Hydraulics Report

Dutch Gap Bridge (No. 3951)

Dutch Gap Road over

Little Norridgewock Stream

Chesterville

October 18, 2018

Hoyle, Tanner & Associates, Inc.

STATE OF MAINE
AARON M. LACHANCE
No. 13294
LICENSED
PROFESSIONAL ENGINEER
10-23-18

WIN 021688.00

HYDROLOGY REPORT

Dutch Gap Bridge (#3951) is located in Chesterville, ME and carries Dutch Gap Road over Little Norridgewock Stream. The watershed of Little Norridgewock Stream is approximately 32.5 mi^2. Approximately 3 miles downstream from the bridge, Little Norridgewock Stream drains into Wilson Stream. Wilson Stream drains into the Sandy River at an approximate distance of 1.5 miles downstream of the confluence with Little Norridgewock Stream.

The Maine Department of Transportation (MaineDOT) Environmental Office, Hydrology Section, provided the drainage basin characteristics and flow data for this crossing. The original flow data are based on peak flow calculations using U. S. Geological Survey (USGS) Regression Equations. The hydraulic model of the existing twin culvert system showed no overtopping of the existing roadway at this crossing when using flows predicted by the USGS equations with an estimated freeboard of approximately 1’ during the 500-year storm event (see Hydraulic Report section for additional modeling information). These results are contrary to the flood history of the bridge. During the Preliminary Public Meeting held on Wednesday, June 21, 2017, one of the audience members stated that during the 1987 flood, the roadway at this crossing was completely submerged. The design team and Maine DOT Environmental Office analyzed the existing condition modeling results and concluded that the regression-only estimated flows appear to underestimate the peak flow hydrology for the subject watershed.

The stream gage data available for surrounding watersheds was reviewed because there is no stream gage on Little Norridgewock Stream. Although there is a Wilson Stream gage, there is less than 10 years of data and it cannot be used to develop flows for Little Norridgewock Stream. Therefore, revised flow data was developed based on the Sandy River stream gage near Mercer, ME. These flows are based on the document “Guidelines for Determining Flood Flow Frequency, Bulletin #17B of the Hydrology Subcommittee” dated September 1981, known as the Bull 17B estimates, and have been adjusted for the gage watershed area (516 mi^2) and the project watershed area (32.5 mi^2). The Sandy River Mercer gage has been collecting flow data since 1929, and recorded a flow of 51,100 ft^3/s during the 1987 flood, which is estimated to be a 200-year event.

The adjusted Bull 17B estimated flows are much larger than the originally calculated USGS regression flows, as shown in the Summary of Calculated Flows table. The existing condition hydraulic model was updated with these adjusted flows, and the results indicate overtopping of the roadway at and above the 10-year storm event. This hydraulic performance also does not match the flood history of the bridge, which indicates overtopping during large storm events, but not as frequently and as severe as shown in the revised model. Revised hydraulic modeling results based on adjusted Bull 17B flows were reviewed and it was concluded that the adjusted flows likely overestimate the peak flow hydrology for this crossing.

The existing condition hydraulic model was used to determine the magnitude of flow that initiates overtopping of the roadway in the sag curve adjacent to the culvert crossing, and to set that value as the 200-year flow for this crossing. This assumes that the roadway overtopped during the 1987 event, but was not as inundated as suggested by the audience during the Public Information Meeting. The adjusted 200-year flow, which is approximately 3,100 ft^3/s, can then be used to correlate the flood history of the bridge to the stream gage data from the Sandy River using a Log-Normal Probability Plot trendline. Design flows for each storm event are based on a shifted trendline of the estimated Bull 17B flows. The Log-Normal Probability Plot with the trendlines is included in Appendix E.

The summary of the three sets of flows evaluated for this crossing is shown in the table below. Typically, the 200-year flow event is not of interest to MaineDOT, however, it is included in the table because the 1987 flooding experienced in this area is estimated to have been a 200-year event, and the Q200 was used to calculate the design flows.

SUMMARY OF CALCULATED FLOWS

	USGS Regression Equation Flows		Adjusted Bull 17B Sandy River Stream Gage Flows		Design Flows per Flood History & Sandy River Stream Gage Data	
Q1.1	278	ft^3/s	757	ft^3/s	324	ft^3/s
Q10	903	ft^3/s	3130	ft^3/s	1468	ft^3/s
Q25	1116	ft^3/s	4110	ft^3/s	1925	ft^3/s
Q50	1278	ft^3/s	4898	ft^3/s	2293	ft^3/s
Q100	1452	ft^3/s	5738	ft^3/s	2684	ft^3/s
Q200	1625	ft^3/s	6650	ft^3/s	3100	ft^3/s
Q500	1863	ft^3/s	7933	ft^3/s	3691	ft^3/s

SUMMARY

Drainage Area	32.5	mi^2
Q1.1	324	ft^3/s
Q10	1,468	ft^3/s
Q25	1,925	ft^3/s
Q50	2,293	ft^3/s
Q100	2,684	ft^3/s
Q500	3,691	ft^3/s

Reported by: Kayla Hampe
Date: October 10, 2017

Note: All elevations based on North American Vertical Datum (NAVD) of 1988.

HYDRAULIC REPORT

Hydraulic Modeling:

The existing bridge and proposed structure were analyzed using the Army Corps of Engineers' one-dimensional river hydraulic analysis program, HEC-RAS, version 5.0.1. The hydraulic models were developed using a combination of as-built plans, topographic survey, LiDAR, and other available information. The initial HEC-RAS model of the existing crossing included an approximately 2,550' long segment of Little Norridgewock Stream containing ten cross-sections, five upstream and five downstream. The model did not capture the overtopping of the bridge that was reported during the 1987 flood, so the length of the downstream reach was increased to better capture potential tailwater effects. The revised HEC-RAS model represents an approximately 4,500' long segment of Little Norridgewock Stream and includes sixteen cross-sections, five upstream and 11 downstream.

The existing bridge creates a localized contraction in the stream due to the narrow width of the twin culvert system in comparison to the natural channel width up- and downstream of the crossing. For this segment of Little Norridgewock Stream, the bank full width is approximately 39' per MaineDOT estimates, but the existing culverts are only 14' in diameter each. In addition, the culverts are oriented perpendicular to the roadway, but the stream is orientated at an approximate 5° skew to the road in the vicinity of the bridge.

The following parameters and assumptions are made for both the existing and proposed hydraulic models:

- Steady flow
- Manning's "n"
    - Channel = 0.04
    - Overbanks = 0.07 – 0.10
    - Existing culverts = 0.027
- Entrance loss coefficient of 0.7 and exit loss coefficient of 1.0 for the existing culverts
- The default values for contraction (0.1) and expansion (0.3) were used at all cross-sections except for the following:
    - Values of 0.3 and 0.5 were used for contraction and expansion, respectively, for the cross-section immediately upstream of the bridge, the one immediately downstream of the bridge, and an additional three downstream where the stream widens, splits around an island, and merges again
    - Values of 0.2 and 0.4 were used for contraction and expansion, respectively, for the second cross-section downstream of the bridge at the edge of the scour pool

- Subcritical flows
- Normal depth boundary condition
    - S = 0.00043 ft./ft.
- Ineffective flow areas were defined at cross-sections where the stream “pools” and is outside of the active flow area

Due to the lack of stream gauge data to correlate water surface elevations (WSE) to known discharges, a sensitivity analysis was performed to evaluate the modeling assumptions. For this analysis, the downstream boundary condition was adjusted to see if the water surface elevations converge near the subject crossing. Convergence is considered to occur when a value is adjusted but the solution does not change significantly, either due to roughness changes or downstream boundary conditions. This sensitivity analysis considered the following normal slopes as the downstream boundary conditions:

S = 0.00043 ft/ft (used to size bridge, determined from LIDAR topographic data)

S = 0.001 ft/ft

S = 0.005 ft/ft

S = 0.01 ft/ft

Profile plots illustrating results for models with the various normal slope boundary conditions listed above for the Q1.1, Q10, Q50, and Q100 events are included in Appendix E. The results indicate that during high flow events (Q10 through Q100), the water surface elevations converge near the bridge. For the Q100 event, there is a maximum deviation of 0.32’ between the maximum Q100 WSE (the S = 0.00043 ft/ft model) and the minimum Q100 WSE (the S= 0.01 ft/ft model). Conversely, there is higher variability between solutions for the Q1.1 event, with a maximum deviation of approximately 1.0’ between the same models. The downstream friction slope may change during different flow events within a given river, and it appears that during low flow conditions, the friction slope for this particular reach may become steeper. It is also likely that the next downstream crossing causes backwater at the subject crossing. For this project, the most critical events for analyzing hydraulic performance are the Q50 and Q100 storms, and a flatter normal slope boundary condition results in more conservative (higher) estimated water surface elevations. Therefore, a normal slope boundary condition of S = 0.00043 ft/ft, as determined from LIDAR topographic data, was used for analysis.

The effective FEMA FIS Flood Map from August 1985 does not provide flow information for the project location because this crossing is located in FEMA Zone A, which means it is not within a detailed study area. Therefore, the flood history accounts provided by audience members at the Preliminary Public Information Meeting held on June 21, 2017 were relied on to calibrate the existing condition model. Reports indicate that the existing roadway at this crossing overtopped during the April 1987 flood, which is estimated to be approximately a 200-year event for this area.

The design flows were used in HEC-RAS for the existing structure and the proposed structure. The following assumptions were used for modeling the proposed structure:

- 80' single span structure with 77' clear between abutment faces
- Low chord elevation of 344.81'
- Streambed at/within the structure reflects the proposed channel
- Streambed at all other cross-sections remains the same
    - No filling or modifications to the downstream scour hole will be completed as part of this project

Headwater elevations and stream velocities are reported in the table below for the peak flows for both the existing and proposed structures. The HEC-RAS results for the existing conditions and proposed conditions are provided in Appendix E. The flow top width for the Q1.1 flood event is about 50.1'.

SUMMARY

		Existing Structure	Recommended Structure
		Two 14' Diam. Steel Culverts	80' Single Span Steel
Total Area of Waterway Opening	ft^2	308	712.62
Headwater elevation @ $Q_{1.1}$	ft	337.9	337.69
Headwater elevation @ Q_{10}	ft	342.79	341.71
Headwater elevation @ Q_{25}	ft	344.12	342.56
Headwater elevation @ Q_{50}	ft	345.15	343.15
Headwater elevation @ Q_{100}	ft	346.25	343.74
Headwater elevation @ Q_{500}	ft	347.56	345.09
Freeboard @ Q_{50}	ft	0.85	1.08
Freeboard @ Q_{100}	ft	submerged	0.49
Flood Of Record (April 1987) Elevation 347.7 ft ±			
Outlet Velocity @ $Q_{1.1}$	ft/s	2.75	1.55
Outlet Velocity @ Q_{10}	ft/s	6.41	3.43
Outlet Velocity @ Q_{25}	ft/s	7.67	4.02
Outlet Velocity @ Q_{50}	ft/s	8.65	4.45
Outlet Velocity @ Q_{100}	ft/s	9.67	4.87
Outlet Velocity @ Q_{500}	ft/s	9.7	5.82

Note: All elevations based on North American Vertical Datum (NAVD) of 1988.

Scour:

Scour at the proposed abutments was analyzed per FHWA Hydraulic Engineering Circular 18 – Evaluating Scour at Bridges (HEC-18), Fifth Edition, published April 2012. Guidance from recent coordination with FHWA with regards to the NCHRP method for determining local abutment scour was also considered and includes the following recommendations:

- For Scour Condition A (abutments near the main channel), the average unit discharges (transporting sediment) at the approach section and the contracted section should be used
- For Scour Condition B (set back from the main channel), the maximum unit discharge within two flow depths of the abutment toe should be used.

These recommendations are not found in the Fifth Edition of HEC-18, but it is our understanding from communication with FHWA that these recommendations will be included in the next revision to HEC-18.

The proposed hydraulic data used in the scour and riprap sizing calculations are taken from the HEC-RAS model of the proposed conditions. Per MaineDOT Bridge Design Guide Section 2.3.11.1, the design flood for scour is the lesser of Q100 or the overtopping flood. The proposed condition model indicates no overtopping occurs for all flood events, including the 500-year flood. Therefore, the scour and riprap design calculations are completed using the 100-year flood event. The scour should also be computed for the superflood, defined as Q500 or the overtopping flood if it is between Q100 and Q500, per the Bridge Design Guide.

For scour calculations, estimating the location of the approach section within a 1-D model is a subjective process. Based on engineering judgement, it appears that the flow from the overbanks may start to be directed into the main channel in the vicinity of cross-section 12+83. The average flow velocity within the main channel at this section is also higher than the critical velocity for incipient motion, indicating live-bed scour could occur. Therefore, cross-section 12+83 is assumed to be the approach section. The upstream bridge values at cross-section 9+82 are used for the bridge variables.

The total scour at a bridge is the sum of the following three components:

- Long-term aggradation and degradation
- General Scour
- Local Scour

Scour from long-term aggradation and degradation due to long-term elevation changes of the streambed due to natural or man-made causes was assumed to not occur at this crossing because Little Norridgewock Stream is fairly flat and uniform in profile. In addition, the nearest upstream crossing is over a mile away from Dutch Gap Bridge, and the nearest downstream crossing is about three-quarters of a mile away, locating this crossing outside the potential hydraulic influence of other crossings.

The general scour at the abutments will be caused by contraction scour due to the bridge partially obstructing the stream flow. The median diameter of bed material (D_{50}) of the streambed is 0.10mm. Although the D_{50} is below the 0.2mm limit to use clear-water scour analysis, the material is described as mostly sand with trace to some silt that is very mobile. Therefore, the scour depth was calculated using the HEC-18 Section 6.3, Live-Bed Contraction Scour, and Section 6.4, Clear-Water Contraction Scour rather than Section 6.7, Contraction Scour in Cohesive Materials. The contraction scour was determined to be live-bed scour and calculated to be 6.0’ for Q100.

The local scour at the abutments is the removal of aggregate from around the abutments caused by acceleration of the stream flow due to an obstruction.

The total scour (general and local) at the abutments was also calculated following procedures from NCHRP 24-20 as presented in Section 8.6.3 of HEC-18. These equations use contraction scour as the starting calculation for abutment scour and apply a factor to account for large-scale turbulence that develops in the vicinity of the abutment. Both abutments have live-bed scour and the total scour depth was calculated as 7.3’ at both abutments. The scour calculations can be found in Appendix E.

There is a scour pool immediately downstream of the existing crossing. Based on the field survey, the bottom of the scour pool is approximately at elevation 323’. This is 9’ below the culvert invert elevation of 332’. Based on the scour calculations using NCHRP 24-20, the bottom of scour is estimated to be at elevation 323.7’ based on a streambed elevation of 331’. Therefore, the estimated scour depths appear reasonable based on the depth of the existing downstream scour pool. Note that, per guidance from MaineDOT Environmental Section, this downstream scour hole will not be regraded (filled) as part of this project.

Riprap slopes will be provided in front of the proposed integral abutments, which will be located outside the river. Based on the riprap sizing calculations included in Appendix E, a 3’ thick layer of plain riprap will be required. The riprap sizing was calculated using HEC-23 – Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance, Third Edition, published in September 2009, as well as the MaineDOT Standard Specification Section 703 and MaineDOT Standard Detail sheet 610(03). Although riprap will be provided for scour protection, the design of piles of the integral abutments must consider the potential loss of the riprap. Therefore, the piles will be designed for the additional unbraced length due to scour assuming the riprap protection is not there.

Piles checked for this condition in final design - OK!

At the direction of the Department, the proposed bridge changed to a 75' NEXT beam. The hydraulic analyses were reanalyzed and water surface elevations and velocities are very similar to that reported in the summary tables.

HYDROLOGY

WIN:	21688.00	**Project Name:**	Dutch Gap Bridge
Town:	Chesterville	**Stream Name:**	Little Norridgewock Str
Route No.	Dutch Gap Rd	**Bridge Name:**	Dutch Gap Bridge
Asset ID:	3951	**Analysis by:**	CSH
Lat:	44.5681 **Long:** -70.0869	**Date:**	6/19/2017

Peak Flow Calculations by USGS Regression Equations (Hodgkins, 1999 & Lombard/Hodgkins, 2015)

Enter data in blue cells only!

	km^2	mi^2	ac	*Enter data in [mi^2]*
A	84.18	32.50	20800.0	Watershed Area *DRNAREA*
W	16.03	6.2	3960.3	Wetlands area (by NWI)
P_c	410290	4930224		watershed centroid (E, N; UTM 19N; meters)
County	Kennebec			*choose county from drop-down menu*
pptA	41.7			mean annual precipitation (inches; by look-up)
SG	0.06			sand & gravel aquifer as decimal fraction of watershed A

Worksheet prepared by:
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ver. 2016 Feb 05

A (km^2)	84.18	**Conf Lvl**	0.67
W (%)	19.04		NWI Wetlands % *STORNWI*

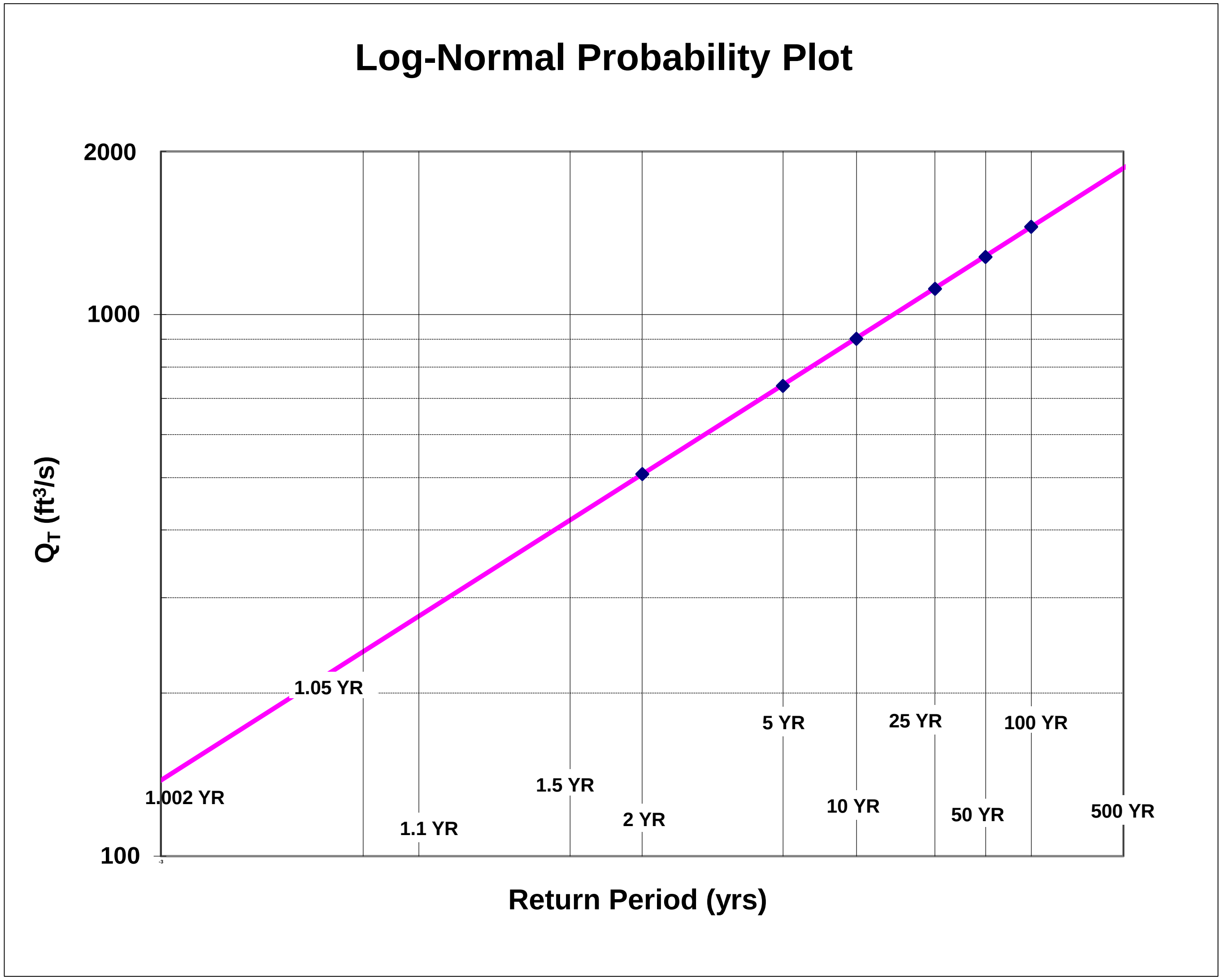
Ret Pd T (yr)	Peak Flow Estimate Lower	Q_T (m^3/s)	Upper	Q_T (ft^3/s)
1.1		7.86		277.5
2		14.37		507.5
5		20.93		739.1
10		25.57		902.7
25		31.60		1115.9
50		36.19		1277.9
100		41.12		1451.9
500		52.77		1863.4

References:

Hodgkins, G.A., 1999.
Estimating the magnitude of peak flows for streams in Maine for selected recurrence intervals
WRIR 99-4008, USGS Augusta, ME

Lombard, P.J. & G.A. Hodgkins, 2015.
Peak flow regression equations for small, ungaged streams in Maine - Comparing map-based to field-based variables
SIR 2015-4059, USGS, Augusta, ME

$Q_T = b \times A^a \times 10^{-wW}$



Log-Normal Probability Plot
2000
1000
100
Q_T (ft³/s)
1.002 YR
1.05 YR
1.1 YR
1.5 YR
2 YR
5 YR
10 YR
25 YR
50 YR
100 YR
500 YR
Return Period (yrs)

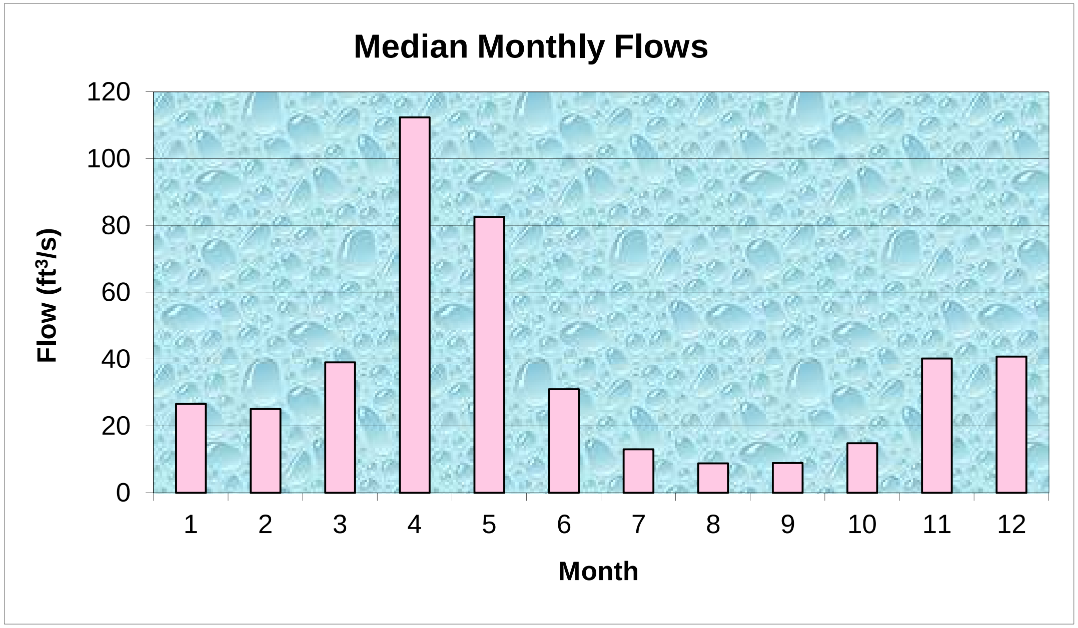
WIN:	21688.00	**Project Name:**	Dutch Gap Bridge
Town:	Chesterville	**Stream Name:**	Little Norridgewock Str
Route No.	Dutch Gap Rd	**Bridge Name:**	Dutch Gap Bridge
Asset ID:	3951	**Analysis by:**	CSH
Lat:	44.56810 **Long:** -70.0869	**Date:**	6/19/2017

DO NOT ENTER ANY DATA ON THIS PAGE; EVERYTHING IS CALCULATED

MAINE MONTHLY MEDIAN FLOWS and HYDRAULIC GEOMETRY BY USGS REGRESSION EQUATIONS (2004)

	Value	Variable	Explanation
	32.50	*A*	Area (mi^2)
410290.1	4930224	P_c	Watershed centroid (E,N; UTM; Zone 19; meters)
	81.51	*DIST*	Distance from Coastal reference line (mi)
	41.7	*pptA*	Mean Annual Precipitation (inches)
	0.06	*SG*	Sand & Gravel Aquifer (decimal fraction of watershed area)

Month	Q_{median} (ft3/s)	(m^3/s)
Jan	**26.68**	0.7560
Feb	**25.08**	0.7108
Mar	**39.07**	1.1073
Apr	**112.36**	3.1842
May	**82.62**	2.3413
Jun	**31.08**	0.8808
Jul	**13.05**	0.3697
Aug	**8.86**	0.2509
Sep	**8.89**	0.2521
Oct	**14.86**	0.4210
Nov	**40.27**	1.1412
Dec	**40.80**	1.1561



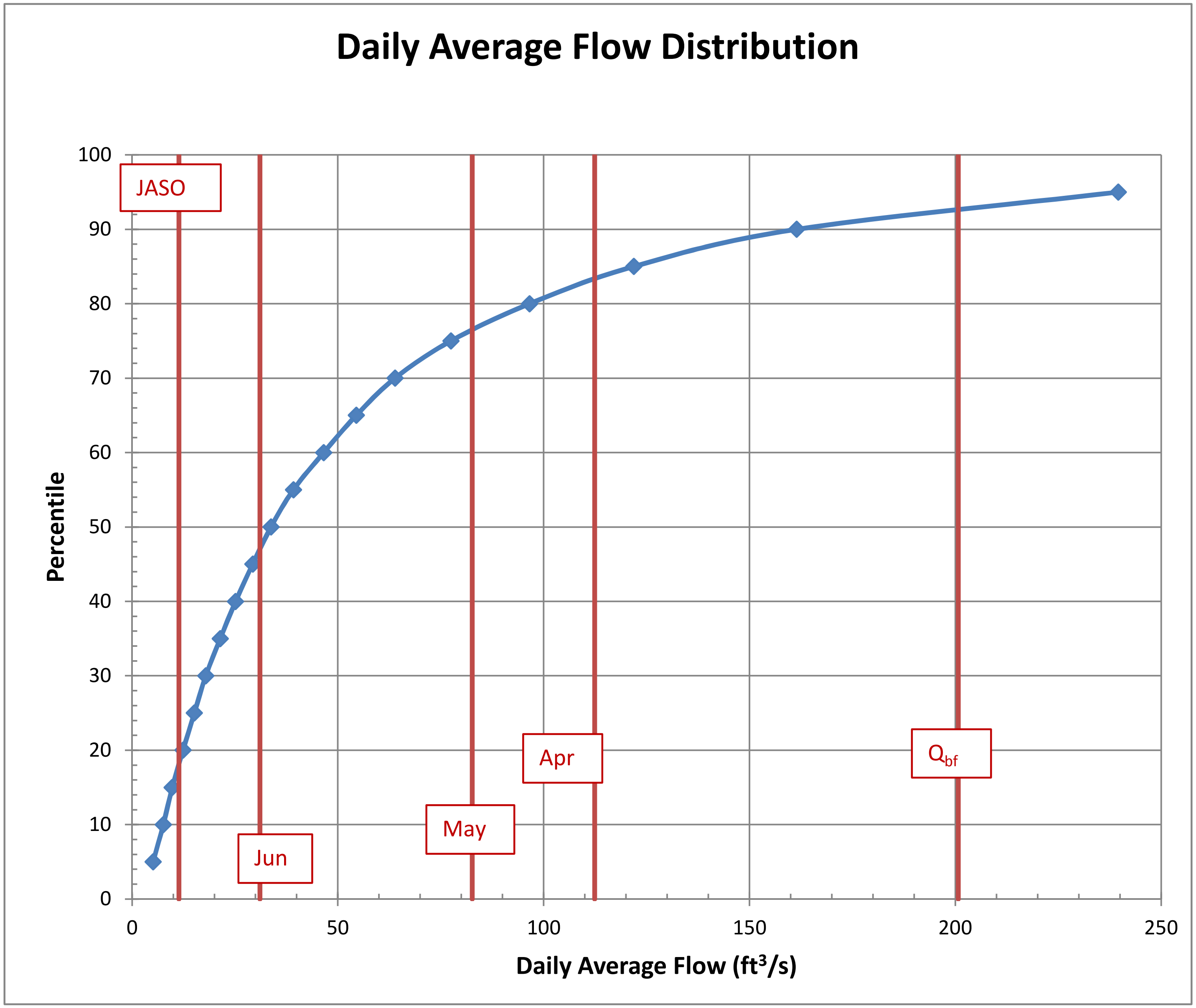
Q_{bf}	**200.7**	
ann avg	**63.0**	
ann med	**31.2**	
$Q_{1.002}$	**138.1**	
$Q_{1.01}$	**176.9**	
$Q_{1.05}$	**238.6**	
Q_{bf}	**366.8**	assume v = 4ft/s

W_{bf}	**47.3**	estimated bankfull width (ft)
d_{bf}	**1.9**	estimated bankfull depth (ft)
A_{bf}	**90.8**	estimated bankfull flow area (ft^2)

References

Dudley, R.W., 2013. FY2013 Progress Report - Phase 1 …, USFWS QRP Project

Dudley, R.W., 2004. Estimating Monthly Streamflows … , SIR 2004-5026



Daily Avg Flow Dist

A_{ws} = (mi^2) 32.5

Q (ft^3/s)

Pctl	Median	84th pctl
5	5.12	8.23
10	7.60	11.43
15	9.77	14.27
20	12.37	17.30
25	15.13	20.28
30	17.91	23.10
35	21.45	26.40
40	25.16	30.36
45	29.32	34.33
50	33.76	40.53
55	39.20	47.17
60	46.56	55.37
65	54.47	64.51
70	63.89	75.26
75	77.46	90.50
80	96.60	108.05
85	121.88	138.47
90	161.45	185.93
95	239.61	289.14

