Volume 1 of 2
Maintenance, Inspection, and Monitoring Manual
I-471 Mt. Adams
Cincinnati, Ohio

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PREFACE

Construction activities for the I-471 Mt. Adams interchange project included remedial measures for stabilization of the Mt. Adams Hillside and conventional roadway construction of the I-471 interchange complex. The purpose of this Maintenance, Inspection, and Monitoring Manual is to establish guidelines for periodic inspections and monitoring observation of the above structures. These activities are required to ascertain that the structures continue to perform satisfactorily, and that minor maintenance and repair work can readily be accomplished before developing into major improvements.

This manual is divided into two volumes. Volume 1 contains four parts including descriptions of the project construction; purpose of maintenance, monitoring and inspection; and figures, tables, and samples of checklists to be used to document specific observations and inspection tasks. Part I summarizes the general surveillance program. Part II presents the maintenance, operation, and inspection program. The instrumentation measurements for all inspection areas are discussed in Part III. Part IV contains reference material mentioned in Parts I, II, and III. Also, Part IV includes samples of checklists and instrumentation reporting figures. The checklists and reporting figures will be made available in electronic format. In addition to the checklists, a General Inspection Schedule (Table I), and an Instrumentation Monitoring Schedule (Table VI) are presented to provide the basic framework for all observation, inspection, and monitoring tasks. Parts I and II are divided into four sections that coincide with the four areas of construction activities including the Buttress Fill, the Tied-Back Cylinder Pile Wall, the Anchorage Tunnel, and the Areas Above and Below the Cylinder Pile Wall. Part III is also divided into four sections: inclinometers, piezometers, cylinder pile wall and anchorage tunnel, and survey data. Volume 2 contains Appendix A and B. These appendices include instrumentation Service and User's Manuals (Appendix A) and Tunnel Equipment Manufacturer's Literature (Appendix B). This volume was provided for continuity and completeness to facilitate the transfer of inspection duties to other inspectors or monitoring agencies.

This manual was developed by Shannon & Wilson, Inc., with extensive input from Hazelet & Erdal Consulting Engineer, City of Cincinnati Engineering Division and the State of Ohio Department of Transportation. This manual was revised in October 2000 and November 2003, by the State of Ohio Department of Transportation, District 8 with information provided by Burgess and Niple, Limited.

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PART I. I-471 MT. ADAMS SURVEILLANCE PROGRAM

1. Project Background and Purpose of Construction

A portion of the I-471 highway project connecting Kentucky and Ohio was designed to pass along the southwest flanks of Mt. Adams with several proposed ramps in the vicinity of Mt. Adams. These ramps connect to existing arterials and provide local access (Figure 1). Landslides developed during initial construction of I-471 nourthbound and associated ramps in the Mt. Adams area in late 1973 and early 1974. These landslides forced the temporary shutdown of construction activity on the project until slide stabilization measures were designed and constructed.

The remedial stabilization measures (HAM-471-0.24 Part One) which began in 1980 and were completed in 1983, included constructing a large buttress fill, a tied-back concrete cylinder pile wall, and an anchorage tunnel, located as shown on Figure 1. The purpose of this construction was to stabilize the lower flanks of Mt. Adams so future construction of I-471 highway and interchange excavations could be made along the toe of the original hillside while limiting additional ground movements uplsope of Kilgour Street.

A second contract (HAM-471-0.24 Part Two) was started in 1983, and completed in 1985. It involved construction of permanent northbound and southbound lanes for I-471 and several ramp structures connecting I-471 with existing Columbia Viaduct and other local routes. This work included numerous retaining walls, cuts and fills, bridge abutments, and other elevated structures–generally non-specialized construction. It also included permanent tie down anchors on abutment slopes below Fort Washington Way and the Columbia Viaduct.

This Maintenance, Inspection, and Monitoring Manual provides guidance on detailed monitoring of the performance of the work constructed under HAM-471-0.24 Parts One and Two.

2. Description of Construction

The I-471 stabilization measures are composed of four parts that interact to maintain local slope stability; the Buttress Fill, the Tied-Back Cylinder Pile Wall, the Anchorage Tunnel, and the Downslope Ramp Structures. Each of these structures is briefly described in this section.

2.1 Buttress Fill

The Buttress Fill is located on the west end of the I-471 interchange complex as shown on Figures 1 and 2. It consists of compacted granular structural fill overlying a gravel drainage blanket. Before excavation for the buttress fill began, a temporary tied-back soldier pile wall was installed along the north edge of the slide area to maintain temporary slope stability. The area south of the wall was then graded down to the top of rock. The rock surfaces were benched and subsequently backfilled with the drainage blanket and granular fill; see Figure 3 for a typical cross section. A system of perforated underdrains collects groundwater from the drainage blanket and routes it into the storm drainage system (Figure 2). As the buttress fill construction neared completion, the tiebacks for the soldier pile wall were detensioned and the fill was continued up over the top of the wall. The surface of the buttress fill is covered with 2 feet of relatively impermeable compacted clayey soil intended to prevent erosion and the intrusion of surface water. Several inclinometer casings and piezometers were installed uplsope of the Buttress Fill Area to monitor stability during and after construction.

Because the Buttress Fill has an important function in maintaining slope stability at the west end of the I-471 interchange, any proposed future construction within the Buttress Fill Area and in areas immediately uplsope of the Buttress Fill should be thoroughly evaluated. The effects of any new construction on the integrity of the fill and local slope stability should be determined. Specific areas requiring evaluation prior to future development should include the buttress fill itself and the limits of the detensioned tieback anchors as shown on Figure 2. Engineers and planners should be aware that the soldier pile wall and buried tieback anchors are still in place along the upper edge of the Buttress Fill Area. Although the tieback anchors were detensioned as the buttress fill was constructed, they still present a considerable obstruction to any future construction work in this vicinity; see Figure 2. In general, the Buttress Fill Area, as previously defined, should be designated as “off limits” for any new construction.

2.2 Tied-Back Cylinder Pile Wall

The Cylinder Pile Wall extends eastward from the Buttress Fill to near the east end of Oregon Street. The alignment of the wall parallels Kilgour Street in the central portions of the structure and curves upslope at each end, as shown on Figure 1. This wall consists of 161 large-diameter concrete cylinder piles spaced approximately 1-

foot apart and reinforced with either a steel I-beam, a steel tube, or a conventional rebar cage. The lower ends of the cylinder piles extend up to 25 feet into bedrock. The upper ends of the piles are connected by a segment cap beam that runs the full length of the wall. The cap beams are constructed with a vertical construction joint, and connect four or five cylinder piles, depending upon the pile diameter, as a unit. Cylinder Piles No. 1 through 137 are individually tied back to tunnel deadman anchorages using high capacity steel wire tendons. For plan location, see Figures 4A and 4B; for a typical section, see Figure 5. Cylinder piles 138 through 161 are individually tied back by permanently grouted rock anchors. For plan location, see Figure 4B; for a typical section, see Figure 6.

The Cylinder Pile Wall was designed to carry the out-of-balance slide force from the hillside north of the wall. This out-of-balance slide force includes the forces which will occur several years after construction, until the hillside is completely stabilized. Theses hillside loads were determined from inclinometer data to act perpendicular to Kilgour Street. Using this full design load, the wall was analyzed as a structure with anchorage at the bottom (embedment 25 feet into rock) and ties (tendons) at the top. The loads on the tendons were calculated and the tendons were sized based on a working stress equal to 60 percent of their ultimate strength. The tendons consist of an appropriate number of high tensile strength, single wires, each with a minimum tensile strength of 240,000 PSI. The cap beam was then designed so that if a tendon failed, the load carried by that pile would be transmitted to adjacent piles. During construction, the full design load was initially loaded into each tendon anchor. In the curved portion of the wall where the tendons are constructed on radial lines, stressing of the tendons compressed the vertical joints of the cap beam, making the cap beam act as a unit throughout the length of the wall. Therefore, with this built-in factor of safety, if a tendon fails, there is no need for immediate concern; however, the failed tendon should be replaced as soon as possible because of the potential failure of an adjacent or nearby tendon.

Typically, a 12-inch-thick shotcrete filler was placed between adjacent piles for the full length of the wall. This filler extends from the underside of the cap beam to approximately 2 feet below the existing ground surface. It provides protection and lateral support of vertical drains located between adjacent piles. An as-built profile of the Cylinder Pile Wall is shown on Figures 7A and 7B. Figure 8 shows the details of the upper-end tendon head assembly.

The Cylinder Pile Wall drainage system consists of slotted vertical drain pipes surrounded by gravel installed between adjacent cylinder piles. These are connected to a horizontal perforated underdrain pipe that is installed along the downslope toe of the wall near the top of rock; see Wall Profile, Figures 7A and 7B. The underdrain system discharges into Manhole No. 19, see Figures 9A, 9B, and 9C for Drainage Location plan. A number of the vertical drain pipes are accessible from the top of the cap beam along Kilgour Street and are identified in Figures 4A and 4B.

Instrumentation was included in the cylinder pile wall to monitor its performance. Figures 4A and 4B show the location of inclinometer casings installed immediately upslope of the wall. Additional inclinometer casings are also located within certain cylinder piles along the wall. Cylinder piles 31 and 90 are also instrumented with strain gages and soil pressure cells to determine stresses in the steel reinforcement and the surrounding bedrock. Stainless steel EDM (electronic distance measurement) brackets are mounted at the ends of each cap beam segment to monitor deformation of the top of the wall.

The area between the cylinder pile wall and the tunnel should be considered a restricted zone. The tendons extending from the wall to the tunnel are spaced approximately 8 feet apart and are stressed to loads up to 800 tons. The rock anchor tendons in piles 138 to 161 also present an underground hazard. The layout of these tieback anchors is shown on Figure 4B. State and City engineers and planners should consider designating these two areas as “off limits” for deep excavation or underground construction work. These areas are shown on the Urban Design Plan and on zoning maps in the Department of Buildings and Inspections.

2.3 Anchorage Tunnel

The anchorage tunnel is a 9-foot-diameter, horseshoe-shaped tunnel constructed in claystone bedrock about 80 feet north of the cylinder pile wall and approximately 100 feet below ground surface. Concrete deadman anchorage blocks are located in the tunnel and are used to resist the individual tendon loads from cylinder piles 1 through 137. Figures 10A and 10B show the approximate relative location of the 137 anchor blocks along the south (downslope)side of the tunnel wall. Figure 11 shows a typical tunnel section including an anchor block and lower-end tendon assembly detail. Tunnel drainage discharges from the tunnel through Manhole No. 17, located in plan on Figure 9B and in section on Figure 12.

Instrumentation in the tunnel consists of two hydraulic tendon load cells, tendon and tunnel wall extensometers, and anchor block movement reference points. The tunnel has mechanical ventilation system, an emergency communication system, and a gas detection system. Emergency escape ladders are located at both the vent and access shafts.

2.4 Downslope Ramp Structures

The buttress fill, tied-back cylinder pile wall, and anchorage tunnel, as described previously, are designed to restrain slide loads encountered above Kilgour Street. However, because materials below Kilgour Street have essentially the same strength parameters as those encountered upslope, the ramp structures and permanent slopes in the downslope areas are design to limit long-term downslope creep movements. As a result, the overall permanent slopes in the areas below the cylinder pile wall are, in general, limited to 8 degrees. Localized cut slopes in the over consolidated clays are limited to 10 degrees. In areas where the required ramp grades could not be located within these slope limits, the site soils were over excavated and replaced with higher strength compacted fill material in conjunction with L-shaped reinforced concrete retaining walls. Some of the retaining walls constructed on granular fill are shown on Figures 2 and 9C. Elsewhere, the ramps were designed as elevated structures.

In the area below the existing Fort Washington Way Viaduct, steep cut slopes were required to accommodate Monastery Street grades. Existing viaduct support piers and abutments on the slope further restricted suitable stabilization schemes. In this area the slope was cut on a 2H (horizontal) and on a 1V (vertical) grade with a series of individual concrete reaction blocks, tied down against the cut slope to provide the needed lateral restraint to stabilize the hillside. These reaction blocks are shown on Figure 9C. The tiedown reaction block system consists of a drilled permanent earth anchor extending through the concrete reaction block with the anchor grouted in soil (or rock) at a depth below the hillside.

3. Purpose of Maintenance, Observation, and Inspection Program

The construction of the Mt. Adams I-471 stabilization project represents a large civil engineering investment. The structures have a design life span of at least 50 years, and with proper maintenance, probably 100 years. As with bridge and other major civil engineering structures, it is necessary to perform periodic inspections and observations to be sure that the structures continue to function properly, and to detect as early as possible any unexpected behavior. Unattended minor maintenance and repair work can frequently grow into extensive major corrections. The key to long life, trouble-free structures consists of thorough periodic observations and repair of all deficiencies as promptly as possible. This manual provides the inspection/observation schedule and a series of checklists for specific items.

4. Purpose of Monitoring Program

Instrumentation for this project was installed for the dual purpose of construction and long-term monitoring. During construction the primary purpose of monitoring was to determine the effectiveness of the construction measures in reducing downslope movement. Now that construction is complete, continued monitoring of certain instruments is necessary to verify that the Buttress Fill, The Tied-Back Cylinder Pile Wall, the Anchorage Tunnel, and the Downslope Ramp Structures continue to perform satisfactorily. Monitoring data will also provide a database that may be useful in the event of future litigation.

PART II
MAINTENANCE, OBSERVATION, AND INSPECTION PROGRAM

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PART II. MAINTENANCE, OBSERVATION, AND INSPECTION PROGRAM

1. General

For the purpose of determining maintenance requirements, the observation and inspection work for the I-471 project is divided into four inspection areas: The Buttress Fill Area, the Cylinder Pile Wall, the Anchorage Tunnel, and the Areas Above and Below the Cylinder Pile Wall. Each inspection area is included in a separate section to this part of the Maintenance Manual. These sections focus on required observations and specific inspection tasks. Instrumentation measurements for all inspection areas are discussed in Part III.

To assist the inspector in making thorough observations and inspections, detailed checklists shall be used. These lists include only minimum anticipated observation and inspection tasks. Individual inspectors shall be alert for any unusual conditions and clearly describe any special observations they make.

In addition to general routine observations and inspections, this part of the manual includes a discussion of the Tendon Surveillance Program. If there are indications that a cylinder pile wall or the anchorage tendon system is not performing within the design limitations, a detailed inspection of the individual tendons may be required. Requirements of the Tendon Surveillance Program can be found in Part IV. This surveillance will be accomplished under a separate contract.

Special requirements and procedures are included to deal with backflooding in the anchorage tunnel in the event of Ohio River flooding.

All general observation and inspection work is included on the General Inspection Schedule, Table I. Instrumentation monitoring and measurement work is shown on the Instrumentation Monitoring Schedule, Table VI in Part IV. Together these two schedules provide the basic framework for the required observation, inspection and monitoring work. Figures that are referenced in Part II of the Manual are presented in Part IV.

The General Inspection Schedule lists a series of specific tasks for each inspection area. It includes a list of any special equipment required to complete each task. Visual inspections shall be performed at 6-month intervals, supplemented by more detailed inspections once a year.

A formal technical report shall be prepared for permanent record and reference purposes, and to form a basis for major remedial work when required. This report must contain the results of the observations/inspections; including written summaries for each inspection item, color photographs to supplement the written portion, completed checklists, and recommendations for remedial/maintenance work. The report shall also detail significant changes that have been discovered since the last inspection. The report shall be completed after each 6-month inspection cycle. Three copies of the report shall be submitted to the ODOT Project Manager.

2. Buttress Fill Area

The Buttress Fill stabilizes the lower northwest flank of the Mt. Adams slope near the junction of Baum, Van Meter, and Monastery Streets. Figure 2 shows the location of the Buttress Fill, the buried soldier pile wall, and the approximate area of the detensioned tieback anchors. This figure also identifies the various drainage facilities in the Buttress Fill Area. Figure 3 shows a typical section through the Buttress Fill.

2.1 Ground Surface Inspection

Visual inspections shall be made to determine the general condition of the sloping ground surface of the Buttress Fill. Inspectors shall look for evidence of surface cracking, surface settlement, erosion, surface movement, and evidence of groundwater seepage. In addition, inspectors shall examine the physical condition of the Van Meter and Monastery Street pavements above the Buttress Fill Area.

The technical report shall document, by location and magnitude, any problems observed in the Buttress Fill Area. Table I shows the frequency of these inspections and lists the necessary equipment required to complete the task.

2.2 Drainage Facility Inspection

Visual inspections shall be made to determine the general performance of the drainage facilities installed at the Buttress Fill. Figure 2 shows the location of the Buttress Fill drainage facilities. In general, groundwater collected from the drainage blanket and underdrains is routed into Manhole No. 25 located beyond the east end of Retaining Wall No. 9. Surface runoff is collected in a gutter near the top of the retaining wall and then routed into catch basin for eventual discharge into Manhole No. 25. There is also a footing drain behind Retaining Wall No. 9 that discharges into this manhole.

Personnel inspecting the Buttress Fill drainage facilities shall look for clearance of the gutter at the top of the retaining wall, clearance of the catch basins and Manhole No. 25, and estimate the volume of flow from each of the drains discharging into Manhole No. 25.

The inspection report along with checklist 2.2 shall be used to document the finding of the drainage facility inspections. Table I shows the frequency of these inspections and lists the necessary equipment required to complete the task.

3. Cylinder Pile Wall

The Cylinder Pile Wall was constructed to maintain stability of Mt. Adams above Kilgour Street so excavations consistent with the grade requirements for the I-471 interchange could be accomplished along the toe of the slope. Figures 4A and 4B show the location of the Cylinder Pile Wall and its relation to other features of the project. Figures 9A, 9B, and 9C show the location of the drainage facilities associated with the Cylinder Pile Wall. Figures 7A and 7B present profiles along the front of the wall.

3.1 Concrete Inspection

The wall is constructed of reinforced concrete and consists of a railing at the top, a cap beam below the railing, cylinder piles below the cap beam, and shotcrete between the adjacent cylinder piles.

The inspection report along with checklist 3.1.1 and 3.1.2 (combined together) shall be used to document the concrete railing and cap beam inspections. A legend describing typical crack orientations is also provided. Table I shows the frequency of these inspections and lists the necessary equipment required to complete the task.

3.1.1 Wall Railing Concrete

The reinforced concrete railing extends from cylinder pile 34 to the end of the wall at cylinder pile 161. Both sides of the railing shall be visually inspected to determine the general condition of the concrete. The location, size, and orientation of any cracks, spalls, unusual offsets between segments, or other deterioration shall be carefully noted and recorded.

3.1.2 Cap Beam Concrete

The reinforced concrete cap beam extends the full length of the cylinder pile wall. Only the downslope side is exposed and available for visual inspection. Where access is difficult because of the height of the wall, roadway ramps, or other obstructions, it may be necessary to use binoculars or ladders to make a thorough inspection and determine the general condition of the concrete surface. The cap beam face adjacent to the vertical joints should be particularly noted since spalling occurred during initial tendon stressing and repairs were required. The location, size, and orientation of any cracks, spalls, or other deterioration, such as water seeps or staining, shall be carefully noted and recorded.

Movement of the Cylinder Pile Wall is monitored with an extensive electronic distance measuring (EDM) system. EDM target mounts consisting of stainless steel angle brackets are bolted to the concrete at the ends of each cap beam segment. It is important that these brackets remain securely attached to the cap beam and not be disturbed. The concrete adjacent to the brackets may be more susceptible to cracking because of the bracket mounting bolts. Any evidence of concrete deterioration adjacent to the EDM mounts shall be documented. It is also essential that a continuous line of sight be maintained between the EDM control points and the target mounts. All plant growth over the railing shall be kept clear of these brackets. Figure 13 shows the location and survey data for the EDM control points and reference points. Figures 7A and 7B show the Cylinder Pile Wall profile which can be used as a reference to locate positions along the railing and the cap beam.

3.1.3 Cylinder Pile Concrete

Each cylinder pile shall be visually inspected for concrete cracking and spalling. The length, width, and nature or orientation of the cracks shall be noted. Any deposits, such as calcium or iron-oxide deposits, shall also be indicated. Of particular importance is the area adjacent to the bearing plates where the tendons and cylinder piles are connected. Because of the high tendon loads, this area is subject to stress concentrations; therefore, may exhibit more deterioration. In addition, the steel reinforcement in some of the piles is close to the surface of the concrete. This area may also be subject to more deterioration as a result of differential thermal expansion and contraction.

Checklist 3.1.3, along with the appropriate legend sheet, and the written report shall be used to document the inspections of the cylinder piles. The legend differentiates locations along the pile and provides abbreviations and designations for cracks as well as foreign deposits, specifically calcium or iron-oxide.

3.1.4 Shotcrete Between Cylinder Piles

Shotcrete was placed between adjacent cylinder piles to cover and protect the vertical drains constructed between the piles. All shotcrete shall be carefully inspected for signs of cracking and spalling. Special attention shall be given to any evidence of water seepage or staining that may indicate improper functioning of the drainage system behind the shotcrete. The lengths, width, and locations of cracks and all unusual conditions shall be carefully noted and recorded.

Checklist 3.1.4 and the written report shall be used to document the inspections of the shotcrete between the cylinder piles. The legend provided with checklist 3.1.3 shall be used for the shotcrete inspection to differentiate crack orientations and locations.

3.2 Ground Surface Inspection

The general surface soil conditions within about 25 feet downslope of the Cylinder Pile Wall shall be inspected at the same time the concrete inspection is conducted. The inspector shall look for surface cracking, settlement, heave, surface erosion, soil creep, and groundwater seepage along the toe of the wall. Any wet marshy areas near the bottom of the wall may indicate that the wall drainage system is not working properly and that immediate repairs are required.

The visual inspection report shall document, by magnitude and location, any areas of concern in the ground surface in front to the Cylinder Pile Wall.

3.3 Tendon Bearing Assembly Inspection

The tendon bearing assembly at the cylinder pile wall is shown on Figures 5 and 14 for the tunnel anchored tendons, and on Figure 15 for the rock anchored tendons. The two types of bearing assemblies differ in that for the tunnel anchored tendons the upper end steel bearing plates bear directly against the steel reinforcement of the cylinder piles. For the rock anchored tendons the upper end steel bearing plates bear directly against the cylinder pile or cap beam concrete, or on a cement grout pad used to seat the plate against the concrete.

The exterior portions of the bearing assembly consist of the galvanized steel bearing plate, a grease cap, threaded studs and lug nuts, a vent plug on the grease cap, and a brass extensometer head on selected grease caps. In general, the tendon bearing assembly is visible from the ground surface below the wall. In some cases; however, it may be necessary to use a ladder to provide close access to the assembly and to enable detailed visual inspection.

Checklists are provided to document general visual inspections of the tendon bearing assembly at the cylinder pile location. Table I lists the inspection frequency and the necessary basic equipment for these inspections.

3.3.1 Bearing Plate Contact

A thorough visual examination of the bearing plate contact conditions at each cylinder pile shall be accomplished. Refer to Figures 5, 14, and 15. Water may collect in any space between the back of the inclined bearing plate and the steel reinforcement, concrete, or grout pad possibly causing deterioration or corrosion. This space, originally filled with grout or caulk, shall be carefully observed for signs of rusting, concrete cracking, spalling, or staining. For cylinder piles 138 to 161, the tendon bearing plates bear directly on concrete. Inspections of these piles shall include careful observation of any cracking or spalling of the concrete or grout pad placed beneath the bearing plate. The grout pad shall be picked or probed to determine its integrity. Any loss of concrete or grout from beneath the bearing plate could cause a reduction of tendon load and necessitate retensioning. Damaged areas shall be brought to the attention of the ODOT Project Manager as soon as feasible.

The written report and checklist 3.3.1 shall be used to document the inspections of the bearing plate contact for each cylinder pile.

3.3.2 Bearing Assembly Hardware

All steel hardware shall be carefully examined for signs of rusting, pitting, dents, missing lug nuts, vent caps, or extensometer fittings. Any missing items shall be promptly replaced. Damage caused by vandals shall be repaired. The observer shall look for evidence of rusting on any exposed structural steel above the bearing plate. This area was painted, but future weathering may require additional corrosion protection. The inspector shall be alert for evidence of grease leaking from the base of the grease cap or from the vent plug. A qualitative description of the leak shall be made. Any evidence of the corrosion or precipitate deposits near a grease leak shall be noted and recorded.

The report and checklist 3.3.2–included with checklist 3.3.1–shall be used to document the inspections of the bearing assembly hardware for each cylinder pile. To provide uniformity in corrosion evaluations, a criteria used for visual inspections of steel is provide in Table II.

3.3.3 Grease Cap Removal and Inspection

Grease cap removal and inspection of the grease, washers, shims, and buttonheads is a special task that requires the inspector to be very safety conscious. All tendons shall be considered to be under full design load. Observation and inspection work shall be performed from the side of the bearing assembly so personnel do not position themselves directly in front of the buttonheads. Each buttonheaded wire has the potential for snapping off, and could inflict serious injury to anyone in its direct path.

The tendon wires were threaded through thick steel washers followed by cold forming buttonheads at the end of each wire. Load is maintained by shims located between the bearing plate and the washer. The tunnel anchored tendons use a two part threaded washer with exterior threads at the cylinder pile bearing (upper) end. In the event that restressing or load adjustment is necessary, a jack with a female coupling can be attached to this end of the tendon by threading over the washer. Donut washers are used on the tunnel (lower) end to these anchors and at the cylinder pile bearing (upper) end for the rock anchors. These washers have threaded central holes so that for restressing or load adjustment, a jack with a male coupling can be attached to the tendon by threading into this central aperture.

Removal and inspection of the upper end grease caps for the tunnel tendons shall be coordinated with similar inspections of the lower end grease caps in the anchorage tunnel. Table III presents the schedule for removal and inspection of all grease caps including the upper end caps for the tunnel and rock anchor tendons, and the lower end caps for the tunnel anchors. This schedule shall be followed unless the results of other inspection tasks accomplished in the tunnel suggest modification. Section 4.3.4 provides consideration for modification of Table III and inspection procedures for the lower end grease caps in the anchorage tunnel. The ODOT Project Manager shall be contacted prior to deviation from the schedule established in Table III.

In accordance with Table III, selected grease caps shall be removed for inspection of the tendon. Excess grease shall be cleaned from the washer to expose the tendon wire buttonheads. Any condensation or water in the grease cap shall be noted. The observer shall describe the location of the moisture and its approximate volume. An assessment shall be made regarding the adequacy of the grease covering, the condition of the grease and O-ring; and evidence of corrosion of the shims, the washer, and the buttonheads. The inspector shall count the number of button heads and note any that are cracked, split, or loose. Tolerances for buttonheads shall be evaluated in general accordance with the "Quality Control Procedures" established by the Prescon Corporation and provided in Table IV. UNDER NO CIRCUMSTANCES SHALL THE INSPECTOR TAP OR TRY TO PRY TENDON BUTTOHEADS. Loose buttonheads or button heads that are not fully seated on the washer may indicate broken wires. If such wires are noted, then the relative position of the individual wire in the buttonhead pattern shall be recorded. If observed in a tunnel anchored tendon, a check shall be made to identify the broken wire at the other end of the anchorage. See Section 4.3.4.

A failed buttonhead shall not be of immediate concern unless the number of wires installed, less failed wires, is less than 98 percent of the design number of wires. A failed wire would include any of the following:

- Nick in the wire

- Loss of buttonhead
- Broken wire
- a wire more than 1-1/2 inches to short
- Fault or bend in the wire, etc.

Once the inspection is complete, the grease cap shall be cleaned. The grease cap and tendon head shall then be repacked with grease and rebolted into position.

Many of the grease caps on the cylinder pile wall are inaccessible and are located up to 25 feet above the existing ground surface. A platform lift may be required to remove these caps efficiently and safely.

The report and checklist 3.3.3 shall be used to document the grease cap removal and inspections of the upper end tendon head for the tunnel and rock anchor tendons.

3.4 Drainage Facility Inspection

Water pressure behind the Cylinder Pile Wall are dissipated by vertical drains installed between adjacent piles. Several of these drains extend through the cap beams, so access receptacles and cleanouts can be provided at the ground surface. All of the vertical drains are connected to a horizontal drain, either U-5 or U-6, located at the toe of the cylinder pile wall. These drains extend along the full length of the wall and discharge into Manhole No. 19. Figures 4A and 4B show the plan location of the existing access receptacles for the

vertical drains. Figures 9A and 9B show the plan location of the horizontal drains and Manhole No. 19. Figure 7A and 7B present the horizontal drains in profile.

The inspection report shall document suspected problems in the vertical drains and the horizontal drain discharge. Table I gives the frequency of these inspections and lists the necessary equipment to complete them.

3.4.1 Vertical Drains

Two-inch-diameter, perforated vertical drain pipes were installed between cylinder piles to provide drainage and prevent the buildup of hydrostatic pressure behind the cylinder pile wall. These pipes are surrounded by gravel and are located behind a 12-inch-thick shotcrete cover. The drains extend from the underside of the cap beam down to the top of rock level, and are connected to a horizontal drain that runs along the cylinder pile wall. Fifty-three of these drains extend through the cap beam to access receptacles located at the ground surface. Inspection of the wall drainage system shall include checking these vertical drains with an electric water level indicator to determine that they are functioning properly. Blocked drains shall be flushed with water. It shall be noted that all the drains were not installed completely vertical. A few of the drains were constructed with angled couplings around concrete protrusions on the cylinder piles. There are no records that indicate which drains are built as such. Therefore, if a drain appears to be blocked, and after flushing still appears blocked, it may be due to the above conditions. The location of blocked drains shall be recorded. When replacing the caps of the access receptacles to the vertical drains, the threads shall be greased to allow for easy removal during subsequent inspections.

3.4.2 Horizontal Drain Discharge at Manhole No. 19

All of the vertical drains between adjacent cylinder piles are connected to a horizontal drain designated as either U-5 or U-6. These drains discharge into Manhole No. 19 located downslope, in the general vicinity of cylinder pile Nos. 94 and 95. A thorough inspection of the wall drainage system shall include removing the cover of Manhole No. 19 and evaluating the volume of water flow and any evidence of sediment deposition.

4. Anchorage Tunnel

The main portion of the Cylinder Pile Wall is anchored with tendons tied back to deadman anchor blocks located in a tunnel which is constructed about 80 feet upslope of the Cylinder Pile Wall. Figures 4A and 4B show the general location of the tunnel. The tunnel includes 137 concrete anchor blocks, access shaft, a ventilation shaft, and an extensive drainage system. The tunnel and access shaft are lined with reinforced concrete and shotcrete while the ventilation shaft is constructed with a steel liner. The tunnel complex (the access shaft building, access shaft, tunnel, vent shaft, and vent shaft building) contain mechanical and electrical equipment including a gas detection system, a forced air ventilation system, an emergency phone/intercom system, and a manlift.

Keys for access to the tunnel will be provided to the consultant. Additional keys are available from the Ohio Department of Transportation Project Manager.

The following safety checklist provides procedures for entering and exiting the tunnel. These routines shall be followed each time the tunnel is accessed regardless of the length and nature of the visit.

1. Enter the access shaft building and view the circuit breaker box. Determine if circuits 5, 9, and 12 (room light, gas detector, and telephone) are operating. These circuits should be functioning continuously. Turn on the remainder of the circuits as shown on Figure 17. The gas level within the tunnel, as noted on the gas detection meters, shall be monitored prior to activation of the ventilation fan which will be accomplished at the vent shaft building near the east end of the tunnel.

2. Move to the ventilation shaft building and unlock the stainless steel breaker box located on the service pole nearby. Check the fan switch for “Forward” mode and relock the box. Unlock and enter the hatch of the ventilation shaft building. Turn on the light switch, which also turns on the power for the rear half of the tunnel telephone system, and move the inside fan control switch to the “ON” position. Exit the ventilation shaft building, closing and locking the hatch lid. Move back to the access shaft building.

3. Reenter the access shaft building, and after the fan has been operating for at least 10 minutes, note again the reading on the gas meters. The gas level should be the same or lower than the initial readings observed in Step 1. If a safe level or no gas is indicated by the green light on the meter box, leave the fan operating in the forward mode and proceed to Step 5.

4. The presence of gas in the tunnel is indicated on the gas meters by an amber light (greater than 20% Lower Explosive Limit (LEL)) with the danger level indicated by a red light (greater the 40% LEL). If gases are in the tunnel, the fans should be switched to the reverse mode, thereby pulling air out of the ventilation shaft, while monitoring the gas detection system. It should be

noted that the fan directional controls are located on the service pole adjacent to the ventilation shaft building. To change the direction of the fan; therefore, it will require either a second person, or a trip from the access shaft to the vent shaft building. When a safe gas level is indicated, the fan shall be switched back to the forward mode and operated for an additional 10 minutes before entering the tunnel. The fan must remain in operation at all times while the tunnel is occupied.

5. Before descending into the tunnel, the communications system should be turned on in the vent shaft building and breaker No. 12 checked in the access shaft building. Picking up the telephone handset with the selector switch set on the “emergency” position will automatically dial “911" and any emergency situation can be reported directly to the operator.

6. Before descending into the tunnel using the manlift, check that all access doors are properly closed and that the manlift light is functioning. One should be familiar with the location of all controls and possess an alternate light source. The manlift has a maximum weight capacity of 500 pounds. A Portable gas detection monitor is required during entry and work in the anchorage tunnel. In addition, employees shall wear appropriate personal protective equipment including harnesses for climbing exit.

7. Upon arrival at the tunnel invert, the emergency phone system should be checked for internal communication by setting the selector switch on position 2 before talking into the handset. This transmits the voice to all other phone stations within the tunnel complex. After this check, replace the phone and reset the selector switch to position 1 for emergency “911" communication. The atmosphere within the anchorage tunnel shall be periodically tested as necessary to ensure that the continuous force air ventilation is preventing the accumulation of a hazardous atmosphere.

8. Observe the sump pit grating and discharge drain near anchor block No. 96 to assure adequate drainage.

9. Proceed with maintenance, monitoring, or inspection tasks.

10. After completion of the tasks, return to the Access Shaft Building via the manlift and shut off all circuit breakers except for Nos. 5, 9, and 12. Turn off

the overhead light with the switch adjacent to the access door, and lock both doors upon exiting.

11. Proceed to the Ventilation Shaft Building. Enter the hatch opening and turn off the fan and light switches. Exit through the hatch and secure it with the padlock. Check that the panel on the nearby service pole is also locked.

12. If a hazardous atmosphere is detected during entry:
    a. Each employee shall leave the space immediately;
    b. The space shall be evaluated to determine houw the hazardous atmosphere developed; and
    c. Measures shall be implemented to protect employees from the hazardous atmosphere before any subsequent entry takes place.

Emergency Exits

1. Escape ladders are located in both the access and ventilation shafts. In the access shaft the guide rails for the manlift are equipped with non-slip ladder rungs. In the ventilation shaft an aluminum ladder equipped with a “ladder climber’s safety device” and a safety belt is fastened to the inside of the shaft liner. To provide access to this ladder, a short ladder has been attached form the tunnel.
2. If the manlift malfunctions during operation and stops midway during travel, the ceiling is equipped with an escape hatch providing access to the emergency ladder.
3. If the escape ladder is used in the ventilation shaft, a hinged door is provide in the steel shaft to provide access to the ventilation shaft building. Egress form the building can be obtained through the lockable manhole cover.

4.1 Inspection of Installed Equipment

A general inspection of the interior and exterior of the access and ventilation shaft buildings shall be completed. All louvers and screens shall be maintained and cleaned of leaves and debris. Any evidence of vandalism shall be recorded and promptly brought to the attention of the ODOT Project Manager. General deterioration of the buildings shall be noted including size and location of cracks in the concrete.

The report and checklist 4.1 shall be used to document inspections of the equipment installed in the Anchorage Tunnel. Table I shows the frequency of required inspections and lists the basic equipment necessary to perform them.

4.1.1 Power and Light Check

Power to the access and vent shaft buildings shall be monitored. Distribution panels at the pole near the vent shaft building and in the access shaft building shall be checked. Lighting circuits shall be monitored. Burned out bulbs shall be replaced.

4.1.2 Gas Detection System Check

In January 1995, a new gas monitor and sensor heads were installed. The gas detection system (MSA Model 5100) consists of two indicating units mounted on the north wall of the access shaft building, and two sensors located in the tunnel approximately 270 and 760 feet east of the access shaft. This system is designed to sample and analyze the local atmosphere to detect the presence of flammable gases or vapors up to their lower explosive limit (LEL) in air. The presence of gas must always be checked before entering the tunnel. The control unit indicators in the access shaft include a gauge registering from 0 to 100% LEL, a white pilot light indicating power to the control unit, a green ready light indicating the system is operative, an amber warning light indicating a gas level greater the 20% LEL, and a red alarm light indicating a gas level greater than 40% LEL.

To quickly field check the system, one could release butane gas from an appropriate source, such as a cigarette lighter, at each sensor and detect corresponding movement of the control unit gauge. If a lighter is utilized, it shall not be ignited until it is determined that explosive gases are not present within the tunnel. The sensor heads should have a useful life of five to 10 years. If the system does not appear to be functioning properly, the ODOT Project Manager shall be notified. The gas detection system shall be calibrated every three years. Calibration shall be performed in accordance with the manufacturers instructions.

The detailed operation of the gas detection system and its maintenance requirements are described in the Manufacturer’s literature presented in Appendix B, Volume 2.

4.1.3 Ventilation Fan Operation

Once the presence or absence of gas has been determined, the fan located in the ventilation shaft building shall be operated. The fan selector switch is located in the distribution panel mounted on a service pole just west of the

vent shaft building. Routine maintenance shall include exercising the fan for a minimum of 10 minutes in both the forward and reverse modes.

The detailed operation of the ventilation fan and its maintenance requirements are described in the Manufacturer's literature presented in Appendix B, Volume 2.

4.1.4 Manlift Operation

The manlift is an electrical elevator that is capable of transporting personnel and small equipment up and down the access shaft. It has a maximum rated capacity of 500 pounds. The consultant shall administer/coordinate the monthly routine maintenance of the elevator, the semi-annual State Certification Inspection, all necessary repairs, and routine inspections of the elevator's condition by a qualified elevator technician.

The detailed operation of the manlift (Serial No. S/O-6123) and its maintenance requirements are described in the Manufacturer's literature presented in Appendix B, Volume 2.

4.1.5 Safety Equipment

The safety equipment in the tunnel includes an aluminum ladder in the ventilation shaft equipped with a "ladder climber's safety device", a short ladder attached to the vent shaft escape ladder, a permanent safety ladder in the access shaft, and emergency phones throughout the tunnel. Other safety equipment, such as flashlights, protective clothing, and harnesses and associated equipment for climbing exit of the anchorage tunnel shall be provided by each inspector, for each inspection.

4.1.6 Communications Equipment

The access shaft phone and four tunnel phones are powered by a breaker switch on the panel box located in the access shaft building. This breaker shall remain “on” continuously in order that the battery backup for the system will not be discharged. The vent shaft phone and four rear tunnel phones are powered by turning on the light switch inside the ventilation shaft building. These phones shall be monitored for proper working condition prior to completion of the inspection tasks within the tunnel.

With the selector switch in position 2, the intercom system at both the access and vent shaft buildings shall be checked, along with all eight phone stations located throughout the tunnel. Checking of the emergency position for access to “911" shall be done annually. Emergency Services in the City of Cincinnati shall be contacted for procedures and requirements.

In addition to the above, the communication equipment shall be inspected for signs of corrosion, excessive moisture, or other potential damage.

The detailed operation of the communication system and its maintenance requirements are described in the Manufacturer’s literature presented in Appendix B, Volume 2.

4.1.7 Miscellaneous Equipment

The rolling service door of the access shaft building shall be maintained so it operates freely and has adequate protection against corrosion (see Appendix B, Volume 2, for detailed operation). In addition, the escape hatch in the ceiling of the manlift, the lockable manhole cover and the hinged emergency exit in the ventilation shaft shall all be exercised and lubricated.

