CARPENTER MARTY transportation

PIK-C.R. 00008-05.750

Pike County Engineer's Office

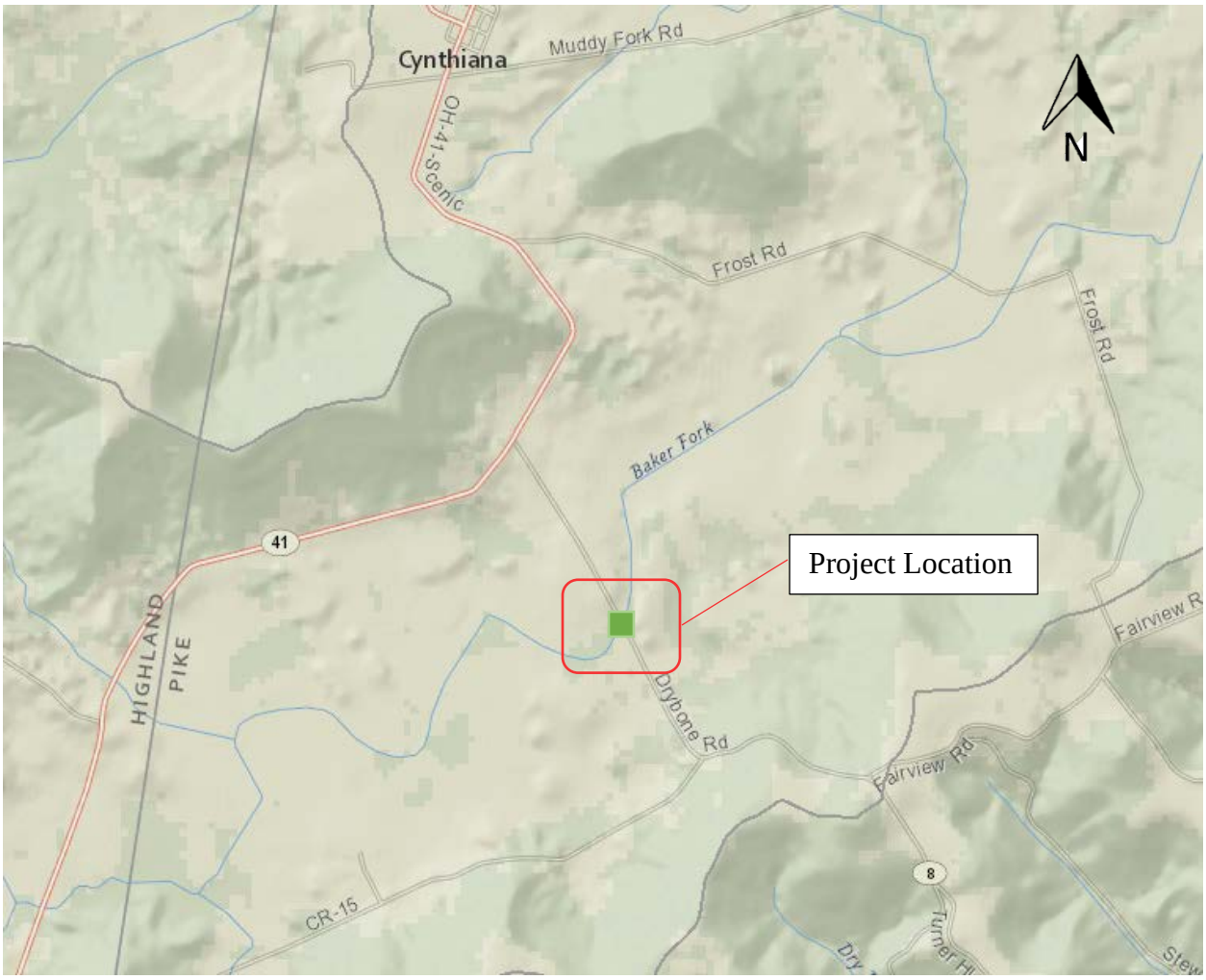
HYDROLOGY AND HYDRAULICS REPORT

February 2022

6612 Singletree Drive
Columbus, OH 43229
614.656.2424
www.cmtran.com

Table of Contents

I. Location Map



II. Project Description

A. General

This project involves the preparation of a design-build scope for the replacement of Bridge No. PIK-C.R. 00008-05.750 (SFN 6630820) carrying Drybone Road over Baker Fork in Pike County, Ohio. The purpose of this study is to perform a hydraulic analysis on the existing structure to estimate the design (10-year) and check (100-year) discharge frequency headwater elevations. This project is not located within a FEMA designated flood zone.

B. Site Location
This site is located 0.64 miles south of S.R. 41.

Site coordinates are:
Latitude: 39°08'54.06" N
Longitude: 83°20'23.35" W

C. Existing Structure
The existing structure on Drybone Road is a single span (38'-6" ±) non-composite steel girder bridge with concrete abutments. The low chord elevation of the existing structure is 888.73. The bridge is 16'± wide on a straight alignment with a 10° right forward skew. The traversable bridge width has been decreased to about 14'± due to the addition of guardrail mounted to barrels to keep traffic off the severely deteriorated fascia beams. The existing bridge uses over the side drainage.

D. Design Year Frequency
The ODOT Location and Design Manual (L&D) Volume 2 Section 1004.2 specifies that a 10-year frequency be used for the design flood for this structure based on an ADT less than 3000. The design will also be checked for the 100-year frequency.

E. Topography
The project structure is in Perry Township in Pike County. The existing channel has an average width of approximately 24 feet. A Manning's coefficient of 0.030 was used for the upstream main channel for a clean, straight channel with no rifts or deep pools, and increased to 0.035 for the downstream main channel for more stones and weeds. At the left and right overbanks, the Manning's coefficient was changed to 0.05 due to the presence of light trees and brush.

III. Hydraulic Data

A. Discharge Calculations and Drainage Area
The bridge is not located within a FEMA flood zone. Base flood elevations (BFEs) have not been determined. Downstream of the project, the channel is designated within FEMA Zone A as Baker Fork flows into Highland County to the west.

The USGS web-based application StreamStats was used to determine the basin characteristics of Baker Fork. The drainage area of Baker Fork at the project location is 11.80 square miles.
The discharges listed in Table 1 were used.

Table 1 – Peak Discharges

Discharge Year Frequency	Peak Discharge (cfs)
10-year	2170
100-year	3960

B. Boundary Conditions

The *Normal Depth* boundary condition was used to establish the starting water surface elevation at the ends of the studied reach. The slope of the Energy Grade Line was estimated as the slope of the channel bottom. This slope was estimated as 0.003125 ft./ft. in the immediate area of the project.

IV. HEC-RAS Results

Results are tabulated for the 10-year and 100-year frequency storm events.

Table 2 – Summary of HEC-RAS Results

Section	Location	Discharge Year Frequency	Ex. Bridge Headwater Elevation	Velocity (Feet Per Second)
1548		10-year	889.53	4.75
		100-year	894.28	3.88
1526	Upstream of Bridge	10-year	888.01	9.88
		100-year	892.09	11.56
1480	Downstream of Bridge	10-year	886.18	13.46
		100-year	888.82	16.56
1455		10-year	885.88	8.35
		100-year	886.85	9.33

V. Summary of Results

The design event clears the low chord of the existing bridge and will not overtop the roadway. While the 100-year event does not clear the low chord of the existing bridge, it does not overtop the roadway. There are no buildings within the 100-year frequency floodplain as determined from this study.

VI. Project Photographs

Upstream channel

Downstream channel

Upstream Bridge opening

Typical Underside of Bridge opening

VII. Appendices

A. Drainage Area Map and StreamStats Data
B. Cross-Section Locations
C. Existing Bridge Cross Sections
D. HEC-RAS Output for Existing Bridge

