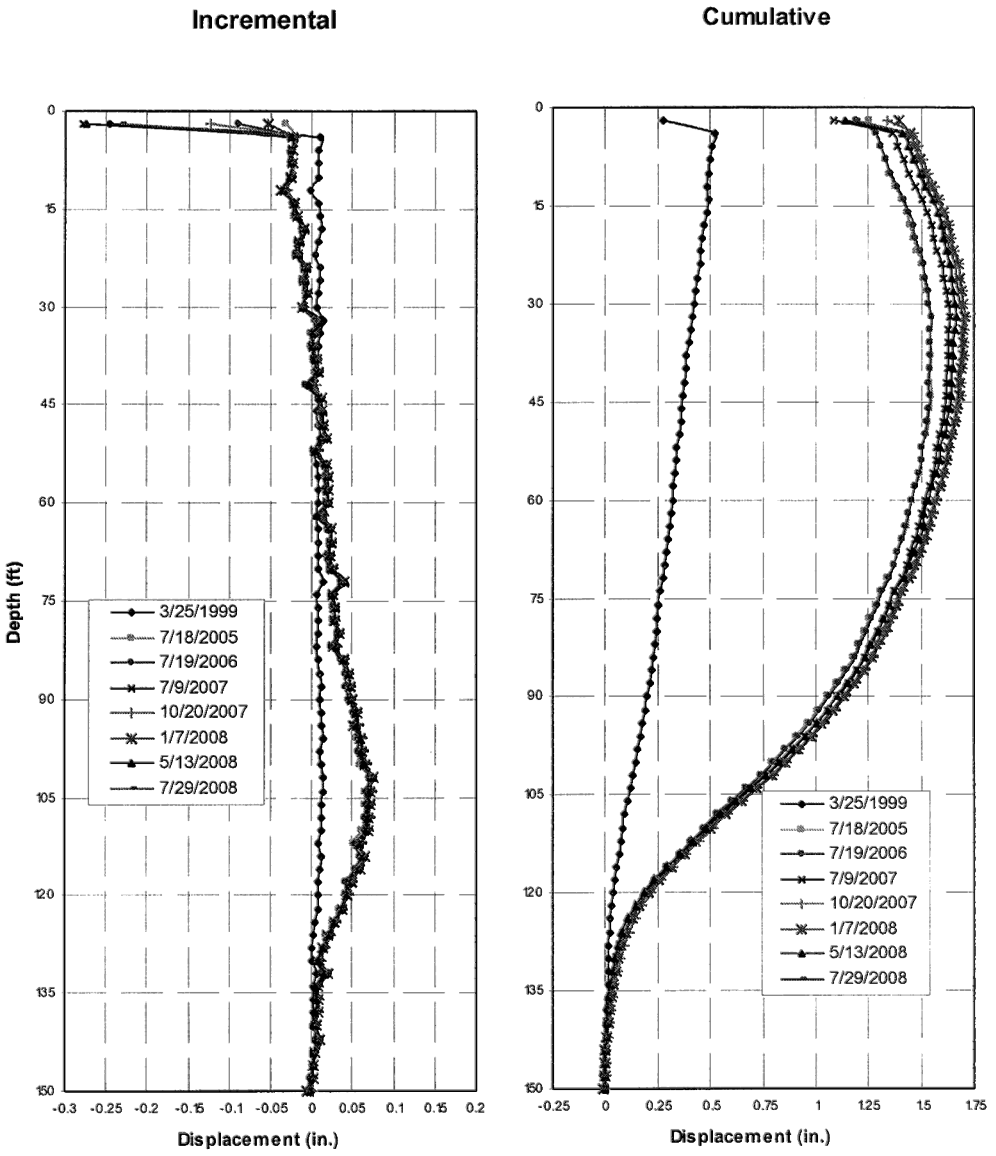
Incremental



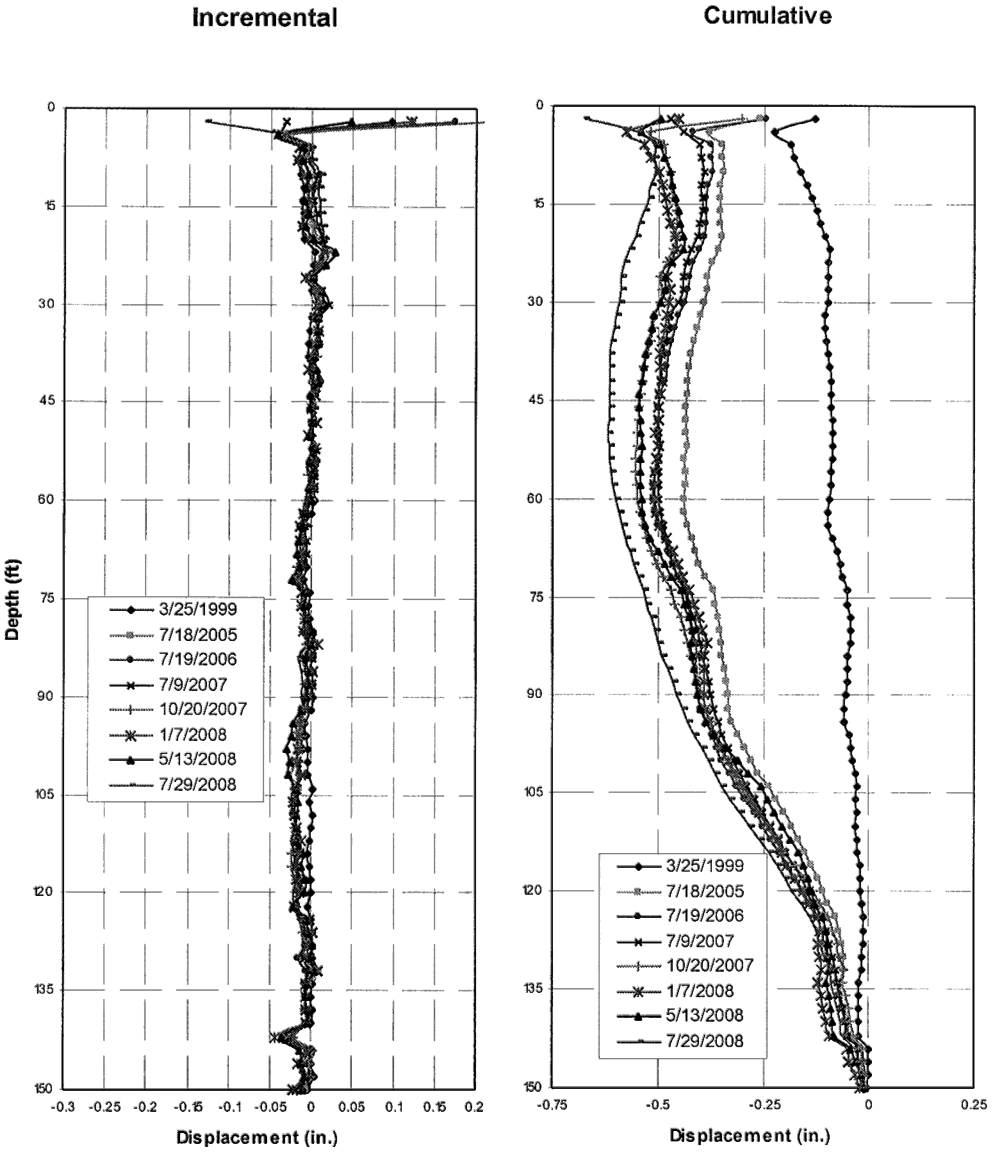
Cumulative



Inclinometer #17 Displacement in the A+ Direction
Downslope (River direction) Base Line 12/11/1998



Inclinometer #17 Displacement in the B+ Direction
Downslope (River direction) Base Line 12/11/1998



RICHLAND ENGINEERING LIMITED
29 North Park Street, Mansfield, Ohio 44902-1769 • 419-524-0074 FAX 419-524-1812

106017

December 11, 2008

Ohio Department of Transportation
5500 Transportation Boulevard
Garfield Heights, Ohio 44125-5396

Attn: Mr. Mike Malloy

Re: CUY-90-1524
Central Viaduct
PID No. 20752
Slope and Pier Monitoring Services
Interim Report

Dear Mr. Malloy:

The following is our report on monitoring activity and collected data for the west slope of the Cuyahoga River and Bridge No. CUY-90-1524 west end pier, pier 1, and slope stabilization structure. The last report of data was the interim report submitted August 19, 2008 for data collected through July 2008. This report is for data collected through October 2008.

Enclosed is one CD with the electronic .pdf files of the detailed reports from BBC&M, REL, Dr. Huckelbridge, and Dr. Liang.

The slope monitoring began in 1994. The stabilization structure was constructed and the span 1 superstructure was relocated in 1999. The stabilization structure monitoring began in 1999. Additional slope monitoring north of the existing bridge began in 2006.

BBC&M Engineering, Inc. obtained inclinometer readings, piezometer readings, and calipered crack distances October 13 through 15, 2008. A total of 19 inclinometers, 6 pneumatic piezometers and 18 vibrating wire (VW) piezometers are actively monitored as part of the project. Comments on the data collected are summarized as follows:

- There continues to be a noticeable increase in the rate of movement in the deep failure plane in inclinometers B-204, B-05-04, and B-303 within the influence of the stabilization structure; and inclinometers B-05-03 and B-105A south of the bridge. A time-displacement plot for inclinometer B-303 is on the next page. The increase in rate of movement was noticed in B-105A since October 2007 and in the others since April 2008. The rate is 3 to 7 times as much as in the past 4 years, but less than or equal to the rate from 2000 to 2004. In the other inclinometers, no significant changes in the rates of movement have been observed in the shallow or deep failure planes.

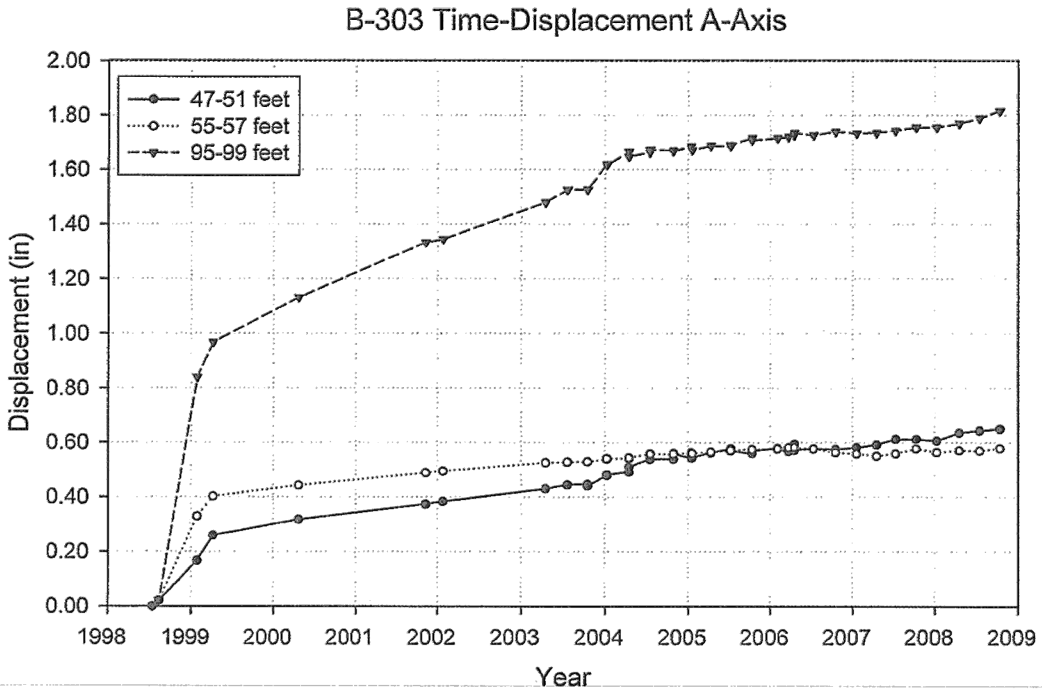


PLATE 21

- The cantilever displacement of the top 60 to 70 feet of inclinometer B-105A is moving at an increasing rate (1.28 inches per year). B-105A is located south of pier 1 near the river dock wall. It appears the dock wall may be bulging or moving outward. The displacement may be due to slope movement or failure of the dock wall tiebacks.

- A noticeable increase in the rate of movement of the shallow slip plane, and the depth and magnitude of the cantilever displacement in B-05-03 has been observed. B-05-03 is located upslope from B-105A. These changes in the shallow movements in B-05-03 indicate the cantilever displacement observed in B-105A may be progressively extending further away from the river. There is a new crack in the concrete pavement adjacent to B-05-03.

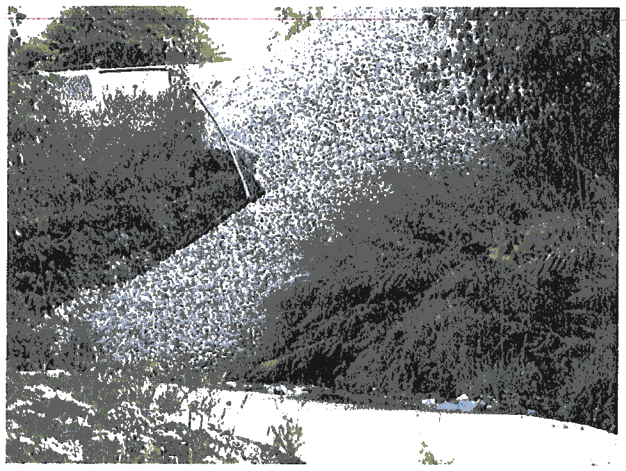
- All of the pneumatic piezometers exhibited slightly lower readings than those recorded in July 2007, except the B-303 piezometer which exhibited a slightly higher reading. The piezometers at B-105 continue to indicate elevated water pressures (i.e., a total head above the ground surface, artesian conditions).

- The measured total head values in the vibrating wire (VW) piezometers were relatively constant during the current reporting period with a difference between maximum and minimum total head values of no more than 1.4 feet in all of the VW piezometers where readings were recorded at regular intervals. The 21955 piezometer in B-05-13 continues to indicate an elevated water pressure similar to that observed in the pneumatic piezometers at B-105.

- The left calipered location indicates the gap is continuing to open and the gap at the right calipered surface distance location is continuing to close. The right calipered location has been oscillating since late 2000 indicating that there might not be a trend.

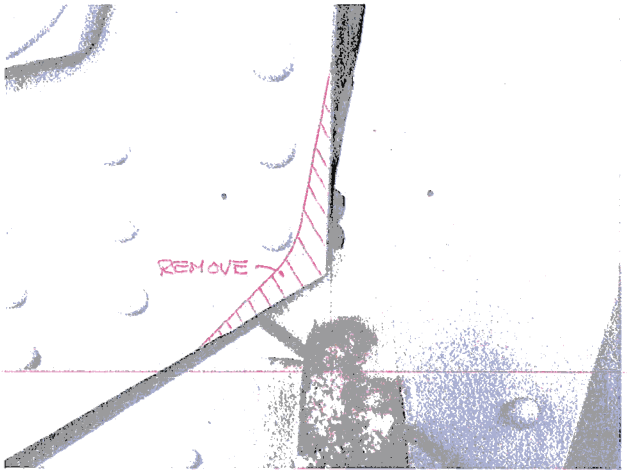
- The small landslide adjacent to the large excavation near the west right-of-way fence does not appear to have experienced a significant change since the quarterly readings were last taken in July 2008.

- In October 2008, an aggregate pile, roughly 20 to 25 feet high, was observed next to and encroaching on the east right-of-way fence. The aggregate pile covered roughly less than 15 percent of the property currently being used to stockpile aggregate adjacent to the east right-of-way fence. A portion of the fence was knocked over by the stockpile as it was spilling over into the right-of-way with the edge of the pile touching the edge of the concrete drive near B-05-03. **The encroaching aggregate pile needs to be removed and the fence repaired.** Another smaller aggregate pile, roughly 10 to 15 feet high, was observed at the far east end of the property covering roughly less than 25 percent of the property. The aggregate piles observed during the July 2008 and October 2008 quarterly readings have been larger in size and placed closer to the east right-of-way fence than has been observed during quarterly readings over the past several years. The increased rates of movements in the inclinometers B-204, B-05-04, B-303, B-05-03, and B-105A; the increased rate of the top cantilever displacement in B-105A and B-05-03; and the slightly increased pore pressures observed in piezometers B-05-03 and B-303 could all be influenced by the presence of the aggregate piles.



Richland Engineering Limited measured deck expansion joint openings at the west end pier, near pier 2, and near pier 4 on October 16, 2008. The deck expansion joint opening near pier 2 opened 5/8" with the 27 degree drop in temperature since July 2008.

Richland Engineering Limited has measured truss expansion joint openings at the north and south upper and lower truss chords at span 2 floorbeam 12. There is a point on the lower chord gusset plates that comes in contact when the temperature expands the structure. Recent measurements indicate the south gusset plate gap closes at about 50 or 60 degrees. The north gusset plate gap is usually open a little more than the south gusset plate gap. The south lower truss chord member affected by the closed joint is also the lowest rated member on the bridge for load carrying capacity. Temperature affect on the member with the joint closed further lowers the load carrying capacity. **The expansion joint at span 2 panel 12 needs to be opened by moving truss span 1.** The work would be similar to the project in 1999. An intermediate repair would be to trim the gusset plates at the contact points to avoid transfer on load by the closed joint. The contact point would become the wind shear key in the center of the bridge at the bottom of the stringers. This contact point would distribute the closed joint force to the deck and stringer areas.



Richland Engineering Limited measured substructure elevations; relative span 1 and 2 lengths; and pier monument coordinates on October 16 and 17, 2008. No significant change in locations from previous data was noted. The south leg of pier 1 and the south side of the drilled shaft cap continue to move more than the north sides. This reflects the trend in the deep failure plane in the inclinometers.

Art Huckelbridge obtained tiltmeter readings at the west end pier and pier 1 on October 17, 2008. The tiltmeters show no substantive changes in readings for the past quarter.

Robert Liang monitored instrumentation between September 28 and October 30, 2008. The instrumentation readings in the rock anchors, driven piles, tieback beams, drilled shafts, and inclinometers showed no significant change during this quarter. Inclinometers #10 and #17 in the drilled shafts showed some movement in the transverse (B) direction north, toward the lake. This movement will be reviewed with the next readings to see if the trend continues.

The next readings are scheduled about January 15, 2009. Authorization to proceed with the 2009 monitoring will be requested.

Please contact us if you have any questions (email reltd@r-e-l.com). Copies of detailed quarterly reports are available upon request.

Very truly yours,

RICHLAND ENGINEERING LIMITED

Dean A. Palmer, P.E.

DAP:dap
cc: Craig Hebebrand, District 12
Youssef Seif, District 12
Naureen Dar, District 12
Tim Keller, Office of Structures
Gene Geiger, Office of Geotechnical Services
Tom Lefchik, FHWA
Steve Pasternack, BBC&M Engineering, Inc., Dublin
Jeff Snyder, BBC&M Engineering, Inc., Valley View
Art Huckelbridge
Robert Liang
Rick Engel, E.L. Robinson Engineering Co.
Jeff Broadwater, Michael Baker, Jr., Inc.

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DECK EXPANSION JOINT OPENINGS

Finger Type Joints
Measurements are in inches.

Date	Temp (F)	West End Pier North	West End Pier South	Near Pier 2 North	Near Pier 2 South	Near Pier 4 North	Near Pier 4 South
Expansion Distance		476 feet		650 feet			
Design	60°	3.25	3.25	3.25	3.25	3.25	3.25
06-01-70	80°	4.00		0.00		N.A.	
09-19-75	60°	5.25		2.00		N.A.	
05-08-78	60°	4.75	5.50	2.00	2.00	3.25	2.50
07-30-81	75°	5.50	5.50	2.25	2.25	3.25	2.75
06-09-83	70°	5.00	5.00	1.50	1.50	2.75	2.25
07-31-85	73°	5.25	4.75	1.50	1.00	2.75	2.25
10-31-88	40°	7.75	8.38	1.50	0.75	3.81	3.38
11-01-89	50°	7.75	7.00	1.13	0.63	3.25	3.13
10-26-90	50°	7.75	7.25	1.00	0.50	3.00	3.00
09-30-91	55°	7.50	7.00	0.88	0.00	3.00	3.00
10-13-92	60°	7.25	6.81	0.63	0.00	2.50	2.50
10-01-93	50°	7.50	7.13	0.75	0.31	2.75	2.63
09-01-94	63°	7.25	6.38	0.31	0.00	2.88	1.88
09-08-95	60°	7.00	6.63	0.44	0.00	2.00	1.88
09-05-96	77°	6.50	6.63	0.38	0.00	1.25	1.00
09-19-97	75°	6.88	7.00	0.31	0.06	1.68	1.42
09-24-98	69°	7.63	7.00	0.00	0.00	1.88	1.75
10-14-99	45°	6.19	5.50	2.38	1.88	3.13	2.75
10-16-00	55°	6.00	4.88	1.75	1.25	2.56	2.43
04-23-01	70°	5.50	4.25	1.38	0.63	2.13	1.75
07-16-01	80°	5.00	3.88	1.00	0.25	1.50	1.25

Date	Temp (F)	West End Pier		Near Pier 2		Near Pier 4	
		North	South	North	South	North	South
10-15-01	50°	6.63	5.63	1.63	1.06	3.25	2.75
1-15-02	30°	6.88	6.25	2.13	1.50	3.88	3.50
4-15-02	61°	6.00	5.25	1.38	0.88	2.50	2.38
7-15-02	76°	5.13	4.13	1.13	0.50	1.75	1.50
10-17-02	48°	7.00	6.38	1.75	1.25	3.25	2.88
11-1-02	35°	7.25	6.13	1.88	1.38	3.63	3.38
1-15-03	7°	8.13	6.63	2.38	1.88	5.00	4.75
4-15-03	67°	5.63	4.63	1.25	0.63	2.25	2.00
7-15-03	74°	5.38	4.38	1.00	0.50	2.00	1.63
10-16-03	46°	7.00	5.75	1.50	1.13	3.25	3.13
1-15-04	11°	8.00	6.75	2.00	1.38	4.63	4.00
4-15-04	41°	6.88	5.75	1.38	0.88	3.50	3.25
7-15-04	67°	5.63	4.75	1.00	0.50	2.13	1.75
10-15-04	50°	6.38	5.50	1.25	0.75	3.00	2.75
1-15-05	12°	7.75	7.00	2.00	1.38	4.63	4.25
4-16-05	47°	6.50	5.63	1.25	0.75	3.25	2.88
7-16-05	74°	5.50	4.50	0.75	0.375	1.75	1.63
10-14-05	51°	6.25	5.50	1.13	0.63	2.81	2.56
1-16-06	26°	7.63	6.38	1.75	1.13	4.13	3.75
4-14-06	65°	5.75	4.88	0.75	0.50	2.25	2.00
7-14-06	78°	5.00	4.00	0.63	0.19	1.63	1.25
10-16-06	50°	6.50	5.88	1.00	0.75	3.25	3.00
1-15-07	41°	7.00	6.13	1.13	0.88	3.56	3.38
4-16-07	34°	7.25	6.38	1.38	0.88	3.75	3.50
7-16-07	70°	5.38	4.75	0.88	0.25	2.13	1.63
10-15-07	56°	6.38	5.50	1.13	0.75	2.88	2.69

Date	Temp (F)	West End Pier		Near Pier 2		Near Pier 4	
		North	South	North	South	North	South
1-15-08	19°	7.63	6.63	1.63	1.00	4.13	4.00
4-15-08	41°	7.13	6.25	1.44	0.88	3.75	3.19
7-16-08	83°	4.75	4.00	0.50	0.00	1.13	0.81
10-16-08	56°	6.25	5.56	1.13	0.69	2.75	2.25

N.A. - No measurements available

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EXPANSION OPENINGS AT SPAN 2 FLOORBEAM 12

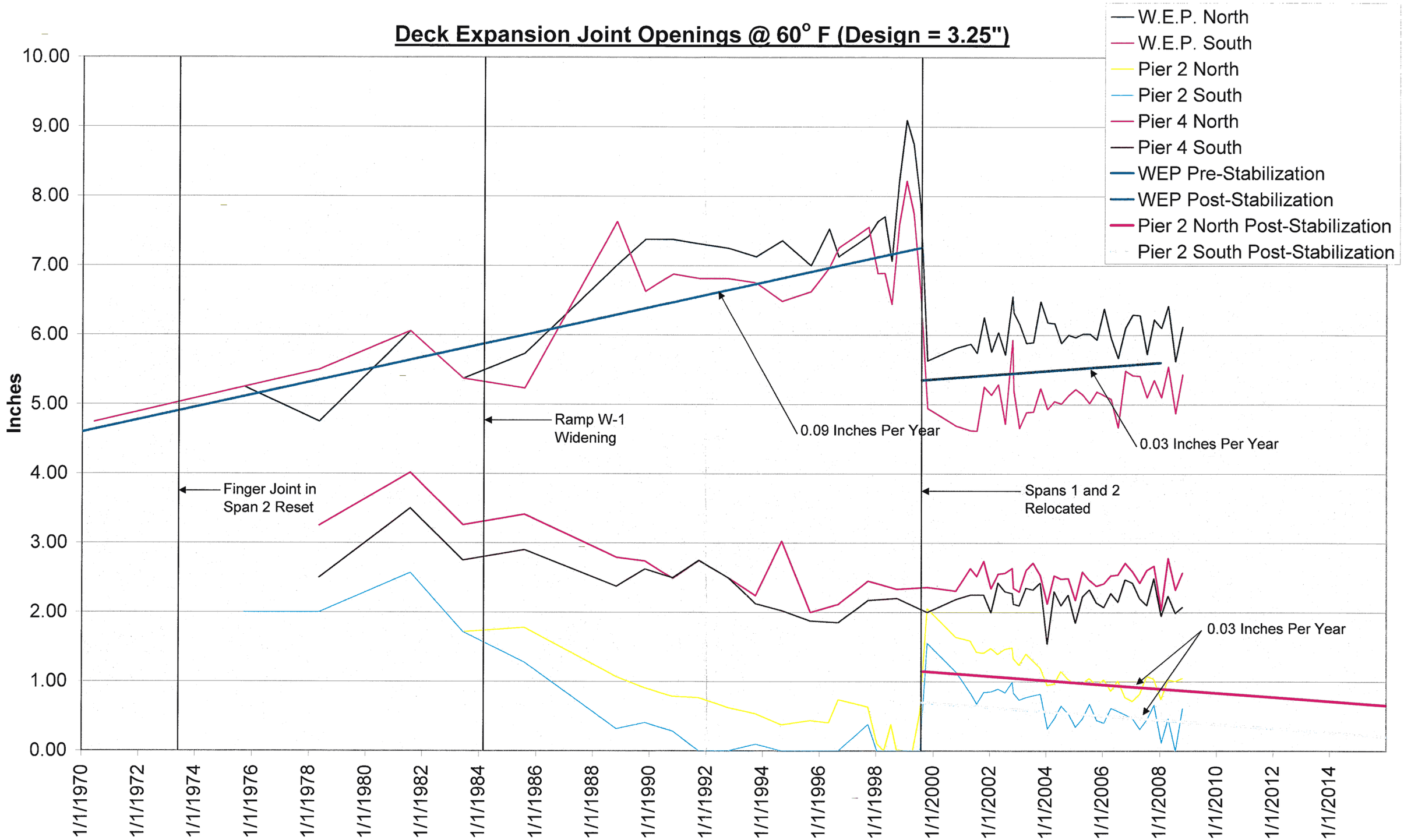
Measurements are in inches

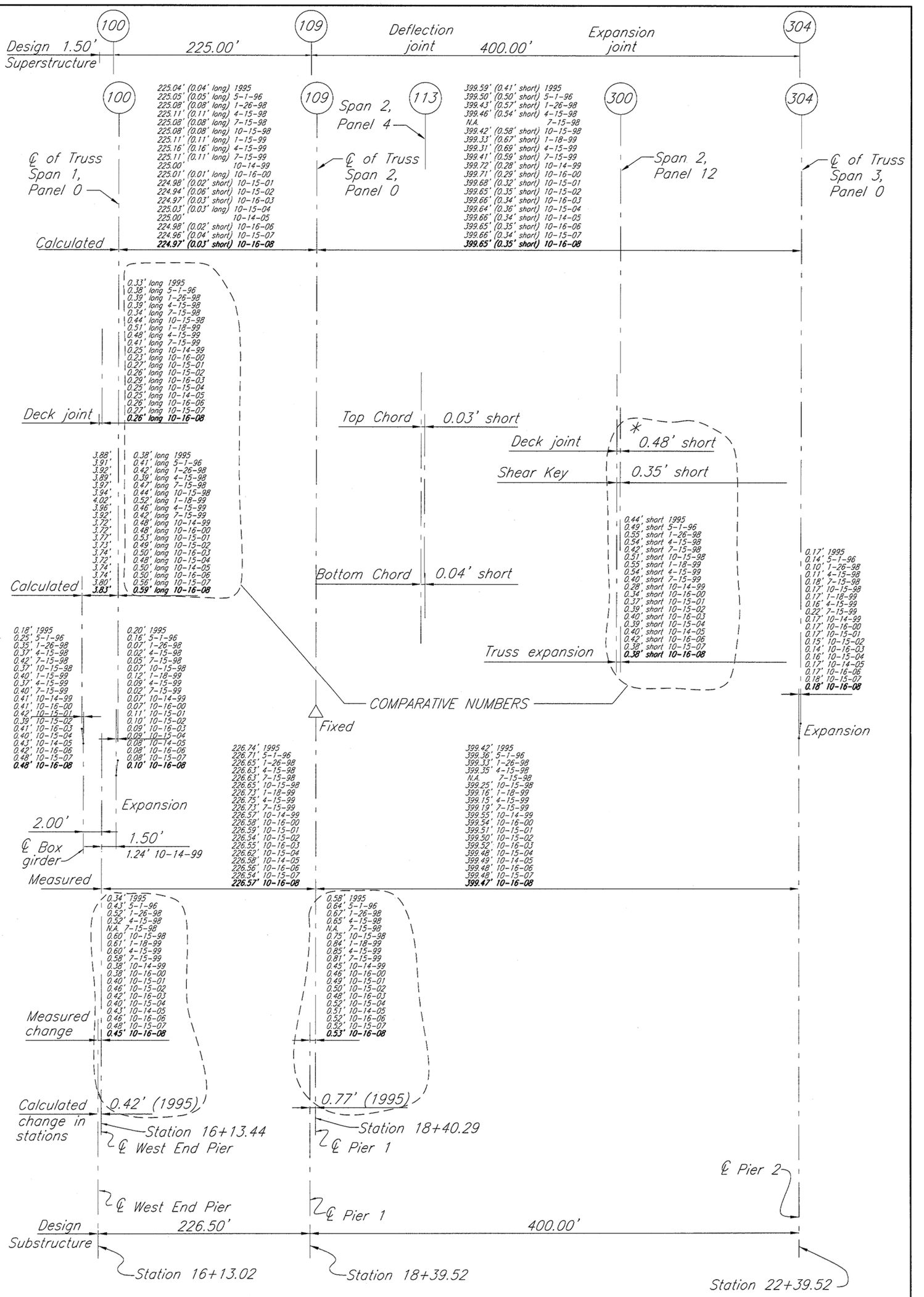
Date	Temp (F)	North Lower Chord Expansion Opening	Deck Expansion Joint Near Pier 2		South Lower Chord Expansion Opening
			North	South	
04-23-01	70°	0.54	1.38	0.63	0.04
07-16-01	80°	0.11	1.00	0.25	N.A.
10-15-01	50°	0.48	1.00	0.25	0.10
1-15-02	30°	1.23	2.13	1.50	0.67
4-15-02	61°	0.48	1.38	0.88	0.17
7-15-02	76°	0.17	1.13	0.50	0.04
10-15-02	41°	0.36	1.75	1.25	0.23
11-1-02	35°	N.A.	1.88	1.38	N.A.
1-15-03	7°	1.17	2.38	1.88	0.73
4-15-03	67°	0.30	1.25	0.63	0.12
7-15-03	74°	0.18	1.00	0.50	0.12
10-16-03	46°	0.30	1.50	1.13	0.12
1-15-04	11°	0.90	2.00	1.38	0.48
4-15-04	41°	0.42	1.38	0.88	0.06
7-15-04	67°	0.06	1.00	0.50	0.00
10-15-04	50°	0.17	1.25	0.75	0.04
1-15-05	12°	0.66	2.00	1.38	0.30
4-16-05	47°	0.30	1.25	0.75	0.00
7-16-05	74°	0.00	0.75	0.375	0.00
10-14-05	51°	0.18	1.13	0.63	0.18
1-16-06	26°	0.66	1.75	1.13	0.24
4-14-06	65°	0.18	0.75	0.50	0.00
7-14-06	78°	0.00	0.63	0.19	0.00

Date	Temp (F)	North Lower Chord Expansion Opening	Deck Expansion Joint Near Pier 2		South Lower Chord Expansion Opening
			North	South	
10-16-06	50°	0.30	1.00	0.75	0.00
1-15-07	41°	0.30	1.13	0.88	0.12
4-16-07	34°	0.36	1.38	0.88	0.12
7-16-07	70°	0.06	0.88	0.25	0.00
10-15-07	56°	0.12	1.13	0.75	0.00
1-15-08	19°	0.42	1.63	1.00	0.18
4-15-08	41°	0.36	1.44	0.88	0.06
7-16-08	83°	0.00	0.50	0.00	0.00
10-16-08	56°	0.12	1.13	0.69	0.12
12-05-08	23°	0.36	1.13	0.69	0.18

N.A. – Not Available

Deck Expansion Joint Openings @ 60° F (Design = 3.25")





* 1972 Joint repositioned open 0.21'
1998 Joint closed 0.27'
0.48'

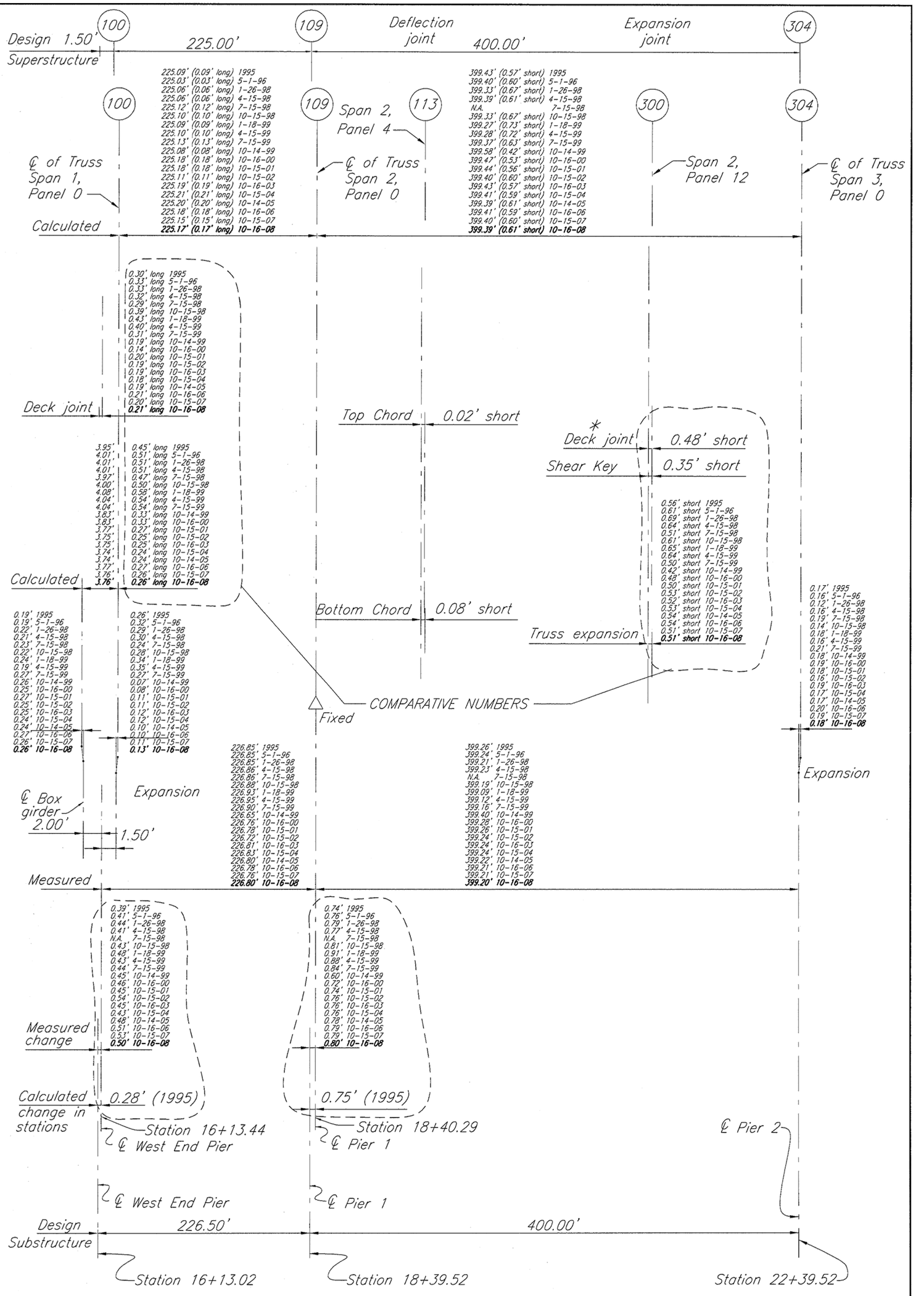
(100) – Panel Number given in Original Construction drawings

Summary of Truss Measurements

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

SCHEMATIC – NORTH TRUSS @ 60° F (10-16-08)
CUY-90-1524

D8017/2008 Measurments/Cuy90SCH.DWG



* 1972 Joint repositioned open 0.21'
1998 Joint closed 0.27'
0.48'

(100) – Panel Number given in Original Construction drawings

Summary of Truss Measurements

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

SCHEMATIC – SOUTH TRUSS @ 60° F (10-16-08)
CUY-90-1524

10801772008 Measurements/CUY90SCH.DWG

RELATIVE SPAN LENGTHS

(Distance between points set on consecutive piers)

	Span 1		Span 2	
	North Truss	South Truss	North Truss	South Truss
1985	215.35	215.30	399.49	399.74
1988	215.47	215.46	399.38	399.57
1989	215.48	215.44	399.36	399.59
1990	215.48	215.45	399.35	399.56
1991	215.48	215.42	399.29	399.57
1992	215.51	215.50	399.30	399.52
1993	215.46	215.49	399.34	399.51
1994	215.47	215.44	399.31	399.52
1995	215.49	215.45	399.34	399.55
5 / 1996	215.46	215.45	399.28	399.53
8 / 1996	215.45	215.46	399.28	399.54
9 / 1997	215.45	215.48	399.29	399.53
1 / 1998	215.40	215.45	399.25	399.50
4 / 1998	215.38	215.46	399.27	399.52
7 /1998	215.35	215.44	¥	¥
10 / 1998	215.40	215.48	399.16	399.47
12 / 1998	215.48	215.53	399.08	399.41
1 / 1999	215.48	215.53	399.08	399.39
4 / 1999	215.51	215.55	399.07	399.41
10 / 1999	215.48	215.50	399.11	399.45
***10/ 1999	215.56	215.66	398.98	399.25
10/2000	215.57	215.77	398.97	399.13
10/2001	215.58	215.79	398.94	399.12
10/2002	215.53	215.73	398.93	399.10
10/2003	215.55	215.82	398.95	399.10
10/2004	215.61	215.84	398.91	399.09
10/2005	215.58	215.81	398.92	399.08
10/2006	215.55	215.79	398.91	399.06
10/2007	215.53	215.77	398.91	399.06
Net Change	0.01	0.14	-0.07	-0.20
Design	215.25	215.10	399.92	400.29
10/2008	215.56	215.81	398.90	399.06
Change from 10/07 to 10/08	0.03	0.04	-0.00	-0.01

¥ Points destroyed during construction. New points set atop of pier 2, first reading taken 10/15/98

Net change is current reading compared to the last compatible reading (10/1999)

*** Bridge relocated

SEAT ELEVATIONS

POINT NO.	DESCRIPTION	10/17/94	02/26/98	04/15/98	07/15/98	07/22/98	10/15/98	1/19/99	3/5/99	4/15/99	7/15/99	10/14/99	10/16/00	10/15/01	10/15/02	10/16/03	10/14/04	10/14/05	10/16/06	10/15/07	10/16/08
WEST END PIER SOUTH																					
103	ROD IN PIER SEAT	667.18	667.15	667.18	667.18	-	667.14	667.16	-	667.17	667.17	667.16	667.16	667.20	667.17	667.17	667.19	667.15	667.16	667.16	667.16
401	ROD IN SOUTH FACE	-	677.91	677.93	677.92	-	677.92	677.93	-	677.93	677.92	677.91	677.92	677.94	677.93	677.92	677.94	677.91	677.92	677.91	677.90
402	ROD IN NORTH FACE	-	670.79	670.81	670.80	-	670.78	670.80	-	670.79	670.80	670.78	670.80	670.83	670.80	670.80	670.81	670.78	670.79	670.79	670.78
WEST END PIER NORTH																					
	ROD IN PIER SEAT																				
102	Destroyed	667.04	667.03	667.07	667.05	-	667.04	667.03	-	667.04	-	-	-	-	-	-	-	-	-	-	-
802	(SET 7/16/99)									-	667.02	667.01	667.01	667.05	667.01	667.02	667.03	667.00	667.01	667.01	667.00
404	ROD IN NORTH FACE	-	660.83	660.86	660.86	-	660.82	660.88	-	660.84	660.85	660.84	660.84	660.87	660.85	660.84	660.86	660.82	660.83	660.83	660.83
PIER 1 NORTH																					
	ROD IN PIER SEAT																				
104	Destroyed	626.29	626.33	-	626.38	-	626.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-
606	(SET 7/22/98)							626.35	-	626.33	626.34	626.33	626.33	626.34	626.30	626.33	626.34	626.31	626.29	626.34	626.36
607	(SET 12/29/98)							626.32	-	626.30	626.30	-	-	-	-	-	-	-	-	-	-
608	(SET 12/29/98)							626.24	-	626.21	626.21	626.22	626.23	626.23	626.22	626.23	626.23	626.20	626.19	626.23	626.25
609	(SET 12/29/98)							626.23	-	626.22	626.21	626.21	626.21	-	-	-	-	-	-	-	-
903	(SET 10/13/99)											626.30	626.30	626.30	626.33	626.30	626.30	626.27	626.26	626.31	626.32
902	(SET 10/13/99)											626.25	626.26	626.26	626.25	626.26	626.25	626.23	626.21	626.26	626.28
308	ROD IN NORTH FACE	-	604.51	-	-	-	604.48	604.51	-	604.55	604.52	604.50	604.50	604.52	604.51	604.51	604.52	604.49	604.48	604.52	604.53
407	ROD IN SOUTH FACE	-	-	-	-	-	604.25	§	-	604.26	604.28	604.23	604.24	604.27	604.25	604.25	604.26	604.23	604.20	604.26	604.27
PIER 1 SOUTH																					
	ROD IN PIER SEAT																				
105	Destroyed	626.25	626.27	-	626.34	626.32	626.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-
602	(SET 7/22/98)	-	-	-	-	626.29	626.24	626.25	-	626.23	626.23	-	-	-	-	-	-	-	-	-	-
603	(SET 12/29/98)							626.26	-	626.25	626.24	-	-	-	-	-	-	-	-	-	-
604	(SET 12/29/98)							626.23	-	626.21	626.20	-	-	-	-	-	-	-	-	-	-
605	(SET 12/29/98)							626.24	-	626.22	626.21	-	-	-	-	-	-	-	-	-	-
901	(SET 10/13/99)											626.22	626.23	626.23	626.22	626.23	626.22	626.20	626.18	626.23	626.24
900	(SET 10/13/99)											626.21	626.22	626.22	626.21	626.22	626.21	626.19	626.17	626.22	626.23
306	ROD IN NORTH FACE	-	606.55	-	-	-	606.53	§	-	606.51	606.54	606.50	606.50	606.52	606.51	606.51	606.51	606.49	606.47	-	606.52
305	ROD IN SOUTH FACE	-	607.33	-	-	-	607.33	607.32	-	607.31	607.34	607.29	607.30	607.32	607.31	607.31	607.33	607.30	607.27	607.31	607.32
PIER 2 NORTH																					
	ROD IN PIER SEAT																				
601	(SET 7/22/98)	-	-	-	-	628.65	628.58	628.66	-	628.62	628.65	628.63	628.64	628.65	628.65	628.64	628.61	628.61	628.58	628.68	628.68
206	ROD IN SOUTH FACE	-	586.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
610	ROD IN SOUTH FACE (SET 7/22/98)	-	-	-	-	-	586.09	586.15	-	-	586.11	586.12	586.14	586.16	586.18	586.17	586.18	586.15	586.17	586.16	586.16
PIER 2 SOUTH																					
600	ROD IN PIER SEAT (SET 7/22/98)	-	-	-	-	628.78	628.72	628.77	-	628.76	628.78	628.76	628.78	628.78	628.76	628.77	628.73	628.75	628.72	628.79	628.80
207	ROD IN NORTH FACE	-	586.08	-	-	-	586.07	586.10	-	-	586.16	586.16	586.10	586.11	586.13	586.12	586.13	586.11	586.12	586.11	586.11
ANCHOR STRUCTURE																					
500	ROD SOUTH END	-	591.00	-	-	591.00	590.97	590.98	591.00	590.99	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
501	ROD CENTER +-	-	590.96	-	-	590.97	590.94	590.96	590.96	590.96	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
502	ROD NORTH END	-	590.98	-	-	590.99	590.97	590.99	590.99	590.99	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
DRILLED SHAFT CAP (SET 3/4/99)																					
700	BRASS DISK NORTH END	-	-	-	-	-	-	-	589.61	589.62	589.66	589.65	589.65	589.66	589.66	589.67	589.68	589.65	589.62	589.68	589.70
701	BRASS DISK CENTER +-	-	-	-	-	-	-	-	589.66	589.66	589.68	589.68	589.69	589.69	589.69	589.70	589.71	589.68	589.65	589.71	589.73
702	BRASS DISK SOUTH END	-	-	-	-	-	-	-	589.62	589.62	589.63	589.64	589.65	589.65	589.64	589.66	589.66	589.63	589.60	589.66	589.68
CONTROL POINT																					
64	PK IN CONC DRIVE	633.37	633.30	-	-	633.31	633.26	633.27	-	633.22	633.23	633.22	633.22	633.23	633.21	633.21	633.22	633.16 ***	633.15 ***	633.17 ***	633.20 ***

| Calculated from top of concrete using an average rod height
§ Shots were not taken due to heat tent for rock anchor placement procedure.
¥¥ No future shots will be taken due to anchor structure being buried
*** Head of Nail Missing

PIER SEAT COORDINATES

(Reference Point Locations on Top of Piers)

Pier	Direction	B&N 1985	REL 1988‡	REL 1989‡	REL 1990‡	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 5/96	REL 8/96	REL 9/97	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 3/99	REL 4/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06	REL 10/07	REL 10/08
WEP North	N	5114.58	5114.53	5114.55	5114.55	5114.58	5114.64	5114.64	5114.65	5114.65	5114.67	5114.67	5114.68	5114.66	5114.65	5114.67	5114.66	5114.64	5114.68	N.A.	N.A.	5114.71	5114.69	5114.66	5114.65	5114.63	5114.67	5114.65	5114.64	5114.66	5114.63	5114.65	5114.66
	E	4840.08	4839.58	4839.59	4839.59	4839.59	4839.59	4839.62	4839.62	4839.60	4839.67	4839.67	4839.69	4839.75	4839.77	4839.82	4839.84	4839.83	4839.83	N.A.	N.A.	4839.81	4839.81	4839.85	4839.84	4839.85	4839.88	4839.85	4839.87	4839.90	4839.91	4839.93	4839.93
WEP South	N	5033.90	5033.84	5033.85	5033.86	5033.87	5033.96	5033.98	5033.98	5033.96	5033.98	5034.01	5033.96	5033.99	5033.99	5033.98	5033.99	NA	5033.99	N.A.	N.A.	5033.99	5033.96	5033.95	5033.94	5033.94	5033.94	5033.94	5033.95	5033.94	5033.96	5033.94	5033.91
	E	4839.62	4839.12	4839.14	4839.14	4839.12	4839.11	4839.14	4839.15	4839.13	4839.15	4839.13	4839.15	4839.16	4839.17	4839.20	4839.22	NA	4839.23	N.A.	N.A.	4839.19	4839.21	4839.22	4839.22	4839.24	4839.26	4839.19	4839.21	4839.25	4839.27	4839.29	4839.28
Pier 1 North	N	5124.44	5124.42	5124.40	5124.43	5124.39	5124.46	5124.50	5124.47	5124.44	5124.44	5124.48	5124.46	5124.47	5124.46	5124.46	5124.47	5124.47 £	5124.47	N.A.	N.A.	5124.46	5124.48	5124.42	5124.43	5124.44	5124.43	5124.43	5124.47	5124.45	5124.46	5124.47	5124.44
	E	5055.20	5054.83	5054.84	5054.84	5054.85	5054.88	5054.86	5054.86	5054.87	5054.91	5054.90	5054.92	5054.93	5054.94	5054.95	5055.02	5055.09 £	5055.09	N.A.	N.A.	5055.10	5055.07	5055.18	5055.19	5055.21	5055.19	5055.18	5055.25	5055.25	5055.24	5055.24	5055.27
Pier 1 South	N	5034.50	5034.49	5034.49	5034.53	5034.45	5034.53	5034.57	5034.55	5034.52	5034.54	5034.56	5034.54	5034.55	5034.54	5034.53	5034.57	5034.55 £	5034.56	N.A.	N.A.	5034.57	5034.56	5034.60	5034.59	5034.61	5034.64	5034.62	5034.65	5034.65	5034.66	5034.64	5034.64
	E	5054.91	5054.59	5054.58	5054.60	5054.54	5054.60	5054.62	5054.59	5054.57	5054.60	5054.59	5054.63	5054.61	5054.63	5054.64	5054.70	5054.73 £	5054.76	N.A.	N.A.	5054.74	5054.71	5054.89	5054.99	5055.03	5054.99	5055.00	5055.05	5055.06	5055.06	5055.06	5055.09
Pier 2 North	N	5124.60	5124.53	5124.55	5124.57	5124.43	5124.46	5124.45	5124.48	5124.40	5124.40	5124.40	5124.41	5124.37	5124.40	¥	5124.44	5124.42	5124.42	N.A.	N.A.	5124.43	5124.41	5124.40	5124.39	5124.41	5124.39	5124.42	5124.43	5124.41	5124.43	5124.44	5124.40
	E	5454.68	5454.21	5454.21	5454.20	5454.14	5454.18	5454.20	5454.18	5454.21	5454.19	5454.19	5454.21	5454.17	5454.21	¥	5454.18	5454.17	5454.17	N.A.	N.A.	5454.17	5454.18	5454.16	5454.16	5454.15	5454.12	5454.13	5454.16	5454.17	5454.15	5454.14	5454.17
Pier 2 South	N	5024.98	5024.89	5024.91	5024.91	5024.78	5024.81	5024.81	5024.84	5024.74	5024.76	5024.76	5024.76	5024.75	5024.78	¥	5024.72	5024.73	5024.73	N.A.	N.A.	5024.73	5024.70	5024.71	5024.69	5024.68	5024.73	5024.71	5024.72	5024.73	5024.73	5024.73	5024.73
	E	5454.54	5454.04	5454.06	5454.04	5453.99	5454.01	5454.01	5453.99	5454.00	5454.01	5454.00	5454.04	5453.99	5454.03	¥	5454.05	5454.03	5454.03	N.A.	N.A.	5454.03	5454.04	5454.02	5454.00	5454.02	5453.96	5453.98	5454.01	5454.02	5454.00	5454.00	5454.02
Anchor Structur	N													5143.42	5143.42	5143.45	5143.44	NA	5143.44	5143.39	5143.41	5143.43	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
North	E													5018.39	5018.44	5018.44	5018.50	NA	5018.54	5018.55	5018.56	5018.52	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structur	N													5075.81	5075.77	5075.82	5075.81	NA	5075.82	5075.78	5075.80	5075.82	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Center	E													5018.37	5018.40	5018.48	5018.48	NA	5018.58	5018.58	5018.59	5018.53	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structur	N													5009.41	5009.36	5009.42	5009.42	NA	5009.42	5009.40	5009.40	5009.41	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
South	E													5018.53	5018.56	5018.61	5018.61	NA	5018.75	5018.77	5018.78	5018.71	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Drilled Shaft Cap	N																			5138.49	5138.50	5138.53	5138.52	5138.49	5138.52	5138.52	5138.52	5138.53	5138.55	5138.55	5138.55	5138.56	5138.55
North	E																			5109.81	5109.81	5109.78	5109.77	5109.80	5109.80	5109.81	5109.84	5109.82	5109.83	5109.83	5109.84	5109.85	5109.85
Drilled Shaft Cap	N																			5074.42	5074.41	5074.43	5074.44	5074.40	5074.43	5074.43	5074.45	5074.45	5074.46	5074.47	5074.46	5074.48	5074.47
Center	E																			5109.81	5109.82	5109.79	5109.78	5109.81	5109.81	5109.83	5109.84	5109.84	5109.84	5109.87	5109.86	5109.87	5109.89
Drilled Shaft Cap	N																			5010.31	5010.32	5010.33	5010.33	5010.31	5010.32	5010.33	5010.35	5010.35	5010.36	5010.36	5010.37	5010.37	5010.36
South	E																			5109.83	5109.83	5109.80	5109.80	5109.83	5109.84	5109.87	5109.89	5109.89	5109.92	5109.92	5109.92	5109.93	5109.95

* Monumentation damaged by earth moving operations.

‡ Monuments appear to have been displaced 6" along the bridge.

¥ Points destroyed durning construction. New points set. First reading taken 10/15/98

£ Monumentation removed for new pier caps for jacking procedure. New points set and first readings taken 12/29/98

¥¥ No future shots will be taken due to anchor structure being buried

Reference North (Inches)

WEST END PIER

PIER 1

DRILLED SHAFT CAP

PIER 2

Oct. 1999
Oct. 2008
0.91"
Oct. 2008
Oct. 1999

Oct. 2008
0.92"
Oct. 2008
Oct. 1999
Oct. 1999
Oct. 2008
Oct. 2008
Oct. 1999

REFERENCE

N
W
E
S

Oct. 1999
Oct. 1999
Oct. 2000
Oct. 2008
Oct. 2008
Oct. 1999
1.21"
0.50"
SCALE
Oct. 2008
Oct. 1999

Reference East (Inches)

PIER SEAT COORDINATES

DIFFERENTIAL MOVEMENT

(A positive value indicates movement to the north or east.
A negative value indicates movement to the south or west.)

Pier	Point	Direction	85-88 *	88-89 ‡	89-90 ‡	90-91 ‡	91-92	92-93	93-94	94-95	95-5/96	95-8/96	8/96-97	97-1/98	1/98-4/98	4/98-7/98	7/98-10/98	10/98-12/98	10/98-1/99	1/99-3/99	3/99-4/99	1/99-4/99	4/99-7/99	7/99-10/99	10/99-10/00	10/00-10/01	10/01-10/02	10/02-10/03	10/03-10/04	10/04-10/05	10/05-10/06	10/06-10/07	10/07-10/08	¤ Net Change
WEP North	50	N	-0.05	0.03	-0.00	0.03	0.06	-0.00	0.00	0.00	0.02	0.00	0.01	-0.02	-0.01	0.02	-0.01	-0.02	0.04	NA	NA	0.03	-0.02	-0.03	-0.01	-0.02	0.04	-0.02	-0.01	0.02	-0.02	0.02	0.01	0.14
Pier Seat		E	-0.50	0.01	0.01	-0.00	0.00	0.03	-0.00	-0.02	0.07	-0.00	0.02	0.06	0.02	0.05	0.02	-0.01	-0.00	NA	NA	-0.02	0.00	0.03	-0.01	0.01	0.03	-0.03	0.02	0.03	0.02	0.02	-0.00	0.34
WEP South	60	N	-0.05	0.01	0.01	0.01	0.09	0.02	-0.00	-0.02	0.02	0.03	-0.04	0.03	-0.00	-0.01	0.01	NA	0.04	NA	NA	-0.01	-0.03	-0.01	-0.01	0.00	0.00	-0.00	0.00	-0.00	0.02	-0.02	-0.04	0.06
Pier Seat		E	-0.50	0.02	0.00	-0.02	-0.02	0.03	0.01	-0.02	0.03	-0.02	0.02	0.01	0.01	0.03	0.02	NA	0.03	NA	NA	-0.04	0.02	0.02	-0.00	0.02	0.02	-0.07	0.02	0.04	0.01	0.02	-0.01	0.16
Pier 1 North	30	N	-0.02	-0.02	0.03	-0.04	0.07	0.04	-0.03	-0.03	0.00	0.04	-0.01	0.00	-0.01	0.00	0.01	-0.01	0.00	NA	NA	-0.01	0.02	-0.06	0.01	0.01	-0.02	0.01	0.04	-0.02	0.01	0.01	-0.04	0.02
Pier Seat		E	-0.37	0.01	0.00	0.01	0.03	-0.02	0.00	0.01	0.04	-0.01	0.01	0.01	0.01	0.02	0.07	0.07	0.00	NA	NA	0.01	-0.02	0.11	0.01	0.02	-0.02	-0.01	0.08	-0.00	-0.01	-0.01	0.03	0.44
Pier 1 South	40	N	-0.01	0.01	0.04	-0.08	0.08	0.04	-0.02	-0.03	0.02	0.02	-0.02	0.01	-0.01	-0.01	0.04	-0.02	0.01	NA	NA	0.01	-0.01	0.04	-0.00	0.02	0.03	-0.02	0.03	-0.01	0.01	-0.01	-0.01	0.15
Pier Seat		E	-0.33	-0.00	0.01	-0.06	0.06	0.02	-0.04	-0.01	0.03	-0.02	0.04	-0.02	0.02	0.01	0.06	0.03	0.03	NA	NA	-0.02	-0.03	0.18	0.10	0.04	-0.04	0.02	0.04	0.02	-0.01	0.00	0.03	0.50
Pier 2 North	10	N	-0.06	0.02	0.02	-0.14	0.02	-0.01	0.02	-0.07	-0.00	0.00	0.01	-0.05	0.03	NA	§	-0.02	0.00	NA	NA	0.01	-0.02	-0.01	-0.01	0.02	-0.02	0.03	0.01	-0.02	0.03	0.01	-0.04	-0.04
Pier Seat		E	-0.47	-0.00	-0.01	-0.05	0.03	0.02	-0.02	0.03	-0.01	-0.01	0.03	-0.04	0.04	NA	§	-0.01	0.00	NA	NA	-0.00	0.02	-0.03	0.00	-0.01	-0.03	0.01	0.04	0.00	-0.02	-0.01	0.03	-0.01
Pier 2 South	20	N	-0.09	0.01	0.00	-0.13	0.03	-0.00	0.03	-0.10	0.01	0.01	-0.00	-0.02	0.03	NA	§	0.01	0.00	NA	NA	-0.00	-0.03	0.01	-0.02	-0.01	0.04	-0.01	0.00	0.01	0.00	0.00	-0.00	0.01
Pier Seat		E	-0.50	0.01	-0.01	-0.05	0.02	0.01	-0.02	0.01	0.01	-0.01	0.03	-0.05	0.04	NA	§	-0.03	0.00	NA	NA	0.00	0.01	-0.02	-0.02	0.03	-0.06	0.02	0.04	0.00	-0.02	0.00	0.02	-0.03
Anchor Structure	502	N												¥	-0.00	0.03	-0.01	NA	0.02	-0.05	0.01	0.02	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
North		E												¥	0.05	0.01	0.05	NA	0.07	0.01	0.01	-0.04	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure	501	N												¥	-0.04	0.05	-0.00	NA	0.05	-0.03	0.02	0.02	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Center		E												¥	0.03	0.08	0.00	NA	0.07	-0.00	0.01	-0.06	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure	500	N												¥	-0.05	0.06	-0.01	NA	0.03	-0.02	-0.00	0.01	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
South		E												¥	0.03	0.05	-0.00	NA	0.06	0.03	0.01	-0.07	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Drilled Shaft Cap	700	N																		£	0.01	0.03	-0.01	-0.03	0.03	0.00	0.00	0.01	0.02	0.00	-0.00	0.01	-0.01	0.06
North		E																		£	-0.00	-0.03	-0.01	0.03	0.00	0.01	0.03	-0.02	0.00	0.01	0.00	0.01	0.00	0.04
Drilled Shaft Cap	701	N																		£	-0.00	0.02	0.00	-0.04	0.03	-0.00	0.02	-0.00	0.01	0.01	-0.01	0.02	-0.01	0.05
Center		E																		£	0.01	-0.04	-0.00	0.02	-0.00	0.02	0.02	-0.00	-0.01	0.03	-0.01	0.01	0.02	0.07
Drilled Shaft Cap	702	N																		£	0.01	0.01	0.01	-0.02	0.02	0.01	0.01	0.00	0.01	0.00	0.00	0.01	-0.01	0.05
South		E																		£	0.01	-0.04	0.00	0.03	0.01	0.03	0.02	-0.00	0.03	0.00	0.00	0.01	0.02	0.12

* Monumentation damaged by earth moving operations.
‡ Monuments appear to have been displaced 6" along the bridge.
¥ First measurements taken 2/26/98
§ First measurements taken 10/15/98
¤ Net change is initial reading compared to the last compatible reading
£ First measurements taken 3/08/99
¥¥ No future shots will be taken due to anchor structure being buried

PIER SIDE COORDINATES

(Reference Point Locations on Sides of Piers)

Pier	Direction	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 5/96	REL 8/96	REL 1997	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06	REL 10/07	REL 10/08
WEP North (Inside)	N	5162.58	5162.67	5162.69	5161.99	5162.66	-------	5161.00	5160.98	5160.96	5160.92	5160.94	5160.96	5160.89	5160.93	5160.93	5160.90	5160.89	5160.89	5160.88	5160.86	5160.89	5160.90	5160.90	5160.90	5160.91	5160.89
	E	4879.46	4879.32	4879.17	4878.94	4879.23	-------	4884.16	4884.18	4884.26	4884.27	4884.27	4884.22	4884.30	4884.32	4884.29	4884.29	4884.29	4884.30	4884.33	4884.34	4884.29	4884.34	4884.34	4884.35	4884.38	4884.37
WEP North (Outside)	N	-------	-------	5184.24	NA	5184.22	-------	5184.04	5184.03	5183.97	5183.98	5183.99	5183.94	5183.99	5184.01	5184.06	5184.06	5184.06	5184.04	5184.04	5184.03	5184.04	5184.03	5183.98	5184.03	5184.03	5183.98
	E	-------	-------	4887.48	NA	4887.51	-------	4888.05	4888.09	4888.14	4888.16	4888.19	4888.24	4888.20	4888.19	4888.21	4888.23	4888.23	4888.25	4888.25	4888.28	4888.28	4888.26	4888.26	4888.28	4888.29	4888.29
WEP South (Inside)	N	5088.80	5088.86	5088.87	5088.86	5088.85	-------	5076.56	5076.51	5076.53	5076.52	5076.50	5076.49	5076.53	5076.53	5076.49	5076.53	5076.51	5076.45	5076.42	5076.46	5076.45	5076.46	5076.43	5076.46	5076.46	5076.44
	E	4854.36	4854.51	4854.43	4854.46	4854.43	-------	4857.97	4857.97	4857.98	4858.01	4858.02	4858.10	4858.02	4858.05	4858.00	4858.02	4858.03	4858.01	4858.02	4858.04	4858.03	4858.04	4858.05	4858.07	4858.08	4858.08
WEP South (Outside)	N	-------	-------	5051.47	5051.45	5051.45	-------	5051.41	5051.37	5051.40	5051.38	5051.34	5051.40	NA	5051.37	5051.35	5051.34	5051.33	5051.32	5051.30	5051.33	5051.34	5051.33	5051.34	5051.34	5051.36	5051.33
	E	-------	-------	4840.79	4840.84	4840.80	-------	4841.07	4841.08	4841.07	4841.08	4841.07	4841.04	NA	4841.10	4841.08	4841.08	4841.08	4841.08	4841.08	4841.12	4841.07	4841.09	4841.09	4841.11	4841.13	4841.12
Pier 1 North (Inside)	N	-------	-------	5087.19	5087.15	5087.09	-------	5086.18	5086.17	5086.17	5086.14	5086.14	5086.16	§	§	5086.13	5086.09	5086.06	5086.08	5086.06	5086.06	5086.05	5086.07	5086.10	5086.08	5086.09	5086.09
	E	-------	-------	5093.22	5093.16	5093.17	-------	5095.93	5095.94	5095.94	5096.01	5096.03	5096.01	§	§	5096.16	5096.15	5096.17	5096.16	5096.21	5096.20	5096.19	5096.23	5096.23	5096.22	5096.26	5096.25
Pier 1 North (Outside	N	-------	-------	5100.04	NA	5100.11	5100.12	5100.13	5100.13	5100.12	5100.13	5100.12	5100.06	5100.08	5100.09	5100.12	5100.06	5100.03	5100.09	5100.04	5099.98	5100.01	5099.99	5099.99	5099.99	5100.00	5099.97
	E	-------	-------	5098.27	NA	5098.01	5098.03	5098.06	5098.08	5098.08	5098.11	5098.15	5098.22	5098.24	5098.24	5098.24	5098.25	5098.27	5098.30	5098.29	5098.31	5098.32	5098.31	5098.32	5098.33	5098.34	5098.33
Pier 1 South (Inside)	N	5014.59	5014.57	5014.66	5014.61	5014.55	5014.59	5014.60	5014.61	5014.62	5014.61	5014.61	5014.56	§	§	5014.59	5014.53	5014.53	5014.54	5014.52	5014.53	5014.55	5014.55	5014.53	5014.56	5014.52	5014.52
	E	5068.67	5068.93	5068.70	5068.68	5068.65	5068.68	5068.68	5068.70	5068.67	5068.70	5068.74	5068.78	§	§	5068.84	5068.87	5068.96	5068.94	5068.99	5069.04	5069.04	5069.01	5069.03	5069.02	5069.05	5069.05
Pier 1 South (Outside	N	-------	-------	5001.94	5001.90	5001.87	5001.89	5001.90	5001.87	5001.90	5001.86	5001.86	5001.91	5001.83	5001.84	5001.84	5001.83	5001.80	5001.82	5001.81	5001.81	5001.80	5001.81	5001.83	5001.86	5001.85	5001.83
	E	-------	-------	5063.39	5063.42	5063.34	5063.39	5063.41	5063.42	5063.38	5063.43	5063.46	5063.42	5063.56	5063.58	5063.56	5063.61	5063.69	5063.69	5063.70	5063.74	5063.74	5063.76	5063.75	5063.78	5063.78	5063.79
Pier 2 North (Inside)	N	4954.01	4953.99	4953.99	4953.97	4953.95	4953.95	4953.97	NA	4953.95	4953.95	¥	4953.96	4953.96	4953.93	4953.93	4953.92	4953.94	4953.96	4953.94	4953.94	4953.95	4953.96	4953.97	4953.98	4953.98	4953.97
	E	5469.91	5470.01	5470.04	5469.99	5470.02	5470.03	5470.00	NA	5470.03	5470.03	¥	5469.96	5469.97	5470.05	5470.01	5470.01	5469.99	5469.99	5470.02	5470.00	5469.97	5469.97	5469.98	5469.97	5469.99	5469.99
Pier 2 South (Inside)	N	4883.44	4883.44	4883.44	4883.46	4883.38	4883.39	4883.40	NA	4883.31	4883.37	‡	4883.33	4883.40	4883.35	4883.42	4883.44	4883.40	4883.37	4883.34	4883.37	4883.36	4883.35	4883.39	4883.38	4883.38	4883.38
	E	5445.32	5445.45	5445.46	5445.41	5445.40	5445.40	5445.36	NA	5445.37	5445.39	‡	5445.45	5445.40	5445.50	5445.35	5445.37	5445.38	5445.41	5445.42	5445.40	5445.39	5445.41	5445.41	5445.40	5445.40	5445.41

------- No reading taken (point not yet set).

NA Information not available.

¥ Points destroyed during construction. New points set

‡ Unable to shoot points due to rock piles next to piers

§ Shots were not taken due to heat tent for rock anchor placement procedure.

PIER TILT

(The difference between the coordinates of the points set on the pier seat and the points at the ground line using the first year measured as the zero point. A positive value indicates top tilt to the north or east. A negative value indicates top tilt to the south or west.)

Pier	Direction	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 8/96	REL 9/97	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06	REL 10/07	REL 10/08
WEP North (Inside)	N	=====	-0.03	-0.05	0.66	-0.01	=====	0.03	0.03	0.06	0.06	0.02	0.08	0.07	0.10	0.12	0.10	0.10	0.08	0.14	0.09	0.08	0.09	0.07	0.07	0.11
	E	=====	0.14	0.32	0.55	0.24	=====	-0.00	-0.02	-0.00	0.04	0.11	0.03	0.00	0.01	0.01	0.04	0.02	0.01	0.03	0.05	0.02	0.04	0.05	0.04	0.05
WEP North (Outside	N	=====	-------	=====	NA	0.03	=====	0.02	0.06	0.04	0.05	0.08	0.02	0.03	0.02	-0.00	-0.04	-0.02	-0.04	0.01	-0.02	-0.03	0.04	-0.03	-0.02	0.05
	E	=====	-------	=====	NA	-0.04	=====	-0.02	-0.01	-0.01	0.01	-0.02	0.01	0.02	-0.03	-0.04	-0.01	-0.03	-0.03	-0.03	-0.05	-0.02	0.02	0.01	0.02	0.02
WEP South (Inside)	N	=====	0.02	0.03	0.04	0.03	=====	0.01	0.02	0.02	0.03	0.05	-0.03	0.01	0.04	-0.02	-0.00	0.03	0.07	0.04	0.04	0.04	0.07	0.06	0.04	0.02
	E	=====	-0.16	-0.05	-0.08	-0.06	=====	0.02	0.02	0.00	0.02	-0.05	0.02	0.02	0.03	0.02	0.03	0.04	0.05	0.06	-0.01	0.01	0.04	0.04	0.04	0.04
WEP South (Outside	N	=====	-------	=====	0.01	-0.01	=====	-0.01	-0.01	0.02	0.03	-0.01	NA	0.02	0.03	0.02	0.02	0.02	0.04	0.01	0.01	0.01	0.01	0.02	-0.02	-0.02
	E	=====	-------	=====	-0.05	-0.02	=====	0.01	0.03	0.04	0.07	0.12	NA	0.07	0.05	0.07	0.09	0.08	0.10	0.08	0.06	0.06	0.10	0.10	0.10	0.10
Pier 1 North (Inside)	N	=====	-------	=====	0.01	0.03	=====	-0.00	0.00	0.02	0.03	0.02	NA	NA	0.04	0.09	0.06	0.06	0.09	0.07	0.09	0.11	0.05	0.08	0.09	0.05
	E	=====	-------	=====	0.06	0.06	=====	0.01	0.02	-0.04	-0.04	0.04	NA	NA	-0.03	-0.05	0.05	0.06	0.03	0.02	0.01	0.06	0.05	0.05	0.01	0.04
Pier 1 North (Outside	N	=====	-------	=====	NA	-0.14	-0.11	-0.13	-0.12	-0.13	-0.13	-0.05	-0.08	-0.09	-0.13	-0.05	-0.08	-0.12	-0.06	-0.02	-0.04	0.02	-0.00	0.01	0.01	0.00
	E	=====	-------	=====	NA	0.27	0.26	0.25	0.26	0.24	0.22	0.21	0.26	0.26	0.27	0.24	0.33	0.30	0.33	0.30	0.27	0.35	0.35	0.33	0.31	0.35
Pier 1 South (Inside)	N	=====	0.10	0.05	0.07	0.11	0.09	0.06	0.06	0.07	0.05	0.15	NA	NA	0.12	0.16	0.20	0.18	0.22	0.24	0.21	0.23	0.24	0.23	0.26	0.24
	E	=====	-0.20	0.05	0.03	0.05	0.04	0.05	0.07	0.06	0.02	0.05	NA	NA	0.03	-0.03	0.05	0.17	0.17	0.08	0.09	0.16	0.16	0.16	0.14	0.16
Pier 1 South (Outsid	N	=====	-------	=====	0.01	0.02	0.02	0.04	0.02	0.05	0.04	0.02	0.09	0.09	0.10	0.09	0.16	0.14	0.17	0.20	0.19	0.21	0.19	0.16	0.17	0.18
	E	=====	-------	=====	-0.07	-0.01	-0.06	-0.03	-0.01	-0.04	-0.06	0.04	-0.07	-0.06	-0.06	-0.13	-0.04	0.06	0.10	0.01	0.03	0.05	0.08	0.04	0.04	0.06
Pier 2 North (Inside)	N	=====	0.04	0.03	0.07	0.03	0.01	NA	-0.01	0.03	NA	=====	0.03	0.06	0.06	0.06	0.03	0.00	0.04	0.02	0.04	0.04	0.01	0.02	0.03	0.01
	E	=====	-0.07	-0.08	-0.05	-0.04	-0.04	NA	-0.09	-0.05	NA	=====	-0.03	-0.12	-0.08	-0.06	-0.07	-0.07	-0.10	-0.12	-0.08	-0.04	-0.04	-0.05	-0.08	-0.05
Pier 2 South (Inside)	N	=====	0.03	0.03	0.04	0.03	0.02	NA	0.10	0.07	NA	=====	-0.00	0.04	-0.03	-0.08	-0.03	-0.02	0.01	0.02	0.01	0.02	0.00	0.02	0.01	0.01
	E	=====	-0.11	-0.11	-0.08	-0.07	-0.03	NA	-0.05	-0.03	NA	=====	-0.04	-0.14	0.02	0.00	-0.02	-0.08	-0.06	-0.11	-0.07	-0.06	-0.06	-0.07	-0.07	-0.05

-------	No reading taken. (Point not set.)
=====	First reading (Point set/reset)
NA	Information Not Available

CHANGE IN PIER TILTS

(The change in tilts are difference between the coordinates and elevations of the points set on the pier seat and side of the pier. The first angle of compatible data is set to zero and compared to the preceding years A positive value indicates top tilt to the north or east. A negative value indicates top tilt to the south or west.)

Pier	Direction	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 8/96	REL 9/97	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06	REL 10/07	REL 10/08
WEP North (Inside)	N	NA	NA	NA	NA	NA	0.00 °	0.01 °	0.00 °	0.01 °	0.01 °	0.00 °	0.01 °	0.01 °	0.02 °	0.02 °	0.02 °	0.02 °	0.01 °	0.02 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.02 °
	E	NA	NA	NA	NA	NA	0.00 °	-0.00 °	-0.00 °	-0.00 °	0.01 °	0.02 °	0.00 °	0.00 °	0.00 °	0.00 °	0.01 °	0.00 °	0.00 °	0.00 °	0.01 °	0.00 °	0.01 °	0.01 °	0.01 °	0.01 °
WEP North (Outside	N	NA	NA	NA	NA	NA	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	0.01 °	0.00 °	0.00 °	0.00 °	-0.00 °	-0.00 °	-0.00 °	-0.00 °	0.00 °	-0.00 °	-0.00 °	0.00 °	-0.00 °	-0.00 °	0.00 °
	E	NA	NA	NA	NA	NA	0.00 °	-0.00 °	-0.00 °	-0.00 °	0.00 °	-0.00 °	0.00 °	0.00 °	-0.00 °	-0.01 °	-0.00 °	-0.00 °	-0.00 °	-0.00 °	-0.01 °	-0.00 °	0.00 °	0.00 °	0.00 °	0.00 °
WEP South (Inside)	N	NA	NA	NA	NA	NA	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	0.01 °	-0.00 °	0.00 °	0.01 °	-0.00 °	-0.00 °	0.00 °	0.01 °	0.00 °	0.00 °	0.00 °	0.01 °	0.01 °	0.00 °	0.00 °
	E	NA	NA	NA	NA	NA	0.00 °	0.01 °	0.01 °	0.00 °	0.01 °	-0.03 °	0.01 °	0.01 °	0.02 °	0.01 °	0.02 °	0.03 °	0.03 °	0.03 °	-0.00 °	0.00 °	0.02 °	0.02 °	0.02 °	0.02 °
WEP South (Outside	N	NA	NA	NA	NA	NA	0.00 °	-0.01 °	-0.01 °	0.02 °	0.05 °	-0.02 °	NA	0.03 °	0.05 °	0.03 °	0.03 °	0.02 °	0.05 °	0.02 °	0.01 °	0.02 °	0.01 °	0.04 °	-0.03 °	-0.03 °
	E	NA	NA	NA	NA	NA	0.00 °	0.06 °	0.16 °	0.19 °	0.37 °	0.62 °	NA	0.36 °	0.26 °	0.36 °	0.45 °	0.41 °	0.52 °	0.42 °	0.32 °	0.29 °	0.52 °	0.50 °	0.52 °	0.51 °
Pier 1 North (Inside)	N	NA	NA	NA	0.00 °	0.01 °	0.63 °	0.63 °	0.63 °	0.64 °	0.65 °	0.64 °	NA	NA	0.65 °	0.69 °	0.67 °	0.67 °	0.68 °	0.68 °	0.68 °	0.70 °	0.66 °	0.68 °	0.69 °	0.66 °
	E	NA	NA	NA	NA	NA	0.00 °	0.00 °	0.01 °	-0.02 °	-0.02 °	0.03 °	NA	NA	-0.02 °	-0.03 °	0.03 °	0.03 °	0.02 °	0.01 °	0.01 °	0.03 °	0.03 °	0.03 °	0.00 °	0.03 °
Pier 1 North (Outside	N	NA	NA	NA	NA	0.00 °	0.03 °	0.01 °	0.02 °	0.00 °	0.01 °	0.11 °	0.06 °	0.05 °	0.01 °	0.10 °	0.06 °	0.02 °	0.09 °	0.14 °	0.11 °	0.18 °	0.16 °	0.16 °	0.17 °	0.16 °
	E	NA	NA	NA	NA	0.00 °	-0.01 °	-0.01 °	-0.00 °	-0.02 °	-0.03 °	-0.03 °	-0.01 °	-0.00 °	0.00 °	-0.02 °	0.03 °	0.02 °	0.03 °	0.01 °	-0.00 °	0.04 °	0.04 °	0.03 °	0.02 °	0.04 °
Pier 1 South (Inside)	N	0.00 °	0.14 °	0.07 °	0.11 °	0.15 °	0.13 °	0.08 °	0.09 °	0.09 °	0.07 °	0.21 °	NA	NA	0.17 °	0.23 °	0.29 °	0.26 °	0.31 °	0.35 °	0.29 °	0.33 °	0.35 °	0.33 °	0.37 °	0.35 °
	E	0.00 °	-0.38 °	0.10 °	0.07 °	0.10 °	0.08 °	0.10 °	0.13 °	0.12 °	0.05 °	0.09 °	NA	NA	0.05 °	-0.06 °	0.10 °	0.33 °	0.32 °	0.15 °	0.18 °	0.31 °	0.32 °	0.31 °	0.27 °	0.31 °
Pier 1 South (Outsid	N	NA	NA	NA	0.00 °	0.01 °	0.01 °	0.02 °	0.00 °	0.03 °	0.02 °	0.01 °	0.06 °	0.06 °	0.07 °	0.06 °	0.11 °	0.10 °	0.12 °	0.14 °	0.13 °	0.15 °	0.13 °	0.11 °	0.12 °	0.12 °
	E	NA	NA	NA	0.00 °	0.16 °	0.03 °	0.11 °	0.16 °	0.08 °	0.03 °	0.29 °	0.01 °	0.04 °	0.03 °	-0.15 °	0.08 °	0.33 °	0.42 °	0.21 °	0.26 °	0.30 °	0.37 °	0.28 °	0.28 °	0.34 °
Pier 2 North (Inside)	N	0.00 °	0.00 °	0.00 °	0.01 °	0.00 °	0.00 °	NA	-0.00 °	0.00 °	NA	0.00 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °
	E	0.00 °	-0.08 °	-0.09 °	-0.05 °	-0.05 °	-0.05 °	NA	-0.10 °	-0.06 °	NA	0.00 °	-0.04 °	-0.15 °	-0.10 °	-0.08 °	-0.09 °	-0.09 °	-0.13 °	-0.15 °	-0.10 °	-0.05 °	-0.06 °	-0.07 °	-0.10 °	-0.07 °
Pier 2 South (Inside)	N	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	NA	0.01 °	0.01 °	NA	0.00 °	-0.00 °	0.00 °	-0.00 °	-0.01 °	-0.00 °	-0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °
	E	0.00 °	-0.14 °	-0.14 °	-0.10 °	-0.09 °	-0.03 °	NA	-0.06 °	-0.04 °	NA	0.00 °	-0.07 °	-0.20 °	0.00 °	-0.02 °	-0.05 °	-0.13 °	-0.10 °	-0.16 °	-0.12 °	-0.10 °	-0.10 °	-0.11 °	-0.11 °	-0.09 °

0.00 °	First reading (Tilt set/reset)
NA	Information Not Available

OCTOBER 2008 QUARTERLY REPORT
FIELD MONITORING SERVICES
CUY-90-14.52/15.24
PID #77332
CLEVELAND, OHIO

Report to

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

Prepared by

BBC&M ENGINEERING, INC.
CLEVELAND, OHIO

November 2008

November 10, 2008
012-00946-300

Mr. Dean A. Palmer, P.E.
Richland Engineering Limited
29 North Park Street
Mansfield, Ohio 44902

Re: CUY-90-14.52/15.24 Bridge (PID No. 77332)
Quarterly Report - Field Monitoring Services
October 2008 (Fourth Quarter)

Dear Mr. Palmer:

BBC&M Engineering, Inc. (BBCM) has completed the field monitoring services for the October 2008 quarter as part of the CUY-90-14.92/15.24 project. This quarterly report presents our general site observations and the results and evaluation of data collected from all the actively monitored instrumentation (inclinometers, piezometers and calipered distance locations) installed by BBCM at or near the West Abutment of the existing I-90 Central Viaduct Bridge.

A total of 19 inclinometers, six (6) pneumatic piezometers and 18 vibrating wire (VW) piezometers are actively monitored as part of the project. A Summary Table and Site Plan of Active Instrumentation are submitted as Plates 1 and 2 of the Appendix. Quarterly readings were taken during the period of October 13 through October 15, 2008.

Inclinometers

All the data sets presented in the Appendix have been corrected for measured spiral of the inclinometer casings and for systematic errors such as bias-shift, sensor rotation and depth positioning error, where necessary. The rates of movement were computed using linear regression for the depth ranges shown on the Displacement vs. Time plots in the Appendix.

There continues to be noticeable increased rates of movement observed in the inclinometers at B-204, B-303, B-05-03 and B-05-04 between the April 2008 and October 2008 quarterly readings (see Table 1 below). In the deep failure plane in B-105A, an increase in the rate of movement began in October 2007 at the time the cantilevered displacement in this inclinometer began exhibiting a significant increase in the rate of movement. In the other inclinometers, no significant changes in the rates of movement have been observed in the shallow or deep failure planes.

Shallow Failure Plane

No shallow slip-plane movements have been observed in the inclinometers within the Pier 1 stabilization system (B-204 and B-05-04) since completion of construction of the stabilization system. In the vicinity of Pier 1 just outside of the stabilization system (B-05-03 and B-108A), the shallow failure plane is moving at an average rate of about 0.065 inches per year (in/yr) from 2006 to the present. This is a slight increase from the rate of 0.06 in/yr as reported in the July 2008 Quarterly Report, dated August 5, 2008. Upslope from Pier 1 (B-203 and B-303), the shallow failure plane continues to move at an average rate of about 0.025 in/yr from 2004 to the present. Well outside the Pier 1 Area (B-05-16), the shallow failure plane is moving at an average rate of about 0.21 in/yr from 2006 to the present. This is a slight decrease from the rate of 0.24 in/yr as reported in the July 2008 Quarterly Monitoring Report. Additionally, the rate of the shallow movement in B-05-16 has decreased to about 0.14 in/yr from January 2007 to the present.

Deep Failure Plane

South of the West End Pier (B-102 and B-107), the deep failure plane continues to move at an average rate of about 0.03 in/yr from around 2000 to the present. In the Pier 1 area (B-203, B-204, B-303, B-105A, B-108A, B-05-03 and B-05-04), the deep failure plane is moving at an average rate of about 0.03 in/yr from 2004 (or 2006 for new or replacement inclinometers) to the present. This is a slight increase from the rate of movement of 0.025 in/yr as reported in the July 2008 Quarterly Monitoring Report. Well outside the Pier 1 area (B-05-16), the deep failure plane continues to move at an average rate of 0.02 in/yr.

Additional Observations in Active Inclinometers Installed between 1994 and 1999

The B-101 inclinometer has indicated nominal movement since its installation. The inclinometer at P-9N (installed in one of the drilled shafts) indicates the top of the drilled shaft is restrained laterally and that the maximum lateral deflection is about 1.0 inches and occurs approximately 40 to 60 feet below the top of the inclinometer casing.

The inclinometer at B-303 will likely need to be abandoned within the next few quarterly readings as it has become somewhat difficult to lower and raise the inclinometer probe past the "kink" in the pipe that has developed within the deep failure plane at a depth of about 95 feet.

Additional Observations in Active Inclinometers Installed in 2006

The cantilever displacement continually observed in B-105A to a depth of about 60 to 70 feet (see Plates 22 and 23 in the Appendix) is moving at a rate of about 1.28 in/yr. This is an increase from the rate of movement of 1.06 in/yr as reported in the July 2008 Quarterly Monitoring Report. The bulkhead at this location may be progressively leaning outwards toward the Cuyahoga River. A Displacement vs. Time

plot for B-105A has been submitted as Plate 26 in the Appendix. Additionally, a photo of the bulkhead adjacent to B-105A taken in October 2008 has been submitted as Plate 67 in the Appendix. It appears that there may be a bulge in the bulkhead in the vicinity of B-105A.

The small cantilever displacement that has been previously observed in B-05-03 within the top 10 feet has increased in magnitude and depth (up to almost 20 feet) since the July 2008 reading (see Plates 32 and 33 in the Appendix). This increased rate and depth of movement indicates that the shallow movements as indicated by the cantilever displacement in B-105A may be progressively extending further away from the Cuyahoga River thereby influencing B-05-03.

Table 1 below summarizes the changes in the rates of movement that have been observed in five (5) inclinometers.

Table 1: Summary of Rate Changes in Some Inclinometers – CUY-90-15.24

Inclinometer	Failure Plane	Time Range	Avg. Rate of Movement (in/yr)	Percentage Increase in the Avg. Rate of Movement (%)
B-204	Deep (117'-119')	Jan 04 – Apr 08	0.025	260
		Apr 08 - Present	0.065	
B-303	Deep (95'-99')	Jan 04 – Apr 08	0.03	317
		Apr 08 - Present	0.095	
B-05-03	Shallow (35'-39')	Jun 06 – Apr 08	0.075	400
		Apr 08 - Present	0.30	
	Deep (123'-125')	Jun 06 – Apr 08	0.03	767
		Apr 08 - Present	0.23	
B-05-04	Deep (117'-119')	Jun 06 – Apr 08	0.015	367
		Apr 08 - Present	0.055	
B-105A	Deep (105'-111')	Jun 06 – Oct 07	0.015	433
		Oct 07 - Present	0.065	

The most significant increases in the average rates of movement have occurred in the shallow and deep failure planes in the B-05-03 inclinometer (400% to 767%). Note that all five (5) inclinometers summarized in Table 1 are located underneath or east of the existing I-90 bridge near the east right-of-way fence where aggregate piles of variable sizes have been stored for many years. During the July 2008 and October 2008 quarterly readings, the aggregate pile(s) have been larger and placed closer to the right-of-way fence than has been previously observed over the last several years. A more detailed discussion regarding these aggregate piles adjacent to the east right-of-way fence is subsequently provided. The increased rates of movements in these inclinometers may be caused by the aggregate piles, the possible increased rate of

outward movement of the bulkhead adjacent to B-105A, and/or the slightly increased pore pressures observed in the piezometers at B-05-03 and B-303.

Potential slope movements not yet developed enough to be called definitive slide planes (i.e., movements that have not been consistent or are still within the limits of the accuracy of the instrumentation) have been observed in some of the inclinometers, which are listed as follows:

- In B-105A, depth of about 85 feet (see Plate 22 in the Appendix); and,
- In B-05-02, depth of about 109 ft and 129 ft (see Plate 30 in the Appendix).

Additional readings are needed in these inclinometers to evaluate whether these potential slide planes are true displacements.

The movement in B-105A at a depth of about 105 to 111 feet is considered to be a definitive slide plane and has been included on the Displacement vs. Time plot for B-105A submitted as Plate 26 in the Appendix.

Piezometers

Pneumatic Piezometers

The results of the active pneumatic piezometer readings taken on October 14 and 15, 2008 are summarized in Table 2 below.

Table 2: Summary of Readings for Active Pneumatic Piezometers – CUY-90-15.24

Piezometer Identifier		Ground Surface Elevation (ft)	Elevation Head, h_e (ft)	Pore Pressure Reading, u (psi)	Total Head, h_t (ft)
B-101 (P-1*)	orange	676.6	626.3	0.7	627.9
	pink	676.6	552.3	32.2	626.6
B-105 (P-3*)	pink	585.6	497.6	38.3	586.0
	blue	585.6	479.9	47.8	590.2
B-107 (P-5*)	orange	662.3	562.3	25.8	621.8
B-303 (P-2*)	pink	627.0	586.2	7.1	602.6

*BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers.

All the piezometers exhibited slightly lower readings than those recorded in July 2007, except the B-303 piezometer, which exhibited a slightly higher reading. Note that the piezometers at B-105 continue to indicate elevated water pressures (i.e., a total head above the ground surface, artesian conditions). Total Head vs. Time plots have been submitted as Plates 51 through 54 in the Appendix of this report.

Vibrating Wire (VW) Piezometers

Table 3 provides a summary of the maximum and minimum values of all the pressure readings taken from July 2008 (end of previous reporting period) to the time when the collected data was last downloaded from VW Miniloggers between October 13 and October 15, 2008.

The measured total head values were relatively constant during the current reporting period with a difference between maximum and minimum total head values of no more than 1.4 feet in all of the VW piezometers where readings were recorded at regular intervals (see footnotes in Table 3). Total Head vs. Time plots have been submitted as Plates 55 through 63 in the Appendix.

The 21955 piezometer in B-05-13 continues to indicate an elevated water pressure (i.e., a total head above the ground surface, artesian conditions) similar to that observed in the pneumatic piezometers at B-105 previously discussed.

Table 3: Summary of Readings for VW Piezometers – CUY-90-14.92

Piezometer Identifier		Time Interval of Readings Reported [1]	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-01	21961 - 65 ft	7/14/08 to 10/14/08	13.2/13.0	675.4	610.4	13.0/12.4	640.3/639.0
	21967 - 95 ft	7/14/08 to 10/14/08[3]	13.1/13.1[3]	675.4	580.4	24.4/24.1[3]	636.6/635.9[3]
B-05-02	21963 - 46 ft	7/15/08 to 10/15/08	12.2/12.1	617.9	571.9	8.3/7.9	591.2/590.1
	21951 - 122 ft	7/15/08 to 10/15/08	12.2/12.1	617.9	495.9	40.6/40.2	589.7/588.7
B-05-03	21957 - 32 ft	10/13/08[2]	12.0[2]	605.1	573.1	8.4[2]	592.4[2]
	21965 - 112 ft	10/13/08[2]	12.4[2]	605.1	493.1	41.6[2]	589.1[2]
B-05-04	21958 - 59 ft	7/15/08 to 10/15/08[3]	12.8/12.8[3]	600.8	541.8	18.0/18.0[3]	583.4/583.4[3]
	21952 - 119 ft	7/15/08 to 10/15/08	13.0/13.0	600.8	481.8	45.0/44.9	585.6/585.3
B-05-07	21966 - 102 ft	7/14/08 to 10/14/08	12.4/10.2	678.9	576.9	24.4/24.0	633.1/632.2
	21956 - 220 ft	7/14/08 to 10/14/08	11.9/11.9	678.9	458.9	71.6/71.3	624.2/623.4

1 – Readings generally were taken every 8 hours during the reported time interval.
2 – Only one (1) manual reading was taken at the time of data collection during the October 2008 quarterly readings due to Minilogger issues. For additional details, see the Total Head vs. Time plot for the specific Minilogger in the Appendix.
3 – Malfunction of Minilogger resulting in several scheduled readings being missed during the reported time interval. For additional details, see the Total Head vs. Time plot for the specific Minilogger in the Appendix.

Table 3 (continued): Summary of Readings for VW Piezometers – CUY-90-14.92

Piezometer Identifier		Time Interval of Readings Reported [1]	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-08	21954 - 65.5 ft	7/14/08 to 10/14/08	12.7/12.6	679.9	614.4	12.9/12.3	644.2/642.8
	21959 - 110.5 ft	7/14/08 to 10/14/08	12.4/12.4	679.9	569.4	29.8/29.3	638.2/637.0
B-05-11	21968 - 95 ft	10/14/08[2]	12.6[2]	675.1	580.1	23.8[2]	635.1[2]
	21953 - 130 ft	10/14/08[2]	12.5[2]	675.1	545.1	36.7[2]	629.8[2]
B-05-12	21960 - 75 ft	10/15/08[2]	12.8[2]	652.7	577.7	18.9[2]	621.3[2]
	21964 - 120 ft	10/15/08[2]	12.4[2]	652.7	532.7	36.9[2]	617.8[2]
B-05-13	21962 - 60 ft	7/16/08 to 10/15/08	12.7/12.6	580.0	520.0	24.3/23.9	576.2/575.3
	21955 - 135 ft	7/16/08 to 10/15/08	12.8/12.8	580.0	445.0	60.5/60.3	584.6/584.2

1 – Readings generally were taken every 8 hours during the reported time interval.
2 – Only one (1) manual reading was taken at the time of data collection during the October 2008 quarterly readings due to Minilogger issues. For additional details, see the Total Head vs. Time plot for the specific Minilogger in the Appendix.
3 – Malfunction of Minilogger resulting in several scheduled readings being missed during the reported time interval. For additional details, see the Total Head vs. Time plot for the specific Minilogger in the Appendix.

In six (6) of the VW piezometers, only one (1) manual reading was taken at the time of data collection during the October 2008 quarterly readings due to malfunctioning VW Miniloggers (21957 and 21965 at B-05-03, 21968 and 21954 at B-05-11, and 21960 and 21964 at B-05-12). Additionally, many scheduled readings were missed in two (2) of the VW piezometers (21967 at B-05-01 and 21958 at B-05-04) between the July 2008 and October 2008 quarterly readings. It is our understanding that ODOT is planning on purchasing new Miniloggers for BBCM to install as replacements for the nonfunctional Miniloggers.

Additional Field Measurements and Observations

The two calipered surface distance locations (left and right) are provided in the Site Plan of Active Instrumentation (Plate 2 of the Appendix). A Calipered Surface Distance Table and Calipered Distance Readings vs. Time plots have been included as Plates 64 through 66 in the Appendix. The left calipered location indicates the gap is continuing to open at a rate of about 0.06 in/yr and the gap at the right calipered location is continuing to close at a rate of about 0.02 in/yr. The right calipered location has been oscillating above and below a distance of about 4.4 inches since late 2000 indicating that there might not be a trend.

In October 2008, an aggregate pile, roughly 20 to 25 feet high, was observed right next to the east right-of-way fence and covered roughly less than 15 percent of the property

currently being used to stockpile aggregate adjacent to the east right-of-way fence. A portion of the fence was knocked over by the stockpile as it was spilling over into the I-90 bridge right-of-way with the edge of the pile touching the edge of the concrete drive near B-05-03 (see Plates 68 through 70 in the Appendix). Another smaller aggregate pile, roughly 10 to 15 feet high, was observed at the far east end of the property covering roughly less than 25 percent of the property. The aggregate piles observed during the July 2008 and October 2008 quarterly readings have been larger in size and placed closer to the east right-of-way fence than has been observed during previous quarterly readings over the past several years.

The large excavation and the repair effort of the bulkhead near the west right-of-way fence appear to remain unfinished as of October 2008. The small landslide adjacent to the large excavation near the west right-of-way fence (just north of B-05-16, see Plate 2 in the Appendix for the approximate landslide location) does not appear to have experienced a significant change since the quarterly readings were last taken in July 2008. However, the area was covered heavily with vegetation during the site visit making it difficult to see the scarps.

Closing

We appreciate being of continued service during this project. Please contact our office if you have any questions or require additional information. The next quarterly readings are scheduled to take place around January 15, 2008.

Sincerely,
BBC&M ENGINEERING, INC.
Cleveland, Ohio

Jeffrey L. Snyder, P.E.
Project Engineer

Stephen C. Pasternack, P.E.
Senior Project Engineer

cc: Mr. Jeff Broadwater, P.E. (Michael Baker Jr., Inc.)

Submitted: pdf copy submitted to Richland Engineering at reltd@r-e-l.com and Michael Baker Jr., Inc. via their ftp site
Attachments: Appendix (Plates 1 through 70)

APPENDIX

CUY-90-14.52/15.24 INSTRUMENTATION MONITORING

APPENDIX

Plate No.

General Information

Summary Table of Active Instrumentation....1
Site Plan of Active Instrumentation....2

Plots for Active BBCM Inclinometers Installed from 1994 to 1999–CUY-90-15.24

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B-102 – A and B-Axis....5-6
B-107 – A and B-Axis....7-8
B-203 – A and B-Axis....9-10
B-204 – A and B-Axis....11-12
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P-9N – A and B-Axis....15-16

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B-107 – A-Axis....18
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Plots for Replacement Inclinometers Installed by BBCM in 2006 – CUY-90-15.24

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B-108A – A and B-Axis....24-25

Displacement versus Time Plots
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Plots for Inclinometers Installed by BBCM in 2006 – CUY-90-14.52

Cumulative and Incremental Displacement versus Depth Plots
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B-05-04 – A and B-Axis....34-35
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APPENDIX (continued)

Plate No.

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B-05-16 – A and B-Axis 46-47

Displacement versus Time Plots

B-05-03 – A-Axis 48
B-05-04 – A-Axis 49
B-05-16 – A-Axis 50

Plots for Active Pneumatic Piezometers Installed by BBCM in 1994 – CUY-90-15.24

Total Head (h_t) versus Time Plots

B-101 (P-1) 51
B-105 (P-3) 52
B-107 (P-5) 53
B-303 (P-2) 54

Plots for Vibrating Wire (VW) Piezometers Installed by BBCM in 2006 – CUY-90-14.52

Total Head (h_t) versus Time Plots

B-05-01 55
B-05-02 56
B-05-03 57
B-05-04 58
B-05-07 59
B-05-08 60
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Calipered Surface Distance Data – CUY-90-15.24

Calipered Surface Distance Table 64
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Aggregate Pile Damage – Taken on 10/13/08 and 10/30/08 68-70

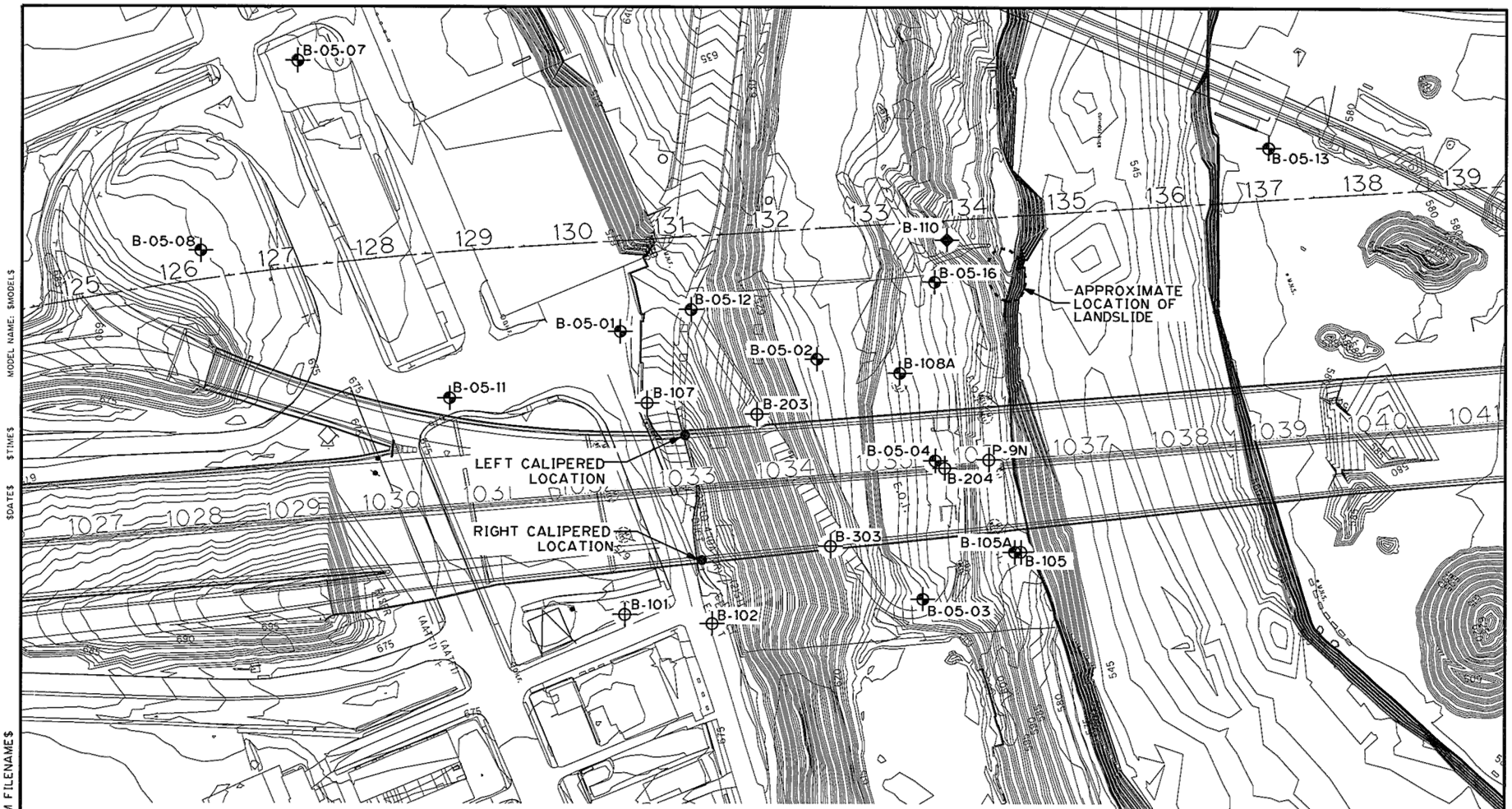
SUMMARY OF ACTIVE INSTRUMENTATION
CUY-90-14.52/15.24

Active Instrumentation	Active Inclinometer ?	Inclinometer Depth (ft)	Active Piezometer?	VW or Pneumatic?	# of Active Piezometers	Piezometer Depth(s) Below Existing G.S. (ft)	Instrumentation Installation Date	G.S. Elevation (ft)
B-101	Y	190	Y[1]	Pneumatic[1]	2 [1]	50.3, 124.3	Aug-Sep 1994	676.6 (676.6[3])
B-102	Y	224	N	---	---	---	Sep 1994	675.7
B-105	N	---	Y[1]	Pneumatic[1]	2 [1]	88, 105.7	Aug 1994	585.4 (585.6[3])
B-105A	Y	156	N	---	---	---	May 2006	585.7
B-107	Y	210	Y[1]	Pneumatic[1]	1 [1]	100	Sep 1994	662.7 (662.3[3])
B-108A	Y	168	N	---	---	---	Apr-May 2006	603.0
B-203	Y	190	N	---	---	---	Aug 1996	638.0
B-204	Y	134	N	---	---	---	Jul 1998	599.0
B-303	Y	178	Y[2]	Pneumatic[2]	1 [2]	40.8	Aug 1994[2], Jul 1998	622.0 (627.0[3])
P-9N	Y	148	N	---	---	---	Feb 1999	588.0
B-05-01	Y	228	Y	VW	2	65, 95	Apr-May 2006	675.4
B-05-02	Y	176	Y	VW	2	46, 122	Apr-May 2006	617.9
B-05-03	Y	168	Y	VW	2	32, 112	Apr-May 2006	605.1
B-05-04	Y	172	Y	VW	2	59, 119	Mar-May 2006	600.8
B-05-07	Y	224	Y	VW	2	102, 220	Apr-Jun 2006	678.9
B-05-08	Y	224	Y	VW	2	65.5, 110.5	Apr-May 2006	679.9
B-05-11	Y	226	Y	VW	2	95, 130	Apr-Jun 2006	675.1
B-05-12	Y	210	Y	VW	2	75, 120	Apr-May 2006	652.7
B-05-13	Y	134	Y	VW	2	60, 135	May-Jun 2006	580.0
B-05-16	Y	162	N	---	---	---	Jun 2006	598.5

1 BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers (i.e. P-1 to B-101, P-3 to B-105, and P-5 to B-107).

2 The pneumatic piezometer was actually installed in August 1994 at Boring P-2 in the vicinity of the B-103 inclinometer (now inactive). However, the piezometer has since been renamed to B-303 due to its close proximity to the active inclinometer at B-303, which was installed in July 1998.

3 Elevation in parenthesis refers to the ground surface (G.S.) elevation of the P boring location where the pneumatic piezometer was installed.



LEGEND

B-05-01 — LOCATION OF INCLINOMETER/PIEZOMETER INSTALLED BY BBCM IN 2006 (B-05-01 THROUGH B-05-04, B-05-07, B-05-08, B-05-11 THROUGH B-05-13, AND B-05-16).

B-105A — LOCATION OF REPLACEMENT INCLINOMETER INSTALLED BY BBCM IN 2006 (B-105A AND B-108A).

B-101 — LOCATION OF INCLINOMETER AND/OR PIEZOMETER INSTALLED BY BBCM BETWEEN 1994 AND 1999 (B-101, B-102, B-105, B-107, B-203, B-204, B-303, AND P-9N).

B-110 — LOCATION OF INCLINOMETER AT B-110, WHICH WAS DESTROYED BY EXCAVATION ACTIVITIES IN MARCH, 2006

SCALE IN FEET
0 50 100

SITE PLAN OF ACTIVE INSTRUMENTATION

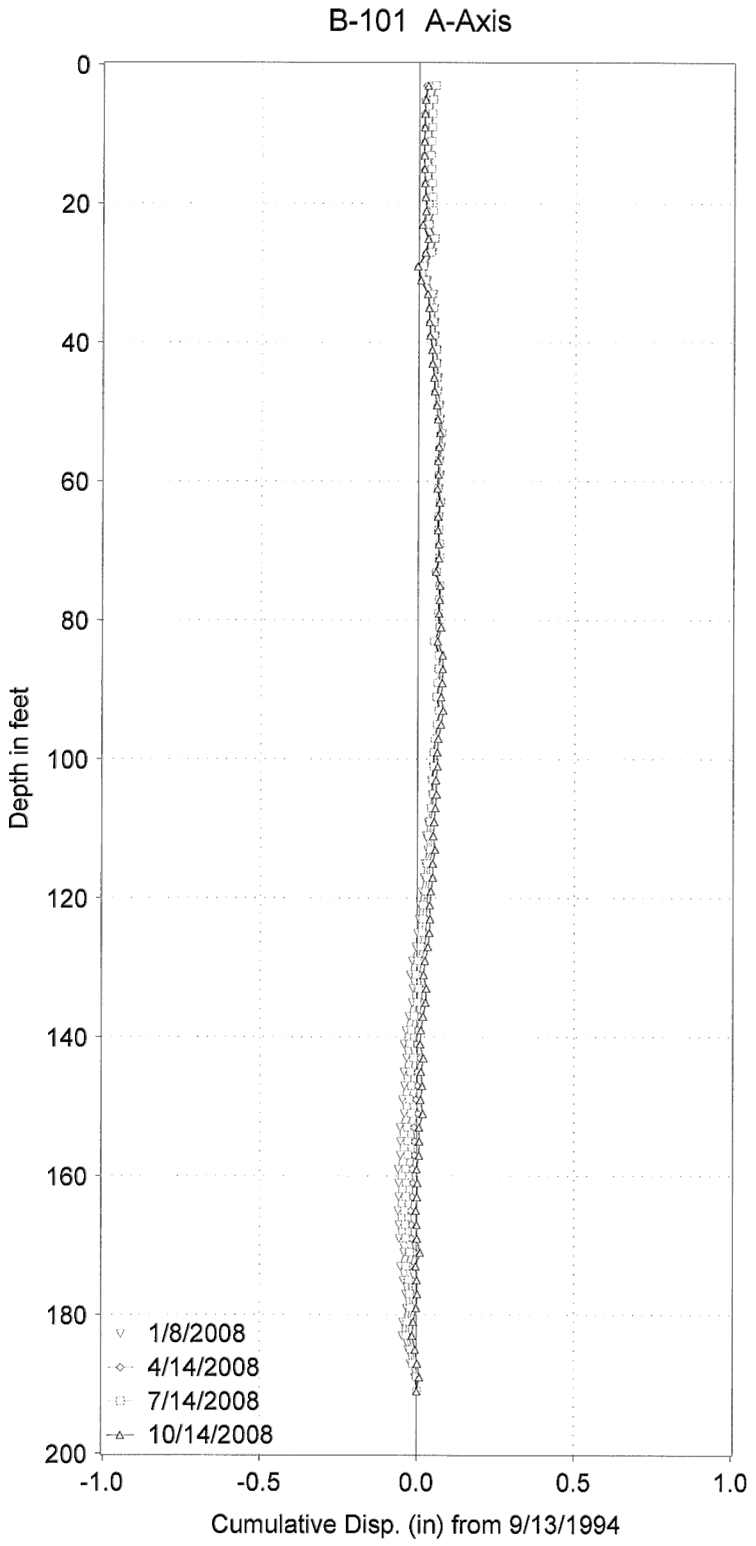
CUY-90-14.52/15.24 WEST ABUTMENT
CLEVELAND, OHIO

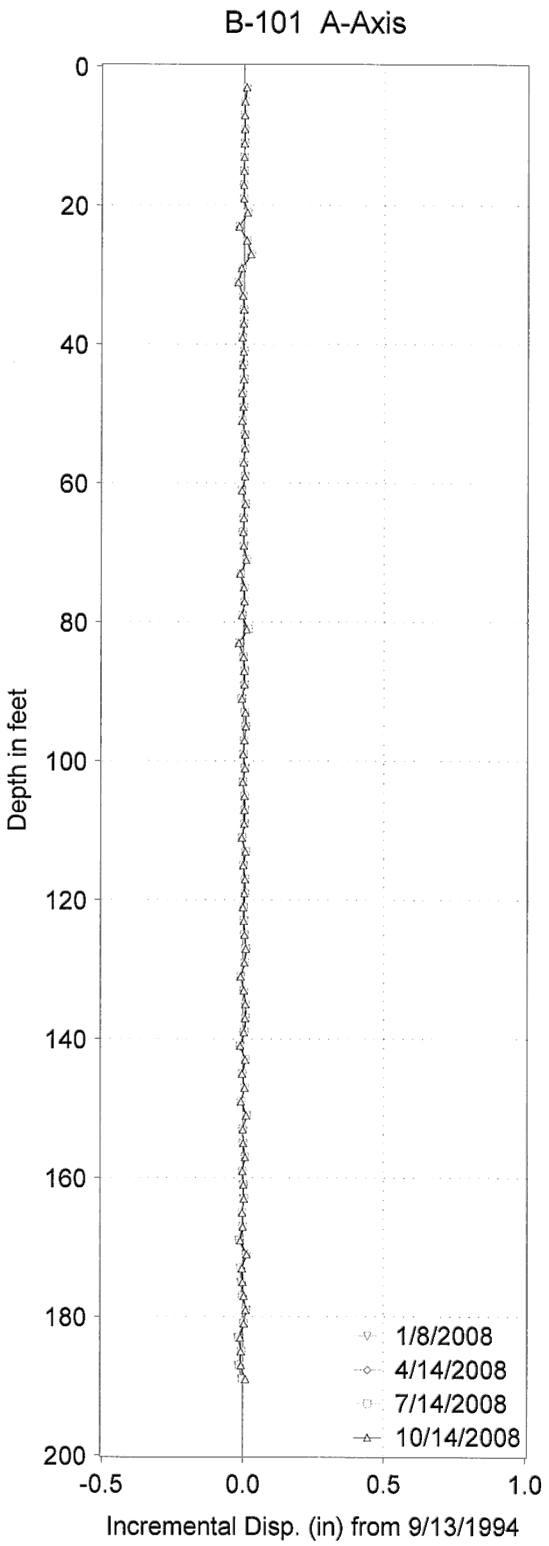
Project: 012-00946-300	Drawn By: EDV
Drawing Date: 7/25/06	Approved By: JLS
Revision Date: 2/9/07	Scale: 1" = 100'

BBCM
SOLUTIONS TO BUILD ON
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

BBC&M DRAWING FILE: $BBCM FILENAME$ $DATE$ $TIME$ MODEL NAME: $MODEL$

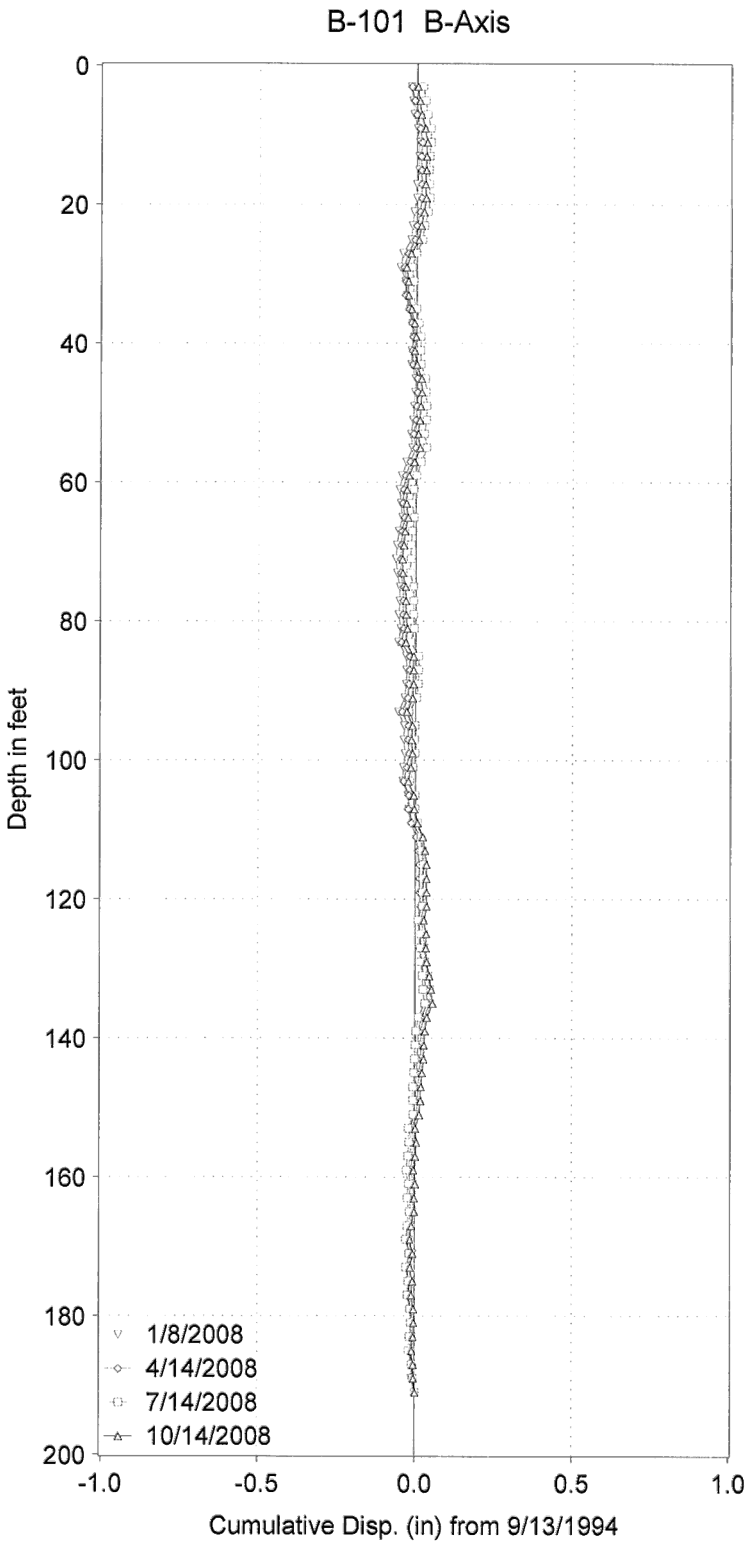
PLATE 2

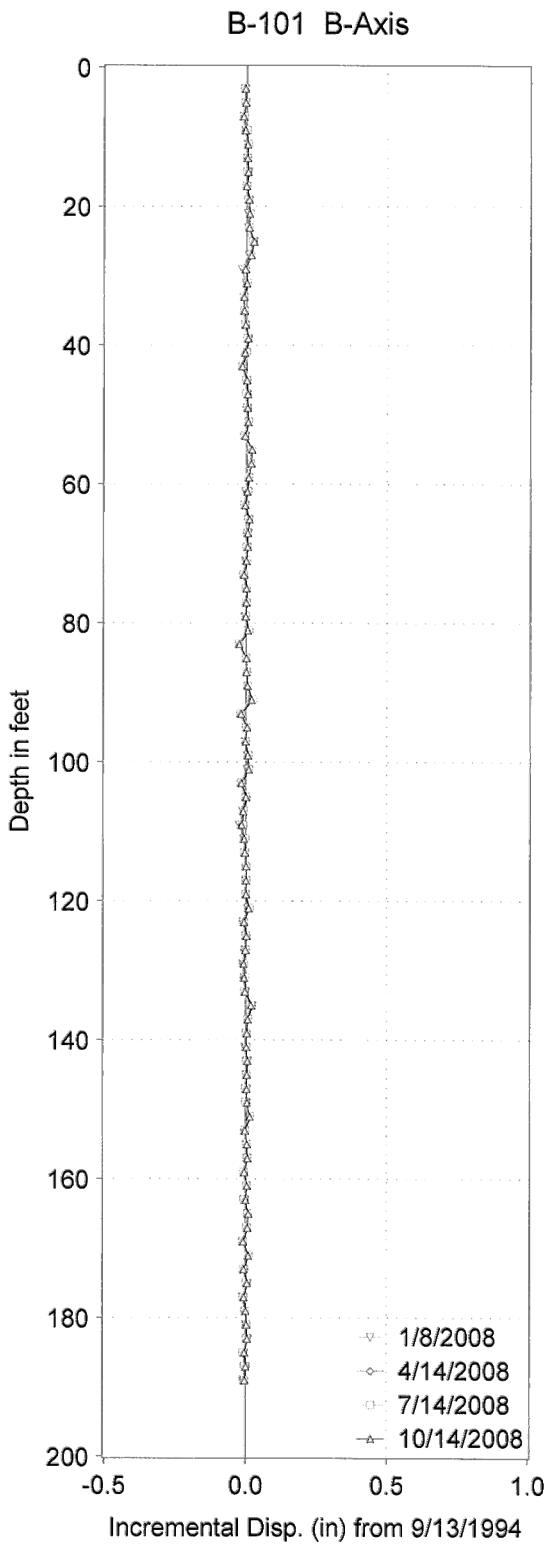




B-101
-Includes readings from the last four quarters.

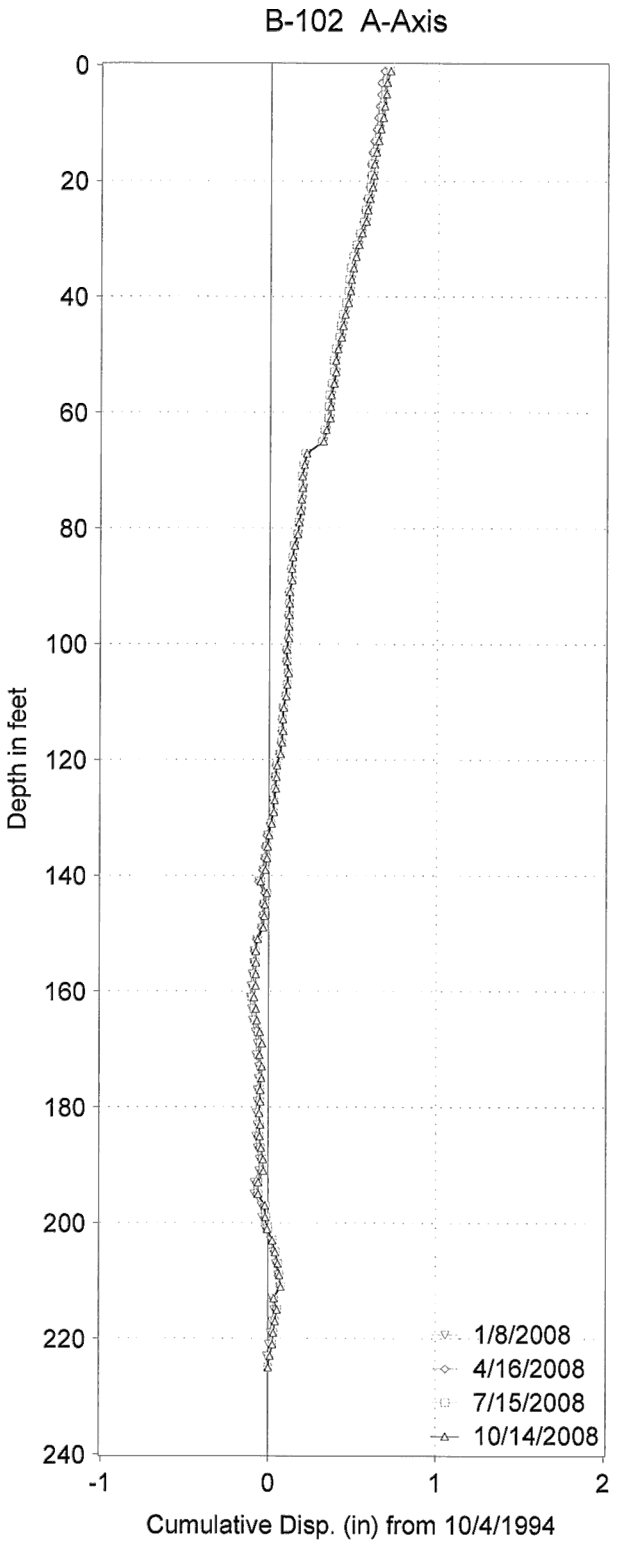
PLATE 3

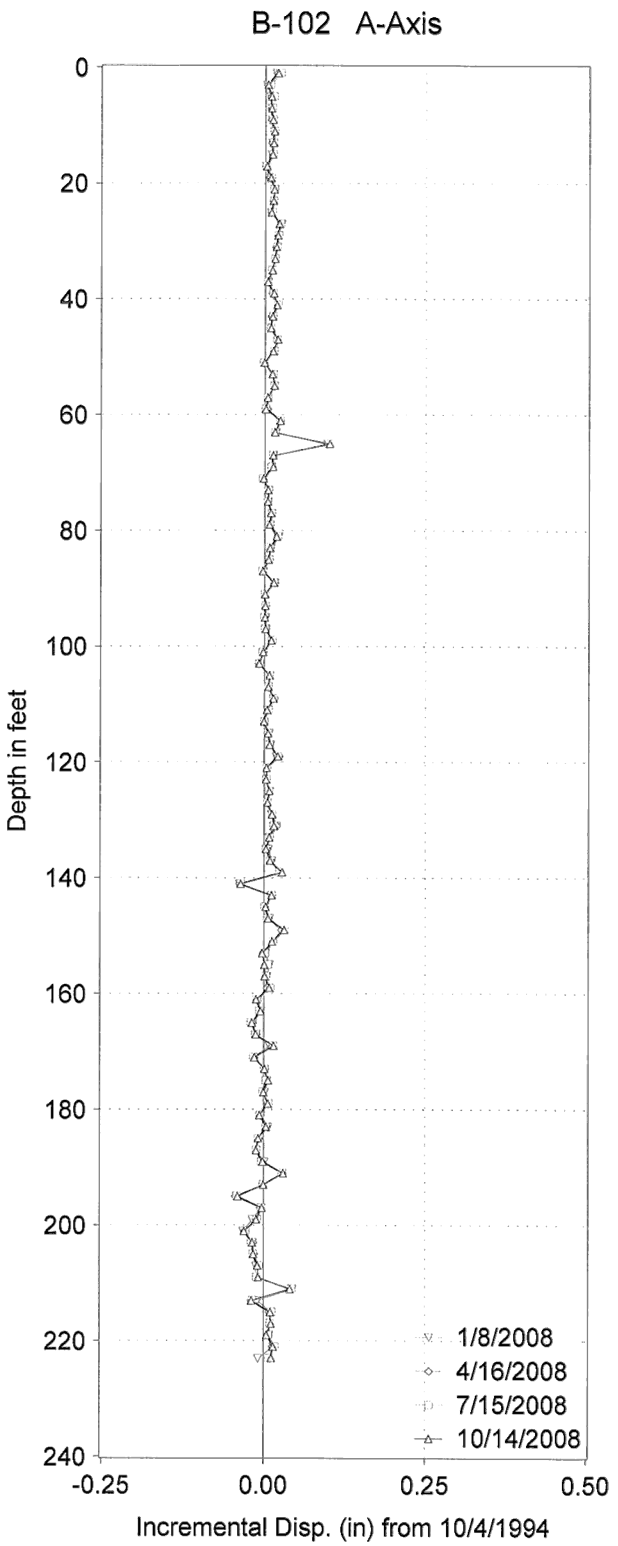




B-101
-Includes readings from the last four quarters.

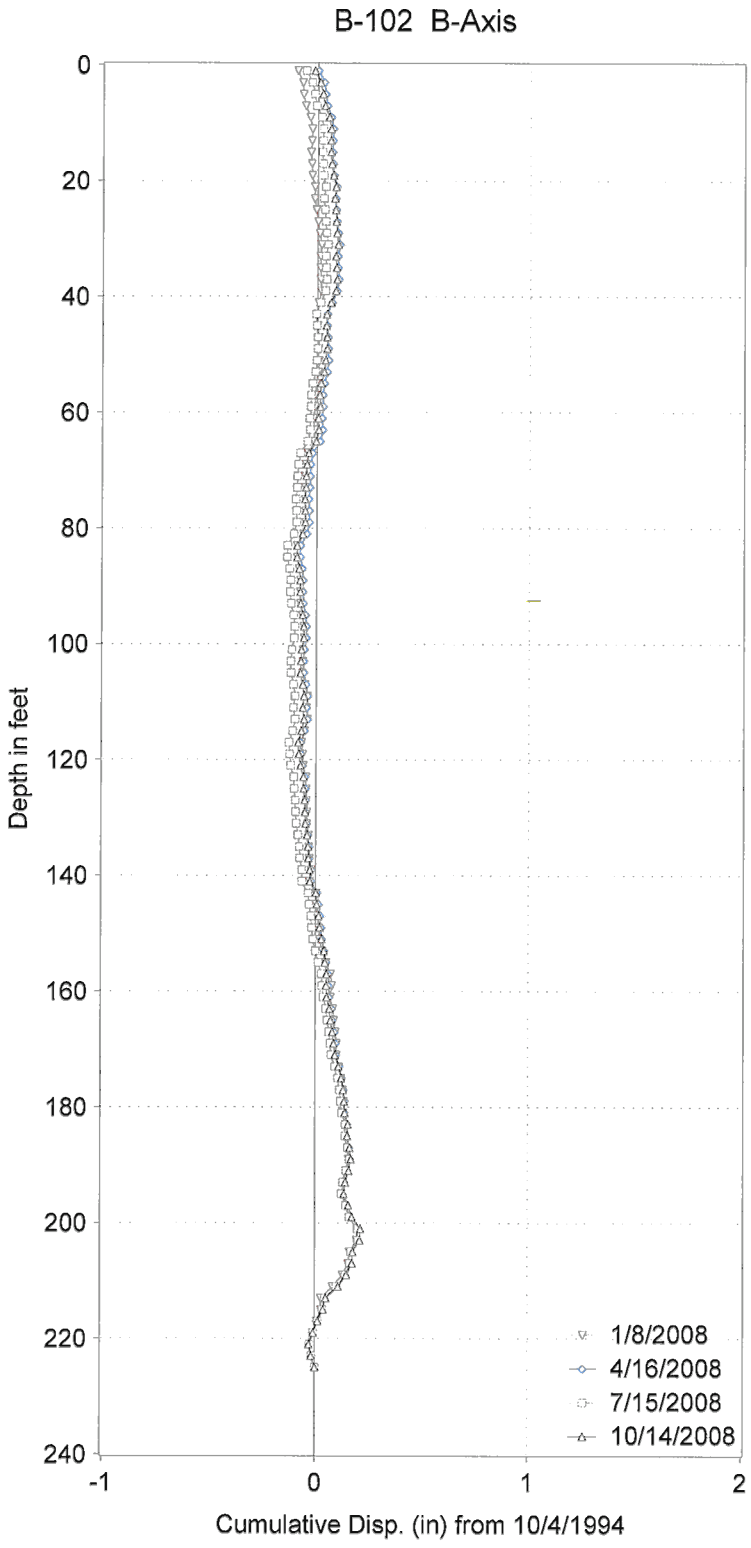
PLATE 4

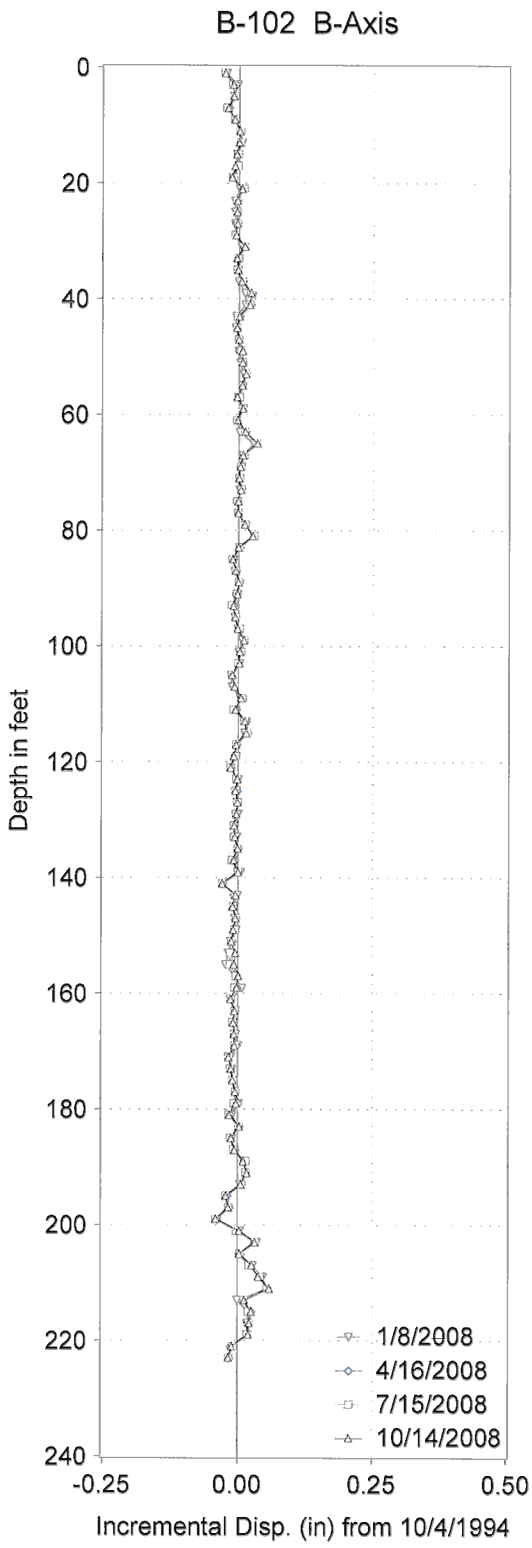




B-102
-Includes readings from the last four quarters.

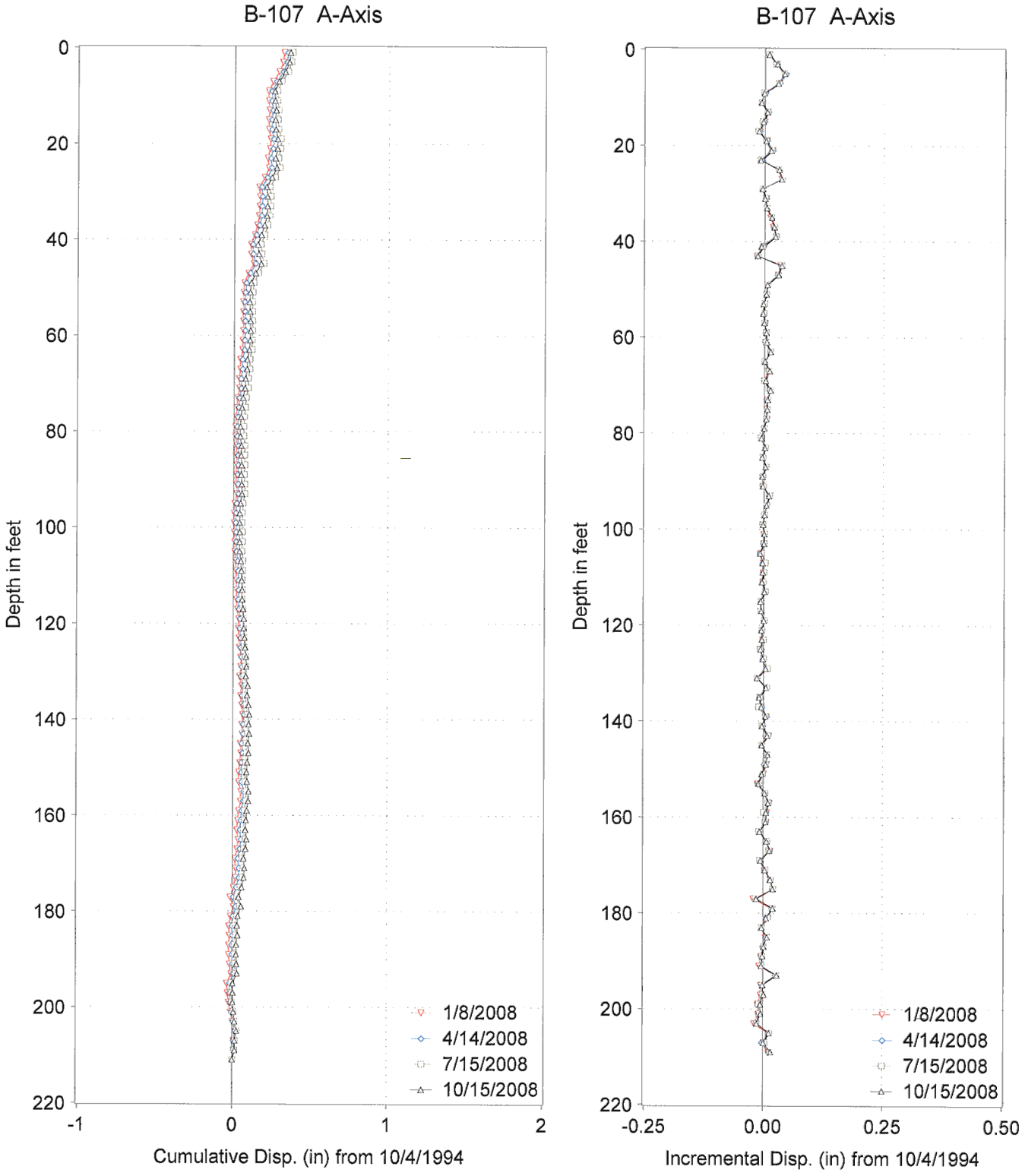
PLATE 5





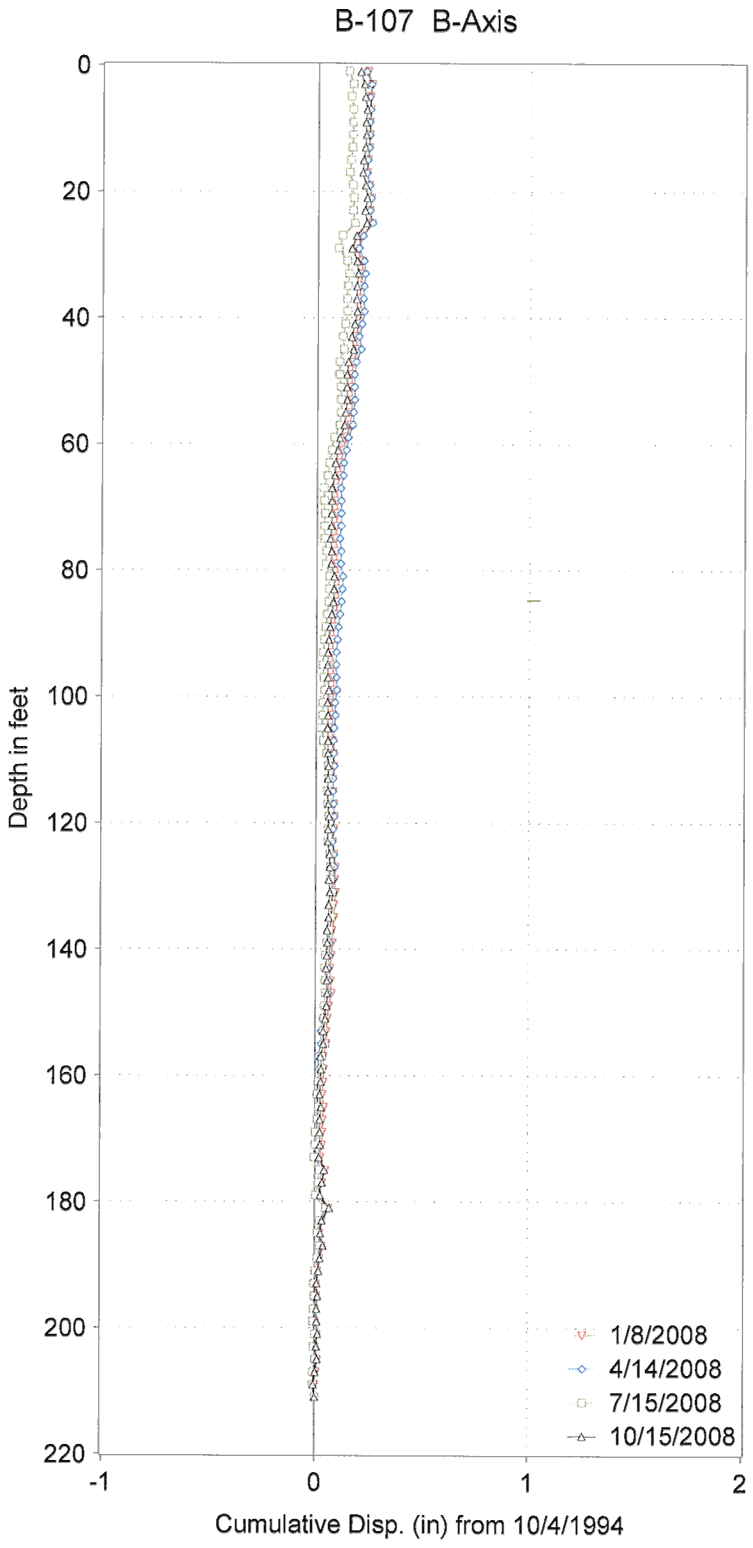
B-102
-Includes readings from the last four quarters.

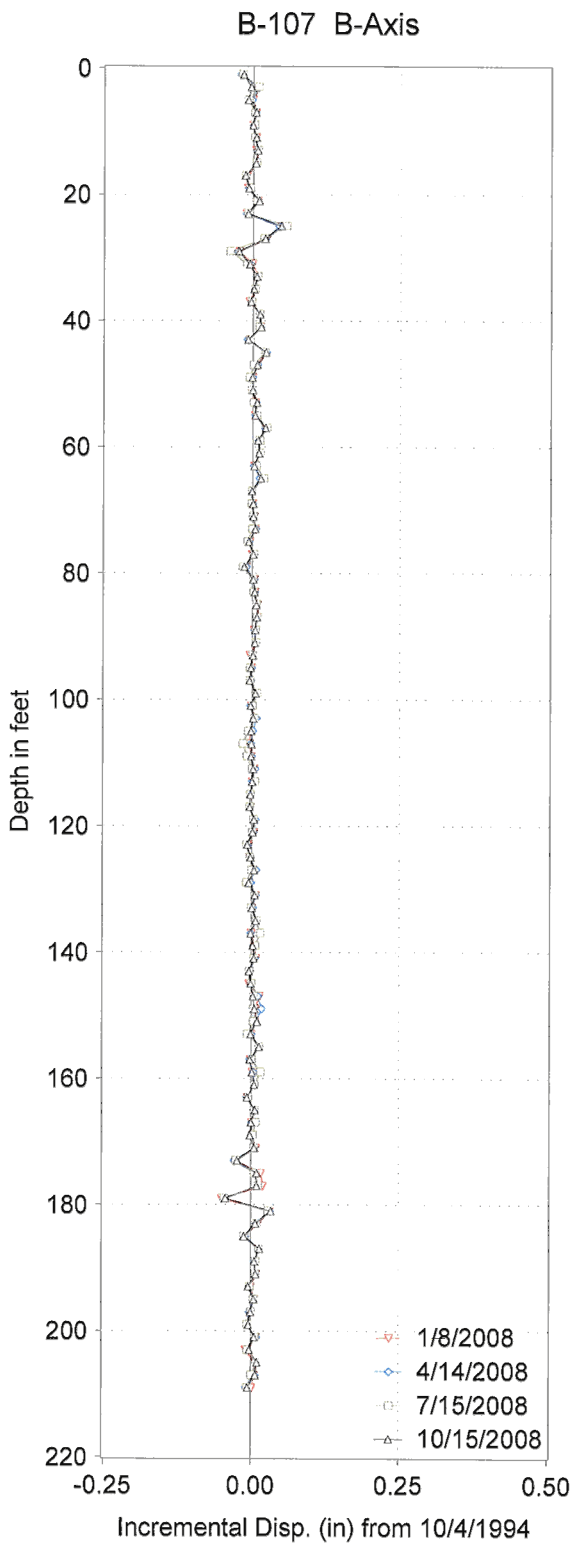
PLATE 6



B-107
-Includes readings from the last four quarters.

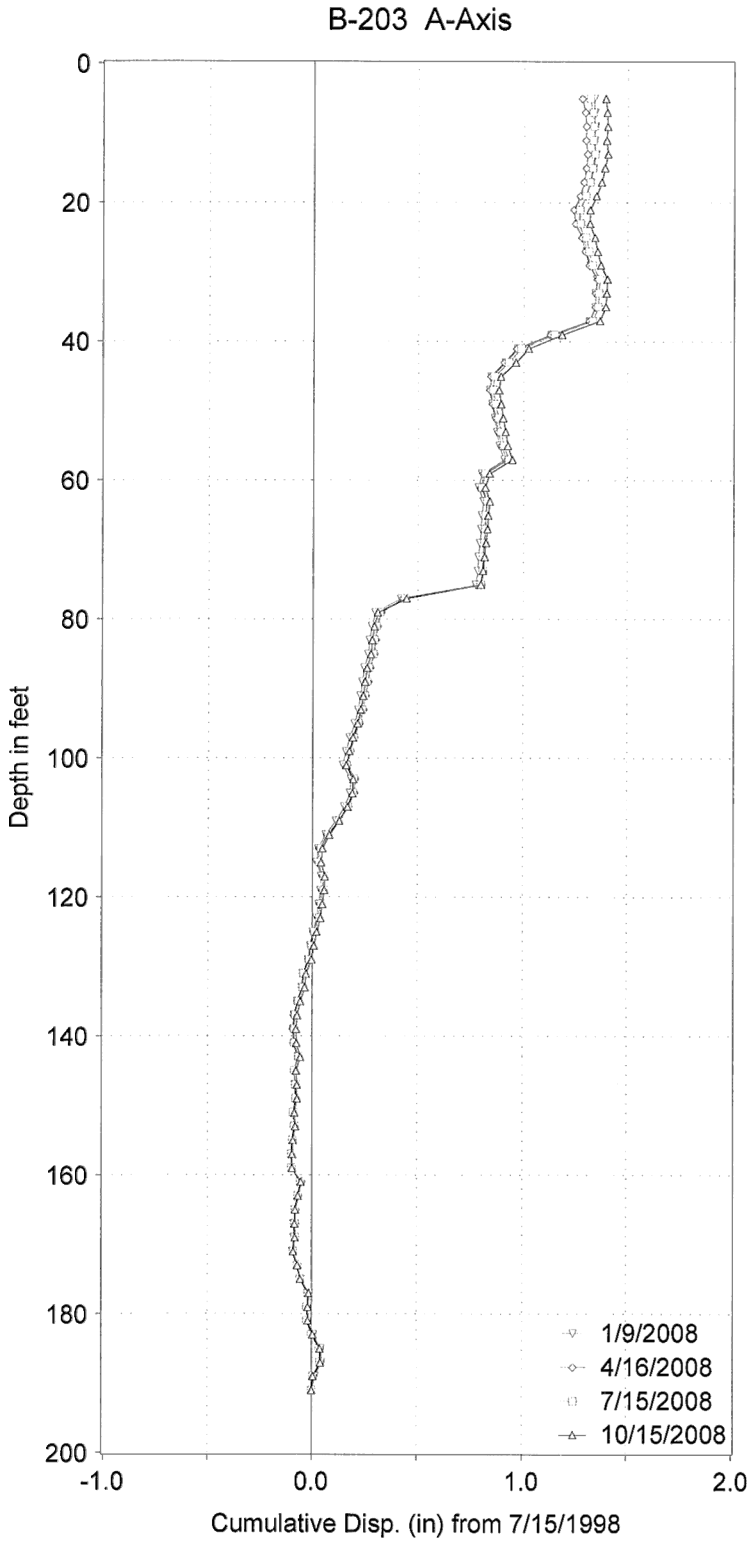
PLATE 7

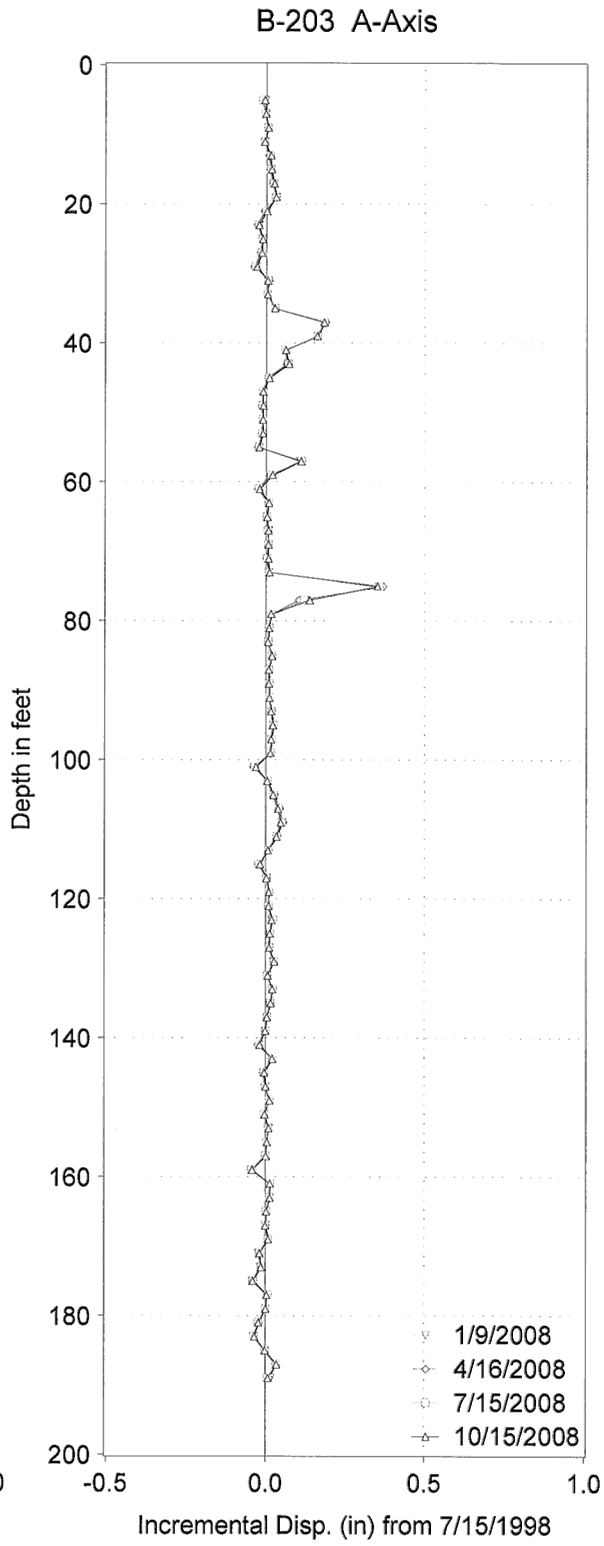




B-107
-Includes readings from the last four quarters.

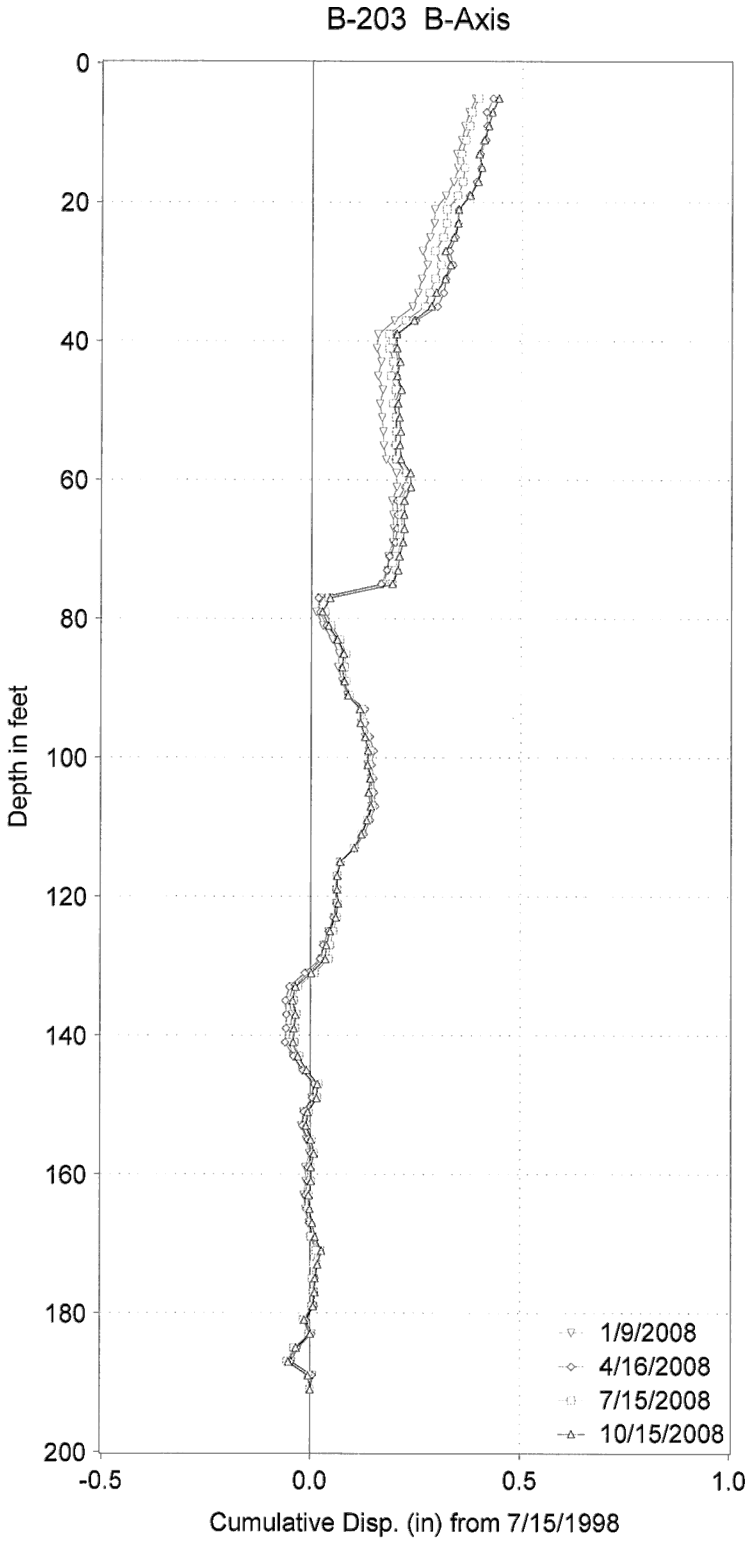
PLATE 8

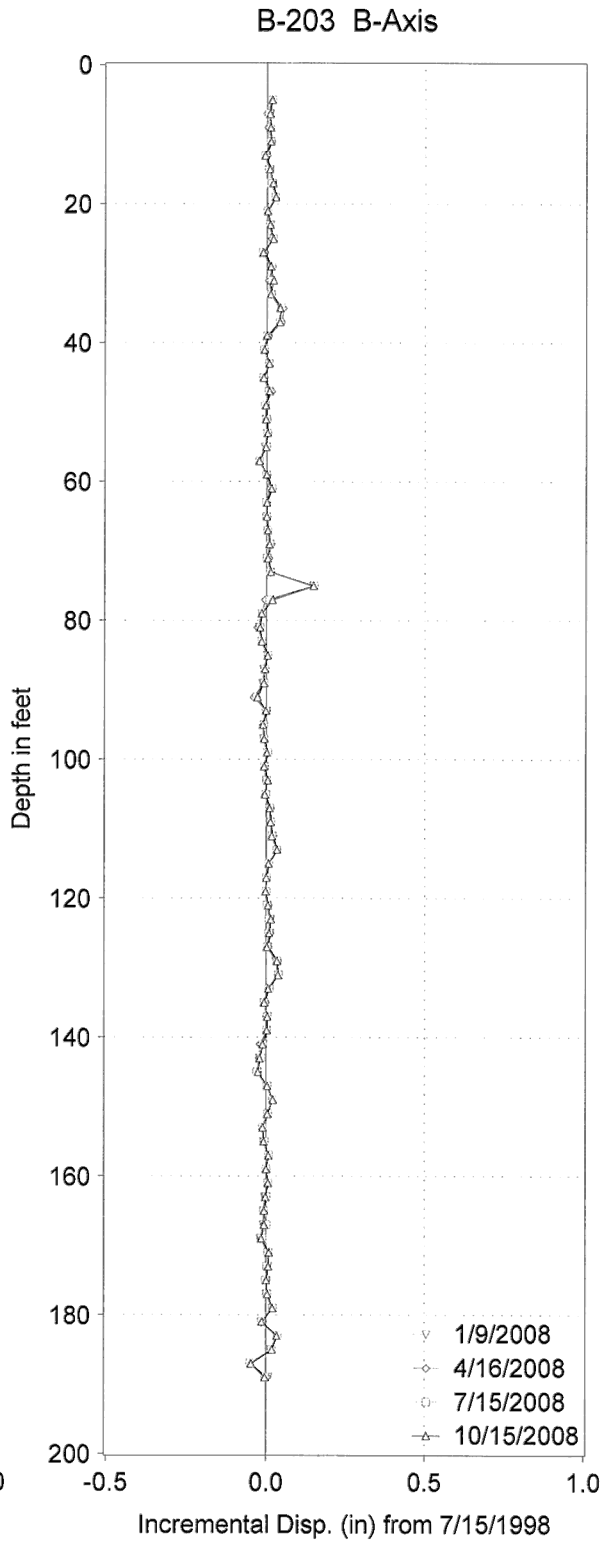




B-203
-Includes readings from the last four quarters.

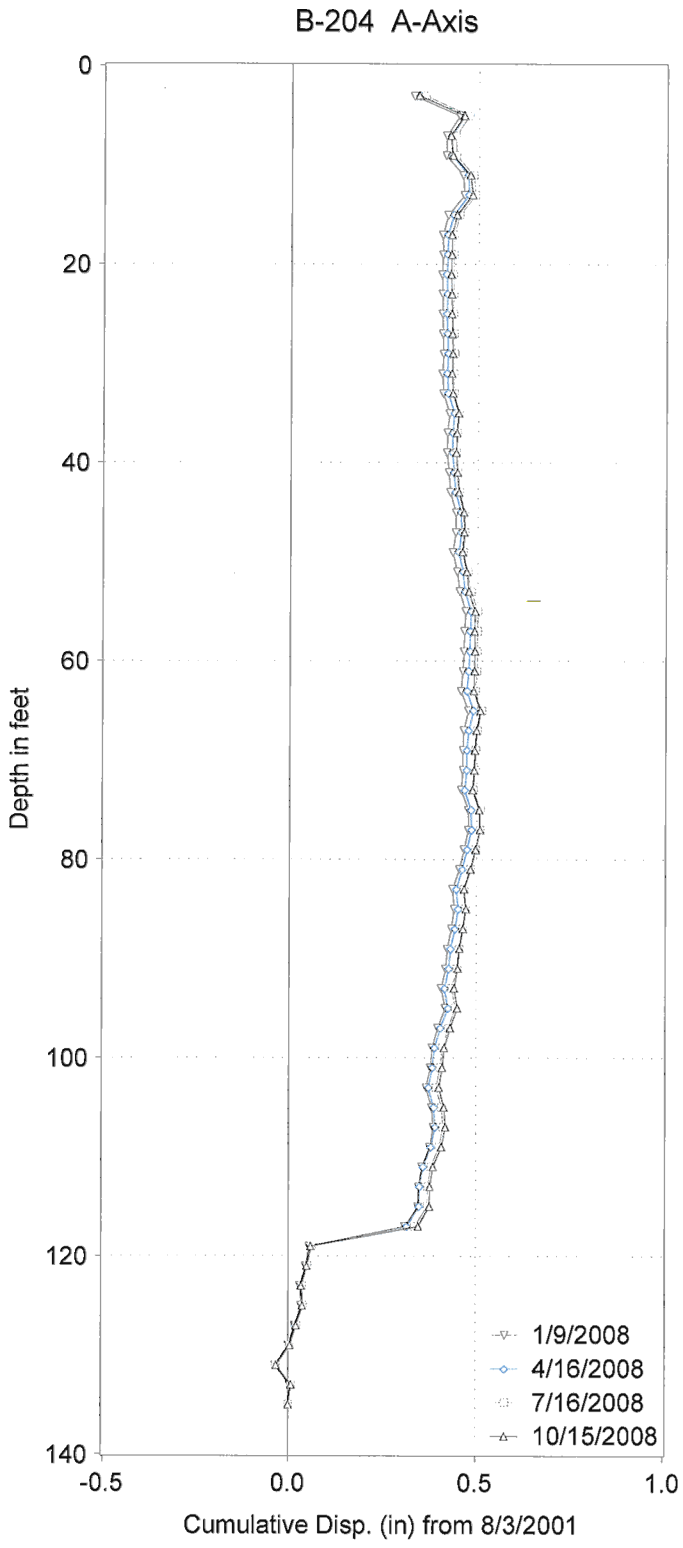
PLATE 9

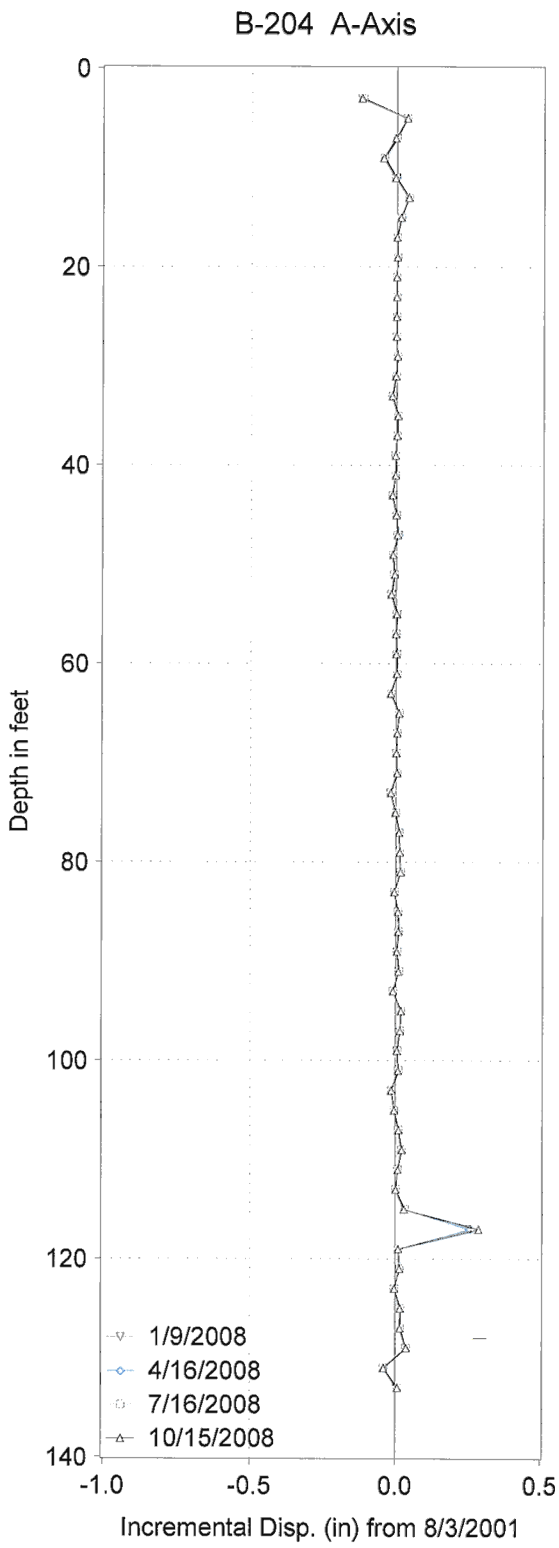




B-203
-Includes readings from the last four quarters.

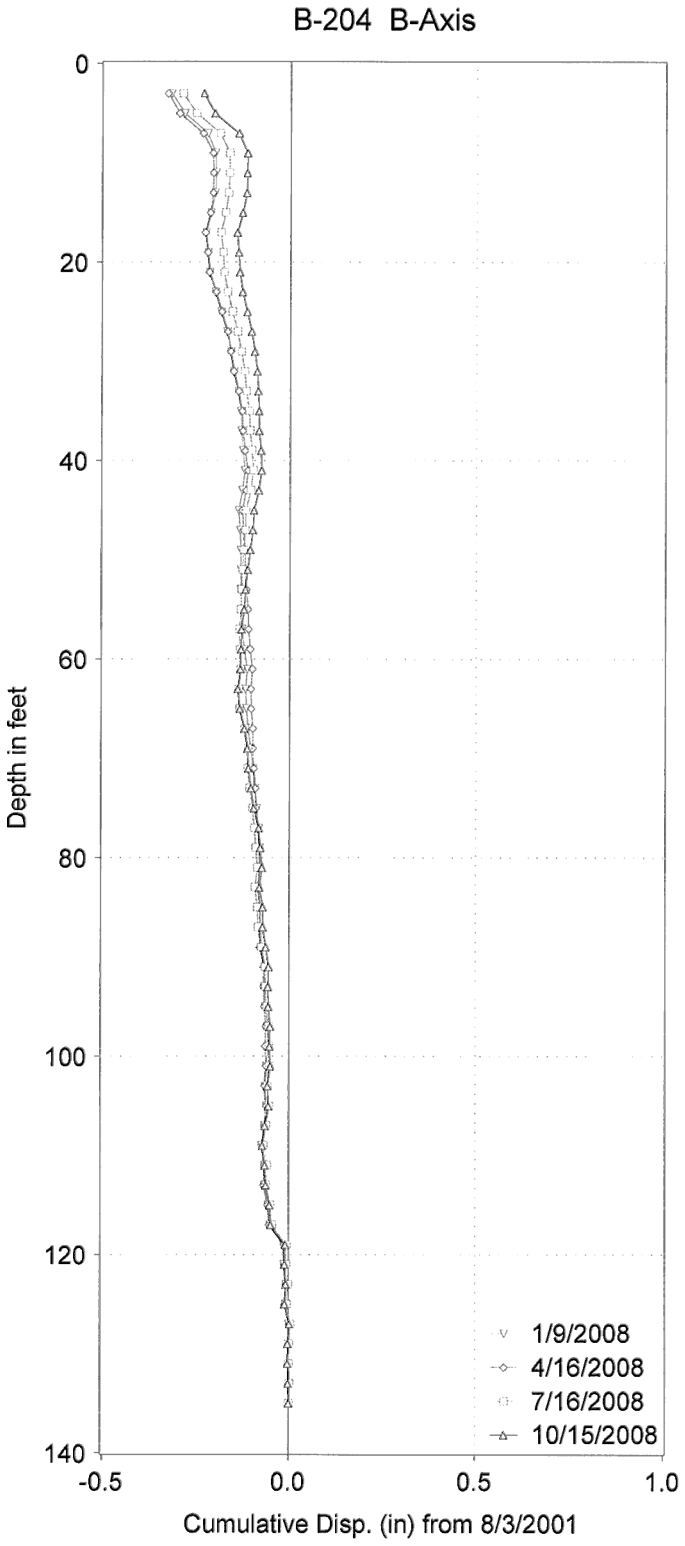
PLATE 10

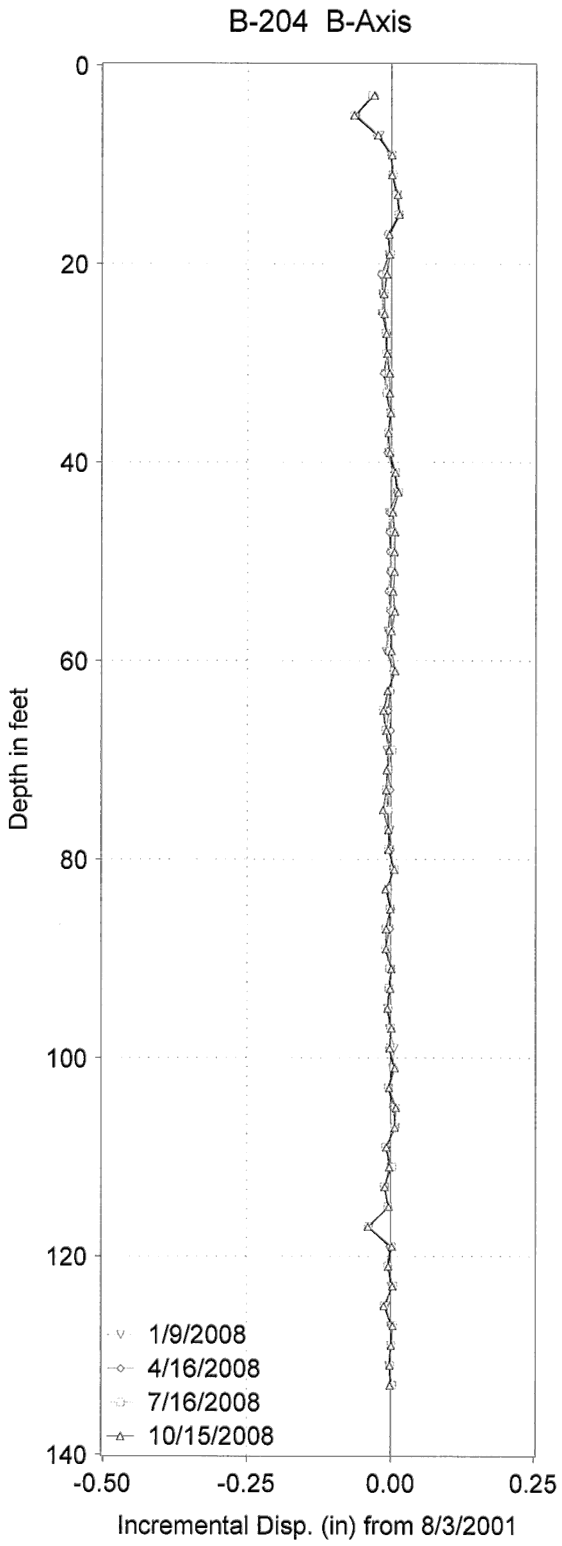




B-204
-Includes readings from the last four quarters.

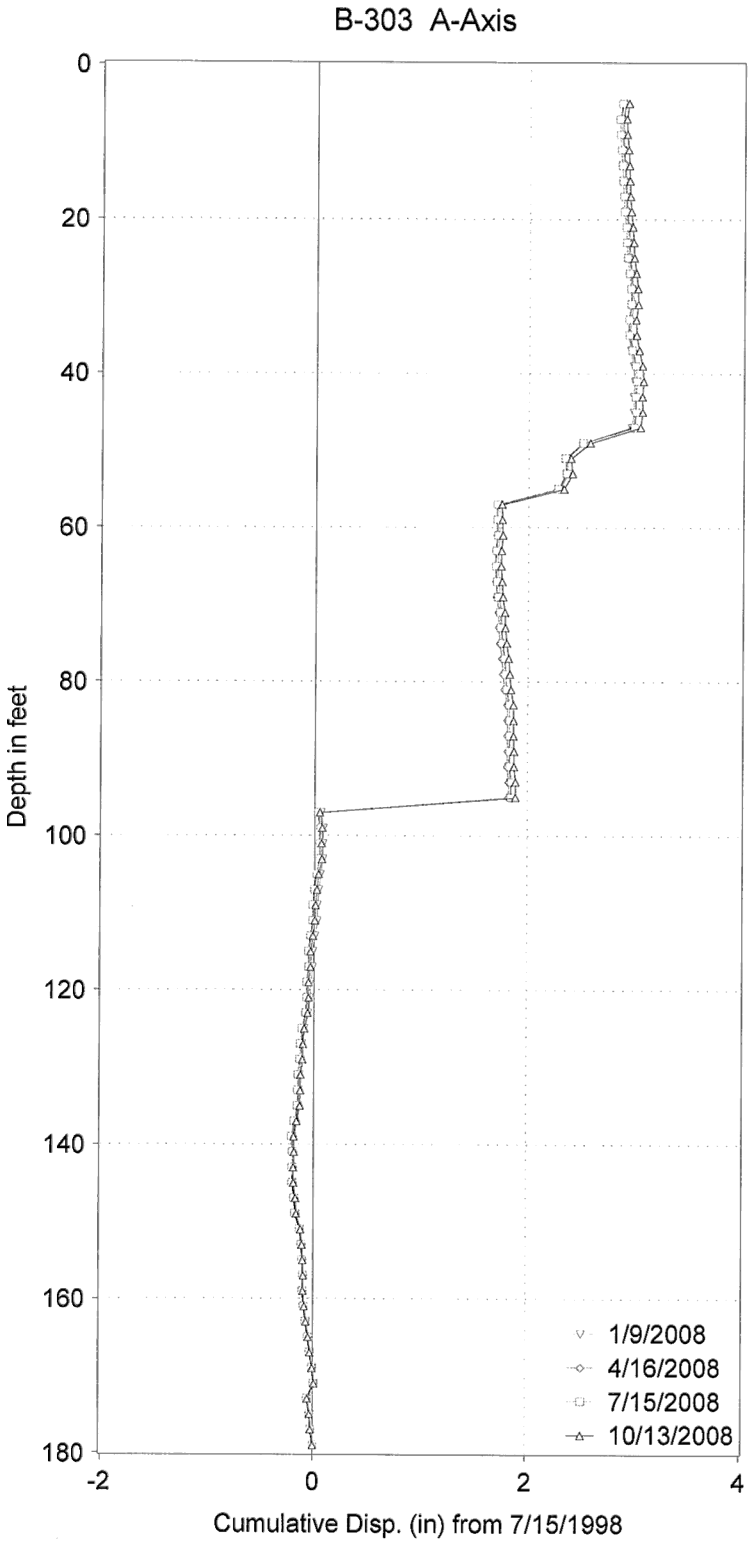
PLATE 11

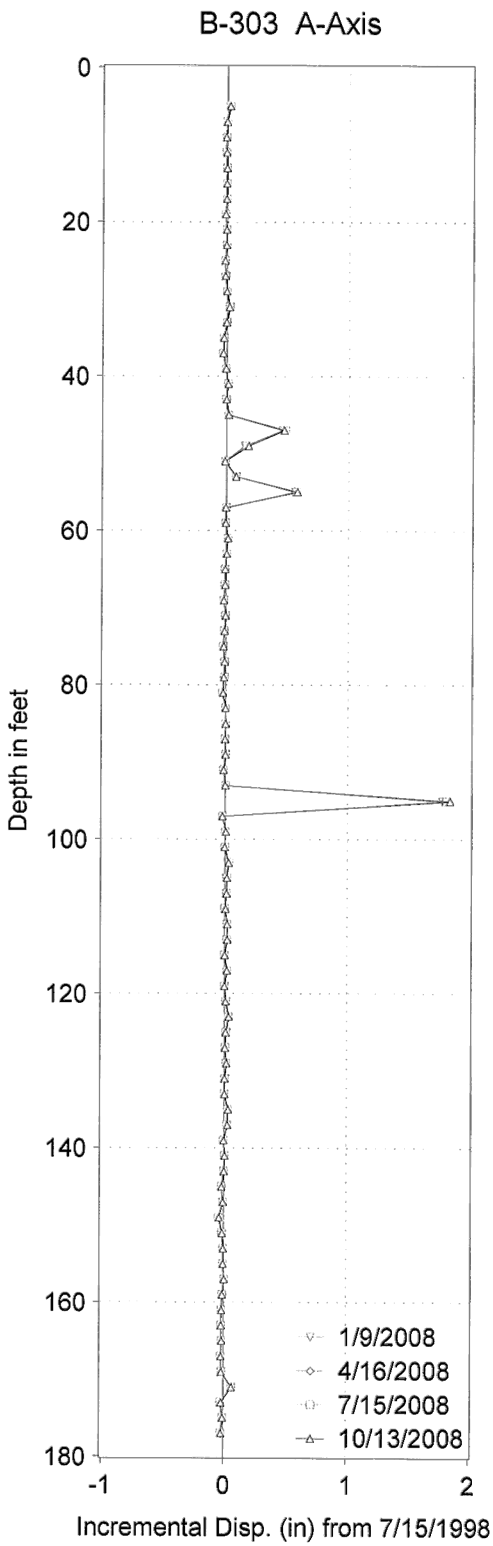




B-204
-Includes readings from the last four quarters.

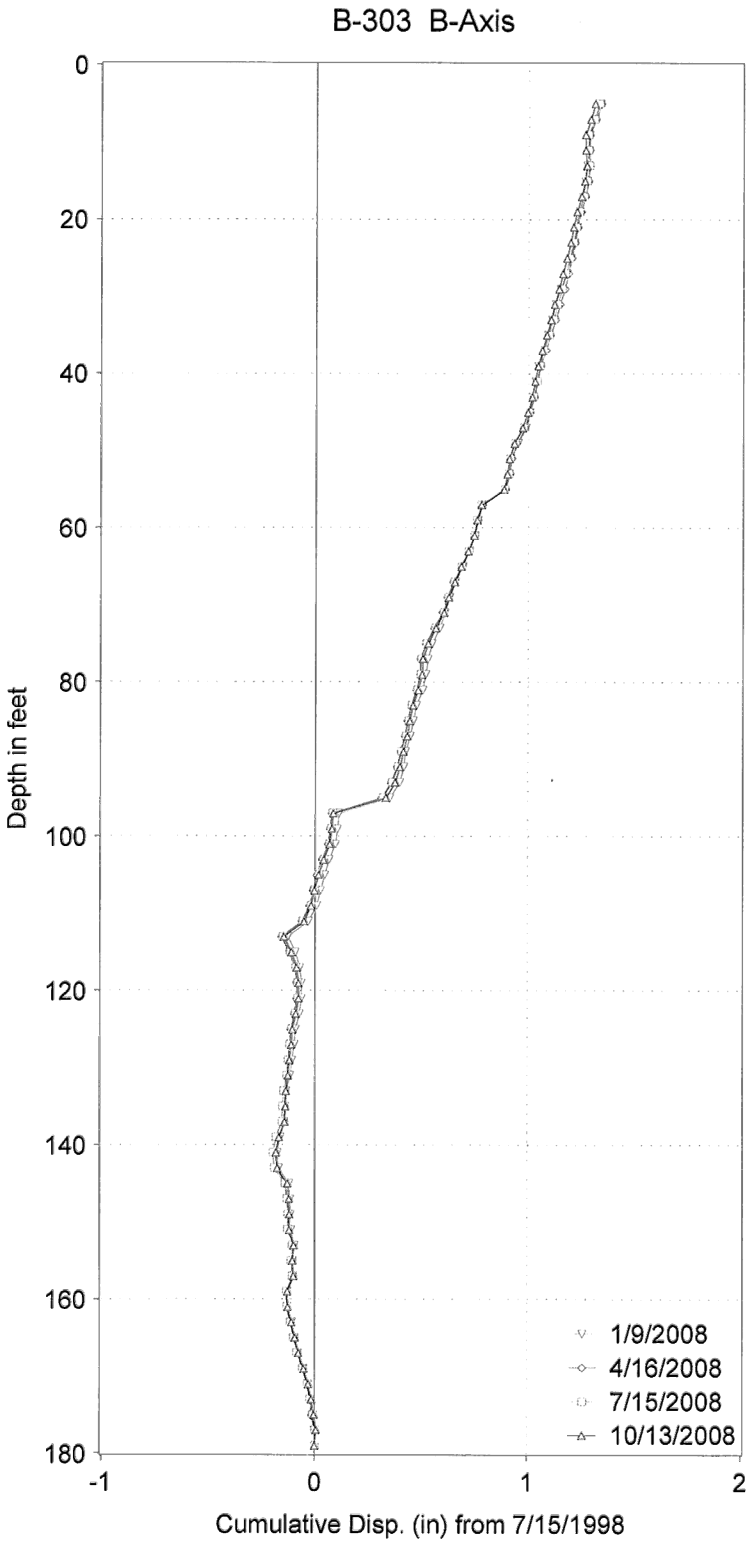
PLATE 12

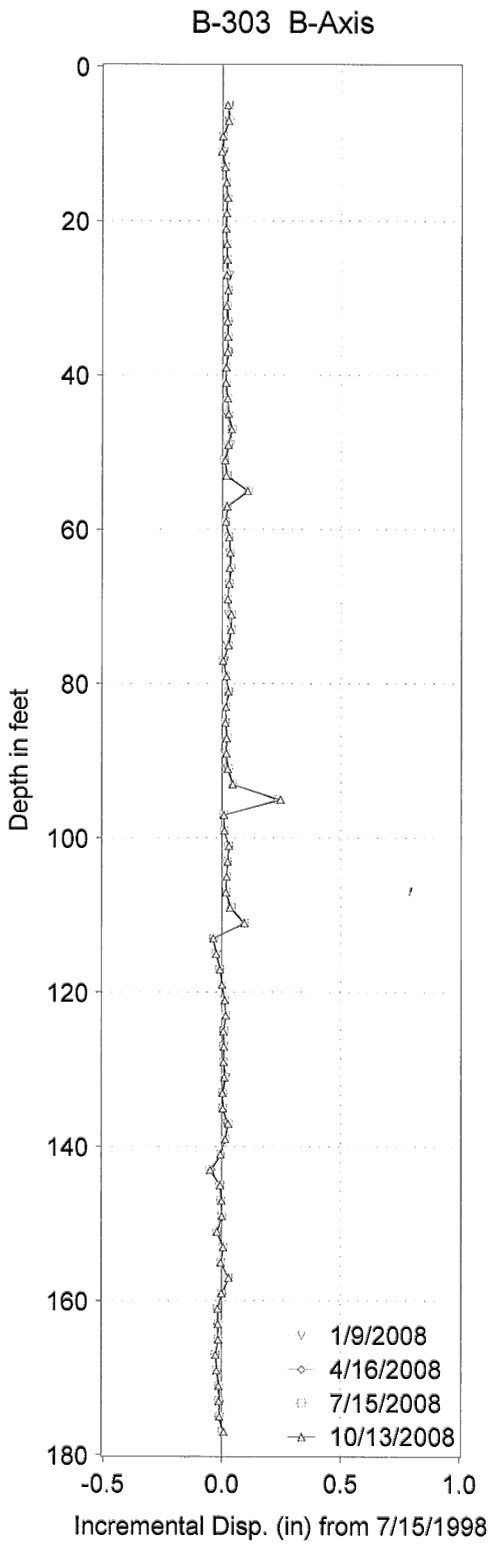




B-303
-Includes readings from the last four quarters.

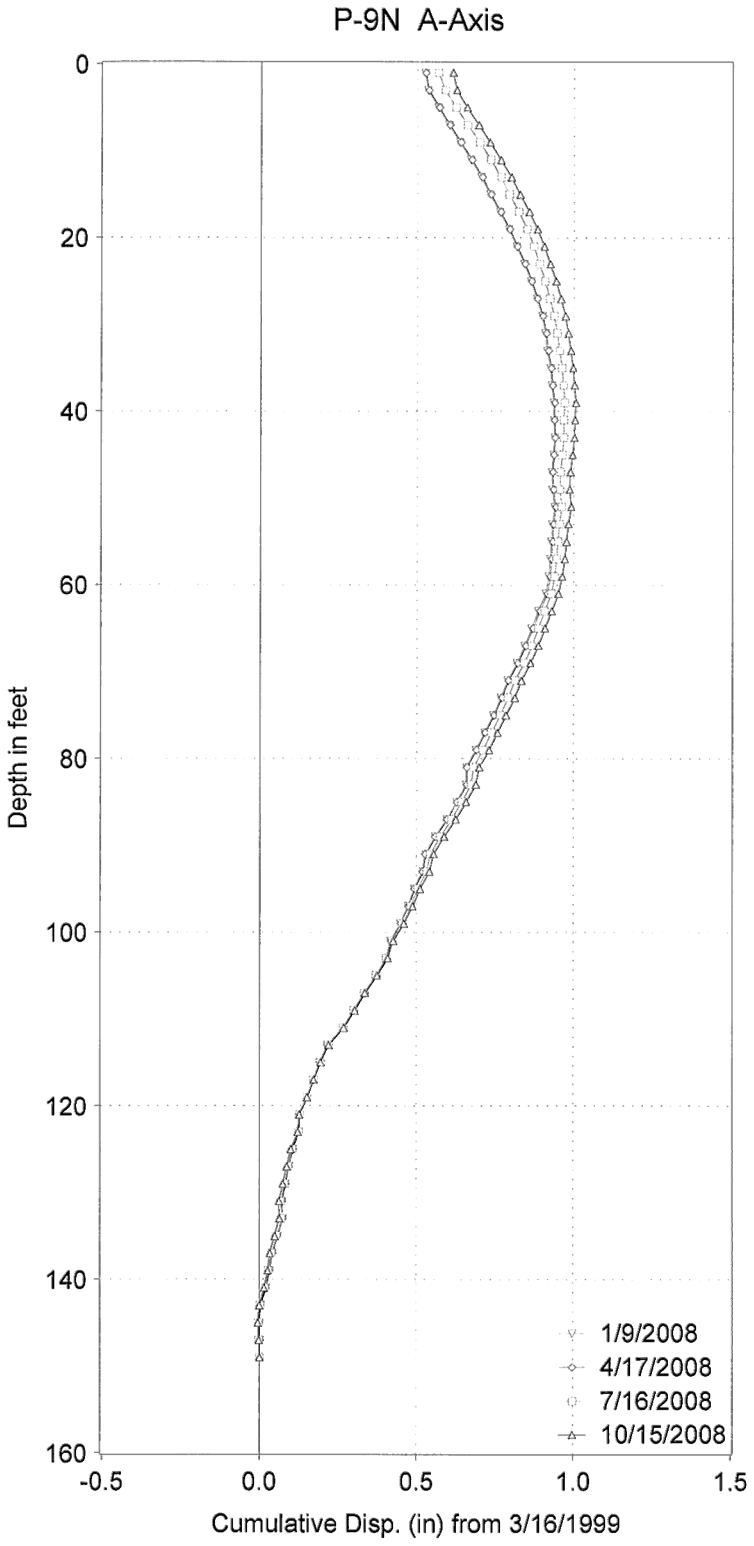
PLATE 13

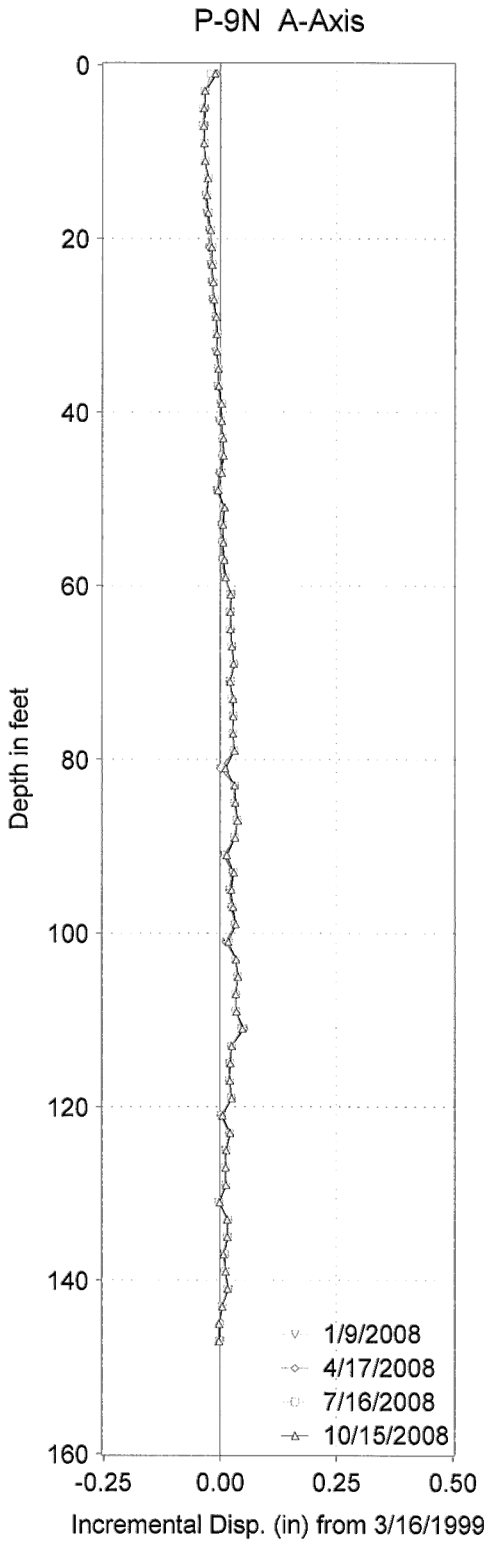




B-303
-Includes readings from the last four quarters.

PLATE 14

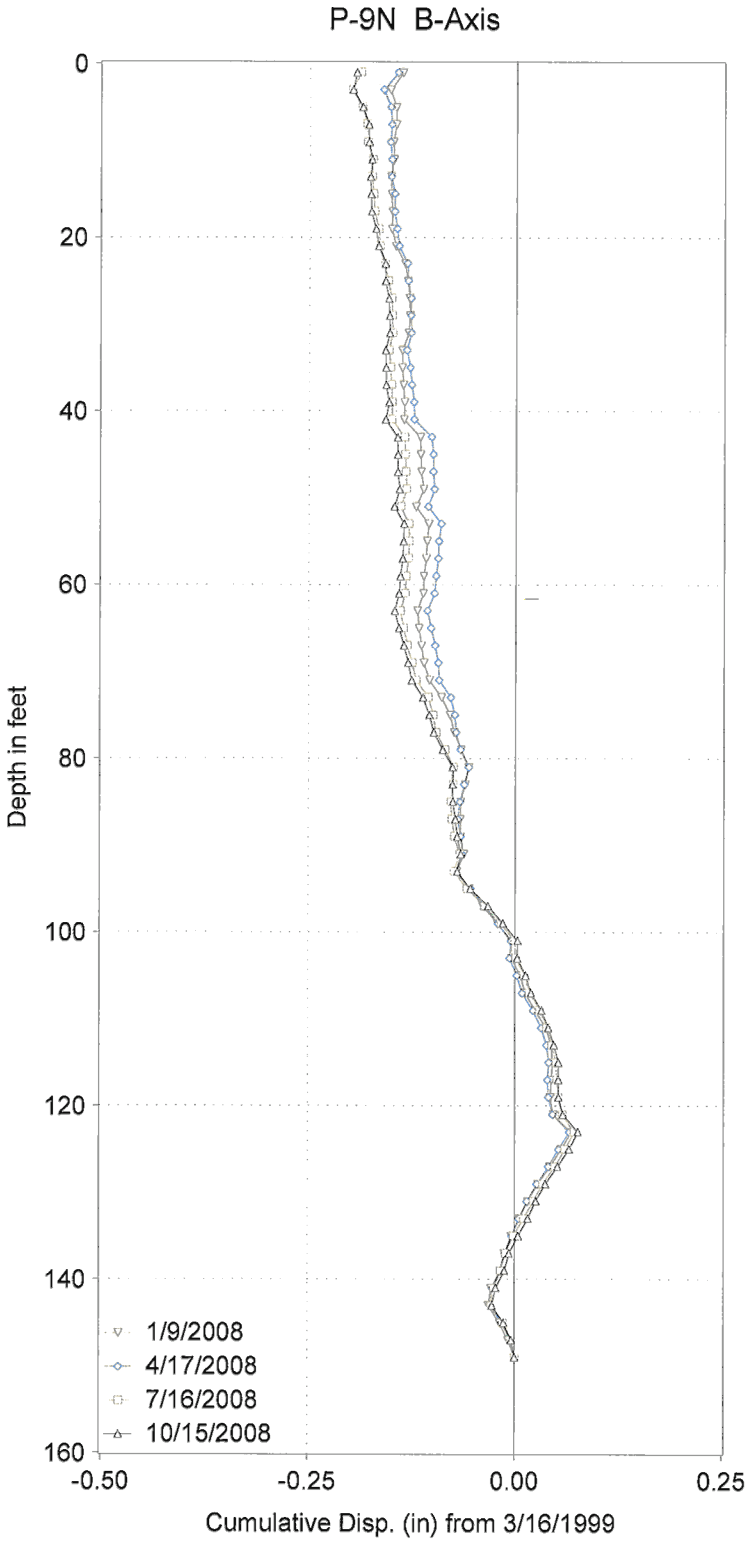


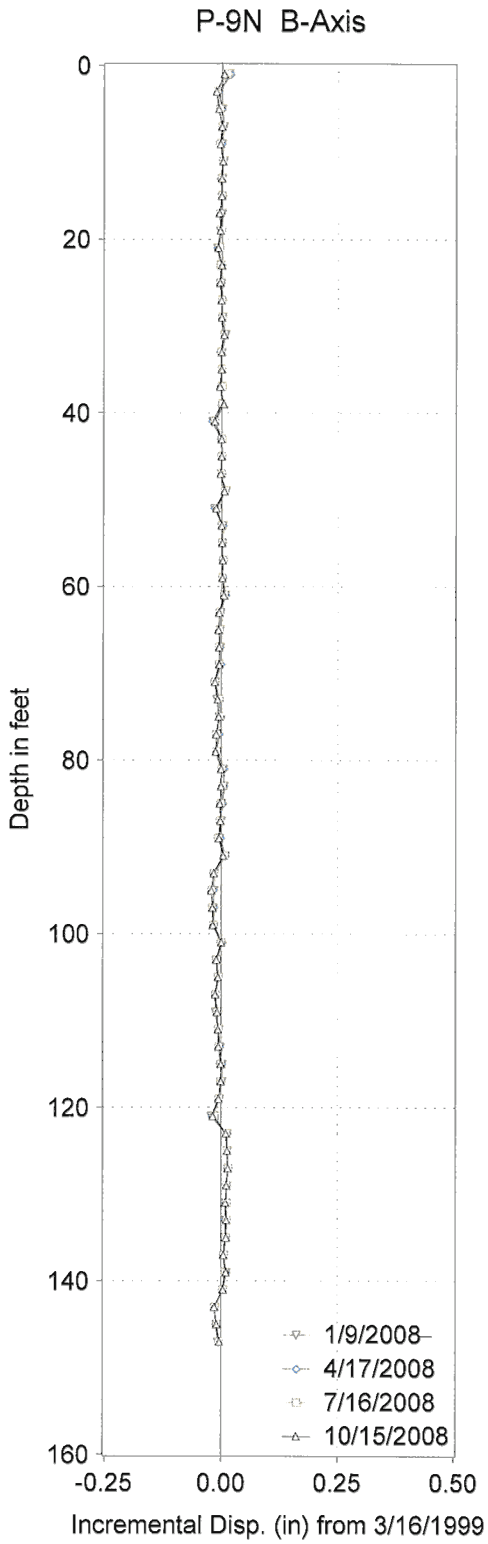


P-9N

-Includes readings from the last four quarters.

PLATE 15





P-9N
-Includes readings from the last four quarters.

PLATE 16

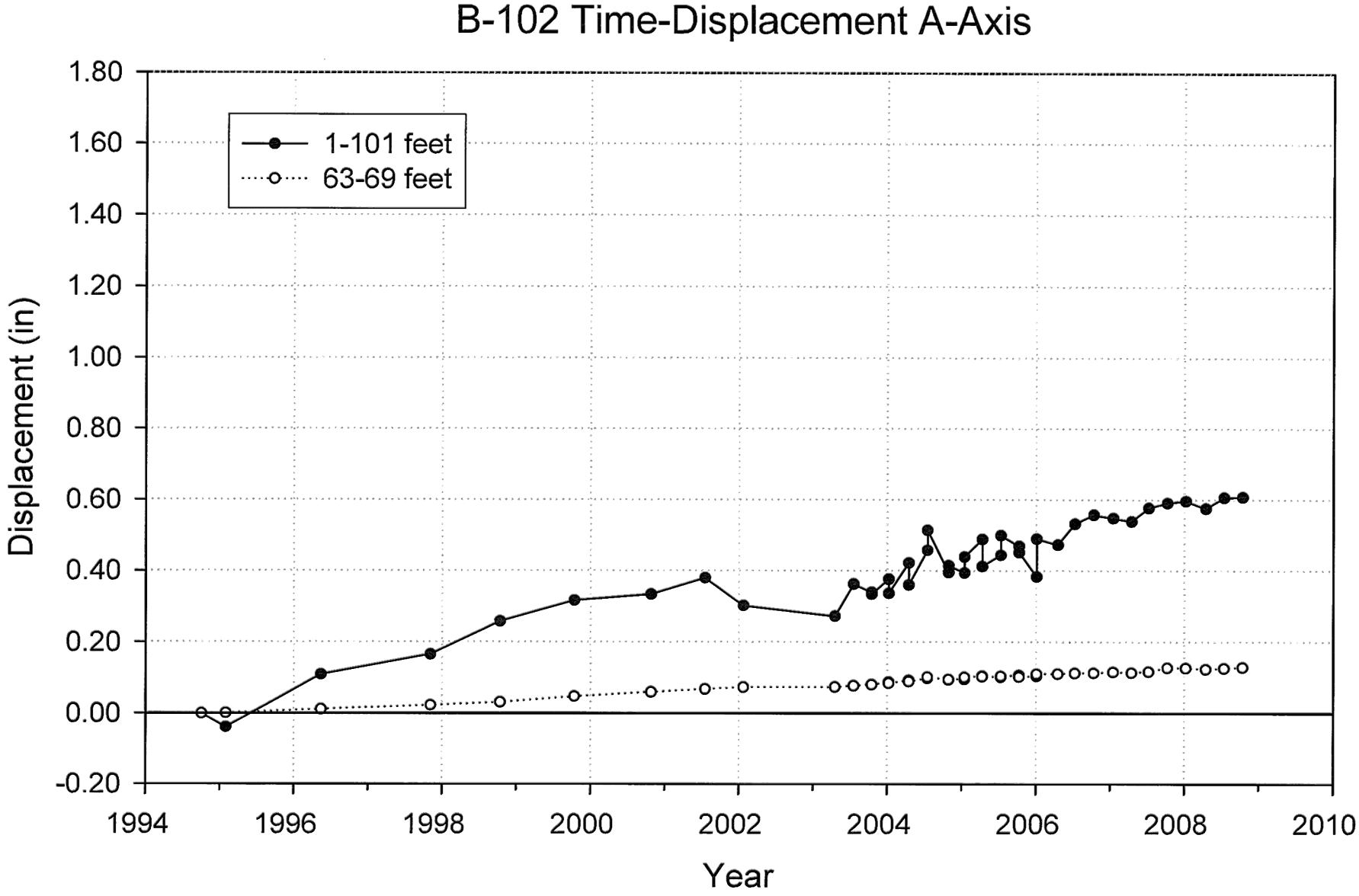

B-102 Time-Displacement A-Axis
1-101 feet
63-69 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 17

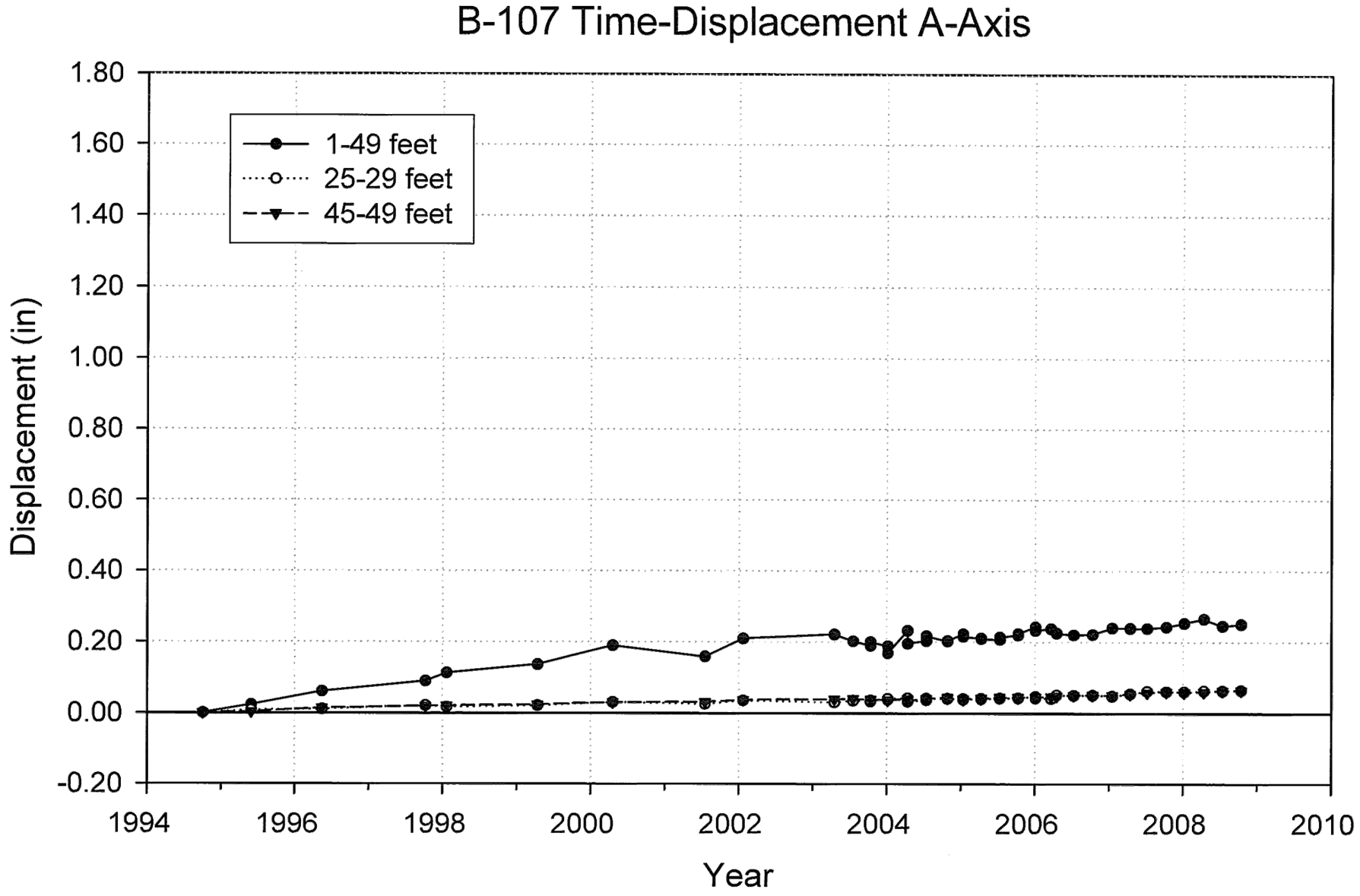

B-107 Time-Displacement A-Axis
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Displacement (in)
1-49 feet
25-29 feet
45-49 feet
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 18

B-203 Time-Displacement A-Axis

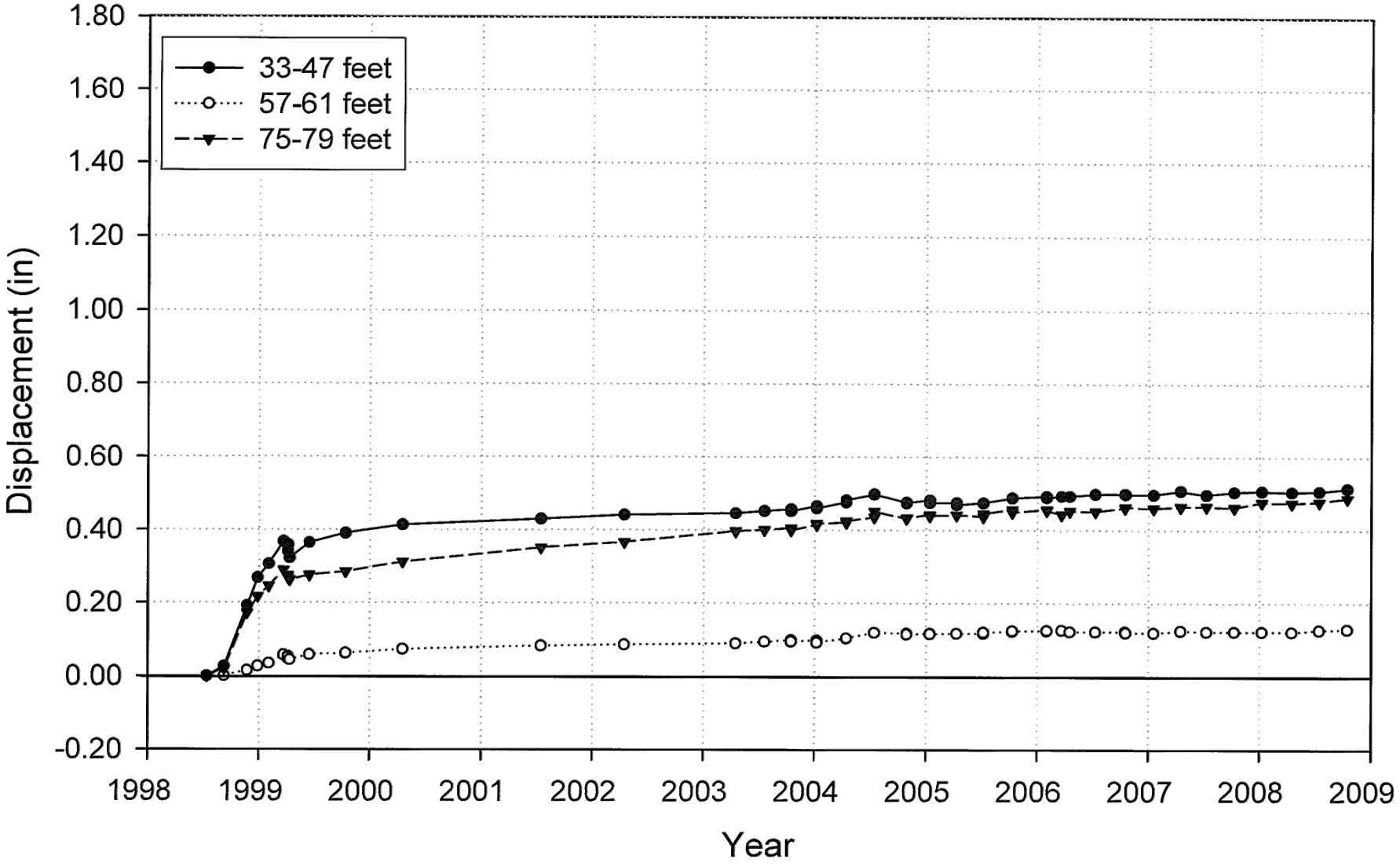


PLATE 19

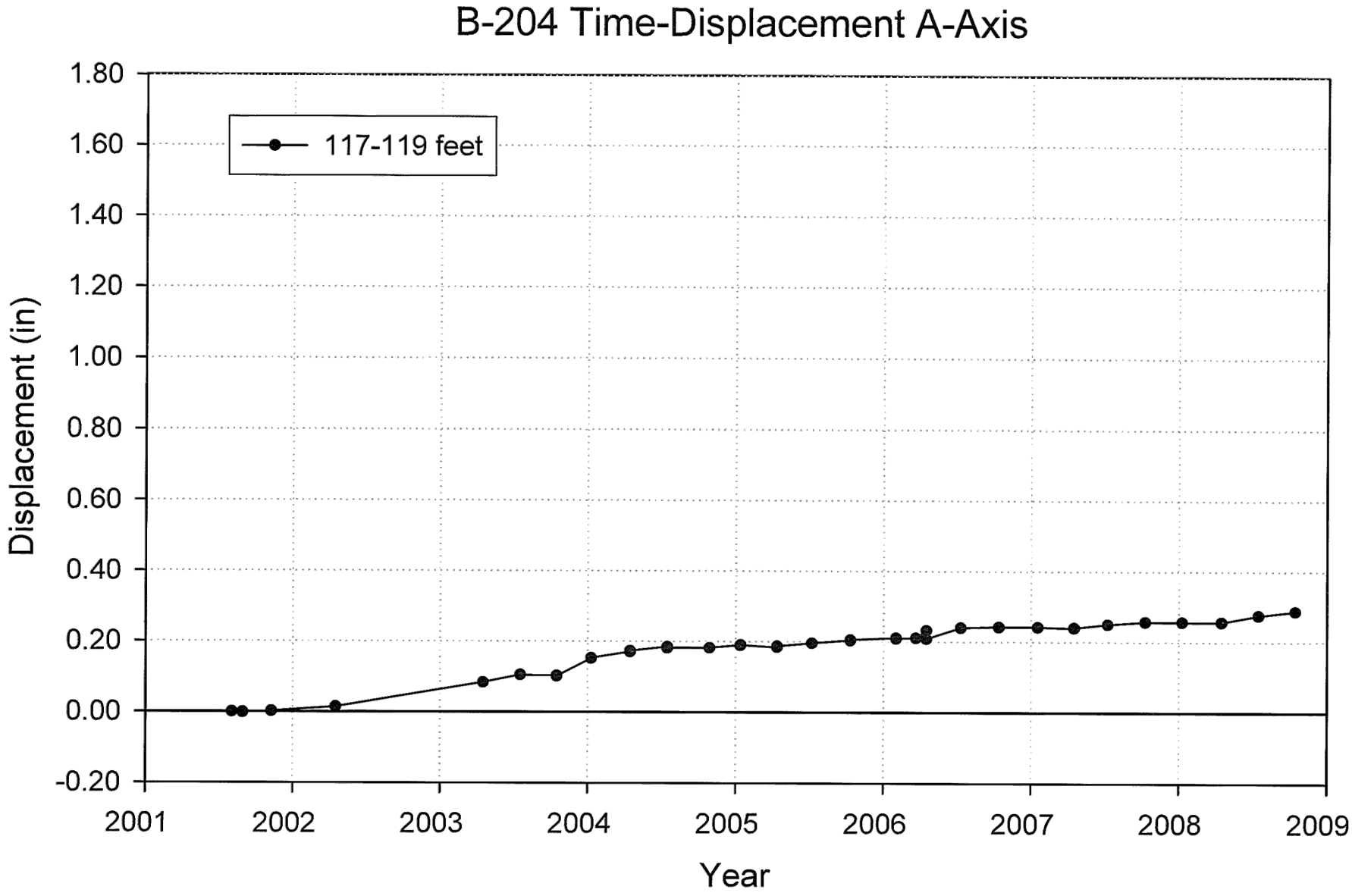

B-204 Time-Displacement A-Axis
117-119 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

PLATE 20

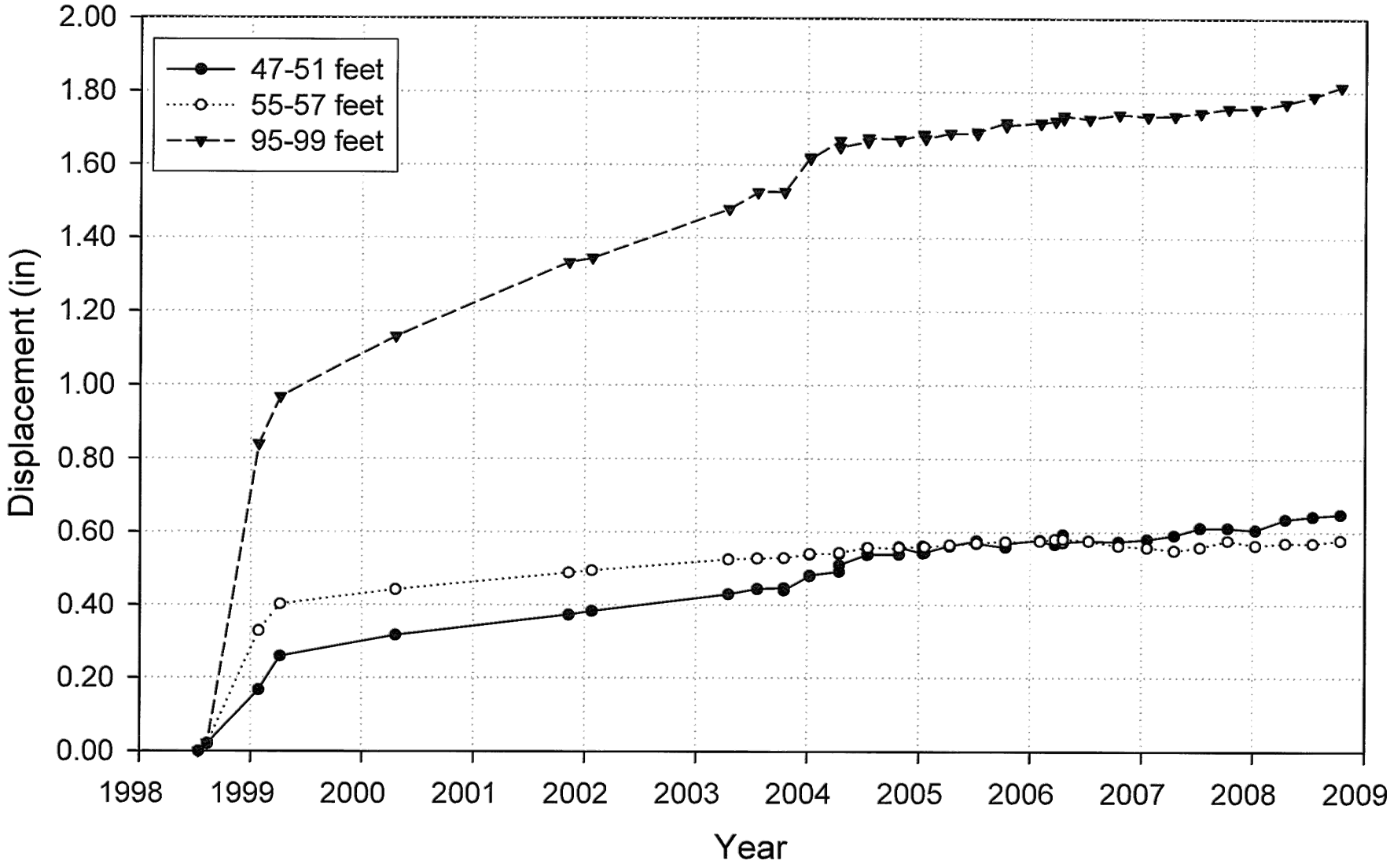
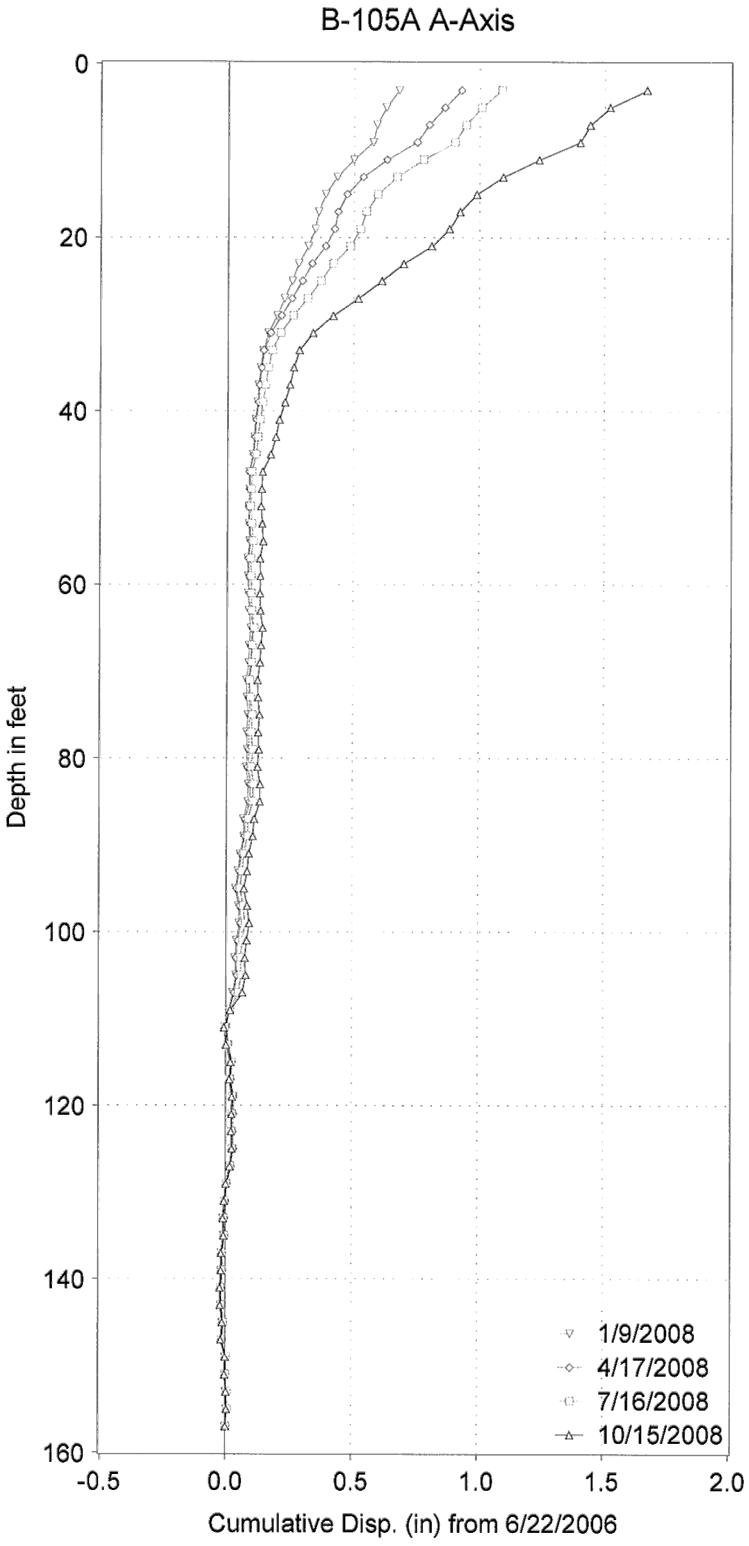
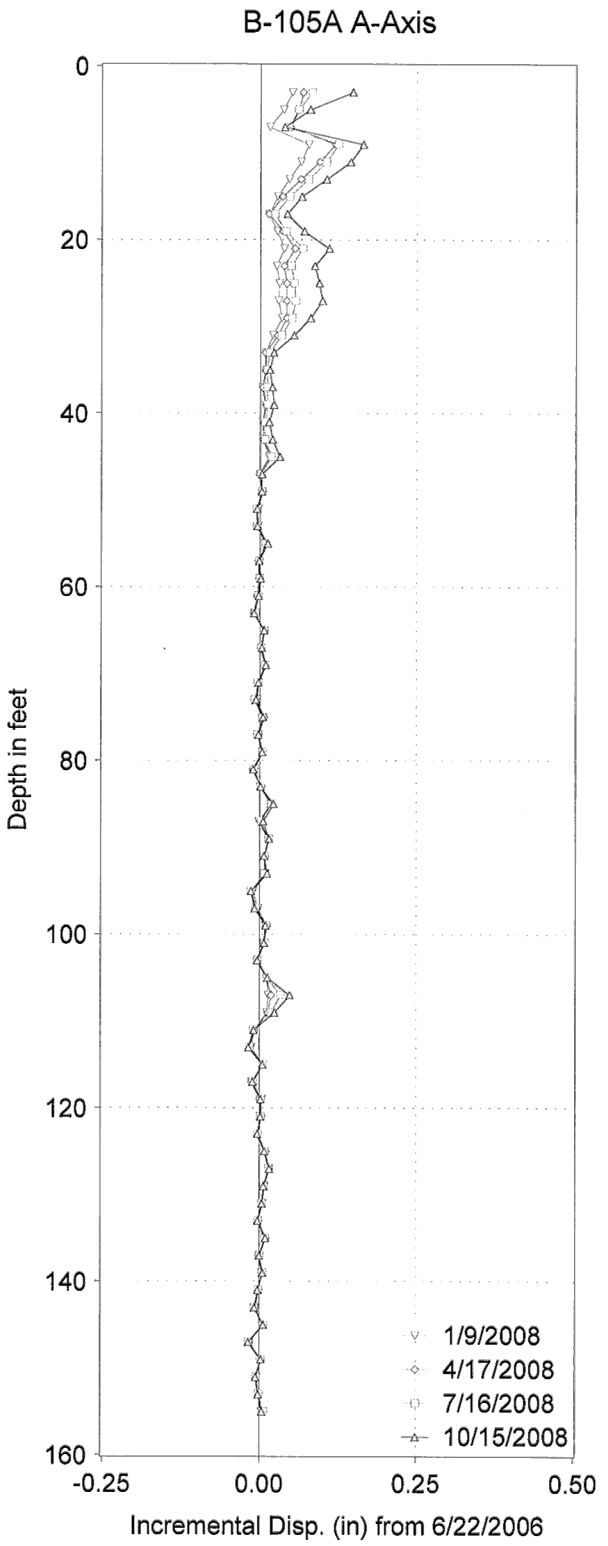

B-303 Time-Displacement A-Axis
47-51 feet
55-57 feet
95-99 feet
Displacement (in)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

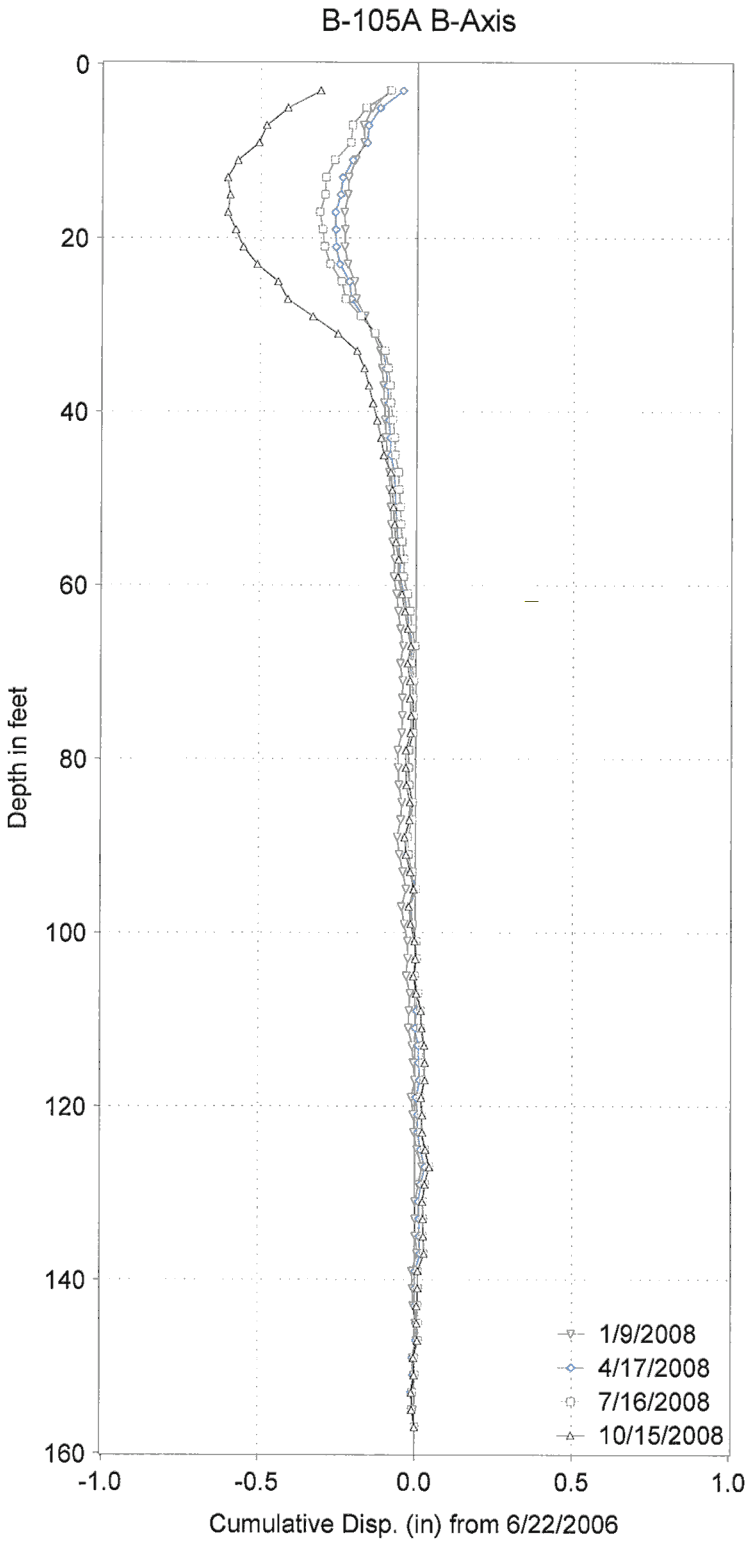
PLATE 21

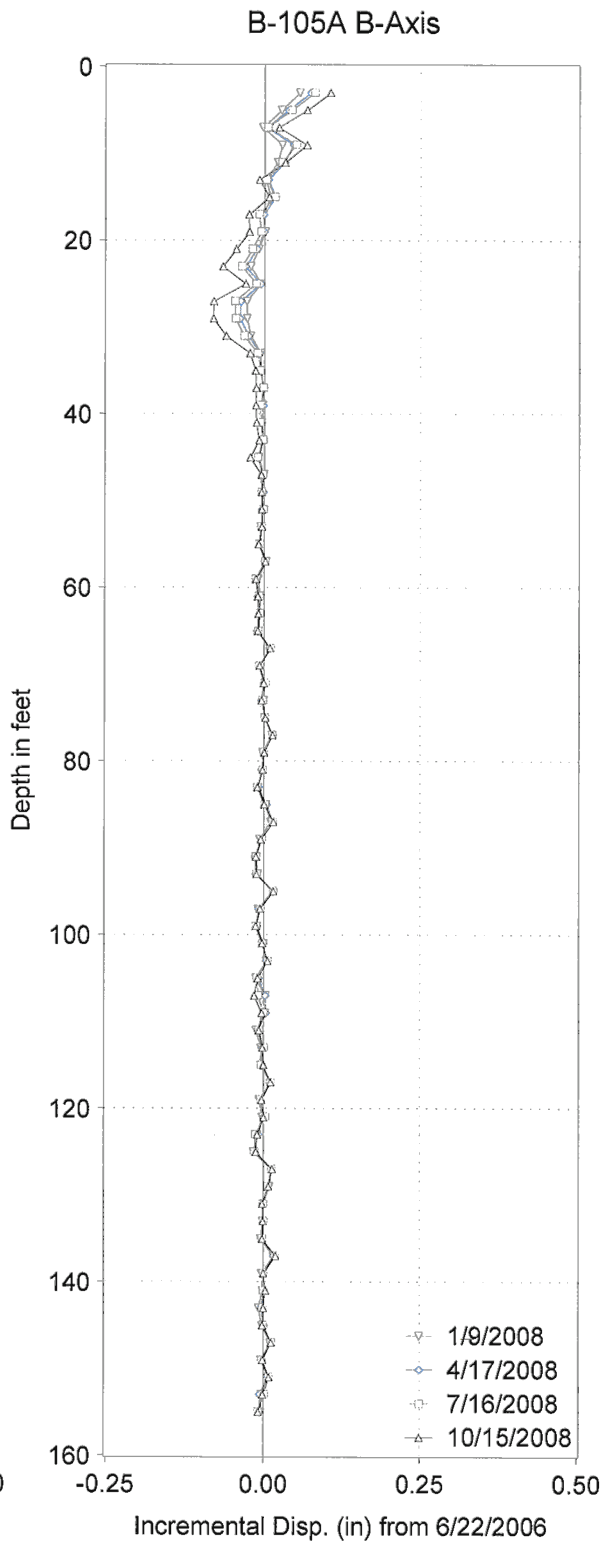




B-105A
-Includes readings from the last four quarters.

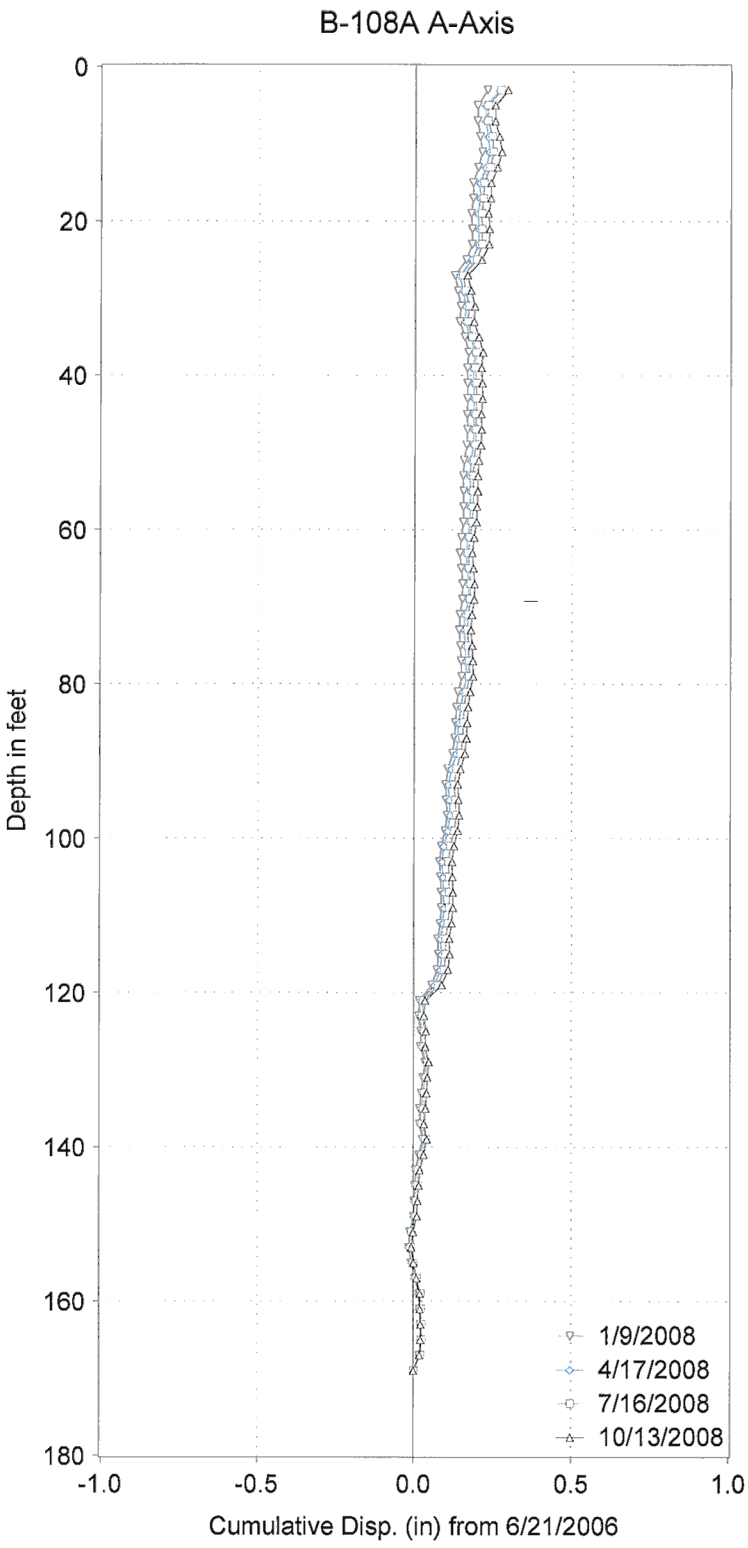
PLATE 22

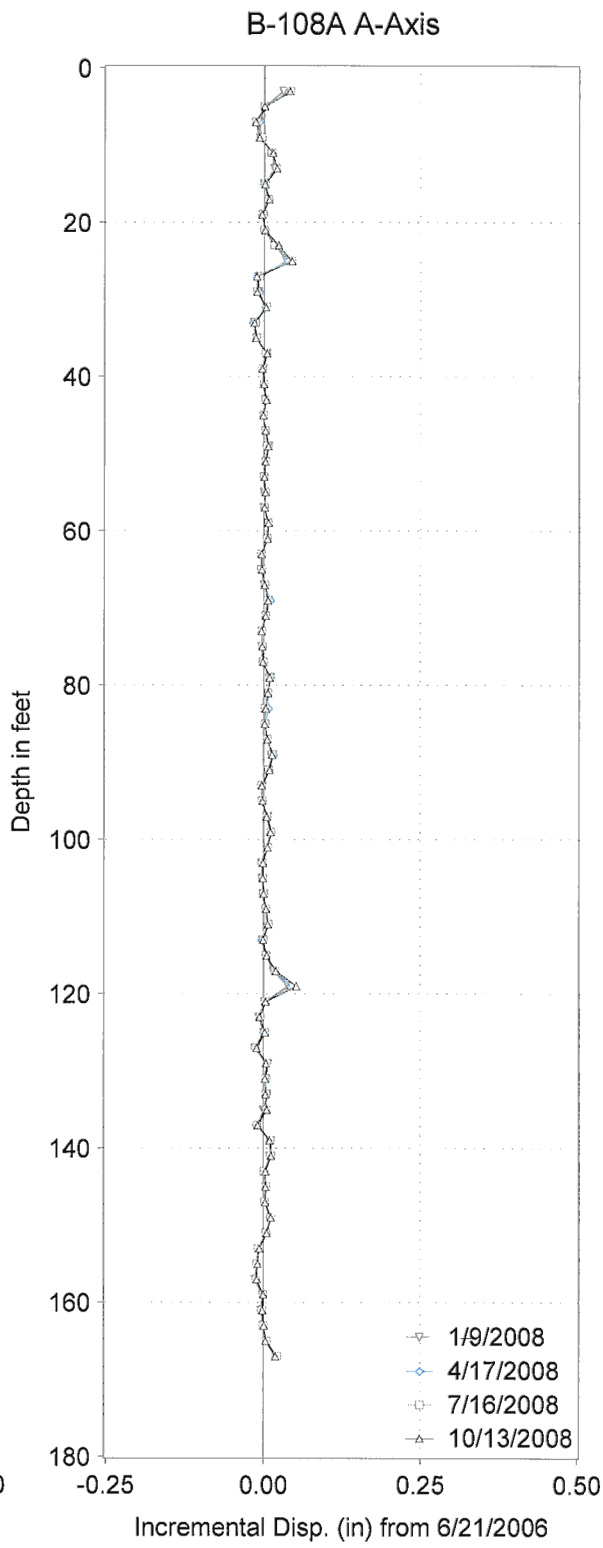




B-105A
-Includes readings from the last four quarters.

PLATE 23

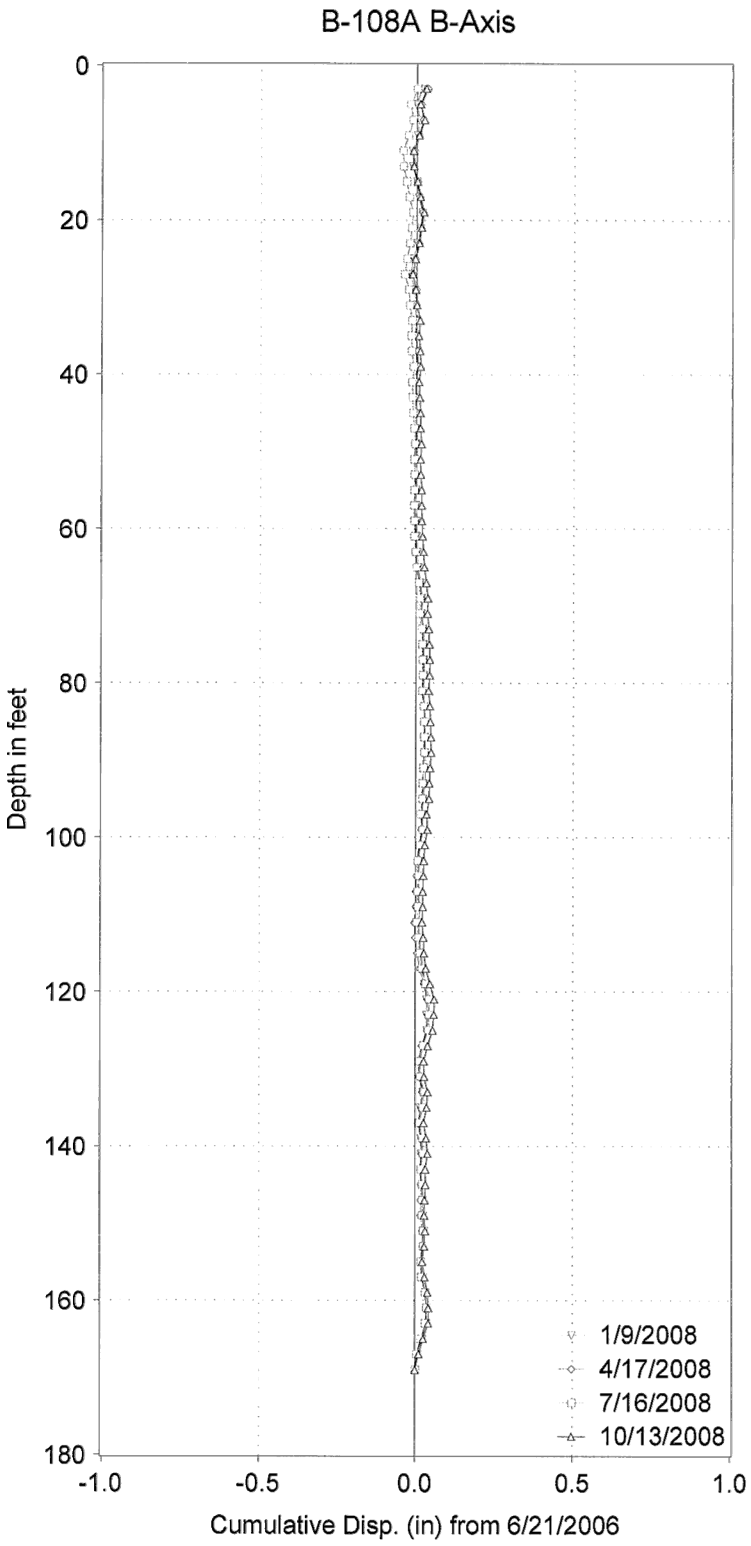


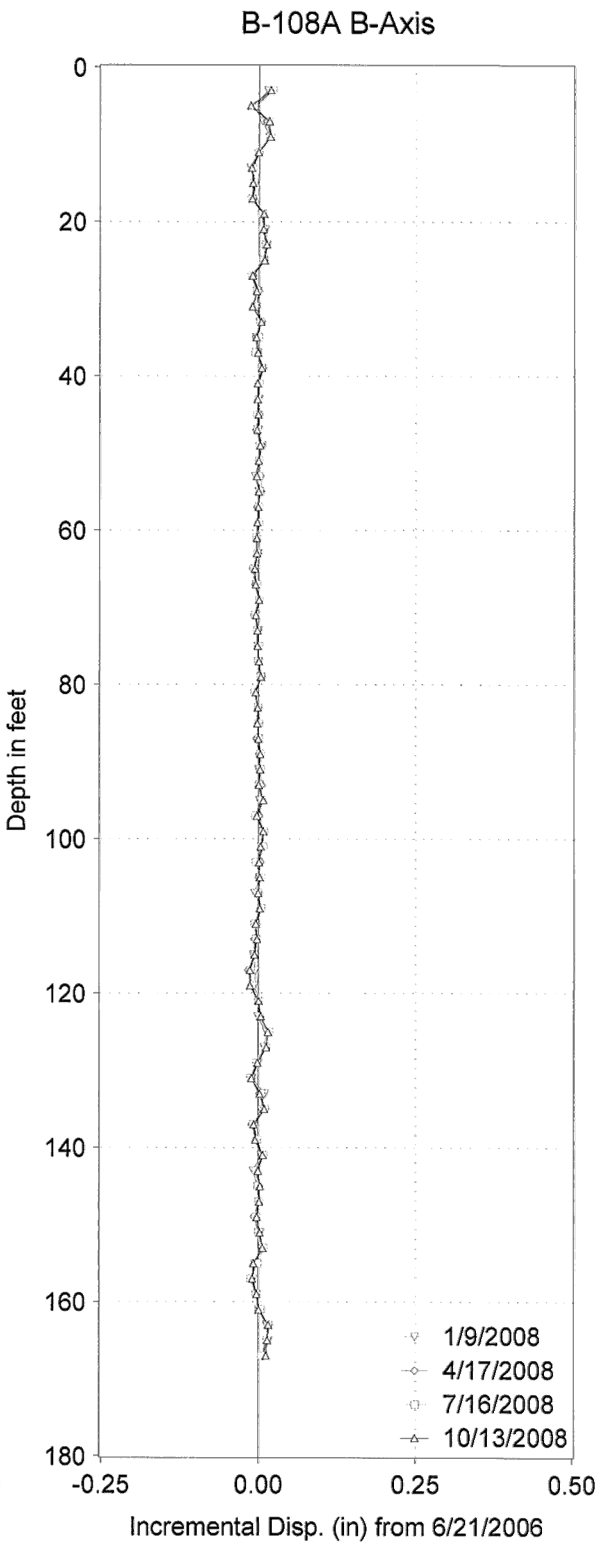


B-108A

-Includes readings from the last four quarters.

PLATE 24





B-108A
-Includes readings from the last four quarters.

PLATE 25

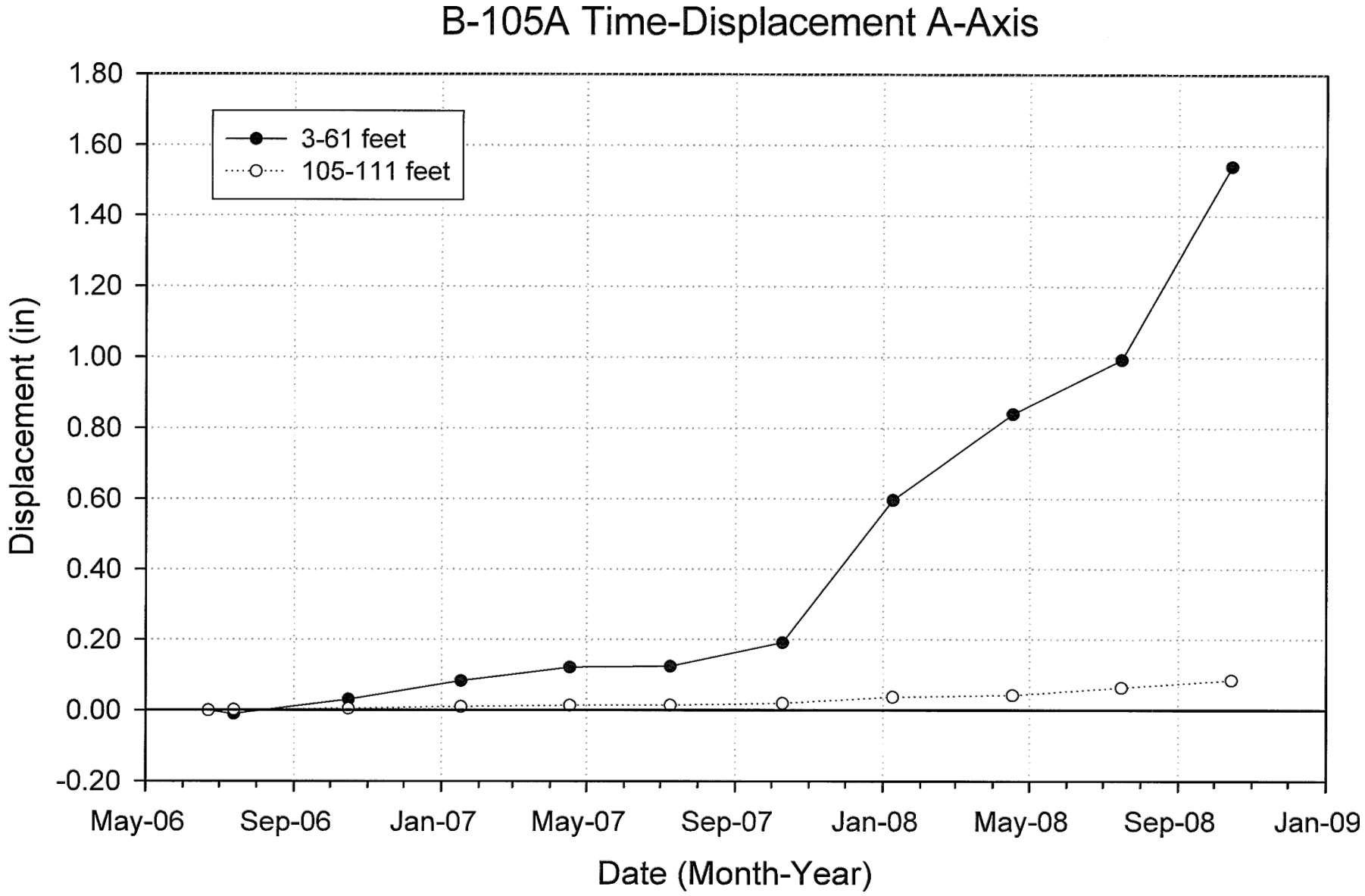

B-105A Time-Displacement A-Axis
3-61 feet
105-111 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
Date (Month-Year)

PLATE 26

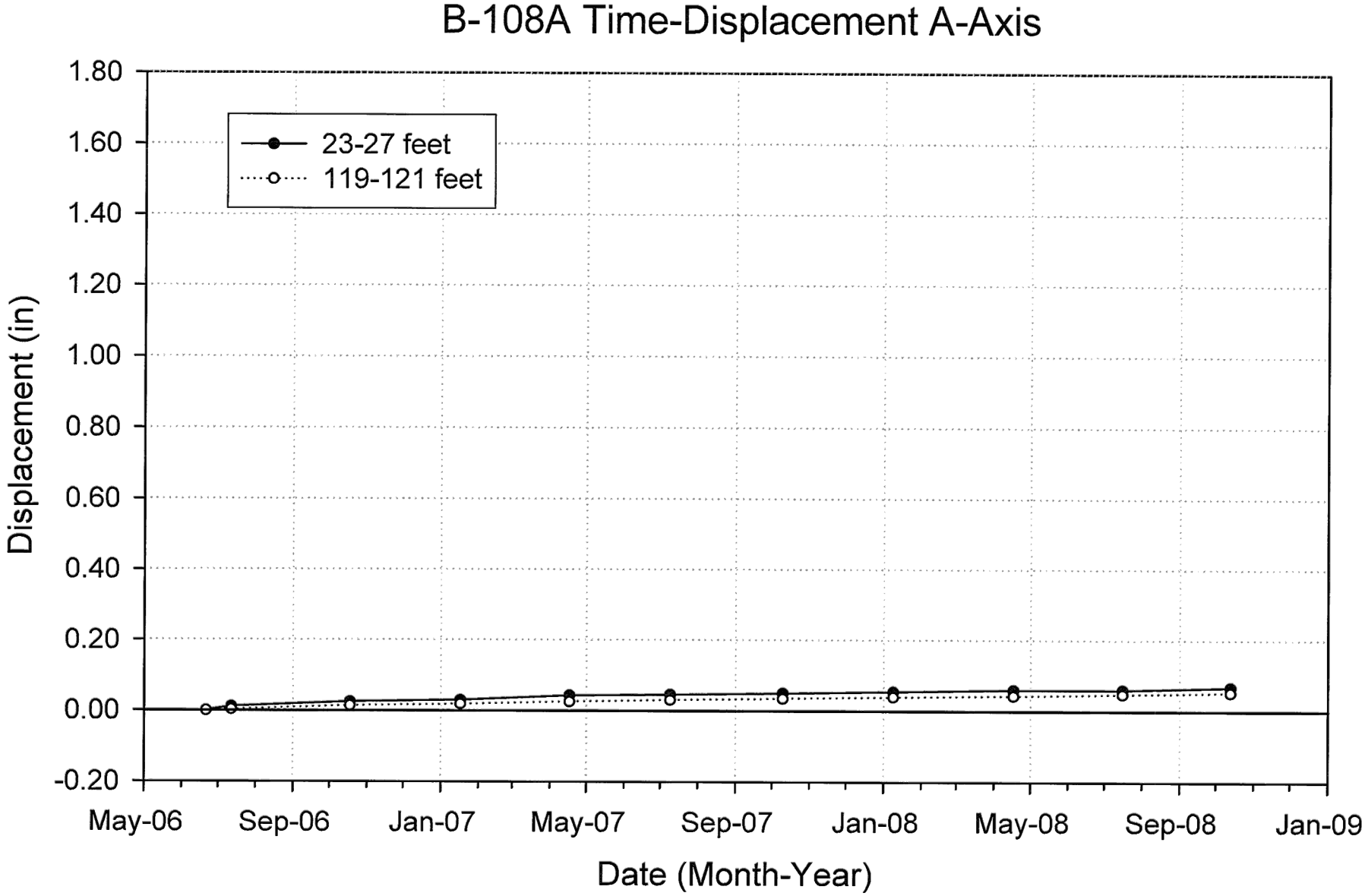
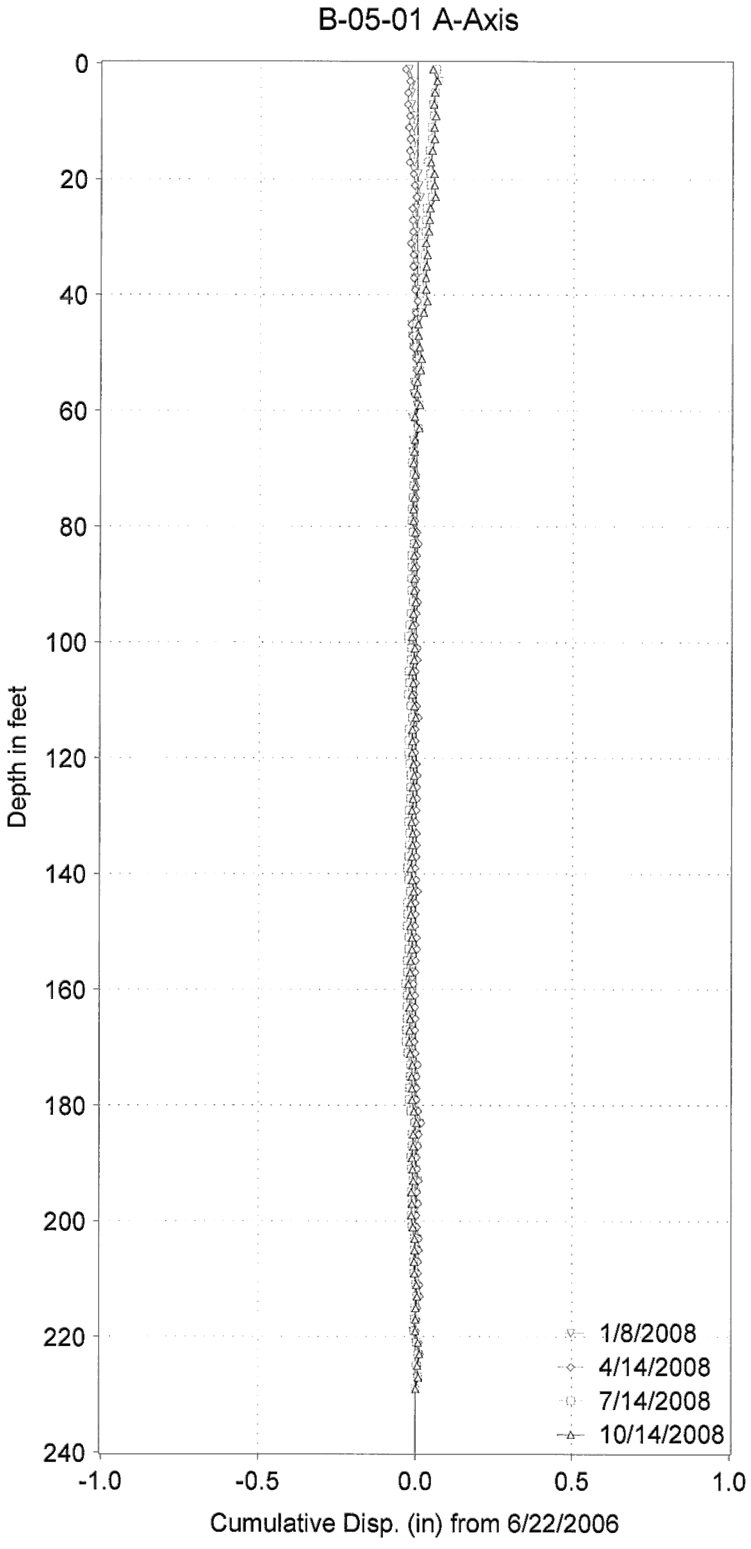
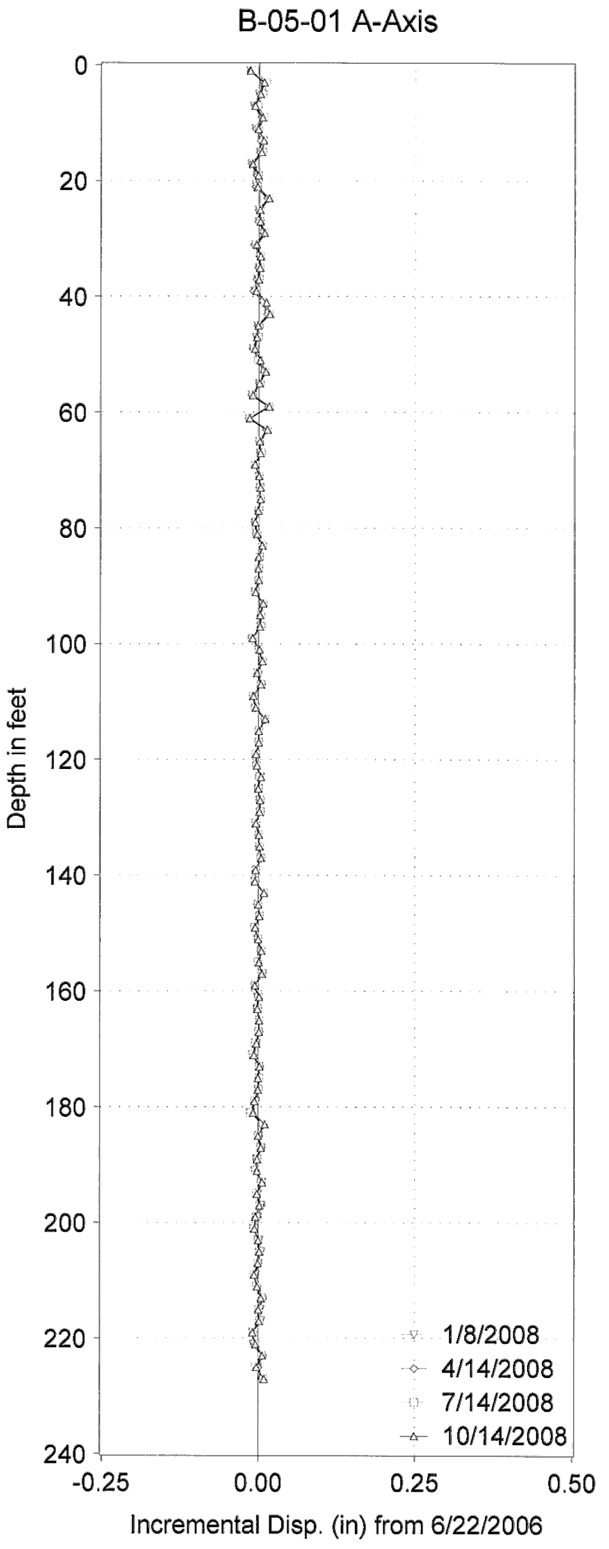

B-108A Time-Displacement A-Axis
23-27 feet
119-121 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
Date (Month-Year)

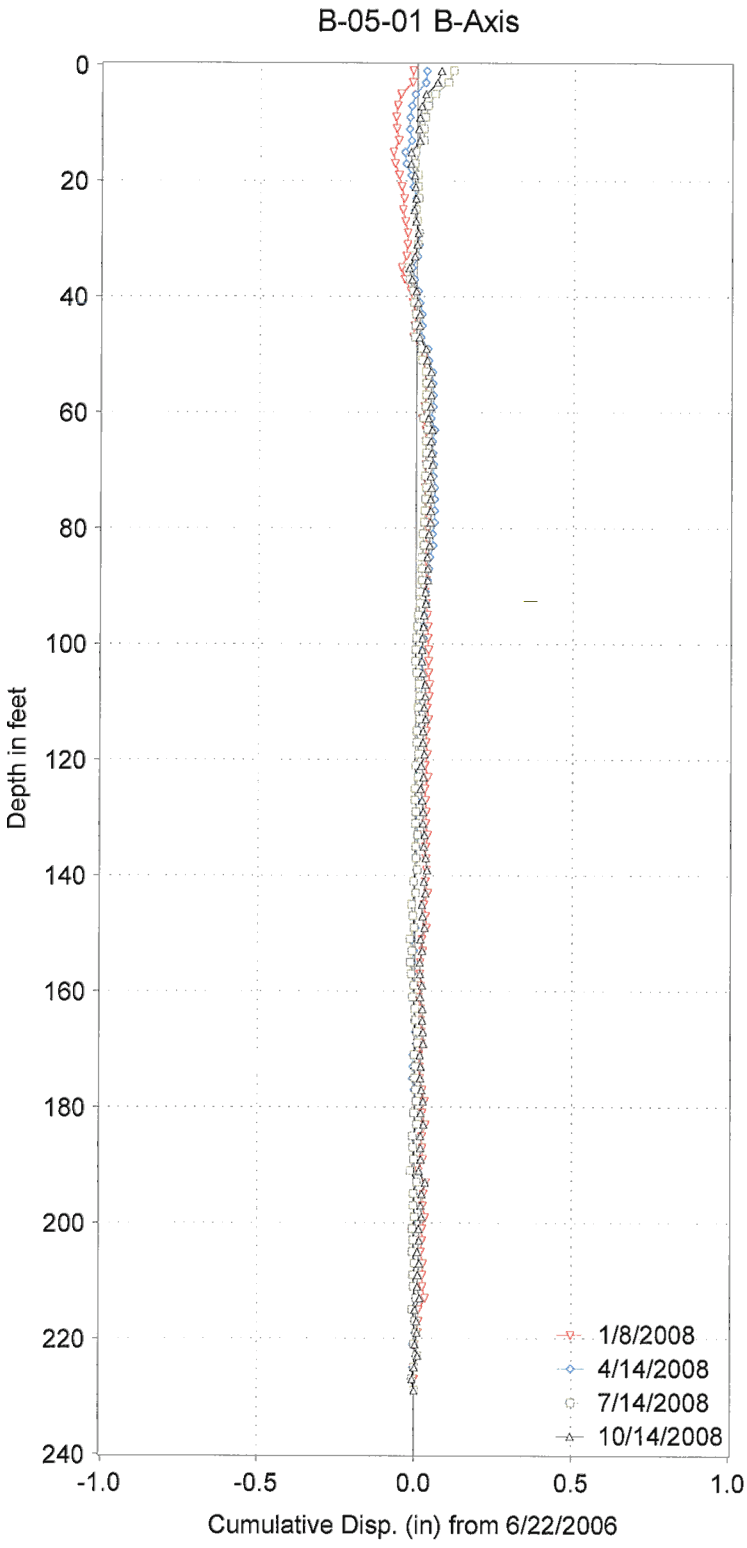
PLATE 27

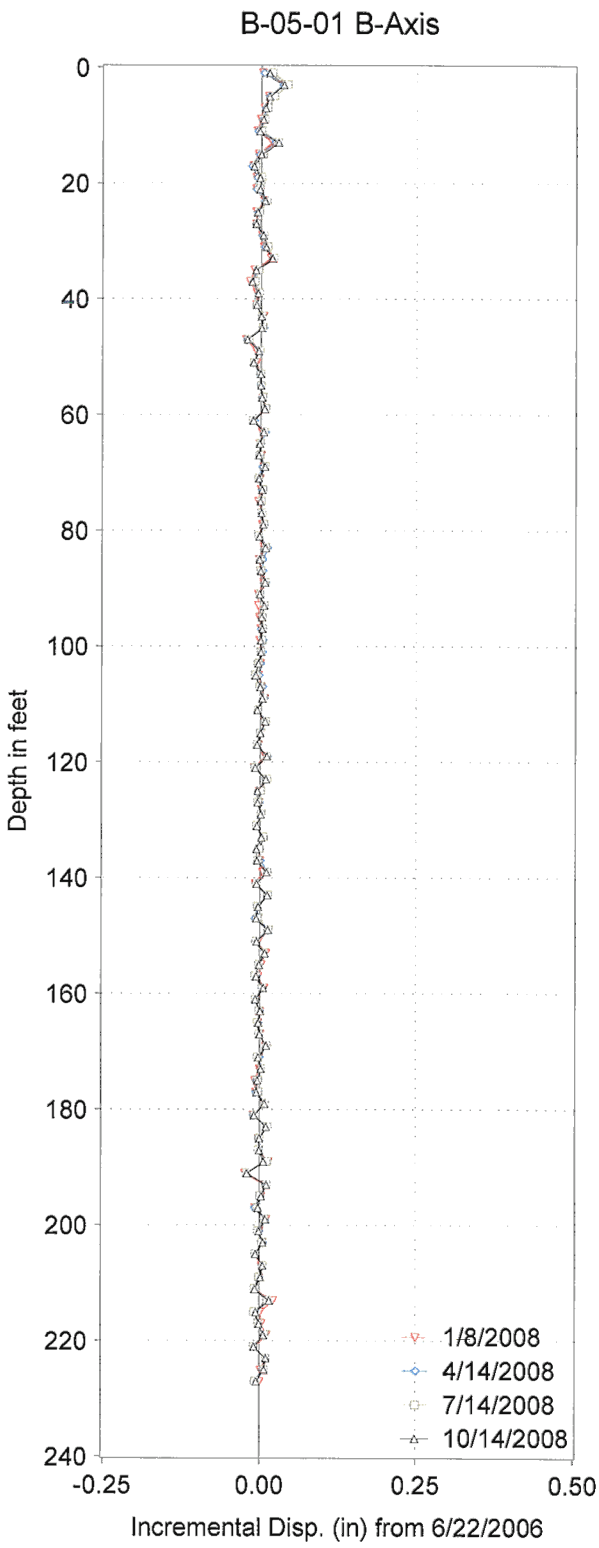




B-05-01
-Includes readings from the last four quarters.

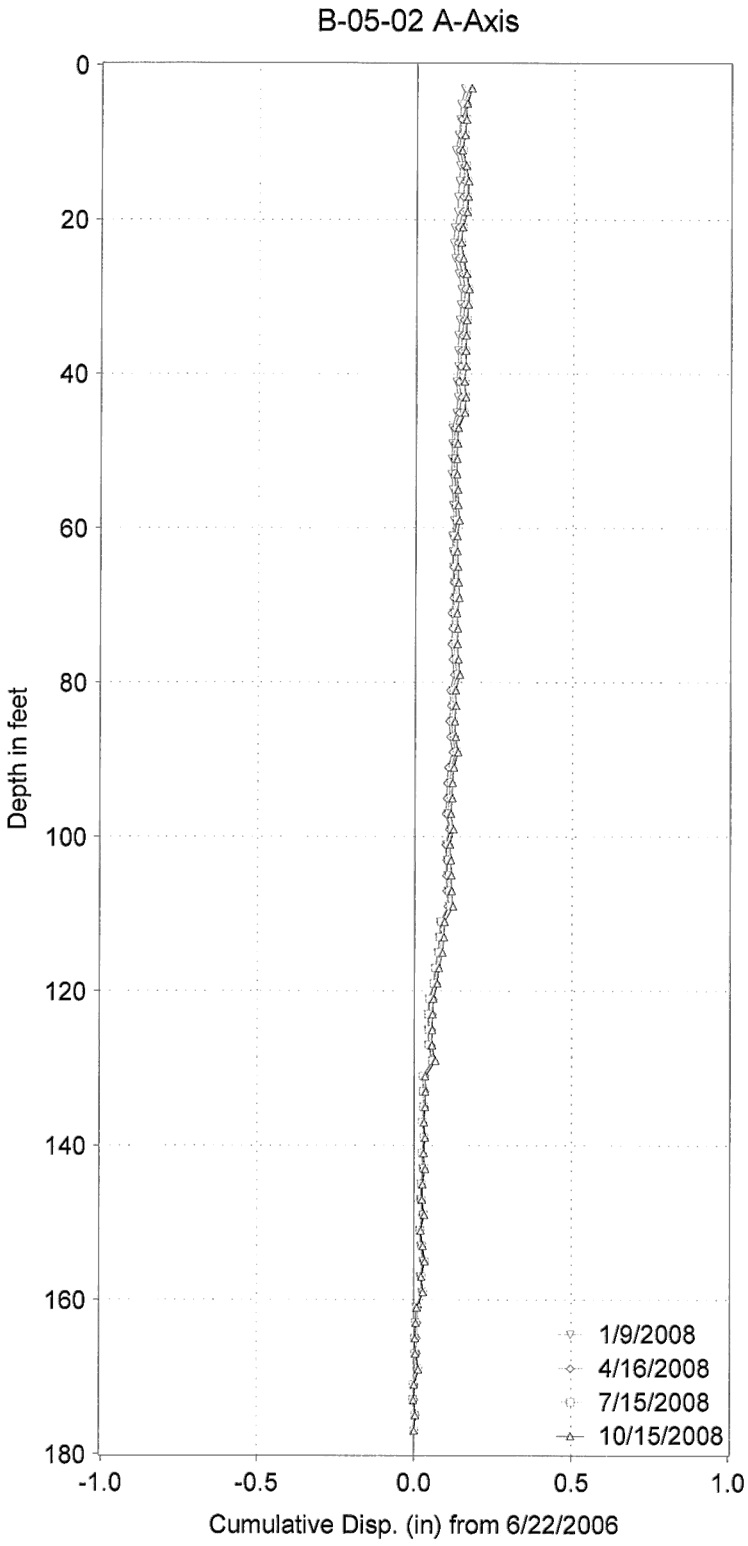
PLATE 28

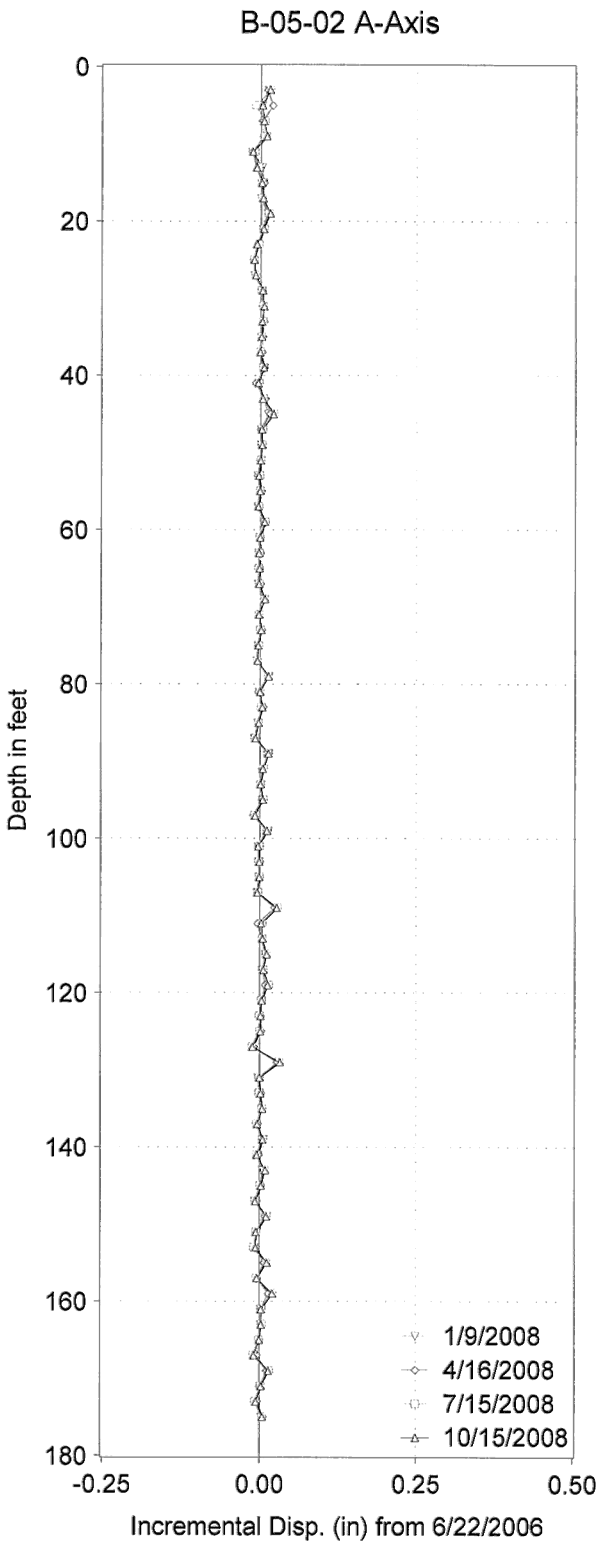




B-05-01
-Includes readings from the last four quarters.

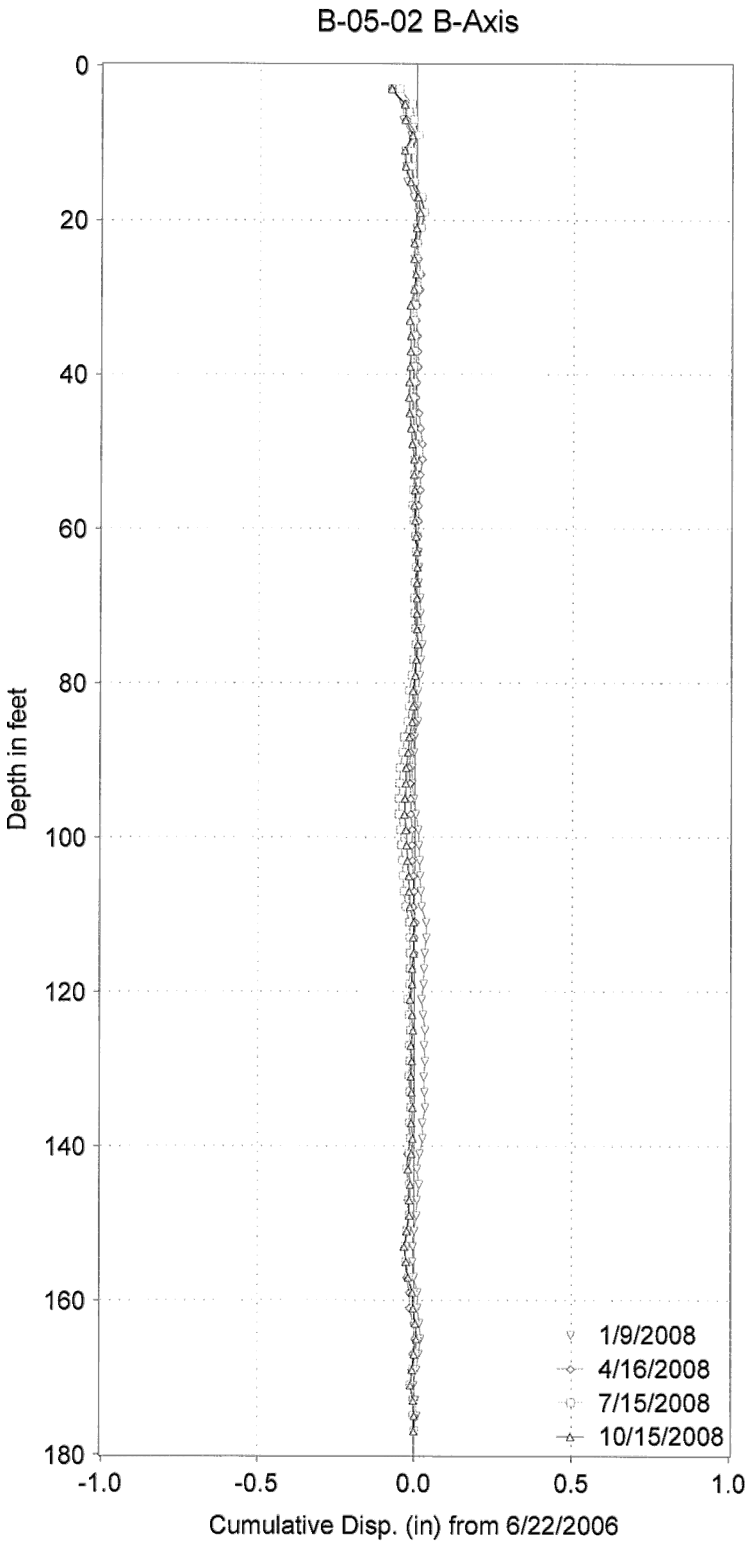
PLATE 29

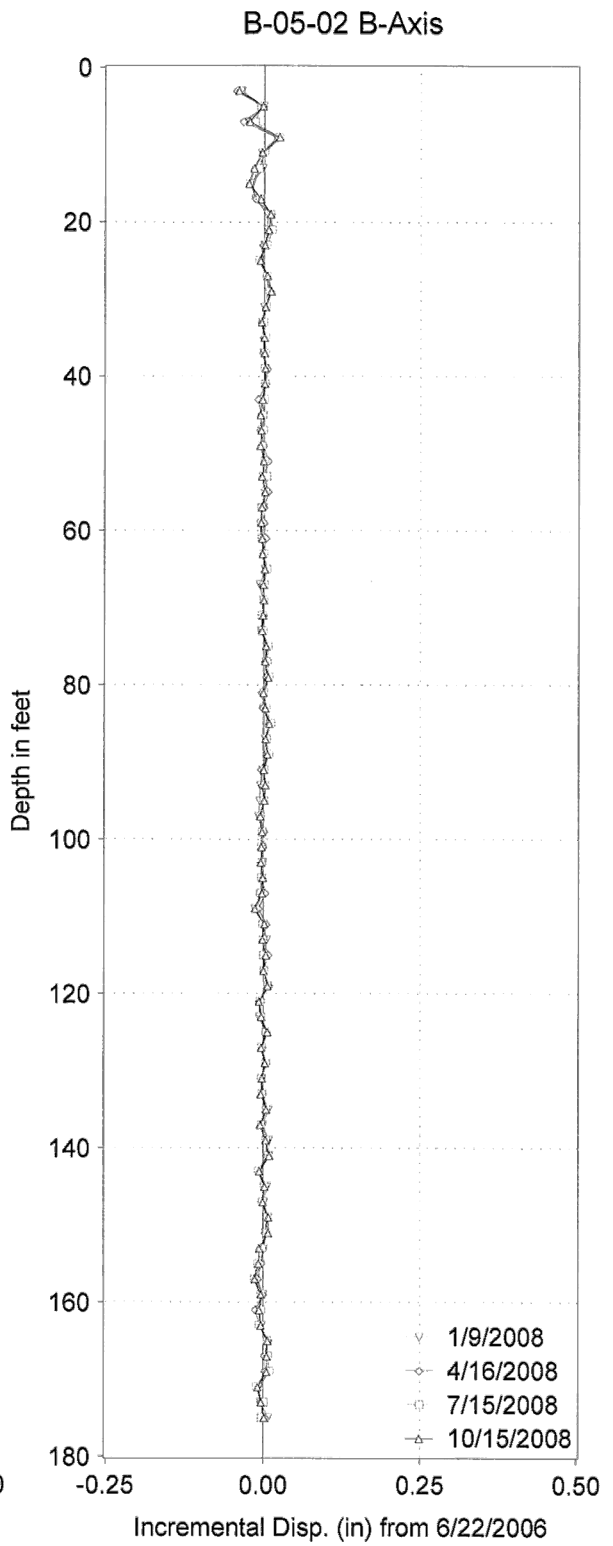




B-05-02
-Includes readings from the last four quarters.

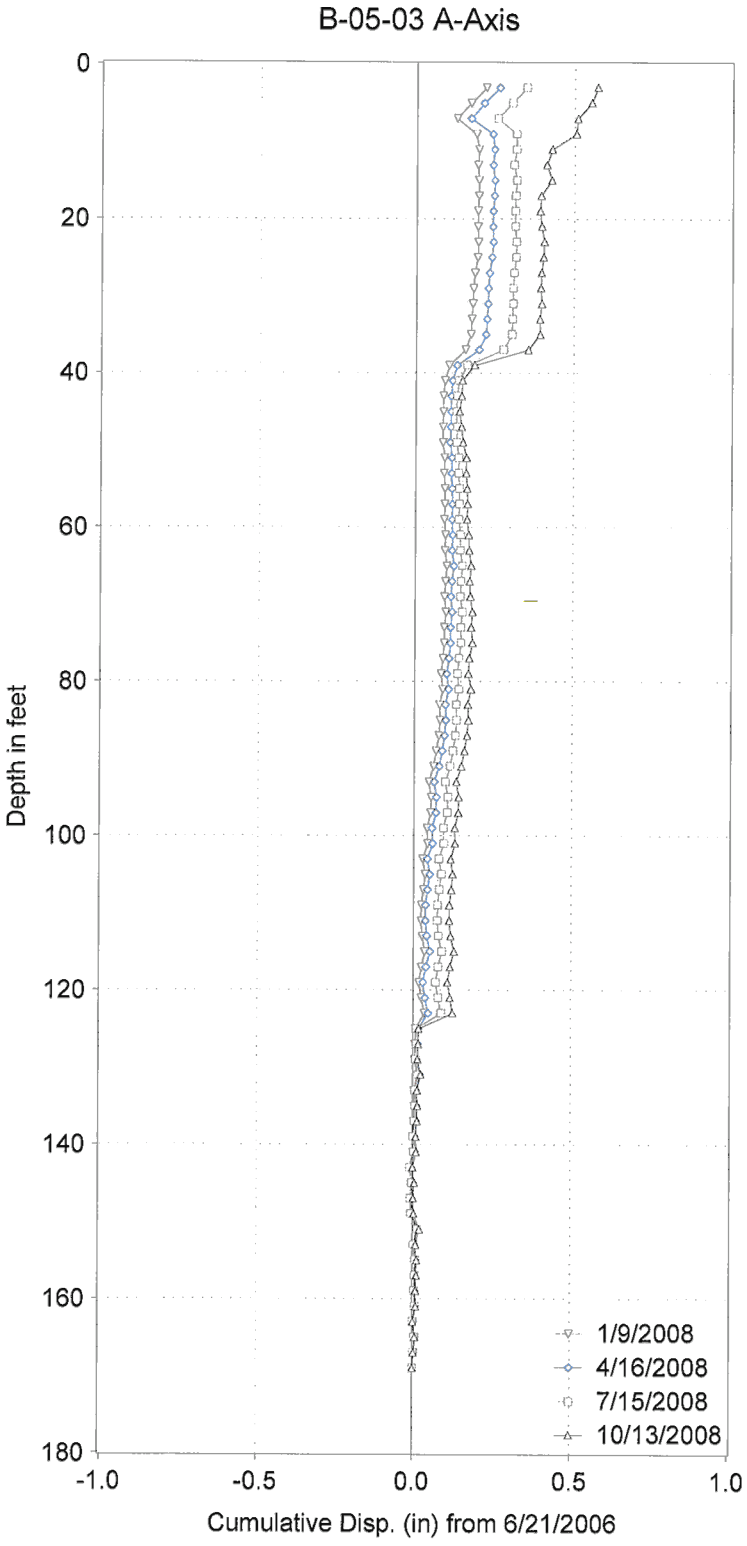
PLATE 30

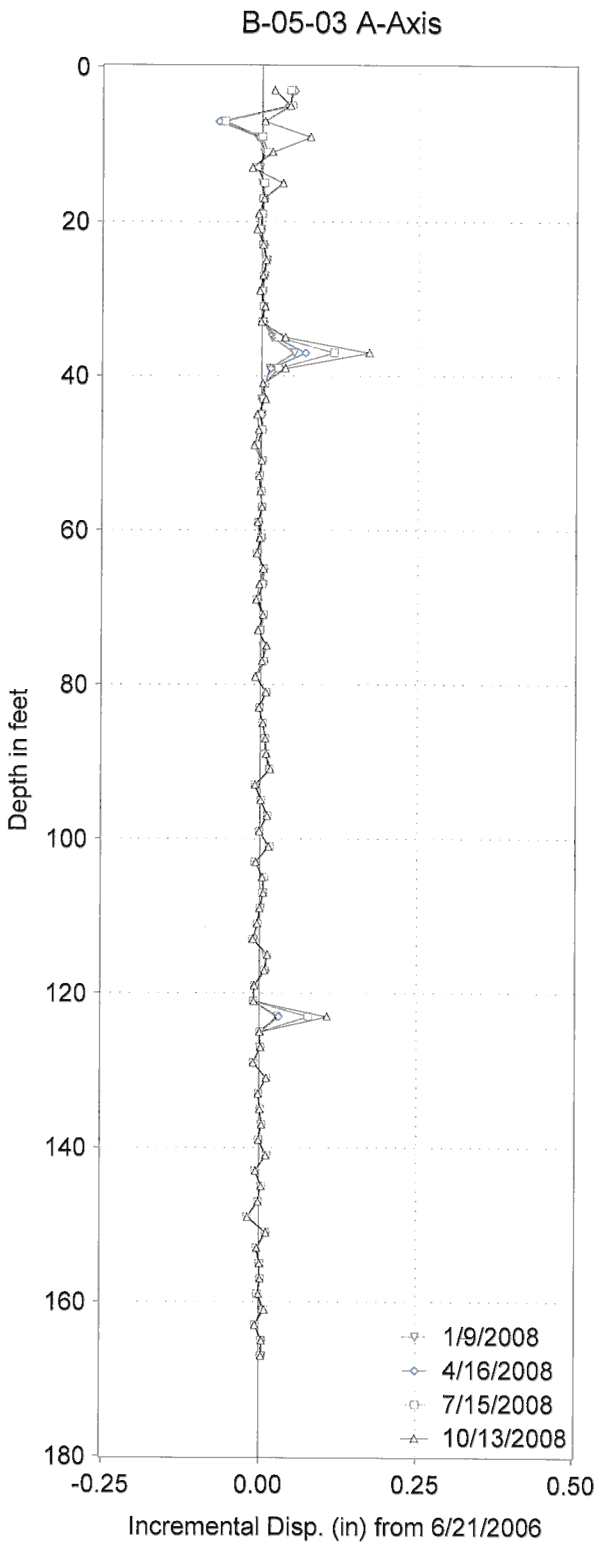




B-05-02
-Includes readings from the last four quarters.

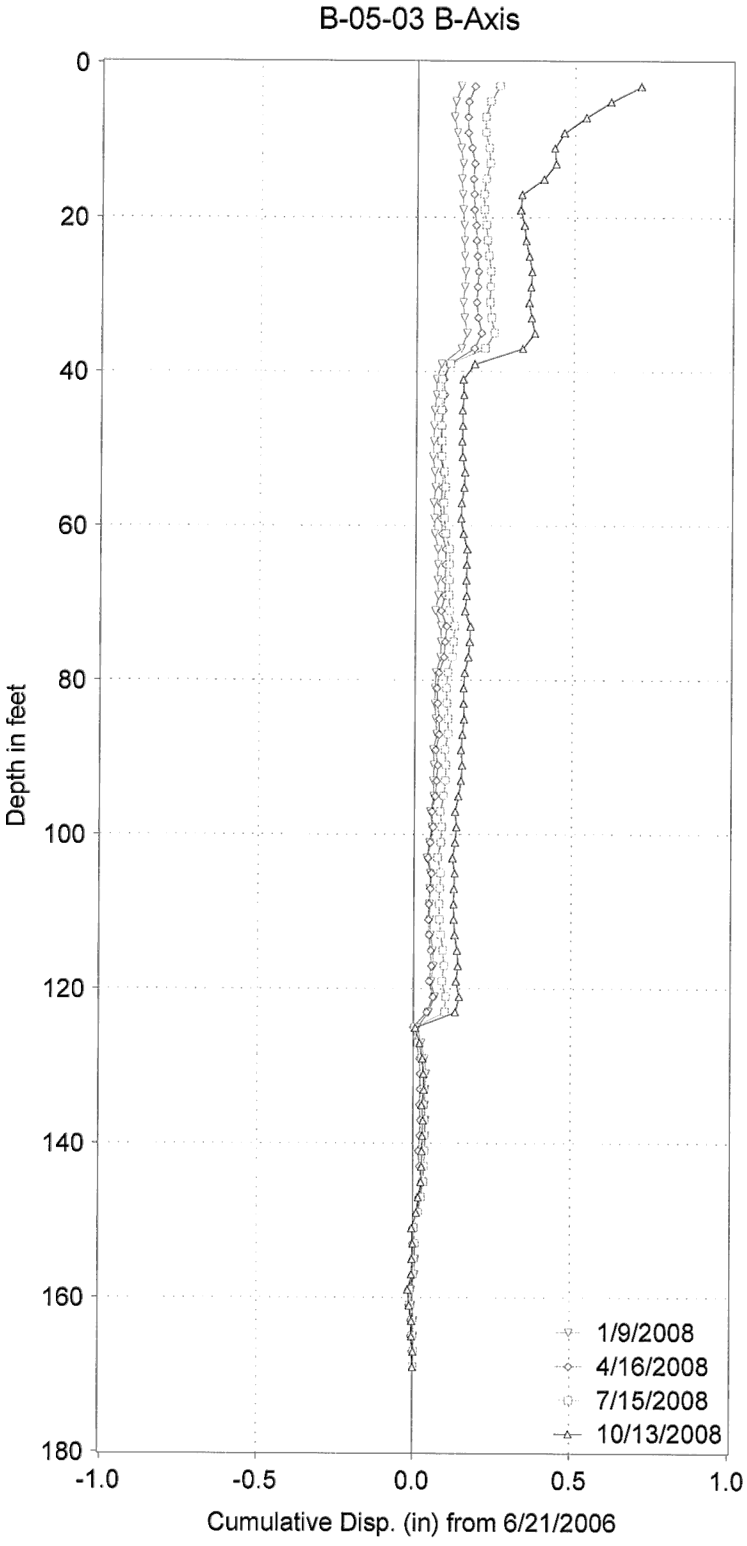
PLATE 31

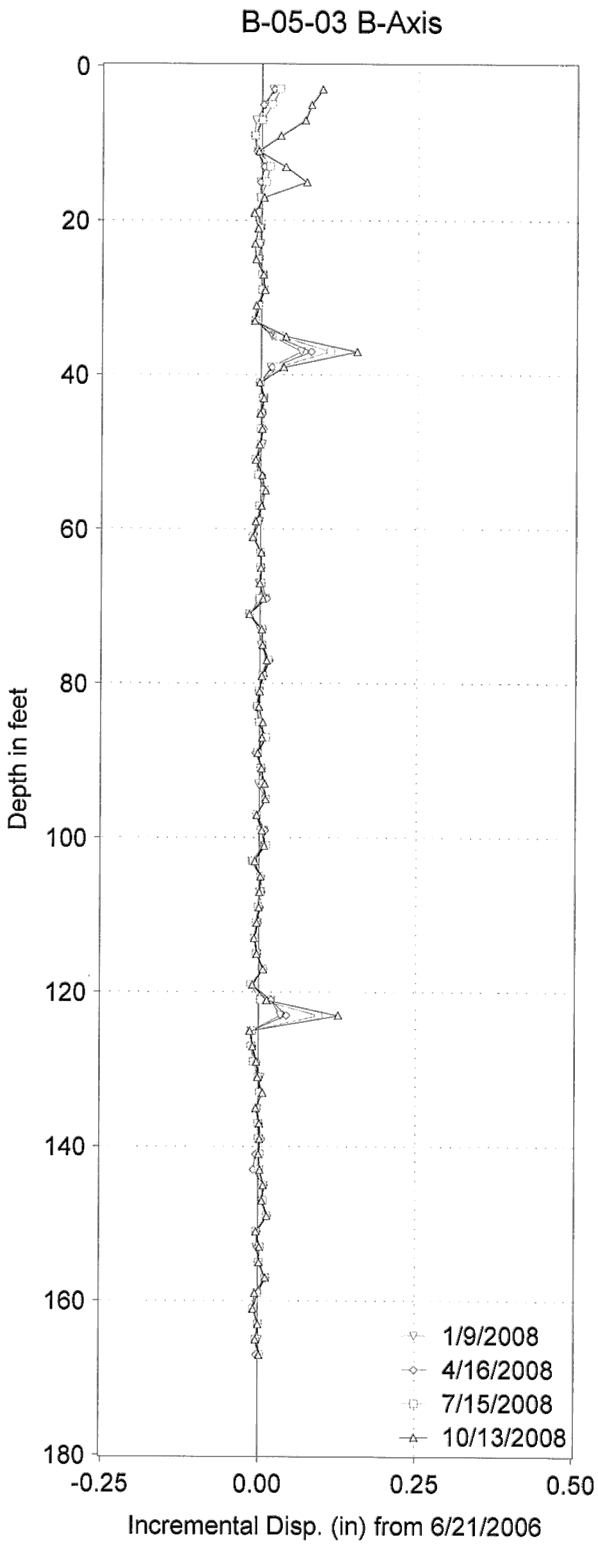




B-05-03
-Includes readings from the last four quarters.

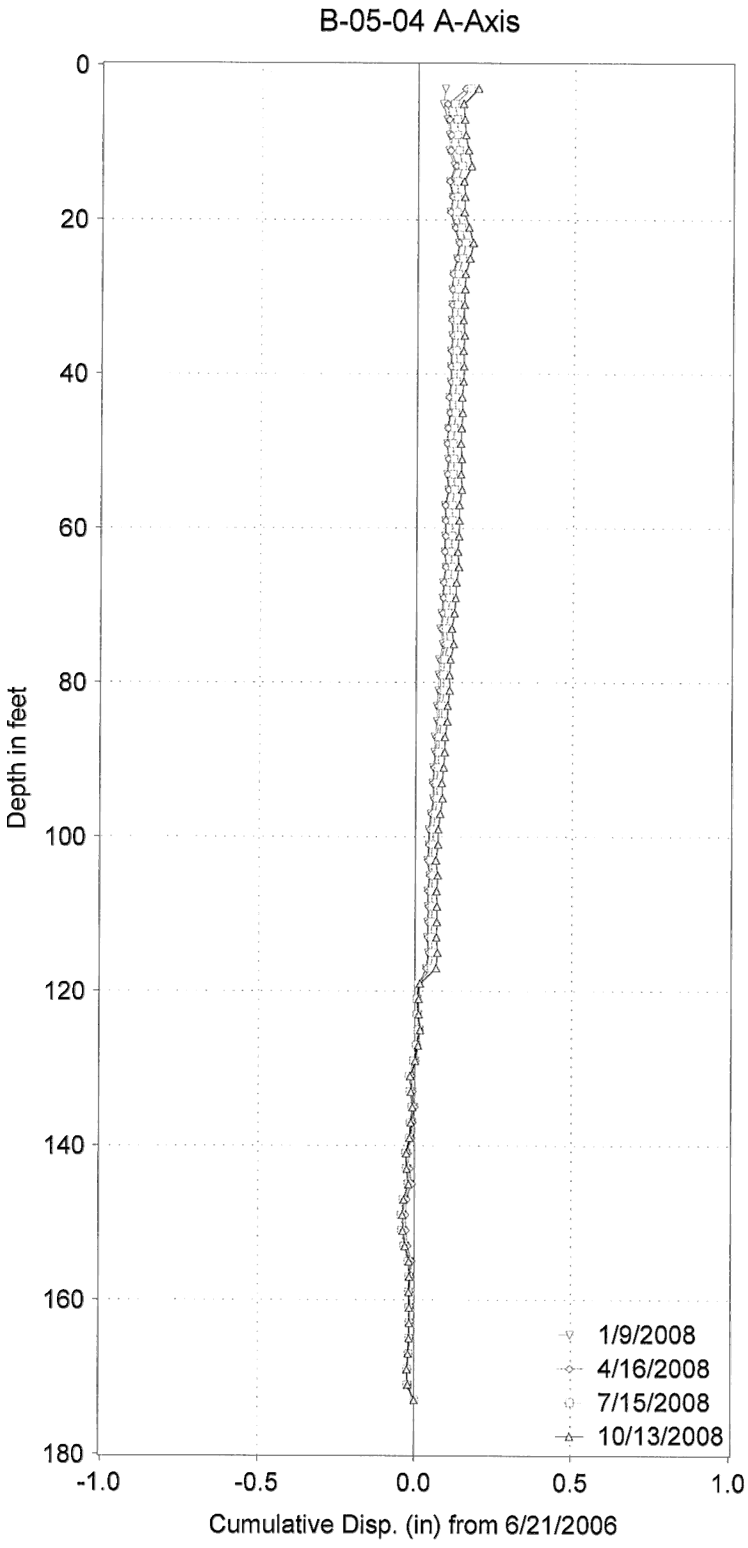
PLATE 32

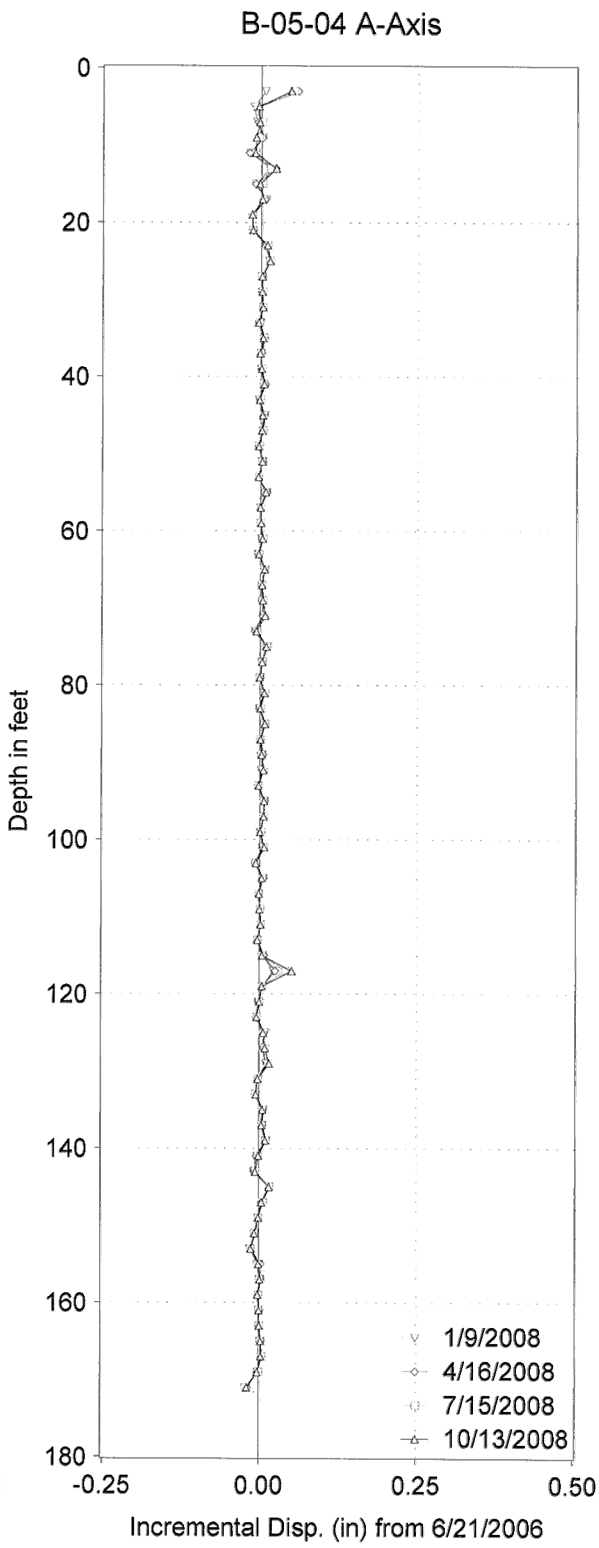




B-05-03
-Includes readings from the last four quarters.

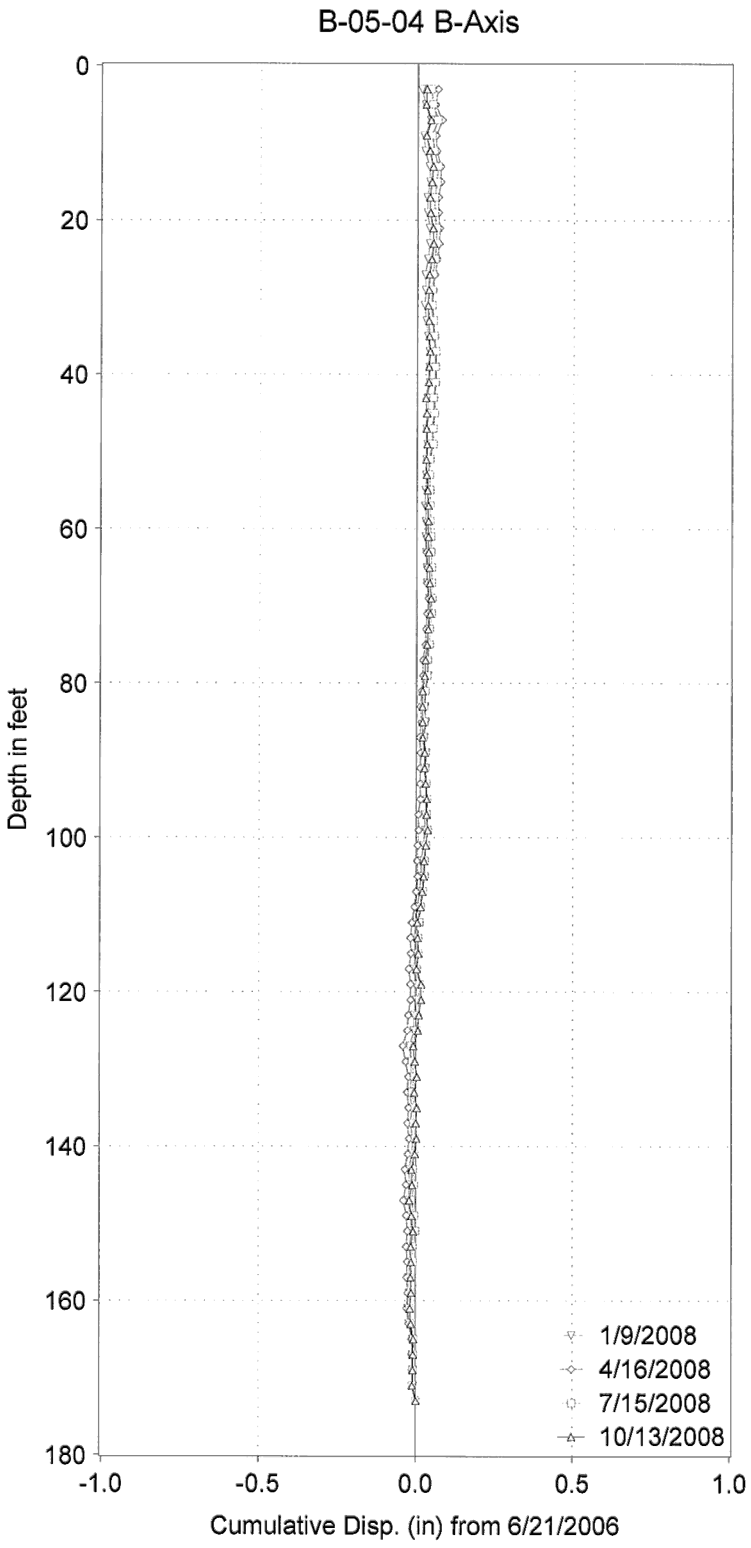
PLATE 33

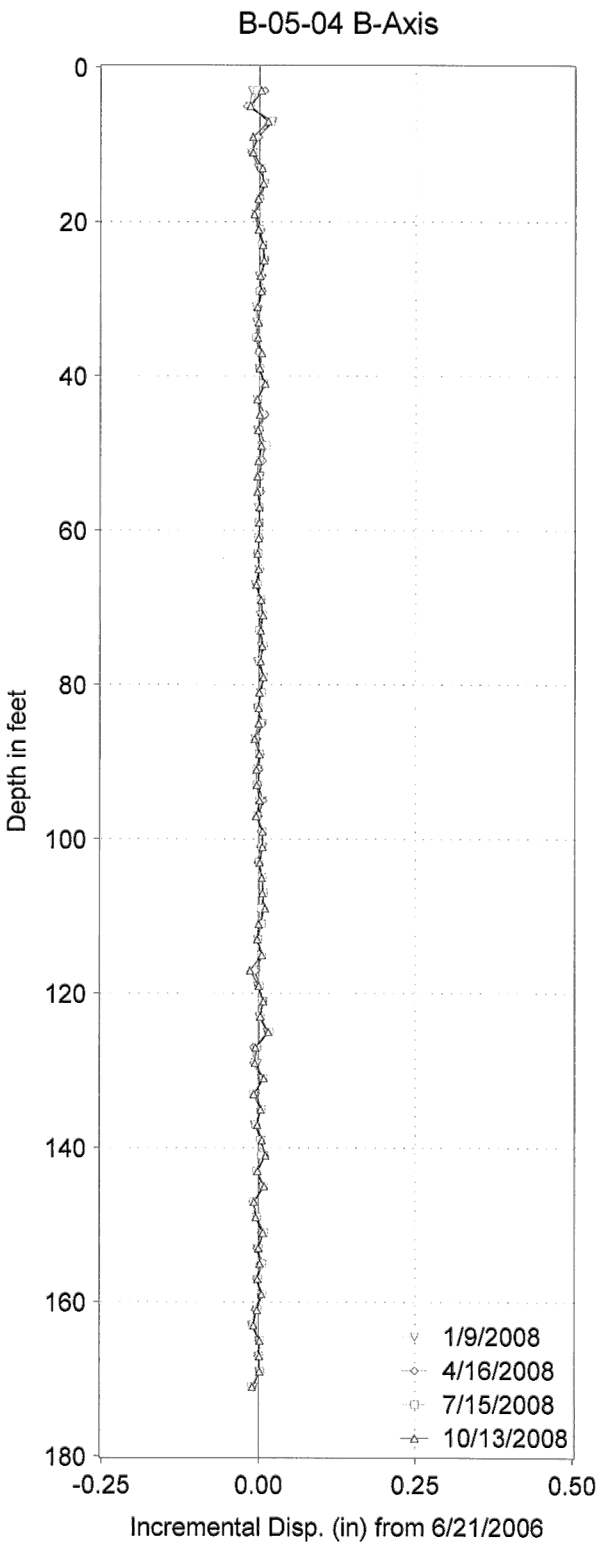




B-05-04
-Includes readings from the last four quarters.

PLATE 34

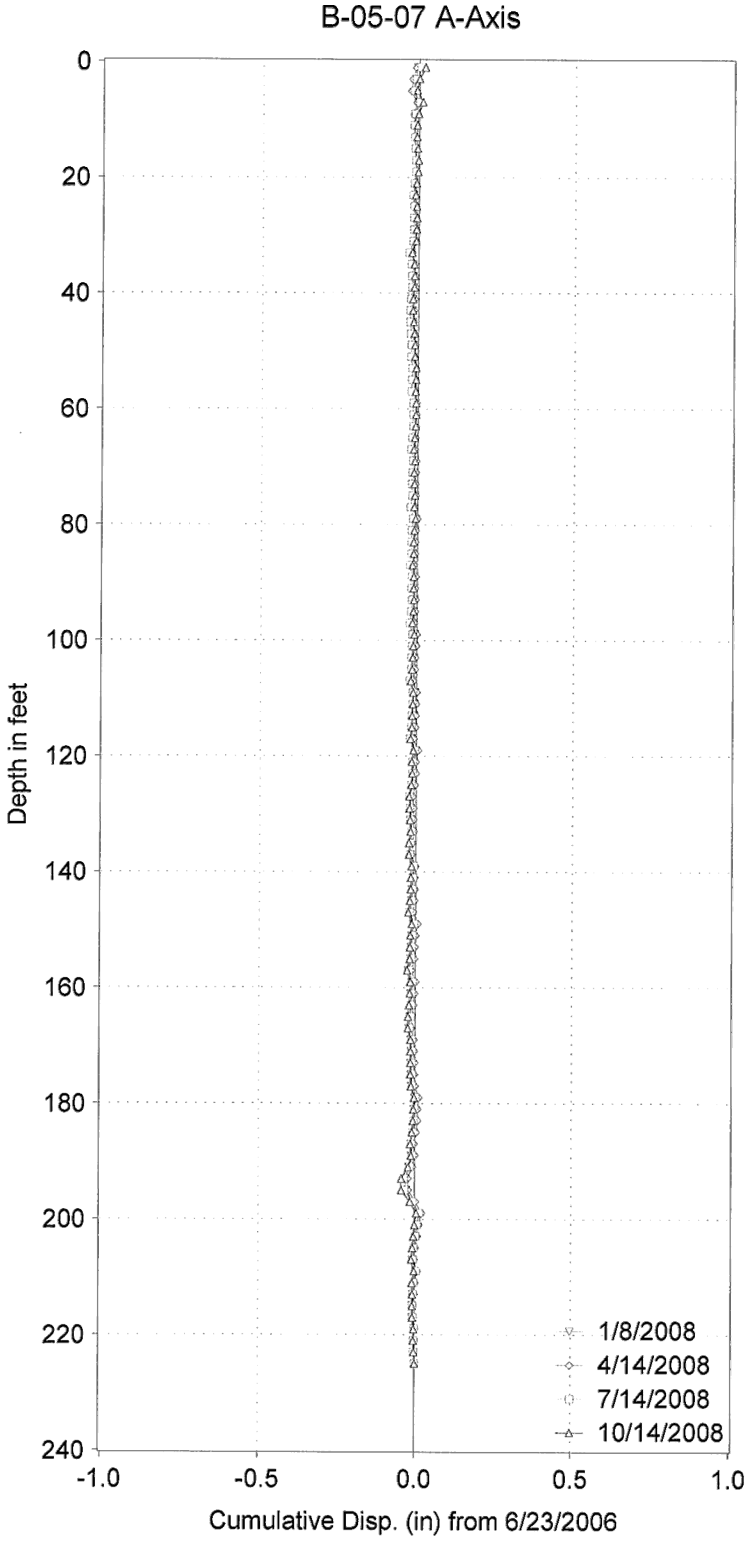


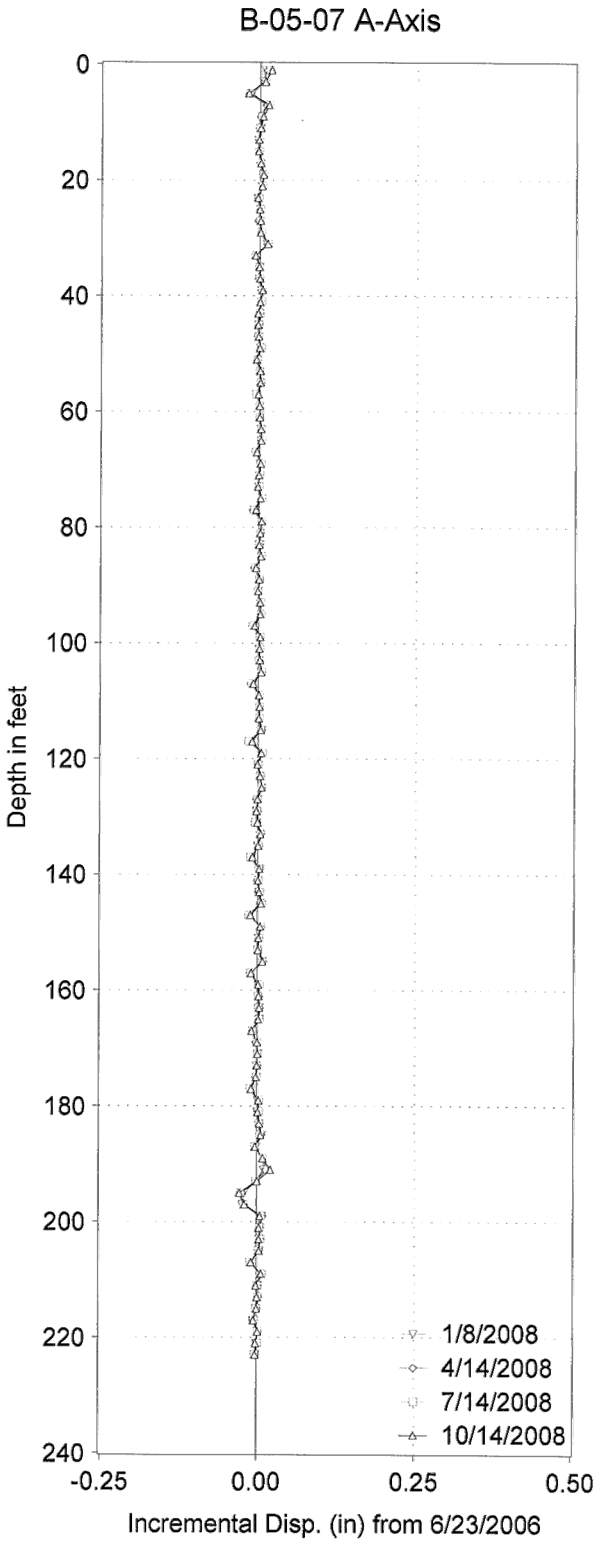


B-05-04

-Includes readings from the last four quarters.

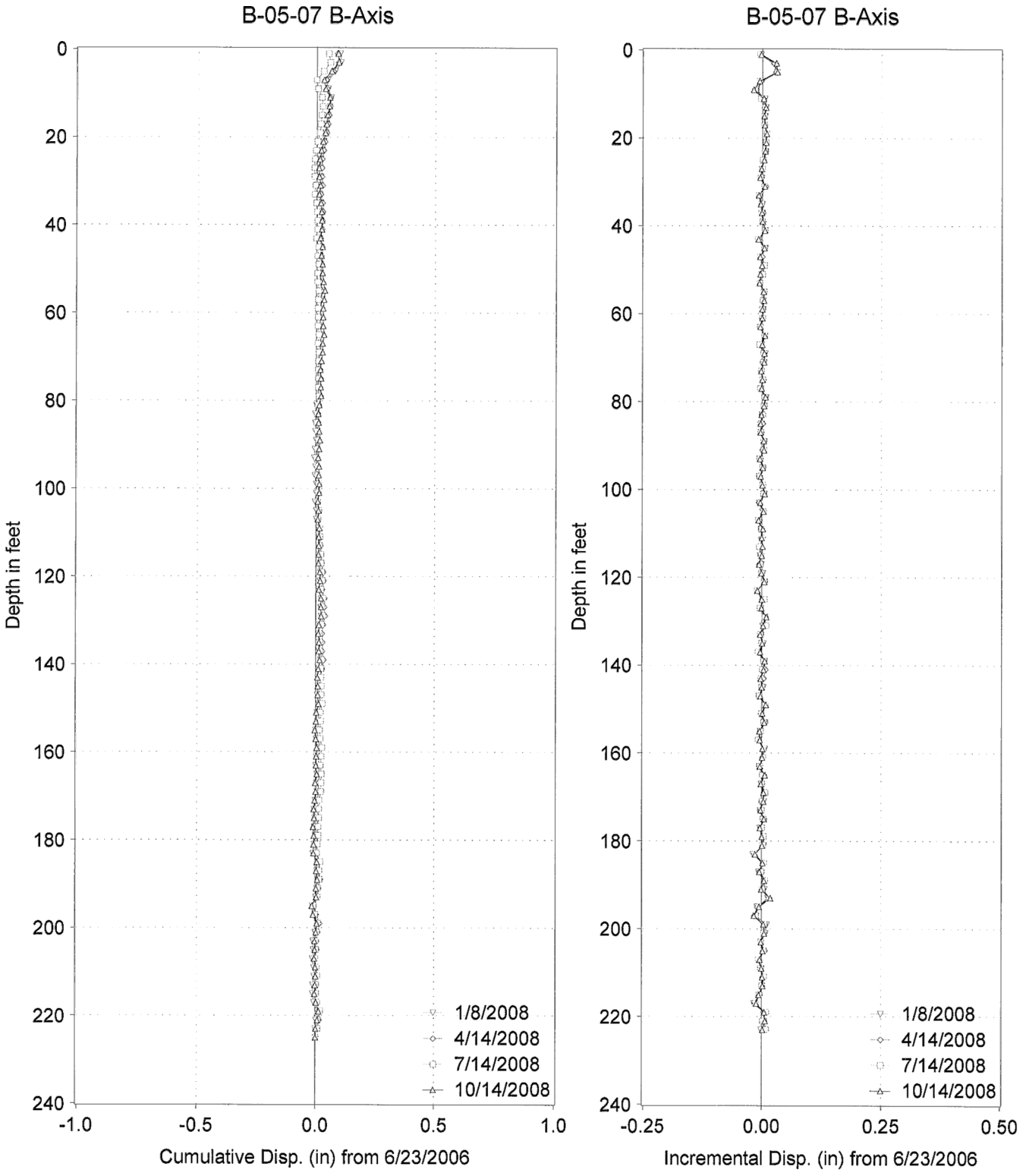
PLATE 35





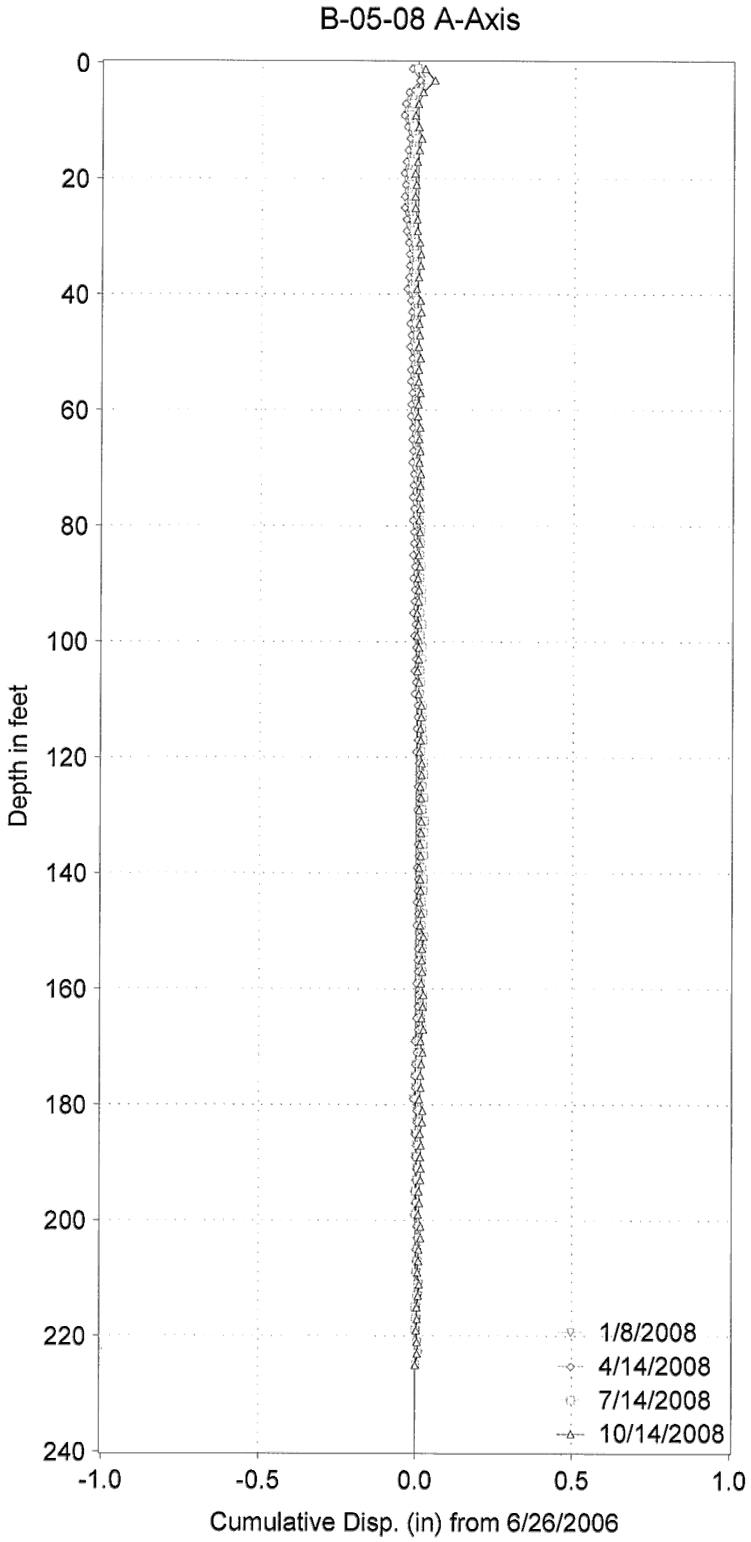
B-05-07
-Includes readings from the last four quarters.

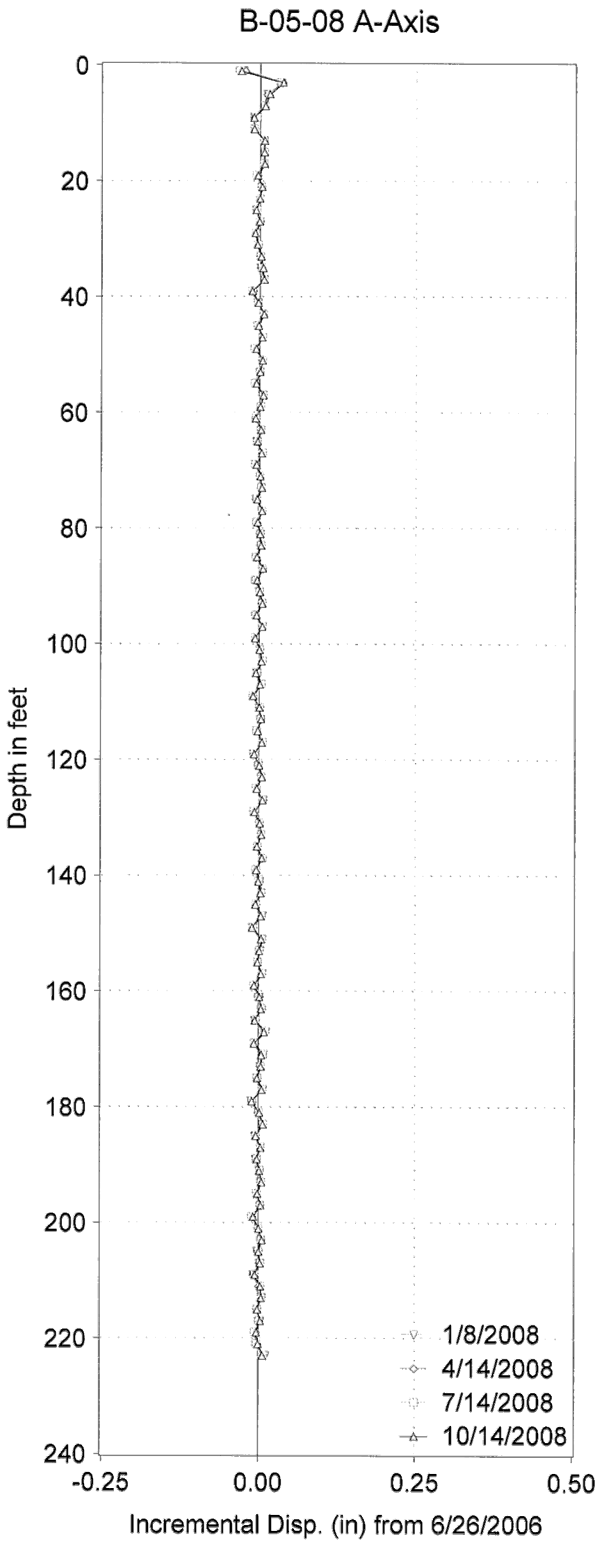
PLATE 36



B-05-07
-Includes readings from the last four quarters.

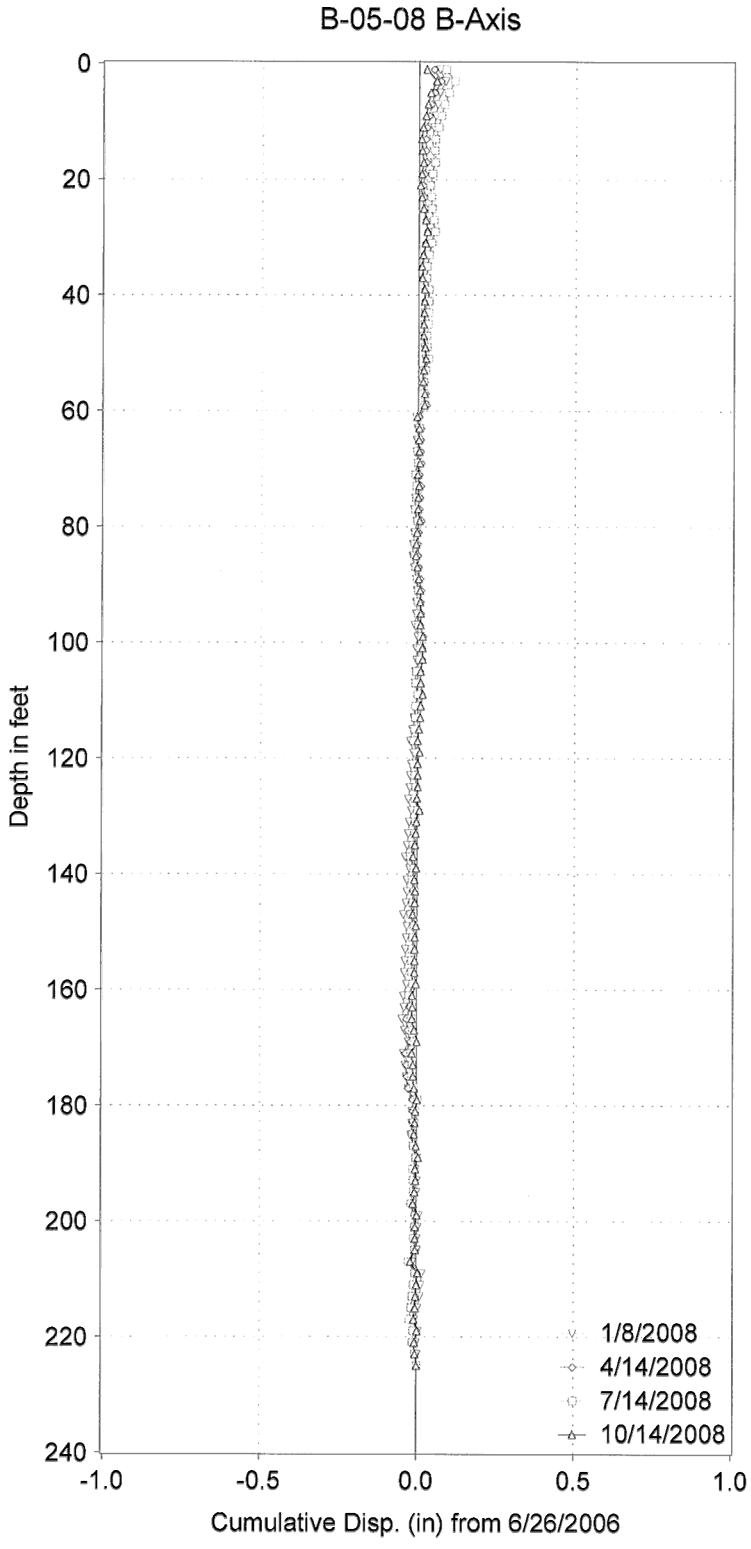
PLATE 37

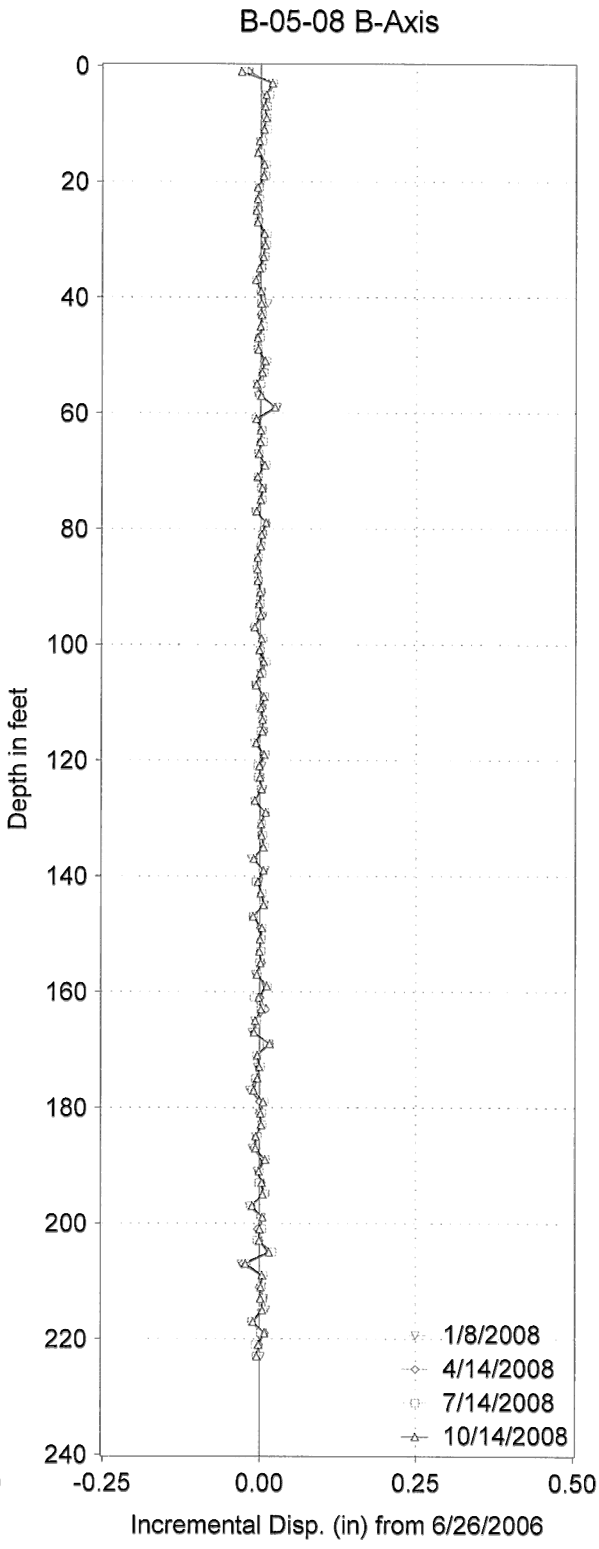




B-05-08
-Includes readings from the last four quarters.

PLATE 38

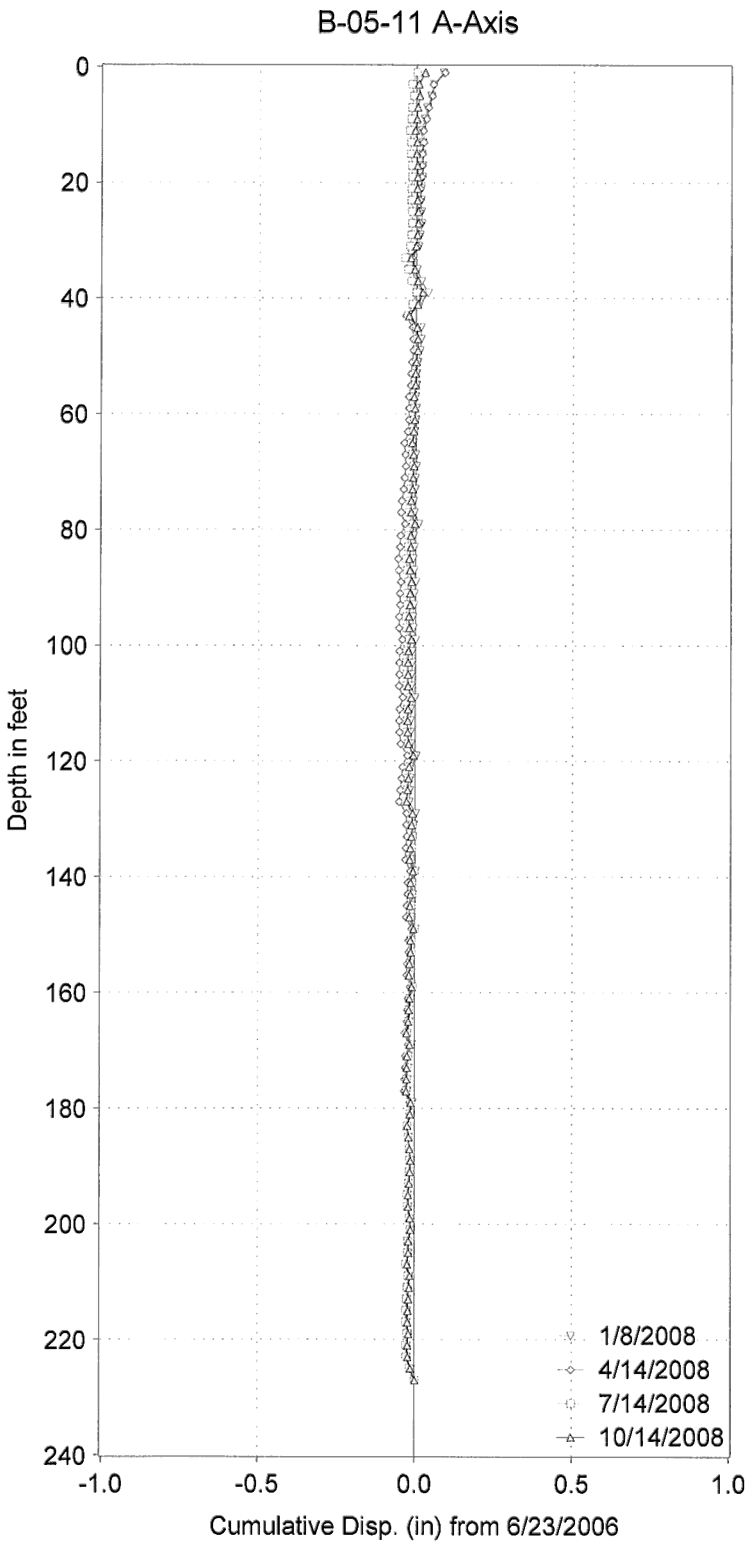


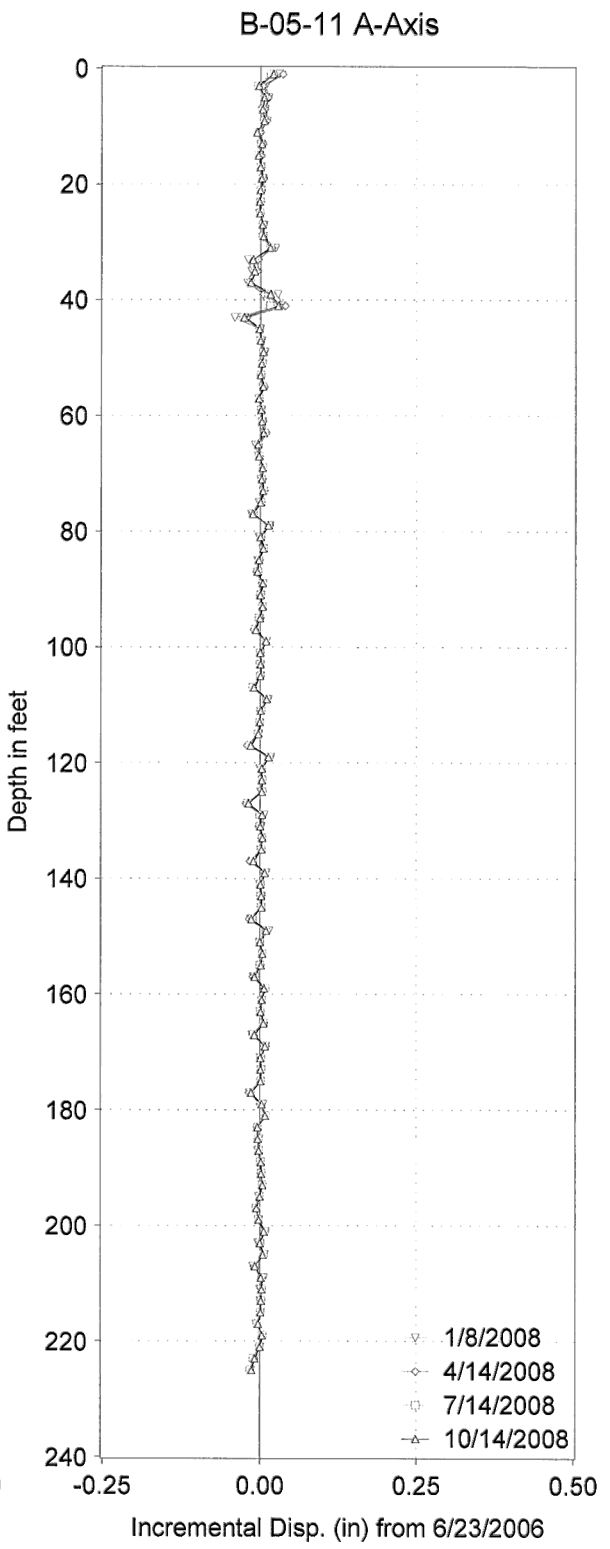


B-05-08

-Includes readings from the last four quarters.

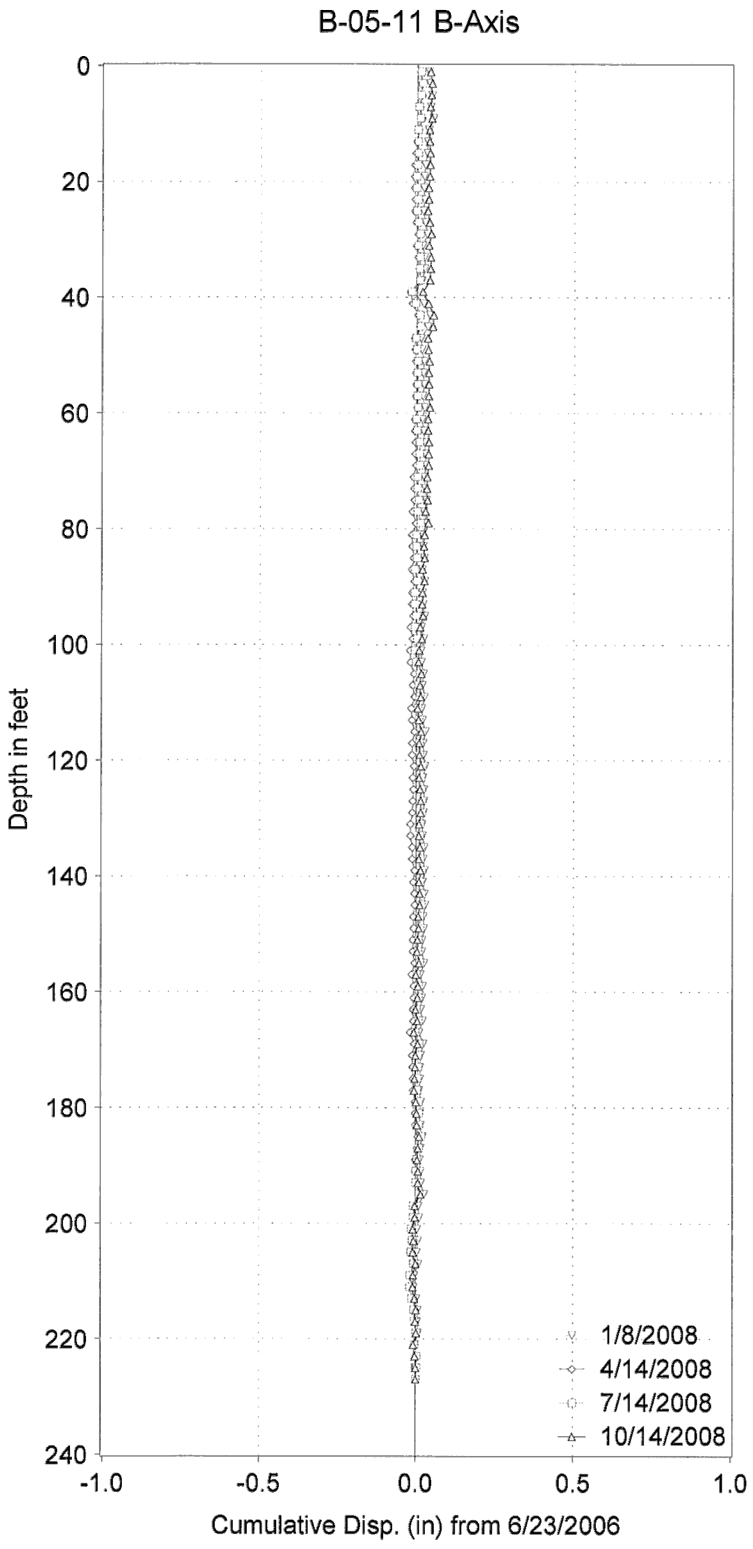
PLATE 39

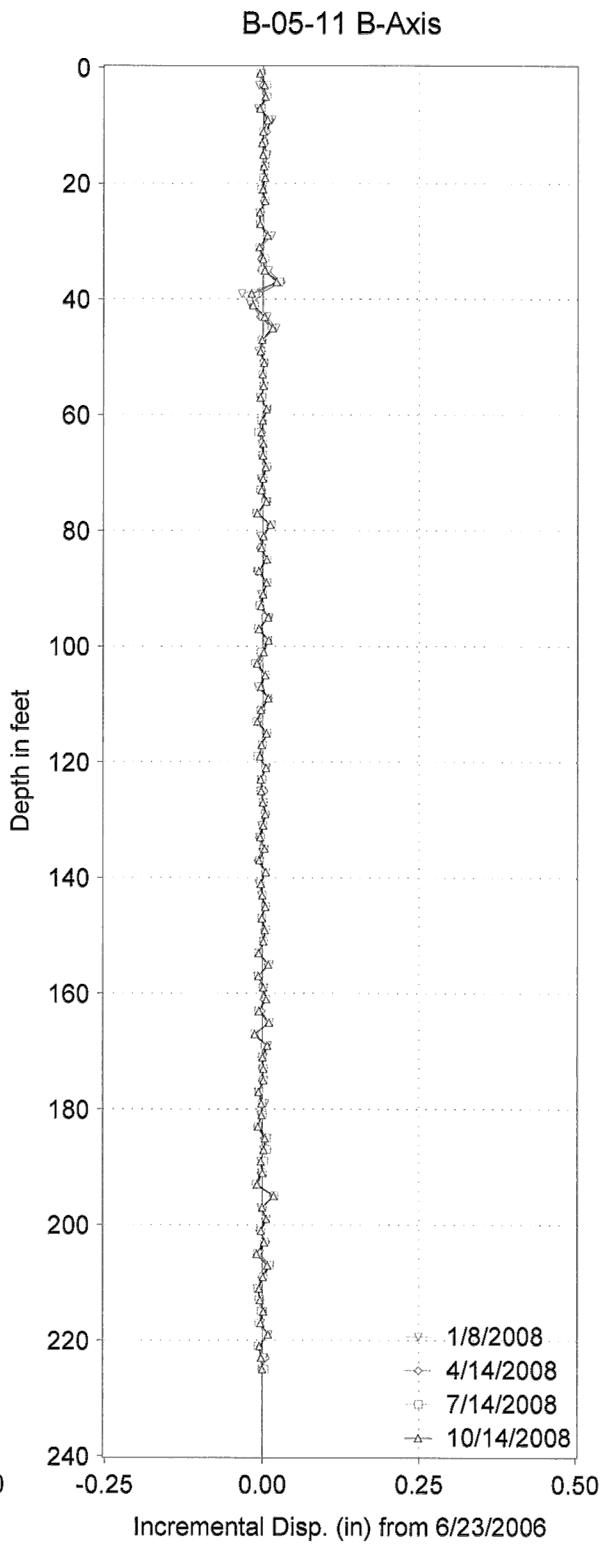




B-05-11
-Includes readings from the last four quarters.