A winch with a 700 pound capacity can be used in the access shaft. It can be attached to the winch bracket mounted on the overhead steel beam.

4.2 Concrete Inspection

Both the tunnel and the access shaft are lined with 10 to 12 inches of reinforced concrete. In some areas the concrete was cast in place using wood or steel forms, while at other locations shotcrete lining was installed.

The inspection report and checklists shall be used to record findings of the inspection of the concrete in the Anchorage Tunnel. Table I gives the frequency of these inspections and lists the necessary equipment needed to perform them.

4.2.1 Access Shaft Liner Concrete

The Access Shaft Liner Concrete shall be examined to determine location of cracks, spalls, water staining, seepage, etc. The location, length, width, and orientation of the cracks and the areas of spalling shall be noted and recorded. Offsets across cracks or construction joints shall be noted. Any evidence of exposed reinforcing steel shall be recorded.

Checklist 4.2.1 shall be used to document the visual inspections of the access shaft liner concrete.

4.2.2 Tunnel Invert Concrete

The Tunnel Invert Concrete shall be examined to determine location of cracks, spalls, water staining, seepage, heaving, etc. The location, length, width, and orientation of the cracks and the areas of spalling shall be noted and recorded. Offsets across cracks or construction joints shall be noted. Any evidence of staining, precipitate, or freewater seepage through cracks or construction joints shall be recorded. Any evidence of exposed reinforcing steel shall be noted.

Checklist 4.2.2 shall be used to document the visual inspections of the tunnel invert concrete.

4.2.3 Tunnel Liner Concrete/Shotcrete

The tunnel lining shall be examined to determine location of cracks, spalls, water staining, seepage, etc. The location, length, width, and orientation of the cracks and the areas of spalling shall be noted and recorded. Offsets across cracks or construction joints shall be noted and measured. Any evidence of staining, precipitate, or water seepage through cracks or construction joints shall be recorded. Particular emphasis shall be place on the observation of concrete areas adjacent to the tendon anchor blocks where liner cracking may become more severe. Any evidence of exposed reinforcing steel shall be noted.

Checklist 4.2.3 shall be used to document the visual inspections of the tunnel liner concrete.

4.2.4 Anchor Block Concrete

Each anchor block shall be carefully examined to determine the location of cracks, spalls, or other deterioration. Inspectors shall be alert for evidence of staining, precipitate, or water seepage–particularly where construction support bolts extend through the anchor blocks.

Checklist 4.2.4 shall be used to document the visual inspections of the anchor block concrete. A legend is provided for quick identification of the deteriorated locations on the anchor block.

4.3 Tendon Bearing Assembly Inspection

The lower end tendon bearing assembly is presented on Figure 11. The exterior portions of the bearing assembly consist of the galvanized steel bearing plate, a grease cap, fastening bolts, a grease fill plug; and on selected grease caps a brass extensometer head. In general, the lower end tendon bearing assembly is visible from the tunnel floor. In some cases; however, it may be necessary to use a ladder to provide close access to the assembly and to enable detailed visual inspection.

Checklist are provided to document general visual inspections of the tendon bearing assembly. Table I lists the inspection frequency and the necessary basic equipment for these inspections.

4.3.1 Bearing Plate Contact

A thorough visual examination of the bearing plate contact conditions at each anchor block shall be accomplished. Refer to Figure 11. Inspections shall include careful observation of any cracking or spalling of the concrete or grout pad placed beneath the bearing plate. The grout pad shall be picked or probed to determine its integrity. Any loss of concrete or grout from beneath the bearing plate could cause a reduction of tendon load and necessitate retensioning. Damaged areas shall be brought to the attention of the ODOT Project Manager as soon as feasible.

4.3.2 Bearing Assembly Hardware

All steel hardware shall be carefully examined for signs of rusting, pitting, dents, missing bolts, grease fill plugs, or extensometer fittings. Any missing items shall be promptly replaced. The observer shall look for evidence of rusting on any exposed structural steel. The inspector shall be alert for evidence of grease leaking from the base of the grease cap or from the grease fill plug. A qualitative description of the leak shall be made. Any evidence of corrosion or precipitate deposits near a grease leak shall be noted and recorded.

To provide uniformity in corrosion evaluations, a criteria used for visual inspections of steel is provide in Table II.

4.3.3 Grease Cap Plug Water Check

During construction of the remedial measures, water was occasionally observed to be seeping from the lower end of several of the greased tendons. The source of this water may be the grease itself or a leak in the containment system. PH measurements indicate that the water currently in the tendons is non-corrosive. Nevertheless, the presence of water in the tendons is an important concern, particularly with regard to the potential for long-term corrosion. An inspection of the anchorage tunnel shall include checking the tendons to determine if water is present. This may be accomplished by removing the drain plugs in the grease caps. If water is found, its pH shall be determined, and it shall be allowed to drain provided there is no major loss of grease. The pH and approximate volume of water shall be recorded. If the pH is less than 7 there is a potential for steel corrosion and immediate remedial action may be necessary to prevent deterioration of the tendon wires. If the pH is greater than 7, the water can be considered non-corrosive and not of immediate concern.

The pH of water may be measured using sensitive paper. The volume of water that drains will be measured using a graduated cylinder. If the volume is greater than 1,000 cc then the rate and total time of flow shall be determined. The drain valve shall be kept open as long as necessary in order to completely drain the water. Not more the 250 cc of grease shall be allowed to extrude during this water bleeding operation.

Checklist 4.3.3 shall be used to record the presence of water at each grease cap.

4.3.4 Grease Cap Removal and Inspection

Grease cap removal and inspection of the grease, washers, shims, and buttonheads is a special task that requires the inspector to be very safety conscious. All tendons shall be considered to be under full design load. Observation and inspection work shall be performed from the side of the bearing assembly so personnel do not position themselves directly in front of the buttonheads. Each buttonheaded wire has the potential for snapping off and could inflict serious injury to anyone in its direct path.

Removal and inspection of the lower end grease caps for the tunnel tendons shall be coordinated with similar inspections of the upper end grease caps in the cylinder pile wall. Table III presents the schedule for removal and inspection of all grease caps including the upper end caps for the tunnel and rock anchor tendons, and the lower end caps for the tunnel anchors. This schedule shall be followed unless the grease cap plug water inspection (see Section 4.3.3) identifies tendons that warrant immediate evaluation due to 1) the volume of water encountered, 2) the volume of grease loss, 3) the pH of water, or 4) grease leaking through the grease cap seal. The ODOT Project Manager shall be notified prior to deviating from the schedule in Table III.

In accordance with Table III, selected grease caps shall be removed for inspection of the tendon. Excess grease shall be cleaned from the washer to expose the tendon wire buttonheads. Any condensation or water in the grease cap shall be noted. The observer shall describe the location of the moisture and its approximate volume. An assessment shall be made regarding the adequacy of the grease covering, the condition of the grease and O-ring; and evidence of corrosion of the shims, the washer, and the buttonheads. The inspector shall count the number of buttonheads and note any that are cracked, split, or loose. Tolerances for buttonheads shall be evaluated in general accordance with the "Quality Control Procedures" established by the Prescon Corporation and provided in Table IV. UNDER NO CIRCUMSTANCES SHALL THE INSPECTOR TAP OR TRY TO PRY TENDON BUTTOHEADS. Loose buttonheads or buttonheads that are not full seated on the washer may indicate broken wires. If such wires are noted, then the relative position of the individual wire in the buttonhead pattern shall be recorded. If loose buttonheads or broken wires are found, a check shall be made to identify the broken wire at the cylinder pile bearing end. See Section 3.3.3.

Once the inspection is complete, the grease cap shall be cleaned. The grease cap and tendon head shall then be repacked with grease and rebolted into position.

Removing and installing the grease cap is not an easy task. It is heavy, cumbersome, and in a tilted-overhead position causing problems with bolt-hole alignment. Removal and replacement of the grease cap can be performed using a hydraulic lift table. The table can be raised or lowered, as appropriate, to enable the inspectors to get conveniently close to the grease cap. A wood cradle that is mounted on the lift table is typically raised to a tight fit beneath the cap. The stud bolts are then removed from the grease cap; and the cap, cradle, and table are lowered for inspection. After any water

in the tendon system has drained; and the corrosion inspection has been performed, the grease cap shall be replaced. Care must be taken not to cross-thread the bolts in the bearing plate upon replacement.

Twenty-three grease caps have brass extensometer reference heads mounted in the ends of each cap. These extensometers were monitored during construction, but have not performed as anticipated. As a result, during the removal and inspection of all the grease caps accomplished in 1987-88, the extensometers were disconnected from their reference heads. Removal and inspection of these grease caps can therefore proceed in the same manner as that utilized for the remaining caps.

Checklist 4.3.4 shall be used to document the grease cap removal and inspections of the lower end tendon head.

4.4 Drainage Facility Inspection

A number of crown and sidewall drains are located in the tunnel along with several sidewall drains in the access shaft. These drains relieve groundwater pressures in the rock and aid in minimizing cracking of the concrete liners. All of the water collected in the tunnel and access shaft discharges by a gravity drainline to Manhole No. 17, as shown on Figure 9B.

The report and checklists shall be used to record results of the Anchorage Tunnel drainage facilities inspections. Table I gives the frequency of these inspections and lists the basic equipment necessary to perform them.

4.4.1 Vertical and Sidewall Tunnel Drains

Thirty-nine 2-inch-diameter vertical drains are installed in the crown of the tunnel. These drains extend to the top of rock to intercept groundwater seepage along the soil-rock contact, thereby reducing pore water pressure acting on the Cylinder pile wall. A series of 3-foot-long horizontal relief drains are also installed in the sidewalls of the tunnel to prevent high pore water pressures behind the liner. These drains shall be inspected to determine the estimated flow rate, any sediment content, the tightness of the drain pipe, the pH of the effluent, and any precipitate collecting on the liner.

Checklist 4.4.1A and B shall be used to document the inspection of the vertical and sidewall tunnel drains respectively.

4.4.2 Sidewall Drains in Access Shaft

A series of 3-foot-long horizontal relief drains are also installed in the sidewalls of the access shaft. Water drains by gravity flow from these drains to the tunnel discharge drain and then empties into Manhole No. 17. These drains shall be inspected to determine the estimated flow rate, any sediment content, and any precipitate collecting on the liner.

Checklist 4.4.2 shall be used to document the inspection of the sidewall drains in the access shaft.

4.4.3 Tunnel Discharge Drain

Groundwater from the access shaft and the tunnel flows along the gutter located on the south side of the tunnel invert to the discharge drain located at Station 9+10. Drainage inspection inside the tunnel shall include observation of the tunnel floor and removal of any debris that may restrict flow. The sump pit at the discharge drain shall be inspected and cleaned as required.

A complete drainage facility inspection shall include observing Manhole No. 17 located downslope of the cylinder pile wall. This drain shall be evaluated to assure that it functions properly, and to estimate the flow rate of the discharge.

Checklist 4.4.3 is included on checklist 4.4.2, and shall be used to document the inspection of the tunnel drain facilities.

5. Areas Above and Below the Cylinder Pile Wall

There are a number of facilities and structures above and below the Cylinder Pile Wall that affect the overall project performance, and they shall be inspected on a regular basis to determine maintenance requirements. This work includes general inspection of the ground surface, inspection of retaining walls and related structures, inspection of tiedown reaction blocks, and inspection of drainage facilities.

The report and checklists shall be used to record results of the inspections of the Areas Above and Below the Cylinder Pile Wall. Table I gives the frequency of these inspections and lists the basic equipment necessary to perform them.

5.1 Ground Surface Inspection

A general inspection shall include visual observations of the slopes and adjacent areas above and below the cylinder pile wall. Cracks developing in the ground surface, paved streets, or concrete slope protection shall be examined. Offsets in street-curb alignment shall be observed. Any serious cracking or offsetting may be an indication of hillside instability and shall be carefully evaluated.

Localized soil creep and surface erosion shall also be noted. Any evidence of surface subsidence or heaving shall be noted. Selected buildings shall be inspected for new and old cracks. The crack locations, general magnitude, and orientation shall be recorded.

Table I gives the frequency of this inspection and lists the basic equipment necessary to perform it.

5.2 Retaining Walls and Related Structure Inspection

Where possible, the ramps below the Cylinder Pile Wall were constructed on grade or on structural fill buttresses. In conjunction with the buttresses, conventional L-shaped reinforced concrete retaining walls were utilized. Retaining walls Nos. 4, 5, 13, 15, 17, and 18, as shown on Figures 2, 4B, 9A, and 9C, were constructed on, and backfilled with structural fill. Retaining wall Nos. 2 and 9, as shown on Figures 2 and 4B; however, were founded on claystone bedrock.

Foundations for ramps supported on overhead or elevated structures were required for Monastery Street as is ascends over the Kilgour Street Cylinder pile wall; for

Ramp L over most of its length; and for Sixth Street where it passes over the I-471 nourthbound ramp. This structure is founded on the Buttress Fill that was constructed to stabilize the slope.

An inspection of the areas below the cylinder pile wall shall include general visual observation of the above structures and more detailed observation of the retaining

walls constructed on structural fill material. These walls may experience more movement than structures founded on rock or those founded on pile or pier supports.

The walls shall be visually inspected to determine the general condition of the concrete. The location, size, and orientation of the cracks, spalls, or offsets between segments, or other deterioration, shall be carefully noted and recorded.

Water seeps or stains on the walls or at the joints of wall segments shall be given special attention as this may indicate improper functioning of the drainage system behind the walls.

The inspector shall look for tilting of the walls and joint displacements between the top of the wall and roadway or shoulder areas. Subsidence immediately behind the walls and differential settlement occurring between the retaining walls founded in fill material, and the wingwalls or abutments founded on deep foundation, shall be noted and recorded. Roadway settlements adjacent to abutments, evidenced by cracks and displacements in concrete approach slabs shall also be noted and recorded.

Checklist 5.2 shall be used to document the inspection of the retaining walls. Table I lists the inspection frequency and the necessary basic equipment for these inspections.

5.3 Tiedown Reaction Block Inspection

Fifty tiedown anchor blocks are located near the Monastery Street - Fort Washington Way underpass as shown on Figure 9C. These tiedown blocks are designed to reduce the risk of lateral slope movements beneath Fort Washington Way, thereby minimizing the development of lateral loads on the bridge structure.

The permanent tiedown ground anchors consist of steel stranded tendons grouted at a depth and tensioned. The tendon head is covered with non-shrinking epoxy mortar and is therefore inaccessible. The anchor blocks are constructed flush with the ground surface with adjacent areas covered with concrete medians or concrete slope protection.

A general inspection shall be performed for each anchor block as well as the slopes and adjacent areas surrounding the blocks. Each anchor block shall be carefully examined to determine the location of cracks, spalls, or other deterioration. The integrity of the epoxy coating that surrounds the tendon head shall also be examined. Any evidence of water intrusion or deterioration shall be noted and recommendations for repair shall be made since this could lead to corrosion of the anchor head and possible loss of load. The expansion joints that surround the anchor blocks shall be examined for offsets or displacements. Elevation and longitudinal offsets between the anchor block surface and the adjacent concrete may indicate loss of tendon load or downslope hillside movements.

The inspector shall note any localized subsidence or settlements of the anchor blocks or surrounding areas particular emphasis shall be place on the blocks that overlie abandoned and existing sewer pipes as shown on Figure 9C.

Checklist 5.3 shall be used to document the inspection of the tiedown reaction blocks and adjacent areas. Table I lists the inspection frequency and the necessary basic equipment for these inspections.

5.4 Drainage Facilities Inspection

Drainage inlets including catch basins, paved gutters, and drainage ditches located below and above the cylinder pile wall shall be maintained free of debris to prevent ponding water and to assure proper drainage.

Several manholes above and below the cylinder pile wall shall be emphasized during inspection. Manhole Nos. 2, 3, 4, 5, 6, 13, and 15 are located immediately behind the cylinder pile wall. Due to the high tendon loads applied to the wall, the soil in this area is relatively highly stressed. Consequently, it is important to frequently make a structural inspection of each manhole and drainage pipe for evidence of concrete cracking and spalling; see Figures 9A, 9B, and 9C for the drainage plan. Soil near Manholes Nos. 27, 28, and 29, shown adjacent to the surcharge tiedown reaction blocks, may also be similarly stressed. These manholes and drainage pipes shall also be frequently inspected. It is essential that all of these manholes and those below the wall, including Nos. 7, 9, and 14, be kept free of debris and sediment. Surface runoff from drainage ditches located below the cylinder pile wall may enter Manhole Nos. 7 and 9. Therefore, it is essential that these two manholes in particular, be frequently inspected and maintained.

The drainage inspection shall not be limited to these specific locations. There are many ground level catch basins, catch basins associated with overhead structures, and underdrains that are not indicated in the figures or specifically addressed. All of these drainage facilities shall be properly maintained to minimize potential problems. The inspector shall include problem areas in the technical report recommendations section.

Checklist 5.4 shall be used to document the inspection of specific drainage facilities in the areas above and below the Cylinder Pile Wall. Table I lists the inspection frequency and the necessary basic equipment for these inspections.

6. River Flood Inspection

Local storm drainage and surface runoff from the Mt. Adams area flows toward the Ohio River located just south of the project site. During periods of river flooding, the higher river levels can cause water to backup into the local storm drainage systems. River Flood Stage for the Cincinnati area is reported to be at a river depth of 52 feet or elevation 482 feet. The time duration of this water level is generally considered to be one to two weeks maximum.

Flooding of the Ohio River and the resulting backup in the local storm drainage systems could cause flooding of the Anchorage Tunnel. This could occur as a result of water backing up through the tunnel drain that is connected to the local storm drainage system. At the same time, additional groundwater inflow from the internal drains will accumulate in the tunnel. As noted in Part II, Section 4.4.3, groundwater entering the tunnel flows into a discharge drain that empties into Manhole No. 17, as shown on Figure 9B. This manhole has a sluice gate that can be closed during river flooding to prevent backwater from inundating the tunnel. The invert elevation of the sluice gate is 486 feet, or 4 feet above the Flood Stage. Closing the sluice gate also prevents discharge of the water flowing into the tunnel from crown and sidewall drains. Depending upon the rate of inflow and how long the sluice gate is closed, the normal inflow could pond and cause flooding in the tunnel. The following subsections describe criteria for closing the sluice gate and procedures for post-flood tunnel inspections.

6.1 Sluice Gate Operation

The sluice gate is operated from the ground surface at Manhole No. 17 using a removeable T-handle Wrench. The wrench is inserted into a stem that rises from the sluice gate to a floor box built into the reinforced concrete manhole cover, as shown on Figure 16.

This gate shall be closed during flood periods to prevent backwaters from entering the tunnel. Based upon the elevation differences in flood stage and invert levels, and assuming some potential backup into the storm sewer system, the gate shall be closed when the Ohio River reaches the 52-foot Flood Stage.

Estimates based on field data indicate that during normal rainfall periods the groundwater infiltration rate into the tunnel is approximately 40 gallons per hour. If the sluice gate is closed, the depth of water likely to pond in the tunnel was estimated assuming that during flooding the inflow rate is three times the above estimated value. Figure 18 shows the increase in water depth in the tunnel with time. This figure indicates that the sluice gate could be closed for up to four weeks before the water depth reaches approximately 3.3 feet at the low point of the tunnel invert. This is still approximately 2 feet below the nearby electrical receptacles located on the upslope wall of the tunnel.

Based on historical flood experience, a four week period should provide ample time for the flood waters to recede, the sluice gate to be opened, and the discharge drain to return normal operations.

If flooding occurs and the sluice gate is closed, the tunnel shall be monitored to determine the actual groundwater infiltration rate; and more importantly, to determine that the water depths do not inundate the tunnel electrical systems. If the water levels should exceed the estimated depth and submerge the grease cans and tendon hardware, a pumping program shall be developed prior to inundation of the electrical system.

6.2 Post-Flood Inspection

After the sluice gate has been opened and the tunnel permitted to drain, the tunnel shall be inspected to verify that no harmful gases are present. The electrical systems shall be checked to assure that they are functioning properly. Any rodents shall be exterminated, and sediments or debris shall be cleaned or flushed down from the area. Debris and sediments would probably not be present unless the sluice gate malfunctions.

During this initial inspection, the depth of the ponded water shall be estimated. If it is determined that water has submerged any of the grease cans or tendon hardware, inspections detailed in sections 4.3 and 4.4 shall be accomplished in the tunnel.

Grease cap removal shall begin with those suspected of being submerged.

In addition, if an Ohio River flood stage condition occurs, a complete inspection of the Buttress Fill Area, Cylinder Pile Wall, and Areas Above and Below the Cylinder Pile Wall may be required.

7. Tendon Surveillance Inspection

In the event that the cylinder pile wall or the anchorage tendon system does not perform within the established design limitations, or if the maintenance observation/inspections indicate broken tendon wires or evidence of corrosion; it may be necessary to conduct a special detailed inspection of selected tendons. This special inspection is call a Tendon Surveillance Inspection and will be accomplished under a separate contract. The consultant shall recommend any locations that require this inspection. The recommendation shall be included in the inspection report; however, if warranted, the recommendation shall be made directly to the ODOT Project Manager. Procedures for the Tendon Surveillance Inspection are located in Part IV.

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PART III
INSTRUMENTATION MONITORING AND SURVEY PROGRAM

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PART III. INSTRUMENTATION MONITORING AND SURVEY PROGRAM

1. General

For the purposes of addressing the instrumentation monitoring and survey program, the I-471 project is divided into four areas: Inclinometers; Piezometers; the Cylinder Pile Wall and Anchorage Tunnel; and Survey Data. Figures referenced in Part III of the Manual are presented Part IV.

Piezometer monitoring, the Cylinder Pile Wall and Anchorage Tunnel instrumentation monitoring, and survey collection work is shown on the Instrumentation Monitoring Schedule, Table VI. This schedule includes a series of monitoring tasks for each area, the number of instrument locations, the frequency of readings, and the format for reporting the data. The procedures for the inclinometer monitoring and reporting shall be describe in Section 2, Part III. Table VI also includes maximum allowable changes in monitoring data. Changes greater than these values may indicate new instability, inadequate performance of the stabilizing structures, or instrumentation malfunction. If a change in any of the measured values exceeds the indicated maximum allowable deviation, a detailed review shall be made of all recent instrumentation data. This data shall be analyzed by qualified personnel familiar with the original design and construction to determine the significance of the changes and make appropriate recommendations for remedial action. The base values from which instrumentation reading changes are determined was established from a final set of all data following completion of construction activities.

Throughout the I-471 project, instrumentation has been utilized to monitor the Mt. Adams hillside. Monitoring with inclinometers and piezometers began during the design phase of the project. The instrumentation program was subsequently increased during construction of the remedial measures. The instrumentation installed and the measurements collected during this phase of the project have included the following:

1) Inclinometers
2) Piezometers
3) Strain Gages
4) Pressure Cells
5) Cap Beam Railing Offset Measurements
6) EDM Cap Beam Measurements
7) Hydraulic Load Cells
8) Anchor Block Measurements
9) Surface Surveys
10) Extensometers

Rock Anchors
Tunnel Tendons
Tunnel Wall

In general, the majority of these instruments, excluding the tendon extensometers, have functioned satisfactorily during the construction phase of the project. However, since that time, additional instruments, including the strain gages, pressure cells, and tunnel extensometers, have ceased to be functional. Several of the strain gages and pressure cells have discontinued to operate. The ideal conditions required for the tunnel extensometers to be read accurately have been destroyed due to calcium and iron-oxide deposits in the tunnel environment. As a result, the following sections review the instrumentation that will continue to be monitored for the I-471 project, including inclinometers, piezometers, hydraulic load cells, anchor block measurements, surface surveys, and EDM cap beam measurements.

A formal technical report shall be prepared for permanent record and reference purposes, and to form a basis for major remedial work when required. This report must contain the results of the measurements; including written summaries for each inspection monitoring item, color photographs to supplement the written portion, completed reporting figures, and recommendations for remedial/maintenance work. Table VI identifies sample forms to be used in the reporting of information. Sample reporting figures can be found in Part IV. Electronic versions of these figures will be provided. The report shall also detail significant changes that have been discovered since the last inspection. The report shall be completed after each 12 month inspection cycle. Three copies of the report shall be submitted to the ODOT Project Manager.

Appropriate instruction manuals for each instrument used for the collection of data are included in Appendix A, Volume 2.

2. Inclinometers

Fifty three active inclinometer casings are located in the Mt. Adams area. Some of these casings have been monitored since 1975 while others were installed prior to the beginning of Part I construction in 1980. Inclinometer data are the primary method of evaluating the changes in the rate of subsurface horizontal movements and the performance of the slope stability system.

Inclinometer measurements are obtained by traversing the casing using a portable depth probe. Measurements are made using a battery powered readout; (Probe-Slope Indicator Co., model #50320; Readout-Slope Indicator Co., Model #50306, instruction manuals included in Appendix A, Volume 2).

The data obtained from the inclinometer measurements shall be reviewed by a Professional Engineer familiar with subsurface conditions and past movement rates so potential problems can be identified.

The annual monitoring report shall include the most recent time-displacement and cumulative-displacement profiles for each installation. Information is to be reported according to sample reporting figures A-2.1 and A-3.1.

2.1 Inclinometer Data Evaluation Guidelines
(Developed by Burgess and Niple Limited)

The goal of the evaluation system is to provide a forewarning of potential slope failures. Through the establishment of an evaluation system, specific inclinometer installation are categorized according to the potential for slope failure at that location. In order to more efficiently monitor an installation where the potential for slope failure exists, the frequency of inclinometer surveys and visual ground surface inspection are based on these established categories. These guidelines are intended to serve as a supplement to the normal evaluation of each installation's time-displacement and cumulative-displacement profiles using engineering judgement to assess the movements at each location.

Historical evaluation of the Mt. Adams inclinometer data has focused on the review of changes in movement between critical depth intervals, which were established by Shannon & Wilson. Developing guidelines for the categorization of installations requires that historical movement trends be evaluated along with new inclinometer survey data. For this reason, evaluation guidelines will only apply to each inclinometer's previously established critical depth intervals.

Each installation may be categorized by one of three hazard warning levels, identified as Green (or Level 1), Yellow (or Level 2), and Red (or Level 2). A brief description of each warning level is as follows:

- Green (Level 0) - No instability currently exist at this location.
- Yellow (Level 1) - a constant movement trend has continued for at least the last 18 months (A-F Series inclinometers) or 24 months (CP Series inclinometers), or a long-term movement trend is evident at this location. Continued movement trend has not resulted in slope failure.
- Red (Level 2) - The rate of downslope movement has accelerated

significantly over the last monitoring period. Slope failure may be imminent at this location.

Instead of monitoring every installation at the same frequency regardless of its movement history, assigning warning levels to each installation allows for a more efficient and effective varied monitoring schedule. Under this schedule, Level 0 installation in the A through F Series shall be surveyed once every six (6) months and Level 0 installations in the CP Series would be monitored once every twelve (12) months. Level 1 installation in the A-F Series shall be surveyed once every three (3) months and Level 1 CP Series installations shall be monitored once every six (6) months. Both the A-F Series and CP Series installation that are categorized as Level 2 shall be surveyed once every six (6) weeks.

A letter summarizing the findings of the survey for the Level 2 installations shall be sent to the ODOT Project manager after each six (6) week survey. The letter shall include the time-displacement and cumulative-displacement profiles for each inclinometer.

The criteria for categorizing installations are based on the review of historical movement trends of Mt. Adams inclinometers. A brief description of these criteria is as follows:

- Green (0): - No constant movement trends apparent over the last 18 months (A- through F-Series) or 24 months (CP-Series); and
  - Less than 0.10 in/year movement during the last survey period; and
  - No long-term movement trend is evident at this location.
- Yellow (1): - No constant movement trends apparent over the last 18 months (A- through F-Series) or 24 months (CP-Series); and
  - Less than 0.10 in/year movement during the last survey period
- Red (2): -There has been ≥0.10 in/year movement during the last survey period. (Either a Level 0 or 1 installation may jump to a Level 2 under this condition.)

The following additional criteria apply to the evaluation of inclinometer survey data when determining warning level categories:

- Warning level categories established for interim surveys apply to upslope and downslope movements, not just downslope movements.

- Both "constant" and "long-term" movement trends are used to determine whether or not an installation is categorized as Yellow (Level 1). A "constant movement trend" implies that continuous upslope or downslope movement has been recorded for each interim survey performed over the specified time period (18 or 24 months). A "long-term movement trend" allows for engineering judgment to be used when assessing whether or not a true movement trend exists over an unspecified time period.
- If an installation moves from a lower warning level category to a higher one, the installation shall be monitored at the higher category's monitoring frequency for a minimum of 12 months, or shall be monitored at the higher category's monitoring frequency until the end of the current yearly monitoring period only if it is determined at the end of the yearly monitoring period that the installation's warning level category may be changed.
- All Red (Level 2) and Yellow (Level 1) installations will be reviewed at the conclusion of each yearly monitoring period (July 31) to determine whether or not changes should be made to these installation's warning level category. The interpretation of installation movements shall be evaluated over the entire 12-month monitoring period using engineering judgment. This annual review may take into account, but is not limited to, the evaluation of movement direction, the occurrence of cyclical movements, and the evaluation of net movements occurring over the entire yearly monitoring period. The results of this annual review will determine if Red (Level 2) installations may move to Yellow (Level 1), and Yellow (Level 1) installations may move to Green (Level 0). Any changes to an installation's warning level category should be documented and justified in the annual *Review of Instrumentation Measurements*. Installations will be surveyed according to their new category's monitoring schedule at the start of the following yearly monitoring period (June + 6 Weeks).

Currently, there are thirty-three (33) inclinometers classified Level 0, nine (9) inclinometers classified Level 1, and eleven (11) inclinometers classified Level 2. Figure A-1.4 shows an Inclinometer Warning Level Site Plan.

2.2 Buttress Fill Inclinometers

Only one active inclinometer casing is located in the Buttress Fill Area (A8). This casing has been monitored since 1975. Inclinometer data is the primary method of evaluating the changes in the rate of subsurface horizontal movements and the performance of the Buttress Fill in maintaining the stability of the surrounding area.

2.3 Cylinder Pile Wall Inclinometers

There are twenty (20) inclinometer casing in the Cylinder Pile Wall (CP Series) and 4 (CP-31-1, CP-33-1, CP-90-1, and CP-90-2) located immediately behind the wall at two test sections. Measurements of these casings are the primary method of determining overall wall displacements and detecting deep foundation movements below the wall. They also give indirect information about the tendon loads.

Measurements and analyses have shown that the wall has basically stabilized. Data from future inclinometer readings shall be compared to historical readings.

2.4 Vent Shaft Inclinometers

An inclinometer casing (C-41) is located just upslope of the access and ventilation shafts. This was installed to provide a check on shaft stability and adjacent ground movements. This casing was utilized primarily during the excavation of the shafts; nevertheless, this casing shall continue to be monitored according to the guidelines give in Section 2.1.

2.5 Inclinometers in Areas Upslope and Downslope of the Cylinder Pile Wall

There are twenty-seven (27) active inclinometer casings located in areas uplsope and downslope of the cylinder pile wall (A-F Series). Data from these casings are the primary method of evaluating the changes in rate of subsurface horizontal movements and hence the general stability of the areas.

Analysis of the data from most inclinometer casings located upslope of the cylinder pile wall show either decreasing movement or no movement, indicating that the hillside is re-establishing equilibrium. Inclinometers located in the vicinity of the upper limits of "Slide A", as shown on Figure A-1.4, are showing the highest levels of incremental movement.

3. Piezometers

There are six active piezometers in the Mt. Adams area (see figure E-1, Piezometer Location Plan). These casings have been monitored since the early stages of the I-471 project. Most locations have at least a shallow and a deep standpipe. Several locations also contain a medium level standpipe. Piezometer TWP-1 has only a functioning deep standpipe. Piezometer data are the primary method of evaluating the levels groundwater in the Mt. Adams area. The piezometers shall be surveyed every three months. Results of the survey shall be reported according to sample reporting figure E-2.2

Piezometer measurements are obtained by using an electrical water level indicator (Slope Indicator Co., model #51450, instruction manual included in Appendix A, Volume 2).

The data obtained from the piezometers shall be reviewed by a Professional Engineer familiar with subsurface conditions and past water levels, so potential problems can be identified.

3.1 Buttress Fill Piezometers

Two active inclinometers remain in the vicinity of the Buttress Fill, TWP-1 and TWP-6. These are located behind the buried temporary soldier pile wall and provide information about any pore water pressure build-up in the area. They also indicate how well the underdrain system placed beneath the buttress fill is functioning.

Past data analyses indicate that water level changes from a base set greater than 5 feet may represent undesirable pore water pressure fluctuations. It is noted; however, that piezometer readings also tend to fluctuate with rainfall and may show a direct correlation with precipitation. Because of this, a change greater than 5 feet shall be an established constant change and not just an isolated periodic fluctuation.

3.2 Piezometers in Areas Upslope and Downslope of the Cylinder Pile Wall

Piezometers are being monitored in four locations upslope of the cylinder pile wall (C-3, C-4, C-6, and C-7). They provide information concerning pore water pressures of the hillside and also aid in interpreting flow from the tunnel drains.

As with piezometers located in the Buttress Fill Area, water level changes from a base set of readings greater than 5 feet may indicate significant pore pressure changes.

4. Cylinder Pile Wall and Anchorage Tunnel

In addition to the inclinometers installed in the cylinder pile wall, three additional monitoring tasks shall be performed on the anchorage tunnel and cylinder pile wall. These tasks shall be performed according to the frequency listed in Table VI. These tasks are Tendon Load Cell Measurements, Anchor Block Tape Extensometer Measurements, and EDM Targets.

The data obtained from these tasks shall be reviewed by a Professional Engineer, so potential problems can be identified. The results of the monitoring shall be included in the annual report, along with any recommendations for repair or changes to the monitoring frequency.

4.1 Hydraulic Load Cells

Hydraulic load cells (Model #K660 A 325 M, manufactured by Glotzl Fur Baumesstechnick, mbh, West Germany; distributed by Terrametrics, Inc., Information Brochure included in Appendix A, Volume 2) are located at the tunnel end of tendons CP-31 and CP-90. At these two locations, the tendon load is read directly in metric tons from a pressure gage. These are the only instruments that provide a direct reading of tendon load. A tendon load change of more than 3 percent from the base reading could be significant and may indicate upslope stability problems. Changes less than 3 percent may be expected due to the natural creep of the hillside. Measurements shall be reported according to sample reporting figure B-1

4.2 EDM Cap Beam Target Measurements

There are 74 points located along the wall and five reference points below the wall that shall be monitored with electronic distance measuring (EDM) equipment from 8 control points. This is a backup system that supplements the wall inclinometer measurements. It is used for determining single-point displacement at the ends of each cap beam segment. Figure 13 shows the location of the EDM control points and reference points.

The measurements are made by mounting the EDM instrument on a control point. A reflector prism Rod/Range Pole lowered over the cap beam railing and mounted in a socket (stainless steel angle bolted to the cap beam) fixed on either end of the camp beam. The distance from the Control Point to the reflector is then determined with the EDM instrument.

Experience indicates that distances measured with EDM equipment are affected by climatic conditions and target reflector placement. If wall deflections greater than 8 mm (0.3-inch) are measured, the readings shall be repeated, and the data reviewed by experienced personnel.

Each time the wall is monitored, the distance between Control Points and Reference points shall also be measured. Changes greater than 5 mm (0.2-inch) could indicate deviations in the positions of the Control Points or calibration changes in the instrument. Changes in Control Point to Reference Point distances that occur because of Control Point movements shall be taken into account in evaluating changes between Control Point and Cap Beam Target measurements.

EDM measurements shall be reported according to sample reporting figure B-3.

4.3 Tunnel Anchor Block Extensometer Measurements

Twenty-five anchor blocks are monitored for eccentric block movements and tunnel distortions using a tape extensometer (Slope Indicator Co., Model #518115, Instruction Manual included in Appendix A, Volume 2). Five permanent reference points including one point at each corner and one located on the bearing plate near the center of the anchor block are established (see Figure B-4.1 for locations). Similar reference points are fixed opposite the anchor block in the tunnel wall and crown.

Movements of these points up to 0.15-inch were observed during the tendon tensioning sequence. Most of this movement was likely due to seating of the grouted anchor block against excavated rock. Now that the anchor block has stabilized and the reference points in the tunnel wall and crown have been transferred from the rock surface to the concrete tunnel liner, changes in anchor block movement from the base readings are expected to be less than 0.1-inch.

Extensometer measurements shall be reported according to sample reporting figure B-3.

5. Survey Data

There are three established surveying tasks associated with the monitoring of the Mt. Adams Hillside. These tasks shall be performed according to the frequency listed in Table VI. These tasks are the Four Street Survey, Survey Line Measurements, and the Ramp P Measurements. The street survey was initially established to monitor settlement and damage to buildings and structures as part of litigation. The Survey Line Measurements have been performed throughout the I-471 monitoring program. The Ramp P measurements were established due to the findings of the visual inspection reports in the area of Ramp P.

The data obtained from these tasks shall be reviewed by a Professional Engineer, so potential problems can be identified. The results of the monitoring shall be included in the annual report, along with any recommendations for repair or changes to the monitoring frequency.

5.1 Four Street Survey

Vertical and horizontal offset measurements are determined from baselines established along Kilgour, Baum, Oregon, and Monestary Streets to points in front of existing buildings and structures (see Figure C-1 for the location of surface points). This data provides a basis for identifying the location and areas of lateral surface movements and evaluating movement rates. The surveyor shall also take annual color photographs to document the conditions of the buildings and structures and any noticeable settlement or cracking. The photographs shall be stored digitally on a computer CD, and sent to the ODOT Project Manager.

5.2 Survey Line Measurements

Five survey lines are located perpendicular to and between Baum and Kilgour Streets for the purpose of monitoring horizontal and vertical surface movements (see Figure C-3, Survey Line Plan). This data provides a basis for identifying the location and areas of lateral surface movements and evaluating movement rates.

Table VI shows that if the maximum allowable horizontal offset change from the survey measurements compared with current base readings is greater than 0.5-inch, then the data shall be reviewed by qualified personnel to determine its significance with regard to wall performance and hillside stability.

Results of the survey line measurements shall be reported according to sample reporting figures C-4.1 and C-4.1a.

5.3 Ramp P Measurements

Tape extensometer reference points and EDM target brackets have been established on the columns of Pier 7 that support Ramp L (I-471 North to U.S. 50 West). See Figure D-3 for point locations. These devices were placed to monitor and evaluate potential downslope movement in the area of Ramp P (U.S. 50 West Ramp to Eggleston Ave.).

Results of the Ramp P measurements shall be reported according to sample reporting figures D-1 and D-2.