Appendix A

Drainage Area Map and StreamStats Data

Appendix A

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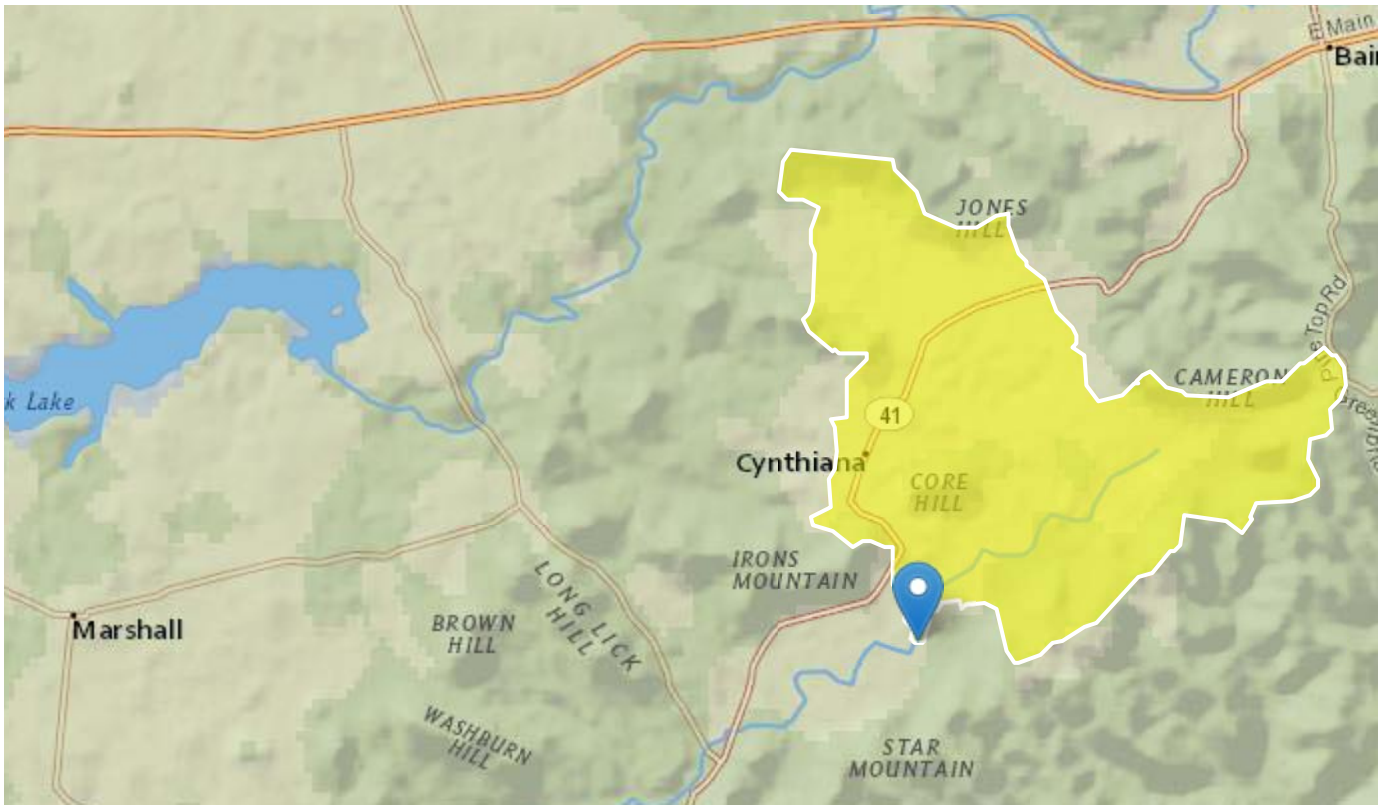
StreamStats Report

Region ID: OH
Workspace ID: OH20220203223223818000
Clicked Point (Latitude, Longitude): 39.14848, -83.33982
Time: 2022-02-03 17:32:43 -0500



SFN6630820 StreamStats Report

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	11.8	square miles
LC92STOR	Percentage of water bodies and wetlands determined from the NLCD	0.0619	percent
STREAM_VARG	Streamflow variability index as defined in WRIR 02-4068, computed from regional grid	0.75	dimensionless
LAT_CENT	Latitude of Basin Centroid	39.178	decimal degrees

Parameter Code	Parameter Description	Value	Unit
LONG_CENT	Longitude Basin Centroid	-83.323	decimal degrees
OHREGC	Ohio Region C Indicator	1	dimensionless
OHREGA	Ohio Region A Indicator	0	dimensionless
CSL1085LFP	Change in elevation divided by length between points 10 and 85 percent of distance along the longest flow path to the basin divide, LFP from 2D grid	16.5	feet per mi
PRECIP	Mean Annual Precipitation	41.6	inches
FOREST	Percentage of area covered by forest	33	percent

Flow Percentile Statistics Parameters [Low Flow LatGT 41.2 wri02 4068]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	11.8	square miles	0.12	7422
LC92STOR	Percent Storage from NLCD1992	0.0619	percent	0	19
STREAM_VARG	Streamflow Variability Index from Grid	0.75	dimensionless	0.25	1.13
LAT_CENT	Latitude of Basin Centroid	39.178	decimal degrees	41.2	41.59
LONG_CENT	Longitude of Basin Centroid	-83.323	decimal degrees	80.53	84.6

Flow Percentile Statistics Parameters [Low Flow LatLE 41.2 wri02 4068]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	11.8	square miles	0.12	7422
LC92STOR	Percent Storage from NLCD1992	0.0619	percent	0	19
STREAM_VARG	Streamflow Variability Index from Grid	0.75	dimensionless	0.25	1.13
LAT_CENT	Latitude of Basin Centroid	39.178	decimal degrees	38.68	41.2

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
LONG_CENT	Longitude of Basin Centroid	-83.323	decimal degrees	80.53	84.6

Flow Percentile Statistics Flow Report [Low Flow LatGT 41.2 wri02 4068]

Statistic	Value	Unit

Flow Percentile Statistics Flow Report [Low Flow LatLE 41.2 wri02 4068]

Statistic	Value	Unit

Flow Percentile Statistics Citations

Peak-Flow Statistics Parameters [100.0 Percent (11.8 square miles) Peak Flow Full Model Reg C SIR2019 5018]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	11.8	square miles	0.26	2514
OHREGC	Ohio Region C Indicator 1 if in C else 0	1	dimensionless	0	1
OHREGA	Ohio Region A Indicator 1 if in A else 0	0	dimensionless	0	1
CSL1085LFP	Stream Slope 10 and 85 Longest Flow Path	16.5	feet per mi	3.24	131
LC92STOR	Percent Storage from NLCD1992	0.0619	percent	0	1.23

Peak-Flow Statistics Flow Report [100.0 Percent (11.8 square miles) Peak Flow Full Model Reg C SIR2019 5018]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PIl	PIu	ASEp
50-percent AEP flood	1060	ft^3/s	550	2040	40.1
20-percent AEP flood	1690	ft^3/s	918	3110	37.2
10-percent AEP flood	2170	ft^3/s	1170	4020	37.6
4-percent AEP flood	2850	ft^3/s	1530	5320	38.1
2-percent AEP flood	3390	ft^3/s	1800	6400	37.8

Statistic	Value	Unit	PII	Plu	ASEp
1-percent AEP flood	3960	ft^3/s	2080	7550	39.6
0.2-percent AEP flood	5450	ft^3/s	2830	10500	40.3

Peak-Flow Statistics Citations

Koltun, G.F.,2019, Flood-frequency estimates for Ohio streamgages based on data through water year 2015 and techniques for estimating flood-frequency characteristics of rural, unregulated Ohio streams: U.S. Geological Survey Scientific Investigations Report 2019–5018, 25 p. (https://dx.doi.org/10.3133/sir20195018)

Monthly Flow Statistics Parameters [Low Flow LatLE 41.2 wri02 4068]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	11.8	square miles	0.12	7422
LC92STOR	Percent Storage from NLCD1992	0.0619	percent	0	19
PRECIP	Mean Annual Precipitation	41.6	inches	34	43.2
FOREST	Percent Forest	33	percent	0	99.1
LAT_CENT	Latitude of Basin Centroid	39.178	decimal degrees	38.68	41.2
STREAM_VARG	Streamflow Variability Index from Grid	0.75	dimensionless	0.25	1.13

Monthly Flow Statistics Flow Report [Low Flow LatLE 41.2 wri02 4068]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SE	ASEp
January Mean Flow	19.1	ft^3/s	16.6	16.6
February Mean Flow	24.2	ft^3/s	11.9	11.9
March Mean Flow	27.1	ft^3/s	14	14
April Mean Flow	24.6	ft^3/s	11.2	11.2
May Mean Flow	18	ft^3/s	19.5	19.5
June Mean Flow	8.85	ft^3/s	27	27
July Mean Flow	4.73	ft^3/s	28.2	28.2
August Mean Flow	3.86	ft^3/s	36.8	36.8

Statistic	Value	Unit	SE	ASEp
September Mean Flow	2.56	ft^3/s	43.6	43.6
October Mean Flow	1.98	ft^3/s	50.8	50.8
November Mean Flow	6.67	ft^3/s	37.5	37.5
December Mean Flow	14	ft^3/s	21.8	21.8

Monthly Flow Statistics Citations

Koltun, G. F., and Whitehead, M. T.,2002, Techniques for Estimating Selected Streamflow Characteristics of Rural, Unregulated Streams in Ohio: U. S. Geological Survey Water-Resources Investigations Report 02-4068, 50 p (https://pubs.er.usgs.gov/publication/wri024068)

General Flow Statistics Parameters [Low Flow LatLE 41.2 wri02 4068]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	11.8	square miles	0.12	7422
LC92STOR	Percent Storage from NLCD1992	0.0619	percent	0	19
STREAM_VARG	Streamflow Variability Index from Grid	0.75	dimensionless	0.25	1.13
LAT_CENT	Latitude of Basin Centroid	39.178	decimal degrees	38.68	41.2

General Flow Statistics Flow Report [Low Flow LatLE 41.2 wri02 4068]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	SE	ASEp
Harmonic Mean Streamflow	0.702	ft^3/s	65.9	65.9

General Flow Statistics Citations

Koltun, G. F., and Whitehead, M. T.,2002, Techniques for Estimating Selected Streamflow Characteristics of Rural, Unregulated Streams in Ohio: U. S. Geological Survey Water-Resources Investigations Report 02-4068, 50 p (https://pubs.er.usgs.gov/publication/wri024068)