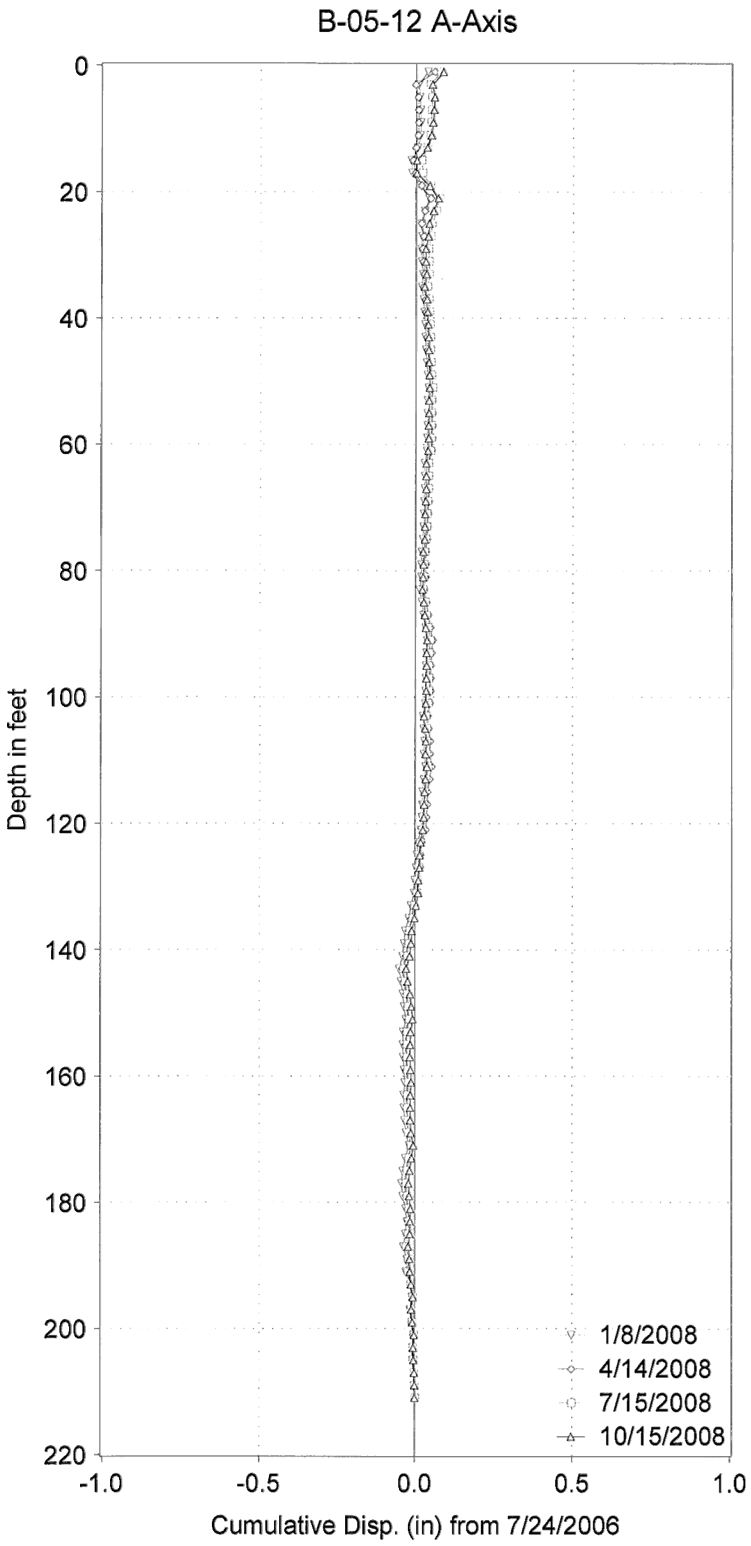
PLATE 40

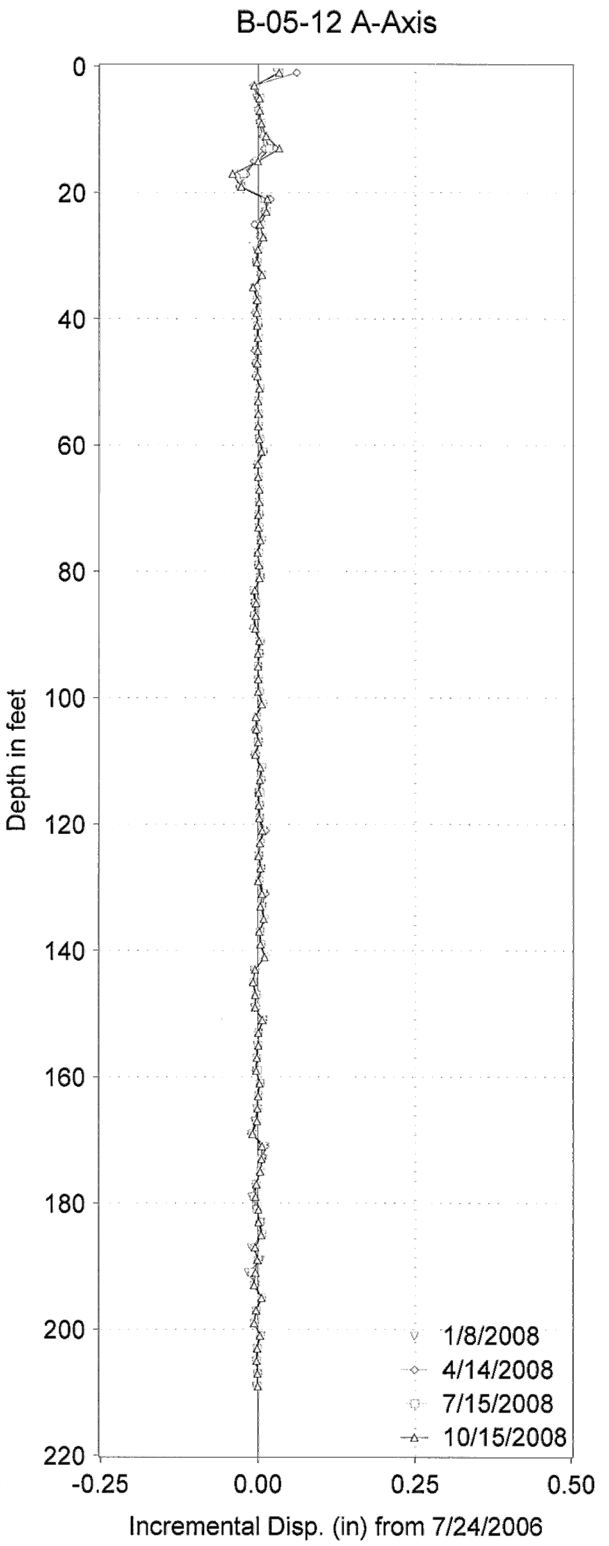




B-05-11
-Includes readings from the last four quarters.

PLATE 41

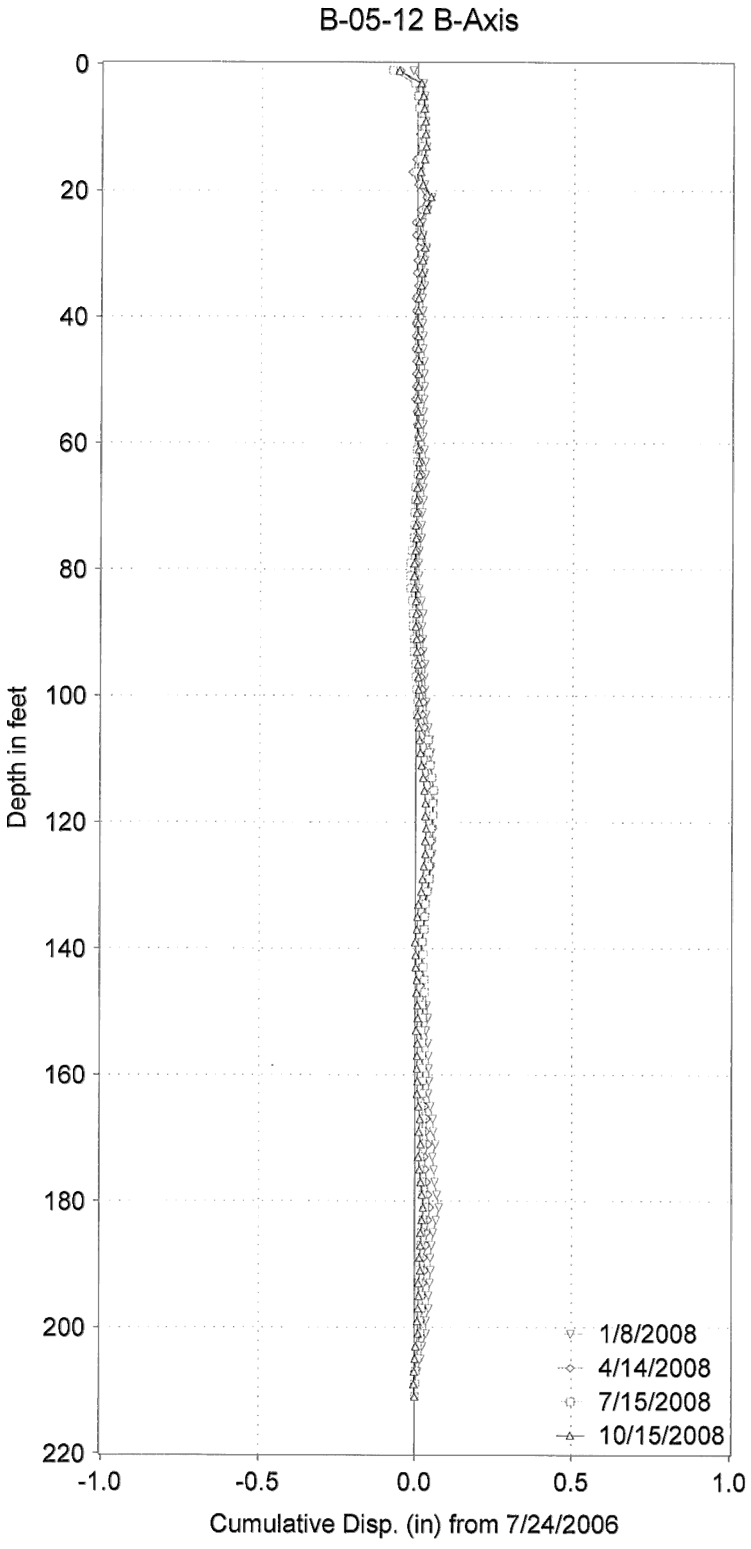


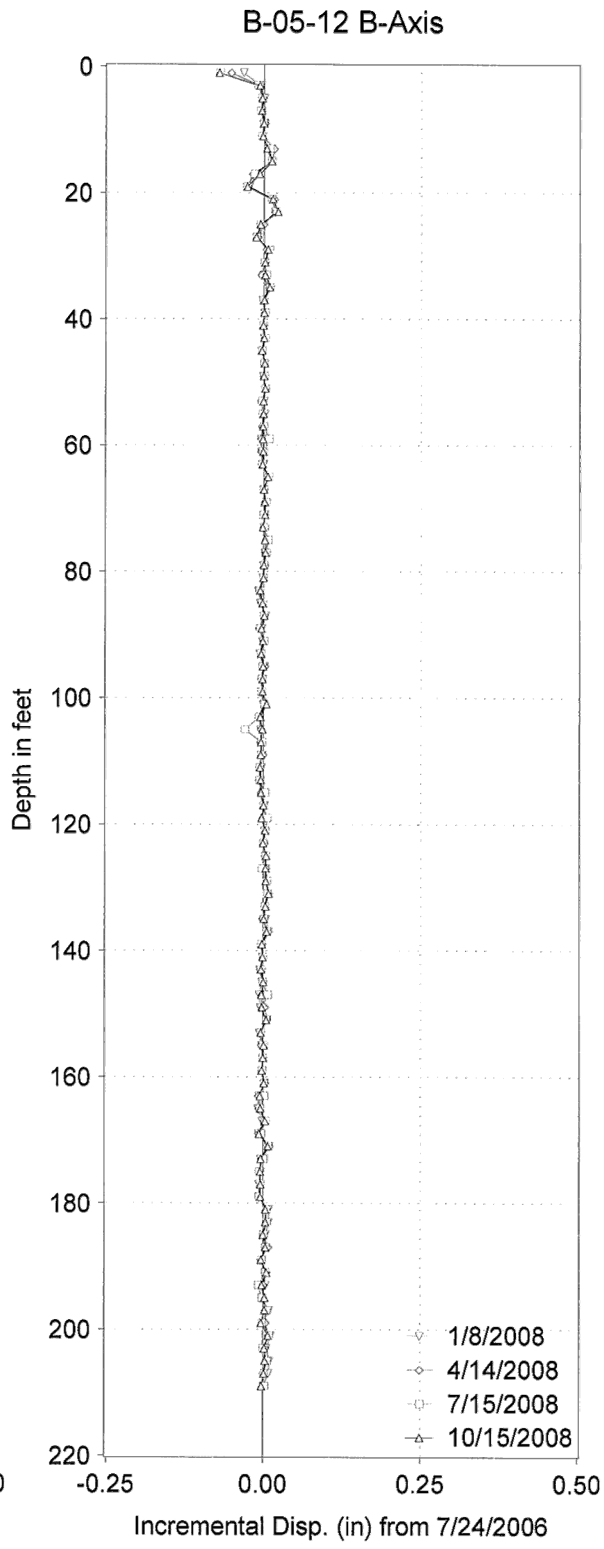


B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

PLATE 42

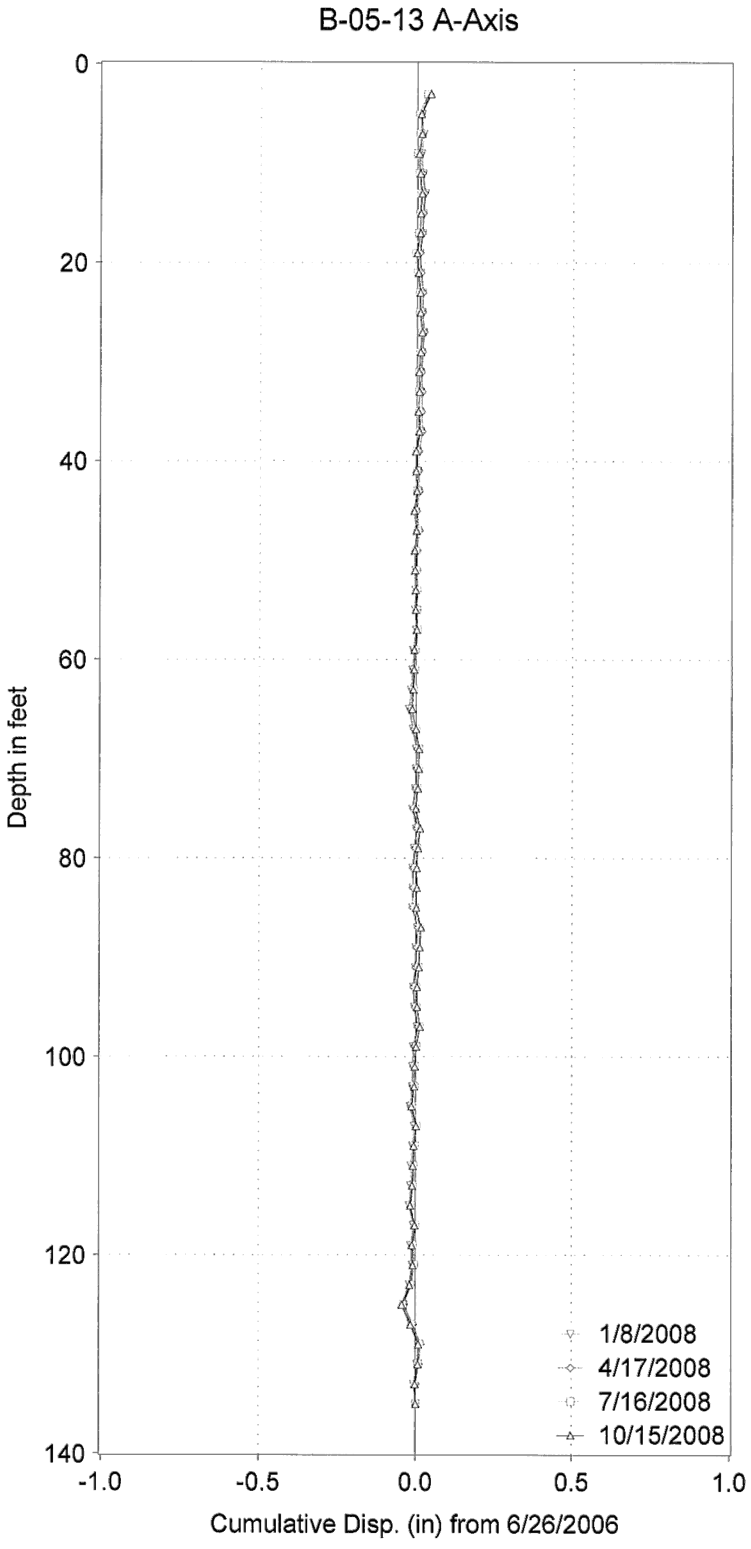


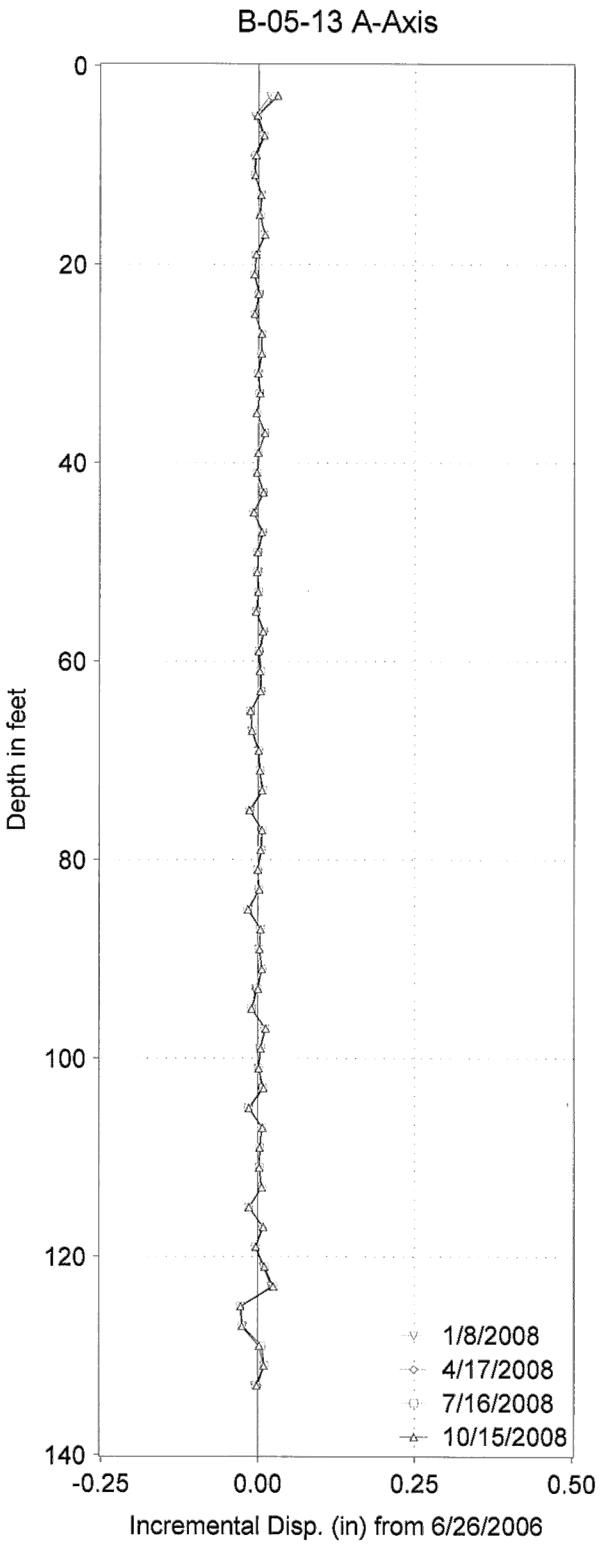


B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

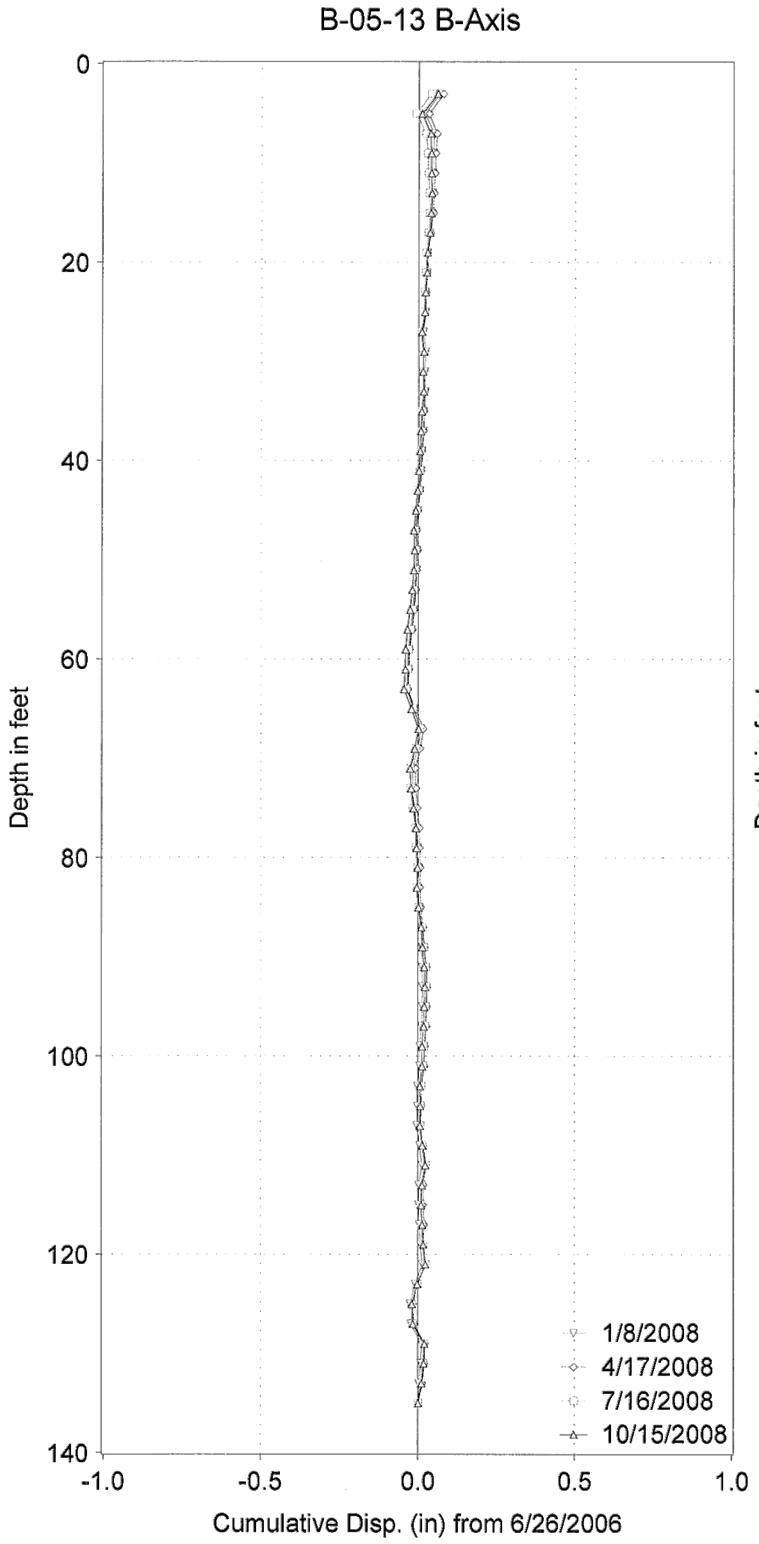
PLATE 43

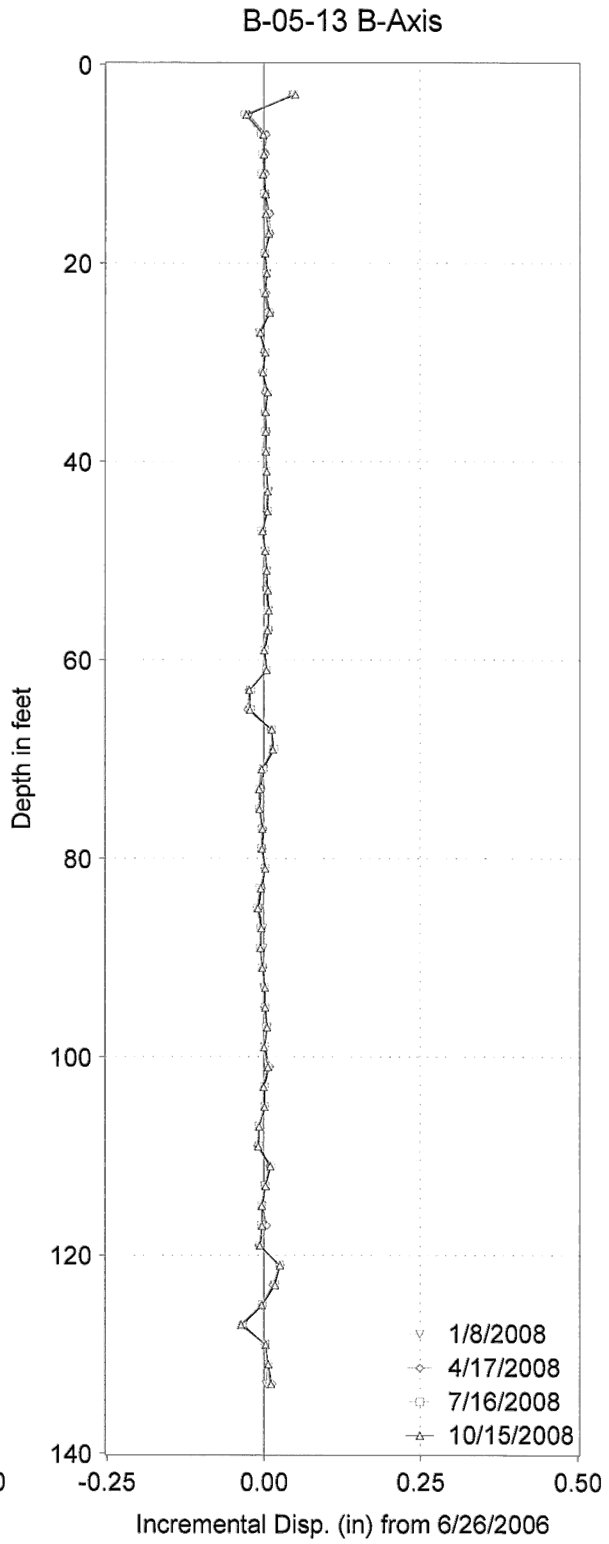




B-05-13
-Includes readings from the last four quarters.

PLATE 44

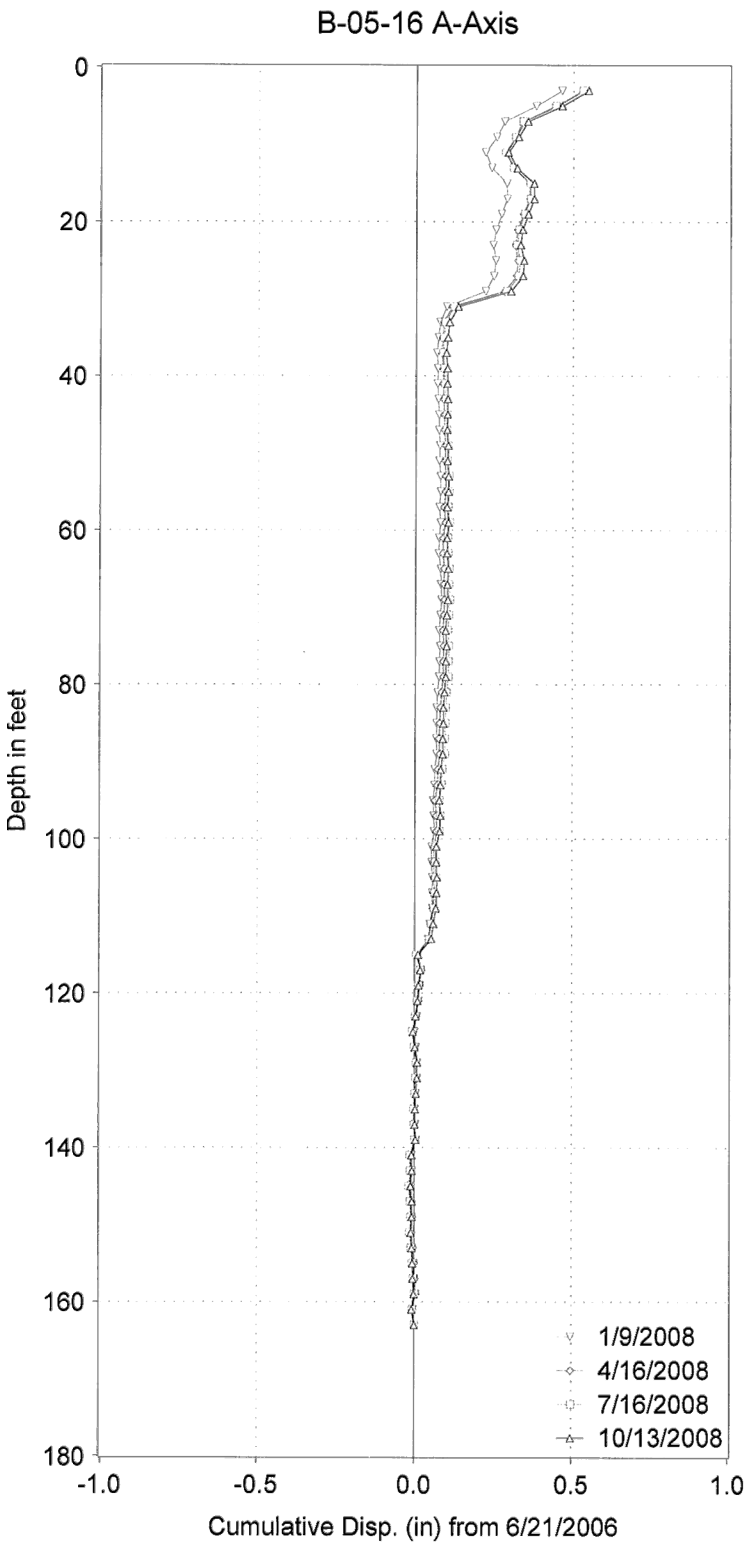


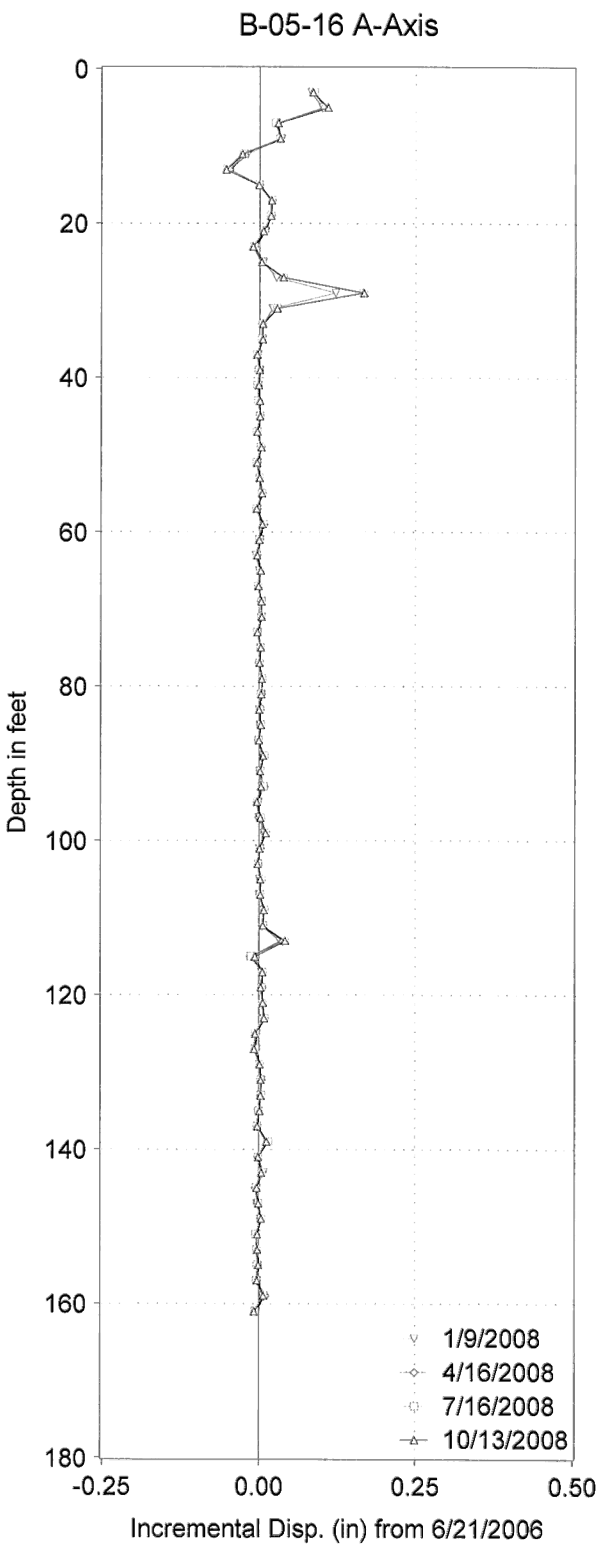


B-05-13

-Includes readings from the last four quarters.

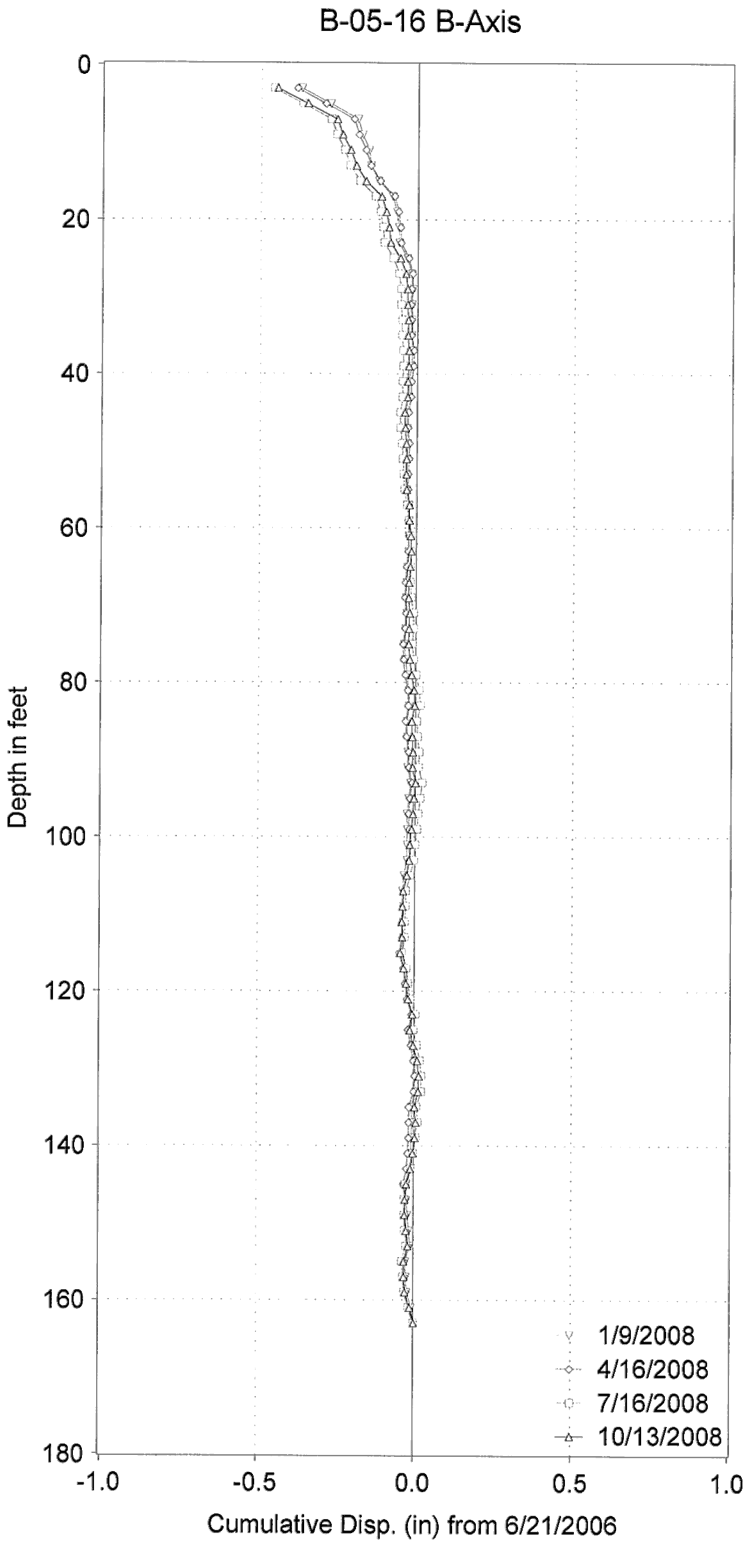
PLATE 45

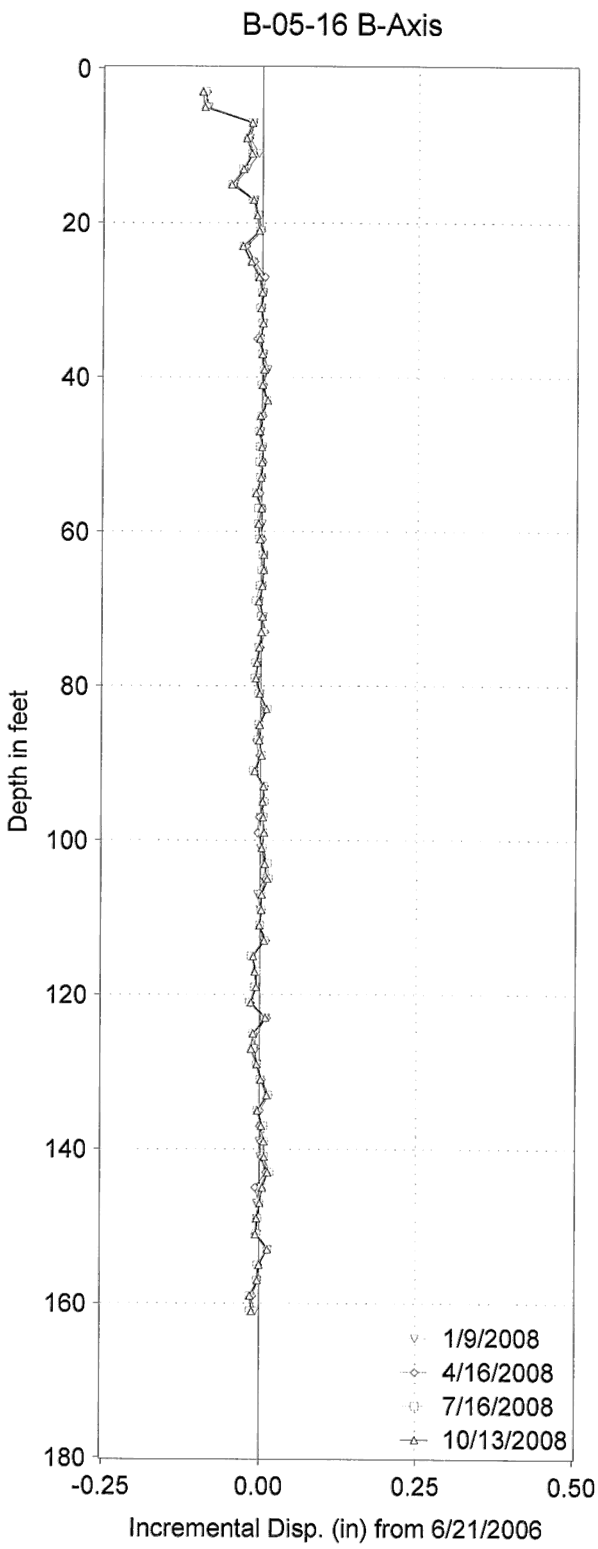




B-05-16
-Includes readings from the last four quarters.

PLATE 46





B-05-16

-Includes readings from the last four quarters.

PLATE 47

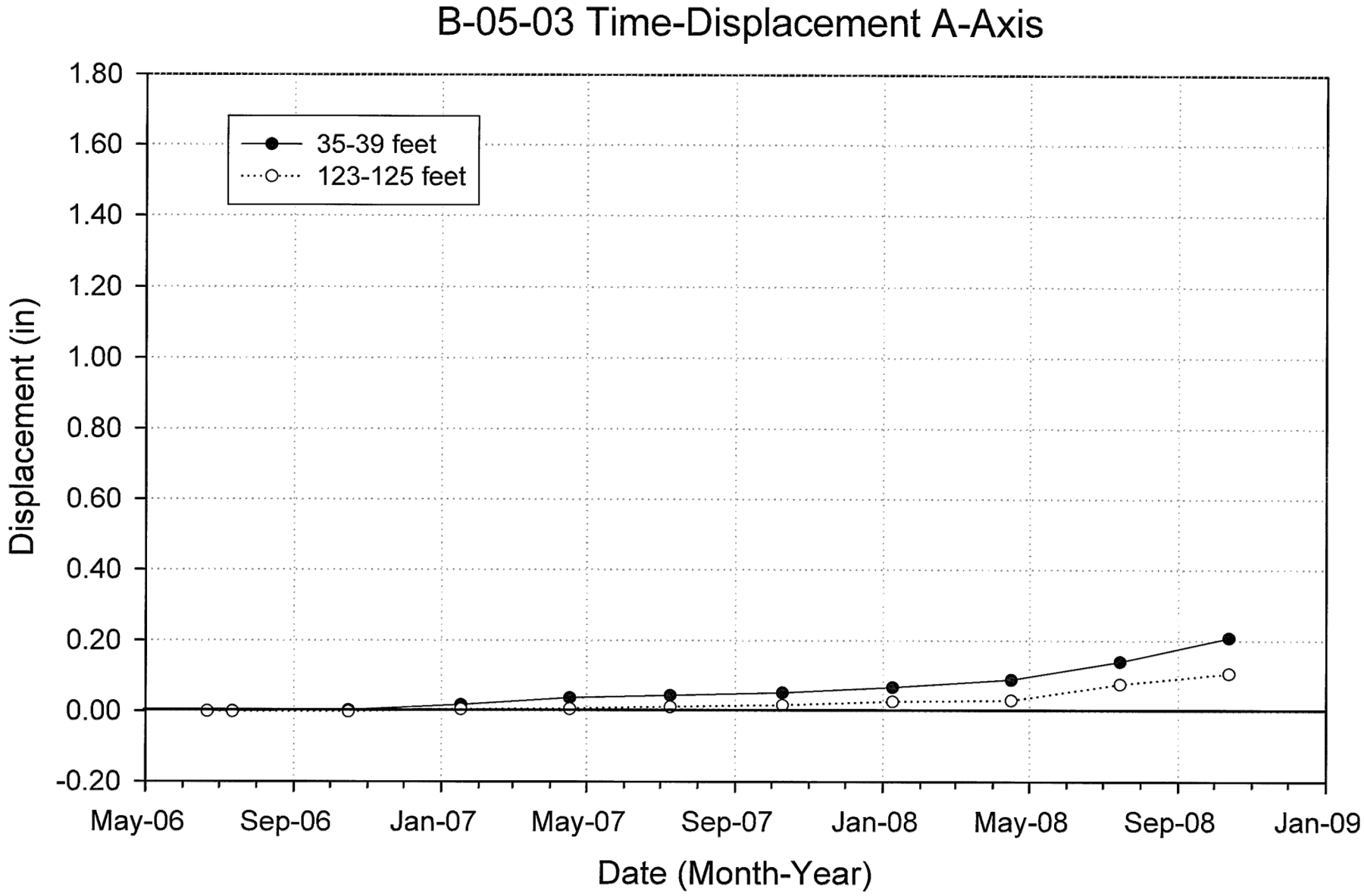

B-05-03 Time-Displacement A-Axis
35-39 feet
123-125 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
Date (Month-Year)

PLATE 48

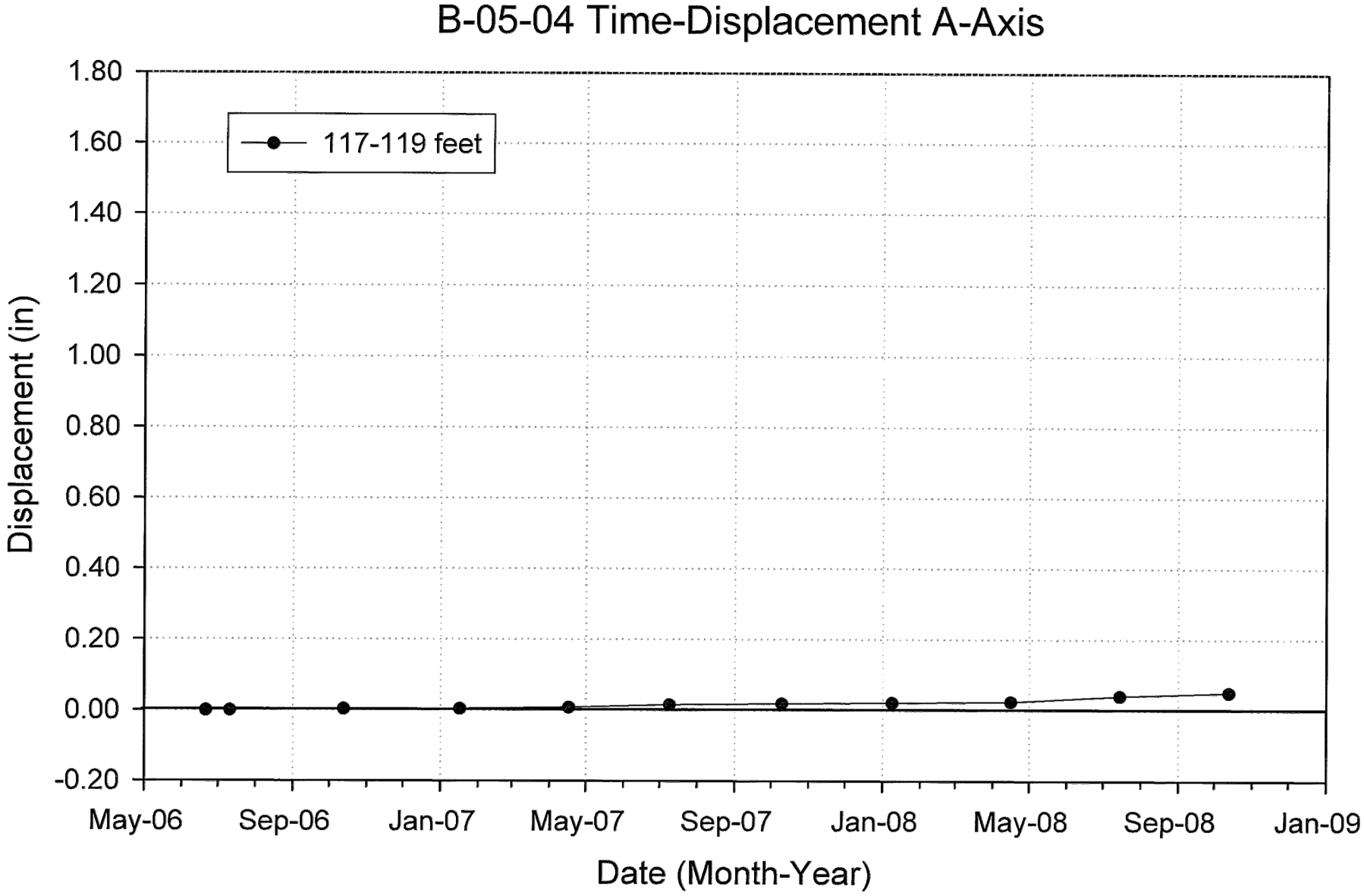

B-05-04 Time-Displacement A-Axis
117-119 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
Date (Month-Year)

PLATE 49

B-05-16 Time-Displacement A-Axis

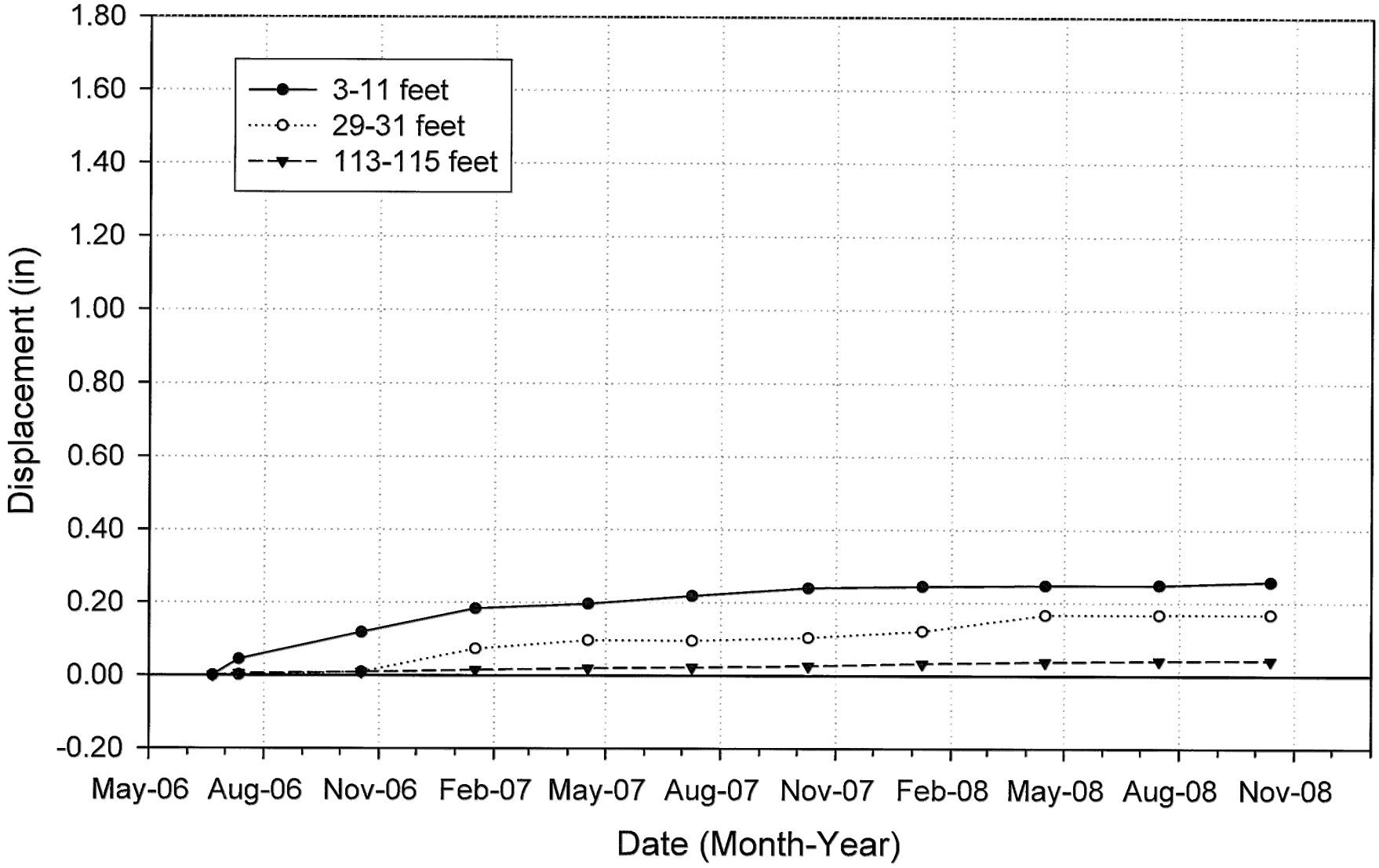


PLATE 50

B-101 (P-1) Pneumatic Piezometer Readings

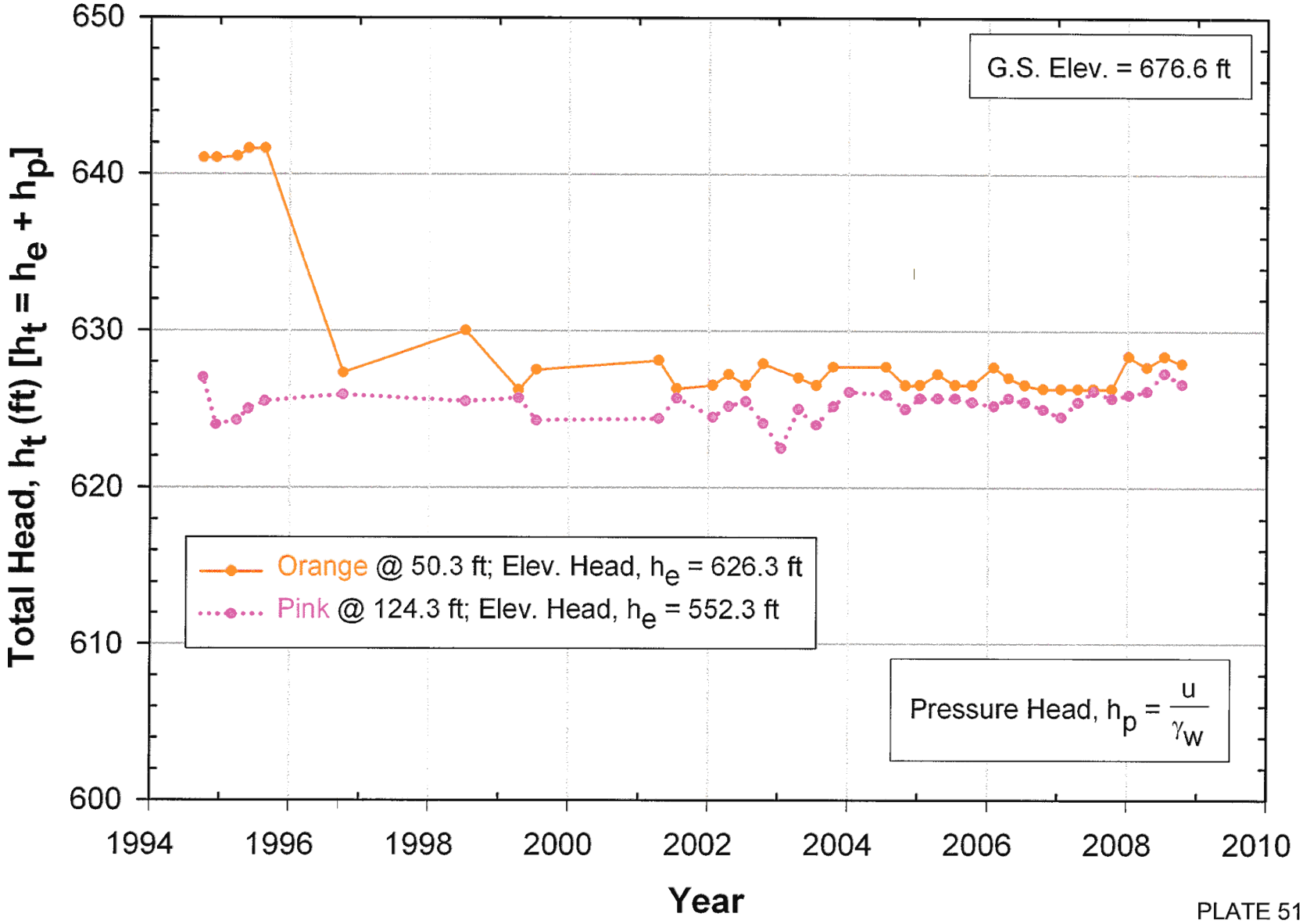


PLATE 51

B-105 (P-3) Pneumatic Piezometer Readings

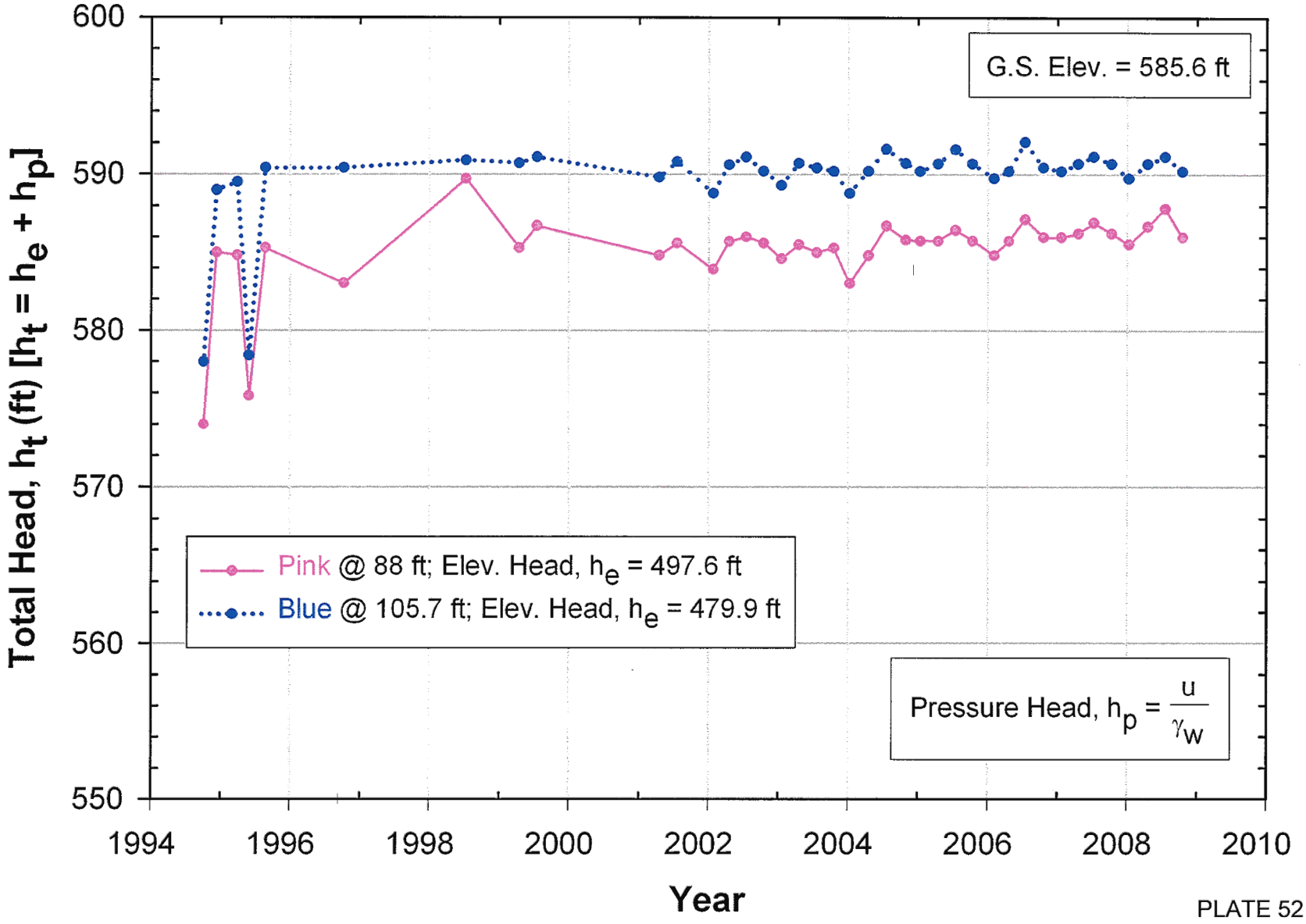


PLATE 52

B-107 (P-5) Pneumatic Piezometer Readings

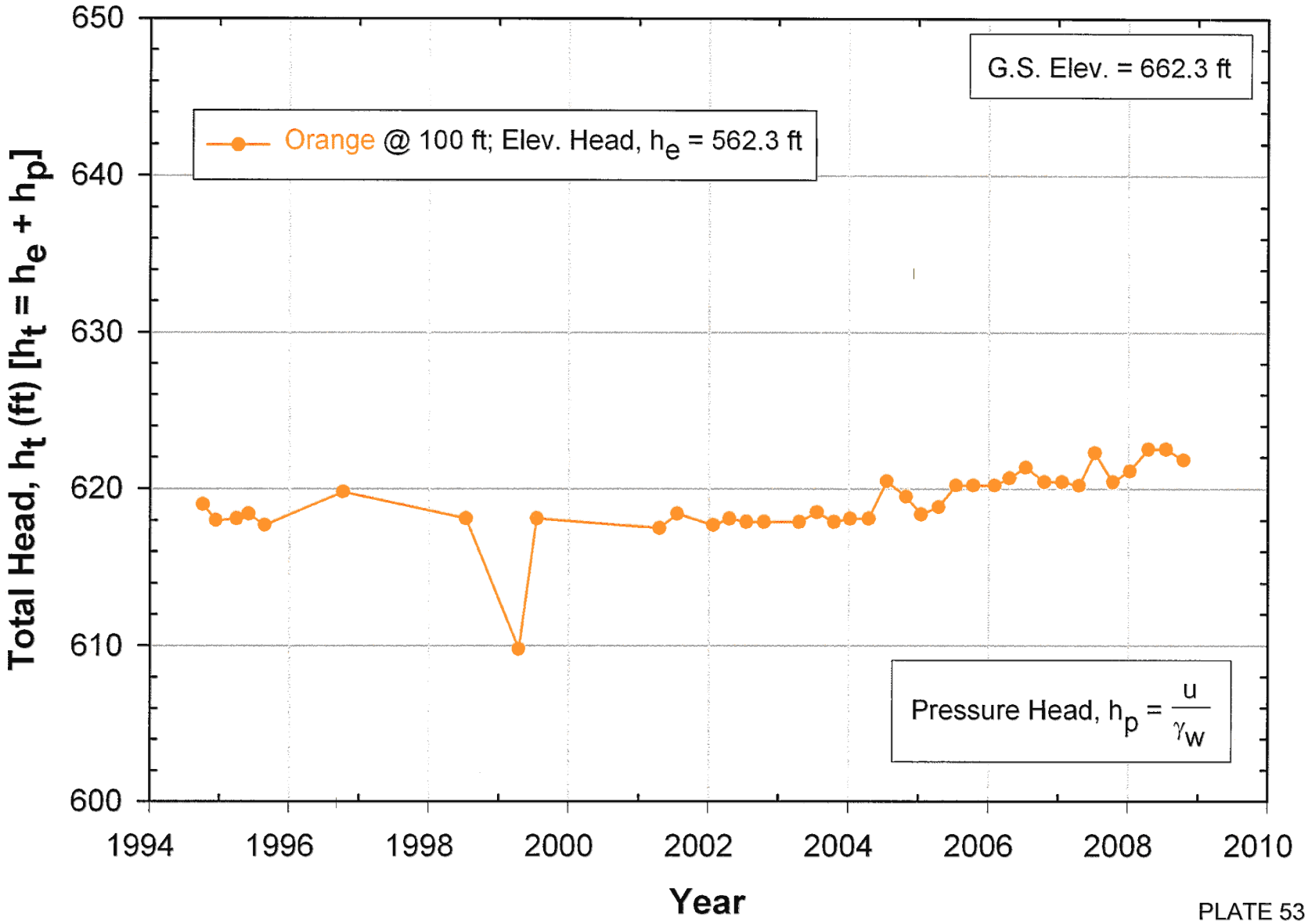


PLATE 53

B-303 (P-2) Pneumatic Piezometer Readings

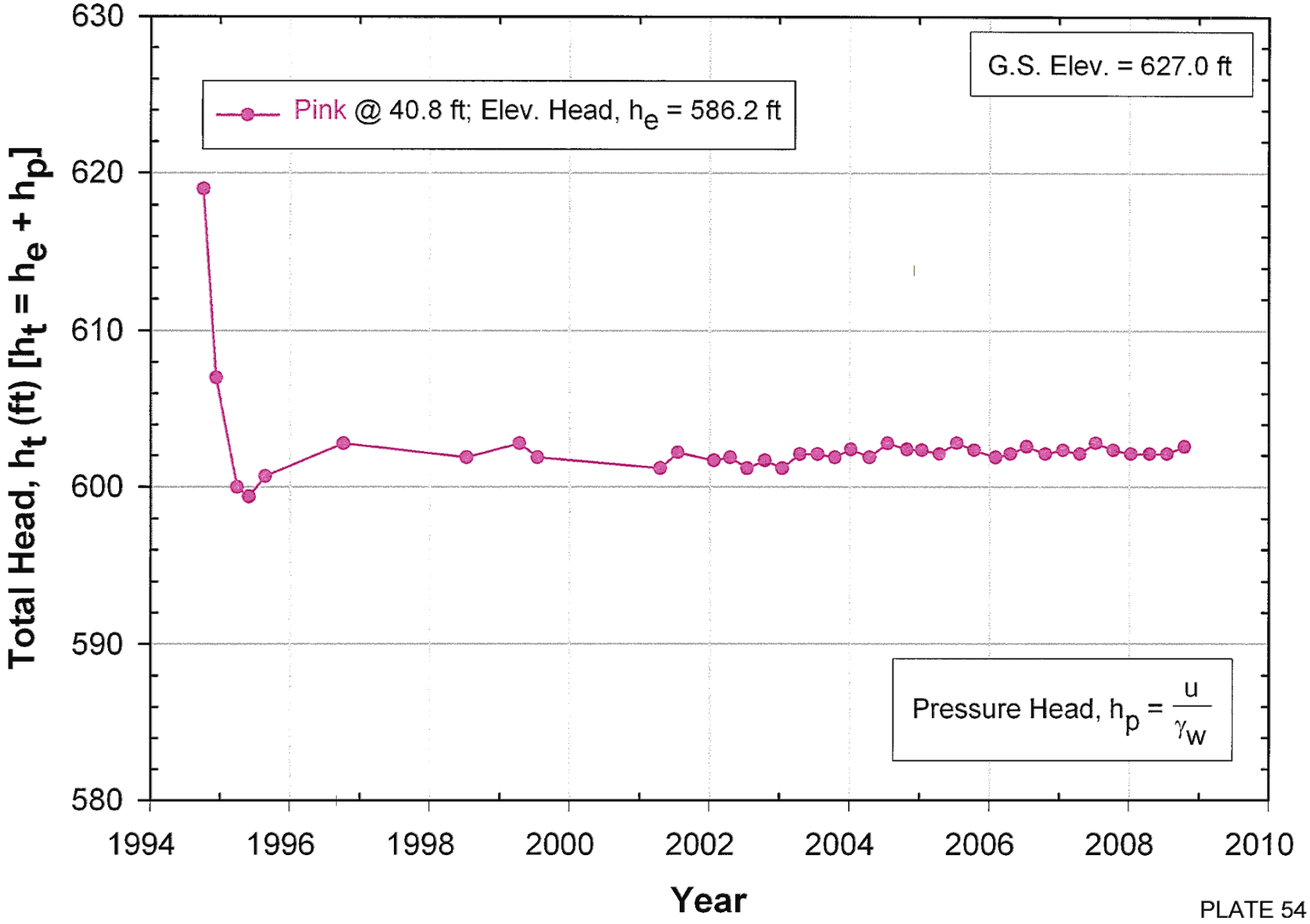


PLATE 54

B-05-01 VW Piezometer Readings

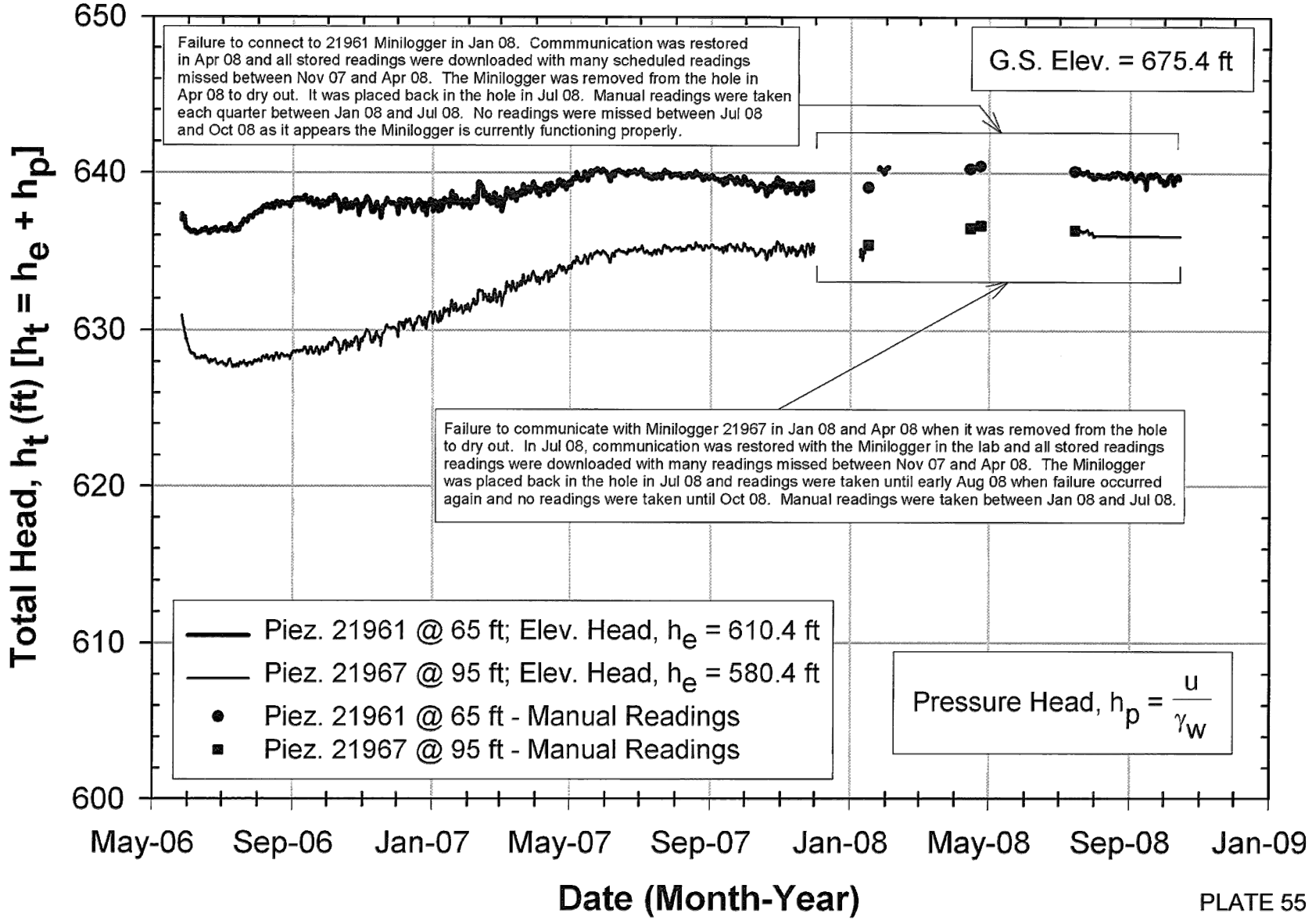


PLATE 55

B-05-02 VW Piezometer Readings

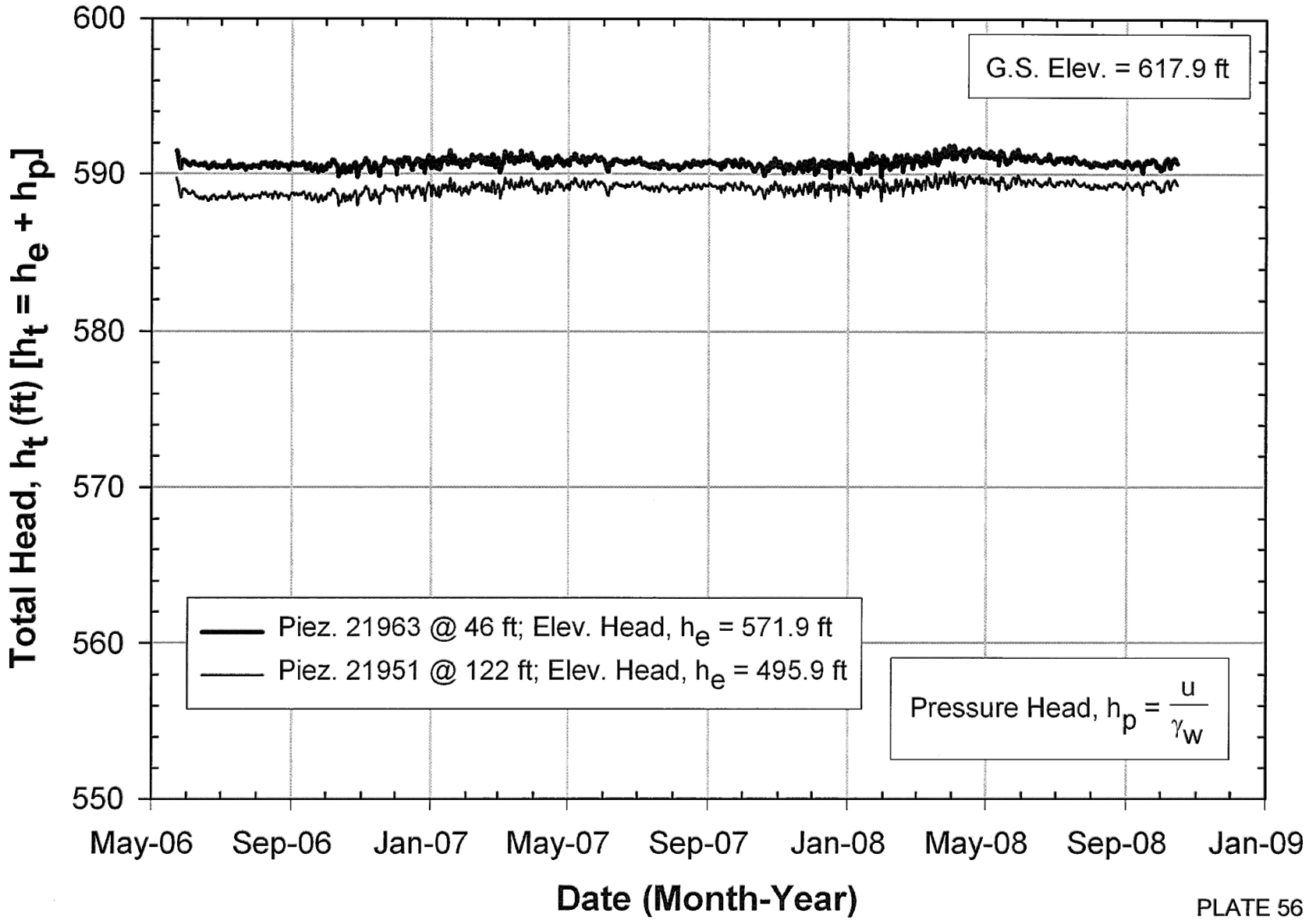


PLATE 56

B-05-03 VW Piezometer Readings

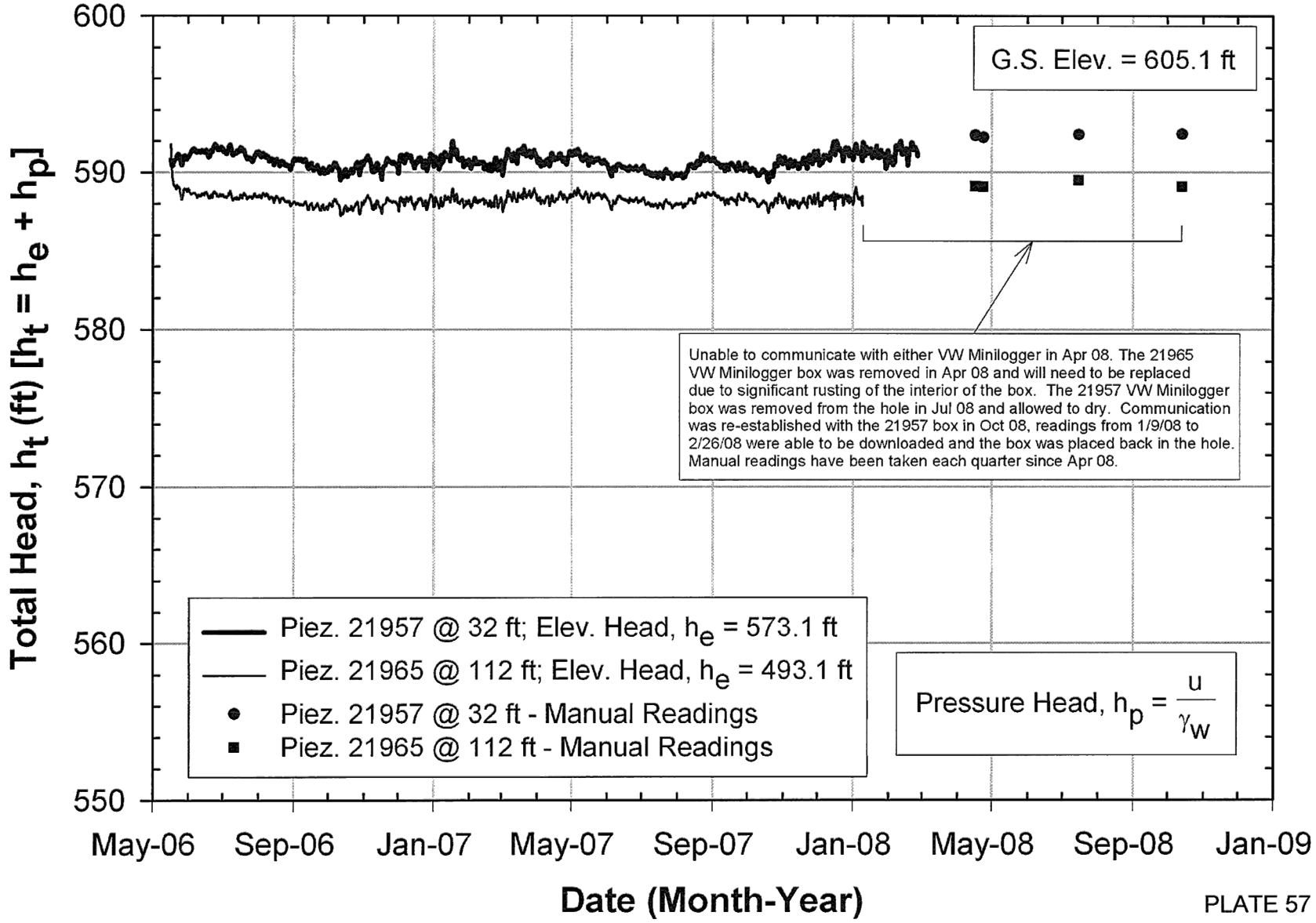


PLATE 57

B-05-04 VW Piezometer Readings

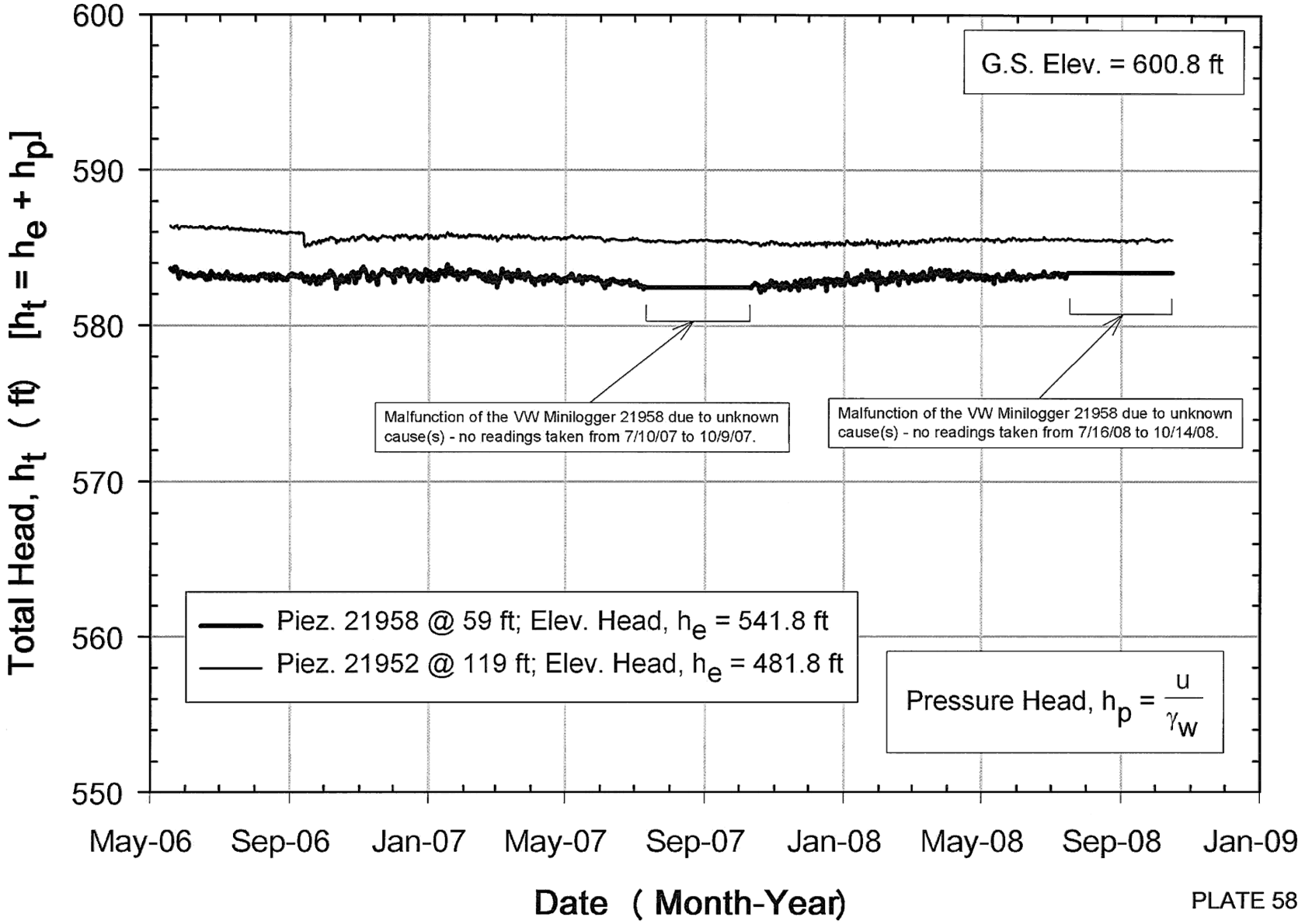


PLATE 58

B-05-07 VW Piezometer Readings

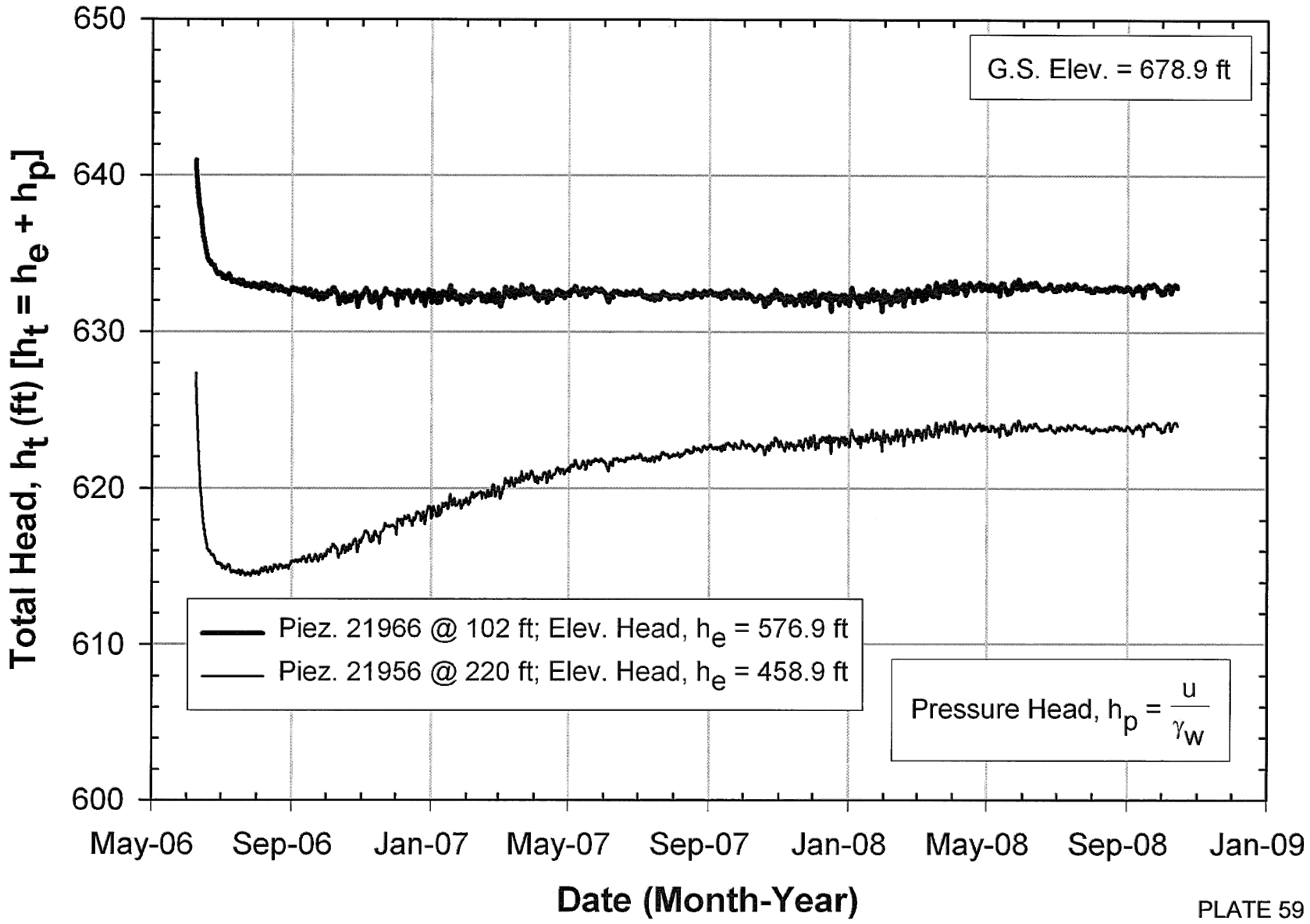


PLATE 59

B-05-08 VW Piezometer Readings

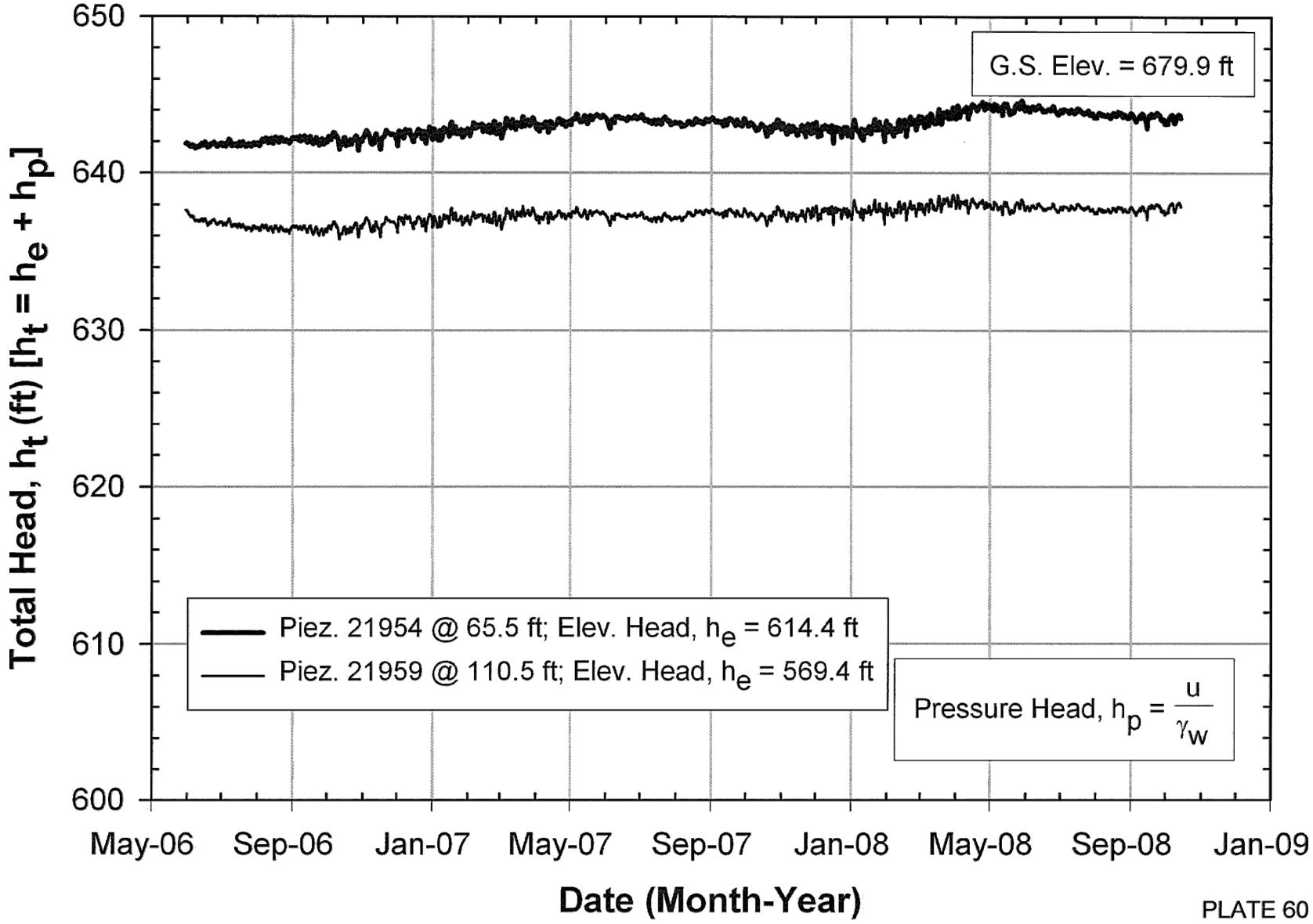


PLATE 60

B-05-11 VW Piezometer Readings

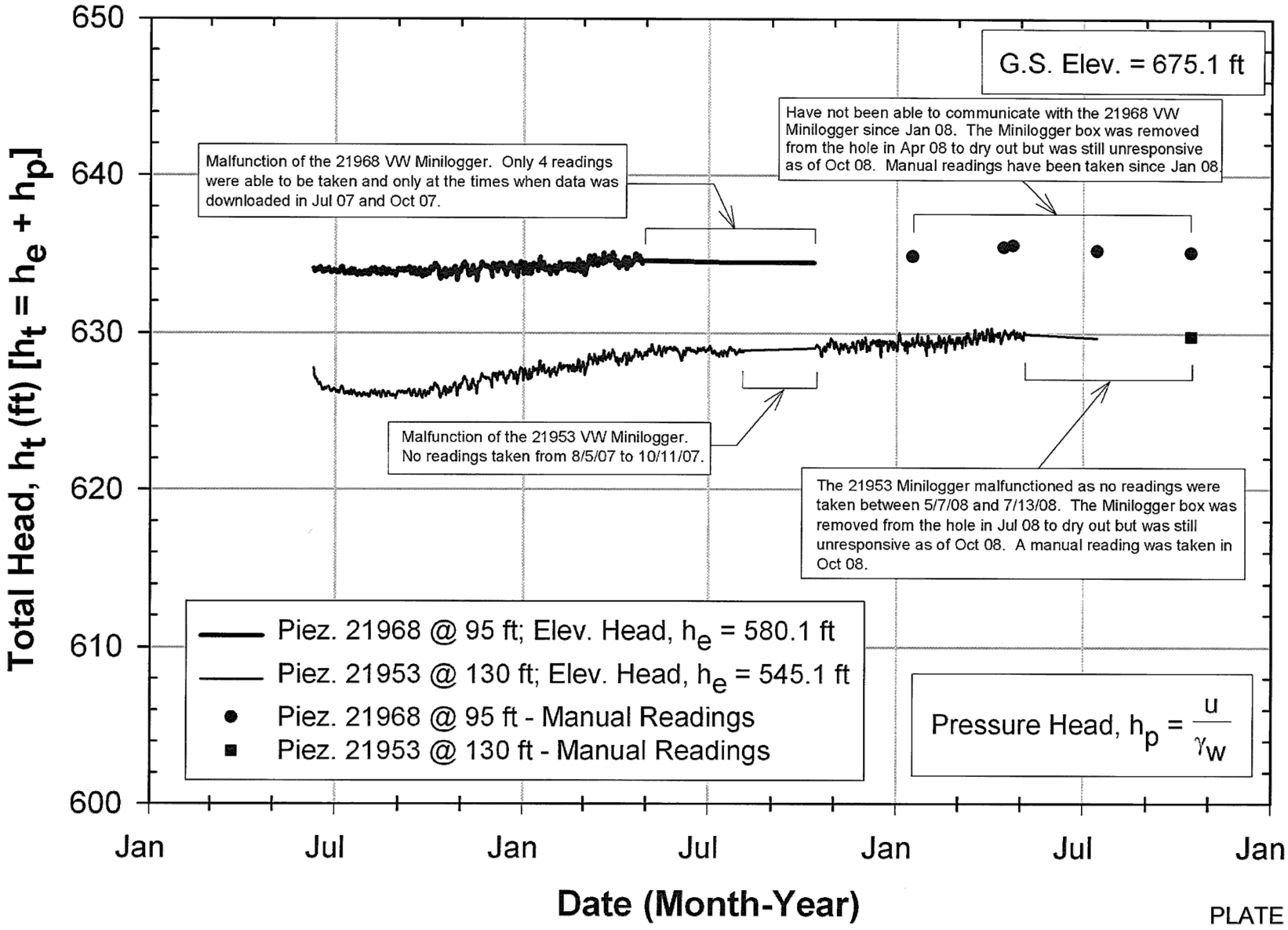


PLATE 61

B-05-12 VW Piezometer Readings

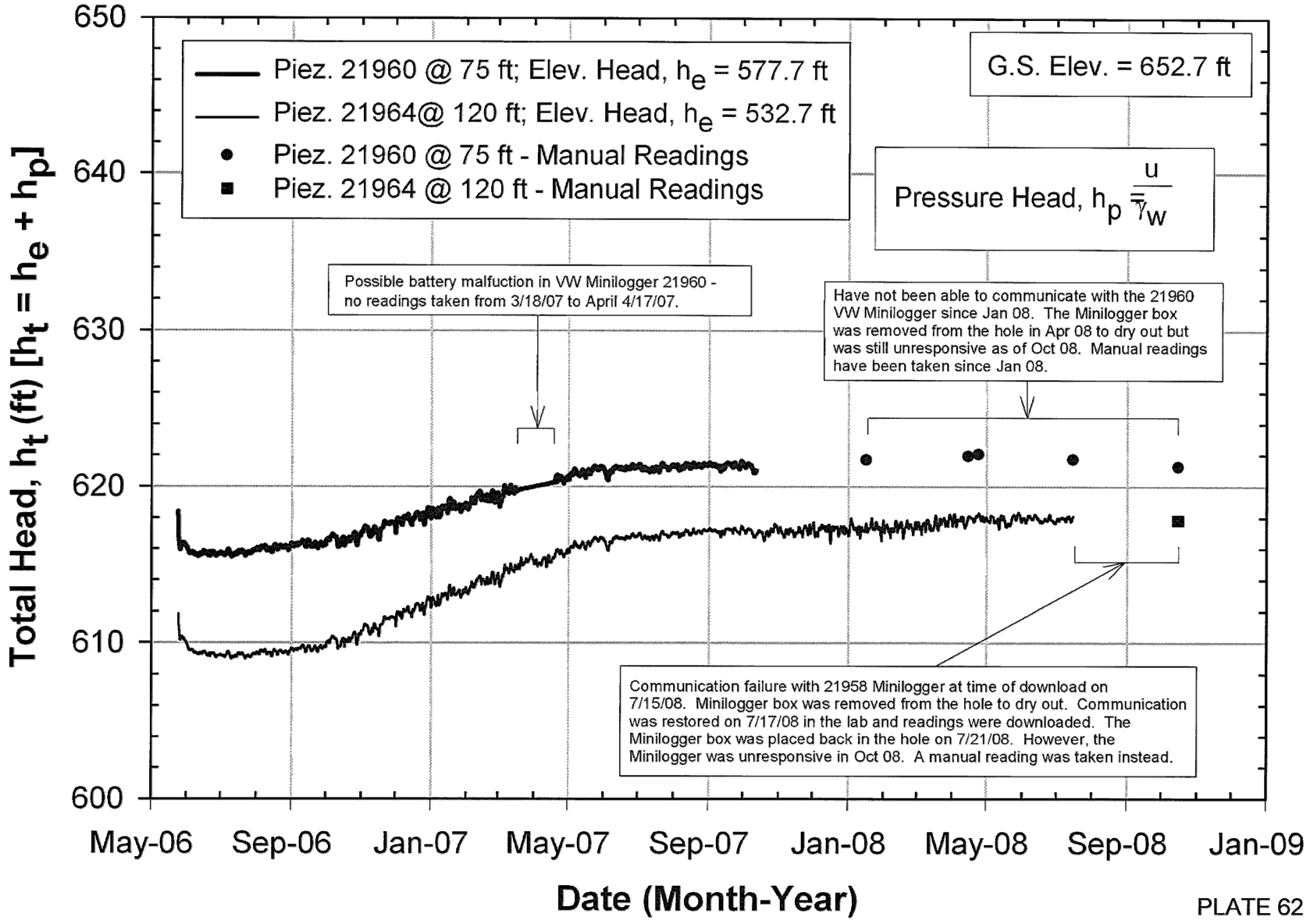


PLATE 62

B-05-13 VW Piezometer Readings

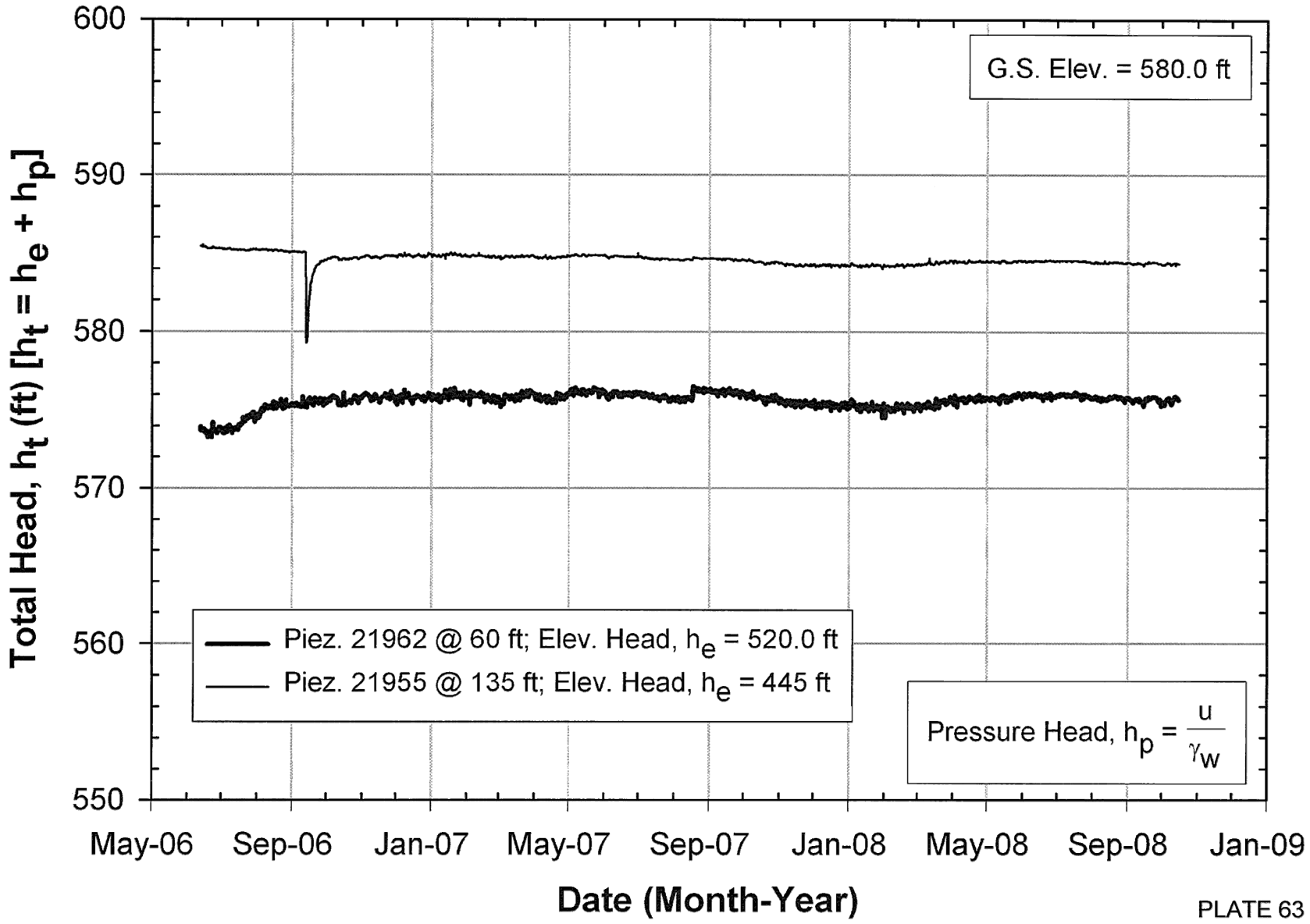


PLATE 63

CALIPERED SURFACE DISTANCE TABLE
CUY-90-15.24

Date	Left Pier Calipered Surface Distance		Center Line Calipered Surface Distance		Right Pier Calipered Surface Distance	
	Present reading	Change (in.)	Present reading	Change (in.)	Present reading	Change (in.)
01/23/02	6.253	--	Not Accessible		4.518	--
04/17/02	6.285	0.032	Not Accessible		4.435	-0.083
07/16/02	6.290	0.005	Discontinued		4.444	0.009
10/15/02	6.333	0.043			4.482	0.038
01/15/03	6.405	0.072			4.473	-0.009
04/17/03	6.333	-0.072			4.482	0.009
07/18/03	6.186	-0.147			4.350	-0.132
10/16/03	6.385	0.199			4.519	0.169
01/08/04	6.124	-0.261			4.594	0.075
04/14/04	6.129	0.005			4.402	-0.193
07/16/04	6.250	0.122			4.277	-0.125
10/27/04	6.375	0.125			4.467	0.190
01/12/05	6.250	-0.125			4.349	-0.118
04/14/05	6.375	0.125			4.372	0.023
07/14/05	6.313	-0.063			4.392	0.020
10/12/05	6.375	0.063			4.358	-0.034
02/01/06	6.438	0.063			4.395	0.037
04/20/06	6.500	0.063			4.430	0.035
07/14/06	6.375	-0.125			4.381	-0.049
10/18/06	6.438	0.063			4.400	0.020
01/19/07	6.500	0.062			4.506	0.106
04/18/07	6.375	-0.125			4.357	-0.150
07/11/07	6.438	0.063			4.341	-0.015
10/12/07	6.438	0.000			4.384	0.043
01/08/08	6.469	0.031			4.349	-0.036
04/14/08	6.500	0.031			4.410	0.062
07/14/08	6.500	0.000			4.410	0.000
10/15/08	6.375	-0.125			4.395	-0.016

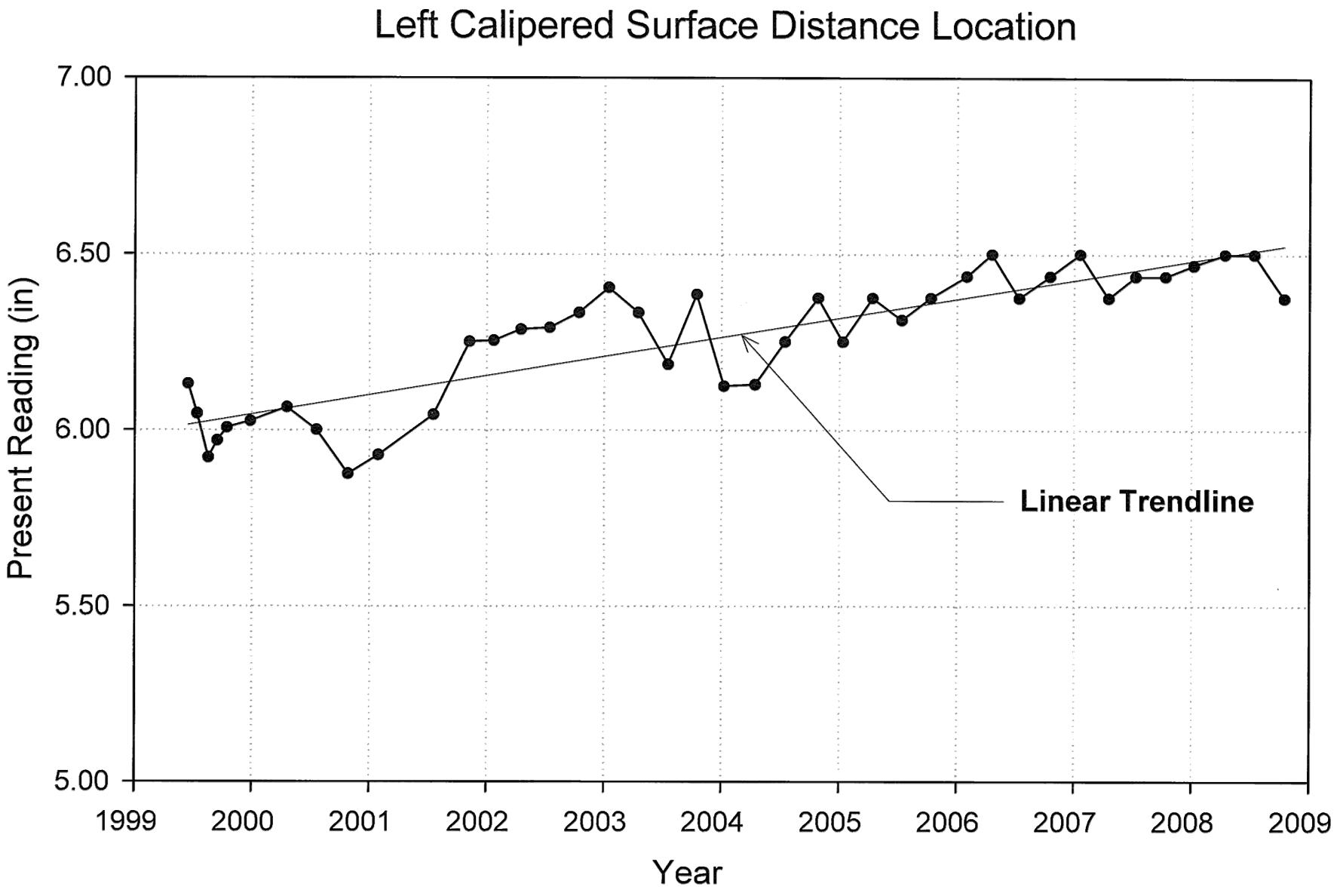

Left Calipered Surface Distance Location
7.00
6.50
6.00
5.50
5.00
Present Reading (in)
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year
Linear Trendline

PLATE 65

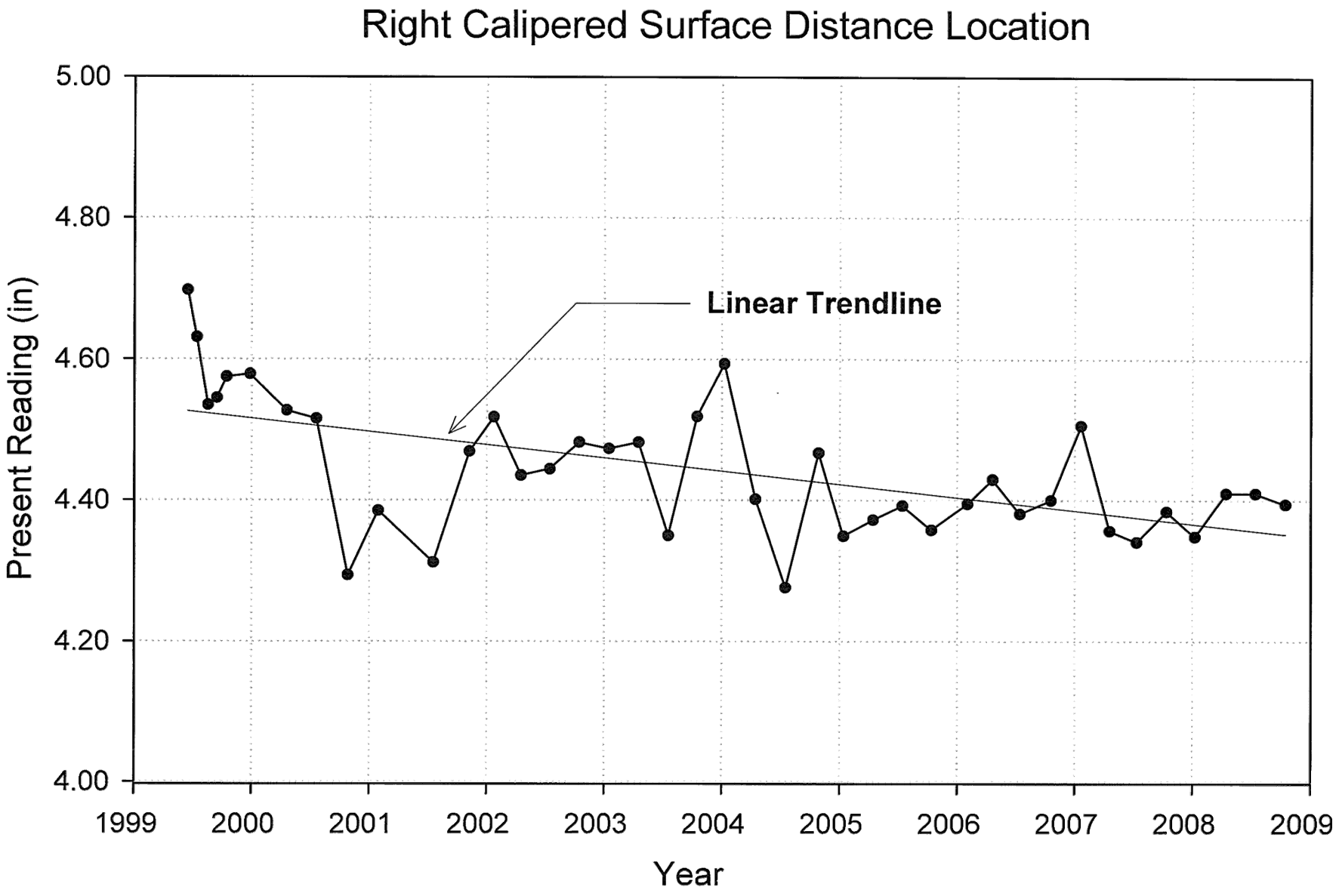
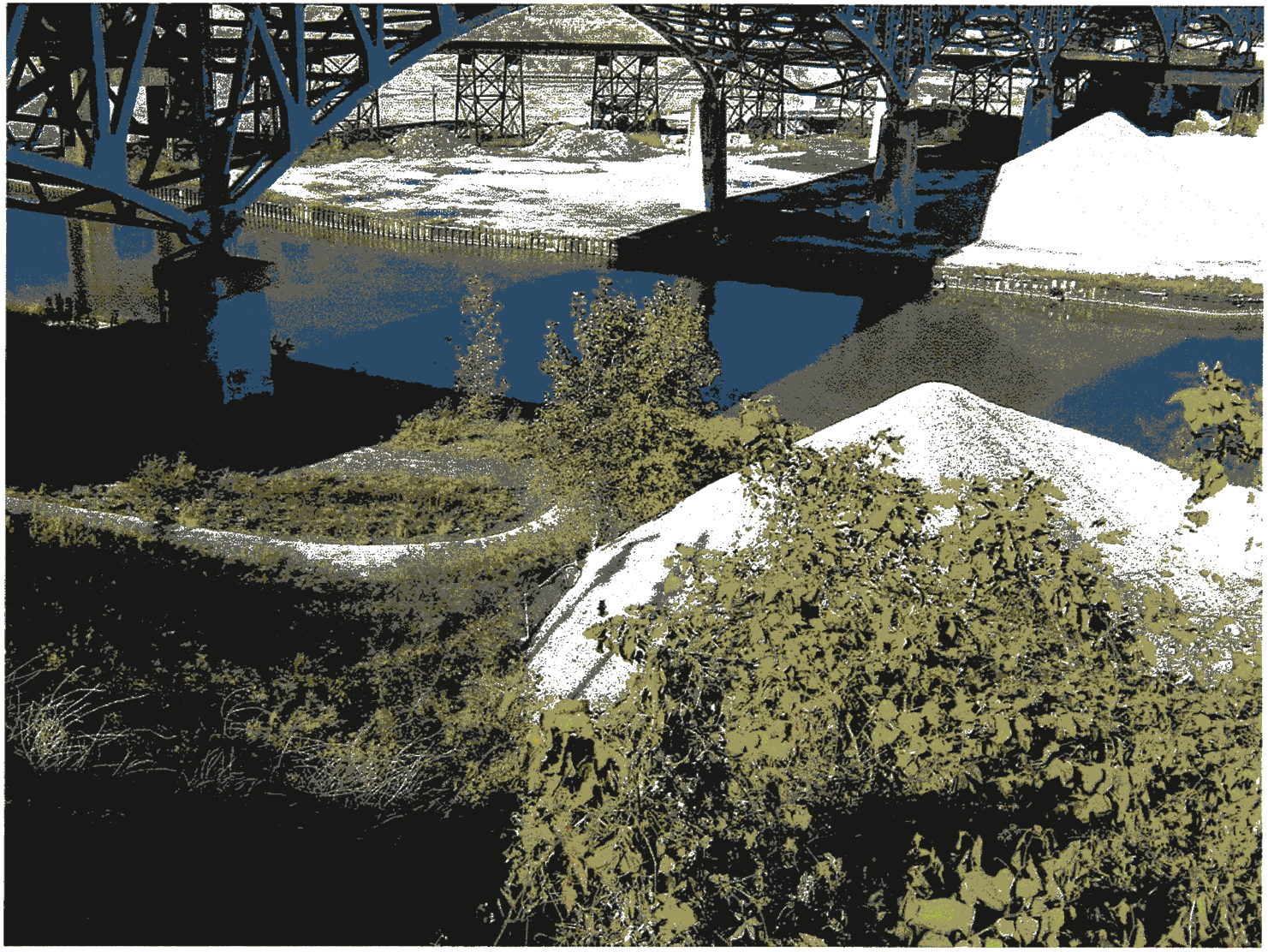

Right Calipered Surface Distance Location
5.00
4.80
4.60
4.40
4.20
4.00
Present Reading (in)
Linear Trendline
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Year

PLATE 66

View towards the east (upriver) of the bulkhead adjacent to B-105A. Photo taken on October 13, 2008.

PLATE 67



View towards the north-northwest of the aggregate pile adjacent to the east right-of-way fence. Photo taken on October 30, 2008.

PLATE 68

View towards the east-southeast of the aggregate pile with a portion of the fence damaged and the pile spilling into the I-90 bridge right-of-way. Photo taken on October 13, 2008. PLATE 69

A close-up view towards the east-northeast of the portion of the aggregate pile that has broken through the fence and spilled into the I-90 bridge right-of-way. Photo taken on October 13, 2008.

PLATE 70

Richland Engineering Limited

From: "arthur huckelbridge" <aah4@case.edu>
To: "'Richland Engineering Limited'" <reltd@r-e-l.com>
Sent: Friday, October 17, 2008 12:29 PM
Attach: Tilts Oct 08.ppt
Subject: tiltmeter readings

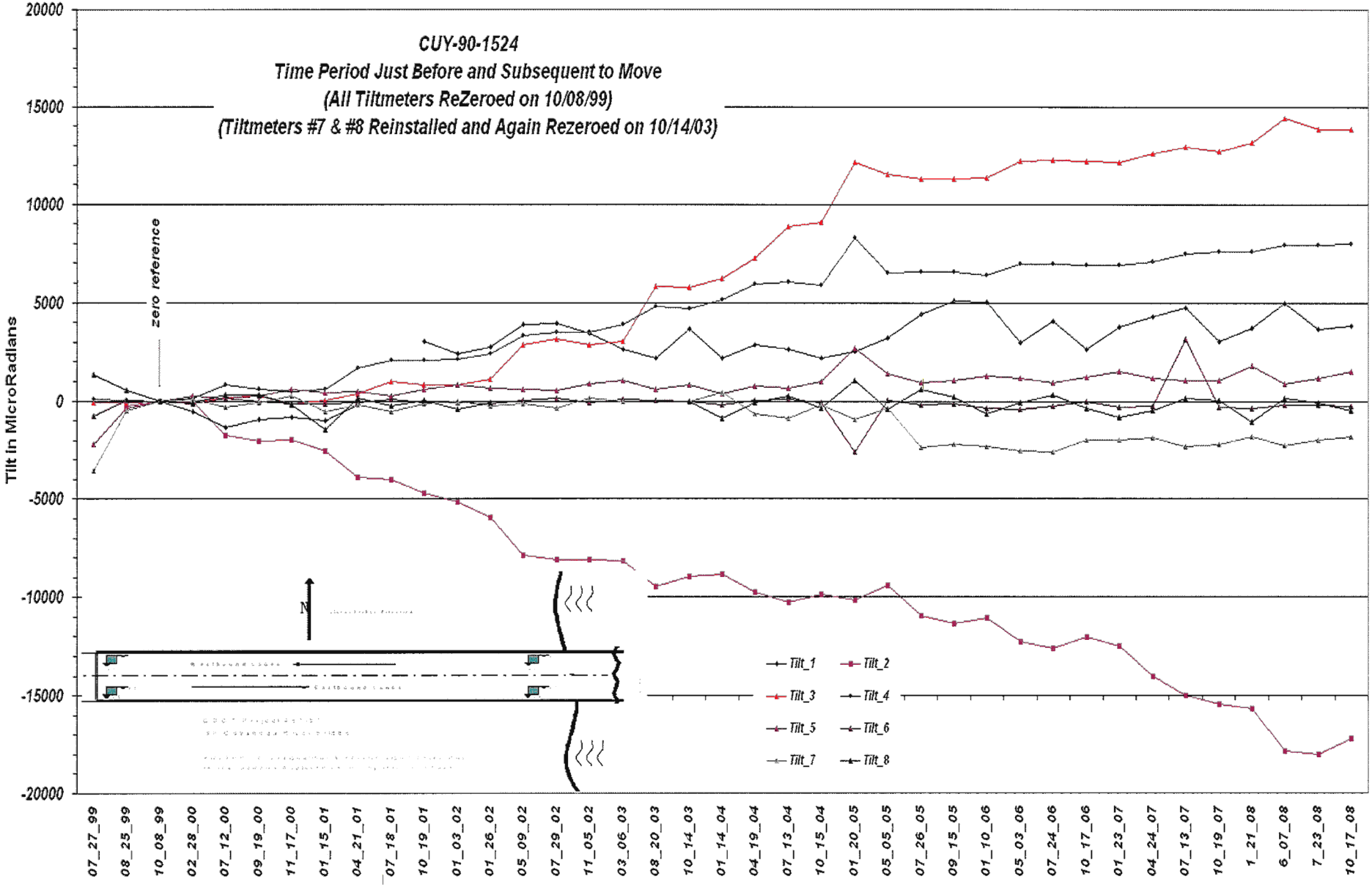
Dean:

There were no substantive changes in tiltmeter readings to report this quarter. The updated plot is attached.

Regards,

Art

Arthur A. Huckelbridge, Jr., D.Eng., P.E.
Department of Civil Engineering
Case School of Engineering
Case Western Reserve University
Cleveland, OH 44106-7201
off: (216) 368 2474
cell: (216) 534 9141
hm: (216) 321 1844
fax: (216) 368 5229



Tiltmeter Readings Through October 2008

Robert Y. Liang, Ph.D., P.E
8441 Timber Tr.
Brecksville, Ohio 44141

Cell Phone: (440) 725-7425
e-mail: RYLIANG@AOL.COM

November 4, 2008

Mr. Dean Palmer, P.E.
Richland Engineering, Ltd.
29 North Park St.
Mansfield, OH 44902

Ref: CUY-90-14.52, PID No. 77332

Dear Mr. Palmer:

The monitoring data for the slope stabilization subsurface structures at the referenced project site for the last three months (July, August, and September) are enclosed. The inclinometer reading and strain data were taken on October 28 and 29, 2008. We also replaced the old batteries and performed maintenance on the data logger during our site visit.

From the enclosed strain-related data sheets and the plotted figures, there was no noticeable significant change during this monitoring period. Most of the inclinometer reading of the six casings in the drilled shafts did not show significant movement in this period. However, inclinometer #10 and #17 showed some movements in the B- direction. We will pay a closer attention to the shaft deflections in the B-direction in the next reading to see if this trend continues.

Please call me at (440) 725-7425, if you have any question. Thank you.

Sincerely,

Robert Liang

Robert Liang

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Table 1 Numerical reading of anchor load as a function of time for anchors #1, #8, #9 and #17

Date	Anchor # 1 Load, kips	Anchor # 8 Load, kips	Anchor # 9 Load, kips	Anchor # 17 Load, kips	Comment
4/7/1999		560			
4/8/1999	408			499	Anchor Lock off
4/14/1999	400	473	590 (Lock off)	401	
5/7/1999	462	473	572	445	End of construction
7/1/1999	448	460	564	439	
10/1/1999	441	457	560	440	
1/1/2000	438	461	560	424	
4/1/2000	432	453	546	414	
7/1/2000	431	451	621	415	
10/1/2000	431	451	519	416	
1/1/2001	430	456	517	400	
4/1/2001	421	443	513	397	
7/1/2001	422	443	510	399	
10/1/2001	425	445	512	403	
1/1/2002	424	444	511	398	
4/1/2002	421	440	509	396	
7/1/2002	410	438	508	391	
10/1/2002	423	442	508	396	
1/1/2003	423	435	508	389	
1/16/2003	416	427	501	389	
0/7/2003	418	420	503	394	
10/7/2003	416	429	504	387	
12/31/2003	417	426	503	378	
4/13/2004	408	418	494	370	
7/13/2004	409	418	494	374	
10/8/2004	411	427	496	377	
1/7/2005	411	421	496	374	
4/6/2005	407	414	495	368	
7/18/2005	407	415	495	370	
11/12/2005	410	419	488	374	
1/10/2006	400	417	487	369	
4/9/2006	399	411	487	365	
7/19/2006	399	412	487	368	
10/18/2006	407.3	414.8	488.6	371.7	
1/10/2007	406	412	487	368	
4/19/2007	401	408	501	361	
7/9/2007	401	408	502	365	
10/20/2007	404	411	506	369	
1/7/2008	403	410	504	364	
5/13/2008	397	408	497	359	
7/28/2008	399	408	500	368	
10/30/2008	401	407	502	366	

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side)

Tie #	Date	s1	s2	s3	s4	Avg. s	(s1+s2)/2	(s3+s4)/2	(s1+s3)/2	(s2+s4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
1	7/1/1999	-47.1	68.5	551.7	681.9	313.73	10.70	616.75	252.30	375.15	83.06	-40.28	-2.75
	7/15/1999	-70.1	53.8	538.8	666.8	297.33	-8.15	602.80	234.35	360.30	76.72	-40.60	-2.82
	8/15/1999	10.7	114.3	613.7	728.1	366.70	62.50	670.90	312.20	421.20	97.09	-40.43	-2.44
	8/31/1999	12.0	114.3	617.3	732.8	369.10	63.15	675.05	314.65	423.55	97.73	-40.67	-2.44
	9/15/1999	13.1	113.5	619.7	737.5	370.95	63.30	678.60	316.40	425.50	98.22	-40.69	-2.44
	9/30/1999	29.6	122.3	634.4	753.4	384.93	75.95	693.90	332.00	437.85	101.92	-41.07	-2.37
	10/15/1999	34.7	123.9	637.8	757.9	388.58	79.30	697.85	336.25	440.90	102.88	-41.11	-2.34
	10/31/1999	39.8	127.2	646.6	762	393.90	83.50	704.30	343.20	444.60	104.29	-41.26	-2.27
	11/15/1999	62.3	139.3	662.9	780.1	411.15	100.80	721.50	362.60	459.70	108.86	-41.25	-2.18
	11/30/1999	73.7	146.3	670.6	788.6	419.80	110.00	729.60	372.15	467.45	111.15	-41.18	-2.13
	12/15/1999	72.8	143.6	668.9	789.7	418.75	108.20	729.30	370.85	466.65	110.87	-41.28	-2.15
	12/31/1999	88.8	152.1	680.1	802.5	430.88	120.45	741.30	384.45	477.30	114.08	-41.26	-2.08
	3/31/2000	95.3	158.7	682.5	826.2	440.43	127.00	753.85	388.90	491.95	116.61	-41.68	-2.31
	6/30/2000	80.2	138.2	662.7	804.5	416.40	99.20	733.60	361.45	471.35	110.25	-42.16	-2.46
	9/30/2000	50.1	142.5	668.8	796.7	414.28	96.30	732.25	359.45	469.10	109.69	-42.26	-2.46
	1/13/2001	109.5	179.9	712.3	845.5	461.80	144.70	778.90	410.90	512.70	122.27	-42.15	-2.28
	4/20/2001	126.8	283.2	715.3	881.9	501.80	205.00	798.60	421.05	582.55	132.86	-39.45	-3.62
	7/16/2001	68.3	149.8	674.3	837.1	432.38	109.05	755.70	371.30	493.45	114.48	-42.99	-2.74
	10/9/2001	71.4	157.1	685.5	840.9	438.70	114.25	763.15	378.45	498.95	116.15	-43.12	-2.70
	1/9/2002	102.7	177.8	713	872	466.38	140.25	792.50	407.85	524.90	123.48	-43.35	-2.62
	4/12/2002	125.5	192.8	738.8	904.9	490.45	159.15	821.75	432.05	548.85	129.86	-44.04	-2.62
	7/18/2002	62.3	151.8	706.334	859.6	445.01	107.05	782.97	384.32	505.70	117.82	-44.92	-2.72
	10/8/2002	43.7	151.1	711.3	846.7	438.20	97.40	779.00	377.50	498.90	116.02	-45.30	-2.72
	1/6/2003	84.7	180.5	748.5	891.8	476.38	132.60	820.15	416.60	536.15	126.13	-45.69	-2.68
	4/15/2003	96.1	191.9	739.9	869.3	504.30	144.00	864.60	418.00	590.60	133.52	-47.89	-3.97
	7/1/2003	57.4	168	713	859	474.35	112.70	836.00	385.20	563.50	125.59	-48.07	-3.99
	10/7/2003	42.1	166.8	714	946.6	467.38	104.45	830.30	378.05	556.70	123.75	-48.24	-4.00
	12/31/2003	80	197.9	753.9	985.1	504.23	138.95	869.50	416.95	591.50	133.50	-48.55	-3.91
	4/13/2004	92	209.9	760.4	1006.6	516.98	150.45	883.50	426.20	607.75	136.88	-48.72	-4.07
	7/13/2004	14.6	163.9	707.3	954.4	460.05	89.25	830.85	360.95	559.15	121.81	-49.29	-4.44
	10/6/2004	-8.6	233.4	704.6	941	467.60	112.40	822.80	348.00	587.20	123.81	-47.21	-5.36
	1/7/2005	19.5	190.4	746.5	962.5	484.73	104.95	864.50	383.00	596.45	128.34	-50.48	-4.56
	4/6/2005	3.4	397.6	751.6	1003.4	539.00	200.50	877.50	377.50	700.50	142.71	-44.98	-7.24
	7/18/2005	3.1	164.3	709.7	969.6	461.68	83.70	839.65	356.40	566.95	122.24	-50.24	-4.72
	8/26/2005	3.1	157.5	702.5	956.3	454.85	80.30	829.40	352.80	556.90	120.43	-49.78	-4.57
	10/11/2005	3.1	164.2	712.6	960.1	460.00	83.65	836.35	357.85	562.15	121.79	-50.02	-4.58
	1/10/2006	3.1	191.9	742.5	997	483.63	97.50	869.75	372.80	594.45	128.05	-51.32	-4.97
	4/9/2006	3.5	205.3	750.7	1018.8	494.56	104.40	884.75	377.10	612.05	130.95	-51.86	-5.26
	7/19/2006	3.5	166.6	703.7	975.5	462.33	85.05	839.60	353.60	571.05	122.41	-50.15	-4.87
	10/18/2006	3.5	170.2	709	967.5	462.55	86.85	838.25	356.25	568.85	122.47	-49.94	-4.76
	1/18/2007	3.5	209.1	748.7	1013.1	493.60	106.30	880.90	376.10	611.10	130.69	-51.48	-5.26
	4/18/2007	3.5	216.6	743.7	1021.2	496.25	110.05	882.45	373.60	618.90	131.39	-51.33	-5.50
	7/11/2007	3.5	169.6	700.9	981.6	463.90	86.55	841.25	352.20	575.60	122.83	-50.16	-5.00
	10/20/2007	3.5	163.4	696	963.7	456.65	83.45	829.85	349.75	563.55	120.91	-49.60	-4.79
	1/7/2008	3.5	193.1	730.4	1002.9	482.48	98.30	866.65	366.95	598.00	127.74	-51.06	-5.18
	5/13/2008	3.5	202.2	733	1019.1	489.45	102.85	876.05	368.25	610.65	129.59	-51.39	-5.43
	7/29/2008	3.5	171.2	699.7	981.8	464.05	87.35	840.75	351.60	576.60	122.87	-50.07	-5.04
	10/30/2008	3.5	185.2	717.8	995	472.88	94.35	851.40	360.65	585.10	125.20	-50.31	-5.03

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	s1	s2	s3	s4	Avg. s	(s1+s2)/2	(s3+s4)/2	(s1+s3)/2	(s2+s4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
12	7/1/1999	374.9	6	549.6	471.8	350.58	190.45	510.70	462.25	238.90	92.82	-21.28	5.00
	7/15/1999	368.6	-3.6	544.2	467.3	344.13	182.50	505.75	456.40	231.85	91.11	-21.48	5.03
	8/15/1999	373.7	0.2	569.4	485.2	357.13	186.95	527.30	471.55	242.70	94.56	-22.62	5.13
	8/31/1999	368.4	-4.7	567	486.2	354.23	181.85	526.60	467.70	240.75	93.79	-22.91	5.08
	9/15/1999	365.9	-9.2	566.3	485.1	351.78	178.35	525.20	466.60	237.95	93.14	-23.05	5.10
	9/30/1999	364.6	-11.7	570.1	487.6	352.65	176.45	528.85	467.35	237.95	93.37	-23.42	5.14
	10/15/1999	361.7	-14.8	569.9	487.4	351.05	173.45	528.65	465.80	236.30	92.95	-23.61	5.14
	10/31/1999	362.8	-13.5	575.6	493.1	354.50	174.65	534.35	469.20	239.80	93.86	-23.91	5.14
	11/15/1999	365.0	-11.5	581.4	498	356.23	176.75	539.70	473.20	243.25	94.85	-24.12	5.15
	11/30/1999	365.6	-11.8	583.7	500.1	359.40	176.90	541.90	474.65	244.15	95.16	-24.26	5.16
	12/15/1999	368.0	-9.2	589.7	504.2	363.18	179.40	546.95	478.85	247.50	96.16	-24.43	5.18
	12/31/1999	369.0	-8	592.9	506.8	365.13	180.50	549.75	480.95	249.30	96.67	-24.54	5.19
	3/31/2000	376.6	7.3	617	524.1	382.00	193.45	570.55	498.30	265.70	101.14	-25.06	5.21
	6/30/2000	376.1	4.4	608.9	519.1	377.13	190.25	564.00	492.50	261.75	99.85	-24.84	5.17
	9/30/2000	360.7	-12.3	588.3	503.5	360.05	174.20	545.90	474.50	245.60	95.33	-24.70	5.13
	1/13/2001	372.1	2.2	618.1	526.1	379.83	187.15	572.10	495.10	264.15	100.51	-25.58	5.17
	4/20/2001	367.8	21	646.8	549.2	400.80	204.30	597.50	516.70	285.10	106.15	-26.13	5.19
	7/16/2001	374.6	6.5	621.5	532.9	383.88	190.55	577.20	498.05	269.70	101.84	-25.70	5.12
	10/9/2001	360.9	-9.4	598.9	515.8	366.55	175.75	557.35	479.90	253.20	97.05	-25.36	5.08
	1/9/2002	363.5	-2.5	611.5	524.5	374.25	180.50	568.00	487.50	261.00	99.09	-25.75	5.07
	4/12/2002	381.7	16.9	642.7	550.5	397.95	199.30	596.60	512.20	283.70	105.37	-26.40	5.12
	7/18/2002	375	10.5	629	544.7	389.80	192.75	586.85	502.00	277.60	103.21	-26.19	5.03
	10/8/2002	357.7	-9.6	598.2	523	367.58	174.05	561.10	478.45	256.70	97.32	-25.72	4.97
	1/8/2003	367.3	6.5	626.7	542.7	385.80	186.90	584.70	497.00	274.60	102.15	-26.44	4.98
	4/15/2003	385.9	27.3	655.3	566.2	408.68	206.60	610.75	520.60	296.75	108.20	-26.86	5.01
	7/1/2003	384.7	26.3	649.2	565.6	406.45	205.50	607.40	516.95	295.95	107.62	-26.71	4.95
	10/7/2003	360.6	3.5	613	539.7	379.20	182.05	576.35	486.80	271.60	100.40	-26.20	4.82
	12/31/2003	372	19.4	636	558.3	396.43	195.70	597.15	504.00	288.85	104.96	-26.68	4.82
	4/13/2004	389.4	39.6	665.5	583.1	419.45	214.50	624.30	527.45	311.45	111.06	-27.23	4.84
	7/13/2004	379.5	27.7	643.3	571.1	405.40	203.60	607.20	511.40	299.40	107.34	-26.82	4.75
	10/6/2004	361.6	10.3	615.2	550.9	384.50	185.95	583.05	488.40	280.60	101.90	-26.39	4.66
	1/7/2005	367.5	16.1	630.6	561.5	393.93	191.80	596.05	499.05	288.80	104.30	-26.87	4.71
	4/6/2005	388.2	35.6	662.3	587.2	418.33	211.90	624.75	525.25	311.40	110.76	-27.44	4.79
	7/18/2005	382.6	28.3	647.7	580.1	409.18	204.45	613.90	515.15	303.20	108.34	-27.21	4.75
	8/26/2005	373.6	15.7	629.8	566.8	396.48	194.65	598.30	501.70	291.25	104.97	-26.83	4.71
	10/11/2005	365.9	6.1	617.8	557.9	386.93	186.00	587.85	491.85	282.00	102.45	-26.71	4.70
	1/10/2006	376.2	17.5	639	572.2	401.23	196.85	605.60	507.60	294.85	106.23	-27.16	4.77
	4/9/2006	393.8	32.7	665.7	594	421.55	213.25	629.85	529.75	313.35	111.61	-27.69	4.85
	7/19/2006	384.2	20.3	646.2	582.7	408.35	202.25	614.45	515.20	301.50	108.12	-27.39	4.79
	10/18/2006	365	-2	614.4	558.2	393.90	181.50	586.30	489.70	278.10	101.65	-26.90	4.74
	1/16/2007	376	9.6	635.9	573.8	398.85	192.80	604.90	505.95	291.75	106.60	-27.39	4.80
	4/19/2007	390.7	24.1	659.3	592.7	416.70	207.40	626.00	525.00	308.40	110.33	-27.82	4.86
	7/11/2007	384.1	15	644.8	584.6	407.08	199.55	614.80	514.35	299.80	107.76	-27.58	4.81
	10/20/2007	363.7	-9.6	611.5	560.6	381.55	177.05	586.05	487.60	275.50	101.02	-27.18	4.75
	1/7/2008	371.2	-2.9	625.1	569.7	390.78	184.15	597.40	498.15	283.40	103.47	-27.46	4.81
	5/13/2008	390.8	11.5	650.8	592.6	411.43	201.15	621.70	520.80	302.05	108.93	-27.95	4.90
	7/29/2008	379.9	-2.5	629.3	579.9	396.65	188.70	604.60	504.60	288.70	105.02	-27.64	4.84
	10/30/2008	365	-20.3	605.3	562.2	378.05	172.35	583.75	485.15	270.95	100.10	-27.34	4.80

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	s1	s2	s3	s4	Avg. s	(s1+s2)/2	(s3+s4)/2	(s1+s3)/2	(s2+s4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
13	7/1/1999	306.3	72.2	490.8	675.2	396.13	189.25	583.00	398.55	373.70	102.23	-26.17	0.68
	7/15/1999	288.0	63.1	484.2	670.6	373.98	170.55	577.40	386.10	361.85	99.02	-27.04	0.64
	8/15/1999	280.9	61.8	508.3	693.7	385.68	171.35	600.00	393.60	377.75	102.12	-28.49	0.36
	8/31/1999	270.4	52.1	503.1	691.4	379.25	161.25	597.25	386.75	371.75	100.41	-28.98	0.34
	9/15/1999	261.3	43.9	501.2	689.9	374.08	152.60	595.55	381.25	366.90	99.04	-29.44	0.32
	9/30/1999	257.1	40.7	503.1	690.7	372.90	148.90	596.90	380.10	365.70	98.73	-29.77	0.32
	10/15/1999	250.1	33.8	501.2	691	369.03	141.95	596.10	375.65	362.40	97.71	-30.18	0.30
	10/31/1999	251.4	38	507.6	697.6	373.65	144.70	602.60	379.50	367.80	98.93	-30.43	0.26
	11/15/1999	253.9	41.6	512.1	701.9	377.38	147.75	607.00	383.00	371.75	99.92	-30.52	0.25
	11/30/1999	253.5	41.2	513.6	704.4	378.18	147.35	609.00	383.55	372.80	100.13	-30.68	0.24
	12/15/1999	255.8	46.7	519.1	709.3	382.73	151.25	614.20	387.45	378.00	101.33	-30.77	0.21
	12/31/1999	256.7	48.9	522.3	712.4	385.08	152.80	617.35	389.50	380.65	101.96	-30.87	0.20
	3/31/2000	267.5	64.6	542.8	734.2	402.28	166.05	638.50	405.15	399.40	106.51	-31.40	0.13
	6/30/2000	258.9	46.4	531.2	726.1	390.65	152.65	628.65	395.05	386.25	103.43	-31.63	0.20
	9/30/2000	237.1	10.1	504.9	705.9	364.50	123.60	605.40	371.00	358.00	96.51	-32.02	0.29
	1/13/2001	254.0	40.9	535.1	734.8	391.15	147.45	634.95	394.55	387.75	103.56	-32.39	0.15
	4/20/2001	275.4	72.6	561.4	763.7	418.28	174.00	662.55	418.40	418.15	110.75	-32.47	0.01
	7/16/2001	256.3	37.7	534.8	740.9	392.18	146.50	637.85	395.05	389.30	103.84	-32.65	0.13
	10/9/2001	235.7	7.5	510.6	719.6	368.35	121.60	615.10	373.15	363.55	97.53	-32.80	0.22
	1/9/2002	240	18.9	523.3	731	378.30	129.45	627.15	381.65	374.95	100.16	-33.08	0.15
	4/12/2002	263.4	58.5	554.8	763	409.93	160.95	658.90	409.10	410.75	108.54	-33.09	-0.04
	7/18/2002	256.5	40.1	566.1	754.5	404.05	147.80	660.30	410.80	397.30	106.98	-34.06	0.30
	10/8/2002	231.2	3.4	508.7	726.1	367.35	117.30	617.40	369.95	364.75	97.26	-33.24	0.12
	1/6/2003	249.4	38.5	540.1	754.4	395.60	143.95	647.25	394.75	396.45	104.74	-33.45	-0.04
	4/15/2003	276.4	78.5	571.6	784.9	427.85	177.45	678.25	424.00	431.70	113.28	-33.28	-0.17
	7/1/2003	273	69	561.4	779.9	420.83	171.00	670.65	417.20	424.45	111.42	-33.21	-0.16
	10/7/2003	246.6	22.5	524.7	744.6	384.60	134.55	634.65	385.65	383.55	101.93	-33.24	0.05
	12/31/2003	264.8	58.9	552.8	770.1	411.65	161.85	661.45	408.80	414.50	108.99	-33.20	-0.13
	4/13/2004	291.3	97.7	584	803.2	444.05	194.50	693.60	437.65	450.45	117.57	-33.17	-0.29
	7/13/2004	275.5	64.3	556.1	781	419.23	169.90	668.55	415.80	422.65	111.00	-33.14	-0.15
	10/6/2004	262.8	29.9	527.5	756.8	391.50	141.35	641.65	390.15	392.85	103.66	-33.25	-0.06
	1/7/2005	284	60.8	544.5	770.6	407.48	157.40	657.55	404.25	410.70	107.99	-33.24	-0.14
	4/6/2005	289.9	90.7	576	802	439.65	190.30	689.00	432.95	446.35	116.41	-33.14	-0.30
	7/18/2005	277.8	67.7	556.4	787.1	422.25	172.75	671.75	417.10	427.40	111.80	-33.16	-0.23
	9/26/2005	266.7	46.5	539.8	771.9	406.23	156.60	655.85	403.25	409.20	107.56	-33.18	-0.13
	10/11/2005	257.2	33.8	526.8	760.8	394.65	145.50	643.80	392.00	397.30	104.49	-33.12	-0.12
	1/10/2006	269.3	59.9	551.2	780.4	415.20	164.60	665.80	410.25	420.15	109.93	-33.31	-0.22
	4/5/2006	289.9	90	576.3	806.2	440.60	189.95	691.25	433.10	448.10	116.86	-33.32	-0.34
	7/18/2006	277.7	63.9	553.8	787.8	420.80	170.80	670.80	415.75	425.85	111.42	-33.23	-0.23
	10/18/2006	253.3	27.9	523.7	757.8	390.68	140.60	640.75	388.50	392.85	103.44	-33.24	-0.10
	1/16/2007	267.4	54.9	548.5	778.5	411.83	161.15	663.50	408.96	416.70	109.04	-33.32	-0.22
	4/15/2007	289	88.7	575.1	806.8	439.90	188.85	690.95	432.05	447.75	116.47	-33.37	-0.35
	7/11/2007	280	67	558	793.6	424.65	173.50	675.80	419.00	430.30	112.43	-33.39	-0.25
	10/20/2007	255.4	29.1	525	762.8	393.33	142.25	644.40	390.20	396.45	104.14	-33.37	-0.14
	1/7/2008	266.4	49.2	542.8	778	406.85	157.80	660.40	404.10	413.60	108.26	-33.44	-0.21
	5/13/2008	290.2	83.3	573.5	809.3	439.15	186.75	691.55	432.00	446.30	116.27	-33.55	-0.32
	7/25/2008	274	55.1	548.5	787.7	416.33	164.55	668.10	411.25	421.40	110.23	-33.47	-0.23
	10/30/2008	256.5	28.1	526.4	766.9	394.23	142.30	646.15	391.45	397.00	104.36	-33.49	-0.12

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	s1	s2	s3	s4	Avg. s	(s1+s2)/2	(s3+s4)/2	(s1+s3)/2	(s2+s4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	446.4	53.9	802	298.7	400.00	249.65	550.35	623.70	176.30	105.91	-19.68	10.02
	7/15/1999	440.5	34.4	799.5	280.7	388.78	237.45	540.10	620.00	157.55	102.94	-20.11	10.36
	8/15/1999	455.6	40.8	837.6	284.8	404.85	248.20	561.10	646.60	162.70	107.14	-20.78	10.84
	8/31/1999	452.7	30.7	837.1	274.1	398.65	241.70	555.60	644.90	152.40	106.55	-20.88	11.03
	9/15/1999	448.5	21.7	836.8	266.2	393.30	235.10	551.50	642.65	143.95	104.13	-21.03	11.17
	9/30/1999	447.0	16.1	838.5	260.8	390.60	231.55	549.65	642.75	138.45	103.42	-21.14	11.30
	10/15/1999	446.5	9.8	839.3	256.1	387.43	227.65	547.20	642.90	131.95	102.56	-21.24	11.45
	10/31/1999	450.9	11.7	847.9	257.8	392.08	231.30	552.85	649.40	134.75	103.81	-21.37	11.53
	11/15/1999	455.9	16.1	856.2	259.8	397.00	236.00	558.00	656.05	137.95	105.11	-21.40	11.61
	11/30/1999	456.3	15.5	858.3	259	397.28	235.90	558.65	657.30	137.25	105.19	-21.45	11.65
	12/15/1999	461.3	20.5	865.8	261.7	402.28	240.90	563.65	663.45	141.10	106.51	-21.45	11.70
	12/31/1999	463.4	22.5	871.6	262.9	405.10	242.95	567.25	667.50	142.70	107.26	-21.55	11.78
	3/31/2000	477.8	35.6	903.8	282.7	424.98	256.70	593.25	690.80	159.15	112.52	-22.37	11.91
	6/30/2000	469.2	17.4	889.7	267.4	410.93	243.30	578.55	679.45	142.40	108.80	-22.28	12.03
	9/30/2000	453.5	-23.5	856.8	240.4	381.80	215.00	548.60	655.15	108.45	101.09	-22.17	12.25
	1/13/2001	476.9	5	891.3	257.8	407.70	240.95	574.45	684.10	131.30	107.95	-22.16	12.38
	4/20/2001	494.8	40.8	932.8	281.2	437.40	267.80	607.00	713.80	161.00	115.81	-22.54	12.38
	7/16/2001	475.7	4.9	900.7	255.9	409.30	240.30	578.30	688.20	130.40	108.37	-22.48	12.60
	10/9/2001	459.3	-30.8	870.4	236.8	383.93	214.25	553.60	664.85	103.00	101.65	-22.55	12.69
	1/9/2002	468.8	-16.5	883.7	241.5	393.88	225.15	562.60	676.25	111.50	104.29	-22.43	12.85
	4/12/2002	492.8	22.5	926.5	270.2	428.00	257.65	598.35	709.65	146.35	113.32	-22.64	12.82
	7/15/2002	483.5	3.8	911.9	257.3	414.13	243.65	584.60	697.70	130.55	109.65	-22.66	12.71
	10/8/2002	462.7	-35	875.8	233	384.08	213.85	554.30	669.15	99.00	101.69	-22.63	12.77
14	1/8/2003	485.5	2.5	912.6	253.9	413.63	244.00	583.25	699.05	128.20	109.52	-22.55	12.79
	4/15/2003	501.9	612.9	952.7	285.1	588.15	557.40	618.90	727.30	449.00	156.72	-4.09	8.23
	7/1/2003	521.6	28.8	943.4	278.1	442.98	275.20	610.75	732.50	153.45	117.29	-22.30	12.97
	10/7/2003	472.3	-16.5	903.8	247.5	401.78	227.90	575.65	688.05	115.50	106.38	-23.11	12.83
	12/31/2003	495.5	18.6	939.3	268.7	430.53	257.05	604.00	717.40	143.65	113.99	-23.08	12.85
	4/13/2004	504.6	68.9	969	299.2	465.43	286.75	644.10	746.80	184.05	123.23	-23.75	12.81
	7/13/2004	487.3	38.7	961.8	277.7	440.88	262.00	619.75	724.55	157.20	116.73	-23.78	12.71
	10/6/2004	468.9	-0.5	928.8	256.4	413.40	234.20	592.60	699.85	127.95	109.46	-23.82	12.79
	1/7/2005	485.2	21.4	952.7	269.7	432.25	253.30	611.20	718.95	145.55	114.45	-23.79	12.85
	4/6/2005	512.9	68.8	998.7	302.5	470.73	290.85	650.60	755.80	185.65	124.63	-23.91	12.77
	7/18/2005	498.2	40	977.1	280.8	450.53	269.10	631.95	737.65	163.40	119.29	-24.11	12.86
	8/26/2005	486.3	17.1	955.5	271.8	432.68	251.70	613.65	720.90	144.45	114.56	-24.05	12.91
	10/11/2005	478.5	2.4	942.6	263.6	421.85	240.50	603.10	710.70	133.00	111.69	-24.09	12.94
	1/10/2006	497.9	28.2	970.6	280.6	444.33	263.05	625.50	734.25	154.40	117.64	-24.09	12.99
	4/9/2006	519.6	65.1	1008.9	306	474.90	292.35	657.45	764.25	185.55	126.74	-24.28	12.96
	7/19/2006	506.7	73.4	984.2	290.7	463.50	289.55	637.45	744.95	182.05	122.72	-23.12	12.61
	10/16/2006	494	-5.7	946.5	265.8	422.65	239.15	606.15	715.25	130.05	111.91	-24.39	13.11
	1/16/2007	503	21.5	974.4	282.6	445.35	262.25	628.45	738.70	152.00	117.92	-24.34	13.14
	4/16/2007	526.1	60.9	1012.9	309.1	477.00	293.00	661.00	769.00	185.00	126.30	-24.46	13.08
	7/11/2007	533.6	36.6	994.5	295.1	465.05	285.30	644.90	764.15	165.85	123.13	-23.89	13.40
	10/20/2007	487.8	-9.1	963.6	269.9	425.60	239.35	611.85	720.80	130.40	112.69	-24.76	13.23
	1/7/2008	504.2	11.4	976	284.1	443.93	257.80	630.05	740.10	147.75	117.54	-24.74	13.27
	5/13/2008	552.9	62.7	1019.4	316.4	495.10	302.80	667.40	786.15	184.05	128.44	-24.23	13.49
	7/29/2008	533.4	17.1	989.1	296.9	458.88	275.25	642.50	761.25	156.50	121.50	-24.41	13.65
	10/30/2008	494.5	-16.2	961.7	277.5	429.38	239.15	619.60	728.10	130.65	113.89	-25.28	13.38

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side)(cont'd)

Tie #	Date	s1	s2	s3	s4	Avg. s	(s1+s2)/2	(s3+s4)/2	(s1+s3)/2	(s2+s4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	468.3	92.2	387.7	511.7	364.98	280.25	449.70	428.00	301.95	96.83	-11.26	2.82
	7/15/1999	460.1	81	381.5	505.7	357.08	270.55	443.60	420.80	293.35	94.54	-11.50	2.86
	8/15/1999	482.3	98.1	410.7	526	378.78	289.20	468.35	446.50	311.05	100.29	-11.91	3.03
	8/31/1999	490.3	101.9	422.4	535	387.40	296.10	478.70	456.35	318.45	102.57	-12.14	3.09
	9/15/1999	491.0	101.4	426.3	536.4	388.78	296.20	481.35	458.65	318.90	102.84	-12.30	3.13
	9/30/1999	497.9	106.7	424.7	543.8	395.73	302.30	484.15	466.30	325.15	104.78	-12.42	3.16
	10/15/1999	505.0	112.3	443.2	550.9	402.85	308.65	497.05	474.10	331.60	106.66	-12.52	3.19
	10/31/1999	516.8	118.8	452.5	560.9	411.85	317.20	506.70	484.65	339.85	109.07	-12.59	3.23
	11/15/1999	526.0	128.3	463.4	570.2	421.73	326.85	516.80	494.20	349.25	111.66	-12.64	3.25
	11/30/1999	532.5	134.9	471.5	576.8	428.93	333.70	524.15	502.00	355.85	113.57	-12.66	3.27
	12/15/1999	534.1	138.1	476.5	580.2	432.23	336.10	528.35	505.30	359.15	114.44	-12.78	3.27
	12/31/1999	540.4	144.3	484.4	587.2	439.08	342.35	535.80	512.40	365.75	116.25	-12.86	3.29
	3/31/2000	551.1	156	501.3	602.1	452.63	353.55	551.70	526.20	379.05	119.84	-13.17	3.30
	5/30/2000	533.5	137.3	477.6	577.9	431.58	335.40	527.75	505.55	357.60	114.27	-12.78	3.31
	9/30/2000	536.6	136.8	480.7	575.1	433.05	338.20	527.90	510.15	355.95	114.66	-12.61	3.45
	1/13/2001	571.4	169.7	522.7	611.8	468.90	370.55	567.25	547.05	390.75	124.15	-13.07	3.50
	4/20/2001	580.2	184.8	537.9	624.6	481.88	382.50	581.25	559.05	404.70	127.59	-13.21	3.46
	7/16/2001	556.8	159.1	508	598.8	455.38	357.45	553.30	531.90	378.85	120.57	-13.02	3.43
	10/9/2001	556.2	154.1	506	595.8	453.03	355.15	550.90	531.10	374.95	119.95	-13.01	3.50
	1/9/2002	572	170.3	527.3	614.7	471.08	371.15	571.00	549.65	392.50	124.73	-13.28	3.52
	4/12/2002	584.6	187.7	546.3	632.8	487.85	386.15	589.55	565.45	410.25	129.17	-13.52	3.48
	7/18/2002	559.5	162.1	516.1	606	460.93	360.80	561.05	537.80	384.05	122.04	-13.31	3.44
	10/8/2002	557	154.4	511	599.8	455.55	355.70	555.40	534.00	377.10	120.82	-13.27	3.51
26	1/6/2003	591	189.2	562.8	639	493.00	390.10	595.90	571.90	414.10	130.53	-13.69	3.54
	4/15/2003	597.9	204.3	567.5	650.5	505.05	401.10	609.00	582.70	427.40	133.72	-13.82	3.48
	7/1/2003	580.7	184.3	545.4	632.5	485.73	382.50	588.95	563.05	408.40	128.61	-13.72	3.46
	10/7/2003	578.2	176.3	536	627	479.88	377.25	582.50	558.10	401.65	127.06	-13.64	3.50
	12/31/2003	610.3	207.7	572.6	661.8	513.05	409.00	617.10	591.45	434.65	135.54	-13.83	3.51
	4/13/2004	617.1	224.2	589.5	675.7	526.63	420.65	632.60	603.30	449.95	139.43	-14.09	3.44
	7/13/2004	584	186.6	546.1	642.8	490.58	385.30	594.45	565.05	414.70	129.89	-13.99	3.40
	10/6/2004	581.5	181.2	543.7	638.3	486.25	381.50	591.00	562.75	409.75	128.74	-13.92	3.43
	1/7/2005	609.9	209	574.8	669.1	515.70	409.45	621.95	592.35	439.05	136.54	-14.12	3.43
	4/8/2005	617.5	226	590.2	683.9	529.15	421.25	637.05	603.85	454.45	140.10	-14.34	3.35
	7/18/2005	590.4	192.7	554.7	656	498.45	391.55	605.35	572.55	424.35	131.97	-14.21	3.32
	8/26/2005	584.4	183.1	544	647.8	489.83	383.75	595.90	564.20	415.45	129.69	-14.10	3.33
	10/11/2005	589.3	185.9	548.5	652	493.93	387.60	600.25	568.90	418.95	130.78	-14.13	3.36
	1/10/2006	616	216.1	582.8	683.4	524.58	416.05	633.10	599.40	449.75	138.59	-14.42	3.35
	4/9/2006	629	235.4	605.8	701.1	542.83	432.20	653.45	617.40	468.25	143.72	-14.70	3.34
	7/19/2006	595.8	199	563.1	668.3	506.55	397.40	615.70	579.45	433.65	134.12	-14.51	3.27
	10/18/2006	595.6	193	557.4	662.8	502.20	394.30	610.10	576.50	427.90	132.97	-14.34	3.33
	1/16/2007	622.2	223.4	590.2	694.8	532.60	422.80	642.40	606.20	459.00	141.02	-14.59	3.30
	4/15/2007	624.5	231.7	598.4	701.1	536.93	428.10	649.75	611.45	466.40	142.69	-14.73	3.25
	7/11/2007	594.6	199.2	561.5	670.8	506.53	396.90	616.15	578.05	435.00	134.11	-14.57	3.20
	10/20/2007	588.7	187	550.3	661.8	496.95	387.85	606.05	569.50	424.40	131.58	-14.50	3.25
	1/7/2008	619.8	219.6	589.6	697.1	531.53	419.70	643.35	604.70	458.35	140.73	-14.86	3.28
	5/13/2008	624.3	232.4	600.5	707.3	541.13	428.35	653.90	612.40	469.85	143.27	-14.99	3.19
	7/29/2008	600.8	202.7	568.1	681.9	513.38	401.75	625.00	584.45	442.30	135.93	-14.84	3.18
	10/30/2008	616.5	213.5	580.6	694.2	526.20	415.00	637.40	598.55	453.85	139.32	-14.78	3.24

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side)

Tie #	Date	s1	s2	s3	s4	Avg. s	(s1+s2)/2	(s3+s4)/2	(s1+s3)/2	(s2+s4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
1	7/1/1999	-115.0	299.7	422.9	109.6	179.30	92.35	266.25	153.95	204.65	47.47	-11.58	-1.14
	7/15/1999	-122.0	289	405.2	95.6	166.95	83.50	250.40	141.60	192.30	44.20	-11.09	-1.14
	8/15/1999	-139.4	265.8	401.5	101.8	157.43	63.20	251.65	131.05	183.80	41.68	-12.52	-1.18
	8/31/1999	-144.1	259.4	394.7	99.6	152.15	57.15	247.15	125.30	179.00	40.28	-12.63	-1.20
	9/15/1999	-144.1	255.9	395.1	102	152.23	55.90	248.55	125.50	178.95	40.30	-12.80	-1.20
	9/30/1999	-141.7	260.4	408.3	112.3	159.83	59.35	260.30	133.30	186.35	42.32	-13.35	-1.19
	10/15/1999	-138.1	275.3	441.9	138.4	179.38	68.60	290.15	151.90	206.85	47.49	-14.72	-1.23
	10/31/1999	-148.1	272.7	430.1	118.5	168.30	62.30	274.30	141.00	195.60	44.56	-14.09	-1.22
	11/15/1999	-142.3	278.9	446.6	134.9	179.53	68.30	290.75	152.15	206.90	47.53	-14.79	-1.23
	11/30/1999	-137.9	284.4	462	150.8	189.83	73.25	306.40	162.05	217.60	50.26	-15.49	-1.24
	12/15/1999	-135.4	290	468.8	152.5	192.73	77.30	308.15	164.20	221.25	51.03	-15.34	-1.26
	12/31/1999	-128.8	301.4	481.4	168.9	206.23	87.30	325.15	177.30	235.15	54.60	-15.81	-1.30
	3/31/2000	-133.9	283.1	455.7	149.8	188.83	74.60	302.85	160.90	216.35	49.94	-15.18	-1.24
	5/30/2000	-157.3	230.6	397.4	119.3	147.50	36.65	258.35	120.05	174.95	39.05	-14.73	-1.23
	9/30/2000	-142.8	237.4	427.4	156.8	159.70	47.30	292.10	142.30	197.10	44.93	-16.27	-1.23
	1/13/2001	-118.2	295.4	511.7	182.5	217.95	88.60	347.10	196.75	238.95	57.68	-17.19	-0.95
	4/20/2001	-128.9	270.9	454	163.4	189.85	71.00	308.70	162.55	217.15	50.27	-15.80	-1.22
	7/16/2001	-146.4	213.9	384.1	133.3	146.23	33.75	258.70	118.85	173.60	38.72	-14.95	-1.23
	10/9/2001	-135.7	237.5	439.4	178.3	179.98	50.90	308.85	151.85	207.90	47.63	-17.14	-1.26
	1/9/2002	-120.2	281.4	483	190.7	208.73	80.60	336.85	181.40	236.05	55.26	-17.03	-1.22
	4/12/2002	-133.2	263.6	441.1	154.2	181.43	65.20	297.65	153.95	208.90	48.04	-15.45	-1.23
	7/16/2002	-158.1	191.2	355.6	118	126.68	16.55	236.80	98.75	154.60	33.54	-14.64	-1.25
	10/7/2002	-149.2	192.4	391.7	156.3	147.80	21.60	274.00	121.25	174.35	39.13	-16.77	-1.19
	1/8/2003	-123.2	268.7	469.3	191.8	201.65	72.75	330.55	173.05	230.25	53.39	-17.13	-1.28
	4/15/2003	-137.5	248.4	427.1	157.1	173.78	55.45	292.10	144.80	202.75	46.01	-15.73	-1.30
	7/1/2003	-159.7	183.9	351.2	124.6	125.00	12.10	237.90	95.75	154.25	33.10	-15.01	-1.31
	10/7/2003	-148.6	206.4	412.6	177.8	162.55	28.90	295.20	133.00	192.10	43.04	-17.63	-1.32
	12/31/2003	-135.4	243.4	450.4	190	187.10	54.00	320.20	157.50	216.70	49.54	-17.69	-1.33
	4/13/2004	-144.6	228.6	422.1	168	168.53	42.00	295.05	138.75	198.30	44.62	-16.82	-1.33
	7/13/2004	-179.1	155.6	334.2	117.5	107.05	-11.75	225.85	77.55	136.55	28.34	-15.79	-1.32
	10/6/2004	-169	170.9	373.7	152.9	132.13	0.95	263.30	102.35	161.90	34.98	-17.44	-1.33
	1/7/2005	-145.5	227.6	440.5	168.2	177.75	41.15	314.35	147.50	208.00	47.06	-18.16	-1.36
	4/8/2005	-159.4	209.2	398.5	148.8	149.28	24.90	273.65	119.55	179.00	39.52	-16.53	-1.33
	7/16/2005	-182.8	141.5	330.3	131.3	105.08	-20.65	230.80	73.75	136.40	27.82	-16.71	-1.40
	8/26/2005	-184	140.7	341.3	131.3	107.33	-21.65	236.30	78.65	136.00	28.42	-17.14	-1.28
	10/11/2005	-174.2	159.1	370.9	131.3	121.78	-7.55	251.10	98.35	145.20	32.24	-17.19	-1.05
	1/10/2006	-162.5	216.4	430.7	131.3	156.48	31.95	281.00	139.10	173.85	41.43	-16.65	-0.78
	4/5/2006	-157.2	206.1	413	131.3	148.30	24.45	272.15	127.90	168.70	39.27	-16.46	-0.91
	7/15/2006	-189.4	135.9	330	131.3	101.95	-26.75	230.65	70.30	133.60	26.99	-17.11	-1.42
	10/16/2006	-170.5	170.2	390.6	131.3	130.40	-0.15	260.95	110.05	150.75	34.53	-17.35	-0.91
	1/18/2007	-145.4	217.2	448.1	131.3	182.80	35.90	289.70	151.35	174.25	43.10	-16.87	-0.51
	4/19/2007	-159.2	203.2	410.4	131.3	146.43	22.00	270.85	125.60	167.25	38.77	-16.64	-0.93
	7/11/2007	-192.9	128.3	318.7	131.3	96.35	-32.30	225.00	62.90	129.80	25.51	-17.10	-1.50
	10/20/2007	-183.2	145.9	358.7	131.3	113.18	-18.65	245.00	87.75	138.60	29.97	-17.52	-1.14
	1/7/2008	-166.6	207.5	426.7	131.3	152.48	25.95	279.00	135.55	169.40	40.37	-16.82	-0.76
	5/13/2008	-172.2	170	384.2	131.3	126.33	-1.10	257.75	106.00	150.65	33.96	-17.20	-1.00
	7/29/2008	-197.5	120	328.1	131.3	95.48	-38.75	229.70	65.30	125.65	25.28	-17.84	-1.35
	10/30/2008	-167.1	170	413	131.3	136.90	1.45	272.15	122.95	150.65	36.22	-17.99	-0.62

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	s1	s2	s3	s4	Avg. s	(s1+s2)/2	(s3+s4)/2	(s1+s3)/2	(s2+s4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
12	7/1/1999	356.2	257	201.2	275.1	272.38	306.60	238.15	278.70	266.05	72.12	4.56	0.28
	7/15/1999	353.8	251.6	188.4	273.4	266.80	302.70	230.90	271.10	262.50	70.64	4.77	0.19
	8/15/1999	350.0	242.8	195.3	301.1	272.30	296.40	248.20	272.65	271.95	72.10	3.20	0.02
	8/31/1999	350.2	247.8	201.7	307.9	276.90	299.00	254.80	275.95	277.85	73.31	2.94	-0.04
	9/15/1999	349.8	249.1	203.6	314	279.13	299.45	258.80	276.70	281.55	73.90	2.70	-0.11
	9/30/1999	352.2	256.8	212.1	322.7	286.95	304.50	267.40	282.15	289.75	75.71	2.47	-0.17
	10/15/1999	352.8	257.7	225.5	337.3	293.28	305.15	281.40	289.05	297.60	77.65	1.58	-0.19
	10/31/1999	361.0	268.5	222.6	333.7	296.45	314.75	278.15	291.80	301.10	78.49	2.43	-0.21
	11/15/1999	364.5	273.1	237.1	353.6	307.08	318.80	295.35	300.80	313.35	81.30	1.56	-0.28
	11/30/1999	367.6	276.3	249.1	369.4	315.60	321.95	309.25	308.35	322.85	83.56	0.84	-0.32
	12/15/1999	370.6	280.7	248.5	364.3	316.03	325.65	306.40	309.55	322.50	83.67	1.28	-0.29
	12/31/1999	371.2	282.5	254.8	368.8	319.33	326.85	311.80	313.00	325.65	84.55	1.00	-0.28
	3/31/2000	376.0	289.2	244.7	361.1	317.75	332.60	302.90	310.35	325.15	84.13	1.97	-0.33
	6/30/2000	358.4	247.7	207.4	329.3	285.70	303.05	268.35	282.90	288.50	75.64	2.31	-0.13
	9/30/2000	357.6	235.9	230.1	366.4	297.50	296.75	298.25	293.85	301.15	78.77	-0.10	-0.16
	1/13/2001	362.0	289.5	264.4	384.8	330.18	335.75	324.60	323.20	337.15	87.42	0.74	-0.31
	4/20/2001	362.9	294.9	260.1	378.2	329.03	338.90	319.15	321.50	336.55	87.12	1.31	-0.34
	7/16/2001	352.4	249.4	219.2	330.8	287.90	300.90	274.90	285.80	290.00	76.23	1.73	-0.09
	10/9/2001	357.7	267.9	262.1	382	317.43	312.80	322.05	309.90	324.95	84.04	-0.61	-0.34
	1/9/2002	365.8	301.2	285.1	395.8	341.83	343.50	340.35	335.45	348.40	90.53	0.21	-0.29
	4/12/2002	390.9	310.2	263.2	370.1	333.60	350.55	316.65	327.05	340.15	88.33	2.25	-0.29
	7/18/2002	346.39	265.03	220.4	323.3	288.78	305.71	271.85	283.39	294.17	76.46	2.25	-0.24
	10/7/2002	344.5	265.3	262.4	363.5	306.43	304.90	307.95	269.45	314.40	81.13	-0.20	-0.36
	1/6/2003	365.9	308.5	295.9	394.3	346.15	347.20	345.10	340.90	351.40	91.85	0.14	-0.24
	4/15/2003	392.4	317.3	275.8	371.1	339.15	354.85	323.45	334.10	344.20	89.80	2.09	-0.23
	7/1/2003	360	288.1	239.7	332.8	304.90	324.05	285.75	299.35	310.45	80.73	2.56	-0.25
	10/7/2003	357.1	284.5	277.7	372.1	322.85	320.80	324.90	317.40	328.30	85.48	-0.27	-0.24
	12/31/2003	367.7	318.7	304.1	392.5	350.75	343.20	348.30	345.90	355.60	92.87	0.33	-0.22
	4/13/2004	369.4	324.2	294.9	381.2	347.43	346.80	338.05	342.15	352.70	91.99	1.25	-0.24
	7/13/2004	348	285.8	241	324.8	299.90	316.90	282.90	294.50	305.30	79.40	2.26	-0.24
	10/6/2004	342.4	281.8	269.4	353.1	311.68	312.10	311.25	305.90	317.45	82.52	0.06	-0.26
	1/7/2005	374.1	315.2	302.9	382.8	343.75	344.65	342.85	338.50	349.00	91.01	0.12	-0.24
	4/8/2005	386.7	328.9	284.3	365	341.23	357.80	324.65	335.50	346.95	90.35	2.20	-0.26
	7/18/2005	343.2	285.5	242.4	322.1	298.30	314.35	282.25	292.80	303.80	78.98	2.13	-0.25
	8/26/2005	337	278.7	260.1	331.1	299.23	307.85	290.60	293.55	304.90	79.23	1.15	-0.25
	10/11/2005	338.7	283.6	264.1	348.8	308.75	311.15	306.35	301.40	316.10	81.75	0.32	-0.33
	1/10/2006	371.5	317.4	297	373.5	339.85	344.45	335.25	334.25	345.45	89.96	0.61	-0.25
	4/9/2006	377.4	324.1	290.6	368.2	340.08	350.75	329.40	334.00	346.15	90.04	1.42	-0.27
	7/19/2006	341.9	289.2	238.8	315.3	296.30	315.55	277.05	290.35	302.25	78.45	2.56	-0.27
	10/18/2006	342.7	289.5	274.8	354.5	315.38	316.10	314.65	308.75	322.00	83.50	0.10	-0.30
	1/16/2007	366.4	316.6	305.5	395	343.88	342.50	345.25	336.95	350.80	91.05	-0.18	-0.31
	4/16/2007	370.5	320.9	279.2	353.9	331.13	345.70	316.55	324.85	337.40	87.87	1.94	-0.28
	7/11/2007	326.8	278.1	219	294	279.43	302.35	256.50	272.90	286.05	73.98	3.06	-0.30
	10/25/2007	326.9	278.3	243.8	321.7	292.43	302.10	282.75	284.85	300.00	77.43	1.28	-0.34
	1/7/2008	356.2	310.2	282.6	353	325.50	334.70	317.90	321.00	331.60	86.39	1.12	-0.24
	5/13/2008	350.5	304.1	260.9	336.4	312.73	327.30	298.15	305.70	319.75	82.90	1.94	-0.31
	7/28/2008	326.9	281.2	234.5	306.4	286.75	303.55	269.95	280.20	293.30	76.92	2.23	-0.29
	10/30/2008	336.7	288	283.1	360.3	316.78	311.85	321.70	309.40	324.15	83.87	-0.65	-0.33

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	s1	s2	s3	s4	Avg. s	(s1+s2)/2	(s3+s4)/2	(s1+s3)/2	(s2+s4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
13	7/1/1999	177.4	380.2	417.8	236.2	302.85	278.80	326.90	297.50	308.20	80.19	-3.20	-0.24
	7/15/1999	173.8	378	412.7	230.2	298.68	275.90	321.45	293.25	304.10	79.06	-3.03	-0.24
	8/15/1999	172.8	380.2	439.6	252.8	311.30	276.50	346.10	306.20	316.40	82.42	-4.63	-0.23
	8/31/1999	172.6	378	445.8	257.5	313.48	275.30	351.65	309.20	317.75	83.00	-5.07	-0.19
	9/15/1999	170.9	377.2	447.2	261	314.08	274.05	354.10	309.05	319.10	83.16	-5.32	-0.23
	9/30/1999	176.4	380.7	455.9	269.3	320.58	278.55	362.60	316.15	325.00	84.88	-5.59	-0.20
	10/15/1999	176.7	378.9	468.1	279.5	325.80	277.80	373.80	322.40	329.20	86.26	-6.38	-0.15
	10/31/1999	182.4	385.8	502.1	273.8	336.03	284.10	387.95	342.25	329.80	88.97	-6.90	0.28
	11/15/1999	186.8	392.4	482.7	292	338.48	289.60	387.35	334.75	342.20	89.82	-6.50	-0.17
	11/30/1999	189.8	396.6	638.9	305.6	382.78	293.30	472.25	414.35	351.20	101.35	-11.69	1.41
	12/15/1999	193.5	401.1	516.7	302.2	353.38	297.30	409.45	355.10	351.65	93.56	-7.45	0.08
	12/31/1999	194.7	408.1	507.2	308	354.00	300.40	407.60	350.95	357.05	93.73	-7.12	-0.14
	3/31/2000	194.8	409	492.7	298.7	348.80	301.90	395.70	343.75	353.85	92.35	-6.23	-0.23
	6/30/2000	177.7	389.4	467.2	278.7	328.25	283.55	372.95	322.45	334.05	86.91	-5.94	-0.26
	9/30/2000	174.2	385.1	498.7	308	341.00	279.65	402.35	336.45	346.55	90.29	-6.15	-0.25
	1/13/2001	200.0	418.2	530.3	318.8	366.78	309.10	424.45	365.15	368.40	97.11	-7.67	-0.07
	4/20/2001	194.1	416.2	512.8	310.8	358.43	305.15	411.70	353.45	363.40	94.90	-7.09	-0.22
	7/16/2001	186.5	388.2	469	273.8	323.88	276.35	371.40	317.75	330.00	85.75	-6.32	-0.27
	10/9/2001	171.5	389.1	514.8	316.2	347.65	280.30	415.00	343.15	352.15	92.05	-6.95	-0.20
	1/9/2002	193.6	413.6	539.3	324.8	367.78	303.60	431.95	366.45	369.10	97.38	-8.53	-0.06
	4/12/2002	198.8	418.5	509.3	299.2	356.45	308.65	404.25	354.05	358.85	94.38	-6.35	-0.11
	7/18/2002	181.4	379.1	462.4	262.8	316.38	270.25	362.50	311.90	320.85	83.77	-6.13	-0.20
	10/7/2002	155.8	373.6	686.8	301.1	379.33	264.70	493.95	421.30	337.35	100.43	-15.24	1.88
	1/6/2003	193.1	414	547.8	331	371.43	303.55	439.30	370.35	372.50	98.34	-9.02	-0.05
	4/15/2003	195.8	419.9	560.6	305.7	370.50	307.85	433.15	378.20	362.80	98.10	-8.33	0.34
	7/11/2003	172.1	394.8	479.4	273.9	330.05	283.45	376.65	325.75	334.35	87.39	-6.19	-0.19
	10/7/2003	169	389.1	527.1	317.5	350.68	279.05	422.30	348.05	353.30	92.85	-9.52	-0.12
	12/31/2003	196.2	423.2	560.3	334.7	378.60	309.70	447.50	378.25	378.95	100.24	-9.16	-0.02
	4/13/2004	197.9	424.7	546.1	321.7	372.60	311.30	433.90	372.00	373.20	98.65	-8.15	-0.03
	7/13/2004	155.6	383.5	482.7	266.1	321.98	269.55	374.40	319.15	324.80	86.25	-6.97	-0.13
	10/6/2004	152.2	378.4	519	298.8	337.05	265.30	408.90	335.60	338.60	89.24	-9.54	-0.08
	1/7/2005	180.6	410.6	568.1	324.9	368.05	295.60	446.50	368.35	367.75	97.45	-9.63	0.01
	4/6/2005	188.3	419.5	529.1	301	359.48	303.90	415.05	358.70	360.25	95.18	-7.39	-0.03
	7/18/2005	150.7	376.8	482.9	262.2	318.15	263.75	372.55	316.80	319.50	84.24	-7.23	-0.06
	8/26/2005	144.7	373.1	494.1	276.3	321.80	258.90	384.70	319.40	324.20	85.20	-8.36	-0.11
	10/11/2005	146.5	375.2	533.7	291.5	336.73	260.85	412.60	340.10	333.35	89.15	-10.09	0.15
	1/10/2006	176	407.1	548.8	313.5	361.35	291.55	431.15	362.40	360.30	95.67	-9.28	0.05
	4/9/2006	180.8	412.1	538.7	307.8	359.80	296.35	423.25	359.65	359.95	95.26	-8.43	-0.01
	7/19/2006	149.4	377.4	480.1	259.8	316.68	263.40	369.95	314.75	318.60	83.85	-7.08	-0.09
	10/18/2006	155.2	382.8	532.6	304.1	343.68	269.00	418.35	343.90	343.45	90.99	-9.93	0.01
	1/18/2007	179.5	407.9	563.5	330.9	370.45	293.70	447.20	371.50	369.40	98.08	-10.20	0.05
	4/19/2007	182.7	413.5	536	305.6	359.45	298.10	420.80	359.35	359.55	95.17	-8.15	0.00
	7/11/2007	146.1	373.2	467.5	250.9	309.35	259.65	359.05	306.80	311.90	81.91	-6.61	-0.11
	10/20/2007	144.3	373.6	638.9	278.5	358.83	258.95	458.70	391.60	326.05	96.01	-13.28	1.47
	1/7/2008	179.2	408.8	548	312	362.00	294.00	430.00	363.60	360.40	95.85	-9.04	0.07
	5/13/2008	172.2	403.9	523.7	297.2	349.25	288.05	410.45	347.95	350.55	92.47	-8.13	-0.08
	7/29/2008	149.7	380.4	489.1	265	321.05	265.05	377.05	319.40	322.70	85.00	-7.44	-0.07
	10/30/2008	160.1	391.8	555	321.9	357.20	275.95	438.45	357.55	356.85	94.58	-10.80	0.02

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	s1	s2	s3	s4	Avg. s	(s1+s2)/2	(s3+s4)/2	(s1+s3)/2	(s2+s4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
14	7/1/1999	199.5	418.4	473.8	323.8	353.83	308.95	398.70	336.55	371.10	93.68	-5.96	-0.77
	7/15/1999	194.3	414.4	461.1	314.4	346.05	304.35	387.75	327.70	364.40	91.82	-5.54	-0.82
	8/15/1999	191.0	402.1	488.7	347.5	357.33	296.55	418.10	339.85	374.80	94.81	-6.08	-0.78
	8/31/1999	189.5	395.4	496	352.6	358.38	292.45	424.30	342.75	374.00	94.89	-6.78	-0.70
	9/15/1999	186.8	391.6	503.6	359.8	360.45	289.20	431.70	345.20	375.70	95.44	-9.47	-0.68
	9/30/1999	188.5	396.7	516	389	367.55	292.60	442.50	352.25	382.85	97.32	-9.96	-0.69
	10/15/1999	235.3	403	530.4	378.9	386.90	319.15	454.65	382.85	390.95	102.44	-9.01	-0.18
	10/31/1999	202.7	418.5	524.2	371.5	379.23	310.60	447.85	363.45	395.00	100.41	-9.12	-0.71
	11/15/1999	208.9	426.2	548.2	393.2	394.13	317.55	470.70	378.55	409.70	104.35	-10.18	-0.70
	11/30/1999	212.9	429.2	568.6	409.5	404.55	321.05	489.05	389.75	419.35	107.11	-11.10	-0.66
	12/15/1999	216.9	433.5	561.4	403.7	403.88	325.20	482.55	389.15	418.60	106.93	-10.46	-0.66
	12/31/1999	220.7	443.8	568.8	407.4	409.63	332.25	487.00	393.65	425.60	108.46	-10.28	-0.72
	3/31/2000	215.2	438.2	567.9	406.5	406.95	326.70	487.20	391.55	422.35	107.75	-10.67	-0.69
	6/30/2000	191.3	415.8	542.4	380.7	382.55	303.55	461.55	366.85	398.25	101.29	-10.50	-0.70
	6/30/2000	183.3	409.8	571	409.9	393.50	296.55	490.45	377.15	409.85	104.19	-12.89	-0.73
	1/13/2001	215.4	447.2	588.9	421.9	418.35	331.30	505.40	402.15	434.55	110.77	-11.57	-0.73
	4/20/2001	210.2	445.1	586.6	415.7	414.40	327.65	501.15	398.40	430.40	109.72	-11.53	-0.72
	7/16/2001	171.2	413	554.5	377.7	379.10	292.10	466.10	362.85	395.35	100.37	-11.56	-0.73
	10/5/2001	178.5	417.9	566.2	418.9	402.95	298.20	507.50	387.35	418.35	106.86	-13.91	-0.69
	1/5/2002	206.2	445.9	608.4	430	422.13	326.05	518.20	406.30	437.95	111.77	-12.77	-0.71
	4/12/2002	208.6	449.5	584.1	408.1	412.58	329.05	496.10	396.35	428.80	109.24	-11.10	-0.73
	7/16/2002	161.7	410.1	551.9	368.5	373.05	285.90	460.20	356.80	389.30	98.77	-11.59	-0.73
	10/7/2002	160.2	405.5	592.3	407.7	391.43	282.85	500.00	376.25	406.60	103.64	-14.43	-0.65
	1/6/2003	202	449.1	620.2	437.7	427.25	325.55	528.95	411.10	443.40	113.12	-13.52	-0.72
	4/15/2003	205.4	453.6	590	409.8	414.70	329.50	499.90	397.70	431.70	109.80	-11.32	-0.76
	7/1/2003	171.9	426.9	569.5	377.3	393.90	299.40	468.40	385.70	402.10	101.85	-11.23	-0.82
	10/7/2003	172	424.4	600.8	422.4	404.90	298.20	511.60	386.40	423.40	107.21	-14.18	-0.83
	12/31/2003	205.6	461.3	624.2	444.8	434.00	333.45	534.55	414.90	453.10	114.91	-13.38	-0.86
	4/13/2004	204.7	463.4	611.5	433.1	428.18	334.05	522.30	408.10	448.25	113.37	-12.61	-0.90
	7/13/2004	159.6	424.2	568.4	383.7	383.48	291.90	476.05	363.65	403.95	101.53	-12.17	-0.92
	10/6/2004	153	416.8	580.5	409.5	392.45	284.90	500.00	371.75	413.15	103.91	-14.30	-0.93
	1/7/2005	192.8	464.9	627.8	446.9	430.60	328.85	537.35	410.30	450.90	114.01	-14.19	-0.91
	4/6/2005	206.2	467.5	600.9	425.2	424.70	336.85	513.05	403.05	446.35	112.45	-11.74	-0.97
	7/16/2005	154.9	424.1	560.9	386.2	381.28	289.50	473.05	357.90	404.65	100.95	-12.20	-1.05
	8/26/2005	168.3	416.1	569.1	391.2	386.18	292.20	480.15	368.70	403.65	102.25	-12.49	-0.75
	10/11/2005	152.5	418.5	590.5	413.4	393.73	285.50	501.95	371.50	415.95	104.25	-14.38	-1.00
	1/10/2006	190.7	465.4	615	436.7	424.45	328.05	525.85	402.85	446.05	112.38	-13.48	-0.97
	4/9/2006	196.7	460.2	612.3	436.6	426.45	328.45	524.45	404.50	448.40	112.91	-13.03	-0.98
	7/19/2006	159.7	426.1	562.3	382.1	382.55	292.90	472.20	361.00	404.10	101.29	-11.92	-0.97
	10/18/2006	161.9	425.9	600.5	422.5	402.70	293.90	511.50	381.20	424.20	106.62	-14.46	-0.98
	1/18/2007	192.2	464.2	638.5	460	436.23	328.20	549.25	415.35	457.10	116.50	-15.02	-0.94
	4/19/2007	198.7	462.5	611.3	432	426.13	330.60	521.65	405.00	447.25	112.93	-12.70	-0.95
	7/11/2007	149.3	419.9	567.4	379.8	379.23	284.60	473.60	358.60	399.85	100.41	-12.64	-0.92
	10/20/2007	208.9	417	590.1	409	406.25	312.95	499.55	399.50	413.00	107.56	-12.40	-0.30
	1/7/2008	194.6	460.1	617.4	439.8	427.98	327.35	528.60	406.00	449.95	113.31	-13.37	-0.95
	5/13/2008	188	456	606	431.7	420.18	321.50	518.85	397.00	443.85	111.25	-13.12	-1.04
	7/29/2008	155	428.4	572.6	394	387.50	291.70	483.30	363.80	411.20	102.60	-12.73	-1.06
	10/30/2008	172.9	442.6	629.9	452.7	424.53	307.75	541.30	401.40	447.65	112.40	-15.62	-1.04

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	s1	s2	s3	s4	Avg. s	(s1+s2)/2	(s3+s4)/2	(s1+s3)/2	(s2+s4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
26	7/1/1999	222.2	-19.9	305.2	560	266.88	101.15	432.60	263.70	270.05	70.66	-22.03	-0.14
	7/15/1999	207.8	-36.8	294.3	540.9	251.55	85.50	417.60	251.05	252.05	66.60	-22.07	-0.02
	8/15/1999	189.9	-53.4	320.4	546.8	250.93	68.25	433.60	255.15	246.70	66.44	-24.28	0.19
	8/31/1999	184.8	-60	330.2	555.2	252.55	62.40	442.70	257.50	247.60	66.87	-25.27	0.22
	9/15/1999	185.7	-57.2	336.8	556.2	255.88	64.25	447.40	261.15	250.50	67.73	-25.46	0.24
	9/30/1999	187.5	-53.7	349.9	570.1	263.45	66.90	460.00	268.70	258.20	69.75	-26.12	0.24
	10/15/1999	195.3	-50.5	375.2	601.5	280.38	72.40	488.35	285.25	275.50	74.23	-27.64	0.22
	10/31/1999	197.3	-39.9	370.8	589.7	279.48	78.70	480.25	284.05	274.90	74.00	-26.69	0.20
	11/15/1999	202.5	-32.3	385.9	601.1	289.30	85.10	493.50	294.20	284.40	76.60	-27.14	0.22
	11/30/1999	206.5	-27.3	398.1	613.9	297.80	89.60	506.00	302.30	293.30	78.85	-27.67	0.20
	12/15/1999	216.1	-19.5	401.6	620.9	304.78	98.30	511.25	308.85	300.70	80.70	-27.44	0.18
	12/31/1999	223.8	-15	410.7	633.4	313.23	104.40	522.05	317.25	309.20	82.93	-27.76	0.18
	3/31/2000	203.5	-18	395.7	633.5	304.18	93.75	514.60	299.60	308.75	80.54	-27.97	-0.20
	6/30/2000	149.3	-41	371.2	553.8	258.33	54.15	462.50	260.25	256.40	68.40	-27.14	0.09
	6/30/2000	154.3	-22.3	411.5	580.2	280.93	66.00	495.85	282.90	278.95	74.38	-28.57	0.09
	1/13/2001	197.9	7.7	446.8	627.1	319.88	102.80	536.95	322.35	317.40	84.69	-28.85	0.11
	4/20/2001	167.6	1.3	434.9	589.5	298.33	84.45	512.20	301.25	295.40	78.99	-28.43	0.13
	7/16/2001	112.8	-20.6	409.7	555.1	284.25	46.10	482.40	261.25	267.25	69.97	-29.00	-0.13
	10/5/2001	136.9	-5.4	451.7	582.7	291.48	65.75	517.20	294.30	288.65	77.17	-30.00	0.13
	1/9/2002	176.6	9	461.6	618.2	316.35	92.80	539.90	319.10	313.60	83.76	-29.71	0.12
	4/12/2002	158.20	3.40	438	581.00	295.25	80.80	509.70	298.30	292.20	78.17	-28.50	0.14
	7/18/2002	86.10	-23.70	405	503.86	242.87	31.20	454.53	245.55	240.08	64.30	-28.13	0.12
	10/7/2002	96.1	2.90	446.20	562.80	276.75	49.50	504.00	270.65	282.85	73.26	-30.21	-0.27
	1/6/2003	165.9	41.91	480.40	628.48	329.17	103.91	554.44	323.15	335.20	87.16	-29.64	-0.27
	4/15/2003	147.5	33.95	455.30	592.01	307.19	90.73	523.65	301.40	312.98	81.33	-28.77	-0.26
	7/1/2003	88.2	9.86	424.1	577.30	274.92	48.93	500.70	256.15	293.48	72.76	-30.02	-0.84
	10/7/2003	103.5	24.24	466.9	574.34	292.25	63.87	520.62	285.20	299.29	77.38	-30.35	-0.32
	12/31/2003	130.5	44.68	481.6	566.95	305.93	87.59	524.27	306.05	305.81	81.00	-29.02	0.01
	4/13/2004	118.2	42.06	471.6	585.31	304.30	80.14	528.45	294.90	313.69	80.57	-29.79	-0.42
	7/13/2004	49.6	8.40	430.9	548.80	259.43	29.00	489.85	240.25	278.60	68.69	-30.63	-0.86
	10/6/2004	54.7	18.19	457.3	588.15	279.59	36.45	522.72	256.00	303.17	74.03	-32.32	-1.06
	1/7/2005	108.7	42.65	486.4	597.82	308.89	75.67	542.11	297.55	320.23	81.76	-31.00	-0.51
	4/6/2005	91.7	33.99	457.3	601.47	296.12	62.85	529.39	274.50	317.73	78.40	-31.01	-0.97
	7/18/2005	28.7	12.91	432.3	605.33	269.81	20.81	518.82	230.50	309.12	71.44	-33.10	-1.75
	8/26/2005	31.4	16.85	447.8	586.39	271.11	24.13	518.10	239.60	302.62	71.78	-32.83	-1.41
	10/11/2005	43.7	14.58	464.4	588.60	277.82	29.14	526.50	254.05	301.59	73.56	-33.05	-1.06
	1/10/2006	96.3	14.58	483.8	588.60	295.82	55.44	536.20	290.05	301.59	78.32	-31.95	-0.26
	4/9/1906	87.1	29.40	477	588.60	295.52	58.25	532.80	282.05	309.00	78.25	-31.54	-0.60
	7/19/1906	18.4	-2.90	430.9	588.60	258.75	7.75	509.75	224.65	292.65	68.51	-33.36	-1.53
	10/18/1906	61.1	14.58	483.2	588.60	286.87	37.84	535.90	272.15	301.59	75.95	-33.10	-0.66
	1/16/2007	99.2	14.58	505.9	588.60	302.07	56.89	547.25	302.55	301.59	79.98	-32.59	0.02
	4/19/2007	80.5	14.58	477.1	588.60	290.19	47.54	532.85	278.80	301.59	76.83	-32.25	-0.51
	7/11/2007	11.2	14.5768	431.3	588.5957	261.42	12.89	509.95	221.25	301.59	69.22	-33.03	-1.80
	10/20/2007	19.8	14.5768	455.1	588.5957	269.52	17.19	521.85	237.45	301.59	71.36	-33.54	-1.44
	1/7/2008	82.9	14.5768	469.6	588.5957	293.92	48.74	539.10	286.25	301.59	77.82	-32.59	-0.34
	5/13/2008	44.6	14.5768	469.6	588.5957	279.14	48.74	539.10	286.25	301.59	77.82	-32.59	-0.34
	7/29/2008	0.2	14.5768	442.6	588.5957	261.54	48.74	539.10	286.25	301.59	77.82	-32.59	-0.34
	10/30/2008	34	14.5768	496.7	588.5957	283.22	48.74	539.10	286.25	301.59	77.82	-32.59	-0.34

Table 4 Pile Forces and Bending Moments

Pile #	Date	s1	s2	s3	s4	Avg. s	(s1+s2)/2	(s3+s4)/2	(s1+s3)/2	(s2+s4)/2	Axial Force(Kip)	Moment(x)(−Kip-ft)	Moment(y)(Kip-ft)
1	07/01/99	903.00	42.30	679.00	-	541.43	472.65	679.00	791.00	42.30	456.92	-73.98	99.66
	07/15/99	918.00	48.00	885.00	-	617.00	483.00	885.00	901.50	48.00	520.69	-144.12	113.86
	07/31/99	932.43	51.99	907.34	-	623.92	492.21	907.34	909.09	51.99	526.55	-141.60	114.44
	08/15/99	940.56	34.46	923.00	-	632.67	487.51	923.00	931.78	34.46	533.91	-156.19	119.70
	08/30/99	948.69	31.28	931.09	-	637.02	489.98	931.09	939.89	31.28	537.58	-158.14	121.21
	09/15/99	956.75	27.83	938.36	-	640.65	491.79	938.36	947.06	27.83	540.64	-160.10	122.62
	09/30/99	958.08	23.03	947.01	-	643.04	491.06	947.01	953.05	23.03	542.66	-163.47	124.06
	10/15/00	963.38	18.86	954.86		646.70	491.12	954.86	959.12	18.85	544.90	166.26	125.43
	10/31/99	973.25	5.56	966.30	-	648.04	489.42	966.30	970.78	5.58	547.73	-171.69	126.76
	11/15/00	973.34	1.26	977.48	-	650.80	487.30	977.48	975.41	1.26	549.12	-175.74	129.95
	11/30/99	975.73	-2.04	980.87	-	651.25	486.45	980.87	978.30	-2.84	549.59	-177.26	130.86
	12/15/99	974.90	-2.47	982.11	-	651.08	486.25	982.11	978.54	-2.47	549.03	-177.77	130.87
	12/31/00	974.03	-54.00	984.71		634.91	460.02	984.71	979.37	-54.00	535.80	-188.11	137.85
	00/01/00	984.52	3.96	981.83	-	650.07	484.19	981.83	973.17	3.86	548.59	-178.41	129.31
	00/30/00	977.80	-36.92	980.73	-	640.54	470.44	980.73	979.27	-36.92	540.55	-182.94	135.56
	00/30/00	1000.20	10.20	1005.99		668.33	499.50	1005.99	1007.60	10.20	564.01	181.58	135.77
	01/15/01	1014.12	-29.4499	1029.11	-	671.20	492.33	1029.11	1021.61	-29.45	560.46	-192.44	140.21
	04/20/01	1008.27	-18.8867	1022.57	-	670.72	494.79	1022.57	1015.42	-18.69	566.07	-189.21	137.95
	07/10/01	1030.41	-0.36772	1010.56	-	660.53	511.02	1010.56	1024.98	-8.37	574.30	-182.32	137.85
	10/09/01	1054.25	-20.5131	1030.05	-	690.80	516.87	1030.05	1040.45	-20.51	582.96	-187.07	142.33
	01/09/02	1056.98	-29.65	1045.80	-	690.70	513.15	1045.80	1050.88	-29.65	582.88	-190.96	144.14
	04/12/02	1041.9	-24.6100	1040.36	-	695.01	508.54	1040.36	1041.13	-24.82	578.76	-190.66	142.20
	07/18/02	1062.21	-17.26	1035.12	17.14	693.30	522.47	1035.12	1048.67	-17.26	585.12	-183.79	142.20
	10/09/02	1088.98	-30.07	1049.75	-8.63	702.02	528.16	1049.75	1068.06	-30.07	592.43	-187.00	146.49
	01/09/03	1080.45	-42.89	1062.04	0.41	700.17	518.78	1062.04	1071.70	-42.89	590.87	-195.09	148.60
	04/15/03	1058.37	-29.65	1049.86	22.95	695.19	514.66	1049.86	1054.67	-29.65	584.99	-191.81	144.64
	06/01/03	1081.03	31.16	1053.52	21.00	696.77	516.89	1053.52	1059.23	31.16	587.16	192.39	145.46
	08/07/03	1083.80	-27.00	1053.40	9.26	703.20	528.10	1053.40	1060.63	-27.00	590.43	-190.30	146.25
	10/07/03	1095.65	-38.67	1066.64	-0.69	707.84	528.45	1066.64	1081.10	-38.67	597.35	-192.95	149.38
	12/31/03	1100.16	64.89	1082.97	0.89	700.11	522.64	1082.97	1091.56	64.88	598.68	200.89	152.93
	04/19/04	1080.17	-43.07	1074.07	21.65	703.52	518.25	1074.07	1077.12	-43.67	593.70	-199.27	149.51
	07/13/04	1101.53	-34.89	1072.49	10.76	713.04	533.32	1072.49	1087.01	-34.89	601.74	-193.30	149.66
	10/00/04	1122.02	-45.70	1085.57	-8.86	720.80	538.56	1085.57	1104.19	-45.70	608.36	-196.11	153.40
	01/07/05	1116.60	-56.49	1097.39	-8.94	716.50	529.06	1097.39	1107.00	-56.49	606.34	-203.76	155.46
	04/09/05	1090.01	52.77	1096.58	5.48	714.29	523.12	1096.58	1097.80	52.77	602.78	205.59	153.49
	07/18/05	1110.44	-41.55	1096.50	-2.36	723.52	537.44	1096.50	1106.51	-41.55	610.03	-200.46	153.15
	08/26/05	1128.14	-43.63	1095.73	-10.20	726.75	542.26	1095.73	1111.93	-43.63	613.30	-198.43	154.15
	11/12/05	1127.46	44.76	1095.72	9.67	728.11	541.31	1095.72	1111.58	44.76	612.79	198.75	154.26
	01/10/00	1129.30	-64.30	1095.72	-19.70	720.20	532.53	1095.72	1112.54	-64.30	607.03	-201.91	156.99
	04/08/06	1114.90	-55.20	1095.72	-1.14	718.47	529.85	1095.72	1105.31	-55.20	606.32	-202.87	154.81
	07/10/06	1130.04	46.83	1095.72	9.42	726.61	542.05	1095.72	1113.33	46.83	613.19	198.50	154.77
	10/15/06	1154.81	-56.29	1095.72	-27.50	730.78	548.31	1095.72	1125.32	-56.29	618.71	-196.26	157.89
	01/18/07	1130.55	-68.49	1095.72	-21.73	722.26	535.53	1095.72	1117.64	-68.49	609.52	-200.84	158.23
	04/19/07	1125.50	-59.82	1095.72	-9.40	720.00	533.38	1095.72	1110.65	-59.82	608.31	-201.61	156.01
	07/20/07	1141.98	-47.08	1095.72	-16.09	730.01	547.15	1095.72	1118.55	-47.08	616.05	-196.67	155.50
	10/20/07	1161.91	62.03	1095.72	36.23	731.84	549.89	1095.72	1128.77	62.03	617.60	195.69	158.85
	01/07/00	1155.80	-80.00	1095.72	-28.03	727.75	543.76	1095.72	1125.66	-68.08	614.15	-197.80	159.24
	05/13/08	1100.48	-46.92	1095.72	7.39	716.43	526.78	1095.72	1098.10	-46.92	604.59	-203.97	152.75
	07/20/08	1169.20	67.76	1095.72	17.10	732.05	550.22	1095.72	1126.96	57.76	617.78	195.57	158.04
	10/30/08	1172.74	-73.81	1095.72	-23.97	731.50	549.47	1095.72	1134.23	-73.01	617.36	-195.84	161.15

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
17	07/01/99	575.00	589.00	243.00	-	469.00	582.00	243.00	409.00	589.00	395.79	121.54	-24.01
	07/15/99	585.00	602.00	237.00	-	474.67	593.50	237.00	411.00	602.00	400.57	127.81	-25.48
	07/30/99	594.35	611.17	230.68	-	478.73	602.76	230.68	412.52	611.17	404.00	133.40	-26.50
	08/15/99	595.87	611.09	242.56	336.68	446.81	603.98	289.63	419.73	473.89	377.06	112.70	-7.22
	08/31/99	601.58	616.82	241.00	-	486.47	609.20	241.00	421.29	616.82	410.53	132.00	-26.08
	09/15/99	605.96	622.42	240.47	-	489.62	614.19	240.47	423.22	622.42	413.19	133.98	-26.57
	09/30/99	608.62	624.20	240.71	336.96	452.88	616.91	288.85	425.17	480.59	382.18	117.62	-7.39
	10/15/99	612.67	629.40	240.27	336.21	454.69	621.14	288.24	426.57	482.81	383.71	119.35	-7.50
	10/31/99	616.46	631.80	243.11	336.29	456.91	624.13	289.70	429.78	484.05	385.59	119.90	-7.24
	11/15/99	618.54	632.45	245.83	337.79	458.90	626.00	291.81	432.69	485.12	387.27	119.81	-6.99
	11/30/99	623.35	635.58	240.71	340.31	461.99	629.47	294.51	436.03	487.95	389.07	120.09	-6.93
	12/15/99	624.21	637.77	247.77	339.95	462.43	630.99	293.86	435.99	488.86	390.24	120.07	-7.05
	12/31/99	626.00	640.60	249.07	341.45	464.57	633.73	295.41	437.99	491.16	392.05	121.29	-7.09
	03/31/00	634.53	648.30	254.09	346.09	471.10	641.41	300.79	444.01	497.60	397.56	122.12	-7.07
	06/30/00	640.05	652.80	250.00	342.06	471.40	646.43	296.53	445.52	497.43	397.88	125.44	-6.93
	09/30/00	647.10	661.13	247.62	338.70	473.17	654.14	292.20	447.36	499.90	399.31	129.70	-6.80
	01/13/01	654.080	665.1118	256.30	342.22	479.45	659.60	299.31	455.23	503.67	404.61	129.16	-6.46
	04/20/01	664.420	664.7067	260.37	345.47	481.25	659.57	302.92	457.40	505.09	406.12	127.86	6.36
	07/10/01	661.456	672.0905	256.15	342.75	483.11	666.78	299.45	458.80	507.43	407.70	131.69	-6.49
	10/09/01	669.361	679.0030	251.93	338.20	484.37	673.68	295.06	460.14	508.60	408.76	135.74	6.46
	01/09/02	671.093	683.4721	252.17	337.92	486.16	677.28	295.04	461.63	510.69	410.27	137.04	6.55
	04/12/02	660.17	680.02	256.68	342.06	486.08	674.60	299.37	462.93	511.04	410.96	134.52	6.42
	07/10/02	671.60	683.98	253.27	272.93	470.46	677.83	263.10	462.48	478.44	397.02	148.69	2.13
	10/08/02	679.60	692.21	247.01	332.37	487.54	685.40	289.69	462.80	512.29	411.44	141.87	-6.60
	01/08/03	678.44	689.32	251.28	334.22	488.31	683.88	292.75	464.86	511.77	412.09	140.22	-6.26
	04/15/03	679.46	692.46	254.73	341.09	491.93	685.95	297.91	467.09	516.77	415.14	139.12	-6.63
	08/01/03	678.76	689.86	256.43	341.09	491.53	684.30	298.76	467.60	515.47	414.80	138.22	-6.39
	08/07/03	682.33	695.54	251.15	336.74	491.44	688.94	293.95	466.74	516.14	414.73	141.61	-6.59
	10/07/03	688.23	700.57	250.14	334.87	492.95	693.40	292.50	468.19	517.72	416.00	143.73	-6.61
	12/31/03	689.48	700.61	257.04	341.05	497.05	695.05	299.04	473.26	520.83	419.46	141.97	-6.35
	04/13/04	689.24	699.88	260.70	346.65	499.12	694.56	303.68	474.97	523.27	421.21	140.14	-6.44
	07/13/04	688.10	687.50	255.46	341.33	493.37	680.34	298.39	474.28	504.46	412.98	136.93	-4.03
	10/08/04	699.03	710.89	250.83	337.39	499.53	704.96	294.11	474.93	524.14	421.56	147.30	-6.56
	01/07/05	699.07	711.40	253.31	339.95	500.95	705.26	296.63	476.19	525.70	422.75	148.50	-6.61
	04/08/05	696.43	708.09	257.94	343.81	501.57	702.26	300.87	477.18	525.95	423.27	143.90	-6.51
	07/18/05	699.56	708.33	253.71	338.36	499.99	703.94	296.04	476.64	523.35	421.94	146.24	-6.23
	08/20/05	702.04	711.17	250.91	335.97	500.02	706.61	293.44	476.47	523.57	421.97	148.13	-6.26
	11/12/05	701.95	699.00	251.60	337.06	497.57	700.70	294.37	476.02	518.33	419.90	145.70	-5.54
	01/10/06	705.16	715.03	253.47	339.58	503.31	710.10	296.53	479.32	527.31	424.75	148.27	-6.40
	04/09/06	703.84	713.04	259.52	343.20	504.93	708.49	301.36	481.70	528.12	426.11	145.96	-6.19
	07/19/06	700.37	716.01	256.84	339.95	505.29	712.19	298.39	482.61	527.98	426.42	148.35	-6.05
	10/18/06	713.29	721.20	251.76	334.02	505.08	717.27	292.89	482.52	527.63	426.24	152.14	-6.02
	01/10/07	712.04	717.98	256.52	336.54	505.96	715.40	296.53	484.68	527.25	426.08	150.17	-5.68
	04/19/07	711.13	716.21	260.62	340.56	507.13	713.67	300.59	485.88	528.38	427.07	148.10	-5.67
	07/09/07	713.04	716.74	255.22	334.18	504.79	714.80	294.70	484.13	525.46	426.00	150.64	-5.51
	10/20/07	715.97	721.74	250.87	329.51	504.52	718.85	290.19	483.42	525.62	425.77	153.68	-5.63
	01/07/08	710.26	723.03	256.47	335.12	508.80	721.59	295.79	487.87	529.52	429.29	152.65	5.56
	05/13/08	696.61	707.10	257.94	343.56	501.30	701.85	300.75	477.22	525.38	423.05	143.80	6.42
	07/20/08	720.07	723.56	259.40	335.76	509.70	721.82	297.58	489.74	529.66	430.14	152.09	5.33
	10/30/08	723.81	727.50	255.66	332.68	509.91	725.66	294.17	489.74	530.09	430.32	154.69	-5.38

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	s1	s2	s3	s4	Avg. s	(s1+s2)/2	(s3+s4)/2	(s1+s3)/2	(s2+s4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
18	07/01/99	546.00	501.00	248.00	173	367.00	523.50	210.50	397.00	337.00	309.71	112.21	8.00
	07/15/99	557.00	513.00	243.00	229	386.50	535.00	236.00	400.00	371.00	325.32	107.20	3.87
	07/30/99	555.55	518.94	239.54	224.26	387.32	537.75	231.90	402.55	372.10	326.86	111.44	4.06
	08/15/99	557.71	520.14	230.56	232.51	387.73	543.93	231.54	399.14	376.33	327.21	112.00	3.04
	08/31/99	573.72	528.60	247.46	232.87	395.14	550.15	240.17	410.59	379.70	333.46	111.17	4.17
	09/15/00	578.06	532.08	246.65	233.61	397.80	555.07	240.13	412.36	382.85	335.53	112.91	3.94
	09/30/00	582.49	534.07	247.46	234.05	399.74	558.73	240.76	414.98	384.51	337.34	114.00	4.06
	10/15/00	586.68	538.17	247.25	235.23	401.83	562.43	241.24	416.97	386.70	339.11	115.15	4.04
	10/31/00	590.77	539.40	249.37	235.6	403.79	565.09	242.49	420.07	387.50	340.75	115.66	4.34
	11/15/00	592.66	540.66	251.68	237.47	405.61	566.65	244.58	422.17	389.06	342.30	116.47	4.42
	11/30/00	596.63	527.26	254.12	239.69	404.42	561.94	246.91	425.38	383.47	341.29	112.94	5.58
	12/15/00	600.47	545.63	254.12	239.05	409.61	572.50	246.59	426.80	392.29	345.61	116.84	4.60
	12/31/99	601.54	549.45	255.38	239.17	411.14	575.00	247.28	428.46	393.81	346.96	117.49	4.62
	03/31/00	610.32	554.07	262.08	243.60	417.72	582.50	252.84	436.20	399.23	352.51	118.22	4.93
	06/30/00	616.94	539.60	260.08	238.93	414.11	578.27	249.06	438.96	389.26	349.47	117.70	6.63
	09/30/00	625.03	409.70	255.50	232.10	378.54	517.19	243.00	440.01	319.47	319.45	90.55	16.56
	01/13/01	632.372	500.0390	264.44	235.84	424.83	566.53	250.14	448.40	401.26	358.52	125.26	6.29
	04/20/01	632.575	501.0309	266.30	236.21	424.07	567.05	252.29	450.40	398.07	358.38	125.00	6.08
	07/10/01	638.684	509.2893	264.84	234.54	427.04	604.49	249.59	452.16	401.91	360.38	127.23	6.70
	10/09/01	646.508	510.5187	259.81	232.14	428.74	611.51	245.97	453.16	404.33	361.82	131.05	6.51
	01/09/02	650.885	516.8446	259.66	230.92	429.59	613.87	245.30	455.29	403.88	362.53	132.14	6.88
	04/17/02	650.123	519.1017	264.197	232.55	429.24	610.11	248.37	457.16	401.33	362.24	129.69	7.45
	07/18/02	654.45	522.48	260.80	226.38	428.30	612.96	243.64	457.18	399.42	361.44	132.40	7.71
	10/08/02	654.68	521.14	254.65	222.68	426.54	620.41	238.66	457.17	401.91	362.49	136.86	7.37
	01/08/03	657.75	519.89	257.57	224.47	429.17	617.32	241.02	457.67	400.68	362.18	134.91	7.60
	04/15/03	661.78	518.19	262.16	228.04	432.04	618.99	245.10	461.97	402.12	364.60	134.04	7.98
	06/01/03	661.37	522.66	264.07	227.59	431.43	617.02	245.83	462.72	400.13	364.08	133.07	8.35
	09/07/03	665.78	527.29	258.18	222.76	431.00	621.53	240.47	461.97	400.03	363.72	136.81	8.26
	10/07/03	660.26	522.73	256.11	222.56	432.66	625.99	239.33	462.68	402.65	365.13	138.62	8.01
	12/31/03	670.27	531.30	262.53	229.62	436.05	625.83	246.08	466.40	405.51	367.90	136.15	8.12
	04/13/04	660.42	578.64	266.47	232.35	436.22	623.03	249.41	467.94	404.49	368.12	133.95	8.46
	07/10/04	672.95	570.63	261.80	224.79	434.54	625.79	243.29	467.37	401.71	366.71	137.13	8.76
	10/09/04	677.95	567.12	255.42	222.31	435.70	632.53	238.87	466.68	404.72	367.69	141.14	8.27
	01/07/05	677.50	568.02	257.61	226.05	436.00	631.76	241.83	467.56	406.04	368.61	139.80	8.21
	04/08/05	674.17	580.83	260.14	227.80	436.48	627.50	245.47	468.65	404.31	368.35	136.96	8.50
	07/18/05	677.87	580.70	259.40	221.74	434.93	629.29	240.57	468.63	401.22	367.04	139.36	8.99
	08/20/05	679.25	583.30	256.27	219.43	434.56	631.28	237.85	467.76	401.37	366.73	141.05	9.06
	11/12/05	679.13	583.14	256.00	220.00	434.81	631.13	238.40	468.00	401.61	366.93	140.77	9.06
	01/10/06	679.45	587.32	257.33	223.00	436.78	633.39	240.17	468.39	405.16	368.60	140.97	8.43
	04/09/06	678.57	583.14	263.01	226.46	438.05	631.36	244.74	471.29	404.80	369.67	138.61	8.87
	07/19/06	683.27	585.78	260.94	222.31	438.08	634.53	241.63	472.11	404.05	369.69	140.86	9.08
	10/18/06	687.01	592.40	255.09	218.65	438.29	639.70	236.88	471.05	405.53	369.87	144.42	8.74
	01/18/07	685.10	588.58	259.16	221.83	438.67	636.84	240.49	472.13	405.20	370.19	142.10	8.93
	04/15/07	685.18	584.40	264.40	222.96	439.23	634.79	243.68	474.79	403.68	370.67	140.22	9.49
	07/09/07	687.74	584.85	259.24	215.85	436.92	636.29	237.55	473.49	400.35	368.72	142.96	9.76
	10/20/07	690.01	591.22	253.79	213.46	437.12	640.62	233.63	471.90	402.34	368.89	145.91	9.28
	01/07/08	691.80	593.98	258.30	218.94	440.73	642.89	238.62	475.05	406.40	371.93	144.91	9.16
	05/13/08	675.23	578.71	263.42	226.74	436.03	626.97	245.08	469.32	402.73	367.96	136.91	8.88
	07/20/08	691.03	590.46	261.06	217.03	440.87	642.69	239.05	478.00	403.74	372.05	144.71	9.91
	10/30/08	696.63	596.14	256.52	215.81	441.28	646.39	236.16	476.57	405.98	372.39	147.07	9.42

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
19	07/01/99	588.97	588.00	298.00	297.9	419.97	576.49	263.45	437.49	407.45	354.41	112.23	3.34
	07/15/99	581.00	597.00	294.00	274	423.75	568.50	259.00	437.00	410.50	357.60	118.13	3.54
	07/30/99	588.71	608.46	291.35	278.82	426.29	597.59	255.00	440.05	417.54	359.75	122.82	3.67
	08/15/99	591.02	607.35	300.95	277.92	431.81	599.19	264.44	445.99	417.64	364.40	120.01	3.78
	08/31/99	595.94	613.52	300.59	279.63	434.92	604.73	265.11	448.27	421.58	367.03	121.76	3.56
	09/15/99	598.88	617.91	300.67	279.54	437.00	608.90	265.11	450.28	423.73	368.78	123.25	3.54
	09/30/99	603.53	621.86	302.70	279.75	439.41	612.69	266.23	453.12	425.70	370.82	124.18	3.66
	10/15/99	607.51	625.02	302.29	279.71	441.13	616.27	266.00	454.90	427.37	372.27	125.57	3.67
	10/31/99	611.37	627.25	306.07	279.7	443.60	619.31	267.89	458.72	428.48	374.35	125.99	4.03
	11/15/99	613.61	627.78	308.31	282.67	446.59	620.70	270.49	460.96	430.23	376.04	125.55	4.10
	11/30/99	615.09	630.54	313.83	284.7	448.84	623.42	274.27	465.06	432.62	378.78	125.17	4.33
	12/15/99	617.83	631.44	314.03	284.9	449.55	624.64	274.47	465.93	433.17	379.36	125.54	4.37
	12/31/99	619.94	634.20	314.36	286.45	451.24	627.07	275.41	467.15	435.33	380.80	126.08	4.25
	01/31/00	628.45	638.44	320.33	289.74	456.74	634.44	280.03	474.89	439.59	385.86	127.06	4.71
	06/30/00	636.16	643.50	317.81	51.91	412.34	639.83	184.86	476.98	347.71	347.98	163.11	17.25
	09/30/00	648.59	651.99	312.33	291.29	468.55	649.29	271.81	479.46	441.64	388.66	135.33	5.04
	01/15/01	653.464	657.0691	320.71	296.77	466.88	655.26	278.49	486.83	446.92	394.00	135.06	5.32
	04/20/01	651.464	653.2102	324.03	297.42	466.53	652.34	280.72	487.74	445.32	393.71	133.23	5.66
	07/10/01	658.858	661.1717	320.61	295.03	468.92	660.01	277.82	489.74	448.10	397.72	137.02	5.55
	10/04/01	667.368	669.2561	315.37	290.97	470.74	668.30	273.17	491.36	450.11	397.25	141.66	5.50
	01/08/02	670.88	671.7736	315.66	229.71	472.00	671.33	272.68	493.27	450.74	396.32	142.92	5.67
	04/12/02	667.71	665.64	321.06	231.62	471.51	666.68	276.34	494.39	448.63	397.90	139.94	6.10
	07/19/02	673.44	667.87	319.86	227.72	472.23	670.66	273.80	496.66	447.79	398.51	142.28	6.52
	10/08/02	661.93	676.18	313.24	222.91	473.56	679.05	268.07	497.58	449.54	399.64	147.34	6.41
	01/08/03	662.42	673.60	316.88	225.03	474.48	678.01	270.96	499.65	449.32	400.42	145.93	6.71
	04/15/03	668.11	672.95	321.26	226.37	477.17	679.53	274.81	503.69	450.66	402.69	145.10	7.07
	06/01/03	665.30	670.80	322.46	227.84	476.60	678.05	275.16	503.89	449.32	402.21	144.44	7.28
	08/07/03	668.12	675.35	317.28	223.09	476.21	682.23	270.18	503.20	449.22	401.87	147.72	7.20
	10/07/03	664.46	661.03	314.64	222.27	478.11	687.76	268.46	504.56	451.65	403.47	150.32	7.06
	12/31/03	695.94	680.95	322.73	229.34	482.24	688.45	276.03	509.33	455.15	406.96	147.86	7.23
	04/13/04	695.62	676.77	330.77	231.41	483.64	686.19	281.09	513.19	454.09	408.15	145.23	7.66
	07/13/04	703.37	679.61	327.88	224.22	483.02	689.99	276.05	514.13	451.92	407.62	148.40	8.30
	10/08/04	705.18	688.67	321.87	221.22	484.48	697.43	271.54	514.03	454.94	408.86	152.68	7.88
	01/07/05	705.37	688.14	324.72	224.55	486.69	696.75	274.63	515.04	456.35	409.86	151.34	7.83
	04/08/05	702.85	687.86	329.75	226.66	486.53	695.36	278.21	516.30	454.76	409.74	148.66	8.21
	07/18/05	705.50	683.55	327.15	219.55	484.19	695.03	273.35	516.83	451.55	408.61	151.18	8.71
	08/26/05	708.05	686.48	322.81	217.89	483.80	697.26	270.35	515.43	452.18	408.26	153.05	8.44
	11/12/05	707.97	686.27	323.74	216.33	484.08	697.12	271.04	515.85	452.30	408.51	152.76	8.48
	01/10/06	710.04	690.54	324.66	221.62	486.72	700.29	273.15	517.36	456.08	410.74	153.13	8.17
	04/08/06	709.47	688.72	329.75	224.34	487.57	698.10	277.05	519.61	455.53	411.46	150.95	8.55
	07/18/06	714.26	690.38	326.09	220.57	488.32	702.32	274.33	521.17	455.47	412.10	153.44	8.76
	10/18/06	718.93	696.80	321.91	216.75	488.60	707.86	269.33	520.42	456.77	412.33	157.22	8.49
	01/18/07	717.19	692.98	326.63	219.88	489.17	705.08	273.25	521.91	456.43	412.81	154.82	8.73
	04/19/07	716.98	689.52	331.50	221.54	489.89	703.25	276.52	524.24	455.53	413.42	152.99	9.17
	07/09/07	720.84	690.13	327.60	214.47	488.21	705.39	271.04	524.12	452.30	412.00	155.72	9.56
	10/20/07	723.97	695.70	321.16	211.96	488.20	709.83	266.57	522.58	453.83	411.99	156.92	9.17
	01/07/08	725.43	698.46	326.71	217.89	492.12	711.95	272.30	526.07	458.17	415.30	157.62	9.06
	05/13/08	703.58	681.44	330.20	225.12	485.08	692.51	277.66	516.89	453.28	409.36	148.73	8.49
	07/29/08	728.03	698.92	329.23	216.75	492.73	712.47	272.99	528.63	456.83	415.82	157.56	9.58
	10/30/08	730.876	701.5886	324.269	216.383	493.28	716.23	270.33	527.57	458.99	416.26	159.86	9.15

Table 4 Pile Forces and Bending Moments (cont'd)

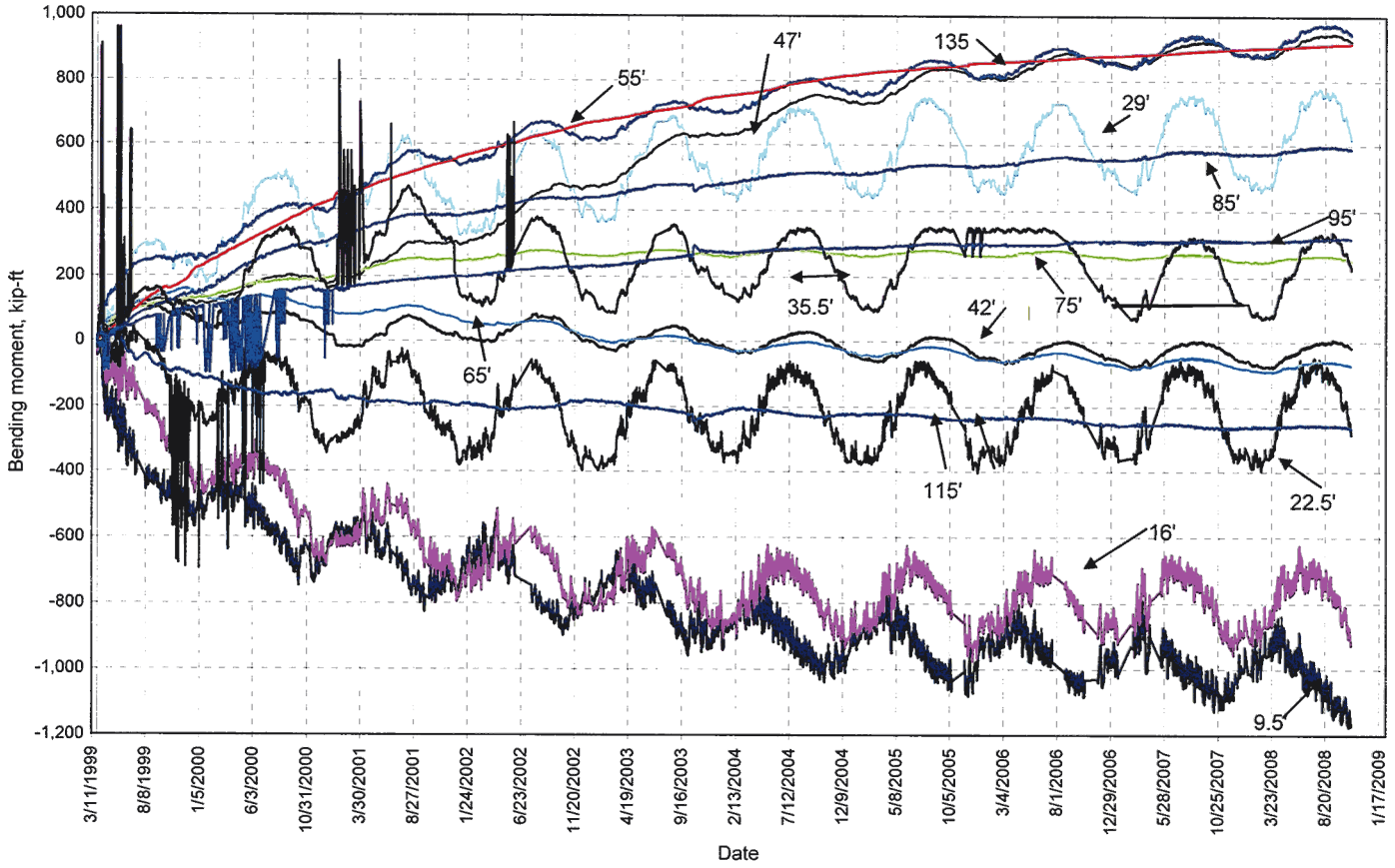
Pile #	Date	c1	c2	s3	s4	Avg. c	(s1+s2)/2	(s3+s4)/2	(s1+s3)/2	(s2+s4)/2	Axial Force(Kip)	Moment(x)(−Kip ft)	Moment(y)(Kip ft)
34	07/01/99	271.75	436.00	261.00	583.00	387.94	353.88	422.00	266.38	509.50	327.38	-24.42	-32.43
	07/15/99	279.00	617.00	253.00	583.00	433.00	448.00	418.00	266.00	600.00	365.41	10.76	-44.56
	07/30/99	282.70	647.00	243.61	585.13	439.61	464.90	414.39	263.22	616.07	371.01	18.11	-47.07
	08/15/99	272.80	600.00	251.16	614.66	457.20	481.49	432.91	262.03	652.38	385.83	17.12	-52.07
	08/31/99	266.66	576.80	245.14	627.09	428.87	421.23	436.12	255.40	601.95	361.76	-5.34	-46.23
	09/15/99	266.08	602.81	242.34	635.26	486.87	533.95	438.80	253.71	719.04	410.45	34.11	-62.07
	09/30/99	260.50	607.10	238.64	642.65	487.30	533.95	440.65	249.57	725.03	411.23	33.45	-63.43
	10/15/99	266.43	611.14	234.46	648.58	487.86	533.79	441.52	245.45	729.86	411.53	33.08	-64.62
	10/31/99	240.47	624.02	221.62	665.31	487.96	532.25	443.47	231.05	744.67	411.70	31.89	-68.52
	11/15/99	241.03	631.46	224.75	676.77	493.73	536.69	450.76	233.34	754.11	416.65	30.81	-69.47
	11/31/99	240.47	636.89	224.26	648.85	487.37	538.18	436.56	232.37	742.37	411.29	36.13	-68.03
	12/15/99	241.41	636.77	222.35	684.04	496.14	539.09	453.20	231.88	760.41	418.69	30.79	-70.51
	12/31/99	242.22	638.00	224.14	684.03	496.94	540.15	454.54	233.18	760.51	419.29	30.34	-70.35
	03/31/00	267.37	629.86	237.38	675.92	490.95	543.11	456.65	247.38	752.38	421.85	31.00	-67.37
	06/30/00	268.43	646.32	226.20	600.93	456.72	556.37	363.06	245.81	673.62	387.96	69.30	-57.07
	09/30/00	257.37	665.02	196.89	705.00	513.57	576.19	450.94	227.13	800.01	433.40	44.00	-76.42
	01/13/01	247.90	658.11	197.37	720.58	507.74	552.01	463.47	222.64	702.84	428.48	31.74	-76.07
	04/20/01	44.66	983.01	212.28	457.21	306.20	463.83	334.74	128.47	670.11	336.96	46.28	72.25
	07/10/01	-279.84	502.08	204.24	66.21	123.34	111.46	135.22	-37.85	284.53	104.09	-8.52	-43.01
	10/09/01	442.16	725.37	50.98	1109.80	804.80	583.76	625.44	246.57	962.63	510.22	-14.94	-95.52
	01/08/02	260.80	618.73	159.27	765.05	451.17	440.18	462.16	211.45	690.89	380.74	-7.88	-63.06
	04/12/02	67.35	578.97	58.13	501.01	301.81	323.66	279.57	62.74	540.49	254.53	15.81	-63.73
	07/19/02	200.88	841.04	187.83	727.59	536.29	614.86	457.71	238.26	834.31	452.57	56.34	-79.51
	10/09/02	277.15	862.54	162.58	740.98	535.91	610.84	451.78	219.86	851.76	452.17	60.25	-84.29
	01/09/03	258.07	848.53	162.24	758.66	531.82	602.80	460.45	209.15	854.10	448.64	51.04	-86.04
	04/15/03	277.18	828.37	109.53	744.52	534.90	602.70	467.03	203.36	836.45	451.41	40.67	-80.45
	06/01/03	277.96	808.01	184.90	749.68	537.98	608.40	467.29	231.43	844.35	453.03	50.62	-81.76
	09/07/03	200.88	865.06	171.66	750.09	543.90	626.80	460.87	230.17	857.50	458.08	59.52	-83.70
	10/07/03	274.90	878.21	155.53	762.04	542.88	620.50	459.19	215.25	870.53	456.14	60.01	-87.41
	12/31/03	258.20	863.57	156.03	795.22	548.47	620.92	476.03	207.55	869.40	462.00	51.95	-90.96
	04/13/04	261.17	960.30	188.88	781.65	553.00	620.73	485.27	235.03	870.97	466.68	48.57	-84.84
	07/13/04	302.80	991.98	173.93	772.27	560.20	647.42	473.10	238.40	902.12	472.00	62.50	-85.07
	10/08/04	295.03	1004.49	151.19	786.40	558.43	650.06	468.80	223.41	895.45	472.10	64.99	-89.65
	01/07/05	277.30	987.91	140.79	790.02	555.52	637.60	473.41	213.07	897.97	468.00	56.00	-91.36
	04/08/05	280.74	978.21	166.99	788.76	555.17	632.47	477.87	226.86	883.49	468.51	55.40	-87.59
	07/18/05	304.00	1000.02	160.94	783.60	562.14	652.01	472.27	232.47	891.81	474.09	64.44	-87.96
	08/20/05	301.80	1018.4	147.73	791.01	564.94	660.12	469.77	224.79	905.09	476.76	66.24	-90.75
	11/12/05	300.51	1018.3	147.02	793.35	564.98	659.40	470.56	224.16	905.03	476.00	67.70	-90.93
	01/10/06	274.59	1009.41	138.15	806.34	567.62	642.00	473.24	206.37	906.87	470.56	60.50	-93.71
	04/08/06	283.04	980.08	160.45	790.02	556.90	634.57	479.23	221.74	892.06	469.97	55.09	-89.42
	07/18/06	295.07	1009.41	149.73	796.56	562.64	652.54	473.14	222.70	902.90	474.90	64.32	-90.75
	10/18/06	284.79	1030.77	131.20	806.38	563.79	657.76	469.79	207.99	919.58	475.78	67.40	-94.92
	01/18/07	270.29	1012.82	134.82	813.33	557.51	641.55	474.08	202.55	913.08	470.74	60.04	-94.78
	04/19/07	262.35	980.04	150.99	805.37	558.44	639.20	479.60	210.17	900.71	472.11	57.19	-91.05
	07/09/07	306.44	1014.48	154.64	795.38	567.74	660.46	475.01	230.54	904.93	479.11	66.49	-89.96
	10/20/07	290.51	1037.35	126.69	809.72	566.07	663.93	468.21	208.60	923.54	477.71	70.17	-95.37
	01/07/08	274.00	1024.92	126.69	820.48	562.09	649.49	474.69	201.48	922.70	474.35	62.67	-96.21
	05/13/08	292.20	978.90	109.79	794.94	550.47	635.50	477.37	201.03	901.92	469.61	56.72	-90.03
	07/29/08	293.44	1034.59	136.97	816.54	570.39	664.02	476.76	215.20	925.57	481.35	67.13	-94.76
	10/30/08	272.32	1053.97	115.20	839.53	570.25	663.14	477.37	193.76	946.75	481.24	66.60	-100.45

Shaft 1: Bending moment along shaft, kip ft

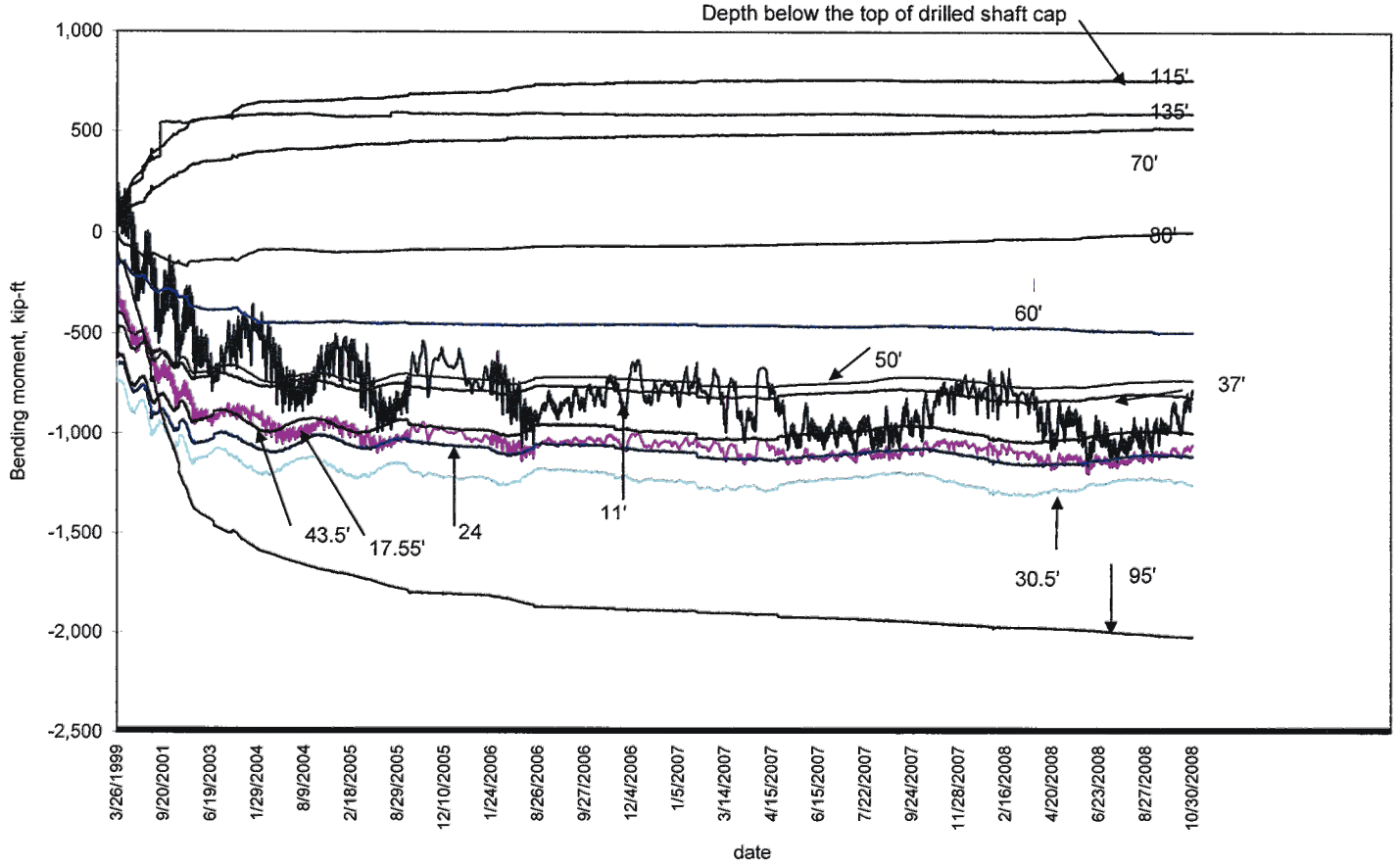
Depth, ft / Date	9.5	16	22.5	29	35.5	42	47	54.8	64.8	74.8	84.8	94.8	115	135
7/1/1999	-357.65	-148.91	-2.99	242.13	107.73	94.77	103.67	221.87	109.32	93.67	66.77	48.25	-38.94	91.57
1/8/2003	-774.82	-792.9	-360.63	403.12	139.71	-1.79	473.87	620.31	11.19	262.65	439.51	230.65	-179.6	668.9
4/15/2003	-657.74	-650	-232.57	481.71	156.43	-14.02	517.65	659.68	2.44	268.91	457.85	238.57	-192.49	684.79
7/1/2003	-763.24	-602.42	-72.91	660.28	319.17	32.14	588.57	715.87	14.21	278.09	474.99	251.23	-206	702.94
8/7/2003	-817.04	-638.73	-81.08	678	343.79	44.44	615.09	726.92	17.44	279.15	477.58	254.31	-210.32	708.78
10/7/2003	-913.81	-801.08	-248.05	552.54	251.84	20.93	623.3	710.92	6.8	271.9	474.43	265.58	-225.46	720.58
12/31/2003	-870.9	-838.68	-322.24	476.14	168.18	-13.93	630.87	701.76	-19.51	263.35	479.49	275.24	-220.96	748.57
4/13/2004	-831.87	-777.37	-255.87	514.98	175.37	-24.83	659.66	727.03	-27.47	269.67	495.81	277.88	-211.65	763.52
7/13/2004	-889.99	-676.85	-77.13	709.38	338.24	22.05	727.23	792.27	-5.75	281.7	512.3	283.5	-221.34	787.54
10/8/2004	-983.05	-812	-201.66	636.33	293	16.71	752.87	793.14	-7.37	272.19	514.89	286.68	-231.1	803.15
1/7/2005	-925.21	-882.29	-353.38	471.75	139.59	-39.87	733.05	761.38	-34.6	264.1	510.62	288.64	-223.06	817.18
4/8/2005	-775.03	-726	-235.05	530.47	150.69	-53.27	749.88	786.67	-40.37	267.3	525.48	290.73	-219.8	828.14
7/18/2005	-957.73	-709.43	-81.75	735.77	338.63	7.97	821.52	856.49	-16.82	278.55	538.72	298.79	-226.87	857.24
8/26/2005	-1005.57	-755.34	-117.03	721.71	336.36	13.6	835.13	860.64	-16.18	278.76	539.43	301.65	-233.64	840.82
10/11/2005	-1033.08	-827.24	-199.79	654.9	284.17	7.2946	833.72	848.04	-26.29	275.5	537.36	299.53	-240.08	843.25
1/10/2006	-918.83	-858.03	-339.71	489.13	122.55	-48.55	810.18	815.92	-54.94	262.93	536.1	298.82	-234.11	855.77
4/9/2006	901.14	812	289.67	510.35	123.88	55.75	815.9	831.32	58.19	267.19	540.25	311.97	239.53	860
7/19/2006	-975.46	-709.09	-86.84	727.21	303.99	-3.19	876.46	899.71	-33.29	280.02	563.21	306.55	-235.87	865.96
10/18/2006	-1030.45	-848.40	-245.88	609.17	218.59	-17.57	872.05	872.96	-49.65	267.05	557.80	306.95	-246.77	873.58
1/18/2007	-1015.18	-915.62	-363.79	485.63	115.44	-53.84	856.25	849.07	-71.01	257.71	555.06	310.45	-258.05	878.10
4/19/2007	-904.71	-791.93	-272.27	527.72	122.40	-65.28	862.30	869.52	-74.95	259.50	564.85	305.74	-254.07	882.60
7/11/2007	990.93	694.73	72.44	749.91	312.39	2.99	910.88	934.53	49.88	269.47	582.93	306.29	251.96	888.31
10/20/2007	-1018.74	-786.18	-177.53	678.23	263.08	-13.72	915.47	922.26	-57.70	265.45	581.36	309.85	-259.55	895.13
1/7/2008	-932.03	-833.86	-321.36	513.46	112.58	-59.96	880.84	888.07	-82.44	252.01	576.25	309.48	-259.33	899.85
5/13/2008	-996.19	-767.07	-192.33	624.95	201.71	-38.80	905.64	926.40	-76.11	259.52	583.95	312.62	-259.90	906.34
7/29/2008	-1053.77	-718.38	-76.47	765.95	324.25	-0.78	940.74	969.80	-60.05	264.41	595.70	316.01	-256.75	910.18
10/30/2008	-1167.90	-922.92	-282.64	616.39	225.65	-17.33	928.18	942.58	-71.33	250.22	588.42	319.79	-262.90	917.28

Shaft 9: Bending moment along shaft, kip-ft

Depth, ft / Date	11	17.5	24	30.5	37	43.25	50	60	70	80	95	115	135
7/1/1999	-67.89	-31.81	8.56	12.84	20.8	19.57	14.07	0.61	9.79	11.62	-53.55	18.55	26.5
1/8/2003	-347.44	-805.74	-998.93	-1106.33	-698.39	-905.77	-661.43	-553.18	324.27	-148.11	-1315.52	540.06	541.35
4/15/2003	-392.31	-919.8	-1030.61	-1153.34	-725.59	-939.66	-696.63	-569.12	336.59	-143.51	-1378.77	555.2	549.67
7/1/2003	-666.55	-902.58	-1016.77	-1090.93	-715.88	-914.42	-686.74	-565.16	340.01	-144.29	-1455.98	557.09	553.5
8/7/2003	-687.84	-917.2	-1003.18	-1077.98	-695.58	-886.87	-664.36	-584.64	332	-133.3	-1462.77	566.15	563.69
10/7/2003	-490.45	-866.81	-1007.81	-1107.14	-708.81	-891.63	-636.83	-578.93	360.91	-134.77	-1498.83	577.44	567.18
12/31/2003	-514.68	-913.37	-1054.9	-1163.2	-741.63	-949.18	-697.77	-421.12	390.01	-101.42	-1555.5	653.85	579.55
4/13/2004	-604.44	-966.22	-1090.5	-1188	-761.54	-987.22	-743.54	-446.54	402.54	-82.56	-1609.1	644.77	583.97
7/13/2004	-817.01	-1007.24	-1051.35	-1122.59	-730.91	-933.53	-709.92	-447.66	411.36	-83.06	-1648.19	649.1	585.94
10/8/2004	-674.74	-949.72	-1005.93	-1128.49	-732.6	-927.74	-697.54	-445.16	413.37	-90.78	-1677.71	652.24	581.64
1/7/2005	-572.76	-951.94	-1036.44	-1183	-760.9	-966.49	-718.51	-441.27	424.15	-94.18	-1699.91	657.05	578.07
4/8/2005	-773.86	-1039.72	-1072.89	-1200.56	-775.89	-989.82	-743.85	-446.59	435.56	-92.57	-1726.57	664.45	574.55
7/18/2005	-885.57	-1041.08	-1038.29	-1152.24	-752.36	-948.63	-719.09	-449.39	438.06	-89.12	-1762.02	670.82	576.24
8/26/2005	-845.3	-1020.01	-1028.45	-1146.98	-746.96	-935.35	-702.48	-447.31	442.07	-86.41	-1773.96	672.92	593.07
10/11/2005	-749.53	-997.4	-1026.45	-1157.47	-750.11	-932.26	-695.29	-443.61	446.57	-84.01	-1786.07	677.95	594.21
1/10/2006	-753.34	-1025.94	-1070.26	-1220.95	-784.71	-986.06	-728.35	-455.6	455.8	-79.41	-1811.1	694.94	585.21
4/9/2006	-761.63	-1055.46	-1104.66	-1250.13	-799.79	-1009.4	-750.25	-456.86	465.33	-75.95	-1830.39	709.25	584.13
7/19/2006	-986.65	-1097.57	-1069.44	-1182.51	-765.49	-967.32	-726.98	-458.20	468.35	-67.36	-1860.26	728.74	591.17
10/18/2006	-785.55	-1028.56	-1059.04	-1198.03	-770.44	-962.79	-714.95	-455.21	472.24	-63.08	-1878.38	740.33	587.52
1/18/2007	-652.26	-1012.08	-1093.82	-1249.92	-798.31	-1001.31	-738.72	-453.20	481.92	-62.15	-1891.06	749.16	583.45
4/19/2007	-878.81	-1101.41	-1131.14	-1269.03	-817.30	-1023.35	-760.98	-458.74	484.61	-55.95	-1908.23	757.30	587.07
7/11/2007	-1020.68	-1113.23	-1096.67	-1211.04	-787.54	-982.11	-738.79	-463.61	490.76	-47.79	-1930.33	760.68	591.55
10/20/2007	-959.39	-1084.45	-1073.44	-1199.41	-780.45	-961.01	-714.61	-460.69	495.15	-40.84	-1949.93	755.58	587.47
1/7/2008	-913.31	-1106.23	-1119.18	-1262.45	-816.00	-1007.26	-741.89	-466.44	500.87	-33.08	-1965.87	755.43	582.76
5/13/2008	-919.37	-1116.30	-1144.79	-1275.67	-828.86	-1025.45	-760.98	-473.48	501.61	-23.44	-1981.23	753.14	584.24
7/29/2008	-1028.17	-1130.81	-1113.35	-1223.79	-801.01	-987.62	-739.09	-483.79	512.25	-5.89	-2001.20	757.38	590.22
10/30/2008	-795.34	-1059.58	-1112.41	-1254.85	-817.39	-995.34	-732.06	-493.84	517.37	5.70	-2022.36	758.24	590.22



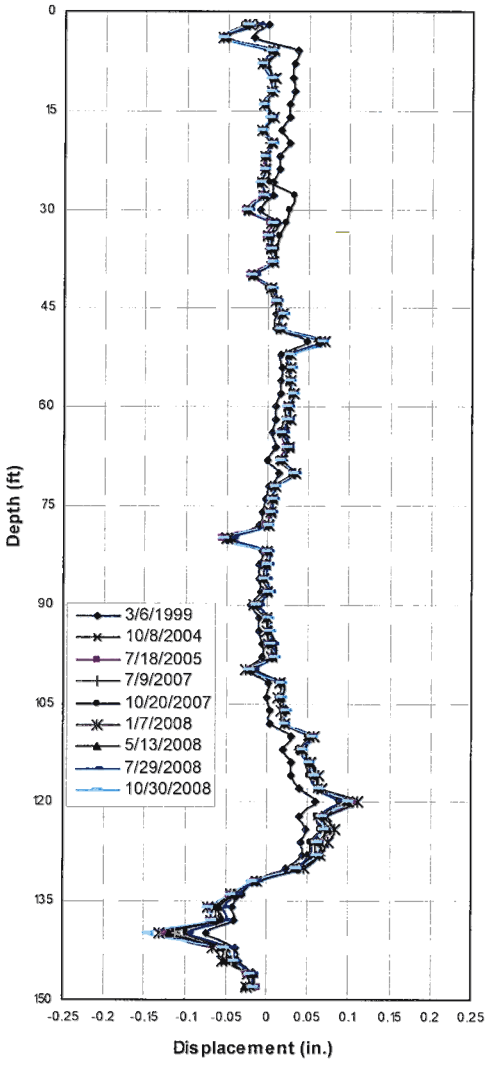
Shaft #1, Bending moment vs. date in different elevations below the top of cap



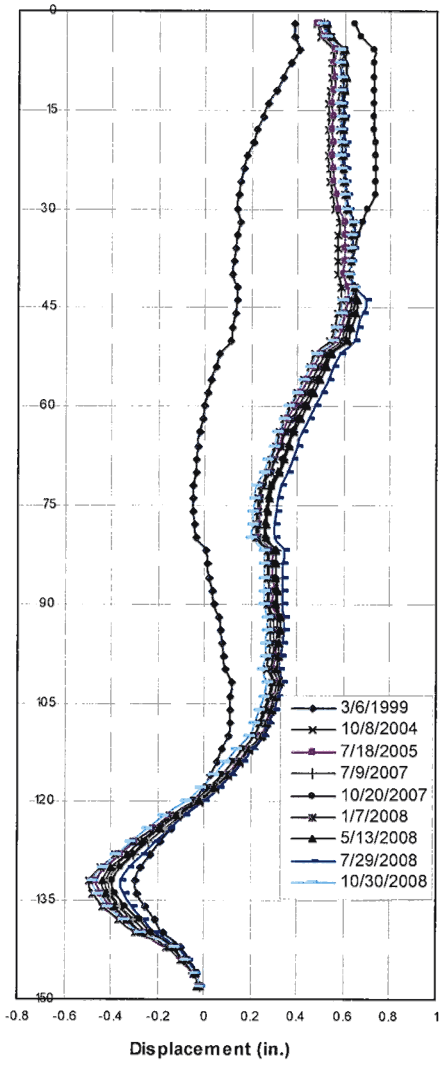
Shaft #9, Bending moment vs. date in different elevations below the top of cap

Inclinometer #1 Displacement in the A+ Direction
Downslope (Toward river direction) Base Line 12/11/1998

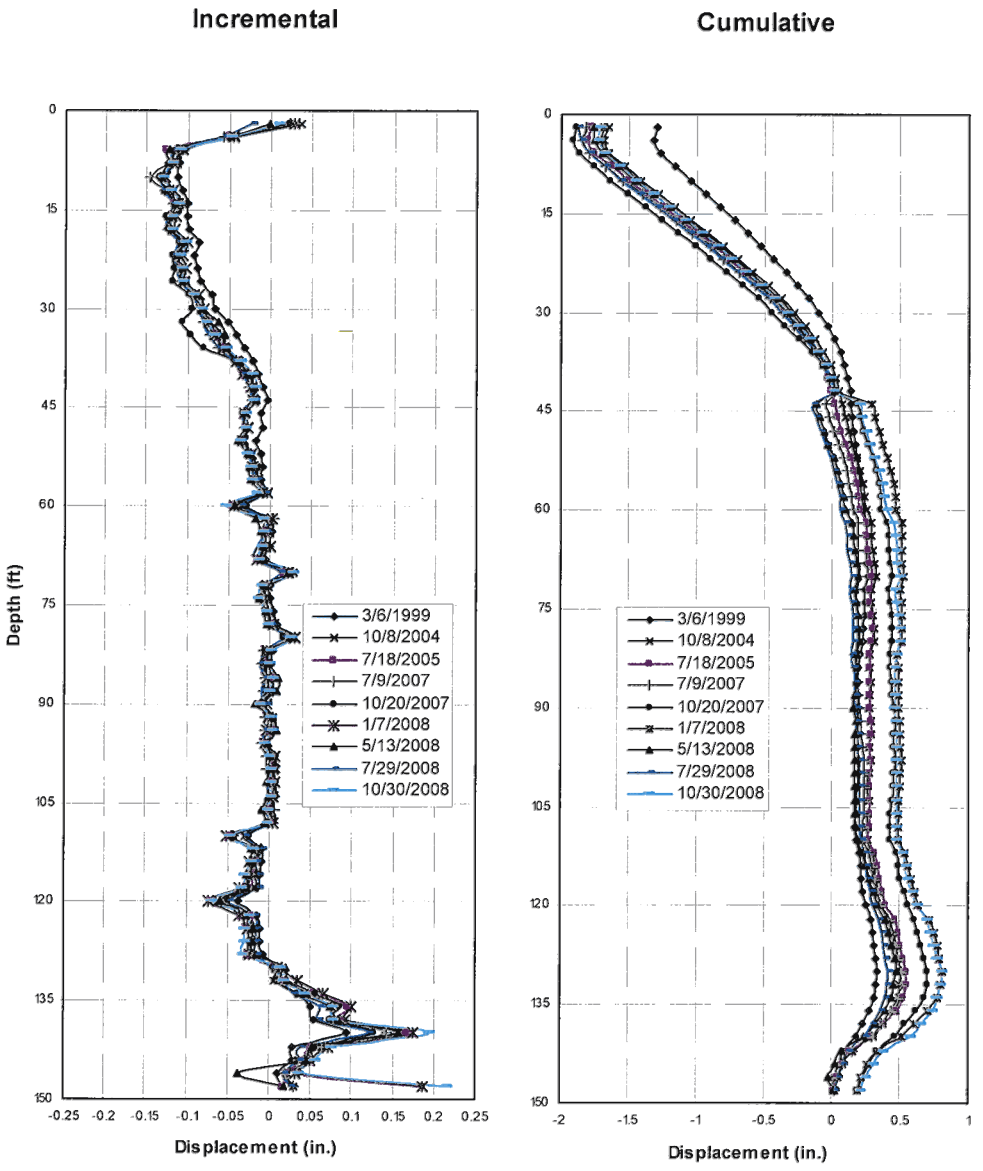
Incremental



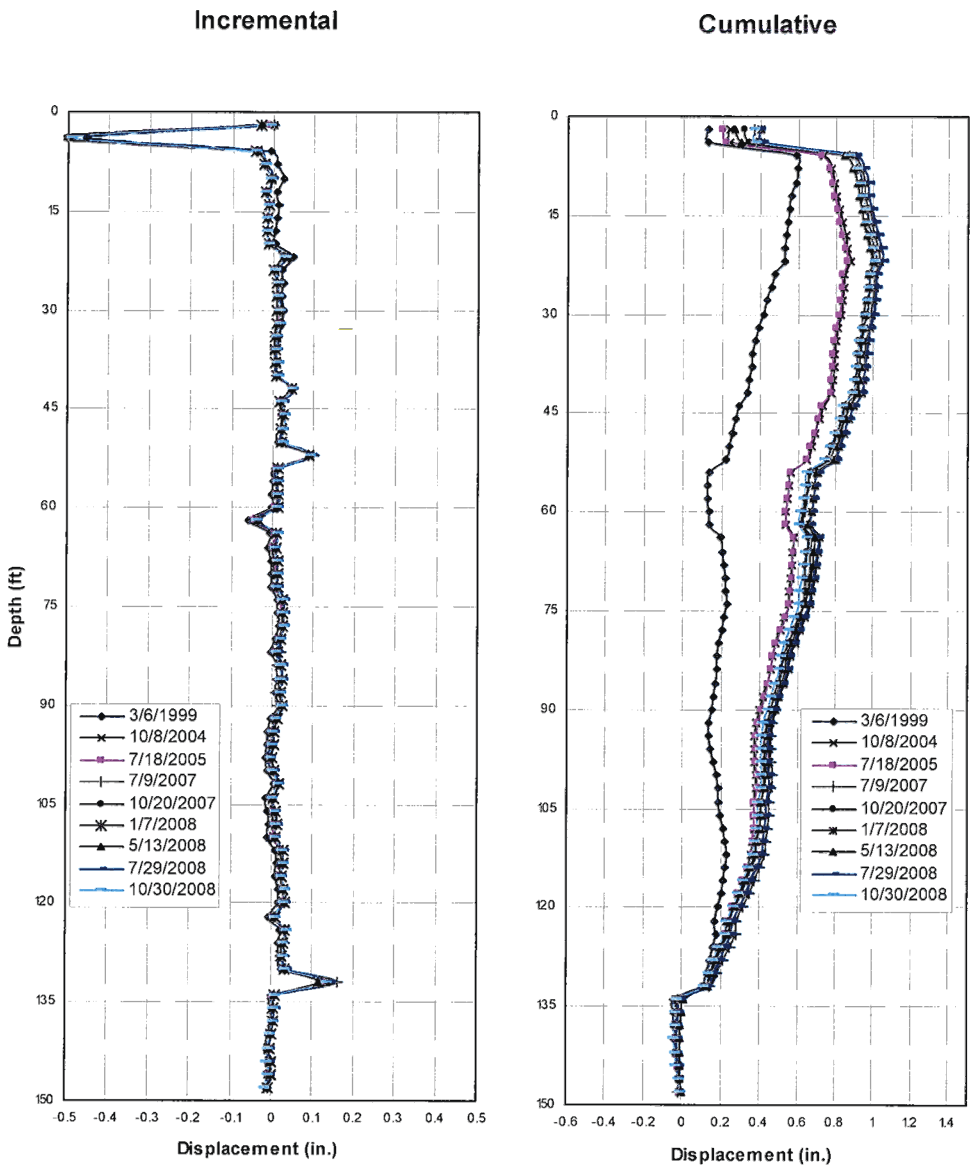
Cumulative



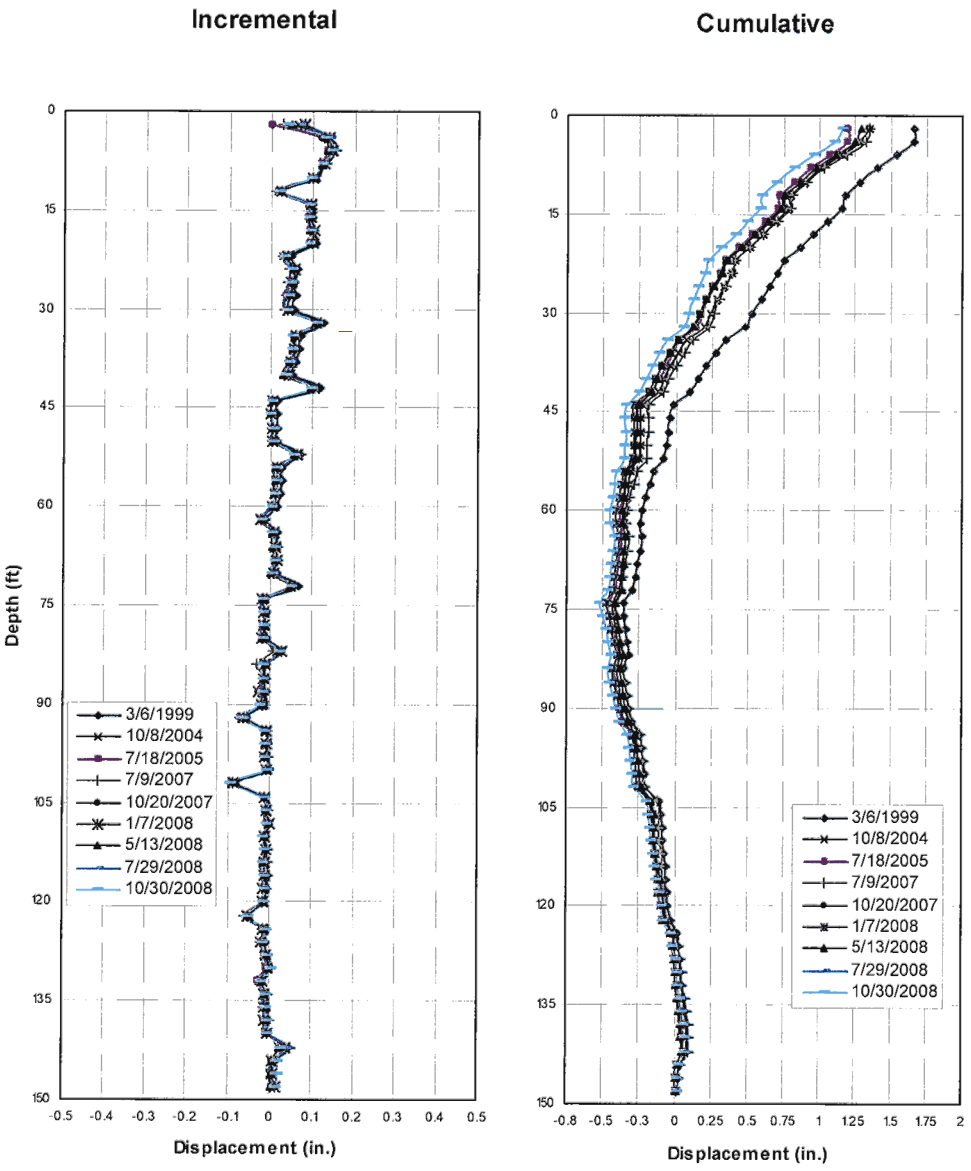
Inclinometer #1 Displacement in the B+ Direction
Along slope (Along river direction) Base Line 12/11/1998



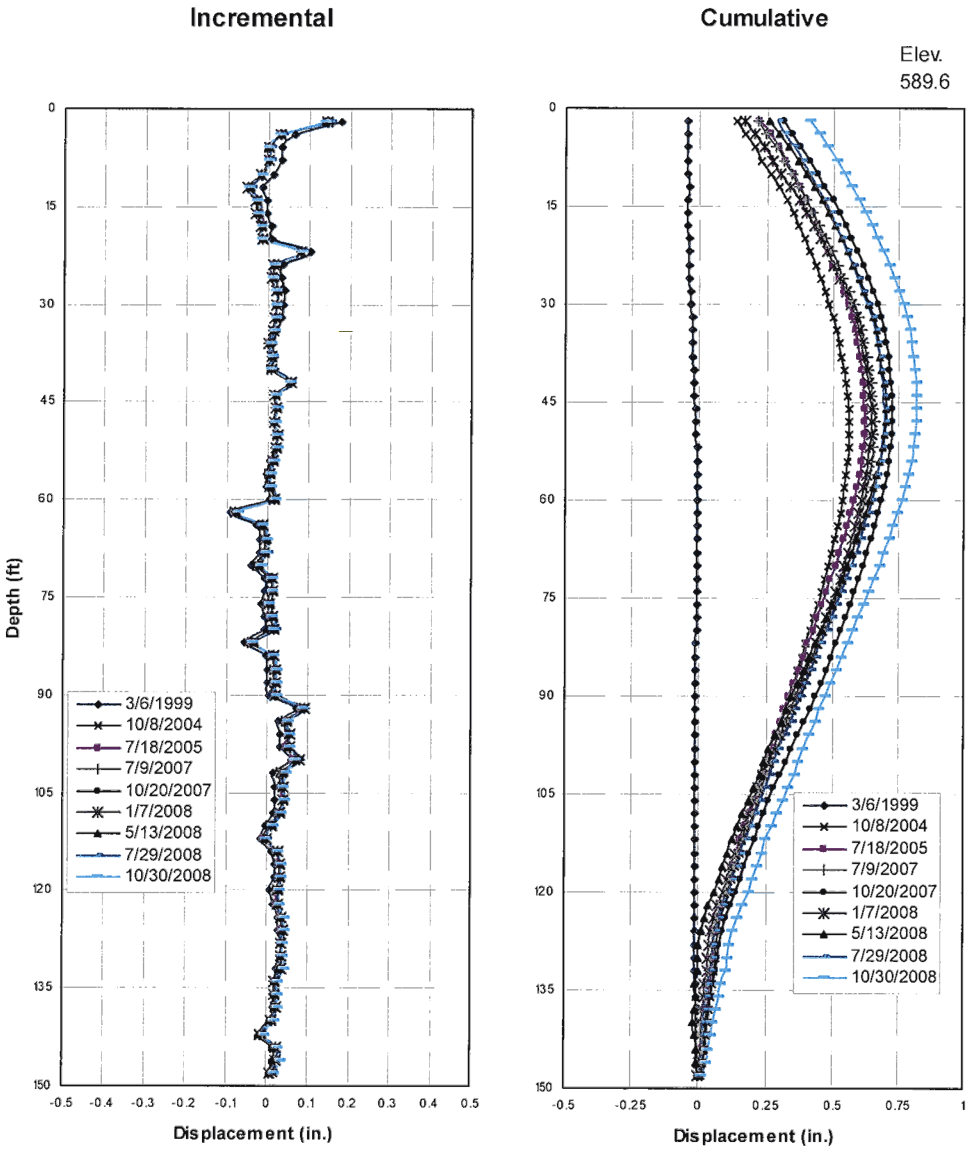
Inclinometer #3 Displacement in the A+ Direction
Downslope (Toward river direction) Base Line 12/11/1998



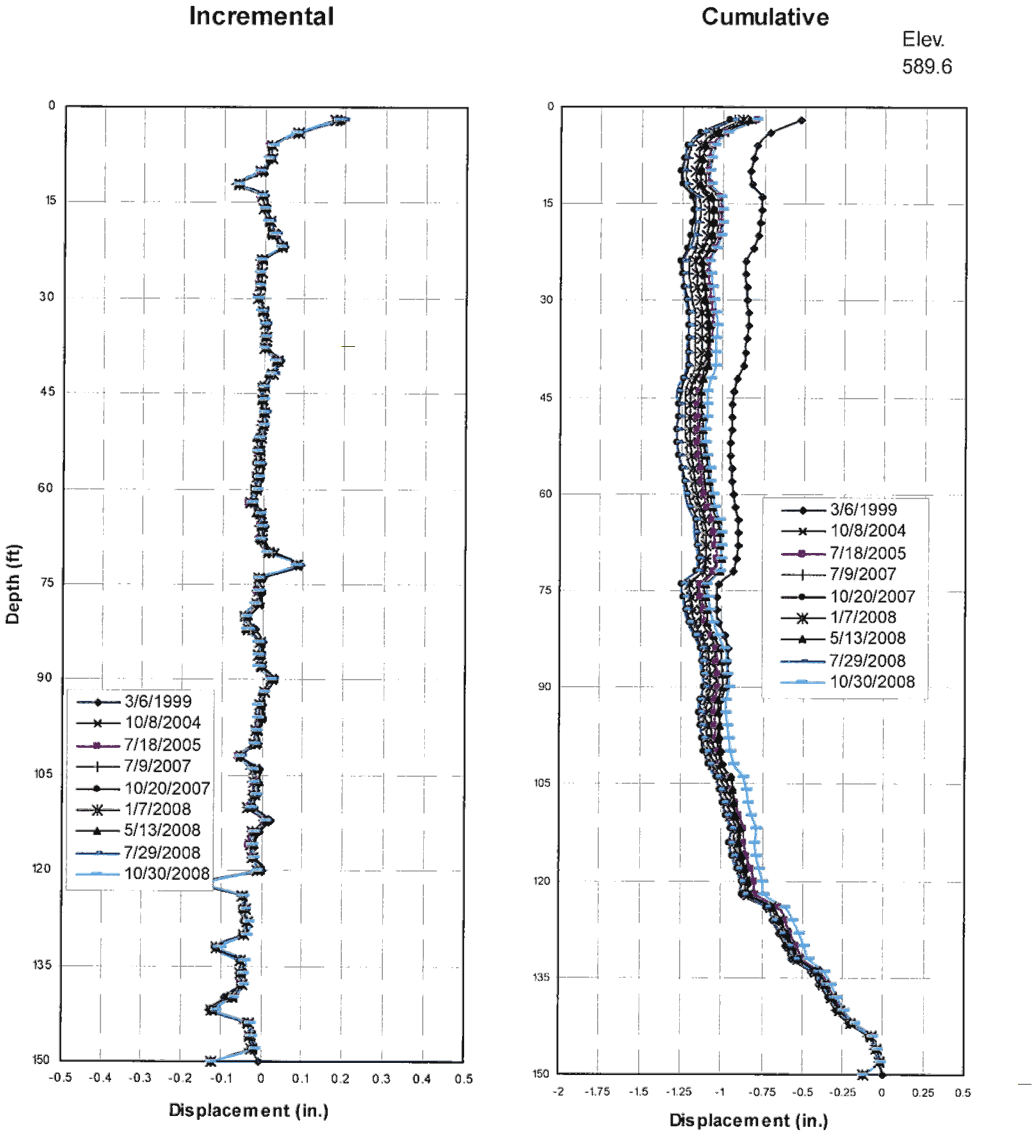
Inclinometer #3 Displacement in the B+ Direction
Along slope (Along river direction) Base Line 12/11/1998



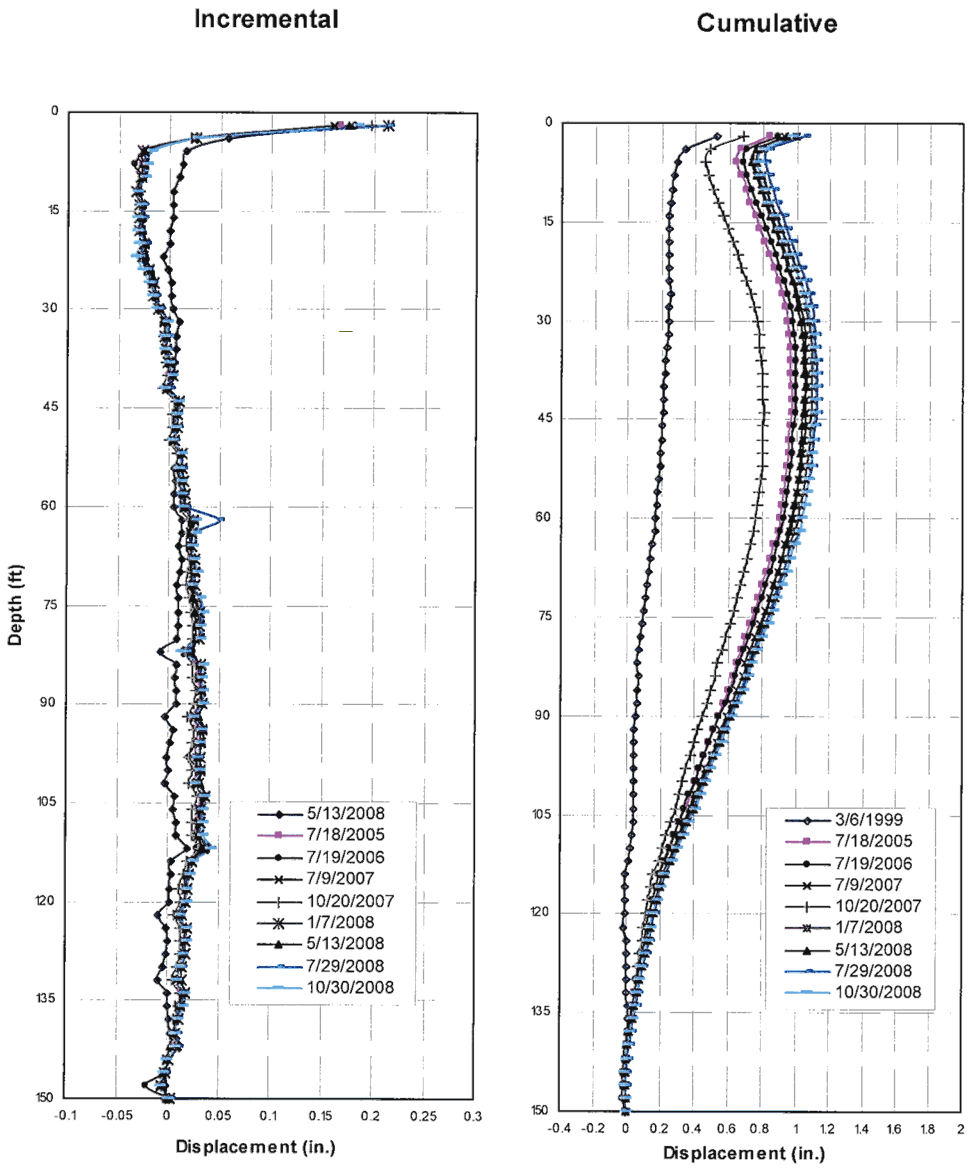
Inclinometer #8 Displacement in the A+ Direction
Downslope (Toward river direction) Base Line 12/11/1998



Inclinometer #8 Displacement in the B+ Direction
Along slope (Along river direction) Base Line 12/11/1998

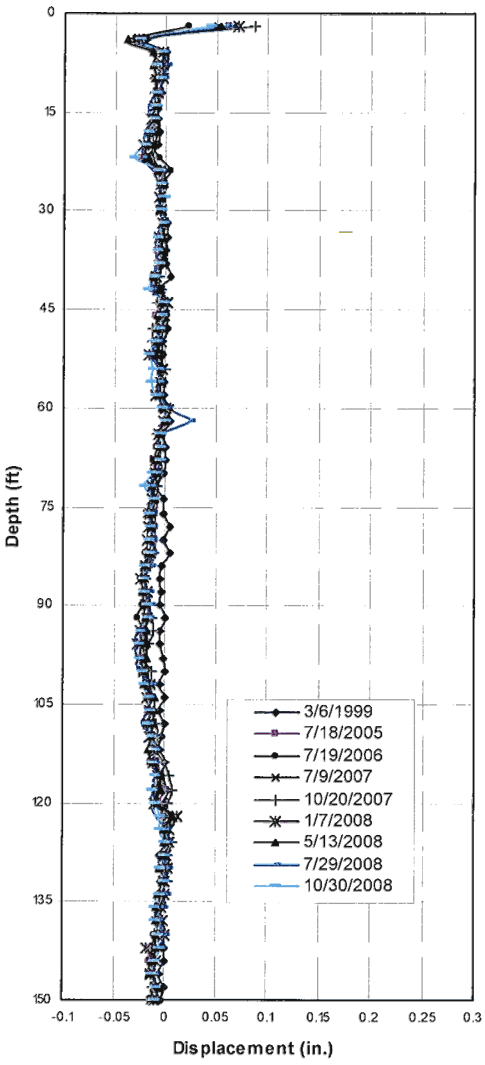


Inclinometer #9A Displacement in the A+ Direction
Downslope (Toward river direction) Base Line 12/11/1998

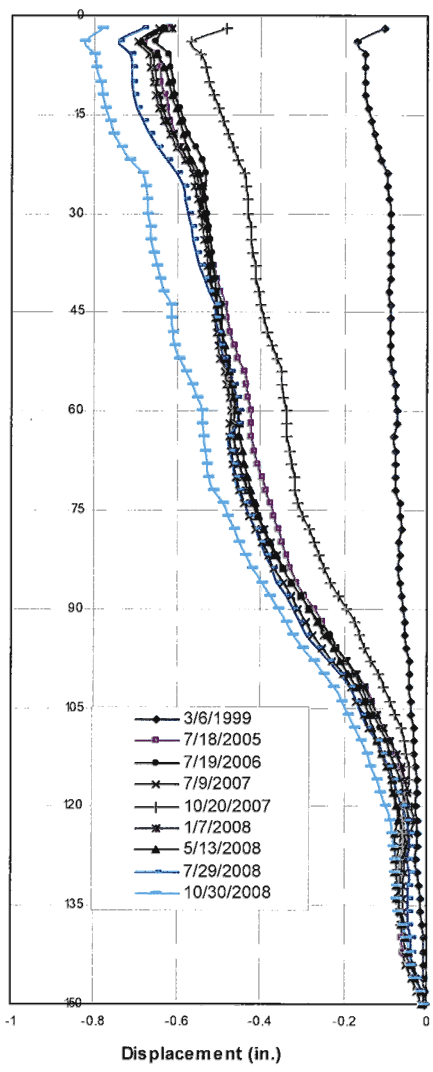


Inclinometer #9A Displacement in the B+ Direction
Along slope (Along river direction) Base Line 12/11/1998

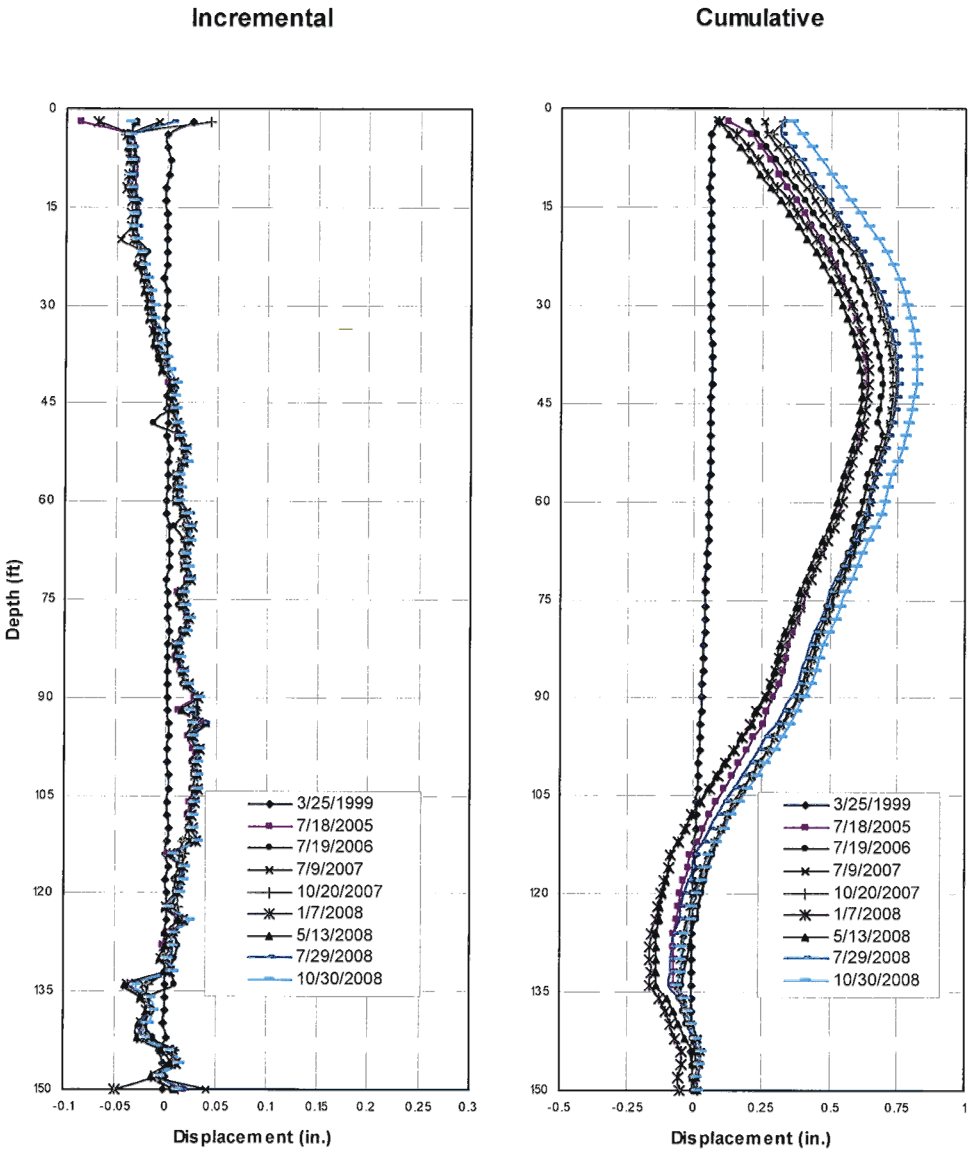
Incremental



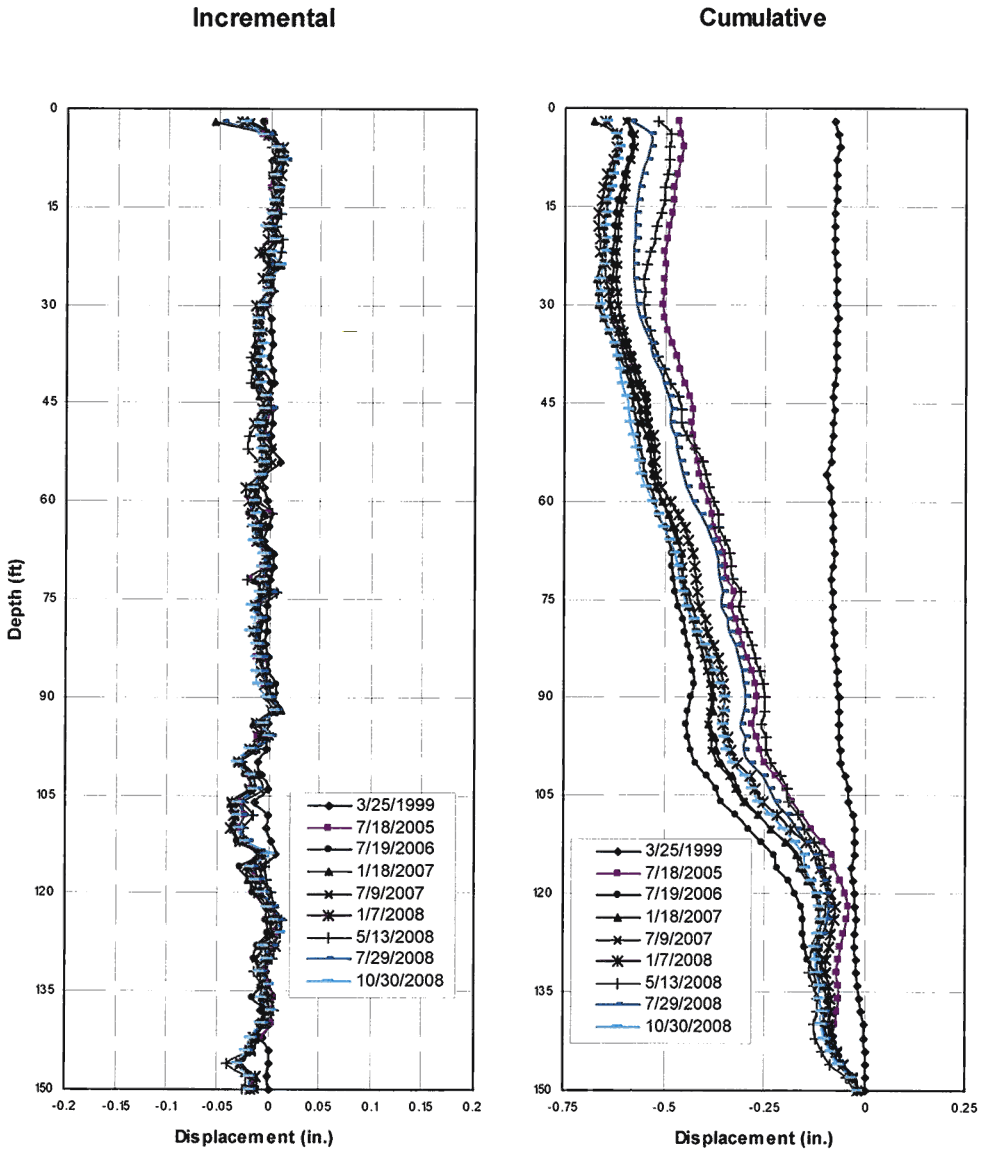
Cumulative



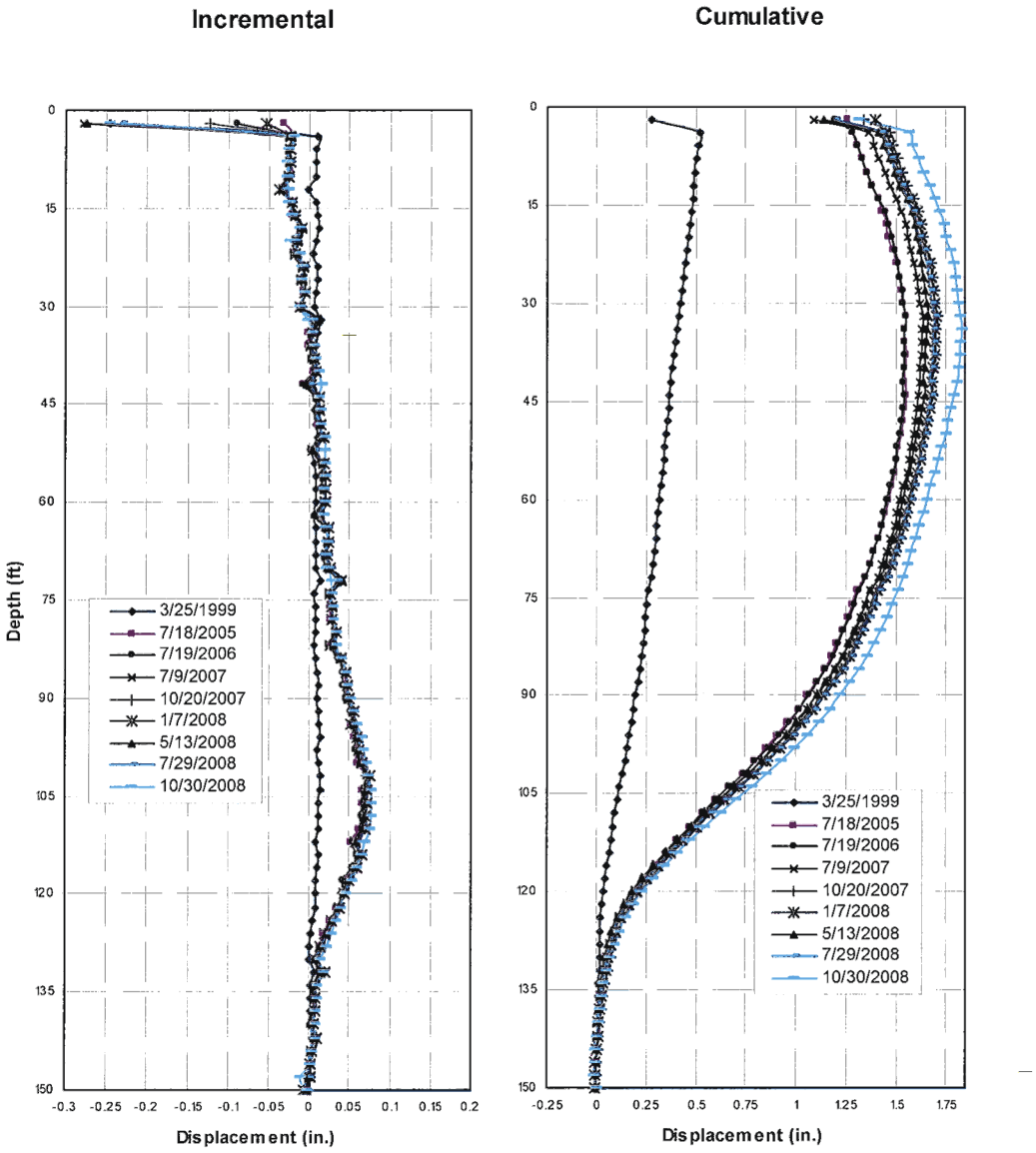
Inclinometer #10 Displacement in the A+ Direction
Downslope (Toward river direction) Base Line 12/11/1998



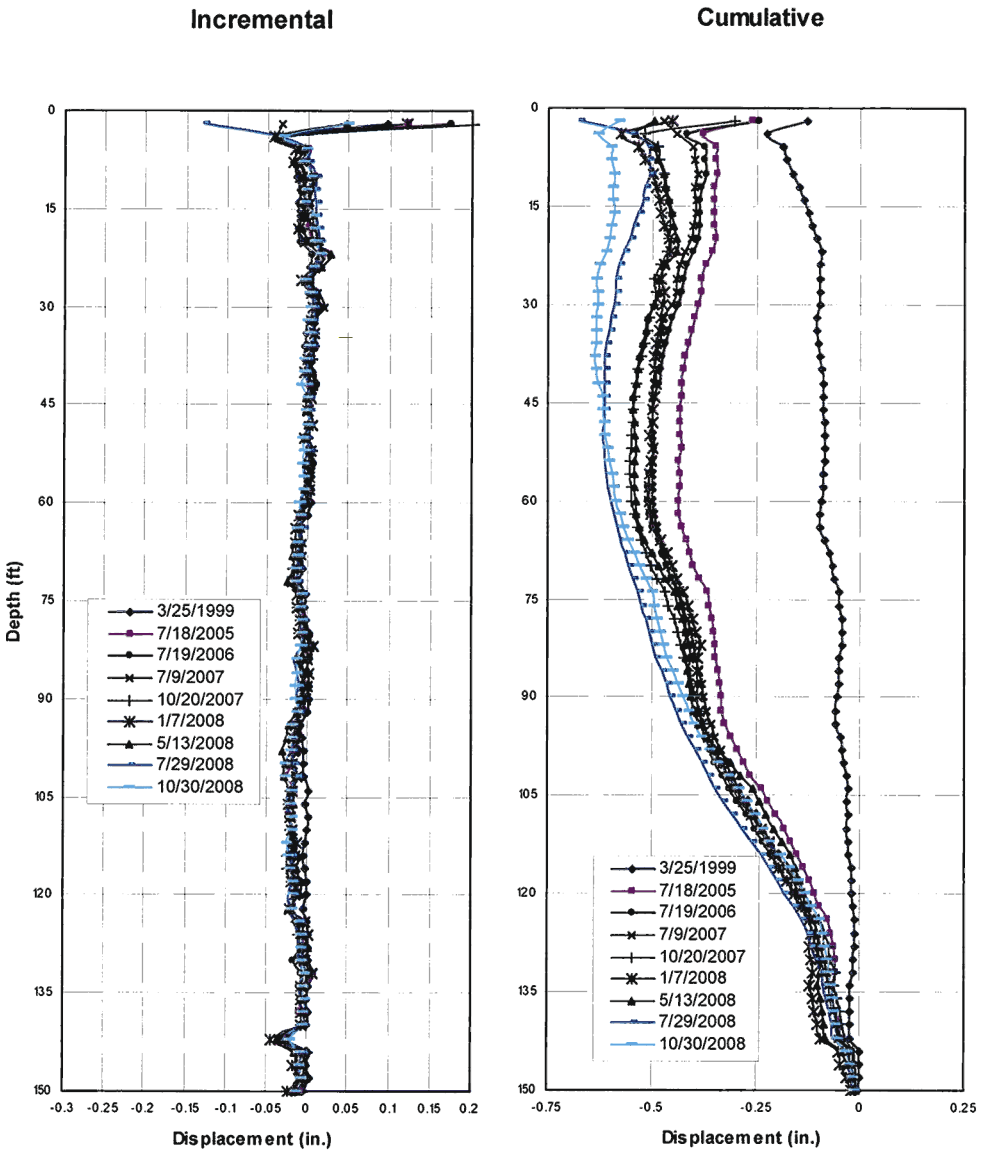
Inclinometer #10 Displacement in the B+ Direction
Along slope (Along river direction) Base Line 12/11/1998



Inclinometer #17 Displacement in the A+ Direction
Downslope (Toward river direction) Base Line 12/11/1998



Inclinometer #17 Displacement in the B+ Direction
Along slope (Along river direction) Base Line 12/11/1998



RICHLAND ENGINEERING LIMITED
29 North Park Street, Mansfield, Ohio 44902-1769 • 419-524-0074 FAX 419-524-1812

106017

February 18, 2009

Ohio Department of Transportation
5500 Transportation Boulevard
Garfield Heights, Ohio 44125-5396

Attn: Mr. Mike Malloy

Re: CUY-90-1524
Central Viaduct
PID No. 20752
Slope and Pier Monitoring Services
Interim Report

Dear Mr. Malloy:

The following is our report on monitoring activity and collected data for the west slope of the Cuyahoga River and Bridge No. CUY-90-1524 west end pier, pier 1, and slope stabilization structure. The last report of data was the interim report submitted December 11, 2008 for data collected through October 2008. This report is for data collected through January 2009.

Enclosed is one CD with the electronic .pdf files of the detailed reports from BBC&M Engineering, Inc., Richland Engineering Limited, Dr. Huckelbridge, and Dr. Liang.

The slope monitoring began in 1994. The stabilization structure was constructed and the span 1 superstructure was relocated in 1999. The stabilization structure monitoring began in 1999. Additional slope monitoring north of the existing bridge began in 2006.

BBC&M Engineering, Inc. obtained inclinometer readings, piezometer readings, and calipered crack distances January 12 through 23, 2009. A total of 19 inclinometers, 6 pneumatic piezometers and 18 vibrating wire (VW) piezometers are actively monitored as part of the project. Comments on the data collected are summarized as follows:

- There was an increased rate of movement between April and October 2008 in the deep failure plane in inclinometers B-204, B-05-04, and B-303 within the influence of the stabilization structure; and inclinometers B-05-03 and B-105A south of the bridge. The rate increase may have been a short term occurrence as it did not continue between October 2008 and January 2009. In the other inclinometers, no significant changes in the rates of movement have been observed in the shallow or deep failure planes.

- The cantilever displacement of the top 60 to 70 feet of inclinometer B-105A is continuing to move at an increasing rate (1.32 inches per year). B-105A is located south of pier 1 near the river dock wall. It appears the dock wall may be bulging or moving outward. The displacement may be due to slope movement or failure of the dock wall tiebacks.

- All of the pneumatic piezometers exhibited slightly lower readings than those recorded in October 2008, except the B-101 orange piezometer which exhibited a slightly higher reading. The B-105 blue piezometer continues to indicate elevated water pressures (i.e., a total head above the ground surface, artesian conditions).

- The measured total head values in the vibrating wire (VW) piezometers were relatively constant during the current reporting period with a difference between maximum and minimum total head values of no more than 1.6 feet in all of the VW piezometers where readings were recorded at regular intervals. The 21955 piezometer in B-05-13 continues to indicate an elevated water pressure similar to that observed in the pneumatic piezometers at B-105.

- The linear trend line for the left calipered surface distance location indicates the gap is opening and the gap at the right calipered surface distance location is closing. The right calipered location has been oscillating since late 2000 indicating that there might not be a trend.

- The small landslide adjacent to the large excavation near the west right-of-way fence does not appear to have experienced a significant change since the quarterly readings were last taken in October 2008.

- In October 2008, an aggregate pile, roughly 20 to 25 feet high, was observed next to and encroaching on the east right-of-way fence. A portion of the fence was knocked over by the stockpile as it was spilling over into the right-of-way with the edge of the pile touching the edge of the concrete drive near B-05-03. The aggregate piles observed during the July 2008 and October 2008 quarterly readings were larger in size and placed closer to the east right-of-way fence than has been observed during quarterly readings over the past several years. The encroaching aggregate pile was moved back from the fence in mid-December 2008. In January 2009 the aggregate pile nearest the fence was roughly 20 feet high and covered less than 10 percent of the property. Smaller aggregate piles roughly 10 to 15 feet high were observed farther away from the fence, which combined to cover roughly less than 25 percent of the property. The decreased rates of movements in the inclinometers B-204, B-05-04, B-303, B-05-03, and B-105A; could have been influenced by the relocation of the aggregate piles. The right of way fence needs to be reconstructed.

Richland Engineering Limited measured deck expansion joint openings at the west end pier, near pier 2, and near pier 4; and measured truss expansion joint openings at the north and south upper and lower truss chords at span 2 floorbeam 12 on January 15, 2009. The expansion joint near pier 2 opened with the 49 degree drop in temperature since October 2008. The theoretical change should be 2.48 inches. Each location at the expansion joint moved differently and not directly proportional to the temperature change as shown in the following table:

	North Lower Chord Expansion Joint	North Deck Expansion Joint Opening	South Deck Expansion Joint Opening	South Lower Chord Expansion Joint
Measured Opening (inches)	0.73	2.00	1.13	0.29
Change in Opening (inches)	0.37	0.87	0.44	0.11

Art Huckelbridge obtained tiltmeter readings at the west end pier and pier 1 on January 22, 2009. The tiltmeters show no substantive changes in readings for the past quarter.

Robert Liang monitored instrumentation on January 12 and 13, 2009. The instrumentation readings in the rock anchors, driven piles, tieback beams, drilled shafts, and inclinometers show the strain readings, the forces, and the moments on the slope stabilization structures have been steady in the last three months.

Monitoring has been authorized through 2009. The next readings are scheduled about April 15, 2009.

Please contact us if you have any questions (email reltd@r-e-l.com). Copies of detailed quarterly reports are available upon request.

Very truly yours,

RICHLAND ENGINEERING LIMITED

Dean A. Palmer, P.E.

DAP:dap

cc: Craig Hebebrand, District 12
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Rick Engel, E.L. Robinson Engineering Co.
Jeff Broadwater, Michael Baker, Jr., Inc.

JANUARY 2009 QUARTERLY REPORT
FIELD MONITORING SERVICES
CUY-90-14.52/15.24
PID #77332
CLEVELAND, OHIO

Report to

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

Prepared by

BBC&M ENGINEERING, INC.
CLEVELAND, OHIO

February 2009

February 10, 2009
012-00946-300

Mr. Dean A. Palmer, P.E.
Richland Engineering Limited
29 North Park Street
Mansfield, Ohio 44902

Re: CUY-90-14.52/15.24 Bridge (PID No. 77332)
Quarterly Report - Field Monitoring Services
January 2009 (First Quarter)

Dear Mr. Palmer:

BBC&M Engineering, Inc. (BBCM) has completed the field monitoring services for the January 2009 quarter as part of the CUY-90-14.92/15.24 project. This quarterly report presents our general site observations and the results and evaluation of data collected from all the actively monitored instrumentation (inclinometers, piezometers and calipered distance locations) installed by BBCM at or near the West Abutment of the existing I-90 Central Viaduct Bridge.

A total of 19 inclinometers, six (6) pneumatic piezometers and 18 vibrating wire (VW) piezometers are actively monitored as part of the project. A Summary Table and Site Plan of Active Instrumentation are submitted as Plates 1 and 2 of the Appendix. Quarterly readings were taken during the period of January 12 through January 23, 2009.

Inclinometers

All the data sets presented in the Appendix have been corrected for measured spiral of the inclinometer casings and for systematic errors such as bias-shift, sensor rotation and depth positioning error, where necessary. The rates of movements were computed using linear regression for the depth ranges shown on the Displacement vs. Time plots in the Appendix.

Noticeable increased rates of movements were observed in five (5) of the inclinometers (B-204, B-303, B-05-03, B-05-04, and B-105A) between the April 2008 (October 2007 in B-105A) and October 2008 quarterly readings. This trend of increased rates may have been a short term occurrence as it did not appear to continue between the October 2008 and January 2009 quarterly readings, with the exception of the B-105A inclinometer. In the other inclinometers, no significant changes in the rates of movement have been observed in the shallow or deep failure planes.

Shallow Failure Plane

No shallow slip-plane movements have been observed in the inclinometers within the Pier 1 stabilization system (B-204 and B-05-04) since completion of construction of the stabilization system. In the vicinity of Pier 1 just outside of the stabilization system (B-05-03 and B-108A), the shallow failure plane is moving at an average rate of about 0.07 inches per year (in/yr) from 2006 to the present. This is a slight increase from the rate of 0.065 in/yr as reported in BBCM's October 2008 Quarterly Report, dated November 10, 2008 (October 2008 report). Upslope from Pier 1 (B-203 and B-303), the shallow failure plane continues to move at an average rate of about 0.025 in/yr from 2004 to the present. Well outside the Pier 1 Area (B-05-16), the shallow failure plane is moving at an average rate of about 0.19 in/yr from 2006 to the present. This is a slight decrease from the rate of 0.21 in/yr as reported in our October 2008 report. Additionally, the rate of the shallow movement in B-05-16 has decreased to about 0.13 in/yr from January 2007 to the present.

Deep Failure Plane

South of the West End Pier (B-102 and B-107), the deep failure plane continues to move at an average rate of about 0.03 in/yr from around 2000 to the present. In the Pier 1 area (B-203, B-204, B-303, B-105A, B-108A, B-05-03 and B-05-04), the deep failure plane continues to move at an average rate of about 0.03 in/yr from 2004 (or 2006 for new or replacement inclinometers) to the present. Well outside the Pier 1 area (B-05-16), the deep failure plane continues to move at an average rate of 0.02 in/yr.

Additional Observations in Active Inclinometers Installed between 1994 and 1999

The B-101 inclinometer has indicated nominal movement since its installation. The inclinometer at P-9N (installed in one of the drilled shafts) indicates the top of the drilled shaft is restrained laterally and that the maximum lateral deflection is about one (1) inch and occurs approximately 40 to 60 feet below the top of the inclinometer casing.

The inclinometer at B-303 will likely need to be abandoned within the next few quarterly readings as it has become somewhat difficult to lower and raise the inclinometer probe past the "kink" in the pipe that has developed within the deep failure plane at a depth of about 95 feet.

Additional Observations in Active Inclinometers Installed in 2006

The cantilever displacement continually observed in B-105A to a depth of about 60 to 70 feet (see Plates 22 and 23 in the Appendix) has been moving at a rate of about 1.32 in/yr since October 2007. This is a slight increase from the rate of movement of 1.28 in/yr as reported in our October 2008 report. The bulkhead at this location may be progressively leaning outwards toward the Cuyahoga River. A Displacement vs. Time plot for B-105A has been submitted as Plate 26 in the Appendix.

Table 1 below summarizes the changes in the rates of movement that have been observed in the five (5) inclinometers previously discussed.

Table 1: Summary of Rate Changes in Some Inclinometers – CUY-90-15.24

Inclinometer	Failure Plane	Time Ranges Evaluated	Avg. Rate of Movement within Time Range (in/yr)	Percentage Increase in the Avg. Rate of Movement Compared to Time Range #1 (%)
B-204	Deep (117'-119')	#1 - Jan 04 - Apr 08	0.025	--
		#2 - Apr 08 – Oct 08	0.065	160*
		#3 - Apr 08 – Jan 09	0.04	60
B-303	Deep (95'-99')	#1 - Jan 04 - Apr 08	0.03	--
		#2 - Apr 08 – Oct 08	0.095	217*
		#3 - Apr 08 – Jan 09	0.07	133
B-05-03	Shallow (35'-39')	#1 - Jun 06 - Apr 08	0.075	--
		#2 - Apr 08 – Oct 08	0.30	300*
		#3 - Apr 08 – Jan 09	0.23	207
	Deep (123'-125')	#1 - Jun 06 - Apr 08	0.03	--
		#2 - Apr 08 – Oct 08	0.23	667*
		#3 - Apr 08 – Jan 09	0.15	400
B-05-04	Deep (117'-119')	#1 - Jun 06 - Apr 08	0.015	--
		#2 - Apr 08 – Oct 08	0.055	267*
		#3 - Apr 08 – Jan 09	0.04	167
B-105A	Deep (105'-111')	#1 - Jun 06 – Oct 07	0.015	--
		#2 - Oct 07 – Oct 08	0.065	333*
		#3 – Oct 07 – Jan 09	0.07	367

*Revised percentage increase in the average rate of movement as the value was misreported in Table 1 of our October 2008 report. All of the revised percentage increases are a value of 100 percentage points lower than was previously reported.

In the inclinometers at B-204, B-303, B-05-03, and B-05-04, the average rates of movements in the deep and shallow failure planes from April 2008 to the present decreased from the average rates from April 2008 to October 2008 reported in our October 2008 report. However, in B-105A, the average rate of movement from October 2007 to the present was slightly higher than reported in our October 2008 report. Note that all five (5) inclinometers summarized in Table 1 are located underneath or east of the existing I-90 bridge near the east right-of-way fence where aggregate piles of variable sizes have been stored for many years. The aggregate piles observed in January 2009 were not as large and were located farther away from the right-of-way fence than was observed during the July 2008 and October 2008 quarterly readings. A more detailed discussion regarding these aggregate piles adjacent to the east right-of-way fence is subsequently provided. The decline from the possible short term increases in the rates of movements in four (4) of the inclinometers may be a result of

the changed conditions involving the aggregate piles and/or the slightly decreased pore pressures observed in the piezometers at B-05-03 and B-303.

Potential slope movements not yet developed enough to be called definitive slide planes (i.e., movements that have not been consistent or are still within the limits of the accuracy of the instrumentation) have been observed in some of the inclinometers, which are listed as follows:

- In B-105A, depth of about 85 ft (see Plate 22 in the Appendix); and,
- In B-05-02, depth of about 109 ft and 129 ft and newly observed depth of about 45 ft (see Plate 30 in the Appendix).

Additional readings are needed in these inclinometers to evaluate whether these potential slide planes are true displacements.

Piezometers

Pneumatic Piezometers

The results of the active pneumatic piezometer readings taken between January 12 and January 22, 2009 are summarized in Table 2 below.

Table 2: Summary of Readings for Active Pneumatic Piezometers – CUY-90-15.24

Piezometer Identifier		Ground Surface Elevation (ft)	Elevation Head, h_e (ft)	Pore Pressure Reading, u (psi)	Total Head, h_t (ft)
B-101 (P-1*)	orange	676.6	626.3	1.6	630.0
	pink	676.6	552.3	31.8	625.7
B-105 (P-3*)	pink	585.6	497.6	38.1	585.5
	blue	585.6	479.9	47.7	590.0
B-107 (P-5*)	orange	662.3	562.3	25.5	621.1
B-303 (P-2*)	pink	627.0	586.2	6.6	601.4

*BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers.

All the piezometers exhibited slightly lower readings than those recorded in October 2008, except the B-101 orange piezometer, which exhibited a slightly higher reading. Note that the piezometer B-105 blue continues to indicate elevated water pressure (i.e., a total head above the ground surface, artesian conditions). The piezometer B-105 pink has indicated an elevated water pressure in the past several readings. However, the current reading indicates the total head at that depth is just slightly below the existing ground surface. Total Head vs. Time plots have been submitted as Plates 51 through 54 in the Appendix of this report.

Vibrating Wire (VW) Piezometers

Table 3 provides a summary of the maximum and minimum values of all the pressure readings taken from October 2008 (end of previous reporting period) to the time when the collected data was last downloaded from VW Miniloggers between January 12 and January 23, 2009.

Table 3: Summary of Readings for VW Piezometers – CUY-90-14.92

Piezometer Identifier		Time Interval of Readings Reported [1]	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-01	21961 - 65 ft	10/14/08 to 1/23/09[3]	13.6/13.0[3]	675.4	610.4	13.0/12.4[3]	640.4/639.0[3]
	21967 - 95 ft	1/12,23/09[2]	13.1/13.1[2]	675.4	580.4	24.3/24.1[2]	636.6/636.1[2]
B-05-02	21963 - 46 ft	10/15/08 to 1/20/09	12.2/11.6	617.9	571.9	8.5/7.8	591.5/589.9
	21951 - 122 ft	1/20/09[2]	12.1[2]	605.1	573.1	40.5[2]	589.4[2]
B-05-03	21957 - 32 ft	1/20/09[2]	12.4[2]	605.1	573.1	8.2[2]	592.0[2]
	21965 - 112 ft	1/20/09[2]	12.4[2]	605.1	493.1	41.3[2]	588.5[2]
B-05-04	21958 - 59 ft	10/15/08 to 1/20/09	12.8/12.8	600.8	541.8	18.2/17.7	583.8/582.7
	21952 - 119 ft	10/15/08 to 1/20/09	13.0/12.9	600.8	481.8	45.0/44.8	585.7/585.2
B-05-07	21966 - 102 ft	10/14/08 to 1/23/09	12.4/11.2	678.9	576.9	24.5/23.8	633.3/631.8
	21956 - 220 ft	10/14/08 to 1/23/09	11.9/11.9	678.9	458.9	71.8/71.2	624.6/623.1
B-05-08	21954 - 65.5 ft	10/14/08 to 1/12/09	12.7/12.6	679.9	614.4	12.7/12.1	643.8/642.4
	21959 - 110.5 ft	10/14/08 to 1/12/09	12.4/12.4	679.9	569.4	29.9/29.3	638.4/636.9
B-05-11	21968 - 95 ft	1/12/09[2]	12.6[2]	675.1	580.1	24.0[2]	635.5[2]
	21953 - 130 ft	1/12/09[2]	12.5[2]	675.1	545.1	36.9[2]	630.3[2]
B-05-12	21960 - 75 ft	1/13/09[2]	12.5[2]	652.7	577.7	18.7[2]	620.8[2]
	21964 - 120 ft	1/13/09[2]	12.5[2]	652.7	532.7	36.8[2]	617.7[2]
B-05-13	21962 - 60 ft	10/15/08 to 1/23/09	12.6/12.6	580.0	520.0	24.4/23.9	576.3/575.1
	21955 - 135 ft	10/15/08 to 1/23/09	12.8/12.7	580.0	445.0	60.5/60.2	584.6/584.0

1 – Readings generally were taken every 8 hours during the reported time interval.
2 – One (1) or two (2) manual readings were taken during the January 2009 quarterly readings due to Minilogger issues. For additional details, see the Total Head vs. Time plot for the specific Minilogger in the Appendix.
3 – Malfunction of Minilogger resulting in several scheduled readings being missed during the reported time interval. For additional details, see the Total Head vs. Time plot for the specific Minilogger in the Appendix.

The measured total head values were relatively constant during the current reporting period with a difference between maximum and minimum total head values of no more than 1.6 feet in all of the VW piezometers where readings were recorded at regular intervals (see footnotes in Table 3). Total Head vs. Time plots have been submitted as Plates 55 through 63 in the Appendix.

The 21955 piezometer in B-05-13 continues to indicate an elevated water pressure (i.e., a total head above the ground surface, artesian conditions) similar to that observed in the pneumatic piezometers at B-105 previously discussed.

In eight (8) of the VW piezometers, only one (1) or two (2) manual readings were taken at the time of data collection during the January 2009 quarterly readings due to malfunctioning VW Miniloggers (see Table 3). Additionally, many scheduled readings were missed in one (1) of the VW piezometers (21961 at B-05-01) between October 2008 and January 2009. It is our understanding that ODOT is planning on purchasing new Miniloggers for BBCM to install as replacements for the nonfunctional Miniloggers.

Additional Field Measurements and Observations

The two calipered surface distance locations (left and right) are provided in the Site Plan of Active Instrumentation (Plate 2 of the Appendix). A Calipered Surface Distance Table and Calipered Distance Readings vs. Time plots have been included as Plates 64 through 66 in the Appendix. The left calipered location indicates the gap is closing at a rate of about 0.05 in/yr. This is a slight decrease from the rate of about 0.06 in/yr as reported in our October 2008 report. The gap at the right calipered location is continuing to close at a rate of about 0.02 in/yr. The right calipered location has been oscillating above and below a distance of about 4.4 inches since late 2000 indicating that there might not be a trend.

As reported in our October 2008 report, an aggregate pile was observed immediately adjacent to the east right-of-way fence with a portion of the fence knocked over by the pile. In January 2009, the aggregate pile had since been moved farther away from the fence line and a relatively long section of the fence appeared to have either been removed or knocked over (see Plates 67 and 68 in the Appendix). There was a significant amount of snow cover in the area during data collection making it difficult to observe the aggregate pile(s) and right-of-way fence area. The aggregate pile nearest the fence was roughly 20 feet high and covered roughly less than 10 percent of the property. Smaller aggregate piles roughly 10 to 15 feet high were observed farther away from the fence, which combined covered roughly less than 25 percent of the property.

The large excavation and the repair effort of the bulkhead near the west right-of-way fence appear to remain unfinished as of January 2009. The small landslide adjacent to the large excavation near the west right-of-way fence (just north of B-05-16, see Plate 2 in the Appendix for the approximate landslide location) does not appear to have experienced a significant change since the quarterly readings were last taken in

October 2008 although the gap in the bulkhead adjacent to the landslide area appears to be wider than previously observed. The area was covered heavily with snow during the site visit making it difficult to see the scarps.

Closing

We appreciate being of continued service during this project. Please contact our office if you have any questions or require additional information. The next quarterly readings are scheduled to take place around April 15, 2009.

Sincerely,
BBC&M ENGINEERING, INC.
Cleveland, Ohio

Jeffrey L. Snyder, P.E.
Project Engineer

Stephen C. Pasternack, P.E.
Senior Project Engineer

cc: Mr. Jeff Broadwater, P.E. (Michael Baker Jr., Inc.)

Submitted: pdf copy submitted to Richland Engineering at reltd@r-e-l.com and Michael Baker Jr., Inc. via their ftp site
Attachments: Appendix (Plates 1 through 68)

APPENDIX

CUY-90-14.52/15.24 INSTRUMENTATION MONITORING

APPENDIX

Plate No.

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Plots for Replacement Inclinometers Installed by BBCM in 2006 – CUY-90-15.24

Cumulative and Incremental Displacement versus Depth Plots

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B-105 (P-3) 52
B-107 (P-5) 53
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Total Head (h_t) versus Time Plots
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B-05-02 56
B-05-03 57
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B-05-11 61
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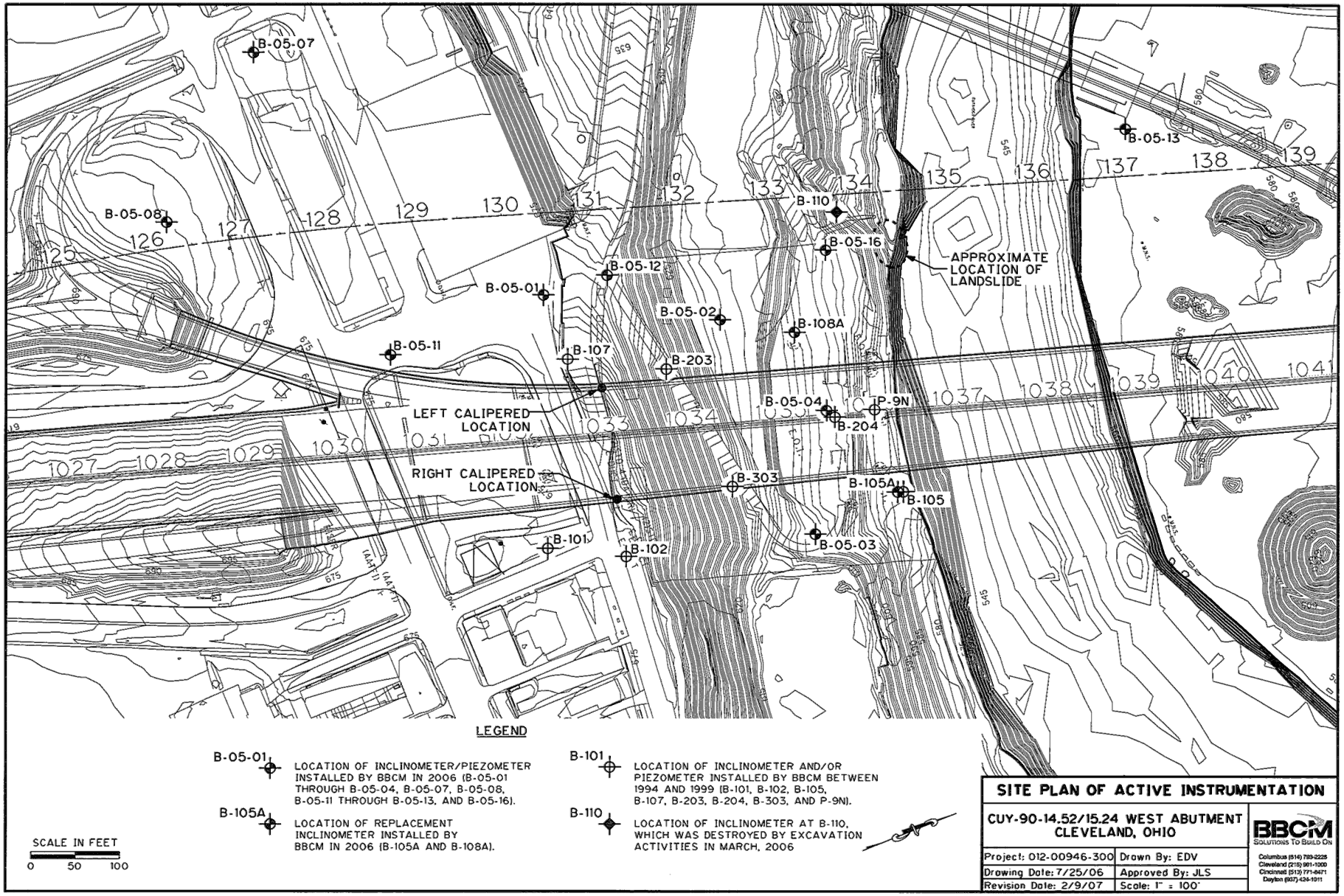
SUMMARY OF ACTIVE INSTRUMENTATION
CUY-90-14.52/15.24

Active Instrumentation	Active Inclinometer ?	Inclinometer Depth (ft)	Active Piezometer?	VW or Pneumatic?	# of Active Piezometers	Piezometer Depth(s) Below Existing G.S. (ft)	Instrumentation Installation Date	G.S. Elevation (ft)
B-101	Y	190	Y[1]	Pneumatic[1]	2 [1]	50.3, 124.3	Aug-Sep 1994	676.6 (676.6[3])
B-102	Y	224	N	---	---	---	Sep 1994	675.7
B-105	N	---	Y[1]	Pneumatic[1]	2 [1]	88, 105.7	Aug 1994	585.4 (585.6[3])
B-105A	Y	156	N	---	---	---	May 2006	585.7
B-107	Y	210	Y[1]	Pneumatic[1]	1 [1]	100	Sep 1994	662.7 (662.3[3])
B-108A	Y	168	N	---	---	---	Apr-May 2006	603.0
B-203	Y	190	N	---	---	---	Aug 1996	638.0
B-204	Y	134	N	---	---	---	Jul 1998	599.0
B-303	Y	178	Y[2]	Pneumatic[2]	1 [2]	40.8	Aug 1994[2], Jul 1998	622.0 (627.0[3])
P-9N	Y	148	N	---	---	---	Feb 1999	588.0
B-05-01	Y	228	Y	VW	2	65, 95	Apr-May 2006	675.4
B-05-02	Y	176	Y	VW	2	46, 122	Apr-May 2006	617.9
B-05-03	Y	168	Y	VW	2	32, 112	Apr-May 2006	605.1
B-05-04	Y	172	Y	VW	2	59, 119	Mar-May 2006	600.8
B-05-07	Y	224	Y	VW	2	102, 220	Apr-Jun 2006	678.9
B-05-08	Y	224	Y	VW	2	65.5, 110.5	Apr-May 2006	679.9
B-05-11	Y	226	Y	VW	2	95, 130	Apr-Jun 2006	675.1
B-05-12	Y	210	Y	VW	2	75, 120	Apr-May 2006	652.7
B-05-13	Y	134	Y	VW	2	60, 135	May-Jun 2006	580.0
B-05-16	Y	162	N	---	---	---	Jun 2006	598.5

1 BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers (i.e. P-1 to B-101, P-3 to B-105, and P-5 to B-107).

2 The pneumatic piezometer was actually installed in August 1994 at Boring P-2 in the vicinity of the B-103 inclinometer (now inactive). However, the piezometer has since been renamed to B-303 due to its close proximity to the active inclinometer at B-303, which was installed in July 1998.

3 Elevation in parenthesis refers to the ground surface (G.S.) elevation of the P boring location where the pneumatic piezometer was installed.



LEGEND

B-05-01 — LOCATION OF INCLINOMETER/PIEZOMETER INSTALLED BY BBCM IN 2006 (B-05-01 THROUGH B-05-04, B-05-07, B-05-08, B-05-11 THROUGH B-05-13, AND B-05-16).

B-105A — LOCATION OF REPLACEMENT INCLINOMETER INSTALLED BY BBCM IN 2006 (B-105A AND B-108A).

B-101 — LOCATION OF INCLINOMETER AND/OR PIEZOMETER INSTALLED BY BBCM BETWEEN 1994 AND 1999 (B-101, B-102, B-105, B-107, B-203, B-204, B-303, AND P-9N).

B-110 — LOCATION OF INCLINOMETER AT B-110, WHICH WAS DESTROYED BY EXCAVATION ACTIVITIES IN MARCH, 2006

SCALE IN FEET
0 50 100

SITE PLAN OF ACTIVE INSTRUMENTATION

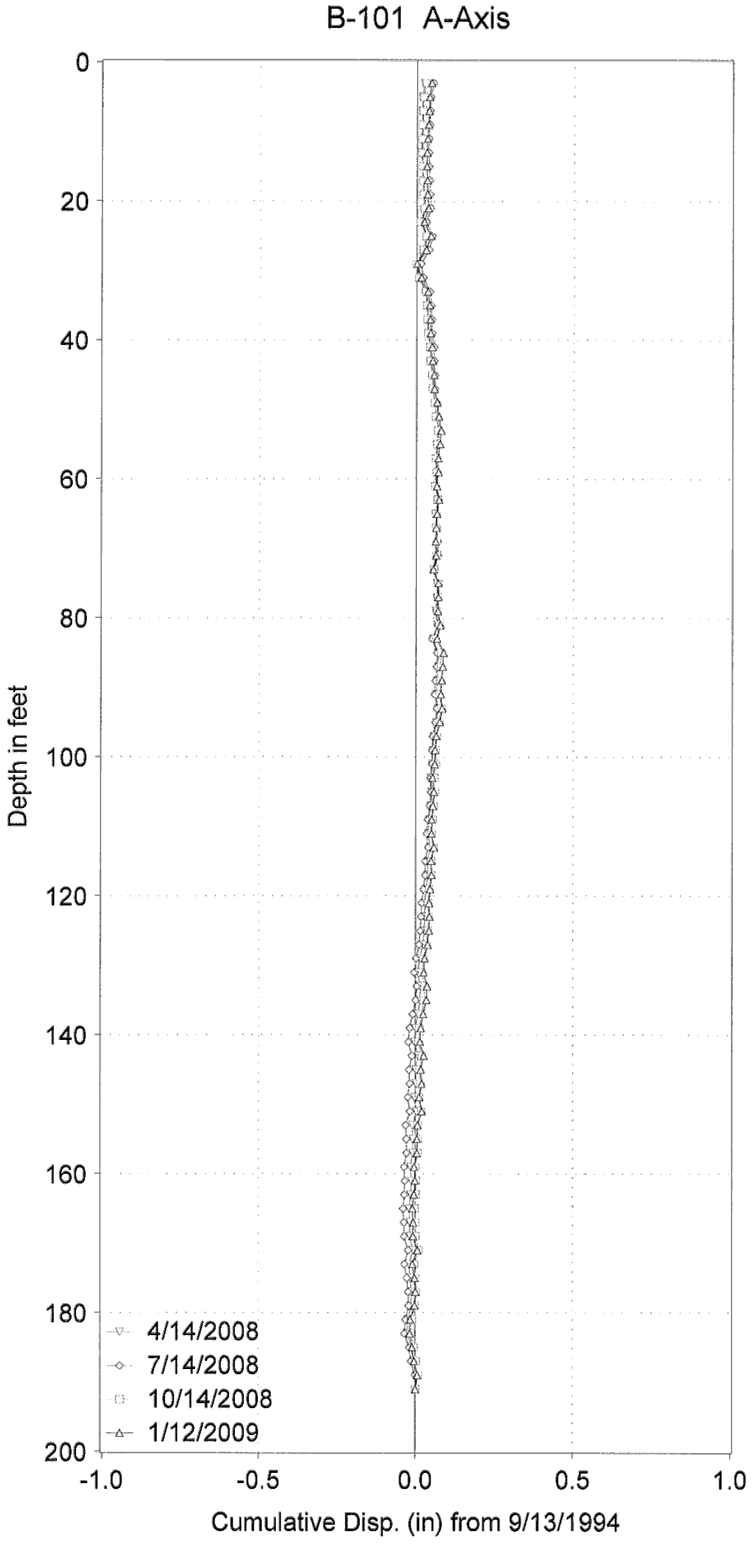
CUY-90-14.52/15.24 WEST ABUTMENT
CLEVELAND, OHIO

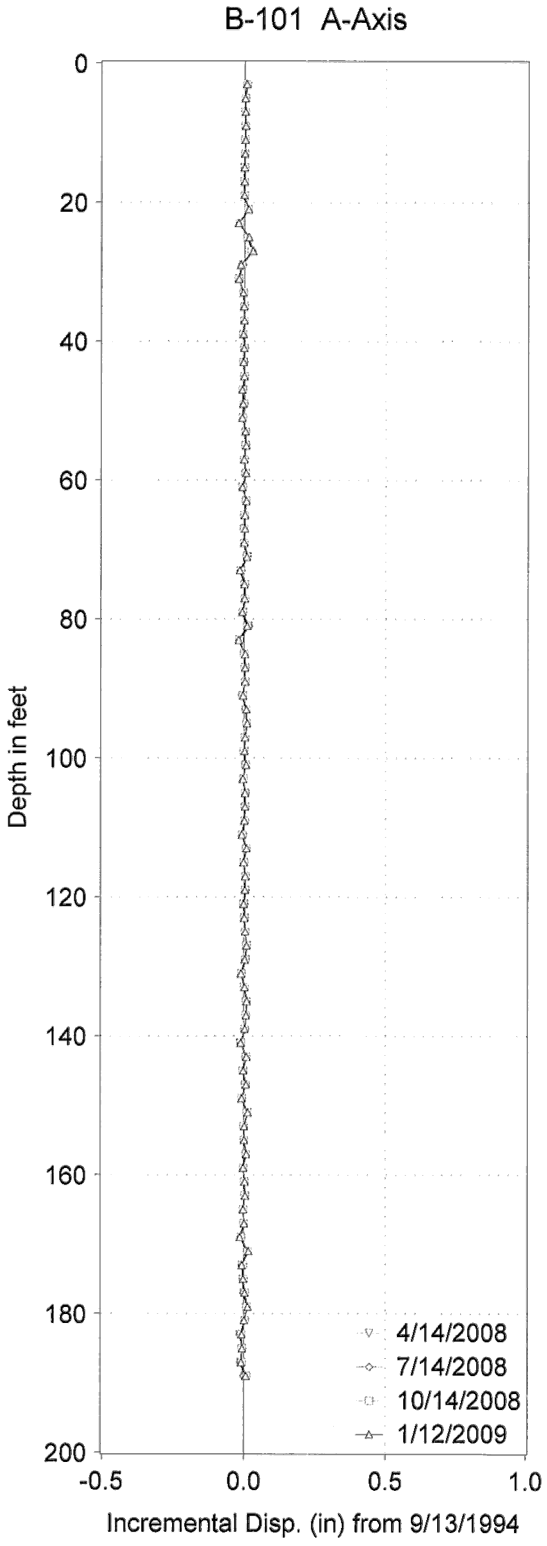
Project: 012-00946-300	Drawn By: EDV
Drawing Date: 7/25/06	Approved By: JLS
Revision Date: 2/9/07	Scale: 1" = 100'

BBCM
SOLUTIONS TO BUILD ON
Columbus (614) 793-2225
Cleveland (216) 901-1000
Cincinnati (513) 771-6471
Dayton (937) 436-1911

PLATE 2

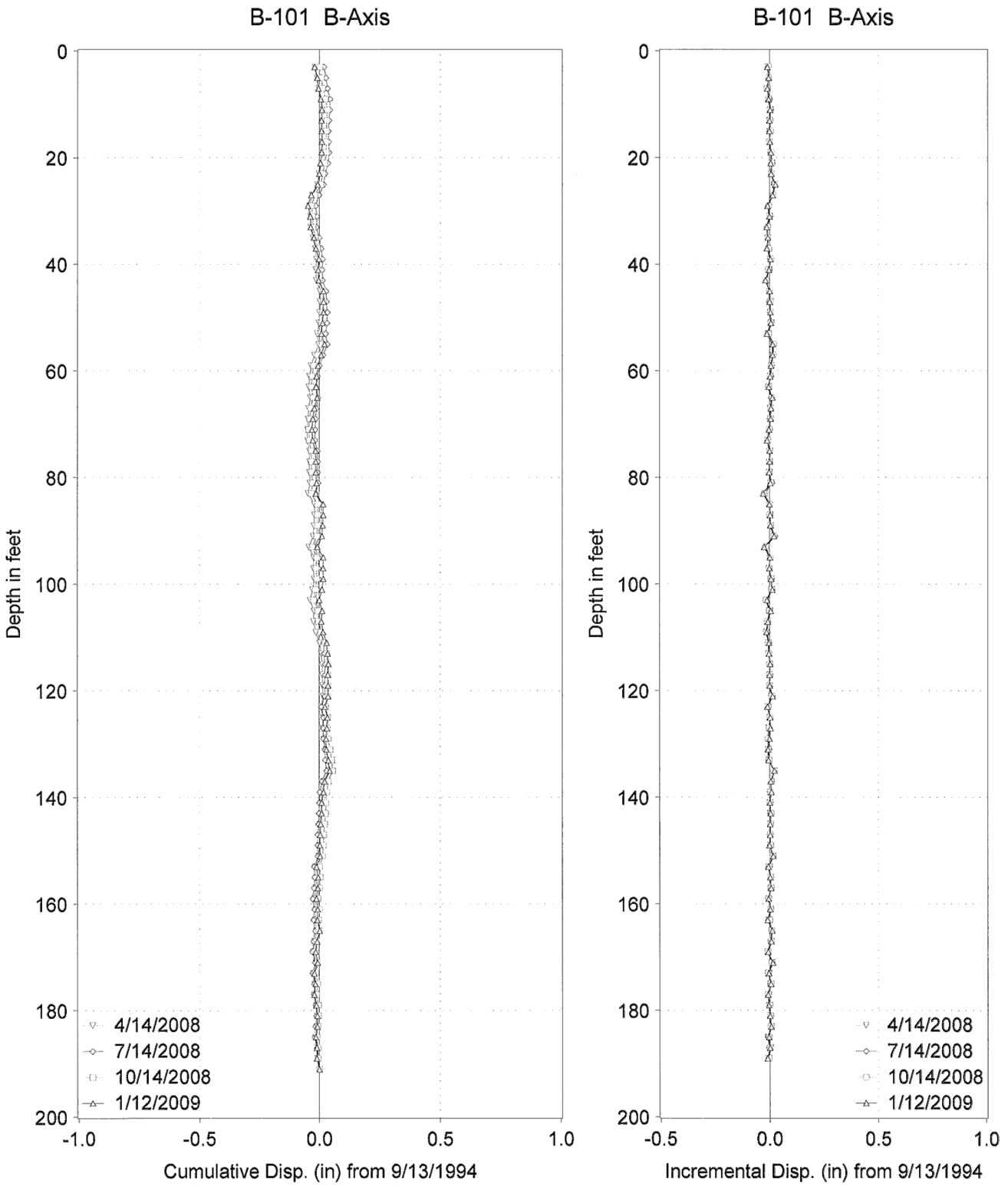
BBC&M DRAWING FILE: $BBCM FILENAME$ $DATE$ $TIME$ MODEL NAME: $MODEL$





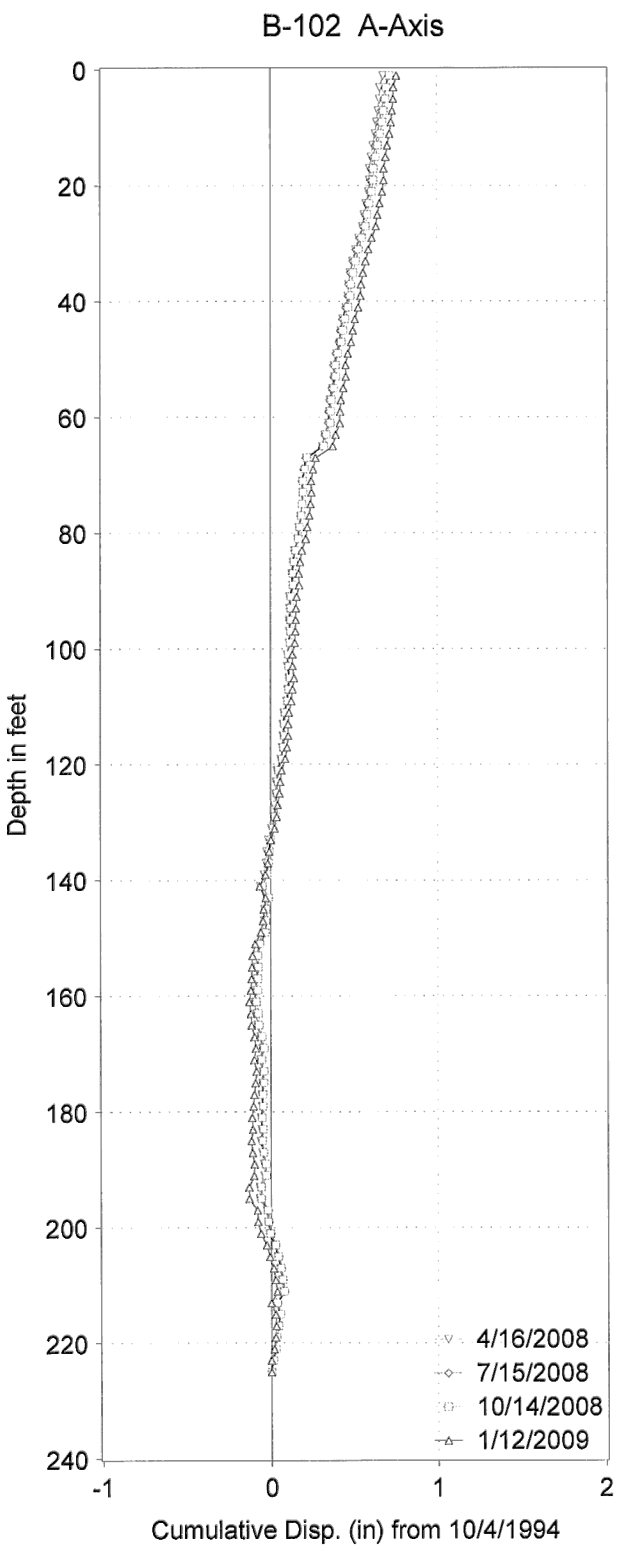
B-101
-Includes readings from the last four quarters.

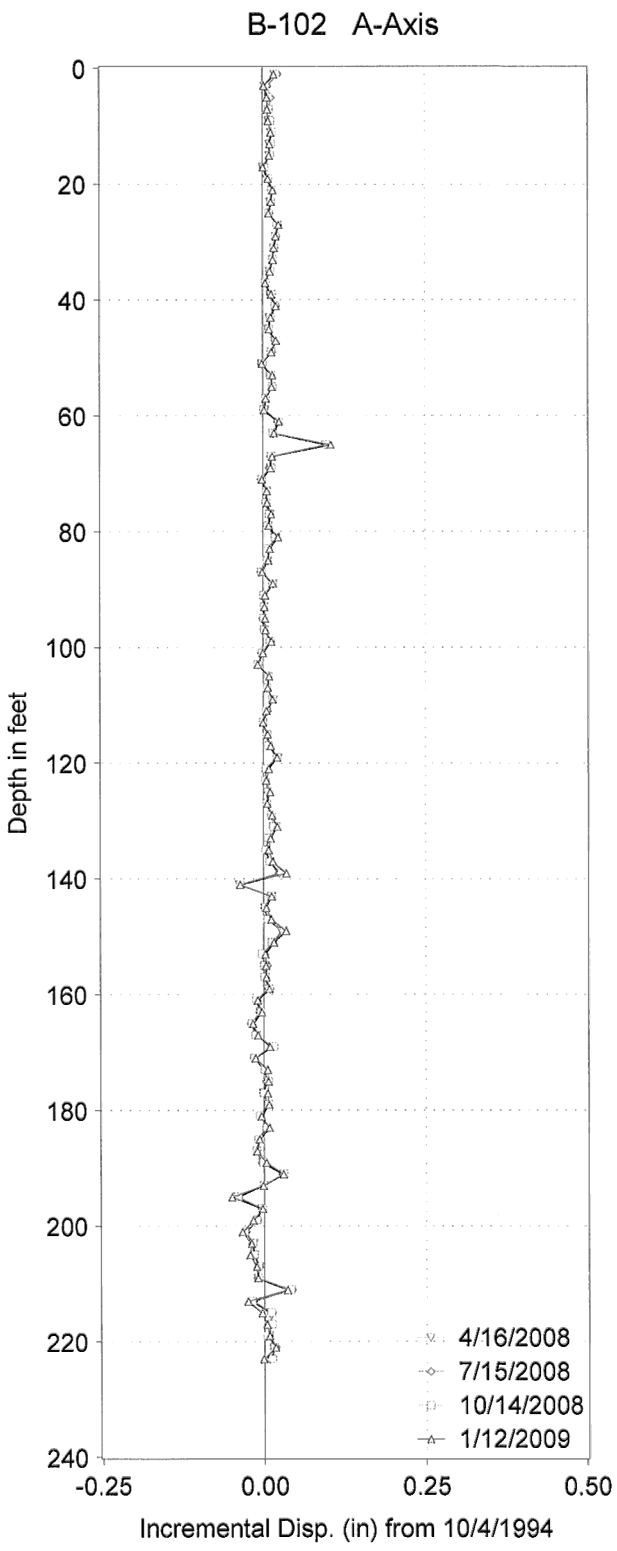
PLATE 3



B-101
-Includes readings from the last four quarters.

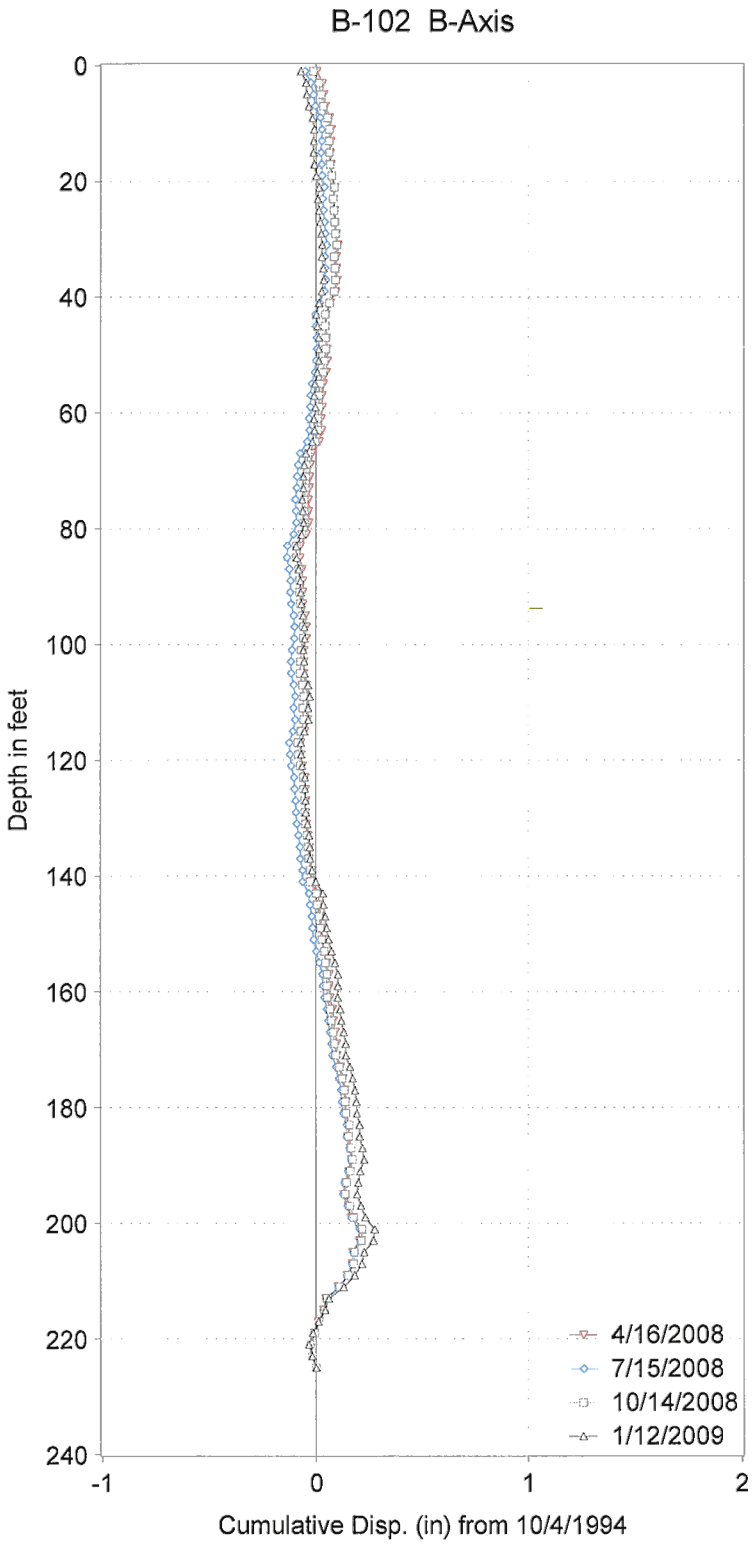
PLATE 4

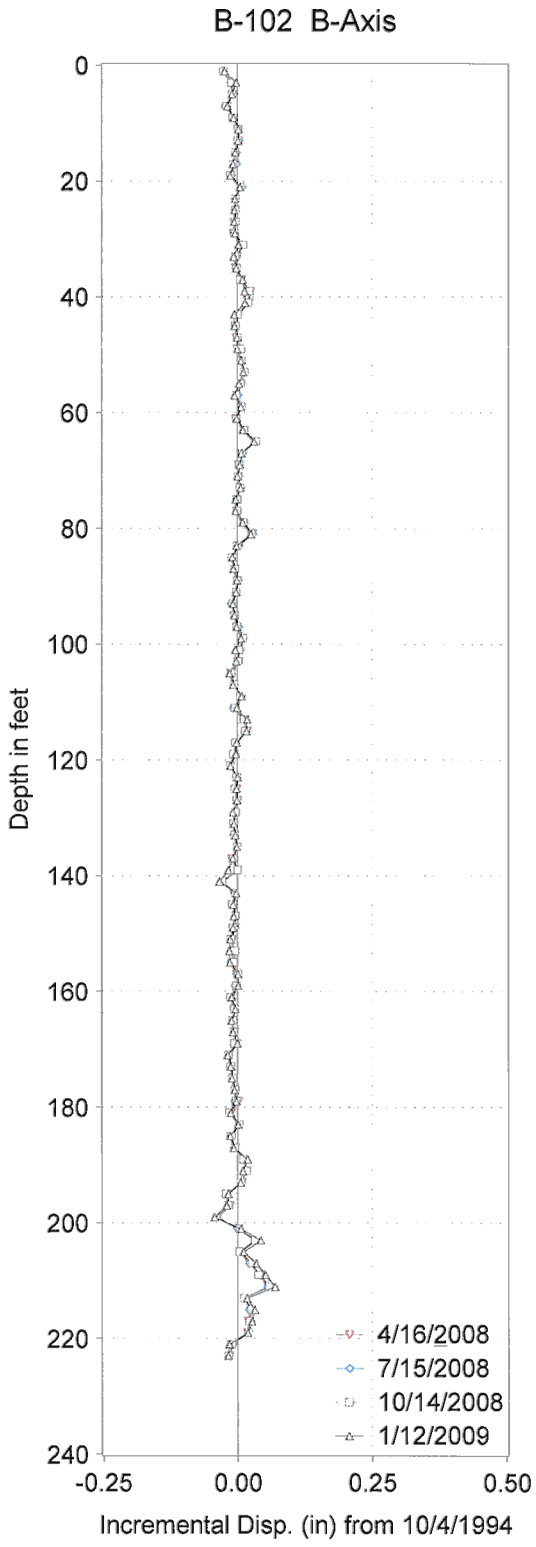




B-102
-Includes readings from the last four quarters.

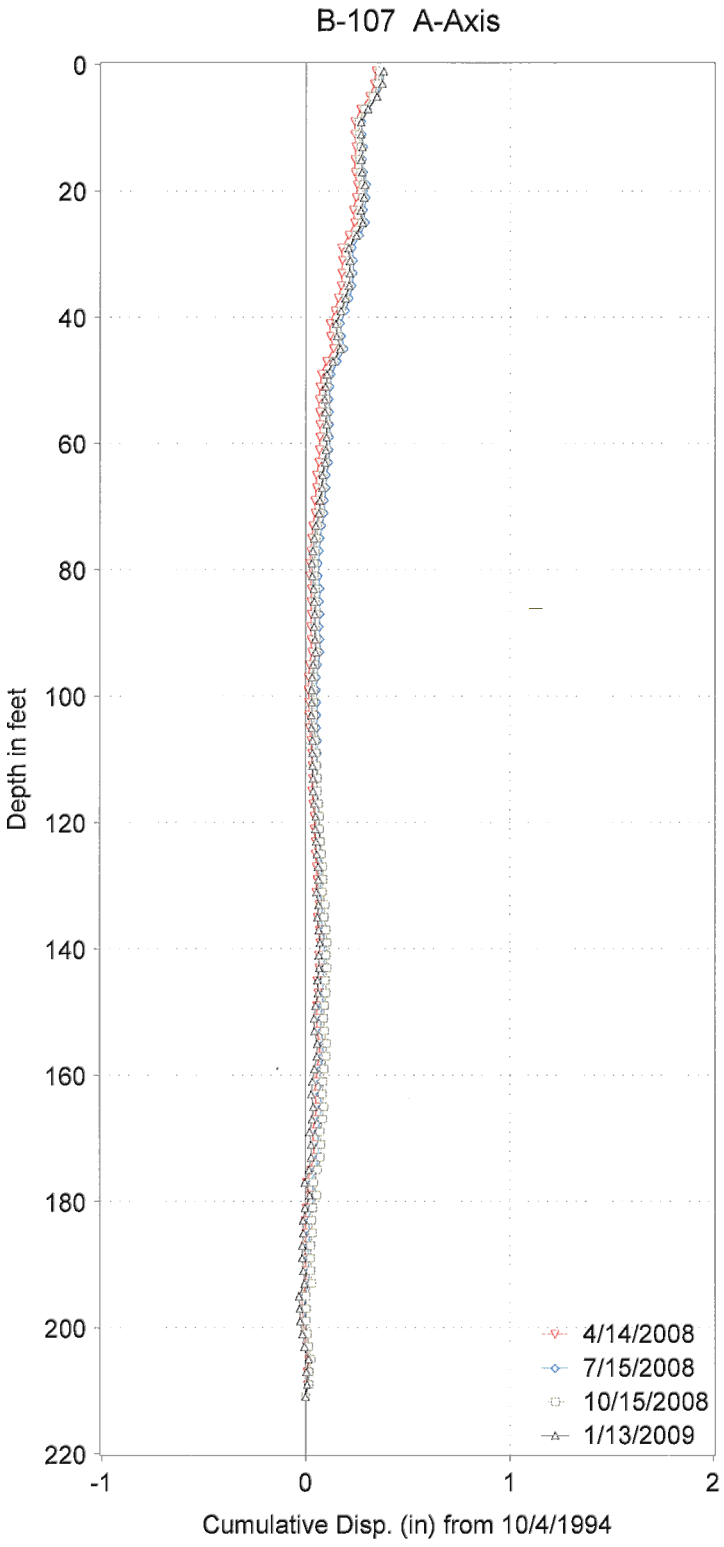
PLATE 5

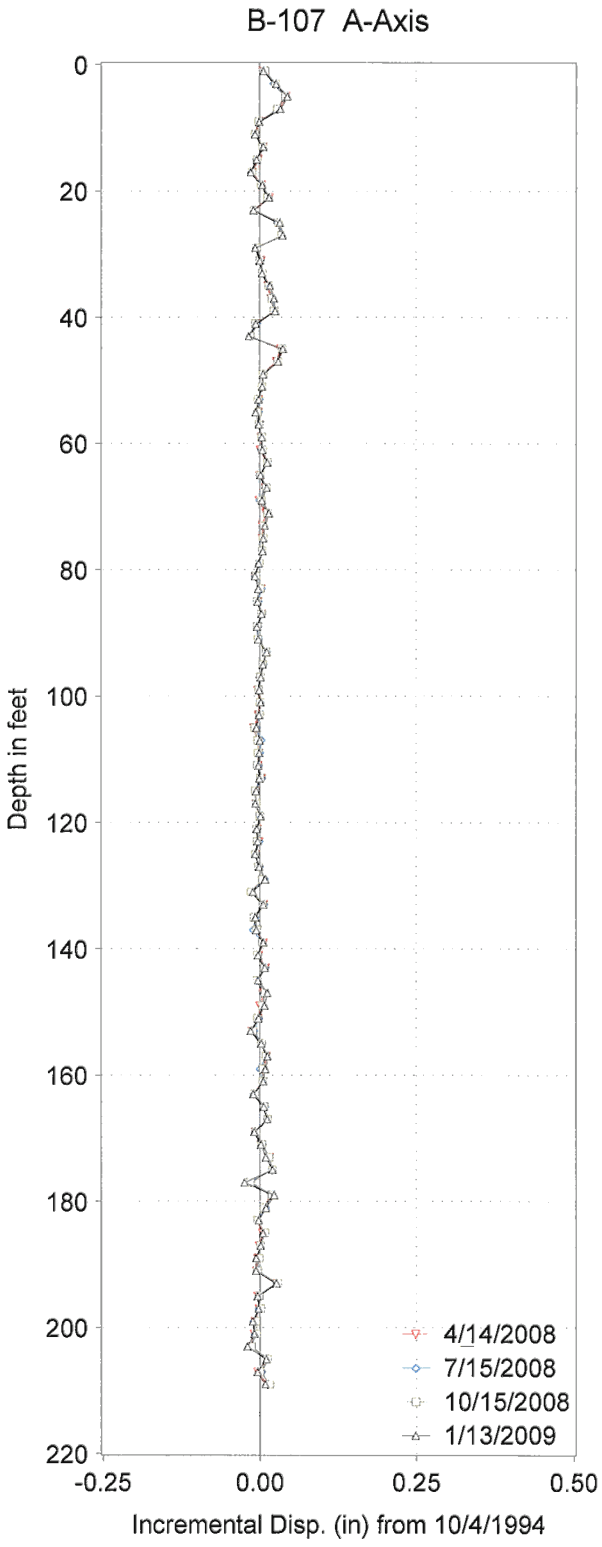




B-102
-Includes readings from the last four quarters.