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PART IV
FIGURES, TABLES, SAMPLE CHECKLISTS, SAMPLE INSTRUMENTATION REPORTING FIGURES, AND TENDON SURVEILLANCE PROCEDURES

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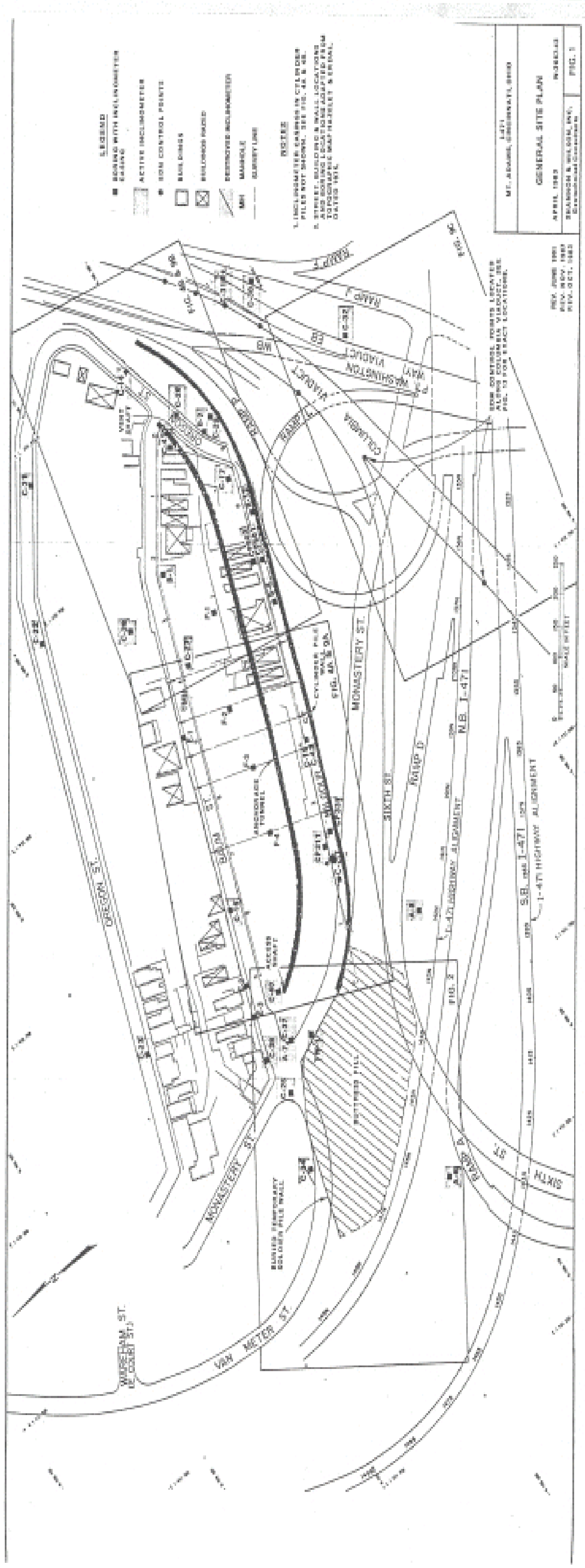
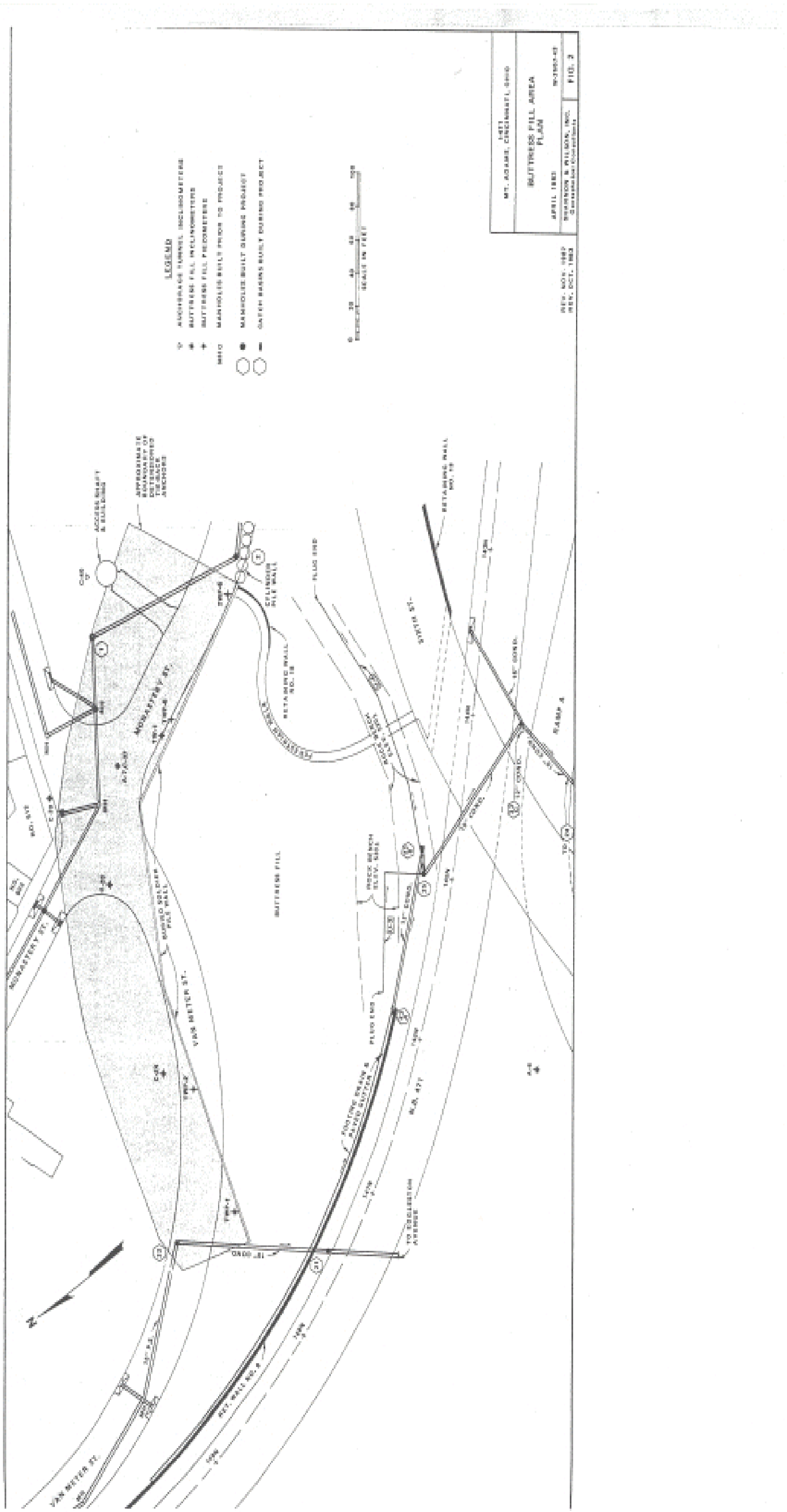
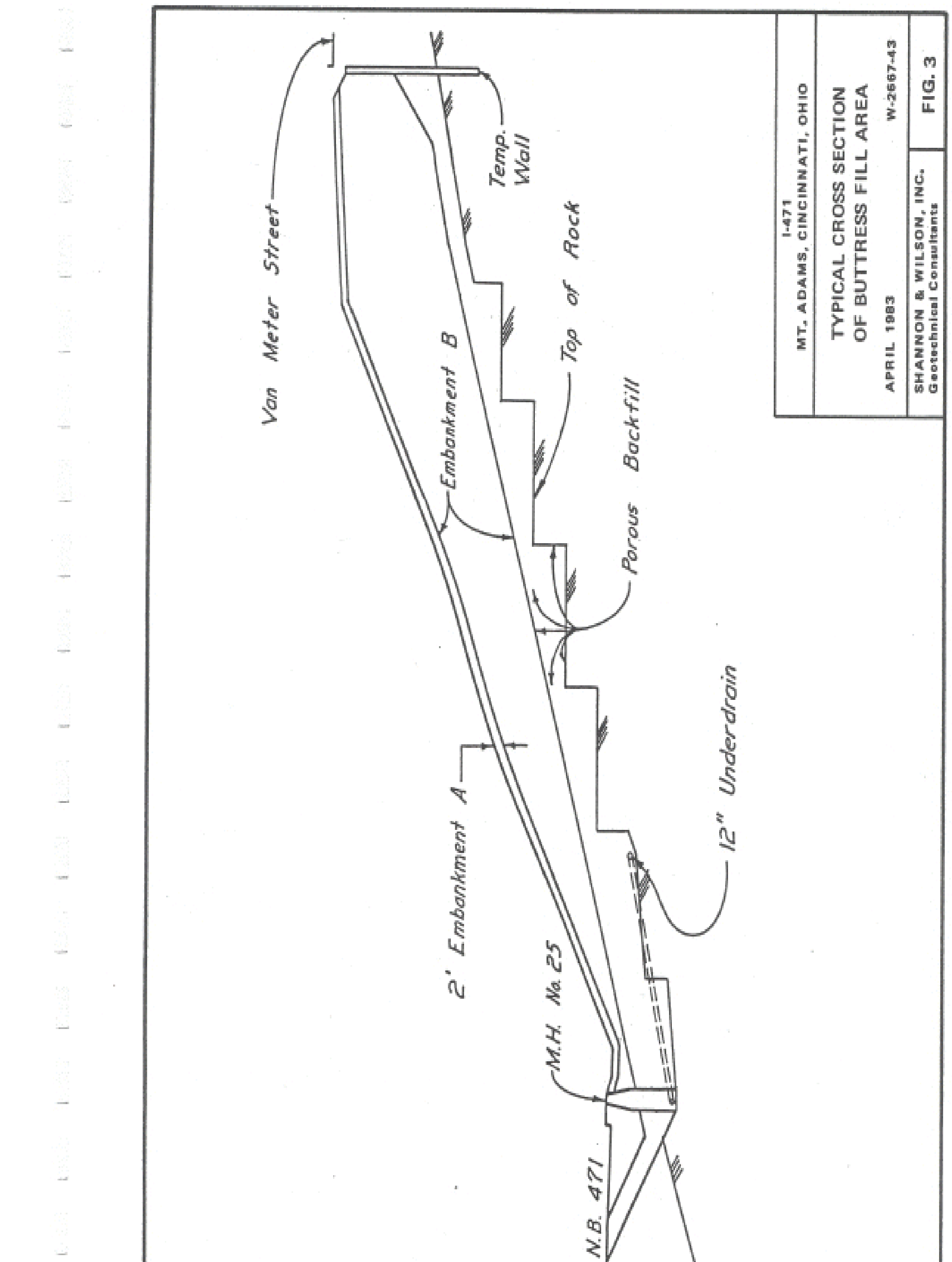
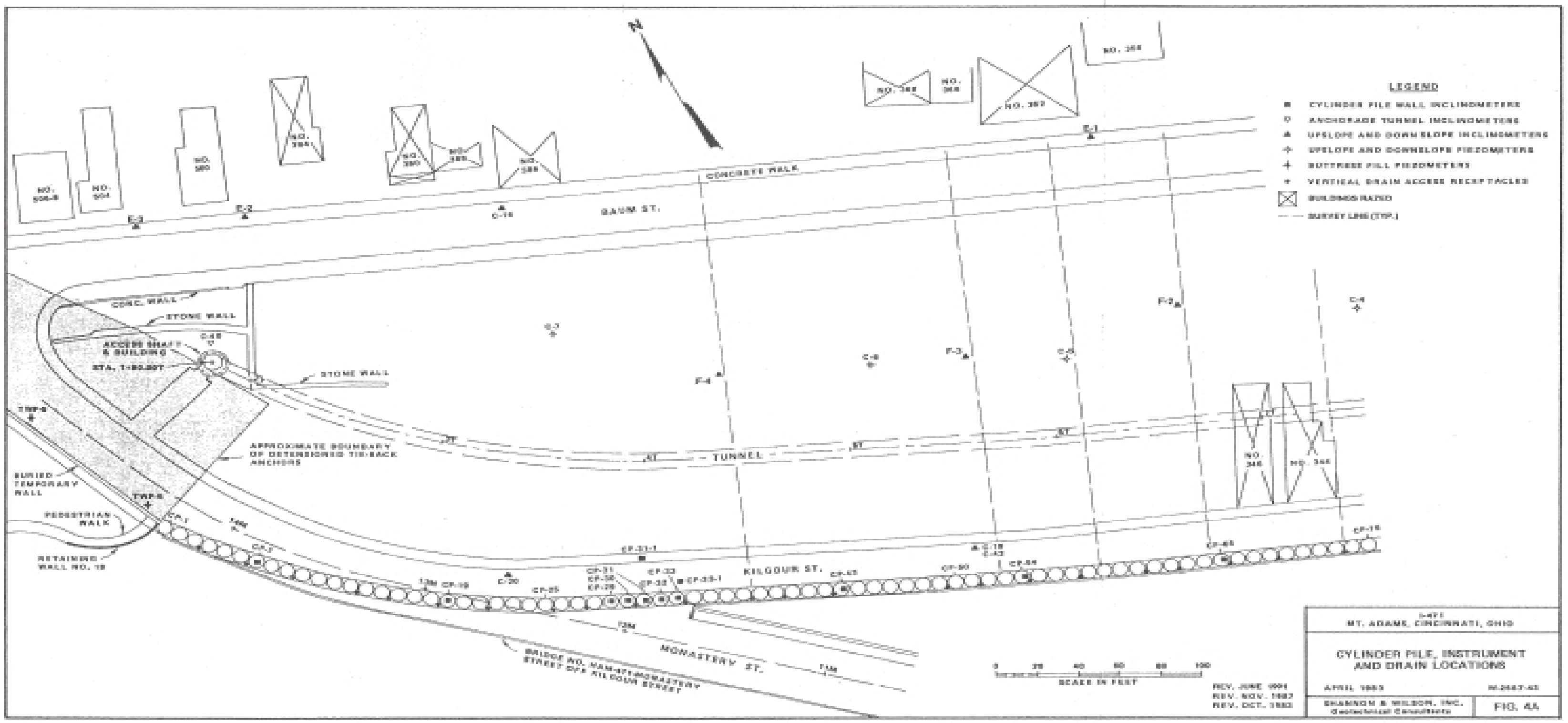
PART IV
SECTION 1: FIGURES

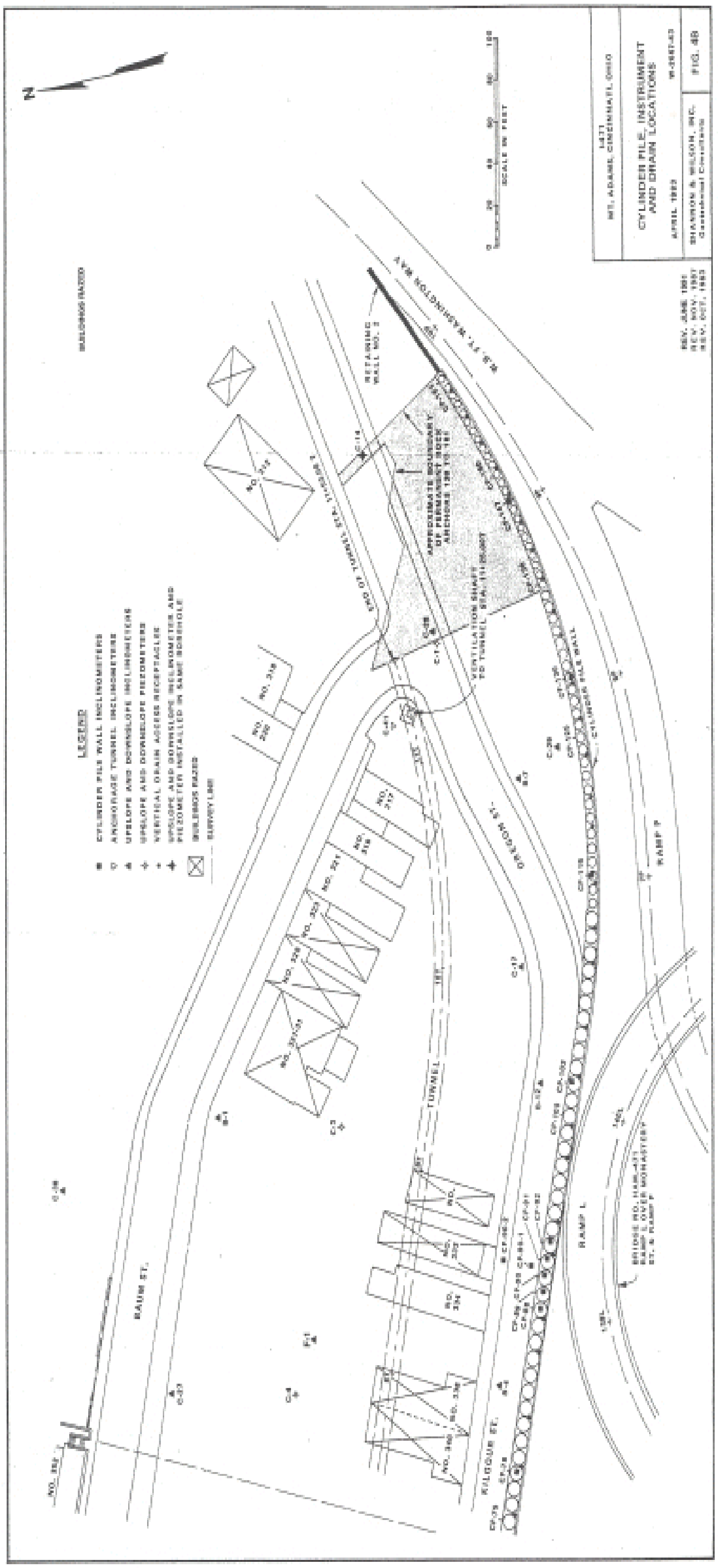


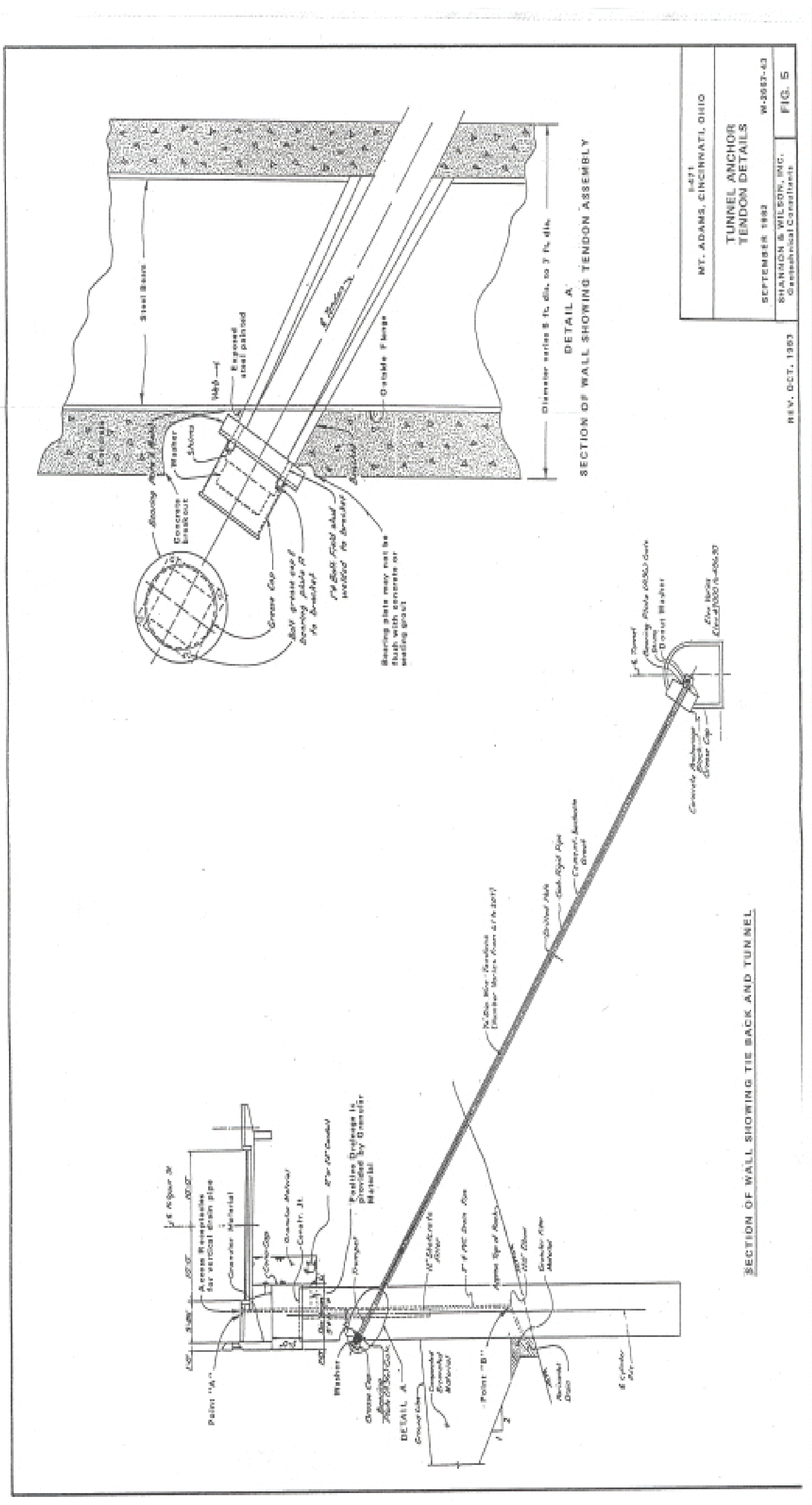
OREGON ST.
MONASTERY ST.
VAN METER ST.
SIXTH ST.
N.B. I-471
S.B. I-471
RAMP D
RAMP A
GENERAL SITE PLAN


I-471
MT. ADAMS, CINCINNATI, OHIO
BUTTRESS FILL AREA
PLAN
APRIL 1983
SHANNON & WILSON, INC.
FIG. 3


Van Meter Street
Temp. Wall
Top of Rock
Embankment B
Backfill
Porous
2' Embankment A
12" Underdrain
M.H. No. 25
N.B. 471
I-471
MT. ADAMS, CINCINNATI, OHIO
TYPICAL CROSS SECTION
OF BUTTRESS FILL AREA
APRIL 1983
W-2667-43
SHANNON & WILSON, INC.
Geotechnical Consultants
FIG. 3
FIG. 3


LEGEND
CYLINDER PILE WALL INCLINOMETERS
ANCHORAGE TUNNEL INCLINOMETERS
UPSLOPE AND DOWNSLOPE INCLINOMETERS
UPSLOPE AND DOWNSLOPE PIEZOMETERS
BUTTRESS FILL PIEZOMETERS
VERTICAL DRAIN ACCESS RECEPTACLES
BUILDINGS RAZED
SURVEY LINE (TYP.)
N
BAUM ST.
CONCRETE WALL
CONC. WALL
STONE WALL
ACCESS SHAFT & BUILDING
STA. 1+80.80T
TUNNEL
APPROXIMATE BOUNDARY OF DETENSIONED TIE-BACK ANCHORS
BURIED TEMPORARY WALL
PEDESTRIAN WALK
RETAINING WALL NO. 15
KILGOUR ST.
MONASTERY ST.
BRIDGE NO. HAM-471-MONASTERY STREET OFF KILGOUR STREET
SCALE IN FEET
REV. JUNE 1991
REV. NOV. 1987
REV. OCT. 1983
I-471
MT. ADAMS, CINCINNATI, OHIO
CYLINDER PILE, INSTRUMENT AND DRAIN LOCATIONS
APRIL 1983
SHANNON & WILSON, INC.
Geotechnical Consultants
FIG. 4A


LEGEND
CYLINDER PILE WALL INCLINOMETERS
ANCHORAGE TUNNEL INCLINOMETERS
UPSLOPE AND DOWNSLOPE INCLINOMETERS
UPSLOPE AND DOWNSLOPE PIEZOMETERS
VERTICAL DRAIN ACCESS RECEPTACLES
UPSLOPE AND DOWNSLOPE INCLINOMETER AND PIEZOMETER INSTALLED IN SAME BOREHOLE
BUILDINGS RAZED
SURVEY LINE
RAUM ST.
KILGOUR ST.
OREGON ST.
TUNNEL
RAMP L
RAMP F
CYLINDER PILE WALL
RETAINING WALL NO. 2
VENTILATION SHAFT
APPROXIMATE BOUNDARY OF PERMANENT ROCK ANCHORS
SCALE IN FEET
I-471
MT. ADAMS, CINCINNATI, OHIO
CYLINDER PILE, INSTRUMENT AND DRAIN LOCATIONS
APRIL 1983
SHANNON & WILSON, INC.
FIG. 4B



MT. ADAMS, CINCINNATI, OHIO
TUNNEL ANCHOR TENDON DETAILS
SEPTEMBER 1982
W-3657-43
SHANNON & WILSON, INC. Geotechnical Consultants
FIG. 5
REV. OCT. 1983
DETAIL A
SECTION OF WALL SHOWING TENDON ASSEMBLY
SECTION OF WALL SHOWING TIE BACK AND TUNNEL

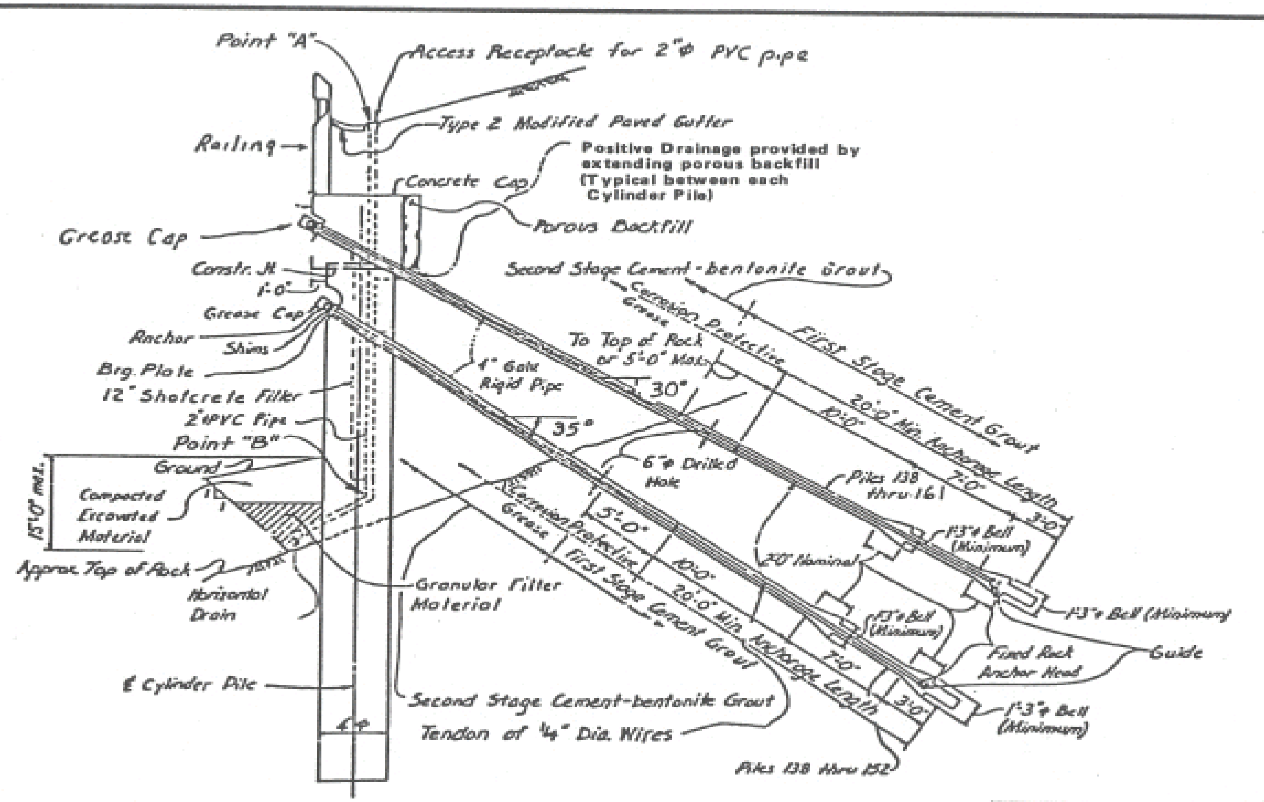


FIG. 6

I-471
MT. ADAMS, CINCINNATI, OHIO

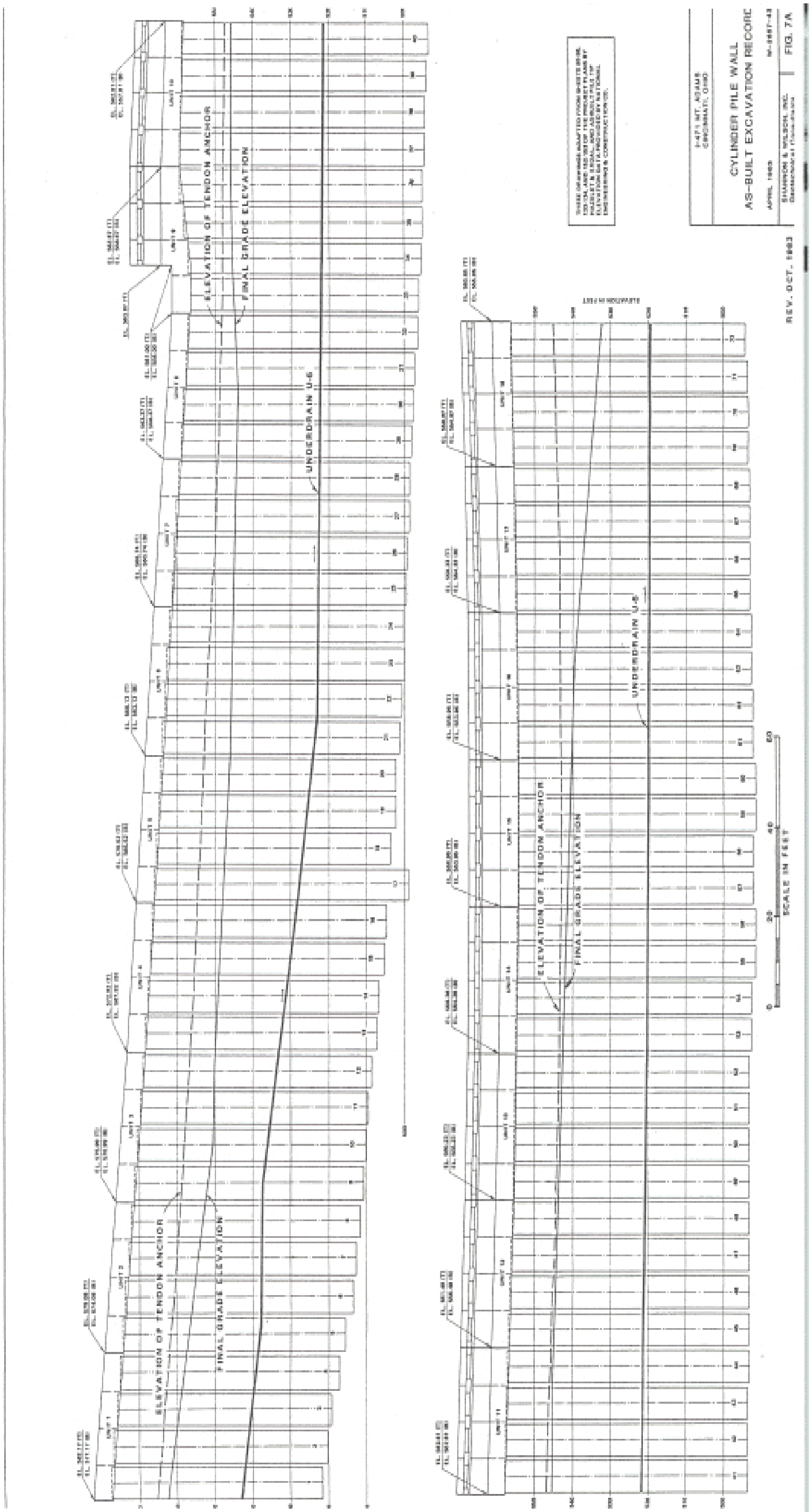
ROCK ANCHOR
TENDON DETAILS

APRIL 1983 W-2667-43

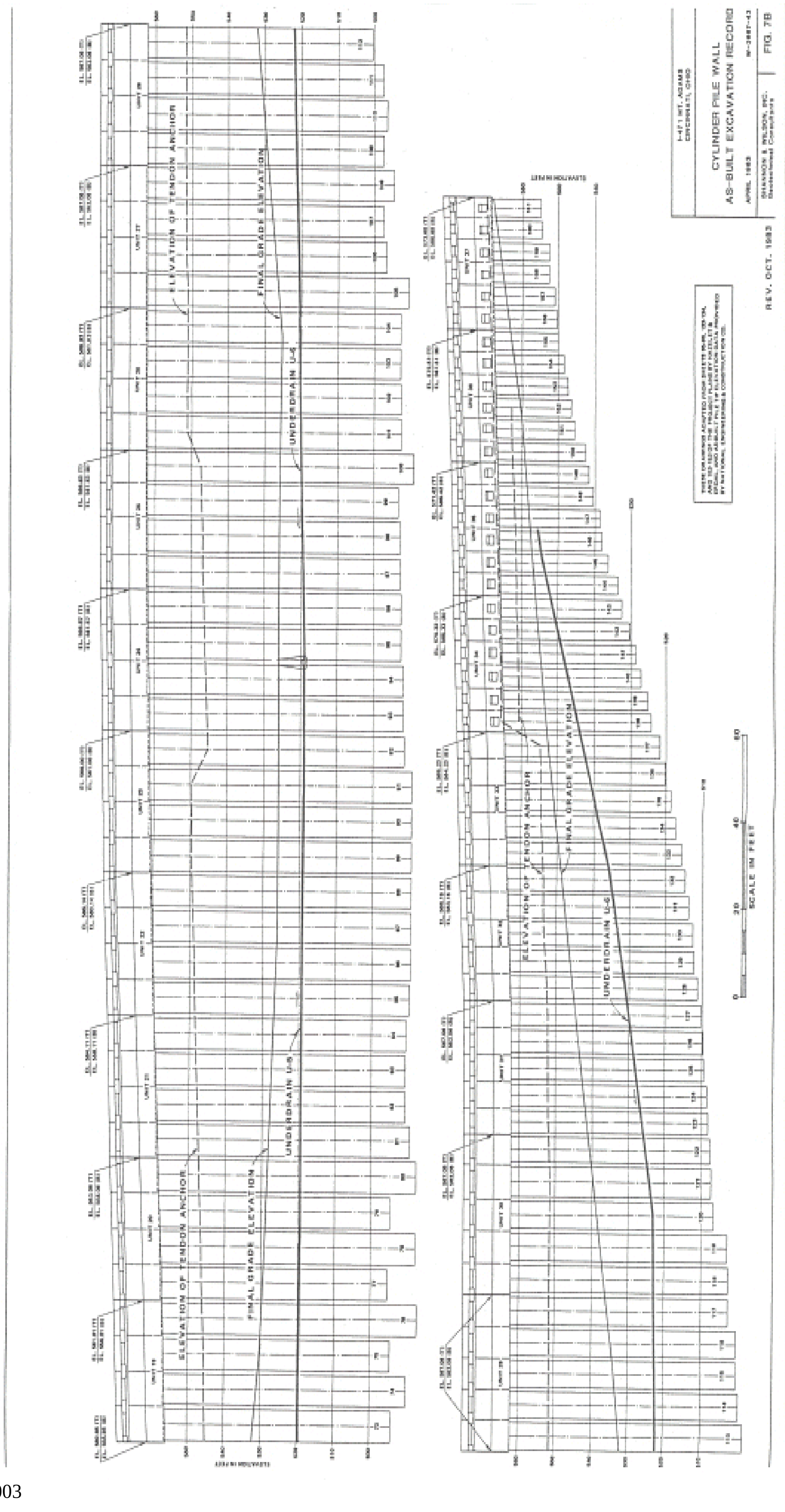
REV. NOV. 1987

SHANNON & WILSON, INC.
Geotechnical Consultants

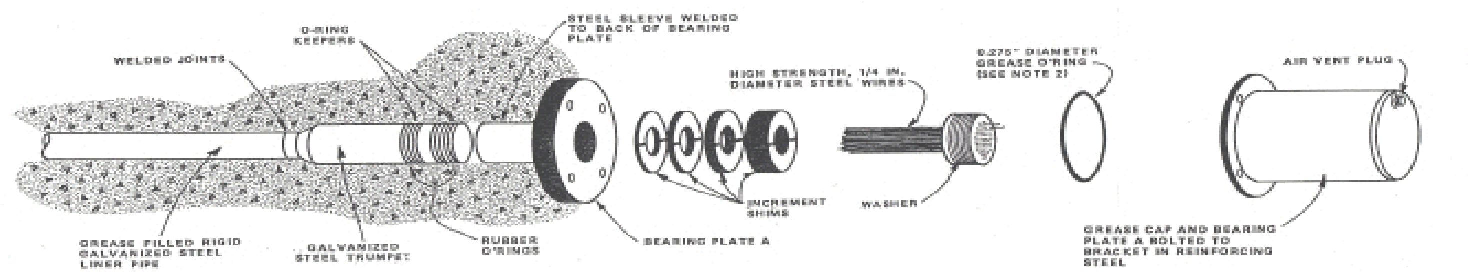
FIG. 6



ELEVATION OF TENDON ANCHOR
FINAL GRADE ELEVATION
UNDERDRAIN U-6
SCALE IN FEET
CYLINDER PILE WALL
AS-BUILT EXCAVATION RECORD
SHANNON & WILSON, INC.
FIG. 7A
REV. OCT. 1983



I-471 MT. ADAMS
CINCINNATI, OHIO
CYLINDER PILE WALL
AS-BUILT EXCAVATION RECORD
APRIL 1983
FIG. 7B
SHANNON & WILSON, INC.
Geotechnical Consultants
REV. OCT. 1983
ELEVATION OF TENDON ANCHOR
FINAL GRADE ELEVATION
UNDERDRAIN U-5
SCALE IN FEET



PILES	I.D.
1 - 122	13.875"
123 - 137	11.475"

O-RING DETAIL
(FROM SHOP DRAWINGS)

NOTES

1. SOME GREASE CAPS HAVE BRASS EXTENSOMETER FITTINGS NEAR AIR VENTS.
2. REPLACEMENT O-RINGS INSTALLED DURING THE 1987-88 INSPECTION WERE SUPPLIED BY NETHERLAND RUBBER CO., CINCINNATI, OHIO.