Probability Statistics Parameters [P zero Flow 2012 5138]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	11.8	square miles	1	1250
STREAM_VARG	Streamflow Variability Index from Grid	0.75	dimensionless	0.24	1.12

Probability Statistics Flow Report [P zero Flow 2012 5138]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

Statistic	Value	Unit	PC
Probability zero flow 1Day	0.173	dim	91
Probability zero flow 7Day	0.0937	dim	94
Probability zero flow 30Day	0.00671	dim	97

Probability Statistics Citations

Koltun, G.F., and Kula, S.P.,2013, Methods for estimating selected low-flow statistics and development of annual flow-duration statistics for Ohio: U.S. Geological Survey Scientific Investigations Report 2012–5138, 195 p. (http://pubs.usgs.gov/sir/2012/5138/)

Application Version: 4.6.2
StreamStats Services Version: 1.2.22
NSS Services Version: 2.1.2

Appendix B
Cross-Section Locations

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Appendix B

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Appendix C
Existing Bridge Cross Sections

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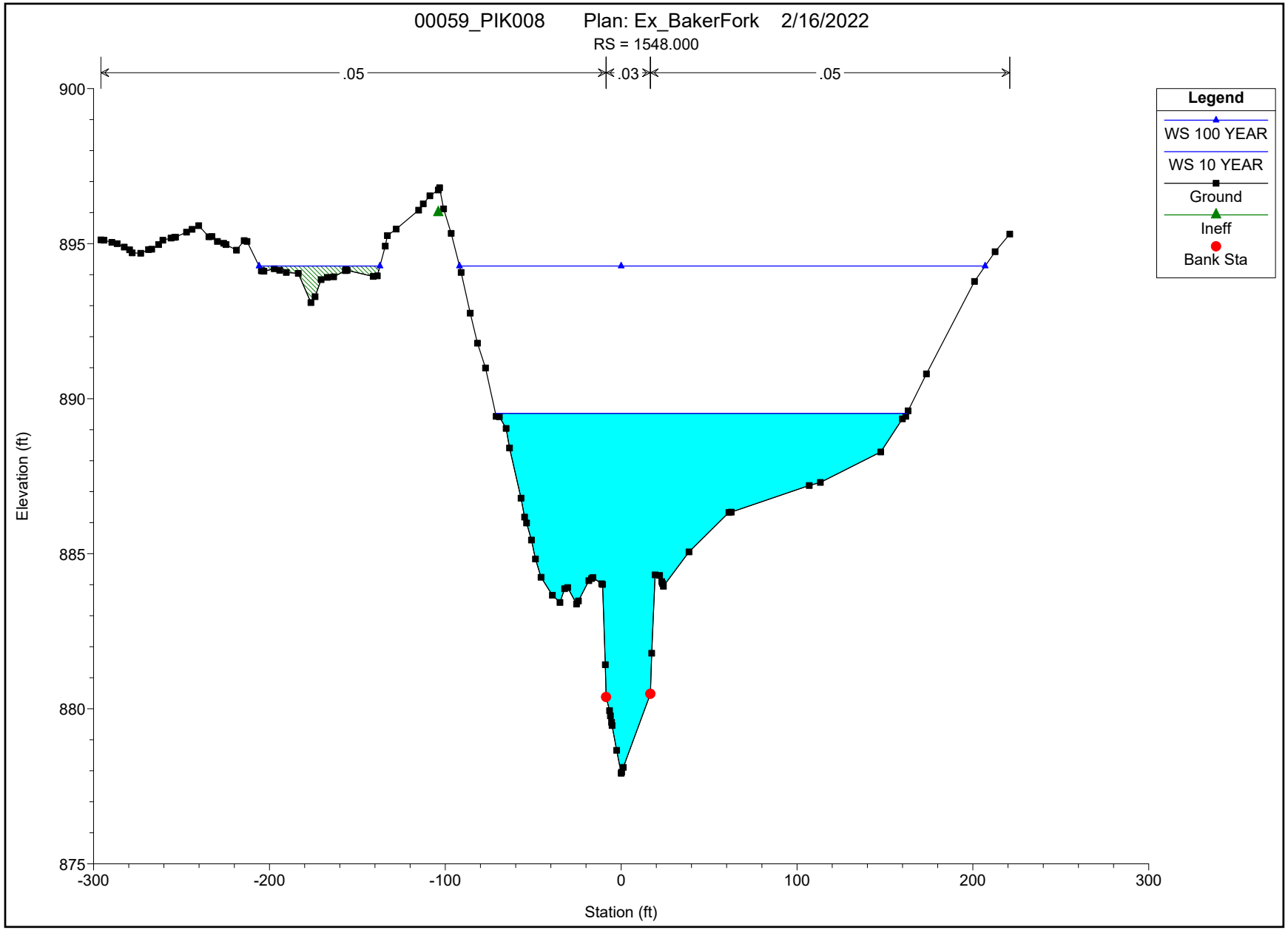
Appendix C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.03
.05