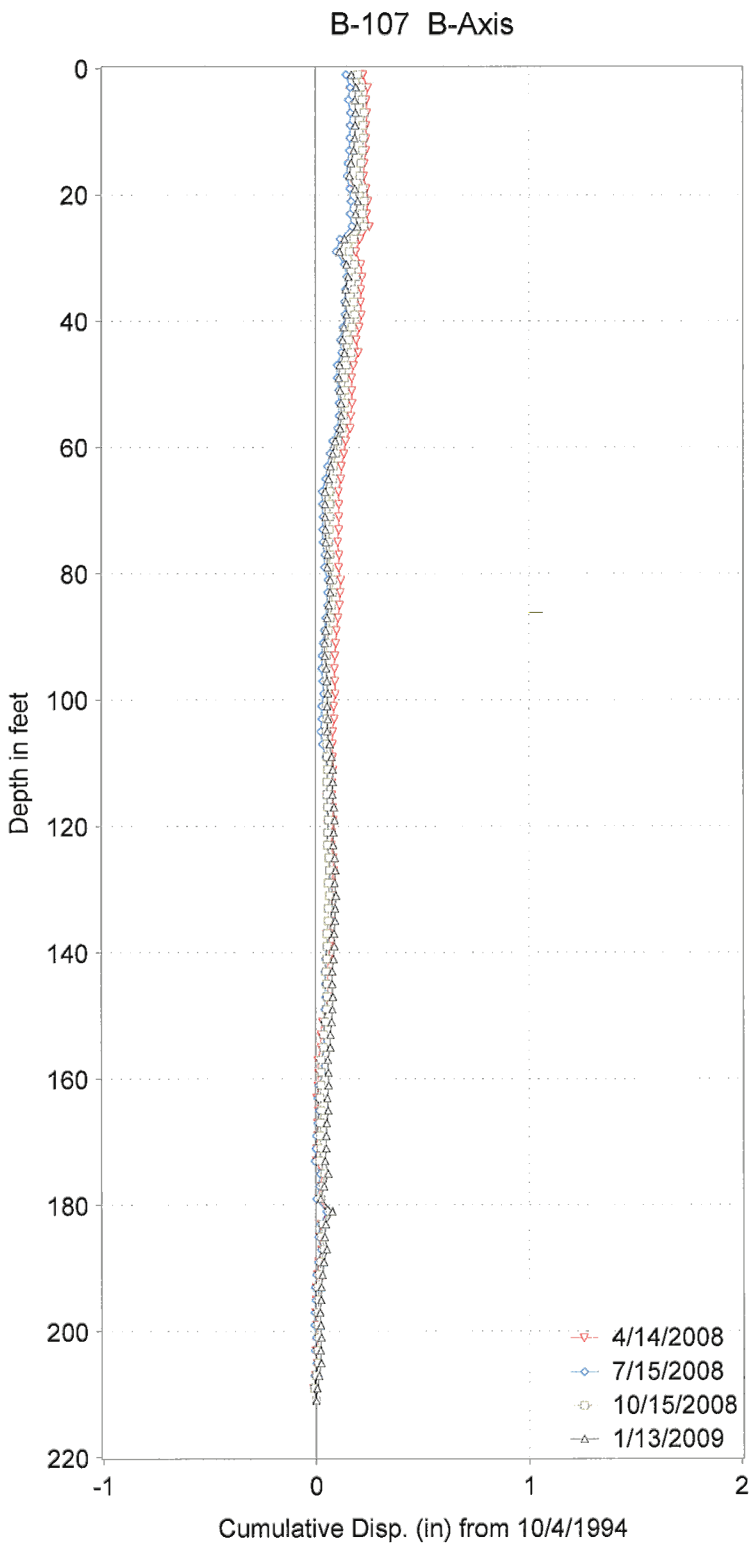
PLATE 6

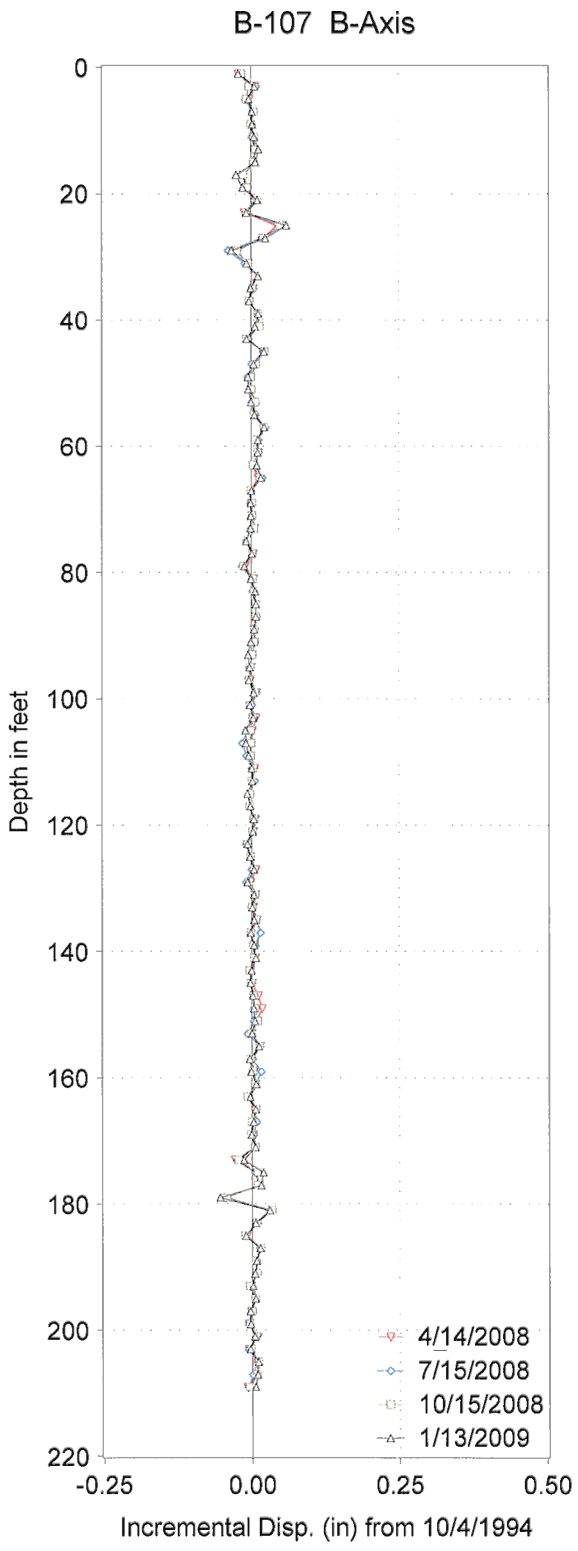




B-107
-Includes readings from the last four quarters.

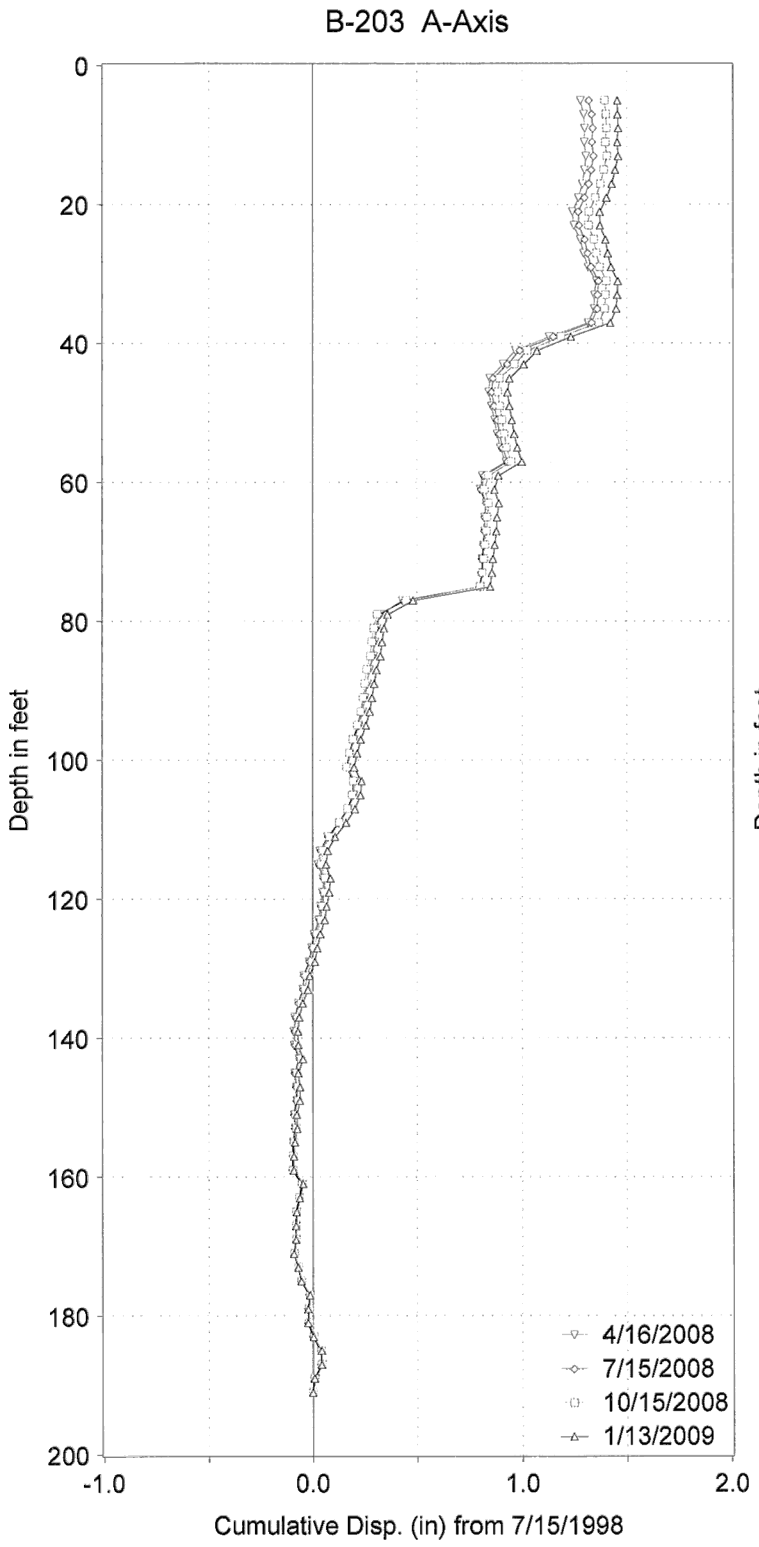
PLATE 7

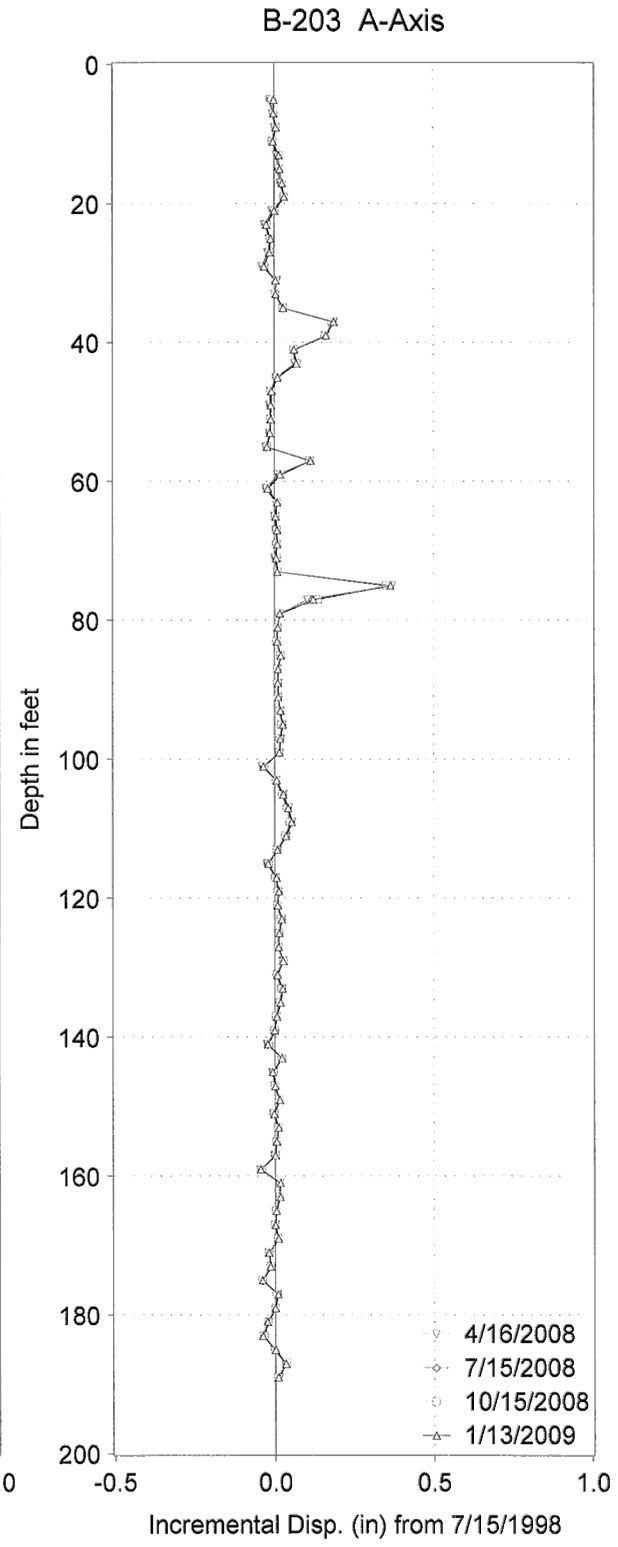




B-107
-Includes readings from the last four quarters.

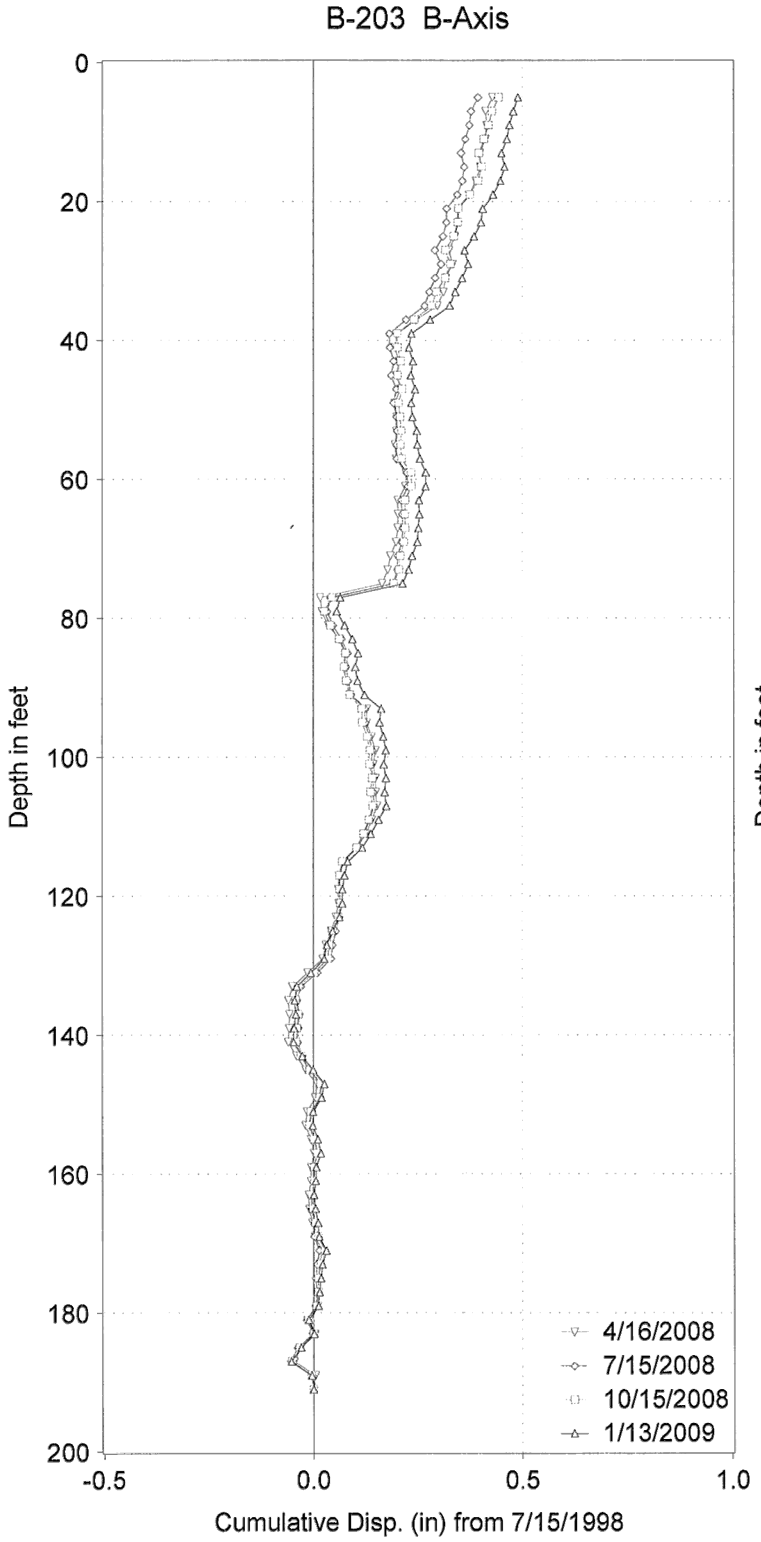
PLATE 8

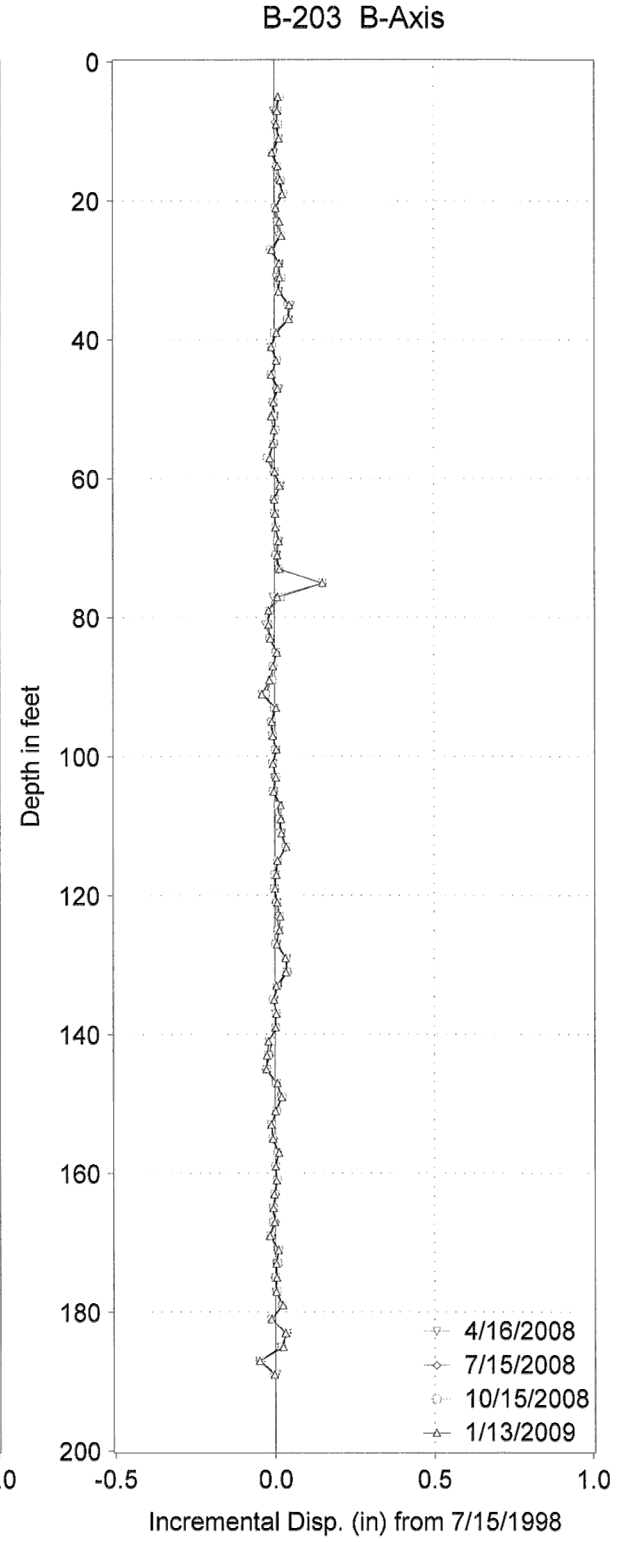




B-203
-Includes readings from the last four quarters.

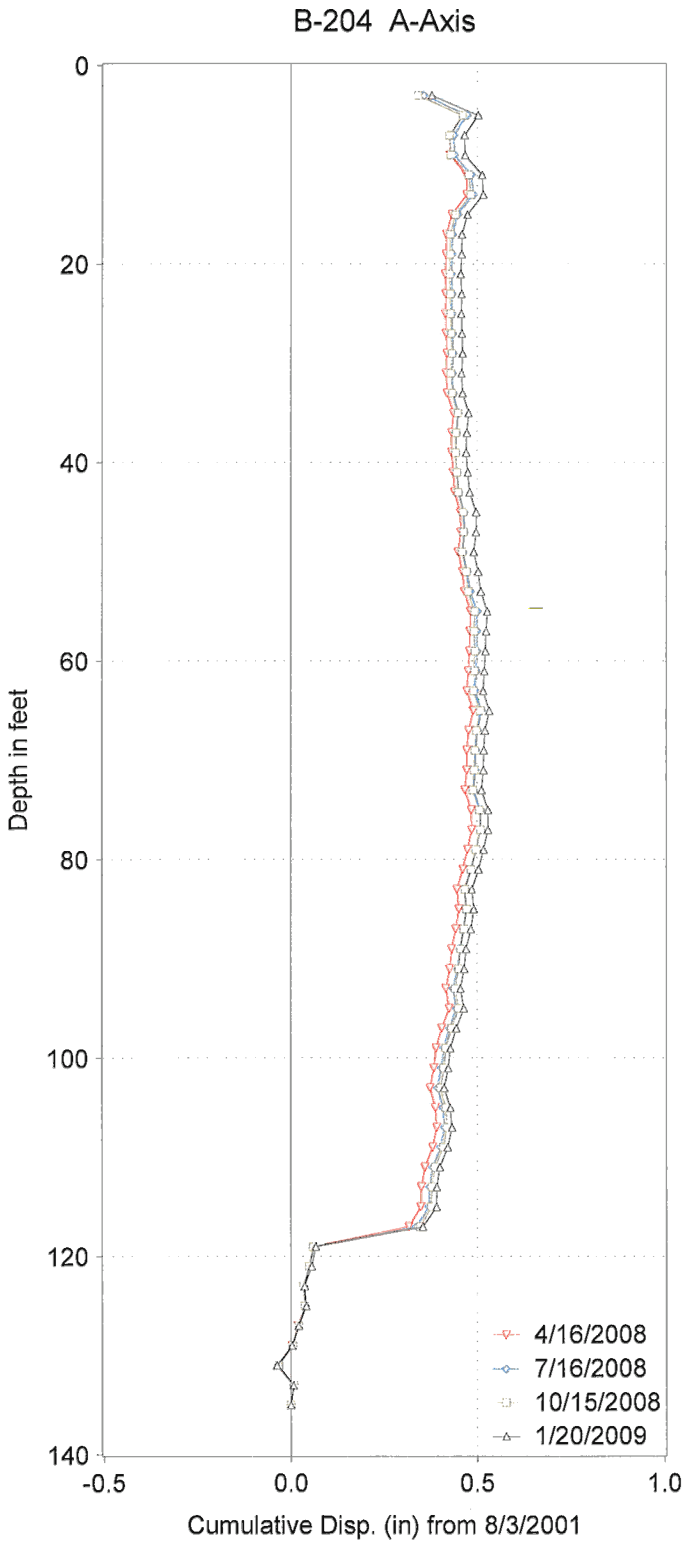
PLATE 9

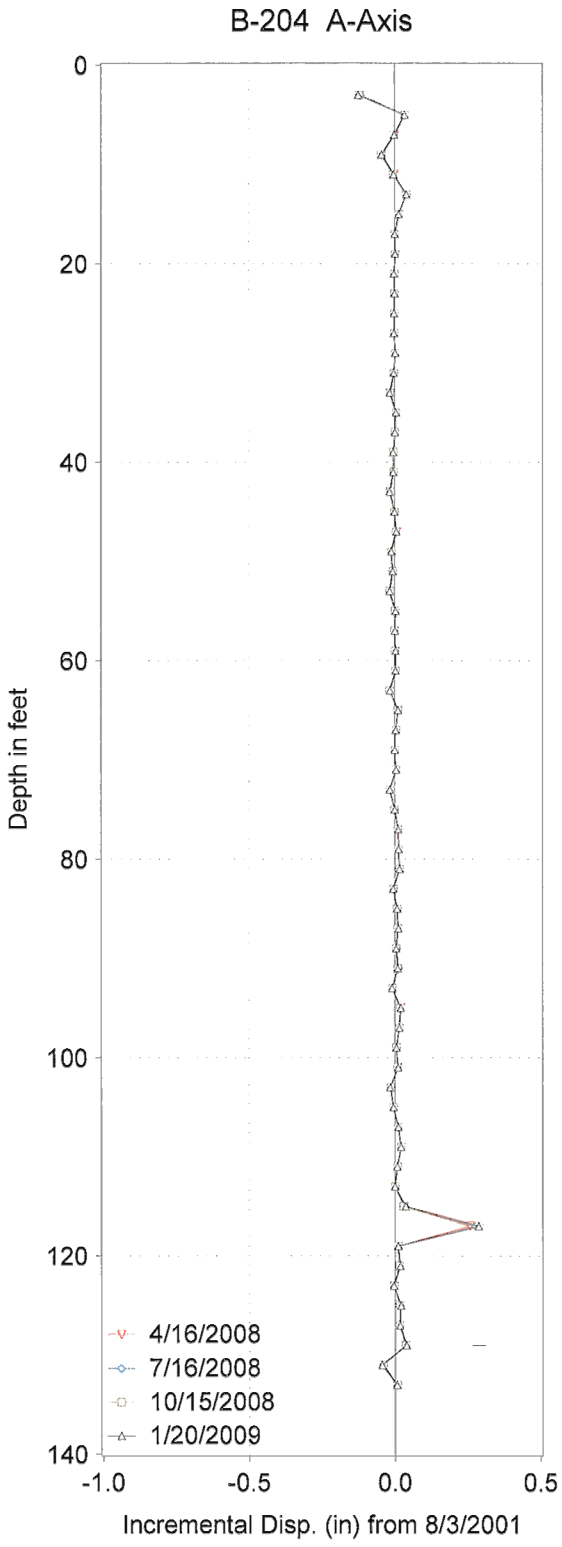




B-203
-Includes readings from the last four quarters.

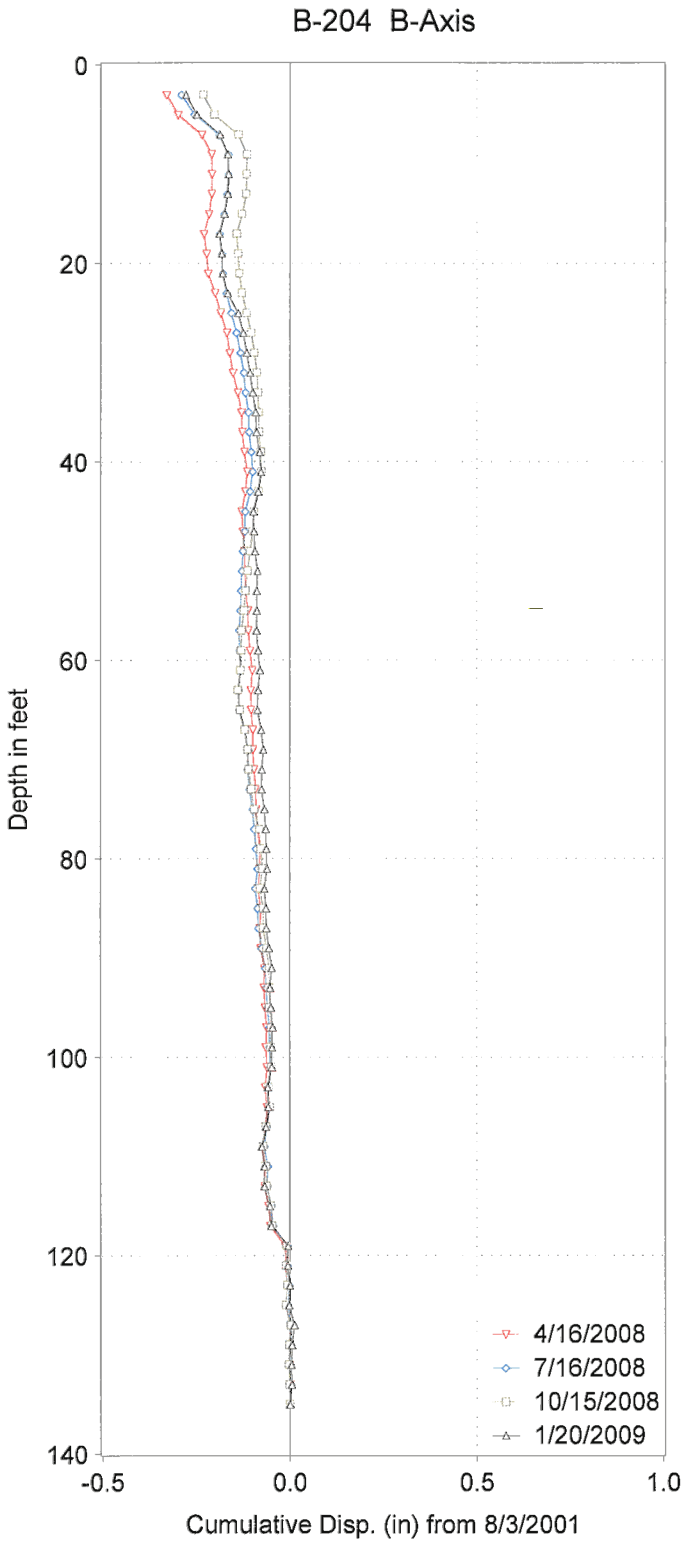
PLATE 10

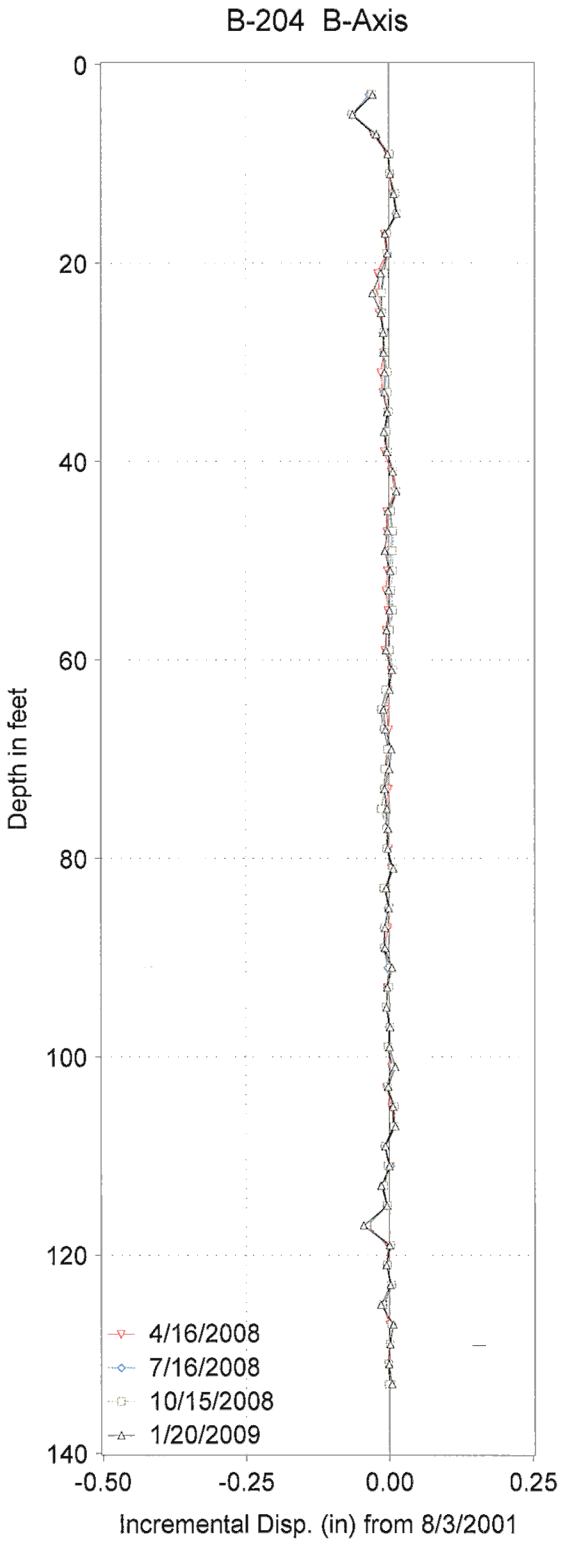




B-204
-Includes readings from the last four quarters.

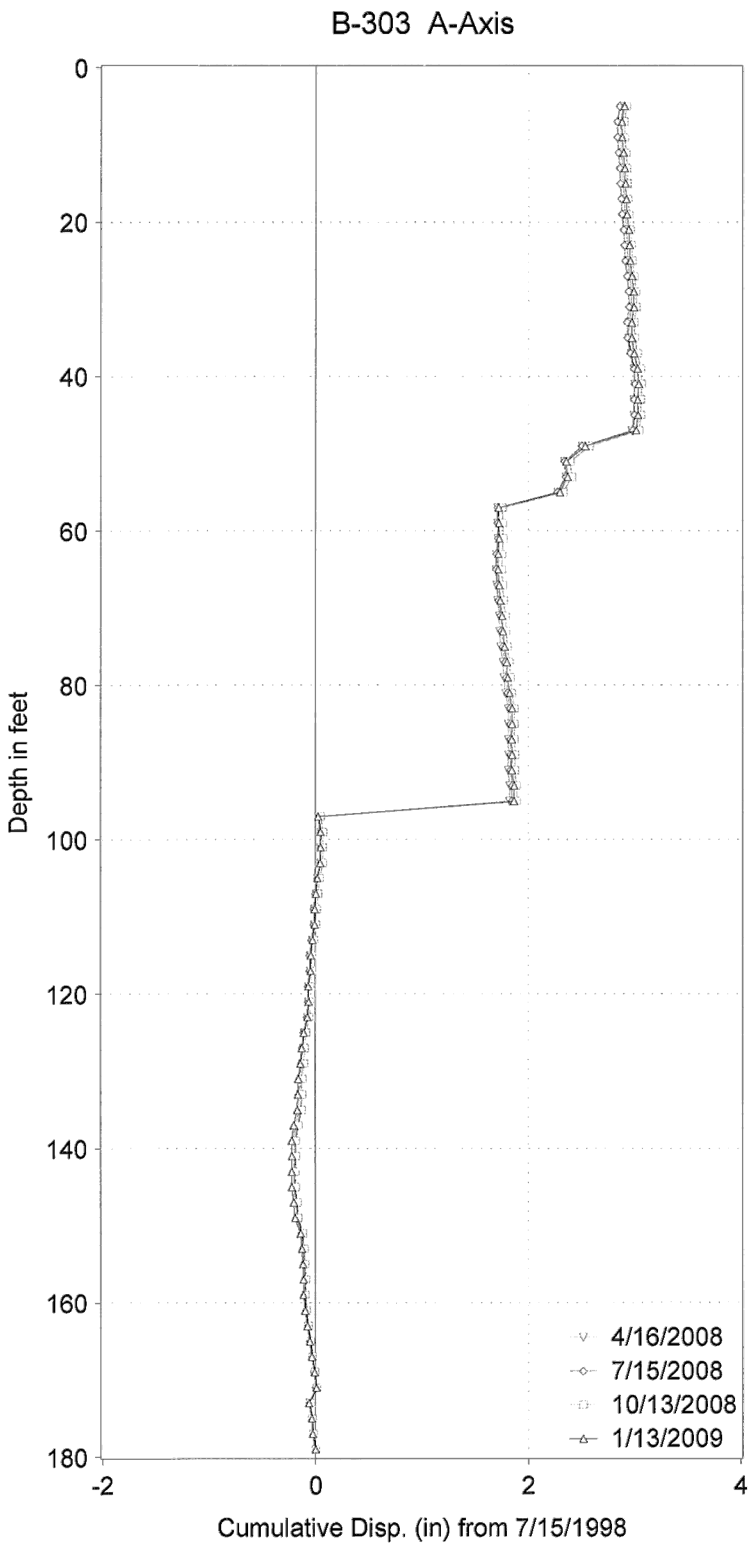
PLATE 11

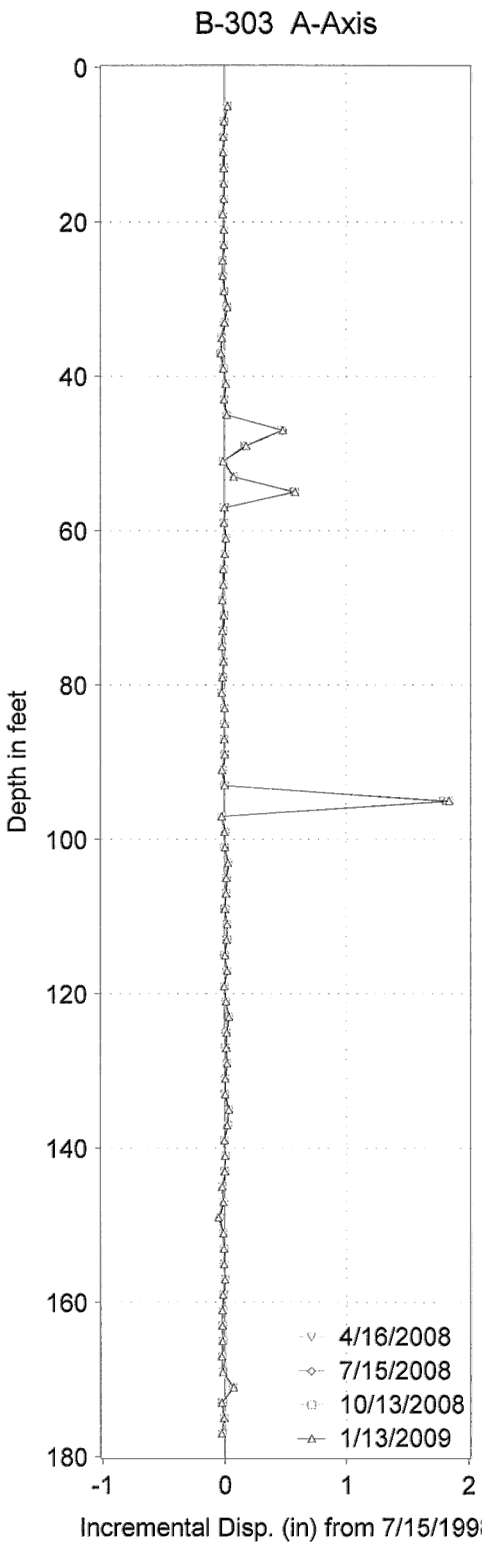




B-204
-Includes readings from the last four quarters.

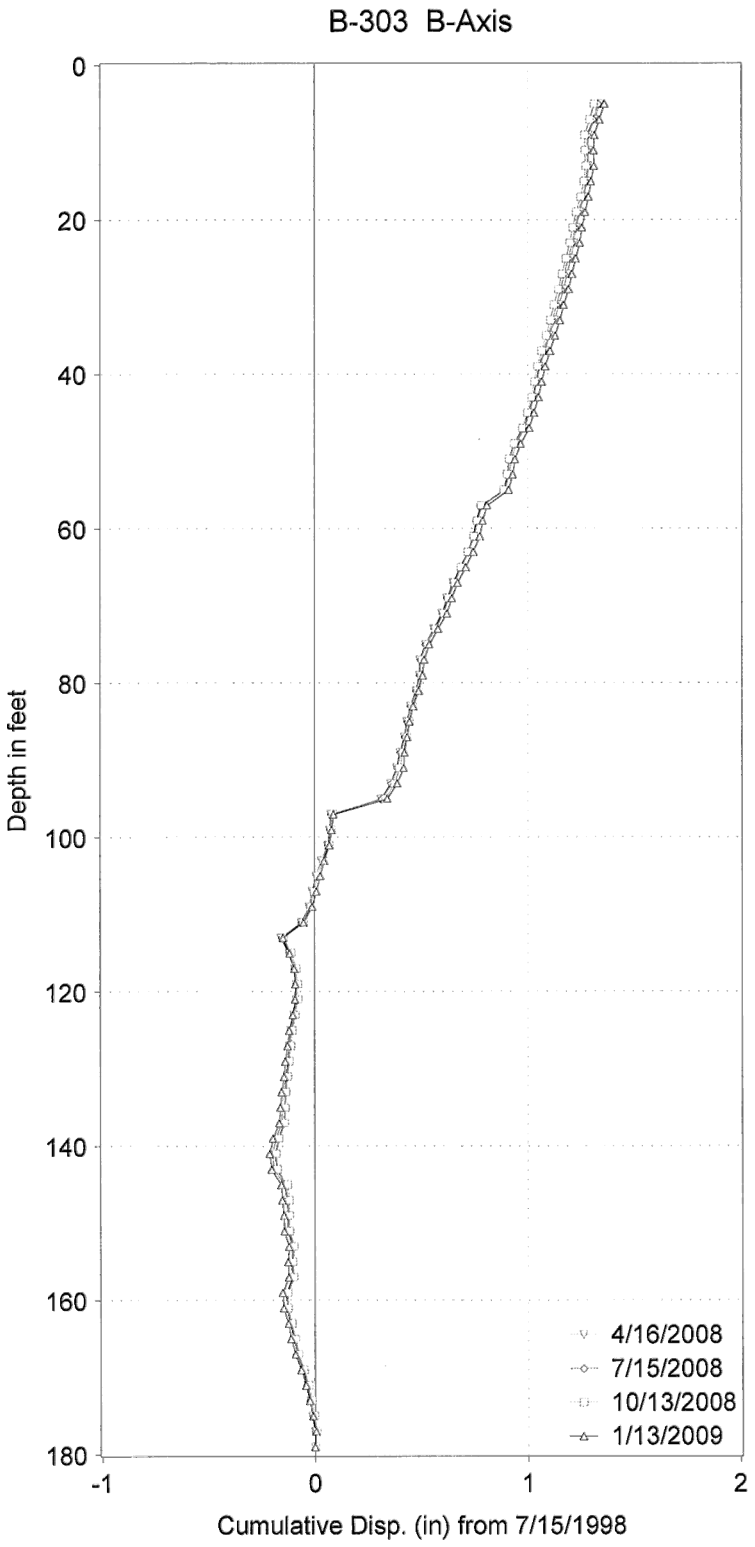
PLATE 12

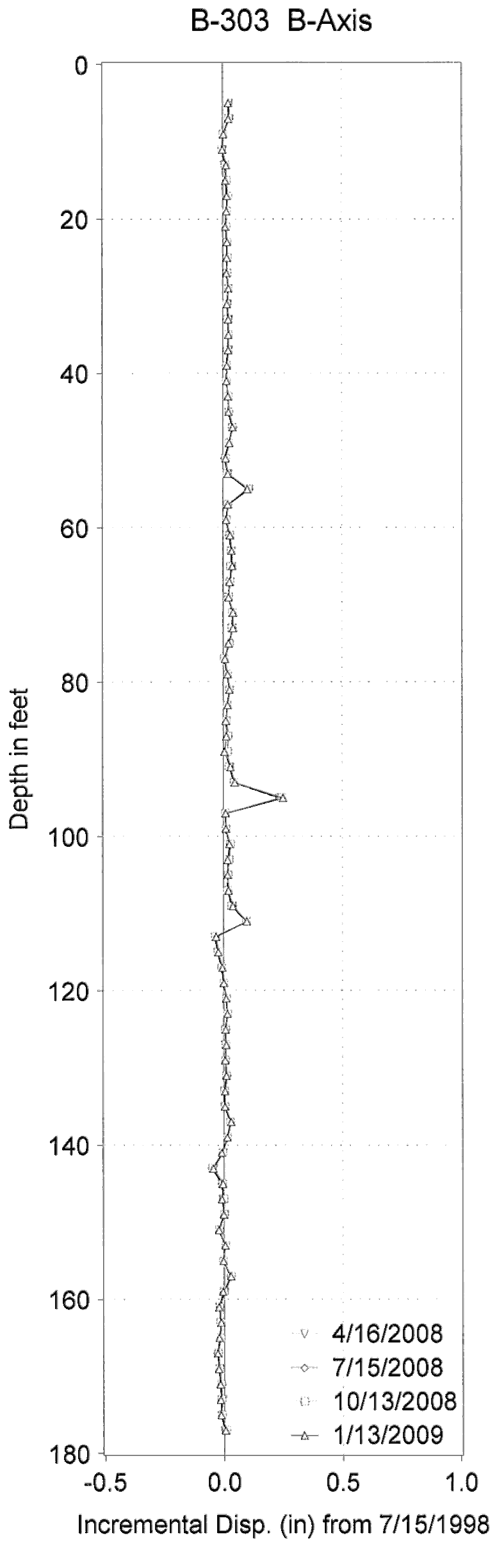




B-303
-Includes readings from the last four quarters.

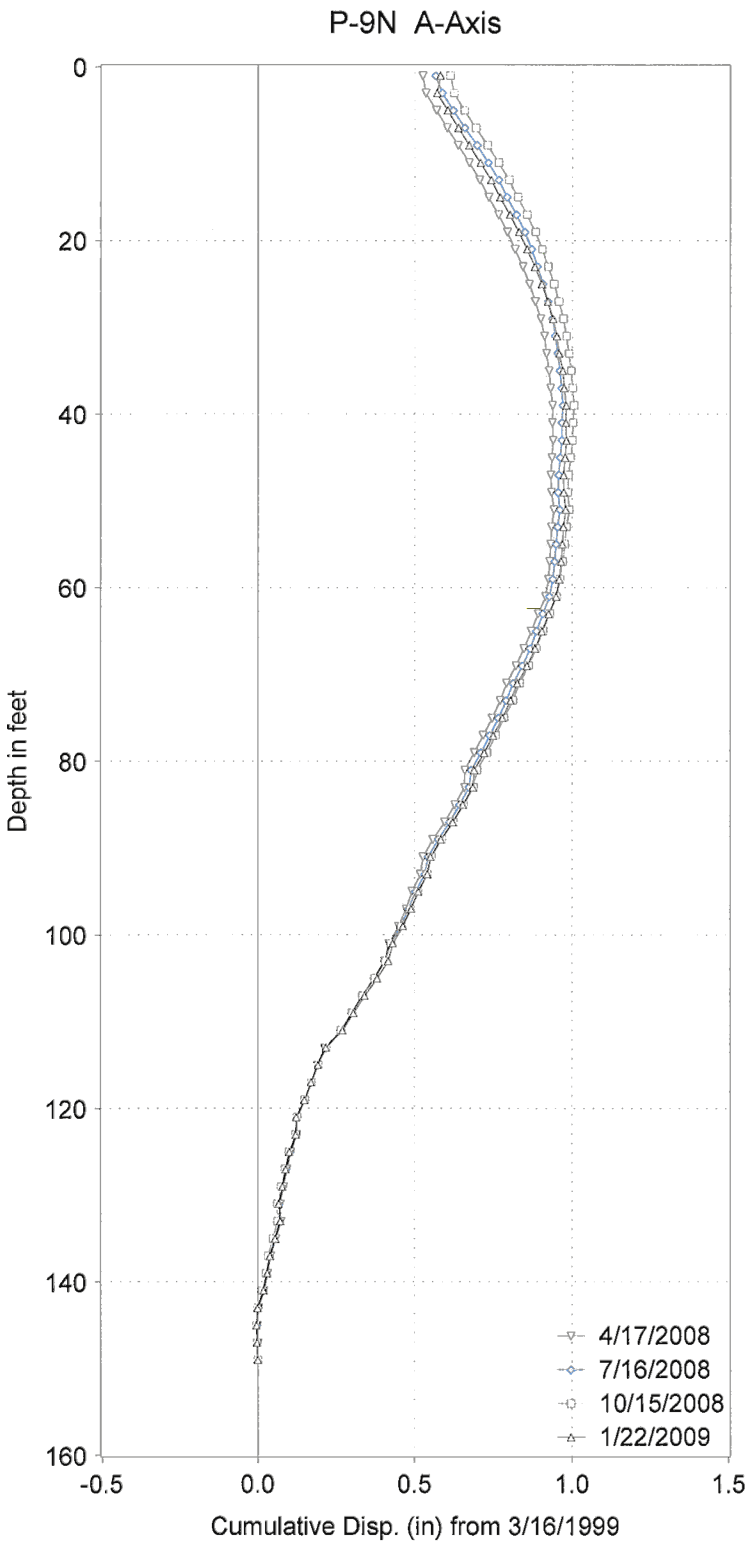
PLATE 13

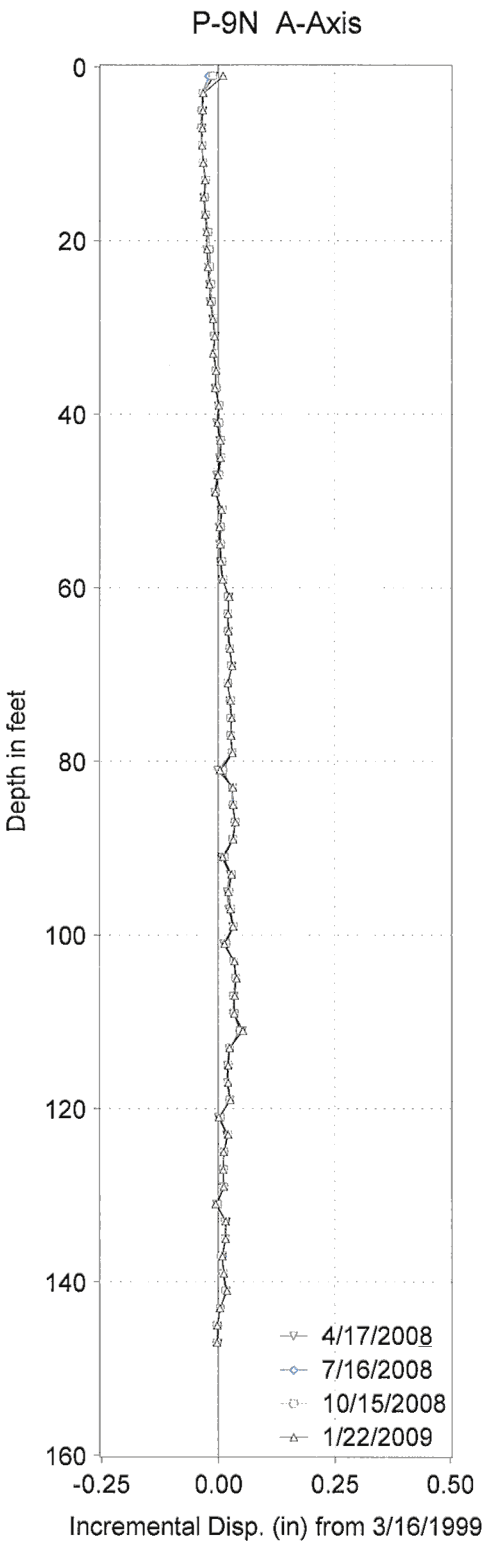




B-303
-Includes readings from the last four quarters.

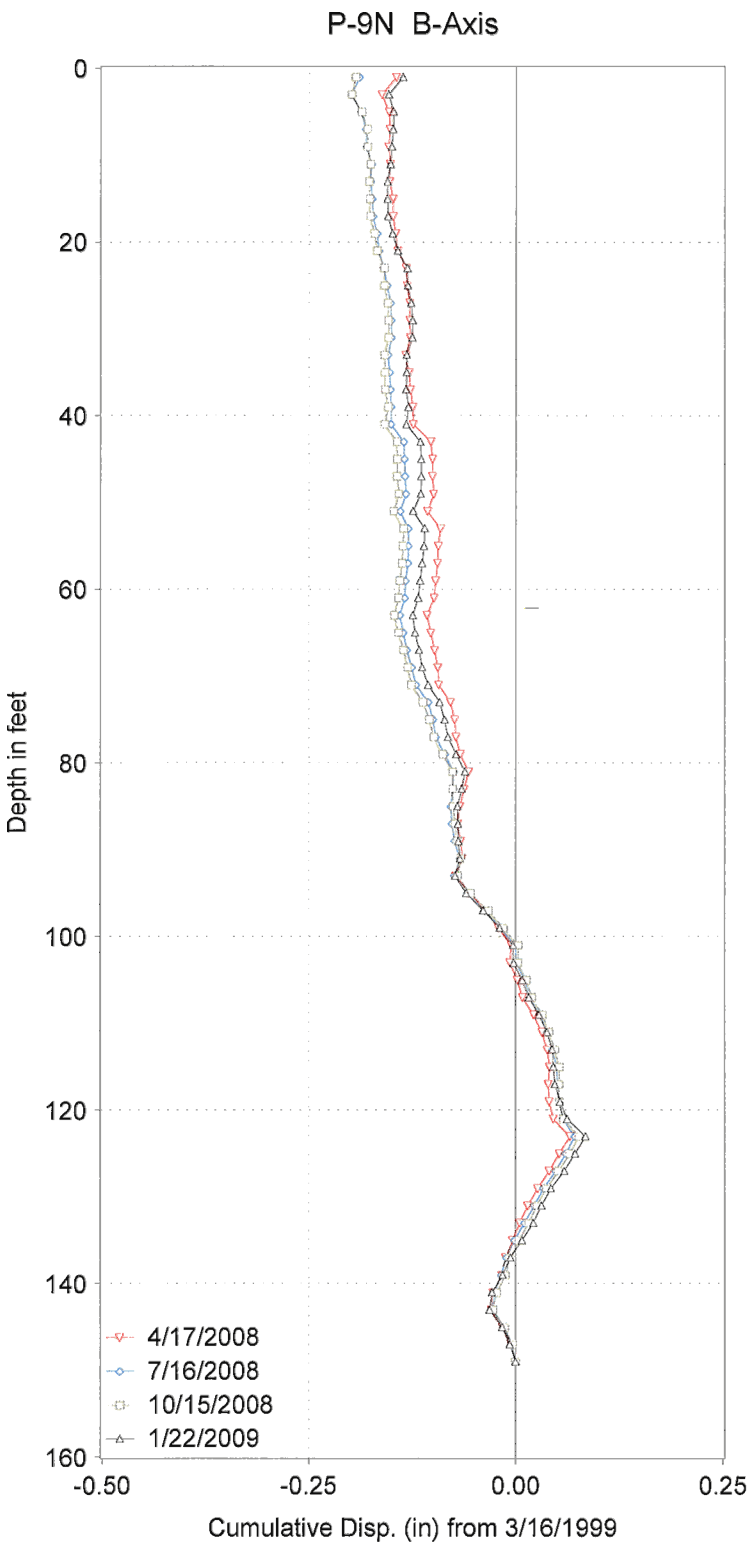
PLATE 14

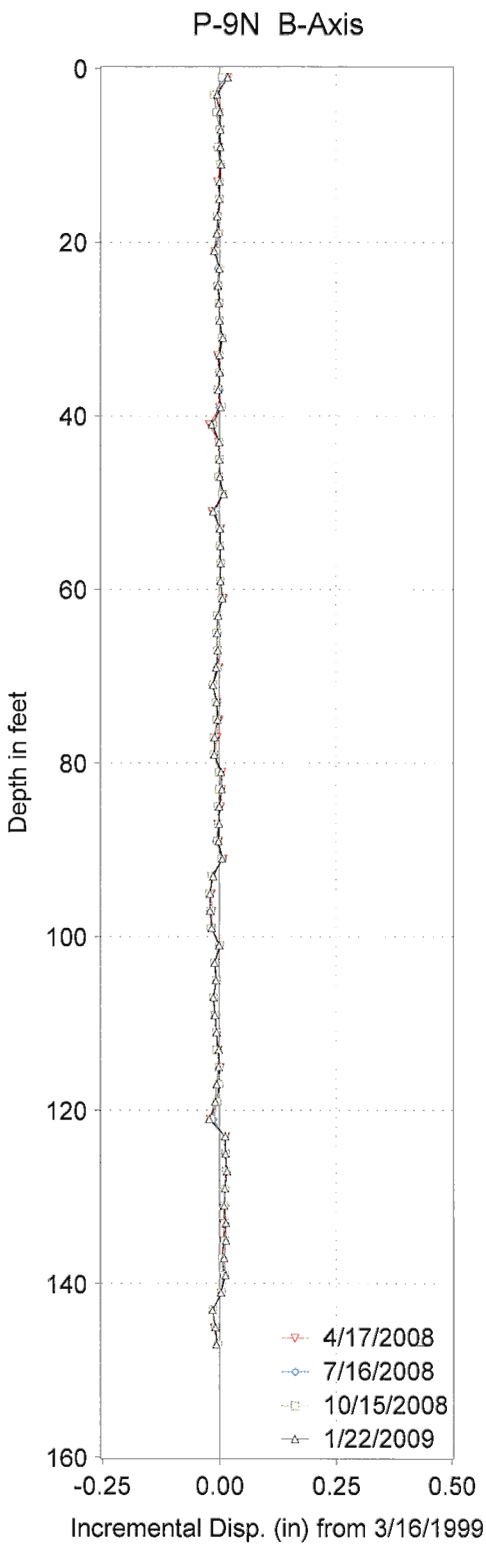




P-9N
-Includes readings from the last four quarters.

PLATE 15





P-9N
-Includes readings from the last four quarters.

PLATE 16

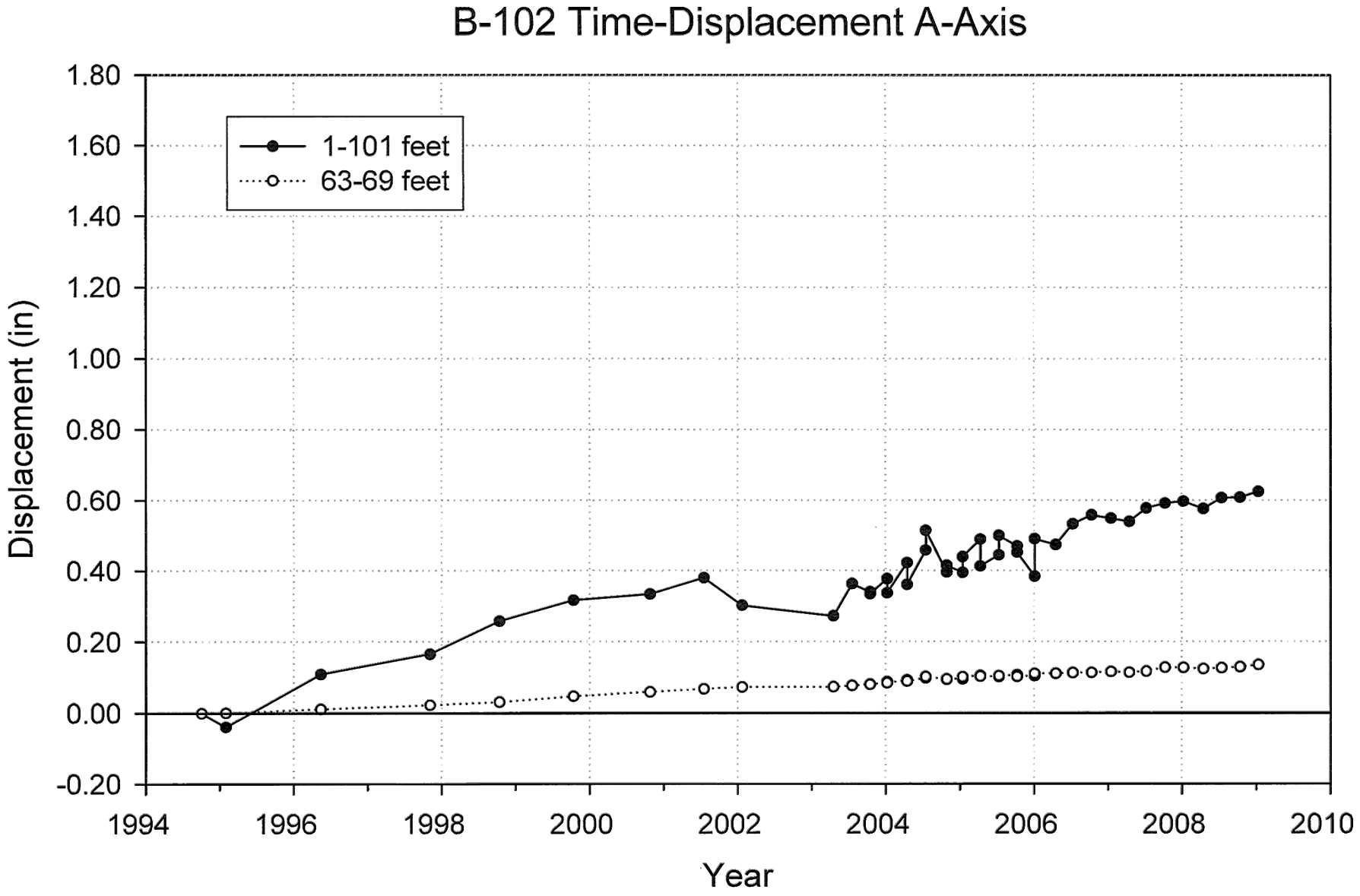

B-102 Time-Displacement A-Axis
1-101 feet
63-69 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 17

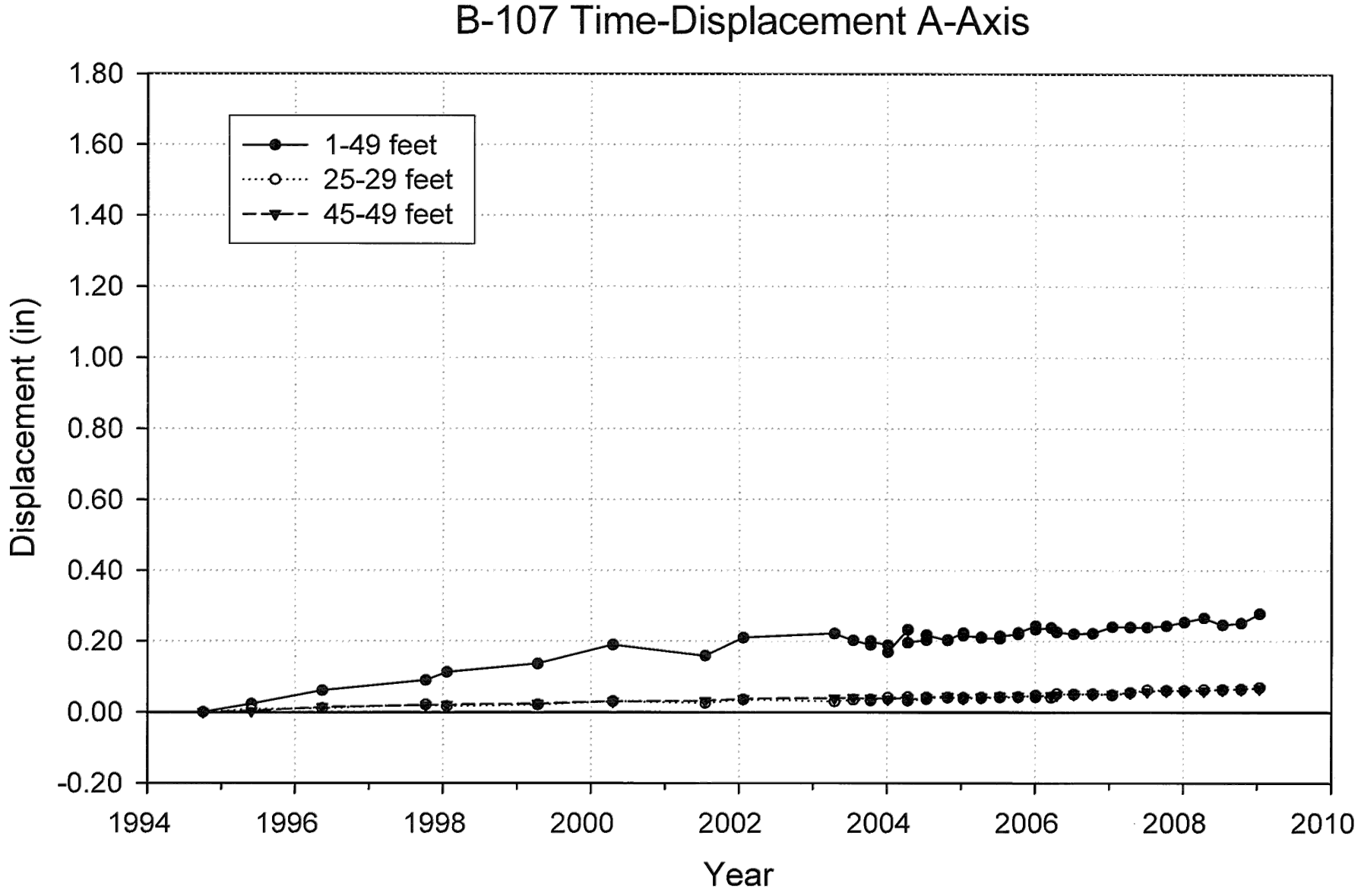

B-107 Time-Displacement A-Axis
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Displacement (in)
1-49 feet
25-29 feet
45-49 feet
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 18

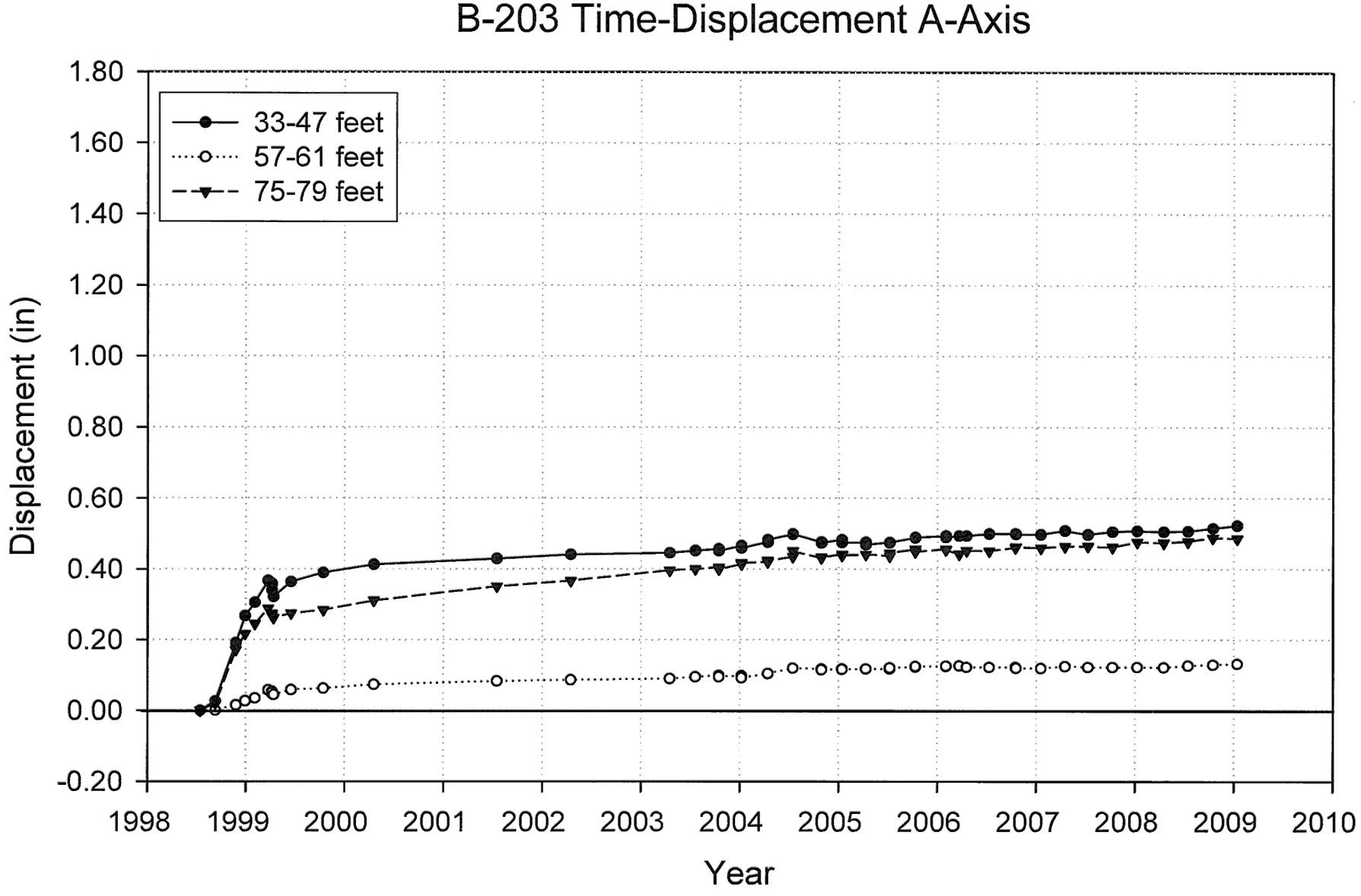

B-203 Time-Displacement A-Axis
33-47 feet
57-61 feet
75-79 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

PLATE 19

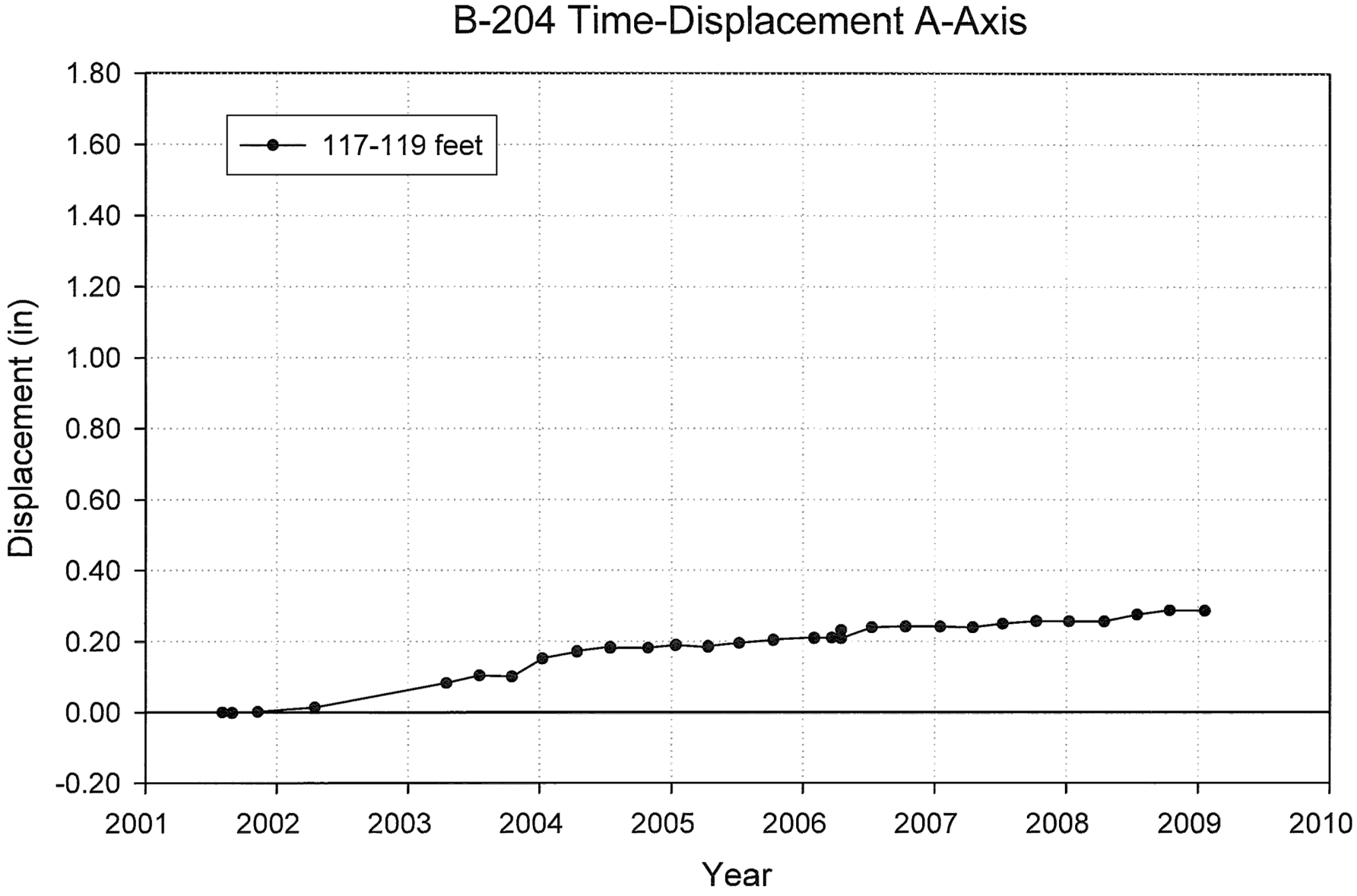

B-204 Time-Displacement A-Axis
117-119 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

PLATE 20

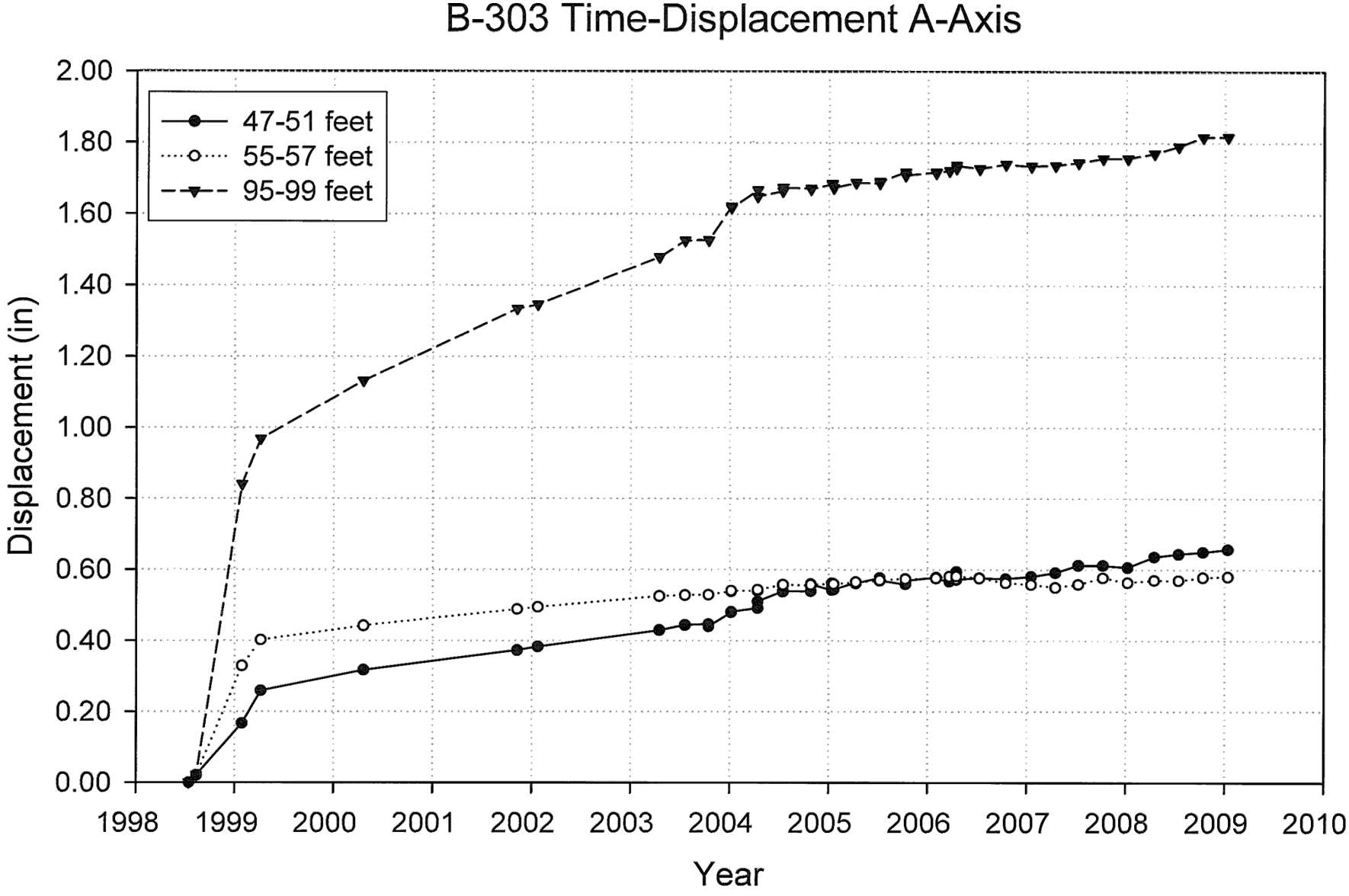
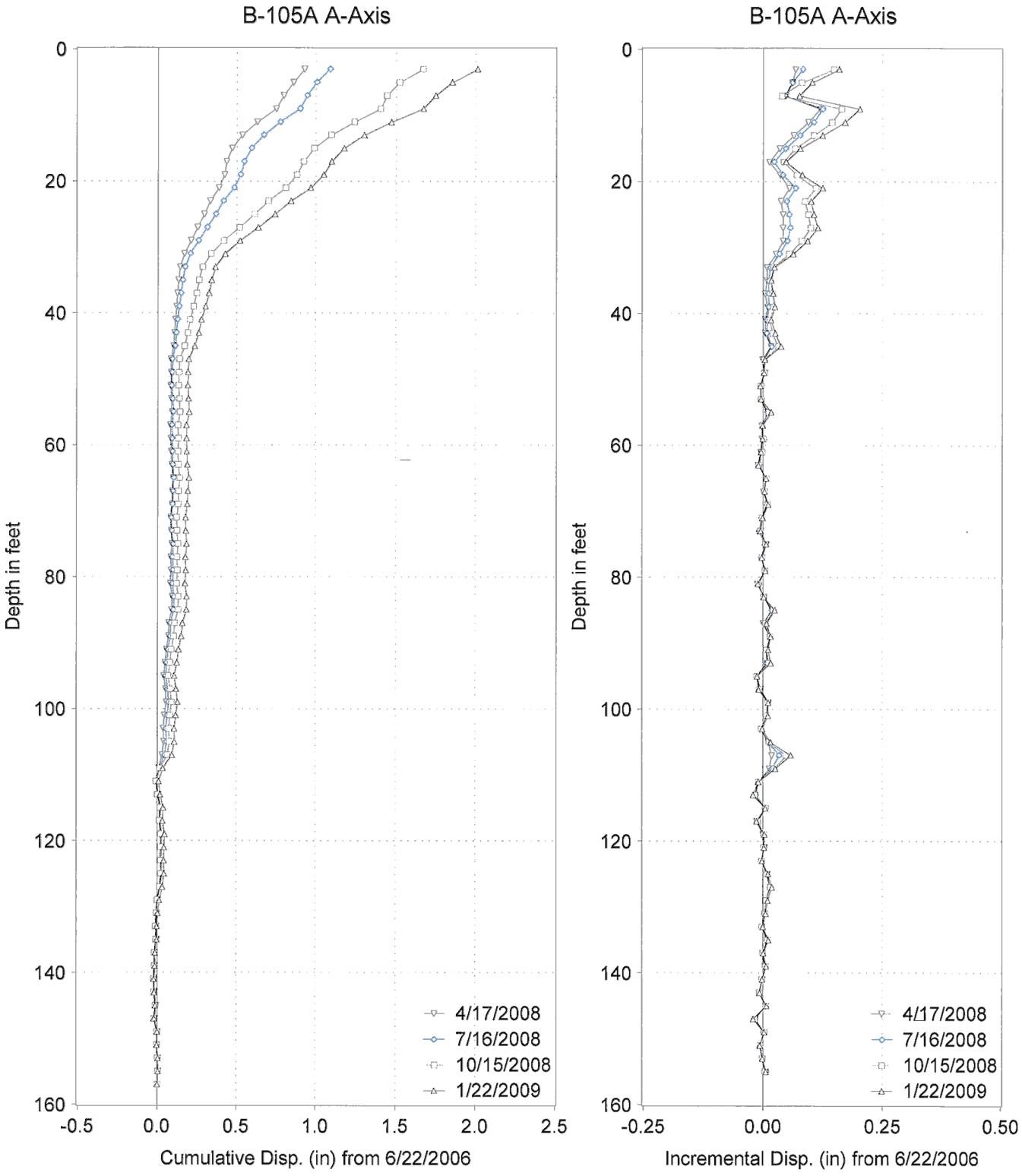
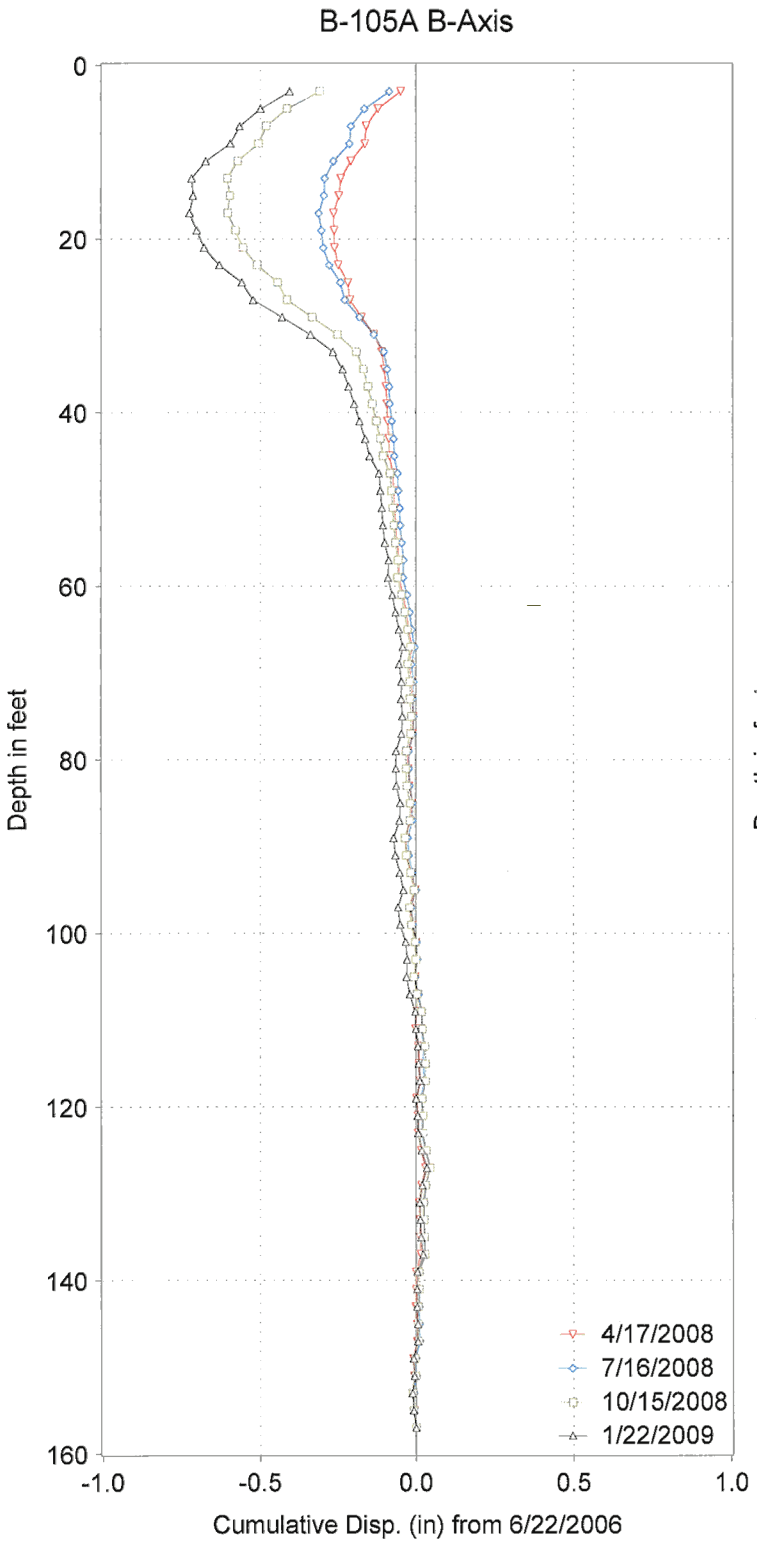

B-303 Time-Displacement A-Axis
47-51 feet
55-57 feet
95-99 feet
Displacement (in)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

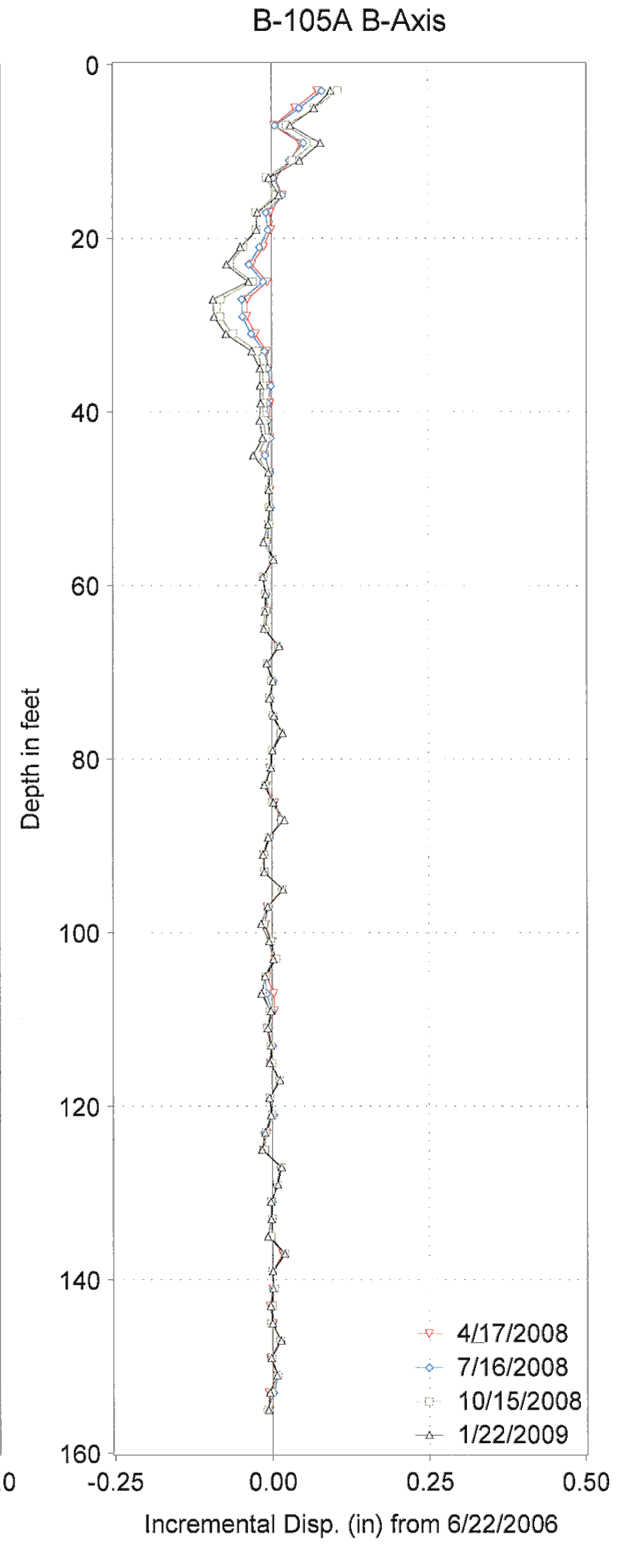
PLATE 21



B-105A
-Includes readings from the last four quarters.

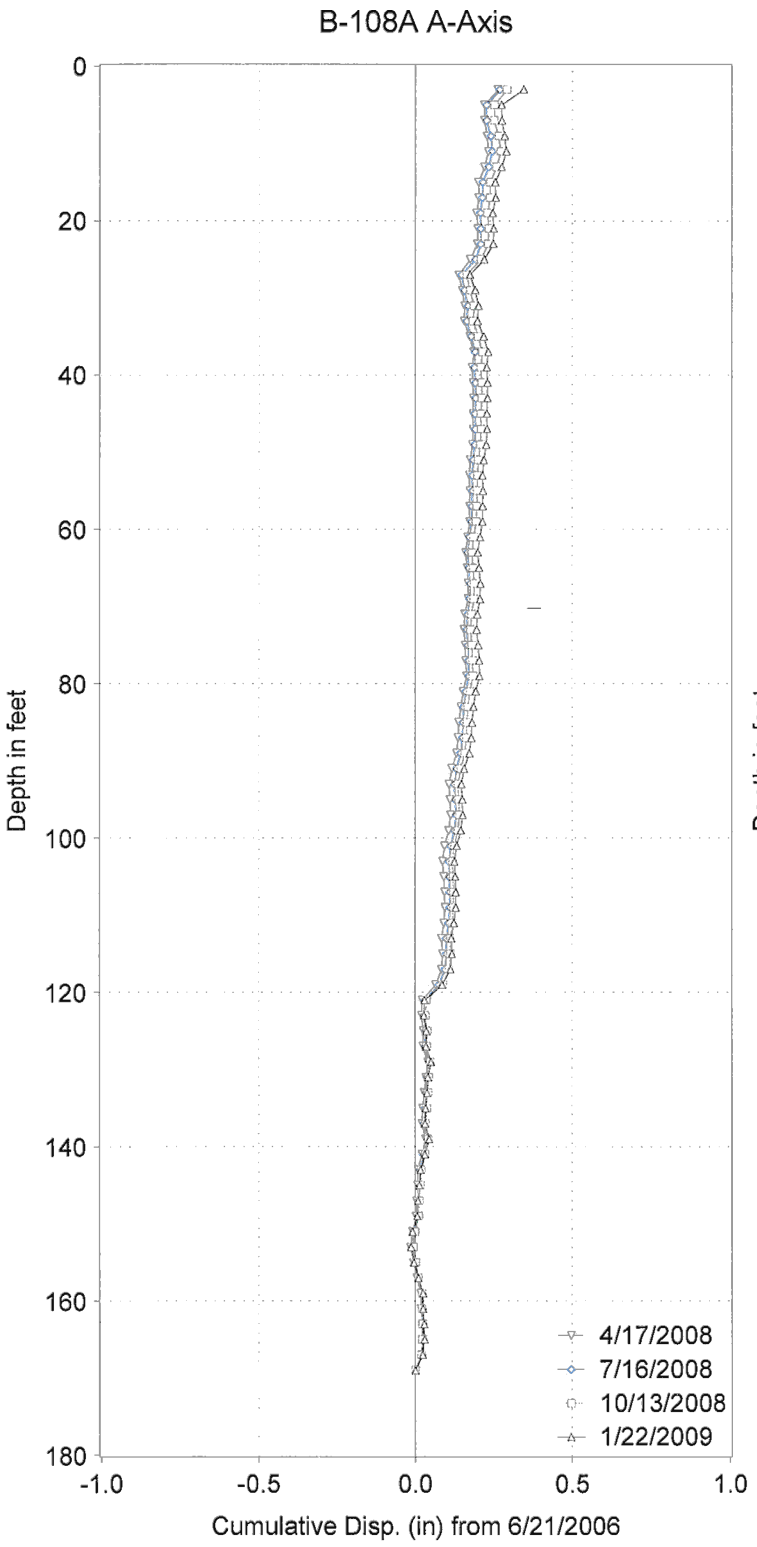
PLATE 22

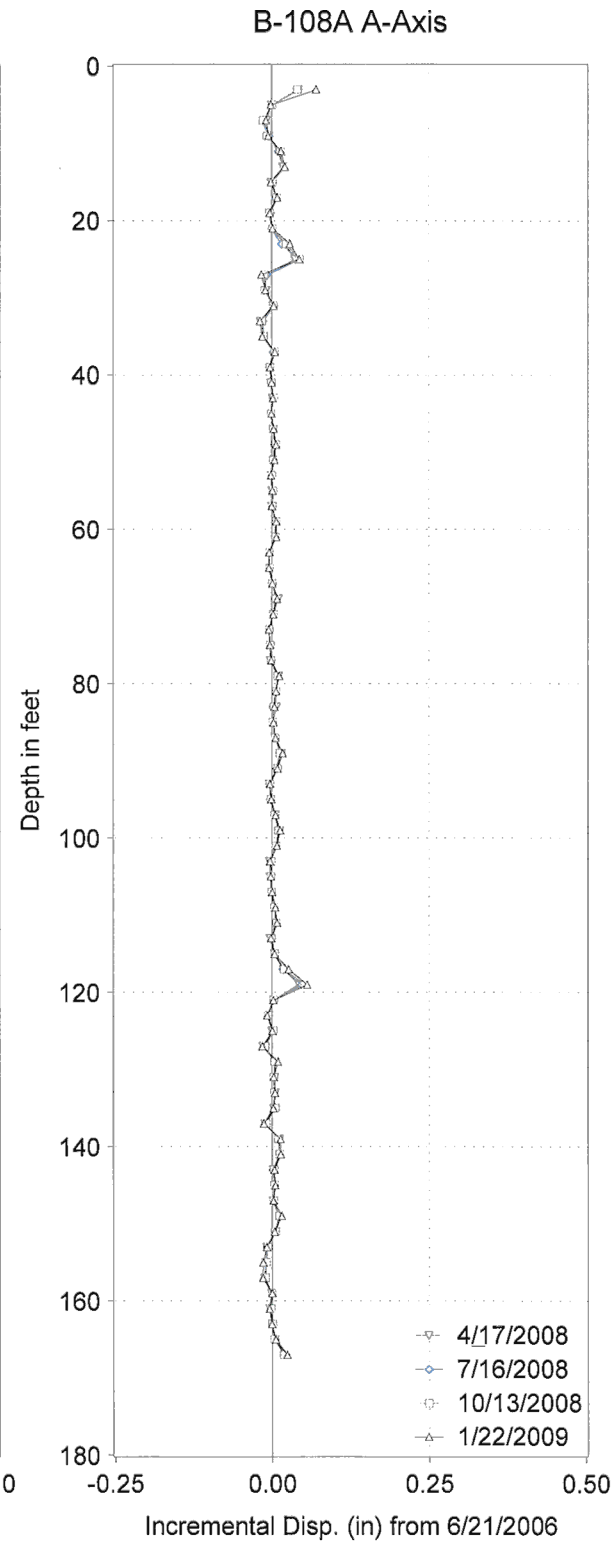




B-105A
-Includes readings from the last four quarters.

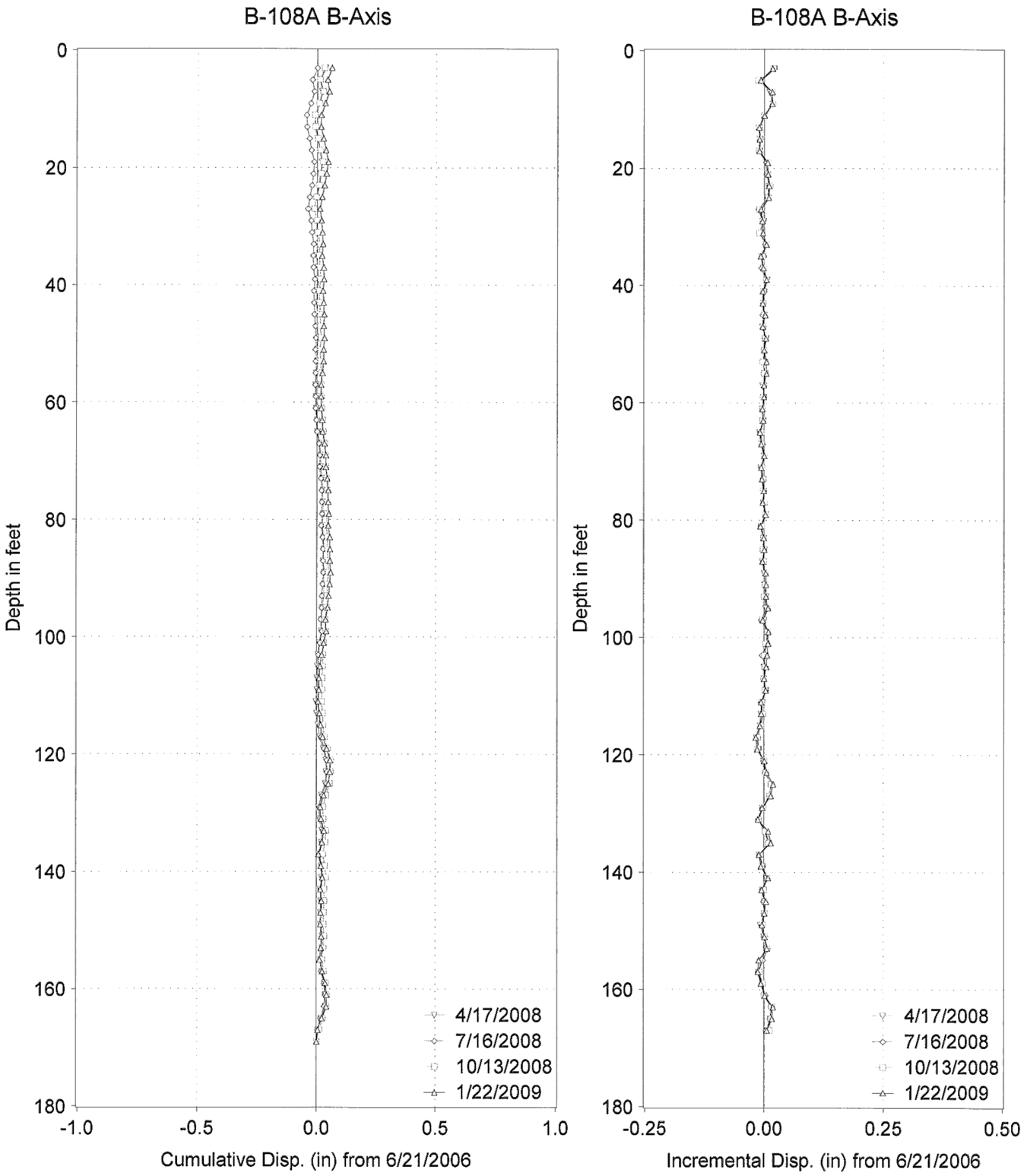
PLATE 23





B-108A
-Includes readings from the last four quarters.

PLATE 24



B-108A
-Includes readings from the last four quarters.

PLATE 25

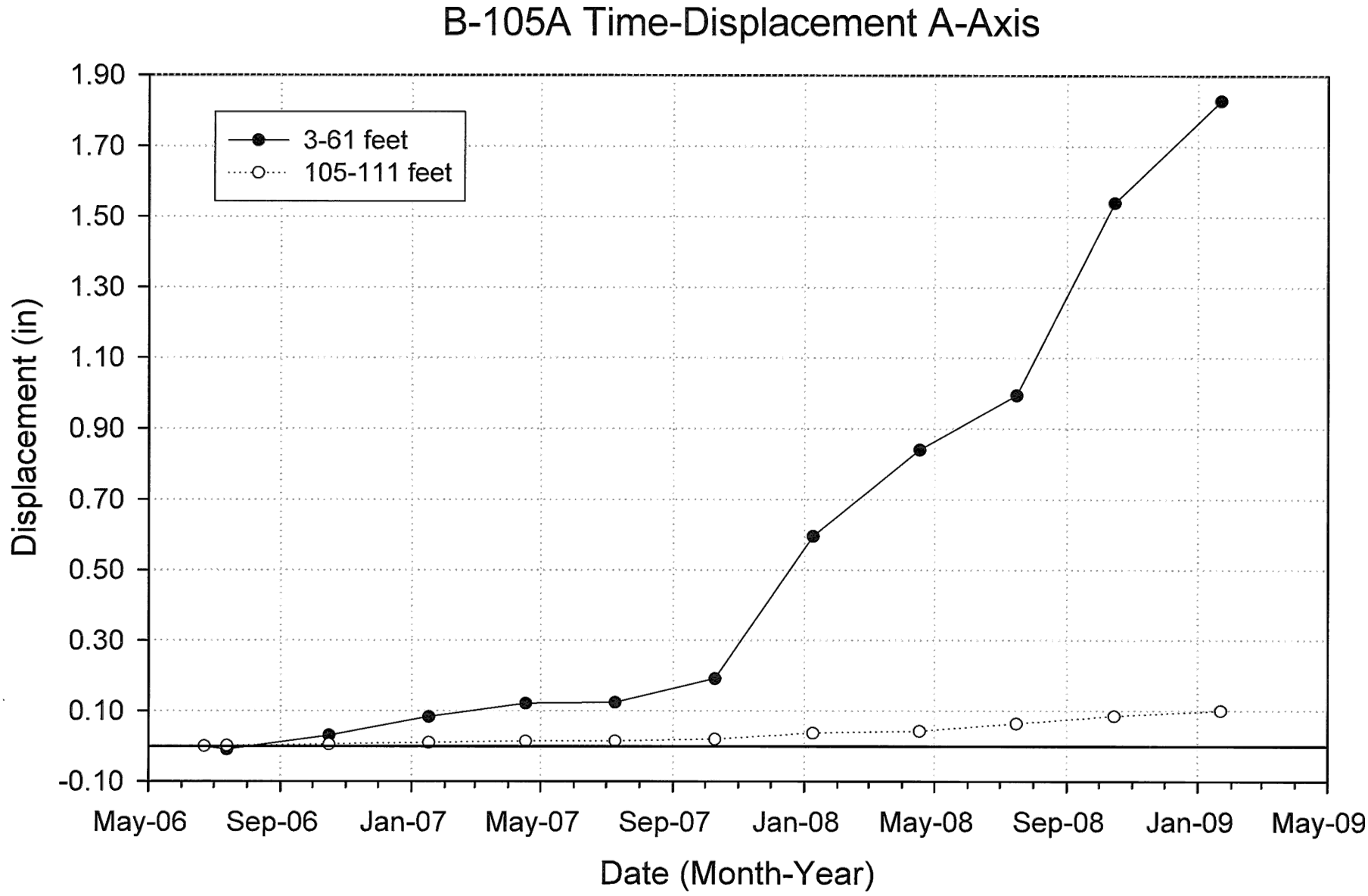

B-105A Time-Displacement A-Axis
3-61 feet
105-111 feet
Displacement (in)
1.90
1.70
1.50
1.30
1.10
0.90
0.70
0.50
0.30
0.10
-0.10
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Date (Month-Year)

PLATE 26

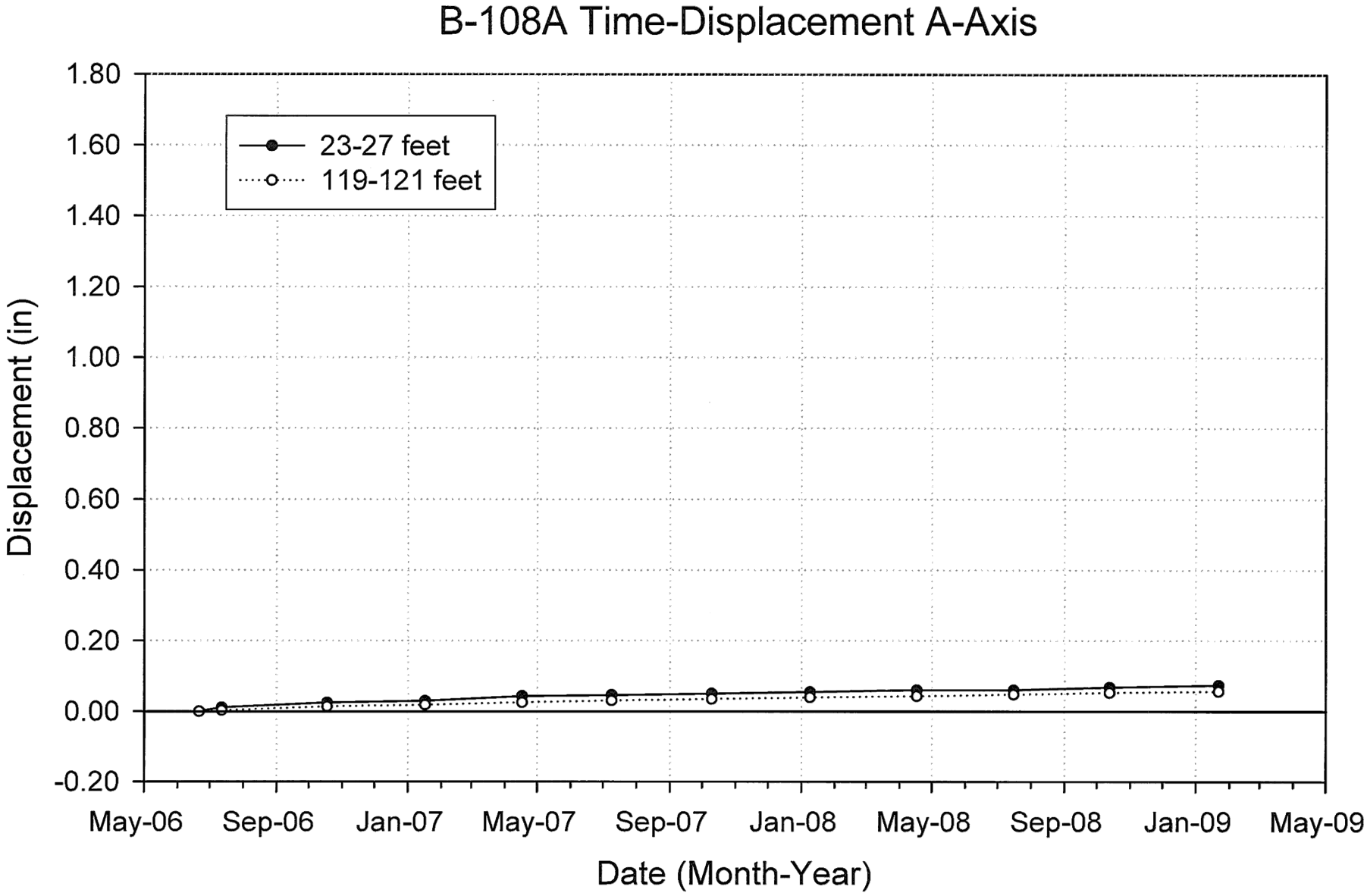
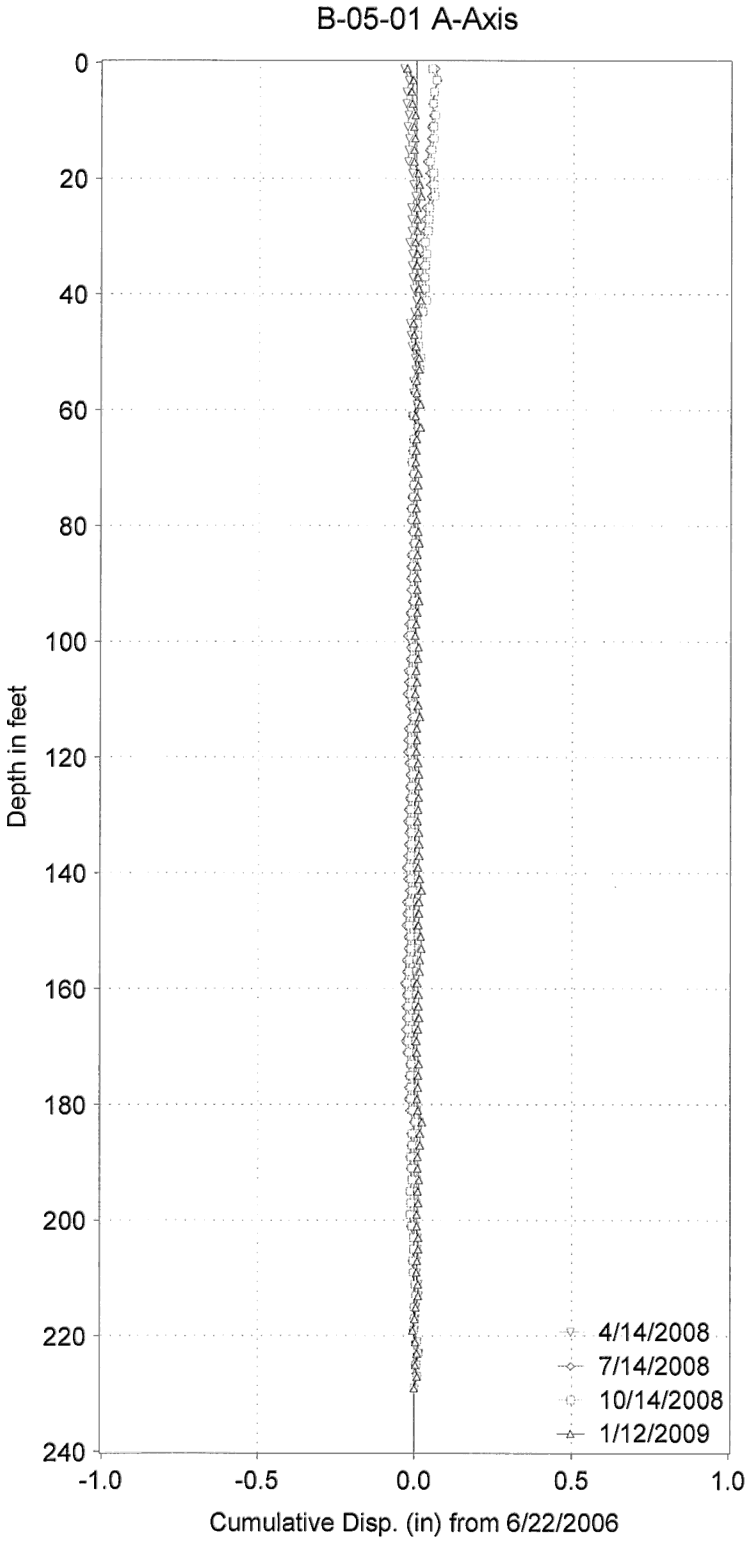
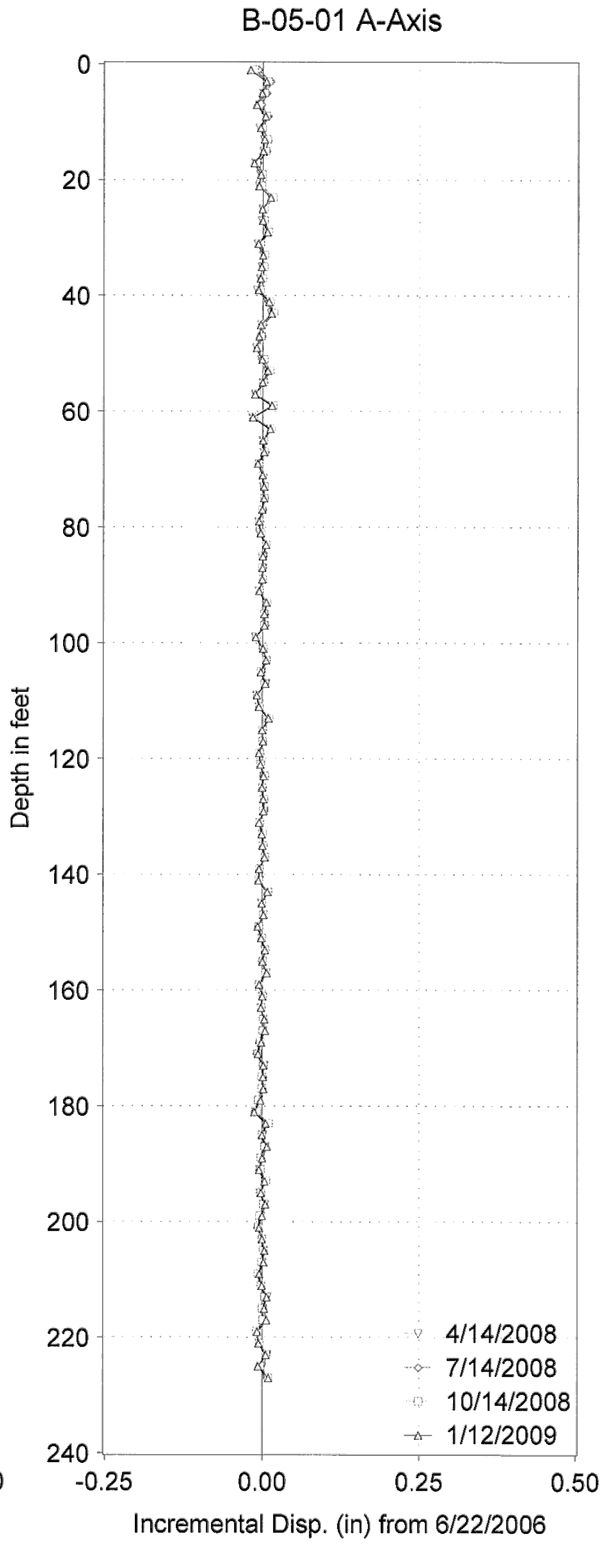

B-108A Time-Displacement A-Axis
23-27 feet
119-121 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Date (Month-Year)

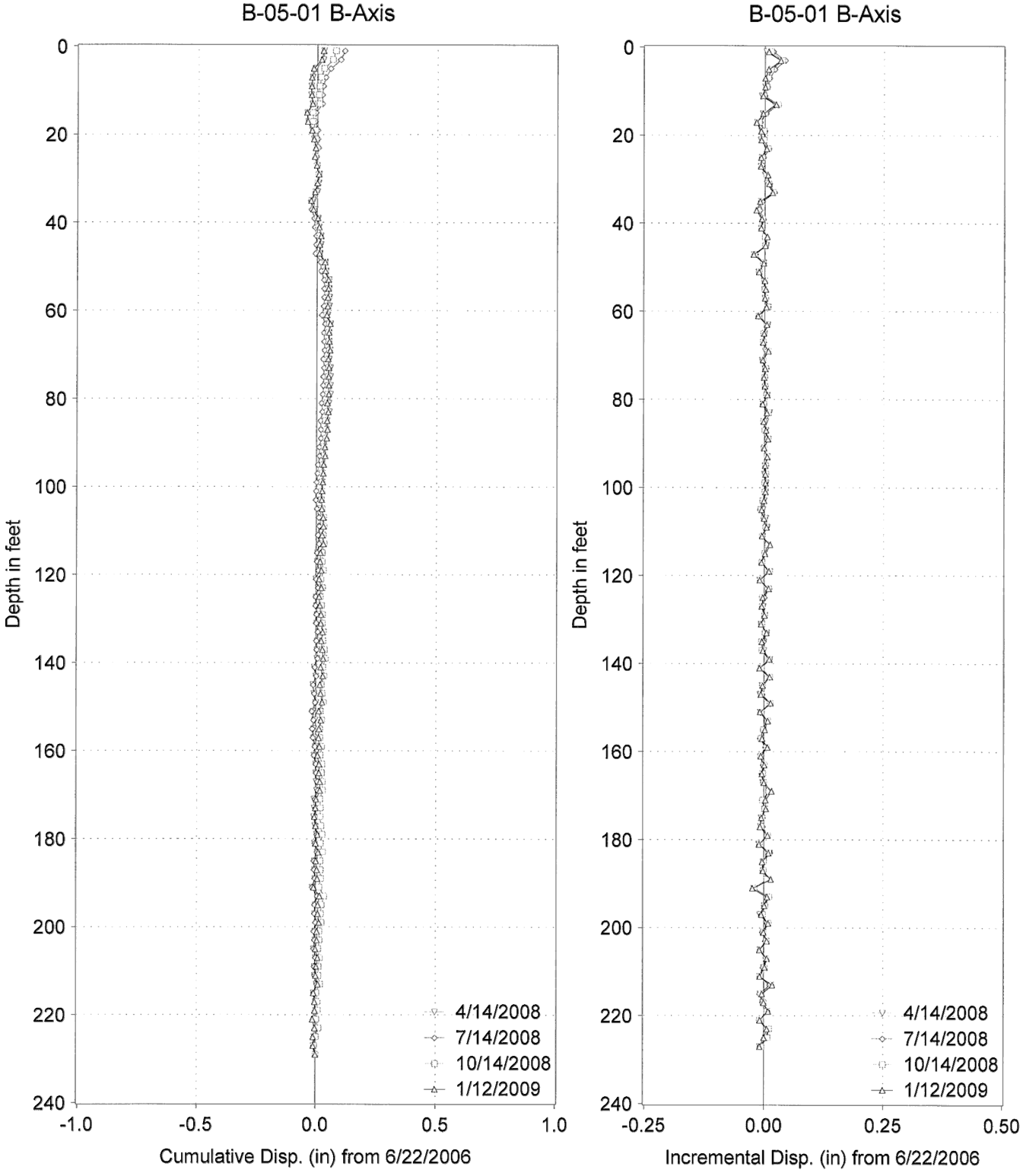
PLATE 27





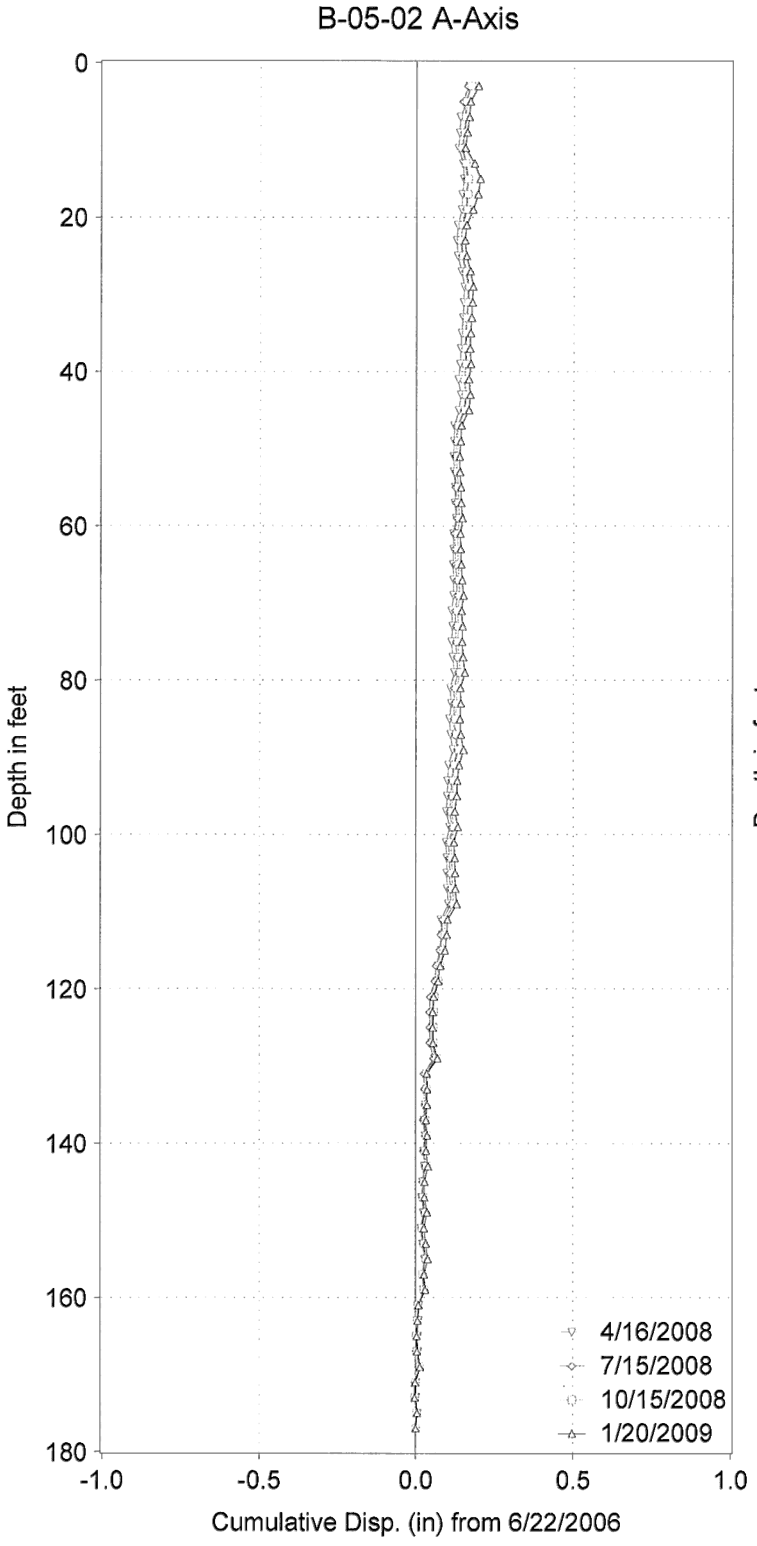
B-05-01
-Includes readings from the last four quarters.

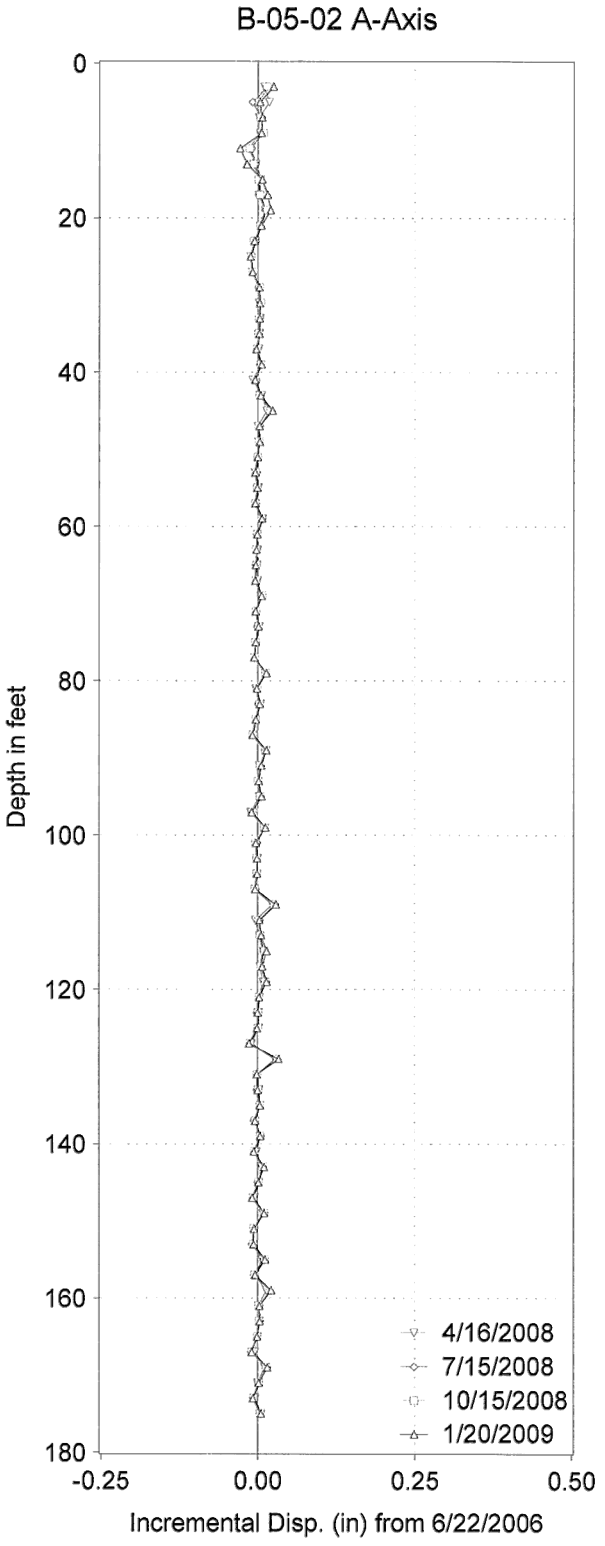
PLATE 28



B-05-01
-Includes readings from the last four quarters.

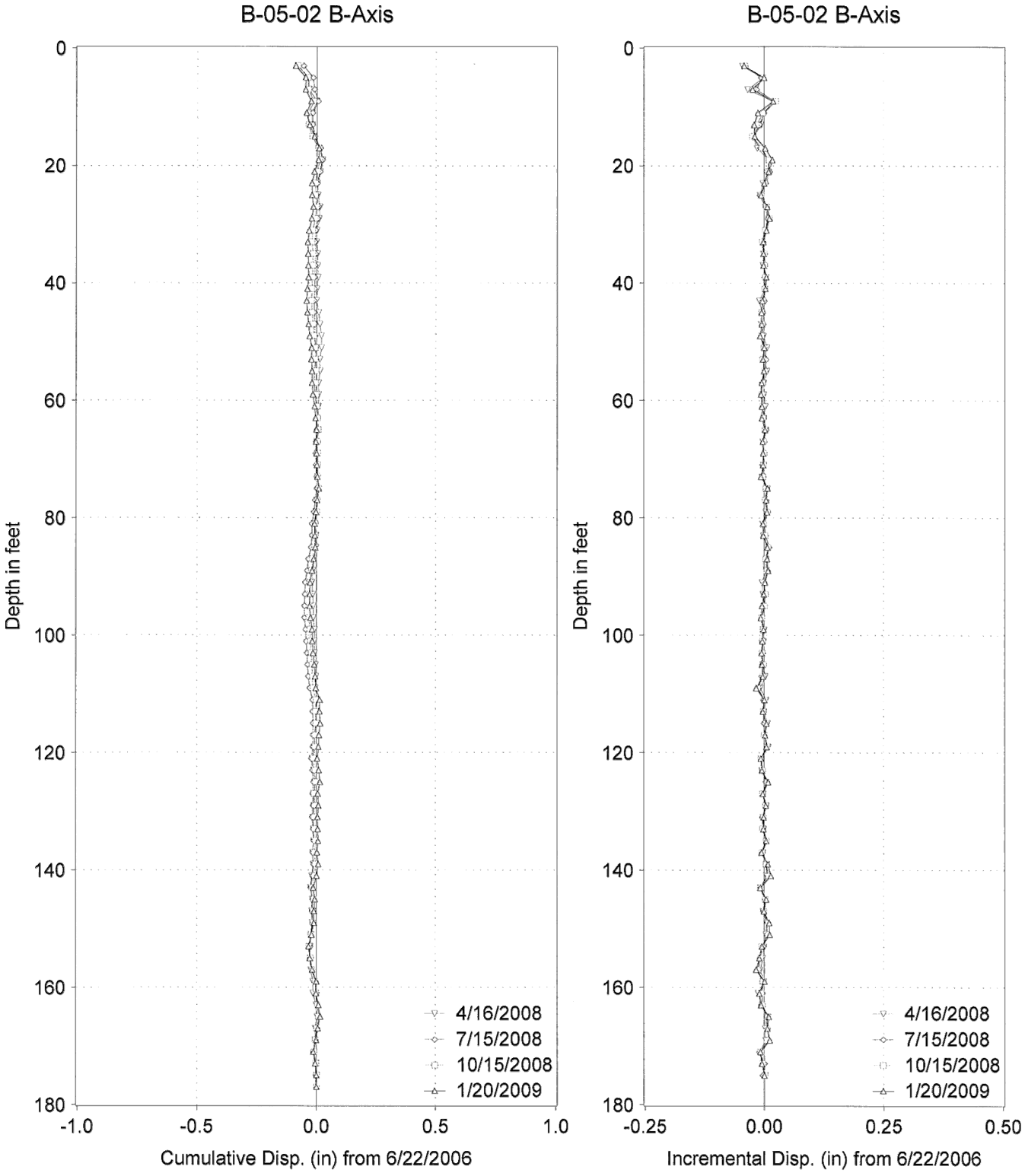
PLATE 29





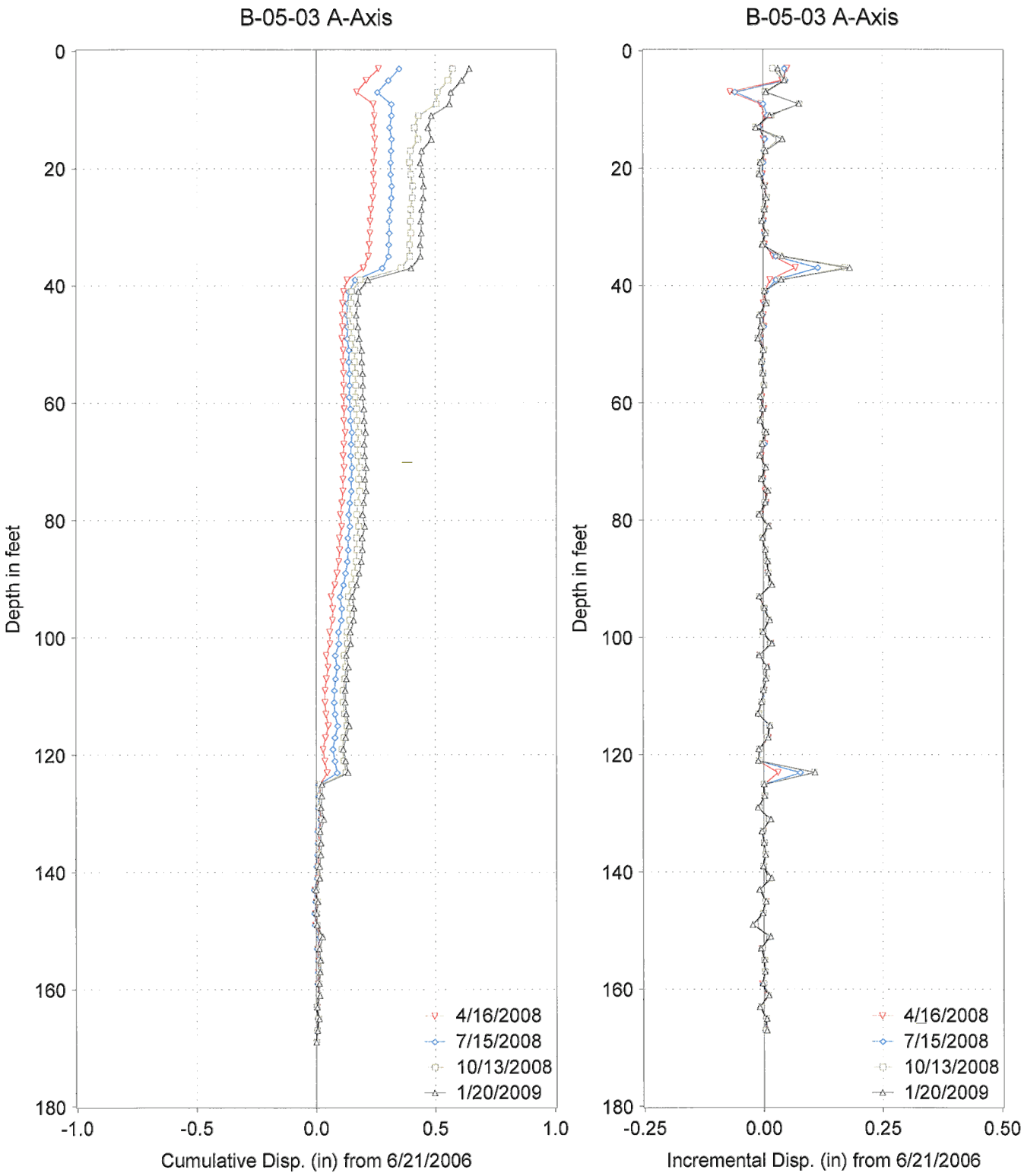
B-05-02
-Includes readings from the last four quarters.

PLATE 30



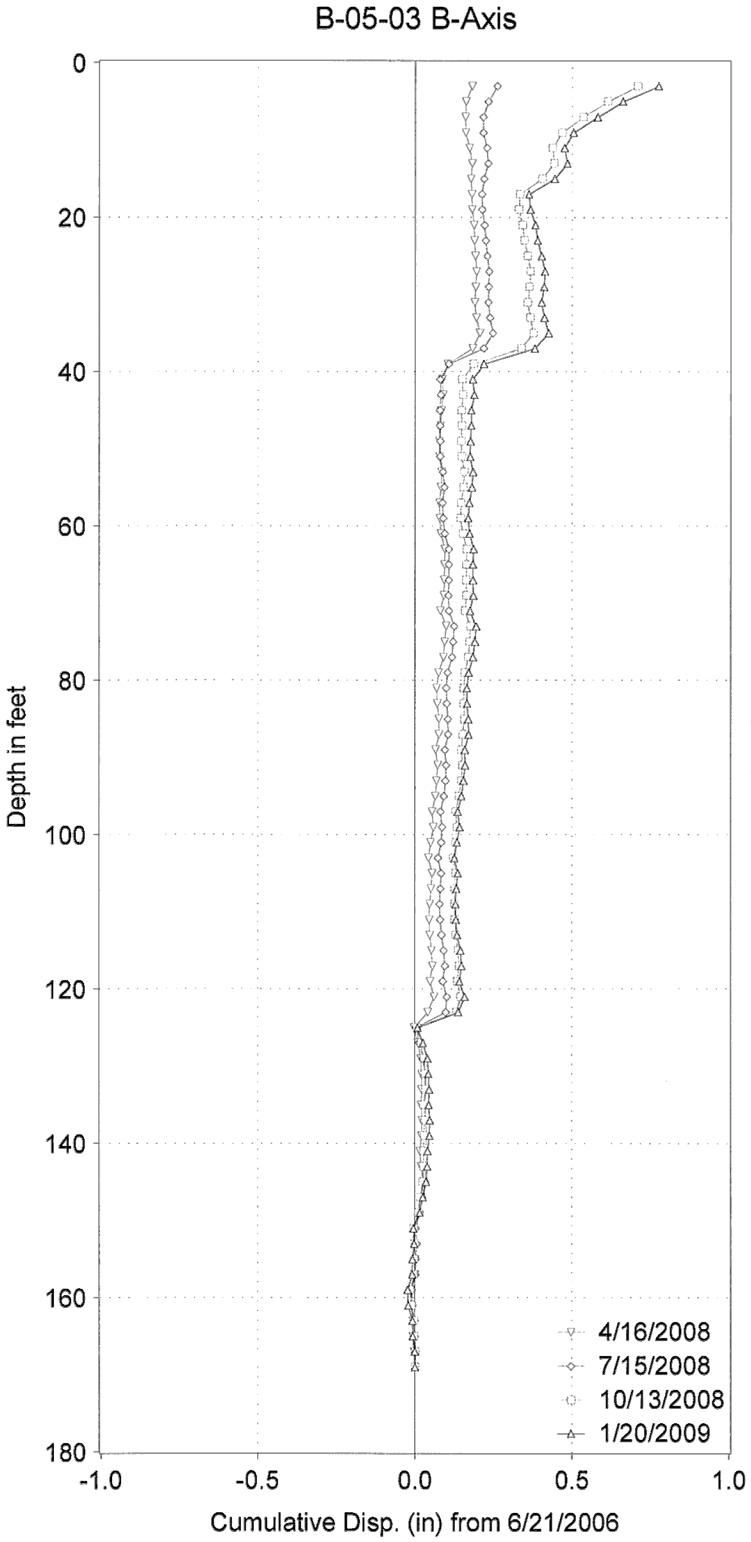
B-05-02
-Includes readings from the last four quarters.

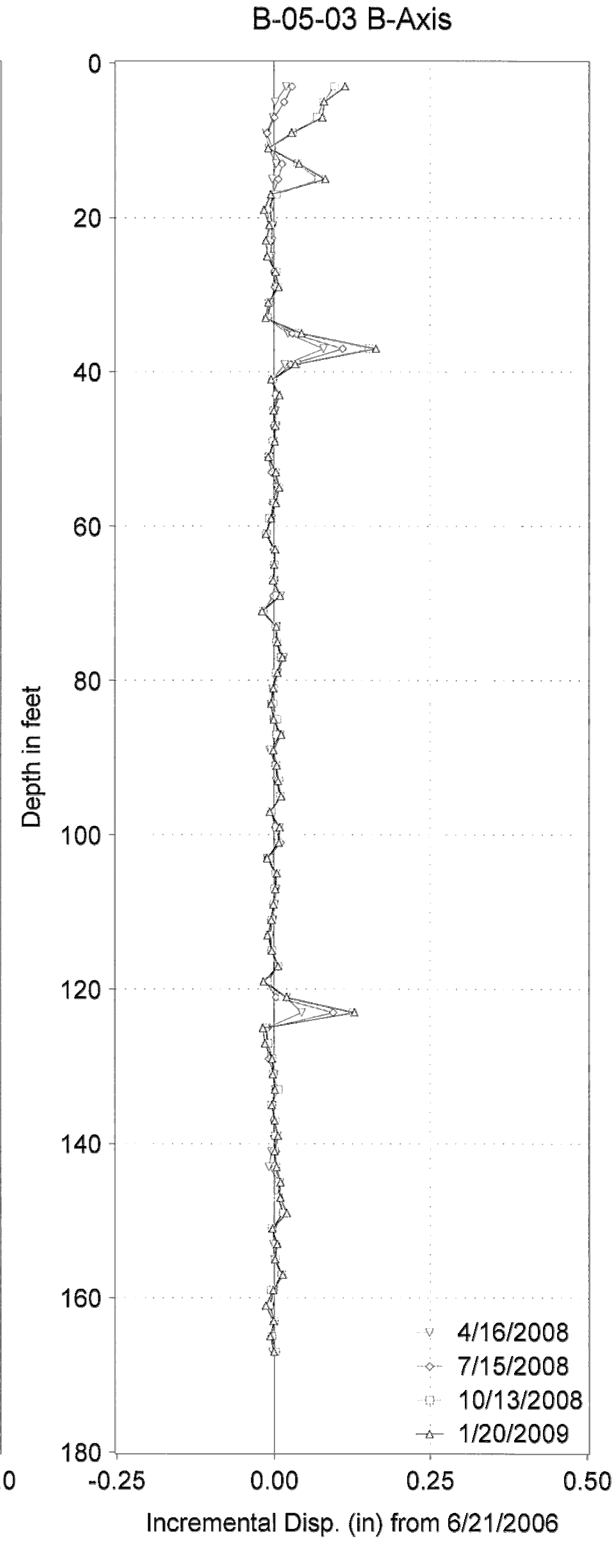
PLATE 31



B-05-03
-Includes readings from the last four quarters.

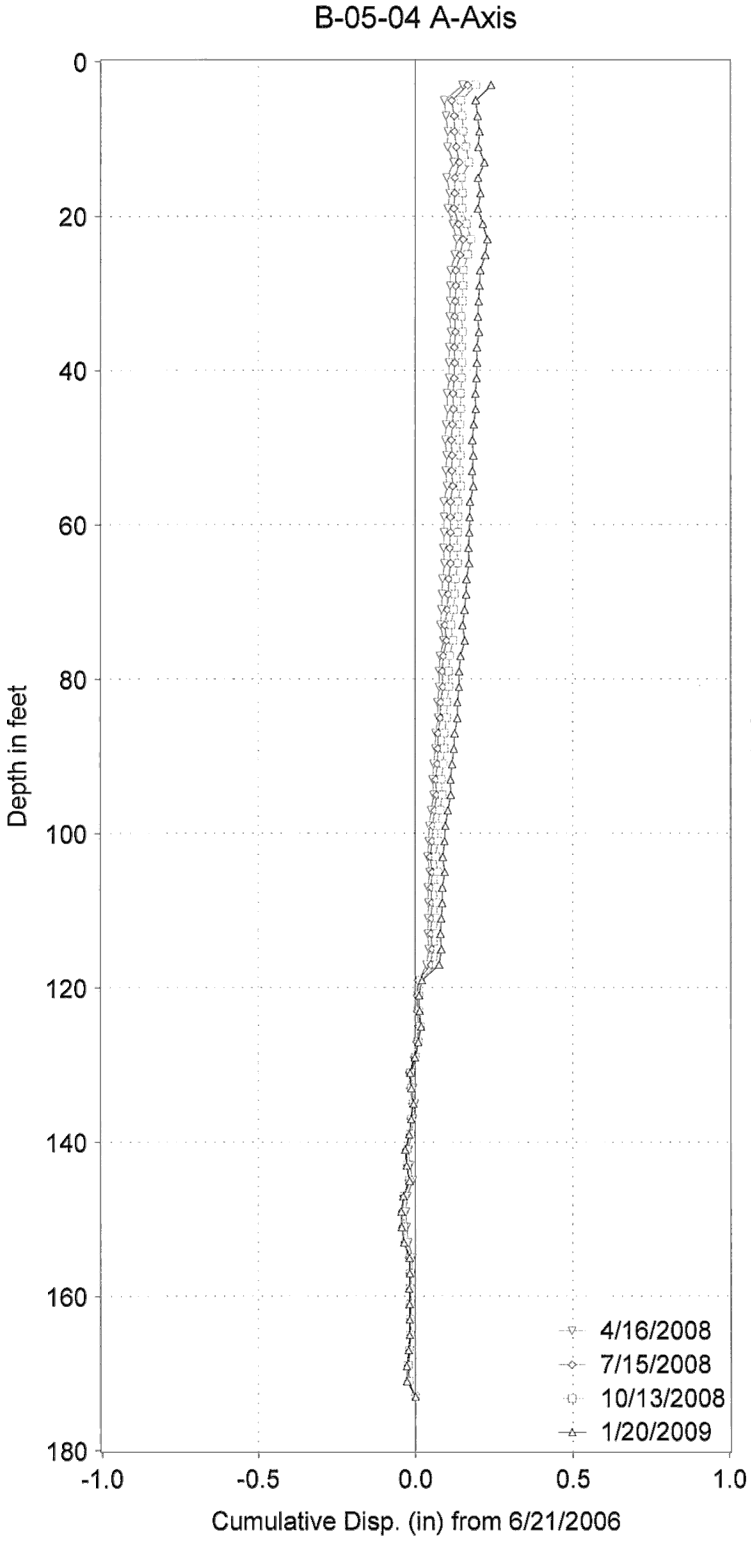
PLATE 32

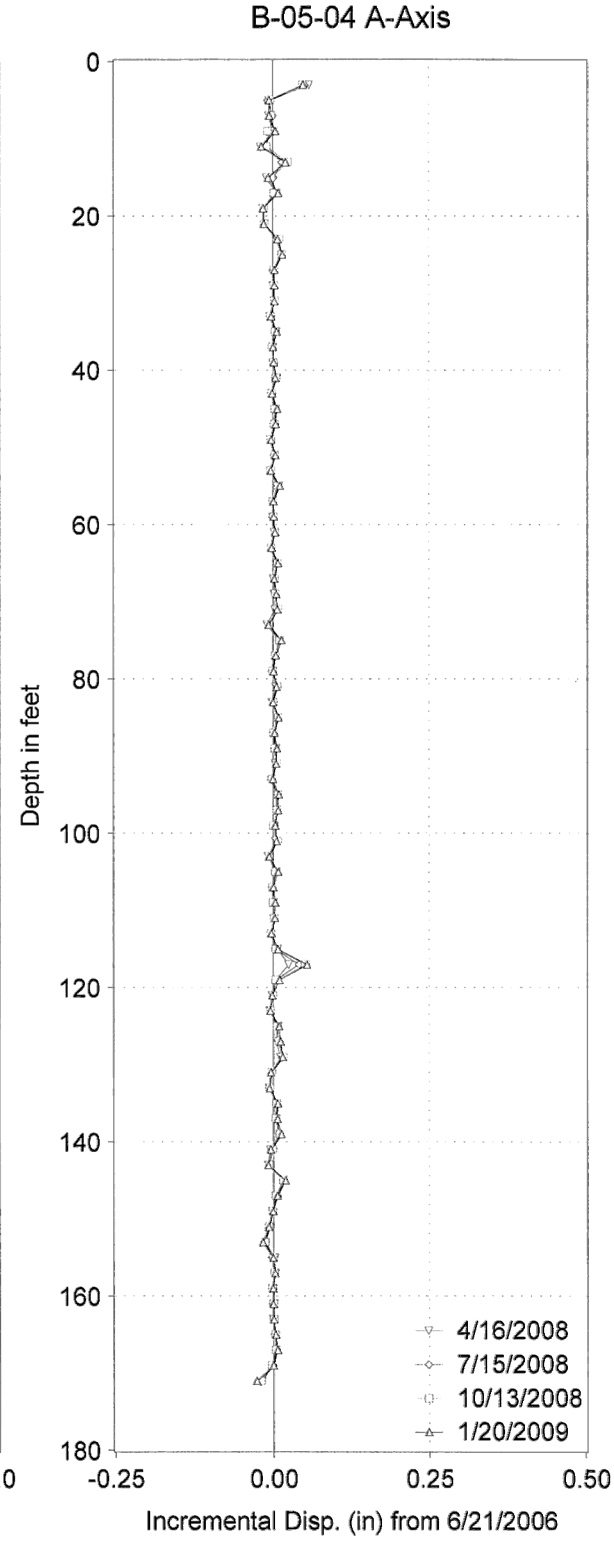




B-05-03
-Includes readings from the last four quarters.

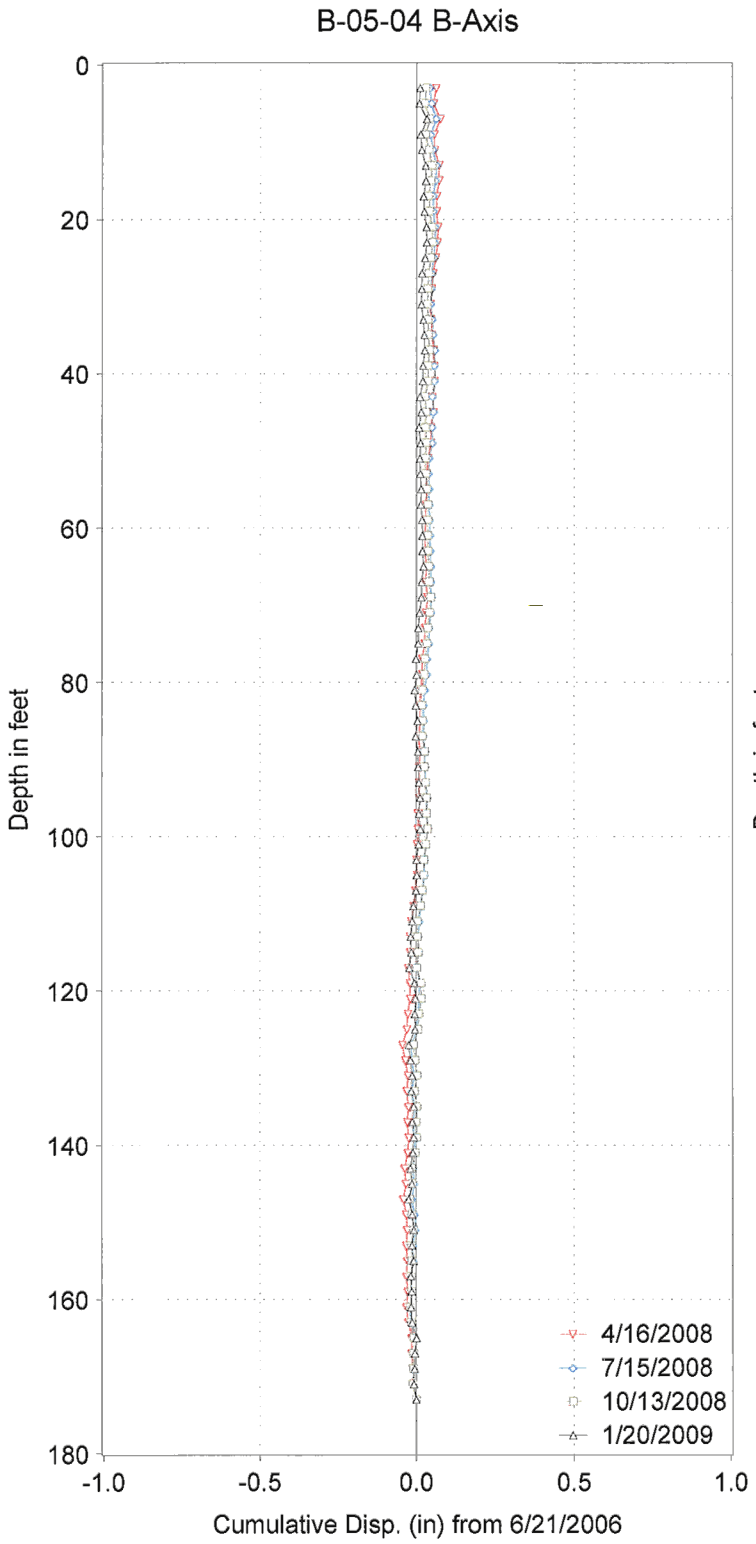
PLATE 33

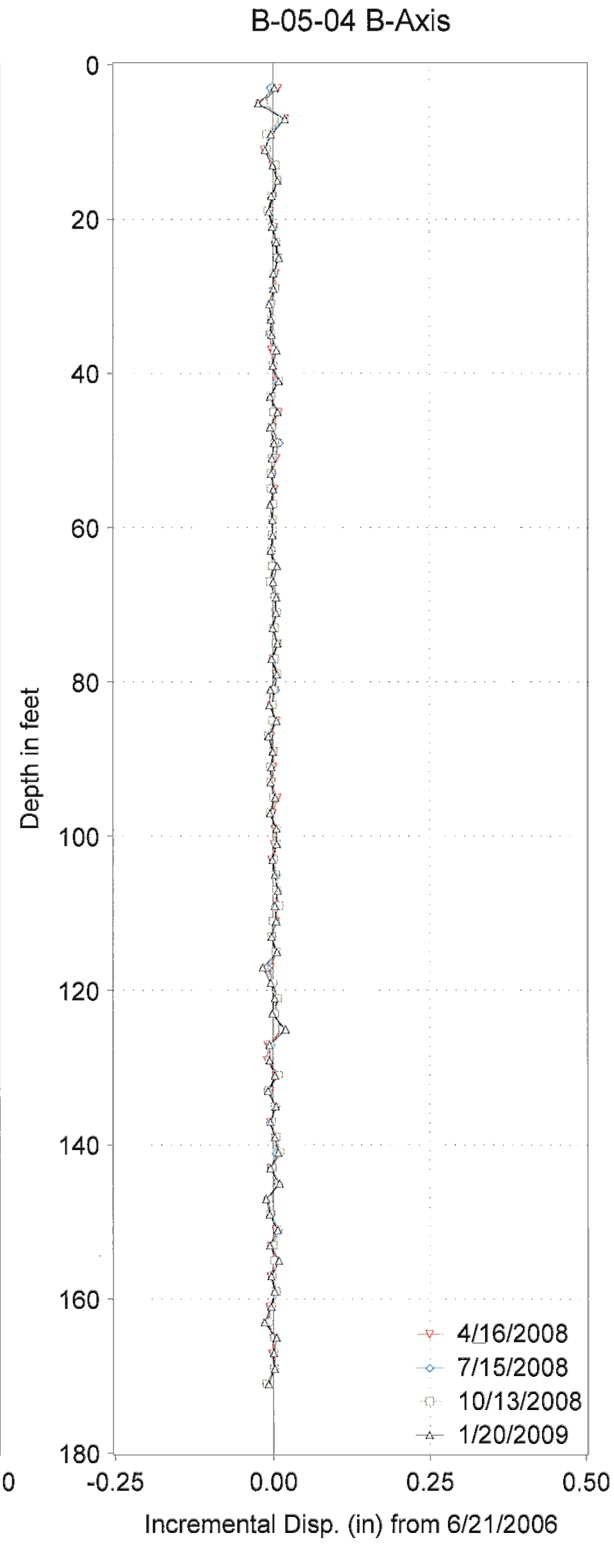




B-05-04
-Includes readings from the last four quarters.

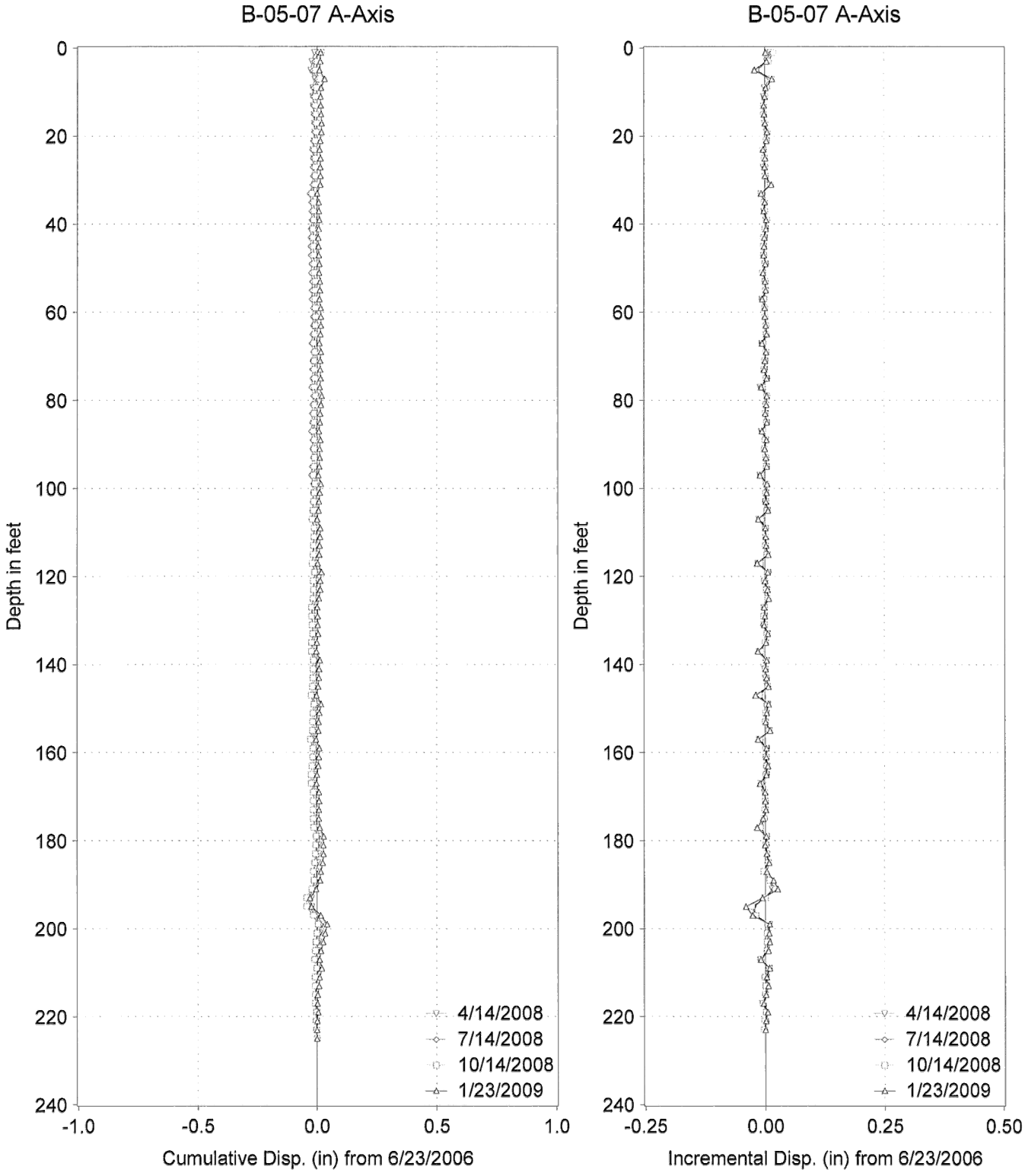
PLATE 34





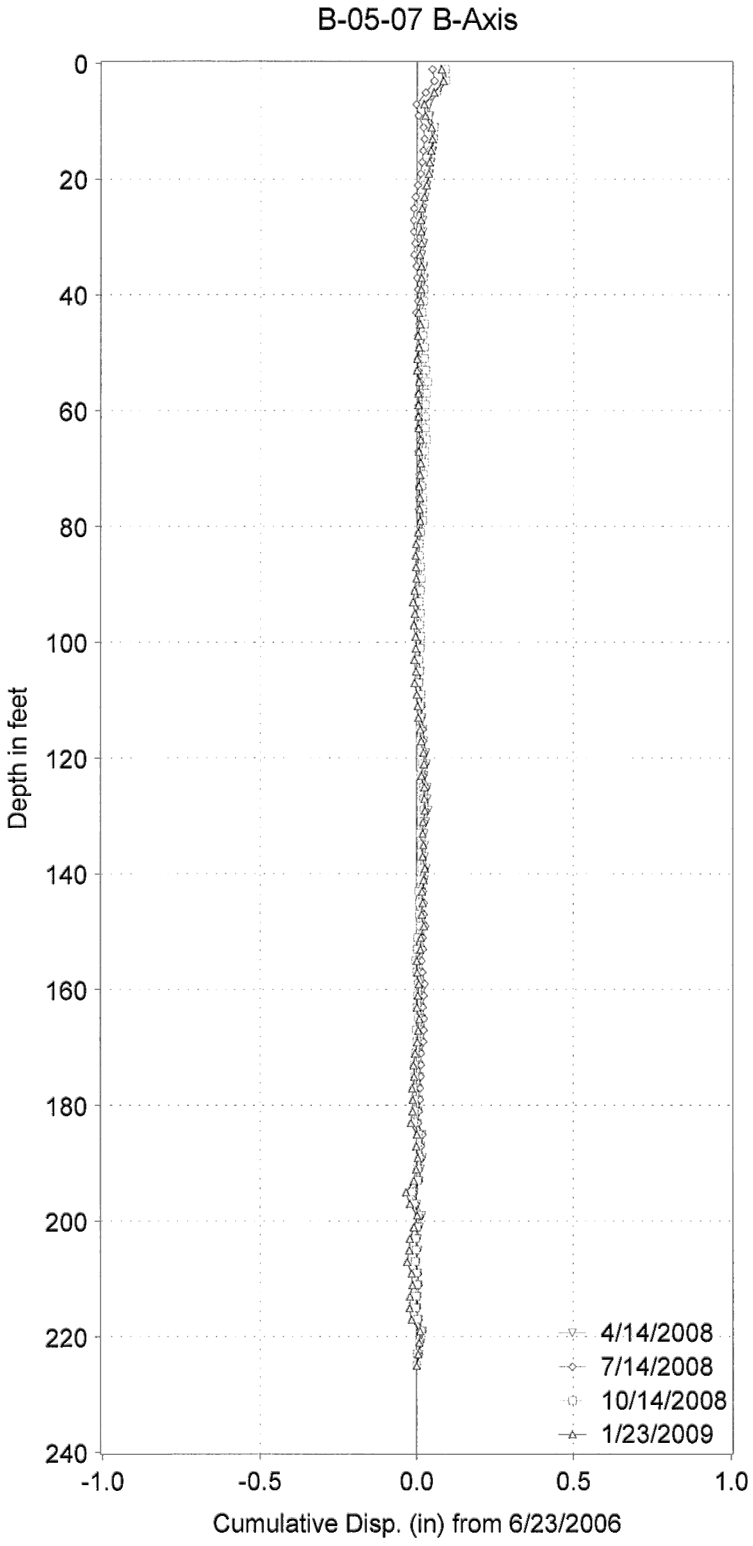
B-05-04
-Includes readings from the last four quarters.

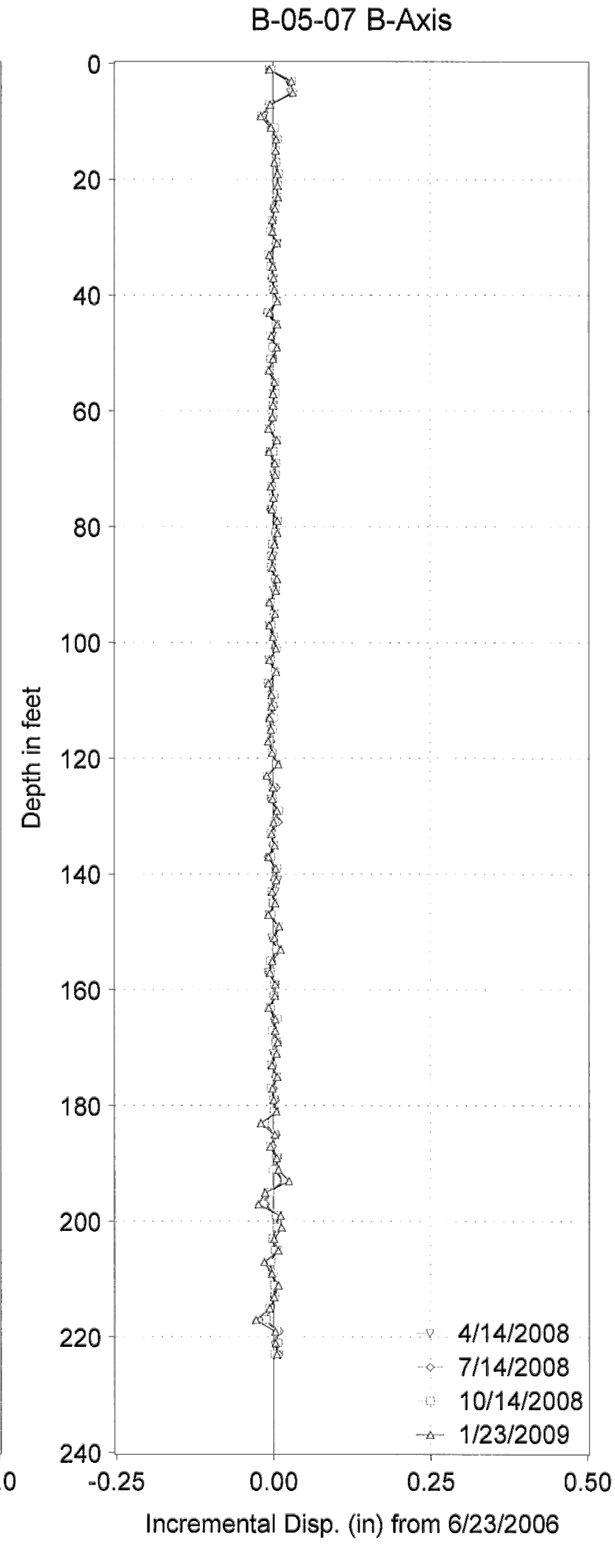
PLATE 35



B-05-07
-Includes readings from the last four quarters.

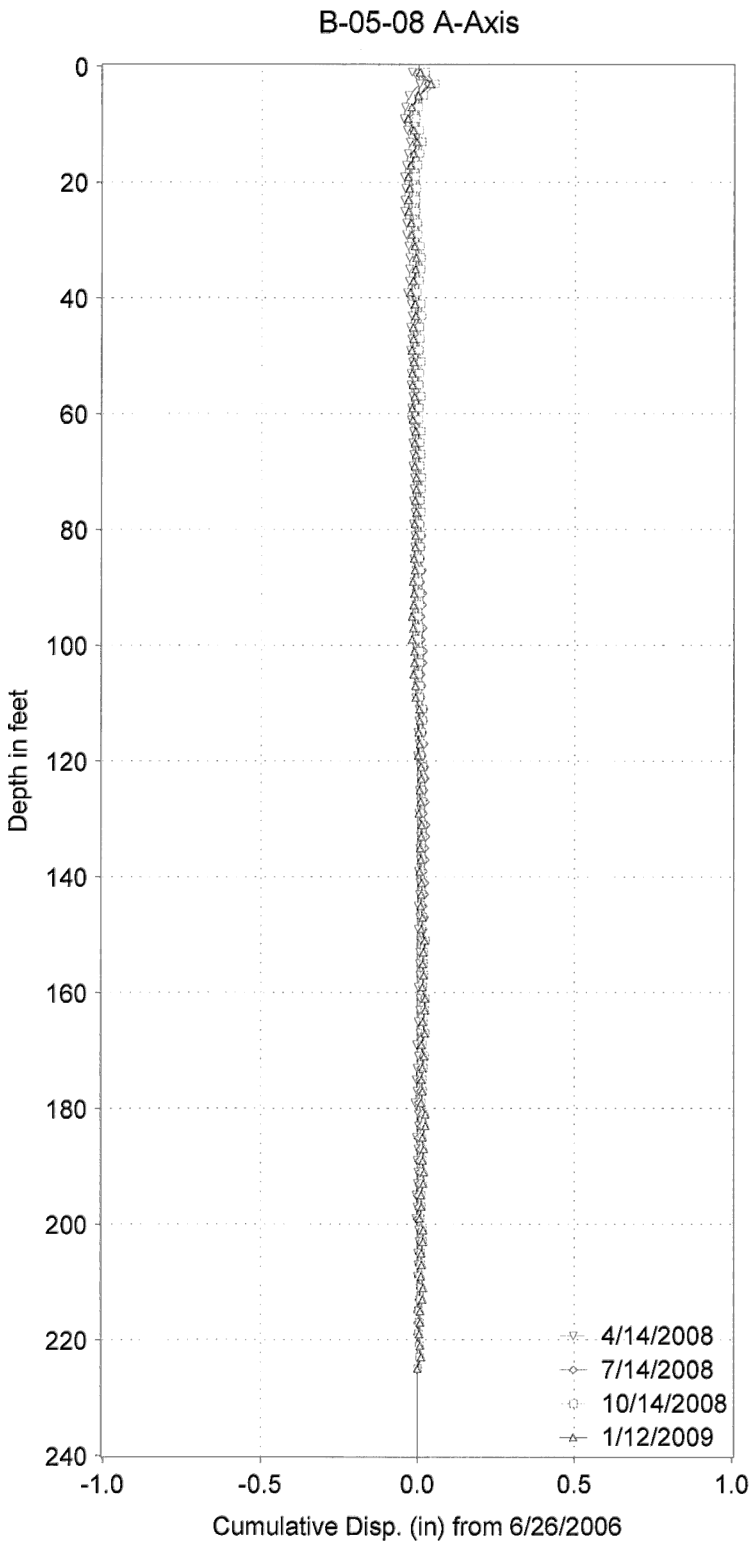
PLATE 36

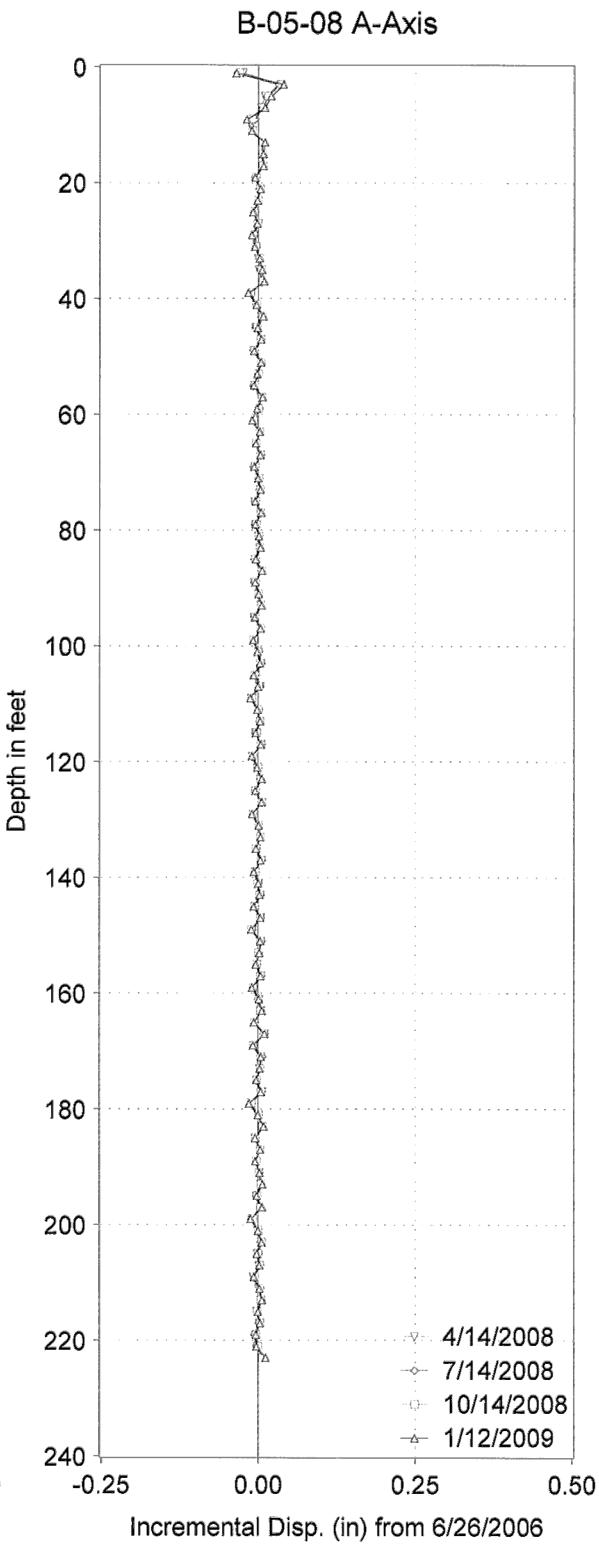




B-05-07
-Includes readings from the last four quarters.

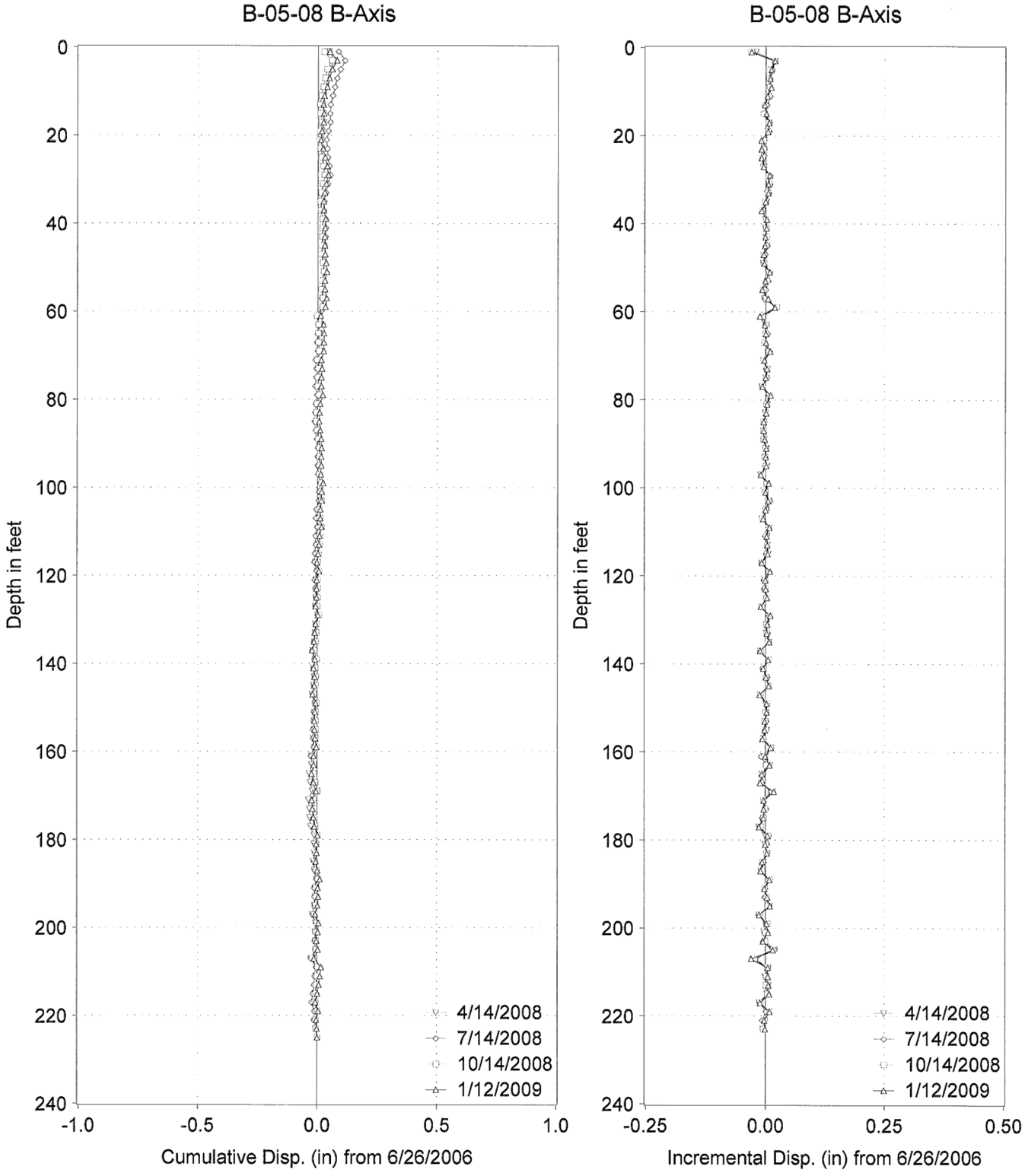
PLATE 37





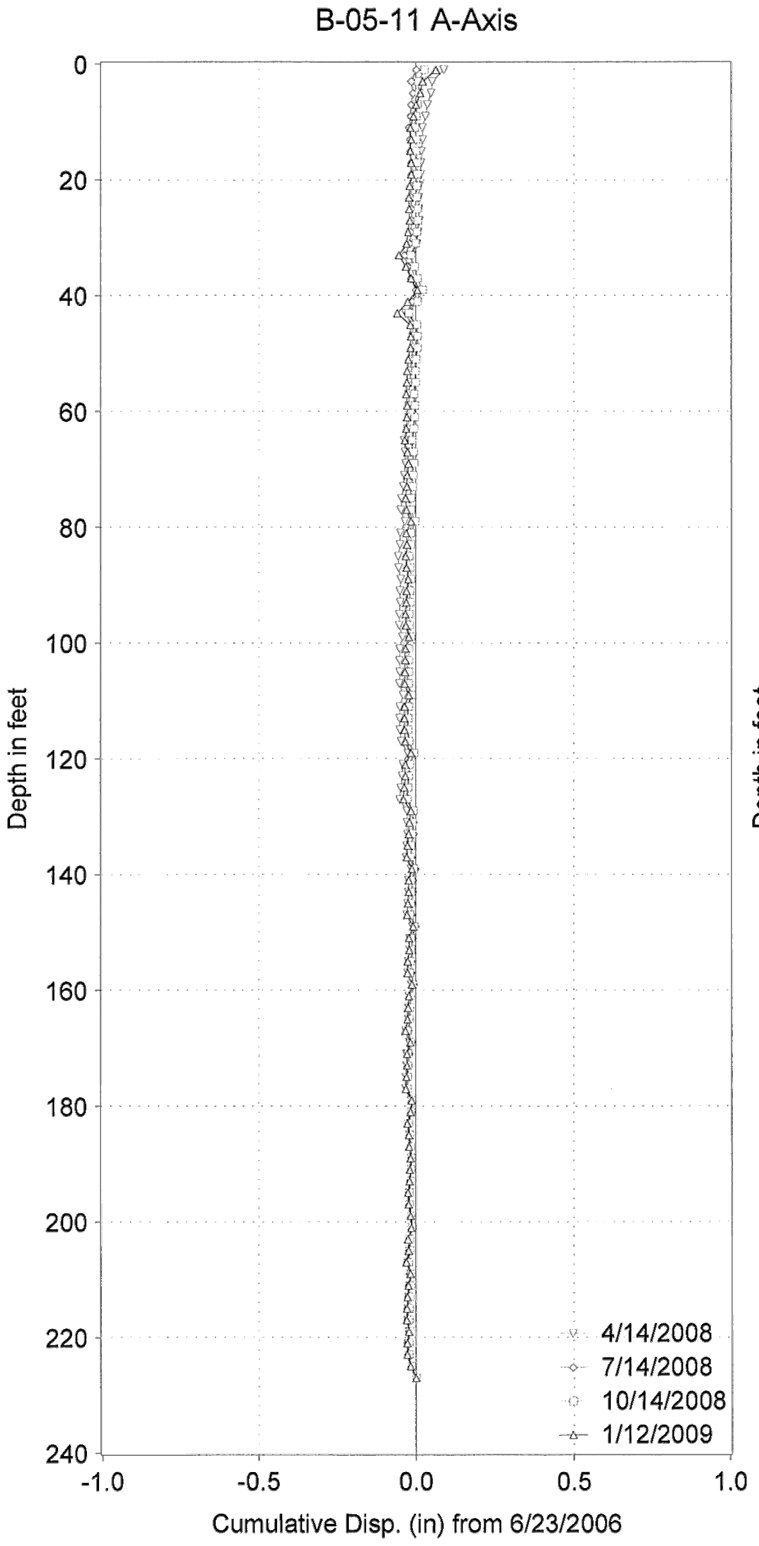
B-05-08
-Includes readings from the last four quarters.

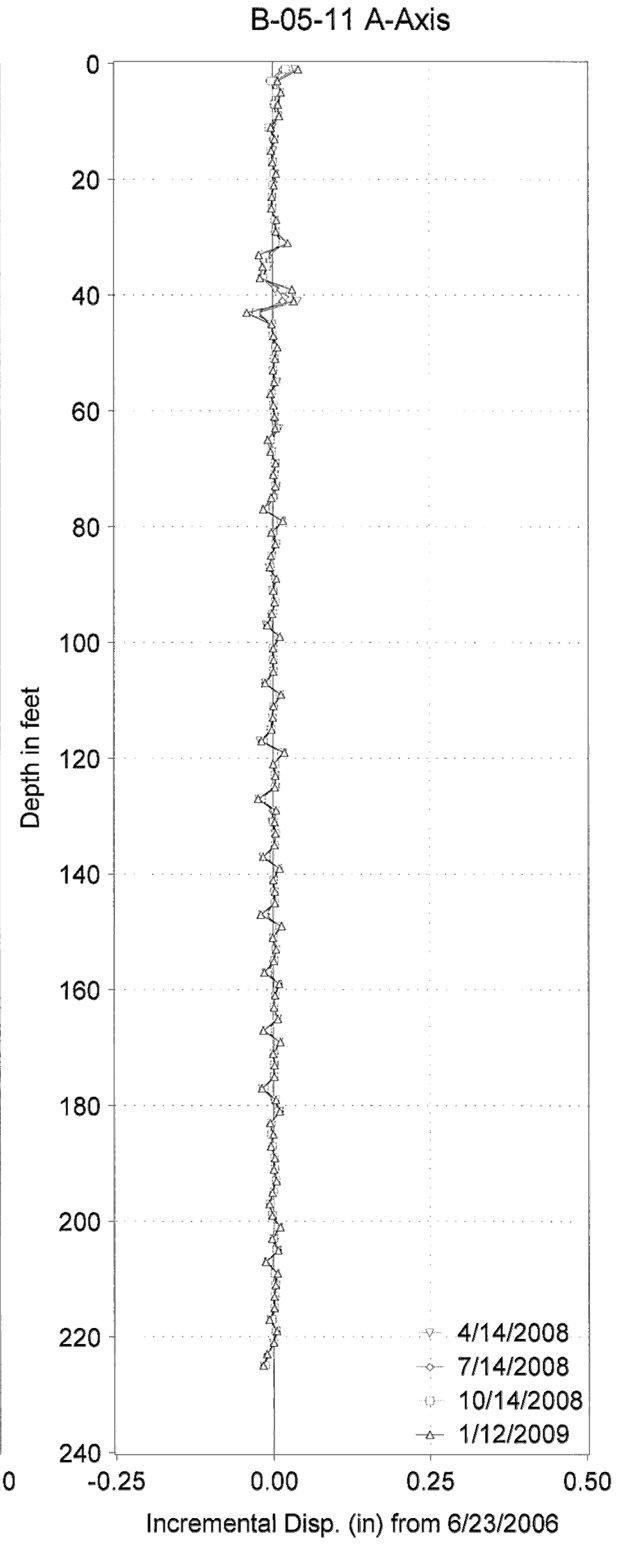
PLATE 38



B-05-08
-Includes readings from the last four quarters.

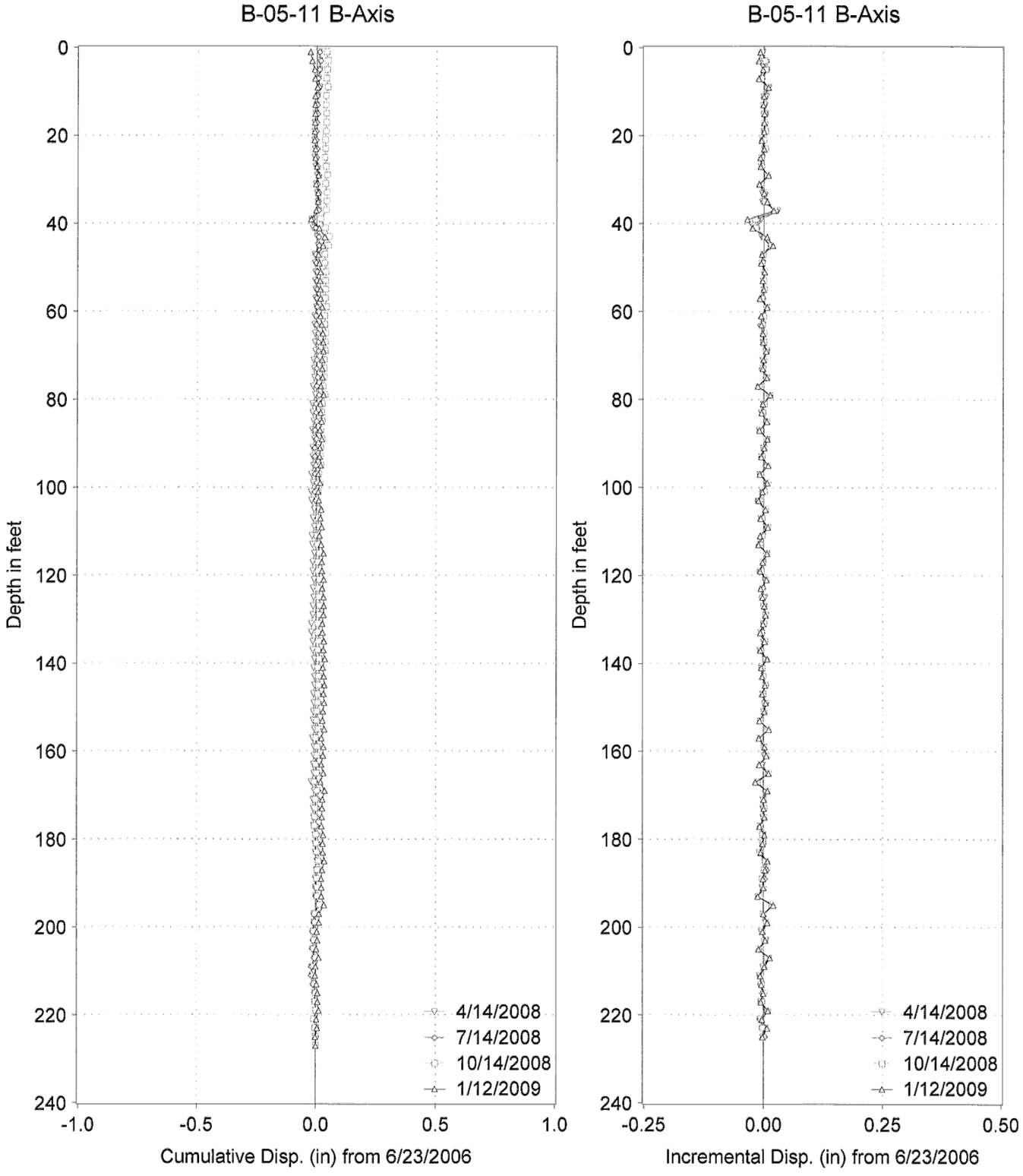
PLATE 39





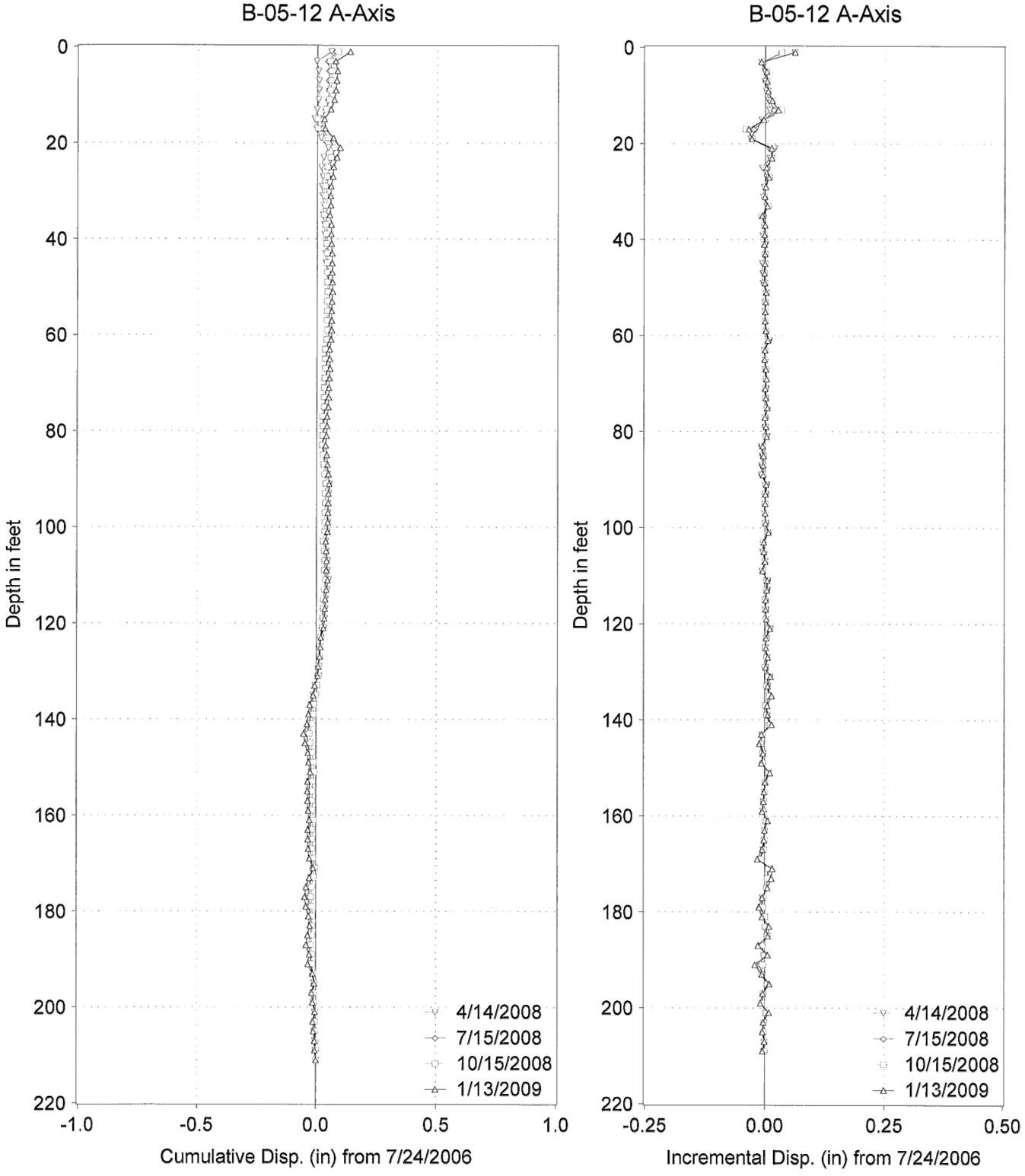
B-05-11
-Includes readings from the last four quarters.

PLATE 40



B-05-11
-Includes readings from the last four quarters.

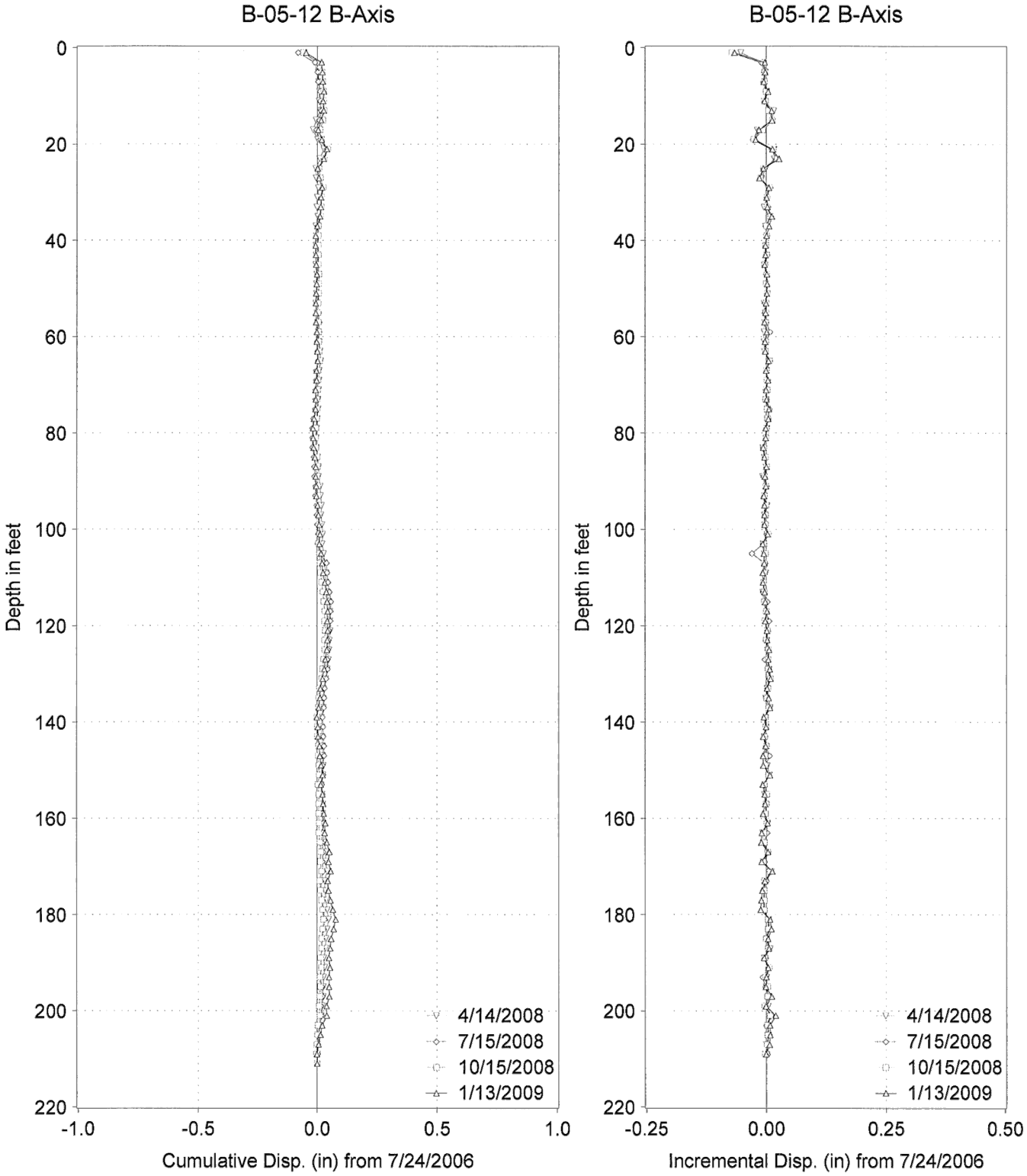
PLATE 41



B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

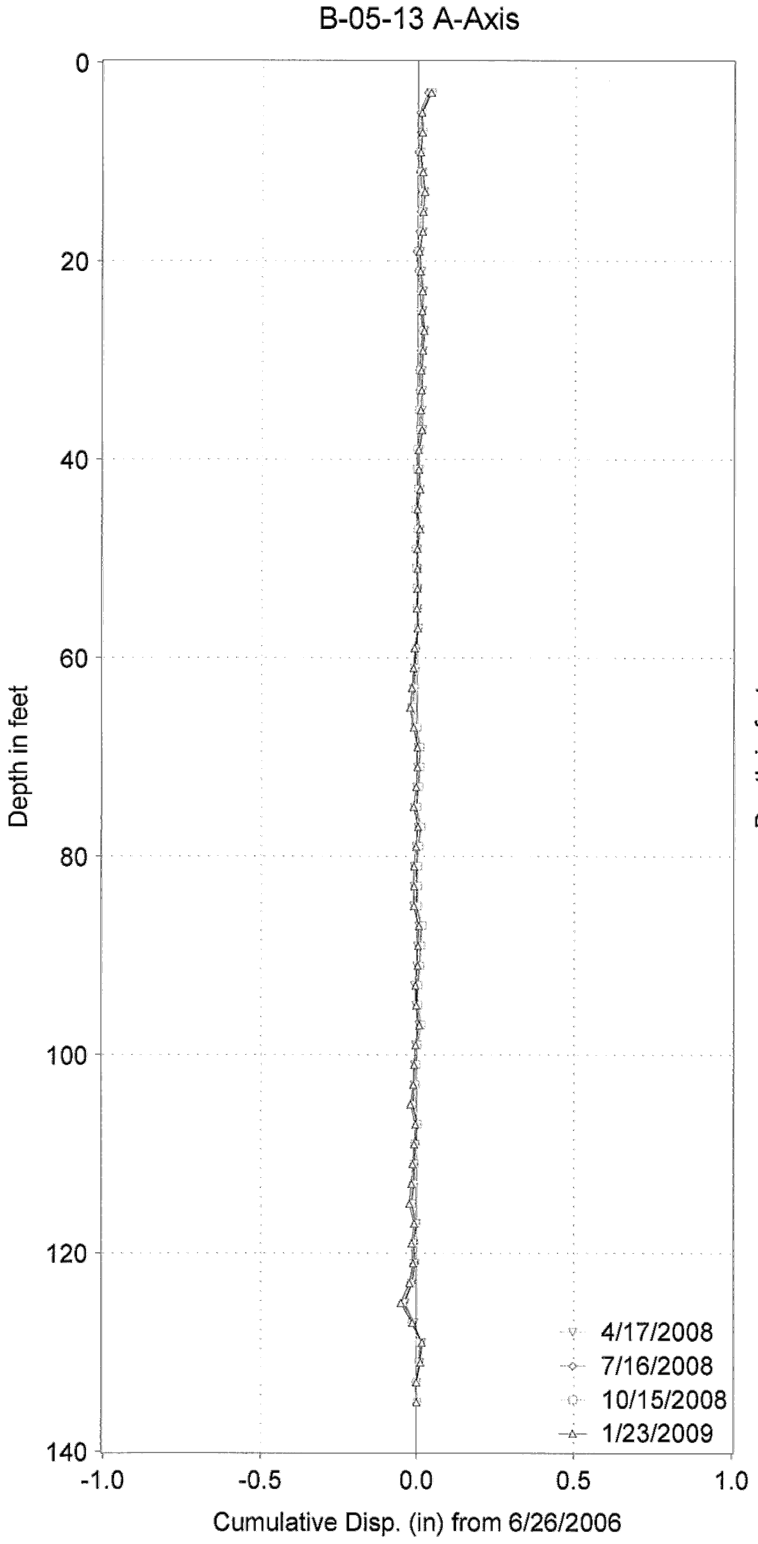
PLATE 42

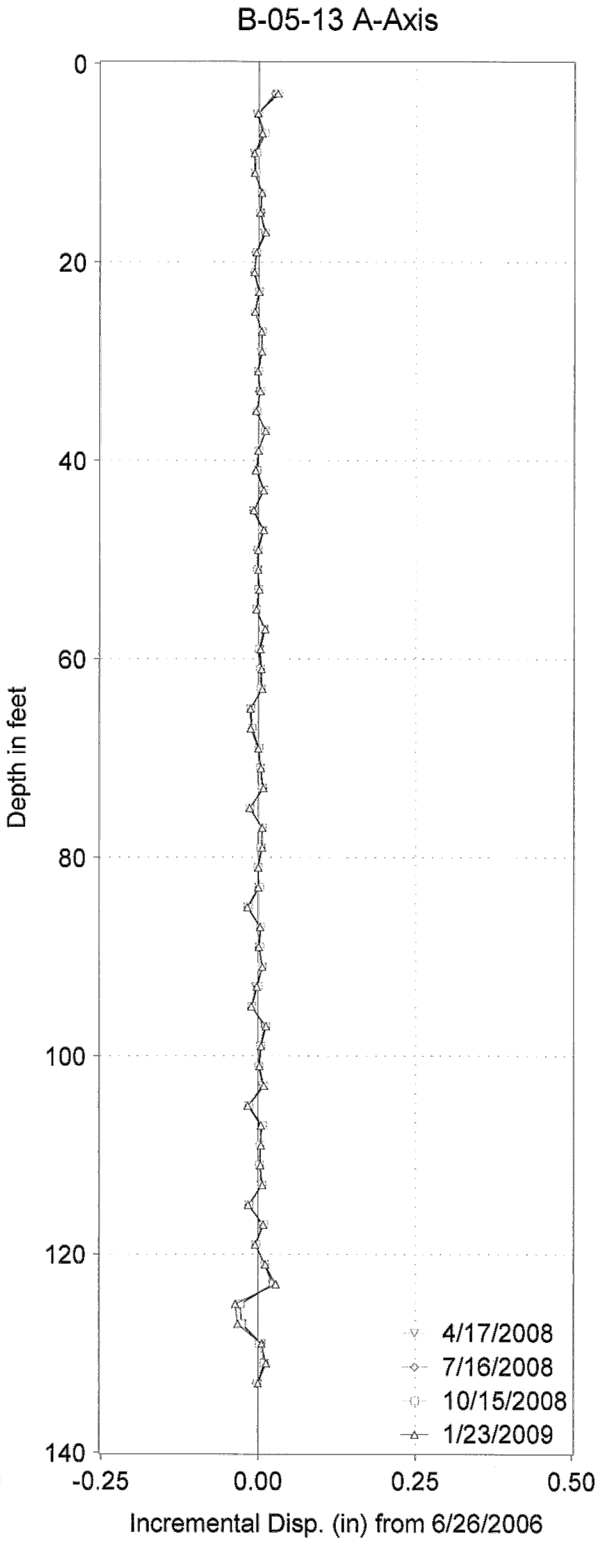


B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

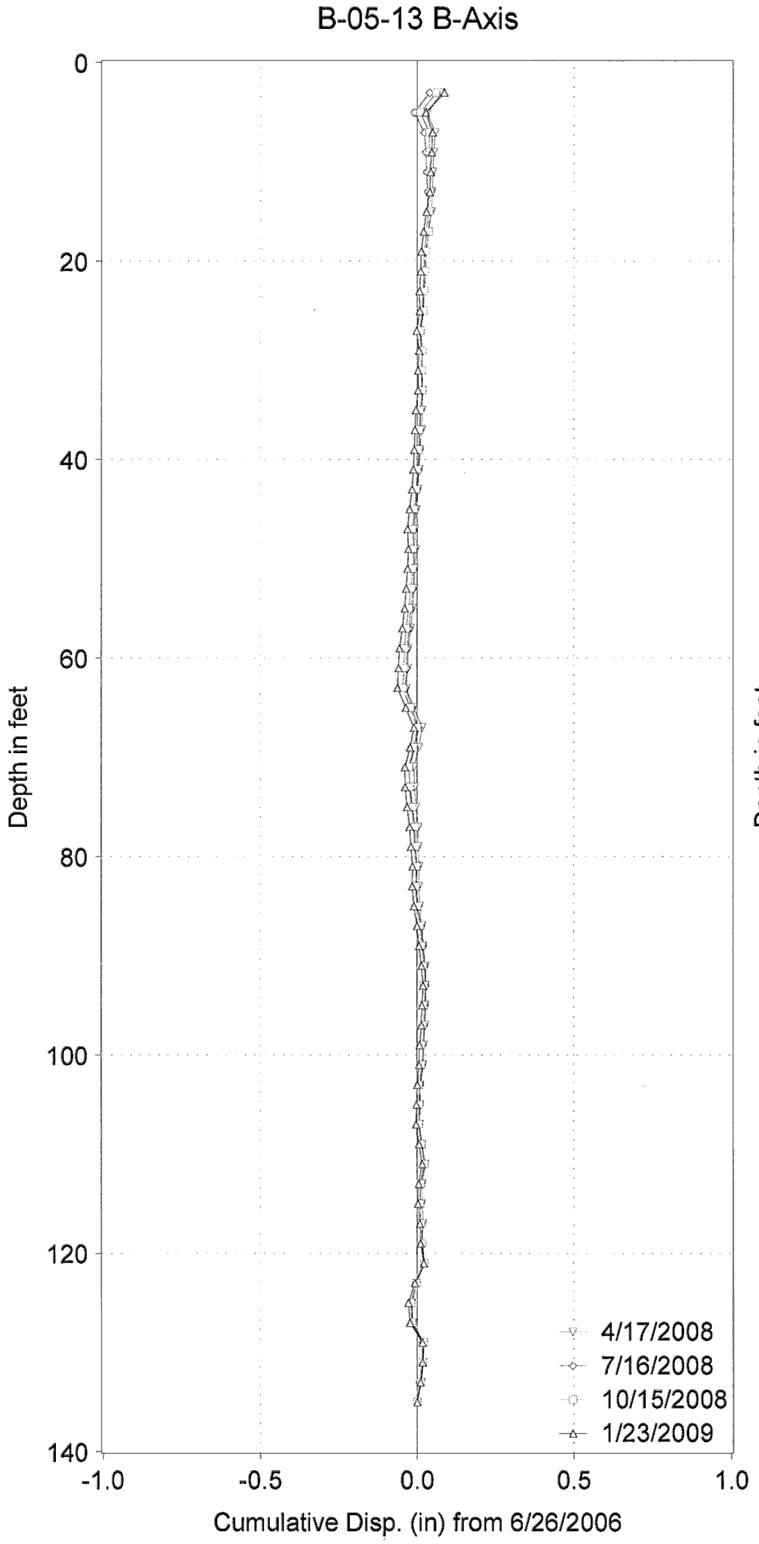
PLATE 43

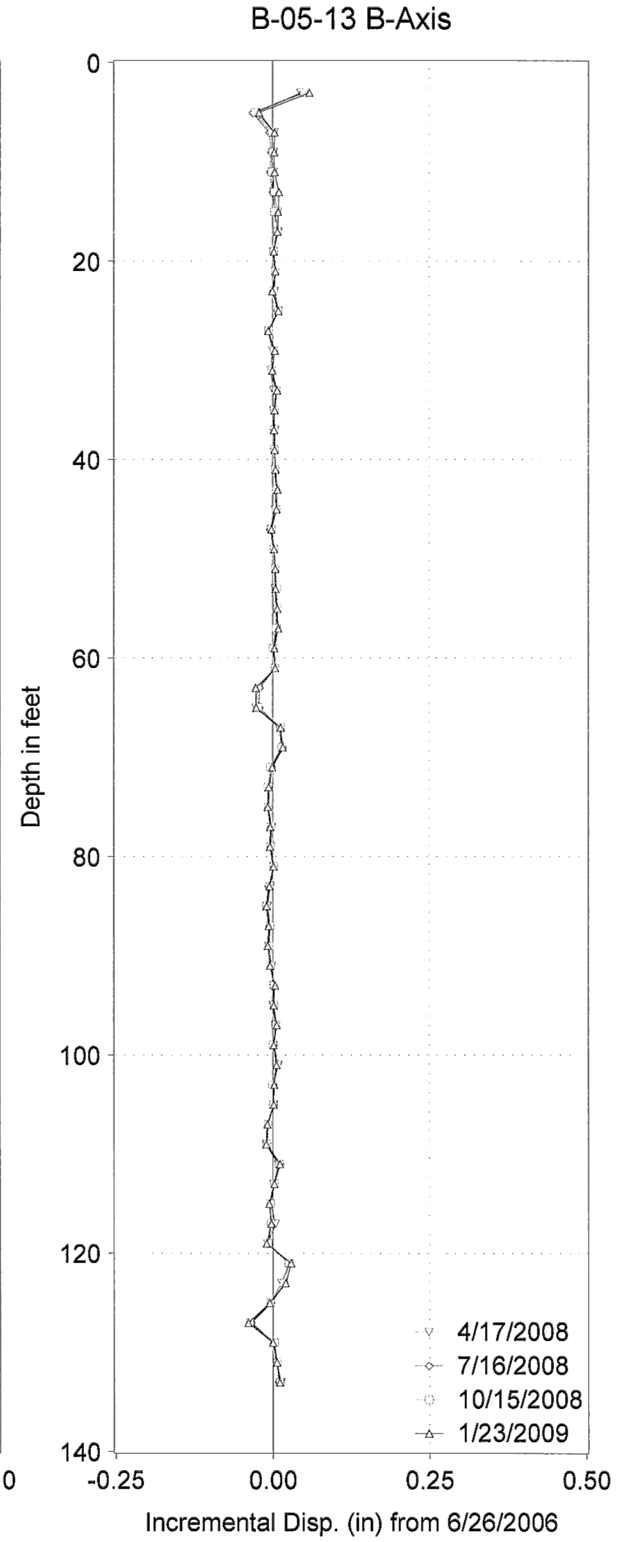




B-05-13
-Includes readings from the last four quarters.

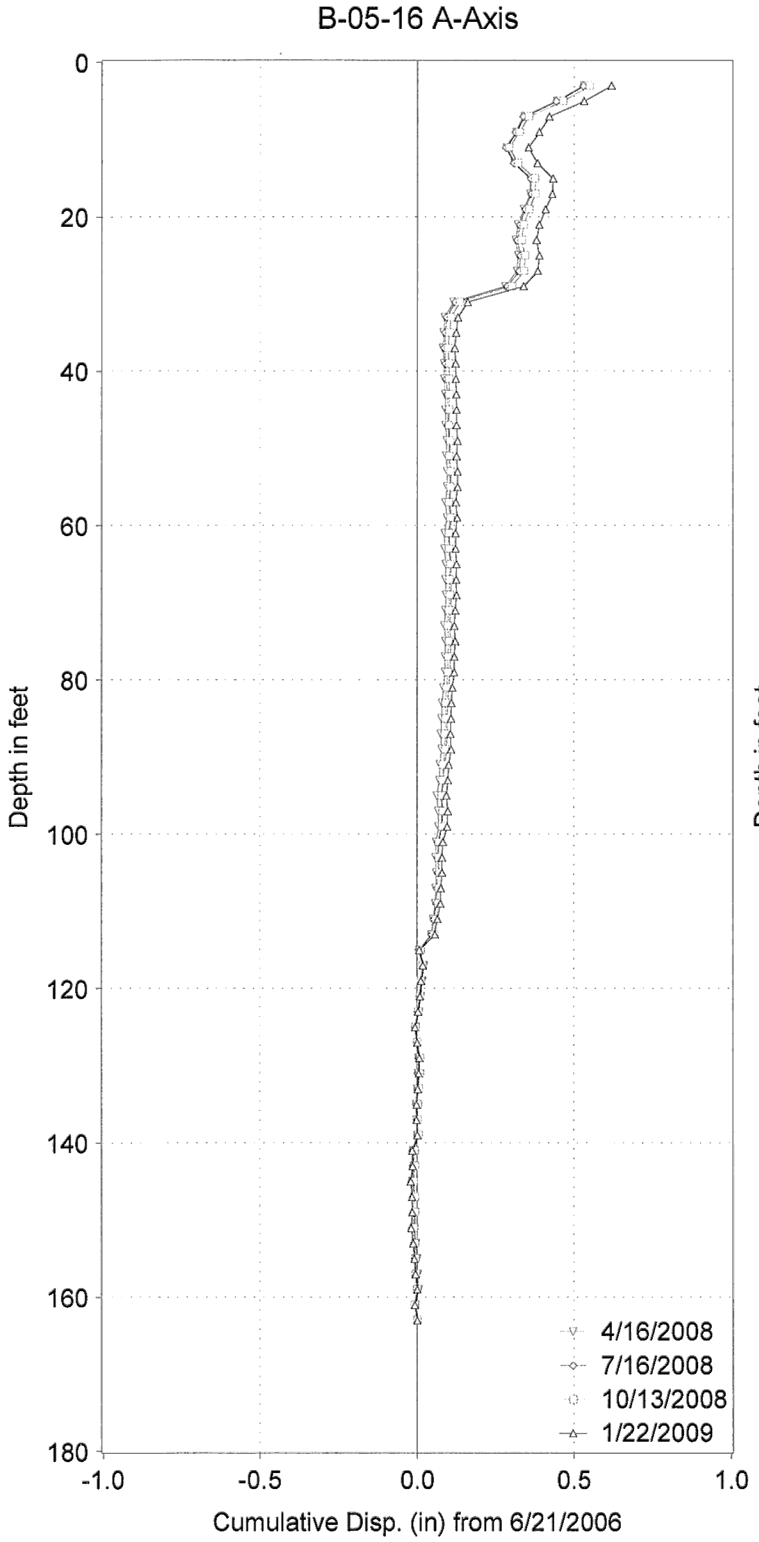
PLATE 44

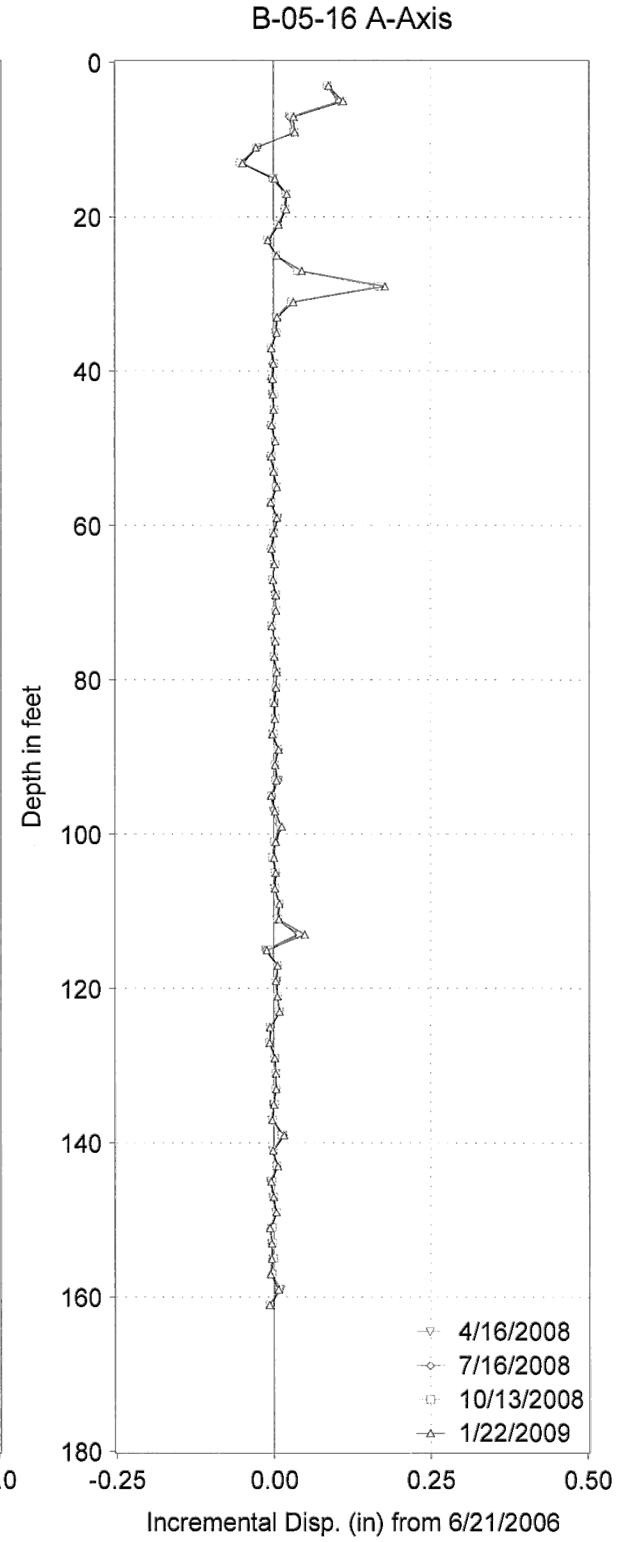




B-05-13
-Includes readings from the last four quarters.

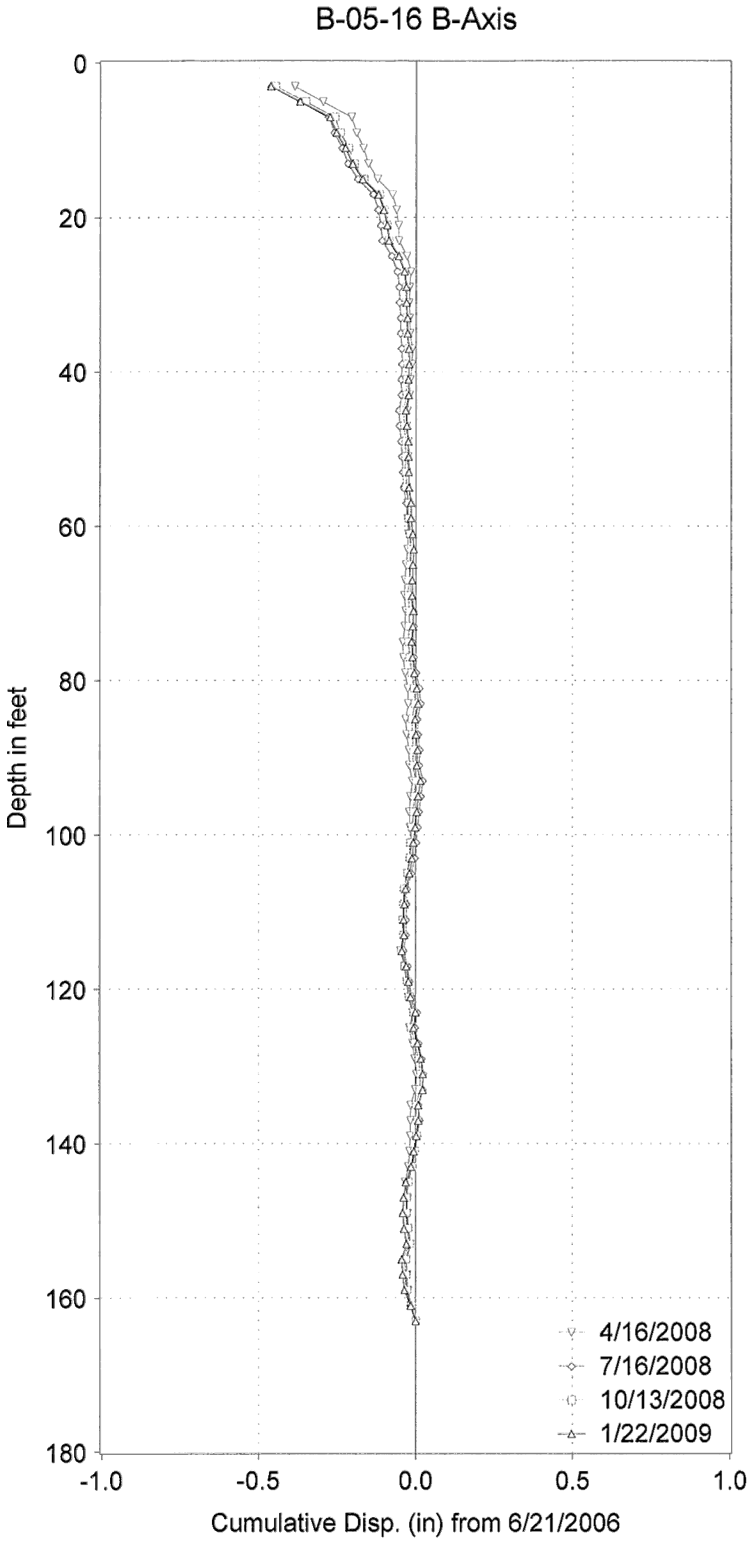
PLATE 45

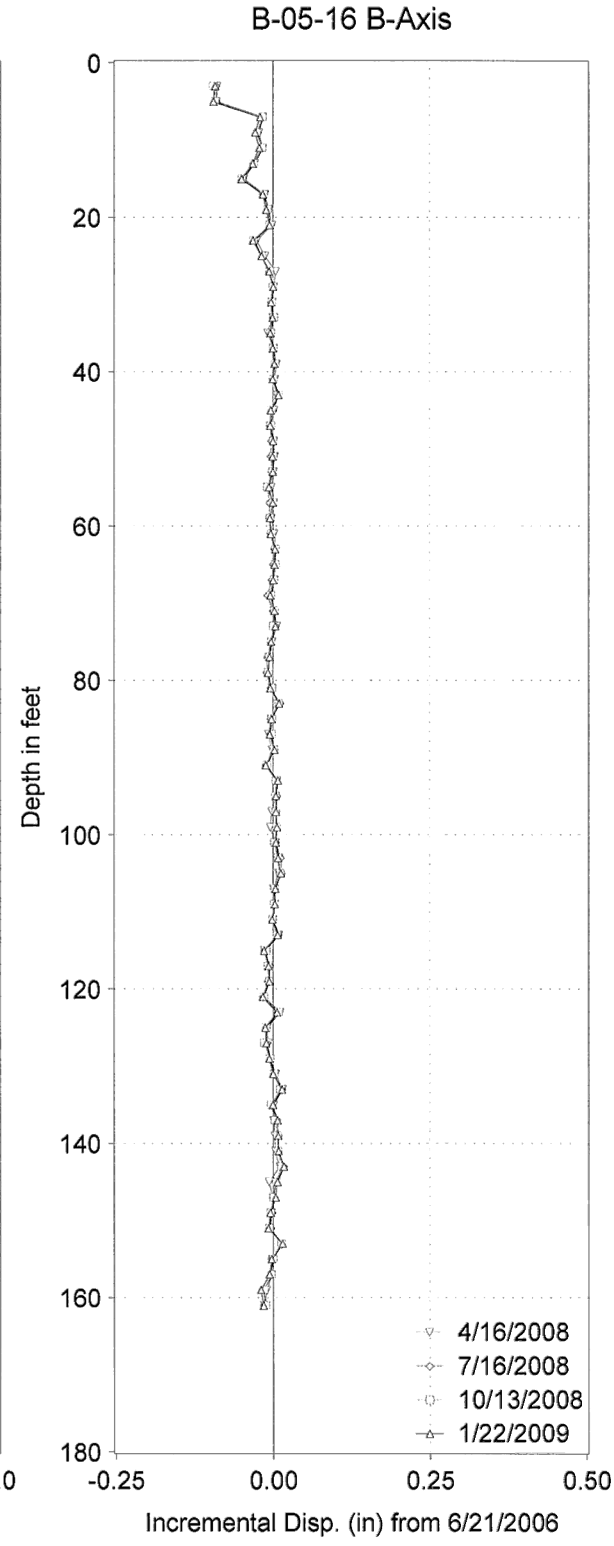




B-05-16
-Includes readings from the last four quarters.

PLATE 46





B-05-16
-Includes readings from the last four quarters.

PLATE 47

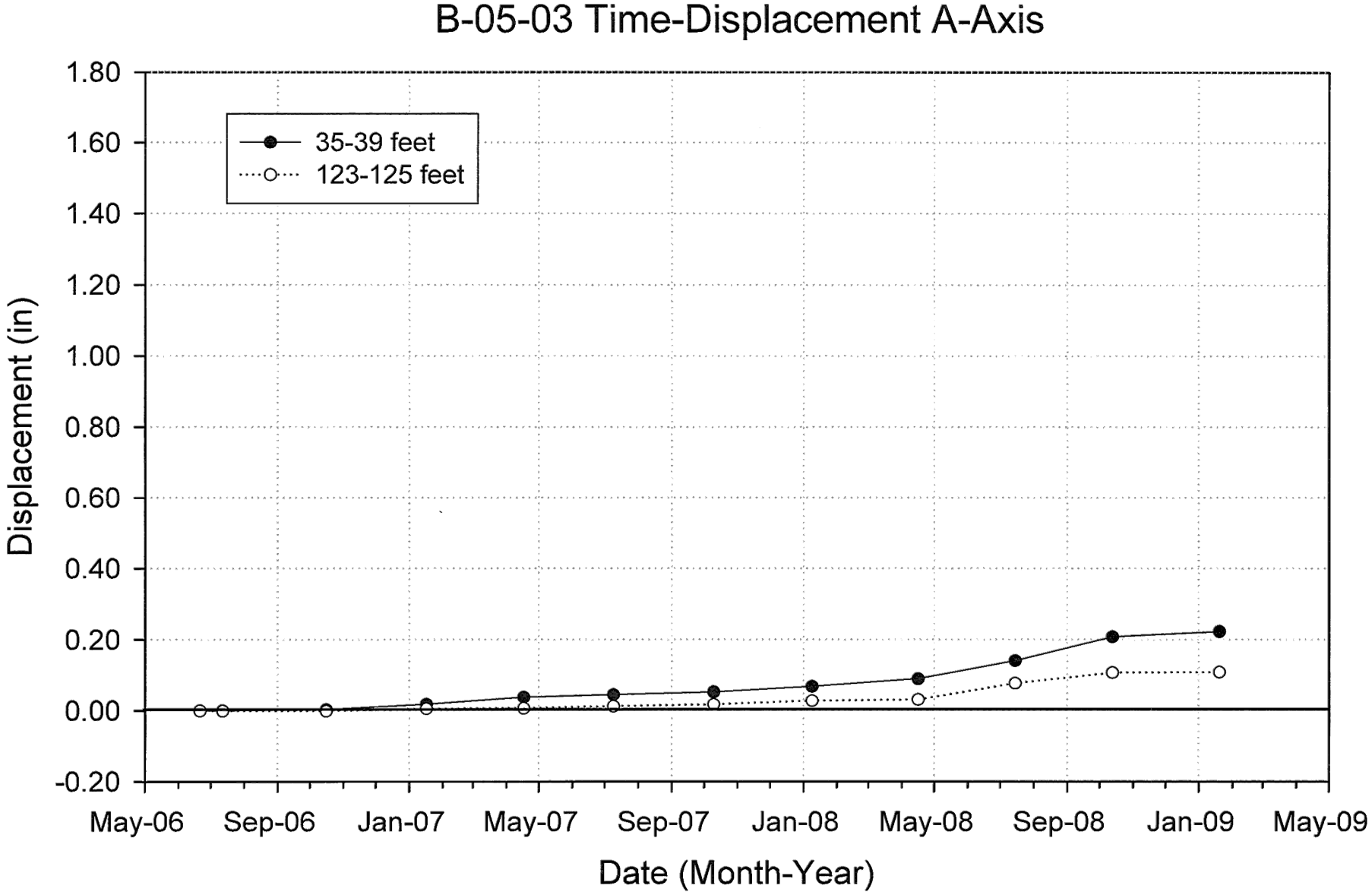

B-05-03 Time-Displacement A-Axis
35-39 feet
123-125 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Date (Month-Year)

PLATE 48

B-05-04 Time-Displacement A-Axis

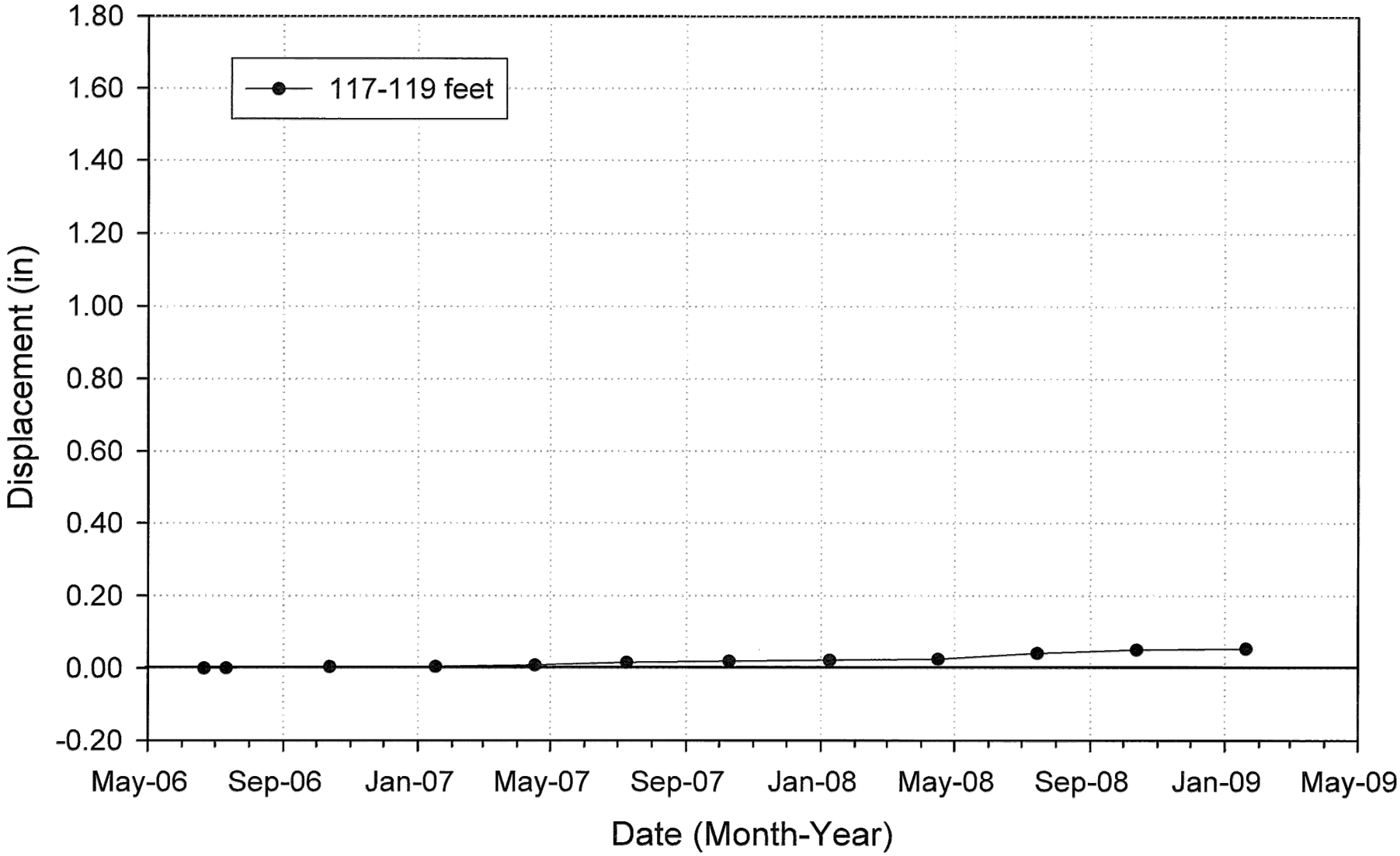


PLATE 49

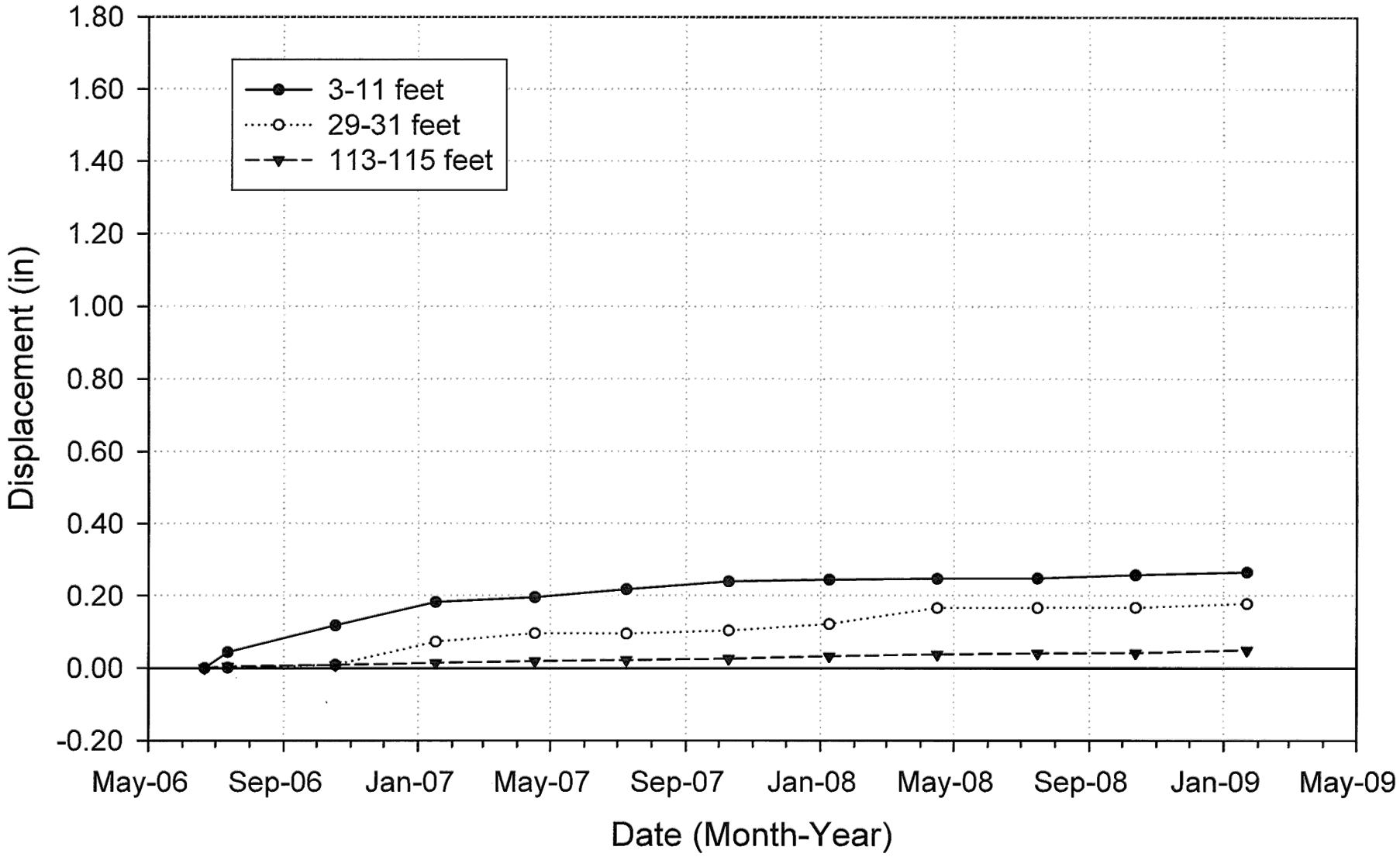

B-05-16 Time-Displacement A-Axis
3-11 feet
29-31 feet
113-115 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Date (Month-Year)

PLATE 50

B-101 (P-1) Pneumatic Piezometer Readings

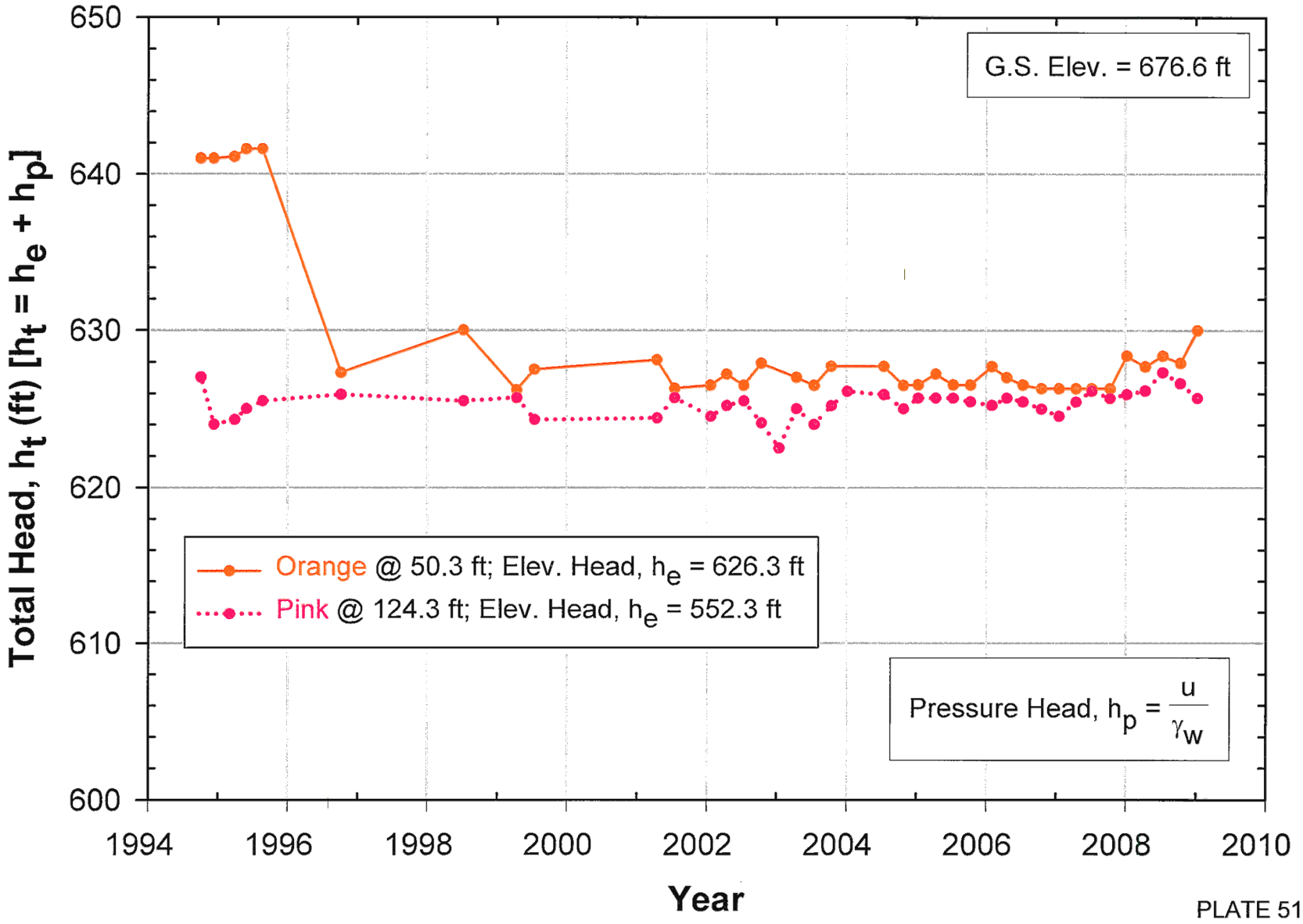


PLATE 51

B-105 (P-3) Pneumatic Piezometer Readings

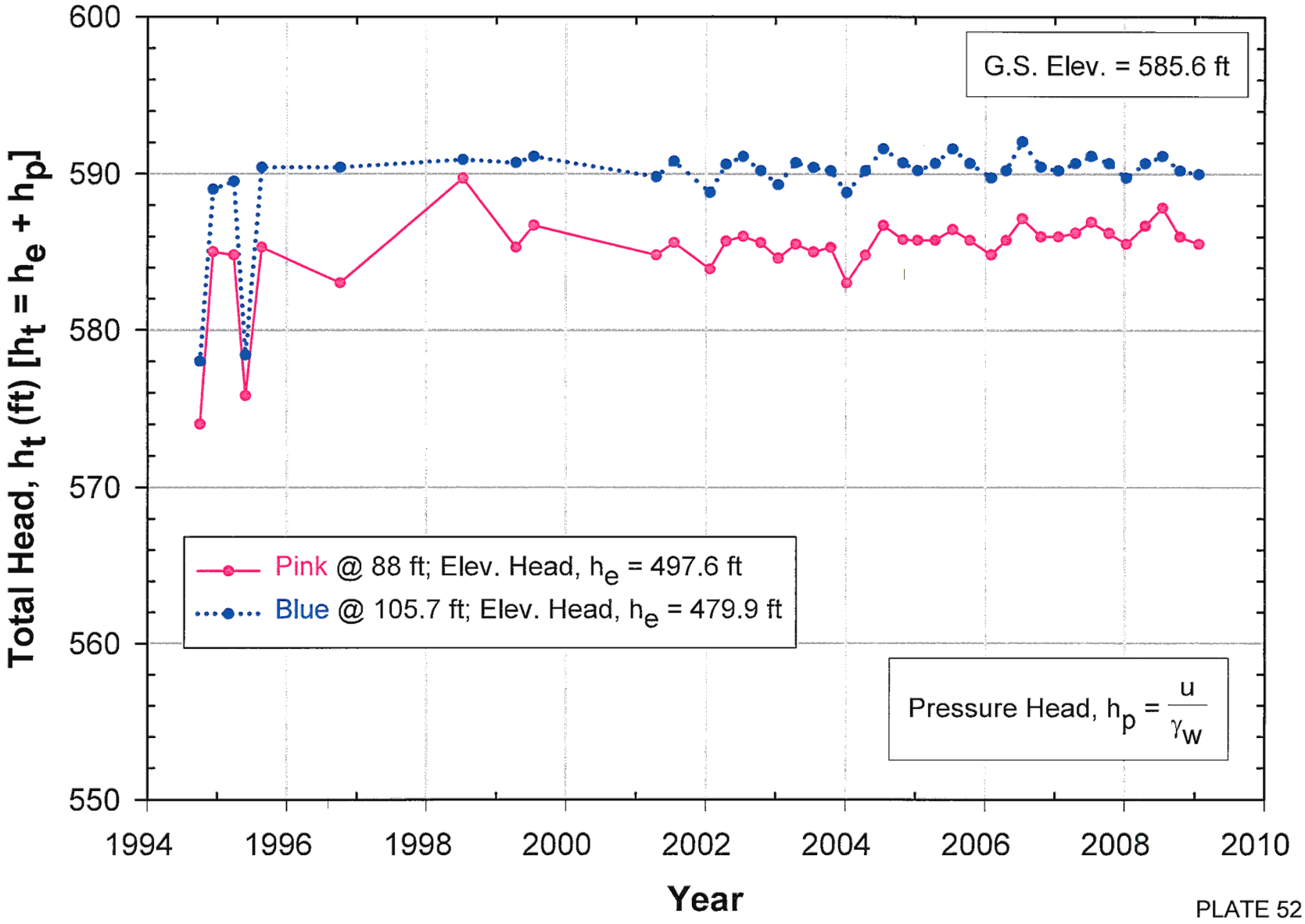


PLATE 52

B-107 (P-5) Pneumatic Piezometer Readings

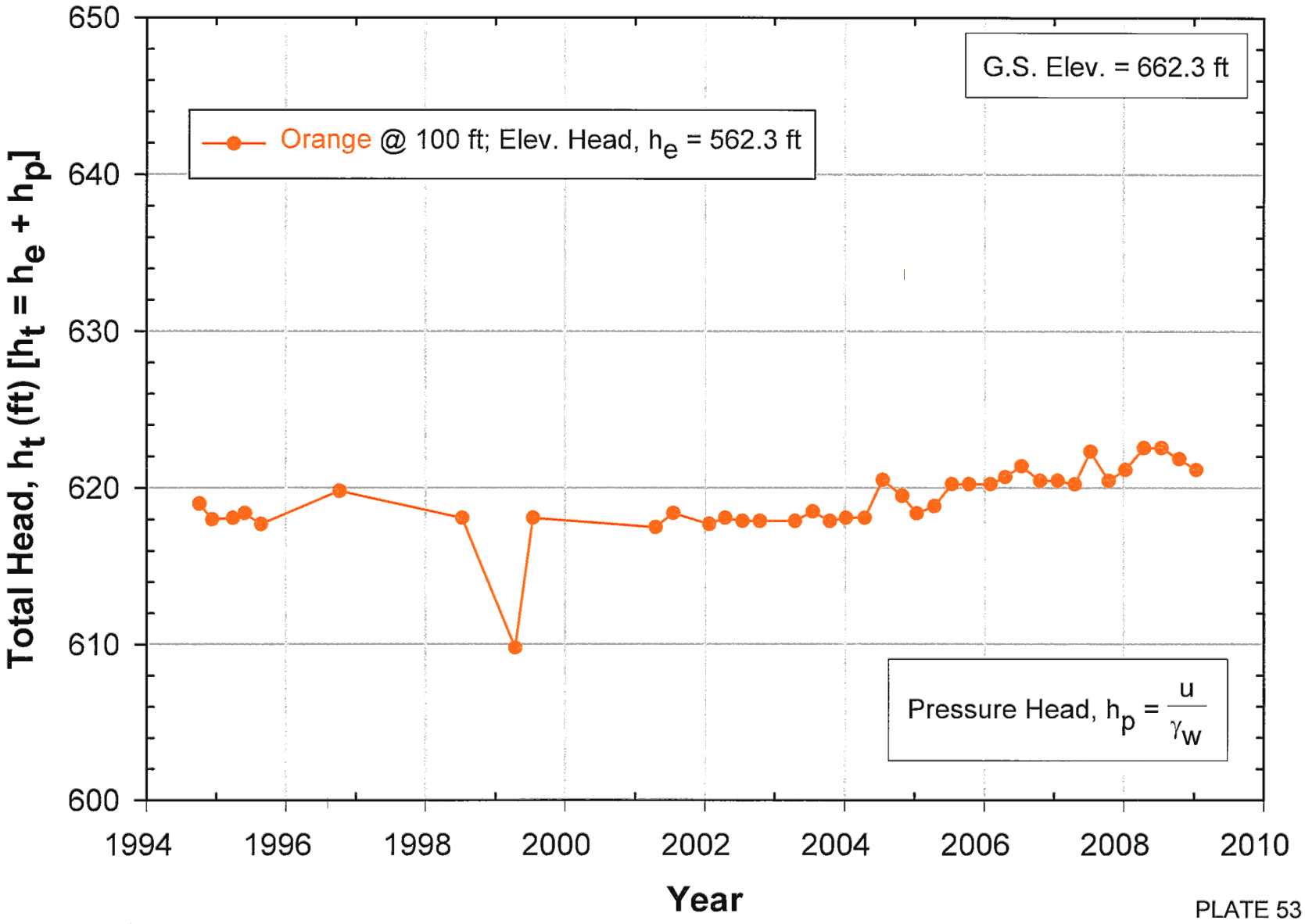


PLATE 53

B-303 (P-2) Pneumatic Piezometer Readings

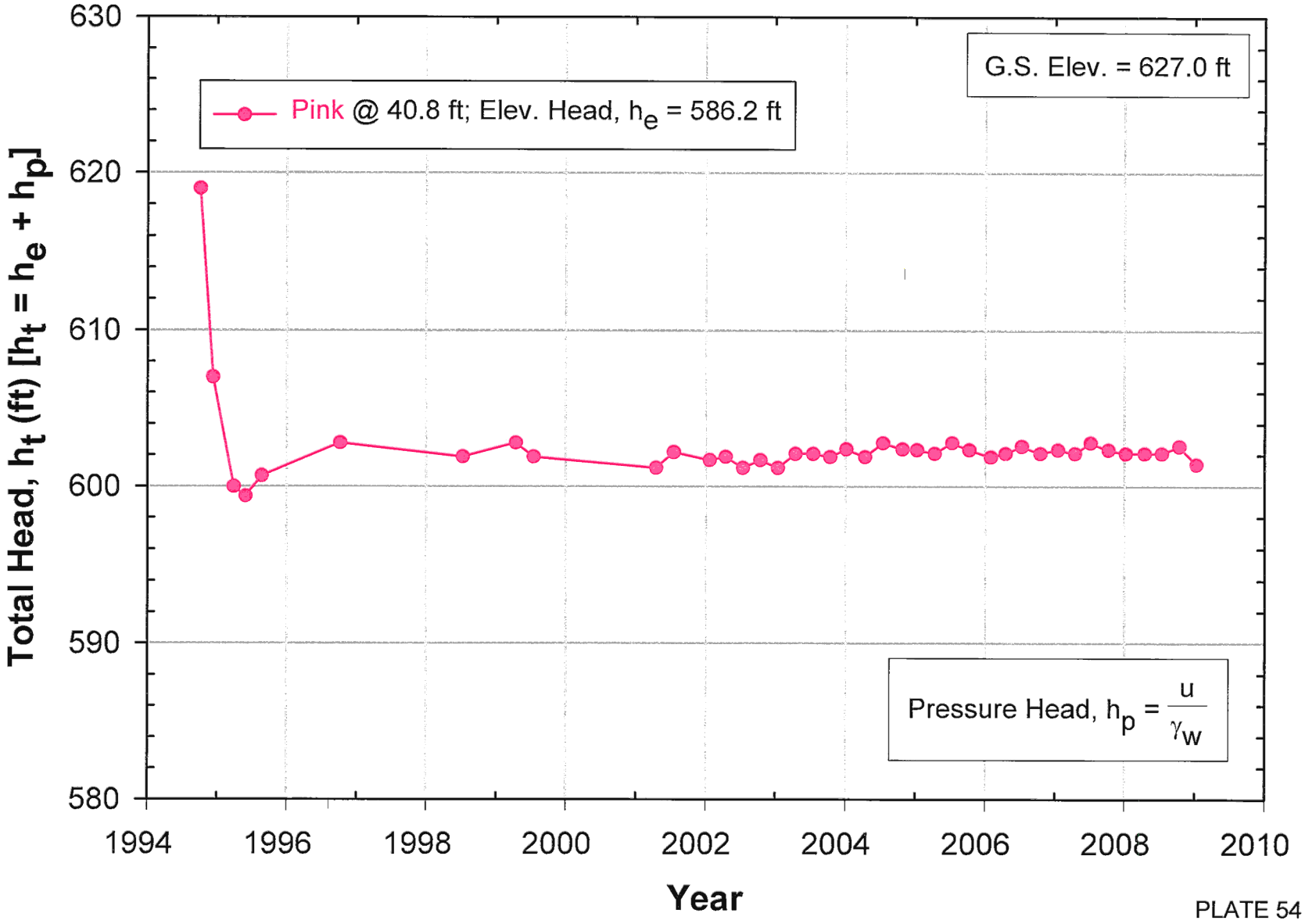


PLATE 54

B-05-01 VW Piezometer Readings

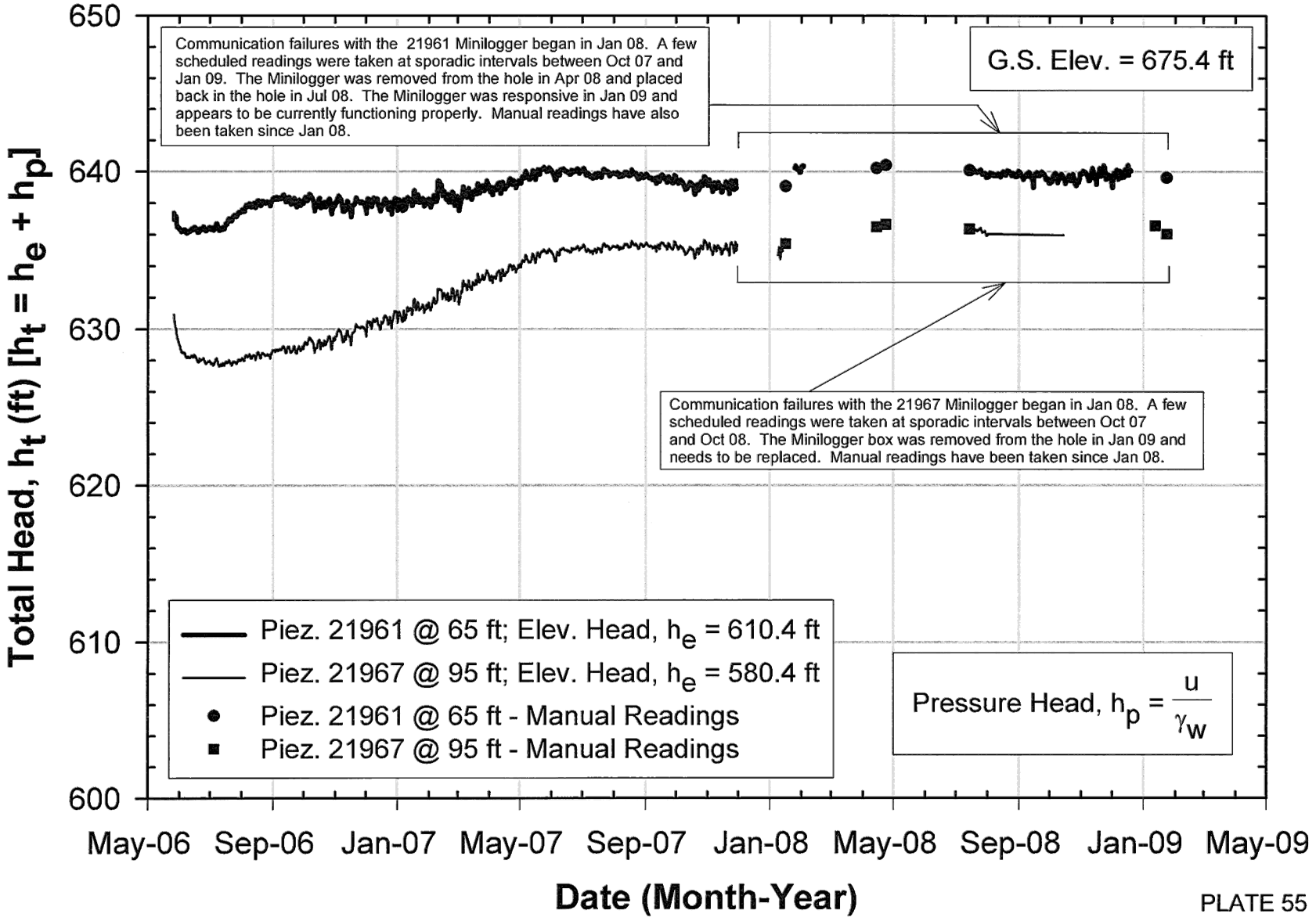


PLATE 55

B-05-02 VW Piezometer Readings

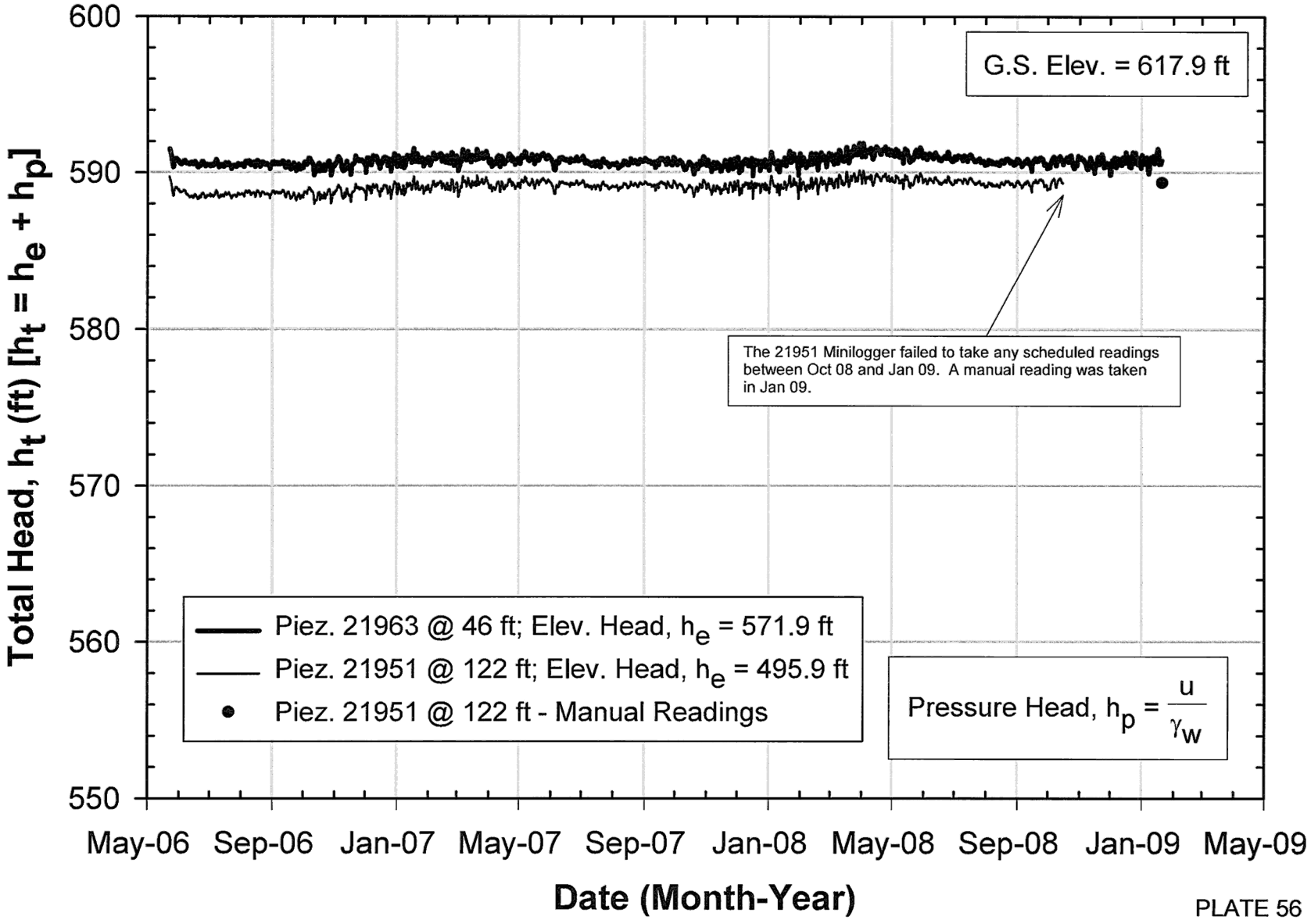


PLATE 56

B-05-03 VW Piezometer Readings

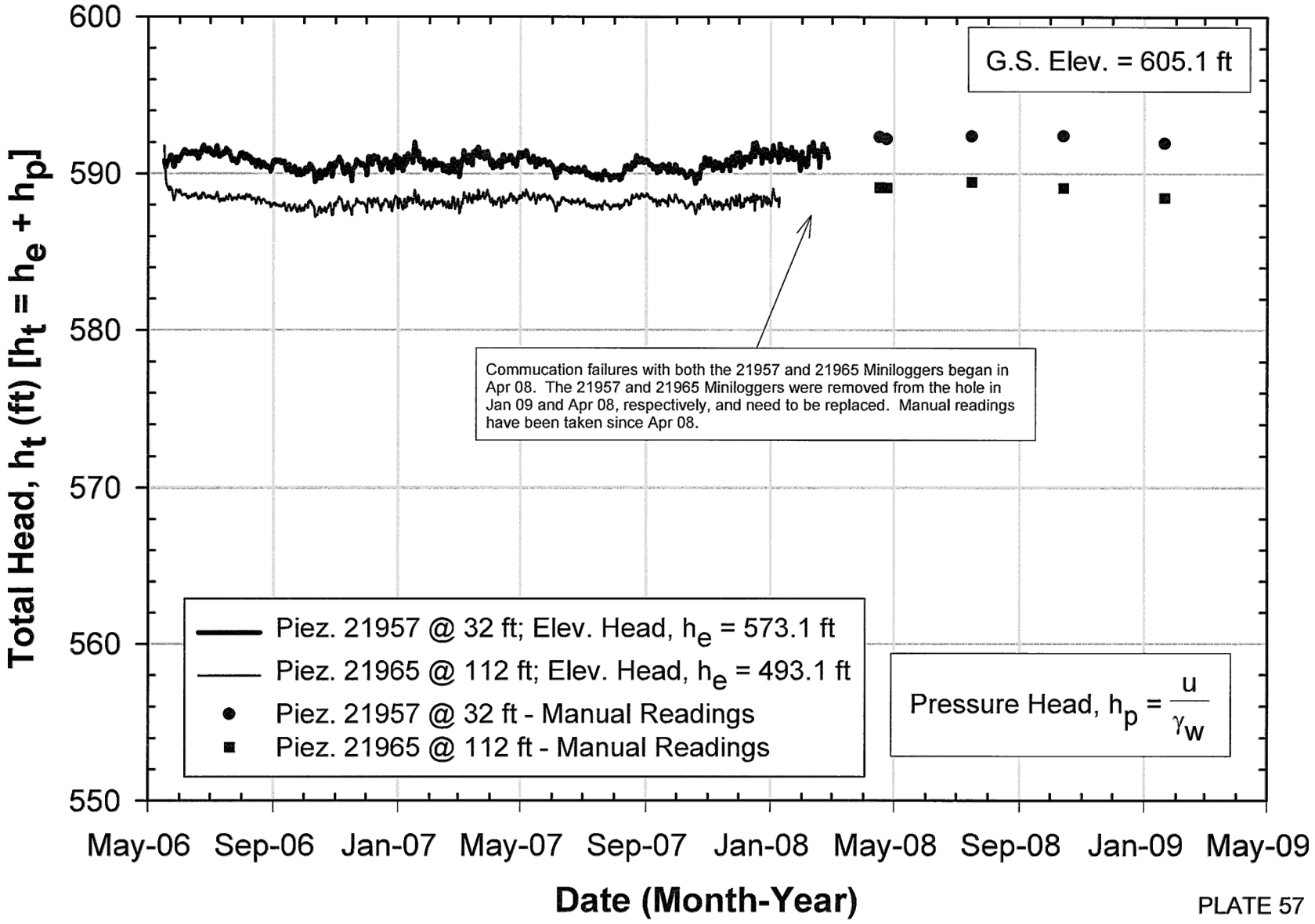


PLATE 57

B-05-04 VW Piezometer Readings

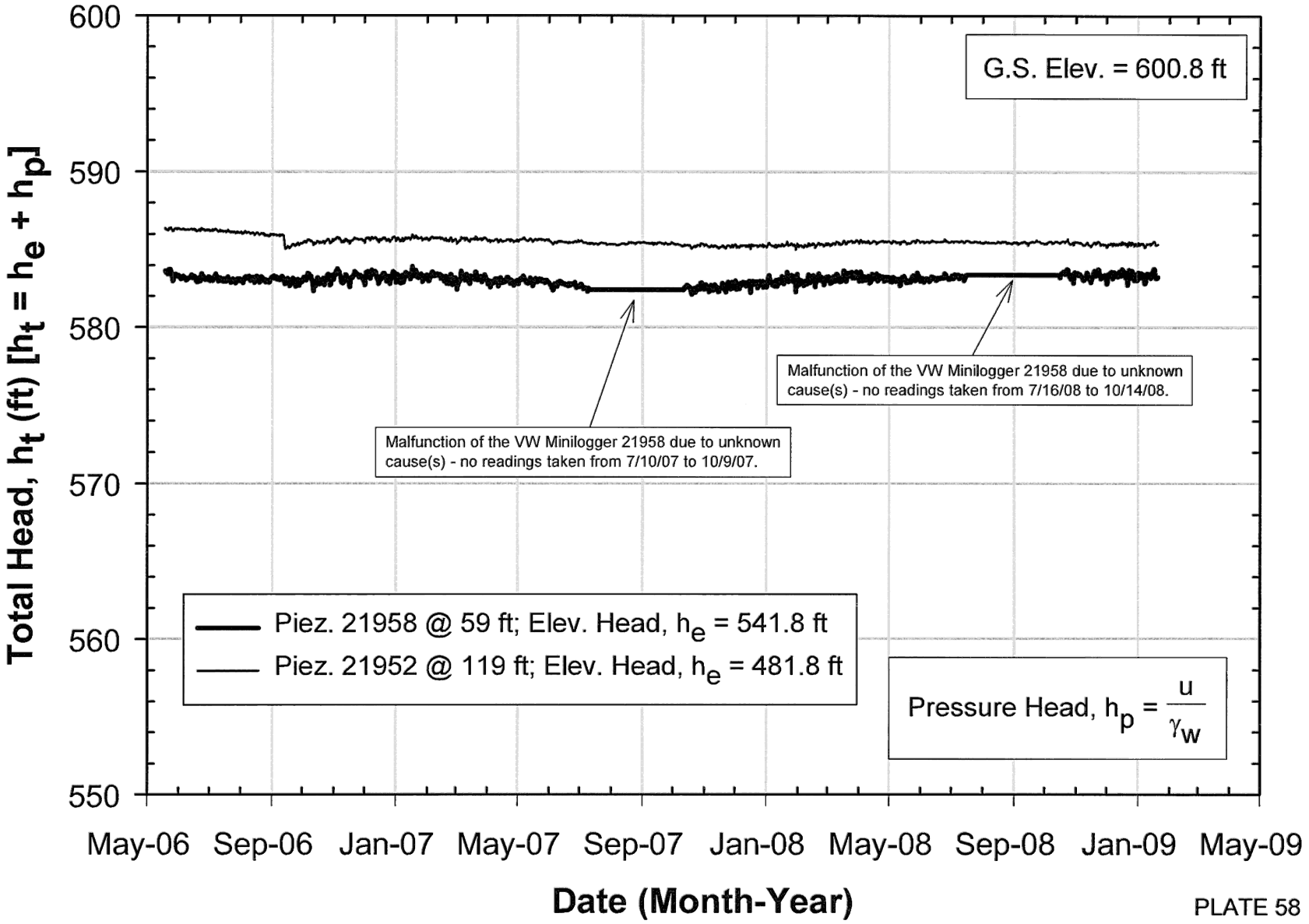


PLATE 58

B-05-07 VW Piezometer Readings

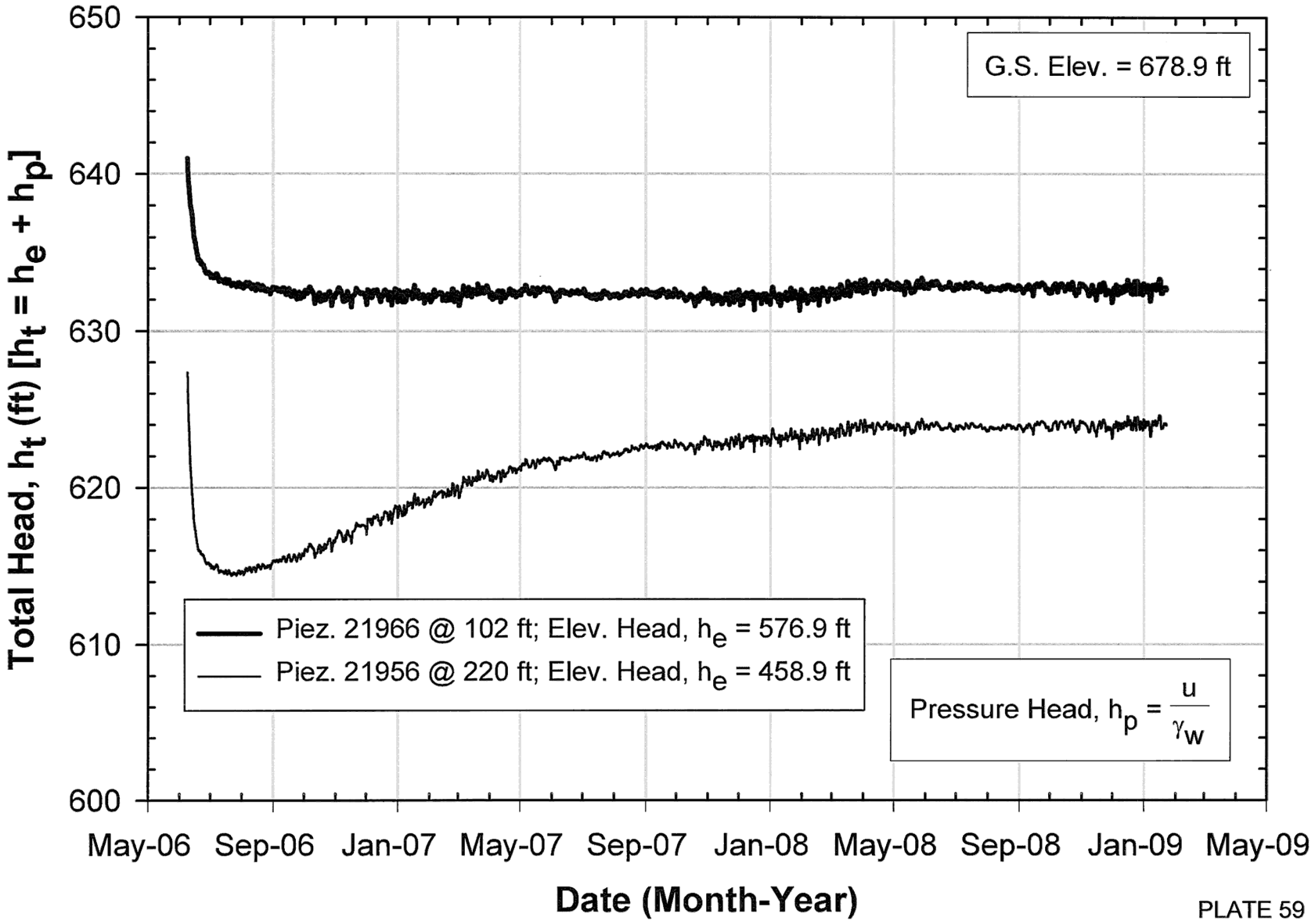


PLATE 59

B-05-08 VW Piezometer Readings

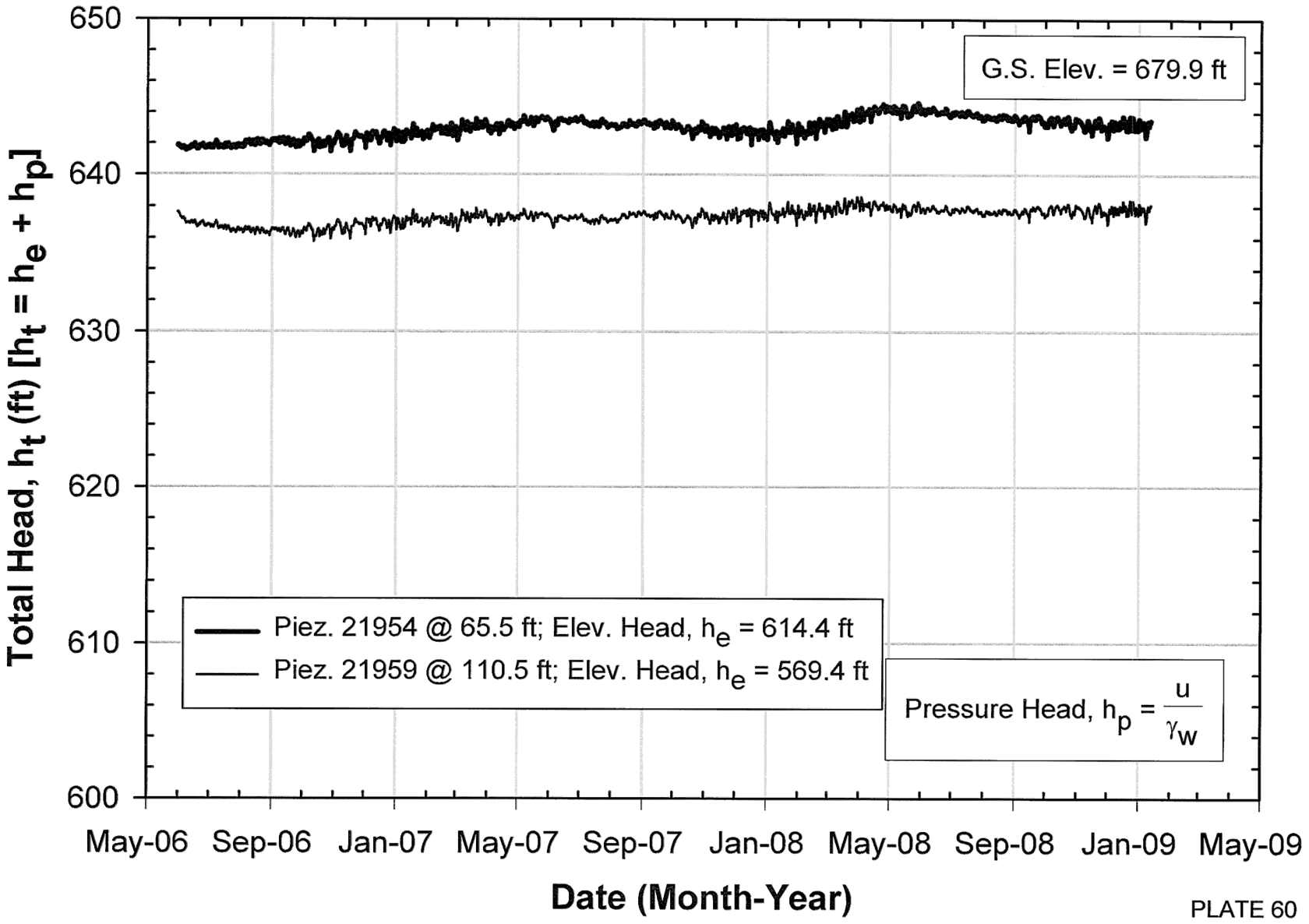


PLATE 60

B-05-11 VW Piezometer Readings

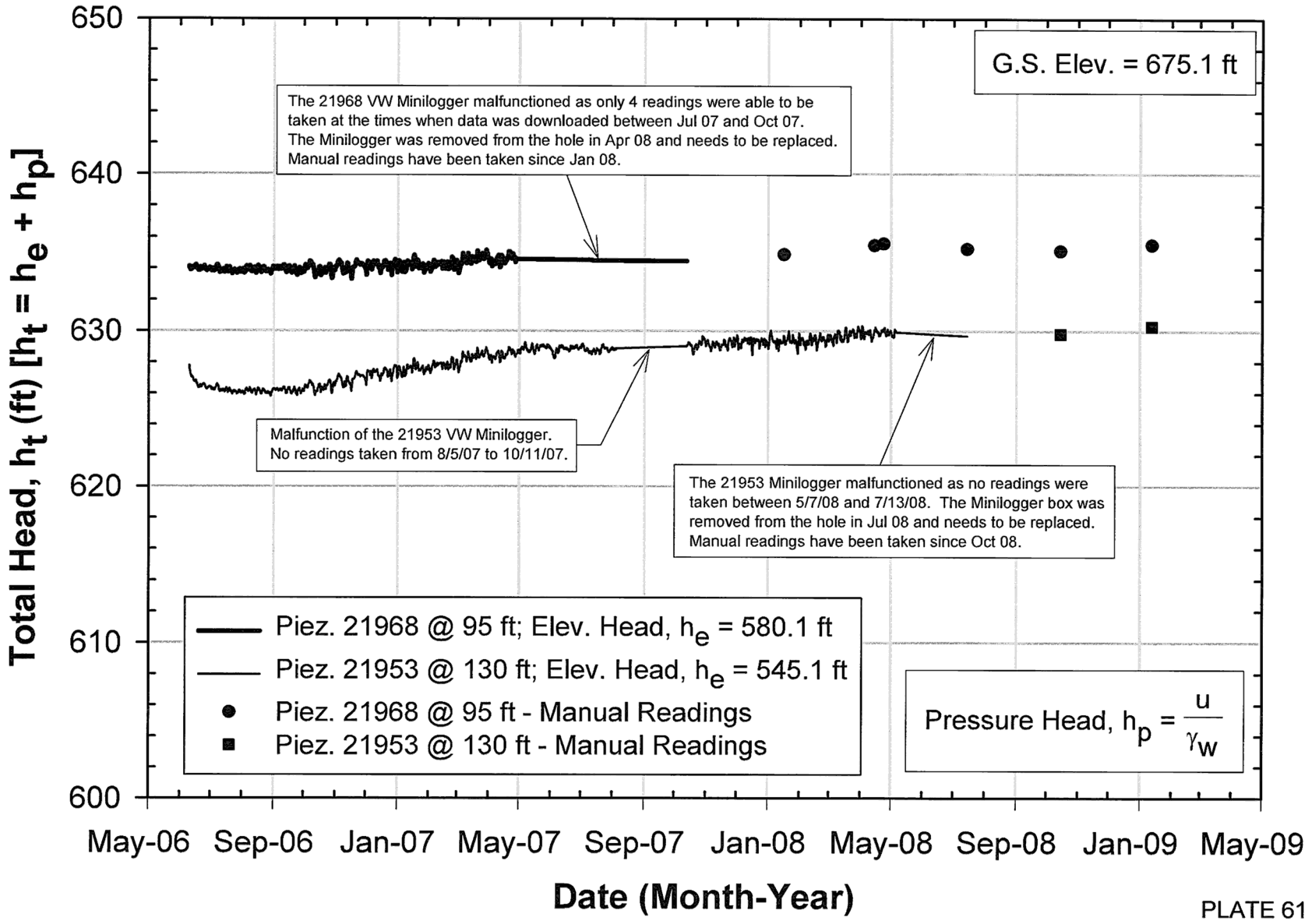


PLATE 61

B-05-12 VW Piezometer Readings

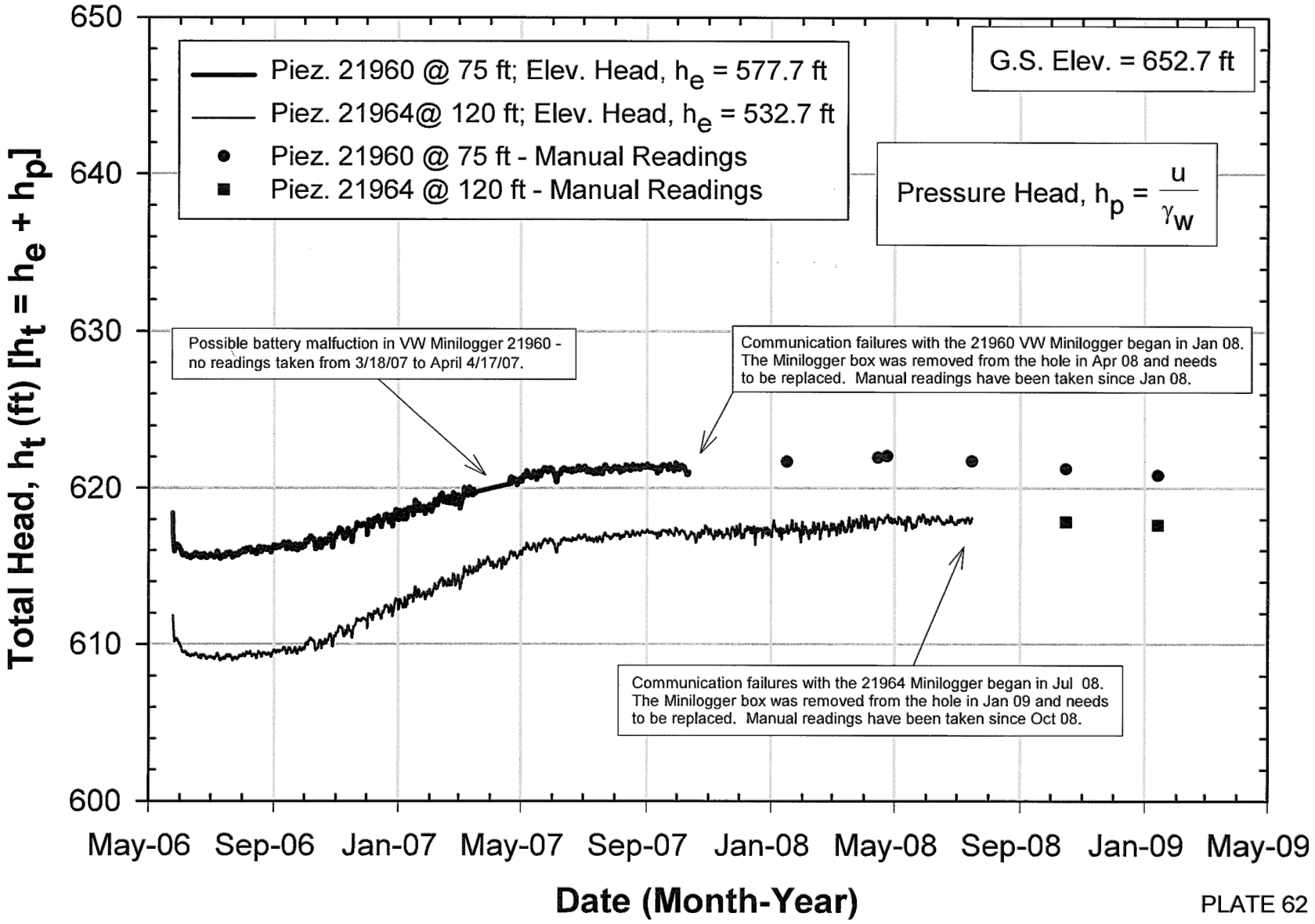


PLATE 62

B-05-13 VW Piezometer Readings

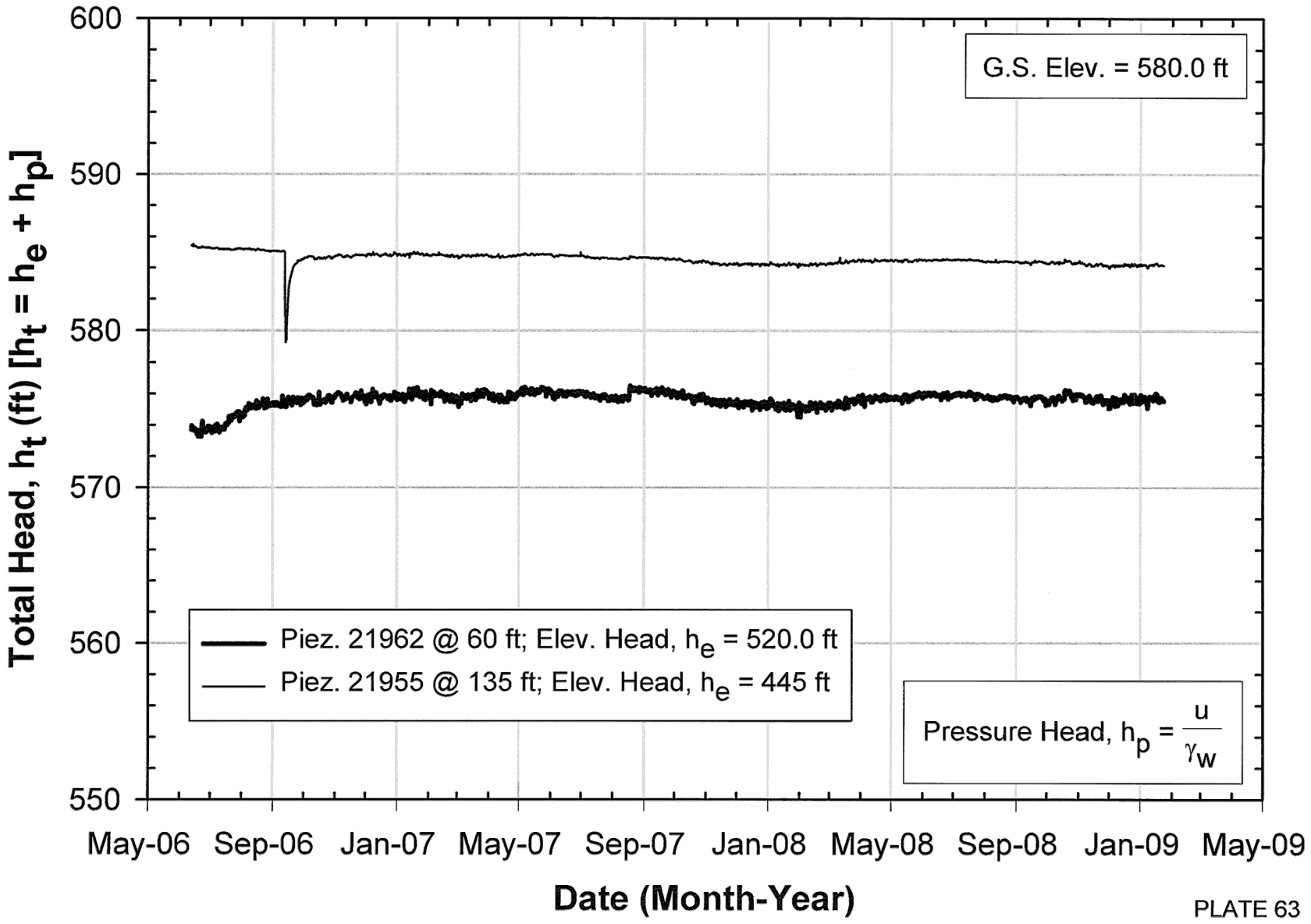


PLATE 63

CALIPERED SURFACE DISTANCE TABLE
CUY-90-15.24

Date	Left Pier Calipered Surface Distance		Center Line Calipered Surface Distance		Right Pier Calipered Surface Distance	
	Present reading	Change (in.)	Present reading	Change (in.)	Present reading	Change (in.)
04/17/02	6.285	--	Not Accessible		4.435	--
07/16/02	6.290	0.005	Discontinued		4.444	0.009
10/15/02	6.333	0.043			4.482	0.038
01/15/03	6.405	0.072			4.473	-0.009
04/17/03	6.333	-0.072			4.482	0.009
07/18/03	6.186	-0.147			4.350	-0.132
10/16/03	6.385	0.199			4.519	0.169
01/08/04	6.124	-0.261			4.594	0.075
04/14/04	6.129	0.005			4.402	-0.193
07/16/04	6.250	0.122			4.277	-0.125
10/27/04	6.375	0.125			4.467	0.190
01/12/05	6.250	-0.125			4.349	-0.118
04/14/05	6.375	0.125			4.372	0.023
07/14/05	6.313	-0.063			4.392	0.020
10/12/05	6.375	0.063			4.358	-0.034
02/01/06	6.438	0.063			4.395	0.037
04/20/06	6.500	0.063			4.430	0.035
07/14/06	6.375	-0.125			4.381	-0.049
10/18/06	6.438	0.063			4.400	0.020
01/19/07	6.500	0.062			4.506	0.106
04/18/07	6.375	-0.125			4.357	-0.150
07/11/07	6.438	0.063			4.341	-0.015
10/12/07	6.438	0.000			4.384	0.043
01/08/08	6.469	0.031			4.349	-0.036
04/14/08	6.500	0.031			4.410	0.062
07/14/08	6.500	0.000			4.410	0.000
10/15/08	6.375	-0.125			4.395	-0.016
01/13/09	6.500	0.125			4.449	0.055

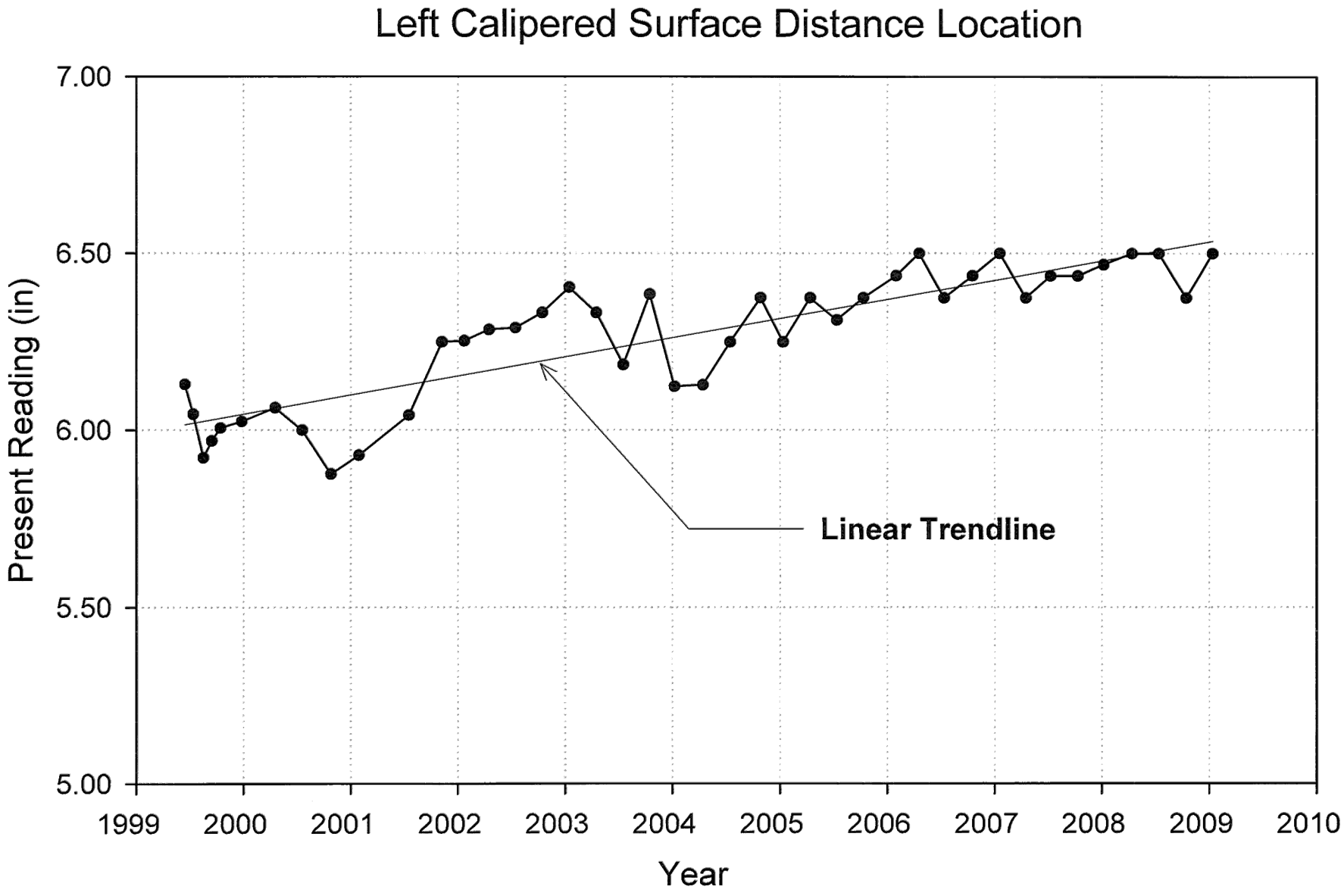

Left Calipered Surface Distance Location
7.00
6.50
6.00
5.50
5.00
Present Reading (in)
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year
Linear Trendline

PLATE 65

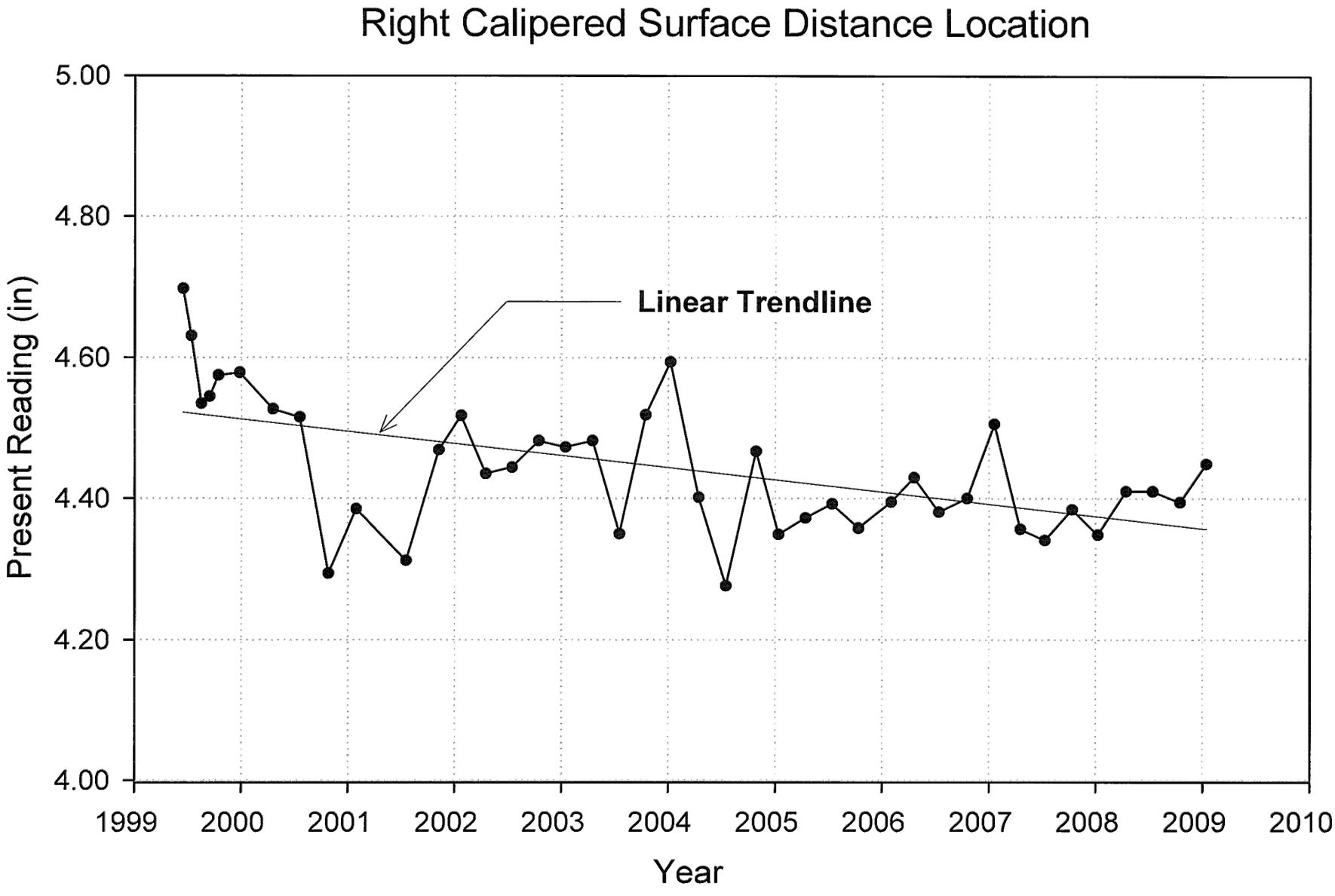

Right Calipered Surface Distance Location
5.00
4.80
4.60
4.40
4.20
4.00
Present Reading (in)
Linear Trendline
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

PLATE 66

View towards the east-southeast of the aggregate pile and east right-of-way fence. Photo taken on January 22, 2008.

PLATE 67

Close-up view towards the east-southeast of the aggregate pile and east right-of-way fence.
Photo taken on January 22, 2008.

PLATE 68

CUY-90-1524
106017

DECK EXPANSION JOINT OPENINGS

Finger Type Joints

Measurements are in inches.

Date	Temp (F)	West End Pier North	West End Pier South	Near Pier 2 North	Near Pier 2 South	Near Pier 4 North	Near Pier 4 South
Expansion Distance		476 feet		650 feet			
Design	60°	3.25	3.25	3.25	3.25	3.25	3.25
06-01-70	80°	4.00		0.00		N.A.	
09-19-75	60°	5.25		2.00		N.A.	
05-08-78	60°	4.75	5.50	2.00	2.00	3.25	2.50
07-30-81	75°	5.50	5.50	2.25	2.25	3.25	2.75
06-09-83	70°	5.00	5.00	1.50	1.50	2.75	2.25
07-31-85	73°	5.25	4.75	1.50	1.00	2.75	2.25
10-31-88	40°	7.75	8.38	1.50	0.75	3.81	3.38
11-01-89	50°	7.75	7.00	1.13	0.63	3.25	3.13
10-26-90	50°	7.75	7.25	1.00	0.50	3.00	3.00
09-30-91	55°	7.50	7.00	0.88	0.00	3.00	3.00
10-13-92	60°	7.25	6.81	0.63	0.00	2.50	2.50
10-01-93	50°	7.50	7.13	0.75	0.31	2.75	2.63
09-01-94	63°	7.25	6.38	0.31	0.00	2.88	1.88
09-08-95	60°	7.00	6.63	0.44	0.00	2.00	1.88
09-05-96	77°	6.50	6.63	0.38	0.00	1.25	1.00
09-19-97	75°	6.88	7.00	0.31	0.06	1.68	1.42
09-24-98	69°	7.63	7.00	0.00	0.00	1.88	1.75
10-14-99	45°	6.19	5.50	2.38	1.88	3.13	2.75
10-16-00	55°	6.00	4.88	1.75	1.25	2.56	2.43
04-23-01	70°	5.50	4.25	1.38	0.63	2.13	1.75
07-16-01	80°	5.00	3.88	1.00	0.25	1.50	1.25

Date	Temp (F)	West End Pier		Near Pier 2		Near Pier 4	
		North	South	North	South	North	South
10-15-01	50°	6.63	5.63	1.63	1.06	3.25	2.75
1-15-02	30°	6.88	6.25	2.13	1.50	3.88	3.50
4-15-02	61°	6.00	5.25	1.38	0.88	2.50	2.38
7-15-02	76°	5.13	4.13	1.13	0.50	1.75	1.50
10-17-02	48°	7.00	6.38	1.75	1.25	3.25	2.88
11-1-02	35°	7.25	6.13	1.88	1.38	3.63	3.38
1-15-03	7°	8.13	6.63	2.38	1.88	5.00	4.75
4-15-03	67°	5.63	4.63	1.25	0.63	2.25	2.00
7-15-03	74°	5.38	4.38	1.00	0.50	2.00	1.63
10-16-03	46°	7.00	5.75	1.50	1.13	3.25	3.13
1-15-04	11°	8.00	6.75	2.00	1.38	4.63	4.00
4-15-04	41°	6.88	5.75	1.38	0.88	3.50	3.25
7-15-04	67°	5.63	4.75	1.00	0.50	2.13	1.75
10-15-04	50°	6.38	5.50	1.25	0.75	3.00	2.75
1-15-05	12°	7.75	7.00	2.00	1.38	4.63	4.25
4-16-05	47°	6.50	5.63	1.25	0.75	3.25	2.88
7-16-05	74°	5.50	4.50	0.75	0.375	1.75	1.63
10-14-05	51°	6.25	5.50	1.13	0.63	2.81	2.56
1-16-06	26°	7.63	6.38	1.75	1.13	4.13	3.75
4-14-06	65°	5.75	4.88	0.75	0.50	2.25	2.00
7-14-06	78°	5.00	4.00	0.63	0.19	1.63	1.25
10-16-06	50°	6.50	5.88	1.00	0.75	3.25	3.00
1-15-07	41°	7.00	6.13	1.13	0.88	3.56	3.38
4-16-07	34°	7.25	6.38	1.38	0.88	3.75	3.50
7-16-07	70°	5.38	4.75	0.88	0.25	2.13	1.63
10-15-07	56°	6.38	5.50	1.13	0.75	2.88	2.69

Date	Temp (F)	West End Pier North	West End Pier South	Near Pier 2 North	Near Pier 2 South	Near Pier 4 North	Near Pier 4 South
1-15-08	19°	7.63	6.63	1.63	1.00	4.13	4.00
4-15-08	41°	7.13	6.25	1.44	0.88	3.75	3.19
7-16-08	83°	4.75	4.00	0.50	0.00	1.13	0.81
10-16-08	56°	6.25	5.56	1.13	0.69	2.75	2.25
1-15-09	7°	8.31	7.69	2.00	1.13	5.00	4.94

N.A. - No measurements available

EXPANSION OPENINGS AT SPAN 2 FLOORBEAM 12

Measurements are in inches

Date	Temp (F)	North Lower Chord Expansion Opening	Deck Expansion Joint Near Pier 2		South Lower Chord Expansion Opening
			North	South	
04-23-01	70°	0.54	1.38	0.63	0.04
07-16-01	80°	0.11	1.00	0.25	N.A.
10-15-01	50°	0.48	1.00	0.25	0.10
1-15-02	30°	1.23	2.13	1.50	0.67
4-15-02	61°	0.48	1.38	0.88	0.17
7-15-02	76°	0.17	1.13	0.50	0.04
10-15-02	41°	0.36	1.75	1.25	0.23
11-1-02	35°	N.A.	1.88	1.38	N.A.
1-15-03	7°	1.17	2.38	1.88	0.73
4-15-03	67°	0.30	1.25	0.63	0.12
7-15-03	74°	0.18	1.00	0.50	0.12
10-16-03	46°	0.30	1.50	1.13	0.12
1-15-04	11°	0.90	2.00	1.38	0.48
4-15-04	41°	0.42	1.38	0.88	0.06
7-15-04	67°	0.06	1.00	0.50	0.00
10-15-04	50°	0.17	1.25	0.75	0.04
1-15-05	12°	0.66	2.00	1.38	0.30
4-16-05	47°	0.30	1.25	0.75	0.00
7-16-05	74°	0.00	0.75	0.375	0.00
10-14-05	51°	0.18	1.13	0.63	0.18
1-16-06	26°	0.66	1.75	1.13	0.24
4-14-06	65°	0.18	0.75	0.50	0.00
7-14-06	78°	0.00	0.63	0.19	0.00

Date	Temp (F)	North Lower Chord Expansion Opening	Deck Expansion Joint Near Pier 2		South Lower Chord Expansion Opening
			North	South	
10-16-06	50°	0.30	1.00	0.75	0.00
1-15-07	41°	0.30	1.13	0.88	0.12
4-16-07	34°	0.36	1.38	0.88	0.12
7-16-07	70°	0.06	0.88	0.25	0.00
10-15-07	56°	0.12	1.13	0.75	0.00
1-15-08	19°	0.42	1.63	1.00	0.18
4-15-08	41°	0.36	1.44	0.88	0.06
7-16-08	83°	0.00	0.50	0.00	0.00
10-16-08	56°	0.12	1.13	0.69	0.12
12-05-08	23°	0.36	1.13	0.69	0.18
1-15-09	7°	0.73	2.00	1.13	0.29

N.A. – Not Available

Richland Engineering Limited 106017

From: "arthur huckelbridge" <aah4@case.edu>
To: "'Richland Engineering Limited'" <reltd@r-e-l.com>
Sent: Thursday, January 22, 2009 1:44 PM
Attach: tiltmeters_Jan_09.ppt
Subject: tiltmeters

Dean:

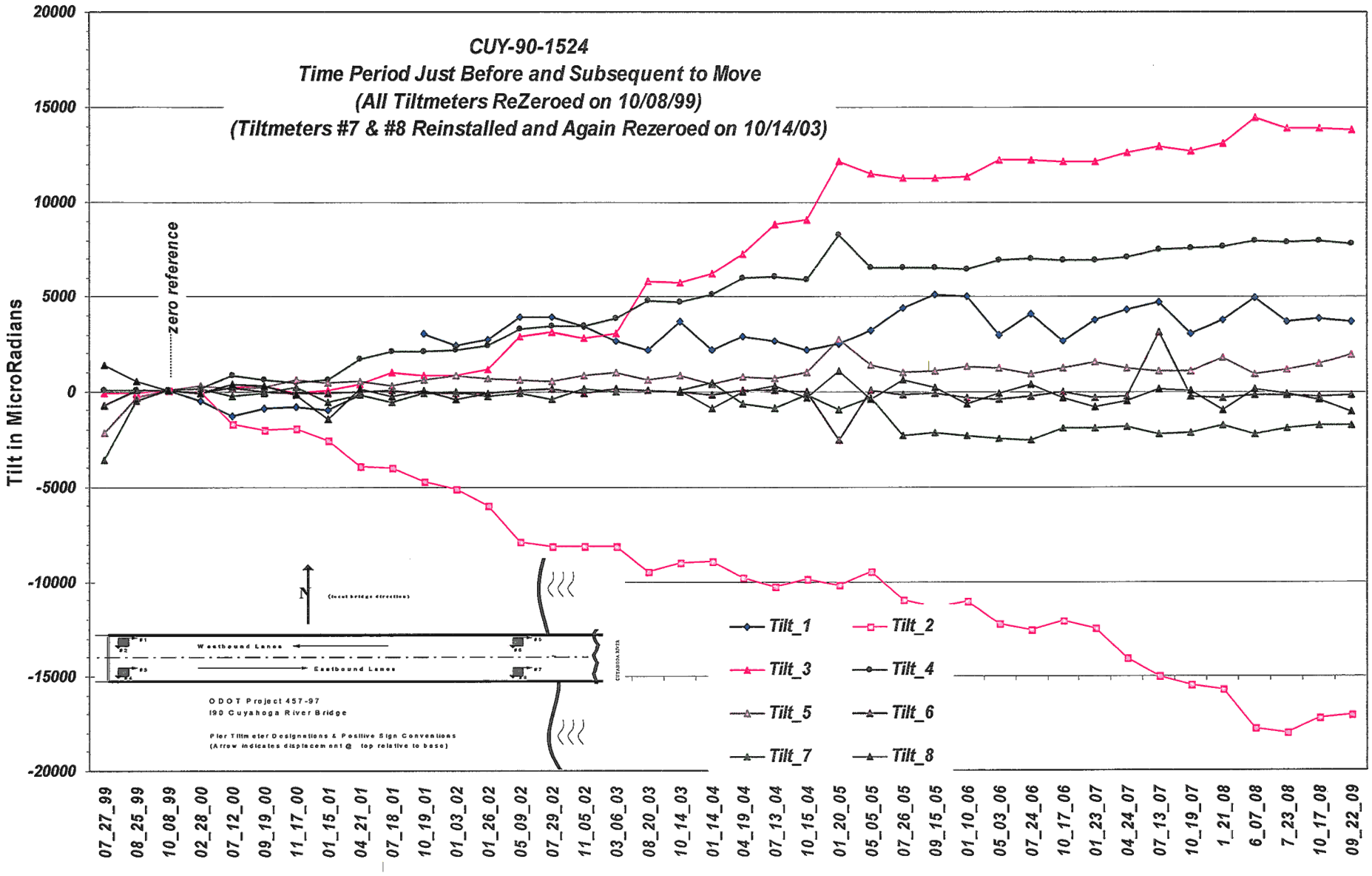
I read the tiltmeters this AM – no substantive changes to report (fortunately, BBCM was there ahead of me, breaking trail through the snow).

Anything new on the widening girder authorization ?

Take care.

Art

Arthur A. Huckelbridge, Jr., D.Eng., P.E.
Department of Civil Engineering
Case School of Engineering
Case Western Reserve University
Cleveland, OH 44106-7201
off: (216) 368 2474
cell: (216) 534 9141
hm: (216) 321 1844
fax: (216) 368 5229


CUY-90-1524
Time Period Just Before and Subsequent to Move
(All Tiltmeters ReZeroed on 10/08/99)
(Tiltmeters #7 & #8 Reinstalled and Again Rezeroed on 10/14/03)
Tilt in MicroRadians
zero reference
20000
15000
10000
5000
0
-5000
-10000
-15000
-20000
07_27_99
08_25_99
10_08_99
02_28_00
07_12_00
09_19_00
11_17_00
01_15_01
04_21_01
07_18_01
10_19_01
01_03_02
01_26_02
05_09_02
07_29_02
11_05_02
03_06_03
08_20_03
10_14_03
01_14_04
04_19_04
07_13_04
10_15_04
01_20_05
05_05_05
07_26_05
09_15_05
01_10_06
05_03_06
07_24_06
10_17_06
01_23_07
04_24_07
07_13_07
10_19_07
1_21_08
6_07_08
7_23_08
10_17_08
09_22_09
Tilt_1
Tilt_2
Tilt_3
Tilt_4
Tilt_5
Tilt_6
Tilt_7
Tilt_8
N
Westbound Lanes
Eastbound Lanes
ODOT Project 457-97
I90 Cuyahoga River Bridge
Pier Tiltmeter Designations & Positive Sign Conventions
(Arrow indicates displacement @ top relative to base)

Robert Y. Liang, Ph.D., P.E
8441 Timber Tr.
Brecksville, Ohio 44141

Cell Phone: (440) 725-7425
e-mail: RYLIANG@AOL.COM

February 7, 2009

Mr. Dean Palmer, P.E.
Richland Engineering, Ltd.
29 North Park St.
Mansfield, OH 44902

Ref: CUY-90-14.52, PID No. 77332

Dear Mr. Palmer:

The monitoring data for the slope stabilization subsurface structures at the referenced project site for the last three months (October, November, and December, 2008) are enclosed. The inclinometer reading and strain data were taken on January 12 and 13, 2009. We also recharged the batteries, fixed the lock of the data logger cabinet, and performed maintenance on the data logger during our site visit.

From the enclosed strain-related data sheets and the plotted figures, it appears that the strain readings and the forces and moments on the foundation structures have been steady in the last three months. Inclinometer readings did not show significant drilled shafts movements.

Please call me at (440) 725-7425, if you have any question. Thank you.

