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HYDROLOGY & HYDRAULIC MODELING AND FLOODPLAIN MANAGEMENT ANALYSIS

EASTON COMMERCE CENTER

FOR EASTON WOOD AVE. PROPCO, LLC

CITY OF EASTON, PALMER TOWNSHIP, AND WILSON BOROUGH

NORTHAMPTON COUNTY

PENNSYLVANIA

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Donald Haas, RLA

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PROJECT: 2022-528

HYDROLOGY & HYDRAULIC MODELING AND FLOODPLAIN MANAGEMENT ANALYSIS NARRATIVE

EASTON COMMERCE CENTER

SCANNELL PROPERTIES

CITY OF EASTON, PLAMER TOWNSHIP, AND WILSON BOROUGH

NORTHAMPTON COUNTY

PENNSYLVANIA

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SITE HISTORY AND CONDITIONS

The site is partially developed with majority of undeveloped portions covered with dirt, grass, and woods. There is one perennial creek as well as an intermittent stream within and adjacent to the site. Bushkill Creek flows from north to south in the eastern side of the project site and the end discharge point is Delaware River. Bushkill Creek is labelled as Bushkill Creek Reach 1 in the FEMA flood map (42095C0278E; revised on July 16, 2014) and FIS (42095CV001A; revised on July 16, 2014). In FEMA documents, the flooding data were studied based on statistical analysis of stage-discharge records of a USGS station. The records were assessed by reginal regression equations developed to estimate different frequency flood flows. The 100-year flood flow is calculated to be 8,100 cfs in this reach of Bushkill Creek. An unnamed tributary to Bushkill Creek, labelled as UNT in this report, is shown as Zone A of the Bushkill Creek floodway (i.e., floodplain without base flood elevation determined) on FEMA flood map. There is no separate study on this stream. It should be noted that the confluence of UNT and Bushkill Creek is located almost 1.34 miles upgradient of where Bushkill Creek discharges into Delaware River. Generally, from the historical records, areas within the City of Easton, Borough of Wilson, and Palmer Township are subject to flooding in all seasons and after tropical storms, rapid melting of snow, and infiltration losses due to frozen ground. Major flooding in the area have been associated with the flooding in Delaware River, however, some within-basin (i.e., related to tributaries of Delaware River) had occurred by cold-front (intense rain followed by cold weather) and warm-front (rainfall on winter snow) storms. Major floods of the Delaware River adjacent to project site have occurred in October 1903, March 1936, May 1942, and August 1955. Since the Bushkill Creek is tributary of the River and project is beyond 1.3 miles away from the River, the magnitude of flooding has been less severe. Similarly, the flooding in UNT is less sever than Bushkill Creek.

Major portions of the stream banks within and adjacent to project site are undeveloped and can provide natural flood storage capacity. Currently, there are a few structural flood protection measures that may mitigate the flooding along the Bushkill Creek. There will be no modifications or disturbance to Bushkill Creek in the post-construction conditions that would potentially change the flow patterns in streams. The UNT would be relocated to provide construction site, and the channel would pass through a culvert that is installed under a proposed access driveway. It should be noted that the current path of UNT also passes through an underground tunnel. The proposed UNT obstruction will be replaced with a proposed relocated channel. The relocation made it feasible to improve the channel condition when comparing with the existing conditions by designing a stable channel with adequate capacity that can safely pass the 100-year flow. The stormwater in the post-construction condition is managed to lower the release rates compared to the existing condition via employing stormwater MRC BMPs, etc. Such stormwater management measures would assist in mitigating and controlling the flooding in the streams in the post-construction conditions.

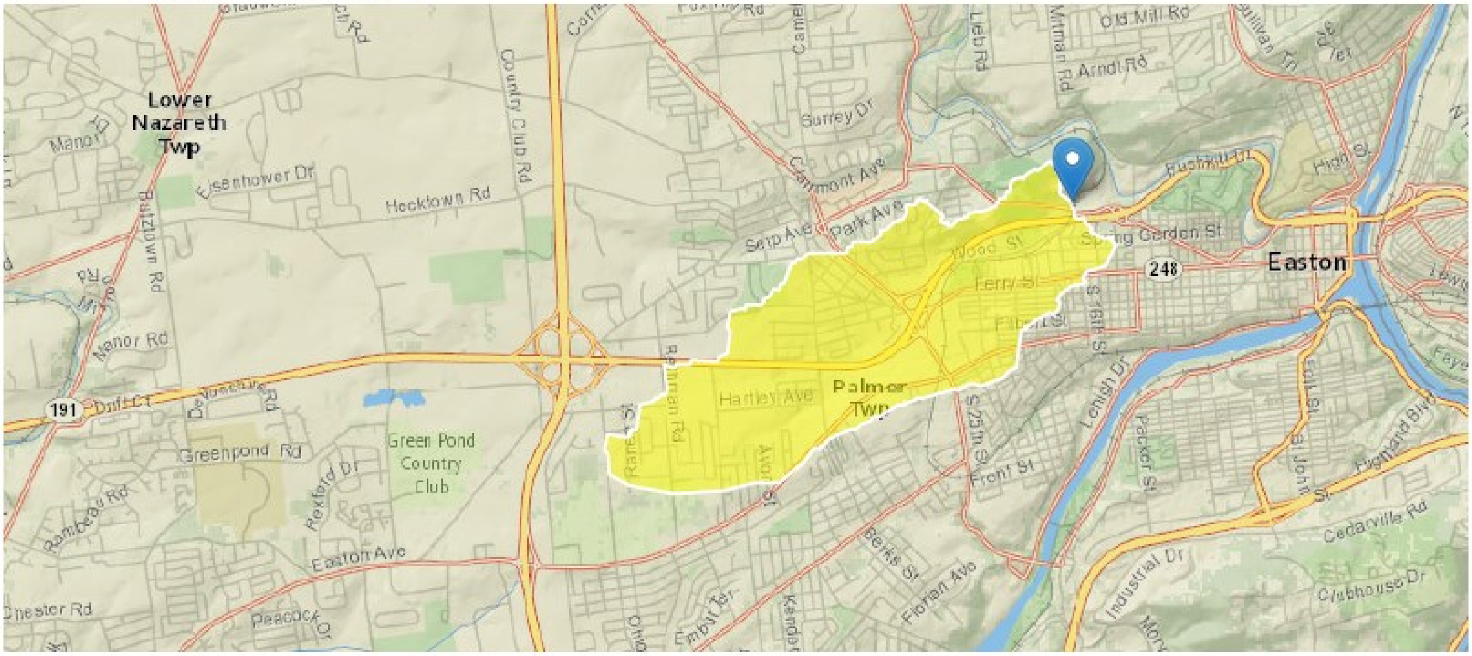
HYDROLOGY

The 100-year flow was used to model the pre- and post-construction floodplain boundaries, flood elevations, and flood flow velocities. Additionally, bank-full and base flow conditions were also modeled to simulate the normal stream condition. As mentioned before, the Bushkill is completely undisturbed and out of limit of disturbance in this project, while UNT is proposed to be relocated. The UNT is not listed and shown in the FEMA map and report, therefore, this stream was studied separately through available hydrological tools such as StreamStats and USGS stations. The 100-year flow data, extracted from StreamStats of 621 cfs is reported for the point at which the relocation is proposed (i.e., the common upstream of existing and proposed creeks), while bank-full and mean annual flows are reported 12.5 cfs and 3.43 cfs, respectively. As depicted below the drainage area associated with this point is estimated to be 2.32 sq.miles. The StreamStats report is presented in Appendix A of this document. In addition to abovementioned steady flow data, the stable channel design needed employing unsteady flow data to properly model the fluctuations in high and low flows and how the cycles of ups and downs in flow would impact sediment transport and as a result deposition and erosion patterns. To do so, the nearest USGS gauge to the site was identified and then the daily flow data for the last 15 years were extracted. Project specific flows were then estimated by adjusting the measured flows (USGS station) by drainage area. Known daily flow rate data from USGS station #01446776 Bushkill Creek at Tatamy, PA (almost 3.5 miles upstream of project site) was sourced from the USGS National Water Information System. The drainage area associated with this gauge is 31.2 sq.miles, while it is 2.3 sq.mile for the point of interest, therefore, the reported flows can be estimated from below conversion factor:

Conversion Factor = $\frac{2.3}{31.2} 0.074$

Bushkill Tributary

Region ID: PA
Workspace ID: PA20230515123543682000
Clicked Point (Latitude, Longitude): 40.69561, -75.23498
Time: 2023-05-15 08:36:06 -0400



Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
CARBON	Percentage of area of carbonate rock	93.03	percent
DRNAREA	Area that drains to a point on a stream	2.32	square miles
ELEV	Mean Basin Elevation	360	feet
FOREST	Percentage of area covered by forest	8.9887	percent
PRECIP	Mean Annual Precipitation	45	inches
ROCKDEP	Depth to rock	5.4	feet
STRDEN	Stream Density -- total length of streams divided by drainage area	0	miles per square mile
URBAN	Percentage of basin with urban development	67.0411	percent

HYDRAULIC ANALYSIS

The UNT in the needed to be modeled to determine the flood boundaries and elevations for pre- and post-construction conditions. It is only Bushkill Creek that is delineated for floodway and reported by FEMA, owing to its larger drainage area, and the other existing UNT within the project site have been considered as tributaries of Bushkill Creek and of a less concern because their flooding does not have floodway delineation. Nonetheless, the hydraulic modeling of the floods in UNT was performed because the project proposes a channel relocation as well as additions of a culvert for necessary stream crossings. As a result of the proposed development, a comparison basis for pre- versus post-construction flood characteristics was needed to show compliance with the chapter 105 requirements for stream obstruction/replacement.

Hydraulic modeling had three parts:

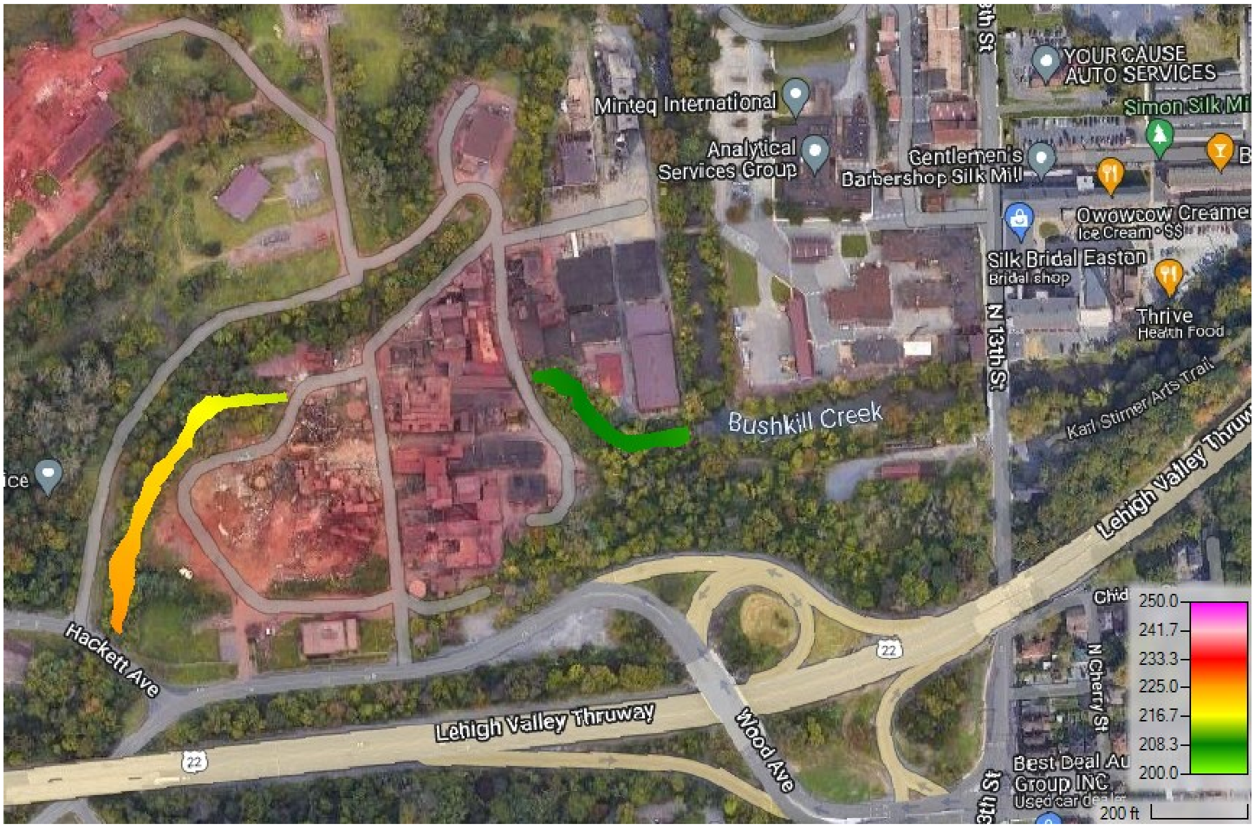
- Modeling 100-year flood for the existing condition
- Modeling 100-year flood for the proposed condition
- Design of the relocated channel as a stable channel

The hydraulic modeling was performed by employing HEC-RAS. The hydrological input to HEC-RAS was provided by the hydrological studies that were described in the previous section. Geometry of the project site as well as offsite locations (to evaluate impacts of proposed development on upstream, downstream, and adjacent properties) was defined based on the site survey. The terrain in the HEC-RAS was generated by exporting the corresponding surfaces from Civil 3D. There is one spot at which the tributary streams of UNT discharges into Bushkill Creek, therefore, 1d hydraulic simulation was adopted to study the proposed project. The basis for flow simulation was Manning’s equation and backwater analysis.

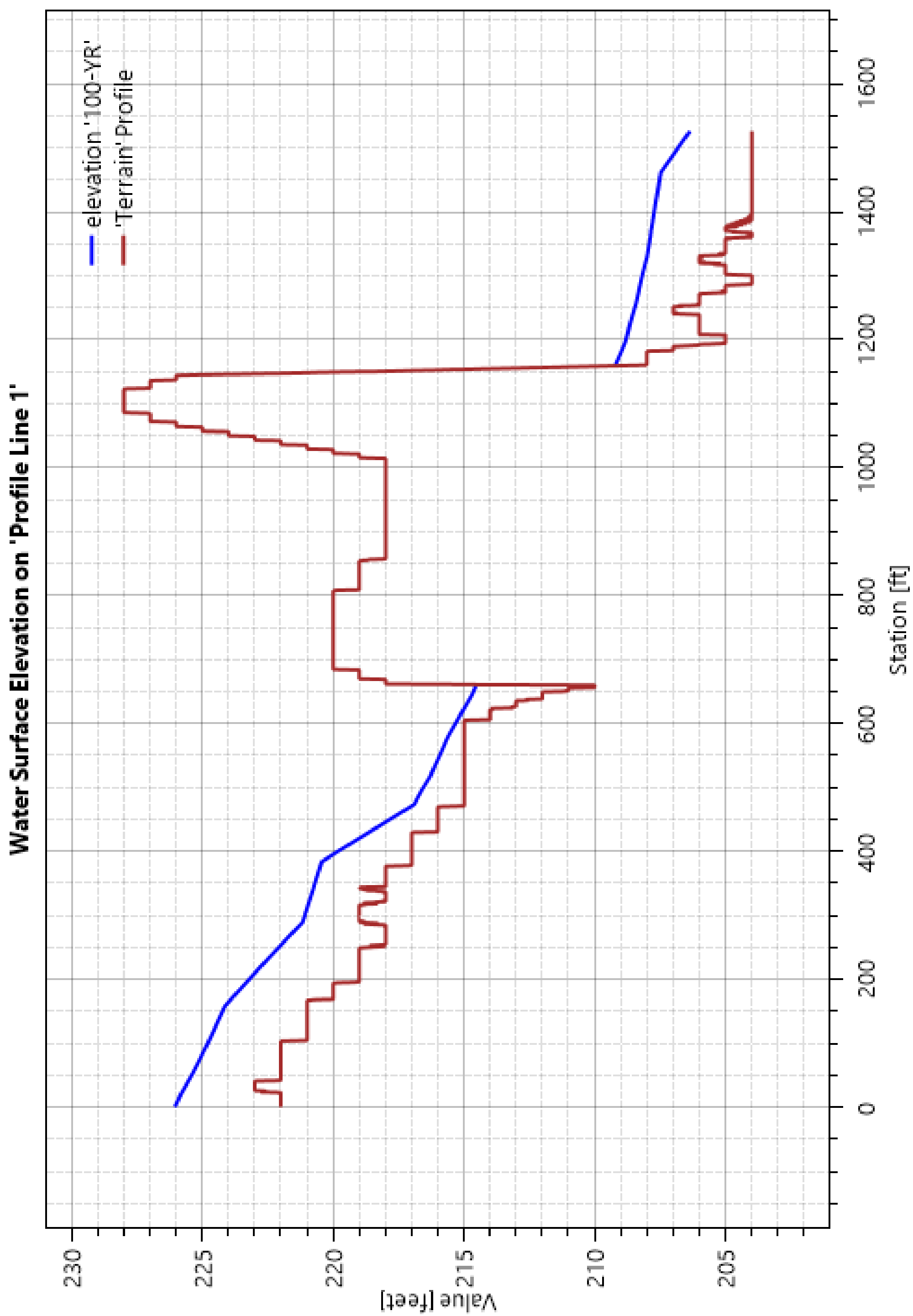
The results from the hydraulic flood modeling using HEC-RAS for the pre- and post-development conditions are presented here. First, the floodplain is delineated for both conditions by showing inundation boundary associated with 100-year flood flow. In the next step, the water surface elevations and flow velocities (velocity at water pool) are shown, and finally the cross-sectional views of pre- and post- construction water surface for each of the sections have depicted the impacts of the development on the flood elevation (reported in Appendices B and C). It should be noted that there is only FEMA flood elevations determined for Bushkill Creek that shows floodway and floodplain associated with Bushkill Creek, and there is no delineated floodway or determined flood elevation for the studied UNT.

- Existing condition results

Inundation boundary of 100-year flood for the pre-development condition.



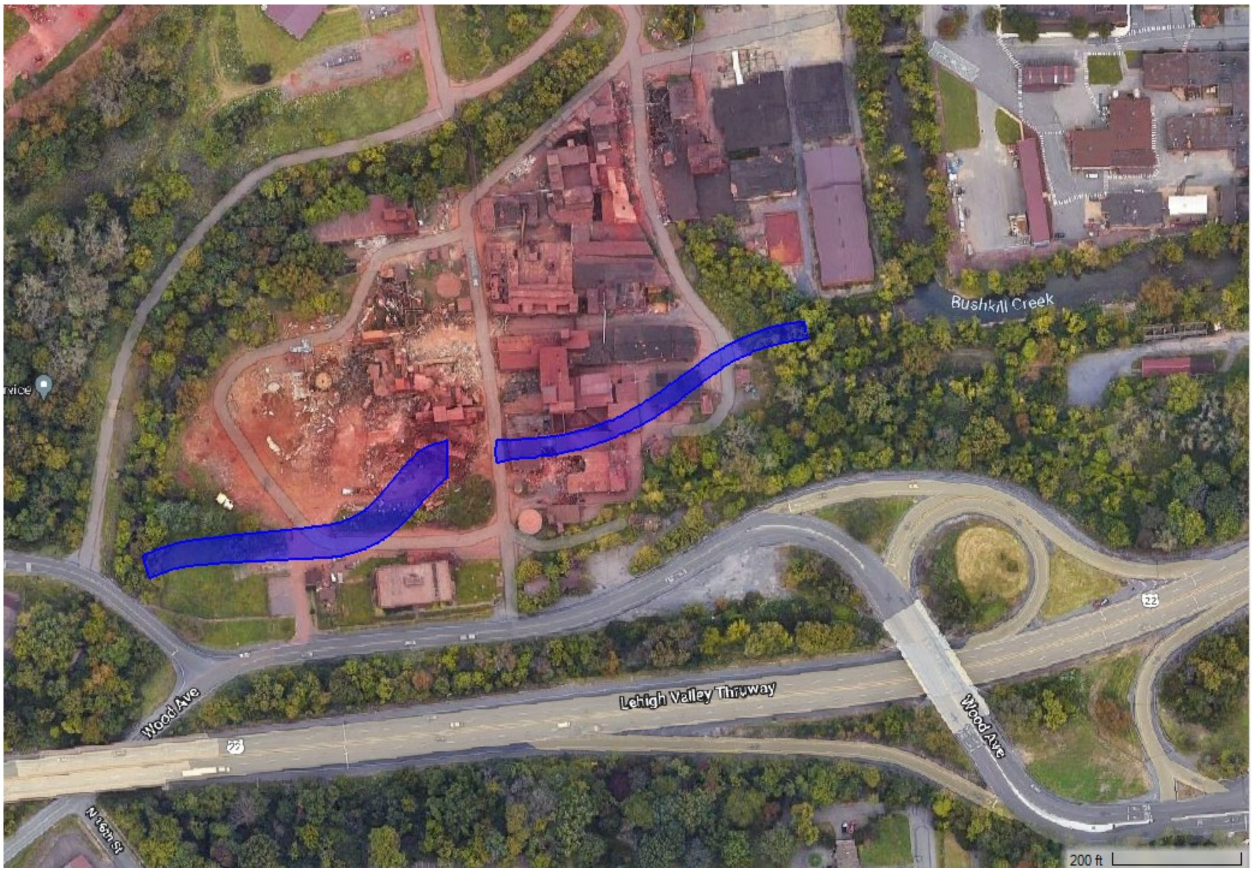
Water surface elevation (ft; NAVD 88) of 100-year flood for the pre-development condition.



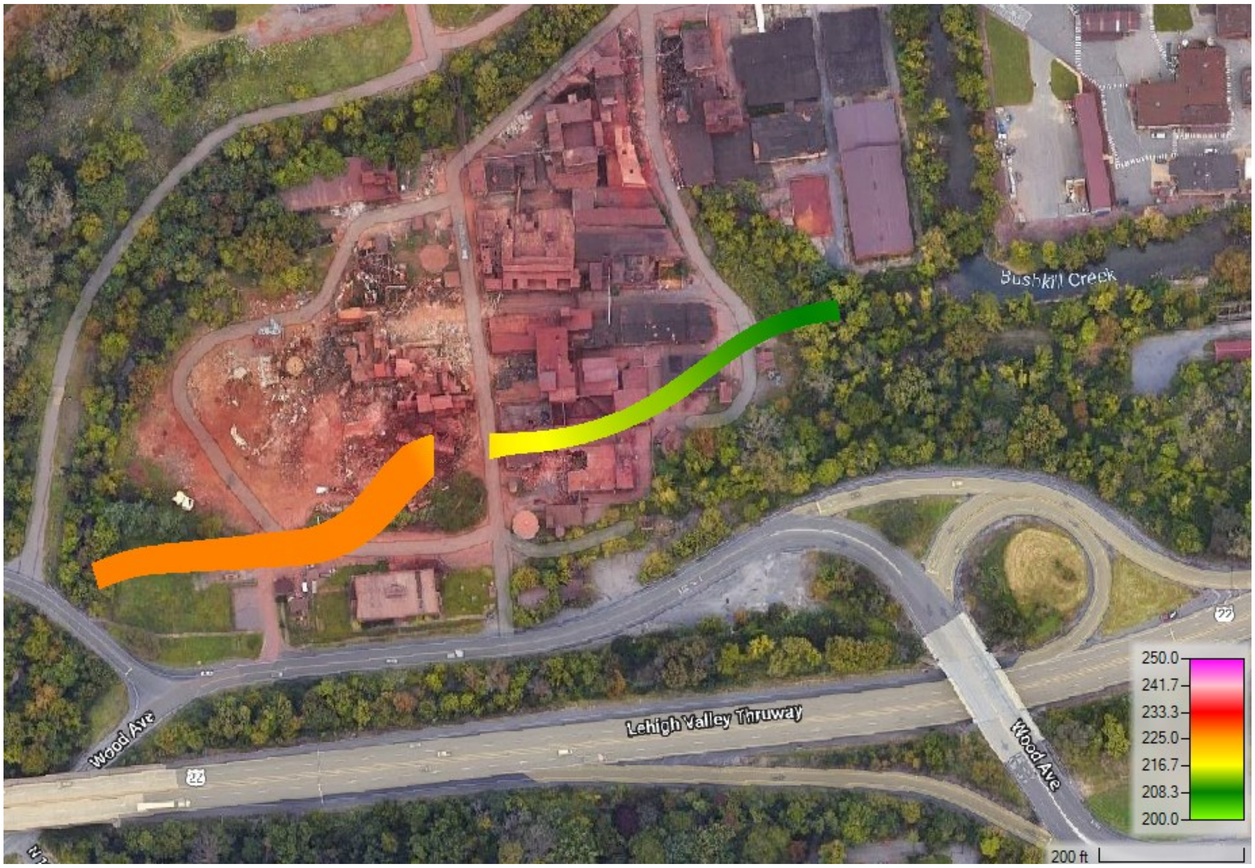
Existing channel profile view of water surface elevation (ft; NAVD 88) for 100-year flood in the pre-development condition.

Maximum flow velocity (ft/s; at water pool) of 100-year flood for the pre-development condition.

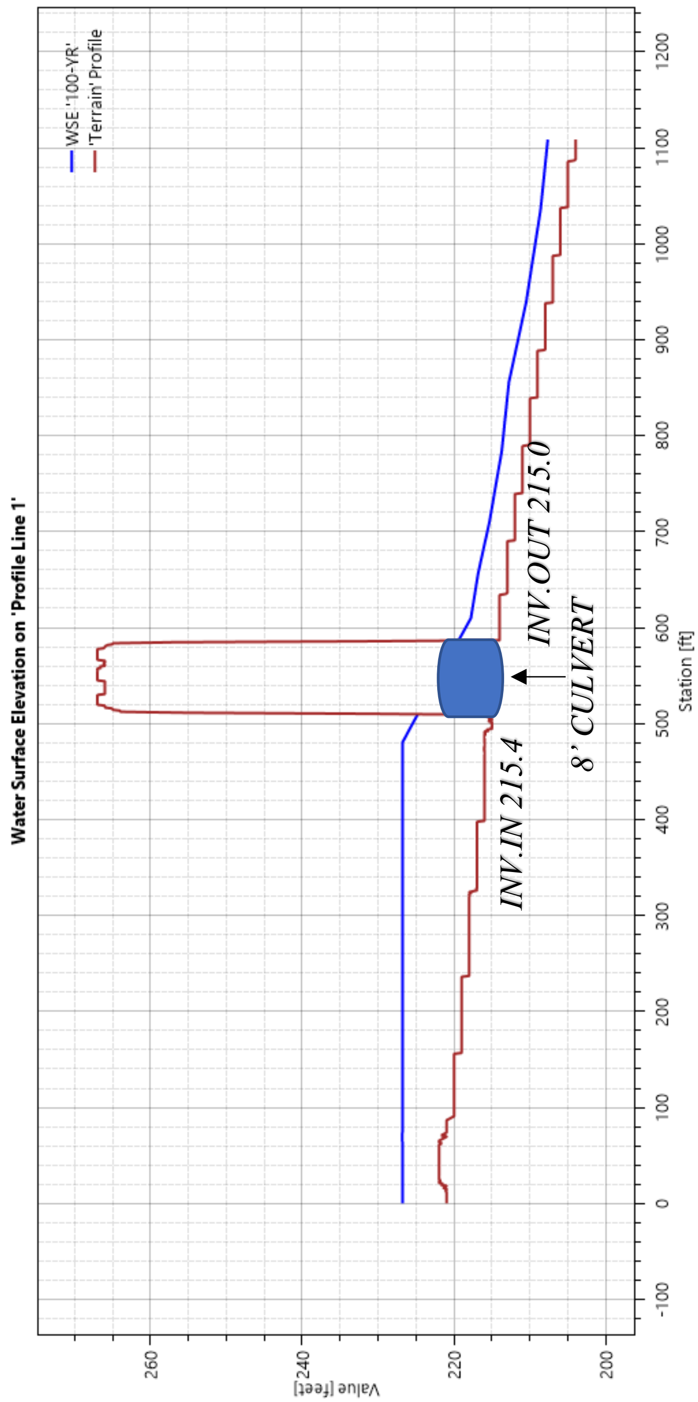
➢ Proposed condition results



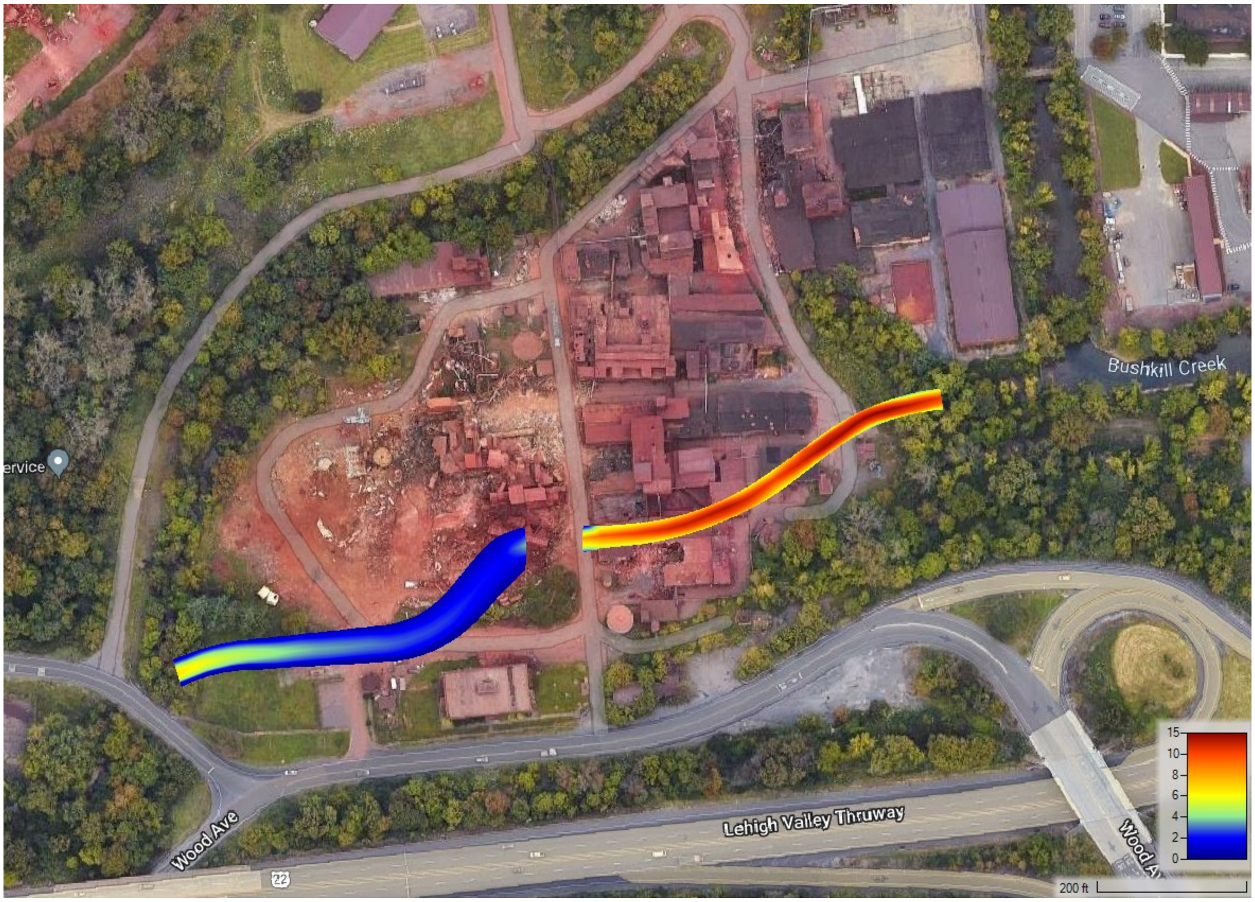
Inundation boundary of 100-year flood for the post-development condition.



Water surface elevation (ft; NAVD 88) of 100-year flood for the post-development condition.



Relocated channel profile view of water surface elevation (ft; NAVD 88) for 100-year flood in the post-development condition.



Maximum flow velocity (ft/s; at water pool) of 100-year flood for the post-development condition.

In summary, the major changes of the relocated stream in the post-construction condition are:

- Installing one 8’ concrete pipe culvert (#1) along UNT with total length of 76’, upstream invert elevation of 215.4’, and downstream invert elevation of 215.0’

As can be seen through the presented graphical results, the following stream crossing criteria are met by employing culverts with adequate hydraulic capacity:

- The floodplain boundaries of pre- and post-construction conditions of existing and proposed UNT are similar and none result in overflow from the banks.
- The post-construction increase in flood elevations in the flood areas delineated by FEMA map is less than 1’, and many sections the post-development water surface is lower.

- The flow velocities in the pre- and post-construction condition as well as in the upstream and downstream of the culverts in the post-construction condition of UNT have improved compared to the pre-development condition.

In addition to the improvement in the flood management in the relocated channel, principles of stable channel design were employed to enhance the current conditions of the channel.

The proposed channel was designed based on the following criteria:

- Mimic the existing upstream cross section and modify cross sections where needed
- Safely convey the 100-year discharge
- Selection of bed material size to minimize the potential cross-sectional morphologic changes over time (i.e., limit scouring to protect downgradient streams)

Relocation of the channel reduces the floodplain dimension as well as mitigates the stream velocity. However, since the stream velocity in the post-development condition was still high and could pose erosive potential, the sediment transport through the channel was modeled. Based on the results from the sediment transport, the bed and bank material size was designed to impede erosion and therefore protect the downgradient stream. The sediment transport model was done by HEC-RAS and used flow data as explained in the Hydrology section of this document. Total suspended solid (TSS) data were extracted from USGS Gauge and based on that two concentrations each corresponding to minimum and maximum flow were determined.

A typical suspended solid size distribution in the stormwater for low flow conditions (TSS of 10 mg/L when the flow is 1.92 cfs), presented below, was employed as the incoming sediment into the channel:

Clay (0.002 mm to 0.004 mm): 15 %

VFM (0.004 mm to 0.008 mm): 20 %

FM (0.008 mm to 0.016 mm): 25 %

MM (0.016 mm to 0.032 mm): 25 %

CM (0.032 mm to 0.0625 mm): 10 %

VFS (0.0625 mm to 0.125 mm): 5 %

A typical suspended solid size distribution in the stormwater for high flow conditions (TSS of 20 mg/L when the flow is 191.54 cfs), presented below, was employed as the incoming sediment into the channel:

Clay (0.002 mm to 0.004 mm): 15 %

VFM (0.004 mm to 0.008 mm): 15 %

FM (0.008 mm to 0.016 mm): 15 %

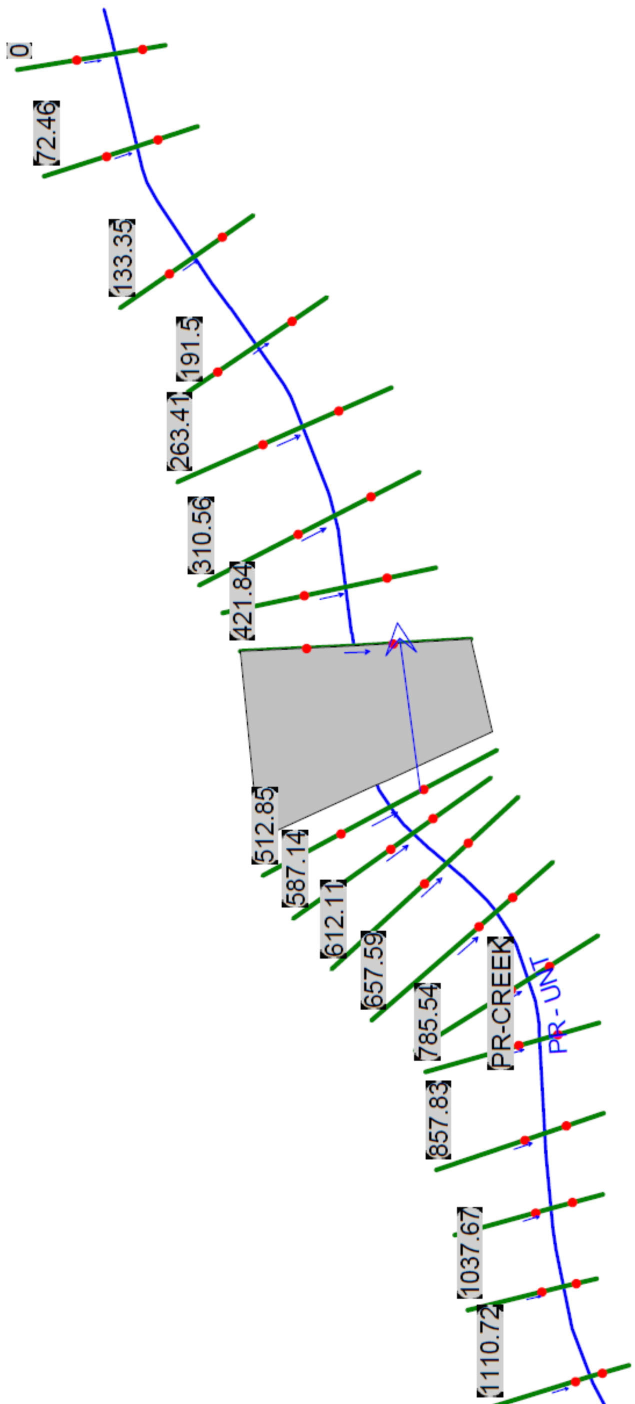
MM (0.016 mm to 0.032 mm): 10 %

CM (0.032 mm to 0.0625 mm): 20 %

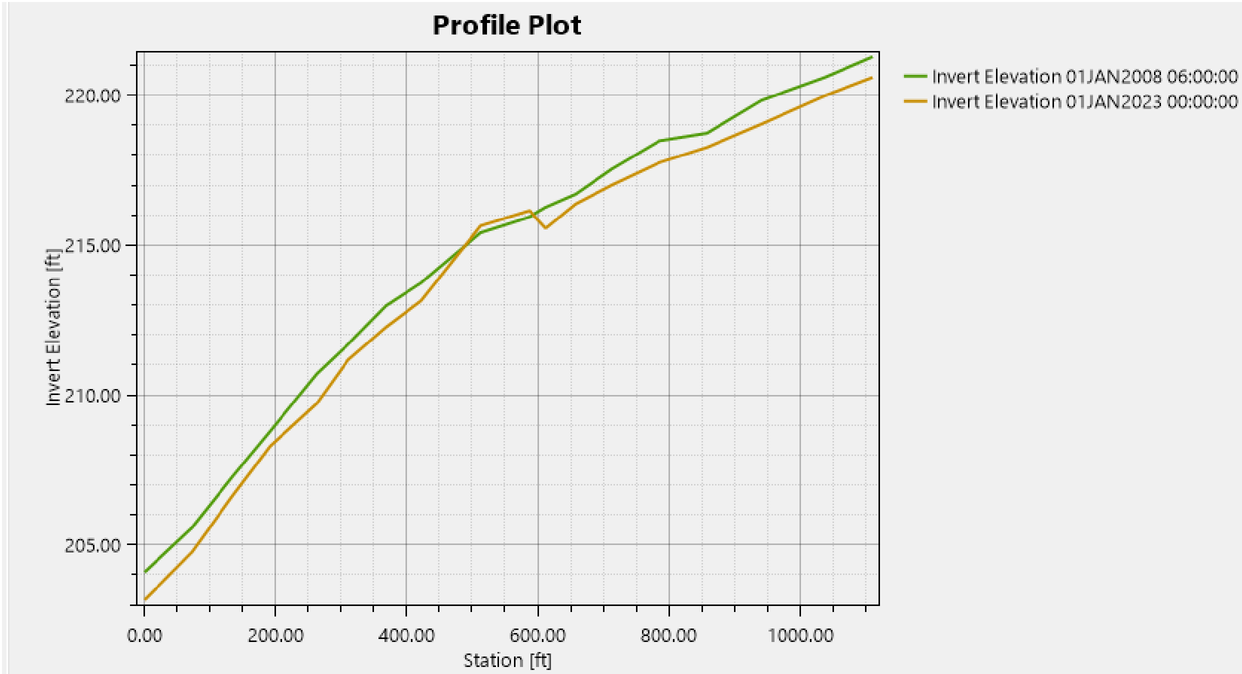
VFS (0.0625 mm to 0.125 mm): 20 %

FS (0.125 mm to 0.250 mm): 5 %

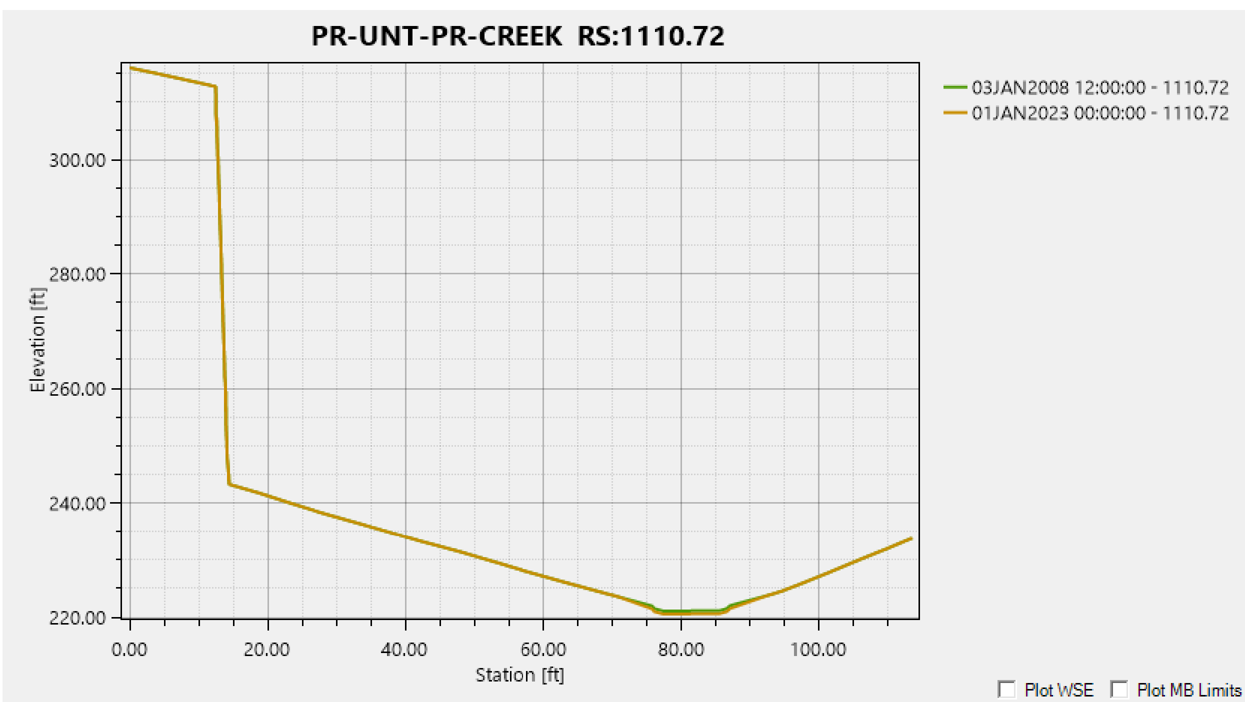
The bed and bank material size distribution was determined by iterations in a way that the changes in the cross-section morphology (i.e., erosion/deposition) would be minimal. The upstream boundary condition of sediment transport model was flow data, while it was the normal depth (i.e., in form of slope) for the downstream end. The sediment transport simulation employed backwater analysis for the hydraulic part. A maximum moveable bed of 1' was assumed for the simulation, and the moveable bed was considered at bed as well as at banks up to the main channel elevation. Laursen, Copeland, and Rubey were selected as transport function, sorting method, and settlement velocity method, respectively. An annual average temperature of 55 ^{o}F was adopted to estimate water characteristics such as viscosity etc. The flow data was introduced on a daily basis, while the transport model computation increment was set to 6 hours to increase the resolution and accuracy of the simulation. The highlights from the results of 15 years of simulation are summarized in the following figures to illustrate the adequacy of the selected bed gradation.



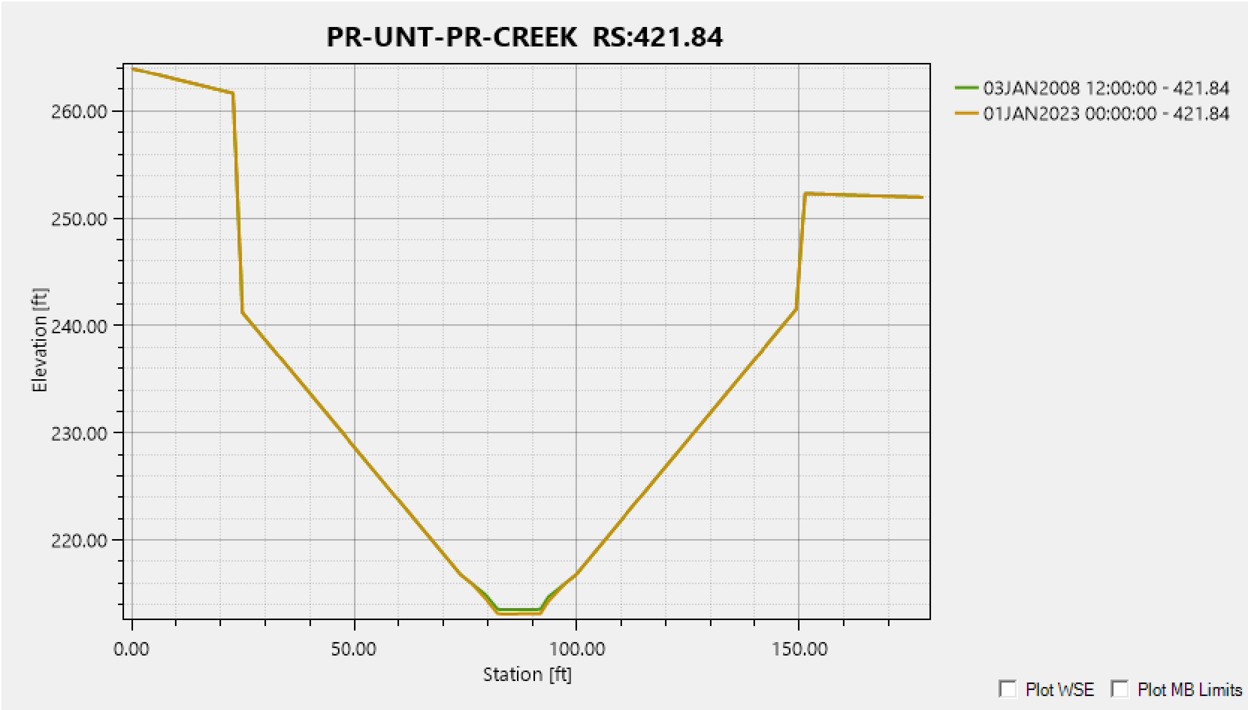
Plan of relocated channel and cross section labels.



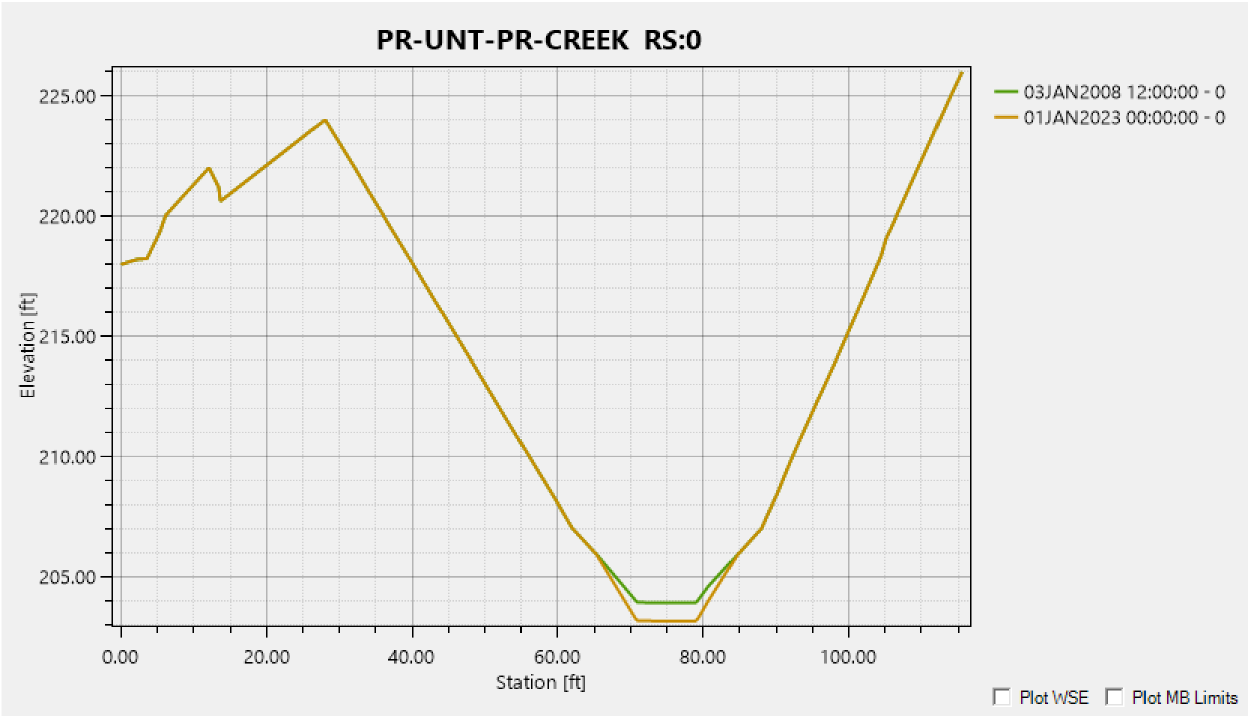
Profile view of the Invert elevations at the beginning and end of sediment transport simulation.



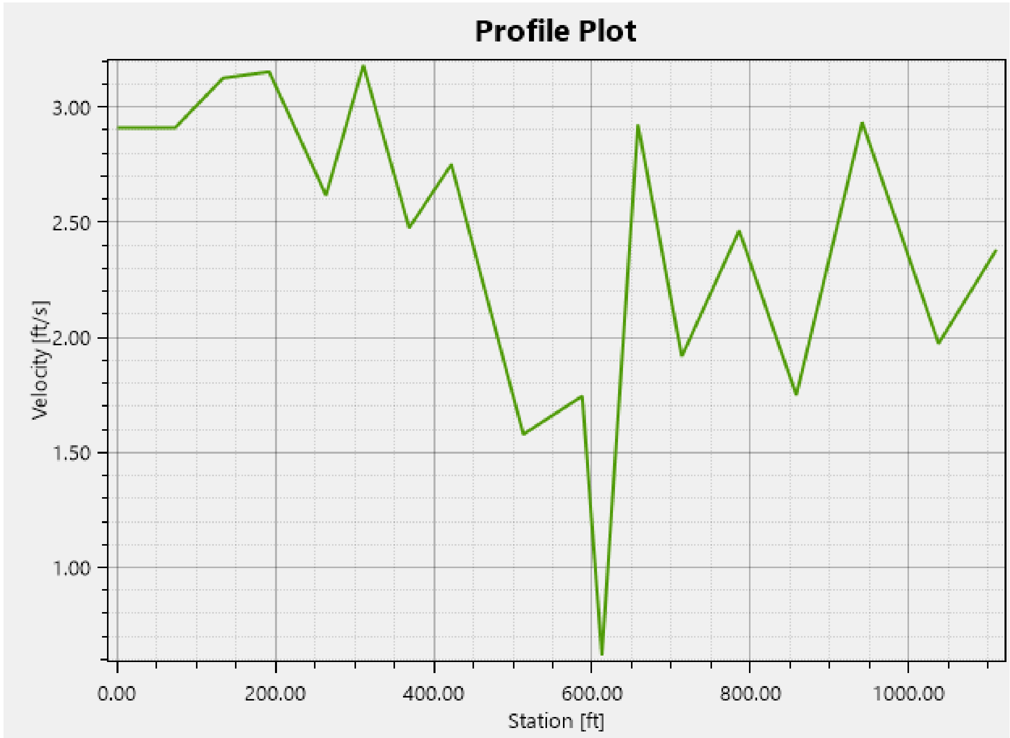
Upstream section view of the Invert elevations at the beginning and end of sediment transport simulation.



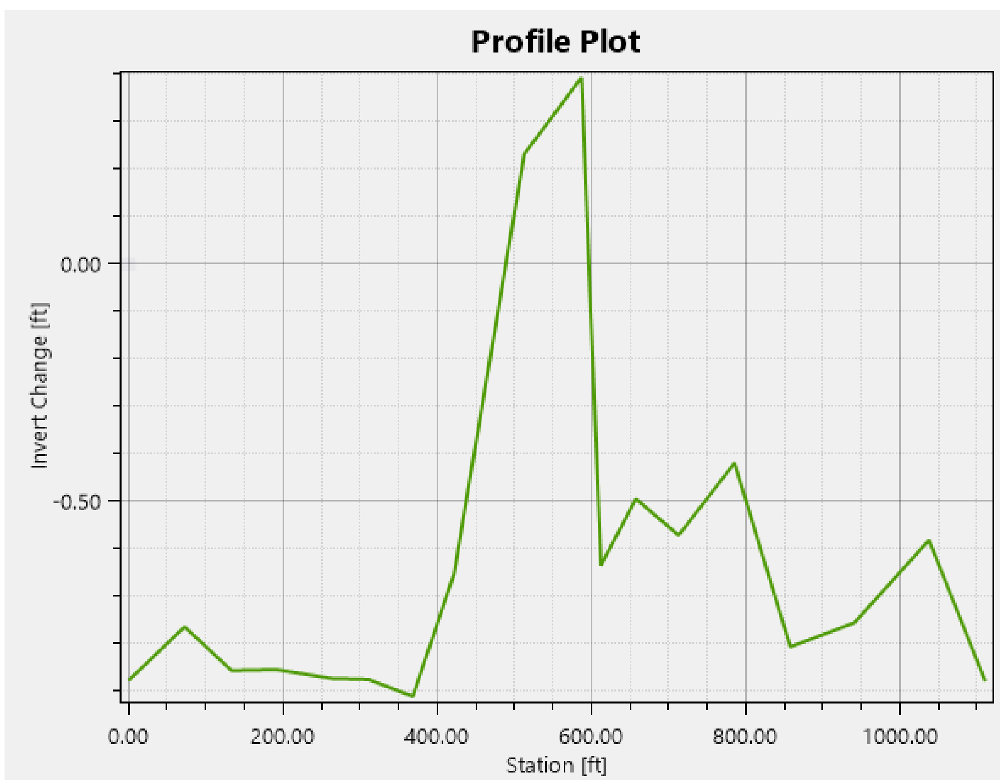
Immediately downgradient of culvert Invert elevations at the beginning and end of sediment transport simulation.



Downstream section view of the Invert elevations at the beginning and end of sediment transport simulation.

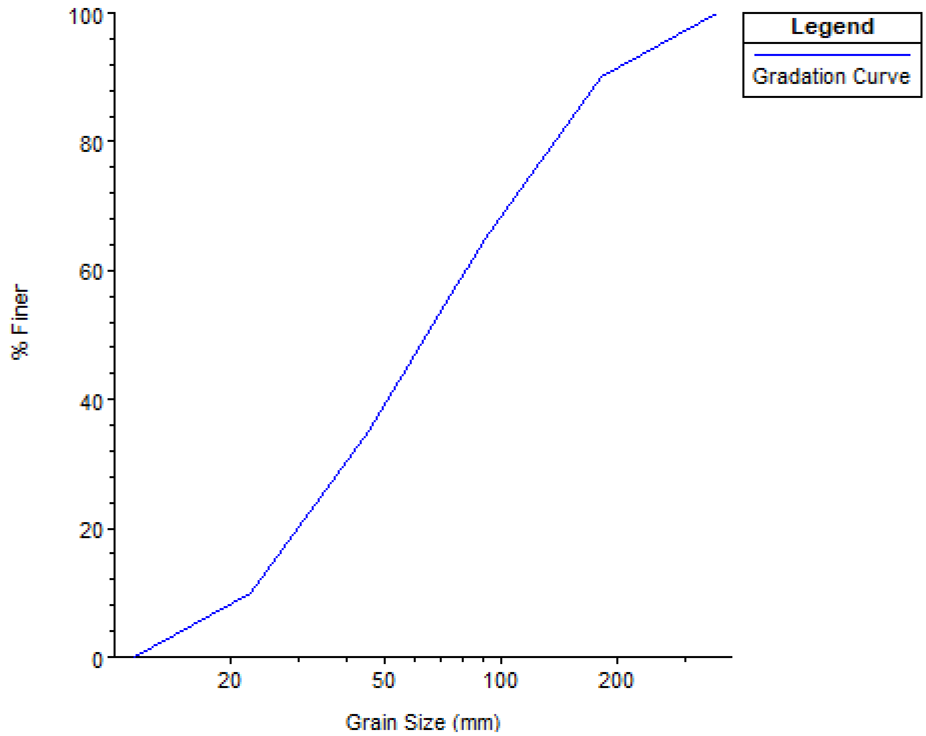


Profile view of the stream maximum velocities at bed elevation.



Profile view of the invert changes after 15 years of simulation.

As can be seen through the figures, the elevation change after 15 years of simulation is minimal and is mostly less than 1’ scouring. Moreover, the stream velocity profiles at bed elevation indicated that the velocities do not exceed 6.5 ft/s. Table 8-12 of PENNDOT publication 584 (chapter 8; 2010 edition) has reported permissible velocities for various linings. The relocated channel is considered stable because the simulated velocities are below the lowest permissible velocities listed for the riprap lining. It should be noted that the proposed bed material is boulder with a d50 of ~ 60mm (2.4”) and the following size distribution.



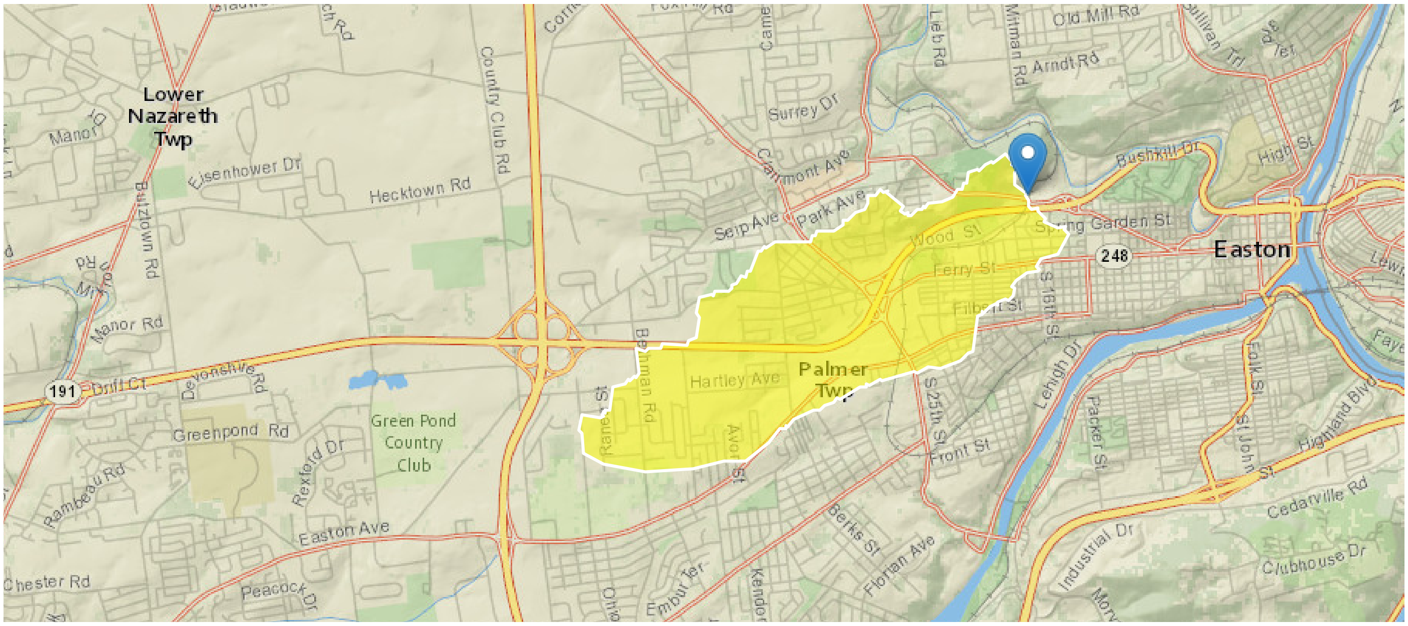
Size distribution of the proposed bed and banks material (the chart is in mm; 25.4 mm = 1 inch).