REV. APR. 1988

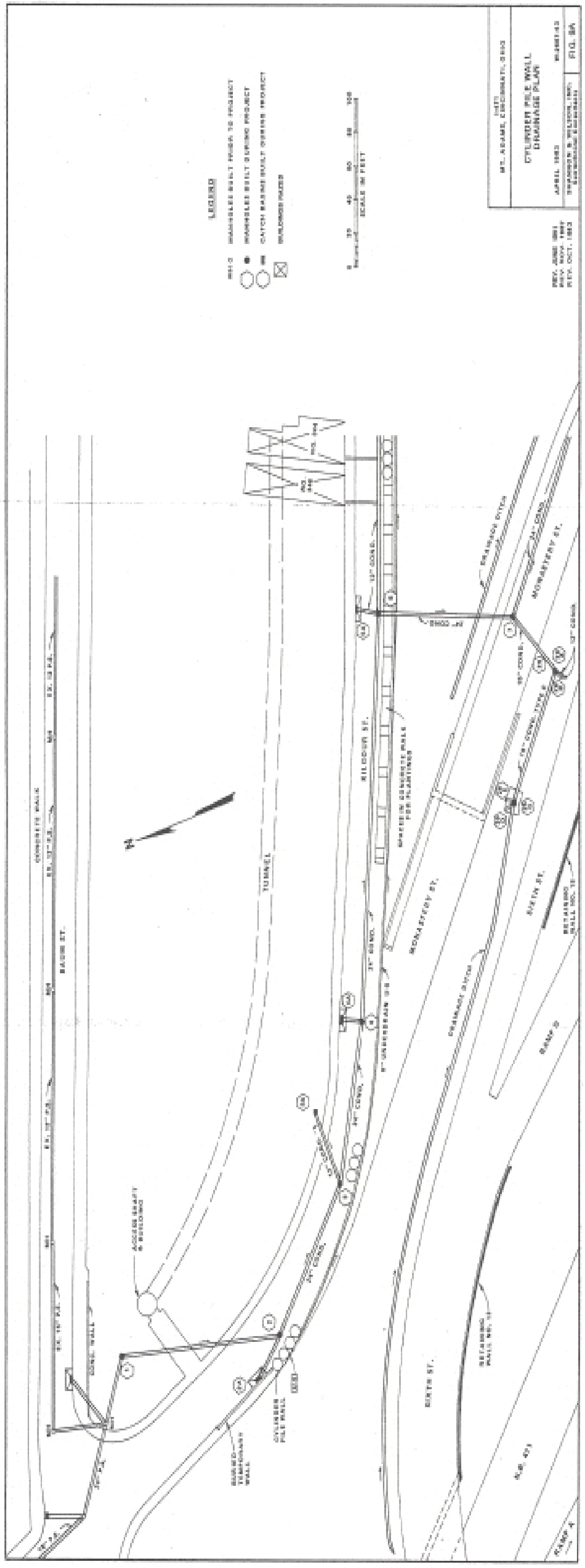
I-471
MT. ADAMS, CINCINNATI, OHIO

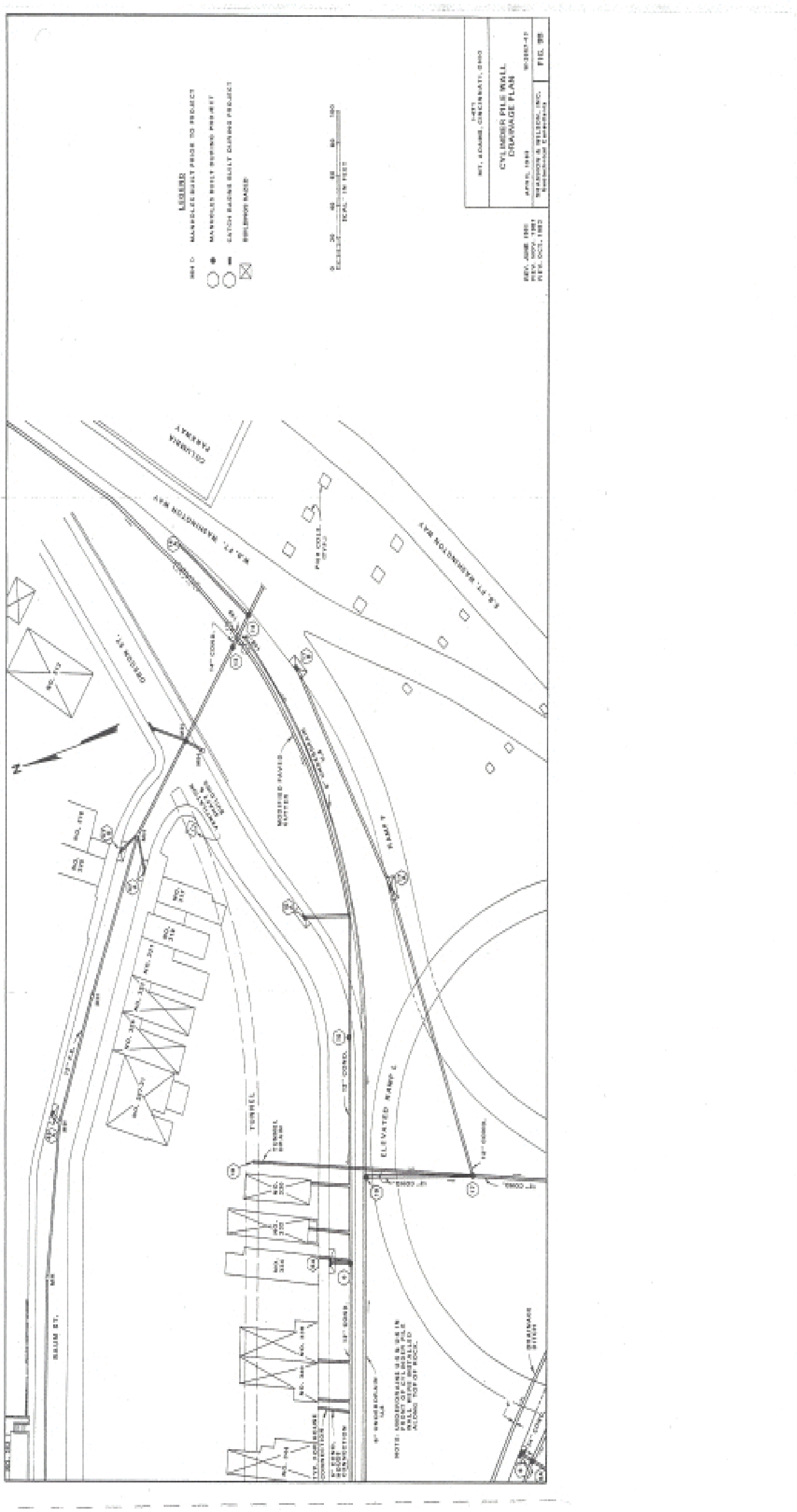
UPPER END TENDON HEAD ASSEMBLY
PILES 1 THRU 137

APRIL 1983 W-2667-43

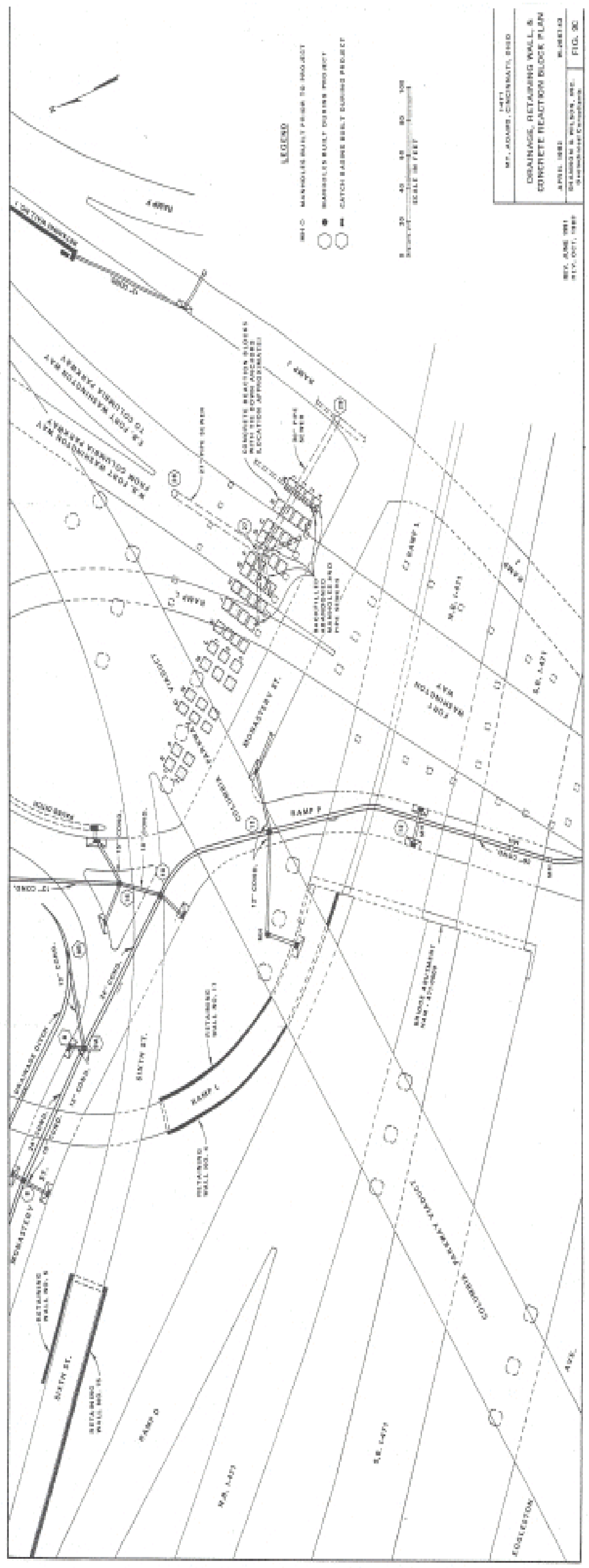
SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. 8

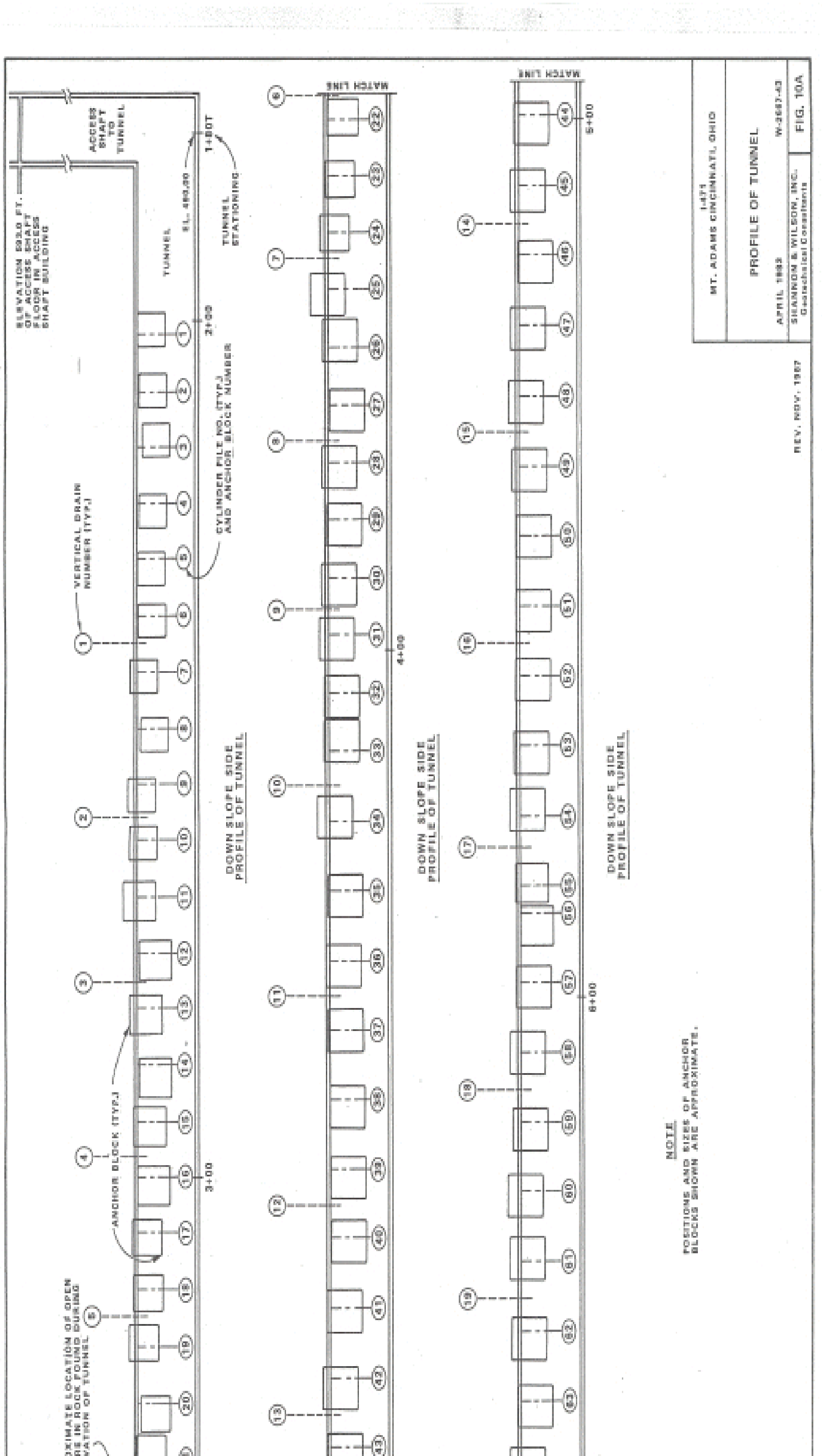

LEGEND
SCALE IN FEET
MT. ADAMS, CINCINNATI, OHIO
CYLINDER PILE WALL DRAINAGE PLAN
FIG. 9A
BAUM ST.
CONCRETE WALK
TUNNEL
KILGOUR ST.
MONASTERY ST.
SIXTH ST.
RAMP B
RAMP A
DRAINAGE DITCH
CYLINDER PILE WALL

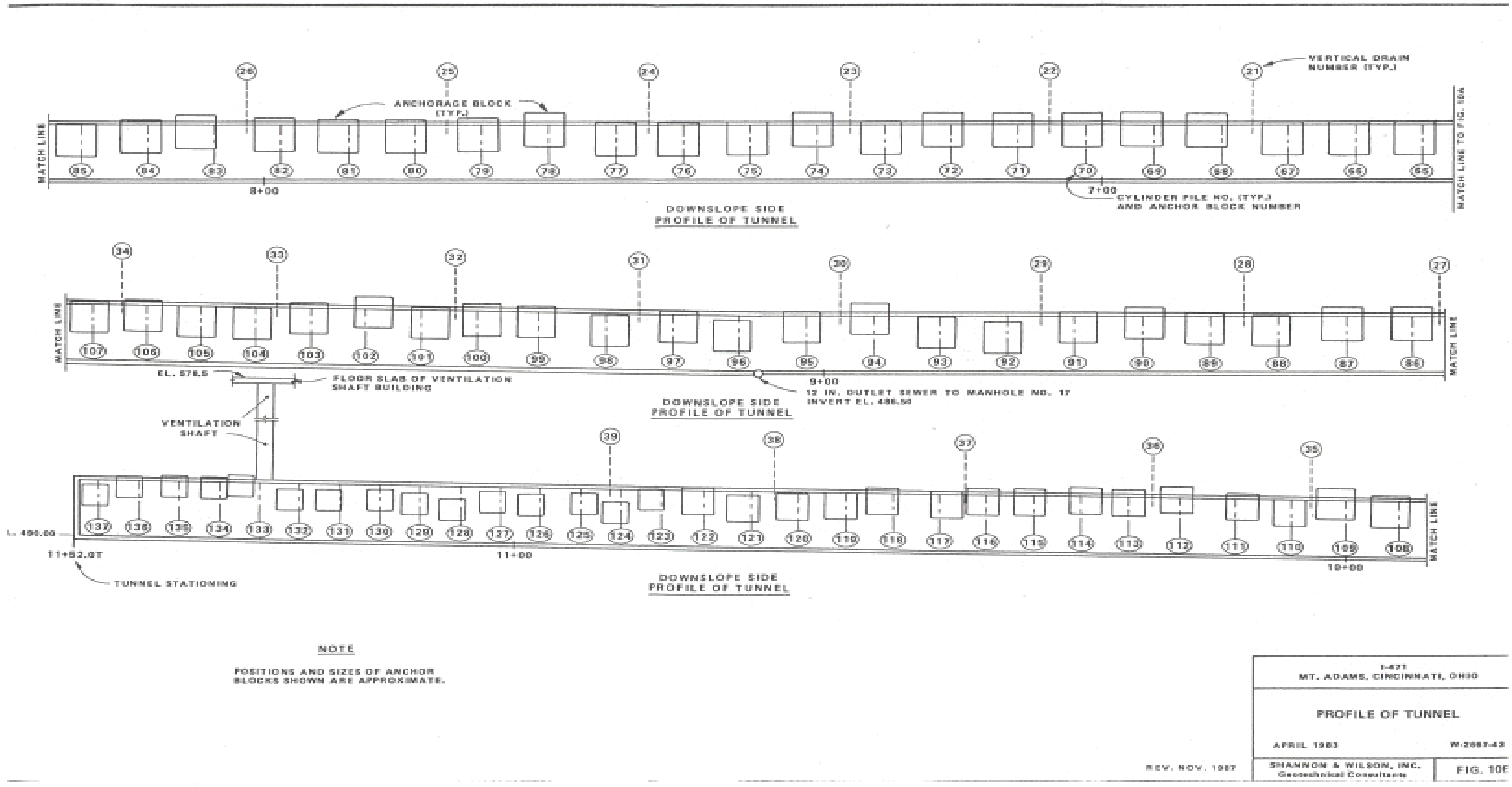


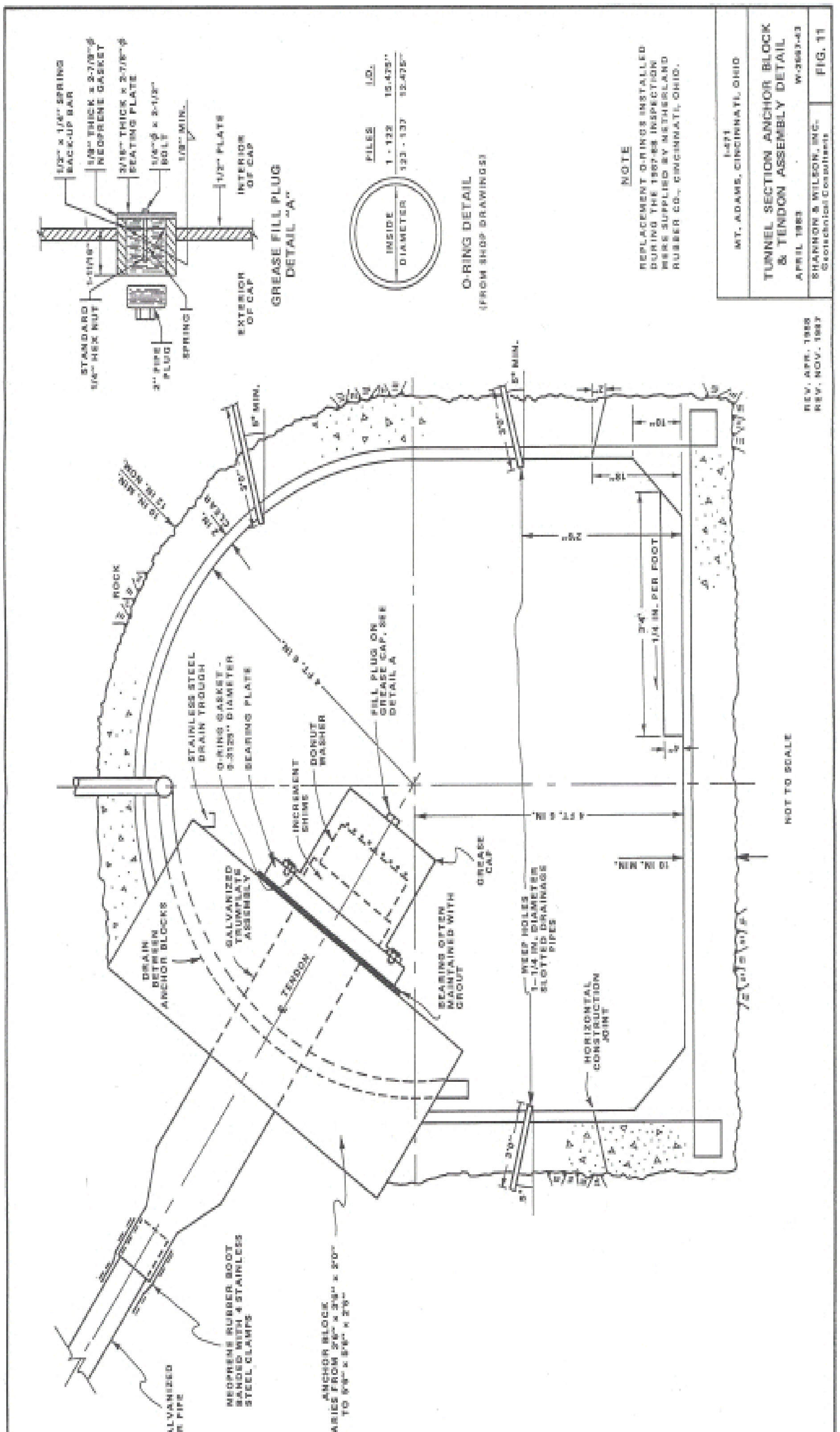
CYLINDER PILE WALL
DRAINAGE PLAN
LEGEND
SCALE IN FEET
COLUMBIA PARKWAY
BAUM ST.
TUNNEL
ELEVATED RAMP

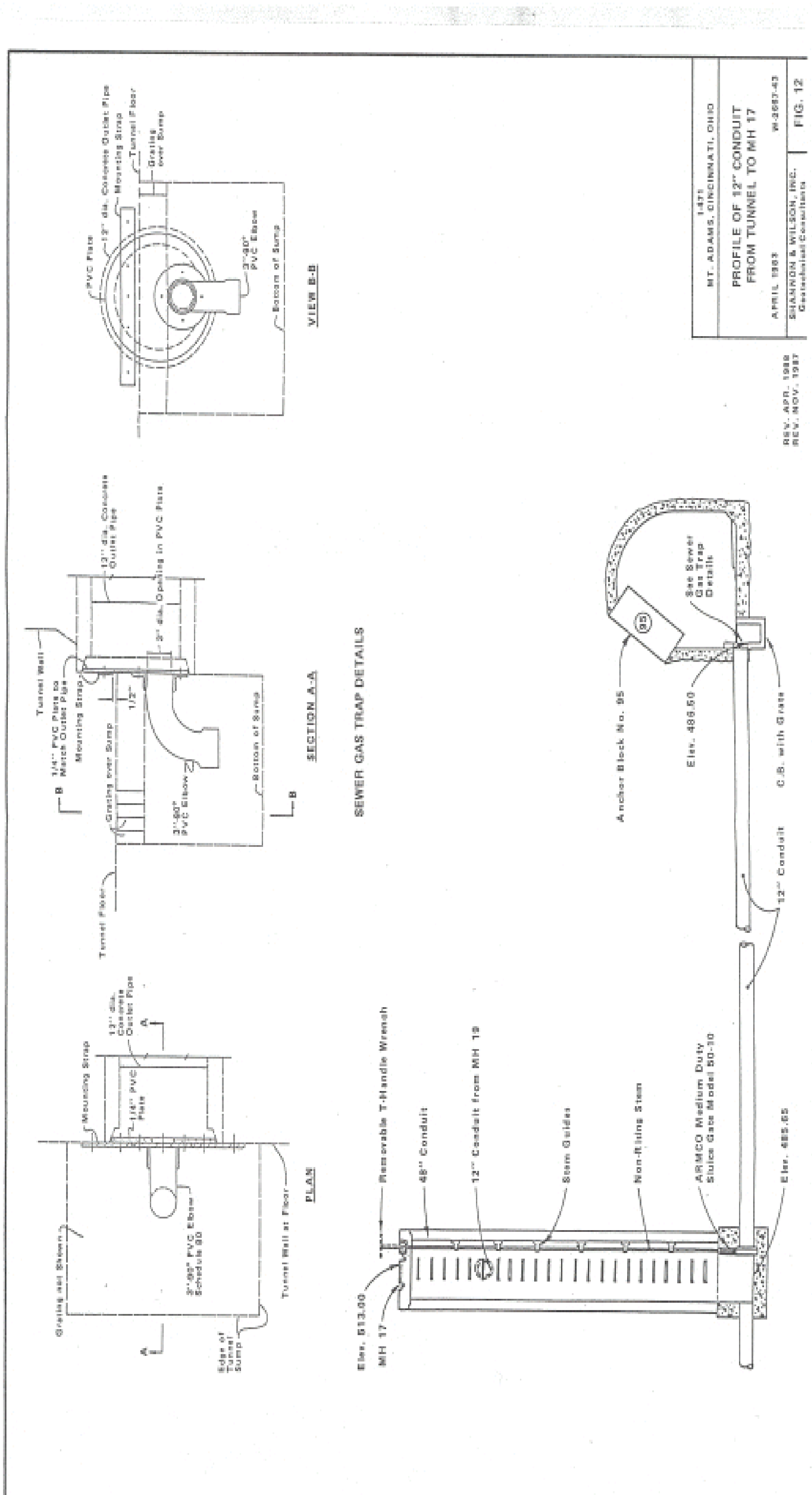


DRAINAGE, RETAINING WALL &
CONCRETE REACTION BLOCK PLAN

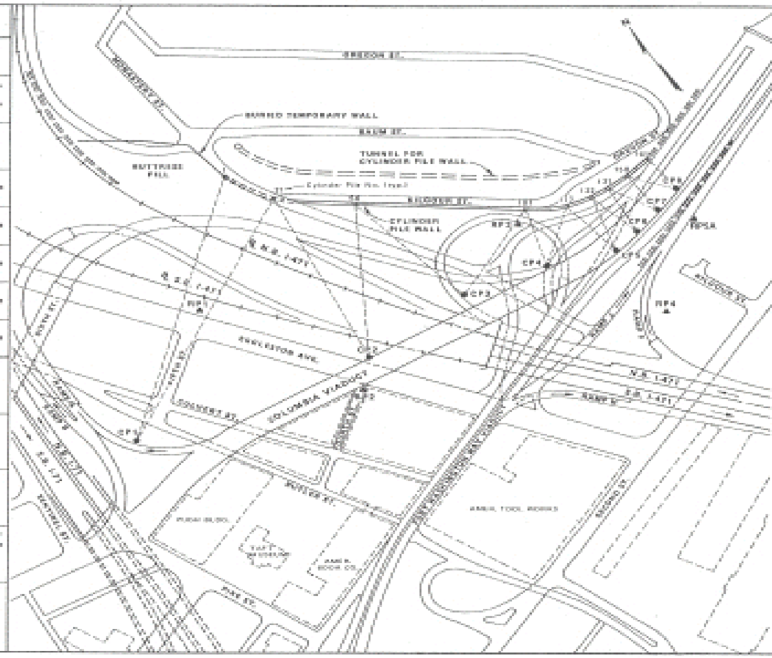

ELEVATION 593.0 FT. OF ACCESS SHAFT FLOOR IN ACCESS SHAFT BUILDING
ACCESS SHAFT TO TUNNEL
TUNNEL
EL. 460.00
TUNNEL STATIONING
1+80T
2+00
3+00
4+00
5+00
6+00
VERTICAL DRAIN NUMBER (TYP.)
CYLINDER PILE NO. (TYP.) AND ANCHOR BLOCK NUMBER
ANCHOR BLOCK (TYP.)
APPROXIMATE LOCATION OF OPEN FISSURE IN ROCK FOUND DURING EXCAVATION OF TUNNEL
DOWN SLOPE SIDE PROFILE OF TUNNEL
MATCH LINE
MATCH LINE TO FIG. 10B
NOTE
POSITIONS AND SIZES OF ANCHOR BLOCKS SHOWN ARE APPROXIMATE.
I-471
MT. ADAMS CINCINNATI, OHIO
PROFILE OF TUNNEL
APRIL 1983
SHANNON & WILSON, INC.
Geotechnical Consultants
FIG. 10A
REV. NOV. 1987


VERTICAL DRAIN NUMBER (TYP.)
ANCHORAGE BLOCK (TYP.)
MATCH LINE
MATCH LINE TO FIG. 10A
CYLINDER PILE NO. (TYP.) AND ANCHOR BLOCK NUMBER
7+00
8+00
DOWNSLOPE SIDE PROFILE OF TUNNEL
EL. 578.5
FLOOR SLAB OF VENTILATION SHAFT BUILDING
9+00
12 IN. OUTLET SEWER TO MANHOLE NO. 17 INVERT EL. 486.50
DOWNSLOPE SIDE PROFILE OF TUNNEL
VENTILATION SHAFT
11+52.07
TUNNEL STATIONING
11+00
10+00
DOWNSLOPE SIDE PROFILE OF TUNNEL
NOTE
POSITIONS AND SIZES OF ANCHOR BLOCKS SHOWN ARE APPROXIMATE.
I-471
MT. ADAMS, CINCINNATI, OHIO
PROFILE OF TUNNEL
APRIL 1983
REV. NOV. 1987
SHANNON & WILSON, INC. Geotechnical Consultants
FIG. 10B


RIGID GALVANIZED LINER PIPE
NEOPRENE RUBBER BOOT BANDED WITH 4 STAINLESS STEEL CLAMPS
ANCHOR BLOCK VARIES FROM 3'6" x 3'6" x 2'0" TO 5'6" x 5'6" x 2'6"
DRAIN BETWEEN ANCHOR BLOCKS
GALVANIZED TRUMPLATE ASSEMBLY
℄ TENDON
STAINLESS STEEL DRAIN TROUGH
O-RING GASKET - 0.3125" DIAMETER
BEARING PLATE
INCREMENT SHIMS
DONUT WASHER
FILL PLUG ON GREASE CAP, SEE DETAIL A
BEARING OFTEN MAINTAINED WITH GROUT
GREASE CAP
ROCK
10 IN. MIN. 12 IN. NOM.
2 IN. CLEAR
4 FT. 6 IN.
3'0"
5" MIN.
WEEP HOLES 1-1/4 IN. DIAMETER SLOTTED DRAINAGE PIPES
HORIZONTAL CONSTRUCTION JOINT
10 IN. MIN.
2'6"
3'4"
1/4 IN. PER FOOT
18"
10"
NOT TO SCALE
STANDARD 1/4" HEX NUT
1-11/16"
3" PIPE PLUG
SPRING
1/2" x 1/4" SPRING BACK-UP BAR
1/8" THICK x 2-7/8"ϕ NEOPRENE GASKET
3/16" THICK x 2-7/8"ϕ SEATING PLATE
1/4"ϕ x 2-1/2" BOLT
1/8" MIN.
1/2" PLATE
EXTERIOR OF CAP
INTERIOR OF CAP
GREASE FILL PLUG DETAIL "A"
INSIDE DIAMETER
FILES
I.D.
1 - 122
15.475"
123 - 137
12.475"
O-RING DETAIL (FROM SHOP DRAWINGS)
NOTE
REPLACEMENT O-RINGS INSTALLED DURING THE 1987-88 INSPECTION WERE SUPPLIED BY NETHERLAND RUBBER CO., CINCINNATI, OHIO.
REV. APR. 1988
REV. NOV. 1987
I-471
MT. ADAMS, CINCINNATI, OHIO
TUNNEL SECTION ANCHOR BLOCK & TENDON ASSEMBLY DETAIL
APRIL 1983
SHANNON & WILSON, INC. Geotechnical Consultants
FIG. 11


SEWER GAS TRAP DETAILS
PLAN
SECTION A-A
VIEW B-B
PVC Plate
12" dia. Concrete Outlet Pipe
Mounting Strap
Tunnel Floor
Grating over Sump
3"-90° PVC Elbow
Bottom of Sump
Tunnel Wall
1/4" PVC Plate to Match Outlet Pipe
2" dia. Opening in PVC Plate
Grating not Shown
3"-90° PVC Elbow Schedule 80
Tunnel Wall at Floor
Edge of Tunnel Sump
1/4" PVC Plate
Removable T-Handle Wrench
48" Conduit
12" Conduit from MH 19
Stem Guides
Non-Rising Stem
ARMCO Medium Duty Sluice Gate Model 50-30
Elev. 485.65
Elev. 513.00
MH 17
12" Conduit
C.B. with Grate
Elev. 486.50
Anchor Block No. 95
See Sewer Gas Trap Details
I-471
MT. ADAMS, CINCINNATI, OHIO
PROFILE OF 12" CONDUIT FROM TUNNEL TO MH 17
APRIL 1983
W-2687-43
SHANNON & WILSON, INC. Geotechnical Consultants
FIG. 12
REV. APR. 1988
REV. NOV. 1987

POINT	NORTH COORDINATE	EAST COORDINATE	ELEVATION	ELEVATION ℄ OF REFLECTOR	POINT DESCRIPTION
CP1	408,136.273	1,431,446.494	538.07	538.29	Control Pt. 1 is mounted on the north side of Ramp A. The point is easily accessible by foot from Ramp A or Butler St.
CP2	408,176.658	1,432,128.171	524.21	524.33	Control Pt. 2 is mounted beneath the Columbia Viaduct on the north side of Pier 8. The point is just north of Eggleston Ave. and is accessible only by ladder.
CP3	408,398.627	1,432,421.502	522.76	523.98	Control Pt. 3 is mounted along Ramp L on the outside face of parapet of Retaining Wall No. 17. The point is easily accessible by foot from Monastery St.
CP4	408,278.911	1,432,602.446	555.80	557.02	Control Pt. 4 is mounted beneath the Columbia Viaduct on the north side of Pier 13. The point is accessible only by ladder.
CP5	408,262.447	1,432,830.853	565.22	565.44	Control Pt. 5 is mounted beneath the Columbia Viaduct on the north side of Pier 14. The point is accessible only by ladder.
CP6	408,307.313	1,432,512.219	568.36	568.58	Control Pt. 6 is mounted beneath the Columbia Viaduct on the south side of Pier 15. The point is accessible only by ladder.
CP7	408,399.518	1,432,871.082	572.28	572.50	Control Pt. 7 is mounted beneath the Columbia Viaduct on the south side of Pier 16. The point is accessible only by ladder.
CP8	408,378.846	1,433,026.178	573.50	573.17	Control Pt. 8 is mounted beneath the Columbia Viaduct on the south side of Pier 17. The point is accessible only by ladder.
RP1	408,437.463	1,431,780.838	513.60	516.60	Reference Pt. 1 is located between the sidewalk and the R/W fence on the east side of Eggleston Ave. on the projected ℄ of Fifth St. The point is recessed below the ground surface, covered by a vandal proof bolted steel lid. The reflector must be mounted on a three-foot extension to be visible.
RP2	408,492.[illegible]	1,432,030.[illegible]	501.83	501.63	Reference Pt. 2 is located in the sidewalk on the south side of Fourth St., just west of the intersection of Fourth St. and Eggleston Ave. The point is recessed in the sidewalk, covered by a vandal proof bolted steel lid.
RP3	408,412.112	1,433,416.711	521.78	521.78	Reference Pt. 3 is located along the north edge of the concrete slope protection under the Ramp L bridge on the proposed ℄ of Pier 4. The point is recessed below the ground surface, covered by a vandal proof bolted steel lid.
RP4	408,395.003	1,432,606.852	535.48	535.51	Reference Pt. 4 is located at the top of a grassed slope, just south of Ramp F off N.B. I-471. The point is within the fenced off area for the ramp. The point is recessed below the ground surface, covered by a vandal proof bolted steel lid.
RP5A	408,262.443	1,433,040.788	534.88	534.65	Reference Pt. 5A is located in the grass area along the south side of Ramp J to Columbia Parkway and just inside the right-of-way fence. It is east of a vehicle access gate which is in the fence system. The point is recessed below the ground surface and covered with a steel lid.

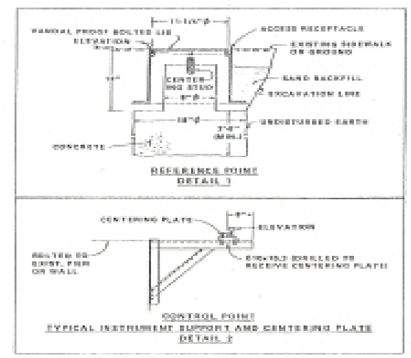


NOTES

1. ELEVATION OF REFERENCE POINTS ARE AT THE TOP OF CASTING (SEE DETAIL 1). ELEVATION OF CONTROL POINTS ARE AT THE TOP OF THE STUD IN THE CENTERING PLATE (SEE DETAIL 2).
2. FOR CONTROL POINTS ADD 0.[illegible] FT. TO ELEVATION TO DETERMINE THE HEIGHT OF INSTRUMENT, AND 0.22 FT. TO ELEVATION TO DETERMINE THE ℄ ELEVATION OF THE REFLECTOR (COLUMN 5).
3. FOR REFERENCE POINTS THE ℄ ELEVATION OF THE REFLECTOR (COLUMN 5) IS GIVEN BY:

   RP4 ELEVATION + 0.[illegible] FT

   RP5A ELEVATION + 0.[illegible] FT (SEE POINT DESCRIPTION)



0 200 400

SCALE IN FEET

REV. JUNE 1991
REV. APR. 1989
REV. NOV. 1987

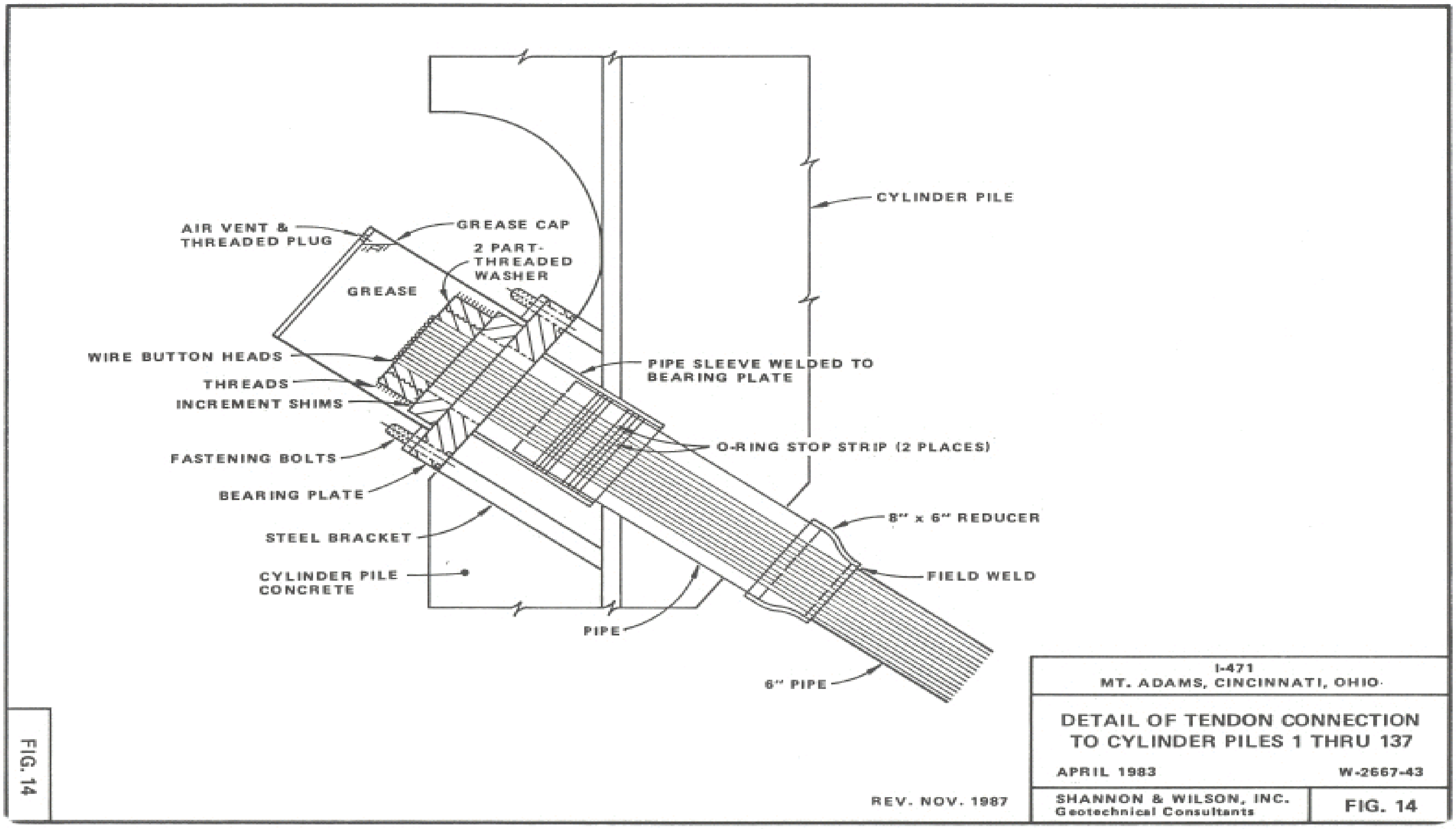
I-471
MT. ADAMS, CINCINNATI, OHIO

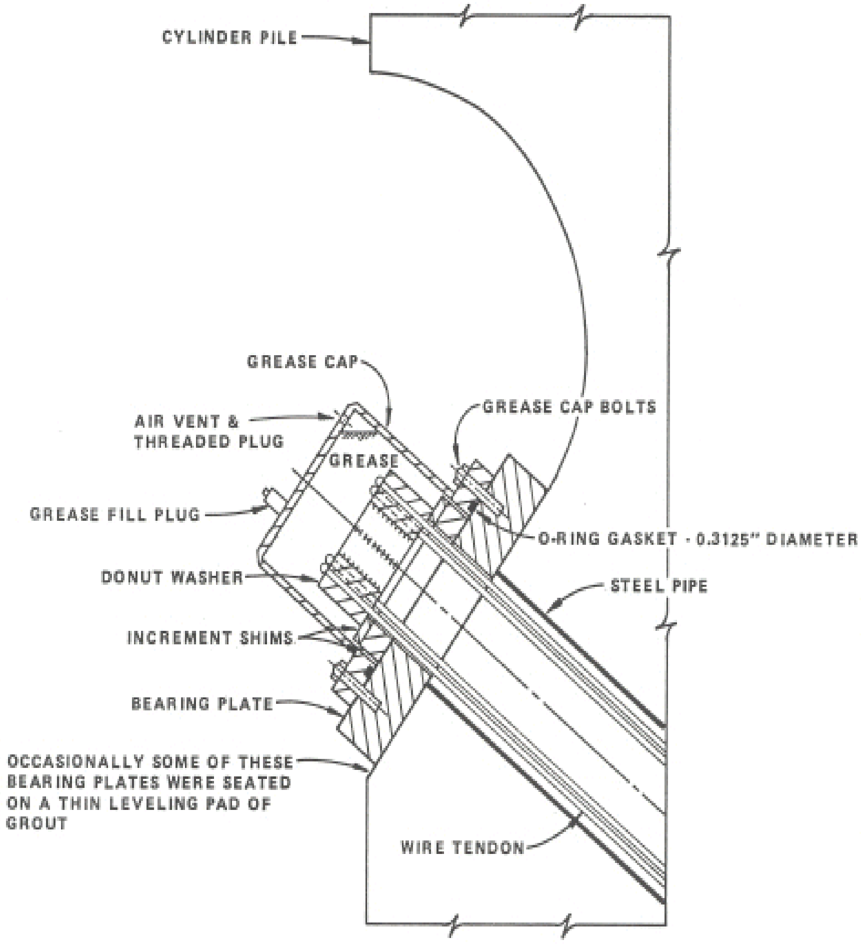
EDM CONTROL POINT & REFERENCE POINT SURVEY DATA AND SITE PLAN

APRIL 1986

DIANNON & WILSON, INC.
Geotechnical Consultants

FIG. 12


CYLINDER PILE
AIR VENT &
THREADED PLUG
GREASE CAP
2 PART-
THREADED
WASHER
GREASE
WIRE BUTTON HEADS
THREADS
INCREMENT SHIMS
PIPE SLEEVE WELDED TO
BEARING PLATE
O-RING STOP STRIP (2 PLACES)
FASTENING BOLTS
BEARING PLATE
STEEL BRACKET
8" x 6" REDUCER
FIELD WELD
CYLINDER PILE
CONCRETE
PIPE
6" PIPE
I-471
MT. ADAMS, CINCINNATI, OHIO
DETAIL OF TENDON CONNECTION
TO CYLINDER PILES 1 THRU 137
APRIL 1983
W-2667-43
REV. NOV. 1987
SHANNON & WILSON, INC.
Geotechnical Consultants
FIG. 14
FIG. 14



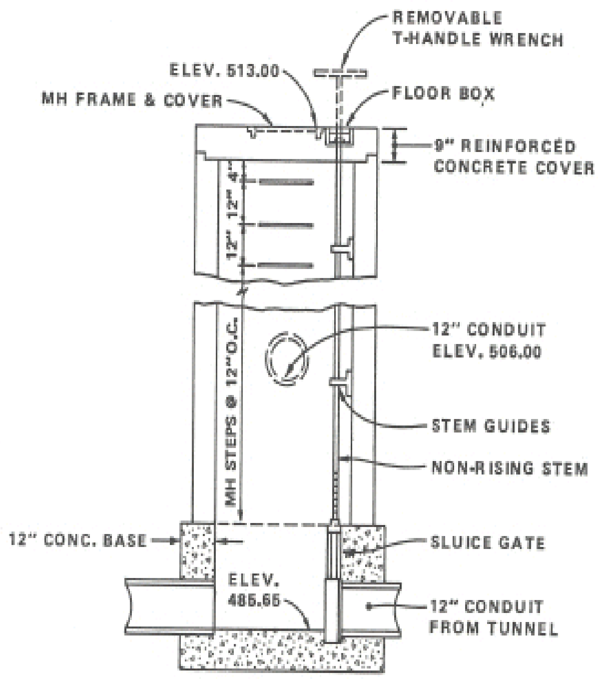
O-RING DETAIL
(FROM SHOP DRAWINGS)

NOTE

REPLACEMENT O-RINGS INSTALLED DURING THE 1987-88 INSPECTION WERE SUPPLIED BY NETHERLAND RUBBER CO., CINCINNATI, OHIO.