Sincerely,

Robert Liang

FEB 10 2009
RICHLAND ENGINEERING

Table 1 Numerical reading of anchor load as a function of time for anchors #1, #8, #9 and #17

Date	Anchor # 1 Load, kips	Anchor # 8 Load, kips	Anchor # 9 Load, kips	Anchor # 17 Load, kips	Comment
4/7/1999		560			
4/8/1999	489			499	Anchor Lock off
4/14/1999	460	473	596 (Lock off)	461	
5/7/1999	452	473	572	445	End of construction
7/1/1999	446	468	564	439	
10/1/1999	441	467	560	440	
1/1/2000	439	461	555	424	
4/1/2000	432	453	546	414	
7/1/2000	431	451	521	415	
10/1/2000	431	451	519	416	
1/1/2001	430	455	517	400	
4/1/2001	421	443	513	397	
7/1/2001	422	443	510	399	
10/1/2001	425	445	512	403	
1/1/2002	424	444	511	398	
4/1/2002	421	440	508	386	
7/1/2002	419	439	506	391	
10/1/2002	423	442	508	396	
1/1/2003	423	435	508	389	
4/15/2003	416	427	501	380	
8/7/2003	416	428	503	384	
10/7/2003	418	429	504	387	
12/31/2003	417	426	503	378	
4/13/2004	408	418	494	370	
7/13/2004	409	419	494	374	
10/8/2004	411	422	496	377	
1/7/2005	411	421	495	374	
4/8/2005	407	414	485	366	
7/18/2005	407	415	485	370	
11/12/2005	410	419	489	374	
1/10/2006	409	417	487	369	
4/9/2006	399	411	487	365	
7/19/2006	399	412	487	368	
10/18/2006	407.3	414.8	489.6	371.7	
1/18/2007	405	412	487	366	
4/19/2007	401	406	501	361	
7/9/2007	401	408	502	365	
10/20/2007	404	411	506	369	
1/7/2008	403	410	504	364	
5/13/2008	397	403	497	359	
7/29/2008	398	403	500	363	
10/30/2008	401	407	502	366	
1/12/2009	401	407	502	363	

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	-47.1	68.5	551.7	681.8	313.73	10.70	616.75	252.30	375.15	83.06	-40.28	-2.75
	7/15/1999	-70.1	53.8	538.8	666.8	297.33	-8.15	602.80	234.35	360.30	78.72	-40.60	-2.82
	8/15/1999	10.7	114.3	613.7	728.1	366.70	62.50	670.90	312.20	421.20	97.09	-40.43	-2.44
	8/31/1999	12.0	114.3	617.3	732.8	369.10	63.15	675.05	314.65	423.55	97.73	-40.67	-2.44
	9/15/1999	13.1	113.5	619.7	737.5	370.95	63.30	678.60	316.40	425.50	98.22	-40.89	-2.44
	9/30/1999	29.6	122.3	634.4	753.4	384.93	75.95	693.90	332.00	437.85	101.92	-41.07	-2.37
	10/15/1999	34.7	123.9	637.8	757.9	388.58	79.30	697.85	336.25	440.90	102.88	-41.11	-2.34
	10/31/1999	39.8	127.2	646.6	762	393.90	83.50	704.30	343.20	444.60	104.29	-41.26	-2.27
	11/15/1999	62.3	139.3	662.9	780.1	411.15	100.80	721.50	362.60	459.70	108.86	-41.25	-2.18
	11/30/1999	73.7	146.3	670.6	788.6	419.80	110.00	729.60	372.15	467.45	111.15	-41.18	-2.13
	12/15/1999	72.8	143.6	668.9	789.7	418.75	108.20	729.30	370.85	466.65	110.87	-41.28	-2.15
	12/31/1999	88.8	152.1	680.1	802.5	430.88	120.45	741.30	384.45	477.30	114.08	-41.26	-2.08
	3/31/2000	95.3	158.7	682.5	825.2	440.43	127.00	753.85	388.90	491.95	116.61	-41.66	-2.31
	6/30/2000	60.2	138.2	662.7	804.5	416.40	99.20	733.60	361.45	471.35	110.25	-42.16	-2.46
	9/30/2000	50.1	142.5	668.8	795.7	414.28	96.30	732.25	359.45	469.10	109.69	-42.26	-2.46
	1/13/2001	109.5	179.9	712.3	845.5	461.80	144.70	778.90	410.90	512.70	122.27	-42.15	-2.28
	4/20/2001	126.8	283.2	715.3	881.9	501.80	205.00	798.60	421.05	582.55	132.86	-39.45	-3.62
	7/16/2001	68.3	149.8	674.3	837.1	432.38	109.05	755.70	371.30	493.45	114.48	-42.98	-2.74
	10/9/2001	71.4	157.1	685.5	840.8	438.70	114.25	763.15	378.45	498.95	116.15	-43.12	-2.70
	1/9/2002	102.7	177.8	713	872	466.38	140.25	792.50	407.85	524.90	123.48	-43.35	-2.62
	4/12/2002	125.5	192.8	738.6	904.9	490.45	159.15	821.75	432.05	548.85	129.86	-44.04	-2.62
	7/18/2002	62.3	151.8	706.334	859.6	445.01	107.05	782.97	384.32	505.70	117.82	-44.92	-2.72
	10/8/2002	43.7	151.1	711.3	846.7	438.20	97.40	779.00	377.50	498.90	116.02	-45.30	-2.72
	1/8/2003	84.7	180.5	748.5	891.8	476.38	132.60	820.15	416.60	536.15	126.13	-45.69	-2.68
1	4/15/2003	96.1	191.9	739.9	989.3	504.30	144.00	864.60	418.00	590.60	133.52	-47.89	-3.87
	7/1/2003	57.4	168	713	959	474.35	112.70	836.00	385.20	563.50	125.59	-48.07	-3.99
	10/7/2003	42.1	166.8	714	946.6	467.38	104.45	830.30	378.05	556.70	123.75	-48.24	-4.00
	12/31/2003	80	197.9	753.9	985.1	504.23	138.95	869.50	416.95	591.50	133.50	-48.55	-3.91
	4/13/2004	92	208.9	760.4	1006.6	516.98	150.45	883.50	426.20	607.75	136.88	-48.72	-4.07
	7/13/2004	14.6	163.9	707.3	954.4	460.05	89.25	830.85	360.95	559.15	121.81	-49.29	-4.44
	10/8/2004	-8.6	233.4	704.6	941	467.60	112.40	822.80	348.00	587.20	123.81	-47.21	-5.36
	1/7/2005	19.5	190.4	746.5	982.5	484.73	104.95	864.50	383.00	586.45	128.34	-50.48	-4.56
	4/8/2005	3.4	397.6	751.6	1003.4	539.00	200.50	877.50	377.50	700.50	142.71	-44.99	-7.24
	7/18/2005	3.1	164.3	709.7	969.6	461.68	83.70	839.65	356.40	566.95	122.24	-50.24	-4.72
	8/26/2005	3.1	157.5	702.5	956.3	454.85	80.30	829.40	352.80	556.90	120.43	-49.78	-4.57
	10/11/2005	3.1	164.2	712.6	960.1	460.00	83.65	836.35	357.85	562.15	121.79	-50.02	-4.58
	1/10/2006	3.1	191.9	742.5	997	483.63	97.50	869.75	372.80	594.45	128.05	-51.32	-4.97
	4/9/2006	3.5	205.3	750.7	1018.8	494.58	104.40	884.75	377.10	612.05	130.95	-51.86	-5.26
	7/19/2006	3.5	166.6	703.7	975.5	462.33	85.05	839.60	353.60	571.05	122.41	-50.15	-4.87
	10/18/2006	3.5	170.2	709	967.5	462.55	86.85	838.25	356.25	568.85	122.47	-49.94	-4.76
	1/18/2007	3.5	209.1	748.7	1013.1	493.60	106.30	880.90	376.10	611.10	130.69	-51.48	-5.26
	4/19/2007	3.5	216.6	743.7	1021.2	496.25	110.05	882.45	373.60	618.90	131.39	-51.33	-5.50
	7/11/2007	3.5	169.6	700.9	981.6	463.90	86.55	841.25	352.20	575.60	122.83	-50.16	-5.00
	10/20/2007	3.5	163.4	696	963.7	456.65	83.45	829.85	349.75	563.55	120.91	-49.60	-4.79
	1/7/2008	3.5	193.1	730.4	1002.9	482.48	98.30	866.65	366.95	598.00	127.74	-51.06	-5.18
	5/13/2008	3.5	202.2	733	1019.1	489.45	102.85	876.05	368.25	610.65	129.59	-51.39	-5.43
	7/29/2008	3.5	171.2	699.7	981.8	464.05	87.35	840.75	351.60	576.50	122.87	-50.07	-5.04
	10/30/2008	3.5	185.2	717.8	985	472.88	94.35	851.40	360.65	585.10	125.20	-50.31	-5.03
	1/12/2009	3.5	213.8	745.7	1020.6	495.90	108.65	883.15	374.60	617.20	131.30	-51.47	-5.43

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	374.9	6	549.6	471.8	350.58	190.45	510.70	462.25	238.90	92.82	-21.28	5.00
	7/15/1999	368.6	-3.6	544.2	467.3	344.13	182.50	505.75	456.40	231.85	91.11	-21.48	5.03
	8/15/1999	373.7	0.2	569.4	485.2	357.13	186.95	527.30	471.55	242.70	94.56	-22.62	5.13
	8/31/1999	368.4	-4.7	567	486.2	354.23	181.85	526.60	467.70	240.75	93.79	-22.91	5.08
	9/15/1999	365.9	-9.2	565.3	485.1	351.78	178.35	525.20	465.60	237.95	93.14	-23.05	5.10
	9/30/1999	364.6	-11.7	570.1	487.6	352.65	176.45	528.85	467.35	237.95	93.37	-23.42	5.14
	10/15/1999	361.7	-14.8	569.9	487.4	351.05	173.45	528.65	465.80	236.30	92.95	-23.61	5.14
	10/31/1999	362.8	-13.5	575.6	493.1	354.50	174.65	534.35	469.20	239.80	93.86	-23.91	5.14
	11/15/1999	365.0	-11.5	581.4	498	358.23	176.75	539.70	473.20	243.25	94.85	-24.12	5.15
	11/30/1999	365.6	-11.8	583.7	500.1	359.40	176.90	541.90	474.65	244.15	95.16	-24.26	5.16
	12/15/1999	368.0	-9.2	589.7	504.2	363.18	179.40	546.95	478.85	247.50	96.16	-24.43	5.18
	12/31/1999	369.0	-8	592.9	506.6	365.13	180.50	549.75	480.95	249.30	96.67	-24.54	5.19
	3/31/2000	379.6	7.3	617	524.1	382.00	193.45	570.55	498.30	265.70	101.14	-25.06	5.21
	6/30/2000	376.1	4.4	608.9	519.1	377.13	190.25	564.00	492.50	261.75	99.85	-24.84	5.17
	9/30/2000	360.7	-12.3	588.3	503.5	360.05	174.20	545.90	474.50	245.60	95.33	-24.70	5.13
	1/13/2001	372.1	2.2	618.1	526.1	379.63	187.15	572.10	495.10	264.15	100.51	-25.58	5.17
	4/20/2001	387.6	21	645.8	549.2	400.90	204.30	597.50	516.70	285.10	106.15	-26.13	5.19
	7/16/2001	374.6	6.5	621.5	532.9	383.88	190.55	577.20	498.05	269.70	101.64	-25.70	5.12
	10/9/2001	360.9	-9.4	598.9	515.8	366.55	175.75	557.35	479.90	253.20	97.05	-25.36	5.08
	1/9/2002	363.5	-2.5	611.5	524.5	374.25	180.50	568.00	487.50	261.00	99.09	-25.75	5.07
	4/12/2002	381.7	16.9	642.7	550.5	397.95	199.30	596.60	512.20	283.70	105.37	-26.40	5.12
	7/18/2002	375	10.5	629	544.7	389.80	192.75	586.85	502.00	277.60	103.21	-26.19	5.03
	10/8/2002	357.7	-9.6	599.2	523	367.58	174.05	561.10	478.45	256.70	97.32	-25.72	4.97
	1/8/2003	367.3	6.5	626.7	542.7	385.80	186.90	584.70	497.00	274.60	102.15	-26.44	4.98
12	4/15/2003	385.9	27.3	655.3	566.2	408.68	206.60	610.75	520.60	296.75	108.20	-26.86	5.01
	7/1/2003	384.7	26.3	649.2	565.6	406.45	205.50	607.40	516.95	295.95	107.62	-26.71	4.95
	10/7/2003	360.6	3.5	613	539.7	379.20	182.05	576.35	486.80	271.60	100.40	-26.20	4.82
	12/31/2003	372	19.4	636	558.3	396.43	195.70	597.15	504.00	288.85	104.96	-26.68	4.82
	4/13/2004	389.4	39.8	665.5	583.1	419.45	214.60	624.30	527.45	311.45	111.06	-27.23	4.84
	7/13/2004	379.5	27.7	643.3	571.1	405.40	203.60	607.20	511.40	299.40	107.34	-26.82	4.75
	10/8/2004	361.6	10.3	615.2	550.9	384.50	185.95	583.05	488.40	280.60	101.80	-26.39	4.66
	1/7/2005	367.5	16.1	630.6	561.5	393.93	191.80	596.05	499.05	288.80	104.30	-26.87	4.71
	4/8/2005	388.2	35.6	662.3	587.2	418.33	211.90	624.75	525.25	311.40	110.76	-27.44	4.79
	7/18/2005	382.6	26.3	647.7	580.1	409.18	204.45	613.90	515.15	303.20	108.34	-27.21	4.75
	8/26/2005	373.6	15.7	629.8	566.8	396.48	194.65	598.30	501.70	291.25	104.97	-26.83	4.71
	10/11/2005	365.9	6.1	617.8	557.9	386.93	186.00	587.85	491.85	282.00	102.45	-26.71	4.70
	1/10/2006	376.2	17.5	639	572.2	401.23	196.85	605.60	507.60	294.85	106.23	-27.16	4.77
	4/9/2006	393.8	32.7	665.7	594	421.55	213.25	629.85	529.75	313.35	111.61	-27.69	4.85
	7/19/2006	384.2	20.3	646.2	582.7	408.35	202.25	614.45	515.20	301.50	108.12	-27.39	4.79
	10/18/2006	365	-2	614.4	558.2	383.90	181.50	586.30	489.70	278.10	101.65	-26.90	4.74
	1/18/2007	376	9.6	635.9	573.9	398.85	192.80	604.90	505.95	291.75	105.60	-27.39	4.80
	4/19/2007	390.7	24.1	659.3	592.7	416.70	207.40	626.00	525.00	308.40	110.33	-27.82	4.85
	7/11/2007	384.1	15	644.6	584.6	407.08	199.55	614.60	514.35	299.80	107.78	-27.58	4.81
	10/20/2007	363.7	-9.6	611.5	560.6	381.55	177.05	586.05	487.60	275.50	101.02	-27.18	4.75
	1/7/2008	371.2	-2.9	625.1	569.7	390.78	184.15	597.40	498.15	283.40	103.47	-27.46	4.81
	5/13/2008	390.8	11.5	650.8	592.6	411.43	201.15	621.70	520.80	302.05	108.93	-27.95	4.90
	7/29/2008	379.9	-2.5	629.3	579.9	396.65	188.70	604.60	504.60	288.70	105.02	-27.64	4.84
	10/30/2008	365	-20.3	605.3	562.2	378.05	172.35	583.75	485.15	270.95	100.10	-27.34	4.80
	1/12/2009	375.3	-11.4	624.8	575	390.93	181.95	599.90	500.05	281.80	103.51	-27.78	4.89

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	306.3	72.2	490.8	675.2	386.13	189.25	583.00	398.55	373.70	102.23	-26.17	0.56
	7/15/1999	288.0	53.1	484.2	670.6	373.98	170.55	577.40	386.10	361.85	99.02	-27.04	0.54
	8/15/1999	280.9	61.8	506.3	693.7	385.68	171.35	600.00	393.60	377.75	102.12	-28.49	0.36
	8/31/1999	270.4	52.1	503.1	691.4	379.25	161.25	597.25	386.75	371.75	100.41	-28.98	0.34
	9/15/1999	261.3	43.9	501.2	689.9	374.08	152.60	595.55	381.25	366.90	99.04	-29.44	0.32
	9/30/1999	257.1	40.7	503.1	690.7	372.90	148.90	596.90	380.10	365.70	98.73	-29.77	0.32
	10/15/1999	250.1	33.8	501.2	691	369.03	141.95	596.10	375.65	362.40	97.71	-30.18	0.30
	10/31/1999	251.4	38	507.6	697.6	373.65	144.70	602.60	379.50	367.80	98.93	-30.43	0.26
	11/15/1999	253.9	41.6	512.1	701.9	377.38	147.75	607.00	383.00	371.75	99.92	-30.52	0.25
	11/30/1999	253.5	41.2	513.6	704.4	378.18	147.35	609.00	383.55	372.80	100.13	-30.68	0.24
	12/15/1999	255.8	46.7	519.1	709.3	382.73	151.25	614.20	387.45	378.00	101.33	-30.77	0.21
	12/31/1999	256.7	48.9	522.3	712.4	385.08	152.80	617.35	389.50	380.65	101.96	-30.87	0.20
	3/31/2000	267.5	64.6	542.8	734.2	402.28	166.05	638.50	405.15	399.40	106.51	-31.40	0.13
	6/30/2000	258.9	46.4	531.2	726.1	390.65	152.65	628.65	395.05	386.25	103.43	-31.63	0.20
	9/30/2000	237.1	10.1	504.9	705.9	364.50	123.60	605.40	371.00	358.00	96.51	-32.02	0.29
	1/13/2001	254.0	40.9	535.1	734.6	391.15	147.45	634.85	394.55	387.75	103.56	-32.39	0.15
	4/20/2001	275.4	72.6	561.4	763.7	418.28	174.00	662.55	418.40	418.15	110.75	-32.47	0.01
	7/16/2001	255.3	37.7	534.8	740.9	392.18	146.50	637.85	395.05	389.30	103.84	-32.65	0.13
	10/9/2001	235.7	7.5	510.6	719.6	368.35	121.60	615.10	373.15	363.55	97.53	-32.80	0.22
	1/9/2002	240	18.9	523.3	731	378.30	129.45	627.15	381.65	374.95	100.16	-33.08	0.15
	4/12/2002	263.4	58.5	554.8	763	409.93	160.95	658.90	409.10	410.75	108.54	-33.09	-0.04
	7/18/2002	255.5	40.1	566.1	754.5	404.05	147.80	660.30	410.80	397.30	106.98	-34.06	0.30
	10/8/2002	231.2	3.4	508.7	726.1	367.35	117.30	617.40	369.95	364.75	97.26	-33.24	0.12
	1/8/2003	249.4	38.5	540.1	754.4	395.60	143.95	647.25	394.75	396.45	104.74	-33.45	-0.04
13	4/15/2003	276.4	78.5	571.6	784.9	427.85	177.45	678.25	424.00	431.70	113.28	-33.28	-0.17
	7/1/2003	273	69	561.4	779.9	420.83	171.00	670.65	417.20	424.45	111.42	-33.21	-0.16
	10/7/2003	246.6	22.5	524.7	744.6	384.60	134.55	634.65	385.65	383.55	101.83	-33.24	0.05
	12/31/2003	264.8	58.9	552.8	770.1	411.65	161.85	661.45	408.80	414.50	108.99	-33.20	-0.13
	4/13/2004	291.3	97.7	584	803.2	444.05	194.50	693.60	437.65	450.45	117.57	-33.17	-0.29
	7/13/2004	275.5	64.3	556.1	781	419.23	169.90	668.55	415.80	422.65	111.00	-33.14	-0.15
	10/8/2004	252.8	29.9	527.5	755.8	391.50	141.35	641.65	390.15	392.85	103.66	-33.25	-0.06
	1/7/2005	264	50.8	544.5	770.6	407.48	157.40	657.55	404.25	410.70	107.89	-33.24	-0.14
	4/8/2005	289.9	90.7	576	802	439.65	190.30	689.00	432.95	446.35	116.41	-33.14	-0.30
	7/18/2005	277.8	67.7	556.4	787.1	422.25	172.75	671.75	417.10	427.40	111.80	-33.16	-0.23
	8/26/2005	266.7	46.5	539.8	771.9	406.23	156.60	655.85	403.25	409.20	107.56	-33.18	-0.13
	10/11/2005	257.2	33.8	526.8	760.8	394.65	145.50	643.80	392.00	397.30	104.49	-33.12	-0.12
	1/10/2006	269.3	59.9	551.2	780.4	415.20	164.60	665.80	410.25	420.15	109.93	-33.31	-0.22
	4/9/2006	289.9	90	576.3	806.2	440.60	189.95	691.25	433.10	448.10	116.66	-33.32	-0.34
	7/19/2006	277.7	63.9	553.8	787.8	420.80	170.80	670.80	415.75	425.85	111.42	-33.23	-0.23
	10/18/2006	253.3	27.9	523.7	757.8	390.68	140.60	640.75	388.50	392.85	103.44	-33.24	-0.10
	1/18/2007	267.4	54.9	546.5	778.5	411.83	161.15	662.50	406.95	416.70	109.04	-33.32	-0.22
	4/19/2007	289	88.7	575.1	806.8	439.90	188.85	690.95	432.05	447.75	116.47	-33.37	-0.35
	7/11/2007	280	67	558	793.6	424.65	173.50	675.80	419.00	430.30	112.43	-33.38	-0.25
	10/20/2007	255.4	29.1	525	763.8	393.33	142.25	644.40	390.20	396.45	104.14	-33.37	-0.14
	1/7/2008	265.4	49.2	542.8	778	408.85	157.30	660.40	404.10	413.60	108.25	-33.44	-0.21
	5/13/2008	290.2	83.3	573.8	809.3	439.15	186.75	691.55	432.00	446.30	116.27	-33.55	-0.32
	7/29/2008	274	55.1	548.5	787.7	416.33	164.55	668.10	411.25	421.40	110.23	-33.47	-0.23
	10/30/2008	256.5	28.1	526.4	765.9	394.23	142.30	646.15	391.45	397.00	104.38	-33.49	-0.12
	1/12/2009	271.1	54.9	550.3	786.8	415.78	163.00	668.55	410.70	420.85	110.08	-33.60	-0.23

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	445.4	53.9	802	298.7	400.00	249.65	550.35	623.70	176.30	105.91	-19.98	10.02
	7/15/1999	440.5	34.4	799.5	280.7	388.78	237.45	540.10	620.00	157.55	102.94	-20.11	10.36
	8/15/1999	455.6	40.8	837.6	284.6	404.65	248.20	561.10	646.60	162.70	107.14	-20.79	10.84
	8/31/1999	452.7	30.7	837.1	274.1	398.65	241.70	555.60	644.90	152.40	105.55	-20.86	11.03
	9/15/1999	448.5	21.7	836.8	266.2	393.30	235.10	551.50	642.65	143.95	104.13	-21.03	11.17
	9/30/1999	447.0	16.1	838.5	260.8	390.60	231.55	549.65	642.75	138.45	103.42	-21.14	11.30
	10/15/1999	446.5	8.8	839.3	255.1	387.43	227.65	547.20	642.90	131.95	102.58	-21.24	11.45
	10/31/1999	450.9	11.7	847.9	257.8	392.08	231.30	552.85	649.40	134.75	103.81	-21.37	11.53
	11/15/1999	455.9	16.1	856.2	259.8	397.00	236.00	558.00	656.05	137.95	105.11	-21.40	11.61
	11/30/1999	456.3	15.5	858.3	259	397.28	235.90	558.65	657.30	137.25	105.19	-21.45	11.65
	12/15/1999	461.3	20.5	865.6	261.7	402.28	240.90	563.65	663.45	141.10	106.51	-21.45	11.70
	12/31/1999	463.4	22.5	871.6	262.9	405.10	242.95	567.25	667.50	142.70	107.26	-21.55	11.76
	3/31/2000	477.8	35.6	903.8	282.7	424.98	256.70	593.25	690.80	159.15	112.52	-22.37	11.91
	6/30/2000	469.2	17.4	889.7	267.4	410.93	243.30	578.55	679.45	142.40	108.80	-22.28	12.03
	9/30/2000	453.5	-23.5	856.8	240.4	381.80	215.00	548.60	655.15	108.45	101.09	-22.17	12.25
	1/13/2001	476.9	5	891.3	257.6	407.70	240.95	574.45	684.10	131.30	107.95	-22.16	12.38
	4/20/2001	494.8	40.8	932.8	281.2	437.40	267.80	607.00	713.80	161.00	115.81	-22.54	12.38
	7/16/2001	475.7	4.9	900.7	255.9	409.30	240.30	578.30	688.20	130.40	108.37	-22.46	12.50
	10/9/2001	459.3	-30.8	870.4	236.8	383.93	214.25	553.60	664.85	103.00	101.65	-22.55	12.59
	1/9/2002	468.8	-18.5	883.7	241.5	393.88	225.15	562.60	676.25	111.50	104.29	-22.43	12.65
	4/12/2002	492.8	22.5	926.5	270.2	428.00	257.65	598.35	709.65	146.35	113.32	-22.64	12.62
	7/18/2002	483.5	3.8	911.9	257.3	414.13	243.65	584.60	697.70	130.55	109.65	-22.66	12.71
	10/8/2002	462.7	-35	875.6	233	384.08	213.85	554.30	669.15	99.00	101.69	-22.63	12.77
	1/8/2003	485.5	2.5	912.6	253.9	413.63	244.00	583.25	699.05	128.20	109.52	-22.55	12.79
14	4/15/2003	501.9	612.9	952.7	285.1	588.15	557.40	618.90	727.30	449.00	155.72	-4.09	6.23
	7/1/2003	521.6	28.8	943.4	278.1	442.98	275.20	610.75	732.50	153.45	117.29	-22.30	12.97
	10/7/2003	472.3	-16.5	903.8	247.5	401.78	227.90	575.65	688.05	115.50	106.38	-23.11	12.83
	12/31/2003	495.5	18.6	939.3	268.7	430.53	257.05	604.00	717.40	143.65	113.99	-23.06	12.85
	4/13/2004	504.6	68.9	989	299.2	465.43	286.75	644.10	746.80	184.05	123.23	-23.75	12.61
	7/13/2004	487.3	36.7	961.8	277.7	440.88	262.00	619.75	724.55	157.20	116.73	-23.78	12.71
	10/8/2004	468.9	-0.5	928.8	256.4	413.40	234.20	592.60	698.85	127.95	109.46	-23.82	12.79
	1/7/2005	485.2	21.4	952.7	269.7	432.25	253.30	611.20	718.95	145.55	114.45	-23.79	12.85
	4/8/2005	512.9	68.8	998.7	302.5	470.73	290.85	650.60	755.80	185.65	124.63	-23.91	12.77
	7/18/2005	498.2	40	977.1	286.8	450.53	269.10	631.95	737.65	163.40	119.29	-24.11	12.86
	8/26/2005	486.3	17.1	955.5	271.8	432.68	251.70	613.65	720.90	144.45	114.56	-24.05	12.91
	10/11/2005	478.8	2.4	942.6	263.6	421.85	240.60	603.10	710.70	133.00	111.69	-24.09	12.94
	1/10/2006	497.9	28.2	970.6	280.6	444.33	263.05	625.60	734.25	154.40	117.64	-24.09	12.99
	4/9/2006	519.6	65.1	1008.9	306	474.90	292.35	657.45	764.25	185.55	125.74	-24.26	12.96
	7/19/2006	505.7	73.4	984.2	290.7	463.50	289.55	637.45	744.95	182.05	122.72	-23.12	12.61
	10/18/2006	484	-5.7	946.5	265.8	422.65	239.15	606.15	715.25	130.05	111.91	-24.39	13.11
	1/18/2007	503	21.5	974.4	282.5	445.35	262.25	628.45	738.70	152.00	117.92	-24.34	13.14
	4/19/2007	525.1	60.9	1012.9	309.1	477.00	293.00	661.00	769.00	185.00	126.30	-24.46	13.08
	7/11/2007	533.8	36.8	994.5	295.1	465.05	285.30	644.80	764.15	165.95	123.13	-23.89	13.40
	10/20/2007	487.8	-9.1	953.8	269.9	425.60	239.35	611.85	720.80	130.40	112.69	-24.76	13.23
	1/7/2008	504.2	11.4	976	284.1	443.93	257.80	630.05	740.10	147.75	117.54	-24.74	13.27
	5/13/2008	552.9	52.7	1019.4	315.4	485.10	302.80	667.40	786.15	184.05	128.44	-24.23	13.49
	7/29/2008	533.4	17.1	989.1	295.9	458.88	275.25	642.50	761.25	156.50	121.50	-24.41	13.55
	10/30/2008	494.5	-16.2	961.7	277.5	429.38	239.15	619.60	728.10	130.65	113.69	-25.28	13.38
	1/12/2009	514.7	12	989.3	296.3	453.08	263.35	642.80	752.00	154.15	119.96	-25.22	13.39

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side)(cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	468.3	92.2	387.7	511.7	364.98	280.25	449.70	428.00	301.95	96.63	-11.26	2.82
	7/15/1999	460.1	81	381.5	505.7	357.08	270.55	443.60	420.80	293.35	94.54	-11.50	2.86
	8/15/1999	482.3	96.1	410.7	526	378.78	289.20	468.35	446.50	311.05	100.29	-11.91	3.03
	8/31/1999	490.3	101.9	422.4	535	387.40	296.10	478.70	456.35	318.45	102.57	-12.14	3.09
	9/15/1999	491.0	101.4	426.3	536.4	388.78	296.20	481.35	458.65	318.90	102.94	-12.30	3.13
	9/30/1999	497.9	106.7	434.7	543.6	395.73	302.30	489.15	466.30	325.15	104.78	-12.42	3.16
	10/15/1999	505.0	112.3	443.2	550.9	402.85	308.65	497.05	474.10	331.60	106.66	-12.52	3.19
	10/31/1999	515.6	118.8	452.5	560.9	411.95	317.20	506.70	484.05	339.85	109.07	-12.59	3.23
	11/15/1999	525.0	128.3	463.4	570.2	421.73	326.65	516.80	494.20	349.25	111.66	-12.64	3.25
	11/30/1999	532.5	134.9	471.5	576.8	428.93	333.70	524.15	502.00	355.85	113.57	-12.66	3.27
	12/15/1999	534.1	138.1	476.5	580.2	432.23	336.10	528.35	505.30	359.15	114.44	-12.78	3.27
	12/31/1999	540.4	144.3	484.4	587.2	439.08	342.35	535.80	512.40	365.75	116.25	-12.86	3.29
	3/31/2000	551.1	156	501.3	602.1	452.63	353.55	551.70	526.20	379.05	119.84	-13.17	3.30
	6/30/2000	533.5	137.3	477.6	577.9	431.58	335.40	527.75	505.55	357.60	114.27	-12.78	3.31
	9/30/2000	539.6	136.8	480.7	575.1	433.05	338.20	527.90	510.15	355.95	114.66	-12.61	3.45
	1/13/2001	571.4	169.7	522.7	611.8	468.90	370.55	567.25	547.05	390.75	124.15	-13.07	3.50
	4/20/2001	580.2	184.8	537.9	624.6	481.88	382.50	581.25	559.05	404.70	127.59	-13.21	3.46
	7/16/2001	555.8	159.1	508	598.6	455.38	357.45	553.30	531.90	378.85	120.57	-13.02	3.43
	10/9/2001	556.2	154.1	506	595.8	453.03	355.15	550.90	531.10	374.95	119.95	-13.01	3.50
	1/9/2002	572	170.3	527.3	614.7	471.08	371.15	571.00	549.65	392.50	124.73	-13.28	3.52
	4/12/2002	584.6	187.7	546.3	632.8	487.85	386.15	589.55	565.45	410.25	129.17	-13.52	3.48
	7/18/2002	559.5	162.1	516.1	606	460.93	360.80	561.05	537.80	384.05	122.04	-13.31	3.44
	10/8/2002	557	154.4	511	599.8	455.55	355.70	555.40	534.00	377.10	120.62	-13.27	3.51
	1/8/2003	591	189.2	552.8	639	493.00	390.10	595.90	571.90	414.10	130.53	-13.68	3.54
26	4/15/2003	597.9	204.3	567.5	650.5	505.05	401.10	609.00	582.70	427.40	133.72	-13.82	3.48
	7/1/2003	580.7	184.3	545.4	632.5	485.73	382.50	588.95	563.05	408.40	128.61	-13.72	3.46
	10/7/2003	578.2	176.3	538	627	479.88	377.25	582.50	558.10	401.65	127.06	-13.64	3.50
	12/31/2003	610.3	207.7	572.6	661.6	513.05	409.00	617.10	591.45	434.65	135.84	-13.83	3.51
	4/13/2004	617.1	224.2	589.5	675.7	526.63	420.65	632.60	603.30	449.95	139.43	-14.09	3.44
	7/13/2004	584	186.6	549.1	642.6	490.58	385.30	595.85	566.55	414.60	129.89	-13.99	3.40
	10/8/2004	581.8	181.2	543.7	638.3	486.25	381.50	591.00	562.75	409.75	128.74	-13.92	3.43
	1/7/2005	609.9	209	574.8	669.1	515.70	409.45	621.95	592.35	439.05	136.54	-14.12	3.43
	4/8/2005	617.5	225	590.2	683.9	529.15	421.25	637.05	603.85	454.45	140.10	-14.34	3.35
	7/18/2005	590.4	192.7	554.7	656	498.45	391.55	605.35	572.55	424.35	131.97	-14.21	3.32
	8/26/2005	584.4	183.1	544	647.8	489.83	383.75	595.90	564.20	415.45	129.69	-14.10	3.33
	10/11/2005	589.3	185.9	548.5	652	493.93	387.60	600.25	568.90	418.95	130.78	-14.13	3.36
	1/10/2006	616	216.1	582.8	683.4	524.58	416.05	633.10	599.40	449.75	138.89	-14.42	3.35
	4/9/2006	629	235.4	605.8	701.1	542.83	432.20	653.45	617.40	468.25	143.72	-14.70	3.34
	7/19/2006	595.8	199	563.1	668.3	506.55	397.40	615.70	579.45	433.65	134.12	-14.51	3.27
	10/18/2006	595.6	193	557.4	662.8	502.20	394.30	610.10	576.50	427.90	132.97	-14.34	3.33
	1/18/2007	622.2	223.4	590.2	694.6	532.60	422.80	642.40	606.20	459.00	141.02	-14.59	3.30
	4/19/2007	624.5	231.7	598.4	701.1	538.93	428.10	649.75	611.45	466.40	142.69	-14.73	3.25
	7/11/2007	594.6	199.2	561.5	670.8	506.53	396.90	616.15	578.05	435.00	134.11	-14.57	3.20
	10/20/2007	588.7	187	550.3	661.8	496.95	387.85	606.05	569.50	424.40	131.58	-14.50	3.25
	1/7/2008	619.8	219.6	589.6	697.1	531.53	419.70	643.35	604.70	458.35	140.73	-14.86	3.28
	5/13/2008	624.3	232.4	600.5	707.3	541.13	428.35	653.90	612.40	469.85	143.27	-14.99	3.19
	7/29/2008	600.8	202.7	568.1	681.9	513.38	401.75	625.00	584.45	442.30	135.93	-14.84	3.18
	10/30/2008	616.5	213.5	580.6	694.2	526.20	415.00	637.40	598.55	453.85	139.32	-14.78	3.24
	1/12/2009	638.2	240.2	611.7	719.3	552.35	439.20	665.50	624.95	479.75	146.25	-15.04	3.25

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	-115.0	299.7	422.9	109.6	179.30	92.35	266.25	153.95	204.65	47.47	-11.56	-1.14
	7/15/1999	-122.0	289	405.2	95.6	166.95	83.50	250.40	141.60	192.30	44.20	-11.09	-1.14
	8/15/1999	-139.4	265.8	401.5	101.8	157.43	63.20	251.65	131.05	183.80	41.68	-12.52	-1.18
	8/31/1999	-144.1	258.4	394.7	99.6	152.15	57.15	247.15	125.30	179.00	40.28	-12.63	-1.20
	9/15/1999	-144.1	255.9	395.1	102	152.23	55.90	248.55	125.50	178.95	40.30	-12.80	-1.20
	9/30/1999	-141.7	260.4	408.3	112.3	159.83	59.35	260.30	133.30	186.35	42.32	-13.35	-1.19
	10/15/1999	-138.1	275.3	441.9	138.4	179.38	68.60	290.15	151.90	206.85	47.49	-14.72	-1.23
	10/31/1999	-148.1	272.7	430.1	118.5	168.30	62.30	274.30	141.00	195.60	44.56	-14.09	-1.22
	11/15/1999	-142.3	278.9	446.6	134.9	179.53	68.30	290.75	152.15	206.90	47.53	-14.78	-1.23
	11/30/1999	-137.9	284.4	462	150.8	189.83	73.25	306.40	162.05	217.60	50.26	-15.49	-1.24
	12/15/1999	-135.4	290	463.8	152.5	192.73	77.30	308.15	164.20	221.25	51.03	-15.34	-1.28
	12/31/1999	-126.8	301.4	481.4	168.9	206.23	87.30	325.15	177.30	235.15	54.60	-15.81	-1.30
	3/31/2000	-133.9	283.1	455.7	149.6	188.63	74.60	302.65	160.90	216.35	49.94	-15.16	-1.24
	6/30/2000	-157.3	230.6	397.4	119.3	147.50	36.65	258.35	120.05	174.95	39.05	-14.73	-1.23
	9/30/2000	-142.8	237.4	427.4	156.8	169.70	47.30	292.10	142.30	197.10	44.93	-16.27	-1.23
	1/13/2001	-118.2	295.4	511.7	182.5	217.85	88.60	347.10	196.75	238.95	57.68	-17.18	-0.95
	4/20/2001	-128.9	270.9	454	163.4	189.85	71.00	308.70	162.55	217.15	50.27	-15.80	-1.22
	7/16/2001	-146.4	213.9	384.1	133.3	146.23	33.75	258.70	118.85	173.60	38.72	-14.95	-1.23
	10/9/2001	-135.7	237.5	439.4	178.3	179.88	50.90	308.85	151.85	207.90	47.63	-17.14	-1.26
	1/9/2002	-120.2	281.4	483	190.7	208.73	80.60	336.85	181.40	236.05	55.26	-17.03	-1.22
	4/12/2002	-133.2	263.6	441.1	154.2	181.43	65.20	297.65	153.95	208.90	48.04	-15.45	-1.23
	7/18/2002	-158.1	191.2	355.6	118	126.68	16.55	236.80	98.75	154.60	33.54	-14.64	-1.25
	10/7/2002	-149.2	192.4	391.7	156.3	147.80	21.60	274.00	121.25	174.35	39.13	-16.77	-1.19
	1/8/2003	-123.2	268.7	469.3	191.8	201.65	72.75	330.55	173.05	230.25	53.39	-17.13	-1.28
1	4/15/2003	-137.5	248.4	427.1	157.1	173.78	55.45	292.10	144.80	202.75	46.01	-15.73	-1.30
	7/1/2003	-159.7	183.9	351.2	124.6	125.00	12.10	237.90	95.75	154.25	33.10	-15.01	-1.31
	10/7/2003	-146.6	206.4	412.6	177.8	162.55	29.90	295.20	133.00	192.10	43.04	-17.63	-1.32
	12/31/2003	-135.4	243.4	450.4	190	187.10	54.00	320.20	157.50	216.70	49.54	-17.69	-1.33
	4/13/2004	-144.6	228.6	422.1	168	168.53	42.00	295.05	138.75	198.30	44.62	-16.82	-1.33
	7/13/2004	-179.1	155.6	334.2	117.5	107.05	-11.75	225.85	77.55	136.55	28.34	-15.79	-1.32
	10/8/2004	-169	170.9	373.7	152.9	132.13	0.95	263.30	102.35	161.90	34.98	-17.44	-1.33
	1/7/2005	-145.5	227.8	440.5	188.2	177.75	41.15	314.35	147.50	208.00	47.06	-18.16	-1.36
	4/8/2005	-159.4	209.2	398.5	148.8	149.28	24.90	273.65	119.55	179.00	39.52	-16.53	-1.33
	7/18/2005	-182.8	141.5	330.3	131.3	105.08	-20.65	230.80	73.75	136.40	27.82	-16.71	-1.40
	8/26/2005	-184	140.7	341.3	131.3	107.33	-21.65	236.30	78.65	136.00	28.42	-17.14	-1.28
	10/11/2005	-174.2	159.1	370.9	131.3	121.78	-7.55	251.10	98.35	145.20	32.24	-17.19	-1.05
	1/10/2006	-152.5	216.4	430.7	131.3	156.48	31.95	281.00	139.10	173.85	41.43	-16.55	-0.78
	4/9/2006	-157.2	206.1	413	131.3	148.30	24.45	272.15	127.90	168.70	39.27	-16.46	-0.91
	7/19/2006	-189.4	135.9	330	131.3	101.95	-26.75	230.65	70.30	133.60	26.99	-17.11	-1.42
	10/18/2006	-170.5	170.2	390.6	131.3	130.40	-0.15	260.95	110.05	150.75	34.53	-17.35	-0.91
	1/18/2007	-145.4	217.2	448.1	131.3	162.80	35.90	289.70	151.35	174.25	43.10	-16.87	-0.51
	4/19/2007	-159.2	203.2	410.4	131.3	146.43	22.00	270.85	125.60	167.25	38.77	-16.54	-0.93
	7/11/2007	-192.9	128.3	318.7	131.3	96.35	-32.30	225.00	62.90	129.80	25.51	-17.10	-1.50
	10/20/2007	-183.2	145.9	358.7	131.3	113.18	-18.65	245.00	87.75	138.60	29.97	-17.52	-1.14
	1/7/2008	-155.6	207.5	426.7	131.3	152.48	25.95	279.00	135.55	169.40	40.37	-16.82	-0.76
	5/13/2008	-172.2	170	384.2	131.3	128.33	-1.10	257.75	106.00	150.65	33.98	-17.20	-1.00
	7/29/2008	-197.5	120	328.1	131.3	95.48	-38.75	229.70	65.30	125.65	25.28	-17.84	-1.35
	10/30/2008	-167.1	170	413	131.3	136.80	1.45	272.15	122.95	150.65	36.22	-17.99	-0.62
	1/12/2009	-147.6	210.8	446.5	131.3	160.25	31.60	288.90	149.45	171.05	42.43	-17.10	-0.48

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	356.2	257	201.2	275.1	272.38	306.60	238.15	278.70	266.05	72.12	4.55	0.28
	7/15/1999	353.8	251.6	188.4	273.4	266.80	302.70	230.90	271.10	262.50	70.64	4.77	0.19
	8/15/1999	350.0	242.8	195.3	301.1	272.30	296.40	248.20	272.65	271.95	72.10	3.20	0.02
	8/31/1999	350.2	247.8	201.7	307.9	276.90	299.00	254.80	275.95	277.85	73.31	2.94	-0.04
	9/15/1999	349.8	249.1	203.6	314	279.13	299.45	258.80	276.70	281.55	73.90	2.70	-0.11
	9/30/1999	352.2	256.8	212.1	322.7	285.95	304.50	267.40	282.15	289.75	75.71	2.47	-0.17
	10/15/1999	352.6	257.7	225.5	337.3	293.28	305.15	281.40	289.05	297.50	77.65	1.58	-0.19
	10/31/1999	361.0	268.5	222.6	333.7	296.45	314.75	278.15	291.80	301.10	78.49	2.43	-0.21
	11/15/1999	364.5	273.1	237.1	353.6	307.08	318.80	295.35	300.80	313.35	81.30	1.56	-0.28
	11/30/1999	367.6	276.3	249.1	369.4	315.60	321.95	309.25	308.35	322.85	83.56	0.84	-0.32
	12/15/1999	370.6	280.7	248.5	364.3	316.03	325.65	306.40	309.55	322.50	83.67	1.28	-0.29
	12/31/1999	371.2	282.5	254.8	368.8	319.33	326.85	311.80	313.00	325.65	84.55	1.00	-0.28
	3/31/2000	376.0	289.2	244.7	361.1	317.75	332.60	302.90	310.35	325.15	84.13	1.97	-0.33
	6/30/2000	358.4	247.7	207.4	329.3	285.70	303.05	268.35	282.90	288.50	75.64	2.31	-0.13
	9/30/2000	357.6	235.9	230.1	366.4	297.50	296.75	298.25	293.85	301.15	78.77	-0.10	-0.16
	1/13/2001	382.0	289.5	264.4	384.8	330.18	335.75	324.60	323.20	337.15	87.42	0.74	-0.31
	4/20/2001	382.9	294.9	260.1	378.2	329.03	338.90	319.15	321.50	336.55	87.12	1.31	-0.34
	7/16/2001	352.4	249.4	219.2	330.6	287.90	300.90	274.90	285.80	290.00	76.23	1.73	-0.09
	10/9/2001	357.7	267.9	262.1	382	317.43	312.80	322.05	309.90	324.95	84.04	-0.61	-0.34
	1/9/2002	385.8	301.2	285.1	395.6	341.93	343.50	340.35	335.45	348.40	90.53	0.21	-0.29
	4/12/2002	390.9	310.2	263.2	370.1	333.60	350.55	316.65	327.05	340.15	88.33	2.25	-0.29
	7/18/2002	346.39	265.03	220.4	323.3	288.78	305.71	271.85	283.39	294.17	76.46	2.25	-0.24
	10/7/2002	344.5	265.3	252.4	363.5	306.43	304.90	307.95	298.45	314.40	81.13	-0.20	-0.36
	1/8/2003	385.9	308.5	295.9	394.3	346.15	347.20	345.10	340.90	351.40	91.65	0.14	-0.24
12	4/15/2003	392.4	317.3	275.8	371.1	339.15	354.85	323.45	334.10	344.20	89.80	2.09	-0.23
	7/1/2003	360	288.1	238.7	332.8	304.90	324.05	285.75	299.35	310.45	80.73	2.55	-0.25
	10/7/2003	357.1	284.5	277.7	372.1	322.85	320.80	324.90	317.40	328.30	85.48	-0.27	-0.24
	12/31/2003	387.7	318.7	304.1	392.5	350.75	353.20	348.30	345.90	355.60	92.87	0.33	-0.22
	4/13/2004	389.4	324.2	294.9	381.2	347.43	356.80	338.05	342.15	352.70	91.99	1.25	-0.24
	7/13/2004	348	285.8	241	324.8	299.90	316.90	282.90	294.50	305.30	79.40	2.26	-0.24
	10/8/2004	342.4	281.8	269.4	353.1	311.68	312.10	311.25	305.90	317.45	82.52	0.06	-0.26
	1/7/2005	374.1	315.2	302.9	382.8	343.75	344.65	342.85	338.50	349.00	91.01	0.12	-0.24
	4/8/2005	386.7	328.9	284.3	365	341.23	357.80	324.65	335.50	346.95	90.35	2.20	-0.26
	7/18/2005	343.2	285.5	242.4	322.1	298.30	314.35	282.25	292.80	303.80	78.98	2.13	-0.25
	8/26/2005	337	278.7	250.1	331.1	299.23	307.85	290.60	293.55	304.90	79.23	1.15	-0.25
	10/11/2005	338.7	283.6	264.1	348.6	308.75	311.15	306.35	301.40	316.10	81.75	0.32	-0.33
	1/10/2006	371.5	317.4	297	373.5	339.85	344.45	335.25	334.25	345.45	89.98	0.61	-0.25
	4/9/2006	377.4	324.1	290.6	368.2	340.08	350.75	329.40	334.00	346.15	90.04	1.42	-0.27
	7/19/2006	341.9	289.2	238.8	315.3	296.30	315.55	277.05	290.35	302.25	78.45	2.56	-0.27
	10/18/2006	342.7	289.5	274.8	354.5	315.38	316.10	314.65	308.75	322.00	83.50	0.10	-0.30
	1/18/2007	368.4	316.6	305.5	385	343.88	342.50	345.25	336.95	350.80	91.05	-0.18	-0.31
	4/19/2007	370.5	320.9	279.2	353.9	331.13	345.70	316.55	324.85	337.40	87.67	1.94	-0.28
	7/11/2007	326.6	278.1	219	294	279.43	302.35	256.50	272.80	286.05	73.98	3.05	-0.30
	10/20/2007	325.9	278.3	243.8	321.7	292.43	302.10	282.75	284.85	300.00	77.43	1.29	-0.34
	1/7/2008	359.2	310.2	282.8	353	326.30	334.70	317.90	321.00	331.60	86.39	1.12	-0.24
	5/13/2008	350.5	304.1	260.9	335.4	312.73	327.30	298.15	305.70	319.75	82.80	1.94	-0.31
	7/29/2008	325.9	281.2	234.5	305.4	286.75	303.55	269.95	280.20	293.30	75.92	2.23	-0.29
	10/30/2008	335.7	288	283.1	360.3	316.78	311.85	321.70	309.40	324.15	83.87	-0.65	-0.33
	1/12/2009	361	312.9	298.7	366.1	334.68	336.95	332.40	329.85	339.50	88.61	0.30	-0.22

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	177.4	380.2	417.6	236.2	302.85	278.80	326.90	297.50	308.20	80.19	-3.20	-0.24
	7/15/1999	173.8	378	412.7	230.2	298.68	275.90	321.45	293.25	304.10	79.08	-3.03	-0.24
	8/15/1999	172.8	380.2	439.6	252.6	311.30	276.50	346.10	306.20	316.40	82.42	-4.63	-0.23
	8/31/1999	172.6	378	445.8	257.5	313.48	275.30	351.65	309.20	317.75	83.00	-5.07	-0.19
	9/15/1999	170.9	377.2	447.2	261	314.08	274.05	354.10	309.05	319.10	83.16	-5.32	-0.23
	9/30/1999	176.4	380.7	455.9	269.3	320.58	278.55	362.60	316.15	325.00	84.88	-5.59	-0.20
	10/15/1999	176.7	378.9	468.1	279.5	325.80	277.80	373.80	322.40	329.20	86.26	-6.38	-0.15
	10/31/1999	182.4	385.8	502.1	273.8	336.03	284.10	387.95	342.25	329.80	88.97	-6.90	0.28
	11/15/1999	186.8	392.4	482.7	292	338.48	289.60	387.35	334.75	342.20	89.62	-6.50	-0.17
	11/30/1999	189.8	396.8	638.9	305.6	382.78	293.30	472.25	414.35	351.20	101.35	-11.89	1.41
	12/15/1999	193.5	401.1	516.7	302.2	353.38	297.30	409.45	355.10	351.65	93.56	-7.45	0.08
	12/31/1999	194.7	406.1	507.2	308	354.00	300.40	407.60	350.95	357.05	93.73	-7.12	-0.14
	3/31/2000	194.8	409	492.7	298.7	348.80	301.90	395.70	343.75	353.85	92.35	-6.23	-0.23
	6/30/2000	177.7	389.4	467.2	278.7	328.25	283.55	372.95	322.45	334.05	86.91	-5.94	-0.26
	9/30/2000	174.2	385.1	496.7	308	341.00	279.65	402.35	335.45	346.55	90.29	-8.15	-0.25
	1/13/2001	200.0	418.2	530.3	318.6	366.78	309.10	424.45	365.15	368.40	97.11	-7.67	-0.07
	4/20/2001	194.1	416.2	512.8	310.6	358.43	305.15	411.70	353.45	363.40	94.90	-7.08	-0.22
	7/16/2001	166.5	386.2	469	273.8	323.88	276.35	371.40	317.75	330.00	85.75	-6.32	-0.27
	10/9/2001	171.5	389.1	514.8	315.2	347.65	280.30	415.00	343.15	352.15	92.05	-8.95	-0.20
	1/9/2002	193.6	413.6	539.3	324.6	367.78	303.60	431.95	366.45	369.10	97.38	-8.53	-0.06
	4/12/2002	198.8	418.5	509.3	299.2	356.45	308.65	404.25	354.05	358.85	94.38	-6.35	-0.11
	7/18/2002	161.4	379.1	462.4	262.6	316.38	270.25	362.50	311.90	320.85	83.77	-6.13	-0.20
	10/7/2002	155.8	373.6	686.8	301.1	379.33	264.70	493.95	421.30	337.35	100.43	-15.24	1.88
	1/8/2003	193.1	414	547.6	331	371.43	303.55	439.30	370.35	372.50	98.34	-9.02	-0.05
13	4/15/2003	195.8	419.9	560.6	305.7	370.50	307.85	433.15	378.20	362.80	98.10	-8.33	0.34
	7/1/2003	172.1	394.8	479.4	273.9	330.05	283.45	376.65	325.75	334.35	87.39	-6.19	-0.19
	10/7/2003	169	389.1	527.1	317.5	350.68	279.05	422.30	348.05	353.30	92.85	-9.52	-0.12
	12/31/2003	196.2	423.2	560.3	334.7	378.60	309.70	447.50	378.25	378.95	100.24	-9.16	-0.02
	4/13/2004	197.9	424.7	546.1	321.7	372.60	311.30	433.90	372.00	373.20	98.65	-8.15	-0.03
	7/13/2004	155.6	383.5	482.7	266.1	321.98	269.55	374.40	319.15	324.80	85.25	-6.97	-0.13
	10/8/2004	152.2	378.4	519	298.6	337.05	265.30	408.80	335.60	338.50	89.24	-9.54	-0.06
	1/7/2005	180.6	410.6	556.1	324.9	368.05	295.60	440.50	368.35	367.75	97.45	-9.63	0.01
	4/8/2005	188.3	419.5	529.1	301	359.48	303.90	415.05	358.70	360.25	95.18	-7.39	-0.03
	7/18/2005	150.7	376.8	482.9	262.2	318.15	263.75	372.55	316.80	319.50	84.24	-7.23	-0.06
	8/26/2005	144.7	373.1	494.1	275.3	321.80	258.90	384.70	319.40	324.20	85.20	-8.36	-0.11
	10/11/2005	146.5	375.2	533.7	291.5	336.73	260.85	412.60	340.10	333.35	89.15	-10.09	0.15
	1/10/2006	176	407.1	548.8	313.5	361.35	291.55	431.15	362.40	360.30	95.67	-9.28	0.05
	4/9/2006	180.6	412.1	538.7	307.8	359.80	296.35	423.25	359.65	359.95	95.26	-8.43	-0.01
	7/19/2006	149.4	377.4	480.1	259.8	316.68	263.40	369.95	314.75	318.60	83.85	-7.08	-0.09
	10/18/2006	155.2	382.8	532.6	304.1	343.68	269.00	418.35	343.90	343.45	90.99	-9.93	0.01
	1/18/2007	179.5	407.9	563.5	330.9	370.45	293.70	447.20	371.50	369.40	98.08	-10.20	0.05
	4/19/2007	182.7	413.5	536	305.6	359.45	298.10	420.80	359.35	359.55	95.17	-8.15	0.00
	7/11/2007	146.1	373.2	467.5	250.6	309.35	259.65	359.05	306.80	311.90	81.91	-6.61	-0.11
	10/20/2007	144.3	373.6	638.9	278.5	358.83	258.95	458.70	391.60	326.05	95.01	-13.28	1.47
	1/7/2008	179.2	408.8	548	312	362.00	294.00	430.00	363.60	360.40	95.85	-9.04	0.07
	5/13/2008	172.2	403.9	523.7	297.2	349.25	288.05	410.45	347.95	350.55	92.47	-8.13	-0.06
	7/29/2008	149.7	380.4	489.1	265	321.05	265.05	377.05	319.40	322.70	85.00	-7.44	-0.07
	10/30/2008	160.1	391.8	555	321.9	357.20	275.95	438.45	357.55	356.85	94.58	-10.80	0.02
	1/12/2009	185.3	417.9	568.5	328.6	375.08	301.60	448.55	376.90	373.25	99.31	-9.77	0.08

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	199.5	418.4	473.6	323.8	353.83	308.95	398.70	336.55	371.10	93.68	-5.96	-0.77
	7/15/1999	194.3	414.4	461.1	314.4	346.05	304.35	387.75	327.70	364.40	91.62	-5.54	-0.82
	8/15/1999	191.0	402.1	488.7	347.5	357.33	296.55	418.10	339.85	374.80	94.61	-8.08	-0.78
	8/31/1999	189.5	395.4	496	352.6	358.38	292.45	424.30	342.75	374.00	94.89	-8.76	-0.70
	9/15/1999	186.8	391.6	503.6	359.8	360.45	289.20	431.70	345.20	375.70	95.44	-9.47	-0.68
	9/30/1999	188.5	396.7	516	369	367.55	292.60	442.50	352.25	382.85	97.32	-9.96	-0.69
	10/15/1999	235.3	403	530.4	378.9	386.90	319.15	454.65	382.85	390.95	102.44	-9.01	-0.18
	10/31/1999	202.7	418.5	524.2	371.5	379.23	310.60	447.85	363.45	395.00	100.41	-9.12	-0.71
	11/15/1999	208.9	426.2	548.2	393.2	394.13	317.55	470.70	378.55	409.70	104.35	-10.18	-0.70
	11/30/1999	212.9	429.2	566.6	409.5	404.55	321.05	488.05	389.75	419.35	107.11	-11.10	-0.66
	12/15/1999	216.9	433.5	561.4	403.7	403.88	325.20	482.55	389.15	418.60	106.93	-10.46	-0.66
	12/31/1999	220.7	443.8	566.6	407.4	409.63	332.25	487.00	393.65	425.60	108.46	-10.28	-0.72
	3/31/2000	215.2	438.2	567.9	406.5	406.95	326.70	487.20	391.55	422.35	107.75	-10.67	-0.69
	6/30/2000	191.3	415.8	542.4	380.7	382.55	303.55	461.55	366.85	398.25	101.29	-10.50	-0.70
	6/30/2000	183.3	409.8	571	409.9	393.50	296.55	490.45	377.15	409.85	104.19	-12.89	-0.73
	1/13/2001	215.4	447.2	588.9	421.9	418.35	331.30	505.40	402.15	434.55	110.77	-11.57	-0.73
	4/20/2001	210.2	445.1	586.6	415.7	414.40	327.65	501.15	398.40	430.40	109.72	-11.53	-0.72
	7/16/2001	171.2	413	554.5	377.7	379.10	292.10	466.10	362.85	395.35	100.37	-11.56	-0.73
	10/9/2001	178.5	417.9	596.2	418.8	402.85	298.20	507.50	387.35	418.35	106.66	-13.91	-0.69
	1/9/2002	206.2	445.9	606.4	430	422.13	326.05	518.20	406.30	437.95	111.77	-12.77	-0.71
	4/12/2002	208.6	449.5	584.1	408.1	412.58	329.05	496.10	396.35	428.80	109.24	-11.10	-0.73
	7/18/2002	161.7	410.1	551.9	368.5	373.05	285.90	460.20	356.80	389.30	98.77	-11.58	-0.73
	10/7/2002	160.2	405.5	592.3	407.7	391.43	282.85	500.00	376.25	406.60	103.64	-14.43	-0.68
	1/8/2003	202	449.1	620.2	437.7	427.25	325.55	528.95	411.10	443.40	113.12	-13.52	-0.72
14	4/15/2003	205.4	453.6	590	409.8	414.70	329.50	499.90	397.70	431.70	109.80	-11.32	-0.76
	7/1/2003	171.9	426.9	559.5	377.3	383.90	299.40	468.40	365.70	402.10	101.65	-11.23	-0.82
	10/7/2003	172	424.4	600.8	422.4	404.90	298.20	511.60	386.40	423.40	107.21	-14.18	-0.83
	12/31/2003	205.6	461.3	624.2	444.9	434.00	333.45	534.55	414.90	453.10	114.91	-13.36	-0.86
	4/13/2004	204.7	463.4	611.5	433.1	428.18	334.05	522.30	408.10	448.25	113.37	-12.51	-0.90
	7/13/2004	159.6	424.2	566.4	383.7	383.48	291.90	475.05	363.00	403.95	101.53	-12.17	-0.92
	10/8/2004	153	416.8	590.5	409.5	392.45	284.90	500.00	371.75	413.15	103.91	-14.30	-0.93
	1/7/2005	192.8	454.9	627.8	446.9	430.60	323.85	537.35	410.30	450.90	114.01	-14.19	-0.91
	4/8/2005	205.2	467.5	600.9	425.2	424.70	336.35	513.05	403.05	446.35	112.45	-11.74	-0.97
	7/18/2005	154.9	424.1	560.9	385.2	381.28	289.50	473.05	357.90	404.65	100.95	-12.20	-1.05
	8/26/2005	168.3	416.1	569.1	391.2	386.18	292.20	480.15	368.70	403.65	102.25	-12.49	-0.78
	10/11/2005	152.5	418.5	590.5	413.4	393.73	285.50	501.95	371.50	415.95	104.25	-14.38	-1.00
	1/10/2006	190.7	455.4	615	436.7	424.45	323.05	525.85	402.85	446.05	112.38	-13.48	-0.97
	4/9/2006	196.7	460.2	612.3	436.6	426.45	328.45	524.45	404.50	448.40	112.91	-13.03	-0.98
	7/19/2006	159.7	426.1	562.3	382.1	382.55	292.90	472.20	361.00	404.10	101.29	-11.92	-0.97
	10/18/2006	161.9	425.9	600.5	422.5	402.70	293.90	511.50	381.20	424.20	106.62	-14.46	-0.96
	1/18/2007	192.2	454.2	638.5	460	436.23	323.20	549.25	415.35	457.10	115.50	-15.02	-0.94
	4/19/2007	198.7	462.5	611.3	432	426.13	330.60	521.65	405.00	447.25	112.83	-12.70	-0.95
	7/11/2007	149.8	419.9	567.4	379.8	379.23	284.85	473.60	358.60	399.85	100.41	-12.54	-0.92
	10/20/2007	208.9	417	590.1	409	406.25	312.95	499.55	399.50	413.00	107.56	-12.40	-0.30
	1/7/2008	194.6	460.1	617.4	439.8	427.98	327.35	528.60	406.00	449.95	113.31	-13.37	-0.98
	5/13/2008	188	455	606	431.7	420.18	321.50	518.85	397.00	443.35	111.25	-13.12	-1.04
	7/29/2008	155	428.4	572.6	394	387.50	291.70	483.30	363.80	411.20	102.60	-12.73	-1.06
	10/30/2008	172.9	442.6	629.9	452.7	424.53	307.75	541.30	401.40	447.65	112.40	-15.52	-1.04
	1/12/2009	205.6	472.9	638	463.6	445.03	339.25	550.80	421.80	468.25	117.83	-14.06	-1.04

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	222.2	-19.9	305.2	560	266.88	101.15	432.60	263.70	270.05	70.66	-22.03	-0.14
	7/15/1999	207.8	-36.8	294.3	540.9	251.55	85.50	417.60	251.05	252.05	66.60	-22.07	-0.02
	8/15/1999	189.9	-53.4	320.4	546.8	250.93	68.25	433.60	255.15	246.70	66.44	-24.28	0.19
	8/31/1999	184.8	-60	330.2	555.2	252.55	62.40	442.70	257.50	247.60	66.87	-25.27	0.22
	9/15/1999	185.7	-57.2	336.6	558.2	255.83	64.25	447.40	261.15	250.50	67.73	-25.46	0.24
	9/30/1999	187.5	-53.7	349.9	570.1	263.45	66.90	460.00	268.70	258.20	69.75	-26.12	0.24
	10/15/1999	195.3	-50.5	375.2	601.5	280.38	72.40	488.35	285.25	275.50	74.23	-27.64	0.22
	10/31/1999	197.3	-39.9	370.8	589.7	279.48	78.70	480.25	284.05	274.90	74.00	-26.69	0.20
	11/15/1999	202.5	-32.3	385.9	601.1	289.30	85.10	493.50	294.20	284.40	76.60	-27.14	0.22
	11/30/1999	206.5	-27.3	398.1	613.9	297.80	89.60	506.00	302.30	293.30	78.85	-27.67	0.20
	12/15/1999	216.1	-19.5	401.6	620.9	304.78	98.30	511.25	308.85	300.70	80.70	-27.44	0.18
	12/31/1999	223.8	-15	410.7	633.4	313.23	104.40	522.05	317.25	309.20	82.93	-27.76	0.18
	3/31/2000	203.5	-16	395.7	633.5	304.18	93.75	514.60	299.60	308.75	80.54	-27.97	-0.20
	6/30/2000	149.3	-41	371.2	553.8	258.33	54.15	462.50	260.25	256.40	68.40	-27.14	0.09
	6/30/2000	154.3	-22.3	411.5	580.2	280.93	66.00	495.85	282.90	278.95	74.38	-28.57	0.09
	1/13/2001	197.9	7.7	446.8	627.1	319.88	102.80	536.95	322.35	317.40	84.69	-28.85	0.11
	4/20/2001	167.6	1.3	434.9	589.5	298.33	84.45	512.20	301.25	295.40	78.99	-28.43	0.13
	7/16/2001	112.8	-20.6	409.7	555.1	264.25	46.10	482.40	261.25	267.25	69.97	-29.00	-0.13
	10/9/2001	136.9	-5.4	451.7	582.7	291.48	65.75	517.20	294.30	288.65	77.17	-30.00	0.13
	1/9/2002	176.6	9	461.6	618.2	316.35	92.80	539.90	319.10	313.60	83.76	-29.71	0.12
	4/12/2002	158.20	3.40	438	581.00	295.25	80.80	509.70	298.30	292.20	78.17	-28.50	0.14
	7/18/2002	86.10	-23.70	405	503.86	242.87	31.20	454.53	245.65	240.08	64.30	-28.13	0.12
	10/7/2002	96.1	2.90	445.20	562.80	276.75	49.50	504.00	270.65	282.85	73.28	-30.21	-0.27
	1/8/2003	165.9	41.91	480.40	628.48	329.17	103.91	554.44	323.15	335.20	87.16	-29.94	-0.27
26	4/15/2003	147.5	33.95	455.30	592.01	307.19	90.73	523.65	301.40	312.98	81.33	-28.77	-0.26
	7/1/2003	88.2	9.66	424.1	577.30	274.82	48.93	500.70	256.15	293.48	72.76	-30.02	-0.84
	10/7/2003	103.5	24.24	466.9	574.34	292.25	63.87	520.62	285.20	299.29	77.38	-30.35	-0.32
	12/31/2003	130.5	44.68	481.6	566.95	305.93	87.59	524.27	306.05	305.81	81.00	-29.02	0.01
	4/13/2004	118.2	42.08	471.6	585.31	304.30	80.14	528.45	294.90	313.69	80.57	-29.79	-0.42
	7/13/2004	49.6	8.40	430.9	548.80	259.43	29.00	489.85	240.25	278.60	68.69	-30.63	-0.86
	10/8/2004	54.7	18.19	457.3	588.15	279.59	36.45	522.72	256.00	303.17	74.03	-32.32	-1.06
	1/7/2005	108.7	42.65	486.4	597.82	308.89	75.67	542.11	297.55	320.23	81.78	-31.00	-0.51
	4/8/2005	91.7	33.99	457.3	601.47	296.12	62.85	529.39	274.50	317.73	78.40	-31.01	-0.97
	7/18/2005	28.7	12.91	432.3	605.33	269.81	20.81	518.82	230.50	309.12	71.44	-33.10	-1.76
	8/26/2005	31.4	16.85	447.8	588.39	271.11	24.13	518.10	239.60	302.62	71.78	-32.83	-1.41
	10/11/2005	43.7	14.58	464.4	588.60	277.82	29.14	526.50	254.05	301.59	73.56	-33.05	-1.06
	1/10/2006	96.3	14.58	483.8	588.60	295.82	55.44	536.20	290.05	301.59	78.32	-31.95	-0.26
	4/9/1906	87.1	29.40	477	588.60	295.52	58.25	532.80	282.05	309.00	78.25	-31.54	-0.60
	7/19/1906	18.4	-2.90	430.9	588.60	258.75	7.75	509.75	224.65	292.85	68.51	-33.36	-1.53
	10/18/1906	61.1	14.58	483.2	588.60	286.87	37.84	535.90	272.15	301.59	75.95	-33.10	-0.66
	1/18/2007	99.2	14.58	505.9	588.60	302.07	56.89	547.25	302.55	301.59	79.98	-32.59	0.02
	4/19/2007	80.5	14.58	477.1	588.60	290.19	47.54	532.85	278.80	301.59	76.83	-32.25	-0.51
	7/11/2007	11.2	14.5768	431.3	588.5957	261.42	12.89	509.95	221.25	301.59	69.22	-33.03	-1.80
	10/20/2007	19.8	14.5768	455.1	588.5957	269.52	17.19	521.85	237.45	301.59	71.36	-33.54	-1.44
	1/7/2008	82.9	14.5768	489.6	588.5957	293.92	48.74	539.10	286.25	301.59	77.82	-32.59	-0.34
	5/13/2008	44.6	14.5768	468.8	588.5957	279.14	29.59	528.70	256.70	301.59	73.91	-33.17	-1.01
	7/29/2008	0.2	14.5768	442.8	588.5957	261.54	7.39	515.70	221.50	301.59	69.25	-33.78	-1.79
	10/30/2008	34	14.5768	495.7	588.5957	283.22	24.29	542.15	264.85	301.59	74.99	-34.42	-0.82
	1/12/2009	73.4	14.5768	498.3	588.5957	293.72	43.99	543.45	285.85	301.59	77.77	-33.19	-0.35

Table 4 Pile Forces and Bending Moments

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	903.00	42.30	679.00	-	541.43	472.65	679.00	791.00	42.30	456.92	-73.98	99.88
	07/15/99	918.00	48.00	885.00	-	617.00	483.00	885.00	901.50	48.00	520.69	-144.12	113.86
	07/31/00	932.43	51.99	887.34	-	623.92	492.21	887.34	909.89	51.99	526.53	-141.66	114.44
	08/15/99	940.56	34.46	923.00	-	632.67	487.51	923.00	931.78	34.46	533.91	-156.13	119.70
	08/30/99	948.68	31.28	931.09	-	637.02	489.98	931.09	939.89	31.28	537.58	-158.14	121.21
	09/15/99	955.75	27.83	938.36	-	640.65	491.79	938.36	947.06	27.83	540.64	-160.10	122.62
	09/30/99	959.08	23.03	947.01	-	643.04	491.06	947.01	953.05	23.03	542.66	-163.47	124.06
	10/15/99	963.38	18.85	954.86	-	645.70	491.12	954.86	959.12	18.85	544.90	-166.26	125.43
	10/31/99	973.25	5.58	968.30	-	649.04	489.42	968.30	970.78	5.58	547.73	-171.69	128.76
	11/15/99	973.34	1.26	977.48	-	650.69	487.30	977.48	975.41	1.26	549.12	-175.74	129.95
	11/30/99	975.73	-2.84	980.87	-	651.25	486.45	980.87	978.30	-2.84	549.59	-177.26	130.88
	12/15/99	974.96	-2.47	982.11	-	651.53	486.25	982.11	978.54	-2.47	549.83	-177.77	130.87
	12/31/99	974.03	-54.00	984.71		634.91	460.02	984.71	979.37	-54.00	535.80	-188.11	137.85
	03/31/00	964.52	3.86	981.83	-	650.07	484.19	981.83	973.17	3.86	548.59	-178.41	129.31
	06/30/00	977.80	-36.92	980.73	-	640.54	470.44	980.73	979.27	-36.92	540.55	-182.94	135.56
	09/30/00	1009.20	-10.20	1005.99	-	668.33	499.50	1005.99	1007.60	-10.20	564.01	-181.58	135.77
	01/13/01	1014.12	-29.4495	1029.11	-	671.26	492.33	1029.11	1021.61	-29.45	566.48	-192.44	140.21
	04/20/01	1008.27	-18.6852	1022.57	-	670.72	494.79	1022.57	1015.42	-18.69	566.02	-189.21	137.95
	07/10/01	1030.41	-8.36772	1019.56	-	680.53	511.02	1019.56	1024.98	-8.37	574.30	-182.32	137.85
	10/09/01	1054.25	-20.5131	1038.65	-	690.80	516.87	1038.65	1046.45	-20.51	582.96	-187.07	142.33
	01/09/02	1055.96	-29.65	1045.80	-	690.70	513.15	1045.80	1050.88	-29.65	582.88	-190.96	144.14
	04/12/02	1041.9	-24.8188	1040.36	-	685.81	508.54	1040.36	1041.13	-24.82	578.76	-190.66	142.20
	07/19/02	1062.21	-17.26	1035.12	17.14	693.36	522.47	1035.12	1048.67	-17.26	585.12	-183.79	142.20
	10/08/02	1086.38	-30.07	1049.75	-6.63	702.02	528.16	1049.75	1068.06	-30.07	592.43	-187.00	146.49
	01/08/03	1080.45	-42.89	1062.94	0.41	700.17	518.78	1062.94	1071.70	-42.89	590.87	-195.09	148.69
1	04/15/03	1059.37	-29.65	1049.86	22.95	693.19	514.86	1049.86	1054.62	-29.65	584.99	-191.81	144.64
	06/01/03	1064.93	-31.16	1053.52	21.00	695.77	516.89	1053.52	1059.23	-31.16	587.16	-192.39	145.46
	08/07/03	1083.86	-27.66	1053.40	9.26	703.20	528.10	1053.40	1068.63	-27.66	593.43	-188.33	146.25
	10/07/03	1095.56	-38.67	1066.64	-0.69	707.84	528.45	1066.64	1081.10	-38.67	597.35	-192.95	149.38
	12/31/03	1100.15	-54.88	1082.97	-0.89	709.41	522.64	1082.97	1091.56	-54.88	598.68	-200.89	152.93
	04/13/04	1080.17	-43.67	1074.07	21.65	703.52	518.25	1074.07	1077.12	-43.67	593.70	-199.27	149.51
	07/13/04	1101.53	-34.89	1072.49	10.76	713.04	533.32	1072.49	1087.01	-34.89	601.74	-193.30	149.66
	10/08/04	1122.82	-45.70	1085.57	-8.86	720.90	538.56	1085.57	1104.19	-45.70	608.36	-196.11	153.40
	01/07/05	1116.60	-58.49	1097.39	-8.94	718.50	529.06	1097.39	1107.00	-58.49	606.34	-203.76	155.48
	04/08/05	1099.01	-52.77	1096.58	5.48	714.28	523.12	1096.58	1097.80	-52.77	602.78	-205.59	153.49
	07/18/05	1116.44	-41.55	1096.58	-2.36	723.82	537.44	1096.58	1106.51	-41.55	610.83	-200.46	153.15
	08/26/05	1128.14	-43.63	1095.73	-10.20	726.75	542.26	1095.73	1111.93	-43.63	613.30	-198.43	154.15
	11/12/05	1127.45	-44.76	1095.72	-9.67	726.14	541.34	1095.72	1111.58	-44.76	612.79	-198.75	154.26
	01/10/06	1129.36	-64.30	1095.72	-19.70	720.26	532.53	1095.72	1112.54	-64.30	607.83	-201.91	156.99
	04/09/06	1114.90	-55.20	1095.72	-1.14	718.47	529.85	1095.72	1105.31	-55.20	606.32	-202.87	154.81
	07/19/06	1130.94	-46.83	1095.72	-9.42	726.61	542.05	1095.72	1113.33	-46.83	613.19	-198.50	154.77
	10/18/06	1154.91	-58.29	1095.72	-27.50	730.78	548.31	1095.72	1125.32	-58.29	616.71	-196.26	157.89
	01/18/07	1139.55	-68.49	1095.72	-21.73	722.26	535.53	1095.72	1117.64	-68.49	609.52	-200.84	158.23
	04/19/07	1125.58	-58.82	1095.72	-8.49	720.83	533.38	1095.72	1110.65	-58.82	608.31	-201.61	156.01
	07/09/07	1141.38	-47.08	1095.72	-16.09	730.01	547.15	1095.72	1118.55	-47.08	616.05	-196.67	155.50
	10/20/07	1161.81	-62.03	1095.72	-36.23	731.84	549.89	1095.72	1128.77	-62.03	617.60	-195.69	158.85
	01/07/08	1155.60	-68.08	1095.72	-28.03	727.75	543.76	1095.72	1125.66	-68.08	614.15	-197.89	159.24
	05/13/08	1100.48	-46.92	1095.72	7.39	716.43	526.78	1095.72	1098.10	-46.92	604.59	-203.97	152.75
	07/29/08	1158.20	-57.76	1095.72	-17.10	732.05	550.22	1095.72	1126.96	-57.76	617.78	-195.57	158.04
	10/30/08	1172.74	-73.81	1095.72	-23.97	731.55	549.47	1095.72	1134.23	-73.81	617.36	-195.84	161.15
	01/12/09	1163.28	-77.95	1095.72	-8.29	727.02	542.66	1095.72	1129.50	-77.95	613.53	-198.28	161.07

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	575.00	589.00	243.00	-	469.00	582.00	243.00	409.00	589.00	395.79	121.54	-24.01
	07/15/99	585.00	602.00	237.00	-	474.67	593.50	237.00	411.00	602.00	400.57	127.81	-25.48
	07/30/99	594.35	611.17	230.68	-	478.73	602.76	230.68	412.52	611.17	404.00	133.40	-26.50
	08/15/99	596.87	611.09	242.58	336.68	446.81	603.98	289.63	419.73	473.89	377.06	112.70	-7.22
	08/31/99	601.58	616.82	241.00	-	486.47	609.20	241.00	421.29	616.82	410.53	132.00	-26.08
	09/15/99	605.96	622.42	240.47	-	489.62	614.19	240.47	423.22	622.42	413.19	133.98	-26.57
	09/30/99	609.62	624.20	240.71	336.98	452.88	616.91	288.85	425.17	480.59	382.18	117.62	-7.39
	10/15/99	612.87	629.40	240.27	336.21	454.69	621.14	288.24	426.57	482.81	383.71	119.35	-7.50
	10/31/99	616.45	631.80	243.11	336.29	456.91	624.13	289.70	429.78	484.05	385.59	119.90	-7.24
	11/15/99	619.54	632.45	245.83	337.79	458.90	626.00	291.81	432.69	485.12	387.27	119.81	-6.99
	11/30/99	623.35	635.58	248.71	340.31	461.99	629.47	294.51	436.03	487.95	389.87	120.09	-6.93
	12/15/99	624.21	637.77	247.77	339.95	462.43	630.99	293.86	435.99	488.86	390.24	120.87	-7.05
	12/31/99	626.60	640.86	249.37	341.45	464.57	633.73	295.41	437.99	491.16	392.05	121.29	-7.09
	03/31/00	634.53	648.30	254.69	346.89	471.10	641.41	300.79	444.61	497.60	397.56	122.12	-7.07
	06/30/00	640.05	652.80	250.99	342.06	471.48	646.43	296.53	445.52	497.43	397.88	125.44	-6.93
	09/30/00	647.16	661.13	247.62	336.78	473.17	654.14	292.20	447.39	498.96	399.31	129.76	-6.88
	01/13/01	654.063	665.1119	256.39	342.22	479.45	659.59	299.31	455.23	503.67	404.61	129.16	-6.46
	04/20/01	654.429	664.7057	260.37	345.47	481.25	659.57	302.92	457.40	505.09	406.12	127.86	-6.36
	07/10/01	661.456	672.0985	256.15	342.75	483.11	666.78	299.45	458.80	507.43	407.70	131.69	-6.49
	10/09/01	668.361	679.0039	251.93	338.20	484.37	673.68	295.06	460.14	508.60	408.76	135.74	-6.46
	01/09/02	671.083	683.4721	252.17	337.92	486.16	677.28	295.04	461.63	510.69	410.27	137.04	-6.55
	04/12/02	669.17	680.02	256.68	342.06	486.98	674.60	299.37	462.93	511.04	410.96	134.52	-6.42
	07/19/02	671.69	683.96	253.27	272.93	470.46	677.83	263.10	462.48	478.44	397.02	148.69	-2.13
	10/08/02	678.60	692.21	247.01	332.37	487.54	685.40	289.69	462.80	512.29	411.44	141.87	-6.60
	01/08/03	678.44	689.32	251.28	334.22	488.31	683.88	292.75	464.86	511.77	412.09	140.22	-6.26
17	04/15/03	679.45	692.45	254.73	341.09	491.93	685.95	297.91	467.09	516.77	415.14	139.12	-6.63
	06/01/03	678.76	689.85	256.43	341.09	491.53	684.30	298.76	467.60	515.47	414.80	138.22	-6.39
	08/07/03	682.33	695.54	251.15	336.74	491.44	688.94	293.95	466.74	516.14	414.73	141.61	-6.59
	10/07/03	686.23	700.57	250.14	334.87	492.95	693.40	292.50	468.19	517.72	416.00	143.73	-6.61
	12/31/03	689.48	700.61	257.04	341.05	497.05	695.05	299.04	473.26	520.83	419.46	141.97	-6.35
	04/13/04	689.24	699.88	260.70	346.65	499.12	694.56	303.68	474.97	523.27	421.21	140.14	-6.44
	07/13/04	693.10	667.59	255.46	341.33	489.37	680.34	298.39	474.28	504.46	412.98	136.93	-4.03
	10/08/04	699.03	710.89	250.83	337.39	499.53	704.96	294.11	474.93	524.14	421.56	147.30	-6.56
	01/07/05	699.07	711.46	253.31	339.95	500.95	705.26	296.63	476.19	525.70	422.75	146.50	-6.61
	04/08/05	696.43	708.09	257.94	343.81	501.57	702.26	300.87	477.18	525.95	423.27	143.90	-6.51
	07/18/05	699.56	708.33	253.71	338.36	499.99	703.94	296.04	476.64	523.35	421.94	146.24	-6.23
	08/26/05	702.04	711.17	250.91	335.97	500.02	706.61	293.44	476.47	523.57	421.97	148.13	-6.28
	11/12/05	701.95	699.60	251.68	337.06	497.57	700.78	294.37	476.82	518.33	419.90	145.70	-5.54
	01/10/06	705.16	715.03	253.47	339.58	503.31	710.10	296.53	479.32	527.31	424.75	148.27	-6.40
	04/09/06	703.94	713.04	259.52	343.20	504.93	708.49	301.36	481.73	528.12	426.11	145.96	-6.19
	07/19/06	708.37	716.01	256.84	339.95	505.29	712.19	298.39	482.61	527.98	426.42	148.35	-6.05
	10/18/06	713.29	721.25	251.76	334.02	505.08	717.27	292.89	482.52	527.63	426.24	152.14	-6.02
	01/18/07	712.84	717.96	256.52	336.54	505.96	715.40	296.53	484.68	527.25	426.98	150.17	-5.68
	04/19/07	711.13	716.21	260.62	340.56	507.13	713.67	300.59	485.88	528.38	427.97	148.10	-5.67
	07/09/07	713.04	716.74	255.22	334.18	504.79	714.89	294.70	484.13	525.46	426.00	150.64	-5.51
	10/20/07	715.97	721.74	250.87	329.51	504.52	718.85	290.19	483.42	525.62	425.77	153.68	-5.63
	01/07/08	719.26	723.93	256.47	335.12	508.69	721.59	295.79	487.87	529.52	429.29	152.65	-5.56
	05/13/08	696.51	707.19	257.94	343.56	501.30	701.85	300.75	477.22	525.38	423.05	143.80	-6.42
	07/29/08	720.07	723.56	259.40	335.76	509.70	721.82	297.58	489.74	529.66	430.14	152.09	-5.33
	10/30/08	723.81	727.50	255.66	332.68	509.91	725.66	294.17	489.74	530.09	430.32	154.69	-5.38
	01/12/09	723.20	727.59	259.07	336.66	511.63	725.39	297.87	491.14	532.12	431.76	153.27	-5.47

Table 4 Pile Forces and Bending Moments (cont'd)

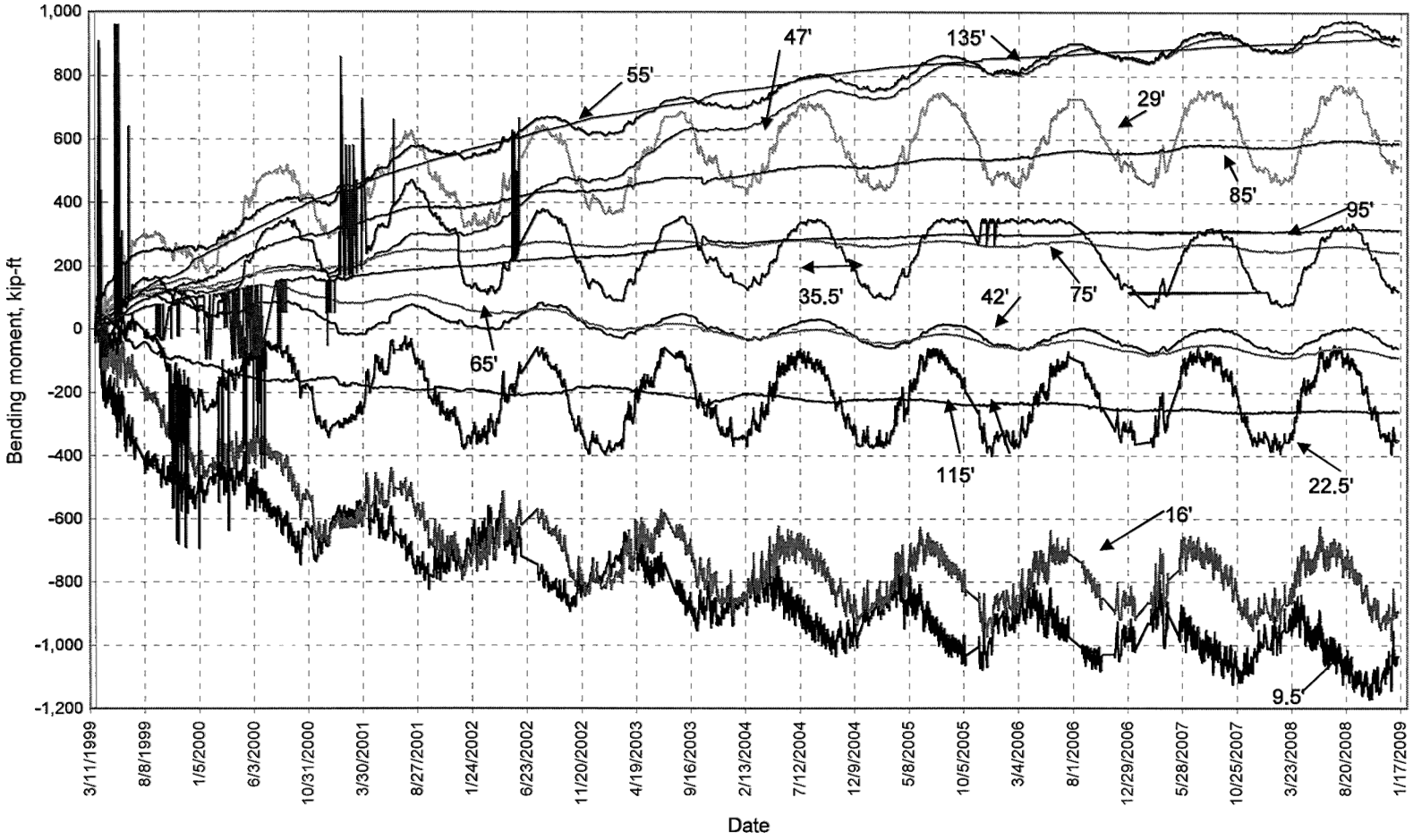
Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	546.00	501.00	248.00	173	367.00	523.50	210.50	397.00	337.00	309.71	112.21	8.00
	07/15/99	557.00	513.00	243.00	229	385.50	535.00	236.00	400.00	371.00	325.32	107.20	3.87
	07/30/99	565.55	519.94	239.54	224.26	387.32	542.75	231.90	402.55	372.10	326.86	111.44	4.06
	08/15/99	567.71	520.14	230.56	232.51	387.73	543.93	231.54	399.14	376.33	327.21	112.00	3.04
	08/31/99	573.72	526.52	247.46	232.87	395.14	550.12	240.17	410.59	379.70	333.46	111.12	4.12
	09/15/99	578.06	532.08	246.65	233.61	397.60	555.07	240.13	412.36	382.85	335.53	112.91	3.94
	09/30/99	582.49	534.97	247.46	234.05	399.74	558.73	240.76	414.98	384.51	337.34	114.00	4.06
	10/15/99	586.68	538.17	247.25	235.23	401.83	562.43	241.24	416.97	386.70	339.11	115.15	4.04
	10/31/99	590.77	539.40	249.37	235.6	403.79	565.09	242.49	420.07	387.50	340.75	115.66	4.34
	11/15/99	592.65	540.65	251.68	237.47	405.61	566.65	244.58	422.17	389.06	342.30	115.47	4.42
	11/30/99	596.63	527.25	254.12	239.69	404.42	561.94	246.91	425.38	383.47	341.29	112.94	5.59
	12/15/99	599.47	545.53	254.12	239.05	409.54	572.50	246.59	426.80	392.29	345.61	116.84	4.60
	12/31/99	601.54	548.45	255.38	239.17	411.14	575.00	247.28	428.46	393.81	346.96	117.49	4.62
	03/31/00	610.32	554.87	262.08	243.60	417.72	582.59	252.84	436.20	399.23	352.51	118.22	4.93
	06/30/00	616.94	539.60	260.98	238.93	414.11	578.27	249.96	438.96	389.26	349.47	117.70	6.63
	09/30/00	625.63	400.76	255.58	232.18	378.54	513.19	243.88	440.61	316.47	319.45	96.55	16.56
	01/13/01	632.372	566.6896	264.44	235.84	424.83	599.53	250.14	448.40	401.26	358.52	125.26	6.29
	04/20/01	632.575	561.5309	268.38	236.21	424.67	597.05	252.29	450.48	398.87	358.38	123.60	6.88
	07/10/01	639.684	569.2893	264.64	234.54	427.04	604.49	249.59	452.16	401.91	360.38	127.23	6.70
	10/09/01	646.508	576.5197	259.81	232.14	428.74	611.51	245.97	453.16	404.33	361.82	131.05	6.51
	01/09/02	650.895	576.8446	259.68	230.92	429.59	613.87	245.30	455.29	403.88	362.53	132.14	6.86
	04/12/02	650.123	570.1017	264.192	232.55	429.24	610.11	248.37	457.16	401.33	362.24	129.69	7.45
	07/19/02	653.45	572.46	260.90	226.38	428.30	612.96	243.64	457.18	399.42	361.44	132.40	7.71
	10/08/02	659.69	581.14	254.65	222.68	429.54	620.41	238.66	457.17	401.91	362.49	136.86	7.37
	01/08/03	657.76	576.89	257.57	224.47	429.17	617.32	241.02	457.67	400.68	362.18	134.91	7.60
18	04/15/03	661.78	576.19	262.16	228.04	432.04	618.99	245.10	461.97	402.12	364.60	134.04	7.98
	06/01/03	661.37	572.66	264.07	227.59	431.43	617.02	245.83	462.72	400.13	364.08	133.07	8.35
	08/07/03	665.76	577.29	258.18	222.76	431.00	621.53	240.47	461.97	400.03	363.72	136.61	8.26
	10/07/03	669.26	582.73	256.11	222.56	432.66	625.99	239.33	462.68	402.65	365.13	138.62	8.01
	12/31/03	670.27	581.39	262.53	229.62	435.95	625.83	246.08	466.40	405.51	367.90	136.15	8.12
	04/13/04	669.42	576.64	266.47	232.35	436.22	623.03	249.41	467.94	404.49	368.12	133.95	8.46
	07/13/04	672.95	578.63	261.80	224.79	434.54	625.79	243.29	467.37	401.71	366.71	137.13	8.76
	10/08/04	677.95	587.12	255.42	222.31	435.70	632.53	238.87	466.68	404.72	367.69	141.14	8.27
	01/07/05	677.50	586.02	257.61	226.05	436.80	631.76	241.83	467.56	406.04	368.61	139.80	8.21
	04/08/05	674.17	580.83	263.14	227.80	436.48	627.50	245.47	468.65	404.31	368.35	136.96	8.58
	07/18/05	677.87	580.70	259.40	221.74	434.93	629.29	240.57	468.63	401.22	367.04	139.36	8.99
	08/26/05	679.25	583.30	256.27	219.43	434.56	631.28	237.85	467.76	401.37	366.73	141.05	8.86
	11/12/05	679.13	583.14	256.88	220.08	434.81	631.13	238.48	468.00	401.61	366.93	140.77	8.86
	01/10/06	679.45	587.32	257.33	223.00	436.78	633.39	240.17	468.39	405.16	368.60	140.97	8.43
	04/09/06	679.57	583.14	263.01	226.46	438.05	631.36	244.74	471.29	404.80	369.67	138.61	8.87
	07/19/06	683.27	585.78	260.94	222.31	438.08	634.53	241.63	472.11	404.05	369.69	140.86	9.08
	10/18/06	687.01	592.40	255.09	218.66	438.29	639.70	236.88	471.05	405.53	369.87	144.42	8.74
	01/18/07	685.10	588.58	259.16	221.83	438.67	636.84	240.49	472.13	405.20	370.19	142.10	8.93
	04/19/07	685.18	584.40	264.40	222.96	439.23	634.79	243.68	474.79	403.68	370.67	140.22	9.49
	07/09/07	687.74	584.85	259.24	215.85	436.92	636.29	237.55	473.49	400.35	368.72	142.96	9.76
	10/20/07	690.01	591.22	253.79	213.46	437.12	640.62	233.63	471.90	402.34	368.89	145.91	9.28
	01/07/08	691.80	593.86	258.30	218.94	440.73	642.83	238.62	475.05	406.40	371.93	144.91	9.16
	05/13/08	675.23	578.71	263.42	226.74	436.03	626.97	245.08	469.32	402.73	367.96	136.91	8.88
	07/29/08	694.93	590.45	261.06	217.03	440.87	642.69	239.05	478.00	403.74	372.05	144.71	9.91
	10/30/08	696.63	596.14	256.52	215.81	441.28	646.39	236.16	476.57	405.98	372.39	147.07	9.42
	01/12/09	695.50	595.73	258.34	219.55	442.28	645.61	238.95	476.92	407.64	373.24	145.80	9.24

Table 4 Pile Forces and Bending Moments (cont'd)

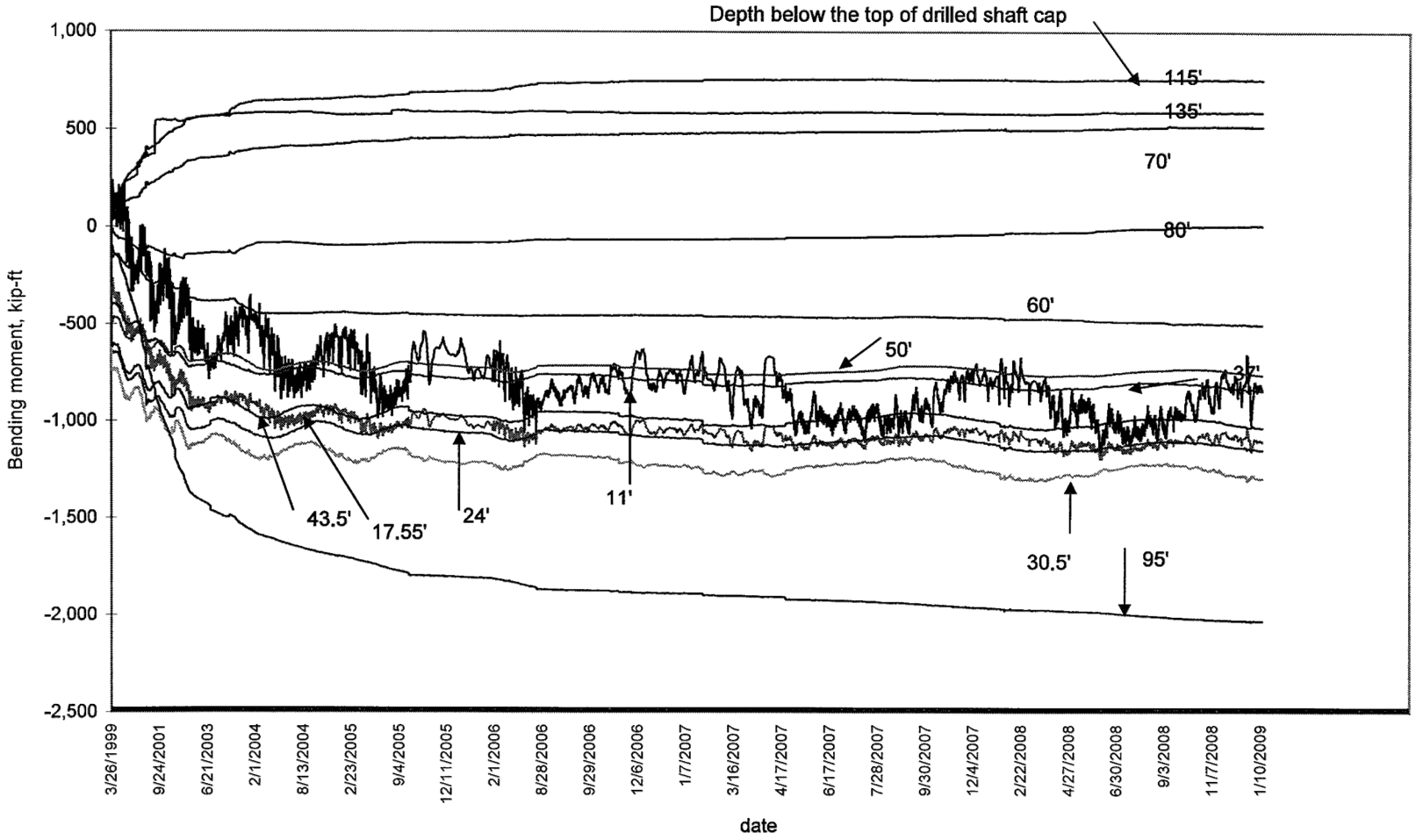
Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	566.97	586.00	298.00	228.9	419.97	576.49	263.45	432.49	407.45	354.41	112.23	3.34
	07/15/99	580.00	597.00	294.00	224	423.75	588.50	259.00	437.00	410.50	357.60	118.13	3.54
	07/30/99	588.71	606.46	291.38	218.62	426.29	597.59	255.00	440.05	412.54	359.75	122.82	3.67
	08/15/99	591.02	607.35	300.95	227.92	431.81	599.19	264.44	445.99	417.64	364.40	120.01	3.78
	08/31/99	595.94	613.52	300.59	229.63	434.92	604.73	265.11	448.27	421.58	367.03	121.76	3.56
	09/15/99	599.88	617.91	300.67	229.54	437.00	608.90	265.11	450.28	423.73	368.78	123.25	3.54
	09/30/99	603.53	621.65	302.70	229.75	439.41	612.59	266.23	453.12	425.70	370.82	124.18	3.66
	10/15/99	607.51	625.02	302.29	229.71	441.13	616.27	266.00	454.90	427.37	372.27	125.57	3.67
	10/31/99	611.37	627.25	306.07	229.7	443.60	619.31	267.89	458.72	428.48	374.35	125.99	4.03
	11/15/99	613.61	627.78	308.31	232.67	445.59	620.70	270.49	460.96	430.23	376.04	125.55	4.10
	11/30/99	616.29	630.54	313.83	234.7	448.84	623.42	274.27	465.06	432.62	378.78	125.17	4.33
	12/15/99	617.83	631.44	314.03	234.9	449.55	624.64	274.47	465.93	433.17	379.38	125.54	4.37
	12/31/99	619.94	634.20	314.36	236.45	451.24	627.07	275.41	467.15	435.33	380.80	126.08	4.25
	03/31/00	629.45	639.44	320.33	239.74	457.24	634.44	280.03	474.89	439.59	385.86	127.06	4.71
	06/30/00	636.15	643.50	317.81	51.91	412.34	639.83	184.86	476.98	347.71	347.98	163.11	17.25
	09/30/00	646.59	651.99	312.33	231.29	460.55	649.29	271.81	479.46	441.64	388.66	135.33	5.04
	01/13/01	653.454	657.0691	320.21	236.77	466.88	655.26	278.49	486.83	446.92	394.00	135.08	5.32
	04/20/01	651.464	653.2102	324.03	237.42	466.53	652.34	280.72	487.74	445.32	393.71	133.23	5.66
	07/10/01	658.856	661.1717	320.61	235.03	468.92	660.01	277.82	489.74	448.10	395.72	137.02	5.55
	10/09/01	667.346	669.2551	315.37	230.97	470.74	668.30	273.17	491.36	450.11	397.25	141.66	5.50
	01/09/02	670.88	671.7736	315.66	229.71	472.00	671.33	272.68	493.27	450.74	398.32	142.92	5.67
	04/12/02	667.71	665.64	321.06	231.62	471.51	666.68	276.34	494.39	448.63	397.90	139.94	6.10
	07/19/02	673.44	667.87	319.88	227.72	472.23	670.66	273.80	496.66	447.79	398.51	142.28	6.52
	10/08/02	681.93	676.18	313.24	222.91	473.56	679.05	268.07	497.58	449.54	399.64	147.34	6.41
	01/08/03	682.42	673.60	316.88	225.03	474.48	678.01	270.96	499.65	449.32	400.42	145.93	6.71
19	04/15/03	686.11	672.95	321.26	228.37	477.17	679.53	274.81	503.69	450.66	402.69	145.10	7.07
	06/01/03	685.30	670.80	322.48	227.84	476.60	678.05	275.16	503.89	449.32	402.21	144.44	7.28
	08/07/03	689.12	675.35	317.28	223.09	476.21	682.23	270.18	503.20	449.22	401.87	147.72	7.20
	10/07/03	694.48	681.03	314.64	222.27	478.11	687.76	268.46	504.56	451.65	403.47	150.32	7.06
	12/31/03	695.94	680.95	322.73	229.34	482.24	688.45	276.03	509.33	455.15	406.96	147.86	7.23
	04/13/04	695.62	676.77	330.77	231.41	483.64	686.19	281.09	513.19	454.09	408.15	145.23	7.88
	07/13/04	700.37	679.61	327.88	224.22	483.02	689.99	276.05	514.13	451.92	407.62	148.40	8.30
	10/08/04	706.18	688.67	321.87	221.22	484.48	697.43	271.54	514.03	454.94	408.86	152.68	7.88
	01/07/05	705.37	688.14	324.72	224.55	485.69	696.75	274.63	515.04	456.35	409.88	151.34	7.83
	04/08/05	702.85	682.86	329.75	226.66	485.53	692.86	278.21	516.30	454.76	409.74	148.66	8.21
	07/18/05	706.50	683.55	327.15	219.55	484.19	695.03	273.35	516.83	451.55	408.61	151.18	8.71
	08/26/05	708.05	686.48	322.81	217.89	483.80	697.26	270.35	515.43	452.18	408.28	153.05	8.44
	11/12/05	707.97	686.27	323.74	218.33	484.08	697.12	271.04	515.85	452.30	408.51	152.76	8.48
	01/10/06	710.04	690.54	324.68	221.62	486.72	700.29	273.15	517.36	456.08	410.74	153.13	8.17
	04/09/06	709.47	686.72	329.75	224.34	487.57	698.10	277.05	519.61	455.53	411.46	150.95	8.55
	07/19/06	714.26	690.38	328.09	220.57	488.32	702.32	274.33	521.17	455.47	412.10	153.44	8.76
	10/18/06	718.93	696.80	321.91	216.75	488.60	707.86	269.33	520.42	456.77	412.33	157.22	8.49
	01/18/07	717.19	692.98	326.63	219.88	489.17	705.08	273.25	521.91	456.43	412.81	154.82	8.73
	04/19/07	716.98	689.52	331.50	221.54	489.89	703.25	276.52	524.24	455.53	413.42	152.99	9.17
	07/09/07	720.64	690.13	327.60	214.47	488.21	705.39	271.04	524.12	452.30	412.00	155.72	9.58
	10/20/07	723.97	695.70	321.18	211.96	488.20	709.83	266.57	522.58	453.83	411.99	158.92	9.17
	01/07/08	725.43	698.46	326.71	217.89	492.12	711.95	272.30	526.07	458.17	415.30	157.62	9.06
	05/13/08	703.58	681.44	330.20	225.12	485.08	692.51	277.66	516.89	453.28	409.36	148.73	8.49
	07/29/08	728.03	696.92	329.23	216.75	492.73	712.47	272.99	528.63	456.83	415.82	157.56	9.58
	10/30/08	730.876	701.5886	324.269	216.383	493.28	716.23	270.33	527.57	458.99	416.28	159.86	9.15
	01/12/09	729.576	702.3198	327.478	220.079	494.86	715.95	273.78	528.53	461.20	417.62	158.52	8.98

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	271.75	436.00	261.00	583.00	387.94	353.88	422.00	266.38	509.50	327.38	-24.42	-32.43
	07/15/99	279.00	617.00	253.00	583.00	433.00	448.00	418.00	266.00	600.00	365.41	10.76	-44.56
	07/30/99	282.79	647.00	243.64	585.13	439.64	464.90	414.39	263.22	616.07	371.01	18.11	-47.07
	08/15/99	272.89	690.09	251.16	614.66	457.20	481.49	432.91	262.03	652.38	385.83	17.42	-52.07
	08/31/99	265.66	576.80	245.14	627.09	428.67	421.23	436.12	255.40	601.95	361.76	-5.34	-46.23
	09/15/99	265.08	802.81	242.34	635.26	486.37	533.95	438.80	253.71	719.04	410.45	34.11	-62.07
	09/30/99	260.50	807.40	238.64	642.65	487.30	533.95	440.65	249.57	725.03	411.23	33.45	-63.43
	10/15/99	256.43	811.14	234.46	648.58	487.65	533.79	441.52	245.45	729.86	411.53	33.08	-64.62
	10/31/99	240.47	824.02	221.62	665.31	487.86	532.25	443.47	231.05	744.67	411.70	31.83	-68.52
	11/15/99	241.93	831.45	224.75	676.77	493.73	536.69	450.76	233.34	754.11	416.65	30.81	-69.47
	11/31/99	240.47	835.88	224.26	648.85	487.37	538.18	436.56	232.37	742.37	411.29	36.43	-68.03
	12/15/99	241.41	836.77	222.35	684.04	496.14	539.09	453.20	231.88	760.41	418.69	30.79	-70.51
	12/31/99	242.22	836.08	224.14	684.93	496.84	539.15	454.54	233.18	760.51	419.29	30.34	-70.35
	03/31/00	257.37	828.85	237.38	675.92	499.88	543.11	456.65	247.38	752.38	421.85	31.00	-67.37
	06/30/00	266.43	846.32	225.20	500.93	459.72	556.37	363.06	245.81	673.62	387.96	69.30	-57.07
	09/30/00	257.37	895.02	196.89	705.00	513.57	576.19	450.94	227.13	800.01	433.40	44.90	-76.42
	01/13/01	247.90	856.11	197.37	729.58	507.74	552.01	463.47	222.64	792.84	428.48	31.74	-76.07
	04/20/01	44.66	883.01	212.28	457.21	399.29	463.83	334.74	128.47	670.11	336.96	46.28	-72.25
	07/10/01	-279.94	502.86	204.24	66.21	123.34	111.46	135.22	-37.85	284.53	104.09	-8.52	-43.01
	10/09/01	442.16	725.37	50.98	1199.89	604.60	583.76	625.44	246.57	962.63	510.22	-14.94	-95.52
	01/09/02	263.63	616.73	159.27	765.05	451.17	440.18	462.16	211.45	690.89	380.74	-7.88	-63.96
	04/12/02	67.35	579.97	58.13	501.01	301.61	323.66	279.57	62.74	540.49	254.53	15.81	-63.73
	07/19/02	288.69	941.04	187.83	727.59	536.29	614.86	457.71	238.26	834.31	452.57	56.34	-79.51
	10/08/02	277.15	962.54	162.58	740.98	535.81	619.84	451.78	219.86	851.76	452.17	60.25	-84.29
	01/08/03	256.07	949.53	162.24	758.66	531.62	602.80	460.45	209.15	854.10	448.64	51.04	-86.04
34	04/15/03	277.19	928.37	189.53	744.52	534.90	602.78	467.03	233.36	836.45	451.41	48.67	-80.45
	06/01/03	277.96	939.01	184.90	749.68	537.89	608.49	467.29	231.43	844.35	453.93	50.62	-81.76
	08/07/03	288.69	965.09	171.66	750.09	543.88	626.89	460.87	230.17	857.59	458.98	59.52	-83.70
	10/07/03	274.96	978.21	155.53	762.84	542.89	626.58	459.19	215.25	870.53	458.14	60.01	-87.41
	12/31/03	258.26	983.57	156.83	795.22	548.47	620.92	476.03	207.55	889.40	462.86	51.95	-90.96
	04/13/04	281.17	960.30	188.88	781.65	553.00	620.73	485.27	235.03	870.97	466.68	48.57	-84.84
	07/13/04	302.86	991.98	173.93	772.27	560.26	647.42	473.10	238.40	882.12	472.80	62.50	-85.87
	10/08/04	295.63	1004.49	151.19	786.40	559.43	650.06	468.80	223.41	895.45	472.10	64.99	-89.65
	01/07/05	277.35	997.91	148.79	798.02	555.52	637.63	473.41	213.07	897.97	468.80	58.88	-91.36
	04/08/05	286.74	978.21	166.99	788.76	555.17	632.47	477.87	226.86	883.49	468.51	55.43	-87.59
	07/18/05	304.00	1000.02	160.94	783.60	562.14	652.01	472.27	232.47	891.81	474.39	64.44	-87.96
	08/26/05	301.85	1018.4	147.73	791.81	564.94	660.12	469.77	224.79	905.09	476.76	68.24	-90.75
	11/12/05	300.51	1018.3	147.82	793.35	564.99	659.40	470.58	224.16	905.83	476.80	67.70	-90.93
	01/10/06	274.59	1009.41	138.15	808.34	557.62	642.00	473.24	206.37	908.87	470.58	60.50	-93.71
	04/09/06	283.04	986.09	160.45	798.02	556.90	634.57	479.23	221.74	892.06	469.97	55.69	-89.42
	07/19/06	295.67	1009.41	149.73	796.56	562.84	652.54	473.14	222.70	902.98	474.98	64.32	-90.75
	10/18/06	284.79	1030.77	131.20	808.38	563.79	657.78	469.79	207.99	919.58	475.78	67.40	-94.92
	01/18/07	270.29	1012.82	134.82	813.33	557.81	641.55	474.08	202.55	913.08	470.74	60.04	-94.78
	04/19/07	282.35	996.04	153.99	805.37	559.44	639.20	479.68	218.17	900.71	472.11	57.19	-91.05
	07/09/07	306.44	1014.48	154.64	795.38	567.74	660.46	475.01	230.54	904.93	479.11	66.49	-89.96
	10/20/07	290.51	1037.35	126.69	809.72	566.07	663.93	468.21	208.60	923.54	477.71	70.17	-95.37
	01/07/08	274.06	1024.92	128.89	820.48	562.09	649.49	474.69	201.48	922.70	474.35	62.67	-96.21
	05/13/08	292.26	978.90	169.79	784.94	556.47	635.58	477.37	231.03	881.92	469.61	56.72	-86.63
	07/29/08	293.44	1034.59	136.97	816.54	570.39	664.02	476.76	215.20	925.57	481.35	67.13	-94.76
	10/30/08	272.32	1053.97	115.20	839.53	570.25	663.14	477.37	193.76	946.75	481.24	66.60	-100.45
	01/12/09	261.92	1033.74	121.25	842.38	564.82	647.83	481.81	191.58	938.06	476.65	59.52	-99.58



Shaft #1, Bending moment vs. date in different elevations below the top of cap



Shaft #9, Bending moment vs. date in different elevations below the top of cap

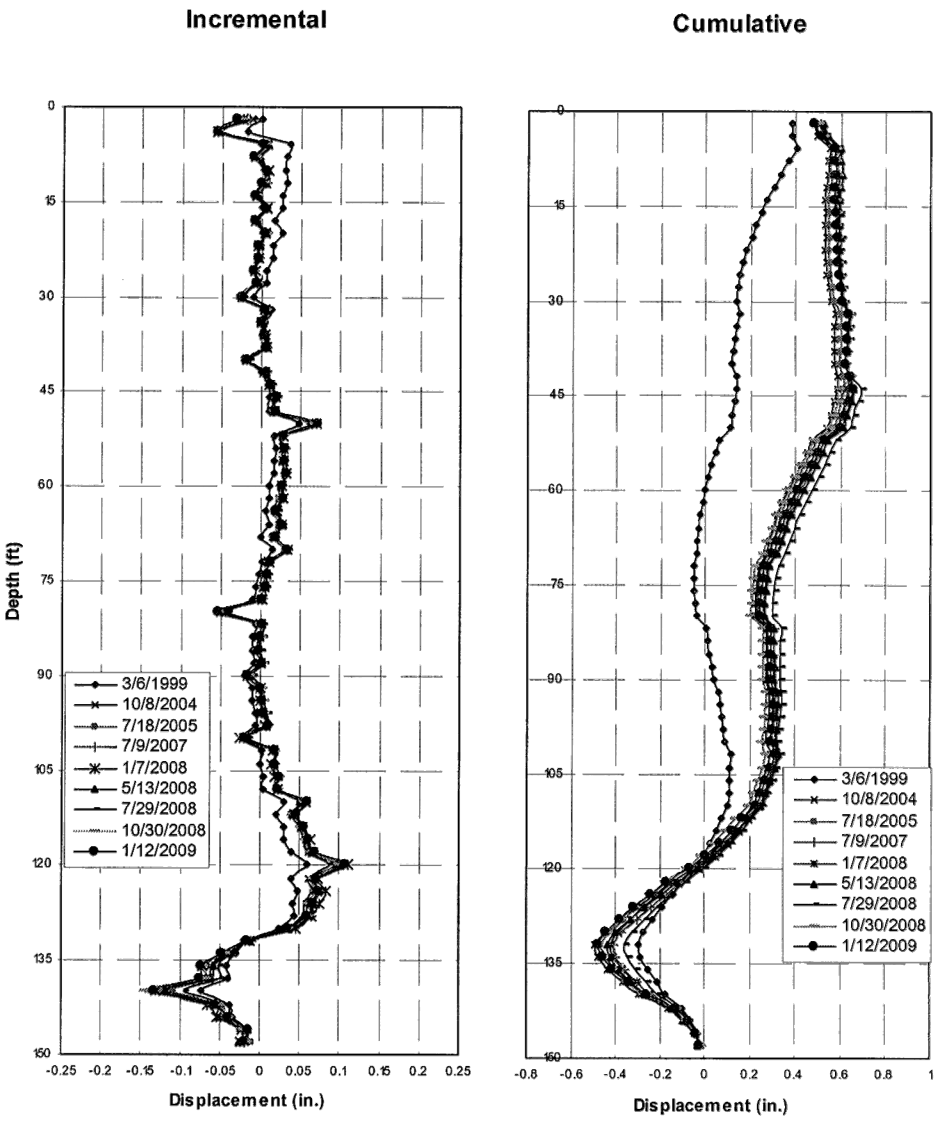
Shaft 1: Bending moment along shaft, kip-ft

Depth, ft / Date	9.5	16	22.5	29	35.5	42	47	54.8	64.8	74.8	84.8	94.8	115	135
7/1/1999	-357.65	-148.91	-2.99	242.13	107.23	94.27	103.67	221.87	109.32	92.67	66.77	48.25	-38.94	91.57
1/8/2003	-774.82	-792.9	-360.63	403.12	139.71	-1.79	473.87	620.31	11.19	262.65	439.51	230.65	-179.6	668.9
4/15/2003	-657.74	-650	-232.57	481.71	156.43	-14.02	517.65	659.68	2.44	268.91	457.85	238.57	-192.49	684.79
7/1/2003	-763.24	-602.42	-72.91	660.28	319.17	32.14	588.57	715.87	14.21	278.09	474.99	251.23	-206	702.94
8/7/2003	-817.04	-638.73	-81.08	678	343.79	44.44	615.09	726.92	17.44	279.15	477.58	254.31	-210.32	708.78
10/7/2003	-913.81	-801.08	-248.05	552.54	251.84	20.93	623.3	710.92	6.8	271.9	474.43	265.38	-225.46	720.58
12/31/2003	-870.9	-838.68	-322.24	476.14	168.18	-13.93	630.87	701.76	-19.51	263.35	479.49	275.24	-220.96	748.57
4/13/2004	-831.87	-777.37	-255.87	514.98	175.37	-24.83	659.66	727.03	-27.47	269.67	495.81	277.88	-211.65	763.52
7/13/2004	-889.99	-676.85	-77.13	709.38	338.24	22.05	727.23	792.27	-5.75	281.7	512.3	283.5	-221.34	787.54
10/8/2004	-983.05	-812	-201.66	636.33	293	16.71	752.87	793.14	-7.37	272.19	514.89	286.68	-231.1	803.15
1/7/2005	-925.21	-882.29	-353.38	471.75	139.59	-39.87	733.05	761.38	-34.6	264.1	510.62	288.64	-223.06	817.18
4/8/2005	-775.03	-726	-235.05	530.47	150.69	-53.27	749.88	786.67	-40.37	267.3	525.48	290.73	-219.8	828.14
7/18/2005	-957.73	-709.43	-81.75	735.77	338.65	7.97	821.52	856.49	-16.82	278.53	538.72	298.79	-226.87	837.24
8/26/2005	-1005.57	-755.34	-117.03	721.71	336.36	13.6	835.13	860.64	-16.18	278.76	539.43	301.65	-233.64	840.82
10/11/2005	-1033.08	-827.24	-199.79	654.9	284.17	7.2946	833.72	848.04	-26.29	273.5	537.36	299.33	-240.08	843.25
1/10/2006	-918.83	-858.03	-339.71	489.13	122.55	-48.55	810.18	815.92	-54.94	262.93	536.1	298.82	-234.11	855.77
4/9/2006	-901.14	-812	-289.67	510.35	123.88	-55.75	815.9	831.32	-58.19	267.19	540.25	311.97	-239.53	860
7/19/2006	-975.46	-709.09	-86.84	727.21	303.99	-3.19	876.46	899.71	-33.29	280.02	563.21	306.55	-235.87	865.96
10/18/2006	-1030.45	-848.40	-245.88	609.17	218.59	-17.57	872.05	872.96	-49.65	267.05	557.80	306.95	-246.77	873.58
1/18/2007	-1015.18	-915.62	-363.79	485.63	115.44	-53.84	856.23	849.07	-71.01	257.71	555.06	310.45	-258.05	878.10
4/19/2007	-904.71	-791.93	-272.27	527.72	122.40	-65.28	862.30	869.52	-74.95	259.50	564.85	305.74	-254.07	882.60
7/11/2007	-990.93	-694.73	-72.44	749.91	312.39	-2.99	910.88	934.53	-49.88	269.47	582.93	306.29	-251.96	888.31
10/20/2007	-1018.74	-786.18	-177.53	678.23	265.08	-13.72	915.47	922.26	-57.70	265.45	581.36	309.85	-259.55	895.13
1/7/2008	-932.03	-833.86	-321.36	513.46	112.58	-59.96	880.84	888.07	-82.44	252.01	576.25	309.48	-259.33	899.85
5/13/2008	-996.59	-767.07	-192.33	624.95	201.21	-38.80	905.64	926.40	-76.11	259.32	583.95	312.62	-259.90	906.34
7/29/2008	-1053.77	-718.38	-76.47	765.95	324.25	-0.78	940.74	969.80	-60.05	264.41	595.70	316.01	-256.75	910.18
10/30/2008	-1167.90	-922.92	-282.64	616.39	225.65	-17.33	923.18	942.58	-71.33	250.22	588.42	319.79	-262.90	917.28
1/12/2009	-1034.86	-891.22	-348.32	515.18	122.37	-59.518	897.501	919.106	-89.7253	244.0942	587.7935	315.77	-261.124	920.0501

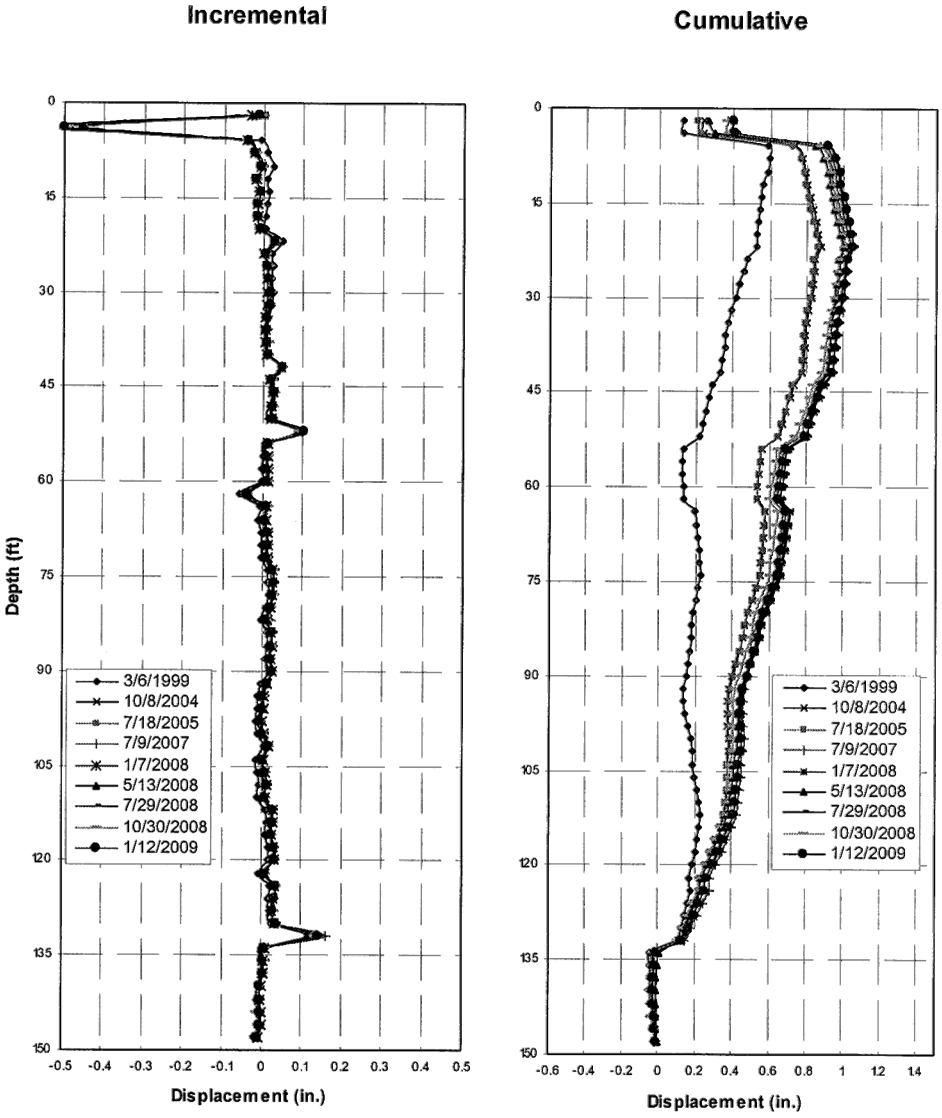
Shaft 9: Bending moment along shaft, kip-ft

Depth, ft / Date	11	17.5	24	30.5	37	43.25	50	60	70	80	95	115	135
7/1/1999	-67.89	-31.81	8.56	12.84	20.8	19.57	14.07	0.61	9.79	11.62	-33.33	18.35	26.3
1/8/2003	-347.44	-803.74	-998.93	-1106.33	-698.39	-903.77	-661.43	-353.18	324.27	-148.11	-1315.52	540.06	541.35
4/15/2003	-592.31	-919.8	-1050.61	-1133.34	-723.59	-939.66	-696.63	-369.12	336.59	-143.51	-1378.77	555.2	549.67
7/1/2003	-666.55	-902.38	-1016.77	-1090.93	-713.88	-914.42	-686.74	-395.16	340.01	-144.29	-1435.98	557.09	553.5
8/7/2003	-687.84	-917.2	-1003.18	-1072.98	-695.58	-886.87	-664.36	-384.64	352	-133.3	-1462.27	566.15	565.69
10/7/2003	-490.45	-863.81	-1007.81	-1107.14	-708.81	-891.63	-656.83	-378.93	360.91	-134.77	-1498.83	577.44	567.18
12/31/2003	-514.68	-913.27	-1054.9	-1163.2	-741.63	-949.18	-697.72	-421.12	390.01	-101.42	-1555.5	633.83	579.35
4/13/2004	-604.44	-966.22	-1090.5	-1188	-761.54	-987.22	-743.54	-446.54	402.54	-82.56	-1609.1	644.77	582.97
7/13/2004	-817.01	-1007.24	-1051.35	-1122.59	-730.91	-933.53	-709.92	-447.66	411.36	-83.06	-1648.19	649.1	585.94
10/8/2004	-674.74	-949.72	-1005.93	-1128.49	-732.6	-927.74	-697.54	-445.16	413.37	-90.78	-1677.71	652.24	581.64
1/7/2005	-572.76	-951.94	-1036.44	-1183	-760.9	-966.49	-718.51	-441.27	424.15	-94.18	-1699.91	657.05	573.07
4/8/2005	-773.86	-1039.72	-1072.89	-1200.56	-775.89	-989.82	-743.85	-446.59	435.56	-92.57	-1726.57	664.45	574.55
7/18/2005	-885.57	-1041.08	-1038.29	-1152.24	-752.36	-948.63	-719.09	-449.39	438.06	-89.12	-1762.02	670.82	576.24
8/26/2005	-835.5	-1020.01	-1028.45	-1146.98	-746.96	-933.35	-702.48	-447.31	442.02	-86.41	-1773.96	672.92	595.07
10/11/2005	-749.53	-997.4	-1026.45	-1157.47	-750.11	-932.26	-695.29	-445.61	446.57	-84.01	-1786.07	677.93	594.21
1/10/2006	-735.54	-1025.94	-1070.26	-1220.95	-784.71	-983.06	-728.35	-455.6	455.8	-79.41	-1811.1	694.94	585.21
4/9/2006	-761.63	-1055.46	-1104.66	-1250.13	-799.79	-1009.4	-750.25	-456.86	465.33	-75.95	-1830.39	709.25	584.13
7/19/2006	-986.65	-1097.57	-1069.44	-1182.51	-765.49	-967.32	-726.98	-458.20	468.35	-67.36	-1860.26	728.74	591.17
10/18/2006	-785.55	-1028.56	-1059.04	-1198.03	-770.44	-962.79	-714.95	-455.21	472.24	-63.08	-1878.38	742.33	587.52
1/18/2007	-652.26	-1012.08	-1093.82	-1249.92	-798.31	-1001.31	-738.72	-453.20	481.92	-62.15	-1891.06	749.16	583.45
4/19/2007	-878.81	-1101.41	-1131.14	-1269.03	-817.30	-1023.35	-760.98	-458.74	484.61	-55.95	-1908.23	757.20	587.07
7/11/2007	-1020.68	-1113.23	-1096.67	-1211.04	-787.54	-982.11	-738.79	-463.61	490.76	-47.79	-1930.33	760.68	591.55
10/20/2007	-959.39	-1084.45	-1073.44	-1199.41	-780.45	-961.01	-714.61	-460.69	495.15	-40.84	-1949.93	755.58	587.47
1/7/2008	-913.31	-1106.23	-1119.18	-1262.45	-816.00	-1007.26	-741.89	-466.44	500.87	-33.08	-1965.87	755.43	582.76
5/13/2008	-919.37	-1116.30	-1144.79	-1275.67	-828.86	-1025.45	-760.98	-473.48	501.61	-23.44	-1981.23	753.14	584.24
7/29/2008	-1028.17	-1130.81	-1113.35	-1223.79	-801.01	-987.62	-739.09	-483.79	512.25	-5.89	-2001.20	757.38	590.22
10/30/2008	-795.34	-1059.58	-1112.41	-1254.85	-817.39	-995.34	-732.06	-493.84	517.37	5.70	-2022.36	758.24	590.22
1/12/2009	-836.22	-1106.04	-1150.74	-1297.76	-843.09	-1034.72	-761.65	-500.28	517.27	10.26	-2032.78	756.89	590.85

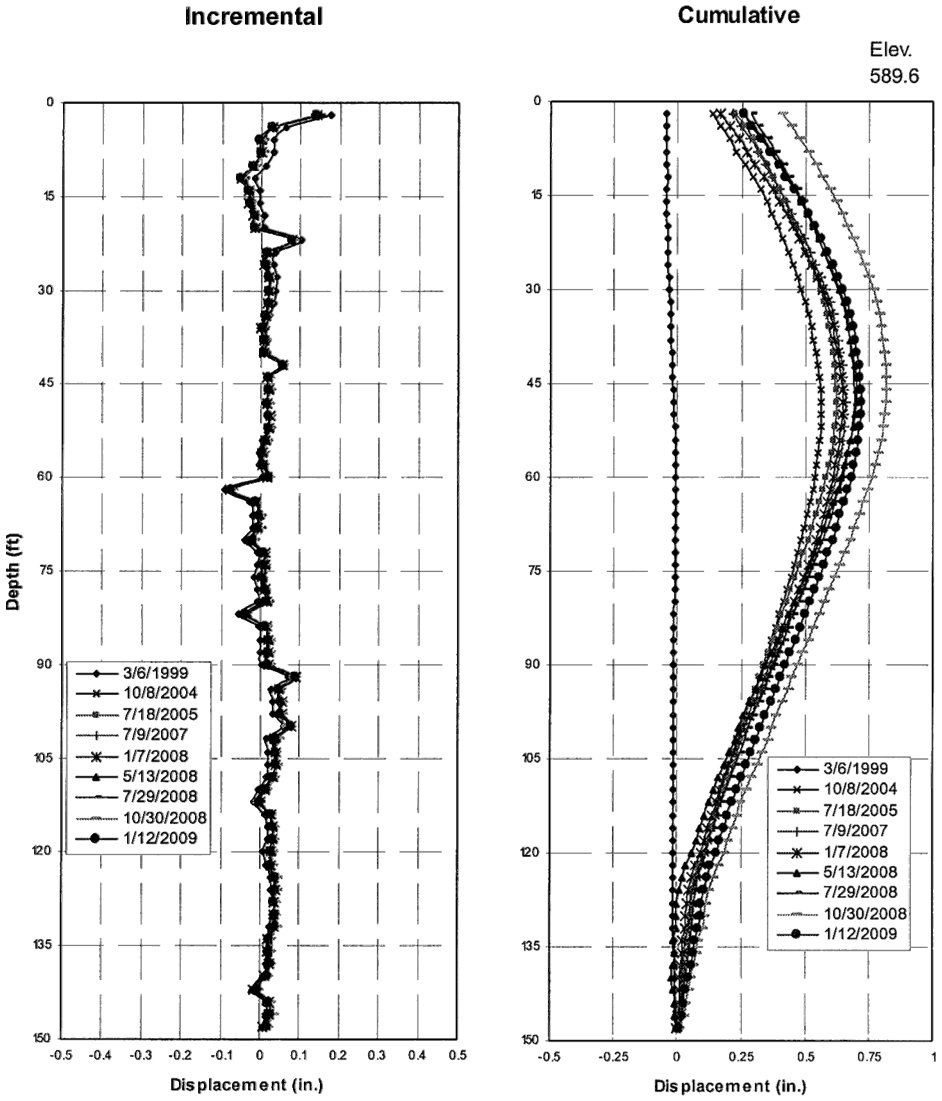
Inclinometer #1 Displacement in the A+ Direction
Downslope (Toward River direction) Base Line 12/11/1998



Inclinometer #3 Displacement in the A+ Direction
Downslope (Toward river direction) Base Line 12/11/1998

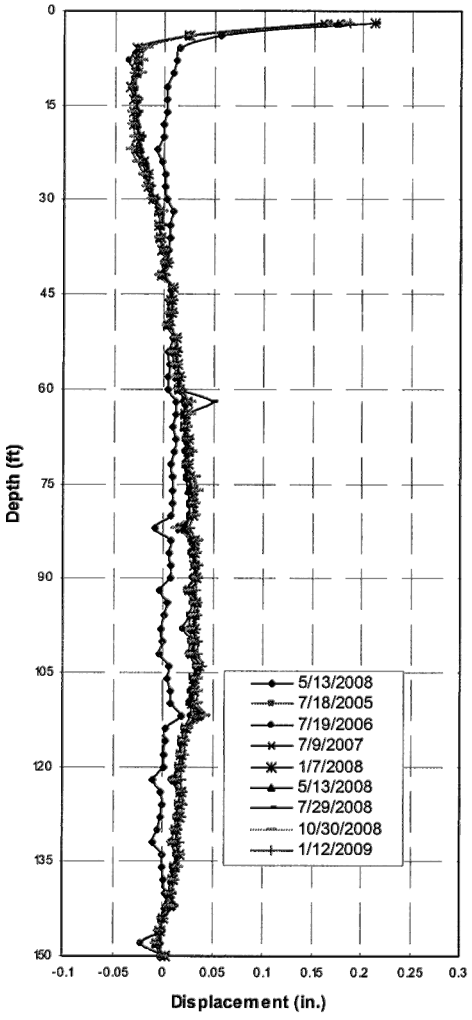


Inclinometer #8 Displacement in the A+ Direction
Downslope (Toward River direction) Base Line 12/11/1998

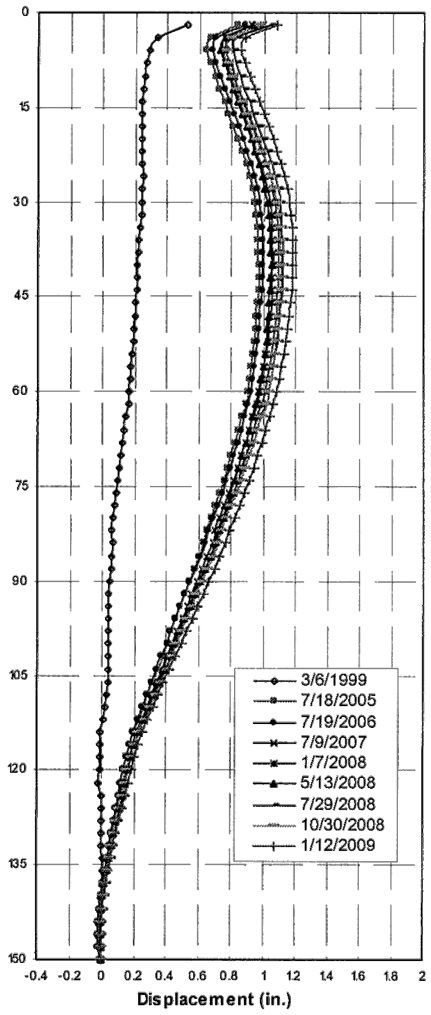


Inclinometer #9A Displacement in the A+ Direction
Downslope (Toward River direction) Base Line 12/11/1998

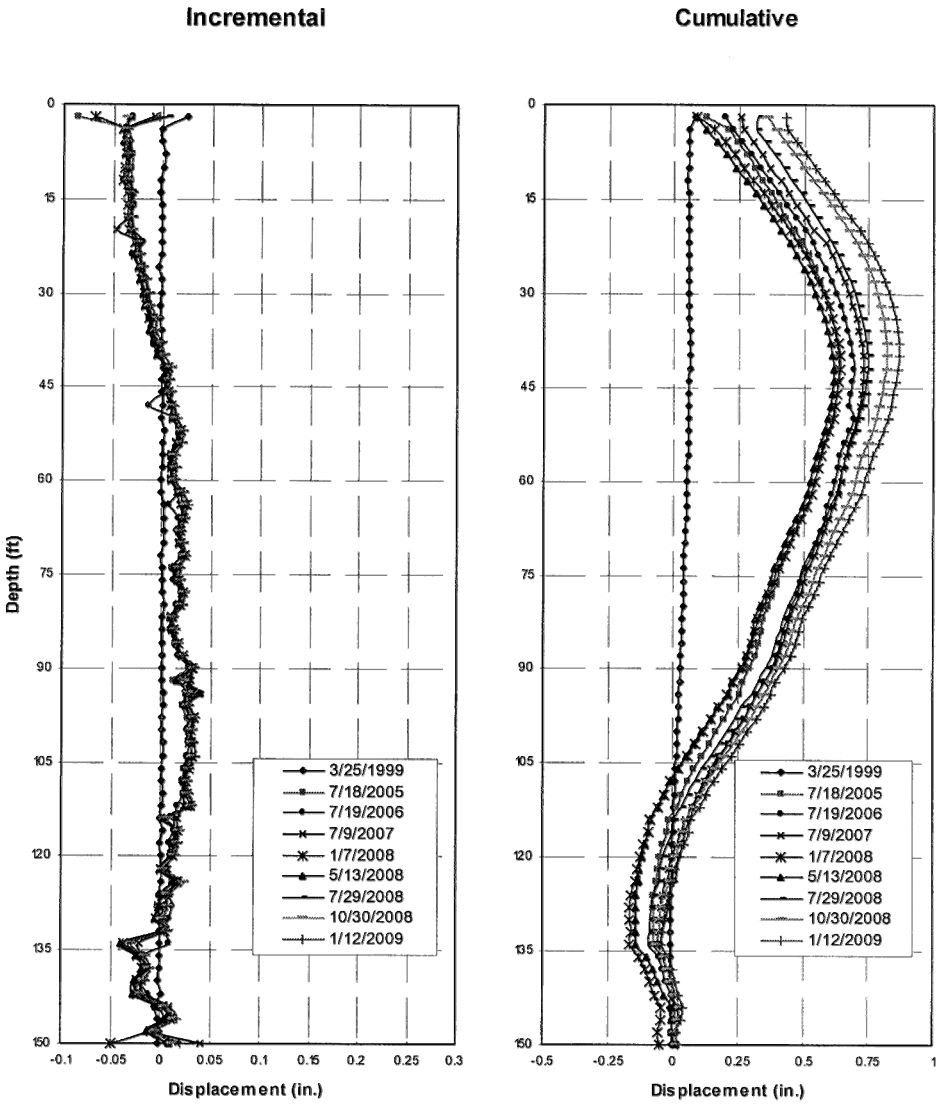
Incremental



Cumulative

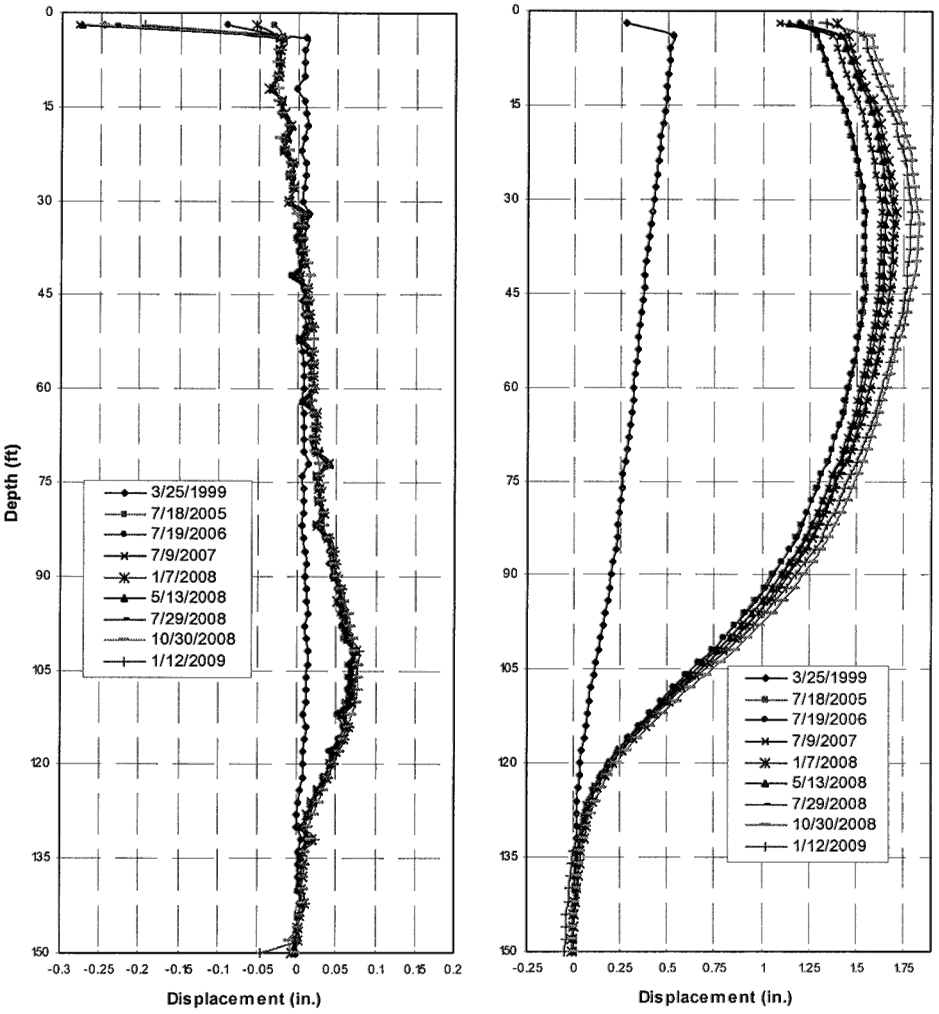


Inclinometer #10 Displacement in the A+ Direction
Downslope (Toward river direction) Base Line 12/11/1998



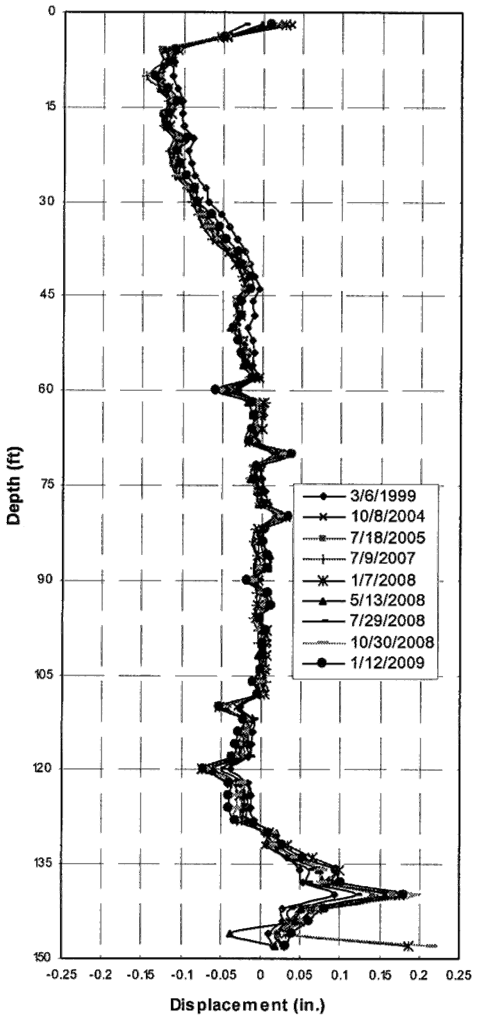
Inclinometer #17 Displacement in the A+ Direction
Downslope (Toward river direction) Base Line 12/11/1998

Incremental **Cumulative**

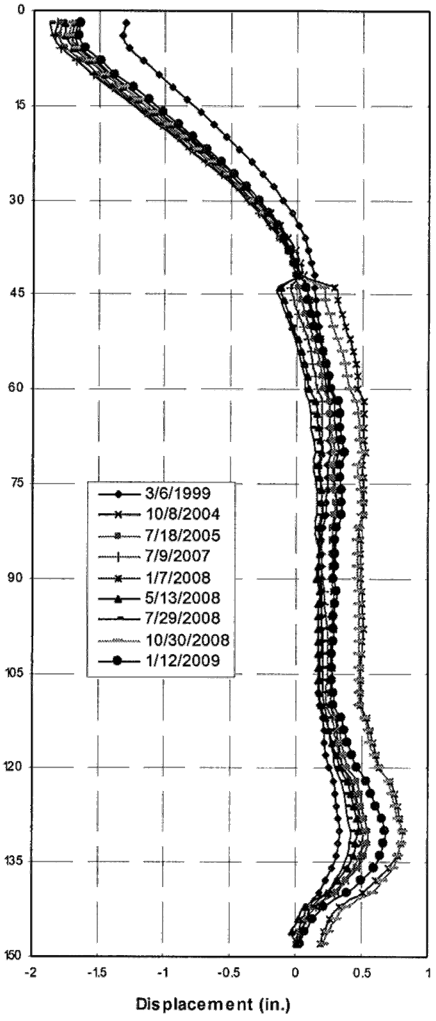


Inclinometer #1 Displacement in the B+ South Direction
(90 Deg Clockwise from A+ direction) Base Line 12/11/1998

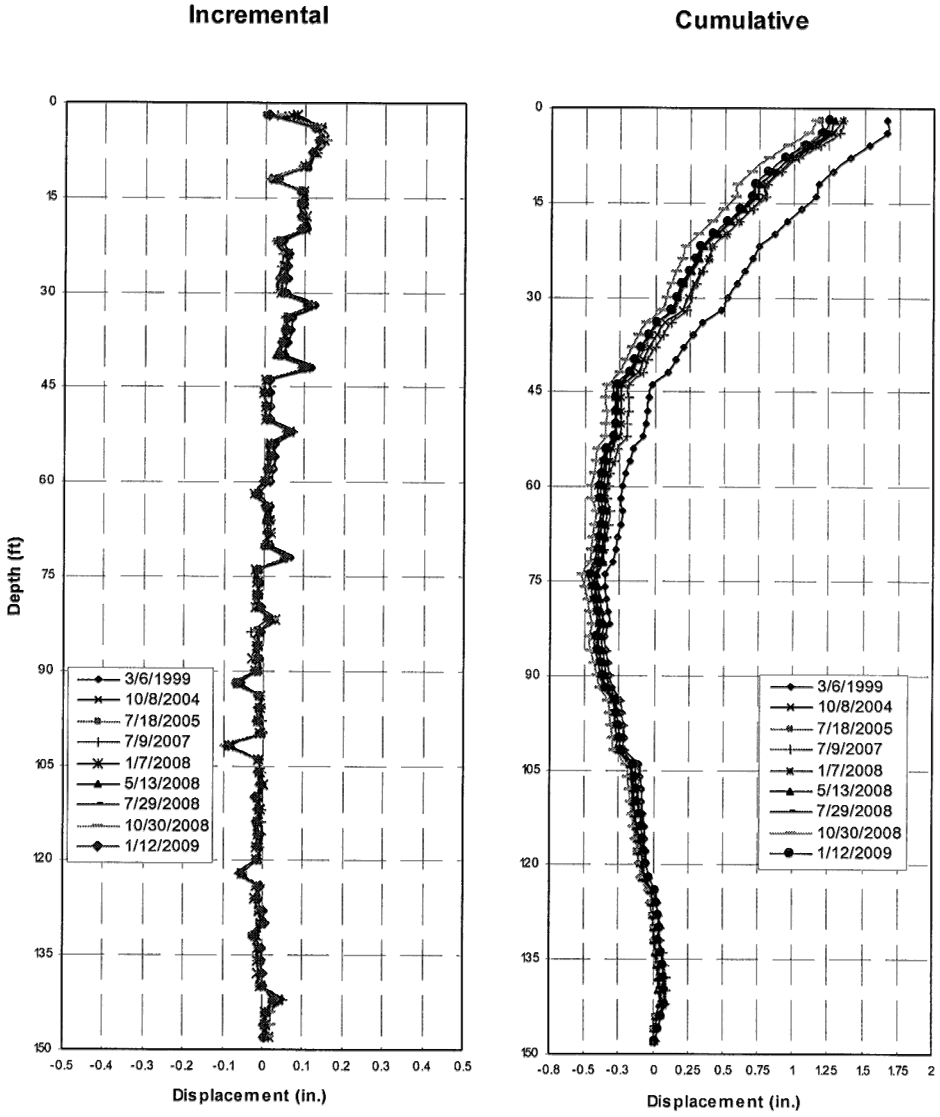
Incremental



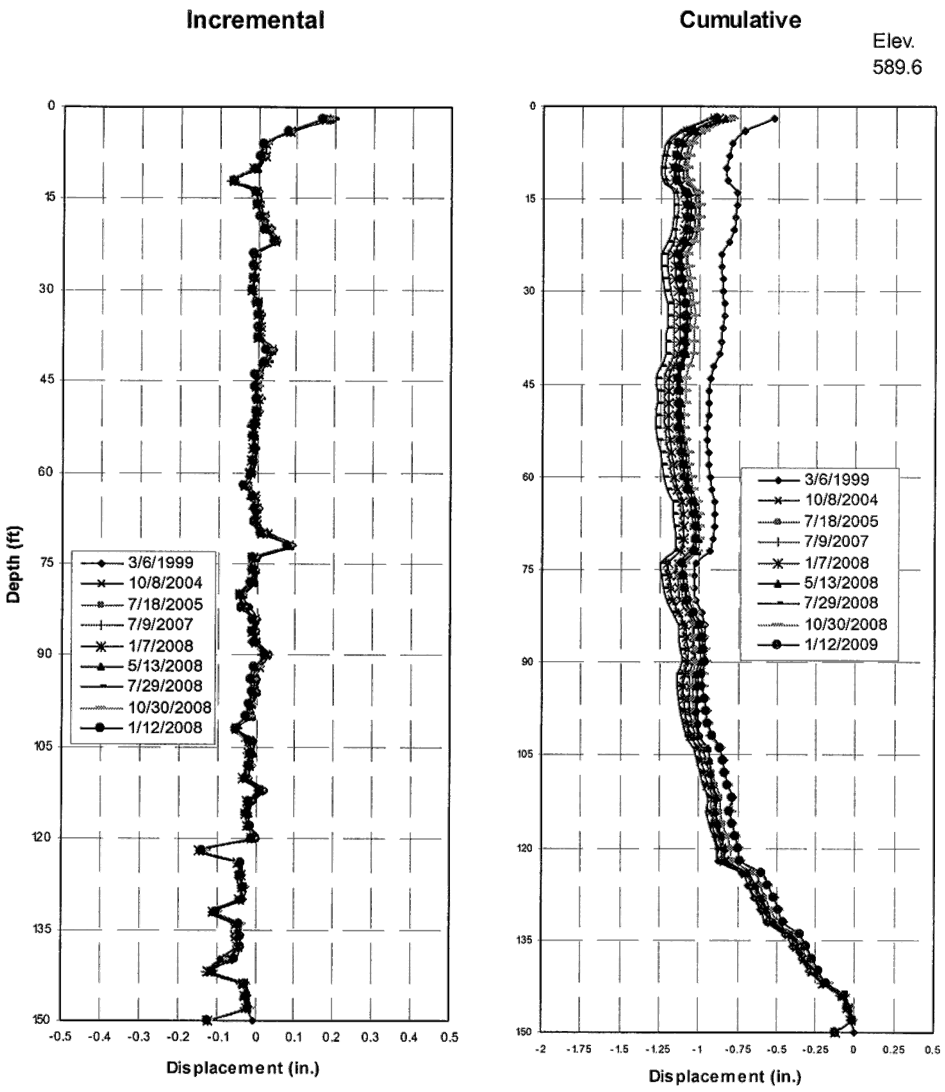
Cumulative



Inclinometer #3 Displacement in the B+ South Direction
(90 Deg Clockwise from A+ direction) Base Line 12/11/1998

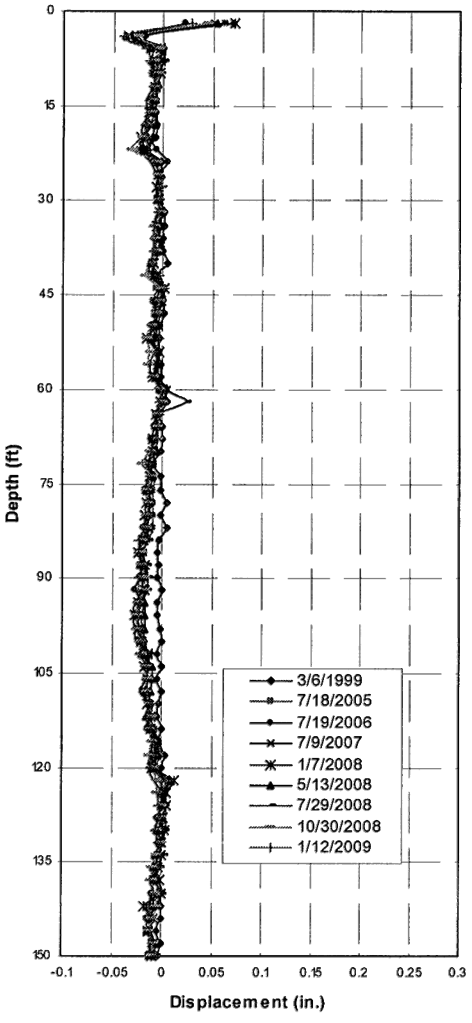


Inclinometer #8 Displacement in the B+ South Direction
(90 Deg Clockwise from A+ direction) Base Line 12/11/1998

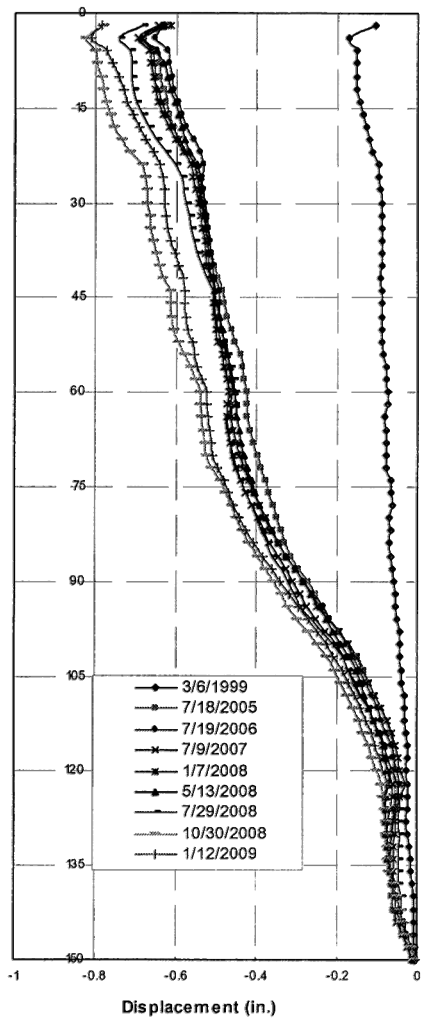


Inclinometer #9A Displacement in the B+ South Direction
(90 Deg Clockwise from A+ Direction) Base Line 12/11/1998

Incremental

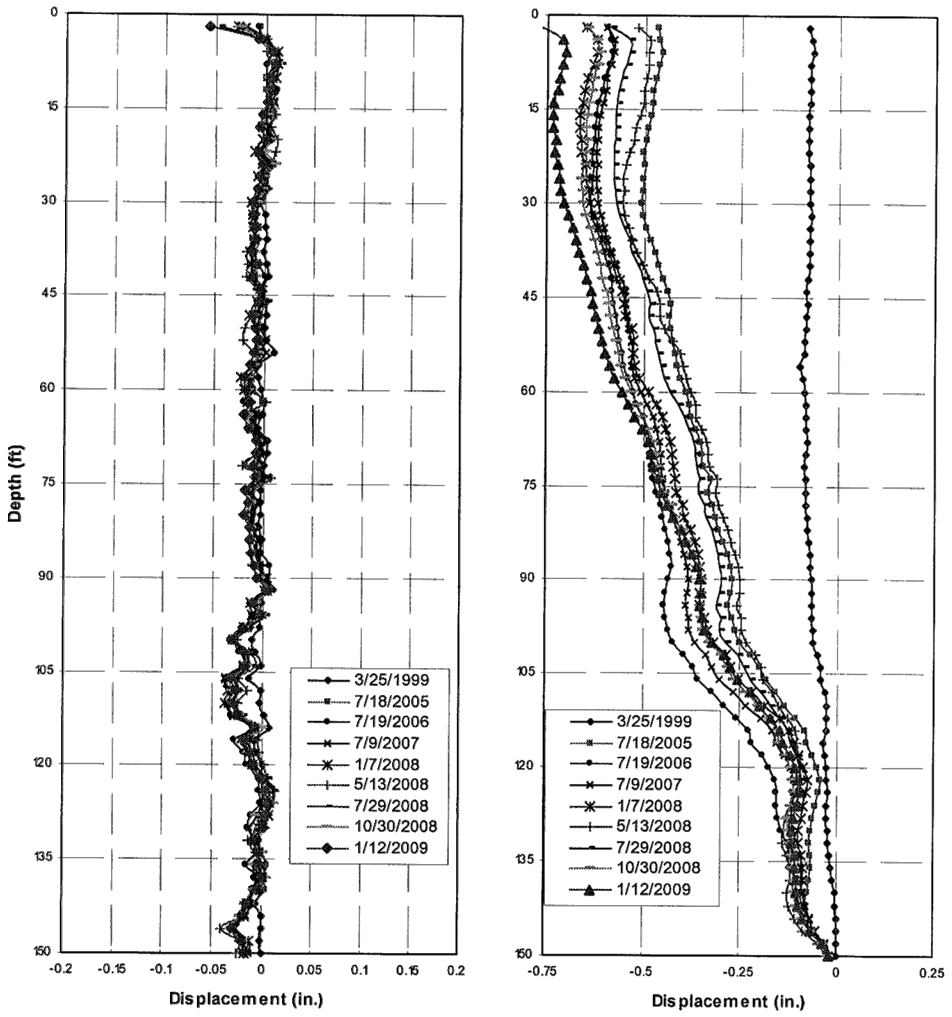


Cumulative



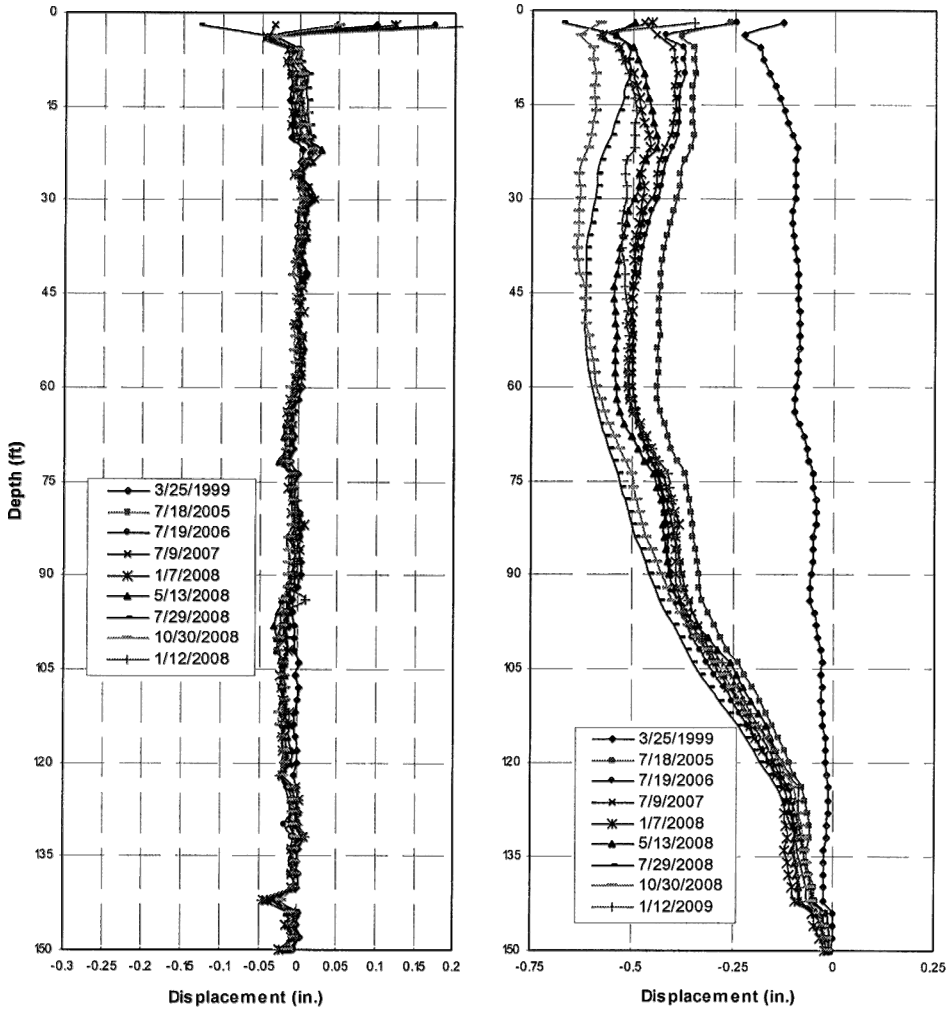
Inclinometer #10 Displacement in the B+ South Direction
(90 Deg Clockwise from A+ Direction) Base Line 12/11/1998

Incremental **Cumulative**



Inclinometer #17 Displacement in the B+ South Direction
(90 Deg Clockwise from A+ Direction) Base Line 12/11/1998

Incremental **Cumulative**



CUY-90-1524
Central Viaduct
PID No. 77332

Monitoring Services
Annual Report

July 23, 2009

RICHLAND ENGINEERING LIMITED
29 North Park Street, Mansfield, Ohio 44902-1769 • 419-524-0074 FAX 419-524-1812

106017

July 23, 2009

Ohio Department of Transportation
5500 Transportation Boulevard
Garfield Heights, Ohio 44125-5396

Attn: Mr. Mike Malloy

Re: CUY-90-1524
Central Viaduct
PID No. 20752
Slope and Pier Monitoring Services
Annual Report

Dear Mr. Malloy:

Enclosed are two (2) copies of the Monitoring Services Annual Report including the following information:

- BBC&M Engineering, Inc.'s Annual Report dated May 15, 2009 with information on the inclinometer and piezometer readings taken through April 2009.
- Richland Engineering Limited schematic drawings of span 1 and 2, north and south truss measurements; relative span lengths; seat elevations; tabulations of pier location data; and plots of pier location data through October 2008; and deck expansion joint openings through April 2009.
- A. Huckelbridge tiltmeter data for pier 1 and the west end pier from July 27, 1999 through April 17, 2009.
- R. Liang annual instrumentation monitoring report dated May 2009.
- CD containing electronic files of the letter and annual report in .pdf format.

Note: For discussion, North is assumed to the left, perpendicular to the local centerline of bridge, toward Lake Erie.

The slope monitoring began in 1994. The stabilization structure was constructed and the rock anchors were tensioned in April 1999. Site grading work was completed in May 1999. The span 1 superstructure was relocated in August 1999. The stabilization structure monitoring began in 1999. Additional slope monitoring north of the existing bridge began in 2006.

A study entitled "West End Slope and Substructure Evaluation," May 2005, was prepared by Richland Engineering Limited, BBC&M Engineering, Inc., Arthur Huckelbridge, and Robert Liang. The study was prepared for ODOT and evaluated the suitability of the existing west end pier, pier 1, west end slope, and slope stabilization structure for reuse in a rehabilitated structure.

The last report of data was the interim report submitted February 18, 2009 for data collected through January 2009. The last annual report was dated July 2, 2008, for data collected through April 2008. This report is for data collected through April 2009.

The span 1 superstructure was relocated again in May 2009.

We have the following observations on the data collected:

1. No shallow failure plane movement has been observed in the immediate vicinity of pier 1 since the pier stabilization structure was constructed. Shallow failure planes are evident in data from inclinometers B-203 and B-303. B-203 and B-303 are located upslope of pier 1 and show an average rate of movement at the shallow failure plane of 0.025 inches per year from 2004 to the present. The shallow failure plane is evident just outside the stabilization structure in inclinometers B-05-03 and B-108A, moving at an average rate of about 0.07 inches per year. Inclinometer B-05-16 to the north of pier 1 near the adjacent property bulkhead excavation shows a shallow failure plane moving at an average rate of 0.18 inches per year.

2. A deep failure plane is evident in data from inclinometers B-203, B-204, and B-303. B-203 and B-303 are located upslope of pier 1 and B-204 is located between the pier 1 legs. The average rate of movement at the deep failure plane in the area of pier 1 is 0.045 inches per year from 1999 to the present. The average rate of movement of the deep failure plane in the immediate vicinity and upslope from the pier 1 area appears to have decreased to about 0.03 inches per year from 2004 to the present.

3. Noticeable increased rates of movement have been observed in inclinometers near the south right of way fence (B-204, B-303, B-05-03, B-05-04, and B-105A) adjacent to the aggregate storage area. The rate increase has been observed since October 2007. The increased rates appear to correspond to larger aggregate storage piles.

4. The cantilever displacement of the top 60 to 70 feet of inclinometer B105A located south of pier 1 near the river dock wall, averaged about 1.32 inches per year between October 2007 and January 2009. No additional displacement was observed between January 2009 and April 2009. It appears the dock wall may be bulging or moving outward. The displacement may be due to slope movement and/or failure of the dock wall tiebacks.

5. Inclinometer B-101, at the top of the slope west of the west end pier, has shown no significant movement since it was installed.

6. Pneumatic piezometer readings have shown no significant change from previous readings. The maximum change in water elevation during the past year occurred in B-101 orange and varied by 3.7 feet. Piezometers B-105 pink and B-105 blue continue to indicate an elevated water pressure (i.e., a total head above the ground surface, artesian conditions).

7. Vibrating wire piezometer measured total head values remain relatively constant. The difference between maximum and minimum total head values has been no more than 2.3 feet in all of the vibrating wire piezometers. The piezometers have shown stable pore pressures.

8. The Calipered Crack Distance measurements at the top of the concrete slope protection by the west end pier show no significant change.

9. Aggregate piles of various sizes and locations in the area adjacent to the south right-of-way fence were observed during the quarterly visits. In July 2008, the largest aggregate pile since 2006 was observed located closer to the right of way than in 2006. In October 2008, the right of way fence had been knocked over by the aggregate pile spilling over onto the right of way. The aggregate pile was moved back by January 2009. The fence was repaired by April 2009.

10. A small landslide was observed in January 2007 located at the north right of way line on the west side of the river. The landslide is near the excavation performed for the dock wall repair on the adjacent property. There was no significant change in the landslide condition in the past year.

11. Comparing October 2008 survey measurements with October 2000 data, it appears that the west end pier and pier 1 have moved toward the river with the span 1 distance showing little change and the span 2 distance decreasing about 1 inch.

12. The position of the north and south west end pier legs have moved toward the river approximately 1.1 inches and 0.7 inches, respectively, since October 2000.

13. The position of the top of the north and south legs of pier 1 appear to have moved toward the river approximately 0.9 inches and 1.2 inches, respectively, since October 2000.

14. The drilled shaft structure appears to be rotating with the south end moving ahead of the north end about 0.9 inches since October 2000.

15. There has been no significant change in the pier seat elevations.

16. In 1999, truss span 1 and supported span 2 were relocated to the west to reopen the expansion joint in span 2. Since that relocation, maximum expansion joint openings were measured of 2.38 inches at the north curb and 1.88 inches at the south curb. During the past year the

openings varied from 0.50 inch to 2.00 inches at the north curb and 0.00 inch to 1.13 inch at the south curb for steel temperatures ranging between 7° and 83°F. Each location at the expansion joint moved differently and not directly proportional to the temperature change. It appears that about 0.6 inches of expansion opening had been lost since October 2000.

17. Tiltmeter readings on the west end pier and pier 1 have been steady for the past few years. There appears to be a systematic drift in the readings for tiltmeter #2 which may be electrical in nature.

18. The instrumentation readings in the rock anchors, driven piles, and tieback beams have been steady with only very small changes in values. The instrumentation readings in the drilled shafts have shown a continued increase in bending moments, however, the rate of change was very small. Inclinometers in the drilled shafts showed no significant movement over the past year.

19. The 17 rock anchors are made up of 16 strands of 0.6 inch diameter 270 ksi steel material. The anchors were initially tensioned to ±10% of the design load. Actual measured values in the 4 anchors being monitored were 490 kips to 600 kips at lock-off. After initial losses the anchors had a gradual reduction in load on the order of 3% to 9% in the first year. Present load levels in the anchors being monitored are 357 kips to 494 kips. The rock anchor loads continue to decrease at a very slow rate.

20. The 34 anchor structure piles are HP 14x89 steel piles. Actual measured values in the 5 piles being monitored were 374 kips to 478 kips for piles #17, 18, 19, and 34 with pile #1 measured at 615 kips. There is significant bending (up to 200 kip-ft.) in some of the piles at the gage locations. The gages are located at the top of the pile. The pile loads have increased very slowly since the stabilization structure was loaded.

21. The tiebacks that are being monitored between the anchor structure and the drilled shaft structure are W8x35 rolled steel sections. Actual measured values in the 5 tiebacks being monitored were 104 kips to 146 kips at the anchor structure end, and 42 to 118 kips at the drilled shaft structure end. There is significant bending (up to 52 kip-ft.) in the tiebacks at the gage locations at the ends of the tiebacks. There is less bending in the tiebacks at the drilled shaft structure end. The tieback loads increased with time for the first year, but have become steady over the past years. The tieback forces oscillate through one cycle in a year due to the seasonal change in temperature. The tieback forces are up to 15 kips higher during the winter than in the summer months.

22. There are seventeen 72 inch diameter reinforced concrete filled drilled shafts in the drilled shaft structure. Actual moments measured in the drilled shafts were a maximum of 2,000 kip-feet at a depth of 95 feet in Shaft #9. The moments in the drilled shafts have been increasing with time. It appears that the rate of increase may be slowing.

23. Dr. Liang has been monitoring inclinometers in 6 of the drilled shafts. The inclinometers indicate a gradual change in the deflection of the shafts with deflection at the top varying from

0.1 to 1.1 inches and the maximum deflection below the top of the shaft at 1.6 inches in the longitudinal direction. The shaft deflections have changed very little in the past year.

We have the following comments regarding the observations of the monitoring data:

1. There is movement at the shallow failure plane within the influence of the stabilization structure, but it is moving at a slower rate than the adjacent soil mass. The movement is at an average rate of about 0.04 inches per year since 1999. This rate appears to have decreased to about 0.025 inches per year from 2004 to the present.

2. There is movement at the deep failure plane within the influence of the stabilization structure. The average rate of movement at the deep failure plane outside the influence of the stabilization structure is about 0.03 inches per year. The average rate of movement within the pier 1 area is about 0.03 inches per year from 2004 to present.

3. The varying size of the aggregate storage pile in the area adjacent to the south right-of-way fence has a noticeable affect on the movement of the shallow failure plane south of pier 1 outside of the stabilization structure influence.

4. The tops of the west end pier and pier 1 legs moved toward the river and closed the span 2 expansion joint about 0.6 inches since October 2000. The span 1 superstructure was relocated again in May 2009. New locations and measurements will be documented in the next report.

5. Duplicate tiltmeters should be installed at tiltmeter #2 and 3 locations to improve the data that appears to have been affected by a systematic drift in the readings which may be electrical in nature.

6. The substructure stabilization structure was originally designed using "LPILE" computer software to calculate forces and member design loads. The Contractor was given loads and designed the rock anchors, anchor structure and tiebacks to resist those loads.

   Under a separate ODOT sponsored research project Dr. Robert Liang prepared a finite element analysis of the stabilization structure as it was being constructed ("Long Term Monitoring at CUY-90-1524 Bridge Project," December 31, 1999).

   The original design loads, the finite element analysis (FEA), and the range of measured values are compared in the attached table.

   a. Rock anchor loads are less than design and FEA values and generally continue to decrease at a slow rate.

   b. The loads in the piles are higher than expected. The anchor structure pile gages are located near the top of the piles in an area of localized bending. The combined axial load and bending may have exceeded the 36 ksi yield value of the steel. However, the piles will redistribute the load in the redundant system through yielding before failure would occur.

c. The axial tension in the tiebacks is less than the design load and slightly higher than the loads calculated by FEA. Again, combined axial loads and bending may approach yield at isolated locations, but the members would not fail.

d. The moment in the piles and tiebacks and the bending in the drilled shafts indicates a rotation of the anchor structure concrete cap about the transverse axis of the cap.

e. The drilled shaft measured moments and deflections are well below the design values. The increasing moments measured in the drilled shafts indicate increased bending in the shafts. The bending is expected as the soil mass lateral loading is gradually transferred to the drilled shafts. The rate of moment increase appears to be decreasing.

6. The stabilization structure is currently performing adequately with only some minor concern for the high loads in the anchor structure piles. The stabilization structure has slowed the rate of creep movement in the soil mass within its influence.

7. Loading and pressures within the stabilization structure and the influenced soil mass are continuing to increase at a very slow rate. The rate of change of moment in the drilled shafts has slowed. The stabilization structure was designed with the concept that the structure and soil mass would reach equilibrium at some time in the future when loads and deflections would remain constant. However, the "West End Slope and Substructure Evaluation Study" 2005, has suggested that the stabilization structure may have a finite life. The creep movement at the failure planes has historically moved at a very slow rate. The data collected over the past 10 years indicates that there is still movement at the failure planes. However, in the last few years this movement appears to be slowing.

8. There is continued construction activity scheduled in the area of the west end slope for repair of the existing Central Viaduct structure. It is recommended that the data collection and monitoring of the stabilization structure, bridge substructure locations, and ground movements be continued while the bridge is in service.

Monitoring has been authorized through 2009. The next readings are scheduled about July 15, 2009. The monitoring will continue by the same parties under the agreement between ODOT and Michael Baker Jr., Inc.

Please contact us if you have any questions (email reltd@r-e-l.com).

Very truly yours,

RICHLAND ENGINEERING LIMITED

Dean A. Palmer, P.E.

DAP:dap
cc: Craig Hebebrand, District 12
Dave Lastovka, District 12
Youssef Seif, District 12
Naureen Dar, District 12
Tim Keller, Office of Structures
Gene Geiger, Office of Geotechnical Services
Tom Lefchik, FHWA
Steve Pasternack, BBC&M Engineering, Inc., Dublin
Jeff Snyder, BBC&M Engineering, Inc., Valley View
Art Huckelbridge
Robert Liang
Rick Engel, E.L. Robinson Engineering Co.
Jeff Broadwater, Michael Baker, Jr., Inc.

COMPARISON OF MEMBER LOADS
DESIGN VALUES AND MEASURED VALUES
CUY-90-1524 SLOPE STABILIZATION STRUCTURE

MEMBER	DESIGN	FINITE ELEMENT ANALYSIS	January 2001 MEASURED	April 2003 MEASURED	April 2005 MEASURED	April 2007 MEASURED	April 2009 MEASURED
Rock Anchors	550 kips	550 kips	430 to 530 kips	380 to 501 kips	366 to 494 kips	361 to 501 kips	357 to 494 kips
Anchor Structure Piles							
Axial Load	279 kips	310 kips	358 to 566 kips	365 to 585 kips	368 to 603 kips	371 to 608 kips	374 to 615 kips
Moment	None	80 kip-feet	32 to 192 kip-feet	49 to 192 kip-feet	55 to 206 kip-feet	57 to 202 kip-feet	59 to 198 kip-feet
Tiebacks							
Axial Load - Anchor End	192 kips	100 kips	101 to 124 kips	108 to 134 kips	111 to 143 kips	110 to 143 kips	104 to 146 kips
Axial Load - Drilled Shaft End	192 kips	100 kips	58 to 111 kips	46 to 110 kips	40 to 112 kips	39 to 113 kips	42 to 118 kips
Moment - Anchor End	None	80 kip-feet	13 to 42 kip-feet	14 to 48 kip-feet	14 to 45 kip-feet	15 to 51 kip-feet	15 to 52 kip-feet
Moment - Drilled Shaft End	None	80 kip-feet	1 to 29 kip-feet	2 to 29 kip-feet	2 to 31 kip-feet	2 to 32 kip-feet	0 to 33 kip-feet
Drilled Shafts							
Deflection at Top	2.0 inch	0.4 inch	0.2 inch	-0.1 to 0.7 inch	0.1 to 1.0 inch	0.3 to 1.1 inch	0.4 to 1.2 inch
Maximum Deflection Below Top	4.0 inch	0.1 inch	0.4 inch	1.3 inch	1.5 inch	1.65 inch	1.7 inch
Maximum Moment	3,141 kip-feet	800 kip-feet	1,000 kip-feet	1,400 kip-feet	1,700 kip-feet	1,900 kip-feet	2,000 kip-feet
Maximum Axial Force	458 kips	420 kips	1,100 kips	3,000 kips	----	----	----

2008-2009 ANNUAL REPORT
FIELD MONITORING SERVICES
CUY-90-14.52/15.24
PID #77332
CLEVELAND, OHIO

Report to

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

Prepared by

BBC&M ENGINEERING, INC.
CLEVELAND, OHIO

May 2009

May 15, 2009
012-00946-300

BBCM
SOLUTIONS TO BUILD ON

Mr. Dean A. Palmer, P.E.
Richland Engineering Limited
29 North Park Street
Mansfield, Ohio 44902

Re: CUY-90-14.52/15.24 Bridge
2008-2009 Annual Report - Field Monitoring Services
PID No. 77332

Dear Mr. Palmer:

In accordance with our proposal dated February 1, 2006, BBC&M Engineering, Inc. (BBCM) has completed the field monitoring services during the period of July 2008 through April 2009 as part of the CUY-90-14.52/15.24 project. Quarterly reports were submitted to Richland Engineering Limited in August 2008, November 2008, and February 2009 for quarterly readings taken in July 2008, October 2008, and January 2009, respectively. A quarterly report was not submitted summarizing the data obtained in April 2009 per your instructions via an e-mail dated April 17, 2009. This annual report summarizes the data obtained from all the actively monitored instrumentation (inclinometers, piezometers, and calipered distance locations), discussions of observations of the data, and general site observations.

We appreciate being of continued service during this project. The next quarterly readings are scheduled to take place around July 15, 2009. Please contact our office if you have any questions or require additional information.

Sincerely,
BBC&M ENGINEERING, INC.
Cleveland, Ohio

Jeffrey L. Snyder, P.E.
Project Engineer

FOR

Stephen C. Pasternack, P.E.
Senior Project Engineer

cc: Mr. Jeff Broadwater, P.E. (Michael Baker Jr., Inc.)
Submitted: 2 hard copies (1 bound, 1 unbound) and 1 pdf copy to Richland Engineering Limited via e-mail, 1 pdf copy to Michael Baker Jr., Inc. via their ftp site

EXECUTIVE SUMMARY

Quarterly readings were taken at the new and remaining active inclinometers and piezometers in July 2008, October 2008, January 2009 and April 2009.

Inclinometers

In general, there are observed movements that correspond to two major slide planes, termed the shallow and deep failure planes.

In the immediate vicinity of the Pier 1 area, no shallow slip-plane movements have been observed since completion of construction of the Pier 1 stabilization system. The shallow failure plane upslope from the Pier 1 area (B-203 and B-303) is continuing to move at an average rate of about 0.025 inches per year from 2004 to the present. In the vicinity of Pier 1 just outside of the stabilization system (B-05-03 and B-108A), the shallow failure plane is moving at an average rate of about 0.07 inches per year. Well outside the Pier 1 area (B-05-16), the shallow failure plane is moving at an average rate of 0.18 inches per year which is a decrease from the rate of 0.26 inches per year reported in the 2007-2008 Annual Report. Furthermore, the rate of the shallow movement in B-05-16 has decreased to about 0.12 inches per year from January 2007 to the present.

South of the West End Pier (B-102 and B-107), the deep failure plane is continuing to move at an average rate of about 0.03 inches per year. In the Pier 1 area (B-203, B-204, B-303, B-05-03, B-05-04, B-105A and B-108A), the deep failure plane is moving at an average rate of about 0.03 inches per year from 2004 (or 2006 for new/replacement inclinometers) to the present. Well outside the Pier 1 area (B-05-16), the deep failure plane is continuing to move at an average rate of about 0.02 inches per year.

Noticeable increased rates of movements (between 160% and 667%) were observed in five (5) of the inclinometers (B-204, B-303, B-05-03, B-05-04, and B-105A) near the east right-of-way fence. Aggregate piles have been stored for many years in the property adjacent to the east right-of-way fence. The changes in the average rates of movement were most distinct in the B-05-03 inclinometer. In the deep failure plane evident in B-105A, this rate increase was observed between the October 2007 and January 2009 quarterly readings, which is consistent with the trends observed in the cantilevered displacement rates observed in B-105A discussed subsequently. In the other four (4) inclinometers, the rate increase was observed between the April 2008 and October 2008 quarterly readings. This trend of increased rates appears to have been a short term occurrence potentially caused by the changed conditions involving the aggregate piles (discussed subsequently) and/or the pore pressure changes observed in the piezometers at B-05-03 and B-303.

Cantilever displacement has been observed in B-105A to a depth of about 60 to 70 feet. The cantilever displacement rate from the time the inclinometer was installed in June 2006 to October 2007 was about 0.16 inches per year. **From about October 2007 to January 2009, the cantilever displacement rate significantly increased to about**

1.32 inches per year. Between January 2009 and April 2009, no additional displacement was observed. The bulkhead at this location may be progressively leaning outwards toward the Cuyahoga River. The small cantilever displacement that had been observed within the top 10 feet at B-05-03 in July 2008 increased in magnitude and depth (up to almost 20 feet) in the October 2008 quarterly reading indicating that the cantilever displacements observed at B-105A may be progressively extending further away from the Cuyahoga River thereby influencing B-05-03.

Pneumatic Piezometers

The readings for the pneumatic piezometers were similar between the four (4) quarters except the B-101 orange piezometer where the maximum change in total head was at least 3.7 feet. The B-105 blue piezometer indicated an elevated water pressure with the total head ranging from 4.4 to 5.5 feet above the existing ground surface. Additionally, the B-105 pink piezometer indicated an elevated total head ranging from 0.1 feet below to 2.2 feet above the existing ground surface. The highest pore pressure yet recorded for the given piezometer was observed at B-101 pink and B-107 orange in July 2008 and April 2009, respectively.

Vibrating Wire (VW) Piezometers

The measured total head values were relatively constant over the last four (4) quarters with a difference between maximum and minimum total head values of no more than 2.3 feet in all of the VW Piezometers. Between April 2008 and April 2009 (the current reporting period), eight (8) of the 18 piezometers exhibited the highest (peak) pore pressures for the given piezometers yet recorded. Additionally, in April 2009, the two piezometers at B-05-07 recorded the highest pore pressures at this location since the summer of 2006 (a few weeks after the piezometers were installed). In the piezometer at a depth of 135 feet in B-05-13, the total head over the reporting period was as high as 4.6 feet above the existing ground surface. Eight (8) non-functioning Miniloggers were replaced during the April 2009 quarterly readings.

Additional Field Observations

Aggregate piles of varying sizes and locations were observed on the property adjacent to the east right-of-way fence during each of the quarterly visits to the site. In July 2008, the largest aggregate pile since 2006 was observed to be located much closer to the bridge than the piles observed in 2006. In October 2008, the right-of-way fence was knocked over by the pile with portions of the pile spilling over into the I-90 right-of-way. In January 2009, the aggregate pile had since been moved farther away from the fence. Also, smaller aggregate piles were observed in October 2008 and January 2009 near the east end of the property. In April 2009, the aggregate piles were similar in size and location to the piles observed in January 2009 and the fence had since been repaired.

In April 2009, the small landslide area located near the west right-of-way fence just north of B-05-16 did not appear to have experienced a significant change since April 2008 except that there is currently less vegetation on the slope face.

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1.0 INTRODUCTION

This Annual Report presents the results and evaluation of data collected from July 2008 to April 2009 in instrumentation installed by BBC&M Engineering, Inc. (BBCM) at or near the West Abutment of the existing I-90 Central Viaduct (Innerbelt) Bridge.

Of the 14 inclinometers and 12 pneumatic piezometers installed by BBCM between 1994 and 1999, seven (7) inclinometers (B-101, B-102, B-107, B-203, B-204, B-303 and P-9N) and six (6) pneumatic piezometers (2 each at B-101 and B-105 and 1 each at B-107 and B-303) are still actively monitored. This active instrumentation is associated with the CUY-90-15.24 project. During the period of March 2006 through June 2006, BBCM installed 12 new inclinometers (including 3 replacement inclinometers) and 18 vibrating wire (VW) piezometers. These newly installed inclinometers and piezometers are associated with the CUY-90-14.52 Innerbelt project. A Summary Table and Site Plan of Active Instrumentation are submitted as Plates 1 and 2 of the Appendix. Quarterly readings were taken at the new and remaining active inclinometers and piezometers in July 2008, October 2008, January 2009 and April 2009.

1.1 Inclinometers and Piezometers Installed in 2006

The inclinometers B-105A, B-108A and B-05-16, installed between April 2006 and June 2006, are replacement inclinometers for B-105, B-108 and B-110, respectively. Baseline (initial) readings were taken at these replacement inclinometers in June 2006. New inclinometers were also installed at B-05-01 through B-05-04, B-05-07, B-05-08 and B-05-11 through B-05-13, between April 2006 and June 2006. Baseline (initial) readings were taken at these new and replacement inclinometers in June 2006.

New VW piezometers were installed in offset boreholes at B-05-01 through B-05-04, B-05-07, B-05-08 and B-05-11 through B-05-13, between May 2006 and June 2006. Two (2) VW piezometers were installed at each of the nine (9) locations. Readings are automatically taken generally every eight (8) hours and stored in portable data collectors called VW Miniloggers. Eight (8) of the VW Miniloggers were unresponsive or malfunctioning (i.e. not taking scheduled readings) and were replaced with new Miniloggers during collection of the April 2009 quarterly readings. Manual readings, which represent the pore pressures at the time of reading, were also taken at the locations where issues were encountered with the VW Miniloggers.

2.0 DISCUSSION OF INSTRUMENTATION DATA

2.1 Inclinometers

Spiral (twist) measurements were performed in January 2005 on the 10 inclinometers that were active at the time. Spiral measurements were also performed in June 2006 on the 12 new/replacement inclinometers. All the data sets presented in the Appendix have been corrected to account for the measured spiral of the inclinometer casings.

The Cumulative and Incremental Displacement vs. Depth plots in the Appendix show one reading from each of the previous four quarters. Additionally, the Displacement vs. Time plots include at least one reading from each year since the baseline readings.

Lateral deflections from slope inclinometer measurements contain both random and systematic errors. Durham Geo Slope Indicator Company provides typical displacement accuracy threshold for slope inclinometer measurements as follows:

1) Ordinary precision of ± 0.3 inches per 100 ft of casing using standard installation procedures;
2) Higher Precision of ± 0.1 inches per 100 ft of casing with careful survey practices and error correction during data reduction; and,
3) Highest Precision of ± 0.05 inches per 100 ft of casing with careful survey and data selection from redundant data sets and excellent casing installation.

BBCM considers the inclinometer measured displacement data presented herein to have a precision in the range of ± 0.1 to ± 0.2 inches per 100 ft. Hence, any measured displacement (especially along deep failure planes) on the order of about 0.1 inches could be due to data precision errors and not actual field movements. The actual estimated rates of slope movement in active inclinometers generally range from about 0.01 inches per year to 0.18 inches per year on the two slide planes.

The rates of movement were computed using linear regression for the depth ranges shown on the Displacement vs. Time plots in the Appendix. The rates of movement are discussed in more detail in Sections 2.1.2 of this report. Linear regression provided a best-fit match through the data points on each of the Displacement vs. Time curves. Typically, the rates of movements in the inclinometers last exhibited a significant change in 1999 or 2000 just after the end of construction of the Pier 1 stabilization system. However, readings from many of the inclinometers have indicated that the rates of movements have somewhat decreased from 2004 to the present. For the inclinometers installed before 2000, the time period(s) for the linear regression (see the time periods presented in Tables 1a and 1b in Section 2.1.2) are provided from 1999 or 2000 to the present as well as 2004 to the present for comparison. The decreased rate of movement likely indicates that greater load is being transferred from the creeping soil mass to the stabilization system. Noticeable and apparently short term increased rates of movements were observed in five (5) of the inclinometers near the east right-of-way fence. These rate changes are discussed in more detail in Section 2.1.2. In the other inclinometers, no significant changes in the rates of movement have been observed in the shallow or deep failure planes.

In general, there are observed movements that correspond to two major slide planes, termed the shallow and deep failure planes. In some of the inclinometers, multiple slide planes may be observed within the shallow or deep failure zones (i.e. B-203, B-303 and B-05-16). In such cases, the multiple slide planes have been grouped together and referred to as part of either the shallow or deep failure plane, whichever is deemed more appropriate. Consequently, the magnitude and rate of movements subsequently

discussed are the summation of the relative movements of the individual slide planes within either the shallow or deep failure plane. This summation is performed in an attempt to quantify the total relative soil movement that would be transferred to a pier or the stabilization structure.

2.1.1 Systematic Error Correction

Systematic errors are correctable errors observed in inclinometer data and are caused by one or more of the following factors: sensor bias-shift, rotation (sensor alignment shift), sensitivity drift, depth positioning error, and casing inclination/curvature. The data presented in this report have been analyzed and corrected for bias-shift, rotation and depth positioning error, where necessary.

2.1.2 Summary of Observed Movements

Tables 1a and 1b below summarize the average rates of movement for the shallow and deep failure planes and the various time ranges chosen for each active inclinometer where consistent movement trends have been observed. The time ranges shown in these tables extend to the last set of readings taken within each respective inclinometer. The inclinometers where movements have been observed have been divided into five (5) categories based on location as follows: 1) the immediate vicinity of the Pier 1 area, which includes the inclinometers within the Pier 1 stabilization system (B-204, B-05-04); 2) vicinity of Pier 1, which includes inclinometers just outside of the Pier 1 stabilization system (B-05-03, B-105A, B-108A); 3) upslope from Pier 1 (B-203, B-303); 4) south of the West End Pier (B-102 and B-107); and, 5) well outside the Pier 1 area (B-05-16).

Table 1a: Average Rate of Movement in Inclinometers – Shallow Failure Plane

Inclinometer	Location	Time Range (1999-2009)	Avg. Rate of Movement (in/yr)	Time Range (2004[1]-2009)	Avg. Rate of Movement (in/yr)
B-203	Upslope from Pier 1	Apr-99 to Apr-09	0.03	Oct-04 to Apr-09	0.015
B-303	Upslope from Pier 1	Apr-99 to Apr-09	0.055	Jan-04 to Apr-09	0.035
Avg. Rate of Movement – Upslope from Pier 1			**0.04**		**0.025**
B-05-03	Vicinity of Pier 1	N/A	N/A	Jun-06 to Apr-09	0.12
B-108A	Vicinity of Pier 1	N/A	N/A	Jun-06 to Apr-09	0.025
Avg. Rate of Movement – Vicinity of Pier 1			**N/A**		**0.07**
B-05-16	Well Outside Pier 1 Area	N/A	N/A	Jun-06 to Apr-09	0.18
				Jan-07 to Apr-09	0.12

1 Time range of 2006-2009 for new inclinometers installed in 2006.

Table 1b: Average Rate of Movement in Inclinometers – Deep Failure Plane

Inclinometer	Location	Time Range (1999[1]-2009)	Avg. Rate of Movement (in/yr)	Time Range (2004[2]-2009)	Avg. Rate of Movement (in/yr)
B-102	South of West End Pier	Oct-99 to Apr-09	0.04	N/A[3]	N/A[3]
B-107	South of West End Pier	Apr-00 to Apr-09	0.015	N/A[3]	N/A[3]
Avg. Rate of Movement – South of West End Pier			**0.03**		**N/A**
B-204	Immediate Vicinity of Pier 1 Area	Aug-01[4] to Apr-09	0.04	Jan-04 to Apr-09	0.025
B-05-04	Immediate Vicinity of Pier 1 Area	N/A	N/A	Jun-06 to Apr-09	0.02
B-05-03	Vicinity of Pier 1	N/A	N/A	Jun-06 to Apr-09	0.07
B-105A	Vicinity of Pier 1	N/A	N/A	Jun-06 to Apr-09	0.04
B-108A	Vicinity of Pier 1	N/A	N/A	Jun-06 to Apr-09	0.02
B-203	Upslope from Pier 1	Apr-99 to Apr-09	0.025	Oct-04 to Apr-09	0.01
B-303	Upslope from Pier 1	Apr-99 to Apr-09	0.07	Jan-04 to Apr-09	0.03
Avg. Rate of Movement – Pier 1 Area			**0.045**		**0.03**
B-05-16	Well Outside Pier 1 Area	N/A	N/A	Jun-06 to Apr-09	0.02

1 The time range generally begins in 1999 or early 2000 (i.e., B-107).
2 Time range of 2006-2009 for new inclinometers installed in 2006.
3 Change of rate not observed in these inclinometers from 2004 to the present.
4 Inclinometer reinitialized on the shown date, which does not necessarily indicate the date when a significant change in the rate of movement occurred.

In the inclinometers installed before 2000, the rates of movements from 1999 to the present for the shallow and deep failure planes have either remained the same or decreased slightly compared to the rates reported in BBCM's 2007-2008 Annual Report for Field Monitoring Services dated May 2, 2008. The rates of movements last significantly changed in these older inclinometers around 1999 shortly after construction of the stabilization system was completed. As indicated in Tables 1a and 1b, the rates of movements generally decreased from 2004 to the present in the inclinometers installed before 2000 in the Pier 1 area. However, the two (2) inclinometers (B-05-03 and B-108A) in the Pier 1 area indicate the shallow failure plane just outside of the Pier 1 stabilization system is currently moving at an average rate higher than observed in the older inclinometers from 1999 to the present.

The rates of movements from 2006 to the present in the shallow and deep failures in B-05-03 and the deep failure plane in B-05-04 increased compared to the rates reported in

the 2007-2008 Annual Report. This is contrasted by a slight rate decrease observed in B-108A compared to the rate reported in the 2007-2008 Annual Report. The increased rates of movement in B-05-03 and B-05-04 are due to a short-term rate increases observed in these inclinometers, subsequently discussed. The average rate of movement of the deep failure plane in the Pier 1 area from 2004 (2006 in the new inclinometers) to the present has increased slightly to 0.03 inches per year compared to 0.02 inches per year reported in the 2007-2008 Annual Report, particularly due to the large short term increase in the rate of movement observed in B-05-03.

No shallow slip-plane movements have been observed in the inclinometers within the Pier 1 stabilization system (B-204 and B-05-04) since completion of construction of the stabilization system.

The complexity of the depths, locations, and orientations of the shallow and deep movements in the inclinometers indicates that there are likely multiple deep and shallow failure planes at the site.

Discussion of Slope Movement Rate Changes

As discussed previously, noticeable increased rates of movements were observed in five (5) inclinometers including B-204, B-303, B-05-03, B-05-04, and B-105A. In the deep failure plane evident in B-105A, this rate increase was observed between the October 2007 and January 2009 quarterly readings, which is consistent with the trends observed in the cantilevered displacement rates observed in B-105A discussed subsequently. In the other four (4) inclinometers, the rate increase was observed between the April 2008 and October 2008 quarterly readings. This trend of increased rates may have been a short term occurrence as it did not appear to continue between the October 2008 (January 2009 at B-105A) and April 2009 quarterly readings as summarized in Table 2 on the next page.

In Table 2, the rates of movement have been summarized for the five (5) inclinometers over three (3) time ranges including before, during and after the times when the rates appeared to have changed which corresponds to time ranges #1, #2 and #3, respectively.

The changes in the average rates of movement were most distinct in the B-05-03 inclinometer. Also, the deep failure plane of B-05-03 exhibited the largest increase in the rate of movement (667% between time ranges #2 and #1). As discussed in Section 3.4, a crack is present in the concrete pavement adjacent to B-05-03 (see Plate 84 of the Appendix). This crack may be caused by the slope movements in this area as observed in B-05-03. The failure planes at B-05-03 are moving at a generally higher rate than other inclinometers in the Pier 1 area (see Tables 1a and 1b).

Table 2: Summary of Rate Changes in Some Inclinometers – CUY-90-15.24

Inclinometer	Failure Plane	Time Ranges Evaluated	Avg. Rate of Movement within Time Range (in/yr)	Percentage Increase in the Avg. Rate of Movement Compared to Time Range #1 (%)
B-204	Deep (117'-119')	#1 - Jan 04 - Apr 08	0.025	--
		#2 - Apr 08 – Oct 08	0.065	160
		#3 - Oct 08 – Apr 09	Negligible/Negative[1]	--
B-303	Deep (95'-99')	#1 - Jan 04 - Apr 08	0.03	--
		#2 - Apr 08 – Oct 08	0.095	217
		#3 - Oct 08 – Apr 09	Negligible/Negative[1]	--
B-05-03	Shallow (35'-39')	#1 - Jun 06 - Apr 08	0.075	--
		#2 - Apr 08 – Oct 08	0.30	300
		#3 - Oct 08 – Apr 09	0.06	--
	Deep (123'-125')	#1 - Jun 06 - Apr 08	0.03	--
		#2 - Apr 08 – Oct 08	0.23	667
		#3 - Oct 08 – Apr 09	0.01	--
B-05-04	Deep (117'-119')	#1 - Jun 06 - Apr 08	0.015	--
		#2 - Apr 08 – Oct 08	0.055	267
		#3 - Oct 08 – Apr 09	0.01	--
B-105A	Deep (105'-111')	#1 - Jun 06 – Oct 07	0.015	--
		#2 - Oct 07 – Jan 09	0.065	333
		#3 – Jan 09 – Apr 09	Negligible/Negative[1]	--

1 The rate of movement is either negative, which is not realistic, or negligible. Time Range #3 is based only on 2 to 3 quarterly readings. Several more readings are needed to better define the current rate of movement. As such, negligible/negative rates of movements may be caused by the limitations of the accuracy of the instrumentation as discussed in Section 2.1.

At B-05-03 and B-05-04, the rates for time range #3 are similar to those observed in time range #1 prior to the short term rate increase. However, the rates of movements for time range #3 are based limited data (2 or 3 readings) and may not reflect the current rates of movements due to limitations in the accuracy of the instrumentation (see Note 1 of Table 2). Note that all five (5) inclinometers summarized in Table 2 are located underneath or east of the existing I-90 bridge near the east right-of-way fence where aggregate piles of variable sizes have been stored for many years. The aggregate piles observed in January 2009 and April 2009 were not as large and were located farther away from the right-of-way fence than was observed during the July 2008 and October 2008 quarterly readings. A more detailed discussion regarding these aggregate piles is provided in Section 3.2. The decline from the possible short term increases in the rates of movements in these five (5) inclinometers may be a result of

the changed conditions involving the aggregate piles and/or the pore pressure changes observed in the piezometers at B-05-03 and B-303.

Additional Observations in Active Inclinometers Installed between 1994 and 1999

The B-101 inclinometer has indicated nominal movement since its installation. The inclinometer at P-9N (installed in one of the drilled shafts) indicates the top of the drilled shaft is restrained laterally and that the maximum lateral deflection is about one (1) inch and occurs approximately 40 to 60 feet below the top of the inclinometer casing.

It is possible that the inclinometer at B-303 will need to be abandoned within the next few quarterly readings as it has become somewhat difficult to lower and raise the inclinometer probe past the "kink" in the pipe that has developed within the deep failure plane at a depth of about 95 feet.

Additional Observations in Active Inclinometers Installed in 2006

The rates of movement of the shallow slide planes in B-05-16 combine to be about 0.18 inches per year, which is higher than the rates of movements observed in the shallow slide plane in other inclinometers at the site but a decrease from the rate of 0.26 inches per year as reported in the 2007-2008 Annual Report. Furthermore, the rate of the shallow movement in B-05-16 has decreased to about 0.12 inches per year from January 2007 to the present. Boring B-05-16 is located in close proximity to the open excavation in the vicinity of the removed B-110 inclinometer (see Section 3.3). As discussed in Section 3.3, no significant change has been observed over the past year in the scarps, tension cracks and ground settlement in the area downslope of the inclinometer.

Cantilever displacement has been observed in B-105A to a depth of about 60 to 70 feet (see Plates 22 and 23 in the Appendix). A Displacement vs. Time plot for B-105A has been submitted as Plate 26 in the Appendix. The cantilever displacement rate from the time the inclinometer was installed in June 2006 to October 2007 was about 0.16 inches per year. **From about October 2007 to January 2009, the cantilever displacement rate significantly increased to about 1.32 inches per year.** Between January 2009 and April 2009, no additional displacement was observed. The bulkhead at this location may be progressively leaning outwards toward the Cuyahoga River. Site photos showing the bulkhead adjacent to B-105A have been submitted as Plates 69 through 73 in the Appendix. It appears that there may be a bulge in the bulkhead as shown on Plates 69, 70 and 73. In April 2009, there was an approximate 3-foot dip in the ground surface observed immediately behind the bulkhead (see Plate 71) which would also indicate the bulkhead is moving outwards.

The small cantilever displacement that had been observed within the top 10 feet at B-05-03 in July 2008 increased in magnitude and depth (up to almost 20 feet) in the October 2008 quarterly reading. This change indicates that the shallow movements (cantilever displacement) in B-105A may be progressively extending further away from

the Cuyahoga River thereby influencing B-05-03. No noticeable change in the cantilever displacement in B-05-03 has been observed since October 2008.

The deep-seated displacement at 117 feet in B-05-04 listed in Table 1b is identical with the depth of the observed slide plane in the B-204 inclinometer, which is located less than 10 feet away from B-05-04. The movement rate of this displacement in B-05-04 (0.02 in/yr) is slightly lower than the rate of movement observed in B-204 (0.025 in/yr).

In addition to the observed slide planes in the new and replacement inclinometers reported in Tables 1a and 1b, potential slope movements not yet developed enough to be called definitive slide planes (i.e., movements that have not been consistent and/or are still within the limits of the accuracy of the instrumentation) have been observed in some of the inclinometers, which are listed as follows:

- In B-105A, depth of about 85 feet (see Plate 22 in the Appendix); and,
- In B-05-02 at depths of 45, 109 and 129 feet (see Plate 30 in the Appendix).

Additional readings are needed in these inclinometers to evaluate whether these potential slide planes are true displacements.

Other apparent movements in the new and replacement inclinometers are generally inconsistent from reading to reading or are unrealistic (i.e., movement upslope) and may be caused by systematic and/or random errors.

2.2 Piezometers

Tables 3 and 4 provided in the following sections present a summary of the measured total head (h_t) for each pneumatic or VW piezometer. Additionally, plots of Total Head vs. Time are provided in the Appendix. The total head (h_t) is calculated using the following equations:

$$h_t = h_e + h_p$$
$$h_p = u/\gamma_w$$

where h_e is the elevation head (elevation where the piezometer was installed), h_p is the pressure head, u is the pore pressure reading, and γ_w is the unit weight of water. The pore pressure readings (u) are measured and recorded in units of pounds per square inch (psi). The remaining variables of these equations (h_e, h_p, h_t, and γ_w) are in units of feet and pounds requiring u to be converted to pounds per square foot (psf).

2.2.1 Pneumatic Piezometers

The results of the active pneumatic piezometer readings taken over the last four (4) quarters are summarized in Table 3. Pneumatic piezometers are identified both by boring number and ribbon color to specify the location and depth of the instrumentation.

Table 3: Summary of Readings for Active Pneumatic Piezometers – CUY-90-15.24

Piezometer Identifier		Ground Surface Elevation (ft)	Elevation Head, h_e (ft)	Pore Pressure Readings (u) and Computed Total Head (h_t) Values				
				Piezo. Data	Jul 14-16, 2008	Oct 14-15, 2008	Jan 12-22, 2009	Apr 16, 2009
B-101 (P-1[1])	orange	676.6	626.3	u (psi)	0.9	0.7	1.6	0.0[2]
				h_t (ft)	628.4	627.9	630.0	626.3
	pink	676.6	552.3	u (psi)	32.5	32.2	31.8	32.1
				h_t (ft)	627.3	626.6	625.7	626.4
B-105 (P-3[1])	pink	585.6	497.6	u (psi)	39.1	38.3	38.1	38.8
				h_t (ft)	587.8	586.0	585.5	587.1
	blue	585.6	479.9	u (psi)	48.2	47.8	47.7	48.1
				h_t (ft)	591.1	590.2	590.0	590.9
B-107 (P-5[1])	orange	662.3	562.3	u (psi)	26.1	25.8	25.5	26.3
				h_t (ft)	622.5	621.8	621.1	623.0
B-303 (P-2[1])	pink	627.0	586.2	u (psi)	6.9	7.1	6.6	6.8
				h_t (ft)	602.1	602.6	601.4	601.9

1 BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers.
2 Pneumatic piezometers *cannot* read negative pressure (i.e., a water level below the depth of the pneumatic piezometer). Thus, it is unknown whether this is an accurate pressure reading.

The readings for the pneumatic piezometers were similar between the four (4) quarters except the B-101 orange piezometer where the maximum change in total head was 3.7 feet (or more, see Note 2 of Table 3) between the four (4) quarters. The maximum change in total head for the other pneumatic piezometers varied by as much as 2.3 feet between the four (4) quarters. The pore pressures observed in the pneumatic piezometers are typically the highest in July and the lowest in January. The highest pore pressure yet recorded for the given piezometer was observed at B-101 pink and B-107 orange in July 2008 and April 2009, respectively.

The B-105 blue piezometer continues to indicate an elevated water pressure (i.e., a total head above the ground surface, artesian conditions) with the total head ranging from 4.4 to 5.5 feet above the existing ground surface. Additionally, the B-105 pink piezometer continues to indicate an elevated total head ranging from 0.1 feet below to 2.2 feet above the existing ground surface. It is possible that the elevated water pressure in B-105 may be attributed to either a thin silt seam sandwiched between fairly thick clay layers located near the base of the piles supporting Pier 1, or the percolation of natural gas out of the underlying Devonian Ohio Shale. Elevated pore pressures can have a detrimental effect on slope stability and may increase the rate of slope creep.

Total Head vs. Time plots, which provide the measured total head from 1994 to the present, have been submitted as Plates 51 through 54 in the Appendix of this report.

2.2.2 Vibrating Wire (VW) Piezometers

The VW piezometers have been placed at various depths with two (2) piezometers at each of the nine (9) offset boring locations. The VW piezometers were installed on 1¼-inch PVC pipe encased in grout with a cable attached to the VW piezometer. Each cable runs up through the PVC pipe and is attached to a MiniLogger, which stores the pore pressure data. A flush mount protective cover was installed at each offset boring location to house the two (2) MiniLoggers. Readings are taken by Miniloggers generally every 8 hours; however, this time interval can be adjusted upon request.

VW Minilogger and Piezometer Issues

Eight (8) VW Miniloggers were either unresponsive at the times of download or failed to take several scheduled readings and are not currently functioning properly. This includes the following: 21961 and 21967 at B-05-01; 21963 at B-05-02; 21957 and 21965 at B-05-03; 21968 and 21953 at B-05-11; and, 21960 at B-05-12. The 21963 Minilogger at B-05-02 was unresponsive for the first time during the April 2009 quarterly readings. These eight (8) non-functioning Miniloggers were replaced with new Miniloggers during the quarterly readings in April 2009. Three (3) VW Miniloggers missed scheduled readings during the current reporting period but appear to be currently functioning properly, which includes 21951 at B-05-02, 21958 at B-05-04 and 21964 at B-05-12. These Miniloggers may need to be replaced eventually. Manual readings were taken with a portable VW Data Recorder during the quarterly readings when a VW Minilogger was unresponsive.

Between the October 2008 and January 2009 quarterly readings, the hole at B-05-07 housing the 21966 and 21956 Miniloggers had filled up with water that became frozen solid at the time of the January 2009 quarterly readings. In an attempt to extract the Miniloggers from the ice, the VW piezometer wires were inadvertently damaged. This damage to the wires went unnoticed until April 2009 when error readings from Miniloggers were downloaded indicating the wires were not properly connected to the Minilogger boxes. The wires were repaired in April 2009 and the readings appear to be normal.

VW Minilogger Data Summary

Table 4 provides a summary of the maximum and minimum values of all the pressure readings taken over the last four (4) quarters which includes data collected between April 2008 and April 2009. The data consists of either downloaded readings from the functioning VW Miniloggers or manual readings taken each quarter within the reporting period including in July 2008, October 2008, January 2009 and April 2009. The VW piezometers are identified by boring number, MiniLogger serial number, and depth the piezometer was installed. The VW piezometers also measure the ground temperature around the piezometer. The maximum and minimum temperature readings are also provided in Table 4.

Table 4: Summary of Readings for VW Piezometers – CUY-90-14.52

Piezometer Identifier		Time Interval of Readings Reported[1]	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-01	21961 - 65 ft	7/14/08 to 4/16/09[2]	13.6/13.0	675.4	610.4	13.1/12.4	640.7/639.0
	21967 - 95 ft	7/14/08 to 4/16/09[2]	13.1/13.0	675.4	580.4	24.5/24.1	637.0/635.9
B-05-02	21963 - 46 ft	4/16/08 to 4/21/09[2]	12.3/11.6	617.9	571.9	8.6/7.8	591.7/589.9
	21951 - 122 ft	4/16/08 to 4/16/09[2]	12.2/12.1	617.9	495.9	40.8/40.2	590.1/588.6
B-05-03	21957 - 32 ft	7/15/08 to 4/17/09[3]	12.4/11.5	605.1	573.1	8.4/8.2	592.5/592.0
	21965 - 112 ft	7/15/08 to 4/17/09[3]	12.4/12.4	605.1	493.1	41.8/41.3	589.5/588.5
B-05-04	21958 - 59 ft	4/16/08 to 4/17/09[2]	12.9/12.8	600.8	541.8	18.2/17.6	583.8/582.4
	21952 - 119 ft	4/16/08 to 4/17/09	13.0/12.9	600.8	481.8	45.0/44.8	585.7/585.2
B-05-07	21966 - 102 ft	4/14/08 to 4/17/09[2]	12.4/10.2	678.9	576.9	24.6/23.8	633.6/631.8
	21956 - 220 ft	4/14/08 to 4/17/09[2]	11.9/11.9	678.9	458.9	72.0/71.2	625.0/623.1
B-05-08	21954 - 65.5 ft	4/14/08 to 4/16/09	12.7/12.6	679.9	614.4	13.1/12.1	644.7/642.4
	21959 - 110.5 ft	4/14/08 to 4/16/09	12.4/12.4	679.9	569.4	30.0/29.3	638.7/636.9
B-05-11	21968 - 95 ft	7/14/08 to 4/16/09[3]	12.7/12.6	675.1	580.1	24.3/23.8	636.1/635.1
	21953 - 130 ft	4/14/08 to 4/16/09[2]	12.5/7.8	675.1	545.1	37.1/36.6	630.8/629.6
B-05-12	21960 - 75 ft	7/15/08 to 4/16/09[3]	12.8/12.5	652.7	577.7	19.1/18.7	621.8/620.8
	21964 - 120 ft	4/14/08 to 4/16/09[2]	12.5/12.4	652.7	532.7	37.3/36.7	618.7/617.3
B-05-13	21962 - 60 ft	4/17/08 to 4/21/09	12.7/12.6	580.0	520.0	24.5/23.9	576.5/575.1
	21955 - 135 ft	4/17/08 to 4/21/09	12.8/12.7	580.0	445.0	60.5/60.2	584.6/584.0

1 Readings generally were taken every 8 hours during the reported time interval.
2 Malfunction of Minilogger or piezometer resulting in scheduled readings being missed during the reported time interval. For additional details, see the Total Head vs. Time plot for the specific Minilogger in the Appendix.
3 One (1) manual reading was taken during each quarter due to Minilogger issues. For additional details, see the Total Head vs. Time plot for the specific Minilogger in the Appendix.

General Observations in VW Piezometers

The measured total head values were relatively constant over the last four (4) quarters with a difference between maximum and minimum total head values of no more than 2.3 feet in all of the VW Piezometers. Between April 2008 and April 2009 (the current reporting period), eight (8) of the 18 piezometers exhibited the highest (peak) pore pressures for the given piezometers yet recorded. In April 2009, peak pore pressures were observed in 21961 and 21967 at B-05-01, 21957 at B-05-03, 21968 and 21953 at B-05-11 and 21964 at B-05-12. At B-05-08, the 21954 and 21959 Miniloggers recorded peak pore pressures in May 2008 and March 2009, respectively. Also, in April 2009, the 21966 and 21956 Miniloggers at B-05-07 recorded the highest pore pressures at this location since the summer of 2006 (a few weeks after the piezometers were installed). Note that the B-05-07 piezometers initially exhibited relatively high pore pressures that quickly dissipated within a few weeks of installation.

In the piezometer at a depth of 135 feet in B-05-13 (as recorded by the 21955 Minilogger), the total head over the reporting period was as high as 4.6 feet above the existing ground surface at Elevation 580 (see Table 4) indicating that there continues to be an elevated water pressure (i.e., total head above the ground surface, artesian conditions) at this location similar to that observed in the pneumatic piezometers at B-105 previously discussed. During drilling of Boring B-05-13, gas pockets were encountered during rock coring, which leads us to believe the elevated water pressure observed in the B-05-13 piezometer at 135 feet may be mostly attributed to percolation of natural gas out of the underlying Devonian Ohio Shale into the sandy silt layer where the piezometer was installed. This sandy silt layer is sandwiched between the shale bedrock below and clay above that could confine the natural gas to the sandy silt due to the low permeability of clays.

Total Head vs. Time plots have been submitted as Plates 55 through 63 in the Appendix of this report.

3.0 ADDITIONAL FIELD MEASUREMENTS AND OBSERVATIONS

3.1 Calipered Surface Distance Locations

The left and right calipered locations (see the Site Plan of Active Instrumentation, Plate 2 in the Appendix), which have been monitored since June 1999, are located just east and west of the I-90 Bridge centerline, respectively. Initially, three (3) locations were monitored, which included a center calipered location. However, the center calipered location became inaccessible in August 1999. A Calipered Surface Distance Table and Calipered Distance Readings vs. Time plots have been included as Plates 64 through 66 in the Appendix.

Close inspection of the data in the plots indicates the possibility of general movement trends at the calipered locations. The data is somewhat oscillatory, which is likely due to the seasonal temperature fluctuations affecting the concrete combined with human

measurement error. In the data plots, linear trendlines were added to estimate the average rate of separation/closure per year. The left calipered location indicates the gap is opening at a rate of about 0.05 inches per year, which is a slight decrease from the rate of 0.06 inches per year reported in BBCM's 2007-2008 Annual Report. The right calipered location indicates the gap is continuing to close at a rate of about 0.02 inches per year. The movements are relatively small (½ of an inch or less since June 1999) and are sensitive to the interpretation of the center of the nails. Thus it is inconclusive that these movements have been caused by the observed slope movements. Additionally, the right calipered location has been oscillating above and below a distance of about 4.4 inches since late 2000 indicating that there might not be a trend (see Plate 66 of the Appendix).

3.2 Stockpiling of Aggregate Adjacent to East Right-of-Way Fence

The property adjacent to the east right-of-way fence is currently being used to stockpile aggregate. Aggregate piles of varying sizes and locations were observed during each of the quarterly visits to the site. Stockpiling of large aggregate piles could have a significant impact on slope movements at the site.

In July 2008, an aggregate pile roughly 25 to 30 feet high was observed near the east right-of-way fence and covered roughly less than 30 to 40 percent of the property (see Plates 74 and 78 in the Appendix). This was the largest aggregate pile observed by BBCM personnel at this location since 2006. However, the aggregate piles observed in 2006 were typically located on the east end of the property farther away from the bridge compared to the pile observed in July 2008.

In October 2008, the aggregate pile was smaller than observed in July 2008 (roughly 20 to 25 feet high covering roughly less than 15 to 20 percent of the property) and was placed right next to the right-of-way fence (see Plate 75 in the Appendix). In fact, the pile had knocked over a portion of the fence and spilled over into the I-90 right-of-way with the edge of the pile touching the edge of the concrete drive near B-05-03 (see Plates 79 and 80 in the Appendix). Additionally, a smaller aggregate pile, roughly 10 to 15 feet high was observed at the east end of the property covering roughly less than 25 percent of the property.

In January 2009, the aggregate pile had since been moved farther away from the fence line and a relatively long section of the fence appeared to have either been removed or knocked over (see Plates 76, 81 and 82 in the Appendix). The significant amount of snow cover in the area during the January 2009 site visit made it difficult to observe the aggregate piles and right-of-way fence area. The aggregate pile nearest the fence was roughly 20 feet high and covered roughly less than 10 percent of the property. Smaller aggregate piles roughly 10 to 15 feet high were observed farther away from the fence, which combined covered roughly less than 25 percent of the property.

In April 2009, the aggregate piles were similar in size and location to the piles observed in January 2009 and the fence had since been repaired as shown on Plates 77 and 83 in the Appendix.

3.3 Excavation Activities Adjacent to West Right-of-Way Fence

A large excavation near the west right-of-way fence was first observed by BBCM personnel in mid-March 2006. The excavation was performed apparently in an effort to repair the failed bulkhead. The B-110 inclinometer was destroyed as a result of these excavation activities. As of April 2009, the repair effort appears to be unfinished as the bulkhead does not appear to be fully repaired and the large excavation has not yet been backfilled.

In January 2007, BBCM personnel observed evidence of a potential small landslide that may have occurred after the quarterly readings were taken in October 2006. This small landslide area is located near the west right-of-way fence just north of B-05-16, adjacent to the river and on the eastern edge of the large excavation (see Plate 2 in the Appendix for the approximate landslide location).

The landslide area does not appear to have experienced a significant change since April 2008 except that there is currently less vegetation on the slope face. Plates 67 and 68 of the Appendix provide site photos of the landslide area in April 2008 and April 2009, respectively. As discussed in Section 2.1.2, the rates of shallow movements in the inclinometer at B-05-16 upslope from this landslide area have declined since January 2007. At the time of the quarterly site visits between July 2008 and January 2009, the area was either covered heavily with vegetation or snow making it difficult to see the scarps.

3.4 Additional Site Observations

On Page 2 of the Interim Report for Slope and Pier Monitoring Services dated December 11, 2008 by Richland Engineering Limited, a new crack in the concrete pavement adjacent to B-05-03 was noted. As discussed in Section 2.1.2, a noticeable increase in the rate of movement of the shallow slip plane, and the depth and magnitude of the cantilever displacement in B-05-03 was observed between April 2008 and October 2008. BBCM located this crack in April 2009 (see Plate 84 of the Appendix for photos). Based on the location of the crack, it is possible it was surveyed as part of the crack survey performed in 2005 at this site which would indicate the crack is not new. However, it is not known what the width of the crack would have been in 2005 (assuming it was there already) compared to its present width of about one (1) inch.

APPENDIX

CUY-90-14.52/15.24 INSTRUMENTATION MONITORING

SUMMARY OF ACTIVE INSTRUMENTATION
CUY-90-14.52/15.24

Active Instrumentation	Active Inclinometer ?	Inclinometer Depth (ft)	Active Piezometer?	VW or Pneumatic?	# of Active Piezometers	Piezometer Depth(s) Below Existing G.S. (ft)	Instrumentation Installation Date	G.S. Elevation (ft)
B-101	Y	190	Y[1]	Pneumatic[1]	2 [1]	50.3, 124.3	Aug-Sep 1994	676.6 (676.6[3])
B-102	Y	224	N	---	---	---	Sep 1994	675.7
B-105	N	---	Y[1]	Pneumatic[1]	2 [1]	88, 105.7	Aug 1994	585.4 (585.6[3])
B-105A	Y	156	N	---	---	---	May 2006	585.7
B-107	Y	210	Y[1]	Pneumatic[1]	1 [1]	100	Sep 1994	662.7 (662.3[3])
B-108A	Y	168	N	---	---	---	Apr-May 2006	603.0
B-203	Y	190	N	---	---	---	Aug 1996	638.0
B-204	Y	134	N	---	---	---	Jul 1998	599.0
B-303	Y	178	Y[2]	Pneumatic[2]	1 [2]	40.8	Aug 1994[2], Jul 1998	622.0 (627.0[3])
P-9N	Y	148	N	---	---	---	Feb 1999	588.0
B-05-01	Y	228	Y	VW	2	65, 95	Apr-May 2006	675.4
B-05-02	Y	176	Y	VW	2	46, 122	Apr-May 2006	617.9
B-05-03	Y	168	Y	VW	2	32, 112	Apr-May 2006	605.1
B-05-04	Y	172	Y	VW	2	59, 119	Mar-May 2006	600.8
B-05-07	Y	224	Y	VW	2	102, 220	Apr-Jun 2006	678.9
B-05-08	Y	224	Y	VW	2	65.5, 110.5	Apr-May 2006	679.9
B-05-11	Y	226	Y	VW	2	95, 130	Apr-Jun 2006	675.1
B-05-12	Y	210	Y	VW	2	75, 120	Apr-May 2006	652.7
B-05-13	Y	134	Y	VW	2	60, 135	May-Jun 2006	580.0
B-05-16	Y	162	N	---	---	---	Jun 2006	598.5

1 BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers (i.e. P-1 to B-101, P-3 to B-105, and P-5 to B-107).

2 The pneumatic piezometer was actually installed in August 1994 at Boring P-2 in the vicinity of the B-103 inclinometer (now inactive). However, the piezometer has since been renamed to B-303 due to its close proximity to the active inclinometer at B-303, which was installed in July 1998.

3 Elevation in parenthesis refers to the ground surface (G.S.) elevation of the P boring location where the pneumatic piezometer was installed.

B-05-07
B-05-08
B-05-01
B-05-11
B-05-12
B-05-02
B-107
B-203
B-110
B-05-16
B-108A
B-05-13
B-05-04
P-9N
B-204
B-303
B-105A
B-105
B-05-03
B-101
B-102
LEFT CALIPERED LOCATION
RIGHT CALIPERED LOCATION
APPROXIMATE LOCATION OF LANDSLIDE

LEGEND

B-05-01 — LOCATION OF INCLINOMETER/PIEZOMETER INSTALLED BY BBCM IN 2006 (B-05-01 THROUGH B-05-04, B-05-07, B-05-08, B-05-11 THROUGH B-05-13, AND B-05-16).

B-105A — LOCATION OF REPLACEMENT INCLINOMETER INSTALLED BY BBCM IN 2006 (B-105A AND B-108A).

B-101 — LOCATION OF INCLINOMETER AND/OR PIEZOMETER INSTALLED BY BBCM BETWEEN 1994 AND 1999 (B-101, B-102, B-105, B-107, B-203, B-204, B-303, AND P-9N).

B-110 — LOCATION OF INCLINOMETER AT B-110, WHICH WAS DESTROYED BY EXCAVATION ACTIVITIES IN MARCH, 2006

SCALE IN FEET
0 50 100

SITE PLAN OF ACTIVE INSTRUMENTATION

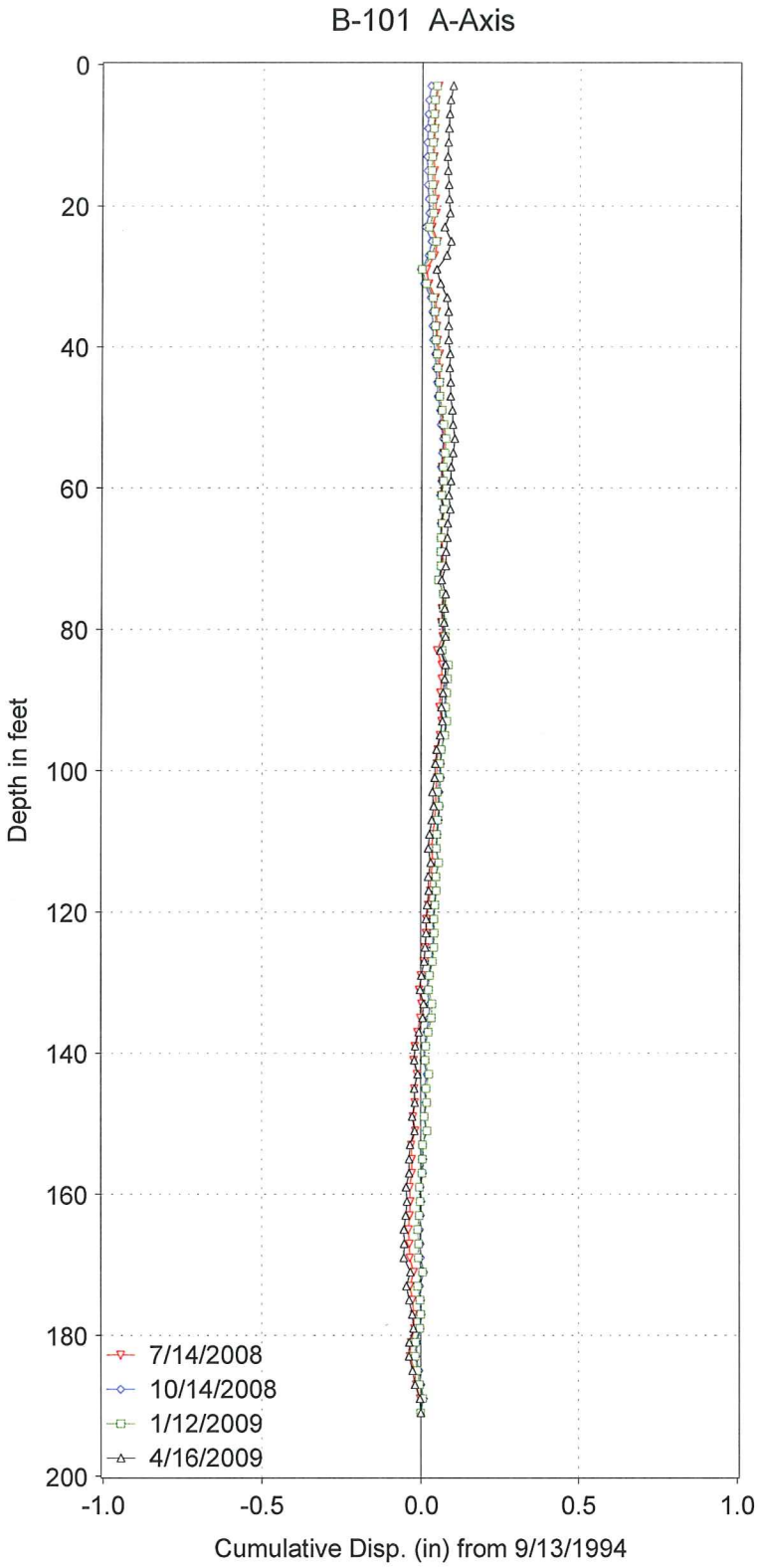
CUY-90-14.52/15.24 WEST ABUTMENT CLEVELAND, OHIO

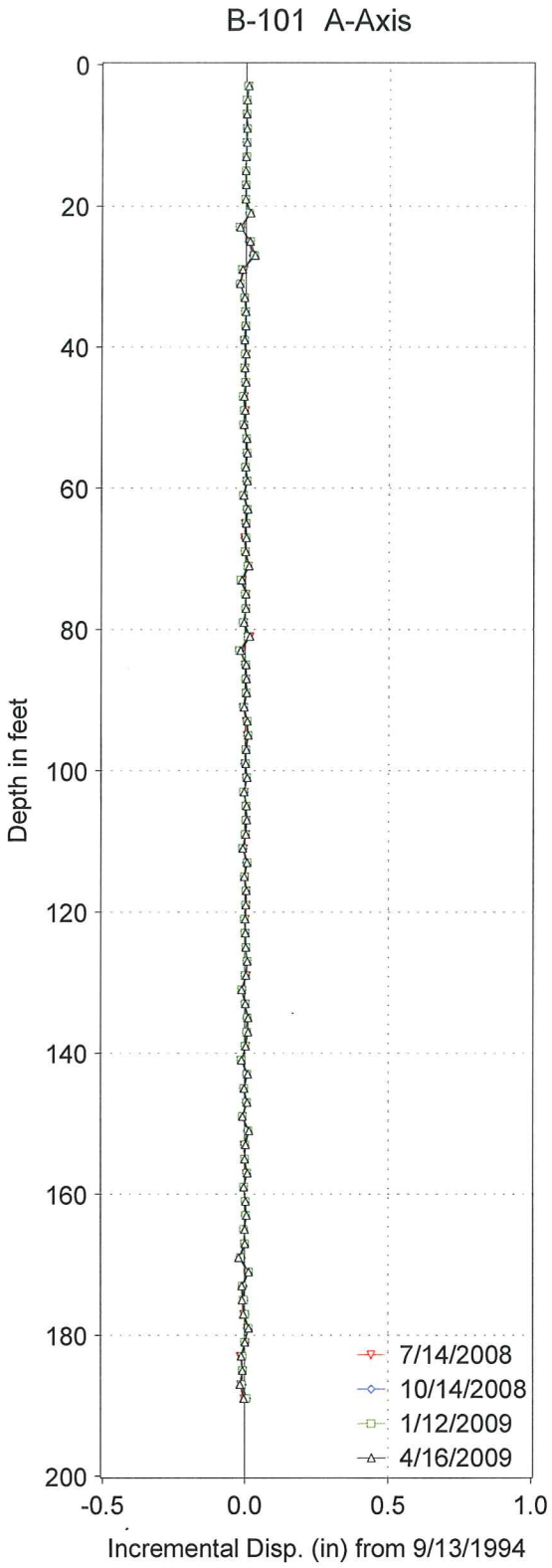
Project: 012-00946-300	Drawn By: EDV
Drawing Date: 7/25/06	Approved By: JLS
Revision Date: 2/9/07	Scale: 1" = 100'

BBCM
SOLUTIONS TO BUILD ON
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

PLATE 2

BBC&M DRAWING FILE: $BBCM FILENAME$ $DATE$ $TIME$ MODEL NAME: $MODEL$

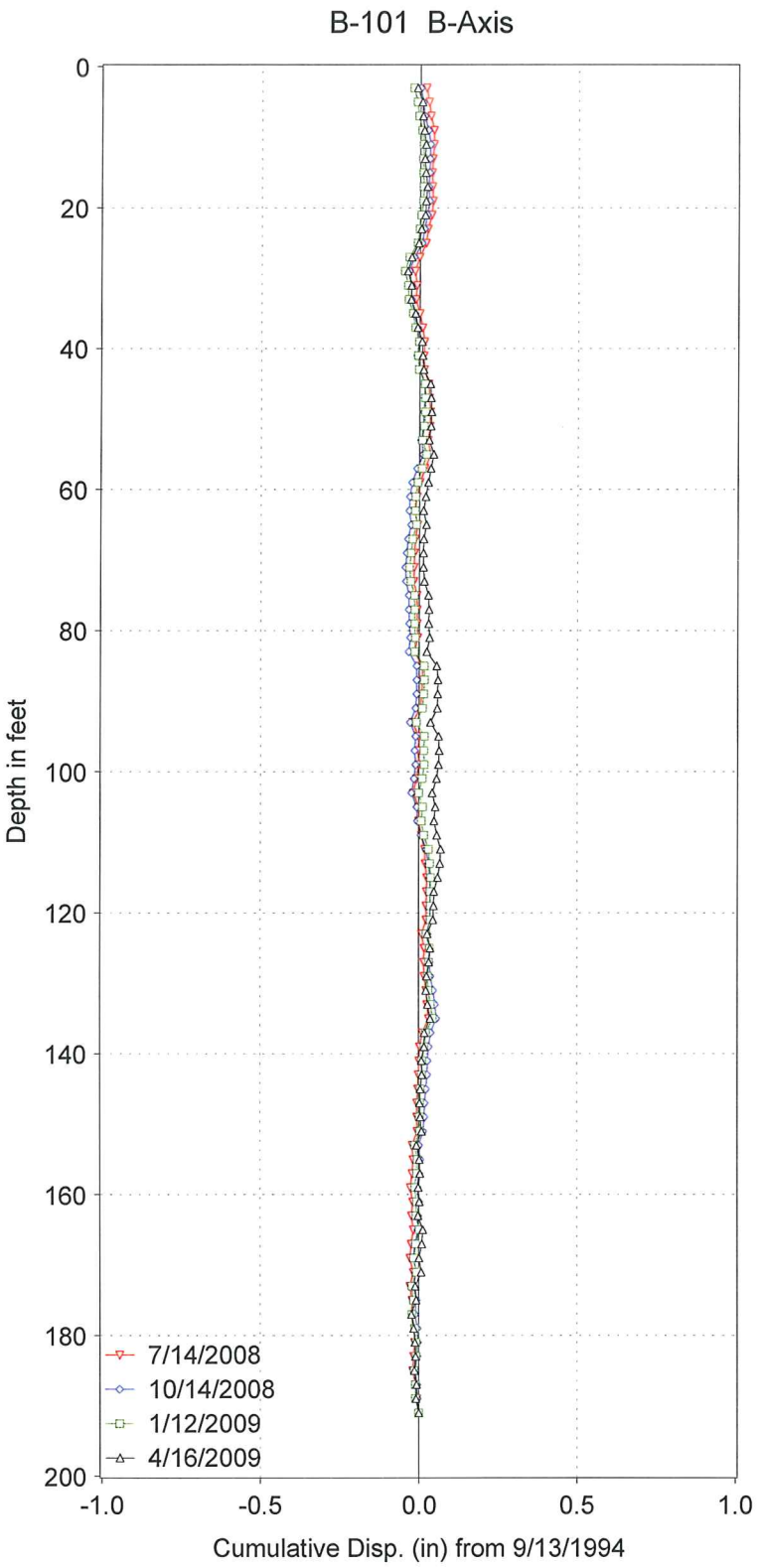


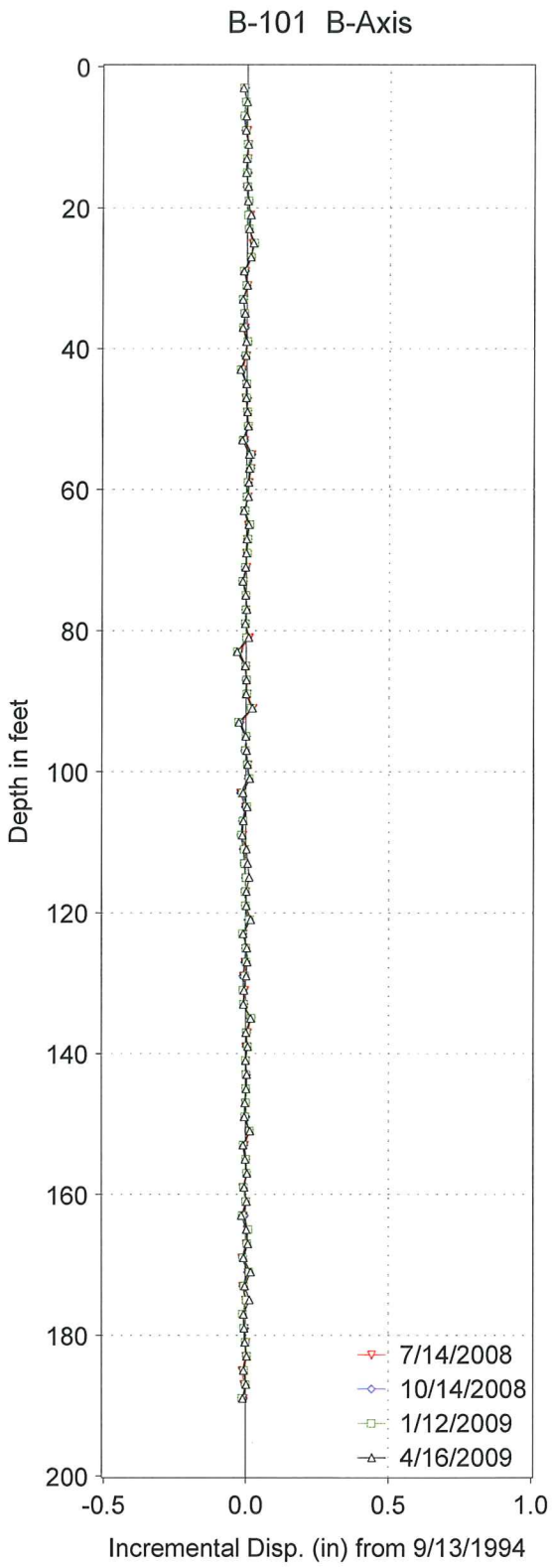


B-101

-Includes readings from the last four quarters.

PLATE 3





B-101

-Includes readings from the last four quarters.

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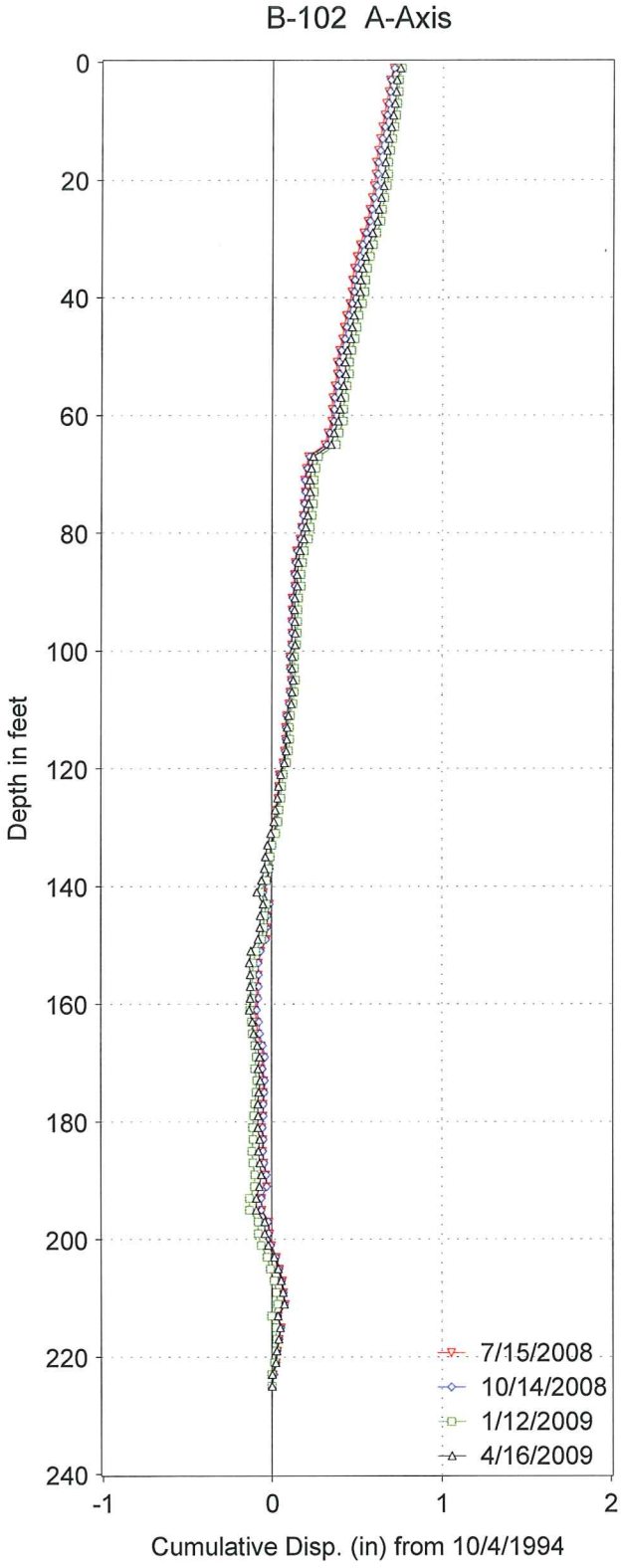
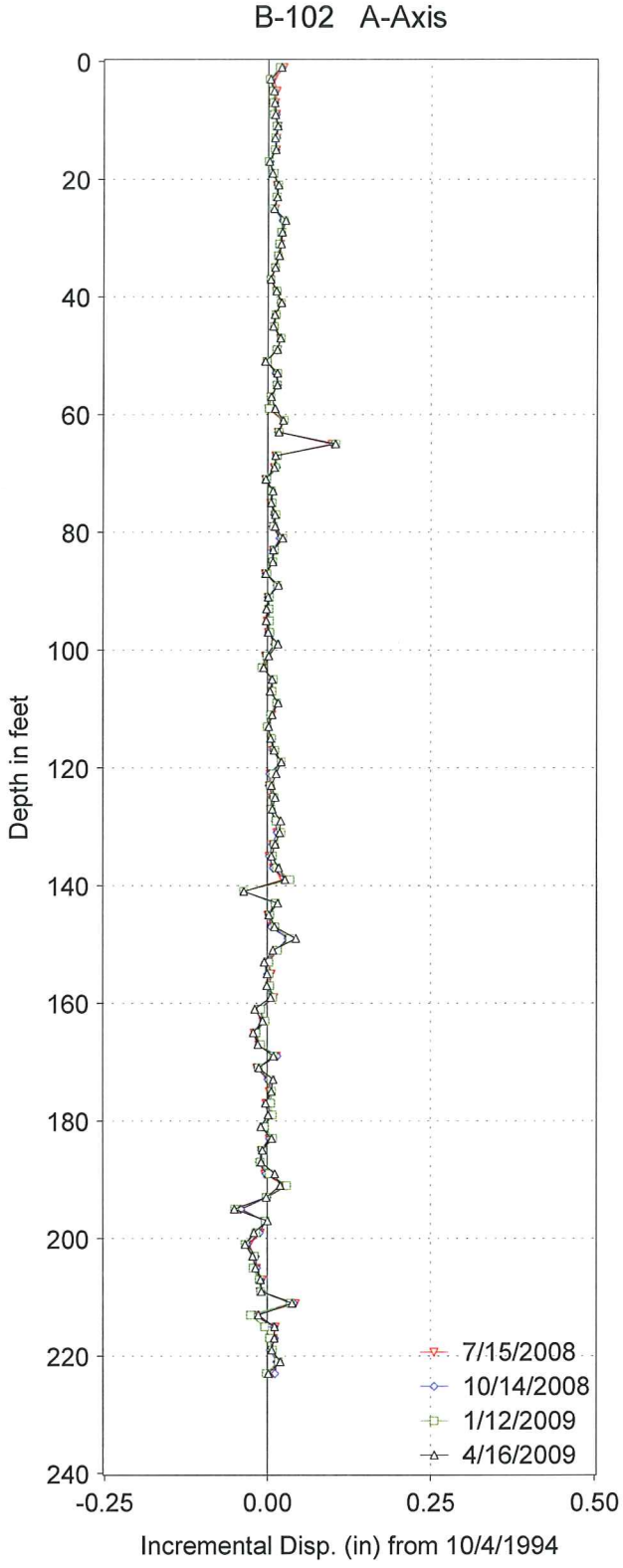
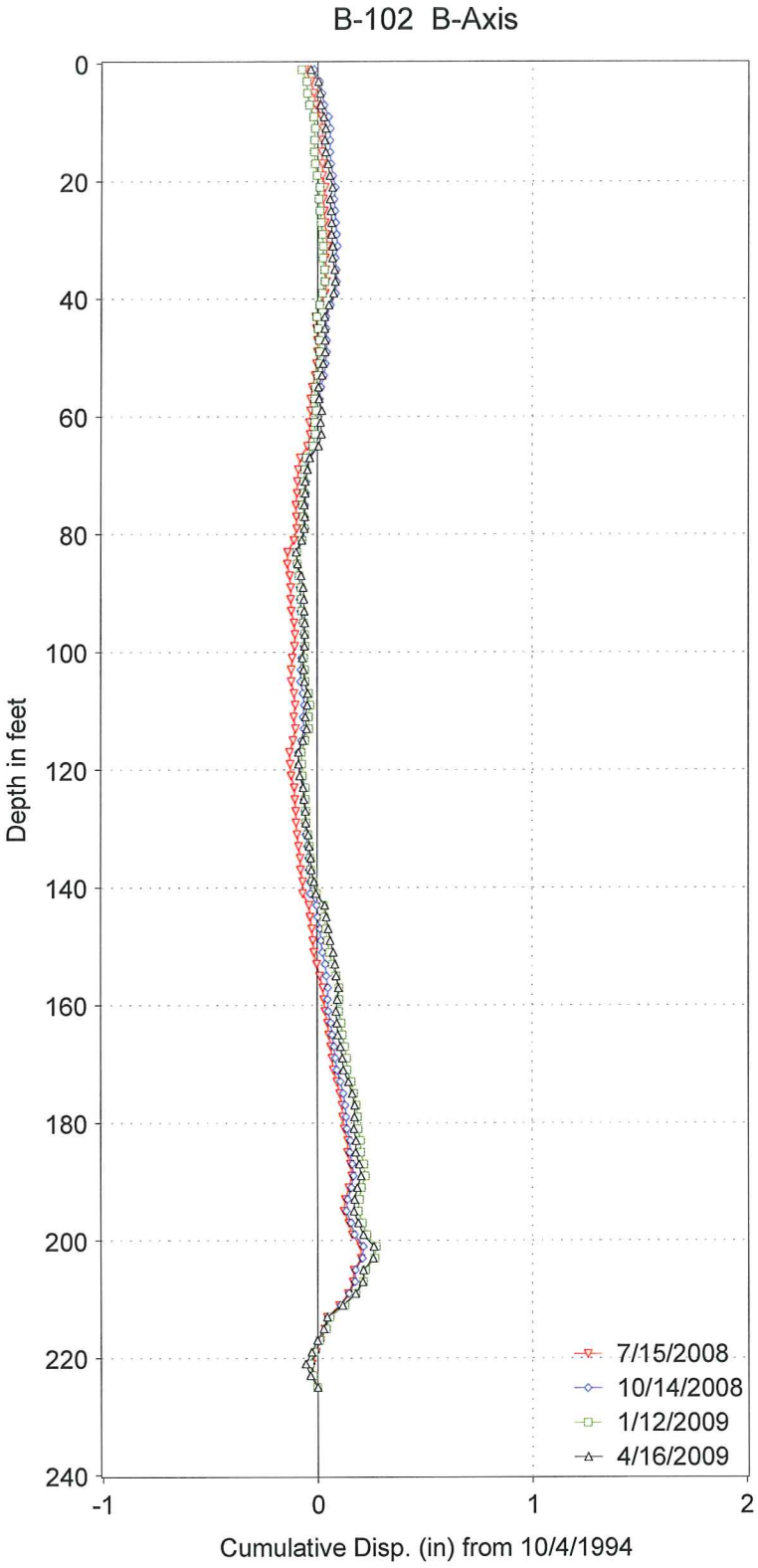


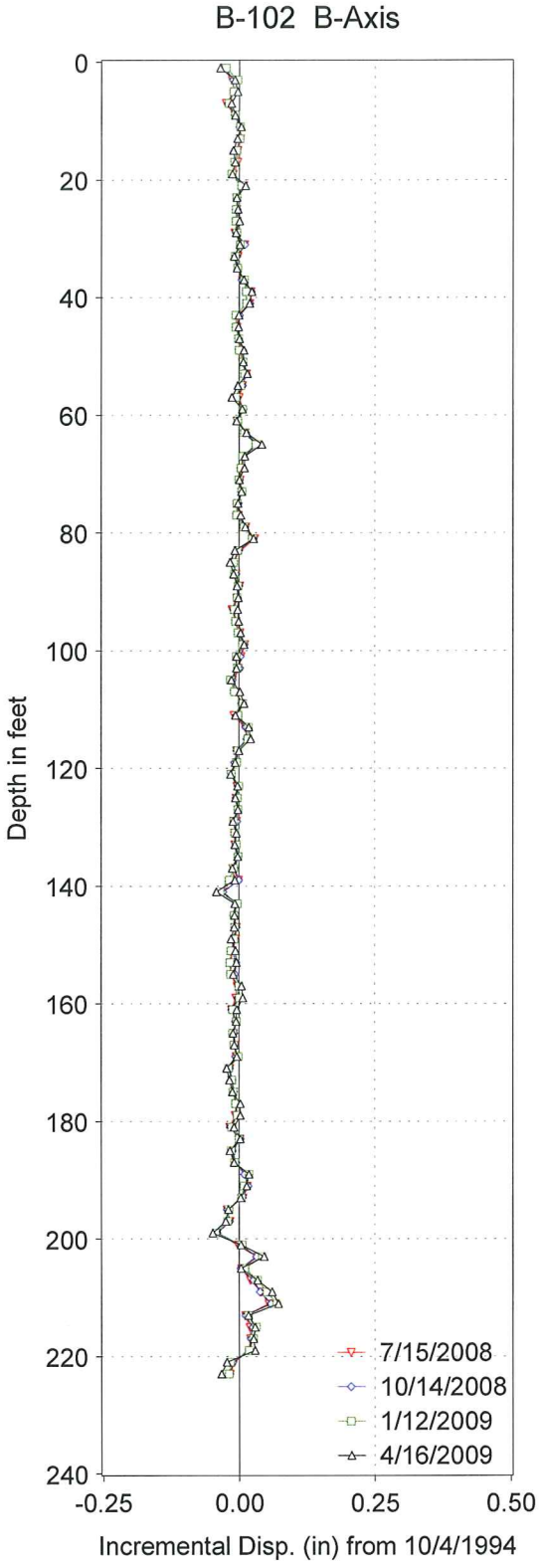


B-102

-Includes readings from the last four quarters.

PLATE 5

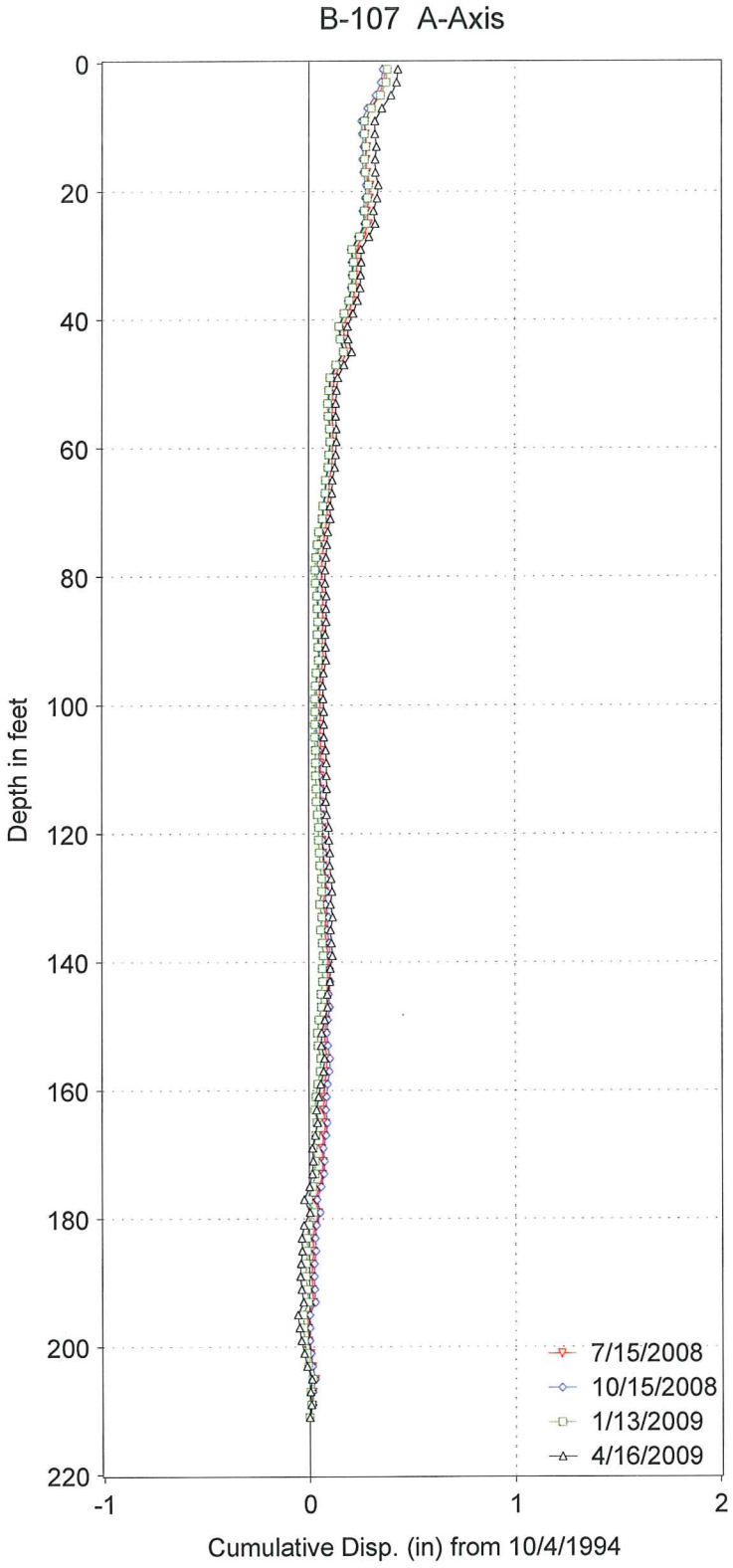


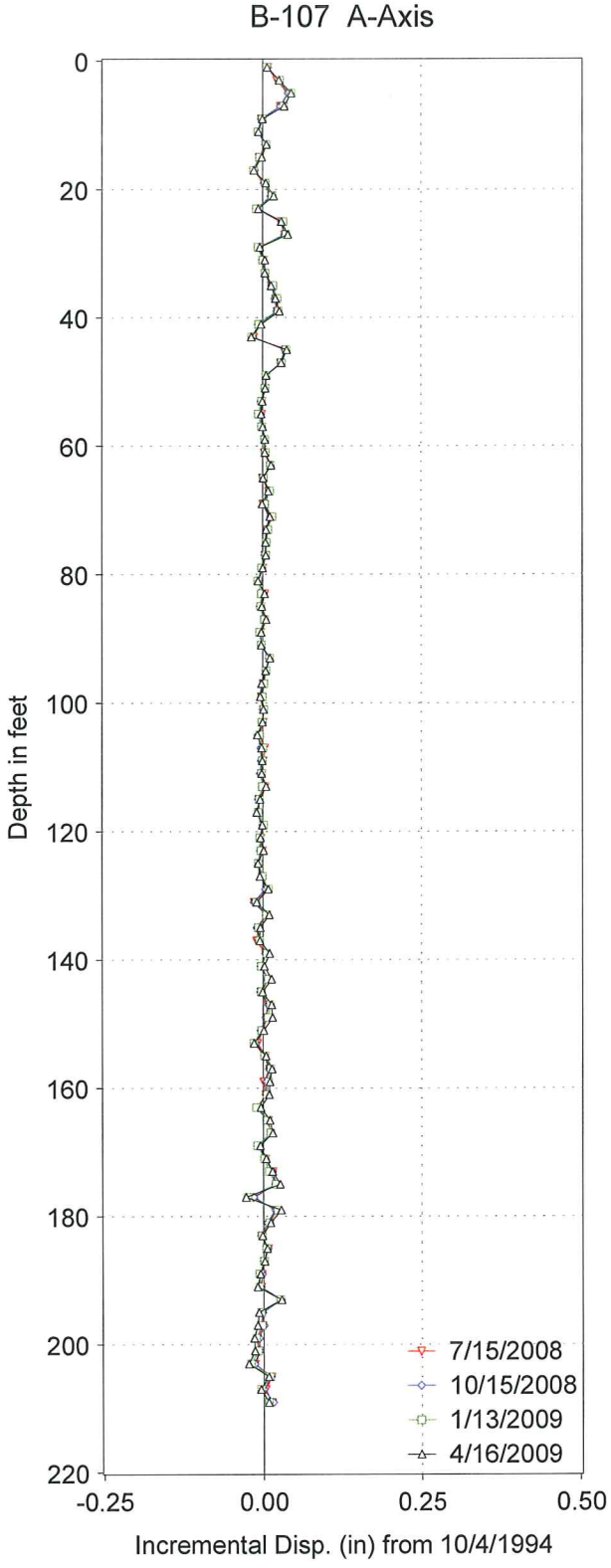


B-102

-Includes readings from the last four quarters.

PLATE 6

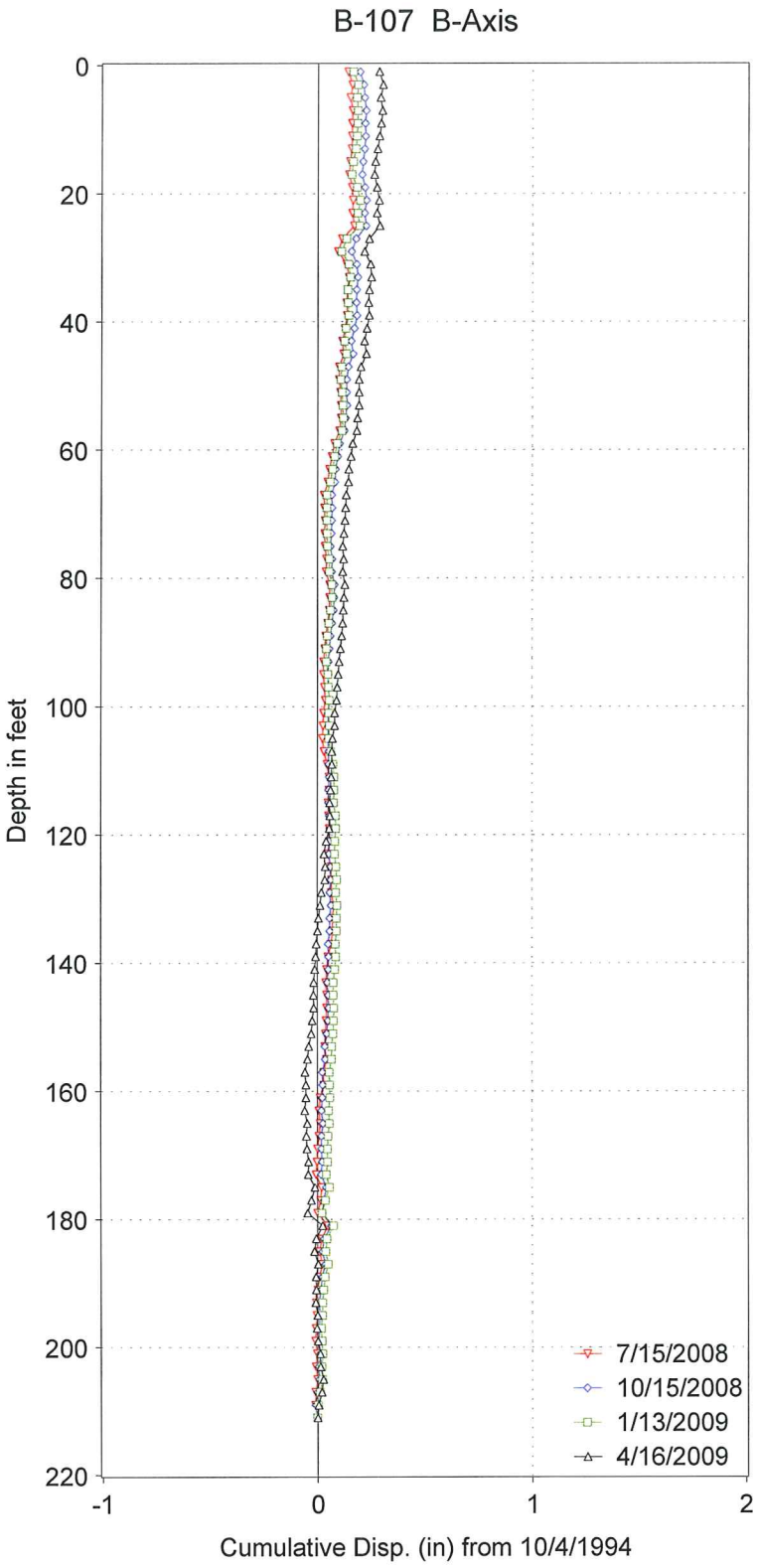


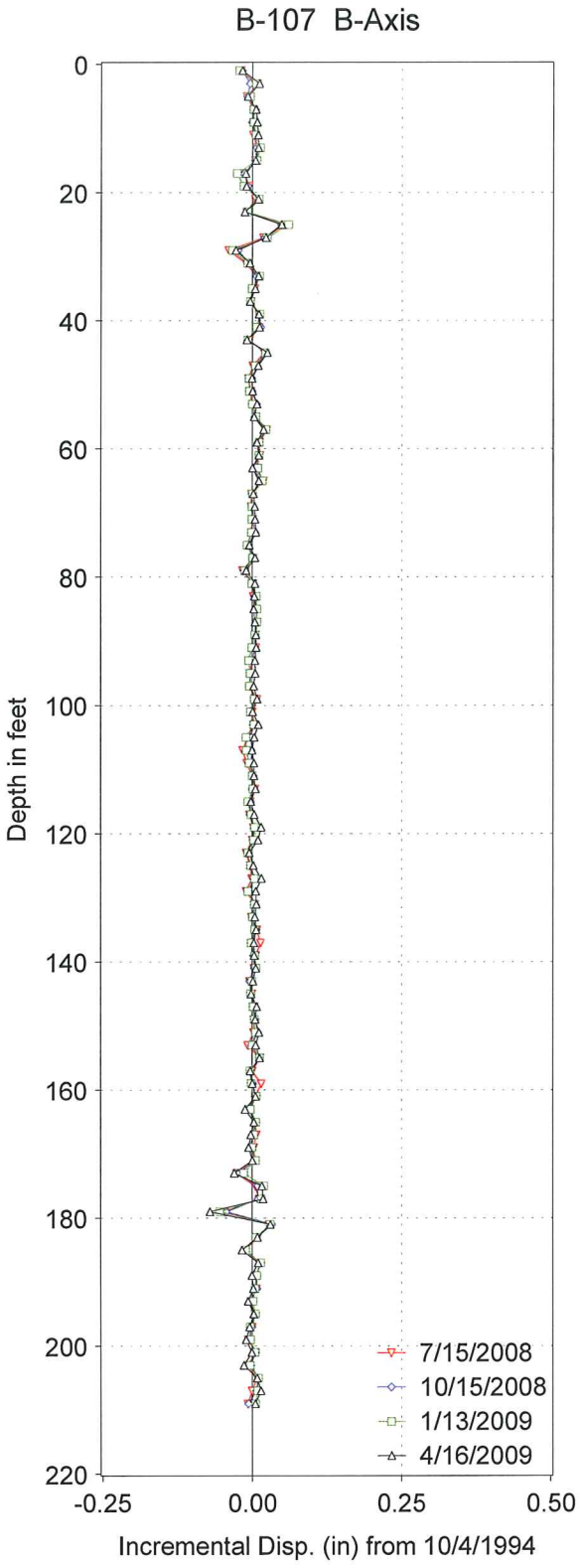


B-107

-Includes readings from the last four quarters.

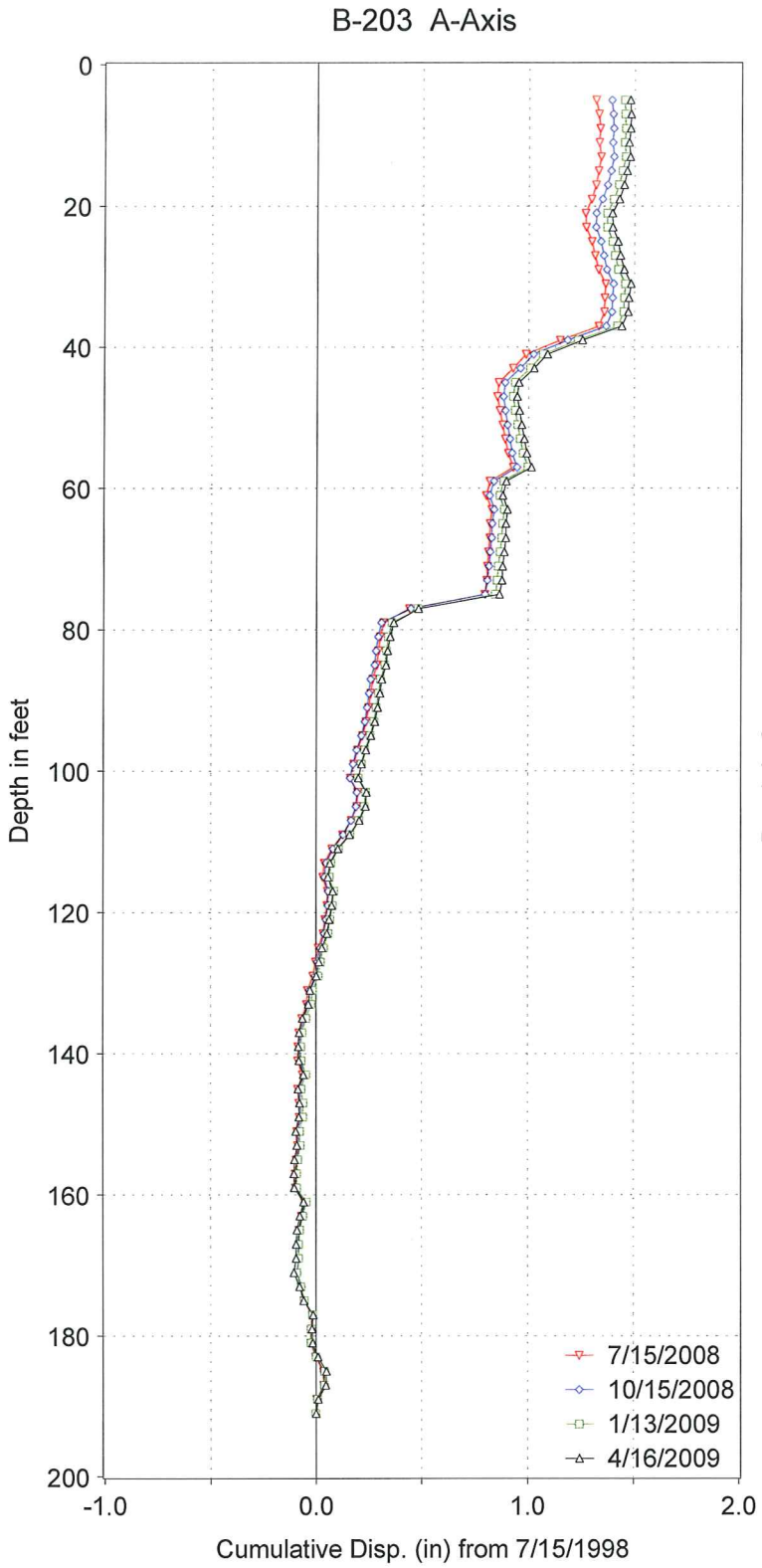
PLATE 7

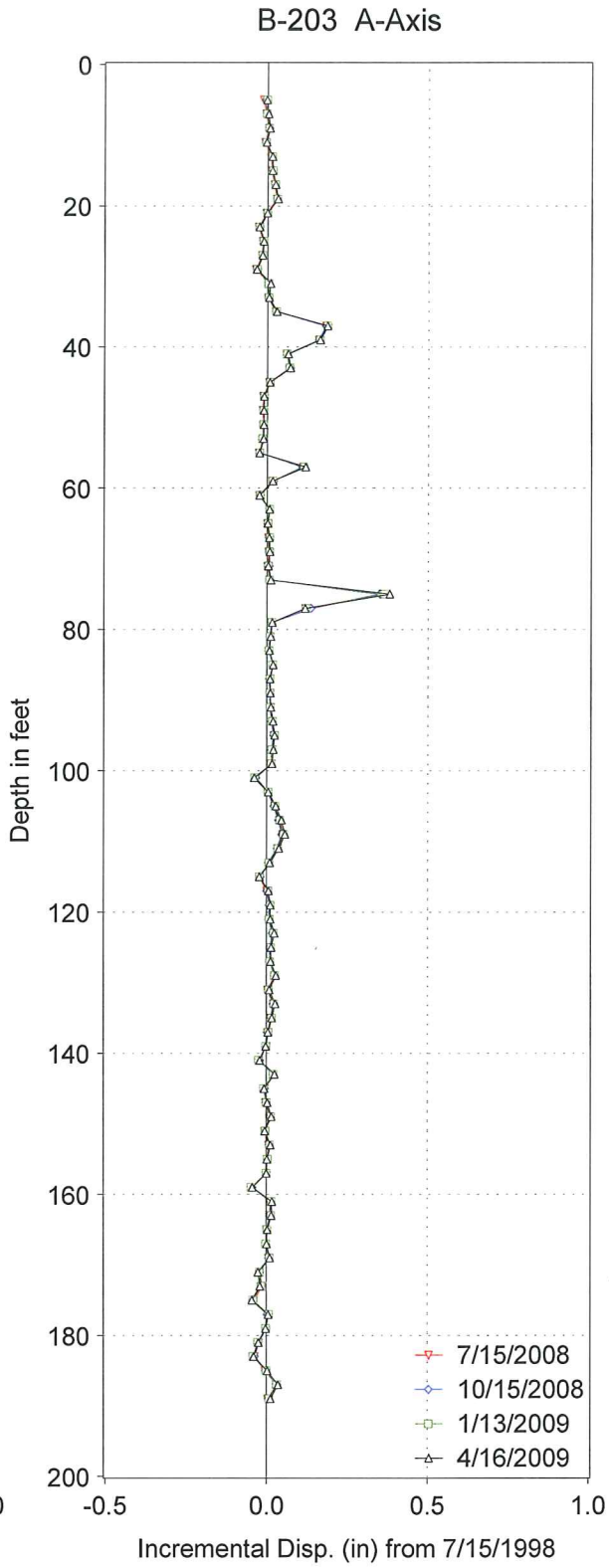




B-107
-Includes readings from the last four quarters.

PLATE 8

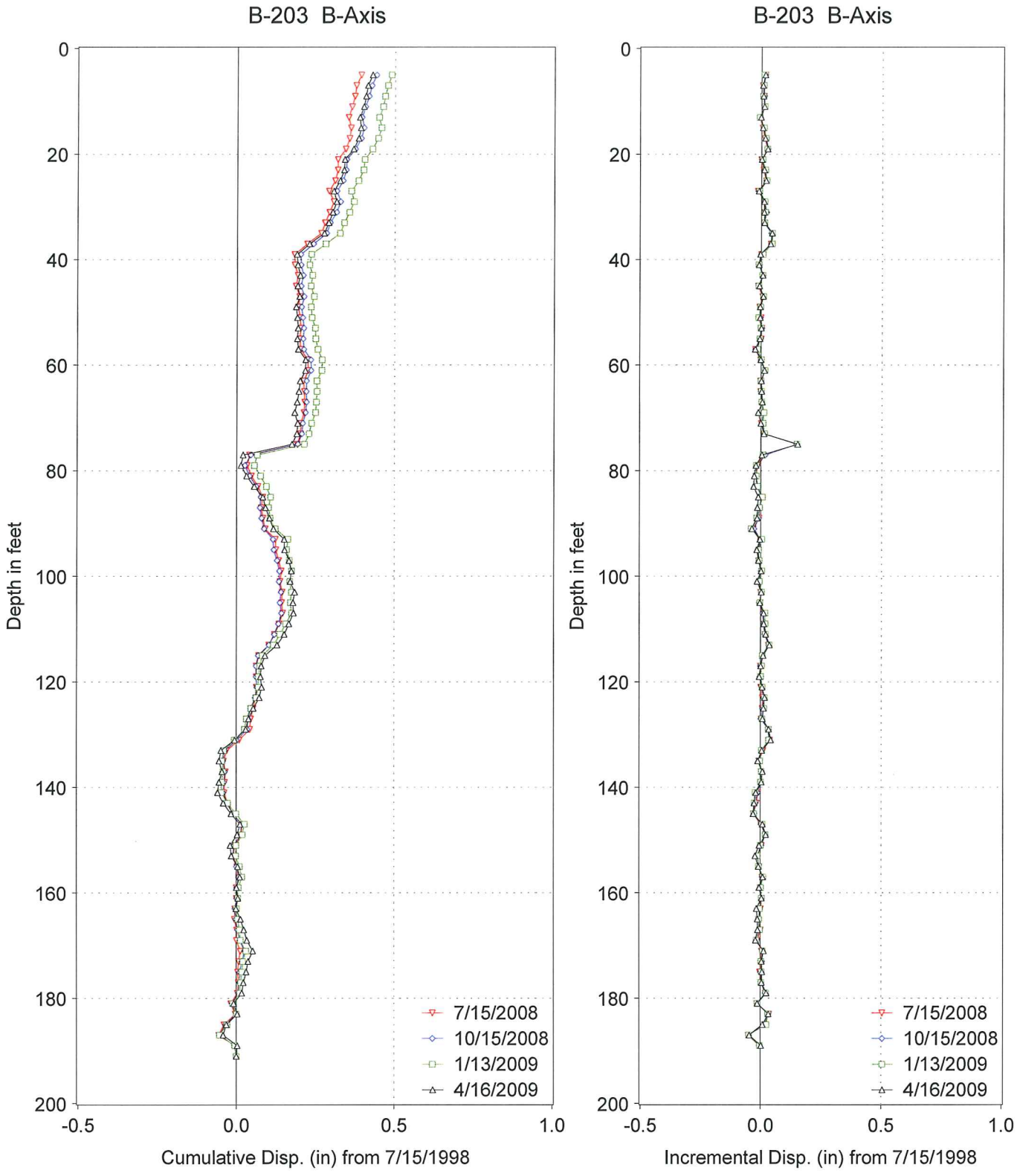




B-203

-Includes readings from the last four quarters.

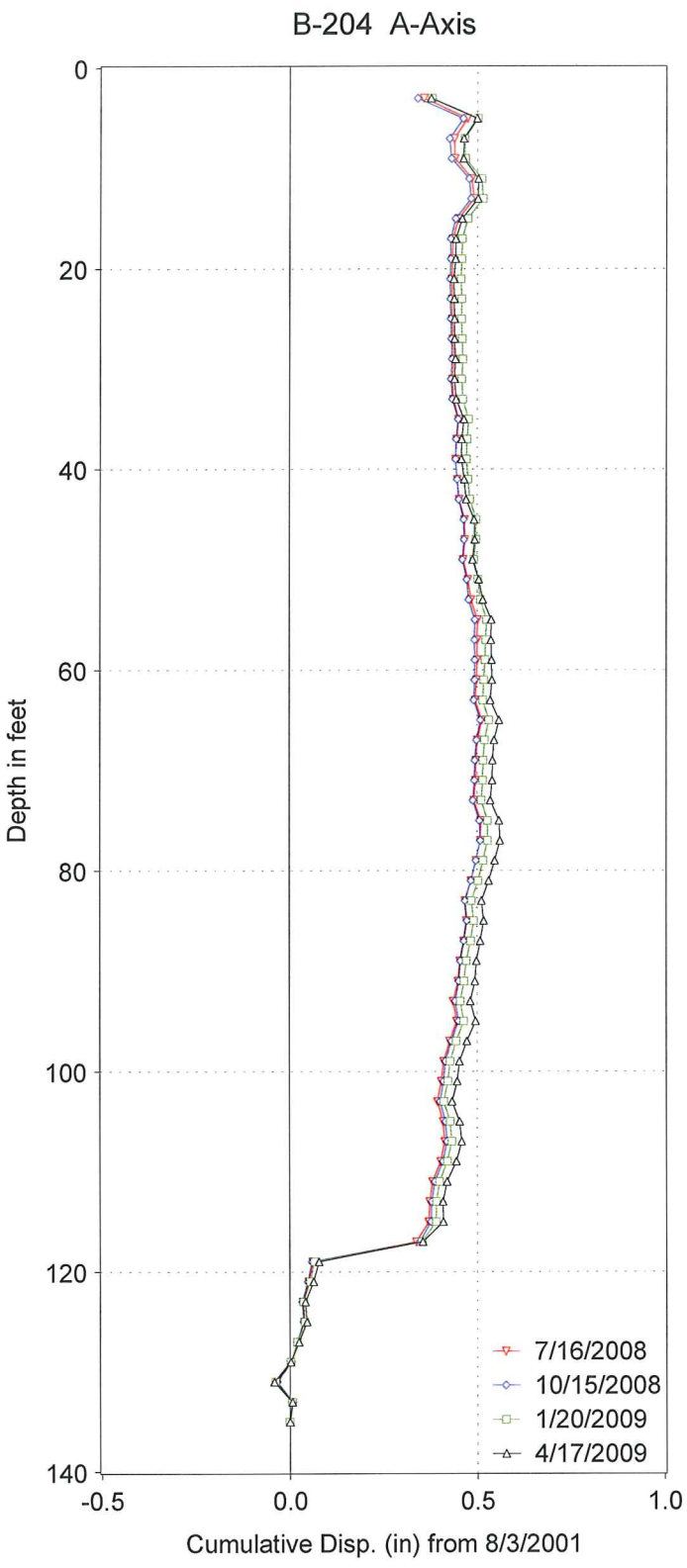
PLATE 9

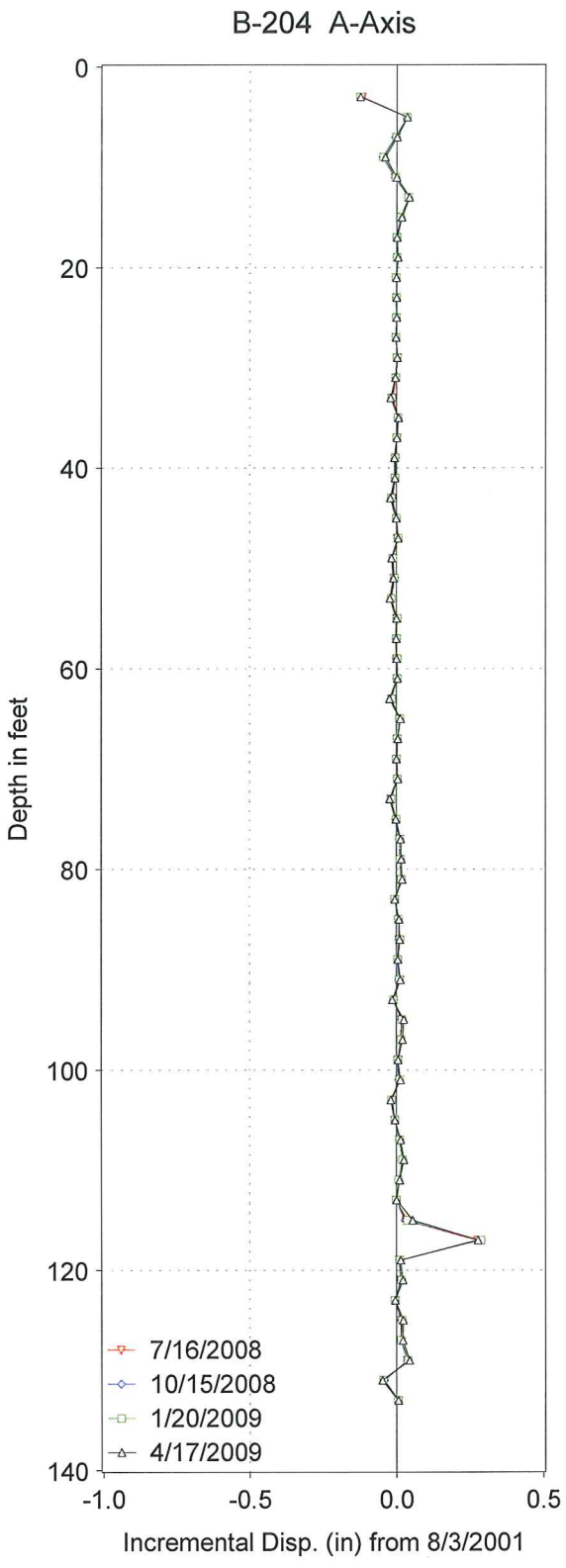


B-203

-Includes readings from the last four quarters.

PLATE 10





B-204

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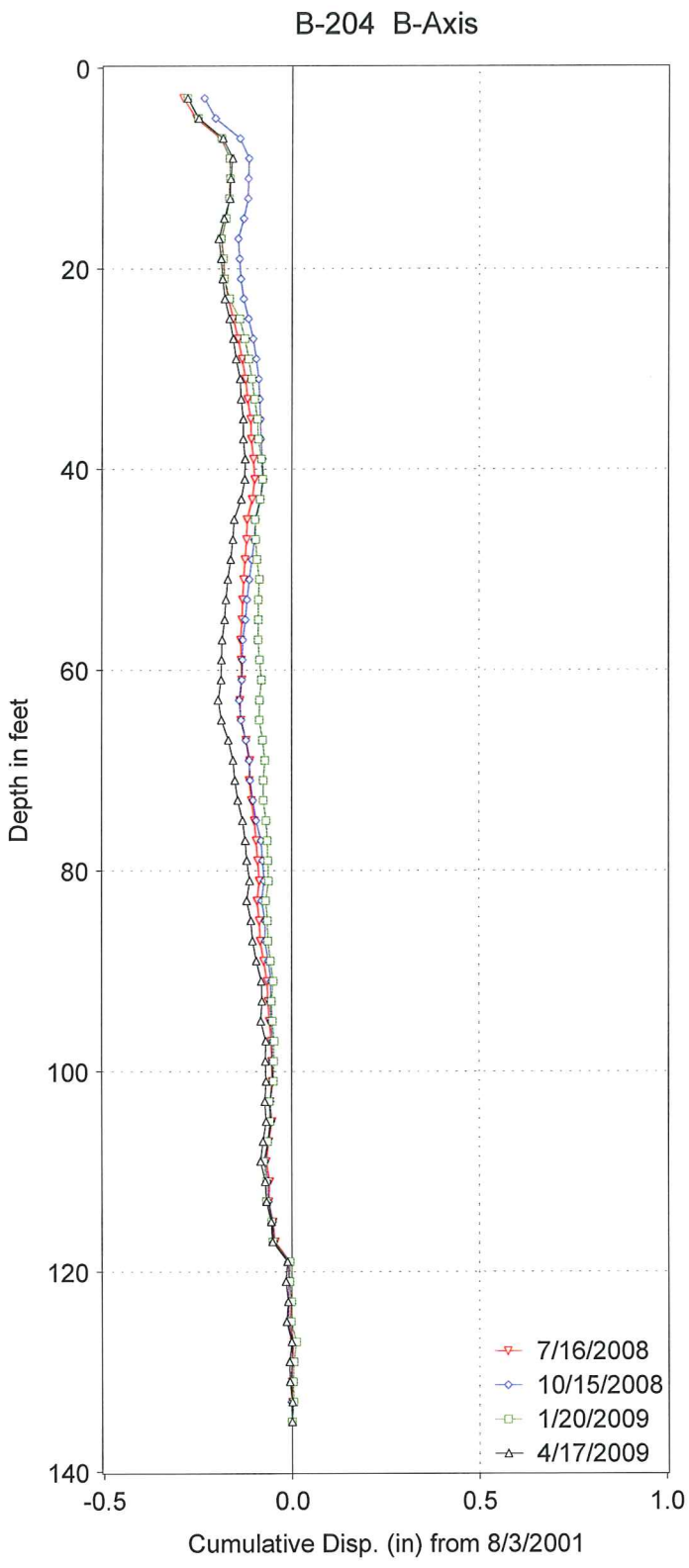
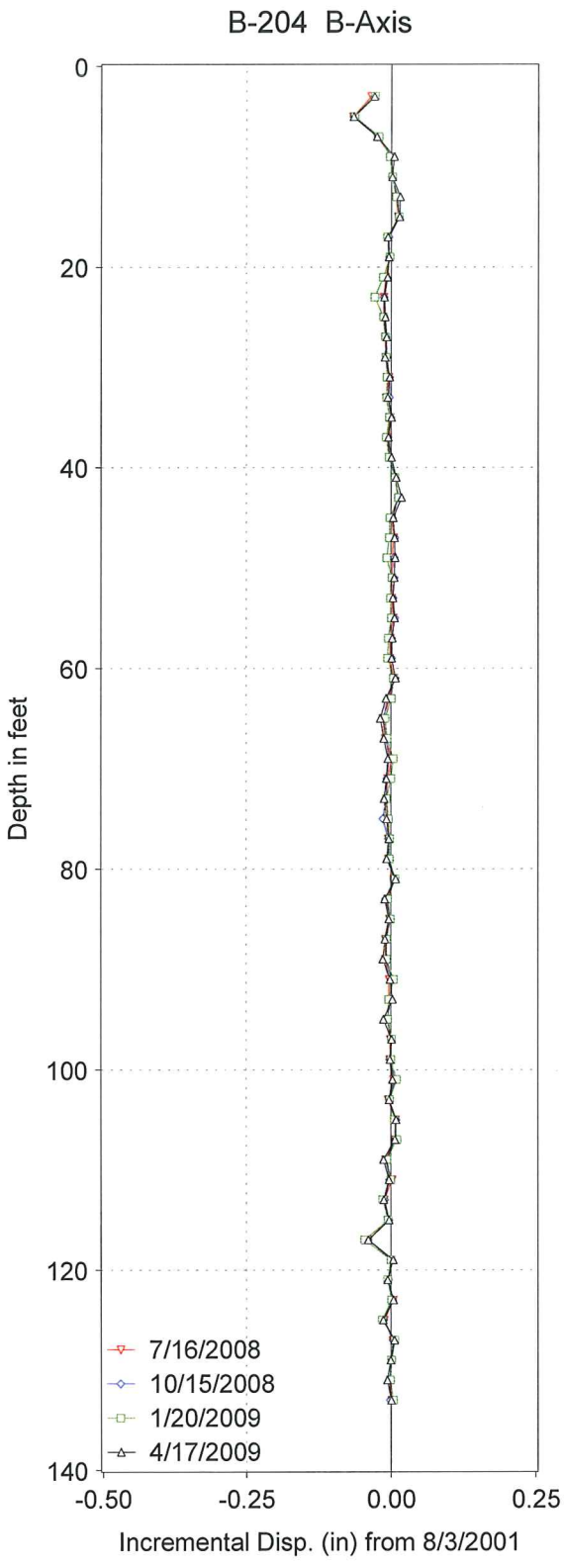
PLATE 11

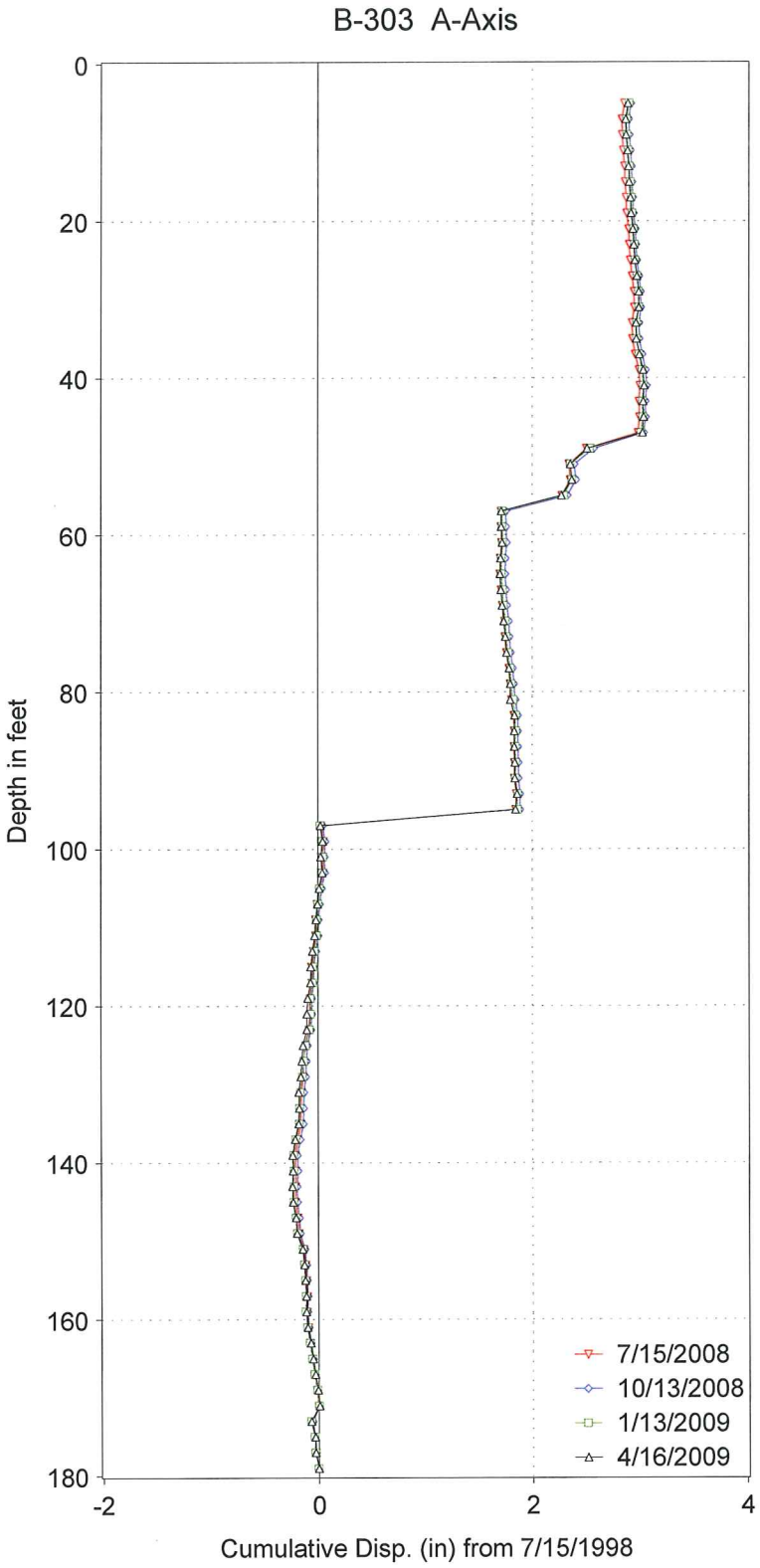


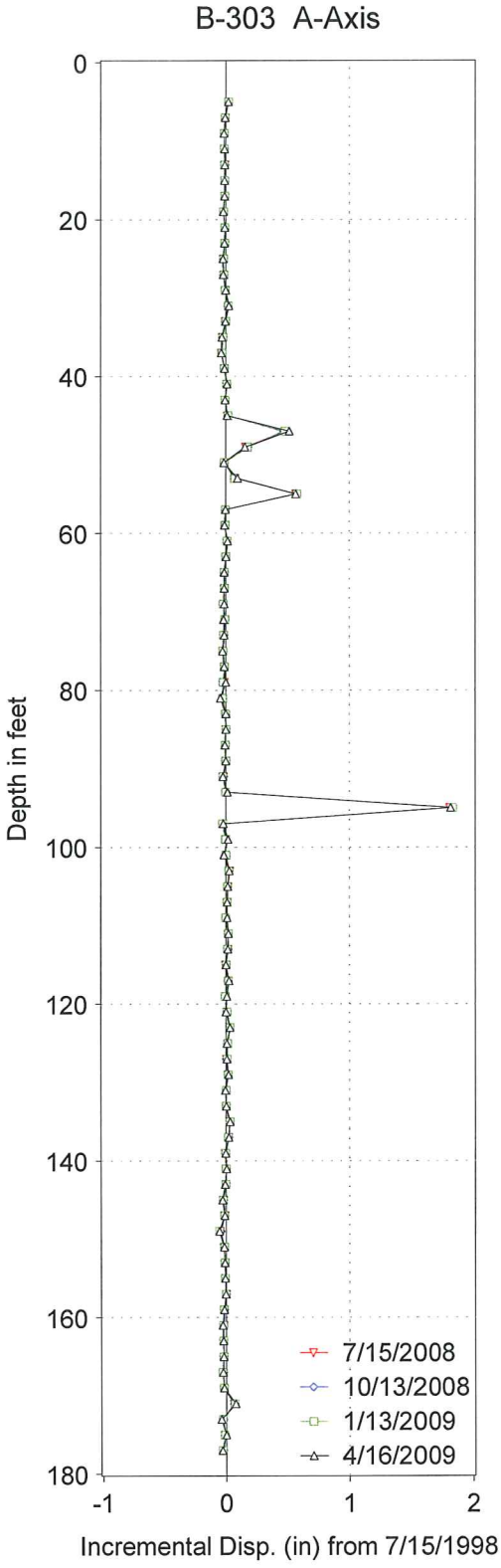


B-204

-Includes readings from the last four quarters.

PLATE 12

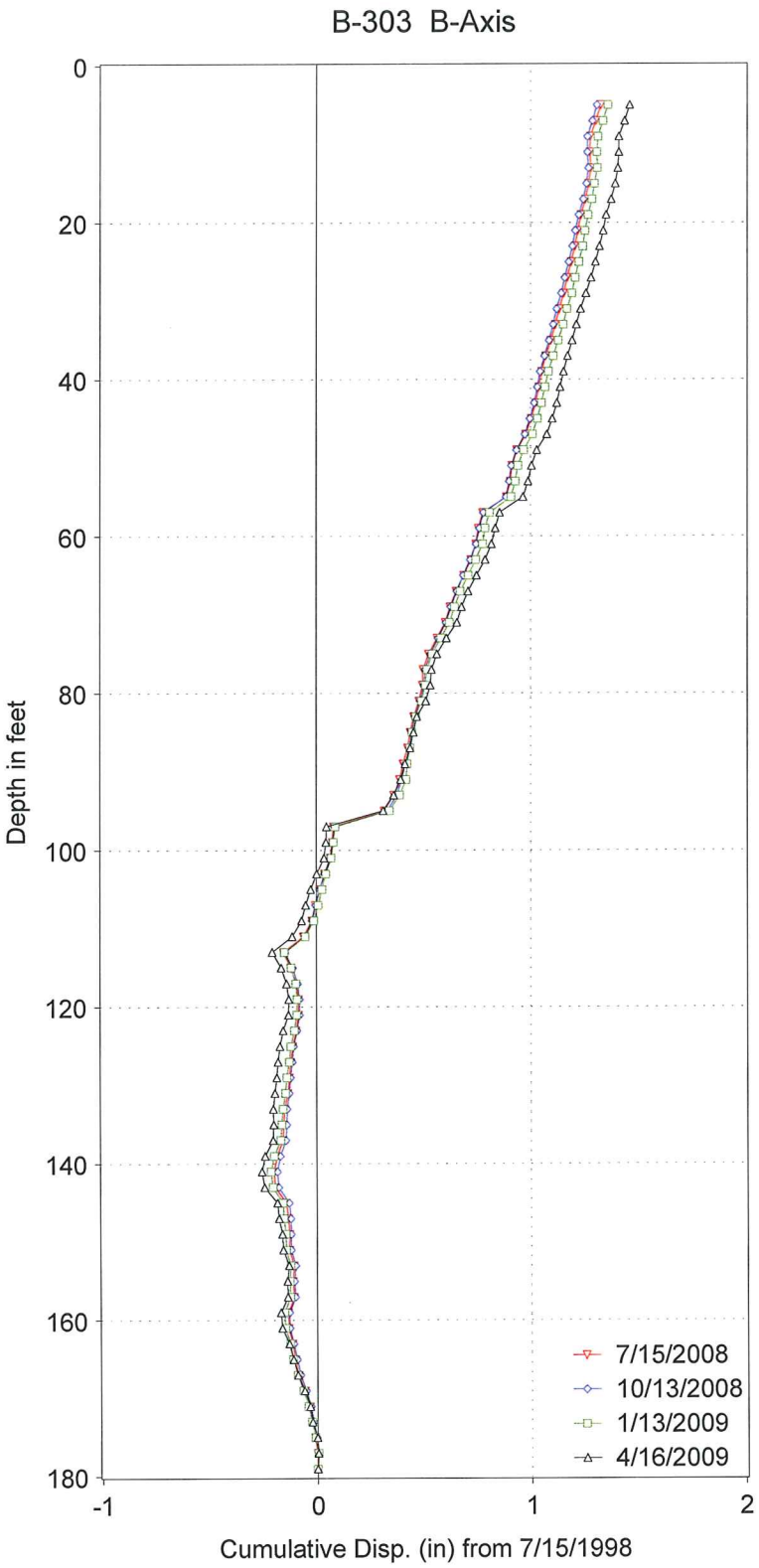


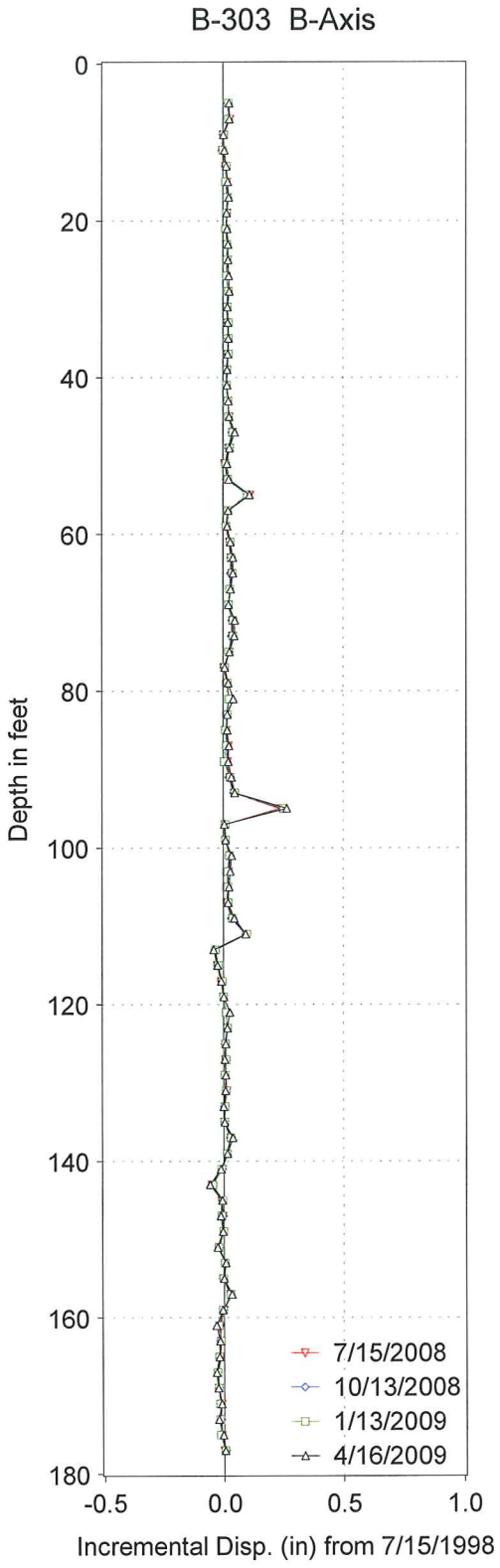


B-303

-Includes readings from the last four quarters.

PLATE 13

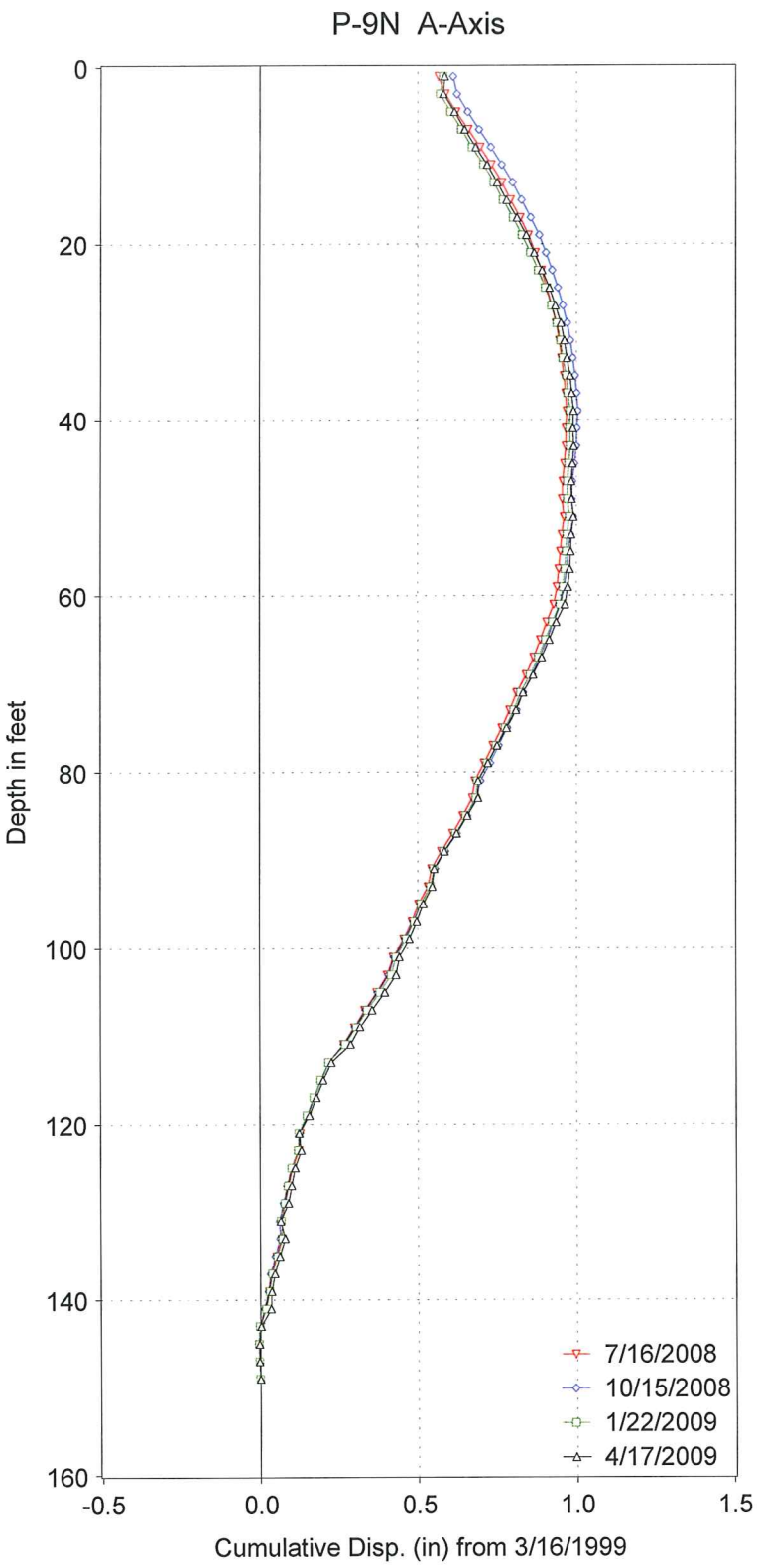


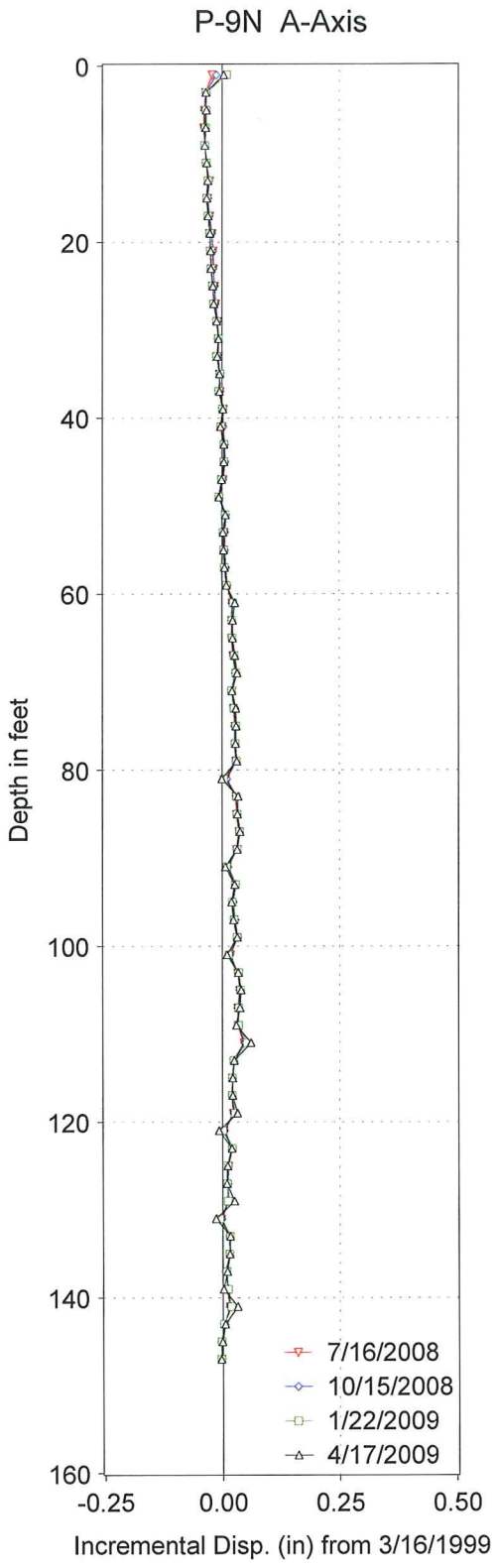


B-303

-Includes readings from the last four quarters.

PLATE 14

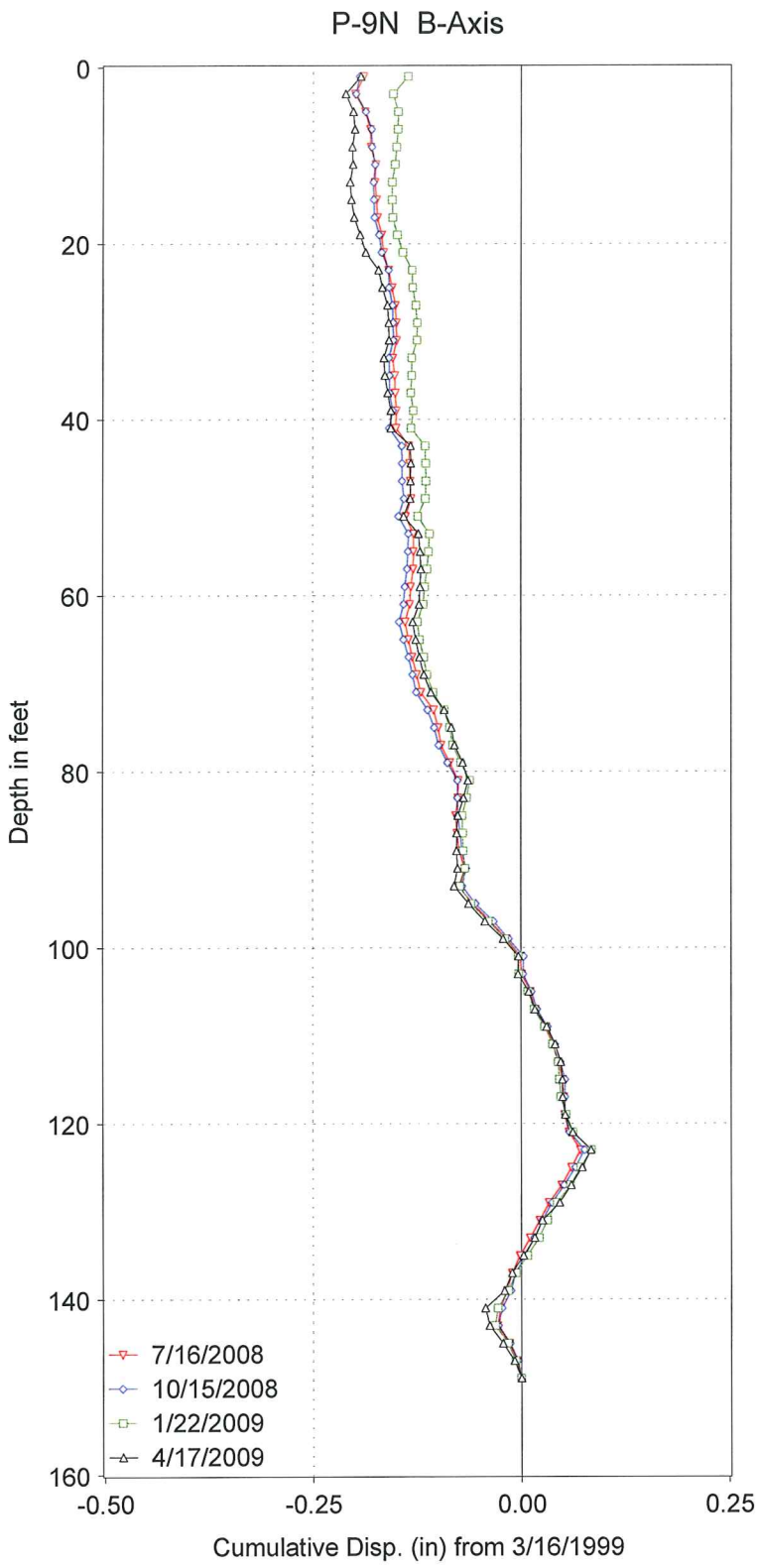


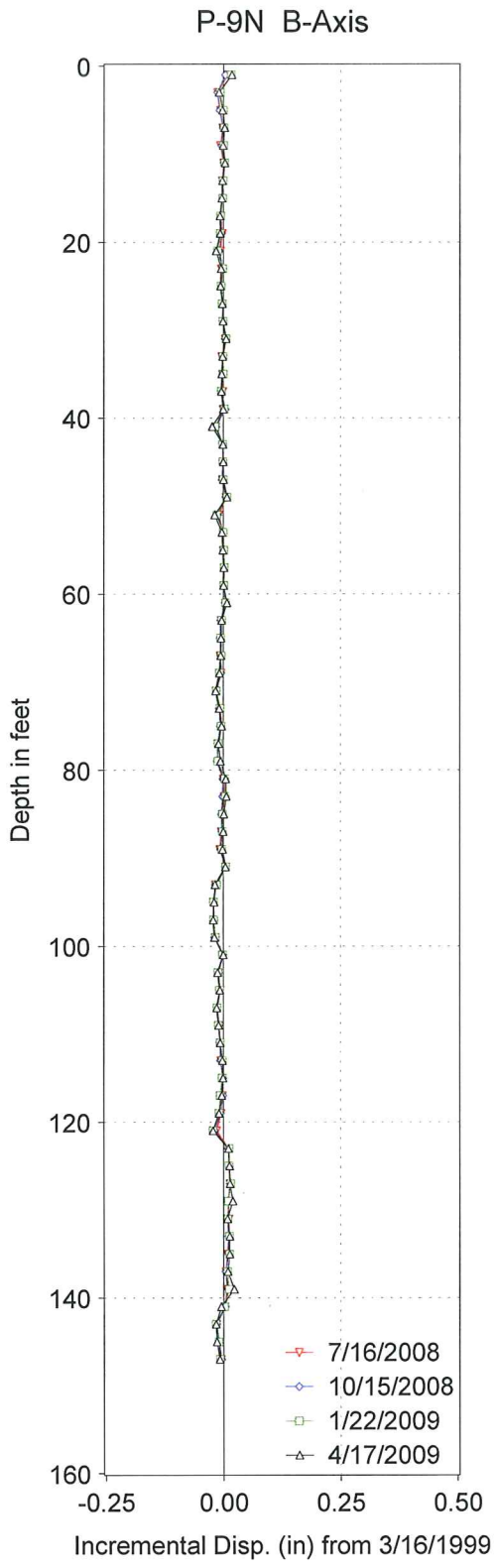


P-9N

-Includes readings from the last four quarters.

PLATE 15





P-9N

-Includes readings from the last four quarters.

PLATE 16

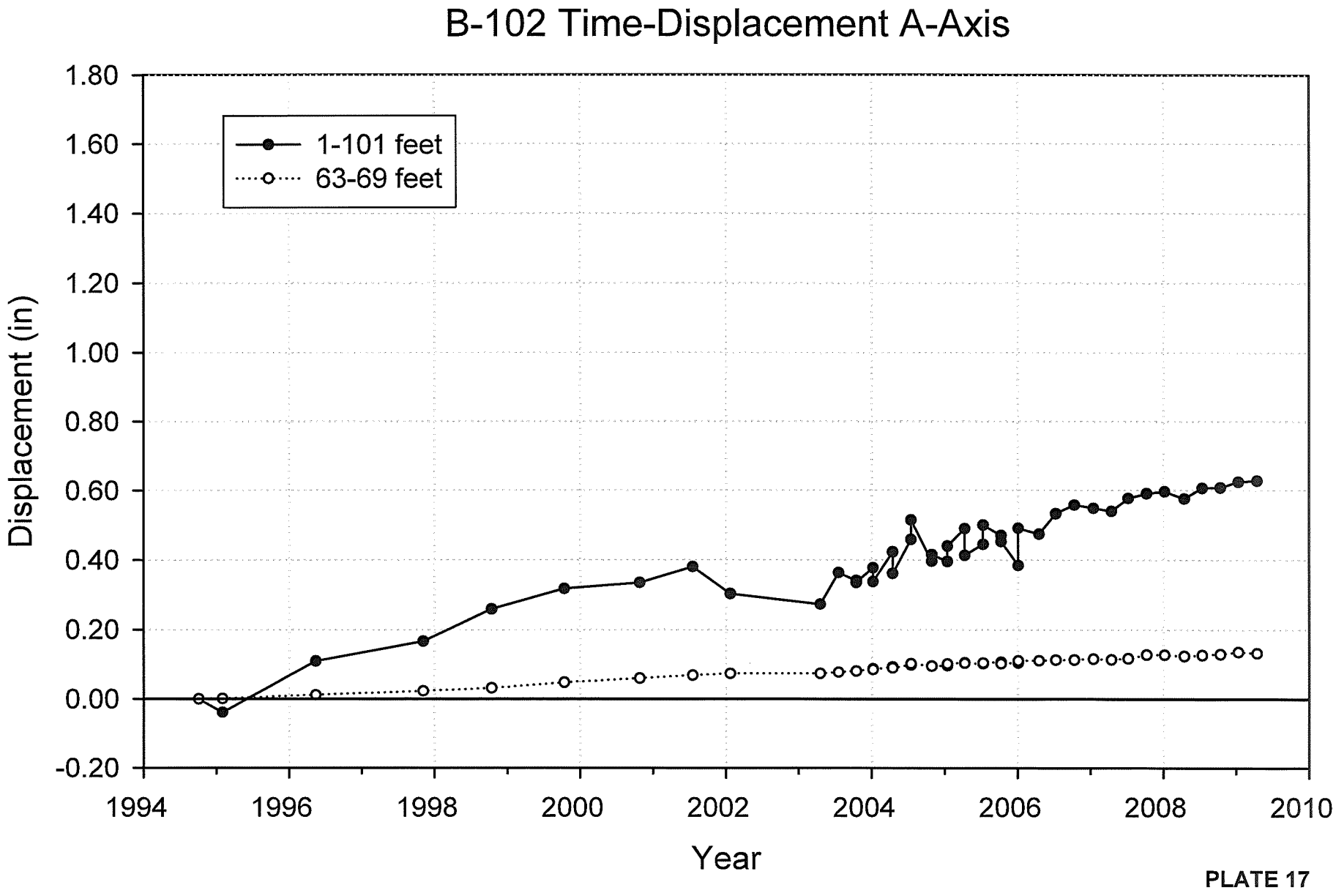

B-102 Time-Displacement A-Axis
1-101 feet
63-69 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 17

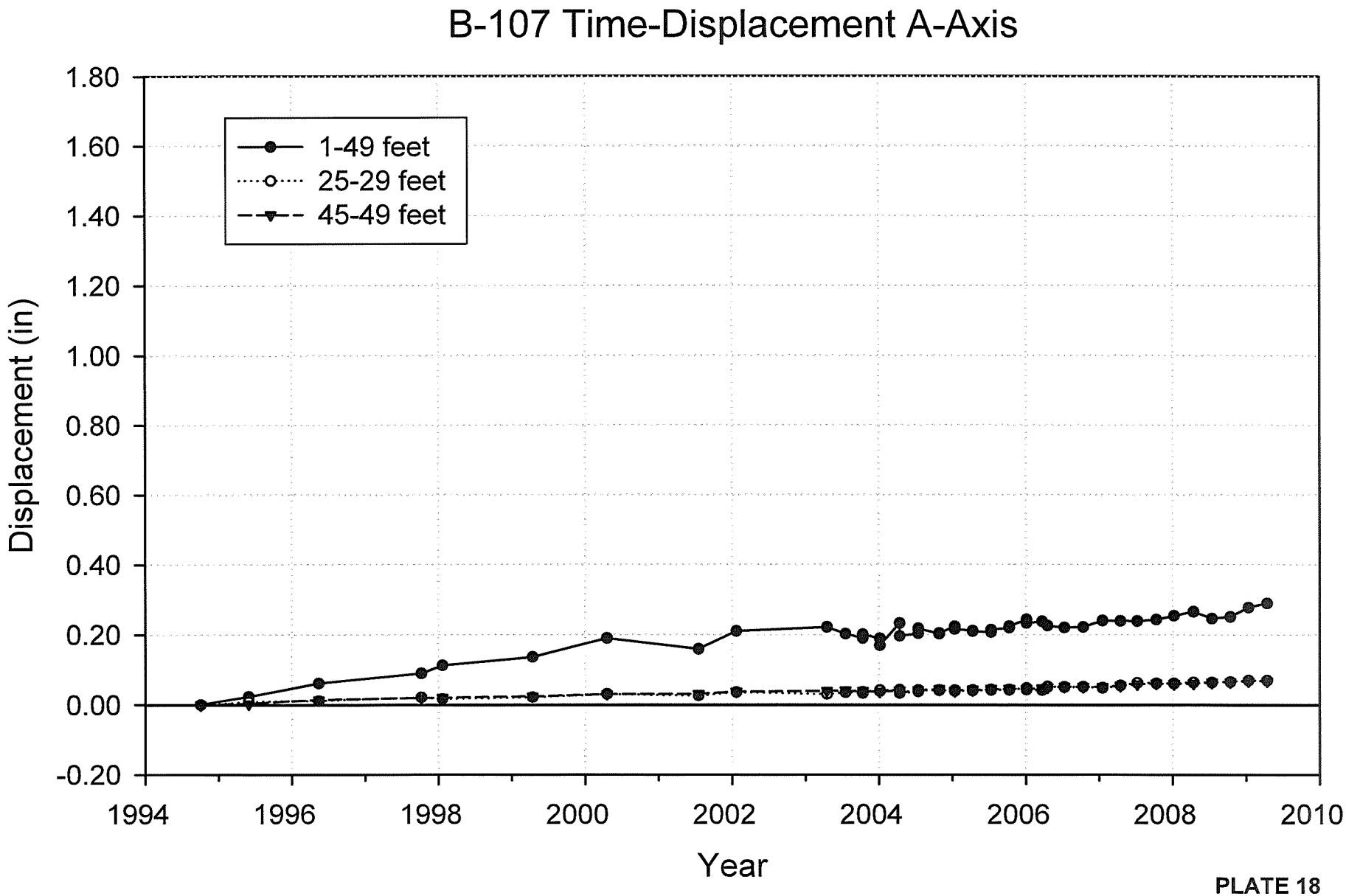

B-107 Time-Displacement A-Axis
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Displacement (in)
1-49 feet
25-29 feet
45-49 feet
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 18

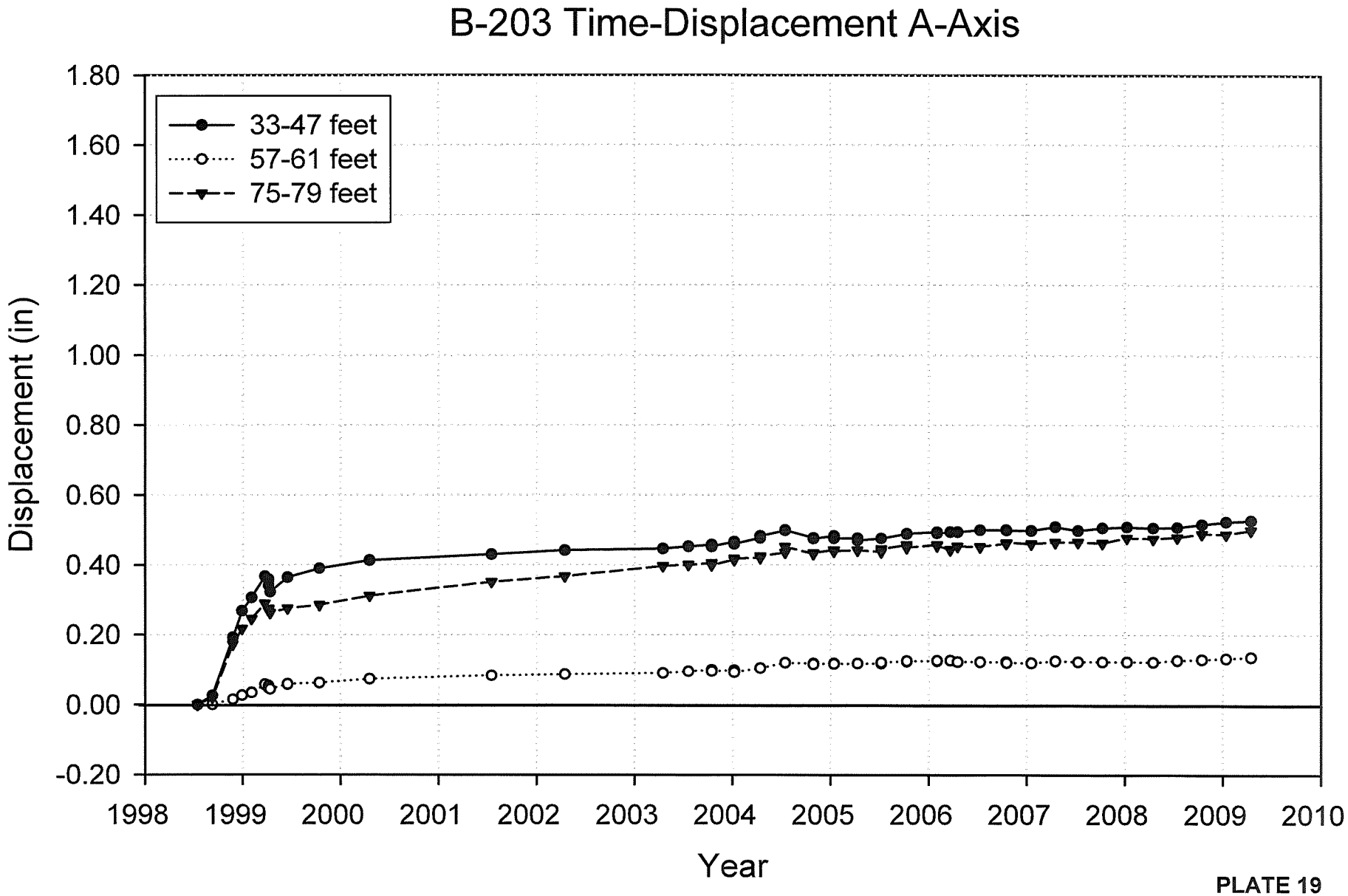

B-203 Time-Displacement A-Axis
33-47 feet
57-61 feet
75-79 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

PLATE 19

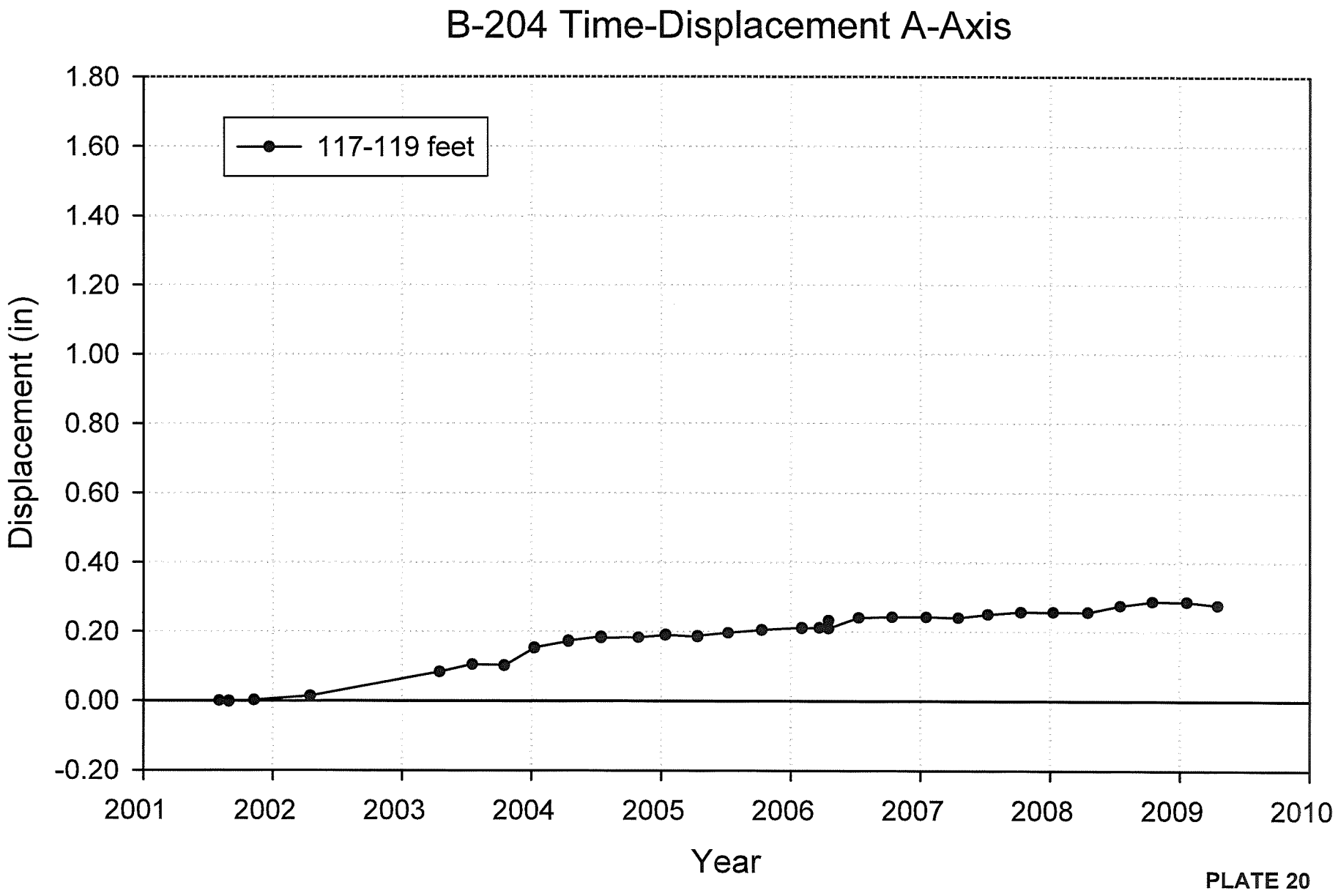

B-204 Time-Displacement A-Axis
117-119 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

PLATE 20

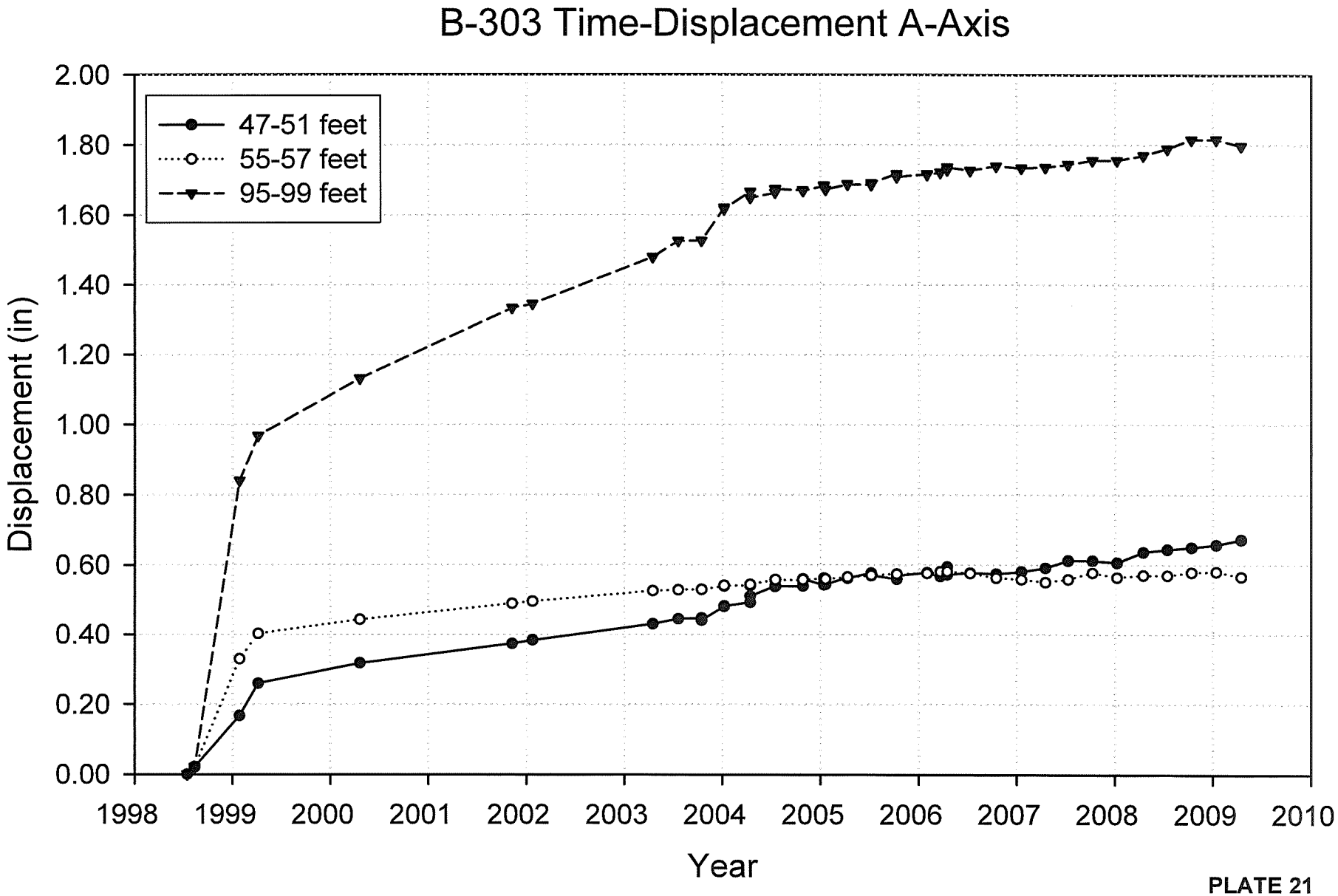
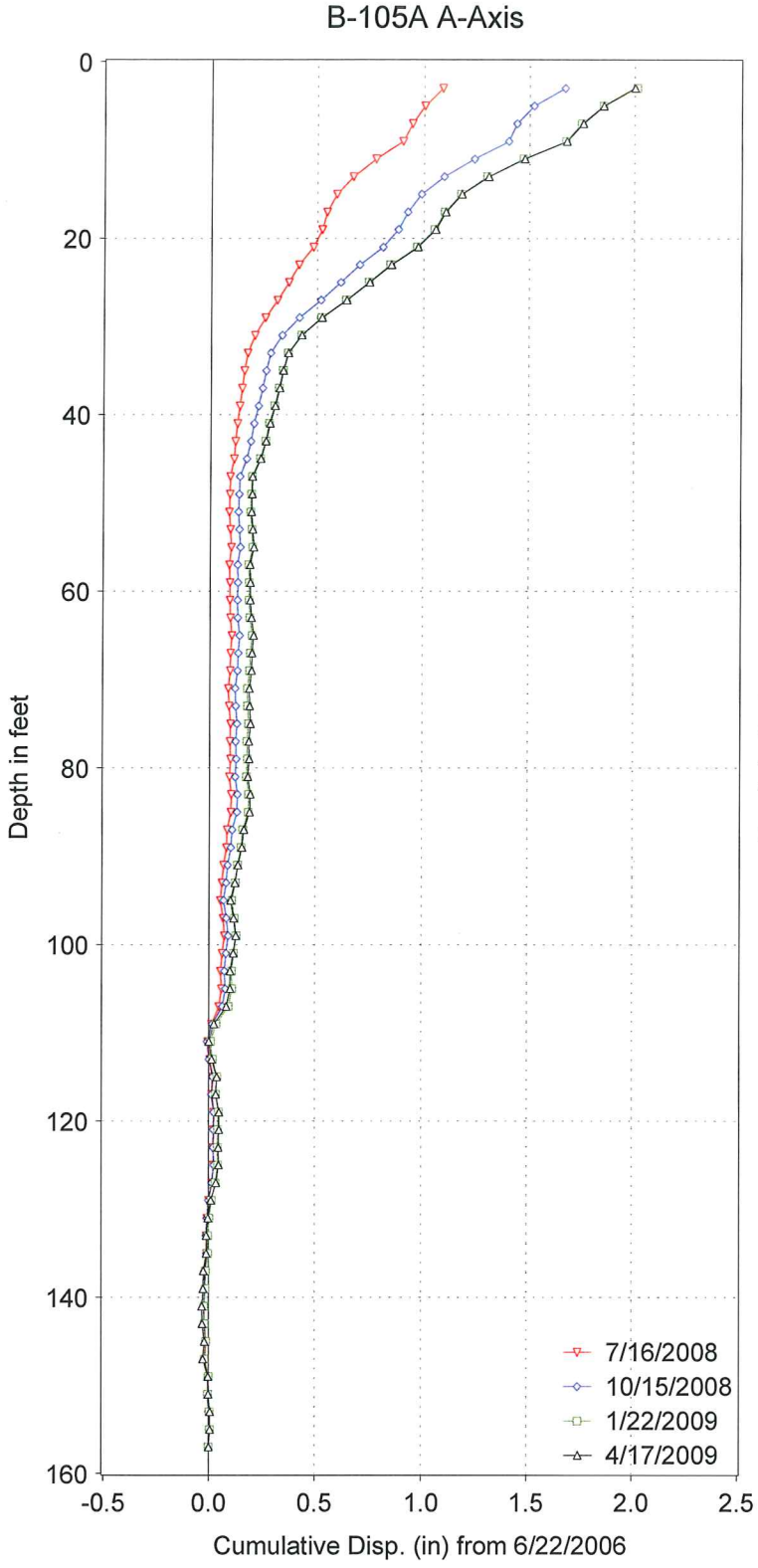
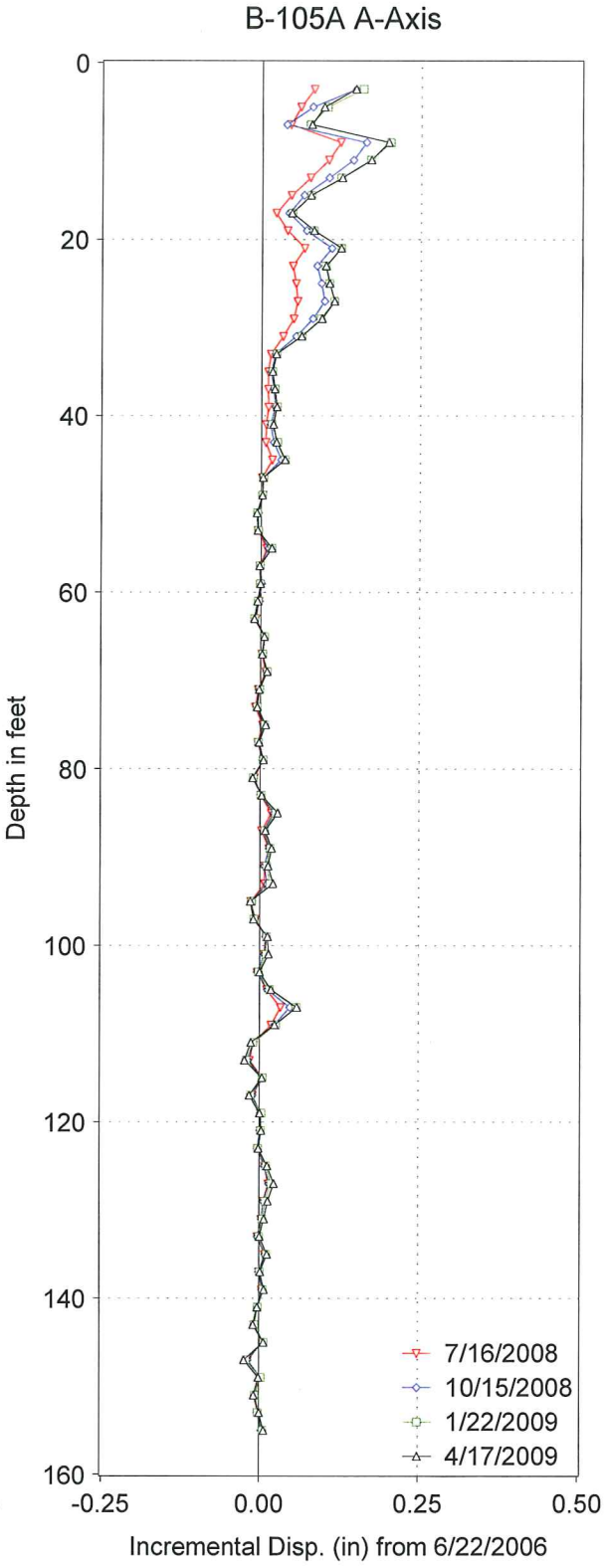

B-303 Time-Displacement A-Axis
47-51 feet
55-57 feet
95-99 feet
Displacement (in)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

PLATE 21

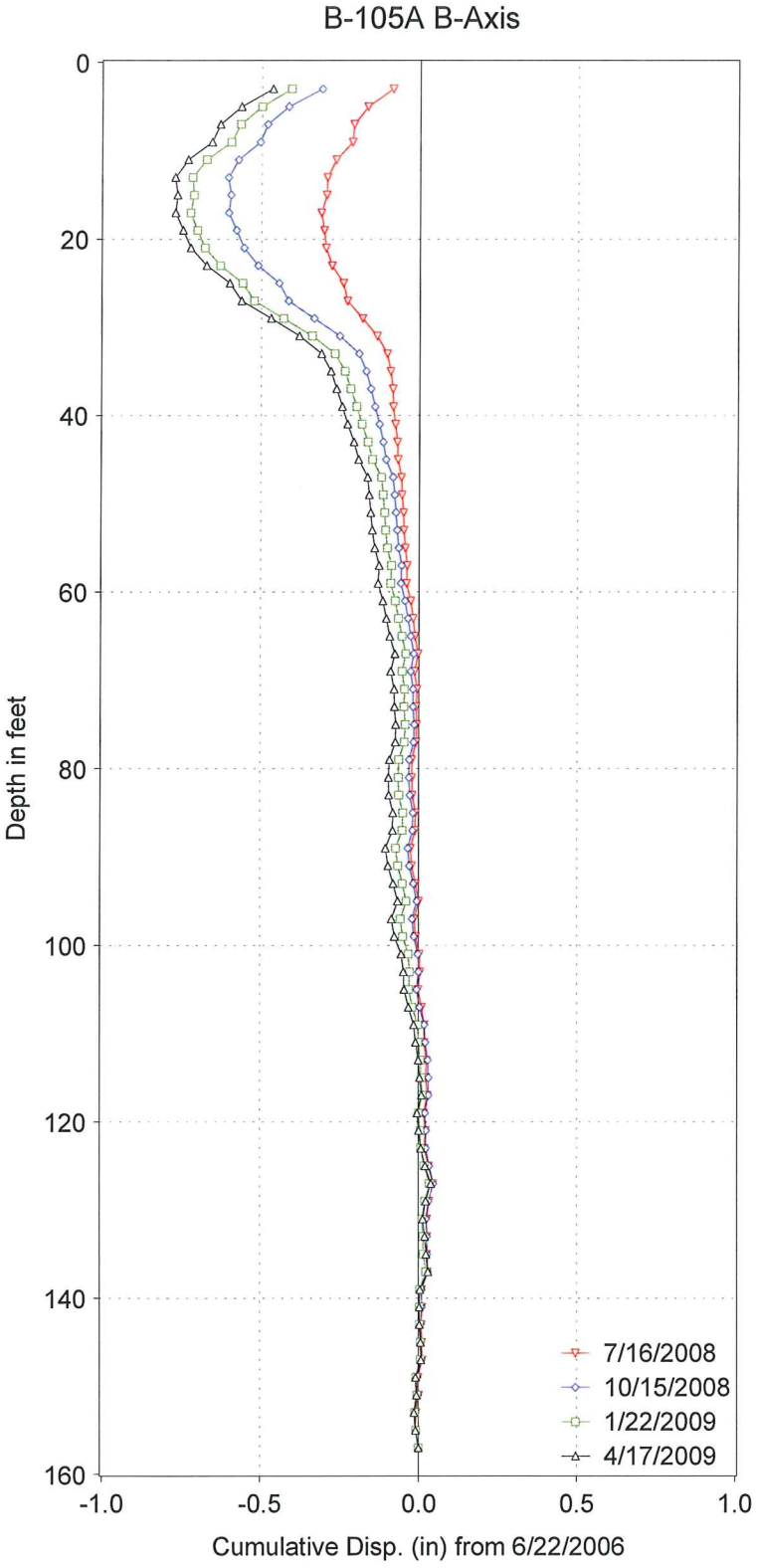


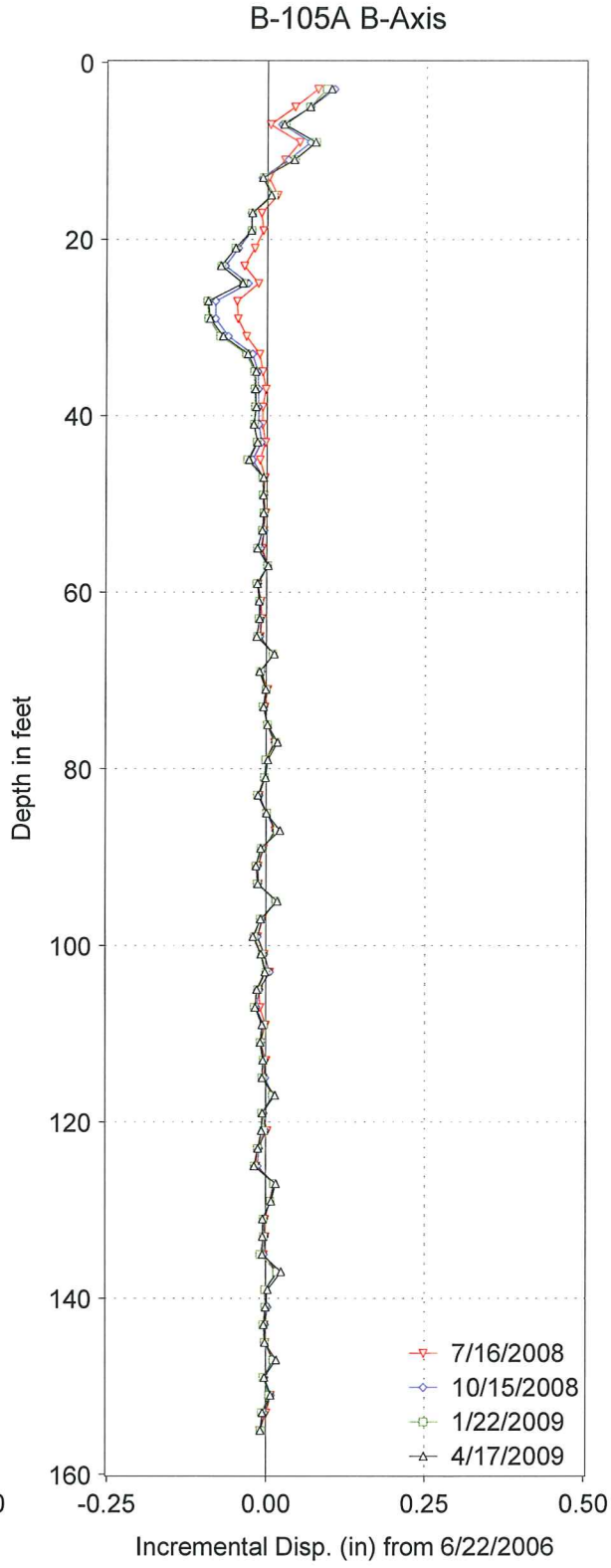


B-105A

-Includes readings from the last four quarters.

PLATE 22

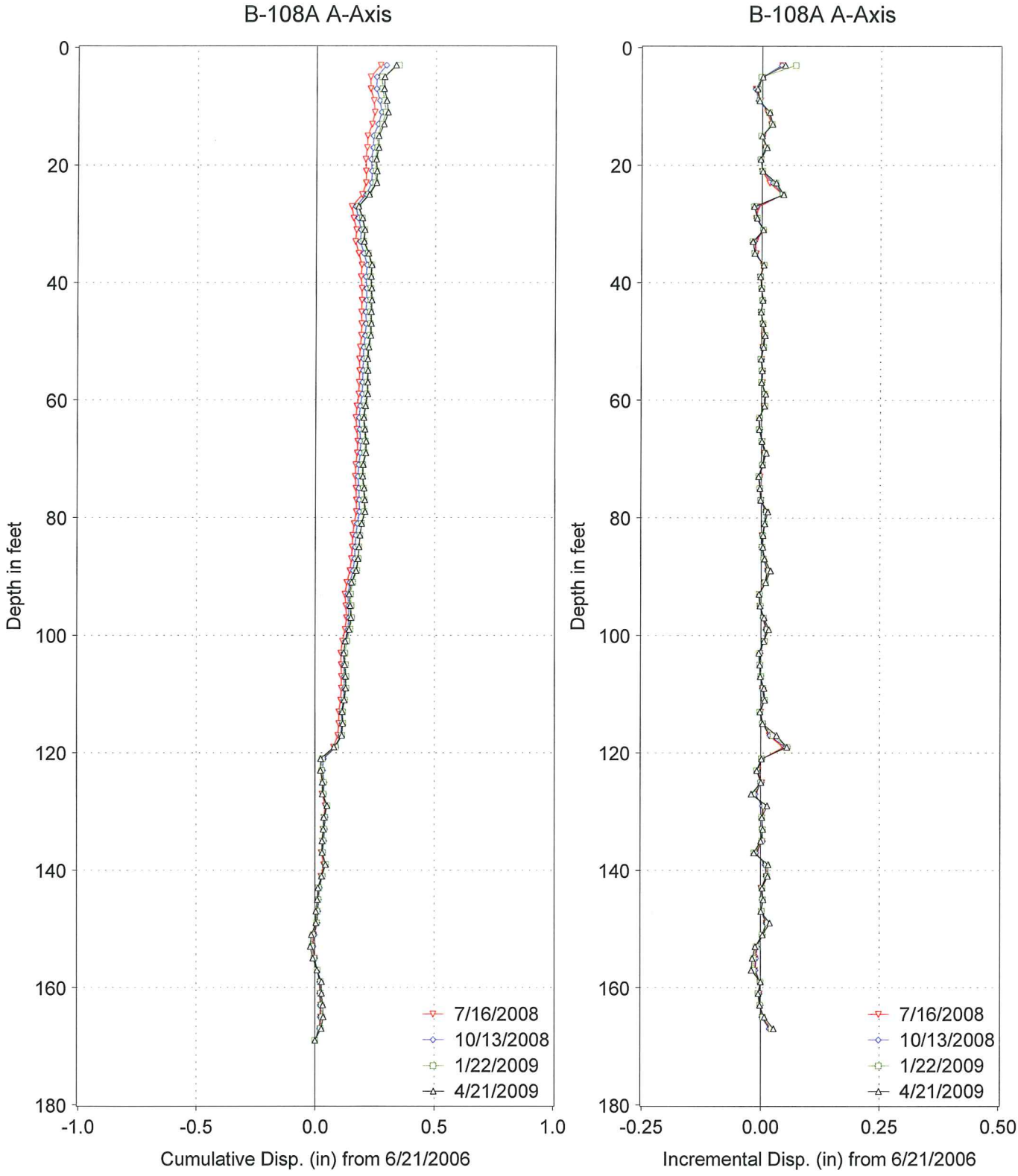




B-105A

-Includes readings from the last four quarters.

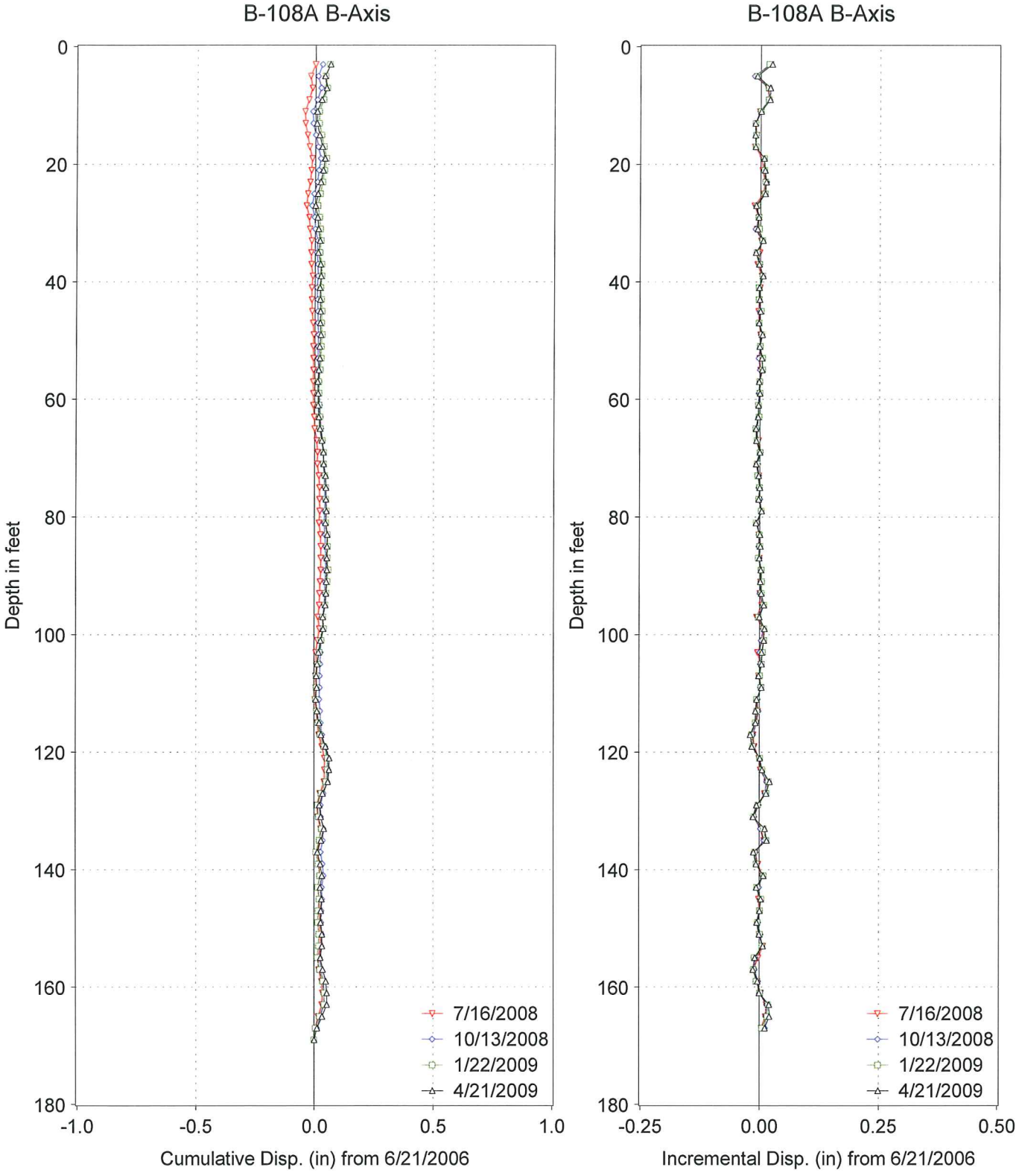
PLATE 23



B-108A

-Includes readings from the last four quarters.

PLATE 24



B-108A

-Includes readings from the last four quarters.

PLATE 25

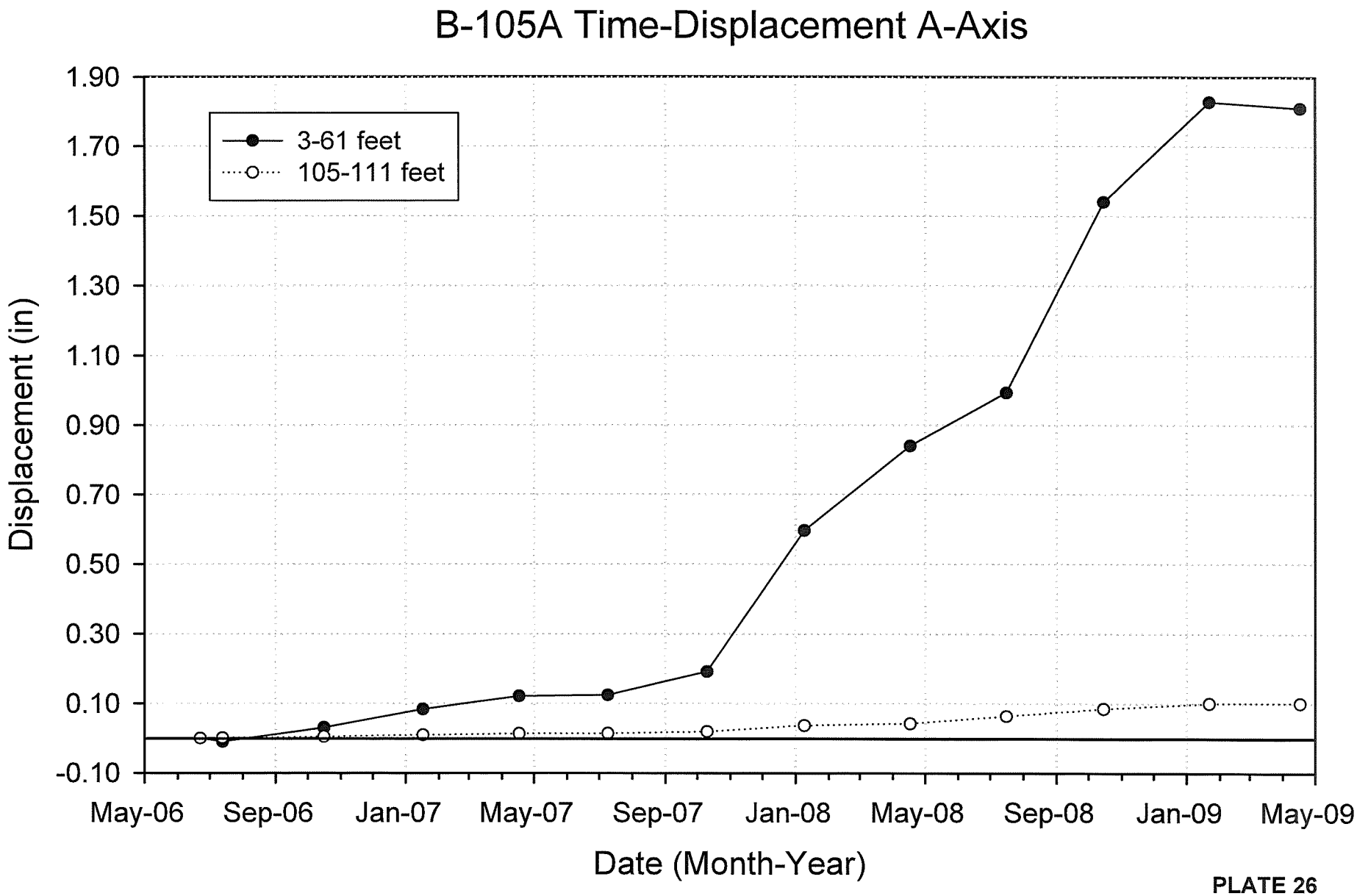

B-105A Time-Displacement A-Axis
3-61 feet
105-111 feet
Displacement (in)
1.90
1.70
1.50
1.30
1.10
0.90
0.70
0.50
0.30
0.10
-0.10
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Date (Month-Year)

PLATE 26

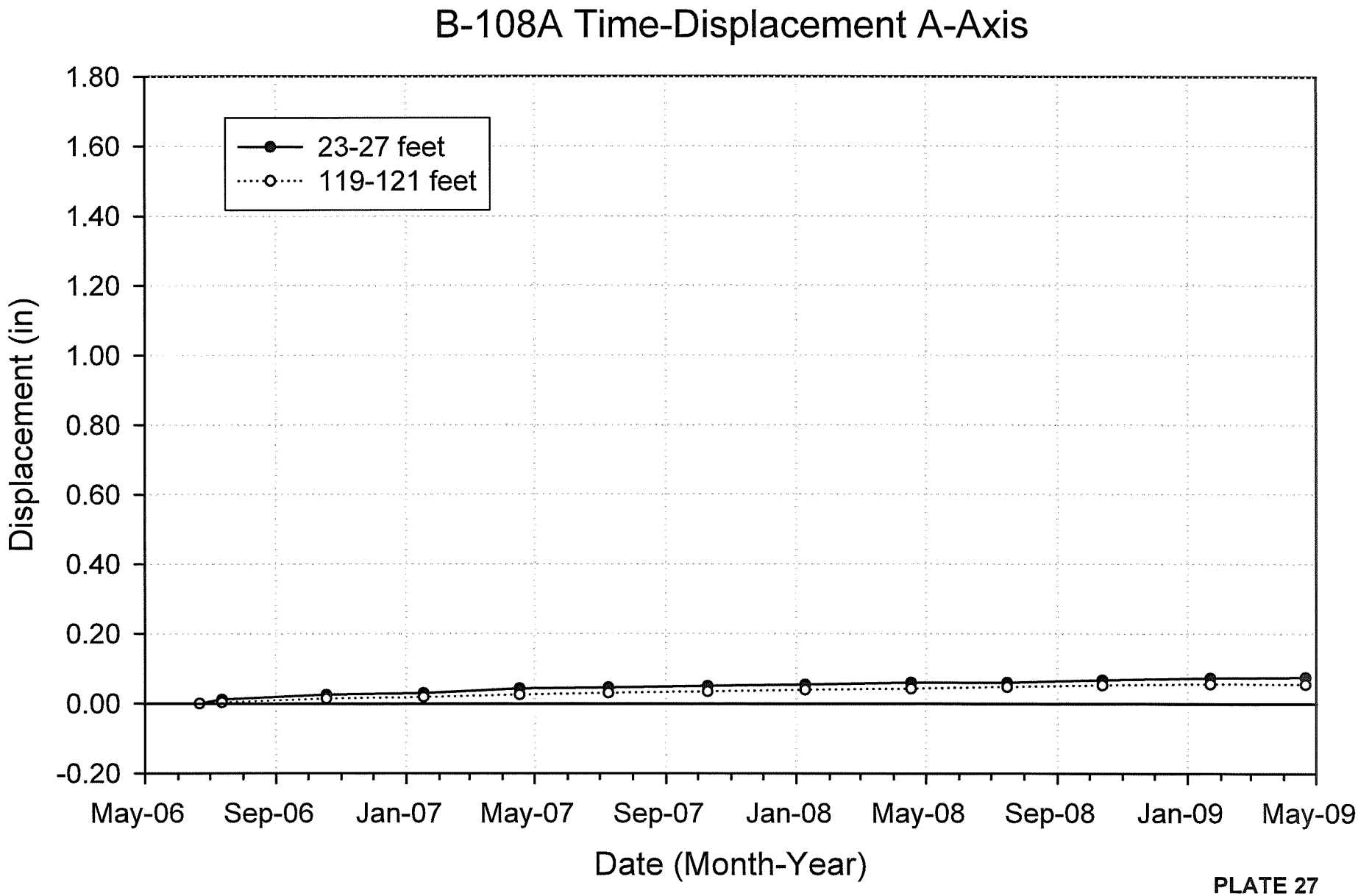
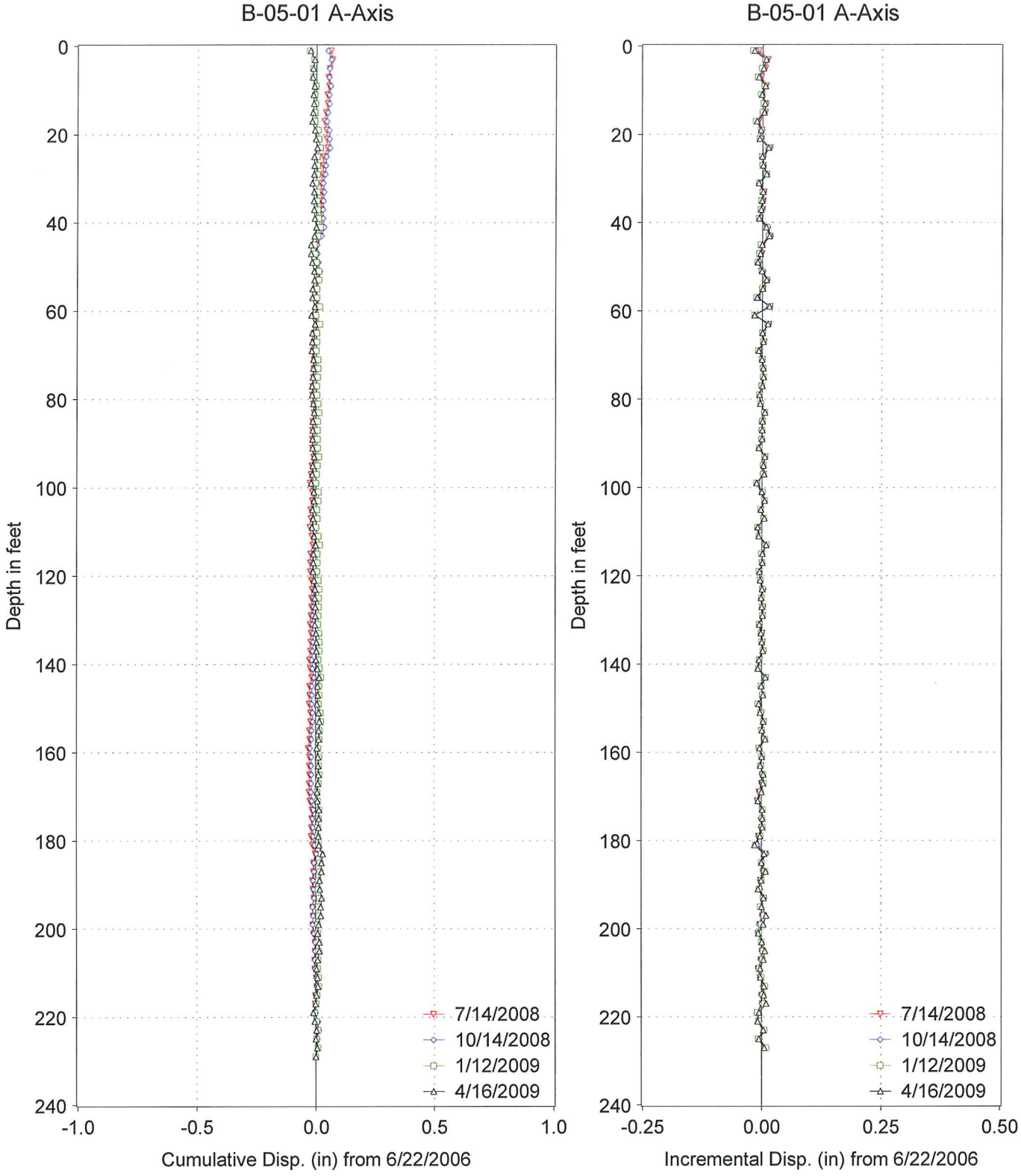

B-108A Time-Displacement A-Axis
23-27 feet
119-121 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Date (Month-Year)

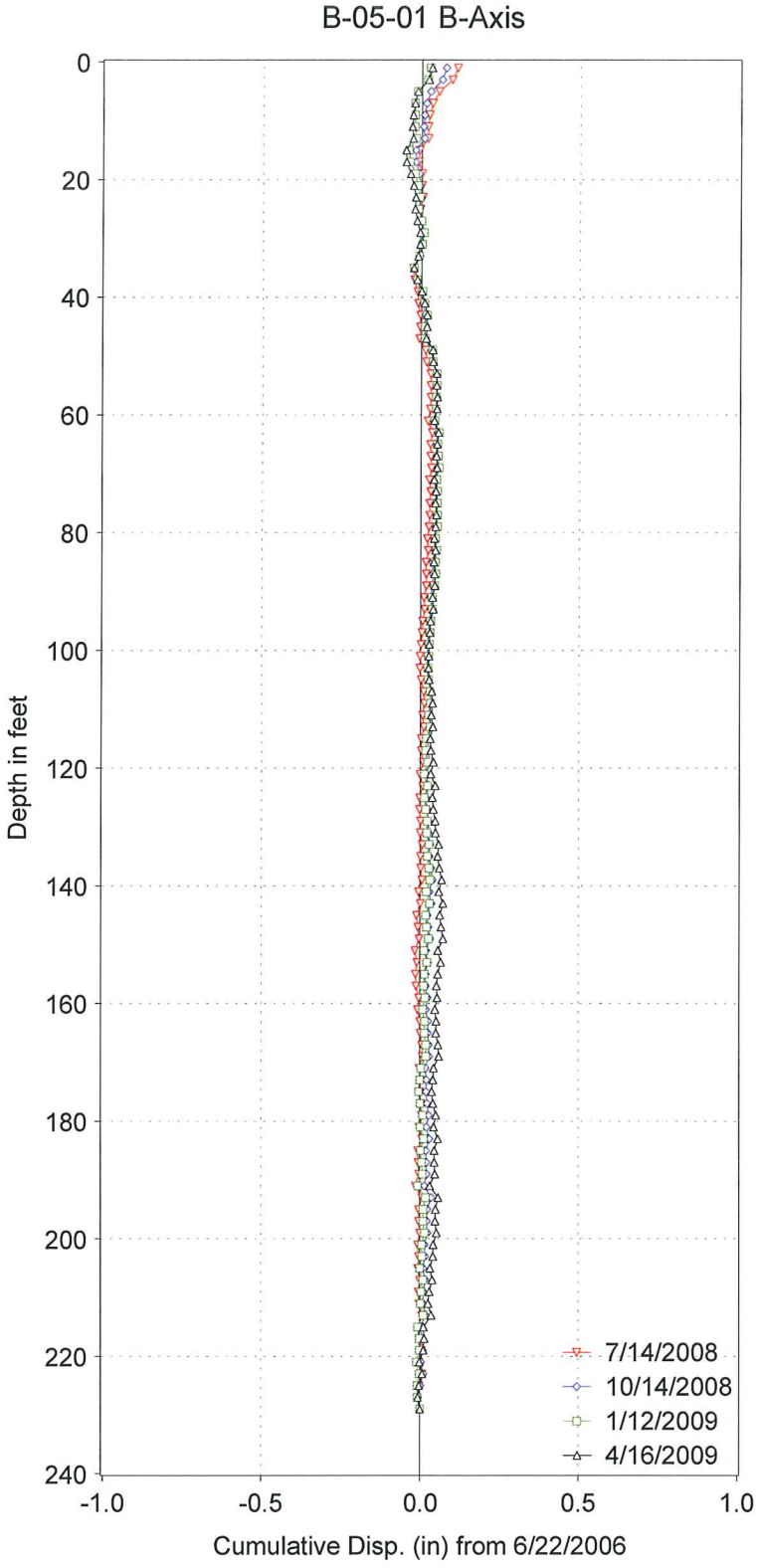
PLATE 27

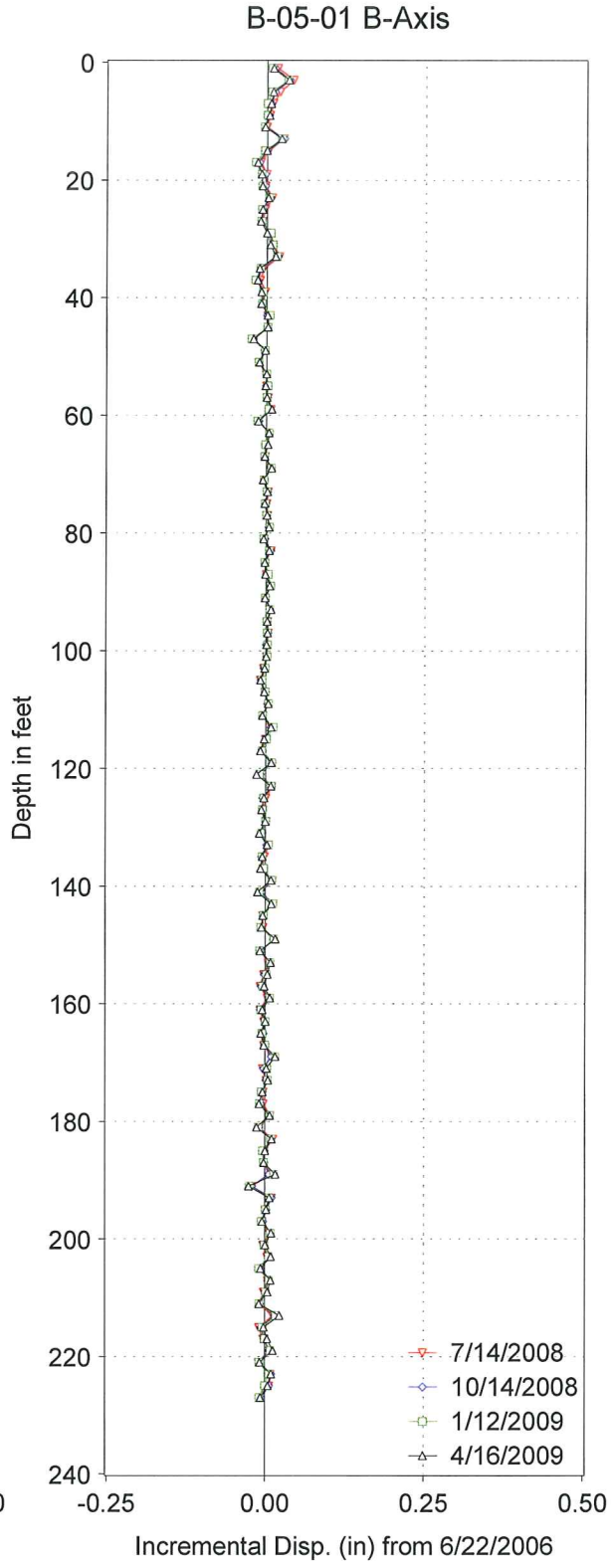


B-05-01

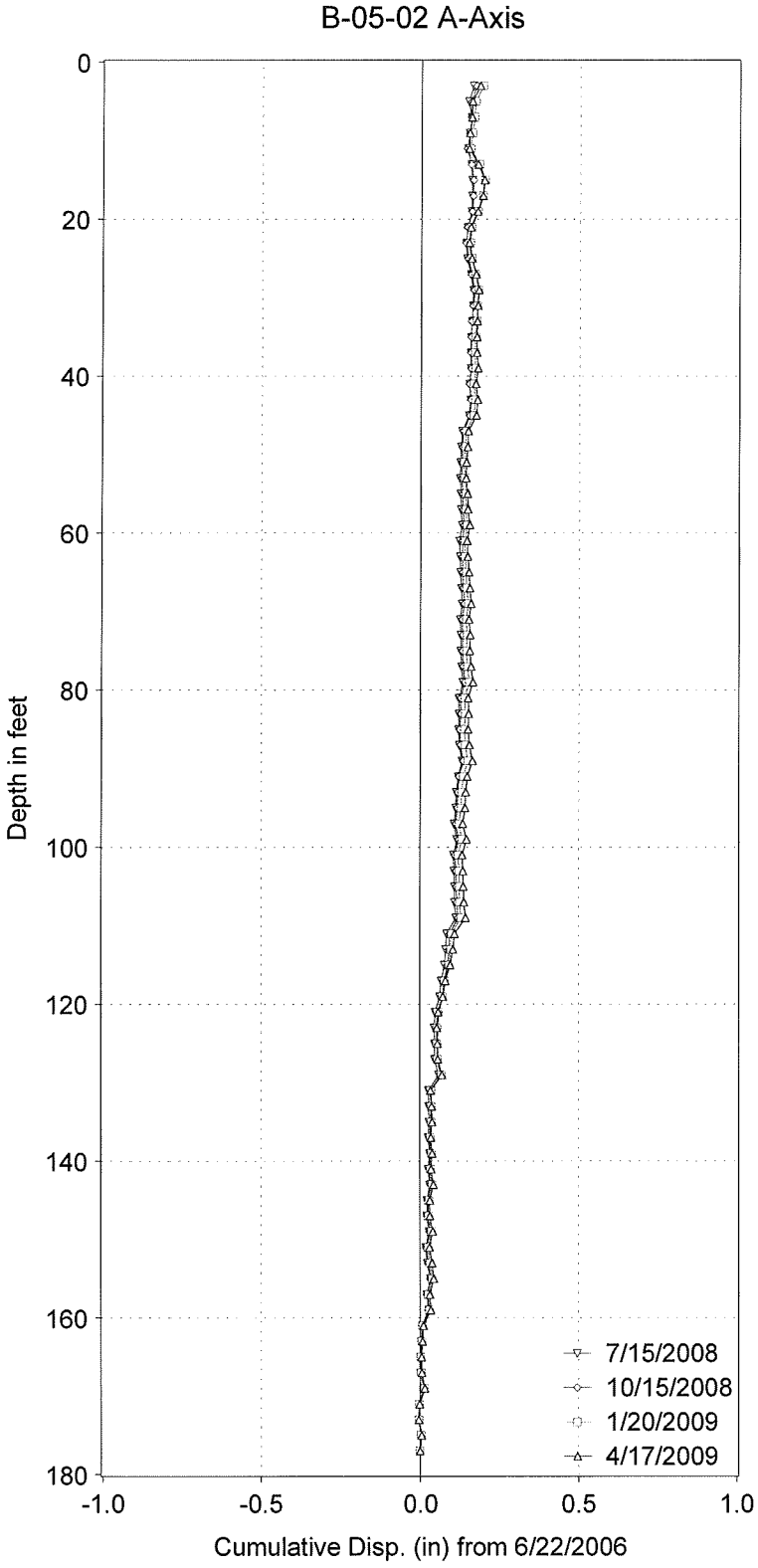
-Includes readings from the last four quarters.

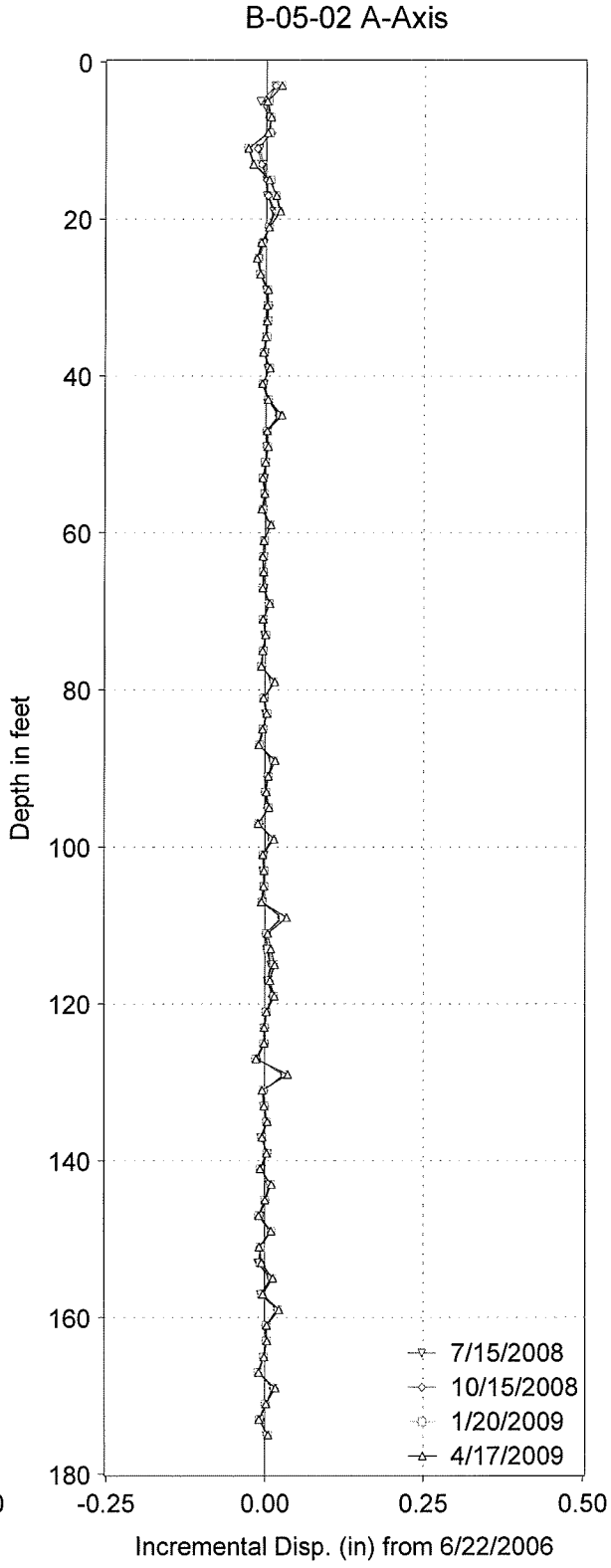
PLATE 28





B-05-01
-Includes readings from the last four quarters.