Appendix A

StreamStats Report

Bushkill Tributary

Region ID: PA
Workspace ID: PA20230515123543682000
Clicked Point (Latitude, Longitude): 40.69561, -75.23498
Time: 2023-05-15 08:36:06 -0400



➕ Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
CARBON	Percentage of area of carbonate rock	93.03	percent
DRNAREA	Area that drains to a point on a stream	2.32	square miles
ELEV	Mean Basin Elevation	360	feet
FOREST	Percentage of area covered by forest	8.9887	percent
PRECIP	Mean Annual Precipitation	45	inches
ROCKDEP	Depth to rock	5.4	feet
STRDEN	Stream Density -- total length of streams divided by drainage area	0	miles per square mile
URBAN	Percentage of basin with urban development	67.0411	percent

Peak-Flow Statistics

Peak-Flow Statistics Parameters [Peak Flow Region 3 SIR 2019 5094]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.32	square miles	1.42	1280
CARBON	Percent Carbonate	93.03	percent	0	100

Peak-Flow Statistics Flow Report [Peak Flow Region 3 SIR 2019 5094]

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

Statistic	Value	Unit	ASEp
50-percent AEP flood	96.7	ft^3/s	41.7
20-percent AEP flood	186	ft^3/s	39.6
10-percent AEP flood	266	ft^3/s	38.3
4-percent AEP flood	389	ft^3/s	38.5
2-percent AEP flood	497	ft^3/s	38.9
1-percent AEP flood	621	ft^3/s	40.1
0.5-percent AEP flood	760	ft^3/s	41.3
0.2-percent AEP flood	973	ft^3/s	43.7

Peak-Flow Statistics Citations

Roland, M.A., and Stuckey, M.H.,2019, Development of regression equations for the estimation of flood flows at ungaged streams in Pennsylvania: U.S. Geological Survey Scientific Investigations Report 2019–5094, 36 p. (https://doi.org/10.3133/sir20195094)

Low-Flow Statistics

Low-Flow Statistics Parameters [Low Flow Region 2]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.32	square miles	4.93	1280
PRECIP	Mean Annual Precipitation	45	inches	35	50.4
STRDEN	Stream Density	0	miles per square mile	0.51	3.1
ROCKDEP	Depth to Rock	5.4	feet	3.32	5.65
CARBON	Percent Carbonate	93.03	percent	0	99

Low-Flow Statistics Flow Report [Low Flow Region 2]

Statistic	Value	Unit

Low-Flow Statistics Citations

Annual Flow Statistics

Annual Flow Statistics Parameters [Statewide Mean and Base Flow]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.32	square miles	2.26	1720
ELEV	Mean Basin Elevation	360	feet	130	2700
PRECIP	Mean Annual Precipitation	45	inches	33.1	50.4

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
FOREST	Percent Forest	8.9887	percent	5.1	100
URBAN	Percent Urban	67.0411	percent	0	89

Annual Flow Statistics Flow Report [Statewide Mean and Base Flow]

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

Statistic	Value	Unit	SE	ASEp
Mean Annual Flow	3.43	ft^3/s	12	12

Annual Flow Statistics Citations

Stuckey, M.H.,2006, Low-flow, base-flow, and mean-flow regression equations for Pennsylvania streams: U.S. Geological Survey Scientific Investigations Report 2006-5130, 84 p. (http://pubs.usgs.gov/sir/2006/5130/)

General Flow Statistics

General Flow Statistics Parameters [Statewide Mean and Base Flow]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.32	square miles	2.26	1720
PRECIP	Mean Annual Precipitation	45	inches	33.1	50.4
CARBON	Percent Carbonate	93.03	percent	0	99
FOREST	Percent Forest	8.9887	percent	5.1	100
URBAN	Percent Urban	67.0411	percent	0	89

General Flow Statistics Flow Report [Statewide Mean and Base Flow]

PII: 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	4.46	ft^3/s	38	38

General Flow Statistics Citations

Stuckey, M.H.,2006, Low-flow, base-flow, and mean-flow regression equations for Pennsylvania streams: U.S. Geological Survey Scientific Investigations Report 2006-5130, 84 p. (http://pubs.usgs.gov/sir/2006/5130/)

Base Flow Statistics

Base Flow Statistics Parameters [Statewide Mean and Base Flow]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.32	square miles	2.26	1720
PRECIP	Mean Annual Precipitation	45	inches	33.1	50.4
CARBON	Percent Carbonate	93.03	percent	0	99
FOREST	Percent Forest	8.9887	percent	5.1	100

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
URBAN	Percent Urban	67.0411	percent	0	89

Base Flow Statistics Flow Report [Statewide Mean and Base Flow]

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

Statistic	Value	Unit	SE	ASEp
Base Flow 10 Year Recurrence Interval	2	ft^3/s	21	21
Base Flow 25 Year Recurrence Interval	1.78	ft^3/s	21	21
Base Flow 50 Year Recurrence Interval	1.66	ft^3/s	23	23

Base Flow Statistics Citations

Stuckey, M.H.,2006, Low-flow, base-flow, and mean-flow regression equations for Pennsylvania streams: U.S. Geological Survey Scientific Investigations Report 2006-5130, 84 p. (http://pubs.usgs.gov/sir/2006/5130/)

Bankfull Statistics

Bankfull Statistics Parameters [Statewide Bankfull Carbonate 2018 5066]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.32	square miles	18.9	213
CARBON	Percent Carbonate	93.03	percent		

Bankfull Statistics Parameters [Appalachian Highlands D Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.32	square miles	0.07722	940.1535

Bankfull Statistics Parameters [New England P Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.32	square miles	3.799224	138.999861

Bankfull Statistics Parameters [USA Bieger 2015]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.32	square miles	0.07722	59927.7393

Bankfull Statistics Disclaimers [Statewide Bankfull Carbonate 2018 5066]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Bankfull Statistics Flow Report [Statewide Bankfull Carbonate 2018 5066]

Statistic	Value	Unit
Bankfull Area	5.58	ft^2
Bankfull Streamflow	12.5	ft^3/s

Statistic	Value	Unit
Bankfull Width	8.34	ft
Bankfull Depth	0.697	ft

Bankfull Statistics Flow Report [Appalachian Highlands D Bieger 2015]

Statistic	Value	Unit
Bieger_D_channel_width	21.5	ft
Bieger_D_channel_depth	1.43	ft
Bieger_D_channel_cross_sectional_area	31.2	ft^2

Bankfull Statistics Disclaimers [New England P Bieger 2015]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Bankfull Statistics Flow Report [New England P Bieger 2015]

Statistic	Value	Unit
Bieger_P_channel_width	32	ft
Bieger_P_channel_depth	1.66	ft
Bieger_P_channel_cross_sectional_area	53.2	ft^2

Bankfull Statistics Flow Report [USA Bieger 2015]

Statistic	Value	Unit
Bieger_USA_channel_width	16.7	ft
Bieger_USA_channel_depth	1.44	ft
Bieger_USA_channel_cross_sectional_area	26.9	ft^2

Bankfull Statistics Flow Report [Area-Averaged]

Statistic	Value	Unit
Bankfull Area	5.58	ft^2
Bankfull Streamflow	12.5	ft^3/s
Bankfull Width	8.34	ft
Bankfull Depth	0.697	ft
Bieger_D_channel_width	21.5	ft
Bieger_D_channel_depth	1.43	ft
Bieger_D_channel_cross_sectional_area	31.2	ft^2
Bieger_P_channel_width	32	ft
Bieger_P_channel_depth	1.66	ft
Bieger_P_channel_cross_sectional_area	53.2	ft^2
Bieger_USA_channel_width	16.7	ft
Bieger_USA_channel_depth	1.44	ft
Bieger_USA_channel_cross_sectional_area	26.9	ft^2

Bankfull Statistics Citations

Clune, J.W., Chaplin, J.J., and White, K.E.,2018, Comparison of regression relations of bankfull discharge and channel geometry for the glaciated and nonglaciated settings of Pennsylvania and southern New York: U.S. Geological Survey Scientific Investigations Report 2018–5066, 20 p. (https://doi.org/10.3133/sir20185066)
Bieger, Katrin; Rathjens, Hendrik; Allen, Peter M.; and Arnold, Jeffrey G.,2015, Development and Evaluation of Bankfull Hydraulic Geometry Relationships for the Physiographic Regions of the United States, Publications from USDA-ARS / UNL Faculty, 17p. (https://digitalcommons.unl.edu/usdaarsfacpub/1515?utm_source=digitalcommons.unl.edu%2Fusdaarsfacpub%2F1515&utm_medium=PDF&utm_campaign=PDFCoverPages)

Maximum Probable Flood Statistics

Maximum Probable Flood Statistics Parameters [Crippen Bue Region 4]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	2.32	square miles	0.1	10000

Maximum Probable Flood Statistics Flow Report [Crippen Bue Region 4]

Statistic	Value	Unit
Maximum Flood Crippen Bue Regional	7790	ft^3/s

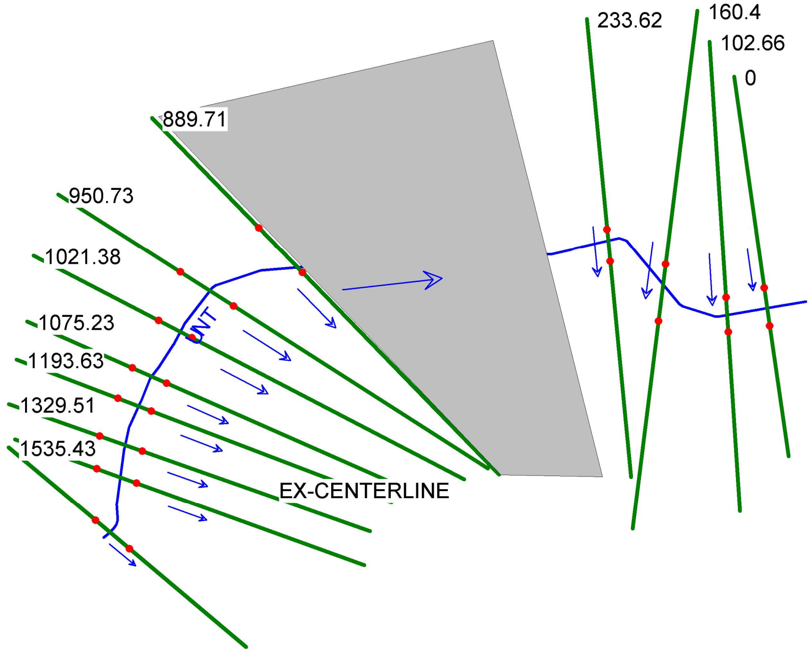
Maximum Probable Flood Statistics Citations

Crippen, J.R. and Bue, Conrad D.1977, Maximum Floodflows in the Conterminous United States, Geological Survey Water-Supply Paper 1887, 52p. (https://pubs.usgs.gov/wsp/1887/report.pdf)

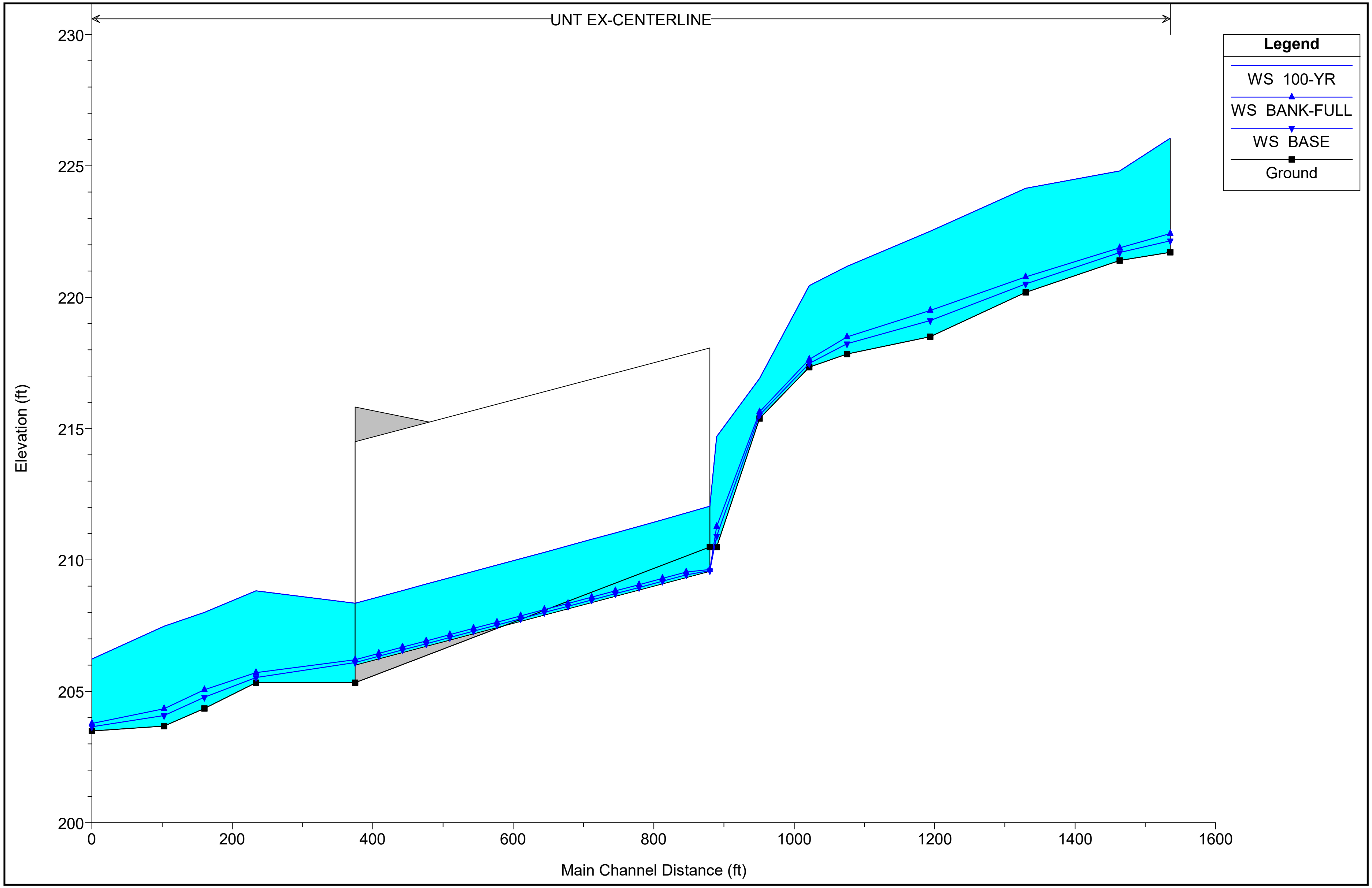
Application Version: 4.14.0
StreamStats Services Version: 1.2.22
NSS Services Version: 2.2.1

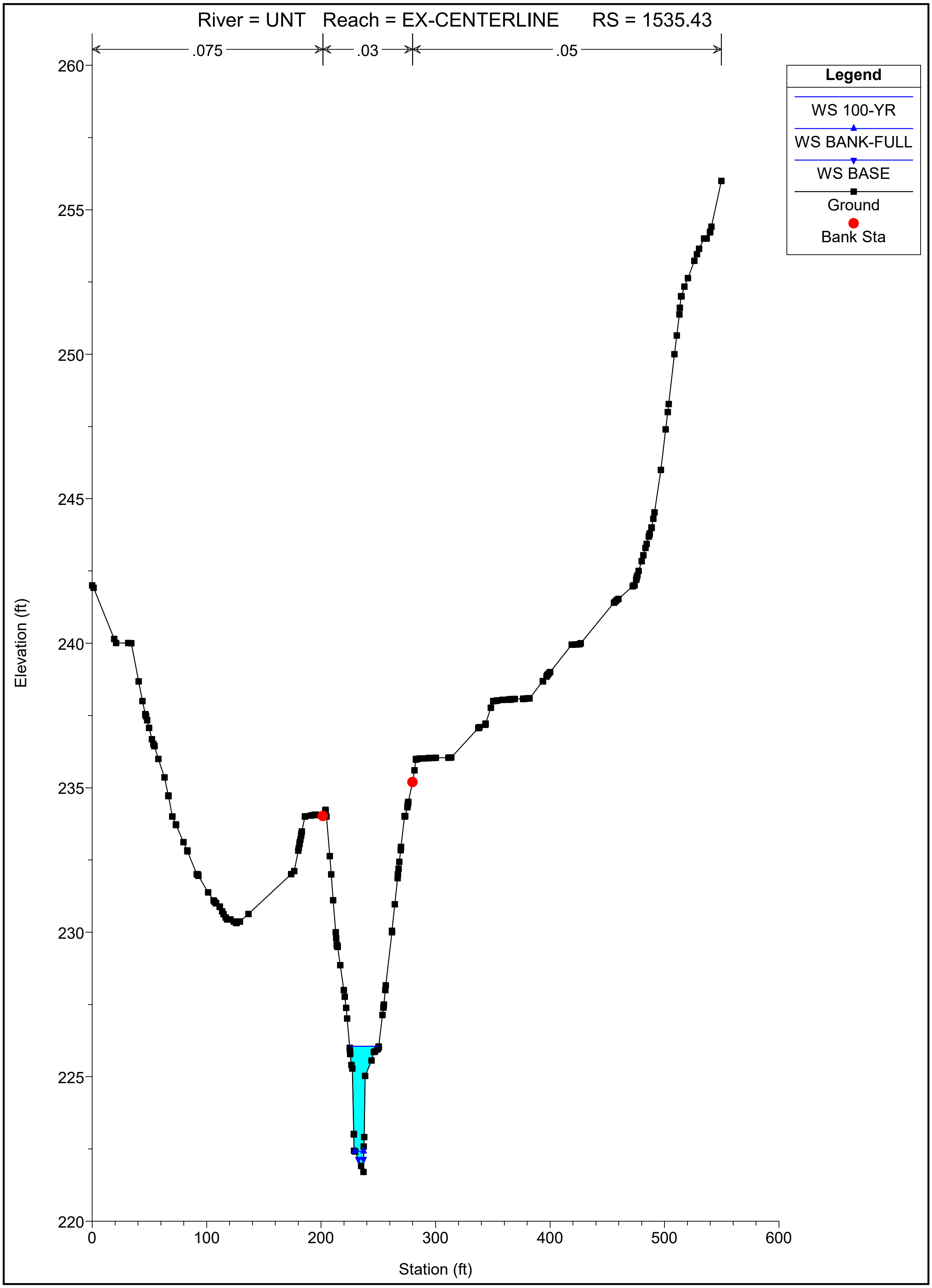
Appendix B

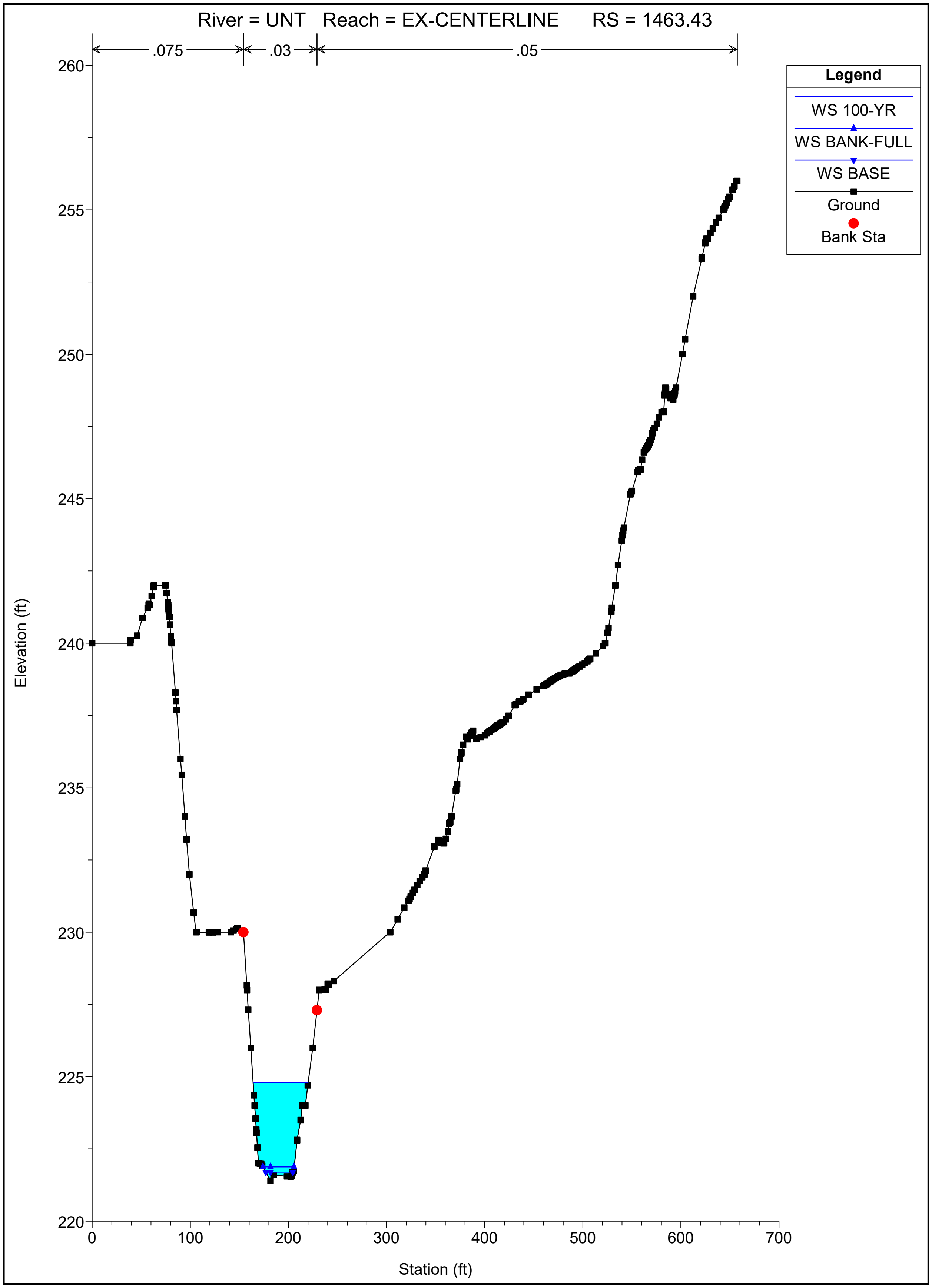
HEC-RAS Outputs for Existing Condition



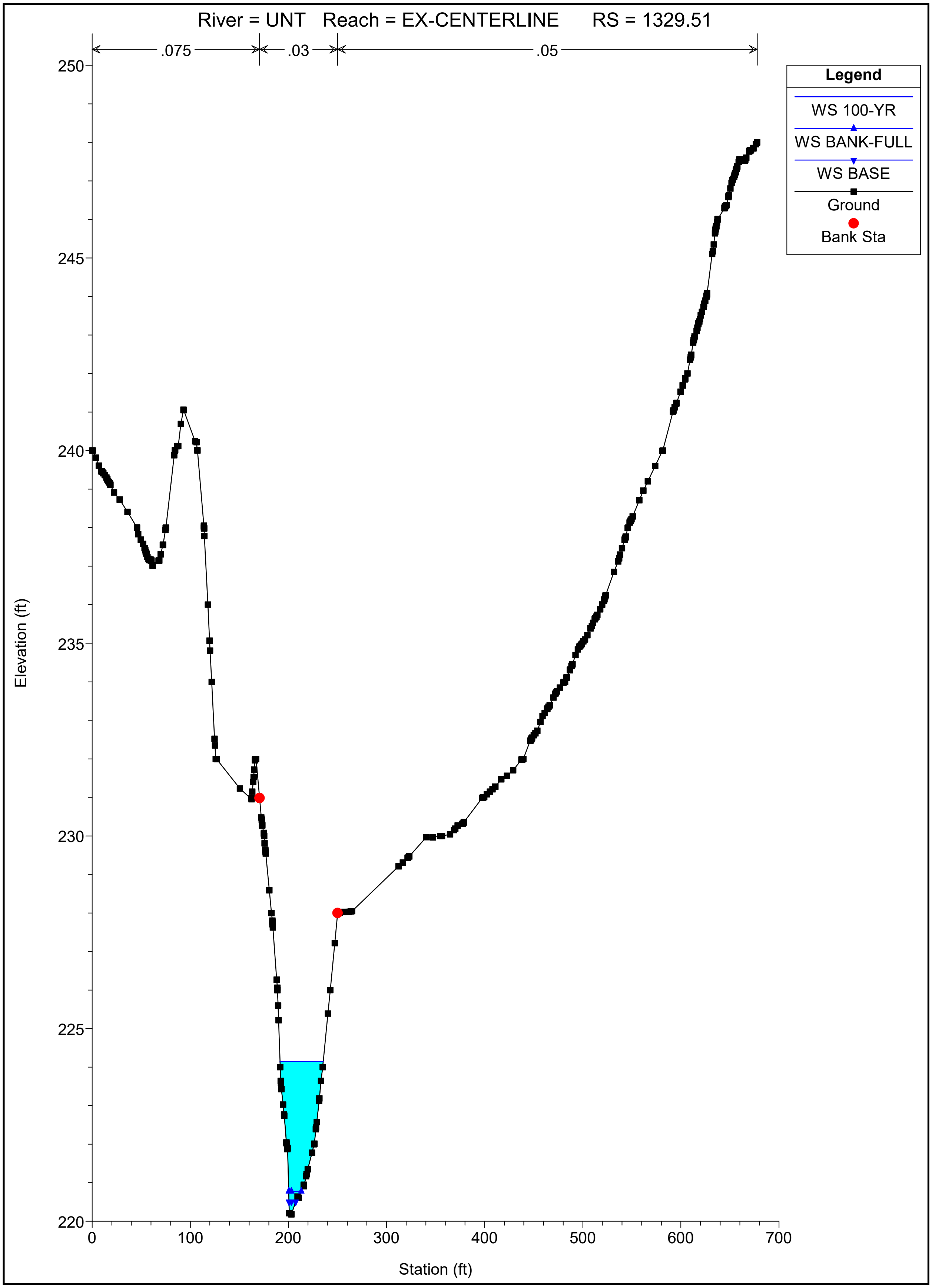
233.62
160.4
102.66
0
889.71
950.73
1021.38
1075.23
1193.63
1329.51
1535.43
UNT
EX-CENTERLINE

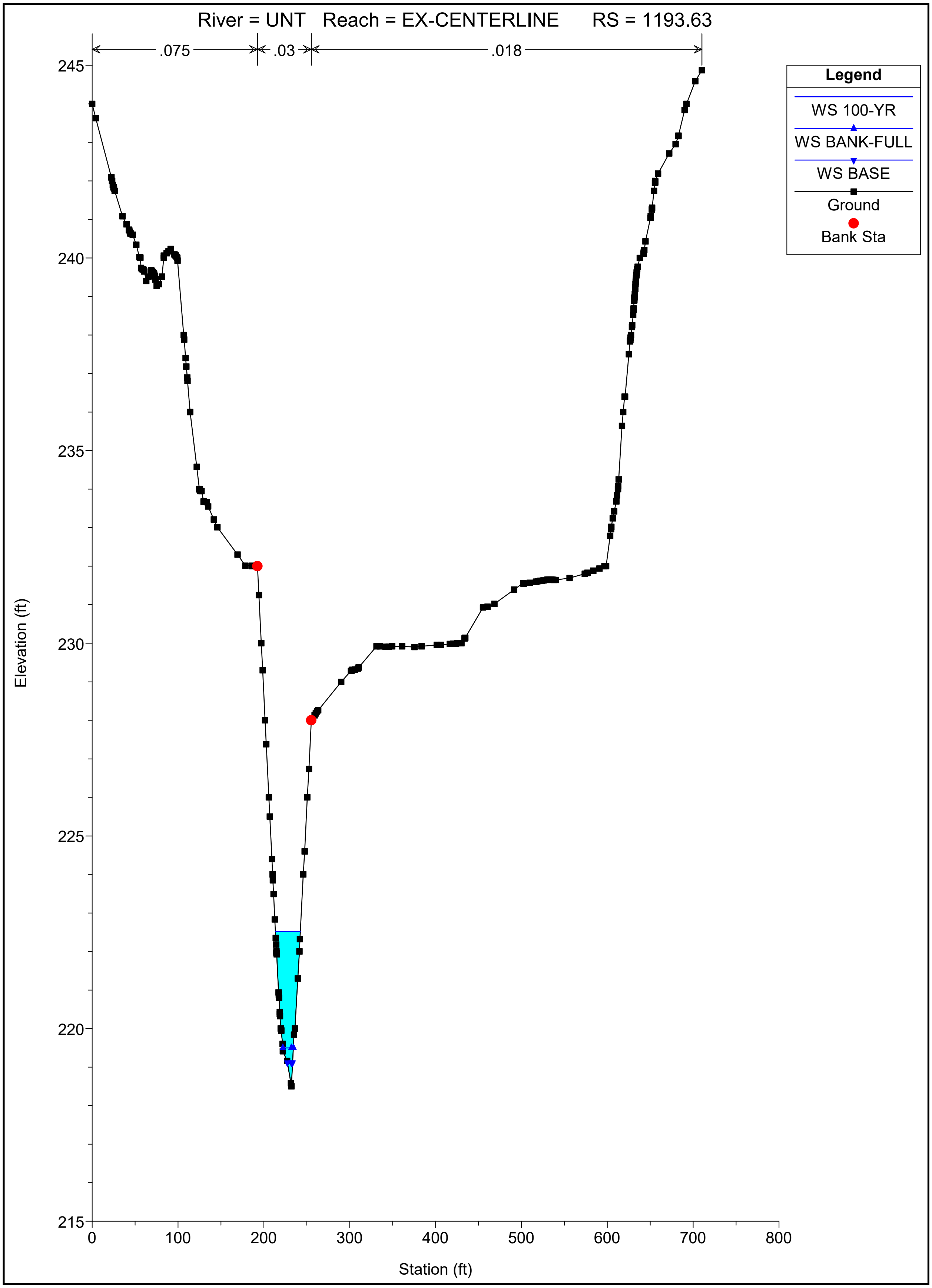

UNT EX-CENTERLINE
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Elevation (ft)
230
225
220
215
210
205
200
0
200
400
600
800
1000
1200
1400
1600
Main Channel Distance (ft)


River = UNT Reach = EX-CENTERLINE RS = 1535.43
.075
.03
.05
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
Station (ft)
260
255
250
245
240
235
230
225
220
0
100
200
300
400
500
600

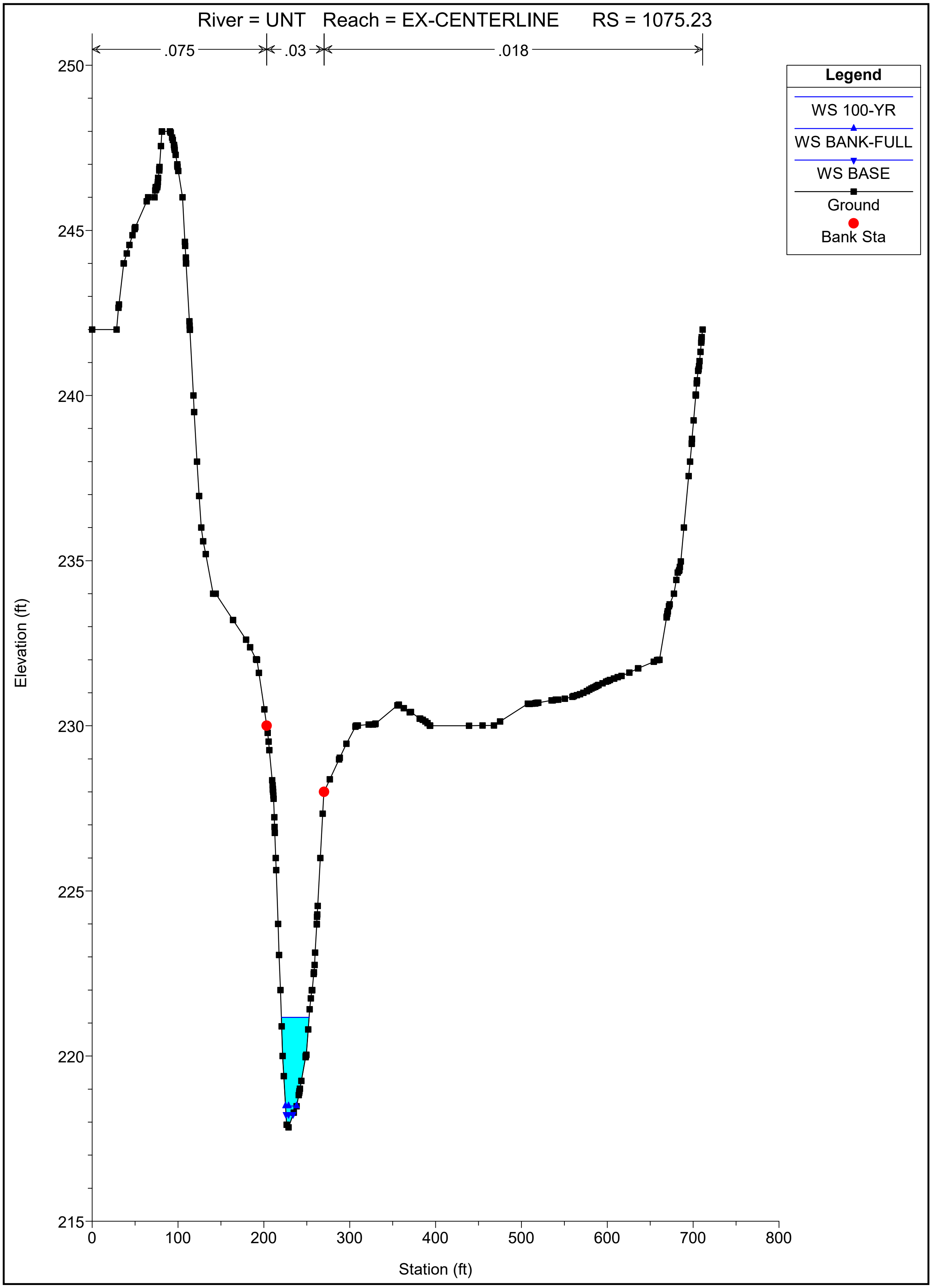


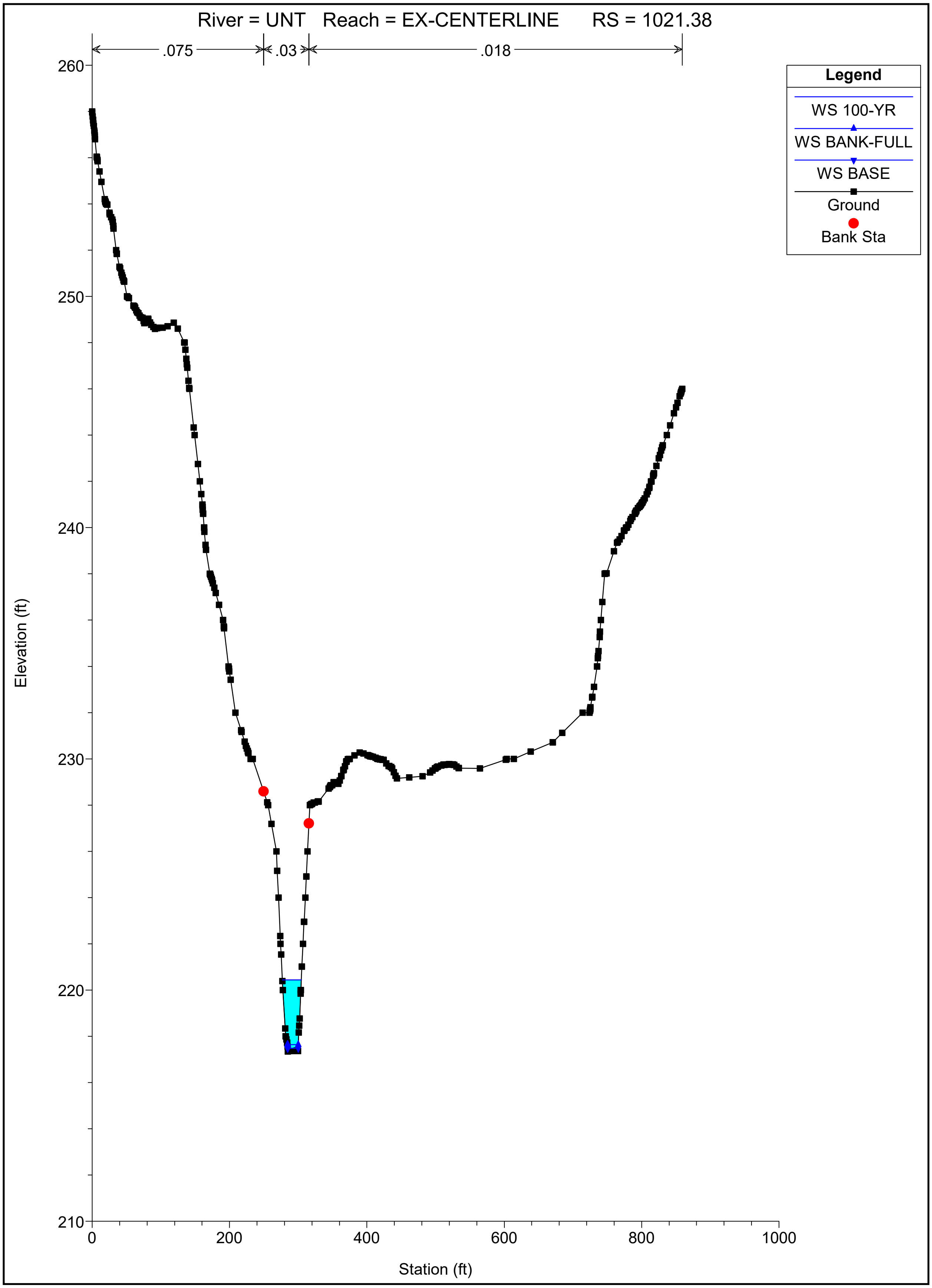
River = UNT   Reach = EX-CENTERLINE   RS = 1463.43
.075
.03
.05
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
Station (ft)
260
255
250
245
240
235
230
225
220
0
100
200
300
400
500
600
700


River = UNT   Reach = EX-CENTERLINE   RS = 1329.51
.075
.03
.05
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
Station (ft)
250
245
240
235
230
225
220
0
100
200
300
400
500
600
700

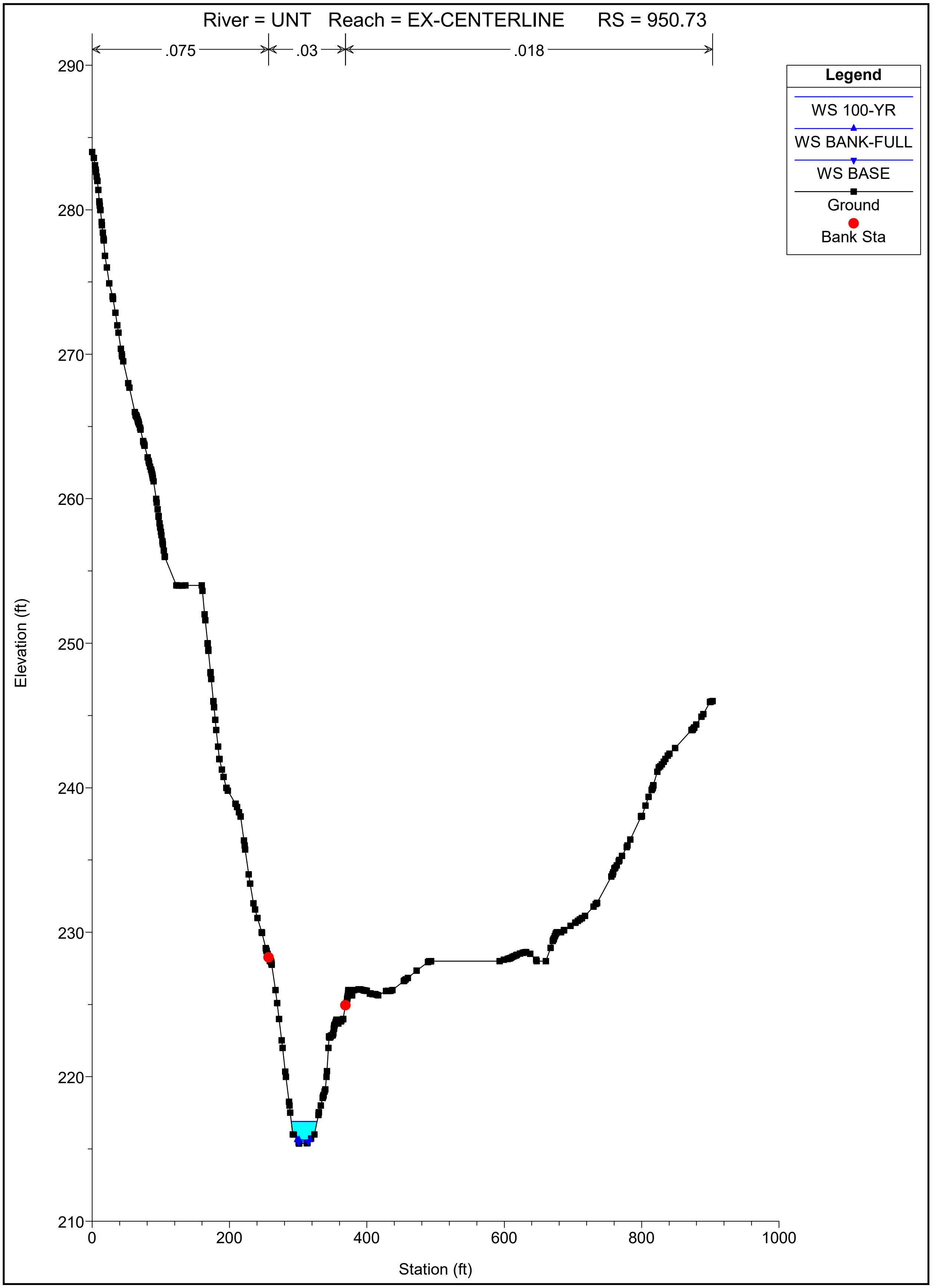


River = UNT Reach = EX-CENTERLINE RS = 1193.63
.075
.03
.018
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
245
240
235
230
225
220
215
Elevation (ft)
0
100
200
300
400
500
600
700
800
Station (ft)

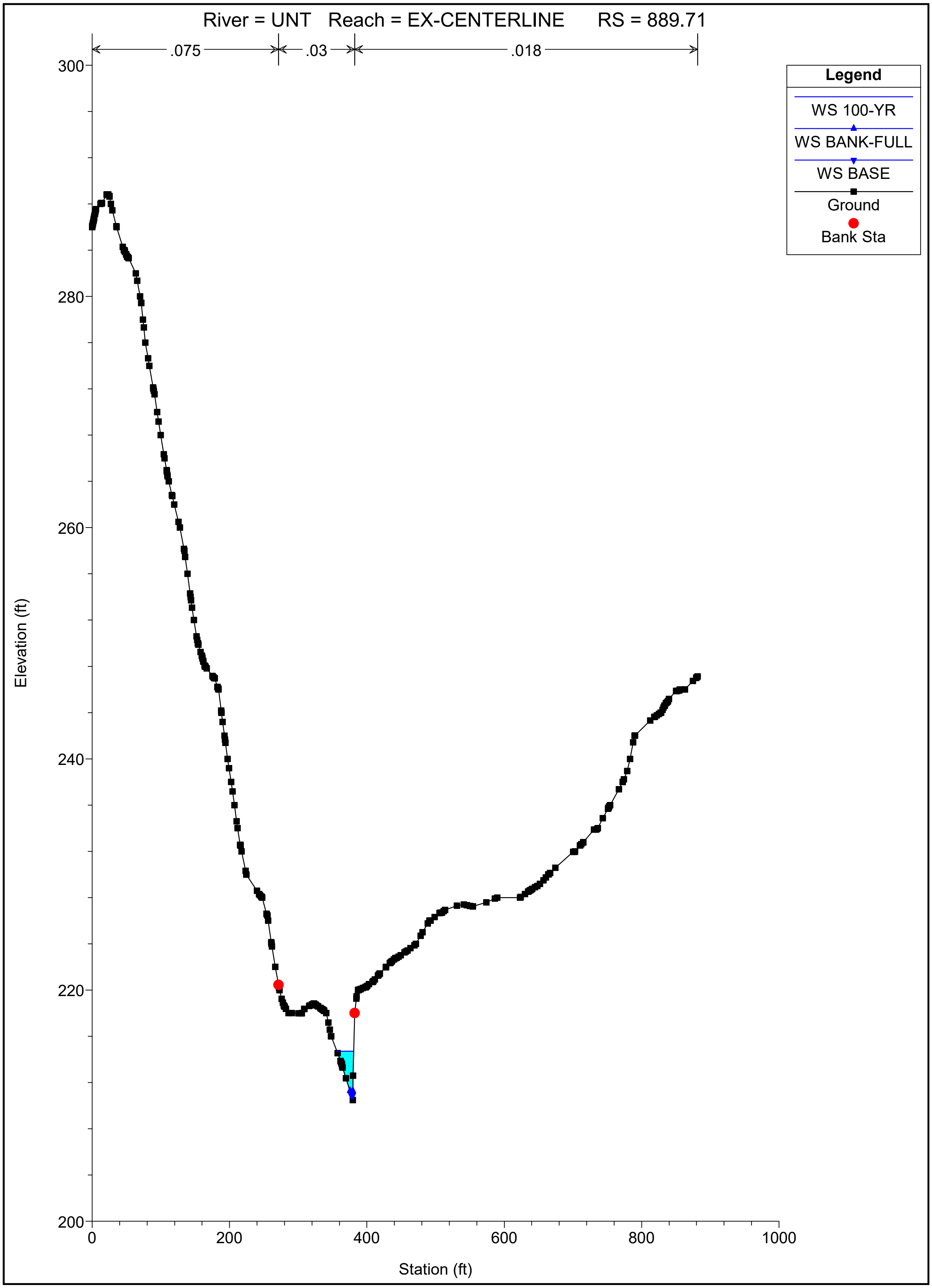

River = UNT Reach = EX-CENTERLINE RS = 1075.23
.075
.03
.018
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
Station (ft)
250
245
240
235
230
225
220
215
0
100
200
300
400
500
600
700
800

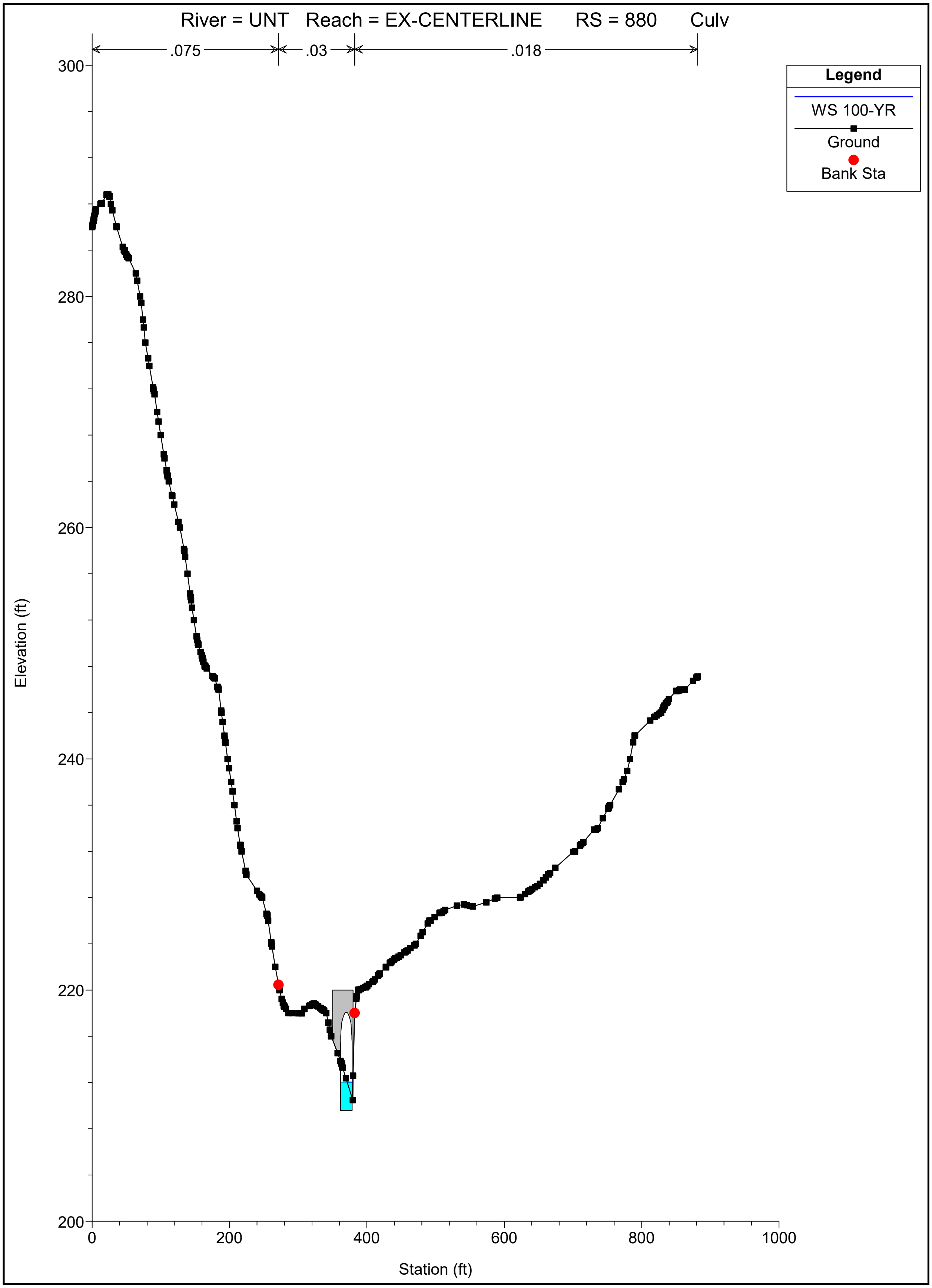


River = UNT Reach = EX-CENTERLINE RS = 1021.38
.075
.03
.018
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
Station (ft)
260
250
240
230
220
210
0
200
400
600
800
1000

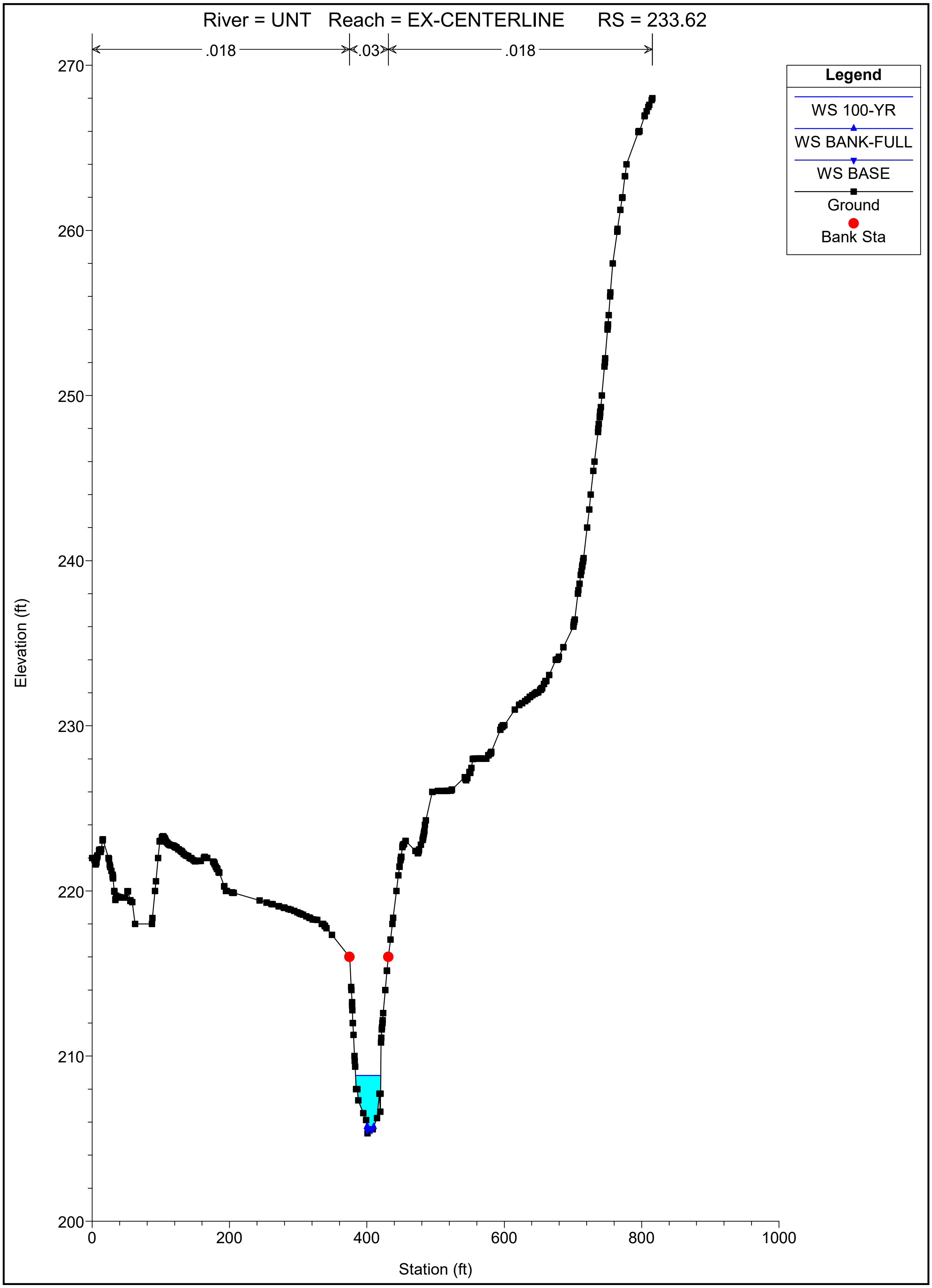


River = UNT Reach = EX-CENTERLINE RS = 950.73
.075
.03
.018
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
290
280
270
260
250
240
230
220
210
0
200
400
600
800
1000
Station (ft)

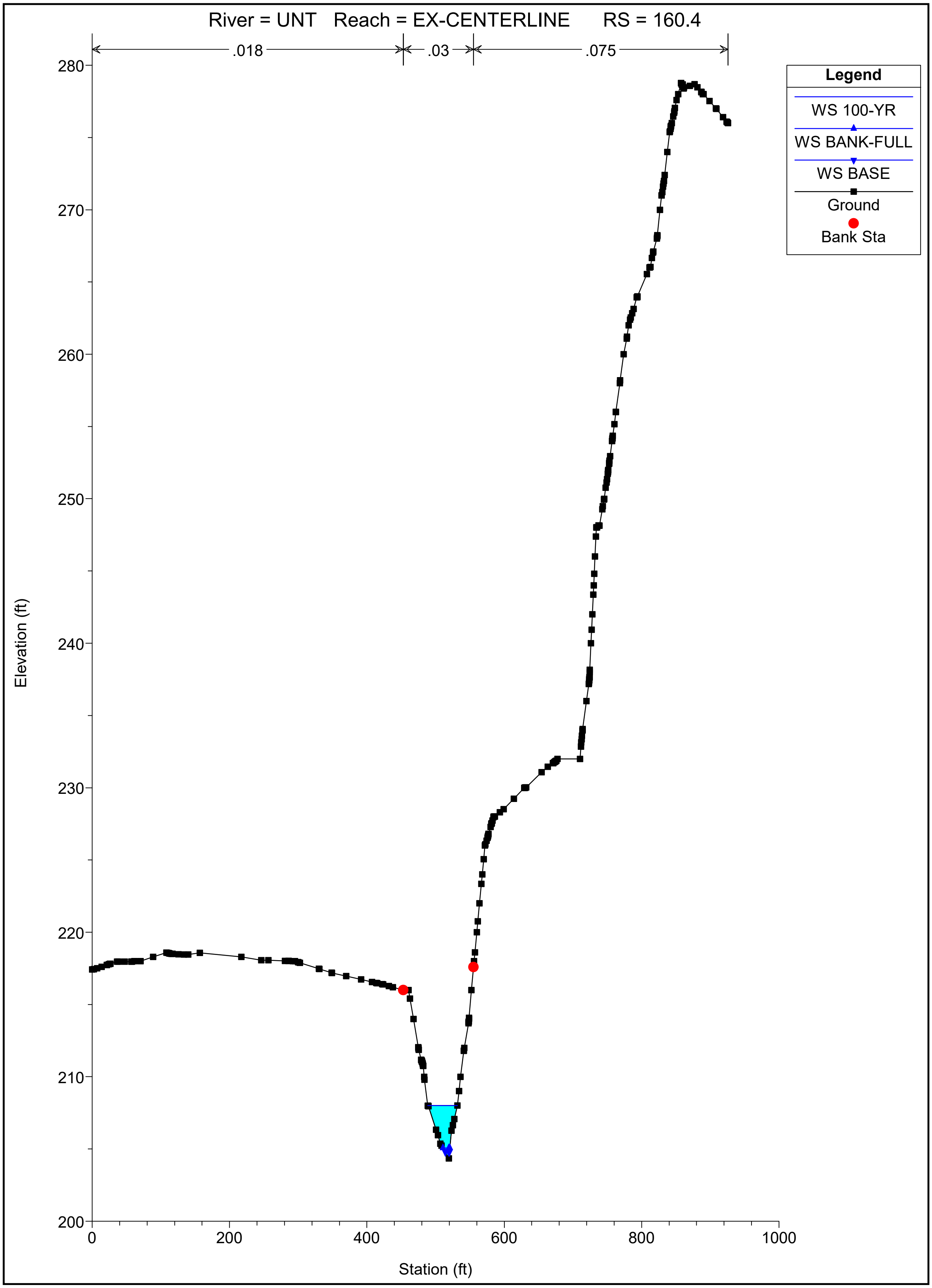

River = UNT Reach = EX-CENTERLINE RS = 889.71
.075
.03
.018
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
300
280
260
240
220
200
0
200
400
600
800
1000
Station (ft)



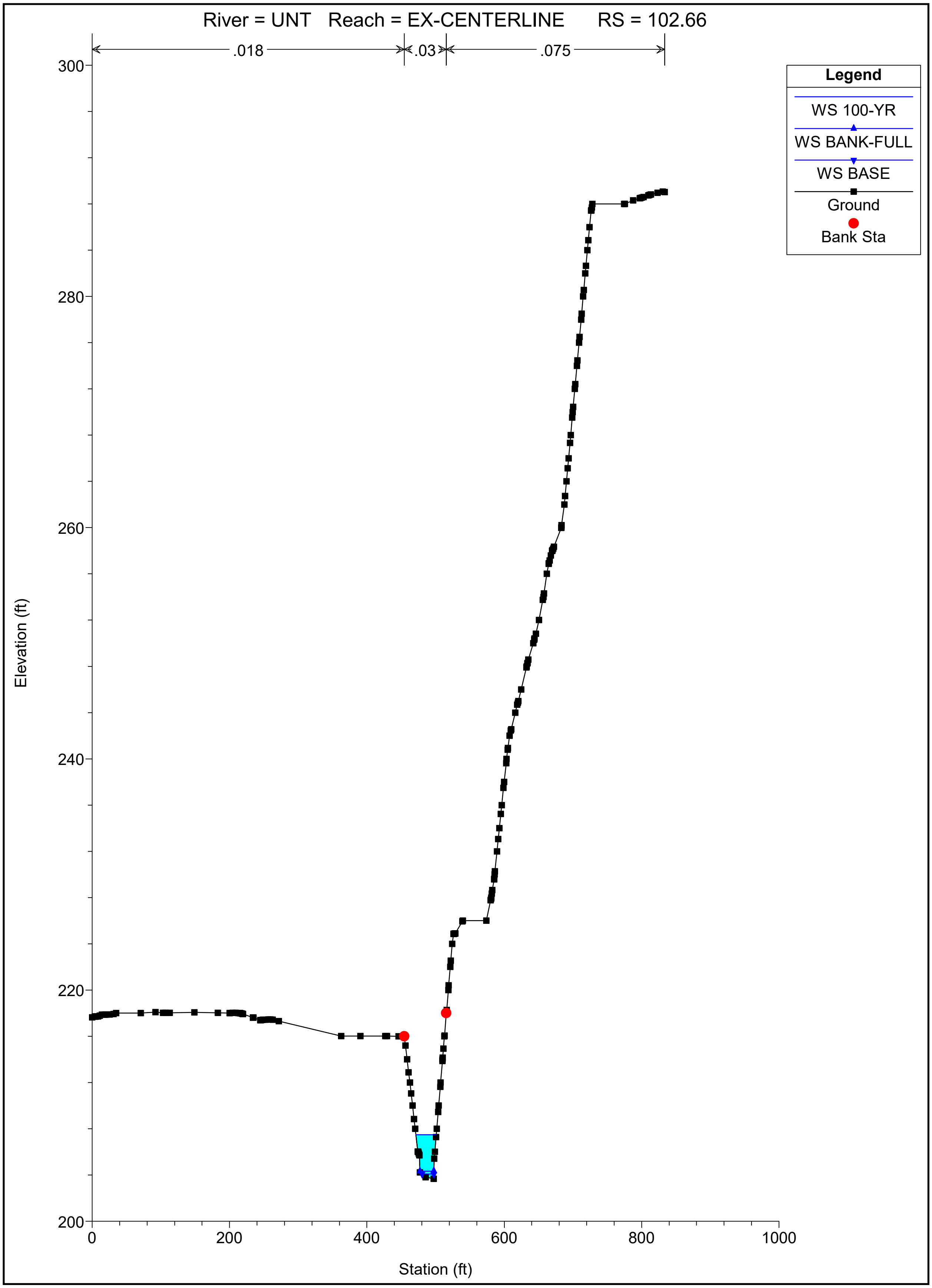
River = UNT   Reach = EX-CENTERLINE   RS = 880   Culv
.075
.03
.018
Legend
WS 100-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
300
280
260
240
220
200
0
200
400
600
800
1000



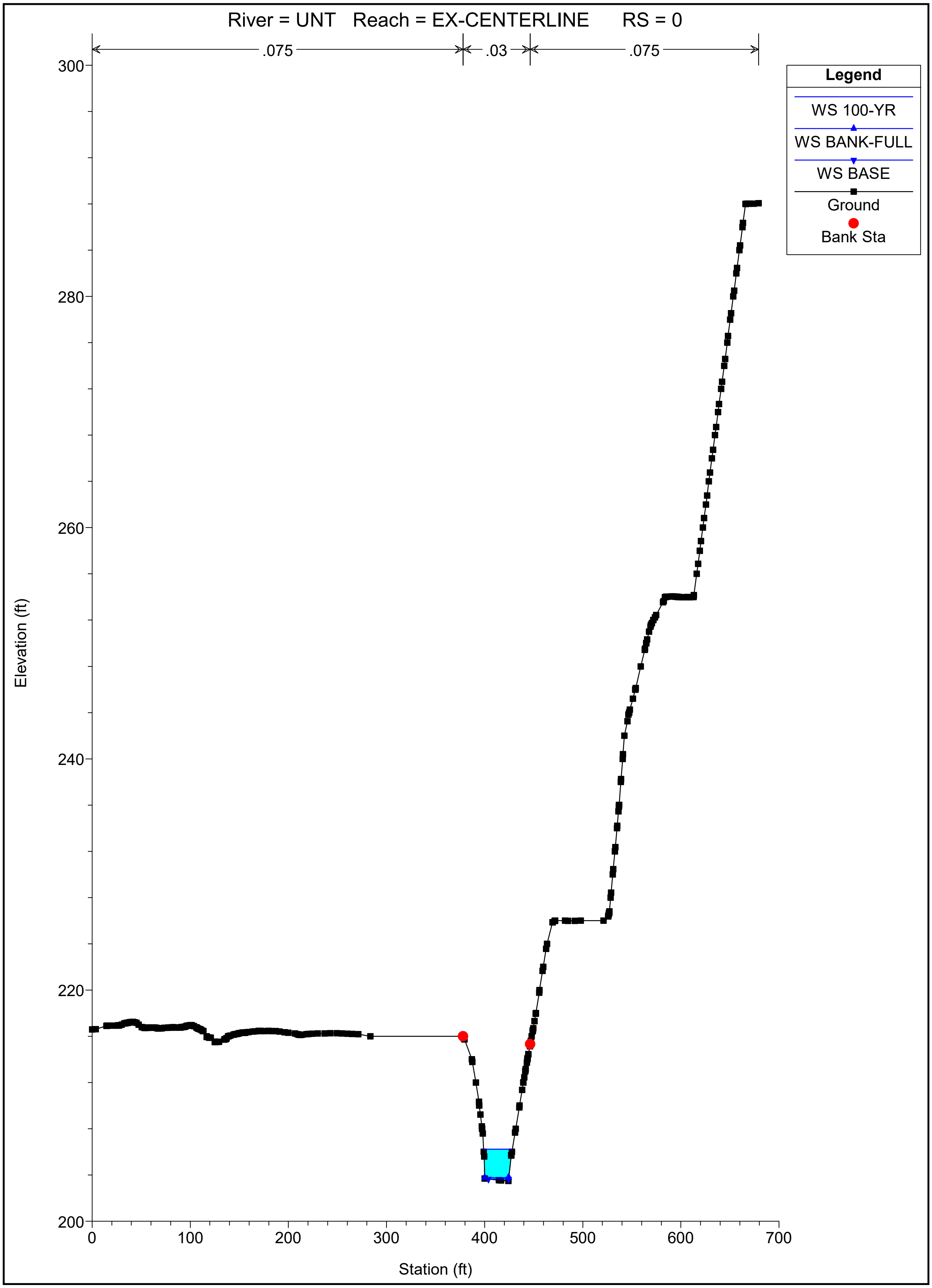
River = UNT Reach = EX-CENTERLINE RS = 233.62
.018
.03
.018
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
Station (ft)
270
260
250
240
230
220
210
200
0
200
400
600
800
1000



River = UNT Reach = EX-CENTERLINE RS = 160.4
.018
.03
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
280
270
260
250
240
230
220
210
200
0
200
400
600
800
1000
Station (ft)



River = UNT   Reach = EX-CENTERLINE   RS = 102.66
.018
.03
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
300
280
260
240
220
200
0
200
400
600
800
1000
Station (ft)



River = UNT Reach = EX-CENTERLINE RS = 0
.075
.03
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
300
280
260
240
220
200
0
100
200
300
400
500
600
700
Station (ft)

HEC-RAS Plan: Plan 02 River: UNT Reach: EX-CENTERLINE

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
EX-CENTERLINE	1535.43	100-YR	621.00	221.71	226.05	226.92	228.84	0.040071	13.38	46.40	25.40	1.75
EX-CENTERLINE	1535.43	BANK-FULL	12.50	221.71	222.42	222.51	222.76	0.040057	4.63	2.70	7.90	1.40
EX-CENTERLINE	1535.43	BASE	3.43	221.71	222.15	222.19	222.33	0.040027	3.41	1.01	4.64	1.29
EX-CENTERLINE	1463.43	100-YR	621.00	221.40	224.80	223.66	225.10	0.002351	4.39	141.34	55.99	0.49
EX-CENTERLINE	1463.43	BANK-FULL	12.50	221.40	221.88	221.75	221.91	0.003906	1.36	9.21	31.70	0.44
EX-CENTERLINE	1463.43	BASE	3.43	221.40	221.70	221.63	221.71	0.004696	0.90	3.79	27.53	0.43
EX-CENTERLINE	1329.51	100-YR	621.00	220.18	224.15		224.67	0.004294	5.77	107.70	43.99	0.65
EX-CENTERLINE	1329.51	BANK-FULL	12.50	220.18	220.77	220.76	220.92	0.018148	3.07	4.07	12.79	0.96
EX-CENTERLINE	1329.51	BASE	3.43	220.18	220.50	220.49	220.59	0.018767	2.37	1.45	6.88	0.91
EX-CENTERLINE	1193.63	100-YR	621.00	218.50	222.52	222.52	223.73	0.010452	8.84	70.24	29.03	1.00
EX-CENTERLINE	1193.63	BANK-FULL	12.50	218.50	219.50		219.58	0.006018	2.23	5.60	12.38	0.58
EX-CENTERLINE	1193.63	BASE	3.43	218.50	219.12		219.17	0.006597	1.80	1.91	6.21	0.57
EX-CENTERLINE	1075.23	100-YR	621.00	217.84	221.18	221.27	222.40	0.012016	8.87	70.03	32.38	1.06
EX-CENTERLINE	1075.23	BANK-FULL	12.50	217.84	218.49	218.43	218.60	0.011851	2.69	4.64	13.01	0.79
EX-CENTERLINE	1075.23	BASE	3.43	217.84	218.23	218.16	218.28	0.008534	1.75	1.96	8.20	0.63
EX-CENTERLINE	1021.38	100-YR	621.00	217.34	220.44	220.50	221.76	0.011300	9.22	67.38	27.44	1.04
EX-CENTERLINE	1021.38	BANK-FULL	12.50	217.34	217.64	217.64	217.77	0.020684	2.92	4.28	16.14	1.00
EX-CENTERLINE	1021.38	BASE	3.43	217.34	217.48	217.48	217.54	0.026948	1.93	1.78	15.39	1.00
EX-CENTERLINE	950.73	100-YR	621.00	215.38	216.91	217.80	219.98	0.065961	14.07	44.14	37.62	2.29
EX-CENTERLINE	950.73	BANK-FULL	12.50	215.38	215.63	215.68	215.81	0.039009	3.33	3.75	18.87	1.32
EX-CENTERLINE	950.73	BASE	3.43	215.38	215.52	215.52	215.58	0.028525	1.97	1.74	15.23	1.03
EX-CENTERLINE	889.71	100-YR	621.00	210.49	214.70	215.48	217.17	0.030286	12.59	49.31	24.44	1.56
EX-CENTERLINE	889.71	BANK-FULL	12.50	210.49	211.27	211.54	212.15	0.098591	7.50	1.67	4.26	2.11
EX-CENTERLINE	889.71	BASE	3.43	210.49	210.91	211.12	211.74	0.218116	7.31	0.47	2.26	2.83
EX-CENTERLINE	880		Culvert									
EX-CENTERLINE	233.62	100-YR	621.00	205.33	208.83		209.62	0.007283	7.14	87.03	36.65	0.82
EX-CENTERLINE	233.62	BANK-FULL	12.50	205.33	205.71	205.85	206.16	0.084009	5.38	2.33	10.07	1.97
EX-CENTERLINE	233.62	BASE	3.43	205.33	205.52	205.63	205.96	0.265749	5.33	0.64	6.72	3.03
EX-CENTERLINE	160.4	100-YR	621.00	204.35	208.00	208.00	208.95	0.011312	7.80	79.61	43.33	1.01
EX-CENTERLINE	160.4	BANK-FULL	12.50	204.35	205.06	205.06	205.25	0.019534	3.44	3.64	10.21	1.01
EX-CENTERLINE	160.4	BASE	3.43	204.35	204.78	204.78	204.88	0.022256	2.61	1.31	6.13	1.00
EX-CENTERLINE	102.66	100-YR	621.00	203.68	207.48	206.92	208.31	0.006150	7.30	85.02	29.60	0.76
EX-CENTERLINE	102.66	BANK-FULL	12.50	203.68	204.34	204.06	204.36	0.001926	1.30	9.65	20.38	0.33
EX-CENTERLINE	102.66	BASE	3.43	203.68	204.08	203.89	204.09	0.001350	0.75	4.60	17.22	0.25
EX-CENTERLINE	0	100-YR	621.00	203.49	206.23	206.23	207.44	0.011081	8.82	70.45	29.48	1.01
EX-CENTERLINE	0	BANK-FULL	12.50	203.49	203.78	203.78	203.87	0.022415	2.53	4.94	24.59	1.00
EX-CENTERLINE	0	BASE	3.43	203.49	203.65	203.65	203.70	0.028832	1.75	1.96	20.56	1.00

Errors Warnings and Notes for Plan : Plan 02

Location:	River: UNT Reach: EX-CENTERLINE RS: 1463.43 Profile: 100-YR
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.
Location:	River: UNT Reach: EX-CENTERLINE RS: 1463.43 Profile: BANK-FULL
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.
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.
Location:	River: UNT Reach: EX-CENTERLINE RS: 1463.43 Profile: BASE
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 energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.
Location:	River: UNT Reach: EX-CENTERLINE RS: 1329.51 Profile: 100-YR
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.
Location:	River: UNT Reach: EX-CENTERLINE RS: 1329.51 Profile: BANK-FULL
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 energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: UNT Reach: EX-CENTERLINE RS: 1329.51 Profile: BASE
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 energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: UNT Reach: EX-CENTERLINE RS: 1193.63 Profile: 100-YR
Warning:	The energy equation could not be balanced within the specified number of iterations. The program
	used critical depth for the water surface and continued on with the calculations.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical
	depth, the calculated water surface came back below critical depth. This indicates that there is not
	a valid subcritical answer. The program defaulted to critical depth.
Location:	River: UNT Reach: EX-CENTERLINE RS: 1193.63 Profile: BANK-FULL
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.
Location:	River: UNT Reach: EX-CENTERLINE RS: 1075.23 Profile: 100-YR
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Note:	Program found supercritical flow starting at this cross section.
Location:	River: UNT Reach: EX-CENTERLINE RS: 1075.23 Profile: BASE
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.
Location:	River: UNT Reach: EX-CENTERLINE RS: 1021.38 Profile: BANK-FULL
Warning:	The energy equation could not be balanced within the specified number of iterations. The program
	used critical depth for the water surface and continued on with the calculations.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical
	depth, the calculated water surface came back below critical depth. This indicates that there is not
	a valid subcritical answer. The program defaulted to critical depth.

Errors Warnings and Notes for Plan : Plan 02 (Continued)

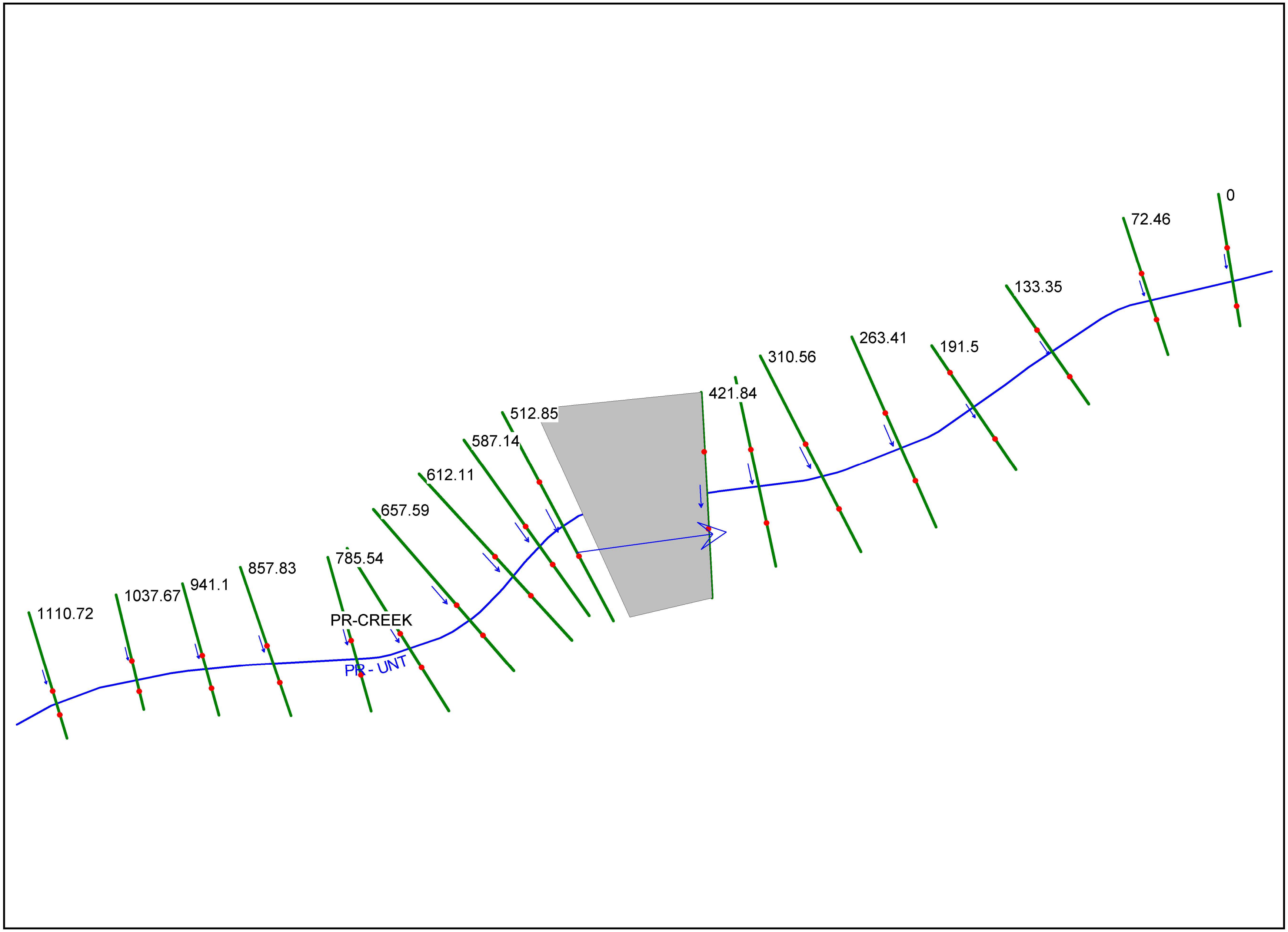
Location:	River: UNT Reach: EX-CENTERLINE RS: 1021.38 Profile: BASE
Warning:	The energy equation could not be balanced within the specified number of iterations. The program
	used critical depth for the water surface and continued on with the calculations.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical
	depth, the calculated water surface came back below critical depth. This indicates that there is not
	a valid subcritical answer. The program defaulted to critical depth.
Location:	River: UNT Reach: EX-CENTERLINE RS: 950.73 Profile: 100-YR
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 energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: UNT Reach: EX-CENTERLINE RS: 950.73 Profile: BANK-FULL
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Note:	Program found supercritical flow starting at this cross section.
Location:	River: UNT Reach: EX-CENTERLINE RS: 950.73 Profile: BASE
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Note:	Program found supercritical flow starting at this cross section.
Location:	River: UNT Reach: EX-CENTERLINE RS: 889.71 Profile: 100-YR
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 energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: UNT Reach: EX-CENTERLINE RS: 889.71 Profile: BANK-FULL
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 energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: UNT Reach: EX-CENTERLINE RS: 889.71 Profile: BASE
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 energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: UNT Reach: EX-CENTERLINE RS: 880 Profile: 100-YR
Note:	During the supercritical calculations a hydraulic jump occurred at the outlet of (leaving) the culvert.
Location:	River: UNT Reach: EX-CENTERLINE RS: 880 Profile: 100-YR Culv: Culvert #1
Note:	The flow in the culvert is entirely supercritical.
Location:	River: UNT Reach: EX-CENTERLINE RS: 880 Profile: BANK-FULL Culv: Culvert #1
Note:	During supercritical analysis, the culvert direct step method went to normal depth. The program
	then assumed normal depth at the outlet.
Note:	The flow in the culvert is entirely supercritical.
Location:	River: UNT Reach: EX-CENTERLINE RS: 880 Profile: BASE Culv: Culvert #1

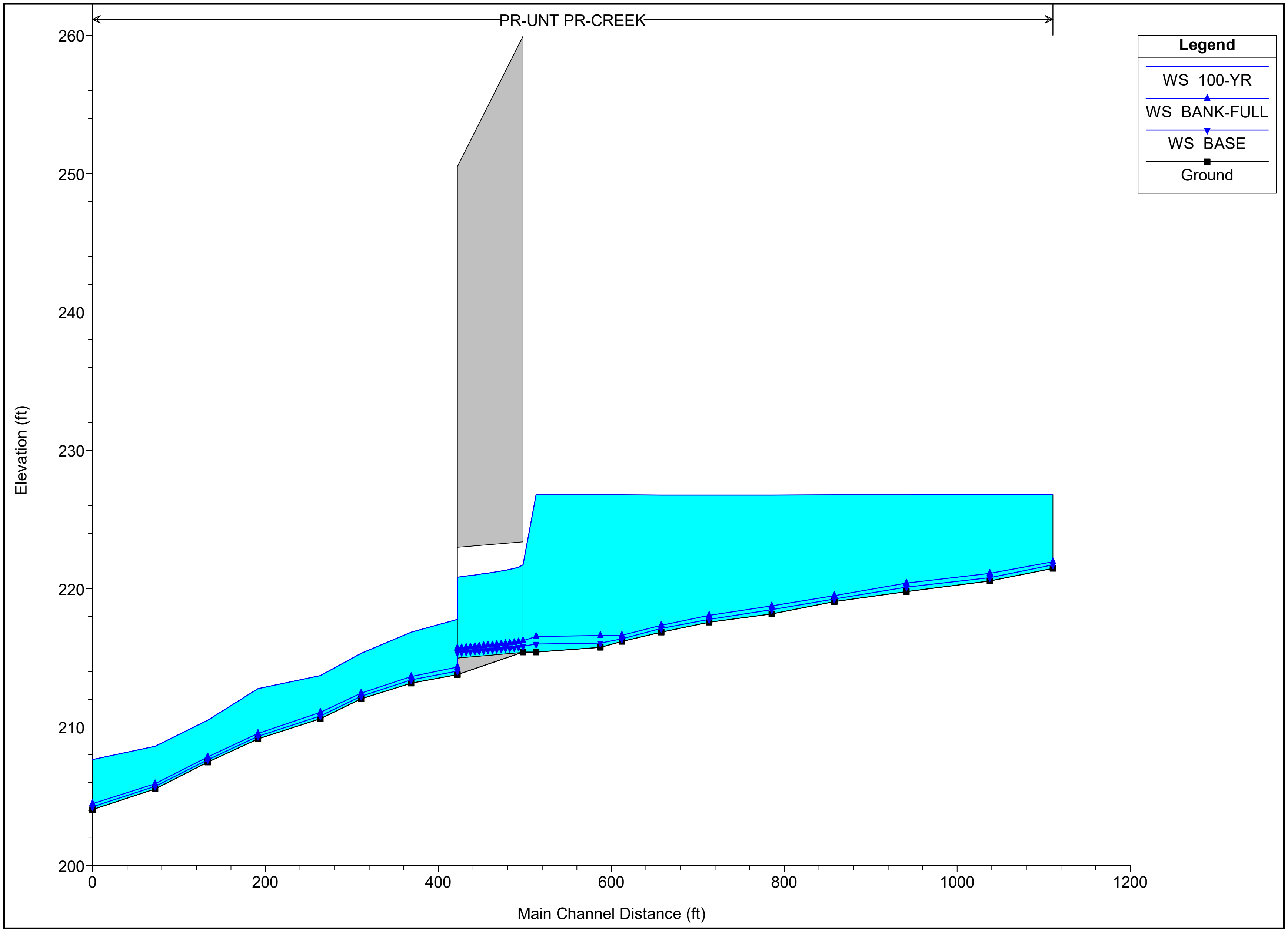
Errors Warnings and Notes for Plan : Plan 02 (Continued)

Warning:	During the supercritical analysis, the program could not converge on a supercritical answer in the
	downstream cross section. The program used the solution with the least error.
Note:	During supercritical analysis, the culvert direct step method went to normal depth. The program
	then assumed normal depth at the outlet.
Note:	During supercritical analysis, the culvert direct step method went to critical depth. The program
	then assumed critical depth at the outlet.
Note:	The flow in the culvert is entirely supercritical.
Note:	During the supercritical calculations a hydraulic jump occurred inside of the culvert.
Location:	River: UNT Reach: EX-CENTERLINE RS: 160.4 Profile: 100-YR
Warning:	The energy equation could not be balanced within the specified number of iterations. The program
	used critical depth for the water surface and continued on with the calculations.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical
	depth, the calculated water surface came back below critical depth. This indicates that there is not
	a valid subcritical answer. The program defaulted to critical depth.
Location:	River: UNT Reach: EX-CENTERLINE RS: 160.4 Profile: BANK-FULL
Warning:	The energy equation could not be balanced within the specified number of iterations. The program
	used critical depth for the water surface and continued on with the calculations.
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:	During the standard step iterations, when the assumed water surface was set equal to critical
	depth, the calculated water surface came back below critical depth. This indicates that there is not
	a valid subcritical answer. The program defaulted to critical depth.
Location:	River: UNT Reach: EX-CENTERLINE RS: 160.4 Profile: BASE
Warning:	The energy equation could not be balanced within the specified number of iterations. The program
	used critical depth for the water surface and continued on with the calculations.
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:	During the standard step iterations, when the assumed water surface was set equal to critical
	depth, the calculated water surface came back below critical depth. This indicates that there is not
	a valid subcritical answer. The program defaulted to critical depth.
Location:	River: UNT Reach: EX-CENTERLINE RS: 102.66 Profile: 100-YR
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.
Location:	River: UNT Reach: EX-CENTERLINE RS: 102.66 Profile: BANK-FULL
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.
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.
Location:	River: UNT Reach: EX-CENTERLINE RS: 102.66 Profile: BASE
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.
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.
Location:	River: UNT Reach: EX-CENTERLINE RS: 0 Profile: 100-YR
Warning:	Slope too steep for slope area to converge during supercritical flow calculations (normal depth is
	below critical depth). Water surface set to critical depth.
Location:	River: UNT Reach: EX-CENTERLINE RS: 0 Profile: BANK-FULL
Warning:	Slope too steep for slope area to converge during supercritical flow calculations (normal depth is
	below critical depth). Water surface set to critical depth.
Location:	River: UNT Reach: EX-CENTERLINE RS: 0 Profile: BASE
Warning:	Slope too steep for slope area to converge during supercritical flow calculations (normal depth is
	below critical depth). Water surface set to critical depth.