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895
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875
Elevation (ft)
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-200
-100
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Station (ft)
Legend
WS 100 YEAR
WS 10 YEAR
Ground
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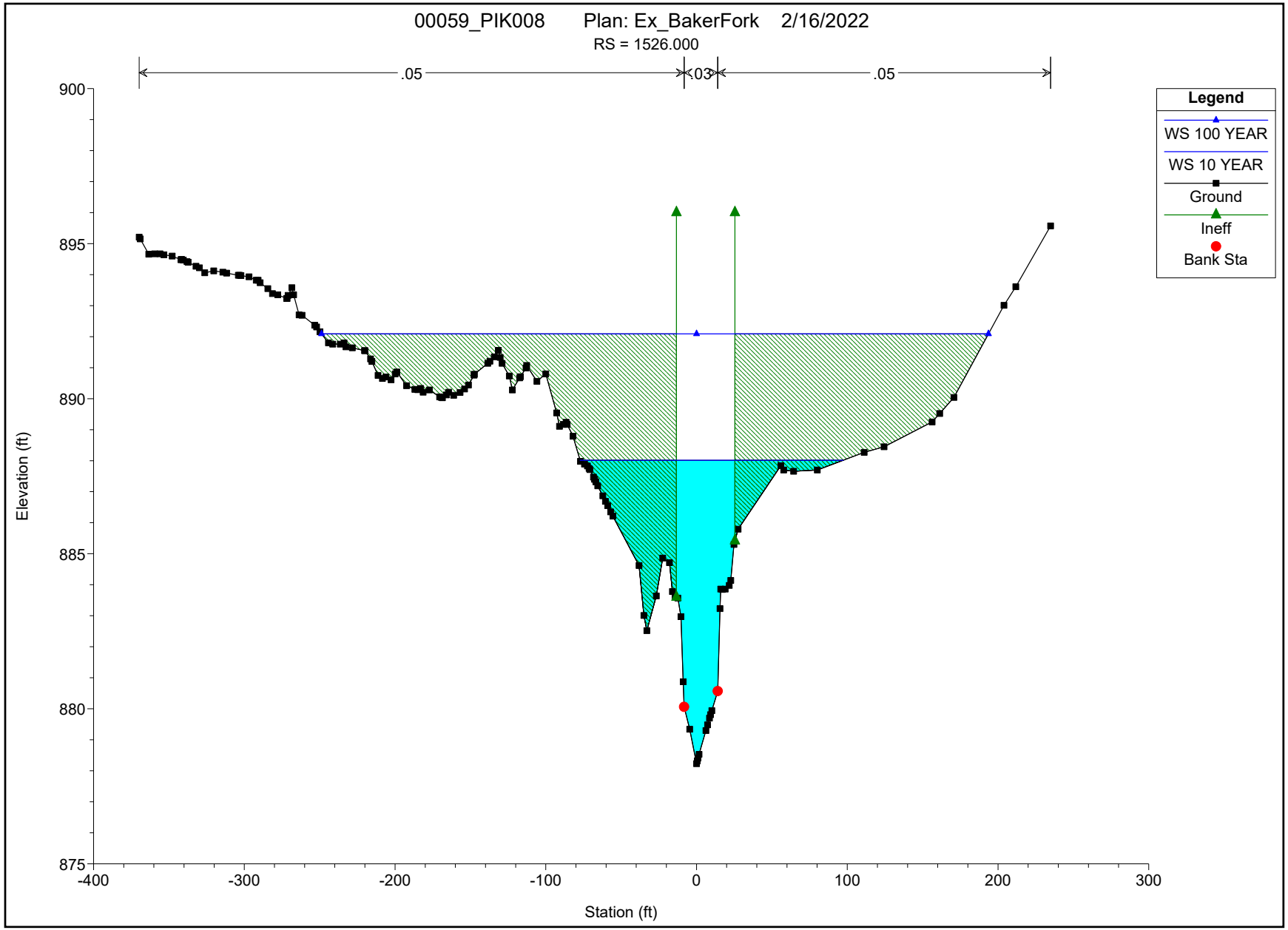
Bank Sta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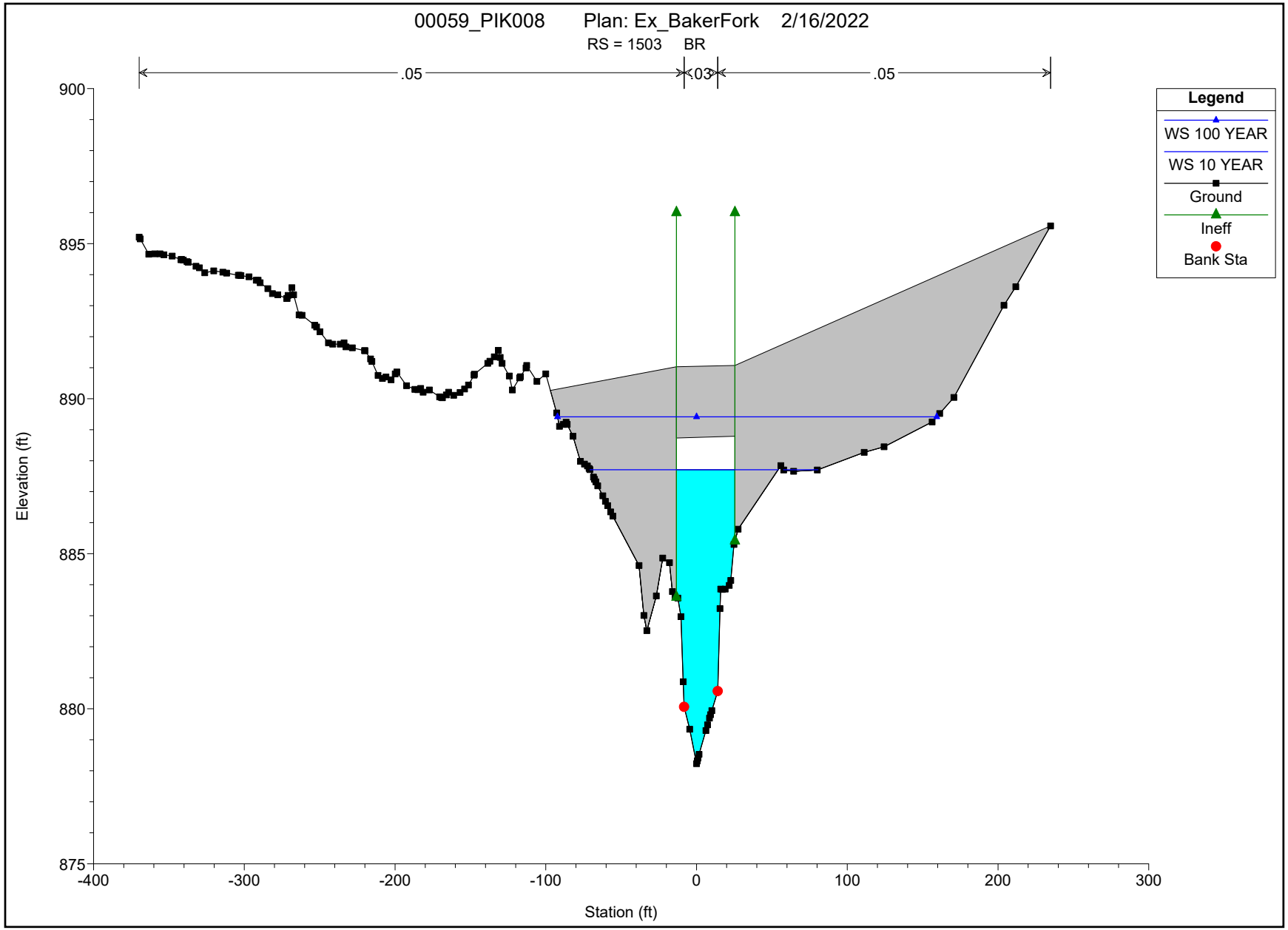
Station (ft)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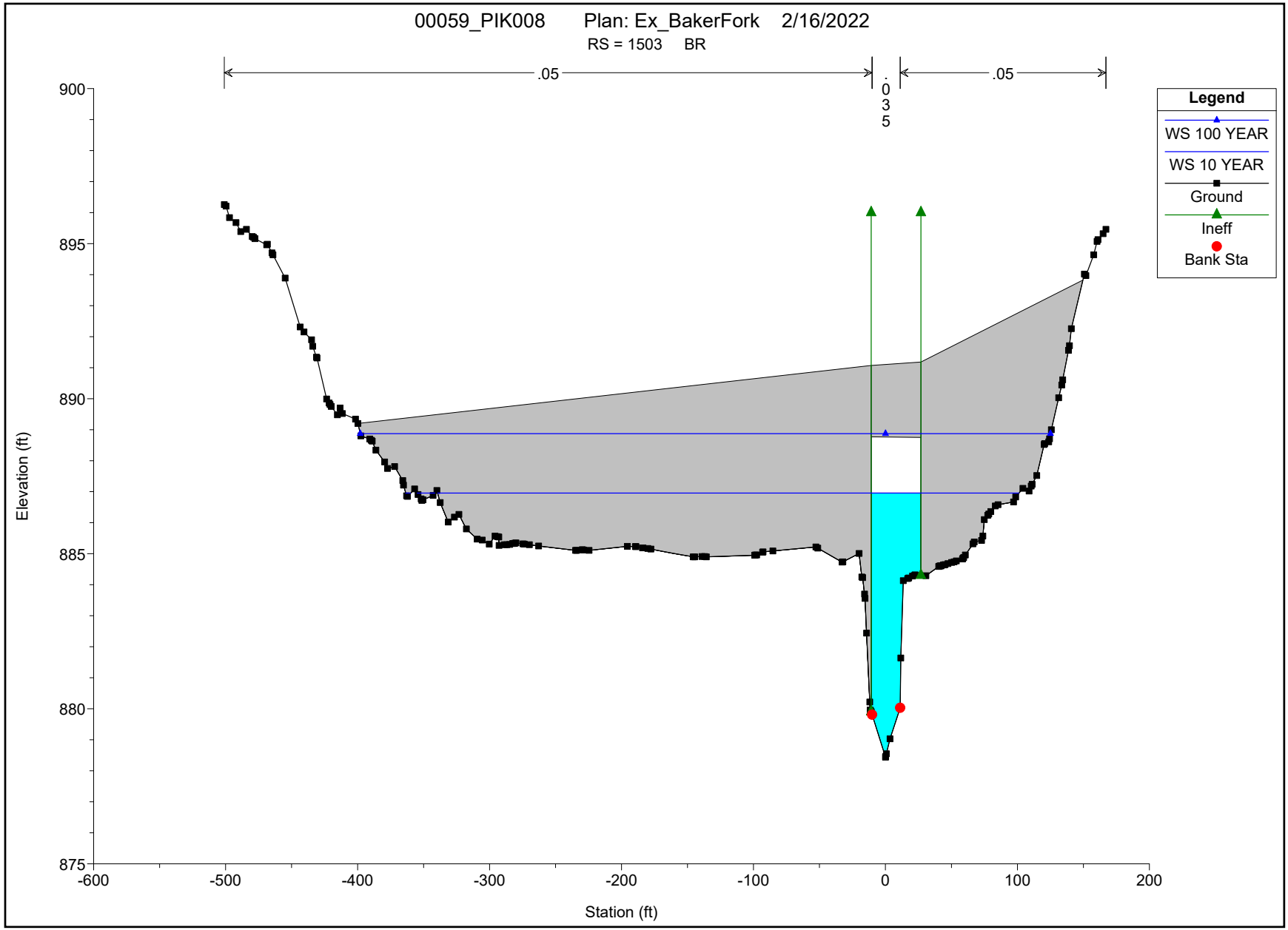
Station (ft)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WS 100 YEAR
WS 10 YEAR
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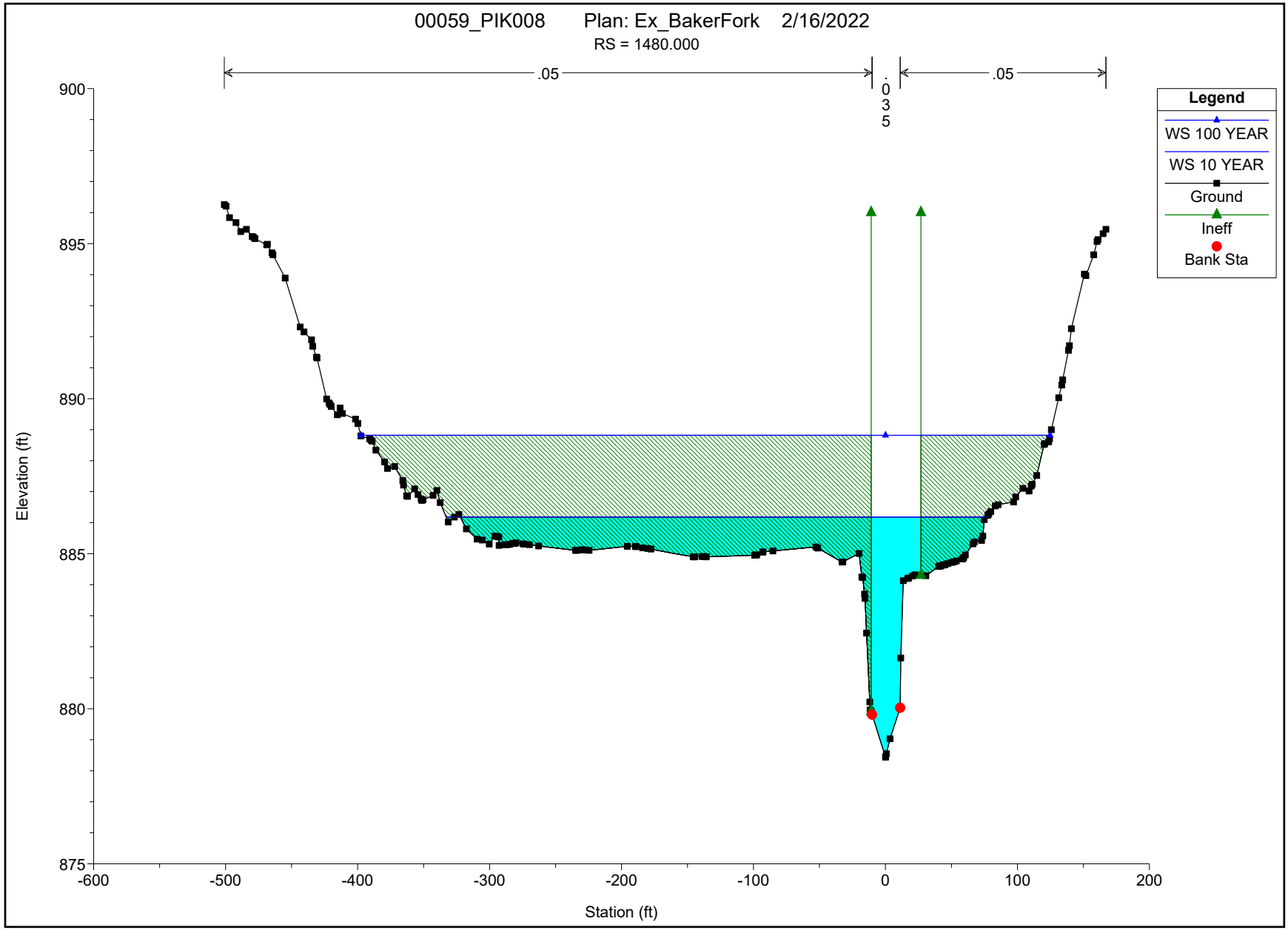
Station (ft)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WS 10 YEAR
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Elevation (ft)
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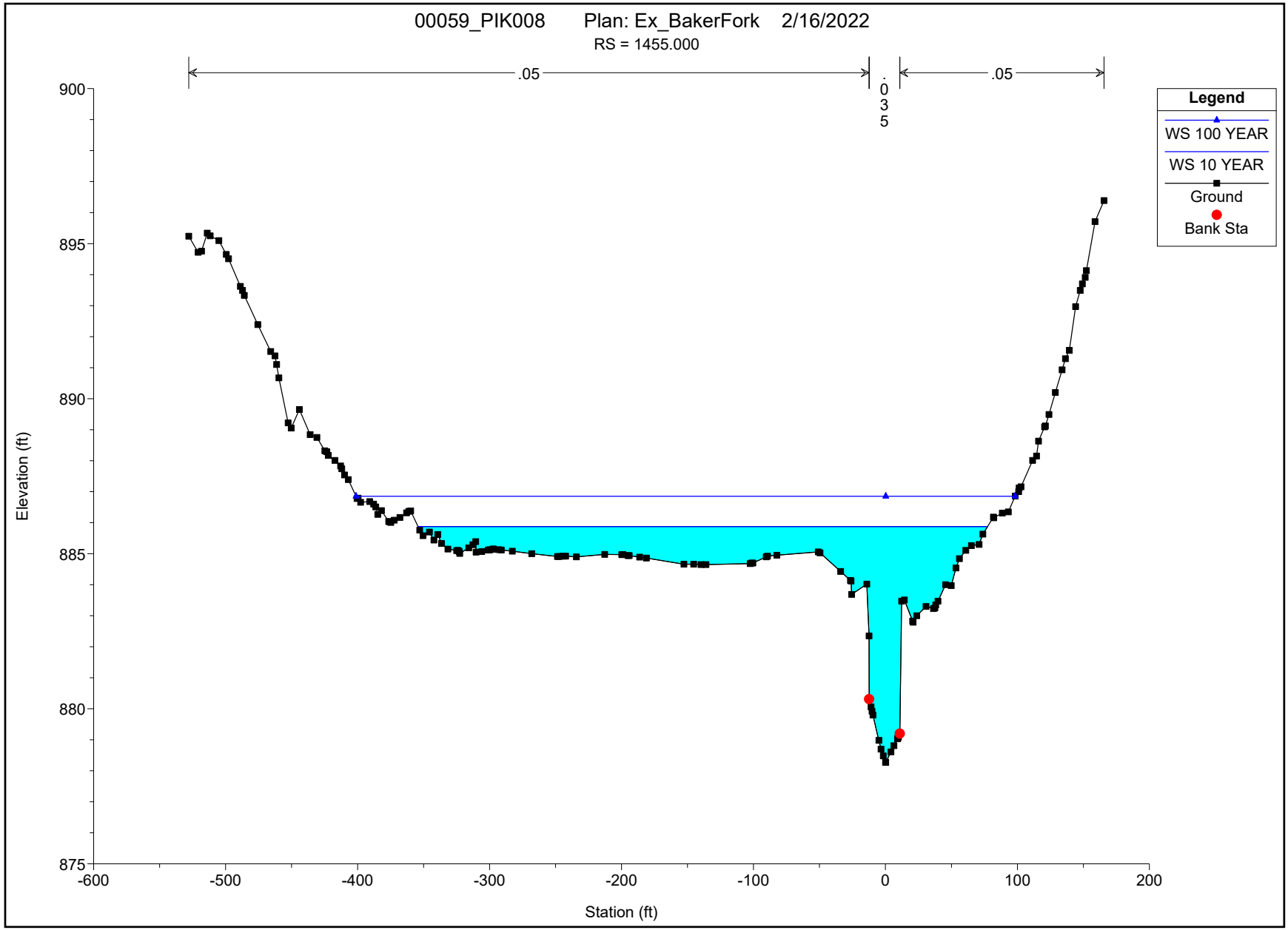
Station (ft)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WS 100 YEAR
WS 10 YEAR
Ground
Bank Sta
Elevation (ft)
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885
880
875
-600
-500
-400
-300
-200
-100
0
100
200
Station (ft)