REV. APR. 1988
REV. NOV. 1987

I-471 MT. ADAMS, CINCINNATI, OHIO	
DETAIL OF TENDON CONNECTION TO CYLINDER PILES 138 THRU 161	
APRIL 1983	W-2667-43
SHANNON & WILSON, INC. Geotechnical Consultants	FIG. 15



MANHOLE NO. 17

NOT TO SCALE

I-471
MT. ADAMS, CINCINNATI, OHIO

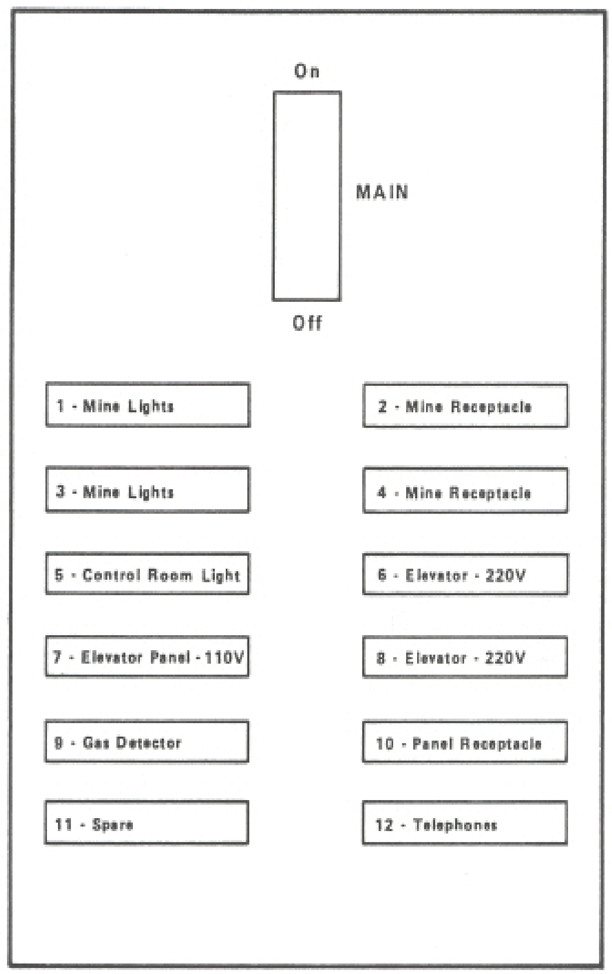
MANHOLE NO. 17

OCTOBER 1983 W-2667-43

REV. NOV. 1987

SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. 16



CIRCUIT NOS. 5, 9 AND 12 SHOULD ALWAYS BE ON

I-471
MT. ADAMS, CINCINNATI, OHIO

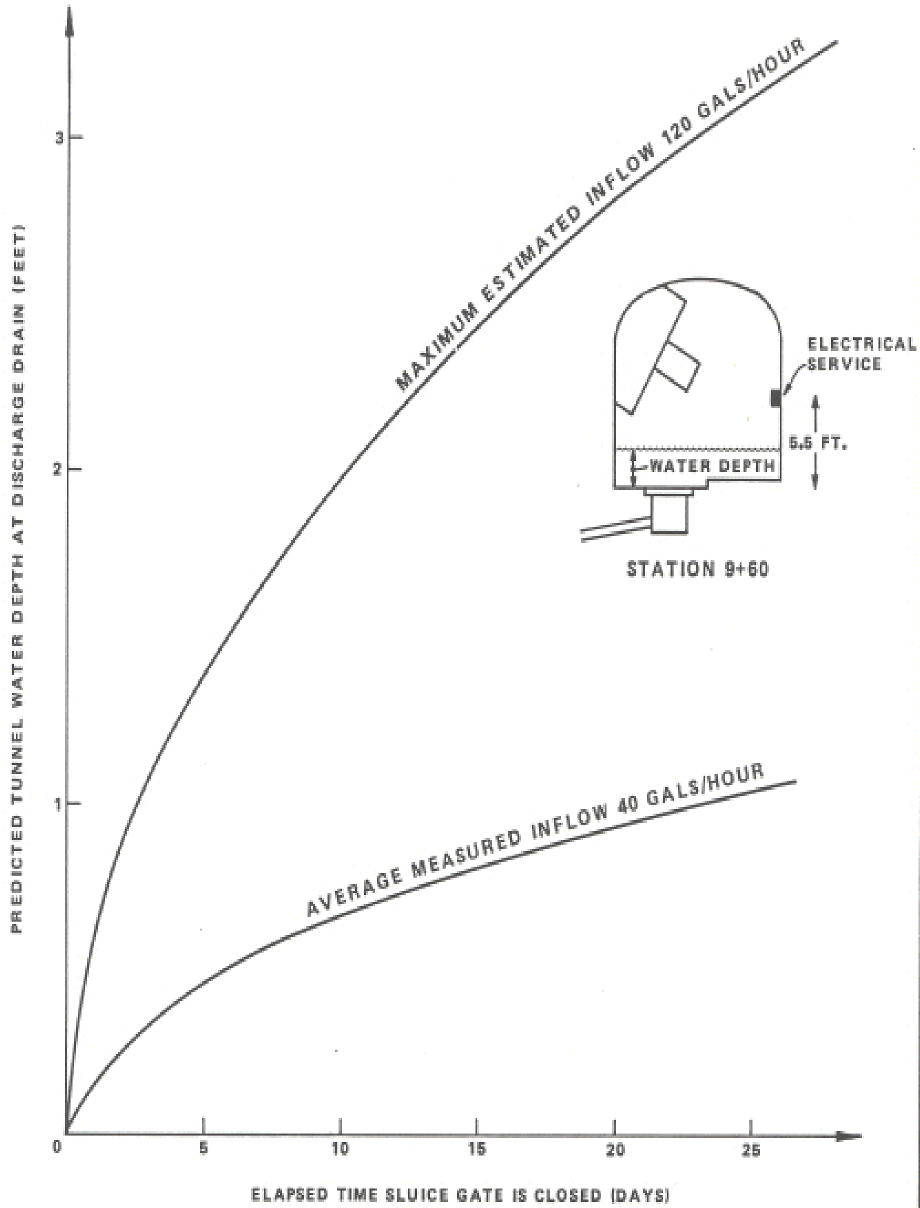
CIRCUIT BOARD DIAGRAM
ACCESS SHAFT BUILDING

NOVEMBER 1987 W-2667-53

REV. JUNE 1991

SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. 17



ASSUMPTIONS

1. AVERAGE MEASURED GROUNDWATER INFLOW RATE TO TUNNEL = 40 GAL/HR.
2. AS BUILT TUNNEL PROFILE IS AS DESIGNED.
3. EFFECTIVE TUNNEL WIDTH = 7 FEET.

REV. NOV. 1987

I-471 MT. ADAMS, CINCINNATI, OHIO	
ESTIMATED TUNNEL WATER DEPTH IF SLUICE GATE IS CLOSED	
OCTOBER 1983	W-2667-43
SHANNON & WILSON, INC. Geotechnical Consultants	FIG. 18

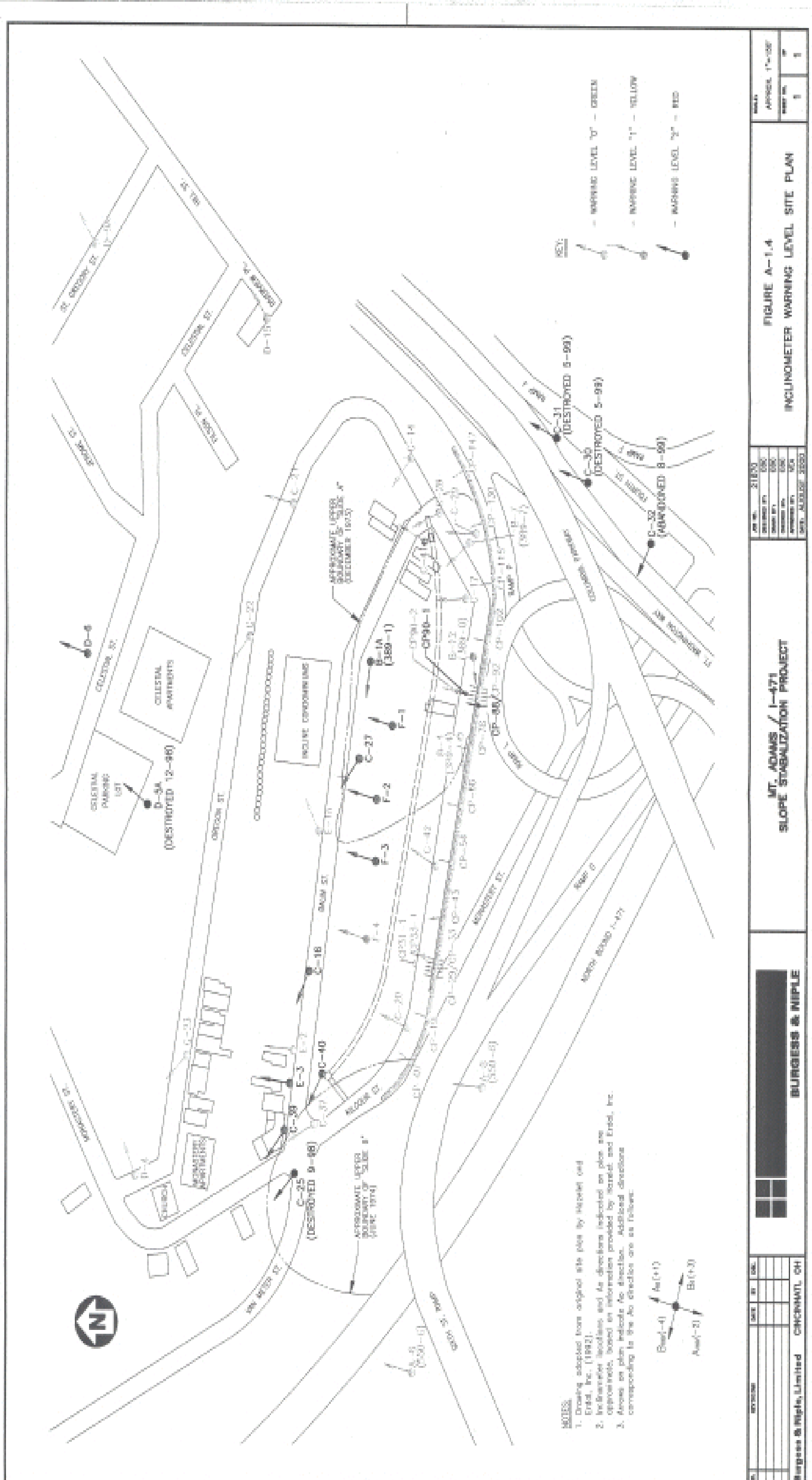


FIGURE A-1.4
INCLINOMETER WARNING LEVEL SITE PLAN
MT. ADAMS / I-471
SLOPE STABILIZATION PROJECT
BURGESS & NIPLE
Burgess & Niple, Limited
CINCINNATI, OH
KEY:
- WARNING LEVEL "0" - GREEN
- WARNING LEVEL "1" - YELLOW
- WARNING LEVEL "2" - RED
NOTES:
C-31 (DESTROYED 5-99)
C-30 (DESTROYED 5-99)
C-32 (ABANDONED 8-99)
C-25 (DESTROYED 9-98)
D-5A (DESTROYED 12-98)
D-6
C-27
C-18
C-40
C-38
E-3
F-1
F-2
F-3
B-1A (389-1)
CP90-1
CP-98
CELESTIAL APARTMENTS
CELESTIAL PARKING LOT
INCLINE CONDOMINIUMS
CELESTIAL ST.
OREGON ST.
BAUM ST.
MONASTERY ST.
VAN METER ST.
NORTH BOUND I-471

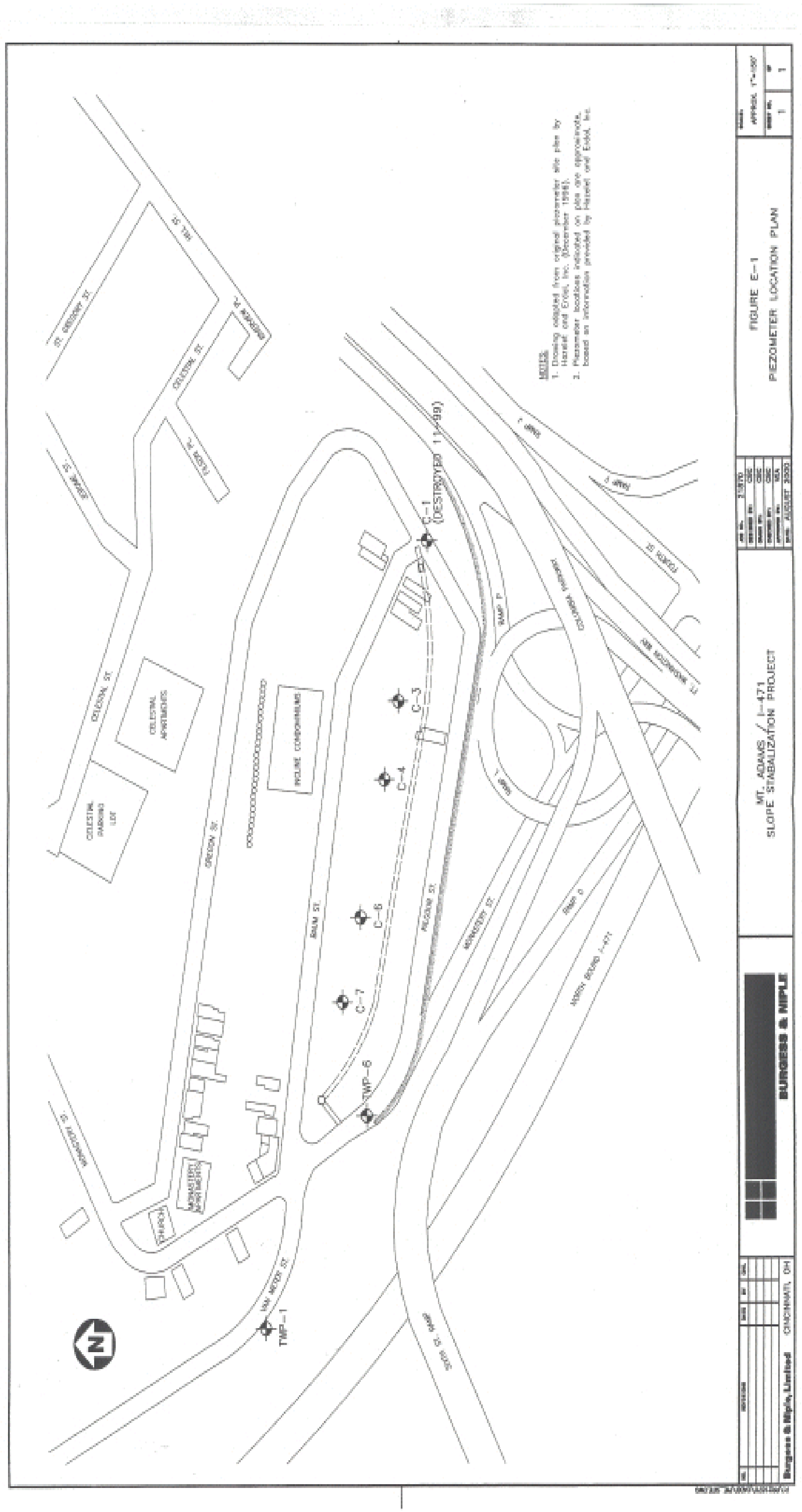


FIGURE E-1
PIEZOMETER LOCATION PLAN
MT. ADAMS / I-471
SLOPE STABILIZATION PROJECT
BURGESS & NIPLE
Burgess & Niple, Limited
CINCINNATI, OH
NOTES:
C-1
(DESTROYED 11/99)
C-3
C-4
C-6
C-7
TWP-6
TWP-1
CELESTIAL ST.
CELESTIAL APARTMENTS
CELESTIAL PARKING LOT
INCLINE CONDOMINIUMS
GREGORY ST.
BAUM ST.
CHURCH
MONASTERY APARTMENTS
MONASTERY ST.
RAMP D
NORTH BOUND I-471

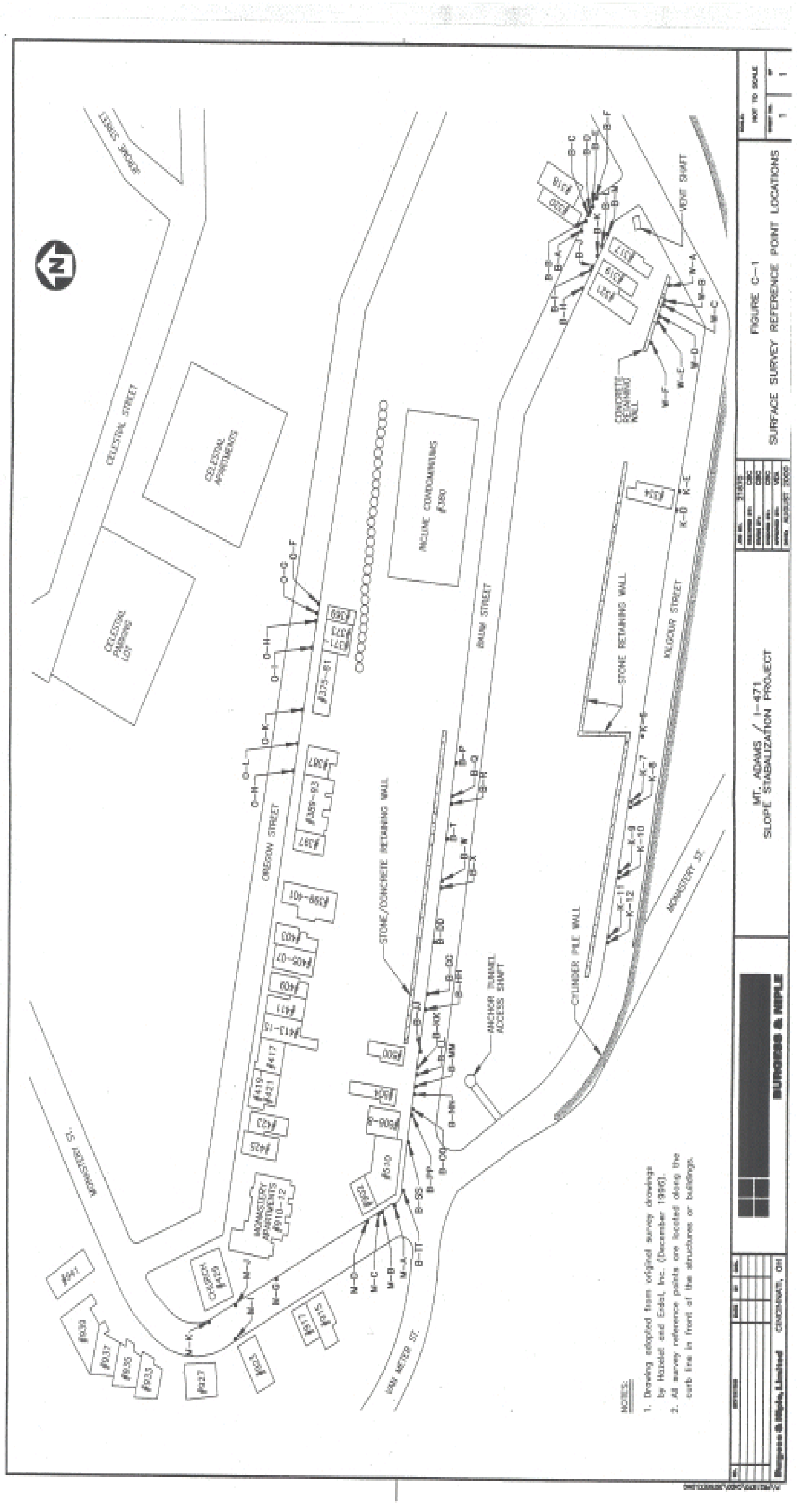


FIGURE C-1
SURFACE SURVEY REFERENCE POINT LOCATIONS
MT. ADAMS / I-471
SLOPE STABILIZATION PROJECT
NOT TO SCALE
NOTES:
1. Drawing adapted from original survey drawings by Habdal and Ezdel, Inc. (December 1996).
2. All survey reference points are located along the curb line in front of the structures or buildings.
CELESTIAL STREET
CELESTIAL APARTMENTS
CELESTIAL PARKING LOT
OREGON STREET
BAUM STREET
INCLINE CONDOMINIUMS
KILGOUR STREET
MONASTERY ST.
VAN METER ST.
MONASTERY APARTMENTS
STONE/CONCRETE RETAINING WALL
STONE RETAINING WALL
CONCRETE RETAINING WALL
CYLINDER PILE WALL
ANCHOR TUNNEL ACCESS SHAFT
VENT SHAFT
CINCINNATI, OH

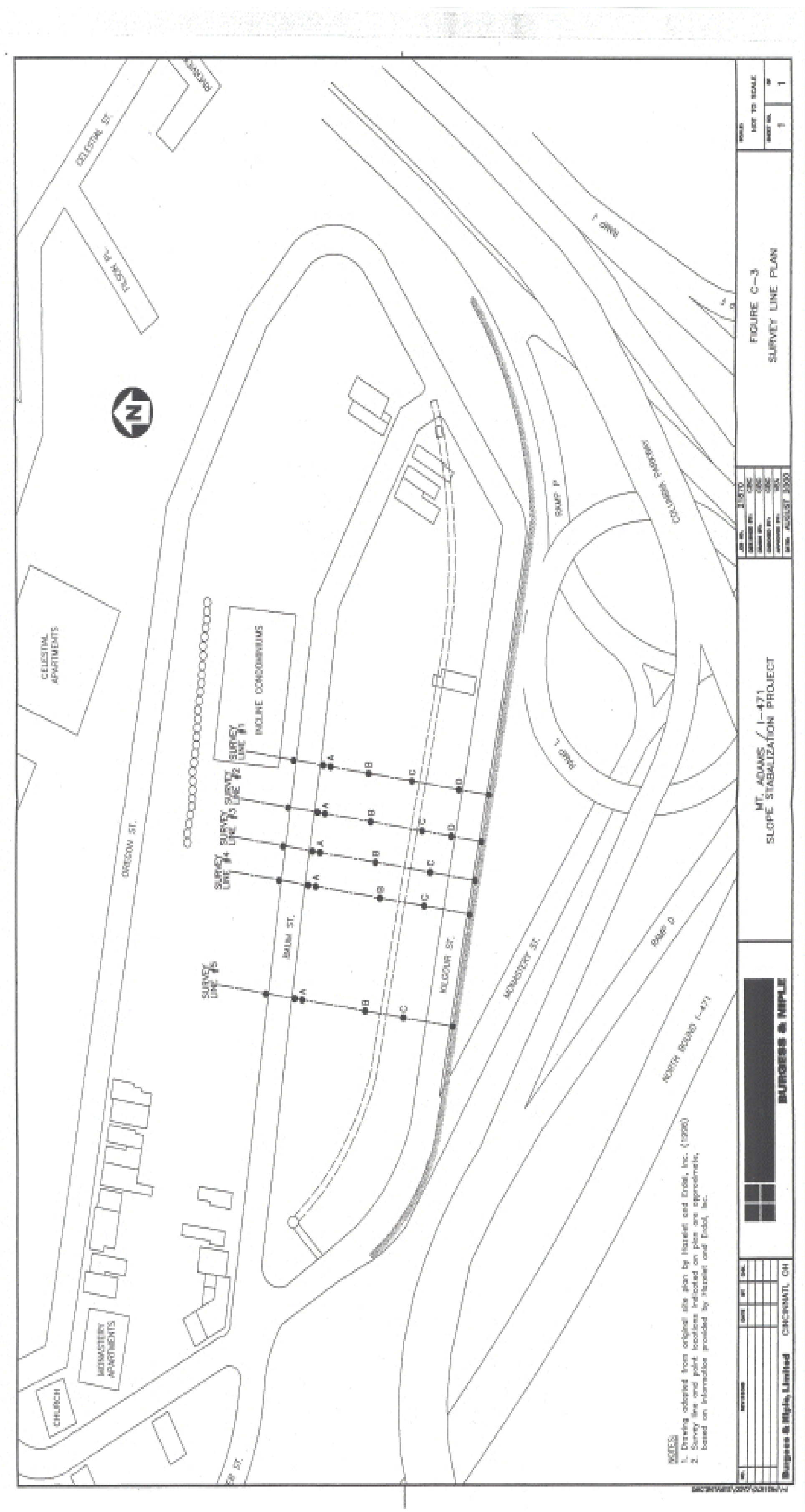
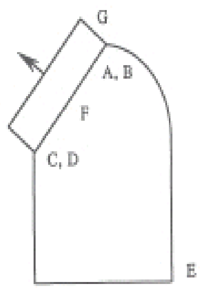
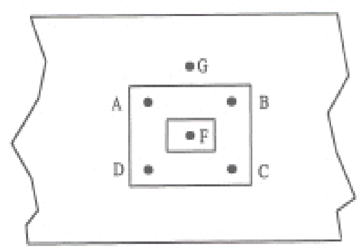


FIGURE C-3
SURVEY LINE PLAN
MT. ADAMS / I-471
SLOPE STABILIZATION PROJECT
BURGESS & NIPLE
Burgess & Niple, Limited
CINCINNATI, OH
NOT TO SCALE
NOTES:
1. Drawing adapted from original site plan by Hazelet and Erdal, Inc. (1996)
2. Survey line and point locations indicated on plan are approximate, based on information provided by Hazelet and Erdal, Inc.
CELESTIAL ST.
CELESTIAL APARTMENTS
INCLINE CONDOMINIUMS
OREGON ST.
BAUM ST.
KILGOUR ST.
MONASTERY ST.
MONASTERY APARTMENTS
CHURCH
SURVEY LINE #1
SURVEY LINE #2
SURVEY LINE #3
SURVEY LINE #4
SURVEY LINE #5
RAMP P
RAMP D
COLUMBIA PARKWAY
NORTH BOUND I-471

FIGURE B-4.1 - LOCATION OF ANCHOR BLOCK MEASUREMENT POINTS

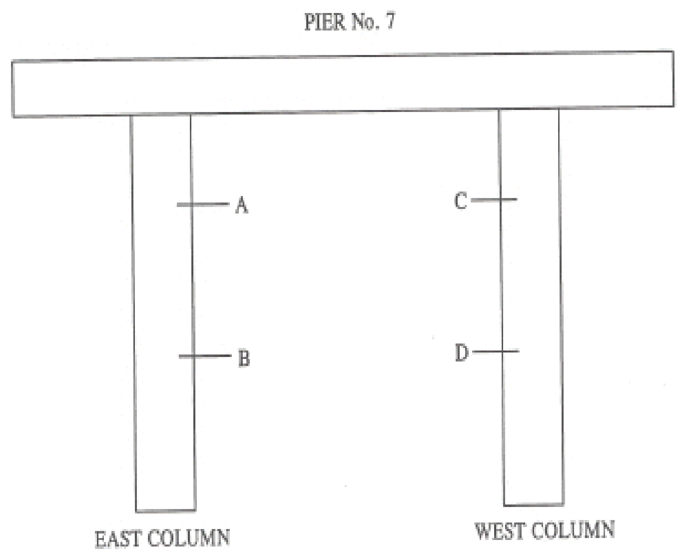




BURGESS & NIPLE

Mt. Adams/I-471 Slope Stabilization Project
Cincinnati, Ohio
August 2000

FIGURE D-3 - RAMP P (PIER No. 7) MEASUREMENT LOCATIONS



PART IV
SECTION 2: TABLES

TABLE I

MT. ADAMS I-471 GENERAL INSPECTION SCHEDULE

INSPECTION AREA	INSPECTION TASK <3>	PART II, ITEM NO.		INSPECTION DETAILS	TOTAL ESTIMATED INSPECTION TIME REQUIREMENTS FOR EACH TASK <1>	FREQUENCY OF INSPECTIONS AND COMMENTS: VISUAL INSPECTION FREQUENCY	FREQUENCY OF INSPECTIONS AND COMMENTS: COMMENTS	EQUIPMENT REQUIREMENTS
BUTTRESS FILL	GROUND SURFACE INSPECTION	2.1				SIX MONTHS		MEASURING TAPE, FLASHLIGHT, TOOL TO REMOVE MANHOLE LIDS.
	DRAINAGE FACILITY INSPECTION	2.2				SIX MONTHS		
CYLINDER PILE WALL	CONCRETE INSPECTION	3.1	3.1.1	WALL RAILING CONCRETE		SIX MONTHS		MEASURING TAPE, BINOCULARS, PROBE OR SCREWDRIVER, 1/100 INCH METAL SCALE, EXTENSION LADDER.
			3.1.2	CAP BEAM CONCRETE		SIX MONTHS		
			3.1.3	CYLINDER PILE CONCRETE		SIX MONTHS		
			3.1.4	SHOTCRETE BETWEEN PILES		SIX MONTHS		
	GROUND SURFACE INSPECTION	3.2				SIX MONTHS		
	TENDON BEARING ASSEMBLY INSPECTION	3.3	3.3.1	BEARING PLATE CONTACT FOR TUNNEL AND ROCK ANCHOR TENDONS		12 MONTHS	Requires two personnel	3/4 BREAKER BAR, PROBE, 5/8 AND 1-1/4 INCH SOCKET WRENCH OR 6 AND 15 INCH CRESCENT WRENCH, 40 FT. SELF PROPELLED PLATFORM LIFT.
			3.3.2	BEARING ASSEMBLY HARDWARE		12 MONTHS	Requires two personnel	
			3.3.3	GREASE CAP REMOVAL AND INSPECTION <3>		12 MONTHS	REMOVE 8 TO 10 GREASE CAPS; Requires two people	
	DRAINAGE FACILITY INSPECTION	3.4	3.4.1	VERTICAL DRAINS		SIX MONTHS	Requires two personnel	ELECTRIC WATER LEVEL INDICATOR, TOOL TO REMOVE ACCESS COVER AND MANHOLE LID
			3.4.2	HORIZONTAL DRAIN DISCHARGE AT MH 19		SIX MONTHS	Requires two personnel	
ANCHORAGE TUNNEL	INSPECTION OF INSTALLED EQUIPMENT	4.1	4.1.1	POWER AND LIGHT CHECK		MONTHLY	Requires two personnel	FLASHLIGHT, LUBRICATING OIL PER MANUFACTURER'S RECOMMENDATIONS, BUTANE SOURCE
			4.1.2	GAS DETECTION SYSTEM CHECK		MONTHLY	Requires two personnel; Annual calibration	
			4.1.3	VENTILATION FAN OPERATION		MONTHLY	Requires two personnel	
			4.1.4	MANLIFT OPERATION		MONTHLY	Semi-Annual State Inspection Required	
			4.1.5	SAFETY EQUIPMENT		MONTHLY		
			4.1.6	COMMUNICATIONS EQUIPMENT		MONTHLY	Requires two personnel; Annual "911" Test Required	
			4.1.7	MISCELLANEOUS EQUIPMENT		MONTHLY		
	CONCRETE INSPECTION	4.2	4.2.1	ACCESS SHAFT LINER CONCRETE		SIX MONTHS		MEASURING TAPE, PROBE OR SCREWDRIVER, 1/100 INCH METAL SCALE, FLASHLIGHT
			4.2.2	TUNNEL LINER CONCRETE/SHOTCRETE		SIX MONTHS		
			4.2.3	TUNNEL INVERT CONCRETE		SIX MONTHS		
			4.2.4	ANCHOR BLOCK CONCRETE		SIX MONTHS		

NOTES

<1> TIME ESTIMATES IN MANHOURS PER TASK.

<2> REMOVAL OF CYLINDER PILE GREASE CAP SHOULD CORRESOPND TO THE SAME TENDON AS THOSE REMOVED IN THE TUNNEL (SEE TABLE III).

<3> REFER TO SCOPE FOR MINUMUM QUALIFICATIONS OF INSPECTOR FOR EACH TASK

REV. OCT. [illegible] (ODOT)
REV. MAR. [illegible] (ODOT)
REV. NOV. [illegible] Shannon & Wilson, Inc. Geotechnical Consultant
REV. OCT. [illegible] Shannon & Wilson, Inc. Geotechnical Consultant
REV. OCT. [illegible] Shannon & Wilson, Inc. Geotechnical Consultant

TABLE I (continued)

MT. ADAMS I-471 GENERAL INSPECTION SCHEDULE

INSPECTION AREA	INSPECTION TASK <4>	PART II, ITEM NO.		INSPECTION DETAILS	TOTAL ESTIMATED INSPECTION TIME REQUIREMENTS FOR EACH TASK <1>	FREQUENCY OF INSPECTIONS AND COMMENTS: VISUAL INSPECTION FREQUENCY	COMMENTS	EQUIPMENT REQUIREMENTS
ANCHORAGE TUNNEL (cont.)	TENDON BEARING ASSEMBLY INSPECTION	4.3	4.3.1	BEARING PLATE CONTACT		12 MONTHS	Requires two personnel	3/4 BREAKER BAR, PROBE OR SCREWDRIVER, 5/8 INCH SOCKET WRENCH, 15 INCH CRESCENT WRENCH, 1/100 INCH METAL SCALE, PH PAPER, FLASHLIGHT, CHAIN HOIST OR HYDRAULIC LIFT TABLE, GREASE
			4.3.2	BEARING ASSEMBLY HARDWARE		12 MONTHS	Requires two personnel	
			4.3.3	GREASE CAP PLUG CHECK		SIX MONTHS	Requires two personnel	
			4.3.4	GREASE CAP REMOVAL AND INSPECTION <3>		12 MONTHS	REMOVE 8 TO 10 GREASE CAPS; Requires two people	
	DRAINAGE FACILITY INSPECTION	4.4	4.4.1	VERTICAL AND SIDEWALL TUNNEL DRAINS		SIX MONTHS		MEASURING TAPE, FLASHLIGHT, GRADUATED CYLINDER, STOP WATCH
			4.4.2	SIDEWALL DRAINS IN ACCESS SHAFT		SIX MONTHS		
			4.4.3	TUNNEL DISCHARGE DRAIN AT MH 17		SIX MONTHS		
AREAS ABOVE AND BELOW THE CYLINDER PILE WALL	GROUND SURFACE INSPECTION	5.1				SIX MONTHS		MEASURING TAPE, FLASHLIGHT, TOOL TO REMOVE MANHOLE, PLUMB BOB
	RETAINING WALL AND RELATED STRUCTURE INSPECTION	5.2		RETAINING WALLS 2, 4, 5, 9, 13, 15, 17, AND 18		SIX MONTHS		
	TIEDOWN REACTION BLOCK INSPECTION	5.3		50 BLOCKS		SIX MONTHS		
	DRAINAGE FACILITIES INSPECTION	5.4		MH 2, 3, 4, 5, 6, 13, AND 15 BEHIND CYLINDER PILE WALL. MH 7, 9, AND 14 INFORNT OF CYLINDER PILE WALL		SIX MONTHS		
RIVER FLOOD INSPECTION	SLUICE GATE OPERATION	6.1		CLOSE SLUICE GATE DURING OHIO RIVER FLOODS		SEE COMMENTS	CLOSE GATE WHEN OHIO RIVER REACHES FLOOD STAGE	SLUICE GATE WRENCH, TOOL TO REMOVE MANHOLE LID
	POST-FLOOD INSPECTION	6.2		PERFORM INSPECTIONS AFTER OHIO RIVER FLOODING		SEE COMMENTS	IF AUTHORIZED INSPECTION ITEM	
TENDON SURVEILLANCE INSPECTION		7.0		TO BE PERFORMED BY SEPARATE CONTRACT; CONSULTANT TO RECOMMEND PERFORMING INSPECTION IF WARRANTED				

NOTES

<1> TIME ESTIMATES IN MANHOURS PER TASK.
<2> REMOVAL OF CYLINDER PILE GREASE CAP SHOULD CORRESOPND TO THE SAME TENDON AS THOSE REMOVED IN THE TUNNEL (SEE TABLE III).
<3> REFER TO SCOPE FOR MINUMUM QUALIFICATIONS OF INSPECTOR FOR EACH TASK

REV. OCT. 2000 (ODOT)
REV. MAR. 1998 (ODOT)
REV. NOV. 1987 Shannon & Wilson, Inc. Geotechnical Consultant
REV. OCT. 1987 Shannon & Wilson, Inc. Geotechnical Consultant
REV. OCT. 1983, Shannon & Wilson, Inc. Geotechnical Consultant

TABLE II

Corrosion Criteria for Visual Inspection of Steel

To provide uniformity of evaluations during inspections, the following criteria should be used in estimating the relative degree of steel corrosion:

1. Bright Metal - Uniformly colored. No visible rust, pitting, or foreign matter. No cleaning required for inspection. Two heavy passes of 100 grit sandpaper to bright metal.