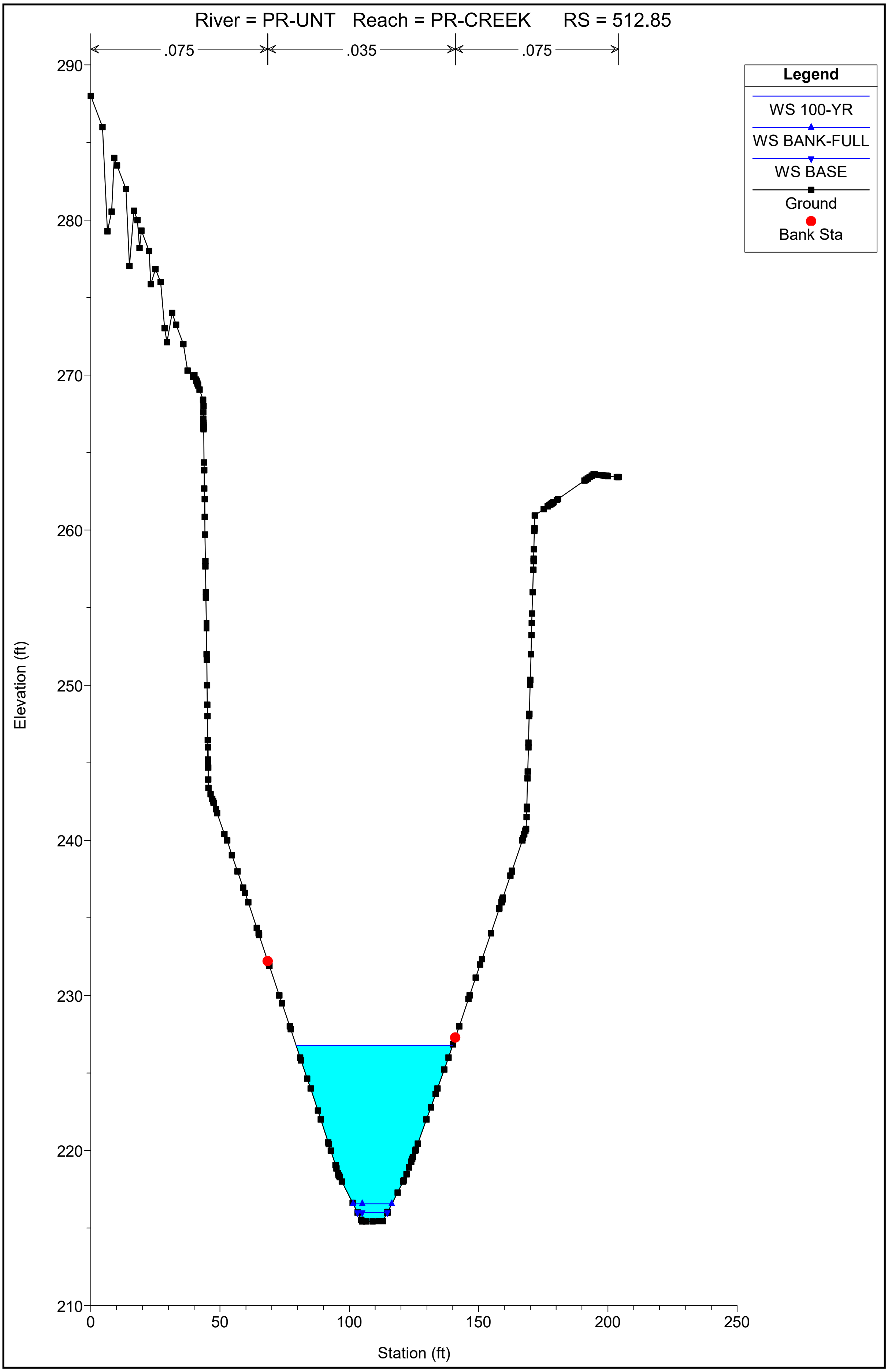
Appendix C

HEC-RAS Outputs for Proposed Condition

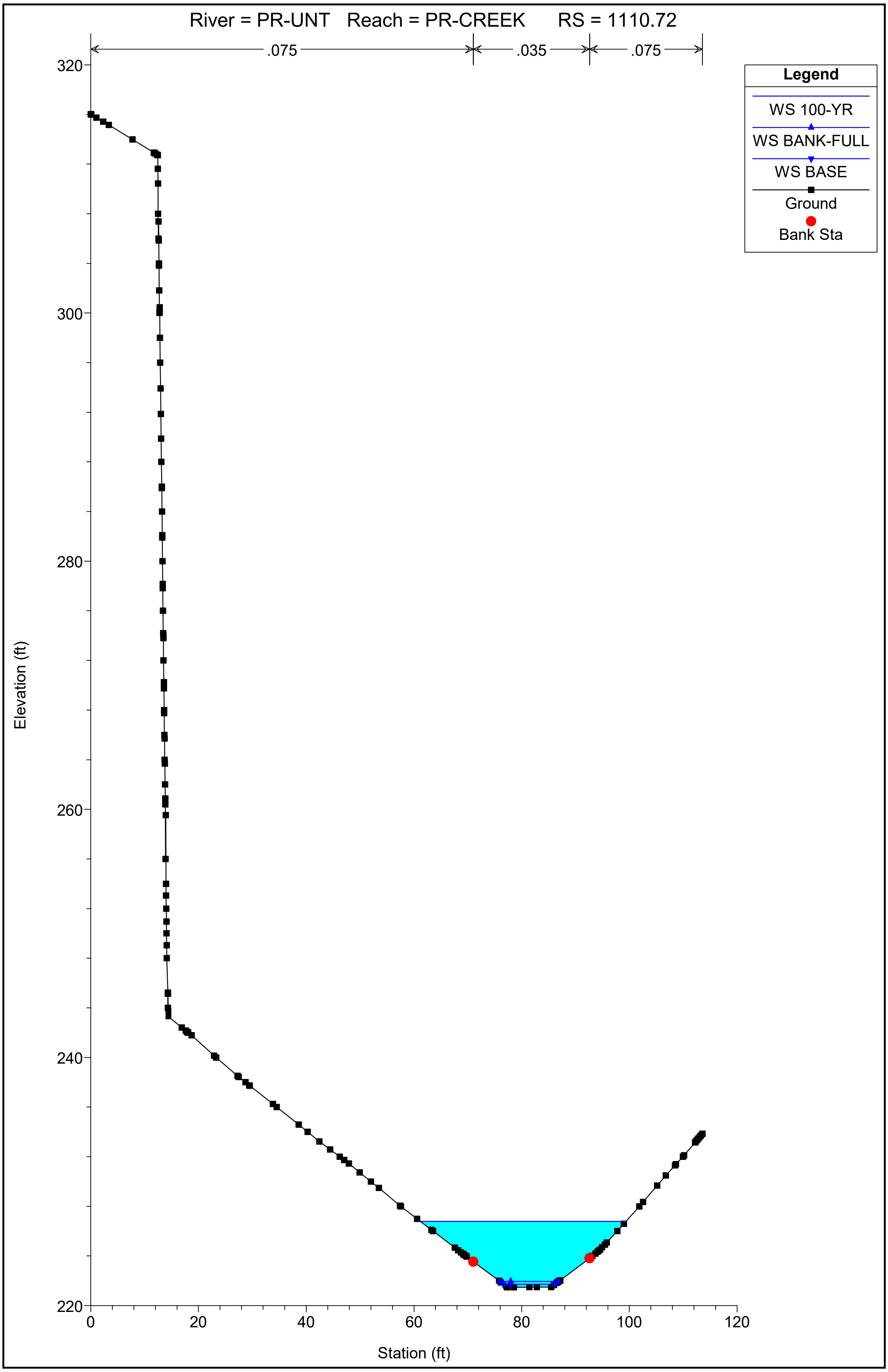

0
72.46
133.35
191.5
263.41
310.56
421.84
512.85
587.14
612.11
657.59
785.54
857.83
941.1
1037.67
1110.72
PR-CREEK
PR - UNT

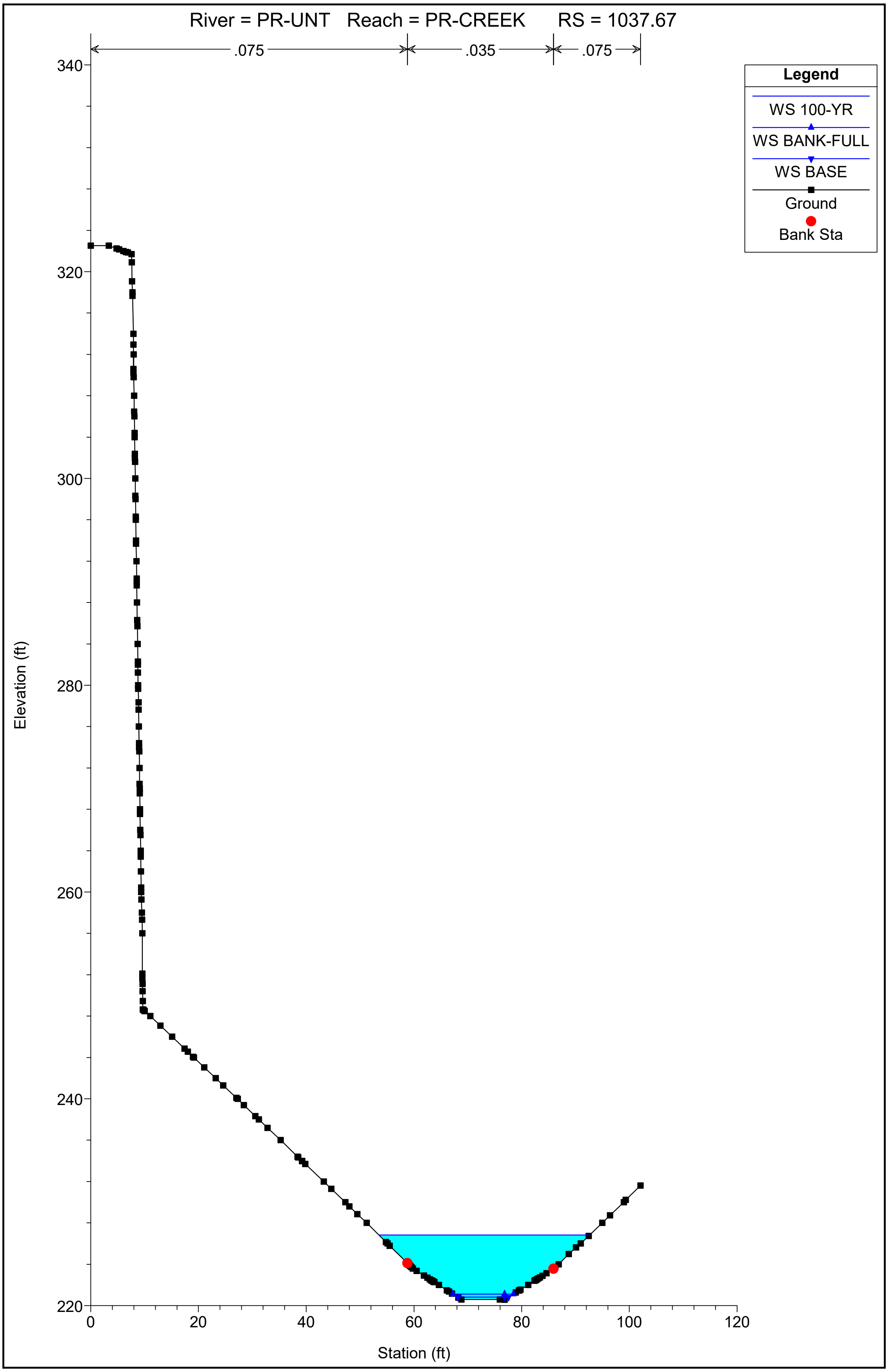


PR-UNT PR-CREEK
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Elevation (ft)
Main Channel Distance (ft)
260
250
240
230
220
210
200
0
200
400
600
800
1000
1200

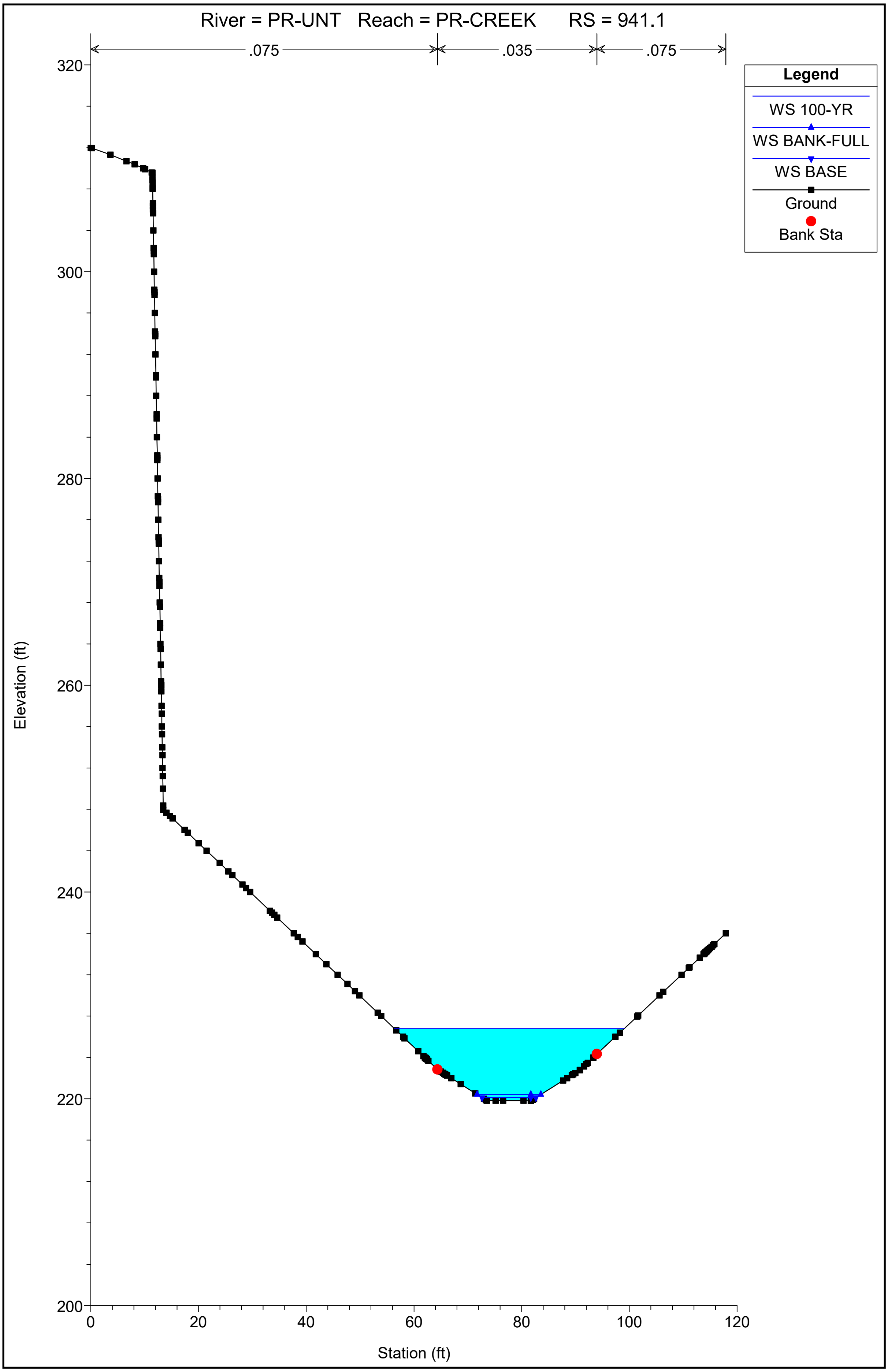


River = PR-UNT   Reach = PR-CREEK   RS = 512.85
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
Station (ft)
290
280
270
260
250
240
230
220
210
0
50
100
150
200
250

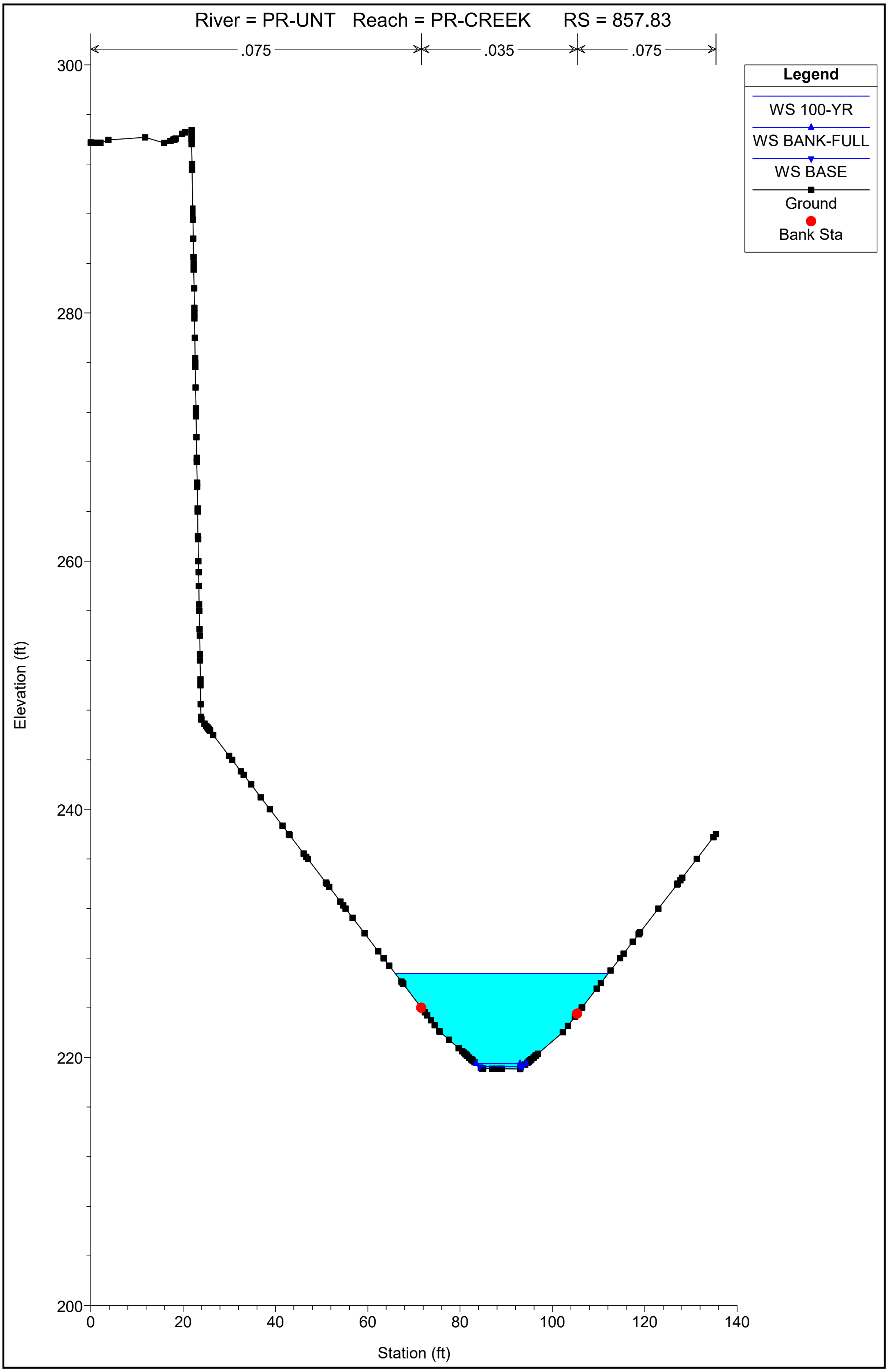

River = PR-UNT Reach = PR-CREEK RS = 1110.72
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
320
300
280
260
240
220
0
20
40
60
80
100
120
Station (ft)



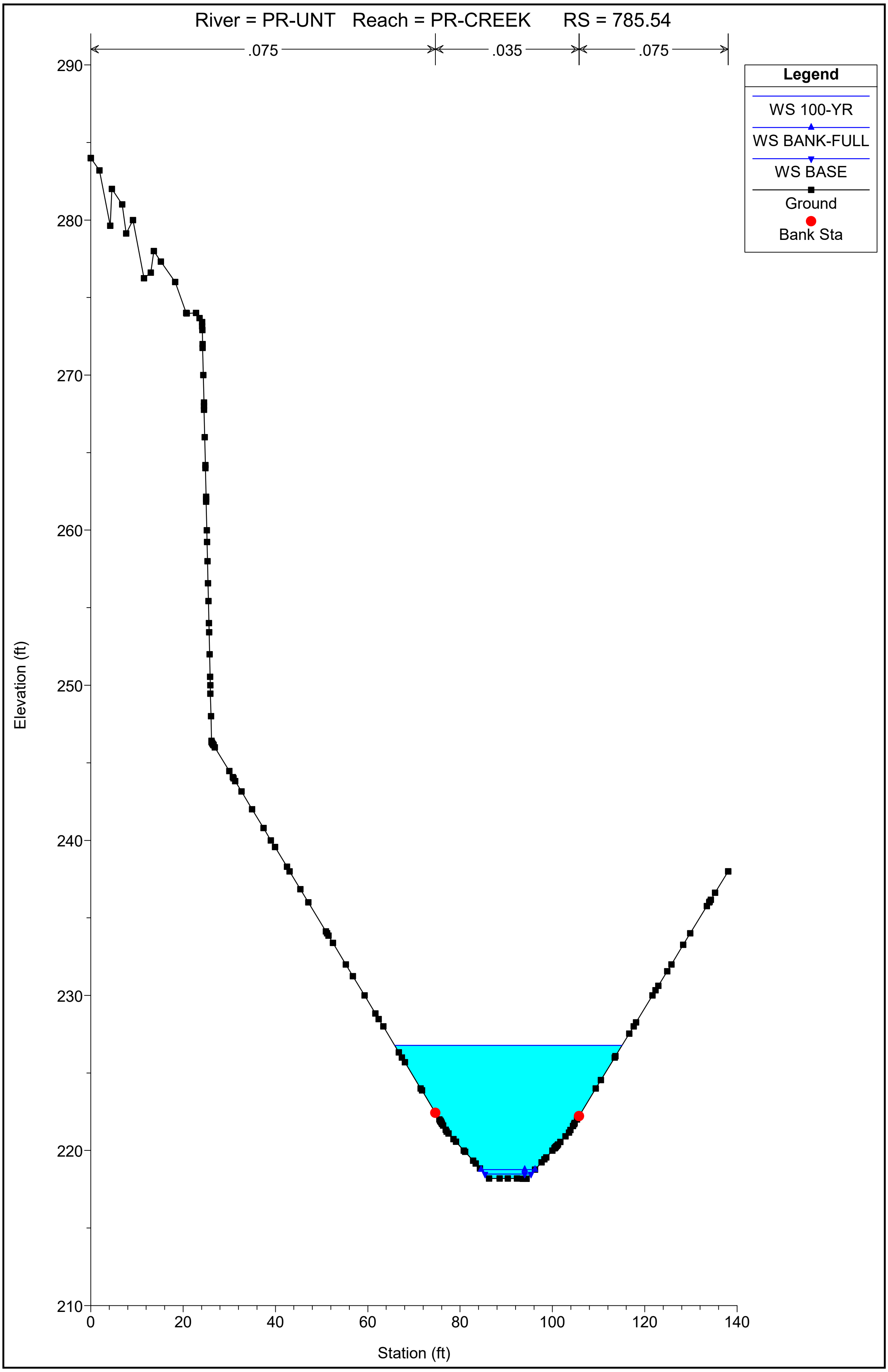
River = PR-UNT Reach = PR-CREEK RS = 1037.67
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
340
320
300
280
260
240
220
0
20
40
60
80
100
120
Station (ft)

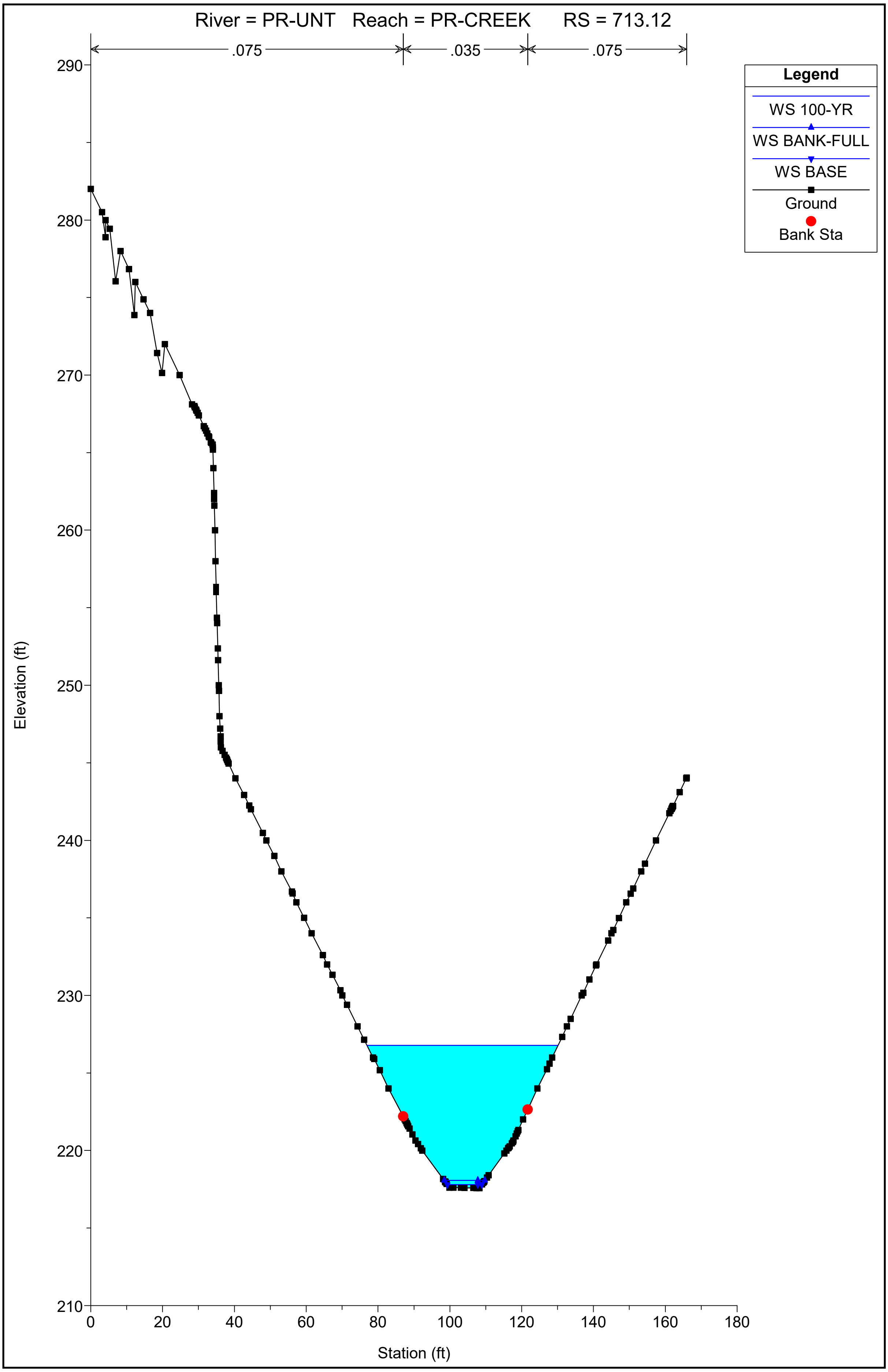


River = PR-UNT Reach = PR-CREEK RS = 941.1
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
320
300
280
260
240
220
200
0
20
40
60
80
100
120
Station (ft)

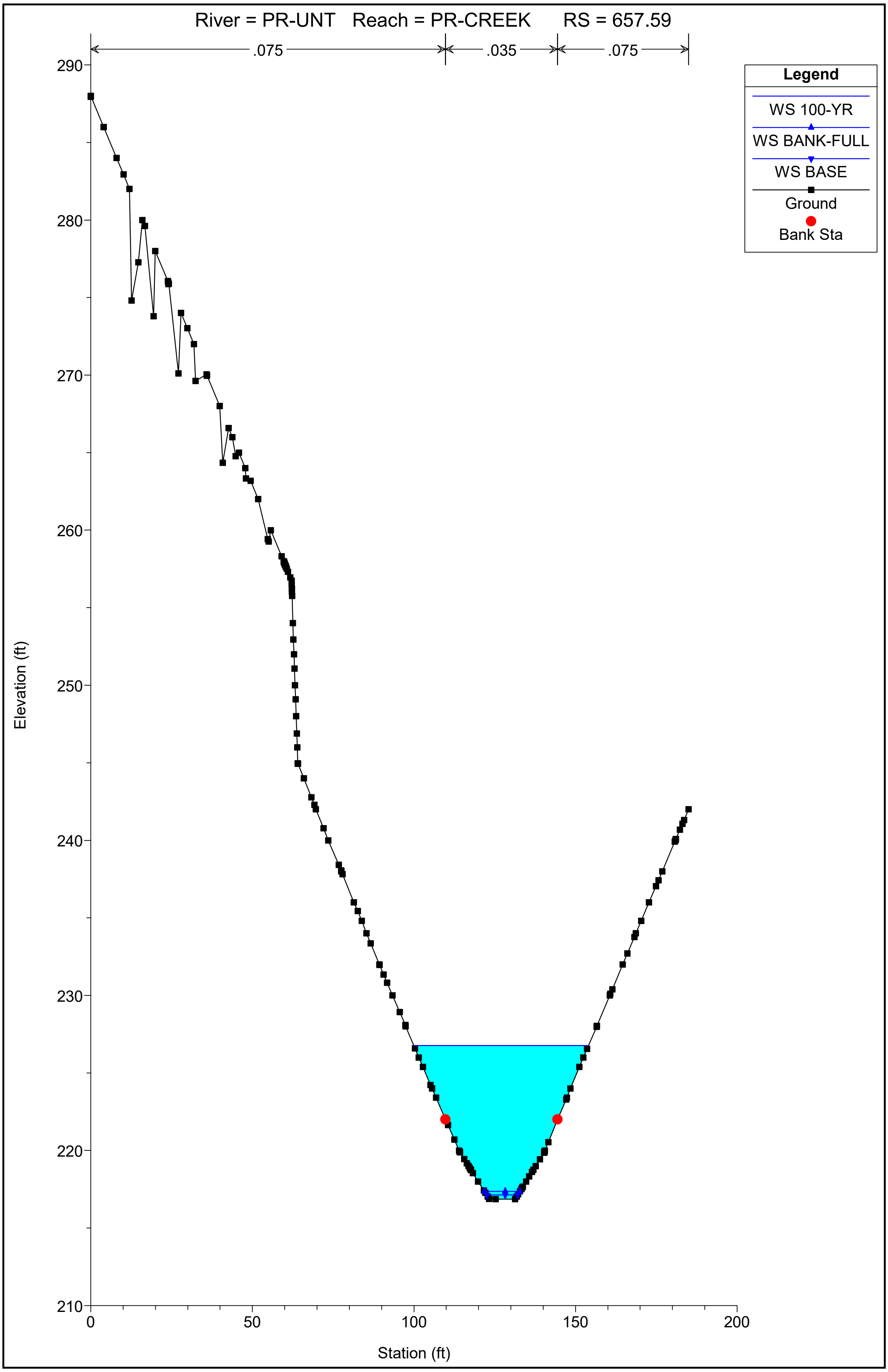


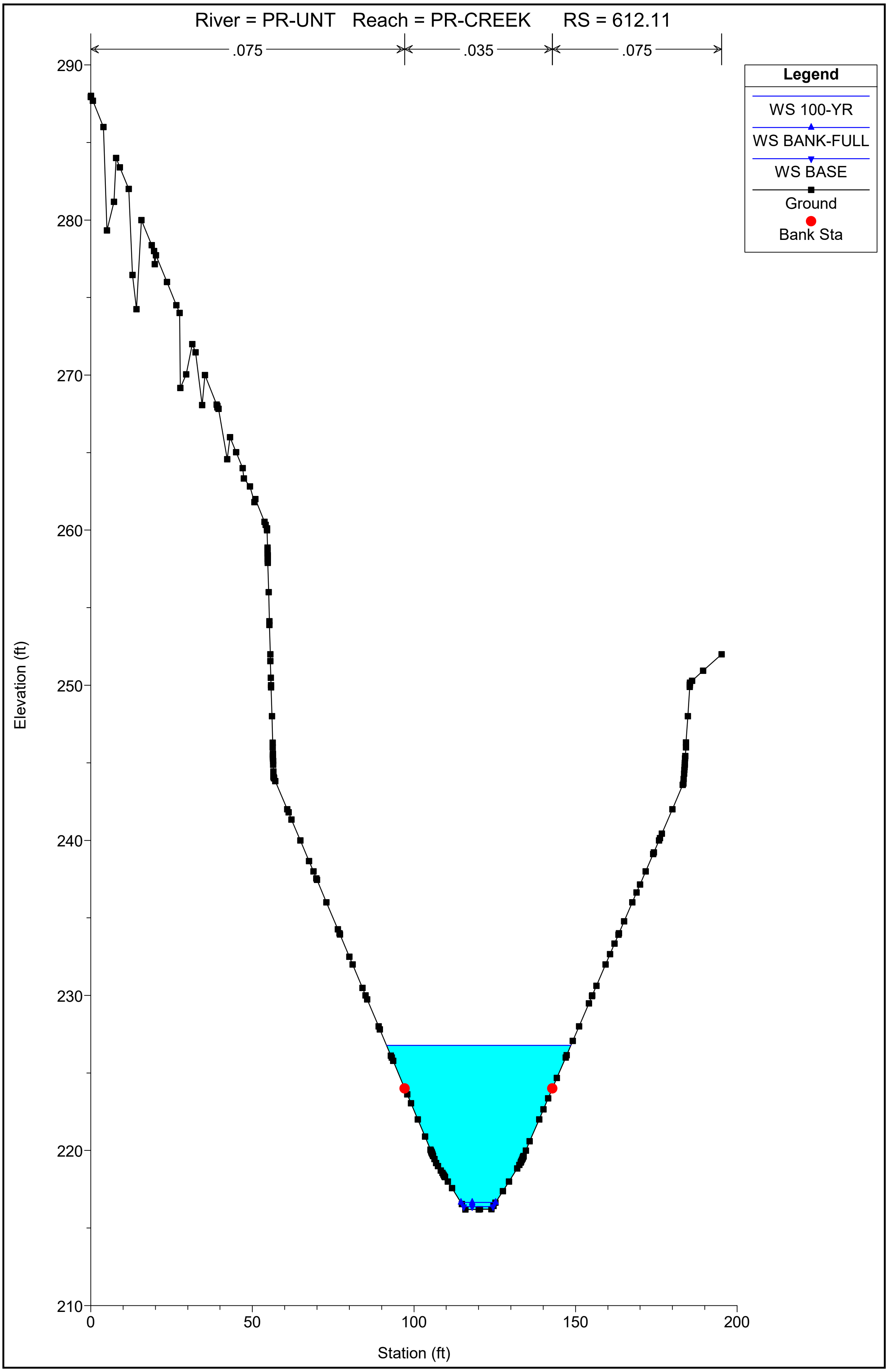
River = PR-UNT Reach = PR-CREEK RS = 857.83
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
Station (ft)
300
280
260
240
220
200
0
20
40
60
80
100
120
140


River = PR-UNT Reach = PR-CREEK RS = 785.54
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
290
280
270
260
250
240
230
220
210
0
20
40
60
80
100
120
140
Station (ft)

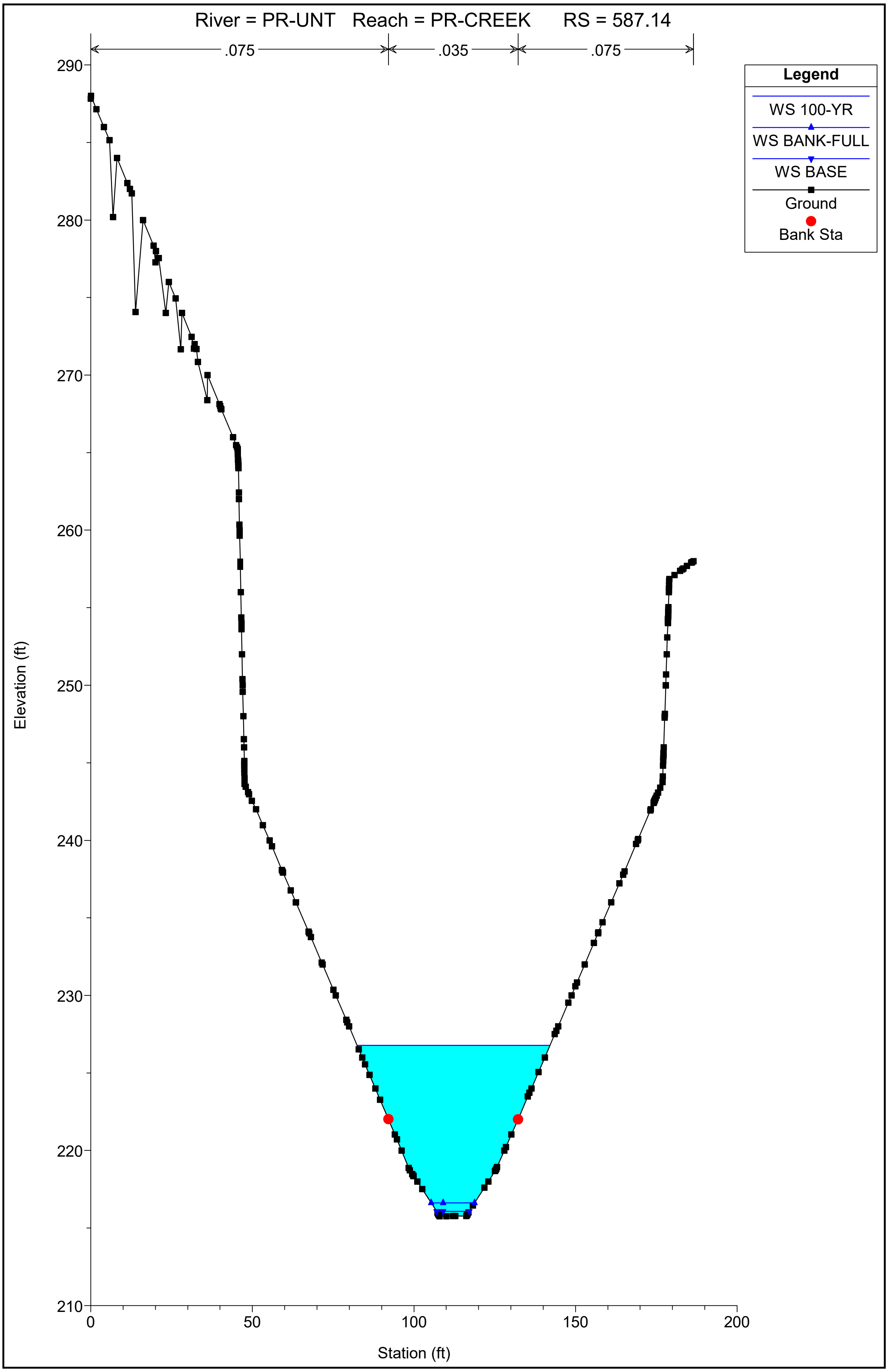


River = PR-UNT Reach = PR-CREEK RS = 713.12
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
290
280
270
260
250
240
230
220
210
0
20
40
60
80
100
120
140
160
180
Station (ft)

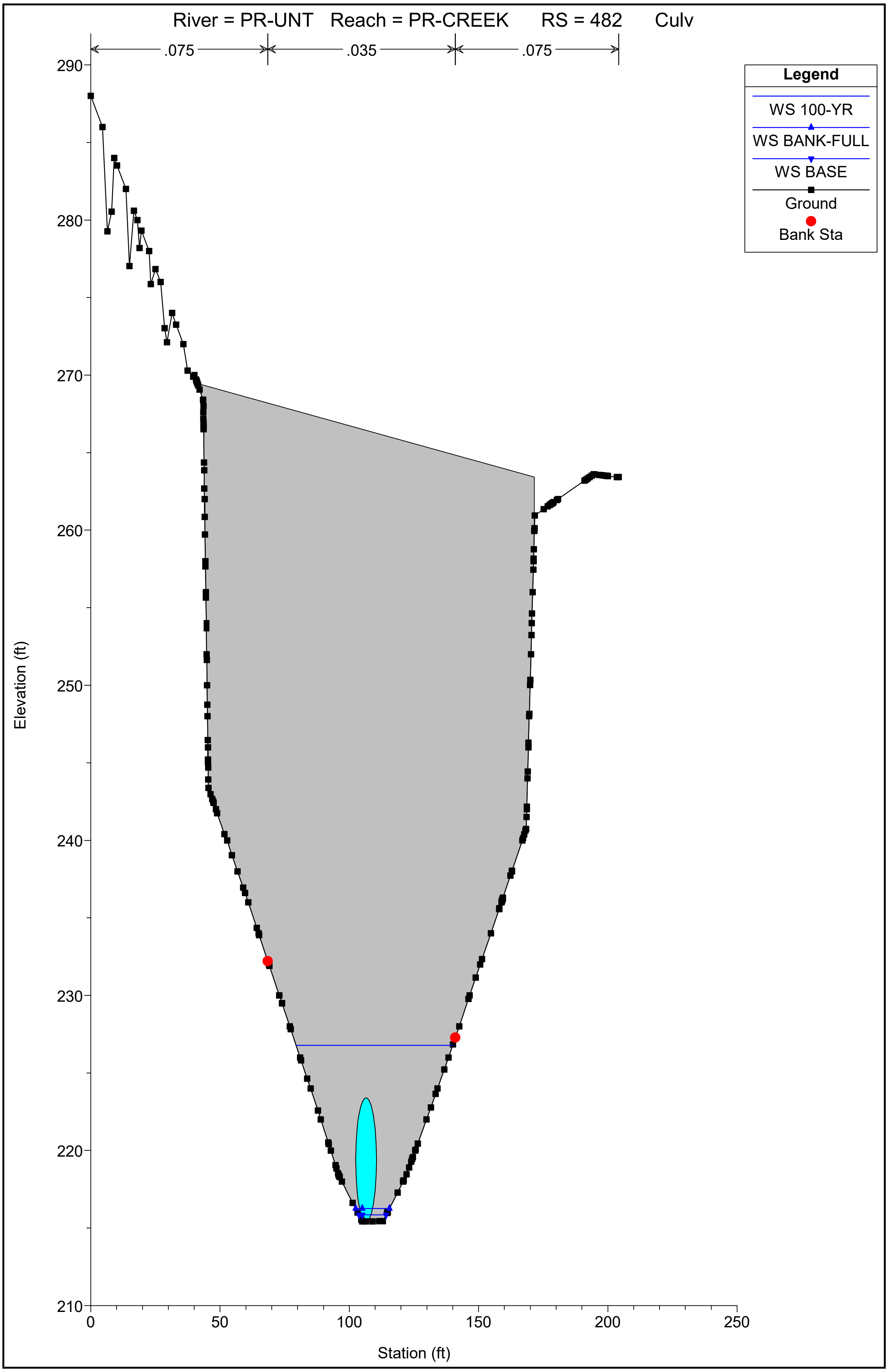

River = PR-UNT Reach = PR-CREEK RS = 657.59
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
290
280
270
260
250
240
230
220
210
0
50
100
150
200
Elevation (ft)
Station (ft)

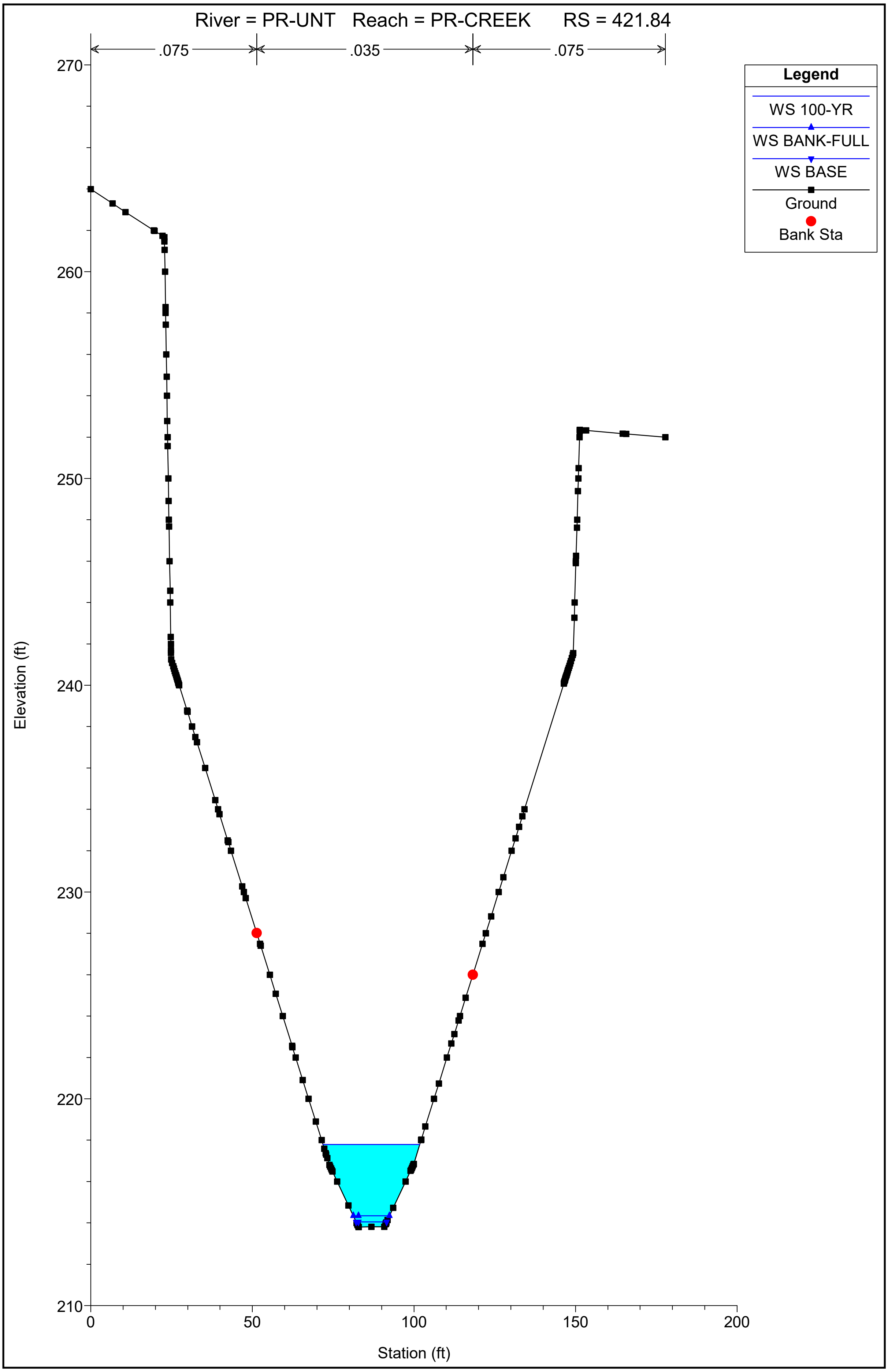


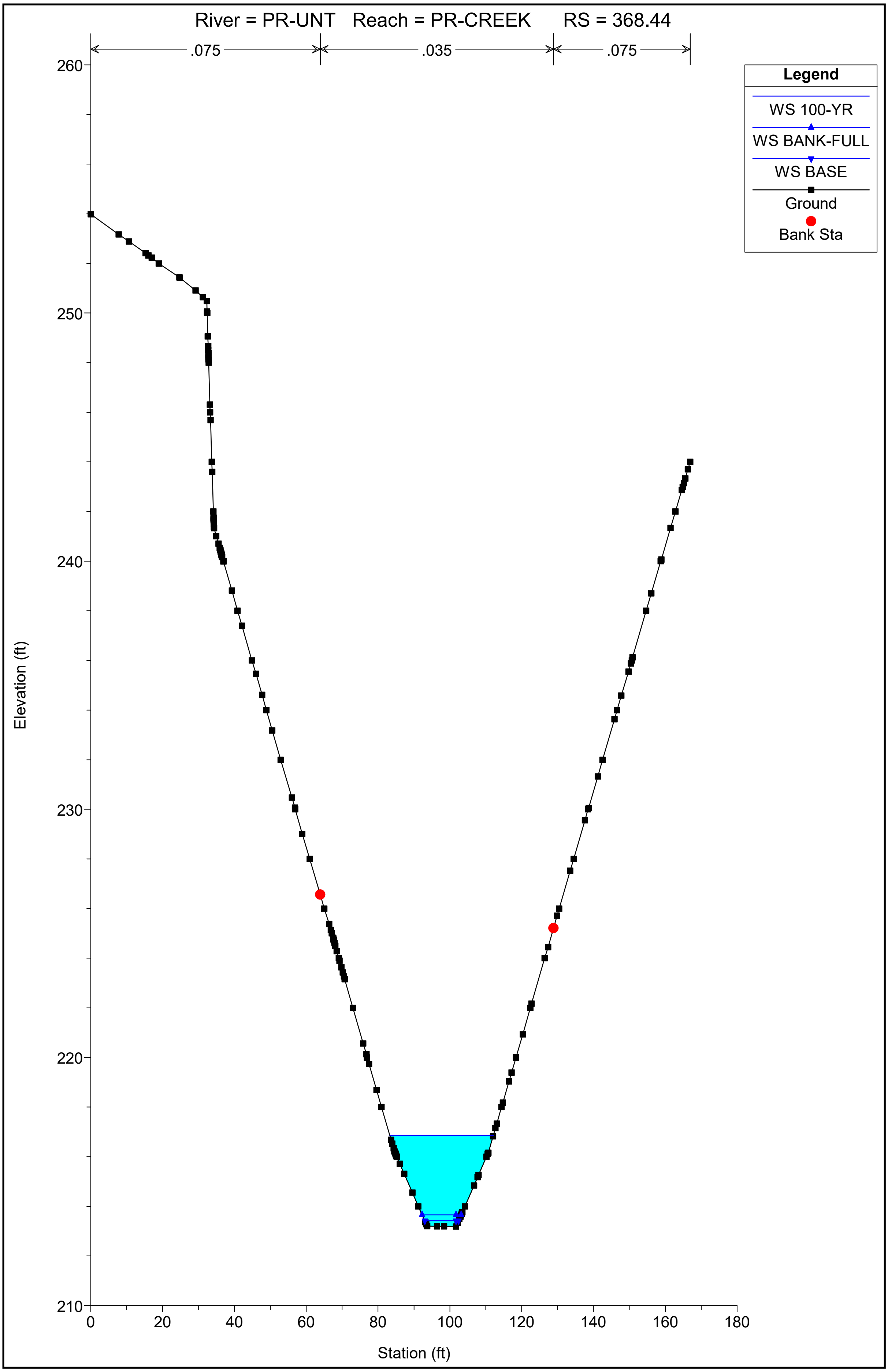
River = PR-UNT Reach = PR-CREEK RS = 612.11
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
290
280
270
260
250
240
230
220
210
0
50
100
150
200
Station (ft)



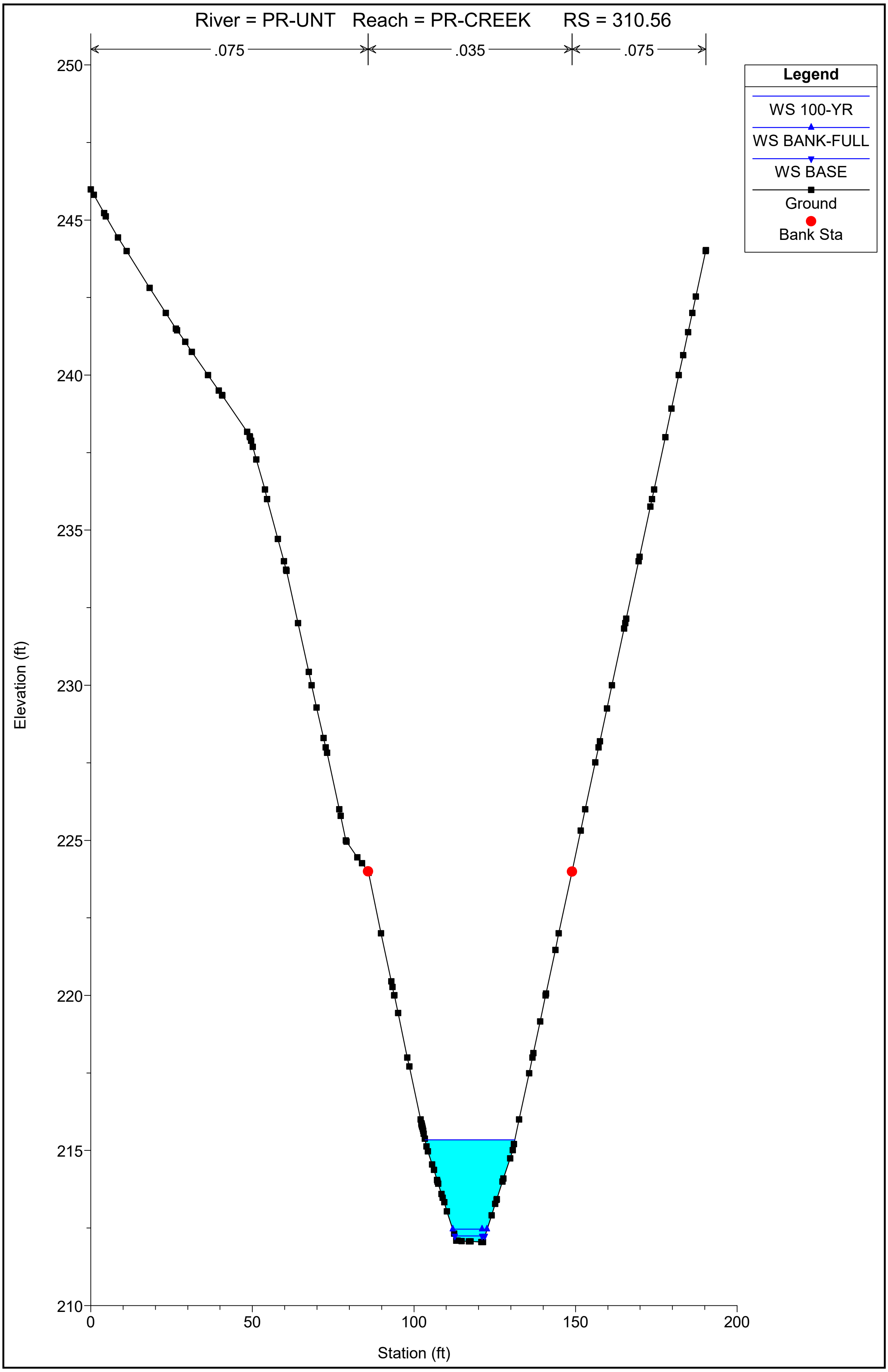
River = PR-UNT Reach = PR-CREEK RS = 587.14
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
290
280
270
260
250
240
230
220
210
Elevation (ft)
0
50
100
150
200
Station (ft)


River = PR-UNT Reach = PR-CREEK RS = 482 Culv
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
290
280
270
260
250
240
230
220
210
0
50
100
150
200
250
Station (ft)

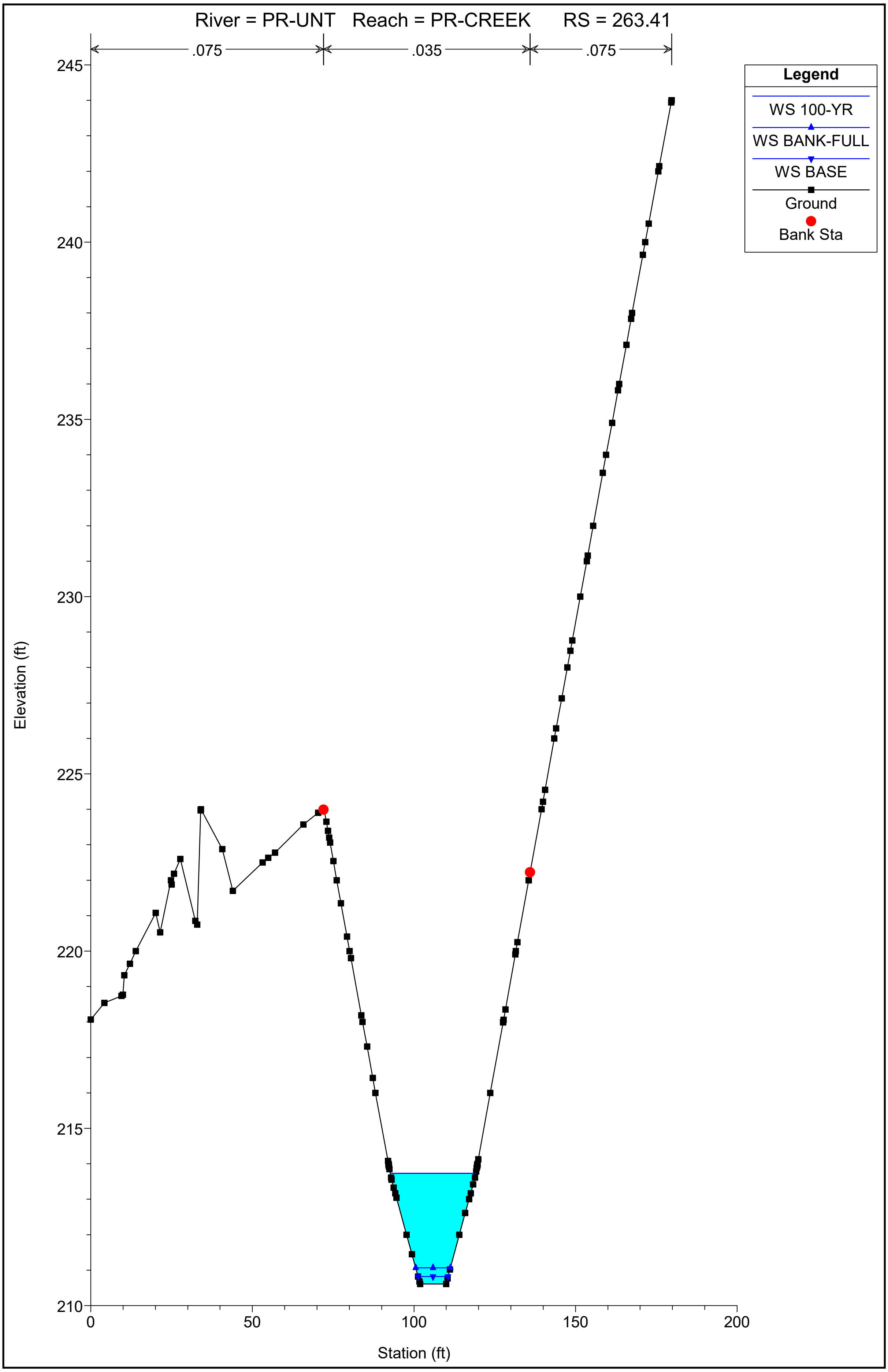

River = PR-UNT Reach = PR-CREEK RS = 421.84
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
270
260
250
240
230
220
210
0
50
100
150
200
Station (ft)



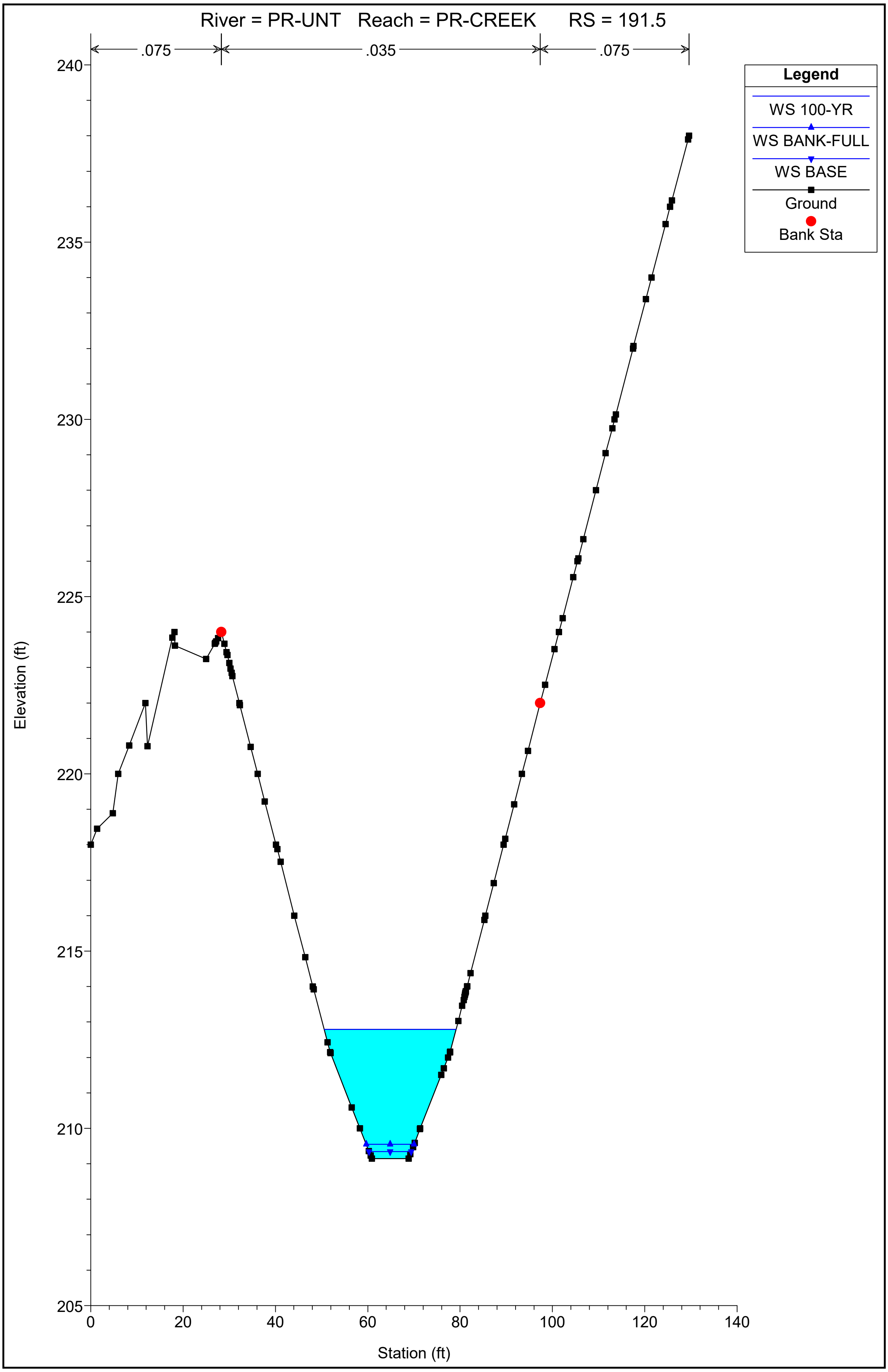
River = PR-UNT Reach = PR-CREEK RS = 368.44
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
Station (ft)
260
250
240
230
220
210
0
20
40
60
80
100
120
140
160
180



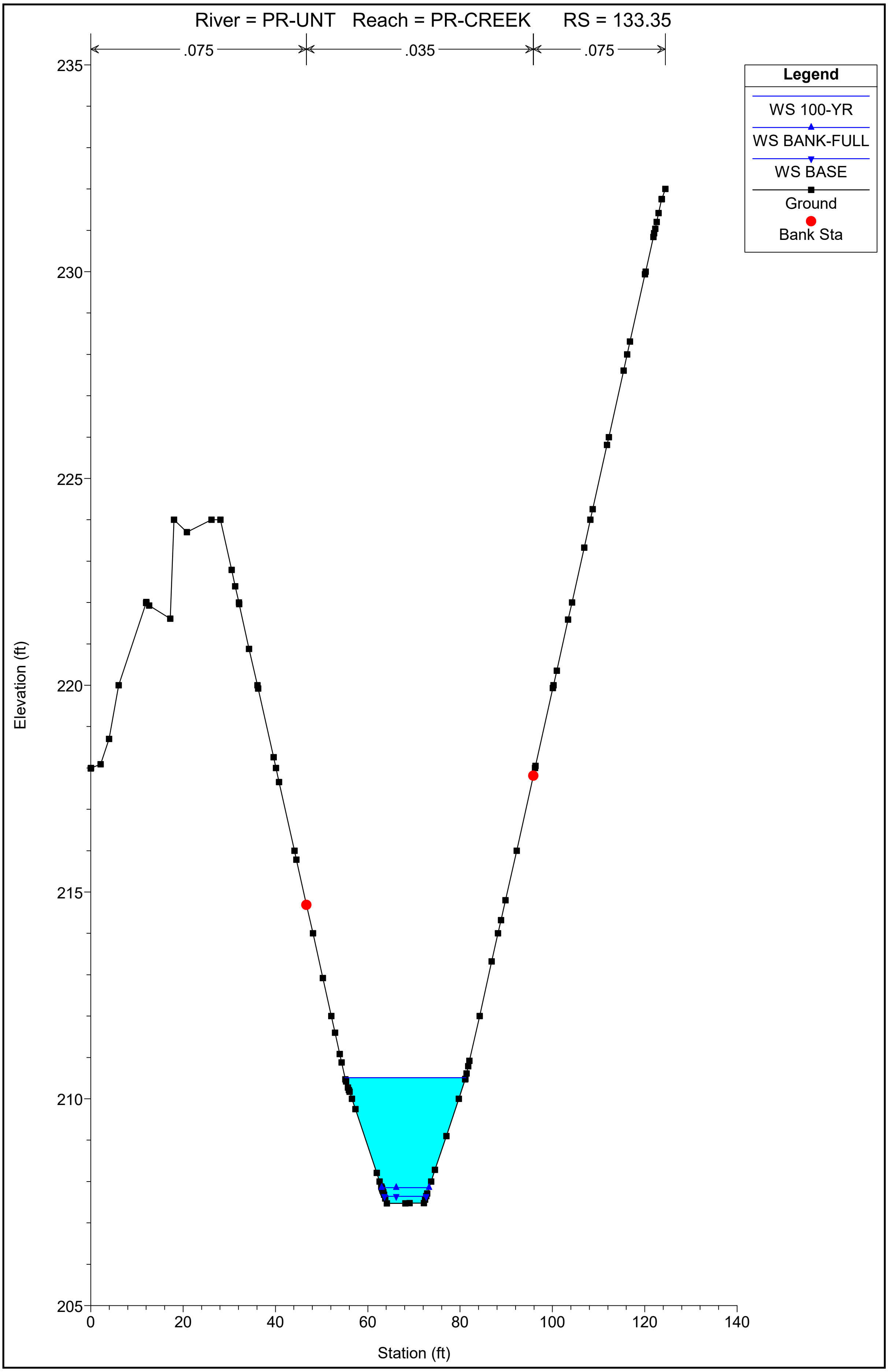
River = PR-UNT Reach = PR-CREEK RS = 310.56
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
250
245
240
235
230
225
220
215
210
0
50
100
150
200
Station (ft)