Appendix D

HEC-RAS Output for Existing Bridge

Appendix D

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HEC-RAS HEC-RAS 6.0.0 May 2021
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX    XXXX        XXXX       XX      XXXX
X     X  X        X    X      X   X     X  X    X
X     X  X        X           X   X    X    X   X
XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
X     X  X        X           X  X     X    X        X
X     X  X        X    X      X   X    X    X        X
X     X  XXXXXX    XXXX       X    X   X    X   XXXXX
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PROJECT DATA
Project Title: 00059_PIK008
Project File : 00059_PIK008.prj
Run Date and Time: 2/16/2022 10:05:45 AM

Project in English units

PLAN DATA

Plan Title: Ex_BakerFork
Plan File :
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Geometry File :
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Flow Title : Steady Flow
Flow File :
p:\PIK\TR\0059_PIK-CR8-5.75\00059\Design\Structures\PIK008_0575C\EngData\Hydraulics\BWR\00059_PIK008.f01

Plan Summary Information:

Number of:	Cross Sections	= 4	Multiple Openings	=	0
	Culverts	= 0	Inline Structures	=	0
	Bridges	= 1	Lateral Structures	=	0

Computational Information
    Water surface calculation tolerance = 0.01
    Critical depth calculation tolerance = 0.01
    Maximum number of iterations   = 20
    Maximum difference tolerance   = 0.3
    Flow tolerance factor   = 0.001

Computation Options
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method: Average Conveyance
    Computational Flow Regime: Subcritical Flow

FLOW DATA

Flow Title: Steady Flow
Flow File :
p:\PIK\TR\0059_PIK-CR8-5.75\00059\Design\Structures\PIK008_0575C\EngData\Hydraulics\BWR\00059_PIK008.f01

Flow Data (cfs)

River	Reach	RS	10 YEAR	25 YEAR	50 YEAR	100 YEAR	500 YEAR
007	RIVX_DRYBONE	1548.000	2170	2850	3390	3960	5450

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
007	RIVX_DRYBONE	10 YEAR	Normal S = 0.003125	Normal S = 0.003125
007	RIVX_DRYBONE	25 YEAR	Normal S = 0.003125	Normal S = 0.003125

GEOMETRY DATA

Geometry Title: Existing_BakerFork
Geometry File :
p:\PIK\TR\0059_PIK-CR8-5.75\00059\Design\Structures\PIK008_0575C\EngData\Hydraulics\BWR\00059_PIK008.g03