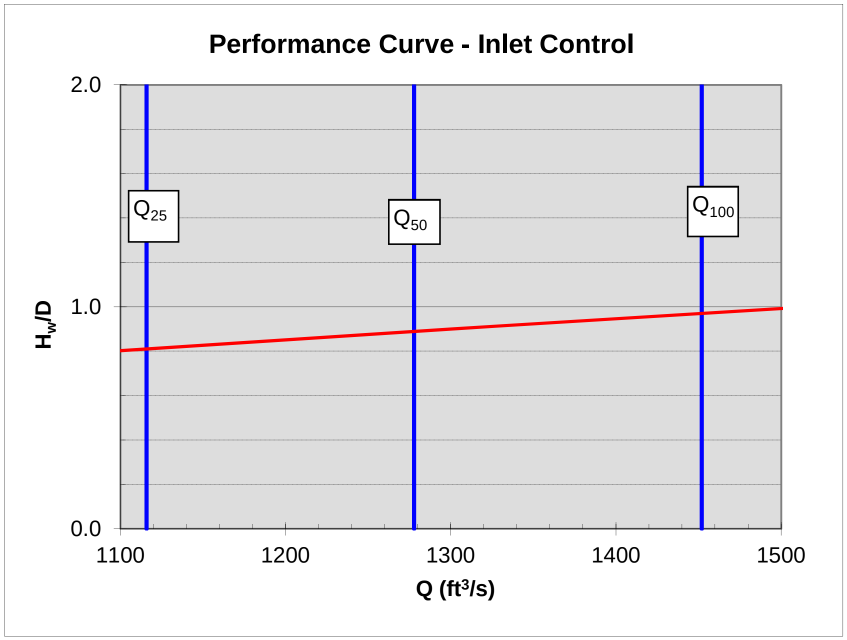
Q_{bf}	200.7
$Q_{1.002}$	138.1
$Q_{1.1}$	277.5
Q_2	507.5

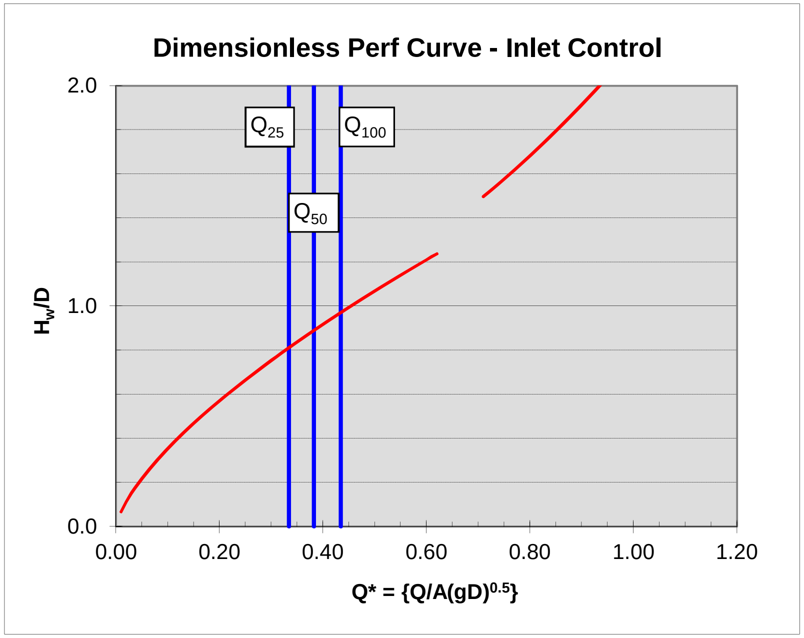
NOTE: ***This page is for preliminary sizing only.***
Final design should be done with HY8 or HDS-5

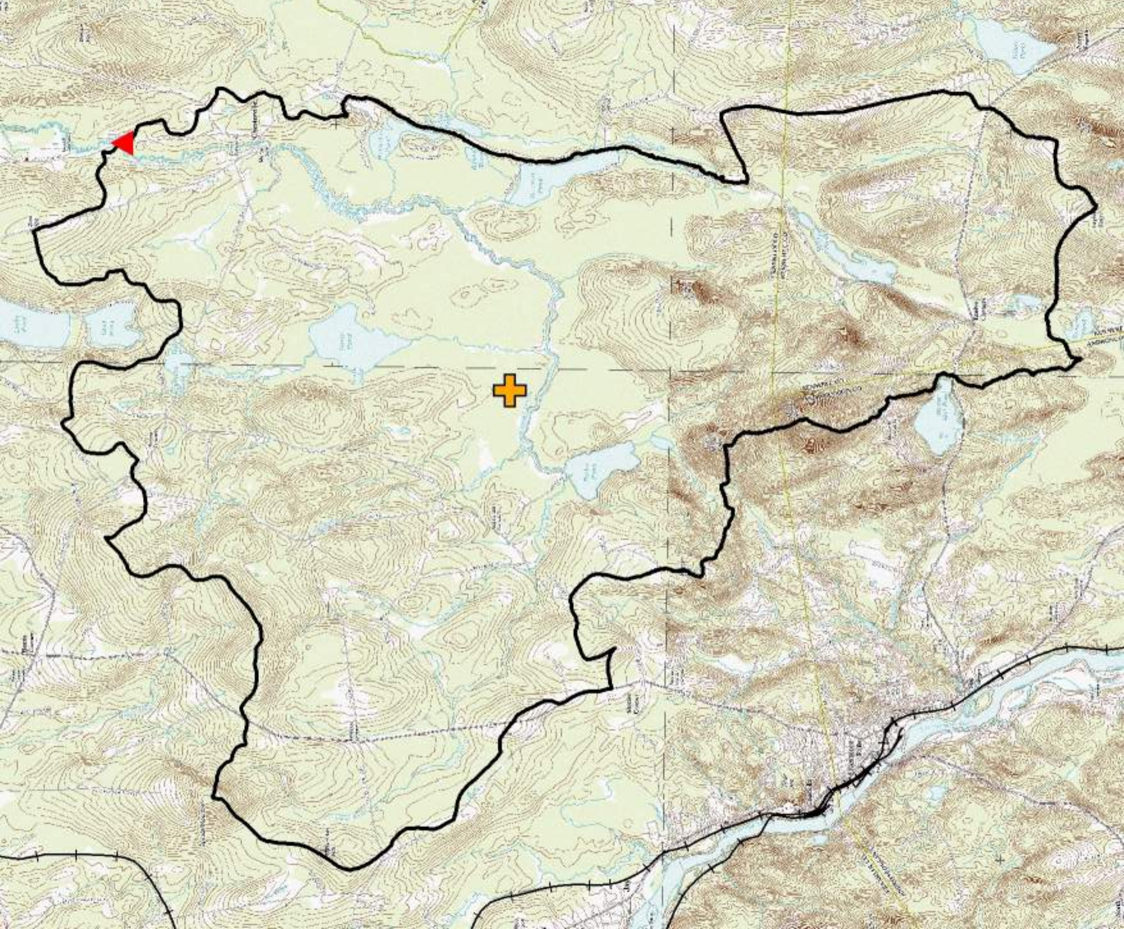
Preliminary Culvert Sizing - Round & Box Culverts

Shape:	Box					
Type:	Box 0 ww		Q_{25}	1115.9		
D or R (ft)	8		Q_{50}	1277.9	trial D / R =	14.3
w (ft)	*26*	*box width*	Q_{100}	1451.9	trial w: BFW =	47.3
Slope (ft/ft)	0.02					
A (ft^2)	208.00					
g (ft/s^2)	32.2					

Note:
culvert dimensions are for open flow area; adjust for lost capacity due to embedding / backfilling (min {2' / 25% rise} embedment)







StreamStats Version 3.0

Basin Characteristics Ungaged Site Report

Date: Mon June 19, 2017 2:43:19 PM GMT-4
Study Area: Maine
NAD 1983 Latitude: 44.5681 (44 34 05)
NAD 1983 Longitude: -70.0869 (-70 05 13)

Label	Value	Units	Definition
DRNAREA	32.5	square miles	Area that drains to a point on a stream
STORNWI	19.04	percent	Percentage of storage (combined water bodies and wetlands) from the National Wetlands Inventory
ELEV	510.1	feet	Mean Basin Elevation
PRECIP	44	inches	Basinwide mean annual precipitation
SANDGRAVAP	5.48	percent	Percentage of land surface underlain by sand and gravel aquifers
COASTDIST	82.7	miles	Shortest distance from the coastline to the basin centroid
CENTROIDX	410290.08	State plane coordinates	Basin centroid horizontal (x) location in state plane coordinates
CENTROIDY	4930223.68	State plane coordinates	Basin centroid vertical (y) location in state plane units
SANDGRAVAF	0.055	dimensionless	Fraction of land surface underlain by sand and gravel aquifers
LC11IMP	0.53	percent	Average percentage of impervious area determined from NLCD 2011 impervious dataset
LC11DEV	3.53	percent	Percentage of developed (urban) land from NLCD 2011 classes 21-24
LC06WATER	2.61	percent	Percent of open water, class 11, from NLCD 2006
ELEVMAX	1114.6	feet	Maximum basin elevation
BSLDEM10M	8.36	percent	Mean basin slope computed from 10 m DEM
STATSGOA	8.07	percent	Percentage of area of Hydrologic Soil Type A from STATSGO

StreamStats Version 3.0

Flow Statistics Ungaged Site Report

Date: Mon June 19, 2017 2:44:41 PM GMT-4
Study Area: Maine
NAD 1983 Latitude: 44.5681 (44 34 05)
NAD 1983 Longitude: -70.0869 (-70 05 13)
Drainage Area: 32.5 mi2

Regional Hydraulic Geometry Basin Characteristics			
100% Central and Coastal Bankfull 2004 5042 (32.5 mi2)			
Parameter	**Value**	**Regression Equation Valid Range**	
		Min	**Max**
Drainage Area (square miles)	32.5	2.92	298

Regional Median Flow Basin Characteristics
100% Undefined Region (32.5 mi2)

The selected watershed is entirely in an area for which flow equations were not defined.

Peak Flow Basin Characteristics			
100% Statewide Peak Flow Full GT 12sqmi WRI 99 4008 (32.5 mi2)			
Parameter	**Value**	**Regression Equation Valid Range**	
		Min	**Max**
Drainage Area (square miles)	32.5	0.93	1653
Percentage of Storage from NWI (percent)	19.04	0.7	26.7

Annual Flow Basin Characteristics			
100% Statewide LowFlow SIR 2004 5026 (32.5 mi2)			
Parameter	**Value**	**Regression Equation Valid Range**	
		Min	**Max**
Drainage Area (square miles)	32.5	9.79	1418
Fraction of Sand and Gravel Aquifers (dimensionless)	0.055	0	0.455

Peak Small Basin Flow Basin Characteristics
100% Statewide Peak Flow DA LT 12sqmi 2015 5049 (32.5 mi2)

Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	32.5 (above max value 12)	0.31	12
Percentage of Storage from NWI (percent)	19.04	0	22.2

Warning: Some parameters are outside the suggested range. Estimates will be extrapolations with unknown errors.

Statewide Annual Flow Basin Characteristics			
100% Statewide Annual SIR 2015 5151 (32.5 mi2)			
Parameter	Value	Regression Equation Valid Range	
		Min	Max
Drainage Area (square miles)	32.5	14.9	1419
Fraction of Sand and Gravel Aquifers (dimensionless)	0.055	0	0.212
Mean Basin Elevation (feet)	510.1	239	2120

Regional Hydraulic Geometry Statistics						
Statistic	Value	Unit	Estimation Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
					Min	Max
BFFLOW	201	ft3/s	54			
BFWDTH	46.9	ft	33			
BFDPTH	1.94	ft	26			
BFAREA	90.8	ft2	57			

http://pubs.usgs.gov/sir/2004/5042/pdf/sir2004-5042.pdf (http://pubs.usgs.gov/sir/2004/5042/pdf/sir2004-5042.pdf)
Dudley_ R.W._ 2004_ Hydraulic-Geometry Relations for Rivers in Coastal and Central Maine: U.S. Geological Survey Scientific Investigations Report 2004-5042_ 30 p

Peak Flow Statistics						
Statistic	Value	Unit	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
					Min	Max
PK2	507	ft3/s	35	1.8	283	909
PK5	739	ft3/s	36	2.5	409	1340
PK10	903	ft3/s	37	3.2	492	1660
PK25	1120	ft3/s	39	4.1	592	2100
PK50	1280	ft3/s	40	4.8	664	2460
PK100	1450	ft3/s	41	5.4	739	2850
PK500	1860	ft3/s	45	6.4	896	3870

http://me.water.usgs.gov/99-4008.pdf (http://me.water.usgs.gov/99-4008.pdf)
Hodgkins_ G. A._ 1999_ Estimating the Magnitude of Peak Flows for Streams in Maine for Selected Recurrence Intervals: U.S. Geological Survey Water-Resources Investigations Report 99-4008_ 45 p.

Annual Flow Statistics						
Statistic	Value	Unit	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
					Min	Max
M7D10Y	1.88	ft3/s	44	2.9		

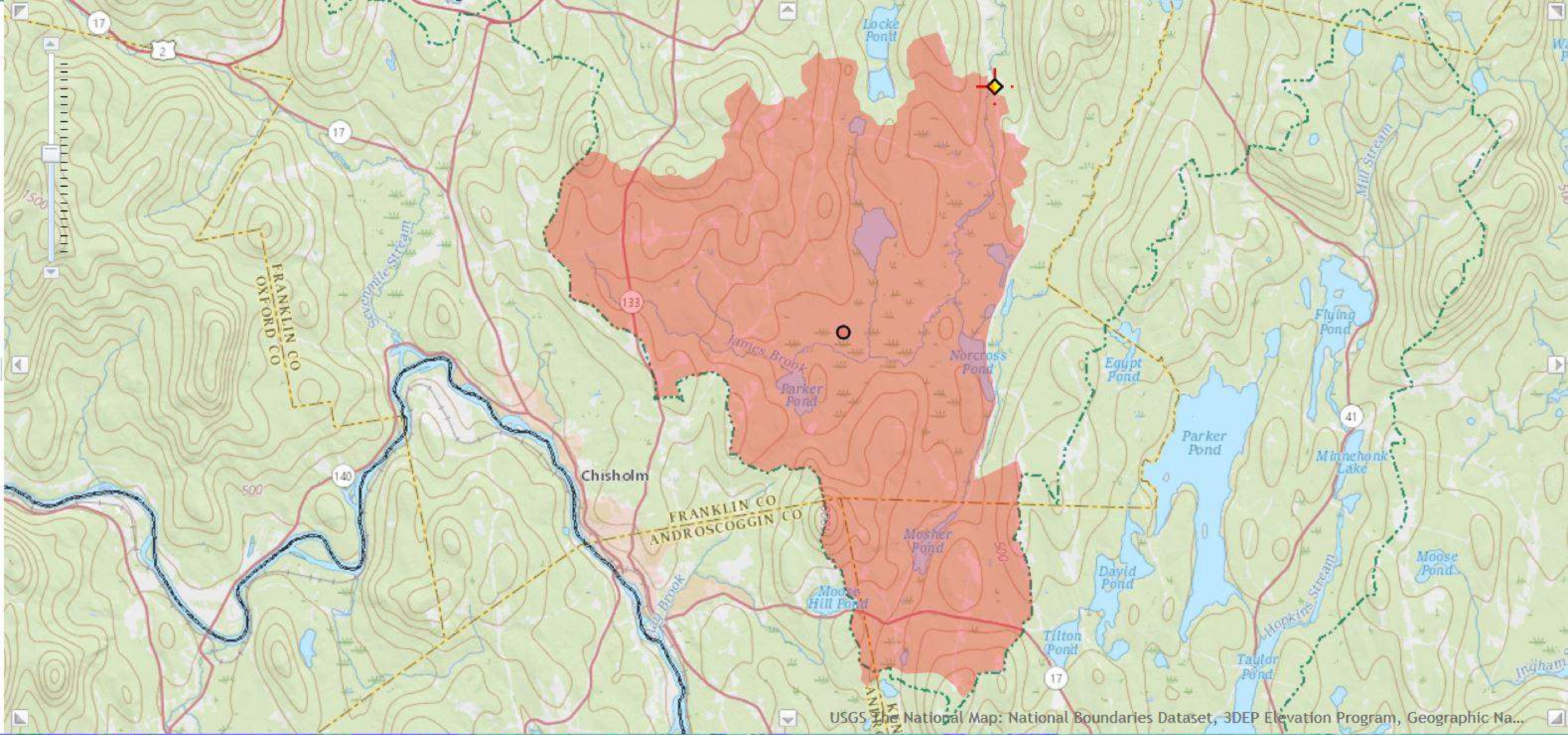
http://water.usgs.gov/pubs/sir/2004/5026/pdf/sir2004-5026.pdf (http://water.usgs.gov/pubs/sir/2004/5026/pdf/sir2004-5026.pdf)
Dudley_ R.W._ 2004_ Estimating Monthly_ Annual_ and Low 7-Day_ 10-Year Streamflows for Ungaged Rivers in Maine: U.S. Geological Survey Scientific Investigations Report 2004-5026_ 22 p.

Peak Small Basin Flow Statistics						
Statistic	Value	Unit	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
					Min	Max
PK1 01	157	ft3/s				
PK2	544	ft3/s				
PK5	850	ft3/s				
PK10	1050	ft3/s				
PK25	1390	ft3/s				
PK50	1590	ft3/s				
PK100	1860	ft3/s				
PK250	2070	ft3/s				
PK500	2470	ft3/s				

http://dx.doi.org/10.3133/sir20155049 (http://dx.doi.org/10.3133/sir20155049)
Lombard_ P.J._ and Hodgkins_ G.A._ 2015_ Peak flow regression equations for small_ ungaged streams in Maine— Comparing map-based to field-based variables: U.S. Geological Survey Scientific Investigations Report 2015-5049_ 12 p.

Statewide Annual Flow Statistics						
Statistic	Value	Unit	Prediction Error (percent)	Equivalent years of record	90-Percent Prediction Interval	
					Min	Max
D1	0.62	ft3/s	140			
D5	2	ft3/s	62			
D10	3.9	ft3/s	41			
D25	11.9	ft3/s	22			
D50	32.3	ft3/s	20			
D75	78.1	ft3/s	17			
D90	166	ft3/s	17			
D95	255	ft3/s	18			
D99	562	ft3/s	29			
QA	69.4	ft3/s	16			

http://dx.doi.org/10.3133/sir20155151 (http://dx.doi.org/10.3133/sir20155151)



USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Na...

Policies and Notices

Estimated Flows Using Sandy River Stream Gage Near Mercer, ME

From: Hebson, Charles [mailto:Charles.Hebson@maine.gov]
Sent: Tuesday, September 26, 2017 3:26 PM
To: Stilwell, Joseph R <Joseph.R.Stilwell@maine.gov>
Cc: Lachance, Aaron M. <alachance@hoyletanner.com>
Subject: RE: Chesterville Dutch Gap Hydrology

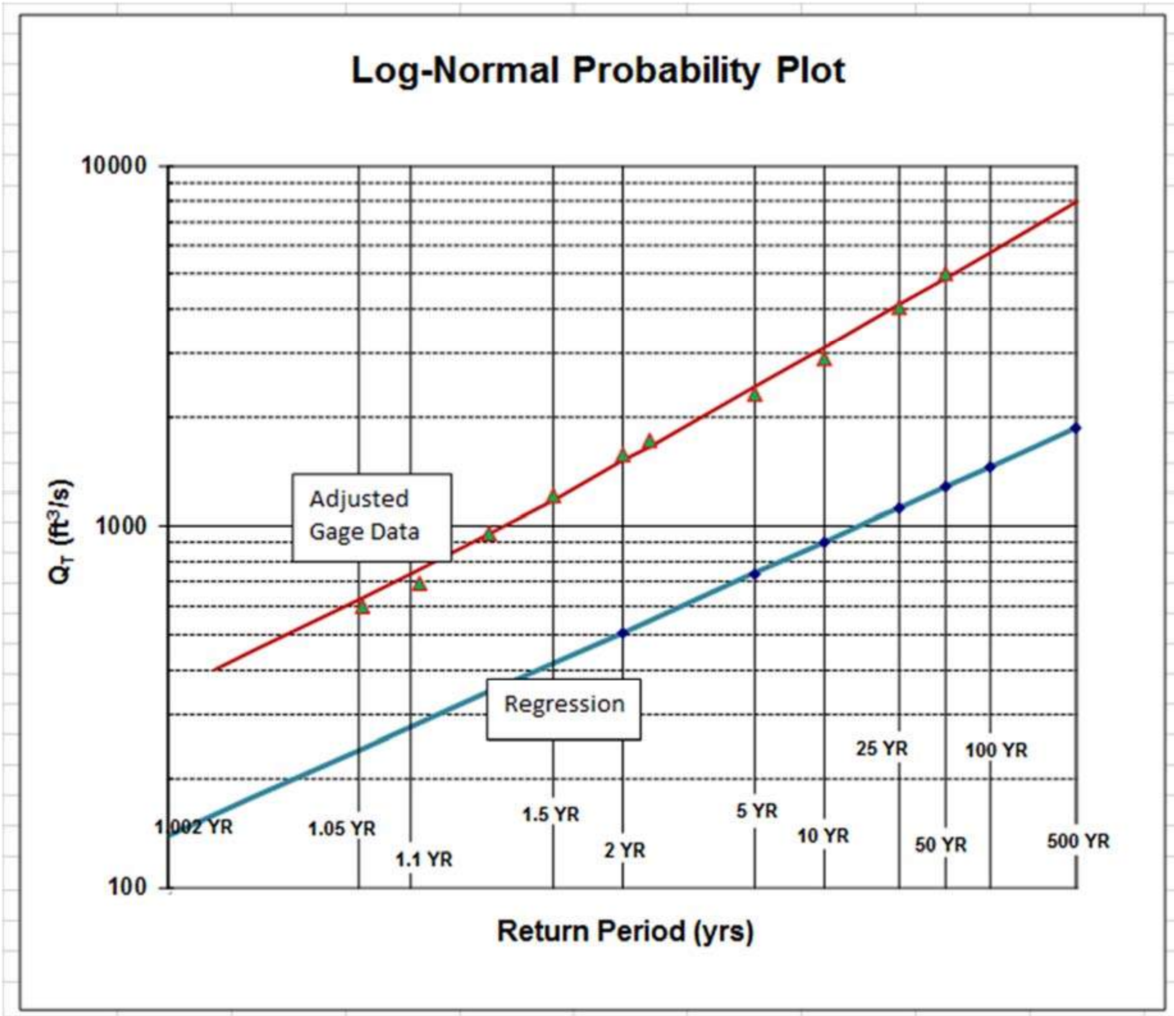
There is no fully satisfactory answer to this. I agree that a regression-only estimate likely underestimates the peak flow hydrology. For example, a regression-only estimate of Q100 at the Sandy gage is 28,800 cfs, while Q100 from the gage (1929 – 2016 & including 1987) is 45,390 cfs. The question is to adjust the gage to estimate the project flows.

The Wilson Stream gage is of little use - less than 10 yrs of data. Strictly speaking, the project and gage watersheds (516 mi2 vs 32.5) are so different in area that we should be making the typical area correction. But since we don't have nothing else to go by, we will do that. I will send an updated hydro report; in the meantime, here are the recommended flows. They are the Bull 17B estimates for the Sandy Mercer gage, adjusted for watershed area. The area adjustment is Qu = Qg x (Au/Ag)^a. As you can see, the new flows are a lot higher than the regression.

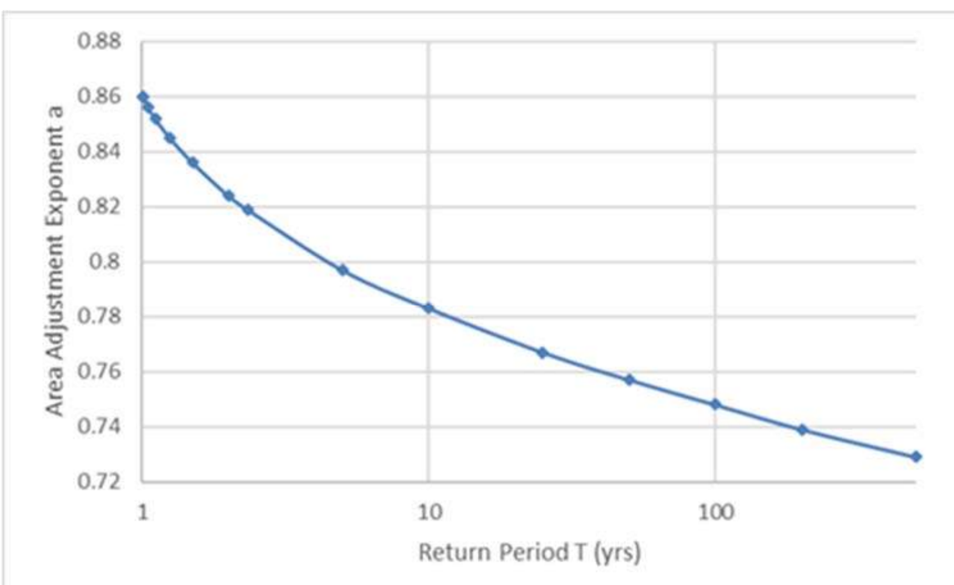
In addition to using these flows, you should also run the existing conditions model for the new 50, 100, 200 & 500-yr flows and see if you get overtopping as reported for 1987 (1987 was approx. the 200-yr flow for the Sandy gage). Also, see what flow produces the observed overtopping and see where it falls on the FF curve.

Charlie

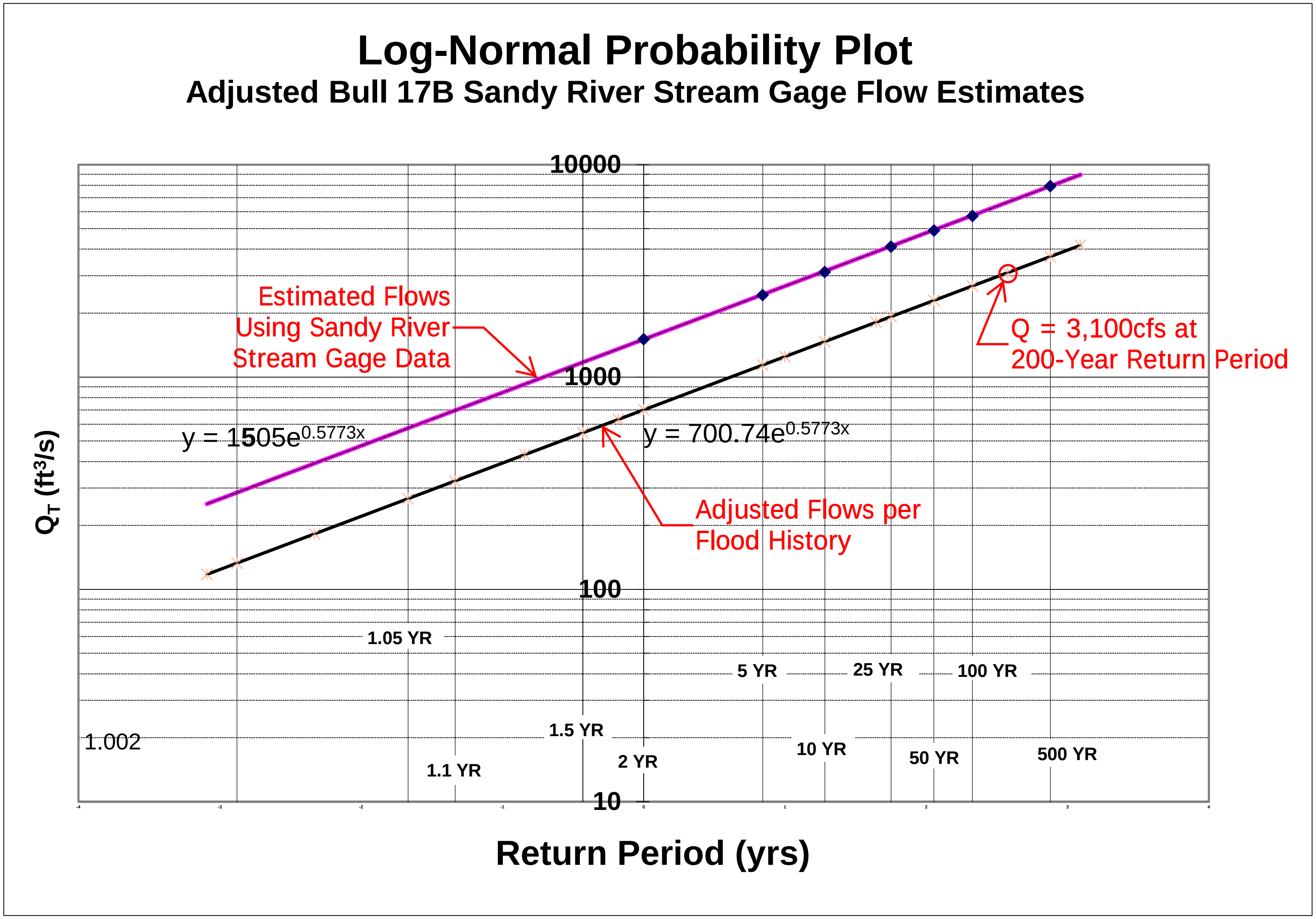
T	Pex	Qadj
1.005	0.995	403
1.010	0.99	452
1.053	0.95	630
1.111	0.9	757
1.250	0.8	951
1.500	0.667	1185
2.000	0.5	1506
2.330	0.429	1663
5.000	0.2	2433
10.000	0.1	3130
25.000	0.04	4110
50.000	0.02	4898
100.000	0.01	5738
200.000	0.005	6650
500.000	0.002	7933

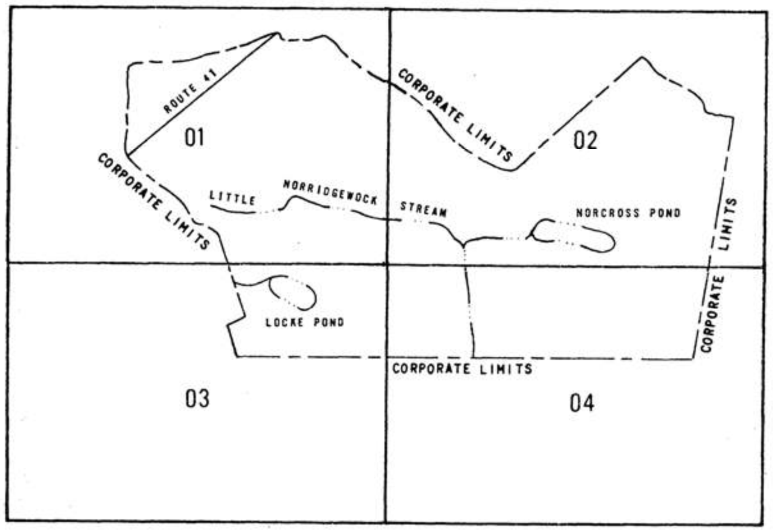


Log-Normal Probability Plot
10000
1000
100
QT (ft3/s)
Adjusted Gage Data
Regression
1.002 YR
1.05 YR
1.1 YR
1.5 YR
2 YR
5 YR
10 YR
25 YR
50 YR
100 YR
500 YR
Return Period (yrs)



0.88
0.86
0.84
0.82
0.8
0.78
0.76
0.74
0.72
Area Adjustment Exponent a
1
10
100
Return Period T (yrs)


Log-Normal Probability Plot
Adjusted Bull 17B Sandy River Stream Gage Flow Estimates
10000
1000
100
10
Estimated Flows Using Sandy River Stream Gage Data
Q = 3,100cfs at 200-Year Return Period
y = 1505e^0.5773x
y = 700.74e^0.5773x
Adjusted Flows per Flood History
1.05 YR
5 YR
25 YR
100 YR
1.002
1.5 YR
10 YR
1.1 YR
2 YR
50 YR
500 YR
QT (ft³/s)
Return Period (yrs)



KEY TO SYMBOLS

ZONE DESIGNATIONS*	ZONE C / ZONE A / ZONE C
Base Flood Elevation Line with elevation in feet	~513~
Base Flood Elevation where uniform within zone	(EL 987)
Elevation Reference Mark	RM7 x
River Mile	• M1.5

*EXPLANATION OF ZONE DESIGNATIONS

A flood insurance map displays the zone designations for a community according to areas of designated flood hazards. The zone designations used by FEMA are

Zone	Explanation
A	Areas of 100-year flood; base flood elevations and flood hazard factors not determined
AO	Areas of 100-year shallow flooding; flood depth 1 to 3 feet; product of flood depth (feet) and velocity (feet per second) less than 15
AH	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; base flood elevations are shown, but no flood hazard factors are determined
A1-A30	Areas of 100-year flood; base flood elevations and flood hazard factors determined
A99	Areas of 100-year flood to be protected by a flood protection system under construction; base flood elevations and flood hazard factors not determined
B	Area between limits of 100-year flood and 500-year flood; areas of 100-year shallow flooding where depths less than 1 foot
C	Areas outside 500-year flood
D	Areas of undetermined, but possible, flood hazards
V	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors not determined
V1-V30	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factor determined

NOTES TO USER

Certain areas not in the special flood hazard areas (zones A and V) may be protected by flood control structures.