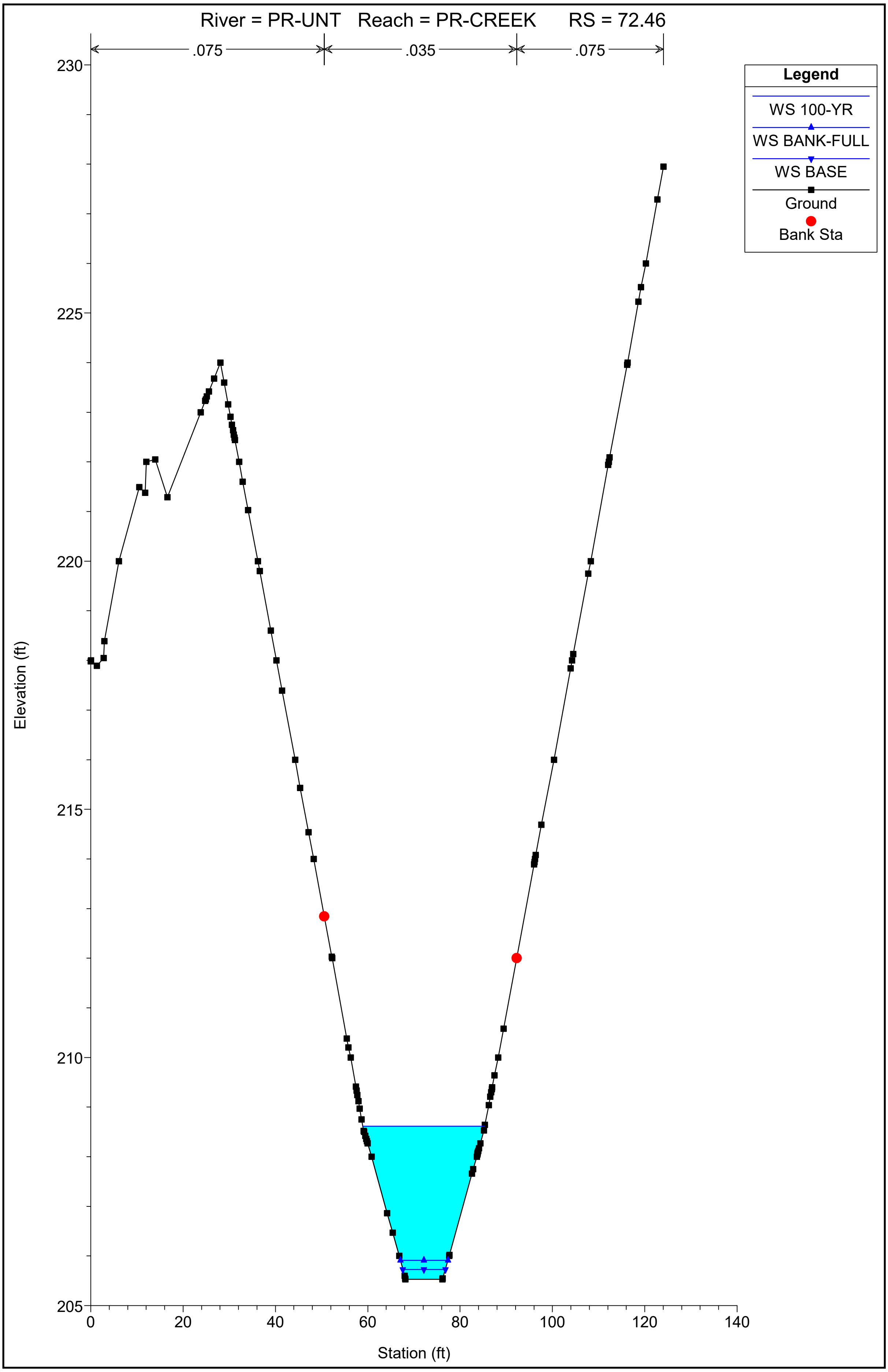
River = PR-UNT Reach = PR-CREEK RS = 263.41
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
245
240
235
230
225
220
215
210
0
50
100
150
200
Station (ft)



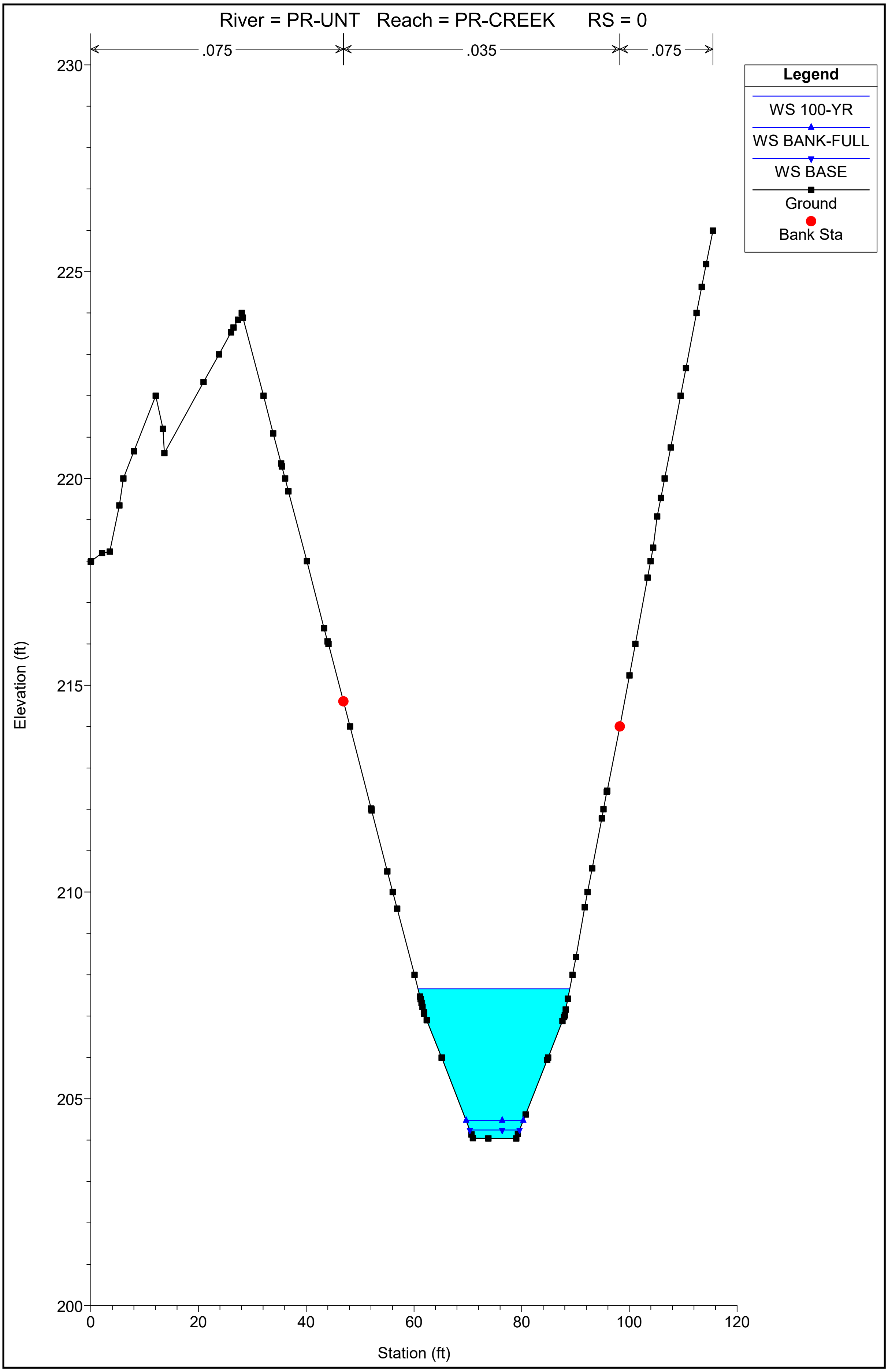
River = PR-UNT Reach = PR-CREEK RS = 191.5
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
240
235
230
225
220
215
210
205
0
20
40
60
80
100
120
140
Station (ft)



River = PR-UNT Reach = PR-CREEK RS = 133.35
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
Station (ft)
235
230
225
220
215
210
205
0
20
40
60
80
100
120
140



River = PR-UNT Reach = PR-CREEK RS = 72.46
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
Station (ft)
230
225
220
215
210
205
0
20
40
60
80
100
120
140



River = PR-UNT Reach = PR-CREEK RS = 0
.075
.035
.075
Legend
WS 100-YR
WS BANK-FULL
WS BASE
Ground
Bank Sta
Elevation (ft)
230
225
220
215
210
205
200
0
20
40
60
80
100
120
Station (ft)

HEC-RAS Plan: 2 River: PR-UNT Reach: PR-CREEK

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
PR-CREEK	1110.72	100-YR	621.00	221.48	226.79	225.16	227.30	0.002606	5.88	126.33	38.20	0.48
PR-CREEK	1110.72	BANK-FULL	12.50	221.48	221.95	221.88	222.08	0.015127	2.83	4.42	10.92	0.78
PR-CREEK	1110.72	BASE	3.43	221.48	221.72	221.66	221.77	0.011638	1.65	2.08	9.57	0.62
PR-CREEK	1037.67	100-YR	621.00	220.57	226.82		227.11	0.001263	4.36	156.82	39.09	0.34
PR-CREEK	1037.67	BANK-FULL	12.50	220.57	221.11		221.20	0.009544	2.43	5.14	11.25	0.64
PR-CREEK	1037.67	BASE	3.43	220.57	220.81		220.85	0.013397	1.73	1.98	9.41	0.66
PR-CREEK	941.1	100-YR	621.00	219.80	226.79		226.99	0.000763	3.61	189.32	42.67	0.27
PR-CREEK	941.1	BANK-FULL	12.50	219.80	220.42		220.49	0.005867	2.06	6.07	11.86	0.51
PR-CREEK	941.1	BASE	3.43	219.80	220.12		220.14	0.004555	1.22	2.81	10.03	0.41
PR-CREEK	857.83	100-YR	621.00	219.07	226.78		226.92	0.000473	2.98	224.15	46.21	0.21
PR-CREEK	857.83	BANK-FULL	12.50	219.07	219.51	219.48	219.65	0.020016	3.08	4.05	10.89	0.89
PR-CREEK	857.83	BASE	3.43	219.07	219.25	219.25	219.34	0.033004	2.28	1.51	9.32	1.00
PR-CREEK	785.54	100-YR	621.00	218.18	226.77		226.88	0.000308	2.69	263.26	49.23	0.18
PR-CREEK	785.54	BANK-FULL	12.50	218.18	218.77		218.85	0.006853	2.17	5.76	11.70	0.54
PR-CREEK	785.54	BASE	3.43	218.18	218.49	218.36	218.51	0.005328	1.28	2.68	9.96	0.44
PR-CREEK	713.12	100-YR	621.00	217.58	226.77		226.85	0.000215	2.31	301.05	53.18	0.15
PR-CREEK	713.12	BANK-FULL	12.50	217.58	218.07		218.18	0.012806	2.65	4.71	11.33	0.73
PR-CREEK	713.12	BASE	3.43	217.58	217.79	217.76	217.85	0.018791	1.90	1.80	9.60	0.77
PR-CREEK	657.59	100-YR	621.00	216.87	226.77		226.84	0.000168	2.14	327.47	54.06	0.13
PR-CREEK	657.59	BANK-FULL	12.50	216.87	217.36		217.47	0.012841	2.69	4.65	10.95	0.73
PR-CREEK	657.59	BASE	3.43	216.87	217.13	217.05	217.17	0.008690	1.51	2.27	9.58	0.55
PR-CREEK	612.11	100-YR	621.00	216.20	226.78		226.83	0.000124	1.76	366.44	57.03	0.11
PR-CREEK	612.11	BANK-FULL	12.50	216.20	216.65		216.79	0.018091	3.01	4.15	10.72	0.85
PR-CREEK	612.11	BASE	3.43	216.20	216.38	216.38	216.46	0.033286	2.31	1.49	9.10	1.01
PR-CREEK	587.14	100-YR	621.00	215.76	226.78		226.82	0.000098	1.72	398.80	59.71	0.10
PR-CREEK	587.14	BANK-FULL	12.50	215.76	216.63		216.65	0.001693	1.35	9.29	13.47	0.29
PR-CREEK	587.14	BASE	3.43	215.76	216.08	215.94	216.11	0.004165	1.18	2.90	10.14	0.39
PR-CREEK	512.85	100-YR	621.00	215.42	226.78	219.11	226.81	0.000107	1.50	413.90	60.51	0.10
PR-CREEK	512.85	BANK-FULL	12.50	215.42	216.56	215.83	216.58	0.000645	0.96	12.96	14.96	0.18
PR-CREEK	512.85	BASE	3.43	215.42	216.01	215.61	216.01	0.000559	0.61	5.60	11.53	0.16
PR-CREEK	482		Culvert									
PR-CREEK	421.84	100-YR	621.00	213.80	217.79	217.49	218.76	0.010198	7.90	78.59	29.97	0.86
PR-CREEK	421.84	BANK-FULL	12.50	213.80	214.34		214.43	0.009694	2.45	5.10	11.19	0.64
PR-CREEK	421.84	BASE	3.43	213.80	214.05		214.09	0.010808	1.62	2.12	9.47	0.60
PR-CREEK	368.44	100-YR	621.00	213.18	216.86	216.86	218.09	0.014312	8.90	69.81	28.82	1.01
PR-CREEK	368.44	BANK-FULL	12.50	213.18	213.65		213.78	0.015511	2.86	4.37	10.85	0.79
PR-CREEK	368.44	BASE	3.43	213.18	213.42		213.46	0.013160	1.72	1.99	9.43	0.66
PR-CREEK	310.56	100-YR	621.00	212.05	215.34	215.73	217.02	0.022628	10.38	59.83	27.79	1.25
PR-CREEK	310.56	BANK-FULL	12.50	212.05	212.46	212.46	212.64	0.026037	3.37	3.71	10.65	1.01
PR-CREEK	310.56	BASE	3.43	212.05	212.24	212.24	212.32	0.032841	2.28	1.50	9.28	1.00
PR-CREEK	263.41	100-YR	621.00	210.61	213.73	214.29	215.77	0.029453	11.45	54.23	26.49	1.41
PR-CREEK	263.41	BANK-FULL	12.50	210.61	211.07	211.01	211.20	0.016442	2.92	4.28	10.76	0.82
PR-CREEK	263.41	BASE	3.43	210.61	210.82	210.78	210.88	0.017891	1.90	1.81	9.27	0.76
PR-CREEK	191.5	100-YR	621.00	209.15	212.79	212.84	214.07	0.015189	9.09	68.31	28.54	1.04
PR-CREEK	191.5	BANK-FULL	12.50	209.15	209.55	209.55	209.73	0.025520	3.38	3.70	10.39	1.00
PR-CREEK	191.5	BASE	3.43	209.15	209.34	209.33	209.41	0.023583	2.08	1.65	9.13	0.86
PR-CREEK	133.35	100-YR	621.00	207.47	210.51	211.16	212.73	0.033215	11.94	52.03	26.16	1.49
PR-CREEK	133.35	BANK-FULL	12.50	207.47	207.85	207.87	208.06	0.032533	3.65	3.42	10.26	1.12
PR-CREEK	133.35	BASE	3.43	207.47	207.64	207.64	207.73	0.036120	2.37	1.45	9.02	1.04
PR-CREEK	72.46	100-YR	621.00	205.53	208.62	209.22	210.73	0.031301	11.68	53.18	26.41	1.45
PR-CREEK	72.46	BANK-FULL	12.50	205.53	205.91	205.93	206.11	0.031127	3.60	3.47	10.29	1.09
PR-CREEK	72.46	BASE	3.43	205.53	205.73	205.70	205.79	0.021212	2.01	1.71	9.20	0.82
PR-CREEK	0	100-YR	621.00	204.04	207.66	207.73	208.96	0.015333	9.16	67.80	28.16	1.04
PR-CREEK	0	BANK-FULL	12.50	204.04	204.47	204.44	204.62	0.020012	3.11	4.01	10.61	0.89
PR-CREEK	0	BASE	3.43	204.04	204.24	204.22	204.30	0.020007	1.97	1.74	9.23	0.80

Errors Warnings and Notes for Plan : 2

Location:	River: PR-UNT Reach: PR-CREEK RS: 1110.72 Profile: 100-YR
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.
Location:	River: PR-UNT Reach: PR-CREEK RS: 1037.67 Profile: BASE
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.
Location:	River: PR-UNT Reach: PR-CREEK RS: 941.1 Profile: BANK-FULL
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.
Location:	River: PR-UNT Reach: PR-CREEK RS: 941.1 Profile: BASE
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.
Location:	River: PR-UNT Reach: PR-CREEK RS: 857.83 Profile: BANK-FULL
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.
Location:	River: PR-UNT Reach: PR-CREEK RS: 857.83 Profile: BASE
Warning:	The energy equation could not be balanced within the specified number of iterations. The program
	used critical depth for the water surface and continued on with the calculations.
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:	During the standard step iterations, when the assumed water surface was set equal to critical
	depth, the calculated water surface came back below critical depth. This indicates that there is not
	a valid subcritical answer. The program defaulted to critical depth.
Location:	River: PR-UNT Reach: PR-CREEK RS: 785.54 Profile: BASE
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.
Location:	River: PR-UNT Reach: PR-CREEK RS: 713.12 Profile: BASE
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.
Location:	River: PR-UNT Reach: PR-CREEK RS: 657.59 Profile: BASE
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.
Location:	River: PR-UNT Reach: PR-CREEK RS: 612.11 Profile: BANK-FULL
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.
Location:	River: PR-UNT Reach: PR-CREEK RS: 612.11 Profile: BASE
Warning:	The energy equation could not be balanced within the specified number of iterations. The program
	used critical depth for the water surface and continued on with the calculations.
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:	During the standard step iterations, when the assumed water surface was set equal to critical
	depth, the calculated water surface came back below critical depth. This indicates that there is not
	a valid subcritical answer. The program defaulted to critical depth.
Location:	River: PR-UNT Reach: PR-CREEK RS: 587.14 Profile: BANK-FULL
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.
Location:	River: PR-UNT Reach: PR-CREEK RS: 587.14 Profile: BASE
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.
Location:	River: PR-UNT Reach: PR-CREEK RS: 482 Profile: 100-YR
Note:	During the supercritical calculations a hydraulic jump occurred at the outlet of (leaving) the culvert.
Location:	River: PR-UNT Reach: PR-CREEK RS: 482 Profile: 100-YR Culv: Culvert #1
Warning:	During the supercritical analysis, the program could not converge on a supercritical answer in the

Errors Warnings and Notes for Plan : 2 (Continued)

	downstream cross section. The program used the solution with the least error.
Note:	The flow in the culvert is entirely supercritical.
Location:	River: PR-UNT Reach: PR-CREEK RS: 482 Profile: BANK-FULL
Note:	During the supercritical calculations a hydraulic jump occurred at the outlet of (leaving) the culvert.
Location:	River: PR-UNT Reach: PR-CREEK RS: 482 Profile: BANK-FULL Culv: Culvert #1
Warning:	During the supercritical analysis, the program could not converge on a supercritical answer in the
	downstream cross section. The program used the solution with the least error.
Note:	The flow in the culvert is entirely supercritical.
Location:	River: PR-UNT Reach: PR-CREEK RS: 482 Profile: BASE
Note:	During the supercritical calculations a hydraulic jump occurred at the outlet of (leaving) the culvert.
Location:	River: PR-UNT Reach: PR-CREEK RS: 482 Profile: BASE Culv: Culvert #1
Warning:	During the supercritical analysis, the program could not converge on a supercritical answer in the
	downstream cross section. The program used the solution with the least error.
Note:	During supercritical analysis, the culvert direct step method went to normal depth. The program
	then assumed normal depth at the outlet.
Note:	The flow in the culvert is entirely supercritical.
Location:	River: PR-UNT Reach: PR-CREEK RS: 368.44 Profile: 100-YR
Warning:	The energy equation could not be balanced within the specified number of iterations. The program
	used critical depth for the water surface and continued on with the calculations.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical
	depth, the calculated water surface came back below critical depth. This indicates that there is not
	a valid subcritical answer. The program defaulted to critical depth.
Location:	River: PR-UNT Reach: PR-CREEK RS: 368.44 Profile: BANK-FULL
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 368.44 Profile: BASE
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 energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 310.56 Profile: 100-YR
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 310.56 Profile: BANK-FULL
Warning:	The energy equation could not be balanced within the specified number of iterations. The program
	used critical depth for the water surface and continued on with the calculations.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical
	depth, the calculated water surface came back below critical depth. This indicates that there is not
	a valid subcritical answer. The program defaulted to critical depth.
Location:	River: PR-UNT Reach: PR-CREEK RS: 310.56 Profile: BASE
Warning:	The energy equation could not be balanced within the specified number of iterations. The program
	used critical depth for the water surface and continued on with the calculations.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical
	depth, the calculated water surface came back below critical depth. This indicates that there is not
	a valid subcritical answer. The program defaulted to critical depth.
Location:	River: PR-UNT Reach: PR-CREEK RS: 263.41 Profile: 100-YR
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.

Errors Warnings and Notes for Plan : 2 (Continued)

	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 263.41 Profile: BANK-FULL
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.
Location:	River: PR-UNT Reach: PR-CREEK RS: 263.41 Profile: BASE
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.
Location:	River: PR-UNT Reach: PR-CREEK RS: 191.5 Profile: 100-YR
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 energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 191.5 Profile: BANK-FULL
Warning:	The energy equation could not be balanced within the specified number of iterations. The program
	used critical depth for the water surface and continued on with the calculations.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical
	depth, the calculated water surface came back below critical depth. This indicates that there is not
	a valid subcritical answer. The program defaulted to critical depth.
Location:	River: PR-UNT Reach: PR-CREEK RS: 191.5 Profile: BASE
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 133.35 Profile: 100-YR
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 energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 133.35 Profile: BANK-FULL
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 133.35 Profile: BASE
Warning:	The energy equation could not be balanced within the specified number of iterations. The program
	used critical depth for the water surface and continued on with the calculations.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical
	depth, the calculated water surface came back below critical depth. This indicates that there is not
	a valid subcritical answer. The program defaulted to critical depth.
Location:	River: PR-UNT Reach: PR-CREEK RS: 72.46 Profile: 100-YR
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 72.46 Profile: BANK-FULL
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 72.46 Profile: BASE
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.

Errors Warnings and Notes for Plan : 2 (Continued)

Location:	River: PR-UNT Reach: PR-CREEK RS: 0 Profile: 100-YR
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 energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 0 Profile: BANK-FULL
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.

Appendix D

Maintenance Plan

The proposed restored channel is designed for an indefinite lifespan, however, field inspection is needed to confirm the stability and functionality to safely pass the flow. Field inspection will be used to gather data and develop understanding of active process and conditions. Personnel with sufficient experience shall look for potential geomorphological landform, destabilizing phenomena, erosion signs, sediment storage, deposition patterns etc.

The safety of the inspection is critical and therefore the inspections shall be conducted during low flow conditions and dormant season. There should be at least a team of two persons with proper equipment for the task.

Basic information to be collected during inspection:

- Measurement of low flow and bank-full channel dimensions and channel slope in critical reaches.
- Identification of terraces and active floodplains.
- Characterization of channel bed and banks. Check gradation by collecting samples from the bed.
- Description of bank profiles, and check for structural or erosional signs of failure
- Description of point bars, pools, riffles, bed instability, and evidence of sedimentation process.
- Observation of impacts due to channel alterations and evidence of stream recovery
- Description of channel debris and bed and bank vegetation.
- Photographic record of critical stream and floodplain characteristics.

For consistency of the investigation, it is recommended that same team do the entire study as feasible. The team shall walk the entire reach, including upstream and downstream of the channel, and document the observations in form of notes.

The channel is designed as a stable channel. Which implies there is balance between slopes and sediment sizes. As long as the stability of bed and banks is maintained, the channel would have adequate hydraulic capacity to pass the design discharge and would also avert contaminating the downstream with extra sediment loads. The following table summarizes evidence of degradation, aggradation, and stability for reference.

Possible Field Indicators of River Stability/Instability

Evidence of Degradation	Terraces (abandoned floodplains) Perched channels or tributaries Headcuts and knickpoints Exposed pipe crossings Suspended culvert outfalls and ditches Undercut bridge piers Exposed or "air" tree roots Leaning trees Narrow/deep channel Banks undercut, both sides Armored bed Hydrophytic vegetation located high on bank
Evidence of Aggradation	Buried structures such as culverts and outfalls Reduced bridge clearance Presence of midchannel bars Outlet of tributaries buried in sediment Sediment deposition in floodplain Buried vegetation Perched main channel Significant backwater in tributaries Uniform sediment deposition across the channel Hydrophobic vegetation located low on bank or dead in floodplain
Evidence of Stability	Vegetated bars and banks Limited bank erosion Older bridges, culverts and outfalls with bottom elevations at or near grade Mouth of tributaries at or near existing main stem stream grade No exposed pipeline crossings

Appendix E

FEMA Map and Report

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations tables in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations tables should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Pennsylvania State Plane South zone (FIPSZONE 3702). The **horizontal datum** was NAD 83, GRS80 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242**, or visit its website at http://www.ngs.noaa.gov.

Base map information shown on this FIRM was originated from PAMAP Program, PA Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey. The imagery was derived from aerial photography flown at 1-foot ground sample distance in April 2008.

Based on updated topographic information, this map reflects more detailed and up-to-date **stream channel configurations and floodplain delineations** than those shown on the previous FIRM for this jurisdiction. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study Report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map. Also, the road to floodplain relationships for unrevised streams may differ from what is shown on previous maps.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

If you have **questions about this map**, how to order products or the National Flood Insurance Program in general, please call the FEMA Map Information eXchange (FMIX) at **1-877-FEMA-MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip.

LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X — Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X — Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D — Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% annual chance floodplain boundary

0.2% annual chance floodplain boundary

Floodway boundary

Zone D boundary

CBRS and OPA boundary

Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.

Limit of Moderate Wave Action

513	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988

A — A	Cross section line
23 - - - 23	Transect line
	Culvert, Flume, Penstock or Aqueduct
	Road or Railroad Bridge
	Footbridge
87°07'45", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere
$^{24}76^{000m}$N	1000-meter Universal Transverse Mercator grid values, zone 18
600000 FT	5000-foot grid values: Pennsylvania State Plane coordinate system, South zone (FIPSZONE 3702), Lambert Conformal Conic projection
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5	River Mile

MAP REPOSITORY
Refer to listing of Map Repositories on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
April 6, 2001

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
July 16, 2014 - To change Base Flood Elevations and Special Flood Hazard Areas, to add Base Flood Elevations and Special Flood Hazard Areas, and to update base map.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your Insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 500 1000 FEET

150 0 150 300 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0278E

FIRM
FLOOD INSURANCE RATE MAP

NORTHAMPTON COUNTY, PENNSYLVANIA
(ALL JURISDICTIONS)

PANEL 278 OF 355

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
EASTON, CITY OF	425383	0278	E
FORKS, TOWNSHIP OF	421930	0278	E
PALMER, TOWNSHIP OF	420728	0278	E
WILSON, BOROUGH OF	421927	0278	E

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
42095C0278E

MAP REVISED
JULY 16, 2014

Federal Emergency Management Agency

FLOOD INSURANCE STUDY

VOLUME 1 OF 2

NORTHAMPTON COUNTY, PENNSYLVANIA
(ALL JURISDICTIONS)

COMMUNITY NAME	COMMUNITY NUMBER	COMMUNITY NAME	COMMUNITY NUMBER
ALLEN, TOWNSHIP OF	421928	MOORE, TOWNSHIP OF	420983
BANGOR, BOROUGH OF	420716	NAZARETH, BOROUGH OF	420725
BATH, BOROUGH OF	420717	NORTH CATASAUQUA, BOROUGH OF	420727
BETHLEHEM, CITY OF	420718	NORTHAMPTON, BOROUGH OF	420726
BETHLEHEM, TOWNSHIP OF	420980	PALMER, TOWNSHIP OF	420728
BUSHKILL, TOWNSHIP OF	421929	PEN ARGYL, BOROUGH OF	421926
CHAPMAN, BOROUGH OF	422251	PLAINFIELD, TOWNSHIP OF	421147
EAST ALLEN, TOWNSHIP OF	420981	PORTLAND, BOROUGH OF	420729
EAST BANGOR, BOROUGH OF	422252	ROSETO, BOROUGH OF	422255
EASTON, CITY OF	425383	STOCKERTOWN, BOROUGH OF	420730
FORKS, TOWNSHIP OF	421930	TATAMY, BOROUGH OF	420731
FREEMANSBURG, BOROUGH OF	420721	UPPER MOUNT BETHEL, TOWNSHIP OF	421933
GLENDON, BOROUGH OF	422254	UPPER NAZARETH, TOWNSHIP OF	421934
HANOVER, TOWNSHIP OF	420722	WALNUTPORT, BOROUGH OF	420732
HELLERTOWN, BOROUGH OF	420723	WASHINGTON, TOWNSHIP OF	421156
LEHIGH, TOWNSHIP OF	421931	WEST EASTON, BOROUGH OF	420733
LOWER MOUNT BETHEL, TOWNSHIP OF	420724	WILLIAMS, TOWNSHIP OF	421036
LOWER NAZARETH, TOWNSHIP OF	422253	WILSON, BOROUGH OF	421927
LOWER SAUCON, TOWNSHIP OF	420982	WIND GAP, BOROUGH OF	420734

REVISED:
JULY 16, 2014

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER

42095CV001A

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

Part or all of this FIS may be revised and republished at any time. In addition, part of this FIS may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS. It is, therefore, the responsibility of the user to consult with community officials and to check the community repository to obtain the most current FIS components.

Initial Countywide FIS Effective Date: April 6, 2001

Revised Countywide FIS Effective Date: July 16, 2014

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FLOOD INSURANCE STUDY
NORTHAMPTON COUNTY, PENNSYLVANIA (ALL JURISDICTIONS)

1.0 INTRODUCTION

1.1 Purpose of Study

This countywide Flood Insurance Study (FIS) investigates the existence and severity of flood hazards in, or revises previous FISs/Flood Insurance Rate Maps (FIRMs) for the geographic area of Northampton County, Pennsylvania, including: the Boroughs of Bangor, Bath, Chapman, East Bangor, Freemansburg, Glendon, Hellertown, Nazareth, North Catasauqua, Northampton, Pen Argyl, Portland, Roseto, Stockertown, Tatamy, Walnutport, West Easton, Wilson, and Wind Gap; the Cities of Bethlehem and Easton; and the Townships of Allen, Bethlehem, Bushkill, East Allen, Forks, Hanover, Lehigh, Lower Mount Bethel, Lower Nazareth, Lower Saucon, Moore, Palmer, Plainfield, Upper Mount Bethel, Upper Nazareth, Washington, and Williams (hereinafter referred to collectively as Northampton County).

The City of Bethlehem is located in more than one county, but is included in its entirety in the Northampton County FIS.

This FIS aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates. This information will also be used by Northampton County to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP), and by local and regional planners to further promote sound land use and floodplain development. Minimum floodplain management requirements for participation in the NFIP are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

In some States or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this FIS are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The original April 6, 2001 Countywide FIS study was prepared to include incorporated communities within Northampton County into a countywide format FIS. Information on the authority and acknowledgments for each jurisdiction included in this countywide FIS, as compiled from their previously printed FIS report narratives, is shown on the following pages.

Allen, Township of:	the hydrologic and hydraulic analyses for the original FIS report dated November 19, 1980, were performed by Pickering, Corts, and Summerson, Inc., for the Federal Insurance Administration (FIA), under Contract No. H-4758. That work was completed in October 1979.
Bangor, Borough of:	the survey and topographic data for the original FIS report dated August 1976 were collected and compiled by Geod Corporation, Oak Ridge, New Jersey, under subcontract from Goodkind & O'Dea, Inc. (Contract H-3747).
Bath, Borough of:	the hydrologic and hydraulic analyses for the original FIS report dated February 17, 1988, were prepared by the U.S. Geological Survey (USGS) for the Federal Emergency Management Agency (FEMA), under Inter-Agency Agreement No. EMW-85-E-1823, Project Order No. 6. That work was completed in September 1986.
Bethlehem, City of:	the hydrologic and hydraulic analyses for the original FIS report dated January 1978 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-3747. That work was completed in September 1976.
Bethlehem, Township of:	the hydrologic and hydraulic analyses for the original FIS report dated December 1979 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-4521. That work was completed in July 1978.
Bushkill, Township of:	the hydrologic and hydraulic analyses for the original FIS report dated March 4, 1988, were prepared by the USGS for FEMA, under Inter-Agency Agreement No. EMW-85-E-1823, Project Order No. 6. That work was completed in October 1986.
Easton, City of:	the hydrologic and hydraulic analyses for the original FIS report dated March 1979 were prepared by the USGS, Water Resources Division, for the FIA, under

Inter-Agency Agreement No. IAA-H-8-76, Project Order No. 3. That work was completed in June 1977.

Forks, Township of:	the hydrologic and hydraulic analyses for the original FIS report dated January 1980 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-4521. That work was completed in November 1978.
Freemansburg, Borough of:	the original FIS report dated September 1977 was conducted by the Delaware River Basin Commission at the request of the Federal Insurance Administration, U.S. Department of Housing and Urban Development, under Contract No. H-3747.
Glendon, Borough of:	the hydrologic and hydraulic analyses for the original FIS report dated July 1979 were prepared by the Delaware River Basin Commission for the FIA under Contract No. H-4521. That work was completed in June 1978.
Hanover, Township of:	the original FIS report dated August 1977 was prepared by the Delaware River Basin Commission at the request of the FIA, U.S. Department of Housing and Urban Development, under Contract No. H-3747.
Hellertown, Borough of:	the hydrologic and hydraulic analyses for the original FIS report dated March 1979 were prepared by the U.S. Army Corps of Engineers, (USACE), Philadelphia District, for the FIA, under Inter-Agency Agreement No. IAA-H-16-75, Project Order No. 6. That work was completed in February 1978.
Lehigh, Township of:	the hydrologic and hydraulic analyses for the original FIS report dated June 15, 1981, were prepared by Pickering, Corts and Summerson, Inc., for FEMA, under Contract No. H-4758. That work was completed in October 1979.
Lower Mount Bethel, Township of:	the hydrologic and hydraulic analyses for the original FIS report dated October 30, 1981, represent a revision of the original

analyses by the Delaware River Basin Commission for FEMA, under Contract No. H-3747. The revised analyses for the Delaware River, taken from the FIS for the Township of Harmony, New Jersey, were conducted by Michael Baker, Jr., Inc., under subcontract to the New Jersey Department of Environmental Protection, Division of Water Resources, under Contract No. H-3959. That work was completed in August 1978. The revised study was prepared by Gannett Fleming Corddry and Carpenter, under agreement with FEMA.

Lower Nazareth, Township of:	the hydrologic and hydraulic analyses for the original FIS report dated May 4, 1988, were prepared by the USGS for FEMA, under Inter-Agency Agreement No. EMW-85-E-1823, Project Order No. 6. That work was completed in October 1986.
Lower Saucon, Township of:	the hydrologic and hydraulic analyses for the original FIS report dated March 1979 were prepared by the USACE, Philadelphia District, for the FIA, under Inter-Agency Agreement No. IAA-H-16-75, Project Order No. 16. That work was completed in October 1977.
Moore, Township of:	the hydrologic and hydraulic analyses for the original FIS report dated April 1978 were prepared by Gannett Fleming Corddry and Carpenter, Inc., for the FIA, under Contract No. H-3812. That work was completed in April 1977.
North Catasauqua, Borough of:	the hydrologic and hydraulic analyses for the original FIS report dated January 16, 1981, were prepared by the USACE, Philadelphia District, for the FIA, under Inter-Agency Agreement No. IAA-H-18-78. That work was completed in January 1980.
Northampton, Borough of:	the hydrologic and hydraulic analyses for the original FIS report dated November 3, 1981, were prepared by the USACE, Philadelphia District, for the FIA, under Inter-Agency Agreement No. IAA-H-18-78,

	Project Order No. 22. That work was completed in February 1980.
Palmer, Township of:	the original FIS report dated June 1976 was prepared by the USACE, Philadelphia District, at the request of the FIA, U.S. Department of Housing and Urban Development, under Inter-Agency Agreement No. IAA-H-2-73, Project Order No. 4.
Plainfield, Township of:	the hydrologic and hydraulic analyses for the original FIS report dated July 1979 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-4521. That work was completed in June 1978.
Portland, Borough of:	the hydrologic and hydraulic analyses for the original FIS report dated March 16, 1981, were prepared by Pickering, Corts and Summerson, Inc., for the FIA, under Contract No. H-4758. That work was completed in December 1979.
Stockertown, Borough of:	the hydrologic and hydraulic analyses for the original FIS report dated June 1979 were prepared by the Delaware River Basin Commission, for the FIA, under Contract No. H-4521. That work was completed in January 1978.
Tatamy, Borough of:	the hydrologic and hydraulic analyses for the original FIS report dated June 1979 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-4521. That work was completed in January 1978.
Upper Mount Bethel, Township of:	the hydrologic and hydraulic analyses for the original FIS report dated March 30, 1981, were prepared by Pickering, Corts & Summerson, Inc., for the FIA, under Contract No. H-4758. That work was completed in December 1979.
Walnutport, Borough of:	the hydrologic and hydraulic analyses for the original FIS report dated December 1977 were prepared by Gannett Fleming Corddry

and Carpenter, Inc., Harrisburg, Pennsylvania, for the FIA, under Contract No. H-3813. That work was completed in March 1977.

Washington, Township of: the hydrologic and hydraulic analyses for the original FIS report dated September 30, 1988, were prepared by the USGS for FEMA, under Inter-Agency Agreement No. EMW-85-E-1823, Project Order No. 6. That work was completed in October 1986.

West Easton, Borough of: the hydrologic and hydraulic analyses for the original FIS report dated September 1978 were prepared by the Delaware River Basin Commission, in January 1976, at the request of the FIA, U.S. Department of Housing and Urban Development, under Contract No. H-3747.

Williams, Township of: the hydrologic and hydraulic analyses for the original FIS report dated March 1979 were prepared by the USACE, Philadelphia District, for the FIA, under Inter-Agency Agreement No. IAA-H-16-75, Project Order No. 16 and Inter-Agency Agreement No. IAA-H-7-76, Project Order No. 1. That work was completed in June 1977.

Wilson, Borough of: the hydrologic and hydraulic analyses for the original FIS report dated July 1979 were prepared by the Delaware River Basin Commission for the FIA, under Contract No. H-4521. That work was completed in June 1977.

Wind Gap, Borough of: the hydrologic and hydraulic analyses for the original FIS report dated May 16, 1994, were prepared by Pickering, Corts & Summerson, Inc., for the FIA, under Contract No. H-4758. That work was completed in November 1979.

The authority and acknowledgments for the City of Bethlehem; Boroughs of Chapman, East Bangor, Nazareth, Pen Argyl, and Roseto; and Townships of East Allen and Upper Nazareth are not included because there were no previously printed FIS reports for those communities.

For the April 6, 2001, countywide FIS, the hydrologic and hydraulic analyses for the Delaware River, Lehigh River, and Saucon Creek, were conducted by the USACE, Philadelphia District, for FEMA, under Inter-Agency Agreement No. EMW-95-E-4756, Project Order No. 9. This work was completed in December 1997.

For this revision, the hydrologic and hydraulic analyses for Nancy Run were conducted. The remaining streams studied by detailed methods were redelineated using Light Detection and Ranging (LiDAR) data flown in 2007. For streams studied with approximate methods, the 1-percent-annual-chance flood elevations were determined from the regional relationship between drainage area and flood depth prepared by the USGS. This relationship was developed by means of regional regression analyses of basin areas and the within channel 1-percent-annual-chance flood depths observed at stream gages. Depths were adjusted on the basis of hydraulic calculations to account for increased depth due to backwater from hydraulic structures, such as bridges and culverts. This work was performed by RAMPP (Risk Assessment, Mapping, and Planning Partners, a joint venture of Dewberry, URS, and ESP), Fairfax, Virginia, for FEMA, under Contract No. HSFEHQ-09-J-0369, Task Order HSFE03-09-J-0003B. This work was completed in August 2011. In addition, revised hydrologic and hydraulic analyses for the Delaware River were prepared for FEMA by T.Y. Lin International / Medina under Contract No. EMN-2003-CO-0005. This work was completed in June 2009.

The orthophotography base mapping was provided by the PAMAP Program, PA Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey. The orthoimagery was derived from aerial photography flown at 1-foot ground sample distance in April 2008.

The digital countywide FIRM was produced in Pennsylvania State Plane South Zone coordinate system (FIPSZONE 3702) with a Lambert Conformal Conic projection, units in feet, and referenced to the North American Datum of 1983 (NAD83), GRS80 spheroid. Differences in datum and spheroid used in the production of the FIRMs for adjacent counties may result in slight positional differences in map features at the county boundaries. These differences do not affect the accuracy of information shown on this FIRM.

1.3 Coordination

An initial Consultation Coordination Officer's (CCO) meeting is held with representatives from FEMA, the community, and the study contractor to explain the nature and purpose of a FIS, and to identify the streams to be studied by detailed methods. A final CCO meeting is held with representatives from FEMA, the community, and the study contractor to review the results of the study.

The dates of the pre-countywide initial and final CCO meetings held for the incorporated communities within the boundaries of Northampton County are shown in Table 1, "CCO Meeting Dates."

TABLE 1 – CCO MEETING DATES

Community Name	Initial CCO Date	Final CCO Date
Allen, Township of	May 9, 1978	April 17, 1980
Bangor, Borough of	*	*
Bath, Borough of	November 20, 1984	March 26, 1987
Bethlehem, City of	*	April 17, 1976
Bethlehem, Township of	June 23, 1977	April 30, 1979
Bushkill, Township of	November 20, 1984	March 26, 1987
Easton, City of	*	April 18, 1977
Forks, Township of	March 29, 1977	April 30, 1979
Freemansburg, Borough of	*	March 22, 1976
Glendon, Borough of	*	February 6, 1979
Hanover, Township of	*	*
Hellertown, Borough of	December 3, 1974	*
Lehigh, Township of	May 9, 1978	April 23, 1980
Lower Mount Bethel, Township of	November 11, 1974	October 20, 1975
Lower Nazareth, Township of	November 20, 1984	March 26, 1987
Lower Saucon, Township of	July 1, 1975	November 16, 1978
Moore, Township of	October 1975	July 20, 1977
North Catasauqua, Borough of	December 13, 1977	July 30, 1980
Northampton, Borough of	December 13, 1977	June 25, 1981
Palmer, Township of	*	December 9, 1975
Plainfield, Township of	June 23, 1977	February 6, 1979
Portland, Borough of	May 10, 1978	September 24, 1980
Stockertown,Borough of	*	October 31, 1978
Tatamy, Borough of	*	October 31, 1978
Upper Mount Bethel, Township of	*	September 24, 1980
Walnutport, Borough of	*	May 5, 1977
Washington, Township of	November 20, 1984	November 10, 1987
West Easton, Borough of	*	March 11, 1976
Williams, Township of	July 1, 1975	August 25, 1978
Wilson, Borough of	March 28, 1977	February 6, 1979
Wind Gap, Borough of	May 10, 1978	April 23, 1980

*Data not available

For the April 6, 2001, countywide FIS, initial CCO meetings were held on July 28, 1993, and July 6, 1994. A final CCO meeting was held on October 5, 1999, and was attended by representatives from the Township of East Allen, Borough of North Catasauqua, and the Township of Williams; USACE; and FEMA.

For this revision, the final CCO meeting was held on February 21, 2012, and was attended by representatives from the Boroughs of Bangor, Hellertown, Northampton, Tatamy, West Easton, and Wilson; the City of Bethlehem; and the Townships of Allen, Bethlehem, Bushkill, East Allen, Hanover, Lehigh, Lower Saucon, Moore, Plainfield, Upper Mount Bethel, Washington, and Williams; PA Department of Community and Economic Development; RAMPP; and FEMA.

2.0 AREA STUDIED

2.1 Scope of Study

This countywide FIS covers the geographic area of Northampton County, Pennsylvania.

All or portions of the flooding sources listed in Table 2, “Flooding Sources Studied by Detailed Methods”, were studied by detailed methods. Limits of detailed study are indicated on the Flood Profiles (Exhibit 1) and on the FIRM (Exhibit 2).

TABLE 2 – FLOODING SOURCES STUDIED BY DETAILED METHODS

Black River
Bushkill Creek Reach 1
Bushkill Creek Reach 2
Bushkill Creek Reach 3
Catasauqua Creek
Delaware River
East Branch Monocacy Creek
Hokendauqua Creek Reach 1
Hokendauqua Creek Reach 2
Hokendauqua Creek Reach 3
Jacoby Creek
Lehigh River
Little Bushkill Creek
Little Martins Creek
Martins Creek Reach 1
Martins Creek Reach 2
Monocacy Creek Reach 1
Monocacy Creek Reach 2
Nancy Run
Saucon Creek
Shoeneck Creek
Silver Creek
Unnamed Tributary to East Branch Monocacy Creek
Unnamed Tributary to Martins Creek Reach 2
Unnamed Tributary to Waltz Creek
Waltz Creek
West Branch Little Bushkill Creek

For the April 6, 2001, countywide FIS, the Delaware River was restudied for its entire length within the county. The Lehigh River was studied from its confluence with the Delaware River in Easton to just above the confluence of Nesquehoning Creek in Carbon County. Saucon Creek was studied from its confluence with the Lehigh River in Bethlehem to the Lower Milford Township/Upper Saucon Township line in Lehigh County. This FIS also incorporated the determination of a Letter of Map Revision (LOMR). A LOMR was issued by FEMA on July 27, 1989, in the vicinity of Wilson Avenue in the Township of Bethlehem.

For this countywide revision, the Delaware River was restudied for its entire reach within the county. Nancy Run was restudied from its confluence with the Lehigh River in the Borough of Freemansburg to Farmersville Road in the Township of Bethlehem. This revision also incorporates the determination of a LOMR. A LOMR was issued by FEMA on December 22, 2009, in the vicinity of Lehigh River in the City of Bethlehem.

The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development and proposed construction.

Numerous flooding sources in the county were studied by approximate methods. Approximate analyses were used to study those areas having a low development potential or minimal flood hazards. The scope and methods of study were proposed to, and agreed upon by, FEMA, and Northampton County.

2.2 Community Description

Northampton County is located in eastern Pennsylvania. The county is bordered by Monroe County to the north; Warren County, New Jersey, to the east; Bucks County to the south; Lehigh County to the southwest; and Carbon County to the northwest.

The climate in Northampton County is humid continental. Summer and winter temperatures average 70.2 degrees Fahrenheit (°F) and 28.7°F, respectively. The annual average precipitation of the county is 43.9 inches, while recorded snowfall totals 17.8 inches (Reference 1). According to the U.S. Census Bureau figures, the population in 2010 was 297,735, and the land area was approximately 370 square miles.

2.3 Principal Flood Problems

Flooding in Northampton County occurs in all seasons from both extra-tropical storms (produced from the passage of either a cold front or a warm front) and tropical storms. Flood conditions may be aggravated by the rapid melting of an existing snow pack, and/or by reduction in infiltration losses due to frozen ground.

Extra-tropical storms associated with cold fronts occur mostly during the warmer months of the year. Precipitation accompanying the passage of a cold front tends to be intense and of short duration, occurring in the form of thunderstorms or snowfall. Major basin-wide floods are rarely caused by cold-front rainfall; however, the majority of floods along the smaller tributaries and in the headwater areas of the main streams are produced by cold-front storms.

Extra-tropical storms associated with warm fronts may be expected at any time during the year, but they are more prevalent during the colder months of the year. Warm-front storms, producing less intense but more protracted rainfall, have produced most of the basin-wide floods. A special type of flooding associated with a warm-front storm is produced when rain falls on a winter snow pack. The rapid spring melting of a deep snow pack combined with heavy rainfall can be the cause of significant runoff.

Several major floods have occurred in the Delaware River Basin in this century. The flood of August 1955 is the flood of record for most of the Delaware River Basin. The event of October 1903 also caused extensive flooding, particularly in the upper basin, where it is still the flood of record in some areas.

Delaware River flood records prior to the establishment of stream gages are available at Trenton, New Jersey. The flood of February 27, 1692 (reported 12 feet above the usual high-water mark) may have been as great or greater than that of August 1955. The flood of January 8, 1841, was reported at that time to be the greatest since 1692. The ice jam flood of February 8, 1857, may have had a stage at Trenton equal to or higher than the ice jam flood of March 8, 1904 (the highest known stage at Trenton).

Flood of October 1903: The flood of October 7-11 occurred as a result of a hurricane-associated storm which centered east of the upper Delaware River Basin. Many stage and discharge records were established as most of the basin above Trenton was severely flooded. These records remained unbroken until August 1955, when flood crests several feet higher were recorded along much of the Delaware River. Flood flows in the upper basin were exceedingly high in 1903 and flood stages reached on the East and West Branches of the Delaware River at Fishs Eddy and Hale Eddy, respectively, remain unequaled.

Flood of March 1936: This flood resulted from a combination of precipitation and appreciable snow melt from a storm that had two periods of precipitation, the first on the 11^{th} and 12^{th} and the second on the 17^{th} to 21^{st}. Snow cover on March 10 expressed as water content in inches, ranged over the basin from 5 to 8 inches in the head waters in New York and Pennsylvania, to zero below Trenton, New Jersey. The precipitation from these storms melted much of the snow in the basin and produced two peaks. Runoff from the second storm was greater than that from the first storm on the main stem.

Flood of May 1942: The storm of May 19-23, 1942, traveled generally northeastward across eastern Pennsylvania and into New York and produced heavy flows along the main stem of the Delaware River. In some areas, this flood caused extensive damage. Thirty-three persons lost their lives, thirty-five bridges were washed out, and ten small dams failed.

Flood of August 1955: The flood of August 1955 was the result of two hurricanes, Connie and Diane, passing over the basin within a few days. Hurricane Connie, which passed over the basin on August 12-13, encountered the extremely dry conditions that had prevailed through July and early August. Most of the precipitation from Connie was absorbed by the dry soil and resulted in relatively little runoff. Connie did, however, help saturate the basin and consequently contributed toward increased runoff from Diane which quickly followed. The high-intensity rainfall during Hurricane Diane caused rapid flooding of record-breaking proportions. Most of the drainage area above Trenton was severely flooded. Along the main stem of the Delaware River, the flooding exceeded the previous flood levels at all points above Trenton.

2.4 Flood Protection Measures

The USACE constructed and operates four flood-control reservoirs in the Delaware River Basin above Burlington. General Edgar Jadwin and Prompton

Reservoirs are located on tributaries in Wayne County, Pennsylvania. Francis E. Walter Dam is on the Lehigh River in Carbon and Luzerne Counties, Pennsylvania, approximately 77 river miles above the confluence with the Delaware River. Beltzville Reservoir is located on Pohopoco Creek approximately 4 miles upstream from the confluence with the Lehigh River in Carbon County, Pennsylvania. Walter and Beltzville are used for low flow augmentation and recreation in addition to flood control. The Commonwealth of Pennsylvania maintains Nockamixon State Park on Tohickon Creek for flood control, recreation, and future water supply.

In addition, several local flood protection projects have been constructed along the Lehigh River in the City of Bethlehem.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the county, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 1-percent-annual-chance flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the county at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied in detail affecting the county.

Information on the methods used to determine peak discharge-frequency relationship for the streams studied by detailed methods is shown below

Precountywide FIS

Each flood-prone community within Northampton County, except the Boroughs of Chapman, East Bangor, Nazareth, Pen Argyl, and Roseto, the Townships of East Allen and Upper Nazareth, and the City of Bethlehem has a previously printed FIS report. The hydrologic analyses described in those reports has been compiled and is summarized below.

For Hokendauqua Creek, the hydrologic analyses were also based on the Regional Frequency Study, which followed the standard log-Pearson Type III analyses (References 2 and 3). Since there are no gages located nearby on the creek, missing flood peaks were estimated by correlation with the nearest long-record stations, and the statistics were then recomputed.

The methodology relates the magnitude of instantaneous-peak stream discharge for selected recurrence intervals to statistically significant drainage basin characteristics. The drainage basin characteristics include channel slope, storage, annual precipitation, and the drainage area as determined from USGS topographic maps and Water Resources Bulletin No. 6 (References 4 and 5).

The flood-flow frequency analysis of Martins Creek was performed by following the procedures shown in the Regional Frequency Study (Reference 2). This study, which was prepared by the USACE, Hydrologic Engineering Center (HEC), utilized the log-Pearson Type III method as described in "A Uniform Technique for Determining Flood Flow Frequency" to analyze the peak yearly flows for all gages in the Delaware and Hudson River Basins (Reference 3). The HEC study provides log-Pearson Type III parameters for stream gaging stations and equations for translating frequency-discharge relations from the gage locations to other desired points upstream and downstream of the gage locations.

The flow analyses of streams studied by detailed methods were performed by using the adopted log-Pearson parameters from the referenced HEC study. The parameters for Gage 01446600 located near East Bangor were used to analyze the Martins Creek flow.

A report entitled "Basin-Wide Program for Flood Plain Delineation" was also used in the analyses of the study flows (Reference 6). The report describes a method to determine flood flows for uncontrolled watersheds and for watersheds in which dams, ponds, swamps, etc., do not control more than 27 percent of the total watershed. The report was used only for comparison of flood flows determined by the method described in the preceding paragraphs.

Flood-frequency discharge values for Monocacy Creek were determined utilizing regional regression equations developed in USGS Water Resources Investigations 82-21 (Reference 7).

For the Monocacy Creek, flood flow frequency data were based on a statistical analysis of stage-discharge records covering a 168-year period at five gaging stations operated by the USGS (Reference 8). The following is a list of the gaging stations used in computing the hydrologic analyses.

Gaging Station	Location	Period of Record
#10447800	Lehigh River below Francis E. Walter Lake near White Haven, PA	1957-1976
#457500	Lehigh River at Tannery, PA	1943-1976 1940-1976
#091453000	Lehigh River at Bethlehem, PA	1902-1905 1909-1976
#01454700	Lehigh River at Glendon, PA	1966-1976

This analysis was based on the Regional Frequency Study (Reference 2), which furnished information on the regulating effects of the Francis E. Walter and the Beltzville Dams on the Lehigh River flow since February 1961 and February 1971, respectively. The study was modified with updated regional readings and flood data. This method of analysis follows the standard log-Pearson Type III method as outlined by the Water Resources Council (References 3 and 4).

For the area of Nancy Run studied by detailed methods, a regional flood-frequency method based on a statistical analysis of USGS stream flow gages in Pennsylvania was utilized to compute the 10-, 50-, 100-, and 500-year flood-frequency values (Reference 8).

The analysis of Monocacy Creek was based on the regional frequency method developed by the USACE (Reference 2). This method was modified by the engineering firm of Justin and Courtney, Inc., to apply specifically to the Lehigh Valley (Reference 9). Flood discharge values for the 10-, 50-, 100-, and 500-yera floods were determined by this method. This method was selected for Monocacy Creek for the purpose of continuity with the FIS for the City of Bethlehem (Reference 10).

Flood-frequency discharge values for Bushkill Creek were determined utilizing regional regression equations developed in USGS Water-Resources Investigations 82-21 (Reference 7).

Modification of the frequency distributions to allow for regulation effects were made by the USACE, Philadelphia District on the basis of its flood routing analysis of the Delaware River (Reference 11).

A similar hydrologic analysis of the Lehigh River was used to obtain values of the 10-, 50-, 100-, and 500-year regulated peak discharges for the Lehigh River (Reference 12). The principal gage on this stream is at Bethlehem, Pennsylvania, 6 miles upstream from the corporate limits. This gage has been in operation since 1902, with exception of the 1906-1909 period (Reference 13).

Peak discharge values for the 10-, 50-, and 1-percent-annual-chance recurrence intervals for Bushkill Creek were determined from the appropriate regional equations in a USGS report, titled “Floods in Pennsylvania, A Manual for Estimation of Their Magnitude and Frequency” (Reference 14). The 500-year value was obtained from the frequency-discharge drainage area data in the Palmer Township FIS (Reference 12).

The 1-percent-annual-chance discharge for the portion of Monocacy Creek that flows through the northeast corner of the Township of Hanover was obtained from a regional flood frequency method developed at Pennsylvania State University (Reference 15).

The hydrologic analysis of Silver Creek was developed using both the USACE HEC-1 computer program and the Regional Frequency Study (References 16 and 2). Both methods were reviewed and compared; however, values computed using the HEC-1 computer program were selected for use.

Flood-frequency analyses of Martins Creek and Little Martins Creek were performed following procedures shown in the Regional Frequency Study (Reference 2). This study utilized the log-Pearson Type III method, as described in Water Resources Bulletin 15, to analyze the peak annual flows at the gage (No. 01446600) located near East Bangor (Reference 3). The USACE study provided log-Pearson Type III parameters for the gaging station and equations for translating the frequency-discharge relationships from the gage location to other desired points upstream and downstream of the gage location. Discharges for the 500-year floods on Martins Creek and Little Martins Creek were developed using additional information from tables of log-Pearson Type III distribution percentage points and K tables developed by the U.S. Department of Agriculture, Soil Conservation Service (SCS) (References 3 and 17).

Flood-frequency discharge values for Monocacy Creek, East Branch Monocacy Creek, and Unnamed Tributary to East Branch Monocacy Creek were developed from Bulletin 17B and the peak discharge records for Monocacy Creek at Bethlehem, gage No. 01542500 (Reference 18). Flood-frequency discharge values for Shoeneck Creek were taken from the FIS for the Township of Palmer (Reference 12). In that study, regionalized frequency curves were taken from the Philadelphia District of the USACE Flood Plain Information Report for Little Bushkill Creek and Shoeneck Creek.

For the detailed study of Hokendauqua Creek, the hydrologic analysis was a modification of the SCS procedure designated in this study as “Journal of the Hydraulics Division,” which relates basin characteristics to streamflow characteristics (Reference 19).

Rainfall data were calculated using the Pennsylvania State University’s “Design Procedures for Rainfall-Duration-Frequency in Pennsylvania” (Reference 20). These data were combined with basin characteristics such as drainage area, stream slope, vegetation, soil cover, and land use characteristics to estimate the resulting discharge values considering a time lapse to the peak discharge calculated by empirical equations.

For the areas of Little Bushkill Creek and Waltz Creek studied by detailed methods, a regional flood-frequency method based on a statistical analysis of Pennsylvania stream flow gages by the USGS was utilized to compute 10-, 50-, and 1-percent-annual-chance flood-frequency values (Reference 21). Discharge values for the 500-year flood were extrapolated from flood-frequency curves developed from these values. The analysis of the shallow flooding area northeast of the Borough of Pen Argyl involved the development of only a 1-percent-annual-chance flood discharge value. This discharge figure was determined by weighing the values determined by the Rational Method and a method used by the SCS (Reference 22). Both methods involve the abstraction of streamflow discharge values from rainfall data based on watershed characteristics such as drainage area, stream slope, land use, and soil cover.

For the detailed study of Jacoby Creek, the hydrologic analyses were performed following the methodology presented in Water Resources Bulletin No. 13 on floods in Pennsylvania, which relates drainage basin characteristics to streamflow characteristics (Reference 21). The resulting discharges compared favorably to discharges computed using the methodology of the Regional Frequency Study (Reference 2).

The source of discharge data for the detailed analysis of Bushkill Creek is information developed for the Flood Plain Information Report for Bushkill Creek (Reference 23). The method utilized by the USACE in establishing the 10- and 50-year flood discharge values is a regional method outlined in USGS Water Supply Paper 1672 (Reference 24). The 1-percent-annual-chance flood discharge was extrapolated from these values, and the 500-year flood was assumed to be equivalent to the standard project flood (Reference 25).

More reliable flood frequency discharge values were determined for Bushkill Creek in the Borough of Tatamy by a flood frequency method developed specifically for Pennsylvania (Reference 21). Five- and ninety-five percent confidence limits were established for the resulting curve according to the method outlined in the publication, Hydrologic Engineering Methods for Water Resources Development, Volume 3, Hydrologic Frequency Analysis (Reference 26). The previously defined USACE frequency discharge figures all fell within this confidence band with the exception of the 500-year flood value, which was found to be above the five-percent confidence limit curve.

Discharge data for the approximate study area of Little Bushkill Creek can be found in the Little Bushkill Creek Flood Plain Information Report (Reference 27).

For the detailed study of West Branch Little Bushkill Creek, the hydrologic analyses were performed following the methodology presented in Water Resources Bulletin No. 13 on floods in Pennsylvania (Reference 21), which relates drainage basin characteristics to streamflow characteristics. The resulting discharges compared favorably to the discharges computed using both the

Regional Frequency Study (Reference 2) and the published streamflow discharges approximated for West Branch Little Bushkill Creek (Reference 27).

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The hydrologic analysis of the Lehigh River was derived directly from the "Modification of the Francis E. Walter Dam and Reservoir, General Design Memorandum, Appendix J – Hydrology and Hydraulics" (Reference 28). Data from the same analysis is also presented in "F. E. Walter Reservoir, Lehigh River, PA, Water Control Manual" (Reference 29). The analysis of Saucon Creek consisted solely of the updated regional study since no gages exist on the creek.

The hydrologic analysis of the Delaware River was directly derived from "Delaware River Basin Study Survey Report, Technical Appendices" (Reference 30).

This Revision

The peak discharge computation procedure for using Pennsylvania Regression Equations is presented in the publication "Regression Equations for Estimating Flood Flows at Selected Recurrence Intervals for Ungaged Streams in Pennsylvania" (Scientific Investigation Report [SIR] no.-2008-5102) (Reference 31). Based on physiography, elevation, and geologic characteristics, the publication divided the State of Pennsylvania into four hydrologic regions. Northampton County falls under hydrologic Region 1. The general form of the regression equation is shown in Equation 2.1 below.

$$\hat{Q}_T = 10^A (DA)^b (El)^c (1+0.01C)^d (1+0.01U)^e (1+0.1Sto)^f$$ ……………………………. (Equation 2.1)

Where

$\hat{Q}_T$	= the T-year predicted flood flow, in cubic feet per second;
A	= the intercept (estimated by GLS);
DA	= drainage area, in square miles;
El	= mean elevation, in feet;
C	= basin underlain by carbonate bedrock, in percent;
U	= urban area in the basin, in percent;
Sto	= storage in the basin, in percent; and
b, c, d, e, and f	= basin characteristic coefficients of regression estimated by GLS.

The SIR 2008-5102 states that the regression equations mentioned in Equation 2.1 can be applied to watersheds with drainage areas ranging from 1 square mile to 2000 square miles. The SIR recommends application of regression equations to only those watersheds that fall within the range of variables that were used for developing regression equations. The applicable range of urban area for Region1 equations is between 0-20 percent.

For Nancy Creek, the percent urban area is more than 20. Hence, a correction to the flows obtained by Pennsylvania Regression equations was applied using Nationwide 7-Parameter Urban Regression equations listed below. The urban equations are valid for urbanized areas that do not contain peak controlling structures and should not be used if any of the seven variables are larger or smaller than those used in the original regression study.

$UQ_2 = 2.35\ A^{.41}\ SL^{.17}\ (RI_2+3)^{2.04}\ (ST+8)^{-.65}\ (13\text{-}BDF)^{-.32}\ IA^{.15}\ RQ_2^{.47}$
$UQ_5 = 2.7\ A^{.35}\ SL^{.16}\ (RI_2+3)^{1.86}\ (ST+8)^{-.59}\ (13\text{-}BDF)^{-.31}\ IA^{.11}\ RQ_5^{.54}$
$UQ_{10} = 2.99\ A^{.32}\ SL^{.15}\ (RI_2+3)^{1.75}\ (ST+8)^{-.57}\ (13\text{-}BDF)^{-.30}\ IA^{.09}\ RQ_{10}^{.58}$
$UQ_{25} = 2.78\ A^{.31}\ SL^{.15}\ (RI_2+3)^{1.76}\ (ST+8)^{-.55}\ (13\text{-}BDF)^{-.29}\ IA^{.07}\ RQ_{25}^{.60}$
$UQ_{50} = 2.67\ A^{.29}\ SL^{.15}\ (RI_2+3)^{1.74}\ (ST+8)^{-.53}\ (13\text{-}BDF)^{-.28}\ IA^{.06}\ RQ_{50}^{.62}$
$UQ_{100} = 2.50\ A^{.29}\ SL^{.15}\ (RI_2+3)^{1.76}\ (ST+8)^{-.52}\ (13\text{-}BDF)^{-.28}\ IA^{.06}\ RQ_{100}^{.63}$
$UQ_{500} = 2.27\ A^{.29}\ SL^{.16}\ (RI_2+3)^{1.86}\ (ST+8)^{-.54}\ (13\text{-}BDF)^{-.27}\ IA^{.05}\ RQ_{500}^{.63}$

Where:

Where:	UQ_T =	Urban T-year Peak Discharge (cubic feet/second)
	A =	Drainage Area (square miles)
	SL =	Main Channel Slope (feet/mile)
	RI_2 =	Rainfall for the 2-hour, 2-year recurrence interval (inches)
	ST =	Basin Storage (percent)
	BDF =	Basin Development Factor
	IA =	Impervious Surfaces (percent)
	RQ_T =	Peak Discharges for an equivalent rural drainage basin in the same hydrologic area as the urban basin for a recurrence interval of T years (cubic feet/second)

For streams studied by approximate methods, where ever the % urban was more than 20, the 3-parameter Urban Regression equations listed below were used to correct the discharges obtained by Pennsylvania Regression Equations.

$UQ_2 = 13.2\ A^{.21}\ (13\text{-}BDF)^{-.43}\ RQ_2^{.73}$
$UQ_5 = 10.6\ A^{.17}\ (13\text{-}BDF)^{-.39}\ RQ_5^{.78}$
$UQ_{10} = 9.51\ A^{.16}\ (13\text{-}BDF)^{-.36}\ RQ_{10}^{.79}$
$UQ_{25} = 8.68\ A^{.15}\ (13\text{-}BDF)^{-.34}\ RQ_{25}^{.80}$
$UQ_{50} = 8.04\ A^{.15}\ (13\text{-}BDF)^{-.32}\ RQ_{50}^{.81}$
$UQ_{100} = 7.70\ A^{.15}\ (13\text{-}BDF)^{-.32}\ RQ_{100}^{.82}$

For the Delaware River, the USGS developed flood magnitude and frequency values, including 10-, 2-, 1-, and 0.2-percent annual chance floods, for eight active USGS streamflow gaging stations on the main stem of the Delaware River. The eight active gages include stations from Trenton, NJ to Callicoon, NY (Reference 32). This data was developed in collaboration with USACE Philadelphia District, New Jersey Department of Environmental Protection (NJDEP), FEMA Regions II and III, and the Delaware Basin Commission (DRBC). The hydrologic analysis was performed in accordance with guidelines published by the Interagency Advisory Committee on Water Data in its Bulletin 17B. This involved the analysis of peak-flow gage data records utilizing the PEAKFQ program. Five additional flow locations were established between USGS gaging stations to provide better flow distribution along the main stem. These flow locations are placed in the vicinity of tributaries with significant drainage area contribution. The discharges, including 10-, 2-, 1-, and 0.2-percent annual chance floods, were estimated per linear-interpolation of a discharge-frequency relationship as a function of drainage area for the eight active USGS gaging stations.

A summary of the drainage area-peak discharge relationships for all the streams studied by detailed methods is shown in Table 3, "Summary of Discharges."