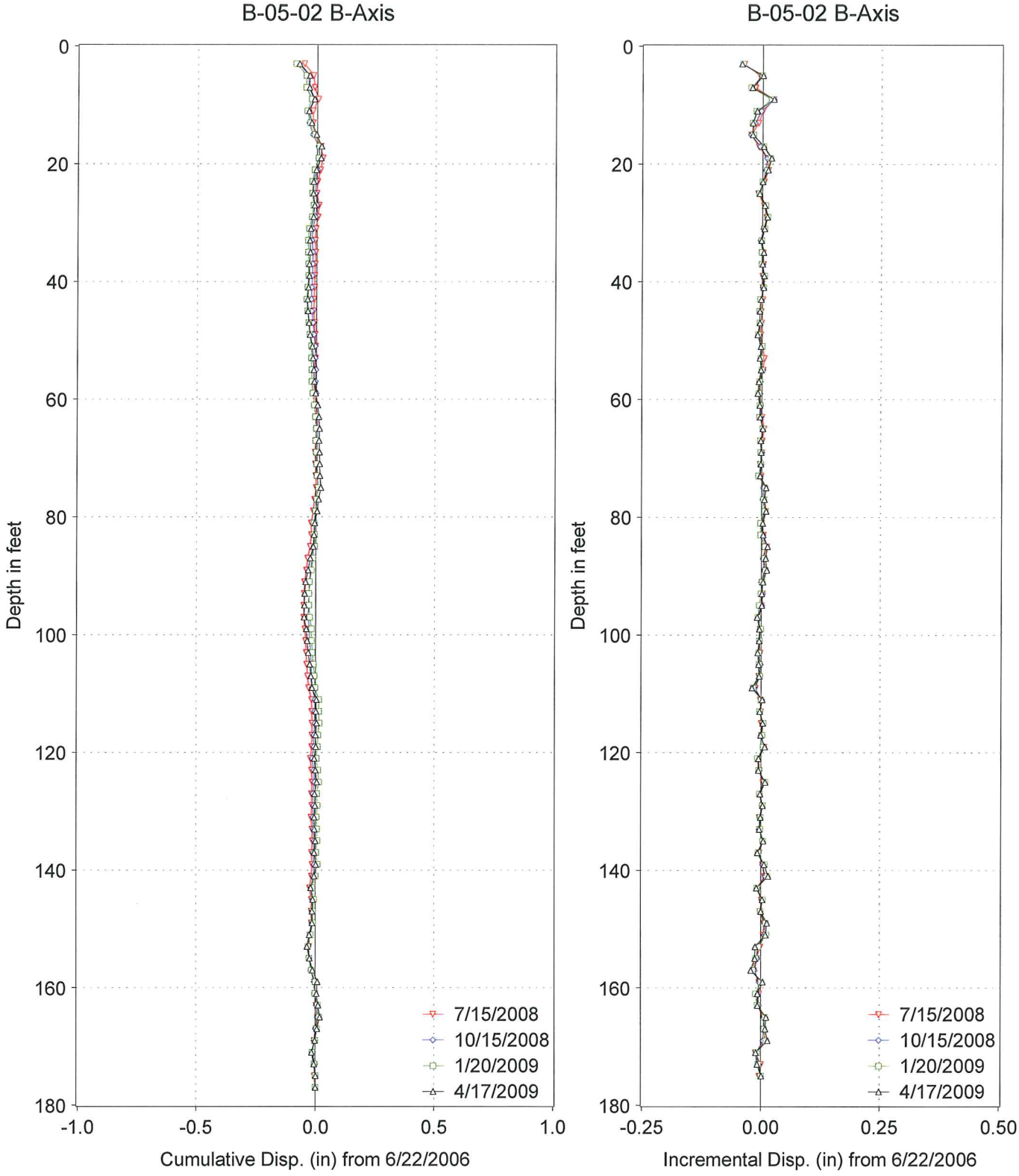




B-05-02

-Includes readings from the last four quarters.

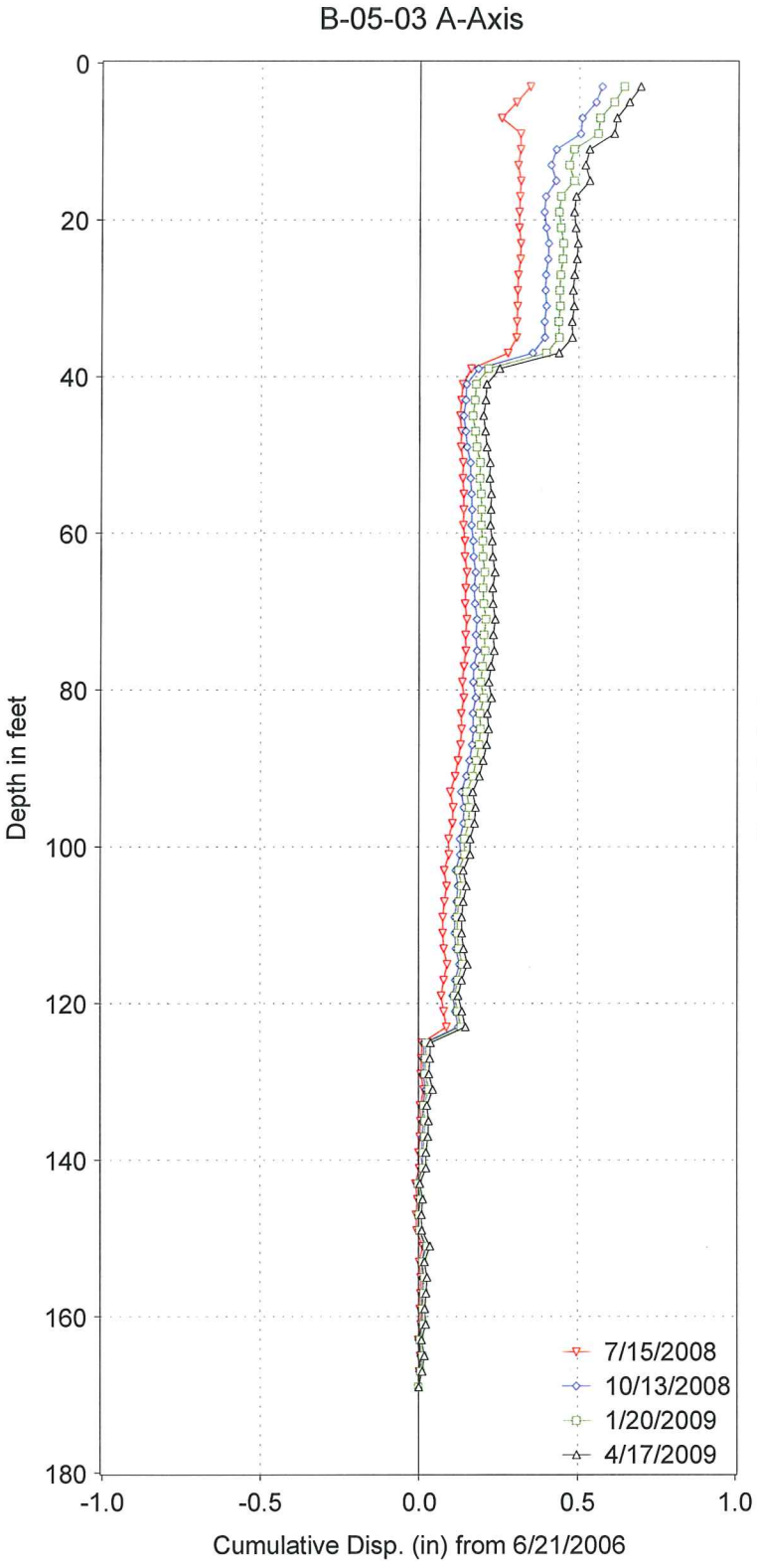
PLATE 30

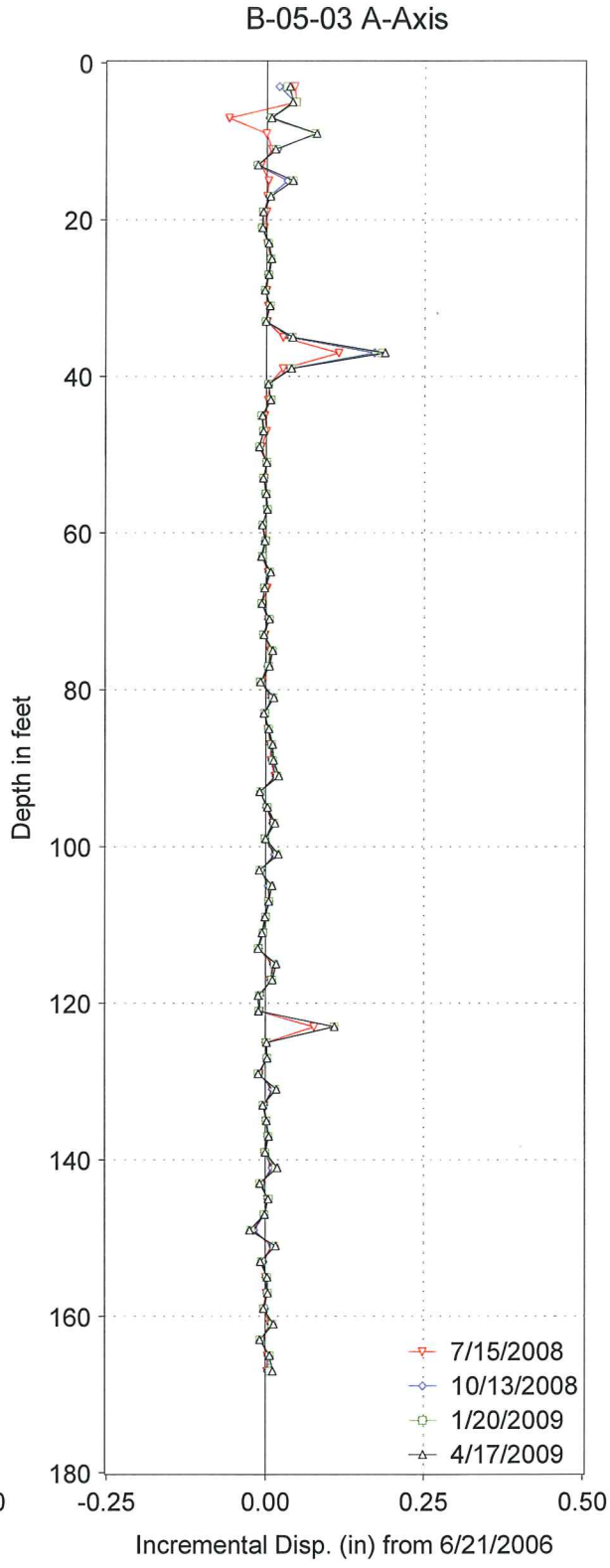


B-05-02

-Includes readings from the last four quarters.

PLATE 31

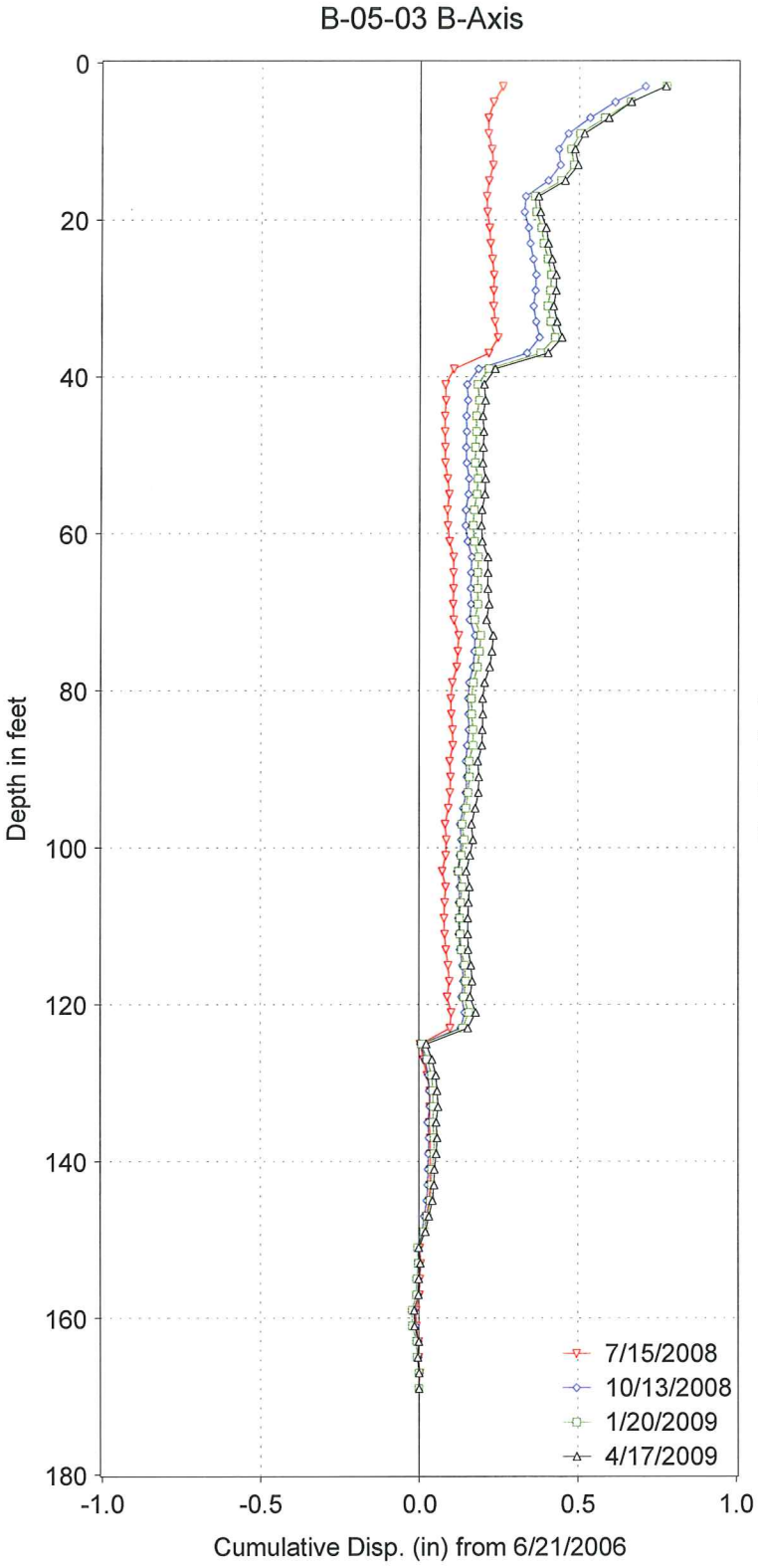


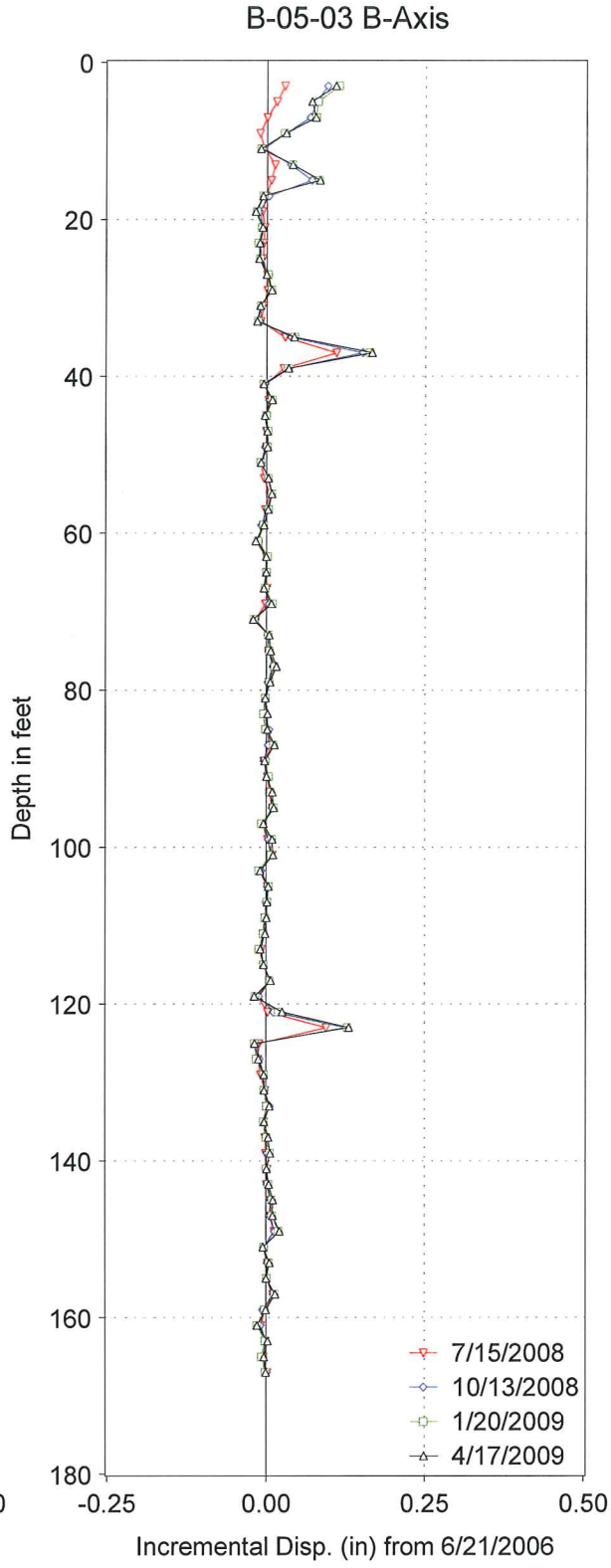


B-05-03

-Includes readings from the last four quarters.

PLATE 32

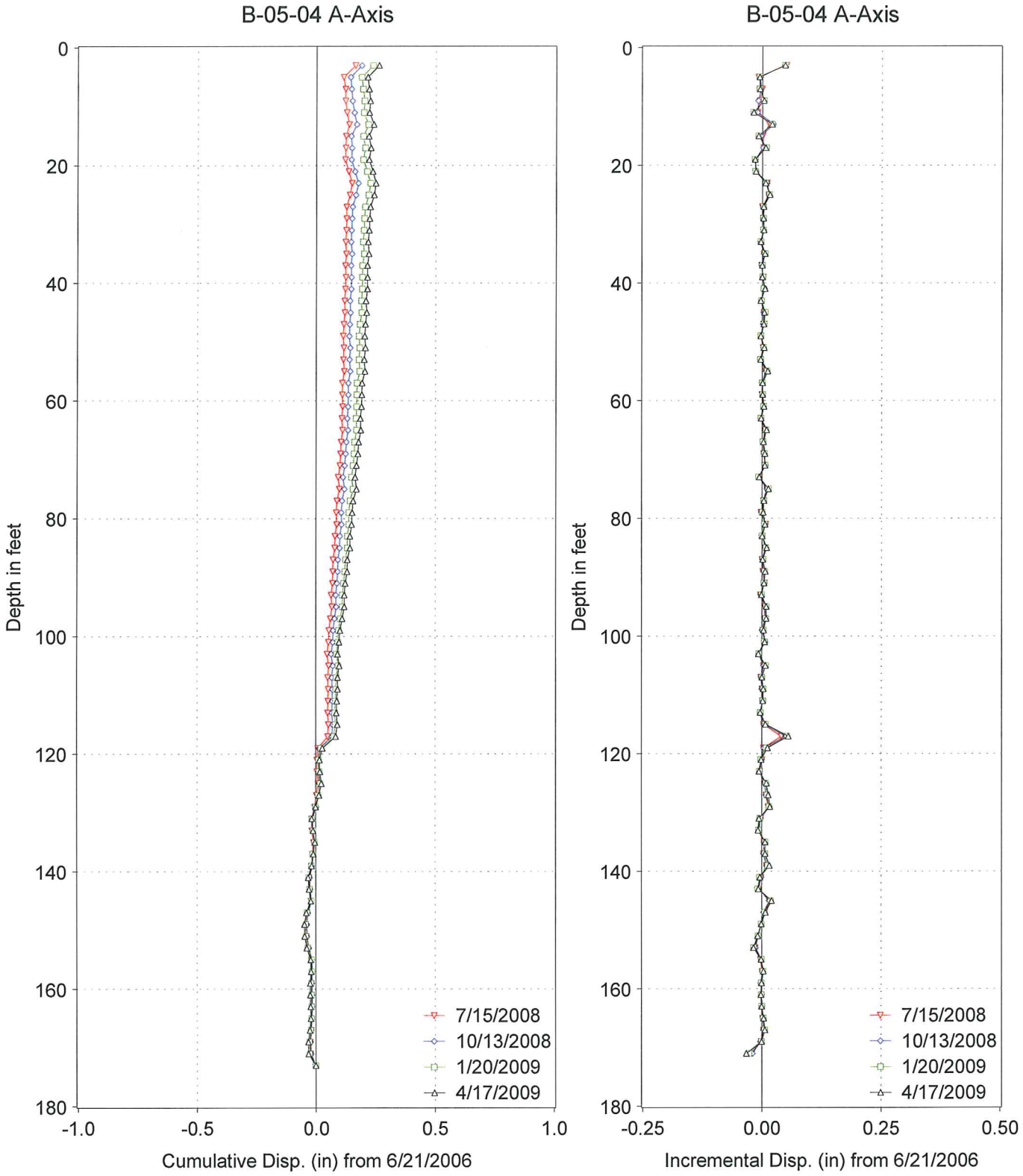




B-05-03

-Includes readings from the last four quarters.

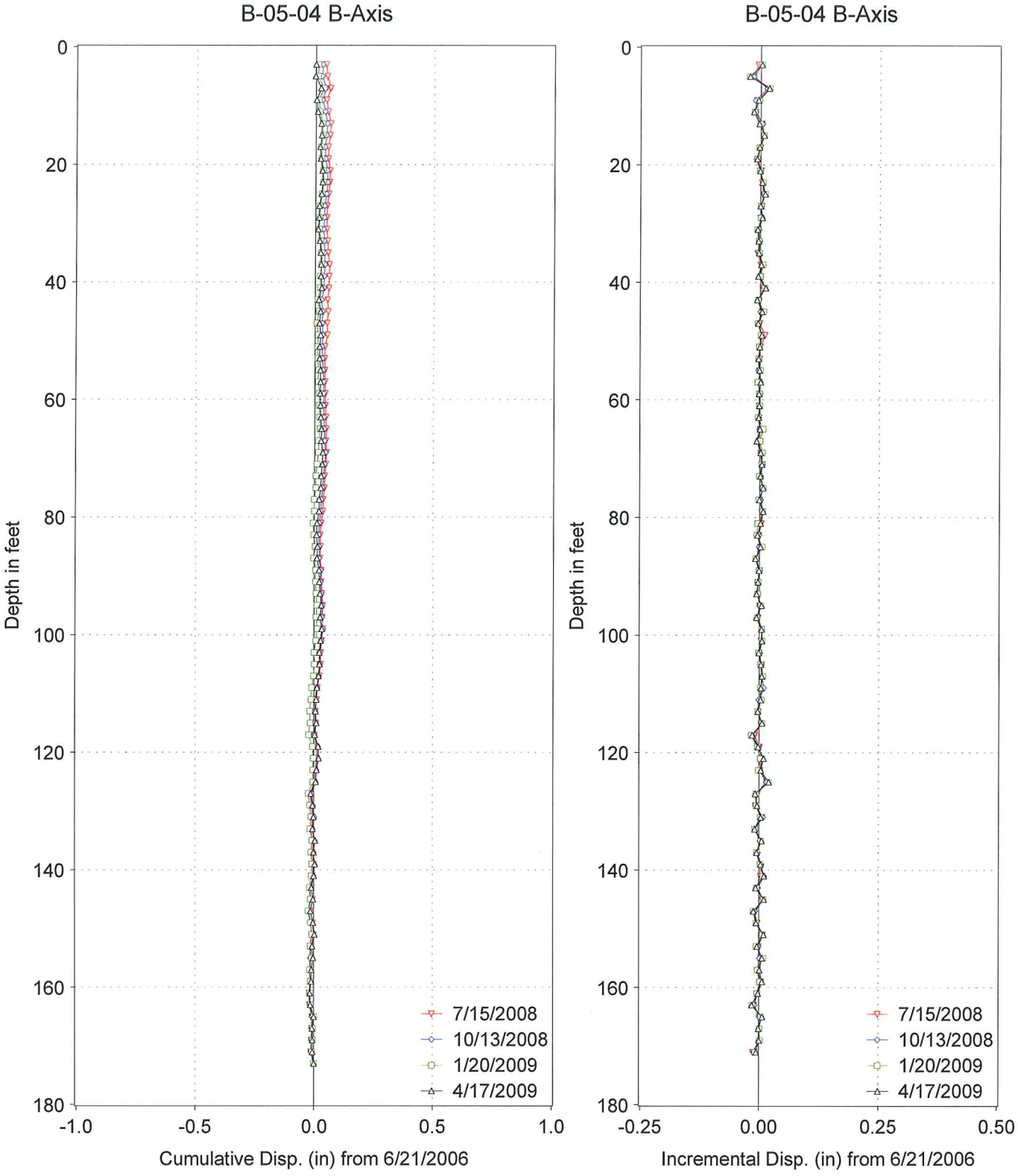
PLATE 33



B-05-04

-Includes readings from the last four quarters.

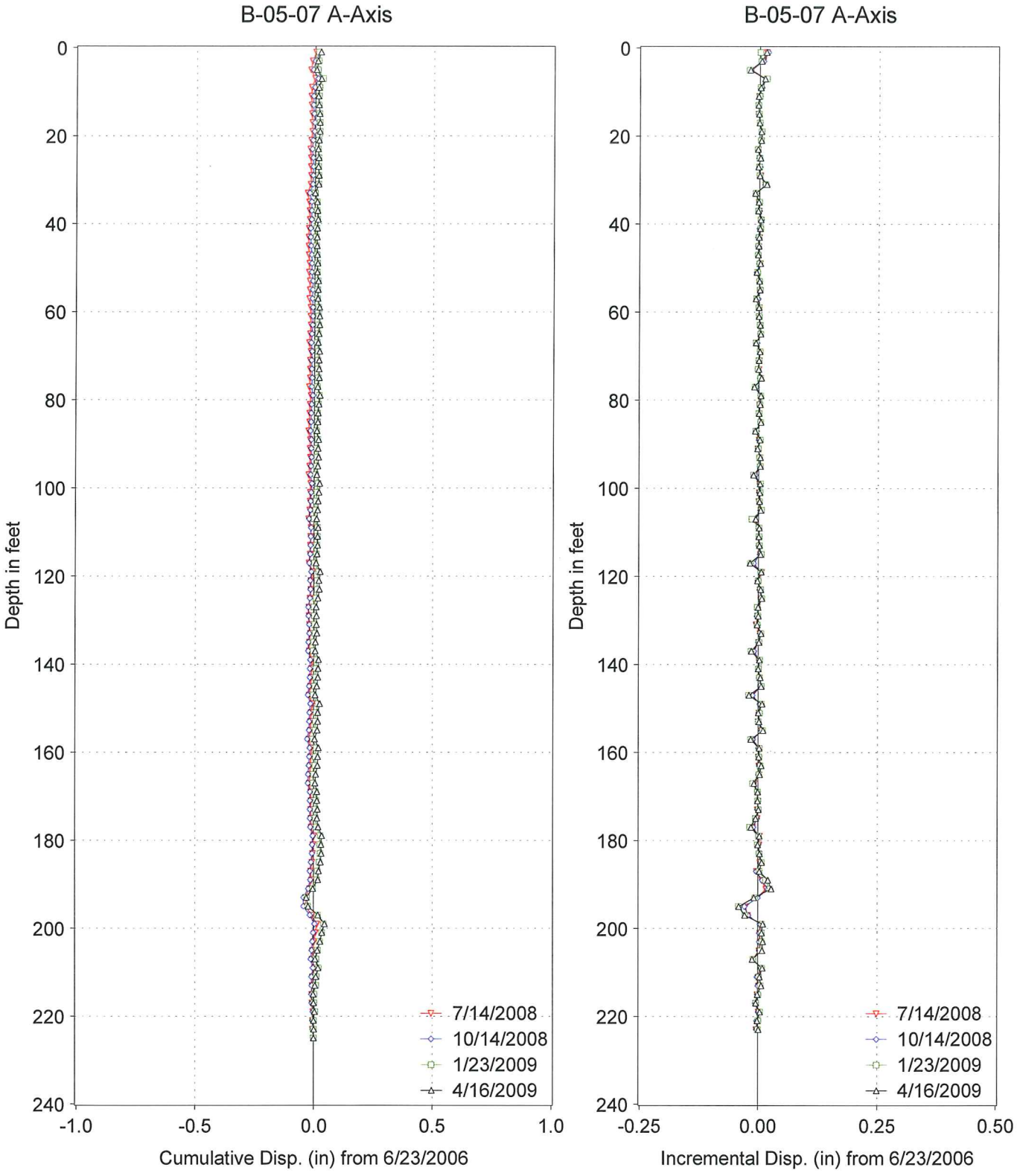
PLATE 34



B-05-04

-Includes readings from the last four quarters.

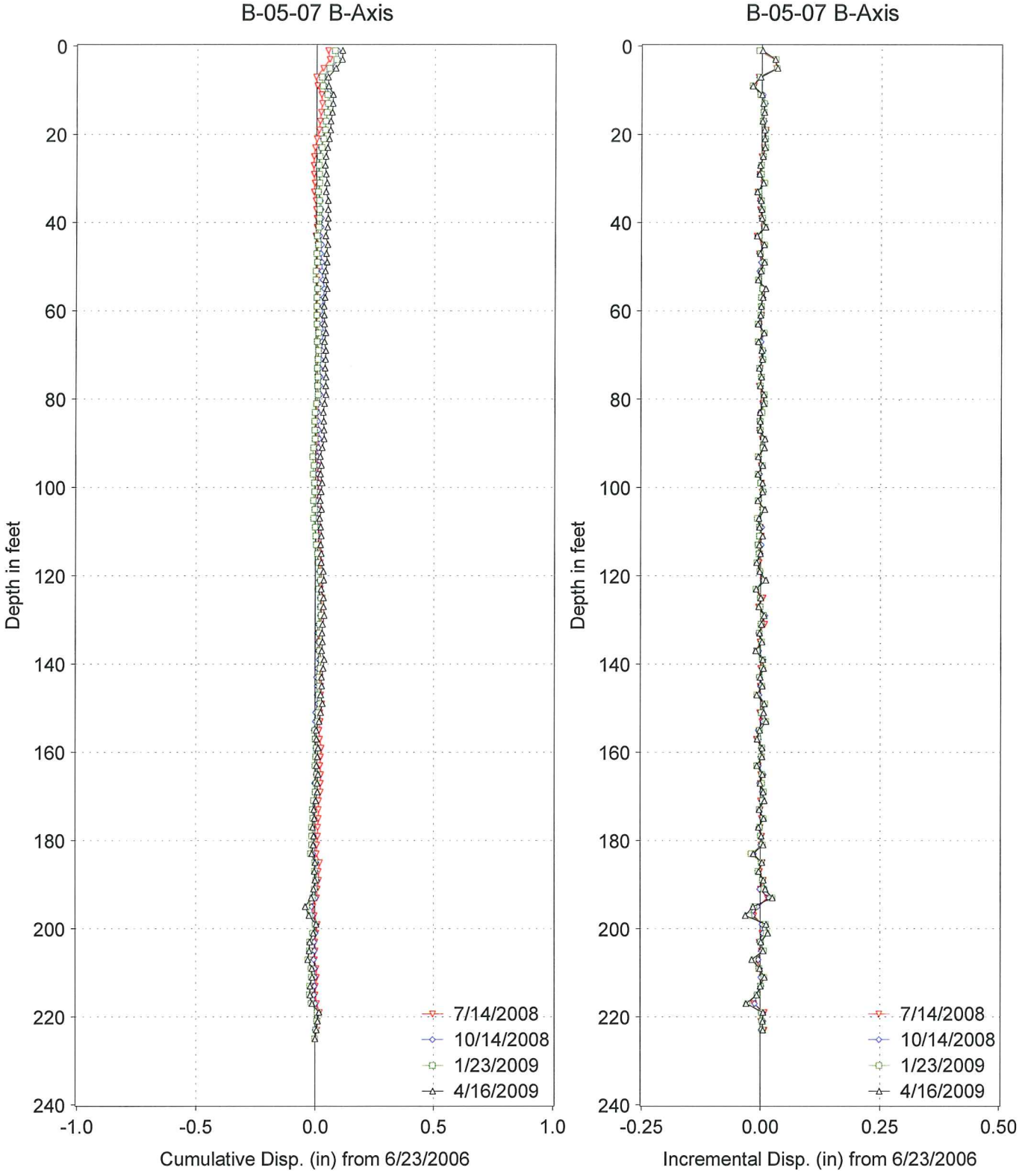
PLATE 35



B-05-07

-Includes readings from the last four quarters.

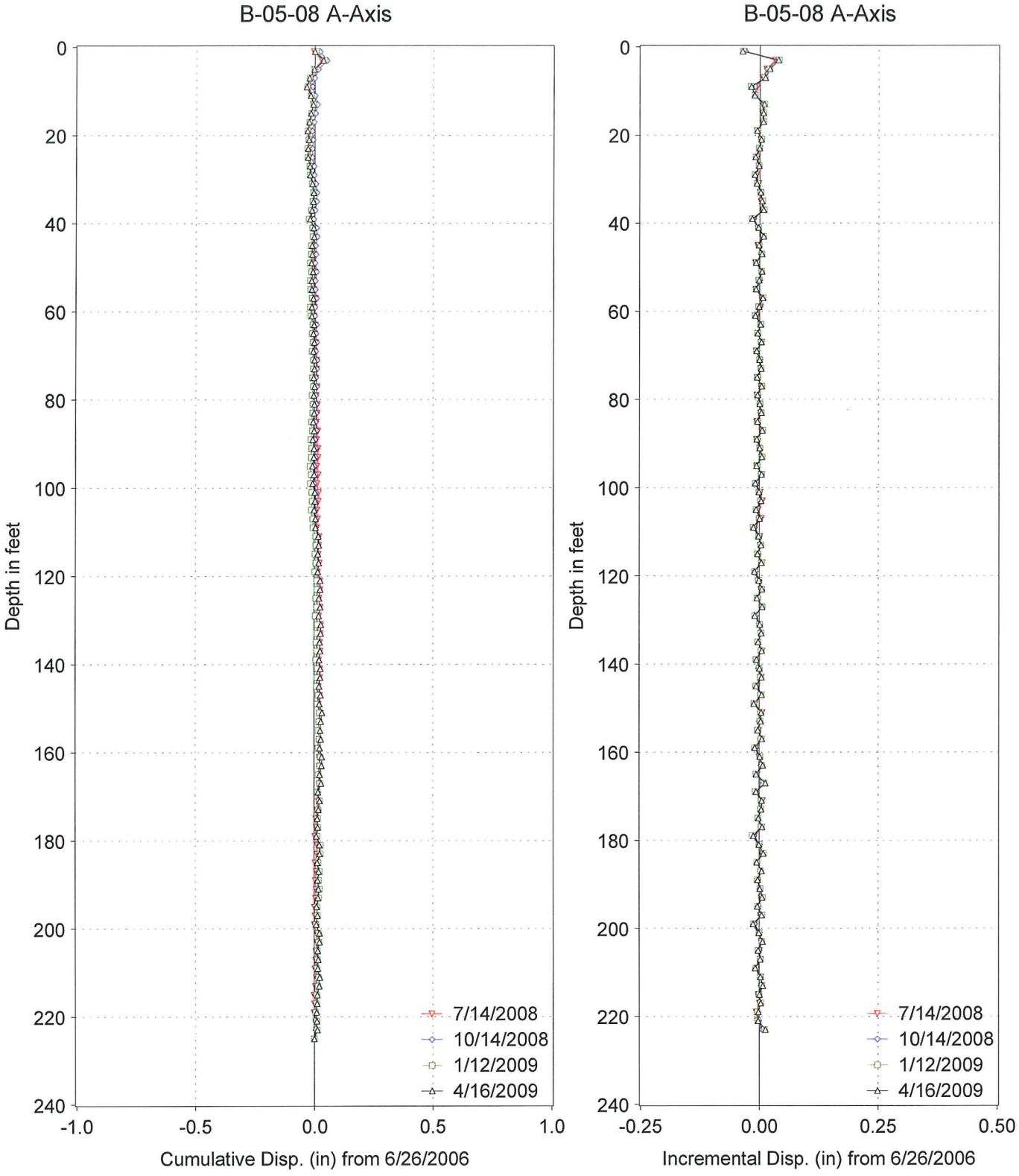
PLATE 36



B-05-07

-Includes readings from the last four quarters.

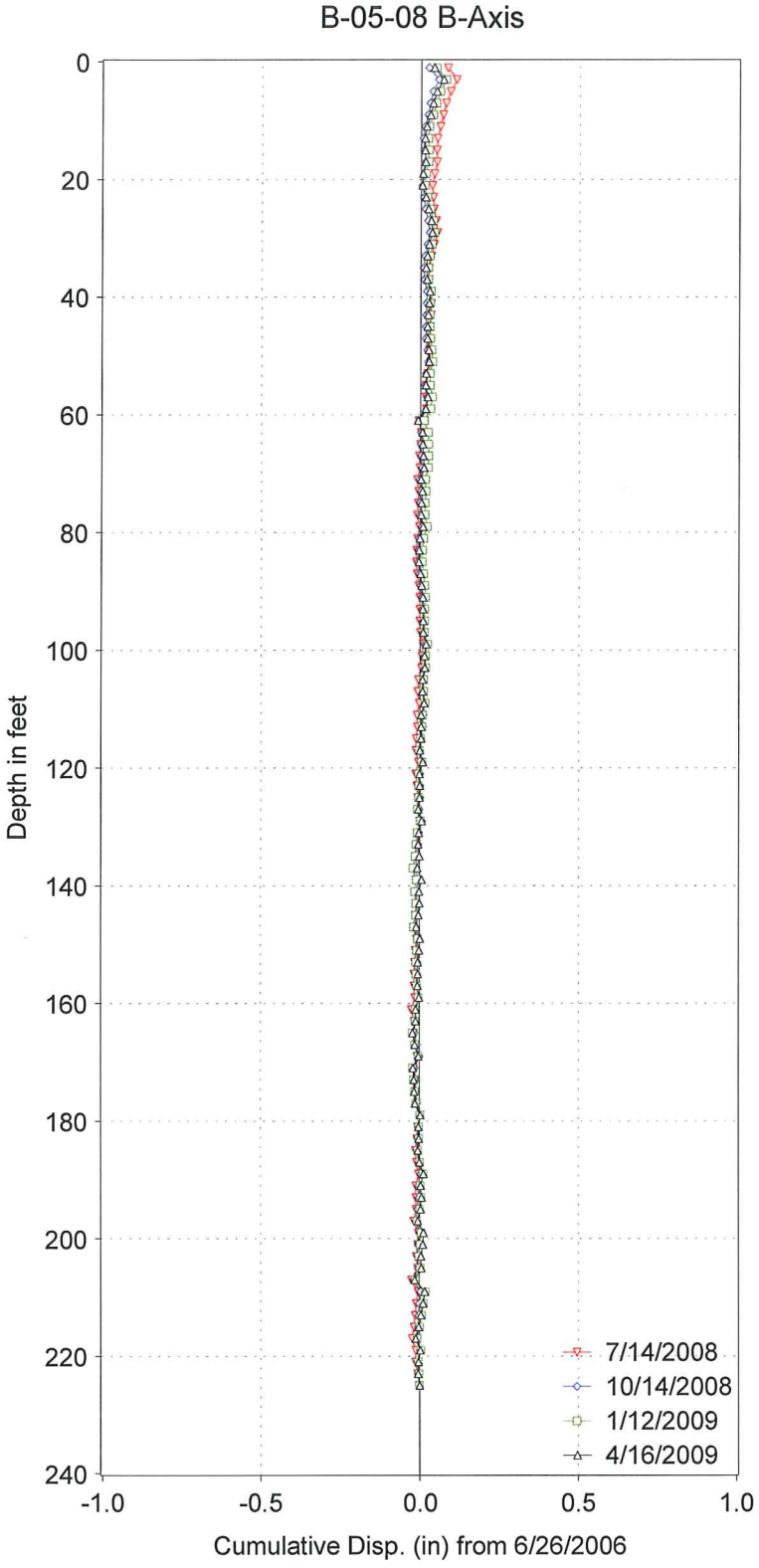
PLATE 37

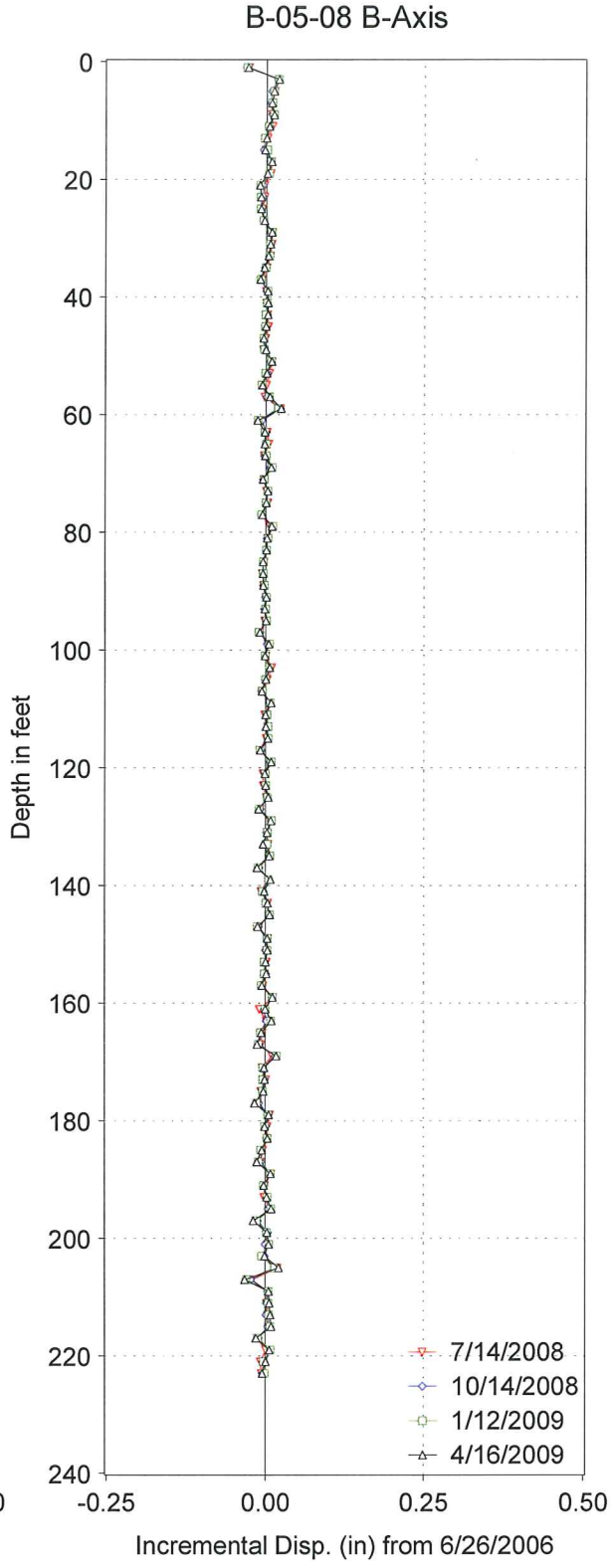


B-05-08

-Includes readings from the last four quarters.

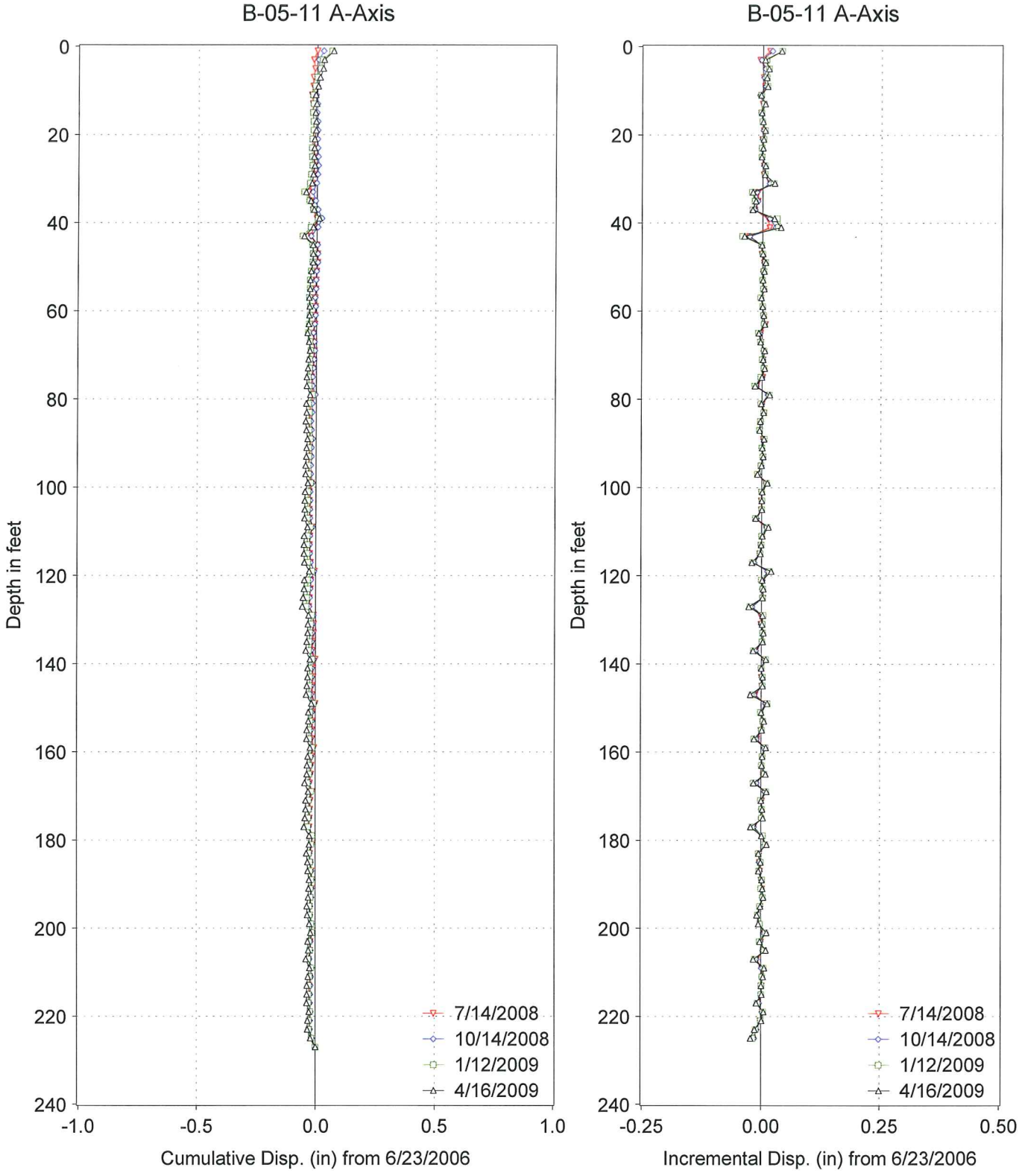
PLATE 38





B-05-08

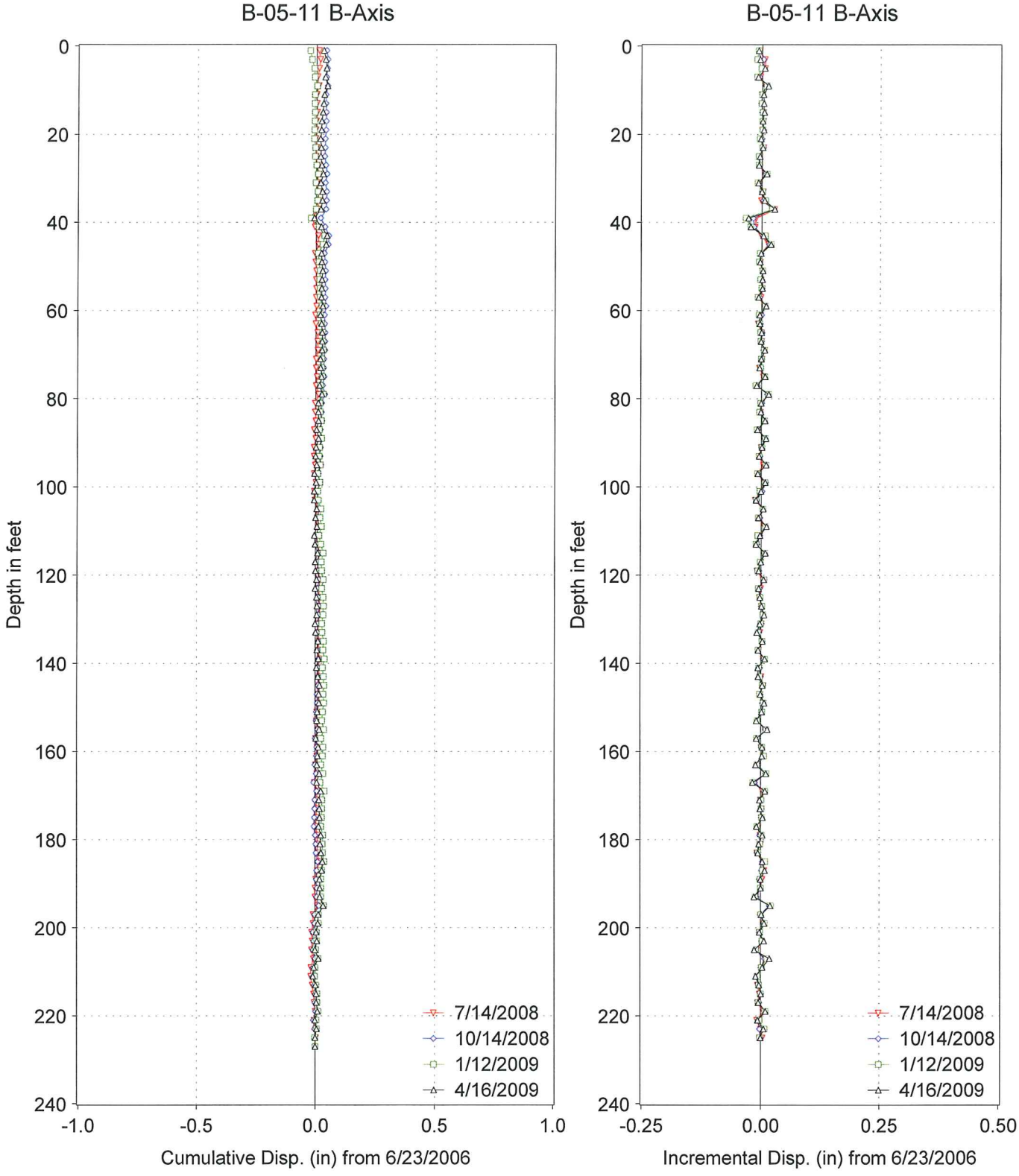
-Includes readings from the last four quarters.



B-05-11

-Includes readings from the last four quarters.

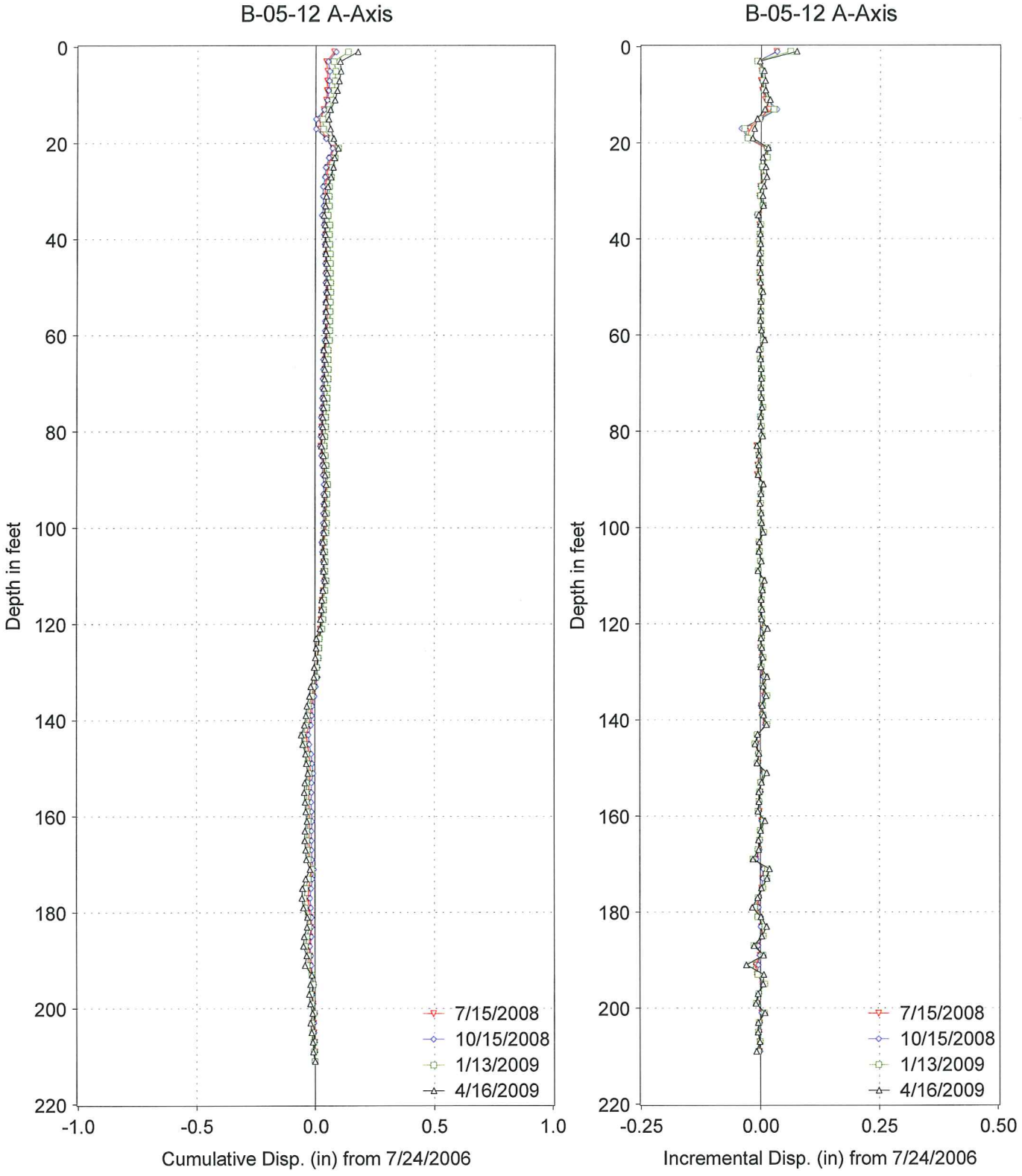
PLATE 40



B-05-11

-Includes readings from the last four quarters.

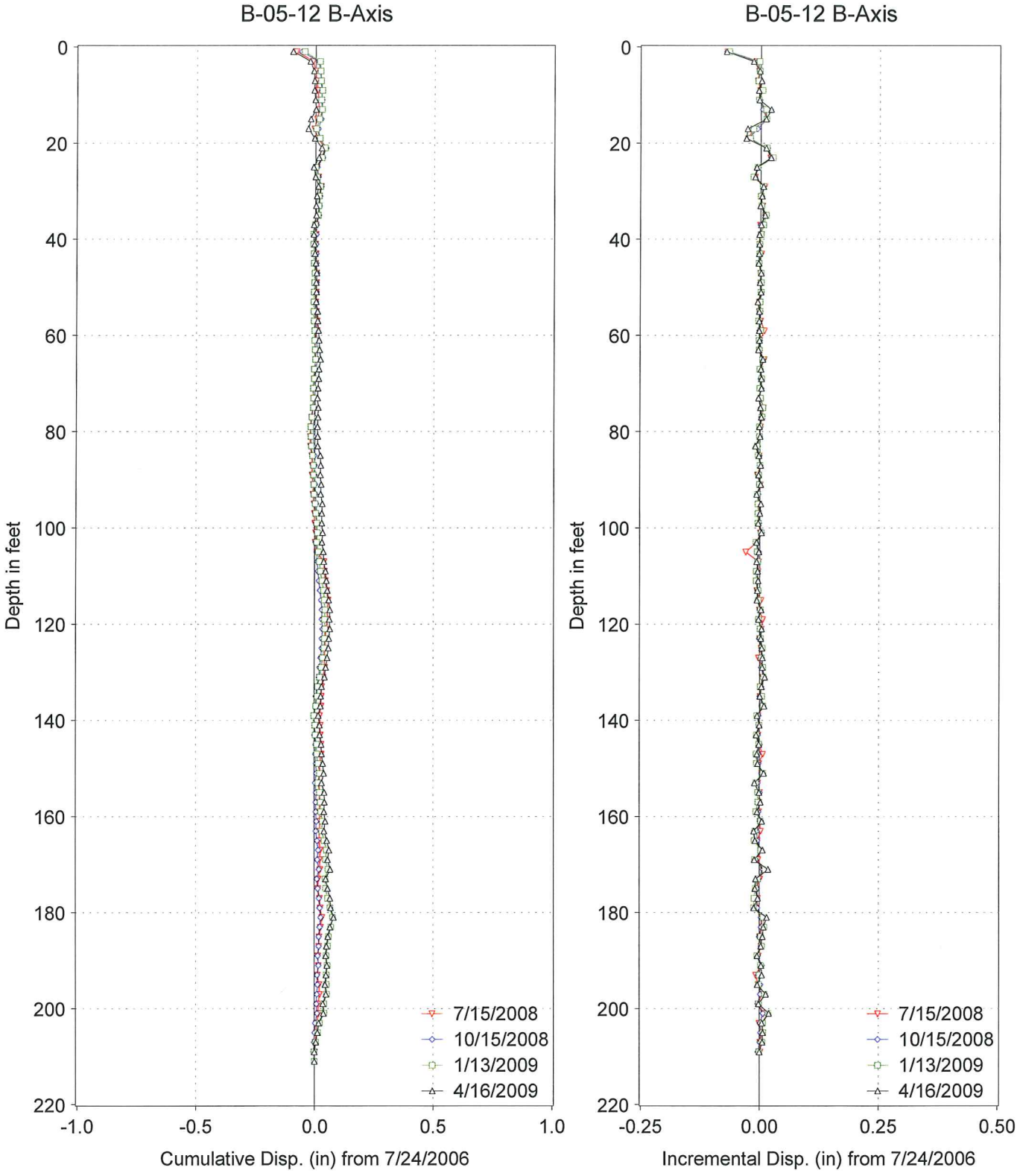
PLATE 41



B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

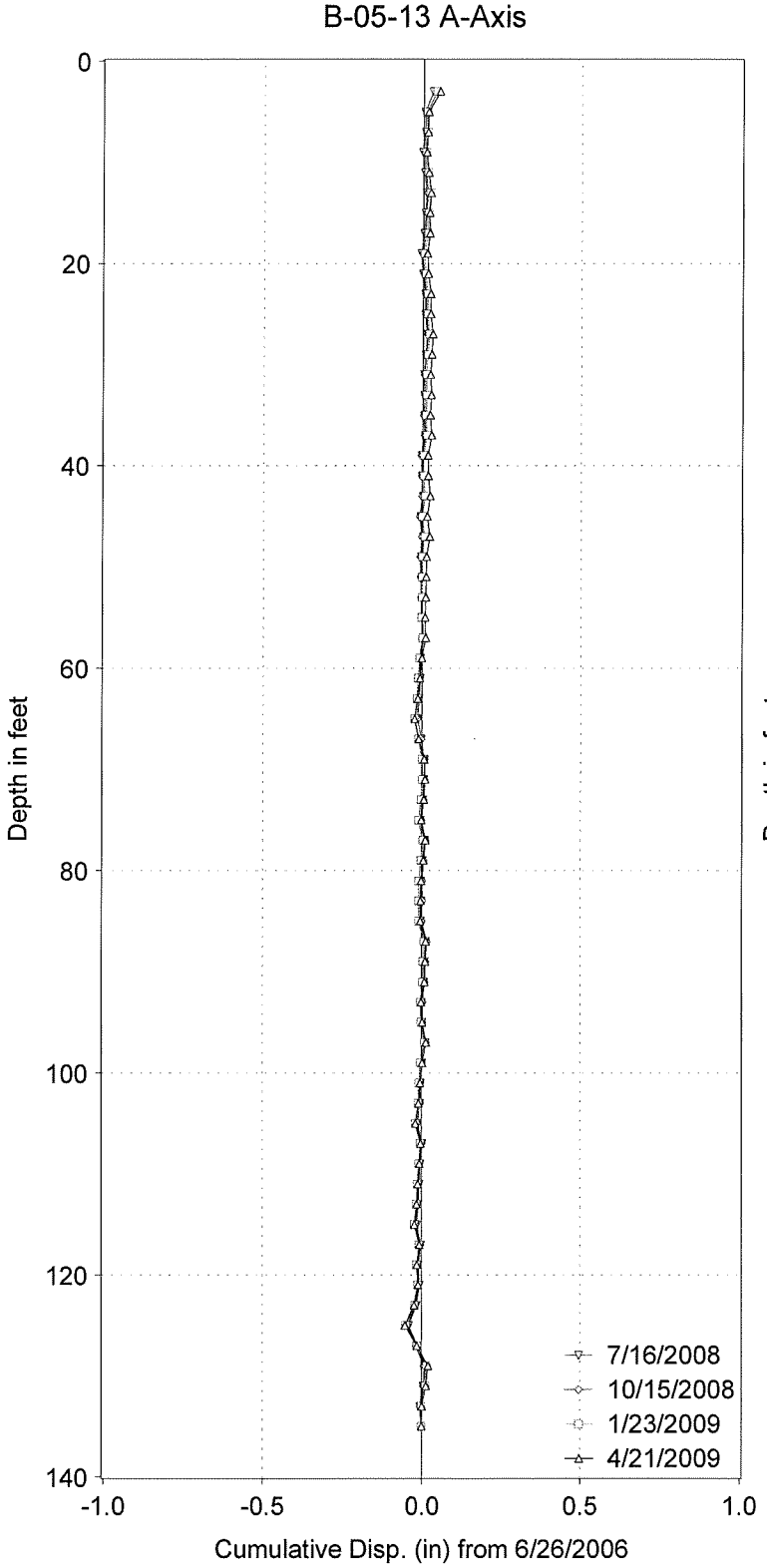
PLATE 42

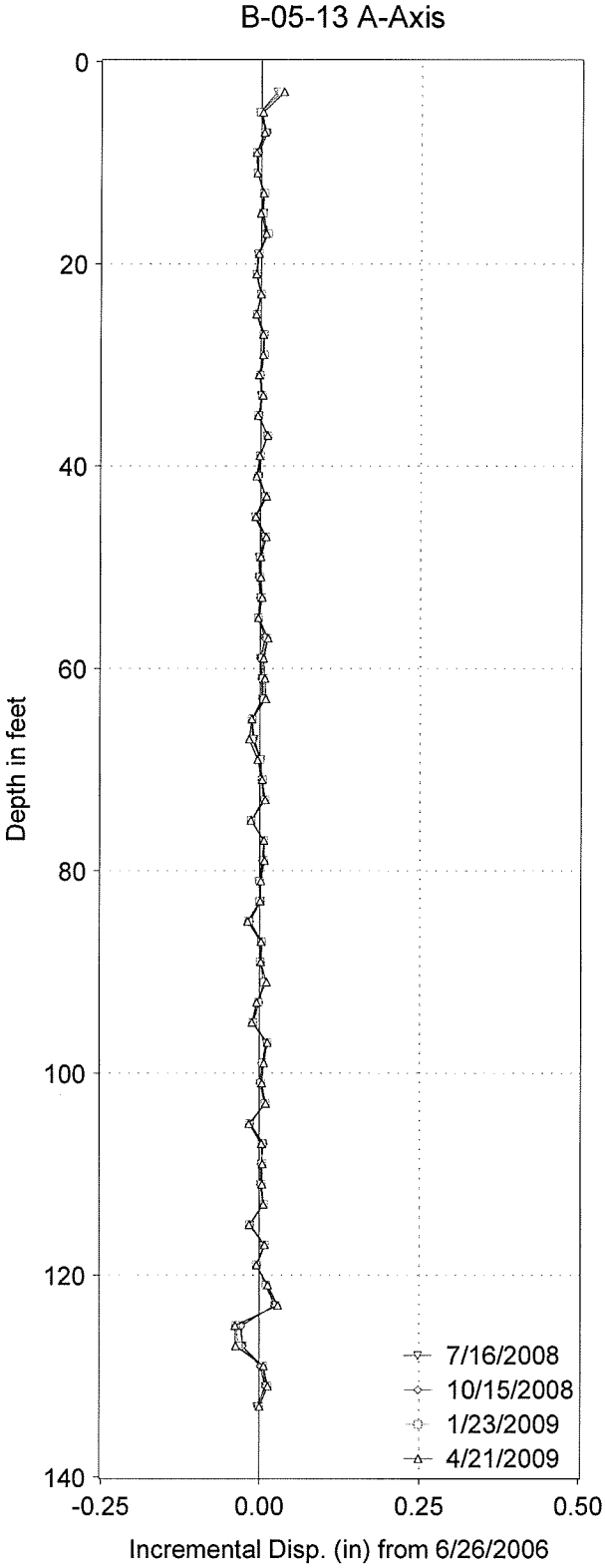


B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

PLATE 43

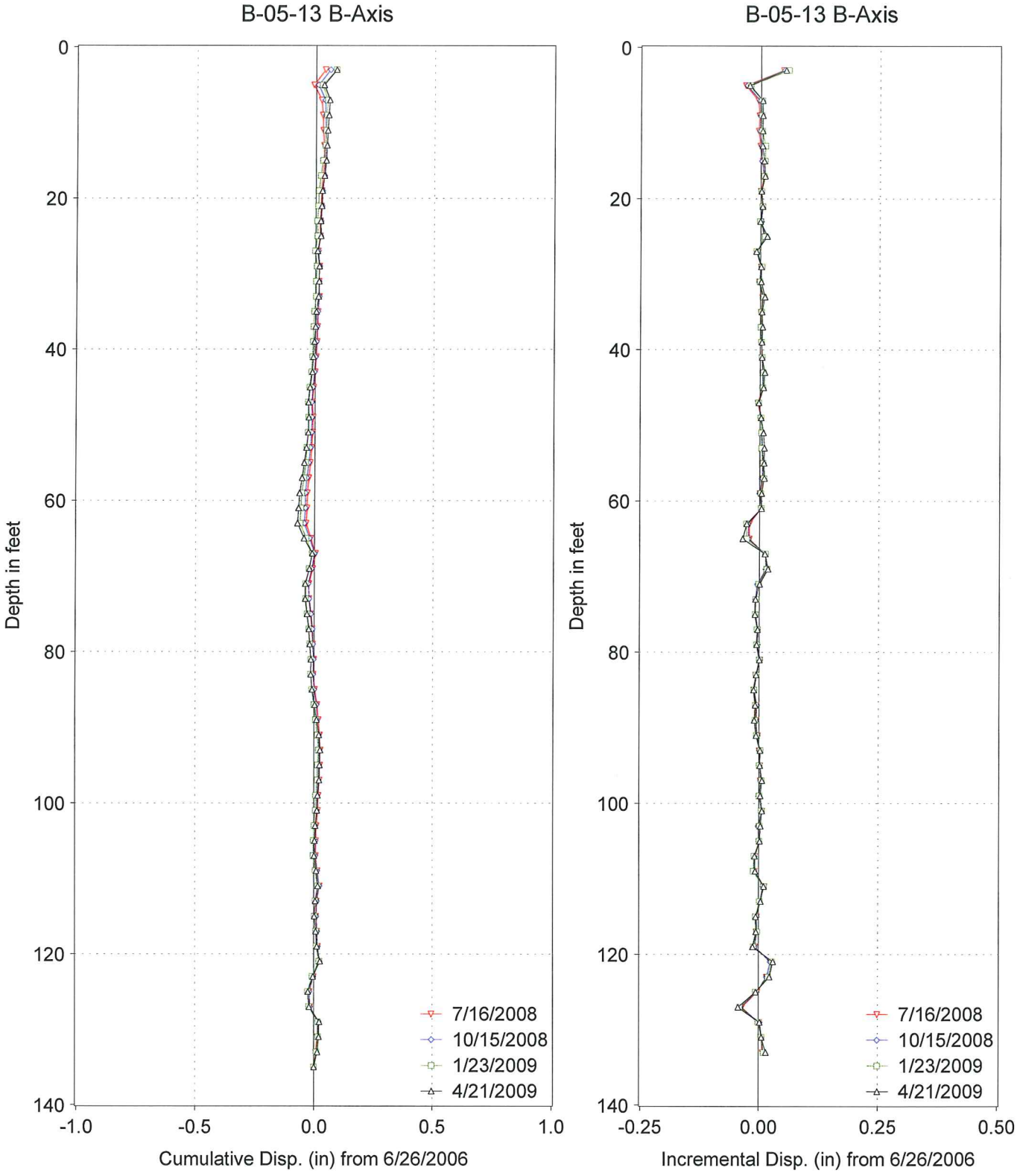




B-05-13

-Includes readings from the last four quarters.

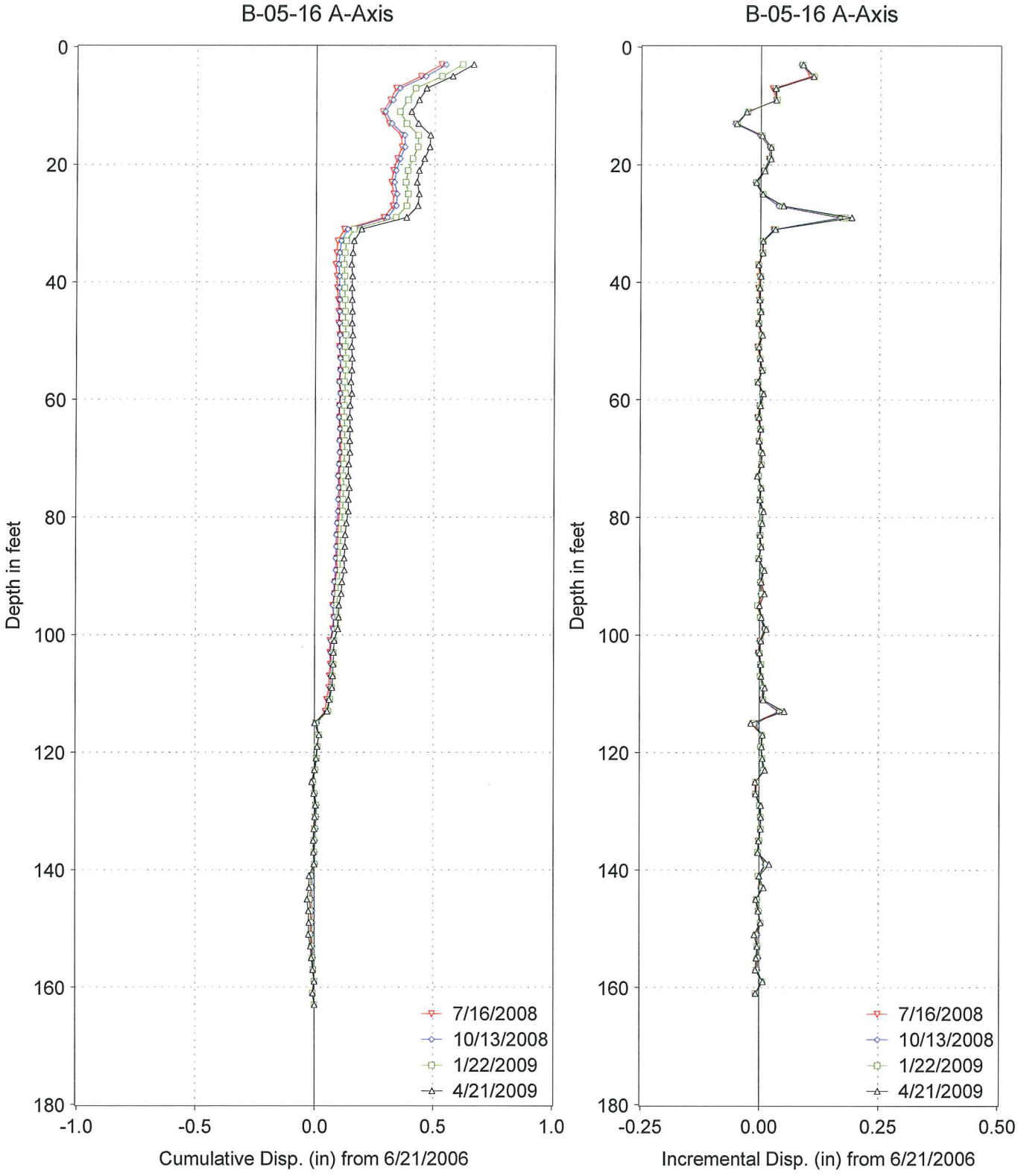
PLATE 44



B-05-13

-Includes readings from the last four quarters.

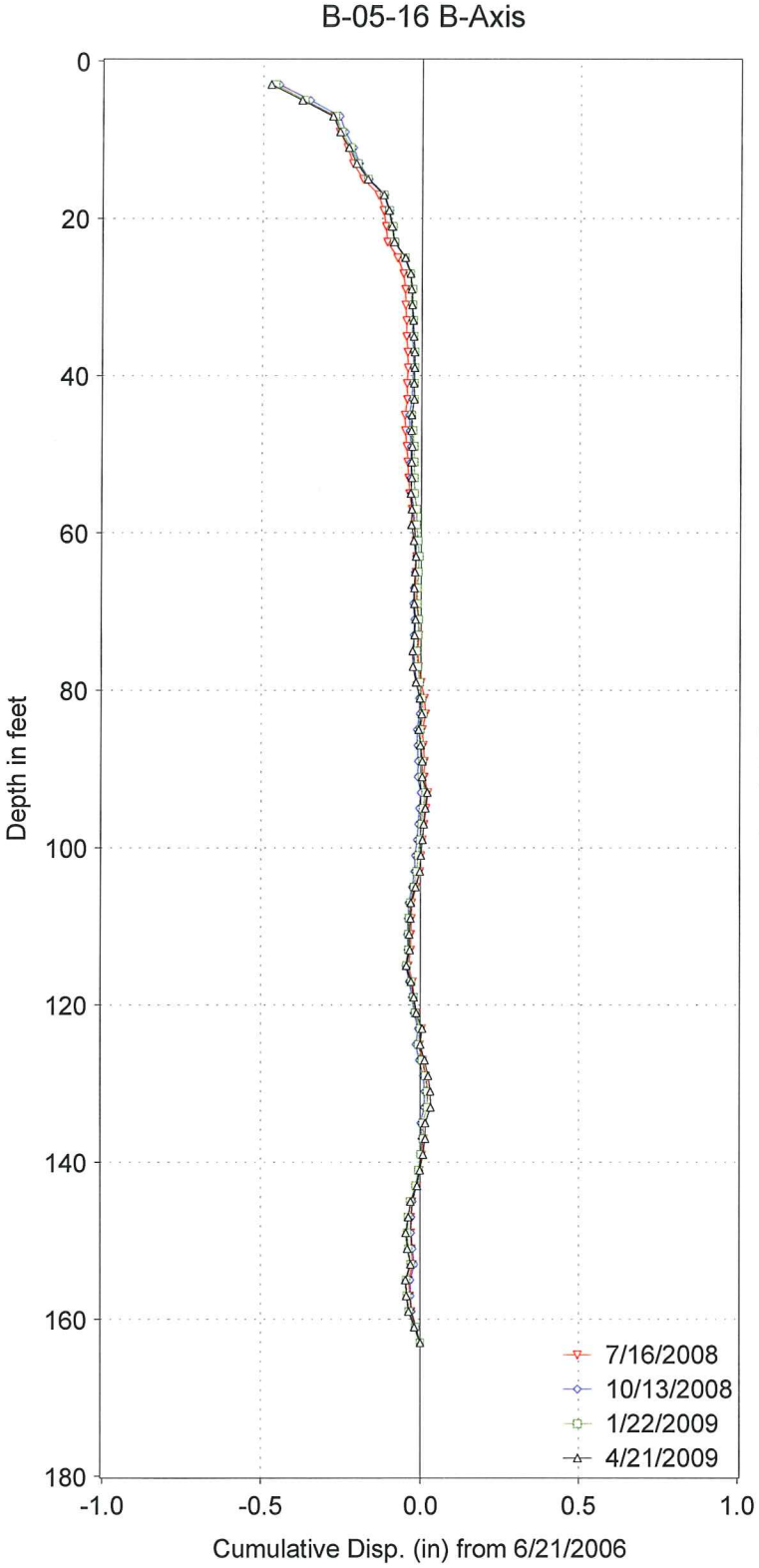
PLATE 45

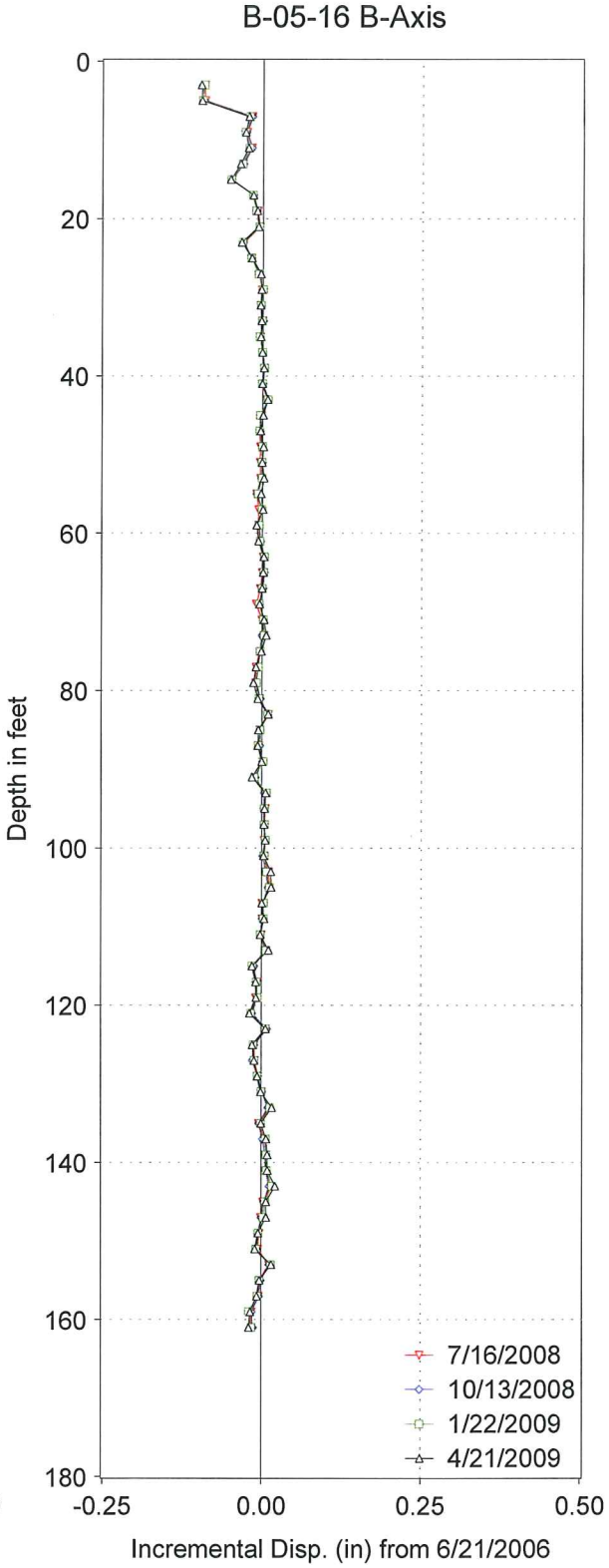


B-05-16

-Includes readings from the last four quarters.

PLATE 46





B-05-16

-Includes readings from the last four quarters.

PLATE 47

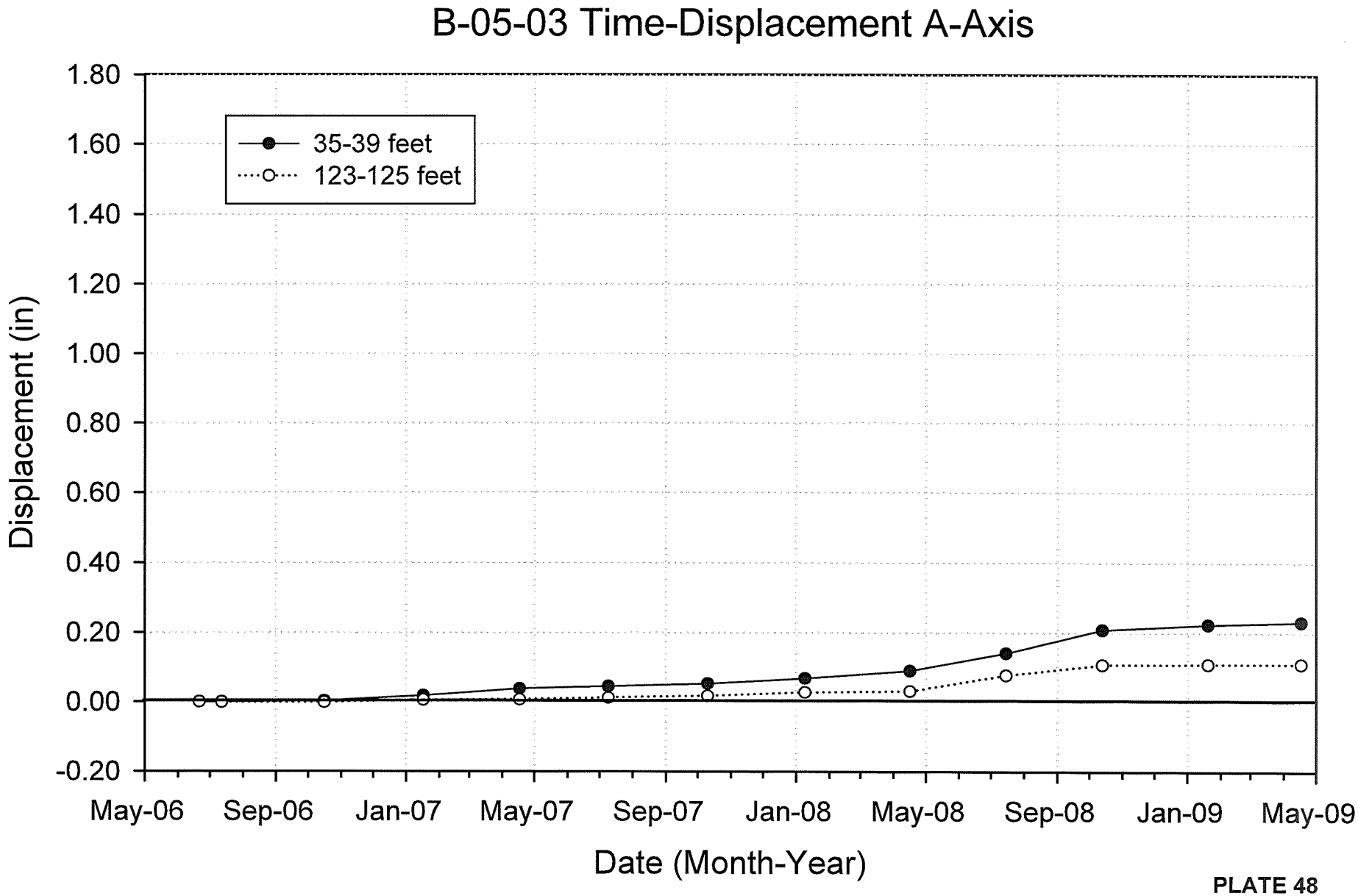

B-05-03 Time-Displacement A-Axis
35-39 feet
123-125 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Date (Month-Year)

PLATE 48

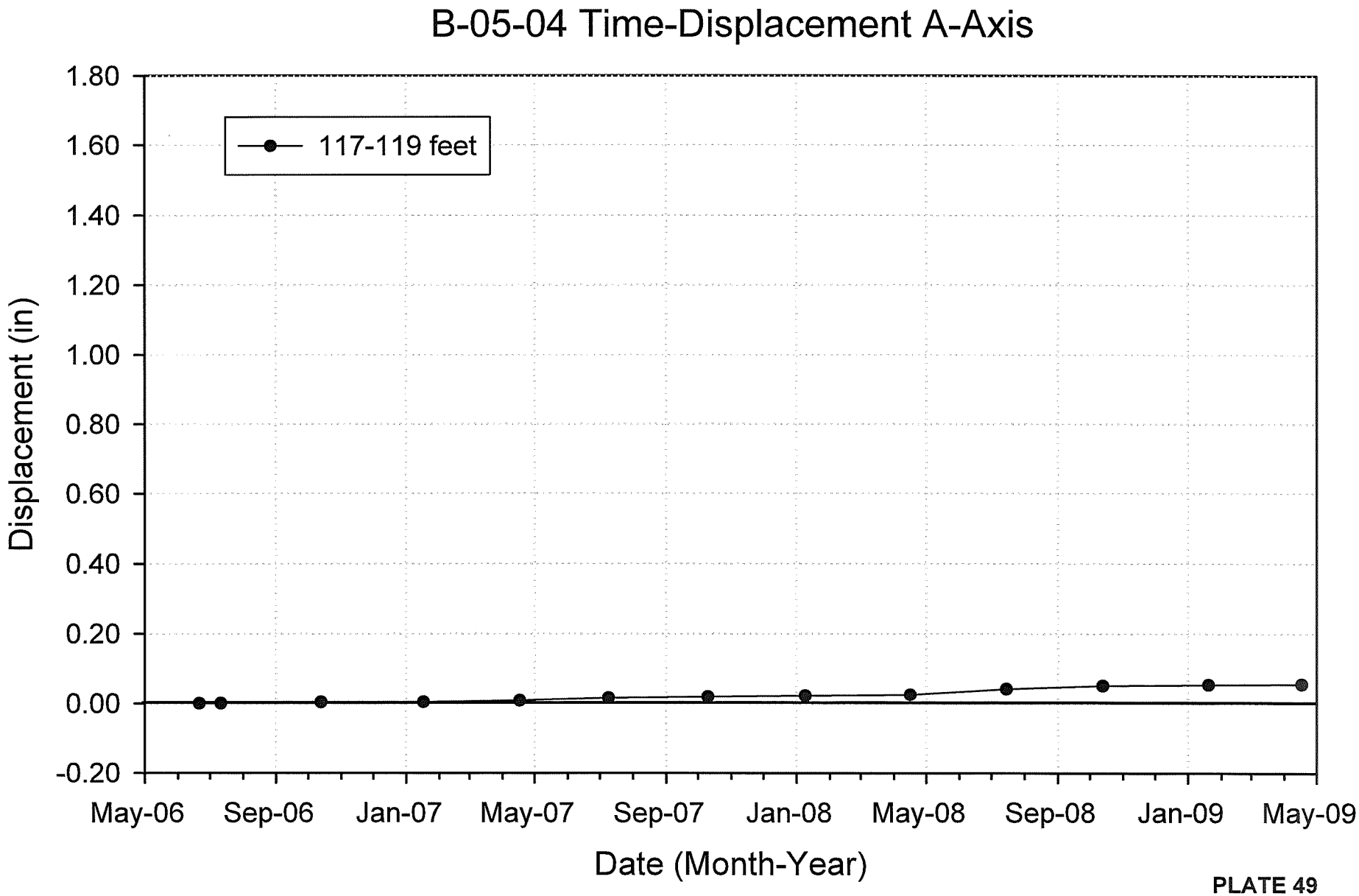

B-05-04 Time-Displacement A-Axis
117-119 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Date (Month-Year)

PLATE 49

B-05-16 Time-Displacement A-Axis

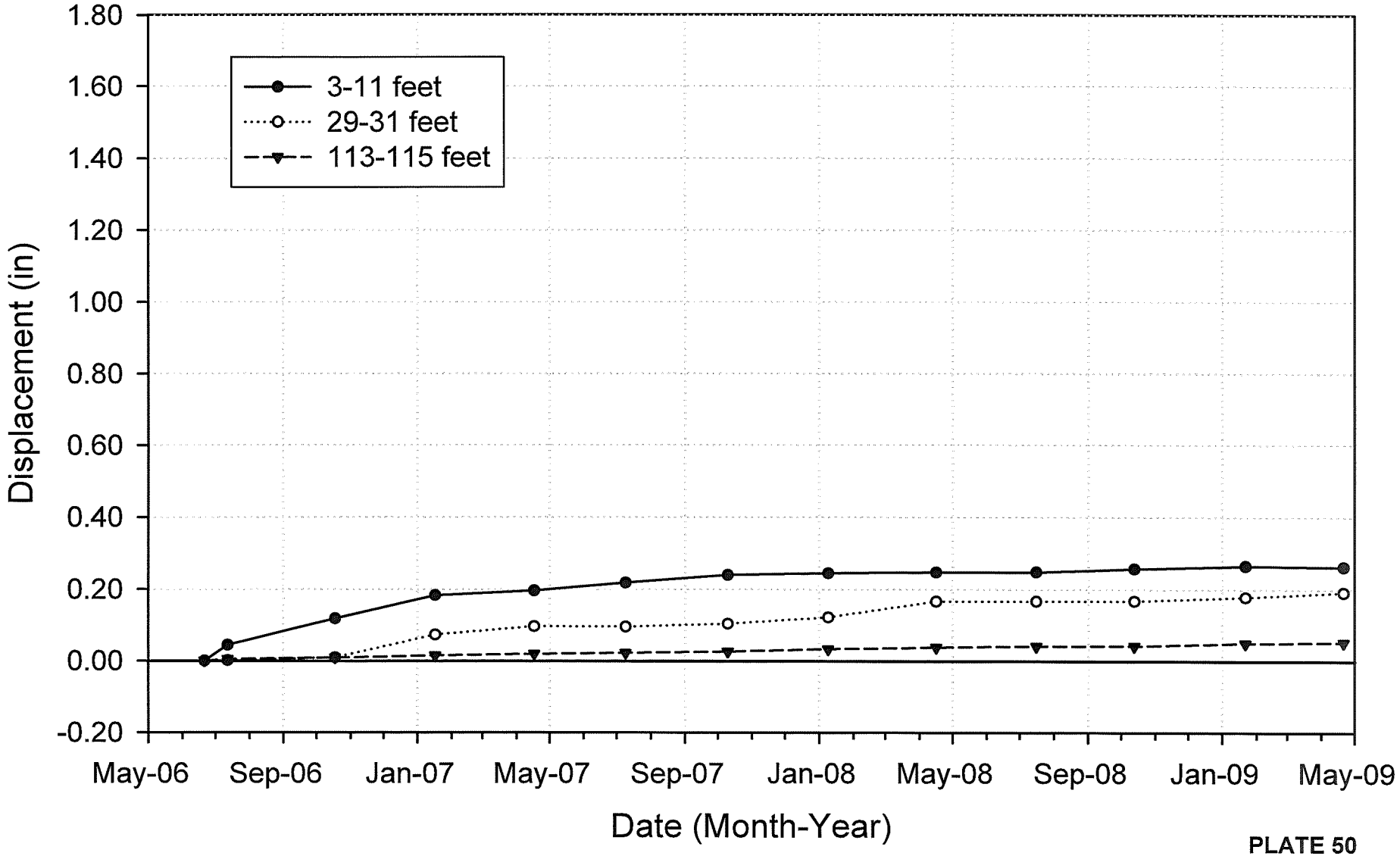


PLATE 50

B-101 (P-1) Pneumatic Piezometer Readings

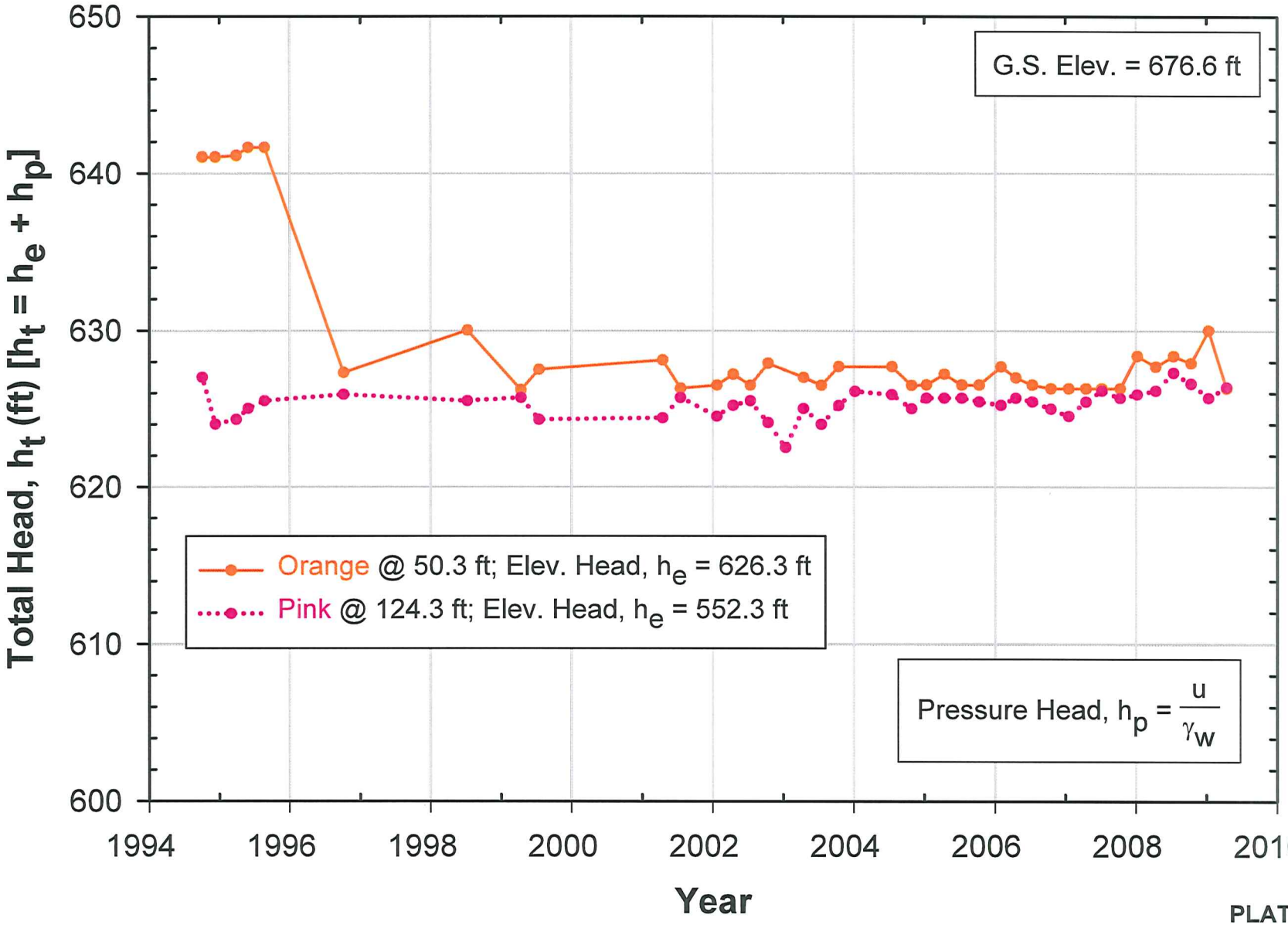


PLATE 51

B-105 (P-3) Pneumatic Piezometer Readings

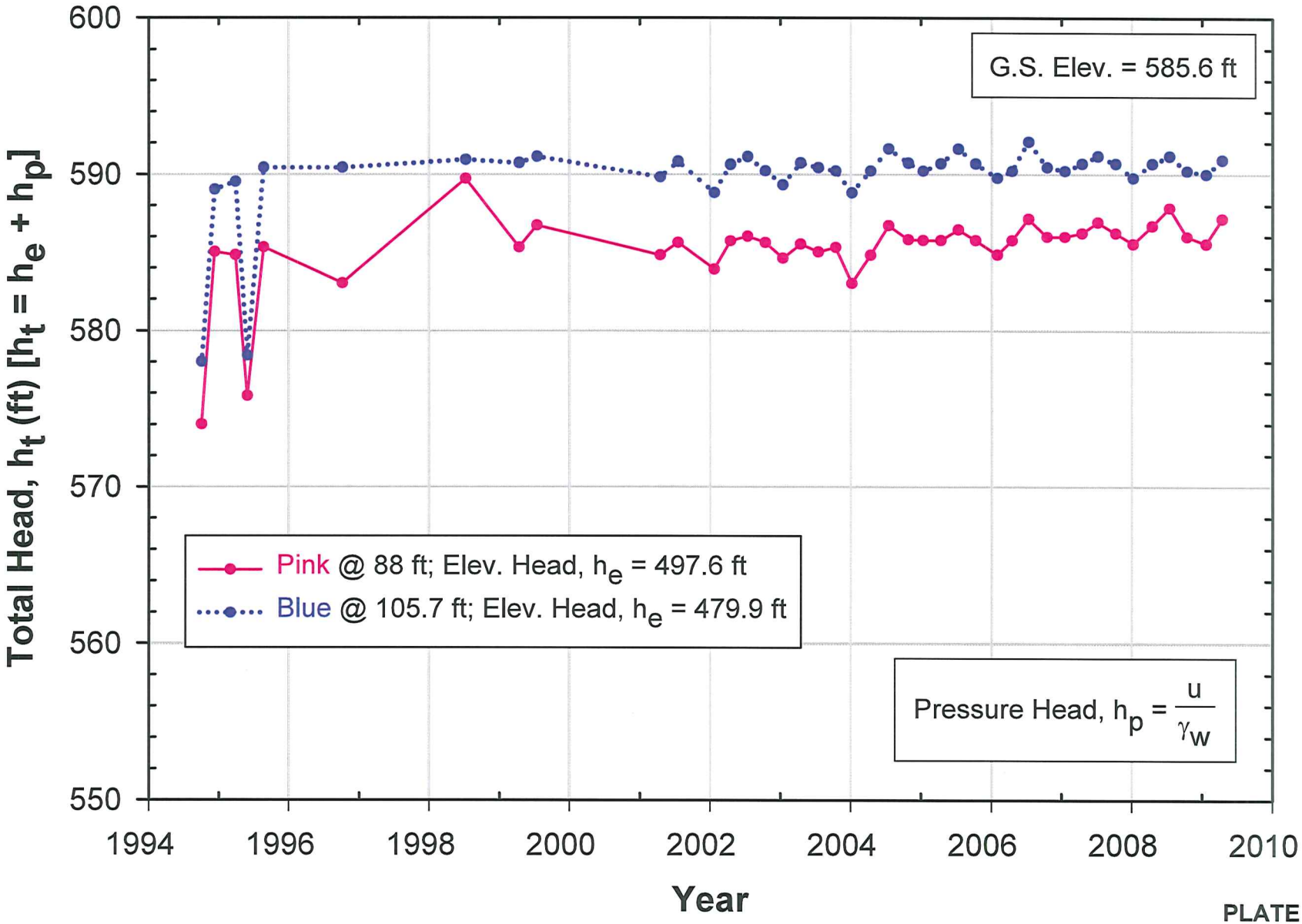


PLATE 52

B-107 (P-5) Pneumatic Piezometer Readings

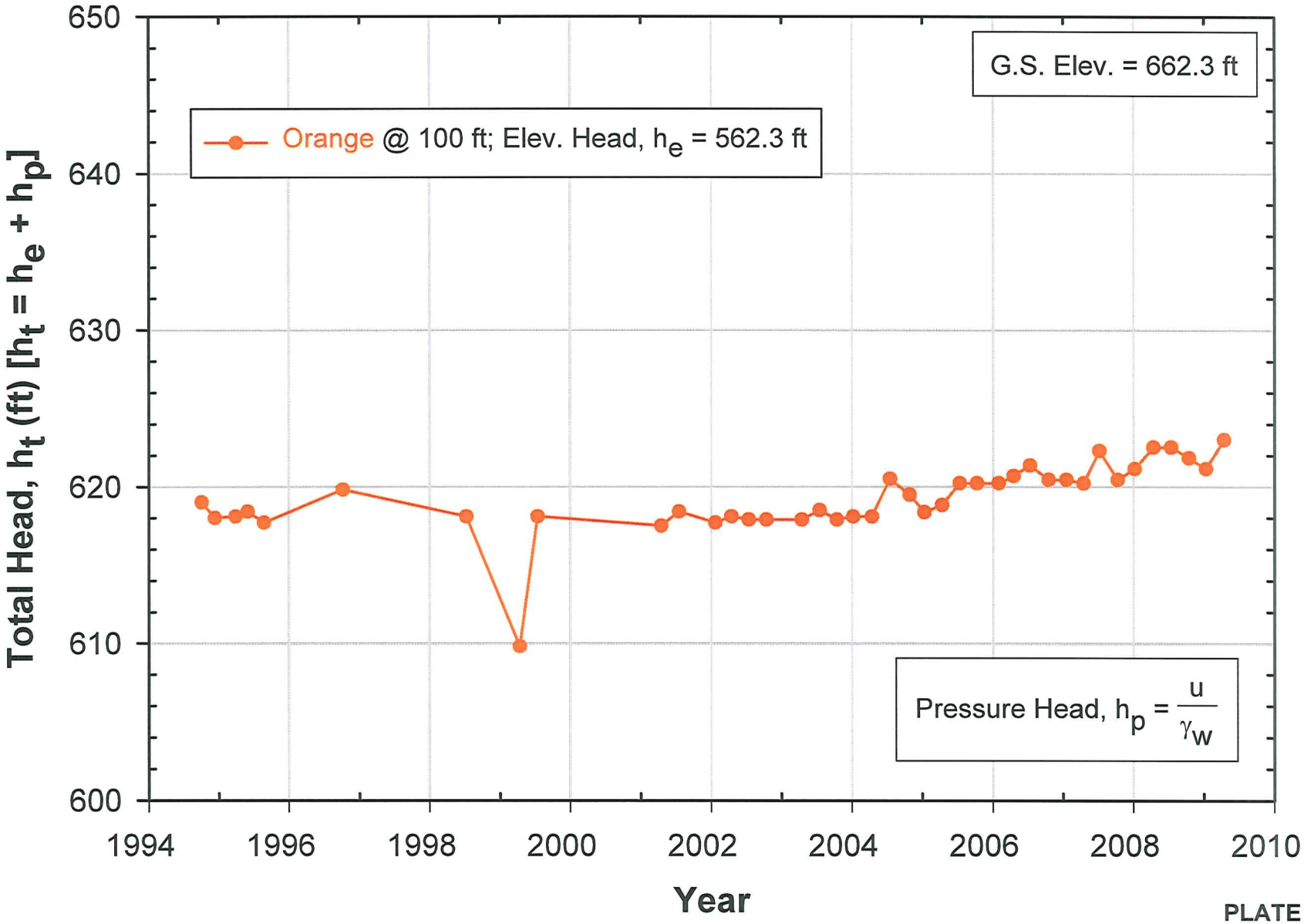


PLATE 53

B-303 (P-2) Pneumatic Piezometer Readings

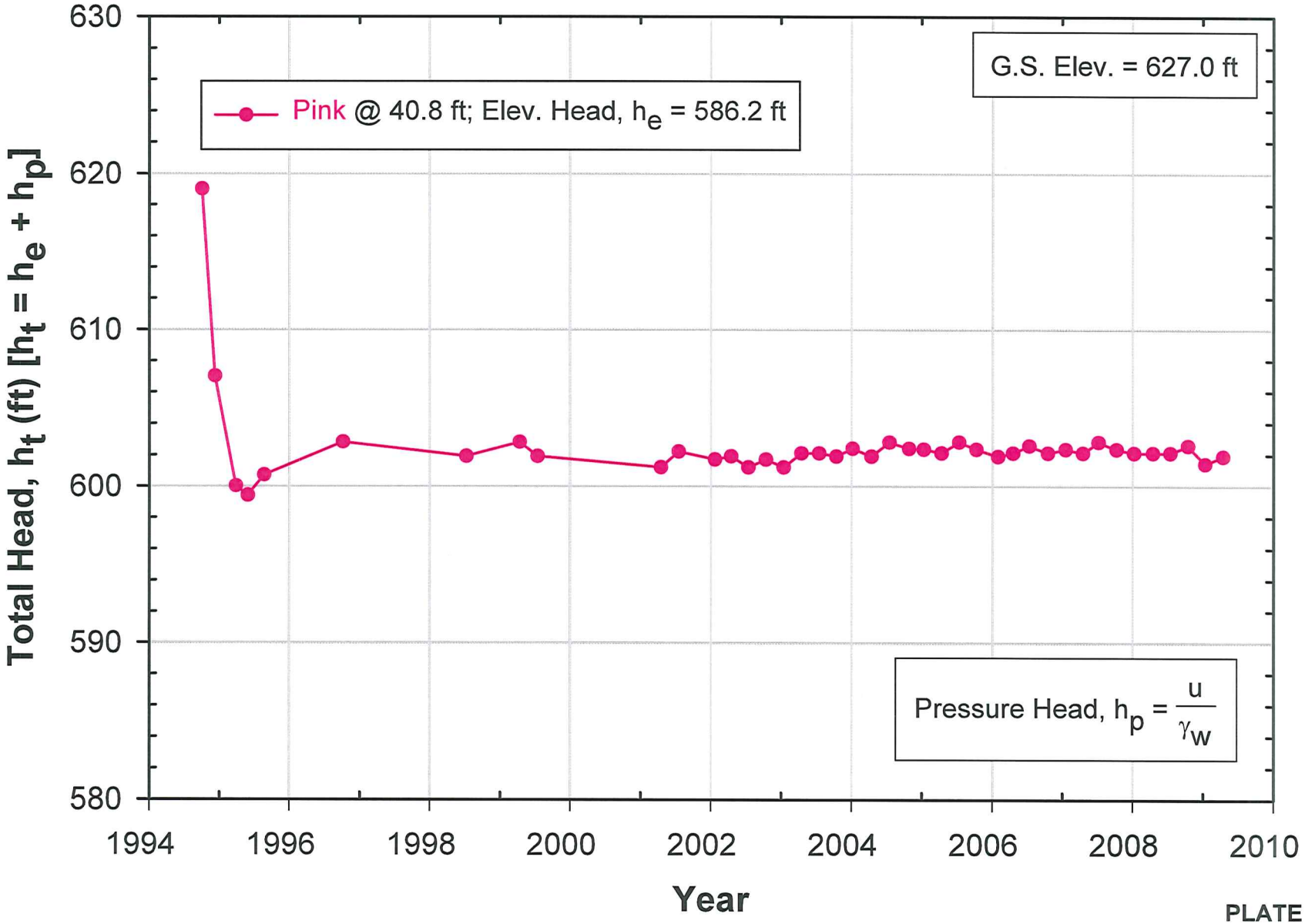


PLATE 54

B-05-01 VW Piezometer Readings

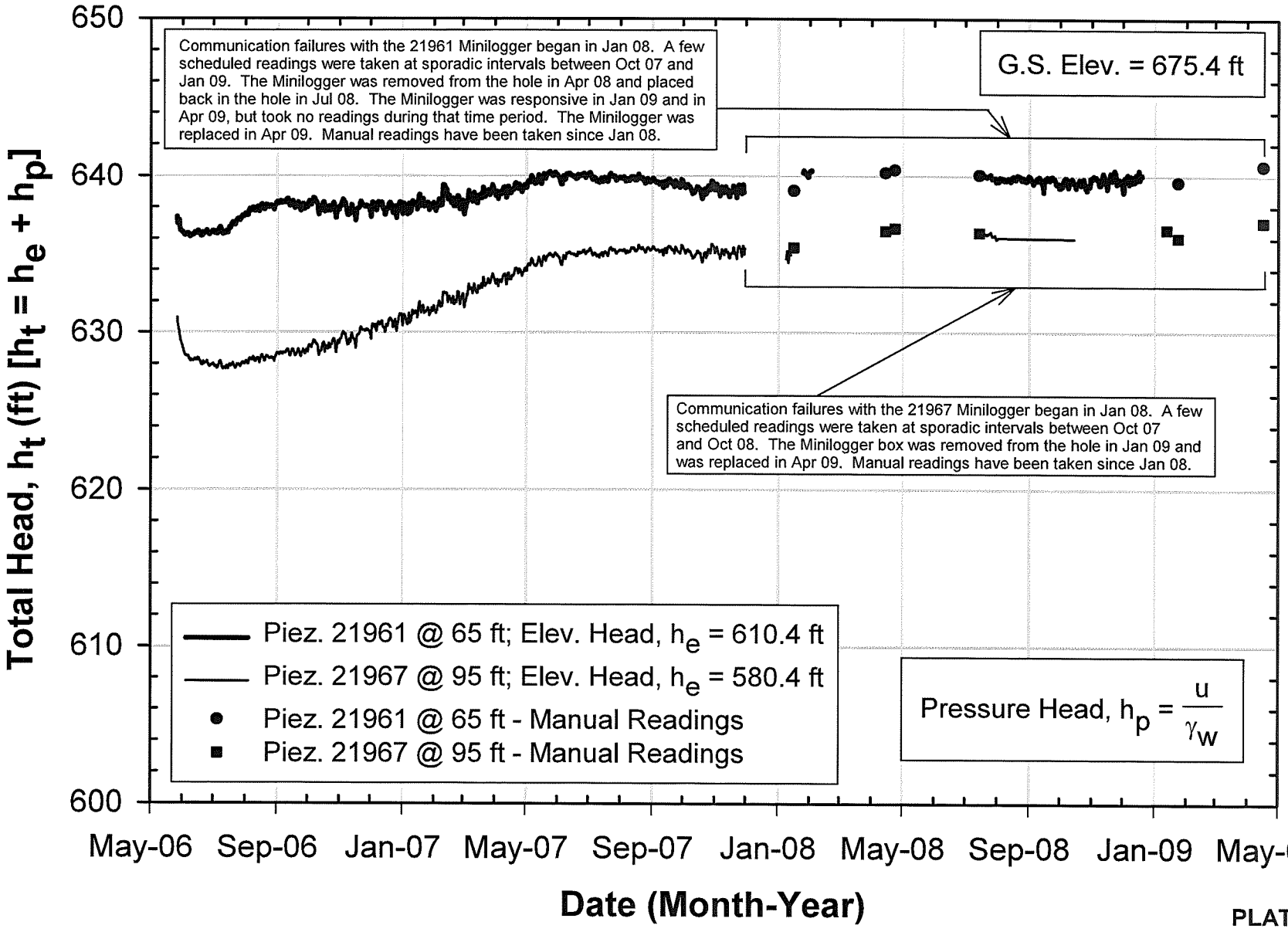


PLATE 55

B-05-02 VW Piezometer Readings

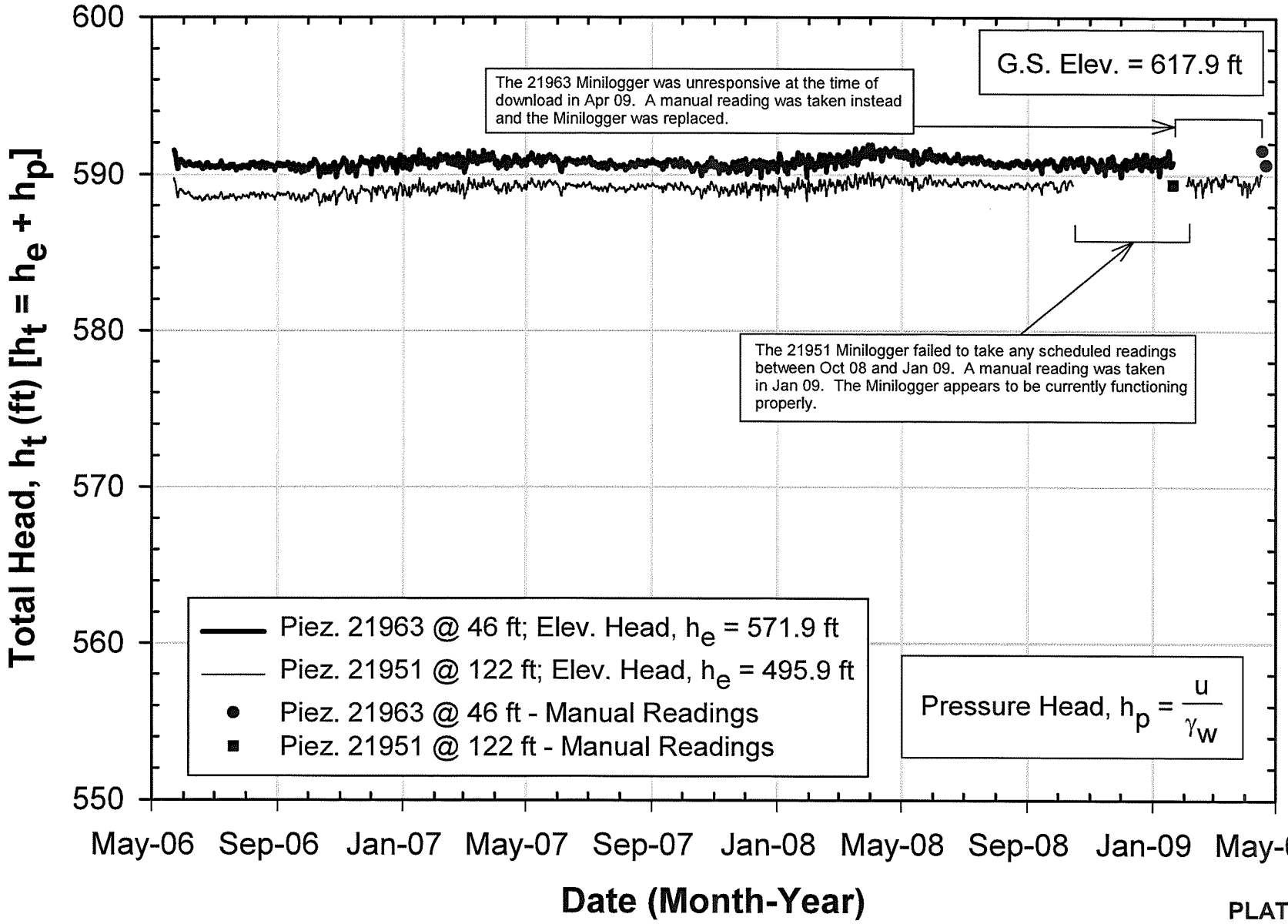


PLATE 56

B-05-03 VW Piezometer Readings

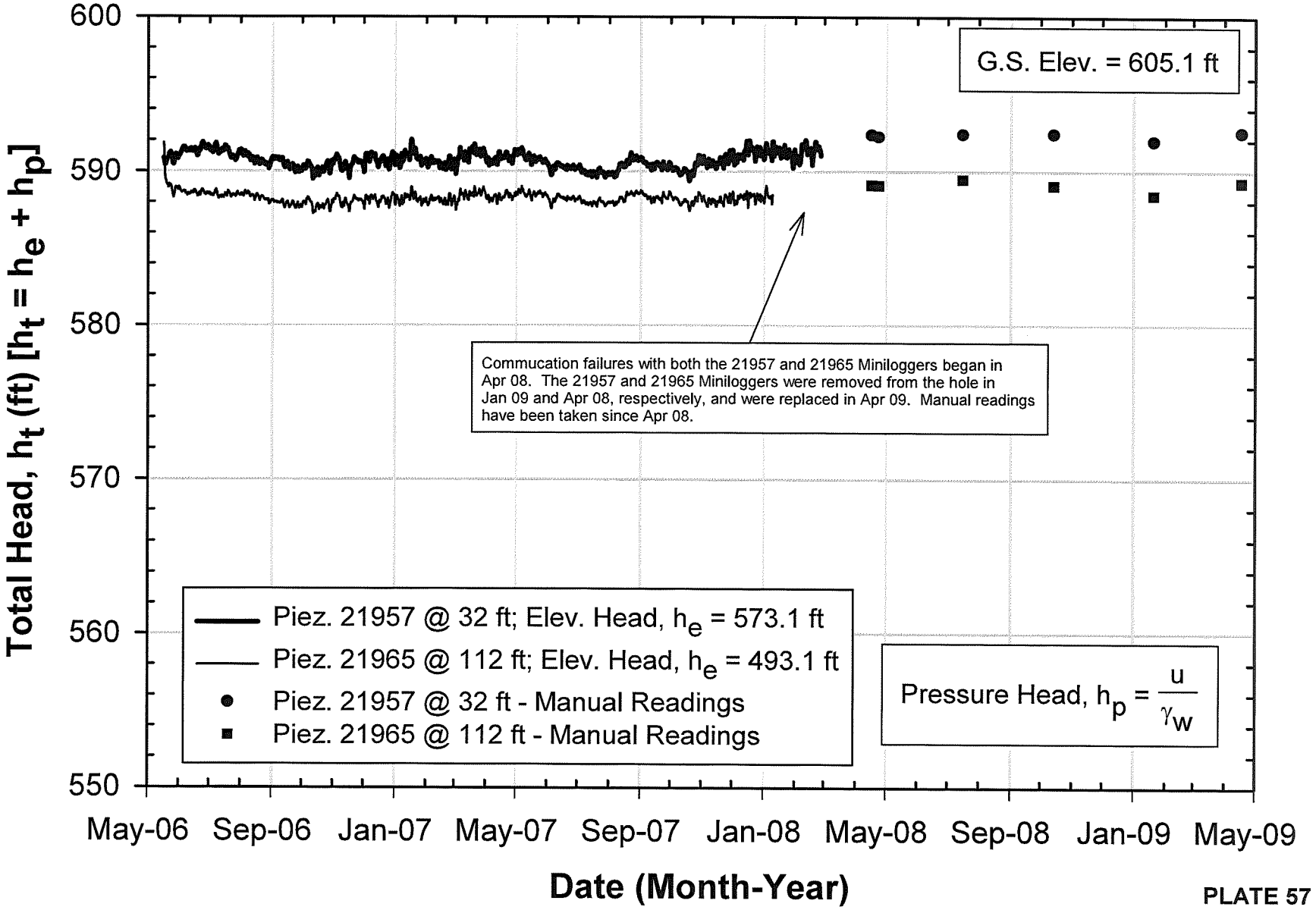


PLATE 57

B-05-04 VW Piezometer Readings

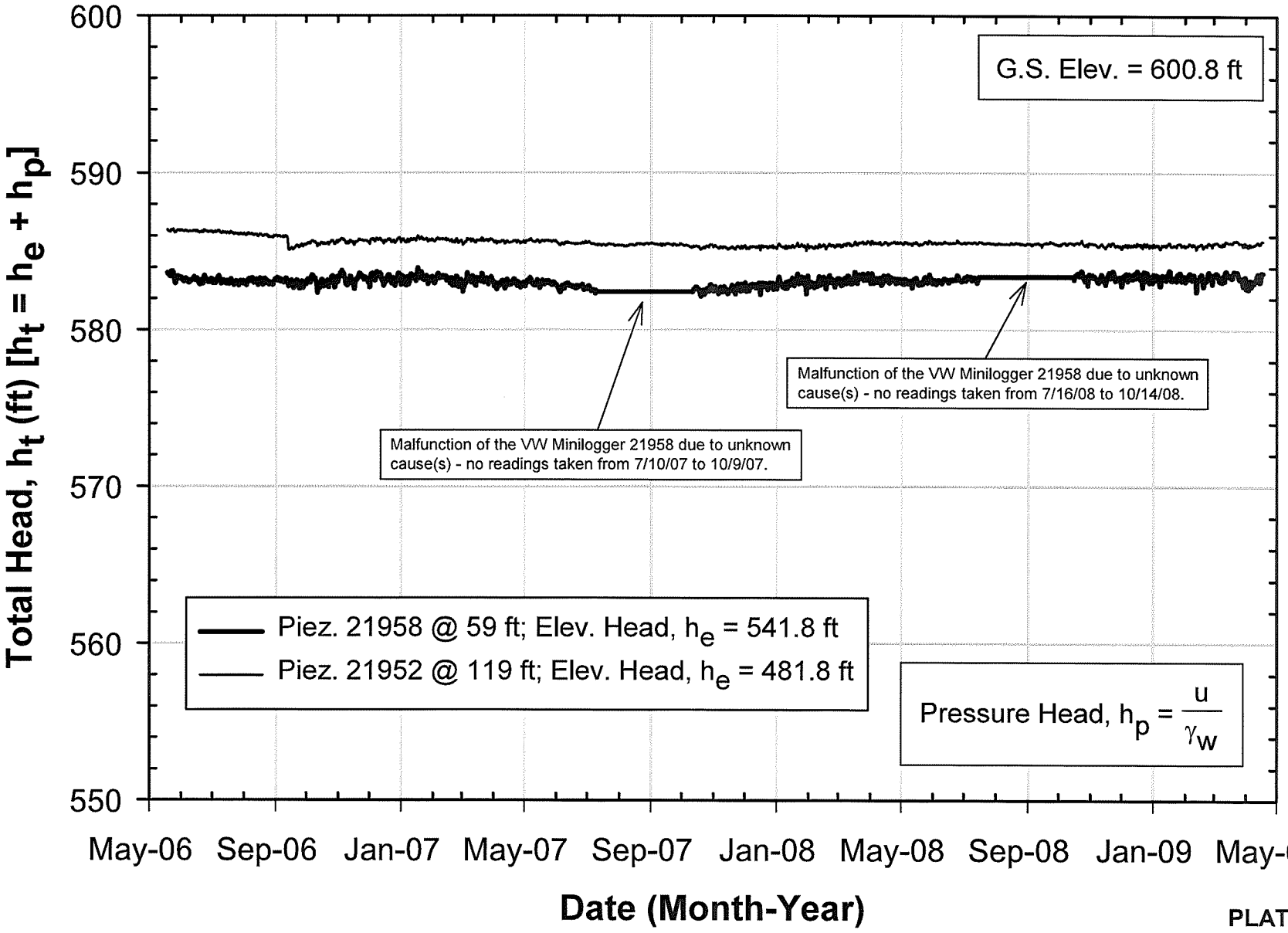


PLATE 58

B-05-07 VW Piezometer Readings

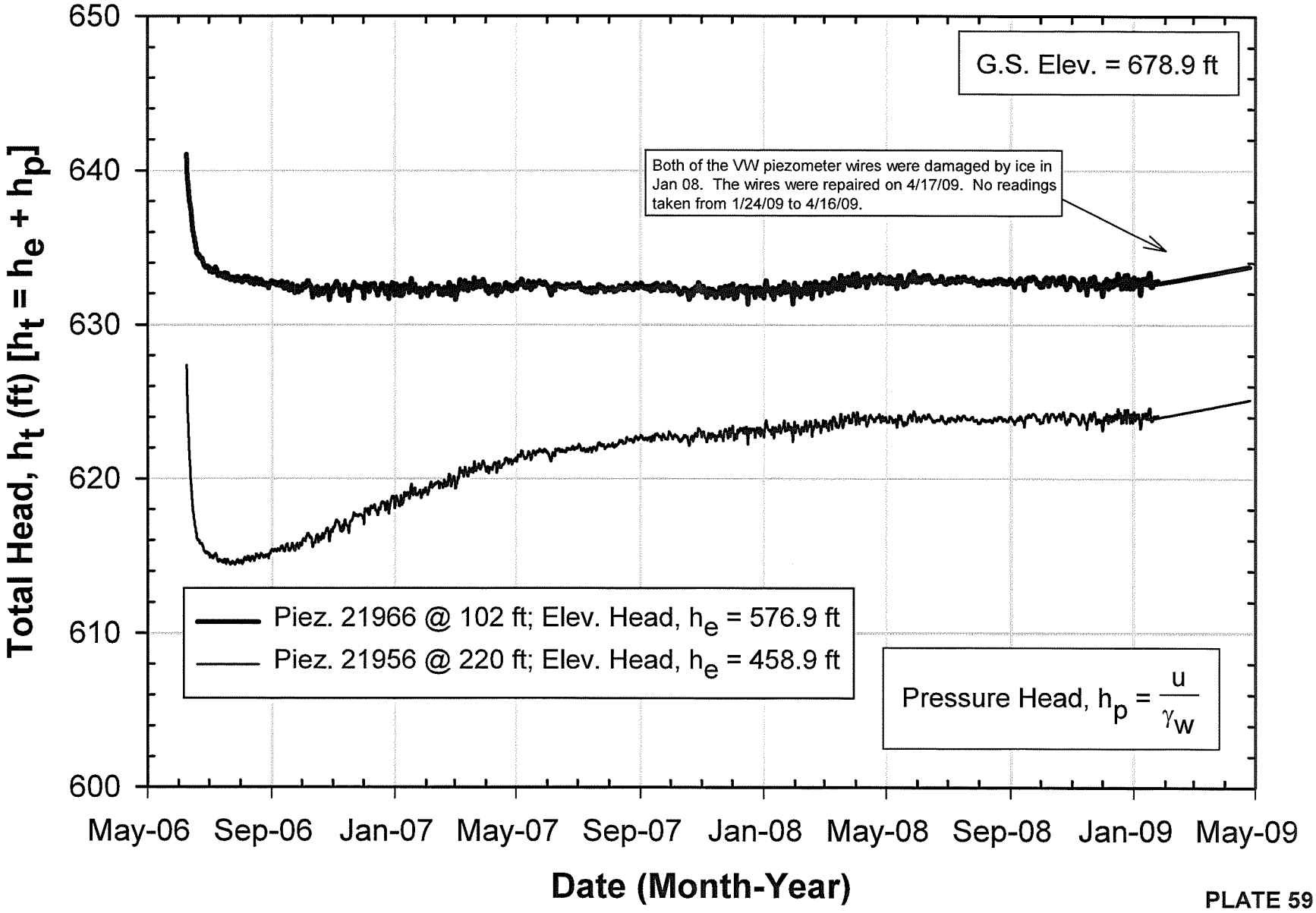


PLATE 59

B-05-08 VW Piezometer Readings

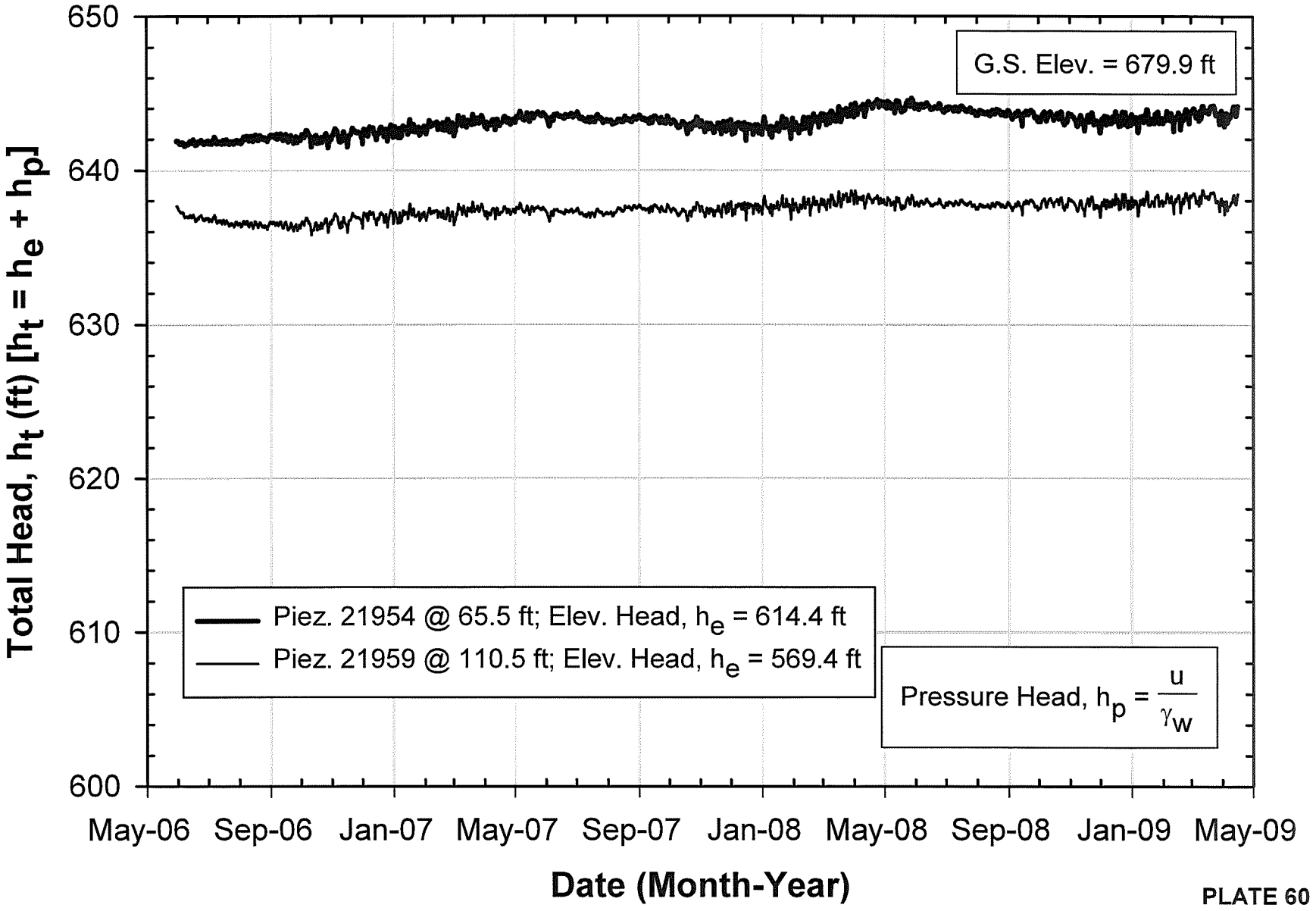


PLATE 60

B-05-11 VW Piezometer Readings

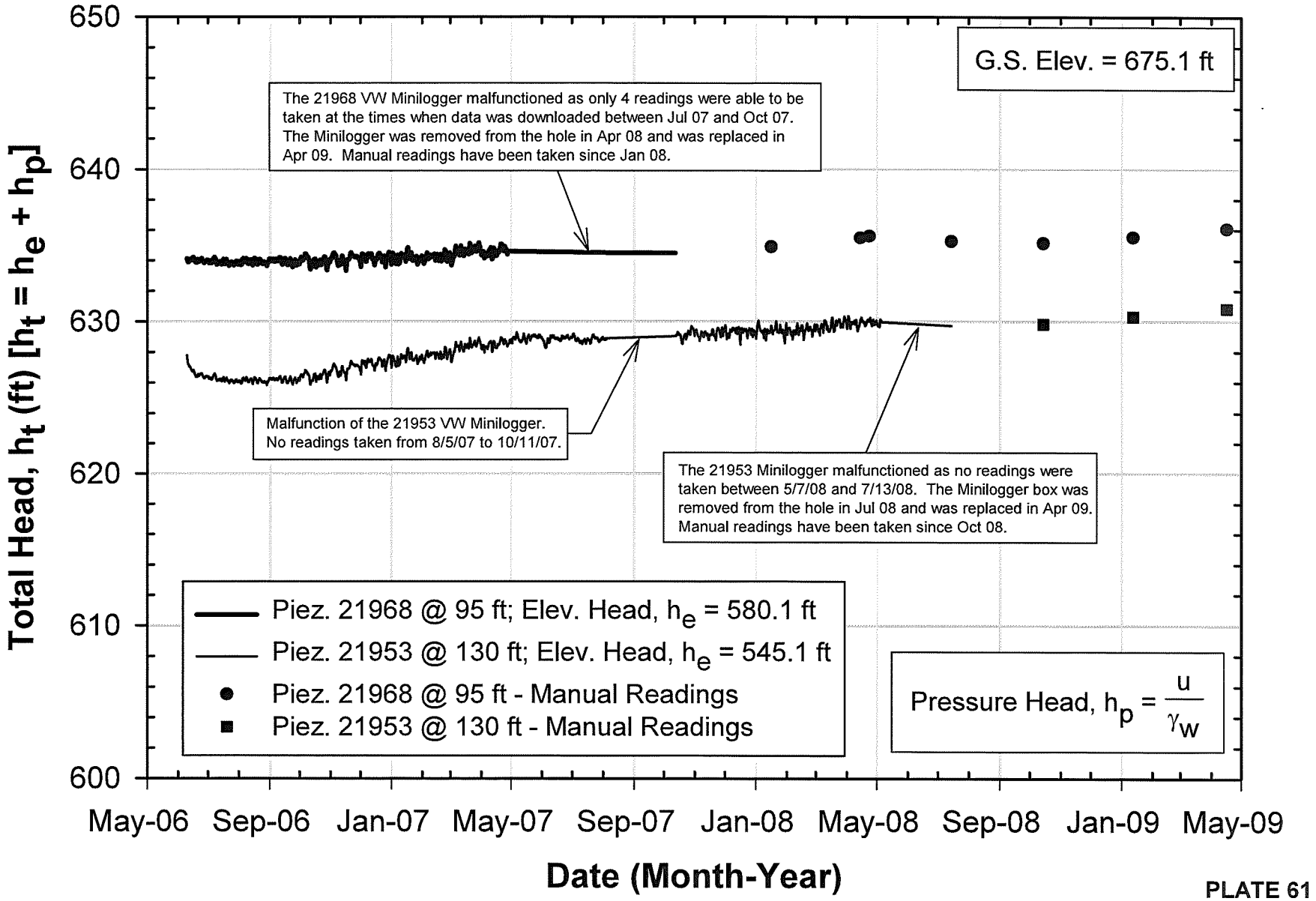


PLATE 61

B-05-12 VW Piezometer Readings

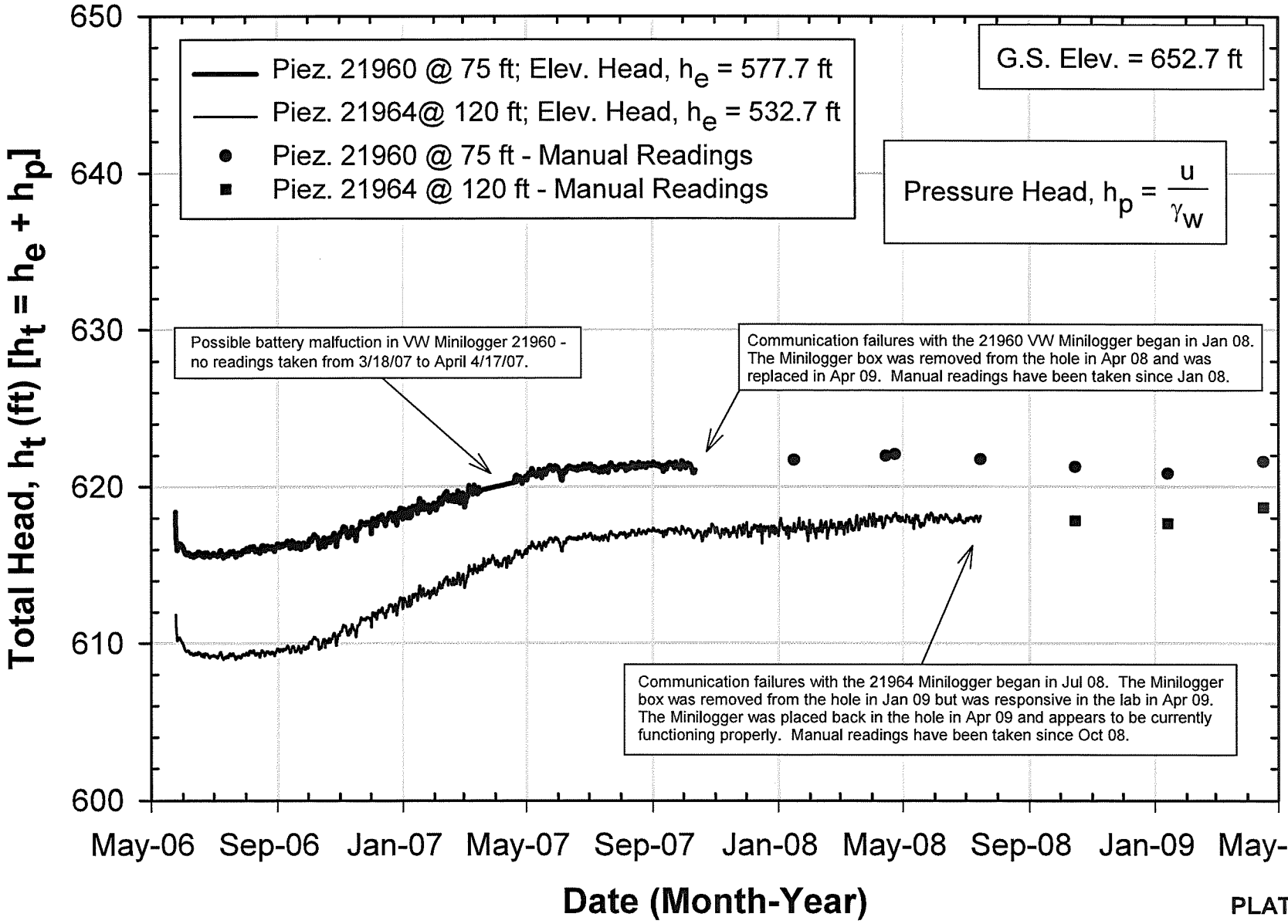


PLATE 62

B-05-13 VW Piezometer Readings

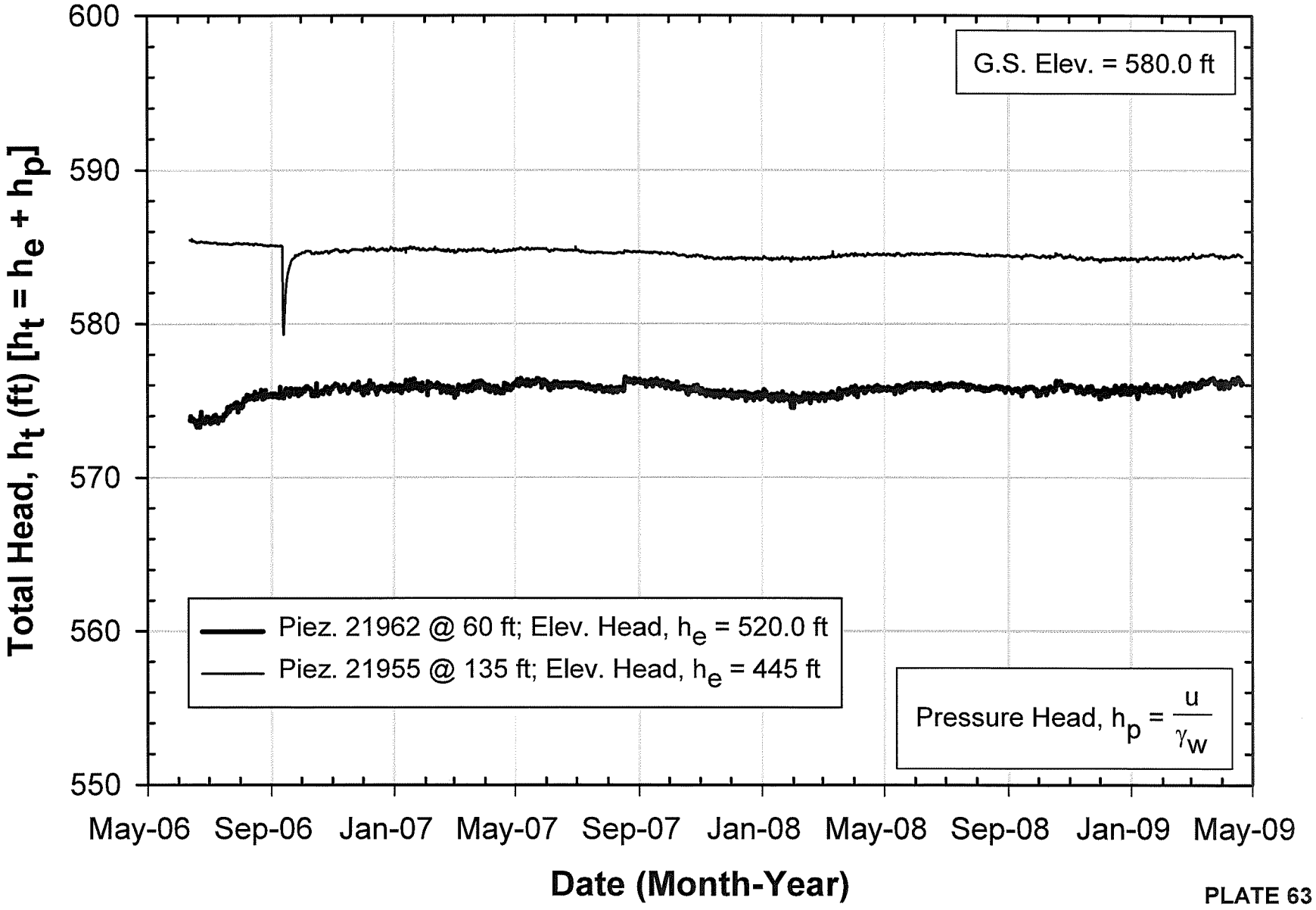


PLATE 63

CALIPERED SURFACE DISTANCE TABLE
CUY-90-15.24

Date	Left Pier Calipered Surface Distance		Center Line Calipered Surface Distance		Right Pier Calipered Surface Distance	
	Present reading	Change (in.)	Present reading	Change (in.)	Present reading	Change (in.)
07/16/02	6.290	--	Discontinued		4.444	--
10/15/02	6.333	0.043			4.482	0.038
01/15/03	6.405	0.072			4.473	-0.009
04/17/03	6.333	-0.072			4.482	0.009
07/18/03	6.186	-0.147			4.350	-0.132
10/16/03	6.385	0.199			4.519	0.169
01/08/04	6.124	-0.261			4.594	0.075
04/14/04	6.129	0.005			4.402	-0.193
07/16/04	6.250	0.122			4.277	-0.125
10/27/04	6.375	0.125			4.467	0.190
01/12/05	6.250	-0.125			4.349	-0.118
04/14/05	6.375	0.125			4.372	0.023
07/14/05	6.313	-0.063			4.392	0.020
10/12/05	6.375	0.063			4.358	-0.034
02/01/06	6.438	0.063			4.395	0.037
04/20/06	6.500	0.063			4.430	0.035
07/14/06	6.375	-0.125			4.381	-0.049
10/18/06	6.438	0.063			4.400	0.020
01/19/07	6.500	0.062			4.506	0.106
04/18/07	6.375	-0.125			4.357	-0.150
07/11/07	6.438	0.063			4.341	-0.015
10/12/07	6.438	0.000			4.384	0.043
01/08/08	6.469	0.031			4.349	-0.036
04/14/08	6.500	0.031			4.410	0.062
07/14/08	6.500	0.000			4.410	0.000
10/15/08	6.375	-0.125			4.395	-0.016
01/13/09	6.500	0.125			4.449	0.055
04/21/09	6.500	0.000			4.449	0.000

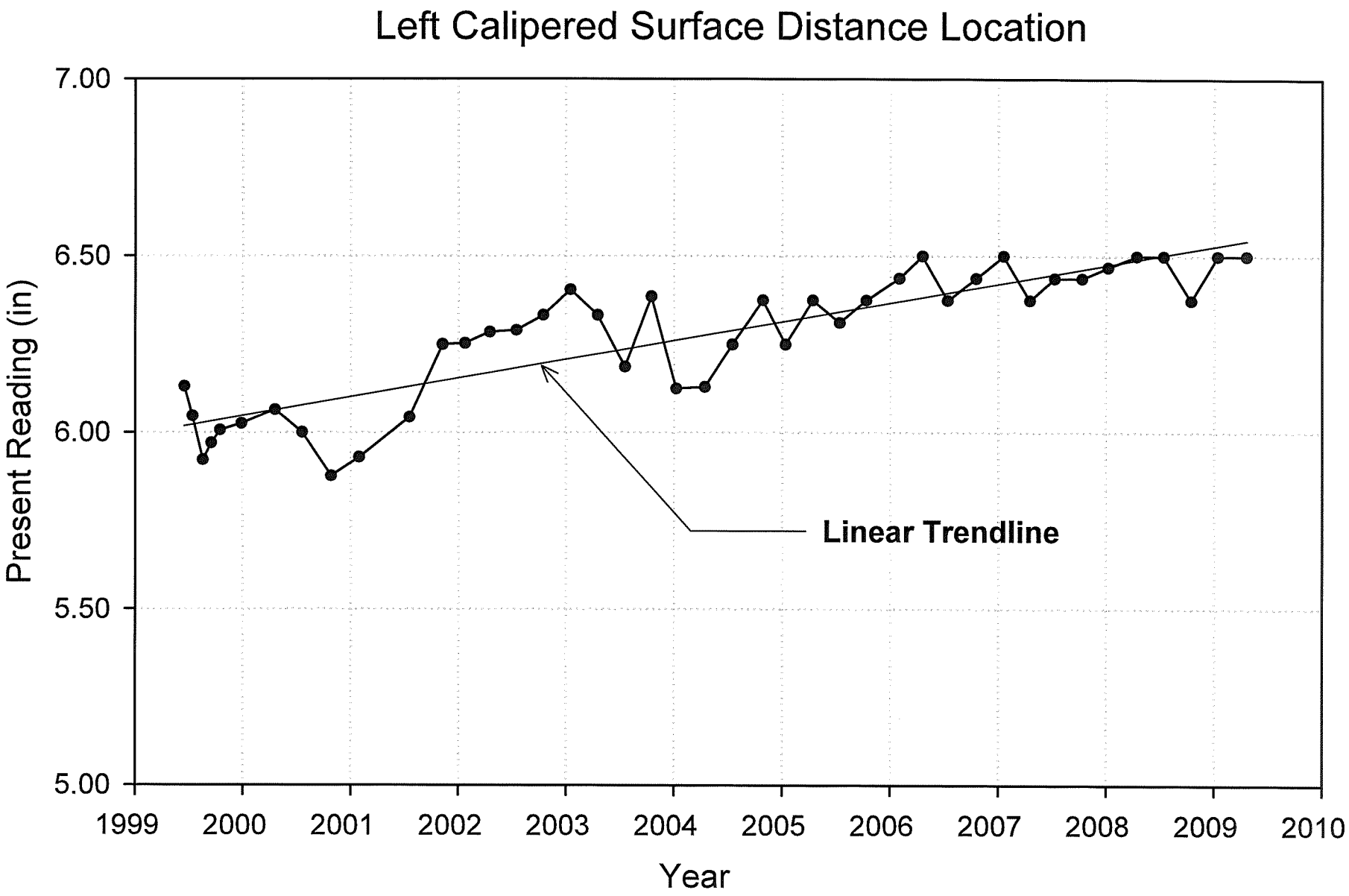

Left Calipered Surface Distance Location
7.00
6.50
6.00
5.50
5.00
Present Reading (in)
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year
Linear Trendline

PLATE 65

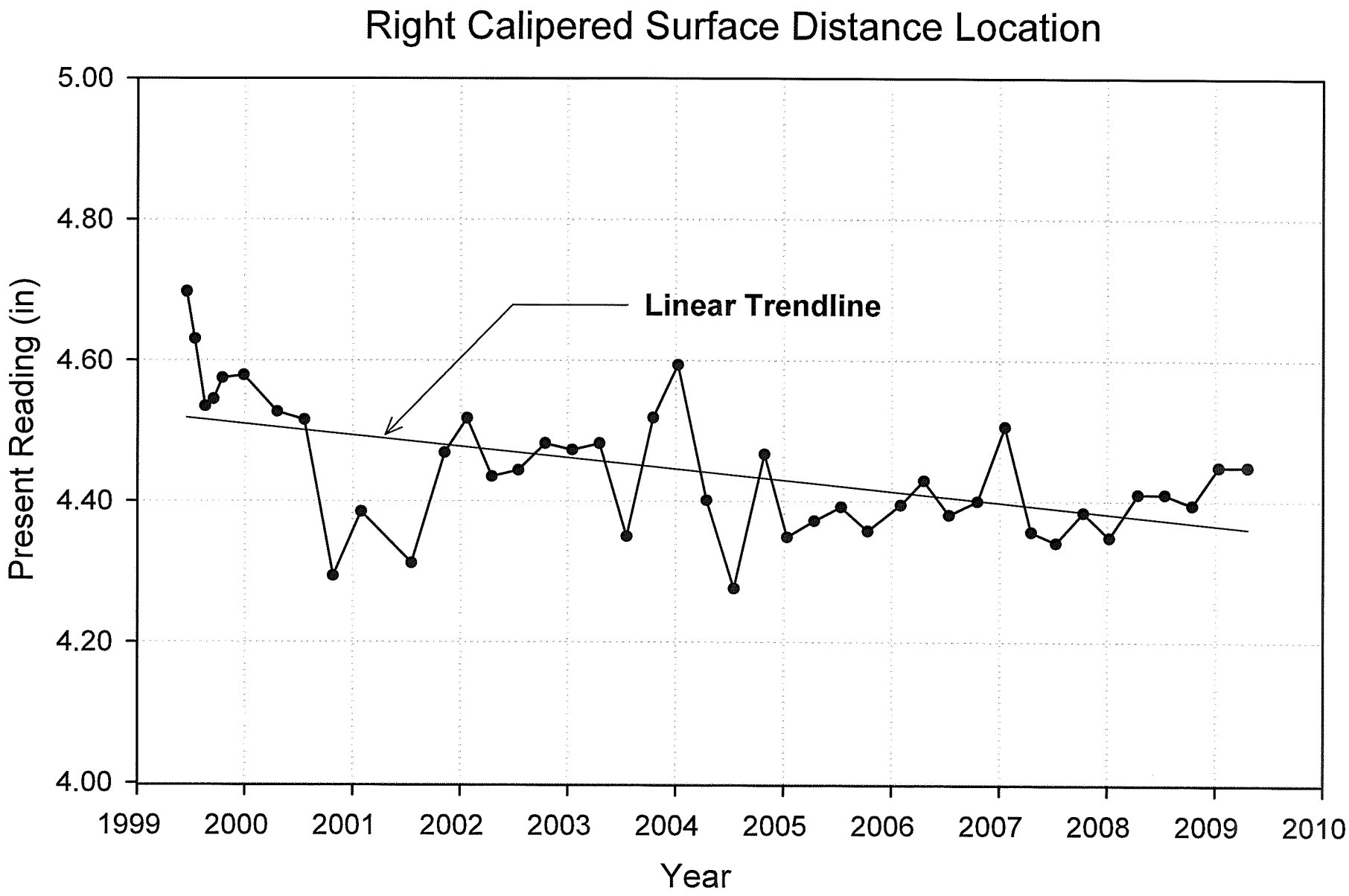

Right Calipered Surface Distance Location
5.00
4.80
4.60
4.40
4.20
4.00
Present Reading (in)
Linear Trendline
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

PLATE 66

View of the landslide area near B-05-16 adjacent to excavation. Photo taken from near B-05-13 on April 17, 2008.

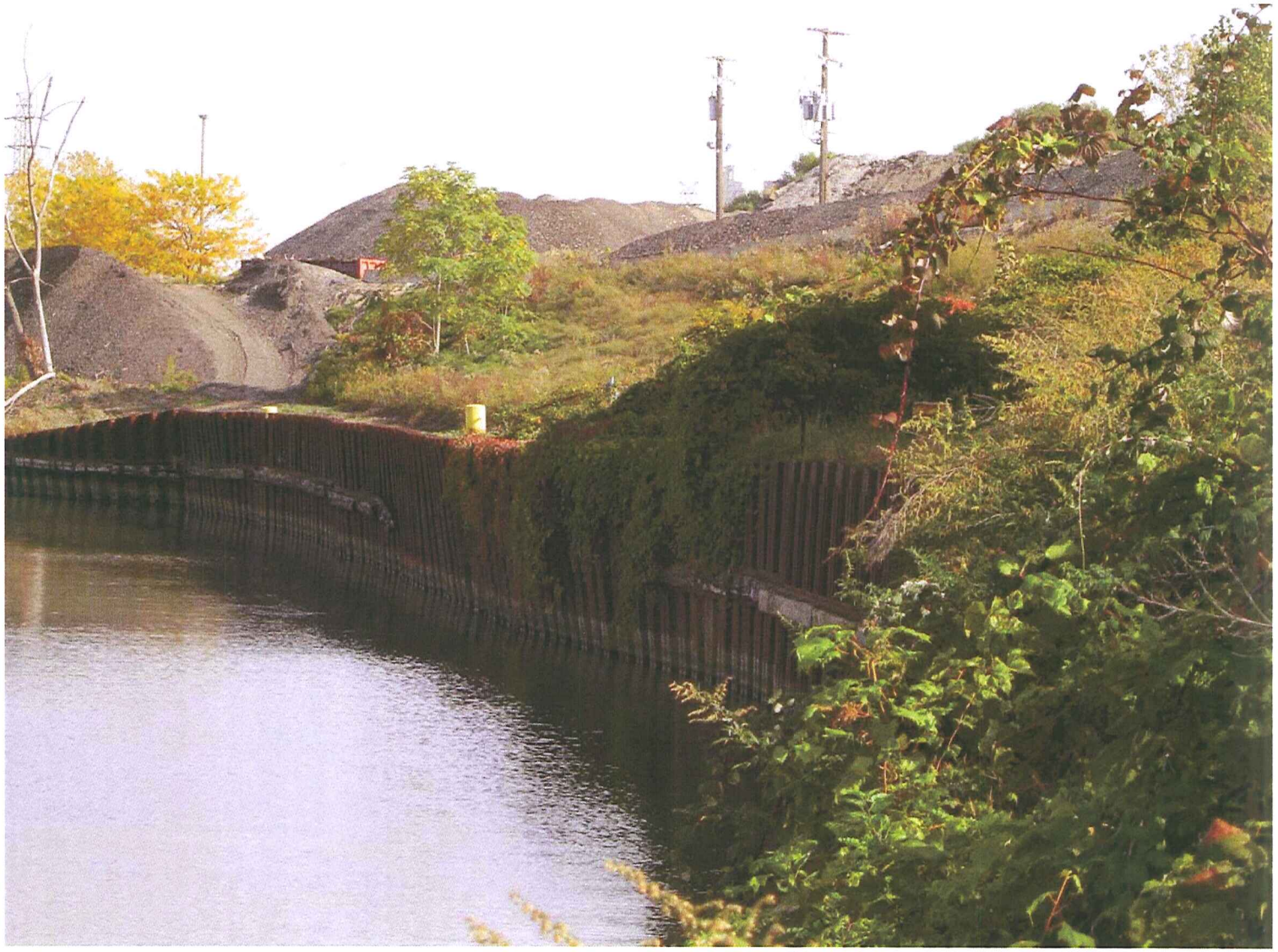
PLATE 67

View of the landslide area near B-05-16 adjacent to excavation. Photo taken from near B-05-13 on April 21, 2009.

PLATE 68

View towards the east (upriver) of the bulkhead adjacent to B-105A. Photo taken on July 16, 2008.

PLATE 69



View towards the east (upriver) of the bulkhead adjacent to B-105A. Photo taken on October 13, 2008.

View of the gap that has formed behind the bulkhead just east (upriver) of B-105A. Photo taken on April 17, 2009.

PLATE 71

View of the bulkhead just east (upriver) of B-105A near the right-of-way fence. Photo taken on April 17, 2009.

PLATE 72

View of the bulkhead just east (upriver) of B-105A near the right-of-way fence. Photo taken on April 17, 2009.

View towards the north of the aggregate pile and east right-of-way fence. Photo taken from near B-102 on July 21, 2008.

PLATE 74

View towards the north-northwest of the aggregate pile adjacent to the east right-of-way fence. Photo taken on October 30, 2008.

PLATE 75

View towards the north of the aggregate pile and east right-of-way fence. Photo taken from near B-102 on January 22, 2009.

PLATE 76

View towards the northeast of the aggregate pile and the newly repaired east right-of-way fence. Photo taken from near B-102 on April 16, 2009.

PLATE 77

View towards the east-southeast of the aggregate pile and east right-of-way fence. Photo taken on July 16, 2008.

PLATE 78

View towards the east-southeast of the aggregate pile with a portion of the fence damaged and the pile spilling into the I-90 bridge right-of-way. Photo taken on October 13, 2008.

PLATE 79

A close-up view towards the east-northeast of the portion of the aggregate pile that broke through the fence and spilled into the I-90 bridge right-of-way. Photo taken on October 13, 2008.

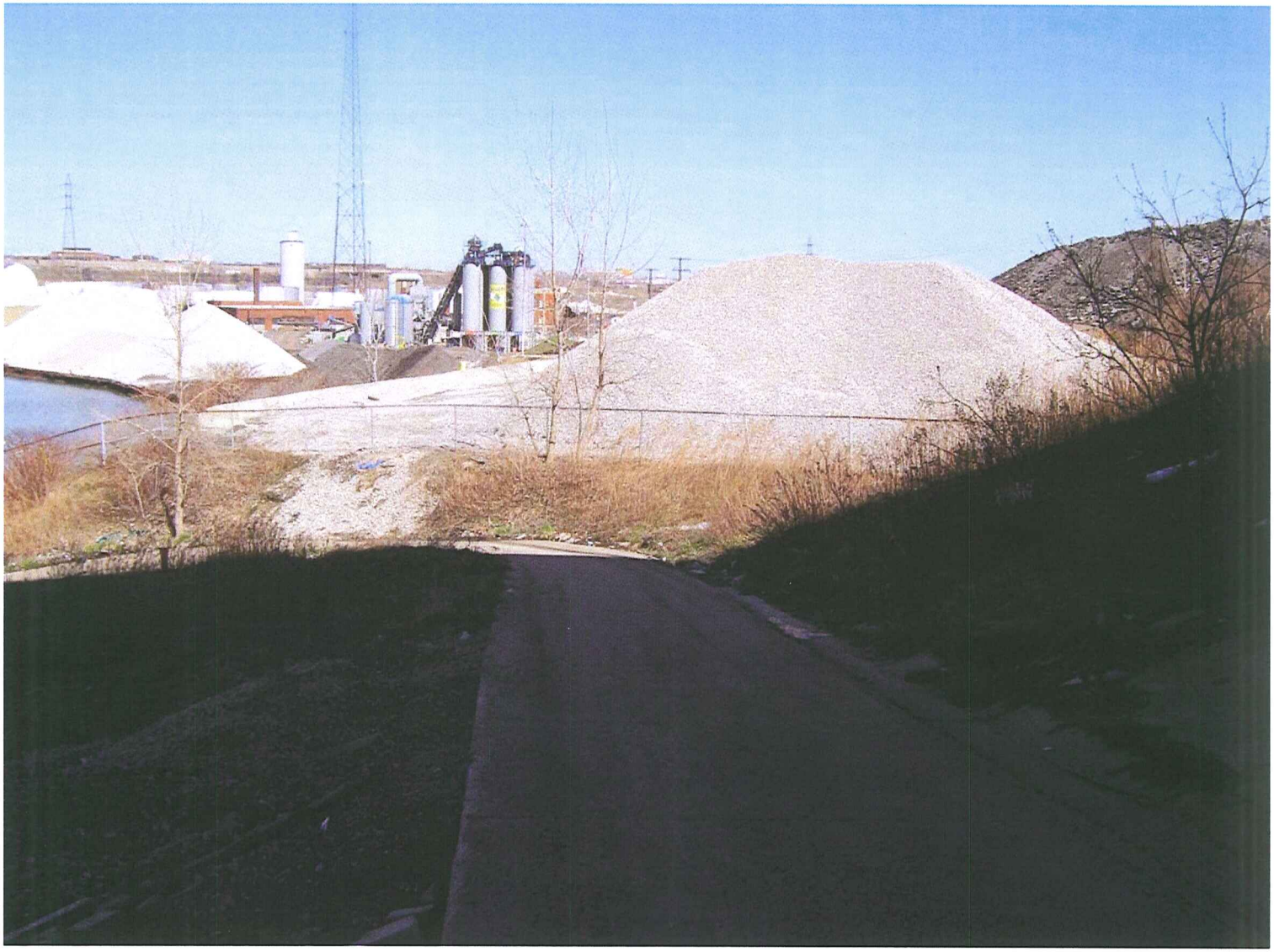
PLATE 80

View towards the east-southeast of the aggregate pile and east right-of-way fence. Photo taken on January 22, 2009.

PLATE 81

Close-up view towards the east-southeast of the aggregate pile and east right-of-way fence. Photo taken on January 22, 2009.

PLATE 82

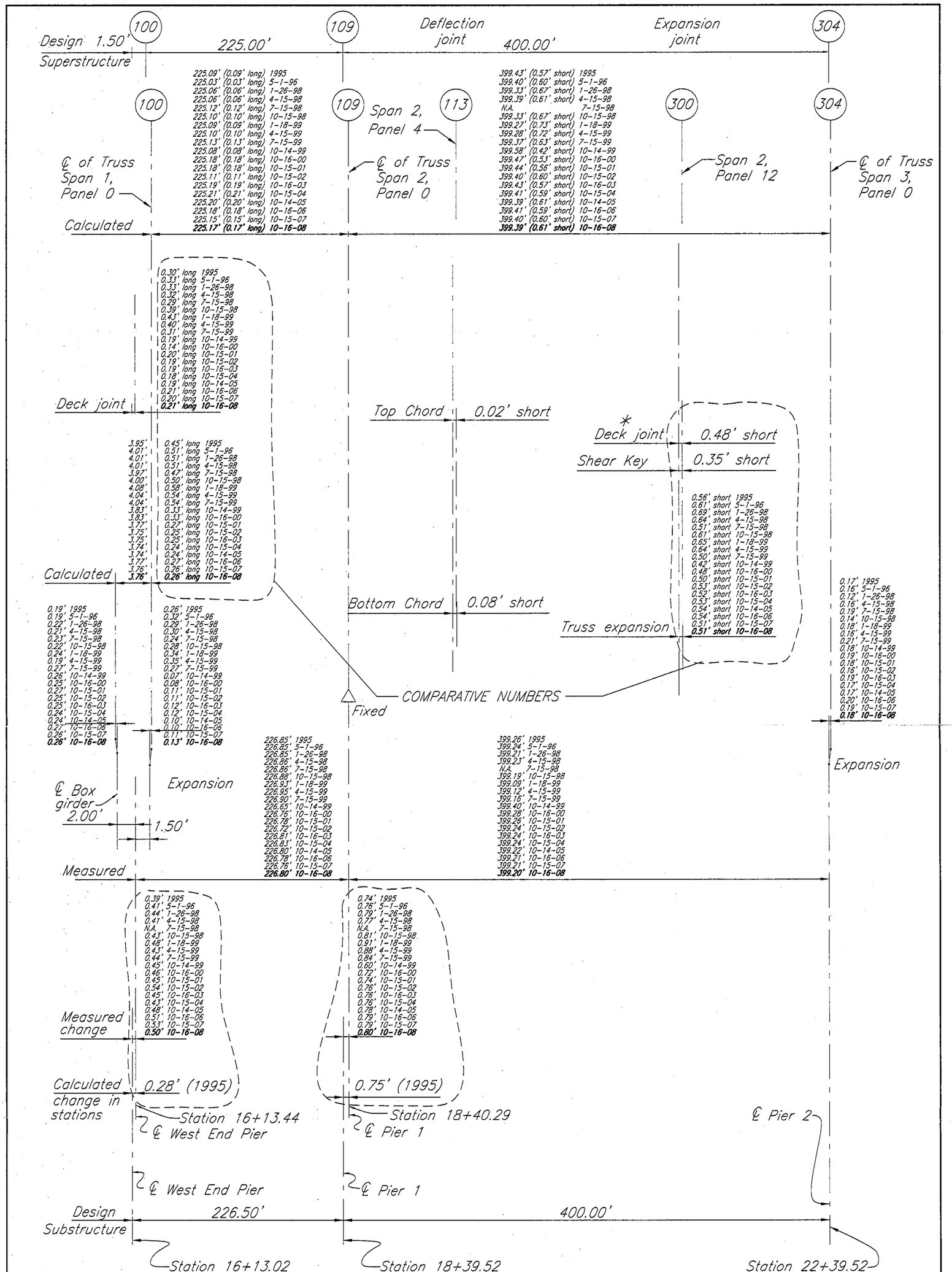


View towards the east-northeast of the aggregate pile and the newly repaired east right-of-way fence. Photo taken from near B-303 on April 17, 2009.

PLATE 83

View towards the east of the crack in the concrete pavement adjacent to B-05-03. Photos taken on April 17, 2009.

PLATE 84



* 1972 Joint repositioned open 0.21'
1998 Joint closed 0.27'
0.48'

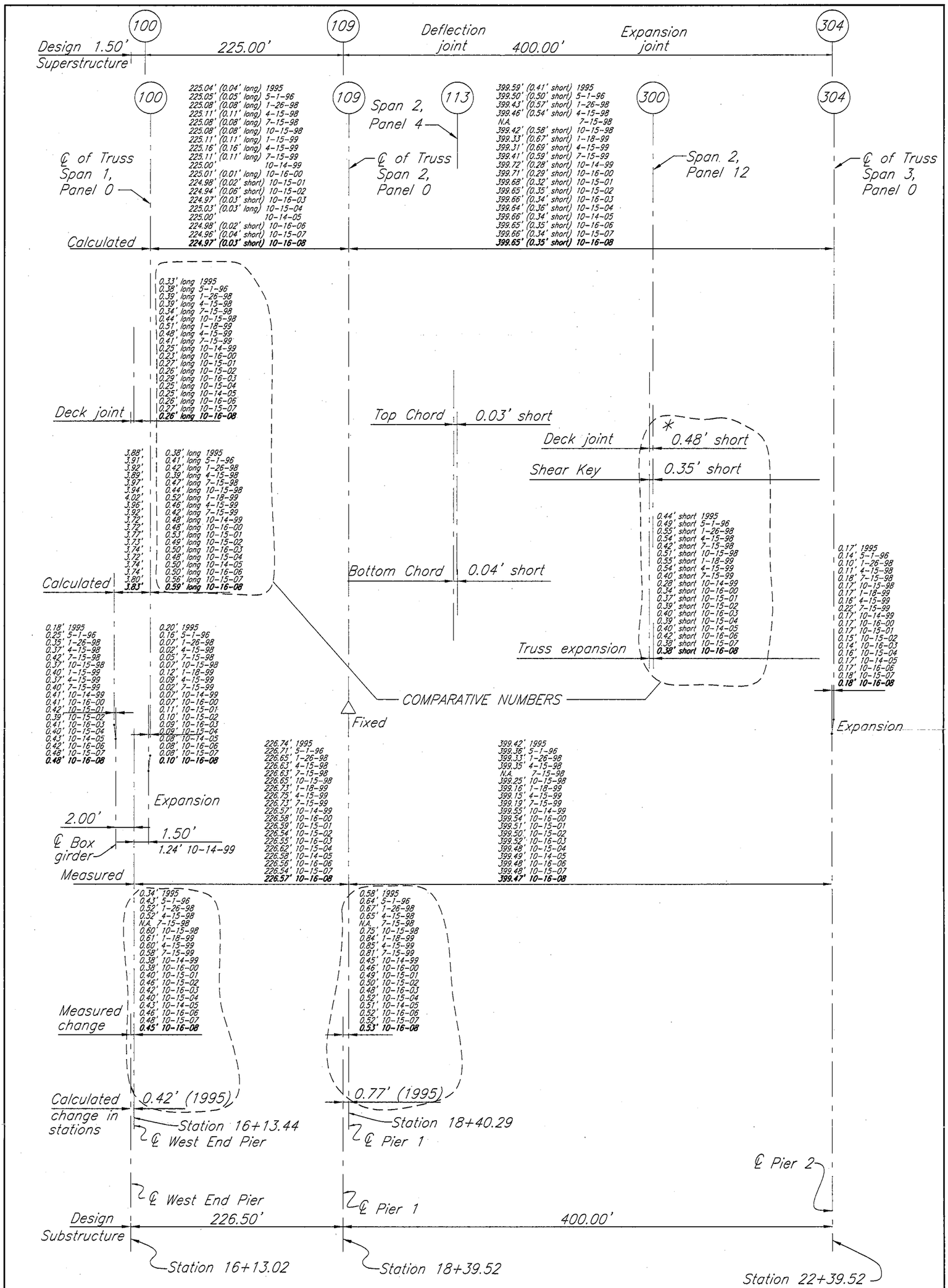
(100) – Panel Number given in Original Construction drawings

Summary of Truss Measurements

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

SCHEMATIC – SOUTH TRUSS @ 60° F (10-16-08)
CUY-90-1524

10601/72008 Measurements/CONSOLDWG



* 1972 Joint repositioned open 0.21'
1998 Joint closed 0.27'
0.48'

(100) – Panel Number given in Original Construction drawings

Summary of Truss Measurements

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

SCHEMATIC – NORTH TRUSS @ 60° F (10-16-08)
CUY-90-1524

10601/2008 Measurements/COMPOSITE.DWG

RELATIVE SPAN LENGTHS

(Distance between points set on consecutive piers)

	Span 1		Span 2	
	North Truss	South Truss	North Truss	South Truss
1985	215.35	215.30	399.49	399.74
1988	215.47	215.46	399.38	399.57
1989	215.48	215.44	399.36	399.59
1990	215.48	215.45	399.35	399.56
1991	215.48	215.42	399.29	399.57
1992	215.51	215.50	399.30	399.52
1993	215.46	215.49	399.34	399.51
1994	215.47	215.44	399.31	399.52
1995	215.49	215.45	399.34	399.55
5 / 1996	215.46	215.45	399.28	399.53
8 / 1996	215.45	215.46	399.28	399.54
9 / 1997	215.45	215.48	399.29	399.53
1 / 1998	215.40	215.45	399.25	399.50
4 / 1998	215.38	215.46	399.27	399.52
7 /1998	215.35	215.44	¥	¥
10 / 1998	215.40	215.48	399.16	399.47
12 / 1998	215.48	215.53	399.08	399.41
1 / 1999	215.48	215.53	399.08	399.39
4 / 1999	215.51	215.55	399.07	399.41
10 / 1999	215.48	215.50	399.11	399.45
***10/ 1999	215.56	215.66	398.98	399.25
10/2000	215.57	215.77	398.97	399.13
10/2001	215.58	215.79	398.94	399.12
10/2002	215.53	215.73	398.93	399.10
10/2003	215.55	215.82	398.95	399.10
10/2004	215.61	215.84	398.91	399.09
10/2005	215.58	215.81	398.92	399.08
10/2006	215.55	215.79	398.91	399.06
10/2007	215.53	215.77	398.91	399.06
Net Change	0.01	0.14	-0.07	-0.20
Design	215.25	215.10	399.92	400.29
10/2008	215.56	215.81	398.90	399.06
Change from 10/07 to 10/08	0.03	0.04	-0.00	-0.01

¥ Points destroyed during construction. New points set atop of pier 2, first reading taken 10/15/98

Net change is current reading compared to the last compatible reading (10/1999)

*** Bridge relocated

CUY-90-1524
106017

DECK EXPANSION JOINT OPENINGS

Finger Type Joints
Measurements are in inches.

Date	Temp (F)	West End Pier North	West End Pier South	Near Pier 2 North	Near Pier 2 South	Near Pier 4 North	Near Pier 4 South
Expansion Distance		476 feet		650 feet			
Design	60°	3.25	3.25	3.25	3.25	3.25	3.25
06-01-70	80°	4.00		0.00		N.A.	
09-19-75	60°	5.25		2.00		N.A.	
05-08-78	60°	4.75	5.50	2.00	2.00	3.25	2.50
07-30-81	75°	5.50	5.50	2.25	2.25	3.25	2.75
06-09-83	70°	5.00	5.00	1.50	1.50	2.75	2.25
07-31-85	73°	5.25	4.75	1.50	1.00	2.75	2.25
10-31-88	40°	7.75	8.38	1.50	0.75	3.81	3.38
11-01-89	50°	7.75	7.00	1.13	0.63	3.25	3.13
10-26-90	50°	7.75	7.25	1.00	0.50	3.00	3.00
09-30-91	55°	7.50	7.00	0.88	0.00	3.00	3.00
10-13-92	60°	7.25	6.81	0.63	0.00	2.50	2.50
10-01-93	50°	7.50	7.13	0.75	0.31	2.75	2.63
09-01-94	63°	7.25	6.38	0.31	0.00	2.88	1.88
09-08-95	60°	7.00	6.63	0.44	0.00	2.00	1.88
09-05-96	77°	6.50	6.63	0.38	0.00	1.25	1.00
09-19-97	75°	6.88	7.00	0.31	0.06	1.68	1.42
09-24-98	69°	7.63	7.00	0.00	0.00	1.88	1.75
10-14-99	45°	6.19	5.50	2.38	1.88	3.13	2.75
10-16-00	55°	6.00	4.88	1.75	1.25	2.56	2.43
04-23-01	70°	5.50	4.25	1.38	0.63	2.13	1.75
07-16-01	80°	5.00	3.88	1.00	0.25	1.50	1.25

Date	Temp (F)	West End Pier		Near Pier 2		Near Pier 4	
		North	South	North	South	North	South
10-15-01	50°	6.63	5.63	1.63	1.06	3.25	2.75
1-15-02	30°	6.88	6.25	2.13	1.50	3.88	3.50
4-15-02	61°	6.00	5.25	1.38	0.88	2.50	2.38
7-15-02	76°	5.13	4.13	1.13	0.50	1.75	1.50
10-17-02	48°	7.00	6.38	1.75	1.25	3.25	2.88
11-1-02	35°	7.25	6.13	1.88	1.38	3.63	3.38
1-15-03	7°	8.13	6.63	2.38	1.88	5.00	4.75
4-15-03	67°	5.63	4.63	1.25	0.63	2.25	2.00
7-15-03	74°	5.38	4.38	1.00	0.50	2.00	1.63
10-16-03	46°	7.00	5.75	1.50	1.13	3.25	3.13
1-15-04	11°	8.00	6.75	2.00	1.38	4.63	4.00
4-15-04	41°	6.88	5.75	1.38	0.88	3.50	3.25
7-15-04	67°	5.63	4.75	1.00	0.50	2.13	1.75
10-15-04	50°	6.38	5.50	1.25	0.75	3.00	2.75
1-15-05	12°	7.75	7.00	2.00	1.38	4.63	4.25
4-16-05	47°	6.50	5.63	1.25	0.75	3.25	2.88
7-16-05	74°	5.50	4.50	0.75	0.375	1.75	1.63
10-14-05	51°	6.25	5.50	1.13	0.63	2.81	2.56
1-16-06	26°	7.63	6.38	1.75	1.13	4.13	3.75
4-14-06	65°	5.75	4.88	0.75	0.50	2.25	2.00
7-14-06	78°	5.00	4.00	0.63	0.19	1.63	1.25
10-16-06	50°	6.50	5.88	1.00	0.75	3.25	3.00
1-15-07	41°	7.00	6.13	1.13	0.88	3.56	3.38
4-16-07	34°	7.25	6.38	1.38	0.88	3.75	3.50
7-16-07	70°	5.38	4.75	0.88	0.25	2.13	1.63
10-15-07	56°	6.38	5.50	1.13	0.75	2.88	2.69

Date	Temp (F)	West End Pier		Near Pier 2		Near Pier 4	
		North	South	North	South	North	South
1-15-08	19°	7.63	6.63	1.63	1.00	4.13	4.00
4-15-08	41°	7.13	6.25	1.44	0.88	3.75	3.19
7-16-08	83°	4.75	4.00	0.50	0.00	1.13	0.81
10-16-08	56°	6.25	5.56	1.13	0.69	2.75	2.25
1-15-09	7°	8.31	7.69	2.00	1.13	5.00	4.94
4-15-09	46°	6.38	5.69	1.31	0.81	3.00	2.69

N.A. - No measurements available

CUY-90-1524
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EXPANSION OPENINGS AT SPAN 2 FLOORBEAM 12

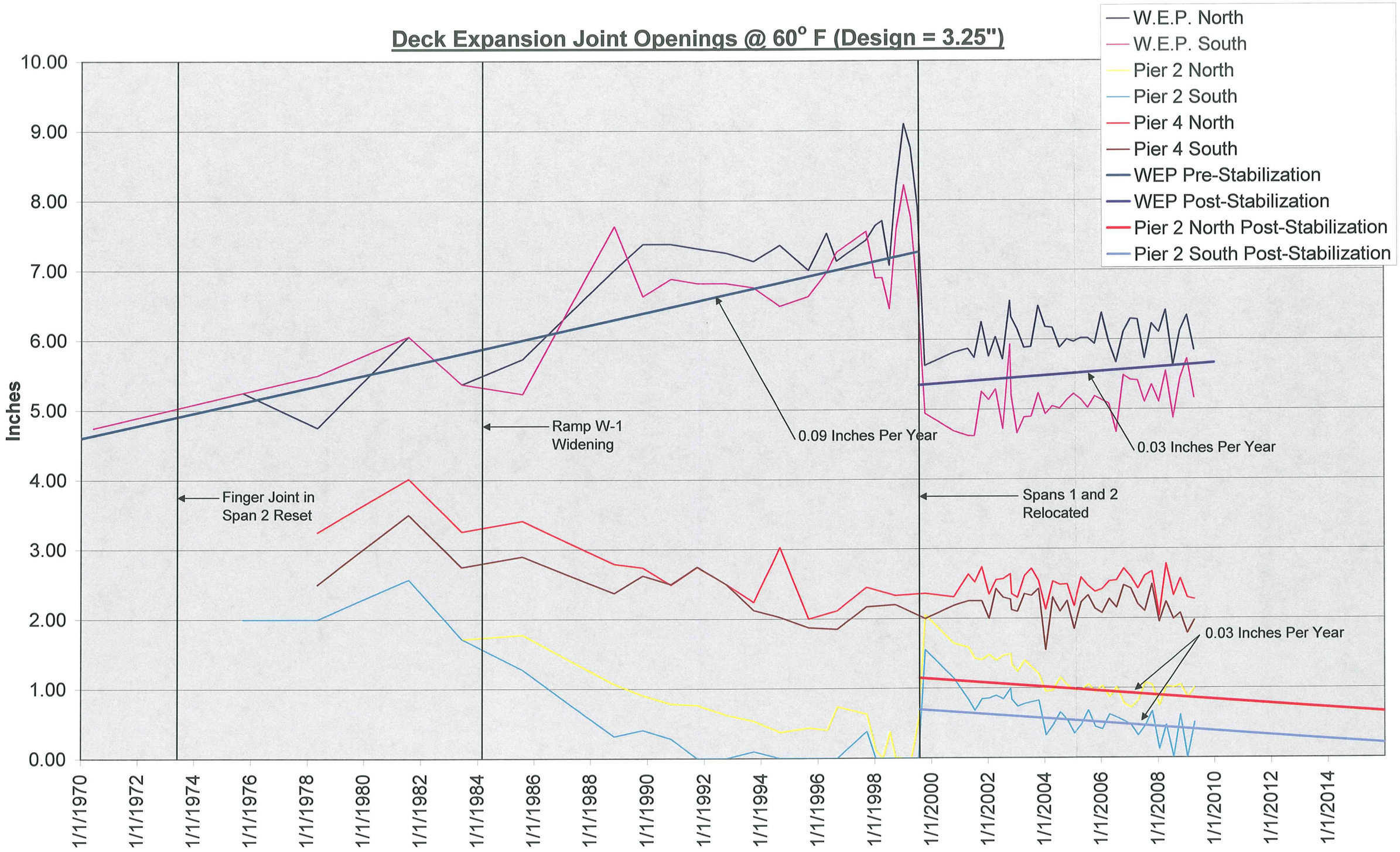
Measurements are in inches

Date	Temp (F)	North Lower Chord Expansion Opening	Deck Expansion Joint Near Pier 2		South Lower Chord Expansion Opening
			North	South	
04-23-01	70°	0.54	1.38	0.63	0.04
07-16-01	80°	0.11	1.00	0.25	N.A.
10-15-01	50°	0.48	1.00	0.25	0.10
1-15-02	30°	1.23	2.13	1.50	0.67
4-15-02	61°	0.48	1.38	0.88	0.17
7-15-02	76°	0.17	1.13	0.50	0.04
10-15-02	41°	0.36	1.75	1.25	0.23
11-1-02	35°	N.A.	1.88	1.38	N.A.
1-15-03	7°	1.17	2.38	1.88	0.73
4-15-03	67°	0.30	1.25	0.63	0.12
7-15-03	74°	0.18	1.00	0.50	0.12
10-16-03	46°	0.30	1.50	1.13	0.12
1-15-04	11°	0.90	2.00	1.38	0.48
4-15-04	41°	0.42	1.38	0.88	0.06
7-15-04	67°	0.06	1.00	0.50	0.00
10-15-04	50°	0.17	1.25	0.75	0.04
1-15-05	12°	0.66	2.00	1.38	0.30
4-16-05	47°	0.30	1.25	0.75	0.00
7-16-05	74°	0.00	0.75	0.375	0.00
10-14-05	51°	0.18	1.13	0.63	0.18
1-16-06	26°	0.66	1.75	1.13	0.24
4-14-06	65°	0.18	0.75	0.50	0.00
7-14-06	78°	0.00	0.63	0.19	0.00

Date	Temp (F)	North Lower Chord Expansion Opening	Deck Expansion Joint Near Pier 2		South Lower Chord Expansion Opening
			North	South	
10-16-06	50°	0.30	1.00	0.75	0.00
1-15-07	41°	0.30	1.13	0.88	0.12
4-16-07	34°	0.36	1.38	0.88	0.12
7-16-07	70°	0.06	0.88	0.25	0.00
10-15-07	56°	0.12	1.13	0.75	0.00
1-15-08	19°	0.42	1.63	1.00	0.18
4-15-08	41°	0.36	1.44	0.88	0.06
7-16-08	83°	0.00	0.50	0.00	0.00
10-16-08	56°	0.12	1.13	0.69	0.12
12-05-08	23°	0.36	1.13	0.69	0.18
1-15-09	7°	0.73	2.00	1.13	0.29
4-15-09	46°	0.60	1.31	0.81	0.18

N.A. – Not Available

Deck Expansion Joint Openings @ 60° F (Design = 3.25")



SEAT ELEVATIONS

POINT NO.	DESCRIPTION	10/17/94	02/26/98	04/15/98	07/15/98	07/22/98	10/15/98	1/19/99	3/5/99	4/15/99	7/15/99	10/14/99	10/16/00	10/15/01	10/15/02	10/16/03	10/14/04	10/14/05	10/16/06	10/15/07	10/16/08
WEST END PIER SOUTH																					
103	ROD IN PIER SEAT	667.18	667.15	667.18	667.18	-	667.14	667.16	-	667.17	667.17	667.16	667.16	667.20	667.17	667.17	667.19	667.15	667.16	667.16	667.16
401	ROD IN SOUTH FACE	-	677.91	677.93	677.92	-	677.92	677.93	-	677.93	677.92	677.91	677.92	677.94	677.93	677.92	677.94	677.91	677.92	677.91	677.90
402	ROD IN NORTH FACE	-	670.79	670.81	670.80	-	670.78	670.80	-	670.79	670.80	670.78	670.80	670.83	670.80	670.80	670.81	670.78	670.79	670.79	670.78
WEST END PIER NORTH																					
	ROD IN PIER SEAT																				
102	Destroyed	667.04	667.03	667.07	667.05	-	667.04	667.03	-	667.04	-	-	-	-	-	-	-	-	-	-	-
802	(SET 7/16/99)									-	667.02	667.01	667.01	667.05	667.01	667.02	667.03	667.00	667.01	667.01	667.00
404	ROD IN NORTH FACE	-	660.83	660.86	660.86	-	660.82	660.88	-	660.84	660.85	660.84	660.84	660.87	660.85	660.84	660.86	660.82	660.83	660.83	660.83
PIER 1 NORTH																					
	ROD IN PIER SEAT																				
104	Destroyed	626.29	626.33	-	626.38	-	626.32	-	-	-	-	-	-	-	-	-	-	-	-	-	-
606	(SET 7/22/98)							626.35	-	626.33	626.34	626.33	626.33	626.34	626.30	626.33	626.34	626.31	626.29	626.34	626.36
607	(SET 12/29/98)							626.32	-	626.30	626.30	-	-	-	-	-	-	-	-	-	-
608	(SET 12/29/98)							626.24	-	626.21	626.21	626.22	626.23	626.23	626.22	626.23	626.23	626.20	626.19	626.23	626.25
609	(SET 12/29/98)							626.23	-	626.22	626.21	626.21	626.21	-	-	-	-	-	-	-	-
903	(SET 10/13/99)											626.30	626.30	626.30	626.33	626.30	626.30	626.27	626.26	626.31	626.32
902	(SET 10/13/99)											626.25	626.26	626.26	626.25	626.26	626.25	626.23	626.21	626.26	626.28
308	ROD IN NORTH FACE	-	604.51	-	-	-	604.48	604.51	-	604.55	604.52	604.50	604.50	604.52	604.51	604.51	604.52	604.49	604.48	604.52	604.53
407	ROD IN SOUTH FACE	-	-	-	-	-	604.25	§	-	604.26	604.28	604.23	604.24	604.27	604.25	604.25	604.26	604.23	604.20	604.26	604.27
PIER 1 SOUTH																					
	ROD IN PIER SEAT																				
105	Destroyed	626.25	626.27	-	626.34	626.32	626.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-
602	(SET 7/22/98)	-	-	-	-	626.29	626.24	626.25	-	626.23	626.23	-	-	-	-	-	-	-	-	-	-
603	(SET 12/29/98)							626.26	-	626.25	626.24	-	-	-	-	-	-	-	-	-	-
604	(SET 12/29/98)							626.23	-	626.21	626.20	-	-	-	-	-	-	-	-	-	-
605	(SET 12/29/98)							626.24	-	626.22	626.21	-	-	-	-	-	-	-	-	-	-
901	(SET 10/13/99)											626.22	626.23	626.23	626.22	626.23	626.22	626.20	626.18	626.23	626.24
900	(SET 10/13/99)											626.21	626.22	626.22	626.21	626.22	626.21	626.19	626.17	626.22	626.23
306	ROD IN NORTH FACE	-	606.55	-	-	-	606.53	§	-	606.51	606.54	606.50	606.50	606.52	606.51	606.51	606.51	606.49	606.47	-	606.52
305	ROD IN SOUTH FACE	-	607.33	-	-	-	607.33	607.32	-	607.31	607.34	607.29	607.30	607.32	607.31	607.31	607.33	607.30	607.27	607.31	607.32
PIER 2 NORTH																					
	ROD IN PIER SEAT																				
601	(SET 7/22/98)	-	-	-	-	628.65	628.58	628.66	-	628.62	628.65	628.63	628.64	628.65	628.65	628.64	628.61	628.61	628.58	628.68	628.68
206	ROD IN SOUTH FACE	-	586.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
610	ROD IN SOUTH FACE (SET 7/22/98)	-	-	-	-	-	586.09	586.15	-	-	586.11	586.12	586.14	586.16	586.18	586.17	586.18	586.15	586.17	586.16	586.16
PIER 2 SOUTH																					
600	ROD IN PIER SEAT (SET 7/22/98)	-	-	-	-	628.78	628.72	628.77	-	628.76	628.78	628.76	628.78	628.78	628.76	628.77	628.73	628.75	628.72	628.79	628.80
207	ROD IN NORTH FACE	-	586.08	-	-	-	586.07	586.10	-	-	586.16	586.16	586.10	586.11	586.13	586.12	586.13	586.11	586.12	586.11	586.11
ANCHOR STRUCTURE																					
500	ROD SOUTH END	-	591.00	-	-	591.00	590.97	590.98	591.00	590.99	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
501	ROD CENTER +-	-	590.96	-	-	590.97	590.94	590.96	590.96	590.96	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
502	ROD NORTH END	-	590.98	-	-	590.99	590.97	590.99	590.99	590.99	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
DRILLED SHAFT CAP (SET 3/4/99)																					
700	BRASS DISK NORTH END	-	-	-	-	-	-	-	589.61	589.62	589.66	589.65	589.65	589.66	589.66	589.67	589.68	589.65	589.62	589.68	589.70
701	BRASS DISK CENTER +-	-	-	-	-	-	-	-	589.66	589.66	589.68	589.68	589.69	589.69	589.69	589.70	589.71	589.68	589.65	589.71	589.73
702	BRASS DISK SOUTH END	-	-	-	-	-	-	-	589.62	589.62	589.63	589.64	589.65	589.65	589.64	589.66	589.66	589.63	589.60	589.66	589.68
CONTROL POINT																					
64	PK IN CONC DRIVE	633.37	633.30	-	-	633.31	633.26	633.27	-	633.22	633.23	633.22	633.22	633.23	633.21	633.21	633.22	633.16 ***	633.15 ***	633.17 ***	633.20 ***

| Calculated from top of concrete using an average rod height
§ Shots were not taken due to heat tent for rock anchor placement procedure.
¥¥ No future shots will be taken due to anchor structure being buried
*** Head of Nail Missing

Reference North (Inches)

WEST END PIER

PIER 1

DRILLED SHAFT CAP

PIER 2

Oct. 1999

Oct. 2008

0.91"

Oct. 2008

Oct. 1999

Oct. 2008

0.92"

Oct. 1999

Oct. 2008

Oct. 1999

REFERENCE

N

W

E

S

Oct. 1999

Oct. 2008

Oct. 1999

Oct. 2000

Oct. 2008

Oct. 1999

1.21"

Oct. 2008

Oct. 1999

0.50"

SCALE

Reference East (Inches)

PIER SEAT COORDINATES

PIER SEAT COORDINATES

(Reference Point Locations on Top of Piers)

Pier	Direction	B&N 1985'	REL 1988‡	REL 1989‡	REL 1990‡	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 5/96	REL 8/96	REL 9/97	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 3/99	REL 4/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06	REL 10/07	REL 10/08
WEP North	N	5114.58	5114.53	5114.55	5114.55	5114.58	5114.64	5114.64	5114.65	5114.65	5114.67	5114.67	5114.68	5114.66	5114.65	5114.67	5114.66	5114.64	5114.68	N.A.	N.A.	5114.71	5114.69	5114.66	5114.65	5114.63	5114.67	5114.65	5114.64	5114.66	5114.63	5114.65	5114.66
	E	4840.08	4839.58	4839.59	4839.59	4839.59	4839.59	4839.62	4839.62	4839.60	4839.67	4839.67	4839.69	4839.75	4839.77	4839.82	4839.84	4839.83	4839.83	N.A.	N.A.	4839.81	4839.81	4839.85	4839.84	4839.85	4839.88	4839.85	4839.87	4839.90	4839.91	4839.93	4839.93
WEP South	N	5033.90	5033.84	5033.85	5033.86	5033.87	5033.96	5033.98	5033.98	5033.96	5033.98	5034.01	5033.96	5033.99	5033.99	5033.98	5033.99	NA	5033.99	N.A.	N.A.	5033.99	5033.96	5033.95	5033.94	5033.94	5033.94	5033.94	5033.95	5033.94	5033.96	5033.94	5033.91
	E	4839.62	4839.12	4839.14	4839.14	4839.12	4839.11	4839.14	4839.15	4839.13	4839.15	4839.13	4839.15	4839.16	4839.17	4839.20	4839.22	NA	4839.23	N.A.	N.A.	4839.19	4839.21	4839.22	4839.22	4839.24	4839.26	4839.19	4839.21	4839.25	4839.27	4839.29	4839.28
Pier 1 North	N	5124.44	5124.42	5124.40	5124.43	5124.39	5124.46	5124.50	5124.47	5124.44	5124.44	5124.48	5124.46	5124.47	5124.46	5124.46	5124.47	5124.47 £	5124.47	N.A.	N.A.	5124.46	5124.48	5124.42	5124.43	5124.44	5124.43	5124.43	5124.47	5124.45	5124.46	5124.47	5124.44
	E	5055.20	5054.83	5054.84	5054.84	5054.85	5054.88	5054.86	5054.86	5054.87	5054.91	5054.90	5054.92	5054.93	5054.94	5054.95	5055.02	5055.09 £	5055.09	N.A.	N.A.	5055.10	5055.07	5055.18	5055.19	5055.21	5055.19	5055.18	5055.25	5055.25	5055.24	5055.24	5055.27
Pier 1 South	N	5034.50	5034.49	5034.49	5034.53	5034.45	5034.53	5034.57	5034.55	5034.52	5034.54	5034.56	5034.54	5034.55	5034.54	5034.53	5034.57	5034.55 £	5034.56	N.A.	N.A.	5034.57	5034.56	5034.60	5034.59	5034.61	5034.64	5034.62	5034.65	5034.65	5034.66	5034.64	5034.64
	E	5054.91	5054.59	5054.58	5054.60	5054.54	5054.60	5054.62	5054.59	5054.57	5054.60	5054.59	5054.63	5054.61	5054.63	5054.64	5054.70	5054.73 £	5054.76	N.A.	N.A.	5054.74	5054.71	5054.89	5054.99	5055.03	5054.99	5055.00	5055.05	5055.06	5055.06	5055.06	5055.09
Pier 2 North	N	5124.60	5124.53	5124.55	5124.57	5124.43	5124.46	5124.45	5124.48	5124.40	5124.40	5124.40	5124.41	5124.37	5124.40	¥	5124.44	5124.42	5124.42	N.A.	N.A.	5124.43	5124.41	5124.40	5124.39	5124.41	5124.39	5124.42	5124.43	5124.41	5124.43	5124.44	5124.40
	E	5454.68	5454.21	5454.21	5454.20	5454.14	5454.18	5454.20	5454.18	5454.21	5454.19	5454.19	5454.21	5454.17	5454.21	¥	5454.18	5454.17	5454.17	N.A.	N.A.	5454.17	5454.18	5454.16	5454.16	5454.15	5454.12	5454.13	5454.16	5454.17	5454.15	5454.14	5454.17
Pier 2 South	N	5024.98	5024.89	5024.91	5024.91	5024.78	5024.81	5024.81	5024.84	5024.74	5024.76	5024.76	5024.76	5024.75	5024.78	¥	5024.72	5024.73	5024.73	N.A.	N.A.	5024.73	5024.70	5024.71	5024.69	5024.68	5024.73	5024.71	5024.72	5024.73	5024.73	5024.73	5024.73
	E	5454.54	5454.04	5454.06	5454.04	5453.99	5454.01	5454.01	5453.99	5454.00	5454.01	5454.00	5454.04	5453.99	5454.03	¥	5454.05	5454.03	5454.03	N.A.	N.A.	5454.03	5454.04	5454.02	5454.00	5454.02	5453.96	5453.98	5454.01	5454.02	5454.00	5454.00	5454.02
Anchor Structur	N													5143.42	5143.42	5143.45	5143.44	NA	5143.44	5143.39	5143.41	5143.43	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
North	E													5018.39	5018.44	5018.44	5018.50	NA	5018.54	5018.55	5018.56	5018.52	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structur	N													5075.81	5075.77	5075.82	5075.81	NA	5075.82	5075.78	5075.80	5075.82	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Center	E													5018.37	5018.40	5018.48	5018.48	NA	5018.58	5018.58	5018.59	5018.53	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structur	N													5009.41	5009.36	5009.42	5009.42	NA	5009.42	5009.40	5009.40	5009.41	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
South	E													5018.53	5018.56	5018.61	5018.61	NA	5018.75	5018.77	5018.78	5018.71	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Drilled Shaft Cap	N																			5138.49	5138.50	5138.53	5138.52	5138.49	5138.52	5138.52	5138.52	5138.53	5138.55	5138.55	5138.55	5138.56	5138.55
North	E																			5109.81	5109.81	5109.78	5109.77	5109.80	5109.80	5109.81	5109.84	5109.82	5109.83	5109.83	5109.84	5109.85	5109.85
Drilled Shaft Cap	N																			5074.42	5074.41	5074.43	5074.44	5074.40	5074.43	5074.43	5074.45	5074.45	5074.46	5074.47	5074.46	5074.48	5074.47
Center	E																			5109.81	5109.82	5109.79	5109.78	5109.81	5109.81	5109.83	5109.84	5109.84	5109.84	5109.87	5109.86	5109.87	5109.89
Drilled Shaft Cap	N																			5010.31	5010.32	5010.33	5010.33	5010.31	5010.32	5010.33	5010.35	5010.35	5010.36	5010.36	5010.37	5010.37	5010.36
South	E																			5109.83	5109.83	5109.80	5109.80	5109.83	5109.84	5109.87	5109.89	5109.89	5109.92	5109.92	5109.92	5109.93	5109.95

* Monumentation damaged by earth moving operations.

‡ Monuments appear to have been displaced 6" along the bridge.

¥ Points destroyed durning construction. New points set. First reading taken 10/15/98

£ Monumentation removed for new pier caps for jacking procedure. New points set and first readings taken 12/29/98

¥¥ No future shots will be taken due to anchor structure being buried

DIFFERENTIAL MOVEMENT

(A positive value indicates movement to the north or east.
A negative value indicates movement to the south or west.)

Pier	Point	Direction	85-88 *	88-89 ‡	89-90 ‡	90-91 ‡	91-92	92-93	93-94	94-95	95-5/96	95-8/96	8/96-97	97-1/98	1/98-4/98	4/98-7/98	7/98-10/98	10/98-12/98	10/98-1/99	1/99-3/99	3/99-4/99	1/99-4/99	4/99-7/99	7/99-10/99	10/99-10/00	10/00-10/01	10/01-10/02	10/02-10/03	10/03-10/04	10/04-10/05	10/05-10/06	10/06-10/07	10/07-10/08	¤ Net Change
WEP North	50	N	-0.05	0.03	-0.00	0.03	0.06	-0.00	0.00	0.00	0.02	0.00	0.01	-0.02	-0.01	0.02	-0.01	-0.02	0.04	NA	NA	0.03	-0.02	-0.03	-0.01	-0.02	0.04	-0.02	-0.01	0.02	-0.02	0.02	0.01	0.14
Pier Seat		E	-0.50	0.01	0.01	-0.00	0.00	0.03	-0.00	-0.02	0.07	-0.00	0.02	0.06	0.02	0.05	0.02	-0.01	-0.00	NA	NA	-0.02	0.00	0.03	-0.01	0.01	0.03	-0.03	0.02	0.03	0.02	0.02	-0.00	0.34
WEP South	60	N	-0.05	0.01	0.01	0.01	0.09	0.02	-0.00	-0.02	0.02	0.03	-0.04	0.03	-0.00	-0.01	0.01	NA	0.04	NA	NA	-0.01	-0.03	-0.01	-0.01	0.00	0.00	-0.00	0.00	-0.00	0.02	-0.02	-0.04	0.06
Pier Seat		E	-0.50	0.02	0.00	-0.02	-0.02	0.03	0.01	-0.02	0.03	-0.02	0.02	0.01	0.01	0.03	0.02	NA	0.03	NA	NA	-0.04	0.02	0.02	-0.00	0.02	0.02	-0.07	0.02	0.04	0.01	0.02	-0.01	0.16
Pier 1 North	30	N	-0.02	-0.02	0.03	-0.04	0.07	0.04	-0.03	-0.03	0.00	0.04	-0.01	0.00	-0.01	0.00	0.01	-0.01	0.00	NA	NA	-0.01	0.02	-0.06	0.01	0.01	-0.02	0.01	0.04	-0.02	0.01	0.01	-0.04	0.02
Pier Seat		E	-0.37	0.01	0.00	0.01	0.03	-0.02	0.00	0.01	0.04	-0.01	0.01	0.01	0.01	0.02	0.07	0.07	0.00	NA	NA	0.01	-0.02	0.11	0.01	0.02	-0.02	-0.01	0.08	-0.00	-0.01	-0.01	0.03	0.44
Pier 1 South	40	N	-0.01	0.01	0.04	-0.08	0.08	0.04	-0.02	-0.03	0.02	0.02	-0.02	0.01	-0.01	-0.01	0.04	-0.02	0.01	NA	NA	0.01	-0.01	0.04	-0.00	0.02	0.03	-0.02	0.03	-0.01	0.01	-0.01	-0.01	0.15
Pier Seat		E	-0.33	-0.00	0.01	-0.06	0.06	0.02	-0.04	-0.01	0.03	-0.02	0.04	-0.02	0.02	0.01	0.06	0.03	0.03	NA	NA	-0.02	-0.03	0.18	0.10	0.04	-0.04	0.02	0.04	0.02	-0.01	0.00	0.03	0.50
Pier 2 North	10	N	-0.06	0.02	0.02	-0.14	0.02	-0.01	0.02	-0.07	-0.00	0.00	0.01	-0.05	0.03	NA	§	-0.02	0.00	NA	NA	0.01	-0.02	-0.01	-0.01	0.02	-0.02	0.03	0.01	-0.02	0.03	0.01	-0.04	-0.04
Pier Seat		E	-0.47	-0.00	-0.01	-0.05	0.03	0.02	-0.02	0.03	-0.01	-0.01	0.03	-0.04	0.04	NA	§	-0.01	0.00	NA	NA	-0.00	0.02	-0.03	0.00	-0.01	-0.03	0.01	0.04	0.00	-0.02	-0.01	0.03	-0.01
Pier 2 South	20	N	-0.09	0.01	0.00	-0.13	0.03	-0.00	0.03	-0.10	0.01	0.01	-0.00	-0.02	0.03	NA	§	0.01	0.00	NA	NA	-0.00	-0.03	0.01	-0.02	-0.01	0.04	-0.01	0.00	0.01	0.00	0.00	-0.00	0.01
Pier Seat		E	-0.50	0.01	-0.01	-0.05	0.02	0.01	-0.02	0.01	0.01	-0.01	0.03	-0.05	0.04	NA	§	-0.03	0.00	NA	NA	0.00	0.01	-0.02	-0.02	0.03	-0.06	0.02	0.04	0.00	-0.02	0.00	0.02	-0.03
Anchor Structure	502	N												¥	-0.00	0.03	-0.01	NA	0.02	-0.05	0.01	0.02	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
North		E												¥	0.05	0.01	0.05	NA	0.07	0.01	0.01	-0.04	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure	501	N												¥	-0.04	0.05	-0.00	NA	0.05	-0.03	0.02	0.02	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Center		E												¥	0.03	0.08	0.00	NA	0.07	-0.00	0.01	-0.06	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Anchor Structure	500	N												¥	-0.05	0.06	-0.01	NA	0.03	-0.02	-0.00	0.01	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
South		E												¥	0.03	0.05	-0.00	NA	0.06	0.03	0.01	-0.07	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥	¥¥
Drilled Shaft Cap	700	N																		£	0.01	0.03	-0.01	-0.03	0.03	0.00	0.00	0.01	0.02	0.00	-0.00	0.01	-0.01	0.06
North		E																		£	-0.00	-0.03	-0.01	0.03	0.00	0.01	0.03	-0.02	0.00	0.01	0.00	0.01	0.00	0.04
Drilled Shaft Cap	701	N																		£	-0.00	0.02	0.00	-0.04	0.03	-0.00	0.02	-0.00	0.01	0.01	-0.01	0.02	-0.01	0.05
Center		E																		£	0.01	-0.04	-0.00	0.02	-0.00	0.02	0.02	-0.00	-0.01	0.03	-0.01	0.01	0.02	0.07
Drilled Shaft Cap	702	N																		£	0.01	0.01	0.01	-0.02	0.02	0.01	0.01	0.00	0.01	0.00	0.00	0.01	-0.01	0.05
South		E																		£	0.01	-0.04	0.00	0.03	0.01	0.03	0.02	-0.00	0.03	0.00	0.00	0.01	0.02	0.12

* Monumentation damaged by earth moving operations.
‡ Monuments appear to have been displaced 6" along the bridge.
¥ First measurements taken 2/26/98
§ First measurements taken 10/15/98
¤ Net change is initial reading compared to the last compatible reading
£ First measurements taken 3/08/99
¥¥ No future shots will be taken due to anchor structure being buried

PIER SIDE COORDINATES

(Reference Point Locations on Sides of Piers)

Pier	Direction	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 5/96	REL 8/96	REL 1997	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06	REL 10/07	REL 10/08
WEP North (Inside)	N	5162.58	5162.67	5162.69	5161.99	5162.66	-------	5161.00	5160.98	5160.96	5160.92	5160.94	5160.96	5160.89	5160.93	5160.93	5160.90	5160.89	5160.89	5160.88	5160.86	5160.89	5160.90	5160.90	5160.90	5160.91	5160.89
	E	4879.46	4879.32	4879.17	4878.94	4879.23	-------	4884.16	4884.18	4884.26	4884.27	4884.27	4884.22	4884.30	4884.32	4884.29	4884.29	4884.29	4884.30	4884.33	4884.34	4884.29	4884.34	4884.34	4884.35	4884.38	4884.37
WEP North (Outside)	N	-------	-------	5184.24	NA	5184.22	-------	5184.04	5184.03	5183.97	5183.98	5183.99	5183.94	5183.99	5184.01	5184.06	5184.06	5184.06	5184.04	5184.04	5184.03	5184.04	5184.03	5183.98	5184.03	5184.03	5183.98
	E	-------	-------	4887.48	NA	4887.51	-------	4888.05	4888.09	4888.14	4888.16	4888.19	4888.24	4888.20	4888.19	4888.21	4888.23	4888.23	4888.25	4888.25	4888.28	4888.28	4888.26	4888.26	4888.28	4888.29	4888.29
WEP South (Inside)	N	5088.80	5088.86	5088.87	5088.86	5088.85	-------	5076.56	5076.51	5076.53	5076.52	5076.50	5076.49	5076.53	5076.53	5076.49	5076.53	5076.51	5076.45	5076.42	5076.46	5076.45	5076.46	5076.43	5076.46	5076.46	5076.44
	E	4854.36	4854.51	4854.43	4854.46	4854.43	-------	4857.97	4857.97	4857.98	4858.01	4858.02	4858.10	4858.02	4858.05	4858.00	4858.02	4858.03	4858.01	4858.02	4858.04	4858.03	4858.04	4858.05	4858.07	4858.08	4858.08
WEP South (Outside)	N	-------	-------	5051.47	5051.45	5051.45	-------	5051.41	5051.37	5051.40	5051.38	5051.34	5051.40	NA	5051.37	5051.35	5051.34	5051.33	5051.32	5051.30	5051.33	5051.34	5051.33	5051.34	5051.34	5051.36	5051.33
	E	-------	-------	4840.79	4840.84	4840.80	-------	4841.07	4841.08	4841.07	4841.08	4841.07	4841.04	NA	4841.10	4841.08	4841.08	4841.08	4841.08	4841.08	4841.12	4841.07	4841.09	4841.09	4841.11	4841.13	4841.12
Pier 1 North (Inside)	N	-------	-------	5087.19	5087.15	5087.09	-------	5086.18	5086.17	5086.17	5086.14	5086.14	5086.16	§	§	5086.13	5086.09	5086.06	5086.08	5086.06	5086.06	5086.05	5086.07	5086.10	5086.08	5086.09	5086.09
	E	-------	-------	5093.22	5093.16	5093.17	-------	5095.93	5095.94	5095.94	5096.01	5096.03	5096.01	§	§	5096.16	5096.15	5096.17	5096.16	5096.21	5096.20	5096.19	5096.23	5096.23	5096.22	5096.26	5096.25
Pier 1 North (Outside	N	-------	-------	5100.04	NA	5100.11	5100.12	5100.13	5100.13	5100.12	5100.13	5100.12	5100.06	5100.08	5100.09	5100.12	5100.06	5100.03	5100.09	5100.04	5099.98	5100.01	5099.99	5099.99	5099.99	5100.00	5099.97
	E	-------	-------	5098.27	NA	5098.01	5098.03	5098.06	5098.08	5098.08	5098.11	5098.15	5098.22	5098.24	5098.24	5098.24	5098.25	5098.27	5098.30	5098.29	5098.31	5098.32	5098.31	5098.32	5098.33	5098.34	5098.33
Pier 1 South (Inside)	N	5014.59	5014.57	5014.66	5014.61	5014.55	5014.59	5014.60	5014.61	5014.62	5014.61	5014.61	5014.56	§	§	5014.59	5014.53	5014.53	5014.54	5014.52	5014.53	5014.55	5014.55	5014.53	5014.56	5014.52	5014.52
	E	5068.67	5068.93	5068.70	5068.68	5068.65	5068.68	5068.68	5068.70	5068.67	5068.70	5068.74	5068.78	§	§	5068.84	5068.87	5068.96	5068.94	5068.99	5069.04	5069.04	5069.01	5069.03	5069.02	5069.05	5069.05
Pier 1 South (Outside	N	-------	-------	5001.94	5001.90	5001.87	5001.89	5001.90	5001.87	5001.90	5001.86	5001.86	5001.91	5001.83	5001.84	5001.84	5001.83	5001.80	5001.82	5001.81	5001.81	5001.80	5001.81	5001.83	5001.86	5001.85	5001.83
	E	-------	-------	5063.39	5063.42	5063.34	5063.39	5063.41	5063.42	5063.38	5063.43	5063.46	5063.42	5063.56	5063.58	5063.56	5063.61	5063.69	5063.69	5063.70	5063.74	5063.74	5063.76	5063.75	5063.78	5063.78	5063.79
Pier 2 North (Inside)	N	4954.01	4953.99	4953.99	4953.97	4953.95	4953.95	4953.97	NA	4953.95	4953.95	¥	4953.96	4953.96	4953.93	4953.93	4953.92	4953.94	4953.96	4953.94	4953.94	4953.95	4953.96	4953.97	4953.98	4953.98	4953.97
	E	5469.91	5470.01	5470.04	5469.99	5470.02	5470.03	5470.00	NA	5470.03	5470.03	¥	5469.96	5469.97	5470.05	5470.01	5470.01	5469.99	5469.99	5470.02	5470.00	5469.97	5469.97	5469.98	5469.97	5469.99	5469.99
Pier 2 South (Inside)	N	4883.44	4883.44	4883.44	4883.46	4883.38	4883.39	4883.40	NA	4883.31	4883.37	‡	4883.33	4883.40	4883.35	4883.42	4883.44	4883.40	4883.37	4883.34	4883.37	4883.36	4883.35	4883.39	4883.38	4883.38	4883.38
	E	5445.32	5445.45	5445.46	5445.41	5445.40	5445.40	5445.36	NA	5445.37	5445.39	‡	5445.45	5445.40	5445.50	5445.35	5445.37	5445.38	5445.41	5445.42	5445.40	5445.39	5445.41	5445.41	5445.40	5445.40	5445.41

------- No reading taken (point not yet set).

NA Information not available.

¥ Points destroyed during construction. New points set

‡ Unable to shoot points due to rock piles next to piers

§ Shots were not taken due to heat tent for rock anchor placement procedure.

PIER TILT

(The difference between the coordinates of the points set on the pier seat and the points at the ground line using the first year measured as the zero point. A positive value indicates top tilt to the north or east. A negative value indicates top tilt to the south or west.)

Pier	Direction	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 8/96	REL 9/97	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06	REL 10/07	REL 10/08
WEP North (Inside)	N	=====	-0.03	-0.05	0.66	-0.01	=====	0.03	0.03	0.06	0.06	0.02	0.08	0.07	0.10	0.12	0.10	0.10	0.08	0.14	0.09	0.08	0.09	0.07	0.07	0.11
	E	=====	0.14	0.32	0.55	0.24	=====	-0.00	-0.02	-0.00	0.04	0.11	0.03	0.00	0.01	0.01	0.04	0.02	0.01	0.03	0.05	0.02	0.04	0.05	0.04	0.05
WEP North (Outside	N	=====	-------	=====	NA	0.03	=====	0.02	0.06	0.04	0.05	0.08	0.02	0.03	0.02	-0.00	-0.04	-0.02	-0.04	0.01	-0.02	-0.03	0.04	-0.03	-0.02	0.05
	E	=====	-------	=====	NA	-0.04	=====	-0.02	-0.01	-0.01	0.01	-0.02	0.01	0.02	-0.03	-0.04	-0.01	-0.03	-0.03	-0.03	-0.05	-0.02	0.02	0.01	0.02	0.02
WEP South (Inside)	N	=====	0.02	0.03	0.04	0.03	=====	0.01	0.02	0.02	0.03	0.05	-0.03	0.01	0.04	-0.02	-0.00	0.03	0.07	0.04	0.04	0.04	0.07	0.06	0.04	0.02
	E	=====	-0.16	-0.05	-0.08	-0.06	=====	0.02	0.02	0.00	0.02	-0.05	0.02	0.02	0.03	0.02	0.03	0.04	0.05	0.06	-0.01	0.01	0.04	0.04	0.04	0.04
WEP South (Outside	N	=====	-------	=====	0.01	-0.01	=====	-0.01	-0.01	0.02	0.03	-0.01	NA	0.02	0.03	0.02	0.02	0.02	0.04	0.01	0.01	0.01	0.01	0.02	-0.02	-0.02
	E	=====	-------	=====	-0.05	-0.02	=====	0.01	0.03	0.04	0.07	0.12	NA	0.07	0.05	0.07	0.09	0.08	0.10	0.08	0.06	0.06	0.10	0.10	0.10	0.10
Pier 1 North (Inside)	N	=====	-------	=====	0.01	0.03	=====	-0.00	0.00	0.02	0.03	0.02	NA	NA	0.04	0.09	0.06	0.06	0.09	0.07	0.09	0.11	0.05	0.08	0.09	0.05
	E	=====	-------	=====	0.06	0.06	=====	0.01	0.02	-0.04	-0.04	0.04	NA	NA	-0.03	-0.05	0.05	0.06	0.03	0.02	0.01	0.06	0.05	0.05	0.01	0.04
Pier 1 North (Outside	N	=====	-------	=====	NA	-0.14	-0.11	-0.13	-0.12	-0.13	-0.13	-0.05	-0.08	-0.09	-0.13	-0.05	-0.08	-0.12	-0.06	-0.02	-0.04	0.02	-0.00	0.01	0.01	0.00
	E	=====	-------	=====	NA	0.27	0.26	0.25	0.26	0.24	0.22	0.21	0.26	0.26	0.27	0.24	0.33	0.30	0.33	0.30	0.27	0.35	0.35	0.33	0.31	0.35
Pier 1 South (Inside)	N	=====	0.10	0.05	0.07	0.11	0.09	0.06	0.06	0.07	0.05	0.15	NA	NA	0.12	0.16	0.20	0.18	0.22	0.24	0.21	0.23	0.24	0.23	0.26	0.24
	E	=====	-0.20	0.05	0.03	0.05	0.04	0.05	0.07	0.06	0.02	0.05	NA	NA	0.03	-0.03	0.05	0.17	0.17	0.08	0.09	0.16	0.16	0.16	0.14	0.16
Pier 1 South (Outsid	N	=====	-------	=====	0.01	0.02	0.02	0.04	0.02	0.05	0.04	0.02	0.09	0.09	0.10	0.09	0.16	0.14	0.17	0.20	0.19	0.21	0.19	0.16	0.17	0.18
	E	=====	-------	=====	-0.07	-0.01	-0.06	-0.03	-0.01	-0.04	-0.06	0.04	-0.07	-0.06	-0.06	-0.13	-0.04	0.06	0.10	0.01	0.03	0.05	0.08	0.04	0.04	0.06
Pier 2 North (Inside)	N	=====	0.04	0.03	0.07	0.03	0.01	NA	-0.01	0.03	NA	=====	0.03	0.06	0.06	0.06	0.03	0.00	0.04	0.02	0.04	0.04	0.01	0.02	0.03	0.01
	E	=====	-0.07	-0.08	-0.05	-0.04	-0.04	NA	-0.09	-0.05	NA	=====	-0.03	-0.12	-0.08	-0.06	-0.07	-0.07	-0.10	-0.12	-0.08	-0.04	-0.04	-0.05	-0.08	-0.05
Pier 2 South (Inside)	N	=====	0.03	0.03	0.04	0.03	0.02	NA	0.10	0.07	NA	=====	-0.00	0.04	-0.03	-0.08	-0.03	-0.02	0.01	0.02	0.01	0.02	0.00	0.02	0.01	0.01
	E	=====	-0.11	-0.11	-0.08	-0.07	-0.03	NA	-0.05	-0.03	NA	=====	-0.04	-0.14	0.02	0.00	-0.02	-0.08	-0.06	-0.11	-0.07	-0.06	-0.06	-0.07	-0.07	-0.05

-------	No reading taken. (Point not set.)
=====	First reading (Point set/reset)
NA	Information Not Available

CHANGE IN PIER TILTS

(The change in tilts are difference between the coordinates and elevations of the points set on the pier seat and side of the pier. The first angle of compatible data is set to zero and compared to the preceding years A positive value indicates top tilt to the north or east. A negative value indicates top tilt to the south or west.)

Pier	Direction	REL 1991	REL 1992	REL 1993	REL 1994	REL 1995	REL 8/96	REL 9/97	REL 1/98	REL 4/98	REL 7/98	REL 10/98	REL 12/98	REL 1/99	REL 4/99	REL 7/99	REL 10/99	REL 10/00	REL 10/01	REL 10/02	REL 10/03	REL 10/04	REL 10/05	REL 10/06	REL 10/07	REL 10/08
WEP North (Inside)	N	NA	NA	NA	NA	NA	0.00 °	0.01 °	0.00 °	0.01 °	0.01 °	0.00 °	0.01 °	0.01 °	0.02 °	0.02 °	0.02 °	0.02 °	0.01 °	0.02 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.02 °
	E	NA	NA	NA	NA	NA	0.00 °	-0.00 °	-0.00 °	-0.00 °	0.01 °	0.02 °	0.00 °	0.00 °	0.00 °	0.00 °	0.01 °	0.00 °	0.00 °	0.00 °	0.01 °	0.00 °	0.01 °	0.01 °	0.01 °	0.01 °
WEP North (Outside	N	NA	NA	NA	NA	NA	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	0.01 °	0.00 °	0.00 °	0.00 °	-0.00 °	-0.00 °	-0.00 °	-0.00 °	0.00 °	-0.00 °	-0.00 °	0.00 °	-0.00 °	-0.00 °	0.00 °
	E	NA	NA	NA	NA	NA	0.00 °	-0.00 °	-0.00 °	-0.00 °	0.00 °	-0.00 °	0.00 °	0.00 °	-0.00 °	-0.01 °	-0.00 °	-0.00 °	-0.00 °	-0.00 °	-0.01 °	-0.00 °	0.00 °	0.00 °	0.00 °	0.00 °
WEP South (Inside)	N	NA	NA	NA	NA	NA	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	0.01 °	-0.00 °	0.00 °	0.01 °	-0.00 °	-0.00 °	0.00 °	0.01 °	0.00 °	0.00 °	0.00 °	0.01 °	0.01 °	0.00 °	0.00 °
	E	NA	NA	NA	NA	NA	0.00 °	0.01 °	0.01 °	0.00 °	0.01 °	-0.03 °	0.01 °	0.01 °	0.02 °	0.01 °	0.02 °	0.03 °	0.03 °	0.03 °	-0.00 °	0.00 °	0.02 °	0.02 °	0.02 °	0.02 °
WEP South (Outside	N	NA	NA	NA	NA	NA	0.00 °	-0.01 °	-0.01 °	0.02 °	0.05 °	-0.02 °	NA	0.03 °	0.05 °	0.03 °	0.03 °	0.02 °	0.05 °	0.02 °	0.01 °	0.02 °	0.01 °	0.04 °	-0.03 °	-0.03 °
	E	NA	NA	NA	NA	NA	0.00 °	0.06 °	0.16 °	0.19 °	0.37 °	0.62 °	NA	0.36 °	0.26 °	0.36 °	0.45 °	0.41 °	0.52 °	0.42 °	0.32 °	0.29 °	0.52 °	0.50 °	0.52 °	0.51 °
Pier 1 North (Inside)	N	NA	NA	NA	0.00 °	0.01 °	0.63 °	0.63 °	0.63 °	0.64 °	0.65 °	0.64 °	NA	NA	0.65 °	0.69 °	0.67 °	0.67 °	0.68 °	0.68 °	0.68 °	0.70 °	0.66 °	0.68 °	0.69 °	0.66 °
	E	NA	NA	NA	NA	NA	0.00 °	0.00 °	0.01 °	-0.02 °	-0.02 °	0.03 °	NA	NA	-0.02 °	-0.03 °	0.03 °	0.03 °	0.02 °	0.01 °	0.01 °	0.03 °	0.03 °	0.03 °	0.00 °	0.03 °
Pier 1 North (Outside	N	NA	NA	NA	NA	0.00 °	0.03 °	0.01 °	0.02 °	0.00 °	0.01 °	0.11 °	0.06 °	0.05 °	0.01 °	0.10 °	0.06 °	0.02 °	0.09 °	0.14 °	0.11 °	0.18 °	0.16 °	0.16 °	0.17 °	0.16 °
	E	NA	NA	NA	NA	0.00 °	-0.01 °	-0.01 °	-0.00 °	-0.02 °	-0.03 °	-0.03 °	-0.01 °	-0.00 °	0.00 °	-0.02 °	0.03 °	0.02 °	0.03 °	0.01 °	-0.00 °	0.04 °	0.04 °	0.03 °	0.02 °	0.04 °
Pier 1 South (Inside)	N	0.00 °	0.14 °	0.07 °	0.11 °	0.15 °	0.13 °	0.08 °	0.09 °	0.09 °	0.07 °	0.21 °	NA	NA	0.17 °	0.23 °	0.29 °	0.26 °	0.31 °	0.35 °	0.29 °	0.33 °	0.35 °	0.33 °	0.37 °	0.35 °
	E	0.00 °	-0.38 °	0.10 °	0.07 °	0.10 °	0.08 °	0.10 °	0.13 °	0.12 °	0.05 °	0.09 °	NA	NA	0.05 °	-0.06 °	0.10 °	0.33 °	0.32 °	0.15 °	0.18 °	0.31 °	0.32 °	0.31 °	0.27 °	0.31 °
Pier 1 South (Outsid	N	NA	NA	NA	0.00 °	0.01 °	0.01 °	0.02 °	0.00 °	0.03 °	0.02 °	0.01 °	0.06 °	0.06 °	0.07 °	0.06 °	0.11 °	0.10 °	0.12 °	0.14 °	0.13 °	0.15 °	0.13 °	0.11 °	0.12 °	0.12 °
	E	NA	NA	NA	0.00 °	0.16 °	0.03 °	0.11 °	0.16 °	0.08 °	0.03 °	0.29 °	0.01 °	0.04 °	0.03 °	-0.15 °	0.08 °	0.33 °	0.42 °	0.21 °	0.26 °	0.30 °	0.37 °	0.28 °	0.28 °	0.34 °
Pier 2 North (Inside)	N	0.00 °	0.00 °	0.00 °	0.01 °	0.00 °	0.00 °	NA	-0.00 °	0.00 °	NA	0.00 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °	0.01 °
	E	0.00 °	-0.08 °	-0.09 °	-0.05 °	-0.05 °	-0.05 °	NA	-0.10 °	-0.06 °	NA	0.00 °	-0.04 °	-0.15 °	-0.10 °	-0.08 °	-0.09 °	-0.09 °	-0.13 °	-0.15 °	-0.10 °	-0.05 °	-0.06 °	-0.07 °	-0.10 °	-0.07 °
Pier 2 South (Inside)	N	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	NA	0.01 °	0.01 °	NA	0.00 °	-0.00 °	0.00 °	-0.00 °	-0.01 °	-0.00 °	-0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °	0.00 °
	E	0.00 °	-0.14 °	-0.14 °	-0.10 °	-0.09 °	-0.03 °	NA	-0.06 °	-0.04 °	NA	0.00 °	-0.07 °	-0.20 °	0.00 °	-0.02 °	-0.05 °	-0.13 °	-0.10 °	-0.16 °	-0.12 °	-0.10 °	-0.10 °	-0.11 °	-0.11 °	-0.09 °

0.00 °	First reading (Tilt set/reset)
NA	Information Not Available

ARTHUR HUCKELBRIDGE, D.ENG., P.E.

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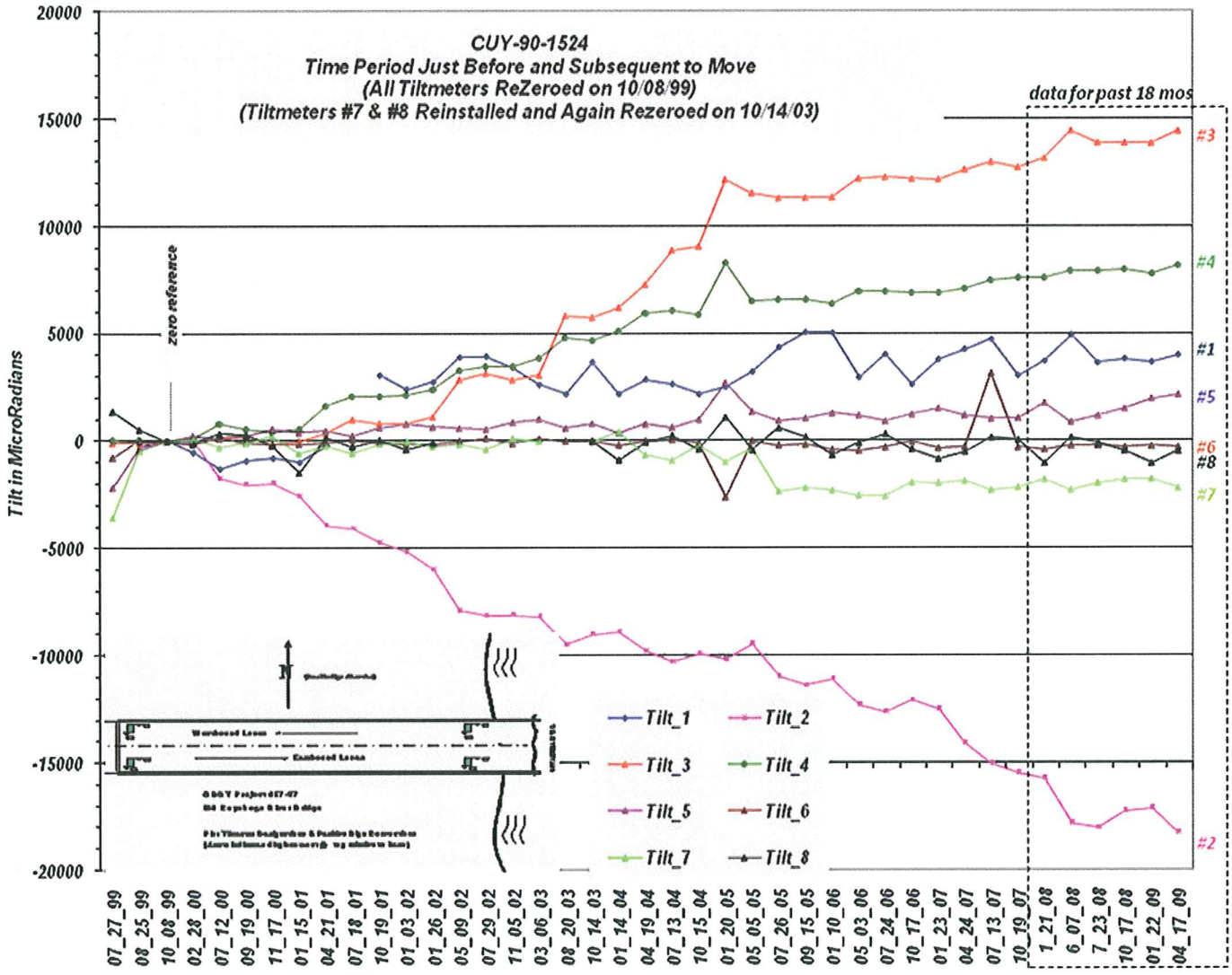
April 24, 2009

Mr. Dean Palmer, P.E.
Richland Engineering Limited
29 N. Park St.
Mansfield, OH 44902-1769

RE: CUY-90-15.24
tiltmeter data over the past year

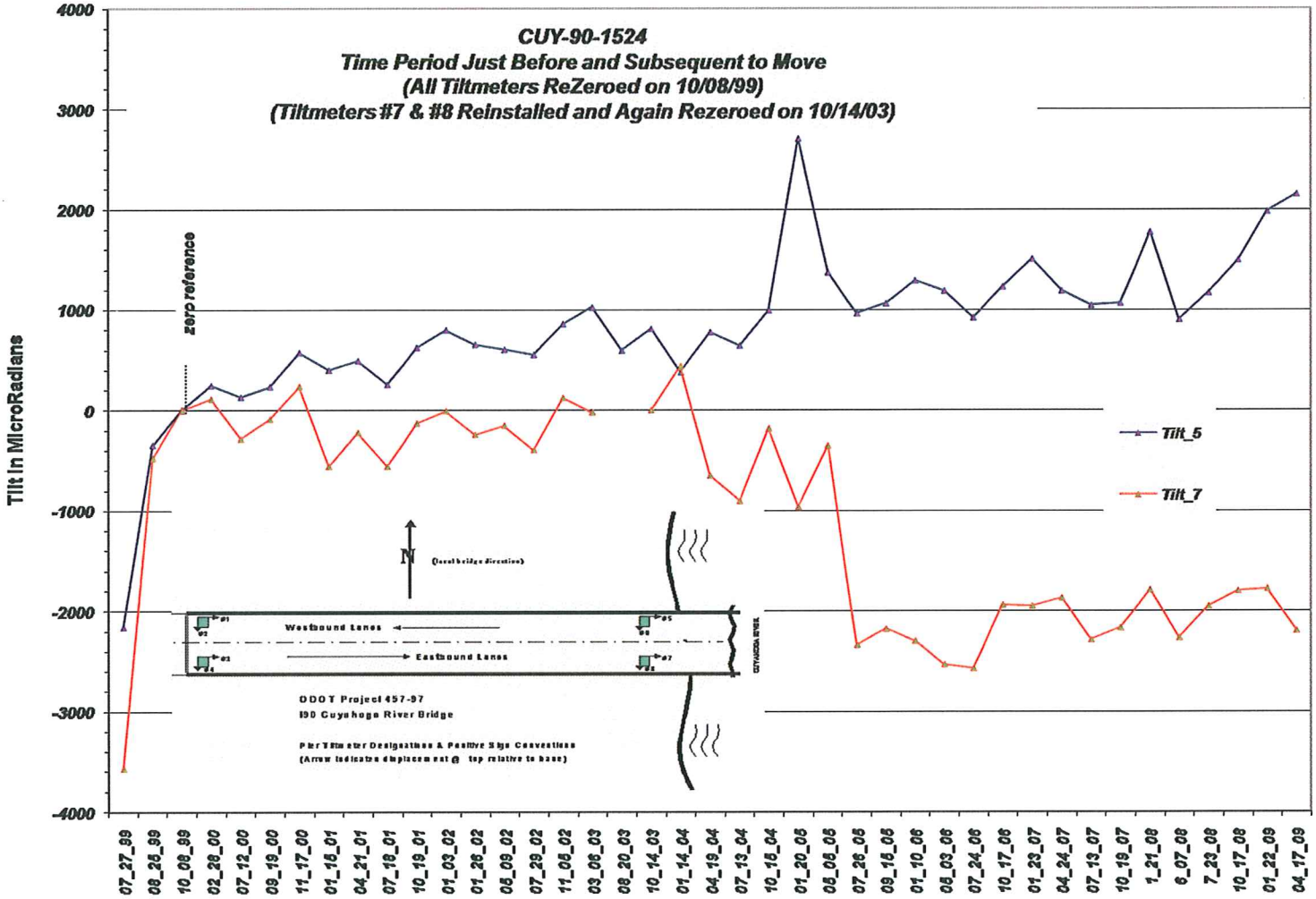
Dear Mr. Palmer:

The past year has not seen any major shift in tiltmeter readings, as shown in the chart below, with data over the past 18 months emphasized by the dashed box.



Only tiltmeter #2, on the NW abutment structure, shows a significant and continuing drift in the local northerly direction. It is probable that at least some of the tiltmeter #2 drift is electrical in nature, as the total tilt difference for that instrument, since the 1999 span 1 relocation, is now up to .018 radian. Such a large tilt should be discernible in other monitored displacements, which is apparently not the case.

The plot below shows isolated data from tiltmeters #5 and #7, monitoring the east-west tilt of the two pier 1 structures. These instruments sould be the most sensitive indicators, if the pier 1 structures were being heavily loaded due to the closed, or nearly closed, expansion joint at the east end of span 1. These instruments have been reasonably stable for nearly 4 years at this point.



Feel free to cantact me should you have questions or need further information.

Regards,

Arthur A. Huckelbridge, Jr., D.Eng., P.E.

LONG TERM MONITORING AT CUY-90-15.24 BRIDGE PROJECT

Annual Report for Year 2008-2009

Robert Y. Liang

May 2009

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I. Introduction

This is an Annual Report on the monitoring results of the stabilization structures at the CUY-90-15.24 west end slope for the period between 5/14/2008 and 4/24//2009. The strain gages and slope inclinometers (SI) previously installed in the stabilization structures between 1997 and 1999 have been monitored continuously. Since the beginning of the monitoring, quarterly reports and annual reports have been submitted to document the monitoring results. For the purpose of completeness and for a better perspective, the presentation of the monitored and deduced data in this report covers the period from the beginning of monitoring to the last reading taken in April 2009. However, the plots of the inclinometer readings were reduced to only cover the readings over the last year.

The plane view of the general layout of the stabilization structures is shown in Fig. 1. A total of five tie-beams (#1, #12, #13, #14, and #26) were instrumented with strain gages at both ends of the beams, as shown in Fig. 2. The gage numbering system is indicated in Fig. 2 as well. A total of five driven piles (#1, #17, #18, #19, and #34) were each instrumented with four strain gages near the top of the pile, as shown in Fig. 3. Rock anchors #1, #8, #9, and #17 were each instrumented with a load cell at the anchor head. Finally, drilled shafts #1 and #9 were instrumented with sister-bar type of strain gages. The locations of these strain gages along the length of the drilled shafts and the gage designation numbers are presented in Fig. 4 and Fig. 5 for shaft #1 and shaft #9, respectively. Furthermore, drilled shafts #1, #3, #8, #9, #10, and #17, shown in Fig. 6, were each embedded with slope inclinometer casings for monitoring shafts deflections.

II. Monitoring Results

II.1 Rock Anchors:

The recorded numerical values of load cells at the anchor heads are summarized in Table 1. Also, the load versus time plot for each anchor is shown in Fig. 7. The measured anchor head loads decreased continuously. However, the rate of decrease was very small.

II.2 Tie-Beams:

The strain readings from the gages in the tie-beams have been converted into axial forces and bending moments at the locations near the driven pile cap side and near the drilled shaft cap side, and they are summarized in Table 2 and Table 3, respectively. The plots of the axial force versus time for the five monitored tie-beams are presented in Fig. 8 and Fig. 9 for the drilled shaft cap side and the driven pile cap side, respectively. The average axial forces of all five monitored tie-beams on the pile cap side and the drilled shaft cap side are plotted in Fig. 10. The axial forces appeared to remain at the same level as those measured during last year, but with some oscillations.

The major bending moments for each of the five monitored tie-beams are shown in Fig. 11 and Fig. 12 for the pile cap side and drilled shaft cap side, respectively. The average bending moments for all five monitored tie-beams for the drilled shaft side and the pile cap side are shown in Fig. 13. These average bending moments on the two ends of the tie-beams appeared to remain at the same level as those measured during last year.

II.3 Driven Piles:

The strain readings from the strain gages on the driven piles have been converted into the bending moments and axial forces for each of the five monitored driven piles and are summarized in Table 4. The axial forces versus time and the major bending moments versus time are plotted in Fig. 14 and Fig. 15, respectively. Within the past year, the change of these readings on driven piles was very small.

II.4 Drilled Shafts:

The bending moments in the drilled shaft #9 at different elevations are shown in Fig. 16. The largest moment was recorded at the depth of 95 ft below the cap top. Over the past year, there was continued increase in the bending moment at that location. However, the rate of change was very small. The bending moments in the drilled shaft #1 at different elevations are shown in Fig. 17. Please note that the bending moments shown in Fig. 17 are smaller than those shown in Fig. 16, due to the fact that the moments measured in shaft #9 (Fig. 16) are in the major bending direction, while the moments measured in shaft #1 are not in the major bending direction.

The distribution of bending moments along the depth of the drilled shafts is depicted in Fig. 18 and Fig. 19 for shaft #9 and shaft #1, respectively. Again, keep in mind that the moment direction in shaft #1 and shaft #9 is different, as noted previously in Fig. 6.

II.5 Slope Inclinometer reading:

Four separate inclinometer readings were taken over the last year for all six slope inclinometer casings embedded in the drilled shafts. The incremental and cumulative deflection plots in the A-direction (toward river direction) are presented in Figs. 20 to 25. For visual clarity, the number of curves shown in the plots was reduced to cover just the last year. There was no significant drilled shaft movement observed during this monitoring period.

III. Concluding Remark

Based on examinations of the monitored data collected over the last year, the stabilization structures in the slope seemed to experience fairly small changes. There was no observed sudden big jump in the monitoring data. However, with impending scheduled rehabilitation work on the bridge, it is recommended that continuing monitoring of these slope stabilization structures, the ground movements, and the behavior of the superstructures be carried out as originally planned.

Table 1 Numerical reading of anchor load as a function of time for anchors #1, #8, #9 and #17

Date	Anchor # 1 Load, kips	Anchor # 8 Load, kips	Anchor # 9 Load, kips	Anchor # 17 Load, kips	Comment
4/7/1999		560			
4/8/1999	489			499	Anchor Lock off
4/14/1999	460	473	596 (Lock off)	461	
5/7/1999	452	473	572	445	End of construction
7/1/1999	446	468	564	439	
10/1/1999	441	467	560	440	
1/1/2000	439	461	555	424	
4/1/2000	432	453	546	414	
7/1/2000	431	451	521	415	
10/1/2000	431	451	519	416	
1/1/2001	430	455	517	400	
4/1/2001	421	443	513	397	
7/1/2001	422	443	510	399	
10/1/2001	425	445	512	403	
1/1/2002	424	444	511	398	
4/1/2002	421	440	508	386	
7/1/2002	419	439	506	391	
10/1/2002	423	442	508	396	
1/1/2003	423	435	508	389	
4/15/2003	416	427	501	380	
8/7/2003	416	428	503	384	
10/7/2003	418	429	504	387	
12/31/2003	417	426	503	378	
4/13/2004	408	418	494	370	
7/13/2004	409	419	494	374	
10/8/2004	411	422	496	377	
1/7/2005	411	421	495	374	
4/8/2005	407	414	485	366	
7/18/2005	407	415	485	370	
11/12/2005	410	419	489	374	
1/10/2006	409	417	487	369	
4/9/2006	399	411	487	365	
7/19/2006	399	412	487	368	
10/18/2006	407.3	414.8	489.6	371.7	
1/18/2007	405	412	487	366	
4/19/2007	401	406	501	361	
7/9/2007	401	408	502	365	
10/20/2007	404	411	506	369	
1/7/2008	403	410	504	364	
5/13/2008	397	403	497	359	
7/29/2008	398	403	500	363	
10/30/2008	401	407	502	366	
1/12/2009	401	407	502	363	
4/24/2009	393	400	494	357	

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
1	7/1/1999	-47.1	68.5	551.7	681.8	313.73	10.70	616.75	252.30	375.15	83.06	-40.28	-2.75
	7/15/1999	-70.1	53.8	538.8	666.8	297.33	-8.15	602.80	234.35	360.30	78.72	-40.60	-2.82
	8/15/1999	10.7	114.3	613.7	728.1	366.70	62.50	670.90	312.20	421.20	97.09	-40.43	-2.44
	8/31/1999	12.0	114.3	617.3	732.8	369.10	63.15	675.05	314.65	423.55	97.73	-40.67	-2.44
	9/15/1999	13.1	113.5	619.7	737.5	370.95	63.30	678.60	316.40	425.50	98.22	-40.89	-2.44
	9/30/1999	29.6	122.3	634.4	753.4	384.93	75.95	693.90	332.00	437.85	101.92	-41.07	-2.37
	10/15/1999	34.7	123.9	637.8	757.9	388.58	79.30	697.85	336.25	440.90	102.88	-41.11	-2.34
	10/31/1999	39.8	127.2	646.6	762	393.90	83.50	704.30	343.20	444.60	104.29	-41.26	-2.27
	11/15/1999	62.3	139.3	662.9	780.1	411.15	100.80	721.50	362.60	459.70	108.86	-41.25	-2.18
	11/30/1999	73.7	146.3	670.6	788.6	419.80	110.00	729.60	372.15	467.45	111.15	-41.18	-2.13
	12/15/1999	72.8	143.6	668.9	789.7	418.75	108.20	729.30	370.85	466.65	110.87	-41.28	-2.15
	12/31/1999	88.8	152.1	680.1	802.5	430.88	120.45	741.30	384.45	477.30	114.08	-41.26	-2.08
	3/31/2000	95.3	158.7	682.5	825.2	440.43	127.00	753.85	388.90	491.95	116.61	-41.66	-2.31
	6/30/2000	60.2	138.2	662.7	804.5	416.40	99.20	733.60	361.45	471.35	110.25	-42.16	-2.46
	9/30/2000	50.1	142.5	668.8	795.7	414.28	96.30	732.25	359.45	469.10	109.69	-42.26	-2.46
	1/13/2001	109.5	179.9	712.3	845.5	461.80	144.70	778.90	410.90	512.70	122.27	-42.15	-2.28
	4/20/2001	126.8	283.2	715.3	881.9	501.80	205.00	798.60	421.05	582.55	132.86	-39.45	-3.62
	7/16/2001	68.3	149.8	674.3	837.1	432.38	109.05	755.70	371.30	493.45	114.48	-42.98	-2.74
	10/9/2001	71.4	157.1	685.5	840.8	438.70	114.25	763.15	378.45	498.95	116.15	-43.12	-2.70
	1/9/2002	102.7	177.8	713	872	466.38	140.25	792.50	407.85	524.90	123.48	-43.35	-2.62
	4/12/2002	125.5	192.8	738.6	904.9	490.45	159.15	821.75	432.05	548.85	129.86	-44.04	-2.62
	7/18/2002	62.3	151.8	706.334	859.6	445.01	107.05	782.97	384.32	505.70	117.82	-44.92	-2.72
	10/8/2002	43.7	151.1	711.3	846.7	438.20	97.40	779.00	377.50	498.90	116.02	-45.30	-2.72
	1/8/2003	84.7	180.5	748.5	891.8	476.38	132.60	820.15	416.60	536.15	126.13	-45.69	-2.68
	4/15/2003	96.1	191.9	739.9	989.3	504.30	144.00	864.60	418.00	590.60	133.52	-47.89	-3.87
	7/1/2003	57.4	168	713	959	474.35	112.70	836.00	385.20	563.50	125.59	-48.07	-3.99
	10/7/2003	42.1	166.8	714	946.6	467.38	104.45	830.30	378.05	556.70	123.75	-48.24	-4.00
	12/31/2003	80	197.9	753.9	985.1	504.23	138.95	869.50	416.95	591.50	133.50	-48.55	-3.91
	4/13/2004	92	208.9	760.4	1006.6	516.98	150.45	883.50	426.20	607.75	136.88	-48.72	-4.07
	7/13/2004	14.6	163.9	707.3	954.4	460.05	89.25	830.85	360.95	559.15	121.81	-49.29	-4.44
	10/8/2004	-8.6	233.4	704.6	941	467.60	112.40	822.80	348.00	587.20	123.81	-47.21	-5.36
	1/7/2005	19.5	190.4	746.5	982.5	484.73	104.95	864.50	383.00	586.45	128.34	-50.48	-4.56
	4/8/2005	3.4	397.6	751.6	1003.4	539.00	200.50	877.50	377.50	700.50	142.71	-44.99	-7.24
	7/18/2005	3.1	164.3	709.7	969.6	461.68	83.70	839.65	356.40	566.95	122.24	-50.24	-4.72
	8/26/2005	3.1	157.5	702.5	956.3	454.85	80.30	829.40	352.80	556.90	120.43	-49.78	-4.57
	10/11/2005	3.1	164.2	712.6	960.1	460.00	83.65	836.35	357.85	562.15	121.79	-50.02	-4.58
	1/10/2006	3.1	191.9	742.5	997	483.63	97.50	869.75	372.80	594.45	128.05	-51.32	-4.97
	4/9/2006	3.5	205.3	750.7	1018.8	494.58	104.40	884.75	377.10	612.05	130.95	-51.86	-5.26
	7/19/2006	3.5	166.6	703.7	975.5	462.33	85.05	839.60	353.60	571.05	122.41	-50.15	-4.87
	10/18/2006	3.5	170.2	709	967.5	462.55	86.85	838.25	356.25	568.85	122.47	-49.94	-4.76
	1/18/2007	3.5	209.1	748.7	1013.1	493.60	106.30	880.90	376.10	611.10	130.69	-51.48	-5.26
	4/19/2007	3.5	216.6	743.7	1021.2	496.25	110.05	882.45	373.60	618.90	131.39	-51.33	-5.50
	7/11/2007	3.5	169.6	700.9	981.6	463.90	86.55	841.25	352.20	575.60	122.83	-50.16	-5.00
	10/20/2007	3.5	163.4	696	963.7	456.65	83.45	829.85	349.75	563.55	120.91	-49.60	-4.79
	1/7/2008	3.5	193.1	730.4	1002.9	482.48	98.30	866.65	366.95	598.00	127.74	-51.06	-5.18
	5/13/2008	3.5	202.2	733	1019.1	489.45	102.85	876.05	368.25	610.65	129.59	-51.39	-5.43
	7/29/2008	3.5	171.2	699.7	981.8	464.05	87.35	840.75	351.60	576.50	122.87	-50.07	-5.04
	10/30/2008	3.5	185.2	717.8	985	472.88	94.35	851.40	360.65	585.10	125.20	-50.31	-5.03
	1/12/2009	3.5	213.8	745.7	1020.6	495.90	108.65	883.15	374.60	617.20	131.30	-51.47	-5.43
	4/24/2009	3.5	213.8	745.7	1020.6	495.90	108.65	883.15	374.60	617.20	131.30	-51.47	-5.43

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
12	7/1/1999	374.9	6	549.6	471.8	350.58	190.45	510.70	462.25	238.90	92.82	-21.28	5.00
	7/15/1999	368.6	-3.6	544.2	467.3	344.13	182.50	505.75	456.40	231.85	91.11	-21.48	5.03
	8/15/1999	373.7	0.2	569.4	485.2	357.13	186.95	527.30	471.55	242.70	94.56	-22.62	5.13
	8/31/1999	368.4	-4.7	567	486.2	354.23	181.85	526.60	467.70	240.75	93.79	-22.91	5.08
	9/15/1999	365.9	-9.2	565.3	485.1	351.78	178.35	525.20	465.60	237.95	93.14	-23.05	5.10
	9/30/1999	364.6	-11.7	570.1	487.6	352.65	176.45	528.85	467.35	237.95	93.37	-23.42	5.14
	10/15/1999	361.7	-14.8	569.9	487.4	351.05	173.45	528.65	465.80	236.30	92.95	-23.61	5.14
	10/31/1999	362.8	-13.5	575.6	493.1	354.50	174.65	534.35	469.20	239.80	93.86	-23.91	5.14
	11/15/1999	365.0	-11.5	581.4	498	358.23	176.75	539.70	473.20	243.25	94.85	-24.12	5.15
	11/30/1999	365.6	-11.8	583.7	500.1	359.40	176.90	541.90	474.65	244.15	95.16	-24.26	5.16
	12/15/1999	368.0	-9.2	589.7	504.2	363.18	179.40	546.95	478.85	247.50	96.16	-24.43	5.18
	12/31/1999	369.0	-8	592.9	506.6	365.13	180.50	549.75	480.95	249.30	96.67	-24.54	5.19
	3/31/2000	379.6	7.3	617	524.1	382.00	193.45	570.55	498.30	265.70	101.14	-25.06	5.21
	6/30/2000	376.1	4.4	608.9	519.1	377.13	190.25	564.00	492.50	261.75	99.85	-24.84	5.17
	9/30/2000	360.7	-12.3	588.3	503.5	360.05	174.20	545.90	474.50	245.60	95.33	-24.70	5.13
	1/13/2001	372.1	2.2	618.1	526.1	379.63	187.15	572.10	495.10	264.15	100.51	-25.58	5.17
	4/20/2001	387.6	21	645.8	549.2	400.90	204.30	597.50	516.70	285.10	106.15	-26.13	5.19
	7/16/2001	374.6	6.5	621.5	532.9	383.88	190.55	577.20	498.05	269.70	101.64	-25.70	5.12
	10/9/2001	360.9	-9.4	598.9	515.8	366.55	175.75	557.35	479.90	253.20	97.05	-25.36	5.08
	1/9/2002	363.5	-2.5	611.5	524.5	374.25	180.50	568.00	487.50	261.00	99.09	-25.75	5.07
	4/12/2002	381.7	16.9	642.7	550.5	397.95	199.30	596.60	512.20	283.70	105.37	-26.40	5.12
	7/18/2002	375	10.5	629	544.7	389.80	192.75	586.85	502.00	277.60	103.21	-26.19	5.03
	10/8/2002	357.7	-9.6	599.2	523	367.58	174.05	561.10	478.45	256.70	97.32	-25.72	4.97
	1/8/2003	367.3	6.5	626.7	542.7	385.80	186.90	584.70	497.00	274.60	102.15	-26.44	4.98
	4/15/2003	385.9	27.3	655.3	566.2	408.68	206.60	610.75	520.60	296.75	108.20	-26.86	5.01
	7/1/2003	384.7	26.3	649.2	565.6	406.45	205.50	607.40	516.95	295.95	107.62	-26.71	4.95
	10/7/2003	360.6	3.5	613	539.7	379.20	182.05	576.35	486.80	271.60	100.40	-26.20	4.82
	12/31/2003	372	19.4	636	558.3	396.43	195.70	597.15	504.00	288.85	104.96	-26.68	4.82
	4/13/2004	389.4	39.8	665.5	583.1	419.45	214.60	624.30	527.45	311.45	111.06	-27.23	4.84
	7/13/2004	379.5	27.7	643.3	571.1	405.40	203.60	607.20	511.40	299.40	107.34	-26.82	4.75
	10/8/2004	361.6	10.3	615.2	550.9	384.50	185.95	583.05	488.40	280.60	101.80	-26.39	4.66
	1/7/2005	367.5	16.1	630.6	561.5	393.93	191.80	596.05	499.05	288.80	104.30	-26.87	4.71
	4/8/2005	388.2	35.6	662.3	587.2	418.33	211.90	624.75	525.25	311.40	110.76	-27.44	4.79
	7/18/2005	382.6	26.3	647.7	580.1	409.18	204.45	613.90	515.15	303.20	108.34	-27.21	4.75
	8/26/2005	373.6	15.7	629.8	566.8	396.48	194.65	598.30	501.70	291.25	104.97	-26.83	4.71
	10/11/2005	365.9	6.1	617.8	557.9	386.93	186.00	587.85	491.85	282.00	102.45	-26.71	4.70
	1/10/2006	376.2	17.5	639	572.2	401.23	196.85	605.60	507.60	294.85	106.23	-27.16	4.77
	4/9/2006	393.8	32.7	665.7	594	421.55	213.25	629.85	529.75	313.35	111.61	-27.69	4.85
	7/19/2006	384.2	20.3	646.2	582.7	408.35	202.25	614.45	515.20	301.50	108.12	-27.39	4.79
	10/18/2006	365	-2	614.4	558.2	383.90	181.50	586.30	489.70	278.10	101.65	-26.90	4.74
	1/18/2007	376	9.6	635.9	573.9	398.85	192.80	604.90	505.95	291.75	105.60	-27.39	4.80
	4/19/2007	390.7	24.1	659.3	592.7	416.70	207.40	626.00	525.00	308.40	110.33	-27.82	4.85
	7/11/2007	384.1	15	644.6	584.6	407.08	199.55	614.60	514.35	299.80	107.78	-27.58	4.81
	10/20/2007	363.7	-9.6	611.5	560.6	381.55	177.05	586.05	487.60	275.50	101.02	-27.18	4.75
	1/7/2008	371.2	-2.9	625.1	569.7	390.78	184.15	597.40	498.15	283.40	103.47	-27.46	4.81
	5/13/2008	390.8	11.5	650.8	592.6	411.43	201.15	621.70	520.80	302.05	108.93	-27.95	4.90
	7/29/2008	379.9	-2.5	629.3	579.9	396.65	188.70	604.60	504.60	288.70	105.02	-27.64	4.84
	10/30/2008	365	-20.3	605.3	562.2	378.05	172.35	583.75	485.15	270.95	100.10	-27.34	4.80
	1/12/2009	375.3	-11.4	624.8	575	390.93	181.95	599.90	500.05	281.80	103.51	-27.78	4.89
	4/24/2009	375.3	-11.4	624.8	575	390.93	181.95	599.90	500.05	281.80	103.51	-27.78	4.89

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
13	7/1/1999	306.3	72.2	490.8	675.2	386.13	189.25	583.00	398.55	373.70	102.23	-26.17	0.56
	7/15/1999	288.0	53.1	484.2	670.6	373.98	170.55	577.40	386.10	361.85	99.02	-27.04	0.54
	8/15/1999	280.9	61.8	506.3	693.7	385.68	171.35	600.00	393.60	377.75	102.12	-28.49	0.36
	8/31/1999	270.4	52.1	503.1	691.4	379.25	161.25	597.25	386.75	371.75	100.41	-28.98	0.34
	9/15/1999	261.3	43.9	501.2	689.9	374.08	152.60	595.55	381.25	366.90	99.04	-29.44	0.32
	9/30/1999	257.1	40.7	503.1	690.7	372.90	148.90	596.90	380.10	365.70	98.73	-29.77	0.32
	10/15/1999	250.1	33.8	501.2	691	369.03	141.95	596.10	375.65	362.40	97.71	-30.18	0.30
	10/31/1999	251.4	38	507.6	697.6	373.65	144.70	602.60	379.50	367.80	98.93	-30.43	0.26
	11/15/1999	253.9	41.6	512.1	701.9	377.38	147.75	607.00	383.00	371.75	99.92	-30.52	0.25
	11/30/1999	253.5	41.2	513.6	704.4	378.18	147.35	609.00	383.55	372.80	100.13	-30.68	0.24
	12/15/1999	255.8	46.7	519.1	709.3	382.73	151.25	614.20	387.45	378.00	101.33	-30.77	0.21
	12/31/1999	256.7	48.9	522.3	712.4	385.08	152.80	617.35	389.50	380.65	101.96	-30.87	0.20
	3/31/2000	267.5	64.6	542.8	734.2	402.28	166.05	638.50	405.15	399.40	106.51	-31.40	0.13
	6/30/2000	258.9	46.4	531.2	726.1	390.65	152.65	628.65	395.05	386.25	103.43	-31.63	0.20
	9/30/2000	237.1	10.1	504.9	705.9	364.50	123.60	605.40	371.00	358.00	96.51	-32.02	0.29
	1/13/2001	254.0	40.9	535.1	734.6	391.15	147.45	634.85	394.55	387.75	103.56	-32.39	0.15
	4/20/2001	275.4	72.6	561.4	763.7	418.28	174.00	662.55	418.40	418.15	110.75	-32.47	0.01
	7/16/2001	255.3	37.7	534.8	740.9	392.18	146.50	637.85	395.05	389.30	103.84	-32.65	0.13
	10/9/2001	235.7	7.5	510.6	719.6	368.35	121.60	615.10	373.15	363.55	97.53	-32.80	0.22
	1/9/2002	240	18.9	523.3	731	378.30	129.45	627.15	381.65	374.95	100.16	-33.08	0.15
	4/12/2002	263.4	58.5	554.8	763	409.93	160.95	658.90	409.10	410.75	108.54	-33.09	-0.04
	7/18/2002	255.5	40.1	566.1	754.5	404.05	147.80	660.30	410.80	397.30	106.98	-34.06	0.30
	10/8/2002	231.2	3.4	508.7	726.1	367.35	117.30	617.40	369.95	364.75	97.26	-33.24	0.12
	1/8/2003	249.4	38.5	540.1	754.4	395.60	143.95	647.25	394.75	396.45	104.74	-33.45	-0.04
	4/15/2003	276.4	78.5	571.6	784.9	427.85	177.45	678.25	424.00	431.70	113.28	-33.28	-0.17
	7/1/2003	273	69	561.4	779.9	420.83	171.00	670.65	417.20	424.45	111.42	-33.21	-0.16
	10/7/2003	246.6	22.5	524.7	744.6	384.60	134.55	634.65	385.65	383.55	101.83	-33.24	0.05
	12/31/2003	264.8	58.9	552.8	770.1	411.65	161.85	661.45	408.80	414.50	108.99	-33.20	-0.13
	4/13/2004	291.3	97.7	584	803.2	444.05	194.50	693.60	437.65	450.45	117.57	-33.17	-0.29
	7/13/2004	275.5	64.3	556.1	781	419.23	169.90	668.55	415.80	422.65	111.00	-33.14	-0.15
	10/8/2004	252.8	29.9	527.5	755.8	391.50	141.35	641.65	390.15	392.85	103.66	-33.25	-0.06
	1/7/2005	264	50.8	544.5	770.6	407.48	157.40	657.55	404.25	410.70	107.89	-33.24	-0.14
	4/8/2005	289.9	90.7	576	802	439.65	190.30	689.00	432.95	446.35	116.41	-33.14	-0.30
	7/18/2005	277.8	67.7	556.4	787.1	422.25	172.75	671.75	417.10	427.40	111.80	-33.16	-0.23
	8/26/2005	266.7	46.5	539.8	771.9	406.23	156.60	655.85	403.25	409.20	107.56	-33.18	-0.13
	10/11/2005	257.2	33.8	526.8	760.8	394.65	145.50	643.80	392.00	397.30	104.49	-33.12	-0.12
	1/10/2006	269.3	59.9	551.2	780.4	415.20	164.60	665.80	410.25	420.15	109.93	-33.31	-0.22
	4/9/2006	289.9	90	576.3	806.2	440.60	189.95	691.25	433.10	448.10	116.66	-33.32	-0.34
	7/19/2006	277.7	63.9	553.8	787.8	420.80	170.80	670.80	415.75	425.85	111.42	-33.23	-0.23
	10/18/2006	253.3	27.9	523.7	757.8	390.68	140.60	640.75	388.50	392.85	103.44	-33.24	-0.10
	1/18/2007	267.4	54.9	546.5	778.5	411.83	161.15	662.50	406.95	416.70	109.04	-33.32	-0.22
	4/19/2007	289	88.7	575.1	806.8	439.90	188.85	690.95	432.05	447.75	116.47	-33.37	-0.35
	7/11/2007	280	67	558	793.6	424.65	173.50	675.80	419.00	430.30	112.43	-33.38	-0.25
	10/20/2007	255.4	29.1	525	763.8	393.33	142.25	644.40	390.20	396.45	104.14	-33.37	-0.14
	1/7/2008	265.4	49.2	542.8	778	408.85	157.30	660.40	404.10	413.60	108.25	-33.44	-0.21
	5/13/2008	290.2	83.3	573.8	809.3	439.15	186.75	691.55	432.00	446.30	116.27	-33.55	-0.32
	7/29/2008	274	55.1	548.5	787.7	416.33	164.55	668.10	411.25	421.40	110.23	-33.47	-0.23
	10/30/2008	256.5	28.1	526.4	765.9	394.23	142.30	646.15	391.45	397.00	104.38	-33.49	-0.12
	1/12/2009	271.1	54.9	550.3	786.8	415.78	163.00	668.55	410.70	420.85	110.08	-33.60	-0.23
	4/24/2009	271.1	54.9	550.3	786.8	415.78	163.00	668.55	410.70	420.85	110.08	-33.60	-0.23

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
14	7/1/1999	445.4	53.9	802	298.7	400.00	249.65	550.35	623.70	176.30	105.91	-19.98	10.02
	7/15/1999	440.5	34.4	799.5	280.7	388.78	237.45	540.10	620.00	157.55	102.94	-20.11	10.36
	8/15/1999	455.6	40.8	837.6	284.6	404.65	248.20	561.10	646.60	162.70	107.14	-20.79	10.84
	8/31/1999	452.7	30.7	837.1	274.1	398.65	241.70	555.60	644.90	152.40	105.55	-20.86	11.03
	9/15/1999	448.5	21.7	836.8	266.2	393.30	235.10	551.50	642.65	143.95	104.13	-21.03	11.17
	9/30/1999	447.0	16.1	838.5	260.8	390.60	231.55	549.65	642.75	138.45	103.42	-21.14	11.30
	10/15/1999	446.5	8.8	839.3	255.1	387.43	227.65	547.20	642.90	131.95	102.58	-21.24	11.45
	10/31/1999	450.9	11.7	847.9	257.8	392.08	231.30	552.85	649.40	134.75	103.81	-21.37	11.53
	11/15/1999	455.9	16.1	856.2	259.8	397.00	236.00	558.00	656.05	137.95	105.11	-21.40	11.61
	11/30/1999	456.3	15.5	858.3	259	397.28	235.90	558.65	657.30	137.25	105.19	-21.45	11.65
	12/15/1999	461.3	20.5	865.6	261.7	402.28	240.90	563.65	663.45	141.10	106.51	-21.45	11.70
	12/31/1999	463.4	22.5	871.6	262.9	405.10	242.95	567.25	667.50	142.70	107.26	-21.55	11.76
	3/31/2000	477.8	35.6	903.8	282.7	424.98	256.70	593.25	690.80	159.15	112.52	-22.37	11.91
	6/30/2000	469.2	17.4	889.7	267.4	410.93	243.30	578.55	679.45	142.40	108.80	-22.28	12.03
	9/30/2000	453.5	-23.5	856.8	240.4	381.80	215.00	548.60	655.15	108.45	101.09	-22.17	12.25
	1/13/2001	476.9	5	891.3	257.6	407.70	240.95	574.45	684.10	131.30	107.95	-22.16	12.38
	4/20/2001	494.8	40.8	932.8	281.2	437.40	267.80	607.00	713.80	161.00	115.81	-22.54	12.38
	7/16/2001	475.7	4.9	900.7	255.9	409.30	240.30	578.30	688.20	130.40	108.37	-22.46	12.50
	10/9/2001	459.3	-30.8	870.4	236.8	383.93	214.25	553.60	664.85	103.00	101.65	-22.55	12.59
	1/9/2002	468.8	-18.5	883.7	241.5	393.88	225.15	562.60	676.25	111.50	104.29	-22.43	12.65
	4/12/2002	492.8	22.5	926.5	270.2	428.00	257.65	598.35	709.65	146.35	113.32	-22.64	12.62
	7/18/2002	483.5	3.8	911.9	257.3	414.13	243.65	584.60	697.70	130.55	109.65	-22.66	12.71
	10/8/2002	462.7	-35	875.6	233	384.08	213.85	554.30	669.15	99.00	101.69	-22.63	12.77
	1/8/2003	485.5	2.5	912.6	253.9	413.63	244.00	583.25	699.05	128.20	109.52	-22.55	12.79
	4/15/2003	501.9	612.9	952.7	285.1	588.15	557.40	618.90	727.30	449.00	155.72	-4.09	6.23
	7/1/2003	521.6	28.8	943.4	278.1	442.98	275.20	610.75	732.50	153.45	117.29	-22.30	12.97
	10/7/2003	472.3	-16.5	903.8	247.5	401.78	227.90	575.65	688.05	115.50	106.38	-23.11	12.83
	12/31/2003	495.5	18.6	939.3	268.7	430.53	257.05	604.00	717.40	143.65	113.99	-23.06	12.85
	4/13/2004	504.6	68.9	989	299.2	465.43	286.75	644.10	746.80	184.05	123.23	-23.75	12.61
	7/13/2004	487.3	36.7	961.8	277.7	440.88	262.00	619.75	724.55	157.20	116.73	-23.78	12.71
	10/8/2004	468.9	-0.5	928.8	256.4	413.40	234.20	592.60	698.85	127.95	109.46	-23.82	12.79
	1/7/2005	485.2	21.4	952.7	269.7	432.25	253.30	611.20	718.95	145.55	114.45	-23.79	12.85
	4/8/2005	512.9	68.8	998.7	302.5	470.73	290.85	650.60	755.80	185.65	124.63	-23.91	12.77
	7/18/2005	498.2	40	977.1	286.8	450.53	269.10	631.95	737.65	163.40	119.29	-24.11	12.86
	8/26/2005	486.3	17.1	955.5	271.8	432.68	251.70	613.65	720.90	144.45	114.56	-24.05	12.91
	10/11/2005	478.8	2.4	942.6	263.6	421.85	240.60	603.10	710.70	133.00	111.69	-24.09	12.94
	1/10/2006	497.9	28.2	970.6	280.6	444.33	263.05	625.60	734.25	154.40	117.64	-24.09	12.99
	4/9/2006	519.6	65.1	1008.9	306	474.90	292.35	657.45	764.25	185.55	125.74	-24.26	12.96
	7/19/2006	505.7	73.4	984.2	290.7	463.50	289.55	637.45	744.95	182.05	122.72	-23.12	12.61
	10/18/2006	484	-5.7	946.5	265.8	422.65	239.15	606.15	715.25	130.05	111.91	-24.39	13.11
	1/18/2007	503	21.5	974.4	282.5	445.35	262.25	628.45	738.70	152.00	117.92	-24.34	13.14
	4/19/2007	525.1	60.9	1012.9	309.1	477.00	293.00	661.00	769.00	185.00	126.30	-24.46	13.08
	7/11/2007	533.8	36.8	994.5	295.1	465.05	285.30	644.80	764.15	165.95	123.13	-23.89	13.40
	10/20/2007	487.8	-9.1	953.8	269.9	425.60	239.35	611.85	720.80	130.40	112.69	-24.76	13.23
	1/7/2008	504.2	11.4	976	284.1	443.93	257.80	630.05	740.10	147.75	117.54	-24.74	13.27
	5/13/2008	552.9	52.7	1019.4	315.4	485.10	302.80	667.40	786.15	184.05	128.44	-24.23	13.49
	7/29/2008	533.4	17.1	989.1	295.9	458.88	275.25	642.50	761.25	156.50	121.50	-24.41	13.55
	10/30/2008	494.5	-16.2	961.7	277.5	429.38	239.15	619.60	728.10	130.65	113.69	-25.28	13.38
	1/12/2009	514.7	12	989.3	296.3	453.08	263.35	642.80	752.00	154.15	119.96	-25.22	13.39
	4/24/2009	514.7	12	989.3	296.3	453.08	263.35	642.80	752.00	154.15	119.96	-25.22	13.39

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side)(cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
26	7/1/1999	468.3	92.2	387.7	511.7	364.98	280.25	449.70	428.00	301.95	96.63	-11.26	2.82
	7/15/1999	460.1	81	381.5	505.7	357.08	270.55	443.60	420.80	293.35	94.54	-11.50	2.86
	8/15/1999	482.3	96.1	410.7	526	378.78	289.20	468.35	446.50	311.05	100.29	-11.91	3.03
	8/31/1999	490.3	101.9	422.4	535	387.40	296.10	478.70	456.35	318.45	102.57	-12.14	3.09
	9/15/1999	491.0	101.4	426.3	536.4	388.78	296.20	481.35	458.65	318.90	102.94	-12.30	3.13
	9/30/1999	497.9	106.7	434.7	543.6	395.73	302.30	489.15	466.30	325.15	104.78	-12.42	3.16
	10/15/1999	505.0	112.3	443.2	550.9	402.85	308.65	497.05	474.10	331.60	106.66	-12.52	3.19
	10/31/1999	515.6	118.8	452.5	560.9	411.95	317.20	506.70	484.05	339.85	109.07	-12.59	3.23
	11/15/1999	525.0	128.3	463.4	570.2	421.73	326.65	516.80	494.20	349.25	111.66	-12.64	3.25
	11/30/1999	532.5	134.9	471.5	576.8	428.93	333.70	524.15	502.00	355.85	113.57	-12.66	3.27
	12/15/1999	534.1	138.1	476.5	580.2	432.23	336.10	528.35	505.30	359.15	114.44	-12.78	3.27
	12/31/1999	540.4	144.3	484.4	587.2	439.08	342.35	535.80	512.40	365.75	116.25	-12.86	3.29
	3/31/2000	551.1	156	501.3	602.1	452.63	353.55	551.70	526.20	379.05	119.84	-13.17	3.30
	6/30/2000	533.5	137.3	477.6	577.9	431.58	335.40	527.75	505.55	357.60	114.27	-12.78	3.31
	9/30/2000	539.6	136.8	480.7	575.1	433.05	338.20	527.90	510.15	355.95	114.66	-12.61	3.45
	1/13/2001	571.4	169.7	522.7	611.8	468.90	370.55	567.25	547.05	390.75	124.15	-13.07	3.50
	4/20/2001	580.2	184.8	537.9	624.6	481.88	382.50	581.25	559.05	404.70	127.59	-13.21	3.46
	7/16/2001	555.8	159.1	508	598.6	455.38	357.45	553.30	531.90	378.85	120.57	-13.02	3.43
	10/9/2001	556.2	154.1	506	595.8	453.03	355.15	550.90	531.10	374.95	119.95	-13.01	3.50
	1/9/2002	572	170.3	527.3	614.7	471.08	371.15	571.00	549.65	392.50	124.73	-13.28	3.52
	4/12/2002	584.6	187.7	546.3	632.8	487.85	386.15	589.55	565.45	410.25	129.17	-13.52	3.48
	7/18/2002	559.5	162.1	516.1	606	460.93	360.80	561.05	537.80	384.05	122.04	-13.31	3.44
	10/8/2002	557	154.4	511	599.8	455.55	355.70	555.40	534.00	377.10	120.62	-13.27	3.51
	1/8/2003	591	189.2	552.8	639	493.00	390.10	595.90	571.90	414.10	130.53	-13.68	3.54
	4/15/2003	597.9	204.3	567.5	650.5	505.05	401.10	609.00	582.70	427.40	133.72	-13.82	3.48
	7/1/2003	580.7	184.3	545.4	632.5	485.73	382.50	588.95	563.05	408.40	128.61	-13.72	3.46
	10/7/2003	578.2	176.3	538	627	479.88	377.25	582.50	558.10	401.65	127.06	-13.64	3.50
	12/31/2003	610.3	207.7	572.6	661.6	513.05	409.00	617.10	591.45	434.65	135.84	-13.83	3.51
	4/13/2004	617.1	224.2	589.5	675.7	526.63	420.65	632.60	603.30	449.95	139.43	-14.09	3.44
	7/13/2004	584	186.6	549.1	642.6	490.58	385.30	595.85	566.55	414.60	129.89	-13.99	3.40
	10/8/2004	581.8	181.2	543.7	638.3	486.25	381.50	591.00	562.75	409.75	128.74	-13.92	3.43
	1/7/2005	609.9	209	574.8	669.1	515.70	409.45	621.95	592.35	439.05	136.54	-14.12	3.43
	4/8/2005	617.5	225	590.2	683.9	529.15	421.25	637.05	603.85	454.45	140.10	-14.34	3.35
	7/18/2005	590.4	192.7	554.7	656	498.45	391.55	605.35	572.55	424.35	131.97	-14.21	3.32
	8/26/2005	584.4	183.1	544	647.8	489.83	383.75	595.90	564.20	415.45	129.69	-14.10	3.33
	10/11/2005	589.3	185.9	548.5	652	493.93	387.60	600.25	568.90	418.95	130.78	-14.13	3.36
	1/10/2006	616	216.1	582.8	683.4	524.58	416.05	633.10	599.40	449.75	138.89	-14.42	3.35
	4/9/2006	629	235.4	605.8	701.1	542.83	432.20	653.45	617.40	468.25	143.72	-14.70	3.34
	7/19/2006	595.8	199	563.1	668.3	506.55	397.40	615.70	579.45	433.65	134.12	-14.51	3.27
	10/18/2006	595.6	193	557.4	662.8	502.20	394.30	610.10	576.50	427.90	132.97	-14.34	3.33
	1/18/2007	622.2	223.4	590.2	694.6	532.60	422.80	642.40	606.20	459.00	141.02	-14.59	3.30
	4/19/2007	624.5	231.7	598.4	701.1	538.93	428.10	649.75	611.45	466.40	142.69	-14.73	3.25
	7/11/2007	594.6	199.2	561.5	670.8	506.53	396.90	616.15	578.05	435.00	134.11	-14.57	3.20
	10/20/2007	588.7	187	550.3	661.8	496.95	387.85	606.05	569.50	424.40	131.58	-14.50	3.25
	1/7/2008	619.8	219.6	589.6	697.1	531.53	419.70	643.35	604.70	458.35	140.73	-14.86	3.28
	5/13/2008	624.3	232.4	600.5	707.3	541.13	428.35	653.90	612.40	469.85	143.27	-14.99	3.19
	7/29/2008	600.8	202.7	568.1	681.9	513.38	401.75	625.00	584.45	442.30	135.93	-14.84	3.18
	10/30/2008	616.5	213.5	580.6	694.2	526.20	415.00	637.40	598.55	453.85	139.32	-14.78	3.24
	1/12/2009	638.2	240.2	611.7	719.3	552.35	439.20	665.50	624.95	479.75	146.25	-15.04	3.25
	4/24/2009	638.2	240.2	611.7	719.3	552.35	439.20	665.50	624.95	479.75	146.25	-15.04	3.25

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
1	7/1/1999	-115.0	299.7	422.9	109.6	179.30	92.35	266.25	153.95	204.65	47.47	-11.56	-1.14
	7/15/1999	-122.0	289	405.2	95.6	166.95	83.50	250.40	141.60	192.30	44.20	-11.09	-1.14
	8/15/1999	-139.4	265.8	401.5	101.8	157.43	63.20	251.65	131.05	183.80	41.68	-12.52	-1.18
	8/31/1999	-144.1	258.4	394.7	99.6	152.15	57.15	247.15	125.30	179.00	40.28	-12.63	-1.20
	9/15/1999	-144.1	255.9	395.1	102	152.23	55.90	248.55	125.50	178.95	40.30	-12.80	-1.20
	9/30/1999	-141.7	260.4	408.3	112.3	159.83	59.35	260.30	133.30	186.35	42.32	-13.35	-1.19
	10/15/1999	-138.1	275.3	441.9	138.4	179.38	68.60	290.15	151.90	206.85	47.49	-14.72	-1.23
	10/31/1999	-148.1	272.7	430.1	118.5	168.30	62.30	274.30	141.00	195.60	44.56	-14.09	-1.22
	11/15/1999	-142.3	278.9	446.6	134.9	179.53	68.30	290.75	152.15	206.90	47.53	-14.78	-1.23
	11/30/1999	-137.9	284.4	462	150.8	189.83	73.25	306.40	162.05	217.60	50.26	-15.49	-1.24
	12/15/1999	-135.4	290	463.8	152.5	192.73	77.30	308.15	164.20	221.25	51.03	-15.34	-1.28
	12/31/1999	-126.8	301.4	481.4	168.9	206.23	87.30	325.15	177.30	235.15	54.60	-15.81	-1.30
	3/31/2000	-133.9	283.1	455.7	149.6	188.63	74.60	302.65	160.90	216.35	49.94	-15.16	-1.24
	6/30/2000	-157.3	230.6	397.4	119.3	147.50	36.65	258.35	120.05	174.95	39.05	-14.73	-1.23
	9/30/2000	-142.8	237.4	427.4	156.8	169.70	47.30	292.10	142.30	197.10	44.93	-16.27	-1.23
	1/13/2001	-118.2	295.4	511.7	182.5	217.85	88.60	347.10	196.75	238.95	57.68	-17.18	-0.95
	4/20/2001	-128.9	270.9	454	163.4	189.85	71.00	308.70	162.55	217.15	50.27	-15.80	-1.22
	7/16/2001	-146.4	213.9	384.1	133.3	146.23	33.75	258.70	118.85	173.60	38.72	-14.95	-1.23
	10/9/2001	-135.7	237.5	439.4	178.3	179.88	50.90	308.85	151.85	207.90	47.63	-17.14	-1.26
	1/9/2002	-120.2	281.4	483	190.7	208.73	80.60	336.85	181.40	236.05	55.26	-17.03	-1.22
	4/12/2002	-133.2	263.6	441.1	154.2	181.43	65.20	297.65	153.95	208.90	48.04	-15.45	-1.23
	7/18/2002	-158.1	191.2	355.6	118	126.68	16.55	236.80	98.75	154.60	33.54	-14.64	-1.25
	10/7/2002	-149.2	192.4	391.7	156.3	147.80	21.60	274.00	121.25	174.35	39.13	-16.77	-1.19
	1/8/2003	-123.2	268.7	469.3	191.8	201.65	72.75	330.55	173.05	230.25	53.39	-17.13	-1.28
	4/15/2003	-137.5	248.4	427.1	157.1	173.78	55.45	292.10	144.80	202.75	46.01	-15.73	-1.30
	7/1/2003	-159.7	183.9	351.2	124.6	125.00	12.10	237.90	95.75	154.25	33.10	-15.01	-1.31
	10/7/2003	-146.6	206.4	412.6	177.8	162.55	29.90	295.20	133.00	192.10	43.04	-17.63	-1.32
	12/31/2003	-135.4	243.4	450.4	190	187.10	54.00	320.20	157.50	216.70	49.54	-17.69	-1.33
	4/13/2004	-144.6	228.6	422.1	168	168.53	42.00	295.05	138.75	198.30	44.62	-16.82	-1.33
	7/13/2004	-179.1	155.6	334.2	117.5	107.05	-11.75	225.85	77.55	136.55	28.34	-15.79	-1.32
	10/8/2004	-169	170.9	373.7	152.9	132.13	0.95	263.30	102.35	161.90	34.98	-17.44	-1.33
	1/7/2005	-145.5	227.8	440.5	188.2	177.75	41.15	314.35	147.50	208.00	47.06	-18.16	-1.36
	4/8/2005	-159.4	209.2	398.5	148.8	149.28	24.90	273.65	119.55	179.00	39.52	-16.53	-1.33
	7/18/2005	-182.8	141.5	330.3	131.3	105.08	-20.65	230.80	73.75	136.40	27.82	-16.71	-1.40
	8/26/2005	-184	140.7	341.3	131.3	107.33	-21.65	236.30	78.65	136.00	28.42	-17.14	-1.28
	10/11/2005	-174.2	159.1	370.9	131.3	121.78	-7.55	251.10	98.35	145.20	32.24	-17.19	-1.05
	1/10/2006	-152.5	216.4	430.7	131.3	156.48	31.95	281.00	139.10	173.85	41.43	-16.55	-0.78
	4/9/2006	-157.2	206.1	413	131.3	148.30	24.45	272.15	127.90	168.70	39.27	-16.46	-0.91
	7/19/2006	-189.4	135.9	330	131.3	101.95	-26.75	230.65	70.30	133.60	26.99	-17.11	-1.42
	10/18/2006	-170.5	170.2	390.6	131.3	130.40	-0.15	260.95	110.05	150.75	34.53	-17.35	-0.91
	1/18/2007	-145.4	217.2	448.1	131.3	162.80	35.90	289.70	151.35	174.25	43.10	-16.87	-0.51
	4/19/2007	-159.2	203.2	410.4	131.3	146.43	22.00	270.85	125.60	167.25	38.77	-16.54	-0.93
	7/11/2007	-192.9	128.3	318.7	131.3	96.35	-32.30	225.00	62.90	129.80	25.51	-17.10	-1.50
	10/20/2007	-183.2	145.9	358.7	131.3	113.18	-18.65	245.00	87.75	138.60	29.97	-17.52	-1.14
	1/7/2008	-155.6	207.5	426.7	131.3	152.48	25.95	279.00	135.55	169.40	40.37	-16.82	-0.76
	5/13/2008	-172.2	170	384.2	131.3	128.33	-1.10	257.75	106.00	150.65	33.98	-17.20	-1.00
	7/29/2008	-197.5	120	328.1	131.3	95.48	-38.75	229.70	65.30	125.65	25.28	-17.84	-1.35
	10/30/2008	-167.1	170	413	131.3	136.80	1.45	272.15	122.95	150.65	36.22	-17.99	-0.62
	1/12/2009	-147.6	210.8	446.5	131.3	160.25	31.60	288.90	149.45	171.05	42.43	-17.10	-0.48
	4/24/2009	-147.6	210.8	446.5	131.3	160.25	31.60	288.90	149.45	171.05	42.43	-17.10	-0.48

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
12	7/1/1999	356.2	257	201.2	275.1	272.38	306.60	238.15	278.70	266.05	72.12	4.55	0.28
	7/15/1999	353.8	251.6	188.4	273.4	266.80	302.70	230.90	271.10	262.50	70.64	4.77	0.19
	8/15/1999	350.0	242.8	195.3	301.1	272.30	296.40	248.20	272.65	271.95	72.10	3.20	0.02
	8/31/1999	350.2	247.8	201.7	307.9	276.90	299.00	254.80	275.95	277.85	73.31	2.94	-0.04
	9/15/1999	349.8	249.1	203.6	314	279.13	299.45	258.80	276.70	281.55	73.90	2.70	-0.11
	9/30/1999	352.2	256.8	212.1	322.7	285.95	304.50	267.40	282.15	289.75	75.71	2.47	-0.17
	10/15/1999	352.6	257.7	225.5	337.3	293.28	305.15	281.40	289.05	297.50	77.65	1.58	-0.19
	10/31/1999	361.0	268.5	222.6	333.7	296.45	314.75	278.15	291.80	301.10	78.49	2.43	-0.21
	11/15/1999	364.5	273.1	237.1	353.6	307.08	318.80	295.35	300.80	313.35	81.30	1.56	-0.28
	11/30/1999	367.6	276.3	249.1	369.4	315.60	321.95	309.25	308.35	322.85	83.56	0.84	-0.32
	12/15/1999	370.6	280.7	248.5	364.3	316.03	325.65	306.40	309.55	322.50	83.67	1.28	-0.29
	12/31/1999	371.2	282.5	254.8	368.8	319.33	326.85	311.80	313.00	325.65	84.55	1.00	-0.28
	3/31/2000	376.0	289.2	244.7	361.1	317.75	332.60	302.90	310.35	325.15	84.13	1.97	-0.33
	6/30/2000	358.4	247.7	207.4	329.3	285.70	303.05	268.35	282.90	288.50	75.64	2.31	-0.13
	9/30/2000	357.6	235.9	230.1	366.4	297.50	296.75	298.25	293.85	301.15	78.77	-0.10	-0.16
	1/13/2001	382.0	289.5	264.4	384.8	330.18	335.75	324.60	323.20	337.15	87.42	0.74	-0.31
	4/20/2001	382.9	294.9	260.1	378.2	329.03	338.90	319.15	321.50	336.55	87.12	1.31	-0.34
	7/16/2001	352.4	249.4	219.2	330.6	287.90	300.90	274.90	285.80	290.00	76.23	1.73	-0.09
	10/9/2001	357.7	267.9	262.1	382	317.43	312.80	322.05	309.90	324.95	84.04	-0.61	-0.34
	1/9/2002	385.8	301.2	285.1	395.6	341.93	343.50	340.35	335.45	348.40	90.53	0.21	-0.29
	4/12/2002	390.9	310.2	263.2	370.1	333.60	350.55	316.65	327.05	340.15	88.33	2.25	-0.29
	7/18/2002	346.39	265.03	220.4	323.3	288.78	305.71	271.85	283.39	294.17	76.46	2.25	-0.24
	10/7/2002	344.5	265.3	252.4	363.5	306.43	304.90	307.95	298.45	314.40	81.13	-0.20	-0.36
	1/8/2003	385.9	308.5	295.9	394.3	346.15	347.20	345.10	340.90	351.40	91.65	0.14	-0.24
	4/15/2003	392.4	317.3	275.8	371.1	339.15	354.85	323.45	334.10	344.20	89.80	2.09	-0.23
	7/1/2003	360	288.1	238.7	332.8	304.90	324.05	285.75	299.35	310.45	80.73	2.55	-0.25
	10/7/2003	357.1	284.5	277.7	372.1	322.85	320.80	324.90	317.40	328.30	85.48	-0.27	-0.24
	12/31/2003	387.7	318.7	304.1	392.5	350.75	353.20	348.30	345.90	355.60	92.87	0.33	-0.22
	4/13/2004	389.4	324.2	294.9	381.2	347.43	356.80	338.05	342.15	352.70	91.99	1.25	-0.24
	7/13/2004	348	285.8	241	324.8	299.90	316.90	282.90	294.50	305.30	79.40	2.26	-0.24
	10/8/2004	342.4	281.8	269.4	353.1	311.68	312.10	311.25	305.90	317.45	82.52	0.06	-0.26
	1/7/2005	374.1	315.2	302.9	382.8	343.75	344.65	342.85	338.50	349.00	91.01	0.12	-0.24
	4/8/2005	386.7	328.9	284.3	365	341.23	357.80	324.65	335.50	346.95	90.35	2.20	-0.26
	7/18/2005	343.2	285.5	242.4	322.1	298.30	314.35	282.25	292.80	303.80	78.98	2.13	-0.25
	8/26/2005	337	278.7	250.1	331.1	299.23	307.85	290.60	293.55	304.90	79.23	1.15	-0.25
	10/11/2005	338.7	283.6	264.1	348.6	308.75	311.15	306.35	301.40	316.10	81.75	0.32	-0.33
	1/10/2006	371.5	317.4	297	373.5	339.85	344.45	335.25	334.25	345.45	89.98	0.61	-0.25
	4/9/2006	377.4	324.1	290.6	368.2	340.08	350.75	329.40	334.00	346.15	90.04	1.42	-0.27
	7/19/2006	341.9	289.2	238.8	315.3	296.30	315.55	277.05	290.35	302.25	78.45	2.56	-0.27
	10/18/2006	342.7	289.5	274.8	354.5	315.38	316.10	314.65	308.75	322.00	83.50	0.10	-0.30
	1/18/2007	368.4	316.6	305.5	385	343.88	342.50	345.25	336.95	350.80	91.05	-0.18	-0.31
	4/19/2007	370.5	320.9	279.2	353.9	331.13	345.70	316.55	324.85	337.40	87.67	1.94	-0.28
	7/11/2007	326.6	278.1	219	294	279.43	302.35	256.50	272.80	286.05	73.98	3.05	-0.30
	10/20/2007	325.9	278.3	243.8	321.7	292.43	302.10	282.75	284.85	300.00	77.43	1.29	-0.34
	1/7/2008	359.2	310.2	282.8	353	326.30	334.70	317.90	321.00	331.60	86.39	1.12	-0.24
	5/13/2008	350.5	304.1	260.9	335.4	312.73	327.30	298.15	305.70	319.75	82.80	1.94	-0.31
	7/29/2008	325.9	281.2	234.5	305.4	286.75	303.55	269.95	280.20	293.30	75.92	2.23	-0.29
	10/30/2008	335.7	288	283.1	360.3	316.78	311.85	321.70	309.40	324.15	83.87	-0.65	-0.33
	1/12/2009	361	312.9	298.7	366.1	334.68	336.95	332.40	329.85	339.50	88.61	0.30	-0.22
	4/24/2009	361	312.9	298.7	366.1	334.68	336.95	332.40	329.85	339.50	88.61	0.30	-0.22

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
13	7/1/1999	177.4	380.2	417.6	236.2	302.85	278.80	326.90	297.50	308.20	80.19	-3.20	-0.24
	7/15/1999	173.8	378	412.7	230.2	298.68	275.90	321.45	293.25	304.10	79.08	-3.03	-0.24
	8/15/1999	172.8	380.2	439.6	252.6	311.30	276.50	346.10	306.20	316.40	82.42	-4.63	-0.23
	8/31/1999	172.6	378	445.8	257.5	313.48	275.30	351.65	309.20	317.75	83.00	-5.07	-0.19
	9/15/1999	170.9	377.2	447.2	261	314.08	274.05	354.10	309.05	319.10	83.16	-5.32	-0.23
	9/30/1999	176.4	380.7	455.9	269.3	320.58	278.55	362.60	316.15	325.00	84.88	-5.59	-0.20
	10/15/1999	176.7	378.9	468.1	279.5	325.80	277.80	373.80	322.40	329.20	86.26	-6.38	-0.15
	10/31/1999	182.4	385.8	502.1	273.8	336.03	284.10	387.95	342.25	329.80	88.97	-6.90	0.28
	11/15/1999	186.8	392.4	482.7	292	338.48	289.60	387.35	334.75	342.20	89.62	-6.50	-0.17
	11/30/1999	189.8	396.8	638.9	305.6	382.78	293.30	472.25	414.35	351.20	101.35	-11.89	1.41
	12/15/1999	193.5	401.1	516.7	302.2	353.38	297.30	409.45	355.10	351.65	93.56	-7.45	0.08
	12/31/1999	194.7	406.1	507.2	308	354.00	300.40	407.60	350.95	357.05	93.73	-7.12	-0.14
	3/31/2000	194.8	409	492.7	298.7	348.80	301.90	395.70	343.75	353.85	92.35	-6.23	-0.23
	6/30/2000	177.7	389.4	467.2	278.7	328.25	283.55	372.95	322.45	334.05	86.91	-5.94	-0.26
	9/30/2000	174.2	385.1	496.7	308	341.00	279.65	402.35	335.45	346.55	90.29	-8.15	-0.25
	1/13/2001	200.0	418.2	530.3	318.6	366.78	309.10	424.45	365.15	368.40	97.11	-7.67	-0.07
	4/20/2001	194.1	416.2	512.8	310.6	358.43	305.15	411.70	353.45	363.40	94.90	-7.08	-0.22
	7/16/2001	166.5	386.2	469	273.8	323.88	276.35	371.40	317.75	330.00	85.75	-6.32	-0.27
	10/9/2001	171.5	389.1	514.8	315.2	347.65	280.30	415.00	343.15	352.15	92.05	-8.95	-0.20
	1/9/2002	193.6	413.6	539.3	324.6	367.78	303.60	431.95	366.45	369.10	97.38	-8.53	-0.06
	4/12/2002	198.8	418.5	509.3	299.2	356.45	308.65	404.25	354.05	358.85	94.38	-6.35	-0.11
	7/18/2002	161.4	379.1	462.4	262.6	316.38	270.25	362.50	311.90	320.85	83.77	-6.13	-0.20
	10/7/2002	155.8	373.6	686.8	301.1	379.33	264.70	493.95	421.30	337.35	100.43	-15.24	1.88
	1/8/2003	193.1	414	547.6	331	371.43	303.55	439.30	370.35	372.50	98.34	-9.02	-0.05
	4/15/2003	195.8	419.9	560.6	305.7	370.50	307.85	433.15	378.20	362.80	98.10	-8.33	0.34
	7/1/2003	172.1	394.8	479.4	273.9	330.05	283.45	376.65	325.75	334.35	87.39	-6.19	-0.19
	10/7/2003	169	389.1	527.1	317.5	350.68	279.05	422.30	348.05	353.30	92.85	-9.52	-0.12
	12/31/2003	196.2	423.2	560.3	334.7	378.60	309.70	447.50	378.25	378.95	100.24	-9.16	-0.02
	4/13/2004	197.9	424.7	546.1	321.7	372.60	311.30	433.90	372.00	373.20	98.65	-8.15	-0.03
	7/13/2004	155.6	383.5	482.7	266.1	321.98	269.55	374.40	319.15	324.80	85.25	-6.97	-0.13
	10/8/2004	152.2	378.4	519	298.6	337.05	265.30	408.80	335.60	338.50	89.24	-9.54	-0.06
	1/7/2005	180.6	410.6	556.1	324.9	368.05	295.60	440.50	368.35	367.75	97.45	-9.63	0.01
	4/8/2005	188.3	419.5	529.1	301	359.48	303.90	415.05	358.70	360.25	95.18	-7.39	-0.03
	7/18/2005	150.7	376.8	482.9	262.2	318.15	263.75	372.55	316.80	319.50	84.24	-7.23	-0.06
	8/26/2005	144.7	373.1	494.1	275.3	321.80	258.90	384.70	319.40	324.20	85.20	-8.36	-0.11
	10/11/2005	146.5	375.2	533.7	291.5	336.73	260.85	412.60	340.10	333.35	89.15	-10.09	0.15
	1/10/2006	176	407.1	548.8	313.5	361.35	291.55	431.15	362.40	360.30	95.67	-9.28	0.05
	4/9/2006	180.6	412.1	538.7	307.8	359.80	296.35	423.25	359.65	359.95	95.26	-8.43	-0.01
	7/19/2006	149.4	377.4	480.1	259.8	316.68	263.40	369.95	314.75	318.60	83.85	-7.08	-0.09
	10/18/2006	155.2	382.8	532.6	304.1	343.68	269.00	418.35	343.90	343.45	90.99	-9.93	0.01
	1/18/2007	179.5	407.9	563.5	330.9	370.45	293.70	447.20	371.50	369.40	98.08	-10.20	0.05
	4/19/2007	182.7	413.5	536	305.6	359.45	298.10	420.80	359.35	359.55	95.17	-8.15	0.00
	7/11/2007	146.1	373.2	467.5	250.6	309.35	259.65	359.05	306.80	311.90	81.91	-6.61	-0.11
	10/20/2007	144.3	373.6	638.9	278.5	358.83	258.95	458.70	391.60	326.05	95.01	-13.28	1.47
	1/7/2008	179.2	408.8	548	312	362.00	294.00	430.00	363.60	360.40	95.85	-9.04	0.07
	5/13/2008	172.2	403.9	523.7	297.2	349.25	288.05	410.45	347.95	350.55	92.47	-8.13	-0.06
	7/29/2008	149.7	380.4	489.1	265	321.05	265.05	377.05	319.40	322.70	85.00	-7.44	-0.07
	10/30/2008	160.1	391.8	555	321.9	357.20	275.95	438.45	357.55	356.85	94.58	-10.80	0.02
	1/12/2009	185.3	417.9	568.5	328.6	375.08	301.60	448.55	376.90	373.25	99.31	-9.77	0.08
	4/24/2009	185.3	417.9	568.5	328.6	375.08	301.60	448.55	376.90	373.25	99.31	-9.77	0.08

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
14	7/1/1999	199.5	418.4	473.6	323.8	353.83	308.95	398.70	336.55	371.10	93.68	-5.96	-0.77
	7/15/1999	194.3	414.4	461.1	314.4	346.05	304.35	387.75	327.70	364.40	91.62	-5.54	-0.82
	8/15/1999	191.0	402.1	488.7	347.5	357.33	296.55	418.10	339.85	374.80	94.61	-8.08	-0.78
	8/31/1999	189.5	395.4	496	352.6	358.38	292.45	424.30	342.75	374.00	94.89	-8.76	-0.70
	9/15/1999	186.8	391.6	503.6	359.8	360.45	289.20	431.70	345.20	375.70	95.44	-9.47	-0.68
	9/30/1999	188.5	396.7	516	369	367.55	292.60	442.50	352.25	382.85	97.32	-9.96	-0.69
	10/15/1999	235.3	403	530.4	378.9	386.90	319.15	454.65	382.85	390.95	102.44	-9.01	-0.18
	10/31/1999	202.7	418.5	524.2	371.5	379.23	310.60	447.85	363.45	395.00	100.41	-9.12	-0.71
	11/15/1999	208.9	426.2	548.2	393.2	394.13	317.55	470.70	378.55	409.70	104.35	-10.18	-0.70
	11/30/1999	212.9	429.2	566.6	409.5	404.55	321.05	488.05	389.75	419.35	107.11	-11.10	-0.66
	12/15/1999	216.9	433.5	561.4	403.7	403.88	325.20	482.55	389.15	418.60	106.93	-10.46	-0.66
	12/31/1999	220.7	443.8	566.6	407.4	409.63	332.25	487.00	393.65	425.60	108.46	-10.28	-0.72
	3/31/2000	215.2	438.2	567.9	406.5	406.95	326.70	487.20	391.55	422.35	107.75	-10.67	-0.69
	6/30/2000	191.3	415.8	542.4	380.7	382.55	303.55	461.55	366.85	398.25	101.29	-10.50	-0.70
	6/30/2000	183.3	409.8	571	409.9	393.50	296.55	490.45	377.15	409.85	104.19	-12.89	-0.73
	1/13/2001	215.4	447.2	588.9	421.9	418.35	331.30	505.40	402.15	434.55	110.77	-11.57	-0.73
	4/20/2001	210.2	445.1	586.6	415.7	414.40	327.65	501.15	398.40	430.40	109.72	-11.53	-0.72
	7/16/2001	171.2	413	554.5	377.7	379.10	292.10	466.10	362.85	395.35	100.37	-11.56	-0.73
	10/9/2001	178.5	417.9	596.2	418.8	402.85	298.20	507.50	387.35	418.35	106.66	-13.91	-0.69
	1/9/2002	206.2	445.9	606.4	430	422.13	326.05	518.20	406.30	437.95	111.77	-12.77	-0.71
	4/12/2002	208.6	449.5	584.1	408.1	412.58	329.05	496.10	396.35	428.80	109.24	-11.10	-0.73
	7/18/2002	161.7	410.1	551.9	368.5	373.05	285.90	460.20	356.80	389.30	98.77	-11.58	-0.73
	10/7/2002	160.2	405.5	592.3	407.7	391.43	282.85	500.00	376.25	406.60	103.64	-14.43	-0.68
	1/8/2003	202	449.1	620.2	437.7	427.25	325.55	528.95	411.10	443.40	113.12	-13.52	-0.72
	4/15/2003	205.4	453.6	590	409.8	414.70	329.50	499.90	397.70	431.70	109.80	-11.32	-0.76
	7/1/2003	171.9	426.9	559.5	377.3	383.90	299.40	468.40	365.70	402.10	101.65	-11.23	-0.82
	10/7/2003	172	424.4	600.8	422.4	404.90	298.20	511.60	386.40	423.40	107.21	-14.18	-0.83
	12/31/2003	205.6	461.3	624.2	444.9	434.00	333.45	534.55	414.90	453.10	114.91	-13.36	-0.86
	4/13/2004	204.7	463.4	611.5	433.1	428.18	334.05	522.30	408.10	448.25	113.37	-12.51	-0.90
	7/13/2004	159.6	424.2	566.4	383.7	383.48	291.90	475.05	363.00	403.95	101.53	-12.17	-0.92
	10/8/2004	153	416.8	590.5	409.5	392.45	284.90	500.00	371.75	413.15	103.91	-14.30	-0.93
	1/7/2005	192.8	454.9	627.8	446.9	430.60	323.85	537.35	410.30	450.90	114.01	-14.19	-0.91
	4/8/2005	205.2	467.5	600.9	425.2	424.70	336.35	513.05	403.05	446.35	112.45	-11.74	-0.97
	7/18/2005	154.9	424.1	560.9	385.2	381.28	289.50	473.05	357.90	404.65	100.95	-12.20	-1.05
	8/26/2005	168.3	416.1	569.1	391.2	386.18	292.20	480.15	368.70	403.65	102.25	-12.49	-0.78
	10/11/2005	152.5	418.5	590.5	413.4	393.73	285.50	501.95	371.50	415.95	104.25	-14.38	-1.00
	1/10/2006	190.7	455.4	615	436.7	424.45	323.05	525.85	402.85	446.05	112.38	-13.48	-0.97
	4/9/2006	196.7	460.2	612.3	436.6	426.45	328.45	524.45	404.50	448.40	112.91	-13.03	-0.98
	7/19/2006	159.7	426.1	562.3	382.1	382.55	292.90	472.20	361.00	404.10	101.29	-11.92	-0.97
	10/18/2006	161.9	425.9	600.5	422.5	402.70	293.90	511.50	381.20	424.20	106.62	-14.46	-0.96
	1/18/2007	192.2	454.2	638.5	460	436.23	323.20	549.25	415.35	457.10	115.50	-15.02	-0.94
	4/19/2007	198.7	462.5	611.3	432	426.13	330.60	521.65	405.00	447.25	112.83	-12.70	-0.95
	7/11/2007	149.8	419.9	567.4	379.8	379.23	284.85	473.60	358.60	399.85	100.41	-12.54	-0.92
	10/20/2007	208.9	417	590.1	409	406.25	312.95	499.55	399.50	413.00	107.56	-12.40	-0.30
	1/7/2008	194.6	460.1	617.4	439.8	427.98	327.35	528.60	406.00	449.95	113.31	-13.37	-0.98
	5/13/2008	188	455	606	431.7	420.18	321.50	518.85	397.00	443.35	111.25	-13.12	-1.04
	7/29/2008	155	428.4	572.6	394	387.50	291.70	483.30	363.80	411.20	102.60	-12.73	-1.06
	10/30/2008	172.9	442.6	629.9	452.7	424.53	307.75	541.30	401.40	447.65	112.40	-15.52	-1.04
	1/12/2009	205.6	472.9	638	463.6	445.03	339.25	550.80	421.80	468.25	117.83	-14.06	-1.04
	4/24/2009	205.6	472.9	638	463.6	445.03	339.25	550.80	421.80	468.25	117.83	-14.06	-1.04

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
26	7/1/1999	222.2	-19.9	305.2	560	266.88	101.15	432.60	263.70	270.05	70.66	-22.03	-0.14
	7/15/1999	207.8	-36.8	294.3	540.9	251.55	85.50	417.60	251.05	252.05	66.60	-22.07	-0.02
	8/15/1999	189.9	-53.4	320.4	546.8	250.93	68.25	433.60	255.15	246.70	66.44	-24.28	0.19
	8/31/1999	184.8	-60	330.2	555.2	252.55	62.40	442.70	257.50	247.60	66.87	-25.27	0.22
	9/15/1999	185.7	-57.2	336.6	558.2	255.83	64.25	447.40	261.15	250.50	67.73	-25.46	0.24
	9/30/1999	187.5	-53.7	349.9	570.1	263.45	66.90	460.00	268.70	258.20	69.75	-26.12	0.24
	10/15/1999	195.3	-50.5	375.2	601.5	280.38	72.40	488.35	285.25	275.50	74.23	-27.64	0.22
	10/31/1999	197.3	-39.9	370.8	589.7	279.48	78.70	480.25	284.05	274.90	74.00	-26.69	0.20
	11/15/1999	202.5	-32.3	385.9	601.1	289.30	85.10	493.50	294.20	284.40	76.60	-27.14	0.22
	11/30/1999	206.5	-27.3	398.1	613.9	297.80	89.60	506.00	302.30	293.30	78.85	-27.67	0.20
	12/15/1999	216.1	-19.5	401.6	620.9	304.78	98.30	511.25	308.85	300.70	80.70	-27.44	0.18
	12/31/1999	223.8	-15	410.7	633.4	313.23	104.40	522.05	317.25	309.20	82.93	-27.76	0.18
	3/31/2000	203.5	-16	395.7	633.5	304.18	93.75	514.60	299.60	308.75	80.54	-27.97	-0.20
	6/30/2000	149.3	-41	371.2	553.8	258.33	54.15	462.50	260.25	256.40	68.40	-27.14	0.09
	6/30/2000	154.3	-22.3	411.5	580.2	280.93	66.00	495.85	282.90	278.95	74.38	-28.57	0.09
	1/13/2001	197.9	7.7	446.8	627.1	319.88	102.80	536.95	322.35	317.40	84.69	-28.85	0.11
	4/20/2001	167.6	1.3	434.9	589.5	298.33	84.45	512.20	301.25	295.40	78.99	-28.43	0.13
	7/16/2001	112.8	-20.6	409.7	555.1	264.25	46.10	482.40	261.25	267.25	69.97	-29.00	-0.13
	10/9/2001	136.9	-5.4	451.7	582.7	291.48	65.75	517.20	294.30	288.65	77.17	-30.00	0.13
	1/9/2002	176.6	9	461.6	618.2	316.35	92.80	539.90	319.10	313.60	83.76	-29.71	0.12
	4/12/2002	158.20	3.40	438	581.00	295.25	80.80	509.70	298.30	292.20	78.17	-28.50	0.14
	7/18/2002	86.10	-23.70	405	503.86	242.87	31.20	454.53	245.65	240.08	64.30	-28.13	0.12
	10/7/2002	96.1	2.90	445.20	562.80	276.75	49.50	504.00	270.65	282.85	73.28	-30.21	-0.27
	1/8/2003	165.9	41.91	480.40	628.48	329.17	103.91	554.44	323.15	335.20	87.16	-29.94	-0.27
	4/15/2003	147.5	33.95	455.30	592.01	307.19	90.73	523.65	301.40	312.98	81.33	-28.77	-0.26
	7/1/2003	88.2	9.66	424.1	577.30	274.82	48.93	500.70	256.15	293.48	72.76	-30.02	-0.84
	10/7/2003	103.5	24.24	466.9	574.34	292.25	63.87	520.62	285.20	299.29	77.38	-30.35	-0.32
	12/31/2003	130.5	44.68	481.6	566.95	305.93	87.59	524.27	306.05	305.81	81.00	-29.02	0.01
	4/13/2004	118.2	42.08	471.6	585.31	304.30	80.14	528.45	294.90	313.69	80.57	-29.79	-0.42
	7/13/2004	49.6	8.40	430.9	548.80	259.43	29.00	489.85	240.25	278.60	68.69	-30.63	-0.86
	10/8/2004	54.7	18.19	457.3	588.15	279.59	36.45	522.72	256.00	303.17	74.03	-32.32	-1.06
	1/7/2005	108.7	42.65	486.4	597.82	308.89	75.67	542.11	297.55	320.23	81.78	-31.00	-0.51
	4/8/2005	91.7	33.99	457.3	601.47	296.12	62.85	529.39	274.50	317.73	78.40	-31.01	-0.97
	7/18/2005	28.7	12.91	432.3	605.33	269.81	20.81	518.82	230.50	309.12	71.44	-33.10	-1.76
	8/26/2005	31.4	16.85	447.8	588.39	271.11	24.13	518.10	239.60	302.62	71.78	-32.83	-1.41
	10/11/2005	43.7	14.58	464.4	588.60	277.82	29.14	526.50	254.05	301.59	73.56	-33.05	-1.06
	1/10/2006	96.3	14.58	483.8	588.60	295.82	55.44	536.20	290.05	301.59	78.32	-31.95	-0.26
	4/9/1906	87.1	29.40	477	588.60	295.52	58.25	532.80	282.05	309.00	78.25	-31.54	-0.60
	7/19/1906	18.4	-2.90	430.9	588.60	258.75	7.75	509.75	224.65	292.85	68.51	-33.36	-1.53
	10/18/1906	61.1	14.58	483.2	588.60	286.87	37.84	535.90	272.15	301.59	75.95	-33.10	-0.66
	1/18/2007	99.2	14.58	505.9	588.60	302.07	56.89	547.25	302.55	301.59	79.98	-32.59	0.02
	4/19/2007	80.5	14.58	477.1	588.60	290.19	47.54	532.85	278.80	301.59	76.83	-32.25	-0.51
	7/11/2007	11.2	14.5768	431.3	588.5957	261.42	12.89	509.95	221.25	301.59	69.22	-33.03	-1.80
	10/20/2007	19.8	14.5768	455.1	588.5957	269.52	17.19	521.85	237.45	301.59	71.36	-33.54	-1.44
	1/7/2008	82.9	14.5768	489.6	588.5957	293.92	48.74	539.10	286.25	301.59	77.82	-32.59	-0.34
	5/13/2008	44.6	14.5768	468.8	588.5957	279.14	29.59	528.70	256.70	301.59	73.91	-33.17	-1.01
	7/29/2008	0.2	14.5768	442.8	588.5957	261.54	7.39	515.70	221.50	301.59	69.25	-33.78	-1.79
	10/30/2008	34	14.5768	495.7	588.5957	283.22	24.29	542.15	264.85	301.59	74.99	-34.42	-0.82
	1/12/2009	73.4	14.5768	498.3	588.5957	293.72	43.99	543.45	285.85	301.59	77.77	-33.19	-0.35
	4/24/2009	73.4	14.5768	498.3	588.5957	293.72	43.99	543.45	285.85	301.59	77.77	-33.19	-0.35

Table 4 Pile Forces and Bending Moments

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
1	07/01/99	903.00	42.30	679.00	-	541.43	472.65	679.00	791.00	42.30	456.92	-73.98	99.88
	07/15/99	918.00	48.00	885.00	-	617.00	483.00	885.00	901.50	48.00	520.69	-144.12	113.86
	07/31/00	932.43	51.99	887.34	-	623.92	492.21	887.34	909.89	51.99	526.53	-141.66	114.44
	08/15/99	940.56	34.46	923.00	-	632.67	487.51	923.00	931.78	34.46	533.91	-156.13	119.70
	08/30/99	948.68	31.28	931.09	-	637.02	489.98	931.09	939.89	31.28	537.58	-158.14	121.21
	09/15/99	955.75	27.83	938.36	-	640.65	491.79	938.36	947.06	27.83	540.64	-160.10	122.62
	09/30/99	959.08	23.03	947.01	-	643.04	491.06	947.01	953.05	23.03	542.66	-163.47	124.06
	10/15/99	963.38	18.85	954.86	-	645.70	491.12	954.86	959.12	18.85	544.90	-166.26	125.43
	10/31/99	973.25	5.58	968.30	-	649.04	489.42	968.30	970.78	5.58	547.73	-171.69	128.76
	11/15/99	973.34	1.26	977.48	-	650.69	487.30	977.48	975.41	1.26	549.12	-175.74	129.95
	11/30/99	975.73	-2.84	980.87	-	651.25	486.45	980.87	978.30	-2.84	549.59	-177.26	130.88
	12/15/99	974.96	-2.47	982.11	-	651.53	486.25	982.11	978.54	-2.47	549.83	-177.77	130.87
	12/31/99	974.03	-54.00	984.71		634.91	460.02	984.71	979.37	-54.00	535.80	-188.11	137.85
	03/31/00	964.52	3.86	981.83	-	650.07	484.19	981.83	973.17	3.86	548.59	-178.41	129.31
	06/30/00	977.80	-36.92	980.73	-	640.54	470.44	980.73	979.27	-36.92	540.55	-182.94	135.56
	09/30/00	1009.20	-10.20	1005.99	-	668.33	499.50	1005.99	1007.60	-10.20	564.01	-181.58	135.77
	01/13/01	1014.12	-29.4495	1029.11	-	671.26	492.33	1029.11	1021.61	-29.45	566.48	-192.44	140.21
	04/20/01	1008.27	-18.6852	1022.57	-	670.72	494.79	1022.57	1015.42	-18.69	566.02	-189.21	137.95
	07/10/01	1030.41	-8.36772	1019.56	-	680.53	511.02	1019.56	1024.98	-8.37	574.30	-182.32	137.85
	10/09/01	1054.25	-20.5131	1038.65	-	690.80	516.87	1038.65	1046.45	-20.51	582.96	-187.07	142.33
	01/09/02	1055.96	-29.65	1045.80	-	690.70	513.15	1045.80	1050.88	-29.65	582.88	-190.96	144.14
	04/12/02	1041.9	-24.8188	1040.36	-	685.81	508.54	1040.36	1041.13	-24.82	578.76	-190.66	142.20
	07/19/02	1062.21	-17.26	1035.12	17.14	693.36	522.47	1035.12	1048.67	-17.26	585.12	-183.79	142.20
	10/08/02	1086.38	-30.07	1049.75	-6.63	702.02	528.16	1049.75	1068.06	-30.07	592.43	-187.00	146.49
	01/08/03	1080.45	-42.89	1062.94	0.41	700.17	518.78	1062.94	1071.70	-42.89	590.87	-195.09	148.69
	04/15/03	1059.37	-29.65	1049.86	22.95	693.19	514.86	1049.86	1054.62	-29.65	584.99	-191.81	144.64
	06/01/03	1064.93	-31.16	1053.52	21.00	695.77	516.89	1053.52	1059.23	-31.16	587.16	-192.39	145.46
	08/07/03	1083.86	-27.66	1053.40	9.26	703.20	528.10	1053.40	1068.63	-27.66	593.43	-188.33	146.25
	10/07/03	1095.56	-38.67	1066.64	-0.69	707.84	528.45	1066.64	1081.10	-38.67	597.35	-192.95	149.38
	12/31/03	1100.15	-54.88	1082.97	-0.89	709.41	522.64	1082.97	1091.56	-54.88	598.68	-200.89	152.93
	04/13/04	1080.17	-43.67	1074.07	21.65	703.52	518.25	1074.07	1077.12	-43.67	593.70	-199.27	149.51
	07/13/04	1101.53	-34.89	1072.49	10.76	713.04	533.32	1072.49	1087.01	-34.89	601.74	-193.30	149.66
	10/08/04	1122.82	-45.70	1085.57	-8.86	720.90	538.56	1085.57	1104.19	-45.70	608.36	-196.11	153.40
	01/07/05	1116.60	-58.49	1097.39	-8.94	718.50	529.06	1097.39	1107.00	-58.49	606.34	-203.76	155.48
	04/08/05	1099.01	-52.77	1096.58	5.48	714.28	523.12	1096.58	1097.80	-52.77	602.78	-205.59	153.49
	07/18/05	1116.44	-41.55	1096.58	-2.36	723.82	537.44	1096.58	1106.51	-41.55	610.83	-200.46	153.15
	08/26/05	1128.14	-43.63	1095.73	-10.20	726.75	542.26	1095.73	1111.93	-43.63	613.30	-198.43	154.15
	11/12/05	1127.45	-44.76	1095.72	-9.67	726.14	541.34	1095.72	1111.58	-44.76	612.79	-198.75	154.26
	01/10/06	1129.36	-64.30	1095.72	-19.70	720.26	532.53	1095.72	1112.54	-64.30	607.83	-201.91	156.99
	04/09/06	1114.90	-55.20	1095.72	-1.14	718.47	529.85	1095.72	1105.31	-55.20	606.32	-202.87	154.81
	07/19/06	1130.94	-46.83	1095.72	-9.42	726.61	542.05	1095.72	1113.33	-46.83	613.19	-198.50	154.77
	10/18/06	1154.91	-58.29	1095.72	-27.50	730.78	548.31	1095.72	1125.32	-58.29	616.71	-196.26	157.89
	01/18/07	1139.55	-68.49	1095.72	-21.73	722.26	535.53	1095.72	1117.64	-68.49	609.52	-200.84	158.23
	04/19/07	1125.58	-58.82	1095.72	-8.49	720.83	533.38	1095.72	1110.65	-58.82	608.31	-201.61	156.01
	07/09/07	1141.38	-47.08	1095.72	-16.09	730.01	547.15	1095.72	1118.55	-47.08	616.05	-196.67	155.50
	10/20/07	1161.81	-62.03	1095.72	-36.23	731.84	549.89	1095.72	1128.77	-62.03	617.60	-195.69	158.85
	01/07/08	1155.60	-68.08	1095.72	-28.03	727.75	543.76	1095.72	1125.66	-68.08	614.15	-197.89	159.24
	05/13/08	1100.48	-46.92	1095.72	7.39	716.43	526.78	1095.72	1098.10	-46.92	604.59	-203.97	152.75
	07/29/08	1158.20	-57.76	1095.72	-17.10	732.05	550.22	1095.72	1126.96	-57.76	617.78	-195.57	158.04
	10/30/08	1172.74	-73.81	1095.72	-23.97	731.55	549.47	1095.72	1134.23	-73.81	617.36	-195.84	161.15
	01/12/09	1163.28	-77.95	1095.72	-8.29	727.02	542.66	1095.72	1129.50	-77.95	613.53	-198.28	161.07
	04/24/09	1152.80	-63.12	1095.72	5.40	728.47	544.84	1095.72	1124.26	-63.12	614.75	-197.50	158.40

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
17	07/01/99	575.00	589.00	243.00	-	469.00	582.00	243.00	409.00	589.00	395.79	121.54	-24.01
	07/15/99	585.00	602.00	237.00	-	474.67	593.50	237.00	411.00	602.00	400.57	127.81	-25.48
	07/30/99	594.35	611.17	230.68	-	478.73	602.76	230.68	412.52	611.17	404.00	133.40	-26.50
	08/15/99	596.87	611.09	242.58	336.68	446.81	603.98	289.63	419.73	473.89	377.06	112.70	-7.22
	08/31/99	601.58	616.82	241.00	-	486.47	609.20	241.00	421.29	616.82	410.53	132.00	-26.08
	09/15/99	605.96	622.42	240.47	-	489.62	614.19	240.47	423.22	622.42	413.19	133.98	-26.57
	09/30/99	609.62	624.20	240.71	336.98	452.88	616.91	288.85	425.17	480.59	382.18	117.62	-7.39
	10/15/99	612.87	629.40	240.27	336.21	454.69	621.14	288.24	426.57	482.81	383.71	119.35	-7.50
	10/31/99	616.45	631.80	243.11	336.29	456.91	624.13	289.70	429.78	484.05	385.59	119.90	-7.24
	11/15/99	619.54	632.45	245.83	337.79	458.90	626.00	291.81	432.69	485.12	387.27	119.81	-6.99
	11/30/99	623.35	635.58	248.71	340.31	461.99	629.47	294.51	436.03	487.95	389.87	120.09	-6.93
	12/15/99	624.21	637.77	247.77	339.95	462.43	630.99	293.86	435.99	488.86	390.24	120.87	-7.05
	12/31/99	626.60	640.86	249.37	341.45	464.57	633.73	295.41	437.99	491.16	392.05	121.29	-7.09
	03/31/00	634.53	648.30	254.69	346.89	471.10	641.41	300.79	444.61	497.60	397.56	122.12	-7.07
	06/30/00	640.05	652.80	250.99	342.06	471.48	646.43	296.53	445.52	497.43	397.88	125.44	-6.93
	09/30/00	647.16	661.13	247.62	336.78	473.17	654.14	292.20	447.39	498.96	399.31	129.76	-6.88
	01/13/01	654.063	665.1119	256.39	342.22	479.45	659.59	299.31	455.23	503.67	404.61	129.16	-6.46
	04/20/01	654.429	664.7057	260.37	345.47	481.25	659.57	302.92	457.40	505.09	406.12	127.86	-6.36
	07/10/01	661.456	672.0985	256.15	342.75	483.11	666.78	299.45	458.80	507.43	407.70	131.69	-6.49
	10/09/01	668.361	679.0039	251.93	338.20	484.37	673.68	295.06	460.14	508.60	408.76	135.74	-6.46
	01/09/02	671.083	683.4721	252.17	337.92	486.16	677.28	295.04	461.63	510.69	410.27	137.04	-6.55
	04/12/02	669.17	680.02	256.68	342.06	486.98	674.60	299.37	462.93	511.04	410.96	134.52	-6.42
	07/19/02	671.69	683.96	253.27	272.93	470.46	677.83	263.10	462.48	478.44	397.02	148.69	-2.13
	10/08/02	678.60	692.21	247.01	332.37	487.54	685.40	289.69	462.80	512.29	411.44	141.87	-6.60
	01/08/03	678.44	689.32	251.28	334.22	488.31	683.88	292.75	464.86	511.77	412.09	140.22	-6.26
	04/15/03	679.45	692.45	254.73	341.09	491.93	685.95	297.91	467.09	516.77	415.14	139.12	-6.63
	06/01/03	678.76	689.85	256.43	341.09	491.53	684.30	298.76	467.60	515.47	414.80	138.22	-6.39
	08/07/03	682.33	695.54	251.15	336.74	491.44	688.94	293.95	466.74	516.14	414.73	141.61	-6.59
	10/07/03	686.23	700.57	250.14	334.87	492.95	693.40	292.50	468.19	517.72	416.00	143.73	-6.61
	12/31/03	689.48	700.61	257.04	341.05	497.05	695.05	299.04	473.26	520.83	419.46	141.97	-6.35
	04/13/04	689.24	699.88	260.70	346.65	499.12	694.56	303.68	474.97	523.27	421.21	140.14	-6.44
	07/13/04	693.10	667.59	255.46	341.33	489.37	680.34	298.39	474.28	504.46	412.98	136.93	-4.03
	10/08/04	699.03	710.89	250.83	337.39	499.53	704.96	294.11	474.93	524.14	421.56	147.30	-6.56
	01/07/05	699.07	711.46	253.31	339.95	500.95	705.26	296.63	476.19	525.70	422.75	146.50	-6.61
	04/08/05	696.43	708.09	257.94	343.81	501.57	702.26	300.87	477.18	525.95	423.27	143.90	-6.51
	07/18/05	699.56	708.33	253.71	338.36	499.99	703.94	296.04	476.64	523.35	421.94	146.24	-6.23
	08/26/05	702.04	711.17	250.91	335.97	500.02	706.61	293.44	476.47	523.57	421.97	148.13	-6.28
	11/12/05	701.95	699.60	251.68	337.06	497.57	700.78	294.37	476.82	518.33	419.90	145.70	-5.54
	01/10/06	705.16	715.03	253.47	339.58	503.31	710.10	296.53	479.32	527.31	424.75	148.27	-6.40
	04/09/06	703.94	713.04	259.52	343.20	504.93	708.49	301.36	481.73	528.12	426.11	145.96	-6.19
	07/19/06	708.37	716.01	256.84	339.95	505.29	712.19	298.39	482.61	527.98	426.42	148.35	-6.05
	10/18/06	713.29	721.25	251.76	334.02	505.08	717.27	292.89	482.52	527.63	426.24	152.14	-6.02
	01/18/07	712.84	717.96	256.52	336.54	505.96	715.40	296.53	484.68	527.25	426.98	150.17	-5.68
	04/19/07	711.13	716.21	260.62	340.56	507.13	713.67	300.59	485.88	528.38	427.97	148.10	-5.67
	07/09/07	713.04	716.74	255.22	334.18	504.79	714.89	294.70	484.13	525.46	426.00	150.64	-5.51
	10/20/07	715.97	721.74	250.87	329.51	504.52	718.85	290.19	483.42	525.62	425.77	153.68	-5.63
	01/07/08	719.26	723.93	256.47	335.12	508.69	721.59	295.79	487.87	529.52	429.29	152.65	-5.56
	05/13/08	696.51	707.19	257.94	343.56	501.30	701.85	300.75	477.22	525.38	423.05	143.80	-6.42
	07/29/08	720.07	723.56	259.40	335.76	509.70	721.82	297.58	489.74	529.66	430.14	152.09	-5.33
	10/30/08	723.81	727.50	255.66	332.68	509.91	725.66	294.17	489.74	530.09	430.32	154.69	-5.38
	01/12/09	723.20	727.59	259.07	336.66	511.63	725.39	297.87	491.14	532.12	431.76	153.27	-5.47
	04/24/09	722.67	727.02	262.49	324.47	509.16	724.84	293.48	492.58	525.74	429.68	154.65	-4.42

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
18	07/01/99	546.00	501.00	248.00	173	367.00	523.50	210.50	397.00	337.00	309.71	112.21	8.00
	07/15/99	557.00	513.00	243.00	229	385.50	535.00	236.00	400.00	371.00	325.32	107.20	3.87
	07/30/99	565.55	519.94	239.54	224.26	387.32	542.75	231.90	402.55	372.10	326.86	111.44	4.06
	08/15/99	567.71	520.14	230.56	232.51	387.73	543.93	231.54	399.14	376.33	327.21	112.00	3.04
	08/31/99	573.72	526.52	247.46	232.87	395.14	550.12	240.17	410.59	379.70	333.46	111.12	4.12
	09/15/99	578.06	532.08	246.65	233.61	397.60	555.07	240.13	412.36	382.85	335.53	112.91	3.94
	09/30/99	582.49	534.97	247.46	234.05	399.74	558.73	240.76	414.98	384.51	337.34	114.00	4.06
	10/15/99	586.68	538.17	247.25	235.23	401.83	562.43	241.24	416.97	386.70	339.11	115.15	4.04
	10/31/99	590.77	539.40	249.37	235.6	403.79	565.09	242.49	420.07	387.50	340.75	115.66	4.34
	11/15/99	592.65	540.65	251.68	237.47	405.61	566.65	244.58	422.17	389.06	342.30	115.47	4.42
	11/30/99	596.63	527.25	254.12	239.69	404.42	561.94	246.91	425.38	383.47	341.29	112.94	5.59
	12/15/99	599.47	545.53	254.12	239.05	409.54	572.50	246.59	426.80	392.29	345.61	116.84	4.60
	12/31/99	601.54	548.45	255.38	239.17	411.14	575.00	247.28	428.46	393.81	346.96	117.49	4.62
	03/31/00	610.32	554.87	262.08	243.60	417.72	582.59	252.84	436.20	399.23	352.51	118.22	4.93
	06/30/00	616.94	539.60	260.98	238.93	414.11	578.27	249.96	438.96	389.26	349.47	117.70	6.63
	09/30/00	625.63	400.76	255.58	232.18	378.54	513.19	243.88	440.61	316.47	319.45	96.55	16.56
	01/13/01	632.372	566.6896	264.44	235.84	424.83	599.53	250.14	448.40	401.26	358.52	125.26	6.29
	04/20/01	632.575	561.5309	268.38	236.21	424.67	597.05	252.29	450.48	398.87	358.38	123.60	6.88
	07/10/01	639.684	569.2893	264.64	234.54	427.04	604.49	249.59	452.16	401.91	360.38	127.23	6.70
	10/09/01	646.508	576.5197	259.81	232.14	428.74	611.51	245.97	453.16	404.33	361.82	131.05	6.51
	01/09/02	650.895	576.8446	259.68	230.92	429.59	613.87	245.30	455.29	403.88	362.53	132.14	6.86
	04/12/02	650.123	570.1017	264.192	232.55	429.24	610.11	248.37	457.16	401.33	362.24	129.69	7.45
	07/19/02	653.45	572.46	260.90	226.38	428.30	612.96	243.64	457.18	399.42	361.44	132.40	7.71
	10/08/02	659.69	581.14	254.65	222.68	429.54	620.41	238.66	457.17	401.91	362.49	136.86	7.37
	01/08/03	657.76	576.89	257.57	224.47	429.17	617.32	241.02	457.67	400.68	362.18	134.91	7.60
	04/15/03	661.78	576.19	262.16	228.04	432.04	618.99	245.10	461.97	402.12	364.60	134.04	7.98
	06/01/03	661.37	572.66	264.07	227.59	431.43	617.02	245.83	462.72	400.13	364.08	133.07	8.35
	08/07/03	665.76	577.29	258.18	222.76	431.00	621.53	240.47	461.97	400.03	363.72	136.61	8.26
	10/07/03	669.26	582.73	256.11	222.56	432.66	625.99	239.33	462.68	402.65	365.13	138.62	8.01
	12/31/03	670.27	581.39	262.53	229.62	435.95	625.83	246.08	466.40	405.51	367.90	136.15	8.12
	04/13/04	669.42	576.64	266.47	232.35	436.22	623.03	249.41	467.94	404.49	368.12	133.95	8.46
	07/13/04	672.95	578.63	261.80	224.79	434.54	625.79	243.29	467.37	401.71	366.71	137.13	8.76
	10/08/04	677.95	587.12	255.42	222.31	435.70	632.53	238.87	466.68	404.72	367.69	141.14	8.27
	01/07/05	677.50	586.02	257.61	226.05	436.80	631.76	241.83	467.56	406.04	368.61	139.80	8.21
	04/08/05	674.17	580.83	263.14	227.80	436.48	627.50	245.47	468.65	404.31	368.35	136.96	8.58
	07/18/05	677.87	580.70	259.40	221.74	434.93	629.29	240.57	468.63	401.22	367.04	139.36	8.99
	08/26/05	679.25	583.30	256.27	219.43	434.56	631.28	237.85	467.76	401.37	366.73	141.05	8.86
	11/12/05	679.13	583.14	256.88	220.08	434.81	631.13	238.48	468.00	401.61	366.93	140.77	8.86
	01/10/06	679.45	587.32	257.33	223.00	436.78	633.39	240.17	468.39	405.16	368.60	140.97	8.43
	04/09/06	679.57	583.14	263.01	226.46	438.05	631.36	244.74	471.29	404.80	369.67	138.61	8.87
	07/19/06	683.27	585.78	260.94	222.31	438.08	634.53	241.63	472.11	404.05	369.69	140.86	9.08
	10/18/06	687.01	592.40	255.09	218.66	438.29	639.70	236.88	471.05	405.53	369.87	144.42	8.74
	01/18/07	685.10	588.58	259.16	221.83	438.67	636.84	240.49	472.13	405.20	370.19	142.10	8.93
	04/19/07	685.18	584.40	264.40	222.96	439.23	634.79	243.68	474.79	403.68	370.67	140.22	9.49
	07/09/07	687.74	584.85	259.24	215.85	436.92	636.29	237.55	473.49	400.35	368.72	142.96	9.76
	10/20/07	690.01	591.22	253.79	213.46	437.12	640.62	233.63	471.90	402.34	368.89	145.91	9.28
	01/07/08	691.80	593.86	258.30	218.94	440.73	642.83	238.62	475.05	406.40	371.93	144.91	9.16
	05/13/08	675.23	578.71	263.42	226.74	436.03	626.97	245.08	469.32	402.73	367.96	136.91	8.88
	07/29/08	694.93	590.45	261.06	217.03	440.87	642.69	239.05	478.00	403.74	372.05	144.71	9.91
	10/30/08	696.63	596.14	256.52	215.81	441.28	646.39	236.16	476.57	405.98	372.39	147.07	9.42
	01/12/09	695.50	595.73	258.34	219.55	442.28	645.61	238.95	476.92	407.64	373.24	145.80	9.24
	04/24/09	696.39	592.69	262.28	221.66	443.26	644.54	241.97	479.34	407.17	374.06	144.32	9.63

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
19	07/01/99	566.97	586.00	298.00	228.9	419.97	576.49	263.45	432.49	407.45	354.41	112.23	3.34
	07/15/99	580.00	597.00	294.00	224	423.75	588.50	259.00	437.00	410.50	357.60	118.13	3.54
	07/30/99	588.71	606.46	291.38	218.62	426.29	597.59	255.00	440.05	412.54	359.75	122.82	3.67
	08/15/99	591.02	607.35	300.95	227.92	431.81	599.19	264.44	445.99	417.64	364.40	120.01	3.78
	08/31/99	595.94	613.52	300.59	229.63	434.92	604.73	265.11	448.27	421.58	367.03	121.76	3.56
	09/15/99	599.88	617.91	300.67	229.54	437.00	608.90	265.11	450.28	423.73	368.78	123.25	3.54
	09/30/99	603.53	621.65	302.70	229.75	439.41	612.59	266.23	453.12	425.70	370.82	124.18	3.66
	10/15/99	607.51	625.02	302.29	229.71	441.13	616.27	266.00	454.90	427.37	372.27	125.57	3.67
	10/31/99	611.37	627.25	306.07	229.7	443.60	619.31	267.89	458.72	428.48	374.35	125.99	4.03
	11/15/99	613.61	627.78	308.31	232.67	445.59	620.70	270.49	460.96	430.23	376.04	125.55	4.10
	11/30/99	616.29	630.54	313.83	234.7	448.84	623.42	274.27	465.06	432.62	378.78	125.17	4.33
	12/15/99	617.83	631.44	314.03	234.9	449.55	624.64	274.47	465.93	433.17	379.38	125.54	4.37
	12/31/99	619.94	634.20	314.36	236.45	451.24	627.07	275.41	467.15	435.33	380.80	126.08	4.25
	03/31/00	629.45	639.44	320.33	239.74	457.24	634.44	280.03	474.89	439.59	385.86	127.06	4.71
	06/30/00	636.15	643.50	317.81	51.91	412.34	639.83	184.86	476.98	347.71	347.98	163.11	17.25
	09/30/00	646.59	651.99	312.33	231.29	460.55	649.29	271.81	479.46	441.64	388.66	135.33	5.04
	01/13/01	653.454	657.0691	320.21	236.77	466.88	655.26	278.49	486.83	446.92	394.00	135.08	5.32
	04/20/01	651.464	653.2102	324.03	237.42	466.53	652.34	280.72	487.74	445.32	393.71	133.23	5.66
	07/10/01	658.856	661.1717	320.61	235.03	468.92	660.01	277.82	489.74	448.10	395.72	137.02	5.55
	10/09/01	667.346	669.2551	315.37	230.97	470.74	668.30	273.17	491.36	450.11	397.25	141.66	5.50
	01/09/02	670.88	671.7736	315.66	229.71	472.00	671.33	272.68	493.27	450.74	398.32	142.92	5.67
	04/12/02	667.71	665.64	321.06	231.62	471.51	666.68	276.34	494.39	448.63	397.90	139.94	6.10
	07/19/02	673.44	667.87	319.88	227.72	472.23	670.66	273.80	496.66	447.79	398.51	142.28	6.52
	10/08/02	681.93	676.18	313.24	222.91	473.56	679.05	268.07	497.58	449.54	399.64	147.34	6.41
	01/08/03	682.42	673.60	316.88	225.03	474.48	678.01	270.96	499.65	449.32	400.42	145.93	6.71
	04/15/03	686.11	672.95	321.26	228.37	477.17	679.53	274.81	503.69	450.66	402.69	145.10	7.07
	06/01/03	685.30	670.80	322.48	227.84	476.60	678.05	275.16	503.89	449.32	402.21	144.44	7.28
	08/07/03	689.12	675.35	317.28	223.09	476.21	682.23	270.18	503.20	449.22	401.87	147.72	7.20
	10/07/03	694.48	681.03	314.64	222.27	478.11	687.76	268.46	504.56	451.65	403.47	150.32	7.06
	12/31/03	695.94	680.95	322.73	229.34	482.24	688.45	276.03	509.33	455.15	406.96	147.86	7.23
	04/13/04	695.62	676.77	330.77	231.41	483.64	686.19	281.09	513.19	454.09	408.15	145.23	7.88
	07/13/04	700.37	679.61	327.88	224.22	483.02	689.99	276.05	514.13	451.92	407.62	148.40	8.30
	10/08/04	706.18	688.67	321.87	221.22	484.48	697.43	271.54	514.03	454.94	408.86	152.68	7.88
	01/07/05	705.37	688.14	324.72	224.55	485.69	696.75	274.63	515.04	456.35	409.88	151.34	7.83
	04/08/05	702.85	682.86	329.75	226.66	485.53	692.86	278.21	516.30	454.76	409.74	148.66	8.21
	07/18/05	706.50	683.55	327.15	219.55	484.19	695.03	273.35	516.83	451.55	408.61	151.18	8.71
	08/26/05	708.05	686.48	322.81	217.89	483.80	697.26	270.35	515.43	452.18	408.28	153.05	8.44
	11/12/05	707.97	686.27	323.74	218.33	484.08	697.12	271.04	515.85	452.30	408.51	152.76	8.48
	01/10/06	710.04	690.54	324.68	221.62	486.72	700.29	273.15	517.36	456.08	410.74	153.13	8.17
	04/09/06	709.47	686.72	329.75	224.34	487.57	698.10	277.05	519.61	455.53	411.46	150.95	8.55
	07/19/06	714.26	690.38	328.09	220.57	488.32	702.32	274.33	521.17	455.47	412.10	153.44	8.76
	10/18/06	718.93	696.80	321.91	216.75	488.60	707.86	269.33	520.42	456.77	412.33	157.22	8.49
	01/18/07	717.19	692.98	326.63	219.88	489.17	705.08	273.25	521.91	456.43	412.81	154.82	8.73
	04/19/07	716.98	689.52	331.50	221.54	489.89	703.25	276.52	524.24	455.53	413.42	152.99	9.17
	07/09/07	720.64	690.13	327.60	214.47	488.21	705.39	271.04	524.12	452.30	412.00	155.72	9.58
	10/20/07	723.97	695.70	321.18	211.96	488.20	709.83	266.57	522.58	453.83	411.99	158.92	9.17
	01/07/08	725.43	698.46	326.71	217.89	492.12	711.95	272.30	526.07	458.17	415.30	157.62	9.06
	05/13/08	703.58	681.44	330.20	225.12	485.08	692.51	277.66	516.89	453.28	409.36	148.73	8.49
	07/29/08	728.03	696.92	329.23	216.75	492.73	712.47	272.99	528.63	456.83	415.82	157.56	9.58
	10/30/08	730.876	701.5886	324.269	216.383	493.28	716.23	270.33	527.57	458.99	416.28	159.86	9.15
	01/12/09	729.576	702.3198	327.478	220.079	494.86	715.95	273.78	528.53	461.20	417.62	158.52	8.98
	04/24/09	729.901	699.3545	332.393	220.851	495.62	714.63	276.62	531.15	460.10	418.26	157.03	9.48

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
34	07/01/99	271.75	436.00	261.00	583.00	387.94	353.88	422.00	266.38	509.50	327.38	-24.42	-32.43
	07/15/99	279.00	617.00	253.00	583.00	433.00	448.00	418.00	266.00	600.00	365.41	10.76	-44.56
	07/30/99	282.79	647.00	243.64	585.13	439.64	464.90	414.39	263.22	616.07	371.01	18.11	-47.07
	08/15/99	272.89	690.09	251.16	614.66	457.20	481.49	432.91	262.03	652.38	385.83	17.42	-52.07
	08/31/99	265.66	576.80	245.14	627.09	428.67	421.23	436.12	255.40	601.95	361.76	-5.34	-46.23
	09/15/99	265.08	802.81	242.34	635.26	486.37	533.95	438.80	253.71	719.04	410.45	34.11	-62.07
	09/30/99	260.50	807.40	238.64	642.65	487.30	533.95	440.65	249.57	725.03	411.23	33.45	-63.43
	10/15/99	256.43	811.14	234.46	648.58	487.65	533.79	441.52	245.45	729.86	411.53	33.08	-64.62
	10/31/99	240.47	824.02	221.62	665.31	487.86	532.25	443.47	231.05	744.67	411.70	31.83	-68.52
	11/15/99	241.93	831.45	224.75	676.77	493.73	536.69	450.76	233.34	754.11	416.65	30.81	-69.47
	11/31/99	240.47	835.88	224.26	648.85	487.37	538.18	436.56	232.37	742.37	411.29	36.43	-68.03
	12/15/99	241.41	836.77	222.35	684.04	496.14	539.09	453.20	231.88	760.41	418.69	30.79	-70.51
	12/31/99	242.22	836.08	224.14	684.93	496.84	539.15	454.54	233.18	760.51	419.29	30.34	-70.35
	03/31/00	257.37	828.85	237.38	675.92	499.88	543.11	456.65	247.38	752.38	421.85	31.00	-67.37
	06/30/00	266.43	846.32	225.20	500.93	459.72	556.37	363.06	245.81	673.62	387.96	69.30	-57.07
	09/30/00	257.37	895.02	196.89	705.00	513.57	576.19	450.94	227.13	800.01	433.40	44.90	-76.42
	01/13/01	247.90	856.11	197.37	729.58	507.74	552.01	463.47	222.64	792.84	428.48	31.74	-76.07
	04/20/01	44.66	883.01	212.28	457.21	399.29	463.83	334.74	128.47	670.11	336.96	46.28	-72.25
	07/10/01	-279.94	502.86	204.24	66.21	123.34	111.46	135.22	-37.85	284.53	104.09	-8.52	-43.01
	10/09/01	442.16	725.37	50.98	1199.89	604.60	583.76	625.44	246.57	962.63	510.22	-14.94	-95.52
	01/09/02	263.63	616.73	159.27	765.05	451.17	440.18	462.16	211.45	690.89	380.74	-7.88	-63.96
	04/12/02	67.35	579.97	58.13	501.01	301.61	323.66	279.57	62.74	540.49	254.53	15.81	-63.73
	07/19/02	288.69	941.04	187.83	727.59	536.29	614.86	457.71	238.26	834.31	452.57	56.34	-79.51
	10/08/02	277.15	962.54	162.58	740.98	535.81	619.84	451.78	219.86	851.76	452.17	60.25	-84.29
	01/08/03	256.07	949.53	162.24	758.66	531.62	602.80	460.45	209.15	854.10	448.64	51.04	-86.04
	04/15/03	277.19	928.37	189.53	744.52	534.90	602.78	467.03	233.36	836.45	451.41	48.67	-80.45
	06/01/03	277.96	939.01	184.90	749.68	537.89	608.49	467.29	231.43	844.35	453.93	50.62	-81.76
	08/07/03	288.69	965.09	171.66	750.09	543.88	626.89	460.87	230.17	857.59	458.98	59.52	-83.70
	10/07/03	274.96	978.21	155.53	762.84	542.89	626.58	459.19	215.25	870.53	458.14	60.01	-87.41
	12/31/03	258.26	983.57	156.83	795.22	548.47	620.92	476.03	207.55	889.40	462.86	51.95	-90.96
	04/13/04	281.17	960.30	188.88	781.65	553.00	620.73	485.27	235.03	870.97	466.68	48.57	-84.84
	07/13/04	302.86	991.98	173.93	772.27	560.26	647.42	473.10	238.40	882.12	472.80	62.50	-85.87
	10/08/04	295.63	1004.49	151.19	786.40	559.43	650.06	468.80	223.41	895.45	472.10	64.99	-89.65
	01/07/05	277.35	997.91	148.79	798.02	555.52	637.63	473.41	213.07	897.97	468.80	58.88	-91.36
	04/08/05	286.74	978.21	166.99	788.76	555.17	632.47	477.87	226.86	883.49	468.51	55.43	-87.59
	07/18/05	304.00	1000.02	160.94	783.60	562.14	652.01	472.27	232.47	891.81	474.39	64.44	-87.96
	08/26/05	301.85	1018.4	147.73	791.81	564.94	660.12	469.77	224.79	905.09	476.76	68.24	-90.75
	11/12/05	300.51	1018.3	147.82	793.35	564.99	659.40	470.58	224.16	905.83	476.80	67.70	-90.93
	01/10/06	274.59	1009.41	138.15	808.34	557.62	642.00	473.24	206.37	908.87	470.58	60.50	-93.71
	04/09/06	283.04	986.09	160.45	798.02	556.90	634.57	479.23	221.74	892.06	469.97	55.69	-89.42
	07/19/06	295.67	1009.41	149.73	796.56	562.84	652.54	473.14	222.70	902.98	474.98	64.32	-90.75
	10/18/06	284.79	1030.77	131.20	808.38	563.79	657.78	469.79	207.99	919.58	475.78	67.40	-94.92
	01/18/07	270.29	1012.82	134.82	813.33	557.81	641.55	474.08	202.55	913.08	470.74	60.04	-94.78
	04/19/07	282.35	996.04	153.99	805.37	559.44	639.20	479.68	218.17	900.71	472.11	57.19	-91.05
	07/09/07	306.44	1014.48	154.64	795.38	567.74	660.46	475.01	230.54	904.93	479.11	66.49	-89.96
	10/20/07	290.51	1037.35	126.69	809.72	566.07	663.93	468.21	208.60	923.54	477.71	70.17	-95.37
	01/07/08	274.06	1024.92	128.89	820.48	562.09	649.49	474.69	201.48	922.70	474.35	62.67	-96.21
	05/13/08	292.26	978.90	169.79	784.94	556.47	635.58	477.37	231.03	881.92	469.61	56.72	-86.83
	07/29/08	293.44	1034.59	136.97	816.54	570.39	664.02	476.76	215.20	925.57	481.35	67.13	-94.76
	10/30/08	272.32	1053.97	115.20	839.53	570.25	663.14	477.37	193.76	946.75	481.24	66.60	-100.45
	01/12/09	261.92	1033.74	121.25	842.38	564.82	647.83	481.81	191.58	938.06	476.65	59.52	-99.58
	04/24/09	280.03	1016.80	140.55	827.06	566.11	648.42	483.80	210.29	921.93	477.74	59.02	-94.93

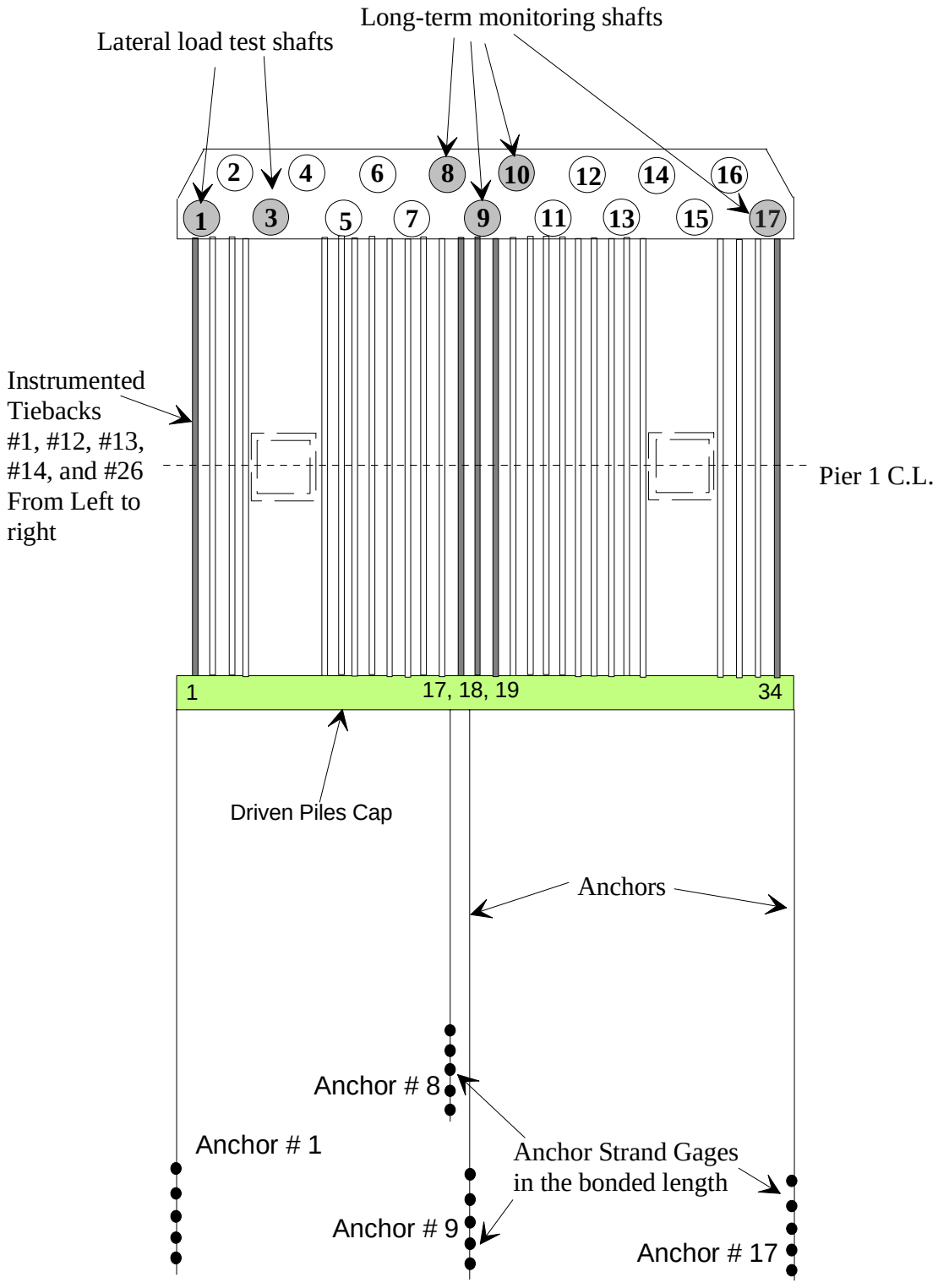


Fig.1 Plan view of the entire stabilization system and the locations of instrumented foundation elements.