This map is for flood insurance purposes only; it does not necessarily show all areas subject to flooding in the community or all planimetric features outside special flood hazard areas.

Refer to the FLOOD INSURANCE RATE MAP EFFECTIVE date shown on this map to determine when acturial rates apply to structures in the zones where elevations or depths have been established.

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

INITIAL IDENTIFICATION FEBRUARY 21, 1975

FLOOD HAZARD BOUNDARY MAP REVISIONS NONE

FLOOD INSURANCE RATE MAP EFFECTIVE AUGUST 19, 1985

FLOOD INSURANCE RATE MAP REVISIONS

federal emergency management agency

FIRM

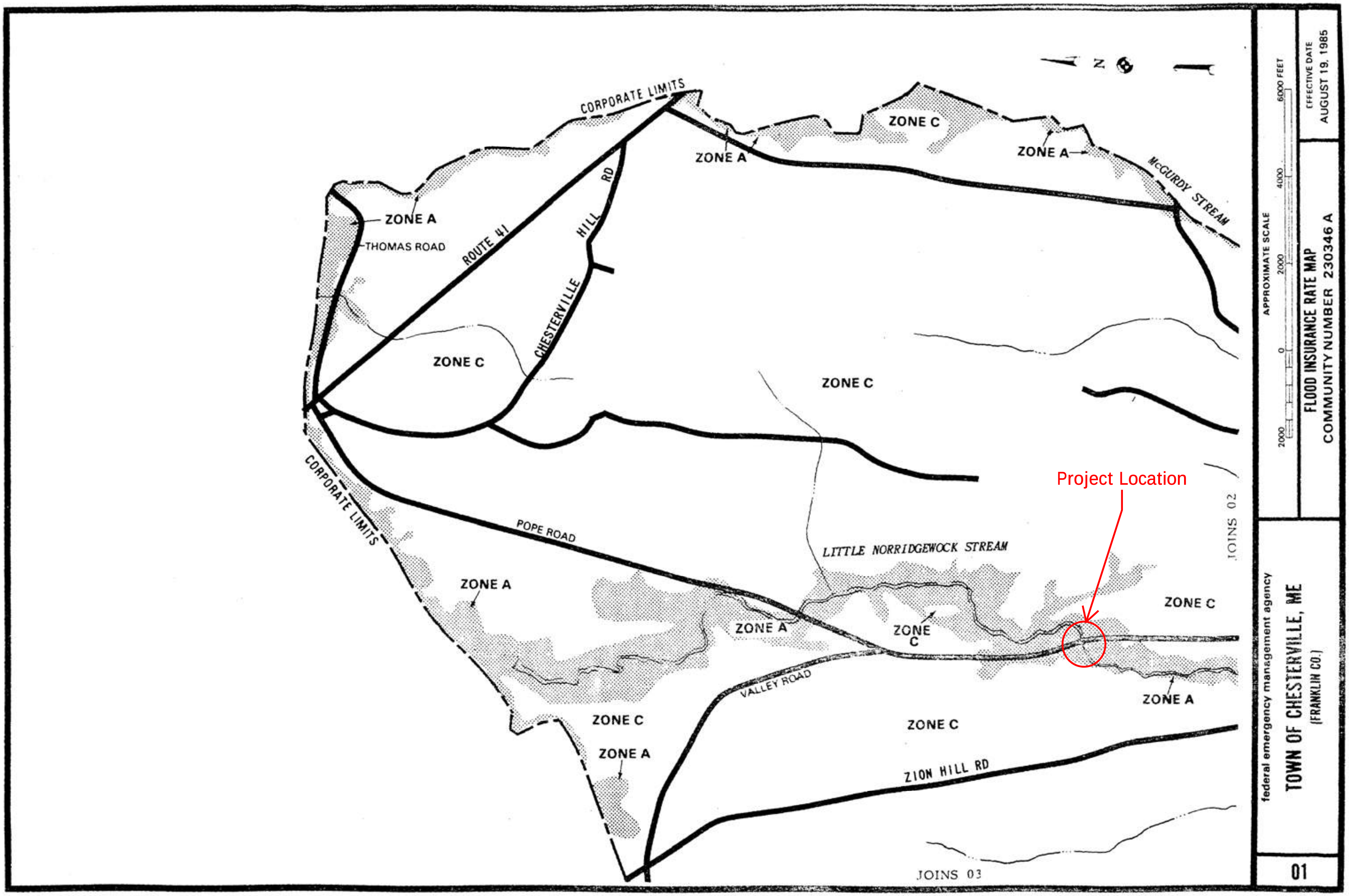
FLOOD INSURANCE RATE MAP 01-04

MAP INDEX

TOWN OF CHESTERVILLE, ME

(FRANKLIN CO.)

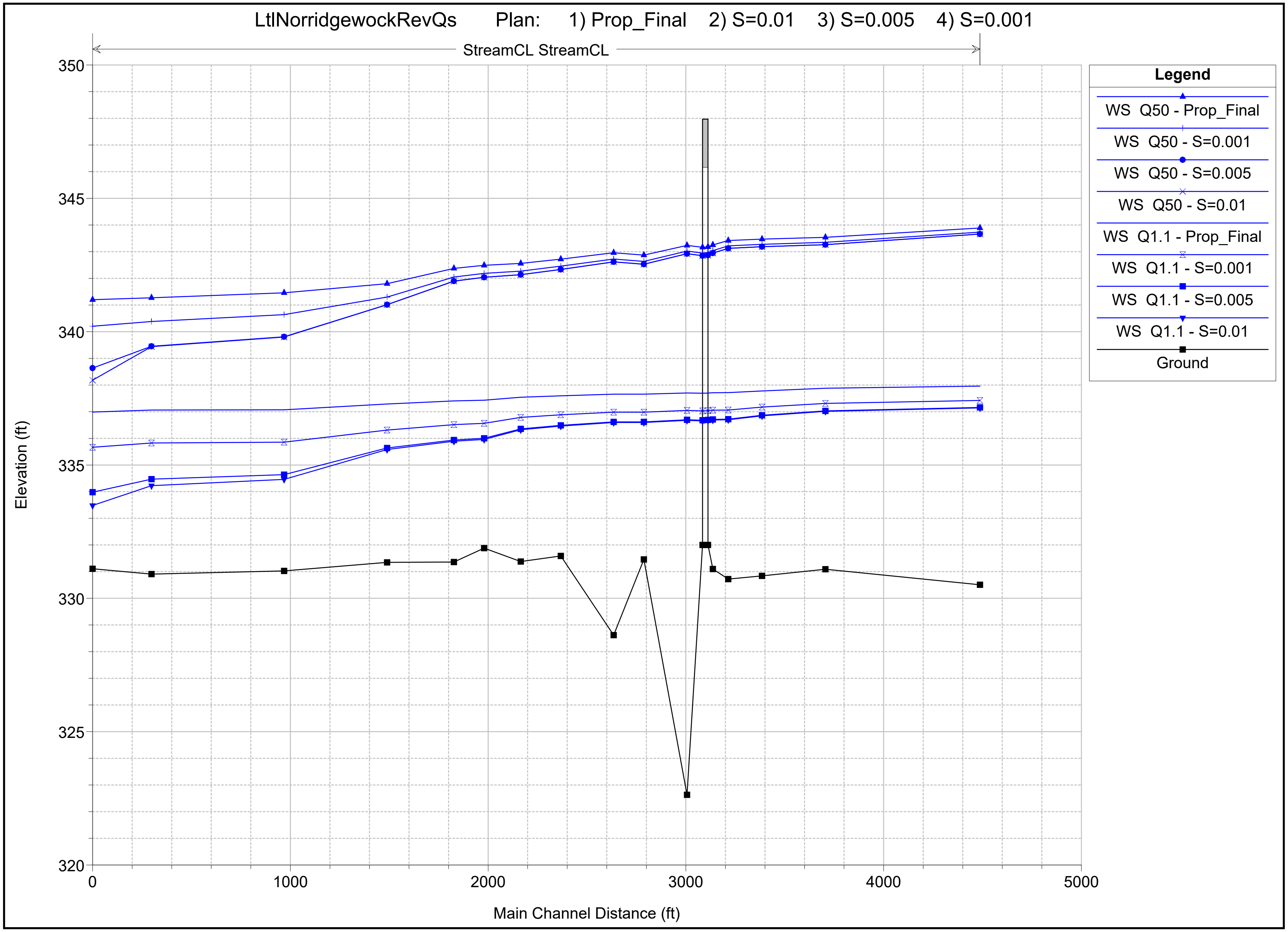
COMMUNITY NUMBER 230346 A


federal emergency management agency
TOWN OF CHESTERVILLE, ME
(FRANKLIN CO.)
FLOOD INSURANCE RATE MAP
COMMUNITY NUMBER 230346 A
EFFECTIVE DATE
AUGUST 19, 1985
APPROXIMATE SCALE
2000 0 2000 4000 6000 FEET
N
01
CORPORATE LIMITS
ROUTE 41
CHESTERVILLE HILL RD
THOMAS ROAD
POPE ROAD
VALLEY ROAD
ZION HILL RD
McGURDY STREAM
LITTLE NORRIDGEWOCK STREAM
ZONE A
ZONE C
Project Location
JOINS 02
JOINS 03

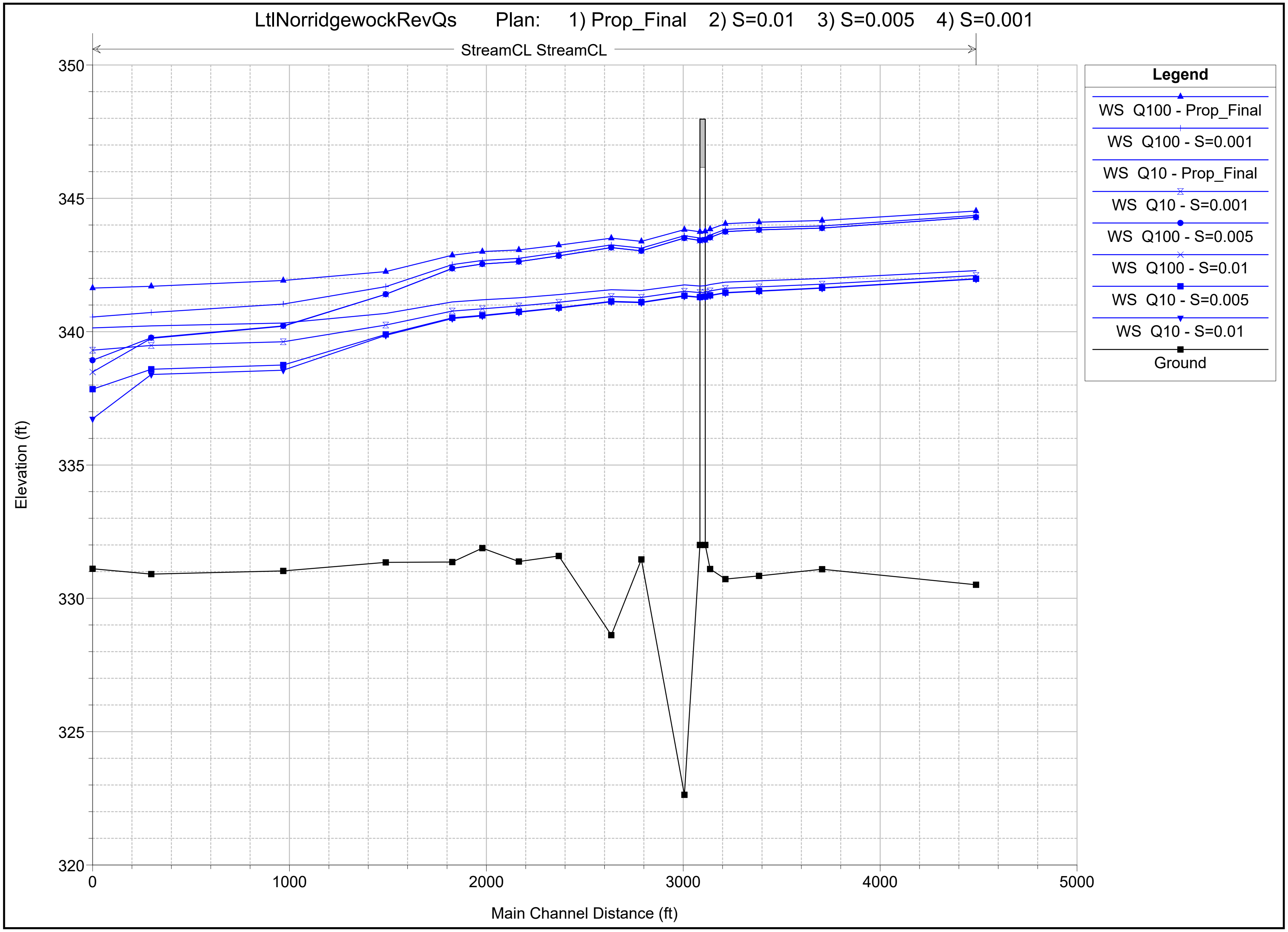
HYDRAULIC ANALYSIS FOR PDR

Stream Alignment and Cross-Section Location Map

EXISTING CONDITIONS
Slope Sensitivity Analysis - Q1.1 & Q50



EXISTING CONDITIONS
Slope Sensitivity Analysis - Q10 & Q100



EXISTING CONDITIONS
Standard Table 1

HEC-RAS Plan: Ex_OvrTp River: StreamCL Reach: StreamCL

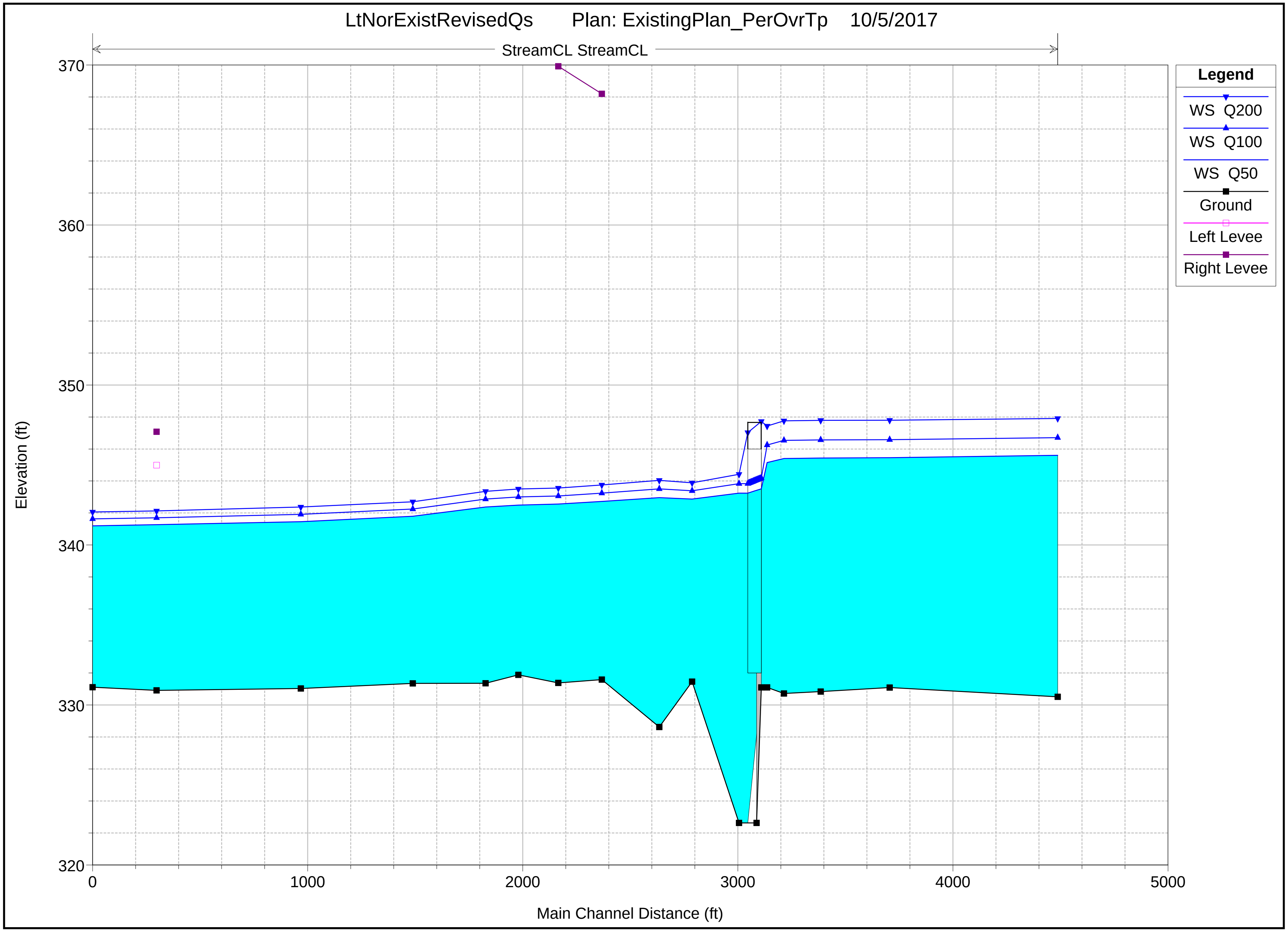
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
StreamCL	2385.65	Q50	2293.00	330.51	345.61		345.68	0.000160	2.31	1500.04	205.36	0.11
StreamCL	2385.65	Q100	2684.00	330.51	346.71		346.79	0.000157	2.41	1732.70	220.24	0.11
StreamCL	2385.65	Q200	3100.00	330.51	347.91		347.99	0.000154	2.53	2022.68	253.89	0.12
StreamCL	1604.26	Q50	2293.00	331.09	345.46		345.53	0.000207	2.53	1830.36	389.03	0.13
StreamCL	1604.26	Q100	2684.00	331.09	346.58		346.65	0.000180	2.50	2283.71	416.42	0.12
StreamCL	1604.26	Q200	3100.00	331.09	347.80		347.86	0.000153	2.45	2808.64	446.04	0.11
StreamCL	1283.94	Q50	2293.00	330.84	345.43		345.47	0.000138	1.95	2156.31	380.47	0.11
StreamCL	1283.94	Q100	2684.00	330.84	346.56		346.60	0.000117	1.92	2610.68	413.64	0.10
StreamCL	1283.94	Q200	3100.00	330.84	347.79		347.81	0.000096	1.86	3125.21	428.37	0.09
StreamCL	1112.94	Q50	2293.00	330.72	345.40		345.44	0.000147	2.11	2427.29	369.98	0.11
StreamCL	1112.94	Q100	2684.00	330.72	346.54		346.57	0.000131	2.12	2853.00	381.99	0.11
StreamCL	1112.94	Q200	3100.00	330.72	347.76		347.80	0.000115	2.12	3327.62	393.90	0.10
StreamCL	1034.95	Q50	2293.00	331.10	345.15	337.52	345.40	0.000518	4.02	571.02	352.18	0.21
StreamCL	1034.95	Q100	2684.00	331.10	346.25	338.00	346.53	0.000520	4.28	626.85	372.36	0.22
StreamCL	1034.95	Q200	3100.00	331.10	347.43	338.53	347.75	0.000510	4.51	687.50	377.60	0.22
StreamCL	982		Culvert									
StreamCL	904.43	Q50	2293.00	322.63	343.24	329.27	343.30	0.000076	1.95	1215.01	245.22	0.09
StreamCL	904.43	Q100	2684.00	322.63	343.84	329.79	343.91	0.000091	2.20	1262.75	248.83	0.10
StreamCL	904.43	Q200	3100.00	322.63	344.42	330.32	344.51	0.000108	2.45	1309.72	252.25	0.11
StreamCL	838.83	Q50	2293.00	331.46	342.87	337.35	343.18	0.000886	4.49	510.99	285.58	0.27
StreamCL	838.83	Q100	2684.00	331.46	343.39	337.82	343.77	0.001005	4.96	540.79	287.79	0.29
StreamCL	838.83	Q200	3100.00	331.46	343.89	338.28	344.35	0.001128	5.44	569.59	289.92	0.31
StreamCL	686.02	Q50	2293.00	328.62	342.96		343.03	0.000215	2.29	1578.63	290.97	0.13
StreamCL	686.02	Q100	2684.00	328.62	343.51		343.58	0.000233	2.47	1738.52	292.55	0.14
StreamCL	686.02	Q200	3100.00	328.62	344.04		344.13	0.000249	2.65	1895.45	294.08	0.15
StreamCL	419.2	Q50	2293.00	331.59	342.72	337.90	342.92	0.000688	4.03	1009.15	212.57	0.24
StreamCL	419.2	Q100	2684.00	331.59	343.24	338.25	343.47	0.000736	4.33	1121.03	213.97	0.25
StreamCL	419.2	Q200	3100.00	331.59	343.75	338.91	344.00	0.000783	4.62	1230.79	215.33	0.26
StreamCL	216.64	Q50	2293.00	331.38	342.56	337.30	342.77	0.000727	4.00	874.26	189.11	0.24
StreamCL	216.64	Q100	2684.00	331.38	343.06	337.80	343.31	0.000786	4.33	970.43	190.41	0.25
StreamCL	216.64	Q200	3100.00	331.38	343.56	338.32	343.84	0.000843	4.64	1064.65	191.68	0.26
StreamCL	31.36	Q50	2293.00	331.88	342.49		342.60	0.000586	3.31	1162.23	250.28	0.21
StreamCL	31.36	Q100	2684.00	331.88	343.00		343.12	0.000596	3.49	1290.73	251.64	0.22
StreamCL	31.36	Q200	3100.00	331.88	343.50		343.63	0.000609	3.67	1416.49	253.09	0.22
StreamCL	-121.5	Q50	2293.00	331.36	342.37		342.51	0.000482	3.28	1043.38	210.99	0.19
StreamCL	-121.5	Q100	2684.00	331.36	342.87		343.02	0.000523	3.54	1148.41	212.87	0.20
StreamCL	-121.5	Q200	3100.00	331.36	343.35		343.53	0.000562	3.79	1251.60	215.05	0.21
StreamCL	-459.58	Q50	2293.00	331.35	341.80		342.18	0.001427	5.37	764.81	236.31	0.32
StreamCL	-459.58	Q100	2684.00	331.35	342.25		342.67	0.001519	5.74	873.01	240.59	0.33
StreamCL	-459.58	Q200	3100.00	331.35	342.70		343.14	0.001598	6.07	980.85	243.44	0.35
StreamCL	-980.34	Q50	2293.00	331.03	341.45		341.58	0.000742	3.61	1195.95	324.91	0.23
StreamCL	-980.34	Q100	2684.00	331.03	341.92		342.05	0.000739	3.75	1346.76	326.59	0.23
StreamCL	-980.34	Q200	3100.00	331.03	342.37		342.51	0.000738	3.89	1495.63	327.98	0.23
StreamCL	-1650.77	Q50	2293.00	330.91	341.27	333.88	341.34	0.000187	2.19	1287.14	257.87	0.13
StreamCL	-1650.77	Q100	2684.00	330.91	341.70	334.17	341.79	0.000217	2.42	1400.99	266.65	0.14
StreamCL	-1650.77	Q200	3100.00	330.91	342.13	334.47	342.23	0.000246	2.65	1515.30	269.13	0.15
StreamCL	-1948.51	Q50	2293.00	331.11	341.20	338.18	341.26	0.000431	2.77	1734.30	469.71	0.18
StreamCL	-1948.51	Q100	2684.00	331.11	341.63	338.49	341.69	0.000430	2.87	1939.47	473.48	0.18
StreamCL	-1948.51	Q200	3100.00	331.11	342.06	338.72	342.12	0.000430	2.97	2145.23	506.24	0.18

EXISTING CONDITIONS
Standard Table 2

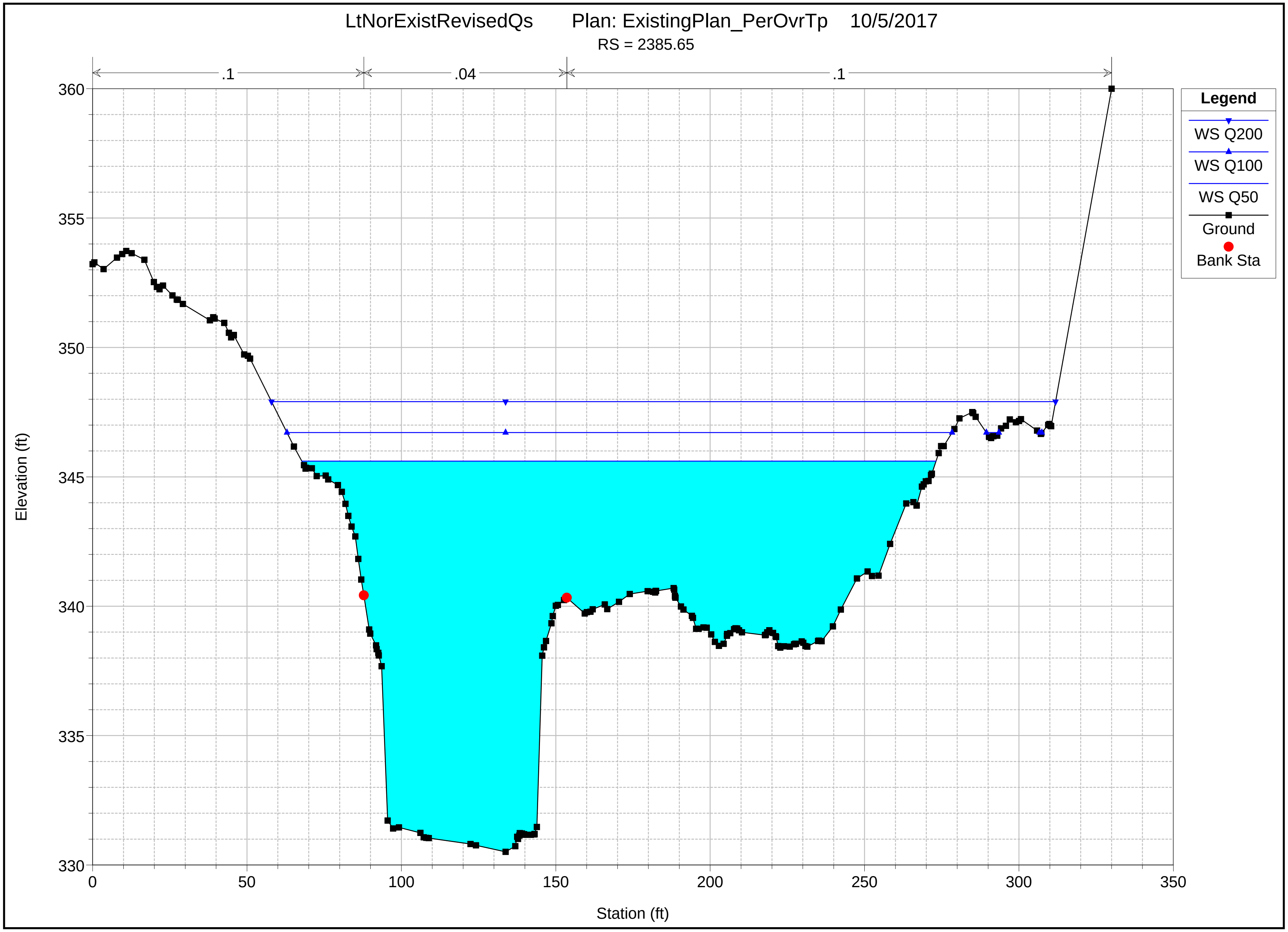
HEC-RAS Plan: Ex_OvrTp River: StreamCL Reach: StreamCL