TABLE 3 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs)			
		10-PERCENT ANNUAL CHANCE	2-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE
BLACK RIVER					
At confluence with Saucon Creek	4.5	950	2,100	2,800	5,000
At limit of detailed study	0.7	270	540	700	1,150
BUSHKILL CREEK REACH 1					
At confluence with Delaware River	80.0	5,070	8,100	9,600	23,000
At Township of Forks downstream corporate limits	75.0	5,000	8,300	9,700	23,000
At Borough of Tatamy downstream corporate limits	51.0	3,690	6,150	7,200	17,000
At Township of Forks upstream corporate limits	48.8	3,690	6,150	7,200	17,000
At confluence of Little Bushkill Creek	29.8	2,620	4,375	5,100	11,250
BUSHKILL CREEK REACH 3					
At Aluta Mill Road bridge	13.2	*	*	2,870	*
Upstream of Bushkill Center Road	10.4	*	*	2,460	*
At State Route 512	7.73	*	*	1,980	*

*Data not available

TABLE 3 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT ANNUAL CHANCE	2-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE
CATASAUQUA CREEK					
At Borough of North Catasauqua southern corporate limits	8.89	1,300	2,900	4,000	7,800
DELAWARE RIVER					
At USGS Gage 01446500 at Belvidere, New Jersey	4,535	145,000	215,000	248,000	334,000
Upstream of confluence of Lehigh River	4,636	146,239	216,465	249,465	335.352
Downstream of confluence of Lehigh River	6,084	164,006	237,462	270,462	354,734
At USGS Gage 01457500 at Riegelsville, New Jersey	6,328	167,000	241,000	274,000	358,000
Downstream of confluence of Tohickon Creek (NJ)	6,588	168,150	243,301	277,451	366,053
At USGS Gage 01463500 at Trenton, New Jersey	6,780	169,000	245,000	280,000	372,000
EAST BRANCH MONOCACY CREEK					
At its confluence with Monocacy Creek	15.7	*	*	2,800	*
Above confluence of Unnamed Tributary to East Branch Monocacy Creek	7.1	*	*	1,830	*
At Township of Lower Nazareth upstream corporate limits	6.8	*	*	1,770	*
HOKENDAUQUA CREEK REACH 1					
At the confluence with the Lehigh River	41.1	3,550	7,070	9,150	15,800

*Data not available

TABLE 3 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT ANNUAL CHANCE	2-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE
HOKENDAUQUA CREEK REACH 2					
At a point approximately 19,750 feet above the Township of Allen-Borough of Northampton corporate limits	38.1	3,350	6,700	8,700	15,000
At the confluence of Indian Creek	21.4	2,600	4,600	5,650	11,000
HOKENDAUQUA CREEK REACH 3					
State Route 248	14.30	2,500	3,800	4,300	5,900
West Walker Road	12.10	2,040	3,110	3,520	4,820
JACOBY CREEK					
At the confluence with the Delaware River	6.3	870	1,550	1,900	3,030
LEHIGH RIVER					
At Glendon tide gage	1,359	40	60	69	98
At Bethlehem tide gage	1,279	39	59	69	98
At Allentown tide gage	1,033	35	55	66	98
At Walnutport tide gage	889	32	53	64	98
At Lehighton tide gage	591	26	42	51	78
At Tannery tide gage	322	9	9	9	14
LITTLE BUSHKILL CREEK					
Private Road No. 1	16.2	1,500	2,520	3,020	4,400
Township Road No. 619	15.6	1,460	2,440	2,930	4,300
Township Road No. 623	13.5	1,300	2,190	2,630	3,800
State Route 191	12.6	1,230	2,080	2,500	3,600
MARTINS CREEK REACH 2					
At State Route 165 bridge, 1.0 mile south of Flicksville	21.8	*	*	5,970	*
At Flicksville corporate limits	20.9	*	*	5,770	*
At downstream Bangor corporate limits	19.0	*	*	5,350	*

*Data not available

TABLE 3 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT ANNUAL CHANCE	2-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE
MARTINS CREEK REACH 2 (continued)					
At upstream Bangor corporate limits	13.0	*	*	4,050	*
At the Township of Upper Mount Bethel downstream corporate limits	10.4	1,470	3,150	4,210	7,850
MONOCACY CREEK REACH 1					
At West Lehigh Street	50.0	1,350	2,800	3,750	7,000
At southern corporate limits	37.1	1,150	2,400	3,200	5,900
At State Route 22	35.7	1,050	2,170	2,920	5,570
MONOCACY CREEK REACH 2					
At Borough of Bath downstream corporate limits	7.65	*	*	1,900	*
At Borough of Bath upstream corporate limits	3.82	*	*	1,150	*
NANCY RUN					
At confluence with Lehigh River	6.14	3,605	4,019	4,291	4,547
Approx. 0.4 miles upstream of confluence with Lehigh River	5.84	3,486	3,885	4,146	4,394
At downstream corporate limits of Township of Bethlehem	5.49	3,273	3,647	3,890	4,119
Downstream of Walnut Street	4.79	2,780	3,113	3,316	3,520
Downstream of Willow Park Road	2.92	1,825	2,058	2,183	2,324
Approx. 0.22 miles upstream of 5th Street	2.48	1,613	1,827	1,935	2,066
Upstream of confluence of Tributary	1.40	1,022	1,153	1,216	1,297
Downstream of Farmersville Road	1.28	953	1,076	1,134	1,210
SAUCON CREEK					
At confluence with Lehigh River	57.9	4,620	8,620	10,910	17,990
At cross section A	56.5	4,540	8,480	10,740	17,730
Downstream of East Branch Saucon Creek	56.0	4,510	8,430	10,680	17,640

*Data not available

TABLE 3 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT ANNUAL CHANCE	2-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE
SAUCON CREEK (continued)					
Upstream of East Branch Saucon Creek	45.7	3,890	7,370	9,370	15,630
Downstream of Silver Creek (Friendensville Road)	38.0	3,400	6,520	8,320	14,010
Upstream of Silver Creek (Friendensville Road)	35.1	3,210	6,180	7,910	13,370
Downstream of South Branch Saucon Creek	26.6	2,630	5,140	6,620	11,340
Upstream of South Branch Saucon Creek	16.1	1,820	3,680	4,800	8,420
Lower Milford Township boundary	3.9	640	1,420	1,920	3,600
SHEET FLOW AREA					
Northeast of the Borough of Pen Argyl	0.63	*	*	897	*
SHOENECK CREEK					
At its confluence with Bushkill Creek	6.7	*	*	1,445	*
SILVER CREEK					
At Borough of Hellertown downstream corporate limits	2.7	600	1,300	1,700	2,900
UNNAMED TRIBUTARY TO EAST BRANCH MONOCACY CREEK					
At its confluence with East Branch Monocacy Creek	6.3	*	*	1,680	*
UNNAMED TRIBUTARY TO MARTINS CREEK REACH 2					
Upstream of Bangor corporate limits	0.85	*	*	560	*

*Data not available

TABLE 3 - SUMMARY OF DISCHARGES - continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-PERCENT ANNUAL CHANCE	2-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE
UNNAMED TRIBUTARY TO WALTZ CREEK					
At Village of Ackermanville	0.79	*	*	520	*
WALTZ CREEK					
Above confluence of unnamed tributary at Village of Ackermanville	7.6	*	*	2,700	*
300 feet downstream of Legislative Route 48036	3.2	419	740	902	1,370
At Township of Plainfield upstream corporate limits	2.4	343	610	745	1,130
WEST BRANCH LITTLE BUSHKILL CREEK					
Upstream of State Route 512	2.5	350	620	760	1,200

*Data not available

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the source studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data tables in the FIS report. For construction and/or floodplain management purposes, users are encouraged to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross-section locations are also shown on the FIRM (Exhibit 2).

Flood profiles were drawn showing computed water-surface elevations for floods of the selected recurrence intervals.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Precountywide FIS

Each flood-prone community within Northampton County, except the Boroughs of Chapman, East Bangor, Nazareth, Pen Argyl, and Roseto, the Townships of East Allen and Upper Nazareth, and the City of Bethlehem, has a previously printed FIS report. The hydraulic analyses described in those reports have been compiled and are summarized below.

Cross sections for the backwater analyses of streams studied in detail were obtained from aerial photographs with a scale of 1"=1,000' taken in 1974 and 1978, or obtained by field measurement (References 33 and 34). For certain unnamed tributaries, Black River, and East Branch, cross sections were determined from USGS 7.5-Minute Series Quadrangle Maps (Reference 35). All bridges and culverts were surveyed to obtain elevation data and structural geometry in order to compute significant backwater effects of these structures. Cross sections were located above and below bridges, at control locations along the stream lengths, and at significant changes in ground relief, land use, or land cover. All structural data for Little Bushkill Creek in the Township of Plainfield were obtained from the USACE (References 36 and 37).

Water-surface elevations of floods of the selected recurrence intervals were computed using the USACE HEC-2 step-backwater computer program, or using normal depth calculations for the 1-percent-annual-chance recurrence interval, which was estimated from the regional relationship between drainage area and flood depth as prepared by the USACE (References 38 and 39). That relationship was developed by means of regional regression analyses of basin areas and 1-percent-annual-chance within-channel depths observed at stream gages. Depths were adjusted on the basis of hydraulic calculations to account for increased depth due to backwater from hydraulic structures such as bridges and culverts (References 40 and 41). Water-surface elevations of the selected recurrence intervals for portions of Bushkill, Waltz, and Martins Creeks were computed by modeling channel and bridge hydraulics with the WSPRO step-backwater computer program (References 42 and 43). The water-surface elevations for these recurrence intervals for some streams were developed using the USGS E341 step-backwater computer program (Reference 44). Manual computations were made to determine water-surface elevations at dams on Bushkill Creek.

For the portion of Martins Creek in the Borough of Bangor, the HEC-2 model was adjusted until the water-surface profiles matched the high water marks observed by residents during the August 1967 flood. Contraction and expansion coefficients of 0.1 and 0.3 were used for normal channel conditions, and 0.3 and 0.5, respectively, were used at the approaches to structures where cross sectional changes were more abrupt. Starting water-surface elevations for the selected discharges were developed by performing hydraulic cross-section analyses to match high water marks. All elevations used in the hydraulic analyses were established by the U.S. Coast & Geodetic Survey in 1932, with supplementary adjustments in 1943 and 1967, measured from mean sea level.

Starting water-surface elevations for Hokendauqua Creek, Little Bushkill Creek, Jacoby Creek, Martins Creek, and Nancy Run were calculated using the slope/area method. Starting water-surface elevations for portions of Bushkill Creek were determined with the USACE HEC-2 step-backwater computer program at the confluence with the Delaware River by initially assuming that the peak fluvial discharge, for each return period, would occur coincident with a bankfull stage on the Delaware River. The backwater effect from the Delaware River was determined by assuming that a 1-percent-annual-chance stage would occur simultaneously on the Delaware River with a 10-year flood on Bushkill Creek. Both sets of profiles were plotted and the condition that is potentially more dangerous was taken as the water-surface elevation at any particular location (Reference 45). Starting water-surface elevations for other portions of Bushkill Creek were calculated based on normal-depth determinations. Starting water-surface elevations for Waltz Creek were calculated using the critical depth method.

Starting water-surface elevations for Monocacy Creek in the City of Bethlehem were based on calculated flood elevations for the Lehigh River at the mouth of the Monocacy Creek. Starting water-surface elevations for Black River and Silver Creek, tributaries to Saucon Creek, were obtained from backwater computations of Saucon Creek; starting water-surface elevations for Catasauqua Creek were taken from backwater computations of the Lehigh River.

For most streams studied by approximate methods, the 1-percent-annual-chance flood elevations were determined by field inspection of the area, engineering judgement, and examination of available topographic mapping. The effects of bridges, culverts, and other structures on the flood elevations were considered. Approximate flood boundaries were then interpolated between each location. The 1-percent-annual-chance flood elevation of that portion of Monocacy Creek studied by approximate methods was defined at selected cross sections using Manning's equation. For the approximate studies of Little Bushkill Creek upstream of Route 191 and the West Branch of Little Bushkill Creek, the 1-percent-annual-chance flood elevations were obtained from the USACE Flood Plain Information Report for Little Bushkill Creek and Shoeneck Creek (Reference 26).

The 1-percent-annual-chance flood elevations of Tributary D of Monocacy Creek, Tributary C of Nancy Run, Tributaries A and B of the Lehigh River, Tributary No. 1 to Little Bushkill Creek, Mud Run, and Tributary No. 1 to Mud Run were obtained by the Stage Index Slope Method (Reference 46). This is basically an empirical relationship used to extrapolate the stages of a flood with a return period greater than 25 years. In order to use this method, it was necessary to estimate the 10- and 25-year flood stages. This was accomplished by utilizing a flood-depth frequency method for New Jersey (Reference 47). The selection of the New Jersey method was made because no similar technique was available for Pennsylvania. The method was considered to be valid since the study region and the non-coastal region of New Jersey have similar precipitation and basin characteristics. In the City of Bethlehem, 1-percent-annual-chance flood elevations of the unnamed tributaries, the Black River, and East Branch were approximated using the Nordep computer program, which calculated water depth and water-surface elevations using data obtained from USGS Quadrangle Sheets (References 35 and 48).

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Information on the methods used to determine water-surface elevation data for the Delaware River, the Lehigh River, and Saucon Creek restudied as part of this countywide study is shown below.

Cross sections for the Delaware River were obtained from a Digital Terrain Model (DTM), that was developed from aerial photography flown in April 1994 (References 49, 50, and 51). The below-water portion of this DTM was developed from recent channel surveys and existing HEC-2 models using CHANNEL, an ARC/INFO software application (References 52, 30, and 53). When appropriate, bridge geometries were taken from existing HEC-2 models. New or recently renovated or altered structures were modeled using as-built drawings provided by the Delaware River Joint Toll Bridge Commission.

Cross sections for the lower portion of the Lehigh River and Saucon Creek were obtained from a DTM that was developed from aerial photography flown in April 1996 (References 54, 55, and 51). Cross sections for the upper portion of the Lehigh River (within Carbon County) were obtained from a DTM that was developed for Carbon County from aerial photography flown in April 1990 (References 51, 56, and 57). The below-water portion of these DTMs for the Lehigh River was developed from existing HEC-2 models using CHANNEL, an ARC/INFO software application (References 28 and 53). Bridge geometry was obtained from existing HEC-2 models, new bridge surveys, and as-built drawings provided by the Pennsylvania Department of Transportation.

Water-surface elevations for the selected recurrence intervals were computed using the USACE HEC-2 standard step-backwater program (Reference 38). The HEC-2 hydraulic models of the Delaware River were calibrated against available gage information. The final profiles all match gage rating curves within acceptable tolerances. Comparisons were made with high water marks collected during the flood of 1955, the flood of record for the Delaware River. These marks were also modeled within acceptable limits.

Water-surface elevations for the selected recurrence intervals were computed using the USACE HEC-RAS (River Analysis System) program (Reference 58). The HEC-RAS hydraulic models for the Lehigh River were calibrated against available gage information. The final profiles all match gage rating curves within acceptable tolerances. Comparisons were made with high water marks collected during the flood of 1955, the flood of record for the Lehigh River. These marks were also modeled within acceptable limits.

Starting water-surface elevations for the Delaware River were set at the one-year tide as obtained from the Philadelphia Tide Gage. Starting water-surface elevations for the Lehigh River were calculated using modified gage data and surveyed cross sections. Starting water-surface elevations for normal-fall profiles on the Lehigh River were determined by weir computations for the dam at its mouth. Manual computations were made to determine water-surface elevations at the dams.

This Revision

New hydraulic modeling was conducted for Nancy Run, superseding previous analyses. HEC-RAS Version 4.0 was used for the hydraulic analysis. GeoRAS Version 4.2.93 for ArcGIS 9.3 was used to generate the required geometry file from the terrain. A RAMPP in-house toolset was used to generate the 3-D elevations from the Terrain and to snap the channel geometry from field-surveyed cross sections for streams studied by detailed methods. Check-RAS version 1.4 was used to verify the model (Reference 59).

For the Delaware River, cross sections were obtained from two-foot contour data developed from LiDAR data collected in the spring of 2008 with two-foot contour accuracy. Below-water sections were obtained by field surveys. All bridges, wing dams, and miscellaneous structures were field surveyed to obtain elevation data and structural geometry. As-built drawings provided by Delaware River Joint Toll Bridge Commission were utilized to supplement survey data where needed. Water-surface elevations for the selected recurrence intervals were computed through use of the USACE HEC-RAS 4.0 step-backwater computer program (Reference 59). The HEC-RAS model was calibrated to the recorded high water mark elevations from the flood event of April 2005 (Reference 60). The Manning's "n" values were adjusted within reasonable parameters so that the computed water surface elevations generally matched the recorded high water marks. Comparisons were made with high water mark elevations collected for floods of August 1955 and June 2006. The results were within acceptable limits. The Delaware River remains under tidal influence downstream from its mouth to approximately 600 feet downstream of U.S. Route 1 in the Borough of Morrisville, Pennsylvania (the corresponding community on the New Jersey side of the river is City of Trenton). Starting water-surface elevations were set per tidal conditions established in Bucks County, Pennsylvania FIS (Reference 61) and per NJDEP Delineation of Floodway & Flood Hazard Area Maps for the City of Trenton (Reference 62).

For all streams studied by approximate methods, water surface profiles were computed using HEC-RAS steady state simulation. HEC-RAS applies a peak discharge at each cross section to determine a maximum water surface elevation. The elevations are calculated using the standard step method and the energy, continuity, and Manning equations. A subcritical flow regime was assumed for all reaches. Manning's n-values were derived based on land use data obtained from Pennsylvania Spatial Data Access (PASDA).

Roughness coefficients (Manning's "n") used in the hydraulic computations were chosen based on field inspection. Table 4, "Manning' "n" Values," provides a listing of roughness coefficients used in the models.

TABLE 4 - MANNING'S "N" VALUES

Stream	Channel "n"	Overbank "n"
Black River	0.025-0.035	0.050-0.090
Bushkill Creek	0.030-0.075	0.040-0.125
Catasauqua Creek	0.035	0.040-0.050
Delaware River	0.020-0.100	0.035-0.100
East Branch Monocacy Creek	0.036-0.048	0.036-0.048
Hokendauqua Creek	0.030-0.045	0.020-0.090
Jacoby Creek	0.025-0.045	0.060-0.120
Lehigh River	0.025-0.050	0.035-0.120
Little Bushkill Creek	0.040-0.045	0.040-0.080
Little Martins Creek	0.040-0.045	0.040-0.080
Martins Creek	0.032-0.045	0.035-0.120
Monocacy Creek	0.025-0.070	0.035-0.180
Nancy Run	0.035-0.062	0.045-0.070
Saucon Creek	0.030-0.040	0.050-0.100
Shoeneck Creek	*	*
Silver Creek	0.025-0.035	0.050-0.150
Unnamed Tributary to East Branch Monocacy Creek	0.036-0.048	0.036-0.048
Unnamed Tributary to Martins Creek	0.032-0.038	0.035-0.100
Unnamed Tributary to Waltz Creek	0.032-0.038	0.035-0.100
Waltz Creek	0.026-0.045	0.040-0.080
West Branch Little Bushkill Creek	0.030-0.045	0.040-0.100

*Data not available

Qualifying bench marks within a given jurisdiction are cataloged by the National Geodetic Survey (NGS) and entered into the National Spatial Reference System (NSRS). First or Second Order Vertical bench marks that have a vertical stability classification of A, B, or C are shown and labeled on the FIRM with their 6-character NSRS Permanent Identifier.

Bench marks cataloged by the NGS and entered into the NSRS vary widely in vertical stability classification. NSRS vertical stability classifications are as follows:

Stability A: Monuments of the most reliable nature, expected to hold position/elevation well (e.g., mounted in bedrock)

Stability B: Monuments which generally hold their position/elevation well (e.g., concrete bridge abutments)

Stability C: Monuments which may be affected by surface ground movements (e.g., concrete mounted below frost line)

Stability D: Mark of questionable or unknown vertical stability (e.g., concrete monument above frost line, or steel witness post)

In addition to NSRS bench marks, the FIRM may also show vertical control monument established by a local jurisdiction; these monuments will be shown on the FIRM with the appropriate designations. Local monuments will only be placed on the FIRM if the community has requested that they be included, and if the monuments meet the aforementioned NSRS inclusion criteria.

To obtain current elevation, description, and/or location information for bench marks shown on the FIRM for this jurisdiction, please contact the Information Services Branch of the NGS at (301) 713-3242, or visit their Web site, www.ngs.noaa.gov.

It is important to note that temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purposes of establishing local vertical control. Although these monuments are not shown on the digital FIRM, they may be found in the Technical Support Data Notebook associated with this FIS and FIRM. Interested individuals may contact FEMA to access this data.

3.3 Vertical Datum

All FISs and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum in use for newly created or revised FISs and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD 29). With the finalization of the North American Vertical Datum (NAVD 88), many FIS reports and FIRMs are being prepared using NAVD 88 as the referenced vertical datum.

All flood elevations shown in the FIS report and on the FIRM are referenced to NAVD88. Structure and ground elevations in the community must, therefore, be referenced to NAVD 88. It is important to note that adjacent communities may be referenced to NGVD 29. This may result in differences in base flood elevations across corporate limits between the communities.

As noted above, the elevations shown in the FIS report and on the FIRM for Northampton County are referenced to NAVD 88. Ground, structure, and flood elevations may be compared and/or referenced to NGVD 29 by applying a standard conversion factor. The conversion factor from NGVD 29 to NAVD 88 for Northampton County is -0.679 foot. The locations used to establish the conversion factor were USGS 7.5-minute topographic quadrangle corners that fell within the County, as well as those that were within 2.5 miles outside the County. The bench marks are referenced to NAVD 88.

All elevations from the original FISs were referenced to NGVD29, but were converted to NAVD88 for this revised countywide FIS using a conversion factor of -0.679 feet.

$$\text{NGVD29} - 0.679 \text{ ft} = \text{NAVD88}$$

The BFEs shown on the FIRM represent whole-foot rounded values. For example, a BFE of 102.4 will appear as 102 on the FIRM and 102.6 will appear as 103. Therefore, users that wish to convert the elevations in this FIS to NGVD 29 should apply the conversion factor (+0.679 foot) to elevations shown on the Flood Profiles and supporting data tables in this FIS report, which are shown at a minimum to the nearest 0.1 foot.

For more information on NAVD 88, see *Converting the National Flood Insurance Program to the North American Vertical Datum of 1988* (Reference 34) or contact the Spatial Reference System Division, National Geodetic Survey, National Oceanic and Atmospheric Administration, Silver Spring Metro Center 3, 1315 East-West Highway, Silver Spring, Maryland 20910-3282, (301) 713-3242, or visit their web site at www.ngs.noaa.gov.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. To assist in this endeavor, each FIS provides 1–percent-annual-chance floodplain data, which may include a combination of the following: 10-, 2-, 1-, and 0.2-percent-annual-chance flood elevations; delineations of the 1- and 0.2–percent-annual-chance floodplains; and the 1–percent-annual-chance floodway. This information is presented on the FIRM and in many components of the FIS, including Flood Profiles, and Floodway Data tables. Users should reference the data presented in the FIS as well as additional information that may be available at the local Community Map Repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent-annual-chance flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance flood is employed to indicate additional areas of flood risk in the community. For the streams studied in detail, the 1- and 0.2-percent-annual-chance floodplain boundaries have been delineated using the flood elevations determined at each cross section.

LiDAR technology was used as the terrain data source for restudied streams, and for redelineation of unrevised detailed and approximate floodplains in this study. This hi-resolution terrain data allows for more accuracy in floodplain mapping. The data was collected under the PAMAP program for several counties in Pennsylvania in Spring 2008.

The 1- and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM (Exhibit 2). On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A and AE, AH, AO, A99, V, and VE), and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of moderate flood hazards. In cases where the 1- and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-percent-annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevation but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM.

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent-annual-chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 1-percent-annual-chance flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this FIS are presented to local agencies as a minimum standard that can be adopted directly or that can be used as a basis for additional floodway studies.

Encroachment into areas subject to inundation by floodwaters having hazardous velocities aggravates the risk of flood damage, and heightens potential flood hazards by further increasing velocities. A listing of stream velocities at selected cross sections is provided in Table 5, “Floodway Data.” To reduce the risk of property damage in areas where the stream velocities are high, the community may wish to restrict development in areas outside the floodway.

The floodways presented in this study were computed for certain stream segments on the basis of equal conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (Table 5, “Floodway Data”). The computed floodway is shown on the FIRM (Exhibit 2). In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary is shown.

Near the mouths of streams studied in detail, floodway computations are made without regard to flood elevations on the receiving water body. Therefore, "Without Floodway" elevations presented in Table 5 for certain downstream cross sections of Bushkill Creek Reach 1, Hokendauqua Creek Reach 1, Jacoby Creek, Lehigh River, Martins Creek Reach 1, Monocacy Creek Reach 1, Saucon Creek, and Silver Creek, are lower than the regulatory flood elevations in that area, which must take into account the 1-percent-annual-chance flooding due to backwater from other sources.

Portions of the floodways for the Delaware River, Lehigh River, and Monocacy Creek extend beyond the county boundary.

No floodway was computed for the following streams: Bushkill Creek Reach 2, Bushkill Creek Reach 3, East Branch Monocacy Creek, Monocacy Creek Reach 2, Unnamed Tributary to East Branch Monocacy Creek, Unnamed Tributary to Martins Creek Reach 1, and Unnamed Tributary to Waltz Creek.

The study of the Delaware River performed for counties in New Jersey was incorporated. As a requirement of the New Jersey Department of Environmental Protection, floodway based on 0.2 foot encroachment was computed for Delaware River. In addition to the standard floodway data, information on the 0.2 ft encroachment floodway is presented in Table 5, “Floodway Data”, in the form of “Width within county (0.2 ft encroachment)”. Should any community decide to adopt a more stringent regulation standard, the boundary of the 0.2 ft encroachment floodway can be determined at each cross section by measuring from the county boundary along the cross section on the FIRM. Please note that there are “holes” in the floodway at some locations. While the 1.0-ft encroachment width listed in Table 5 does not include the “holes”, for the 0.2-ft encroachment floodway, the width is computed with the “holes” filled, so that the outmost boundary of the 0.2-ft encroachment floodway can be determined for regulation purposes. Cross sections that go through “holes” in the 0.2-ft encroachment floodway are marked out by a footnote in Table 5. Digital files showing the 0.2 ft encroachment floodway can be obtained through FEMA.

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Black River								
A	310[1]	330	940	2.4	302.6	302.6	302.6	0.0
B	1,750[1]	110	310	7.4	310.4	310.4	310.5	0.1
C	4,430[1]	110	300	6.0	333.4	333.4	333.9	0.5
D	7,000[1]	120	270	6.6	352.8	352.8	352.9	0.1
E	9,060[1]	130	290	6.2	380.1	380.1	380.1	0.0
F	10,870[1]	250	680	1.7	405.2	405.2	405.2	0.0
G	13,590[1]	100	200	6.2	484.9	484.9	484.9	0.0
Bushkill Creek Reach 1								
A	220[2]	110	1,197	8.0	196.2	168.2[3]	168.2	0.0
B	751[2]	76	830	11.6	196.2	170.2[3]	170.2	0.0
C	1,345[2]	167	767	12.5	196.2	172.4[3]	172.5	0.1
D	1,584[2]	91	710	13.5	196.2	178.5[3]	178.6	0.1
E	1,950[2]	115	1,195	8.0	196.2	181.1[3]	181.3	0.2
F	2,600[2]	158	1,856	8.6	196.2	182.4[3]	182.6	0.2
G	2,745[2]	66	900	10.7	196.2	182.4[3]	182.6	0.2
H	3,745[2]	116	867	11.1	196.2	188.2[3]	188.5	0.3
I	4,910[2]	105	1,203	8.0	196.2	190.9[3]	191.0	0.1
J	5,180[2]	63	833	11.5	196.2	193.3[3]	193.8	0.5
K	6,390[2]	178	1,193	8.1	196.2	195.8[3]	196.0	0.2

[1]Feet above Friedensville Road
[2]Feet above confluence with Delaware River
[3]Elevation computed without consideration of backwater effects from Delaware River

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

BLACK RIVER – BUSHKILL CREEK REACH 1

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Bushkill Creek Reach 1 (continued)								
L	6,870[1]	129	1,123	8.6	198.3	198.3	198.4	0.1
M	9,065[1]	135	1,309	7.3	205.2	205.2	205.4	0.2
N	9,825[1]	145	1,572	6.1	209.9	209.9	210.0	0.1
O	11,430[1]	98	959	10.0	213.2	213.2	213.3	0.1
P	11,850[1]	78	989	9.7	214.7	214.7	214.8	0.1
Q	12,175[1]	73	865	11.1	215.7	215.7	215.8	0.1
R	12,455[1]	96	979	9.8	217.3	217.3	217.4	0.1
S	12,940[1]	169	1,040	9.2	226.5	226.5	226.6	0.1
T	13,720[1]	70	731	13.1	226.9	226.9	227.1	0.2
U	14,190[1]	79	885	10.8	231.2	231.2	231.2	0.0
V	17,355[1]	180	1,569	6.2	243.6	243.6	243.9	0.3
W	22,700[1]	160	1,462	6.3	256.4	256.4	257.1	0.7
X	27,180[1]	120	1,070	8.2	268.8	268.8	269.4	0.6
Y	29,430[1]	200	746	11.8	275.7	275.7	276.3	0.6
Z	31,550[1]	100	513	14.0	282.7	282.7	282.7	0.0
AA	35,180[1]	120	861	8.4	301.0	301.0	301.8	0.8
AB	43,348[1]	120	806	8.9	338.5	338.5	339.5	1.0
AC	44,827[1]	415	2,399	2.1	342.6	342.6	342.6	0.0
AD	49,843[1]	148	794	6.4	369.5	369.5	370.0	0.5
Catasauqua Creek								
A	0[2]	180/85[3]	1,430	2.8	302.2	302.2	303.2	1.0
B	1,570[2]	170	860	4.7	304.5	304.5	305.4	0.9
C	3,420[2]	140	510	7.9	313.5	313.5	314.2	0.7
D	4,950[2]	80	400	9.9	320.5	320.5	321.2	0.7

[1]Feet above confluence with Delaware River
[2]Feet above county boundary
[3]Width/width within county boundary

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

BUSHKILL CREEK REACH 1 – CATASAUQUA CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Delaware River								
A	928.49 / 175.85	686/357/441	27,169	10.1	164.6	164.6	165.6	1.0
B	930.02 / 176.14	591/281/327	20,395	13.4	164.8	164.8	165.7	0.9
C	931.50 / 176.42	980/454/523	31,427	8.7	167.4	167.4	168.4	1.0
D	933.03 / 176.71	567/307/314	25,684	10.7	167.7	167.7	168.6	0.9
E	934.67 / 177.02	1,300/998/1,023	36,821	7.4	169.3	169.3	170.3	1.0
F	936.04 / 177.28	991/794/794	31,618	8.7	169.8	169.8	170.7	0.9
G	937.46 / 177.55	677/324/480	25,717	10.7	170.2	170.2	171.1	0.9
H	938.89 / 177.82	648/371/520	23,003	11.9	170.8	170.8	171.6	0.8
I	940.47 / 178.12	760/313/510	25,999	10.5	172.3	172.3	173.2	0.9
J	942.06 / 178.42	974/231/310	31,388	8.7	173.8	173.8	174.6	0.8
K	943.54 / 178.70	753/374/446	25,674	10.7	174.2	174.2	175.0	0.8
L	944.96 / 178.97	699/387/467	26,936	10.2	175.2	175.2	176.0	0.8
M	946.49 / 179.26	1,071/885/969	31,877	8.6	176.4	176.4	177.2	0.8
N	948.02 / 179.55	1,011/394/469	33,619	8.2	177.3	177.3	178.1	0.8
O	949.45 / 179.82	728/382/450	24,726	11.1	177.5	177.5	178.2	0.8
P	950.98 / 180.11	633/316/416	24,163	11.3	178.4	178.4	179.1	0.7
Q	952.51 / 180.40	585/308/411	21,617	12.7	179.1	179.1	179.8	0.7
R	953.99 / 180.68	847/683/771	28,611	9.6	181.1	181.1	182.0	0.9
S	955.63 / 180.99	523/288/412	19,329	14.2	181.2	181.2	182.1	0.9
T	957.37 / 181.32	580/365/443	21,020	13.0	183.9	183.9	184.8	0.9
U	959.90 / 181.80	630/375/485	23,951	11.4	186.5	186.5	187.4	0.9
V	961.44 / 182.09	598/332/332	23,167	11.8	187.1	187.1	188.1	1.0
W	962.97 / 182.38	675/267/410	26,412	10.4	188.3	188.3	189.1	0.8
X	964.50 / 182.67	716/374/399	26,376	10.4	188.6	188.6	189.5	0.9
Y	966.45 / 183.04	776/448/457	26,670	10.1	189.3	189.3	190.2	0.9
Z	967.67 / 183.27	924/613/627	29,724	9.8	190.8	190.8	191.7	0.9

[1] Thousands of feet above mouth / Miles above mouth
[2] Total width / Width within county (1% annual chance encroachment) / Width within county (0.2% annual chance encroachment)

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

DELAWARE RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Delaware River (continued)								
AA	968.46 / 183.42	718 / 401 / 500	24,339	11.1	191.5	191.5	192.4	0.9
AB	969.46 / 183.61	489 / 255 / 331	20,965	12.9	194.3	194.3	195.3	1.0
AC	970.68 / 183.84	675 / 468 / 483	25,400	10.7	196.2	196.2	197.2	1.0
AD	972.00 / 184.09	687 / 462 / 472	25,289	9.9	196.9	196.9	197.8	0.9
AE	973.47 / 184.37	581 / 302 / 302	22,160	11.3	197.0	197.0	198.0	1.0
AF	974.95 / 184.65	527 / 276 / 305	22,197	11.2	197.5	197.5	198.5	1.0
AG	976.54 / 184.95	571 / 293 / 309	22,143	11.3	198.0	198.0	199.0	1.0
AH	977.96 / 185.22	679 / 344 / 355	25,468	9.8	199.1	199.1	200.0	0.9
AI	979.44 / 185.50	456 / 263 / 315	18,831	13.3	199.2	199.2	200.1	0.9
AJ	980.97 / 185.79	611 / 325 / 351	25,145	9.9	201.4	201.4	202.3	0.9
AK	982.45 / 186.07	651 / 339 / 414	24,430	10.2	202.1	202.1	203.0	0.9
AL	983.98 / 186.36	708 / 440 / 454	24,839	10.0	203.0	203.0	203.9	0.9
AM	985.46 / 186.64	678 / 422 / 663	24,836	10.0	203.9	203.9	204.7	0.8
AN	986.99 / 186.93	778 / 429 / 451	26,538	9.4	204.7	204.7	205.7	1.0
AO	988.47 / 187.21	822 / 441 / 451	28,010	8.9	205.6	205.6	206.5	0.9
AP	990.00 / 187.50	812 / 390 / 412	25,639	9.7	206.3	206.3	207.2	0.9
AQ	991.64 / 187.81	773 / 279 / 360	23,269	10.7	207.2	207.2	208.0	0.8
AR	992.96 / 188.06	517 / 269 / 269	18,422	13.5	207.7	207.7	208.5	0.8
AS	994.49 / 188.35	577 / 287 / 375	22,062	11.3	209.8	209.8	210.6	0.8
AT	996.02 / 188.64	548 / 286 / 438	22,072	11.3	210.7	210.7	211.6	0.9
AU	997.50 / 188.92	653 /351 / 435	22,021	11.3	211.7	211.7	212.5	0.8
AV	998.92 / 189.19	499 / 308 / 472	18,666	13.4	212.3	212.3	213.2	0.9
AW	1000.56 / 189.50	662 / 390 / 465	24,906	10.0	214.7	214.7	215.6	0.9
AX	1001.99 / 189.77	819 / 441 / 468	26,287	9.5	215.5	215.5	216.5	1.0
AY	1003.46 / 190.05	891 / 660 / 702	28,478	8.8	216.3	216.3	217.2	0.9
AZ	1004.94 / 190.33	711 / 325 / 484	22,637	11.0	216.3[3]	216.2	217.1	0.9

[1]Thousands of feet above mouth / Miles above mouth
[2]Total width / Width within county (1% annual chance encroachment) / Width within county (0.2% annual chance encroachment)
[3]Regulatory elevation of downstream cross section is applied at this cross section due to naturally occurring drawdown condition

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

DELAWARE RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Delaware River (continued)								
BA	1006.32 / 190.59	610 / 286 / 290	22,117	11.3	218.0	218.0	218.9	0.9
BB	1008.06 / 190.92	1,227 / 630 / 646	39,847	7.3	220.0	220.0	220.9	0.9
BC	1009.43 / 191.18	1,221 / 761 / 773	37,865	7.2	220.6	220.6	221.5	0.9
BD	1010.96 / 191.47	1,172 / 972 / 980	33,547	7.4	221.3	221.3	222.2	0.9
BE	1012.44 / 191.75	1,316 /1,136/1,136	35,767	7.0	222.2	222.2	223.0	0.8
BF	1013.81 / 192.01	681 / 360 / 364	21,030	11.9	222.3	222.3	223.0	0.7
BG	1015.56 / 192.34	666 / 341 / 414	21,459	11.6	224.1	224.1	224.8	0.7
BH	1016.93 / 192.60	688 / 394 / 540	23,823	10.5	225.8	225.8	226.4	0.6
BI	1018.46 / 192.89	847 / 332 / 419	26,548	9.4	227.2	227.2	227.8	0.6
BJ	1019.99 / 193.18	823 / 346 / 346	25,956	9.6	228.0	228.0	228.6	0.6
BK	1021.47 / 193.46	912 / 412 / 412	27,593	9.0	228.7	228.7	229.3	0.6
BL	1022.95 / 193.74	683 / 347 / 347	23,174	10.8	228.9	228.9	229.6	0.7
BM	1023.95 / 193.93	792 / 532 / 576	23,631	10.6	229.2	229.2	230.0	0.8
BN	1025.11 / 194.15	746 / 504 / 504	21,473	11.6	230.0	230.0	230.7	0.7
BO	1025.80 / 194.28	990 / 727 / 727	27,500	9.1	231.3	231.3	231.9	0.6
BP	1027.49 / 194.60	1,610/1,258/1,258	38,619	6.5	232.5	232.5	233.1	0.6
BQ	1028.91 / 194.87	572 / 283 / 283	17,753	14.1	232.5[3]	232.0	232.6	0.6
BR	1030.44 / 195.16	665 / 354 / 363	19,753	12.6	234.9	234.9	235.4	0.5
BS	1031.98 / 195.45	922 / 459 / 468	30,627	8.2	237.6	237.6	238.1	0.5
BT	1033.51 / 195.74	616 / 289 / 289	17,900	13.9	237.6[3]	237.3	237.9	0.6
BU	1034.99 / 196.02	455 / 199 / 199	11,628	21.4	238.4	238.4	239.0	0.6
BV	1036.41 / 196.29	727 / 361 / 361	22,791	11.0	247.1	247.1	247.4	0.3
BW	1038.00 / 196.59	787 / 326 / 326	20,199	12.4	248.4	248.4	248.8	0.4
BX	1039.47 / 196.87	713 / 300 / 317	19,021	13.1	250.1	250.1	250.5	0.4
BY	1040.95 / 197.15	788 / 448 / 911	18,910	13.2	252.4	252.4	252.7	0.3
BZ	1042.75 / 197.49	651 / 340 / 1,078	20,352	12.2	255.0	255.0	255.3	0.3

[1]Thousands of feet above mouth / Miles above mouth
[2]Total width / Width within county (1% annual chance encroachment) / Width within county (0.2% annual chance encroachment)
[3]Regulatory elevation of downstream cross section is applied at this cross section due to naturally occurring drawdown condition

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

DELAWARE RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Delaware River (continued)								
CA	1043.54 / 197.64	717 / 427 / 816	23,253	10.7	256.6	256.6	257.1	0.5
CB	1044.28 / 197.78	238 / 582 / 618	23,638	10.5	257.1	257.1	257.7	0.6
CC	1045.44 / 198.00	648 / 381 / 400	22,510	11.0	257.8	257.8	258.4	0.6
CD	1046.97 / 198.29	484 / 246 / 246	15,936	15.6	257.8[4]	257.7	258.3	0.6
CE	1048.45 / 198.57	533 / 255 / 255	16,377	15.1	259.1	259.1	259.7	0.6
CF	1049.98 / 198.86	514 / 239 / 239	14,490	17.1	259.2	259.2	259.8	0.6
CG	1051.56 / 199.16	604 / 317 / 317	16,662	14.9	261.4	261.4	291.9	0.5
CH	1052.99 / 199.43	743 / 386 / 398	19,123	13.0	263.6	263.6	264.1	0.5
CI	1054.47 / 199.71	838 / 346 / 346	24,478	10.1	266.6	266.6	267.1	0.5
CJ	1056.05 / 200.01	1,135 / 246 / 246	29,509	8.4	268.6	268.6	268.9	0.3
CK	1057.48 / 200.28	1,374 / 161 / 161	31,672	7.8	269.9	269.9	270.3	0.4
CL	1059.01 / 200.57	834 / 455 / 926	21,727	11.4	271.0	271.0	271.2	0.2
CM	1060.49 / 200.85	1,100 / 764 / 1,395	32,877	7.5	273.0	273.0	273.6	0.6
CN	1061.91 / 201.12	1,577/341/1,097[3]	35,378	7.0	273.9	273.9	274.5	0.6
CO	1063.50 / 201.42	2,084 / 271 / 271	51,807	4.8	274.9	274.9	275.6	0.7
CP	1064.98 / 201.70	2,127 / 170 / 170	47,811	5.2	275.4	275.4	276.0	0.6
CQ	1066.56 / 202.00	1,956 / 459 / 459	38,650	6.4	276.0	276.0	276.6	0.6
CR	1067.99 / 202.27	956 / 552 / 1,174	24,951	9.9	276.6	276.6	277.0	0.4
CS	1069.52 / 202.56	1,154/889/1,537	30,308	8.2	278.1	278.1	278.8	0.7
CT	1071.00 / 202.84	1,246/1,000/1,734	31,478	7.9	279.0	279.0	280.0	1.0
CU	1072.47 / 203.12	758 / 448 / 1,464	22,437	11.1	279.3	279.3	280.3	1.0
CV	1073.95 / 203.40	660/370/1,231[3]	22,184	11.2	280.2	280.2	281.2	1.0
CW	1075.43 / 203.68	723 / 381 / 622	24,292	10.2	281.3	281.3	282.3	1.0
CX	1077.01 / 203.98	960 / 289 / 299	27,212	9.1	282.2	282.2	283.3	1.1
CY	1078.49 / 204.26	976 / 259 / 259	26,302	9.5	282.8	282.8	283.8	1.0
CZ	1079.97 / 204.54	1,176 / 270 / 270	29,122	8.5	284.1	284.1	285.0	0.9

[1]Thousands of feet above mouth / Miles above mouth
[2]Total width / Width within county (1% annual chance encroachment) / Width within county (0.2% annual chance encroachment)
[3]Cross section goes through "holes" in the 0.2-ft encroachment floodway
[4]Regulatory elevation of downstream cross section is applied at this cross section due to naturally occurring drawdown condition

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

DELAWARE RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Delaware River (continued)								
DA	1081.45 / 204.82	1,416 / 268 / 268	32,845	7.6	285.3	285.3	286.2	0.9
DB	1082.66 / 205.05	1,038 / 447 / 447	27,130	9.1	285.8	285.8	286.5	0.7
DC	1084.20 / 205.34	532 / 278 / 292	19,343	12.8	286.4	286.4	287.2	0.8
DD	1085.94 / 205.67	511 / 290 / 290	18,741	13.2	287.5	287.5	288.4	0.9
DE	1087.47 / 205.96	558 / 337 / 345	19,036	13.0	288.9	288.9	289.7	0.8
DF	1088.95 / 206.24	746 / 382 / 382	22,695	10.9	291.0	291.0	291.6	0.6
DG	1090.48 / 206.53	663 / 349 / 393	22,038	11.3	291.9	291.9	292.5	0.6
DH	1091.96 / 206.81	735 / 367 / 367	21,301	11.6	292.9	292.9	293.5	0.6
DI	1092.91 / 206.99	701 / 379 / 568	20,004	12.4	293.5	293.5	294.1	0.6
DJ	1093.86 / 207.17	878 / 498 / 551	24,206	10.3	295.6	295.6	296.3	0.7
DK	1095.44 / 207.47	807 / 347 / 347	22,804	10.9	296.5	296.5	297.2	0.7
DL	1096.50 / 207.67	777 / 348 / 348	21,880	11.3	296.9	296.6	297.6	1.0
DM	1097.98 / 207.95	694 / 297 / 297	18,229	13.6	297.4	297.4	298.0	0.6
DN	1099.40 / 208.22	611 / 236 / 240	16,706	14.8	299.1	299.1	299.7	0.6
DO	1101.25 / 208.57	819 / 476 / 499	22,714	10.9	304.6	304.6	305.0	0.4
DP	1102.46 / 208.80	636 / 359 / 380	20,750	12.0	305.3	305.3	305.7	0.4
DQ	1104.00 / 209.09	547 / 361 / 443	15,745	15.8	305.8	305.8	306.1	0.3
DR	1105.37 / 209.35	594 / 296 / 296	18,296	13.6	308.5	308.5	309.0	0.5
DS	1107.00 / 209.66	739 / 267 / 267	23,343	10.6	311.1	311.1	311.5	0.4
DT	1108.48 / 209.94	612 / 319 / 319	19,607	12.7	311.6	311.6	312.1	0.5
DU	1110.01 / 210.23	872 / 184 / 221	24,705	10.0	313.9	313.9	314.3	0.4
DV	1111.49 / 210.51	923 / 310 / 314	27,678	9.0	315.1	315.1	315.5	0.4

[1]Thousands of feet above mouth / Miles above mouth
[2]Total width / Width within county (1% annual chance encroachment) / Width within county (0.2% annual chance encroachment)

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

DELAWARE RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Hokendauqua Creek Reach 1								
A	640[1]	115	976	9.4	291.4	288.2[2]	288.2	0.0
B	1,630[1]	194	924	9.9	291.4	291.0[2]	291.0	0.0
C	3,180[1]	294	1,061	8.6	298.5	298.5	298.5	0.0
D	4,520[1]	87	611	15.0	307.9	307.9	307.9	0.0
E	8,470[1]	163	1,279	7.0	321.4	321.4	321.7	0.3
F	9,590[1]	104	870	10.3	323.8	323.8	324.7	0.9
G	11,310[1]	188	836	10.7	328.3	328.3	328.3	0.0
Hokendauqua Creek Reach 2								
A	540[3]	234	1,986	4.4	347.9	347.9	348.7	0.8
B	2,340[3]	224	1,493	5.8	351.8	351.8	352.3	0.5
C	3,340[3]	260	1,250	7.0	354.3	354.3	355.0	0.7
D	4,390[3]	176	1,094	8.0	359.1	359.1	359.5	0.4
E	4,930[3]	315	1,645	5.3	361.2	361.2	362.1	0.9
F	5,660[3]	290	1,648	5.3	363.1	363.1	363.9	0.8
G	6,310[3]	98	1,054	8.3	367.2	367.2	367.5	0.3
H	7,090[3]	335	2,510	3.5	369.1	369.1	369.8	0.7
I	7,680[3]	370	1,238	7.0	369.8	369.8	370.2	0.4
J	8,120[3]	176	730	7.7	373.9	373.9	374.0	0.1
K	8,740[3]	187	1,017	5.6	377.8	377.8	378.7	0.9
L	9,560[3]	119	655	8.6	381.2	381.2	381.7	0.5
M	11,170[3]	350	1,465	3.9	390.3	390.3	390.6	0.3
N	11,276[3]	350	1,608	3.5	390.7	390.7	391.3	0.6
O	11,810[3]	142	637	8.9	392.1	392.1	392.1	0.0
P	12,890[3]	191	1,118	5.1	397.3	397.3	398.1	0.8

[1]Feet above confluence with Lehigh River
[2]Elevation computed without consideration of backwater effects from Lehigh River
[3]Feet above Limit of Detailed Study; LODS approximately 1,437 ft downstream of Legislative Route 48061

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

HOKENDAUQUA CREEK REACH 1 – HOKENDAUQUA CREEK REACH 2

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Hokendauqua Creek Reach 2 (continued)								
Q	13,880[1]	217	1,185	4.8	400.0	400.0	400.6	0.6
R	14,800[1]	254	1,467	3.9	402.0	402.0	403.0	1.0
S	15,840[1]	293	993	5.7	405.4	405.4	406.0	0.6
T	17,110[1]	192	987	5.7	411.6	411.6	412.2	0.6
U	17,810[1]	299	1,216	4.6	413.7	413.7	414.0	0.3
V	18,450[1]	280	1,102	5.1	414.8	414.8	415.5	0.7
W	18,940[1]	192	986	5.7	416.3	416.3	417.1	0.8
X	19,660[1]	144	688	8.2	419.2	419.2	419.7	0.5
Hokendauqua Creek Reach 3								
A	220[2]	140	725	5.9	491.6	491.6	492.6	1.0
B	500[2]	325	1,465	2.9	498.3	498.3	498.3	0.0
C	1,110[2]	254	1,578	2.7	498.9	498.9	499.0	0.1
D	2,160[2]	47	298	14.4	500.7	500.7	501.5	0.8
E	3,290[2]	401	1,727	2.4	508.3	508.3	509.3	1.0
F	4,350[2]	155	925	4.5	516.0	516.0	516.2	0.2
G	5,250[2]	121	490	8.5	524.2	524.2	524.7	0.5
H	6,030[2]	185	754	5.5	532.5	532.5	533.5	1.0
I	7,060[2]	90	437	9.5	545.6	545.6	546.2	0.6
J	7,400[2]	240	1,721	2.3	551.1	551.1	552.0	0.9
K	7,960[2]	159	950	4.1	551.6	551.6	552.5	0.9
L	9,250[2]	269	1,588	2.2	563.7	563.7	564.5	0.8
M	10,300[2]	51	269	13.1	569.3	569.3	570.1	0.8
N	11,620[2]	225	851	4.1	584.3	584.3	585.3	1.0

[1]Feet above Limit of Detailed Study; LODS approximately 1,437 ft downstream of Legislative Route 48061
[2]Feet above Limit of Detailed Study; LODS approximately 380 ft downstream of Pheasant Drive

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

HOKENDAUQUA CREEK REACH 2 – HOKENDAUQUA CREEK REACH 3

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Jacoby Creek								
A	416	53	319	6.0	295.6	287.1[2]	287.1	0.0
B	816	37	161	11.8	296.1	296.1	296.1	0.0
C	1,370	87	315	6.0	308.4	308.4	308.4	0.0
D	1,930	62	206	9.2	322.7	322.7	322.7	0.0
E	2,180	100	484	3.9	344.6	344.6	344.6	0.0
F	2,390	100	241	7.9	344.9	344.9	344.9	0.0
G	2,680	137	378	5.0	347.8	347.8	347.8	0.0
H	2,865	98	303	6.3	350.4	350.4	350.4	0.0
I	3,275	41	165	11.5	354.0	354.0	354.0	0.0
J	3,650	50	202	9.4	358.2	358.2	358.2	0.0
K	4,170	46	192	9.9	364.8	364.8	364.8	0.0
L	4,400	62	244	7.8	367.8	367.8	367.8	0.0
M	4,615	47	164	11.6	371.3	371.3	371.3	0.0

[1]Feet above confluence with Delaware River
[2]Elevation computed without consideration of backwater effects from Delaware River

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

JACOBY CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Lehigh River								
A	1,584	271	6,911	10.0	191.4	184.5[2]	185.2	0.7
B	2,746	327	9,064	7.6	191.4	186.3[2]	186.9	0.6
C	4,963	439	11,434	6.0	191.4	187.5[2]	188.2	0.7
D	6,125	319	7,757	8.9	191.4	187.7[2]	188.4	0.7
E	9,979	401	8,194	8.4	191.4	189.9[2]	190.7	0.8
F	11,722	493	7,928	8.7	191.4	190.4[2]	191.2	0.8
G	12,566	319	7,629	9.0	191.4	191.3[2]	192.2	0.9
H	12,778	336	7,109	9.7	191.4	191.4	192.2	0.8
I	13,728	377	6,917	10.0	192.0.	192.0	192.8	0.8
J	15,946	422	8,363	8.3	193.9	193.9	194.9	1.0
K	17,213	699	13,665	5.0	195.4	195.4	196.3	0.9
L	17,794	667	11,893	5.8	202.2	202.2	202.9	0.7
M	19,166	1,332	13,29	5.2	203.0	203.0	203.7	0.7
N	20,803	1,795	17,392	4.0	204.5	204.5	204.9	0.4
O	22,651	885	11,095	6.2	205.7	205.7	206.1	0.4
P	24,658	630	10,167	6.8	207.1	207.1	207.6	0.5
Q	25,450	488	10,630	6.5	207.7	207.7	208.2	0.5
R	27,298	825	11,797	5.8	208.7	208.7	209.2	0.5
S	30,254	602	10,303	6.7	209.8	209.8	210.2	0.4
T	34,109	467	9,465	7.3	211.6	211.6	212.3	0.7
U	35,429	477	8,360	8.3	212.0	212.0	212.6	0.6
V	37,435	584	9,717	7.1	213.4	213.4	214.1	0.7
W	40,973	418	9,214	7.5	215.7	215.7	216.5	0.8
X	43,877	355	6,211	11.1	216.3	216.3	217.2	0.9
Y	44,774	509	9,081	7.6	219.2	219.2	219.7	0.5
Z	46,611	849	13,140	5.3	221.3	221.3	221.9	0.6
AA	49,157	278	7,755	8.9	222.0	222.0	222.8	0.8
AB	51,322	392	7,668	9.0	223.1	223.1	224.1	1.0

[1]Feet above confluence with Delaware River
[2]Elevation computed without consideration of backwater effects from Delaware River

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

LEHIGH RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Lehigh River (continued)								
AC	54,542	385	8,634	8.0	225.5	225.5	226.4	0.9
AD	56,918	286	6,236	11.0	226.2	226.2	227.1	0.9
AE	58,450	292	6,224	11.0	227.9	227.9	228.8	0.9
AF	61,406	247	5,298	12.8	229.7	229.7	230.6	0.9
AG	62,832	322	7,393	9.2	232.3	232.3	233.2	0.9
AH	64,944	348	7,564	9.0	234.3	234.3	235.1	0.8
AI	66,634	449[2]	10,195	6.7	235.6	235.6	236.4	0.8
AJ	71,016	398[2]	8,107	8.4	237.6	237.6	238.4	0.8
AK	72,758	407[2]	8,169	8.3	239.1	239.1	239.8	0.7
AL	112,675	314[2]	5,101	13.0	281.3	281.3	282.0	0.7
AM	116,899	323[2]	6,754	9.8	287.1	287.1	287.9	0.8
AN	118,325	322[2]	6,117	10.8	288.2	288.2	289.2	1.0
AO	118,694	338[2]	7,603	8.6	291.0	291.0	291.8	0.8
AP	121,704	522[2]	8,142	8.1	293.0	293.0	293.9	0.9
AQ	124,396	346[2]	6,240	10.5	294.2	294.2	295.2	1.0
AR	125,453	323[2]	5,861	11.2	295.0	295.0	295.8	0.8
AS	127,459	440[2]	7,773	8.5	301.1	301.1	301.8	0.7
AT	131,314	419[2]	6,542	10.0	302.5	302.5	303.5	1.0
AU	134,165	397[2]	6,574	10.0	305.4	305.4	306.2	0.8
AV	136,752	565[2]	5,709	11.5	308.9	308.9	309.2	0.3
AW	140,290	377[2]	5,237	12.5	316.0	316.0	316.0	0.0
AX	144,830	287[2]	5,073	13.0	321.2	321.2	322.1	0.9
AY	148,474	249[2]	4,745	13.8	328.3	328.3	328.3	0.0
AZ	150,374	343[2]	7,020	9.4	332.2	332.2	333.1	0.9
BA	153,754	462[2]	7,956	8.3	340.5	340.5	341.2	0.7
BB	156,077	336[2]	5,831	11.3	342.1	342.1	343.0	0.9
BC	158,875	590[2]	12,715	5.2	345.4	345.4	346.2	0.8

[1]Feet above confluence with Delaware River
[2]Width extends beyond county boundary

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

LEHIGH RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Lehigh River (continued)								
BD	162,307	387	7,127	9.2	346.1	346.1	346.8	0.7
BE	164,525	384	6,867	9.6	348.5	348.5	349.2	0.7
BF	166,690	299	5,291	12.4	350.2	350.2	351.0	0.8
BG	169,171	215	4,781	13.7	353.0	353.0	354.0	1.0
BH	172,339	337	7,055	9.3	357.5	357.5	358.2	0.7
BI	174,926	425	6,901	9.5	359.7	359.7	360.7	1.0
BJ	177,778	381	5,537	11.6	363.7	363.7	364.6	0.9
BK	181,104	253	4,432	14.4	368.4	368.4	368.9	0.5
BL	183,533	346	5,774	11.1	375.0	375.0	376.0	1.0
BM	185,539	700	9,171	7.0	379.9	379.9	380.8	0.9
BN	188,232	381	4,749	13.5	382.8	382.8	383.4	0.6
BO	189,816	389	7,375	8.7	387.0	387.0	387.6	0.6

[1]Miles above confluence with Delaware River
[2]Width extends beyond county boundary

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

LEHIGH RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Little Bushkill Creek								
A	693[1]	168	498	6.1	388.8	388.8	388.9	0.1
B	1,510[1]	77	452	6.7	392.6	392.6	393.3	0.7
C	2,393[1]	66	409	7.4	395.2	395.2	396.0	0.8
D	3,173[1]	90	541	5.6	398.2	398.2	399.1	0.9
E	3,723[1]	144	606	5.0	400.1	400.1	400.9	0.8
F	5,093[1]	109	597	5.1	404.2	404.2	405.0	0.8
G	5,870[1]	157	517	5.7	406.3	406.3	407.0	0.7
H	6,832[1]	95	437	6.7	411.1	411.1	412.0	0.9
I	7,652[1]	66	381	7.7	415.7	415.7	416.5	0.8
J	9,132[1]	126	546	5.4	422.6	422.6	423.5	0.9
K	9,802[1]	67	368	7.7	425.8	425.8	426.5	0.7
L	10,258[1]	48	303	8.7	428.6	428.6	429.2	0.6
M	10,716[1]	128	556	4.7	431.6	431.6	431.9	0.3
N	11,266[1]	49	283	9.3	433.1	433.1	434.0	0.9
O	12,981[1]	48	325	8.1	442.2	442.2	443.0	0.8
P	13,732[1]	142	669	3.9	448.1	448.1	448.6	0.5
Little Martins Creek								
A	121[2]	160	1,233	2.0	244.8	244.8	245.4	0.6
B	517[2]	73	381	6.4	244.9	244.9	245.2	0.3
C	1,278[2]	92	394	6.2	250.7	250.7	251.3	0.6
D	1,927[2]	46	217	11.1	257.4	257.4	257.4	0.0
E	2,471[2]	38	184	13.2	262.4	262.4	262.4	0.0
F	3,120[2]	68	348	7.0	270.8	270.8	270.9	0.1
G	3,907[2]	77	339	7.2	278.4	278.4	279.0	0.6

[1]Feet above Private Road No. 1
[2]Feet above confluence with Martins Creek Reach 1

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

LITTLE BUSHKILL CREEK – LITTLE MARTINS CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Martins Creek Reach 1								
A	438[1]	155	2,470	4.0	216.2	203.4[3]	204.4	1.0
B	1,278[1]	120	1,682	5.8	216.2	211.2[3]	211.2	0.0
C	2,223[1]	105	808	12.2	216.2	212.6[3]	213.5	0.9
D	2,793[1]	202	1,059	9.3	217.9	217.9	217.9	0.0
E	3,416[1]	190	1,384	7.1	221.6	221.6	221.7	0.1
F	4,235[1]	170	987	10.0	228.4	228.4	228.4	0.0
G	4,852[1]	155	887	11.1	233.0	233.0	233.5	0.5
H	5,217[1]	160	1,486	6.6	239.2	239.2	239.2	0.0
I	6,246[1]	120	907	10.8	242.2	242.2	242.8	0.6
J	7,767[1]	156	802	10.8	251.0	251.0	251.2	0.2
K	8,786[1]	122	836	10.3	261.0	261.0	261.4	0.4
L	9,884[1]	112	786	11.0	268.0	268.0	268.0	0.0
M	10,439[1]	130	802	10.8	271.6	271.6	271.6	0.0
N	10,898[1]	111	851	10.1	277.9	277.9	278.9	1.0
Martins Creek Reach 2								
A-H*								
I	11,448[2]	110	497	10.6	474.4	474.4	474.8	0.4
J	14,484[2]	100	797	5.2	513.5	513.5	514.2	0.7
K	14,886[2]	150	1,155	3.6	520.3	520.3	521.3	1.0
L	17,698[2]	80	395	10.6	553.9	553.9	554.1	0.2
M	22,446[2]	149	477	8.8	614.6	614.6	614.7	0.1
N	22,894[2]	78	358	11.7	621.2	621.2	621.2	0.0
O	23,364[2]	140	768	5.5	627.1	627.1	627.6	0.5

[1]Feet above confluence with Delaware River
[2]Feet above Limit of Detailed Study (Limit of Detailed Study is located approximately 100 feet below State Route 680)
[3]Elevation computed without consideration of backwater effects from Delaware River
*No floodway computed

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

MARTINS CREEK REACH 1 – MARTINS CREEK REACH 2

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Martins Creek Reach 2 (continued)								
P	23,824[1]	108	452	9.3	632.2	632.2	632.5	0.3
Q	24,422[1]	90	544	7.7	638.9	638.9	639.8	0.9
R	25,083[1]	148	455	9.2	645.8	645.8	645.8	0.0
S	25,742[1]	140	705	6.0	653.6	653.6	654.2	0.6
T	26,446[1]	120	607	6.9	660.1	660.1	660.5	0.4
U	27,182[1]	260	981	4.3	665.5	665.5	666.4	0.9
Monocacy Creek Reach 1								
A	2,480[2]	692	5,465	0.7	236.1	236.1	236.9	0.8
B	3,385[2]	403	2,451	1.5	236.3	236.3	237.0	0.7
C	4,080[2]	433	5,252	0.7	236.6	236.6	237.3	0.7
D	4,200[2]	377	3,509	1.1	236.7	236.7	237.4	0.7
E	4,570[2]	237	2,596	1.4	236.8	236.8	237.5	0.7
F	4,720[2]	179	2,323	1.6	237.1	237.1	237.5	0.4
G	5,670[2]	128	996	3.8	237.4	237.4	238.1	0.7
H	5,920[2]	225	1,238	3.0	237.7	237.7	238.4	0.7
I	6,180[2]	143	1,412	2.7	238.5	238.5	239.2	0.7
J	8,070[2]	184	1,023	3.7	240.5	240.5	241.2	0.7
K	8,510[2]	324	2,236	1.7	241.7	241.7	242.5	0.8
L	9,530[2]	61	752	4.7	243.1	243.1	243.8	0.7
M	12,365[2]	90	623	5.7	253.5	253.5	253.8	0.3
N	13,765[2]	83	593	6.0	255.5	255.5	255.8	0.3
O	13,950[2]	89	519	6.8	255.9	255.9	256.5	0.6
P	15,075[2]	85	506	7.0	259.2	259.2	259.2	0.0
Q	15,195[2]	89	326	10.9	263.6	263.6	263.6	0.0

[1]Feet above Limit of Detailed Study (Limit of Detailed Study is located approximately 100 feet below State Route 680)
[2]Feet above confluence with Lehigh River

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

MARTINS CREEK REACH 2 – MONOCACY CREEK REACH 1

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Monocacy Creek Reach 1 (continued)								
R	16,395	104	607	5.8	268.4	268.4	268.9	0.5
S	16,575	121	889	4.0	269.4	269.4	270.2	0.8
T	17,345	88	509	7.0	270.5	270.5	271.0	0.5
U	20,455	88	492	7.1	279.3	279.3	279.6	0.3
V	20,720	78	550	6.4	280.2	280.2	280.7	0.5
W	22,005	108	700	5.0	284.3	284.3	284.5	0.2
X	22,240	100	903	3.9	284.6	284.6	285.0	0.4
Y	23,205	87	629	5.6	285.5	285.5	285.9	0.4
Z	23,555	160	1,375	2.5	290.4	290.4	290.4	0.0
AA	23,725	153	1,412	2.5	290.5	290.5	290.5	0.0
AB	24,935	234	1,362	2.6	290.8	290.8	290.9	0.1
AC	25,060	188	1,392	2.4	290.9	290.9	291.5	0.6
AD	26,765	72	293	11.6	295.6	295.6	295.6	0.0
AE	28,865	170	1,130	2.8	300.9	300.9	301.5	0.6
AF	29,625	144	1,064	3.0	301.5	301.5	302.1	0.6
AG	30,160	47	229	14.0	301.5	301.5	302.1	0.6
AH	30,345	374	1,925	1.7	303.7	303.7	303.8	0.1
AI	31,625	250	2,279	1.4	304.5	304.5	304.8	0.3
AJ	31,885	190	1,326	2.4	304.5	304.5	304.8	0.3
AK	32,120	97	1,392	2.3	304.8	304.8	305.2	0.4
AL	32,975	173	830	3.9	305.4	305.4	305.9	0.5
AM	33,130	380	2,524	1.3	305.4	305.4	305.9	0.5
AN	33,715	240	973	3.3	305.9	305.9	306.5	0.6
AO	34,035	710	2,631	1.2	306.9	306.9	307.1	0.2

[1]Feet above confluence with Lehigh River

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

MONOCACY CREEK REACH 1

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Monocacy Creek Reach 1 (continued)								
AP	35,780	131	764	4.2	309.5	309.5	310.3	0.8
AQ	37,169	208	1,694	1.9	315.2	315.2	316.0	0.8
AR	37,919	361	2,582	1.2	315.7	315.7	316.6	0.9
AS	38,989	233	2,192	1.5	316.4	316.4	317.3	0.9
AT	40,015	150	1,223	2.4	317.2	317.2	318.2	1.0
AU	40,945	116	744	3.9	317.8	317.8	318.7	0.9
AV	42,018	126	798	3.7	318.6	318.6	319.4	0.8
AW	42,824	89	643	4.6	319.7	319.7	320.6	0.9
Nancy Run								
A	259	42	373	11.5	221.0	212.2[2]	213.0	0.8
B	495	132	1084	4.0	221.0	220.1[2]	220.4	0.3
C	1,138	58	590	7.1	228.9	228.9	229.0	0.1
D	1,339	53	405	10.2	230.2	230.2	230.9	0.7
E	1,943	30	255	16.3	239.1	239.1	239.2	0.1
F	2,130	26	307	13.5	243.5	243.5	243.5	0.0
G	3,262	98	635	6.1	257.5	257.5	258.2	0.7
H	3,540	115	541	7.2	258.3	258.3	259.2	0.9
I	3,887	74	446	8.8	261.2	261.2	261.2	0.0
J	4,340	115	706	5.5	265.5	265.5	266.1	0.6
K	4,870	95	530	7.3	266.8	266.8	267.7	0.9
L	5,109	84	543	7.2	269.4	269.4	270.1	0.7
M	5,463	151	858	4.5	271.7	271.7	272.5	0.8
N	5,761	150	705	4.7	275.8	275.8	276.2	0.4
O	6,261	204	877	3.8	277.7	277.7	278.5	0.8
P	7,047	77	331	10.0	282.7	282.7	283.5	0.8
Q	7,780	90	471	7.0	294.6	294.6	295.1	0.5

[1]Feet above confluence with Lehigh River
[2]Elevation computed without consideration of backwater effects from Lehigh River

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

MONOCACY CREEK REACH 1 – NANCY RUN

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Nancy Run (continued)								
R	9,059	127	370	5.9	298.0	298.0	298.2	0.2
S	9,466	70	268	8.2	303.8	303.8	304.5	0.7
T	10,044	52	224	9.7	309.0	309.0	309.2	0.2
U	10,345	142	1,105	2.0	316.6	316.6	316.8	0.2
V	10,748	130	709	3.1	316.9	316.9	317.1	0.2
W	11,044	152	721	3.0	320.1	320.1	320.3	0.2
X	11,991	77	292	6.6	322.6	322.6	323.2	0.6
Y	12,138	83	613	3.2	328.4	328.4	328.4	0.0
Z	13,652	86	362	5.3	331.1	331.1	331.5	0.4
AA	14,427	144	725	2.7	336.6	336.6	336.6	0.0
AB	15,510	168	666	2.9	341.0	341.0	341.2	0.2
AC	16,070	81	176	7.0	342.8	342.8	343.1	0.3
AD	17,662	90	259	4.7	358.7	358.7	359.4	0.7
Saucon Creek								
A	296	118	1,576	6.9	223.2	216.5[2]	217.3	0.8
B	1,267	140	1,771	6.2	223.2	218.9[2]	219.7	0.8
C	2,497	40	497	18.9	223.2	221.7[2]	221.9	0.2
D	3,316	47	868	10.8	228.6	228.6	229.4	0.8
E	3,759	48	643	14.6	228.6	228.6	229.4	0.8
F	5,059	91	2,057	4.6	239.9	239.9	240.0	0.1
G	5,771	139	2,609	3.6	240.1	240.1	240.3	0.2
H	7,056	254	3,573	2.6	240.7	240.7	241.5	0.8
I	7,776	178	1,961	4.8	241.6	241.6	241.8	0.2
J	9,285	359	2,631	3.6	242.2	242.2	243.0	0.8
K	11,195	338	1,871	5.0	243.4	243.4	244.1	0.7

[1]Feet above confluence with Lehigh River
[2]Elevation computed without consideration of backwater effects from Lehigh River

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

NANCY RUN – SAUCON CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Saucon Creek (continued)								
L	12,239	372	1,475	6.4	246.5	246.5	247.1	0.6
M	14,270	192	1,761	5.3	254.1	254.1	254.6	0.5
N	15,503	266	1,972	4.8	257.1	257.1	257.6	0.5
O	16,340	64	635	14.8	259.4	259.4	260.4	1.0
P	17,506	337	3,754	2.5	268.8	268.8	269.6	0.8
Q	18,824	556	2,835	3.3	269.6	269.6	270.4	0.8
R	20,545	236	1,324	6.3	274.2	274.2	275.2	1.0
S	21,067	232	2,086	3.8	277.5	277.5	278.1	0.6
T	22,412	328	1,505	5.3	279.6	279.6	280.2	0.6
U	23,332	372	2,487	3.2	286.4	286.4	287.4	1.0
V	24,667	263	1,290	6.1	290.5	290.5	290.7	0.2
W	25,731	270	1,531	5.2	295.2	295.2	295.8	0.6
X	26,742	360	1,899	4.2	298.9	298.9	299.2	0.3
Y	27,976	106	955	8.3	302.6	302.6	303.5	0.9
Z	28,586	160	855	9.3	306.0	306.0	306.1	0.1
AA	29,501	144	1,255	6.3	311.3	311.3	311.4	0.1
AB	30,590	193	1,782	4.4	317.0	317.0	317.1	0.1
AC	31,421	121	1,318	6.0	317.4	317.4	318.3	0.9
AD	31,863	154	1,402	5.6	318.3	318.3	319.2	0.9
AE	33,109	220	1,640	4.8	321.3	321.3	322.0	0.7
AF	34,150	131	907	8.0	323.6	323.6	324.3	0.7
AG	35,227	100	871	8.3	330.1	330.1	330.2	0.1
AH	36,171	179	1,733	4.2	334.4	334.4	334.8	0.4
AI	36,844	193	1,610	4.5	334.7	334.7	335.3	0.6
AJ	37,520	186	1,382	5.3	335.6	335.6	336.5	0.9

[1]Feet above confluence with Lehigh River

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

SAUCON CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD 88)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Shoeneck Creek								
A	3,274[1]	100	283	8.7	300.3	300.3	300.4	0.1
B	5,386[1]	120	541	4.4	308.8	308.8	309.8	1.0
C	8,184[1]	100	333	6.9	316.1	316.1	316.8	0.7
D	9,768[1]	120	387	6.0	321.4	321.4	322.1	0.7
E	12,936[1]	140	467	3.5	329.7	329.7	330.4	0.7
F	15,629[1]	80	213	7.2	337.6	337.6	338.1	0.5
G	16,685[1]	80	166	9.2	340.5	340.5	341.4	0.9
H	17,846[1]	140	548	2.6	344.0	344.0	344.9	0.9
I	20,222[1]	80	112	7.7	352.6	352.6	353.1	0.5
Silver Creek								
A	338[2]	260	920	1.9	276.8	272.5[5]	273.5	1.0
B	1,563[2]	120	510	3.3	284.6	284.6	285.4	0.8
Waltz Creek								
A-D*								
E	192.50[3]	31	108	8.3	581.0	581.0	582.0	1.0
F	193.95[3]	129	507	1.8	585.2	585.2	585.2	0.0
G	200.22[3]	146	209	4.3	589.5	589.5	590.4	0.9
H	208.83[3]	96	385	2.1	605.9	605.9	606.9	1.0
I	212.33[3]	58	122	6.1	612.0	612.0	612.8	0.8
West Branch Little Bushkill Creek								
A	1,672[4]	29	85	9.0	688.8	688.8	689.0	0.2
B	2,262[4]	38	150	5.1	691.8	691.8	692.1	0.3
C	2,802[4]	35	84	9.0	694.0	694.0	694.0	0.0
D	3,080[4]	355	1,727	0.4	696.1	696.1	697.0	0.9

[1]Feet above confluence with Bushkill Creek
[2]Feet above confluence with Saucon Creek
[3]Hundreds of feet above confluence with Martins Creek
[4]Feet above Limit of Detailed Study (Limit of Detailed Study is located approximately 470 feet downstream of State Route 512)
[5]Elevation computed without consideration of backwater effects from Saucon Creek
*No floodway computed

TABLE 5

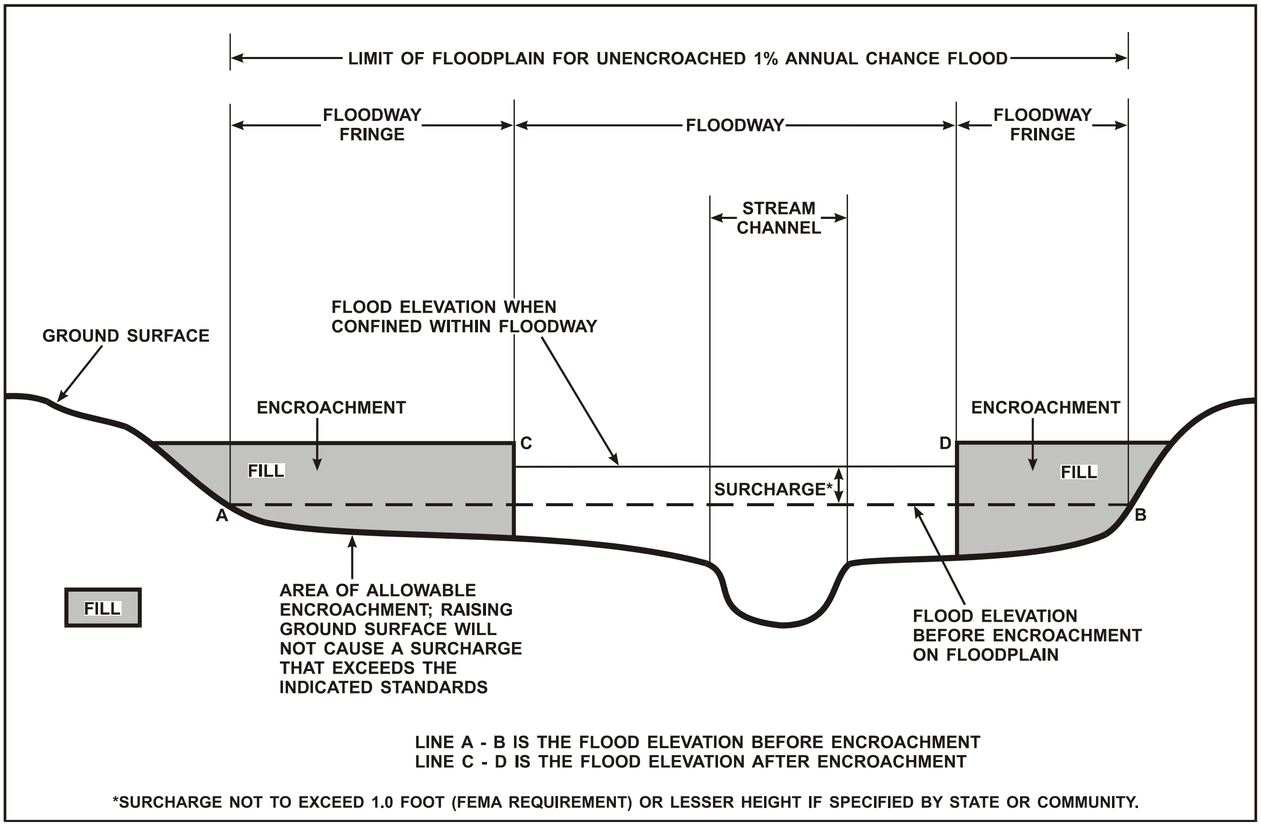
FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA (ALL JURISDICTIONS)

FLOODWAY DATA

SHOENECK CREEK – SILVER CREEK – WALTZ CREEK – WEST BRANCH LITTLE BUSHKILL CREEK

The area between the floodway and 1-percent-annual-chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 1-percent-annual-chance flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 1, "Floodway Schematic."