CROSS SECTION

RIVER: 007
REACH: RIVX_DRYBONE RS: 1548.000

INPUT
Description:
Station Elevation Data num= 108

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-295.86	895.12	-294.11	895.11	-289.66	895.04	-286.58	895	-282.58	894.89
-279.55	894.8	-278.05	894.7	-273.21	894.69	-268.79	894.81	-266.95	894.82
-263.07	894.97	-260.62	895.11	-256.01	895.18	-253.97	895.2	-253.39	895.21
-247.15	895.37	-244	895.46	-240.22	895.58	-234.45	895.22	-232.66	895.23
-229.61	895.07	-226.02	895.01	-224.66	894.97	-218.79	894.79	-214.41	895.1
-212.8	895.07	-204.62	894.13	-204.21	894.12	-203.13	894.11	-197.29	894.19
-194.19	894.14	-190.41	894.07	-183.61	894.04	-176.43	893.1	-174.06	893.29
-170.62	893.84	-167.15	893.91	-163.47	893.93	-156.85	894.13	-156.5	894.17
-155.82	894.14	-141.03	893.94	-138.65	893.96	-134.14	894.92	-132.97	895.26
-127.95	895.47	-115.2	896.08	-112.56	896.28	-108.75	896.54	-104.02	896.73
-103.23	896.8	-100.97	896.12	-96.65	895.33	-91.01	894.07	-85.82	892.76
-81.72	891.79	-77.12	890.99	-71.07	889.43	-69.23	889.42	-65.44	889.04
-63.45	888.41	-56.93	886.79	-54.9	886.18	-53.75	885.99	-50.99	885.44
-48.75	884.83	-45.55	884.24	-39.09	883.66	-34.78	883.43	-32.16	883.87
-30.45	883.91	-25.35	883.38	-24.31	883.48	-18.39	884.13	-16.91	884.2
-16.09	884.23	-11.09	884.03	-10.58	884.01	-9.01	881.42	-8.54	880.38
-6.62	879.94	-6.12	879.77	-5.48	879.56	-5.15	879.46	-2.58	878.66
0	877.92	.25	877.96	1.19	878.11	16.6	880.48	17.34	881.79
19.34	884.32	21.89	884.3	23.08	884.1	23.46	884.04	24.02	883.95
38.57	885.06	61.23	886.33	62.61	886.34	106.93	887.2	113.26	887.3
147.6	888.28	159.94	889.35	161.78	889.43	163.13	889.61	173.6	890.8
200.9	893.78	212.64	894.74	220.97	895.31				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
-295.86	.05	-8.54	.03	16.6	.05

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
-8.54	16.6	24	22	19.5	.3	.5

Ineffective Flow num= 1

Sta L	Sta R	Elev	Permanent
-295.86	-104	896	T

CROSS SECTION

RIVER: 007
REACH: RIVX_DRYBONE RS: 1526.000

INPUT
Description:
Station Elevation Data num= 148

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-369.773	895.21	-369.072	895.15	-363.379	894.66	-359.485	894.67	-355.97	894.67
-353.349	894.64	-347.841	894.6	-342.011	894.48	-341.622	894.49	-340.441	894.47
-338.024	894.42	-337.23	894.4	-332.064	894.27	-329.813	894.22	-326.25	894.06
-320.261	894.12	-314.246	894.08	-311.7	894.05	-303.987	893.98	-303.145	893.98
-302.242	893.97	-296.854	893.93	-292.093	893.82	-290.875	893.82	-289.518	893.74
-284.38	893.55	-281.308	893.39	-277.801	893.35	-271.951	893.23	-271.618	893.23
-270.992	893.33	-268.501	893.58	-267.264	893.35	-263.682	892.7	-261.68	892.69
-253.331	892.37	-252.02	892.31	-249.835	892.16	-244.225	891.8	-241.345	891.76
-236.382	891.76	-233.853	891.8	-232.57	891.67	-228.318	891.64	-220.244	891.55
-219.948	891.55	-216.238	891.28	-215.364	891.2	-211.313	890.75	-208.358	890.65
-206.007	890.7	-202.621	890.61	-199.888	890.8	-198.818	890.86	-192.379	890.42
-186.852	890.3	-184.914	890.29	-182.996	890.33	-181.38	890.21	-177.228	890.28
-170.427	890.06	-169.293	890.04	-168.593	890.03	-165.982	890.12	-164.486	890.21
-161.082	890.11	-156.892	890.2	-153.857	890.31	-151.329	890.44	-147.647	890.76
-147.343	890.79	-138.476	891.14	-137.083	891.21	-134.221	891.35	-131.482	891.56
-130.273	891.33	-129.009	891.14	-124.23	890.73	-122.181	890.28	-117.383	890.67
-116.866	890.71	-113.14	890.99	-112.696	891.07	-105.925	890.56	-100.017	890.8
-92.794	889.54	-90.876	889.11	-88.3	889.17	-86.483	889.24	-85.771	889.17
-81.979	888.79	-77.025	887.98	-74.367	887.89	-72.374	887.83	-71.295	887.75
-70.704	887.71	-68.361	887.47	-67.643	887.4	-66.783	887.32	-65.529	887.19
-62.207	886.87	-60.462	886.69	-58.968	886.55	-56.976	886.35	-55.527	886.21
-38.162	884.62	-34.922	883.01	-32.949	882.52	-26.694	883.64	-22.459	884.86
-17.938	884.71	-16.008	883.78	-14.303	883.62	-12.382	883.57	-10.325	882.97
-8.848	880.87	-8.23	880.06	-4.54	879.34	0	878.23	.489	878.32
.996	878.41	1.679	878.53	6.219	879.3	7.289	879.48	8.608	879.7
9.291	879.81	10.14	879.94	14.117	880.57	15.546	883.23	16.035	883.86
17.171	883.85	19.052	883.86	21.665	883.98	22.698	884.14	24.876	885.3
27.58	885.79	55.915	887.84	57.815	887.7	64.42	887.66	80.144	887.7
111.239	888.27	124.423	888.45	156.282	889.25	161.293	889.52	170.705	890.04
203.939	893.01	211.801	893.61	234.924	895.57				

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
-369.773	.05	-8.23	.03	14.117	.05

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.

-8.23	14.117	46.4	46	46.41	.3	.5

Ineffective Flow num= 2

Sta L	Sta R	Elev	Permanent
-369.773	-13.34	896	T
25.5	234.924	896	T

Skew Angle = 22.679

BRIDGE

RIVER: 007
REACH: RIVX_DRYBONE RS: 1503

INPUT
Description:
Distance from Upstream XS = 14.4
Deck/Roadway Width = 17.2
Weir Coefficient = 2.6
Bridge Deck/Roadway Skew = 22.679
Bridge Pier Skew = 22.679
Upstream Deck/Roadway Coordinates
num= 2