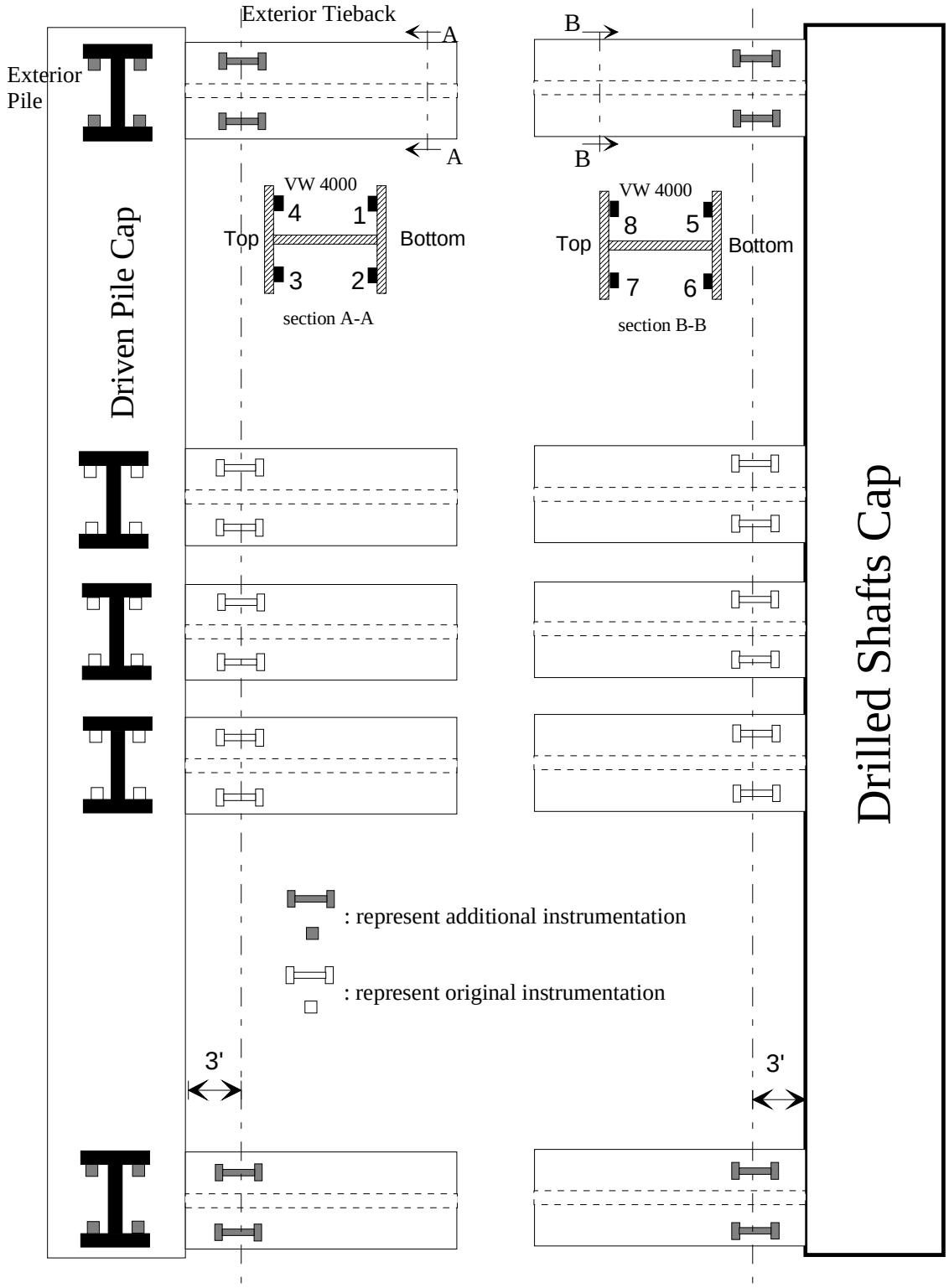


Fig. 2 Instrumentation of tie-beams for long term monitoring

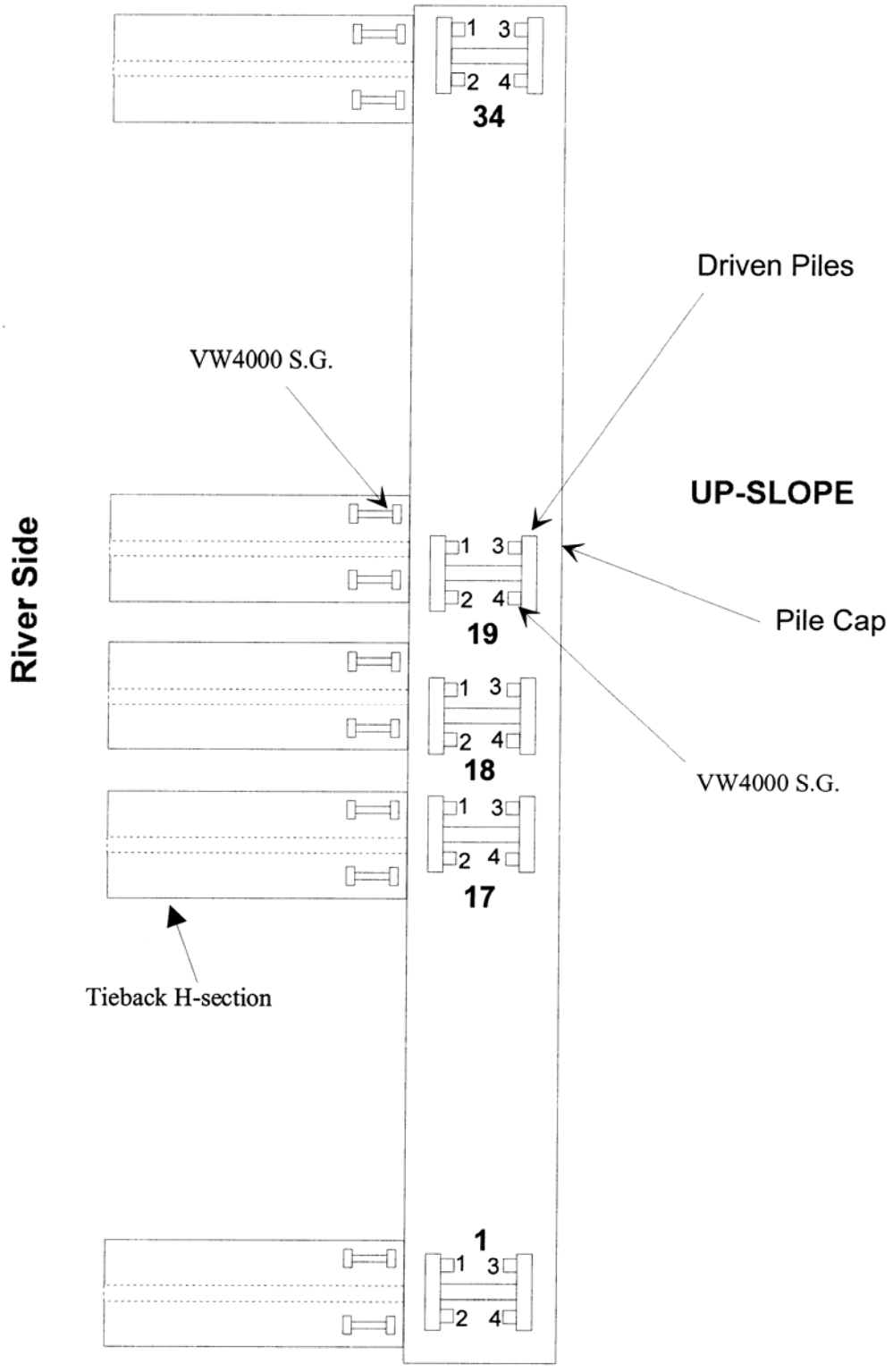


Fig.3 Schematic of gage locations on the driven piles.

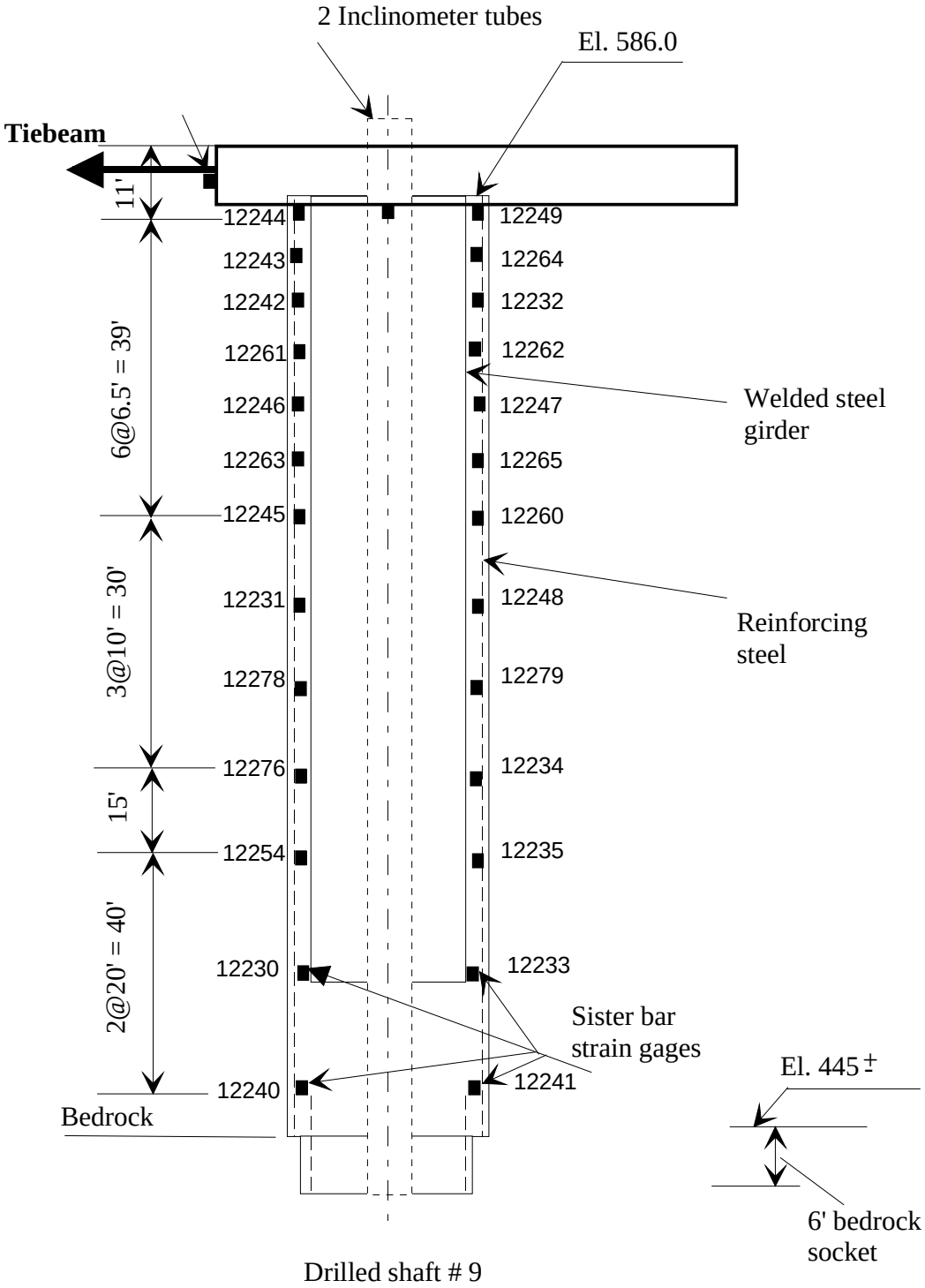


Fig.4 Location and designation of the strain gages in shaft # 9.

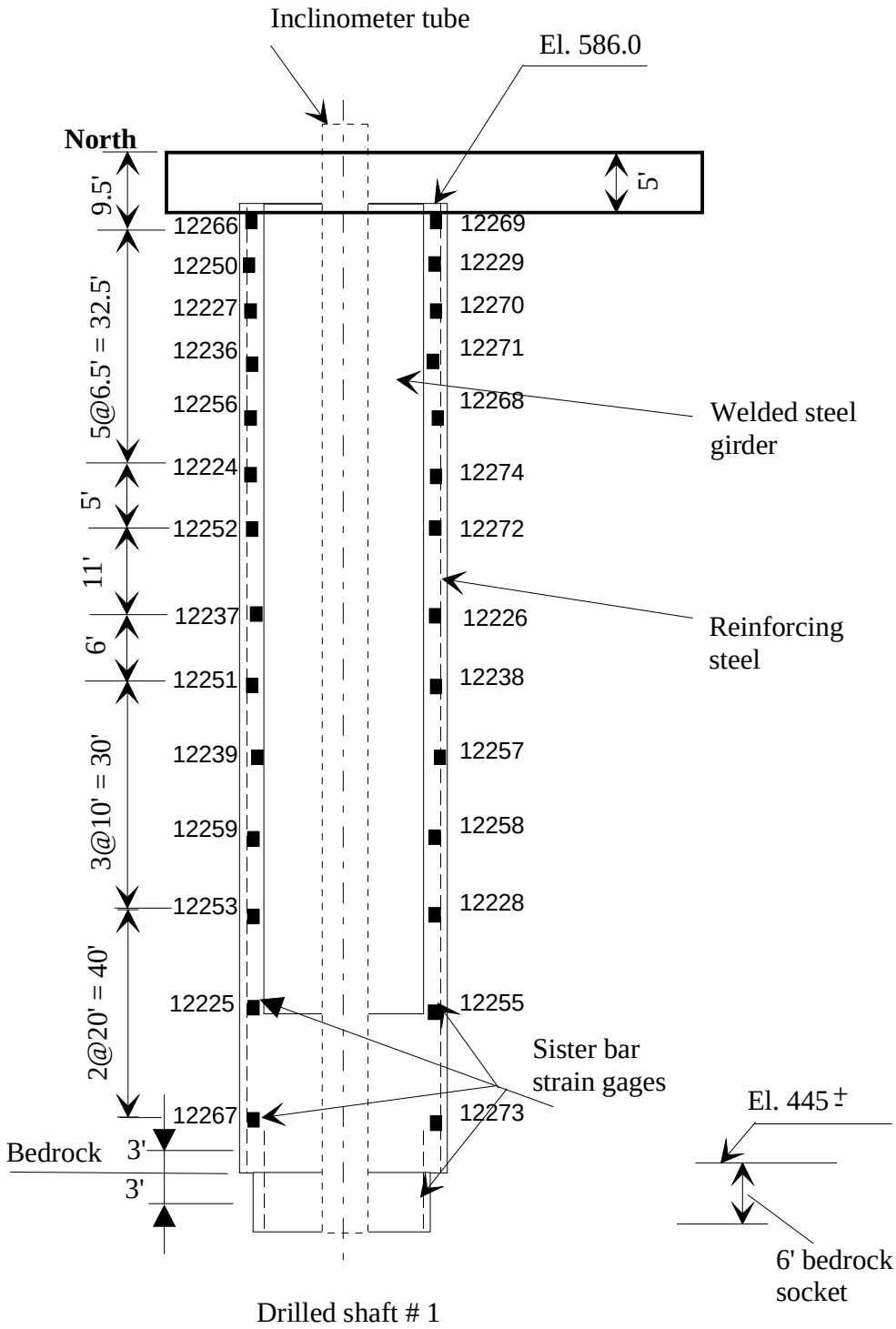


Fig.5: Locations and designations of the strain gages in shaft # 1.

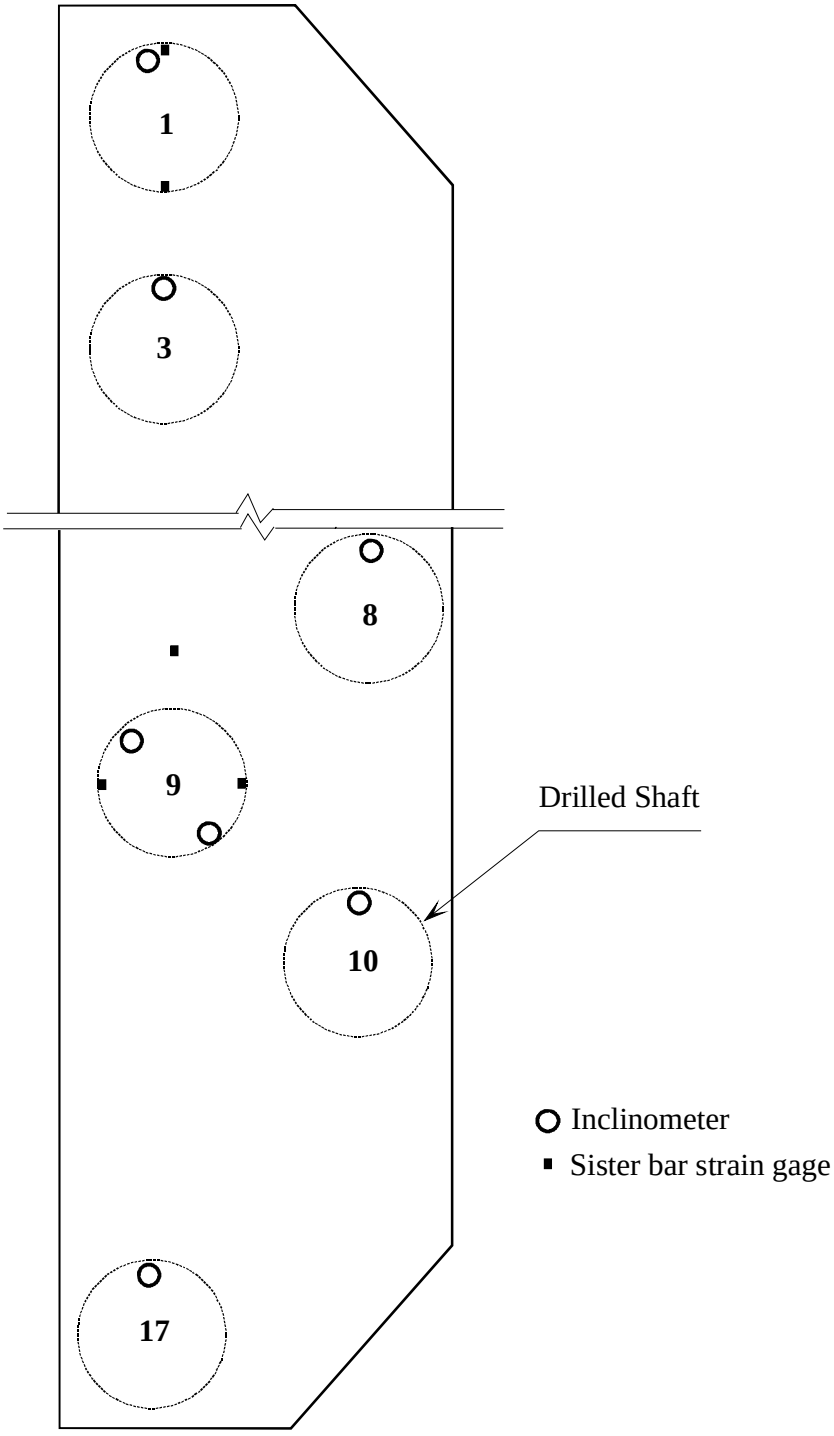


Fig. 6 Location of inclinometers in the drilled shaft cap

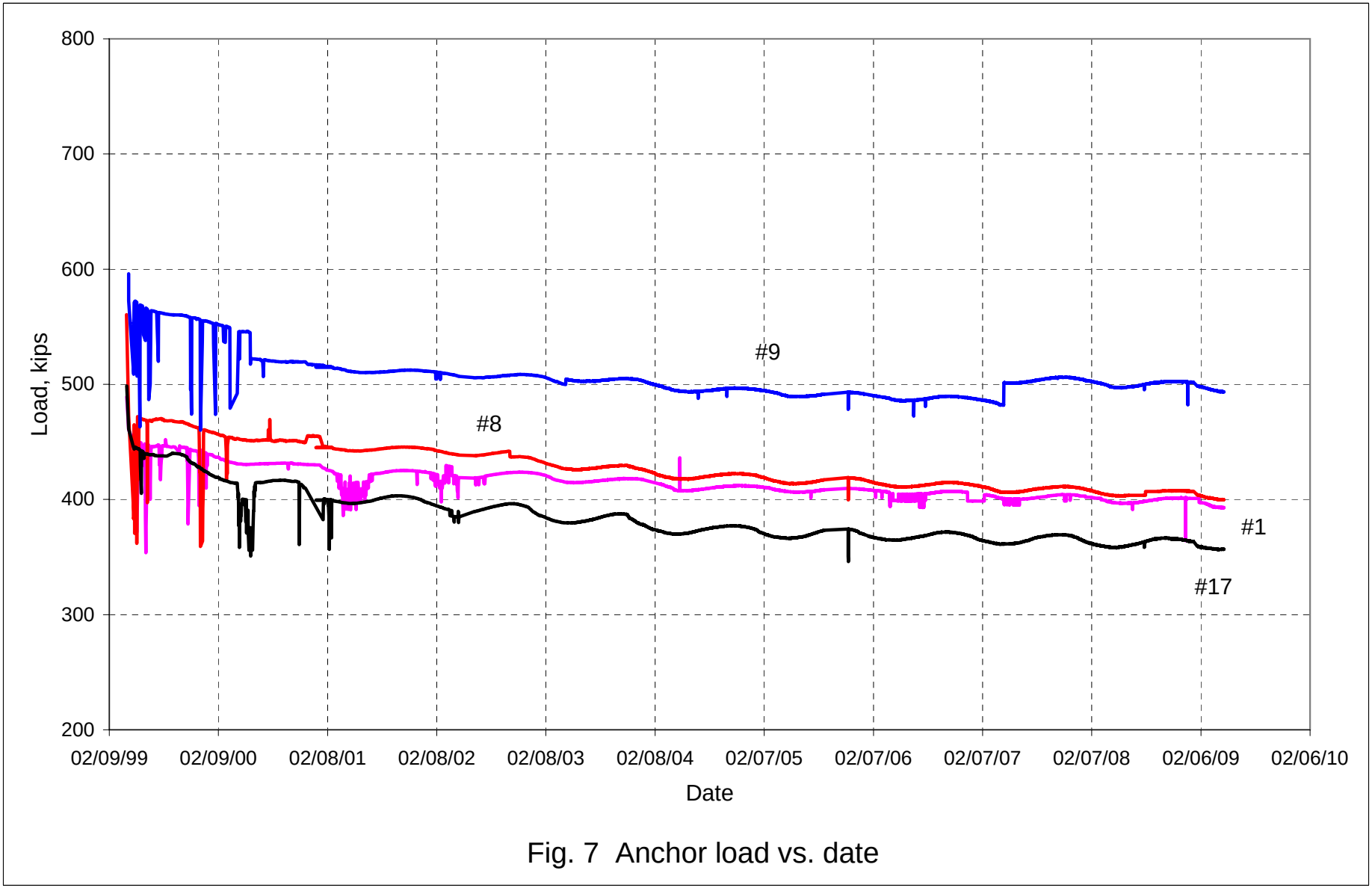


Fig. 7 Anchor load vs. date

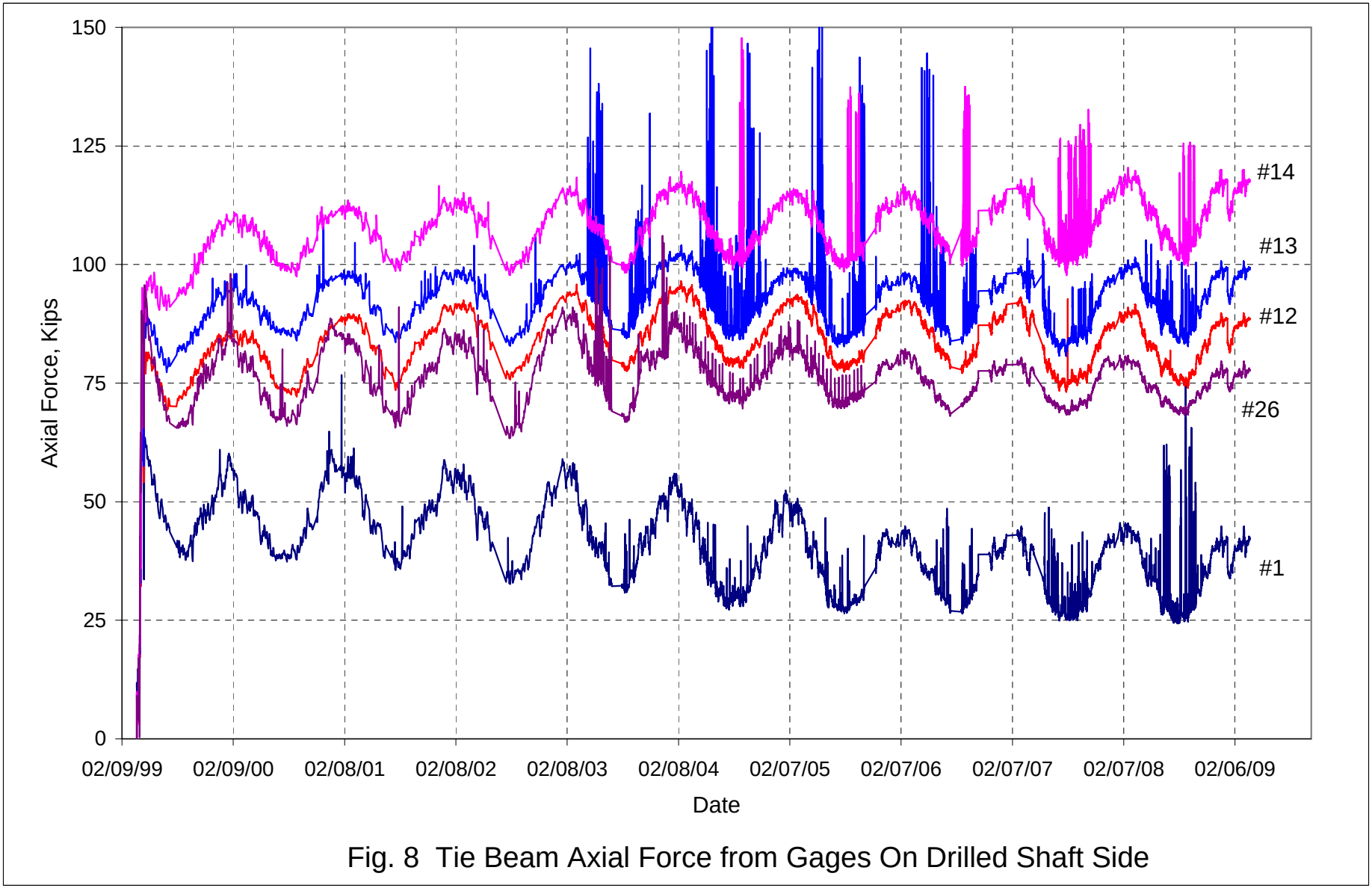


Fig. 8 Tie Beam Axial Force from Gages On Drilled Shaft Side

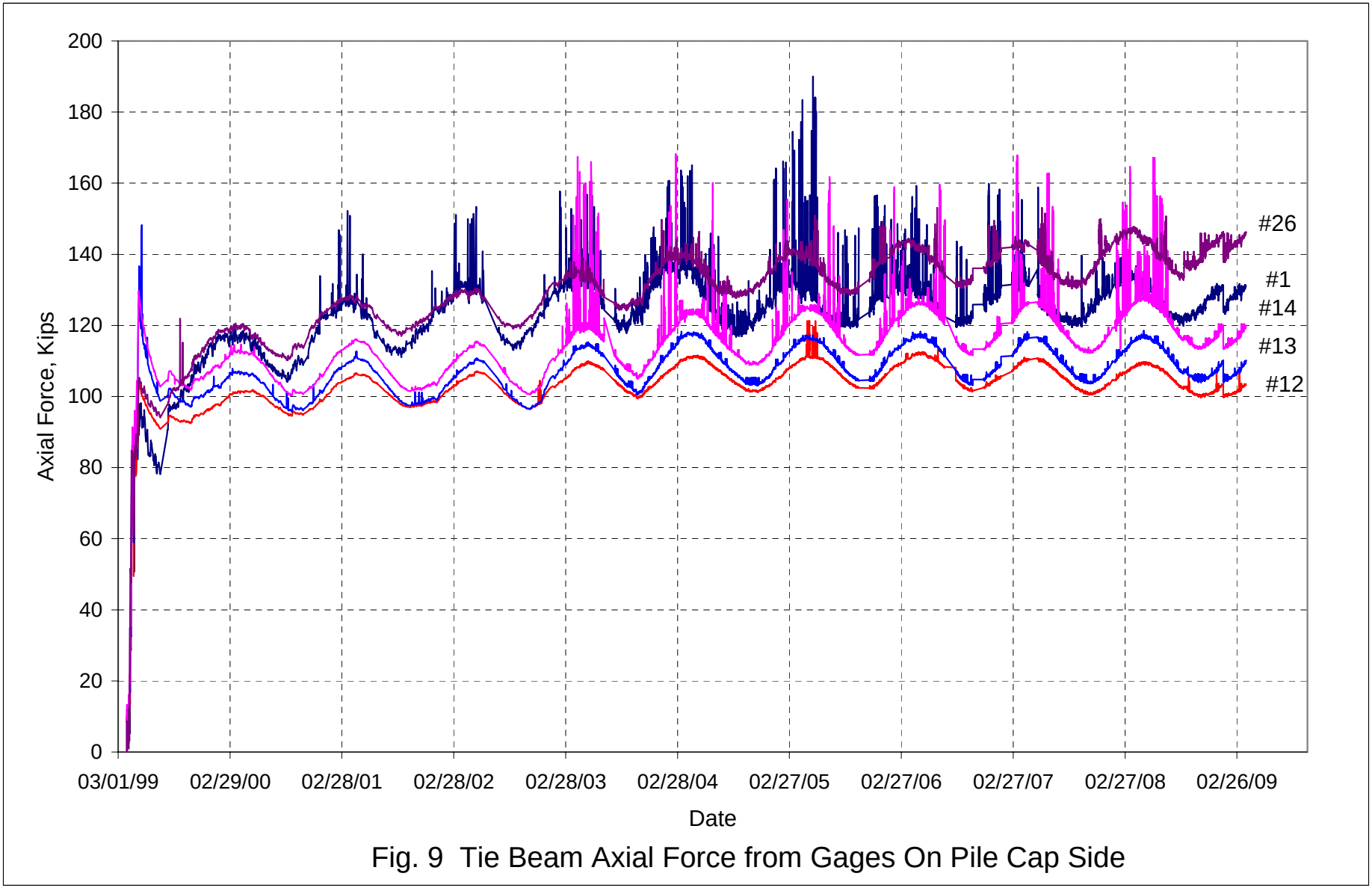


Fig. 9 Tie Beam Axial Force from Gages On Pile Cap Side

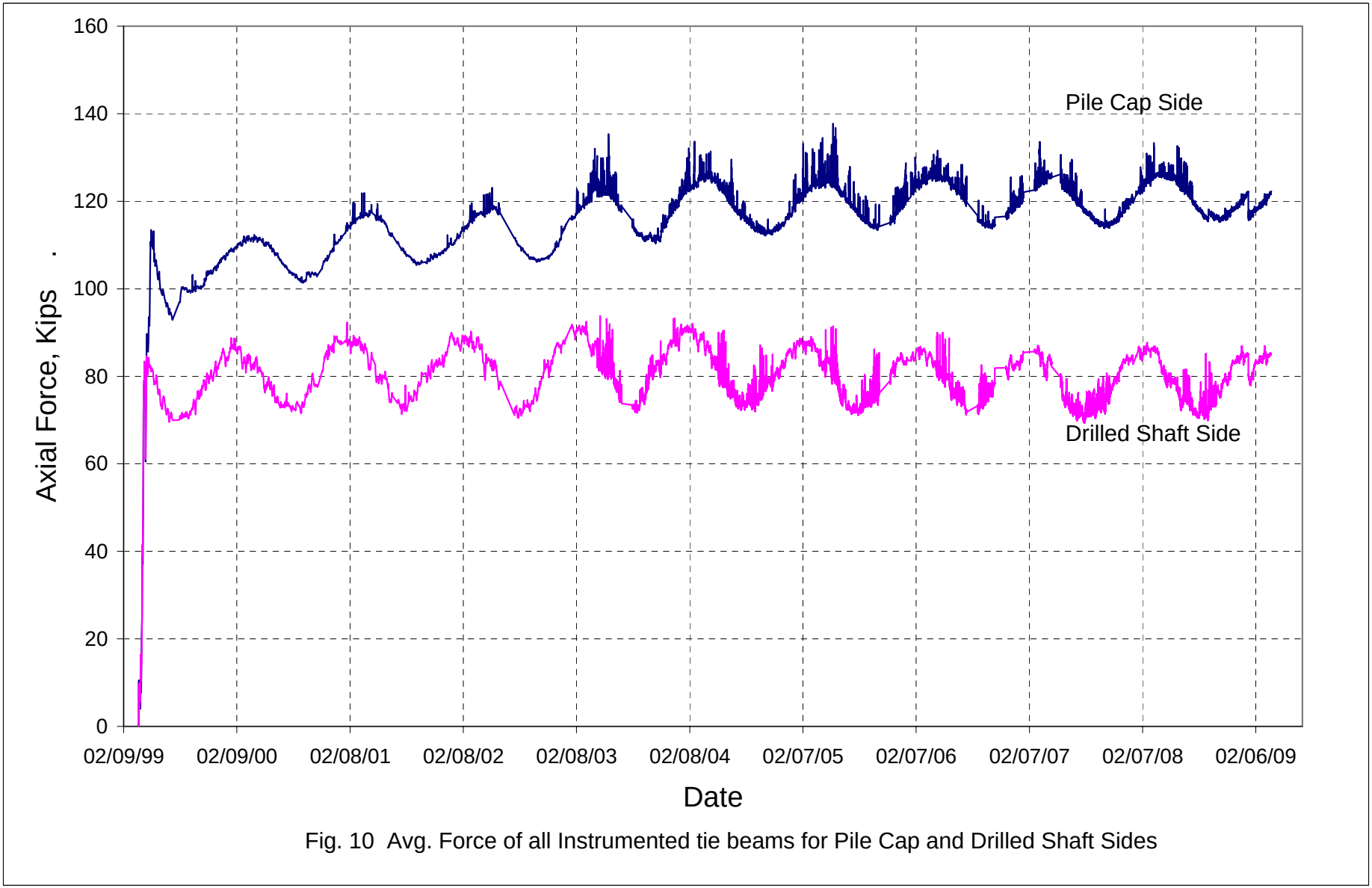


Fig. 10 Avg. Force of all Instrumented tie beams for Pile Cap and Drilled Shaft Sides

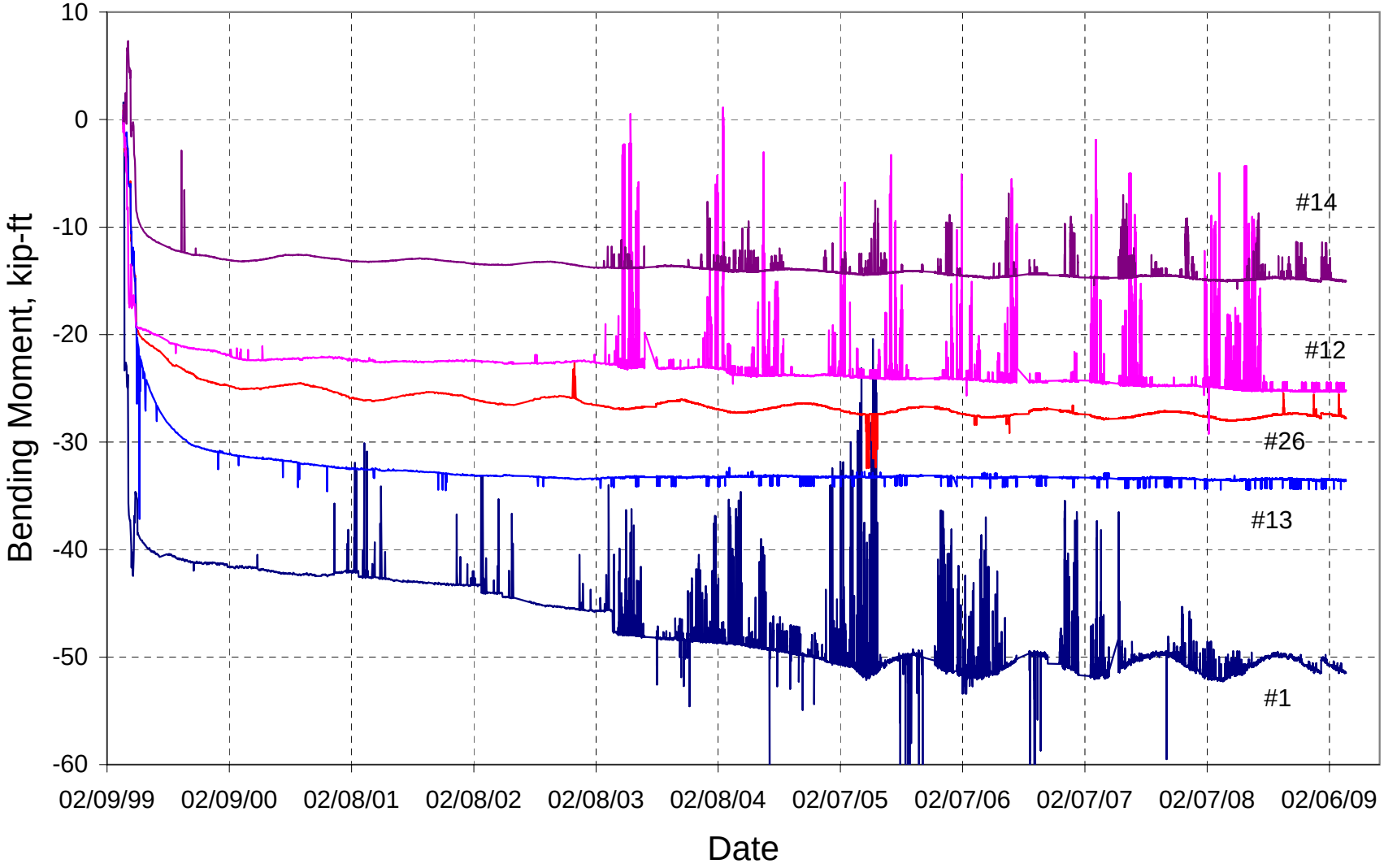


Fig. 11 Tie Beam Major Bending Moment from Gages On Pile Cape Side

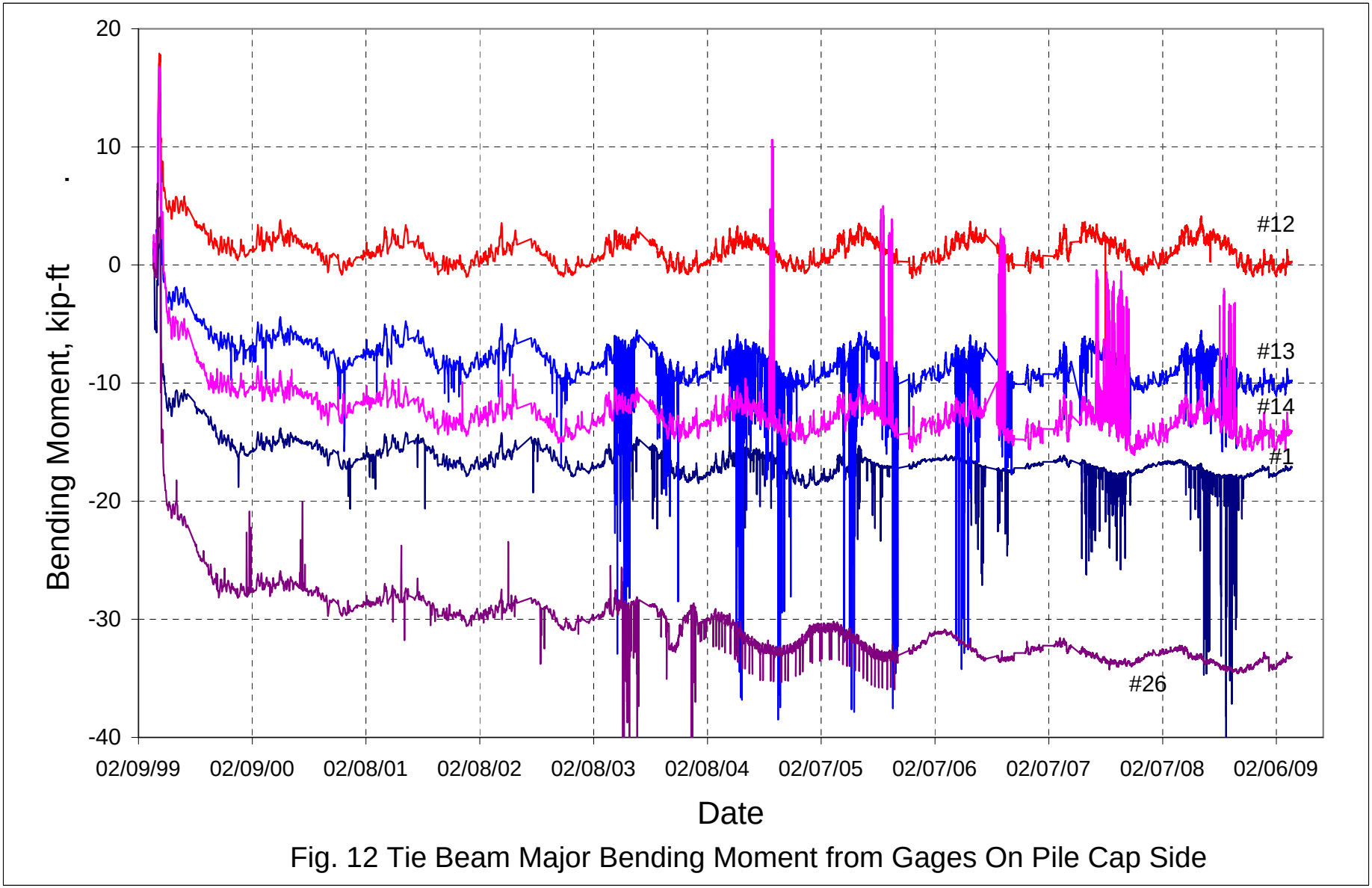


Fig. 12 Tie Beam Major Bending Moment from Gages On Pile Cap Side

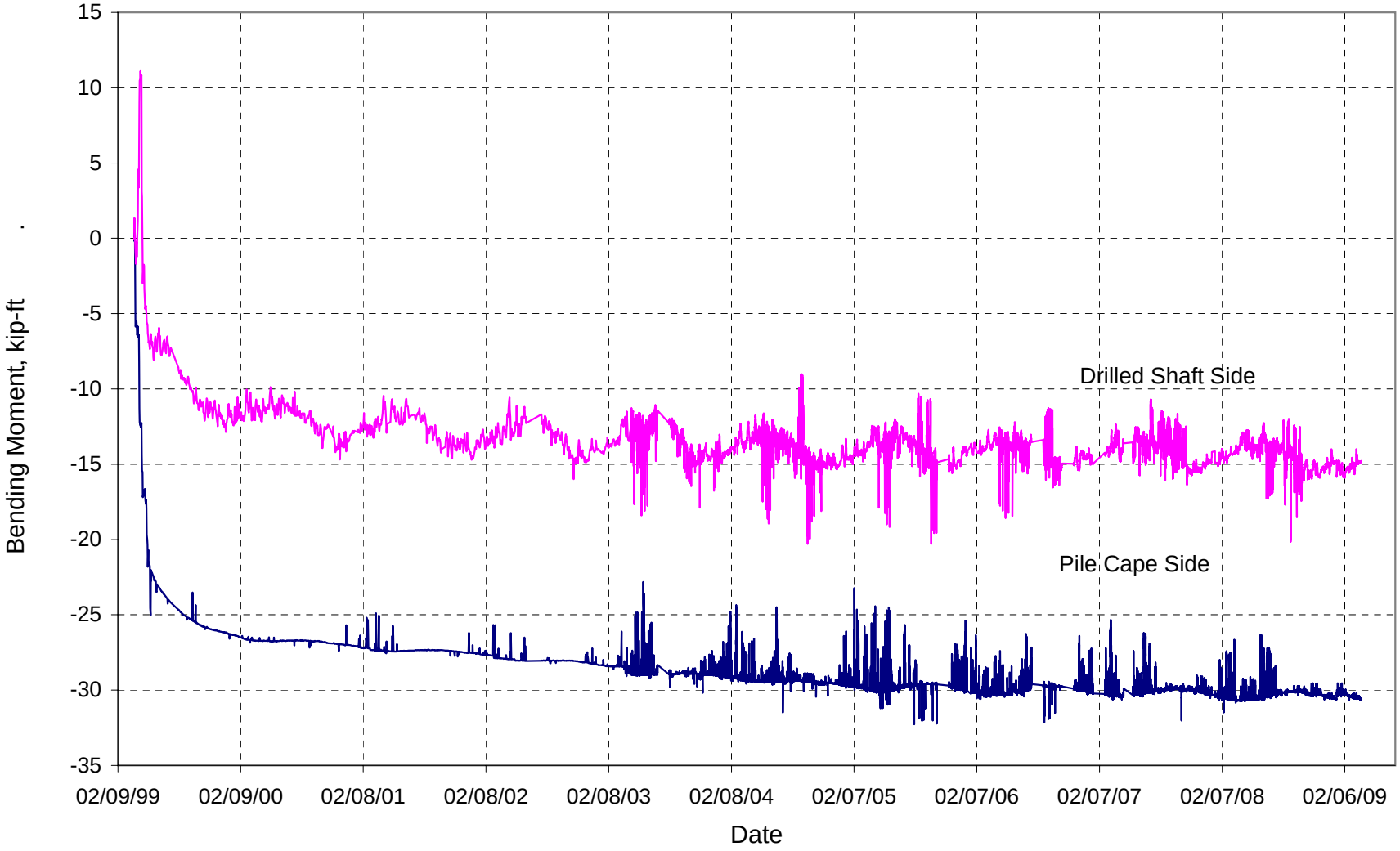


Fig. 13 Tie Beam Avg. Major Bending Moment From Gages for Pile Cap and Drilled Shaft Sides

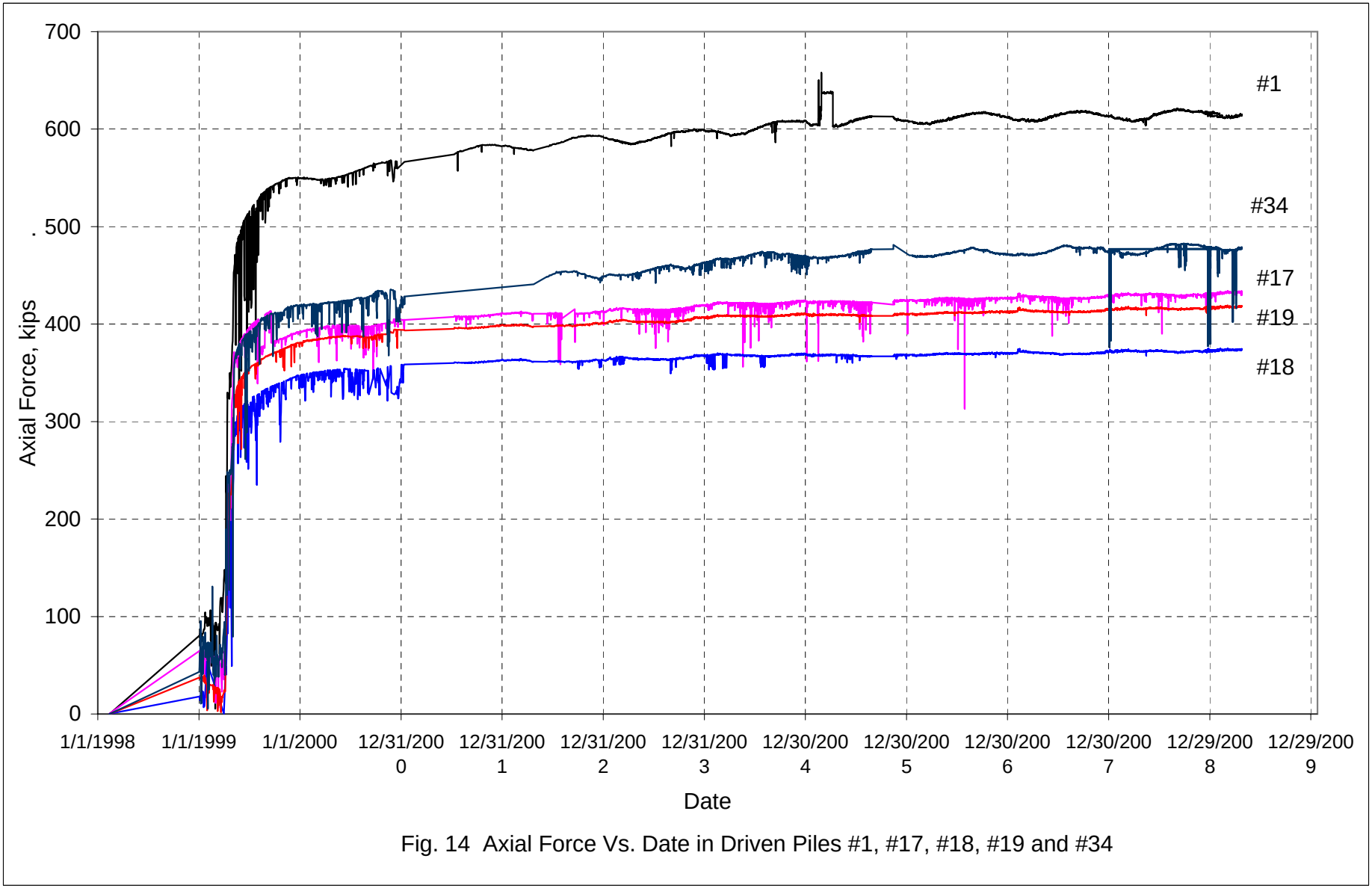


Fig. 14 Axial Force Vs. Date in Driven Piles #1, #17, #18, #19 and #34

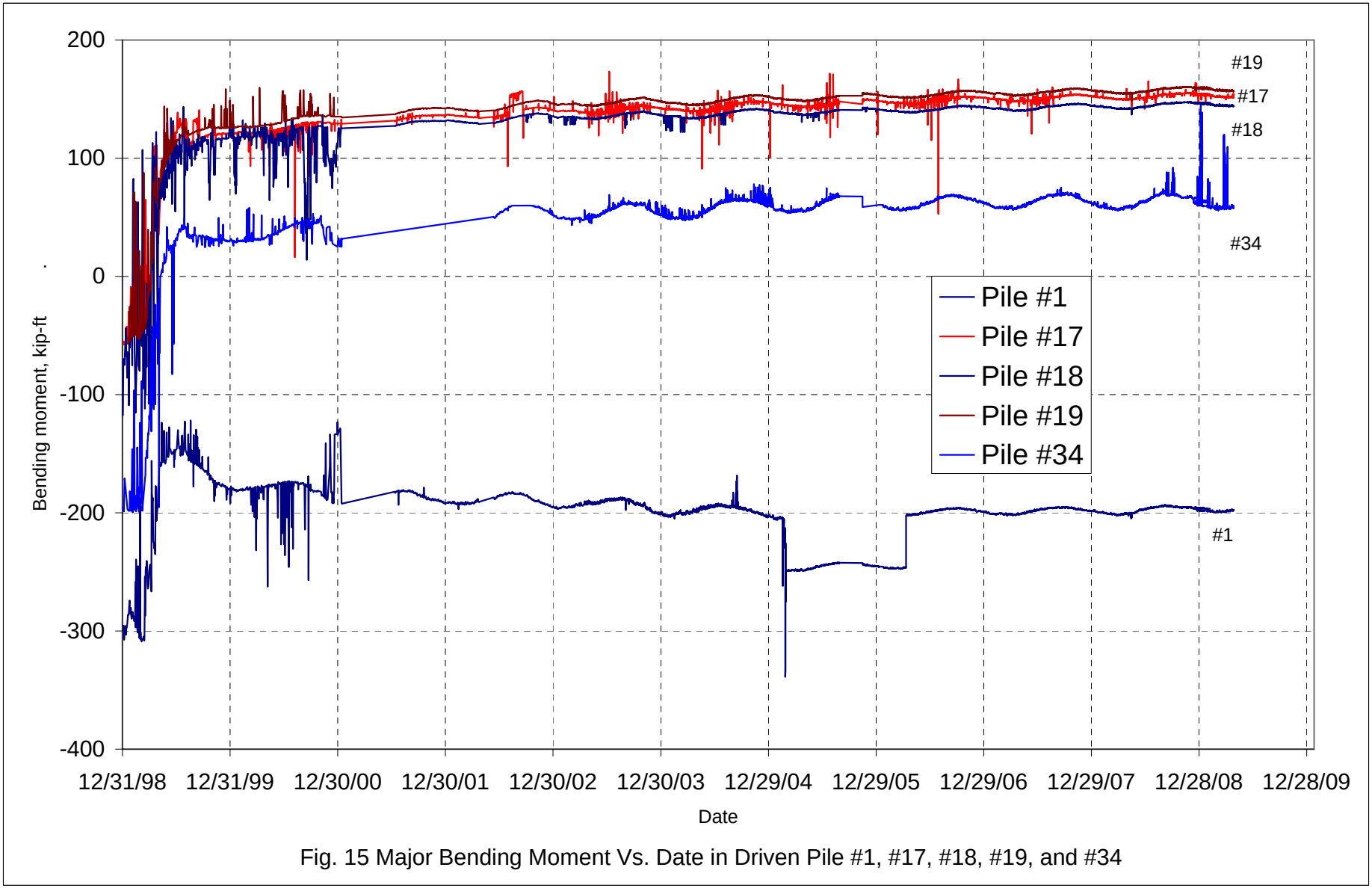


Fig. 15 Major Bending Moment Vs. Date in Driven Pile #1, #17, #18, #19, and #34

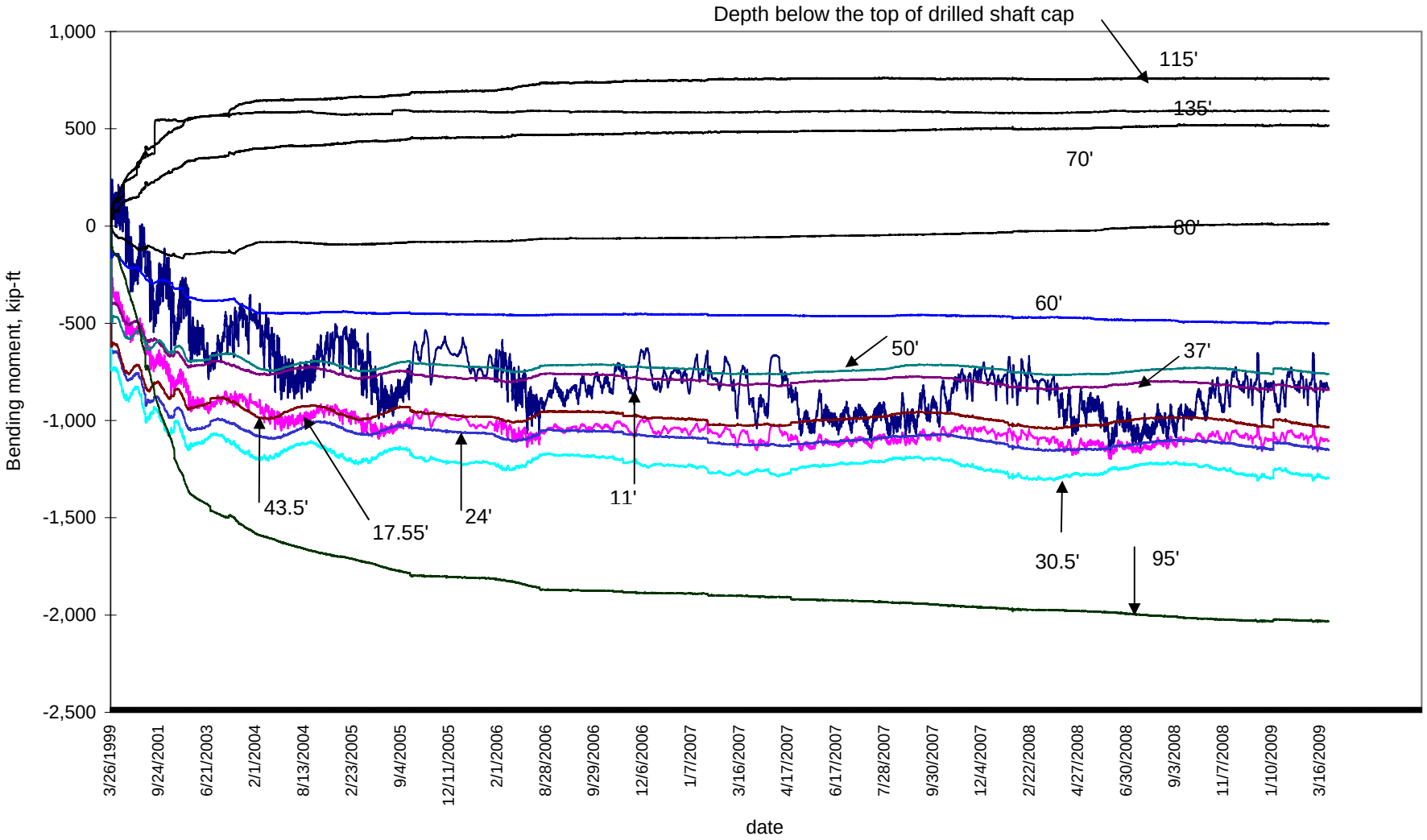


Fig. 16 Shaft #9, Bending moment vs. date in different elevations below the top of cap

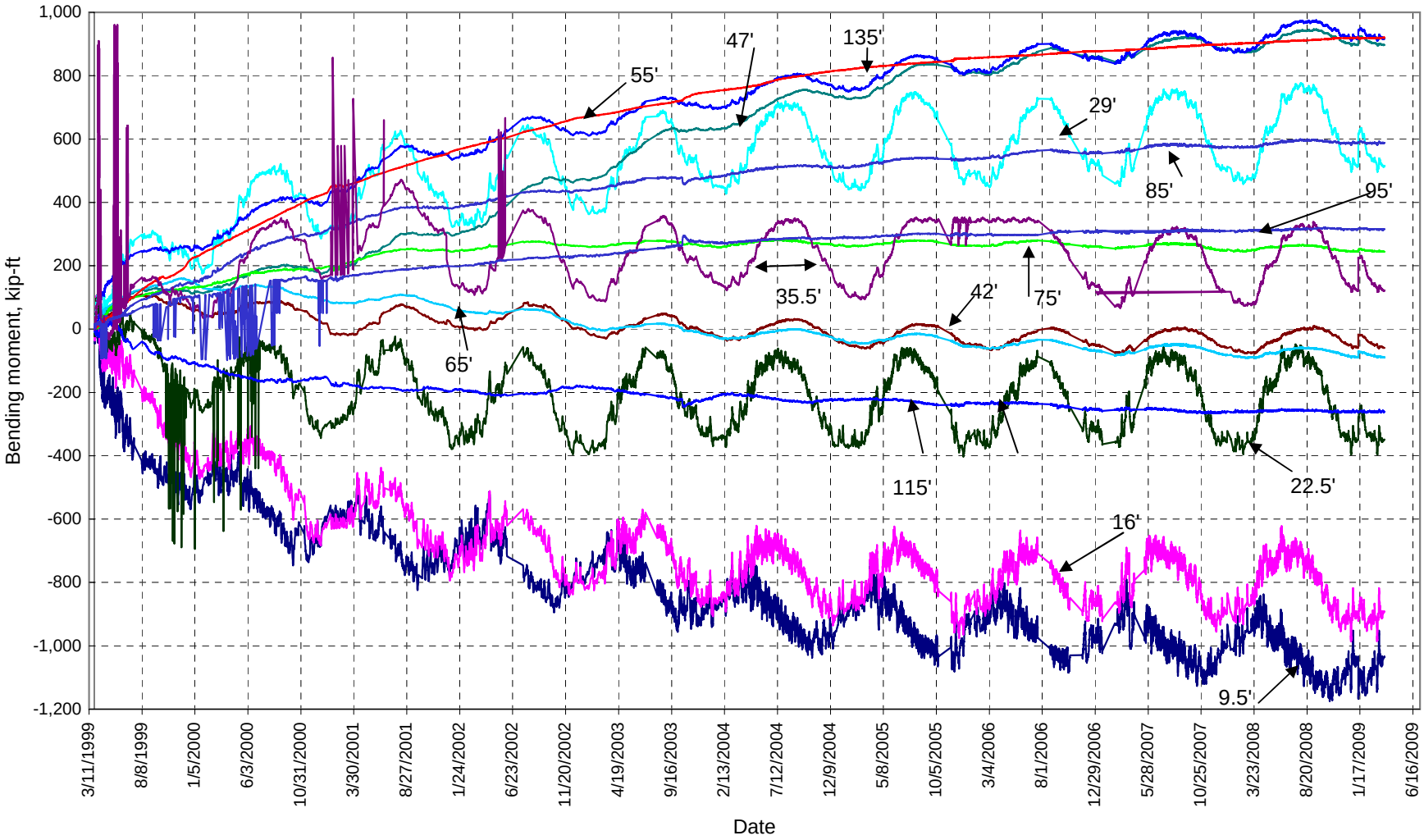


Fig. 17 Shaft #1, Bending moment vs. date in different elevations below the top of cap

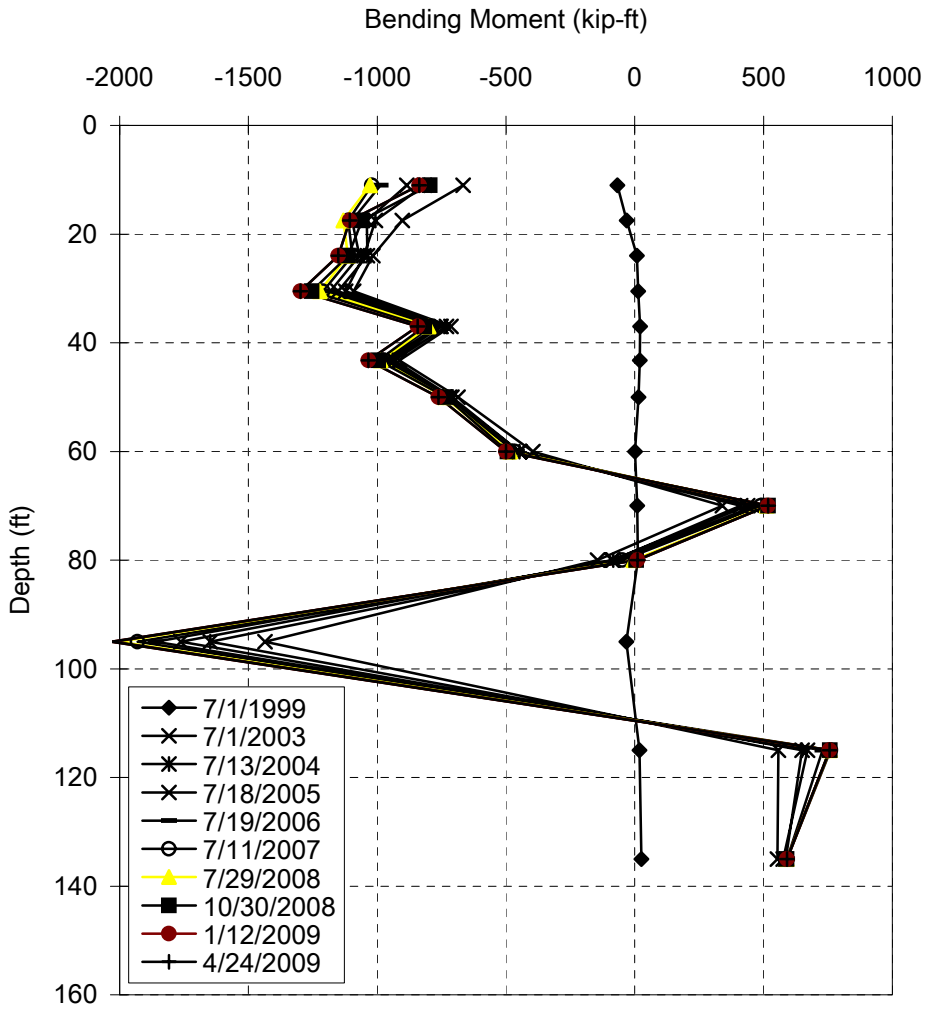


Fig. 18 Shaft #9, Bending Moment vs. Depth After Construction was completed

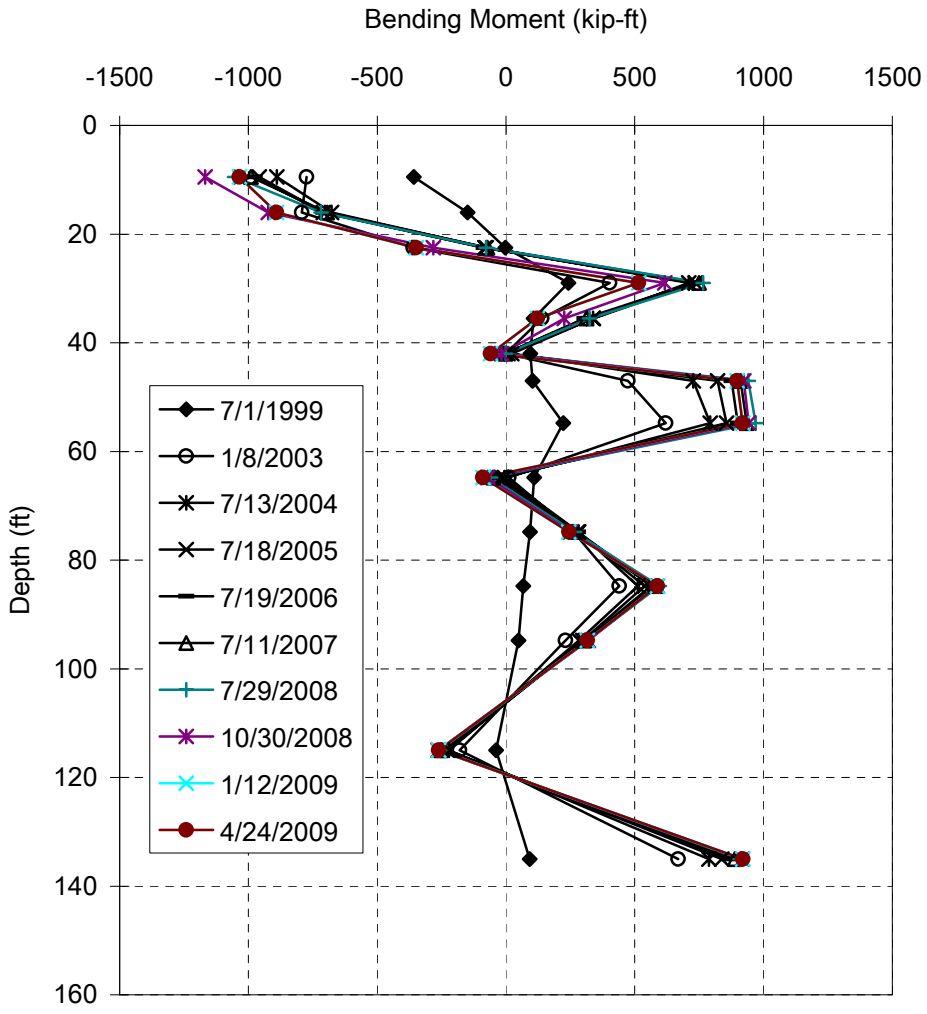


Fig. 19 Shaft #1, Bending Moment vs. Depth After Construction was completed

Fig. 20 Inclinometer #1 Displacement in the A+ Direction
Downslope (Toward River direction) Base Line 12/11/1998

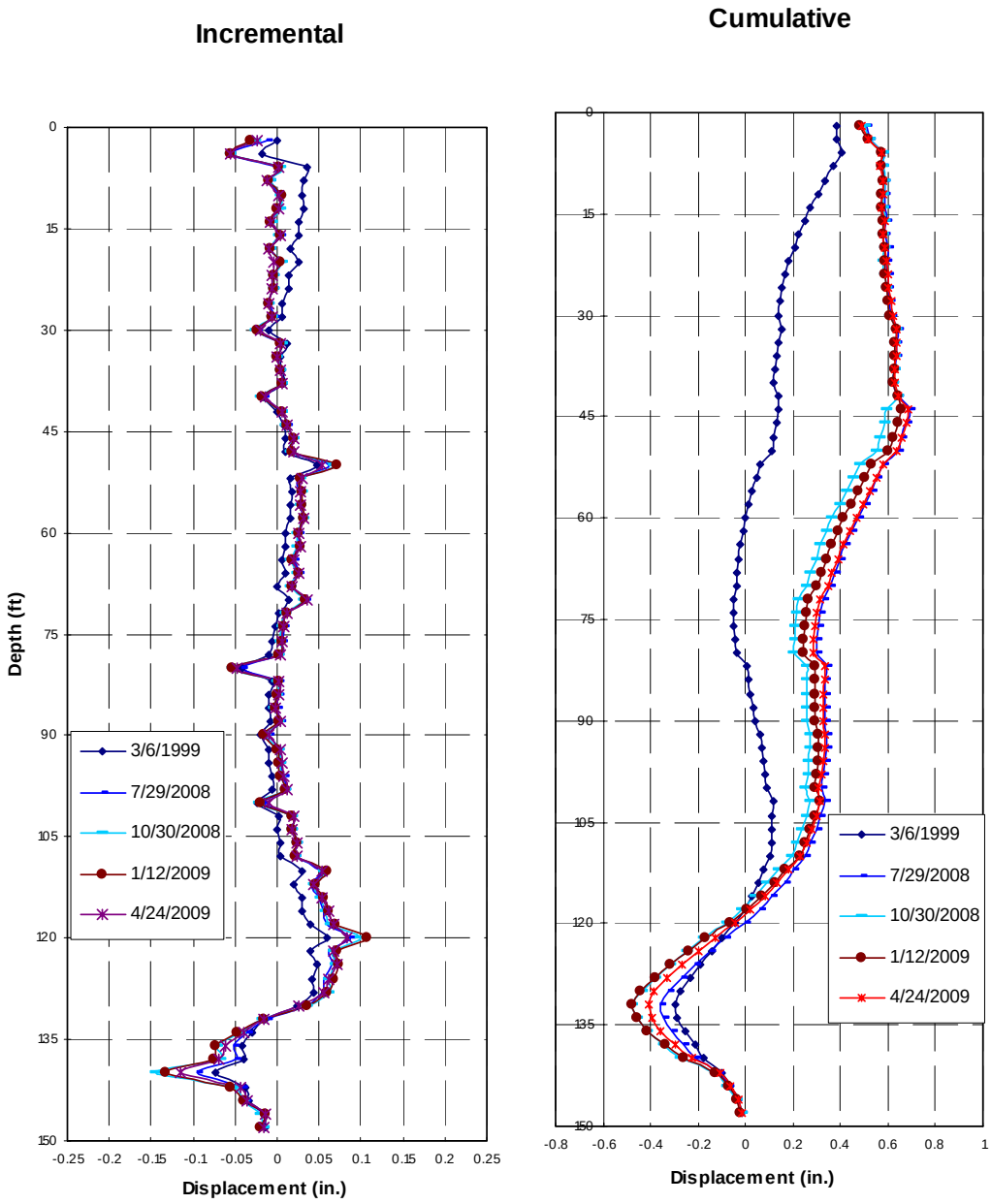


Fig. 21 Inclinometer #3 Displacement in the A+ Direction
Downslope (Toward river direction) Base Line 12/11/1998

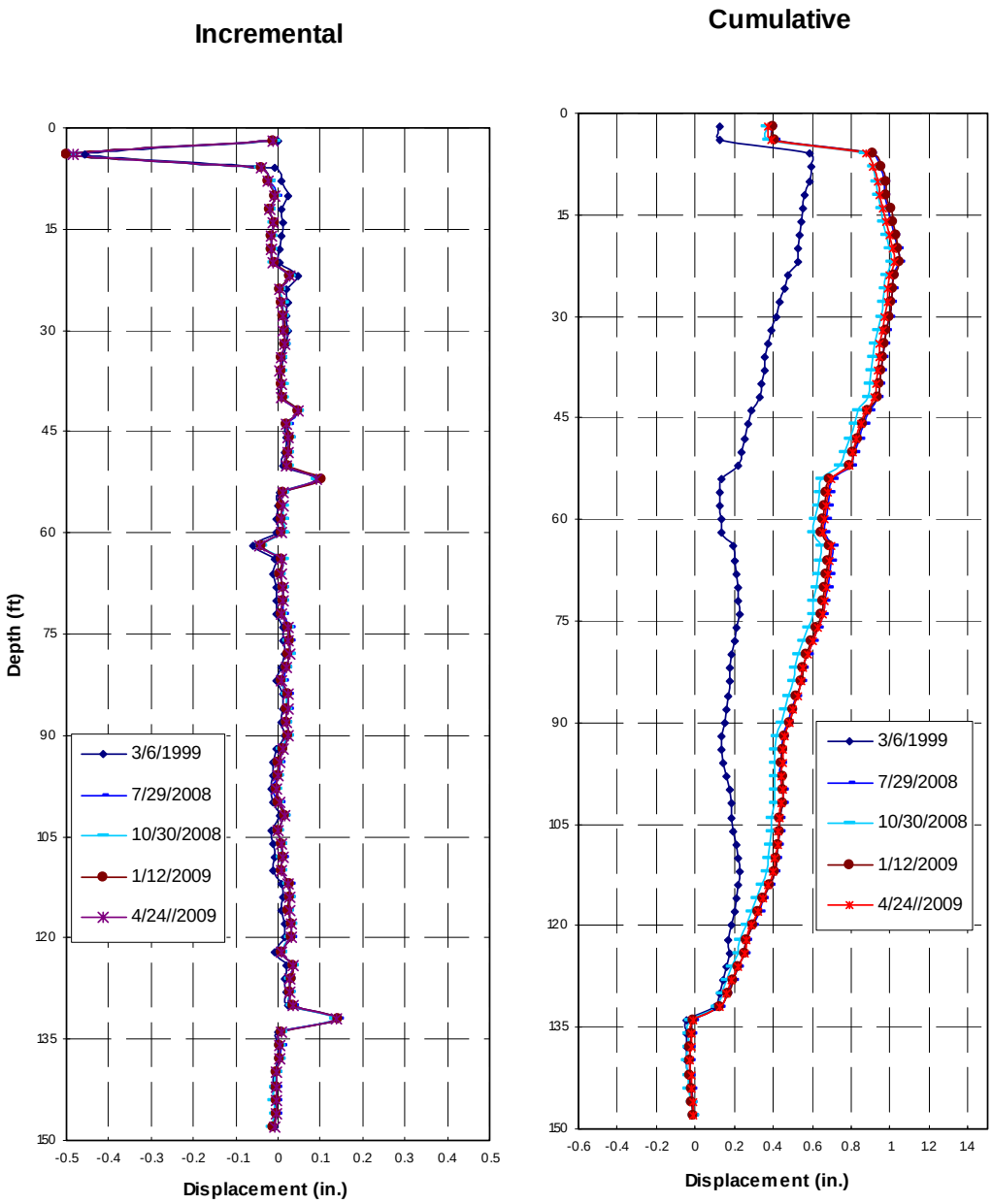


Fig. 22 Inclinometer #8 Displacement in the A+ Direction
Downslope (Toward River direction) Base Line 12/11/1998

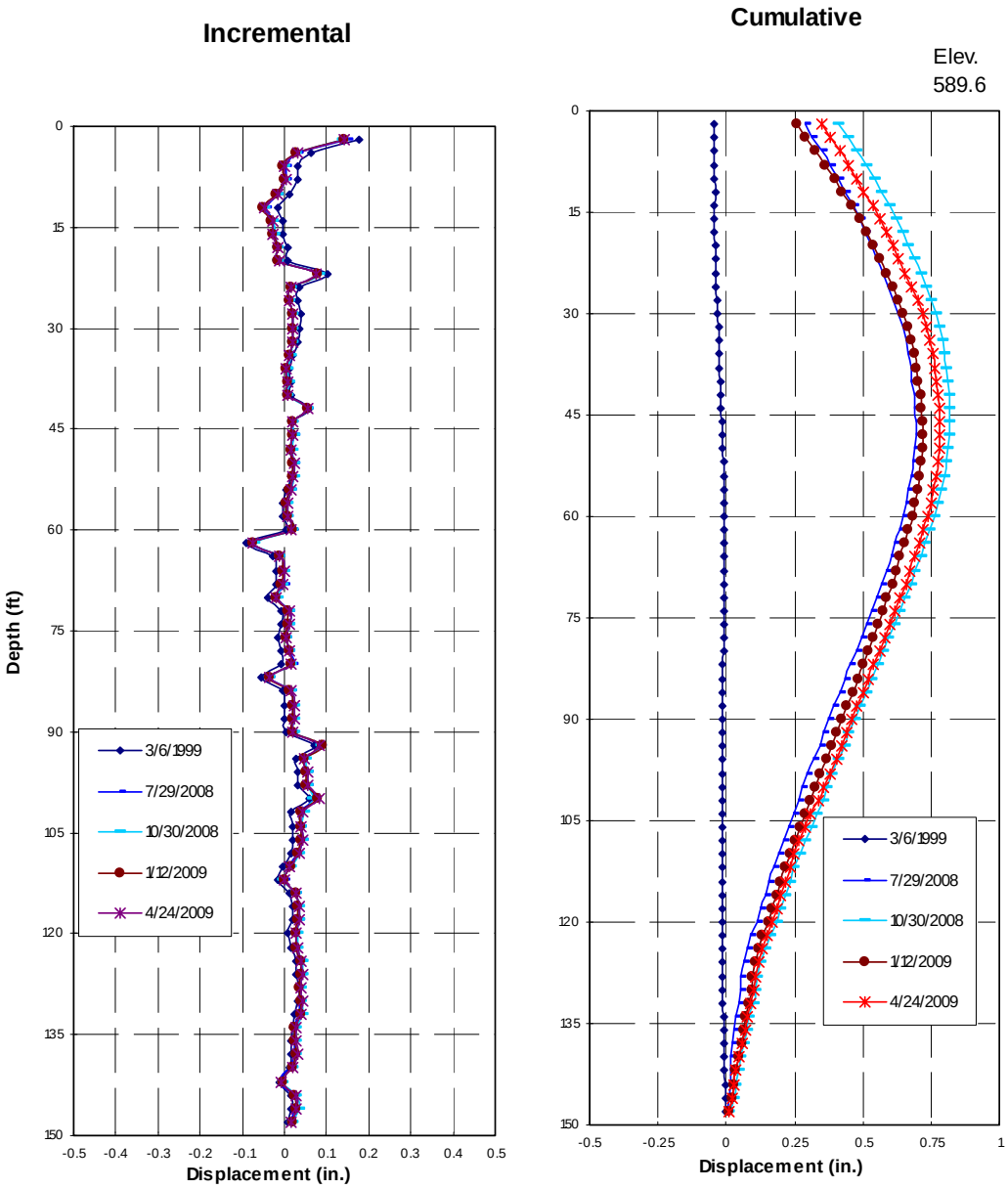


Fig. 23 Inclinometer #9A Displacement in the A+ Direction
Downslope (Toward River direction) Base Line 12/11/1998

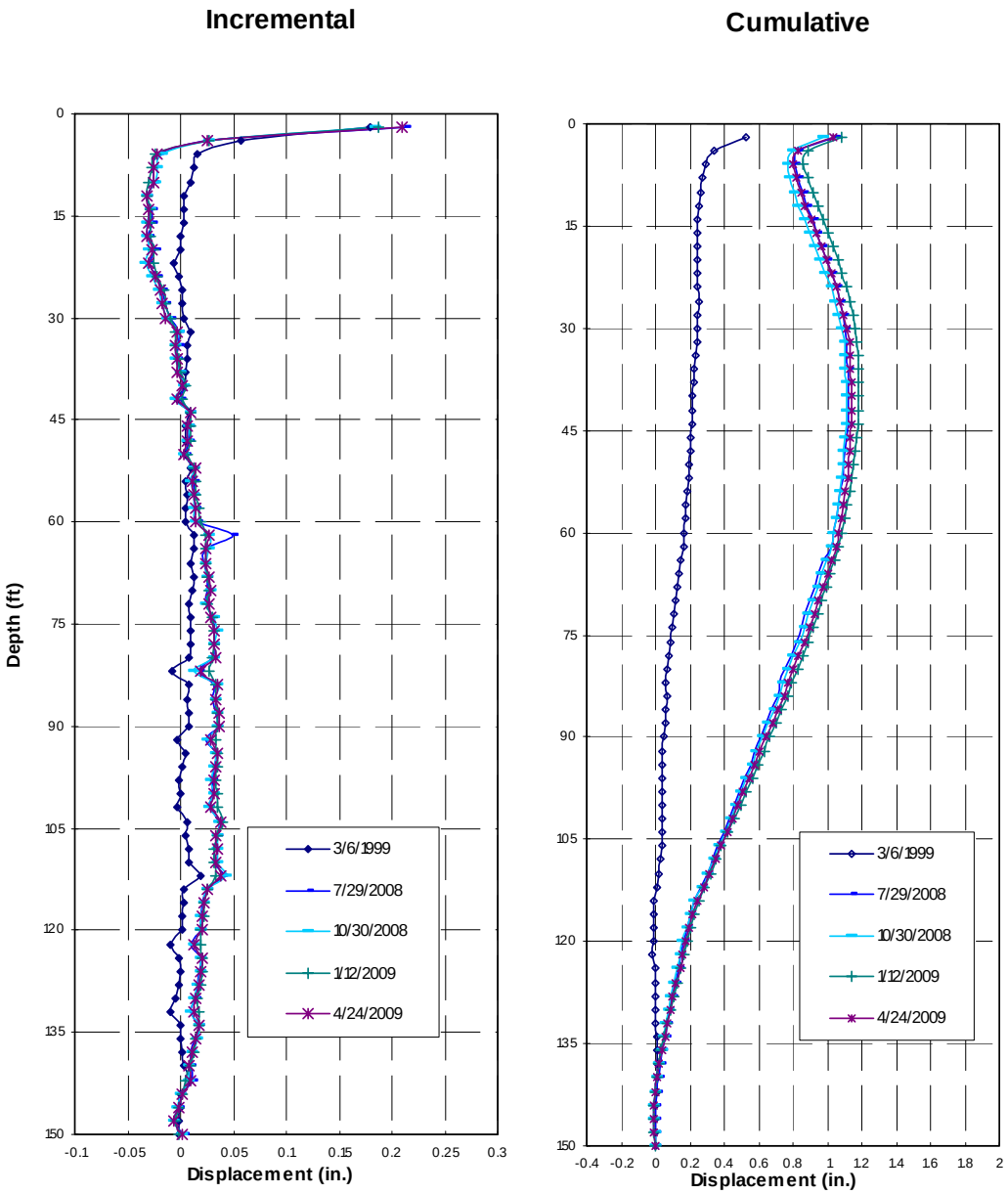


Fig. 24 Inclinometer #10 Displacement in the A+ Direction
Downslope (Toward river direction) Base Line 12/11/1998

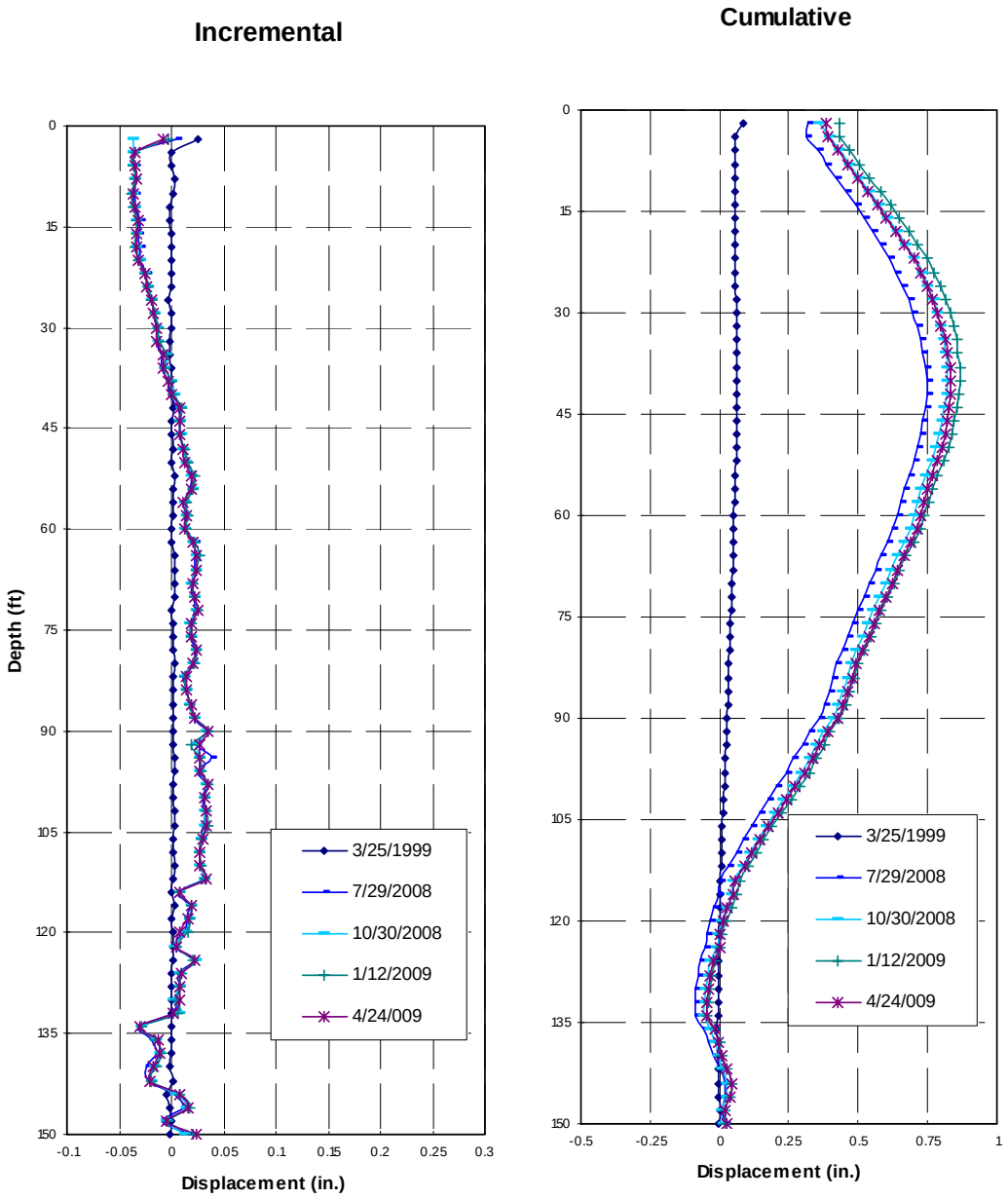
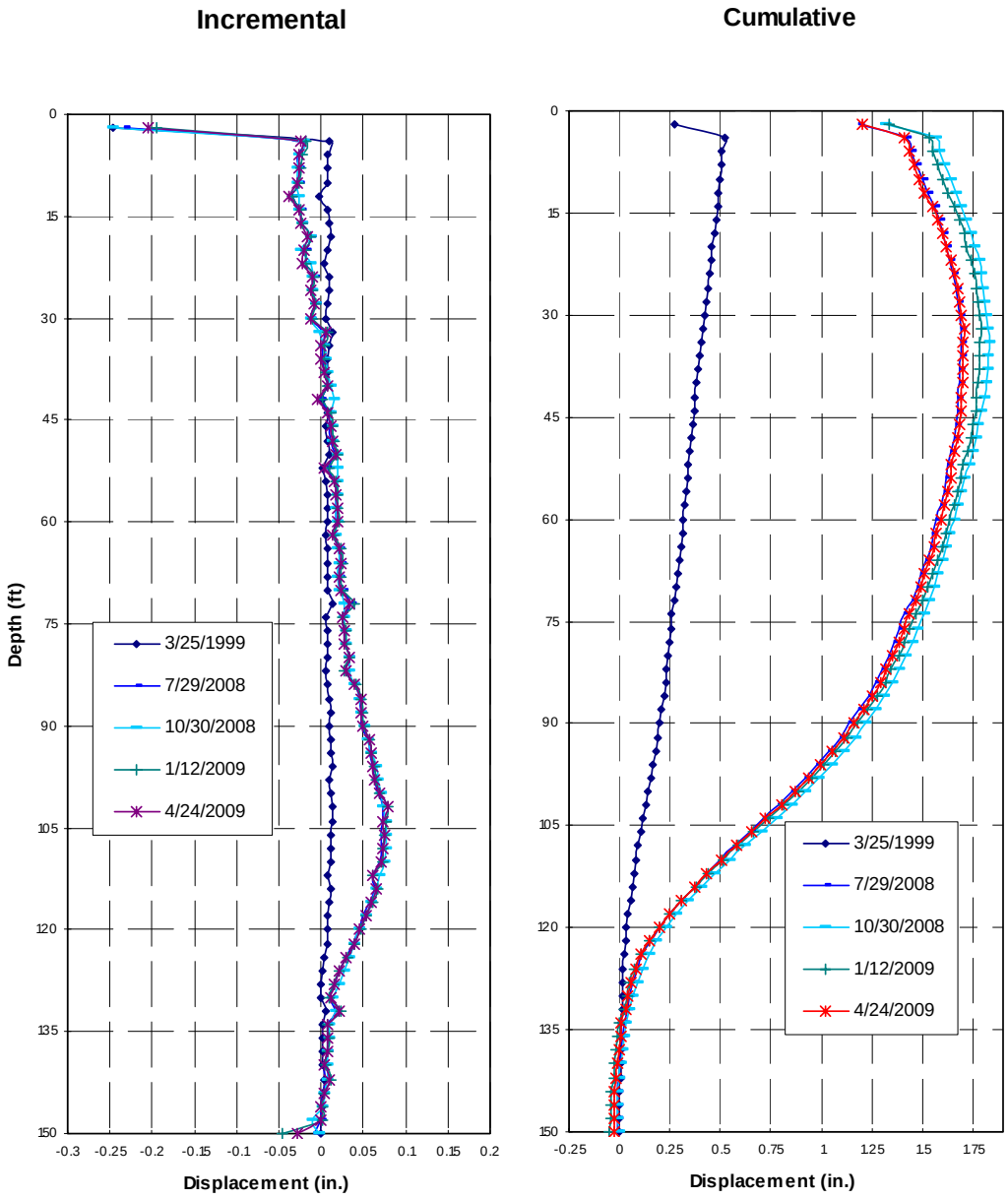


Fig. 25 Inclinometer #17 Displacement in the A+ Direction
Downslope (Toward river direction) Base Line 12/11/1998



RICHLAND ENGINEERING LIMITED
29 North Park Street, Mansfield, Ohio 44902-1769 • 419-524-0074 FAX 419-524-1812

106017

September 23, 2009

Ohio Department of Transportation
5500 Transportation Boulevard
Garfield Heights, Ohio 44125-5396

Attn: Mr. Mike Malloy

Re: CUY-90-1524
Central Viaduct
PID No. 20752
Slope and Pier Monitoring Services
Interim Report

Dear Mr. Malloy:

The following is our report on monitoring activity and collected data for the west slope of the Cuyahoga River and Bridge No. CUY-90-1524 west end pier, pier 1, and slope stabilization structure. The last report of data was the annual report submitted July 23, 2009 for data collected through April 2009. This report is for data collected through July 2009.

Enclosed is one CD with the electronic .pdf files of the detailed reports from BBC&M Engineering, Inc., Richland Engineering Limited, Dr. Huckelbridge, and Dr. Liang.

The slope monitoring began in 1994. The stabilization structure was constructed and the span 1 superstructure was relocated in 1999. The stabilization structure monitoring began in 1999. Additional slope monitoring north of the existing bridge began in 2006. The span 1 superstructure was relocated again in May 2009.

BBC&M Engineering, Inc. obtained inclinometer readings, piezometer readings, and calipered crack distances July 17 through 21, 2009. A total of 19 inclinometers, 6 pneumatic piezometers and 18 vibrating wire (VW) piezometers are actively monitored as part of the project. Comments on the data collected are summarized as follows:

- No significant changes in the rates of movements were observed in the inclinometers between the April 2009 and July 2009 quarterly readings. No shallow slip plane movements have been observed in the inclinometers within the pier 1 stabilization structure since completion of the structure. The shallow failure plane continues to move at a slow rate outside of the stabilization structure. The deep failure plane continues to move at a slow rate.

- The inclinometer B-303 has become difficult to read due to a kink at the deep failure plane at about 95 feet. The inclinometer may need to be abandoned soon.

- The rate of cantilever displacement movement of the top of inclinometer B-105A (located near the river bulkhead south of pier 1) has decreased significantly since January 2009.

- The pneumatic piezometer readings varied by only a small amount from previous readings.

- The measured total head values in the vibrating wire (VW) piezometers were relatively constant during the current reporting period with a difference between maximum and minimum total head values of no more than 2.2 feet in the VW piezometers.

- The three calipered surface distance location gaps continue to move slowly as in the past readings.

- In July 2009 the aggregate pile was roughly 25 to 30 feet high, was within 15 feet of the east right of way fence, and covered less than 50% of the adjacent property.

- The small landslide adjacent to the large excavation near the west right-of-way fence does not appear to have experienced a significant change since the quarterly readings were last taken in April 2009.

Richland Engineering Limited measured deck expansion joint openings at the west end pier, near pier 2, and near pier 4; and measured truss expansion joint openings at the north and south upper and lower truss chords at span 2 floorbeam 12 on July 15, 2009. On May 23, 2009 the 7,000 ton, 525 feet long unit 1 section of the steel truss spans structure was relocated to open the closed expansion joint in span 2. The fixed bearings on pier 1 were moved about 3" on the north leg and 3 3/8" on the south leg. The west end pier deck finger expansion joint was closed about 3 7/8" on the north side and 4 1/4" on the south side. The span 2 deck finger expansion joint was opened about 2 1/4" on the north side and 2 5/8" on the south side. The expansion joints appear to be functioning normally.

Art Huckelbridge obtained tiltmeter readings at the west end pier and pier 1 on May 15 & 23, and August 26, 2009. The tiltmeters show no significant change in readings for the past quarter. Tiltmeters #5 and 7 on the legs of pier 1 show slight movement toward the river. This could have been due to relaxing the load on the piers by relocating truss span 1 or they could have been bumped during construction.

Robert Liang monitored instrumentation on August 3, 2009. The instrumentation readings in the rock anchors, driven piles, tieback beams, and drilled shafts show the strain readings, the forces, and the moments on the slope stabilization structures have been fairly steady in the last three months. Inclinometer readings did not show significant drilled shafts movement.

Monitoring has been authorized through 2009. The last readings under this contract are scheduled about October 15, 2009.

Please contact us if you have any questions (email reltd@r-e-l.com). Copies of detailed quarterly reports are available upon request.

Very truly yours,

RICHLAND ENGINEERING LIMITED

Dean A. Palmer, P.E.

DAP:dap
cc: Craig Hebebrand, District 12
Dave Lastovka, District 12
Youssef Seif, District 12
Naureen Dar, District 12
Tim Keller, Office of Structures
Gene Geiger, Office of Geotechnical Services
Tom Lefchik, FHWA
Steve Pasternack, BBC&M Engineering, Inc., Dublin
Jeff Snyder, BBC&M Engineering, Inc., Valley View
Art Huckelbridge
Robert Liang
Rick Engel, E.L. Robinson Engineering Co.
Jeff Broadwater, Michael Baker, Jr., Inc.

JULY 2009 QUARTERLY REPORT
FIELD MONITORING SERVICES
CUY-90-14.52/15.24
PID #77332
CLEVELAND, OHIO

Report to

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

Prepared by

BBC&M ENGINEERING, INC.
CLEVELAND, OHIO

August 2009

August 7, 2009
012-00946-300

Mr. Dean A. Palmer, P.E.
Richland Engineering Limited
29 North Park Street
Mansfield, Ohio 44902

Re: CUY-90-14.52/15.24 Bridge (PID No. 77332)
Quarterly Report - Field Monitoring Services
July 2009 (Third Quarter)

Dear Mr. Palmer:

BBC&M Engineering, Inc. (BBCM) has completed the field monitoring services for the July 2009 quarter as part of the CUY-90-14.52/15.24 project. This quarterly report presents our general site observations and the results and evaluation of data collected from all the actively monitored instrumentation (inclinometers, piezometers and calipered distance locations) installed by BBCM at or near the West Abutment of the existing I-90 Central Viaduct Bridge.

A total of 19 inclinometers, six (6) pneumatic piezometers and 18 vibrating wire (VW) piezometers are actively monitored as part of the project. A Summary Table and Site Plan of Active Instrumentation are submitted as Plates 1 and 2 of the Appendix. Quarterly readings were taken during the period of July 17 through July 21, 2009.

Inclinometers

All the data sets presented in the Appendix have been corrected for measured spiral of the inclinometer casings and for systematic errors such as bias-shift, sensor rotation and depth positioning error, where necessary. The rates of movements were computed using linear regression for the depth ranges shown on the Displacement vs. Time plots in the Appendix.

No significant changes in the rates of movements were observed in the inclinometers between the April 2009 and July 2009 quarterly readings. At a depth of about 85 feet at B-105A and depths of 45, 109 and 129 feet in B-05-02, the observed slope movements are believed to be real based on the time-displacement trends (see Plates 26 and 48 of the Appendix) and have therefore been incorporated into the slope movement summaries subsequently discussed.

Shallow Failure Plane

No shallow slip-plane movements have been observed in the inclinometers within the Pier 1 stabilization system (B-204 and B-05-04) since completion of construction of the stabilization system. In the vicinity of Pier 1 just outside of the stabilization system (B-05-03 and B-108A), the shallow failure plane is continuing to move at an average rate of about 0.07 inches per year (in/yr) from 2006 to the present. Upslope from Pier 1 (B-203, B-303, and B-05-02), the shallow failure plane is moving at an average rate of about 0.02 in/yr from 2004 to the present. This is a slight decrease from the rate of 0.025 in/yr as reported in our 2008-2009 Annual Report for Field Monitoring Services dated May 15, 2009 (2008-2009 Annual Report). However, this average rate is slightly lower due to the inclusion of the rate of about 0.01 in/yr observed in the shallow failure plane in B-05-02.

Well outside the Pier 1 Area (B-05-16), the shallow failure plane is moving at an average rate of about 0.16 in/yr from 2006 to the present. This is a slight decrease from the rate of 0.18 in/yr as reported in our 2008-2009 Annual Report. Additionally, the rate of the shallow movement in B-05-16 has decreased to about 0.11 in/yr from January 2007 to the present. The rate decreases in B-05-16 are largely due to the fact that there appears to be minimal change in the cantilever displacement observed from a depth of 3 to 11 feet since October 2007 (see Plate 50 in the Appendix).

Deep Failure Plane

South of the West End Pier (B-102 and B-107), the deep failure plane continues to move at an average rate of about 0.03 in/yr from around 2000 to the present. In the Pier 1 area (B-203, B-204, B-303, B-105A, B-108A, B-05-02, B-05-03 and B-05-04), the deep failure plane continues to move at an average rate of about 0.03 in/yr from 2004 (or 2006 for new or replacement inclinometers) to the present. Well outside the Pier 1 area (B-05-16), the deep failure plane continues to move at an average rate of 0.02 in/yr.

Additional Observations in Active Inclinometers Installed between 1994 and 1999

The B-101 inclinometer has indicated nominal movement since its installation. The inclinometer at P-9N (installed in one of the drilled shafts) indicates the top of the drilled shaft is restrained laterally and that the maximum lateral deflection is about one (1) inch and occurs approximately 40 to 60 feet below the top of the inclinometer casing.

The inclinometer at B-303 may need to be abandoned soon due to the "kink" in the inclinometer casing at a depth of about 95 feet. It has become somewhat difficult both to lower and raise the probe and obtain consistent readings at this depth of 95 feet.

Additional Observations in Active Inclinometers Installed in 2006

From about October 2007 to January 2009, the cantilever displacement observed in B-105A to a depth of about 60 to 70 feet (see Plates 22 and 23 in the Appendix) significantly increased from a rate of about 0.16 in/yr to about 1.32 in/yr. Since January 2009, the rate has decreased significantly to about 0.05 in/yr. It is believed that the bulkhead at this location may be progressively leaning outwards toward the Cuyahoga River. A Displacement vs. Time plot for B-105A has been submitted as Plate 26 in the Appendix.

Discussion of Slope Movement Rate Changes

Table 1 below summarizes the changes in the rates of movement that have been observed in five (5) of the inclinometers.

Table 1: Summary of Rate Changes in Some Inclinometers – CUY-90-15.24

Inclinometer	Failure Plane	Time Ranges Evaluated	Avg. Rate of Movement within Time Range (in/yr)	Percentage Increase in the Avg. Rate of Movement Compared to Time Range #1 (%)
B-204	Deep (117'-119')	#1 - Jan 04 - Apr 08	0.025	--
		#2 - Apr 08 – Oct 08	0.065	160
		#3 - Oct 08 – Jul 09	Negligible/Negative[1]	--
B-303	Deep (95'-99')	#1 - Jan 04 – Apr 08	0.03	--
		#2 - Apr 08 – Oct 08	0.095	217
		#3 - Oct 08 – Jul 09	Negligible/Negative[1]	--
B-05-03	Shallow (35'-39')	#1 - Jun 06 – Apr 08	0.075	--
		#2 - Apr 08 – Oct 08	0.30	300
		#3 - Oct 08 – Jul 09	0.06	--
	Deep (123'-125')	#1 - Jun 06 – Apr 08	0.03	--
		#2 - Apr 08 – Oct 08	0.23	667
		#3 - Oct 08 – Jul 09	0.045	--
B-05-04	Deep (117'-119')	#1 - Jun 06 – Apr 08	0.015	--
		#2 - Apr 08 – Oct 08	0.055	267
		#3 - Oct 08 – Jul 09	0.015	--
B-105A	Deep (105'-111')	#1 - Jun 06 – Oct 07	0.015	--
		#2 - Oct 07 – Jan 09	0.065	333
		#3 – Jan 09 – Jul 09	0.04	--

* The rate of movement is either negative, which is not realistic, or negligible. Time Range #3 is based only on 3 to 4 quarterly readings. Several more readings are needed to better define the current rate of movement. As such, negligible/negative rates of movements may be caused by the limitations of the accuracy of the instrumentation.

Based on the reported rates of movements for Time Range #3 in Table 1, it appears that the trend of decreased rates of movements has continued to the present in the five (5) inclinometers listed in Table 1. These inclinometers are located underneath or east of the existing I-90 bridge near the east right-of-way fence where aggregate piles of variable sizes have been stored for many years. It is likely that the rate increases observed previously (Time Range #2 in Table 1) were a short term occurrence. Although, a slight increase in the rate of movement was observed between the April 2009 and July 2009 quarterly readings in B-204, B-05-03 and B-105A inclinometers, which may have been caused by the presence of a relatively large aggregate pile that was observed in June 2009, subsequently discussed. The aggregate pile was, however, significantly smaller in July compared to June. Also note that the bulkhead adjacent to B-105A has shown very little movement since January 2009 (previously discussed). It is evident that these five (5) inclinometers are affected by a combination of the size and location of the aggregate piles, the progressive failure of the bulkhead adjacent to B-105A and the pore pressures in the piezometers in this area.

Piezometers

Pneumatic Piezometers

The results of the active pneumatic piezometer readings taken between July 17 and July 21, 2009 are summarized in Table 2 below.

Table 2: Summary of Readings for Active Pneumatic Piezometers – CUY-90-15.24

Piezometer Identifier		Ground Surface Elevation (ft)	Elevation Head, h_e (ft)	Pore Pressure Reading, u (psi)	Total Head, h_t (ft)
B-101 (P-1*)	orange	676.6	626.3	0.0	626.3
	pink	676.6	552.3	32.2	626.6
B-105 (P-3*)	pink	585.6	497.6	38.6	586.7
	blue	585.6	479.9	48.0	590.7
B-107 (P-5*)	orange	662.3	562.3	25.4	620.9
B-303 (P-2*)	pink	627.0	586.2	7.1	602.6

*BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers.

** Pneumatic piezometers *cannot* read negative pressure (i.e., a water level below the depth of the pneumatic piezometer). Thus, it is unknown whether this is an accurate pressure reading.

The piezometers at B-105 and B-107 exhibited slightly lower readings than those recorded in April 2009, whereas the piezometers at B-101 pink and B-303 exhibited slightly higher readings. A reading of 0 psi was recorded at the B-101 orange piezometer. Note that the piezometers at B-105 continue to indicate elevated water pressures (i.e., a total head above the ground surface, artesian conditions). Total Head vs. Time plots have been submitted as Plates 52 through 55 in the Appendix of this report.

Vibrating Wire (VW) Piezometers

In April 2009, eight (8) non-functioning VW Miniloggers were replaced with new Miniloggers. Consequently, BBCM will hereafter identify the piezometers by their boring number, VW Piezometer serial number (S/N), and depth the piezometer was installed. For reference, Table 3 below summarizes the VW Miniloggers that have been or are currently being used to collect data from the VW piezometers.

Table 3: Summary of VW Miniloggers Used to Collect Readings from VW Piezometers – CUY-90-14.52

Piezometer Identifier		S/N of Inactive VW Minilogger	S/N of Current VW Minilogger
Location	VW Piezo. S/N - Depth		
B-05-01	86124T - 65 ft	21961	33505
	86125T - 95 ft	21967	33507
B-05-02	86126T - 46 ft	21963	33503
	86127T - 122 ft	--	21951
B-05-03	86128T - 32 ft	21957	33501
	86129T - 112 ft	21965	33506
B-05-04	86130T - 59 ft	--	21958
	86131T - 119 ft	--	21952
B-05-07	86455T - 102 ft	--	21966
	86456T - 220 ft	--	21956
B-05-08	86132T - 65.5 ft	--	21954
	86133T - 110.5 ft	--	21959
B-05-11	86457T - 95 ft	21968	33056
	86458T - 130 ft	21953	33502
B-05-12	86134T - 75 ft	21960	33504
	86135T - 120 ft	--	21964
B-05-13	86459T - 60 ft	--	21962
	86460T - 135 ft	--	21955

Table 4 provides a summary of the maximum and minimum values of all the pressure readings taken from April 2009 (end of previous reporting period) to the time when the collected data was last downloaded from VW Miniloggers between July 17 and July 21, 2009.

Table 4: Summary of Readings for VW Piezometers – CUY-90-14.52

Piezometer Identifier		Time Interval of Readings Reported [1]	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-01	86124T - 65 ft	4/17/09 to 7/17/09	13.5/12.8	675.4	610.4	13.2/12.7	640.9/639.7
	86125T - 95 ft	4/17/09 to 7/17/09	13.1/13.1	675.4	580.4	24.6/24.1	637.2/636.1
B-05-02	86126T - 46 ft	4/21/09 to 7/21/09	12.2/12.1	617.9	571.9	8.5/79	591.4/590.2
	86127T - 122 ft	4/17/09 to 7/21/09	12.2/12.2	605.1	573.1	40.8/40.3	590.1/588.9
B-05-03	86128T - 32 ft	4/17/09 to 7/20/09	11.7/11.1	605.1	573.1	8.4/7.4	592.5/590.3
	86129T - 112 ft	4/17/09 to 7/20/09	12.5/12.5	605.1	493.1	41.7/41.0	589.4/588.3
B-05-04	86130T - 59 ft	4/17/09 to 7/20/09	12.8/12.8	600.8	541.8	18.2/17.6	583.7/582.4
	86131T - 119 ft	4/17/09 to 7/20/09	12.9/12.9	600.8	481.8	45.0/44.9	585.7/585.4
B-05-07	86455T - 102 ft	4/17/09 to 7/17/09	12.4/12.3	678.9	576.9	24.6/24.1	633.7/632.5
	86456T - 220 ft	4/17/09 to 7/17/09	11.9/11.9	678.9	458.9	72.0/71.5	625.0/623.9
B-05-08	86132T - 65.5 ft	4/16/09 to 7/17/09	12.7/12.6	679.9	614.4	12.9/12.4	644.2/643.0
	86133T - 110.5 ft	4/16/09 to 7/17/09	12.4/12.4	679.9	569.4	29.9/29.4	638.5/637.2
B-05-11	86457T - 95 ft	4/16/09 to 7/17/09	12.7/12.7	675.1	580.1	24.2/23.7	636.1/634.9
	86458T - 130 ft	4/16/09 to 7/17/09	12.6/12.6	675.1	545.1	37.1/36.6	630.8/629.6
B-05-12	86134T - 75 ft	4/16/09 to 7/20/09	12.8/12.6	652.7	577.7	19.0/18.6	621.6/620.6
	86135T - 120 ft	4/16/09 to 7/20/09	12.5/12.5	652.7	532.7	37.3/36.8	618.8/617.7
B-05-13	86459T - 60 ft	4/21/09 to 7/21/09	12.6/12.6	580.0	520.0	24.7/24.3	577.0/576.0
	86460T - 135 ft	4/17/09 to 7/21/09	12.8/12.7	580.0	445.0	60.5/60.4	584.7/584.4

1 – Readings generally were taken automatically every 8 hours during the reported time interval.

The measured total head values were generally relatively constant during the current reporting period with a difference between maximum and minimum total head values of no more than 2.2 feet in the VW piezometers. Total Head vs. Time plots have been submitted as Plates 56 through 64 in the Appendix.

The 86460T piezometer in B-05-13 continues to indicate an elevated water pressure (i.e., a total head above the ground surface, artesian conditions) similar to that observed in the pneumatic piezometers at B-105 previously discussed. The pore pressures

appear to have gradually decreased over the current reporting in period in the 86128T piezometer in B-05-03 (see Plate 58 in the Appendix).

Additional Field Measurements and Observations

The two calipered surface distance locations (left and right) are provided in the Site Plan of Active Instrumentation (Plate 2 of the Appendix). A Calipered Surface Distance Table and Calipered Distance Readings vs. Time plots have been included as Plates 65 through 67 in the Appendix. The left calipered location indicates the gap is continuing to open at a rate of about 0.05 in/yr. The gap at the right calipered location is continuing to close at a rate of about 0.02 in/yr. The right calipered location has been oscillating above and below a distance of about 4.4 inches since late 2000 indicating that there might not be a trend.

In July 2009, an aggregate pile roughly 25 to 30 feet high was observed within 15 feet of the east right-of-way fence and covered roughly less than 50 percent of the adjacent property (see Plates 68 through 70). A smaller aggregate pile was observed near the east end of the property as shown in the photo submitted as Plate 70 in the Appendix. During a site visit in June 2009 for the ongoing CUY-90-14.52 drilling work, the aggregate pile adjacent to the east right-of-way fence was observed to be much taller, possibly as high as 40 feet or more. However, a site photo of the aggregate pile was not able to be taken during the June 2009 visit.

The large excavation and the repair effort of the bulkhead near the west right-of-way fence appear to remain unfinished as of July 2009. The small landslide adjacent to the large excavation near the west right-of-way fence (just north of B-05-16, see Plate 2 in the Appendix for the approximate landslide location) does not appear to have experienced a significant change since the quarterly readings were last taken in April 2009. However, it was difficult to visually observe the scarps on the slope due to the heavy vegetation throughout the landslide area.

Closing

We appreciate being of continued service during this project. Please contact our office if you have any questions or require additional information. The next quarterly readings are scheduled to take place around October 15, 2009.

Sincerely,
BBC&M ENGINEERING, INC.
Cleveland, Ohio

Jeffrey L. Snyder, P.E.
Project Engineer

Stephen C. Pasternack, P.E.
Senior Project Engineer

cc: Mr. Jeff Broadwater, P.E. (Michael Baker Jr., Inc.)

Submitted: pdf copy submitted to Richland Engineering at reltd@r-e-l.com and Michael Baker Jr., Inc. via their ftp site
Attachments: Appendix (Plates 1 through 70)

APPENDIX

CUY-90-14.52/15.24 INSTRUMENTATION MONITORING

APPENDIX

Plate No.

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Site Plan of Active Instrumentation....2

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B-102 – A and B-Axis....5-6
B-107 – A and B-Axis....7-8
B-203 – A and B-Axis....9-10
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Displacement versus Time Plots
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Plots for Inclinometers Installed by BBCM in 2006 – CUY-90-14.52

Cumulative and Incremental Displacement versus Depth Plots
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B-05-02 – A and B-Axis....30-31
B-05-03 – A and B-Axis....32-33
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B-05-03 – A-Axis 49
B-05-04 – A-Axis 50
B-05-16 – A-Axis 51

Plots for Active Pneumatic Piezometers Installed by BBCM in 1994 – CUY-90-15.24

Total Head (h_t) versus Time Plots
B-101 (P-1) 52
B-105 (P-3) 53
B-107 (P-5) 54
B-303 (P-2) 55

Plots for Vibrating Wire (VW) Piezometers Installed by BBCM in 2006 – CUY-90-14.52

Total Head (h_t) versus Time Plots
B-05-01 56
B-05-02 57
B-05-03 58
B-05-04 59
B-05-07 60
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B-05-11 62
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Site Photos

Aggregate Piles Adjacent to East Right-of-Way Fence 68-70

SUMMARY OF ACTIVE INSTRUMENTATION
CUY-90-14.52/15.24

Active Instrumentation	Active Inclinometer ?	Inclinometer Depth (ft)	Active Piezometer?	VW or Pneumatic?	# of Active Piezometers	Piezometer Depth(s) Below Existing G.S. (ft)	Instrumentation Installation Date	G.S. Elevation (ft)
B-101	Y	190	Y[1]	Pneumatic[1]	2 [1]	50.3, 124.3	Aug-Sep 1994	676.6 (676.6[3])
B-102	Y	224	N	---	---	---	Sep 1994	675.7
B-105	N	---	Y[1]	Pneumatic[1]	2 [1]	88, 105.7	Aug 1994	585.4 (585.6[3])
B-105A	Y	156	N	---	---	---	May 2006	585.7
B-107	Y	210	Y[1]	Pneumatic[1]	1 [1]	100	Sep 1994	662.7 (662.3[3])
B-108A	Y	168	N	---	---	---	Apr-May 2006	603.0
B-203	Y	190	N	---	---	---	Aug 1996	638.0
B-204	Y	134	N	---	---	---	Jul 1998	599.0
B-303	Y	178	Y[2]	Pneumatic[2]	1 [2]	40.8	Aug 1994[2], Jul 1998	622.0 (627.0[3])
P-9N	Y	148	N	---	---	---	Feb 1999	588.0
B-05-01	Y	228	Y	VW	2	65, 95	Apr-May 2006	675.4
B-05-02	Y	176	Y	VW	2	46, 122	Apr-May 2006	617.9
B-05-03	Y	168	Y	VW	2	32, 112	Apr-May 2006	605.1
B-05-04	Y	172	Y	VW	2	59, 119	Mar-May 2006	600.8
B-05-07	Y	224	Y	VW	2	102, 220	Apr-Jun 2006	678.9
B-05-08	Y	224	Y	VW	2	65.5, 110.5	Apr-May 2006	679.9
B-05-11	Y	226	Y	VW	2	95, 130	Apr-Jun 2006	675.1
B-05-12	Y	210	Y	VW	2	75, 120	Apr-May 2006	652.7
B-05-13	Y	134	Y	VW	2	60, 135	May-Jun 2006	580.0
B-05-16	Y	162	N	---	---	---	Jun 2006	598.5

1 BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers (i.e. P-1 to B-101, P-3 to B-105, and P-5 to B-107).

2 The pneumatic piezometer was actually installed in August 1994 at Boring P-2 in the vicinity of the B-103 inclinometer (now inactive). However, the piezometer has since been renamed to B-303 due to its close proximity to the active inclinometer at B-303, which was installed in July 1998.

3 Elevation in parenthesis refers to the ground surface (G.S.) elevation of the P boring location where the pneumatic piezometer was installed.

LEGEND

B-05-01 — LOCATION OF INCLINOMETER/PIEZOMETER INSTALLED BY BBCM IN 2006 (B-05-01 THROUGH B-05-04, B-05-07, B-05-08, B-05-11 THROUGH B-05-13, AND B-05-16).

B-105A — LOCATION OF REPLACEMENT INCLINOMETER INSTALLED BY BBCM IN 2006 (B-105A AND B-108A).

B-101 — LOCATION OF INCLINOMETER AND/OR PIEZOMETER INSTALLED BY BBCM BETWEEN 1994 AND 1999 (B-101, B-102, B-105, B-107, B-203, B-204, B-303, AND P-9N).

B-110 — LOCATION OF INCLINOMETER AT B-110, WHICH WAS DESTROYED BY EXCAVATION ACTIVITIES IN MARCH, 2006

SCALE IN FEET
0 50 100

SITE PLAN OF ACTIVE INSTRUMENTATION

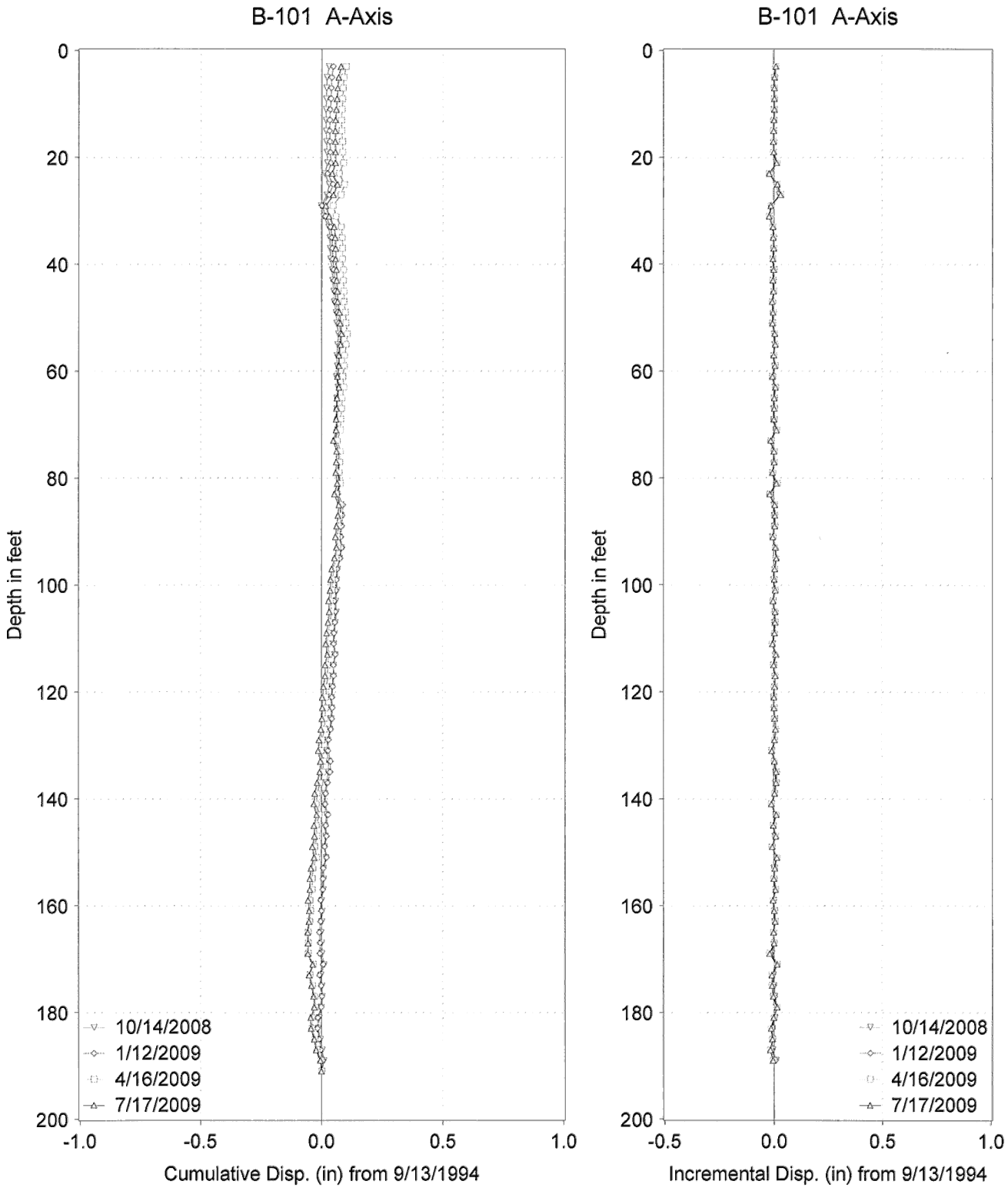
CUY-90-14.52/15.24 WEST ABUTMENT
CLEVELAND, OHIO

Project: 012-00946-300	Drawn By: EDV
Drawing Date: 7/25/06	Approved By: JLS
Revision Date: 2/9/07	Scale: 1" = 100'

BBCM
SOLUTIONS TO BUILD ON
Columbus (614) 793-2226
Cleveland (216) 901-1300
Cincinnati (513) 771-8471
Dayton (937) 424-1011

BBC&M DRAWING FILE: $BBCM FILENAME$ $DATE$ $TIME$ MODEL NAME: $MODEL$

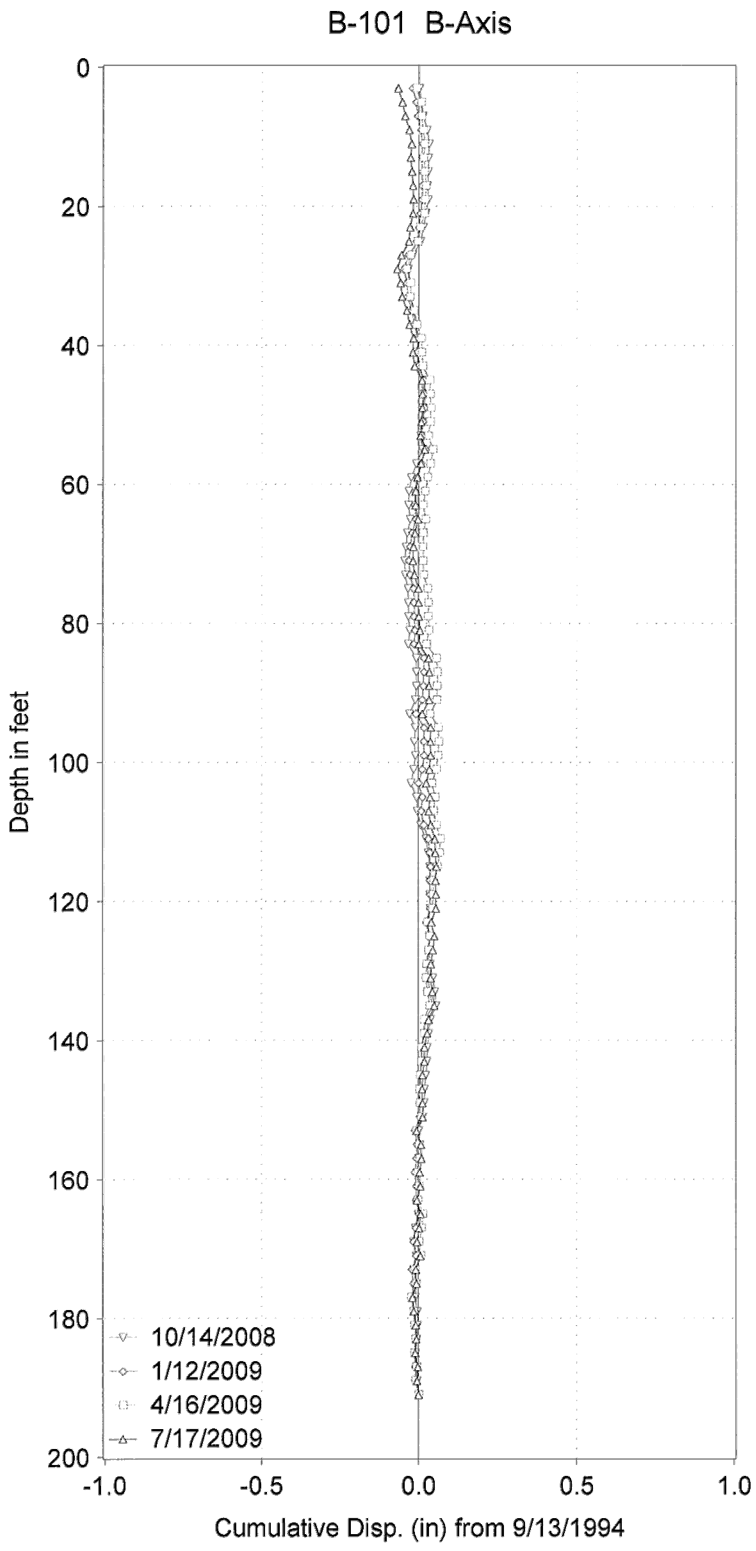
PLATE 2

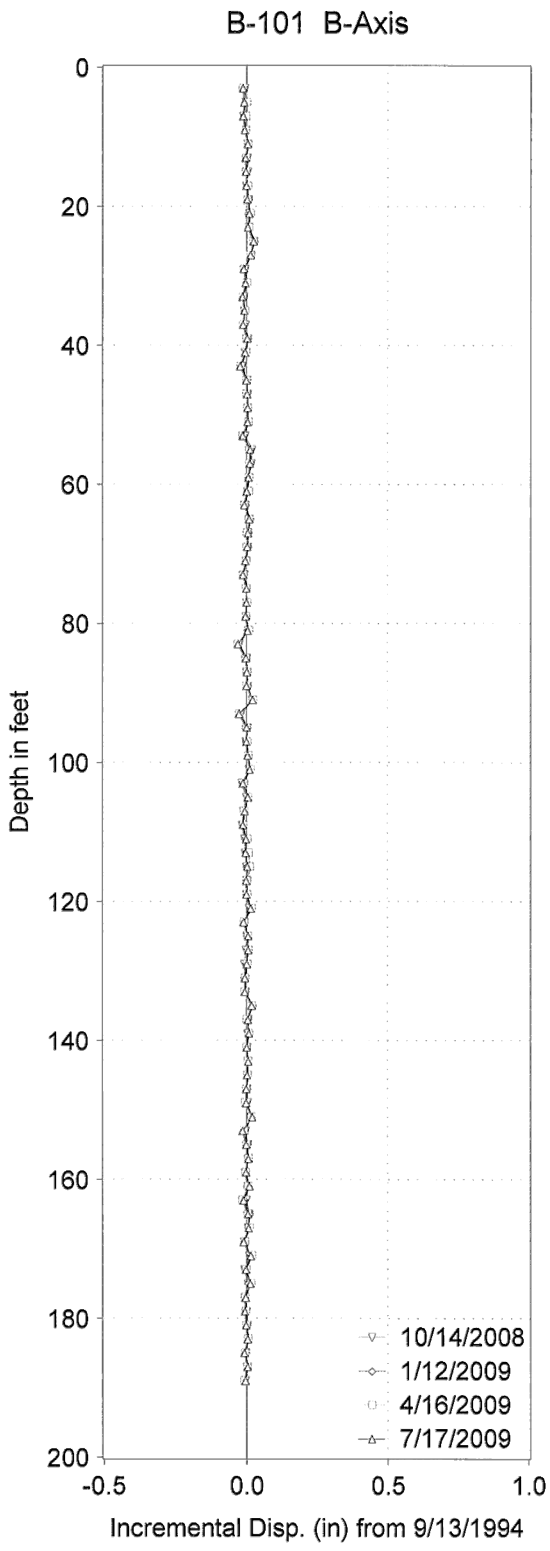


B-101

-Includes readings from the last four quarters.

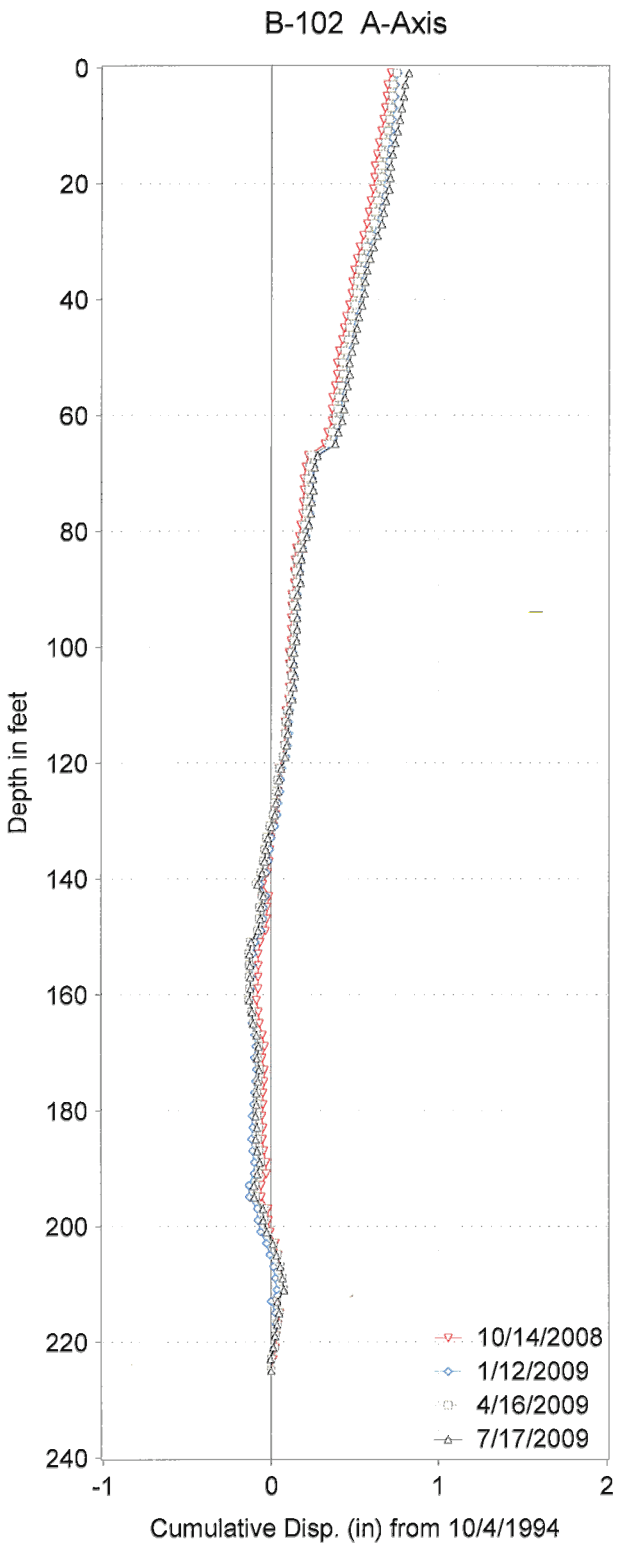
PLATE 3

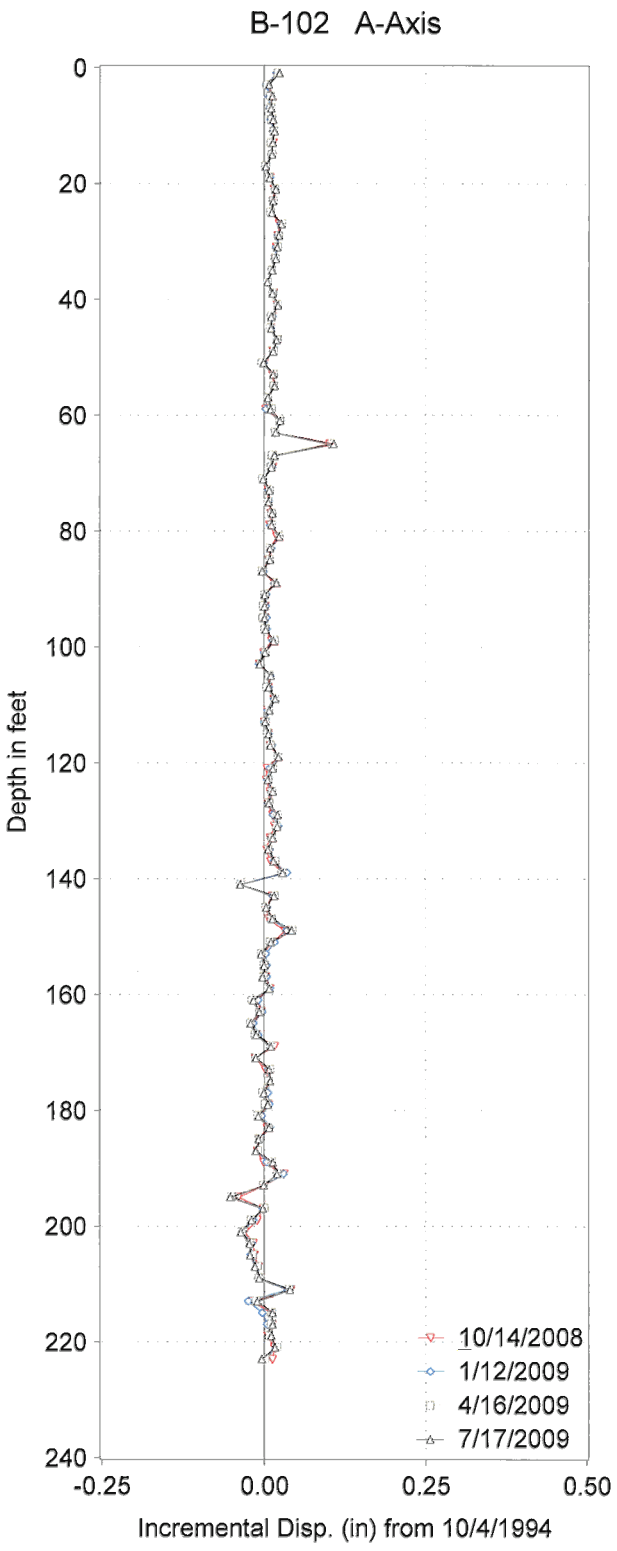




B-101
-Includes readings from the last four quarters.

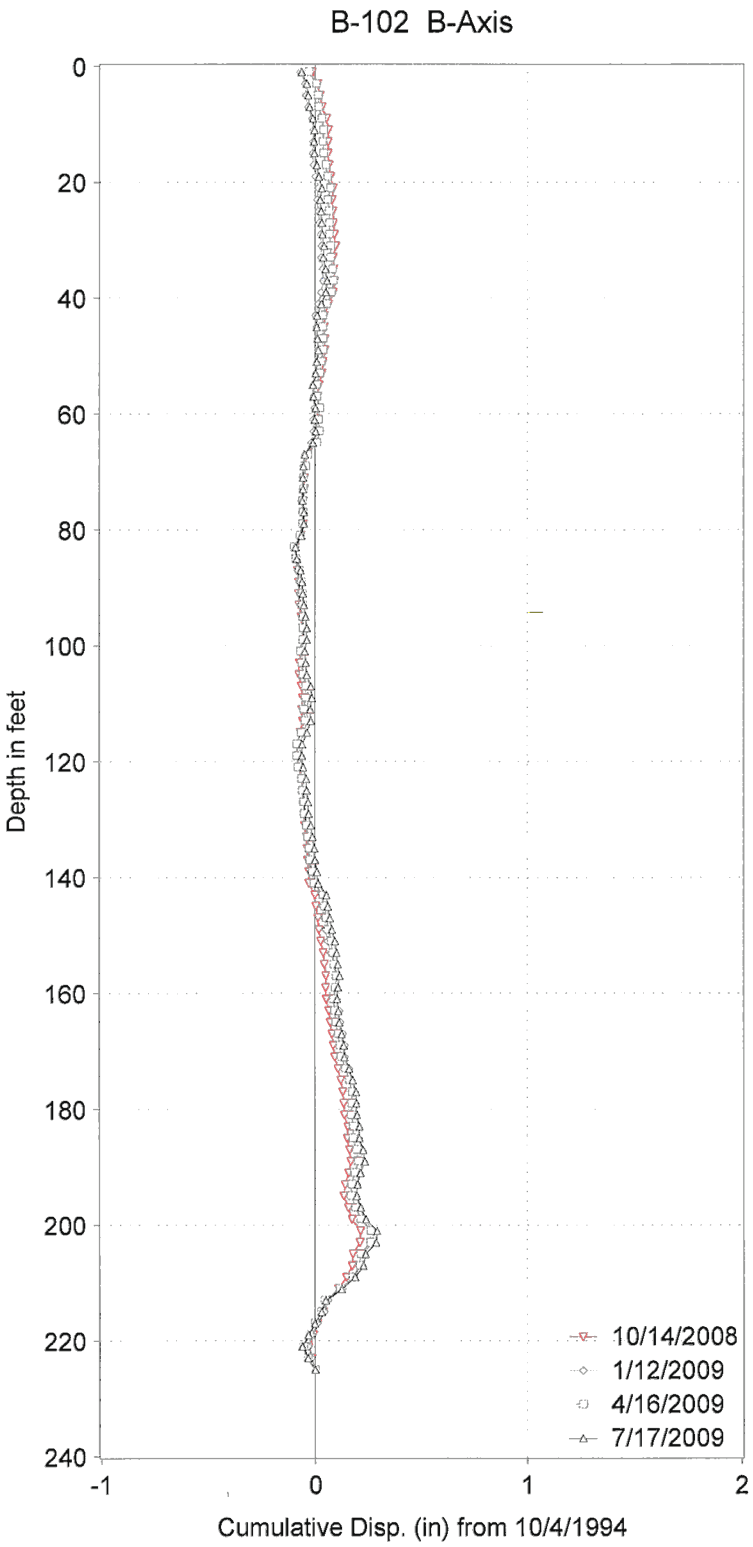
PLATE 4

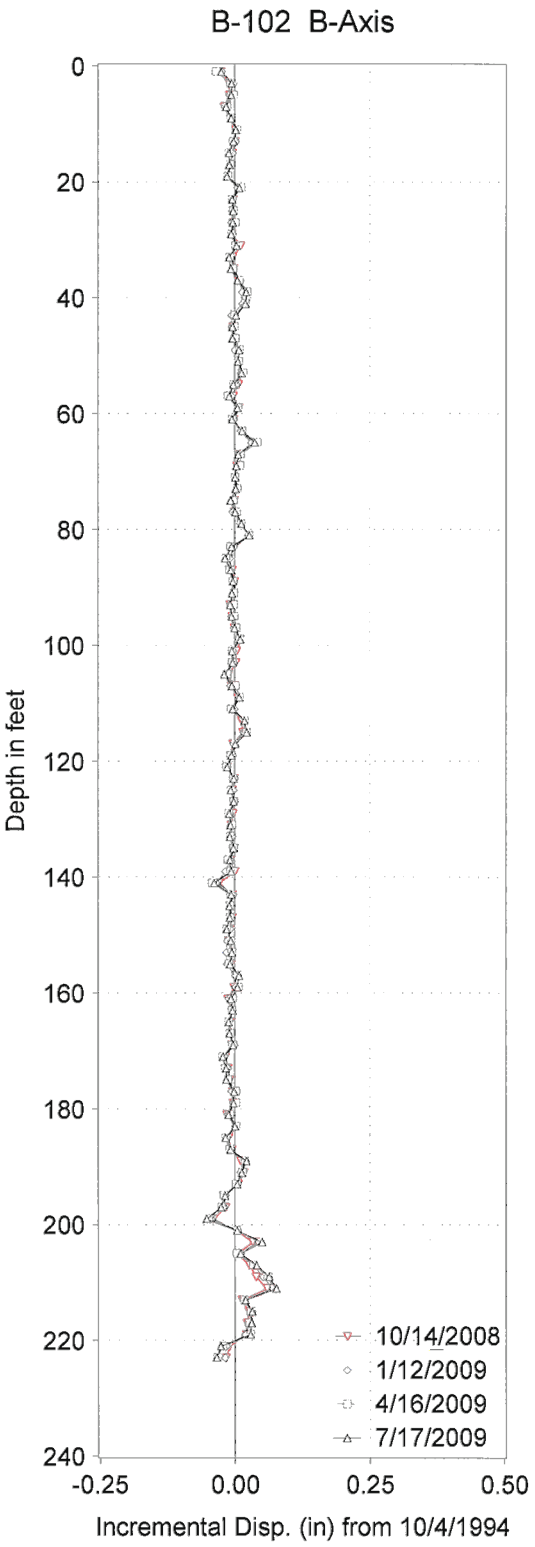




B-102
-Includes readings from the last four quarters.

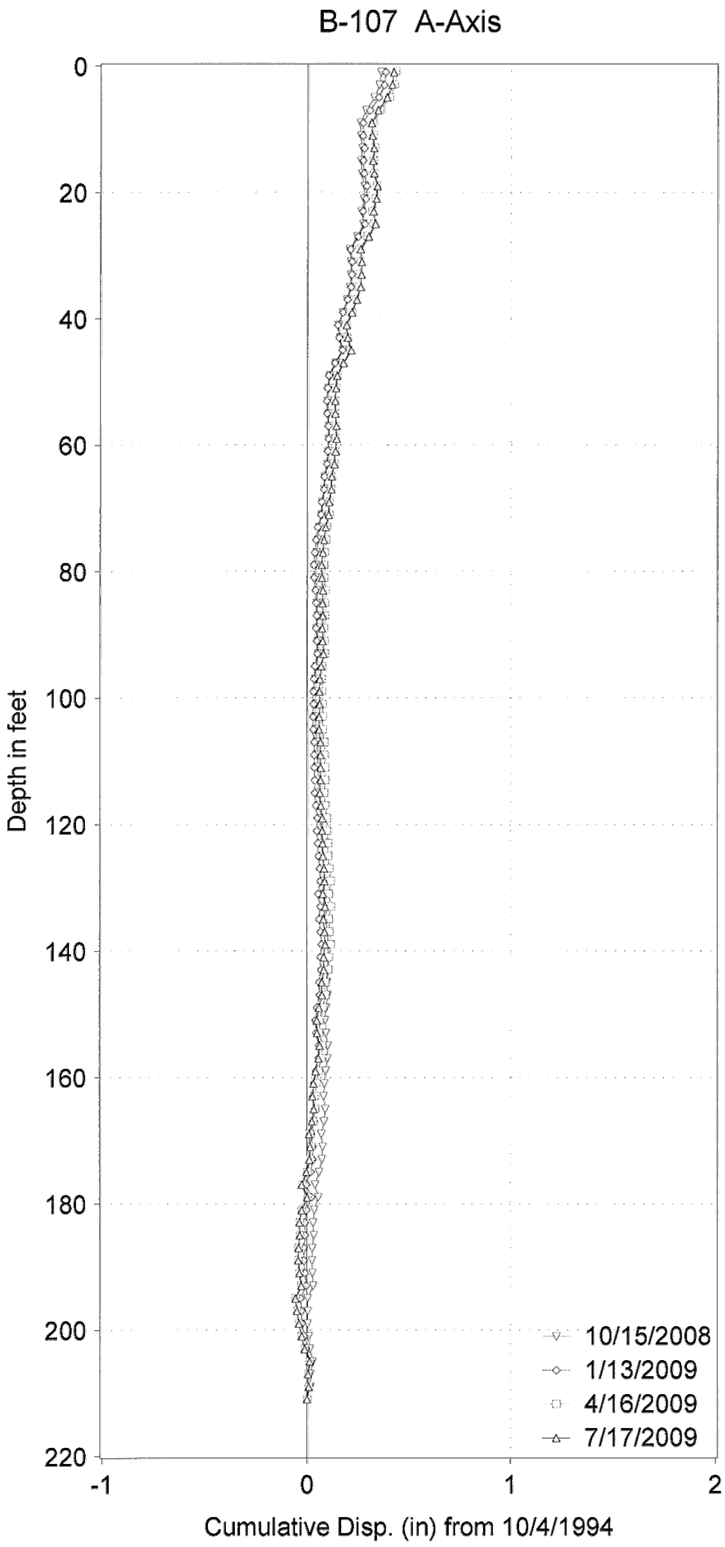
PLATE 5

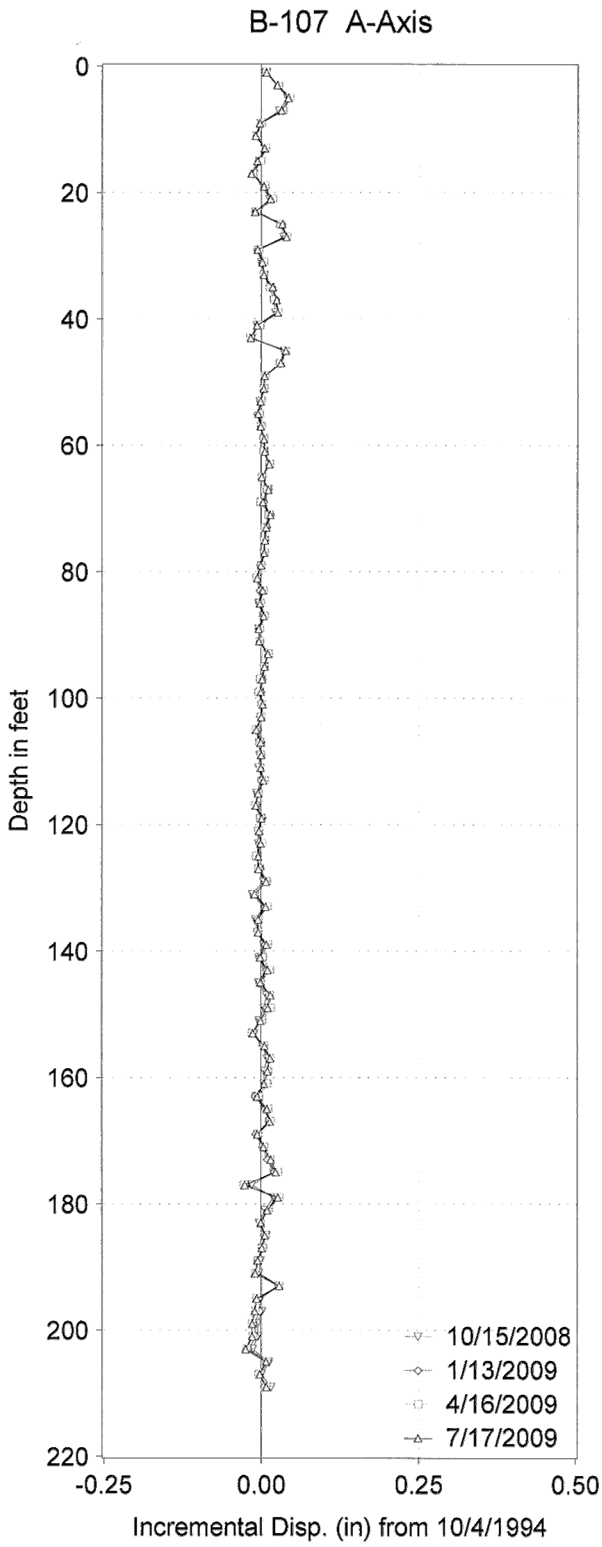




B-102
-Includes readings from the last four quarters.

PLATE 6

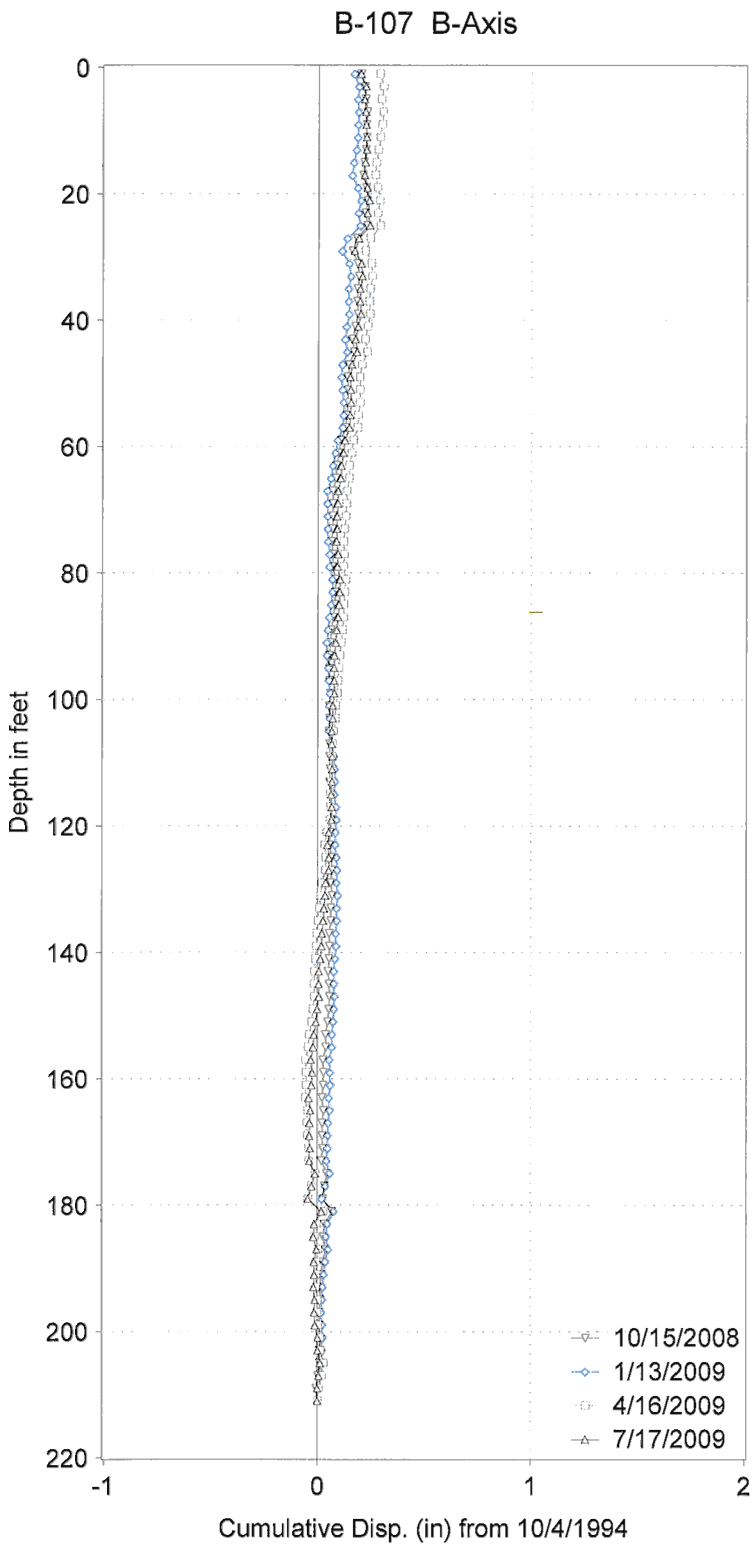


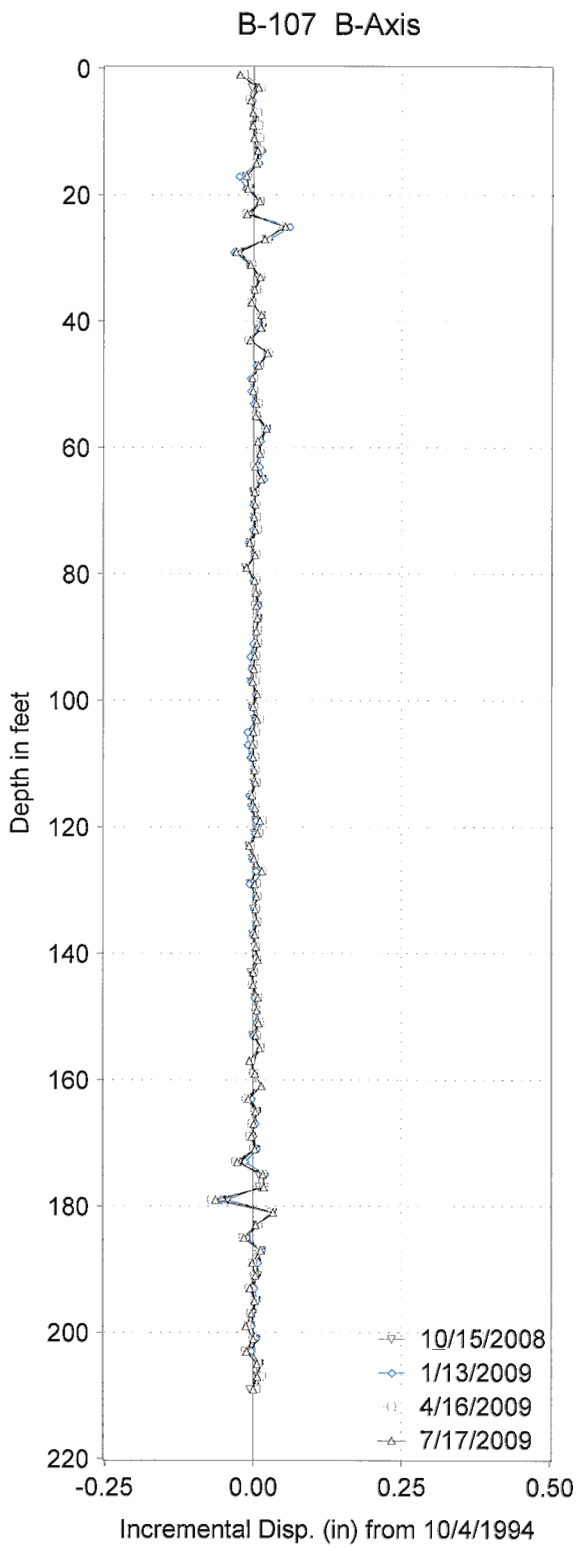


B-107

-Includes readings from the last four quarters.

PLATE 7

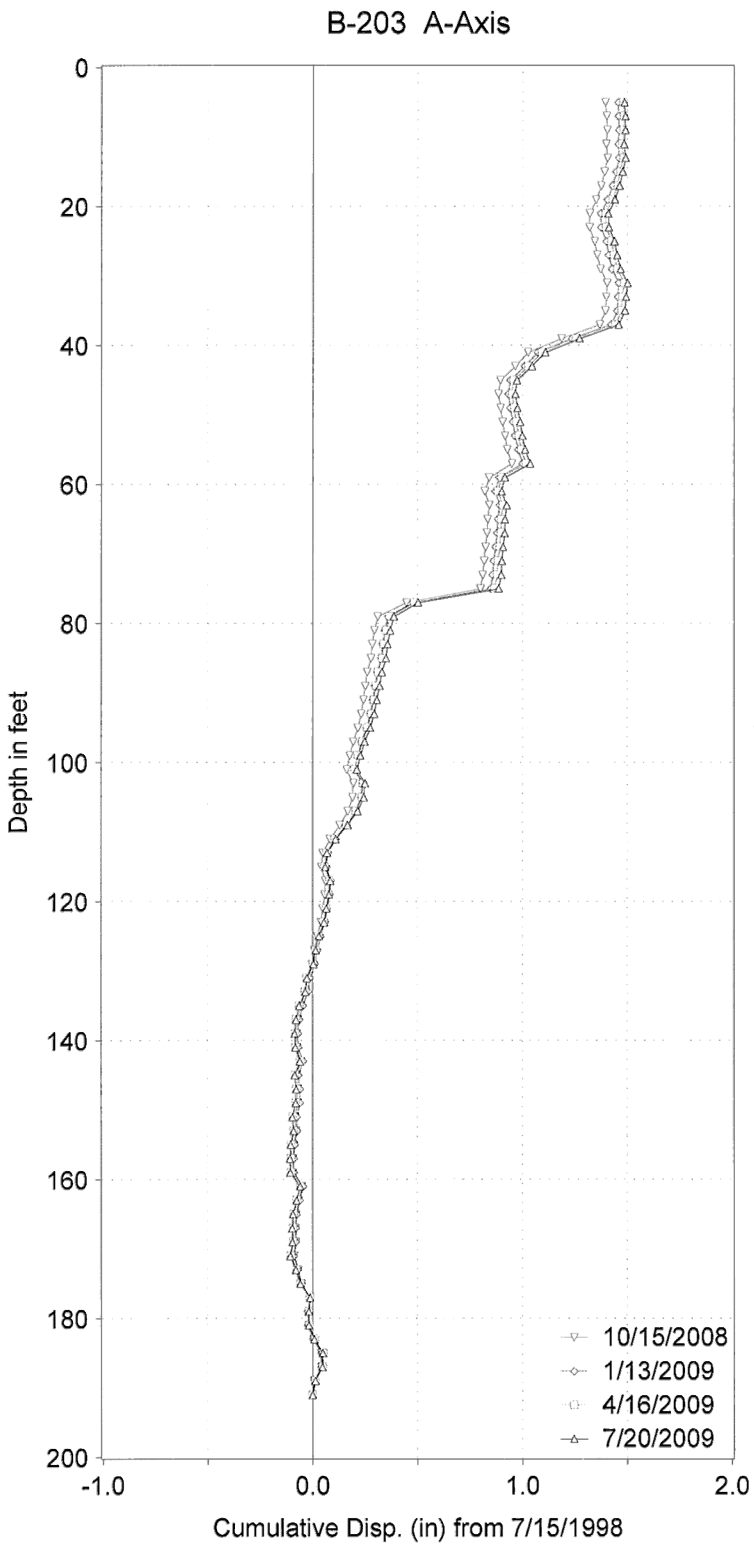


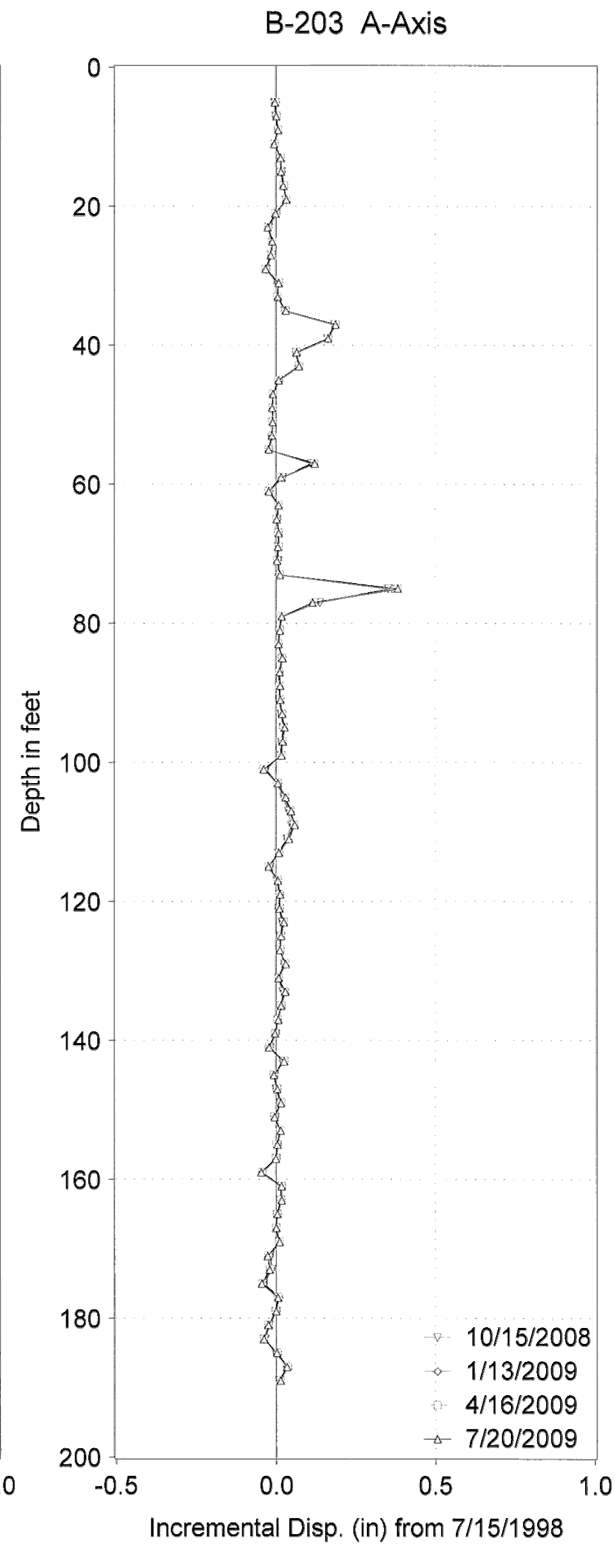


B-107

-Includes readings from the last four quarters.

PLATE 8

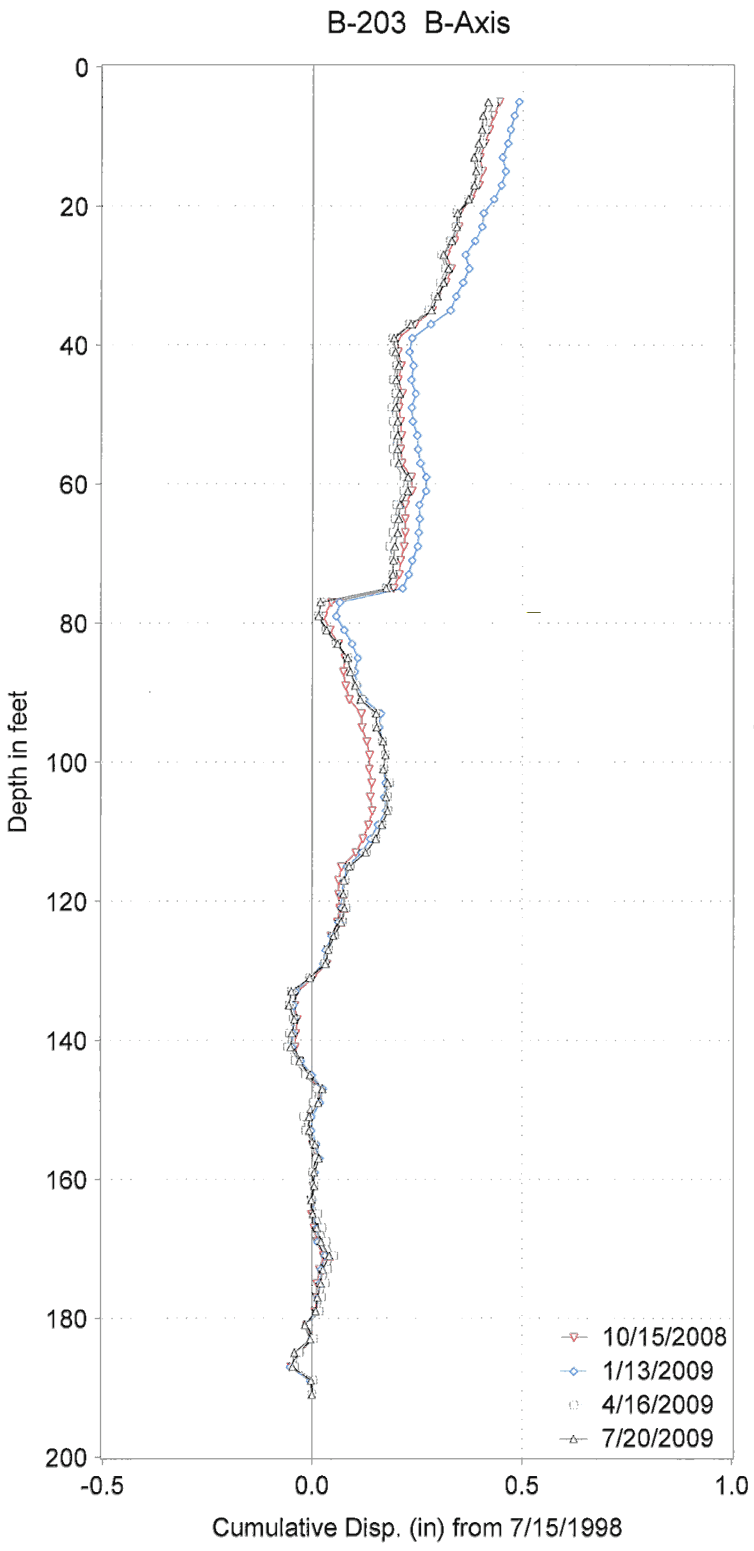


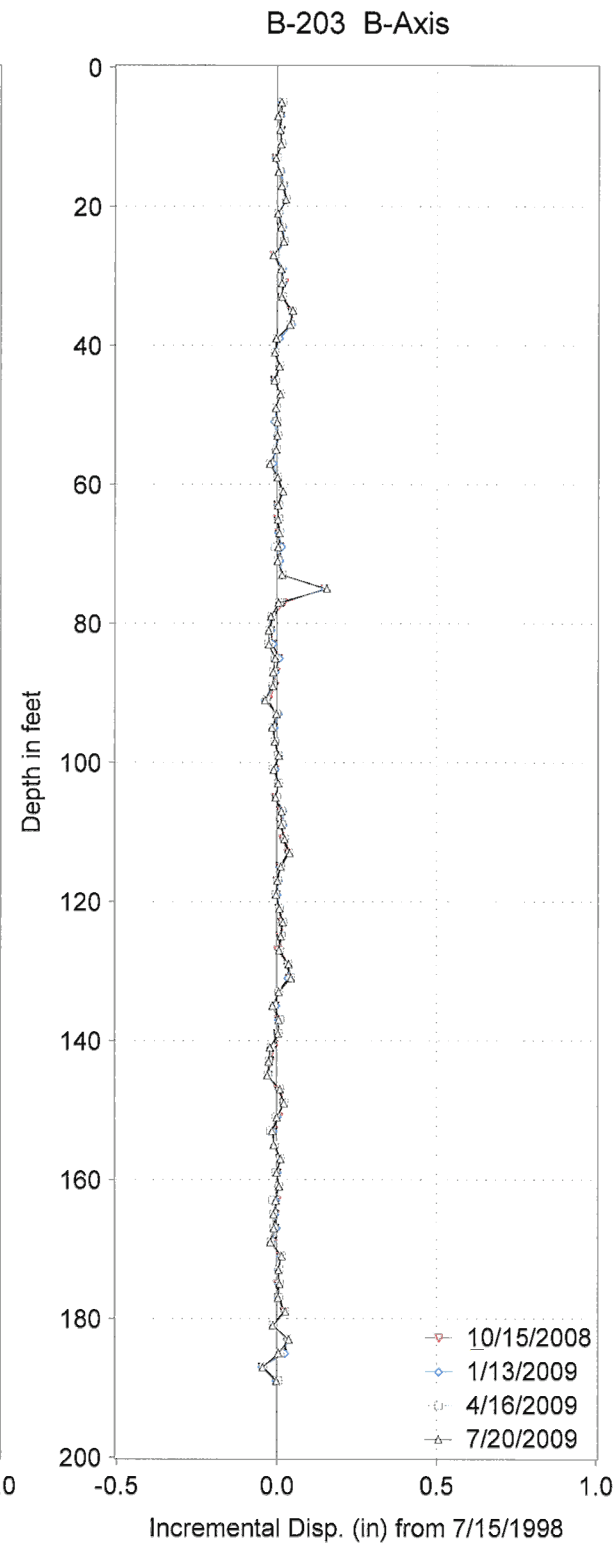


B-203

-Includes readings from the last four quarters.

PLATE 9

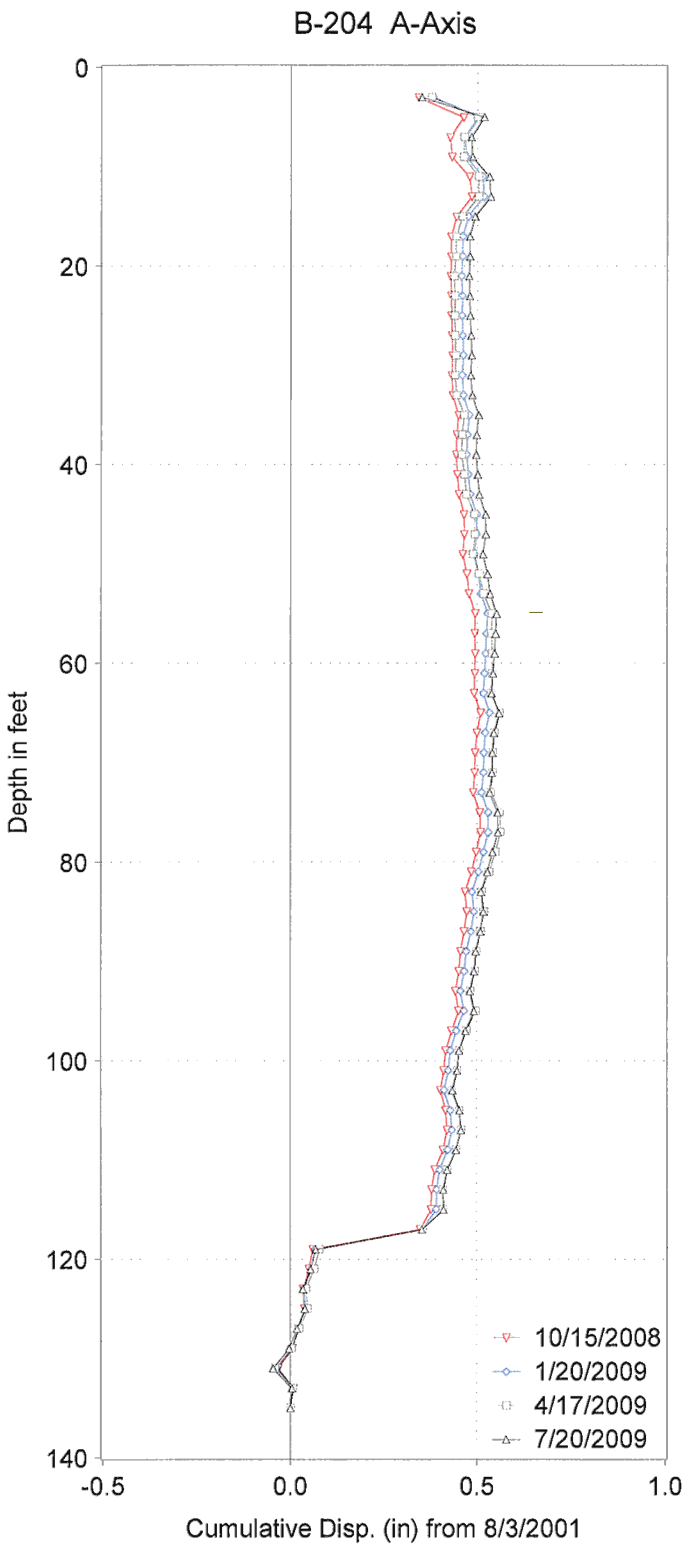


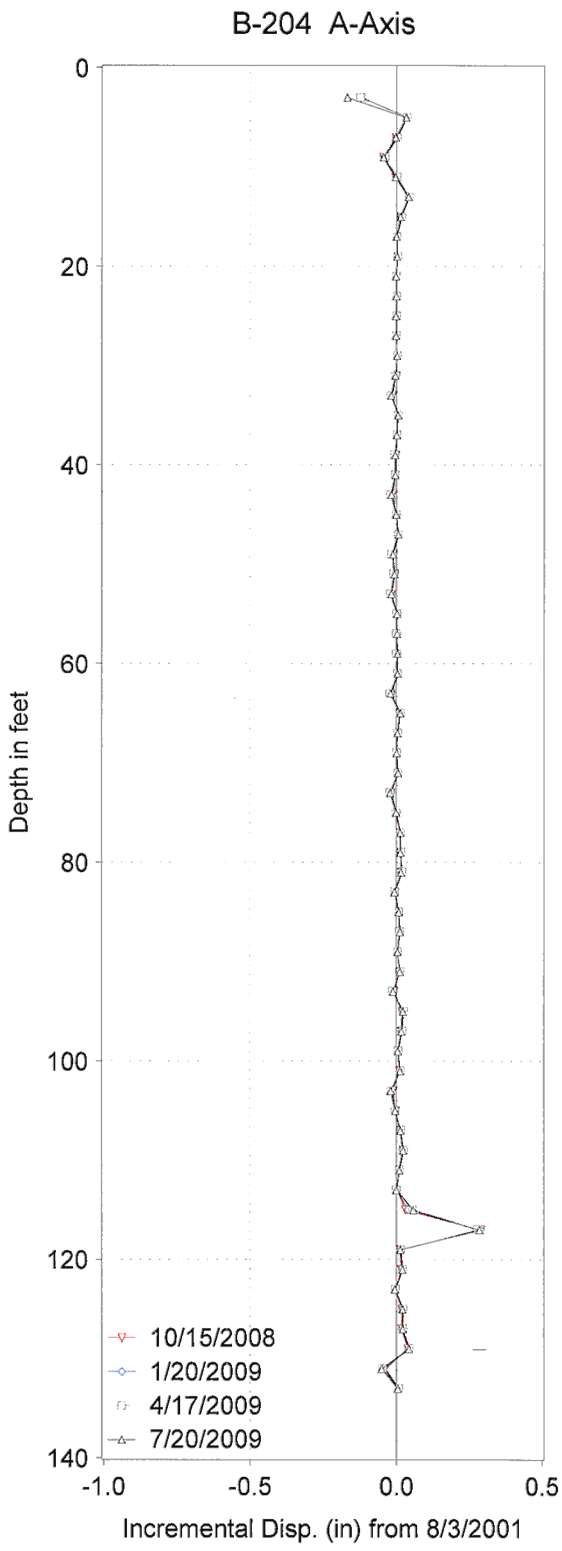


B-203

-Includes readings from the last four quarters.

PLATE 10

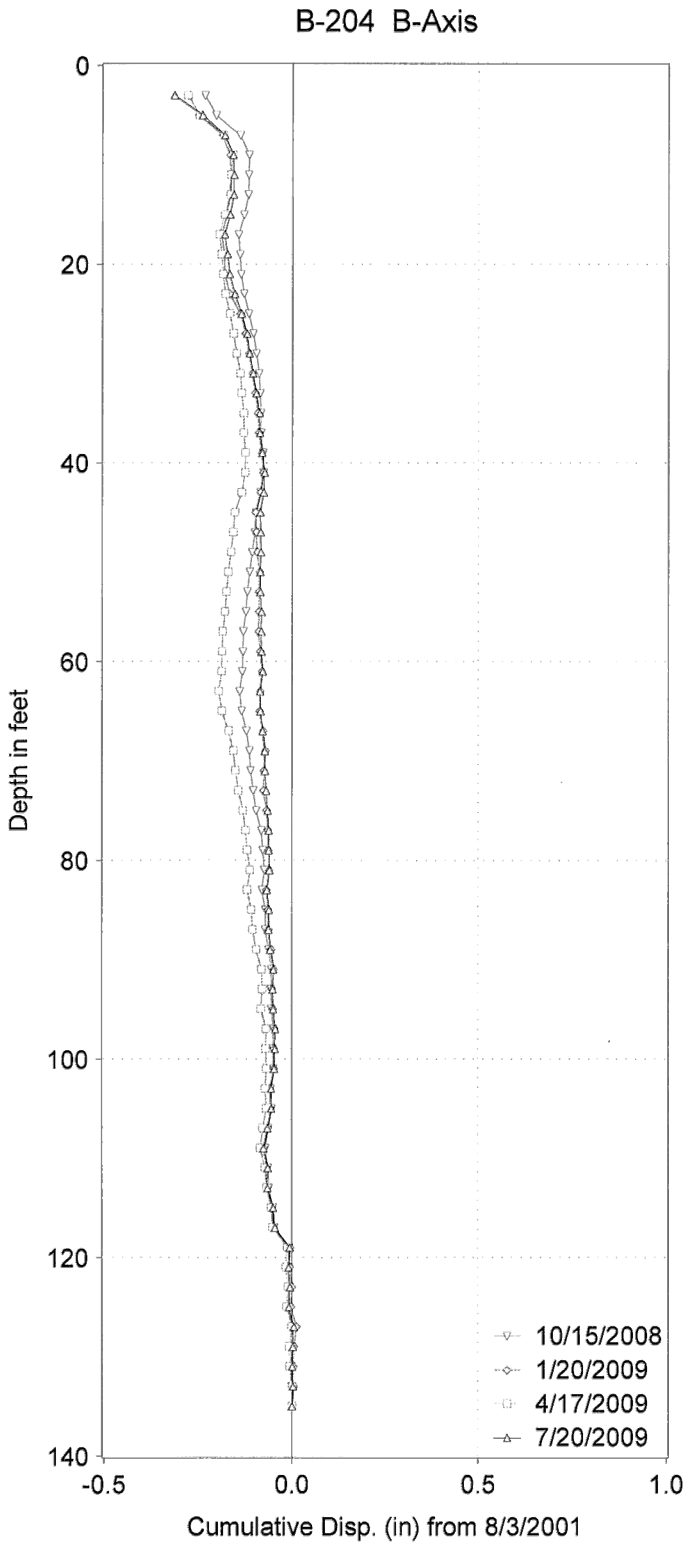


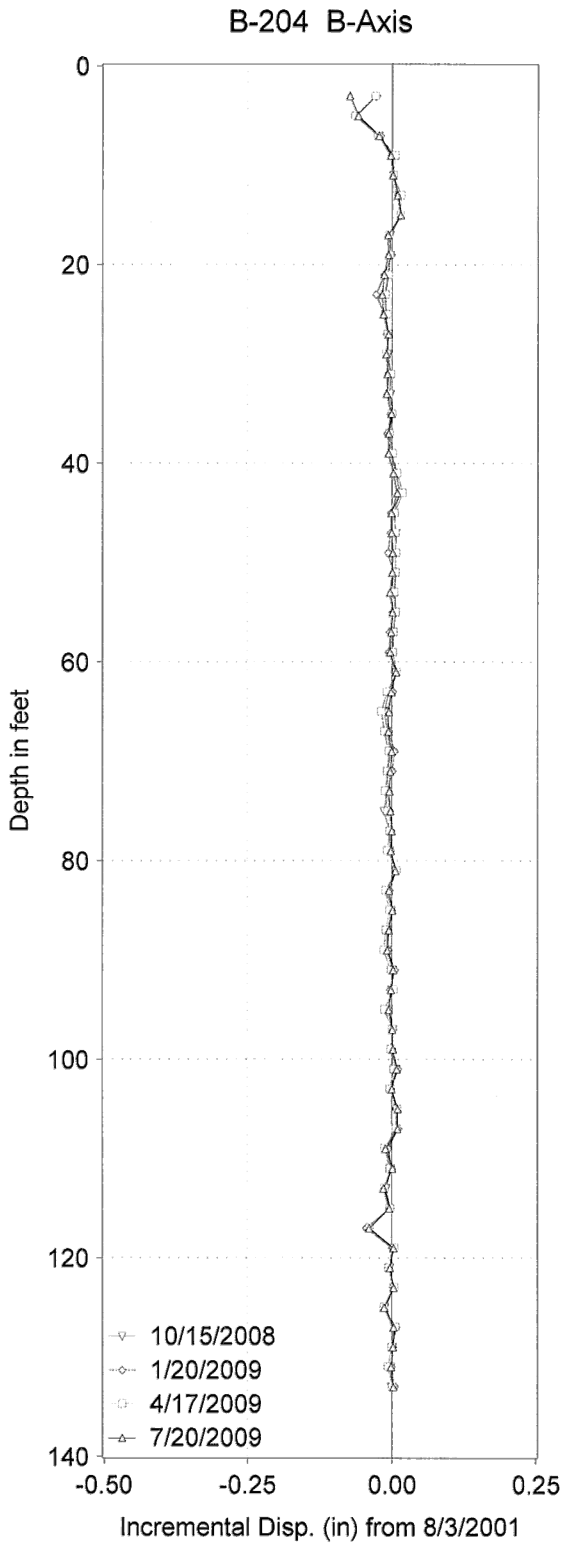


B-204

-Includes readings from the last four quarters.

PLATE 11

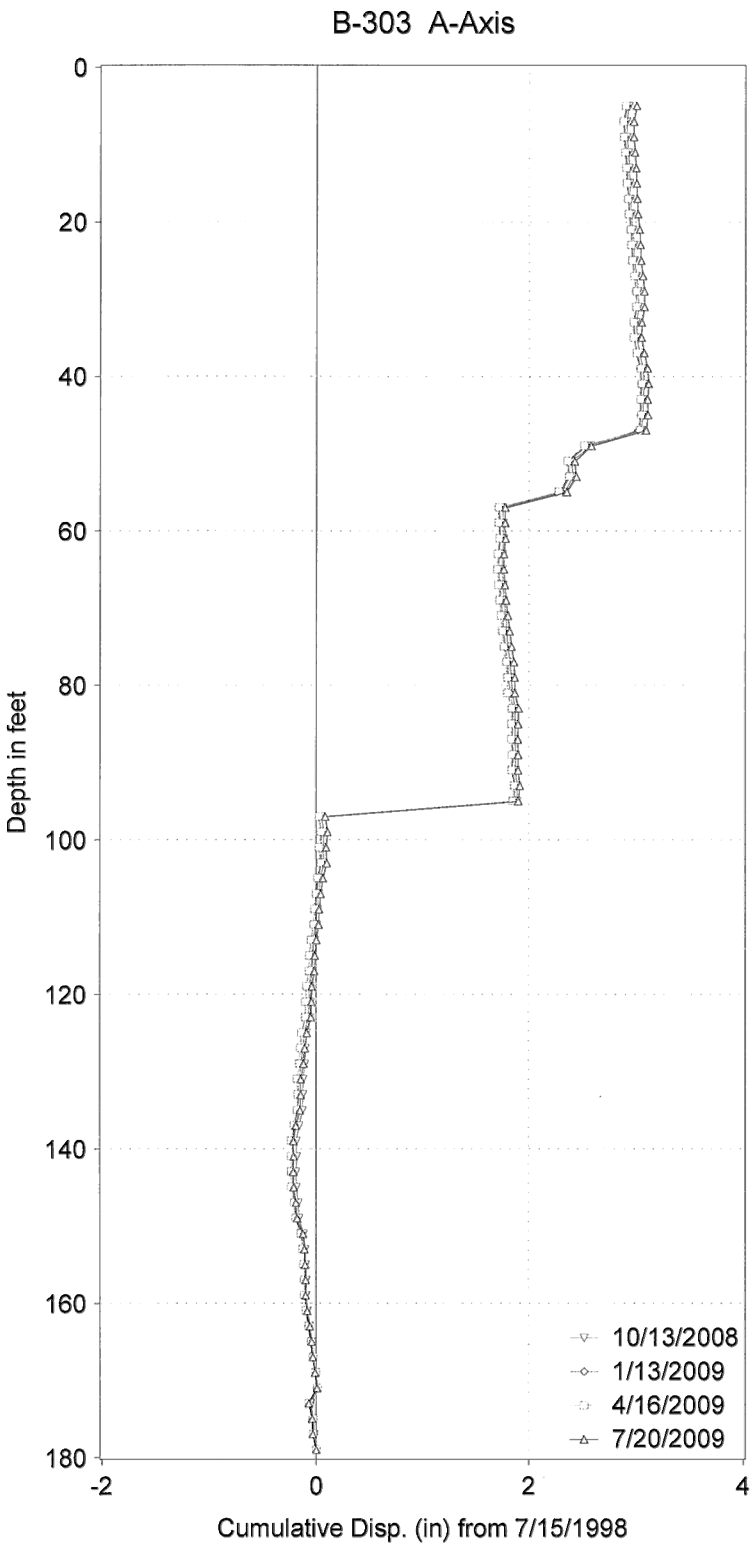


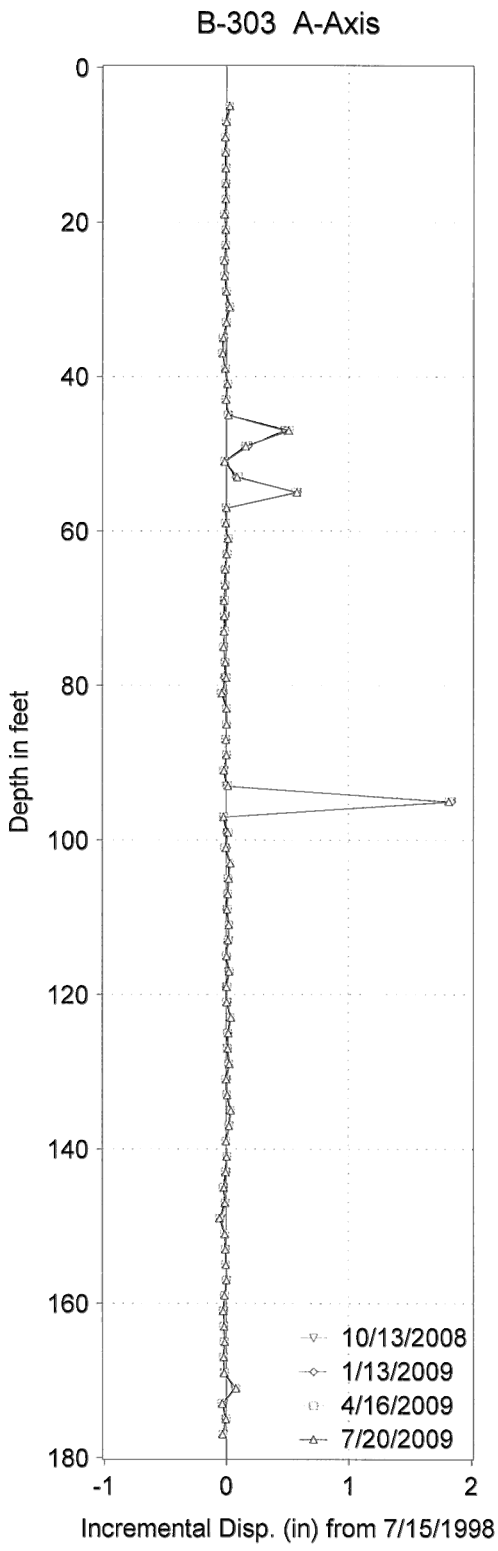


B-204

-Includes readings from the last four quarters.

PLATE 12

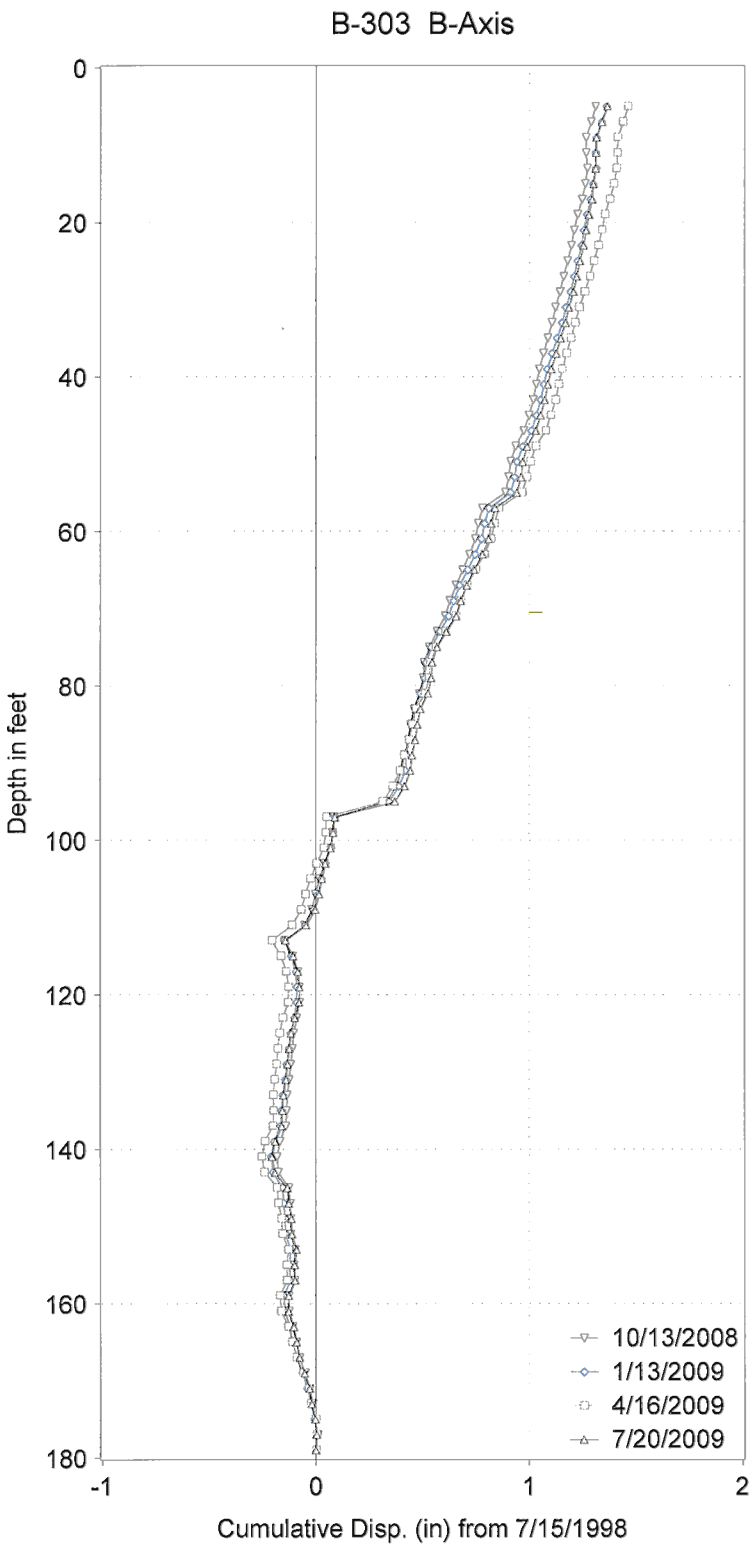


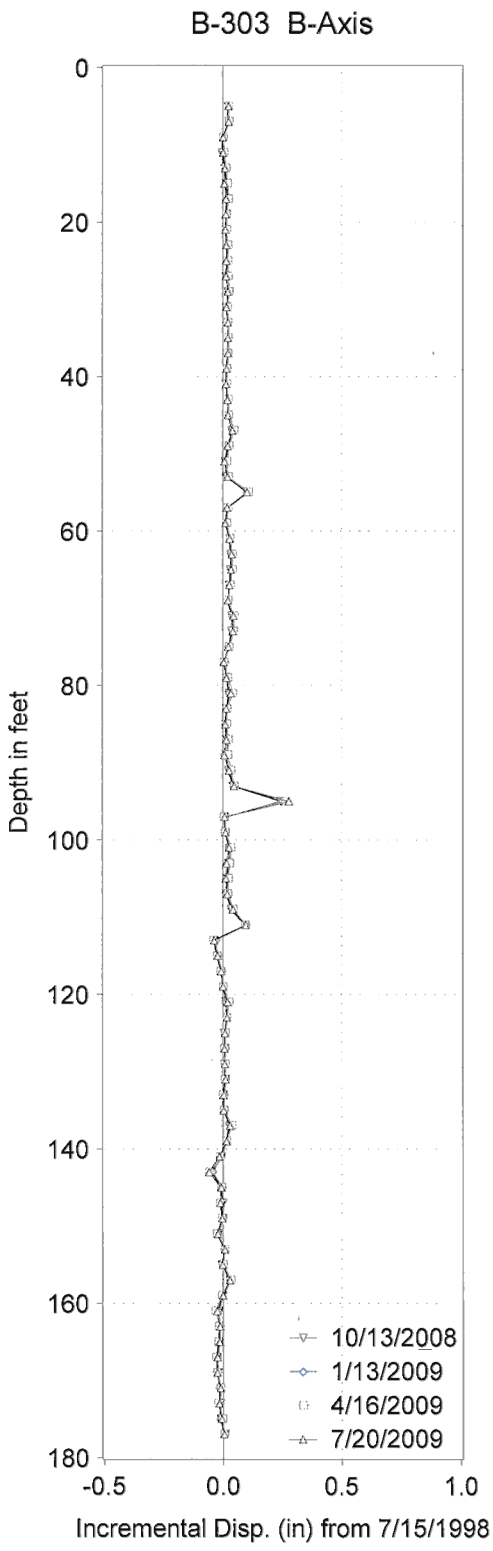


B-303

-Includes readings from the last four quarters.

PLATE 13

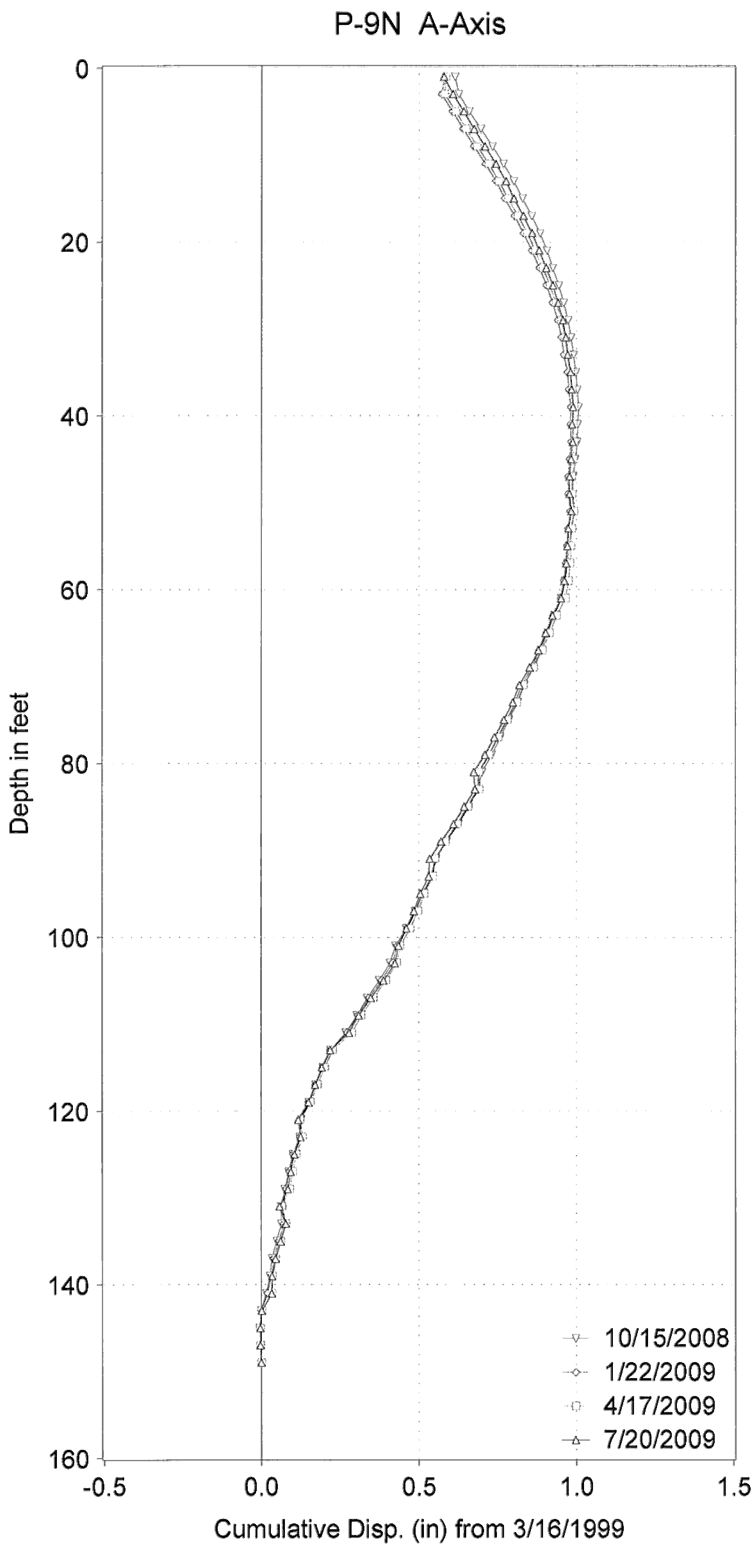


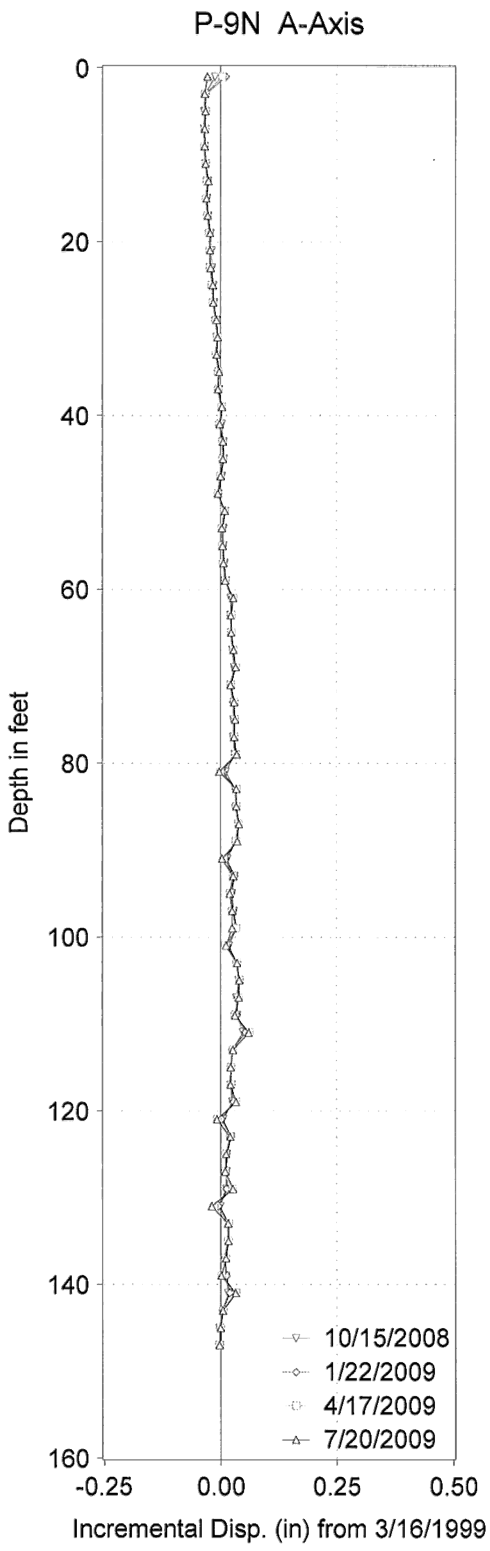


B-303

-Includes readings from the last four quarters.

PLATE 14

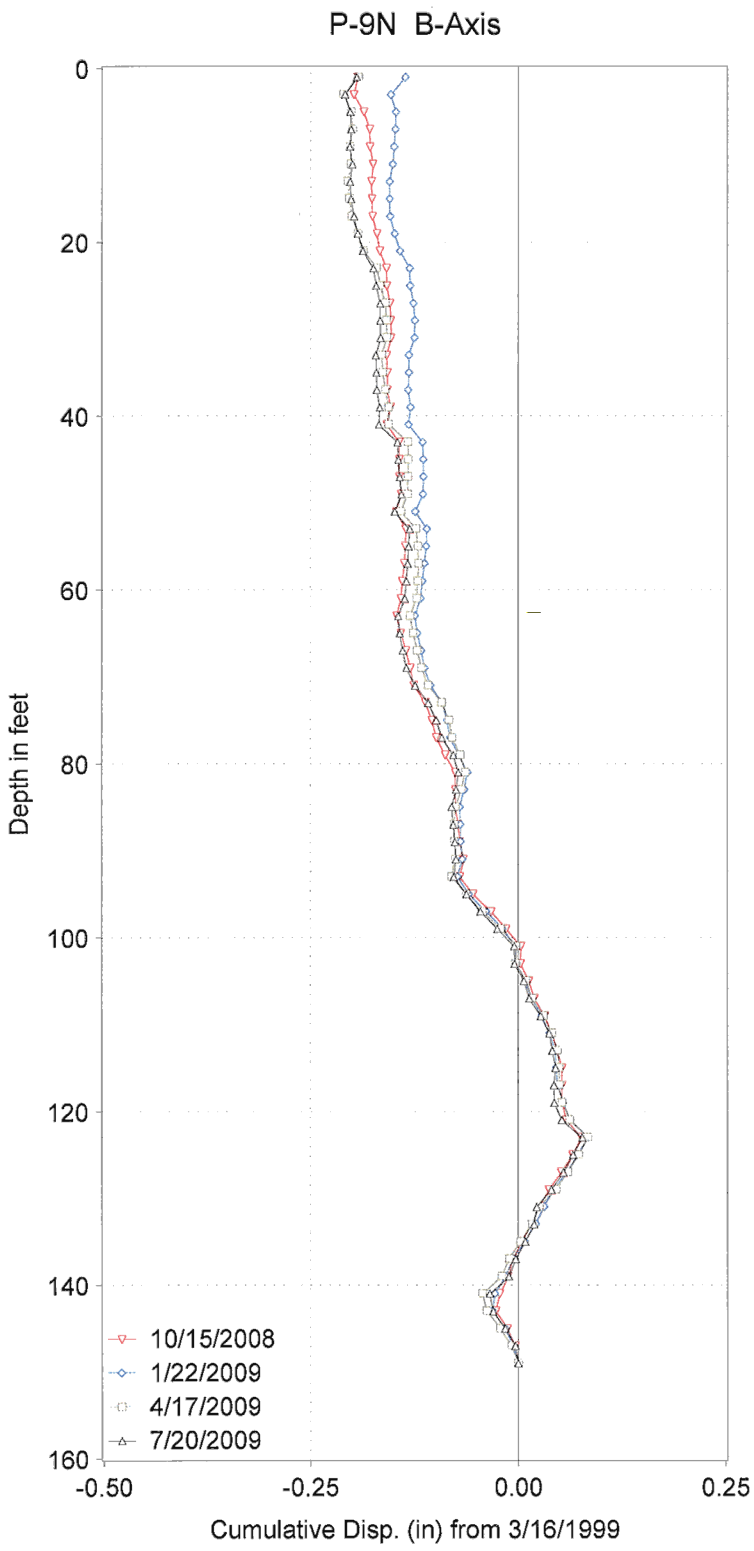


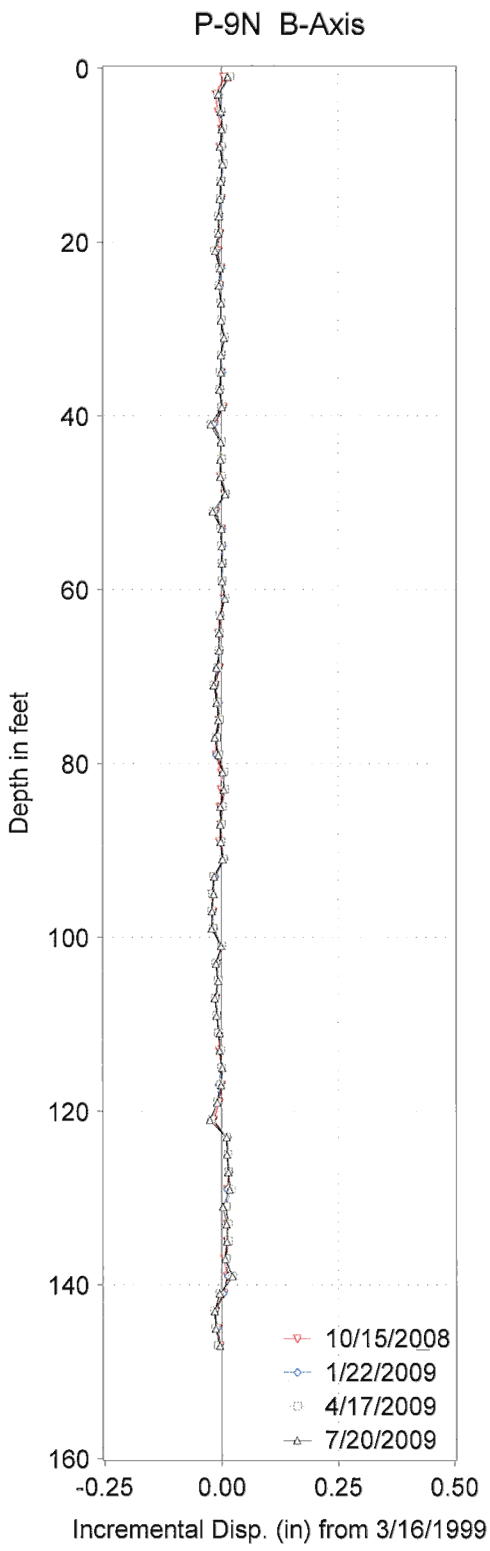


P-9N

-Includes readings from the last four quarters.

PLATE 15





P-9N

-Includes readings from the last four quarters.

PLATE 16

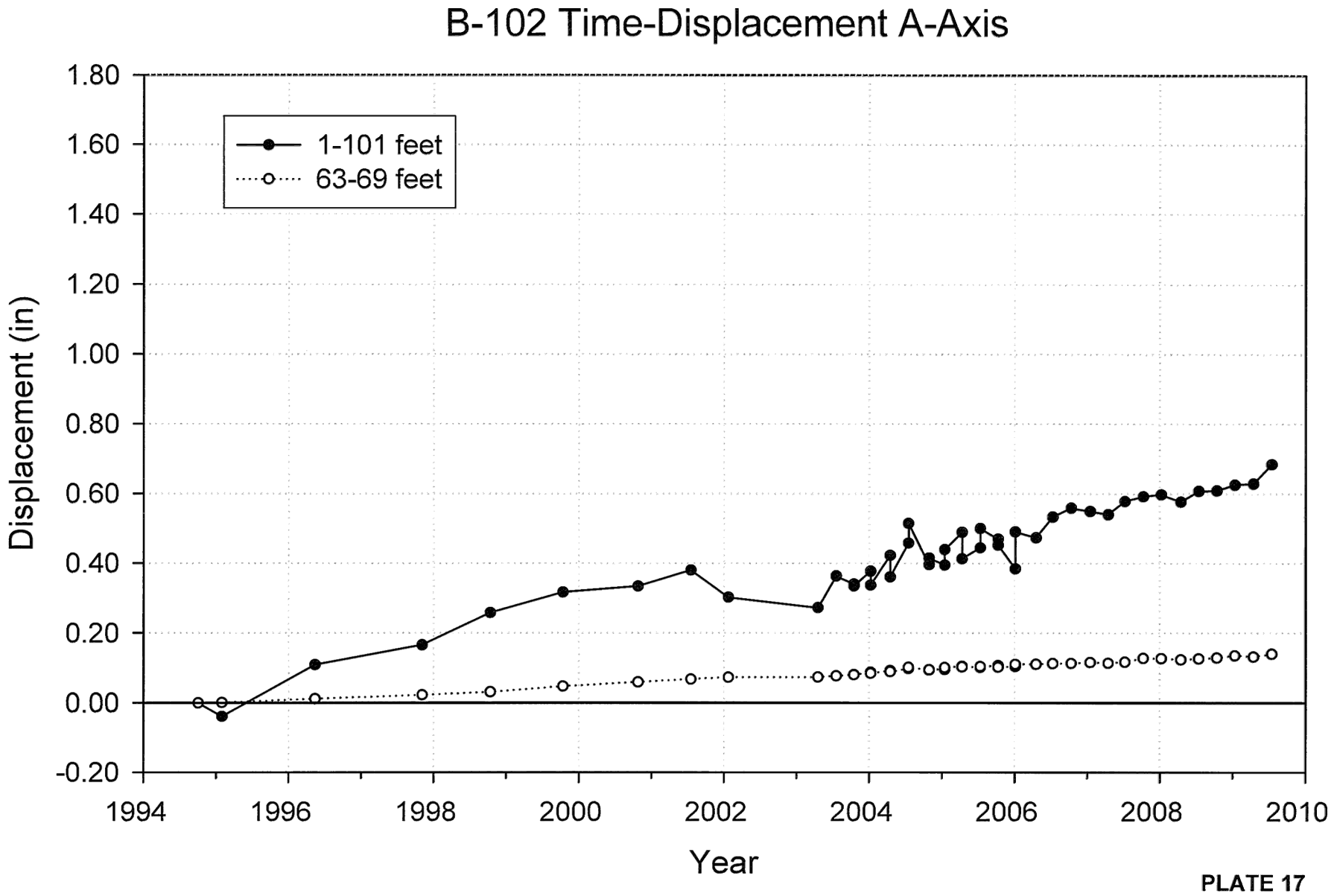

B-102 Time-Displacement A-Axis
1-101 feet
63-69 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 17

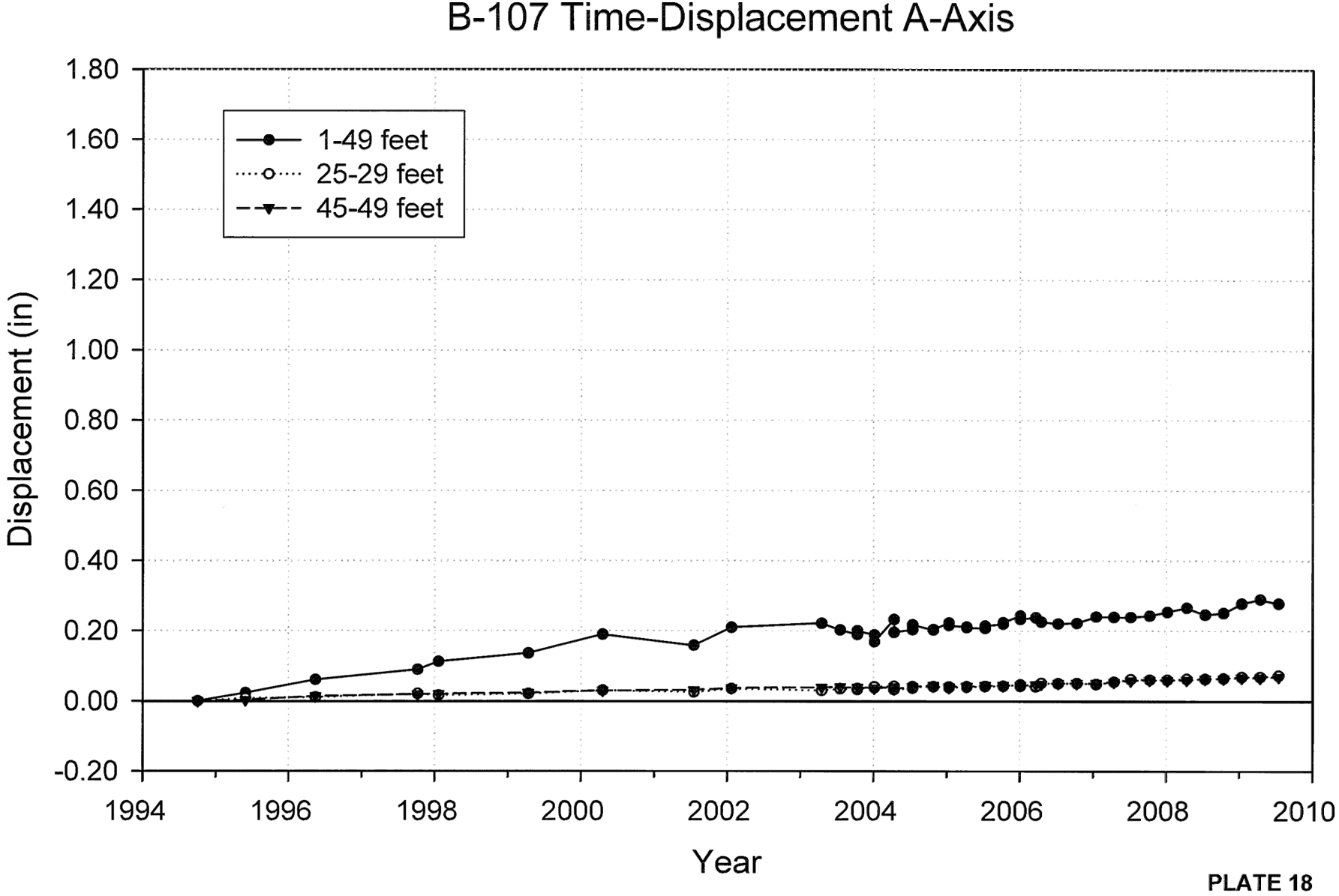

B-107 Time-Displacement A-Axis
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Displacement (in)
1-49 feet
25-29 feet
45-49 feet
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 18

B-203 Time-Displacement A-Axis

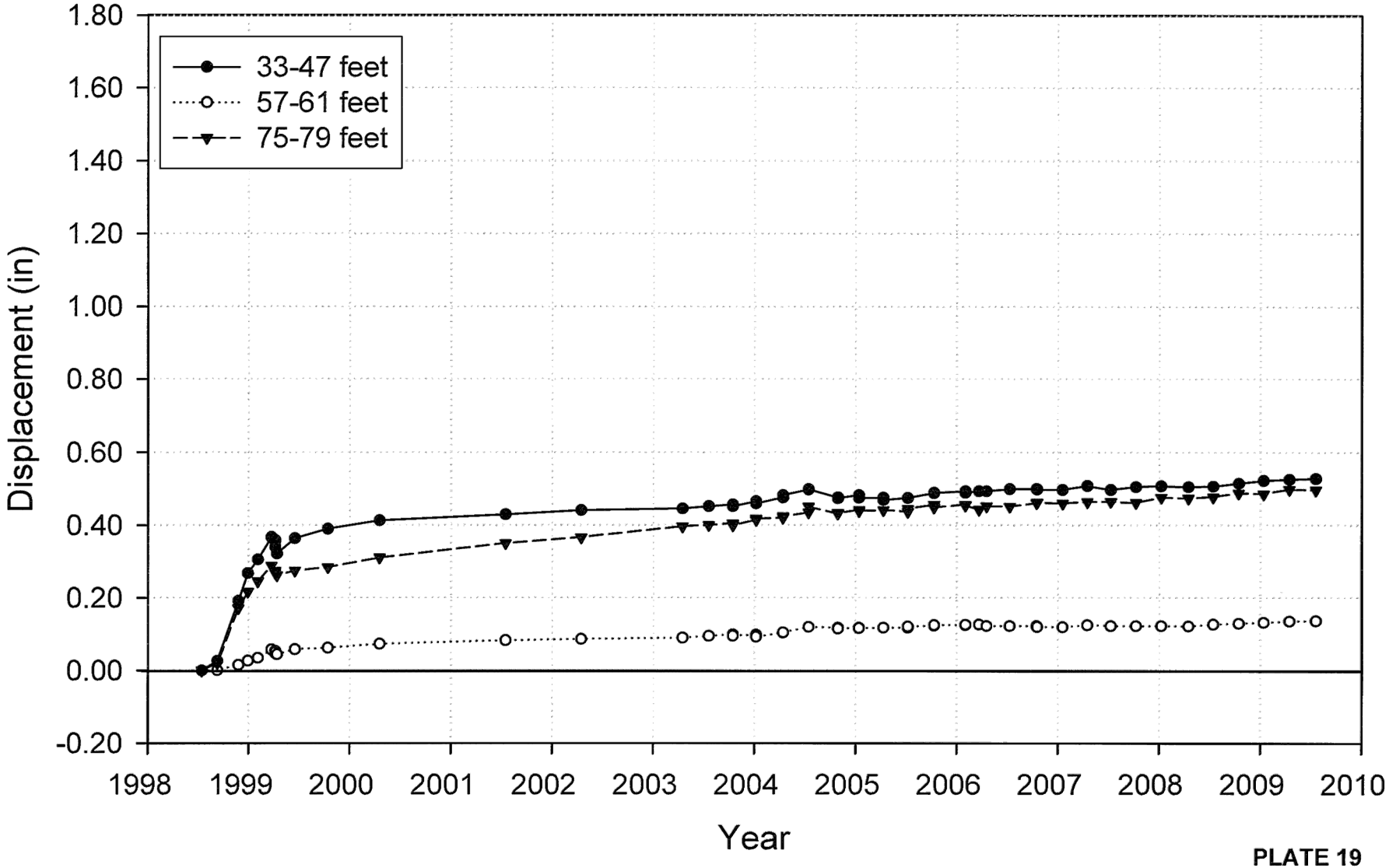


PLATE 19

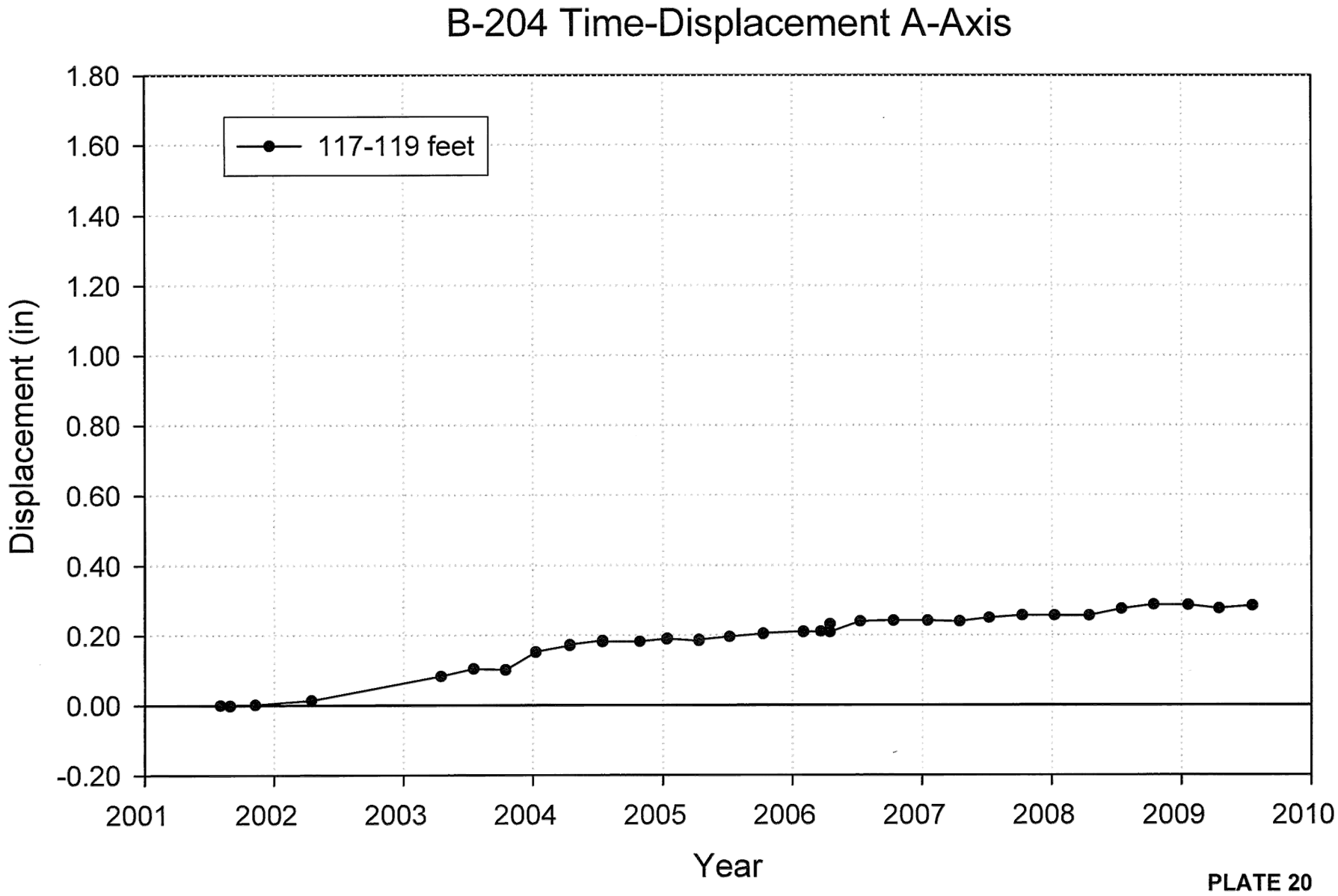

B-204 Time-Displacement A-Axis
117-119 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

PLATE 20

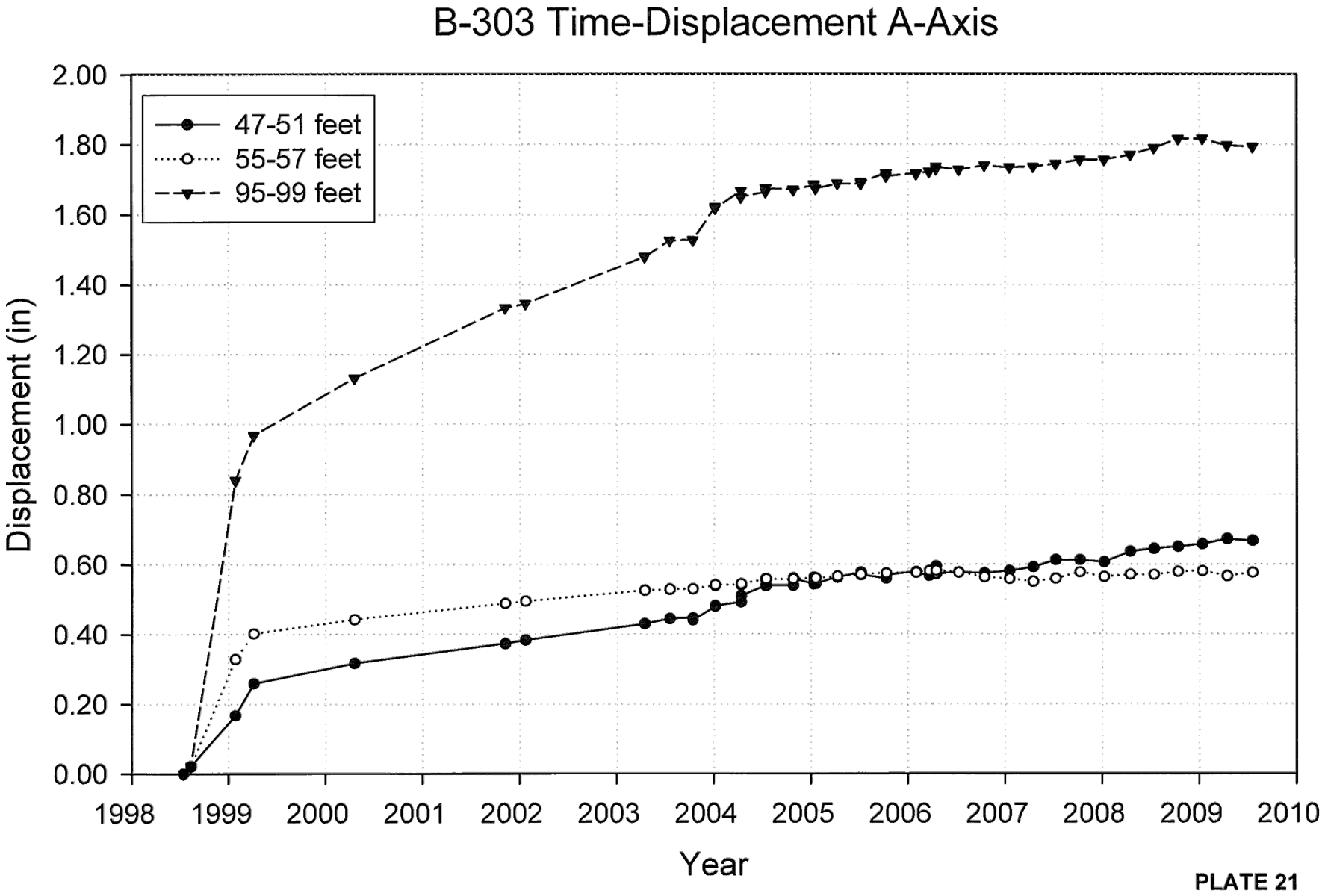
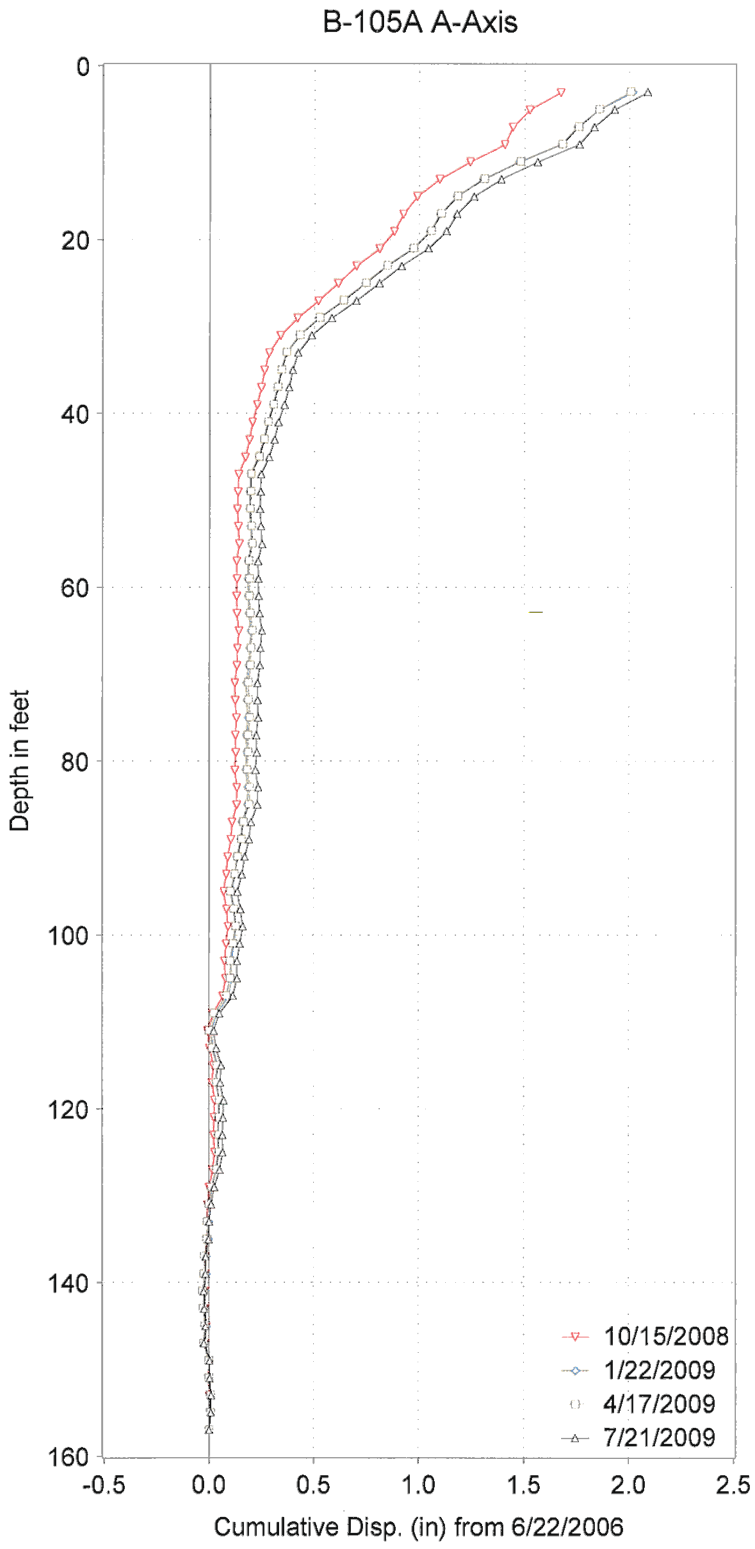
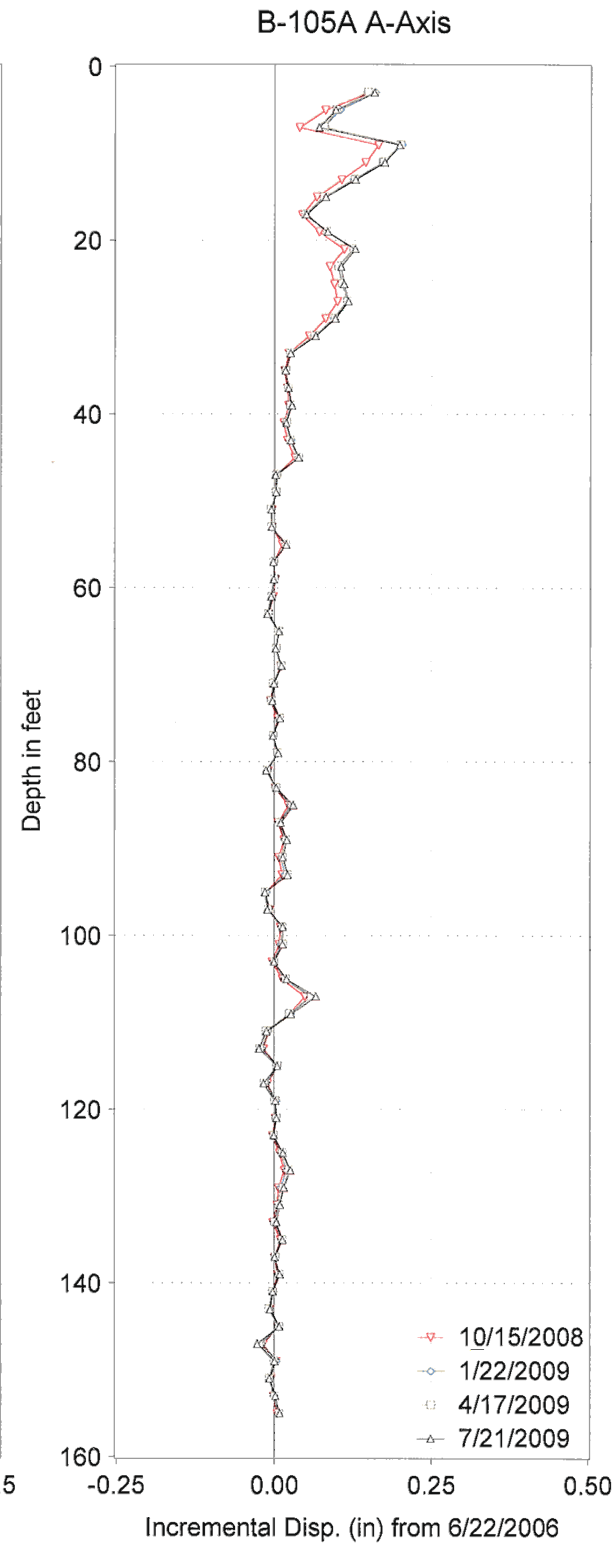

B-303 Time-Displacement A-Axis
47-51 feet
55-57 feet
95-99 feet
Displacement (in)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

PLATE 21

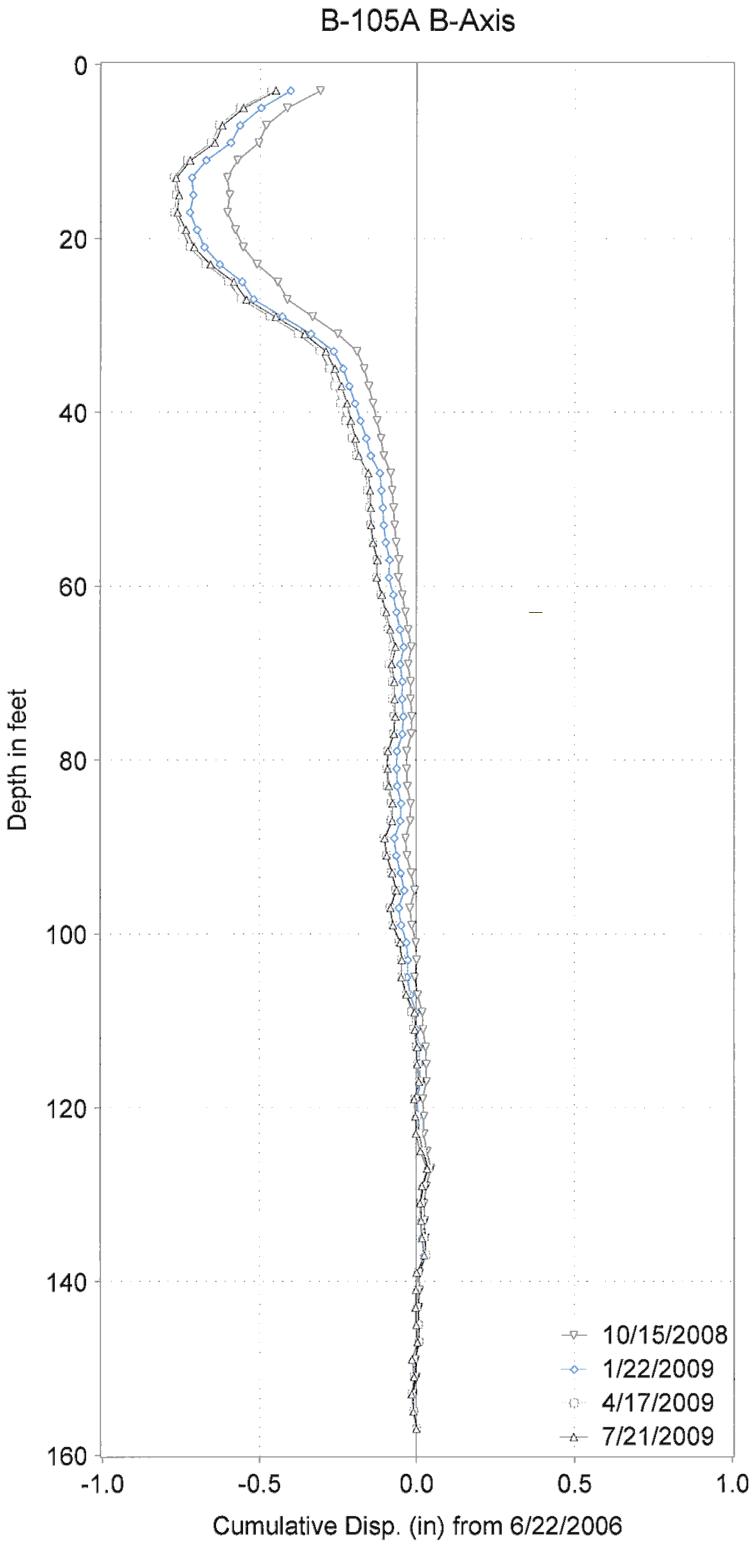


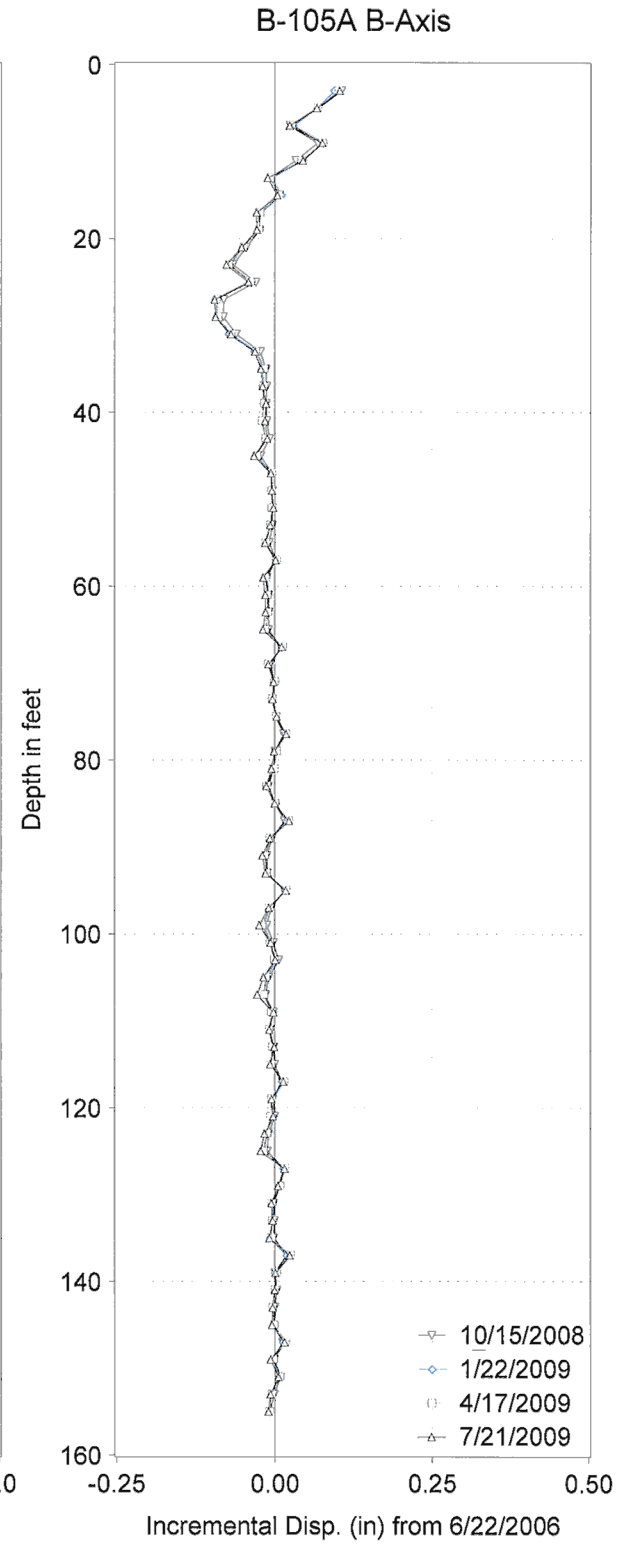


B-105A

-Includes readings from the last four quarters.

PLATE 22

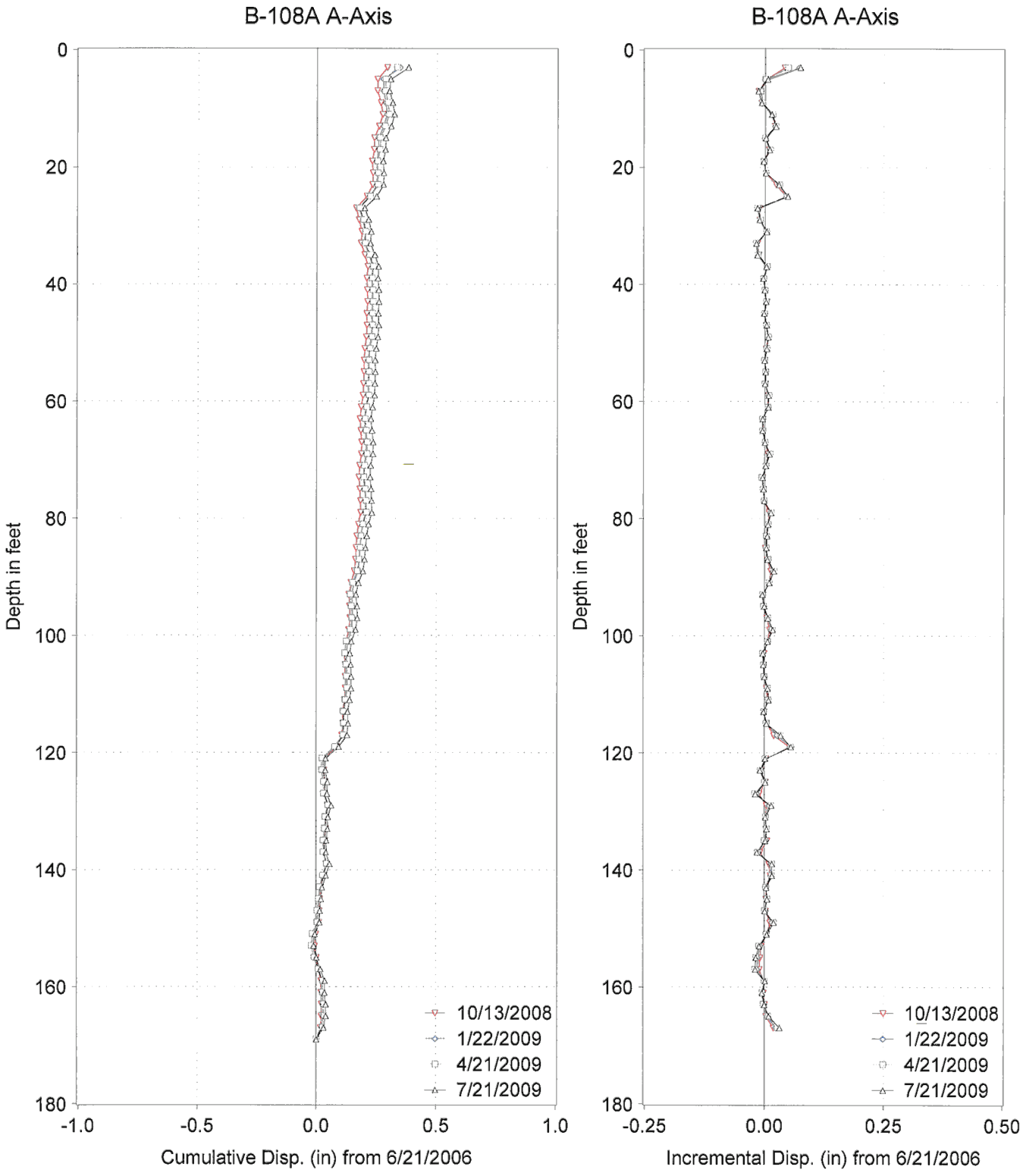




B-105A

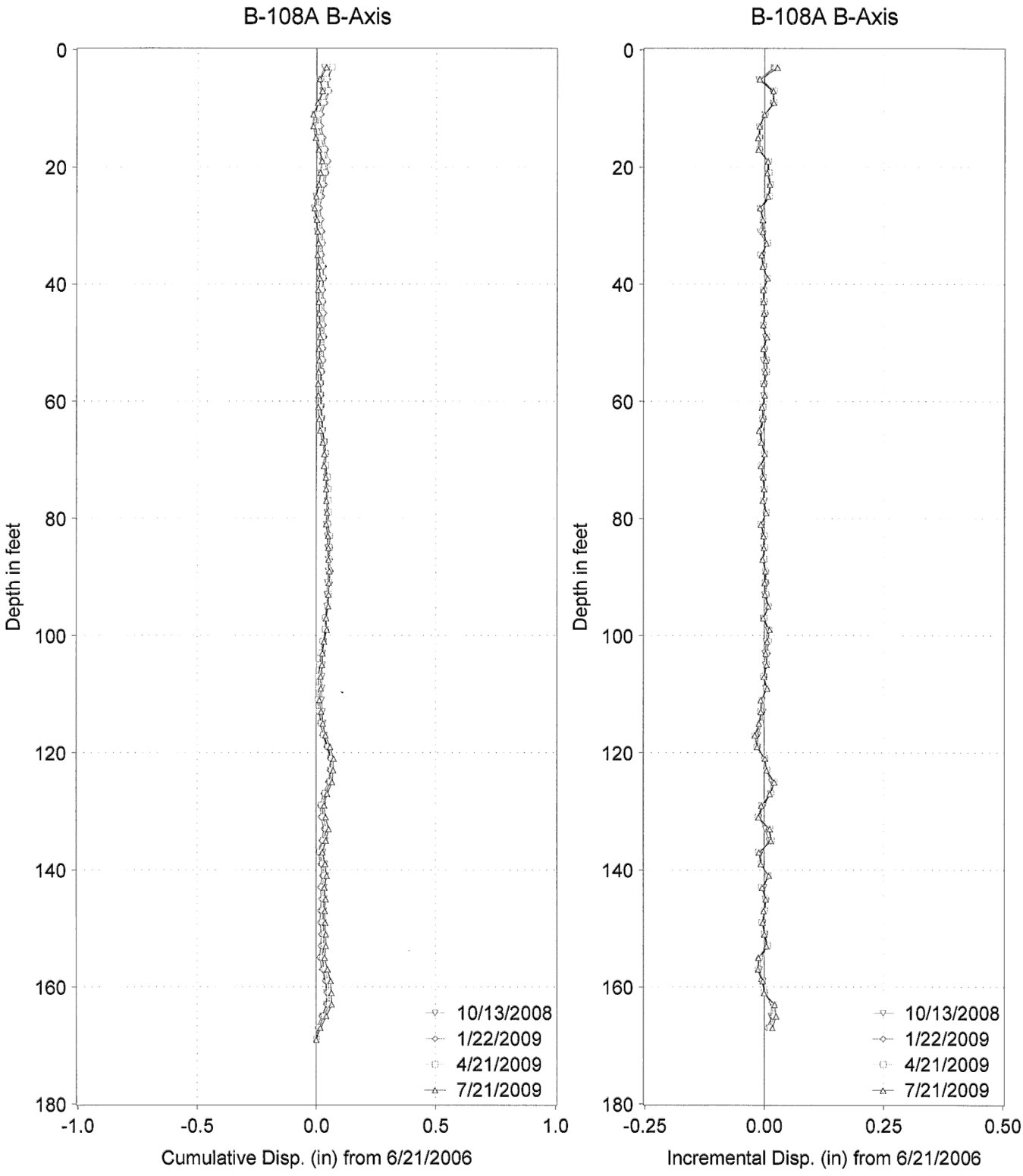
-Includes readings from the last four quarters.

PLATE 23



B-108A
-Includes readings from the last four quarters.

PLATE 24



B-108A
-Includes readings from the last four quarters.

PLATE 25

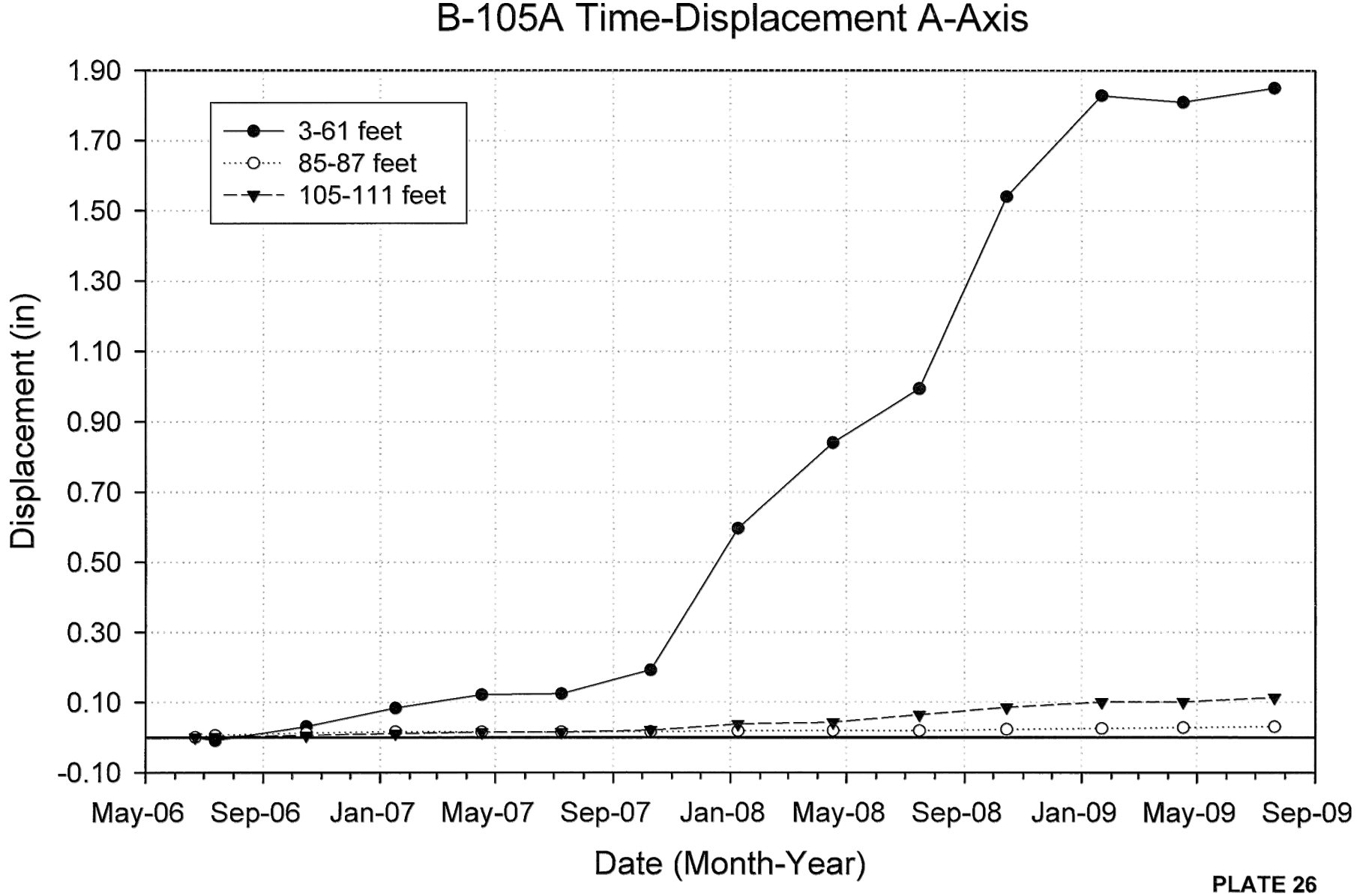

B-105A Time-Displacement A-Axis
3-61 feet
85-87 feet
105-111 feet
Displacement (in)
1.90
1.70
1.50
1.30
1.10
0.90
0.70
0.50
0.30
0.10
-0.10
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Sep-09
Date (Month-Year)

PLATE 26

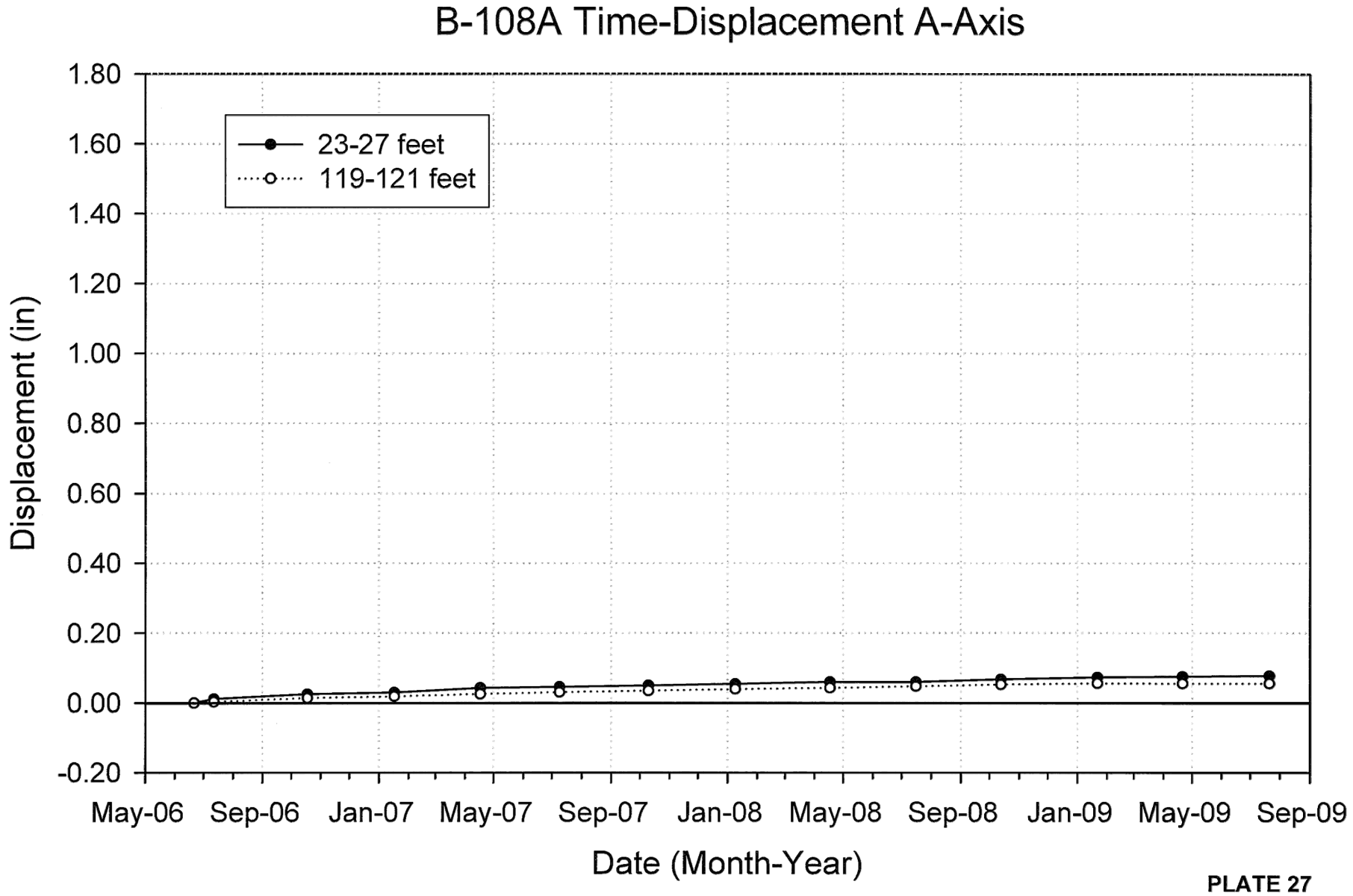
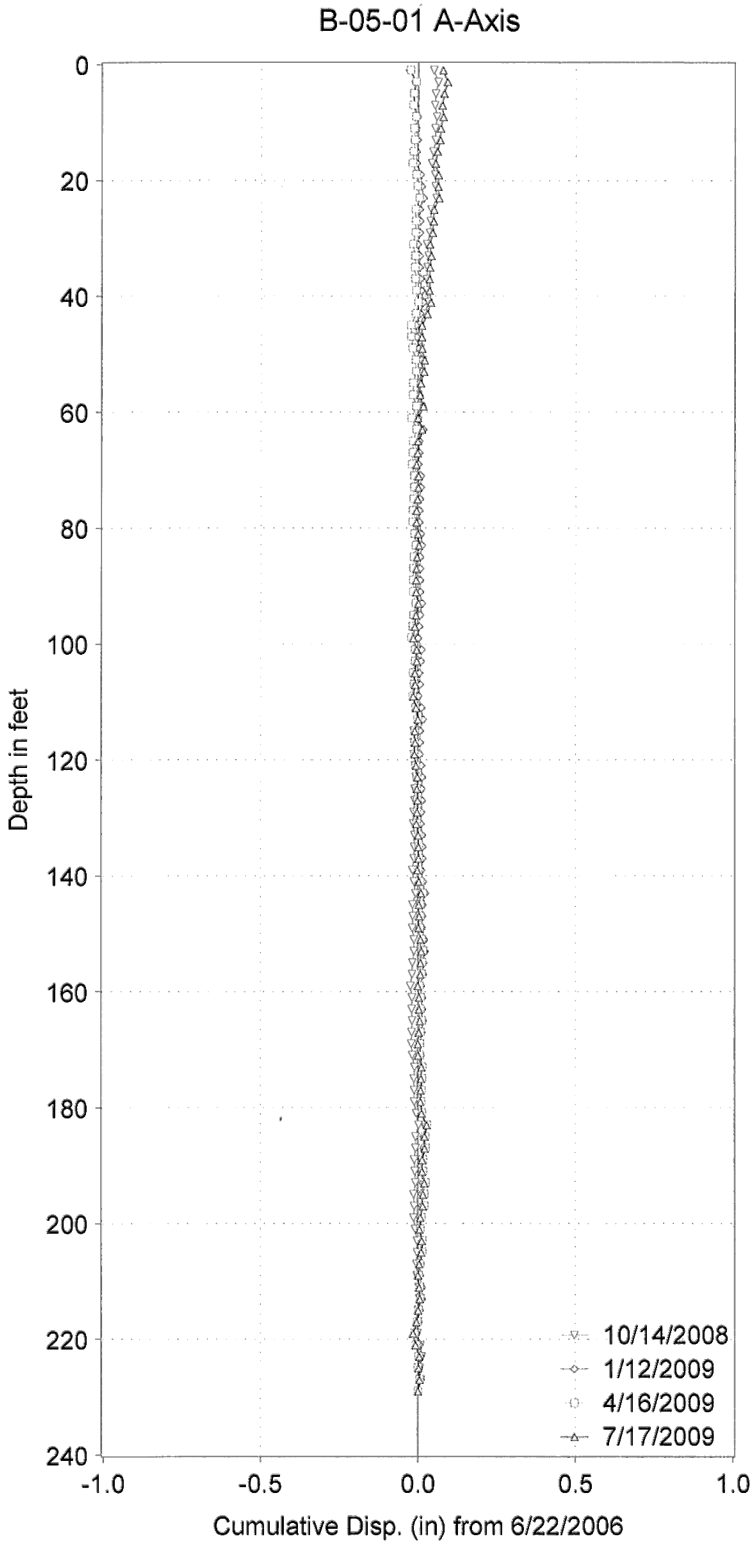
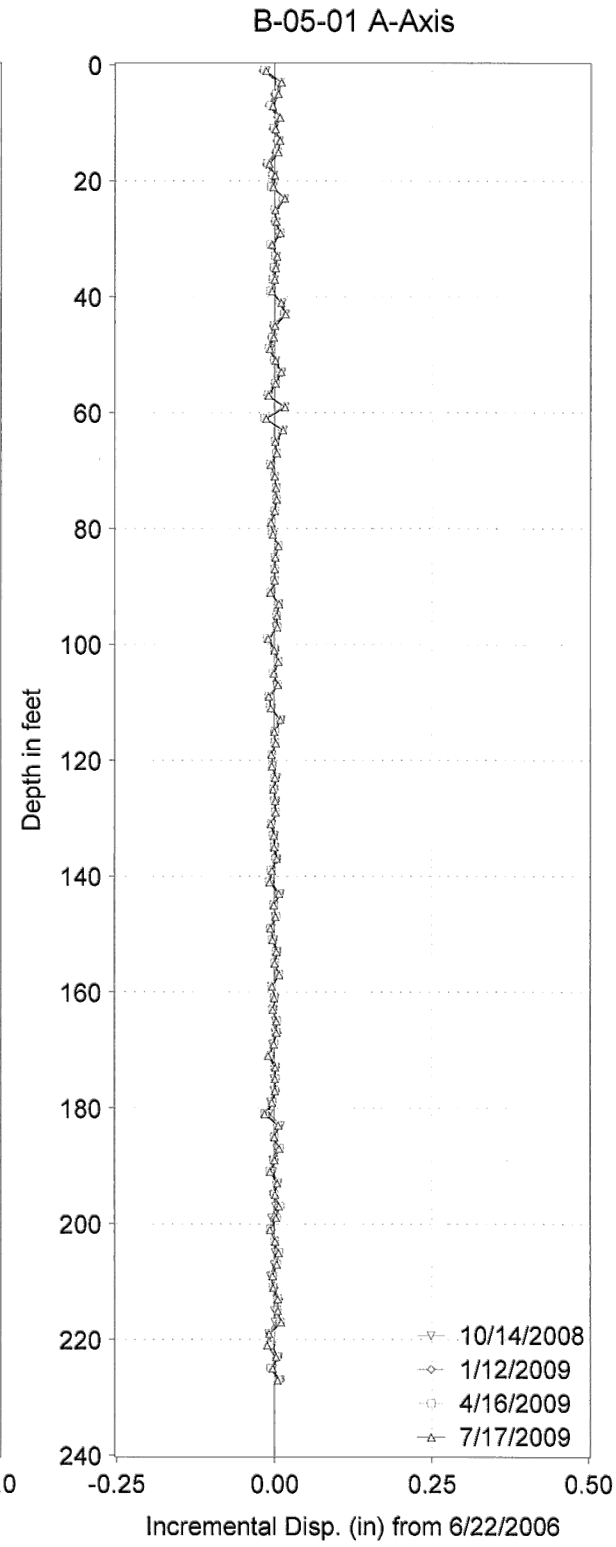

B-108A Time-Displacement A-Axis
23-27 feet
119-121 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Sep-09
Date (Month-Year)

PLATE 27

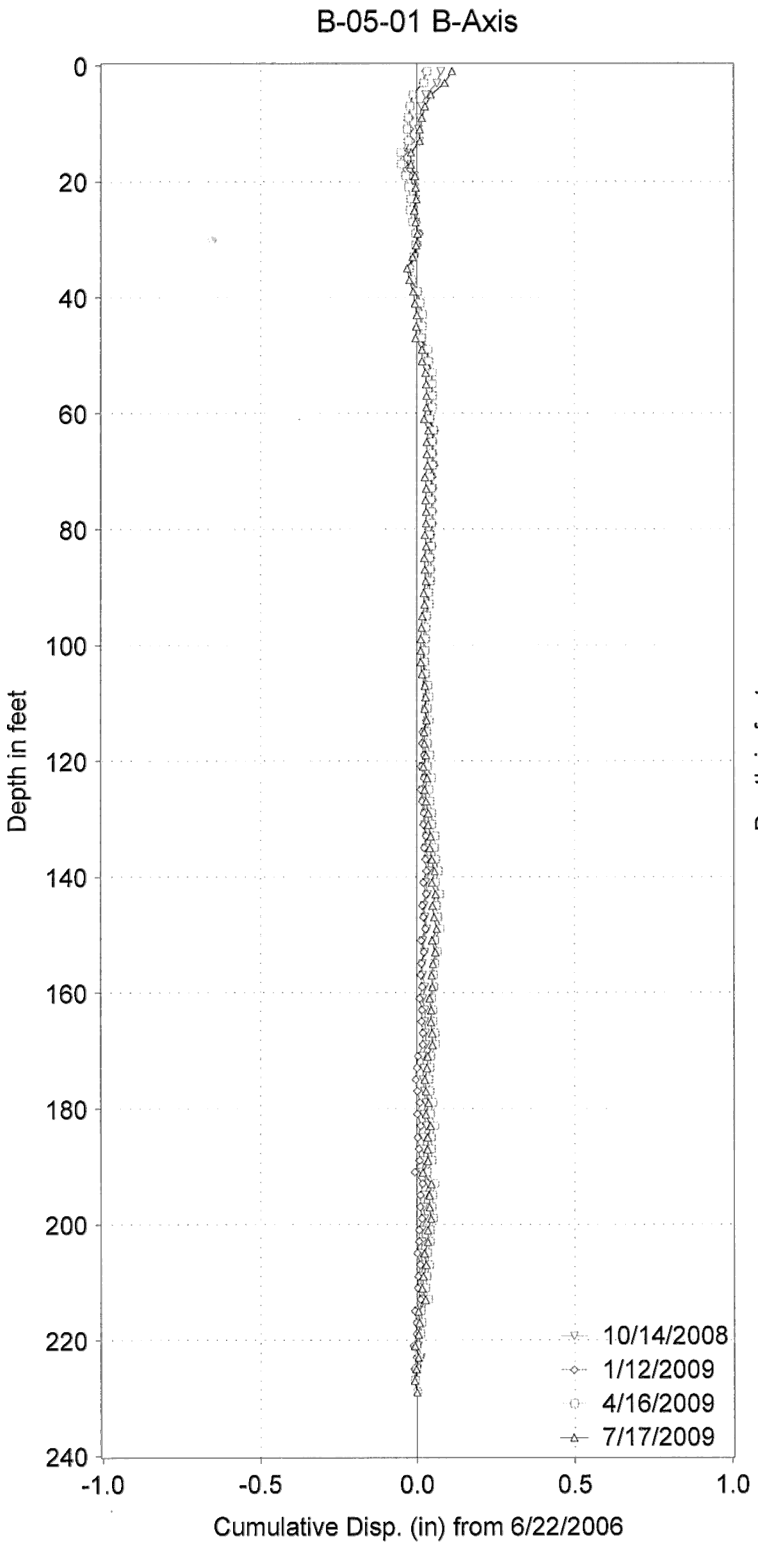


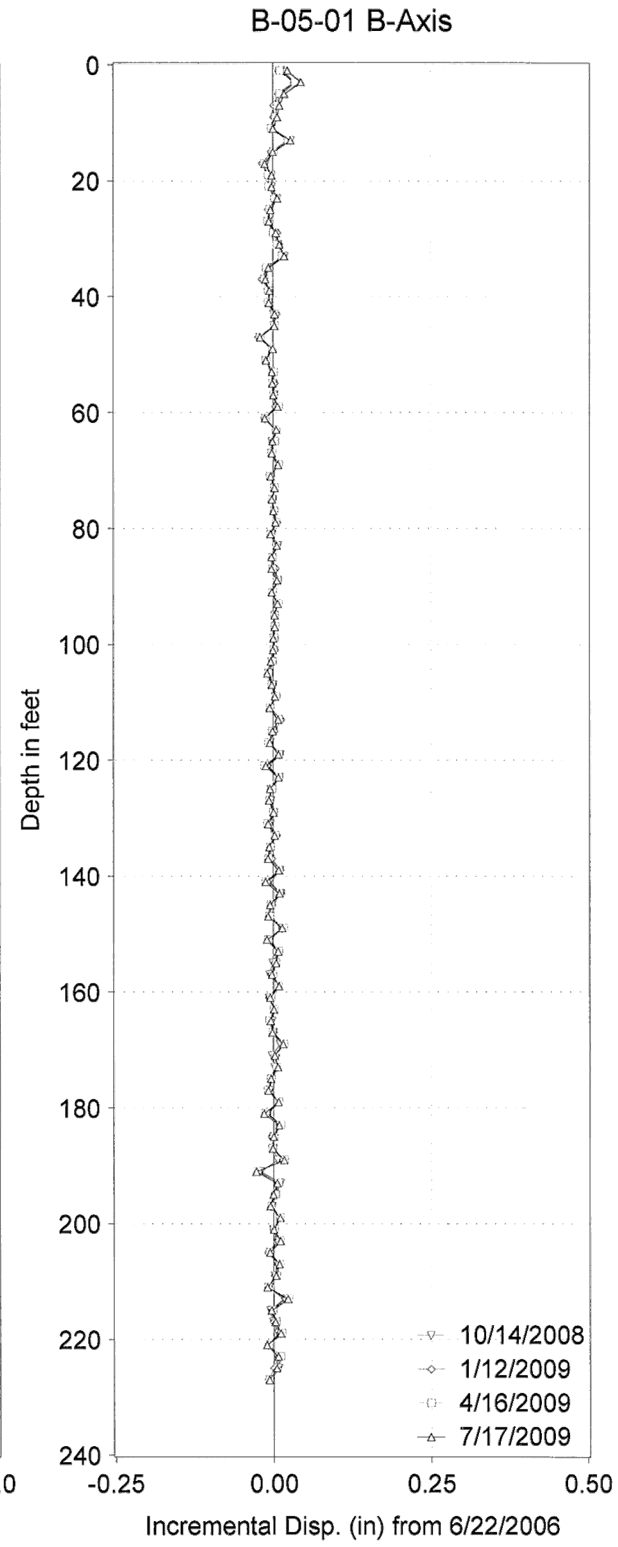


B-05-01

-Includes readings from the last four quarters.

PLATE 28

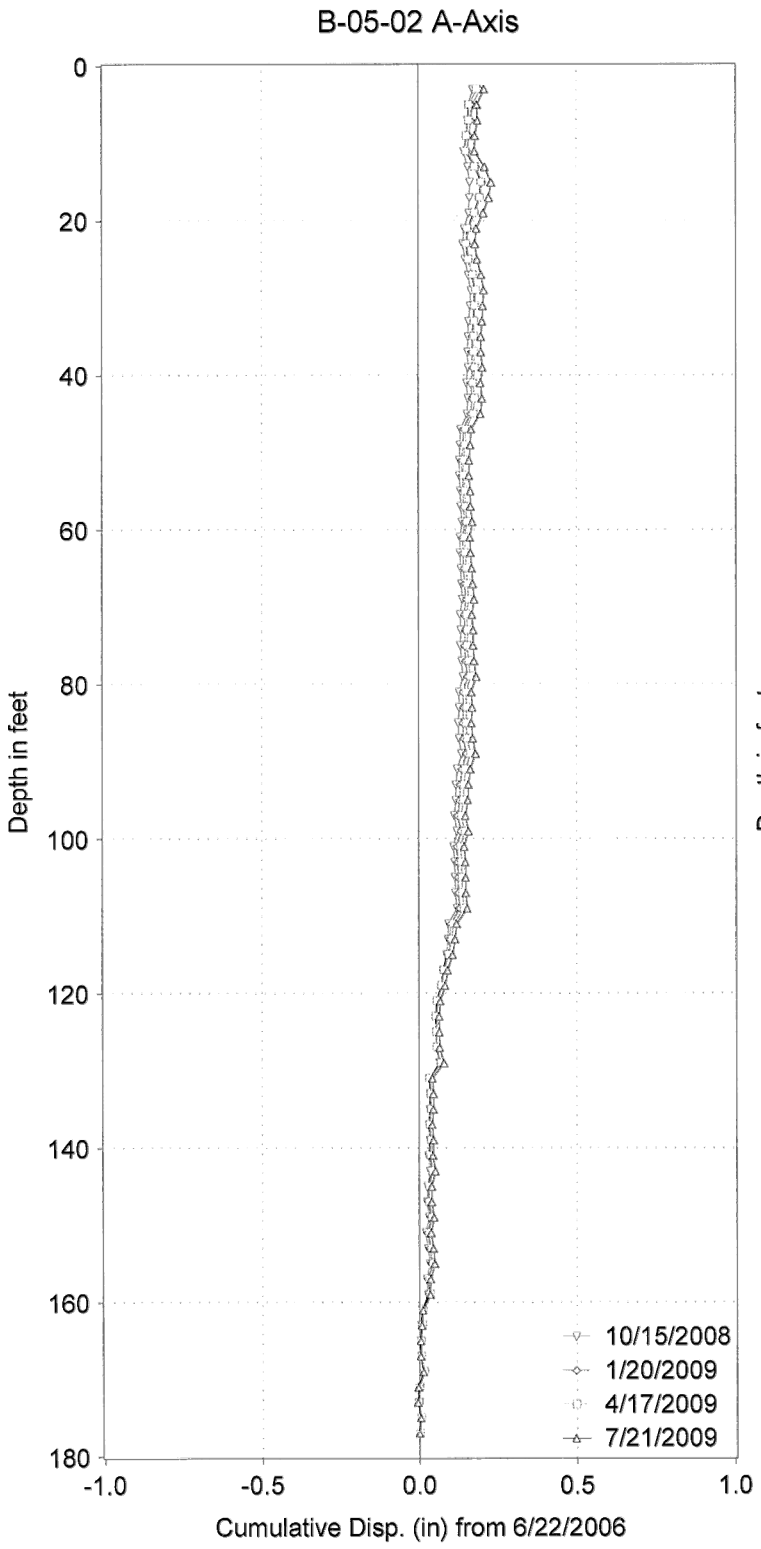


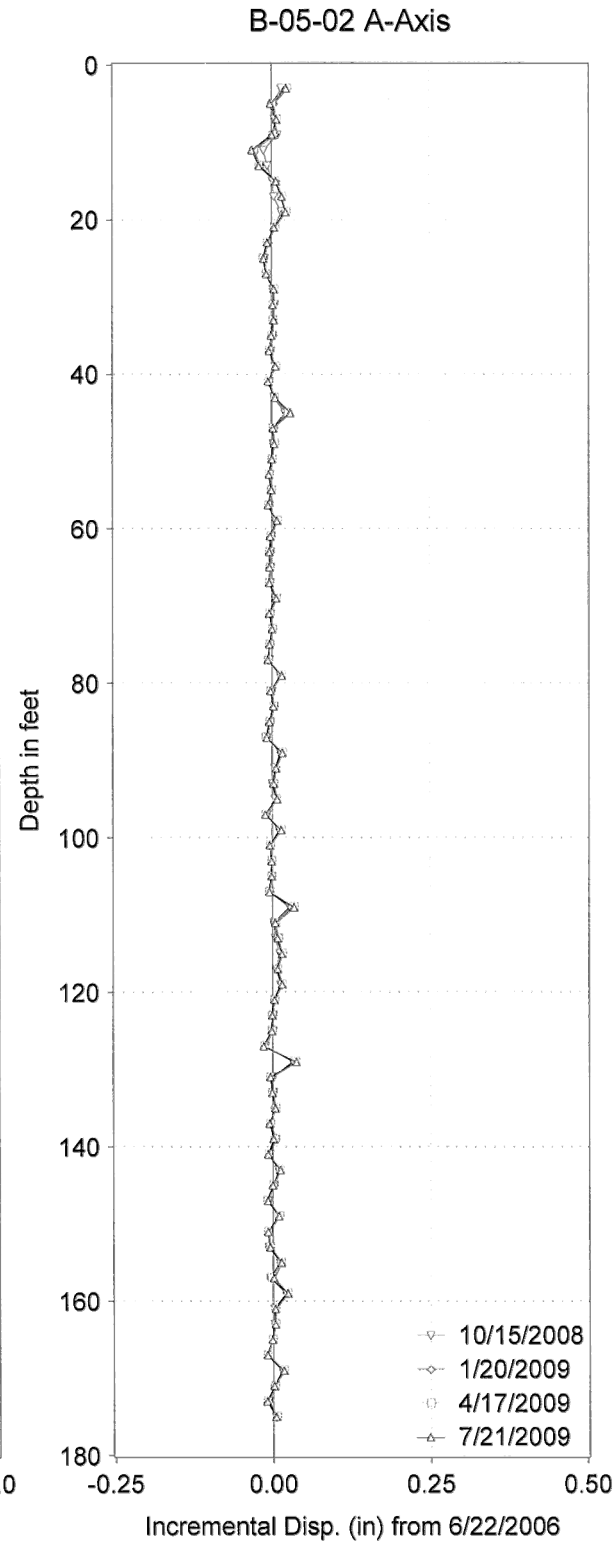


B-05-01

-Includes readings from the last four quarters.

PLATE 29

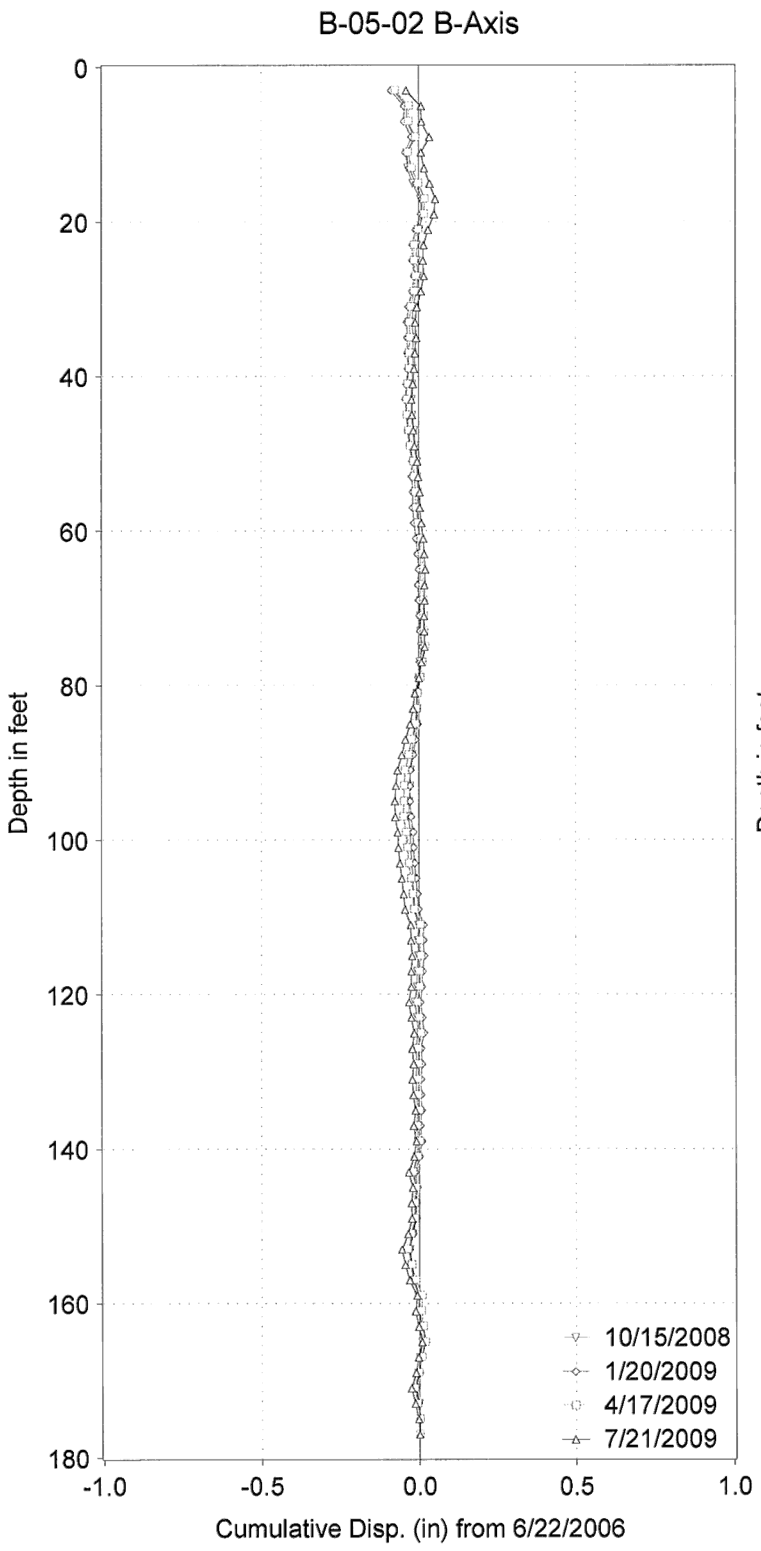


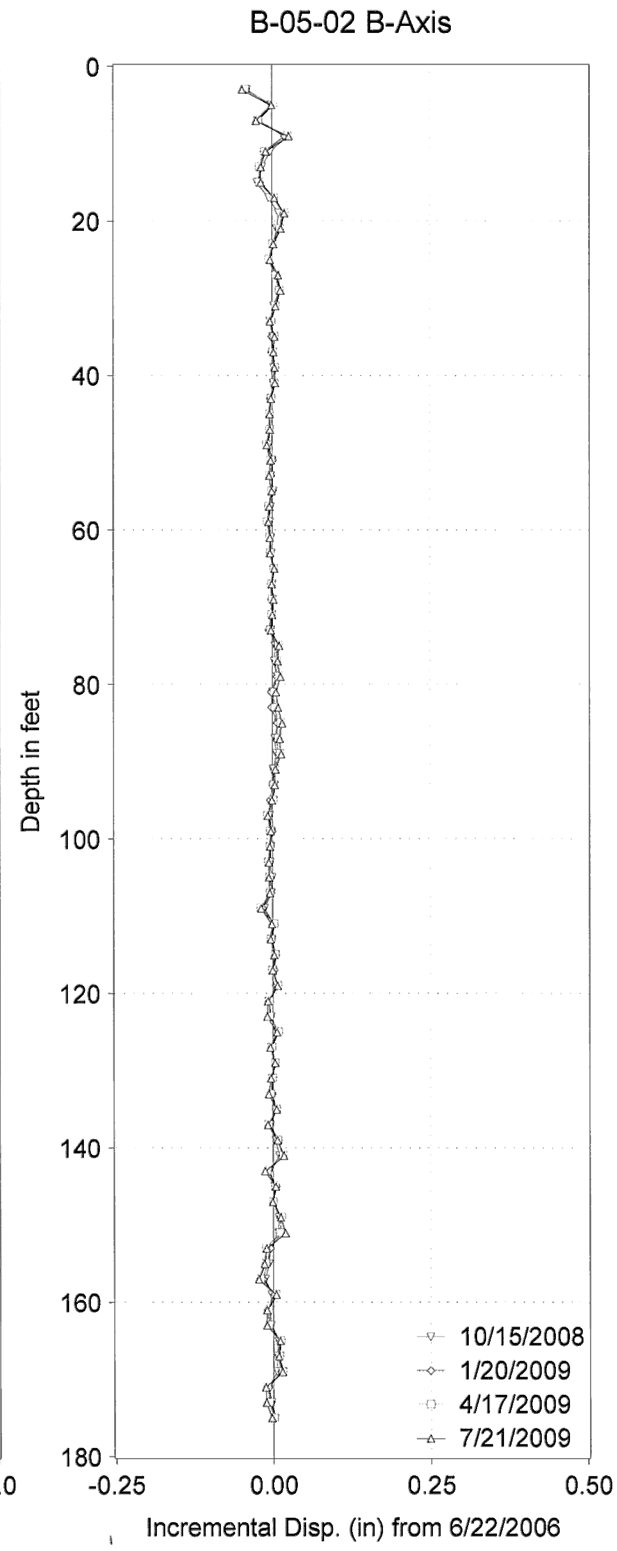


B-05-02

-Includes readings from the last four quarters.

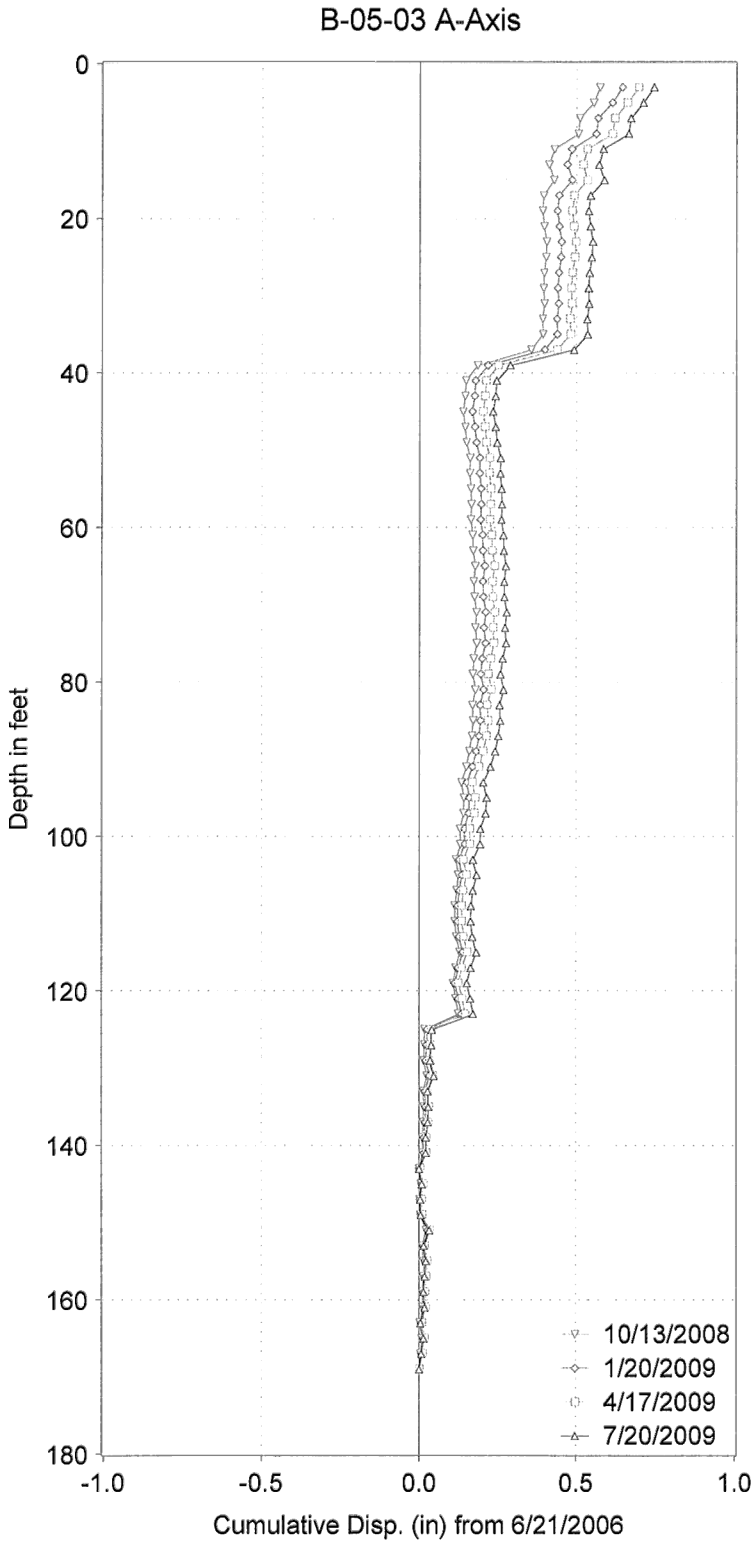
PLATE 30

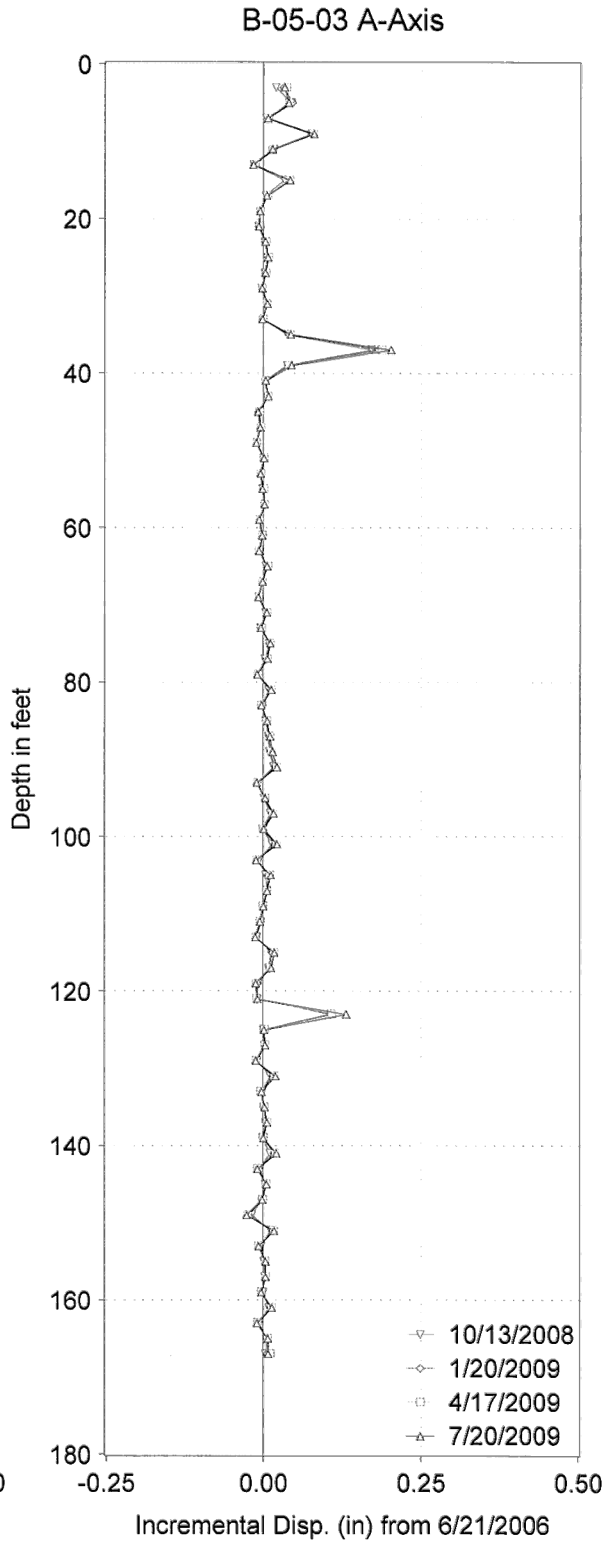




B-05-02
-Includes readings from the last four quarters.

PLATE 31

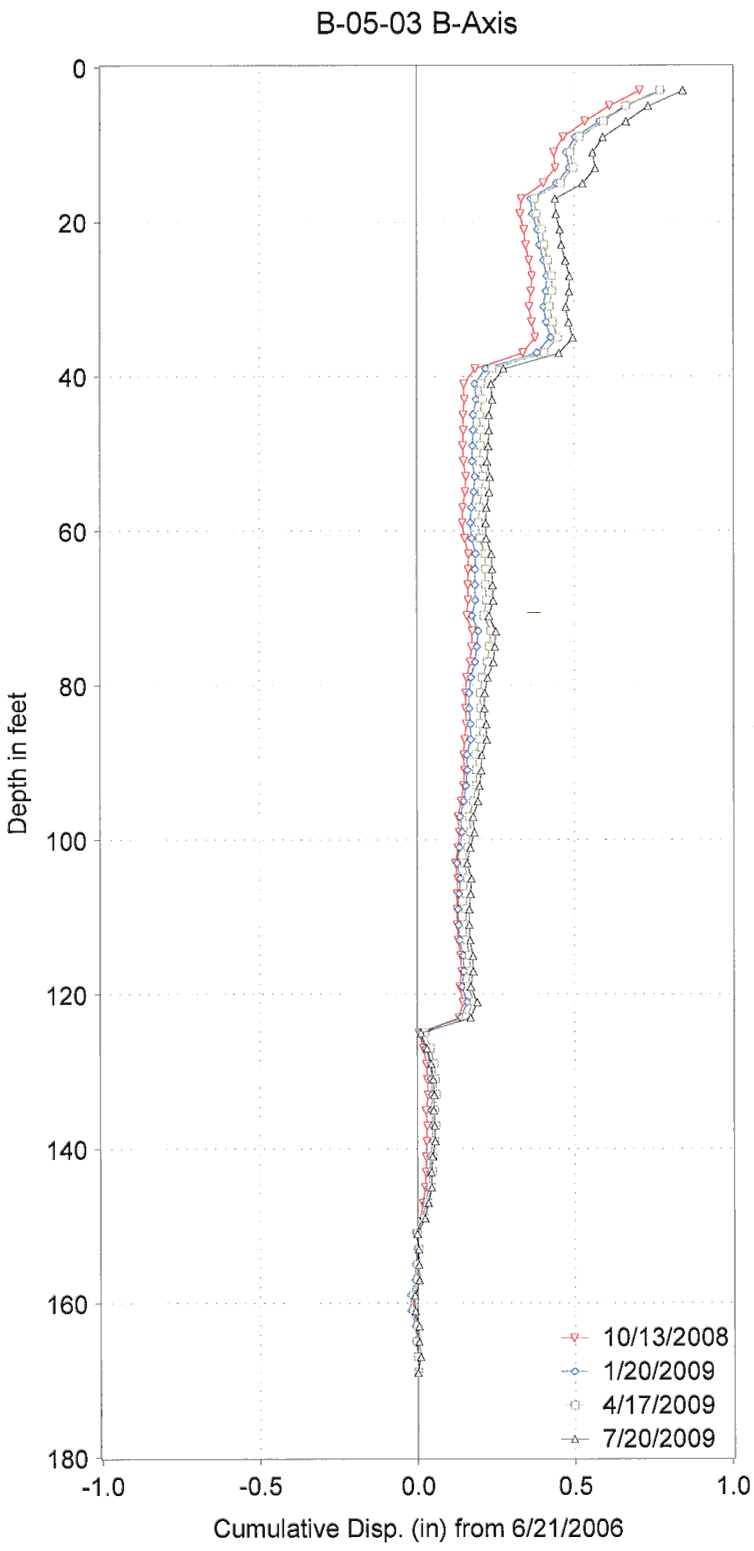


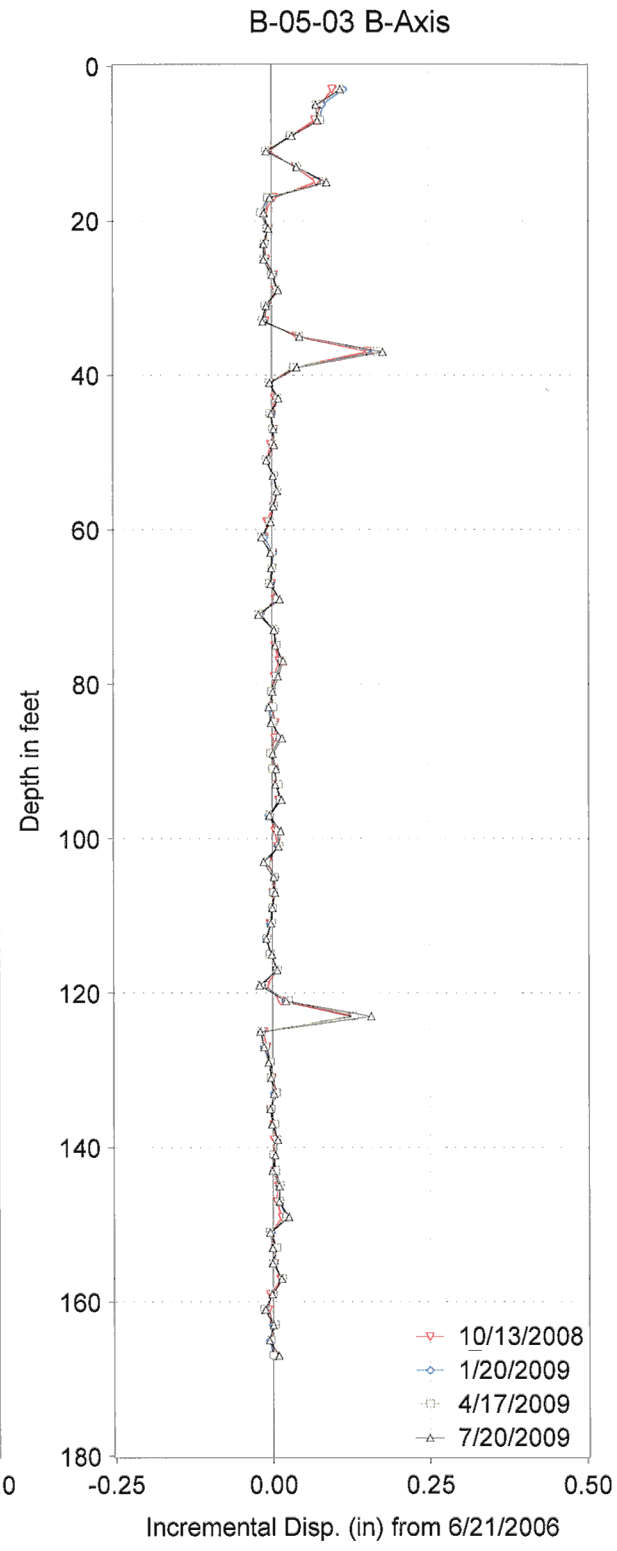


B-05-03

-Includes readings from the last four quarters.

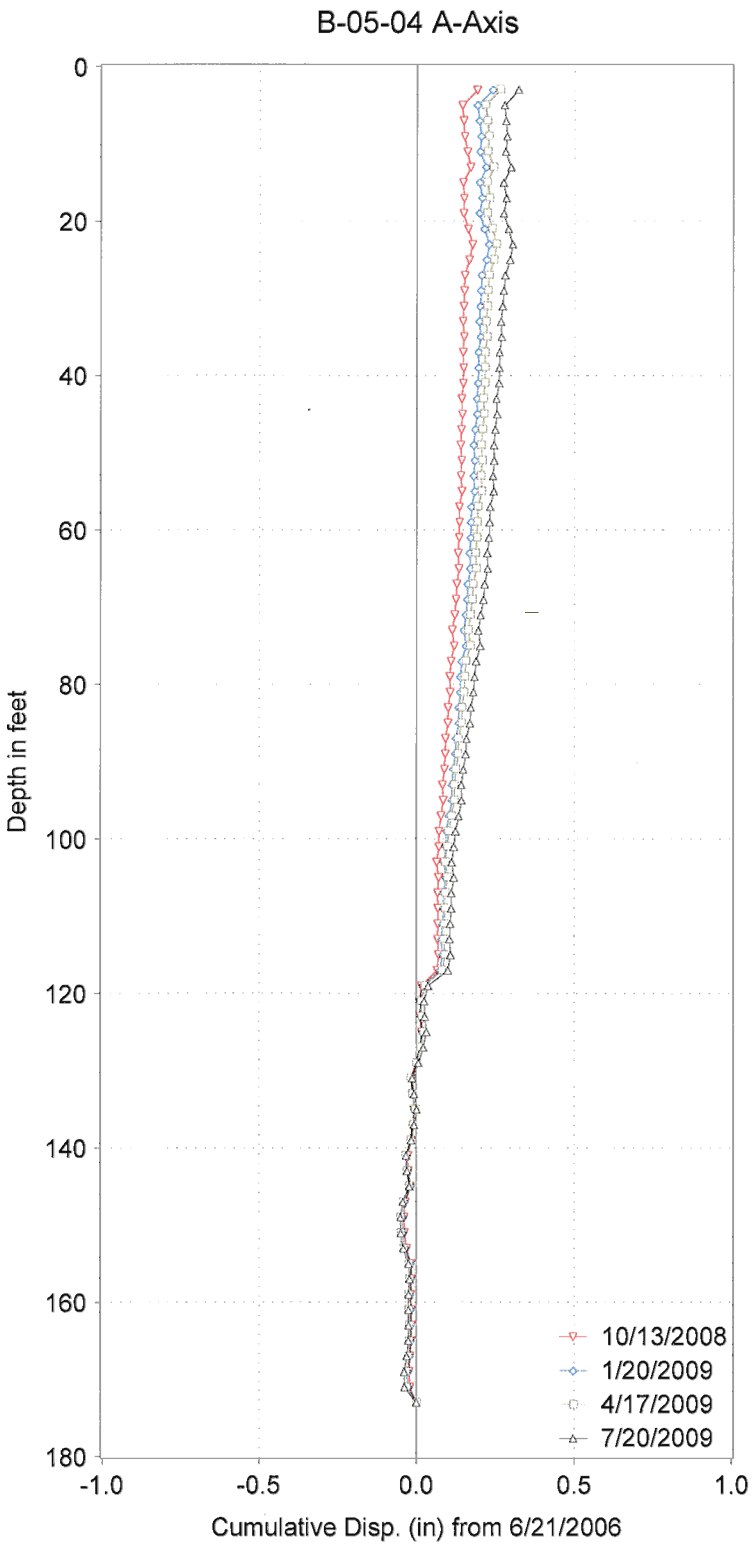
PLATE 32

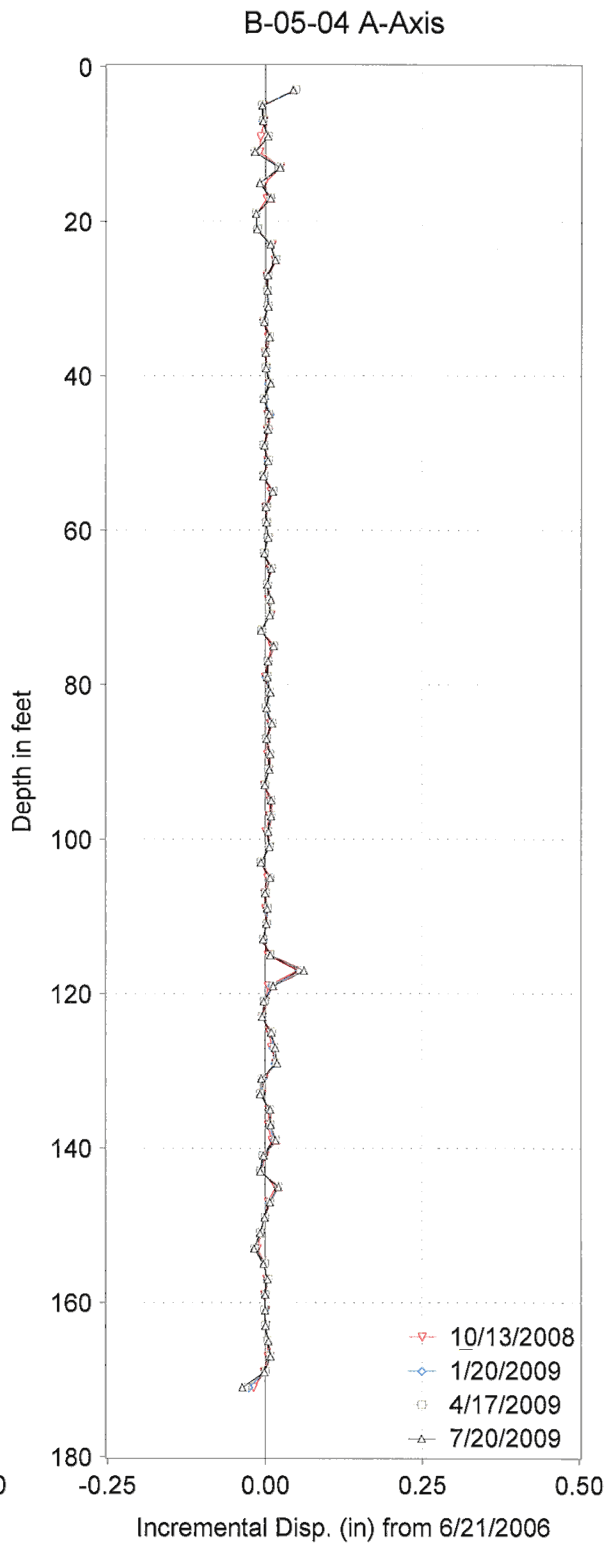




B-05-03
-Includes readings from the last four quarters.

PLATE 33

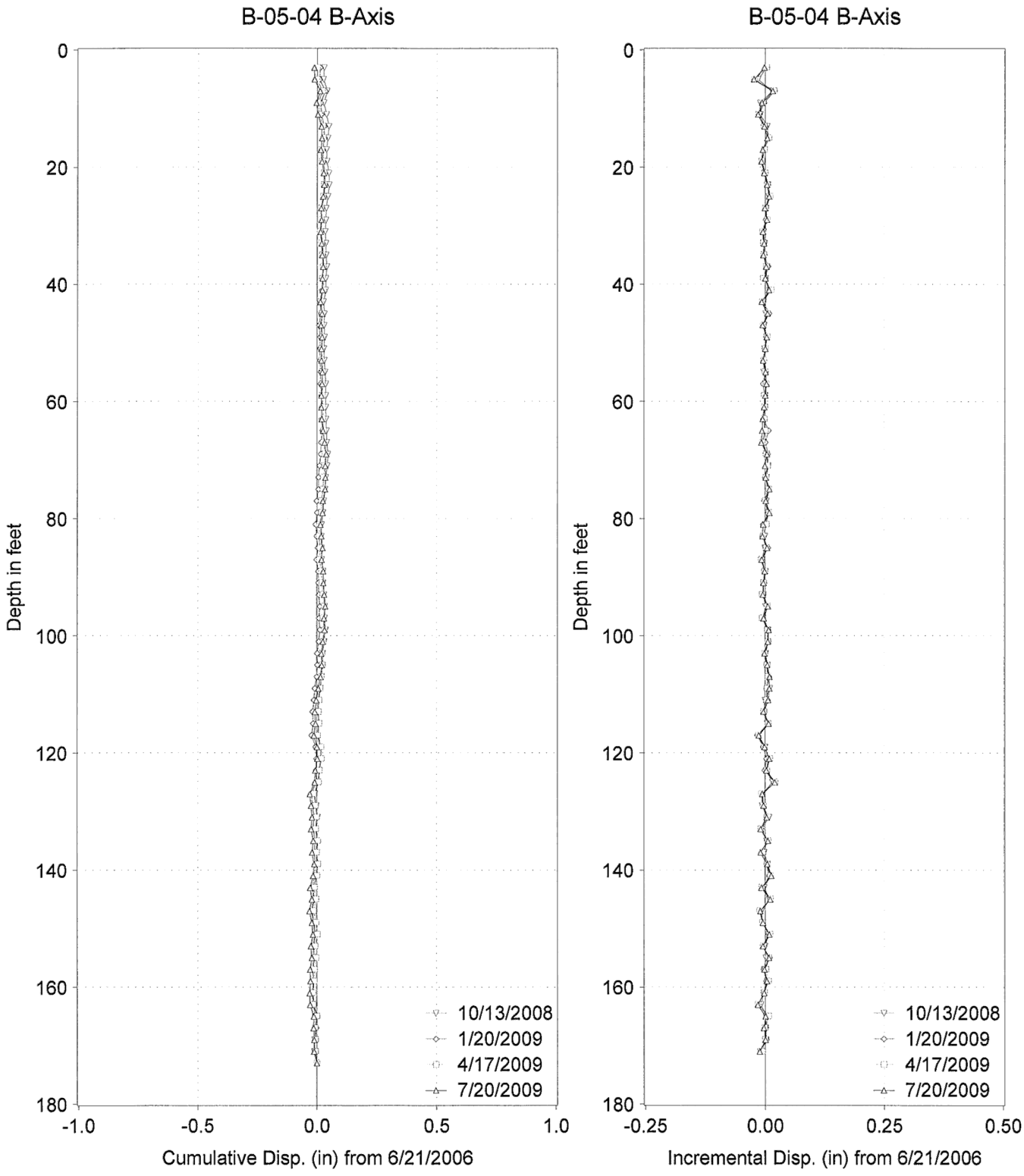




B-05-04

-Includes readings from the last four quarters.

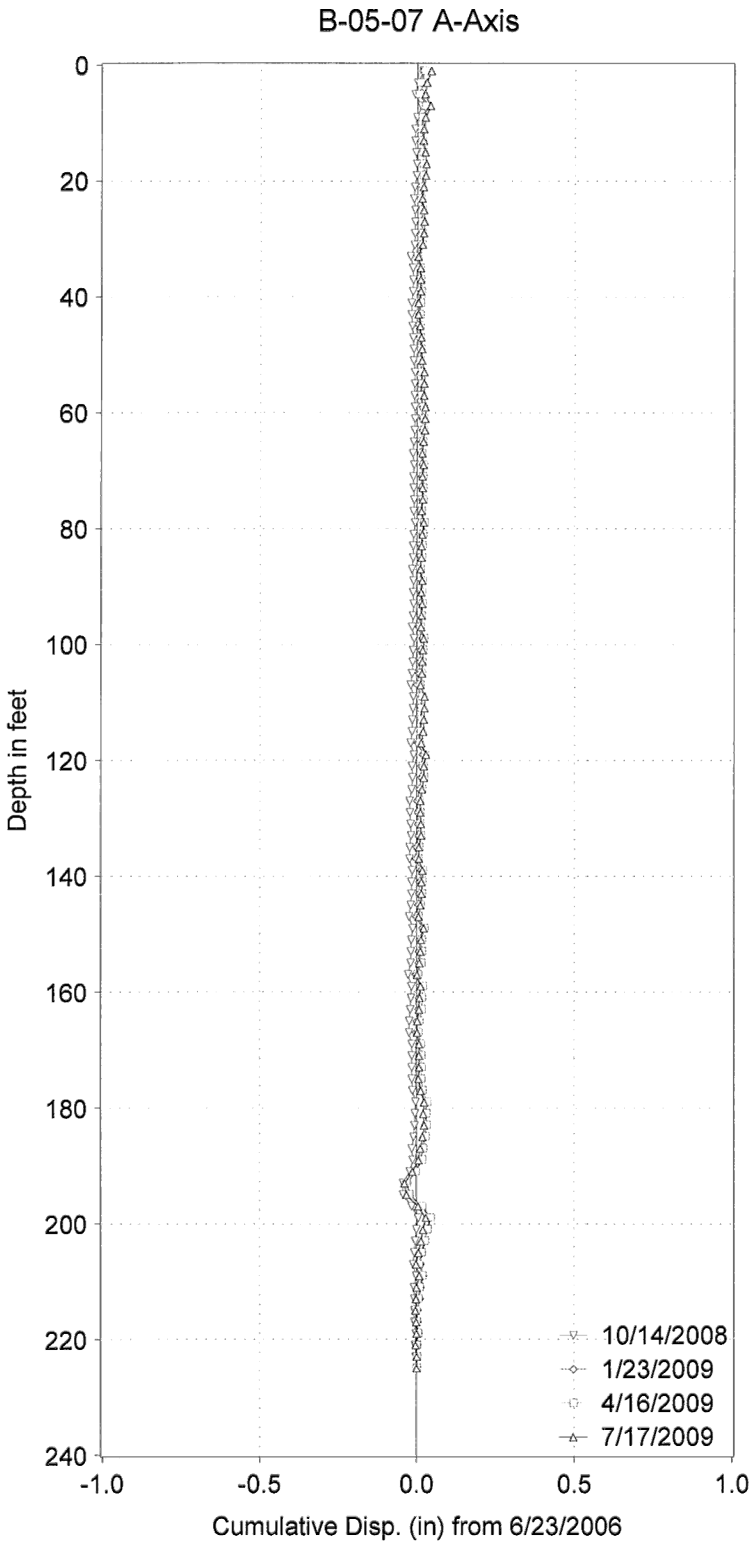
PLATE 34

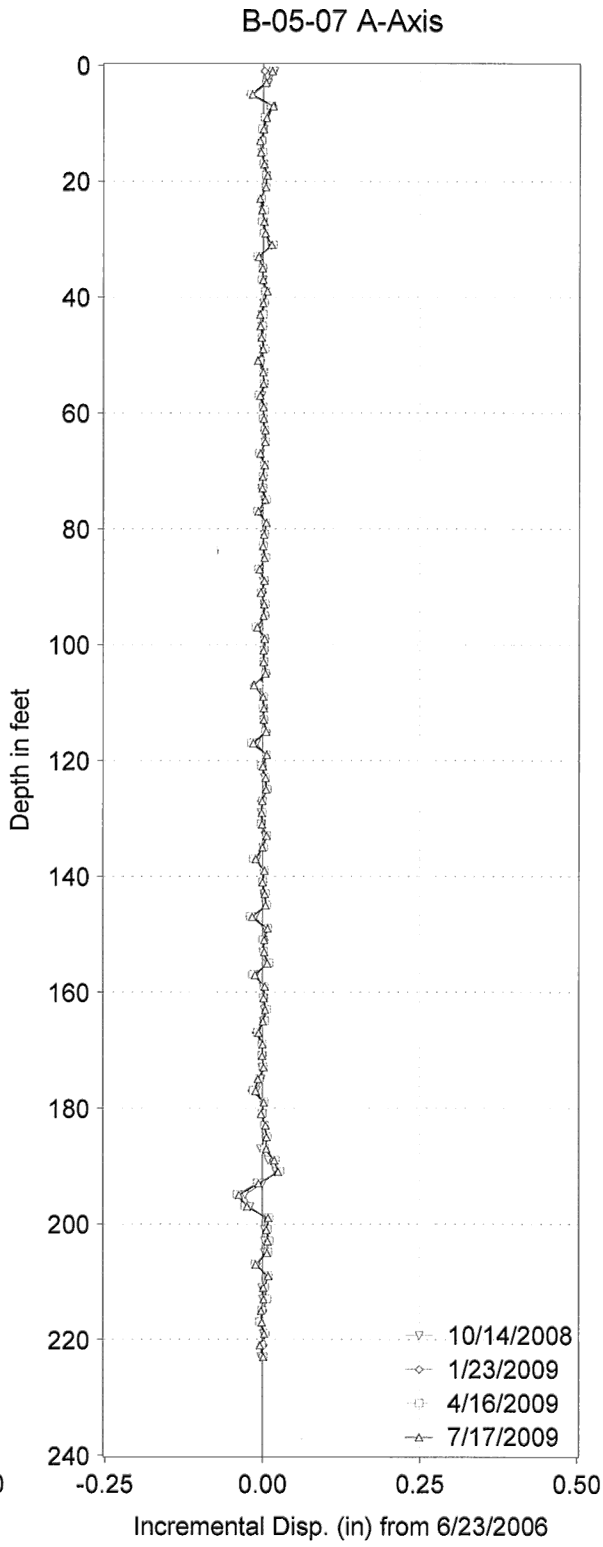


B-05-04

-Includes readings from the last four quarters.

PLATE 35

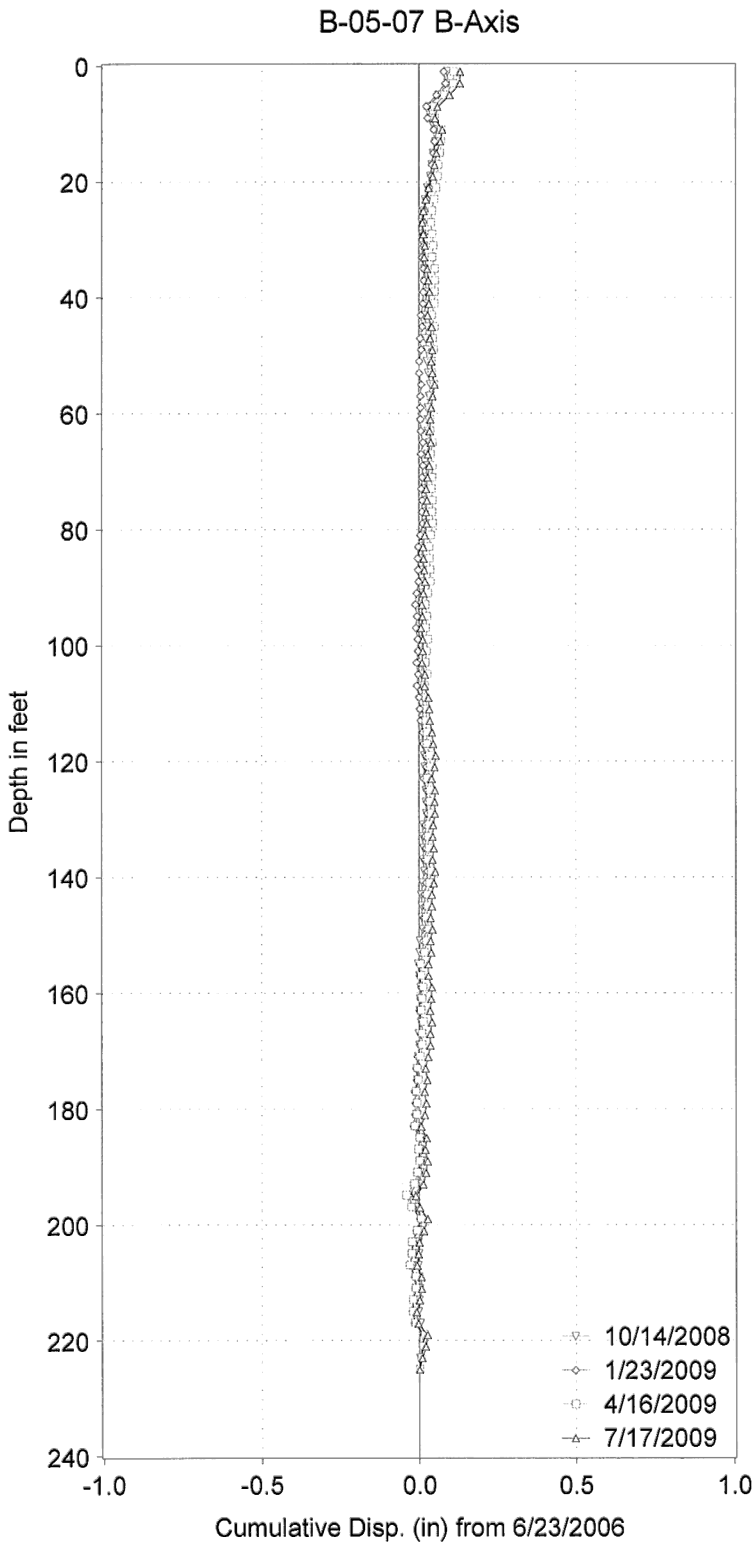


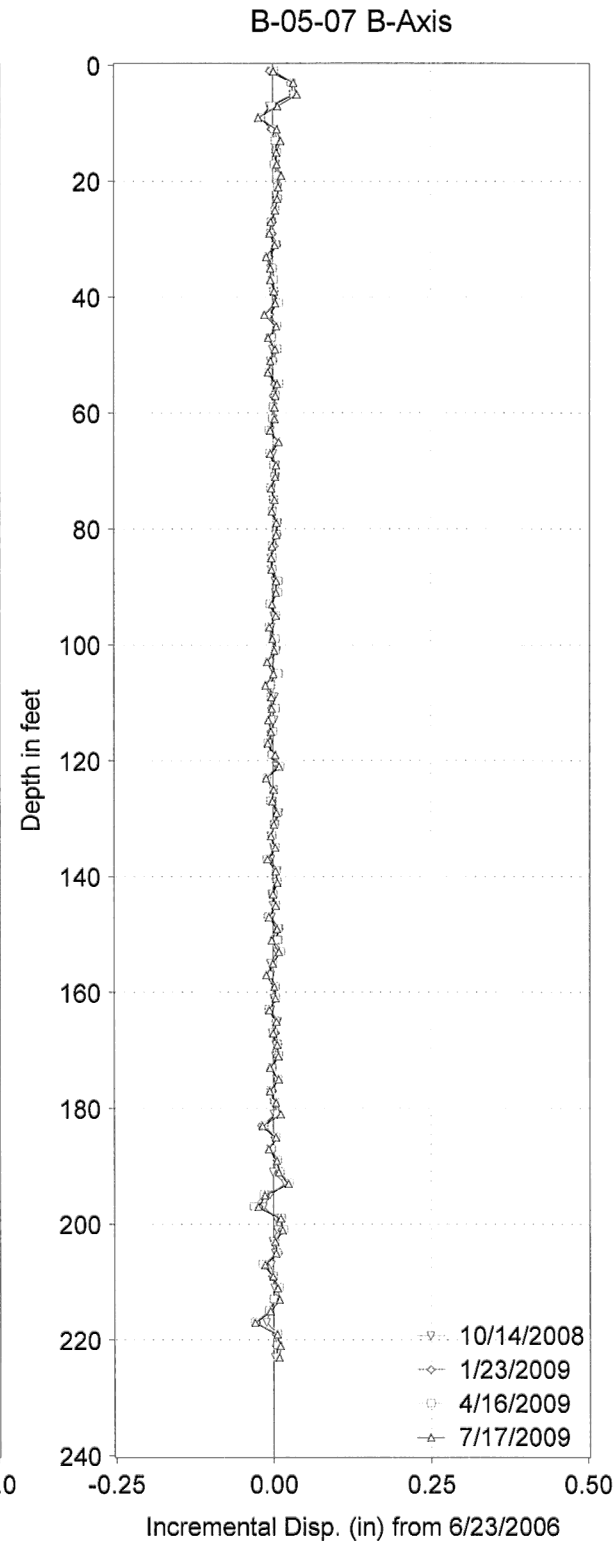


B-05-07

-Includes readings from the last four quarters.

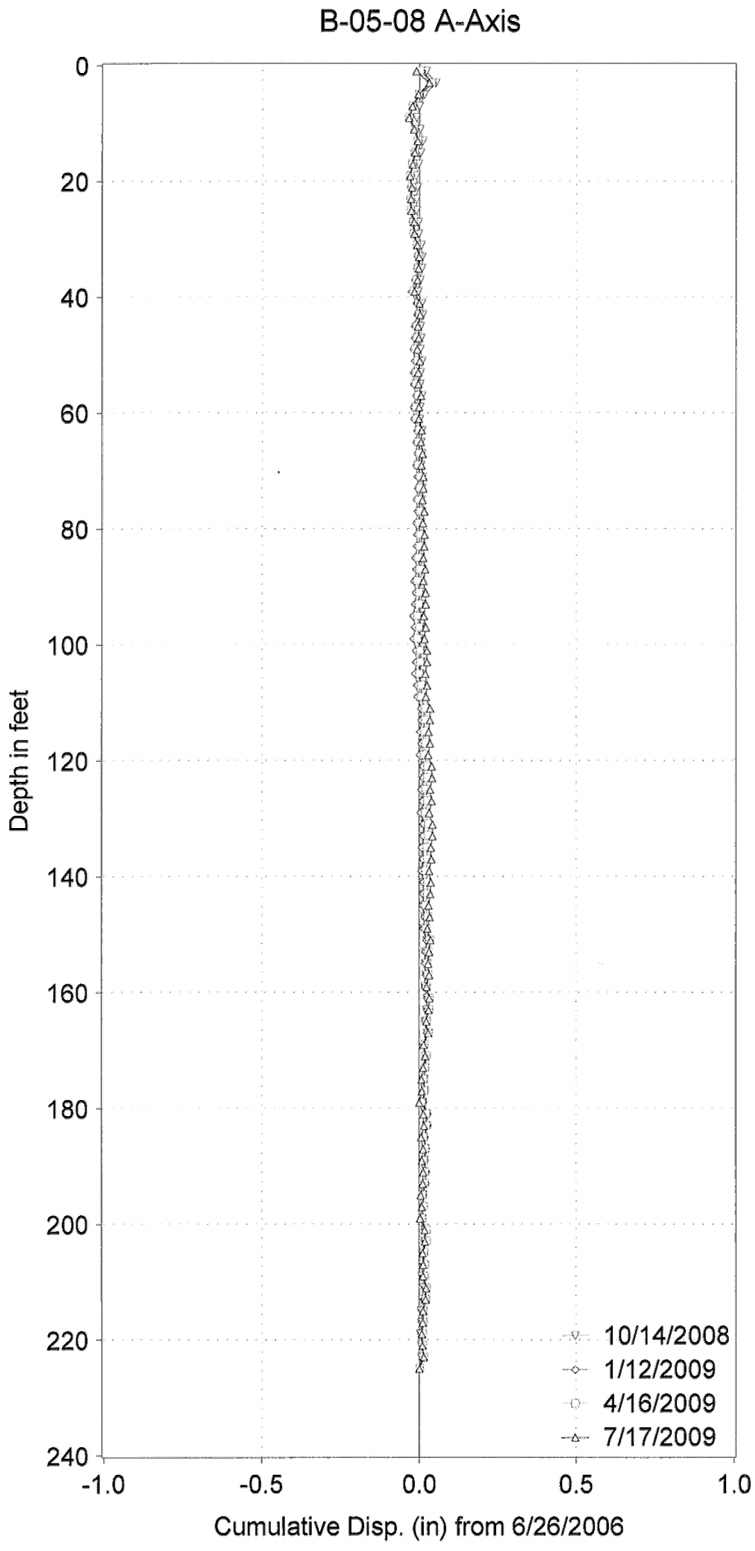
PLATE 36

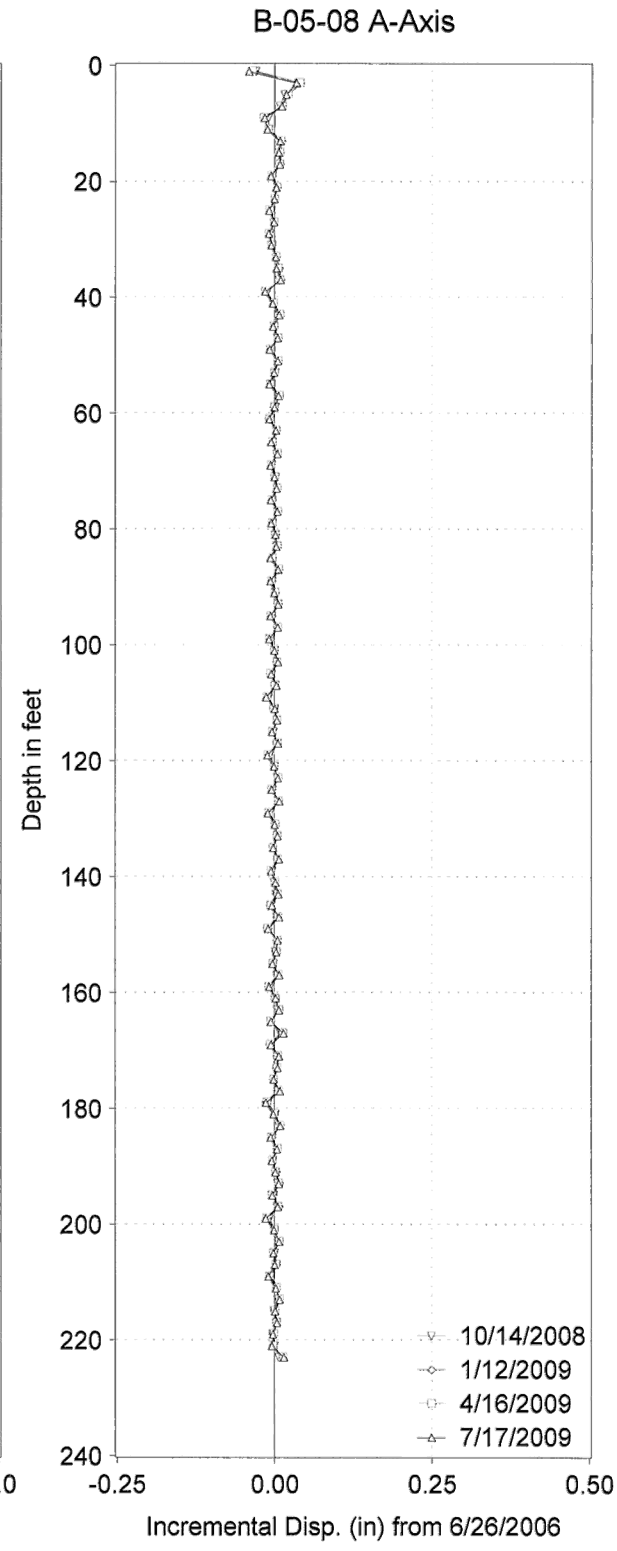




B-05-07
-Includes readings from the last four quarters.

PLATE 37

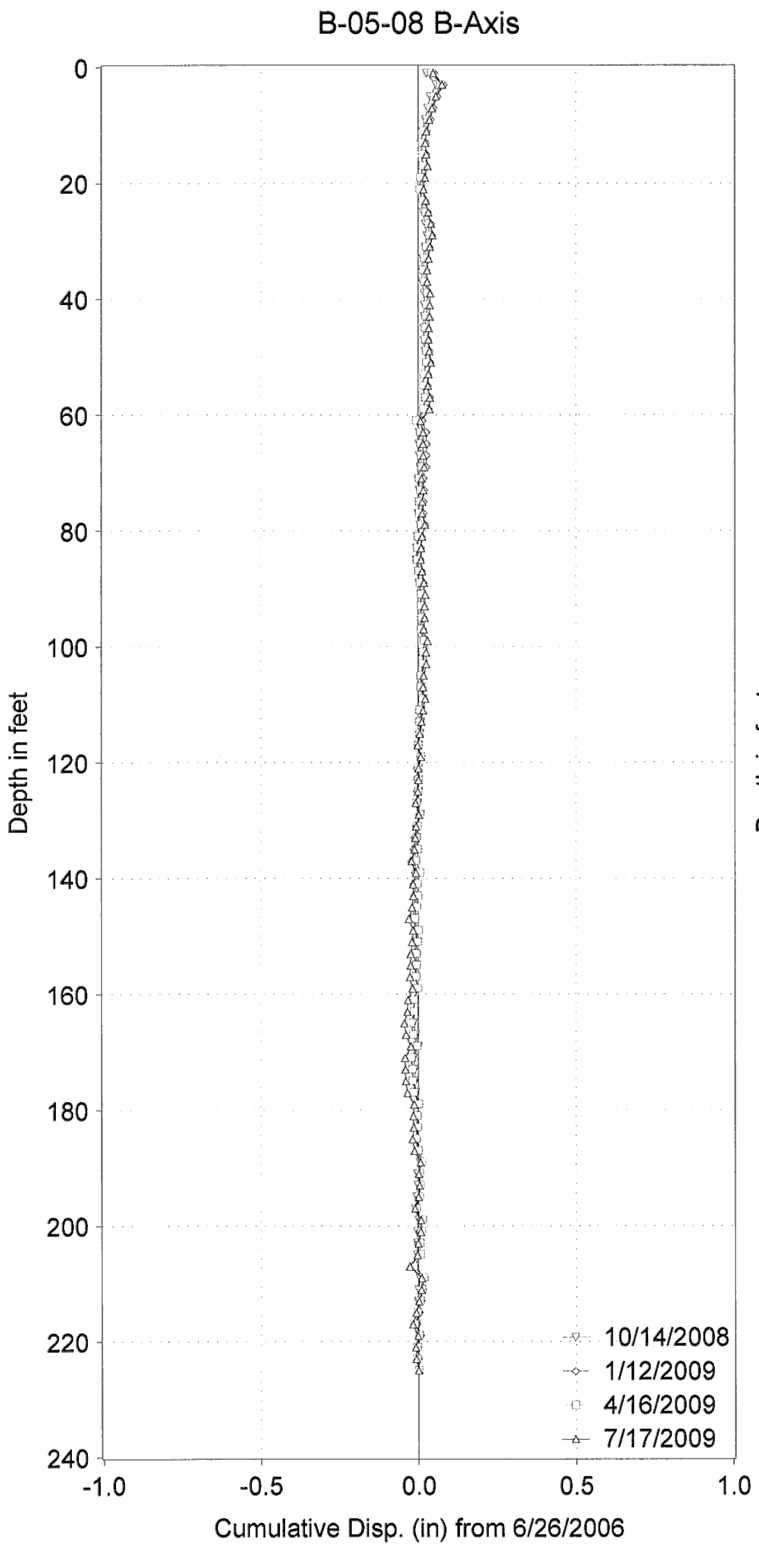


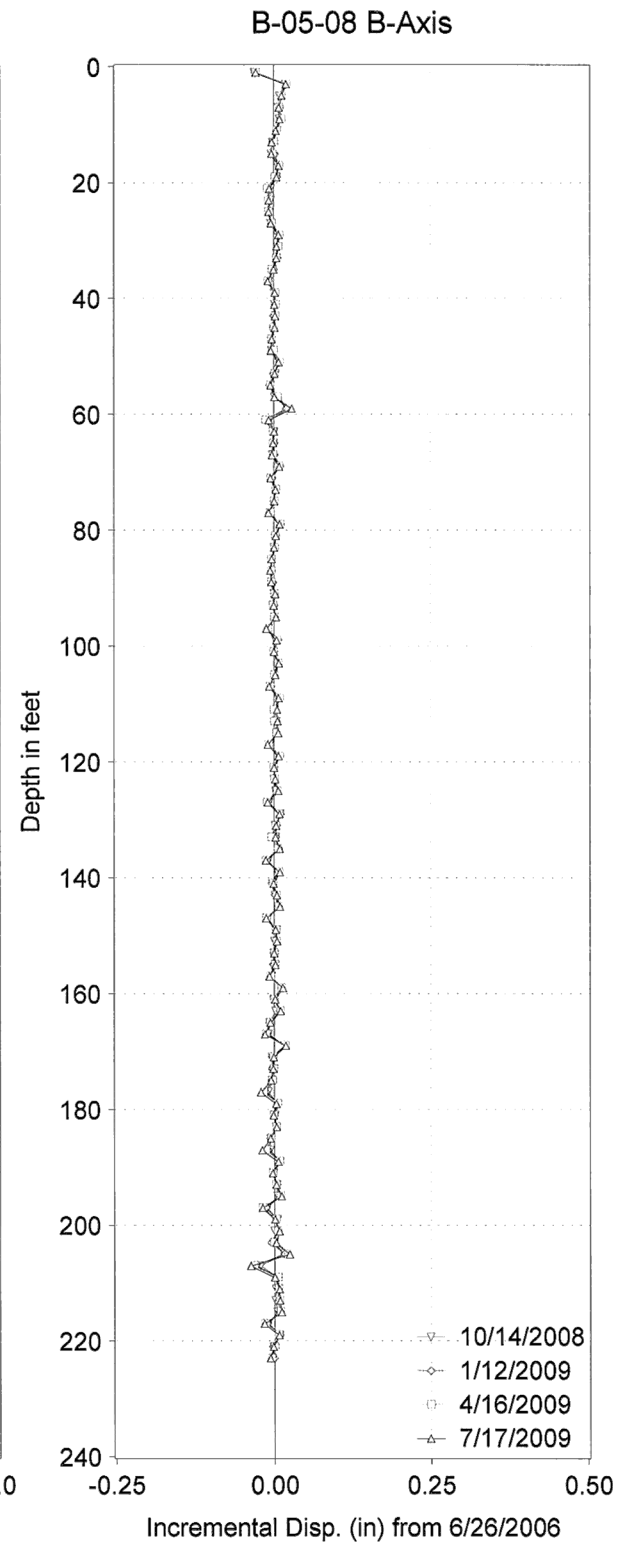


B-05-08

-Includes readings from the last four quarters.

PLATE 38

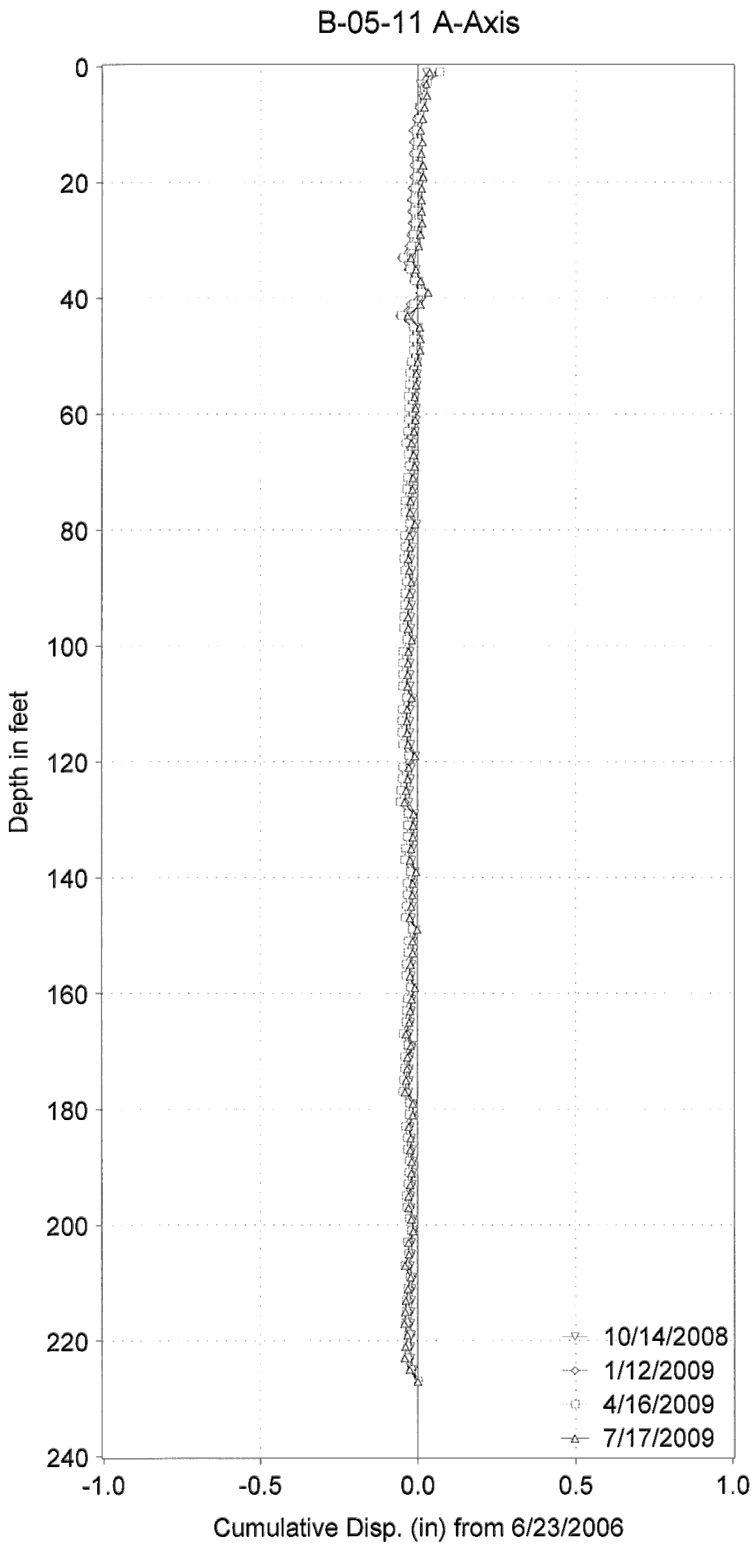


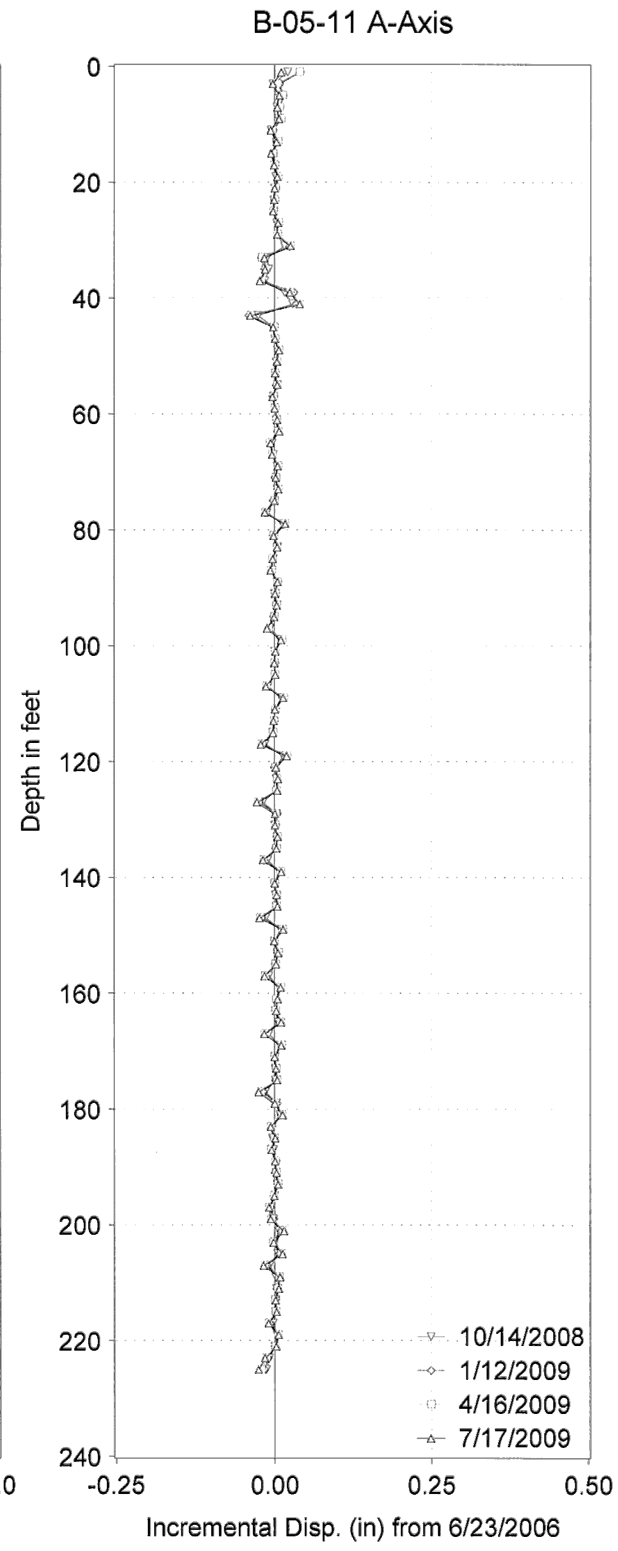


B-05-08

-Includes readings from the last four quarters.