FLOODWAY SCHEMATIC Figure 1

5.0 INSURANCE APPLICATIONS

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. The zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS by detailed methods. In most instances, whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH

Zone AH is the flood insurance rate zone that corresponds to the areas of 1-percent-annual-chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

Zone AO is the flood insurance rate zone that corresponds to the areas of 1-percent-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot depths derived from the detailed hydraulic analyses are shown within this zone.

Zone A99

Zone A99 is the flood insurance rate zone that corresponds to areas of the 1-percent-annual-chance floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No base flood elevations or depths are shown within this zone.

Zone V

Zone V is the flood insurance rate zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no base flood elevations are shown within this zone.

Zone VE

Zone VE is the flood insurance rate zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm waves. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 0.2-percent-annual-chance floodplain, areas within the 0.2-percent-annual-chance floodplain, and to areas of 1-percent-annual-chance flooding where average depths are less than 1 foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent-annual-chance flood by levees. No base flood elevations or depths are shown within this zone.

Zone D

Zone D is the flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.

6.0 FLOOD INSURANCE RATE MAP

The FIRM is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 1-percent-annual-chance floodplains that were studied by detailed methods, shows selected whole-foot base flood elevations or average depths. Insurance agents use the zones and base flood elevations in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 1- and 0.2-percent-annual-chance floodplains. Floodways and the locations of selected cross sections used in the hydraulic analyses and floodway computations are shown where applicable.

The current FIRM presents flooding information for the entire geographic area of Northampton County. Historical data relating to the maps prepared for each community prior to the April 6, 2001, countywide FIS, are presented in Table 6, "Community Map History."

7.0 OTHER STUDIES

FISs have been prepared for Bucks County, Pennsylvania (All Jurisdictions); Carbon County, Pennsylvania (All Jurisdictions); Lehigh County, Pennsylvania (All Jurisdictions); Monroe County, Pennsylvania (All Jurisdictions); and Warren County, New Jersey (All Jurisdictions) (References 61-65).

Information pertaining to revised and unrevised flood hazards for each jurisdiction within Northampton County has been compiled into this FIS. Therefore, this FIS supersedes all previously printed FIS reports, FIRMs, FBFMs, and FHBMs for all of the jurisdictions within Northampton County.

COMMUNITY NAME	INITIAL NFIP MAP DATE	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	INITIAL FIRM DATE	FIRM REVISIONS DATE
Allen, Township of	September 6, 1974	May 21, 1976	May 19, 1981	
Bangor, Borough of	January 25, 1974	None	February 2, 1977	
Bath, Borough of	July 30, 1976	None	February 17, 1988	
Bethlehem, City of	June 15, 1973	September 19, 1975	July 3, 1978	
Bethlehem, Township of	June 14, 1974	September 24, 1976	June 4, 1980	
Bushkill, Township of	November 8, 1974	July 25, 1980	March 4, 1988	
Chapman, Borough of	November 15, 1974	None	July 30, 1982	
East Allen, Township of	February 11, 1983	None	February 11, 1983	
East Bangor, Borough of	November 15, 1974	None	February 12, 1982	
Easton, City of	February 9, 1973	None	February 9, 1973	November 7, 1975 February 6, 1976 March 9, 1979
Forks, Township of	November 8, 1974	January 23, 1976	July 16, 1980	
Freemansburg, Borough of	December 28, 1973	June 4, 1976	September 1, 1977	
Glendon, Borough of	November 15, 1974	November 28, 1975	January 16, 1980	
Hanover, Township of	November 23, 1973	None	August 1, 1977	
Hellertown, Borough of	February 8, 1973	October 22, 1976	September 5, 1979	

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA
(ALL JURISDICTIONS)

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Lehigh, Township of	November 15, 1974	None	December 15, 1981	
Lower Mount Bethel, Township of	January 4, 1974	None	March 1, 1977	October 30, 1981
Lower Nazareth, Township of	November 15, 1974	March 28, 1980	May 4, 1988	
Lower Saucon, Township of	June 28, 1974	September 10, 1976	September 28, 1979	
Moore, Township of	August 2, 1974	July 16, 1976	October 17, 1978	
Nazareth, Borough of	January 9, 1974	May 28, 1976	October 8, 1982	
North Catasauqua, Borough of	May 3, 1974	July 2, 1976	July 16, 1981	
Northampton, Borough of	April 5, 1974	June 4, 1976	May 3, 1982	
Palmer, Township of	April 20, 1973	None	June 28, 1976	March 10, 1978
Pen Argyl, Borough of	November 1, 1974	None	June 25, 1976	
Plainfield, Township of	September 13, 1974	June 11, 1976	January 16, 1980	
Portland, Borough of	April 12, 1974	May 21, 1976	September 16, 1981	
Roseto, Borough of	November 15, 1974	None	April 6, 2001	
Stockertown, Borough of	August 2, 1974	May 28, 1976	December 4, 1979	
Tatamy, Borough of	April 12, 1974	June 25, 1976	December 4, 1979	
Upper Mount Bethel, Township of	November 8, 1974	None	September 30, 1981	

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA
(ALL JURISDICTIONS)

COMMUNITY MAP HISTORY

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATE	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Upper Nazareth, Township of	December 27, 1971	None	February 25, 1983	
Walnutport, Borough of	January 9, 1974	June 4, 1976	June 1, 1978	
Washington, Township of	November 1, 1974	September 24, 1976	September 30, 1988	
West Easton, Borough of	December 28, 1973	June 18, 1976	March 1, 1979	
Williams, Township of	May 17, 1974	June 11, 1976	September 14, 1979	
Wilson, Borough of	September 13, 1974	June 18, 1976	January 16, 1980	
Wind Gap, Borough of	June 28, 1974	June 4, 1976	May 19, 1981	May 16, 1994

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA
(ALL JURISDICTIONS)

COMMUNITY MAP HISTORY

This is a multi-volume FIS. Each volume may be revised separately, in which case it supersedes the previously printed volume. Users should refer to the Table of Contents in Volume 1 for the current effective date of each volume; volumes bearing these dates contain the most up-to-date flood hazard data.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this study can be obtained by contacting FEMA, Mitigation Division, One Independence Mall, Sixth Floor, 615 Chestnut Street, Philadelphia, Pennsylvania 19106-4404.

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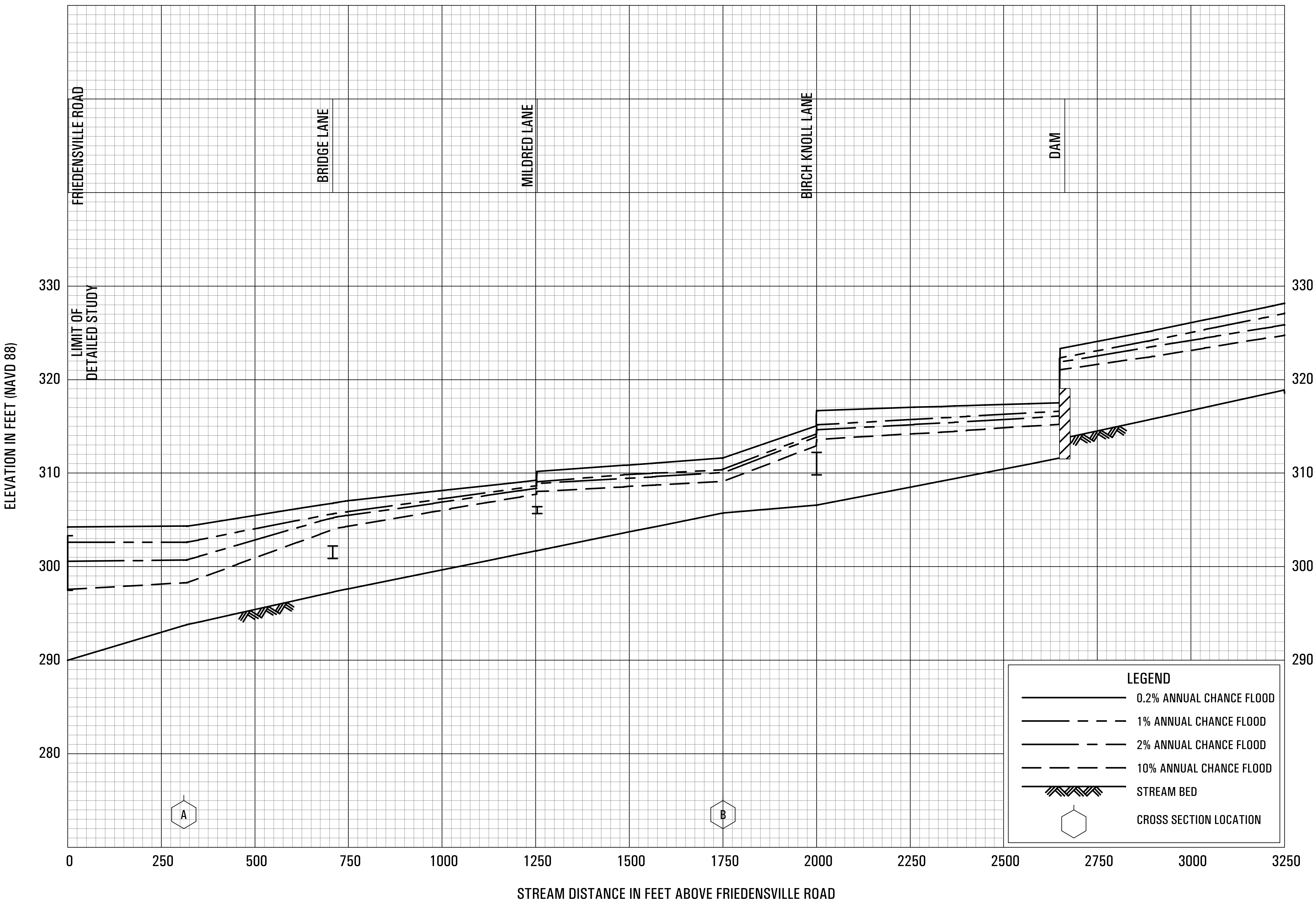

FLOOD PROFILES

BLACK RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)

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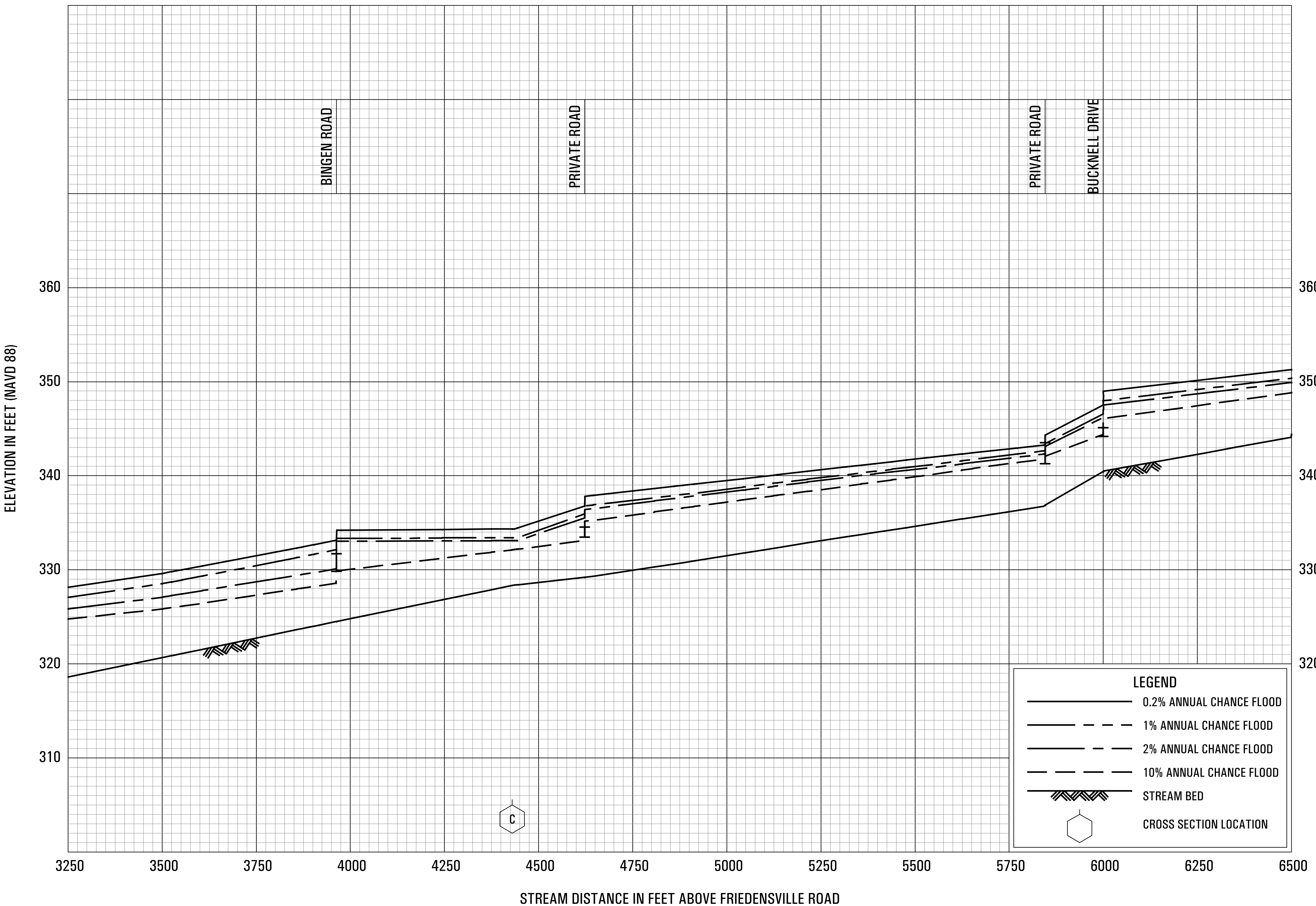


FLOOD PROFILES

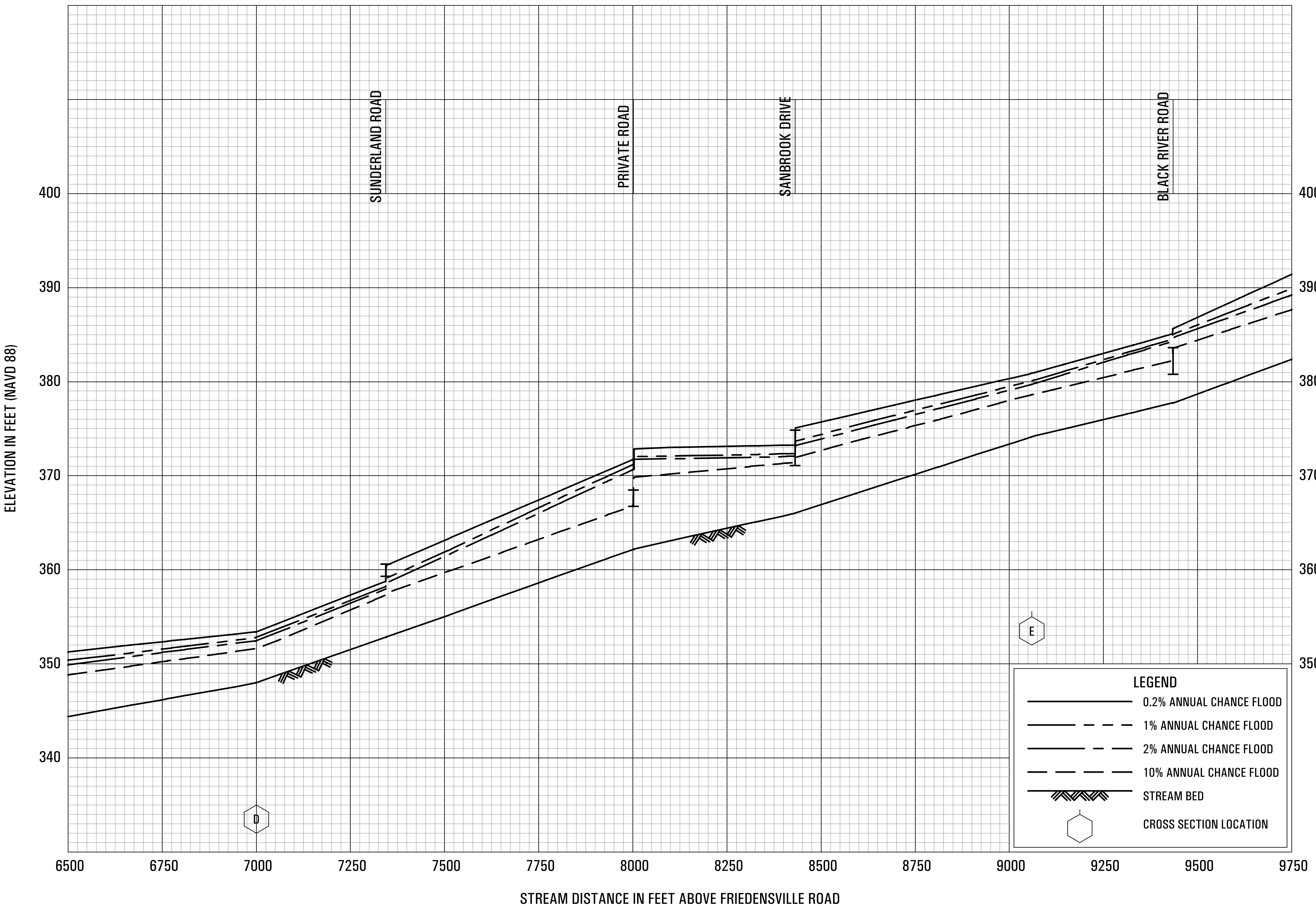
BLACK RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)

02P



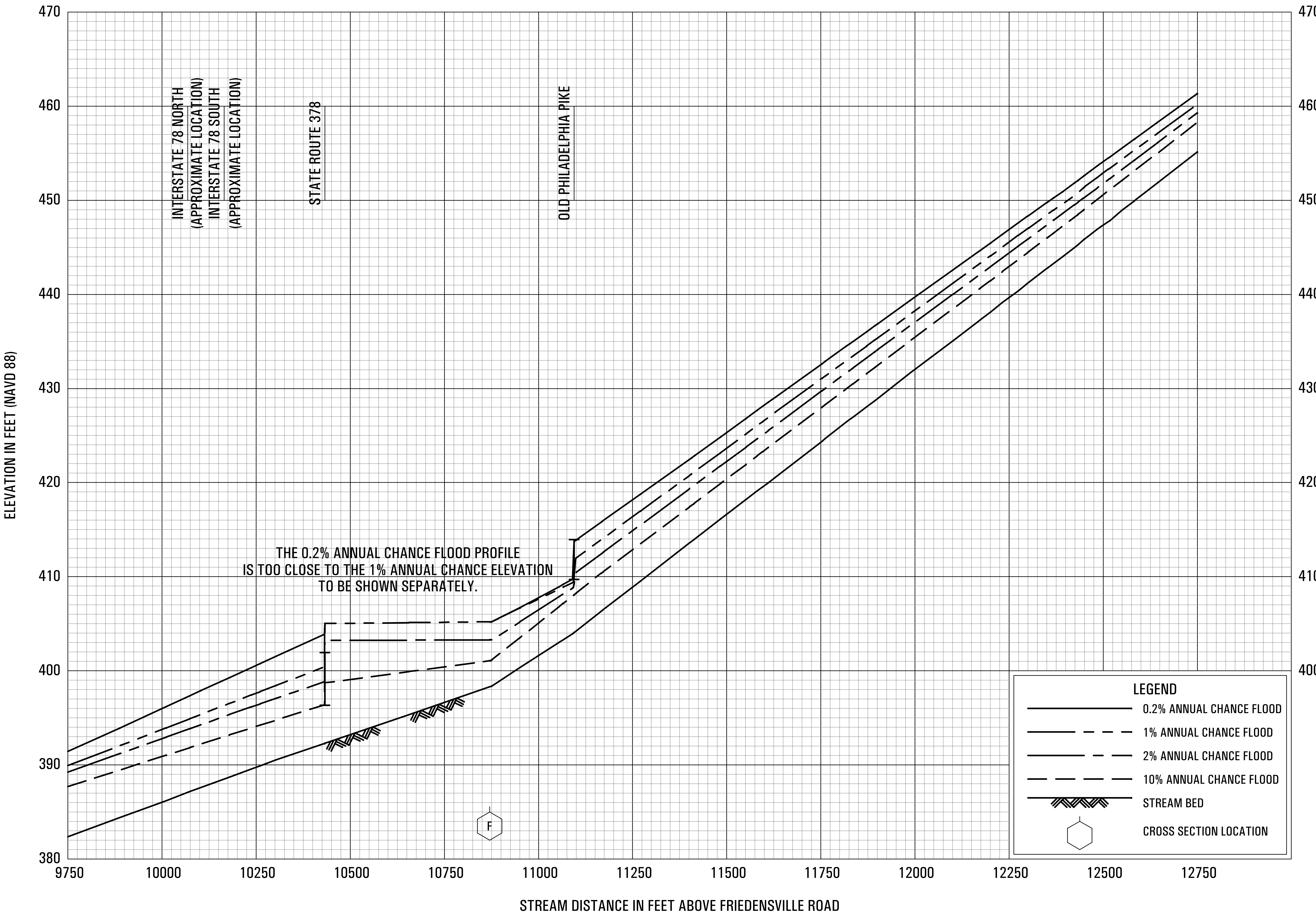
FLOOD PROFILES

BLACK RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



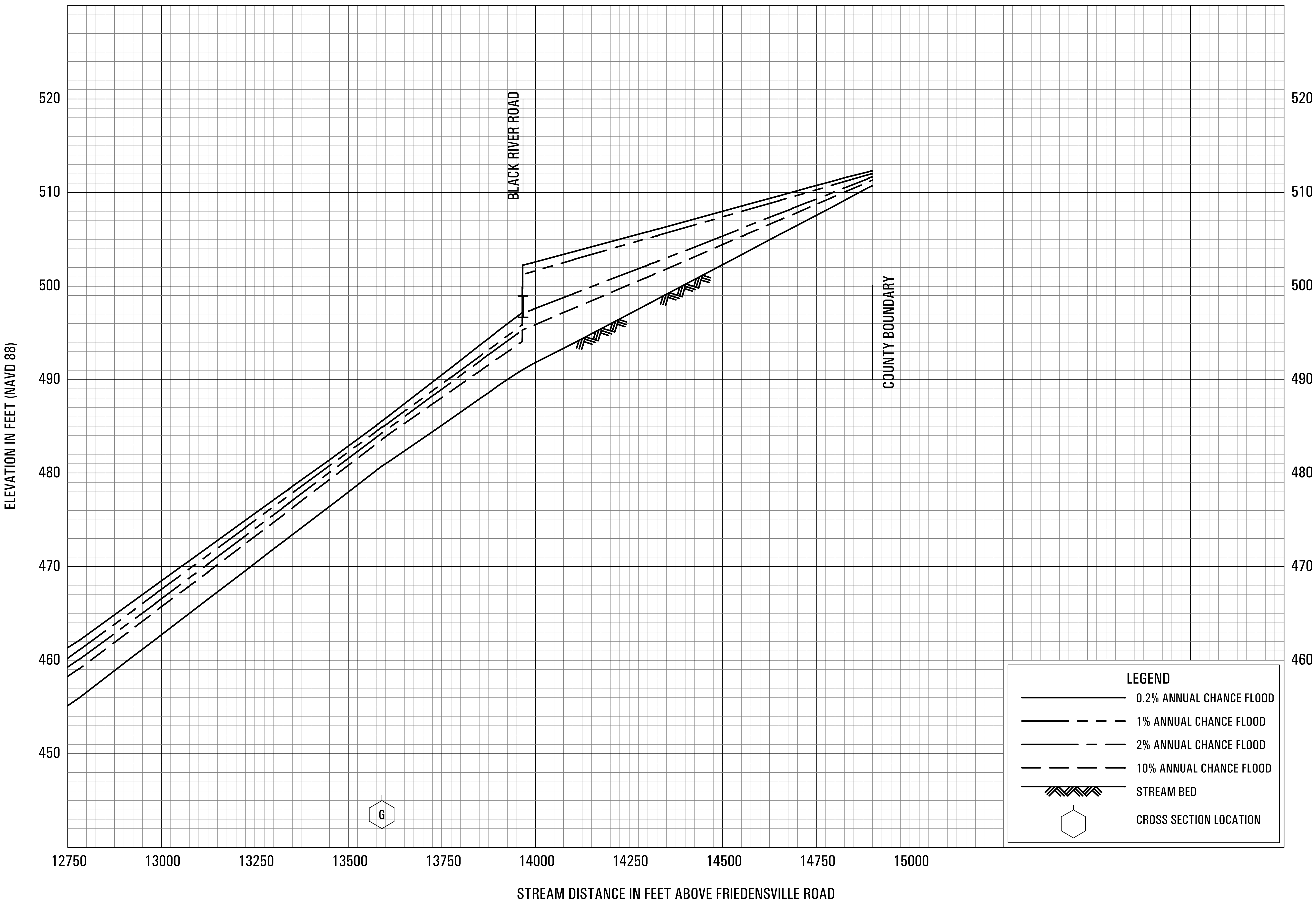
FLOOD PROFILES

BLACK RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



FLOOD PROFILES

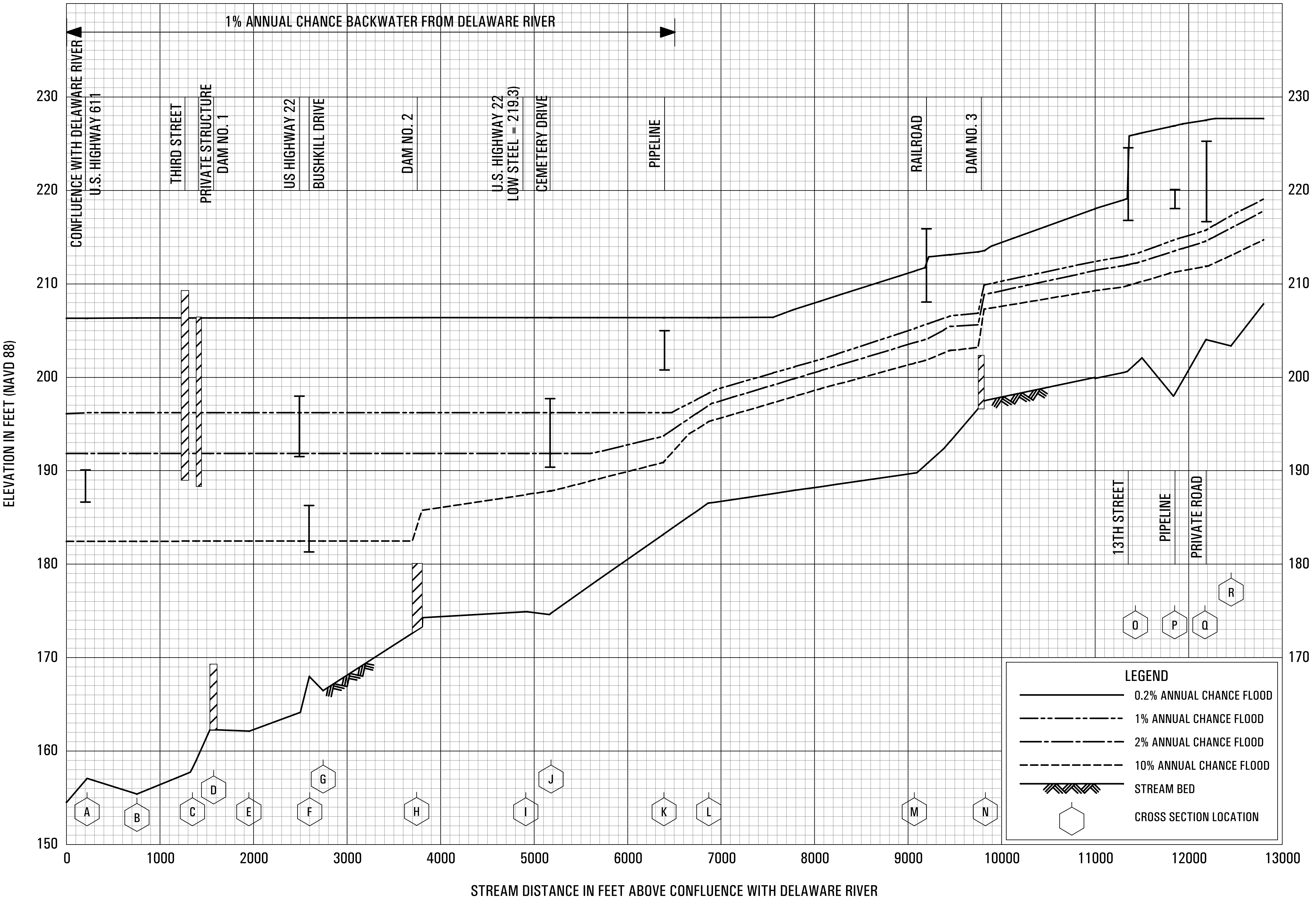
BLACK RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)

05P



FLOOD PROFILES

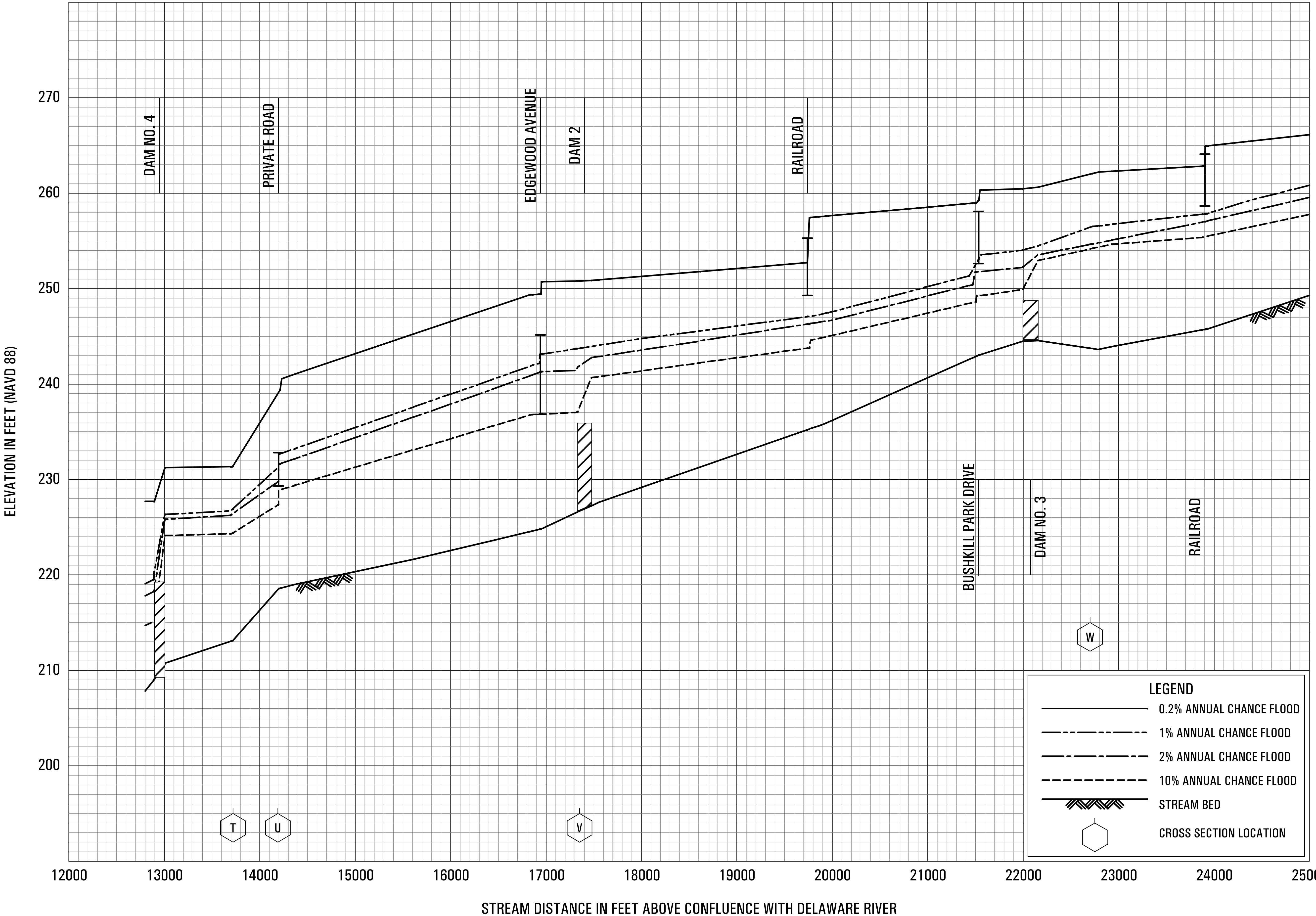
BUSHKILL CREEK REACH 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)

06P



FLOOD PROFILES

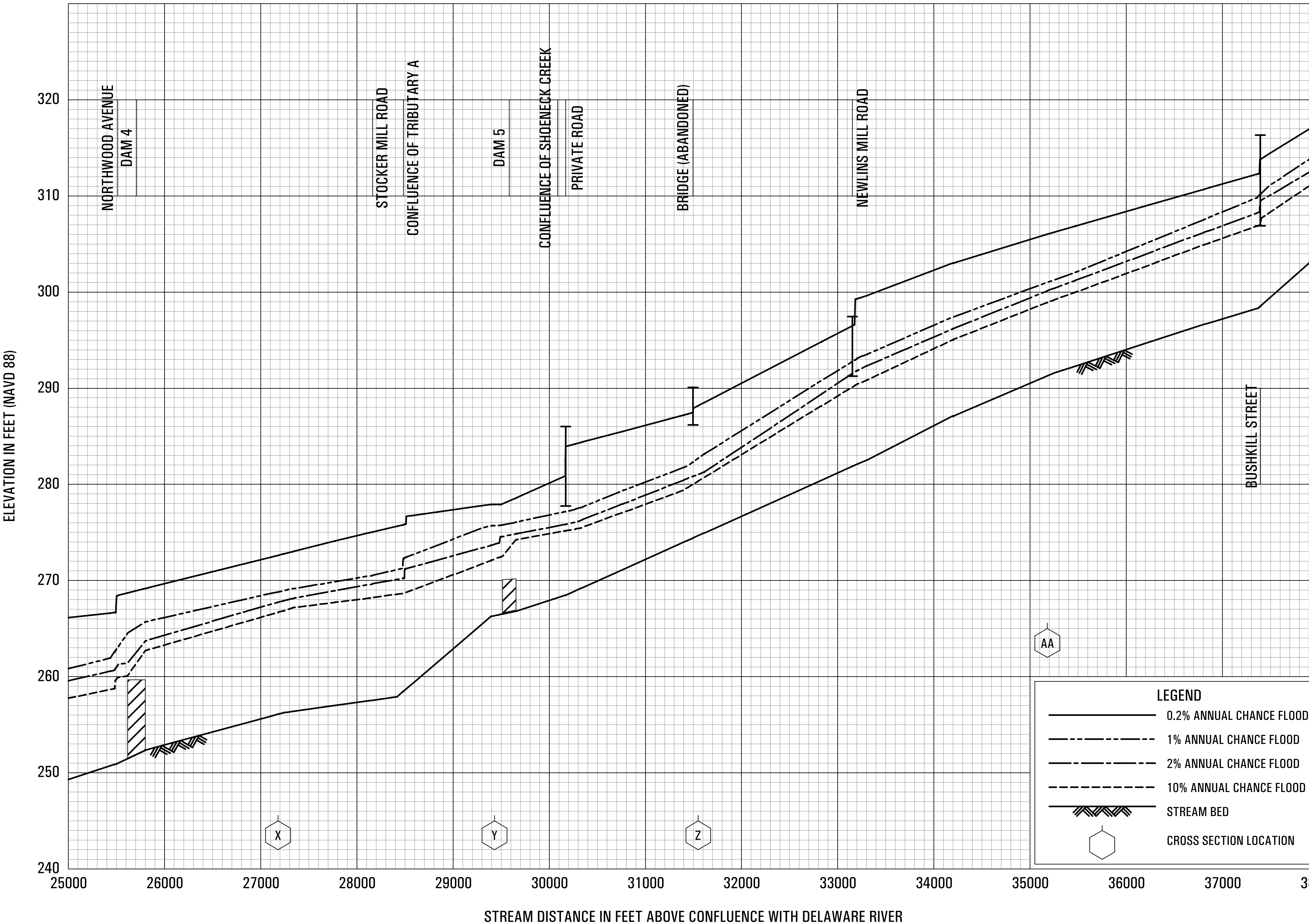
BUSHKILL CREEK REACH 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)

07P



FLOOD PROFILES

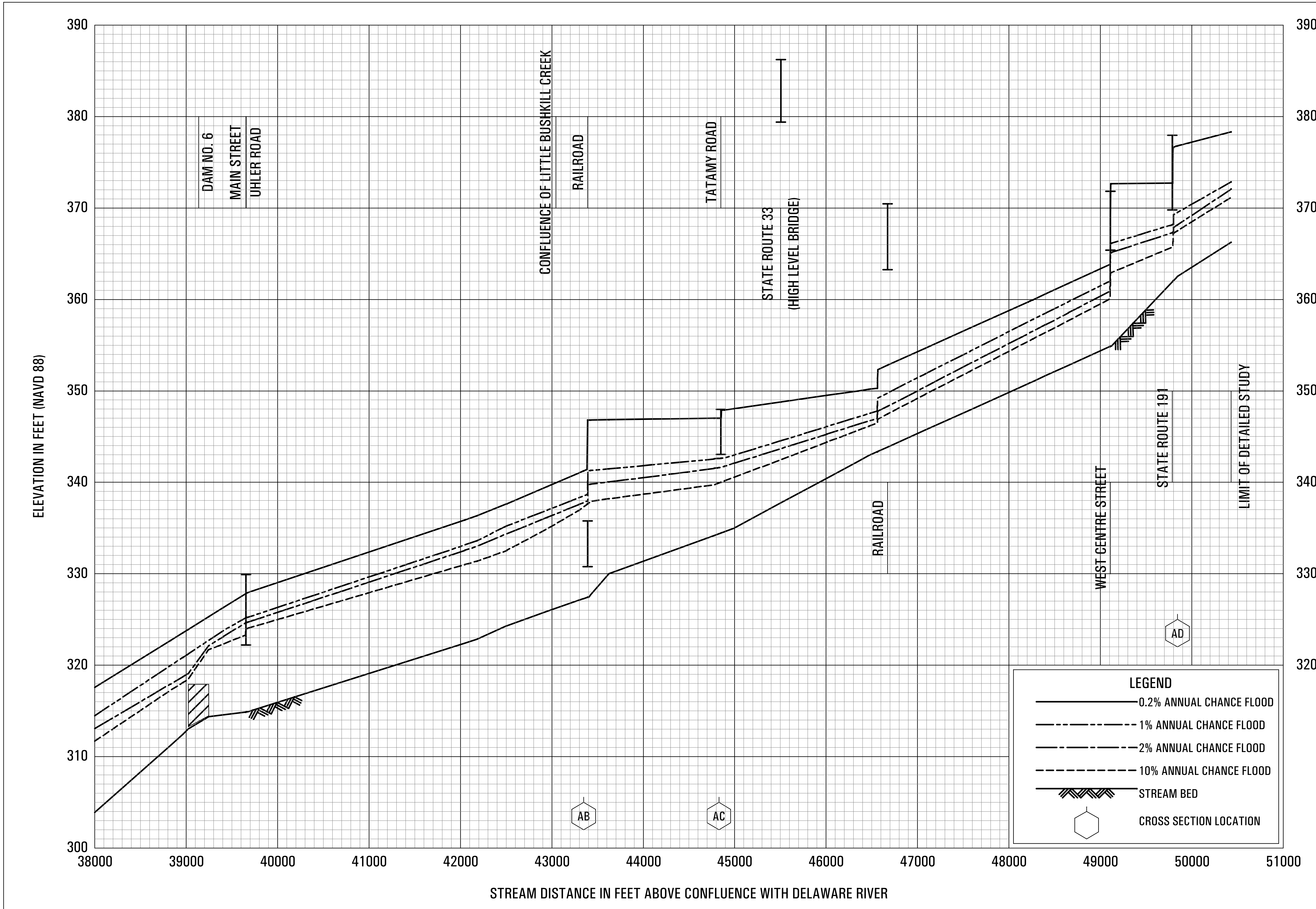
BUSHKILL CREEK REACH 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)

08P



FLOOD PROFILES

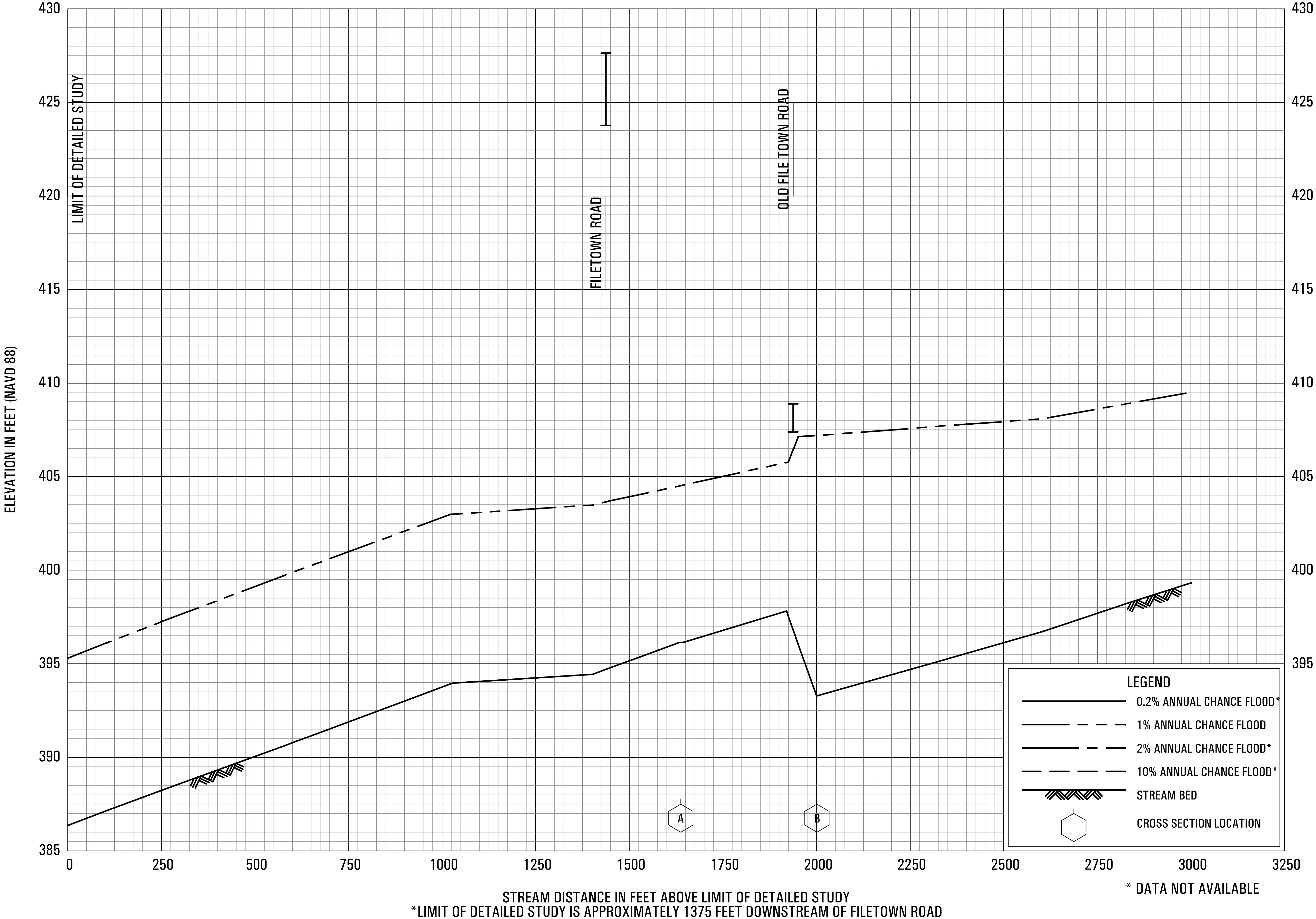
BUSHKILL CREEK REACH 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)

09P



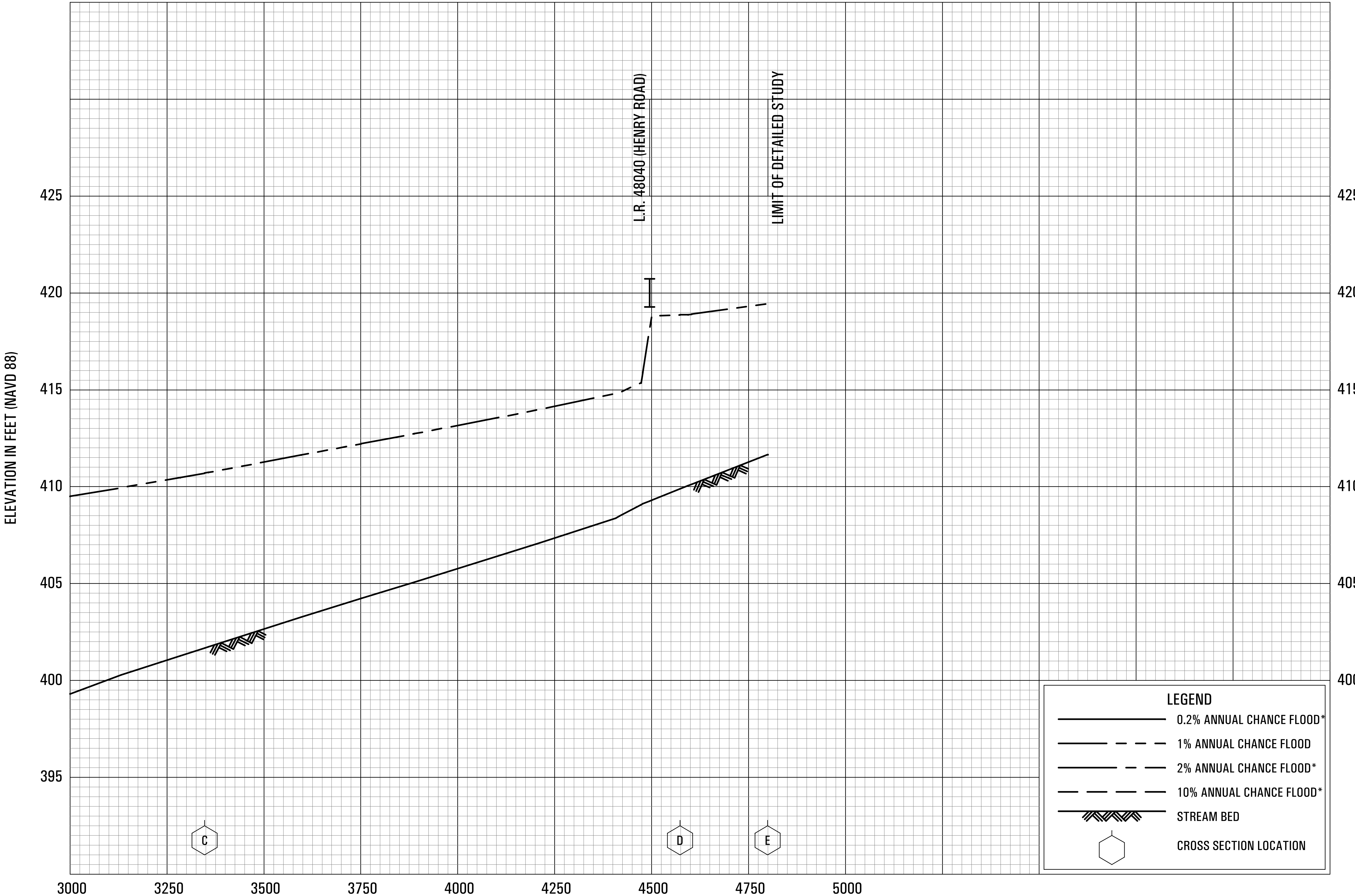
FLOOD PROFILES

BUSHKILL CREEK REACH 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



STREAM DISTANCE IN FEET ABOVE LIMIT OF DETAILED STUDY

*LIMIT OF DETAILED STUDY IS APPROXIMATELY 1375 FEET DOWNSTREAM OF FILETOWN ROAD

* DATA NOT AVAILABLE

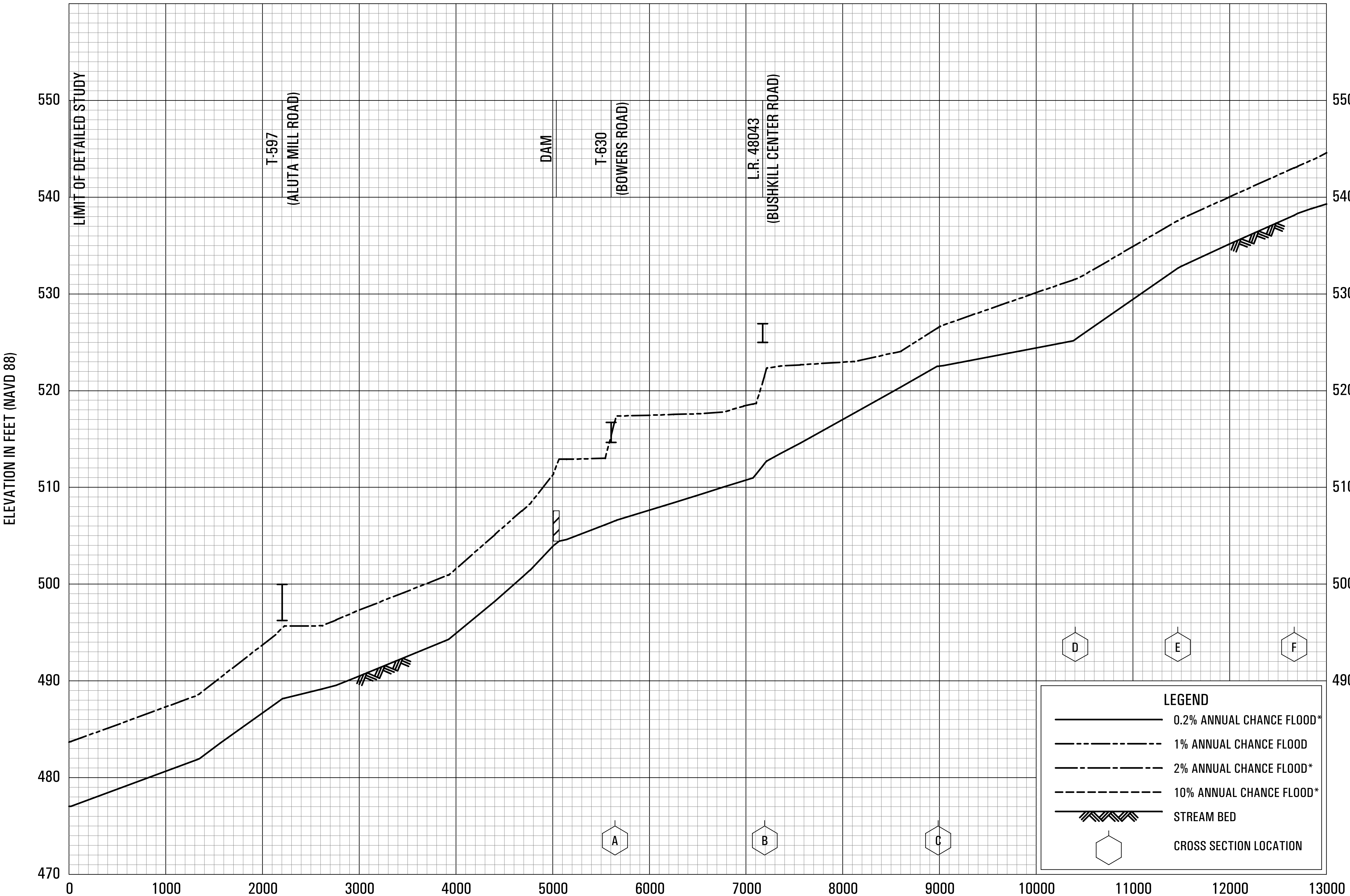
FLOOD PROFILES

BUSHKILL CREEK REACH 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



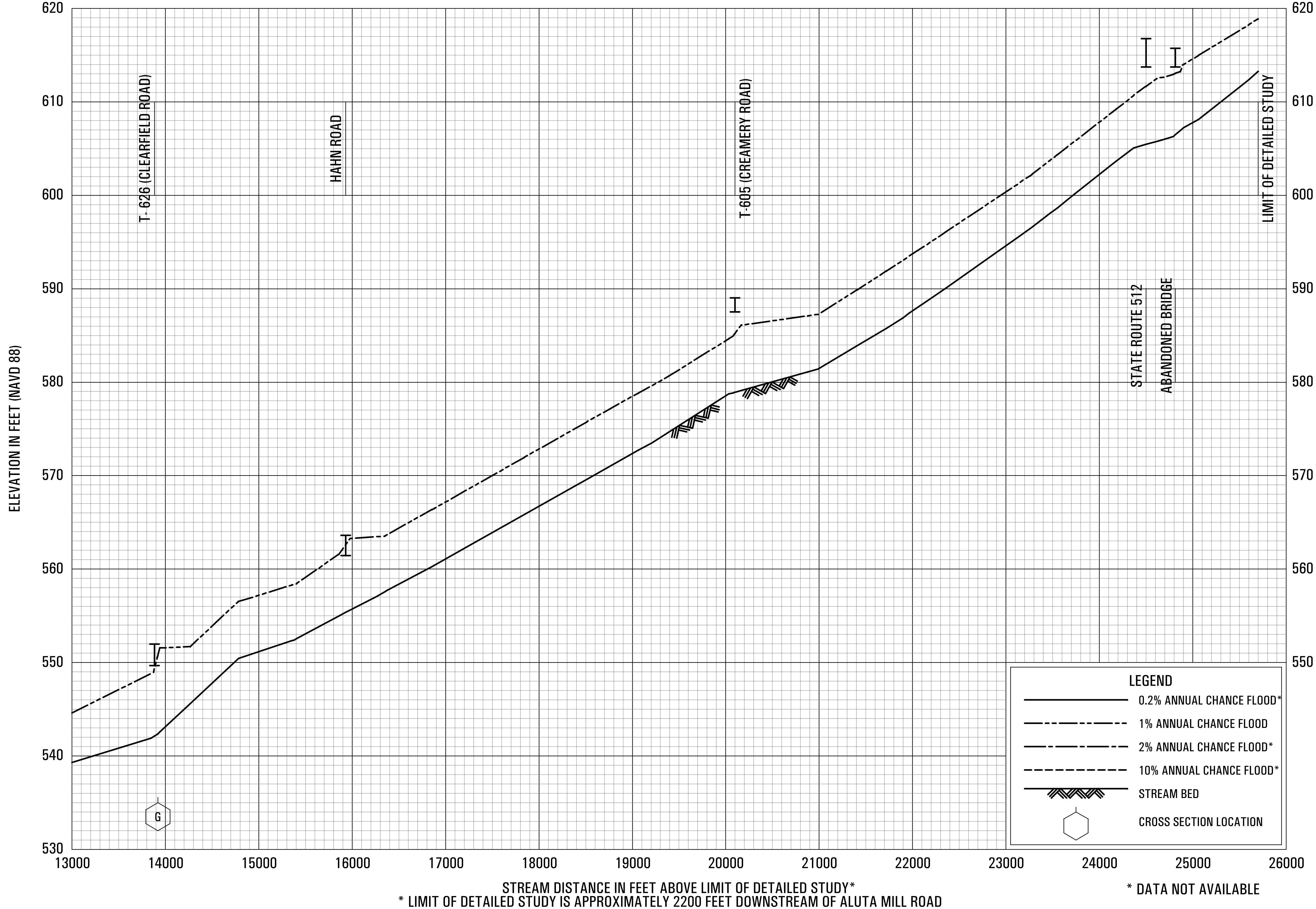
STREAM DISTANCE IN FEET ABOVE LIMIT OF DETAILED STUDY*
* LIMIT OF DETAILED STUDY IS APPROXIMATELY 2200 FEET DOWNSTREAM OF ALUTA MILL ROAD

* DATA NOT AVAILABLE

FLOOD PROFILES

BUSHKILL CREEK REACH 3

FEDERAL EMERGENCY MANAGEMENT AGENCY
NORTHAMPTON COUNTY, PA
(ALL JURISDICTIONS)