2. Reddish Brown - No pitting. Rag wipe cleaning may be required for inspection. Five heavy passes with 100 grit sandpaper to bright metal.

3. Slight Pitting - pitting depth 0-0.003 in. Rust-filled pits. Steel wool cleaning may be required for inspection. Ten heavy passes with 100 grit sandpaper to bright metal.

4. Moderate Pitting - Pitting depth 0.003 to 0.006 in. Rust-filled pits. Steel wool and sandpaper cleaning may be required for inspection. Twenty heavy passes with 100 grit sandpaper to bright metal.

5. Deep Pitting - Pitting depth greater than 0.006 inches. Rust-filled pits. Noticeable rust encrustation and scaling. Steel wool and sandpaper cleaning may be required for inspection. Thirty or more heavy passes with 100 grit sandpaper to bright metal.

TABLE III

Grease Cap Removal Schedule

Year	Tendon Number									Total No. Caps to be Inspected*
1999-00	All Tendon Upper Hardware Replaced									
2001	1	21	41	61	90	101	141U	161		14
2002	13	20	54	76	94	141L	135	147L		14
2003	17	37	57	77	81	117	137	157		15
2004	7	27	47	67	87	107	127	147U		15
2005	12	32	52	72	92	112	132	152U	152L	16
2006	3	23	43	63	83	103	123	143U	143L	16
2007	19	39	59	79	99	119	139U	139L	159	15
2008	6	26	46	66	86	106	126	146U	146L	16
2009	16	36	56	76	97	116	136	156		15
2010	11	31	51	71	91	111	131	151U	151L	16
2011	4	24	44	64	84	104	124	144U	144L	16
2012	14	34	54	74	96	114	134	154		15
2013	9	29	49	69	89	109	129	149U	149L	16
2014	13	76	121	138L	140L	142L	145L	148L	150L	12
2015	20	40	60	80	100	120	140U	160		14
2016	10	30	50	70	110	130	150U			13
2017	5	25	45	65	85	105	125	145U		15
2018	15	35	55	75	95	115	135	155		15
2019	2	22	42	62	82	102	122	142U		15
2020	18	38	58	78	88	118	138U	158		14
2021	8	28	48	68	93	113	128	148U		15
2022	13	33	53	73	98	108	133	153		15
2023	Pattern Repeats After 20 Years									327

*NOTES:

1. Tendon Nos. 1-137 have grease caps at both the tunnel end and at the cylinder pile end. Both should be removed for inspection
2. Tendon Nos. 138-152 are twin tendons. There are two grease caps at the face of the cylinder pile wall.
3. Tendon Nos. 153-161 are single tendons. There is only one grease cap located at the face of the cylinder pile wall.
4. Removal of some grease caps at the face of the cylinder pile wall may require special equipment such as a lifting hoist, ladders, and traffic diversion signs.

TABLE V

TENDON SURVEILLANCE INSPECTION

TENDON NUMBER	SHOP OR FIELD END*	GREASE COVERAGE						CORROSION LEVEL						BUTTON HEAD INSPECTION					WIRE INSPECTION			GREASE CHEM. ANALYSIS				TENDON LOAD		
		GREASE CAP	BUTTON HEADS	ANCHOR HEAD	SHIMS	BEARING PLATE	TENDON WIRES	GREASE CAP	BUTTON HEADS	ANCHOR HEAD	SHIMS	BEARING PLATE	TENDON WIRES	NO. DESIGN BUTTONS	NO. COUNTED BUTTONS	NO. OFF SIZE BUTTONS	NO. SPLIT BUTTONS	NO. BROKEN WIRES	NO. DISCOUNTED WIRES**	NO. WIRES REMOVED	NO. EFFECTIVE WIRES	WATER CONTENT, %	Cl — (mg/l)	S — (mg/l)	$NO_{\bar{3}}N$ (mg/l)	DESIGN LOAD	LIFT-OFF LOAD	FINAL RELOCK-OFF LOAD

*SHOP END IS AT CP WALL
FIELD END IS IN TUNNEL

** BASED ON INDIVIDUAL
PULL TESTS

TABLE VI

MT. ADAMS I-471 GENERAL INSPECTION SCHEDULE

MONITORING AREA <5>	PART III, ITEM NO.	TYPE OF INSTRUMENTATION	NO. LOCATIONS	INSTRUMENTATION REPORTING FIGURE NO.	ESTIMATED MONITORING TIME REQUIREMENTS <1>	FREQUENCY OF READINGS	MAXIMUM ALLOWABLE CHANGE FROM BASE READING <4>	EQUIPMENT REQUIREMENTS <2> & <3>
INCLINOMETERS	2.2	INCLINOMETER CASINGS	BUTTRESS FILL - ONE EACH	FIGURES A-2.1 AND A-3.1		SEE SECTION 2.1 - INCLINOMETER DATA EVALUATION GUIDELINES		DIGITILT PROBE AND READOUT
	2.3		CYLINDER PILE WALL - 24 EACH					
	2.4		VENT SHAFT - ONE EACH					
	2.5		AREAS UPSLOPE/DOWNSLOPE OF CP WALL - 27 EACH					
PIEZOMETERS	3.1	PIEZOMETER CASINGS	BUTTRESS FILL - TWO EACH	FIGURE E-2.2		EVERY 3 MONTHS	DELTA = 5.0'	ELEC. AND PNEUMATIC WATER LEVEL INDICATORS
	3.2		AREAS UPSLOPE/DOWNSLOPE OF CP WALL - 4 EACH					
CYLINDER PILE WALL AND ANCHORAGE TUNNEL	4.1	CP-31, CP-90 HYDRAULIC LOAD CELLS	1 LOAD CELL EACH CYLINDER PILE	FIGURE B-1		EVERY 3 MONTHS	DELTA = 3%	VISUAL READING
	4.2	EDM CAP BEAM TARGET MEASUREMENTS	74 WALL POINTS AND 5 REF. POINTS FROM 8 CONTROL POINTS	FIGURE B-3		EVERY 6 MONTHS	DELTA = 8 mm (0.3")	EDM UNIT, TARGETS, RANGE POLE, EXTENSION LADDER
	4.2	TUNNEL ANCHOR BLOCK MEASUREMENTS	25 BLOCKS, 6 POINTS EACH BLOCK	FIGURE B-4		EVERY 6 MONTHS	DELTA = 0.1"	TAPE EXTENSOMETER, FLASHLIGHT
SURVEY DATA	5.1	FOUR STREET SURVEY	POINTS ON OREGON, BAUM, MONESTARY, AND KILGOUR STREETS	FIGURE TO BE ESTABLISHED BY CONSULTANT		EVERY 12 MONTHS	DELTA EL. = 0.5" DELTA OFFSET = 0.5"	ROD AND LEVEL, TRANSIT, TAPE
	5.2	FIVE SURVEY LINE MEASUREMENTS	FIVE LINES BETWEEN KILGOUR AND BAUM STREETS	FIGURES C-4.1 AND C-4.1a		EVERY 3 MONTHS		
	5.3	RAMP P MEASUREMENTS	FOUR EXTENSOMETER POINTS AND TWO EDM POINTS	FIGURES D-1 AND D-2		EVERY 6 MONTHS		

NOTES

<1> TIME ESTIMATES IN MAN DAYS PER SET OF READINGS.
<2> ALL EQUIPMENT OWNED BY STATE, AND MAINTAINED BY CONSULTANT ON REIMBURSEMENT BASIS. SEE APPENDIX A.
<3> SOME ACCESS COVERS REQUIRE A WRENCH TO REMOVE FASTENING BOLTS. OTHERS ARE LOCKED WITH CONVENTIONAL PADLOCKS.
<4> THE BASE READINGS FROM WHICH INSTRUMENTATION READING CHANGES ARE DETERMINED HAVE BEEN ESTABLISHED FROM A FINAL SET OF ALL DATA AT THE COMPLETION OF CONSTRUCTION ACTIVITIES.
<5> REFER TO SCOPE FOR MINUMUM QUALIFICATIONS OF INSPECTOR FOR EACH TASK.

REV. OCT. [illegible] (ODOT)
REV. MAR. [illegible] (ODOT)
REV. NOV. [illegible] Shannon & Wilson, Inc. Geotechnical Consultant
REV. OCT. [illegible] Shannon & Wilson, Inc. Geotechnical Consultant
REV. OCT. [illegible] Shannon & Wilson, Inc. Geotechnical Consultant

PART IV
SECTION 3: SAMPLE CHECKLISTS

I-471 MT. ADAMS CINCINNATI, OHIO	BUTTRESS FILL AREA REFER TO FIGURE NO. 2	CHECK LIST 2.2 SHEET 1 OF 1

DRAINAGE FACILITY INSPECTION

INCLUDES CATCH BASINS, MANHOLES, & UNDERDRAIN PIPE

BEGIN TIME 8:50 a.m.
DATE 3-7-00
NAME AMG / BDD
WEATHER 52 °F
END TIME 9:10 a.m.

OBSERVATION	APPEARANCE SATISFACTORY	DEBRIS OR SEDIMENTS	ESTIMATED FLOW RATE •
CATCH BASIN 23A	Minor rust on grate. Grate not flush w/ casting. Catch basin concrete good.	Water sitting in trap. Heavy debris blocking flow from retaining wall 9 gutter**.	Standing water in trap.
CATCH BASIN 23B	Minor rust on grate, otherwise good.		Trickle
MANHOLE NO. 25	Concrete in good condition.	Large stick in MH. Rock in flow path.	Outlet – 10" x ¼" Inlet U3 – 4" x ¼" Inlet U4 – 6" x ¼"
UNDERDRAIN U-3	Good		4" x ¼"
UNDERDRAIN U-4	Good		6" x ¼"
DRAIN BEHIND RETAINING WALL NO. 9	Concrete is satisfactory.		Dry. End of drain (CB23A) has a lot of debris blocking the water's flow.

REMARKS:

Underdrains U3 and U4 were inspected from inside Manhole No. 25.

** Debris must be removed.

• ESTIMATE VOLUME OF FLOW BY NOTING PIPE DIAMETER & THEN WHETHER PIPE IS FULL, HALF FULL, QUARTER, TRICKLE, OR DRY.

I-471 MT. ADAMS CINCINNATI, OHIO

CYLINDER PILE WALL
REFER TO FIGURES 7A & 7B

CHECK LIST 3.1.1
CHECK LIST 3.1.2

CONCRETE INSPECTION

RAILINGS AND CAP BEAMS
(SEE CRACK CODE LEGEND, SHEETS 17 & 18)

BEGIN TIME 9:10 a.m.
DATE 3-21-00
NAME AMG
WEATHER 46°F
END TIME 9:22 a.m.

PILE NO.	RAILING KILGOUR ST. SIDE (3.1.1)	RAILING I-471 SIDE (3.1.1)	CAP BEAM (3.1.2)
1	[redacted]	[redacted]	Fe stains on top & on face. Crack around btm rt. corner (6ft^2). _12_ at CL (L=1") btm.
2	[redacted]	[redacted]	Fe stains at top & on face. _12_ at btm (L=1 ½").
3	[redacted]	[redacted]	Fe stains at top. _12_ at btm CL (L=1 ½").
4	[redacted]	[redacted]	Fe stains at top & on face. _11_ at EDM bracket. _12_ at btm 3' rt of lt jt. _11_ (L=8") rt side CL.
5	[redacted]	[redacted]	Fe & Ca stains at top. _15_. _11_ (L=1.5') at CL. Fe stain btm rt. _12_ at CL (L=1'). 2" ϕ spall. Multiple _11_ (L=3") lt side.
6	[redacted]	[redacted]	Fe stains at top & on face. Very minor Ca at top. _12_ at CL btm (L=1 ½').
7	[redacted]	[redacted]	Fe & minor Ca at top & face. _12_ (L=2 ½') at 1' lt of CL.
8	[redacted]	[redacted]	Fe & Ca at top & face. _11_ rt jt (L=4"). Bad patch near EDM bracket. Jt. 8-9 – H_2O stains. 4" offset in cap beam in back at btm. _11_ (L=8") at 1' above CL w/ H_2O stain. _15_.
9	[redacted]	[redacted]	Fe & Ca stains at top & face. _11_ (L=2') w/ _15_ at lt CL w/ Ca & H_2O stain. _15_.
10	[redacted]	[redacted]	Minor Fe & Ca stains at top & face. _15_.

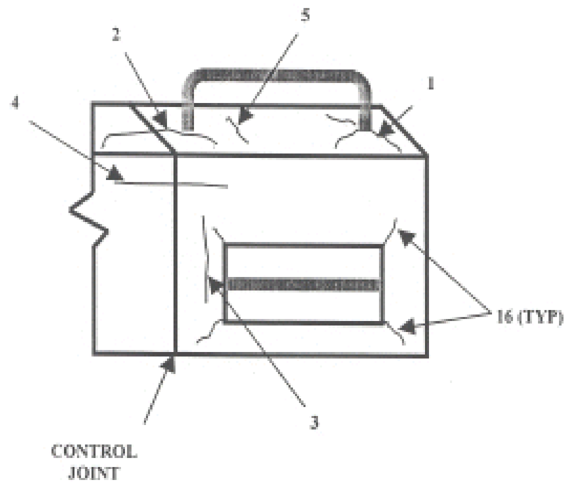
REMARKS:

FL = Full Length   CL = Centerline   MC = Map Cracking

CONCRETE INSPECTION

RAILINGS AND CAP BEAMS
LEGEND SHEET

RAILING FOR KILGOUR STREET SIDE



15 – Minor surface deterioration (minor spalling, bad surface finish, Ca stains)

I-471 MT. ADAMS CINCINNATI, OHIO

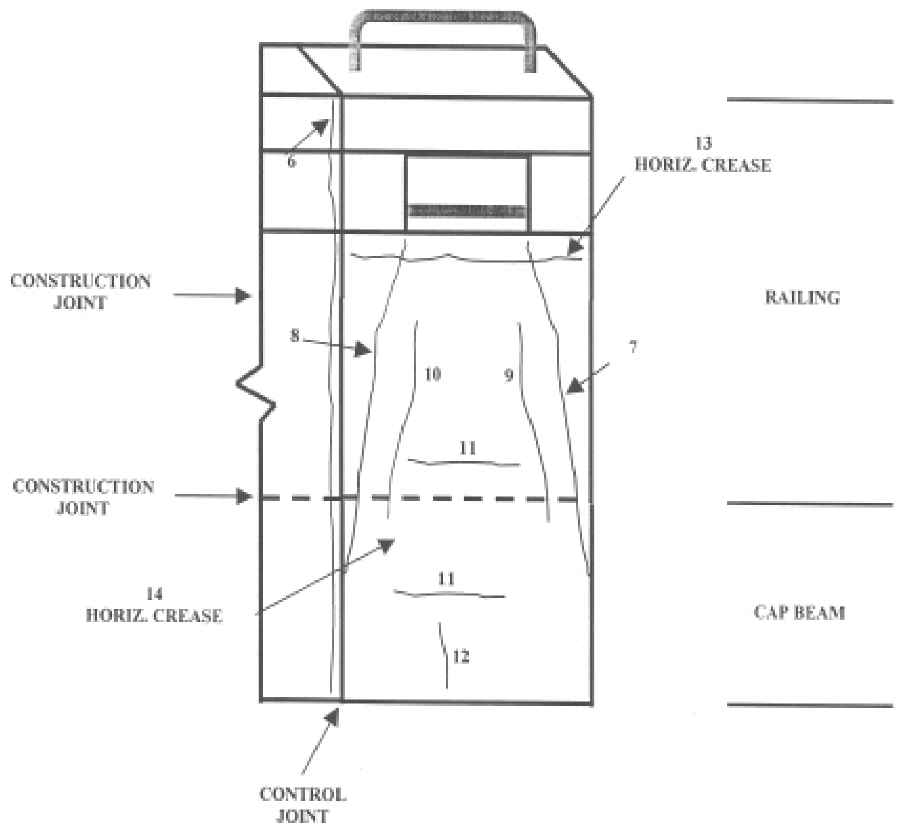
CYLINDER PILE WALL

REFER TO FIGURES 7A & 7B

CONCRETE INSPECTION

RAILINGS AND CAP BEAMS
LEGEND SHEET

RAILING FOR I-471 SIDE & CAP BEAM



15 – Minor surface deterioration (minor spalling, bad surface finish, Ca stains)

I-471 MT. ADAMS CINCINNATI, OHIO	**CYLINDER PILE WALL** REFER TO FIGURES 7A & 7B	**CHECK LIST 3.1.3** SHEET 1 OF 28

CONCRETE INSPECTION

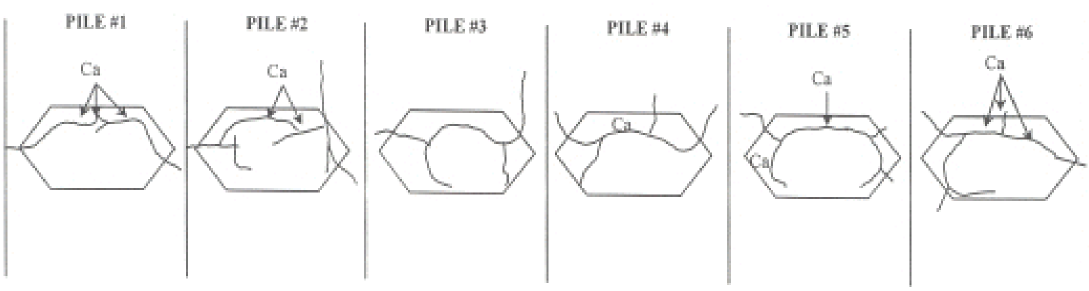
CYLINDER PILES
(SEE LEGEND, SHEET 28)

BEGIN TIME 9:12 a.m.
DATE 3-21-00
NAME BDD
WEATHER 46 °F
END TIME 9:22 a.m.

PILE NO.	CRACK LOCATION 1	CRACK LOCATION 2	CRACK LOCATION 3	SPALLS LOCATION, SQ. IN.	EXPOSED STEEL	SEEPAGE	COMMENTS
1	V FL H L = 4'	H L = πr V L = 1'		1' x 3" – Loc 1		Ca stain from brg plate down front of pile.	Pile grease stained from previous leak.
2	H L = πr V L = 3'	V L = 1' V L = 8" H L = πr		5" x 4" – Loc 1 bot. edge.		Ca stain from brg plate down front of pile.	Horiz. crack for Loc. 1 is deeper on front face. Pile grease under brg plate.
3	V L = 5' H L = πr	V L = 15" H L = 7' V L = 20"				Minor Ca stain under brg plate.	
4	D L = 1.5'	H L = 7' V L = 1' V L = 1'	H L = 4' V FL	Loc. 1 - 8" x 2" (top) Loc. 2 – 2.5' x 6" (behind brg plate); 2' x 4" (lt & rt of brg plate); 0.5" x 5"; comment 1 ; 3" x 1"; Loc. 3- 2.5' x 1.5'	Loc. 3 – front	Moss & H_2Ostain at right top from joint. Ca & Fe down rt. side.	Many spalls around brg plate.
5		H L = πr V L = 1.5' D L = 2.5'	V FL	Loc. 2 – 8" x 5" Loc. 3 – 2' x 1'; 2' x 8"		Moss & H^2O stain at left top from cap beam.	Small pile grease stain under brg plate.
6	V L = 1.5' H L = πr D_1 & D_2 L = 2'	H L = 6' V L = 10" V L = 2.5'		Loc. 2 – 4" x 5"; 2' x 6" (behind brg plate); 2" x 2' (side of brg plate)			V – At top centerline (HL)

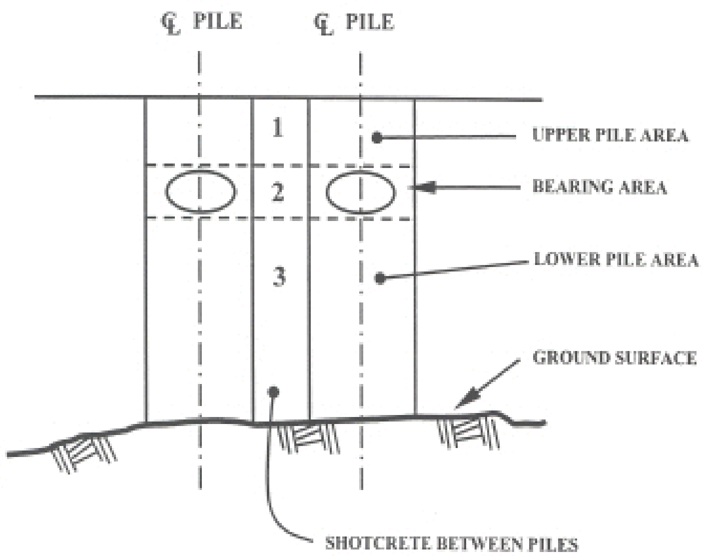
REMARKS:

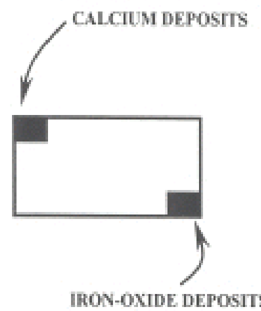
FL = FULL LENGTH. Comment 1 = minor surface deterioration.



CONCRETE INSPECTION

CYLINDER PILES
LEGEND SHEET





V = VERTICAL CRACK
H = HORIZONTAL CRACK
D = DIAGONAL CRACK
L = LENGTH OF CRACK

I-471 MT. ADAMS CINCINNATI, OHIO

CYLINDER PILE WALL
REFER TO FIGURES 7A & 7B

CHECK LIST 3.1.4
SHEET 1 OF 13

CONCRETE INSPECTION

SHOTCRETE BETWEEN PILES
(SEE LEGEND, SHEET 13)

BEGIN TIME 8:30 a.m.
DATE 3-21-00
NAME AMG / BDD
WEATHER 49 °F
END TIME 8:54 a.m.

PILE NOS.	CRACKS					SPALLS LOCATION, SQ. IN.	COMMENTS
	VERTICAL			HORIZONTAL			
	LEFT	RIGHT	CENTER	UPPER	LOWER		
1-2				4H L = 1'	2H L = 1'		
2-3	HL			4H L = 1'	2H L = 1'		
3-4				1H L = 1'	■ 4H L = 1'		
4-5	■ FL	■ L = 4'			■ 2H , D L = 1' , 1'		Heavy Seepage
5-6	FL			4H L = 1'	4H L = 1'		
6-7	FL			5H L = 1'	5H L = 1'		
7-8	FL	FL		2H L = 1'	4H L = 1'		
8-9	■	■	■ 1V L = 3'		■ 1H L = 1'	Spalls along joints for both sides.	Ca & Algae are FL on right & left. Joint leaks.
9-10	■ FL			4H L = 1'	■ 6H L = 1'		
10-11	■ FL			■ 1H L = 1'	■ 5H L = 1'		
11-12				■ 3H L = 1'	■ 4H L = 1'		
12-13	■ FL	■		■ 2H L = 1'	2H L = 1'		Heavy Seepage
13-14		■ FL		■ 4H L = 1'	3H L = 1'		

REMARKS:

CONCRETE INSPECTION

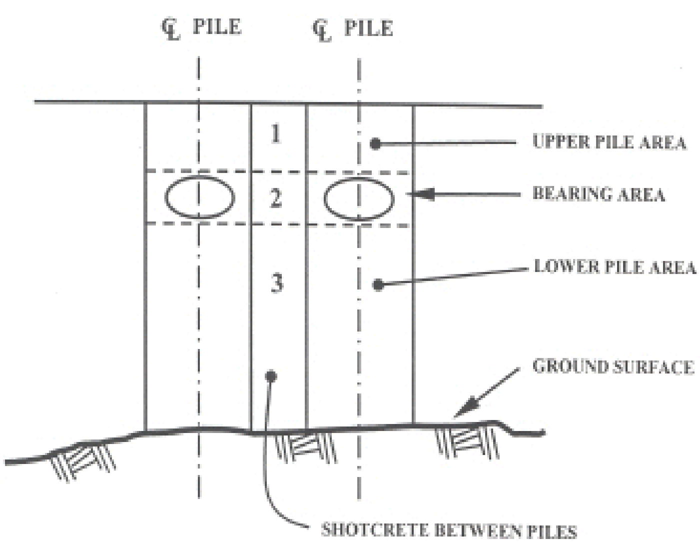
SHOTCRETE BETWEEN PILES
(SEE LEGEND, SHEET 13)

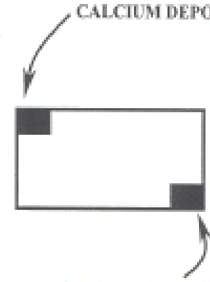
BEGIN TIME
DATE 3-21-00
NAME AMG/BDD
WEATHER 54 °F
END TIME

PILE NOS.	CRACKS					SPALLS LOCATION, SQ. IN.	COMMENTS
	VERTICAL			HORIZONTAL			
	LEFT	RIGHT	CENTER	UPPER	LOWER		
157-158					1H L = 1'		
158-159							
159-160							
160-161							

REMARKS:

SHADED AREAS COULD NOT BE INSPECTED DUE TO CONSTRUCTION.





V = VERTICAL CRACK
H = HORIZONTAL CRACK
D = DIAGONAL CRACK
L = LENGTH OF CRACK

I-471 MT. ADAMS
CINCINNATI, OHIO

CYLINDER PILE WALL

REFER TO FIGURES 5, 8, 14 & 15

CHECK LIST 3.3.1

CHECK LIST 3.3.2

SHEET 12 OF 12

BEARING PLATE CONTACT & BEARING ASSEMBLY HARDWARE

INCLUDES TUNNEL AND ROCK ANCHOR TENDONS

BEGIN TIME ______

DATE ______

NAME ______

WEATHER ______

END TIME ______

TENDON NO.	BEARING PLATE CONTACT CONDITION (3.3.1)	BEARING ASSEMBLY HARDWARE CONDITION* (3.3.2)	MISSING-DAMAGED PARTS
152U			
152L			
153			
154			
155			
156			
157			
158			
159			
160			
161			

REMARKS: ______

*TO ESTIMATE EXTENT OF CORROSION, REFER TO TABLE II FOLLOWING SECTION 7.

I-471 MT. ADAMS
CINCINNATI, OHIO

CYLINDER PILE WALL

REFER TO FIGURE NOS. 5, 8, 14 & 15

BEGIN TIME ______

DATE ______

NAME ______

WEATHER ______

END TIME ______

GREASE CAP REMOVAL & INSPECTION

INCLUDES UPPER END GREASE CAPS FOR TUNNEL & ROCK ANCHOR TENDONS

TEND. NO.	DESIGN NO. WIRES	NO. WIRES INSTALLED	LOCK[1] OFF LOAD (kips)	DATE CAP REMOVED	PRES. OF CONDENS. OR WATER	ADEQUACY OF GREASE COVER CONDITION OF GREASE	EVIDENCE OF CORROSION * ON WASHER, SHIMS BUTTON HEADS - CONDITION OF BUTTON HEADS – SPLITS, ETC.	NO. WIRES COUNTED
1	103	103[1]	747					
2[3]	105	105[1]	747					
3	106	106[1]	751					
4	107	207[2,4]	766					
5	111	111[1]	801					
6	114	114[1]	812					
7[3]	118	118[1]	846					
8	121	121[2]	869					
9	125	149[2,4]	893					
10	128	128[2]	911					
11	131	131[2]	948					
12	135	135[2]	972					
13[3]	138	155[2,4]	990					
14	141	141[2]	996					
15	144	144[2]	1021					

REMARKS: ______

______

______

______

______

*TO ESTIMATE EXTENT OF CORROSION, REFER TO TABLE II FOLLOWING SECTION 7.

I-471 MT. ADAMS
CINCINNATI, OHIO

ANCHORAGE TUNNEL

CHECK LIST 4.1
SHEET 1 OF 3

INSPECTION OF INSTALLED EQUIPMENT

INCLUDES MECHANICAL, ELECTRICAL & SAFETY EQUIPMENT

BEGIN TIME 1:45 p.m.
DATE 11-12-99
NAME BDD, RLH
WEATHER 62 F
END TIME 2:15 p.m.

EQUIPMENT	WORKING CONDITION	MAINTENANCE REQUIRED
LOUVERS AND SCREENS	Minor surface corrosion. Corrosion is heavier near the top.	Clean & Paint
CONCRETE CONDITION	Minor 1' HL vertical crack right of the door. Walkway & driveway in good condition. Minor 12' crack at the end of driveway.	None
LIGHTS & POWER	Good working condition. Minor rusting on electrical boxes & brackets. Ca on pipes by MH exit. **	Tunnel light bulbs are replaced as needed by Burgess & Niple, Limited.
GAS DETECTION SYSTEM	On Nov. 8, 1999, Dennis Blue of Seelaus Instrument Co. calibrated the MSA Model 5100 2-point combustible monitor for Methane. The sensors showed good response. Everything was in good working order upon his departure.	Regular maintenance and inspection of the gas monitoring system should be enforced to assure that the system remains in good working condition throughout the project.
VENTILATION FAN OPERATION	FORWARD / REVERSE: Both directions are in good operating condition.	Housing unit produces a lot of noise, but fan is in good working condition.
VENTILATION SHAFT	Heavy rust on steel casing pipe. Rust constantly falls onto tunnel floor below.	Sandblasting and painting.
EMERGENCY EXIT, MANHOLE COVER	Minor surface rust otherwise in good condition.	None
ROLLING SERVICE DOOR	Minor rust on door & locking bracket.	Painting
SAFETY EQUIPMENT	Railing is loose and chains are not properly secure.	Re-attach chains properly. Anchor railing into the ground better.

REMARKS:

** Outlet between CP 96 and CP 97 has Ca build up.

Electrical Boxes in access shaft are corroding due to water draining from drains and moisture.

I-471 MT. ADAMS CINCINNATI, OHIO	ANCHORAGE TUNNEL REFER TO FIGURES 10A & 10B	CHECK LIST 4.2.1 SHEET 1 OF 1

CONCRETE INSPECTION

ACCESS SHAFT

BEGIN TIME 10:45 a.m.
DATE 11/12/99
NAME BDD, RLH
WEATHER 56°F
END TIME 11:45 a.m.

ITEM	CRACKING, SPALLING HEAVING LENGTHS, WIDTH OFFSETS, AREAS	STAINING PRECIPITATE SEEPAGE	EXPOSED REINFORCEMENT OTHER
SHAFT LINER CONCRETE (4.2.1)	• 50' – 1"x6" honeycomb over tunnel. • 54.5' – 3'x1' honeycomb over tunnel. • 59.6' – 2' wide honeycomb opposite tunnel. • 61.5' – tie hole and 1'x3' honeycomb over tunnel. • 75' – Crack with Ca (L=2πr). • 85' – Crack with Ca (L=πr) • 92.5' – Crack (horiz) (L=πr)	• 10+ - drains deposit soil & water on walls. • 78' – Ca deposit in construction joint with crack all the way around shaft. • 82' – Drain over tunnel continuous drainage. • 85' – Ca deposit over tunnel. • 92.5' – Ca deposit.	• Small calcium deposit on floor under shaft with Fe stains.

REMARKS:

Shaft liner concrete elevations were expressed as approximate lengths from top of shaft downward.

Note: Generally, Ca deposits are increasing in quantity.

I-471 MT. ADAMS CINCINNATI, OHIO

ANCHORAGE TUNNEL
REFER TO FIGURES 10A & 10B

CHECK LIST 4.2.2
SHEET 1 OF 9

CONCRETE INSPECTION
TUNNEL INVERT

BEGIN TIME: 10:45 a.m.
DATE: 11/12/99
NAME: BDD / RLH
WEATHER: 56°F
END TIME: 11:45 a.m.

ANCHOR BLOCK NO.	CRACKING, SPALLING, HEAVING, LENGTHS, WIDTH, OFFSETS, AREAS	STAINING, PRECIPITATE, SEEPAGE	EXPOSED REINFORCEMENT OTHER
1			Deposits in invert cause ponding of water.
2		Moderate calcium deposits at invert.	Deposits in invert cause ponding of water.
3		Moderate calcium deposits at invert.	Deposits in invert cause ponding of water.
4		Calcium deposits on sidewalk.	Deposits in invert cause ponding of water.
5			Deposits in invert cause ponding of water.
6		Moderate calcium deposits at invert.	Deposits in invert cause ponding of water.
7		Moderate iron deposits at invert.	Deposits in invert cause ponding of water.
8		Heavy calcium deposits at invert & sidewalk.	Deposits in invert cause ponding of water.
9		Heavy calcium deposits at invert & invert.	Deposits in invert cause ponding of water.
10			Deposits in invert cause ponding of water.
11		Moderate calcium deposits at invert.	Deposits in invert cause ponding of water.
12	8" x 8" x 1" spall between CP 12 & 13.	Heavy calcium deposits at invert.	Deposits in invert cause ponding of water.
13	8" x 8" x 1" spall between CP 12 & 13.	Heavy iron & calcium deposits at invert.	Deposits in invert cause ponding of water.
14			Deposits in invert cause ponding of water.
15		Moderate calcium deposits at invert.	Deposits in invert cause ponding of water.
16		Moderate calcium deposits at invert.	Deposits in invert cause ponding of water.

REMARKS:
Floor near elevator is constantly wet.

I-471 MT. ADAMS CINCINNATI, OHIO	ANCHORAGE TUNNEL REFER TO FIGURES 10A & 10B	CHECK LIST 4.2.3 SHEET 1 OF 14

CONCRETE INSPECTION
TUNNEL LINER

BEGIN TIME: 8:50 a.m.
DATE: 11/8/99
NAME: BDD
WEATHER: 50 °F
END TIME: 9:05 a.m.

ANCHOR BLOCK NO.	LOCATION	PRECIPITATE		MOIS-TURE	CRACK		SPALL AREA (SQ. IN.)	EXPOSED STEEL
		CALCIUM	IRON-OXIDE		TYPE (H,V,D)*	LENGTH (FT.)		
ACCESS SHAFT / TUNNEL JCT.	FRONT WALL	✓	✓	✓			3" ϕ, few 1" ϕ	
	OPPOSITE WALL	✓	✓	✓			6"x1"	
1	RIGHT	✓	✓	✓	HL-V	1-1/2'		
	BELOW	✓	✓	✓				
	OPPOSITE WALL	✓	✓	✓	HL-V	2-1/2'		
	TOP	✓						
2	RIGHT	✓		✓				
	BELOW	✓		✓				
	OPPOSITE WALL				V	Construction Joint		
	TOP							
3	RIGHT	✓		✓				
	BELOW	✓		✓				
	OPPOSITE WALL	✓						
	TOP	✓			V	1'		
4	RIGHT	✓			V	1'		
	BELOW	✓		✓				
	OPPOSITE WALL	✓						
	TOP							
5	RIGHT	✓		✓				
	BELOW	✓						
	OPPOSITE WALL							
	TOP							
6	RIGHT	✓						
	BELOW	✓		✓	V	1'		
	OPPOSITE WALL		✓	✓			4"x1"	
	TOP							
7	RIGHT	✓		✓				
	BELOW	✓	✓	✓	V	2'		
	OPPOSITE WALL	✓	✓				3"x1"	
	TOP	✓						
8	RIGHT							
	BELOW	✓	✓	✓				✓
	OPPOSITE WALL	✓						
	TOP							
9	RIGHT	✓		✓				
	BELOW	✓		✓				
	OPPOSITE WALL	✓	✓				8"x3"	
	TOP						2"x1/2"	

REMARKS:
C1 (Comment 1) - Spalled base due to bad finshing.

*CRACK TYPE: H = HORIZONTAL, V = VERTICAL, D = DIAGONAL, S = SEEPAGE THRU WALL, NO CRACK.

I-471 MT. ADAMS
CINCINNATI, OHIO

ANCHORAGE TUNNEL

REFER TO FIGURES 10A & 10B

CHECK LIST 4.2.4
SHEET 12 OF 12

CONCRETE INSPECTION

ANCHOR BLOCKS
LEGEND SHEET

BEGIN TIME : 11:00 a.m.
DATE : 11/8/99
NAME : BDD/RLH
WEATHER : 60° F
END TIME : 11:20 a.m.

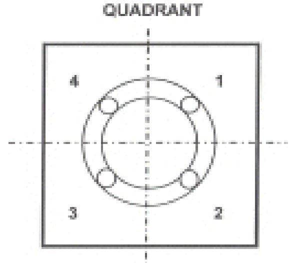
ANCHOR BLOCK NO.	ANCHOR BLOCK CONCRETE																STEEL GUIDE PEGS *				TROUGH	COMMENTS
	PRECIPITATE *				CRACKS				SPALLS													
	1	2	3	4	1	2	3	4	1	2	3	4					1	2	3	4		
133	✓ ✓	✓	✓														✓	✓	✓	✓		Comment 1.
134		✓	✓								1" x 4"						✓	✓	✓	✓		Comment 1. 4" exposed rebar below cap.
135									8" x 2"		C4						✓	✓	✓	✓		Comment 1 & 3.
136									chips								✓	✓	✓	✓		Comment 1.
137		✓ ✓	✓									1" x 6"					✓	✓	✓	✓		Minor rebar exposure @ lower right.

* TYPE A LOWERCASE "a" TO PLACE A CHECKMARK

REMARKS :

LEGEND

QUADRANT

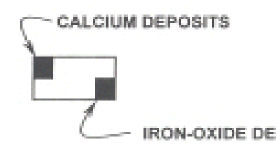


CALCIUM

IRON-OXIDE

EXPOSED STEEL

SEEPAGE



DRAIN TROUGH : N.R. - NEEDS REPAIR
O.K. - INTACT

H = HORIZONTAL
V = VERTICAL
D = DIAGONAL

Comment 1 (C1) - Ca & seepage from anchor block bottom to tunnel liner interface.
Comment 2 (C2) - Ca & seepage from anchor block left to tunnel liner interface.
Comment 3 (C3) - Ca & seepage from anchor block right to tunnel liner interface.
Comment 4 (C4) - Minor surface deterioration.