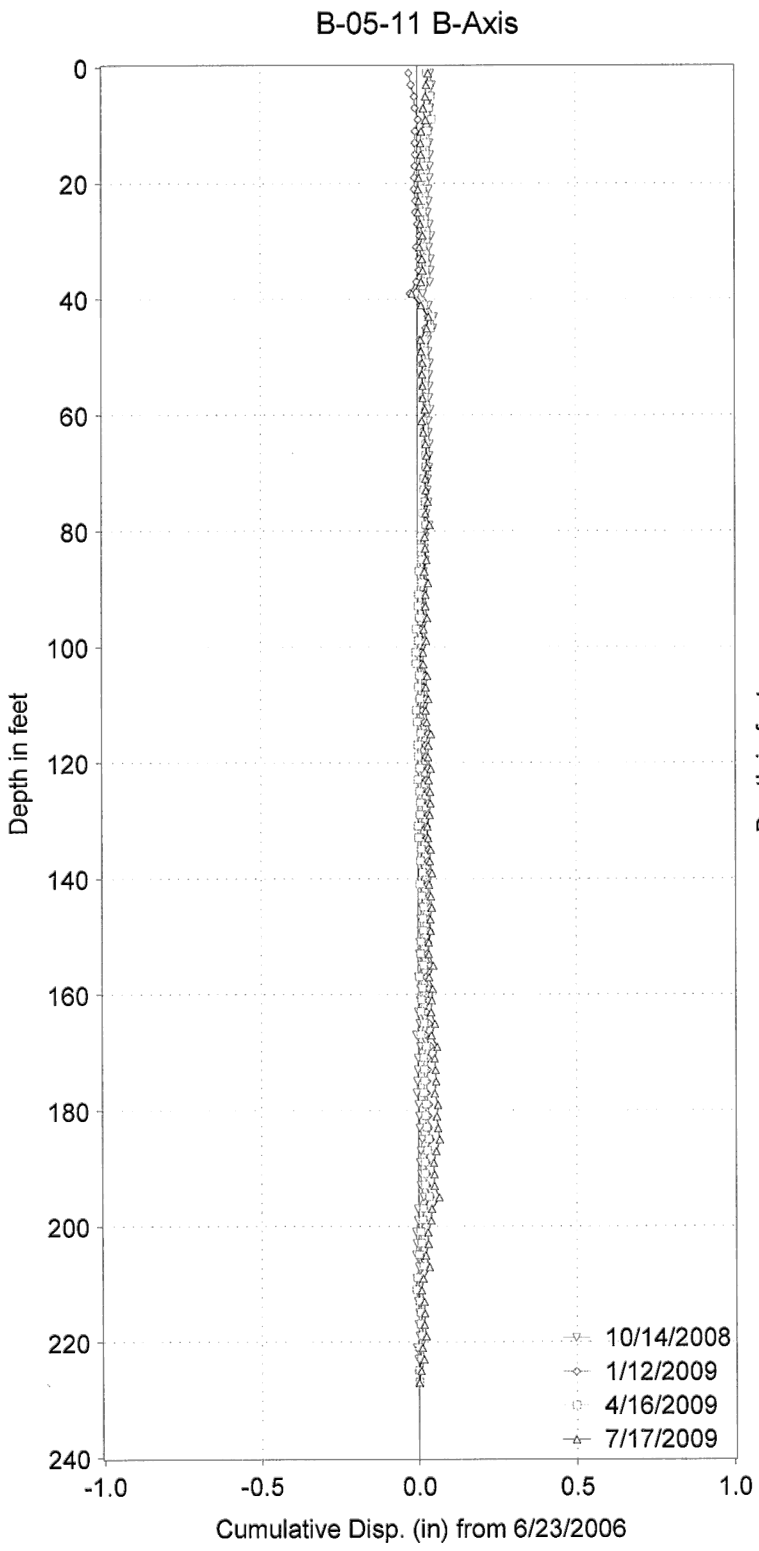
PLATE 39

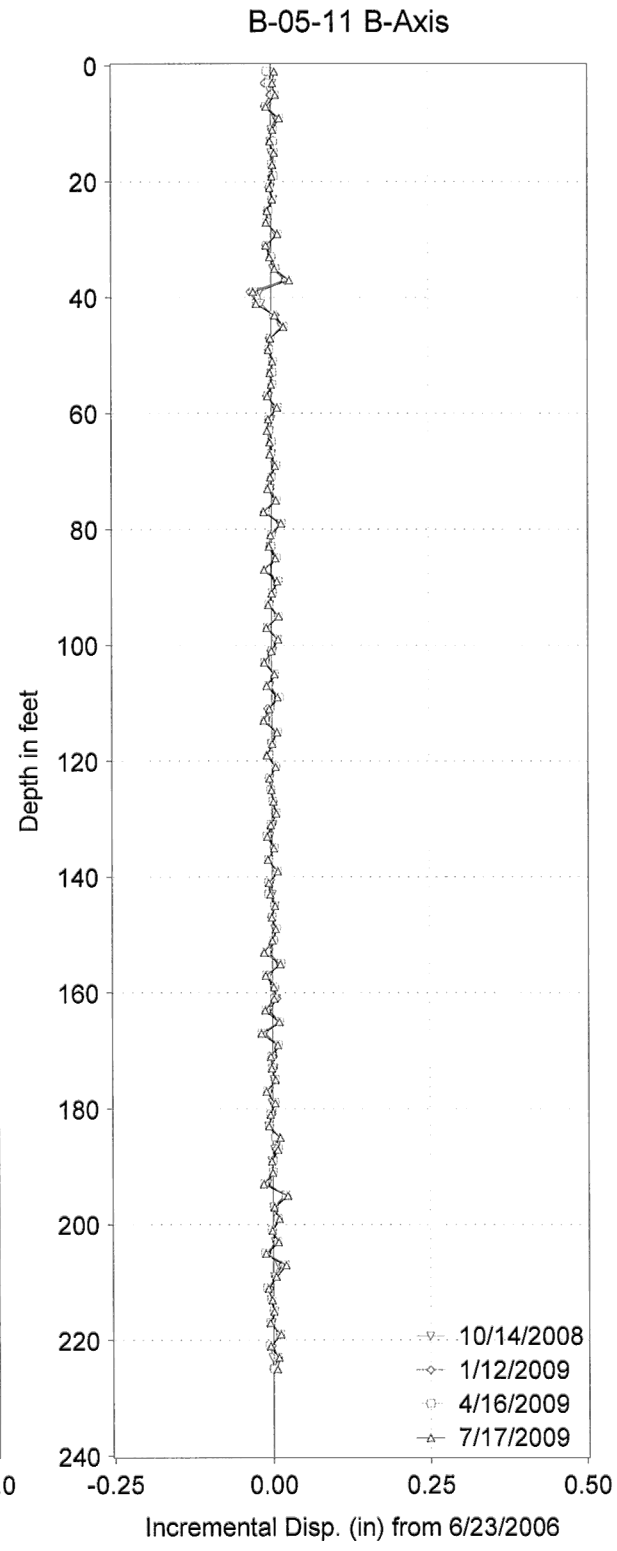




B-05-11
-Includes readings from the last four quarters.

PLATE 40

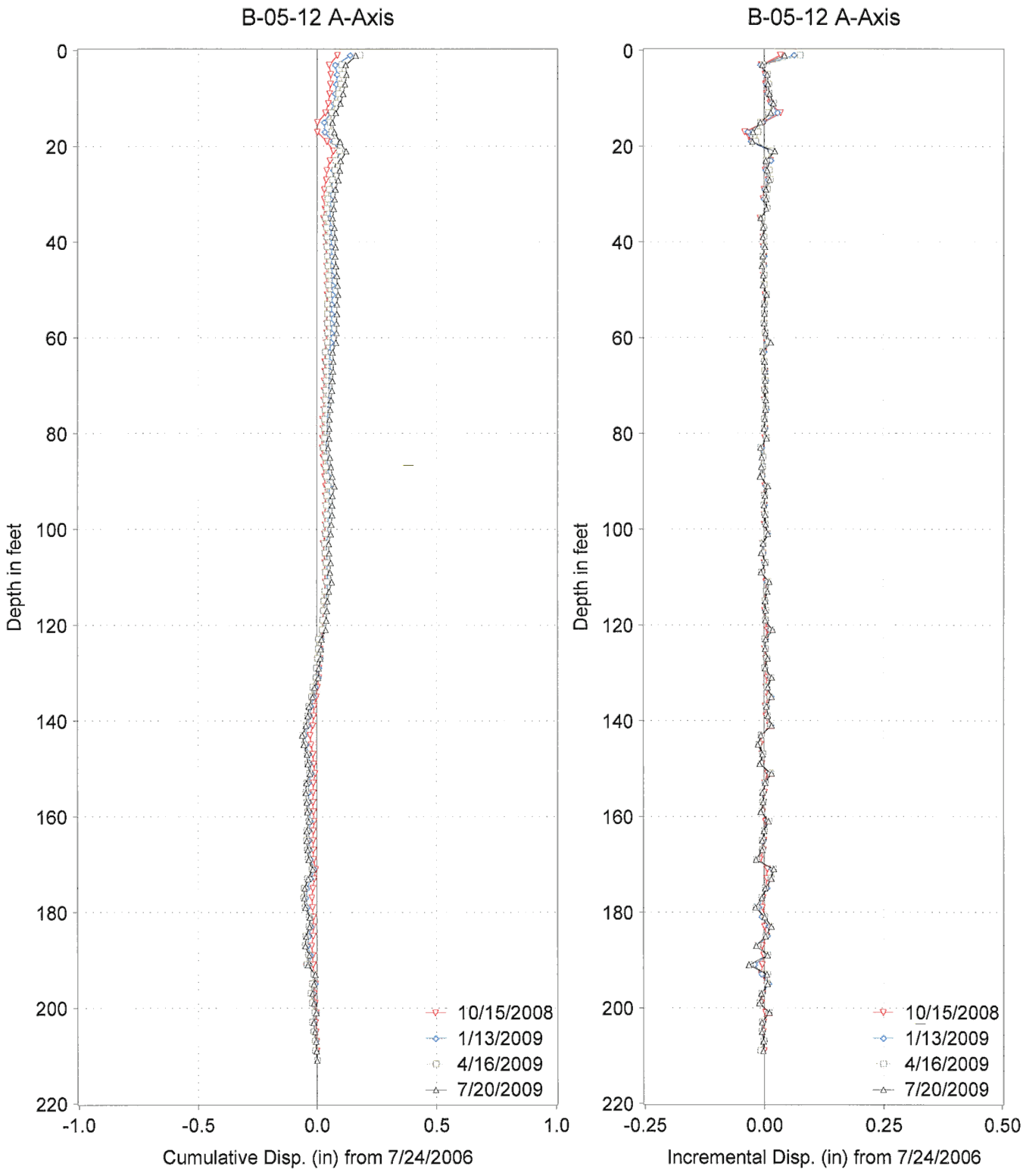




B-05-11

-Includes readings from the last four quarters.

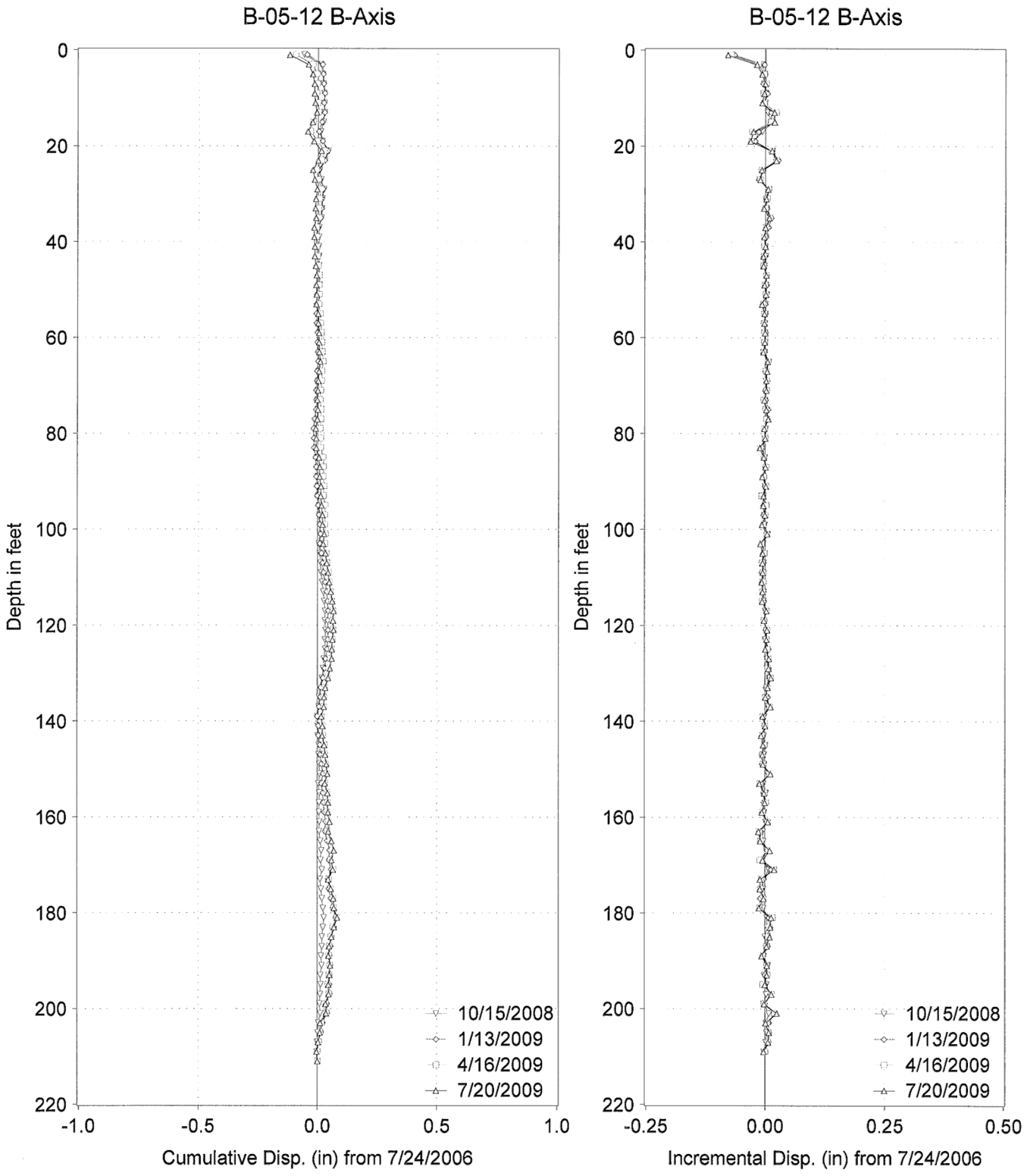
PLATE 41



B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

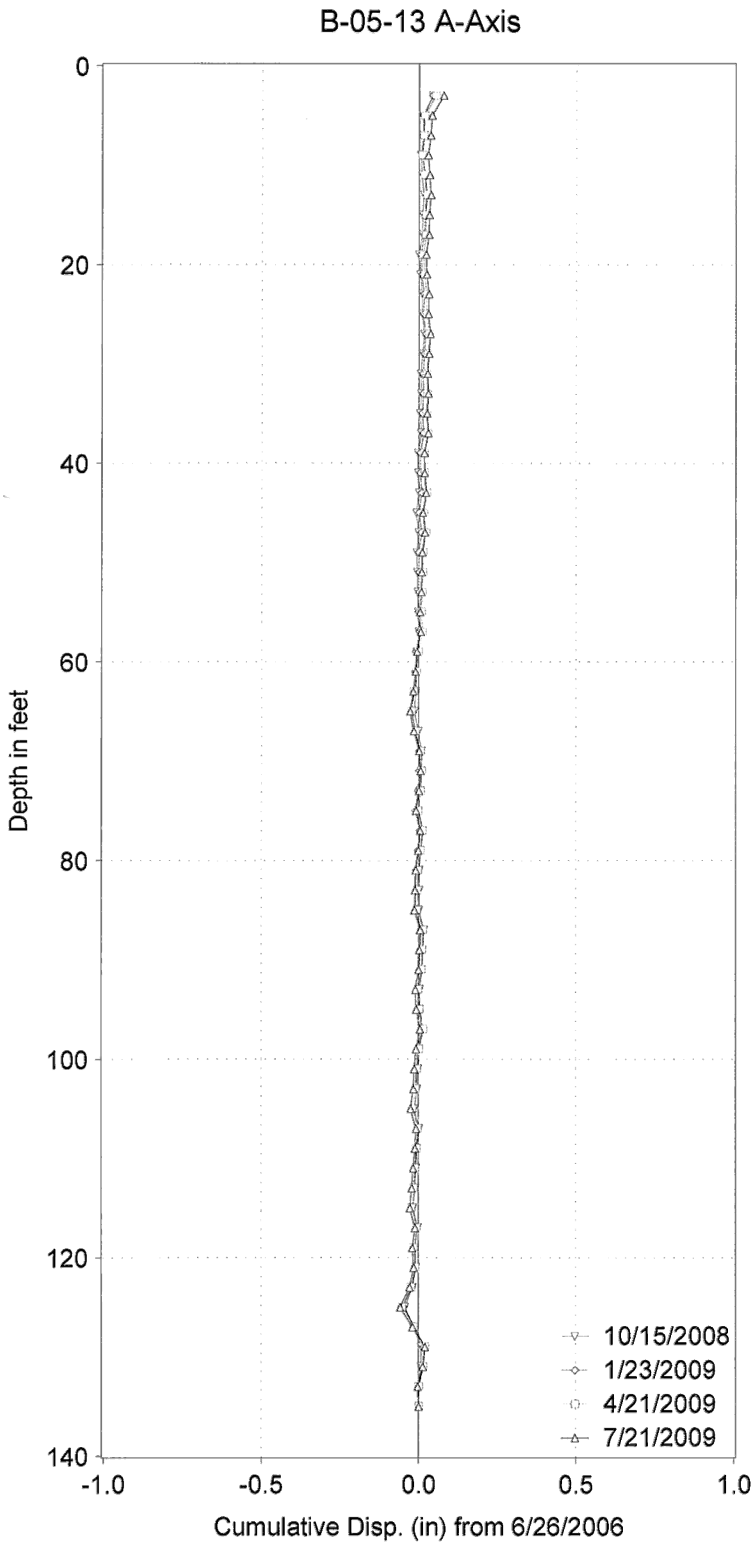
PLATE 42

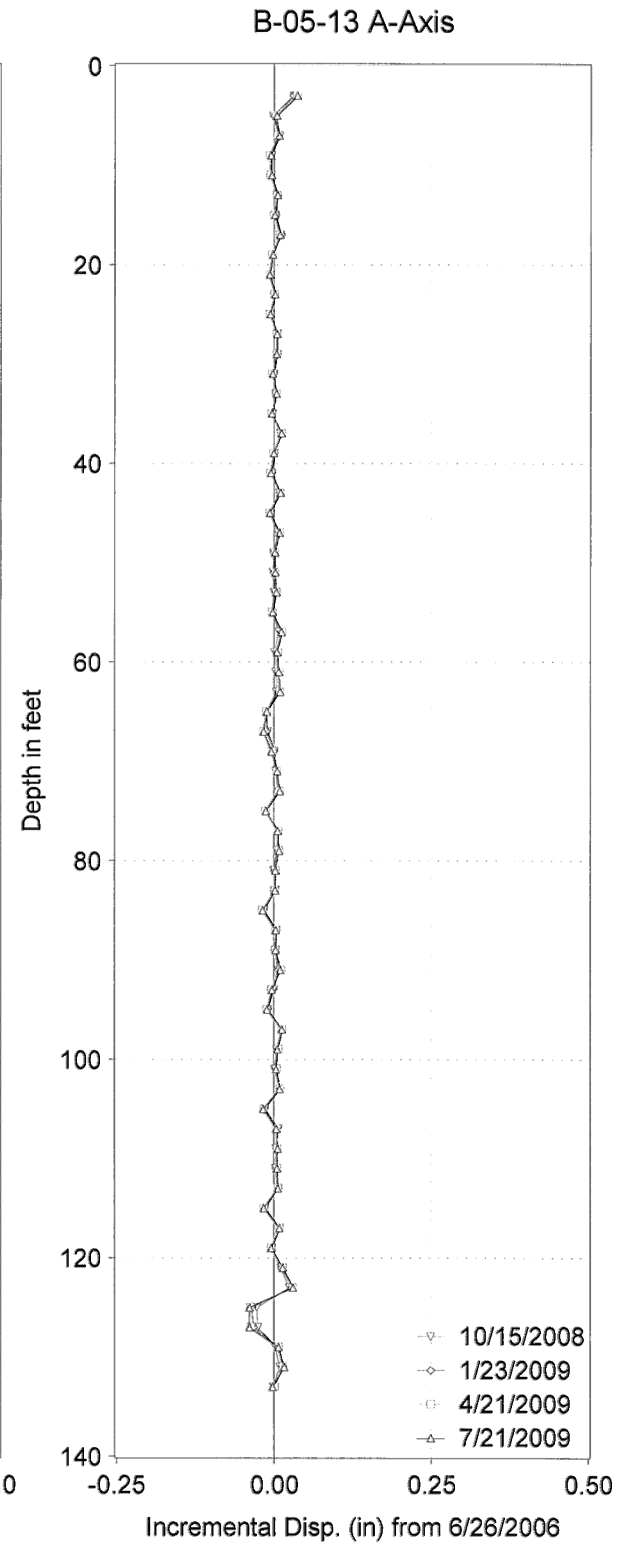


B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

PLATE 43

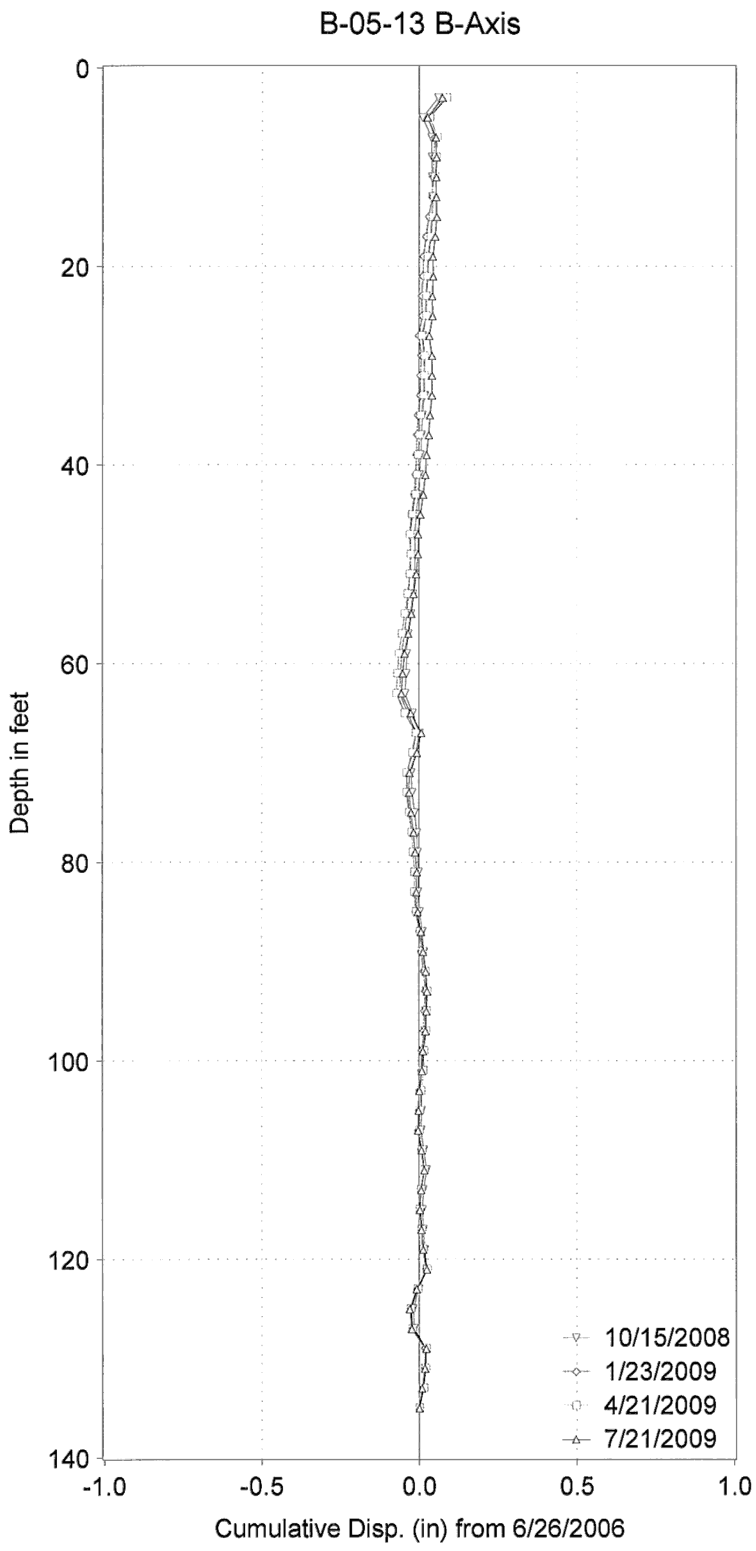


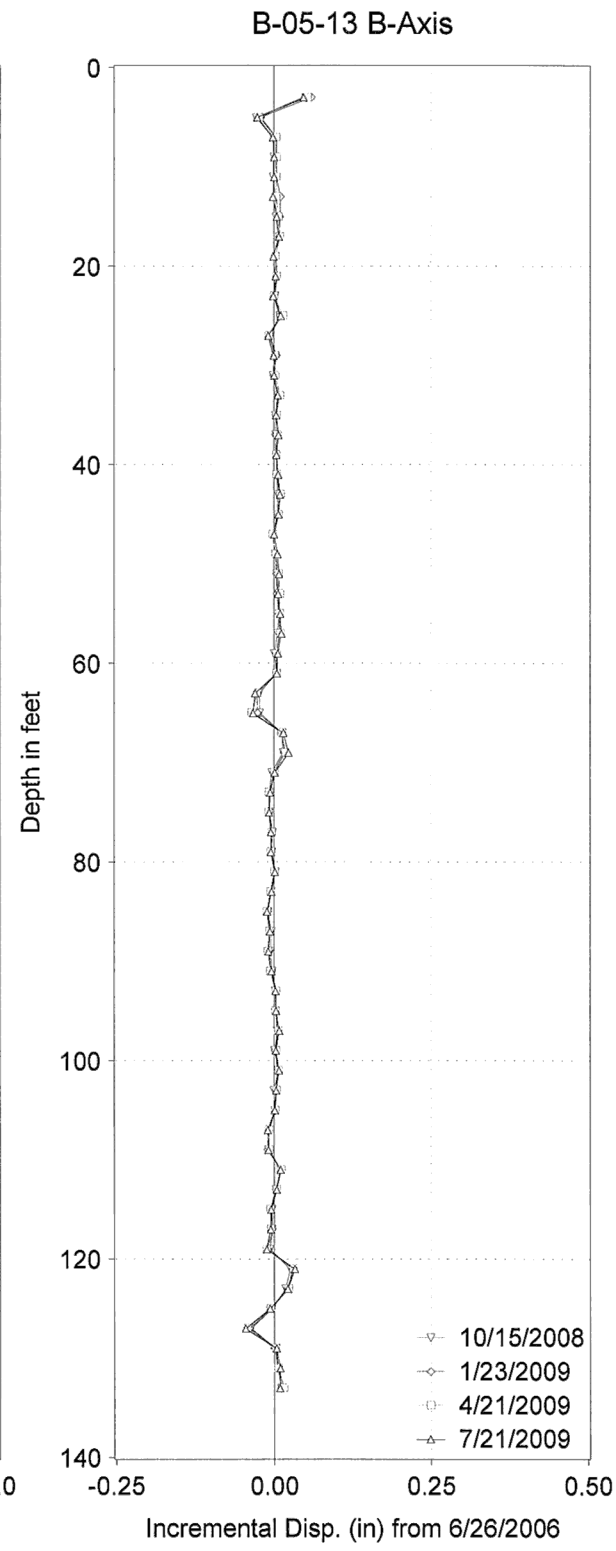


B-05-13

-Includes readings from the last four quarters.

PLATE 44

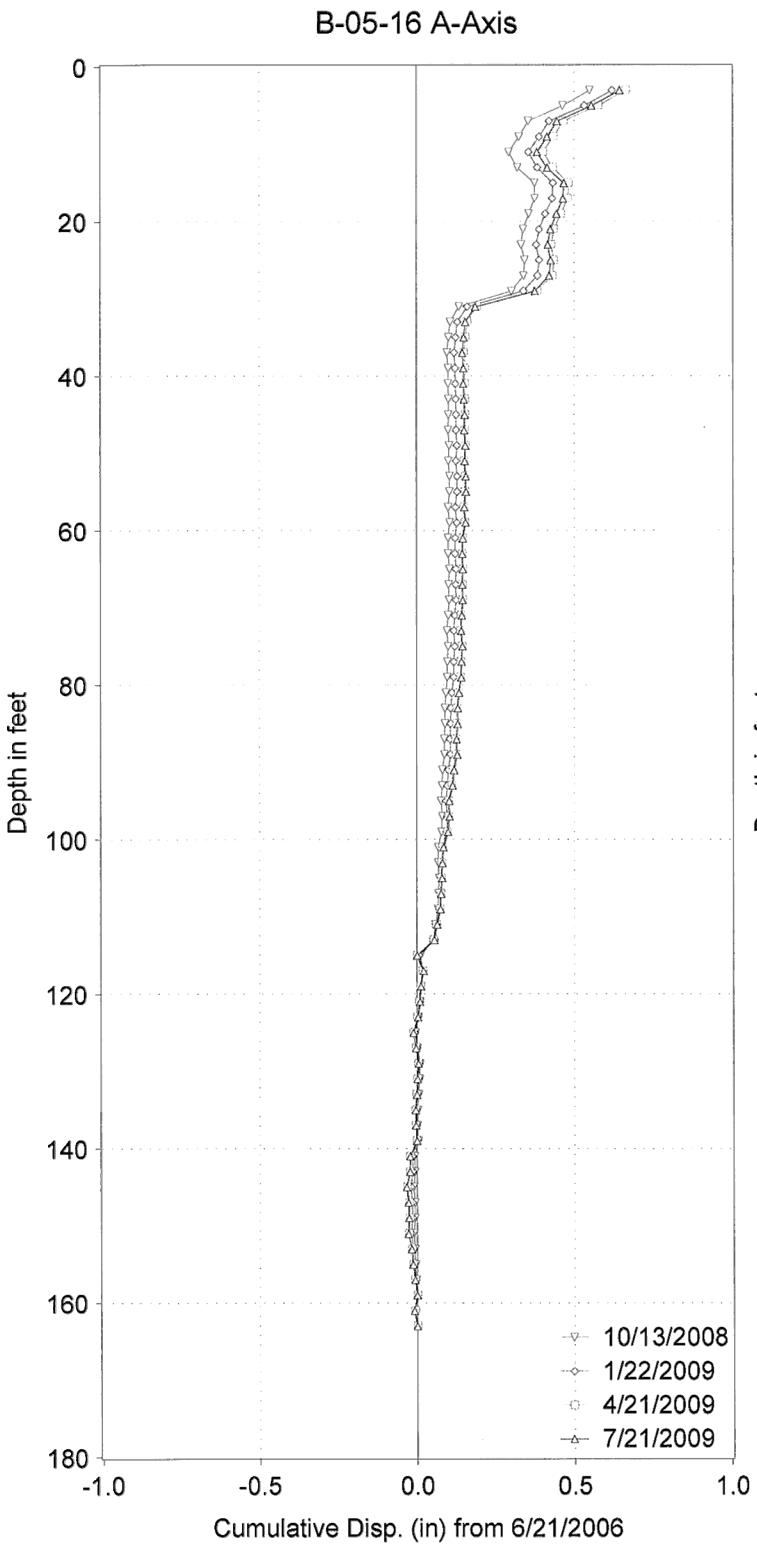


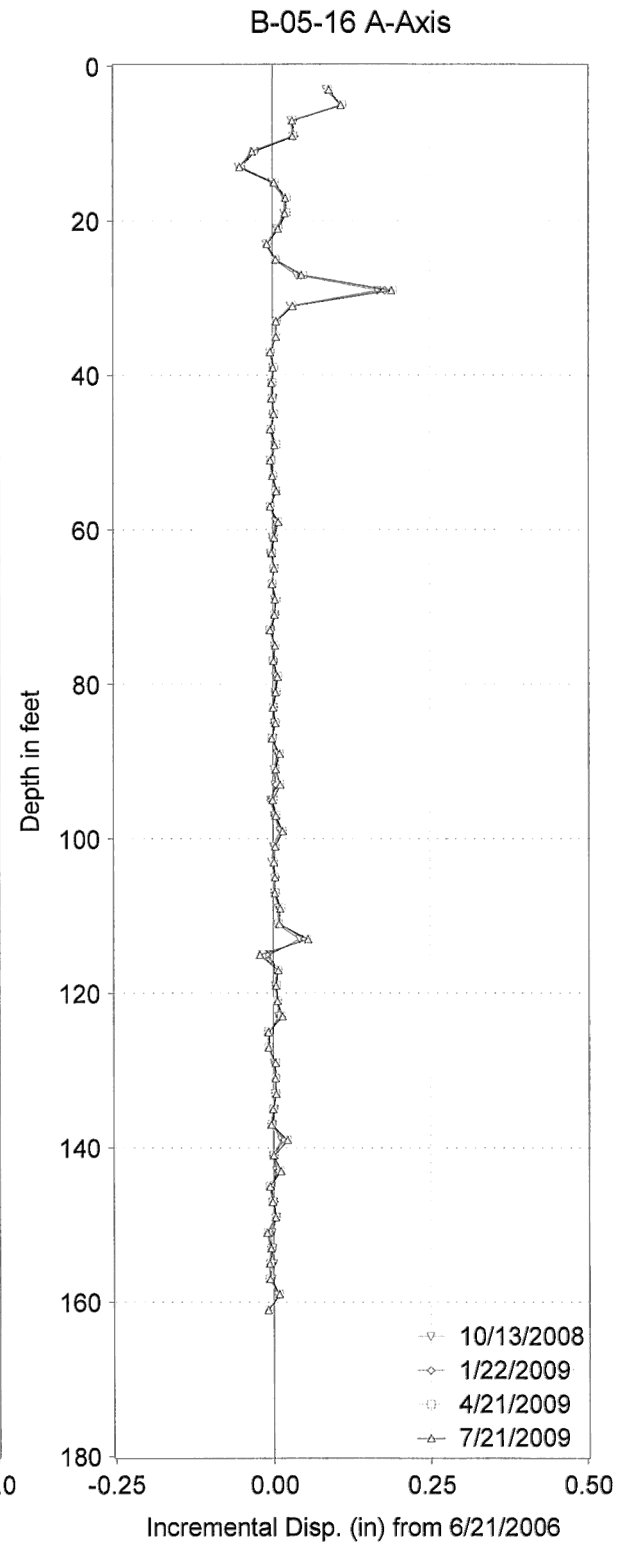


B-05-13

-Includes readings from the last four quarters.

PLATE 45

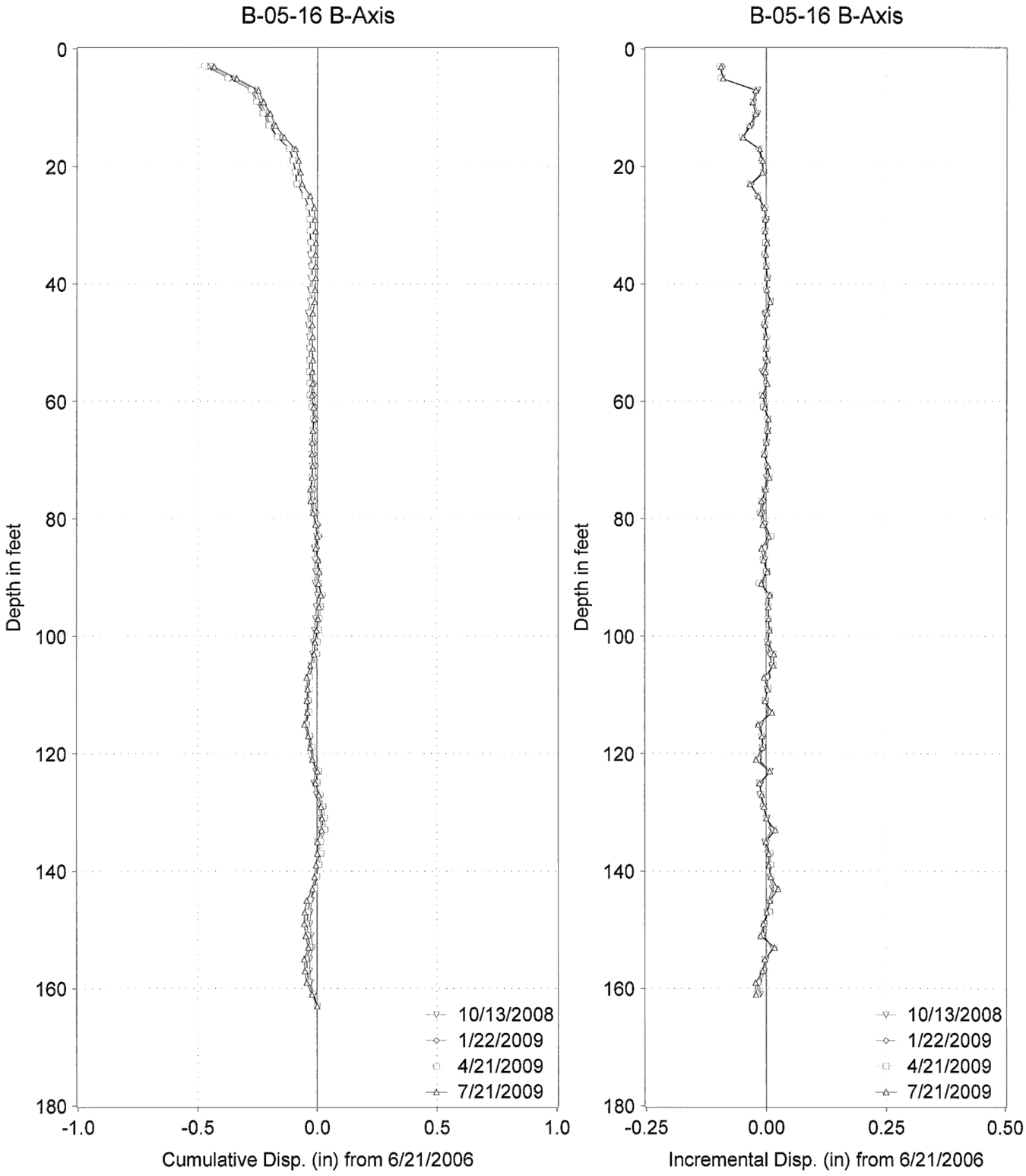




B-05-16

-Includes readings from the last four quarters.

PLATE 46



B-05-16
-Includes readings from the last four quarters.

PLATE 47

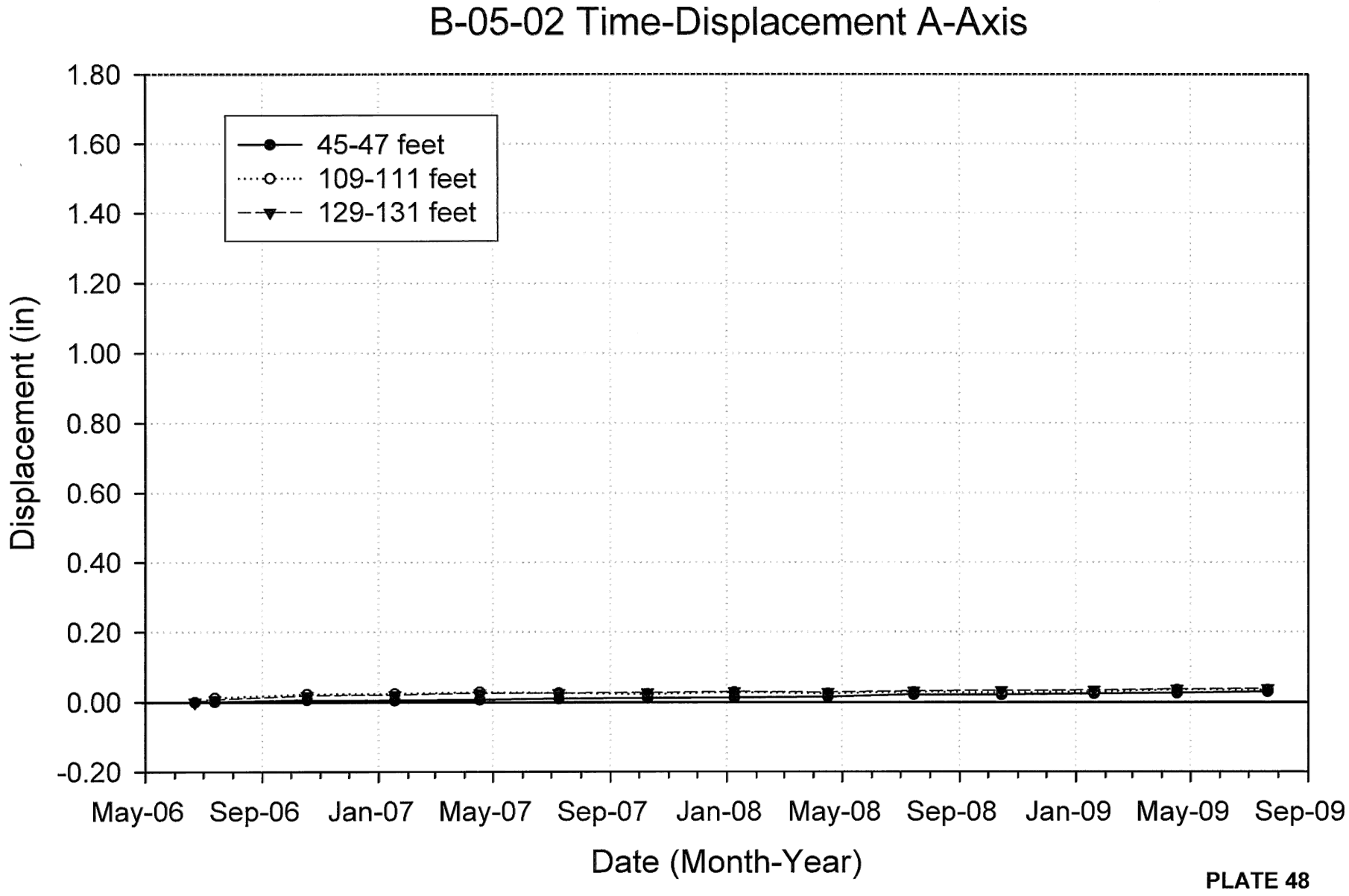

B-05-02 Time-Displacement A-Axis
45-47 feet
109-111 feet
129-131 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Sep-09
Date (Month-Year)

PLATE 48

B-05-03 Time-Displacement A-Axis

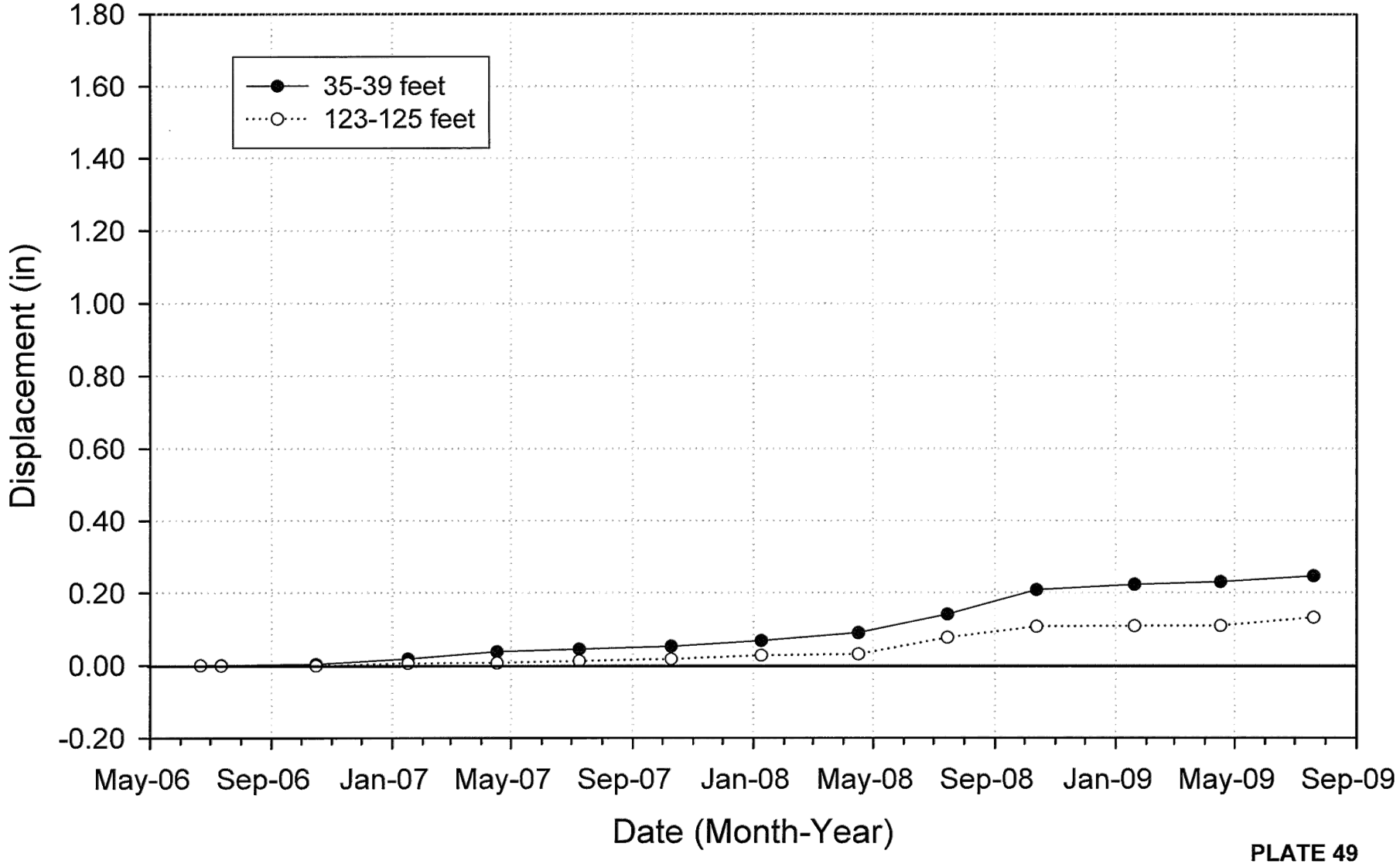


PLATE 49

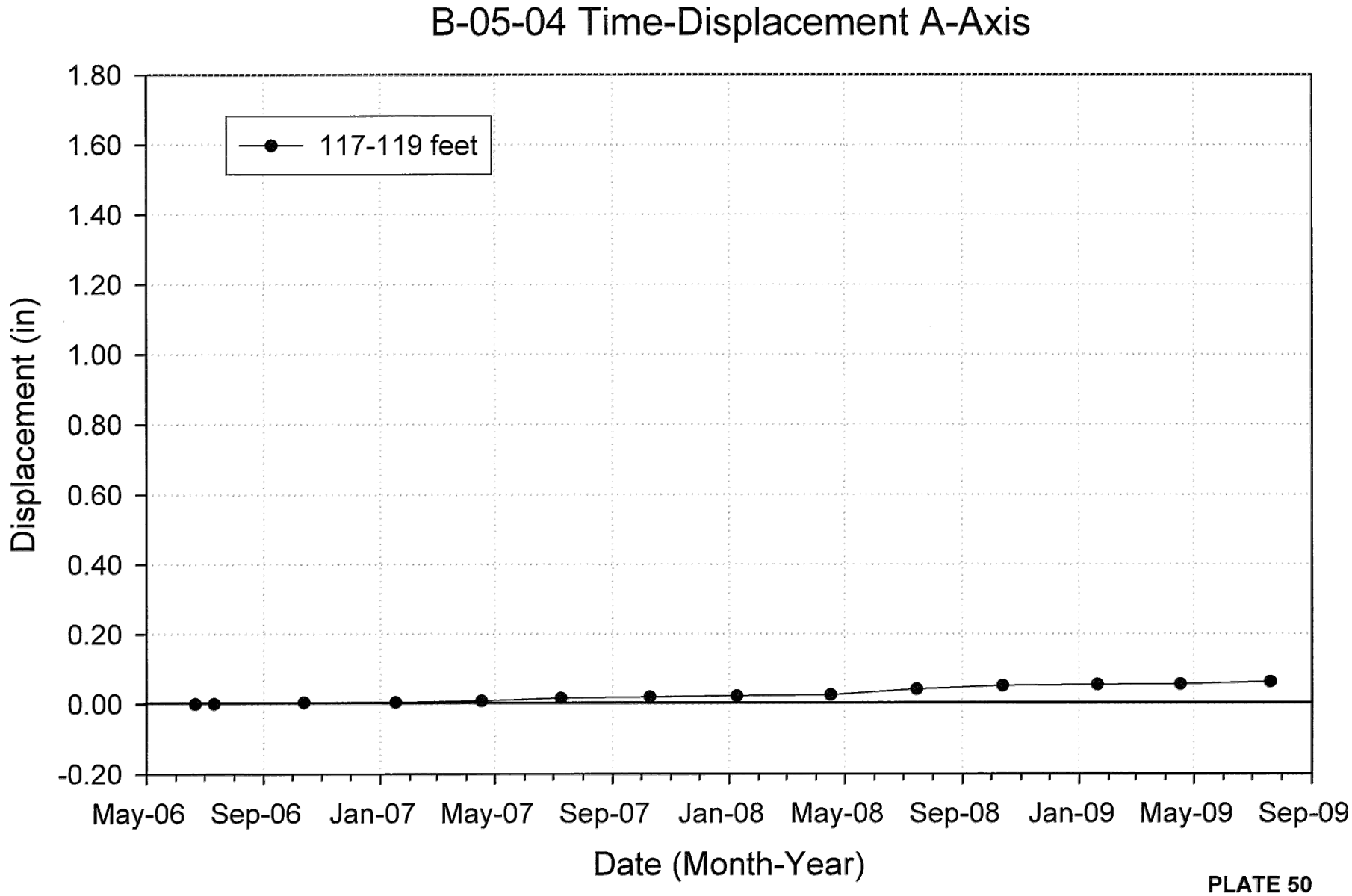

B-05-04 Time-Displacement A-Axis
117-119 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Sep-09
Date (Month-Year)

PLATE 50

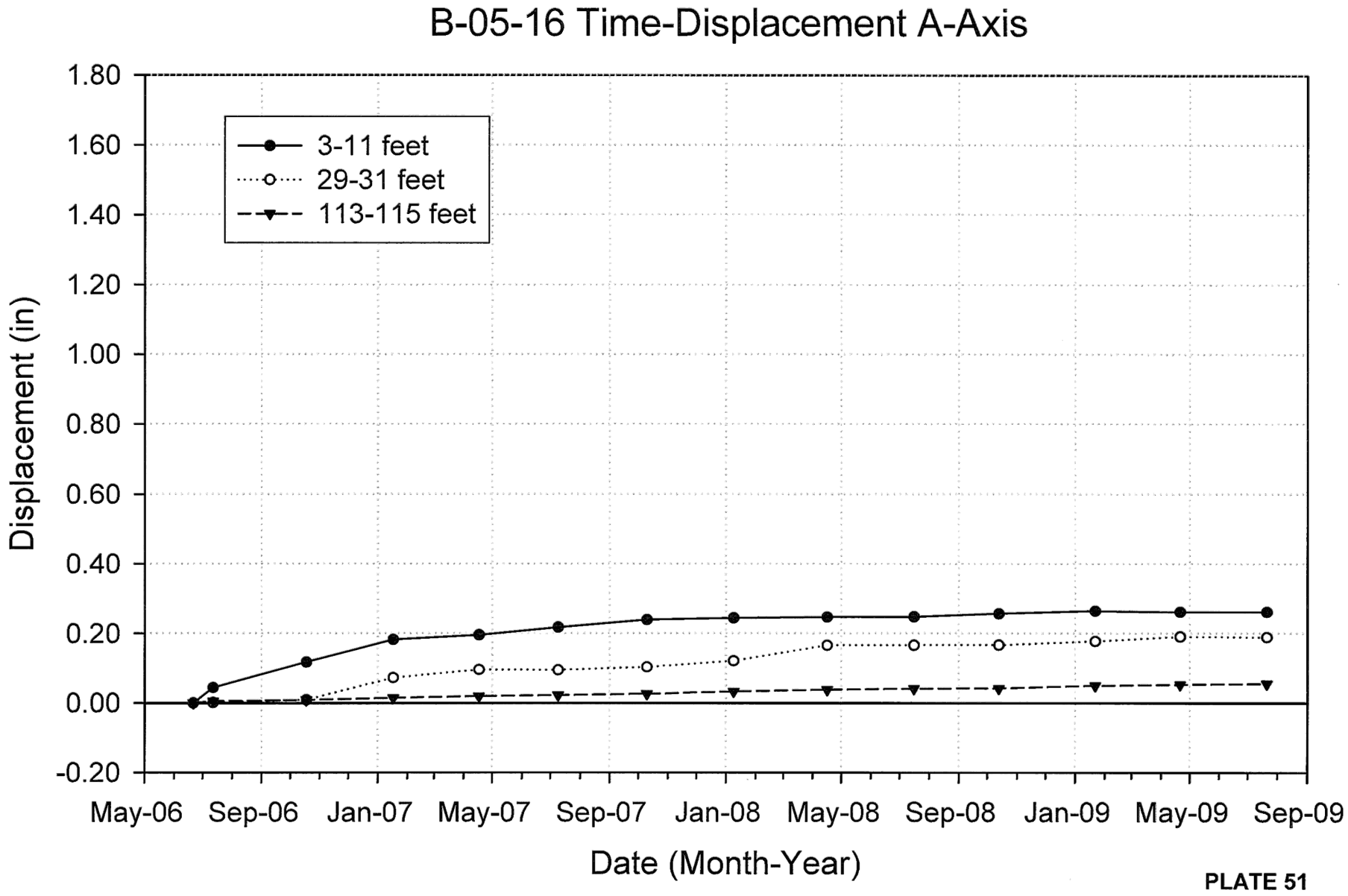

B-05-16 Time-Displacement A-Axis
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Displacement (in)
3-11 feet
29-31 feet
113-115 feet
May-06
Sep-06
Jan-07
May-07
Sep-07
Jan-08
May-08
Sep-08
Jan-09
May-09
Sep-09
Date (Month-Year)

PLATE 51

B-101 (P-1) Pneumatic Piezometer Readings

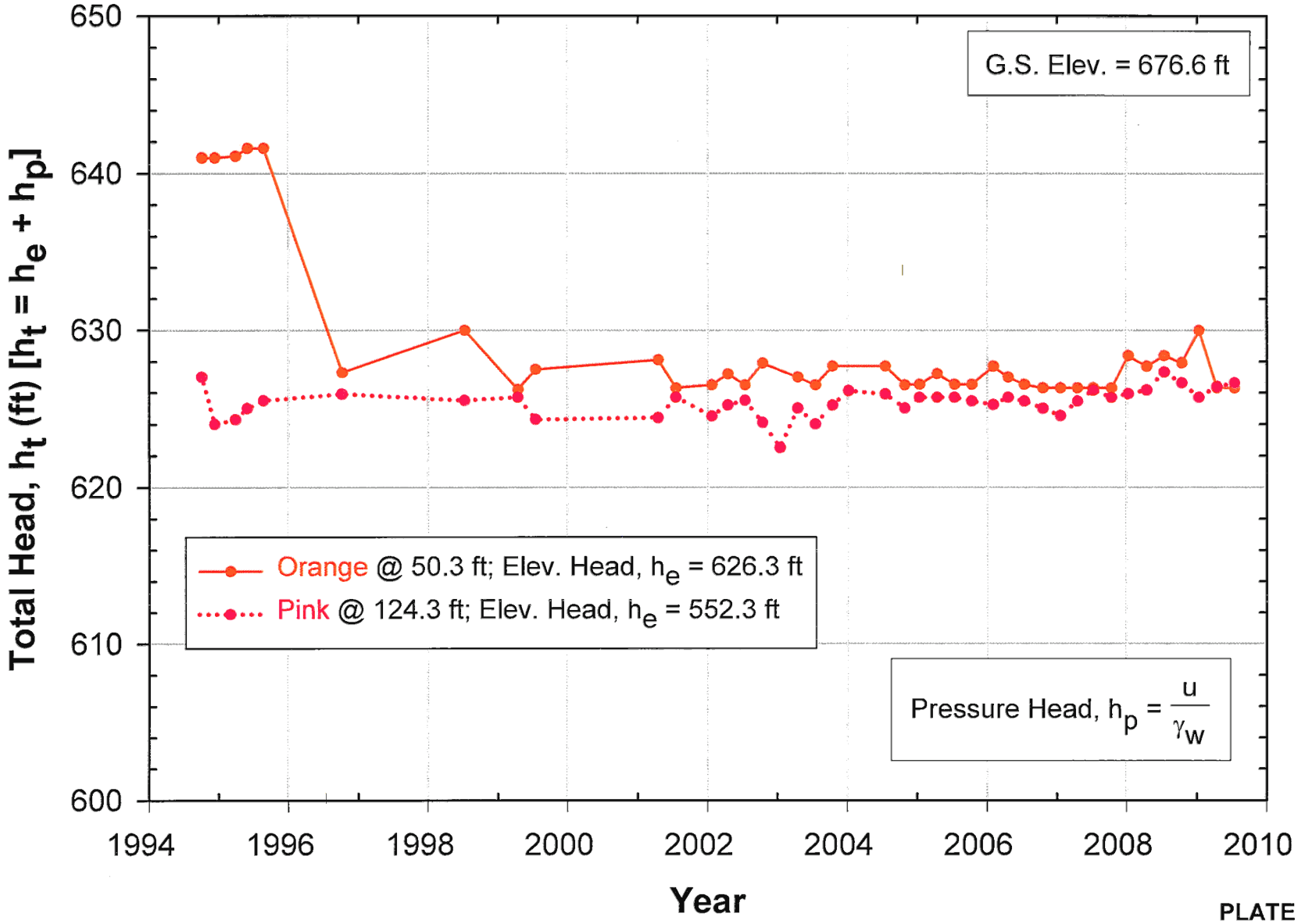


PLATE 52

B-105 (P-3) Pneumatic Piezometer Readings

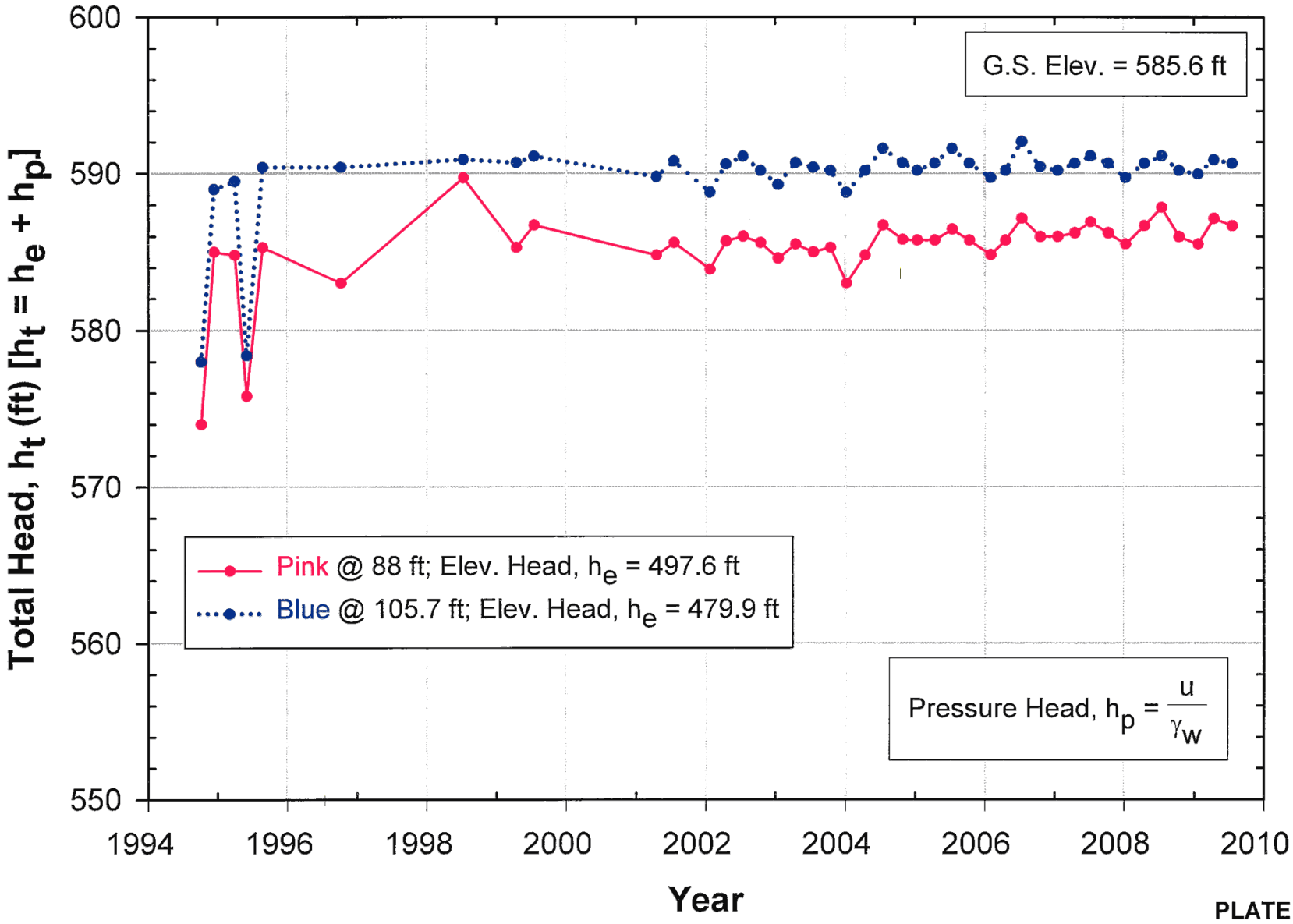


PLATE 53

B-107 (P-5) Pneumatic Piezometer Readings

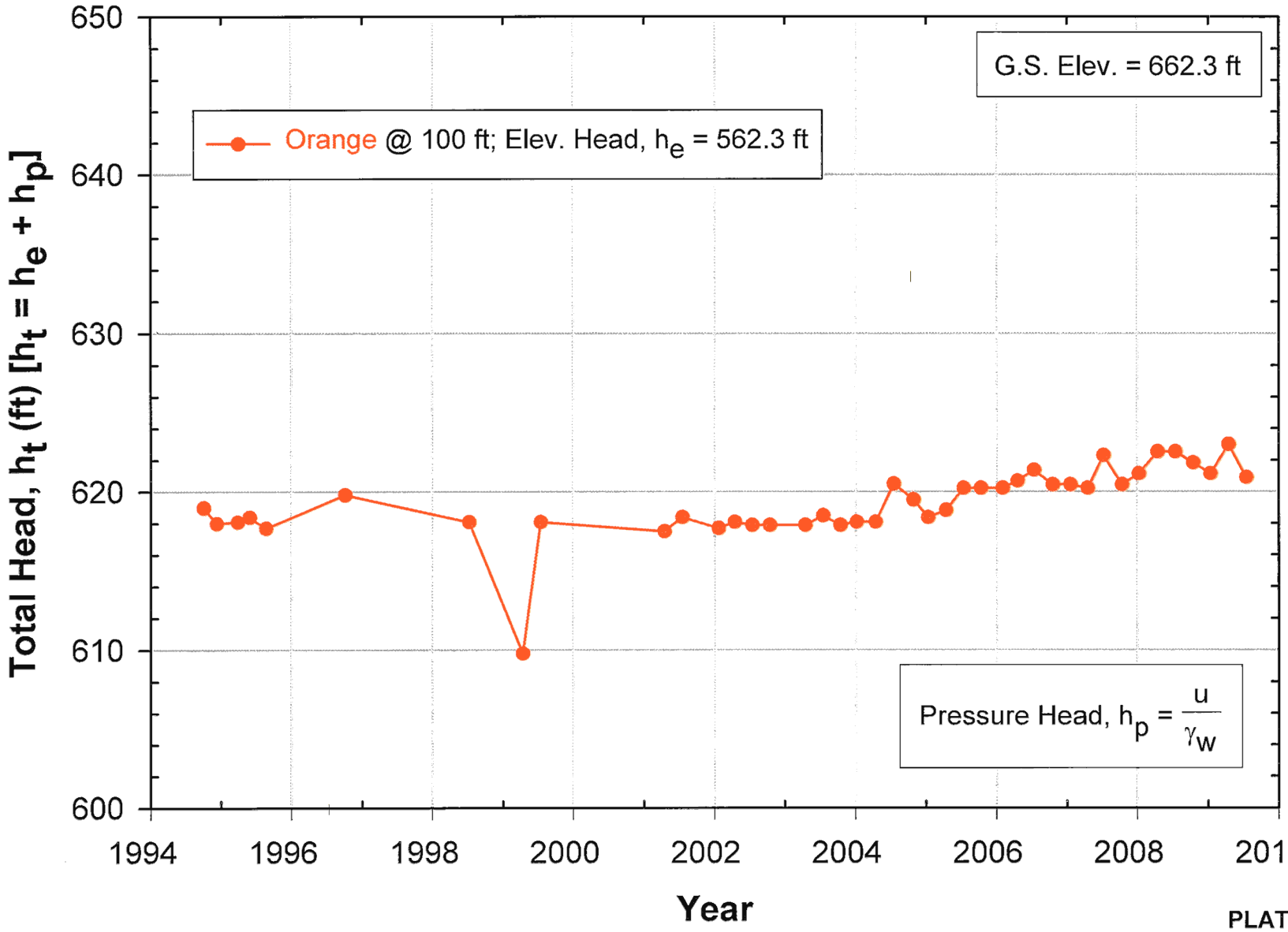


PLATE 54

B-303 (P-2) Pneumatic Piezometer Readings

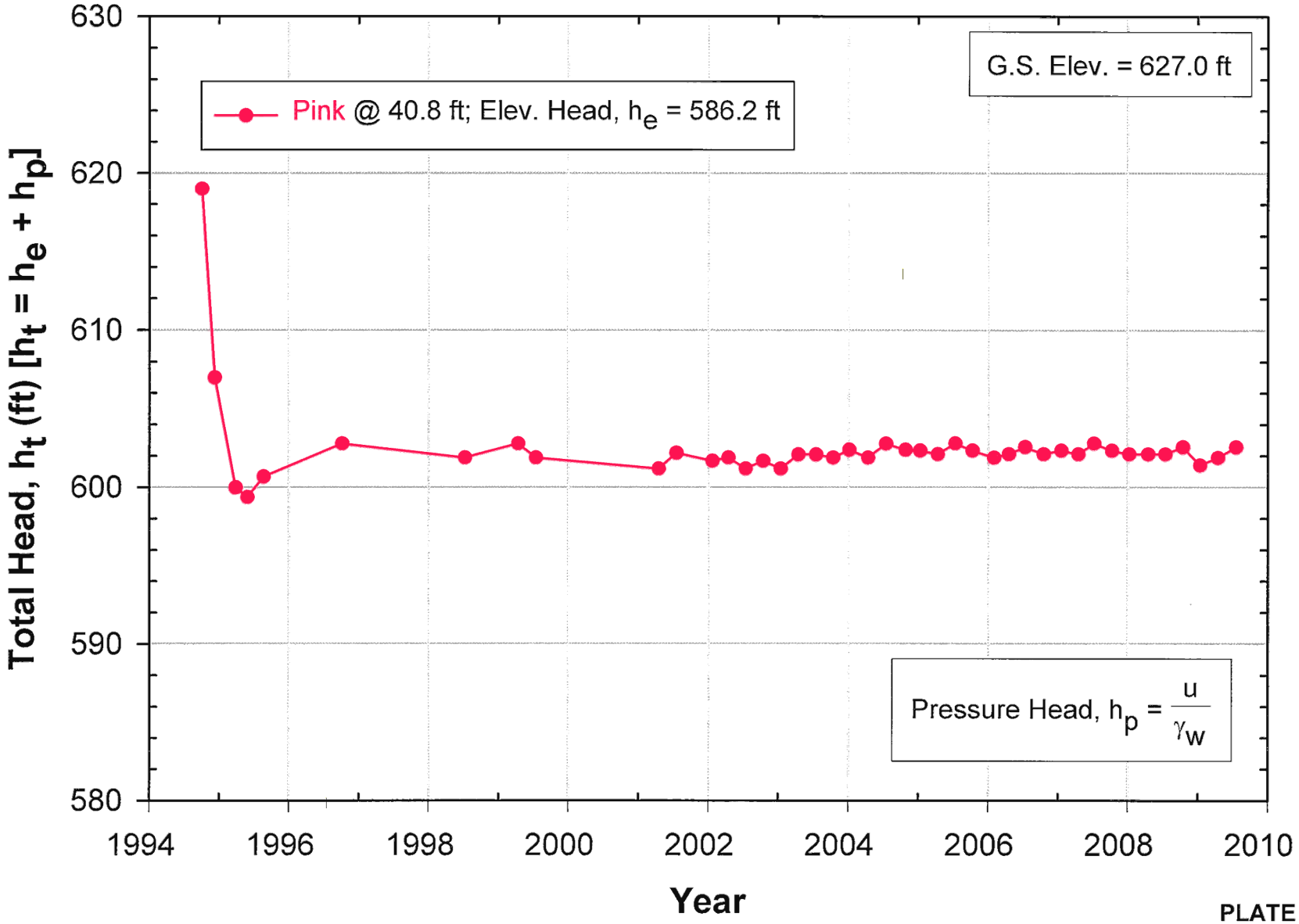


PLATE 55

B-05-01 VW Piezometer Readings

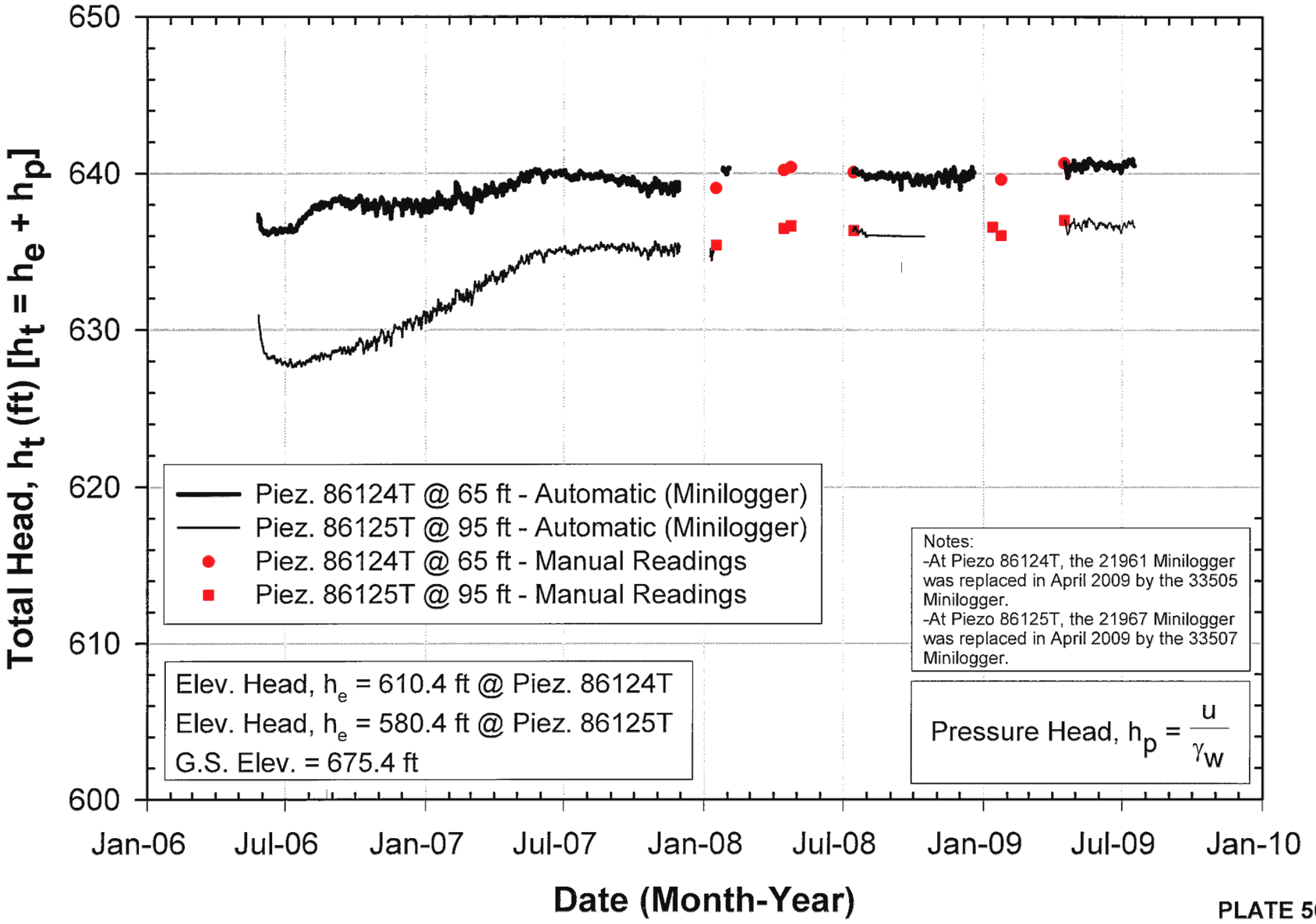


PLATE 56

B-05-02 VW Piezometer Readings

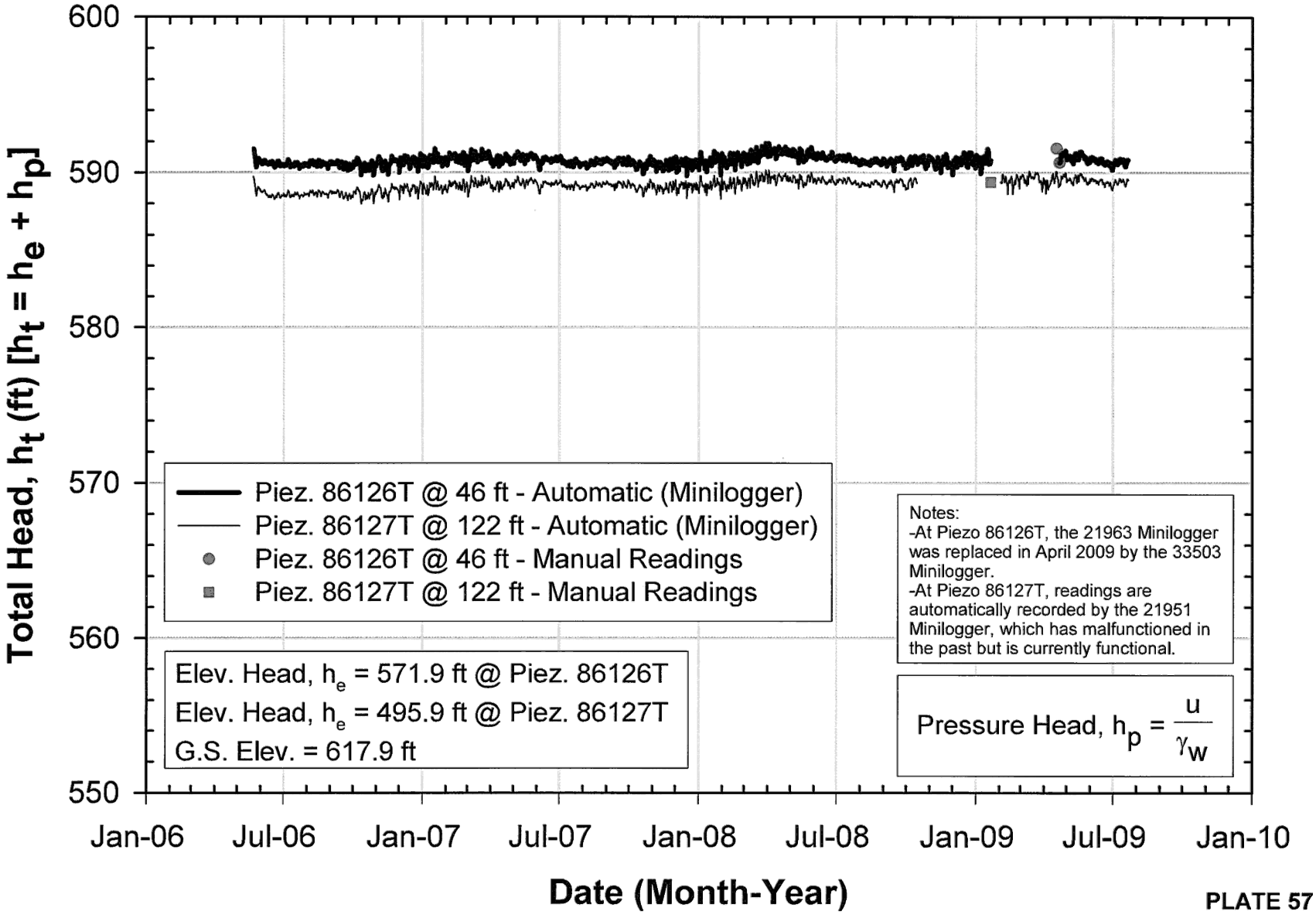


PLATE 57

B-05-03 VW Piezometer Readings

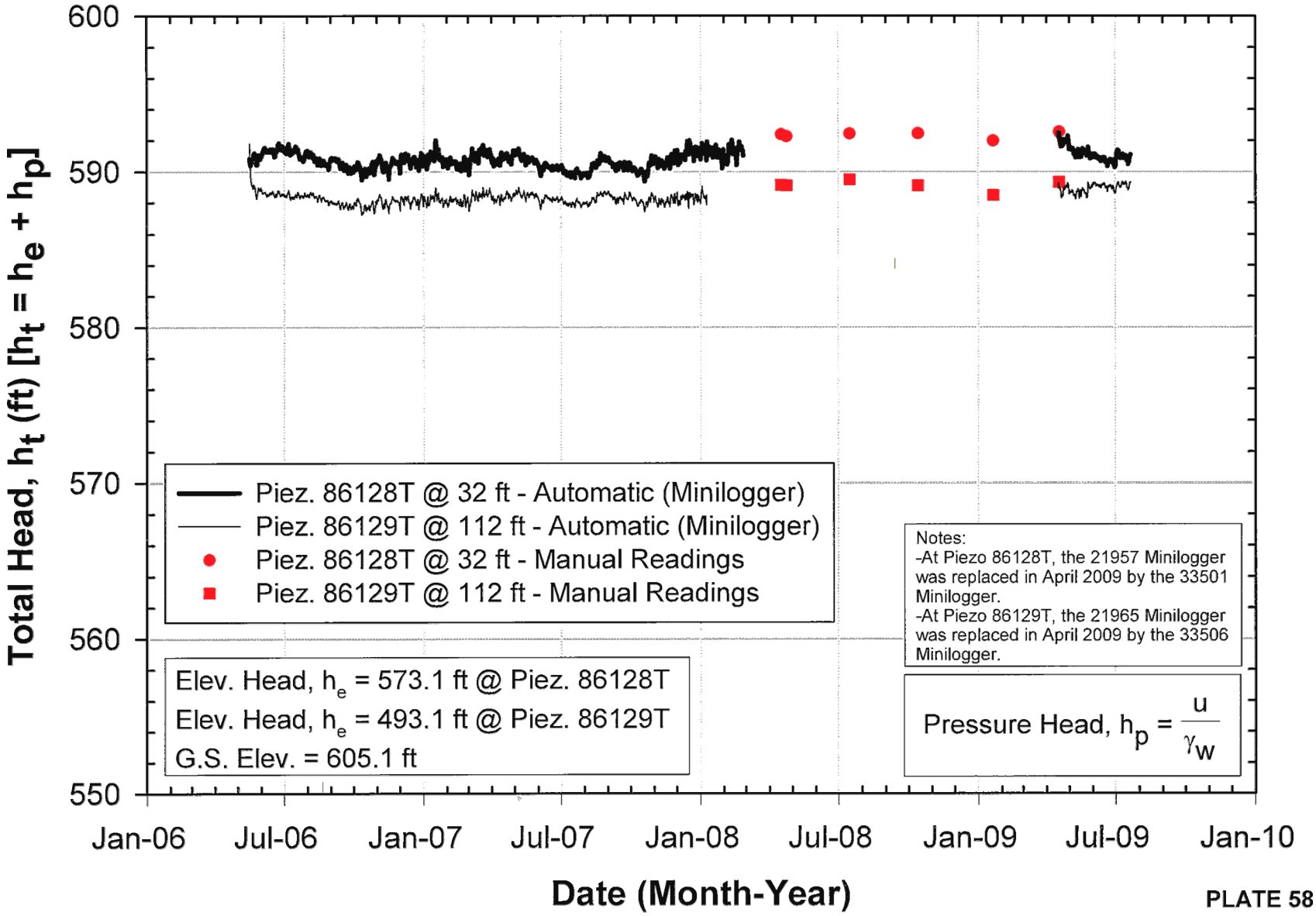


PLATE 58

B-05-04 VW Piezometer Readings

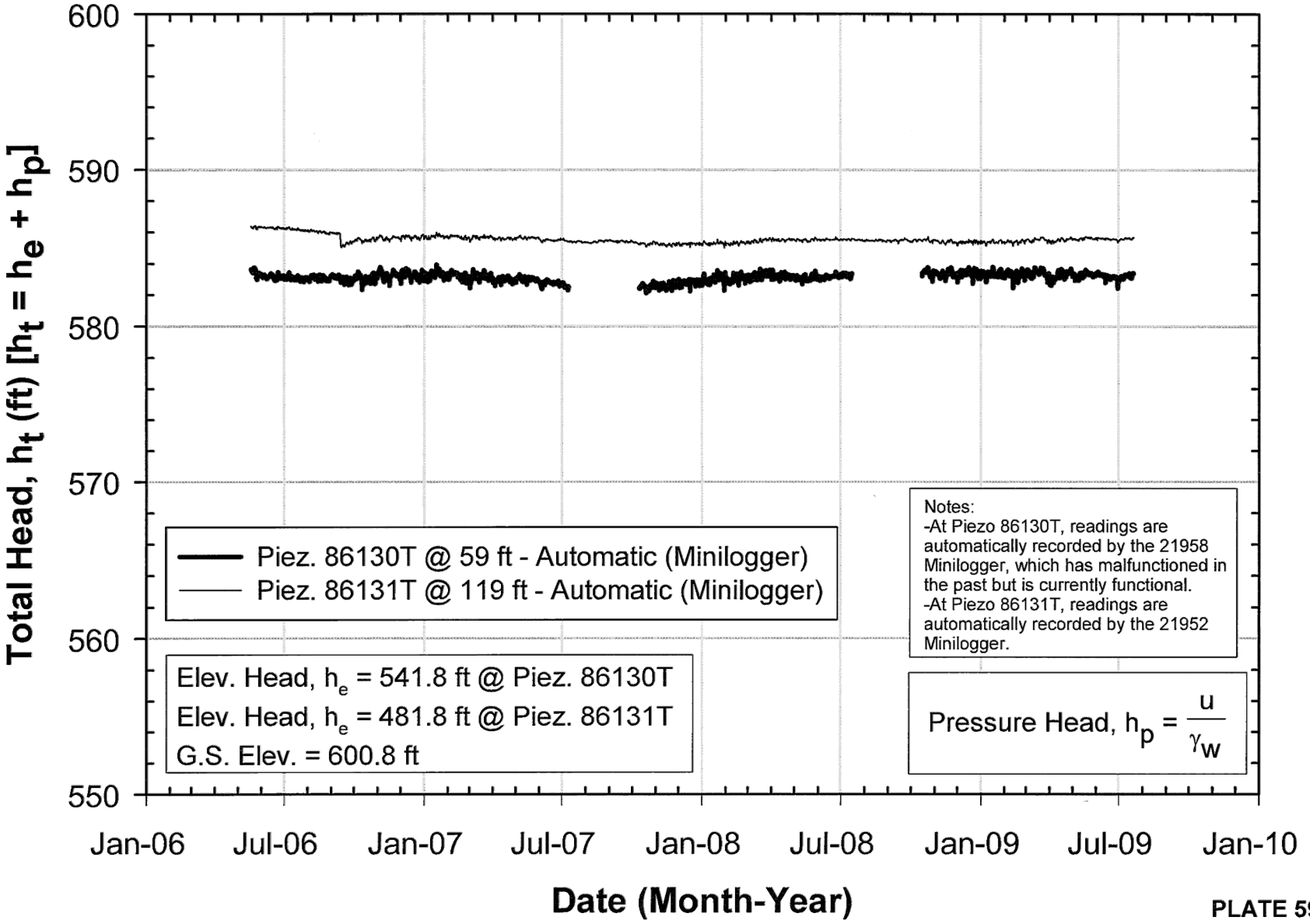


PLATE 59

B-05-07 VW Piezometer Readings

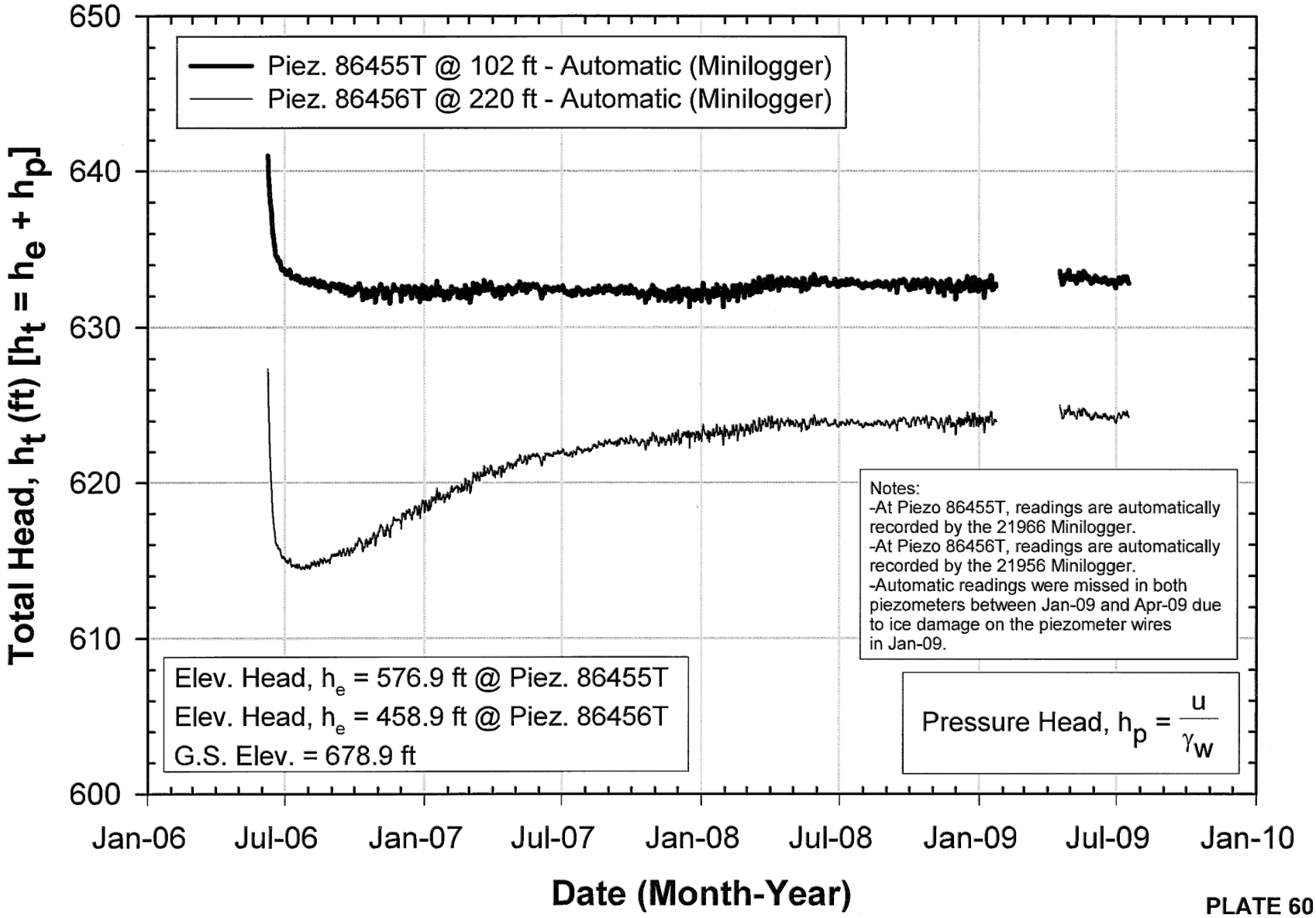


PLATE 60

B-05-08 VW Piezometer Readings

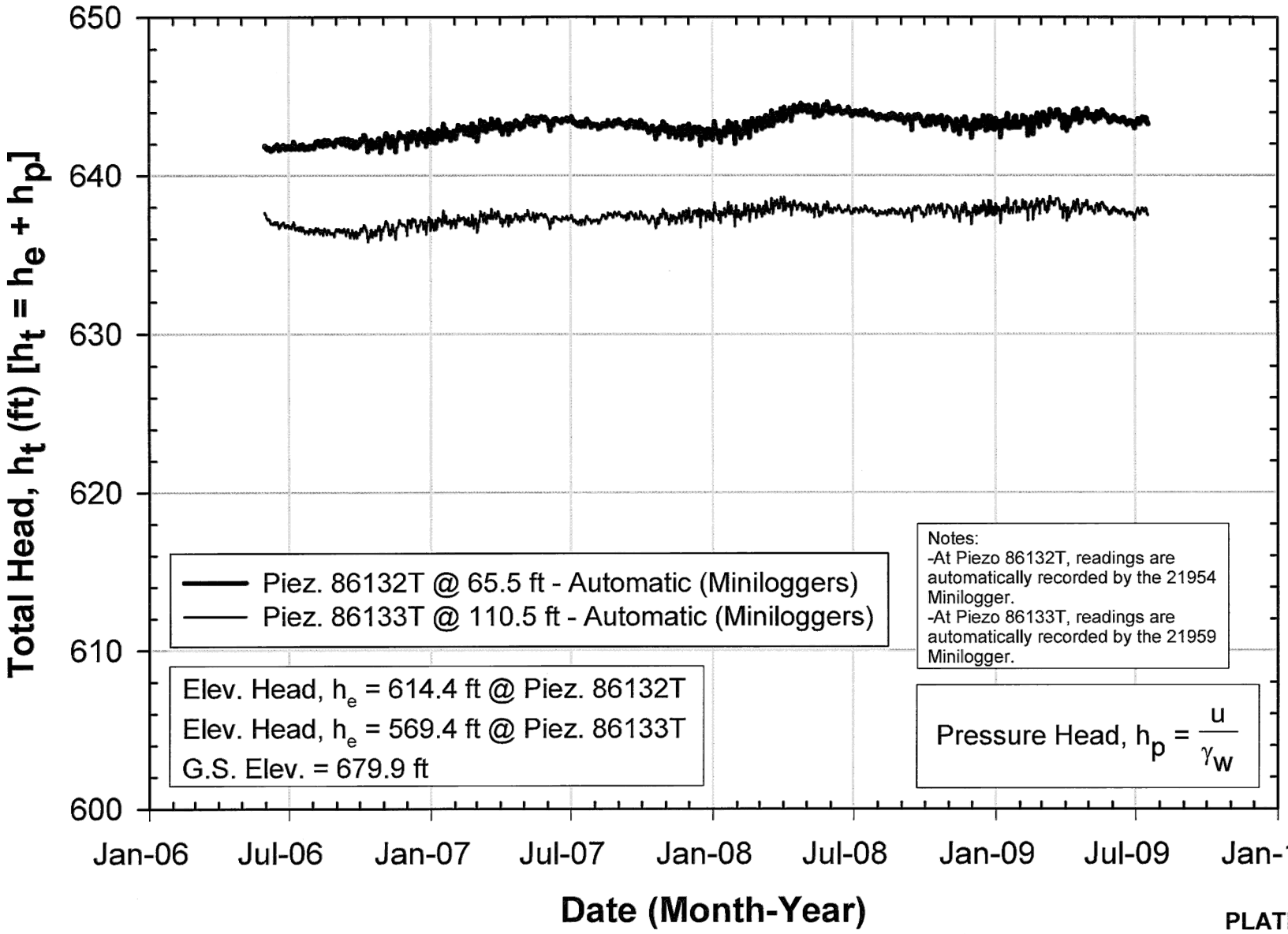


PLATE 61

B-05-11 VW Piezometer Readings

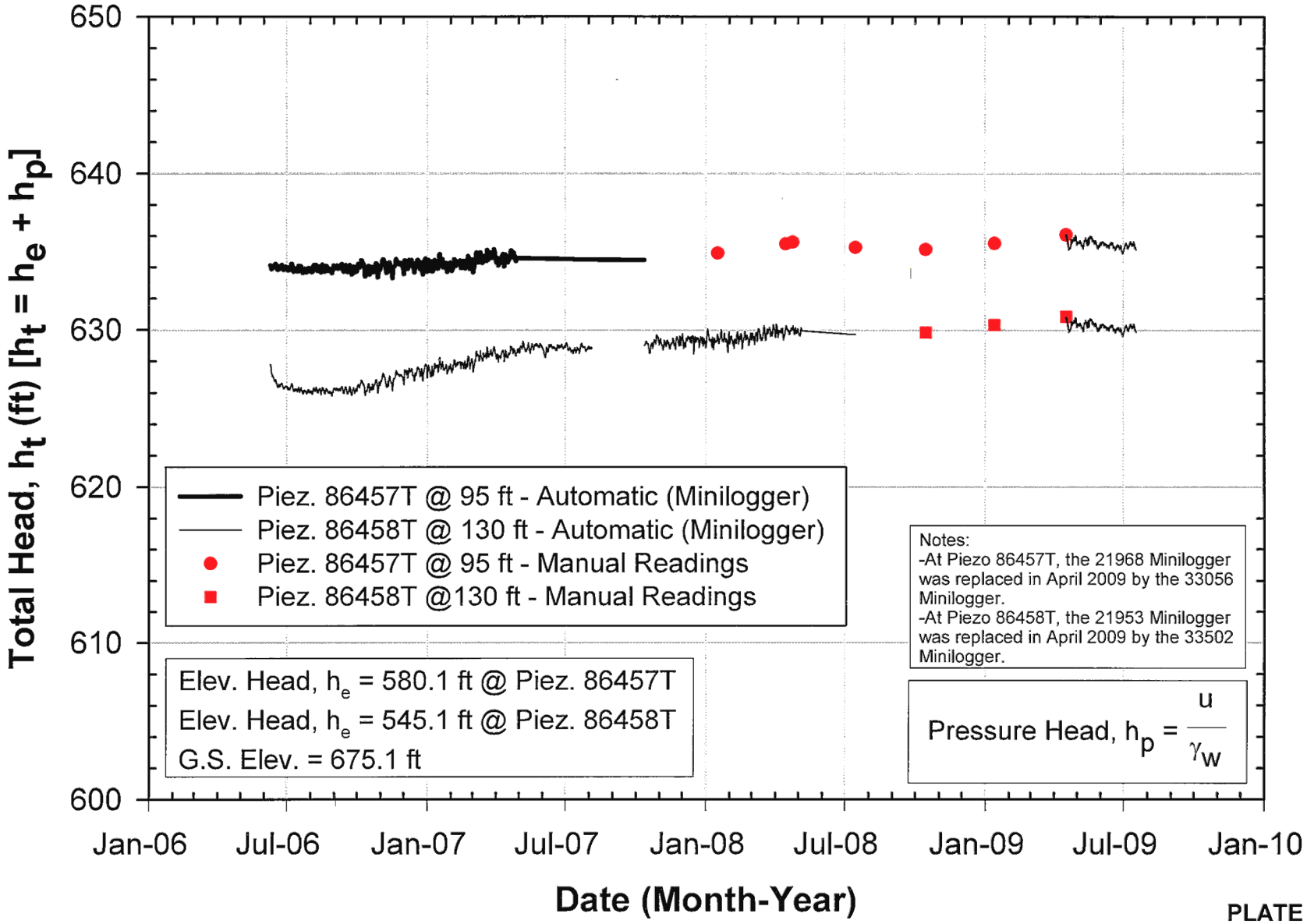


PLATE 62

B-05-12 VW Piezometer Readings

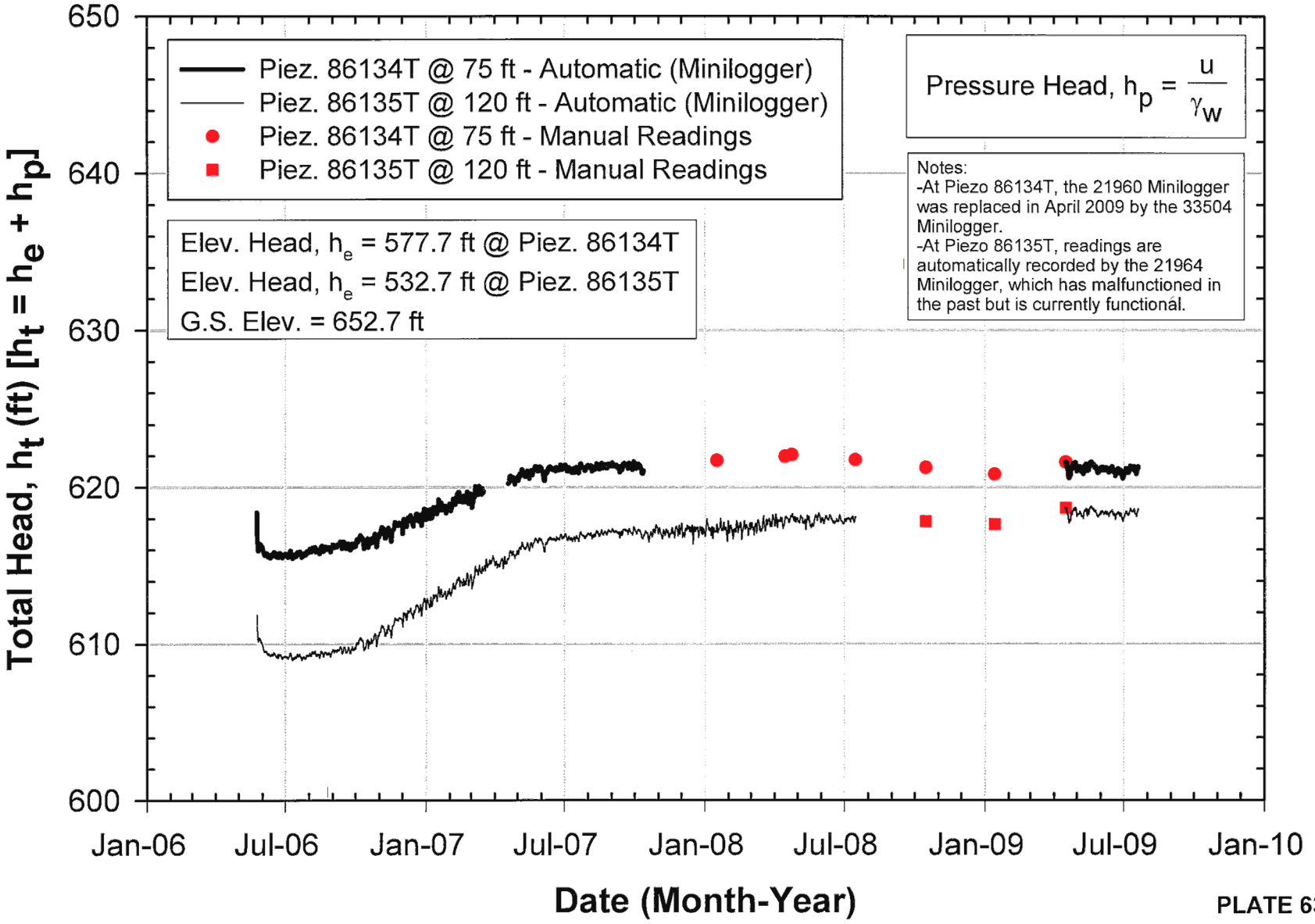


PLATE 63

B-05-13 VW Piezometer Readings

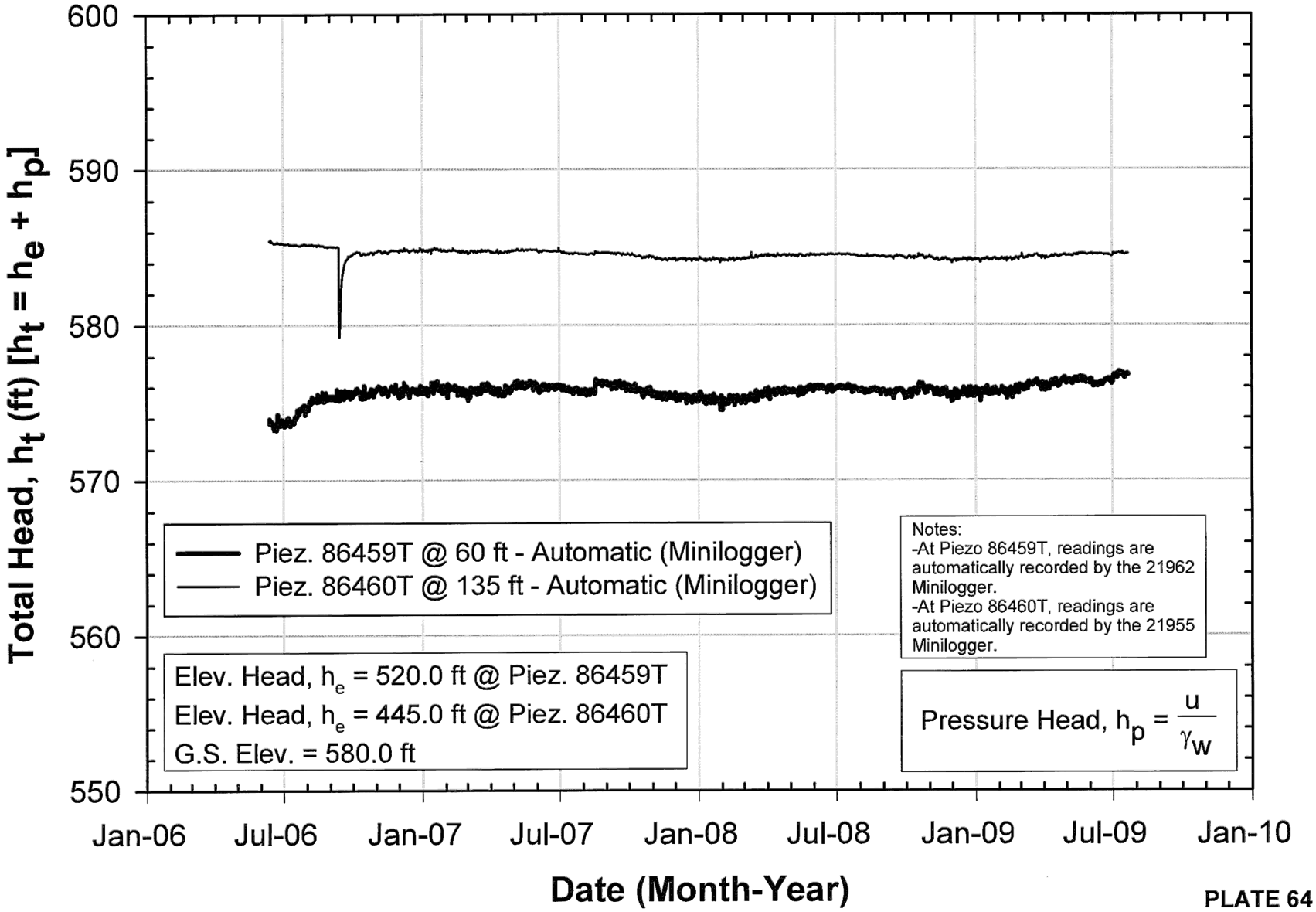


PLATE 64

CALIPERED SURFACE DISTANCE TABLE
CUY-90-15.24

Date	Left Pier Calipered Surface Distance		Center Line Calipered Surface Distance		Right Pier Calipered Surface Distance	
	Present reading	Change (in.)	Present reading	Change (in.)	Present reading	Change (in.)
10/15/02	6.333	--	Discontinued on 7/16/02		4.482	--
01/15/03	6.405	0.072			4.473	-0.009
04/17/03	6.333	-0.072			4.482	0.009
07/18/03	6.186	-0.147			4.350	-0.132
10/16/03	6.385	0.199			4.519	0.169
01/08/04	6.124	-0.261			4.594	0.075
04/14/04	6.129	0.005			4.402	-0.193
07/16/04	6.250	0.122			4.277	-0.125
10/27/04	6.375	0.125			4.467	0.190
01/12/05	6.250	-0.125			4.349	-0.118
04/14/05	6.375	0.125			4.372	0.023
07/14/05	6.313	-0.063			4.392	0.020
10/12/05	6.375	0.063			4.358	-0.034
02/01/06	6.438	0.063			4.395	0.037
04/20/06	6.500	0.063			4.430	0.035
07/14/06	6.375	-0.125			4.381	-0.049
10/18/06	6.438	0.063			4.400	0.020
01/19/07	6.500	0.062			4.506	0.106
04/18/07	6.375	-0.125			4.357	-0.150
07/11/07	6.438	0.063			4.341	-0.015
10/12/07	6.438	0.000			4.384	0.043
01/08/08	6.469	0.031			4.349	-0.036
04/14/08	6.500	0.031			4.410	0.062
07/14/08	6.500	0.000			4.410	0.000
10/15/08	6.375	-0.125			4.395	-0.016
01/13/09	6.500	0.125			4.449	0.055
04/21/09	6.500	0.000			4.449	0.000
07/17/09	6.438	-0.063			4.402	-0.047

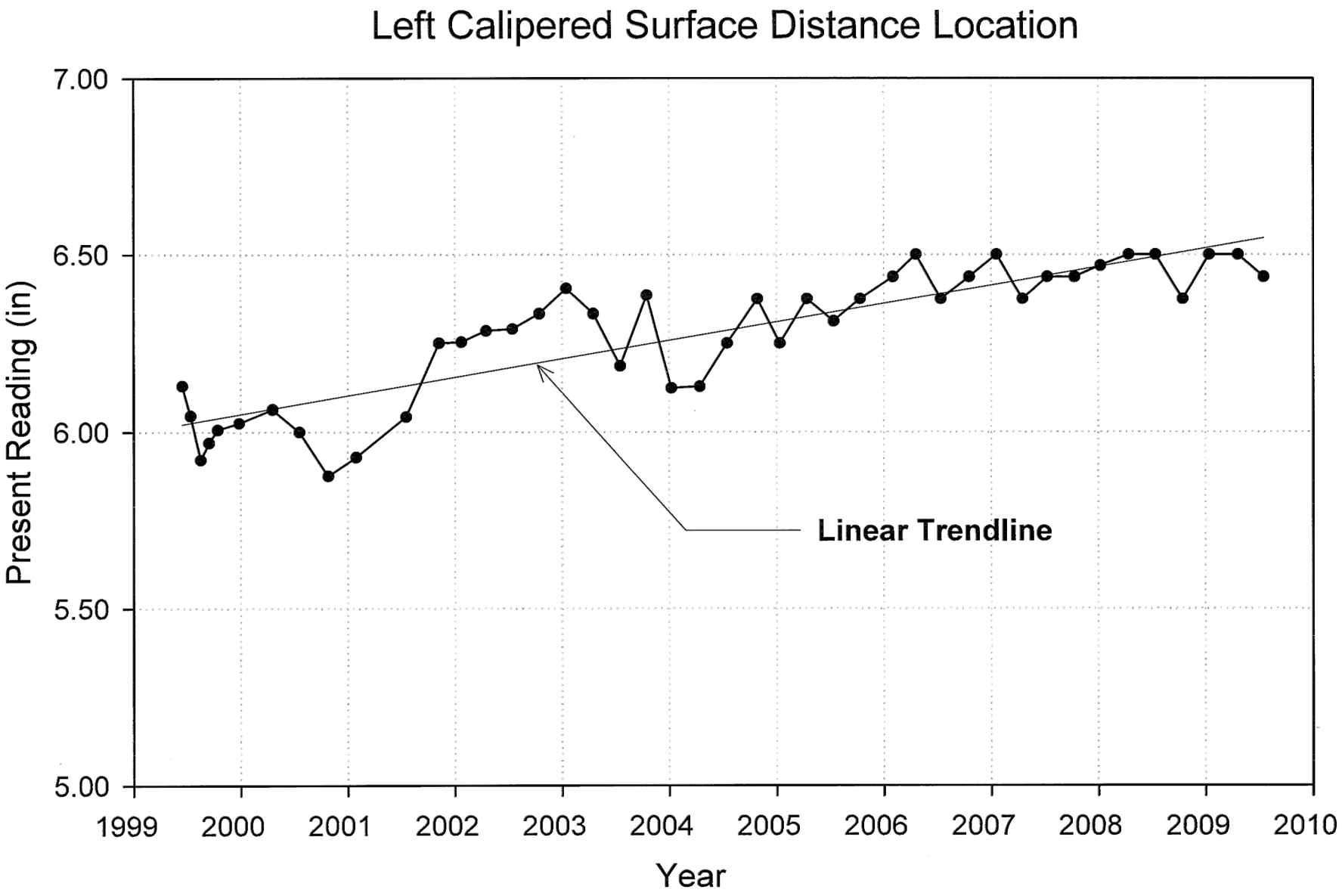

Left Calipered Surface Distance Location
7.00
6.50
6.00
5.50
5.00
Present Reading (in)
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year
Linear Trendline

PLATE 66

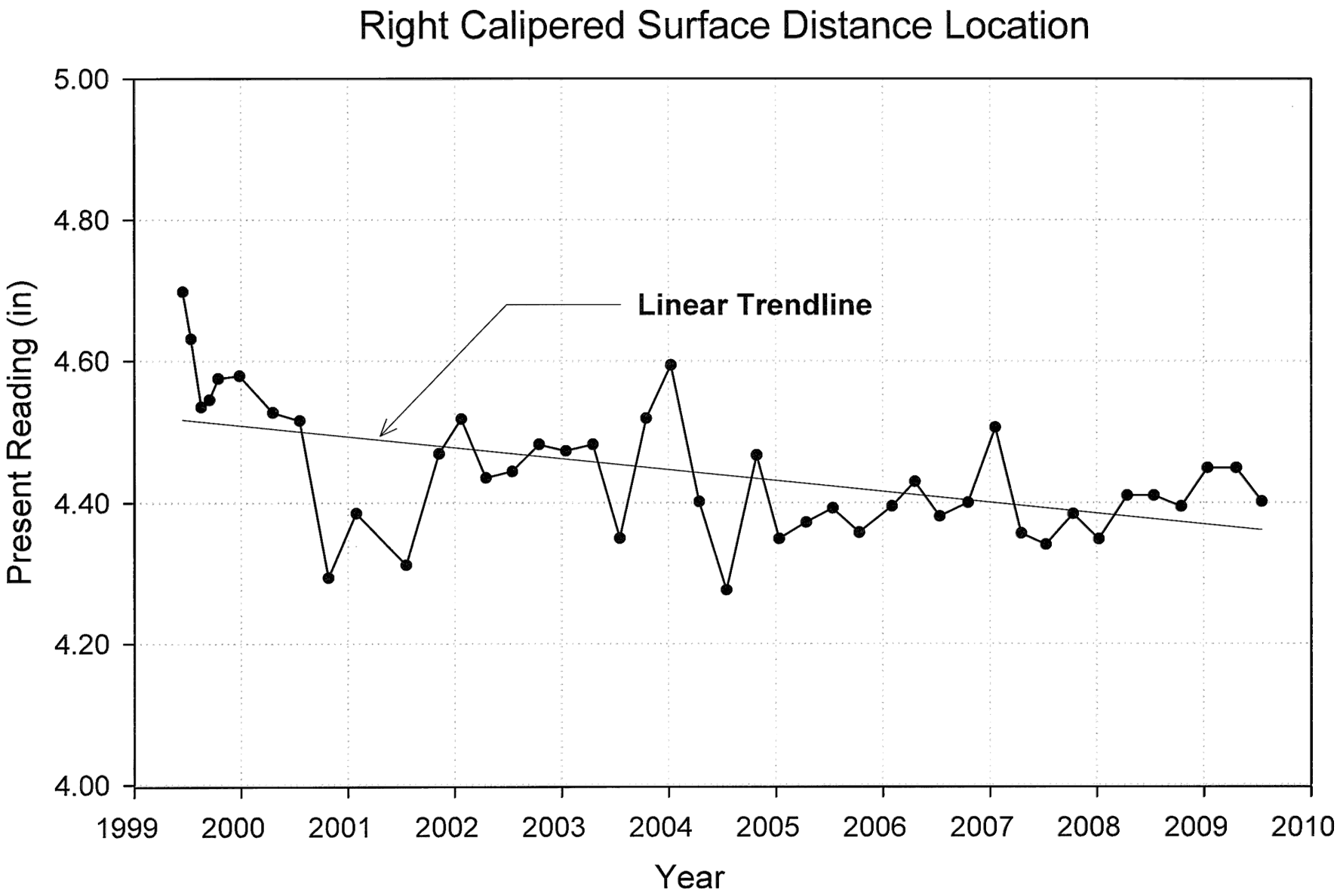

Right Calipered Surface Distance Location
5.00
4.80
4.60
4.40
4.20
4.00
Present Reading (in)
Linear Trendline
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

PLATE 67

View towards the east-northeast of the aggregate pile and east right-of-way fence. Photo taken on July 20, 2009.

PLATE 68

View towards the north of the aggregate pile and east right-of-way fence. Photo taken on July 21, 2009.

PLATE 69

View of the smaller aggregate pile towards the eastern end of the property adjacent to the east right-of-way fence. Photo taken on July 21, 2009.

PLATE 70

CUY-90-1524
106017

DECK EXPANSION JOINT OPENINGS

Finger Type Joints

Measurements are in inches.

Date	Temp (F)	West End Pier North	West End Pier South	Near Pier 2 North	Near Pier 2 South	Near Pier 4 North	Near Pier 4 South
Expansion Distance		476 feet		650 feet			
Design	60˚	3.25	3.25	3.25	3.25	3.25	3.25
06-01-70	80˚	4.00		0.00		N.A.	
09-19-75	60˚	5.25		2.00		N.A.	
05-08-78	60˚	4.75	5.50	2.00	2.00	3.25	2.50
07-30-81	75˚	5.50	5.50	2.25	2.25	3.25	2.75
06-09-83	70˚	5.00	5.00	1.50	1.50	2.75	2.25
07-31-85	73˚	5.25	4.75	1.50	1.00	2.75	2.25
10-31-88	40˚	7.75	8.38	1.50	0.75	3.81	3.38
11-01-89	50˚	7.75	7.00	1.13	0.63	3.25	3.13
10-26-90	50˚	7.75	7.25	1.00	0.50	3.00	3.00
09-30-91	55˚	7.50	7.00	0.88	0.00	3.00	3.00
10-13-92	60˚	7.25	6.81	0.63	0.00	2.50	2.50
10-01-93	50˚	7.50	7.13	0.75	0.31	2.75	2.63
09-01-94	63˚	7.25	6.38	0.31	0.00	2.88	1.88
09-08-95	60˚	7.00	6.63	0.44	0.00	2.00	1.88
09-05-96	77˚	6.50	6.63	0.38	0.00	1.25	1.00
09-19-97	75˚	6.88	7.00	0.31	0.06	1.68	1.42
09-24-98	69˚	7.63	7.00	0.00	0.00	1.88	1.75
10-14-99*	**45˚**	**6.19**	**5.50**	**2.38**	**1.88**	**3.13**	**2.75**
10-16-00	55˚	6.00	4.88	1.75	1.25	2.56	2.43
04-23-01	70˚	5.50	4.25	1.38	0.63	2.13	1.75
07-16-01	80˚	5.00	3.88	1.00	0.25	1.50	1.25

Date	Temp (F)	West End Pier		Near Pier 2		Near Pier 4	
		North	South	North	South	North	South
10-15-01	50˚	6.63	5.63	1.63	1.06	3.25	2.75
1-15-02	30˚	6.88	6.25	2.13	1.50	3.88	3.50
4-15-02	61˚	6.00	5.25	1.38	0.88	2.50	2.38
7-15-02	76˚	5.13	4.13	1.13	0.50	1.75	1.50
10-17-02	48˚	7.00	6.38	1.75	1.25	3.25	2.88
11-1-02	35˚	7.25	6.13	1.88	1.38	3.63	3.38
1-15-03	7˚	8.13	6.63	2.38	1.88	5.00	4.75
4-15-03	67˚	5.63	4.63	1.25	0.63	2.25	2.00
7-15-03	74˚	5.38	4.38	1.00	0.50	2.00	1.63
10-16-03	46˚	7.00	5.75	1.50	1.13	3.25	3.13
1-15-04	11˚	8.00	6.75	2.00	1.38	4.63	4.00
4-15-04	41˚	6.88	5.75	1.38	0.88	3.50	3.25
7-15-04	67˚	5.63	4.75	1.00	0.50	2.13	1.75
10-15-04	50˚	6.38	5.50	1.25	0.75	3.00	2.75
1-15-05	12˚	7.75	7.00	2.00	1.38	4.63	4.25
4-16-05	47˚	6.50	5.63	1.25	0.75	3.25	2.88
7-16-05	74˚	5.50	4.50	0.75	0.375	1.75	1.63
10-14-05	51˚	6.25	5.50	1.13	0.63	2.81	2.56
1-16-06	26˚	7.63	6.38	1.75	1.13	4.13	3.75
4-14-06	65˚	5.75	4.88	0.75	0.50	2.25	2.00
7-14-06	78˚	5.00	4.00	0.63	0.19	1.63	1.25
10-16-06	50˚	6.50	5.88	1.00	0.75	3.25	3.00
1-15-07	41˚	7.00	6.13	1.13	0.88	3.56	3.38
4-16-07	34˚	7.25	6.38	1.38	0.88	3.75	3.50
7-16-07	70˚	5.38	4.75	0.88	0.25	2.13	1.63
10-15-07	56˚	6.38	5.50	1.13	0.75	2.88	2.69

Date	Temp (F)	West End Pier North	West End Pier South	Near Pier 2 North	Near Pier 2 South	Near Pier 4 North	Near Pier 4 South
1-15-08	19˚	7.63	6.63	1.63	1.00	4.13	4.00
4-15-08	41˚	7.13	6.25	1.44	0.88	3.75	3.19
7-16-08	83˚	4.75	4.00	0.50	0.00	1.13	0.81
10-16-08	56˚	6.25	5.56	1.13	0.69	2.75	2.25
1-15-09	7˚	8.31	7.69	2.00	1.13	5.00	4.94
4-15-09	46˚	6.38	5.69	1.31	0.81	3.00	2.69
7-15-09*	**77˚**	**2.50**	**1.75**	**2.88**	**2.44**	**1.88**	**1.50**

N.A. - No measurements available

* Truss Span 1 Relocated

EXPANSION OPENINGS AT SPAN 2 FLOORBEAM 12

Measurements are in inches

Date	Temp (F)	North Lower Chord Expansion Opening	Deck Expansion Joint Near Pier 2		South Lower Chord Expansion Opening
			North	South	
04-23-01	70°	0.54	1.38	0.63	0.04
07-16-01	80°	0.11	1.00	0.25	N.A.
10-15-01	50°	0.48	1.00	0.25	0.10
1-15-02	30°	1.23	2.13	1.50	0.67
4-15-02	61°	0.48	1.38	0.88	0.17
7-15-02	76°	0.17	1.13	0.50	0.04
10-15-02	41°	0.36	1.75	1.25	0.23
11-1-02	35°	N.A.	1.88	1.38	N.A.
1-15-03	7°	1.17	2.38	1.88	0.73
4-15-03	67°	0.30	1.25	0.63	0.12
7-15-03	74°	0.18	1.00	0.50	0.12
10-16-03	46°	0.30	1.50	1.13	0.12
1-15-04	11°	0.90	2.00	1.38	0.48
4-15-04	41°	0.42	1.38	0.88	0.06
7-15-04	67°	0.06	1.00	0.50	0.00
10-15-04	50°	0.17	1.25	0.75	0.04
1-15-05	12°	0.66	2.00	1.38	0.30
4-16-05	47°	0.30	1.25	0.75	0.00
7-16-05	74°	0.00	0.75	0.375	0.00
10-14-05	51°	0.18	1.13	0.63	0.18
1-16-06	26°	0.66	1.75	1.13	0.24
4-14-06	65°	0.18	0.75	0.50	0.00
7-14-06	78°	0.00	0.63	0.19	0.00

Date	Temp (F)	North Lower Chord Expansion Opening	Deck Expansion Joint Near Pier 2		South Lower Chord Expansion Opening
			North	South	
10-16-06	50°	0.30	1.00	0.75	0.00
1-15-07	41°	0.30	1.13	0.88	0.12
4-16-07	34°	0.36	1.38	0.88	0.12
7-16-07	70°	0.06	0.88	0.25	0.00
10-15-07	56°	0.12	1.13	0.75	0.00
1-15-08	19°	0.42	1.63	1.00	0.18
4-15-08	41°	0.36	1.44	0.88	0.06
7-16-08	83°	0.00	0.50	0.00	0.00
10-16-08	56°	0.12	1.13	0.69	0.12
12-05-08	23°	0.36	1.13	0.69	0.18
1-15-09	7°	0.73	2.00	1.13	0.29
4-15-09	46°	0.60	1.31	0.81	0.18
7-15-09*	77°	2.11	2.88	2.44	1.85

N.A. – Not Available

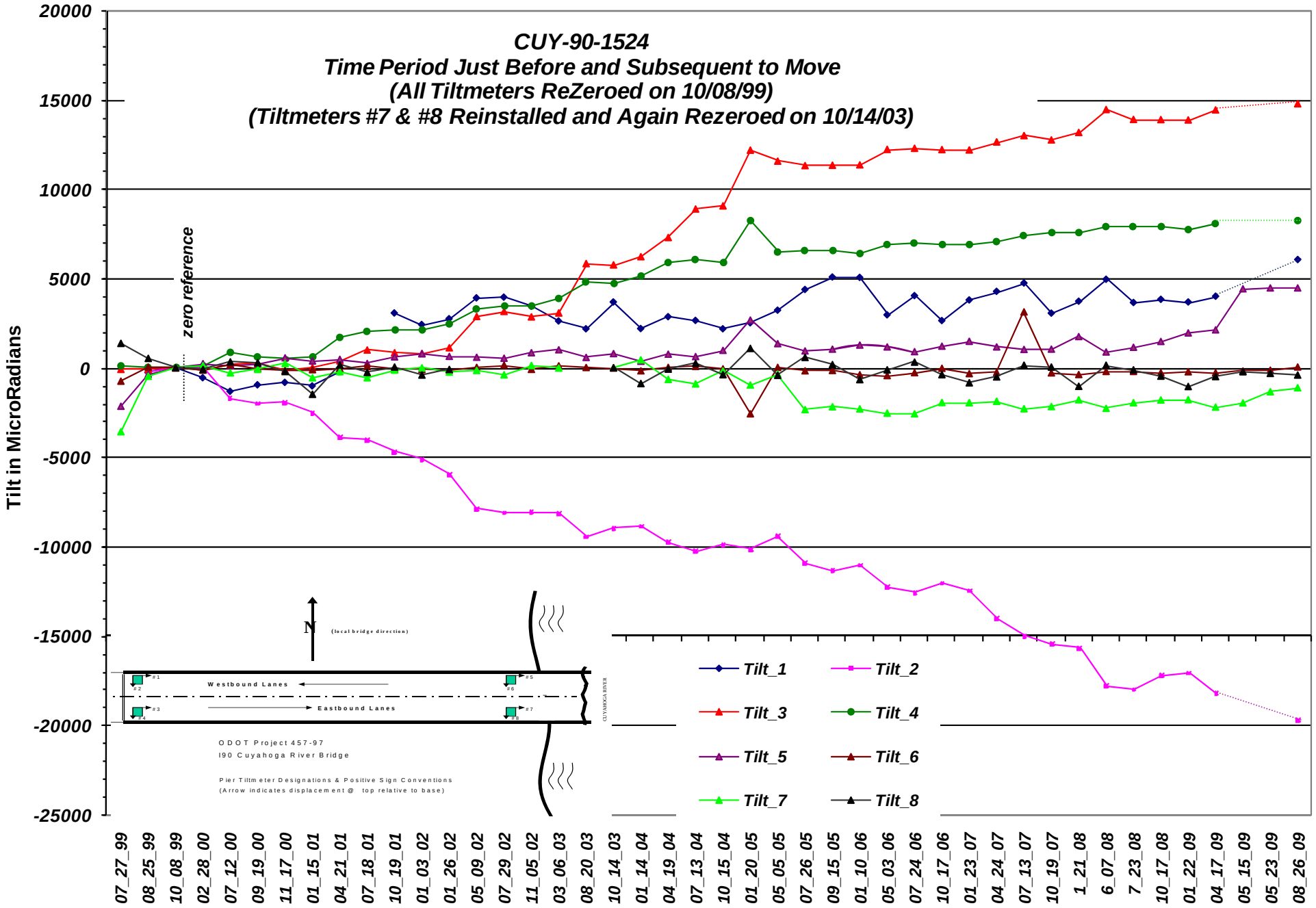
* Truss Span 1 Relocated

Richland Engineering Limited 10607

From: "Arthur Huckelbridge" <aah4@case.edu>
To: "'Richland Engineering Limited'" <reltd@r-e-l.com>
Sent: Wednesday, August 26, 2009 11:19 AM
Attach: tilts Aug 26.docx
Subject: RE: CUY-90-1524 Tiltmeter Monitoring
Dean:

I am a little in arears with tiltmeter readings – my apologies. We got readings this morning, which are attached. I also added in readings for tiltmeters 5 through 8 from May 15 (8 days prior to opening the expansion joint) and May 23 (immediately after opening the expansion joint) for comparison, as recorded by the datalogger we installed temporarily. Tiltmeters 5 and 7 indicate some movement toward the river (5 more so than 7) when compared to the April readings. Most of the significant movement for tiltmeter 5, however, occurred prior to opening the expansion joint. There is a possibility that tiltmeter 5 got "bumped" during construction activities leading up to the expansion joint opening, or possibly the noth pierleg at pier 1 actually was "unloaded" by those construction activities. Tiltmeters 1 and 2 at the northwest abutment indicate some continued drift northward and eastward, which could at least partially be electrical in nature, as mentioned in prior reports. Let me know if you have questions.

Art


CUY-90-1524
Time Period Just Before and Subsequent to Move
(All Tiltmeters ReZeroed on 10/08/99)
(Tiltmeters #7 & #8 Reinstalled and Again Rezeroed on 10/14/03)
Tilt in MicroRadians
zero reference
20000
15000
10000
5000
0
-5000
-10000
-15000
-20000
-25000
07_27_99
08_25_99
10_08_99
02_28_00
07_12_00
09_19_00
11_17_00
01_15_01
04_21_01
07_18_01
10_19_01
01_03_02
01_26_02
05_09_02
07_29_02
11_05_02
03_06_03
08_20_03
10_14_03
01_14_04
04_19_04
07_13_04
10_15_04
01_20_05
05_05_05
07_26_05
09_15_05
01_10_06
05_03_06
07_24_06
10_17_06
01_23_07
04_24_07
07_13_07
10_19_07
1_21_08
6_07_08
7_23_08
10_17_08
01_22_09
04_17_09
05_15_09
05_23_09
08_26_09
Tilt_1
Tilt_2
Tilt_3
Tilt_4
Tilt_5
Tilt_6
Tilt_7
Tilt_8
N
(local bridge direction)
Westbound Lanes
Eastbound Lanes
CUYAHOGA RIVER
ODOT Project 457-97
I90 Cuyahoga River Bridge
Pier Tiltmeter Designations & Positive Sign Conventions
(Arrow indicates displacement @ top relative to base)

106017

Robert Y. Liang, Ph.D., P.E
8441 Timber Tr.
Brecksville, Ohio 44141

Cell Phone: (440) 725-7425
e-mail: RYLIANG@AOL.COM

August 20, 2009

Mr. Dean Palmer, P.E.
Richland Engineering, Ltd.
29 North Park St.
Mansfield, OH 44902

Ref: CUY-90-14.52, PID No. 77332

Dear Mr. Palmer:

The monitoring data for the slope stabilization subsurface structures at the referenced project site for the last three months (April May, and June of 2009) are enclosed.

Based on review of the data obtained during the three-month monitoring period, it appears that the strain readings and the forces and moments on the foundation structures have been fairly steady in the last three months. Inclinometer readings did not show significant drilled shafts movements.

Please call me at (440) 725-7425, if you have any question. Thank you.

Sincerely,

Robert Liang

RECEIVED
AUG 2 4 2009
RICHLAND ENGINEERING LIMITED

CC: DAP w/enc.

Table 1. Numerical reading of anchor load as a function of time for anchors #1, #8, #9 and #17

Date	Anchor # 1 Load, kips	Anchor # 8 Load, kips	Anchor # 9 Load, kips	Anchor # 17 Load, kips	Comment
4/7/1999		560			
4/8/1999	489			499	Anchor Lock off
4/14/1999	460	473	596 (Lock off)	461	
5/7/1999	452	473	572	445	End of construction
7/1/1999	446	468	564	439	
10/1/1999	441	467	560	440	
1/1/2000	439	461	555	424	
4/1/2000	432	453	546	414	
7/1/2000	431	451	521	415	
10/1/2000	431	451	519	416	
1/1/2001	430	455	517	400	
4/1/2001	421	443	513	397	
7/1/2001	422	443	510	399	
10/1/2001	425	445	512	403	
1/1/2002	424	444	511	398	
4/1/2002	421	440	508	386	
7/1/2002	419	439	506	391	
10/1/2002	423	442	508	396	
1/1/2003	423	435	508	389	
4/15/2003	416	427	501	380	
8/7/2003	416	428	503	384	
10/7/2003	418	429	504	387	
12/31/2003	417	426	503	378	
4/13/2004	408	418	494	370	
7/13/2004	409	419	494	374	
10/8/2004	411	422	496	377	
1/7/2005	411	421	495	374	
4/8/2005	407	414	485	366	
7/18/2005	407	415	485	370	
11/12/2005	410	419	489	374	
1/10/2006	409	417	487	369	
4/9/2006	399	411	487	365	
7/19/2006	399	412	487	368	
10/18/2006	407.3	414.8	489.6	371.7	
1/18/2007	405	412	487	366	
4/19/2007	401	406	501	361	
7/9/2007	401	408	502	365	
10/20/2007	404	411	506	369	
1/7/2008	403	410	504	364	
5/13/2008	397	403	497	359	
7/29/2008	398	403	500	363	
10/30/2008	401	407	502	366	
1/12/2009	401	407	502	363	
4/24/2009	393	400	494	357	
8/3/2009	394	401	496	362	

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	-47.1	68.5	551.7	681.8	313.73	10.70	616.75	252.30	375.15	83.06	-40.28	-2.75
	7/15/1999	-70.1	53.8	538.8	666.8	297.33	-8.15	602.80	234.35	360.30	78.72	-40.60	-2.82
	8/15/1999	10.7	114.3	613.7	728.1	366.70	62.50	670.90	312.20	421.20	97.09	-40.43	-2.44
	8/31/1999	12.0	114.3	617.3	732.8	369.10	63.15	675.05	314.65	423.55	97.73	-40.67	-2.44
	9/15/1999	13.1	113.5	619.7	737.5	370.95	63.30	678.60	316.40	425.50	98.22	-40.89	-2.44
	9/30/1999	29.6	122.3	634.4	753.4	384.93	75.95	693.90	332.00	437.85	101.92	-41.07	-2.37
	10/15/1999	34.7	123.9	637.8	757.9	388.58	79.30	697.85	336.25	440.90	102.88	-41.11	-2.34
	10/31/1999	39.8	127.2	646.6	762	393.90	83.50	704.30	343.20	444.60	104.29	-41.26	-2.27
	11/15/1999	62.3	139.3	662.9	780.1	411.15	100.80	721.50	362.60	459.70	108.86	-41.25	-2.18
	11/30/1999	73.7	146.3	670.6	788.6	419.80	110.00	729.60	372.15	467.45	111.15	-41.18	-2.13
	12/15/1999	72.8	143.6	668.9	789.7	418.75	108.20	729.30	370.85	466.65	110.87	-41.28	-2.15
	12/31/1999	88.8	152.1	680.1	802.5	430.88	120.45	741.30	384.45	477.30	114.08	-41.26	-2.08
	3/31/2000	95.3	158.7	682.5	825.2	440.43	127.00	753.85	388.90	491.95	116.61	-41.66	-2.31
	6/30/2000	60.2	138.2	662.7	804.5	416.40	99.20	733.60	361.45	471.35	110.25	-42.16	-2.46
	9/30/2000	50.1	142.5	668.8	795.7	414.28	96.30	732.25	359.45	469.10	109.69	-42.26	-2.46
	1/13/2001	109.5	179.9	712.3	845.5	461.80	144.70	778.90	410.90	512.70	122.27	-42.15	-2.28
	4/20/2001	126.8	283.2	715.3	881.9	501.80	205.00	798.60	421.05	582.55	132.86	-39.45	-3.62
	7/16/2001	68.3	149.8	674.3	837.1	432.38	109.05	755.70	371.30	493.45	114.48	-42.98	-2.74
	10/9/2001	71.4	157.1	685.5	840.8	438.70	114.25	763.15	378.45	498.95	116.15	-43.12	-2.70
	1/9/2002	102.7	177.8	713	872	466.38	140.25	792.50	407.85	524.90	123.48	-43.35	-2.62
	4/12/2002	125.5	192.8	738.6	904.9	490.45	159.15	821.75	432.05	548.85	129.86	-44.04	-2.62
	7/18/2002	62.3	151.8	706.334	859.6	445.01	107.05	782.97	384.32	505.70	117.82	-44.92	-2.72
	10/8/2002	43.7	151.1	711.3	846.7	438.20	97.40	779.00	377.50	498.90	116.02	-45.30	-2.72
	1/8/2003	84.7	180.5	748.5	891.8	476.38	132.60	820.15	416.60	536.15	126.13	-45.69	-2.68
	4/15/2003	96.1	191.9	739.9	989.3	504.30	144.00	864.60	418.00	590.60	133.52	-47.89	-3.87
1	7/1/2003	57.4	168	713	959	474.35	112.70	836.00	385.20	563.50	125.59	-48.07	-3.99
	10/7/2003	42.1	166.8	714	946.6	467.38	104.45	830.30	378.05	556.70	123.75	-48.24	-4.00
	12/31/2003	80	197.9	753.9	985.1	504.23	138.95	869.50	416.95	591.50	133.50	-48.55	-3.91
	4/13/2004	92	208.9	760.4	1006.6	516.98	150.45	883.50	426.20	607.75	136.88	-48.72	-4.07
	7/13/2004	14.6	163.9	707.3	954.4	460.05	89.25	830.85	360.95	559.15	121.81	-49.29	-4.44
	10/8/2004	-8.6	233.4	704.6	941	467.60	112.40	822.80	348.00	587.20	123.81	-47.21	-5.36
	1/7/2005	19.5	190.4	746.5	982.5	484.73	104.95	864.50	383.00	586.45	128.34	-50.48	-4.56
	4/8/2005	3.4	397.6	751.6	1003.4	539.00	200.50	877.50	377.50	700.50	142.71	-44.99	-7.24
	7/18/2005	3.1	164.3	709.7	969.6	461.68	83.70	839.65	356.40	566.95	122.24	-50.24	-4.72
	8/26/2005	3.1	157.5	702.5	956.3	454.85	80.30	829.40	352.80	556.90	120.43	-49.78	-4.57
	10/11/2005	3.1	164.2	712.6	960.1	460.00	83.65	836.35	357.85	562.15	121.79	-50.02	-4.58
	1/10/2006	3.1	191.9	742.5	997	483.63	97.50	869.75	372.80	594.45	128.05	-51.32	-4.97
	4/9/2006	3.5	205.3	750.7	1018.8	494.58	104.40	884.75	377.10	612.05	130.95	-51.86	-5.26
	7/19/2006	3.5	166.6	703.7	975.5	462.33	85.05	839.60	353.60	571.05	122.41	-50.15	-4.87
	10/18/2006	3.5	170.2	709	967.5	462.55	86.85	838.25	356.25	568.85	122.47	-49.94	-4.76
	1/18/2007	3.5	209.1	748.7	1013.1	493.60	106.30	880.90	376.10	611.10	130.69	-51.48	-5.26
	4/19/2007	3.5	216.6	743.7	1021.2	496.25	110.05	882.45	373.60	618.90	131.39	-51.33	-5.50
	7/11/2007	3.5	169.6	700.9	981.6	463.90	86.55	841.25	352.20	575.60	122.83	-50.16	-5.00
	10/20/2007	3.5	163.4	696	963.7	456.65	83.45	829.85	349.75	563.55	120.91	-49.60	-4.79
	1/7/2008	3.5	193.1	730.4	1002.9	482.48	98.30	866.65	366.95	598.00	127.74	-51.06	-5.18
	5/13/2008	3.5	202.2	733	1019.1	489.45	102.85	876.05	368.25	610.65	129.59	-51.39	-5.43
	7/29/2008	3.5	171.2	699.7	981.8	464.05	87.35	840.75	351.60	576.50	122.87	-50.07	-5.04
	10/30/2008	3.5	185.2	717.8	985	472.88	94.35	851.40	360.65	585.10	125.20	-50.31	-5.03
	1/12/2009	3.5	213.8	745.7	1020.6	495.90	108.65	883.15	374.60	617.20	131.30	-51.47	-5.43
	4/24/2009	3.5	203.1	729.9	1023.9	490.10	103.30	876.90	366.70	613.50	129.76	-51.41	-5.53
	8/3/2009	3.5	174	700.6	983.2	465.33	88.75	841.90	352.05	578.60	123.20	-50.05	-5.08

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	374.9	6	549.6	471.8	350.58	190.45	510.70	462.25	238.90	92.82	-21.28	5.00
	7/15/1999	368.6	-3.6	544.2	467.3	344.13	182.50	505.75	456.40	231.85	91.11	-21.48	5.03
	8/15/1999	373.7	0.2	569.4	485.2	357.13	186.95	527.30	471.55	242.70	94.56	-22.62	5.13
	8/31/1999	368.4	-4.7	567	486.2	354.23	181.85	526.60	467.70	240.75	93.79	-22.91	5.08
	9/15/1999	365.9	-9.2	565.3	485.1	351.78	178.35	525.20	465.60	237.95	93.14	-23.05	5.10
	9/30/1999	364.6	-11.7	570.1	487.6	352.65	176.45	528.85	467.35	237.95	93.37	-23.42	5.14
	10/15/1999	361.7	-14.8	569.9	487.4	351.05	173.45	528.65	465.80	236.30	92.95	-23.61	5.14
	10/31/1999	362.8	-13.5	575.6	493.1	354.50	174.65	534.35	469.20	239.80	93.86	-23.91	5.14
	11/15/1999	365.0	-11.5	581.4	498	358.23	176.75	539.70	473.20	243.25	94.85	-24.12	5.15
	11/30/1999	365.6	-11.8	583.7	500.1	359.40	176.90	541.90	474.65	244.15	95.16	-24.26	5.16
	12/15/1999	368.0	-9.2	589.7	504.2	363.18	179.40	546.95	478.85	247.50	96.16	-24.43	5.18
	12/31/1999	369.0	-8	592.9	506.6	365.13	180.50	549.75	480.95	249.30	96.67	-24.54	5.19
	3/31/2000	379.6	7.3	617	524.1	382.00	193.45	570.55	498.30	265.70	101.14	-25.06	5.21
	6/30/2000	376.1	4.4	608.9	519.1	377.13	190.25	564.00	492.50	261.75	99.85	-24.84	5.17
	9/30/2000	360.7	-12.3	588.3	503.5	360.05	174.20	545.90	474.50	245.60	95.33	-24.70	5.13
	1/13/2001	372.1	2.2	618.1	526.1	379.63	187.15	572.10	495.10	264.15	100.51	-25.58	5.17
	4/20/2001	387.6	21	645.8	549.2	400.90	204.30	597.50	516.70	285.10	106.15	-26.13	5.19
	7/16/2001	374.6	6.5	621.5	532.9	383.88	190.55	577.20	498.05	269.70	101.64	-25.70	5.12
	10/9/2001	360.9	-9.4	598.9	515.8	366.55	175.75	557.35	479.90	253.20	97.05	-25.36	5.08
	1/9/2002	363.5	-2.5	611.5	524.5	374.25	180.50	568.00	487.50	261.00	99.09	-25.75	5.07
	4/12/2002	381.7	16.9	642.7	550.5	397.95	199.30	596.60	512.20	283.70	105.37	-26.40	5.12
	7/18/2002	375	10.5	629	544.7	389.80	192.75	586.85	502.00	277.60	103.21	-26.19	5.03
	10/8/2002	357.7	-9.6	599.2	523	367.58	174.05	561.10	478.45	256.70	97.32	-25.72	4.97
	1/8/2003	367.3	6.5	626.7	542.7	385.80	186.90	584.70	497.00	274.60	102.15	-26.44	4.98
	4/15/2003	385.9	27.3	655.3	566.2	408.68	206.60	610.75	520.60	296.75	108.20	-26.86	5.01
12	7/1/2003	384.7	26.3	649.2	565.6	406.45	205.50	607.40	516.95	295.95	107.62	-26.71	4.95
	10/7/2003	360.6	3.5	613	539.7	379.20	182.05	576.35	486.80	271.60	100.40	-26.20	4.82
	12/31/2003	372	19.4	636	558.3	396.43	195.70	597.15	504.00	288.85	104.96	-26.68	4.82
	4/13/2004	389.4	39.8	665.5	583.1	419.45	214.60	624.30	527.45	311.45	111.06	-27.23	4.84
	7/13/2004	379.5	27.7	643.3	571.1	405.40	203.60	607.20	511.40	299.40	107.34	-26.82	4.75
	10/8/2004	361.6	10.3	615.2	550.9	384.50	185.95	583.05	488.40	280.60	101.80	-26.39	4.66
	1/7/2005	367.5	16.1	630.6	561.5	393.93	191.80	596.05	499.05	288.80	104.30	-26.87	4.71
	4/8/2005	388.2	35.6	662.3	587.2	418.33	211.90	624.75	525.25	311.40	110.76	-27.44	4.79
	7/18/2005	382.6	26.3	647.7	580.1	409.18	204.45	613.90	515.15	303.20	108.34	-27.21	4.75
	8/26/2005	373.6	15.7	629.8	566.8	396.48	194.65	598.30	501.70	291.25	104.97	-26.83	4.71
	10/11/2005	365.9	6.1	617.8	557.9	386.93	186.00	587.85	491.85	282.00	102.45	-26.71	4.70
	1/10/2006	376.2	17.5	639	572.2	401.23	196.85	605.60	507.60	294.85	106.23	-27.16	4.77
	4/9/2006	393.8	32.7	665.7	594	421.55	213.25	629.85	529.75	313.35	111.61	-27.69	4.85
	7/19/2006	384.2	20.3	646.2	582.7	408.35	202.25	614.45	515.20	301.50	108.12	-27.39	4.79
	10/18/2006	365	-2	614.4	558.2	383.90	181.50	586.30	489.70	278.10	101.65	-26.90	4.74
	1/18/2007	376	9.6	635.9	573.9	398.85	192.80	604.90	505.95	291.75	105.60	-27.39	4.80
	4/19/2007	390.7	24.1	659.3	592.7	416.70	207.40	626.00	525.00	308.40	110.33	-27.82	4.85
	7/11/2007	384.1	15	644.6	584.6	407.08	199.55	614.60	514.35	299.80	107.78	-27.58	4.81
	10/20/2007	363.7	-9.6	611.5	560.6	381.55	177.05	586.05	487.60	275.50	101.02	-27.18	4.75
	1/7/2008	371.2	-2.9	625.1	569.7	390.78	184.15	597.40	498.15	283.40	103.47	-27.46	4.81
	5/13/2008	390.8	11.5	650.8	592.6	411.43	201.15	621.70	520.80	302.05	108.93	-27.95	4.90
	7/29/2008	379.9	-2.5	629.3	579.9	396.65	188.70	604.60	504.60	288.70	105.02	-27.64	4.84
	10/30/2008	365	-20.3	605.3	562.2	378.05	172.35	583.75	485.15	270.95	100.10	-27.34	4.80
	1/12/2009	375.3	-11.4	624.8	575	390.93	181.95	599.90	500.05	281.80	103.51	-27.78	4.89
	4/24/2009	393.1	4.8	648.3	595	410.30	198.95	621.65	520.70	299.90	108.64	-28.09	4.95
	8/3/2009	384.8	-4	631.4	586.3	399.63	190.40	608.85	508.10	291.15	105.81	-27.81	4.86

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	306.3	72.2	490.8	675.2	386.13	189.25	583.00	398.55	373.70	102.23	-26.17	0.56
	7/15/1999	288.0	53.1	484.2	670.6	373.98	170.55	577.40	386.10	361.85	99.02	-27.04	0.54
	8/15/1999	280.9	61.8	506.3	693.7	385.68	171.35	600.00	393.60	377.75	102.12	-28.49	0.36
	8/31/1999	270.4	52.1	503.1	691.4	379.25	161.25	597.25	386.75	371.75	100.41	-28.98	0.34
	9/15/1999	261.3	43.9	501.2	689.9	374.08	152.60	595.55	381.25	366.90	99.04	-29.44	0.32
	9/30/1999	257.1	40.7	503.1	690.7	372.90	148.90	596.90	380.10	365.70	98.73	-29.77	0.32
	10/15/1999	250.1	33.8	501.2	691	369.03	141.95	596.10	375.65	362.40	97.71	-30.18	0.30
	10/31/1999	251.4	38	507.6	697.6	373.65	144.70	602.60	379.50	367.80	98.93	-30.43	0.26
	11/15/1999	253.9	41.6	512.1	701.9	377.38	147.75	607.00	383.00	371.75	99.92	-30.52	0.25
	11/30/1999	253.5	41.2	513.6	704.4	378.18	147.35	609.00	383.55	372.80	100.13	-30.68	0.24
	12/15/1999	255.8	46.7	519.1	709.3	382.73	151.25	614.20	387.45	378.00	101.33	-30.77	0.21
	12/31/1999	256.7	48.9	522.3	712.4	385.08	152.80	617.35	389.50	380.65	101.96	-30.87	0.20
	3/31/2000	267.5	64.6	542.8	734.2	402.28	166.05	638.50	405.15	399.40	106.51	-31.40	0.13
	6/30/2000	258.9	46.4	531.2	726.1	390.65	152.65	628.65	395.05	386.25	103.43	-31.63	0.20
	9/30/2000	237.1	10.1	504.9	705.9	364.50	123.60	605.40	371.00	358.00	96.51	-32.02	0.29
	1/13/2001	254.0	40.9	535.1	734.6	391.15	147.45	634.85	394.55	387.75	103.56	-32.39	0.15
	4/20/2001	275.4	72.6	561.4	763.7	418.28	174.00	662.55	418.40	418.15	110.75	-32.47	0.01
	7/16/2001	255.3	37.7	534.8	740.9	392.18	146.50	637.85	395.05	389.30	103.84	-32.65	0.13
	10/9/2001	235.7	7.5	510.6	719.6	368.35	121.60	615.10	373.15	363.55	97.53	-32.80	0.22
	1/9/2002	240	18.9	523.3	731	378.30	129.45	627.15	381.65	374.95	100.16	-33.08	0.15
	4/12/2002	263.4	58.5	554.8	763	409.93	160.95	658.90	409.10	410.75	108.54	-33.09	-0.04
	7/18/2002	255.5	40.1	566.1	754.5	404.05	147.80	660.30	410.80	397.30	106.98	-34.06	0.30
	10/8/2002	231.2	3.4	508.7	726.1	367.35	117.30	617.40	369.95	364.75	97.26	-33.24	0.12
	1/8/2003	249.4	38.5	540.1	754.4	395.60	143.95	647.25	394.75	396.45	104.74	-33.45	-0.04
	4/15/2003	276.4	78.5	571.6	784.9	427.85	177.45	678.25	424.00	431.70	113.28	-33.28	-0.17
13	7/1/2003	273	69	561.4	779.9	420.83	171.00	670.65	417.20	424.45	111.42	-33.21	-0.16
	10/7/2003	246.6	22.5	524.7	744.6	384.60	134.55	634.65	385.65	383.55	101.83	-33.24	0.05
	12/31/2003	264.8	58.9	552.8	770.1	411.65	161.85	661.45	408.80	414.50	108.99	-33.20	-0.13
	4/13/2004	291.3	97.7	584	803.2	444.05	194.50	693.60	437.65	450.45	117.57	-33.17	-0.29
	7/13/2004	275.5	64.3	556.1	781	419.23	169.90	668.55	415.80	422.65	111.00	-33.14	-0.15
	10/8/2004	252.8	29.9	527.5	755.8	391.50	141.35	641.65	390.15	392.85	103.66	-33.25	-0.06
	1/7/2005	264	50.8	544.5	770.6	407.48	157.40	657.55	404.25	410.70	107.89	-33.24	-0.14
	4/8/2005	289.9	90.7	576	802	439.65	190.30	689.00	432.95	446.35	116.41	-33.14	-0.30
	7/18/2005	277.8	67.7	556.4	787.1	422.25	172.75	671.75	417.10	427.40	111.80	-33.16	-0.23
	8/26/2005	266.7	46.5	539.8	771.9	406.23	156.60	655.85	403.25	409.20	107.56	-33.18	-0.13
	10/11/2005	257.2	33.8	526.8	760.8	394.65	145.50	643.80	392.00	397.30	104.49	-33.12	-0.12
	1/10/2006	269.3	59.9	551.2	780.4	415.20	164.60	665.80	410.25	420.15	109.93	-33.31	-0.22
	4/9/2006	289.9	90	576.3	806.2	440.60	189.95	691.25	433.10	448.10	116.66	-33.32	-0.34
	7/19/2006	277.7	63.9	553.8	787.8	420.80	170.80	670.80	415.75	425.85	111.42	-33.23	-0.23
	10/18/2006	253.3	27.9	523.7	757.8	390.68	140.60	640.75	388.50	392.85	103.44	-33.24	-0.10
	1/18/2007	267.4	54.9	546.5	778.5	411.83	161.15	662.50	406.95	416.70	109.04	-33.32	-0.22
	4/19/2007	289	88.7	575.1	806.8	439.90	188.85	690.95	432.05	447.75	116.47	-33.37	-0.35
	7/11/2007	280	67	558	793.6	424.65	173.50	675.80	419.00	430.30	112.43	-33.38	-0.25
	10/20/2007	255.4	29.1	525	763.8	393.33	142.25	644.40	390.20	396.45	104.14	-33.37	-0.14
	1/7/2008	265.4	49.2	542.8	778	408.85	157.30	660.40	404.10	413.60	108.25	-33.44	-0.21
	5/13/2008	290.2	83.3	573.8	809.3	439.15	186.75	691.55	432.00	446.30	116.27	-33.55	-0.32
	7/29/2008	274	55.1	548.5	787.7	416.33	164.55	668.10	411.25	421.40	110.23	-33.47	-0.23
	10/30/2008	256.5	28.1	526.4	765.9	394.23	142.30	646.15	391.45	397.00	104.38	-33.49	-0.12
	1/12/2009	271.1	54.9	550.3	786.8	415.78	163.00	668.55	410.70	420.85	110.08	-33.60	-0.23
	4/24/2009	291.4	85.8	576.5	813.8	441.88	188.60	695.15	433.95	449.80	117.00	-33.66	-0.36
	8/3/2009	279.9	62.4	556.5	797.4	424.05	171.15	676.95	418.20	429.90	112.28	-33.61	-0.26

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	445.4	53.9	802	298.7	400.00	249.65	550.35	623.70	176.30	105.91	-19.98	10.02
	7/15/1999	440.5	34.4	799.5	280.7	388.78	237.45	540.10	620.00	157.55	102.94	-20.11	10.36
	8/15/1999	455.6	40.8	837.6	284.6	404.65	248.20	561.10	646.60	162.70	107.14	-20.79	10.84
	8/31/1999	452.7	30.7	837.1	274.1	398.65	241.70	555.60	644.90	152.40	105.55	-20.86	11.03
	9/15/1999	448.5	21.7	836.8	266.2	393.30	235.10	551.50	642.65	143.95	104.13	-21.03	11.17
	9/30/1999	447.0	16.1	838.5	260.8	390.60	231.55	549.65	642.75	138.45	103.42	-21.14	11.30
	10/15/1999	446.5	8.8	839.3	255.1	387.43	227.65	547.20	642.90	131.95	102.58	-21.24	11.45
	10/31/1999	450.9	11.7	847.9	257.8	392.08	231.30	552.85	649.40	134.75	103.81	-21.37	11.53
	11/15/1999	455.9	16.1	856.2	259.8	397.00	236.00	558.00	656.05	137.95	105.11	-21.40	11.61
	11/30/1999	456.3	15.5	858.3	259	397.28	235.90	558.65	657.30	137.25	105.19	-21.45	11.65
	12/15/1999	461.3	20.5	865.6	261.7	402.28	240.90	563.65	663.45	141.10	106.51	-21.45	11.70
	12/31/1999	463.4	22.5	871.6	262.9	405.10	242.95	567.25	667.50	142.70	107.26	-21.55	11.76
	3/31/2000	477.8	35.6	903.8	282.7	424.98	256.70	593.25	690.80	159.15	112.52	-22.37	11.91
	6/30/2000	469.2	17.4	889.7	267.4	410.93	243.30	578.55	679.45	142.40	108.80	-22.28	12.03
	9/30/2000	453.5	-23.5	856.8	240.4	381.80	215.00	548.60	655.15	108.45	101.09	-22.17	12.25
	1/13/2001	476.9	5	891.3	257.6	407.70	240.95	574.45	684.10	131.30	107.95	-22.16	12.38
	4/20/2001	494.8	40.8	932.8	281.2	437.40	267.80	607.00	713.80	161.00	115.81	-22.54	12.38
	7/16/2001	475.7	4.9	900.7	255.9	409.30	240.30	578.30	688.20	130.40	108.37	-22.46	12.50
	10/9/2001	459.3	-30.8	870.4	236.8	383.93	214.25	553.60	664.85	103.00	101.65	-22.55	12.59
	1/9/2002	468.8	-18.5	883.7	241.5	393.88	225.15	562.60	676.25	111.50	104.29	-22.43	12.65
	4/12/2002	492.8	22.5	926.5	270.2	428.00	257.65	598.35	709.65	146.35	113.32	-22.64	12.62
	7/18/2002	483.5	3.8	911.9	257.3	414.13	243.65	584.60	697.70	130.55	109.65	-22.66	12.71
	10/8/2002	462.7	-35	875.6	233	384.08	213.85	554.30	669.15	99.00	101.69	-22.63	12.77
	1/8/2003	485.5	2.5	912.6	253.9	413.63	244.00	583.25	699.05	128.20	109.52	-22.55	12.79
	4/15/2003	501.9	612.9	952.7	285.1	588.15	557.40	618.90	727.30	449.00	155.72	-4.09	6.23
14	7/1/2003	521.6	28.8	943.4	278.1	442.98	275.20	610.75	732.50	153.45	117.29	-22.30	12.97
	10/7/2003	472.3	-16.5	903.8	247.5	401.78	227.90	575.65	688.05	115.50	106.38	-23.11	12.83
	12/31/2003	495.5	18.6	939.3	268.7	430.53	257.05	604.00	717.40	143.65	113.99	-23.06	12.85
	4/13/2004	504.6	68.9	989	299.2	465.43	286.75	644.10	746.80	184.05	123.23	-23.75	12.61
	7/13/2004	487.3	36.7	961.8	277.7	440.88	262.00	619.75	724.55	157.20	116.73	-23.78	12.71
	10/8/2004	468.9	-0.5	928.8	256.4	413.40	234.20	592.60	698.85	127.95	109.46	-23.82	12.79
	1/7/2005	485.2	21.4	952.7	269.7	432.25	253.30	611.20	718.95	145.55	114.45	-23.79	12.85
	4/8/2005	512.9	68.8	998.7	302.5	470.73	290.85	650.60	755.80	185.65	124.63	-23.91	12.77
	7/18/2005	498.2	40	977.1	286.8	450.53	269.10	631.95	737.65	163.40	119.29	-24.11	12.86
	8/26/2005	486.3	17.1	955.5	271.8	432.68	251.70	613.65	720.90	144.45	114.56	-24.05	12.91
	10/11/2005	478.8	2.4	942.6	263.6	421.85	240.60	603.10	710.70	133.00	111.69	-24.09	12.94
	1/10/2006	497.9	28.2	970.6	280.6	444.33	263.05	625.60	734.25	154.40	117.64	-24.09	12.99
	4/9/2006	519.6	65.1	1008.9	306	474.90	292.35	657.45	764.25	185.55	125.74	-24.26	12.96
	7/19/2006	505.7	73.4	984.2	290.7	463.50	289.55	637.45	744.95	182.05	122.72	-23.12	12.61
	10/18/2006	484	-5.7	946.5	265.8	422.65	239.15	606.15	715.25	130.05	111.91	-24.39	13.11
	1/18/2007	503	21.5	974.4	282.5	445.35	262.25	628.45	738.70	152.00	117.92	-24.34	13.14
	4/19/2007	525.1	60.9	1012.9	309.1	477.00	293.00	661.00	769.00	185.00	126.30	-24.46	13.08
	7/11/2007	533.8	36.8	994.5	295.1	465.05	285.30	644.80	764.15	165.95	123.13	-23.89	13.40
	10/20/2007	487.8	-9.1	953.8	269.9	425.60	239.35	611.85	720.80	130.40	112.69	-24.76	13.23
	1/7/2008	504.2	11.4	976	284.1	443.93	257.80	630.05	740.10	147.75	117.54	-24.74	13.27
	5/13/2008	552.9	52.7	1019.4	315.4	485.10	302.80	667.40	786.15	184.05	128.44	-24.23	13.49
	7/29/2008	533.4	17.1	989.1	295.9	458.88	275.25	642.50	761.25	156.50	121.50	-24.41	13.55
	10/30/2008	494.5	-16.2	961.7	277.5	429.38	239.15	619.60	728.10	130.65	113.69	-25.28	13.38
	1/12/2009	514.7	12	989.3	296.3	453.08	263.35	642.80	752.00	154.15	119.96	-25.22	13.39
	4/24/2009	558.4	42.7	1024.6	321.8	486.88	300.55	673.20	791.50	182.25	128.91	-24.77	13.65
	8/3/2009	521.7	18.1	1002.6	307.4	462.45	269.90	655.00	762.15	162.75	122.44	-25.59	13.43

Table 2 Tie Beam Forces and Bending Moments (Driven Pile Cap side)(cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	468.3	92.2	387.7	511.7	364.98	280.25	449.70	428.00	301.95	96.63	-11.26	2.82
	7/15/1999	460.1	81	381.5	505.7	357.08	270.55	443.60	420.80	293.35	94.54	-11.50	2.86
	8/15/1999	482.3	96.1	410.7	526	378.78	289.20	468.35	446.50	311.05	100.29	-11.91	3.03
	8/31/1999	490.3	101.9	422.4	535	387.40	296.10	478.70	456.35	318.45	102.57	-12.14	3.09
	9/15/1999	491.0	101.4	426.3	536.4	388.78	296.20	481.35	458.65	318.90	102.94	-12.30	3.13
	9/30/1999	497.9	106.7	434.7	543.6	395.73	302.30	489.15	466.30	325.15	104.78	-12.42	3.16
	10/15/1999	505.0	112.3	443.2	550.9	402.85	308.65	497.05	474.10	331.60	106.66	-12.52	3.19
	10/31/1999	515.6	118.8	452.5	560.9	411.95	317.20	506.70	484.05	339.85	109.07	-12.59	3.23
	11/15/1999	525.0	128.3	463.4	570.2	421.73	326.65	516.80	494.20	349.25	111.66	-12.64	3.25
	11/30/1999	532.5	134.9	471.5	576.8	428.93	333.70	524.15	502.00	355.85	113.57	-12.66	3.27
	12/15/1999	534.1	138.1	476.5	580.2	432.23	336.10	528.35	505.30	359.15	114.44	-12.78	3.27
	12/31/1999	540.4	144.3	484.4	587.2	439.08	342.35	535.80	512.40	365.75	116.25	-12.86	3.29
	3/31/2000	551.1	156	501.3	602.1	452.63	353.55	551.70	526.20	379.05	119.84	-13.17	3.30
	6/30/2000	533.5	137.3	477.6	577.9	431.58	335.40	527.75	505.55	357.60	114.27	-12.78	3.31
	9/30/2000	539.6	136.8	480.7	575.1	433.05	338.20	527.90	510.15	355.95	114.66	-12.61	3.45
	1/13/2001	571.4	169.7	522.7	611.8	468.90	370.55	567.25	547.05	390.75	124.15	-13.07	3.50
	4/20/2001	580.2	184.8	537.9	624.6	481.88	382.50	581.25	559.05	404.70	127.59	-13.21	3.46
	7/16/2001	555.8	159.1	508	598.6	455.38	357.45	553.30	531.90	378.85	120.57	-13.02	3.43
	10/9/2001	556.2	154.1	506	595.8	453.03	355.15	550.90	531.10	374.95	119.95	-13.01	3.50
	1/9/2002	572	170.3	527.3	614.7	471.08	371.15	571.00	549.65	392.50	124.73	-13.28	3.52
	4/12/2002	584.6	187.7	546.3	632.8	487.85	386.15	589.55	565.45	410.25	129.17	-13.52	3.48
	7/18/2002	559.5	162.1	516.1	606	460.93	360.80	561.05	537.80	384.05	122.04	-13.31	3.44
	10/8/2002	557	154.4	511	599.8	455.55	355.70	555.40	534.00	377.10	120.62	-13.27	3.51
	1/8/2003	591	189.2	552.8	639	493.00	390.10	595.90	571.90	414.10	130.53	-13.68	3.54
	4/15/2003	597.9	204.3	567.5	650.5	505.05	401.10	609.00	582.70	427.40	133.72	-13.82	3.48
26	7/1/2003	580.7	184.3	545.4	632.5	485.73	382.50	588.95	563.05	408.40	128.61	-13.72	3.46
	10/7/2003	578.2	176.3	538	627	479.88	377.25	582.50	558.10	401.65	127.06	-13.64	3.50
	12/31/2003	610.3	207.7	572.6	661.6	513.05	409.00	617.10	591.45	434.65	135.84	-13.83	3.51
	4/13/2004	617.1	224.2	589.5	675.7	526.63	420.65	632.60	603.30	449.95	139.43	-14.09	3.44
	7/13/2004	584	186.6	549.1	642.6	490.58	385.30	595.85	566.55	414.60	129.89	-13.99	3.40
	10/8/2004	581.8	181.2	543.7	638.3	486.25	381.50	591.00	562.75	409.75	128.74	-13.92	3.43
	1/7/2005	609.9	209	574.8	669.1	515.70	409.45	621.95	592.35	439.05	136.54	-14.12	3.43
	4/8/2005	617.5	225	590.2	683.9	529.15	421.25	637.05	603.85	454.45	140.10	-14.34	3.35
	7/18/2005	590.4	192.7	554.7	656	498.45	391.55	605.35	572.55	424.35	131.97	-14.21	3.32
	8/26/2005	584.4	183.1	544	647.8	489.83	383.75	595.90	564.20	415.45	129.69	-14.10	3.33
	10/11/2005	589.3	185.9	548.5	652	493.93	387.60	600.25	568.90	418.95	130.78	-14.13	3.36
	1/10/2006	616	216.1	582.8	683.4	524.58	416.05	633.10	599.40	449.75	138.89	-14.42	3.35
	4/9/2006	629	235.4	605.8	701.1	542.83	432.20	653.45	617.40	468.25	143.72	-14.70	3.34
	7/19/2006	595.8	199	563.1	668.3	506.55	397.40	615.70	579.45	433.65	134.12	-14.51	3.27
	10/18/2006	595.6	193	557.4	662.8	502.20	394.30	610.10	576.50	427.90	132.97	-14.34	3.33
	1/18/2007	622.2	223.4	590.2	694.6	532.60	422.80	642.40	606.20	459.00	141.02	-14.59	3.30
	4/19/2007	624.5	231.7	598.4	701.1	538.93	428.10	649.75	611.45	466.40	142.69	-14.73	3.25
	7/11/2007	594.6	199.2	561.5	670.8	506.53	396.90	616.15	578.05	435.00	134.11	-14.57	3.20
	10/20/2007	588.7	187	550.3	661.8	496.95	387.85	606.05	569.50	424.40	131.58	-14.50	3.25
	1/7/2008	619.8	219.6	589.6	697.1	531.53	419.70	643.35	604.70	458.35	140.73	-14.86	3.28
	5/13/2008	624.3	232.4	600.5	707.3	541.13	428.35	653.90	612.40	469.85	143.27	-14.99	3.19
	7/29/2008	600.8	202.7	568.1	681.9	513.38	401.75	625.00	584.45	442.30	135.93	-14.84	3.18
	10/30/2008	616.5	213.5	580.6	694.2	526.20	415.00	637.40	598.55	453.85	139.32	-14.78	3.24
	1/12/2009	638.2	240.2	611.7	719.3	552.35	439.20	665.50	624.95	479.75	146.25	-15.04	3.25
	4/24/2009	636.5	244.8	616.5	722.1	554.98	440.65	669.30	626.50	483.45	146.94	-15.20	3.20
	8/3/2009	625.3	227.2	589.2	707.8	537.38	426.25	648.50	607.25	467.50	142.28	-14.77	3.13

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	-115.0	299.7	422.9	109.6	179.30	92.35	266.25	153.95	204.65	47.47	-11.56	-1.14
	7/15/1999	-122.0	289	405.2	95.6	166.95	83.50	250.40	141.60	192.30	44.20	-11.09	-1.14
	8/15/1999	-139.4	265.8	401.5	101.8	157.43	63.20	251.65	131.05	183.80	41.68	-12.52	-1.18
	8/31/1999	-144.1	258.4	394.7	99.6	152.15	57.15	247.15	125.30	179.00	40.28	-12.63	-1.20
	9/15/1999	-144.1	255.9	395.1	102	152.23	55.90	248.55	125.50	178.95	40.30	-12.80	-1.20
	9/30/1999	-141.7	260.4	408.3	112.3	159.83	59.35	260.30	133.30	186.35	42.32	-13.35	-1.19
	10/15/1999	-138.1	275.3	441.9	138.4	179.38	68.60	290.15	151.90	206.85	47.49	-14.72	-1.23
	10/31/1999	-148.1	272.7	430.1	118.5	168.30	62.30	274.30	141.00	195.60	44.56	-14.09	-1.22
	11/15/1999	-142.3	278.9	446.6	134.9	179.53	68.30	290.75	152.15	206.90	47.53	-14.78	-1.23
	11/30/1999	-137.9	284.4	462	150.8	189.83	73.25	306.40	162.05	217.60	50.26	-15.49	-1.24
	12/15/1999	-135.4	290	463.8	152.5	192.73	77.30	308.15	164.20	221.25	51.03	-15.34	-1.28
	12/31/1999	-126.8	301.4	481.4	168.9	206.23	87.30	325.15	177.30	235.15	54.60	-15.81	-1.30
	3/31/2000	-133.9	283.1	455.7	149.6	188.63	74.60	302.65	160.90	216.35	49.94	-15.16	-1.24
	6/30/2000	-157.3	230.6	397.4	119.3	147.50	36.65	258.35	120.05	174.95	39.05	-14.73	-1.23
	9/30/2000	-142.8	237.4	427.4	156.8	169.70	47.30	292.10	142.30	197.10	44.93	-16.27	-1.23
	1/13/2001	-118.2	295.4	511.7	182.5	217.85	88.60	347.10	196.75	238.95	57.68	-17.18	-0.95
	4/20/2001	-128.9	270.9	454	163.4	189.85	71.00	308.70	162.55	217.15	50.27	-15.80	-1.22
	7/16/2001	-146.4	213.9	384.1	133.3	146.23	33.75	258.70	118.85	173.60	38.72	-14.95	-1.23
	10/9/2001	-135.7	237.5	439.4	178.3	179.88	50.90	308.85	151.85	207.90	47.63	-17.14	-1.26
	1/9/2002	-120.2	281.4	483	190.7	208.73	80.60	336.85	181.40	236.05	55.26	-17.03	-1.22
	4/12/2002	-133.2	263.6	441.1	154.2	181.43	65.20	297.65	153.95	208.90	48.04	-15.45	-1.23
	7/18/2002	-158.1	191.2	355.6	118	126.68	16.55	236.80	98.75	154.60	33.54	-14.64	-1.25
	10/7/2002	-149.2	192.4	391.7	156.3	147.80	21.60	274.00	121.25	174.35	39.13	-16.77	-1.19
	1/8/2003	-123.2	268.7	469.3	191.8	201.65	72.75	330.55	173.05	230.25	53.39	-17.13	-1.28
	4/15/2003	-137.5	248.4	427.1	157.1	173.78	55.45	292.10	144.80	202.75	46.01	-15.73	-1.30
1	7/1/2003	-159.7	183.9	351.2	124.6	125.00	12.10	237.90	95.75	154.25	33.10	-15.01	-1.31
	10/7/2003	-146.6	206.4	412.6	177.8	162.55	29.90	295.20	133.00	192.10	43.04	-17.63	-1.32
	12/31/2003	-135.4	243.4	450.4	190	187.10	54.00	320.20	157.50	216.70	49.54	-17.69	-1.33
	4/13/2004	-144.6	228.6	422.1	168	168.53	42.00	295.05	138.75	198.30	44.62	-16.82	-1.33
	7/13/2004	-179.1	155.6	334.2	117.5	107.05	-11.75	225.85	77.55	136.55	28.34	-15.79	-1.32
	10/8/2004	-169	170.9	373.7	152.9	132.13	0.95	263.30	102.35	161.90	34.98	-17.44	-1.33
	1/7/2005	-145.5	227.8	440.5	188.2	177.75	41.15	314.35	147.50	208.00	47.06	-18.16	-1.36
	4/8/2005	-159.4	209.2	398.5	148.8	149.28	24.90	273.65	119.55	179.00	39.52	-16.53	-1.33
	7/18/2005	-182.8	141.5	330.3	131.3	105.08	-20.65	230.80	73.75	136.40	27.82	-16.71	-1.40
	8/26/2005	-184	140.7	341.3	131.3	107.33	-21.65	236.30	78.65	136.00	28.42	-17.14	-1.28
	10/11/2005	-174.2	159.1	370.9	131.3	121.78	-7.55	251.10	98.35	145.20	32.24	-17.19	-1.05
	1/10/2006	-152.5	216.4	430.7	131.3	156.48	31.95	281.00	139.10	173.85	41.43	-16.55	-0.78
	4/9/2006	-157.2	206.1	413	131.3	148.30	24.45	272.15	127.90	168.70	39.27	-16.46	-0.91
	7/19/2006	-189.4	135.9	330	131.3	101.95	-26.75	230.65	70.30	133.60	26.99	-17.11	-1.42
	10/18/2006	-170.5	170.2	390.6	131.3	130.40	-0.15	260.95	110.05	150.75	34.53	-17.35	-0.91
	1/18/2007	-145.4	217.2	448.1	131.3	162.80	35.90	289.70	151.35	174.25	43.10	-16.87	-0.51
	4/19/2007	-159.2	203.2	410.4	131.3	146.43	22.00	270.85	125.60	167.25	38.77	-16.54	-0.93
	7/11/2007	-192.9	128.3	318.7	131.3	96.35	-32.30	225.00	62.90	129.80	25.51	-17.10	-1.50
	10/20/2007	-183.2	145.9	358.7	131.3	113.18	-18.65	245.00	87.75	138.60	29.97	-17.52	-1.14
	1/7/2008	-155.6	207.5	426.7	131.3	152.48	25.95	279.00	135.55	169.40	40.37	-16.82	-0.76
	5/13/2008	-172.2	170	384.2	131.3	128.33	-1.10	257.75	106.00	150.65	33.98	-17.20	-1.00
	7/29/2008	-197.5	120	328.1	131.3	95.48	-38.75	229.70	65.30	125.65	25.28	-17.84	-1.35
	10/30/2008	-167.1	170	413	131.3	136.80	1.45	272.15	122.95	150.65	36.22	-17.99	-0.62
	1/12/2009	-147.6	210.8	446.5	131.3	160.25	31.60	288.90	149.45	171.05	42.43	-17.10	-0.48
	4/24/2009	-165.4	181.2	398	545.3	239.78	7.90	471.65	116.30	363.25	63.49	-30.82	-5.53
	8/3/2009	-194.5	109.6	320.1	131	91.55	-42.45	225.55	62.80	120.30	24.24	-17.81	-1.29

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	356.2	257	201.2	275.1	272.38	306.60	238.15	278.70	266.05	72.12	4.55	0.28
	7/15/1999	353.8	251.6	188.4	273.4	266.80	302.70	230.90	271.10	262.50	70.64	4.77	0.19
	8/15/1999	350.0	242.8	195.3	301.1	272.30	296.40	248.20	272.65	271.95	72.10	3.20	0.02
	8/31/1999	350.2	247.8	201.7	307.9	276.90	299.00	254.80	275.95	277.85	73.31	2.94	-0.04
	9/15/1999	349.8	249.1	203.6	314	279.13	299.45	258.80	276.70	281.55	73.90	2.70	-0.11
	9/30/1999	352.2	256.8	212.1	322.7	285.95	304.50	267.40	282.15	289.75	75.71	2.47	-0.17
	10/15/1999	352.6	257.7	225.5	337.3	293.28	305.15	281.40	289.05	297.50	77.65	1.58	-0.19
	10/31/1999	361.0	268.5	222.6	333.7	296.45	314.75	278.15	291.80	301.10	78.49	2.43	-0.21
	11/15/1999	364.5	273.1	237.1	353.6	307.08	318.80	295.35	300.80	313.35	81.30	1.56	-0.28
	11/30/1999	367.6	276.3	249.1	369.4	315.60	321.95	309.25	308.35	322.85	83.56	0.84	-0.32
	12/15/1999	370.6	280.7	248.5	364.3	316.03	325.65	306.40	309.55	322.50	83.67	1.28	-0.29
	12/31/1999	371.2	282.5	254.8	368.8	319.33	326.85	311.80	313.00	325.65	84.55	1.00	-0.28
	3/31/2000	376.0	289.2	244.7	361.1	317.75	332.60	302.90	310.35	325.15	84.13	1.97	-0.33
	6/30/2000	358.4	247.7	207.4	329.3	285.70	303.05	268.35	282.90	288.50	75.64	2.31	-0.13
	9/30/2000	357.6	235.9	230.1	366.4	297.50	296.75	298.25	293.85	301.15	78.77	-0.10	-0.16
	1/13/2001	382.0	289.5	264.4	384.8	330.18	335.75	324.60	323.20	337.15	87.42	0.74	-0.31
	4/20/2001	382.9	294.9	260.1	378.2	329.03	338.90	319.15	321.50	336.55	87.12	1.31	-0.34
	7/16/2001	352.4	249.4	219.2	330.6	287.90	300.90	274.90	285.80	290.00	76.23	1.73	-0.09
	10/9/2001	357.7	267.9	262.1	382	317.43	312.80	322.05	309.90	324.95	84.04	-0.61	-0.34
	1/9/2002	385.8	301.2	285.1	395.6	341.93	343.50	340.35	335.45	348.40	90.53	0.21	-0.29
	4/12/2002	390.9	310.2	263.2	370.1	333.60	350.55	316.65	327.05	340.15	88.33	2.25	-0.29
	7/18/2002	346.39	265.03	220.4	323.3	288.78	305.71	271.85	283.39	294.17	76.46	2.25	-0.24
	10/7/2002	344.5	265.3	252.4	363.5	306.43	304.90	307.95	298.45	314.40	81.13	-0.20	-0.36
	1/8/2003	385.9	308.5	295.9	394.3	346.15	347.20	345.10	340.90	351.40	91.65	0.14	-0.24
	4/15/2003	392.4	317.3	275.8	371.1	339.15	354.85	323.45	334.10	344.20	89.80	2.09	-0.23
12	7/1/2003	360	288.1	238.7	332.8	304.90	324.05	285.75	299.35	310.45	80.73	2.55	-0.25
	10/7/2003	357.1	284.5	277.7	372.1	322.85	320.80	324.90	317.40	328.30	85.48	-0.27	-0.24
	12/31/2003	387.7	318.7	304.1	392.5	350.75	353.20	348.30	345.90	355.60	92.87	0.33	-0.22
	4/13/2004	389.4	324.2	294.9	381.2	347.43	356.80	338.05	342.15	352.70	91.99	1.25	-0.24
	7/13/2004	348	285.8	241	324.8	299.90	316.90	282.90	294.50	305.30	79.40	2.26	-0.24
	10/8/2004	342.4	281.8	269.4	353.1	311.68	312.10	311.25	305.90	317.45	82.52	0.06	-0.26
	1/7/2005	374.1	315.2	302.9	382.8	343.75	344.65	342.85	338.50	349.00	91.01	0.12	-0.24
	4/8/2005	386.7	328.9	284.3	365	341.23	357.80	324.65	335.50	346.95	90.35	2.20	-0.26
	7/18/2005	343.2	285.5	242.4	322.1	298.30	314.35	282.25	292.80	303.80	78.98	2.13	-0.25
	8/26/2005	337	278.7	250.1	331.1	299.23	307.85	290.60	293.55	304.90	79.23	1.15	-0.25
	10/11/2005	338.7	283.6	264.1	348.6	308.75	311.15	306.35	301.40	316.10	81.75	0.32	-0.33
	1/10/2006	371.5	317.4	297	373.5	339.85	344.45	335.25	334.25	345.45	89.98	0.61	-0.25
	4/9/2006	377.4	324.1	290.6	368.2	340.08	350.75	329.40	334.00	346.15	90.04	1.42	-0.27
	7/19/2006	341.9	289.2	238.8	315.3	296.30	315.55	277.05	290.35	302.25	78.45	2.56	-0.27
	10/18/2006	342.7	289.5	274.8	354.5	315.38	316.10	314.65	308.75	322.00	83.50	0.10	-0.30
	1/18/2007	368.4	316.6	305.5	385	343.88	342.50	345.25	336.95	350.80	91.05	-0.18	-0.31
	4/19/2007	370.5	320.9	279.2	353.9	331.13	345.70	316.55	324.85	337.40	87.67	1.94	-0.28
	7/11/2007	326.6	278.1	219	294	279.43	302.35	256.50	272.80	286.05	73.98	3.05	-0.30
	10/20/2007	325.9	278.3	243.8	321.7	292.43	302.10	282.75	284.85	300.00	77.43	1.29	-0.34
	1/7/2008	359.2	310.2	282.8	353	326.30	334.70	317.90	321.00	331.60	86.39	1.12	-0.24
	5/13/2008	350.5	304.1	260.9	335.4	312.73	327.30	298.15	305.70	319.75	82.80	1.94	-0.31
	7/29/2008	325.9	281.2	234.5	305.4	286.75	303.55	269.95	280.20	293.30	75.92	2.23	-0.29
	10/30/2008	335.7	288	283.1	360.3	316.78	311.85	321.70	309.40	324.15	83.87	-0.65	-0.33
	1/12/2009	361	312.9	298.7	366.1	334.68	336.95	332.40	329.85	339.50	88.61	0.30	-0.22
	4/24/2009	357	310.4	275.8	344	321.80	333.70	309.90	316.40	327.20	85.20	1.58	-0.24
	8/3/2009	323.1	286.5	247.2	311.6	292.10	304.80	279.40	285.15	299.05	77.34	1.69	-0.31

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	177.4	380.2	417.6	236.2	302.85	278.80	326.90	297.50	308.20	80.19	-3.20	-0.24
	7/15/1999	173.8	378	412.7	230.2	298.68	275.90	321.45	293.25	304.10	79.08	-3.03	-0.24
	8/15/1999	172.8	380.2	439.6	252.6	311.30	276.50	346.10	306.20	316.40	82.42	-4.63	-0.23
	8/31/1999	172.6	378	445.8	257.5	313.48	275.30	351.65	309.20	317.75	83.00	-5.07	-0.19
	9/15/1999	170.9	377.2	447.2	261	314.08	274.05	354.10	309.05	319.10	83.16	-5.32	-0.23
	9/30/1999	176.4	380.7	455.9	269.3	320.58	278.55	362.60	316.15	325.00	84.88	-5.59	-0.20
	10/15/1999	176.7	378.9	468.1	279.5	325.80	277.80	373.80	322.40	329.20	86.26	-6.38	-0.15
	10/31/1999	182.4	385.8	502.1	273.8	336.03	284.10	387.95	342.25	329.80	88.97	-6.90	0.28
	11/15/1999	186.8	392.4	482.7	292	338.48	289.60	387.35	334.75	342.20	89.62	-6.50	-0.17
	11/30/1999	189.8	396.8	638.9	305.6	382.78	293.30	472.25	414.35	351.20	101.35	-11.89	1.41
	12/15/1999	193.5	401.1	516.7	302.2	353.38	297.30	409.45	355.10	351.65	93.56	-7.45	0.08
	12/31/1999	194.7	406.1	507.2	308	354.00	300.40	407.60	350.95	357.05	93.73	-7.12	-0.14
	3/31/2000	194.8	409	492.7	298.7	348.80	301.90	395.70	343.75	353.85	92.35	-6.23	-0.23
	6/30/2000	177.7	389.4	467.2	278.7	328.25	283.55	372.95	322.45	334.05	86.91	-5.94	-0.26
	9/30/2000	174.2	385.1	496.7	308	341.00	279.65	402.35	335.45	346.55	90.29	-8.15	-0.25
	1/13/2001	200.0	418.2	530.3	318.6	366.78	309.10	424.45	365.15	368.40	97.11	-7.67	-0.07
	4/20/2001	194.1	416.2	512.8	310.6	358.43	305.15	411.70	353.45	363.40	94.90	-7.08	-0.22
	7/16/2001	166.5	386.2	469	273.8	323.88	276.35	371.40	317.75	330.00	85.75	-6.32	-0.27
	10/9/2001	171.5	389.1	514.8	315.2	347.65	280.30	415.00	343.15	352.15	92.05	-8.95	-0.20
	1/9/2002	193.6	413.6	539.3	324.6	367.78	303.60	431.95	366.45	369.10	97.38	-8.53	-0.06
	4/12/2002	198.8	418.5	509.3	299.2	356.45	308.65	404.25	354.05	358.85	94.38	-6.35	-0.11
	7/18/2002	161.4	379.1	462.4	262.6	316.38	270.25	362.50	311.90	320.85	83.77	-6.13	-0.20
	10/7/2002	155.8	373.6	686.8	301.1	379.33	264.70	493.95	421.30	337.35	100.43	-15.24	1.88
	1/8/2003	193.1	414	547.6	331	371.43	303.55	439.30	370.35	372.50	98.34	-9.02	-0.05
	4/15/2003	195.8	419.9	560.6	305.7	370.50	307.85	433.15	378.20	362.80	98.10	-8.33	0.34
13	7/1/2003	172.1	394.8	479.4	273.9	330.05	283.45	376.65	325.75	334.35	87.39	-6.19	-0.19
	10/7/2003	169	389.1	527.1	317.5	350.68	279.05	422.30	348.05	353.30	92.85	-9.52	-0.12
	12/31/2003	196.2	423.2	560.3	334.7	378.60	309.70	447.50	378.25	378.95	100.24	-9.16	-0.02
	4/13/2004	197.9	424.7	546.1	321.7	372.60	311.30	433.90	372.00	373.20	98.65	-8.15	-0.03
	7/13/2004	155.6	383.5	482.7	266.1	321.98	269.55	374.40	319.15	324.80	85.25	-6.97	-0.13
	10/8/2004	152.2	378.4	519	298.6	337.05	265.30	408.80	335.60	338.50	89.24	-9.54	-0.06
	1/7/2005	180.6	410.6	556.1	324.9	368.05	295.60	440.50	368.35	367.75	97.45	-9.63	0.01
	4/8/2005	188.3	419.5	529.1	301	359.48	303.90	415.05	358.70	360.25	95.18	-7.39	-0.03
	7/18/2005	150.7	376.8	482.9	262.2	318.15	263.75	372.55	316.80	319.50	84.24	-7.23	-0.06
	8/26/2005	144.7	373.1	494.1	275.3	321.80	258.90	384.70	319.40	324.20	85.20	-8.36	-0.11
	10/11/2005	146.5	375.2	533.7	291.5	336.73	260.85	412.60	340.10	333.35	89.15	-10.09	0.15
	1/10/2006	176	407.1	548.8	313.5	361.35	291.55	431.15	362.40	360.30	95.67	-9.28	0.05
	4/9/2006	180.6	412.1	538.7	307.8	359.80	296.35	423.25	359.65	359.95	95.26	-8.43	-0.01
	7/19/2006	149.4	377.4	480.1	259.8	316.68	263.40	369.95	314.75	318.60	83.85	-7.08	-0.09
	10/18/2006	155.2	382.8	532.6	304.1	343.68	269.00	418.35	343.90	343.45	90.99	-9.93	0.01
	1/18/2007	179.5	407.9	563.5	330.9	370.45	293.70	447.20	371.50	369.40	98.08	-10.20	0.05
	4/19/2007	182.7	413.5	536	305.6	359.45	298.10	420.80	359.35	359.55	95.17	-8.15	0.00
	7/11/2007	146.1	373.2	467.5	250.6	309.35	259.65	359.05	306.80	311.90	81.91	-6.61	-0.11
	10/20/2007	144.3	373.6	638.9	278.5	358.83	258.95	458.70	391.60	326.05	95.01	-13.28	1.47
	1/7/2008	179.2	408.8	548	312	362.00	294.00	430.00	363.60	360.40	95.85	-9.04	0.07
	5/13/2008	172.2	403.9	523.7	297.2	349.25	288.05	410.45	347.95	350.55	92.47	-8.13	-0.06
	7/29/2008	149.7	380.4	489.1	265	321.05	265.05	377.05	319.40	322.70	85.00	-7.44	-0.07
	10/30/2008	160.1	391.8	555	321.9	357.20	275.95	438.45	357.55	356.85	94.58	-10.80	0.02
	1/12/2009	185.3	417.9	568.5	328.6	375.08	301.60	448.55	376.90	373.25	99.31	-9.77	0.08
	4/24/2009	179.7	414.8	539.6	308.7	360.70	297.25	424.15	359.65	361.75	95.50	-8.43	-0.05
	8/3/2009	148.3	387.2	512.3	263.7	327.88	267.75	388.00	330.30	325.45	86.81	-7.99	0.11

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	199.5	418.4	473.6	323.8	353.83	308.95	398.70	336.55	371.10	93.68	-5.96	-0.77
	7/15/1999	194.3	414.4	461.1	314.4	346.05	304.35	387.75	327.70	364.40	91.62	-5.54	-0.82
	8/15/1999	191.0	402.1	488.7	347.5	357.33	296.55	418.10	339.85	374.80	94.61	-8.08	-0.78
	8/31/1999	189.5	395.4	496	352.6	358.38	292.45	424.30	342.75	374.00	94.89	-8.76	-0.70
	9/15/1999	186.8	391.6	503.6	359.8	360.45	289.20	431.70	345.20	375.70	95.44	-9.47	-0.68
	9/30/1999	188.5	396.7	516	369	367.55	292.60	442.50	352.25	382.85	97.32	-9.96	-0.69
	10/15/1999	235.3	403	530.4	378.9	386.90	319.15	454.65	382.85	390.95	102.44	-9.01	-0.18
	10/31/1999	202.7	418.5	524.2	371.5	379.23	310.60	447.85	363.45	395.00	100.41	-9.12	-0.71
	11/15/1999	208.9	426.2	548.2	393.2	394.13	317.55	470.70	378.55	409.70	104.35	-10.18	-0.70
	11/30/1999	212.9	429.2	566.6	409.5	404.55	321.05	488.05	389.75	419.35	107.11	-11.10	-0.66
	12/15/1999	216.9	433.5	561.4	403.7	403.88	325.20	482.55	389.15	418.60	106.93	-10.46	-0.66
	12/31/1999	220.7	443.8	566.6	407.4	409.63	332.25	487.00	393.65	425.60	108.46	-10.28	-0.72
	3/31/2000	215.2	438.2	567.9	406.5	406.95	326.70	487.20	391.55	422.35	107.75	-10.67	-0.69
	6/30/2000	191.3	415.8	542.4	380.7	382.55	303.55	461.55	366.85	398.25	101.29	-10.50	-0.70
	6/30/2000	183.3	409.8	571	409.9	393.50	296.55	490.45	377.15	409.85	104.19	-12.89	-0.73
	1/13/2001	215.4	447.2	588.9	421.9	418.35	331.30	505.40	402.15	434.55	110.77	-11.57	-0.73
	4/20/2001	210.2	445.1	586.6	415.7	414.40	327.65	501.15	398.40	430.40	109.72	-11.53	-0.72
	7/16/2001	171.2	413	554.5	377.7	379.10	292.10	466.10	362.85	395.35	100.37	-11.56	-0.73
	10/9/2001	178.5	417.9	596.2	418.8	402.85	298.20	507.50	387.35	418.35	106.66	-13.91	-0.69
	1/9/2002	206.2	445.9	606.4	430	422.13	326.05	518.20	406.30	437.95	111.77	-12.77	-0.71
	4/12/2002	208.6	449.5	584.1	408.1	412.58	329.05	496.10	396.35	428.80	109.24	-11.10	-0.73
	7/18/2002	161.7	410.1	551.9	368.5	373.05	285.90	460.20	356.80	389.30	98.77	-11.58	-0.73
	10/7/2002	160.2	405.5	592.3	407.7	391.43	282.85	500.00	376.25	406.60	103.64	-14.43	-0.68
	1/8/2003	202	449.1	620.2	437.7	427.25	325.55	528.95	411.10	443.40	113.12	-13.52	-0.72
	4/15/2003	205.4	453.6	590	409.8	414.70	329.50	499.90	397.70	431.70	109.80	-11.32	-0.76
14	7/1/2003	171.9	426.9	559.5	377.3	383.90	299.40	468.40	365.70	402.10	101.65	-11.23	-0.82
	10/7/2003	172	424.4	600.8	422.4	404.90	298.20	511.60	386.40	423.40	107.21	-14.18	-0.83
	12/31/2003	205.6	461.3	624.2	444.9	434.00	333.45	534.55	414.90	453.10	114.91	-13.36	-0.86
	4/13/2004	204.7	463.4	611.5	433.1	428.18	334.05	522.30	408.10	448.25	113.37	-12.51	-0.90
	7/13/2004	159.6	424.2	566.4	383.7	383.48	291.90	475.05	363.00	403.95	101.53	-12.17	-0.92
	10/8/2004	153	416.8	590.5	409.5	392.45	284.90	500.00	371.75	413.15	103.91	-14.30	-0.93
	1/7/2005	192.8	454.9	627.8	446.9	430.60	323.85	537.35	410.30	450.90	114.01	-14.19	-0.91
	4/8/2005	205.2	467.5	600.9	425.2	424.70	336.35	513.05	403.05	446.35	112.45	-11.74	-0.97
	7/18/2005	154.9	424.1	560.9	385.2	381.28	289.50	473.05	357.90	404.65	100.95	-12.20	-1.05
	8/26/2005	168.3	416.1	569.1	391.2	386.18	292.20	480.15	368.70	403.65	102.25	-12.49	-0.78
	10/11/2005	152.5	418.5	590.5	413.4	393.73	285.50	501.95	371.50	415.95	104.25	-14.38	-1.00
	1/10/2006	190.7	455.4	615	436.7	424.45	323.05	525.85	402.85	446.05	112.38	-13.48	-0.97
	4/9/2006	196.7	460.2	612.3	436.6	426.45	328.45	524.45	404.50	448.40	112.91	-13.03	-0.98
	7/19/2006	159.7	426.1	562.3	382.1	382.55	292.90	472.20	361.00	404.10	101.29	-11.92	-0.97
	10/18/2006	161.9	425.9	600.5	422.5	402.70	293.90	511.50	381.20	424.20	106.62	-14.46	-0.96
	1/18/2007	192.2	454.2	638.5	460	436.23	323.20	549.25	415.35	457.10	115.50	-15.02	-0.94
	4/19/2007	198.7	462.5	611.3	432	426.13	330.60	521.65	405.00	447.25	112.83	-12.70	-0.95
	7/11/2007	149.8	419.9	567.4	379.8	379.23	284.85	473.60	358.60	399.85	100.41	-12.54	-0.92
	10/20/2007	208.9	417	590.1	409	406.25	312.95	499.55	399.50	413.00	107.56	-12.40	-0.30
	1/7/2008	194.6	460.1	617.4	439.8	427.98	327.35	528.60	406.00	449.95	113.31	-13.37	-0.98
	5/13/2008	188	455	606	431.7	420.18	321.50	518.85	397.00	443.35	111.25	-13.12	-1.04
	7/29/2008	155	428.4	572.6	394	387.50	291.70	483.30	363.80	411.20	102.60	-12.73	-1.06
	10/30/2008	172.9	442.6	629.9	452.7	424.53	307.75	541.30	401.40	447.65	112.40	-15.52	-1.04
	1/12/2009	205.6	472.9	638	463.6	445.03	339.25	550.80	421.80	468.25	117.83	-14.06	-1.04
	4/24/2009	219.6	468	616.9	442.7	436.80	343.80	529.80	418.25	455.35	115.65	-12.36	-0.83
	8/3/2009	155.2	441.6	545.8	408.9	387.88	298.40	477.35	350.50	425.25	102.70	-11.89	-1.67

Table 3 Tie Beam Forces and Bending Moments (Drilled Shaft side) (cont'd)

Tie #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(Kip-ft)	Moment(y)(Kip-ft)
	7/1/1999	222.2	-19.9	305.2	560	266.88	101.15	432.60	263.70	270.05	70.66	-22.03	-0.14
	7/15/1999	207.8	-36.8	294.3	540.9	251.55	85.50	417.60	251.05	252.05	66.60	-22.07	-0.02
	8/15/1999	189.9	-53.4	320.4	546.8	250.93	68.25	433.60	255.15	246.70	66.44	-24.28	0.19
	8/31/1999	184.8	-60	330.2	555.2	252.55	62.40	442.70	257.50	247.60	66.87	-25.27	0.22
	9/15/1999	185.7	-57.2	336.6	558.2	255.83	64.25	447.40	261.15	250.50	67.73	-25.46	0.24
	9/30/1999	187.5	-53.7	349.9	570.1	263.45	66.90	460.00	268.70	258.20	69.75	-26.12	0.24
	10/15/1999	195.3	-50.5	375.2	601.5	280.38	72.40	488.35	285.25	275.50	74.23	-27.64	0.22
	10/31/1999	197.3	-39.9	370.8	589.7	279.48	78.70	480.25	284.05	274.90	74.00	-26.69	0.20
	11/15/1999	202.5	-32.3	385.9	601.1	289.30	85.10	493.50	294.20	284.40	76.60	-27.14	0.22
	11/30/1999	206.5	-27.3	398.1	613.9	297.80	89.60	506.00	302.30	293.30	78.85	-27.67	0.20
	12/15/1999	216.1	-19.5	401.6	620.9	304.78	98.30	511.25	308.85	300.70	80.70	-27.44	0.18
	12/31/1999	223.8	-15	410.7	633.4	313.23	104.40	522.05	317.25	309.20	82.93	-27.76	0.18
	3/31/2000	203.5	-16	395.7	633.5	304.18	93.75	514.60	299.60	308.75	80.54	-27.97	-0.20
	6/30/2000	149.3	-41	371.2	553.8	258.33	54.15	462.50	260.25	256.40	68.40	-27.14	0.09
	6/30/2000	154.3	-22.3	411.5	580.2	280.93	66.00	495.85	282.90	278.95	74.38	-28.57	0.09
	1/13/2001	197.9	7.7	446.8	627.1	319.88	102.80	536.95	322.35	317.40	84.69	-28.85	0.11
	4/20/2001	167.6	1.3	434.9	589.5	298.33	84.45	512.20	301.25	295.40	78.99	-28.43	0.13
	7/16/2001	112.8	-20.6	409.7	555.1	264.25	46.10	482.40	261.25	267.25	69.97	-29.00	-0.13
	10/9/2001	136.9	-5.4	451.7	582.7	291.48	65.75	517.20	294.30	288.65	77.17	-30.00	0.13
	1/9/2002	176.6	9	461.6	618.2	316.35	92.80	539.90	319.10	313.60	83.76	-29.71	0.12
	4/12/2002	158.20	3.40	438	581.00	295.25	80.80	509.70	298.30	292.20	78.17	-28.50	0.14
	7/18/2002	86.10	-23.70	405	503.86	242.87	31.20	454.53	245.65	240.08	64.30	-28.13	0.12
	10/7/2002	96.1	2.90	445.20	562.80	276.75	49.50	504.00	270.65	282.85	73.28	-30.21	-0.27
	1/8/2003	165.9	41.91	480.40	628.48	329.17	103.91	554.44	323.15	335.20	87.16	-29.94	-0.27
	4/15/2003	147.5	33.95	455.30	592.01	307.19	90.73	523.65	301.40	312.98	81.33	-28.77	-0.26
26	7/1/2003	88.2	9.66	424.1	577.30	274.82	48.93	500.70	256.15	293.48	72.76	-30.02	-0.84
	10/7/2003	103.5	24.24	466.9	574.34	292.25	63.87	520.62	285.20	299.29	77.38	-30.35	-0.32
	12/31/2003	130.5	44.68	481.6	566.95	305.93	87.59	524.27	306.05	305.81	81.00	-29.02	0.01
	4/13/2004	118.2	42.08	471.6	585.31	304.30	80.14	528.45	294.90	313.69	80.57	-29.79	-0.42
	7/13/2004	49.6	8.40	430.9	548.80	259.43	29.00	489.85	240.25	278.60	68.69	-30.63	-0.86
	10/8/2004	54.7	18.19	457.3	588.15	279.59	36.45	522.72	256.00	303.17	74.03	-32.32	-1.06
	1/7/2005	108.7	42.65	486.4	597.82	308.89	75.67	542.11	297.55	320.23	81.78	-31.00	-0.51
	4/8/2005	91.7	33.99	457.3	601.47	296.12	62.85	529.39	274.50	317.73	78.40	-31.01	-0.97
	7/18/2005	28.7	12.91	432.3	605.33	269.81	20.81	518.82	230.50	309.12	71.44	-33.10	-1.76
	8/26/2005	31.4	16.85	447.8	588.39	271.11	24.13	518.10	239.60	302.62	71.78	-32.83	-1.41
	10/11/2005	43.7	14.58	464.4	588.60	277.82	29.14	526.50	254.05	301.59	73.56	-33.05	-1.06
	1/10/2006	96.3	14.58	483.8	588.60	295.82	55.44	536.20	290.05	301.59	78.32	-31.95	-0.26
	4/9/1906	87.1	29.40	477	588.60	295.52	58.25	532.80	282.05	309.00	78.25	-31.54	-0.60
	7/19/1906	18.4	-2.90	430.9	588.60	258.75	7.75	509.75	224.65	292.85	68.51	-33.36	-1.53
	10/18/1906	61.1	14.58	483.2	588.60	286.87	37.84	535.90	272.15	301.59	75.95	-33.10	-0.66
	1/18/2007	99.2	14.58	505.9	588.60	302.07	56.89	547.25	302.55	301.59	79.98	-32.59	0.02
	4/19/2007	80.5	14.58	477.1	588.60	290.19	47.54	532.85	278.80	301.59	76.83	-32.25	-0.51
	7/11/2007	11.2	14.5768	431.3	588.5957	261.42	12.89	509.95	221.25	301.59	69.22	-33.03	-1.80
	10/20/2007	19.8	14.5768	455.1	588.5957	269.52	17.19	521.85	237.45	301.59	71.36	-33.54	-1.44
	1/7/2008	82.9	14.5768	489.6	588.5957	293.92	48.74	539.10	286.25	301.59	77.82	-32.59	-0.34
	5/13/2008	44.6	14.5768	468.8	588.5957	279.14	29.59	528.70	256.70	301.59	73.91	-33.17	-1.01
	7/29/2008	0.2	14.5768	442.8	588.5957	261.54	7.39	515.70	221.50	301.59	69.25	-33.78	-1.79
	10/30/2008	34	14.5768	495.7	588.5957	283.22	24.29	542.15	264.85	301.59	74.99	-34.42	-0.82
	1/12/2009	73.4	14.5768	498.3	588.5957	293.72	43.99	543.45	285.85	301.59	77.77	-33.19	-0.35
	4/24/2009	48.7	14.5768	466.4	588.5957	279.57	31.64	527.50	257.55	301.59	74.02	-32.95	-0.99
	8/3/2009	-13.3	14.5768	450	588.5957	259.97	0.64	519.30	218.35	301.59	68.83	-34.47	-1.86

Table 4 Pile Forces and Bending Moments

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	903.00	42.30	679.00	-	541.43	472.65	679.00	791.00	42.30	456.92	-73.98	99.88
	07/15/99	918.00	48.00	885.00	-	617.00	483.00	885.00	901.50	48.00	520.69	-144.12	113.86
	07/31/00	932.43	51.99	887.34	-	623.92	492.21	887.34	909.89	51.99	526.53	-141.66	114.44
	08/15/99	940.56	34.46	923.00	-	632.67	487.51	923.00	931.78	34.46	533.91	-156.13	119.70
	08/30/99	948.68	31.28	931.09	-	637.02	489.98	931.09	939.89	31.28	537.58	-158.14	121.21
	09/15/99	955.75	27.83	938.36	-	640.65	491.79	938.36	947.06	27.83	540.64	-160.10	122.62
	09/30/99	959.08	23.03	947.01	-	643.04	491.06	947.01	953.05	23.03	542.66	-163.47	124.06
	10/15/99	963.38	18.85	954.86	-	645.70	491.12	954.86	959.12	18.85	544.90	-166.26	125.43
	10/31/99	973.25	5.58	968.30	-	649.04	489.42	968.30	970.78	5.58	547.73	-171.69	128.76
	11/15/99	973.34	1.26	977.48	-	650.69	487.30	977.48	975.41	1.26	549.12	-175.74	129.95
	11/30/99	975.73	-2.84	980.87	-	651.25	486.45	980.87	978.30	-2.84	549.59	-177.26	130.88
	12/15/99	974.96	-2.47	982.11	-	651.53	486.25	982.11	978.54	-2.47	549.83	-177.77	130.87
	12/31/99	974.03	-54.00	984.71		634.91	460.02	984.71	979.37	-54.00	535.80	-188.11	137.85
	03/31/00	964.52	3.86	981.83	-	650.07	484.19	981.83	973.17	3.86	548.59	-178.41	129.31
	06/30/00	977.80	-36.92	980.73	-	640.54	470.44	980.73	979.27	-36.92	540.55	-182.94	135.56
	09/30/00	1009.20	-10.20	1005.99	-	668.33	499.50	1005.99	1007.60	-10.20	564.01	-181.58	135.77
	01/13/01	1014.12	-29.4495	1029.11	-	671.26	492.33	1029.11	1021.61	-29.45	566.48	-192.44	140.21
	04/20/01	1008.27	-18.6852	1022.57	-	670.72	494.79	1022.57	1015.42	-18.69	566.02	-189.21	137.95
	07/10/01	1030.41	-8.36772	1019.56	-	680.53	511.02	1019.56	1024.98	-8.37	574.30	-182.32	137.85
	10/09/01	1054.25	-20.5131	1038.65	-	690.80	516.87	1038.65	1046.45	-20.51	582.96	-187.07	142.33
	01/09/02	1055.96	-29.65	1045.80	-	690.70	513.15	1045.80	1050.88	-29.65	582.88	-190.96	144.14
	04/12/02	1041.9	-24.8188	1040.36	-	685.81	508.54	1040.36	1041.13	-24.82	578.76	-190.66	142.20
	07/19/02	1062.21	-17.26	1035.12	17.14	693.36	522.47	1035.12	1048.67	-17.26	585.12	-183.79	142.20
	10/08/02	1086.38	-30.07	1049.75	-6.63	702.02	528.16	1049.75	1068.06	-30.07	592.43	-187.00	146.49
	01/08/03	1080.45	-42.89	1062.94	0.41	700.17	518.78	1062.94	1071.70	-42.89	590.87	-195.09	148.69
	04/15/03	1059.37	-29.65	1049.86	22.95	693.19	514.86	1049.86	1054.62	-29.65	584.99	-191.81	144.64
1	06/01/03	1064.93	-31.16	1053.52	21.00	695.77	516.89	1053.52	1059.23	-31.16	587.16	-192.39	145.46
	08/07/03	1083.86	-27.66	1053.40	9.26	703.20	528.10	1053.40	1068.63	-27.66	593.43	-188.33	146.25
	10/07/03	1095.56	-38.67	1066.64	-0.69	707.84	528.45	1066.64	1081.10	-38.67	597.35	-192.95	149.38
	12/31/03	1100.15	-54.88	1082.97	-0.89	709.41	522.64	1082.97	1091.56	-54.88	598.68	-200.89	152.93
	04/13/04	1080.17	-43.67	1074.07	21.65	703.52	518.25	1074.07	1077.12	-43.67	593.70	-199.27	149.51
	07/13/04	1101.53	-34.89	1072.49	10.76	713.04	533.32	1072.49	1087.01	-34.89	601.74	-193.30	149.66
	10/08/04	1122.82	-45.70	1085.57	-8.86	720.90	538.56	1085.57	1104.19	-45.70	608.36	-196.11	153.40
	01/07/05	1116.60	-58.49	1097.39	-8.94	718.50	529.06	1097.39	1107.00	-58.49	606.34	-203.76	155.48
	04/08/05	1099.01	-52.77	1096.58	5.48	714.28	523.12	1096.58	1097.80	-52.77	602.78	-205.59	153.49
	07/18/05	1116.44	-41.55	1096.58	-2.36	723.82	537.44	1096.58	1106.51	-41.55	610.83	-200.46	153.15
	08/26/05	1128.14	-43.63	1095.73	-10.20	726.75	542.26	1095.73	1111.93	-43.63	613.30	-198.43	154.15
	11/12/05	1127.45	-44.76	1095.72	-9.67	726.14	541.34	1095.72	1111.58	-44.76	612.79	-198.75	154.26
	01/10/06	1129.36	-64.30	1095.72	-19.70	720.26	532.53	1095.72	1112.54	-64.30	607.83	-201.91	156.99
	04/09/06	1114.90	-55.20	1095.72	-1.14	718.47	529.85	1095.72	1105.31	-55.20	606.32	-202.87	154.81
	07/19/06	1130.94	-46.83	1095.72	-9.42	726.61	542.05	1095.72	1113.33	-46.83	613.19	-198.50	154.77
	10/18/06	1154.91	-58.29	1095.72	-27.50	730.78	548.31	1095.72	1125.32	-58.29	616.71	-196.26	157.89
	01/18/07	1139.55	-68.49	1095.72	-21.73	722.26	535.53	1095.72	1117.64	-68.49	609.52	-200.84	158.23
	04/19/07	1125.58	-58.82	1095.72	-8.49	720.83	533.38	1095.72	1110.65	-58.82	608.31	-201.61	156.01
	07/09/07	1141.38	-47.08	1095.72	-16.09	730.01	547.15	1095.72	1118.55	-47.08	616.05	-196.67	155.50
	10/20/07	1161.81	-62.03	1095.72	-36.23	731.84	549.89	1095.72	1128.77	-62.03	617.60	-195.69	158.85
	01/07/08	1155.60	-68.08	1095.72	-28.03	727.75	543.76	1095.72	1125.66	-68.08	614.15	-197.89	159.24
	05/13/08	1100.48	-46.92	1095.72	7.39	716.43	526.78	1095.72	1098.10	-46.92	604.59	-203.97	152.75
	07/29/08	1158.20	-57.76	1095.72	-17.10	732.05	550.22	1095.72	1126.96	-57.76	617.78	-195.57	158.04
	10/30/08	1172.74	-73.81	1095.72	-23.97	731.55	549.47	1095.72	1134.23	-73.81	617.36	-195.84	161.15
	01/12/09	1163.28	-77.95	1095.72	-8.29	727.02	542.66	1095.72	1129.50	-77.95	613.53	-198.28	161.07
	04/24/09	1152.80	-63.12	1095.72	5.40	728.47	544.84	1095.72	1124.26	-63.12	614.75	-197.50	158.40
	8/3/2009	1178.59	-62.3923	1095.72	-0.16248	737.31	558.10	1095.72	1137.16	-62.39	622.21	-192.75	160.02

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	575.00	589.00	243.00	-	469.00	582.00	243.00	409.00	589.00	395.79	121.54	-24.01
	07/15/99	585.00	602.00	237.00	-	474.67	593.50	237.00	411.00	602.00	400.57	127.81	-25.48
	07/30/99	594.35	611.17	230.68	-	478.73	602.76	230.68	412.52	611.17	404.00	133.40	-26.50
	08/15/99	596.87	611.09	242.58	336.68	446.81	603.98	289.63	419.73	473.89	377.06	112.70	-7.22
	08/31/99	601.58	616.82	241.00	-	486.47	609.20	241.00	421.29	616.82	410.53	132.00	-26.08
	09/15/99	605.96	622.42	240.47	-	489.62	614.19	240.47	423.22	622.42	413.19	133.98	-26.57
	09/30/99	609.62	624.20	240.71	336.98	452.88	616.91	288.85	425.17	480.59	382.18	117.62	-7.39
	10/15/99	612.87	629.40	240.27	336.21	454.69	621.14	288.24	426.57	482.81	383.71	119.35	-7.50
	10/31/99	616.45	631.80	243.11	336.29	456.91	624.13	289.70	429.78	484.05	385.59	119.90	-7.24
	11/15/99	619.54	632.45	245.83	337.79	458.90	626.00	291.81	432.69	485.12	387.27	119.81	-6.99
	11/30/99	623.35	635.58	248.71	340.31	461.99	629.47	294.51	436.03	487.95	389.87	120.09	-6.93
	12/15/99	624.21	637.77	247.77	339.95	462.43	630.99	293.86	435.99	488.86	390.24	120.87	-7.05
	12/31/99	626.60	640.86	249.37	341.45	464.57	633.73	295.41	437.99	491.16	392.05	121.29	-7.09
	03/31/00	634.53	648.30	254.69	346.89	471.10	641.41	300.79	444.61	497.60	397.56	122.12	-7.07
	06/30/00	640.05	652.80	250.99	342.06	471.48	646.43	296.53	445.52	497.43	397.88	125.44	-6.93
	09/30/00	647.16	661.13	247.62	336.78	473.17	654.14	292.20	447.39	498.96	399.31	129.76	-6.88
	01/13/01	654.063	665.1119	256.39	342.22	479.45	659.59	299.31	455.23	503.67	404.61	129.16	-6.46
	04/20/01	654.429	664.7057	260.37	345.47	481.25	659.57	302.92	457.40	505.09	406.12	127.86	-6.36
	07/10/01	661.456	672.0985	256.15	342.75	483.11	666.78	299.45	458.80	507.43	407.70	131.69	-6.49
	10/09/01	668.361	679.0039	251.93	338.20	484.37	673.68	295.06	460.14	508.60	408.76	135.74	-6.46
	01/09/02	671.083	683.4721	252.17	337.92	486.16	677.28	295.04	461.63	510.69	410.27	137.04	-6.55
	04/12/02	669.17	680.02	256.68	342.06	486.98	674.60	299.37	462.93	511.04	410.96	134.52	-6.42
	07/19/02	671.69	683.96	253.27	272.93	470.46	677.83	263.10	462.48	478.44	397.02	148.69	-2.13
	10/08/02	678.60	692.21	247.01	332.37	487.54	685.40	289.69	462.80	512.29	411.44	141.87	-6.60
	01/08/03	678.44	689.32	251.28	334.22	488.31	683.88	292.75	464.86	511.77	412.09	140.22	-6.26
	04/15/03	679.45	692.45	254.73	341.09	491.93	685.95	297.91	467.09	516.77	415.14	139.12	-6.63
17	06/01/03	678.76	689.85	256.43	341.09	491.53	684.30	298.76	467.60	515.47	414.80	138.22	-6.39
	08/07/03	682.33	695.54	251.15	336.74	491.44	688.94	293.95	466.74	516.14	414.73	141.61	-6.59
	10/07/03	686.23	700.57	250.14	334.87	492.95	693.40	292.50	468.19	517.72	416.00	143.73	-6.61
	12/31/03	689.48	700.61	257.04	341.05	497.05	695.05	299.04	473.26	520.83	419.46	141.97	-6.35
	04/13/04	689.24	699.88	260.70	346.65	499.12	694.56	303.68	474.97	523.27	421.21	140.14	-6.44
	07/13/04	693.10	667.59	255.46	341.33	489.37	680.34	298.39	474.28	504.46	412.98	136.93	-4.03
	10/08/04	699.03	710.89	250.83	337.39	499.53	704.96	294.11	474.93	524.14	421.56	147.30	-6.56
	01/07/05	699.07	711.46	253.31	339.95	500.95	705.26	296.63	476.19	525.70	422.75	146.50	-6.61
	04/08/05	696.43	708.09	257.94	343.81	501.57	702.26	300.87	477.18	525.95	423.27	143.90	-6.51
	07/18/05	699.56	708.33	253.71	338.36	499.99	703.94	296.04	476.64	523.35	421.94	146.24	-6.23
	08/26/05	702.04	711.17	250.91	335.97	500.02	706.61	293.44	476.47	523.57	421.97	148.13	-6.28
	11/12/05	701.95	699.60	251.68	337.06	497.57	700.78	294.37	476.82	518.33	419.90	145.70	-5.54
	01/10/06	705.16	715.03	253.47	339.58	503.31	710.10	296.53	479.32	527.31	424.75	148.27	-6.40
	04/09/06	703.94	713.04	259.52	343.20	504.93	708.49	301.36	481.73	528.12	426.11	145.96	-6.19
	07/19/06	708.37	716.01	256.84	339.95	505.29	712.19	298.39	482.61	527.98	426.42	148.35	-6.05
	10/18/06	713.29	721.25	251.76	334.02	505.08	717.27	292.89	482.52	527.63	426.24	152.14	-6.02
	01/18/07	712.84	717.96	256.52	336.54	505.96	715.40	296.53	484.68	527.25	426.98	150.17	-5.68
	04/19/07	711.13	716.21	260.62	340.56	507.13	713.67	300.59	485.88	528.38	427.97	148.10	-5.67
	07/09/07	713.04	716.74	255.22	334.18	504.79	714.89	294.70	484.13	525.46	426.00	150.64	-5.51
	10/20/07	715.97	721.74	250.87	329.51	504.52	718.85	290.19	483.42	525.62	425.77	153.68	-5.63
	01/07/08	719.26	723.93	256.47	335.12	508.69	721.59	295.79	487.87	529.52	429.29	152.65	-5.56
	05/13/08	696.51	707.19	257.94	343.56	501.30	701.85	300.75	477.22	525.38	423.05	143.80	-6.42
	07/29/08	720.07	723.56	259.40	335.76	509.70	721.82	297.58	489.74	529.66	430.14	152.09	-5.33
	10/30/08	723.81	727.50	255.66	332.68	509.91	725.66	294.17	489.74	530.09	430.32	154.69	-5.38
	01/12/09	723.20	727.59	259.07	336.66	511.63	725.39	297.87	491.14	532.12	431.76	153.27	-5.47
	04/24/09	722.67	727.02	262.49	324.47	509.16	724.84	293.48	492.58	525.74	429.68	154.65	-4.42
	8/3/2009	721.858	726.6512	260.618	338.324	511.86	724.25	299.47	491.24	532.49	431.96	152.29	-5.50

Table 4 Pile Forces and Bending Moments (cont'd)

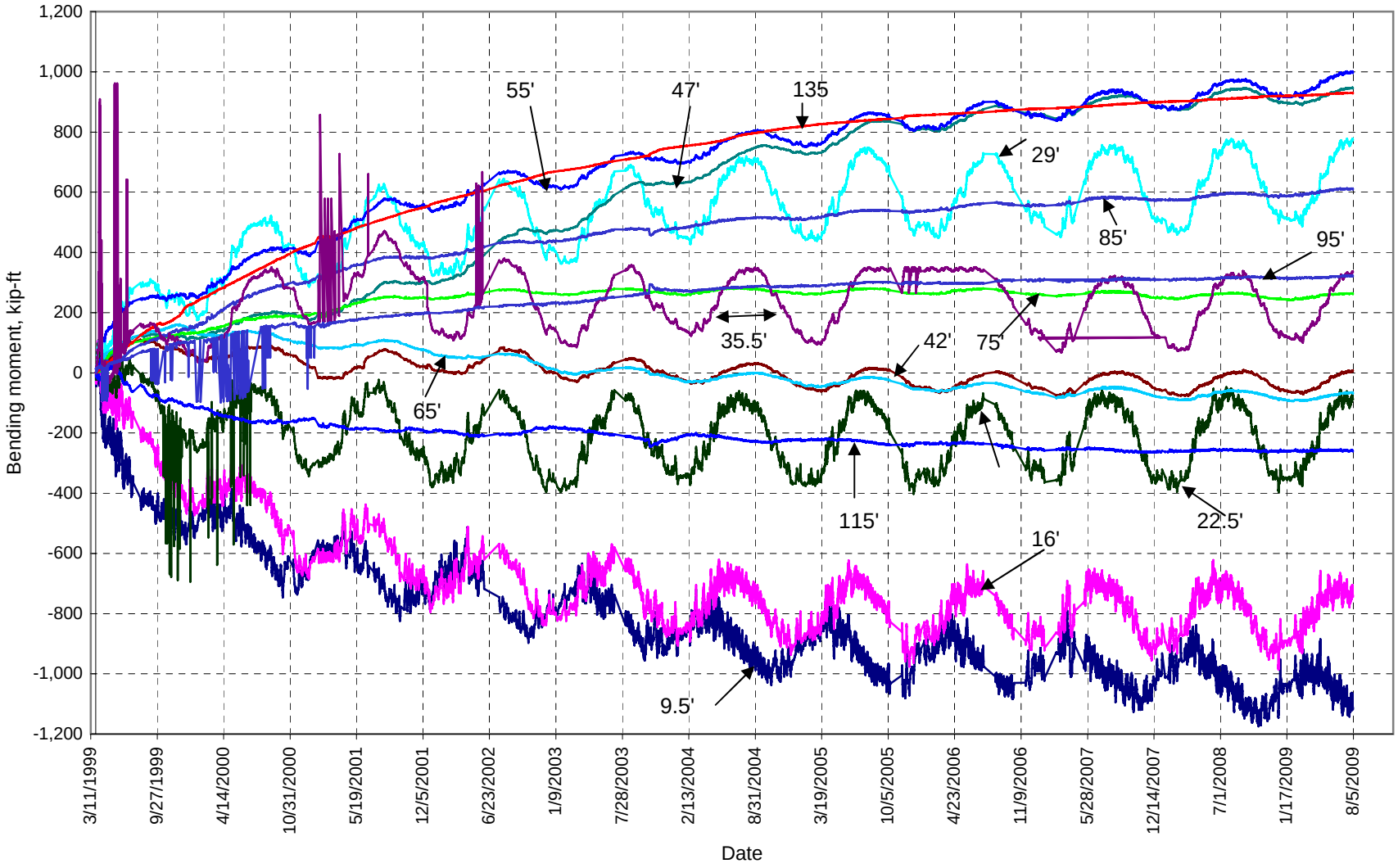
Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	546.00	501.00	248.00	173	367.00	523.50	210.50	397.00	337.00	309.71	112.21	8.00
	07/15/99	557.00	513.00	243.00	229	385.50	535.00	236.00	400.00	371.00	325.32	107.20	3.87
	07/30/99	565.55	519.94	239.54	224.26	387.32	542.75	231.90	402.55	372.10	326.86	111.44	4.06
	08/15/99	567.71	520.14	230.56	232.51	387.73	543.93	231.54	399.14	376.33	327.21	112.00	3.04
	08/31/99	573.72	526.52	247.46	232.87	395.14	550.12	240.17	410.59	379.70	333.46	111.12	4.12
	09/15/99	578.06	532.08	246.65	233.61	397.60	555.07	240.13	412.36	382.85	335.53	112.91	3.94
	09/30/99	582.49	534.97	247.46	234.05	399.74	558.73	240.76	414.98	384.51	337.34	114.00	4.06
	10/15/99	586.68	538.17	247.25	235.23	401.83	562.43	241.24	416.97	386.70	339.11	115.15	4.04
	10/31/99	590.77	539.40	249.37	235.6	403.79	565.09	242.49	420.07	387.50	340.75	115.66	4.34
	11/15/99	592.65	540.65	251.68	237.47	405.61	566.65	244.58	422.17	389.06	342.30	115.47	4.42
	11/30/99	596.63	527.25	254.12	239.69	404.42	561.94	246.91	425.38	383.47	341.29	112.94	5.59
	12/15/99	599.47	545.53	254.12	239.05	409.54	572.50	246.59	426.80	392.29	345.61	116.84	4.60
	12/31/99	601.54	548.45	255.38	239.17	411.14	575.00	247.28	428.46	393.81	346.96	117.49	4.62
	03/31/00	610.32	554.87	262.08	243.60	417.72	582.59	252.84	436.20	399.23	352.51	118.22	4.93
	06/30/00	616.94	539.60	260.98	238.93	414.11	578.27	249.96	438.96	389.26	349.47	117.70	6.63
	09/30/00	625.63	400.76	255.58	232.18	378.54	513.19	243.88	440.61	316.47	319.45	96.55	16.56
	01/13/01	632.372	566.6896	264.44	235.84	424.83	599.53	250.14	448.40	401.26	358.52	125.26	6.29
	04/20/01	632.575	561.5309	268.38	236.21	424.67	597.05	252.29	450.48	398.87	358.38	123.60	6.88
	07/10/01	639.684	569.2893	264.64	234.54	427.04	604.49	249.59	452.16	401.91	360.38	127.23	6.70
	10/09/01	646.508	576.5197	259.81	232.14	428.74	611.51	245.97	453.16	404.33	361.82	131.05	6.51
	01/09/02	650.895	576.8446	259.68	230.92	429.59	613.87	245.30	455.29	403.88	362.53	132.14	6.86
	04/12/02	650.123	570.1017	264.192	232.55	429.24	610.11	248.37	457.16	401.33	362.24	129.69	7.45
	07/19/02	653.45	572.46	260.90	226.38	428.30	612.96	243.64	457.18	399.42	361.44	132.40	7.71
	10/08/02	659.69	581.14	254.65	222.68	429.54	620.41	238.66	457.17	401.91	362.49	136.86	7.37
	01/08/03	657.76	576.89	257.57	224.47	429.17	617.32	241.02	457.67	400.68	362.18	134.91	7.60
	04/15/03	661.78	576.19	262.16	228.04	432.04	618.99	245.10	461.97	402.12	364.60	134.04	7.98
18	06/01/03	661.37	572.66	264.07	227.59	431.43	617.02	245.83	462.72	400.13	364.08	133.07	8.35
	08/07/03	665.76	577.29	258.18	222.76	431.00	621.53	240.47	461.97	400.03	363.72	136.61	8.26
	10/07/03	669.26	582.73	256.11	222.56	432.66	625.99	239.33	462.68	402.65	365.13	138.62	8.01
	12/31/03	670.27	581.39	262.53	229.62	435.95	625.83	246.08	466.40	405.51	367.90	136.15	8.12
	04/13/04	669.42	576.64	266.47	232.35	436.22	623.03	249.41	467.94	404.49	368.12	133.95	8.46
	07/13/04	672.95	578.63	261.80	224.79	434.54	625.79	243.29	467.37	401.71	366.71	137.13	8.76
	10/08/04	677.95	587.12	255.42	222.31	435.70	632.53	238.87	466.68	404.72	367.69	141.14	8.27
	01/07/05	677.50	586.02	257.61	226.05	436.80	631.76	241.83	467.56	406.04	368.61	139.80	8.21
	04/08/05	674.17	580.83	263.14	227.80	436.48	627.50	245.47	468.65	404.31	368.35	136.96	8.58
	07/18/05	677.87	580.70	259.40	221.74	434.93	629.29	240.57	468.63	401.22	367.04	139.36	8.99
	08/26/05	679.25	583.30	256.27	219.43	434.56	631.28	237.85	467.76	401.37	366.73	141.05	8.86
	11/12/05	679.13	583.14	256.88	220.08	434.81	631.13	238.48	468.00	401.61	366.93	140.77	8.86
	01/10/06	679.45	587.32	257.33	223.00	436.78	633.39	240.17	468.39	405.16	368.60	140.97	8.43
	04/09/06	679.57	583.14	263.01	226.46	438.05	631.36	244.74	471.29	404.80	369.67	138.61	8.87
	07/19/06	683.27	585.78	260.94	222.31	438.08	634.53	241.63	472.11	404.05	369.69	140.86	9.08
	10/18/06	687.01	592.40	255.09	218.66	438.29	639.70	236.88	471.05	405.53	369.87	144.42	8.74
	01/18/07	685.10	588.58	259.16	221.83	438.67	636.84	240.49	472.13	405.20	370.19	142.10	8.93
	04/19/07	685.18	584.40	264.40	222.96	439.23	634.79	243.68	474.79	403.68	370.67	140.22	9.49
	07/09/07	687.74	584.85	259.24	215.85	436.92	636.29	237.55	473.49	400.35	368.72	142.96	9.76
	10/20/07	690.01	591.22	253.79	213.46	437.12	640.62	233.63	471.90	402.34	368.89	145.91	9.28
	01/07/08	691.80	593.86	258.30	218.94	440.73	642.83	238.62	475.05	406.40	371.93	144.91	9.16
	05/13/08	675.23	578.71	263.42	226.74	436.03	626.97	245.08	469.32	402.73	367.96	136.91	8.88
	07/29/08	694.93	590.45	261.06	217.03	440.87	642.69	239.05	478.00	403.74	372.05	144.71	9.91
	10/30/08	696.63	596.14	256.52	215.81	441.28	646.39	236.16	476.57	405.98	372.39	147.07	9.42
	01/12/09	695.50	595.73	258.34	219.55	442.28	645.61	238.95	476.92	407.64	373.24	145.80	9.24
	04/24/09	696.39	592.69	262.28	221.66	443.26	644.54	241.97	479.34	407.17	374.06	144.32	9.63
	8/3/2009	695.252	591.9959	258.953	219.632	441.46	643.62	239.29	477.10	405.81	372.55	144.96	9.51

Table 4 Pile Forces and Bending Moments (cont'd)

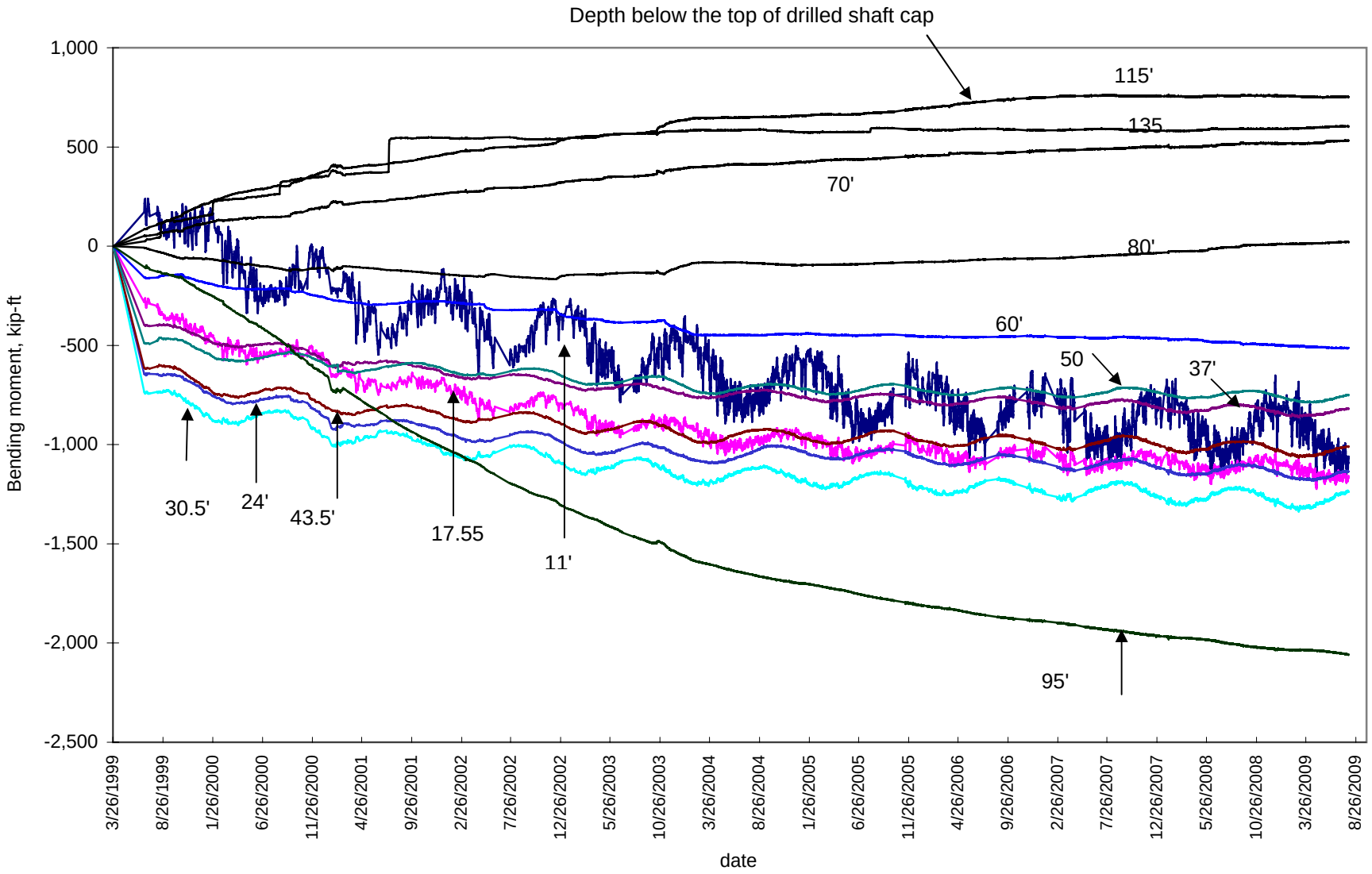
Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	566.97	586.00	298.00	228.9	419.97	576.49	263.45	432.49	407.45	354.41	112.23	3.34
	07/15/99	580.00	597.00	294.00	224	423.75	588.50	259.00	437.00	410.50	357.60	118.13	3.54
	07/30/99	588.71	606.46	291.38	218.62	426.29	597.59	255.00	440.05	412.54	359.75	122.82	3.67
	08/15/99	591.02	607.35	300.95	227.92	431.81	599.19	264.44	445.99	417.64	364.40	120.01	3.78
	08/31/99	595.94	613.52	300.59	229.63	434.92	604.73	265.11	448.27	421.58	367.03	121.76	3.56
	09/15/99	599.88	617.91	300.67	229.54	437.00	608.90	265.11	450.28	423.73	368.78	123.25	3.54
	09/30/99	603.53	621.65	302.70	229.75	439.41	612.59	266.23	453.12	425.70	370.82	124.18	3.66
	10/15/99	607.51	625.02	302.29	229.71	441.13	616.27	266.00	454.90	427.37	372.27	125.57	3.67
	10/31/99	611.37	627.25	306.07	229.7	443.60	619.31	267.89	458.72	428.48	374.35	125.99	4.03
	11/15/99	613.61	627.78	308.31	232.67	445.59	620.70	270.49	460.96	430.23	376.04	125.55	4.10
	11/30/99	616.29	630.54	313.83	234.7	448.84	623.42	274.27	465.06	432.62	378.78	125.17	4.33
	12/15/99	617.83	631.44	314.03	234.9	449.55	624.64	274.47	465.93	433.17	379.38	125.54	4.37
	12/31/99	619.94	634.20	314.36	236.45	451.24	627.07	275.41	467.15	435.33	380.80	126.08	4.25
	03/31/00	629.45	639.44	320.33	239.74	457.24	634.44	280.03	474.89	439.59	385.86	127.06	4.71
	06/30/00	636.15	643.50	317.81	51.91	412.34	639.83	184.86	476.98	347.71	347.98	163.11	17.25
	09/30/00	646.59	651.99	312.33	231.29	460.55	649.29	271.81	479.46	441.64	388.66	135.33	5.04
	01/13/01	653.454	657.0691	320.21	236.77	466.88	655.26	278.49	486.83	446.92	394.00	135.08	5.32
	04/20/01	651.464	653.2102	324.03	237.42	466.53	652.34	280.72	487.74	445.32	393.71	133.23	5.66
	07/10/01	658.856	661.1717	320.61	235.03	468.92	660.01	277.82	489.74	448.10	395.72	137.02	5.55
	10/09/01	667.346	669.2551	315.37	230.97	470.74	668.30	273.17	491.36	450.11	397.25	141.66	5.50
	01/09/02	670.88	671.7736	315.66	229.71	472.00	671.33	272.68	493.27	450.74	398.32	142.92	5.67
	04/12/02	667.71	665.64	321.06	231.62	471.51	666.68	276.34	494.39	448.63	397.90	139.94	6.10
	07/19/02	673.44	667.87	319.88	227.72	472.23	670.66	273.80	496.66	447.79	398.51	142.28	6.52
	10/08/02	681.93	676.18	313.24	222.91	473.56	679.05	268.07	497.58	449.54	399.64	147.34	6.41
	01/08/03	682.42	673.60	316.88	225.03	474.48	678.01	270.96	499.65	449.32	400.42	145.93	6.71
	04/15/03	686.11	672.95	321.26	228.37	477.17	679.53	274.81	503.69	450.66	402.69	145.10	7.07
19	06/01/03	685.30	670.80	322.48	227.84	476.60	678.05	275.16	503.89	449.32	402.21	144.44	7.28
	08/07/03	689.12	675.35	317.28	223.09	476.21	682.23	270.18	503.20	449.22	401.87	147.72	7.20
	10/07/03	694.48	681.03	314.64	222.27	478.11	687.76	268.46	504.56	451.65	403.47	150.32	7.06
	12/31/03	695.94	680.95	322.73	229.34	482.24	688.45	276.03	509.33	455.15	406.96	147.86	7.23
	04/13/04	695.62	676.77	330.77	231.41	483.64	686.19	281.09	513.19	454.09	408.15	145.23	7.88
	07/13/04	700.37	679.61	327.88	224.22	483.02	689.99	276.05	514.13	451.92	407.62	148.40	8.30
	10/08/04	706.18	688.67	321.87	221.22	484.48	697.43	271.54	514.03	454.94	408.86	152.68	7.88
	01/07/05	705.37	688.14	324.72	224.55	485.69	696.75	274.63	515.04	456.35	409.88	151.34	7.83
	04/08/05	702.85	682.86	329.75	226.66	485.53	692.86	278.21	516.30	454.76	409.74	148.66	8.21
	07/18/05	706.50	683.55	327.15	219.55	484.19	695.03	273.35	516.83	451.55	408.61	151.18	8.71
	08/26/05	708.05	686.48	322.81	217.89	483.80	697.26	270.35	515.43	452.18	408.28	153.05	8.44
	11/12/05	707.97	686.27	323.74	218.33	484.08	697.12	271.04	515.85	452.30	408.51	152.76	8.48
	01/10/06	710.04	690.54	324.68	221.62	486.72	700.29	273.15	517.36	456.08	410.74	153.13	8.17
	04/09/06	709.47	686.72	329.75	224.34	487.57	698.10	277.05	519.61	455.53	411.46	150.95	8.55
	07/19/06	714.26	690.38	328.09	220.57	488.32	702.32	274.33	521.17	455.47	412.10	153.44	8.76
	10/18/06	718.93	696.80	321.91	216.75	488.60	707.86	269.33	520.42	456.77	412.33	157.22	8.49
	01/18/07	717.19	692.98	326.63	219.88	489.17	705.08	273.25	521.91	456.43	412.81	154.82	8.73
	04/19/07	716.98	689.52	331.50	221.54	489.89	703.25	276.52	524.24	455.53	413.42	152.99	9.17
	07/09/07	720.64	690.13	327.60	214.47	488.21	705.39	271.04	524.12	452.30	412.00	155.72	9.58
	10/20/07	723.97	695.70	321.18	211.96	488.20	709.83	266.57	522.58	453.83	411.99	158.92	9.17
	01/07/08	725.43	698.46	326.71	217.89	492.12	711.95	272.30	526.07	458.17	415.30	157.62	9.06
	05/13/08	703.58	681.44	330.20	225.12	485.08	692.51	277.66	516.89	453.28	409.36	148.73	8.49
	07/29/08	728.03	696.92	329.23	216.75	492.73	712.47	272.99	528.63	456.83	415.82	157.56	9.58
	10/30/08	730.876	701.5886	324.269	216.383	493.28	716.23	270.33	527.57	458.99	416.28	159.86	9.15
	01/12/09	729.576	702.3198	327.478	220.079	494.86	715.95	273.78	528.53	461.20	417.62	158.52	8.98
	04/24/09	729.901	699.3545	332.393	220.851	495.62	714.63	276.62	531.15	460.10	418.26	157.03	9.48
	8/3/2009	728.398	698.9077	328.535	220.364	494.05	713.65	274.45	528.47	459.64	416.93	157.46	9.18

Table 4 Pile Forces and Bending Moments (cont'd)

Pile #	Date	ε1	ε2	ε3	ε4	Avg. ε	(ε1+ε2)/2	(ε3+ε4)/2	(ε1+ε3)/2	(ε2+ε4)/2	Axial Force(Kip)	Moment(x)(=Kip-ft)	Moment(y)(Kip-ft)
	07/01/99	271.75	436.00	261.00	583.00	387.94	353.88	422.00	266.38	509.50	327.38	-24.42	-32.43
	07/15/99	279.00	617.00	253.00	583.00	433.00	448.00	418.00	266.00	600.00	365.41	10.76	-44.56
	07/30/99	282.79	647.00	243.64	585.13	439.64	464.90	414.39	263.22	616.07	371.01	18.11	-47.07
	08/15/99	272.89	690.09	251.16	614.66	457.20	481.49	432.91	262.03	652.38	385.83	17.42	-52.07
	08/31/99	265.66	576.80	245.14	627.09	428.67	421.23	436.12	255.40	601.95	361.76	-5.34	-46.23
	09/15/99	265.08	802.81	242.34	635.26	486.37	533.95	438.80	253.71	719.04	410.45	34.11	-62.07
	09/30/99	260.50	807.40	238.64	642.65	487.30	533.95	440.65	249.57	725.03	411.23	33.45	-63.43
	10/15/99	256.43	811.14	234.46	648.58	487.65	533.79	441.52	245.45	729.86	411.53	33.08	-64.62
	10/31/99	240.47	824.02	221.62	665.31	487.86	532.25	443.47	231.05	744.67	411.70	31.83	-68.52
	11/15/99	241.93	831.45	224.75	676.77	493.73	536.69	450.76	233.34	754.11	416.65	30.81	-69.47
	11/31/99	240.47	835.88	224.26	648.85	487.37	538.18	436.56	232.37	742.37	411.29	36.43	-68.03
	12/15/99	241.41	836.77	222.35	684.04	496.14	539.09	453.20	231.88	760.41	418.69	30.79	-70.51
	12/31/99	242.22	836.08	224.14	684.93	496.84	539.15	454.54	233.18	760.51	419.29	30.34	-70.35
	03/31/00	257.37	828.85	237.38	675.92	499.88	543.11	456.65	247.38	752.38	421.85	31.00	-67.37
	06/30/00	266.43	846.32	225.20	500.93	459.72	556.37	363.06	245.81	673.62	387.96	69.30	-57.07
	09/30/00	257.37	895.02	196.89	705.00	513.57	576.19	450.94	227.13	800.01	433.40	44.90	-76.42
	01/13/01	247.90	856.11	197.37	729.58	507.74	552.01	463.47	222.64	792.84	428.48	31.74	-76.07
	04/20/01	44.66	883.01	212.28	457.21	399.29	463.83	334.74	128.47	670.11	336.96	46.28	-72.25
	07/10/01	-279.94	502.86	204.24	66.21	123.34	111.46	135.22	-37.85	284.53	104.09	-8.52	-43.01
	10/09/01	442.16	725.37	50.98	1199.89	604.60	583.76	625.44	246.57	962.63	510.22	-14.94	-95.52
	01/09/02	263.63	616.73	159.27	765.05	451.17	440.18	462.16	211.45	690.89	380.74	-7.88	-63.96
	04/12/02	67.35	579.97	58.13	501.01	301.61	323.66	279.57	62.74	540.49	254.53	15.81	-63.73
	07/19/02	288.69	941.04	187.83	727.59	536.29	614.86	457.71	238.26	834.31	452.57	56.34	-79.51
	10/08/02	277.15	962.54	162.58	740.98	535.81	619.84	451.78	219.86	851.76	452.17	60.25	-84.29
	01/08/03	256.07	949.53	162.24	758.66	531.62	602.80	460.45	209.15	854.10	448.64	51.04	-86.04
	04/15/03	277.19	928.37	189.53	744.52	534.90	602.78	467.03	233.36	836.45	451.41	48.67	-80.45
34	06/01/03	277.96	939.01	184.90	749.68	537.89	608.49	467.29	231.43	844.35	453.93	50.62	-81.76
	08/07/03	288.69	965.09	171.66	750.09	543.88	626.89	460.87	230.17	857.59	458.98	59.52	-83.70
	10/07/03	274.96	978.21	155.53	762.84	542.89	626.58	459.19	215.25	870.53	458.14	60.01	-87.41
	12/31/03	258.26	983.57	156.83	795.22	548.47	620.92	476.03	207.55	889.40	462.86	51.95	-90.96
	04/13/04	281.17	960.30	188.88	781.65	553.00	620.73	485.27	235.03	870.97	466.68	48.57	-84.84
	07/13/04	302.86	991.98	173.93	772.27	560.26	647.42	473.10	238.40	882.12	472.80	62.50	-85.87
	10/08/04	295.63	1004.49	151.19	786.40	559.43	650.06	468.80	223.41	895.45	472.10	64.99	-89.65
	01/07/05	277.35	997.91	148.79	798.02	555.52	637.63	473.41	213.07	897.97	468.80	58.88	-91.36
	04/08/05	286.74	978.21	166.99	788.76	555.17	632.47	477.87	226.86	883.49	468.51	55.43	-87.59
	07/18/05	304.00	1000.02	160.94	783.60	562.14	652.01	472.27	232.47	891.81	474.39	64.44	-87.96
	08/26/05	301.85	1018.4	147.73	791.81	564.94	660.12	469.77	224.79	905.09	476.76	68.24	-90.75
	11/12/05	300.51	1018.3	147.82	793.35	564.99	659.40	470.58	224.16	905.83	476.80	67.70	-90.93
	01/10/06	274.59	1009.41	138.15	808.34	557.62	642.00	473.24	206.37	908.87	470.58	60.50	-93.71
	04/09/06	283.04	986.09	160.45	798.02	556.90	634.57	479.23	221.74	892.06	469.97	55.69	-89.42
	07/19/06	295.67	1009.41	149.73	796.56	562.84	652.54	473.14	222.70	902.98	474.98	64.32	-90.75
	10/18/06	284.79	1030.77	131.20	808.38	563.79	657.78	469.79	207.99	919.58	475.78	67.40	-94.92
	01/18/07	270.29	1012.82	134.82	813.33	557.81	641.55	474.08	202.55	913.08	470.74	60.04	-94.78
	04/19/07	282.35	996.04	153.99	805.37	559.44	639.20	479.68	218.17	900.71	472.11	57.19	-91.05
	07/09/07	306.44	1014.48	154.64	795.38	567.74	660.46	475.01	230.54	904.93	479.11	66.49	-89.96
	10/20/07	290.51	1037.35	126.69	809.72	566.07	663.93	468.21	208.60	923.54	477.71	70.17	-95.37
	01/07/08	274.06	1024.92	128.89	820.48	562.09	649.49	474.69	201.48	922.70	474.35	62.67	-96.21
	05/13/08	292.26	978.90	169.79	784.94	556.47	635.58	477.37	231.03	881.92	469.61	56.72	-86.83
	07/29/08	293.44	1034.59	136.97	816.54	570.39	664.02	476.76	215.20	925.57	481.35	67.13	-94.76
	10/30/08	272.32	1053.97	115.20	839.53	570.25	663.14	477.37	193.76	946.75	481.24	66.60	-100.45
	01/12/09	261.92	1033.74	121.25	842.38	564.82	647.83	481.81	191.58	938.06	476.65	59.52	-99.58
	04/24/09	280.03	1016.80	140.55	827.06	566.11	648.42	483.80	210.29	921.93	477.74	59.02	-94.93
	8/3/2009	278.491	1039.1	137.417	844.571	574.89	658.80	490.99	207.95	941.84	485.15	60.16	-97.90



Shaft #1, Bending moment vs. date in different elevations below the top of cap



Shaft #9, Bending moment vs. date in different elevations below the top of cap

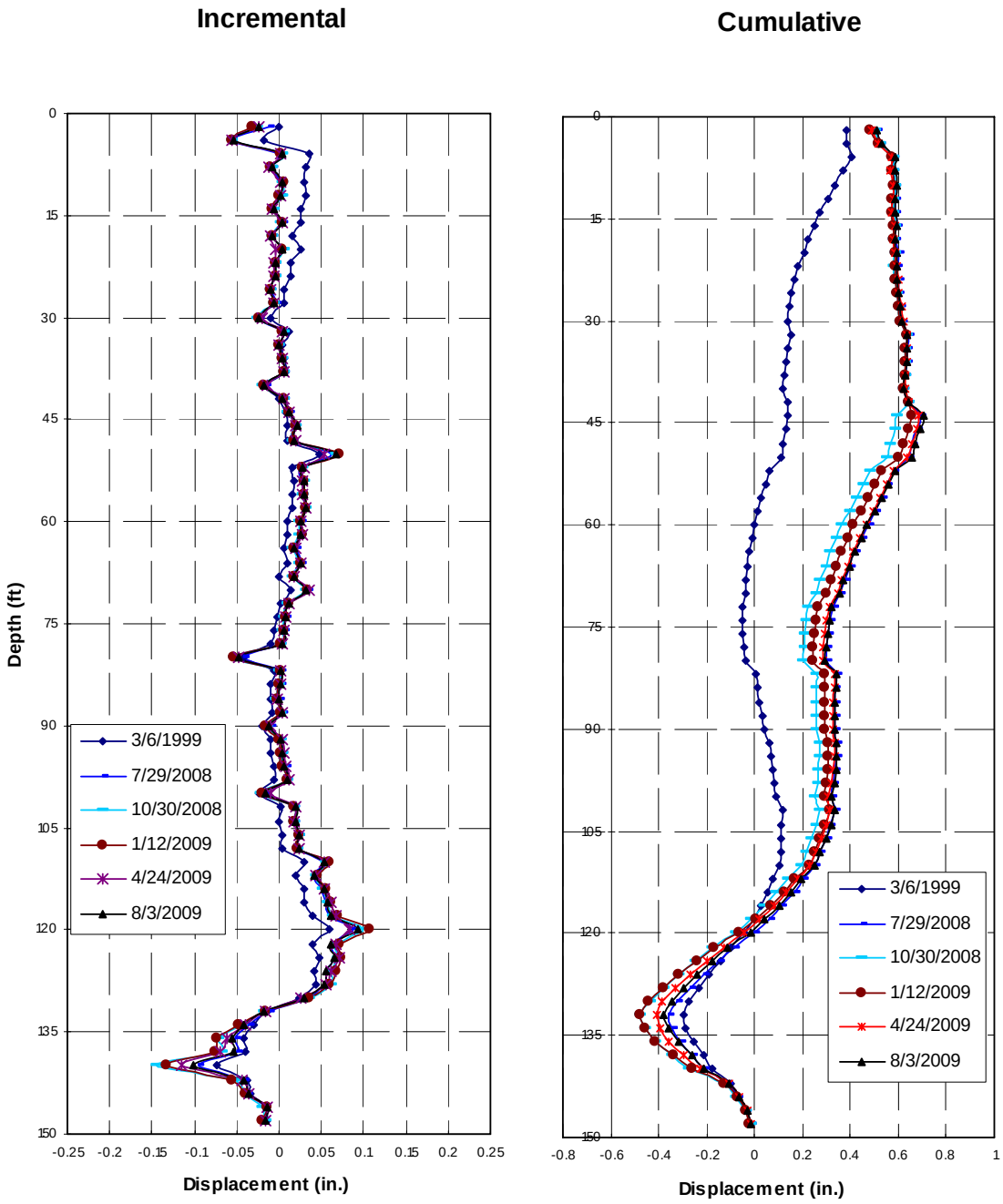
Shaft 1: Bending moment along shaft, kip-ft

Depth, ft / Date	9.5	16	22.5	29	35.5	42	47	54.8	64.8	74.8	84.8	94.8	115	135
7/1/1999	-357.65	-148.91	-2.99	242.13	107.23	94.27	103.67	221.87	109.32	92.67	66.77	48.25	-38.94	91.57
1/8/2003	-774.82	-792.9	-360.63	403.12	139.71	-1.79	473.87	620.31	11.19	262.65	439.51	230.65	-179.6	668.9
4/15/2003	-657.74	-650	-232.57	481.71	156.43	-14.02	517.65	659.68	2.44	268.91	457.85	238.57	-192.49	684.79
7/1/2003	-763.24	-602.42	-72.91	660.28	319.17	32.14	588.57	715.87	14.21	278.09	474.99	251.23	-206	702.94
8/7/2003	-817.04	-638.73	-81.08	678	343.79	44.44	615.09	726.92	17.44	279.15	477.58	254.31	-210.32	708.78
10/7/2003	-913.81	-801.08	-248.05	552.54	251.84	20.93	623.3	710.92	6.8	271.9	474.43	265.38	-225.46	720.58
12/31/2003	-870.9	-838.68	-322.24	476.14	168.18	-13.93	630.87	701.76	-19.51	263.35	479.49	275.24	-220.96	748.57
4/13/2004	-831.87	-777.37	-255.87	514.98	175.37	-24.83	659.66	727.03	-27.47	269.67	495.81	277.88	-211.65	763.52
7/13/2004	-889.99	-676.85	-77.13	709.38	338.24	22.05	727.23	792.27	-5.75	281.7	512.3	283.5	-221.34	787.54
10/8/2004	-983.05	-812	-201.66	636.33	293	16.71	752.87	793.14	-7.37	272.19	514.89	286.68	-231.1	803.15
1/7/2005	-925.21	-882.29	-353.38	471.75	139.59	-39.87	733.05	761.38	-34.6	264.1	510.62	288.64	-223.06	817.18
4/8/2005	-775.03	-726	-235.05	530.47	150.69	-53.27	749.88	786.67	-40.37	267.3	525.48	290.73	-219.8	828.14
7/18/2005	-957.73	-709.43	-81.75	735.77	338.65	7.97	821.52	856.49	-16.82	278.53	538.72	298.79	-226.87	837.24
8/26/2005	-1005.57	-755.34	-117.03	721.71	336.36	13.6	835.13	860.64	-16.18	278.76	539.43	301.65	-233.64	840.82
10/11/2005	-1033.08	-827.24	-199.79	654.9	284.17	7.2946	833.72	848.04	-26.29	273.5	537.36	299.33	-240.08	843.25
1/10/2006	-918.83	-858.03	-339.71	489.13	122.55	-48.55	810.18	815.92	-54.94	262.93	536.1	298.82	-234.11	855.77
4/9/2006	-901.14	-812	-289.67	510.35	123.88	-55.75	815.9	831.32	-58.19	267.19	540.25	311.97	-239.53	860
7/19/2006	-975.46	-709.09	-86.84	727.21	303.99	-3.19	876.46	899.71	-33.29	280.02	563.21	306.55	-235.87	865.96
10/18/2006	-1030.45	-848.40	-245.88	609.17	218.59	-17.57	872.05	872.96	-49.65	267.05	557.80	306.95	-246.77	873.58
1/18/2007	-1015.18	-915.62	-363.79	485.63	115.44	-53.84	856.23	849.07	-71.01	257.71	555.06	310.45	-258.05	878.10
4/19/2007	-904.71	-791.93	-272.27	527.72	122.40	-65.28	862.30	869.52	-74.95	259.50	564.85	305.74	-254.07	882.60
7/11/2007	-990.93	-694.73	-72.44	749.91	312.39	-2.99	910.88	934.53	-49.88	269.47	582.93	306.29	-251.96	888.31
10/20/2007	-1018.74	-786.18	-177.53	678.23	265.08	-13.72	915.47	922.26	-57.70	265.45	581.36	309.85	-259.55	895.13
1/7/2008	-932.03	-833.86	-321.36	513.46	112.58	-59.96	880.84	888.07	-82.44	252.01	576.25	309.48	-259.33	899.85
5/13/2008	-996.59	-767.07	-192.33	624.95	201.21	-38.80	905.64	926.40	-76.11	259.32	583.95	312.62	-259.90	906.34
7/29/2008	-1053.77	-718.38	-76.47	765.95	324.25	-0.78	940.74	969.80	-60.05	264.41	595.70	316.01	-256.75	910.18
10/30/2008	-1167.90	-922.92	-282.64	616.39	225.65	-17.33	923.18	942.58	-71.33	250.22	588.42	319.79	-262.90	917.28
1/12/2009	-1034.86	-891.22	-348.32	515.18	122.37	-59.52	897.50	919.11	-89.73	244.09	587.79	315.77	-261.12	920.05
4/24/2009	-1006.70	-789.14	-233.12	597.06	178.13	-48.78	909.07	952.43	-84.81	254.86	599.21	316.70	-258.94	923.92
8/3/2009	-1113.1	-740.6	-87.7	774.1	335.4	6.9	946.7	998.5	-66.3	263.2	610.9	322.9	-259.2	930.6

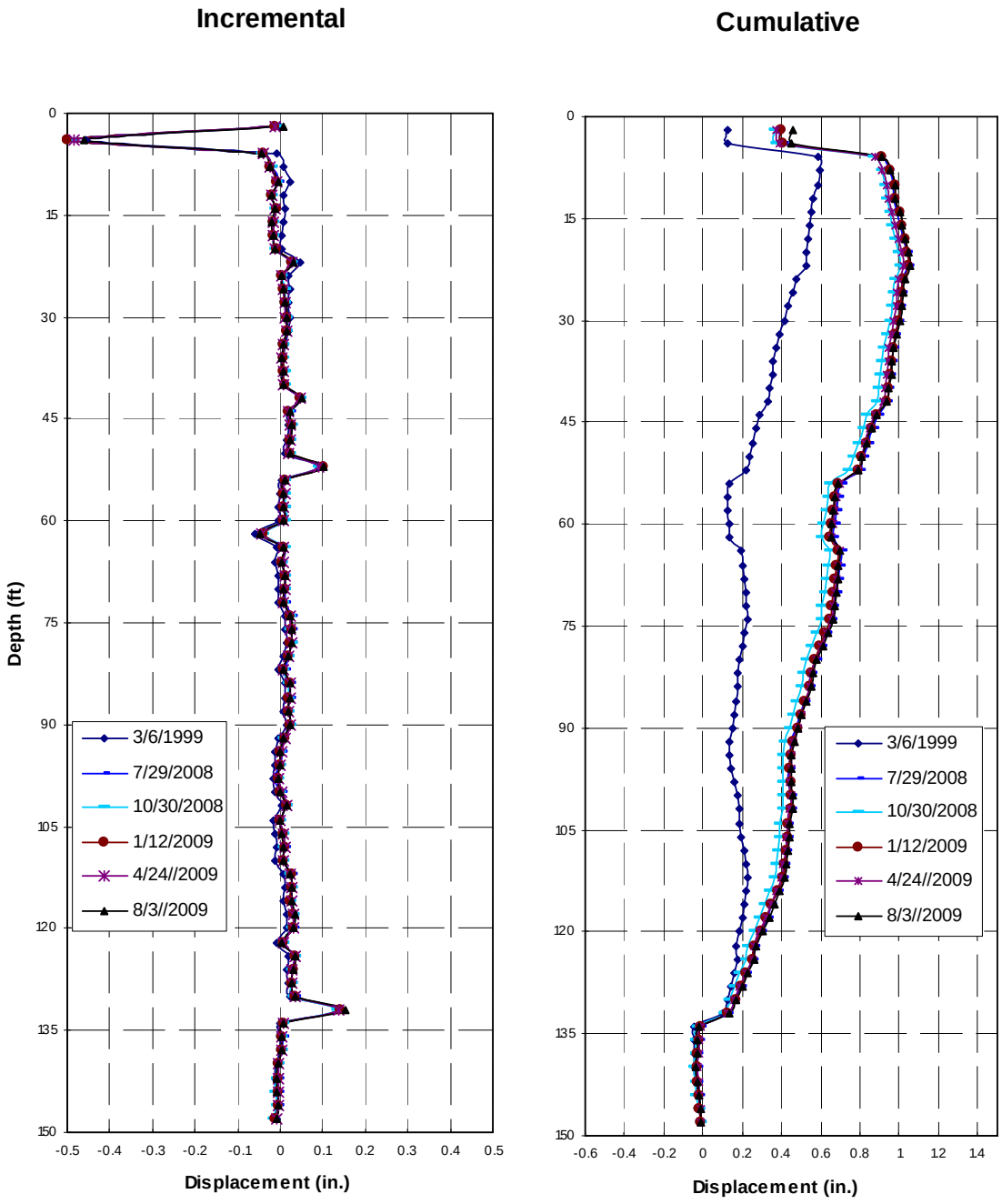
Shaft 9: Bending moment along shaft, kip-ft

Depth, ft / Date	11	17.5	24	30.5	37	43.25	50	60	70	80	95	115	135
7/1/1999	-67.89	-31.81	8.56	12.84	20.8	19.57	14.07	0.61	9.79	11.62	-33.33	18.35	26.3
1/8/2003	-347.44	-803.74	-998.93	-1106.33	-698.39	-903.77	-661.43	-353.18	324.27	-148.11	-1315.52	540.06	541.35
4/15/2003	-592.31	-919.8	-1050.61	-1133.34	-723.59	-939.66	-696.63	-369.12	336.59	-143.51	-1378.77	555.2	549.67
7/1/2003	-666.55	-902.38	-1016.77	-1090.93	-713.88	-914.42	-686.74	-395.16	340.01	-144.29	-1435.98	557.09	553.5
8/7/2003	-687.84	-917.2	-1003.18	-1072.98	-695.58	-886.87	-664.36	-384.64	352	-133.3	-1462.27	566.15	565.69
10/7/2003	-490.45	-863.81	-1007.81	-1107.14	-708.81	-891.63	-656.83	-378.93	360.91	-134.77	-1498.83	577.44	567.18
12/31/2003	-514.68	-913.27	-1054.9	-1163.2	-741.63	-949.18	-697.72	-421.12	390.01	-101.42	-1555.5	633.83	579.35
4/13/2004	-604.44	-966.22	-1090.5	-1188	-761.54	-987.22	-743.54	-446.54	402.54	-82.56	-1609.1	644.77	582.97
7/13/2004	-817.01	-1007.24	-1051.35	-1122.59	-730.91	-933.53	-709.92	-447.66	411.36	-83.06	-1648.19	649.1	585.94
10/8/2004	-674.74	-949.72	-1005.93	-1128.49	-732.6	-927.74	-697.54	-445.16	413.37	-90.78	-1677.71	652.24	581.64
1/7/2005	-572.76	-951.94	-1036.44	-1183	-760.9	-966.49	-718.51	-441.27	424.15	-94.18	-1699.91	657.05	573.07
4/8/2005	-773.86	-1039.72	-1072.89	-1200.56	-775.89	-989.82	-743.85	-446.59	435.56	-92.57	-1726.57	664.45	574.55
7/18/2005	-885.57	-1041.08	-1038.29	-1152.24	-752.36	-948.63	-719.09	-449.39	438.06	-89.12	-1762.02	670.82	576.24
8/26/2005	-835.5	-1020.01	-1028.45	-1146.98	-746.96	-933.35	-702.48	-447.31	442.02	-86.41	-1773.96	672.92	595.07
10/11/2005	-749.53	-997.4	-1026.45	-1157.47	-750.11	-932.26	-695.29	-445.61	446.57	-84.01	-1786.07	677.93	594.21
1/10/2006	-735.54	-1025.94	-1070.26	-1220.95	-784.71	-983.06	-728.35	-455.6	455.8	-79.41	-1811.1	694.94	585.21
4/9/2006	-761.63	-1055.46	-1104.66	-1250.13	-799.79	-1009.4	-750.25	-456.86	465.33	-75.95	-1830.39	709.25	584.13
7/19/2006	-986.65	-1097.57	-1069.44	-1182.51	-765.49	-967.32	-726.98	-458.20	468.35	-67.36	-1860.26	728.74	591.17
10/18/2006	-785.55	-1028.56	-1059.04	-1198.03	-770.44	-962.79	-714.95	-455.21	472.24	-63.08	-1878.38	742.33	587.52
1/18/2007	-652.26	-1012.08	-1093.82	-1249.92	-798.31	-1001.31	-738.72	-453.20	481.92	-62.15	-1891.06	749.16	583.45
4/19/2007	-878.81	-1101.41	-1131.14	-1269.03	-817.30	-1023.35	-760.98	-458.74	484.61	-55.95	-1908.23	757.20	587.07
7/11/2007	-1020.68	-1113.23	-1096.67	-1211.04	-787.54	-982.11	-738.79	-463.61	490.76	-47.79	-1930.33	760.68	591.55
10/20/2007	-959.39	-1084.45	-1073.44	-1199.41	-780.45	-961.01	-714.61	-460.69	495.15	-40.84	-1949.93	755.58	587.47
1/7/2008	-913.31	-1106.23	-1119.18	-1262.45	-816.00	-1007.26	-741.89	-466.44	500.87	-33.08	-1965.87	755.43	582.76
5/13/2008	-919.37	-1116.30	-1144.79	-1275.67	-828.86	-1025.45	-760.98	-473.48	501.61	-23.44	-1981.23	753.14	584.24
7/29/2008	-1028.17	-1130.81	-1113.35	-1223.79	-801.01	-987.62	-739.09	-483.79	512.25	-5.89	-2001.20	757.38	590.22
10/30/2008	-795.34	-1059.58	-1112.41	-1254.85	-817.39	-995.34	-732.06	-493.84	517.37	5.70	-2022.36	758.24	590.22
1/12/2009	-836.22	-1106.04	-1150.74	-1297.76	-843.09	-1034.72	-761.65	-500.28	517.27	10.26	-2032.78	756.89	590.85
4/24/2009	-934.29	-1139.31	-1176.94	-1312.72	-852.96	-1055.92	-785.35	-508.19	520.21	14.73	-2038.11	752.38	597.26
8/3/2009	-1070.48	-1160.32	-1134.36	-1237.86	-817.86	-1008.41	-748.97	-512.81	531.72	22.57	-2057.15	752.54	604.10

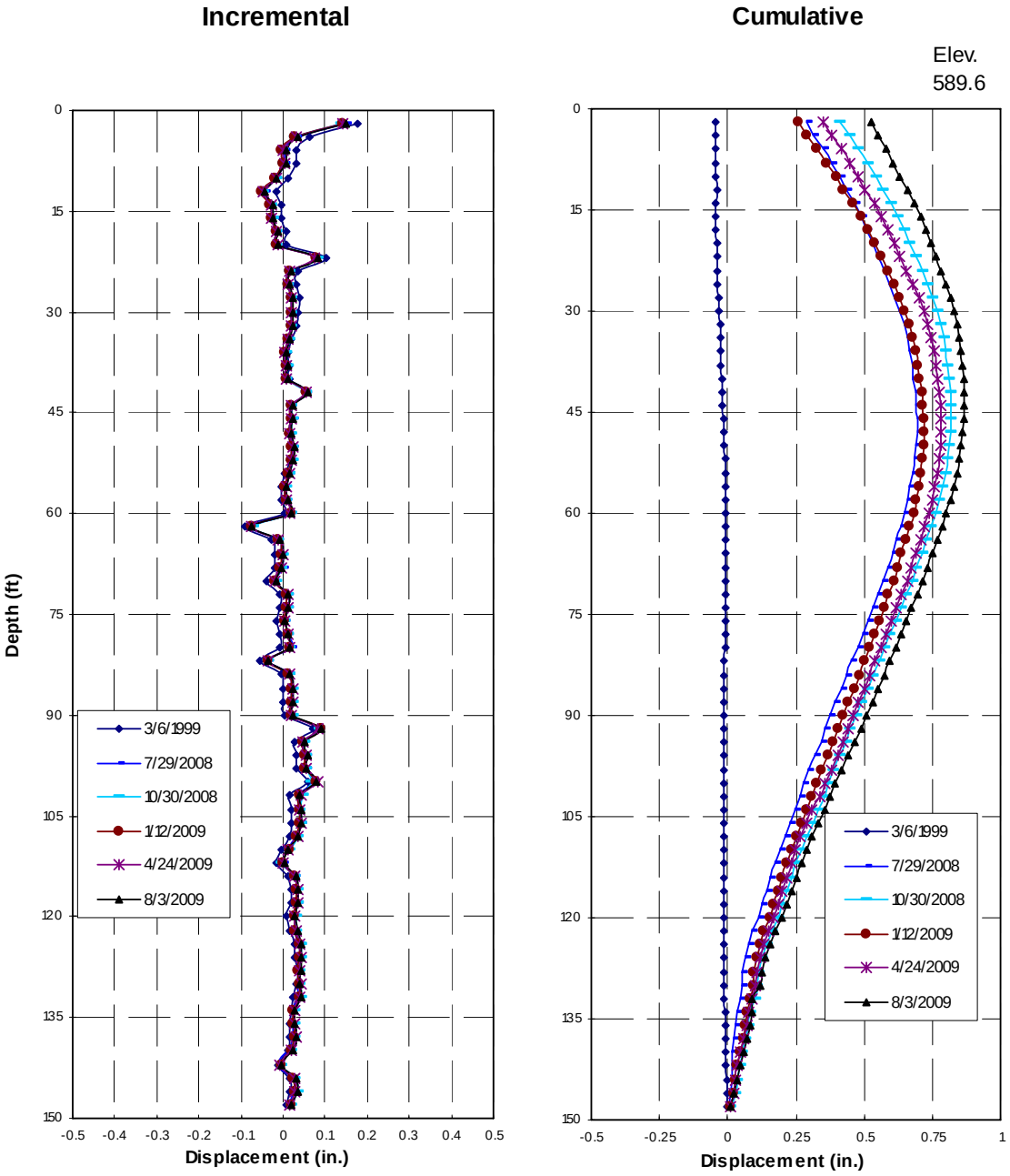
Inclinometer #1 Displacement in the A+ Direction
Downslope (Toward River direction) Base Line 12/11/1998



Inclinometer #3 Displacement in the A+ Direction
Downslope (Toward river direction) Base Line 12/11/1998

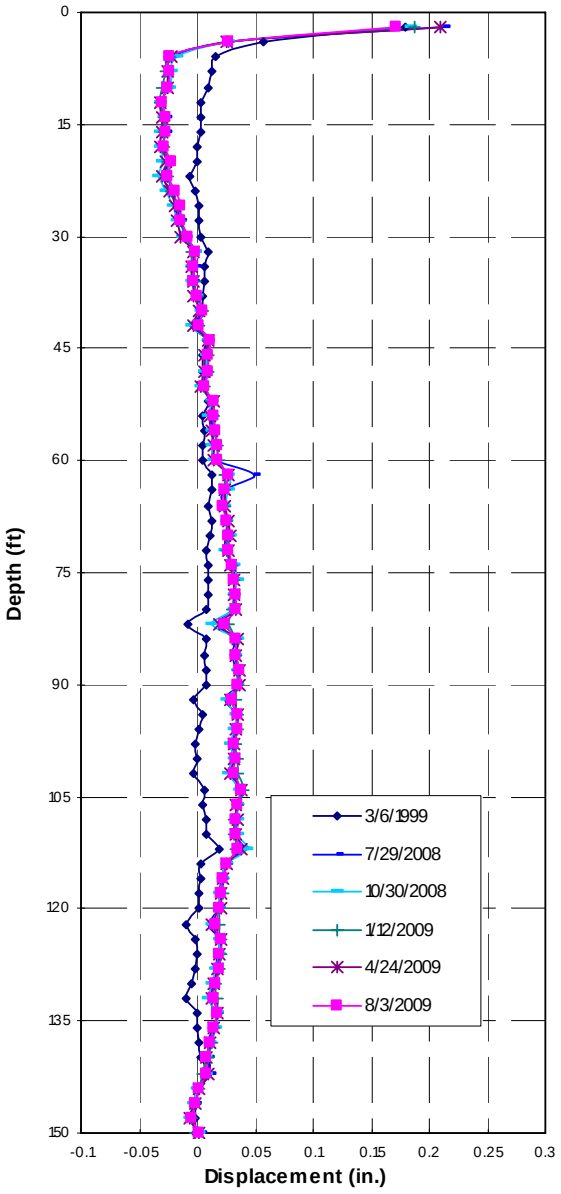


Inclinometer #8 Displacement in the A+ Direction
Downslope (Toward River direction) Base Line 12/11/1998

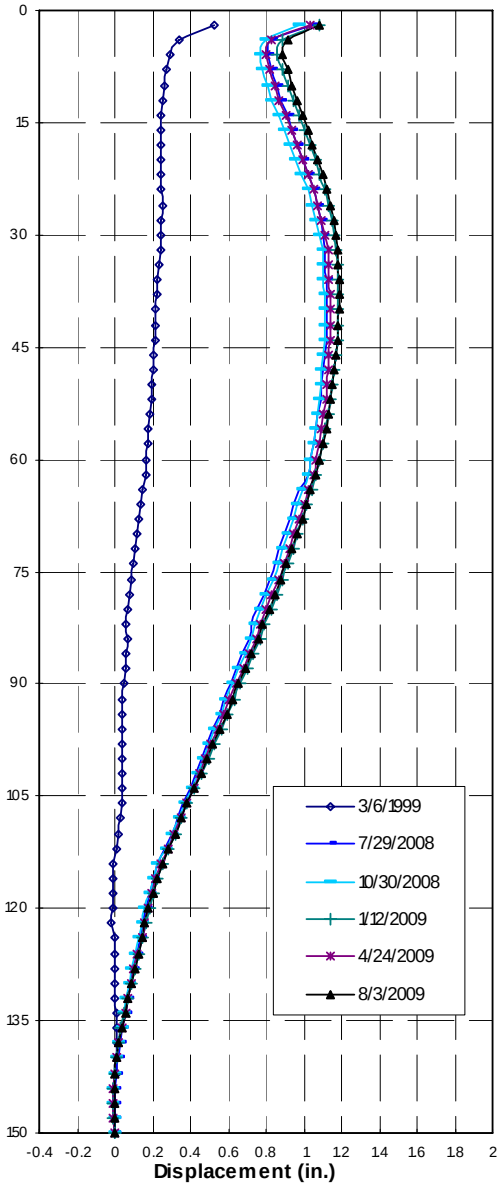


Inclinometer #9A Displacement in the A+ Direction
Downslope (Toward River direction) Base Line 12/11/1998

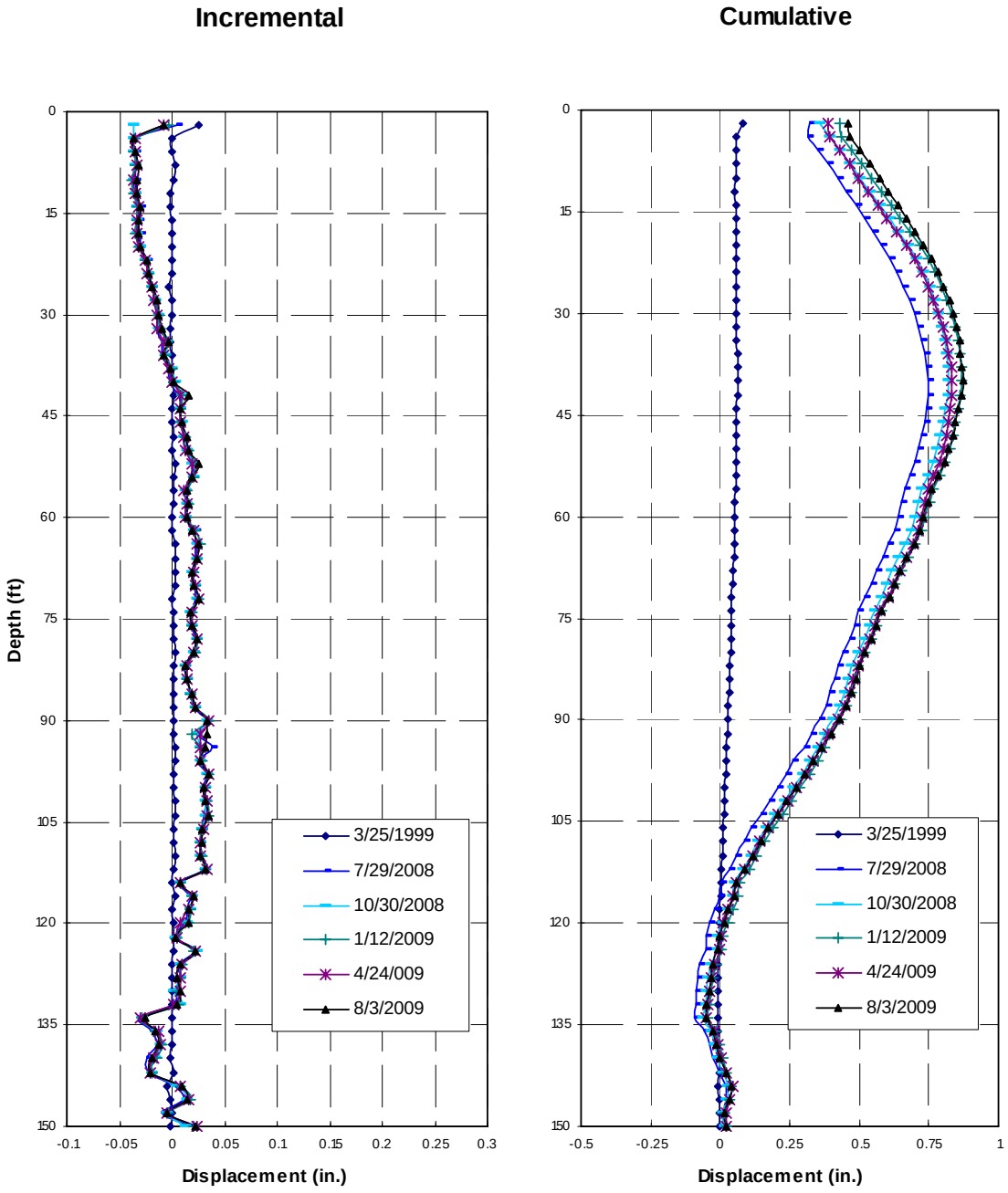
Incremental



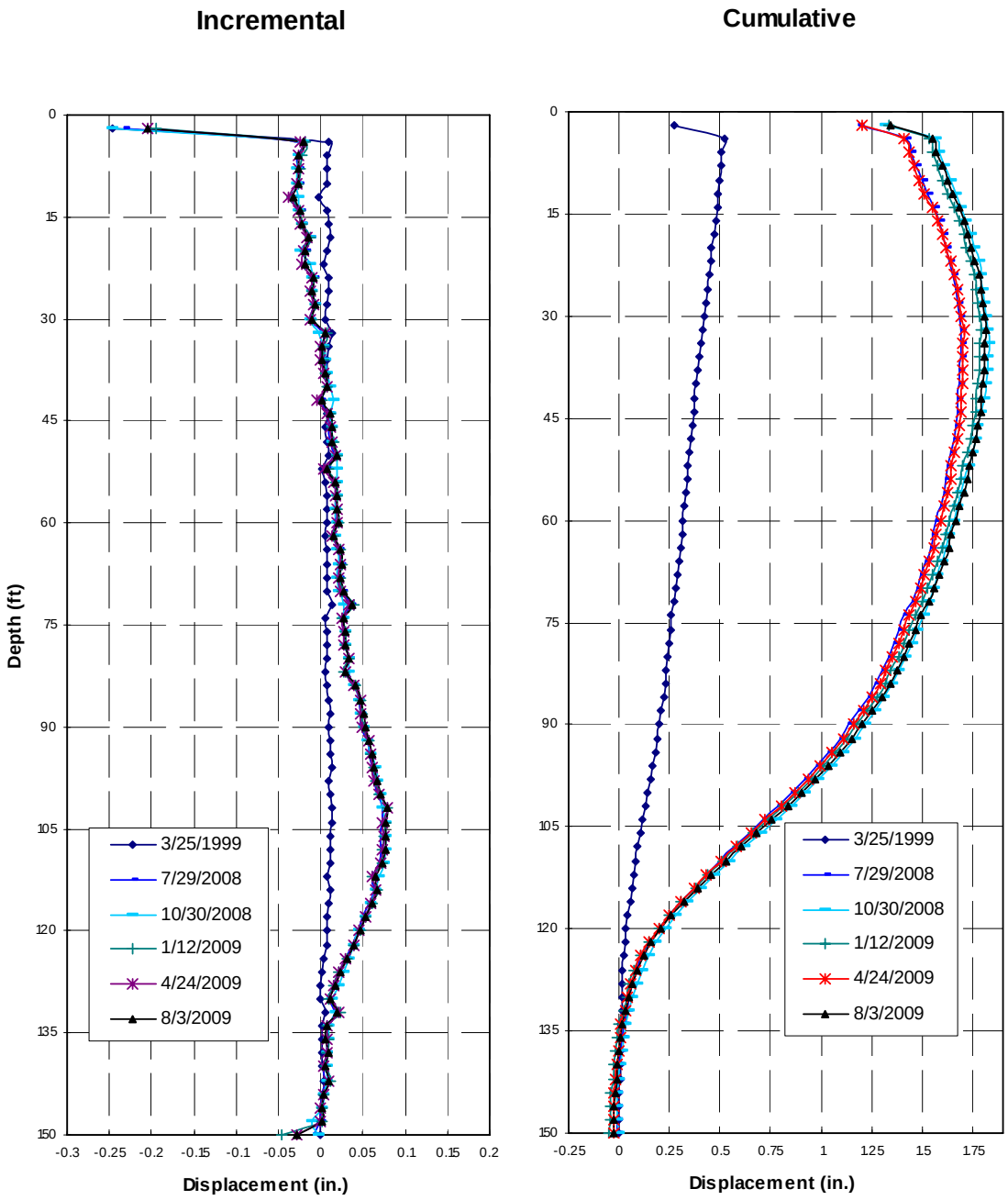
Cumulative



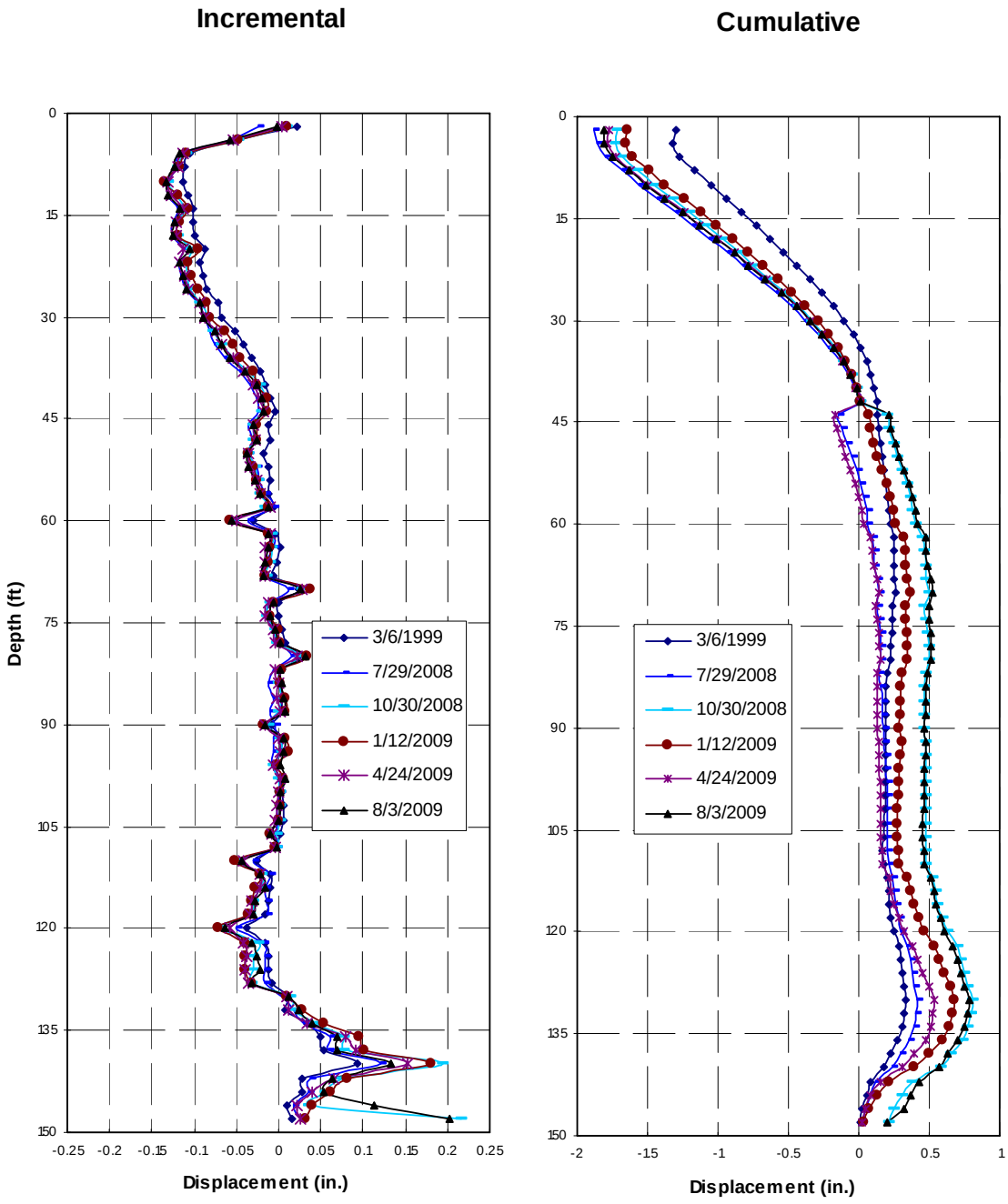
Inclinometer #10 Displacement in the A+ Direction
Downslope (Toward river direction) Base Line 12/11/1998



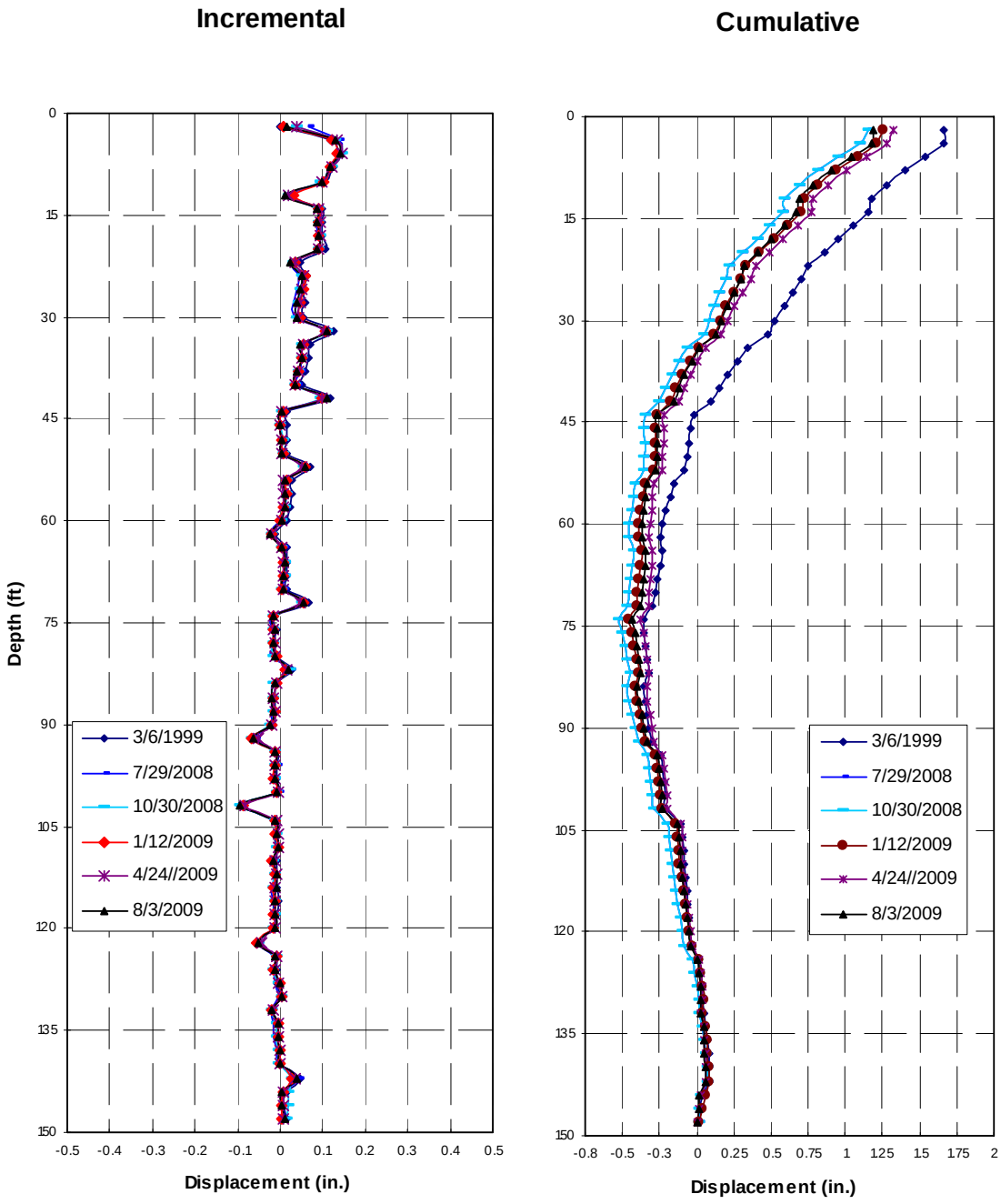
Inclinometer #17 Displacement in the A+ Direction
Downslope (Toward river direction) Base Line 12/11/1998



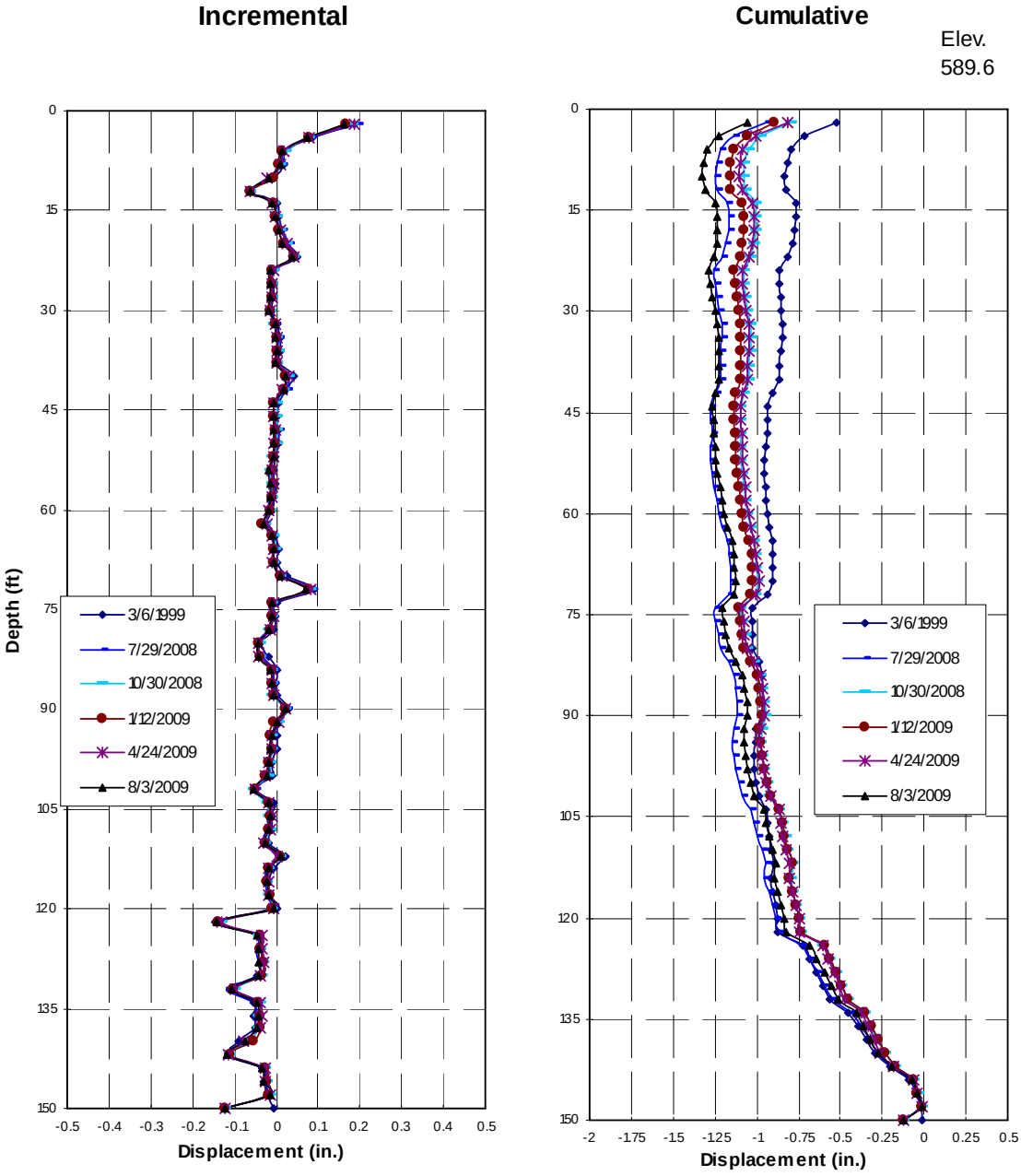
Inclinometer #1 Displacement in the B+ South Direction
(90 Deg Clockwise from A+direction) Base Line 12/11/1998



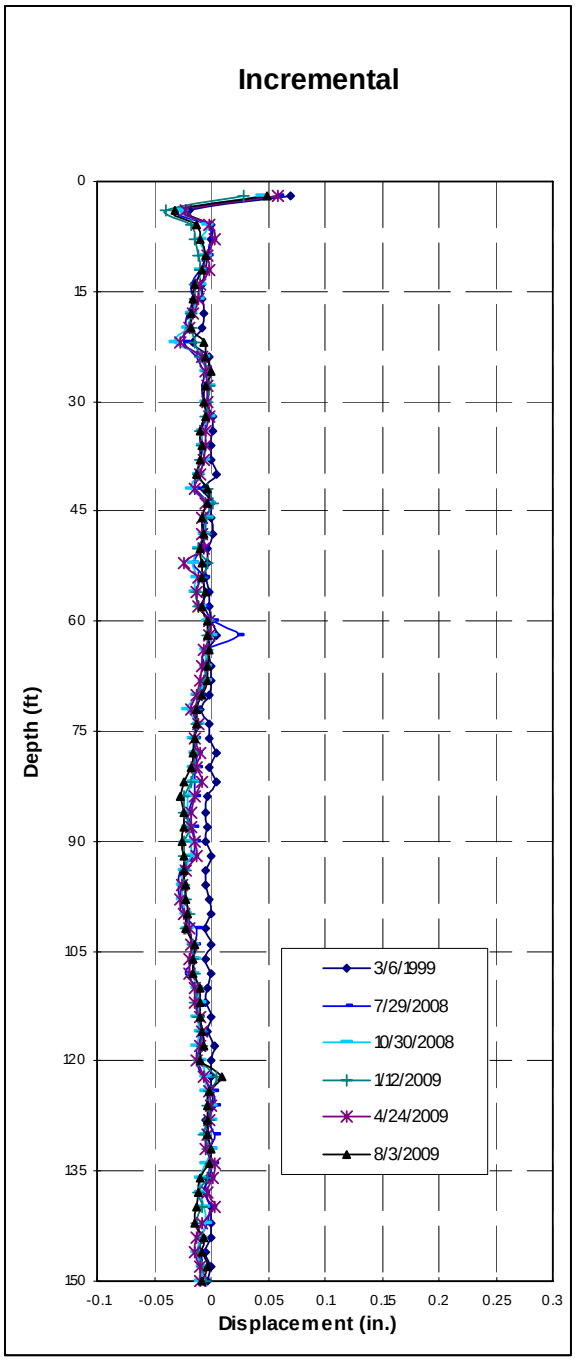
Inclinometer #3 Displacement in the B+ South Direction
(90 Deg Clockwise from A+direction) Base Line 12/11/1998

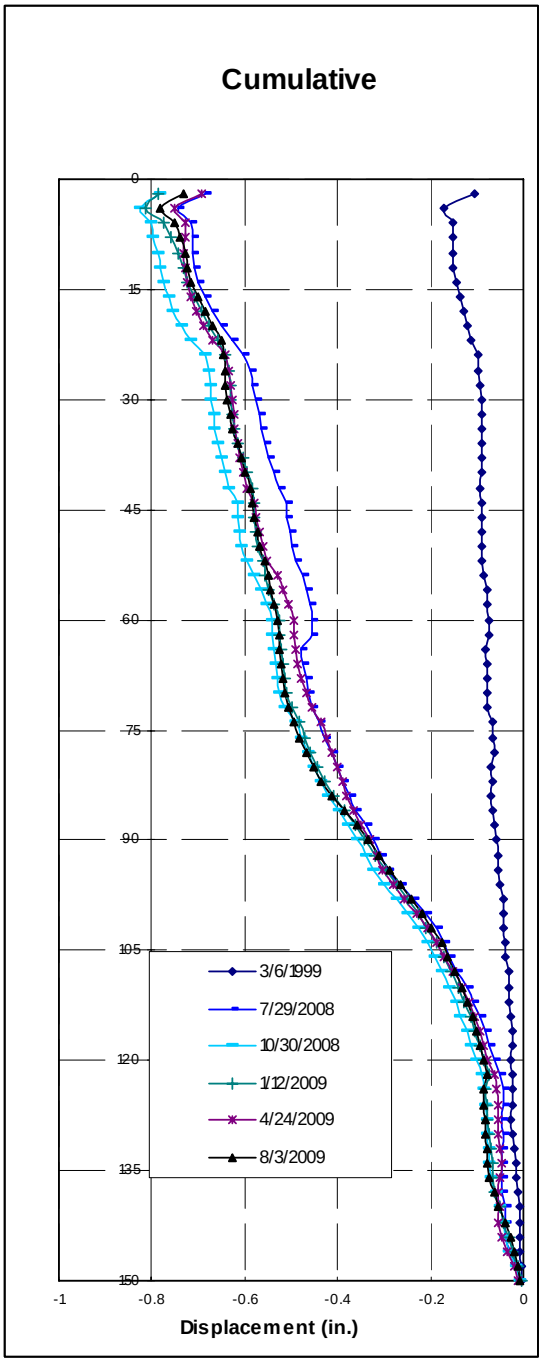


Inclinometer #8 Displacement in the B+ South Direction
(90 Deg Clockwise from A+ direction) Base Line 12/11/1998

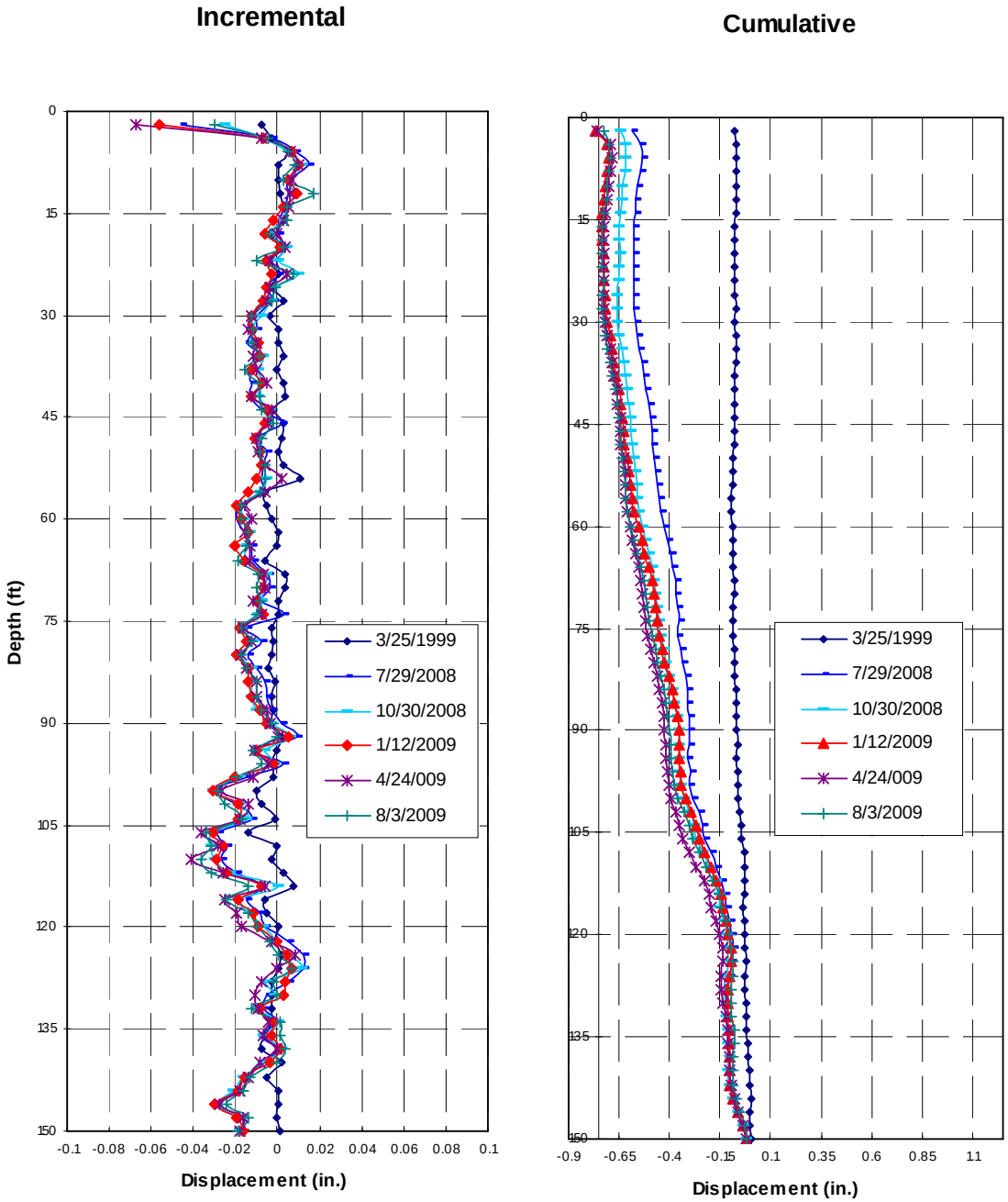


Inclinometer #9A Displacement in the B+ South Direction
(90 Deg Clockwise from A+ Direction) Base Line 12/11/1998

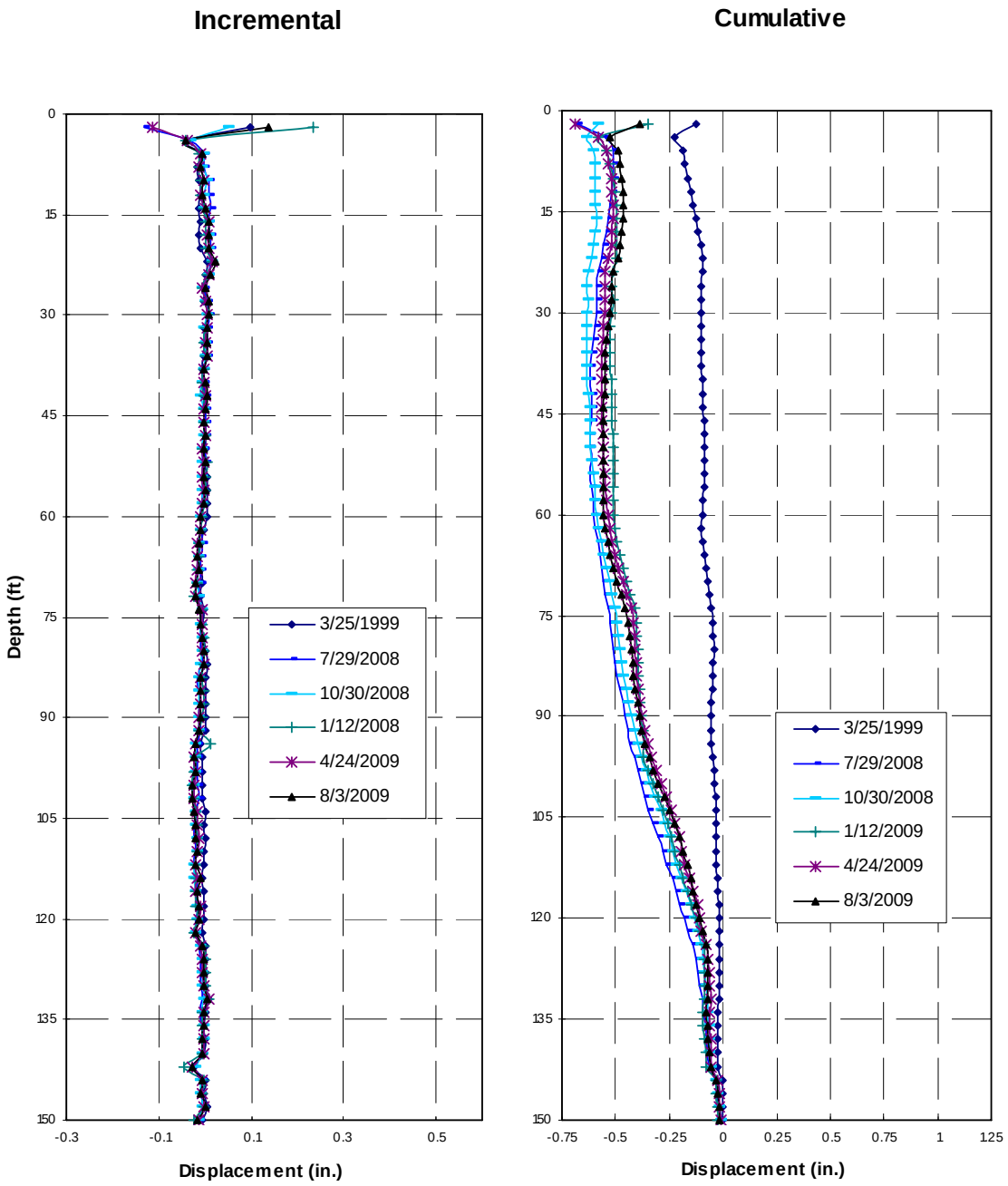




Inclinometer #10 Displacement in the B+ South Direction
(90 Deg Clockwise from A+direction) Base Line 12/11/1998



Inclinometer #17 Displacement in the B+ South Direction
(90 Deg Clockwise from A+direction) Base Line 12/11/1998



OCTOBER 2009 QUARTERLY REPORT
FIELD MONITORING SERVICES
CUY-90-14.52/15.24
PID #77332
CLEVELAND, OHIO

Report to

RICHLAND ENGINEERING LIMITED
MANSFIELD, OHIO

Prepared by

BBC&M ENGINEERING, INC.
CLEVELAND, OHIO

December 2009

December 1, 2009
012-00946-300

Mr. Dean A. Palmer, P.E.
Richland Engineering Limited
29 North Park Street
Mansfield, Ohio 44902

Re: CUY-90-14.52/15.24 Bridge (PID No. 77332)
Quarterly Report - Field Monitoring Services
October 2009 (Fourth Quarter)

Dear Mr. Palmer:

BBC&M Engineering, Inc. (BBCM) has completed the field monitoring services for the October 2009 quarter as part of the CUY-90-14.52/15.24 project. This quarterly report presents our general site observations and the results and evaluation of data collected from all the actively monitored instrumentation (inclinometers, piezometers and calipered distance locations) installed by BBCM at or near the West Abutment of the existing I-90 Central Viaduct Bridge.

A total of 19 inclinometers, six (6) pneumatic piezometers and 18 vibrating wire (VW) piezometers are actively monitored as part of the project. A Summary Table and Site Plan of Active Instrumentation are submitted as Plates 1 and 2 of the Appendix. Quarterly readings were taken during the period of October 19 through October 23, 2009.

Inclinometers

All the data sets presented in the Appendix have been corrected for measured spiral of the inclinometer casings and for systematic errors such as bias-shift, sensor rotation and depth positioning error, where necessary. The rates of movements were computed using linear regression for the depth ranges shown on the Displacement vs. Time plots in the Appendix.

No significant changes in the rates of movements were observed in the inclinometers between the July 2009 and October 2009 quarterly readings with the exception of the cantilever displacement observed in the inclinometer at B-105A (subsequently discussed).

Shallow Failure Plane

No shallow slip-plane movements have been observed in the inclinometers within the Pier 1 stabilization system (B-204 and B-05-04) since completion of construction of the

stabilization system. In the vicinity of Pier 1 just outside of the stabilization system (B-05-03 and B-108A), the shallow failure plane is continuing to move at an average rate of about 0.07 inches per year (in/yr) from 2006 to the present. Upslope from Pier 1 (B-203, B-303, and B-05-02), the shallow failure plane is continuing to move at an average rate of about 0.02 in/yr from 2004 to the present.

Well outside the Pier 1 Area (B-05-16), the shallow failure plane is moving at an average rate of about 0.15 in/yr from 2006 to the present. This is a slight decrease from the rate of 0.16 in/yr as reported in BBCM's July 2009 Quarterly Report, dated August 7, 2009. Additionally, the rate of the shallow movement in B-05-16 has decreased to about 0.10 in/yr from January 2007 to the present. The rate decreases in B-05-16 are largely due to the fact that there appears to be minimal change in the cantilever displacement observed from a depth of 3 to 11 feet since October 2007 (see Plate 51 in the Appendix).

Deep Failure Plane

South of the West End Pier (B-102 and B-107), the deep failure plane continues to move at an average rate of about 0.03 in/yr from around 2000 to the present. In the Pier 1 area (B-203, B-204, B-303, B-105A, B-108A, B-05-02, B-05-03 and B-05-04), the deep failure plane continues to move at an average rate of about 0.03 in/yr from 2004 (or 2006 for new or replacement inclinometers) to the present. Well outside the Pier 1 area (B-05-16), the deep failure plane continues to move at an average rate of 0.02 in/yr.

Additional Observations in Active Inclinometers Installed between 1994 and 1999

The B-101 inclinometer has indicated nominal movement since its installation. The inclinometer at P-9N (installed in one of the drilled shafts) indicates the top of the drilled shaft is restrained laterally and that the maximum lateral deflection is about one (1) inch and occurs approximately 40 to 60 feet below the top of the inclinometer casing.

The inclinometer at B-303 may need to be abandoned soon due to the "kink" in the inclinometer casing at a depth of about 95 feet. It has become somewhat difficult both to lower and raise the probe and obtain consistent readings at this depth of 95 feet.

Additional Observations in Active Inclinometers Installed in 2006

From about October 2007 to January 2009, the cantilever displacement observed in B-105A to a depth of about 60 to 70 feet (see Plates 22 and 23 in the Appendix) significantly increased from a rate of about 0.16 in/yr to about 1.32 in/yr. From January 2009 to July 2009, the rate decreased significantly to about 0.05 in/yr. Between July 2009 and October 2009, the rate of movement again increased as a cantilever displacement of just over 0.25 inches was observed. It is believed that the bulkhead at this location may be progressively leaning outwards toward the Cuyahoga River. A Displacement vs. Time plot for B-105A has been submitted as Plate 26 in the Appendix.

Discussion of Slope Movement Rate Changes

Table 1 below summarizes the changes in the rates of movement that have been observed in five (5) of the inclinometers.

Table 1: Summary of Rate Changes in Some Inclinometers – CUY-90-14.52/15.24

Inclinometer	Failure Plane	Time Ranges Evaluated	Avg. Rate of Movement within Time Range (in/yr)	Percentage Increase in the Avg. Rate of Movement of Time Range #2 Compared to Time Range #1 (%)
B-204	Deep (117'-119')	#1 - Jan 04 - Apr 08	0.025	--
		#2 - Apr 08 – Oct 08	0.065	160
		#3 - Oct 08 – Oct 09	Negligible/Negative[1]	--
B-303	Deep (95'-99')	#1 - Jan 04 – Apr 08	0.03	--
		#2 - Apr 08 – Oct 08	0.095	217
		#3 - Oct 08 – Oct 09	Negligible/Negative[1]	--
B-05-03	Shallow (35'-39')	#1 - Jun 06 – Apr 08	0.075	--
		#2 - Apr 08 – Oct 08	0.30	300
		#3 - Oct 08 – Oct 09	0.065	--
	Deep (123'-125')	#1 - Jun 06 – Apr 08	0.03	--
		#2 - Apr 08 – Oct 08	0.23	667
		#3 - Oct 08 – Oct 09	0.06	--
B-05-04	Deep (117'-119')	#1 - Jun 06 – Apr 08	0.015	--
		#2 - Apr 08 – Oct 08	0.055	267
		#3 - Oct 08 – Oct 09	0.015	--
B-105A	Deep (105'-111')	#1 - Jun 06 – Oct 07	0.015	--
		#2 - Oct 07 – Jan 09	0.065	333
		#3 - Jan 09 – Oct 09	0.04	--

* The rate of movement is either negative, which is not realistic, or negligible. Time Range #3 is based only on 4 to 5 quarterly readings. Several more readings are needed to better define the current rate of movement. As such, negligible/negative rates of movements may be caused by the limitations of the accuracy of the instrumentation.

Based on the reported rates of movements for Time Range #3 in Table 1, it appears that the trend of decreased rates of movements has continued to the present in the five (5) inclinometers listed in the table. These inclinometers are located underneath or east of the existing I-90 bridge near the east right-of-way fence where aggregate piles of variable sizes have been stored for many years and where the bulkhead appears to be moving outward (adjacent to B-105A). It appears that the rate increases observed previously (Time Range #2 in Table 1) were a short term occurrence.

Piezometers

Pneumatic Piezometers

The results of the active pneumatic piezometer readings taken on October 19 and 20, 2009 are summarized in Table 2 below.

Table 2: Summary of Readings for Active Pneumatic Piezometers – CUY-90-15.24

Piezometer Identifier		Ground Surface Elevation (ft)	Elevation Head, h_e (ft)	Pore Pressure Reading, u (psi)	Total Head, h_t (ft)
B-101 (P-1*)	orange	676.6	626.3	0.4	627.2
	pink	676.6	552.3	32.1	626.4
B-105 (P-3*)	pink	585.6	497.6	38.4	586.2
	blue	585.6	479.9	48.1	590.9
B-107 (P-5*)	orange	662.3	562.3	25.1	620.2
B-303 (P-2*)	pink	627.0	586.2	7.0	602.4

*BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers.

The piezometers at B-101 pink, B-105 pink, B-107 and B-303 exhibited slightly lower readings than those recorded in July 2009, whereas the piezometers at B-101 orange and B-105 blue exhibited slightly higher readings. Note that the piezometers at B-105 continue to indicate elevated water pressures (i.e., a total head above the ground surface, artesian conditions). Total Head vs. Time plots have been submitted as Plates 52 through 55 in the Appendix of this report.

Vibrating Wire (VW) Piezometers

Table 3 on the next page provides a summary of the maximum and minimum values of all the pressure readings taken from July 2009 (end of previous reporting period) to the time when the collected data was last downloaded from VW Miniloggers between October 19 and 22, 2009.

The measured total head values were relatively constant during the current reporting period with total head values changing no more than 2.0 feet in all the VW piezometers except at B-05-01 (discussed subsequently). In two of the VW piezometers (86126T at B-05-02 and 86135T at B-05-12), readings were only taken at the time of download in October 2009. At 86126T, it was determined that a faulty battery was the cause of scheduled readings being missed by the Minilogger. At 86135T, the batteries appeared to be functioning. Therefore, it was likely that the 21964 Minilogger at B-05-12 malfunctioned as it has in the past and we recommend that it be replaced. Total Head vs. Time plots have been submitted as Plates 56 through 64 in the Appendix.

Table 3: Summary of Readings for VW Piezometers – CUY-90-14.52

Piezometer Identifier		Time Interval of Readings Reported [1]	Max./Min. Temp. Rdg. (°C)	Ground Surface Elev. (ft)	Elev. Head, h_e (ft)	Max./Min. Pore Pressure Rdg., u (psi)	Max./Min. Total Head, h_t (ft)
B-05-01	86124T - 65 ft	7/17/09 to 10/19/09	12.8/12.6	675.4	610.4	13.4/12.2	641.4/638.5
	86125T - 95 ft	7/17/09 to 10/19/09	13.1/13.1	675.4	580.4	24.7/23.7	637.3/635.1
B-05-02	86126T - 46 ft	10/21/09[2]	12.0[2]	617.9	571.9	8.2[2]	590.8[2]
	86127T - 122 ft	7/21/09 to 10/21/09	12.2/12.2	605.1	573.1	40.7/40.2	589.7/588.7
B-05-03	86128T - 32 ft	7/20/09 to 10/21/09	11.3/11.0	605.1	573.1	8.1/7.3	591.9/589.9
	86129T - 112 ft	7/20/09 to 10/21/09	12.5/12.5	605.1	493.1	41.7/40.9	589.4/588.1
B-05-04	86130T - 59 ft	7/20/09 to 10/22/09	12.8/12.7	600.8	541.8	18.0/17.5	583.5/582.3
	86131T - 119 ft	7/20/09 to 10/22/09	12.9/12.9	600.8	481.8	45.0/44.8	585.7/585.3
B-05-07	86455T - 102 ft	7/17/09 to 10/20/09	12.4/12.4	678.9	576.9	24.5/24.0	633.4/632.3
	86456T - 220 ft	7/17/09 to 10/20/09	12.0/11.9	678.9	458.9	71.9/71.5	624.9/623.9
B-05-08	86132T - 65.5 ft	7/17/09 to 10/19/09	12.6/12.6	679.9	614.4	12.8/12.2	643.9/642.6
	86133T - 110.5 ft	7/17/09 to 10/19/09	12.4/12.3	679.9	569.4	29.8/29.3	638.2/637.1
B-05-11	86457T - 95 ft	7/17/09 to 10/21/09	12.7/12.7	675.1	580.1	24.1/23.6	635.7/634.6
	86458T - 130 ft	7/17/09 to 10/21/09	12.6/12.6	675.1	545.1	37.0/36.5	630.5/629.4
B-05-12	86134T - 75 ft	7/20/09 to 10/21/09	12.8/12.7	652.7	577.7	18.9/18.4	621.3/620.2
	86135T - 120 ft	10/21/09[3]	12.5[3]	652.7	532.7	37.2[3]	618.4[3]
B-05-13	86459T - 60 ft	7/21/09 to 10/22/09	12.6/12.6	580.0	520.0	24.7/24.2	576.9/575.9
	86460T - 135 ft	7/21/09 to 10/22/09	12.7/12.7	580.0	445.0	60.5/60.4	584.7/584.3

1 – Readings generally were taken automatically every 8 hours during the reported time interval.
2 – Due to a faulty battery, no readings were taken during the reported time interval. Readings were only taken at the time of download in October 2009.
3 – Due to a malfunction of Minilogger, no readings were taken during the reported time interval. Readings were only taken at the time of download in October 2009. The Minilogger will likely need to be replaced.

The 86460T piezometer in B-05-13 continues to indicate an elevated water pressure (i.e., a total head above the ground surface, artesian conditions) similar to that observed in the pneumatic piezometers at B-105 previously discussed. Between August 3 and August 11, 2009, the Miniloggers for the 86124T and 86125T piezometers at B-05-01 recorded pressure decreases of 1.23 psi and 0.96 psi, respectively, which corresponds to a decrease in total head of 2.8 feet and 2.2 feet. The pressures measured by both

piezometers began to gradually increase again between August 11 and August 24, 2009 to levels such that the total head measured in both piezometers was within 0.4 to 0.5 feet of the total head values recorded prior to relatively sudden pressure decrease. The Total Head vs. Time plot shown on Plate 56 in the Appendix illustrates these changes. This rapid pore pressure change has not been observed in these B-05-01 piezometers since the summer of 2006 when the piezometers were first installed. It is unknown what may have been the cause of the sudden pore pressure changes at B-05-01 as the piezometers were installed well above the elevation of the shale bedrock where natural gas has been known to accumulate at other locations within the project area. Also, distinct slope movements have not yet been observed in the inclinometer at B-05-01.

Additional Field Measurements and Observations

The two calipered surface distance locations (left and right) are provided in the Site Plan of Active Instrumentation (Plate 2 of the Appendix). A Calipered Surface Distance Table and Calipered Distance Readings vs. Time plots have been included as Plates 65 through 67 in the Appendix. The left calipered location indicates the gap is continuing to open at a rate of about 0.05 in/yr. The gap at the right calipered location is closing at a rate of about 0.015 in/yr. This is a slight decrease in the rate of about 0.02 in/yr as reported in BBCM's July 2009 Quarterly Report. The right calipered location has been oscillating above and below a distance of about 4.4 inches since late 2000 indicating that there might not be a trend.

In October 2009, the aggregate piles were similar in size and location to those observed in July 2009. An aggregate pile roughly 25 to 30 feet high was observed within 15 feet of the east right-of-way fence and covered roughly less than 50 percent of the adjacent property (see Plates 68 through 70). A smaller aggregate pile was observed near the east end of the property as shown in the photo submitted as Plate 70 in the Appendix.

The large excavation and the repair effort of the bulkhead near the west right-of-way fence appear to remain unfinished as of October 2009. The small landslide adjacent to the large excavation near the west right-of-way fence (just north of B-05-16, see Plate 2 in the Appendix for the approximate landslide location) does not appear to have experienced a significant change since the quarterly readings were last taken in July 2009. However, it was difficult to visually observe the scarps on the slope due to the heavy vegetation throughout the landslide area.

Personnel and construction equipment from Kokosing Construction Company, Inc. was onsite removing the exterior lanes from the existing I-90 Central Viaduct Bridge while BBCM personnel were taking readings in October 2009.

Closing

We appreciate being of continued service during this project. Please contact our office if you have any questions or require additional information. Our current monitoring contract is set to expire at the end of 2009. Therefore, no future readings are planned to be performed by BBCM.

Sincerely,
BBC&M ENGINEERING, INC.
Cleveland, Ohio

Jeffrey L. Snyder, P.E.
Project Engineer

Stephen C. Pasternack, P.E.
Senior Project Engineer

cc: Mr. Jeff Broadwater, P.E. (Michael Baker Jr., Inc.)

Submitted: pdf copy submitted to Richland Engineering at reltd@r-e-l.com and Michael Baker Jr., Inc. via their ftp site
Attachments: Appendix (Plates 1 through 70)

APPENDIX

CUY-90-14.52/15.24 INSTRUMENTATION MONITORING

APPENDIX

Plate No.

General Information

Summary Table of Active Instrumentation.....1
Site Plan of Active Instrumentation.....2

Plots for Active BBCM Inclinometers Installed from 1994 to 1999–CUY-90-15.24

Cumulative and Incremental Displacement versus Depth Plots

B-101 – A and B-Axis.....3-4
B-102 – A and B-Axis.....5-6
B-107 – A and B-Axis.....7-8
B-203 – A and B-Axis.....9-10
B-204 – A and B-Axis.....11-12
B-303 – A and B-Axis.....13-14
P-9N – A and B-Axis.....15-16

Displacement versus Time Plots

B-102 – A-Axis.....17
B-107 – A-Axis.....18
B-203 – A-Axis.....19
B-204 – A-Axis.....20
B-303 – A-Axis.....21

Plots for Replacement Inclinometers Installed by BBCM in 2006 – CUY-90-15.24

Cumulative and Incremental Displacement versus Depth Plots

B-105A – A and B-Axis.....22-23
B-108A – A and B-Axis.....24-25

Displacement versus Time Plots

B-105A – A-Axis.....26
B-108A – A-Axis.....27

Plots for Inclinometers Installed by BBCM in 2006 – CUY-90-14.52

Cumulative and Incremental Displacement versus Depth Plots

B-05-01 – A and B-Axis.....28-29
B-05-02 – A and B-Axis.....30-31
B-05-03 – A and B-Axis.....32-33
B-05-04 – A and B-Axis.....34-35
B-05-07 – A and B-Axis.....36-37
B-05-08 – A and B-Axis.....38-39
B-05-11 – A and B-Axis.....40-41

APPENDIX (continued)

Plate No.

B-05-12 – A and B-Axis.....42-43
B-05-13 – A and B-Axis.....44-45
B-05-16 – A and B-Axis.....46-47

Displacement versus Time Plots
B-05-02 – A-Axis.....48
B-05-03 – A-Axis.....49
B-05-04 – A-Axis.....50
B-05-16 – A-Axis.....51

Plots for Active Pneumatic Piezometers Installed by BBCM in 1994 – CUY-90-15.24

Total Head (h_t) versus Time Plots
B-101 (P-1).....52
B-105 (P-3).....53
B-107 (P-5).....54
B-303 (P-2).....55

Plots for Vibrating Wire (VW) Piezometers Installed by BBCM in 2006 – CUY-90-14.52

Total Head (h_t) versus Time Plots
B-05-01.....56
B-05-02.....57
B-05-03.....58
B-05-04.....59
B-05-07.....60
B-05-08.....61
B-05-11.....62
B-05-12.....63
B-05-13.....64

Calipered Surface Distance Data – CUY-90-15.24

Calipered Surface Distance Table.....65
Calipered Distance Readings versus Time Plot - Left Calipered Location.....66
Calipered Distance Readings versus Time Plot - Right Calipered Location.....67

Site Photos

Aggregate Piles Adjacent to East Right-of-Way Fence.....68-70

SUMMARY OF ACTIVE INSTRUMENTATION
CUY-90-14.52/15.24

Active Instrumentation	Active Inclinometer ?	Inclinometer Depth (ft)	Active Piezometer?	VW or Pneumatic?	# of Active Piezometers	Piezometer Depth(s) Below Existing G.S. (ft)	Instrumentation Installation Date	G.S. Elevation (ft)
B-101	Y	190	Y[1]	Pneumatic[1]	2 [1]	50.3, 124.3	Aug-Sep 1994	676.6 (676.6[3])
B-102	Y	224	N	---	---	---	Sep 1994	675.7
B-105	N	---	Y[1]	Pneumatic[1]	2 [1]	88, 105.7	Aug 1994	585.4 (585.6[3])
B-105A	Y	156	N	---	---	---	May 2006	585.7
B-107	Y	210	Y[1]	Pneumatic[1]	1 [1]	100	Sep 1994	662.7 (662.3[3])
B-108A	Y	168	N	---	---	---	Apr-May 2006	603.0
B-203	Y	190	N	---	---	---	Aug 1996	638.0
B-204	Y	134	N	---	---	---	Jul 1998	599.0
B-303	Y	178	Y[2]	Pneumatic[2]	1 [2]	40.8	Aug 1994[2], Jul 1998	622.0 (627.0[3])
P-9N	Y	148	N	---	---	---	Feb 1999	588.0
B-05-01	Y	228	Y	VW	2	65, 95	Apr-May 2006	675.4
B-05-02	Y	176	Y	VW	2	46, 122	Apr-May 2006	617.9
B-05-03	Y	168	Y	VW	2	32, 112	Apr-May 2006	605.1
B-05-04	Y	172	Y	VW	2	59, 119	Mar-May 2006	600.8
B-05-07	Y	224	Y	VW	2	102, 220	Apr-Jun 2006	678.9
B-05-08	Y	224	Y	VW	2	65.5, 110.5	Apr-May 2006	679.9
B-05-11	Y	226	Y	VW	2	95, 130	Apr-Jun 2006	675.1
B-05-12	Y	210	Y	VW	2	75, 120	Apr-May 2006	652.7
B-05-13	Y	134	Y	VW	2	60, 135	May-Jun 2006	580.0
B-05-16	Y	162	N	---	---	---	Jun 2006	598.5

1 BBCM installed pneumatic piezometers at the locations of the P borings in 1994. However, these piezometers were eventually renamed to the nearest inclinometers (i.e. P-1 to B-101, P-3 to B-105, and P-5 to B-107).

2 The pneumatic piezometer was actually installed in August 1994 at Boring P-2 in the vicinity of the B-103 inclinometer (now inactive). However, the piezometer has since been renamed to B-303 due to its close proximity to the active inclinometer at B-303, which was installed in July 1998.

3 Elevation in parenthesis refers to the ground surface (G.S.) elevation of the P boring location where the pneumatic piezometer was installed.

B-05-07
B-05-08
B-05-13
B-110
B-05-16
APPROXIMATE LOCATION OF LANDSLIDE
B-05-12
B-05-01
B-05-02
B-108A
B-05-11
B-107
B-203
B-05-04
P-9N
B-204
LEFT CALIPERED LOCATION
RIGHT CALIPERED LOCATION
B-303
B-105A
B-105
B-101
B-102
B-05-03

LEGEND

B-05-01 — LOCATION OF INCLINOMETER/PIEZOMETER INSTALLED BY BBCM IN 2006 (B-05-01 THROUGH B-05-04, B-05-07, B-05-08, B-05-11 THROUGH B-05-13, AND B-05-16).

B-105A — LOCATION OF REPLACEMENT INCLINOMETER INSTALLED BY BBCM IN 2006 (B-105A AND B-108A).

B-101 — LOCATION OF INCLINOMETER AND/OR PIEZOMETER INSTALLED BY BBCM BETWEEN 1994 AND 1999 (B-101, B-102, B-105, B-107, B-203, B-204, B-303, AND P-9N).

B-110 — LOCATION OF INCLINOMETER AT B-110, WHICH WAS DESTROYED BY EXCAVATION ACTIVITIES IN MARCH, 2006

SCALE IN FEET
0 50 100

SITE PLAN OF ACTIVE INSTRUMENTATION

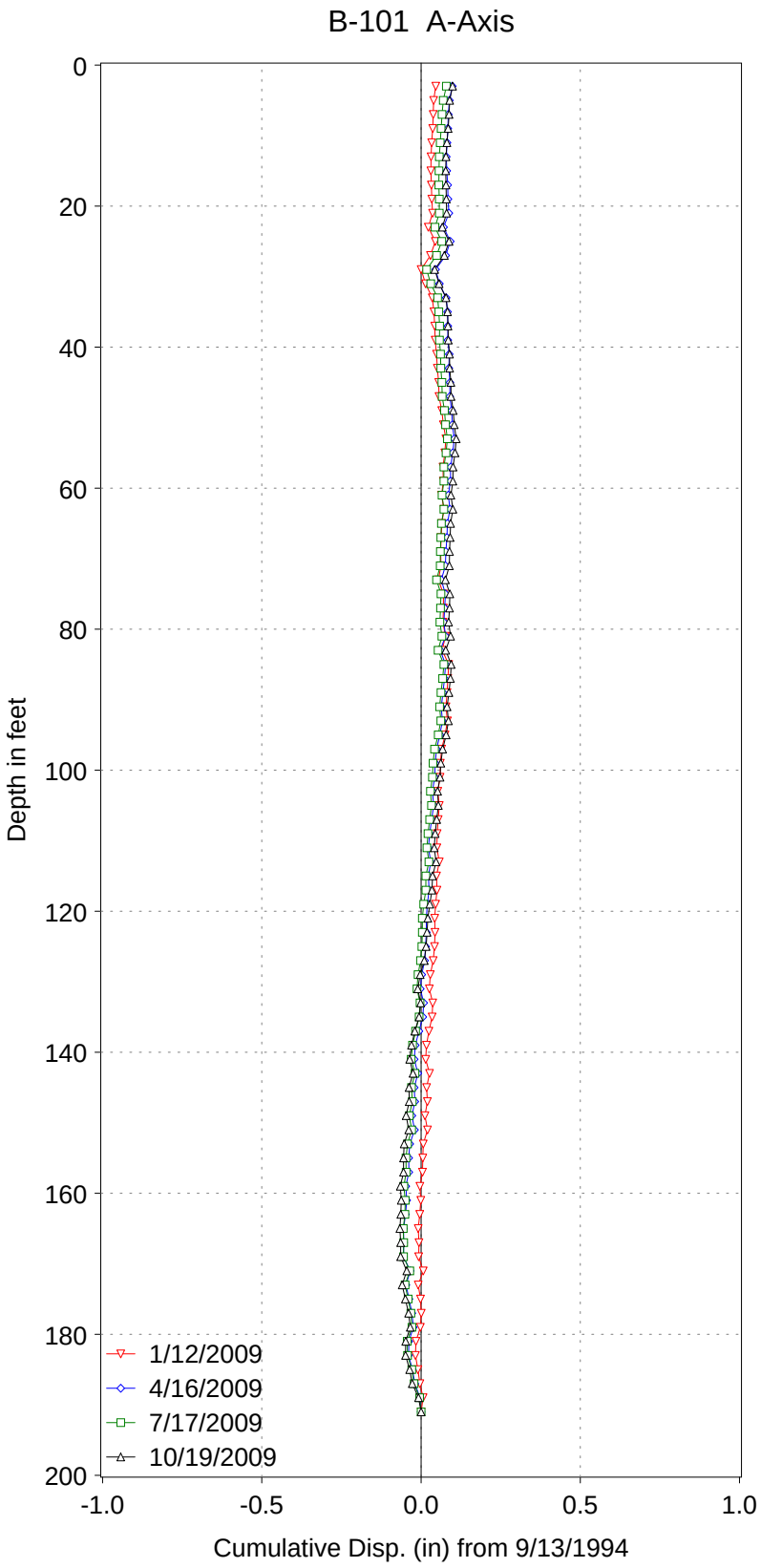
CUY-90-14.52/15.24 WEST ABUTMENT CLEVELAND, OHIO

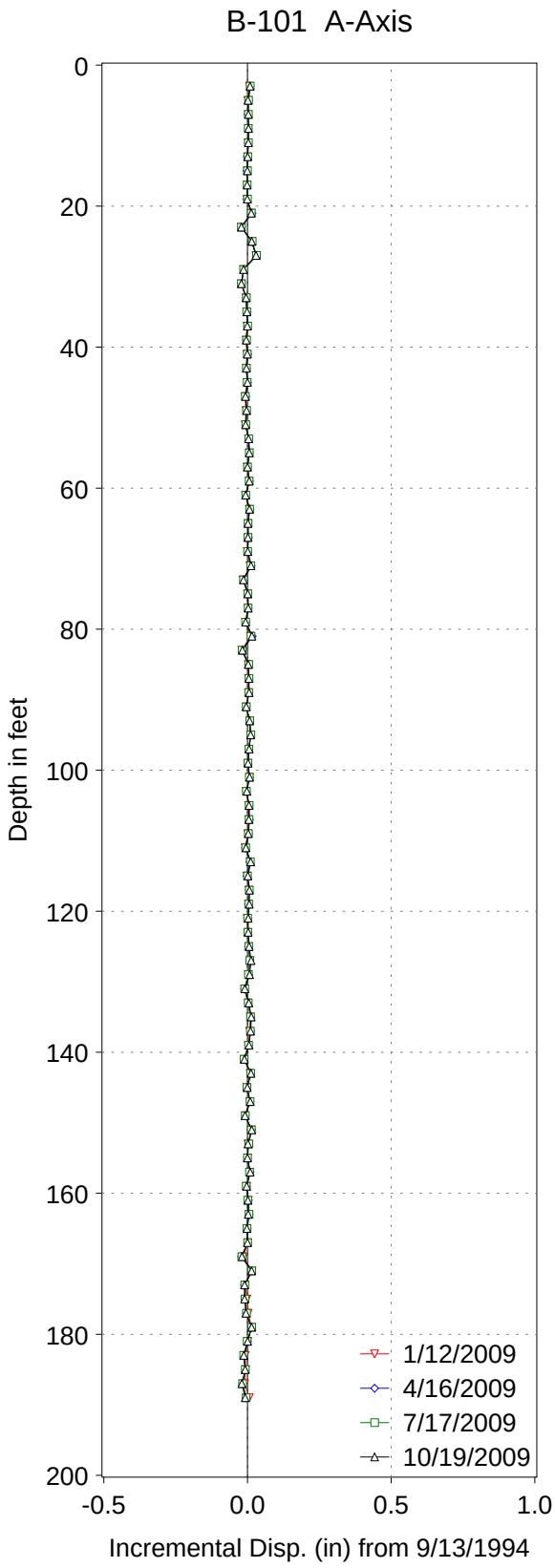
Project: 012-00946-300	Drawn By: EDV
Drawing Date: 7/25/06	Approved By: JLS
Revision Date: 2/9/07	Scale: 1" = 100'

BBCM
SOLUTIONS TO BUILD ON
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

PLATE 2

BBC&M DRAWING FILE: $BBCM FILENAME$ $DATE$ $TIME$ MODEL NAME: $MODEL$

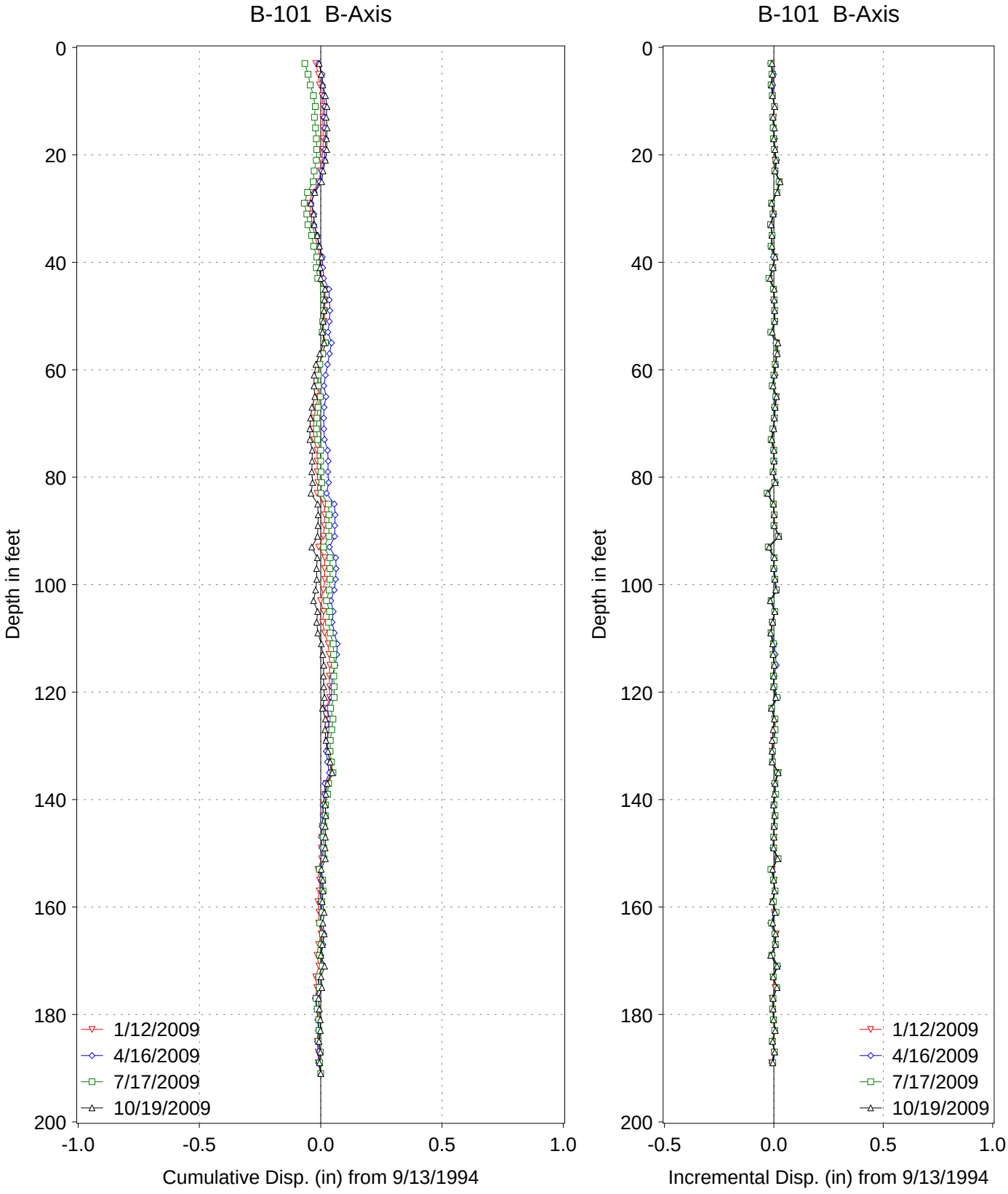




B-101

-Includes readings from the last four quarters.