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
			(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
StreamCL	2385.65	Q50	345.68	345.61	0.07	0.14	0.00	6.25	1923.27	363.48	205.36
StreamCL	2385.65	Q100	346.79	346.71	0.07	0.13	0.00	15.60	2187.71	480.69	220.24
StreamCL	2385.65	Q200	347.99	347.91	0.08	0.12	0.01	30.76	2493.66	575.59	253.89
StreamCL	1604.26	Q50	345.53	345.46	0.08	0.05	0.01	4.81	1740.39	547.80	389.03
StreamCL	1604.26	Q100	346.65	346.58	0.07	0.05	0.01	7.90	1887.64	788.46	416.42
StreamCL	1604.26	Q200	347.86	347.80	0.06	0.04	0.01	11.99	2023.68	1064.33	446.04
StreamCL	1283.94	Q50	345.47	345.43	0.03	0.02	0.00	723.07	1107.17	462.76	380.47
StreamCL	1283.94	Q100	346.60	346.56	0.03	0.02	0.00	847.12	1207.12	629.76	413.64
StreamCL	1283.94	Q200	347.81	347.79	0.03	0.02	0.00	963.71	1290.95	845.35	428.37
StreamCL	1112.94	Q50	345.44	345.40	0.04	0.02	0.02	552.46	1180.02	560.52	369.98
StreamCL	1112.94	Q100	346.57	346.54	0.04	0.02	0.02	642.82	1310.44	730.74	381.99
StreamCL	1112.94	Q200	347.80	347.76	0.04	0.02	0.03	740.41	1440.42	919.17	393.90
StreamCL	1034.95	Q50	345.40	345.15	0.25				2293.00		352.18
StreamCL	1034.95	Q100	346.53	346.25	0.28				2684.00		372.36
StreamCL	1034.95	Q200	347.75	347.43	0.32				3100.00		377.60
StreamCL	982		Culvert								
StreamCL	904.43	Q50	343.30	343.24	0.06	0.04	0.08	3.38	2239.55	50.07	245.22
StreamCL	904.43	Q100	343.91	343.84	0.07	0.05	0.09	4.19	2618.93	60.88	248.83
StreamCL	904.43	Q200	344.51	344.42	0.09	0.06	0.11	5.09	3022.17	72.74	252.25
StreamCL	838.83	Q50	343.18	342.87	0.31	0.06	0.10		2293.00		285.58
StreamCL	838.83	Q100	343.77	343.39	0.38	0.06	0.12		2684.00		287.79
StreamCL	838.83	Q200	344.35	343.89	0.46	0.07	0.15		3100.00		289.92
StreamCL	686.02	Q50	343.03	342.96	0.07	0.09	0.01	387.47	1903.15	2.39	290.97
StreamCL	686.02	Q100	343.58	343.51	0.08	0.10	0.01	503.65	2176.79	3.56	292.55
StreamCL	686.02	Q200	344.13	344.04	0.09	0.11	0.02	632.44	2462.54	5.02	294.08
StreamCL	419.2	Q50	342.92	342.72	0.20	0.14	0.00	258.19	1778.46	256.35	212.57
StreamCL	419.2	Q100	343.47	343.24	0.22	0.15	0.00	315.46	2020.55	347.99	213.97
StreamCL	419.2	Q200	344.00	343.75	0.25	0.16	0.00	377.16	2272.02	450.82	215.33
StreamCL	216.64	Q50	342.77	342.56	0.22	0.12	0.05	95.89	1966.04	231.07	189.11
StreamCL	216.64	Q100	343.31	343.06	0.25	0.13	0.06	143.16	2249.89	290.95	190.41
StreamCL	216.64	Q200	343.84	343.56	0.28	0.13	0.07	198.09	2545.52	356.38	191.68
StreamCL	31.36	Q50	342.60	342.49	0.11	0.08	0.01	956.95	1327.87	8.18	250.28
StreamCL	31.36	Q100	343.12	343.00	0.12	0.09	0.01	1175.95	1494.82	13.24	251.64
StreamCL	31.36	Q200	343.63	343.50	0.13	0.09	0.01	1410.67	1670.00	19.32	253.09
StreamCL	-121.5	Q50	342.51	342.37	0.14	0.26	0.07	106.87	1866.53	319.60	210.99
StreamCL	-121.5	Q100	343.02	342.87	0.16	0.28	0.08	136.83	2122.64	424.54	212.87
StreamCL	-121.5	Q200	343.53	343.35	0.18	0.30	0.08	168.96	2388.85	542.19	215.05
StreamCL	-459.58	Q50	342.18	341.80	0.38	0.52	0.08	364.23	1922.10	6.67	236.31
StreamCL	-459.58	Q100	342.67	342.25	0.41	0.53	0.09	515.60	2158.43	9.97	240.59
StreamCL	-459.58	Q200	343.14	342.70	0.45	0.54	0.09	689.82	2396.10	14.08	243.44
StreamCL	-980.34	Q50	341.58	341.45	0.12	0.22	0.02	331.72	1292.23	669.04	324.91
StreamCL	-980.34	Q100	342.05	341.92	0.13	0.24	0.01	424.03	1421.48	838.49	326.59
StreamCL	-980.34	Q200	342.51	342.37	0.13	0.26	0.01	523.83	1554.88	1021.29	327.98
StreamCL	-1650.77	Q50	341.34	341.27	0.07	0.08	0.00	76.73	2210.43	5.84	257.87
StreamCL	-1650.77	Q100	341.79	341.70	0.09	0.09	0.01	114.45	2560.77	8.78	266.65
StreamCL	-1650.77	Q200	342.23	342.13	0.10	0.09	0.01	163.67	2923.88	12.45	269.13
StreamCL	-1948.51	Q50	341.26	341.20	0.06			631.63	955.38	705.99	469.71
StreamCL	-1948.51	Q100	341.69	341.63	0.06			781.20	1045.99	856.81	473.48
StreamCL	-1948.51	Q200	342.12	342.06	0.06			943.73	1139.05	1017.22	506.24

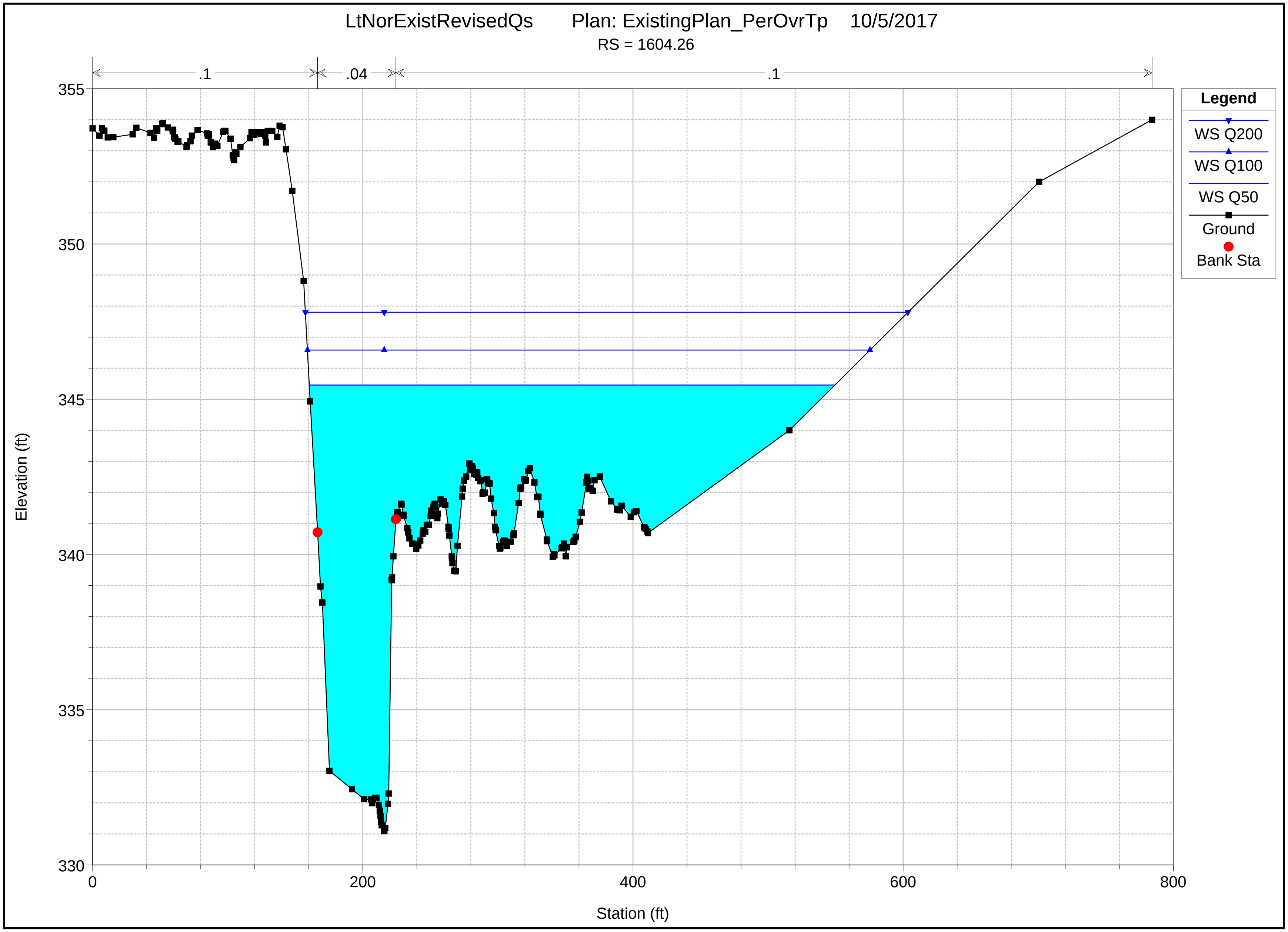
EXISTING CONDITIONS
Water Surface Profile



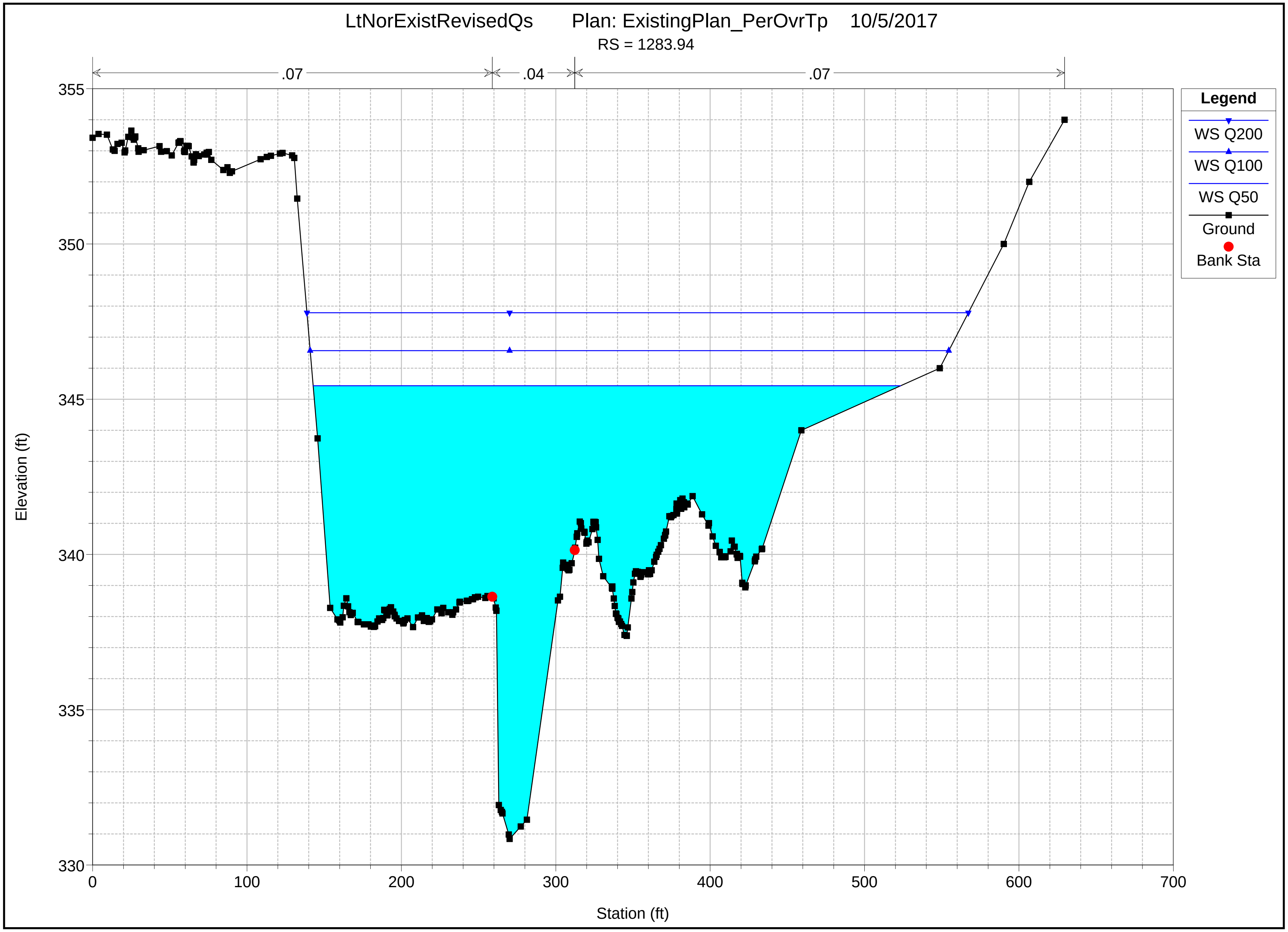
EXISTING CONDITIONS
Cross-Sections



EXISTING CONDITIONS
Cross-Sections



EXISTING CONDITIONS
Cross-Sections



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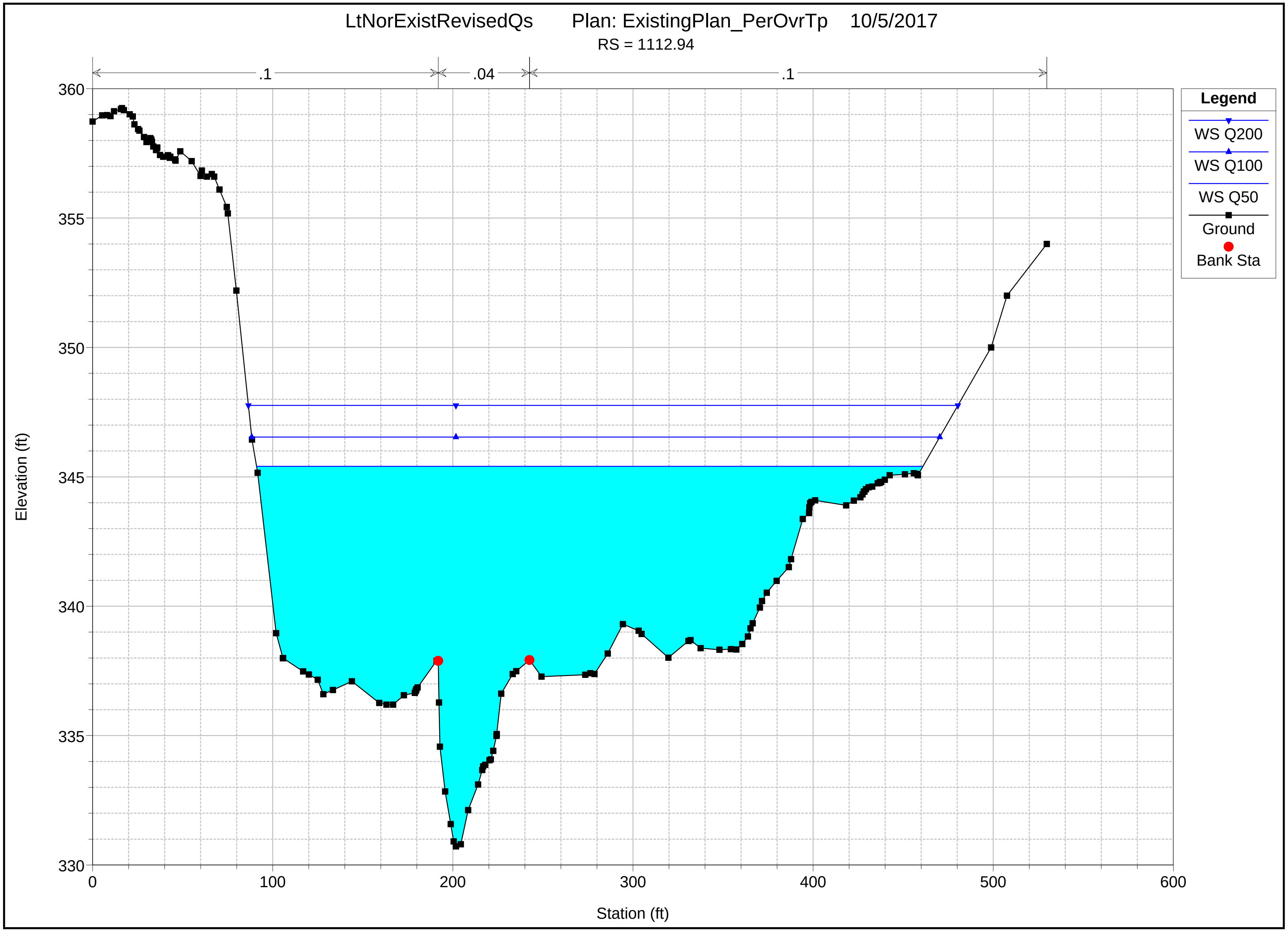
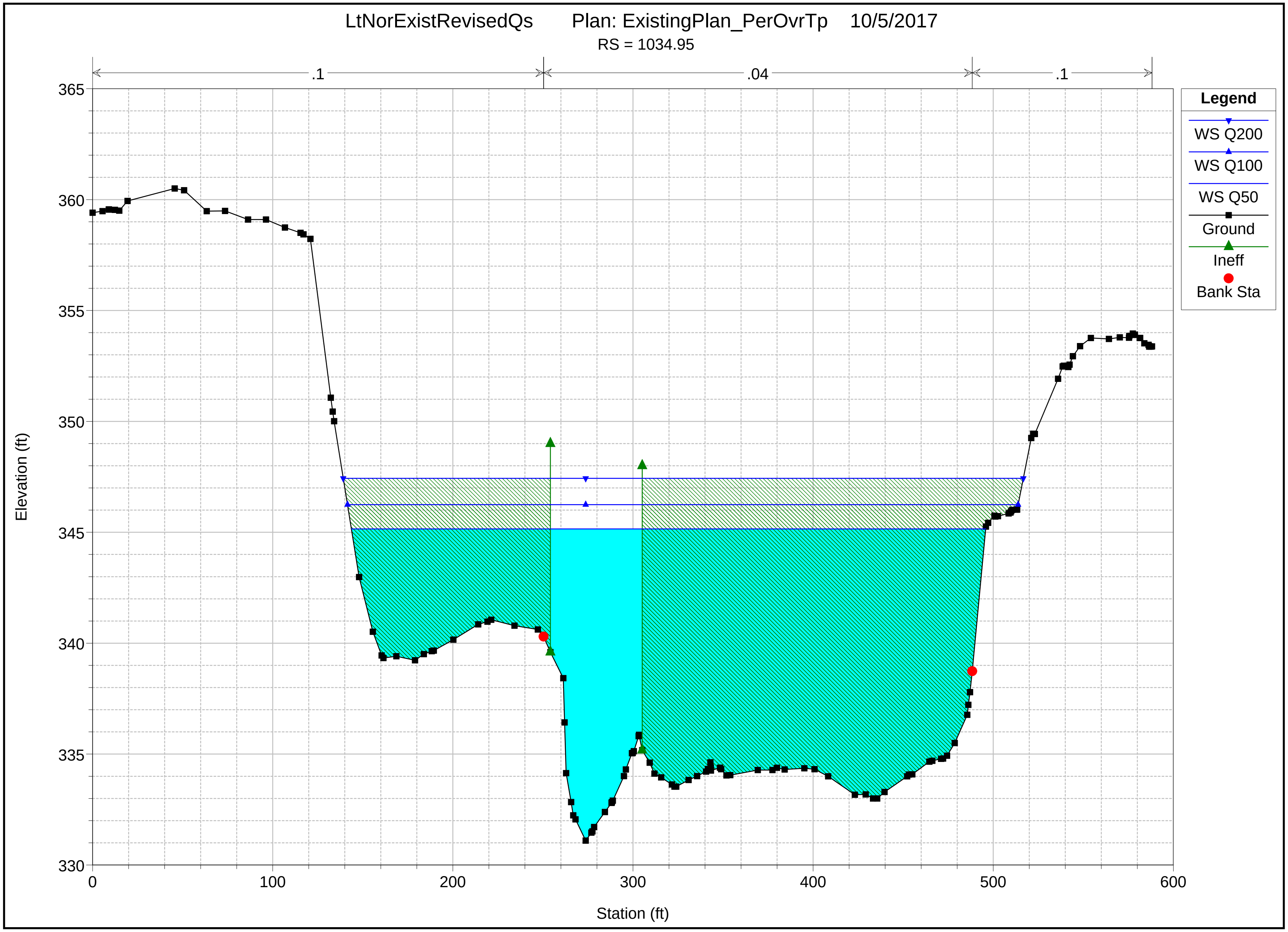
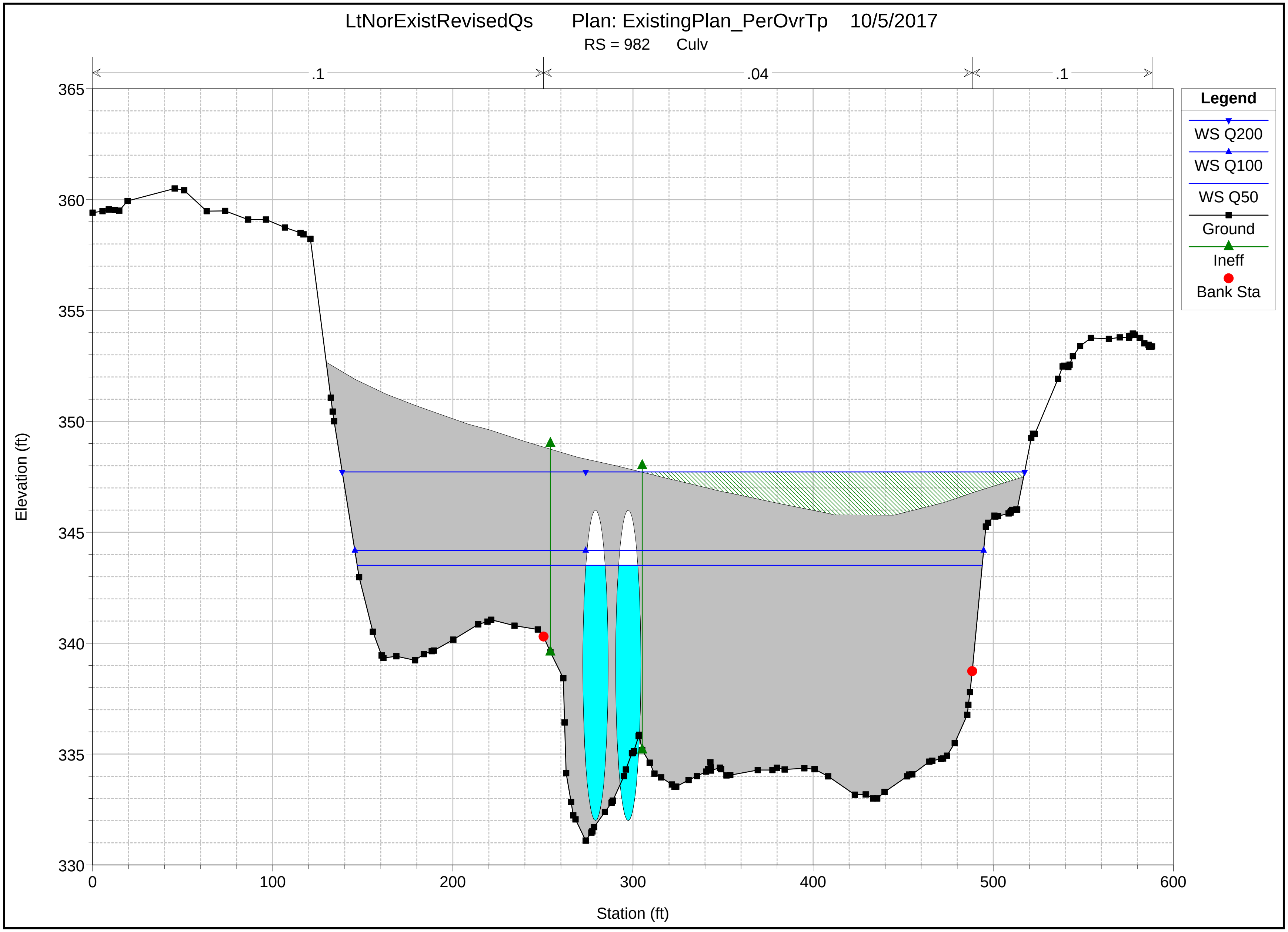
Cross-Sections