I-471 MT. ADAMS CINCINNATI, OHIO

ANCHORAGE TUNNEL
REFER TO FIGURES 10A, 10B, & 11

CHECK LIST 4.3.3
SHEET 1 OF 9

GREASE CAP PLUG WATER CHECK

BEGIN TIME 11:30 a.m.
DATE 11/24/99
NAME BDD / RLH
WEATHER 50°F
END TIME 2:30 p.m.

TENDON NO.	DATE OPENED & CHECKED	VOL. OF WATER DRAINED •	PH OF WATER	VOL. OF GREASE LOSS	COMMENTS
1	11-24-99	0	-	0	
2	11-24-99	0	-	0	
3	11-24-99	0	-	0	
4	11-24-99	0	-	0	
5	11-24-99	0	-	0	
6	11-24-99	0	-	0	
7	11-24-99	230 ml	6	Minor	
8	11-24-99	0	-	0	
9	11-24-99	0	-	Minor	
10	11-24-99	770 ml	7	0	
11	11-24-99	2500 ml	13	0	
12	11-24-99	0	-	0	
13	11-24-99	0	-	0	
14	11-24-99	0	-	Major	
15	11-24-99	0	-	0	

REMARKS:

• ESTIMATE FLOW VOLUME IN CC OR FLOW RATE IN CC/MINUTE USING A GRADUATED CYLINDER & FUNNEL (SEE SECTION 4.3.3 IN TEXT)

I-471 MT. ADAMS
CINCINNATI, OHIO

ANCHORAGE TUNNEL
REFER TO FIGURE NO. 11

CHECK LIST 4.3.4
Sheet 1 of 10

BEGIN TIME ____________
DATE ____________
NAME ____________
WEATHER ____________
END TIME ____________

GREASE CAP REMOVAL & INSPECTION

INCLUDES LOWER END GREASE CAPS FOR TUNNEL TENDONS

TEND. NO.	DESIGN NO. WIRES	NO. WIRES INSTALLED	LOCK[1] OFF LOAD (kips)	DATE CAP REMOVED	PRES. OF CONDENS. OR WATER*	ADEQUACY OF GREASE COVER CONDITION OF GREASE	EVIDENCE OF CORROSION ON WASHER, SHIMS BUTTON HEADS - CONDITION OF BUTTON HEADS – SPLITS, ETC.	NO. WIRES COUNTED
1	103	103[1]	747					
2[3]	105	105[1]	747					
3	106	106[1]	751					
4	107	207[2,4]	766					
5	111	111[1]	801					
6	114	114[1]	812					
7[3]	118	118[1]	846					
8	121	121[2]	869					
9	125	149[2,4]	893					
10	128	128[2]	911					
11	131	131[2]	948					
12	135	135[2]	972					
13[3]	138	155[2,4]	990					
14	141	141[2]	996					
15	144	144[2]	1021					

REMARKS: ____

*MEASURE VOLUME OF WATER IN CC OR RATE OF FLOW IN CC/MIN. (SEE SECTION 4.3.3 IN TEXT)

I-471 MT. ADAMS CINCINNATI, OHIO

ANCHORAGE TUNNEL
REFER TO FIGURES 10A & 10B

CHECK LIST 4.4.1A

VERTICAL DRAIN INSPECTION

BEGIN TIME 10:45 a.m.
DATE 11/11/99
NAME BDD/RLH
WEATHER 52°F
END TIME 11:45 a.m.

VERT. DRAIN NO.	APPROX. TUNNEL STATION	ESTIMATED FLOW RATE * ml/min	SEDIMENT DISCOLORATION		TIGHTNESS OF PICKUP PIPE **	PH OF WATER	PRECIPITATE		COMMENTS
			CLEAR	CLOUDY			CAL - CIUM	IRON - OXIDE	
@ Elevator Shaft		19.3	✓			7.5	✓	✓	
1	2+39	18.0	✓			7.5	✓	✓	
2	2+58	0.9	✓			7.5	✓		
3	2+77	7.8	✓			8.0	✓	✓	
4	2+97	10.0	✓			7.5	✓	✓	
5	3+16	3.0	✓			8.0	✓	✓	
6	3+36	0.8	✓			8.0	✓		Wall bracket broken @ outlet.
7	3+55	2.0	✓		Leaks	7.5	✓	✓	
8	3+75	8.8	✓		Leaks	8.0	✓		
9	3+94	32.0	✓			7.5	✓	✓	
10	4+15	9.4	✓		Leaks	7.5	✓	✓	
11	4+39	4.2	✓			7.5	✓	✓	Wall bracket broken @ outlet.
12	4+63	5.7	✓			7.5	✓	✓	Wall bracket broken @ outlet.
13	4+87	0.5	✓			8.0	✓		

REMARKS:

* EXTIMATE FLOW RATE USING A GRADUATED CYLINDER & FUNNEL (SEE SECTION 4.3.3 FOR DETAILS ON WATER MEASUREMENT).
** TIGHTNESS (LEAKAGE) AT PICKUP POINT WHERE PIPE PROTRUDES FROM LINING.

I-471 MT. ADAMS CINCINNATI, OHIO

ANCHORAGE TUNNEL
REFER TO FIGURES 10A & 10B

CHECK LIST 4.4.1B
SHEET 1 OF 9

SIDEWALL DRAIN INSPECTION

BEGIN TIME 11:30 a.m.
DATE 11/10/99
NAME BDD/RLH
WEATHER 68° F
END TIME 11:35 a.m.

SIDE DRAIN NO.	APPROX. TUNNEL STATION *	ESTIMATED FLOW RATE **			SEDIMENT DISCOLORATION		TIGHTNESS OF PICKUP PIPE ***	PRECIPITATE		COMMENTS
		DRY	TRICKLE	cc/min	CLEAR	CLOUDY		CAL - CIUM	IRON - OXIDE	
1	2+00 R 2+00 L		✓ ✓		✓ ✓			✓ H ✓	✓ H	Patched Patched
2	2+06 R 2+06 L		✓ ✓		✓ ✓			✓ ✓ H	✓	Patched Patched
3	2+13 R 2+13 L		✓ ✓		✓ ✓			✓ ✓	 ✓	Patched Patched
4	2+20 L		✓		✓		Good			Patched
5	2+26 R 2+26 L	 ✓	✓			✓	Good Good	✓ ✓ H		Patched Patched
6	2+36 L	✓					Good	✓		Patched
7	2+42 R 2+42 L		✓ ✓		✓ ✓		Good Good	✓ ✓	✓	Patched Patched
8	2+49 L	✓					Good			Patched
9	2+55 R 2+55 L	✓	 ✓		 ✓		Good Good	✓ H ✓ H		Patched Patched
10	2+65 L	✓					Good	✓		Patched
11	2+71 R 2+71 L	✓	 ✓		 ✓		Good Good	✓ H ✓ H		Patched Patched
12	2+81 L	✓					Good			Patched
13	2+87 R 2+87 L	 ✓	✓			✓	Good Good	✓	✓ H	Patch filled with Ca Patched
14	2+94 L	✓					Good	✓		Patched
15	3+00 R 3+00 L	 ✓	✓			✓		✓ ✓	✓ H/B	Spall, poorly patched Spall

REMARKS:

H = heavy; B = Black

5 – 2+26R is emitting a black substance.
15 – 3+00R is emitting a black substance.

11 L & R – Heavy Ca in pipe; # 9 L & R – Heavy Ca in pipe; #5 L – Heavy Ca in pipe; # 2 L – Heavy Ca in pipe.

* R AND L REPRESENT THE DOWNSLOPE AND UPSLOPE SIDES OF TUNNEL, RESPECTIVELY.

** EXTIMATE FLOW RATE USING A GRADUATED CYLINDER & FUNNEL (SEE SECTION 4.3.3 FOR DETAILS ON WATER MEASUREMENT).

*** TIGHTNESS (LEAKAGE) AT PICKUP POINT WHERE PIPE PROTRUDES FROM LINING.

I-471 MT. ADAMS CINCINNATI, OHIO

ANCHORAGE TUNNEL
REFER TO FIGURES 9B, 11 & 12

CHECK LIST 4.4.2
CHECK LIST 4.4.3
SHEET 1 OF 1

TUNNEL DRAINAGE INSPECTION

INCLUDES ACCESS SHAFT SIDEWALL DRAINS AND DISCHARGE DRAIN

BEGIN TIME 1:00 p.m.
DATE 11/12/99
NAME BDD/RLH
WEATHER 60°F
END TIME 1:30 p.m.

OBSERVATION	DISTANCE FROM TOP OF SHAFT (FT.)	DRAIN	ESTIMATED FLOW RATE *	PRECIPITATE		COMMENTS
				CALCIUM	IRON-OXIDE	
ACCESS SHAFT SIDEWALL DRAINS (4.4.2)	8.5	N	Moist	✓		
		E	Dry	✓		
		S	Moist			
	12.0	N	Dry			
		E	Dry			
		S	Moist			
	20.5	NW	Dry	✓		
		E	Dry			
		S	Dry			
	24.5	N	Dripping	✓		
		E	Dripping	✓		
		S	Dry	✓		
	50.0	N	Wet	✓		
		E	Dry			
		S	Dry			
	68.0	N	Dry	✓		
		E	Dry			
		S	Dry			
	83.5	N	Dripping	✓	✓	
		E	Moist	✓		
		S	Dripping	✓		
	91.0	W	Moist	✓		
	98.0	W	Dripping	✓	✓	Black Stains

OBSERVATION	APPEARANCE	DEBRIS OR SEDIMENT	ESTIMATED FLOW RATE *	STAINING
TUNNEL FLOOR DRAIN, SUMP & TRAP (4.4.3)	Grate is rusting. Doesn't seem to be performing as designed.	Large amount of sediment at bottom (at least 3" to 4"). Debris floating on top of water.	No flow can be seen. Drain is filled with water up to 4" below the surface. **	Ca & Fe near the top.
MANHOLE 17 (4.4.3)	Manhole lid covered with ¼" silt. Silt was removed by Burgess & Niple, Limited.	Very minor sediment. Sluice gate has approximately a 2" gap opening at the bottom. It also cannot be moved due to the Ca build up and Fe.	Flow from the tunnel is 4" wide x ½" deep. MH 19 is dry. MH 17 has ½" deep water over entire bottom.	Area around inlet from MH 19 is spalled. Ca below tunnel inlet.

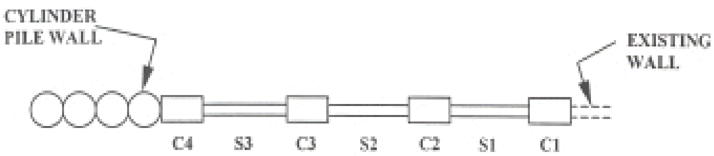
** Tunnel invert is not draining well. Ca build-up is blocking the flow. Something needs to be done to correct the problem.

* ESTIMATE FLOW RATE BY NOTING PIPE DIAMETER & THEN WHETHER PIPE IS FULL, HALF FULL, QUARTER, TRICKLE, OR DRY.

I-471 MT. ADAMS CINCINNATI, OHIO	**AREAS ABOVE & BELOW CYLINDER PILE WALL** REFER TO FIGURES 2, 4A, 4B, 9A, AND 9C	**CHECK LIST 5.2** SHEET 2 OF 9

RETAINING WALL NO. 2
STRUCTURE INSPECTION

BEGIN TIME 1:00 p.m.
DATE 10-11-99
NAME AMG / BDD
WEATHER 65°F
END TIME 1:05 p.m.



RETAINING WALL SEGMENT	CRACKS LENGTH, WIDTH, LOCATION, DIRECTION	SPALLS LOCATION, SQ. IN.	WALL SEGMENT JOINT	SEEPAGE OR WATER STAINING	COMMENTS
C1	HL cr in joints.		1" gap (C1/ Ex. Wall), seal poor or missing.	Minor Fe stain (bot rt).	
S1	3' V cr w/ Ca (top mid), V cr in rt construction joint. 6.5' HL V (bot. mid.). 2' V cr (bot. mid.).		Const. Jt. (S1/C2) Full Length V crack, 1/8" gap.	Minor Ca in V cracks.	
C2		2" x 1" (bot rt).			
S2	V cr in rt construction joint.		Const. Jt. (S2/C3) Full Length V crack, 1/8" to ¼" gap.	Ca in V cracks.	
C3		Minor spalling at construction joints.			
S3	Abundant MC, V cr (typ) in construction joints.			Minor Ca in MC.	
C4		3 spalls @ bot where bolts are anchored for guardrail.			Seal in joint of cylinder pile wall is missing.

REMARKS:

MC = Map Cracking ; P = Panel ; Gr. = Rustication Groove

Minor aggregate pop-outs typical.

I-471 MT. ADAMS CINCINNATI, OHIO	AREAS ABOVE & BELOW CYLINDER PILE WALL REFER TO FIGURE 9C	CHECK LIST 5.3 SHEET 1 OF 6

TIEDOWN REACTION BLOCK INSPECTION

INCLUDES ADJACENT CONCRETE MEDIANS

BEGIN TIME 1:00 p.m.
DATE 11/10/99
NAME BDD/RLH
WEATHER 70° F
END TIME 1:30 p.m.

ANCHOR BLOCK NO.	ANCHOR BLOCK CONCRETE CRACKS, SPALLS, MAGNITUDE AND DIRECTION	TENDON HEAD COVERING	OFFSETS IN ANCHOR BLOCK/ CONCRETE SLOPE PROTECTION	SUBSIDENCE, DIFFERENTIAL SETTLEMENTS
A1	Comment 1. Comment 2.		Heavy vegetation.	Erosion along lt edge.
A2	6" x 6" spall lt bottom corner. Comment 1.		Heavy vegetation.	Erosion along lt edge.
A3	Comment 1.		Heavy vegetation.	Erosion along lt. edge (5" along lt side of block).
A4	Comment 1.	Minor spall (bot rt corner).	Heavy vegetation.	Erosion along lt edge, 4" erosion on lt edge.
B1	Comment 2 (rt surface).	Comment 2.	Lt edge 1" gap, Joint material missing. Heavy vegetation.	Upper lt 2", upper rt ½" below S.P. & bottom is 1" above S.P.,
B2		Comment 2.	½" gap. Heavy vegetation, Tree growing between 2nd & 3rd joint (mid), no joint filler.	Upper lt edge 1", top & bot ¼" above S.P.
B3	2" x 2" spall (bot lt).		Heavy vegetation, no joint filler., ½" gap, ¼" offset.	Upper ¼", bottom ¼" above S.P., Erosion on lt.
B4	Comment 1.	Tendon head has 3 areas of exposed steel (nails for forms). Comment 2.	1" gap at bot edge, joint material deteriorated on lt side 7 bot. Heavy vegetation, Tree growing (bot mid edge), no joint filler.	Minor erosion at rt side, Erosion on lt half.
C1	Void area (top rt corner).		Deteriorating filler on rt & bot, bottom ½".	Top rt ½" below S.P., Rt ½" erosion.

REMARKS:

S. P. = Slope Protection
Crack in S.P. lt of B2 L=6'
General: (1) Preformed joint material along anchor block edges has fallen into void areas under the slab edge leaving large open joints for water penetration. (2) "A" & "B" series of anchor blocks need treatment of weed killer (badly).

Comment 1 – Minor Surface Deterioration
Comment 2 – Rough Finish (uneven surface)

I-471 MT. ADAMS CINCINNATI, OHIO

AREAS ABOVE & BELOW CYLINDER PILE WALL

CHECK LIST 5.4
SHEET 1 OF 2

DRAINAGE FACILITIES INSPECTION

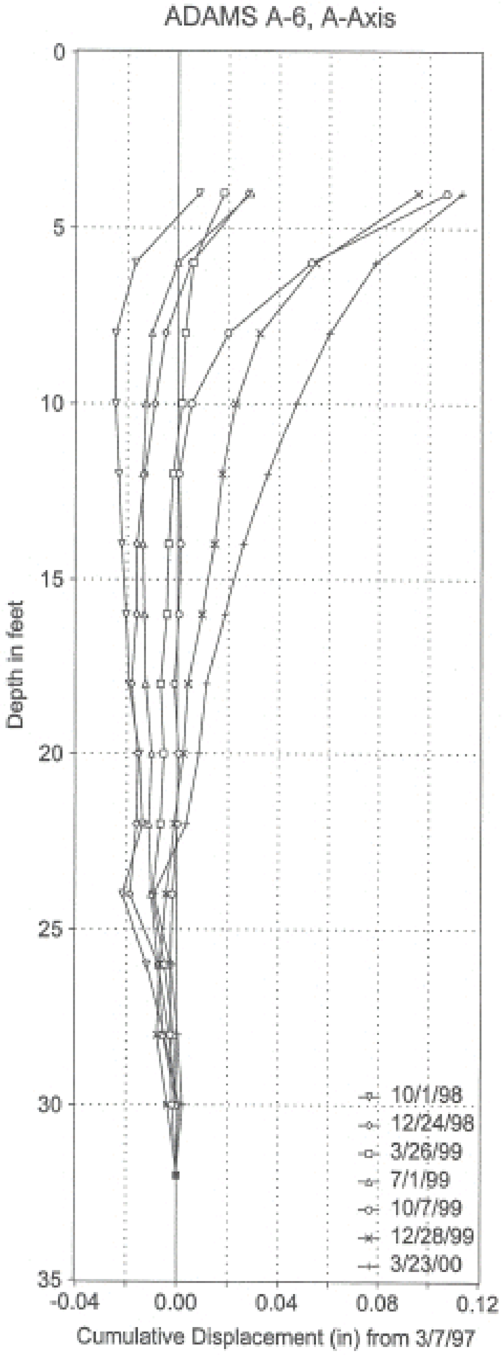
BEGIN TIME 3:00 p.m.
DATE 10-4-99
NAME AMG / BDD
WEATHER 49°F
END TIME 3:20 p.m.

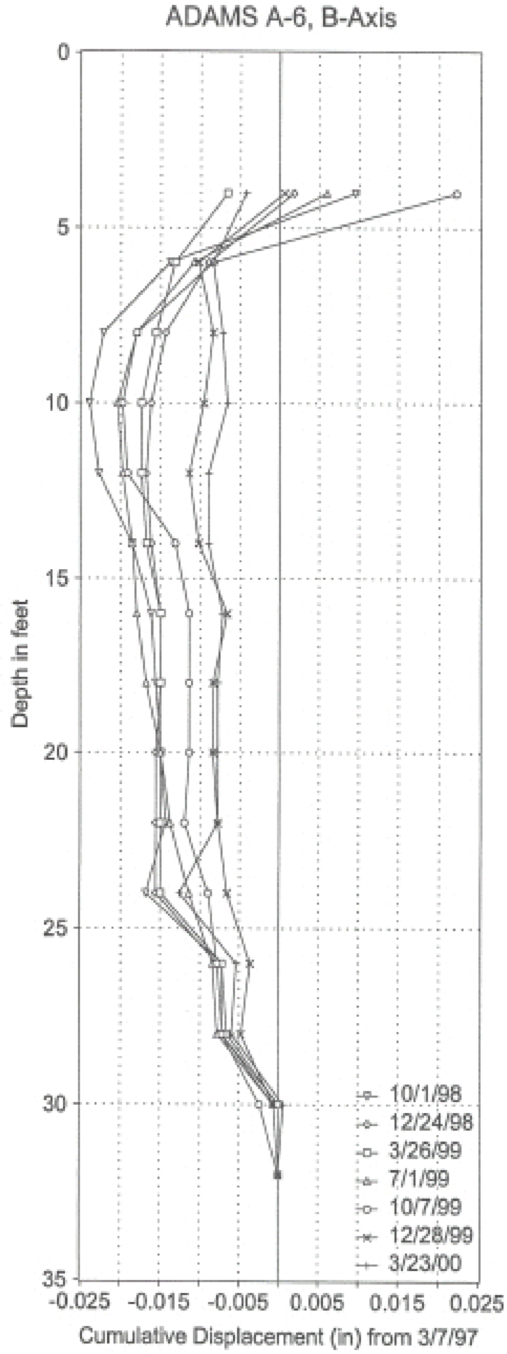
MANHOLE NUMBER	APPEARANCE SATISFACTORY	DEBRIS OR SEDIMENTS	ESTIMATED FLOW RATE *	CRACKS IN FEEDER PIPES OR MANHOLE
NO. 2	Minor rust on lid. Minor seepage on lid. Odor – strong.		Inlet 2A is dry. Flow in 24" pipe is rapid. In 12" x ½" deep Out 16" x ¾" deep Pipe bends @ exit so flow is greater.	
NO. 3	Minor rust on lid. Rust around brim (casting). Minor odor. Exposed rust on lower half with map-cracking. NW side-not enough cover for rebar.		Trickle from 3B. Opening to side drain is dry. 24" pipe is 12" x ½" deep	Multiple map-cracking from top of inlet to 7' up. Asphalt & Ca stains from top. Minor seepage at map-cracking.
NO. 4	Rust on lid & casting. Seepage @ top. Casting is damp.		Rapid and Pulsating Flow. 8" x ½" deep	Constr. Jt cr on east side ~ 10' below top around circumference. V cr on south side ~ 3' with seepage. Constr. Jt. cr ~ 15' below top.
NO. 5	Rust on lid & casting. Strong odor (gas).		5A side drain is dry. MH4 flow is heavy & gushing at 12" x ½" deep. Trickle from MH6. Large elliptical hole about ¾ down on N side-dry-do not know where it is coming from.	Good condition. Construction jt. @ 3' from bottom cracked.
NO. 6	Minor rust on lid & casting. Minor seepage. Strong Odor – sewer gas. Seepage over bricks.		Inlet – Dry Main Line – Ponding Water	Good condition. Construction joint at 3' from bottom cracked.

REMARKS:

* ESTIMATE FLOW RATE BY NOTING PIPE DIAMETER AND THEN WHETHER PIPE IS FULL, HALF FULL, QUARTER, TRICKLE, OR DRY.

PART IV
SECTION 4: INSTRUMENTATION
REPORTING FIGURES





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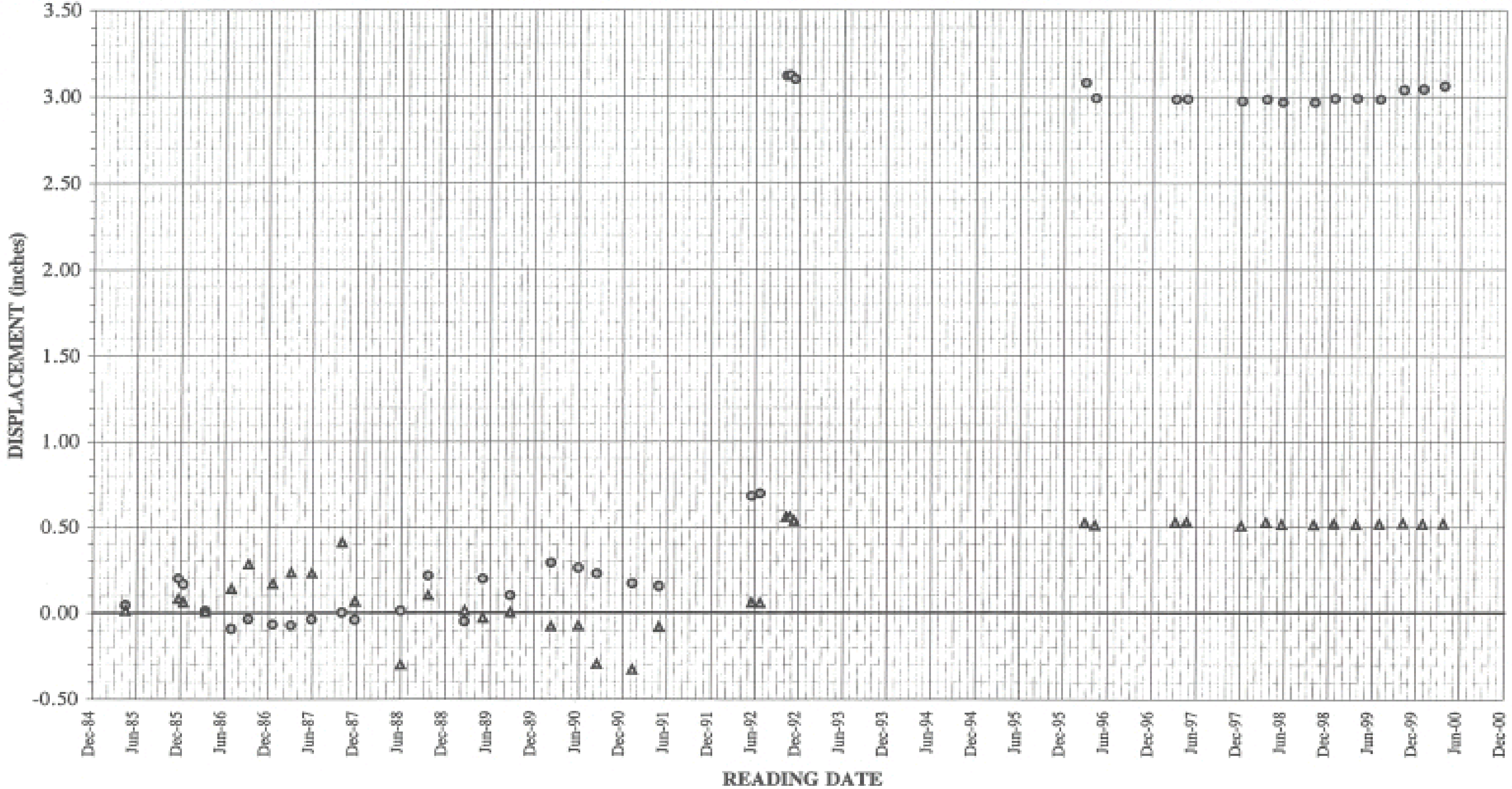
Cincinnati, Ohio
August 2000

FIGURE A-2.1



LEGEND

- o A_0(+) and A_{180}(-) DIRECTION
- ▲ B_0(+) and B_{180}(-) DIRECTION

NOTES

1. Displacement between 7-foot (EL. 531) and 31-foot (EL. 507) depths. (Reduced data from 6-foot and 30-foot depths.) Top of rock = EL. 503.
2. Positive and negative displacements represent movements in A_0/B_0 directions and A_{180}/B_{180} directions, respectively. Refer to Inclinometer Installation Site Plan (Fig. A-1) for axis orientation.
3. All data prior to September 1998 was obtained from Shannon & Wilson, Inc.
4. New inclinometer probe used after May 1992.

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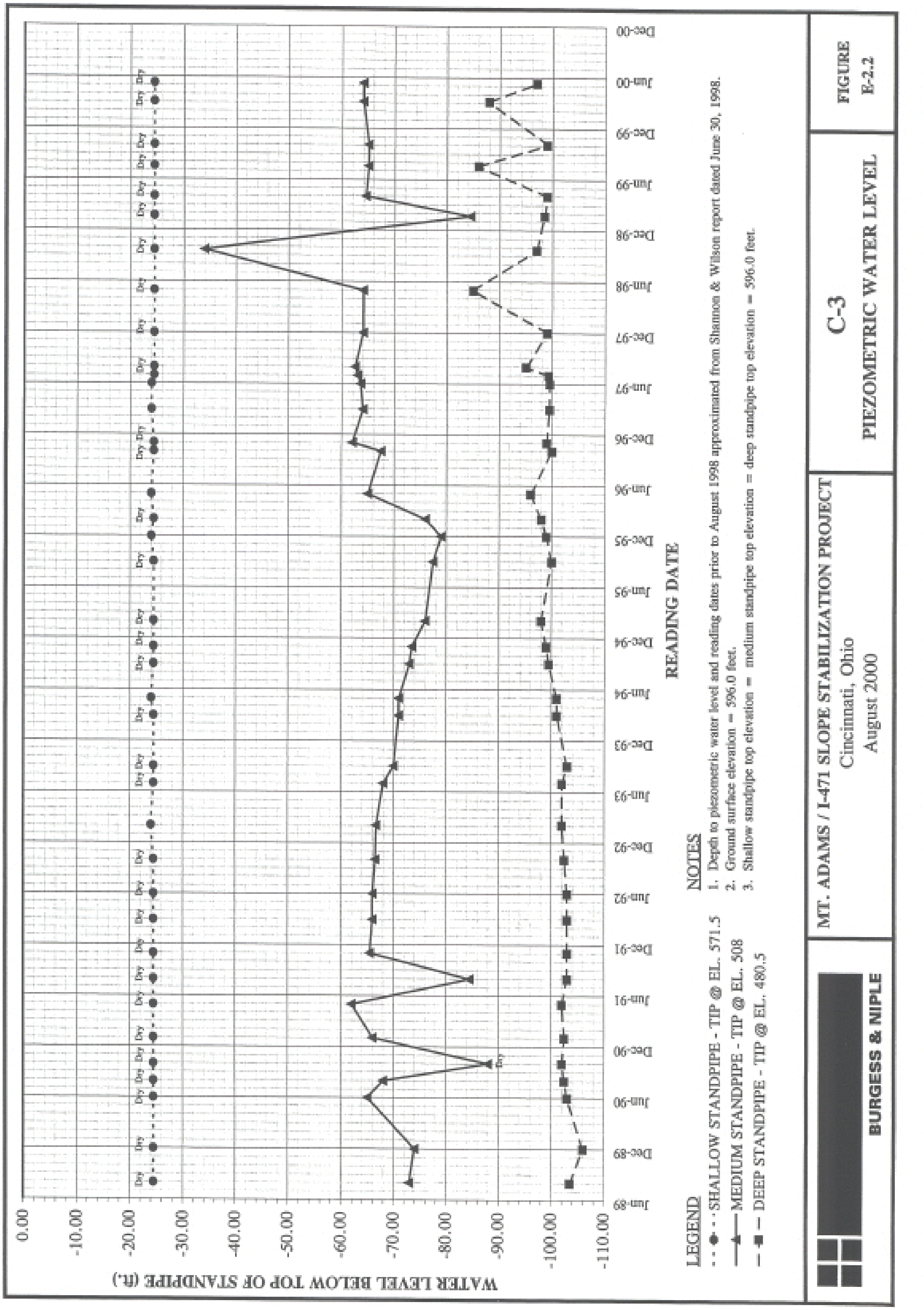
August 2000

A-6
TIME DISPLACEMENT PROFILE

FIGURE
A-3.1


WATER LEVEL BELOW TOP OF STANDPIPE (ft.)
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
-80.00
-90.00
-100.00
-110.00
Jun-89
Dec-89
Jun-90
Dec-90
Jun-91
Dec-91
Jun-92
Dec-92
Jun-93
Dec-93
Jun-94
Dec-94
Jun-95
Dec-95
Jun-96
Dec-96
Jun-97
Dec-97
Jun-98
Dec-98
Jun-99
Dec-99
Jun-00
Dec-00
READING DATE
Dry
LEGEND
SHALLOW STANDPIPE - TIP @ EL. 571.5
MEDIUM STANDPIPE - TIP @ EL. 508
DEEP STANDPIPE - TIP @ EL. 480.5
NOTES
1. Depth to piezometric water level and reading dates prior to August 1998 approximated from Shannon & Wilson report dated June 30, 1998.
2. Ground surface elevation = 596.0 feet.
3. Shallow standpipe top elevation = medium standpipe top elevation = deep standpipe top elevation = 596.0 feet.
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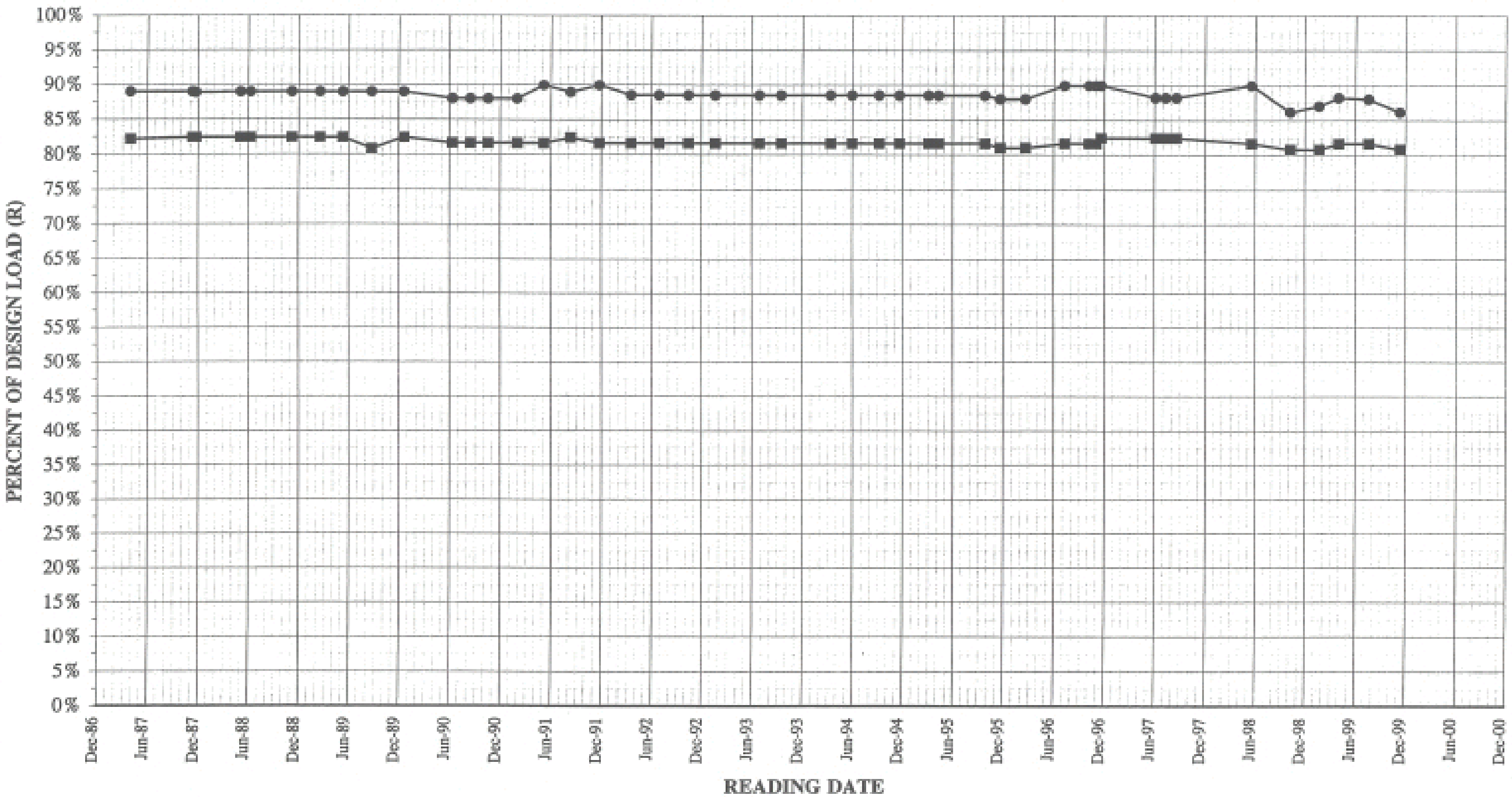
Cincinnati, Ohio
August 2000
C-3
PIEZOMETRIC WATER LEVEL
FIGURE
E-2.2



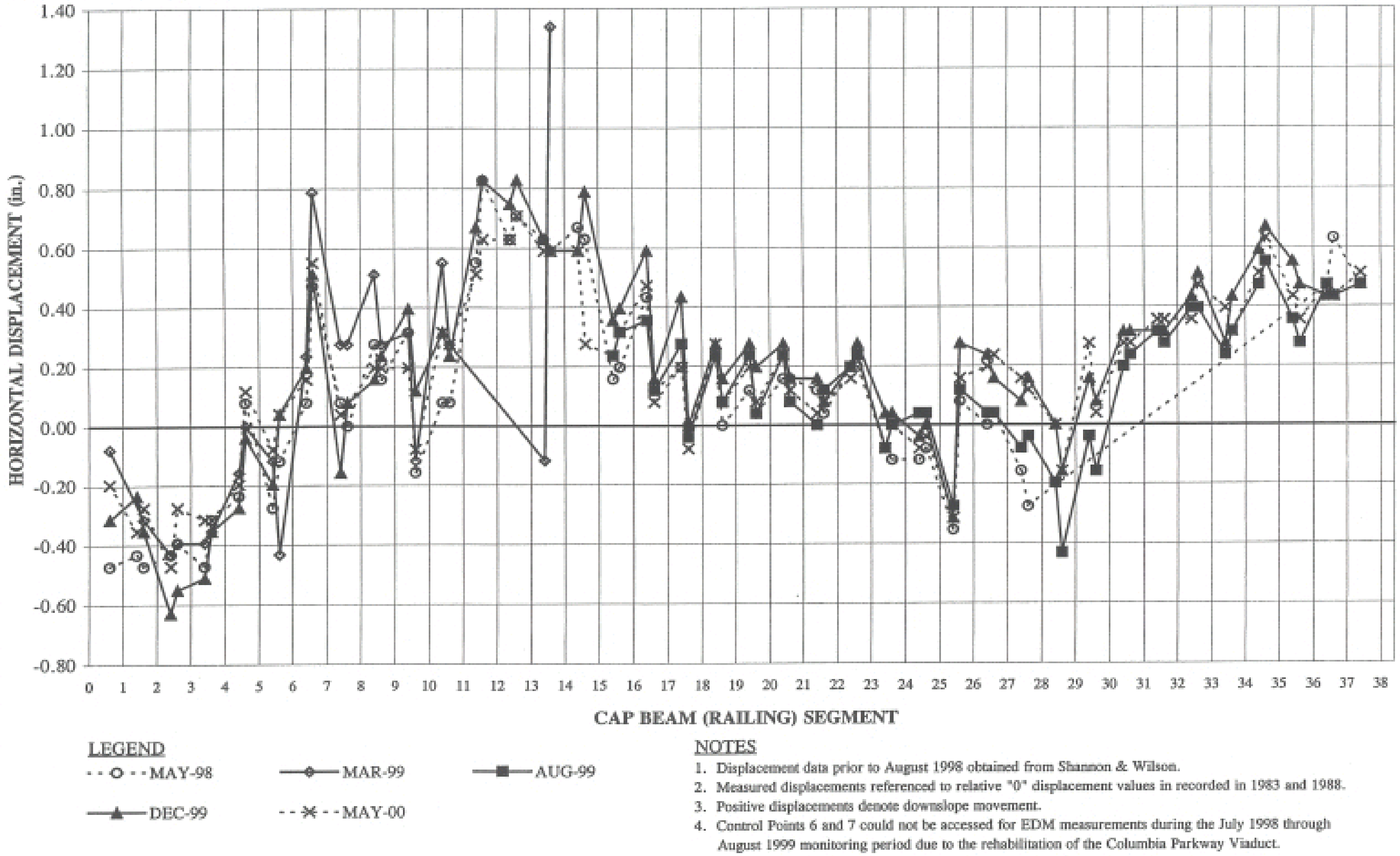
LEGEND

- CP-31 (1330 kips @ 100%)
- CP-90 (1175 kips @ 100%)

NOTES

1. Tendon load data prior to August 1998 obtained from Shannon & Wilson.
2. Tendon load measured in the anchor tunnel with hydraulic load cell.
3. For CP-31, percent of design load (R) = [21.9(X)+1.4]/1330; where X = load cell measurement.
4. For CP-90, percent of design load (R) = [22.3(X)-58.8]/1175; where X = load cell measurement.