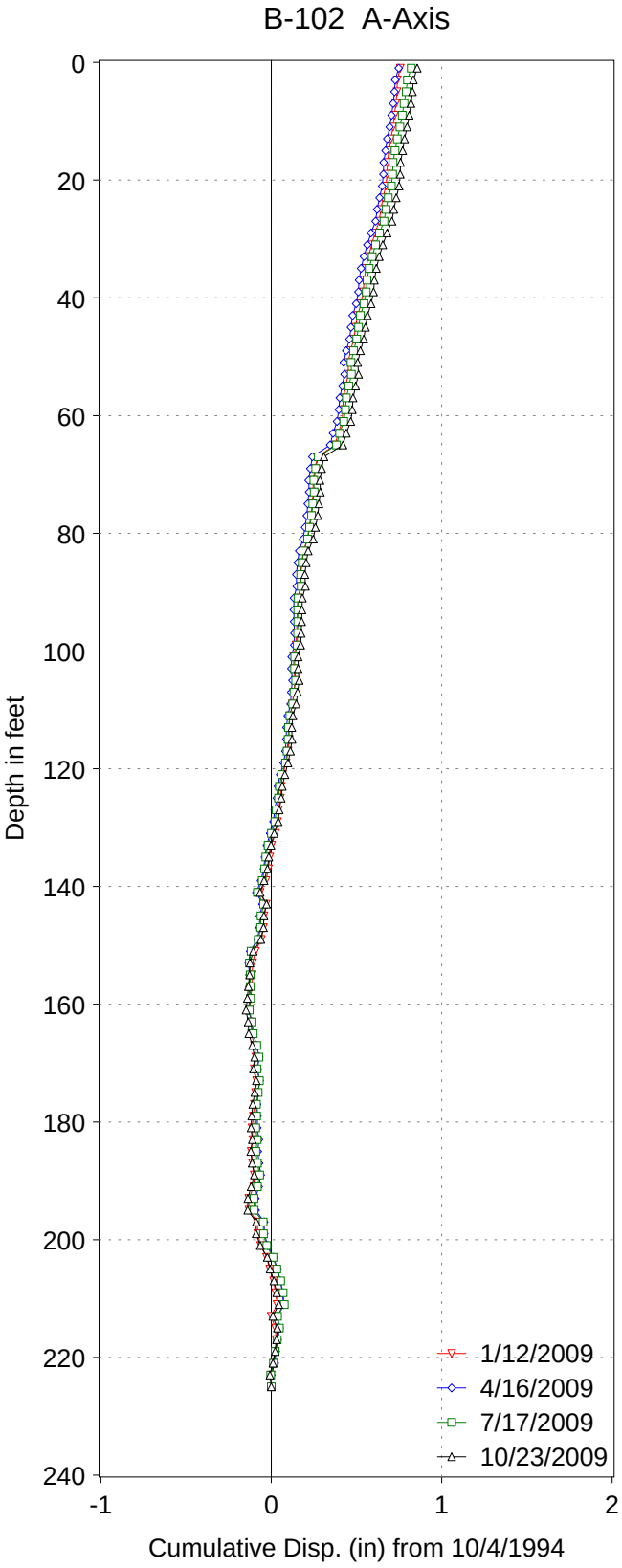
PLATE 3

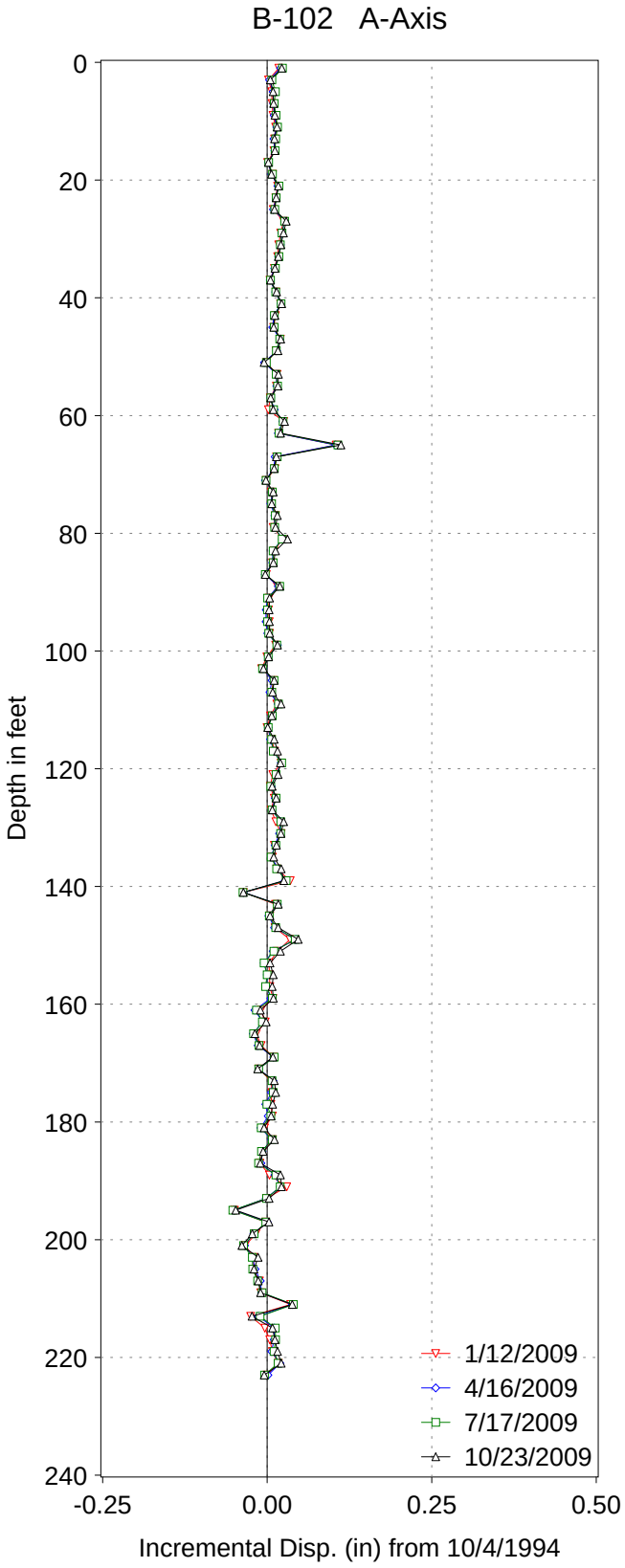


B-101

-Includes readings from the last four quarters.

PLATE 4

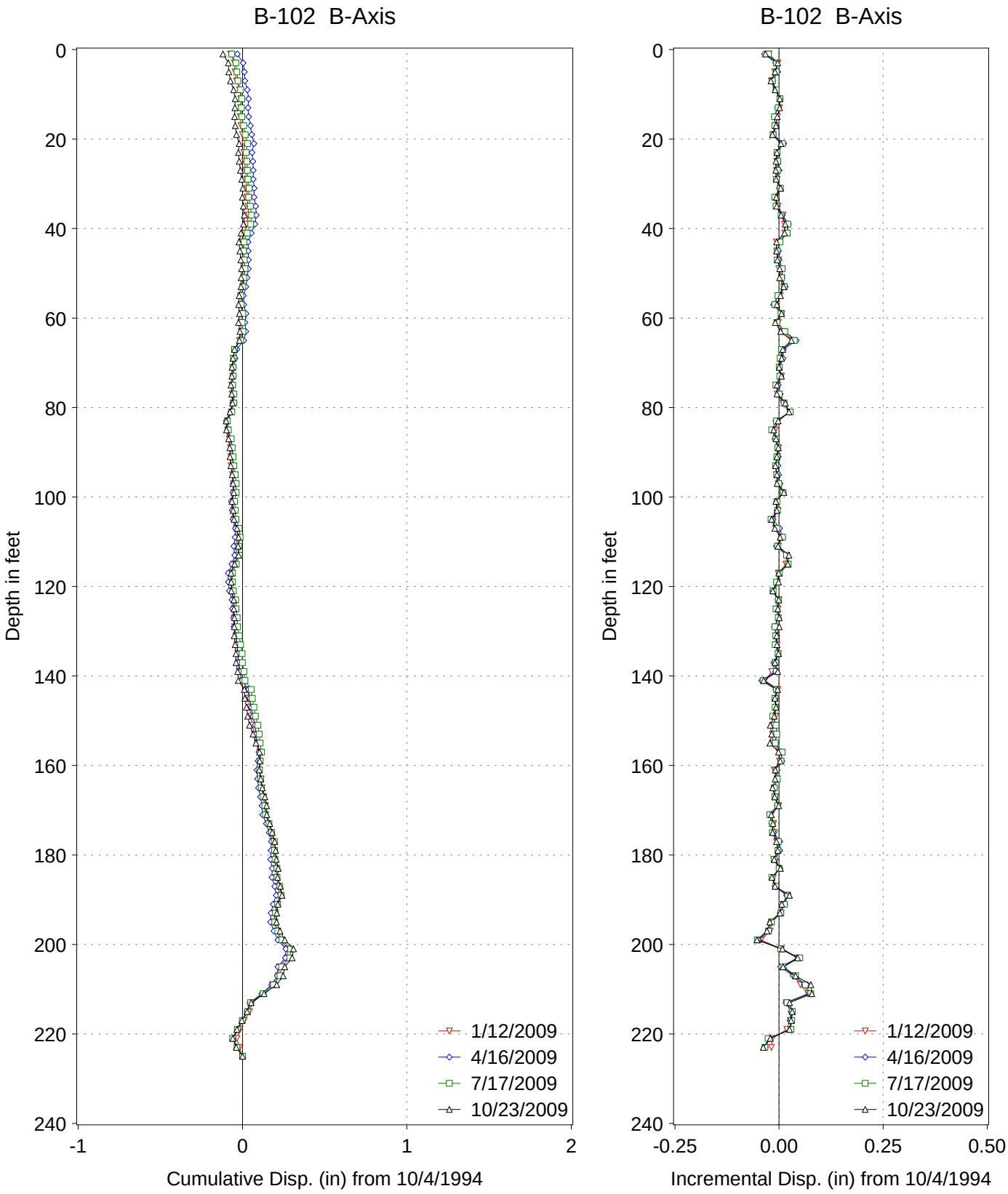




B-102

-Includes readings from the last four quarters.

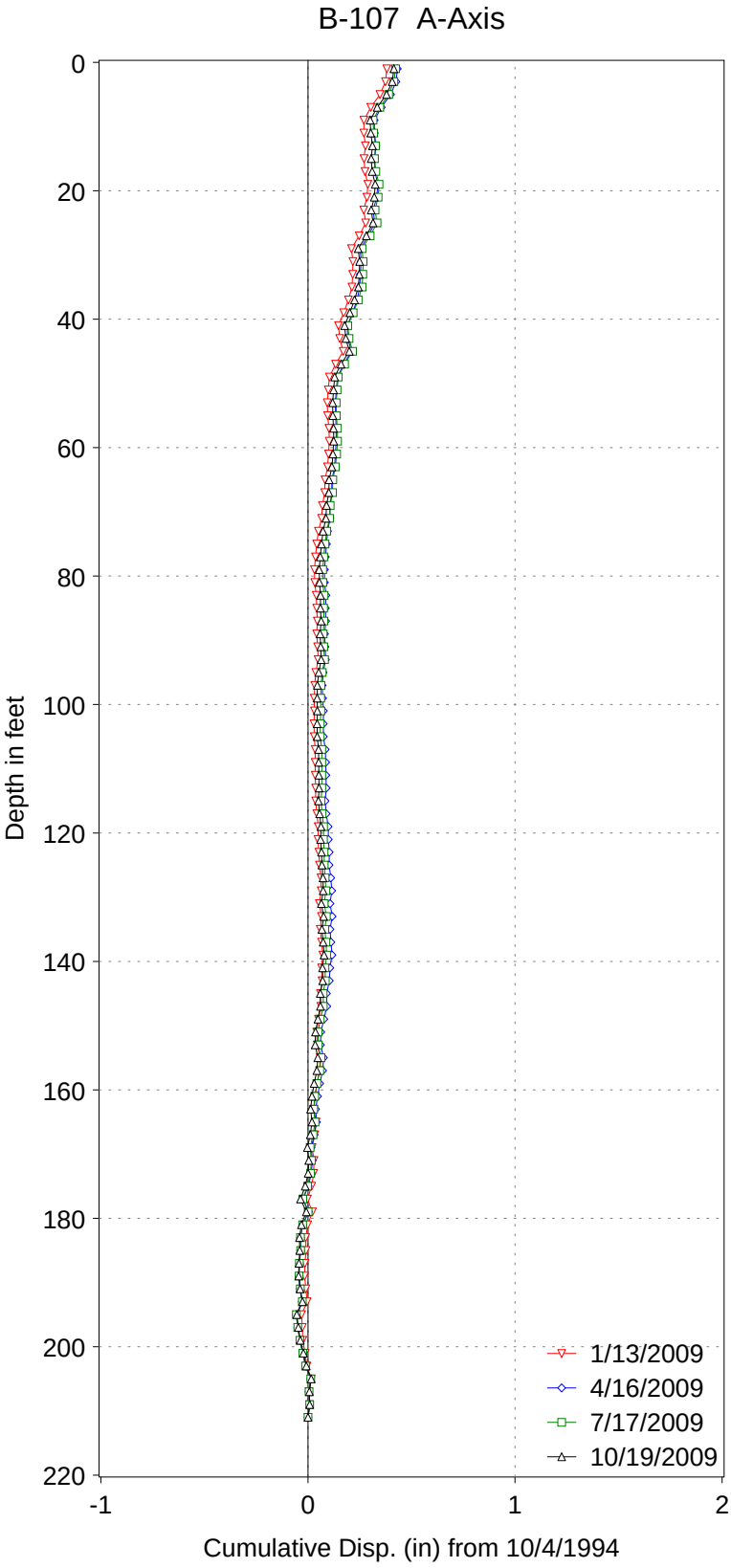
PLATE 5

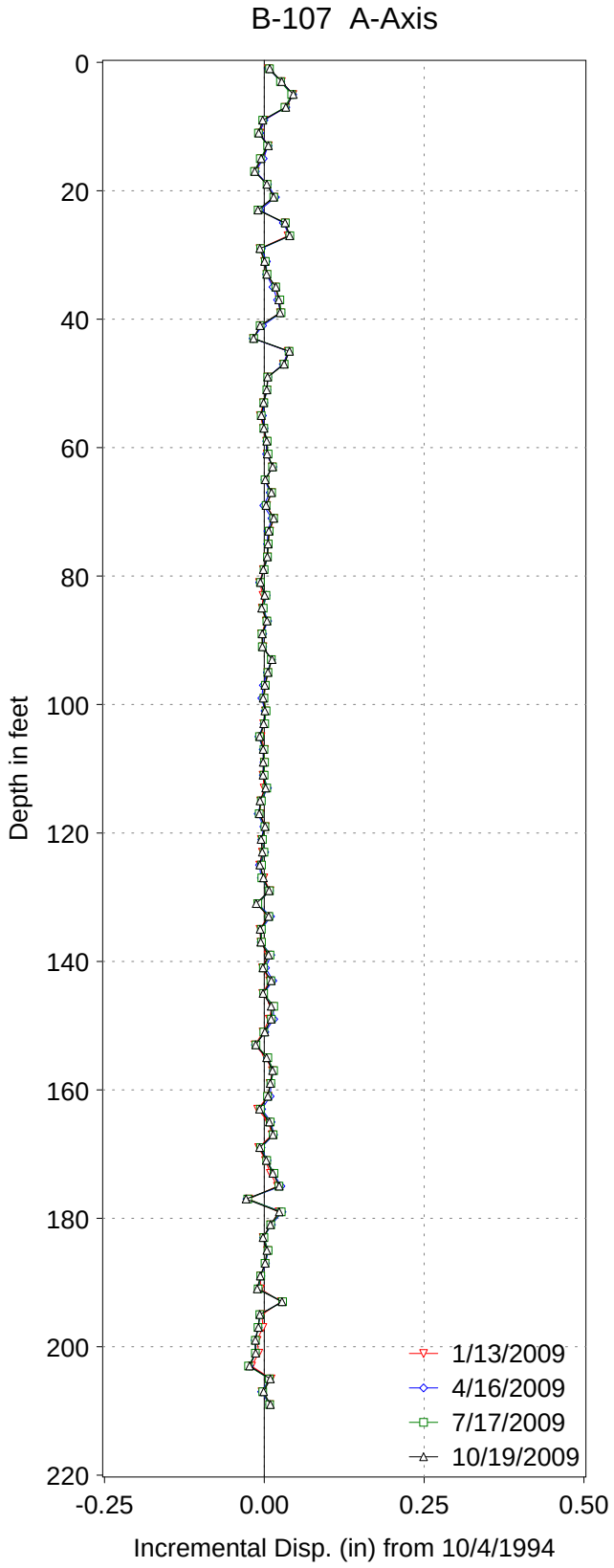


B-102

-Includes readings from the last four quarters.

PLATE 6

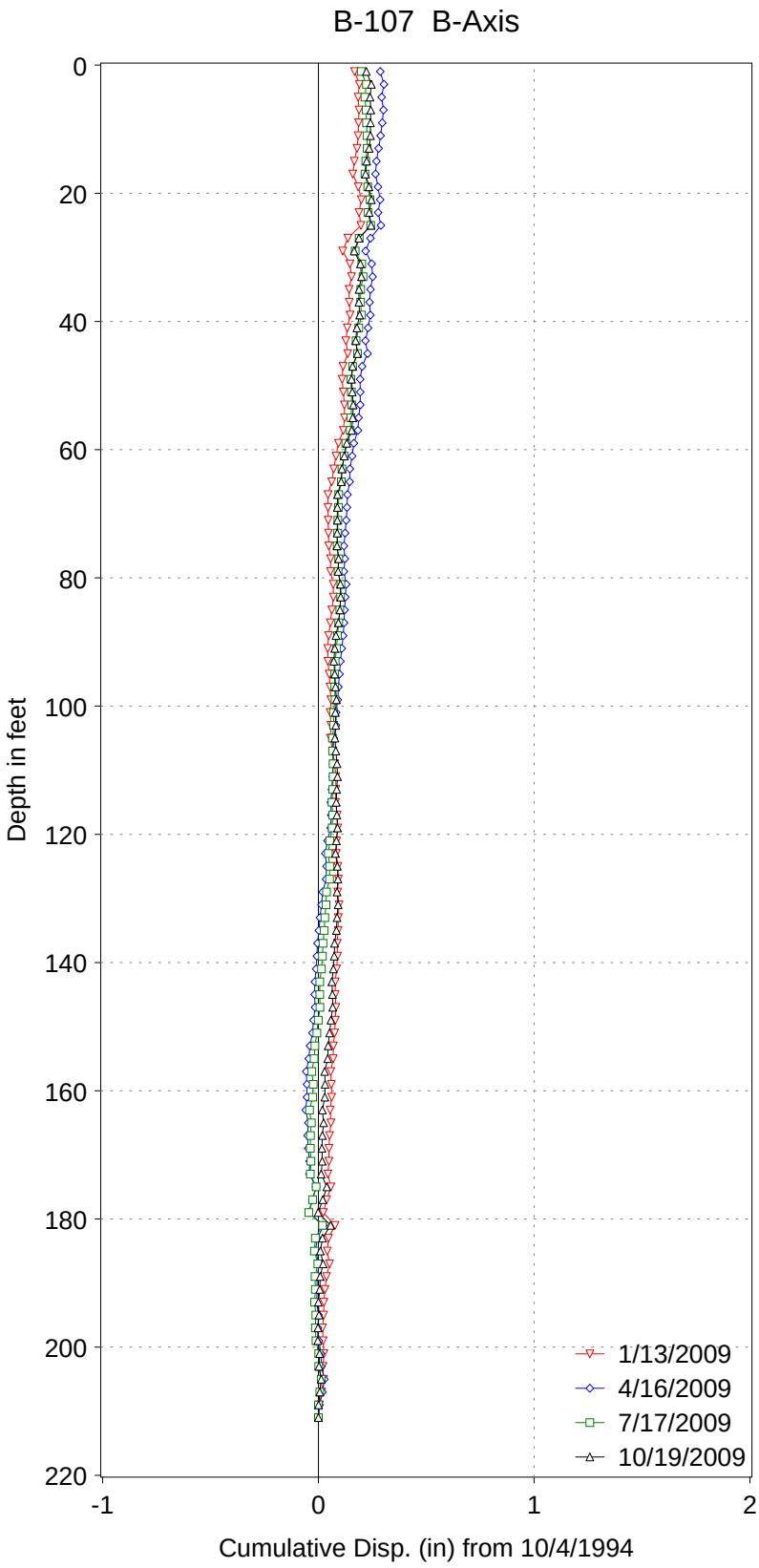


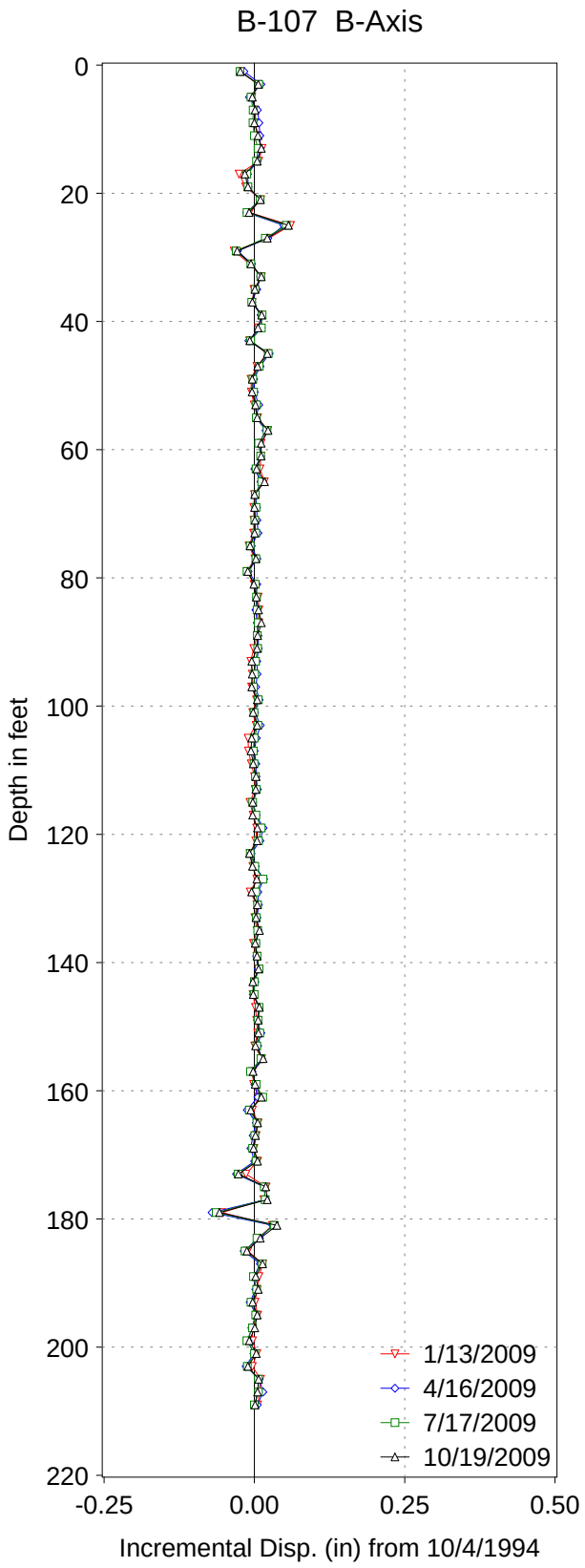


B-107

-Includes readings from the last four quarters.

PLATE 7

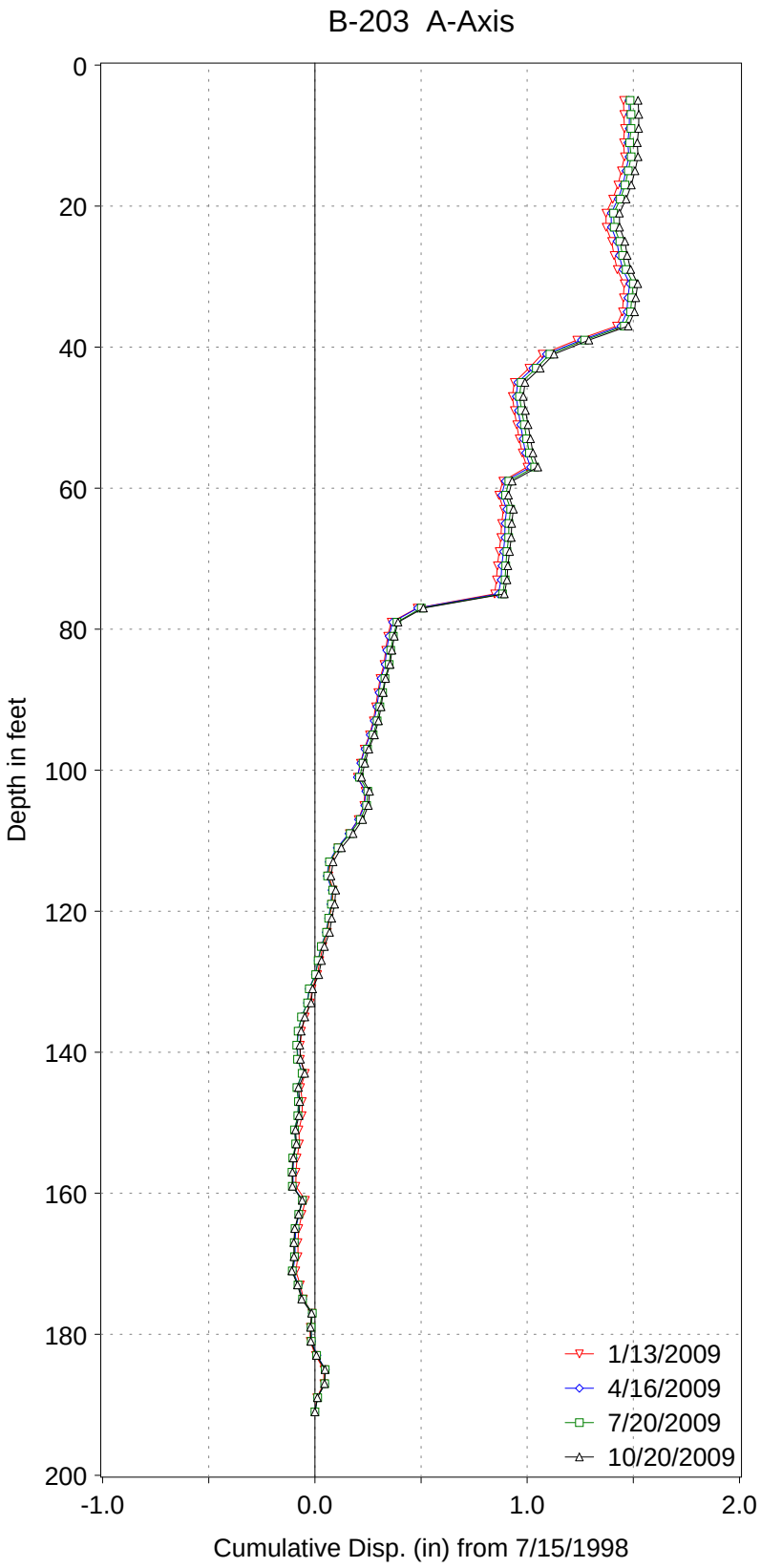


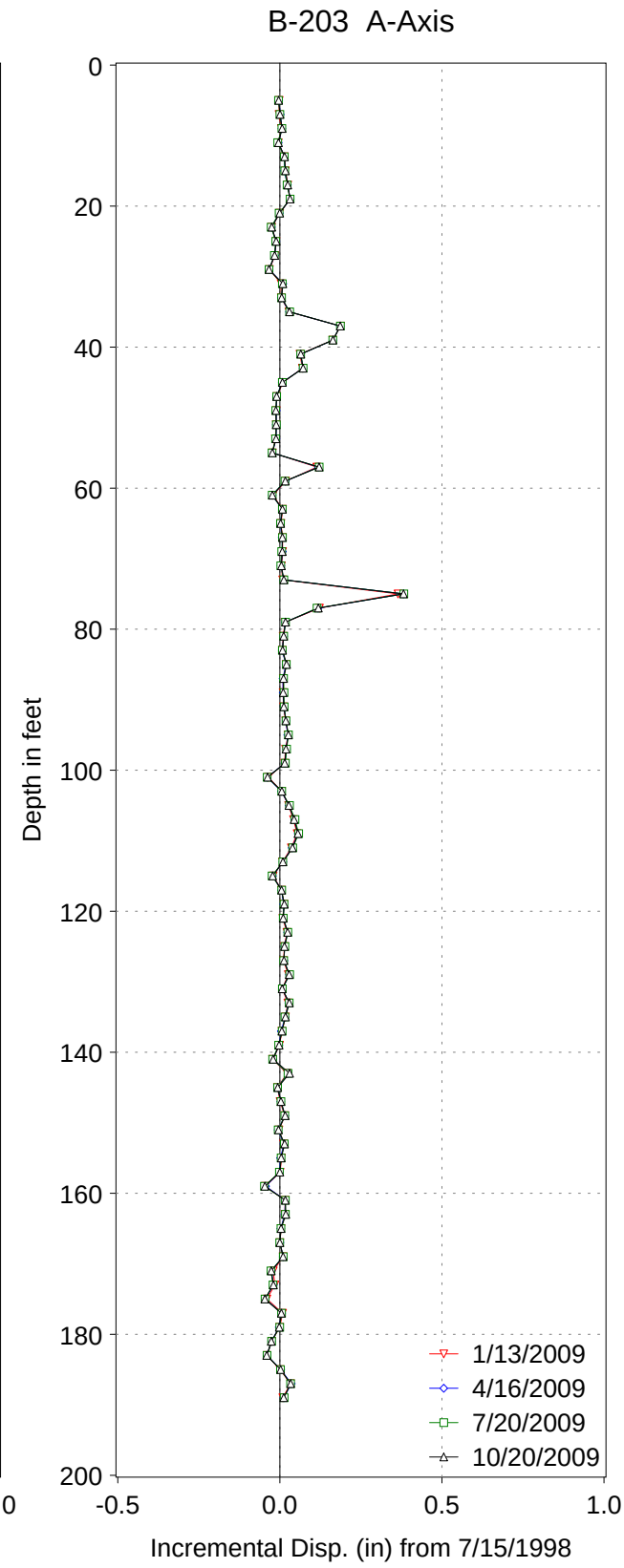


B-107

-Includes readings from the last four quarters.

PLATE 8

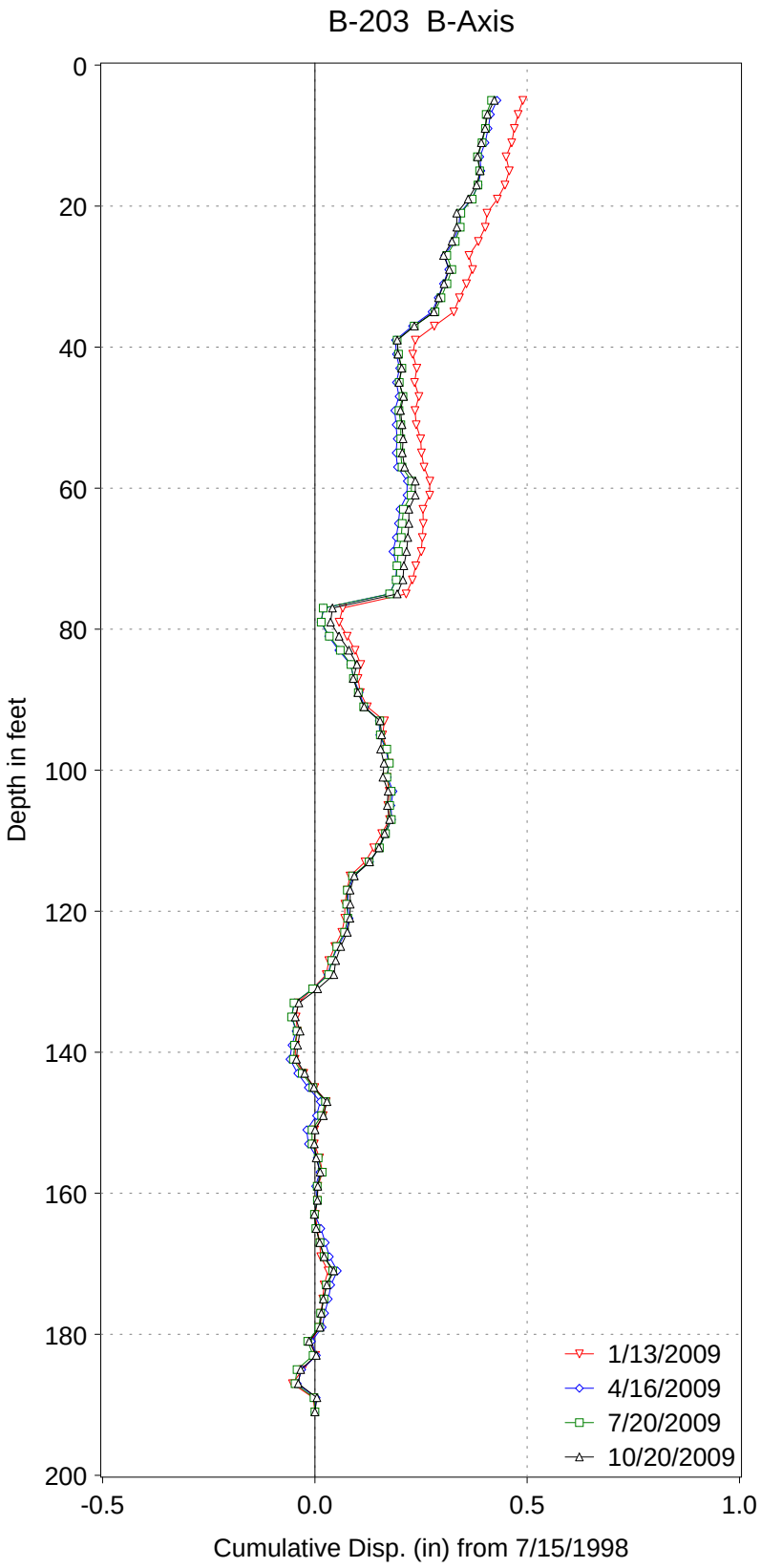


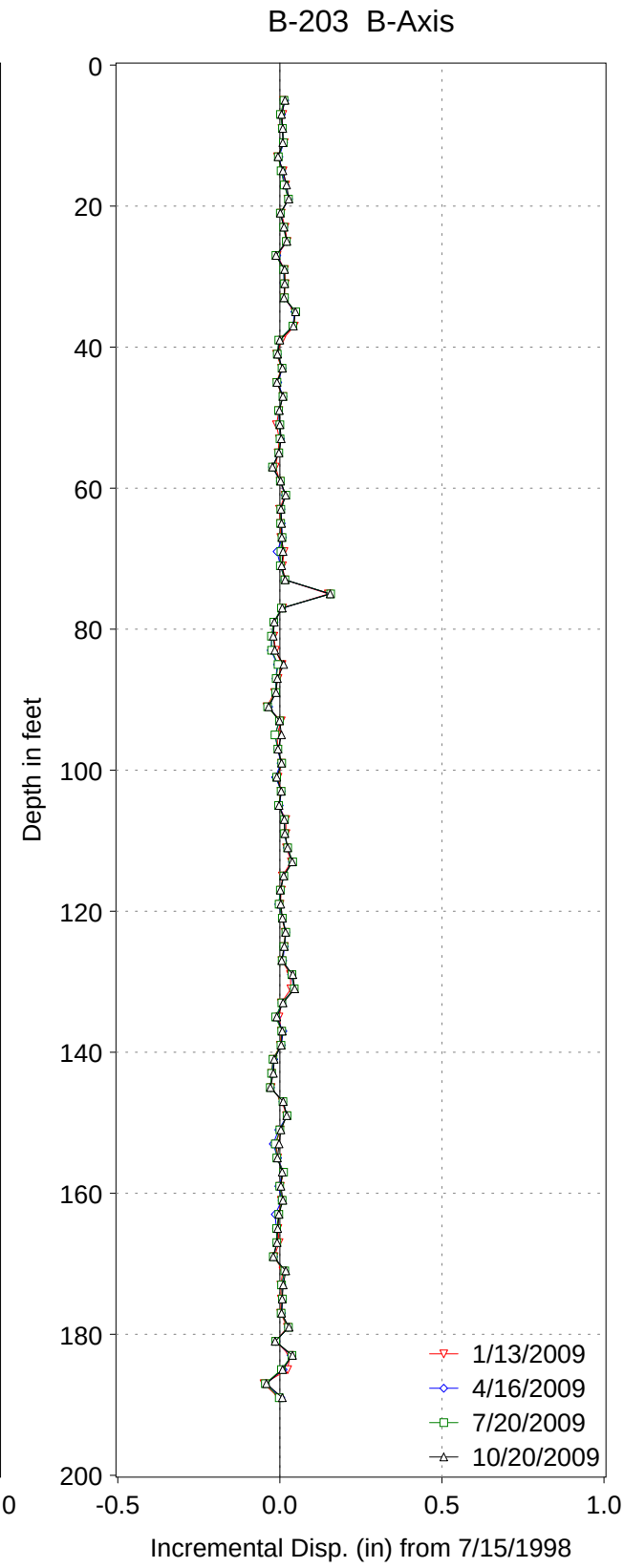


B-203

-Includes readings from the last four quarters.

PLATE 9

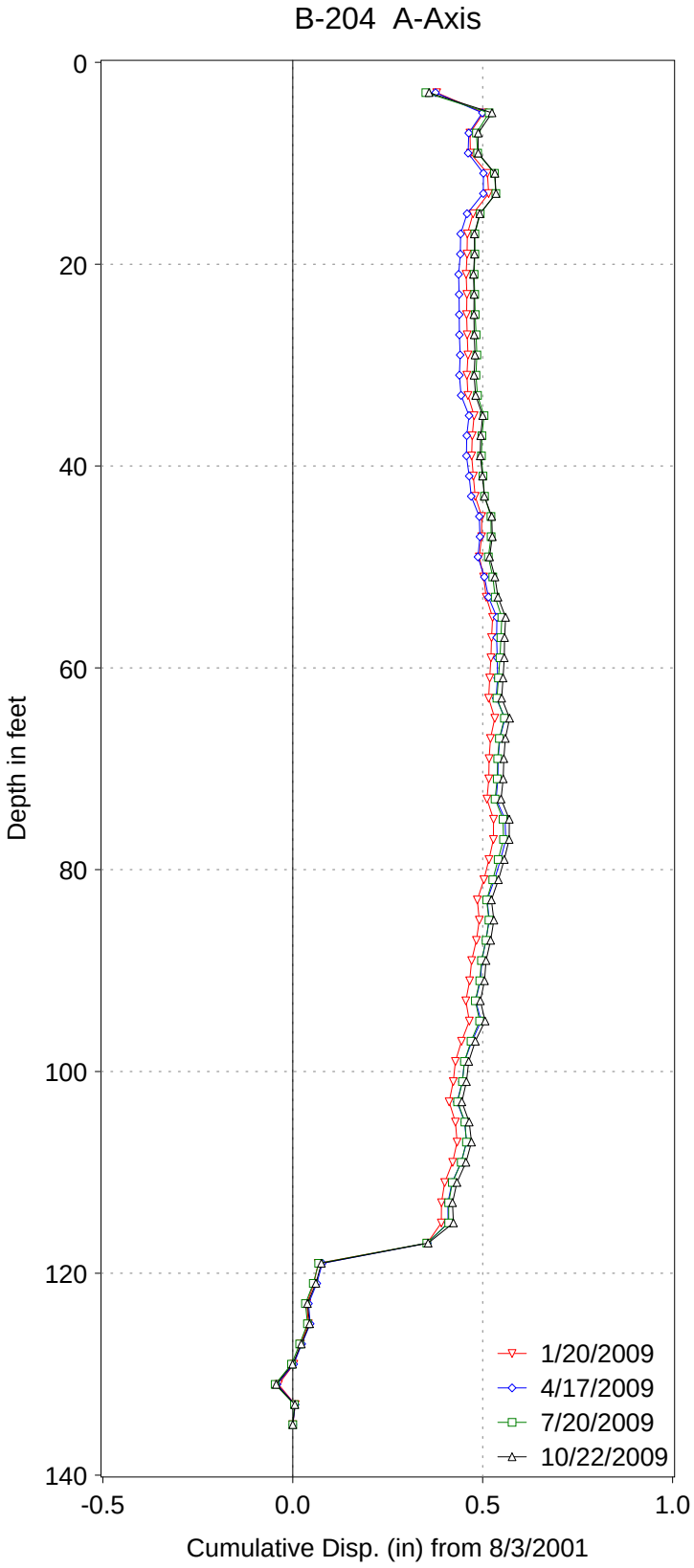


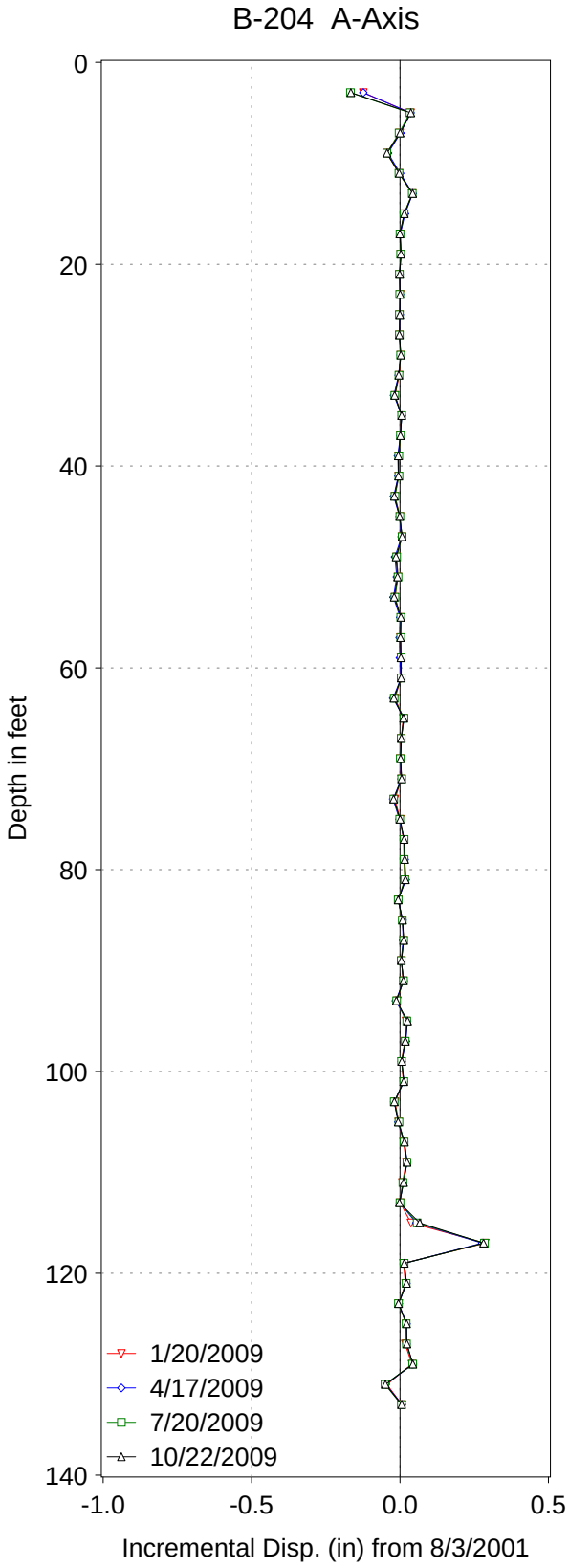


B-203

-Includes readings from the last four quarters.

PLATE 10

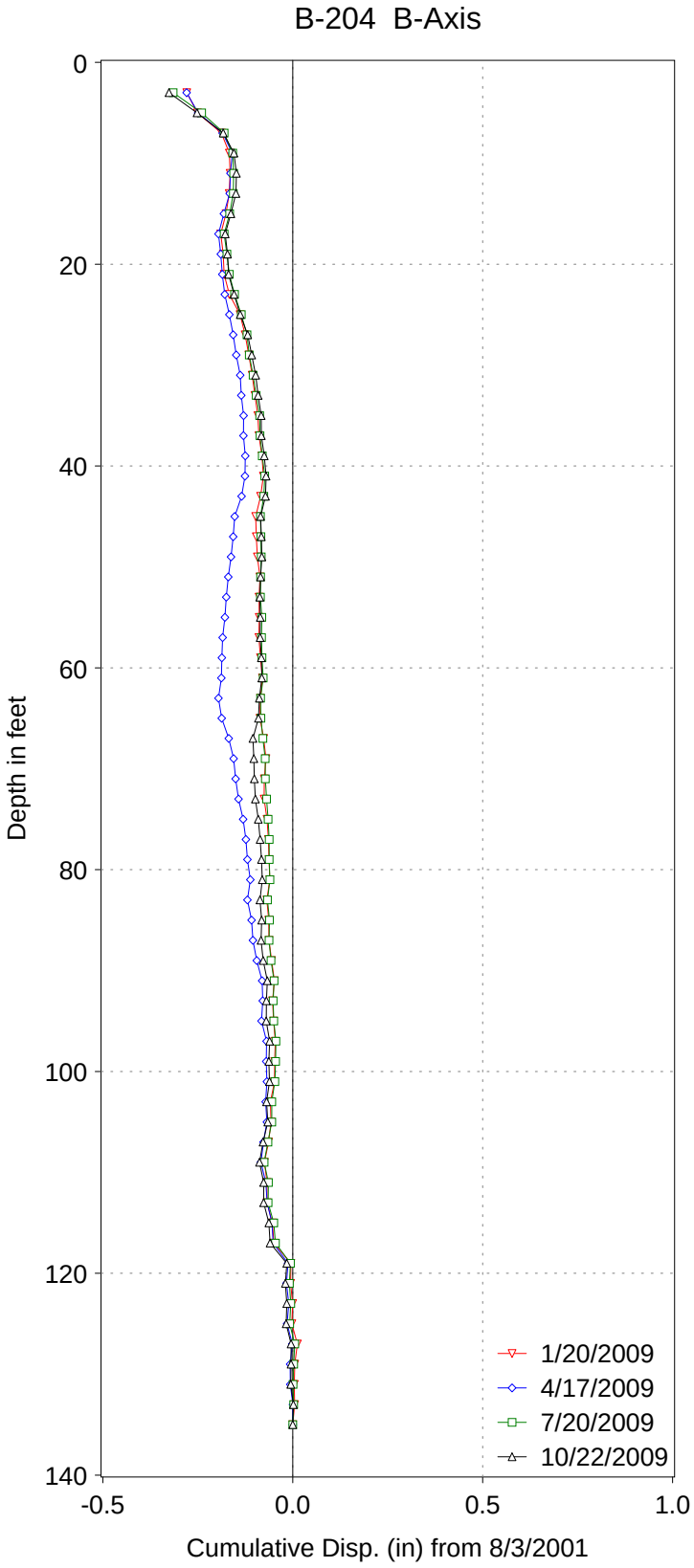


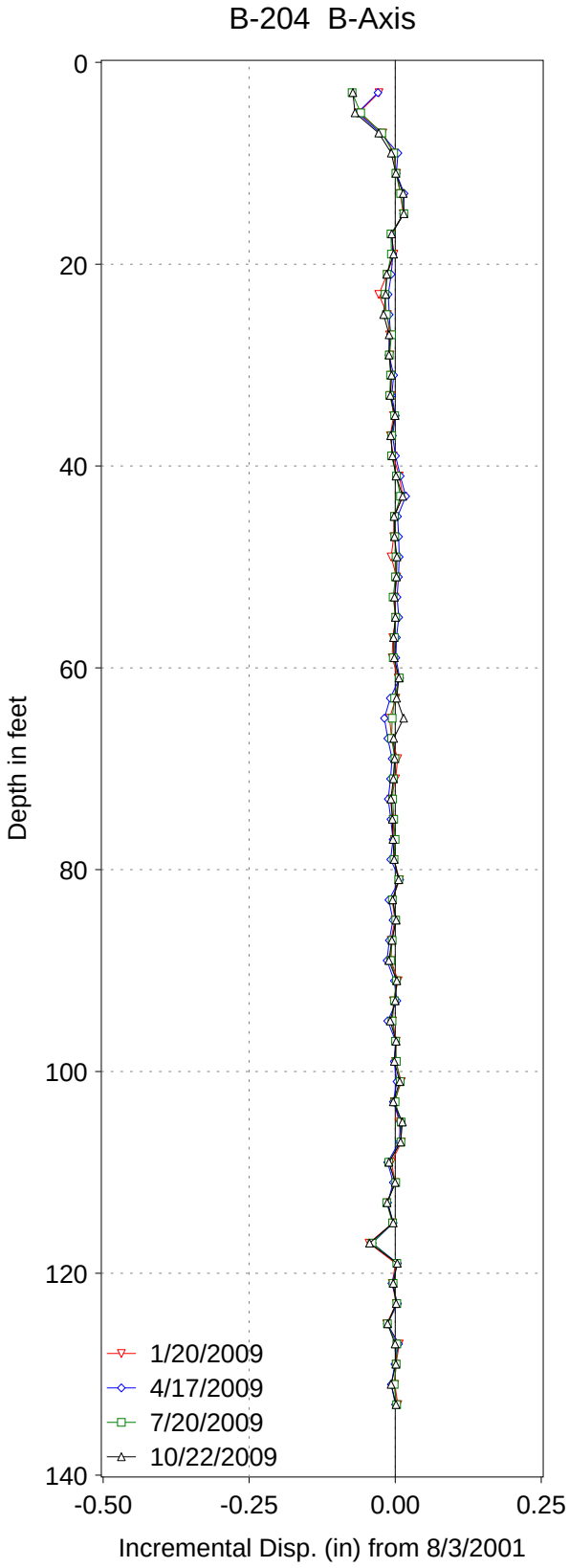


B-204

-Includes readings from the last four quarters.

PLATE 11

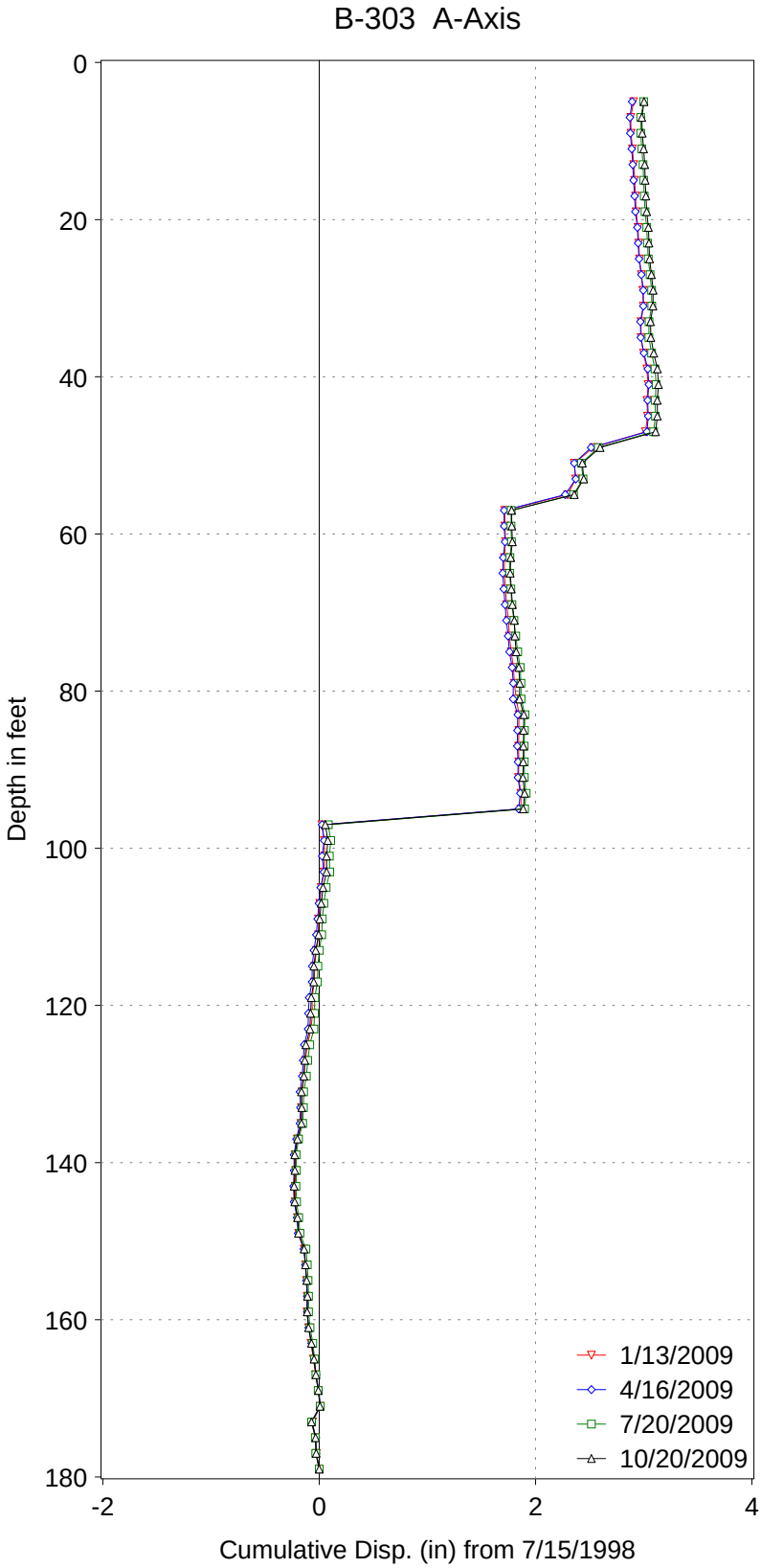


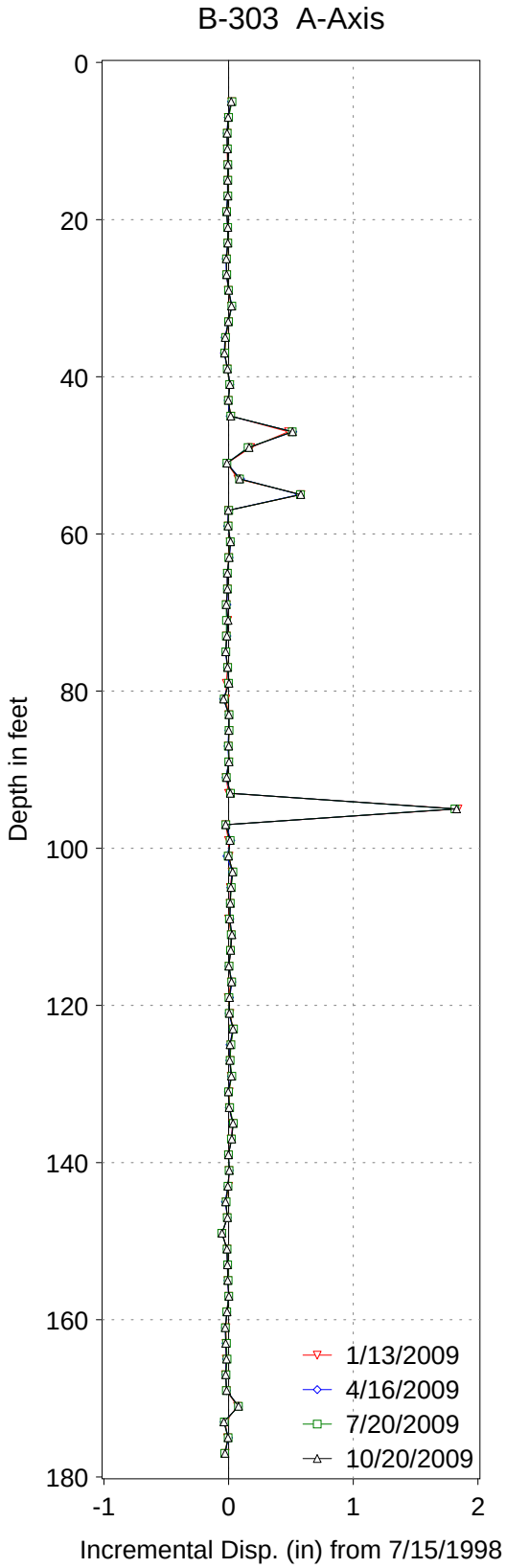


B-204

-Includes readings from the last four quarters.

PLATE 12

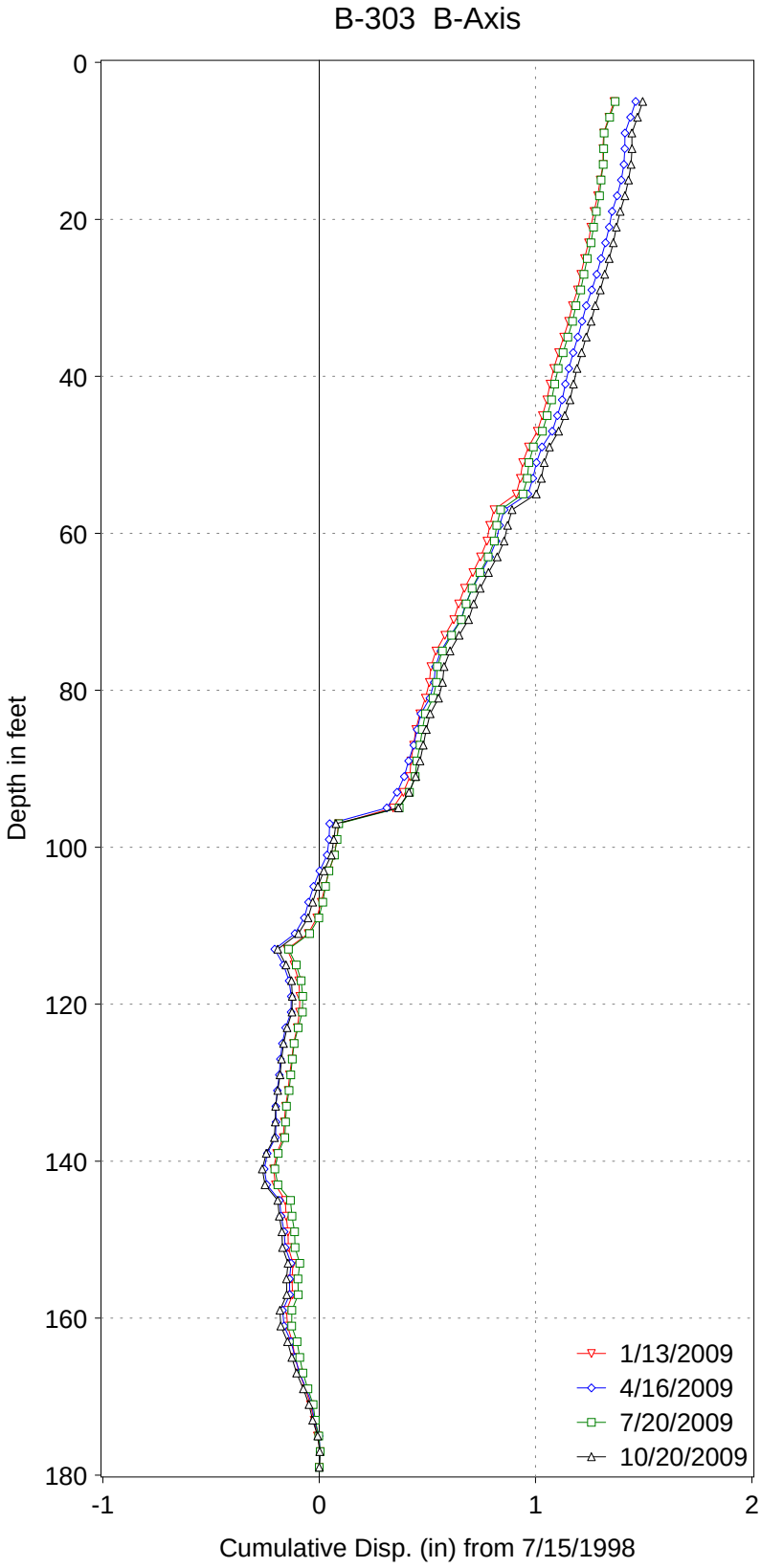


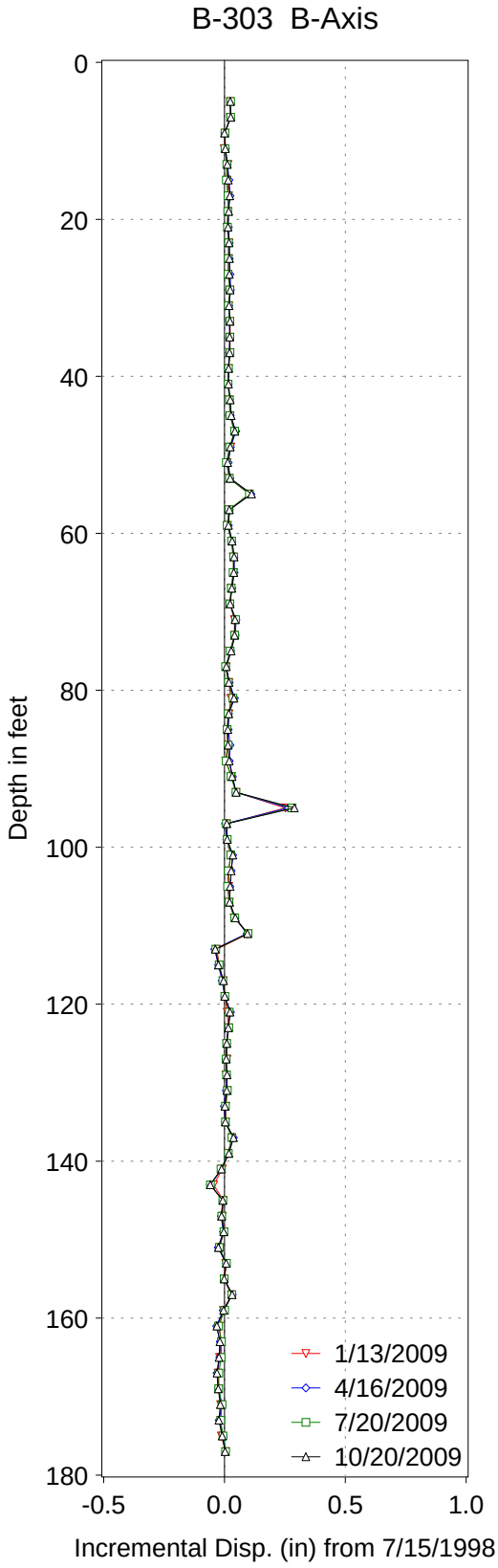


B-303

-Includes readings from the last four quarters.

PLATE 13

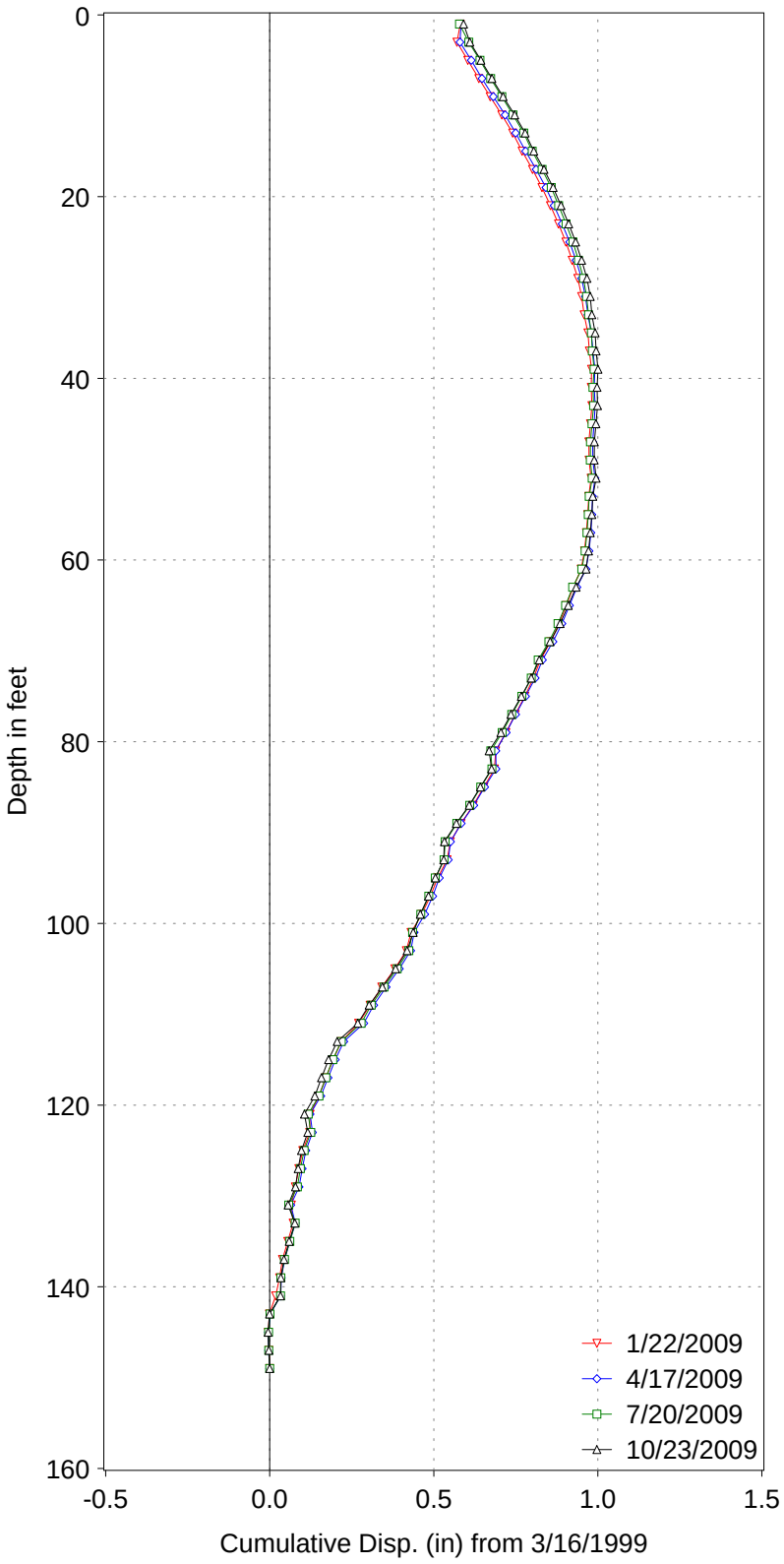


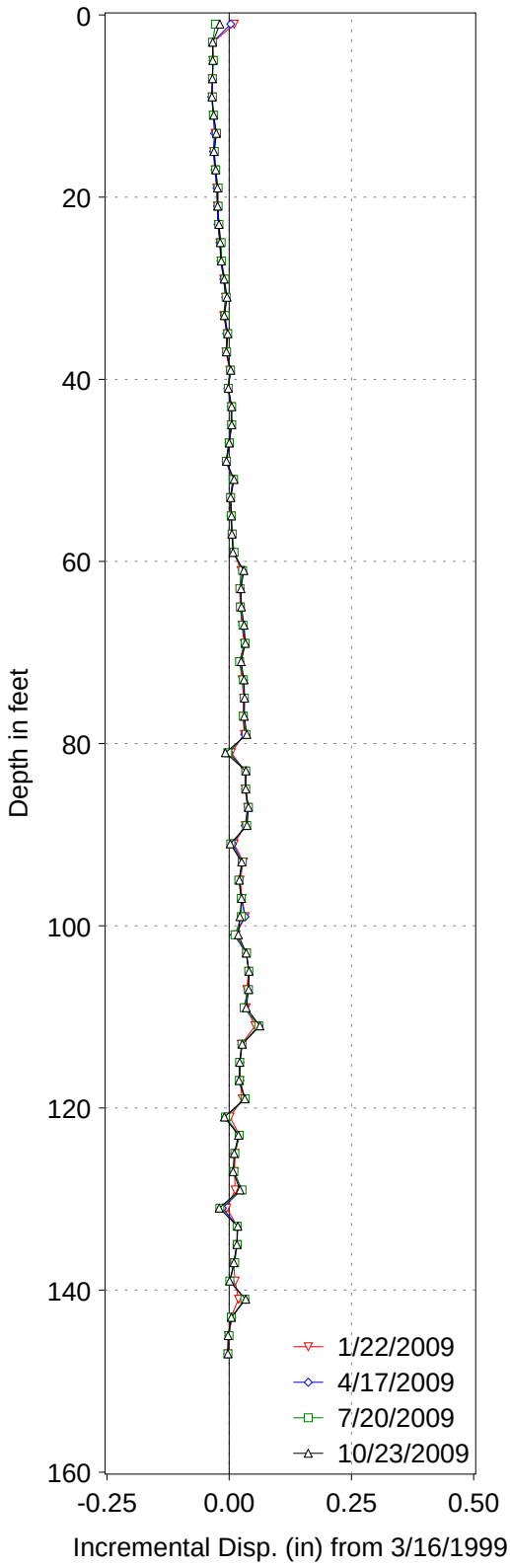


B-303

-Includes readings from the last four quarters.

PLATE 14

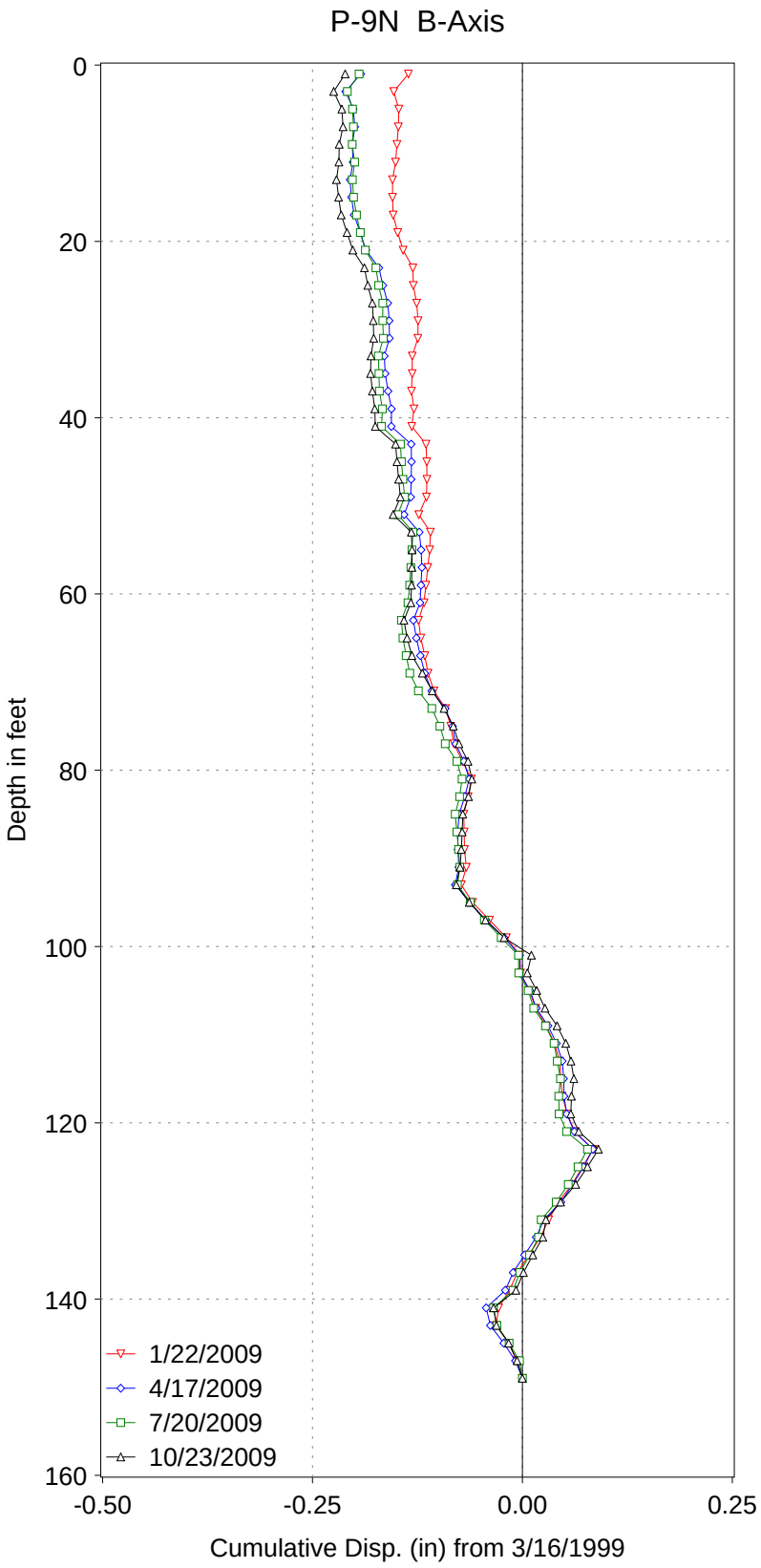


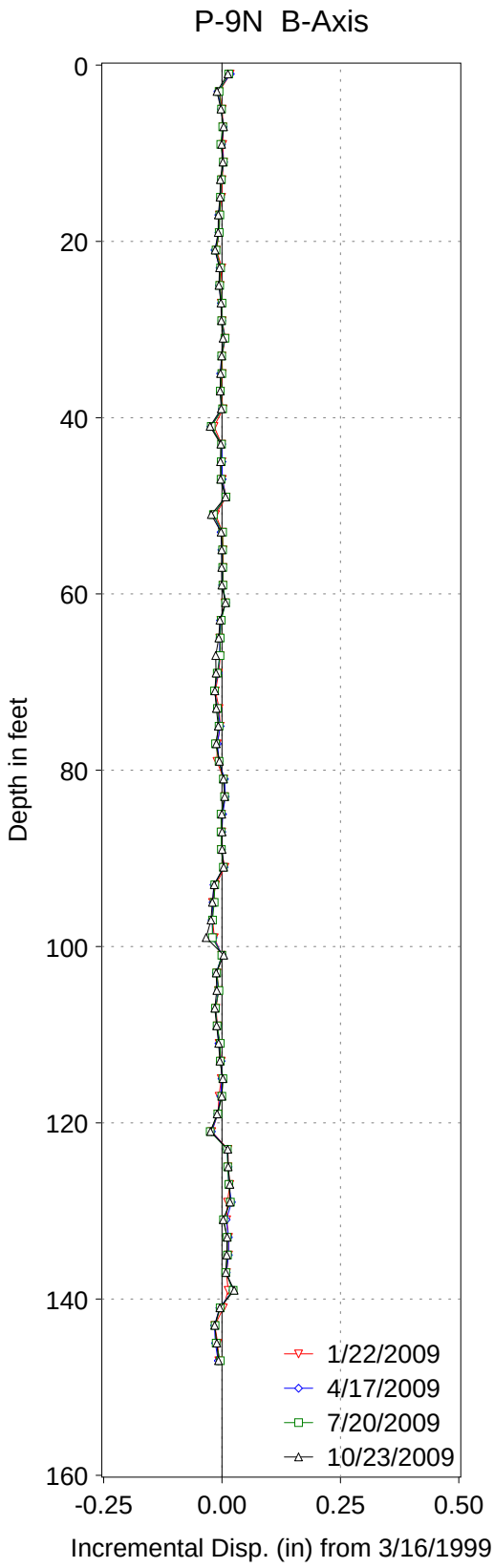


P-9N

-Includes readings from the last four quarters.

PLATE 15





P-9N

-Includes readings from the last four quarters.

PLATE 16

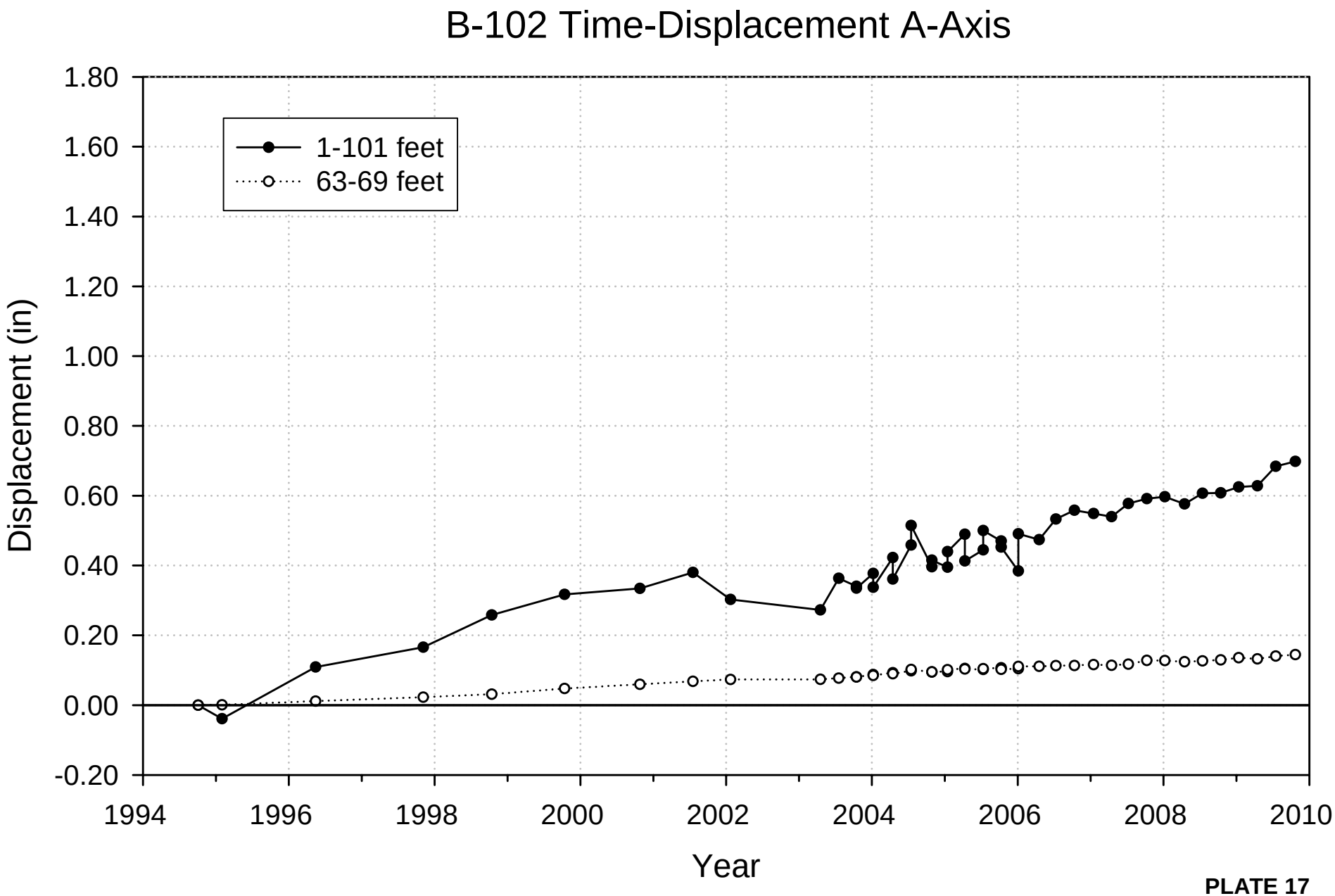

B-102 Time-Displacement A-Axis
1-101 feet
63-69 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 17

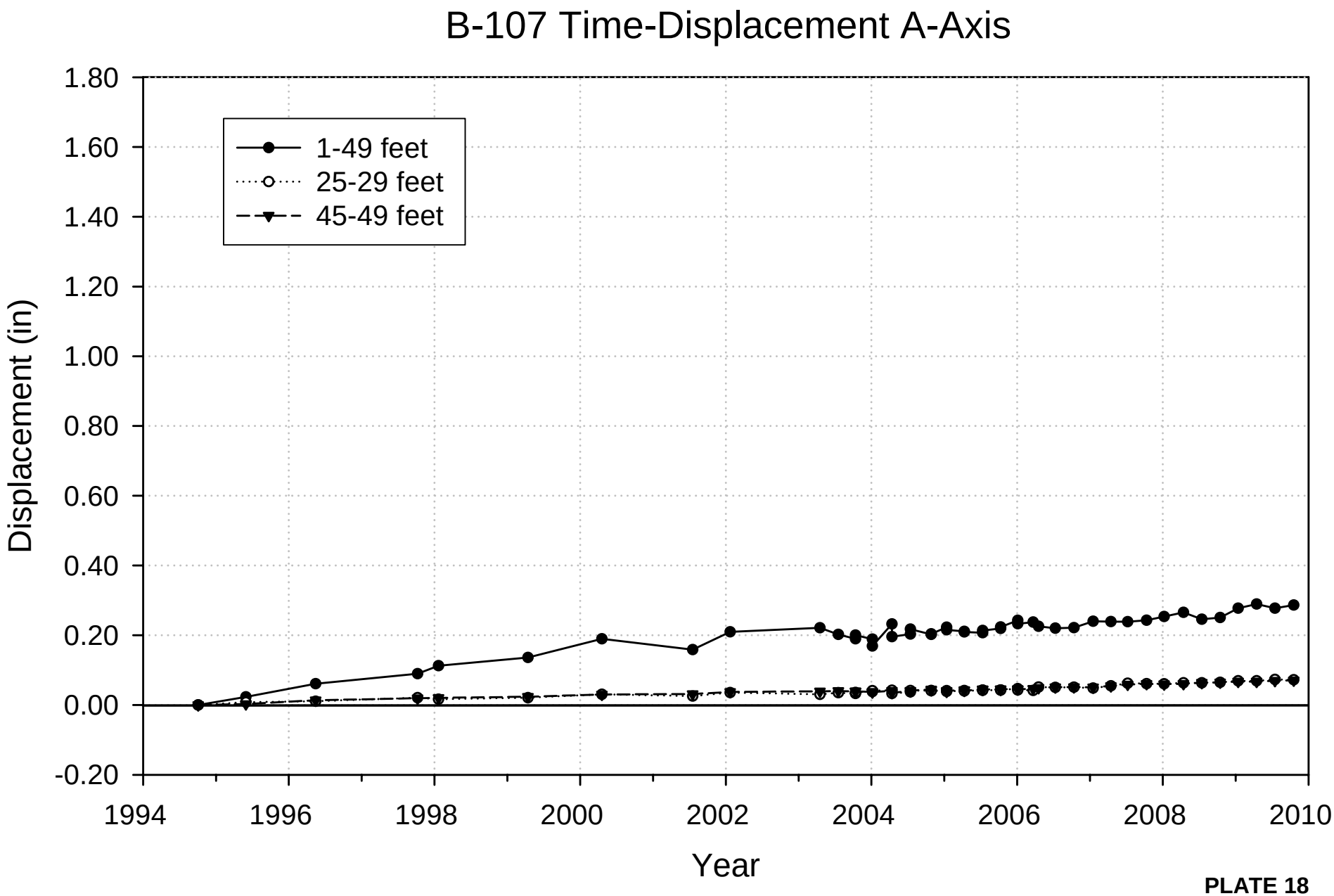

B-107 Time-Displacement A-Axis
1-49 feet
25-29 feet
45-49 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year

PLATE 18

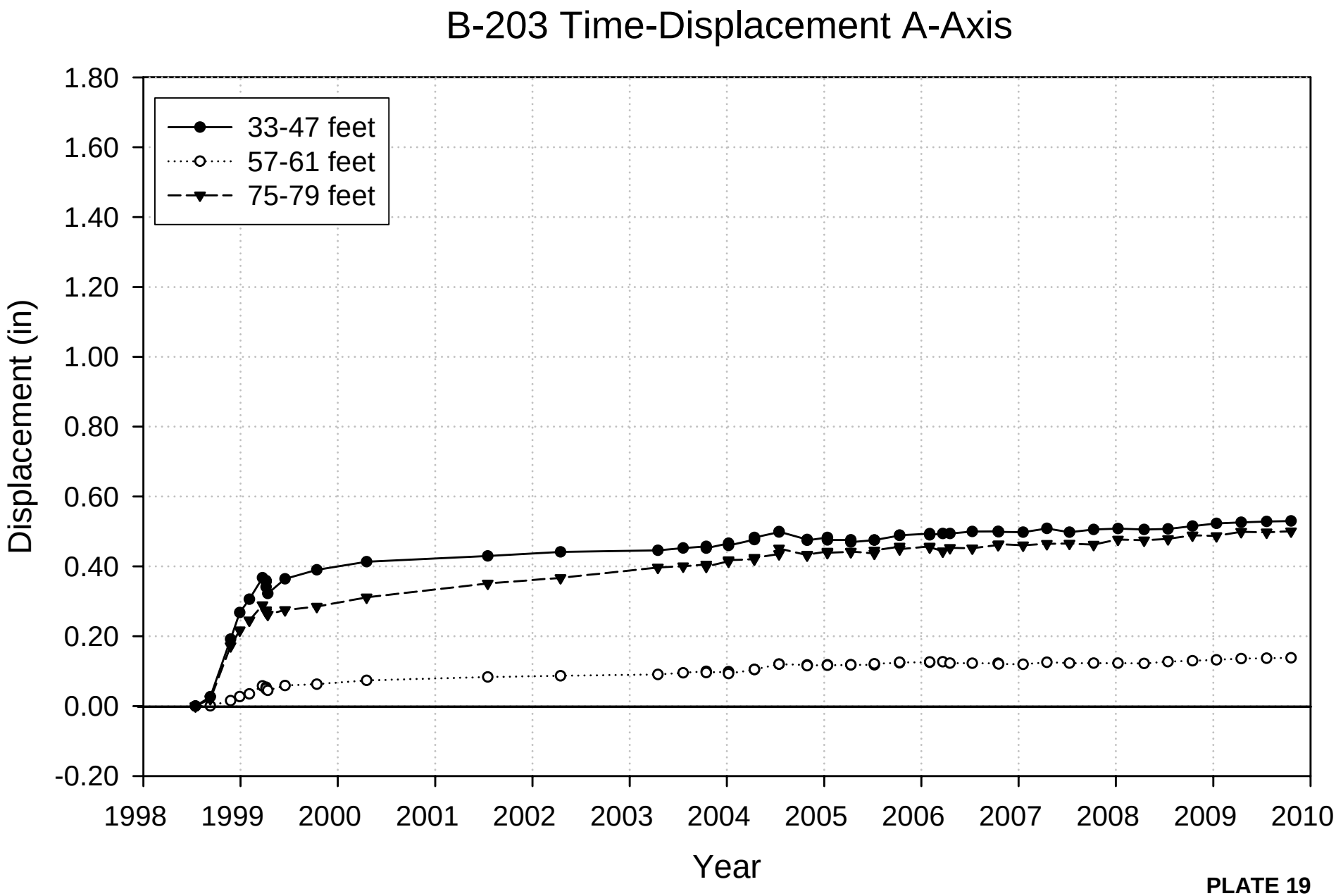

B-203 Time-Displacement A-Axis
33-47 feet
57-61 feet
75-79 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

PLATE 19

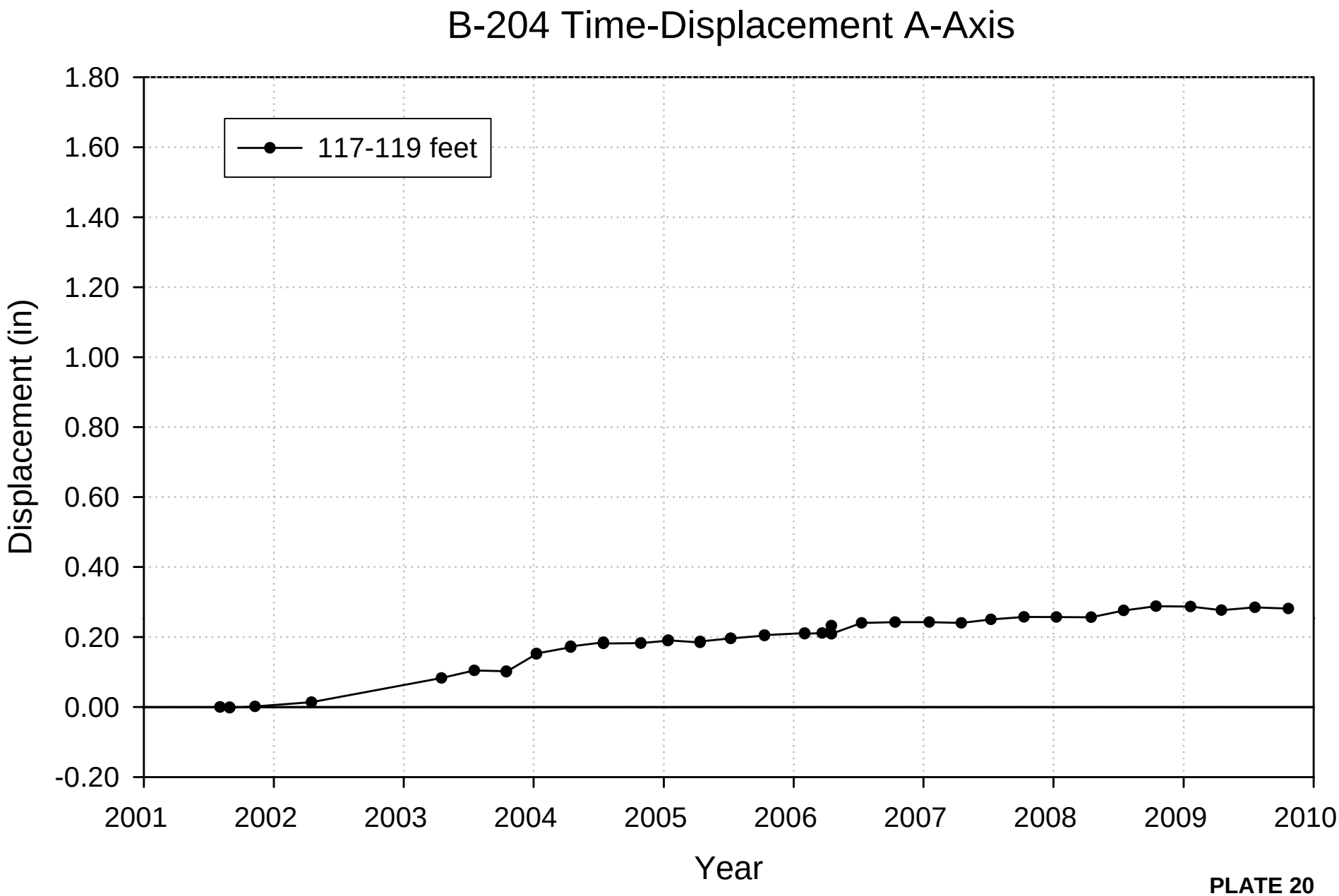

B-204 Time-Displacement A-Axis
117-119 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

PLATE 20

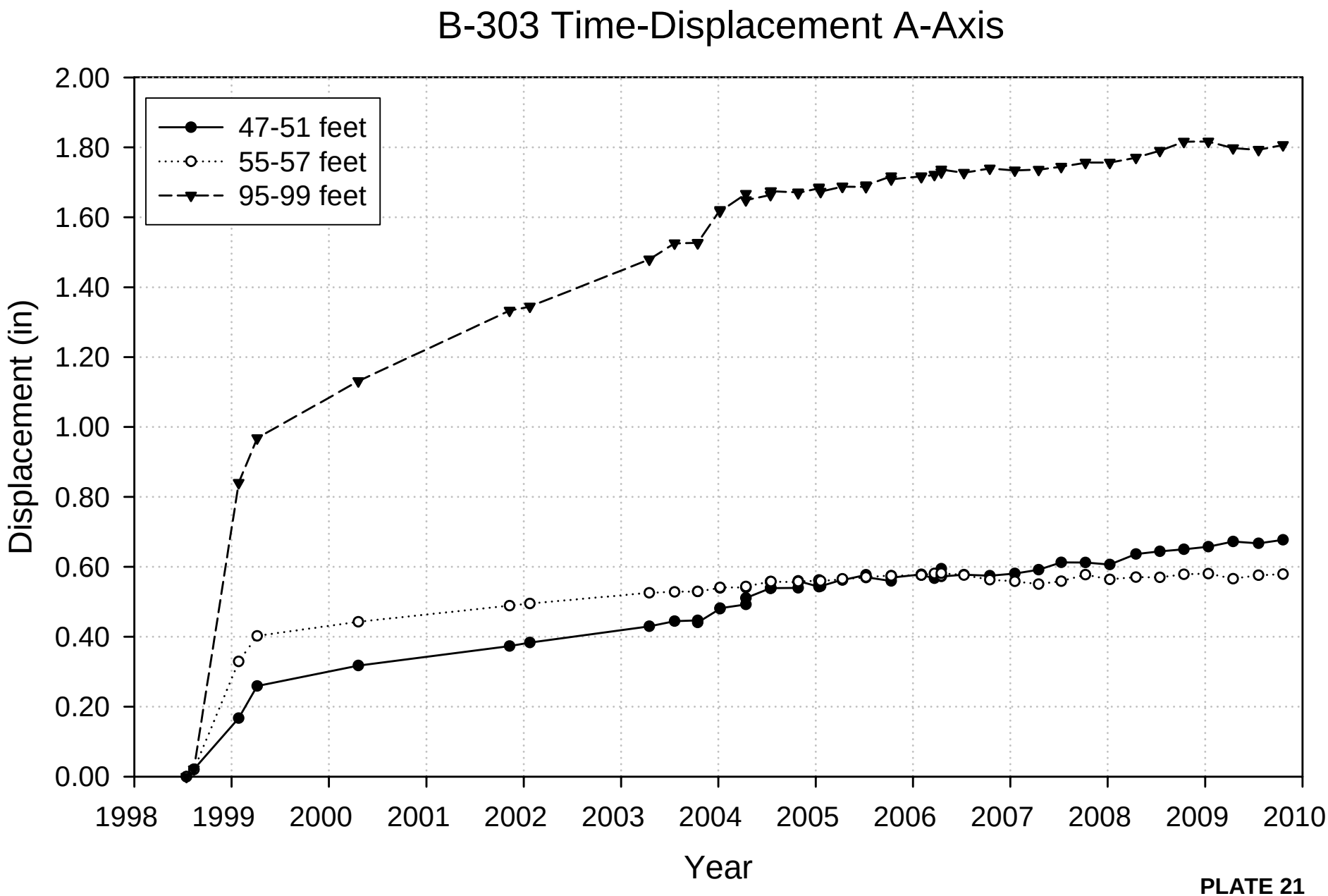
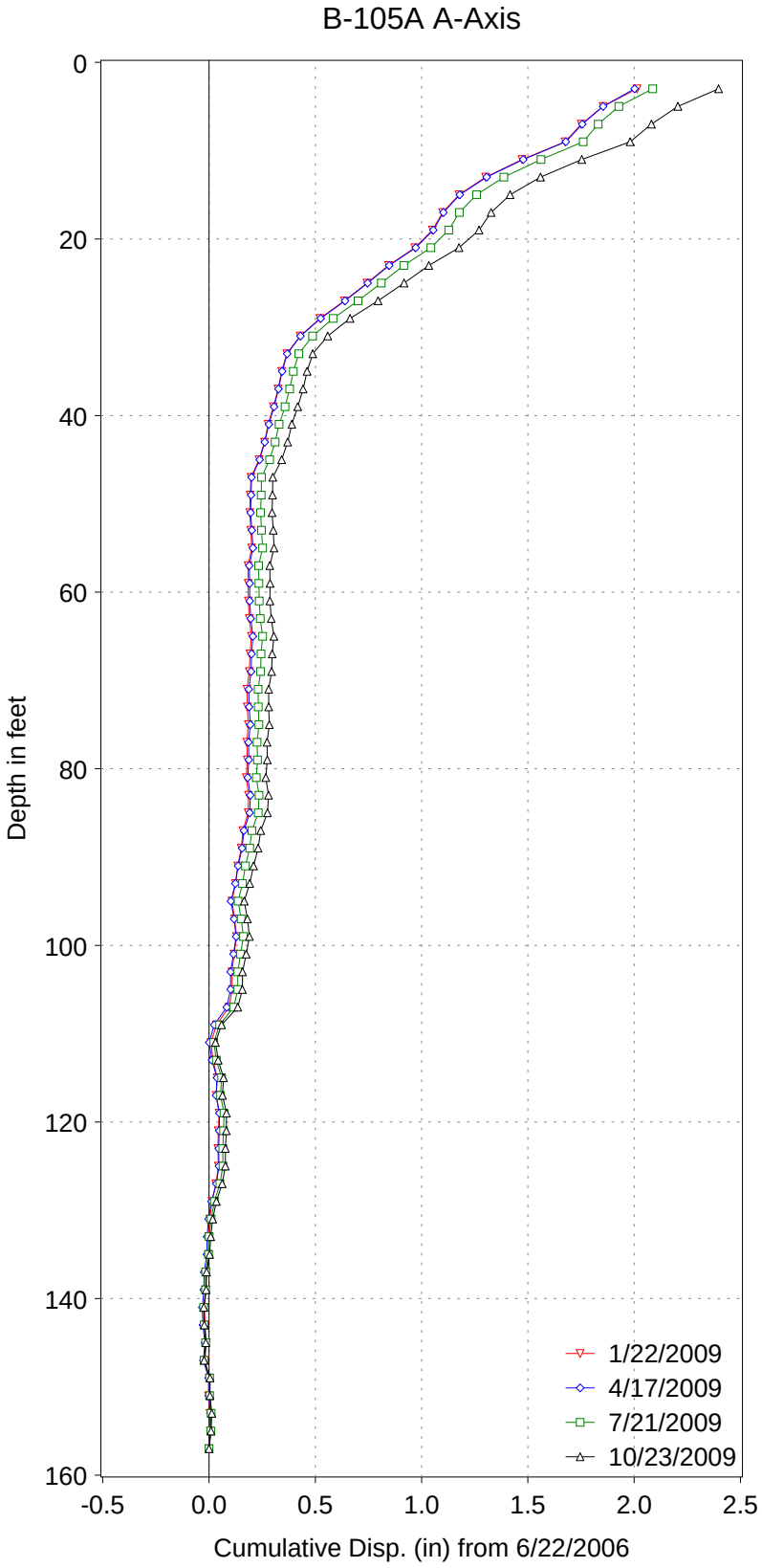
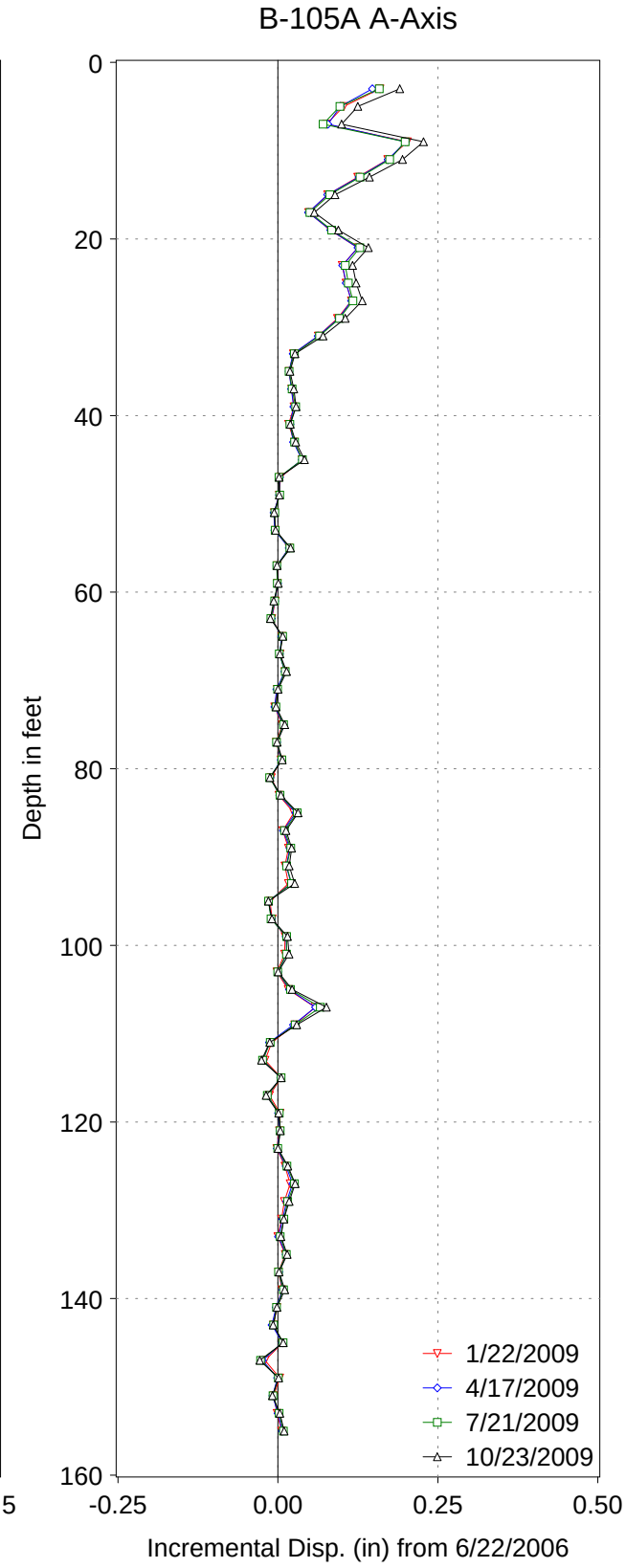

B-303 Time-Displacement A-Axis
47-51 feet
55-57 feet
95-99 feet
Displacement (in)
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

PLATE 21

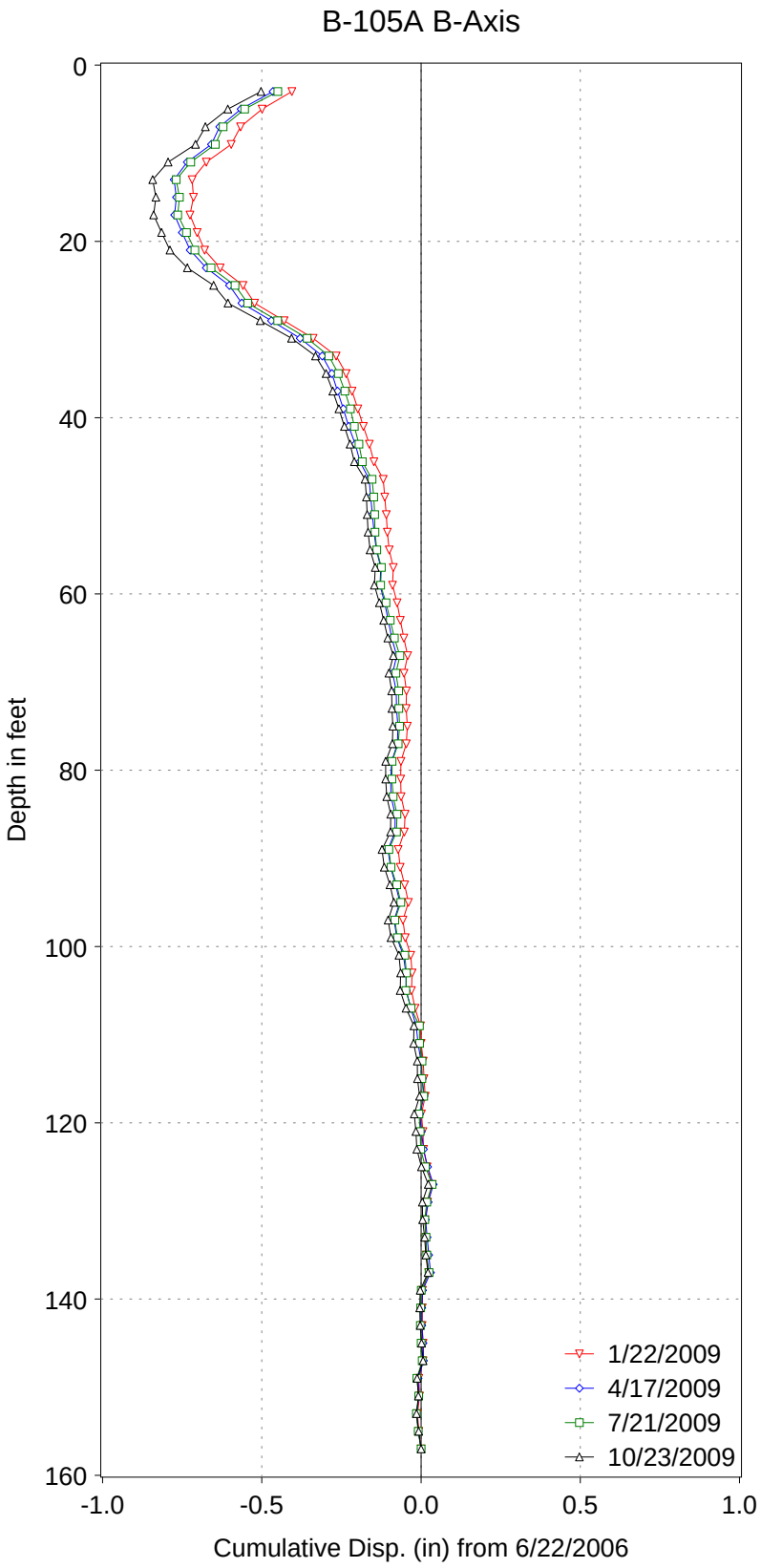


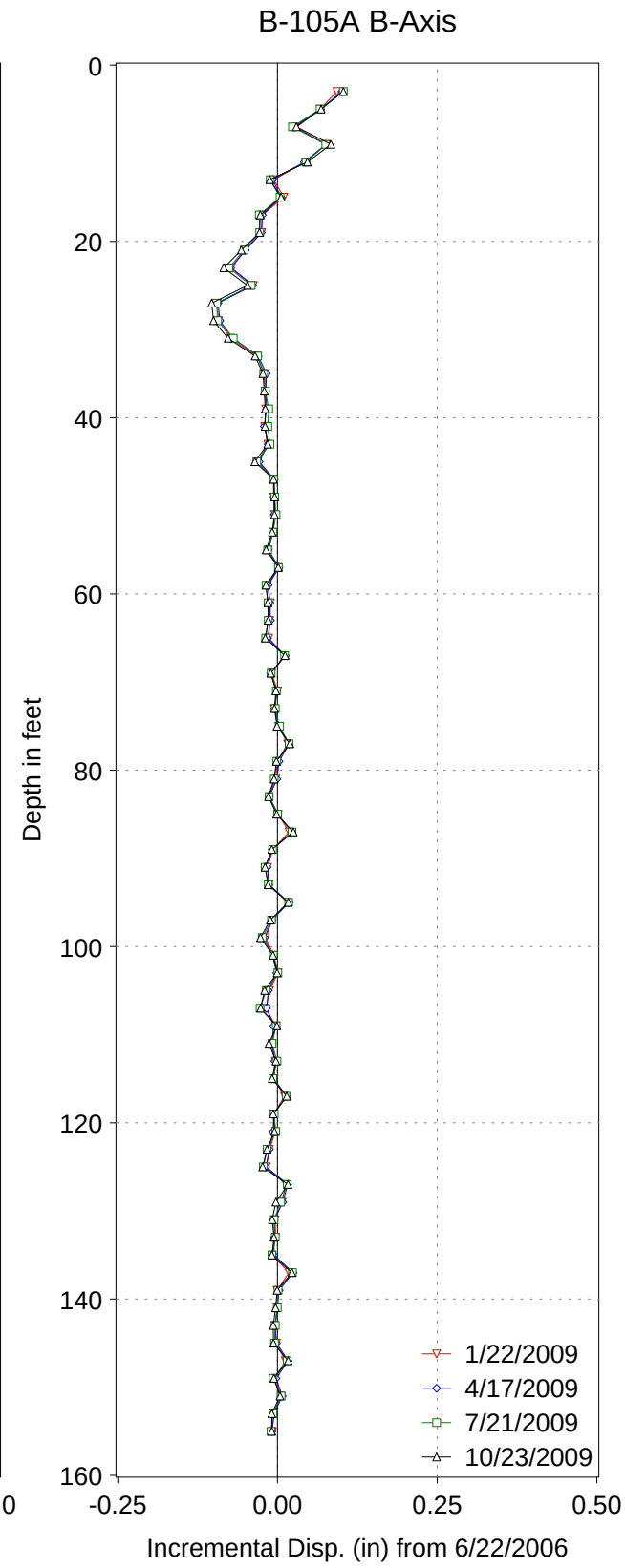


B-105A

-Includes readings from the last four quarters.

PLATE 22

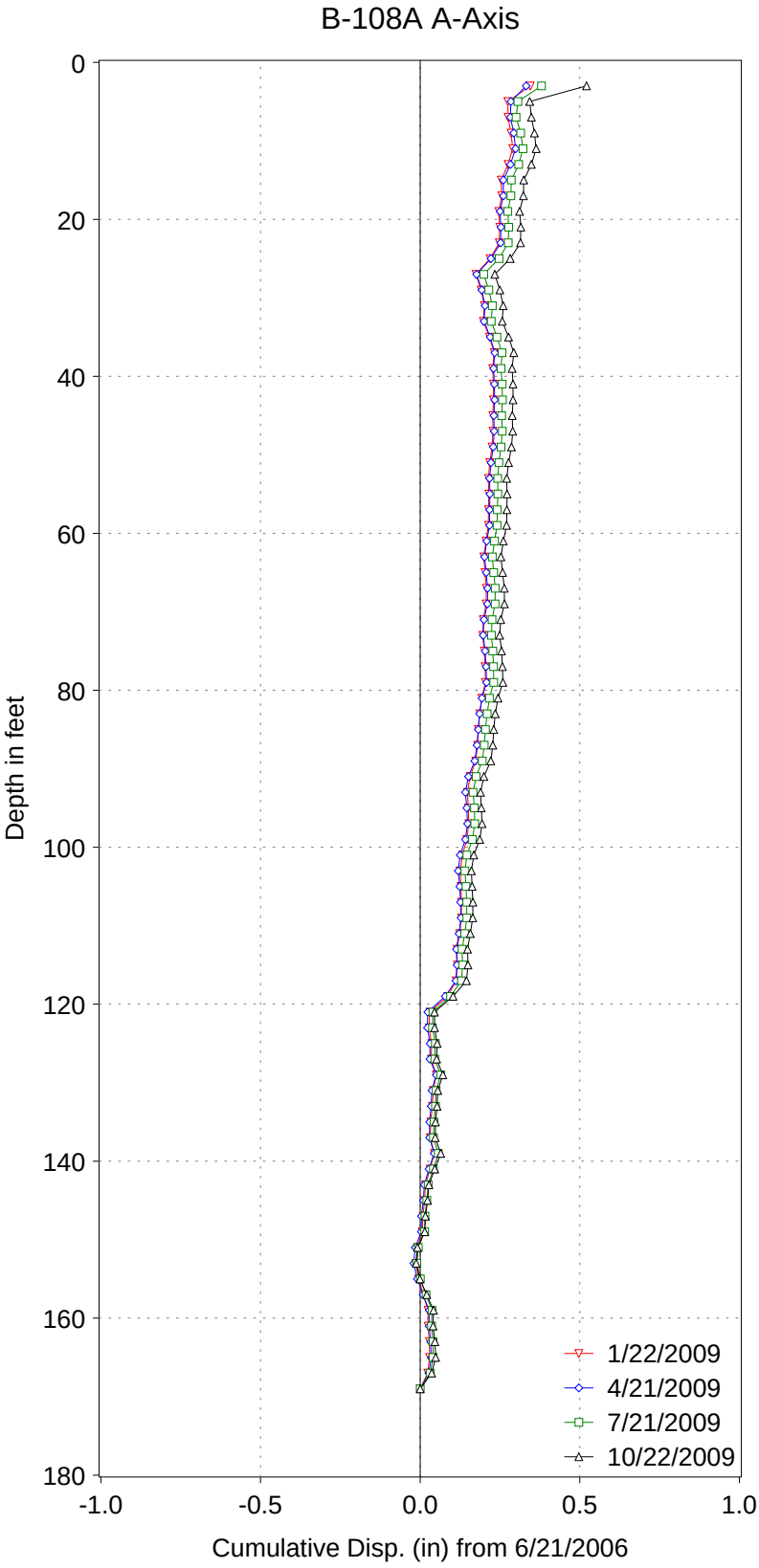


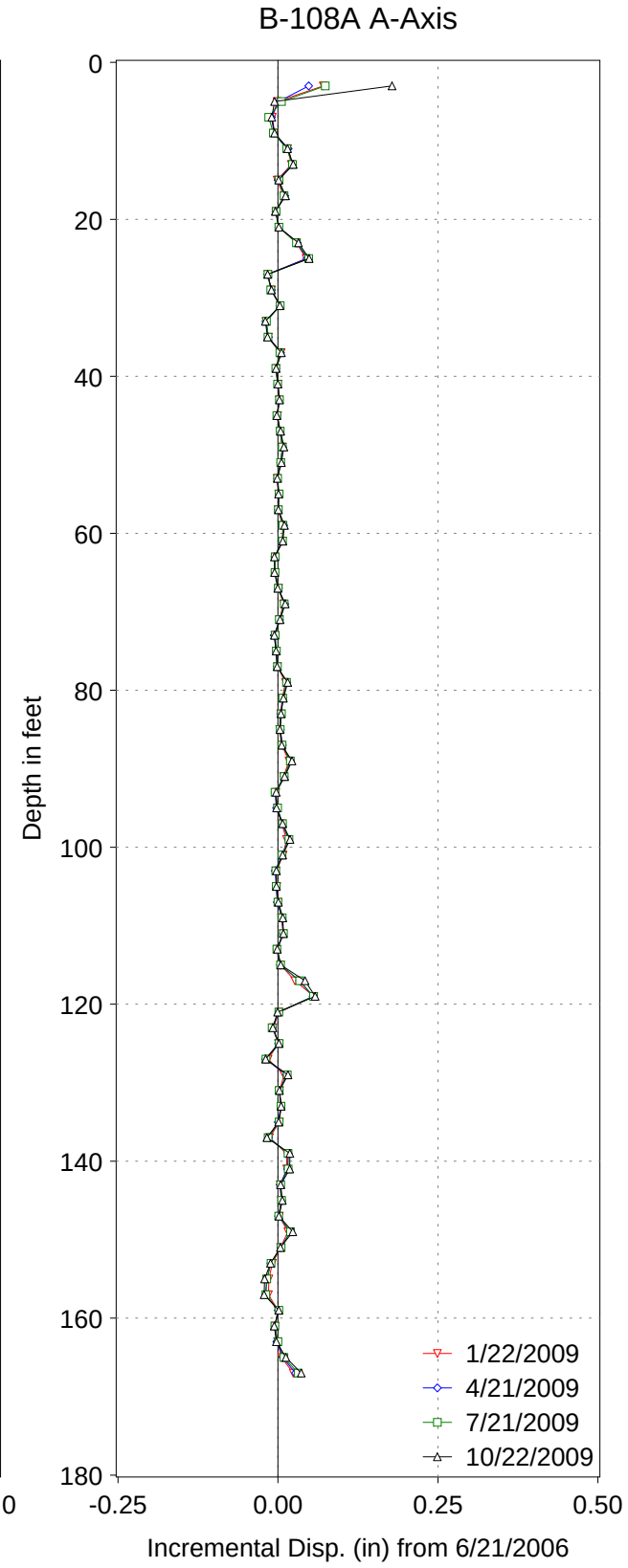


B-105A

-Includes readings from the last four quarters.

PLATE 23

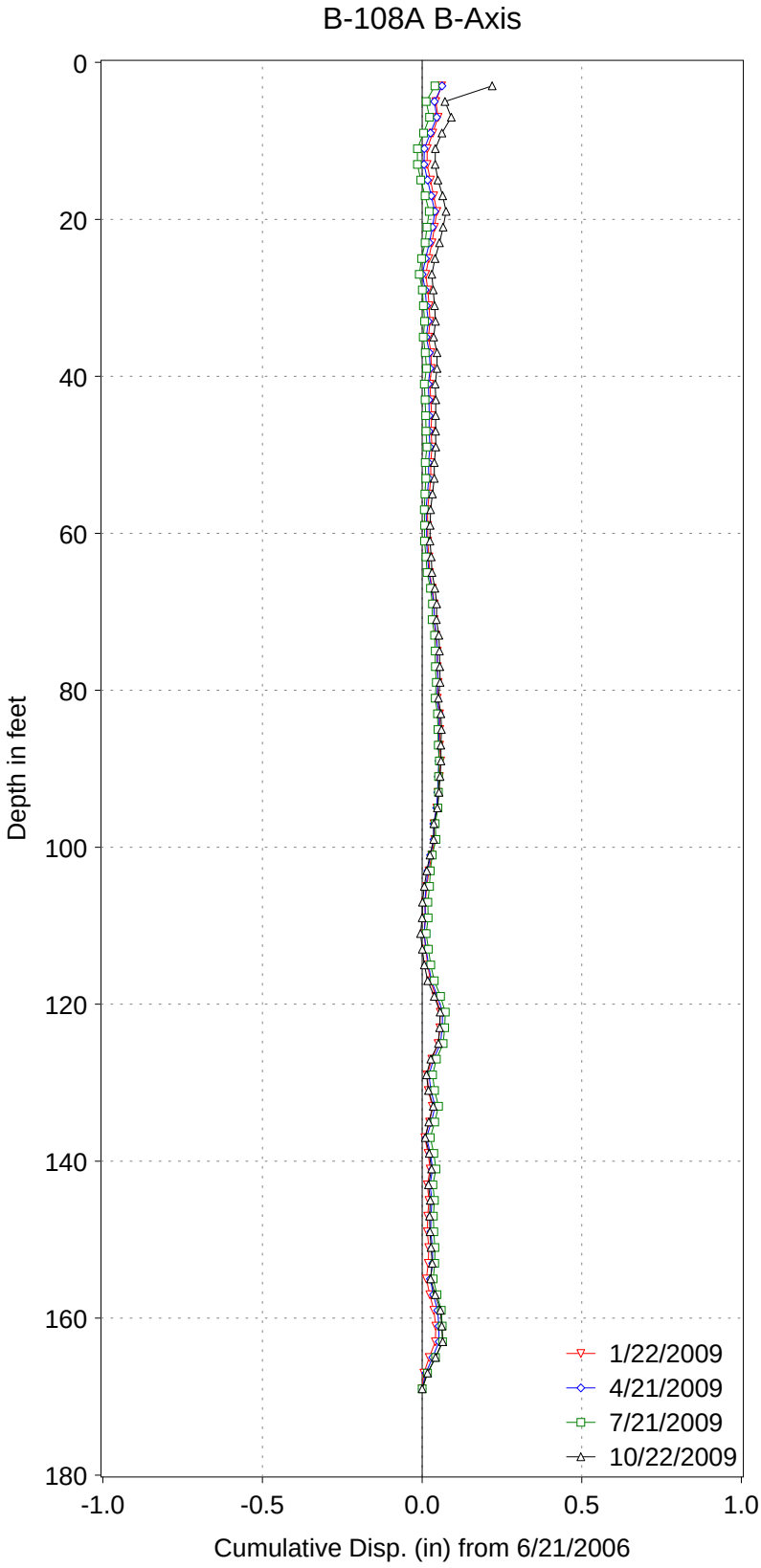


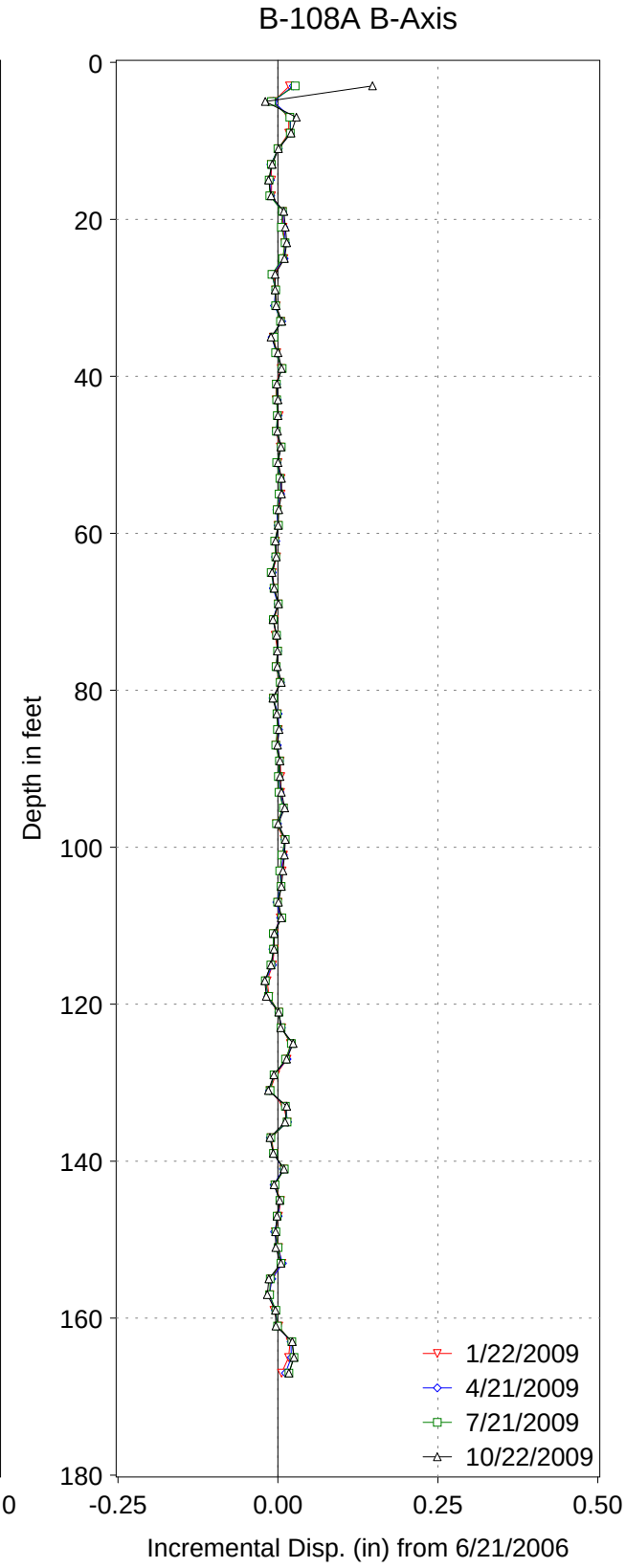


B-108A

-Includes readings from the last four quarters.

PLATE 24





B-108A

-Includes readings from the last four quarters.

PLATE 25

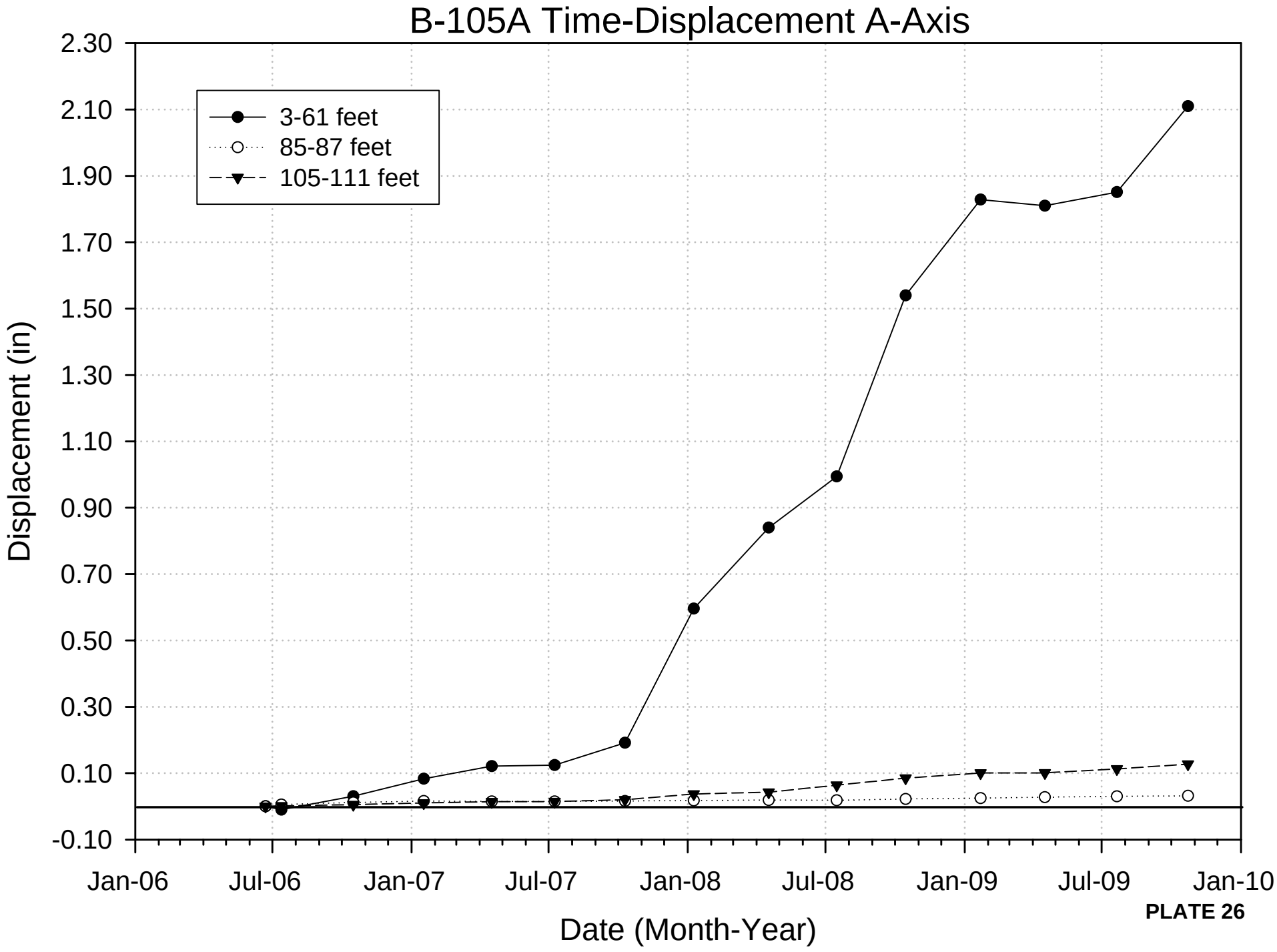

B-105A Time-Displacement A-Axis
3-61 feet
85-87 feet
105-111 feet
Displacement (in)
2.30
2.10
1.90
1.70
1.50
1.30
1.10
0.90
0.70
0.50
0.30
0.10
-0.10
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Date (Month-Year)

PLATE 26

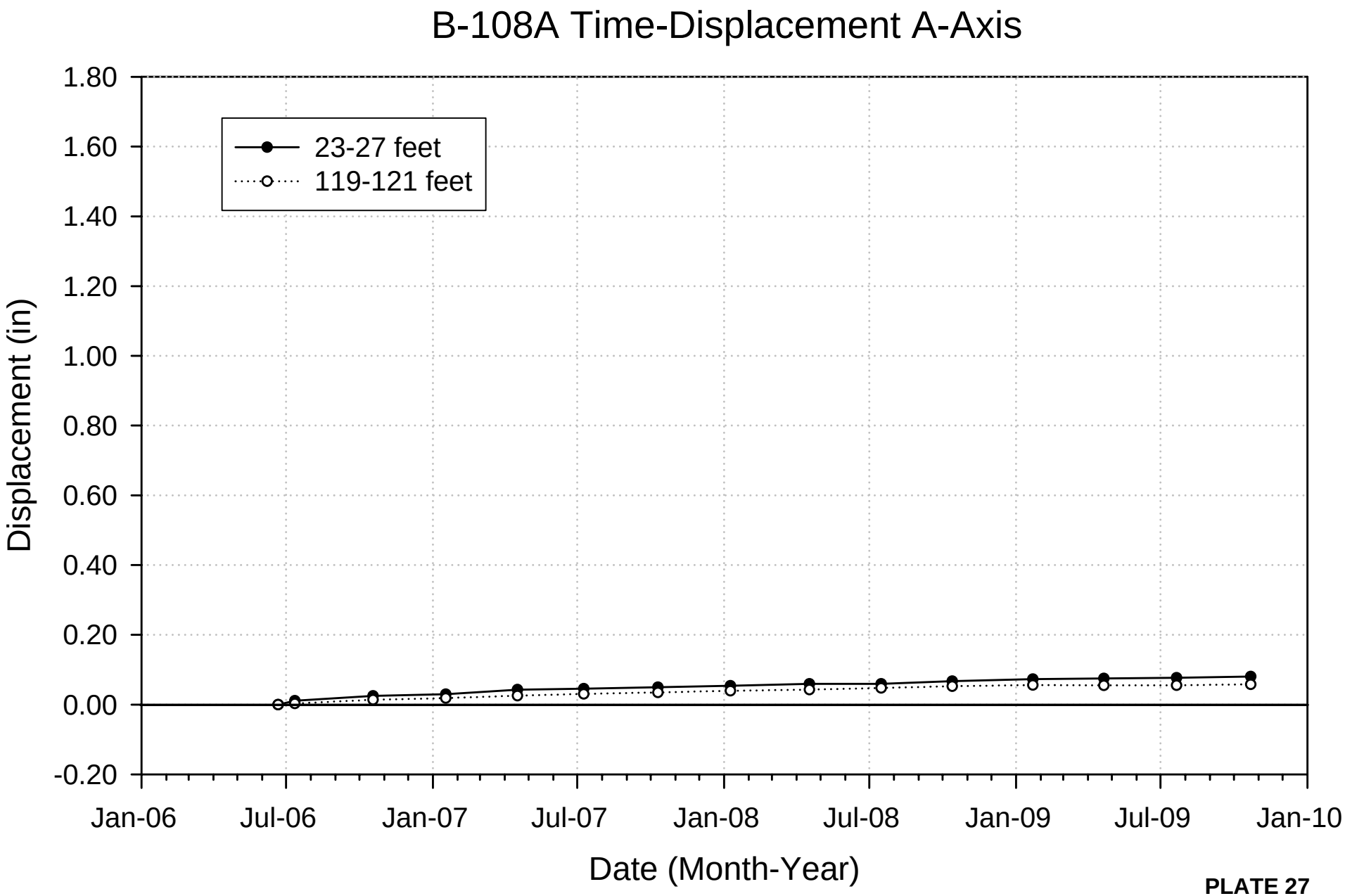
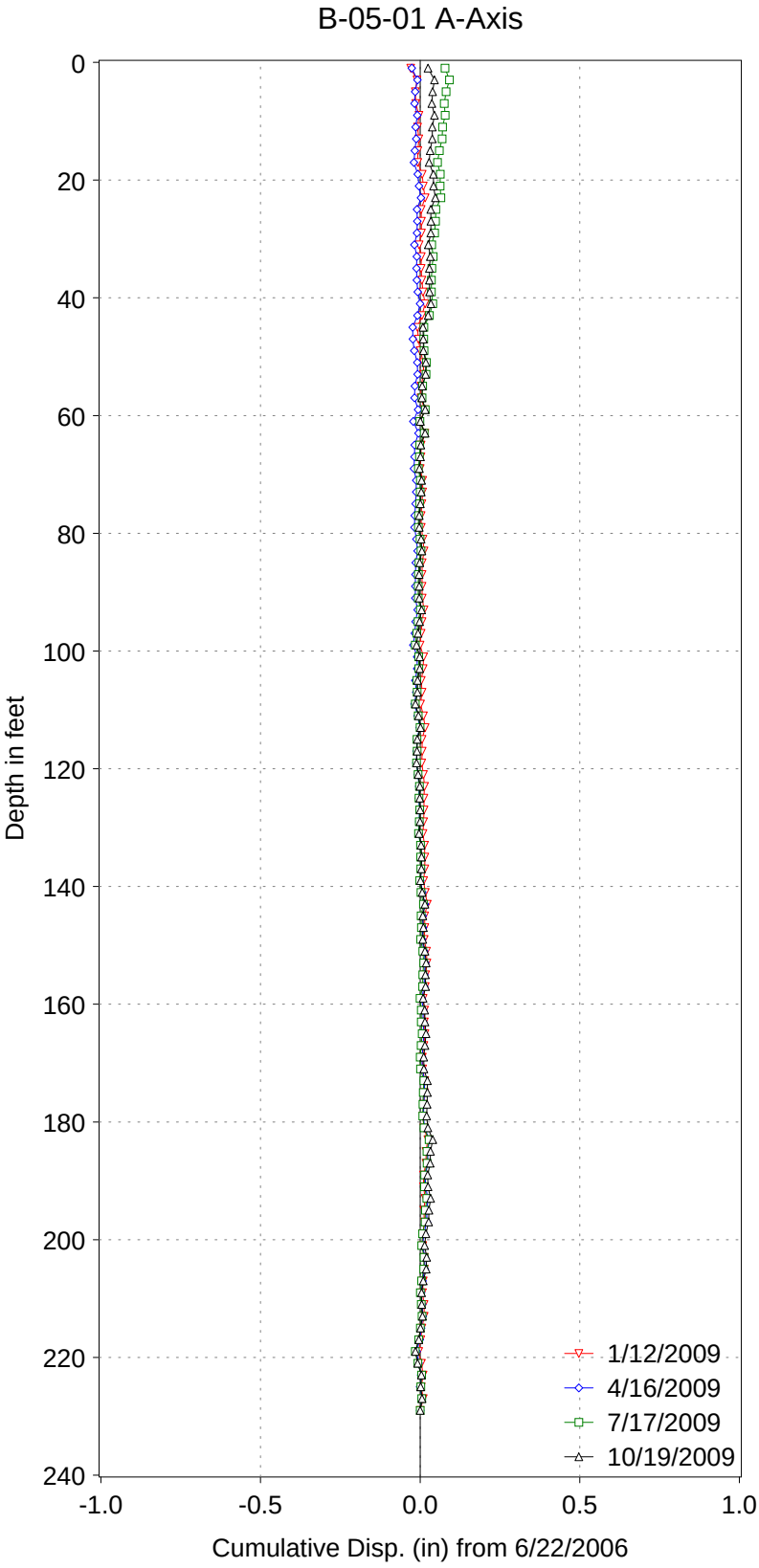
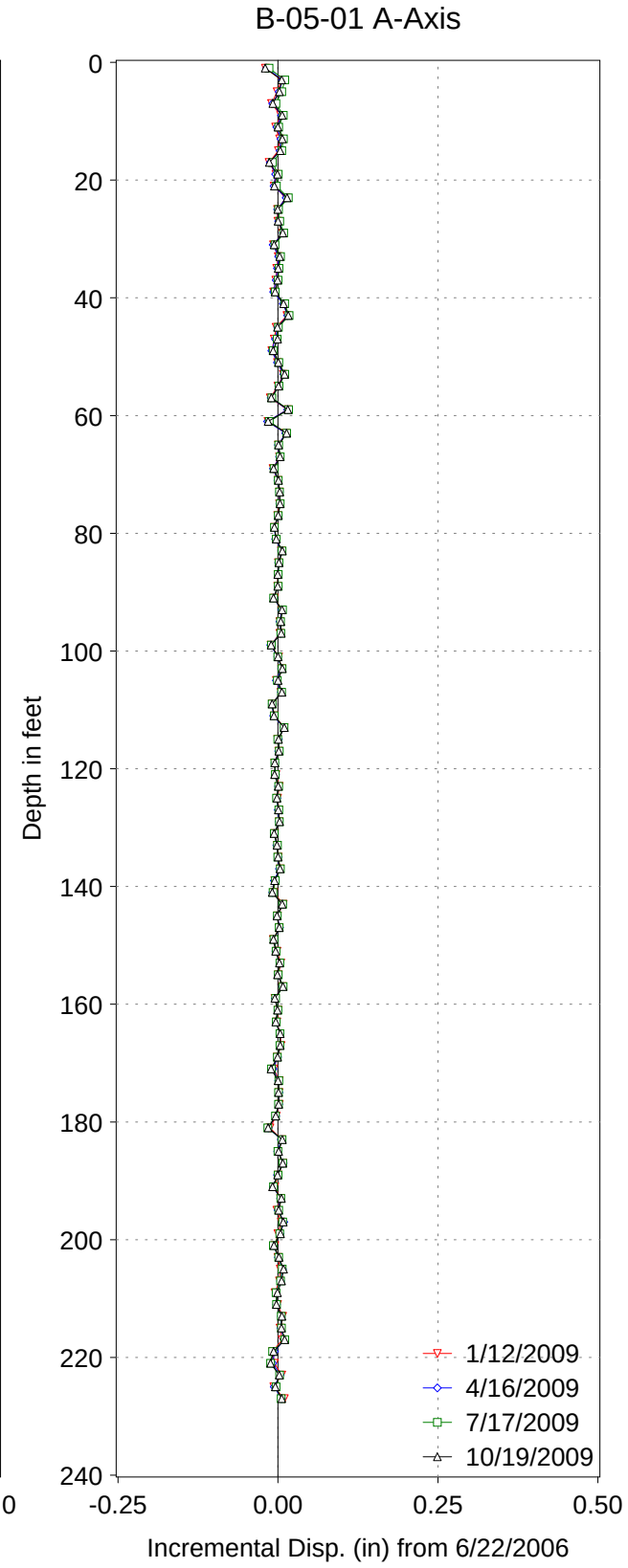

B-108A Time-Displacement A-Axis
23-27 feet
119-121 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Date (Month-Year)

PLATE 27

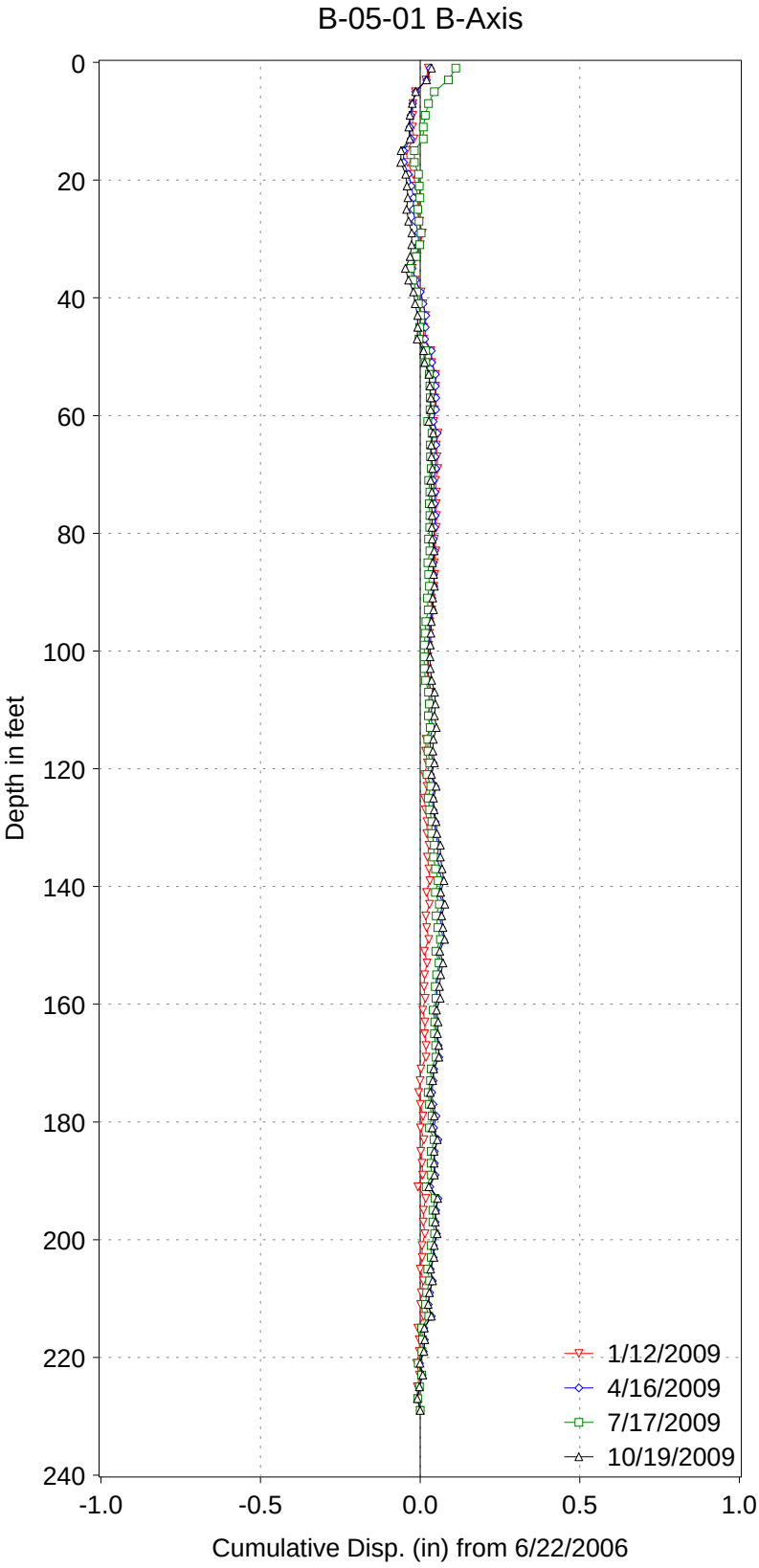


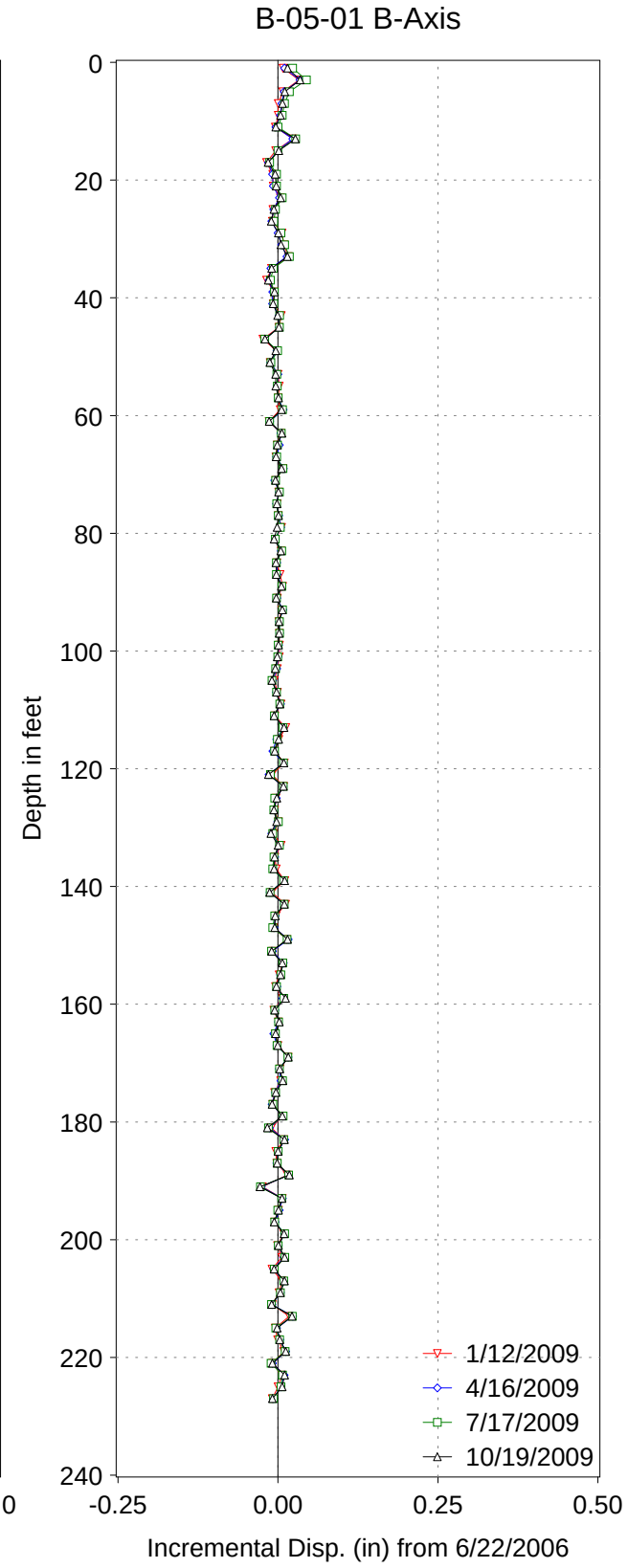


B-05-01

-Includes readings from the last four quarters.

PLATE 28

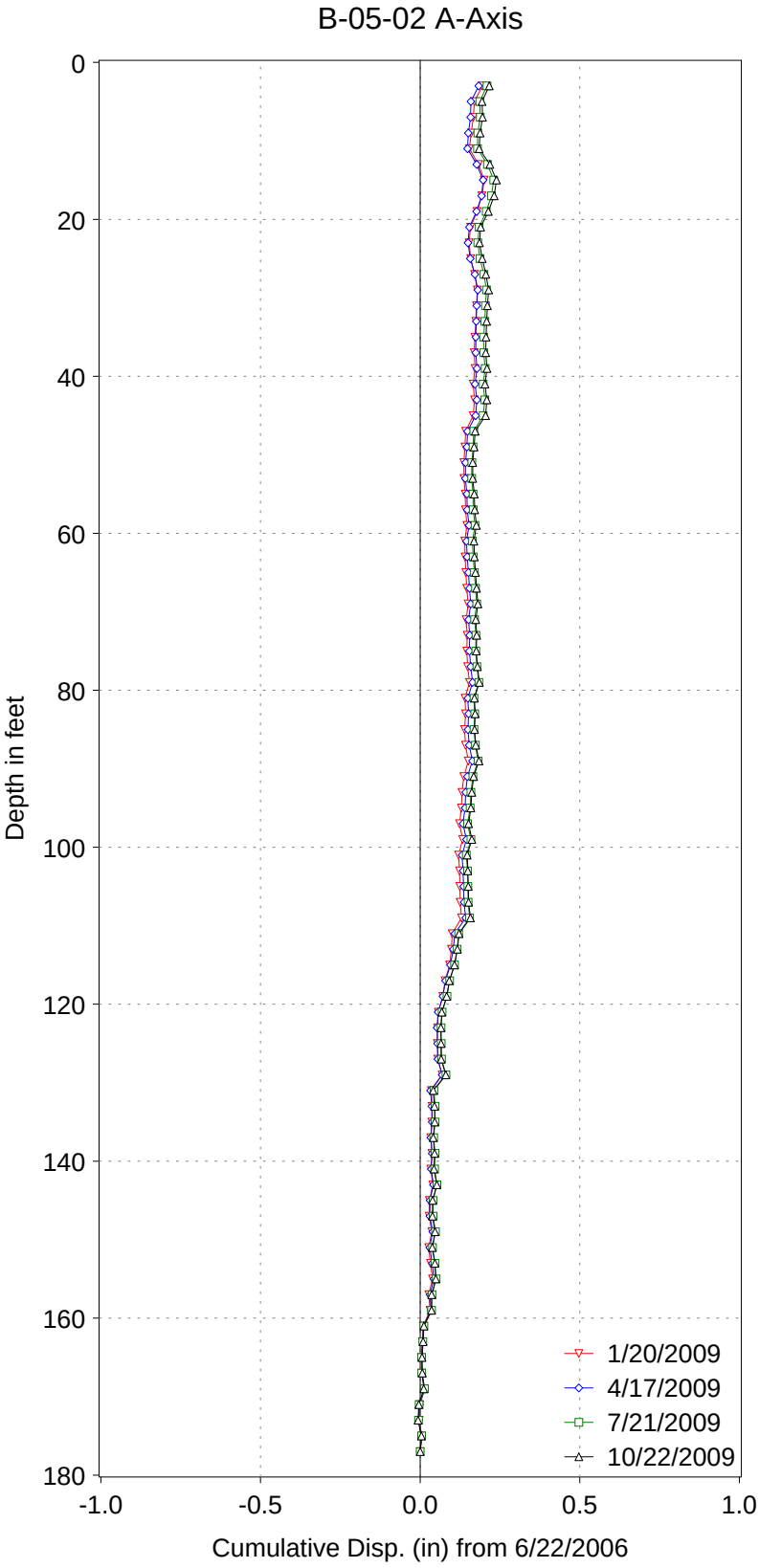


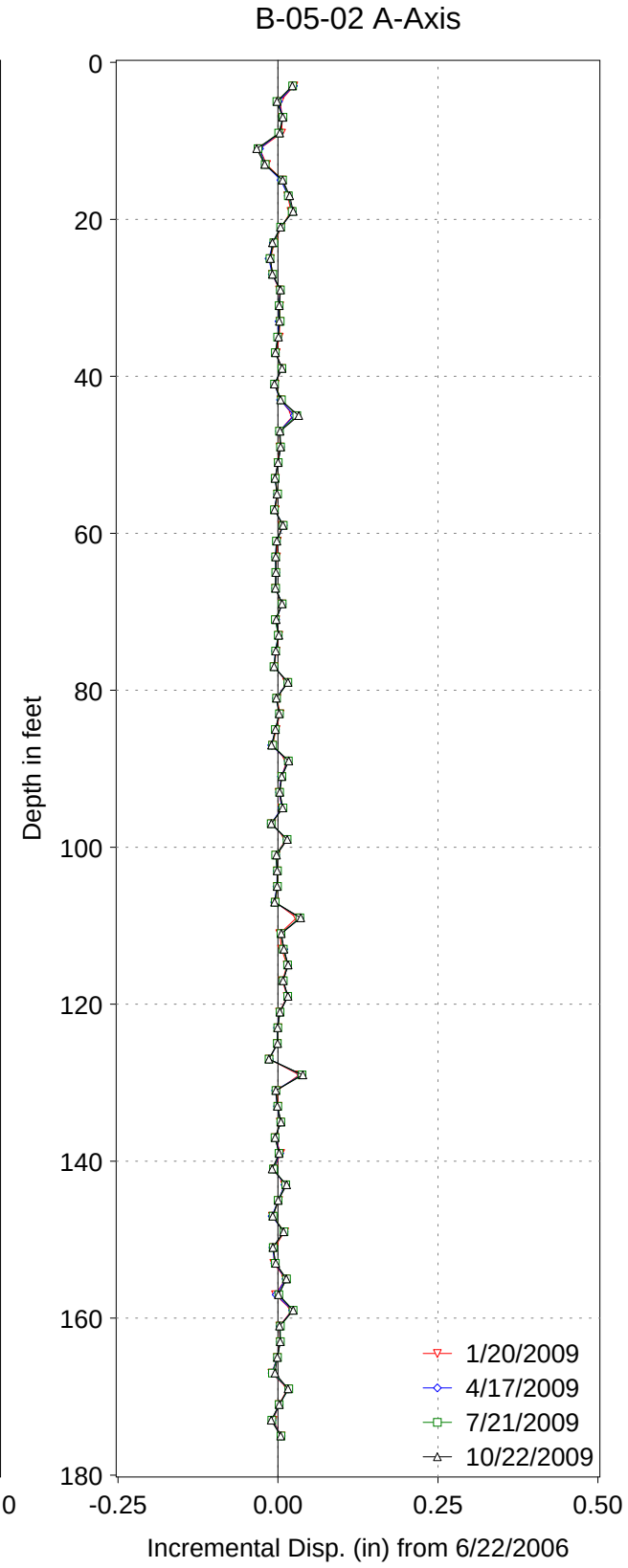


B-05-01

-Includes readings from the last four quarters.

PLATE 29

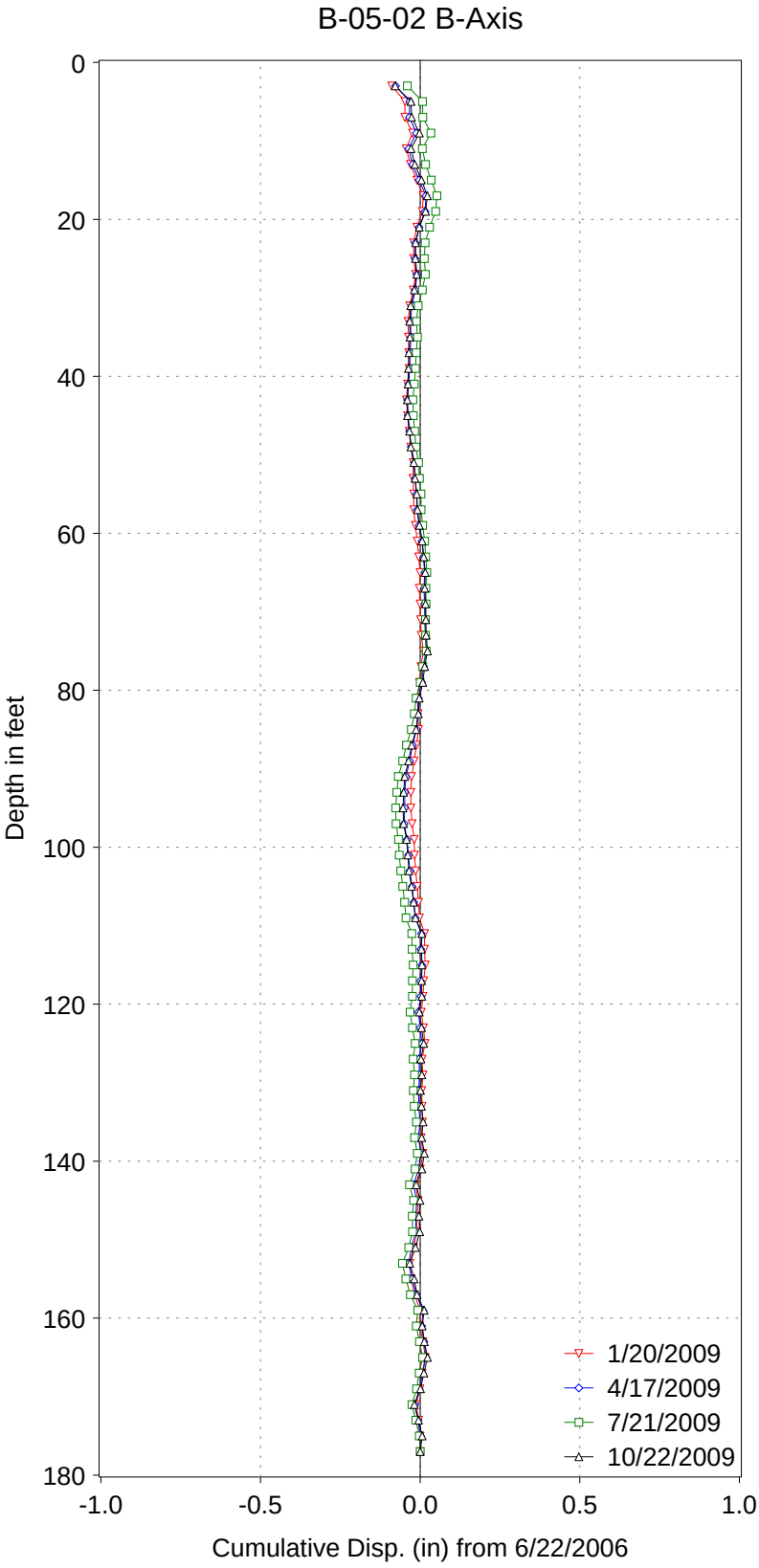


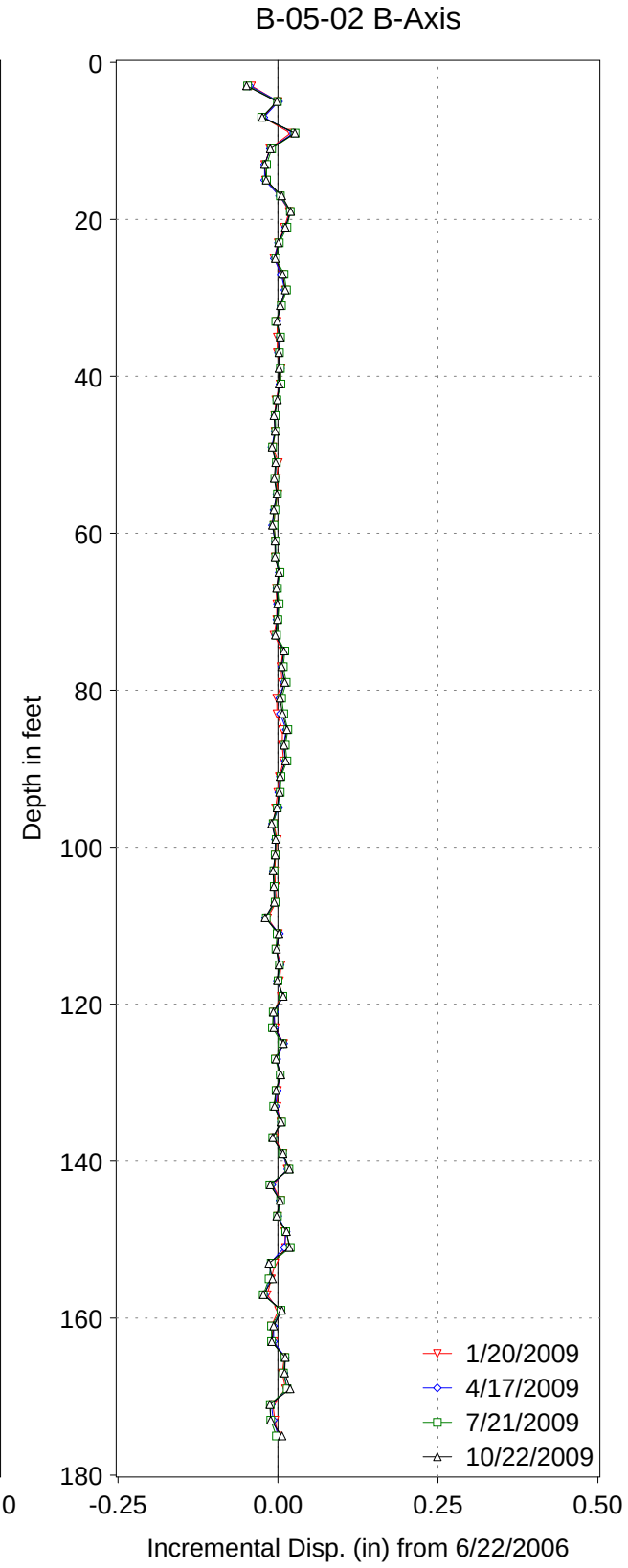


B-05-02

-Includes readings from the last four quarters.

PLATE 30

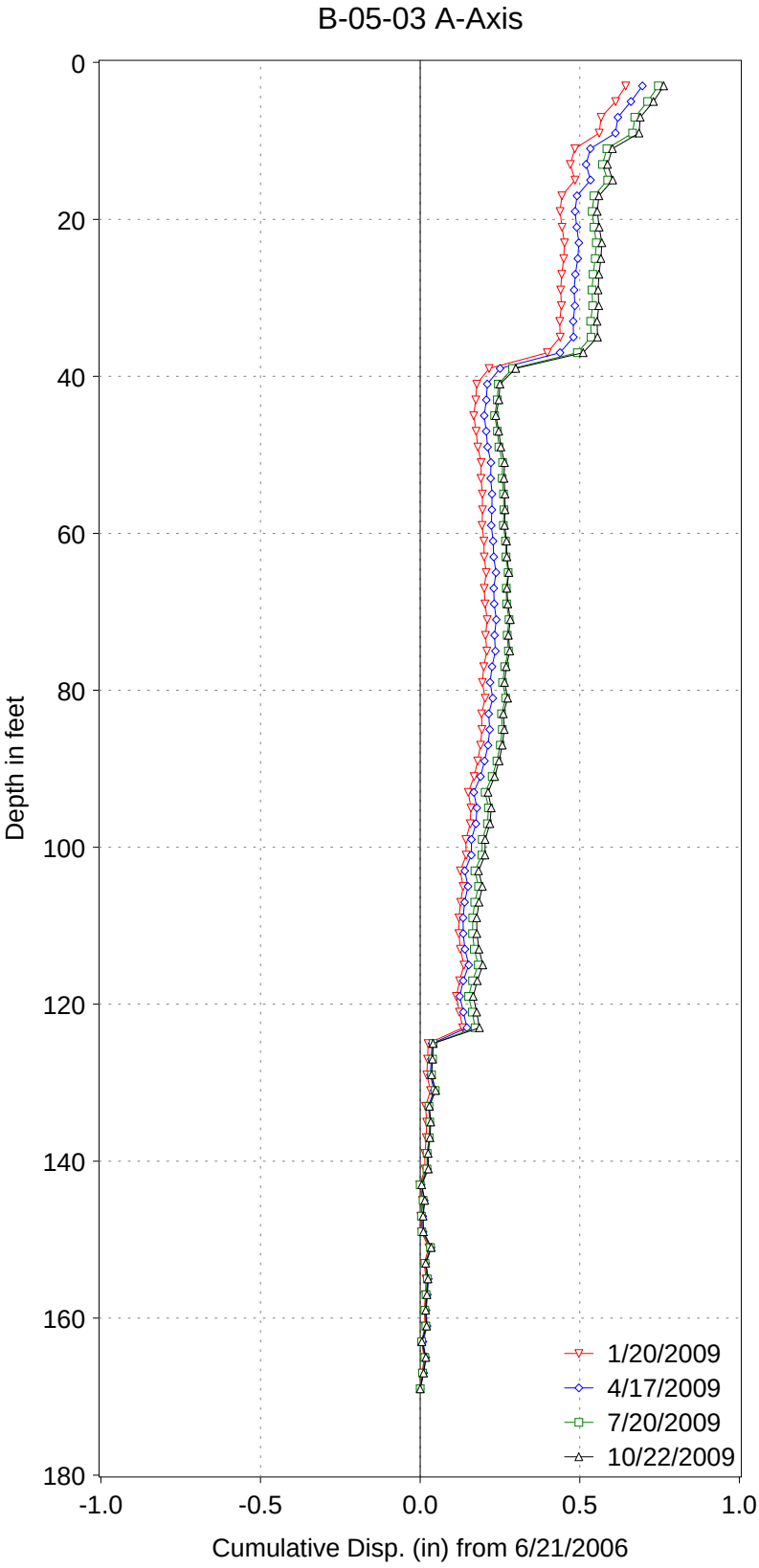


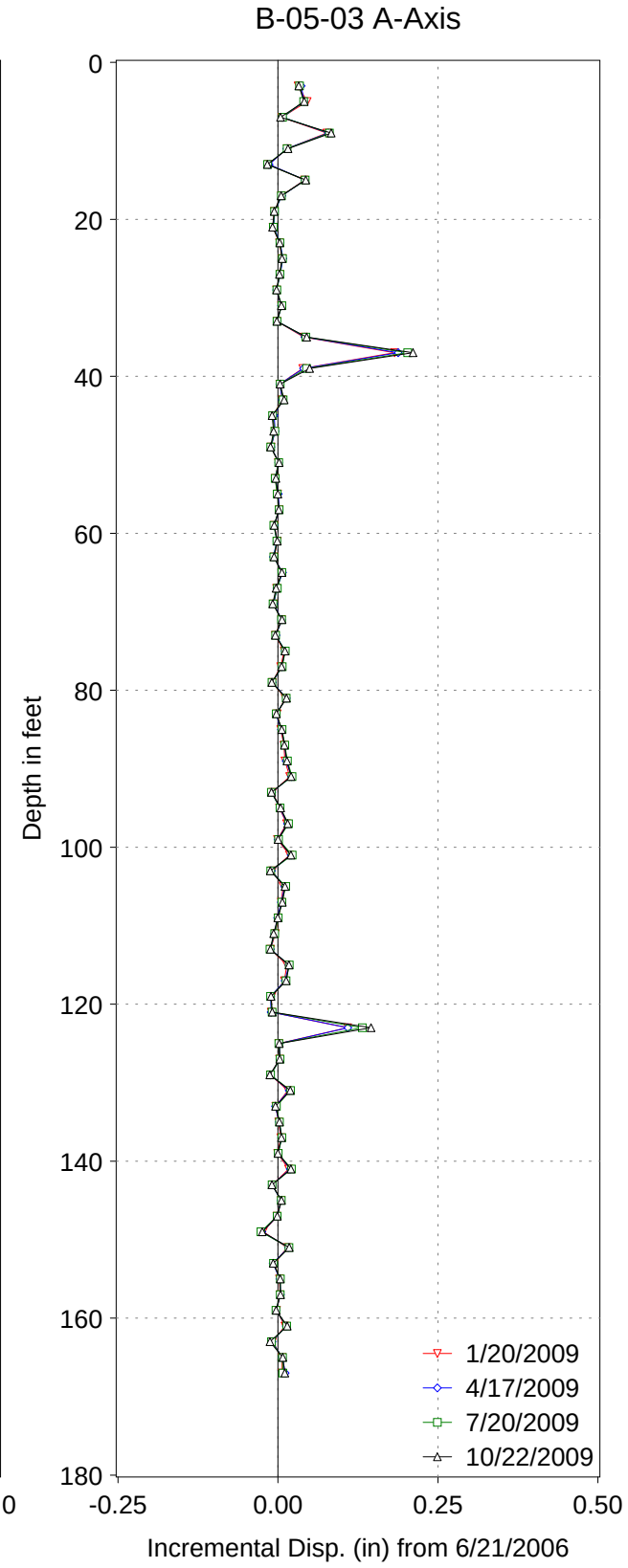


B-05-02

-Includes readings from the last four quarters.

PLATE 31

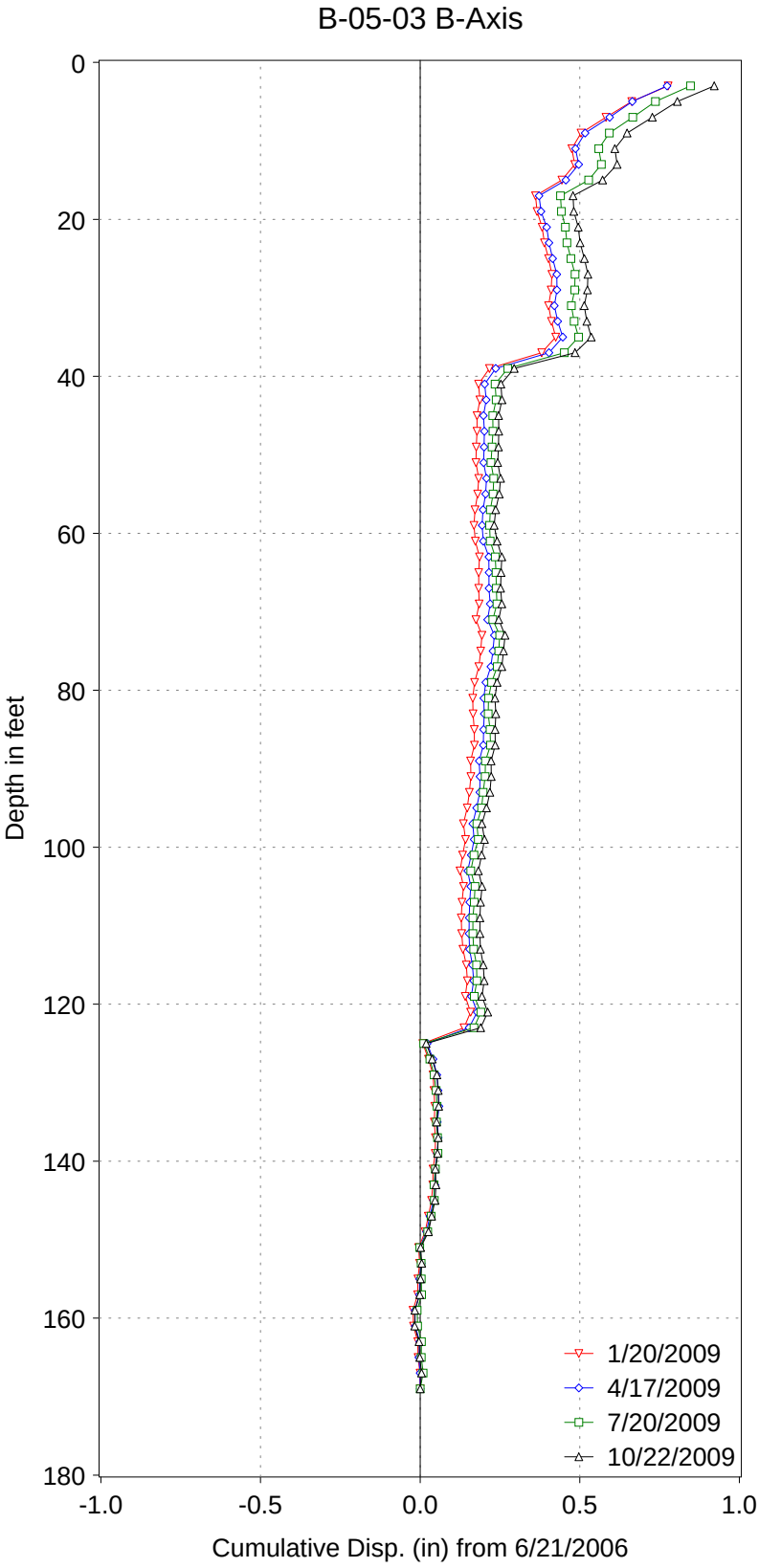


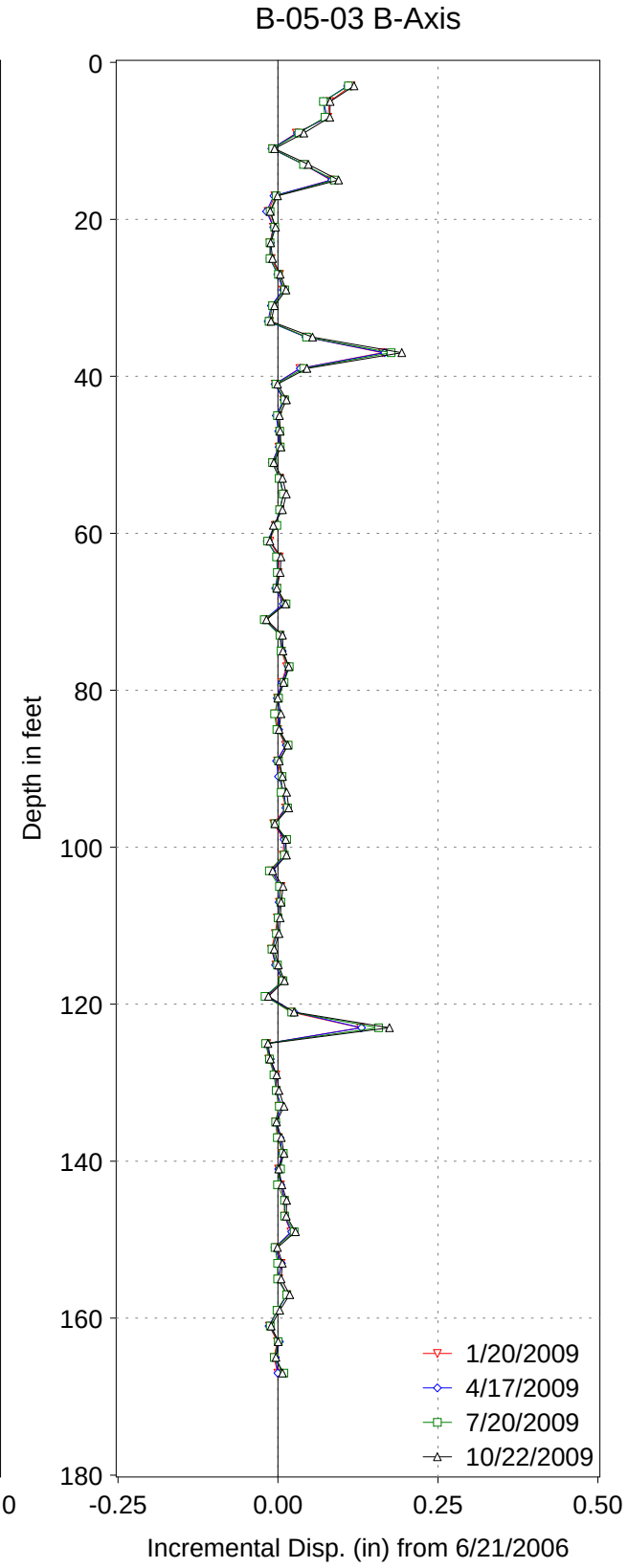


B-05-03

-Includes readings from the last four quarters.

PLATE 32

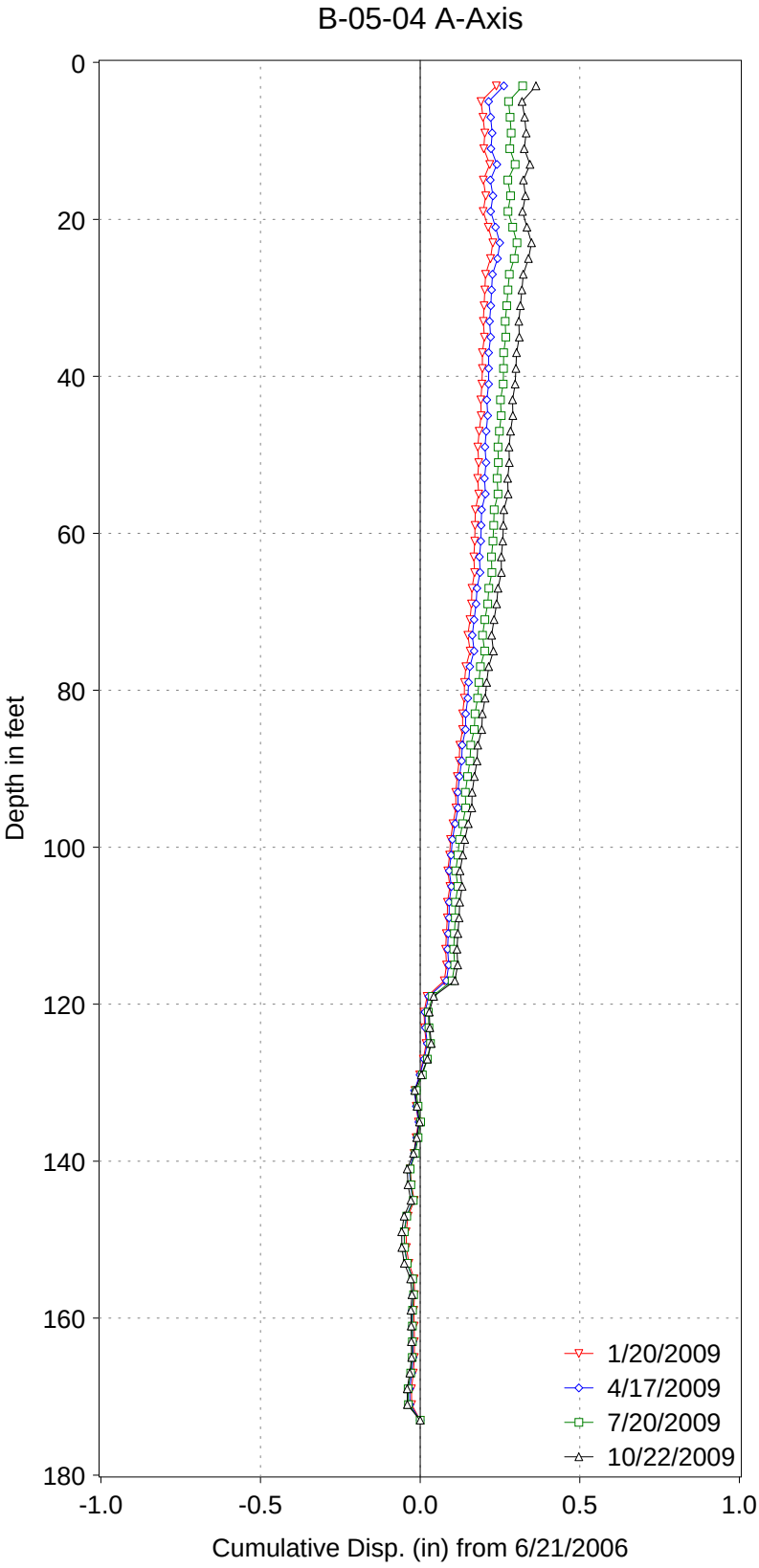


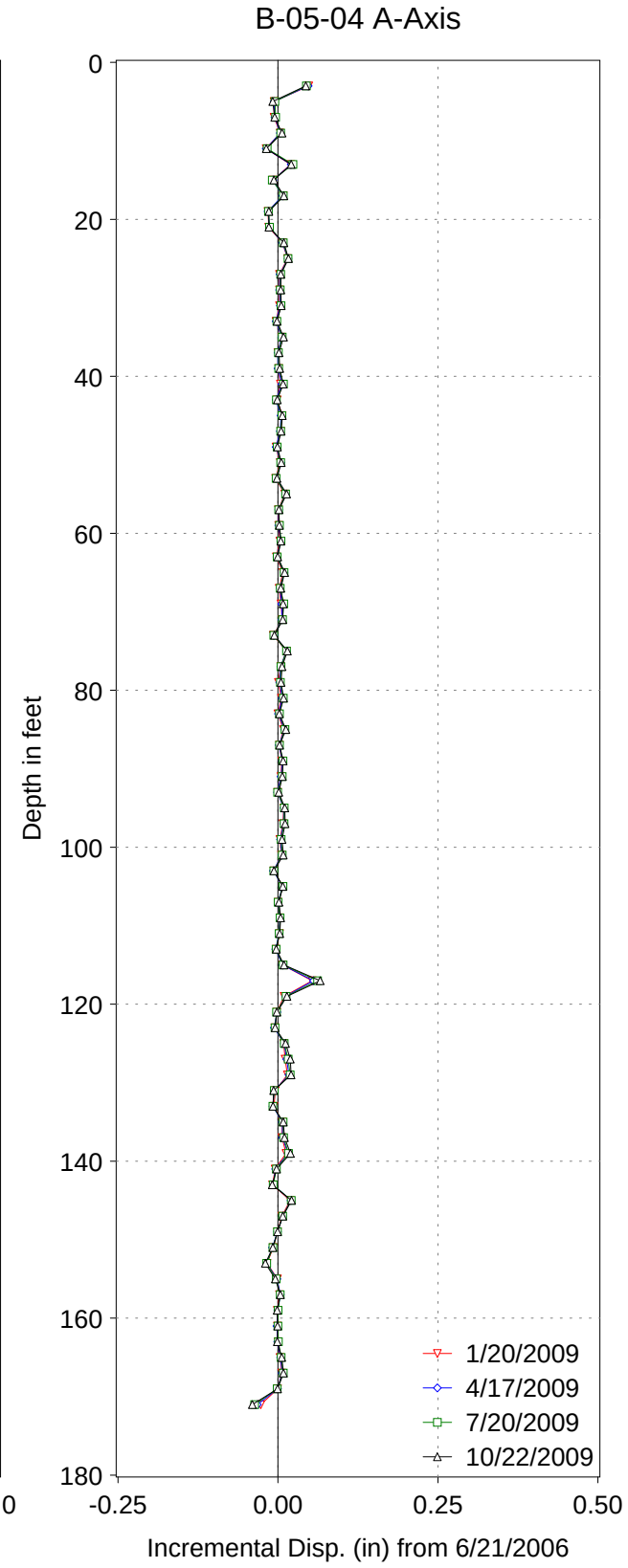


B-05-03

-Includes readings from the last four quarters.

PLATE 33

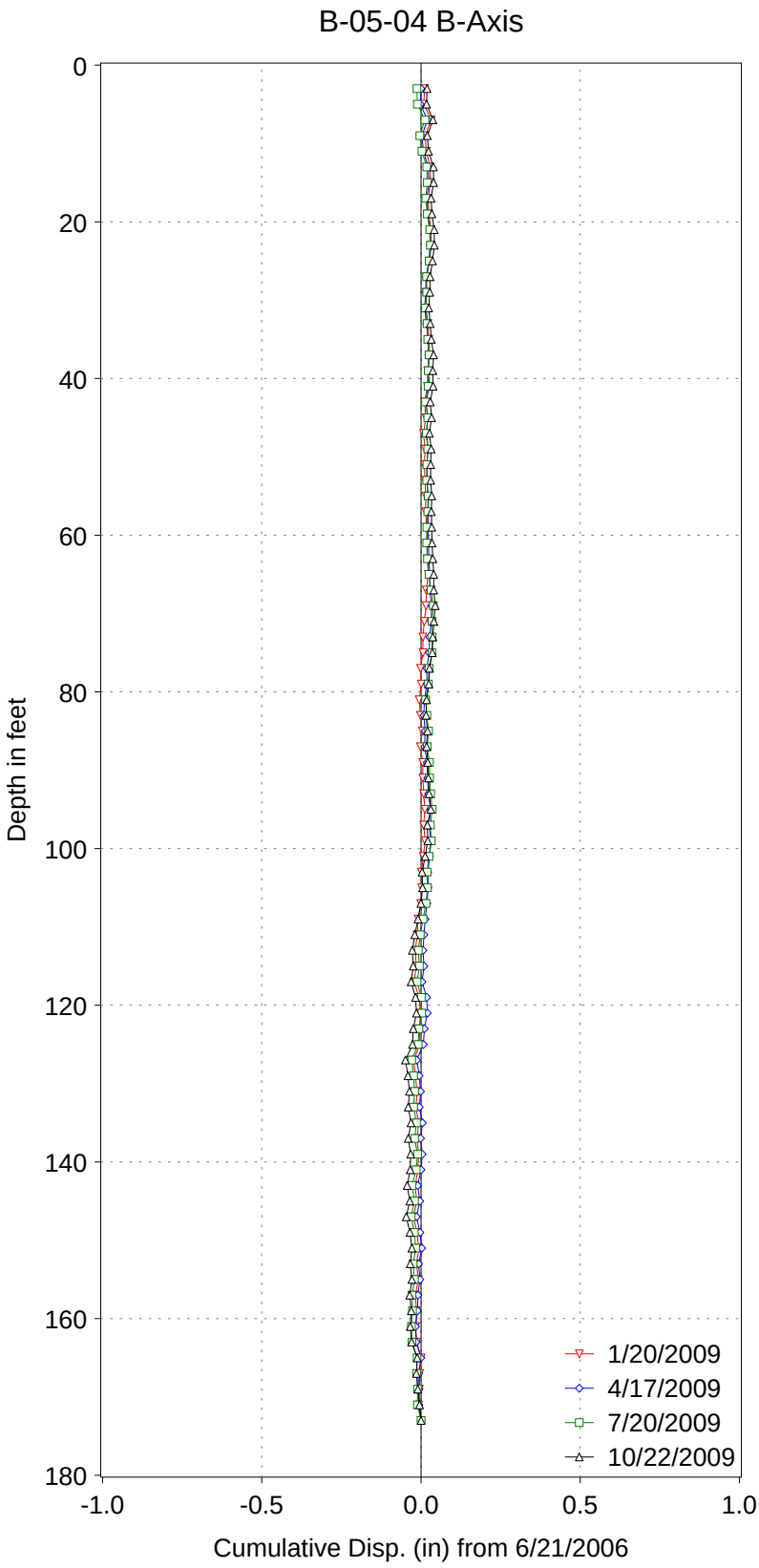


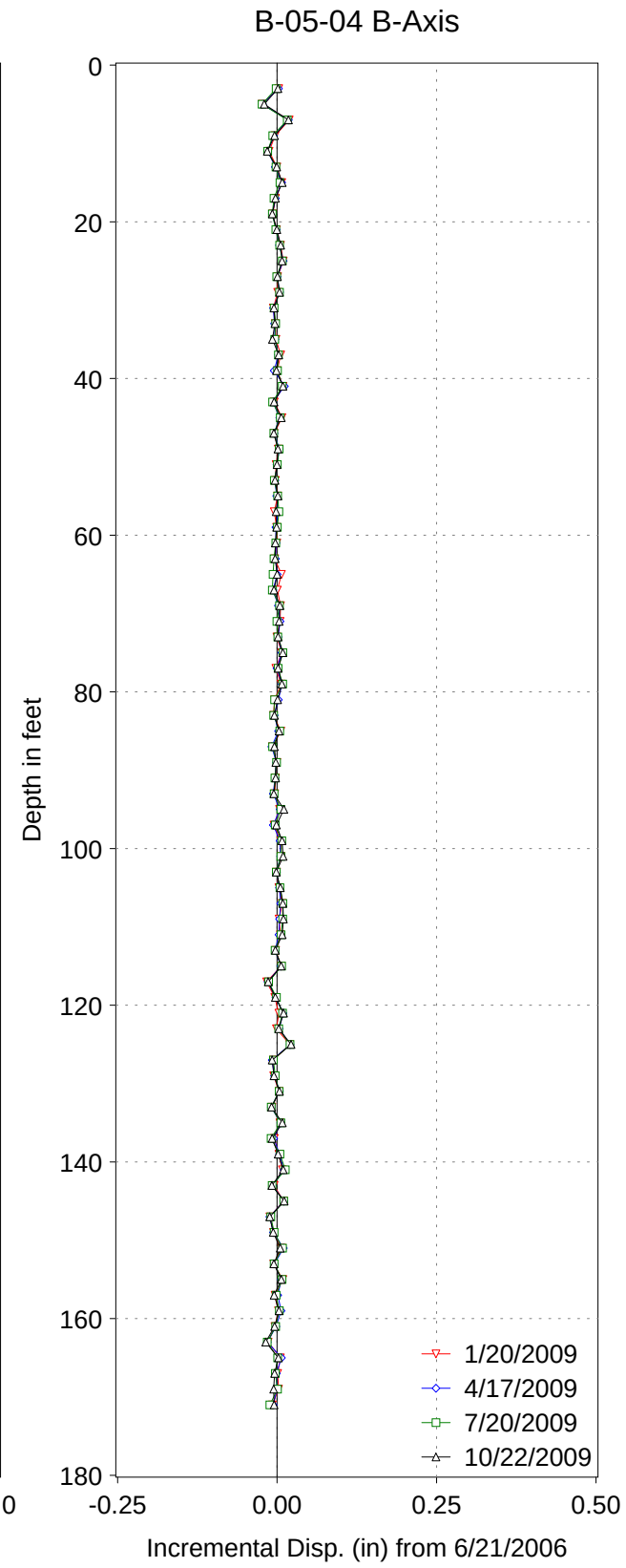


B-05-04

-Includes readings from the last four quarters.

PLATE 34

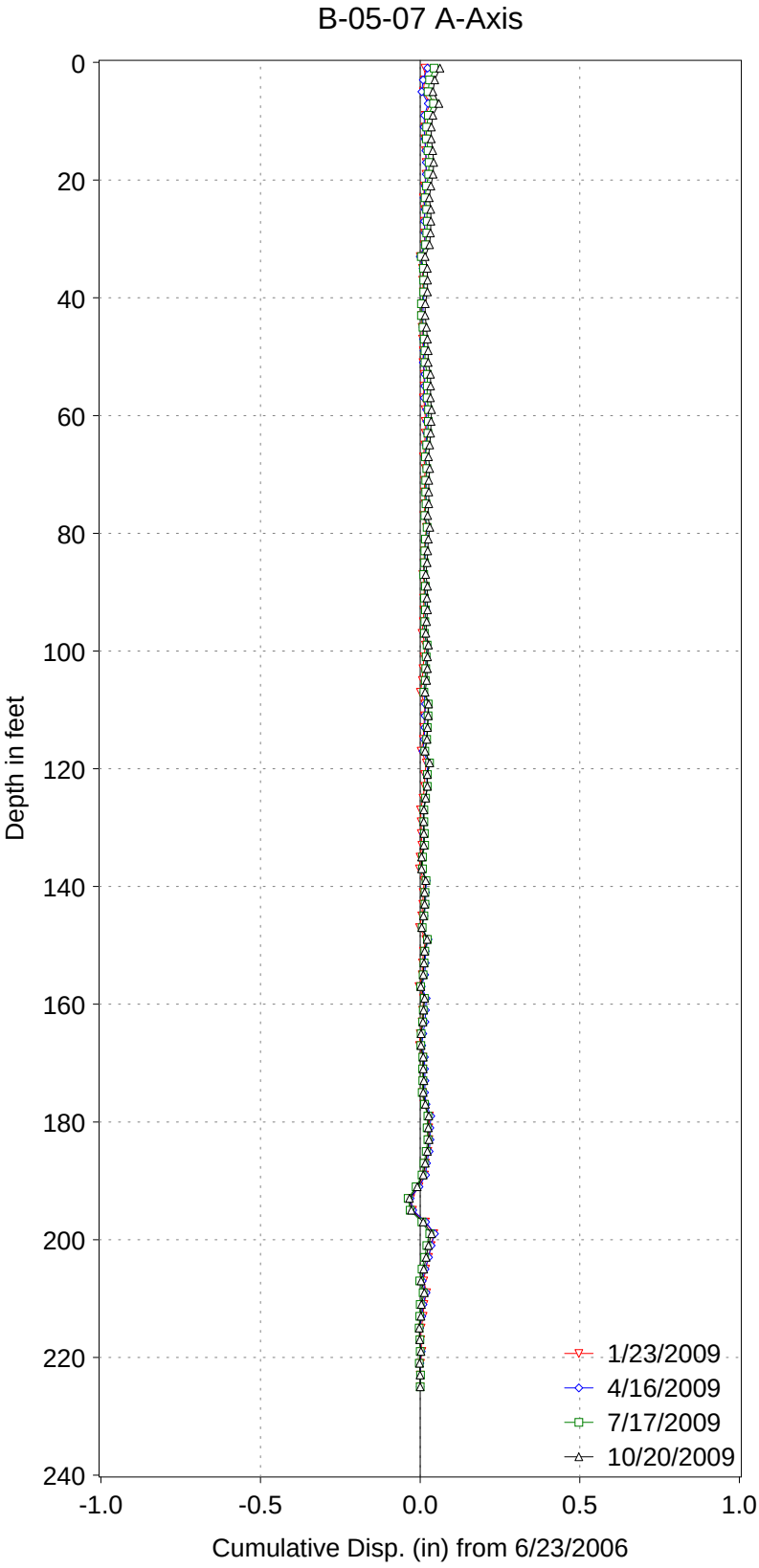


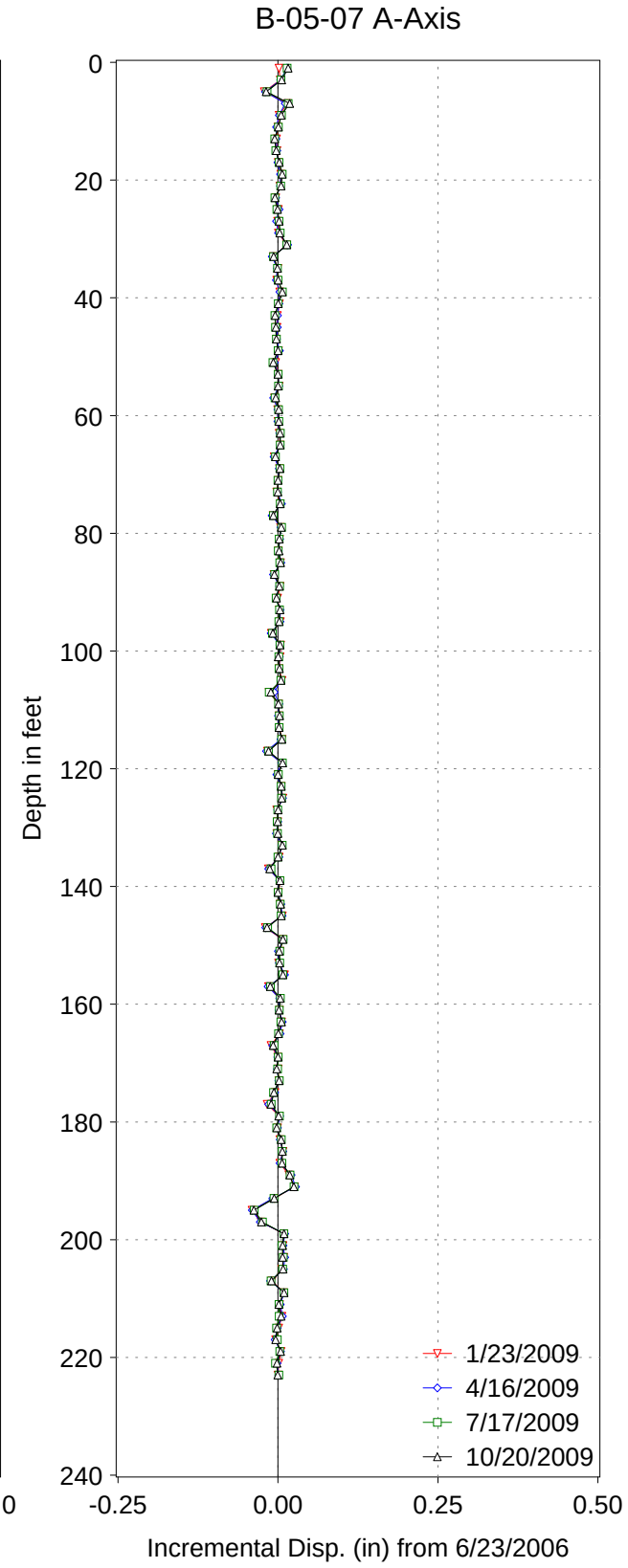


B-05-04

-Includes readings from the last four quarters.

PLATE 35

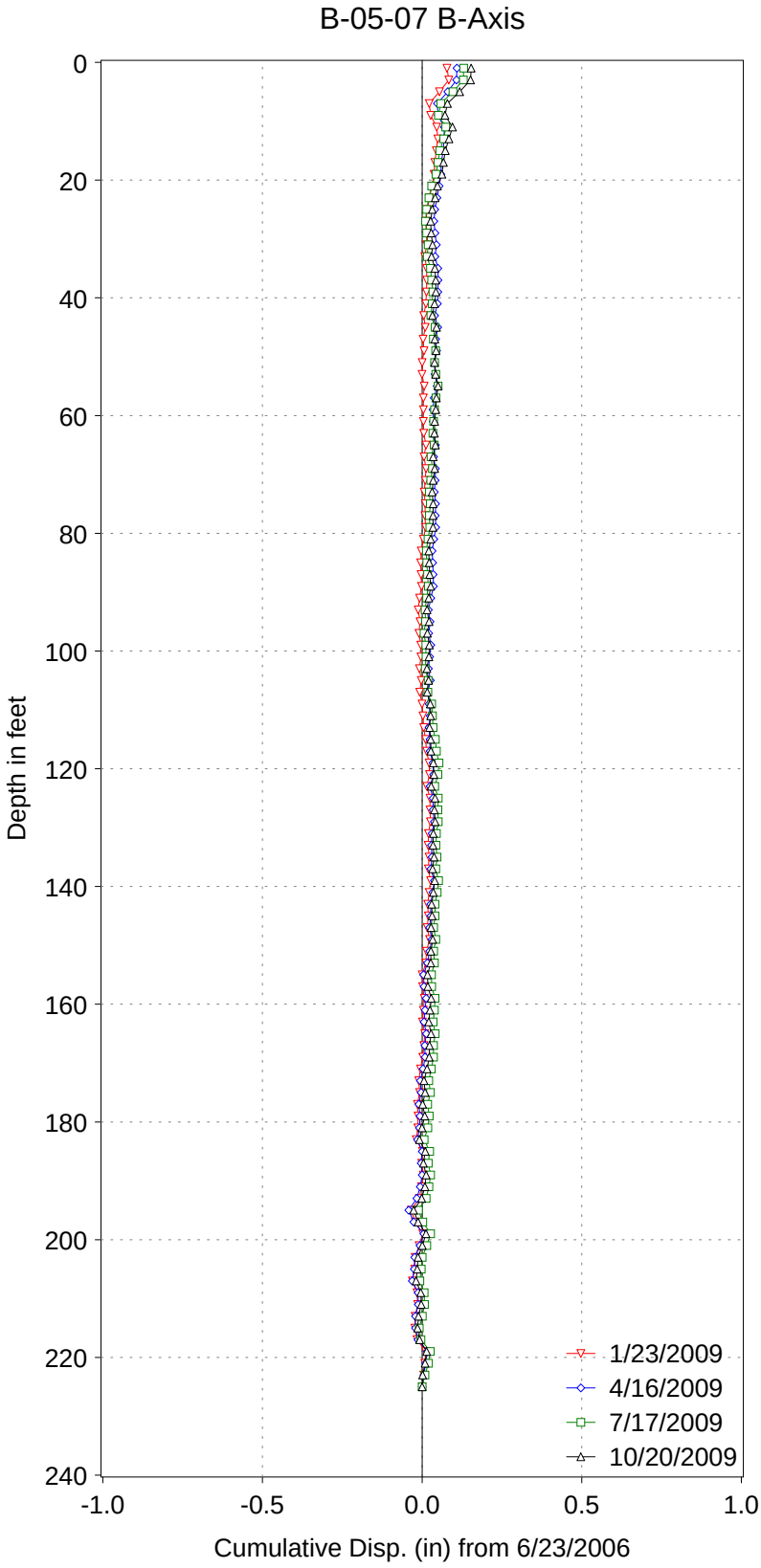


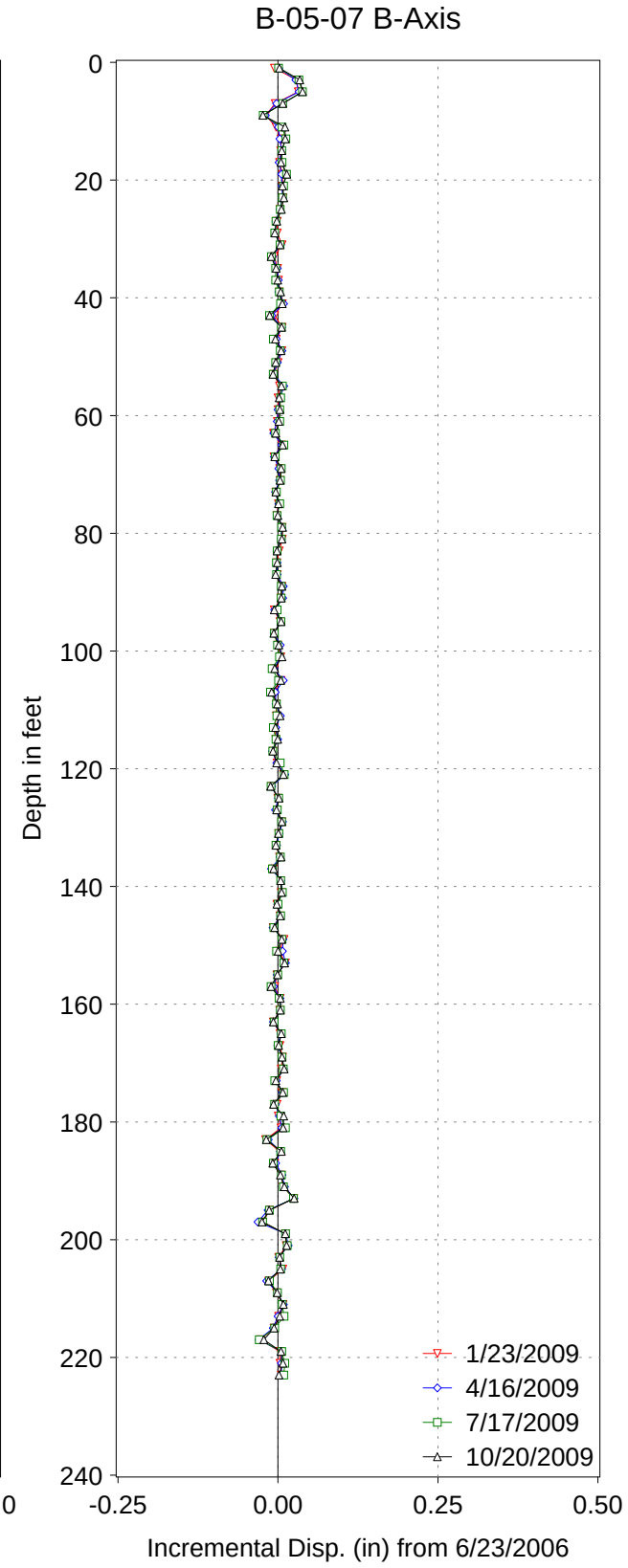


B-05-07

-Includes readings from the last four quarters.

PLATE 36

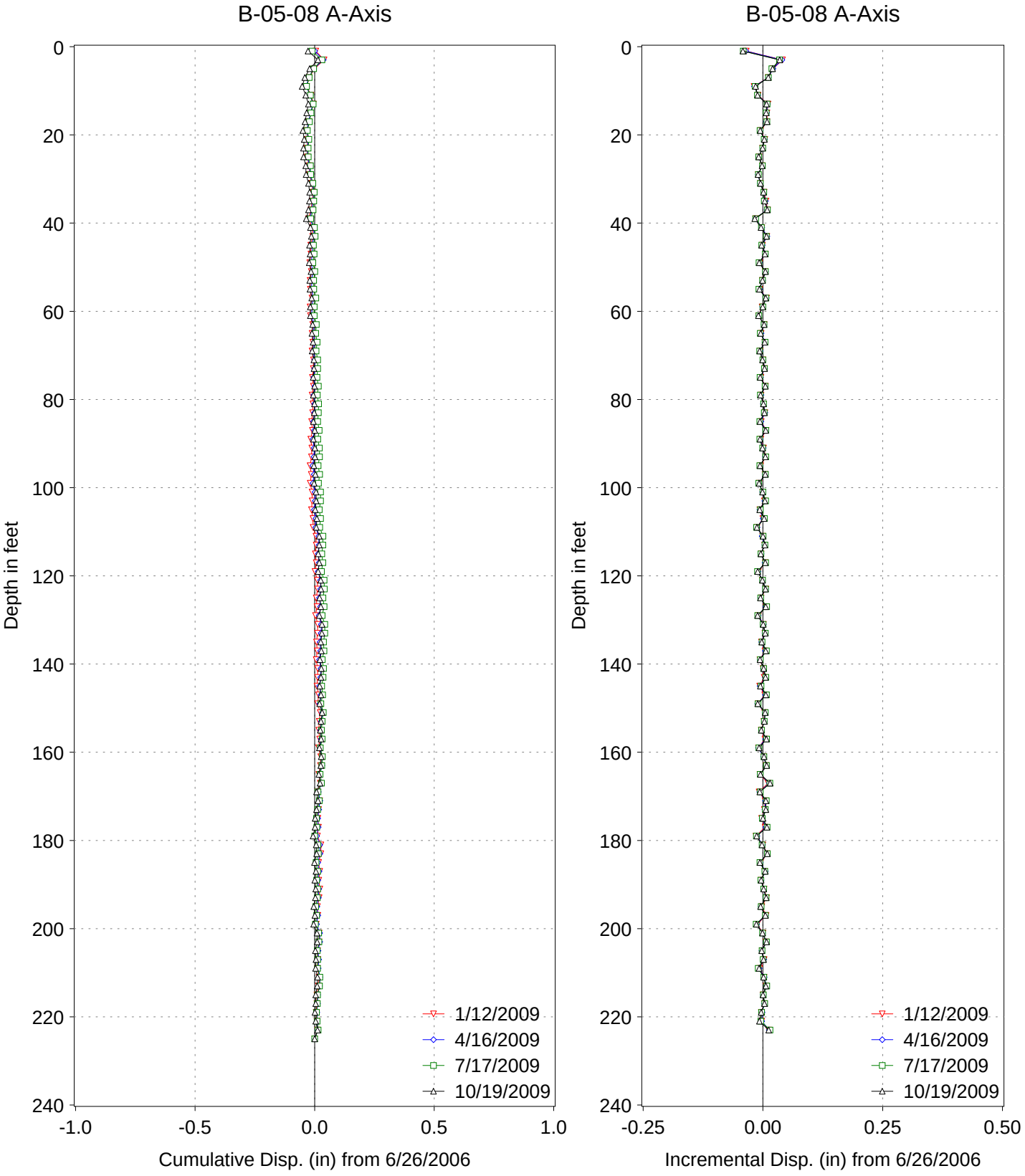




B-05-07

-Includes readings from the last four quarters.

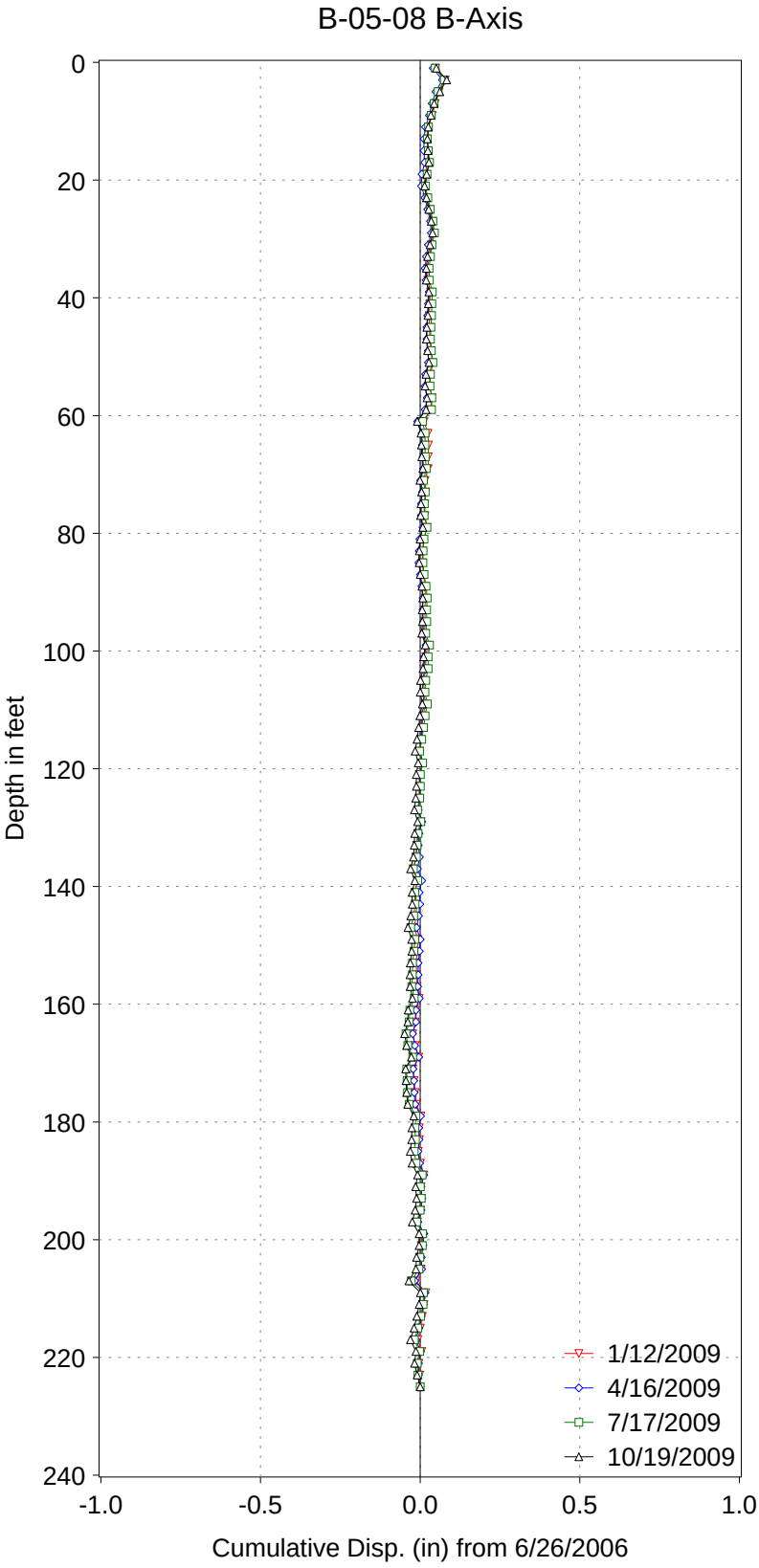
PLATE 37

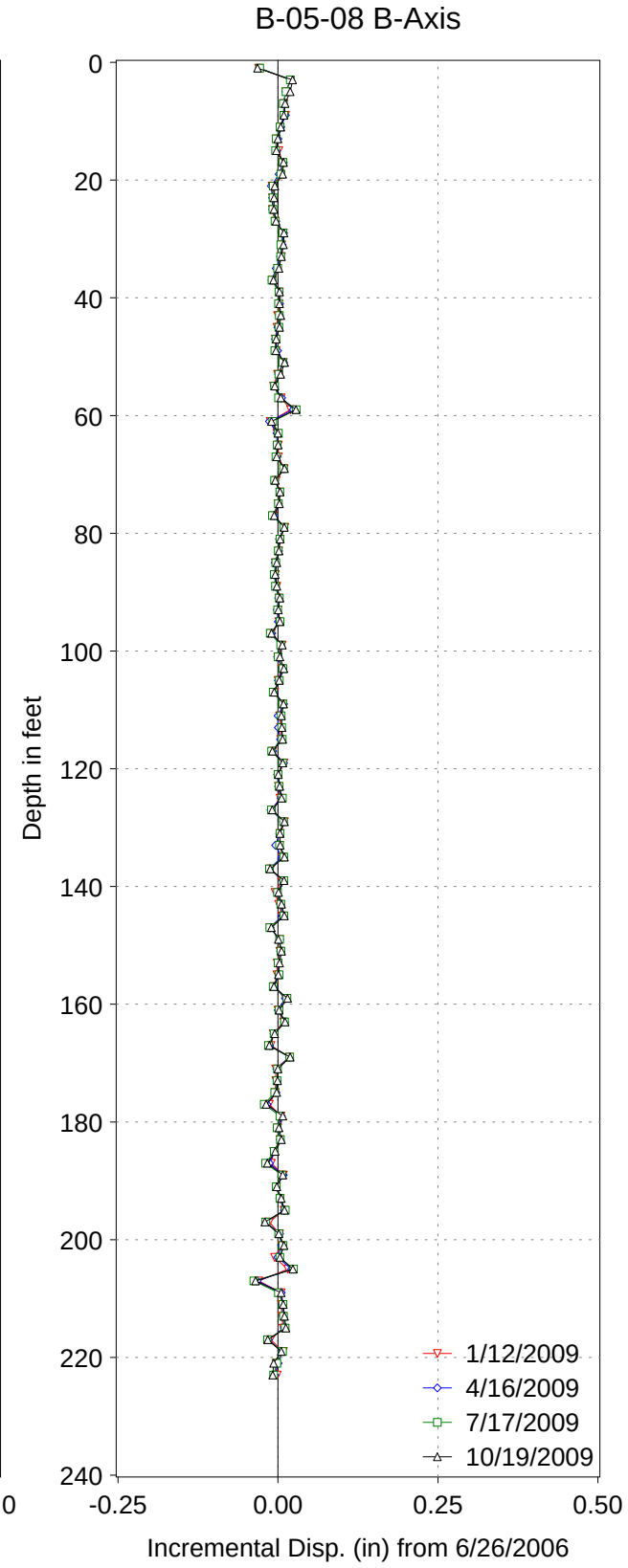


B-05-08

-Includes readings from the last four quarters.

PLATE 38

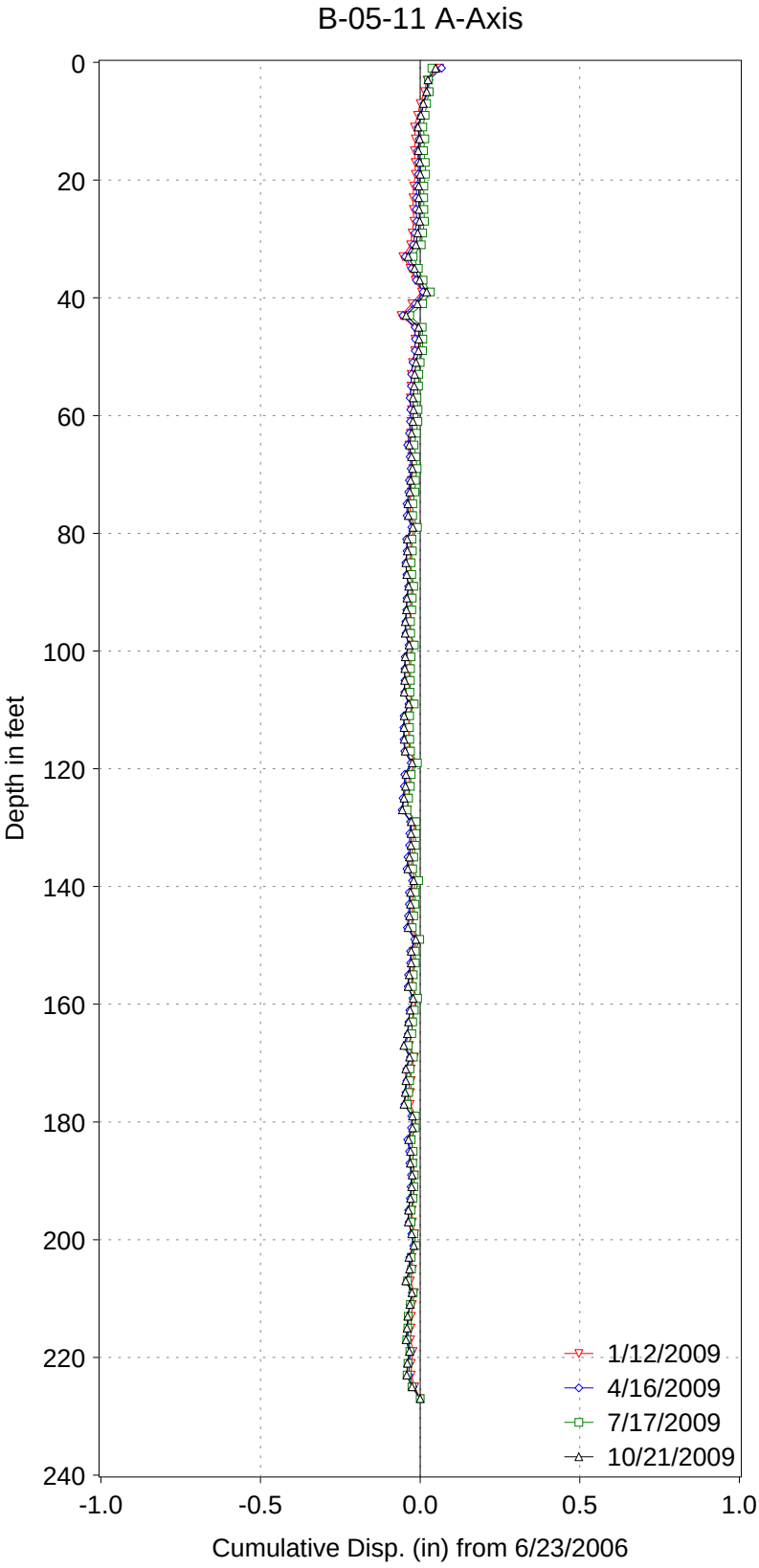


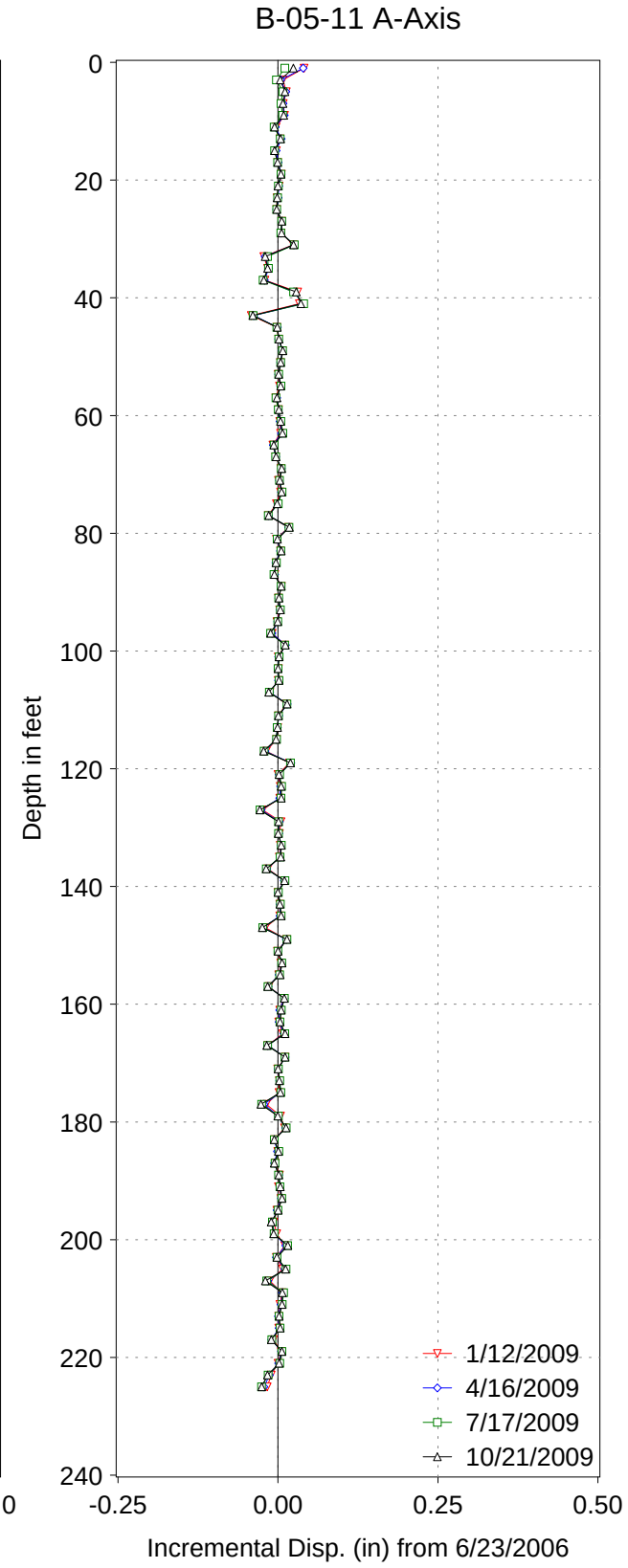


B-05-08

-Includes readings from the last four quarters.

PLATE 39

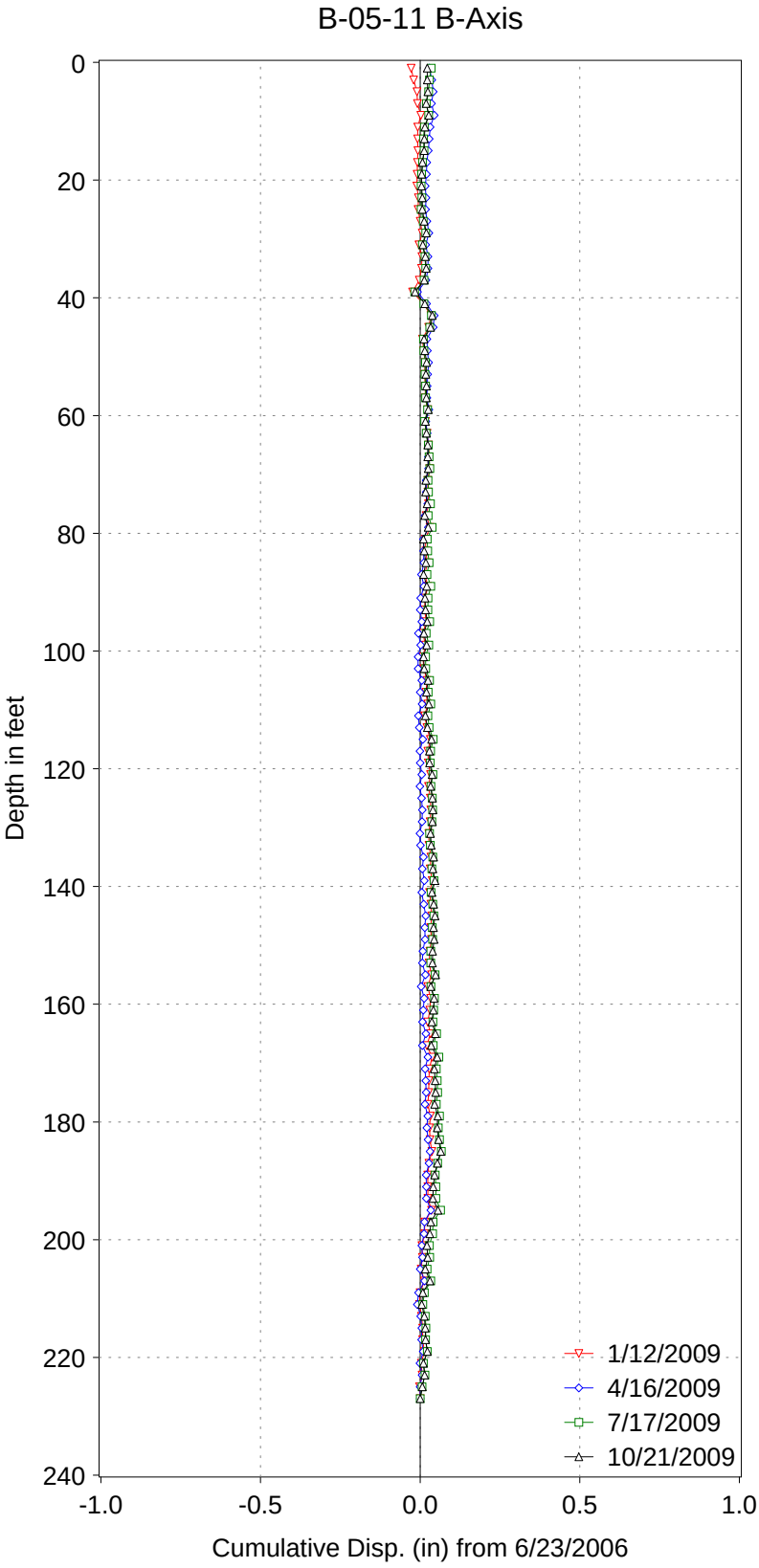


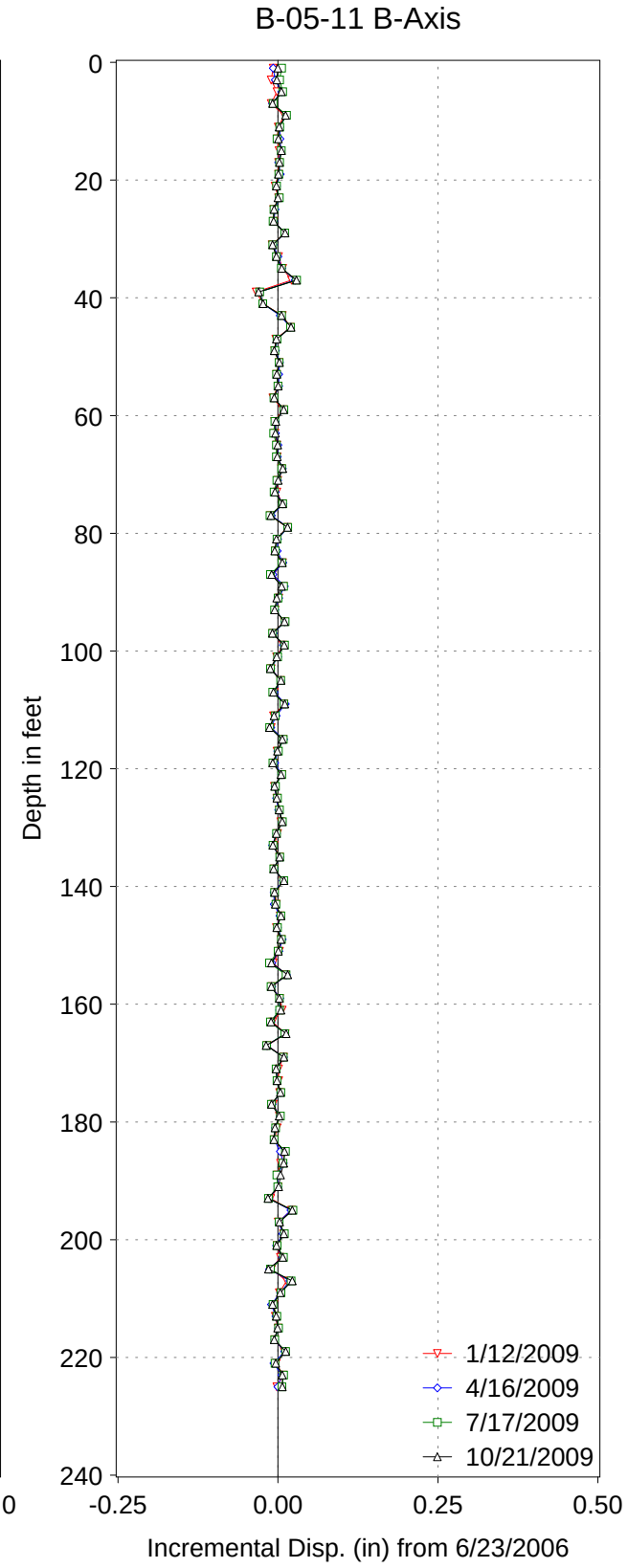


B-05-11

-Includes readings from the last four quarters.

PLATE 40

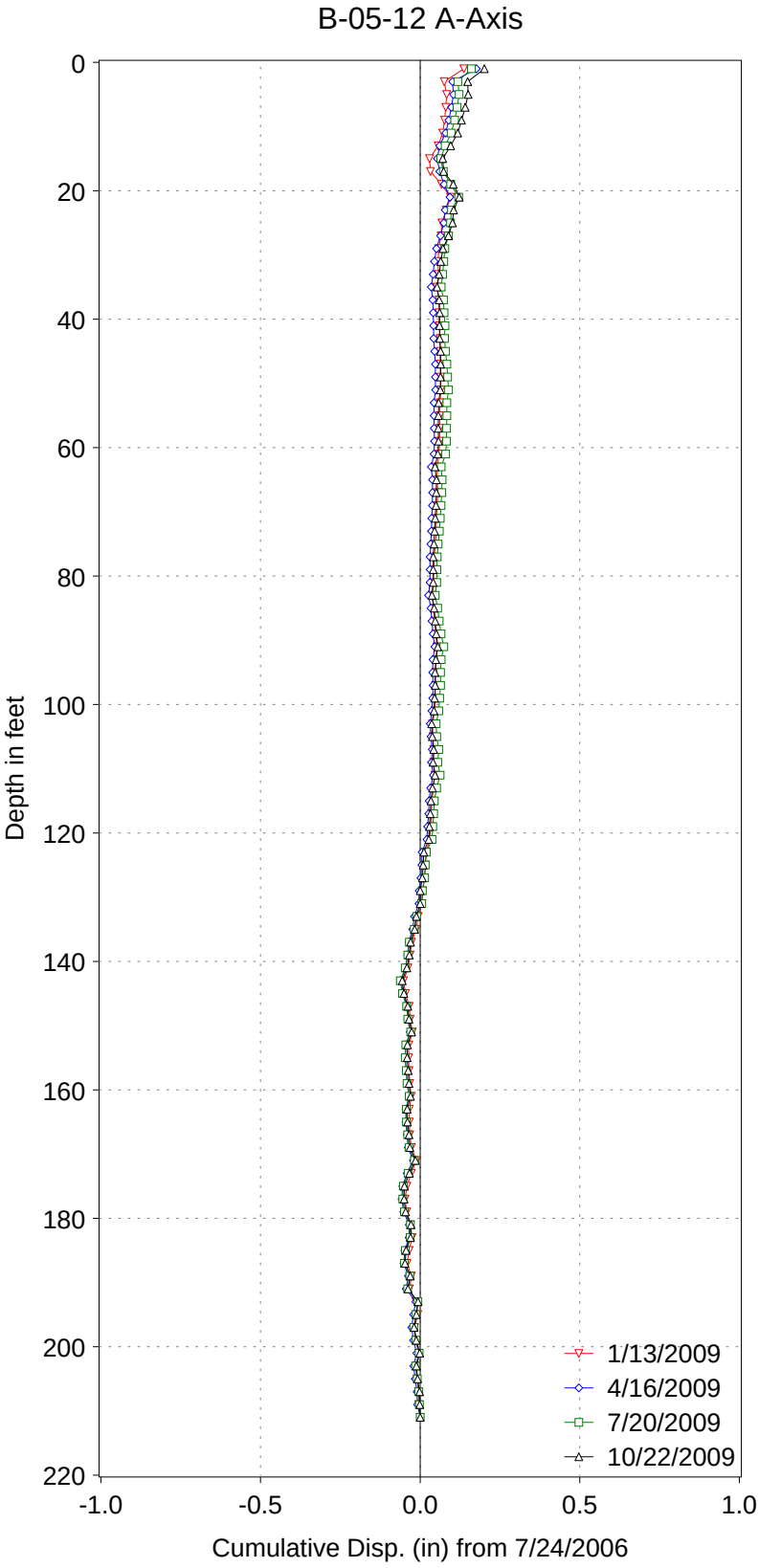


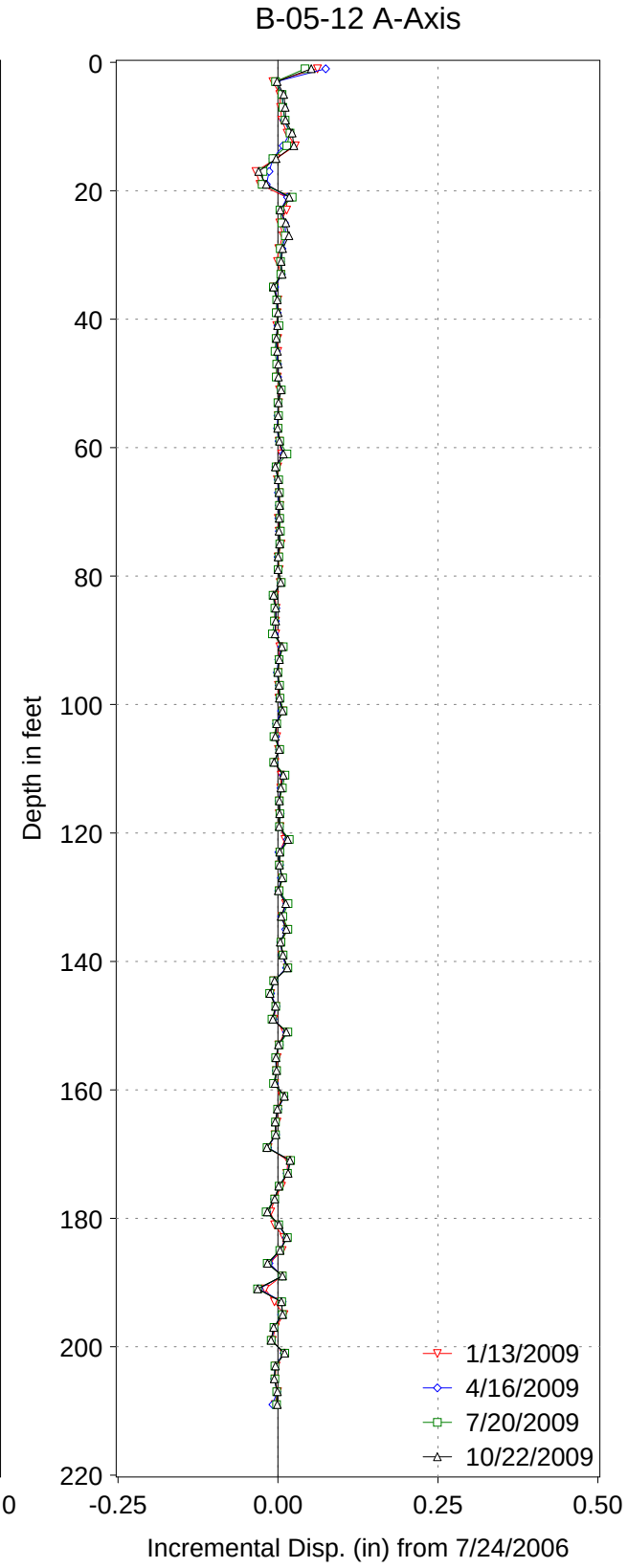


B-05-11

-Includes readings from the last four quarters.

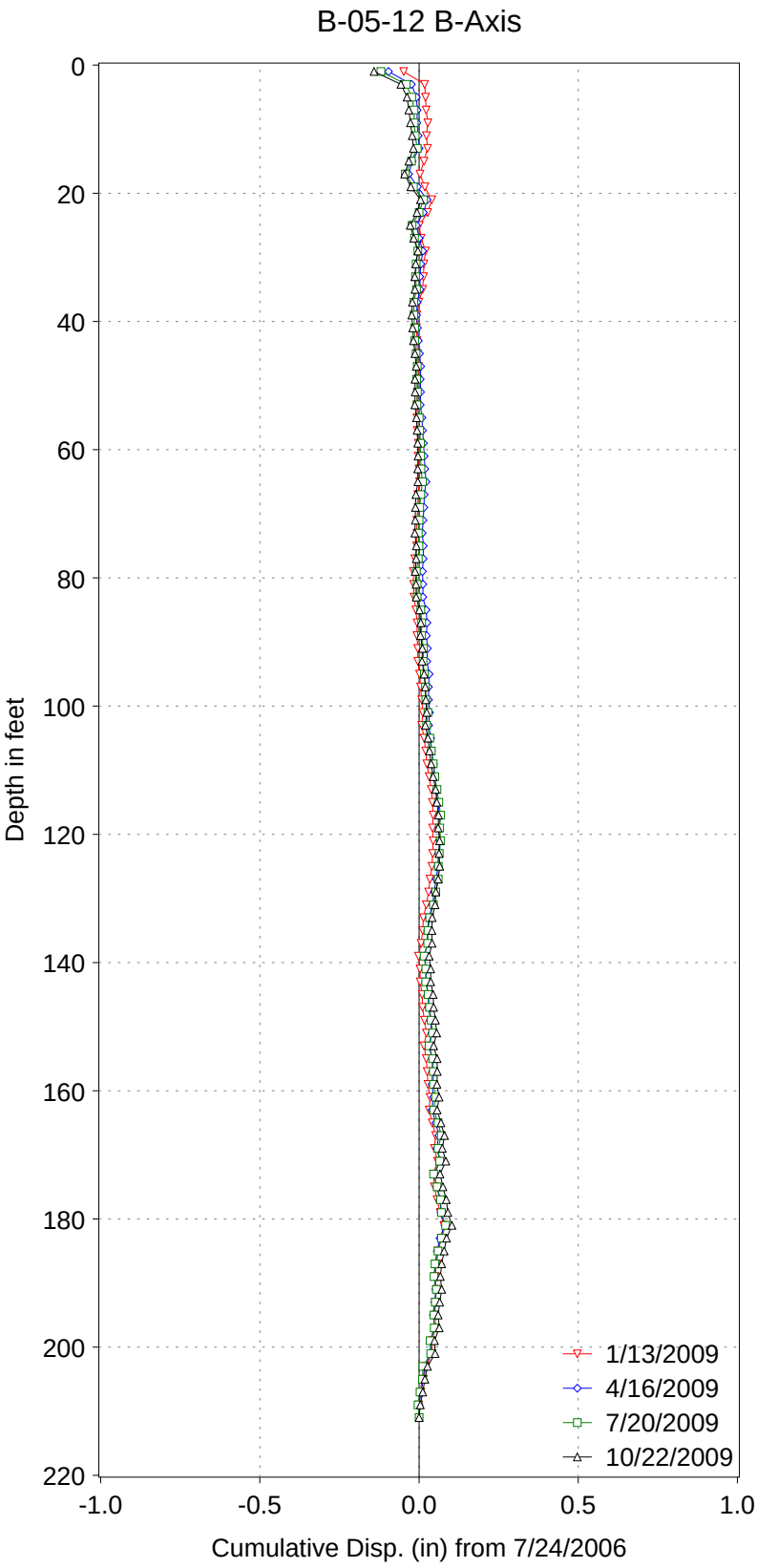
PLATE 41

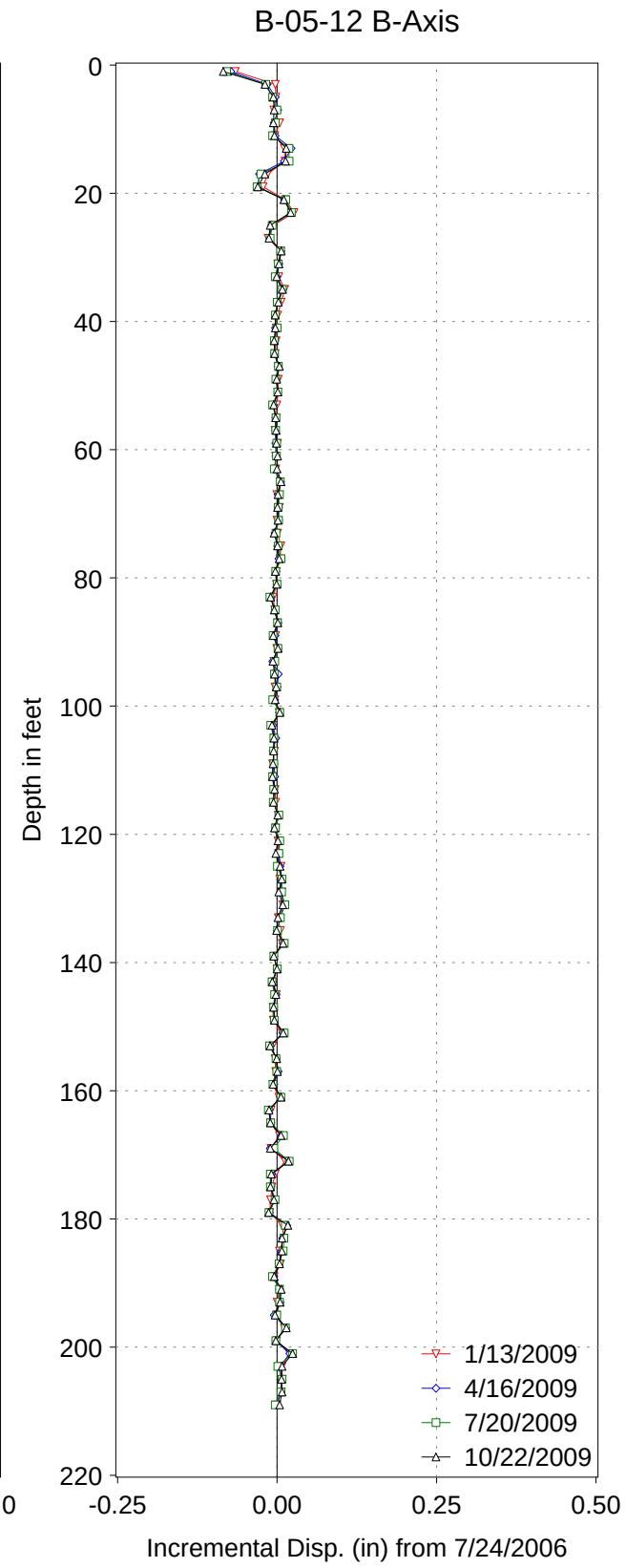




B-05-12

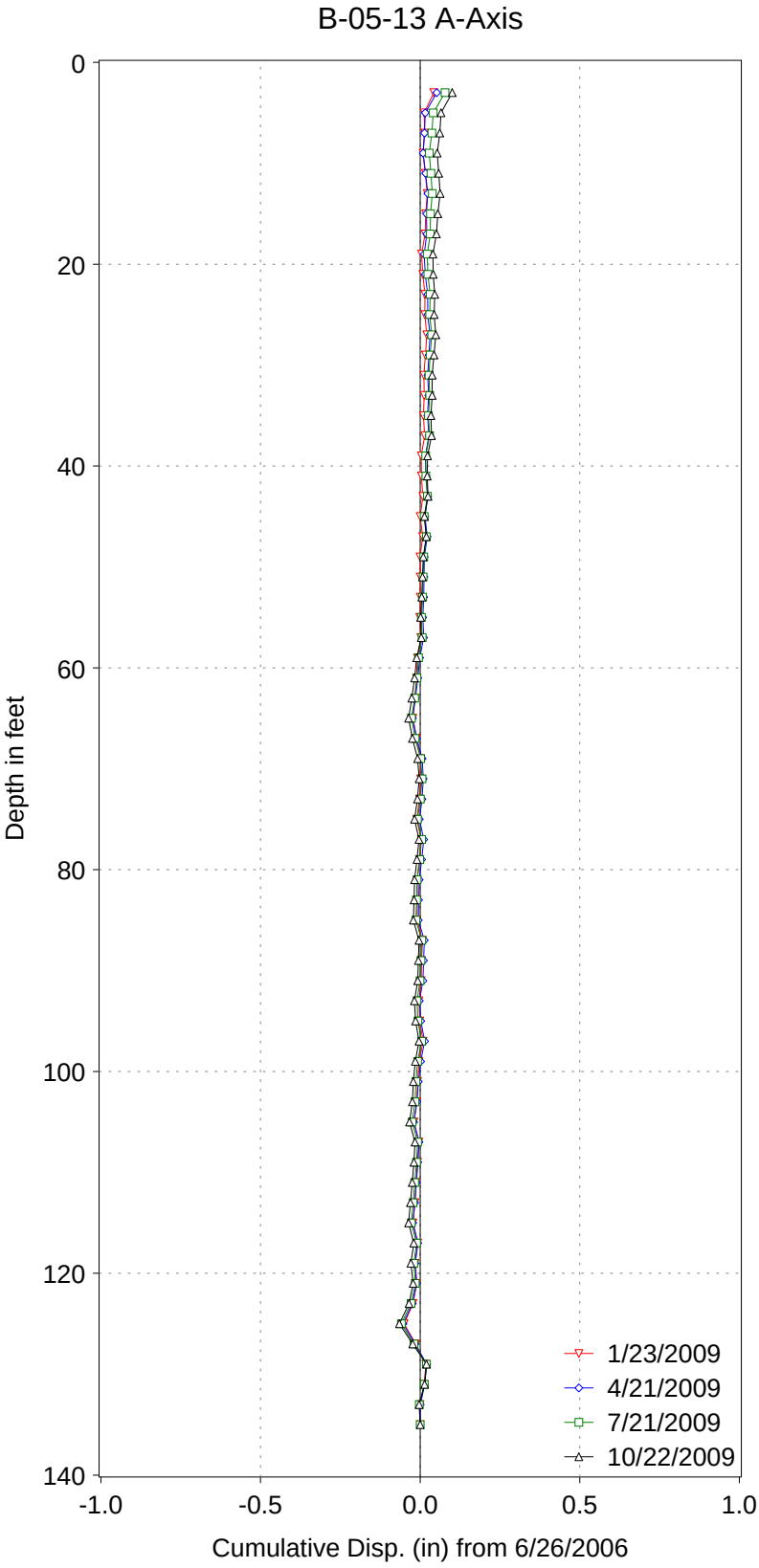
-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

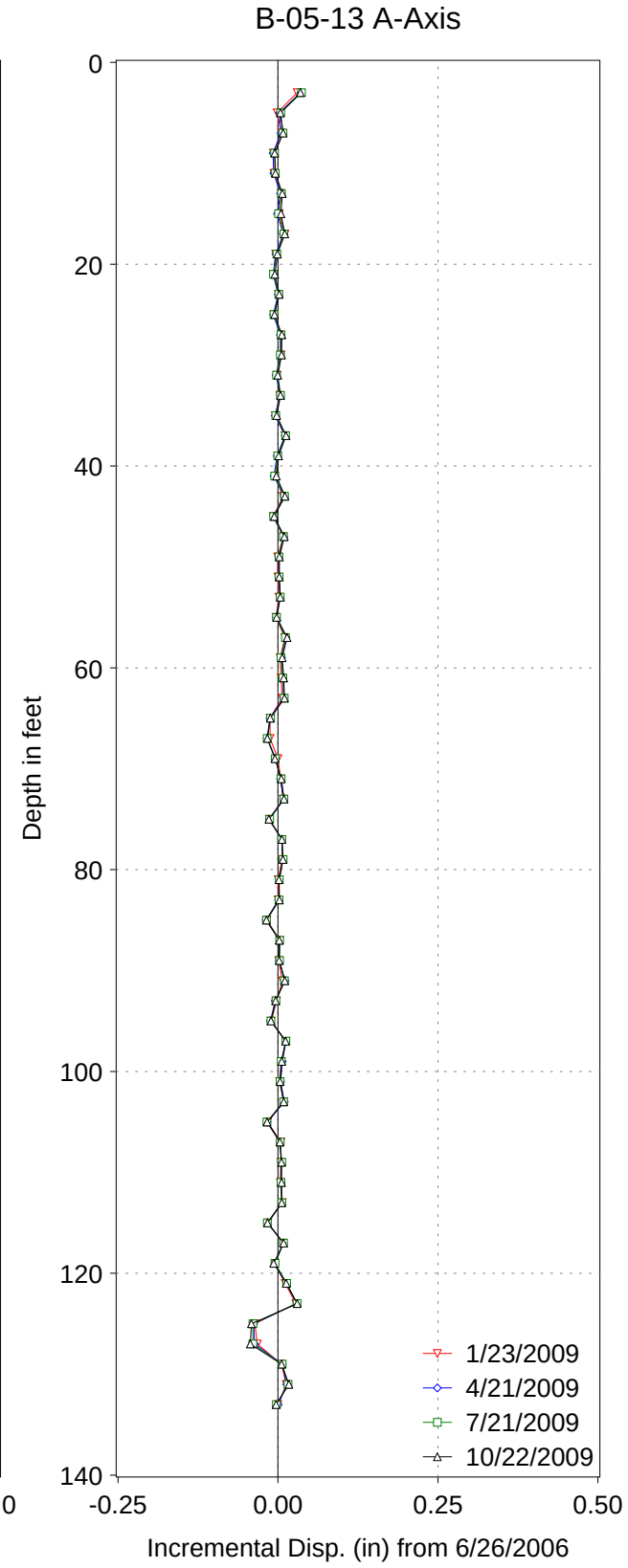




B-05-12

-The initial (baseline) reading is taken from the July 24, 2006 reading as opposed to the June 22, 2006 reading.

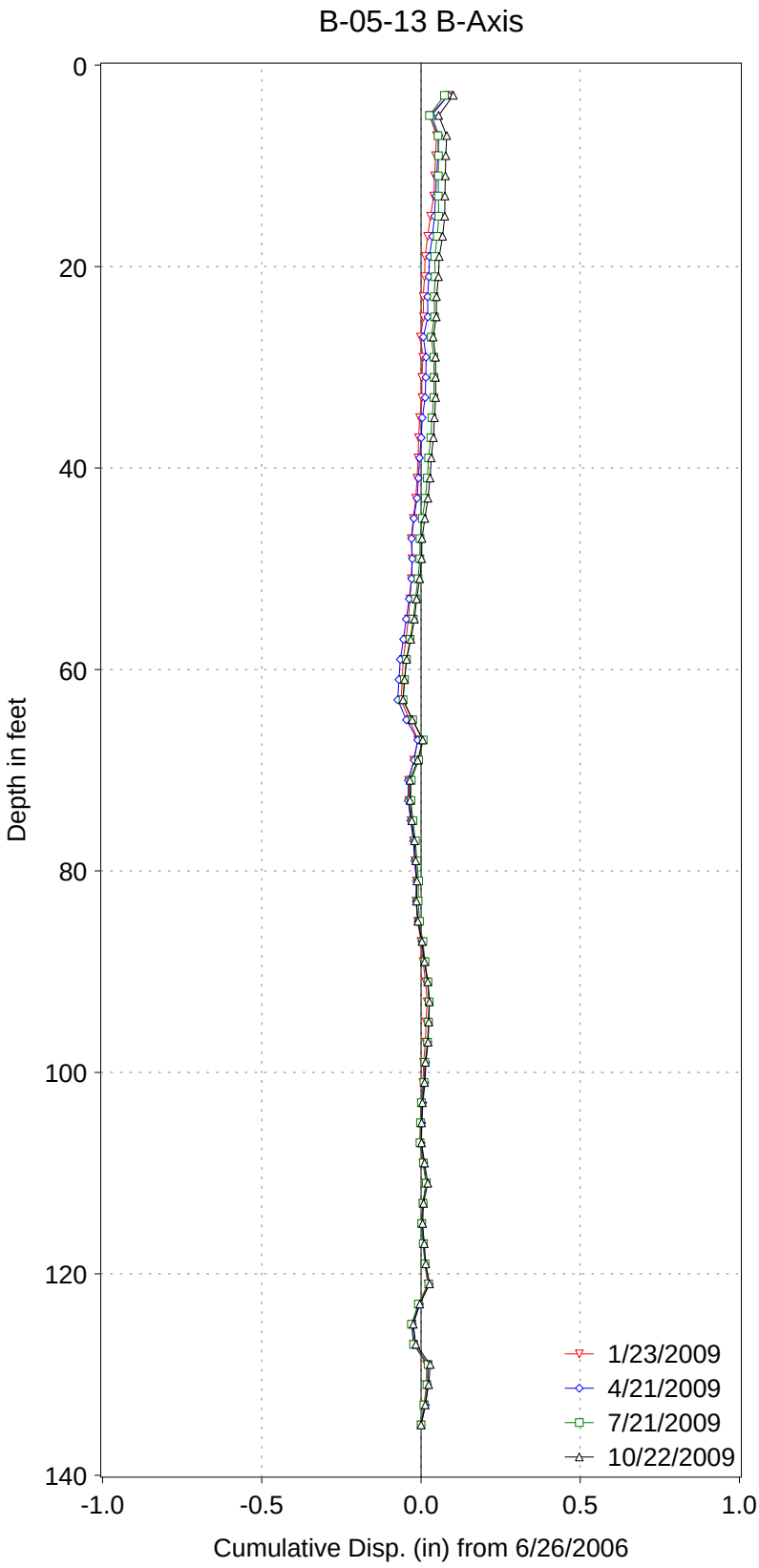


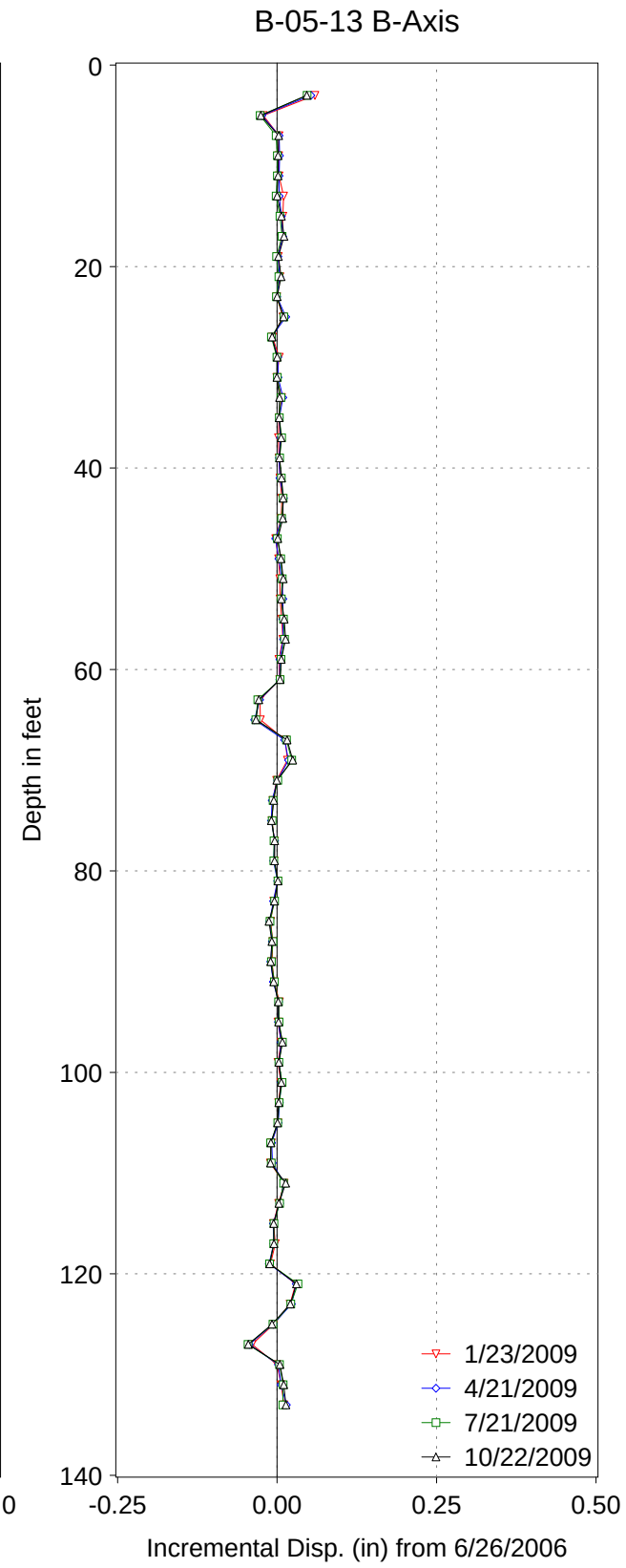


B-05-13

-Includes readings from the last four quarters.

PLATE 44

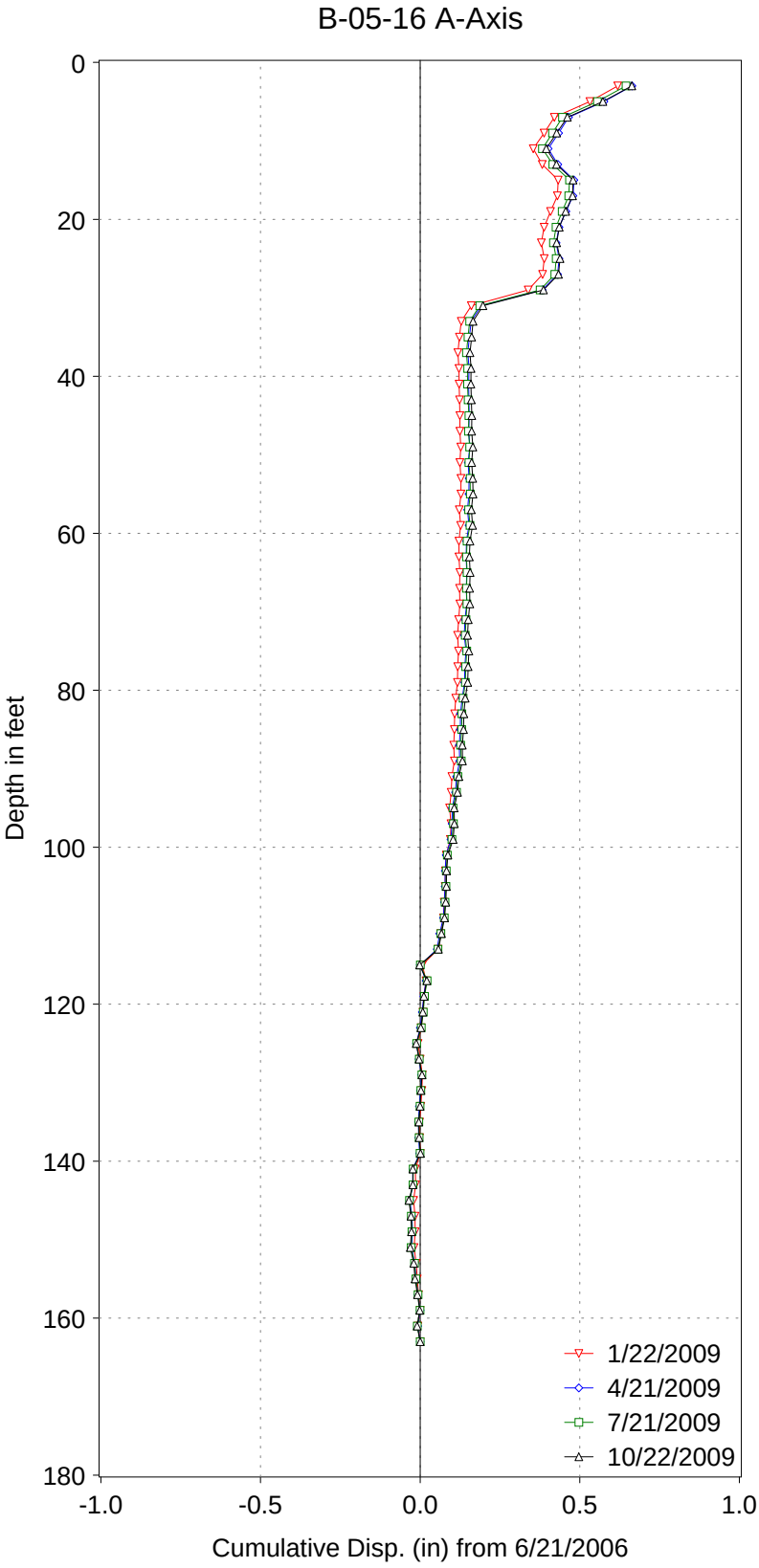


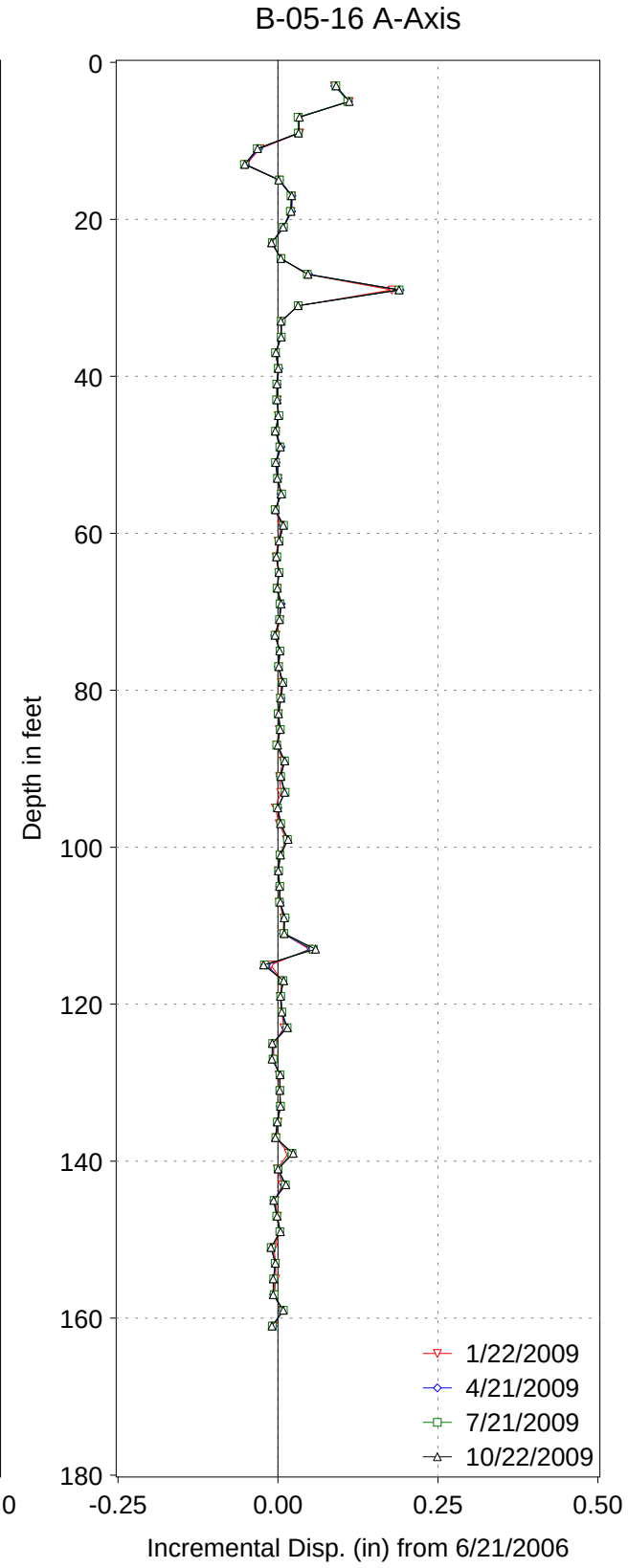


B-05-13

-Includes readings from the last four quarters.

PLATE 45

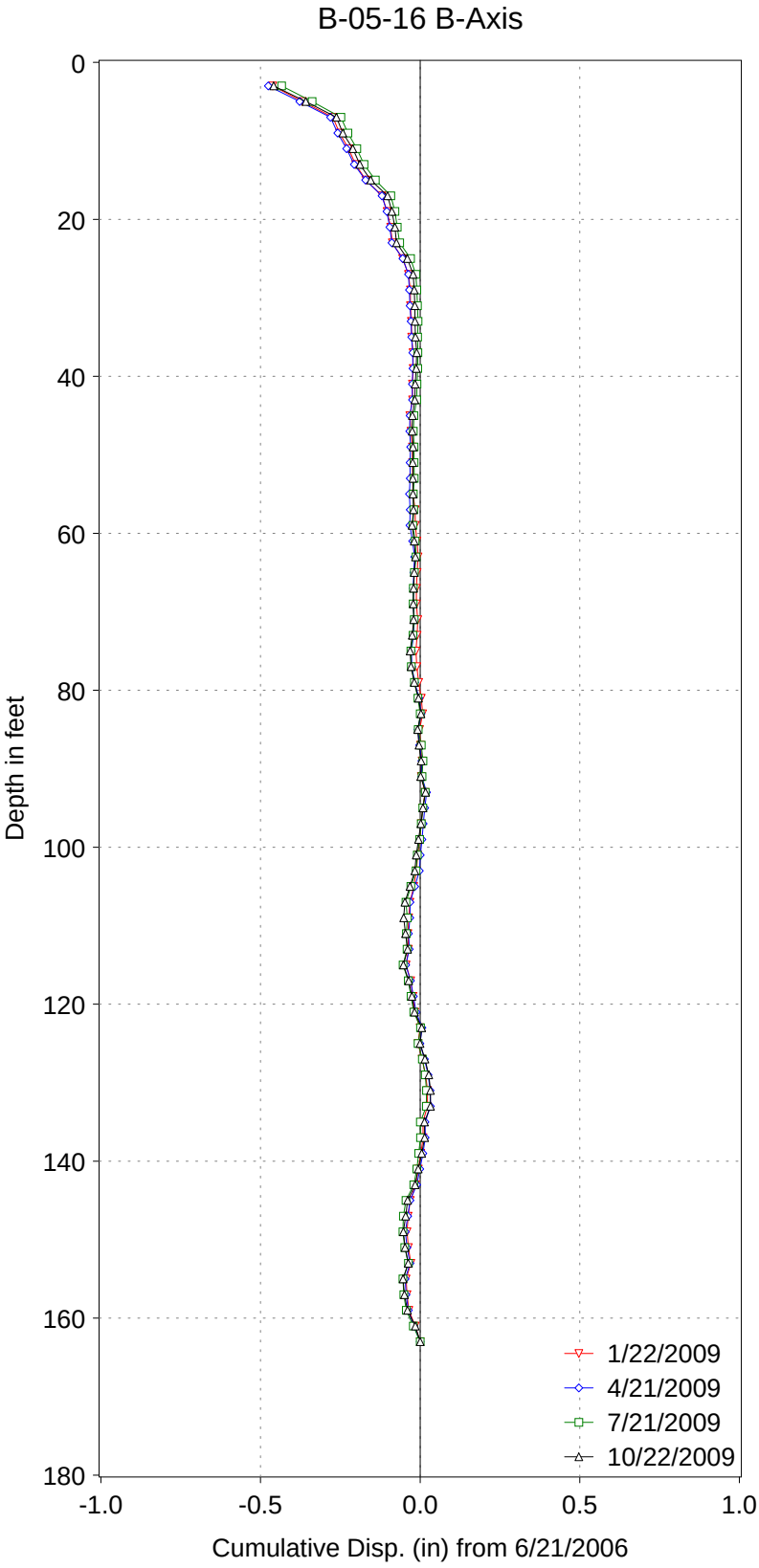


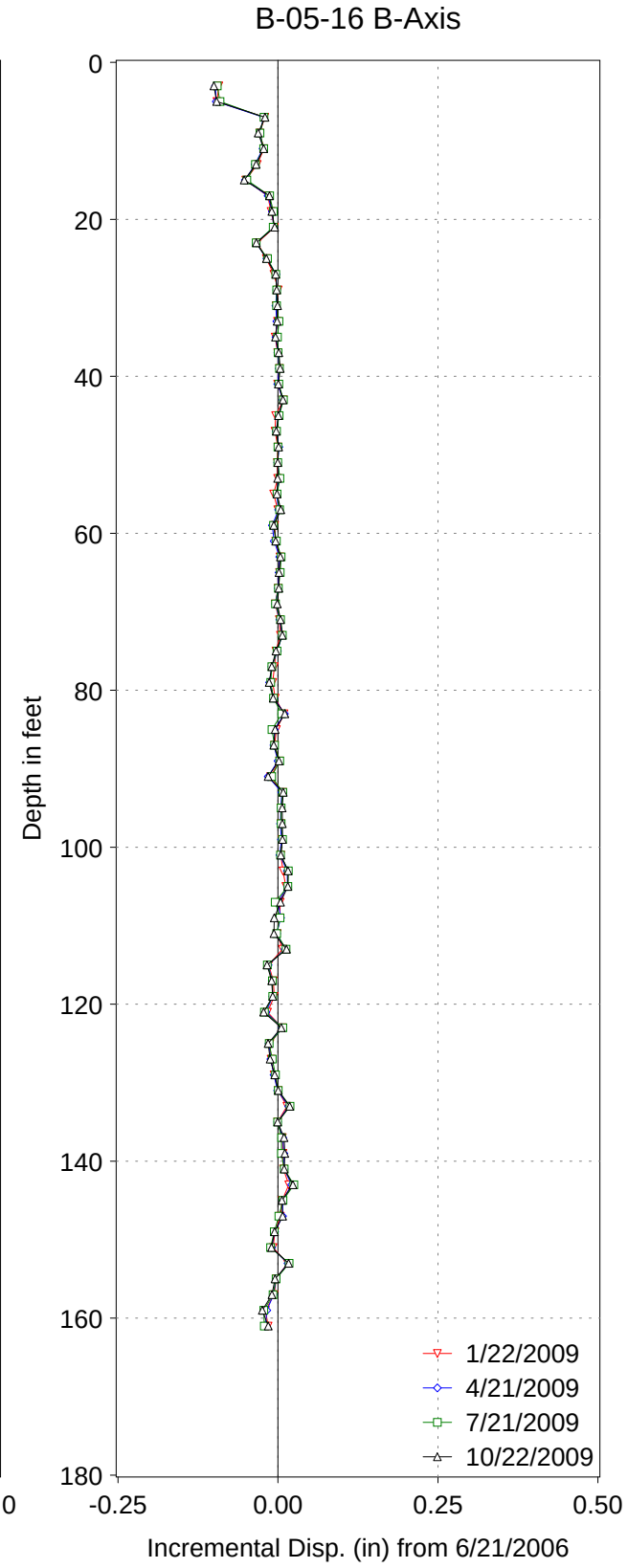


B-05-16

-Includes readings from the last four quarters.

PLATE 46





B-05-16

-Includes readings from the last four quarters.

PLATE 47

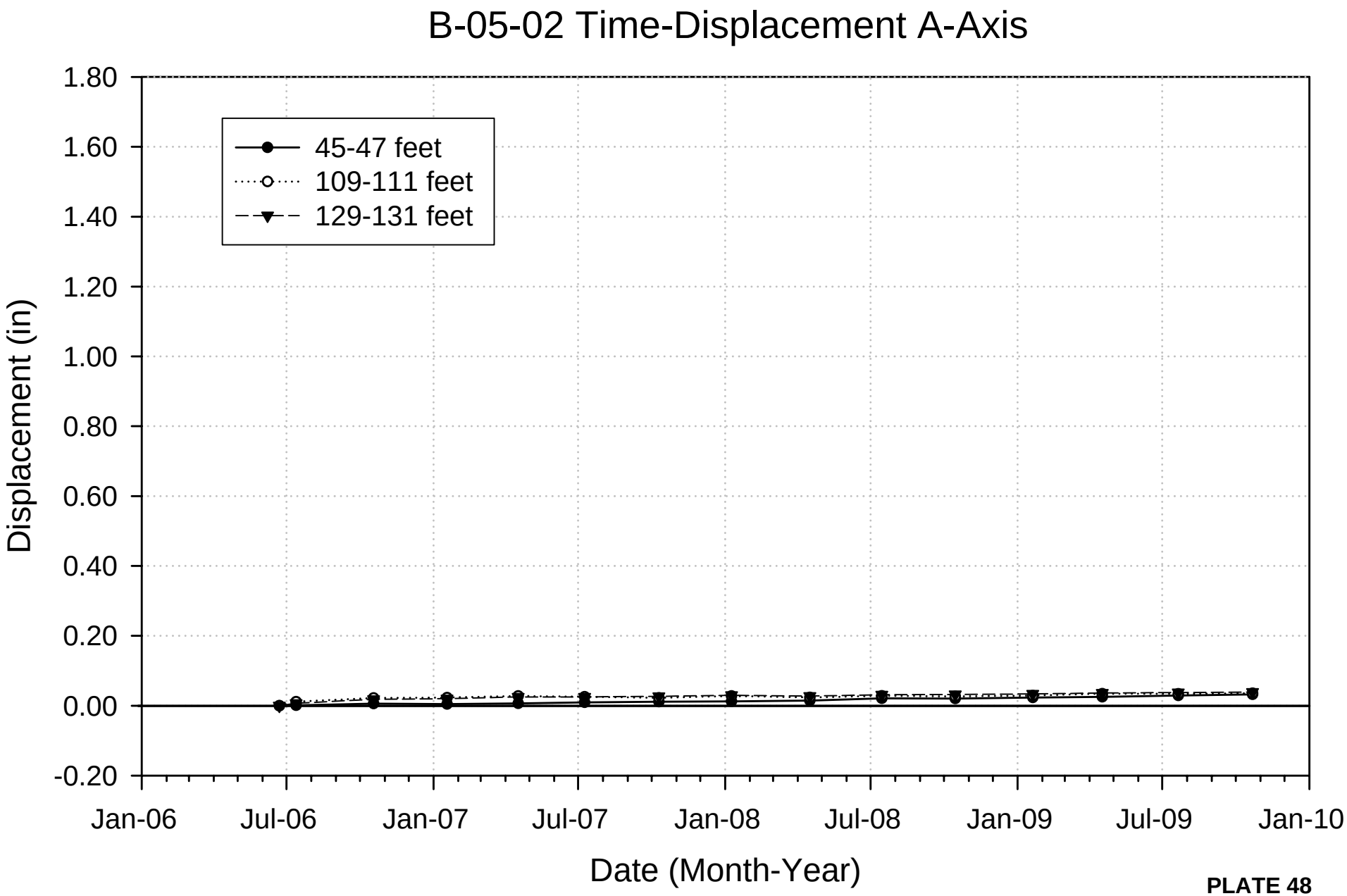

B-05-02 Time-Displacement A-Axis
45-47 feet
109-111 feet
129-131 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Date (Month-Year)

PLATE 48

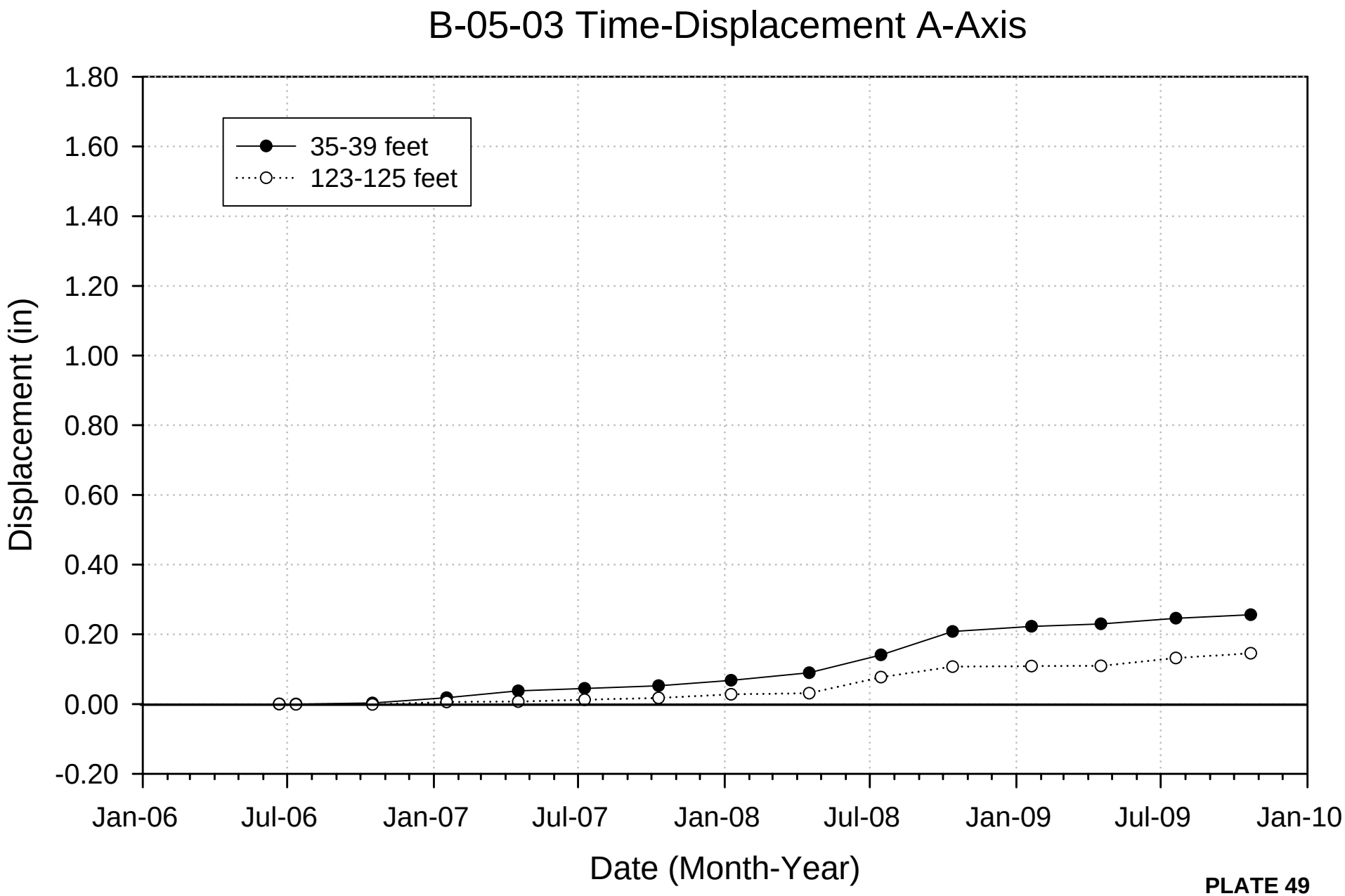

B-05-03 Time-Displacement A-Axis
35-39 feet
123-125 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Date (Month-Year)

PLATE 49

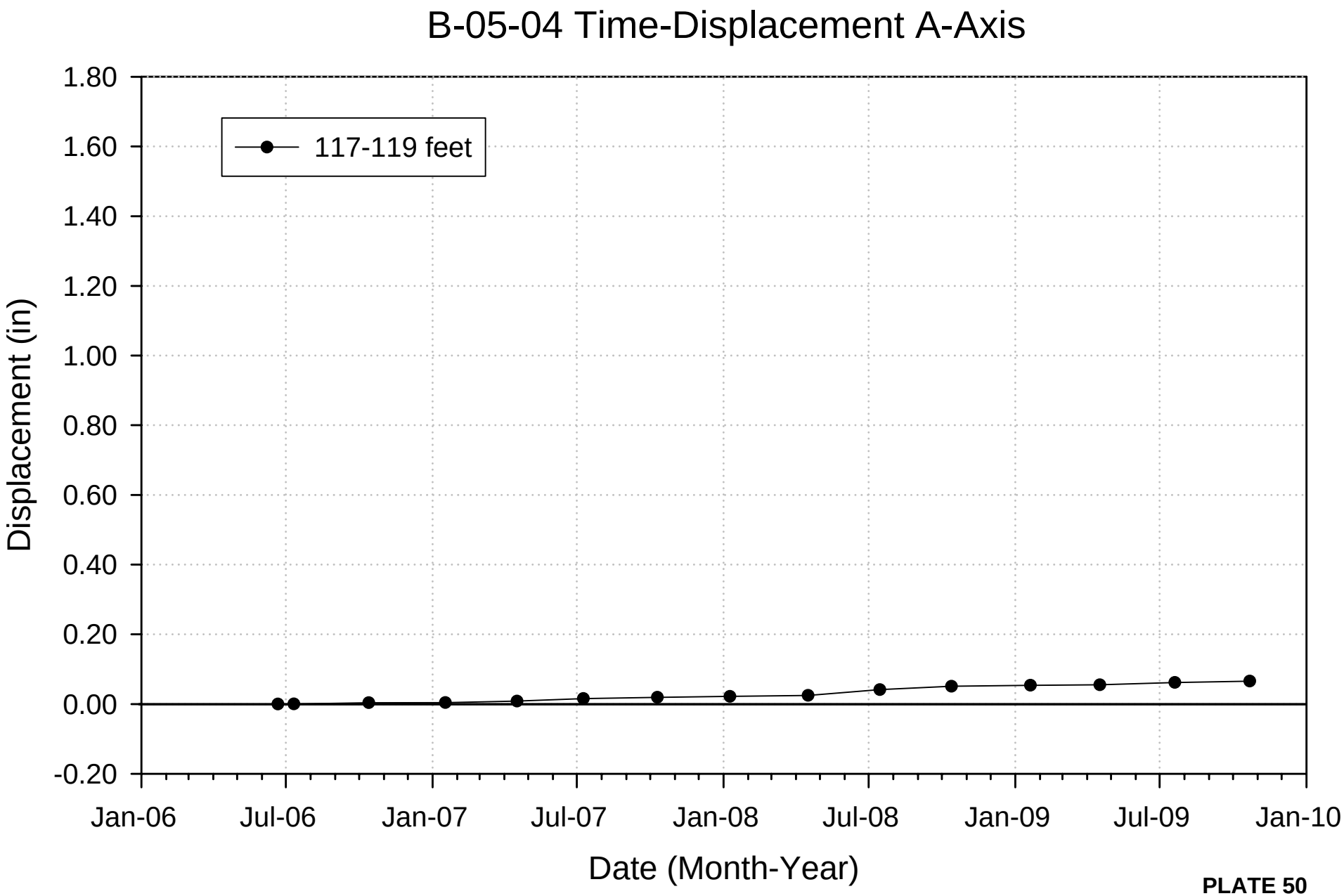

B-05-04 Time-Displacement A-Axis
117-119 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Date (Month-Year)

PLATE 50

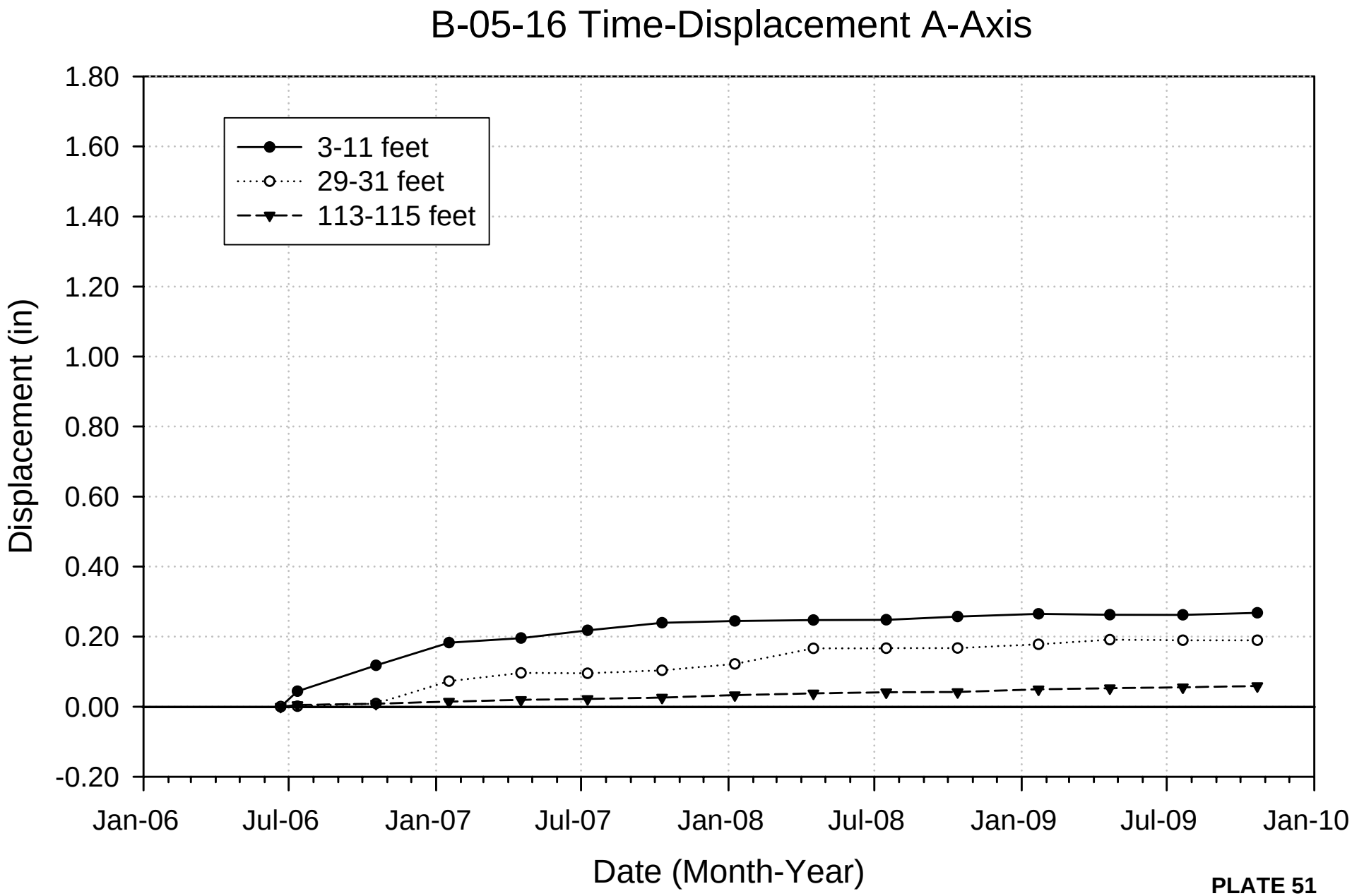

B-05-16 Time-Displacement A-Axis
3-11 feet
29-31 feet
113-115 feet
Displacement (in)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Date (Month-Year)

PLATE 51

B-101 (P-1) Pneumatic Piezometer Readings

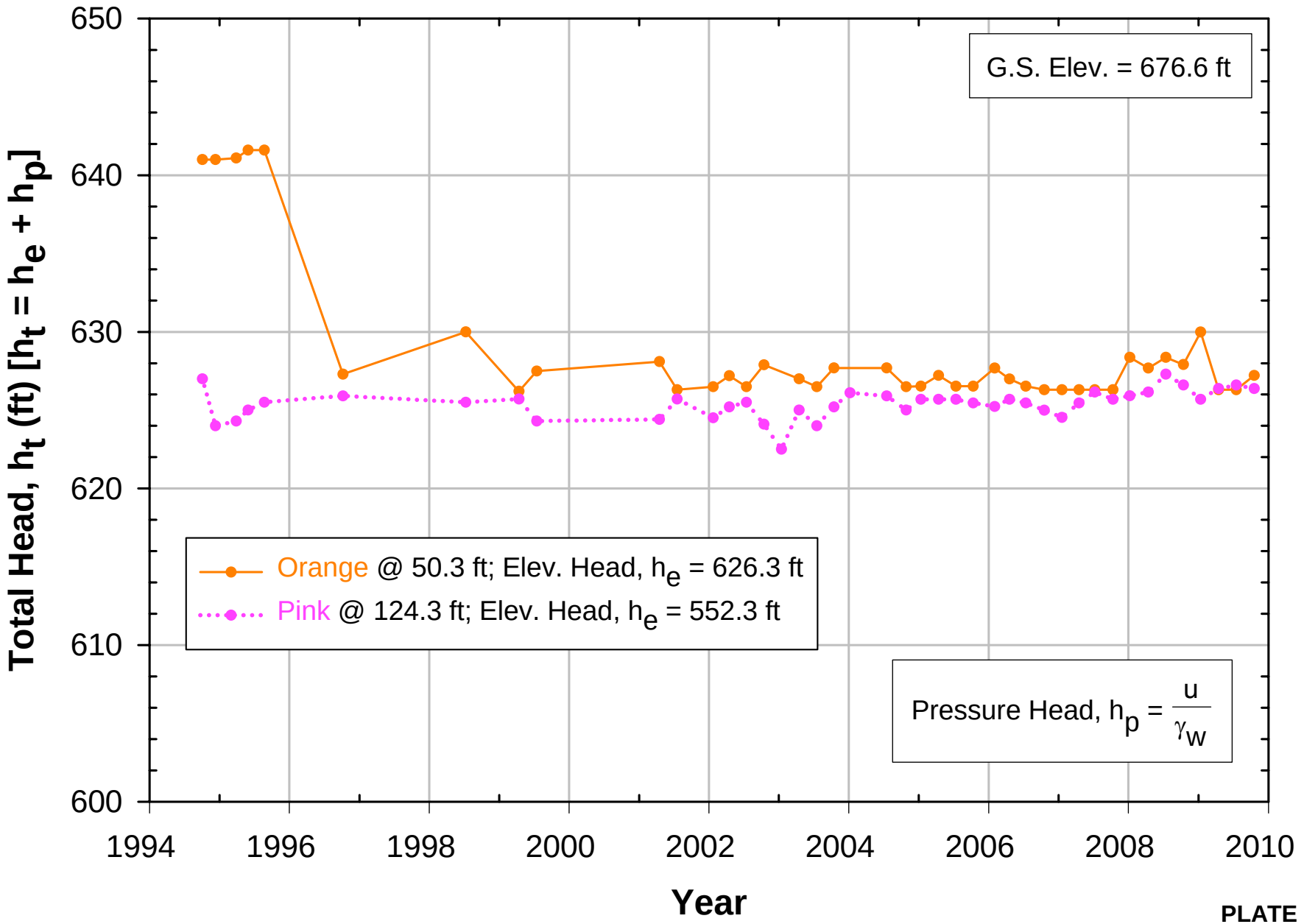


PLATE 52

B-105 (P-3) Pneumatic Piezometer Readings

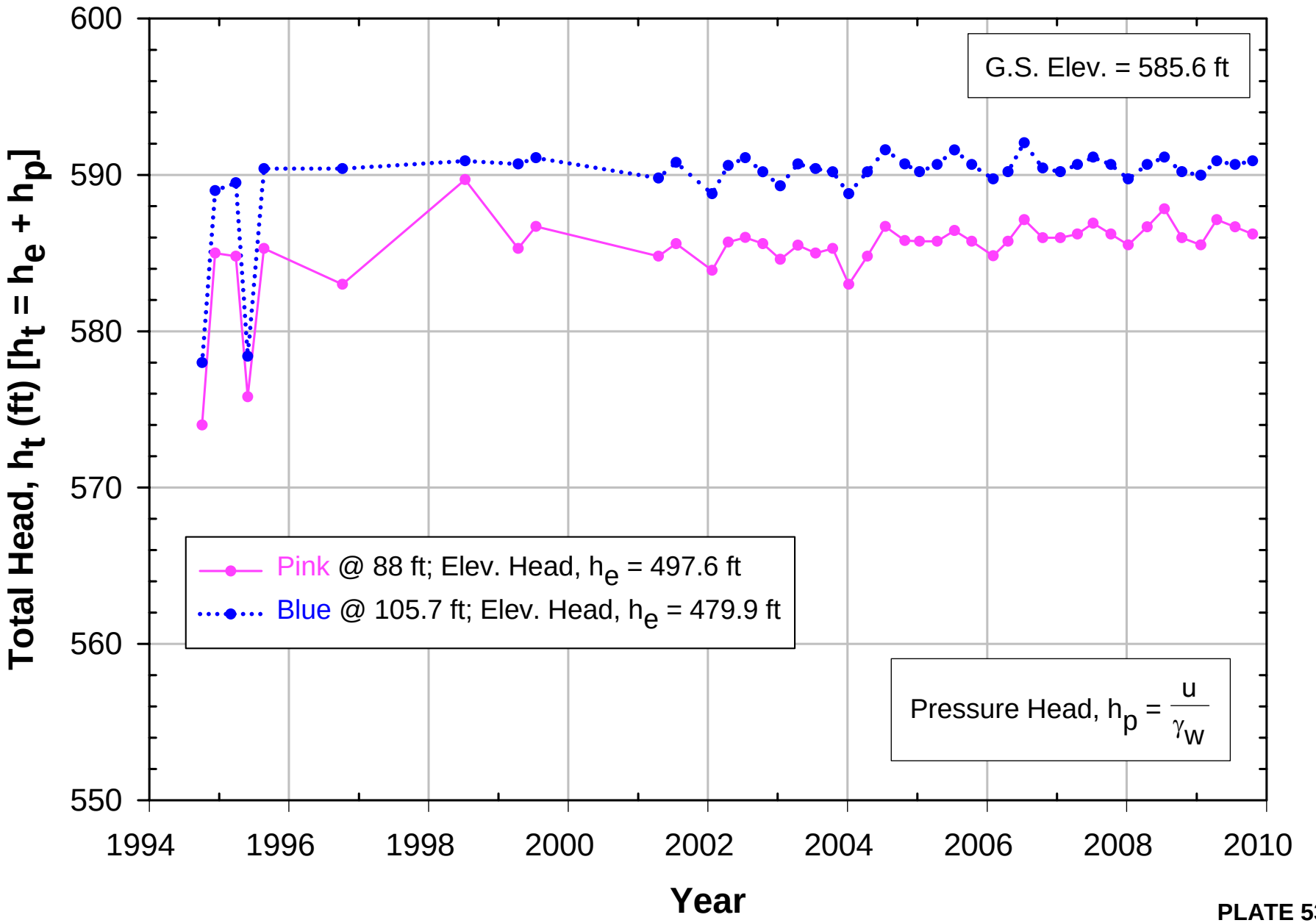


PLATE 53

B-107 (P-5) Pneumatic Piezometer Readings

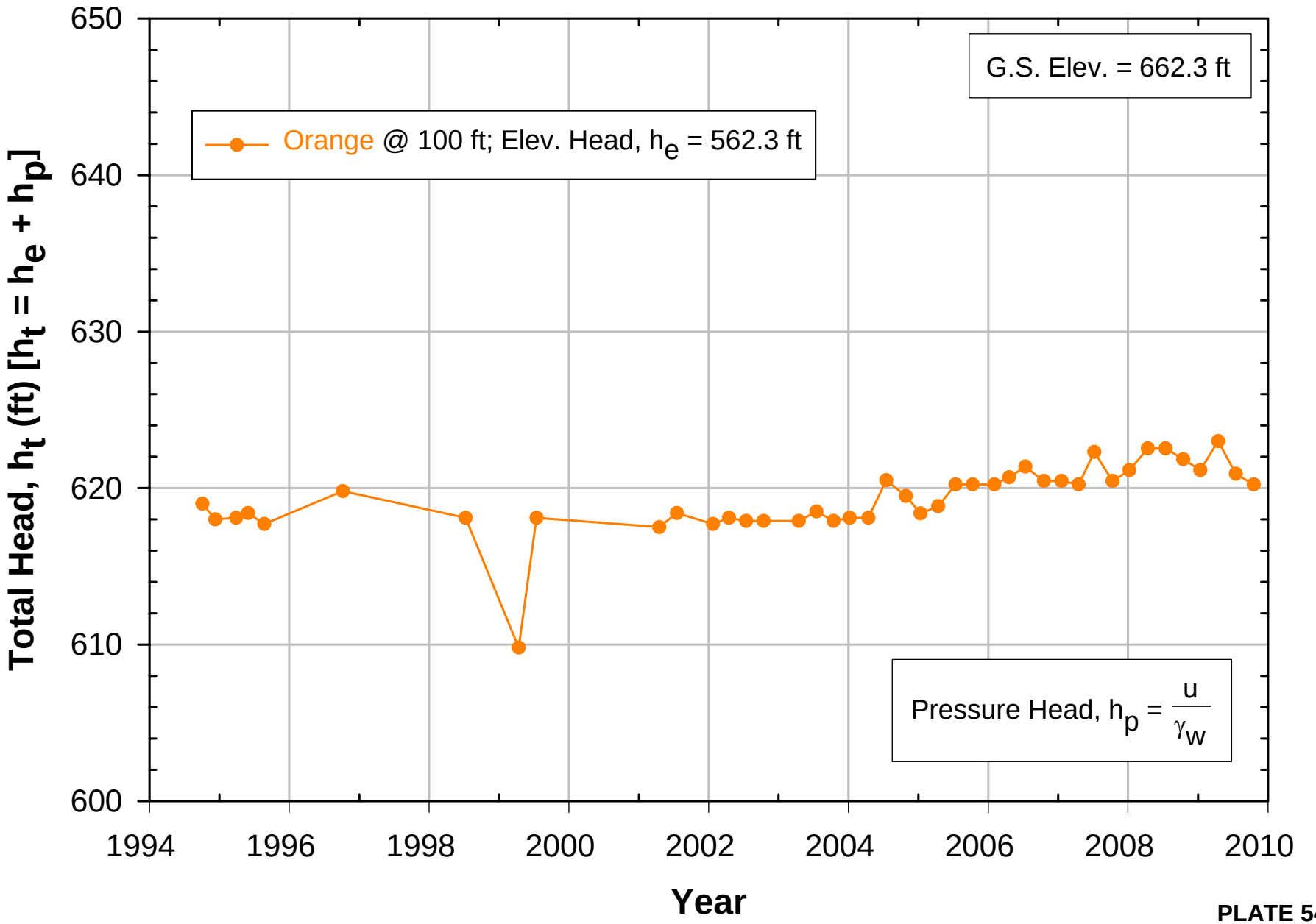


PLATE 54

B-303 (P-2) Pneumatic Piezometer Readings

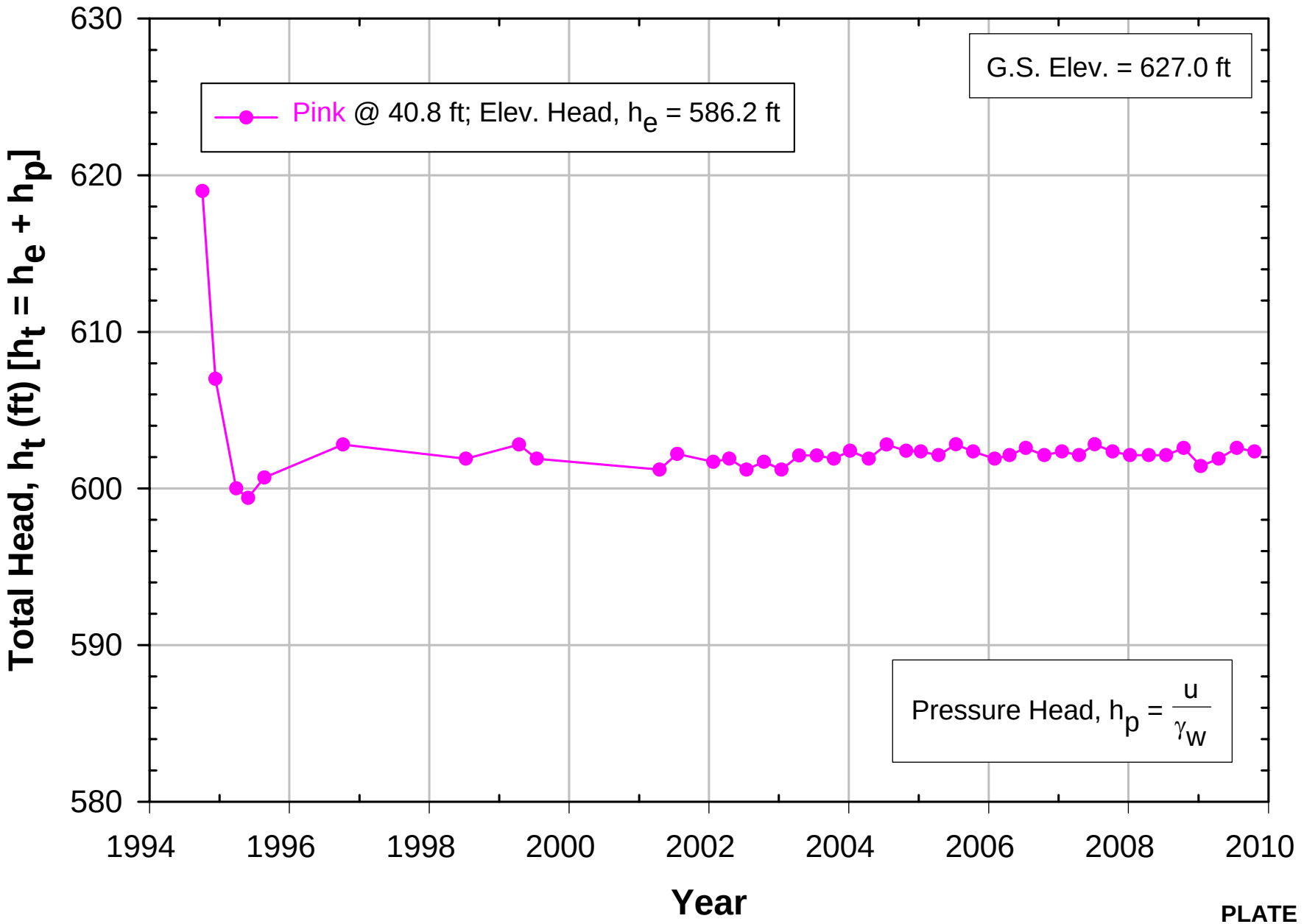


PLATE 55

B-05-01 VW Piezometer Readings

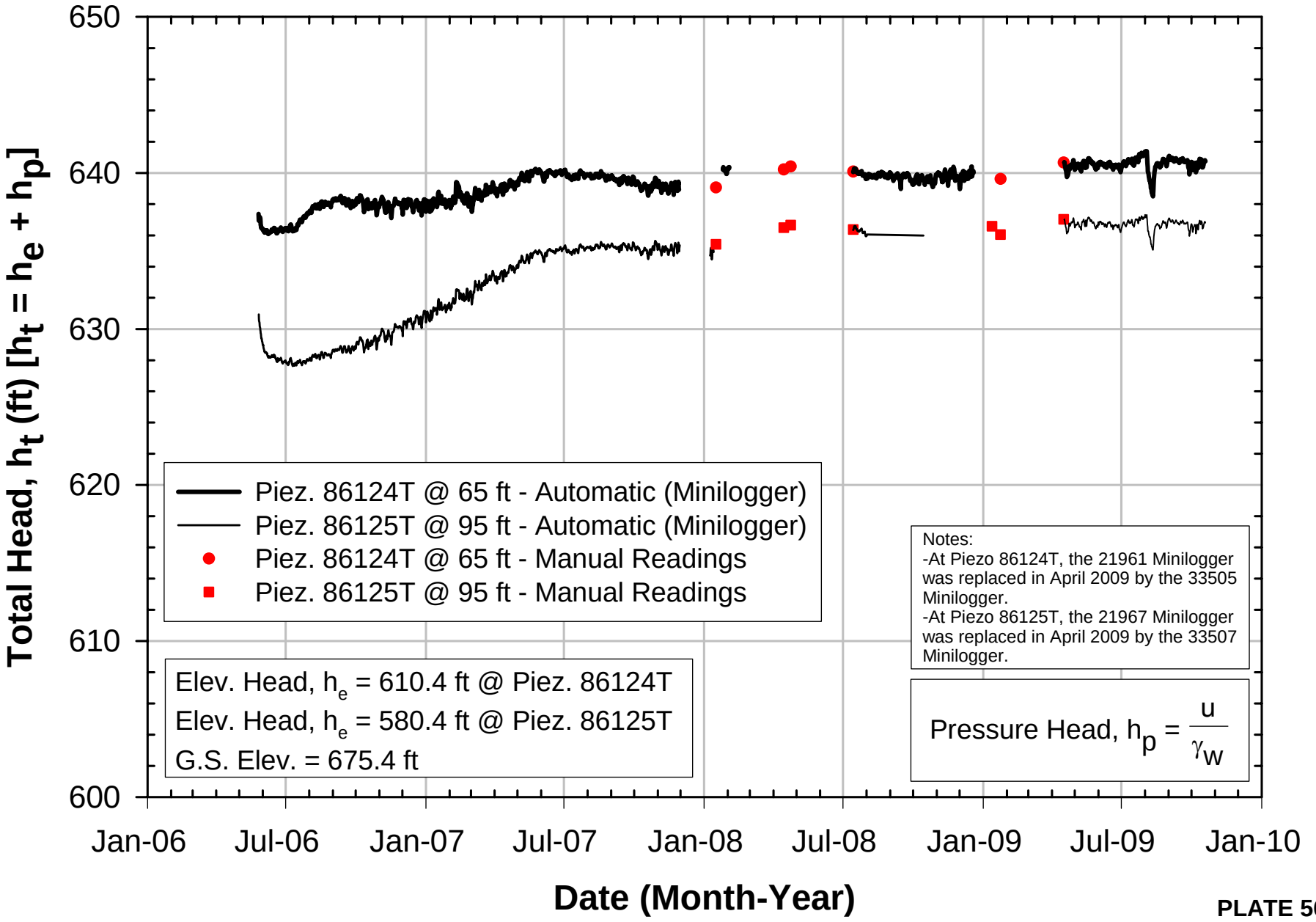


PLATE 56

B-05-02 VW Piezometer Readings

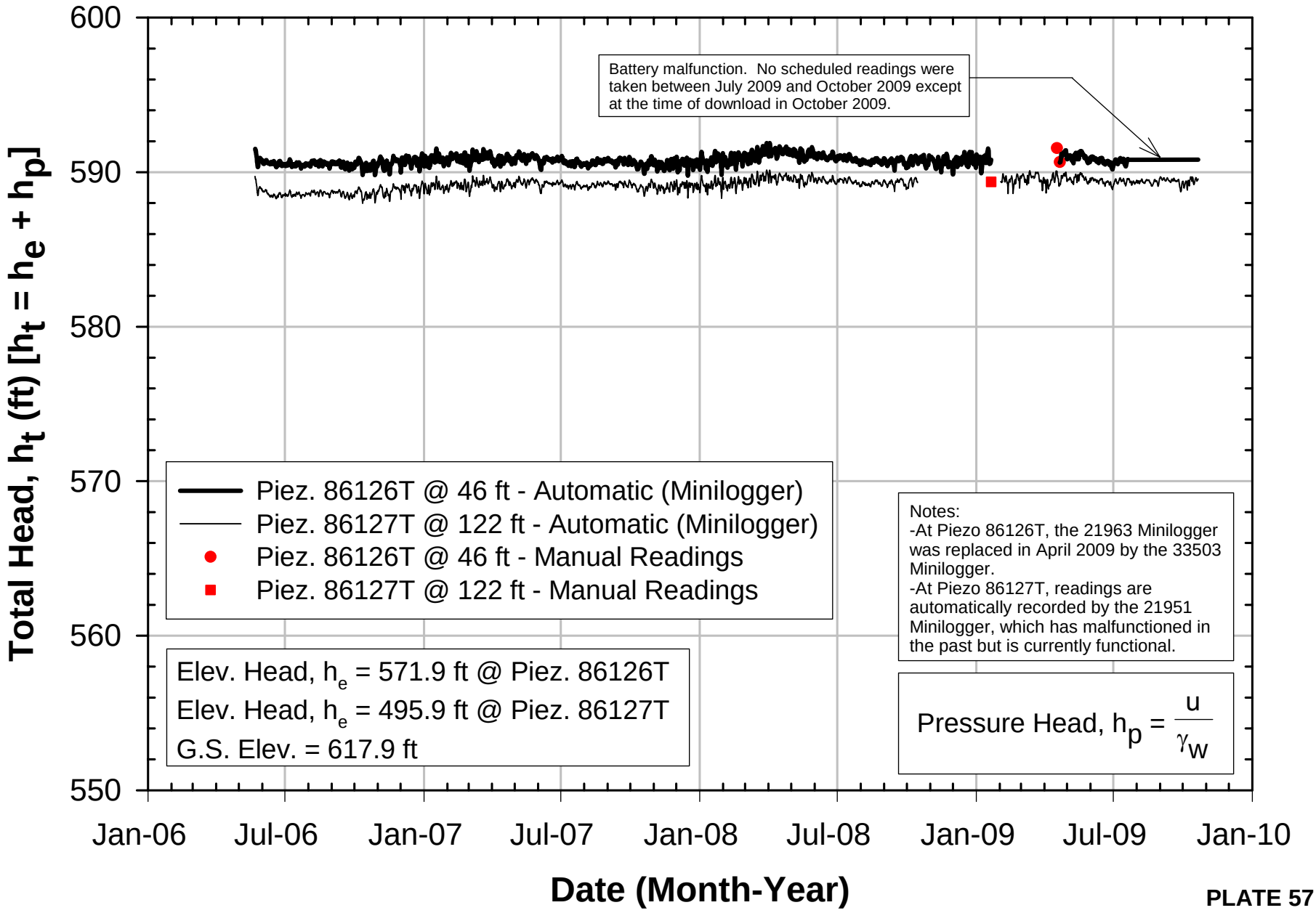


PLATE 57

B-05-03 VW Piezometer Readings

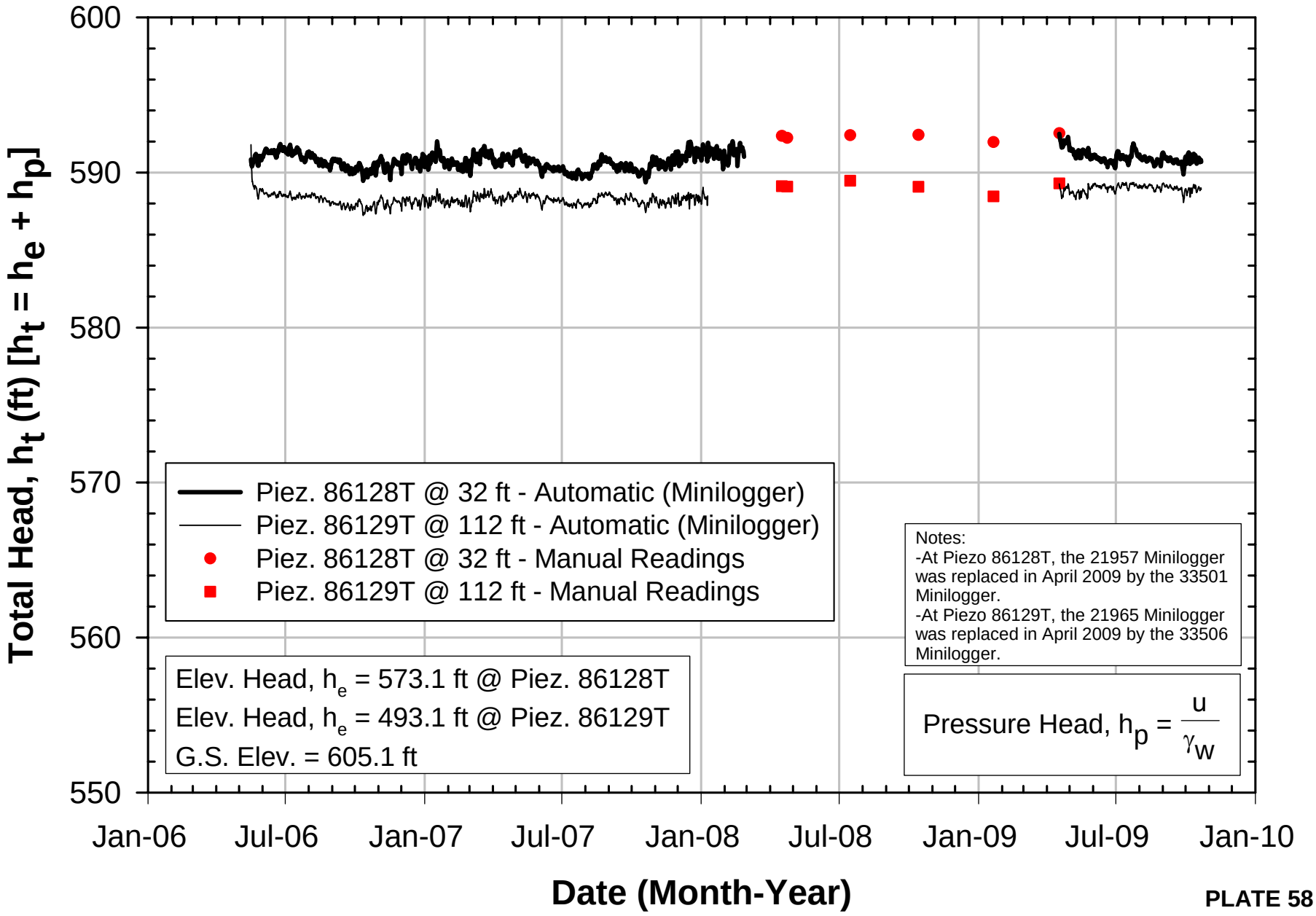


PLATE 58

B-05-04 VW Piezometer Readings

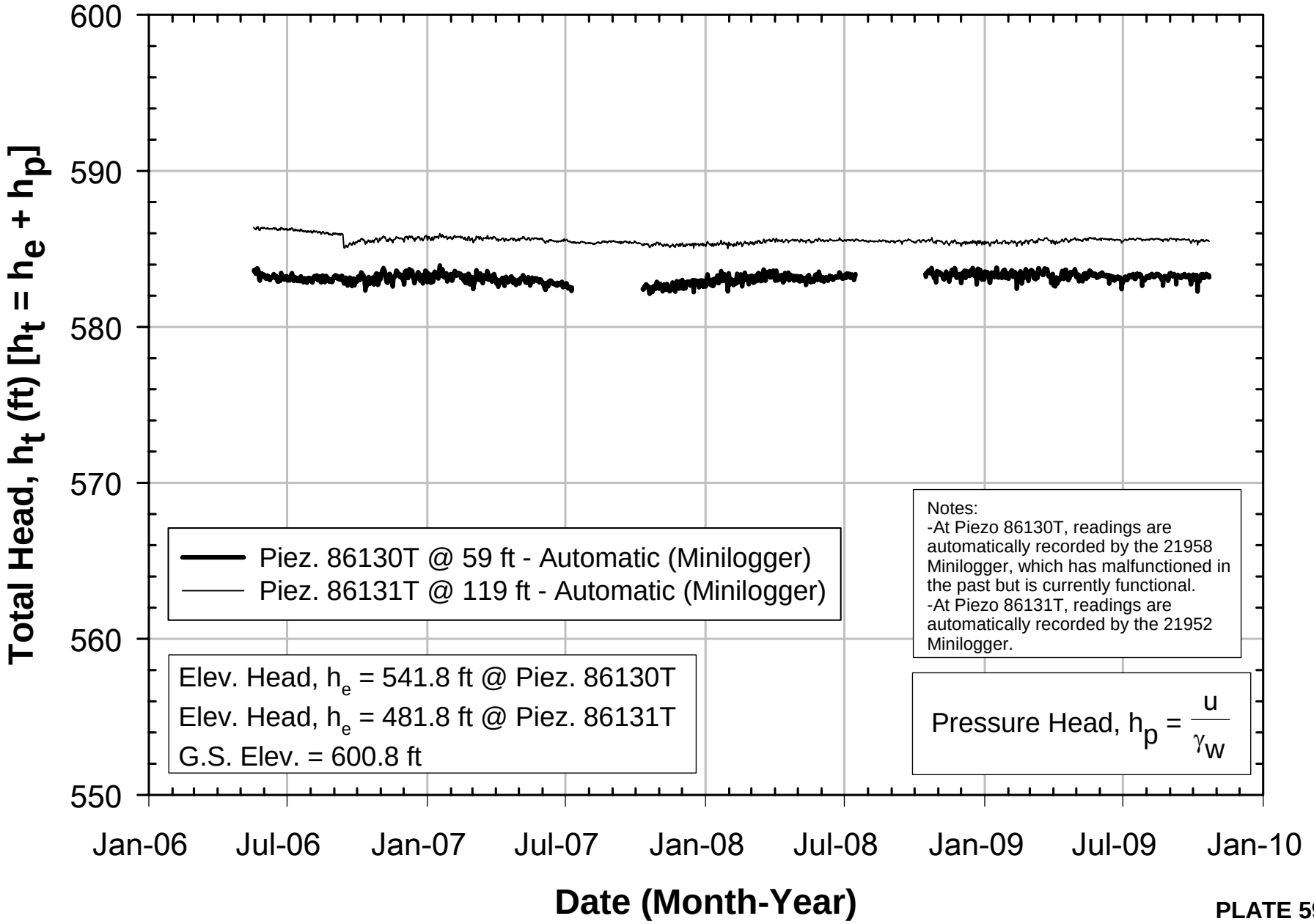


PLATE 59

B-05-07 VW Piezometer Readings

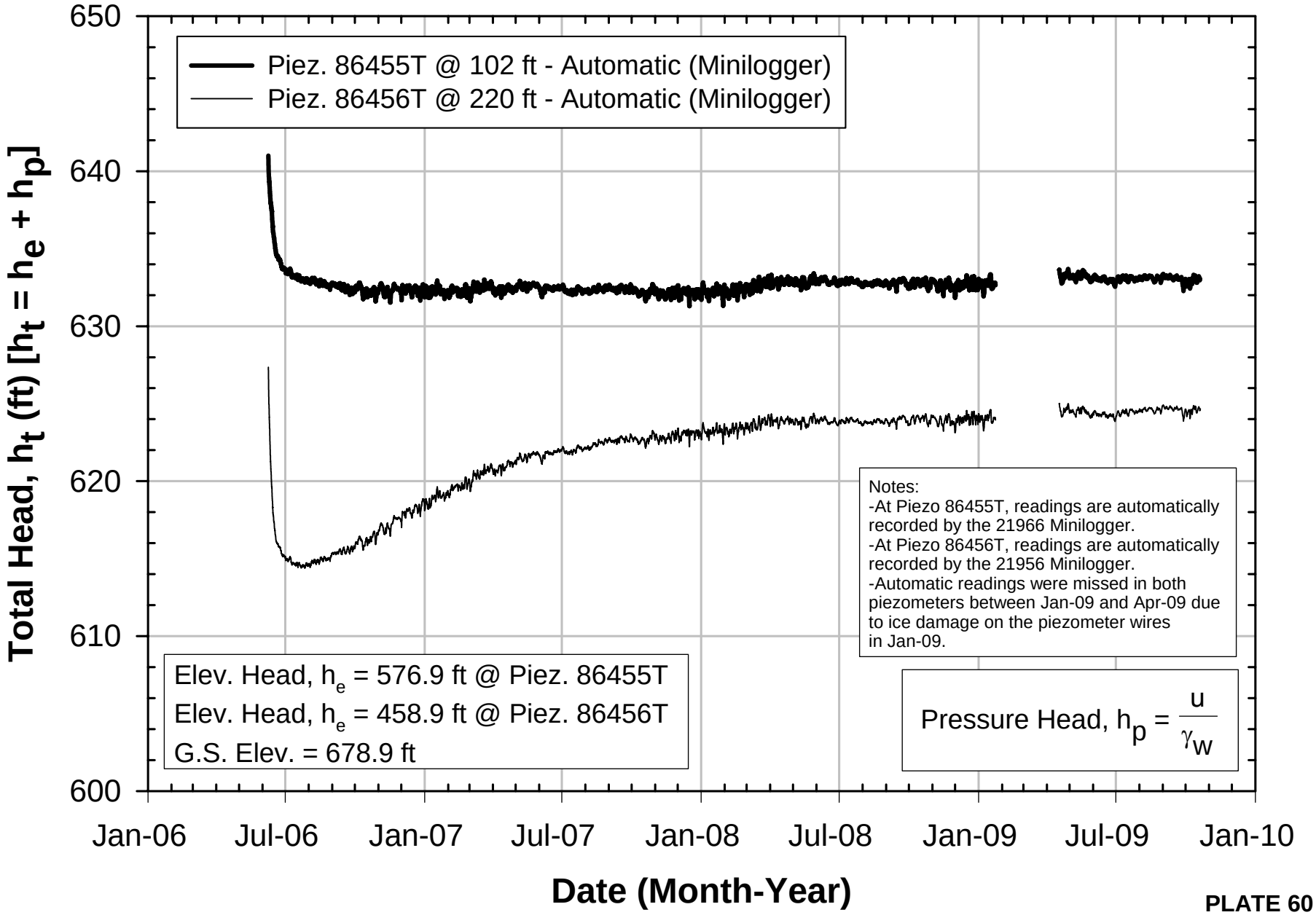


PLATE 60

B-05-08 VW Piezometer Readings

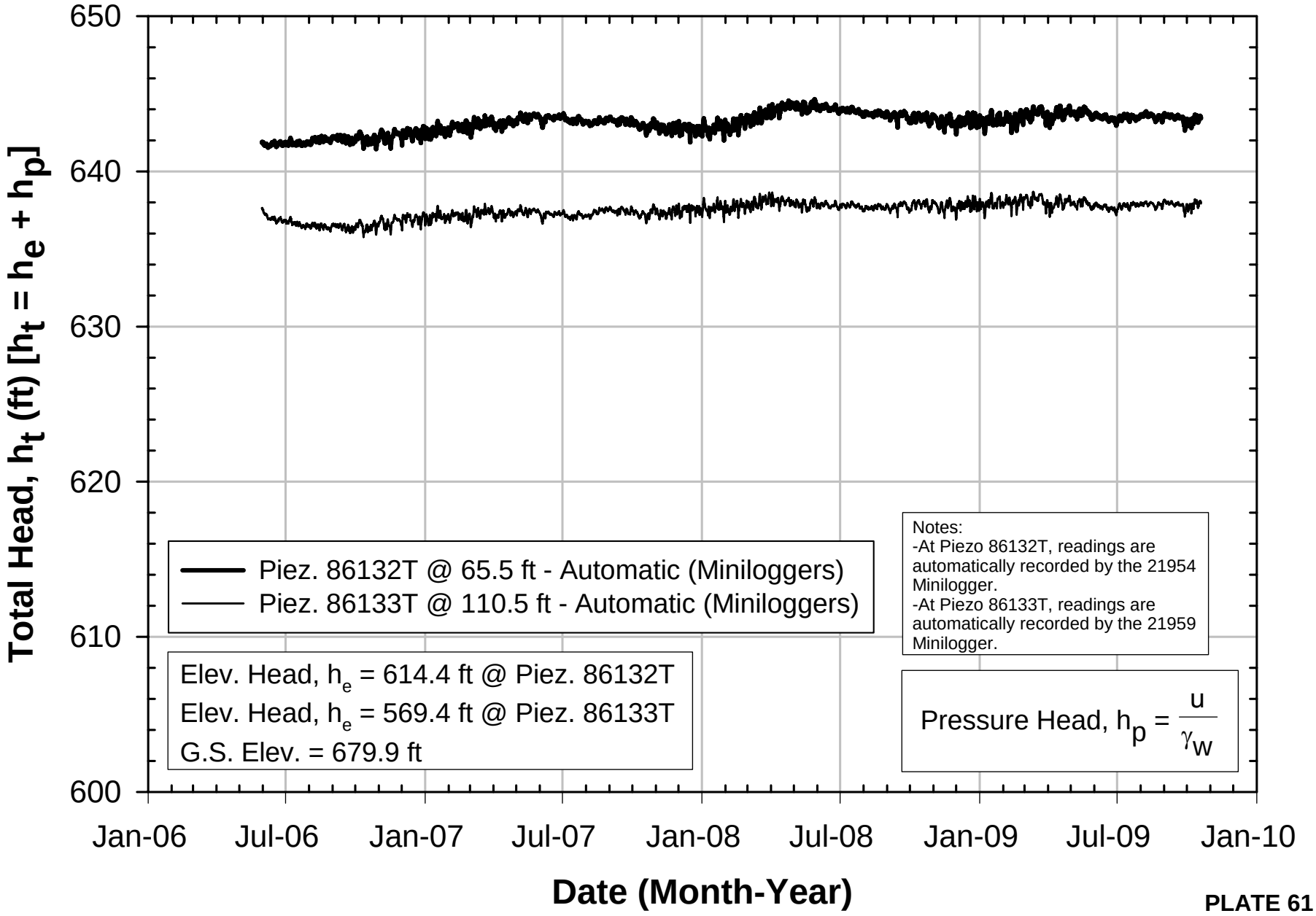


PLATE 61

B-05-11 VW Piezometer Readings

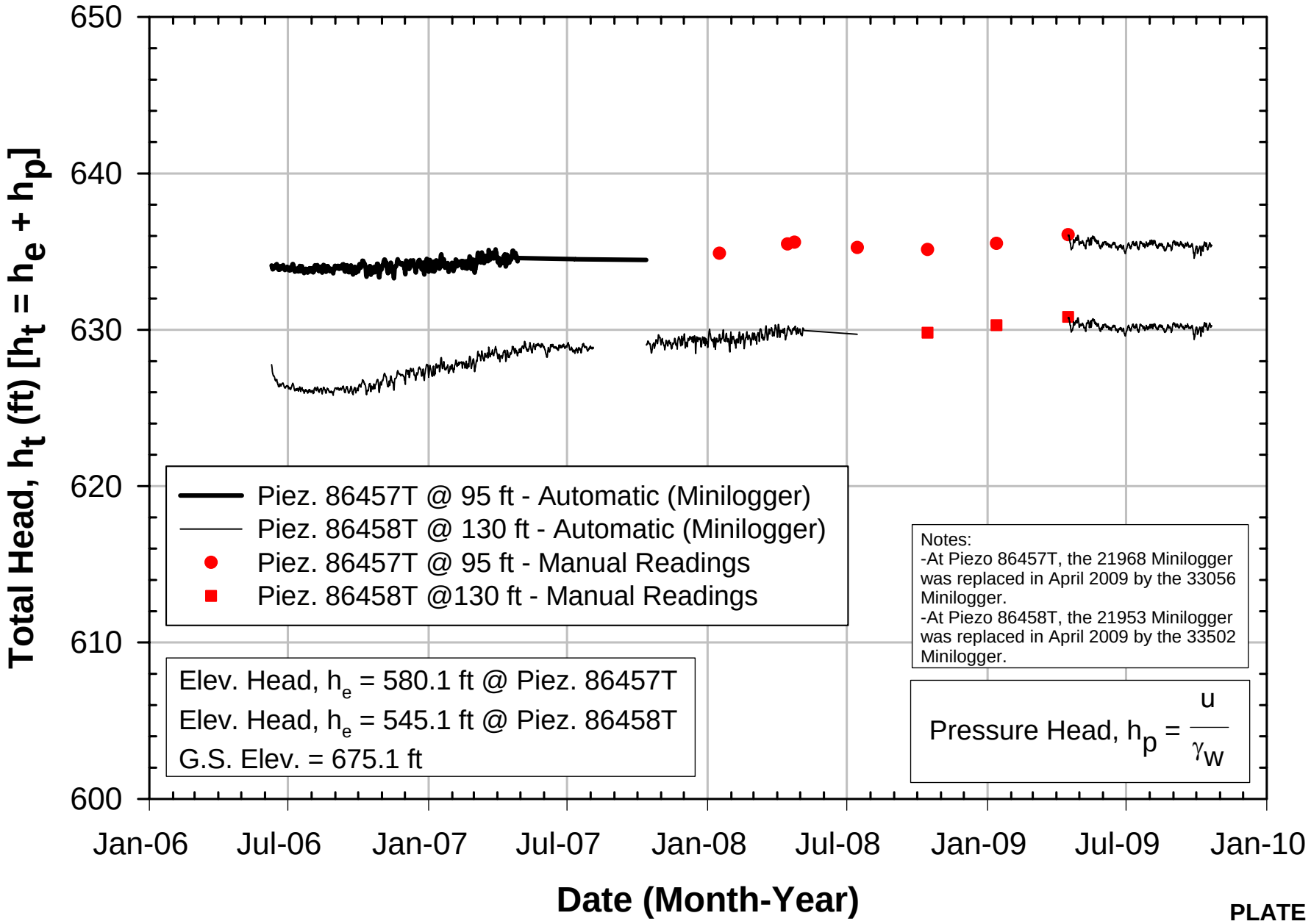


PLATE 62

B-05-12 VW Piezometer Readings

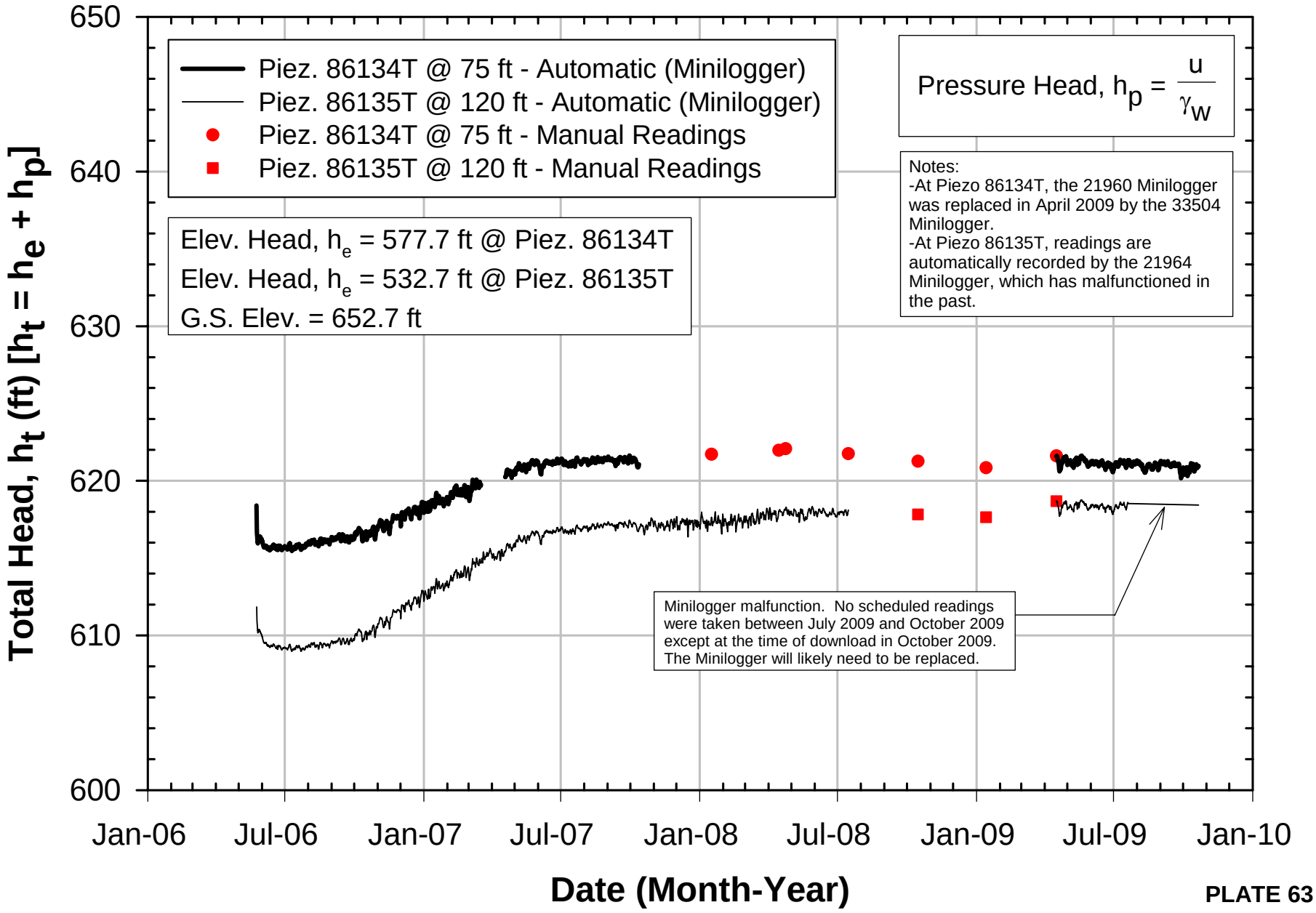


PLATE 63

B-05-13 VW Piezometer Readings

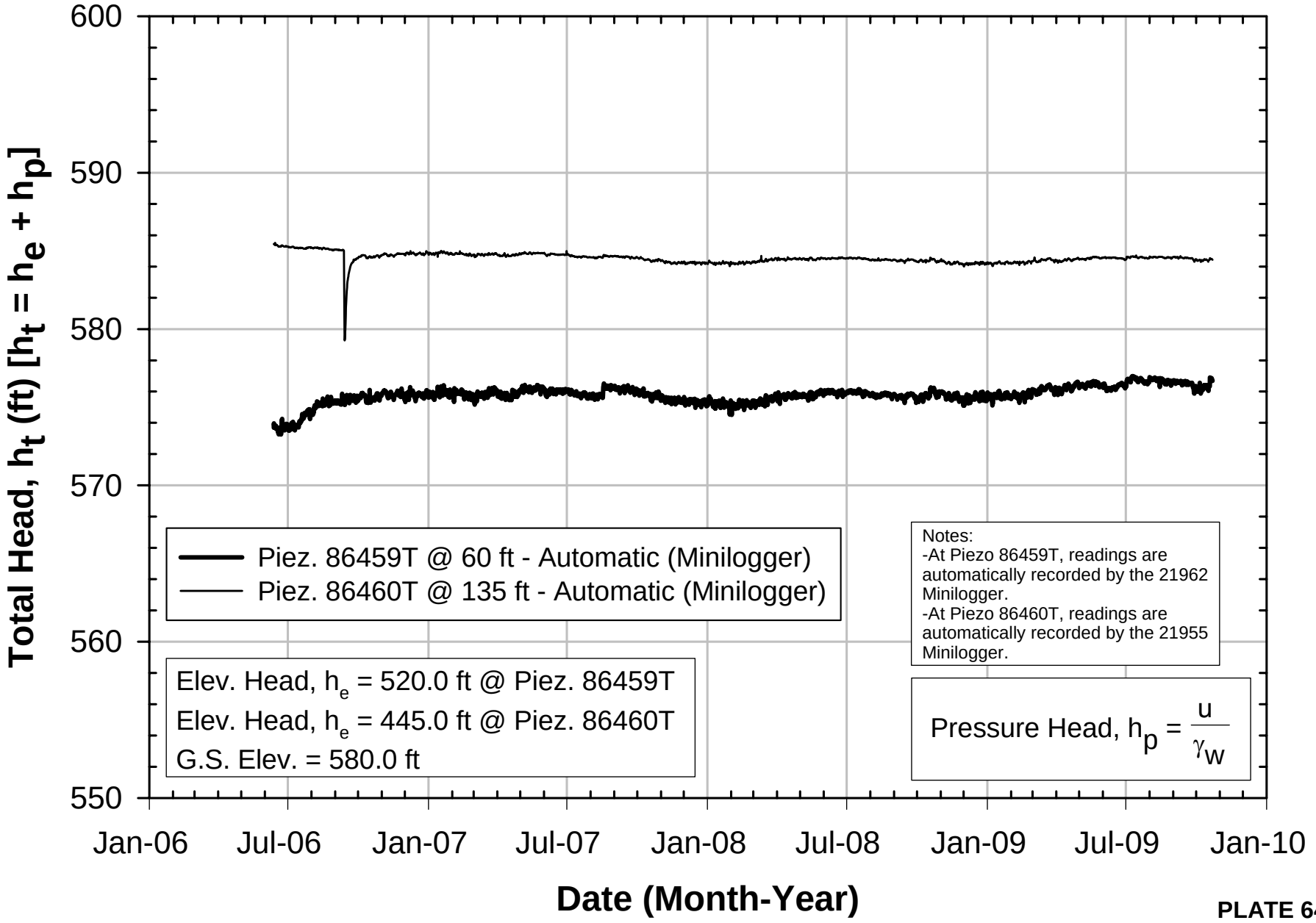


PLATE 64

CALIPERED SURFACE DISTANCE TABLE
CUY-90-15.24

Date	Left Pier Calipered Surface Distance		Center Line Calipered Surface Distance		Right Pier Calipered Surface Distance	
	Present reading	Change (in.)	Present reading	Change (in.)	Present reading	Change (in.)
01/15/03	6.405	0.072	Discontinued on 7/16/02		4.473	-0.009
04/17/03	6.333	-0.072			4.482	0.009
07/18/03	6.186	-0.147			4.350	-0.132
10/16/03	6.385	0.199			4.519	0.169
01/08/04	6.124	-0.261			4.594	0.075
04/14/04	6.129	0.005			4.402	-0.193
07/16/04	6.250	0.122			4.277	-0.125
10/27/04	6.375	0.125			4.467	0.190
01/12/05	6.250	-0.125			4.349	-0.118
04/14/05	6.375	0.125			4.372	0.023
07/14/05	6.313	-0.063			4.392	0.020
10/12/05	6.375	0.063			4.358	-0.034
02/01/06	6.438	0.063			4.395	0.037
04/20/06	6.500	0.063			4.430	0.035
07/14/06	6.375	-0.125			4.381	-0.049
10/18/06	6.438	0.063			4.400	0.020
01/19/07	6.500	0.062			4.506	0.106
04/18/07	6.375	-0.125			4.357	-0.150
07/11/07	6.438	0.063			4.341	-0.015
10/12/07	6.438	0.000			4.384	0.043
01/08/08	6.469	0.031			4.349	-0.036
04/14/08	6.500	0.031			4.410	0.062
07/14/08	6.500	0.000			4.410	0.000
10/15/08	6.375	-0.125			4.395	-0.016
01/13/09	6.500	0.125			4.449	0.055
04/21/09	6.500	0.000			4.449	0.000
07/17/09	6.438	-0.063			4.402	-0.047
10/19/09	6.563	0.125			4.459	0.057

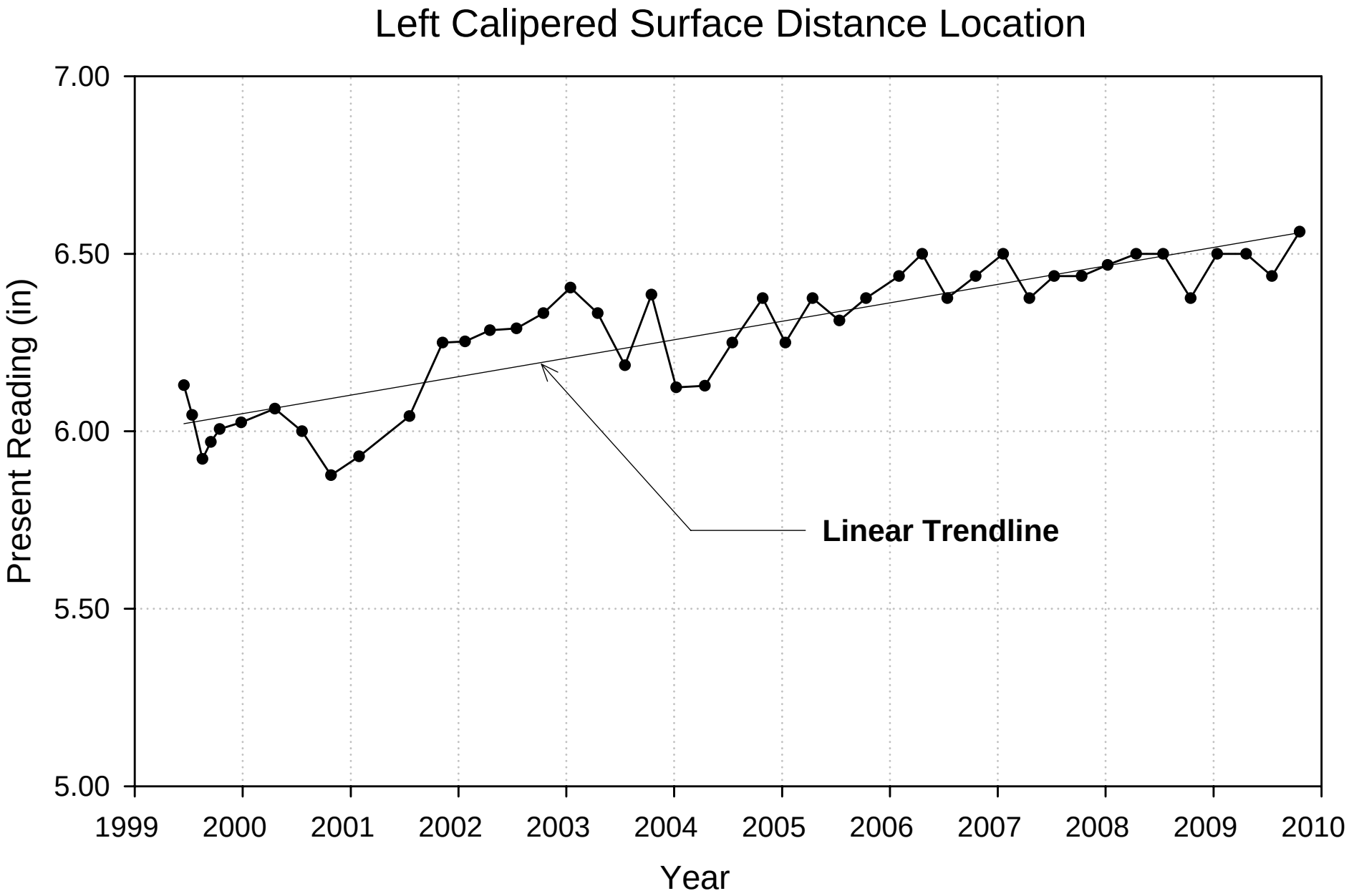

Left Calipered Surface Distance Location
7.00
6.50
6.00
5.50
5.00
Present Reading (in)
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year
Linear Trendline

PLATE 66

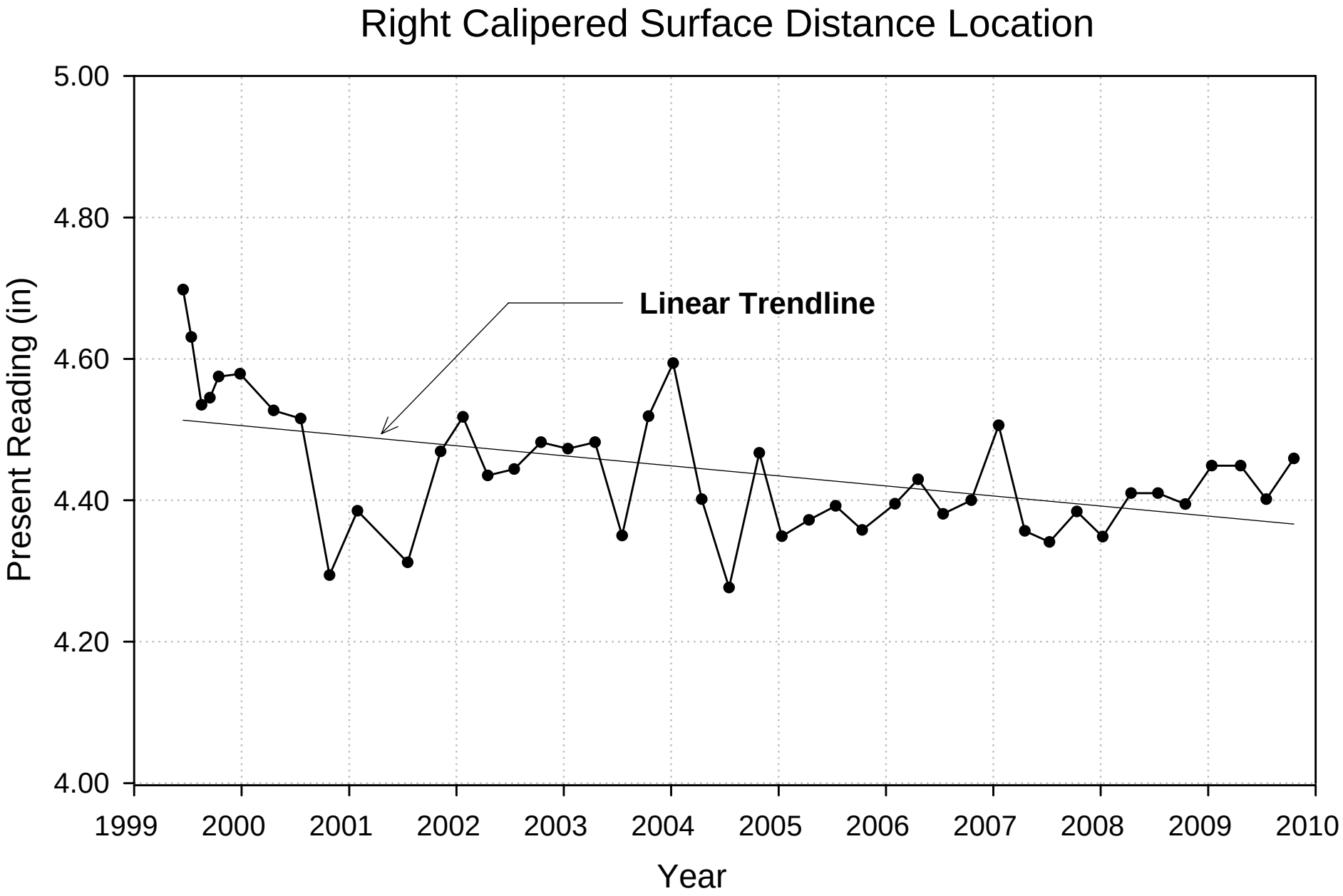

Right Calipered Surface Distance Location
Present Reading (in)
5.00
4.80
4.60
4.40
4.20
4.00
Linear Trendline
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

PLATE 67

View towards the east-northeast of the aggregate pile and east right-of-way fence. Photo taken on October 21, 2009.

PLATE 68

View towards the north of the aggregate pile and east right-of-way fence. Photo taken on October 21, 2009.

View of the smaller aggregate pile towards the eastern end of the property adjacent to the east right-of-way fence. Photo taken on October 21, 2009.