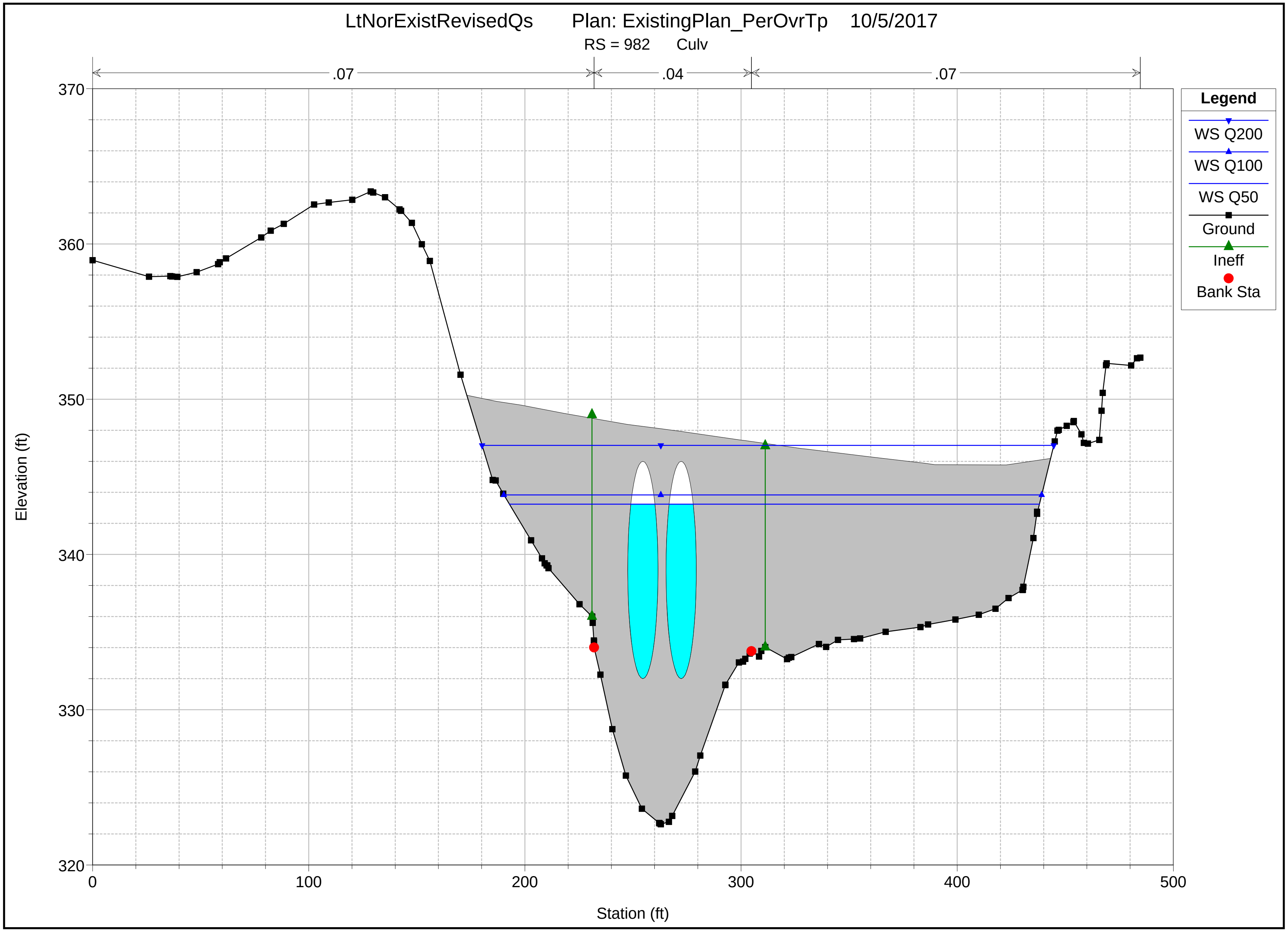
EXISTING CONDITIONS
Cross-Sections



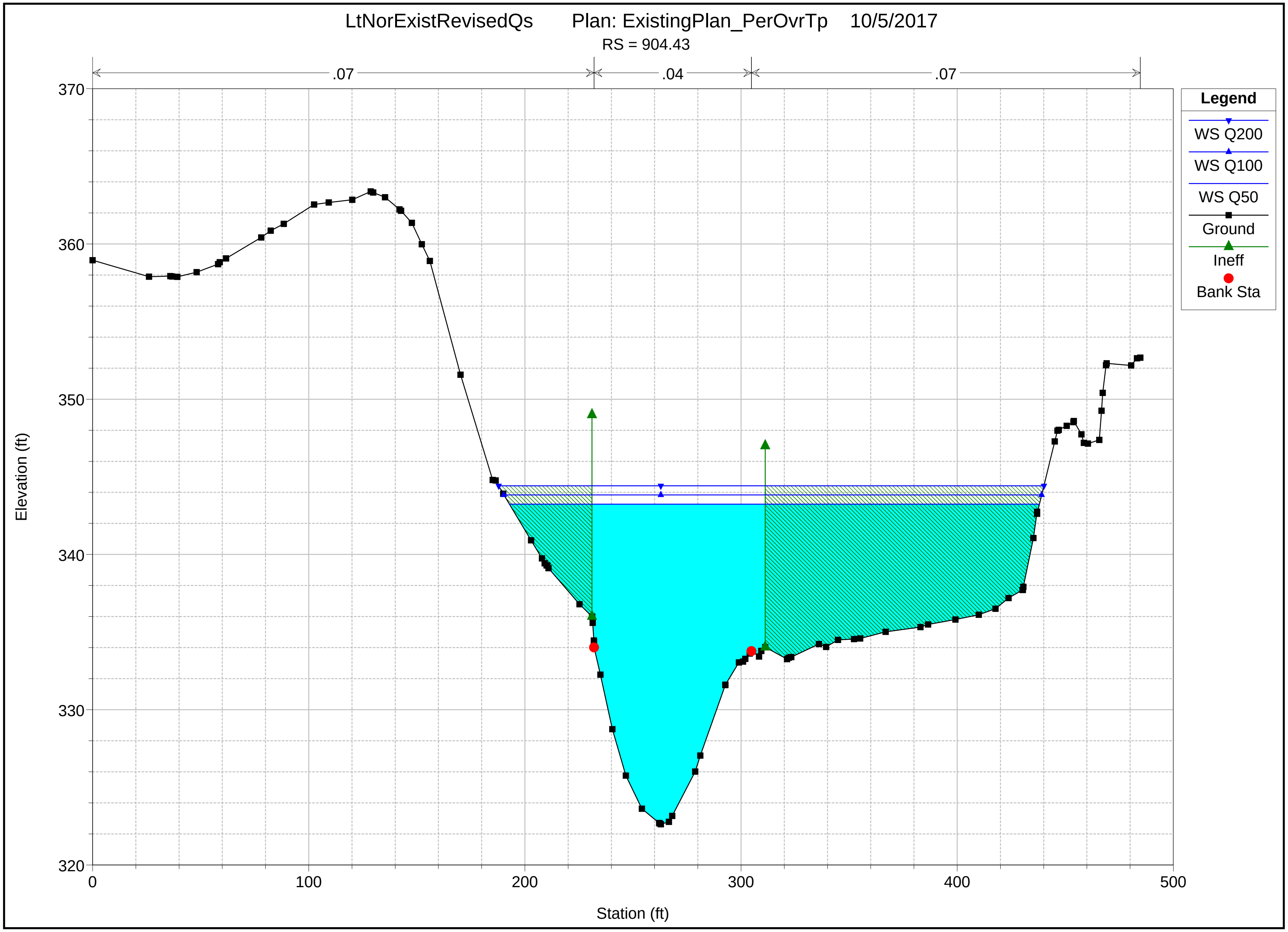
EXISTING CONDITIONS
Cross-Sections



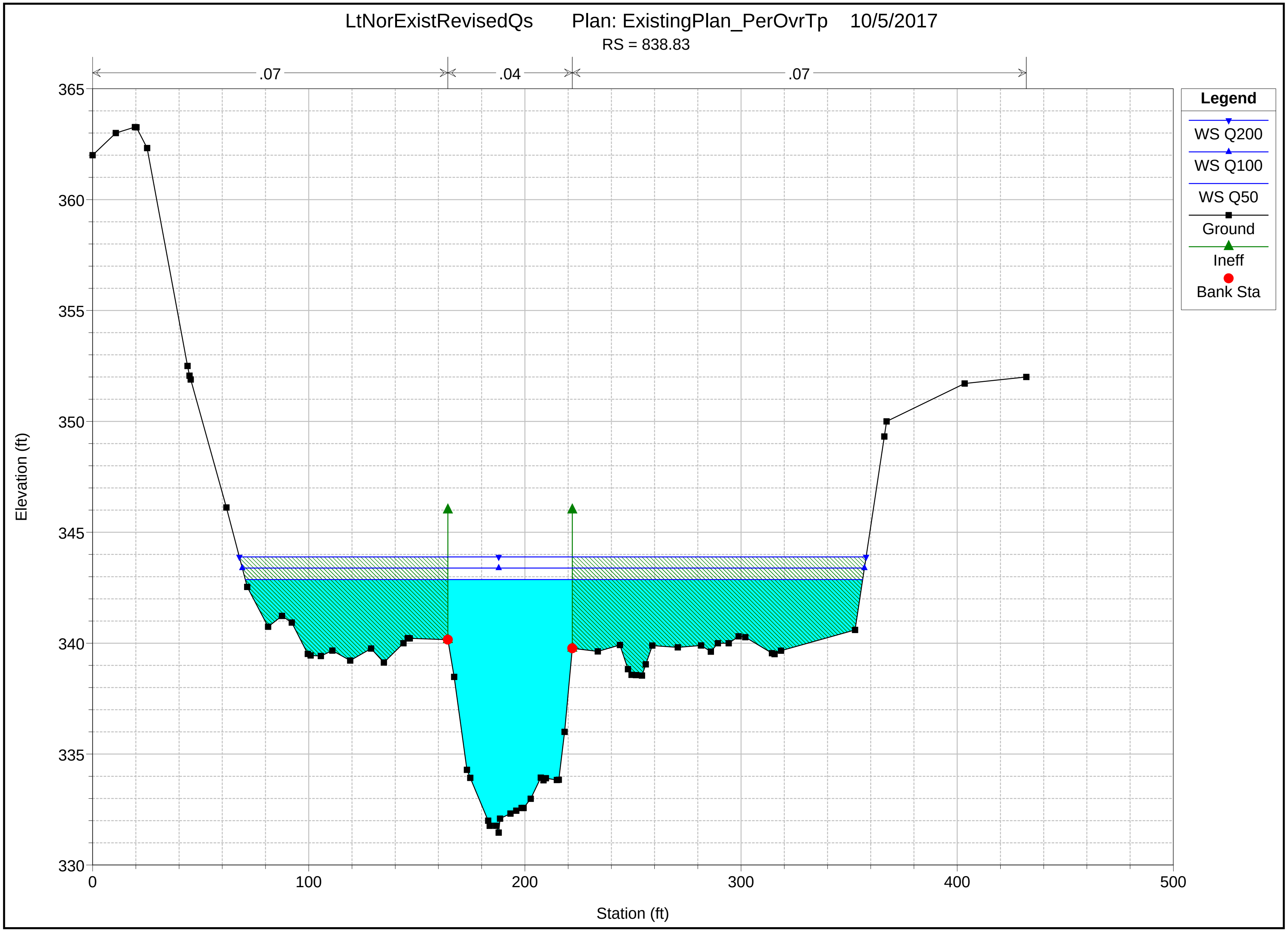
EXISTING CONDITIONS
Cross-Sections



EXISTING CONDITIONS
Cross-Sections



EXISTING CONDITIONS
Cross-Sections



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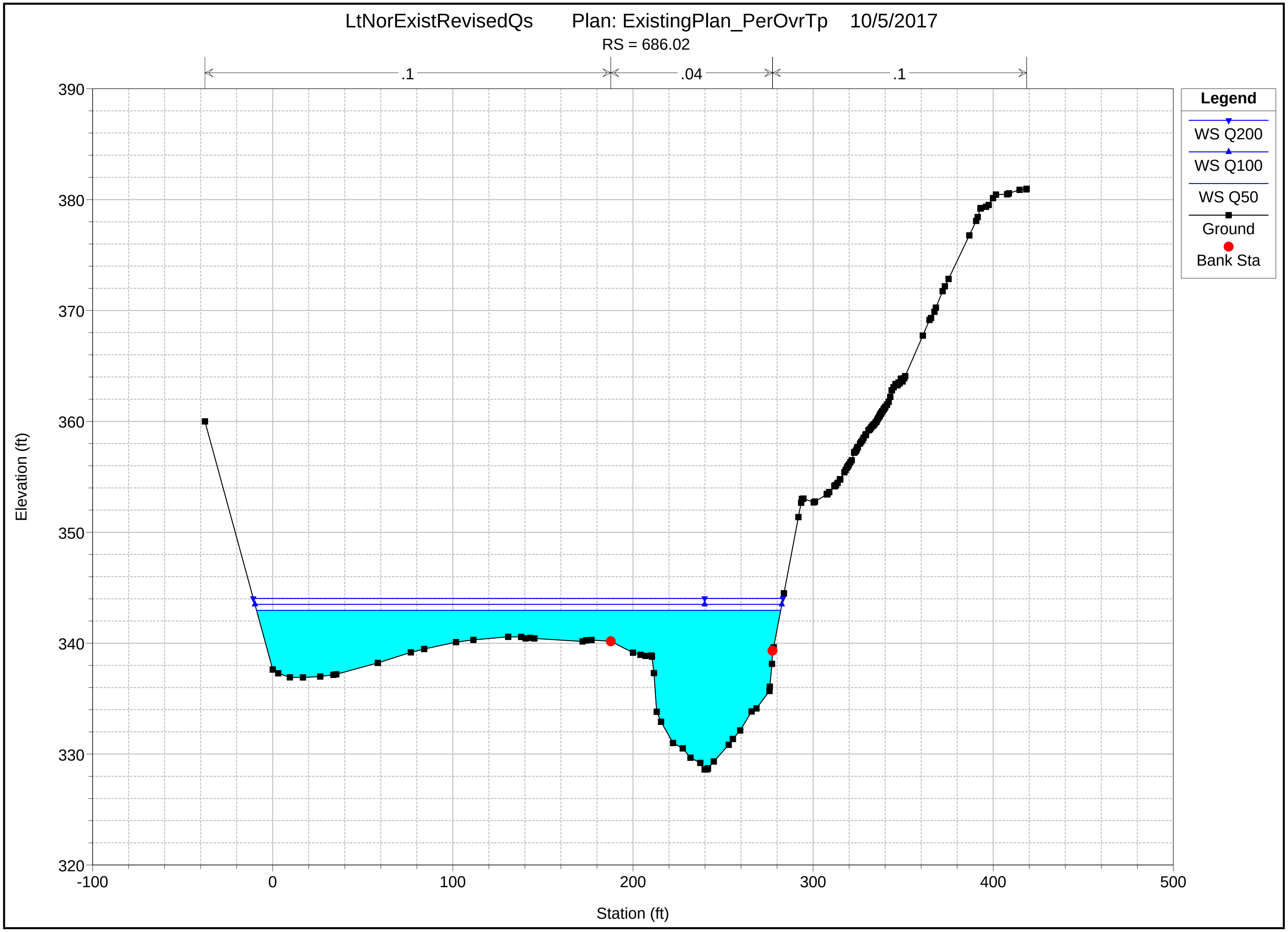
Cross-Sections



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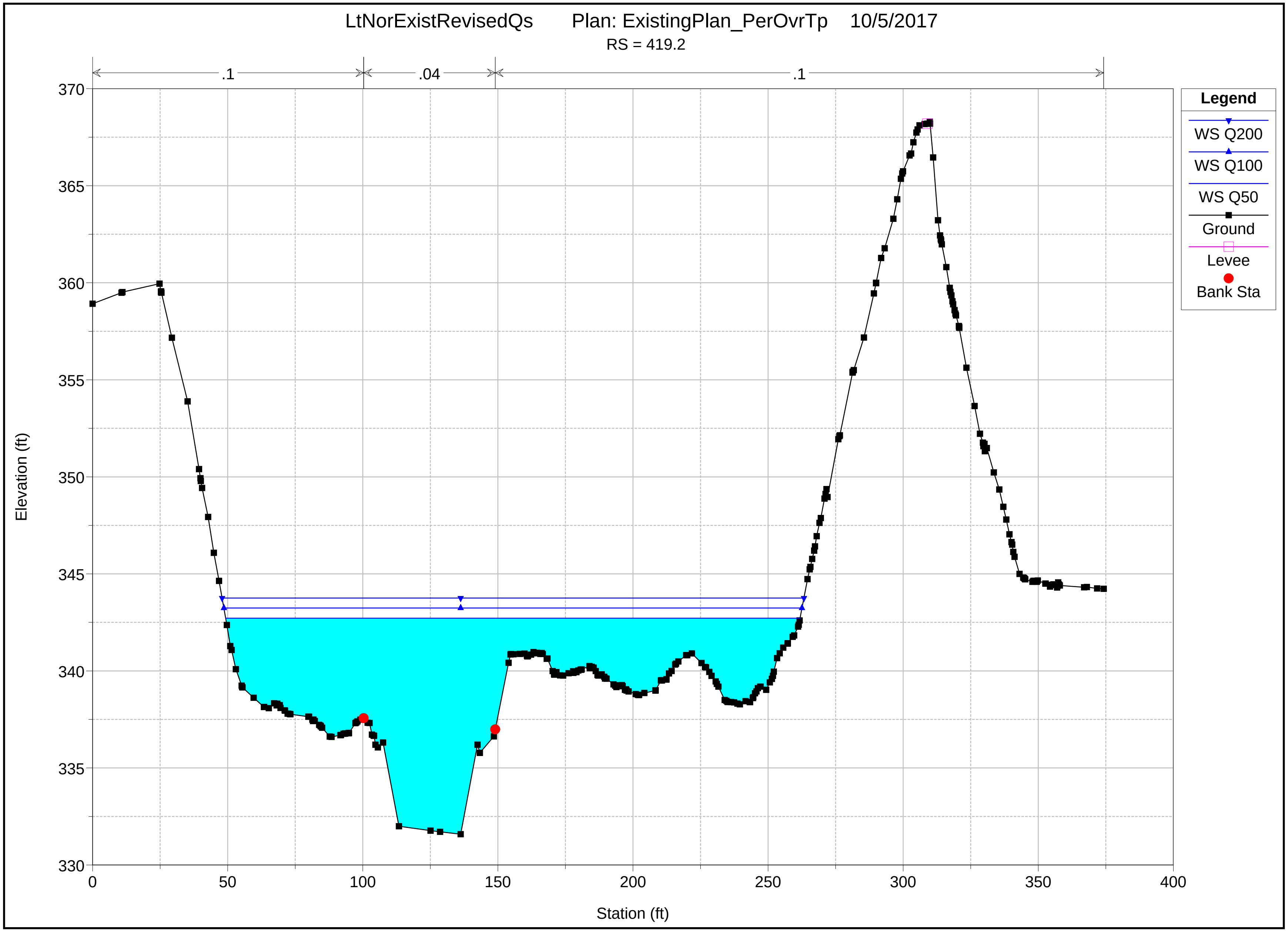

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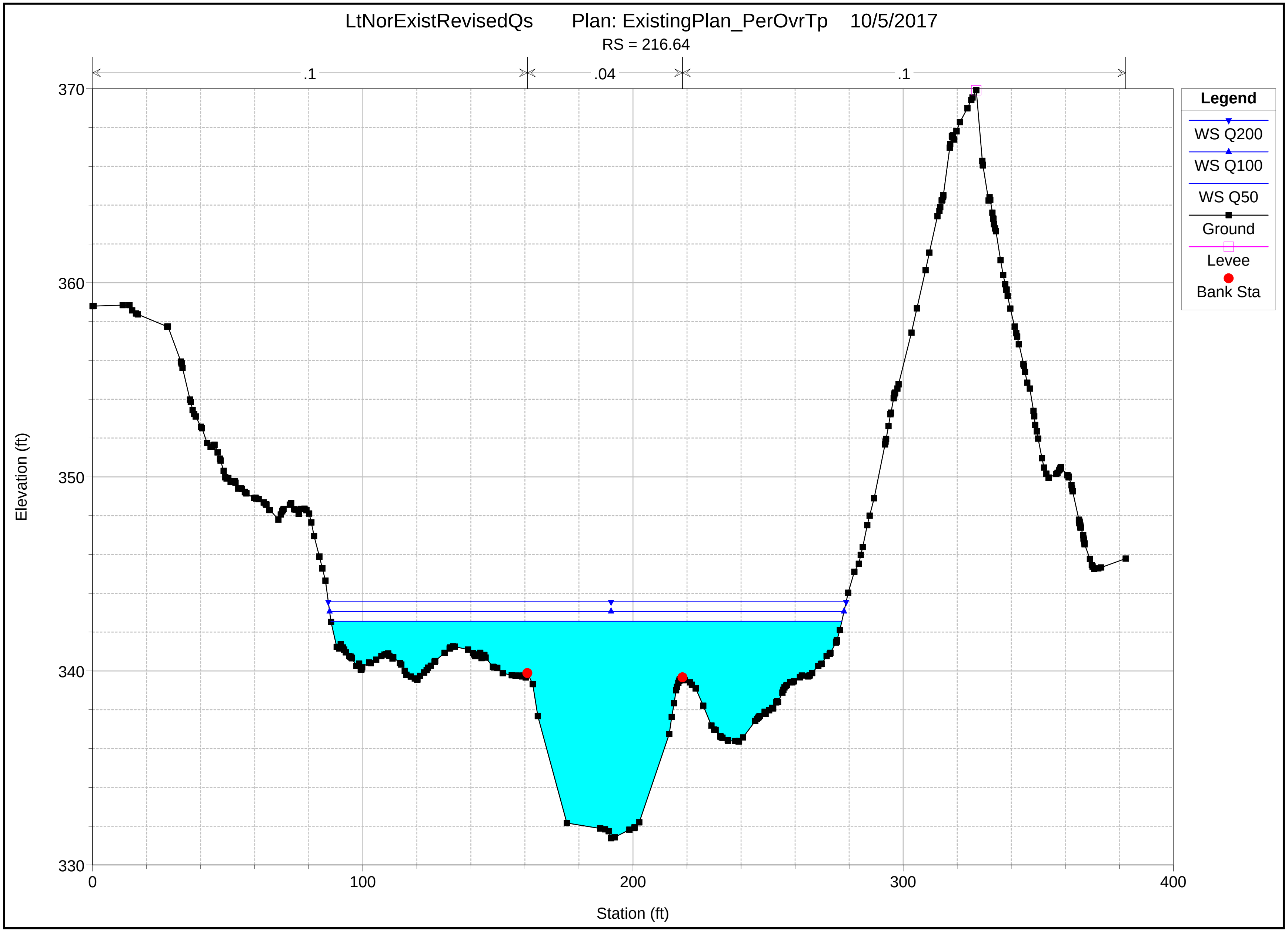
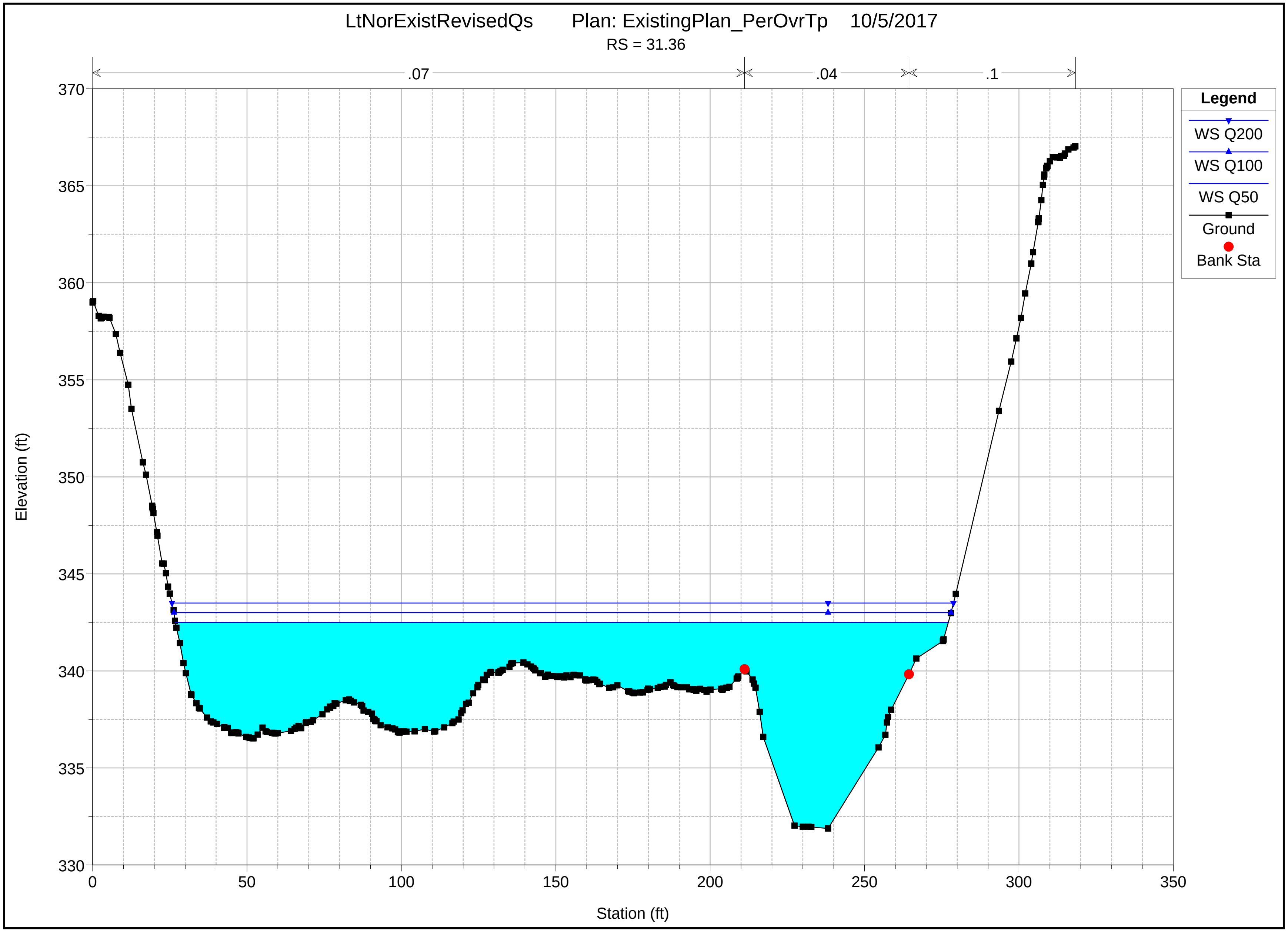
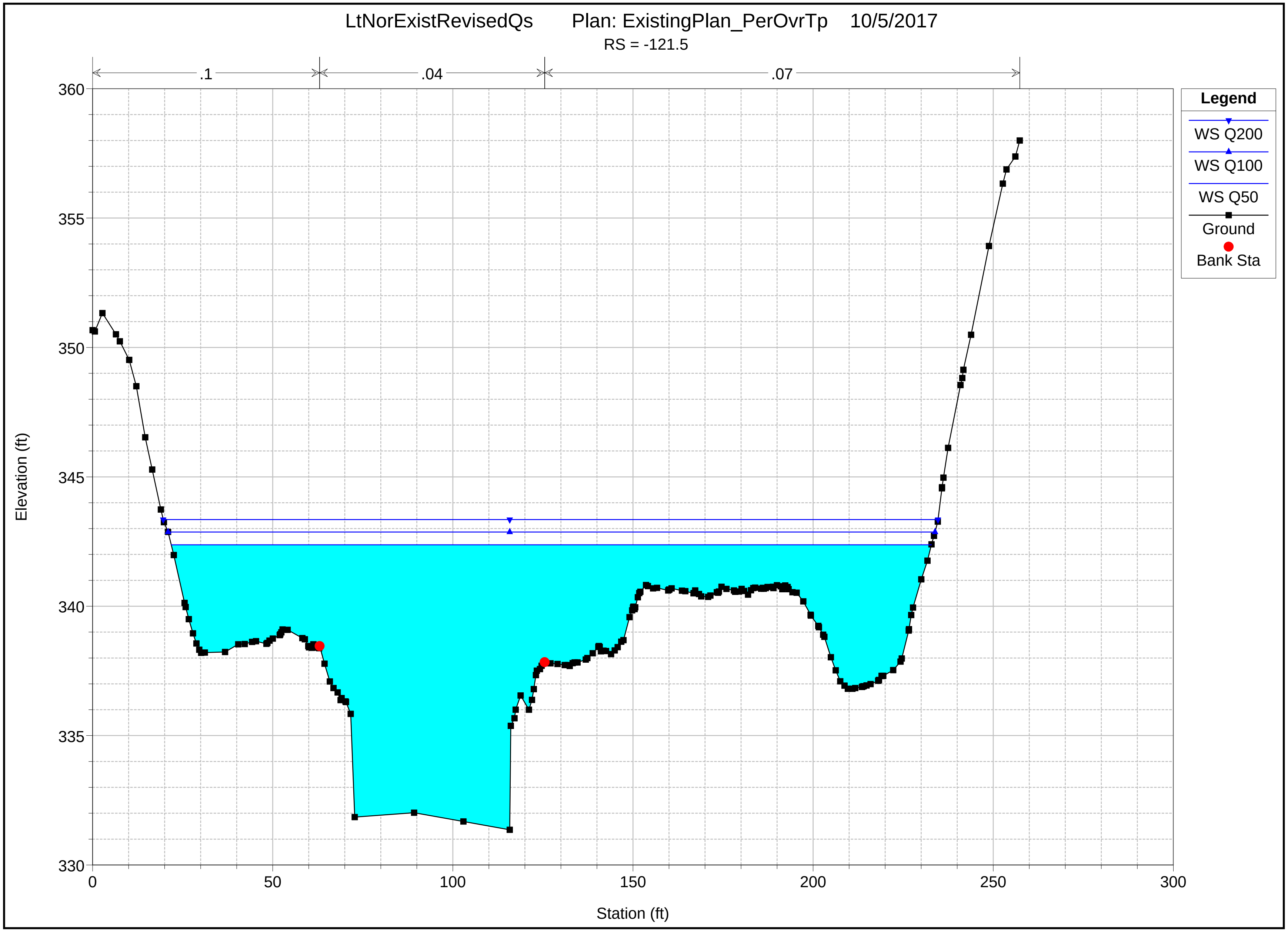