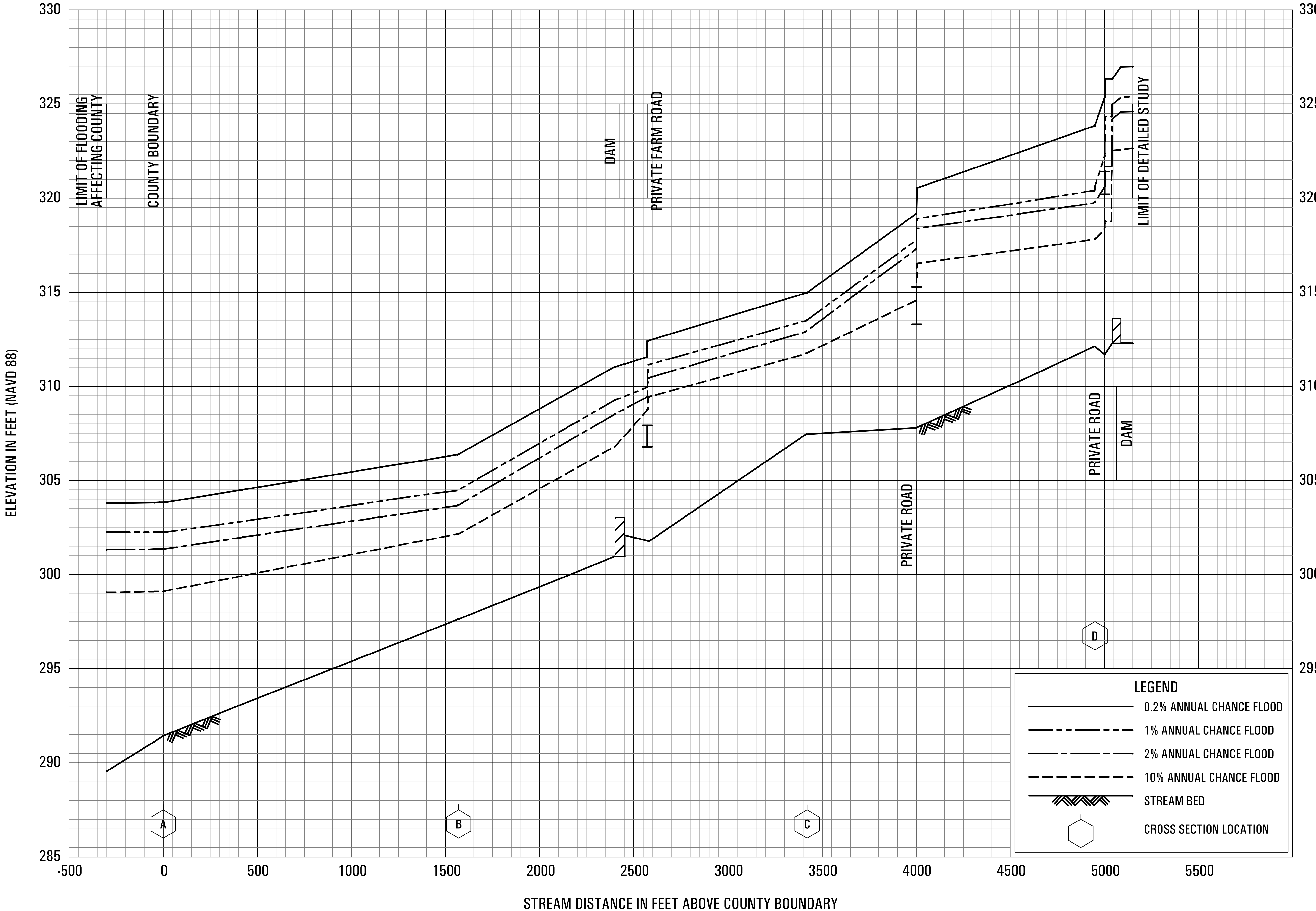
FLOOD PROFILES

BUSHKILL CREEK REACH 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



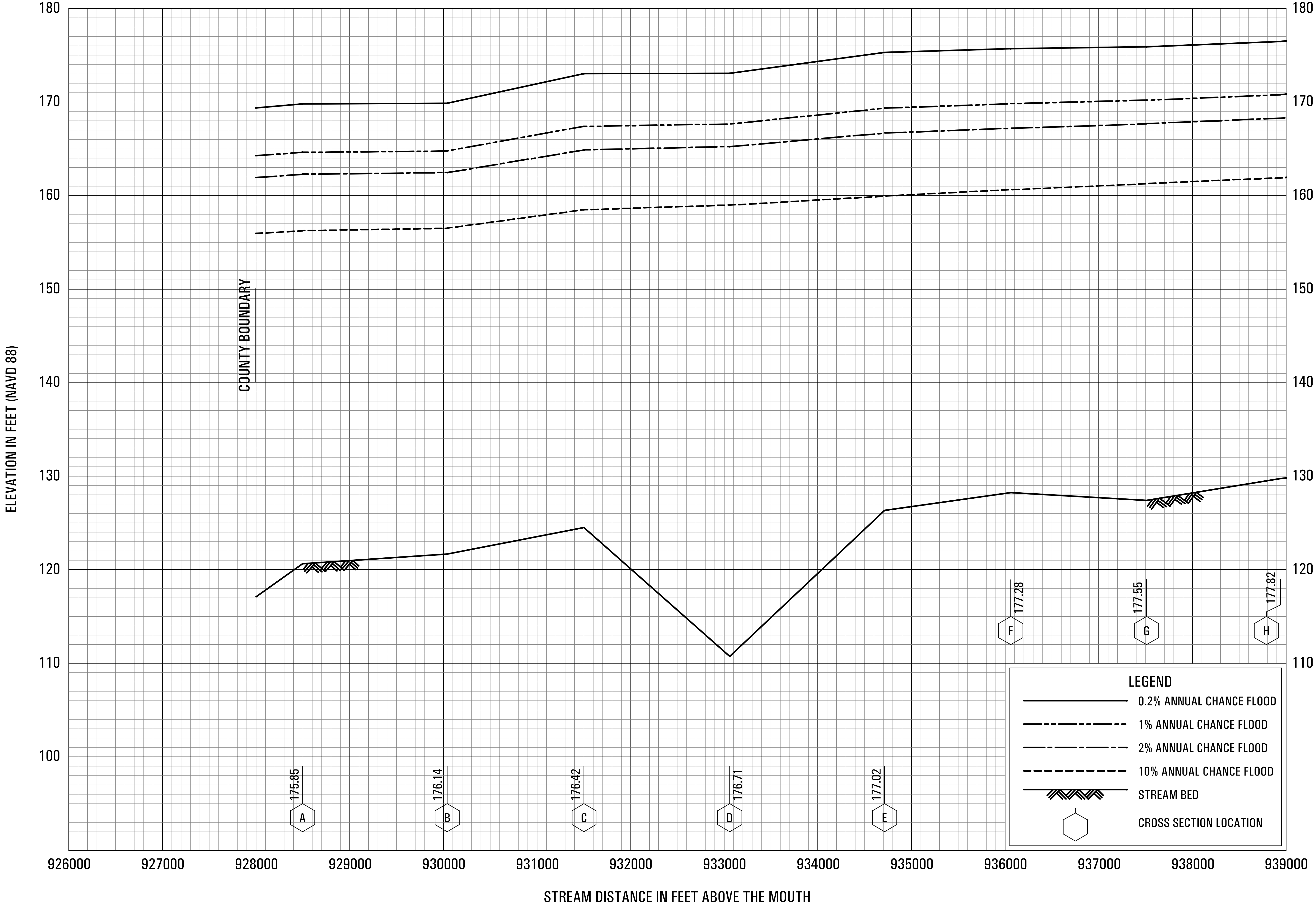
FLOOD PROFILES

CATASAUQUA CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



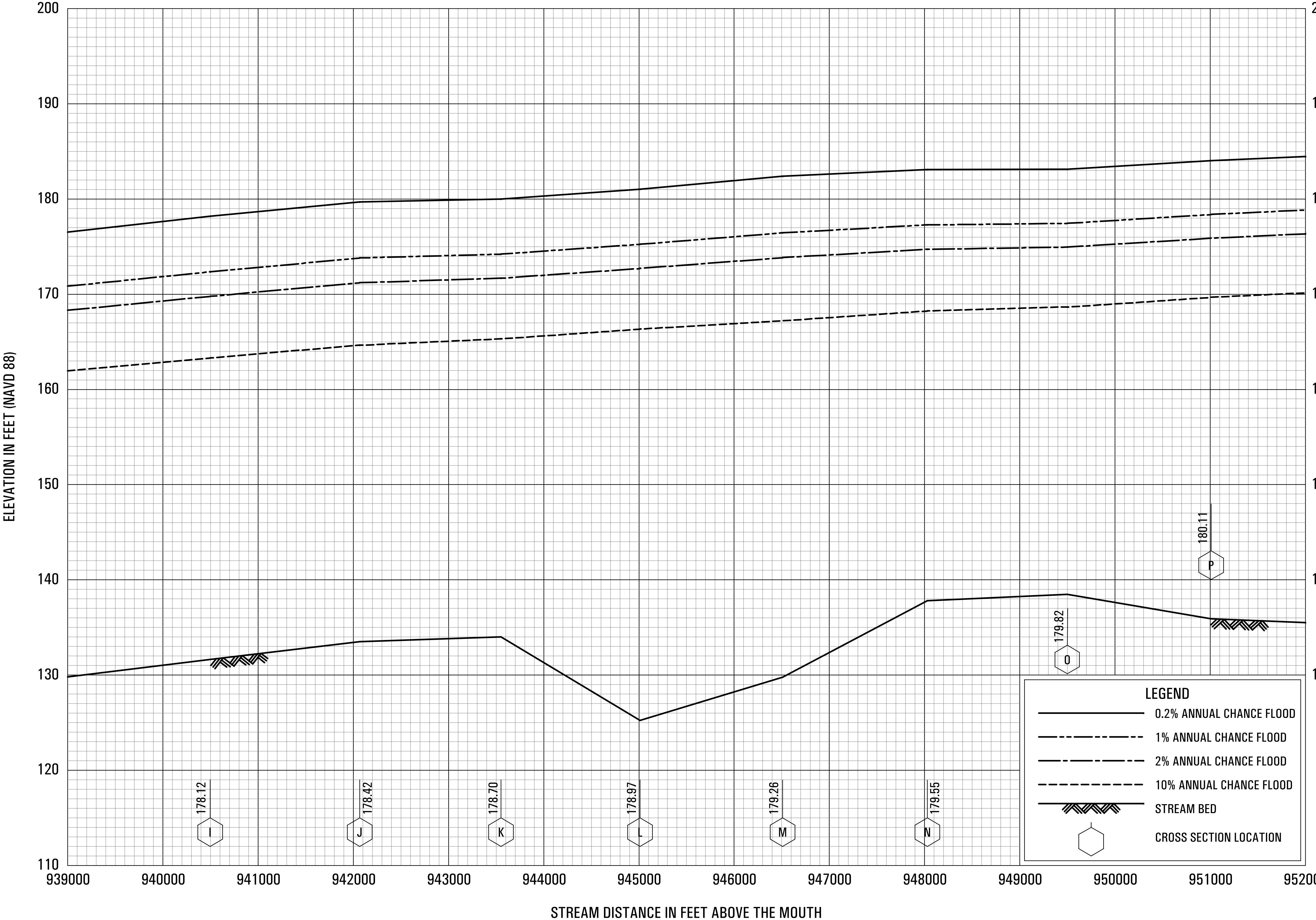
FLOOD PROFILES

DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



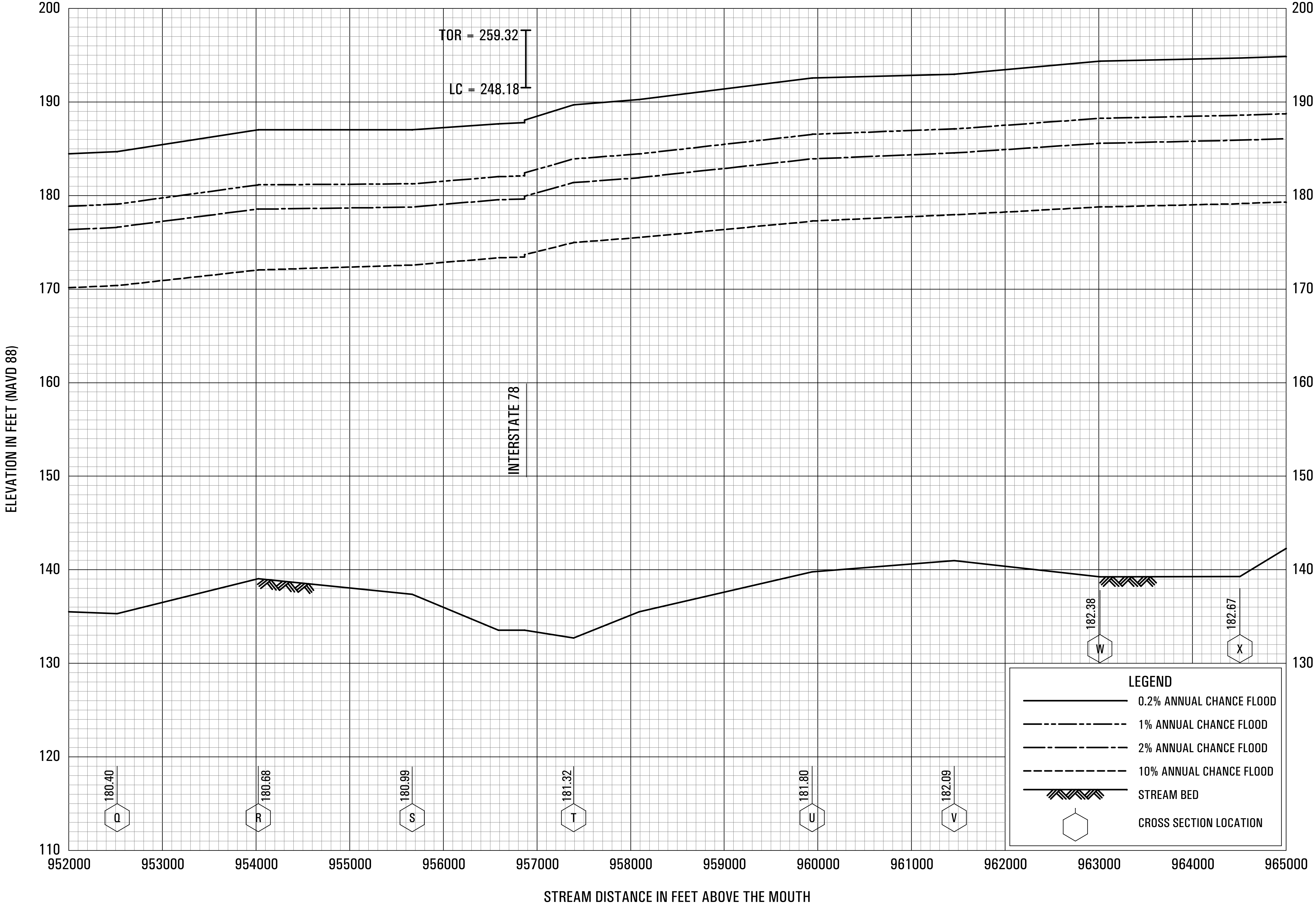
FLOOD PROFILES

DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



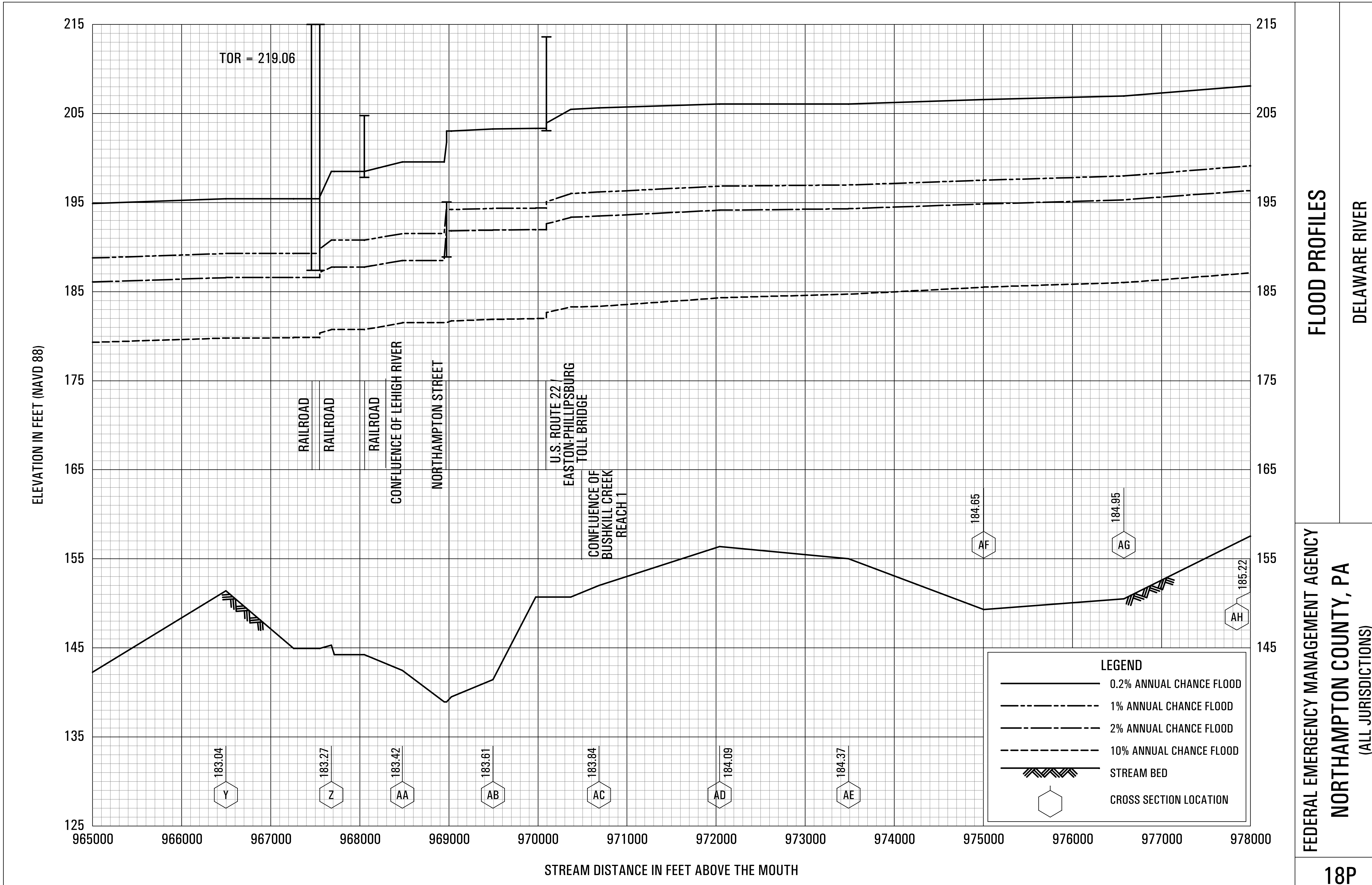
FLOOD PROFILES

DELAWARE RIVER

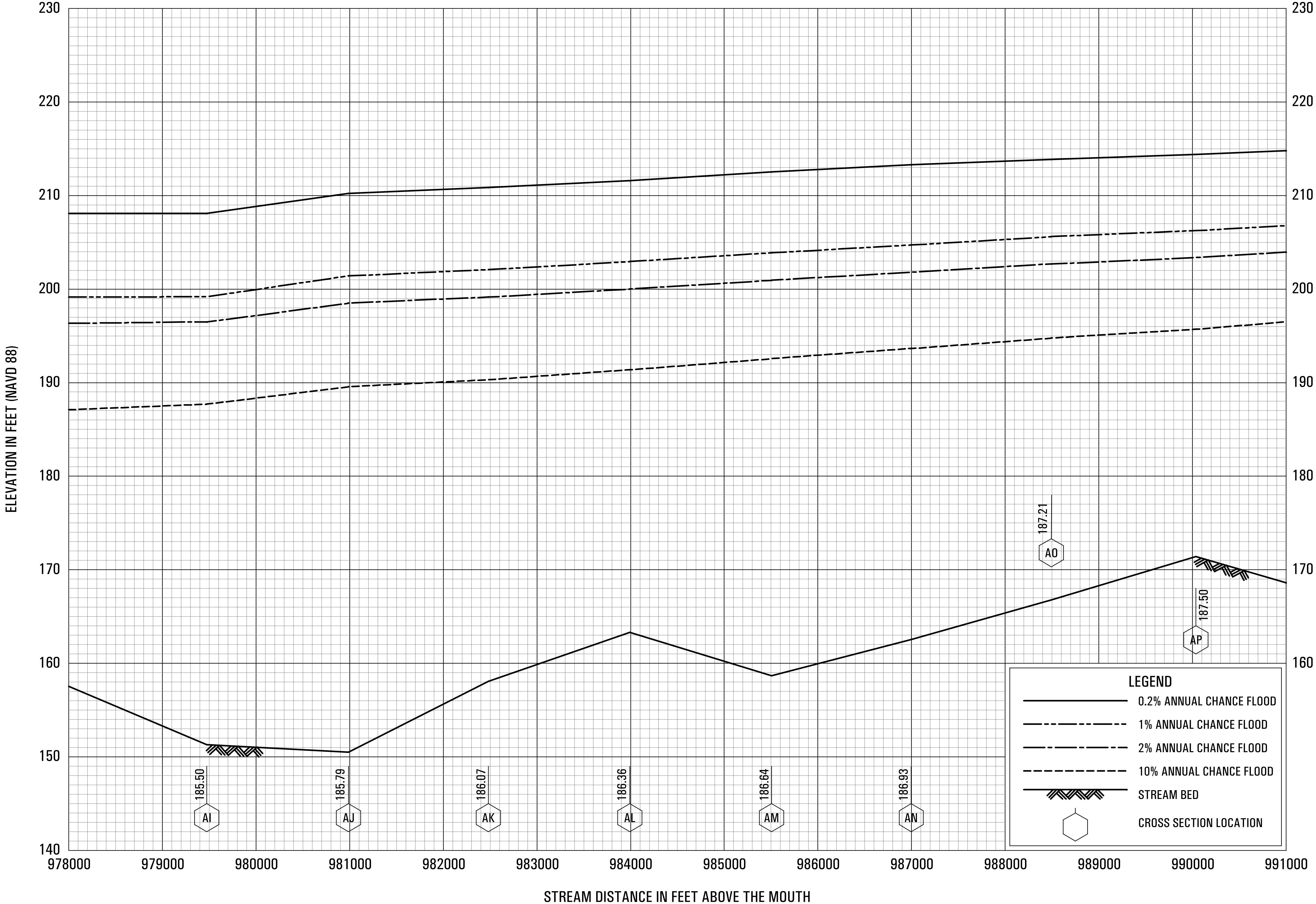
FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



FLOOD PROFILES
DELAWARE RIVER
FEDERAL EMERGENCY MANAGEMENT AGENCY
NORTHAMPTON COUNTY, PA
(ALL JURISDICTIONS)
ELEVATION IN FEET (NAVD 88)
STREAM DISTANCE IN FEET ABOVE THE MOUTH
TOR = 219.06
RAILROAD
RAILROAD
RAILROAD
CONFLUENCE OF LEHIGH RIVER
NORTHAMPTON STREET
U.S. ROUTE 22 / EASTON-PHILLIPSBURG TOLL BRIDGE
CONFLUENCE OF BUSHKILL CREEK REACH 1
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION
Y 183.04
Z 183.27
AA 183.42
AB 183.61
AC 183.84
AD 184.09
AE 184.37
AF 184.65
AG 184.95
AH 185.22



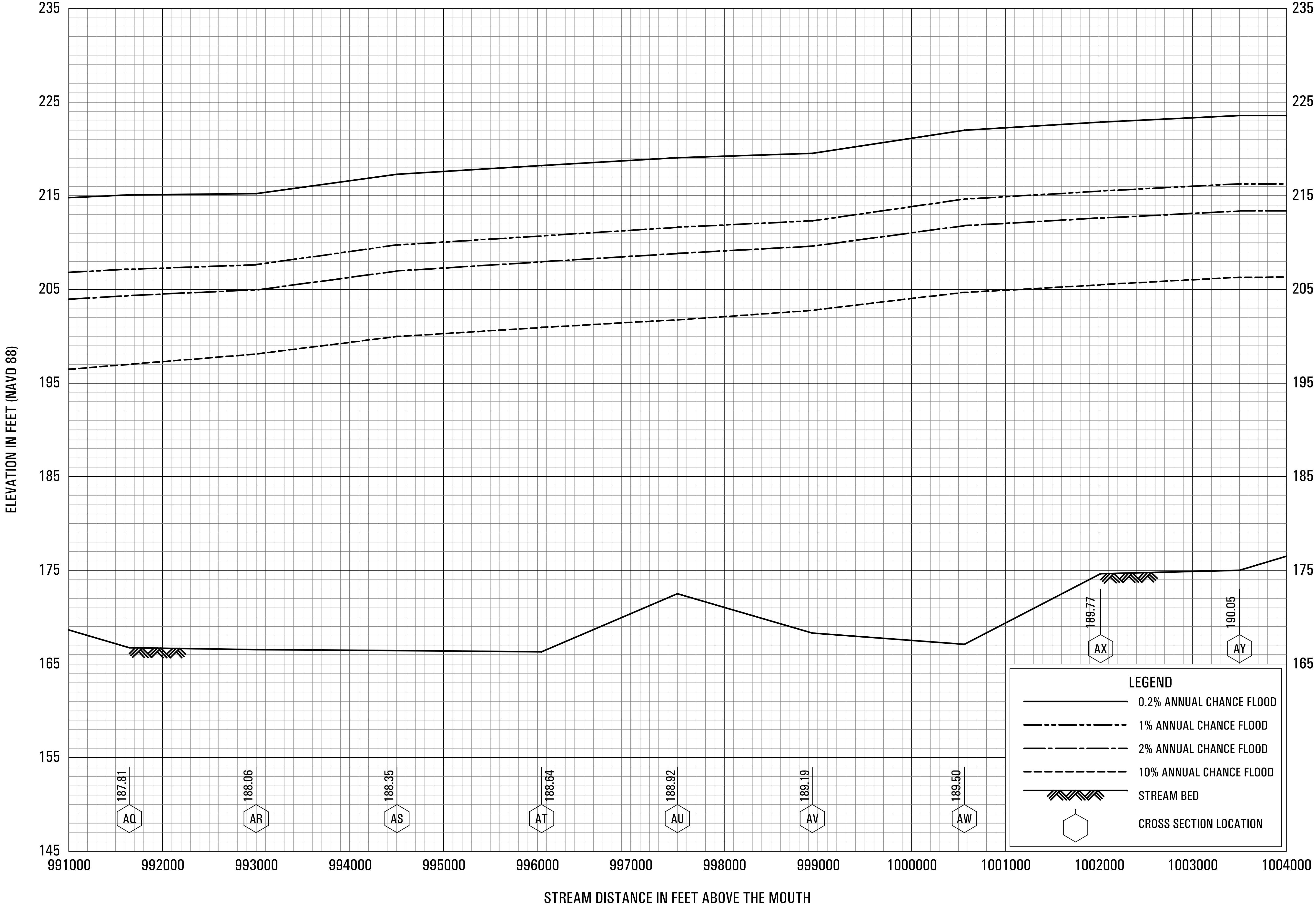
FLOOD PROFILES

DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



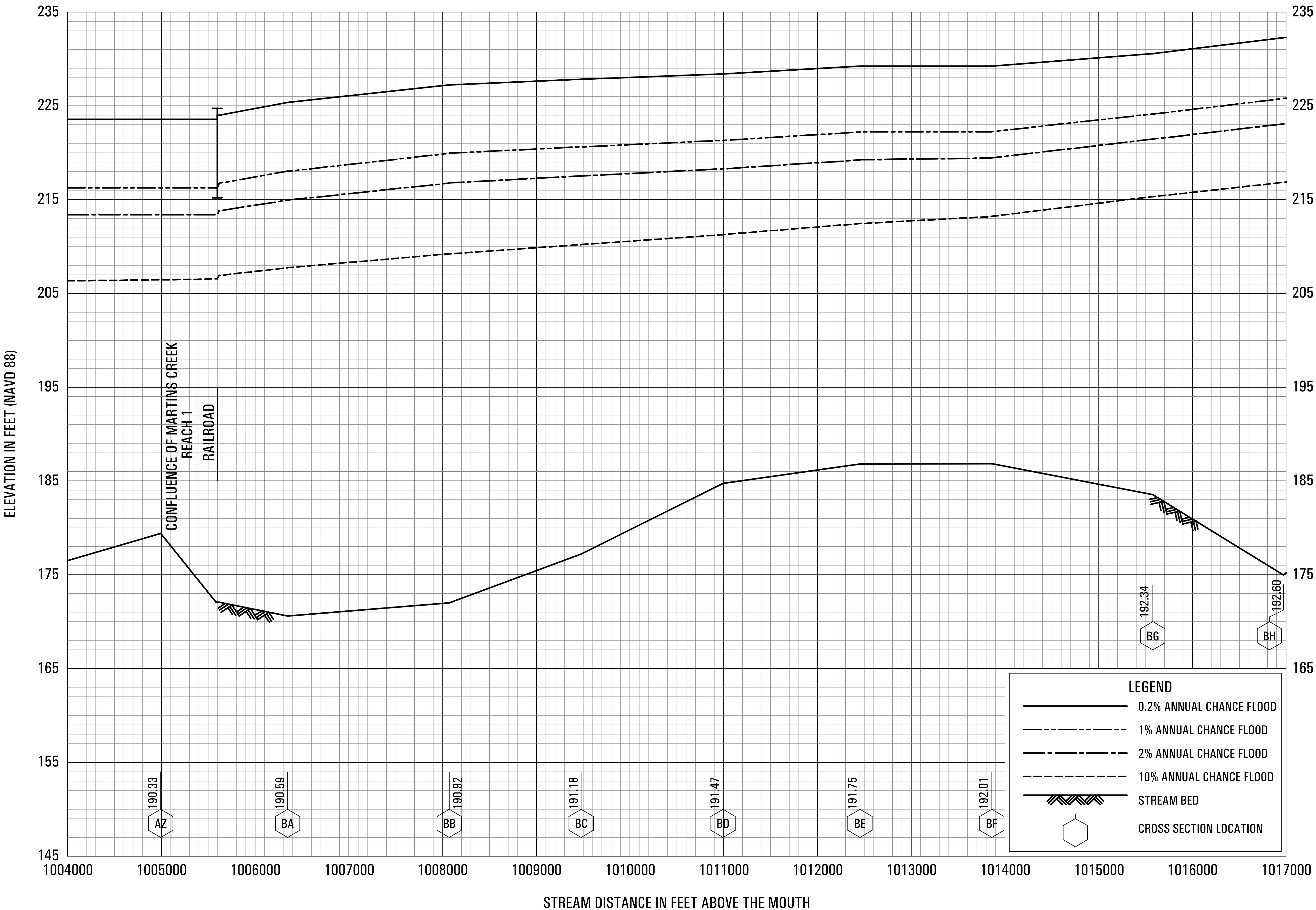
FLOOD PROFILES

DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



FLOOD PROFILES

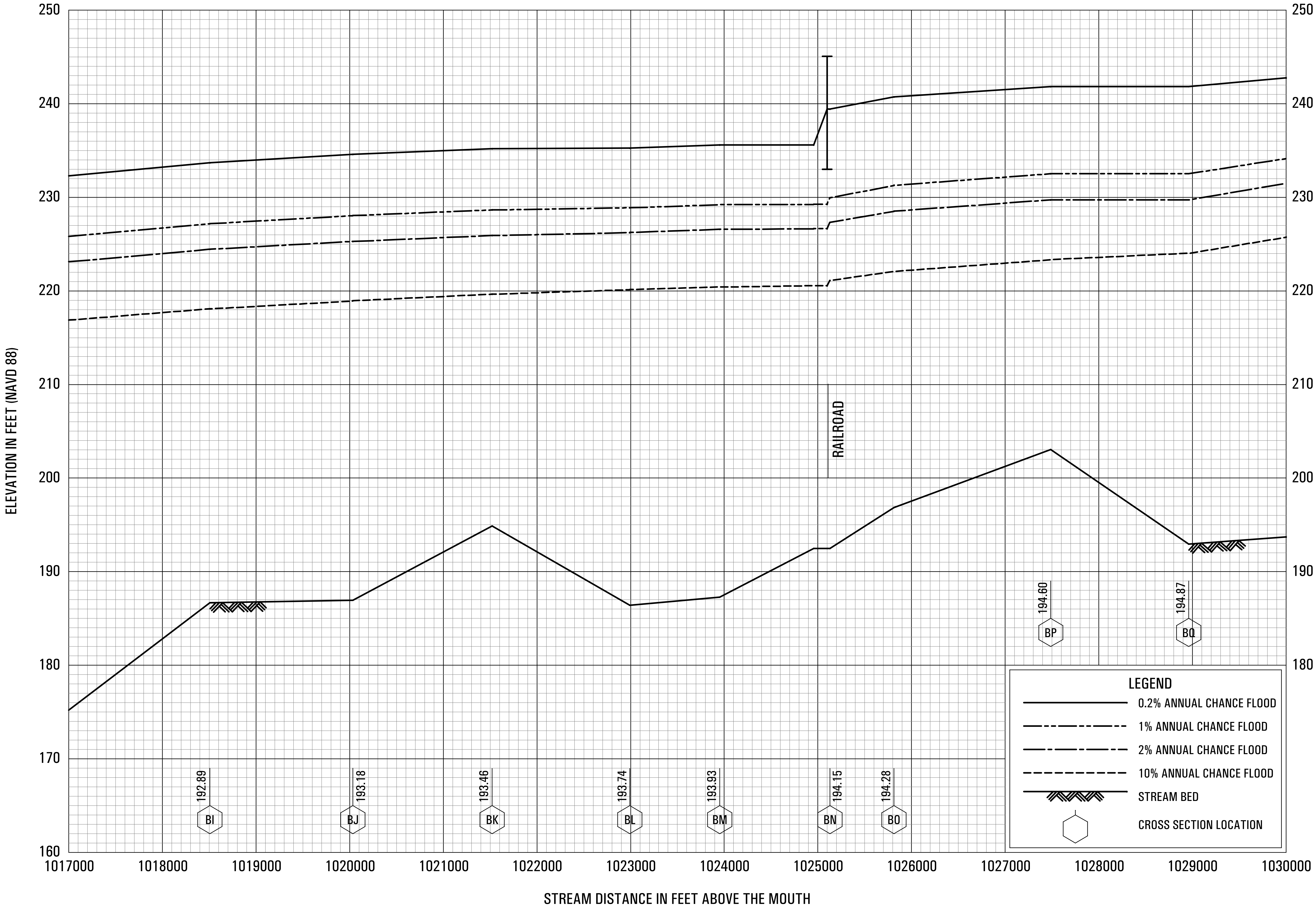
DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)

21P



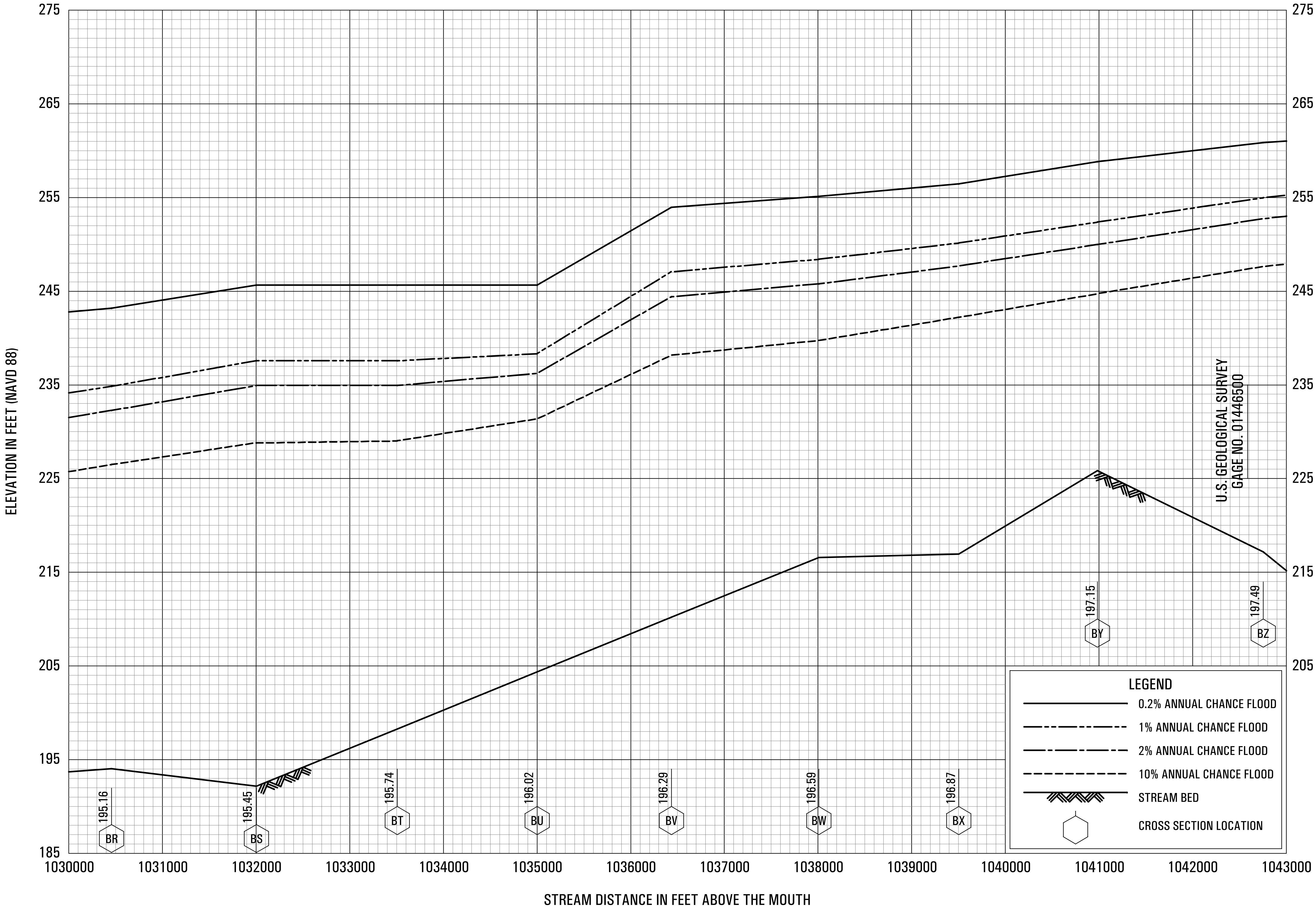
FLOOD PROFILES

DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



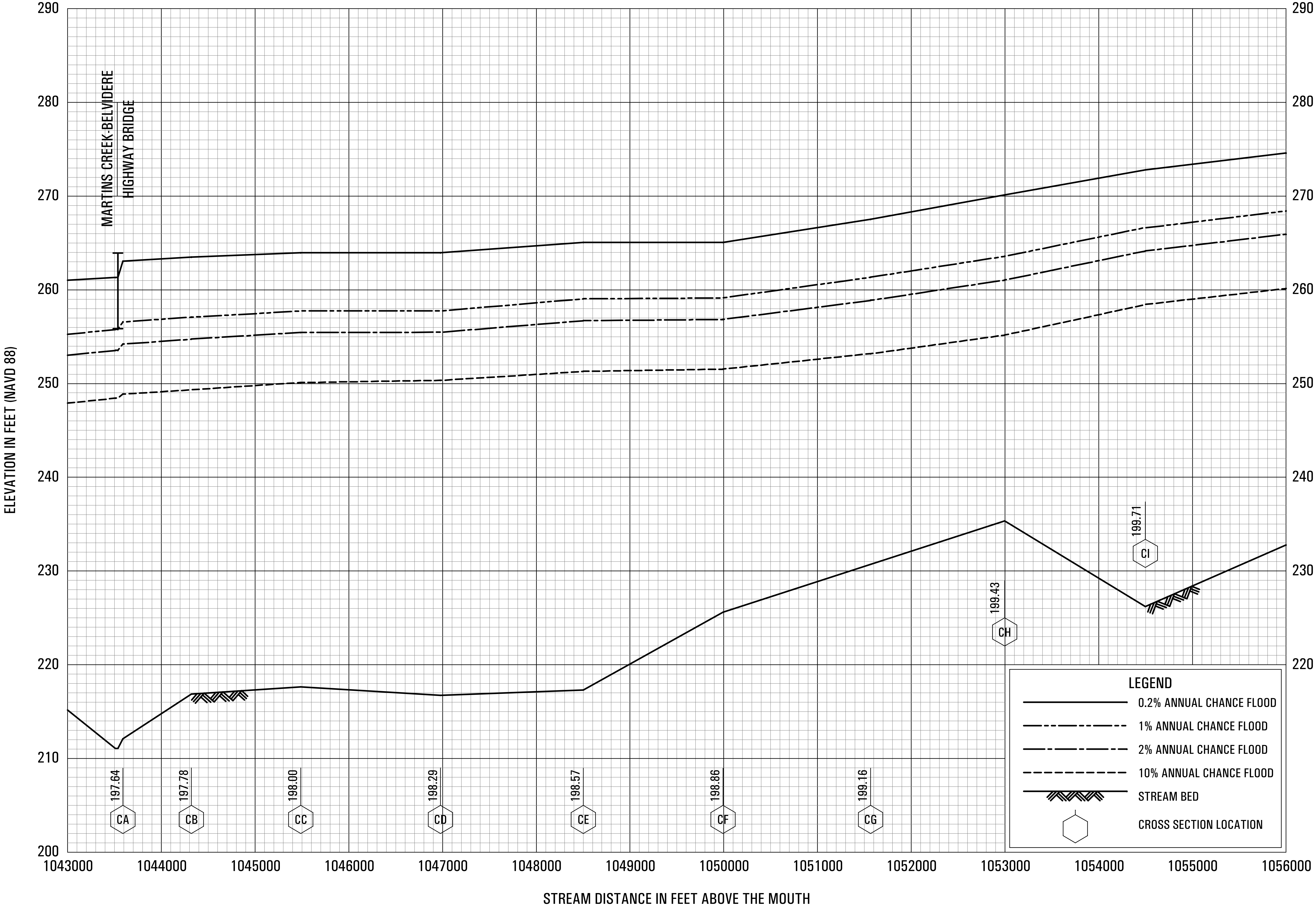
FLOOD PROFILES

DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



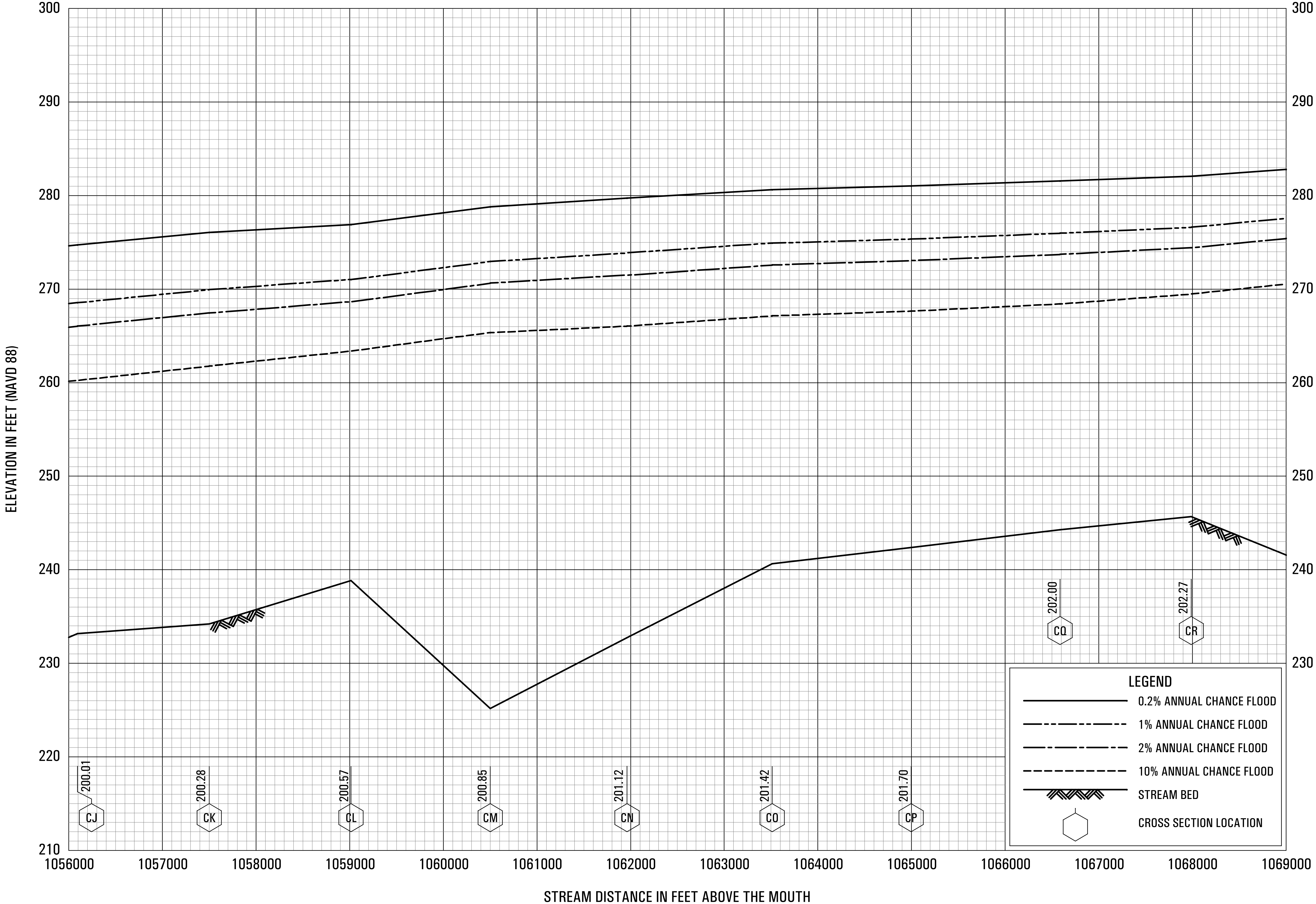
FLOOD PROFILES

DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



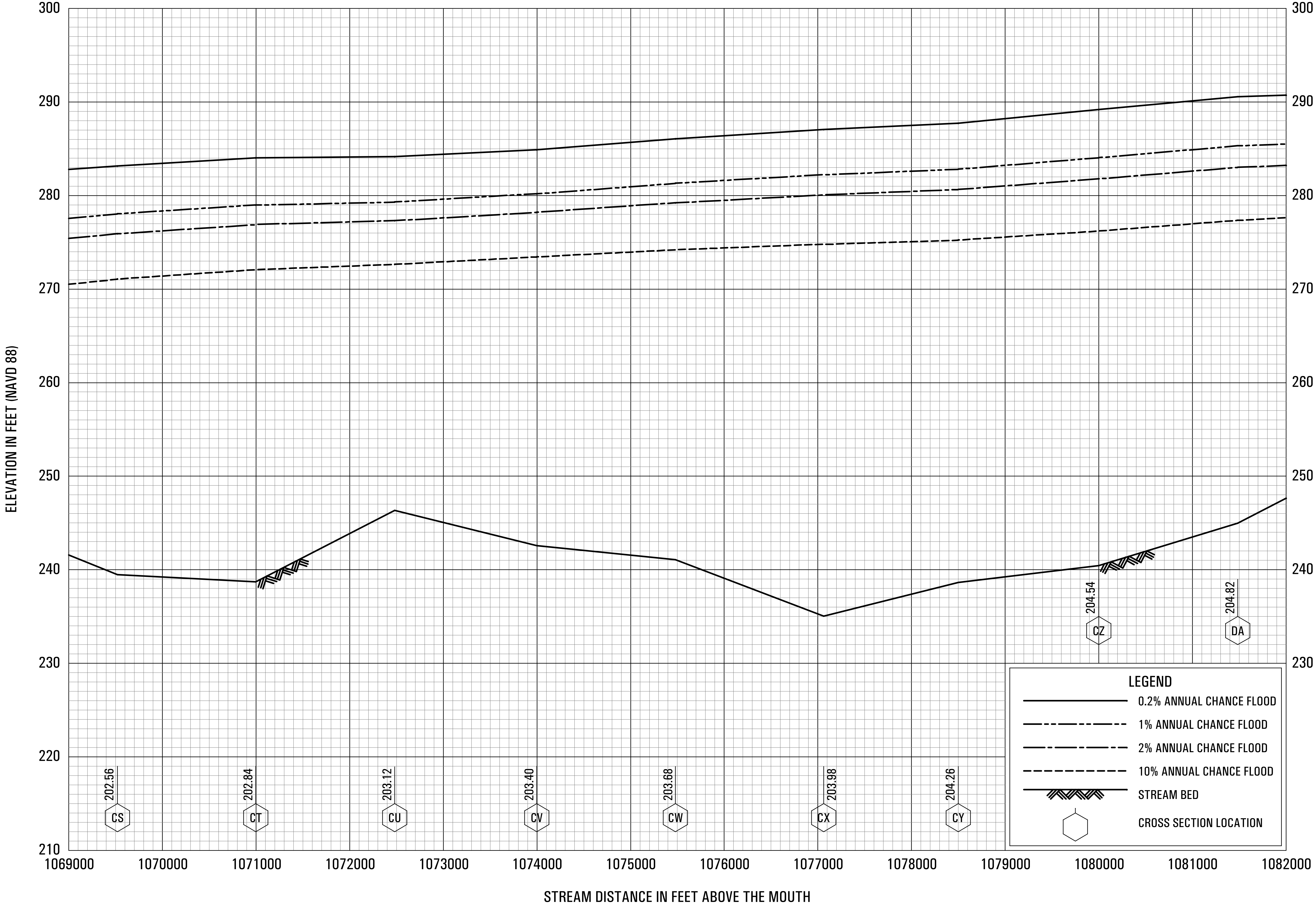
FLOOD PROFILES

DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



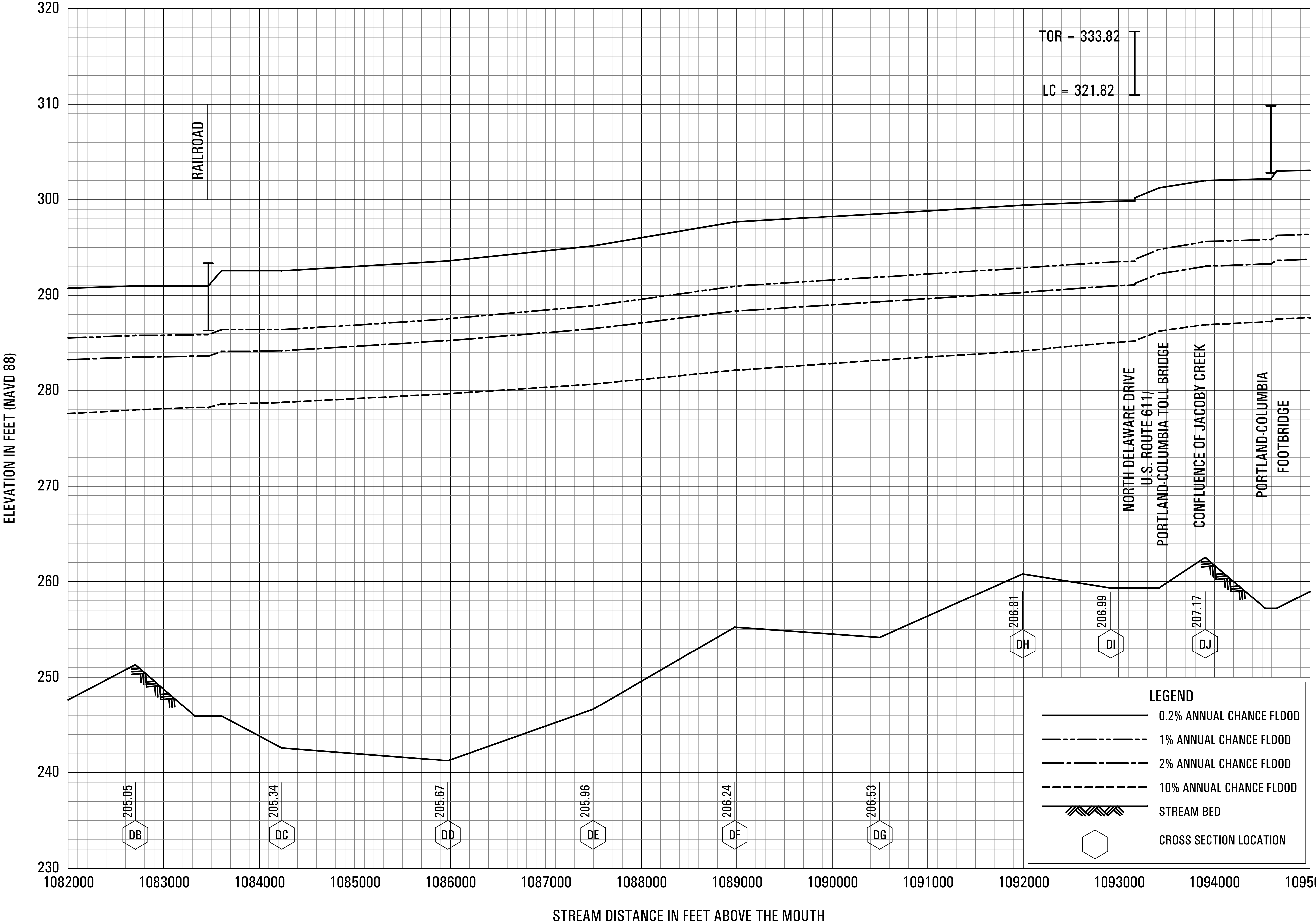
FLOOD PROFILES

DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



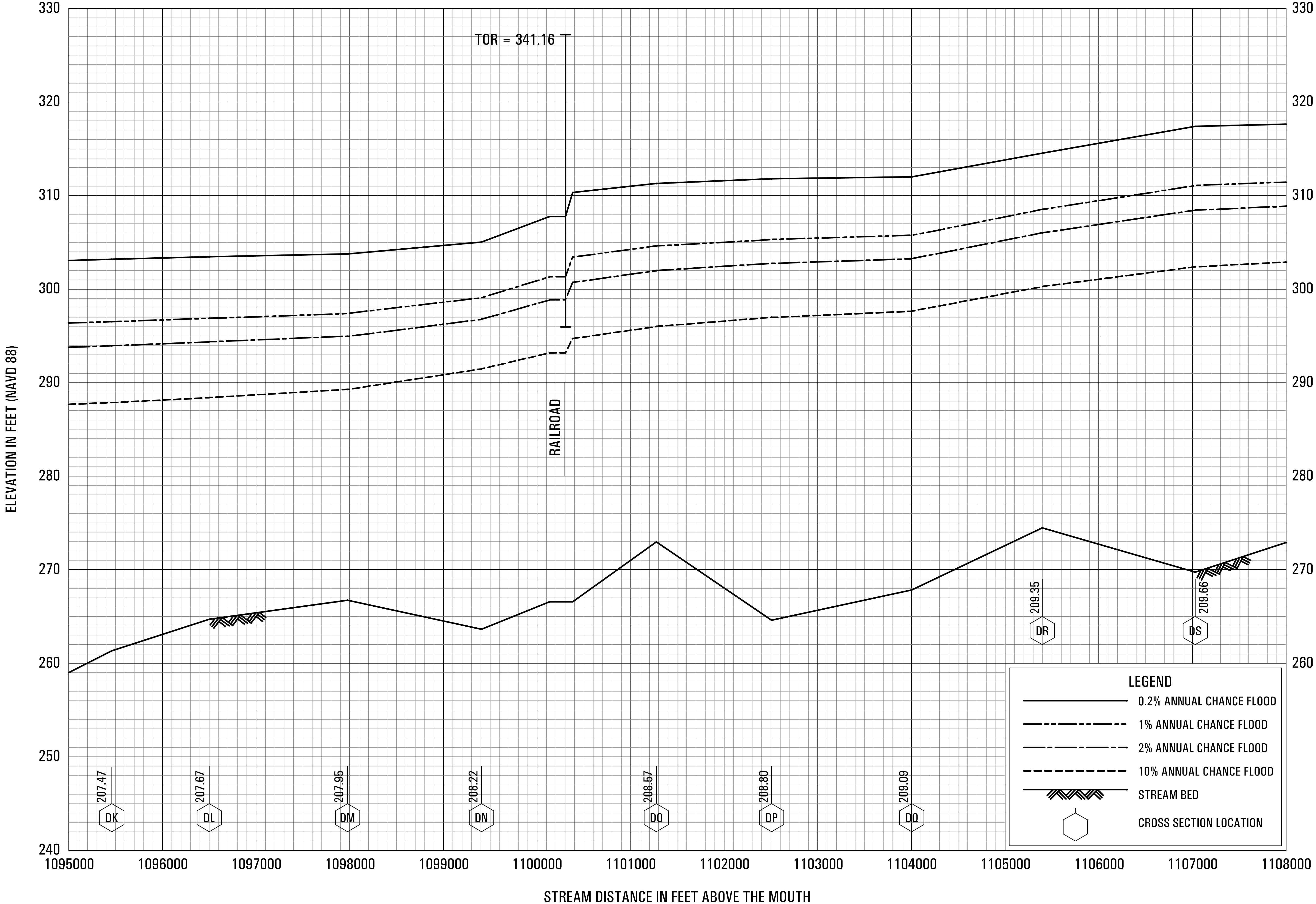
FLOOD PROFILES

DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



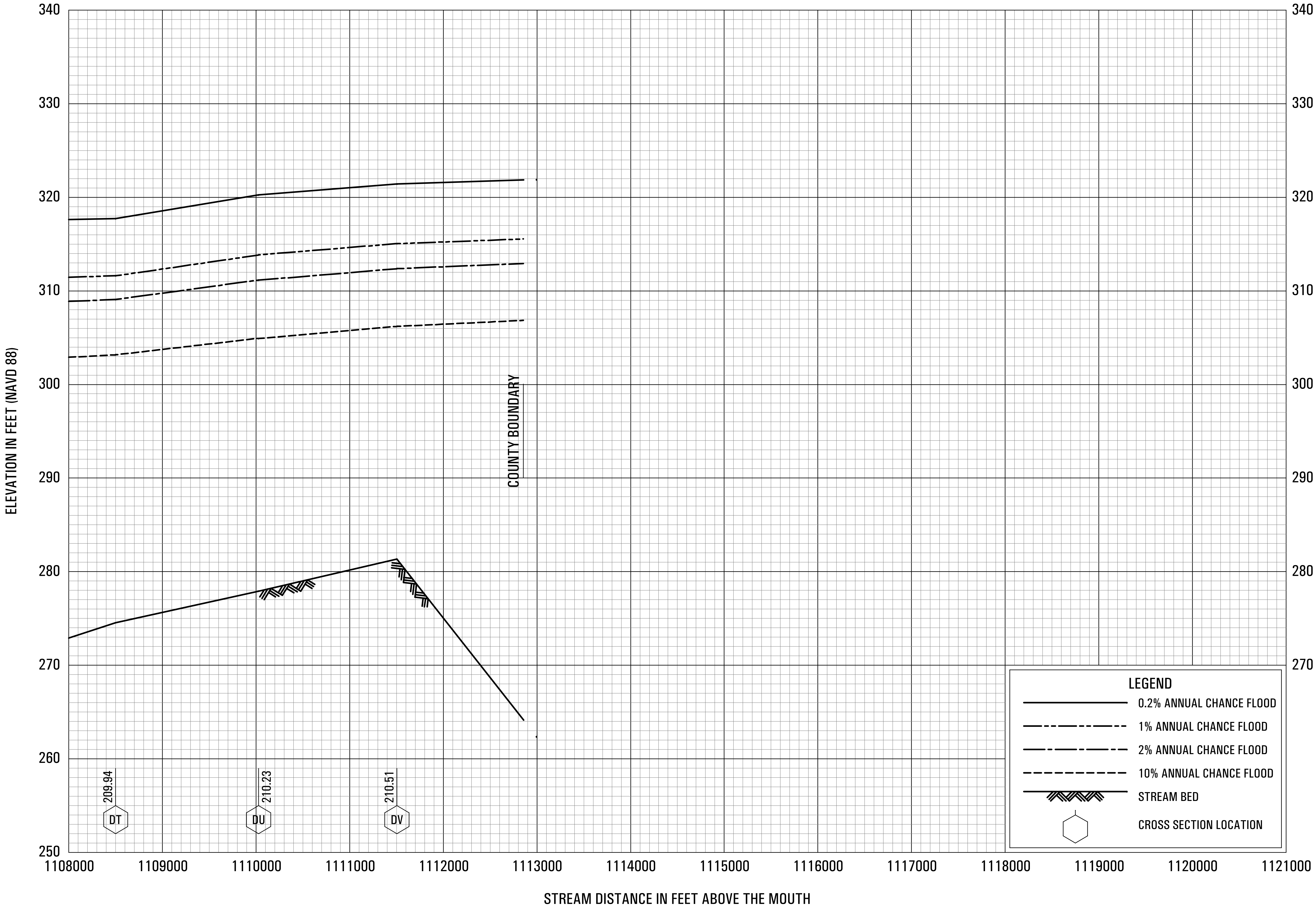
FLOOD PROFILES

DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)



FLOOD PROFILES

DELAWARE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

NORTHAMPTON COUNTY, PA

(ALL JURISDICTIONS)

Appendix F

50-Year Flood Modeling

In addition to the 100-year flood modeling and low flow regimes described in this report, 50-year flood event was also modeled as the suburban flood modeling requirement per DEP requirements. The 5-year flood event was considered to be 497 cfs according to Stream Stats data, as reported previously. Per PADEP chapter 105 any culver design should consider the following criteria:

(a) Bridges and culverts shall be designed and constructed in accordance with the following criteria:

(1) The structure shall pass flood flows without loss of stability.

(2) The structure may not create or constitute a hazard to life or property, or both.

(3) The structure may not materially alter the natural regimen of the stream.

(4) The structure may not so increase velocity or direct flow in a manner which results in erosion of stream beds and banks.

(5) The structure may not significantly increase water surface elevations.

(6) The structure shall be consistent with local flood plain management programs.

(b) In determining flood flows and frequencies for purposes of this subchapter, hydrologic analysis shall be by methods generally accepted in the engineering profession.

(c) The general criteria for design flows are as follows:

(1) Rural area-25-year frequency flood flow.

(2) Suburban area-50-year frequency flood flow.

(3) Urban area-100-year frequency flood flow.

(d) The determination of flood flows for design shall be made with reasonable consideration of development which may alter the runoff characteristics of the watershed during the anticipated life of the structure. Specific design requirements in subsection (c) may be varied to fit the conditions at the site and the requirements of flood plain management regulations and ordinances.

(e) The structures shall pass the 100-year frequency flood with less than a 1.0-foot increase in the natural unobstructed 100-year water surface elevation, except where the structure would be located in a floodway which is delineated on a FEMA map, in which case no increase in the 100-year water surface elevation will be permitted. Exceptions to this criteria may be approved by the Department if the applicant prepares a risk assessment which demonstrates, and the Department finds, that the structure will not significantly increase the flooding threat to life and property or the environment, and if applicable, is consistent with municipal floodplain management programs adopted under the National Flood Insurance Program and a FEMA Flood Insurance Study. This information may be obtained from the Department of Community Affairs, Floodplain Management Division, Forum Building, Harrisburg, Pennsylvania 17120.

25 Pa. Code § 105.161

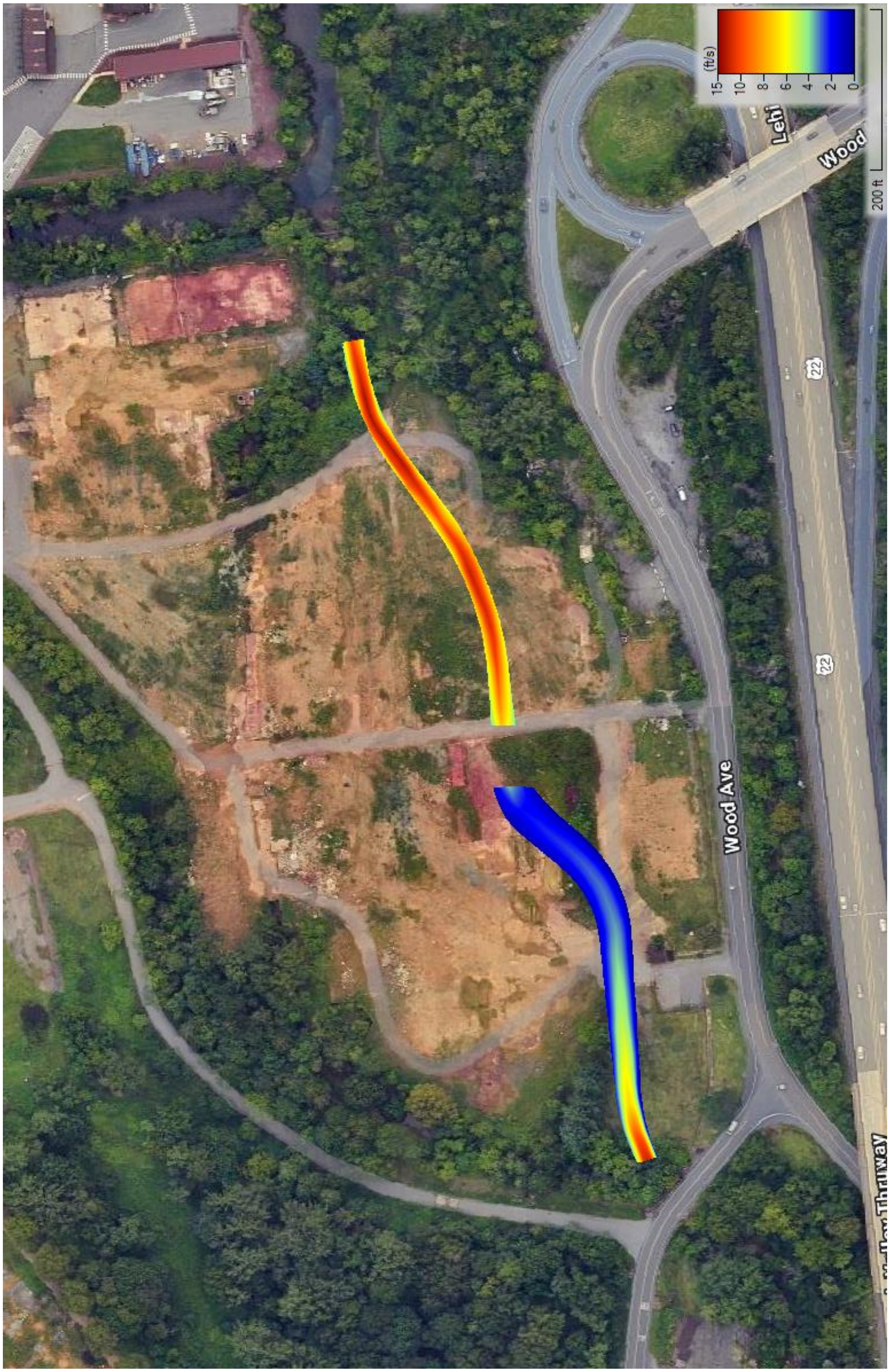
The provisions of this §105.161 adopted August 11, 1978, effective 8/28/1978, 8 Pa.B. 2229; amended September 26, 1980, effective 9/27/1980, 10 Pa.B. 3843; amended October 11, 1991, effective 10/12/1991, 21 Pa.B. 4911.

The provisions of this §105.161 amended under the Dam Safety and Encroachments Act (32 P. S. §§ 693.1-693.27); The Clean Streams Law (35 P. S. §§ 691.1-691.1001); section 7 of the act of June 14, 1923 (P. L. 704, No. 294) (32 P. S. § 597); sections 514, 1901-A, 1908-A, 1917-A and 1920-A of The Administrative Code of 1929 (71 P. S. §§ 194, 510-1, 510-8, 510-17 and 510-20); and the Flood Plain Management Act (32 P. S. §§ 679.101-679.601).

All the above-mentioned criteria are not only met for 50-year but for 100-year flood event. The following sections present the plan view, profile, sections, output table, and warning summary of the 50-year flood modeling.

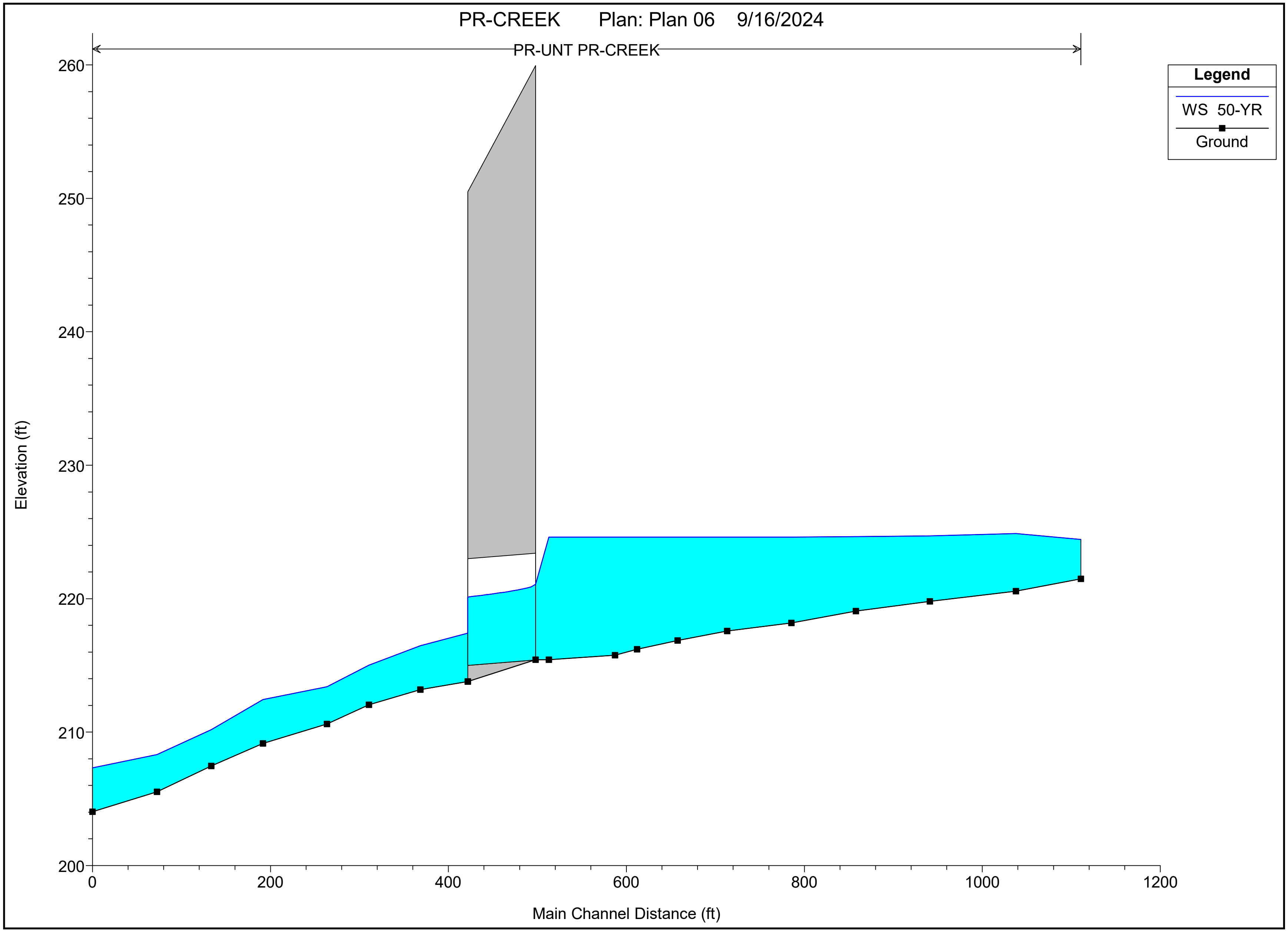
50-year inundation boundary (floodplain)

50-year water surface elevation

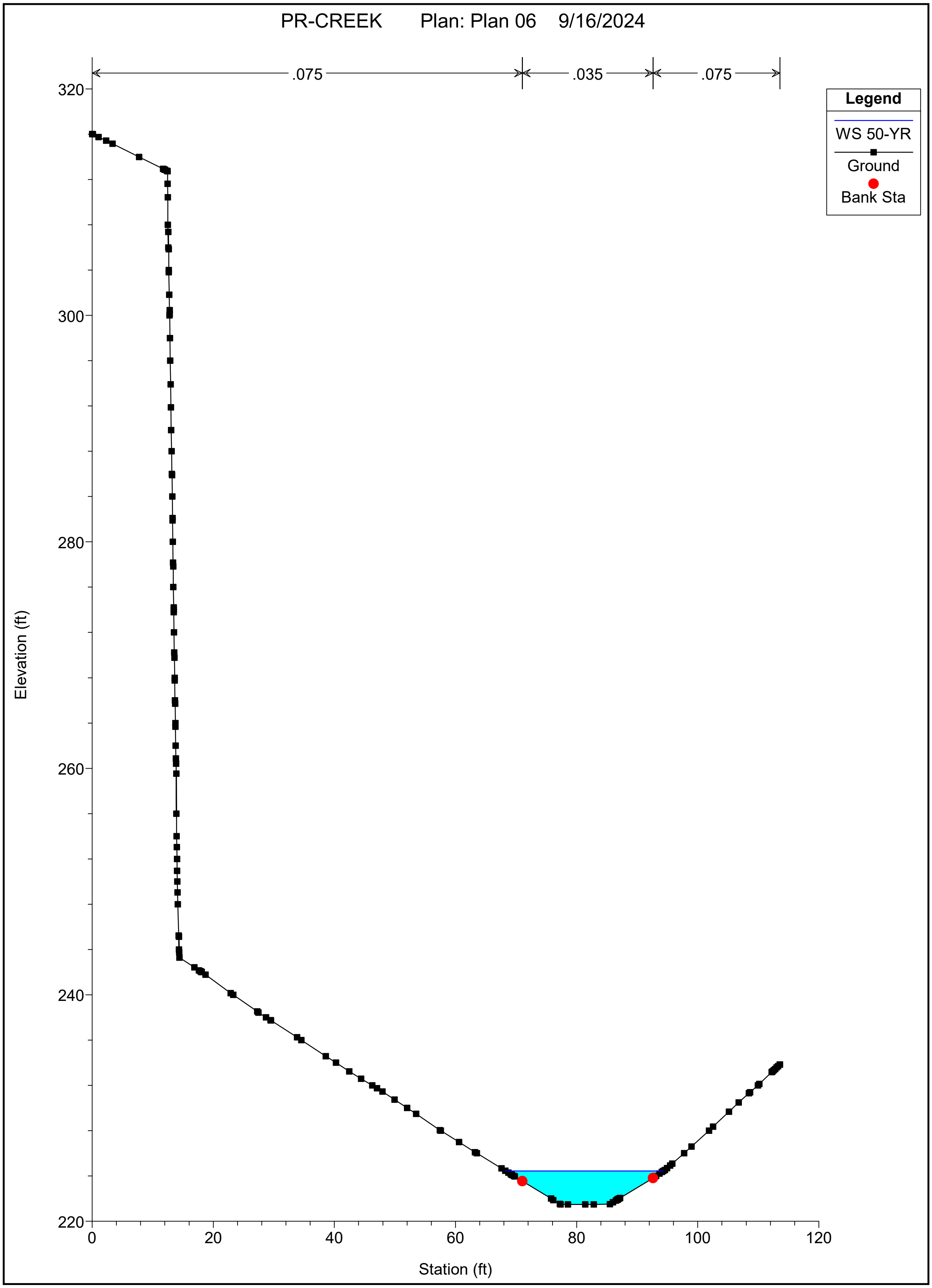


5- year bed velocity (ft/sec)

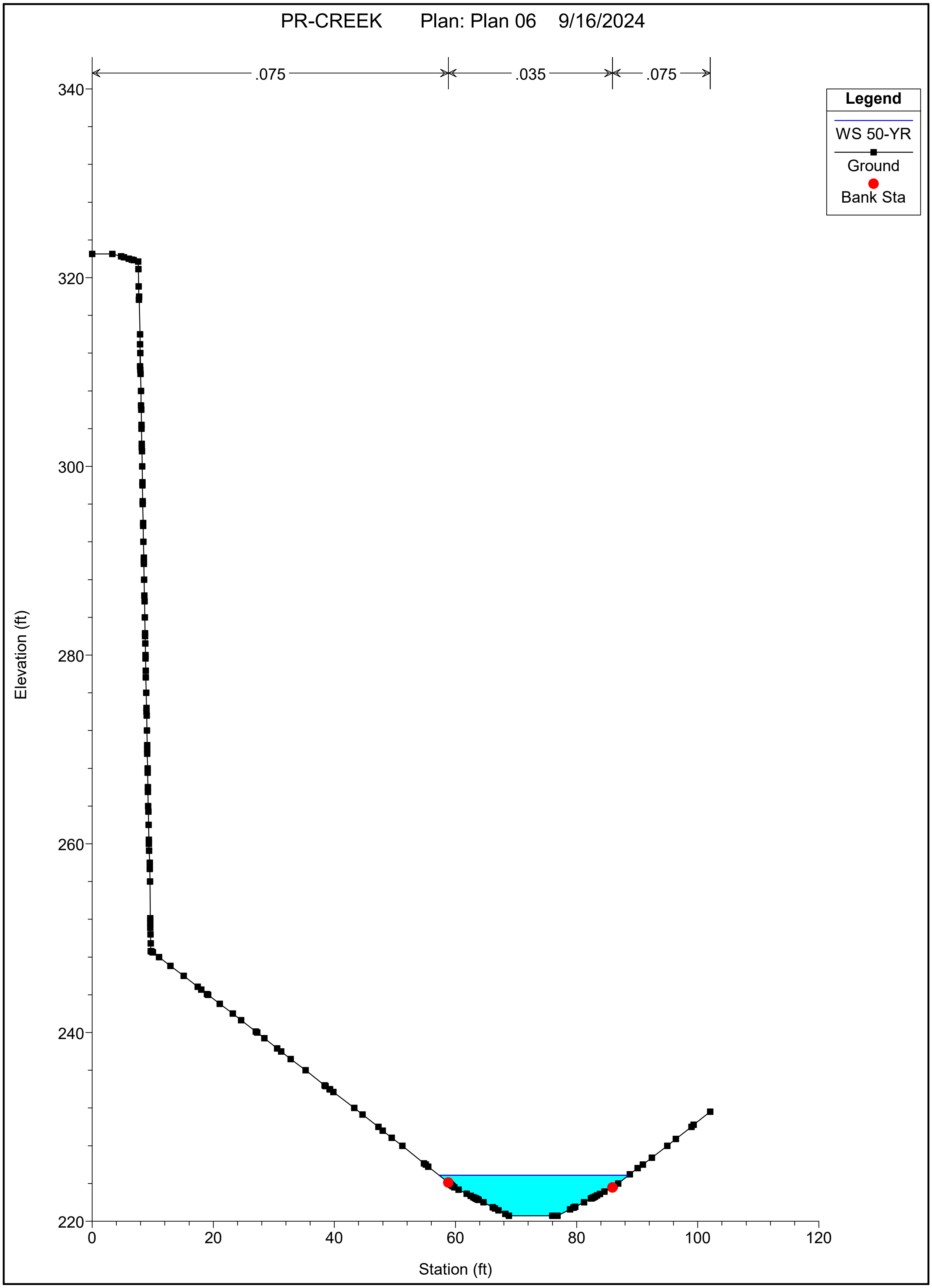
50-year flow depth (ft)