Sta	Hi Cord	Lo Cord	Sta	Hi Cord	Lo Cord
-13.34	891.03	888.73	25.5	891.07	888.79

Upstream Bridge Cross Section Data
Station Elevation Data num= 148

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
-369.773	895.21	-369.072	895.15	-363.379	894.66	-359.485	894.67	-355.97	894.67
-353.349	894.64	-347.841	894.6	-342.011	894.48	-341.622	894.49	-340.441	894.47
-338.024	894.42	-337.23	894.4	-332.064	894.27	-329.813	894.22	-326.25	894.06
-320.261	894.12	-314.246	894.08	-311.7	894.05	-303.987	893.98	-303.145	893.98
-302.242	893.97	-296.854	893.93	-292.093	893.82	-290.875	893.82	-289.518	893.74
-284.38	893.55	-281.308	893.39	-277.801	893.35	-271.951	893.23	-271.618	893.23
-270.992	893.33	-268.501	893.58	-267.264	893.35	-263.682	892.7	-261.68	892.69
-253.331	892.37	-252.02	892.31	-249.835	892.16	-244.225	891.8	-241.345	891.76
-236.382	891.76	-233.853	891.8	-232.57	891.67	-228.318	891.64	-220.244	891.55
-219.948	891.55	-216.238	891.28	-215.364	891.2	-211.313	890.75	-208.358	890.65
-206.007	890.7	-202.621	890.61	-199.888	890.8	-198.818	890.86	-192.379	890.42
-186.852	890.3	-184.914	890.29	-182.996	890.33	-181.38	890.21	-177.228	890.28
-170.427	890.06	-169.293	890.04	-168.593	890.03	-165.982	890.12	-164.486	890.21
-161.082	890.11	-156.892	890.2	-153.857	890.31	-151.329	890.44	-147.647	890.76
-147.343	890.79	-138.476	891.14	-137.083	891.21	-134.221	891.35	-131.482	891.56
-130.273	891.33	-129.009	891.14	-124.23	890.73	-122.181	890.28	-117.383	890.67
-116.866	890.71	-113.14	890.99	-112.696	891.07	-105.925	890.56	-100.017	890.8
-92.794	889.54	-90.876	889.11	-88.3	889.17	-86.483	889.24	-85.771	889.17
-81.979	888.79	-77.025	887.98	-74.367	887.89	-72.374	887.83	-71.295	887.75
-70.704	887.71	-68.361	887.47	-67.643	887.4	-66.783	887.32	-65.529	887.19
-62.207	886.87	-60.462	886.69	-58.968	886.55	-56.976	886.35	-55.527	886.21
-38.162	884.62	-34.922	883.01	-32.949	882.52	-26.694	883.64	-22.459	884.86
-17.938	884.71	-16.008	883.78	-14.303	883.62	-12.382	883.57	-10.325	882.97
-8.848	880.87	-8.23	880.06	-4.54	879.34	0	878.23	.489	878.32
.996	878.41	1.679	878.53	6.219	879.3	7.289	879.48	8.608	879.7
9.291	879.81	10.14	879.94	14.117	880.57	15.546	883.23	16.035	883.86
17.171	883.85	19.052	883.86	21.665	883.98	22.698	884.14	24.876	885.3

```
   27.58  885.79  55.915  887.84  57.815   887.7   64.42  887.66  80.144   887.7
 111.239  888.27 124.423  888.45 156.282  889.25 161.293  889.52 170.705  890.04
 203.939  893.01 211.801  893.61 234.924  895.57

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
-369.773     .05   -8.23     .03  14.117     .05

Bank Sta: Left   Right    Coeff Contr.   Expan.
         -8.23  14.117             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
-369.773  -13.34     896       T
    25.5 234.924     896       T
Skew Angle = 22.679

Downstream  Deck/Roadway Coordinates
    num=       2
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
  -10.81  891.07  888.77    26.9  891.18  888.75

Downstream Bridge Cross Section Data
Station Elevation Data    num=     172
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
-501.015  896.26-499.705  896.21-497.076  895.84-492.139  895.68-488.568  895.39
-484.185  895.46-479.793  895.23-478.797   895.2-477.726  895.16 -468.87  894.96
-468.307  894.98-464.836   894.7-464.099  894.64-454.836  893.89-443.477  892.31
-440.626  892.15-434.831   891.9-433.974  891.69-431.168  891.34-430.771  891.31
-423.437  889.99 -421.59  889.86-420.861  889.81-419.938  889.75-415.288  889.48
-413.194   889.7-411.525  889.52-401.614  889.34-399.815   889.2-397.527   888.8
-390.773   888.7-389.611  888.66-388.919  888.63-386.178  888.34-379.498  887.96
-377.375  887.75 -371.96  887.81-365.768  887.36-365.224  887.21  -362.9  886.87
-362.151  886.85-356.829  887.09-354.143  886.91-351.892  886.77-351.338  886.72
-350.435  886.74-342.775  886.88-339.897  887.04-337.378  886.65-331.269  886.02
-326.676  886.18-323.205  886.27-317.568   885.8-309.375  885.47-305.583  885.44
-300.286  885.31-295.876  885.57-294.012  885.55-292.996  885.54-292.794  885.27
-288.696  885.29-286.971  885.29-284.701   885.3-282.479  885.33-281.204  885.33
-280.882  885.34-279.933  885.35-274.663  885.32-273.705  885.31 -269.79  885.29
-262.844  885.25-234.786  885.11-233.965  885.11-229.746  885.13 -228.64  885.12
-224.571  885.11-195.618  885.24-189.481  885.23-189.028  885.23 -184.13  885.19
-183.733  885.19-180.116  885.17-177.754  885.15-145.682   884.9-144.519   884.9
-139.103  884.91-136.972  884.91-135.707   884.9 -99.106  884.95 -98.624  884.96
  -97.61  884.96 -93.154  885.05 -92.738  885.06 -85.302  885.09 -52.722  885.22
 -51.255  885.18 -32.894  884.73 -32.275  884.74 -19.967  885.01 -17.918  884.25
   -17.3  884.23 -15.879   883.7 -15.464  883.56 -14.356  882.44 -11.912  880.22
 -11.643  879.96 -10.999  879.93 -10.704  879.89 -10.085  879.81       0  878.44
    .157  878.46    .701  878.55   3.414  879.03  11.137  880.03  11.581  881.64
  13.517  884.13  16.783   884.2  17.669  884.22  20.484  884.28  22.172  884.31
  22.496  884.32  30.688  884.29  40.367  884.59  40.893   884.6   41.53  884.61
  42.148  884.61   43.93  884.64  44.518  884.64  45.202  884.65  47.361  884.68
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  50.156  884.72  52.047  884.74  53.719  884.77  58.342  884.83  58.682  884.85
  59.254  884.88  60.528  884.96  66.322  885.32  67.225  885.38  72.789  885.43
  73.842  885.57  74.912   886.1  77.505  886.24  78.326  886.28  79.859  886.36
   83.28  886.54  85.293  886.58  97.103  886.67   98.69  886.83 104.171  887.11
 108.775  887.02 110.444  887.18 111.118  887.24 114.625  887.52 120.253  888.52
 120.686  888.55 123.722  888.61 124.303  888.71 125.696     889 131.288  890.03
 133.558  890.44 134.314  890.61 138.697  891.56 139.455  891.71 140.875  892.26
 150.691  894.02 151.911  893.97 157.833  894.64 160.325  895.07 161.062  895.13
  164.93  895.32 167.079  895.46

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
-501.015     .05 -10.085    .035  11.137     .05

Bank Sta: Left   Right    Coeff Contr.   Expan.
       -10.085  11.137             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
-501.015  -10.81     896       T
    26.9 167.079     896       T
Skew Angle = 22.679

Upstream Embankment side slope              =       0 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .98
Elevation at which weir flow begins         =  891.03
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested

Number of Abutments =  2

Abutment Data
Upstream     num=       2
     Sta    Elev     Sta    Elev
-369.072  887.78  -13.34  891.03
Downstream     num=       2
     Sta    Elev     Sta    Elev
 -399.82   889.2  -10.81  891.07

Abutment Data
Upstream     num=       2
     Sta    Elev     Sta    Elev
    25.5  891.07 234.924  895.57
Downstream     num=       2
     Sta    Elev     Sta    Elev
    26.9  891.18 230.669  895.57

Number of Bridge Coefficient Sets =  1
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Low Flow Methods and Data
       Energy
Selected Low Flow Methods = Highest Energy Answer

High Flow Method
       Energy Only

Additional Bridge Parameters
       Add Friction component to Momentum
       Do not add Weight component to Momentum
       Class B flow critical depth computations use critical depth
           inside the bridge at the upstream end
       Criteria to check for pressure flow = Upstream energy grade line

BRIDGE OUTPUT Profile #10 YEAR

E.G. US. (ft)	889.38	Element	Inside BR US Inside BR DS
W.S. US. (ft)	888.01	E.G. Elev (ft)	889.28 889.05
Q Total (cfs)	2170.00	W.S. Elev (ft)	887.71 886.96
Q Bridge (cfs)	2170.00	Crit W.S. (ft)	885.99 886.21
Q Weir (cfs)		Max Chl Dpth (ft)	9.48 8.52
Weir Sta Lft (ft)		Vel Total (ft/s)	8.45 10.03
Weir Sta Rgt (ft)		Flow Area (sq ft)	256.70 216.29
Weir Submerg		Froude # Chl	0.64 0.77
Weir Max Depth (ft)		Specif Force (cu ft)	1605.41 1498.06
Min El Weir Flow (ft)	891.08	Hydr Depth (ft)	6.61 5.74
Min El Prs (ft)	888.79	W.P. Total (ft)	49.44 50.07
Delta EG (ft)	0.57	Conv. Total (cfs)	41664.0 29642.7
Delta WS (ft)	1.83	Top Width (ft)	38.84 37.71
BR Open Area (sq ft)	284.35	Frctn Loss (ft)	0.06 0.09
BR Open Vel (ft/s)	10.03	C & E Loss (ft)	0.16 0.16
BR Sluice Coef		Shear Total (lb/sq ft)	0.88 1.45
BR Sel Method	Energy only	Power Total (lb/ft s)	7.43

14.50

Warning: For the final momentum answer at the bridge, the upstream energy was computed lower than the downstream
energy. This is not physically possible, the momentum answer has been disregarded.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross
sections.
Warning: The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
1.4. This may indicate the need for additional cross sections.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross
sections.

BRIDGE OUTPUT Profile #100 YEAR

E.G. US. (ft)	893.87	Element	Inside BR US Inside BR DS
W.S. US. (ft)	892.09	E.G. Elev (ft)	893.21 892.86
Q Total (cfs)	3960.00	W.S. Elev (ft)	889.42 888.87
Q Bridge (cfs)	3960.00	Crit W.S. (ft)	888.66 888.77
Q Weir (cfs)		Max Chl Dpth (ft)	11.19 10.43
Weir Sta Lft (ft)		Vel Total (ft/s)	13.31 13.93
Weir Sta Rgt (ft)		Flow Area (sq ft)	297.54 284.35
Weir Submerg		Froude # Chl	0.82 0.87
Weir Max Depth (ft)		Specif Force (cu ft)	3302.73 3137.49
Min El Weir Flow (ft)	891.08	Hydr Depth (ft)	
Min El Prs (ft)	888.79	W.P. Total (ft)	90.38 91.39
Delta EG (ft)	1.29	Conv. Total (cfs)	33103.3 27971.8
Delta WS (ft)	3.27	Top Width (ft)	
BR Open Area (sq ft)	284.35	Frctn Loss (ft)	0.29 0.17
BR Open Vel (ft/s)	13.93	C & E Loss (ft)	0.06

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  0.12
  BR Sluice Coef                          Shear Total (lb/sq ft)         2.94
  3.89
  BR Sel Method           Energy only     Power Total (lb/ft s)         39.14
 54.22



Warning: The conveyance ratio (upstream conveyance divided by downstream
conveyance) is less than 0.7 or greater than
         1.4.  This may indicate the need for additional cross sections.

CROSS SECTION


RIVER: 007
REACH: RIVX_DRYBONE       RS: 1480.000

INPUT
Description:
Station Elevation Data    num=     172
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
-501.015  896.26-499.705  896.21-497.076  895.84-492.139  895.68-488.568  895.39
-484.185  895.46-479.793  895.23-478.797   895.2-477.726  895.16 -468.87  894.96
-468.307  894.98-464.836   894.7-464.099  894.64-454.836  893.89-443.477  892.31
-440.626  892.15-434.831   891.9-433.974  891.69-431.168  891.34-430.771  891.31
-423.437  889.99 -421.59  889.86-420.861  889.81-419.938  889.75-415.288  889.48
-413.194   889.7-411.525  889.52-401.614  889.34-399.815   889.2-397.527   888.8
-390.773   888.7-389.611  888.66-388.919  888.63-386.178  888.34-379.498  887.96
-377.375  887.75 -371.96  887.81-365.768  887.36-365.224  887.21  -362.9  886.87
-362.151  886.85-356.829  887.09-354.143  886.91-351.892  886.77-351.338  886.72
-350.435  886.74-342.775  886.88-339.897  887.04-337.378  886.65-331.269  886.02
-326.676  886.18-323.205  886.27-317.568   885.8-309.375  885.47-305.583  885.44
-300.286  885.31-295.876  885.57-294.012  885.55-292.996  885.54-292.794  885.27
-288.696  885.29-286.971  885.29-284.701   885.3-282.479  885.33-281.204  885.33
-280.882  885.34-279.933  885.35-274.663  885.32-273.705  885.31 -269.79  885.29
-262.844  885.25-234.786  885.11-233.965  885.11-229.746  885.13 -228.64  885.12
-224.571  885.11-195.618  885.24-189.481  885.23-189.028  885.23 -184.13  885.19
-183.733  885.19-180.116  885.17-177.754  885.15-145.682   884.9-144.519   884.9
-139.103  884.91-136.972  884.91-135.707   884.9 -99.106  884.95 -98.624  884.96
  -97.61  884.96 -93.154  885.05 -92.738  885.06 -85.302  885.09 -52.722  885.22
 -51.255  885.18 -32.894  884.73 -32.275  884.74 -19.967  885.01 -17.918  884.25
   -17.3  884.23 -15.879   883.7 -15.464  883.56 -14.356  882.44 -11.912  880.22
 -11.643  879.96 -10.999  879.93 -10.704  879.89 -10.085  879.81       0  878.44
    .157  878.46    .701  878.55   3.414  879.03  11.137  880.03  11.581  881.64
  13.517  884.13  16.783   884.2  17.669  884.22  20.484  884.28  22.172  884.31
  22.496  884.32  30.688  884.29  40.367  884.59  40.893   884.6   41.53  884.61
  42.148  884.61   43.93  884.64  44.518  884.64  45.202  884.65  47.361  884.68
  50.156  884.72  52.047  884.74  53.719  884.77  58.342  884.83  58.682  884.85
  59.254  884.88  60.528  884.96  66.322  885.32  67.225  885.38  72.789  885.43
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  73.842  885.57  74.912   886.1  77.505  886.24  78.326  886.28  79.859  886.36
   83.28  886.54  85.293  886.58  97.103  886.67   98.69  886.83 104.171  887.11
 108.775  887.02 110.444  887.18 111.118  887.24 114.625  887.52 120.253  888.52
 120.686  888.55 123.722  888.61 124.303  888.71 125.696     889 131.288  890.03
 133.558  890.44 134.314  890.61 138.697  891.56 139.455  891.71 140.875  892.26
 150.691  894.02 151.911  893.97 157.833  894.64 160.325  895.07 161.062  895.13
  164.93  895.32 167.079  895.46

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
-501.015     .05 -10.085    .035  11.137     .05

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       -10.085  11.137            24.16      25   25.61             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
-501.015  -10.81     896       T
    26.9 167.079     896       T
Skew Angle = 22.679

CROSS SECTION


RIVER: 007
REACH: RIVX_DRYBONE       RS: 1455.000

INPUT
Description:
Station Elevation Data    num=     159
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
 -527.89  895.24 -520.88  894.72 -518.23  894.76 -513.95  895.34 -511.68  895.25
 -505.14   895.1  -499.5  894.65 -497.78  894.51 -488.82  893.62 -487.16  893.49
 -485.88  893.33 -475.59  892.39 -465.87  891.52 -462.61  891.38 -461.37   891.1
 -459.65  890.67 -452.64  889.22 -450.29  889.05 -444.15  889.65 -435.93  888.84
 -430.83  888.75  -424.8  888.32 -423.29  888.29 -422.23  888.17  -417.2  888.01
 -412.91  887.83 -411.97  887.74  -409.9  887.54 -407.06  887.39  -400.4  886.78
 -399.57  886.79 -397.73  886.66 -390.78  886.68 -387.82   886.6 -386.18  886.51
  -384.7  886.27 -381.94  886.39  -376.4  886.04 -375.63  886.03 -375.22  886.03
 -374.87  886.01 -372.18  886.08 -367.88  886.17 -362.89  886.32  -361.2  886.37
 -359.79  886.38 -352.91  885.76 -350.42  885.58 -345.56   885.7 -342.16  885.44
 -339.23  885.62 -336.38  885.33 -331.57  885.15 -324.89   885.1 -323.83  885.11
 -322.94  885.07 -322.59  885.01 -315.78  885.19 -312.65  885.29 -310.45  885.39
 -310.17  885.05 -305.86  885.07 -301.07  885.12 -300.19  885.12  -299.5  885.13
 -297.45  885.15 -296.92  885.15  -293.1  885.13 -291.05  885.12 -282.76  885.08
 -268.05     885 -248.57  884.91 -247.43  884.91  -244.6  884.92 -242.37  884.92
 -234.19   884.9 -212.73  884.98 -199.81  884.97 -198.88  884.97 -195.03  884.94
 -194.18  884.94 -186.27  884.89 -181.11  884.86 -152.66  884.66  -145.3  884.66
 -139.77  884.65 -136.02  884.65 -102.55  884.68 -101.44   884.7 -100.51   884.7
  -90.33   884.9  -89.37  884.92  -82.24  884.95  -50.95  885.06  -49.55  885.03
  -33.96  884.43  -26.56  884.14  -26.04  884.12   -25.6  883.69  -14.14  884.02
```