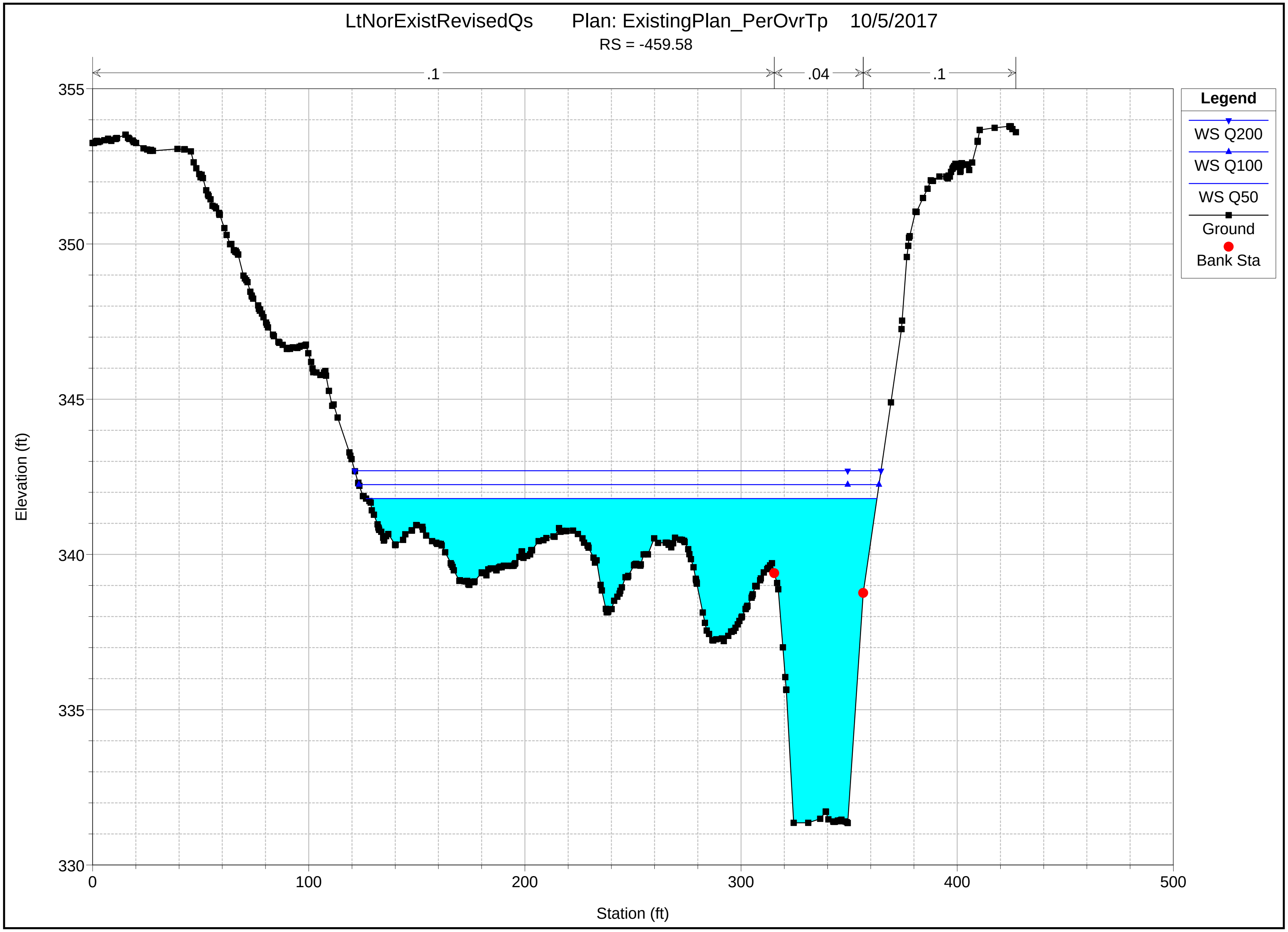
EXISTING CONDITIONS
Cross-Sections



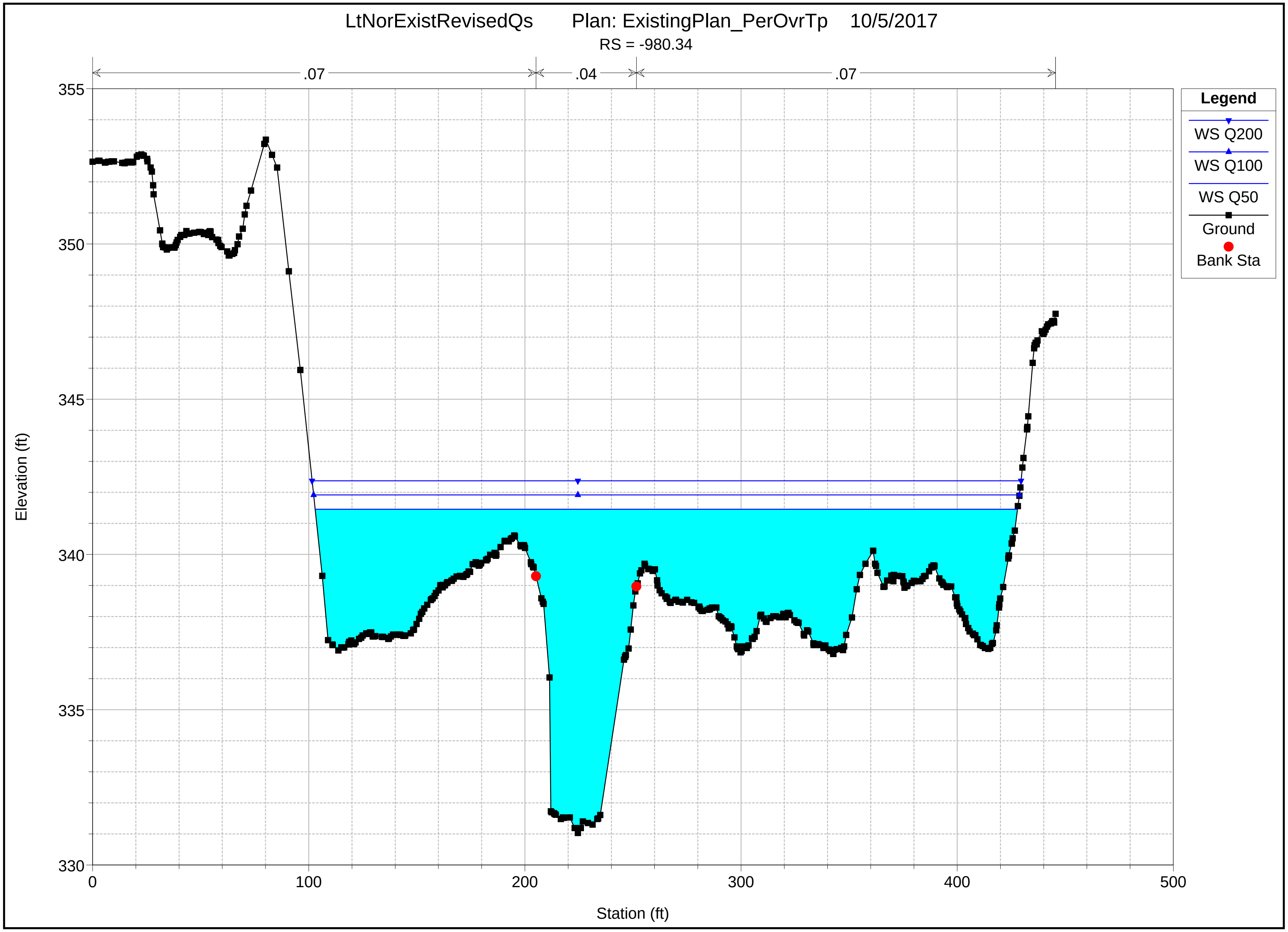
EXISTING CONDITIONS
Cross-Sections



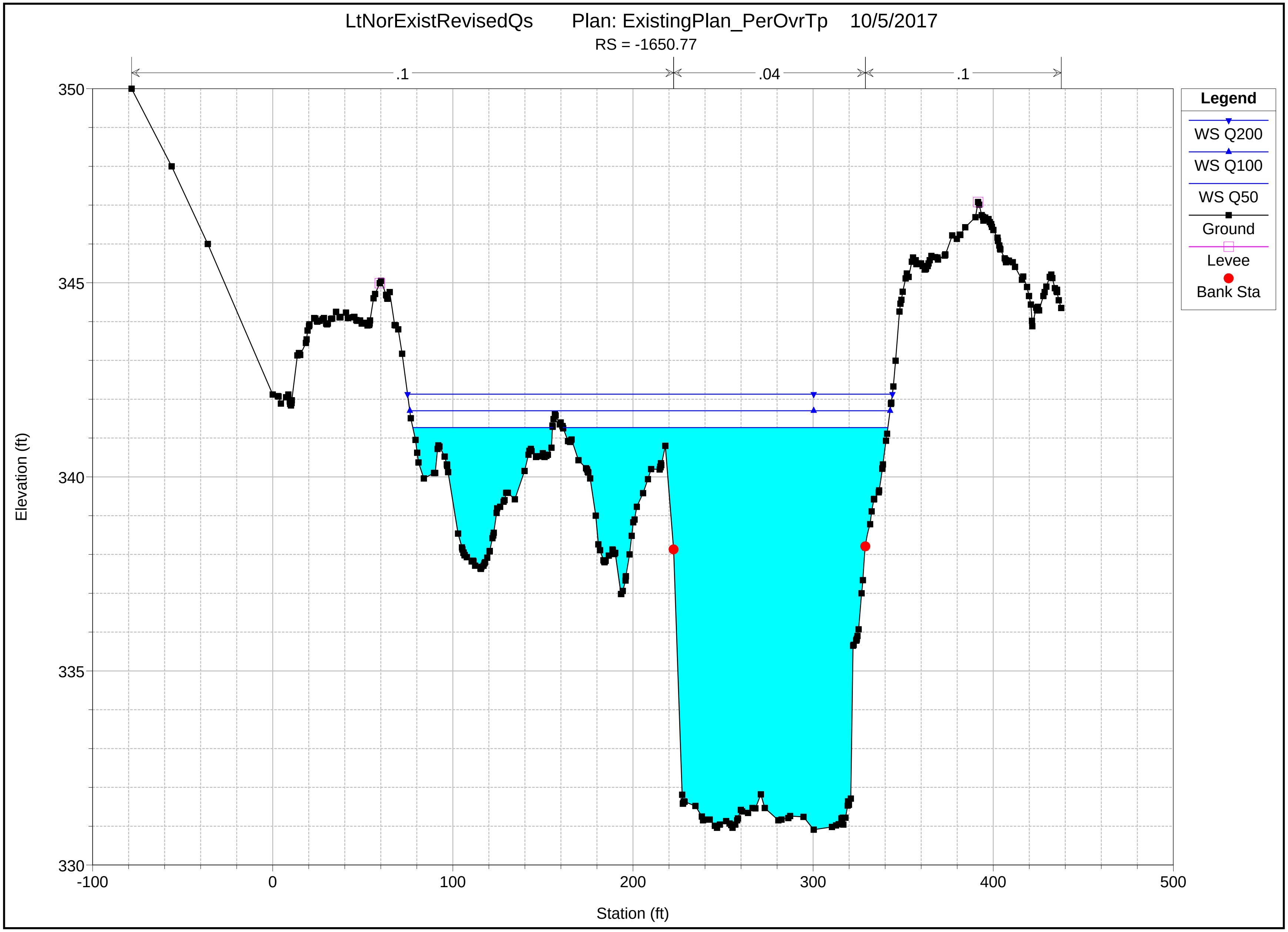
EXISTING CONDITIONS
Cross-Sections



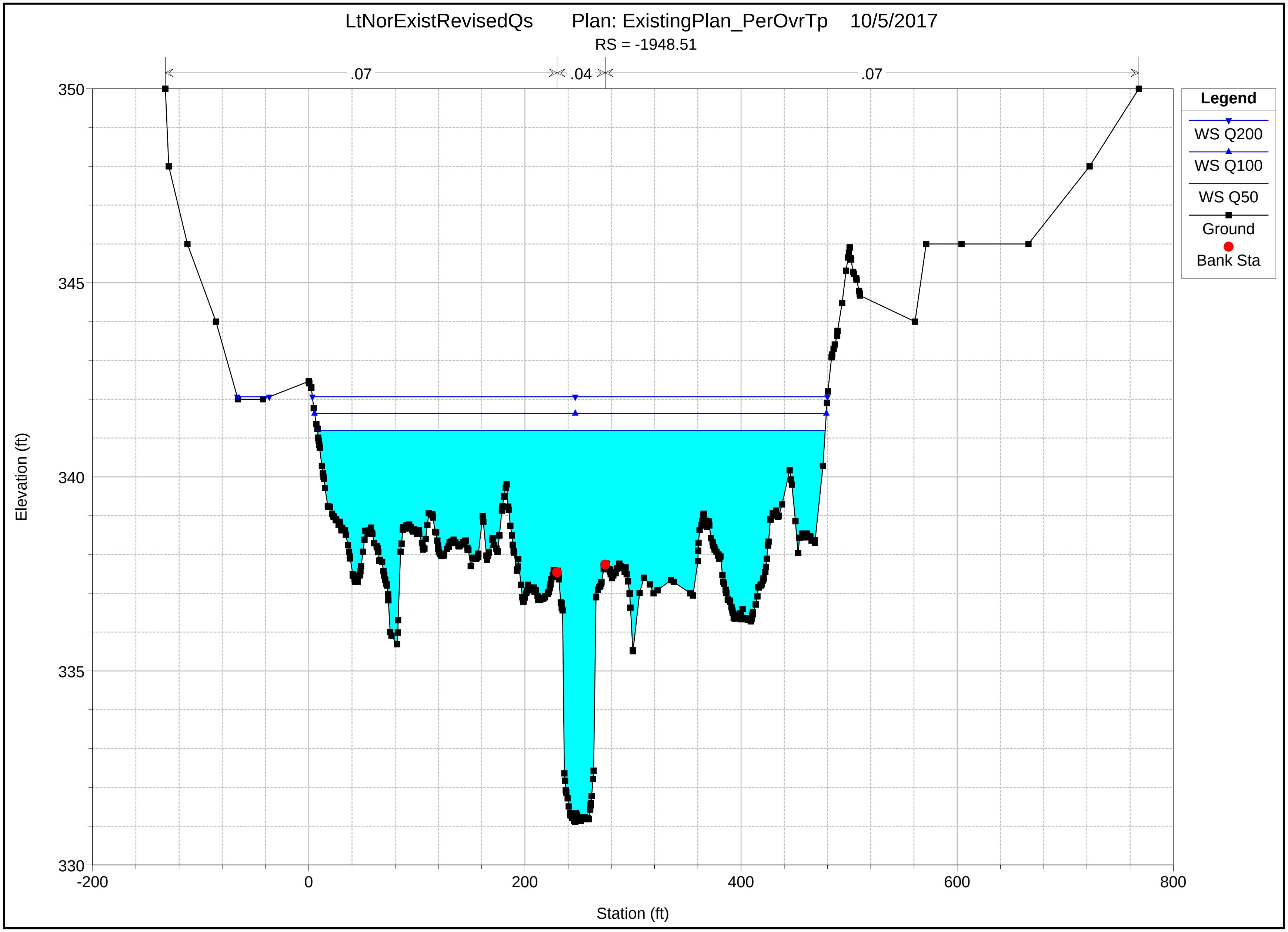
EXISTING CONDITIONS
Cross-Sections



EXISTING CONDITIONS
Cross-Sections



EXISTING CONDITIONS
Cross-Sections



PROPOSED CONDITIONS
Standard Table 1

HEC-RAS Plan: Prop River: StreamCL Reach: StreamCL

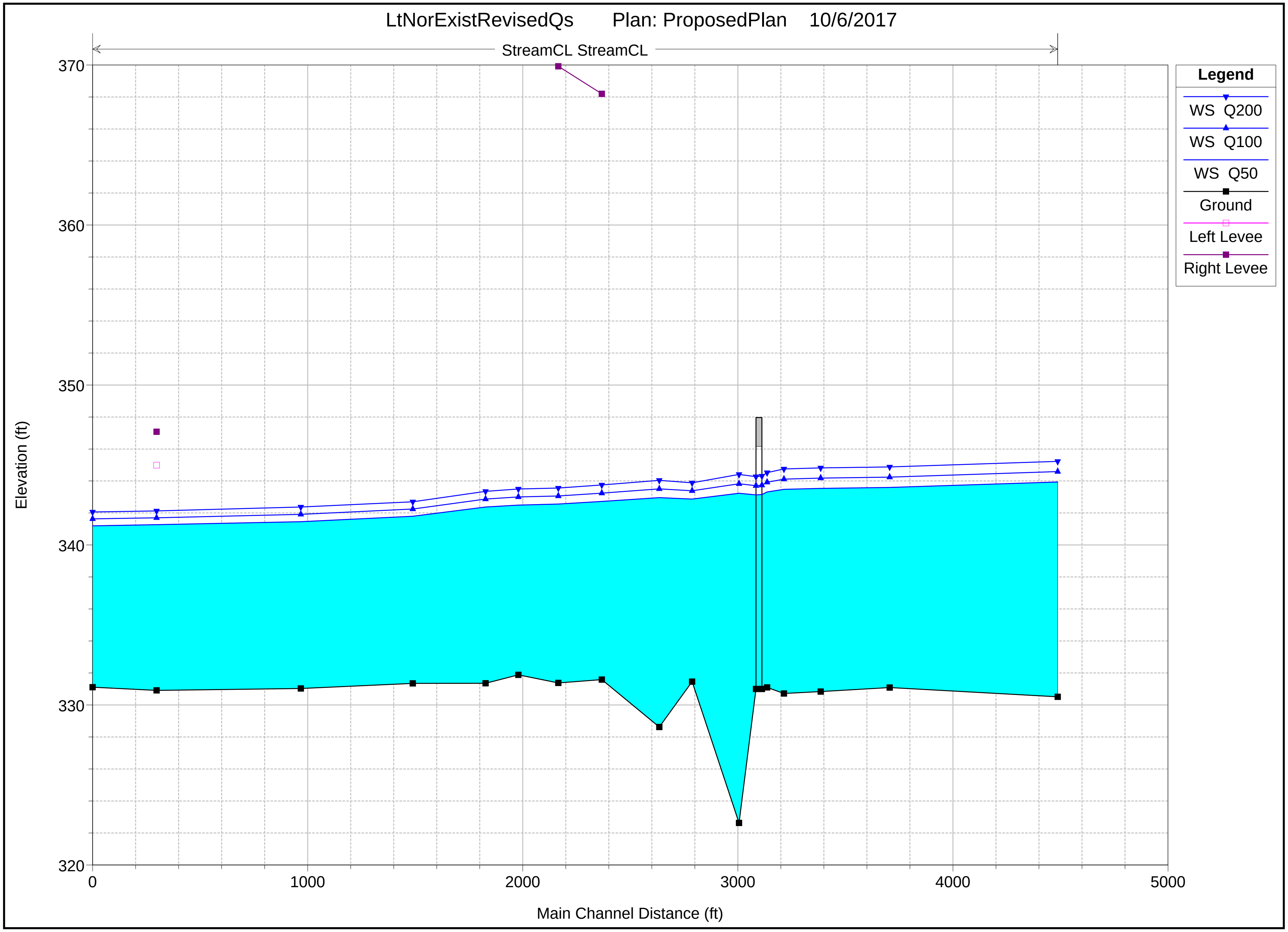
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
StreamCL	2385.65	Q50	2293.00	330.51	343.94		344.04	0.000280	2.78	1177.49	181.92	0.15
StreamCL	2385.65	Q100	2684.00	330.51	344.59		344.71	0.000306	3.02	1298.37	188.57	0.16
StreamCL	2385.65	Q200	3100.00	330.51	345.22		345.37	0.000331	3.25	1422.64	200.54	0.16
StreamCL	1604.26	Q50	2293.00	331.09	343.59		343.76	0.000482	3.44	1148.64	340.13	0.19
StreamCL	1604.26	Q100	2684.00	331.09	344.24		344.41	0.000487	3.61	1374.03	359.29	0.19
StreamCL	1604.26	Q200	3100.00	331.09	344.88		345.05	0.000486	3.75	1609.04	374.92	0.20
StreamCL	1283.94	Q50	2293.00	330.84	343.53		343.60	0.000332	2.65	1513.26	309.88	0.16
StreamCL	1283.94	Q100	2684.00	330.84	344.18		344.25	0.000327	2.76	1716.04	322.12	0.16
StreamCL	1283.94	Q200	3100.00	330.84	344.82		344.90	0.000328	2.89	1931.73	351.92	0.16
StreamCL	1112.94	Q50	2293.00	330.72	343.48		343.55	0.000309	2.69	1783.97	301.53	0.16
StreamCL	1112.94	Q100	2684.00	330.72	344.12		344.19	0.000331	2.92	1980.67	330.28	0.16
StreamCL	1112.94	Q200	3100.00	330.72	344.75		344.84	0.000339	3.08	2194.97	343.80	0.17
StreamCL	1034.95	Q50	2293.00	331.10	343.32	336.90	343.50	0.000505	3.48	668.43	346.41	0.20
StreamCL	1034.95	Q100	2684.00	331.10	343.92	337.29	344.15	0.000556	3.81	715.06	348.31	0.22
StreamCL	1034.95	Q200	3100.00	331.10	344.52	337.68	344.78	0.000606	4.14	761.17	350.19	0.23
StreamCL	982		Bridge									
StreamCL	904.43	Q50	2293.00	322.63	343.23	329.27	343.30	0.000082	2.08	1153.76	245.18	0.09
StreamCL	904.43	Q100	2684.00	322.63	343.83	329.79	343.91	0.000099	2.34	1199.49	248.77	0.10
StreamCL	904.43	Q200	3100.00	322.63	344.41	330.32	344.51	0.000118	2.61	1244.44	252.18	0.11
StreamCL	838.83	Q50	2293.00	331.46	342.87	337.35	343.18	0.000886	4.49	510.99	285.58	0.27
StreamCL	838.83	Q100	2684.00	331.46	343.39	337.82	343.77	0.001005	4.96	540.79	287.79	0.29
StreamCL	838.83	Q200	3100.00	331.46	343.89	338.28	344.35	0.001128	5.44	569.59	289.92	0.31
StreamCL	686.02	Q50	2293.00	328.62	342.96		343.03	0.000215	2.29	1578.62	290.97	0.13
StreamCL	686.02	Q100	2684.00	328.62	343.51		343.58	0.000233	2.47	1738.52	292.55	0.14
StreamCL	686.02	Q200	3100.00	328.62	344.04		344.13	0.000249	2.65	1895.43	294.08	0.15
StreamCL	419.2	Q50	2293.00	331.59	342.72	337.90	342.92	0.000688	4.03	1009.14	212.57	0.24
StreamCL	419.2	Q100	2684.00	331.59	343.24	338.25	343.47	0.000736	4.33	1121.03	213.97	0.25
StreamCL	419.2	Q200	3100.00	331.59	343.75	338.91	344.00	0.000783	4.62	1230.78	215.33	0.26
StreamCL	216.64	Q50	2293.00	331.38	342.56	337.30	342.77	0.000727	4.00	874.25	189.11	0.24
StreamCL	216.64	Q100	2684.00	331.38	343.06	337.80	343.31	0.000786	4.33	970.43	190.41	0.25
StreamCL	216.64	Q200	3100.00	331.38	343.56	338.32	343.84	0.000843	4.64	1064.65	191.68	0.26
StreamCL	31.36	Q50	2293.00	331.88	342.49		342.60	0.000586	3.31	1162.23	250.28	0.21
StreamCL	31.36	Q100	2684.00	331.88	343.00		343.12	0.000596	3.49	1290.73	251.64	0.22
StreamCL	31.36	Q200	3100.00	331.88	343.50		343.63	0.000609	3.67	1416.48	253.09	0.22
StreamCL	-121.5	Q50	2293.00	331.36	342.37		342.51	0.000482	3.28	1043.38	210.99	0.19
StreamCL	-121.5	Q100	2684.00	331.36	342.87		343.02	0.000523	3.54	1148.41	212.87	0.20
StreamCL	-121.5	Q200	3100.00	331.36	343.35		343.53	0.000562	3.79	1251.59	215.05	0.21
StreamCL	-459.58	Q50	2293.00	331.35	341.80		342.18	0.001427	5.37	764.80	236.31	0.32
StreamCL	-459.58	Q100	2684.00	331.35	342.25		342.67	0.001519	5.74	873.01	240.59	0.33
StreamCL	-459.58	Q200	3100.00	331.35	342.70		343.14	0.001598	6.07	980.85	243.44	0.35
StreamCL	-980.34	Q50	2293.00	331.03	341.45		341.58	0.000742	3.61	1195.94	324.91	0.23
StreamCL	-980.34	Q100	2684.00	331.03	341.92		342.05	0.000739	3.75	1346.76	326.59	0.23
StreamCL	-980.34	Q200	3100.00	331.03	342.37		342.51	0.000738	3.89	1495.62	327.98	0.23
StreamCL	-1650.77	Q50	2293.00	330.91	341.27	333.88	341.34	0.000187	2.19	1287.13	257.87	0.13
StreamCL	-1650.77	Q100	2684.00	330.91	341.70	334.17	341.79	0.000217	2.42	1400.99	266.65	0.14
StreamCL	-1650.77	Q200	3100.00	330.91	342.13	334.47	342.23	0.000246	2.65	1515.28	269.13	0.15
StreamCL	-1948.51	Q50	2293.00	331.11	341.20	338.18	341.26	0.000431	2.77	1734.29	469.71	0.18
StreamCL	-1948.51	Q100	2684.00	331.11	341.63	338.49	341.69	0.000430	2.87	1939.46	473.48	0.18
StreamCL	-1948.51	Q200	3100.00	331.11	342.06	338.67	342.12	0.000430	2.97	2145.20	506.24	0.18

PROPOSED CONDITIONS
Standard Table 2

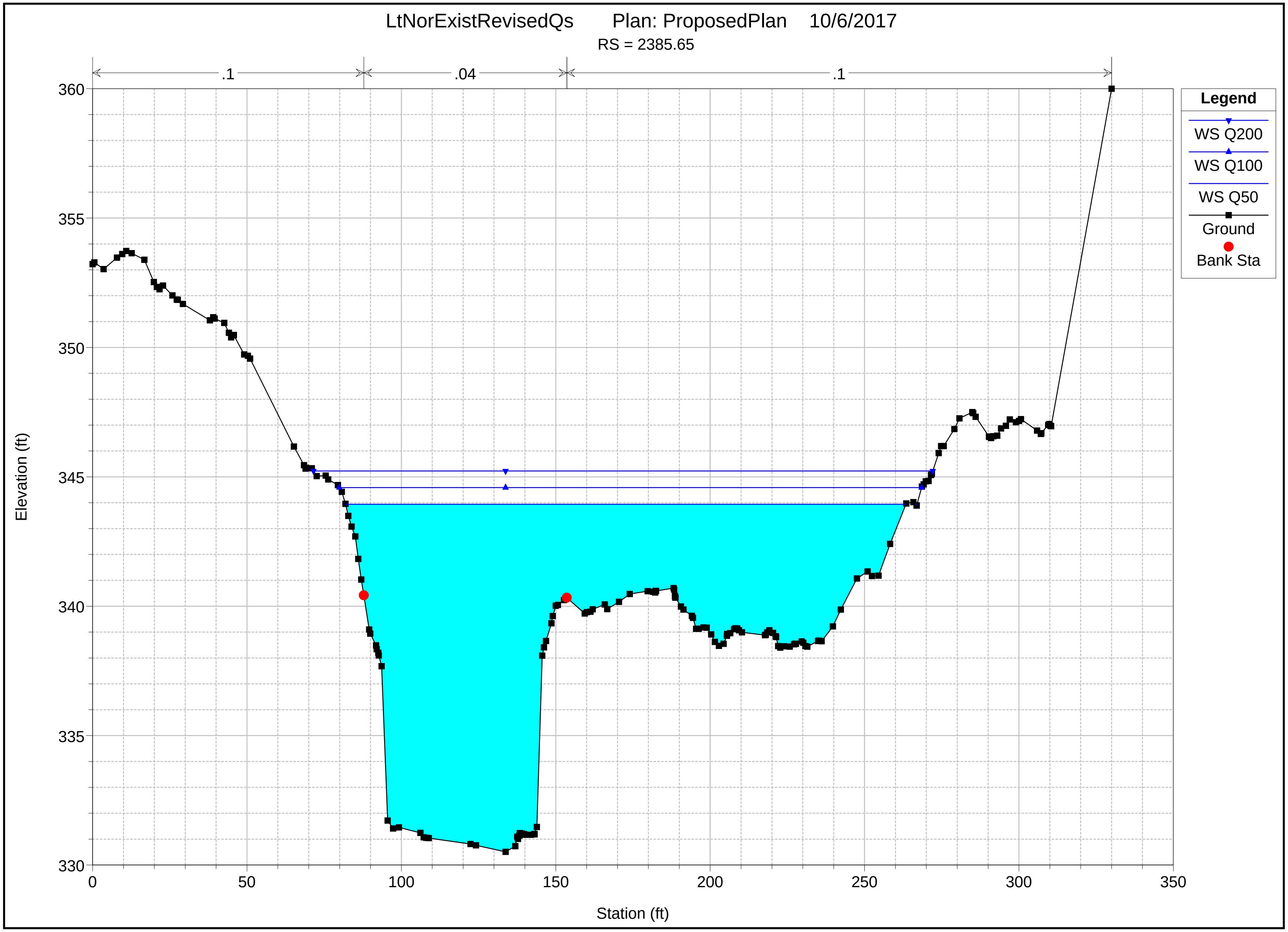
HEC-RAS Plan: Prop River: StreamCL Reach: StreamCL

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
			(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
StreamCL	2385.65	Q50	344.04	343.94	0.11	0.28	0.01	2.58	2011.60	278.82	181.92
StreamCL	2385.65	Q100	344.71	344.59	0.12	0.30	0.00	4.41	2314.32	365.28	188.57
StreamCL	2385.65	Q200	345.37	345.22	0.14	0.31	0.00	6.28	2628.50	465.22	200.54
StreamCL	1604.26	Q50	343.76	343.59	0.16	0.13	0.03	1.94	2000.13	290.92	340.13
StreamCL	1604.26	Q100	344.41	344.24	0.17	0.13	0.03	3.34	2229.93	450.73	359.29
StreamCL	1604.26	Q200	345.05	344.88	0.17	0.13	0.03	5.21	2453.90	640.89	374.92
StreamCL	1283.94	Q50	343.60	343.53	0.07	0.05	0.00	678.74	1235.94	378.32	309.88
StreamCL	1283.94	Q100	344.25	344.18	0.07	0.06	0.00	812.96	1381.78	489.26	322.12
StreamCL	1283.94	Q200	344.90	344.82	0.08	0.06	0.00	963.13	1545.92	590.95	351.92
StreamCL	1112.94	Q50	343.55	343.48	0.07	0.03	0.01	519.09	1244.95	528.96	301.53
StreamCL	1112.94	Q100	344.19	344.12	0.08	0.03	0.01	629.33	1443.57	611.10	330.28
StreamCL	1112.94	Q200	344.84	344.75	0.08	0.03	0.02	735.54	1623.69	740.77	343.80
StreamCL	1034.95	Q50	343.50	343.32	0.19	0.02	0.03	7.54	2285.46		346.41
StreamCL	1034.95	Q100	344.15	343.92	0.22	0.02	0.04	10.93	2673.07		348.31
StreamCL	1034.95	Q200	344.78	344.52	0.27	0.02	0.04	14.92	3085.08		350.19
StreamCL	982		Bridge								
StreamCL	904.43	Q50	343.30	343.23	0.07	0.04	0.07	44.19	2248.81		245.18
StreamCL	904.43	Q100	343.91	343.83	0.08	0.05	0.09	56.05	2627.95		248.77
StreamCL	904.43	Q200	344.51	344.41	0.10	0.06	0.11	69.45	3030.55		252.18
StreamCL	838.83	Q50	343.18	342.87	0.31	0.06	0.10		2293.00		285.58
StreamCL	838.83	Q100	343.77	343.39	0.38	0.06	0.12		2684.00		287.79
StreamCL	838.83	Q200	344.35	343.89	0.46	0.07	0.15		3100.00		289.92
StreamCL	686.02	Q50	343.03	342.96	0.07	0.09	0.01	387.46	1903.15	2.39	290.97
StreamCL	686.02	Q100	343.58	343.51	0.08	0.10	0.01	503.65	2176.79	3.56	292.55
StreamCL	686.02	Q200	344.13	344.04	0.09	0.11	0.02	632.44	2462.54	5.02	294.08
StreamCL	419.2	Q50	342.92	342.72	0.20	0.14	0.00	258.19	1778.46	256.35	212.57
StreamCL	419.2	Q100	343.47	343.24	0.22	0.15	0.00	315.46	2020.55	347.99	213.97
StreamCL	419.2	Q200	344.00	343.75	0.25	0.16	0.00	377.16	2272.02	450.82	215.33
StreamCL	216.64	Q50	342.77	342.56	0.22	0.12	0.05	95.88	1966.04	231.07	189.11
StreamCL	216.64	Q100	343.31	343.06	0.25	0.13	0.06	143.16	2249.89	290.95	190.41
StreamCL	216.64	Q200	343.84	343.56	0.28	0.13	0.07	198.09	2545.53	356.38	191.68
StreamCL	31.36	Q50	342.60	342.49	0.11	0.08	0.01	956.95	1327.87	8.18	250.28
StreamCL	31.36	Q100	343.12	343.00	0.12	0.09	0.01	1175.95	1494.82	13.24	251.64
StreamCL	31.36	Q200	343.63	343.50	0.13	0.09	0.01	1410.67	1670.01	19.32	253.09
StreamCL	-121.5	Q50	342.51	342.37	0.14	0.26	0.07	106.87	1866.54	319.60	210.99
StreamCL	-121.5	Q100	343.02	342.87	0.16	0.28	0.08	136.83	2122.64	424.54	212.87
StreamCL	-121.5	Q200	343.53	343.35	0.18	0.30	0.08	168.96	2388.85	542.19	215.05
StreamCL	-459.58	Q50	342.18	341.80	0.38	0.52	0.08	364.23	1922.10	6.67	236.31
StreamCL	-459.58	Q100	342.67	342.25	0.41	0.53	0.09	515.60	2158.43	9.97	240.59
StreamCL	-459.58	Q200	343.14	342.70	0.45	0.54	0.09	689.82	2396.11	14.08	243.44
StreamCL	-980.34	Q50	341.58	341.45	0.12	0.22	0.02	331.72	1292.24	669.04	324.91
StreamCL	-980.34	Q100	342.05	341.92	0.13	0.24	0.01	424.03	1421.48	838.49	326.59
StreamCL	-980.34	Q200	342.51	342.37	0.13	0.26	0.01	523.83	1554.89	1021.28	327.98
StreamCL	-1650.77	Q50	341.34	341.27	0.07	0.08	0.00	76.73	2210.43	5.84	257.87
StreamCL	-1650.77	Q100	341.79	341.70	0.09	0.09	0.01	114.45	2560.77	8.78	266.65
StreamCL	-1650.77	Q200	342.23	342.13	0.10	0.09	0.01	163.67	2923.88	12.45	269.13
StreamCL	-1948.51	Q50	341.26	341.20	0.06			631.63	955.39	705.98	469.71
StreamCL	-1948.51	Q100	341.69	341.63	0.06			781.20	1046.00	856.80	473.48
StreamCL	-1948.51	Q200	342.12	342.06	0.06			943.73	1139.07	1017.20	506.24

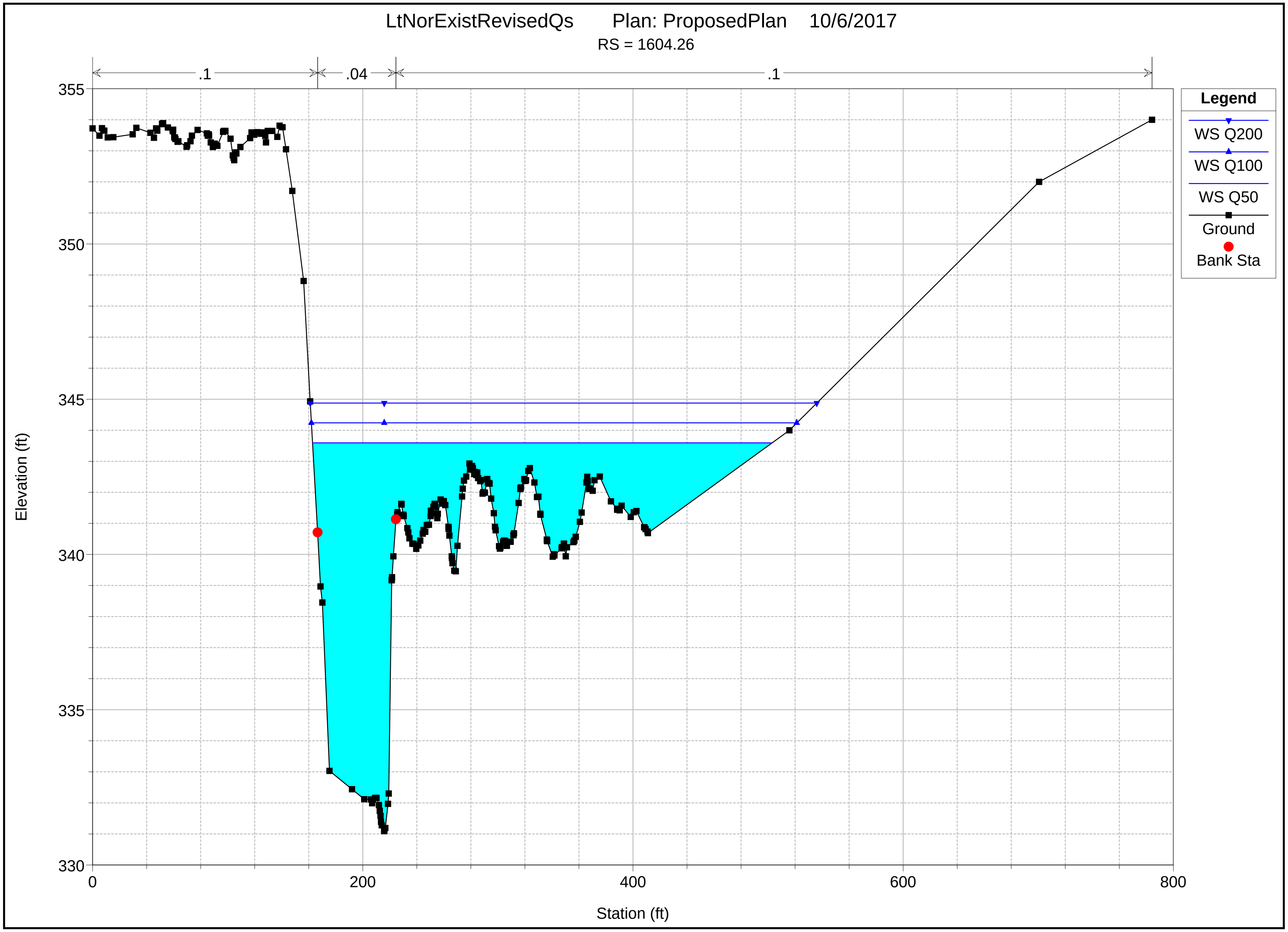
PROPOSED CONDITIONS
Water Surface Profile