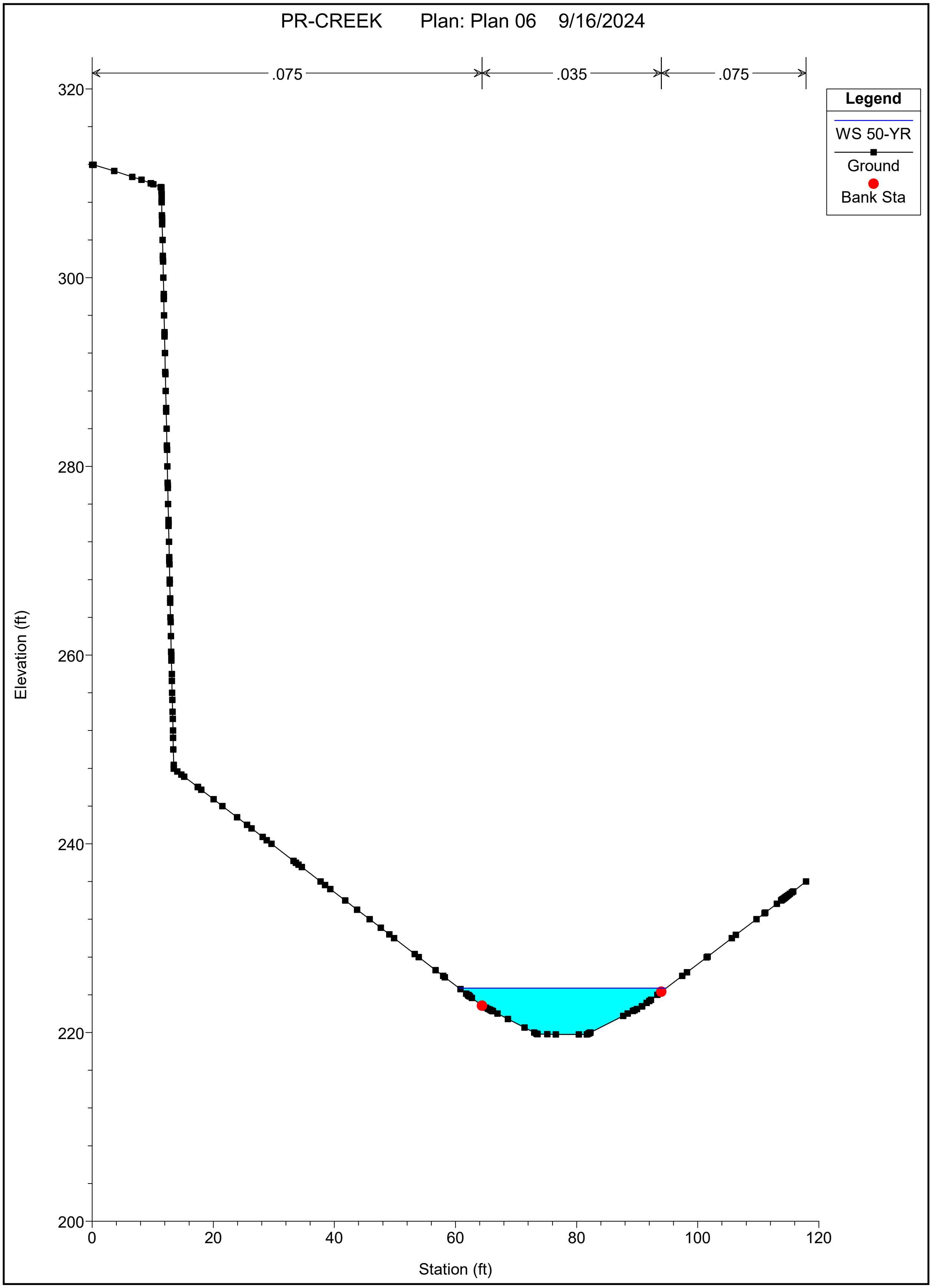


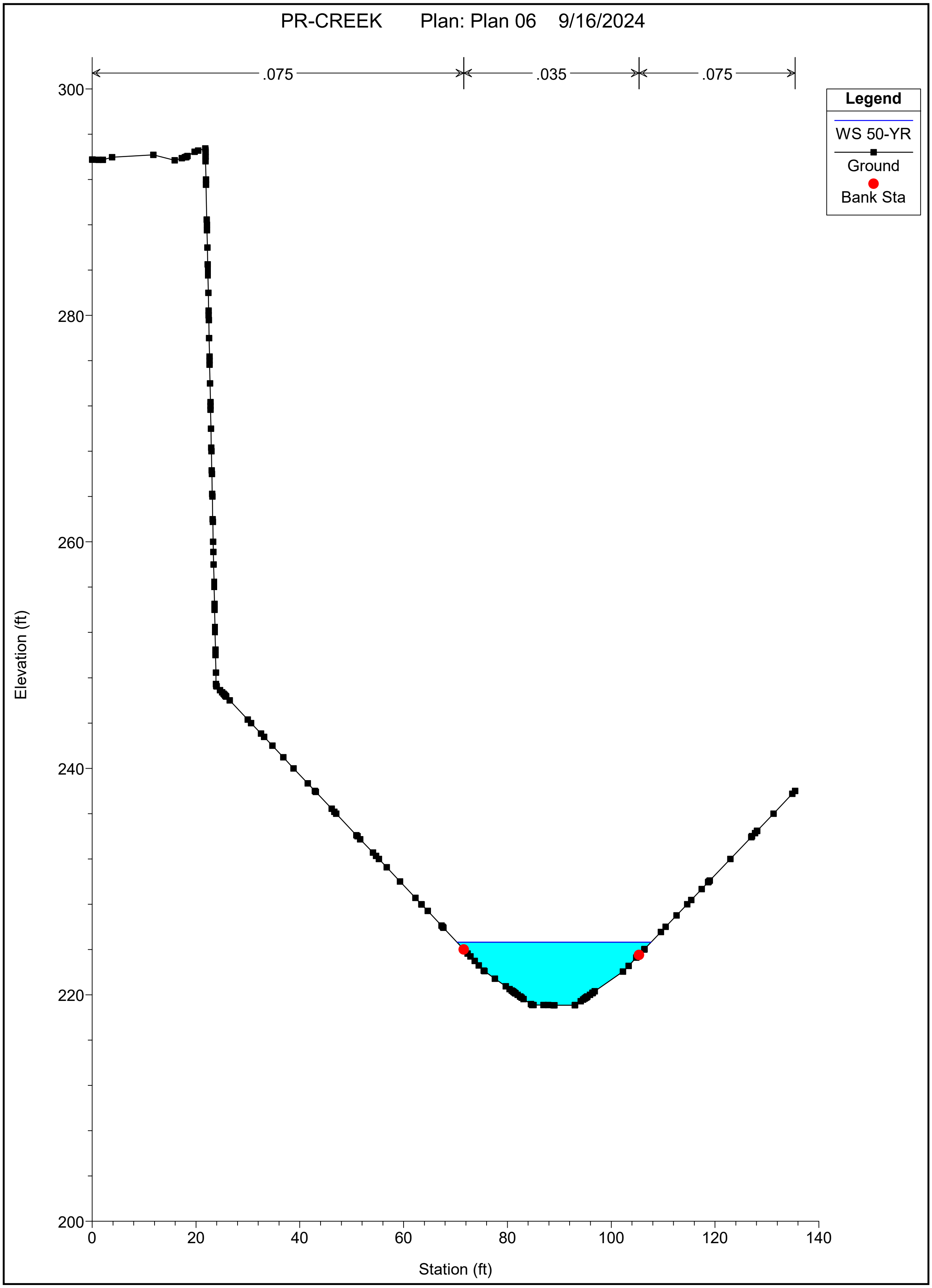
PR-CREEK Plan: Plan 06 9/16/2024
PR-UNT PR-CREEK
Legend
WS 50-YR
Ground
Elevation (ft)
260
250
240
230
220
210
200
0
200
400
600
800
1000
1200
Main Channel Distance (ft)

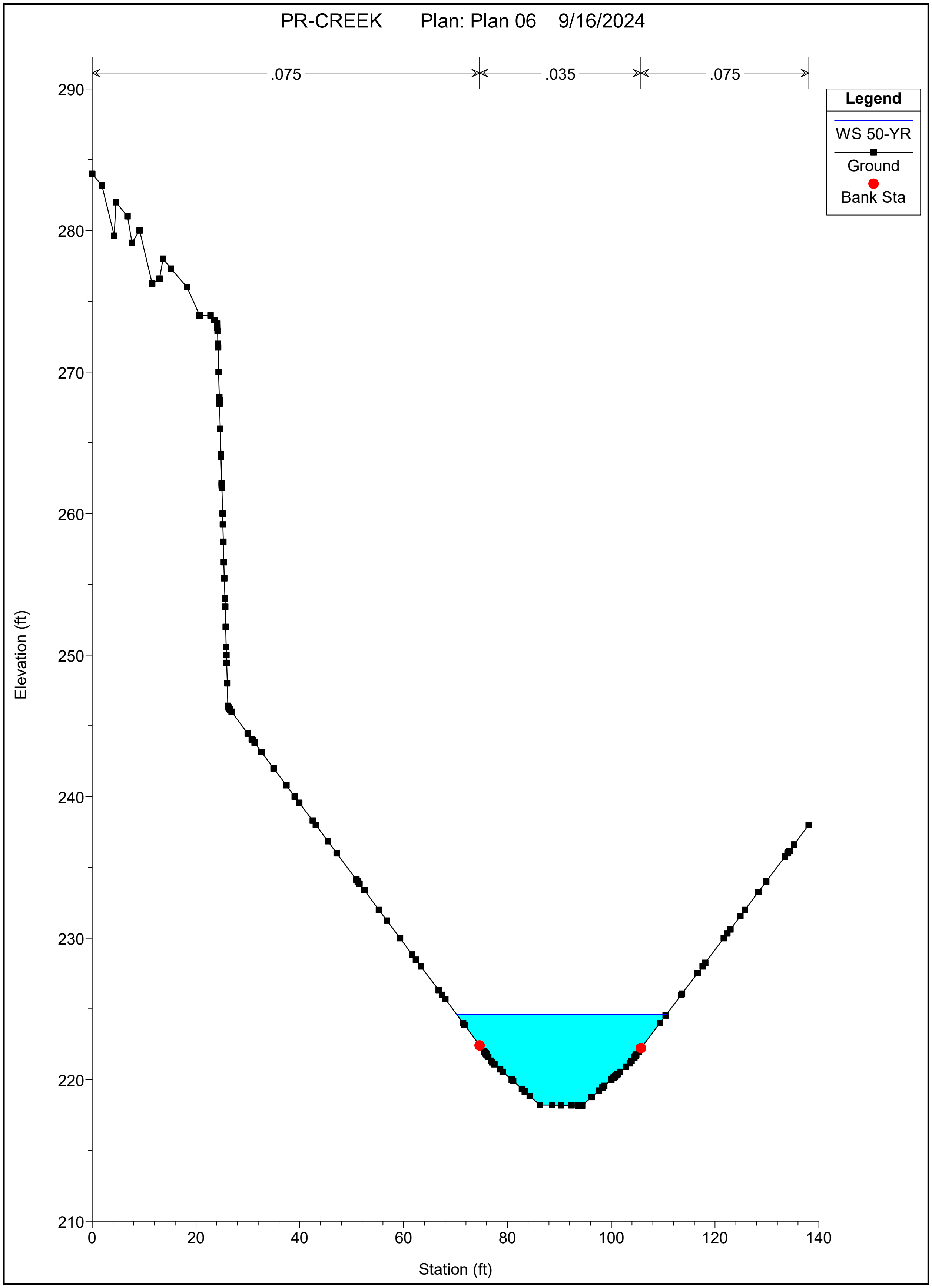


PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
320
300
280
260
240
220
0
20
40
60
80
100
120

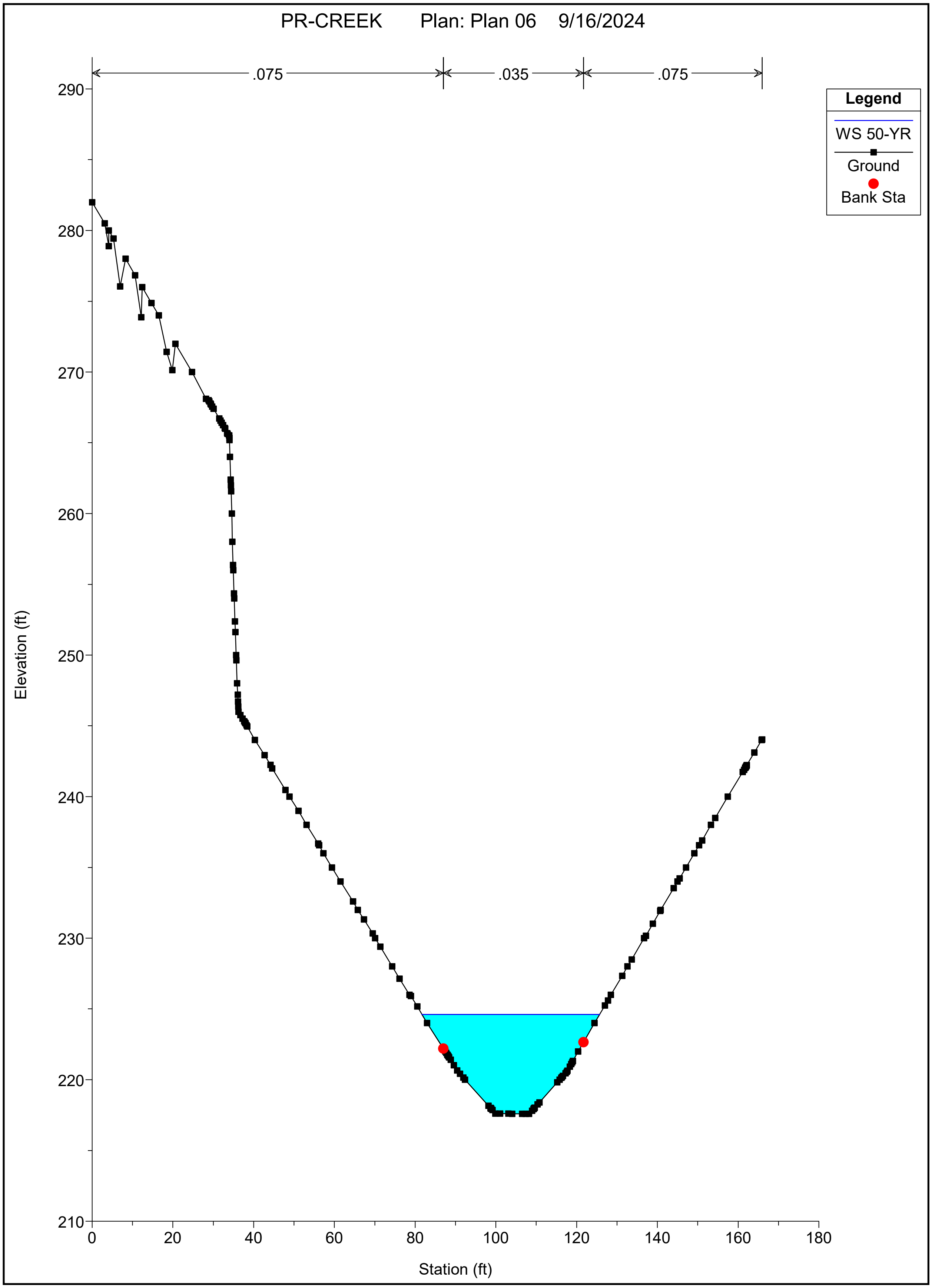

PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
340
320
300
280
260
240
220
0
20
40
60
80
100
120


PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
320
300
280
260
240
220
200
0
20
40
60
80
100
120

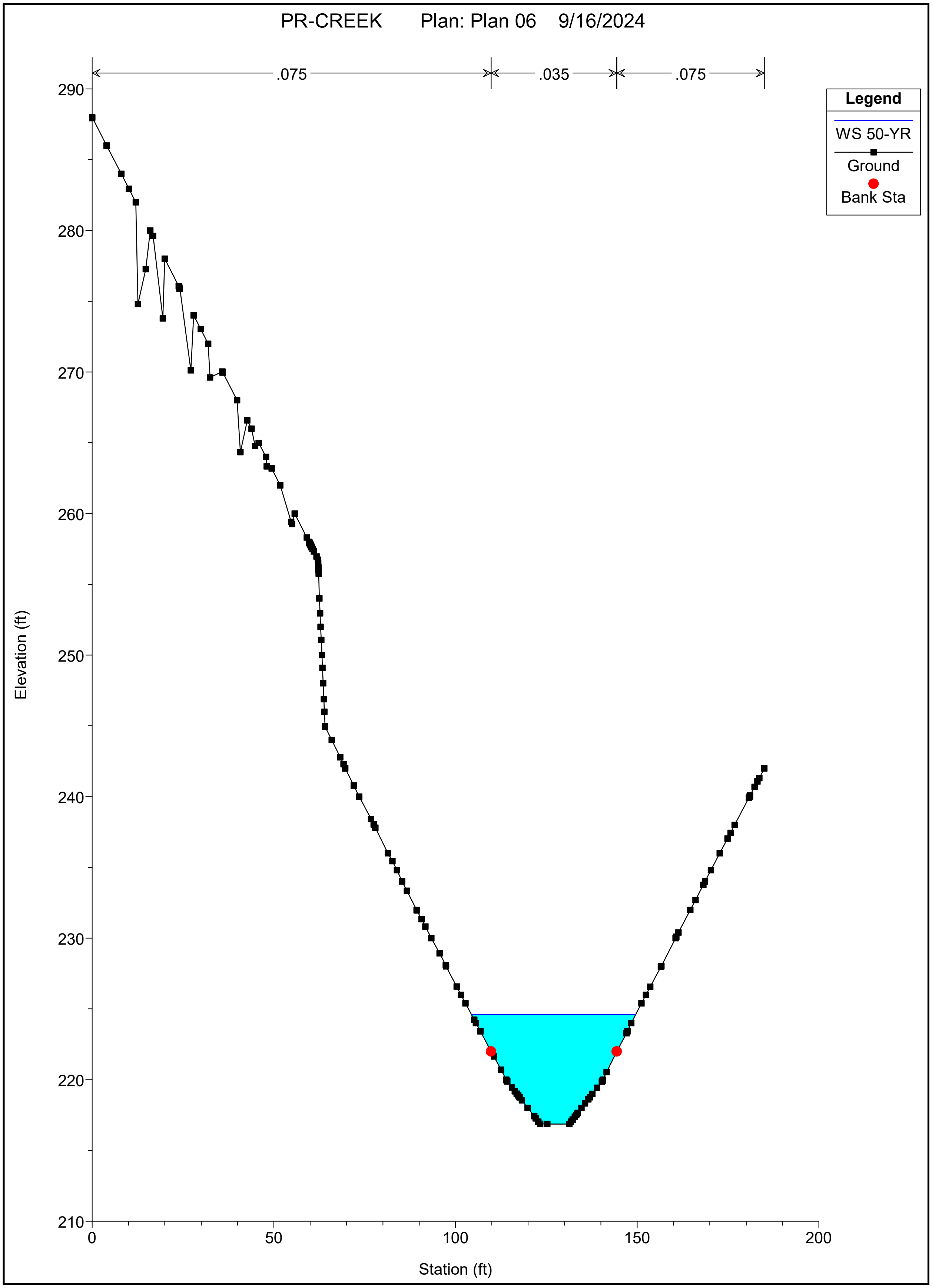

PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
300
280
260
240
220
200
0
20
40
60
80
100
120
140

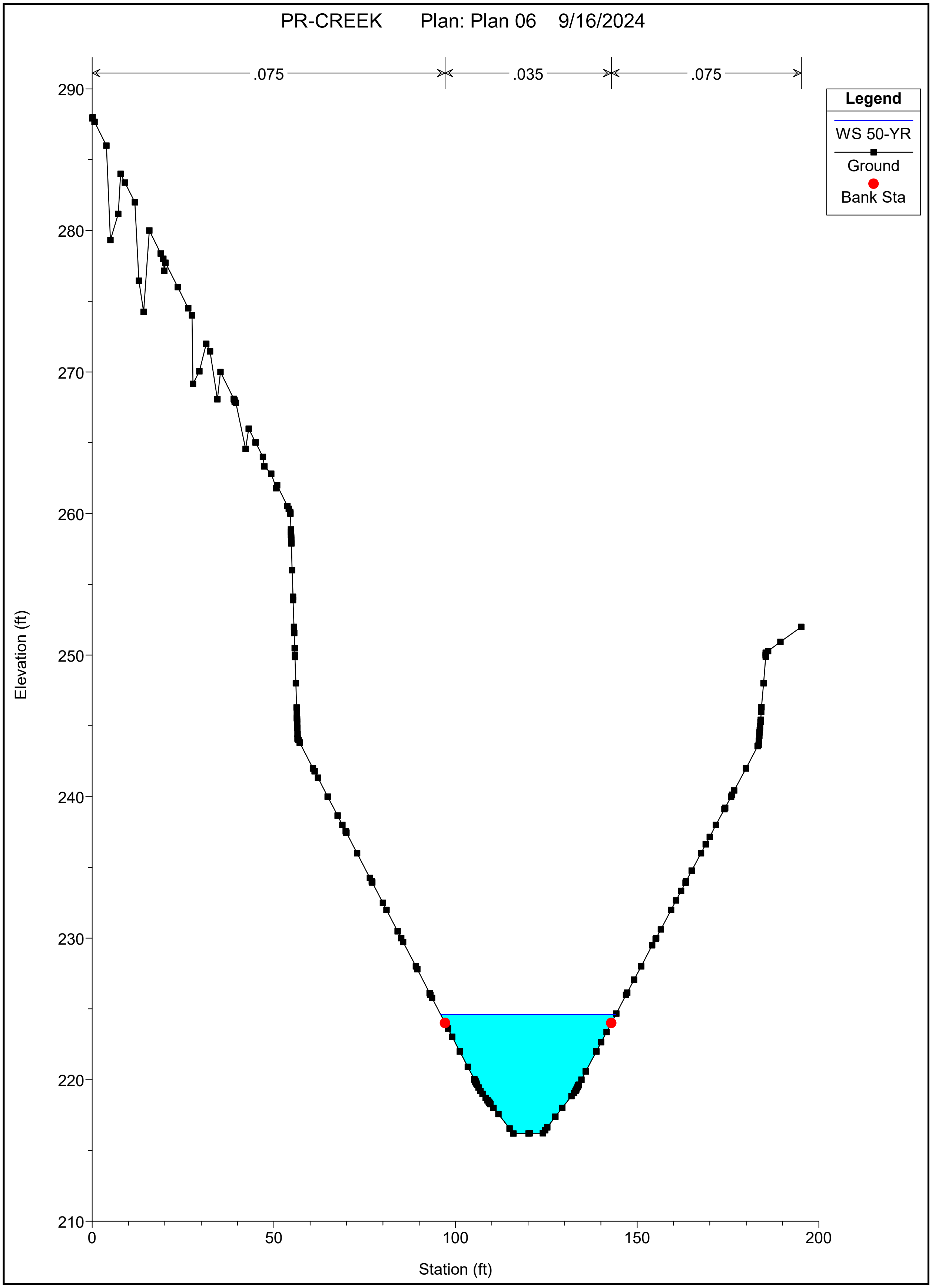


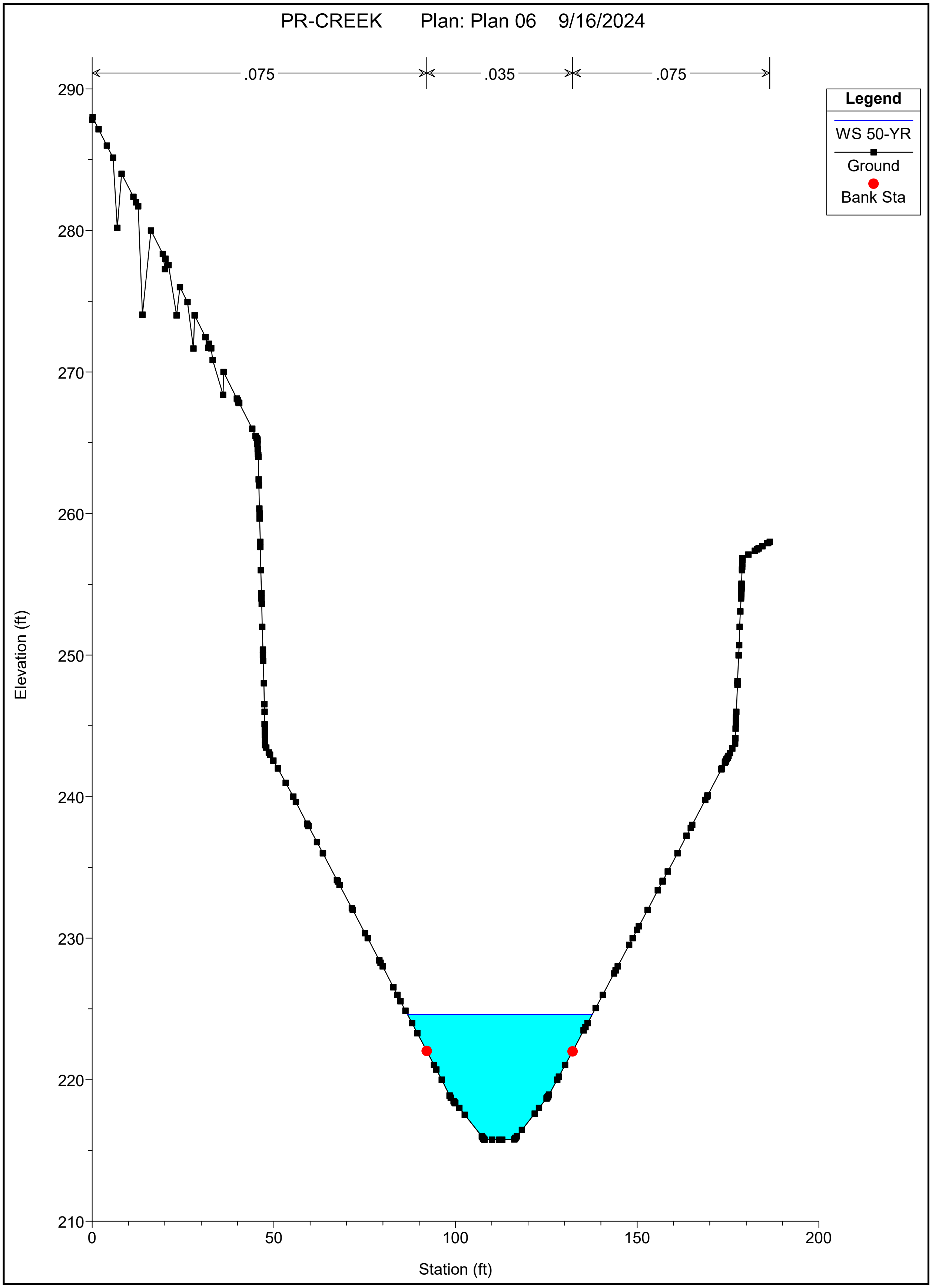
PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
290
280
270
260
250
240
230
220
210
0
20
40
60
80
100
120
140



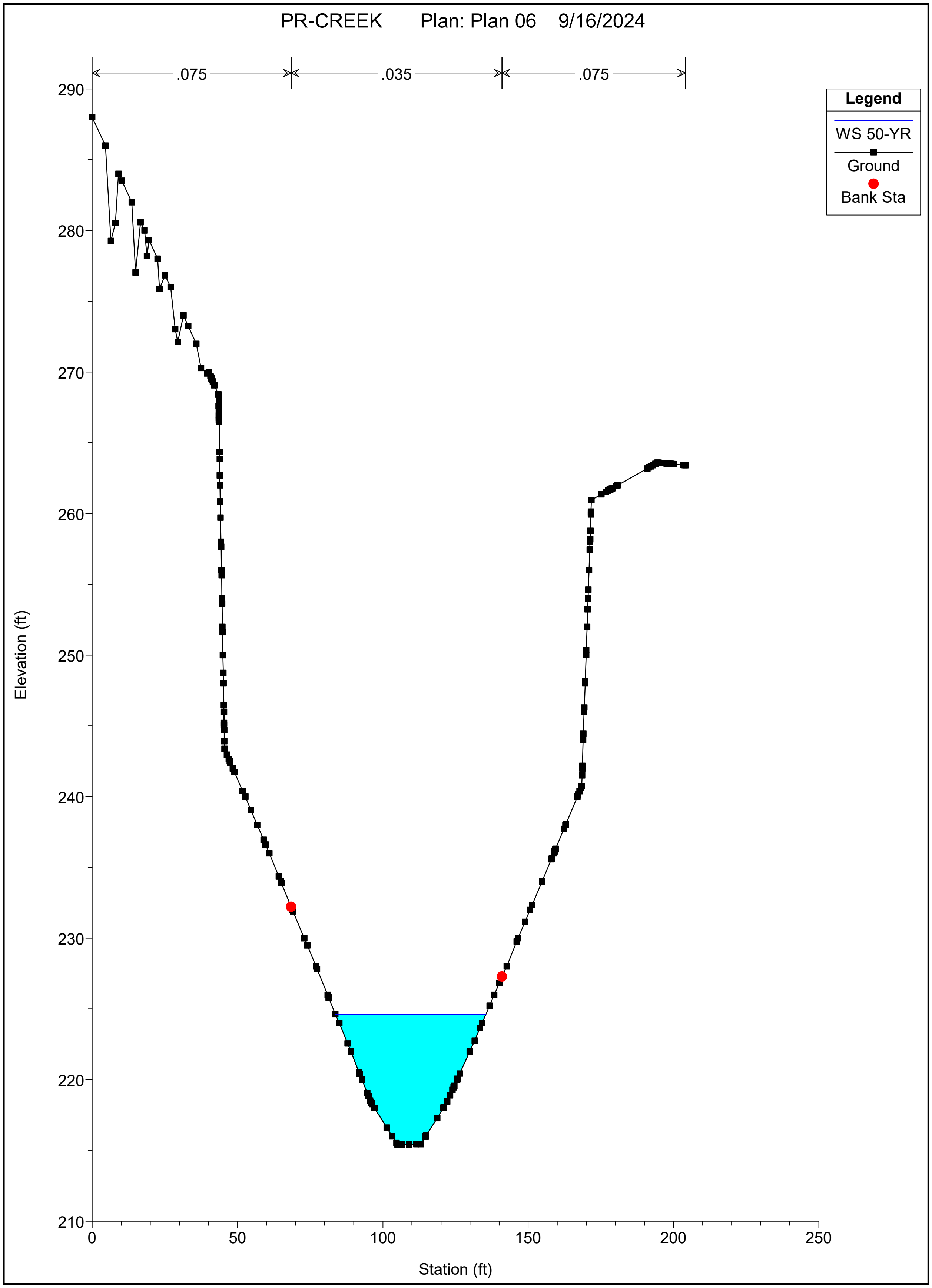
PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
290
280
270
260
250
240
230
220
210
0
20
40
60
80
100
120
140
160
180


PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
290
280
270
260
250
240
230
220
210
0
50
100
150
200

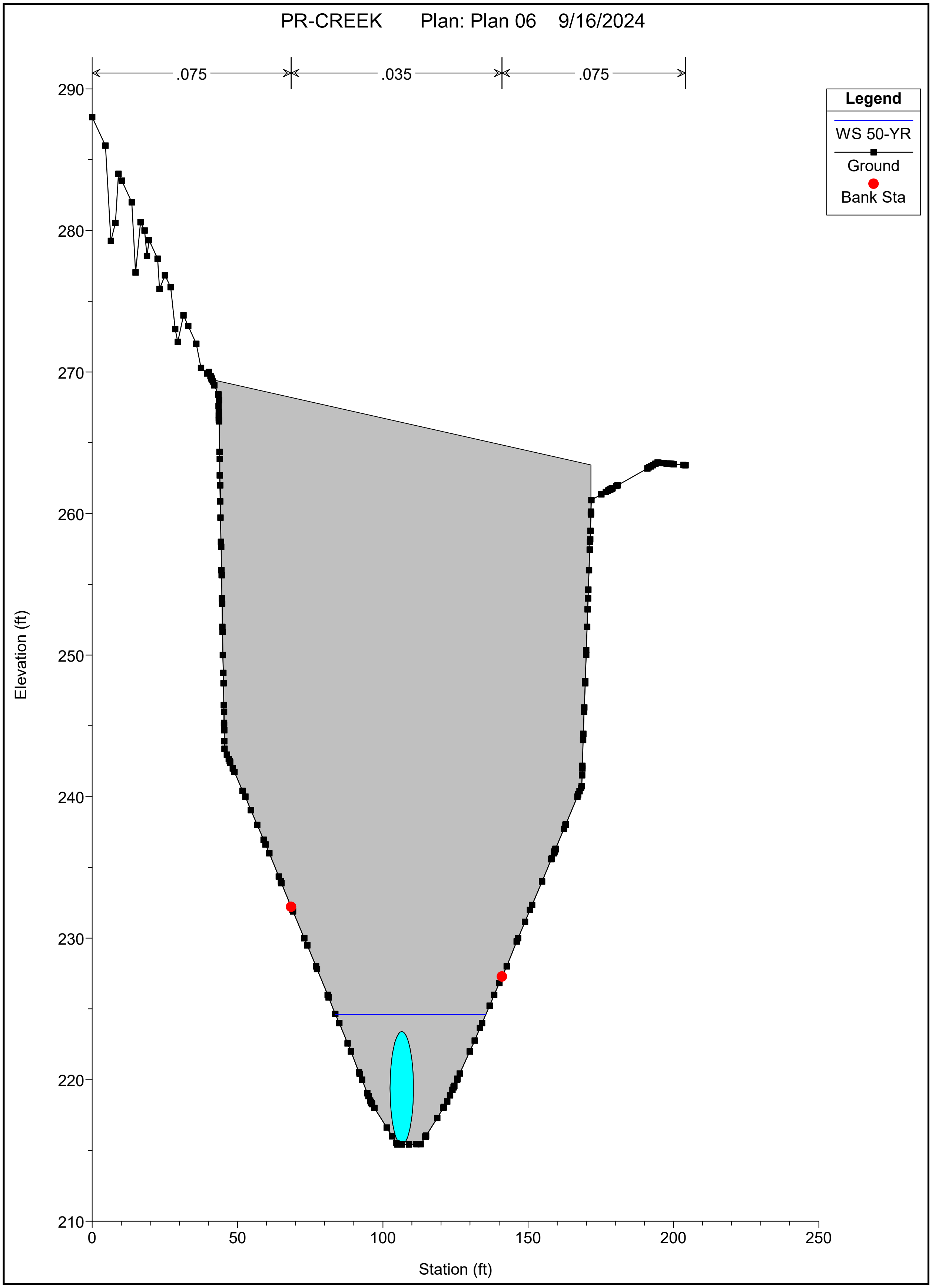

PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
290
280
270
260
250
240
230
220
210
0
50
100
150
200

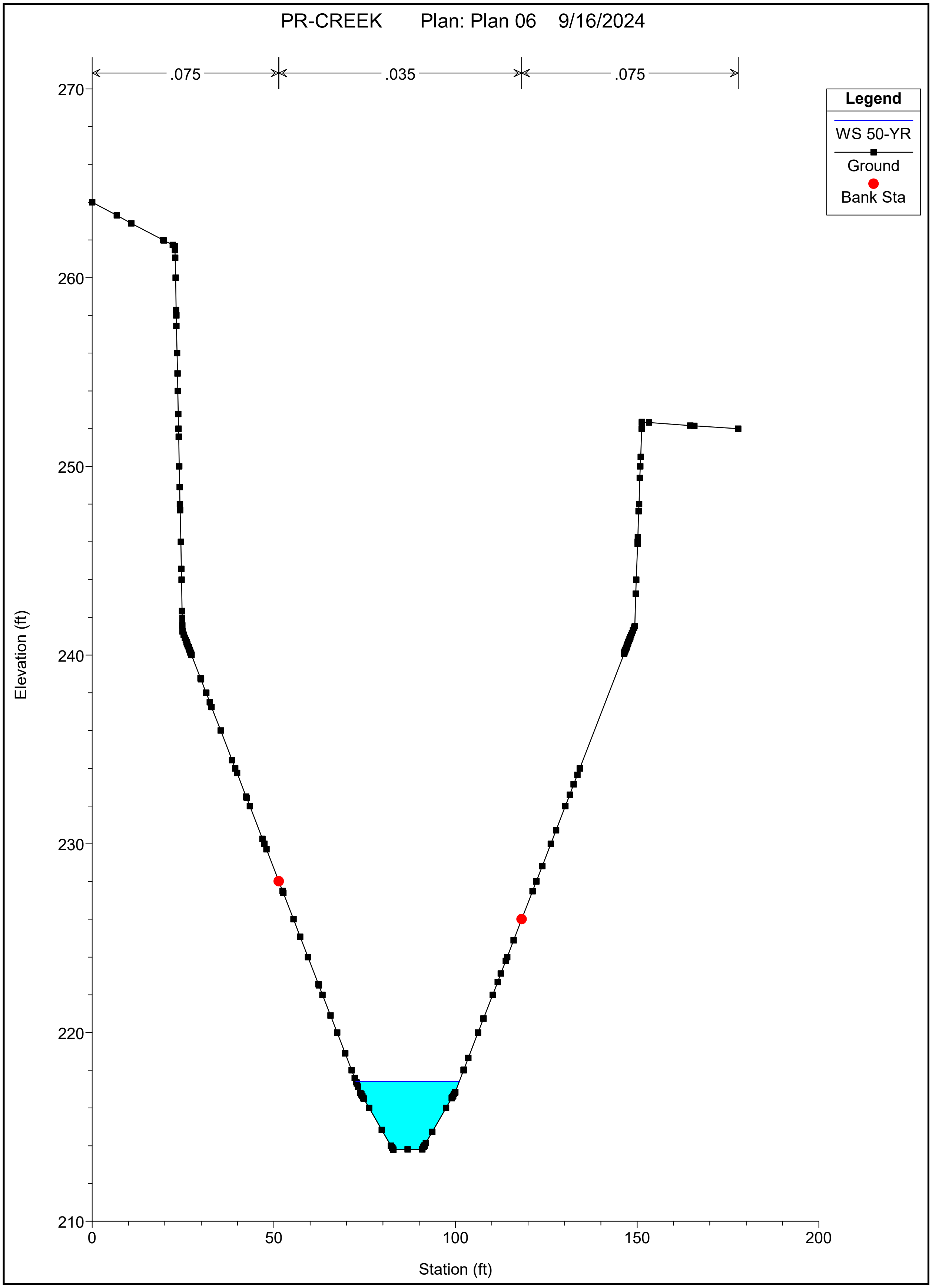


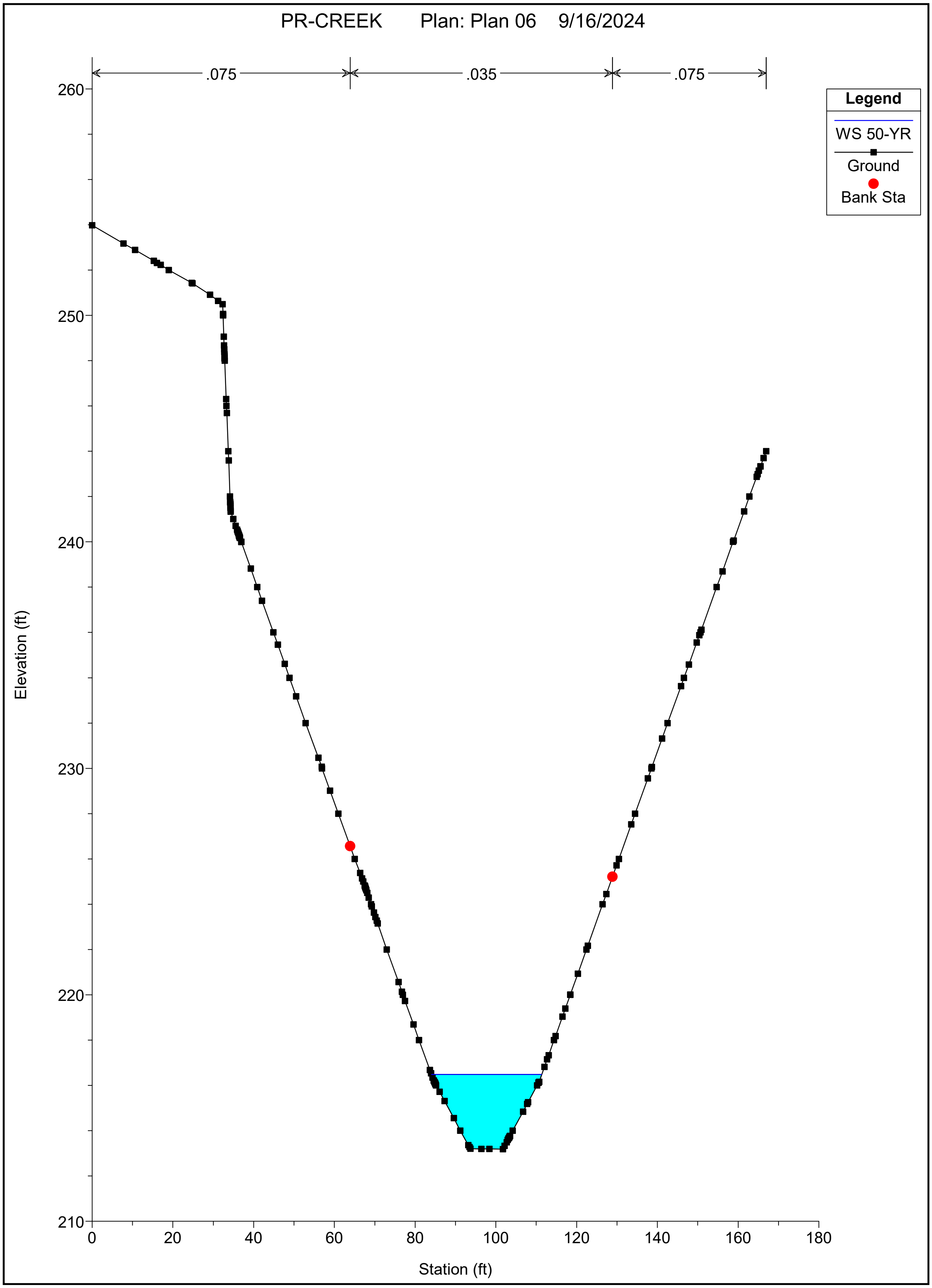
PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
290
280
270
260
250
240
230
220
210
0
50
100
150
200



PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
290
280
270
260
250
240
230
220
210
0
50
100
150
200
250
Station (ft)


PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
290
280
270
260
250
240
230
220
210
0
50
100
150
200
250


PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
270
260
250
240
230
220
210
0
50
100
150
200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.035
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Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
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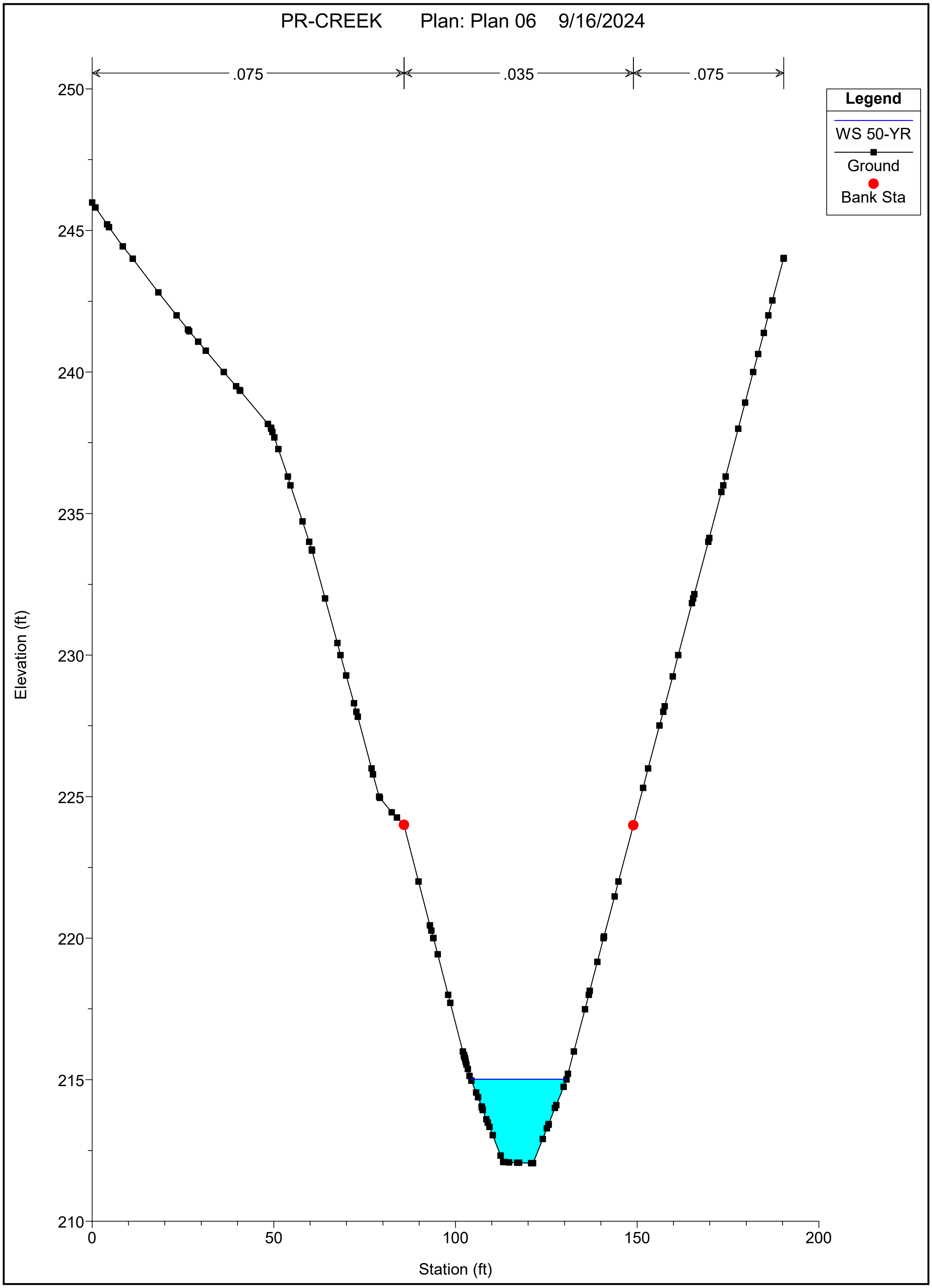
250
240
230
220
210
Station (ft)
0
20
40
60
80
100
120
140
160
180



PR-CREEK Plan: Plan 06 9/16/2024
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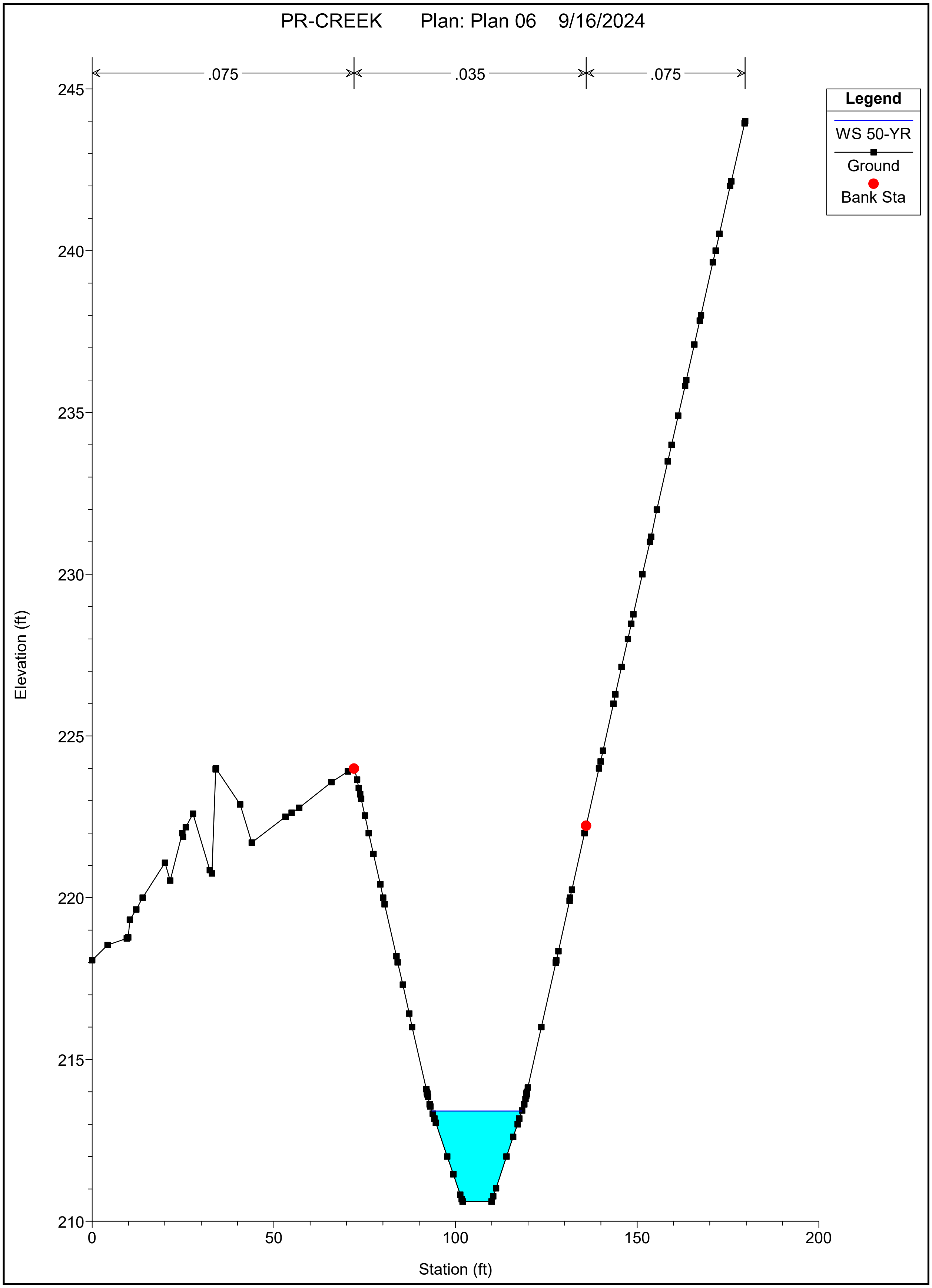
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
250
245
240
235
230
225
220
215
210
0
50
100
150
200


PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
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Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
245
240
235
230
225
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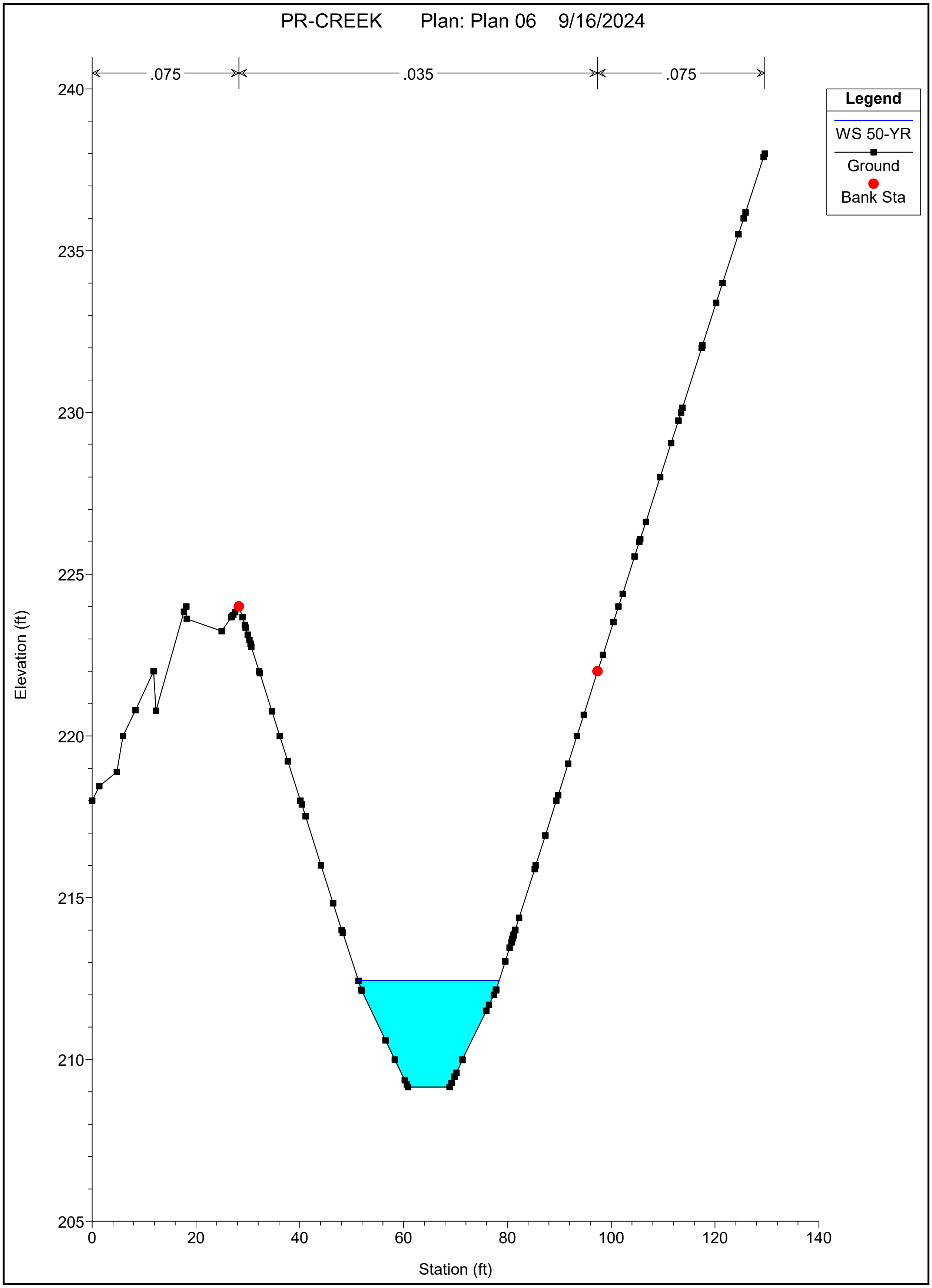
PR-CREEK Plan: Plan 06 9/16/2024
.075
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Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
240
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230
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210
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120
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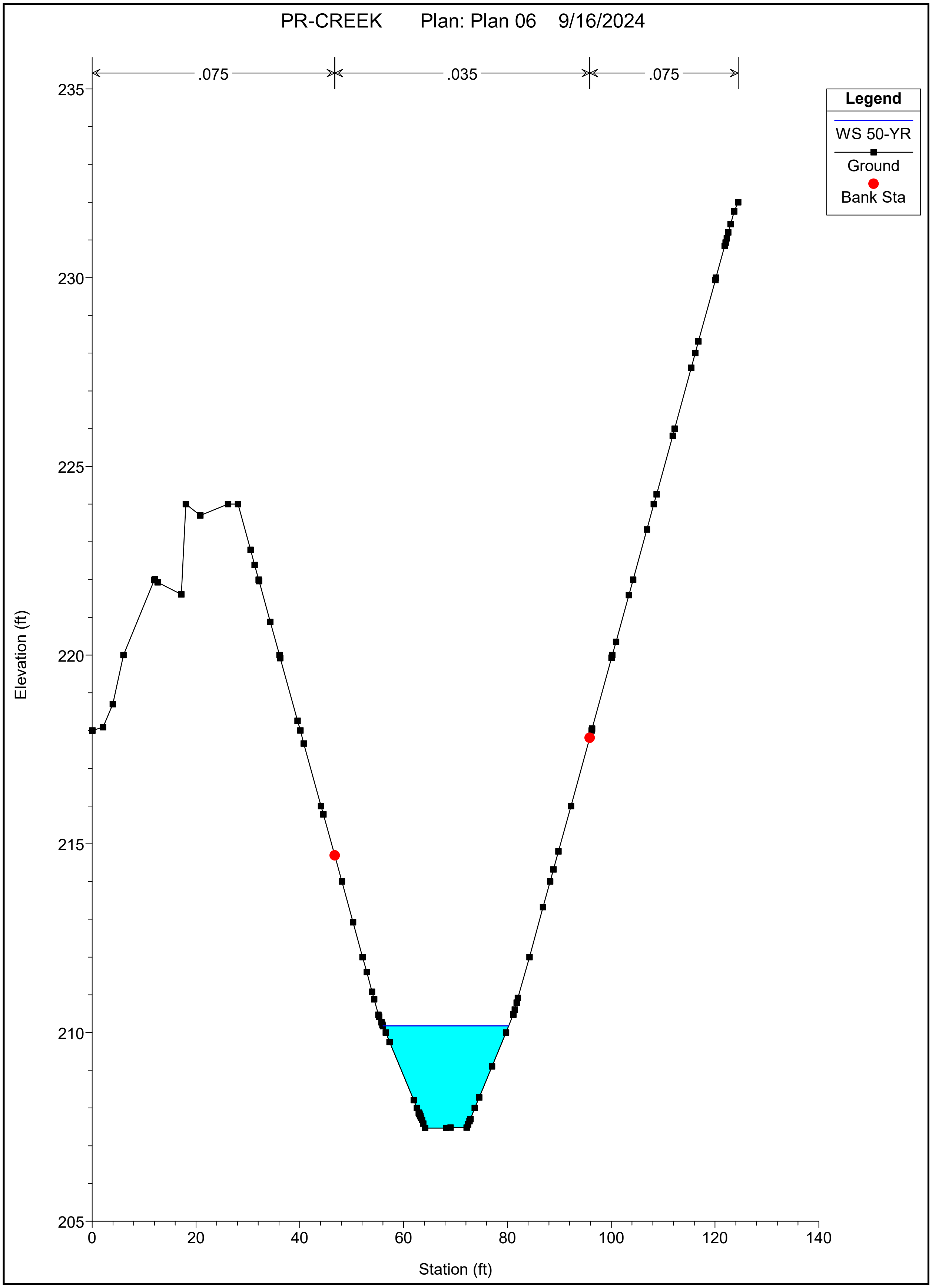

PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
235
230
225
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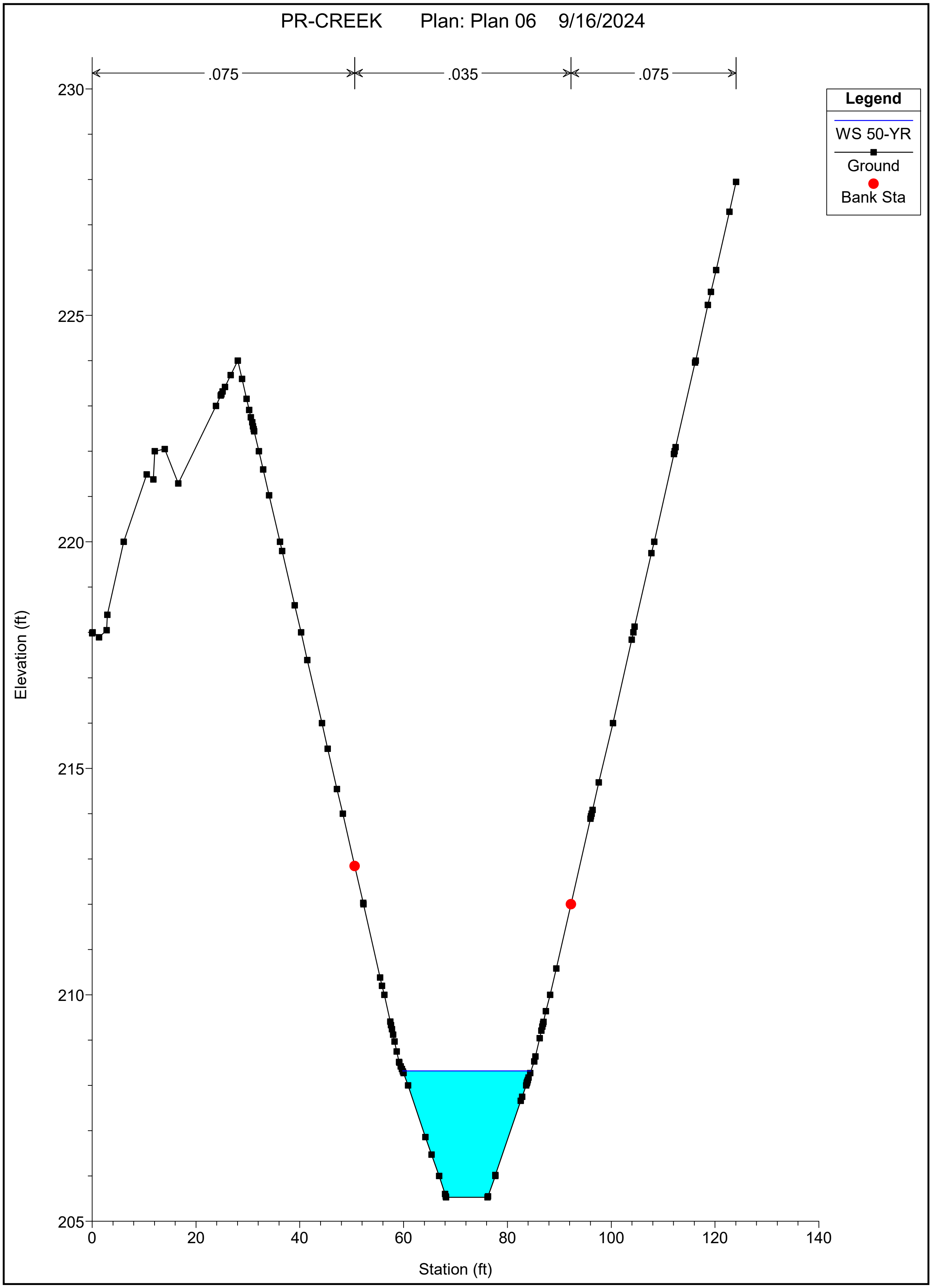

PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
230
225
220
215
210
205
0
20
40
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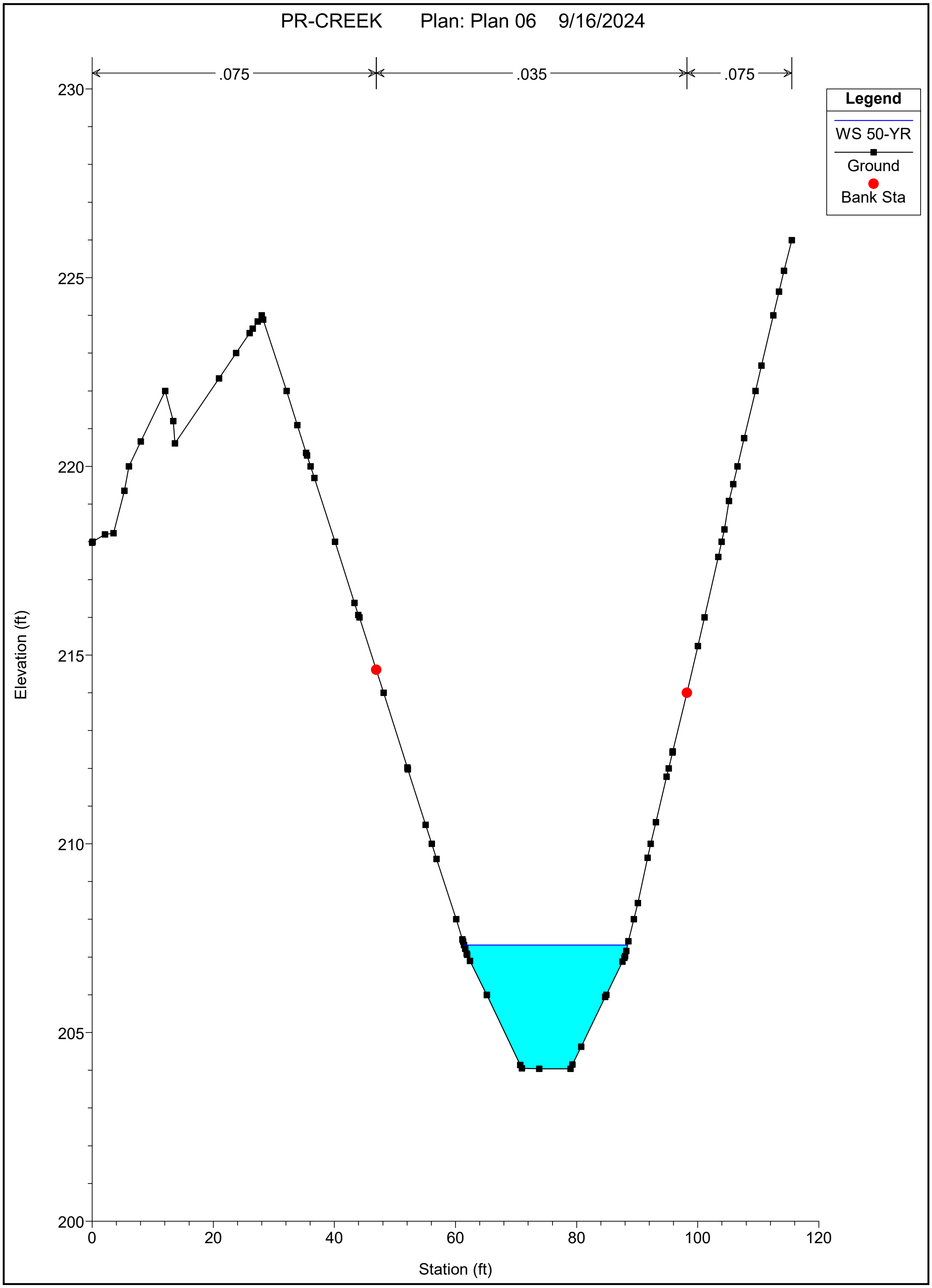
120
140



PR-CREEK Plan: Plan 06 9/16/2024
.075
.035
.075
Legend
WS 50-YR
Ground
Bank Sta
Elevation (ft)
230
225
220
215
210
205
200
0
20
40
60
80
100
120
Station (ft)

HEC-RAS Plan: Plan 06 River: PR-UNT Reach: PR-CREEK Profile: 50-YR

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
PR-CREEK	1110.72	50-YR	497.00	221.48	224.44	224.74	226.03	0.020040	10.14	50.55	26.03	1.19
PR-CREEK	1037.67	50-YR	497.00	220.57	224.88	223.87	225.39	0.004123	5.74	88.58	31.29	0.57
PR-CREEK	941.1	50-YR	497.00	219.80	224.70		225.04	0.002360	4.68	109.28	34.16	0.44
PR-CREEK	857.83	50-YR	497.00	219.07	224.64		224.86	0.001321	3.73	134.85	37.39	0.33
PR-CREEK	785.54	50-YR	497.00	218.18	224.62		224.77	0.000682	3.15	166.80	40.46	0.25
PR-CREEK	713.12	50-YR	497.00	217.58	224.61		224.72	0.000446	2.65	196.12	44.02	0.20
PR-CREEK	657.59	50-YR	497.00	216.87	224.61		224.70	0.000315	2.38	220.04	45.26	0.17
PR-CREEK	612.11	50-YR	497.00	216.20	224.61		224.67	0.000243	1.97	252.48	48.19	0.15
PR-CREEK	587.14	50-YR	497.00	215.76	224.61		224.67	0.000167	1.86	279.06	50.87	0.13
PR-CREEK	512.85	50-YR	497.00	215.42	224.61	218.73	224.65	0.000176	1.70	292.03	51.71	0.13
PR-CREEK	482		Culvert									
PR-CREEK	421.84	50-YR	497.00	213.80	217.41		218.25	0.010100	7.37	67.43	28.44	0.84
PR-CREEK	368.44	50-YR	497.00	213.18	216.48	216.48	217.58	0.014796	8.42	59.06	27.28	1.01
PR-CREEK	310.56	50-YR	497.00	212.05	215.02	215.35	216.50	0.022969	9.76	50.95	26.36	1.24
PR-CREEK	263.41	50-YR	497.00	210.61	213.41	213.91	215.23	0.030075	10.83	45.88	24.80	1.40
PR-CREEK	191.5	50-YR	497.00	209.15	212.44	212.46	213.56	0.015014	8.47	58.70	27.16	1.02
PR-CREEK	133.35	50-YR	497.00	207.47	210.18	210.77	212.20	0.034678	11.41	43.55	24.23	1.50
PR-CREEK	72.46	50-YR	497.00	205.53	208.32	208.83	210.17	0.030546	10.89	45.62	24.73	1.41
PR-CREEK	0	50-YR	497.00	204.04	207.32	207.35	208.44	0.015193	8.51	58.38	27.01	1.02

Errors Warnings and Notes for Plan : Plan 06

Location:	River: PR-UNT Reach: PR-CREEK RS: 1037.67 Profile: 50-YR
Note:	Hydraulic jump has occurred between this cross section and the previous upstream section.
Location:	River: PR-UNT Reach: PR-CREEK RS: 482 Profile: 50-YR
Note:	During the supercritical calculations a hydraulic jump occurred at the outlet of (leaving) the culvert.
Location:	River: PR-UNT Reach: PR-CREEK RS: 482 Profile: 50-YR Culv: Culvert #1
Warning:	During the supercritical analysis, the program could not converge on a supercritical answer in the
	downstream cross section. The program used the solution with the least error.
Note:	The flow in the culvert is entirely supercritical.
Location:	River: PR-UNT Reach: PR-CREEK RS: 368.44 Profile: 50-YR
Warning:	The energy equation could not be balanced within the specified number of iterations. The program
	used critical depth for the water surface and continued on with the calculations.
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Warning:	During the standard step iterations, when the assumed water surface was set equal to critical
	depth, the calculated water surface came back below critical depth. This indicates that there is not
	a valid subcritical answer. The program defaulted to critical depth.
Location:	River: PR-UNT Reach: PR-CREEK RS: 310.56 Profile: 50-YR
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 263.41 Profile: 50-YR
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 191.5 Profile: 50-YR
Warning:	The energy equation could not be balanced within the specified number of iterations. The program
	selected the water surface that had the least amount of error between computed and assumed
	values.
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 energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 133.35 Profile: 50-YR
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 energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 72.46 Profile: 50-YR
Warning:	The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.
Location:	River: PR-UNT Reach: PR-CREEK RS: 0 Profile: 50-YR
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 energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section.
	This may indicate the need for additional cross sections.