-12.42	882.35	-12.32	880.31	-10.94	880.06	-10.15	879.92	-9.48	879.8
-4.99	878.98	-3.41	878.7	-1.65	878.48	0	878.28	.19	878.27
4.17	878.61	6.39	878.81	9.15	879.03	9.5	879.06	9.81	879.09
10.91	879.2	12.24	883.47	14.28	883.51	20.59	882.83	20.99	882.79
23.7	883	30.71	883.3	36.36	883.23	37.51	883.25	38.13	883.35
39.81	883.47	45.51	884	49.87	883.97	53.48	884.54	56.05	884.84
60.93	885.11	65.13	885.26	70.91	885.3	73.83	885.63	81.77	886.18
82.08	886.16	88.53	886.31	93.08	886.35	98.33	886.86	100.89	887
101.3	887.12	102.67	887.16	111.5	888.01	114.45	888.15	115.96	888.63
120.55	889.09	121.19	889.12	123.86	889.49	128.74	890.2	133.83	890.93
136.38	891.29	139.35	891.56	144.12	892.97	147.59	893.49	149.23	893.7
151.32	893.91	152.25	894.13	158.81	895.71	165.63	896.39		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
-527.89	.05	-12.32	.035	10.91	.05

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
-12.32	10.91	0	0	0 .1	.3

SUMMARY OF MANNING'S N VALUES

River:007

Reach	River Sta.	n1	n2	n3
RIVX_DRYBONE	1548.000	.05	.03	.05
RIVX_DRYBONE	1526.000	.05	.03	.05
RIVX_DRYBONE	1503	Bridge		
RIVX_DRYBONE	1480.000	.05	.035	.05
RIVX_DRYBONE	1455.000	.05	.035	.05

SUMMARY OF REACH LENGTHS

River: 007

Reach	River Sta.	Left	Channel	Right
RIVX_DRYBONE	1548.000	24	22	19.5
RIVX_DRYBONE	1526.000	46.4	46	46.41
RIVX_DRYBONE	1503	Bridge		
RIVX_DRYBONE	1480.000	24.16	25	25.61
RIVX_DRYBONE	1455.000	0	0	0

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: 007

Reach	River Sta.	Contr.	Expan.
RIVX_DRYBONE	1548.000	.3	.5
RIVX_DRYBONE	1526.000	.3	.5
RIVX_DRYBONE	1503	Bridge	
RIVX_DRYBONE	1480.000	.3	.5
RIVX_DRYBONE	1455.000	.1	.3