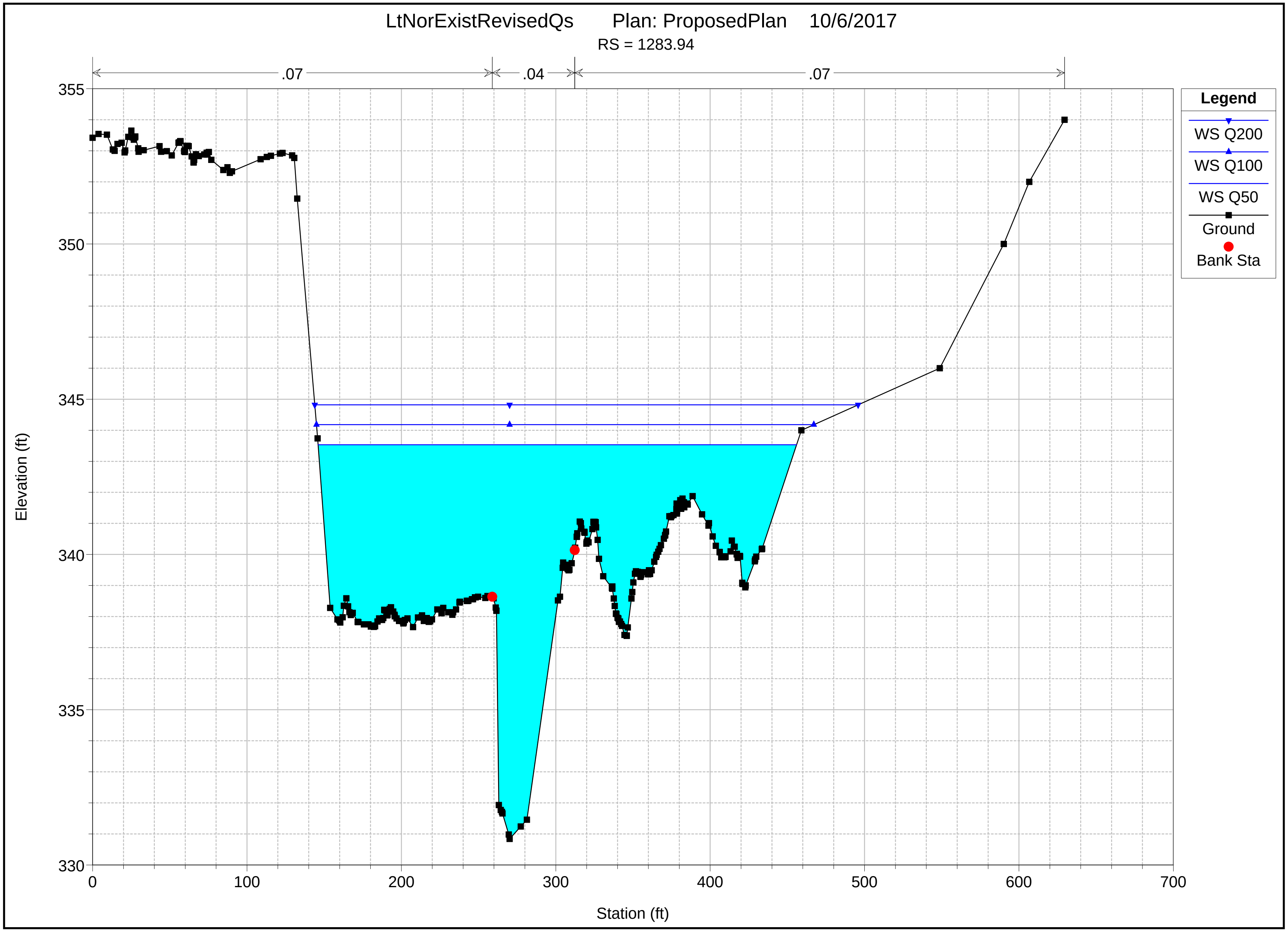
PROPOSED CONDITIONS
Cross-Sections



PROPOSED CONDITIONS
Cross-Sections



PROPOSED CONDITIONS
Cross-Sections



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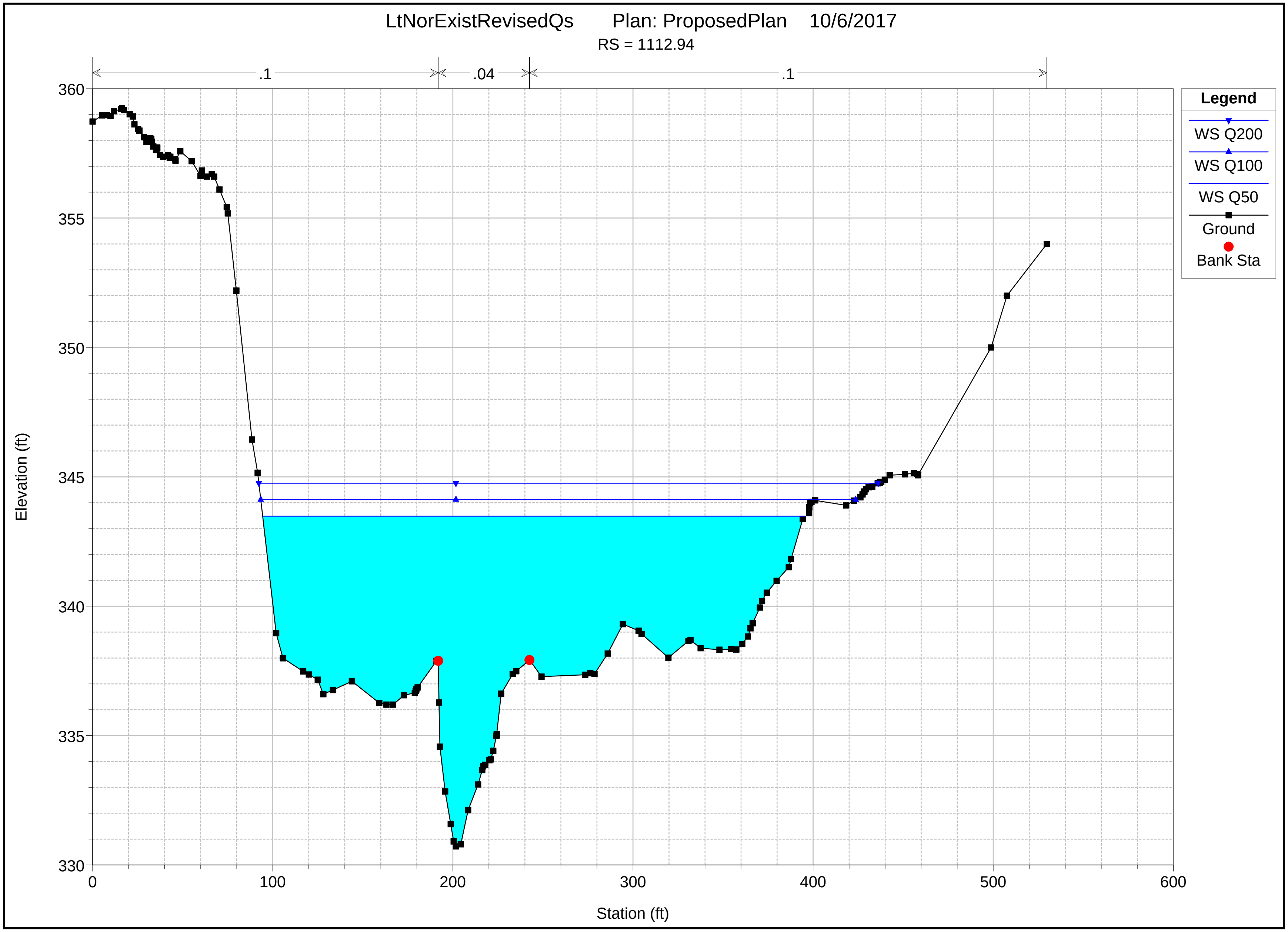
Cross-Sections



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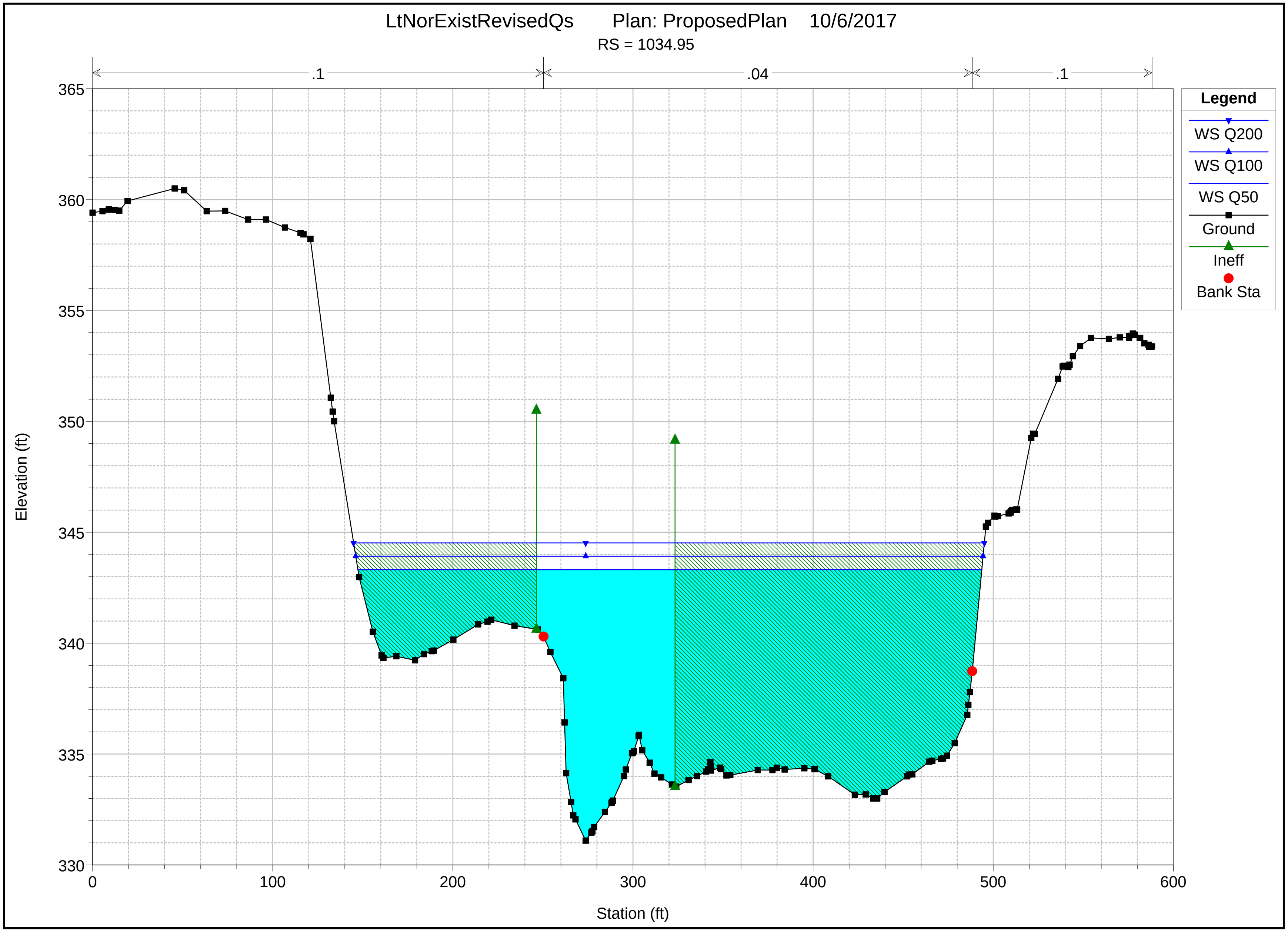
Cross-Sections



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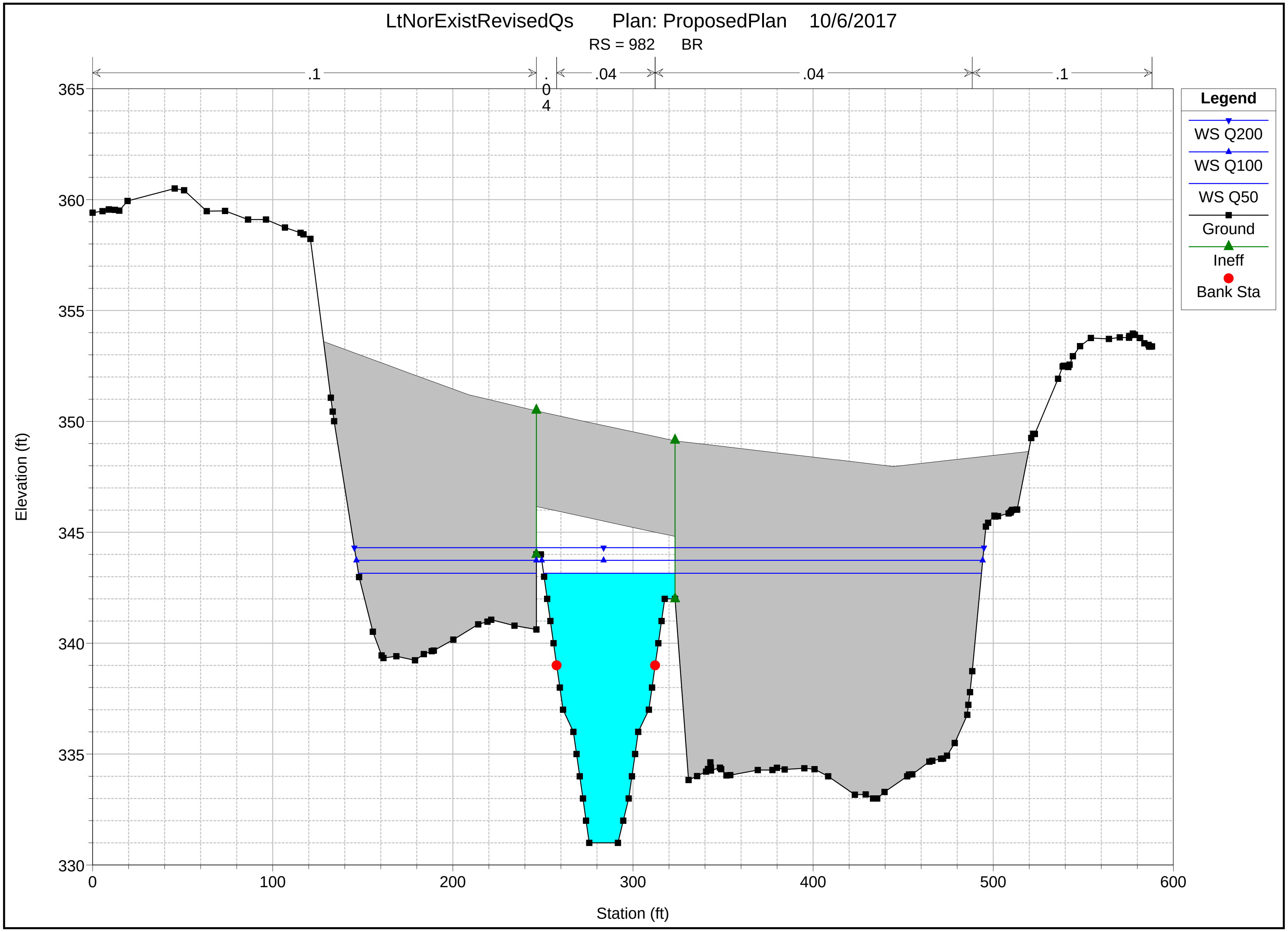
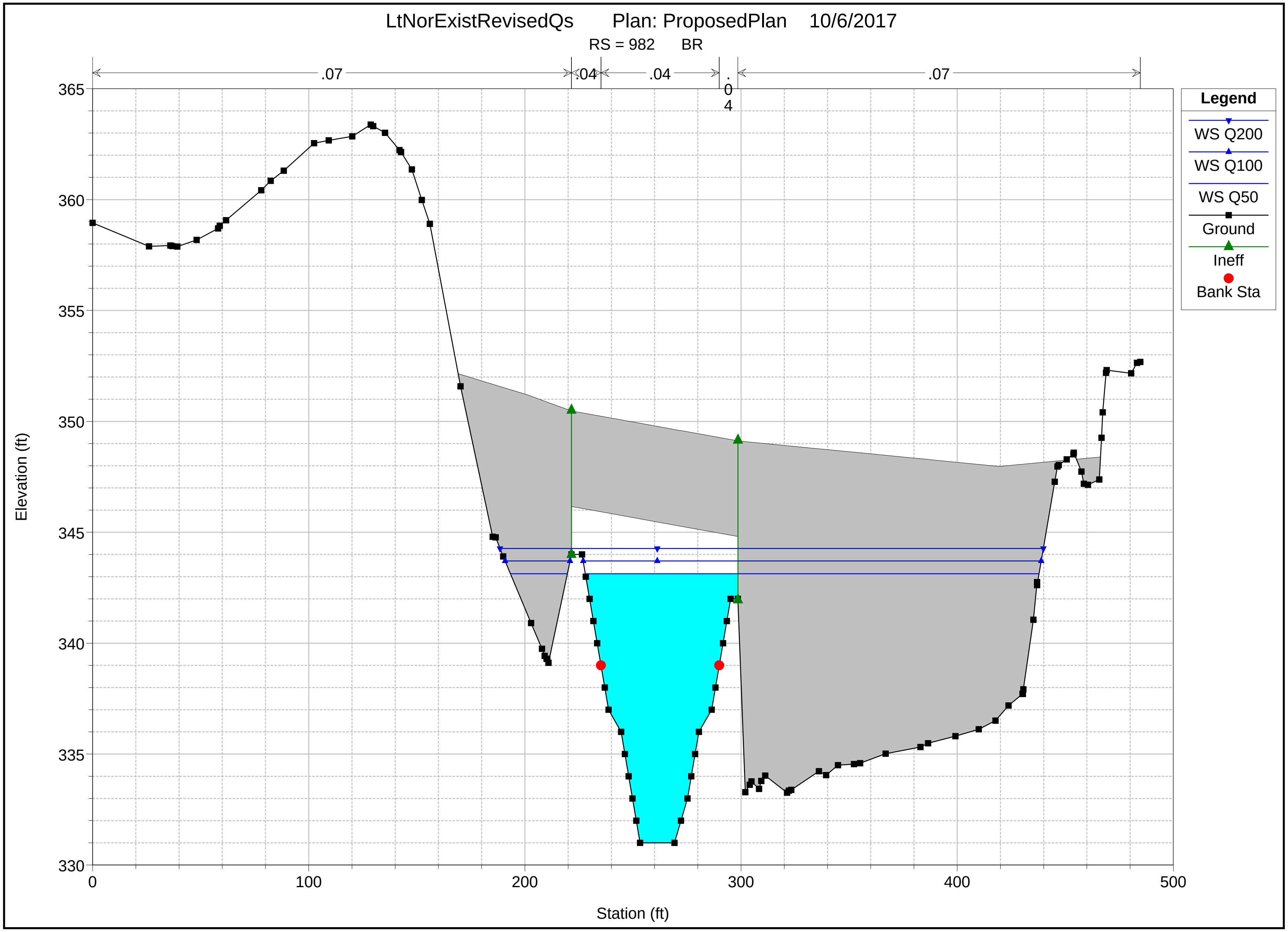
Cross-Sections



PROPOSED CONDITIONS
Cross-Sections



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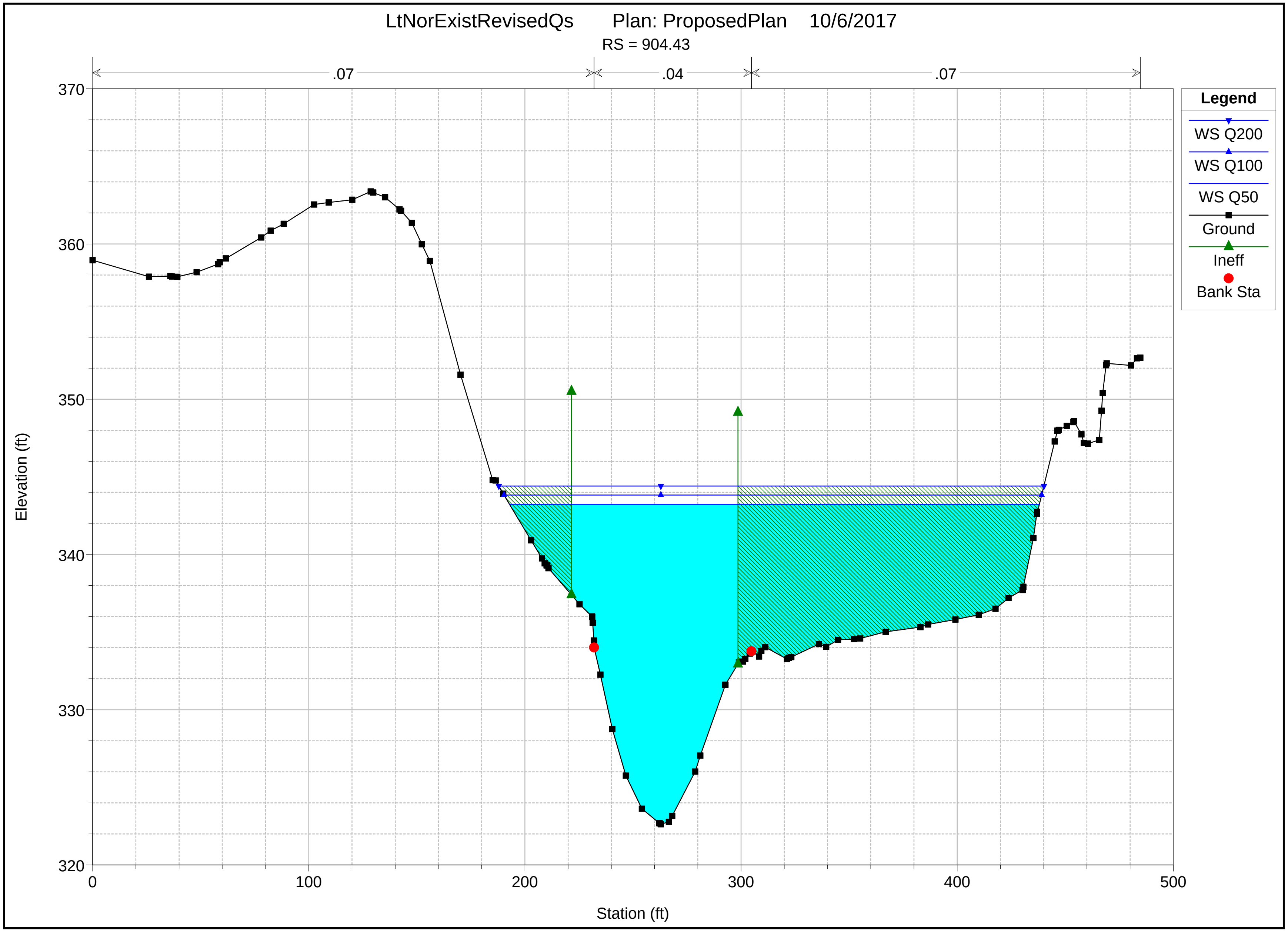
Cross-Sections



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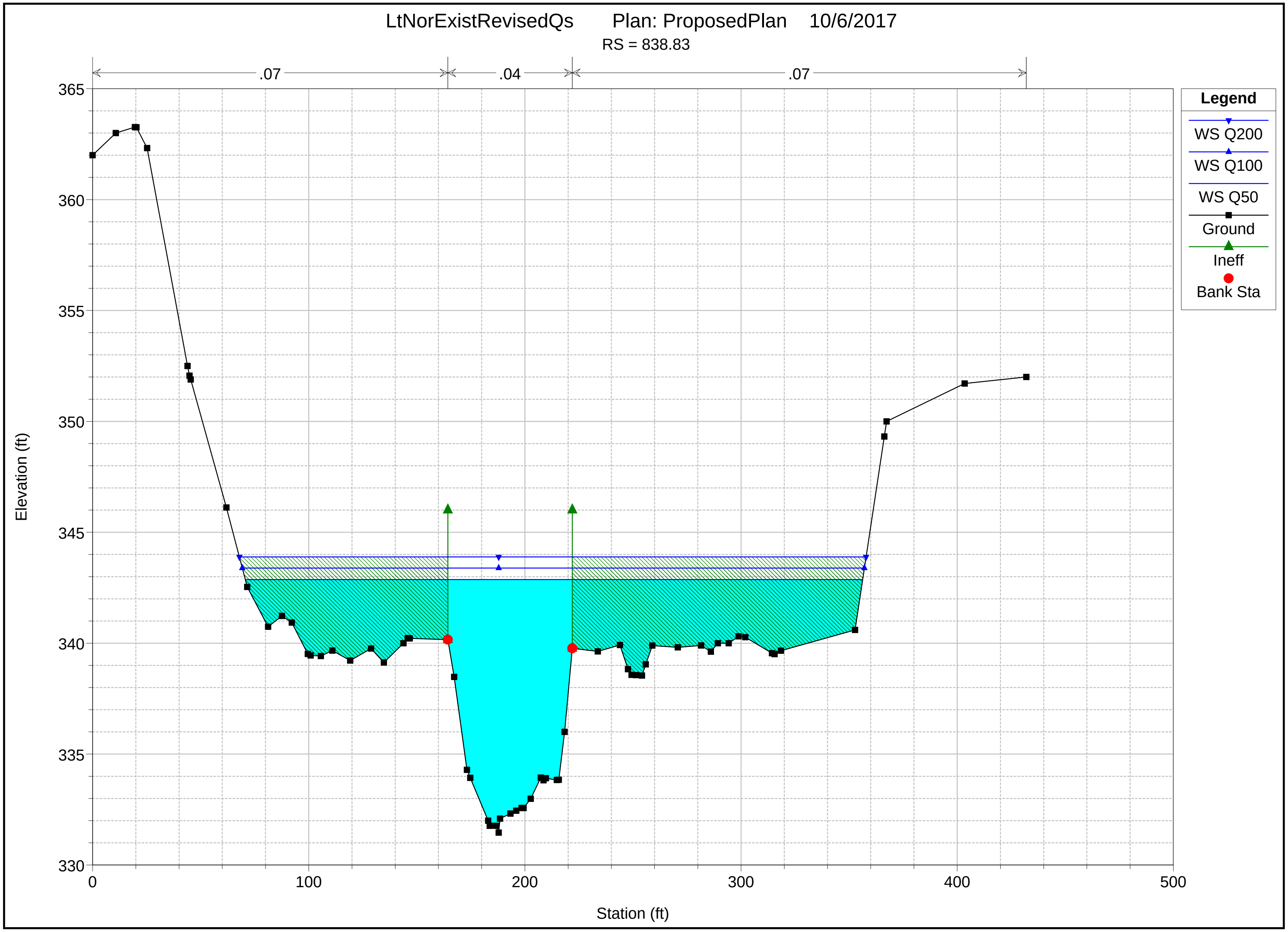
Cross-Sections



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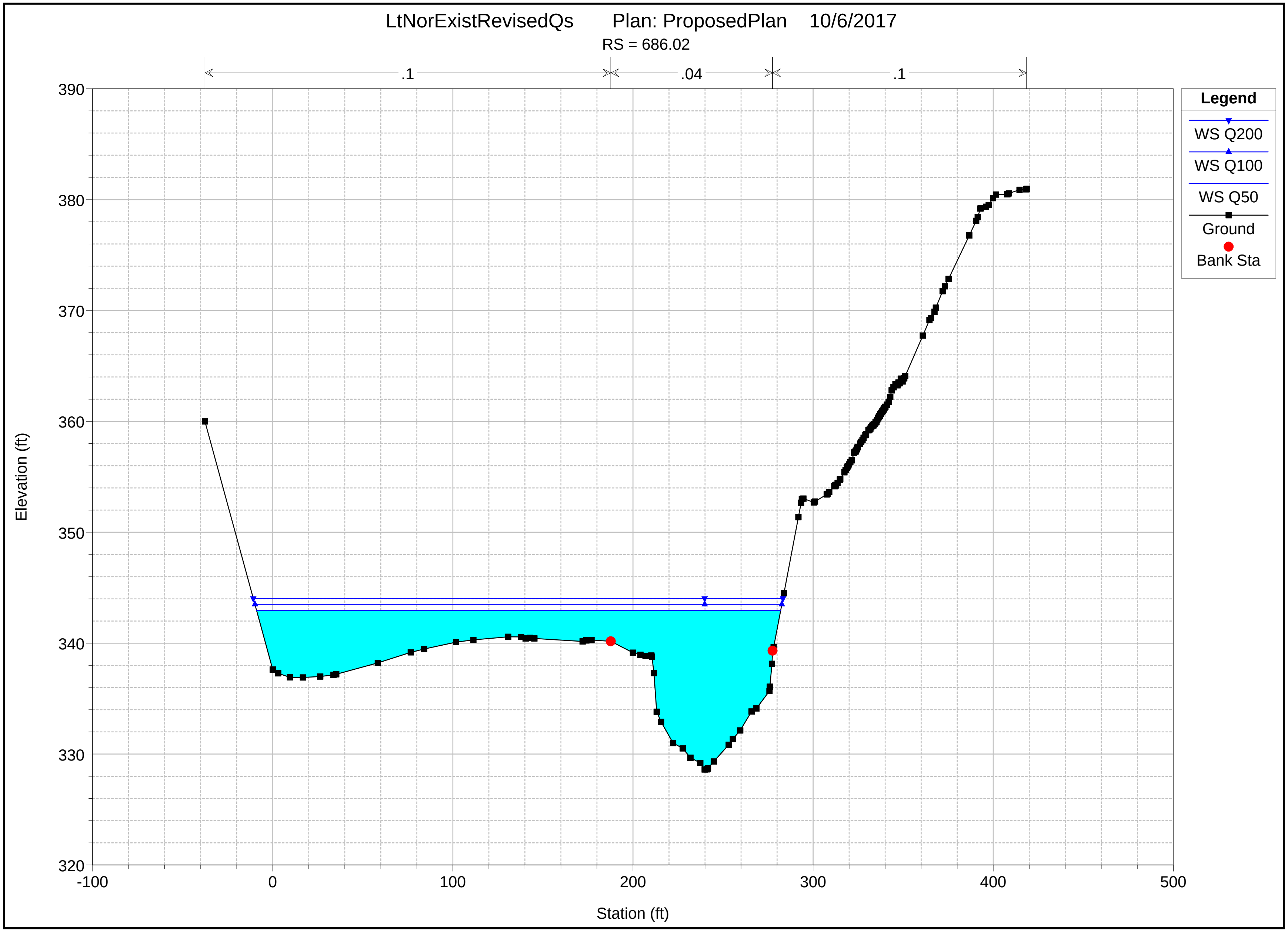
Cross-Sections