BURGESS & NIPLE	MT. ADAMS / I-471 SLOPE STABILIZATION PROJECT Cincinnati, Ohio August 2000	CP-31 AND CP-90 TENDON LOAD MEASUREMENTS	FIGURE B-1



NOTES

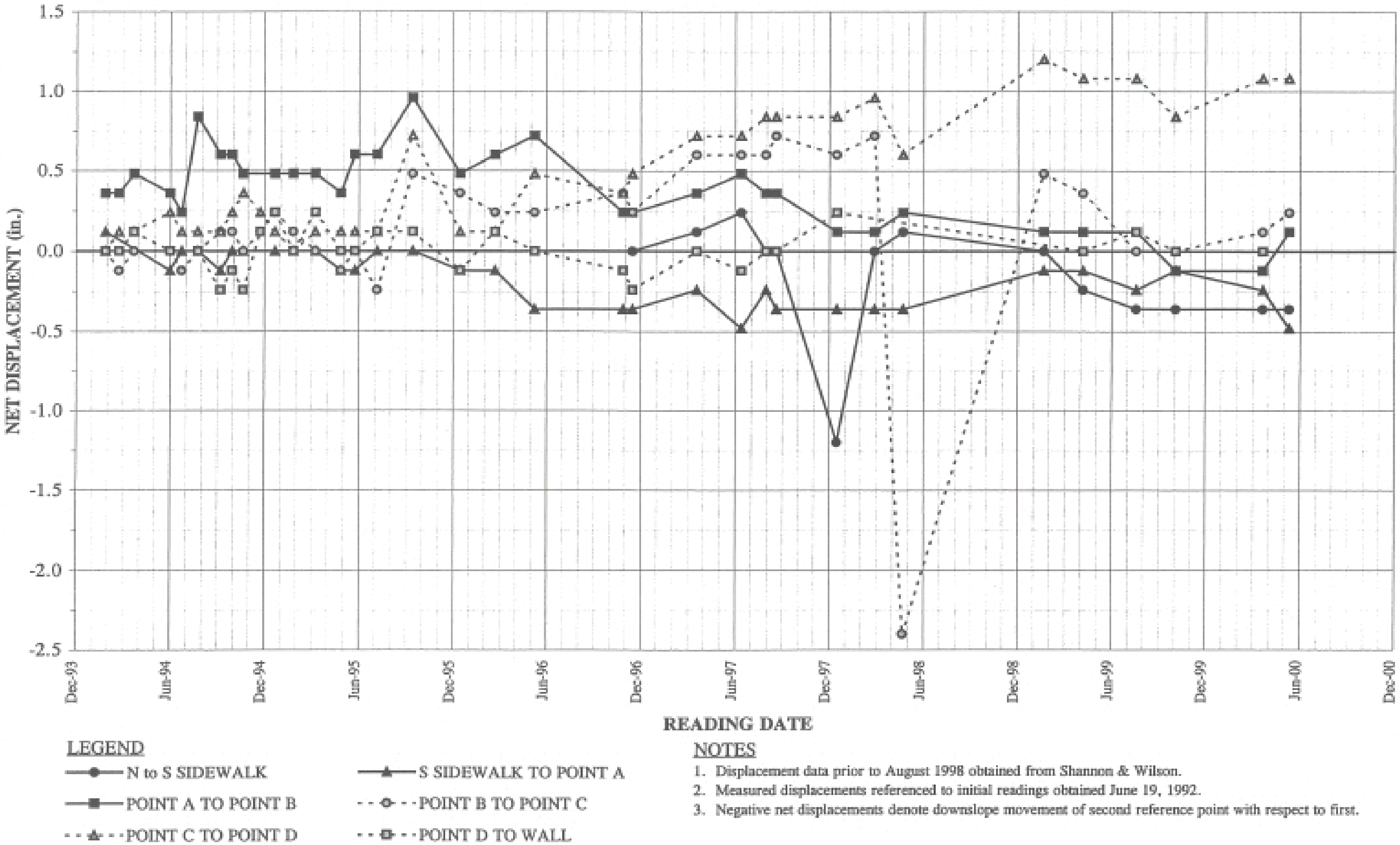
1. Displacement data prior to August 1998 obtained from Shannon & Wilson.
2. Measured displacements referenced to relative "0" displacement values in recorded in 1983 and 1988.
3. Positive displacements denote downslope movement.
4. Control Points 6 and 7 could not be accessed for EDM measurements during the July 1998 through August 1999 monitoring period due to the rehabilitation of the Columbia Parkway Viaduct.

BURGESS & NIPLE	MT. ADAMS / I-471 SLOPE STABILIZATION PROJECT Cincinnati, Ohio August 2000	EDM WALL DISPLACEMENT MEASUREMENTS	FIGURE B-3

FIGURE B-4 - TUNNEL ANCHOR BLOCK EXTENSOMETER MEASUREMENTS

Anchor Block	Reading Date	Distance EA (in.)	Difference From Base	Distance EB (in.)	Difference From Base	Distance EC (in.)	Difference From Base	Distance ED (in.)	Difference From Base	Distance EF (in.)	Difference From Base	Distance EG (in.)	Difference From Base
2	Baseline	76.979		77.999		85.177		82.982		71.985		73.546	
	Nov-98	76.953	-0.026	77.982	-0.017	85.131	-0.046	82.942	-0.040	71.937	-0.048	73.508	-0.038
	Apr-99	76.946	-0.033	77.968	-0.031	85.128	-0.049	82.967	-0.015	71.943	-0.042	73.519	-0.027
	Nov-99	76.950	-0.029	77.968	-0.031	85.153	-0.024	82.975	-0.007	71.943	-0.042	73.510	-0.036
7	Baseline	76.571		78.536		84.466		83.238		71.239		71.648	
	Nov-98	76.513	-0.058	78.514	-0.022	84.417	-0.049	83.204	-0.034	71.209	-0.030	71.618	-0.030
	Apr-99	76.532	-0.039	78.501	-0.035	84.433	-0.033	83.219	-0.019	71.205	-0.034	71.621	-0.027
	Nov-99	76.525	-0.046	78.496	-0.040	84.405	-0.061	83.202	-0.036	71.296	0.057	71.612	-0.036
13	Baseline	77.491		76.788		85.056		85.048		69.696		75.286	
	Nov-98	77.491	0.000	76.786	-0.002	85.046	-0.010	85.046	-0.002	69.677	-0.019	75.275	-0.011
	Apr-99	77.463	-0.028	76.780	-0.008	85.024	-0.032	85.032	-0.016	69.661	-0.035	75.272	-0.014
	Nov-99	77.465	-0.026	76.772	-0.016	85.021	-0.035	85.044	-0.004	69.659	-0.037	75.273	-0.013
19	Baseline	73.409		72.086		81.413		83.430		67.421		65.854	
	Nov-98	73.383	-0.026	72.098	0.012	81.406	-0.007	83.408	-0.022	67.397	-0.024	65.848	-0.006
	Apr-99	73.382	-0.027	72.059	-0.027	81.389	-0.024	83.400	-0.030	67.389	-0.032	65.831	-0.023
	Nov-99	73.371	-0.038	72.052	-0.034	81.384	-0.029	83.389	-0.041	67.374	-0.047	65.825	-0.029
25	Baseline	71.919		70.266		73.628		74.840		62.118		64.583	
	Nov-98	71.906	-0.013	70.258	-0.008	73.605	-0.023	74.798	-0.042	62.119	0.001	64.583	0.000
	Apr-99	71.879	-0.040	70.237	-0.029	73.598	-0.030	74.800	-0.040	62.069	-0.049	64.543	-0.040
	Nov-99	71.868	-0.051	70.226	-0.040	73.574	-0.054	74.787	-0.053	62.060	-0.058	64.538	-0.045
31	Baseline	74.381		75.234		82.943		81.969		61.398		61.139	
	Nov-98	74.388	0.007	75.225	-0.009	82.913	-0.030	81.954	-0.015	61.380	-0.018	61.135	-0.004
	Apr-99	74.367	-0.014	75.214	-0.020	82.917	-0.026	81.955	-0.014	61.365	-0.033	61.115	-0.024
	Nov-99	74.348	-0.033	75.213	-0.021	82.905	-0.038	81.948	-0.021	61.373	-0.025	61.107	-0.032
37	Baseline	77.480		71.671		84.732		89.240		67.441		70.485	
	Nov-98	77.459	-0.021	71.647	-0.024	84.757	0.025	89.222	-0.018	67.449	0.008	70.496	0.011
	Apr-99	77.453	-0.027	71.647	-0.024	84.700	-0.032	89.218	-0.022	67.425	-0.016	70.533	0.048
	Nov-99	77.451	-0.029	71.658	-0.013	84.677	-0.055	89.227	-0.013	67.414	-0.027	70.526	0.041
43	Baseline	74.926		74.887		84.060		86.042		66.776		71.088	
	Nov-98	74.891	-0.035	74.886	-0.001	84.029	-0.031	86.028	-0.014	66.749	-0.027	71.074	-0.014
	Apr-99	74.854	-0.072	74.852	-0.035	84.017	-0.043	85.993	-0.049	66.721	-0.055	71.062	-0.026
	Nov-99	74.864	-0.062	74.871	-0.016	83.999	-0.061	86.001	-0.041	66.732	-0.044	71.049	-0.039
49	Baseline	73.365		71.945		84.654		85.266		64.946		63.630	
	Nov-98	73.342	-0.023	71.942	-0.003	84.639	-0.015	85.233	-0.033	64.943	-0.003	63.685	0.055
	Apr-99	73.317	-0.048	71.921	-0.024	84.629	-0.025	85.238	-0.028	64.925	-0.021	63.658	0.028
	Nov-99	73.323	-0.042	71.932	-0.013	84.614	-0.040	85.209	-0.057	64.923	-0.023	63.569	-0.061
54	Baseline	68.165		69.200		81.315		81.884		60.920		61.187	
	Nov-98	68.127	-0.038	69.199	-0.001	81.314	-0.001	81.768	-0.116	60.907	-0.013	61.189	0.002
	Apr-99	68.117	-0.048	69.180	-0.020	81.293	-0.022	81.754	-0.130	60.897	-0.023	61.155	-0.032
	Nov-99	68.105	-0.060	69.173	-0.027	81.309	-0.006	81.755	-0.129	60.889	-0.031	61.156	-0.031
60	Baseline	70.403		69.880		82.934		84.273		62.889		63.246	
	Nov-98	70.404	0.001	69.872	-0.008	82.931	-0.003	84.262	-0.011	62.870	-0.019	63.249	0.003
	Apr-99	70.387	-0.016	69.846	-0.034	82.900	-0.034	84.236	-0.037	62.846	-0.043	63.227	-0.019
	Nov-99	70.384	-0.019	69.847	-0.033	82.889	-0.045	84.228	-0.045	62.850	-0.039	63.225	-0.021
66	Baseline	70.465		73.020		90.968		89.237		66.234		64.533	
	Nov-98	70.449	-0.016	73.010	-0.010	90.936	-0.032	89.233	-0.004	66.202	-0.032	64.538	0.005
	Apr-99	70.436	-0.029	72.993	-0.027	90.925	-0.043	89.215	-0.022	66.194	-0.040	64.523	-0.010
	Nov-99	70.451	-0.014	73.028	0.008	91.000	0.032	89.239	0.002	66.188	-0.046	64.540	0.007

(CONTINUED)



NOTES

1. Displacement data prior to August 1998 obtained from Shannon & Wilson.
2. Measured displacements referenced to initial readings obtained June 19, 1992.
3. Negative net displacements denote downslope movement of second reference point with respect to first.

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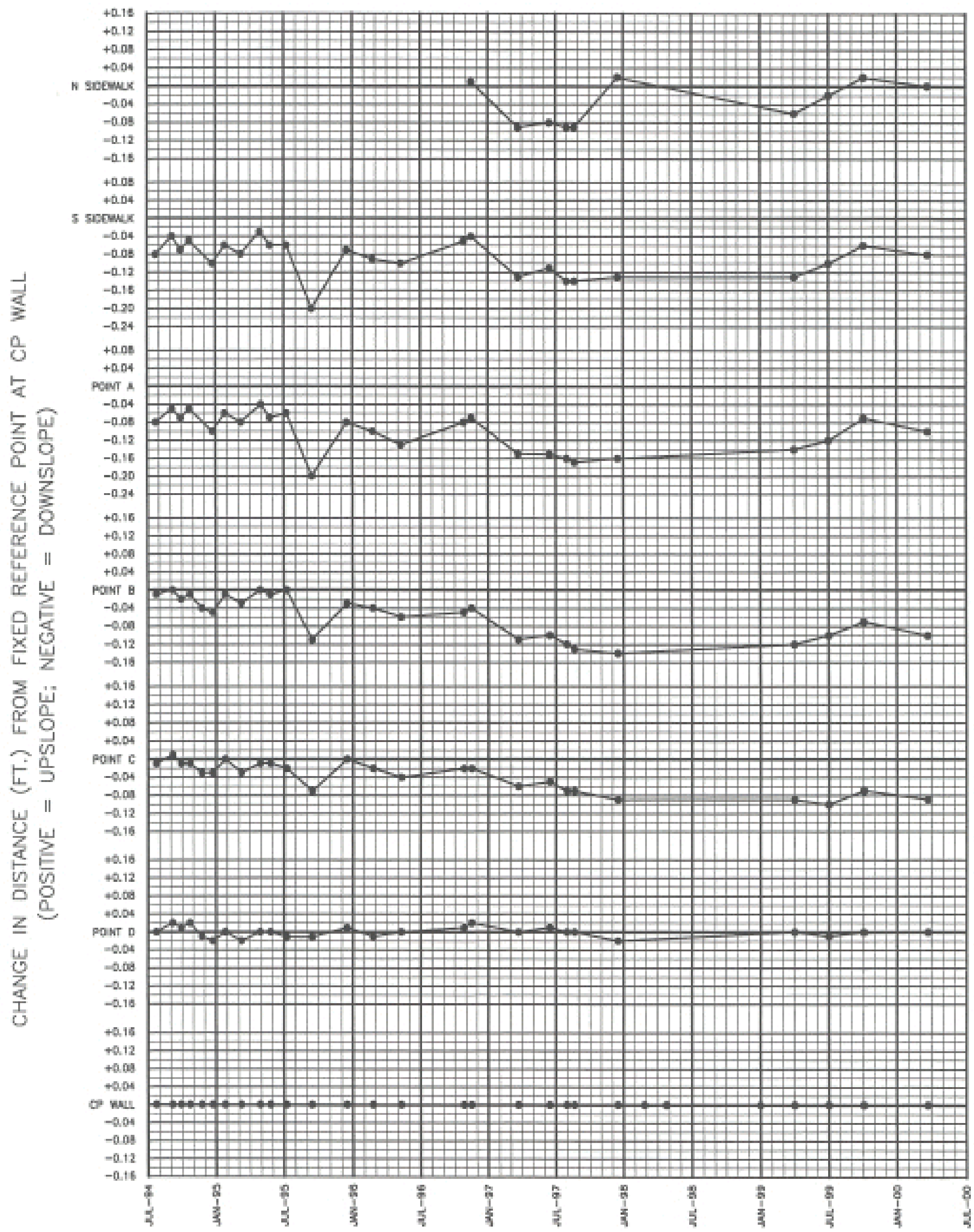
SURVEY LINE 1
MEASUREMENTS

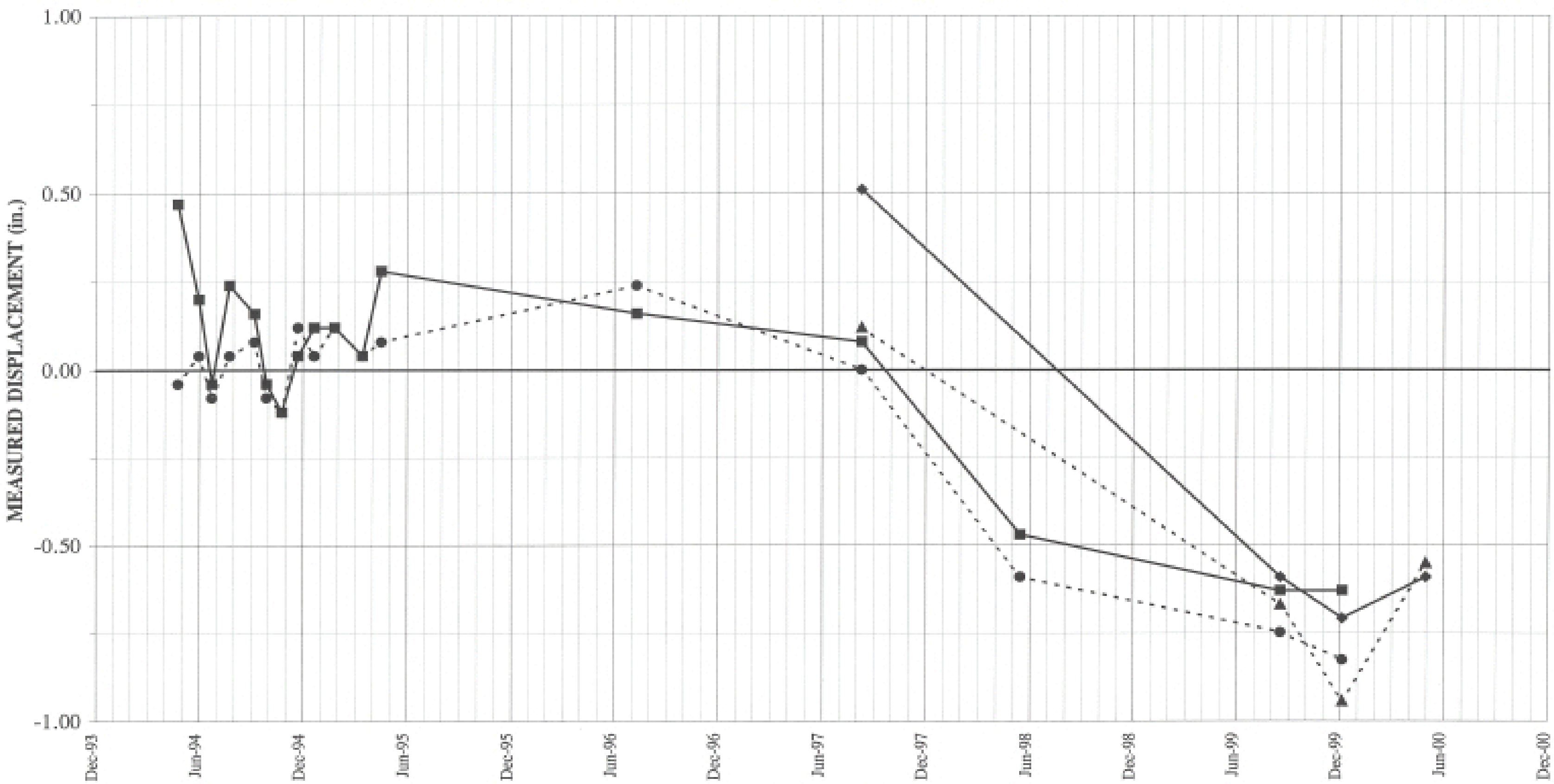
FIGURE
C-4.1



NOTES:

1. Displacements referenced to basline distance of each reference point to an assumed fixed point at the cylinder pile wall.
2. Distances measured sequentially from point to point and parallel to ground surface.
3. Displacement data prior to August 1998 obtained from Shannon & Wilson.

BURGESS AND NIPLE, LTD. ENGINEERS & ARCHITECTS	MT. ADAMS / I-471 SLOPE STABILIZATION PROJECT	SURVEY LINE 1	FIGURE C-4.1a



LEGEND

- CP-3 TO WEST COLUMN
- CP-3 TO EAST COLUMN
- CP-4 TO WEST COLUMN
- CP-4 TO EAST COLUMN

NOTES

1. Displacement data prior to August 1998 obtained from Shannon & Wilson.
2. Initial data for CP-3 obtained March 23, 1994. Initial data for CP-4 obtained April 25, 1994.
3. Only one reading from CP-4 to West and East Columns obtained between 1994 and 1998.
4. Positive displacements denote downslope movements.

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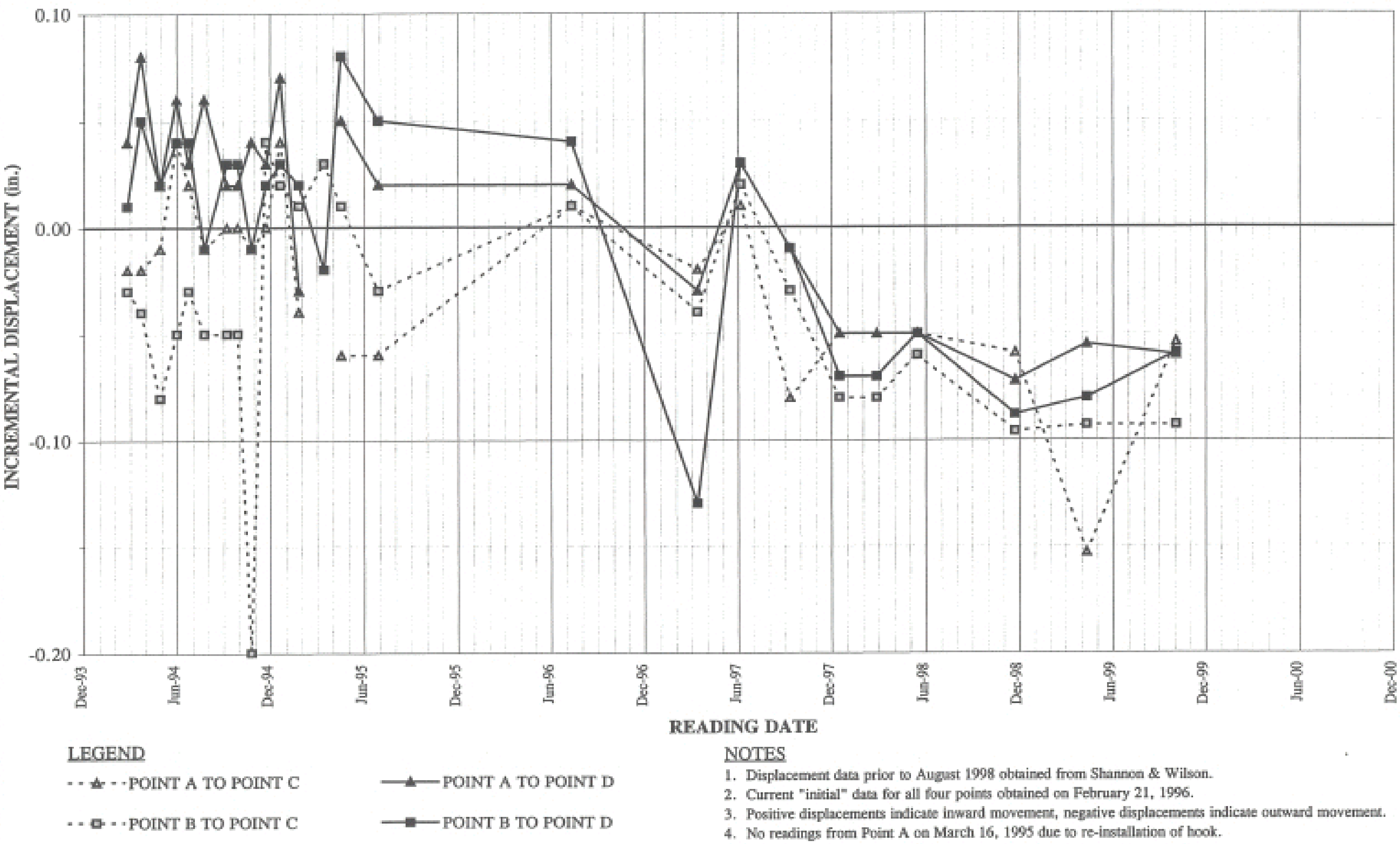
RAMP P (PIER NUMBER 7)
EDM DISPLACEMENTS

FIGURE D-1



NOTES

1. Displacement data prior to August 1998 obtained from Shannon & Wilson.
2. Current "initial" data for all four points obtained on February 21, 1996.
3. Positive displacements indicate inward movement, negative displacements indicate outward movement.
4. No readings from Point A on March 16, 1995 due to re-installation of hook.

BURGESS & NIPLE	MT. ADAMS / I-471 SLOPE STABILIZATION PROJECT Cincinnati, Ohio August 2000	RAMP P (PIER NUMBER 7) EXTENSOMETER DISPLACEMENTS	FIGURE D-2

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PART IV
SECTION 5: TENDON SURVEILLANCE PROCEDURES

5. Tendon Surveillance Inspection Procedures

A tendon surveillance inspection shall include a grease and anchorage inspection, tendon liftoff load measurement, tendon wire continuity testing, tendon wire inspection, and tendon retensioning and resealing. Although initial tensioning was done at the upper end of the tendons along the face of the cylinder pile wall, it may be more convenient to perform retensioning from inside the tunnel at the lower end of the tendons because of the restricted access in front of the cylinder pile wall. Prior to and immediately after surveillance testing, instrumentation adjacent to the tendons being inspected should be carefully monitored.

Each surveillance inspection should include the following tasks:

1. Remove upper- and lower-end grease caps on selected tendons along the length of the wall.

2. Visual inspect the ends of the tendon including:
   a. a check for water or moisture
   b. a check of the pH of the water
   c. a sample of grease for chemical analysis for percentage of water and water soluble chlorides, nitrates, and sulfides
   d. a check for grease coverage on various parts of the bearings assembly and tendon wires
   e. a count of the number of buttonheads
   f. a check of buttonheads for splits
   g. a check of buttonheads for size, using an acceptance die
   h. a check for corrosion level of the grease can, the buttonheads, anchor head, shims, and bearing plate

3. Conduct a liftoff test to determine the tendon load and to detension the tendon for removal of shims.

4. Individually tension a percentage of the tendon wires in each tendon bundle to 1,000 pounds to check for wire integrity and continuity.

5. Select and remove a wire or wires from the tendon bundle.

6. Examine pulled wires for evidence of corrosion.

7. Conduct strength and other laboratory analyses of the wire if appropriate.

8. Retension the tendon, regrease, and replace the grease caps.

9. Provide a detailed report describing the results of the surveillance inspection including results of all laboratory tests.

Table II includes criteria for evaluating the relative degree of corrosion of steel, Table IV provides acceptable tolerances for buttonheads in general accordance with “Quality Control Procedures” established by the Prescon Corporation.

5.1 Materials, Equipment, and Procedures for Tensioning and Detensioning Tendons

(National Engineering and Contracting Company)

Materials:

1. Anti-seizing compound for coating threads of upper washer, bushing, and head of ram.

2. Solvent and rags for removing amber coating on wires prior to buttonheading and for cleaning up excess grease.

3. When replacing tendon, it requires at least two (2) full drums of Visconorust 2090 P-4 casing grease.

4. In addition to proper number of 1/4" wires cut to correct length, a new tendon must have wire grip with washer or bar fastened to live end washer for handling purposes.

5. Sufficient pairs of matched shims to provide proper spacing of anchors off of bearing plates top and bottom. (See tendon drawings and material list for suggested shim stacks.)

Equipment:

1. For Performing Lift-Offs.

    1. Mobile crane for handling ram and other equipment and materials (20 ton minimum - 40 ton rough terrain with Auxiliary Drum recommended).

    2. 50 KW generator with ground rod for providing 440V 3 phase and 220V single phase power supply to hydraulic equipment with sufficient four (4) conductor wire.

    3. 1,000 ton Prescon ram with hydraulic gauge and 10,000 PSI quick disconnect hoses.

    4. Rodgers 10,000 PSI pump for driving 1,000 ton ram with hydraulic gauge. (440V 3 phase)

    5. Power Team 1,400 PSI pump for driving threaded head of ram. (440V 3 phase)

    6. Four (4) ton chainfall for stabilizing and aligning ram on tendon. Two (2) each 2-ton cable come-a-longs and 50' x ½" rope for tag line.

7. Wire rope spreader and chokers for handling equipment.

8. Scaffolding will be necessary when performing lift-offs on tendons that are located too high up on wall to allow access by foot. When scaffolding is required, planks for work platforms and ladders for access to platforms must be provided.

9. Micrometers for measuring elongation when tensioning and detensioning.

10. Neoprene belt cradle and clamps for holding upper shim stack in place prior to releasing ram.

11. Pry bar for applying pressure to shims.

2. For New Tendon Installation–in addition to items 1 through 11 previously listed, the following is also needed:

   1. Prescon Corporation 8' diameter uncoiling tub.

   2. PROCEQ SA Model DS47 hydraulic wire upsetting device (buttonheader) with OTC Model Y-26 hydraulic with gauge power unit (115 V single phase).

   3. Hydraulic grease pump with suction attachment and hoses.

   4. Four (4) band-type drum heaters for heating Visconorust 2090 P-4 casting grease (200V single phase).

   5. One small hydraulic port-a-power or cylinder for pushing bottom washer after wires are threaded.

   6. Die-grinder with carborundum wheels for cutting and grinding tendon wires.

   7. Nylon web slings or chokers for handling tendon.

<u>Procedures for Performing Lift-Off:</u>

Position and set up mobile crane, preferably at a location where it can unload, set up equipment, and perform work without having to move.

Erect scaffolding, build platforms, and erect ladders if needed.

Set up generator with ground rod on a reasonably level area. Locate and secure hydraulic pumps in close proximity. Pumps must be close enough that hydraulic hoses will reach fittings on ram without chaffing, crimping, binding, or causing excess pull on ram fittings.

Wire generator to supply boxes on hydraulic pumps. Both pumps used to operate ram are 440V 3 phase, 60 cycle.

Check that all hydraulic fittings are clean before connecting houses.

Check both hydraulic pumps for oil level. The Rodgers 10,000 PSI pump oil level should be 2-1/2" from the top of the reservoir. The power Team 1400 PSI pump should show full in the oil reservoir sight gauge.

Check both pump motors for correct rotation as indicated by direction arrows on motor or coupler.

Coupler hoses from both pumps to ram. Hose fittings and ram fittings are color coded to avoid improper hook-up. The ram pull rod assembly that is equipped with a hydraulic threading device is operated by the Power Team 1400 PSI pump. The ram itself is operated by the Rodgers 10,000 PSI pump.

Before coupling to a tendon, extend the ram to about 10" in order to bleed the hoses of any air. Retract ram before coupling to tendon. Do not run pressure on gauge after the ram is completely retracted.

Remove tendon grease cap and clean excess grease from upper bushing and washer. Place appropriate amount of anti-seizing compound on threads of bushing and threads in head of ram pull rod assembly.

Using appropriate size shackles, rig two lines from mobile crane to pull rod assembly frame on ram. Hoist ram into position and proper attitude using both lines from crane and tag line fastened to upper end of ram. It is occasionally necessary to fasten 2-ton come-a-long to end of ram and secure to adjacent caisson in order to obtain proper alignment.

Once ram appears to be properly aligned, carefully lower ram down and in towards washer and bushing. When threaded head of ram comes to rest against bushing, you may begin rotating threaded head clockwise in order to engage threads. Using a mirror, monitor this coupling closely. Do not allow cross-threading to occur. When lower end of threaded head approaches bottom end of bushing, cease threading operation with space left between top of shim stack and bottom of threaded head. This space should be a minimum of 1/4". If the head is allowed to approach too near or allowed to come to rest against shim stack, it may be impossible to disengage ram. While monitoring the threading, also observe the alignment of the anchor bolts on trumpet assembly of caisson with holes provided in shoe of ram. Occasionally, bolts must be realigned to fit.

After ram head has been threaded onto bushing with the proper spacing to top of shim stack, use Rodgers pump with hand control to extend ram and seat ram shoe firmly against tendon anchor plate. While seating ram shoe, observe hydraulic gauge on ram. When it records 500-600 PSI, ram should be sufficiently seated on anchor plate without affecting tendon elongation.

USE EXTREME CAUTION: Equipment failure at this point could result in severe injury to anyone working with the shim stack.

Now select Neoprene belting of proper dimensions and thread belting between ram housing and outer surface of shims. Belting must be wide enough to support shim stack and long enough to extend over the clamp to flanges of ram housing. Once this belting is in place, the lift-off can commence.

For the actual lift-off, the only tools required are a pry bar and a measuring device.

The length of the piston protruding beyond the cylinder should be measured with the gauge reading 0. After the lift-off value ha been obtained and again after the gauge has been run back down and the ram relaxed.

The pry bar should be positioned between the ram housing and the shim stack. Using the ram housing as a fulcrum, pry against the shim stack while extending ram. When any discernible movement of shim stack occurs, the reading on the hydraulic gauge on the ram should be recorded. Using this reading, the actual load on the tendon may be extrapolated using the conversion factor for this ram.

After lift-off has been satisfactorily performed, realign shim stack and retract ram to reseat washer and bushing on shims. When piston has retracted completely, ram may be unthreaded from bushing. Repack grease on bushing threads and grease cap and refasten grease cap to caisson.

<u>Procedure for Installing and Stressing New Tendon</u>:

Before installing a new tendon, the old tendon must be removed. There are any number of methods to remove an old tendon. The method utilized will probably depend on the manner of failure. It is beyond the scope of this procedure manual to enumerate and define these methods.

The purpose of these instructions are to provide a step-by-step procedure to allow for the safe and correct installation of a new tendon.

It should be pointed out that if the old tendon has failed, the reinforced concrete anchor block in the tunnel should be braced off the opposite wall and the lower trumpet reseated in anchor block if necessary. If during the failure any grout was lost from behind the anchor block, or if the anchor block will not reseat completely against the old surface, it will have to be re-grouted. This procedure is fully documented in the project records.

As in the lift-off procedure, a mobile crane should be set up and any scaffolding required erected. Also, the generator and hydraulic power units should be located and hooked up as previously described.

At this time, the Prescon uncoiling tub should be set up in front of the cylinder pile. The tub should be positioned in line with tendon liner pipe and at an elevation that will permit the new tendon to be unreeled an d fed down the liner pipe without bending or binding on trumpet assembly. The uncoiling tub might have to be secured to the ground or the scaffolding in order to provide the needed stability.

Once tub is in position, rig new tendon coil with web slings or chokers and hoist into position on uncoiled reel with mobile crane. The hydraulic lines from the Power Team 1,400 PSI pump should now be coupled to the quick disconnect fittings that lead to the pump that operates the pistons on the inner reel. These pistons when extended will expand inner reel and lock new tendon coil into place. Now tie-off live end washer to inner reel with a choker or cable come-a-long to prevent new tendon coil slipping around reel.

When coil is secure, the new tendon is now ready to be fed down liner pipe.

WARNING: When uncoiling the new tendon, have tunnel personnel stand clear of the outlet of the liner pipe in tunnel.

The hydraulic lines can now be disconnected from the inner reel fittings and reconnected to the fittings on the lower outside portion of the uncoiling tub. These fittings lead to a hydraulically powered chain drive unit that turns the reel itself.

During manufacture, the new tendon will have been laid out and cut to length on a shop table. The live end washer is then threaded on and that end buttonheaded. A mesh device with a pulling eye called a “Kellum Grip” is then fastened to the dead end. The new tendon is then banded at uniform intervals throughout. The manufacturer then coils new tendon on a coiling-uncoiling tub. As it is coiled, additional bands are fastened to the tendon until coiling is complete.

As uncoiling commences, the bands nearest the “Kellum Grip” are removed first. There are split-head band cutting tools provided for this task. As the reel rotates and the outer bands are removed, the dead end of the tendon is directed down the liner pipe. The inner bands should be cut just as they approach the upper trumpet. If the inner bands are cut too soon, it allows the tendon wires to separate or “birdcage” and makes it more difficult to feed tendon down the liner pipe and could possibly cause damage to wires.

When tendon has uncoiled completely, the live end wire washer or gripping bar should be rigged to line from mobile crane and unfastened from reel. Any choker or come-a-long fastened to tendon below washer should be removed. The tendon should then be lowered and the live end washer temporarily spaced off upper bearing plate. At this time, measurements should be taken top and bottom to determine the proper cutting length of completed tendon. Temporary spacing is then removed and tendon is lowered until dead end is 5' to 6' into tunnel. The tendon is now ready for cutting to final length.

Remove the “Kellum Grip” from exposed end. Measure all wires from lower end uniformly and mark for cutting. The actual cutting is performed using a die grinder. The wire is cut perpendicular to the wires axis and the end ground smooth.

After all wires are cut, dead end washer is threaded with wires. This is most easily accomplished by suspending washer from ceiling of tunnel with a rope. When all wires have been threaded, washer is pushed up tendon 3' to 4' using a hydraulic cylinder or “Port-a-Power”. Tendon wire ends are now ready for buttonheading.

The buttonheading equipment consists of the “OTC” Model Y-26 hydraulic power unit with gauge and the “PROCEQ” MODEL DS47 wire upsetting device (buttonheader). The power unit operates off the 115 Volt electrical service receptacles in tunnel. An adaptor is needed to plug into the explosion proof receptacles.

Prior to buttonheading, the bottom 6" of each wire should be cleaned with solvent to remove the corrosion protection. If not removed, this coating will prevent machine jaws from gripping wire sufficiently, resulting in malformed buttonheads and gumming up the machine. After cleaning, the wire is fed into the buttonheader as far as it will go. The foot control is then depressed. When the proper pressure is reached, the relief valve opens and the wire is automatically released. The completed buttonhead is then checked with the "go-no go" gauge. When the formed buttonhead is the proper dimension, it will fit into the larger diameter opening on one end, but will not enter the smaller diameter opening at the opposite end. The buttonhead should then be inspected for any cracks or splits, as well as the wire adjacent to it. All wires in the new tendon are finished in this manner.

When buttonheading is completed, the dead end washer is pulled down close to the buttonheads. Now the live end washer is pulled back up the upper trumpet. As the lower washer nears the anchor plate, a matched pair of dead end shims are placed between the washer and anchor plate and the shims and washer are centered on the trumpet opening. This should be temporarily supported to keep assembly centered.

The live end washer will now be above the upper anchor plate assembly. A temporary spacing device should then be placed between the washer and anchor plate to hold the tendon while the crane line is detached and the temporary wire grip removed. The bushing is now threaded onto the live end washer, taking care that the threads are completely engaged. The tendon is now ready for stressing.

Follow the procedure for performing lift-offs in order to wire generator, hook up hydraulic pumps and thread ram onto upper washer. At this point refer to project documents for correct stressing procedure.

When the desired load has been attained, the piston extension of the ram and the space between the upper anchor plate surface and the bottom surface of the upper bushing is measured. These measurements will determine the depth of the shim stack needed. From past lift-off experience, it has been determined that 3/16" should be added to this measurement. The ram should then be extended an additional ½" to 1" to allow room for placing shims. Shims should have been cut from uniform stock and come in matched pairs. To minimize any slight deviation in

thickness, shims should be placed alternating the shim joints 90 degrees with each successive pair. Shims are held in place temporarily by Neoprene building clamp to the lower ram housing.

After stressing is completed and tendon is locked off, ram is unthreaded from upper bushing, disconnects from power sources, and hydraulic units disconnected from generator. Tendon is now ready for grease to be pumped into liner pipe.

The generator will now have to be moved close to either the access shaft or the ventilation shaft depending on which is closer to the tendon. The main control panel of the generator should be rewired for 220V single phase to accommodate the band heaters.

Two band heaters should be clamped around two full drums of casing grease for new tendon installation. Both drums should be heated until grease has thinned to the consistency of motor oil.

While grease is heating, the grease caps top and bottom should be bolted to the anchor blocks. The bolts should be evenly torqued taking care that the O-rings are properly seated in their grooves. The air plug should be removed from the upper grease cap and the center plug removed from the check valve fitting in the lower grease cap.

CAUTION: Use extreme caution. Grease at this point is approximately 250°F and under great pressure. It is also extremely flammable.

The grease pump is driven by the “Power Team” 1,400 PSI hydraulic unit, which is wired to the generator at the closest shaft. The grease pump is coupled by high pressure 1-1/2" hose to the suction unit and inserts into the open top of the grease drums. It is connected by another high pressure hose to the check valve fitting in the grease cap. When grease is hot enough and all connection have been made, grease is pumped into liner pipe continuously until grease is observed coming out of air plug opening in top cap. After grease has cooled, top cap should be probed to detect any possible shrinkage that has occurred. If any void is detected, a small amount of hot grease should be poured in manually to fill this space.

This completes a typical new tendon installation.