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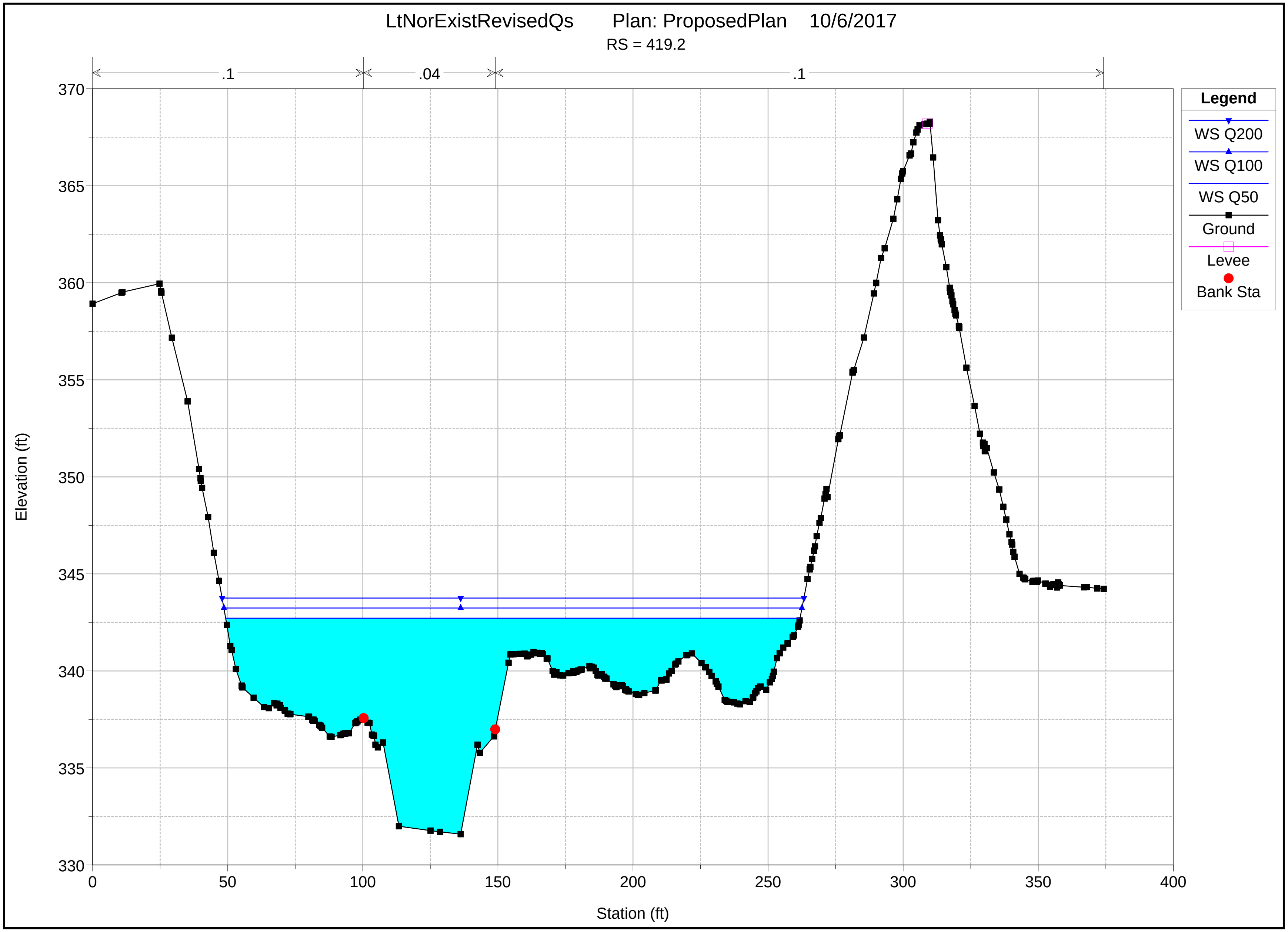
Cross-Sections



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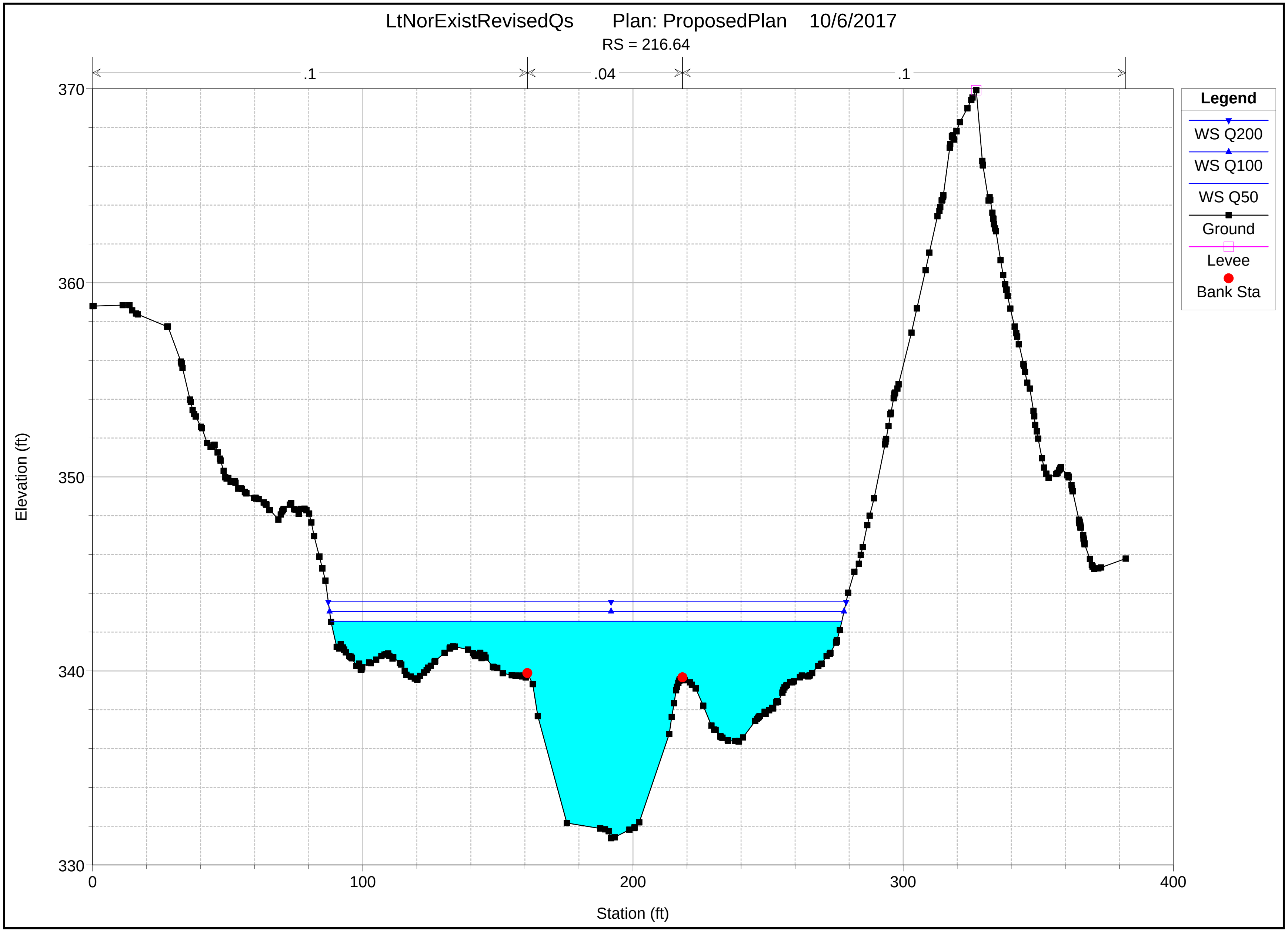

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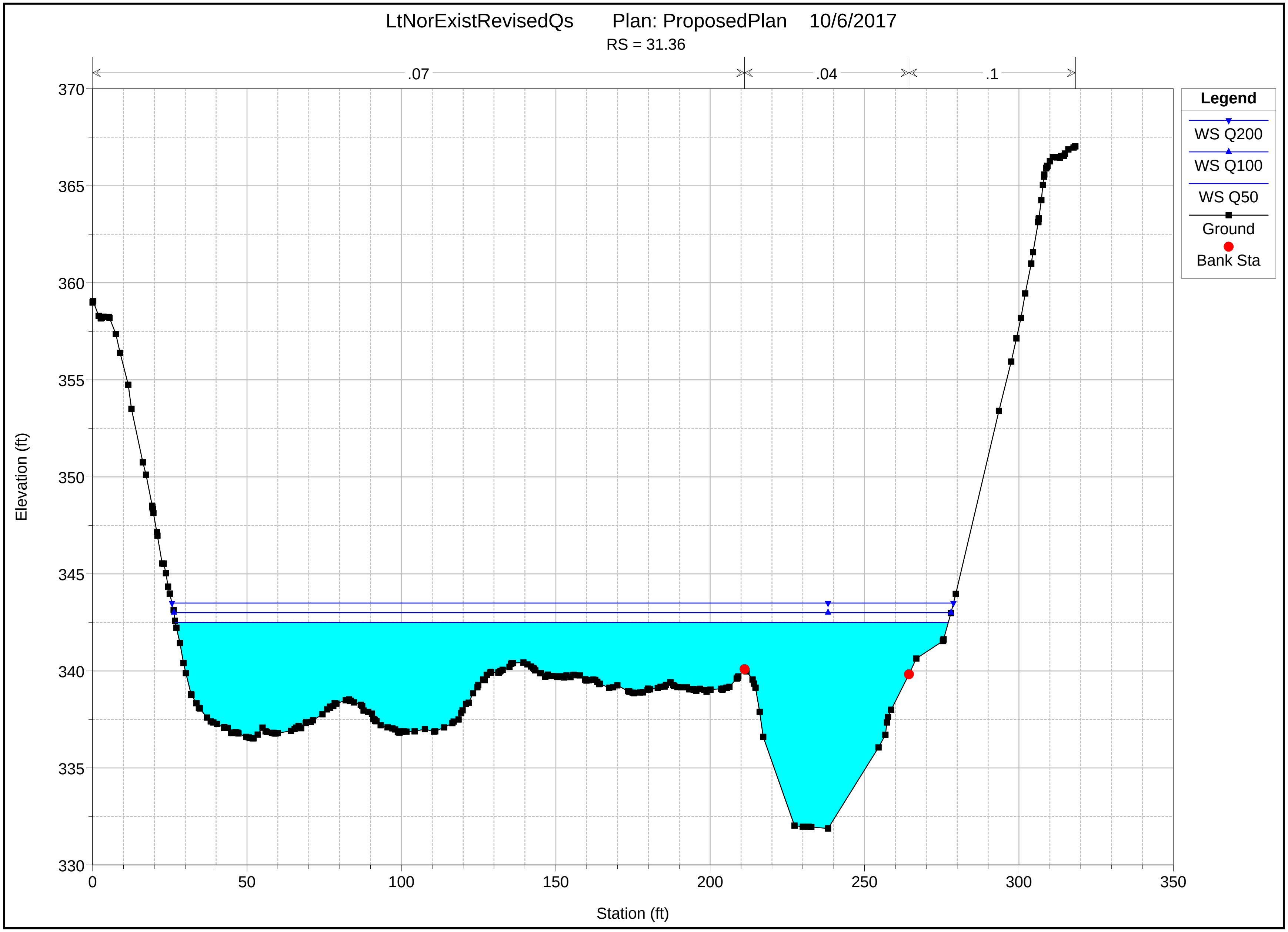
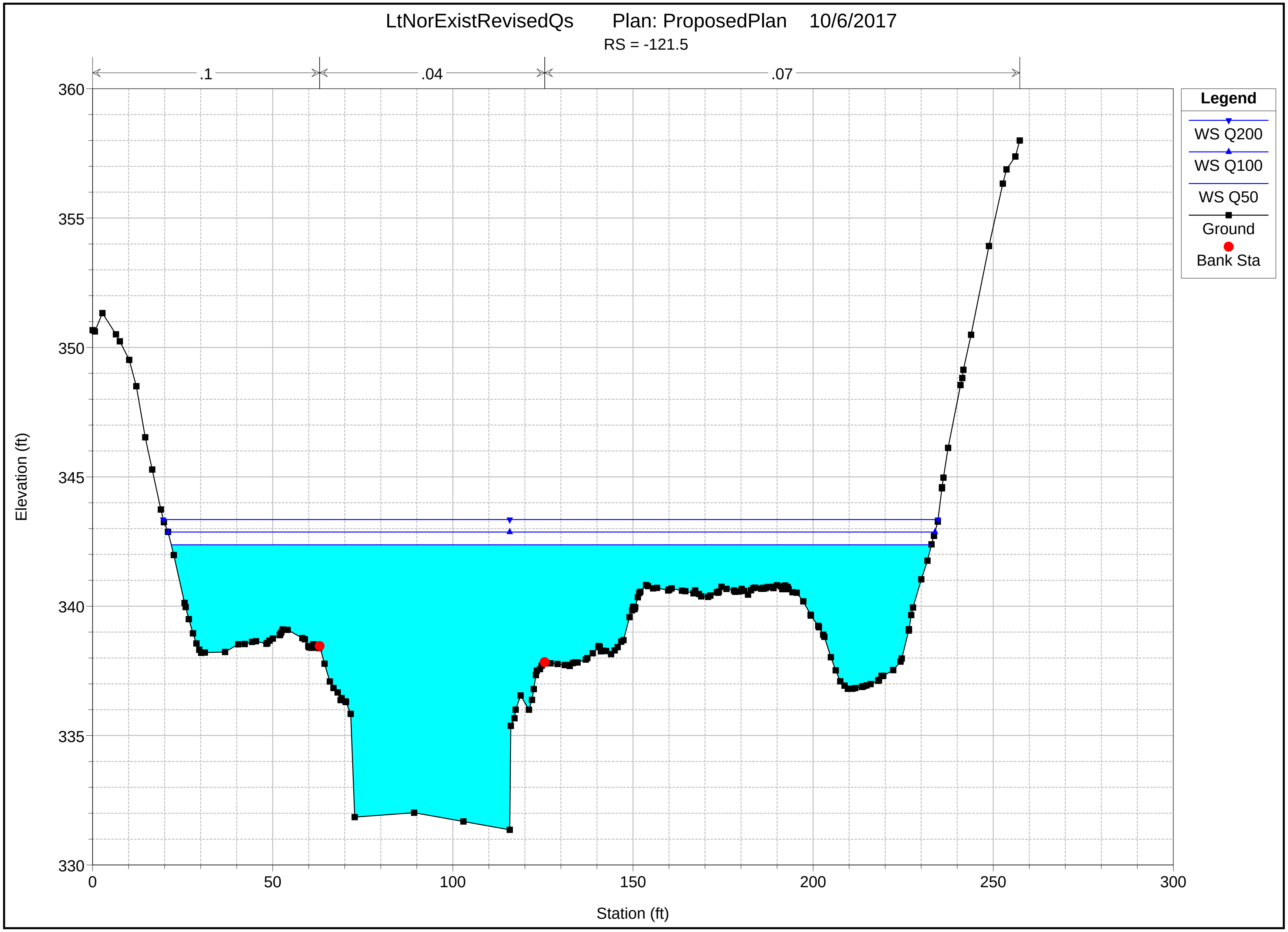
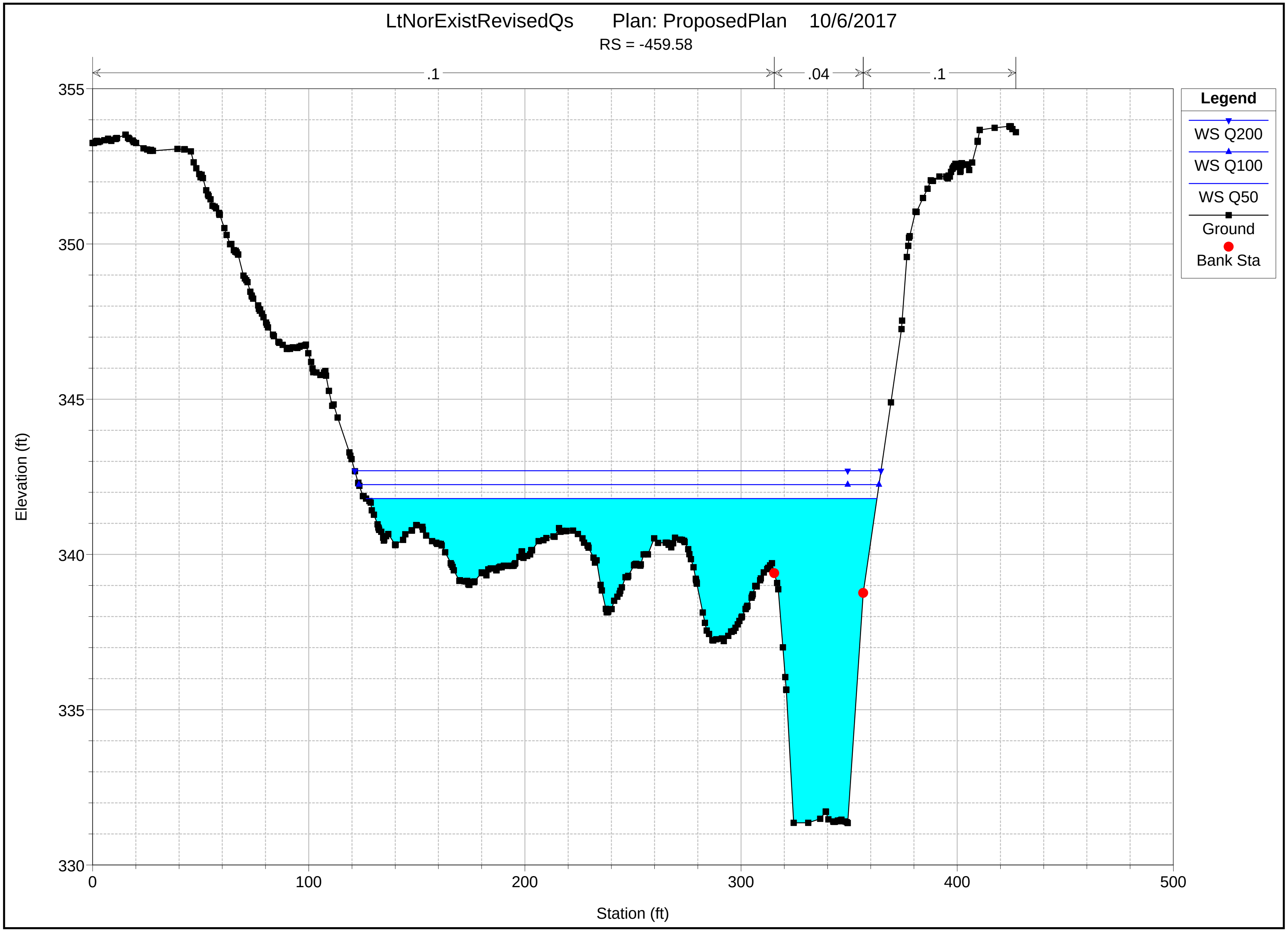
Cross-Sections



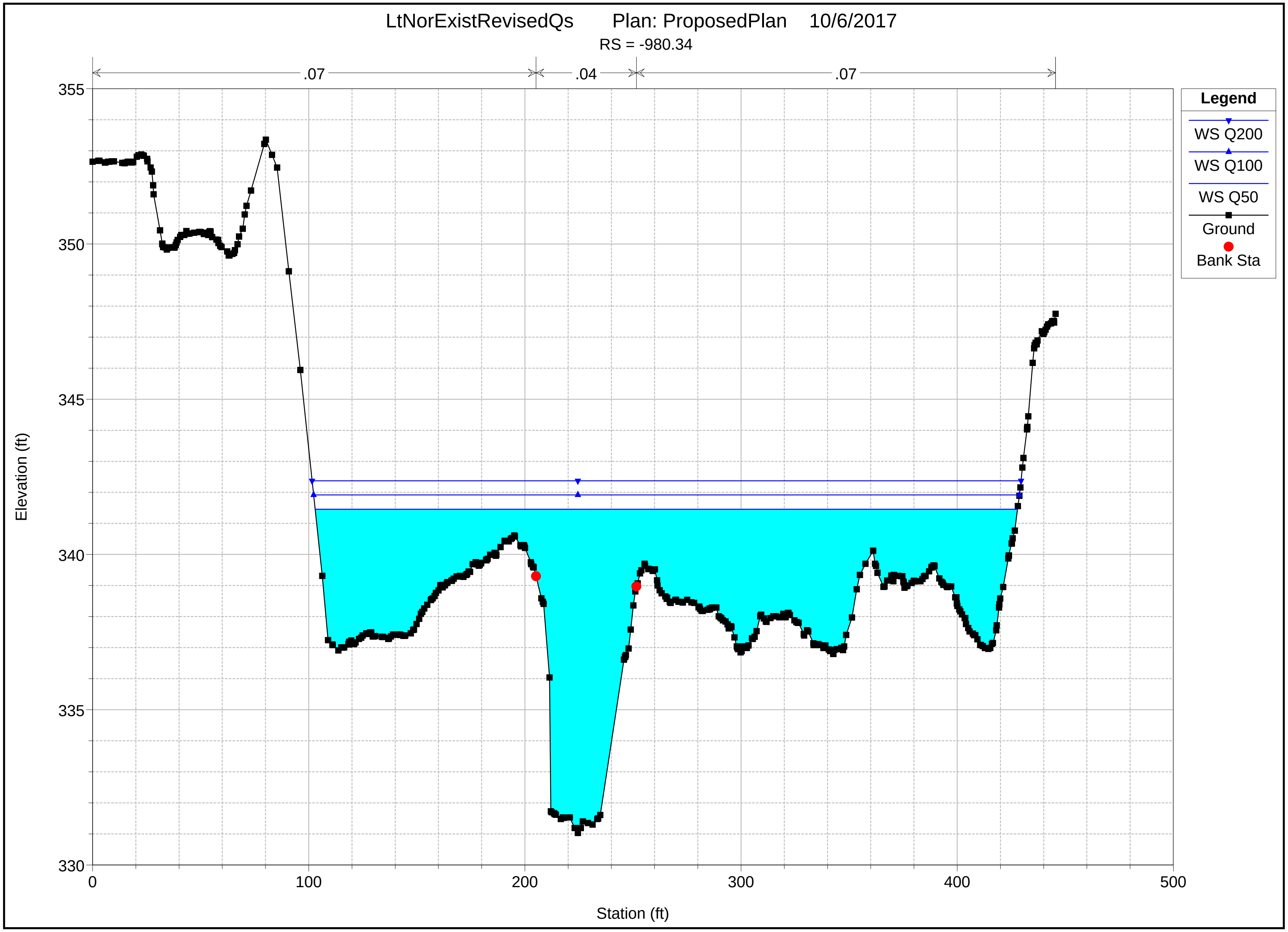
PROPOSED CONDITIONS
Cross-Sections



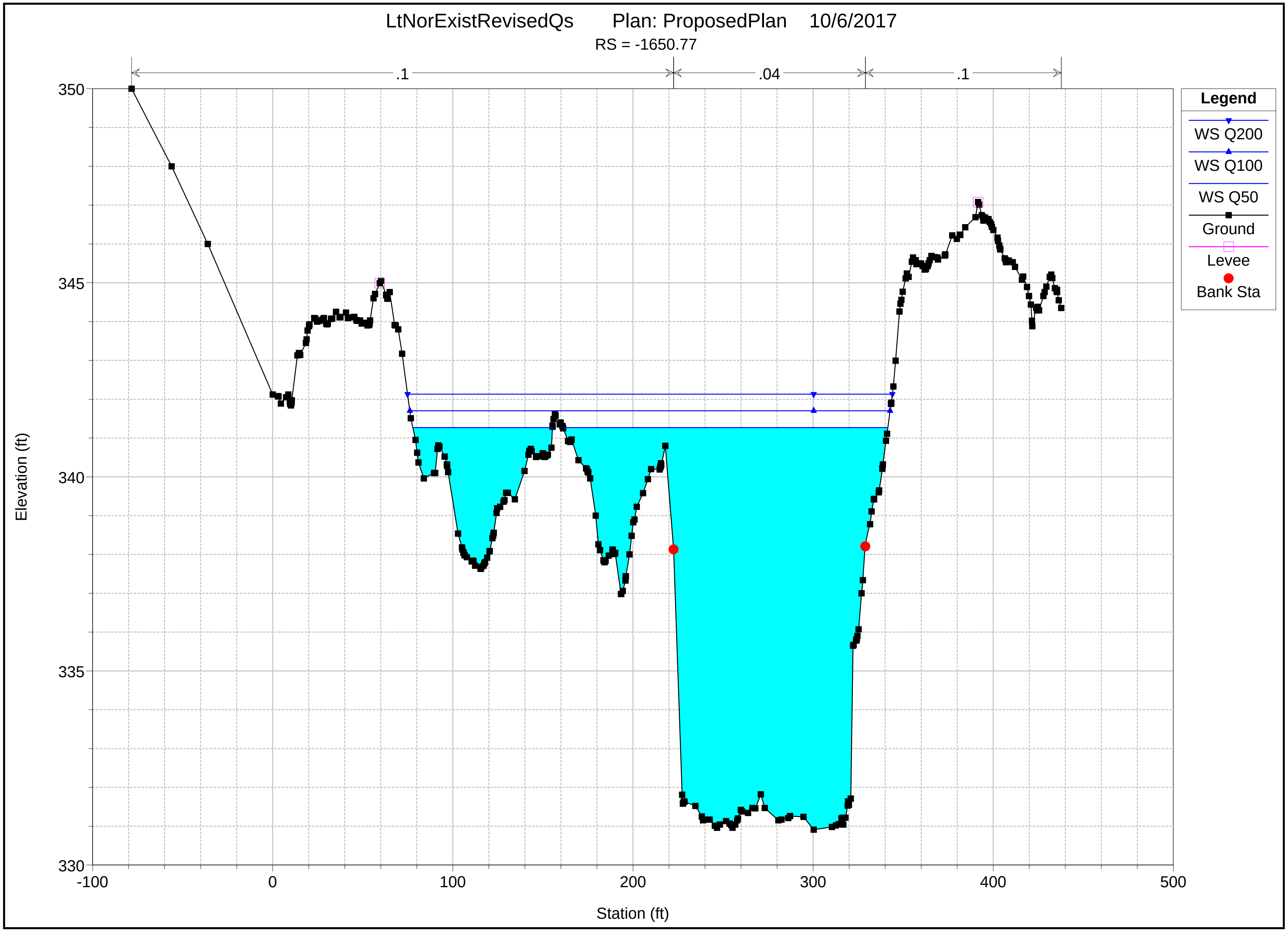
PROPOSED CONDITIONS
Cross-Sections



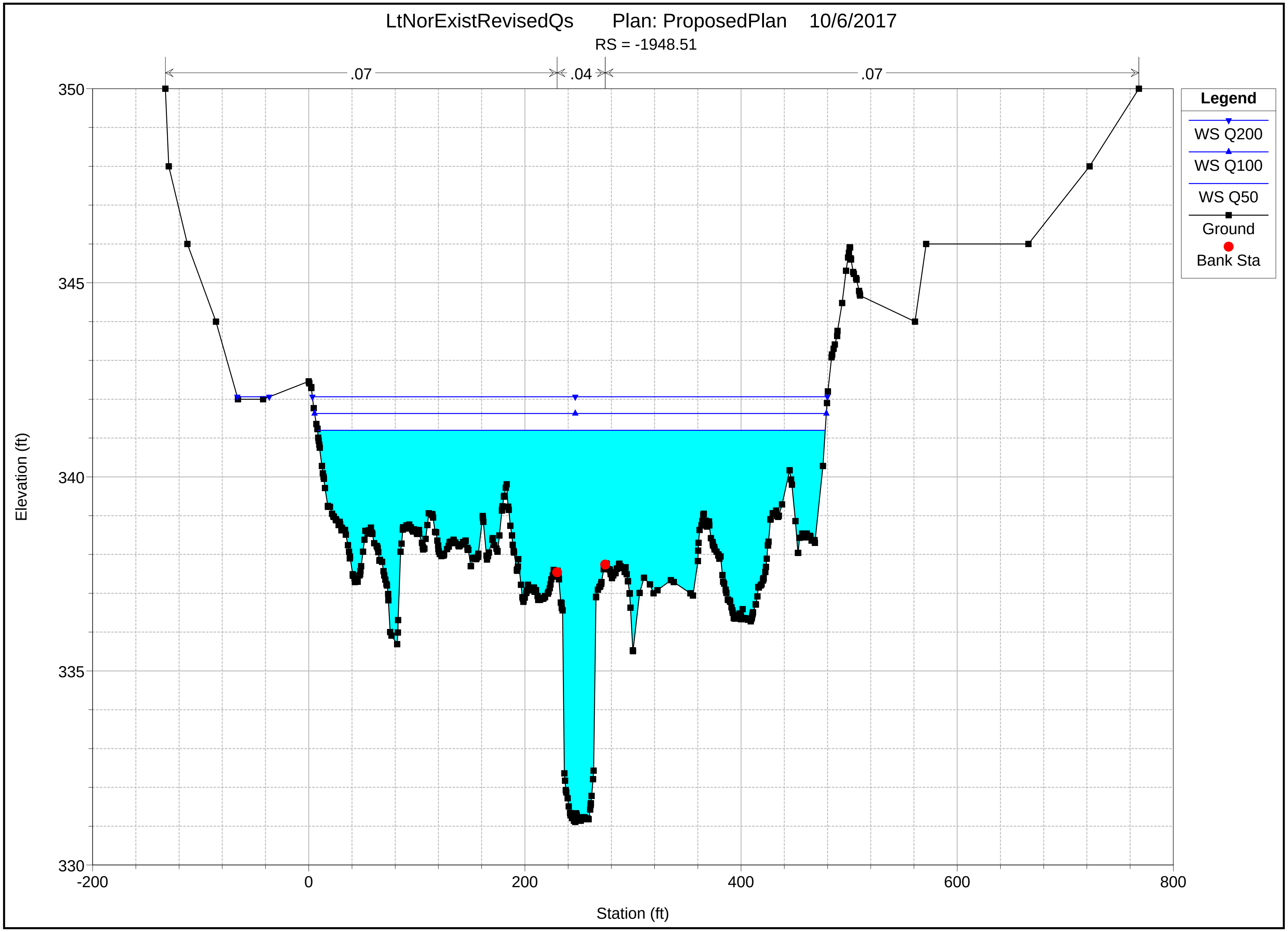
PROPOSED CONDITIONS
Cross-Sections



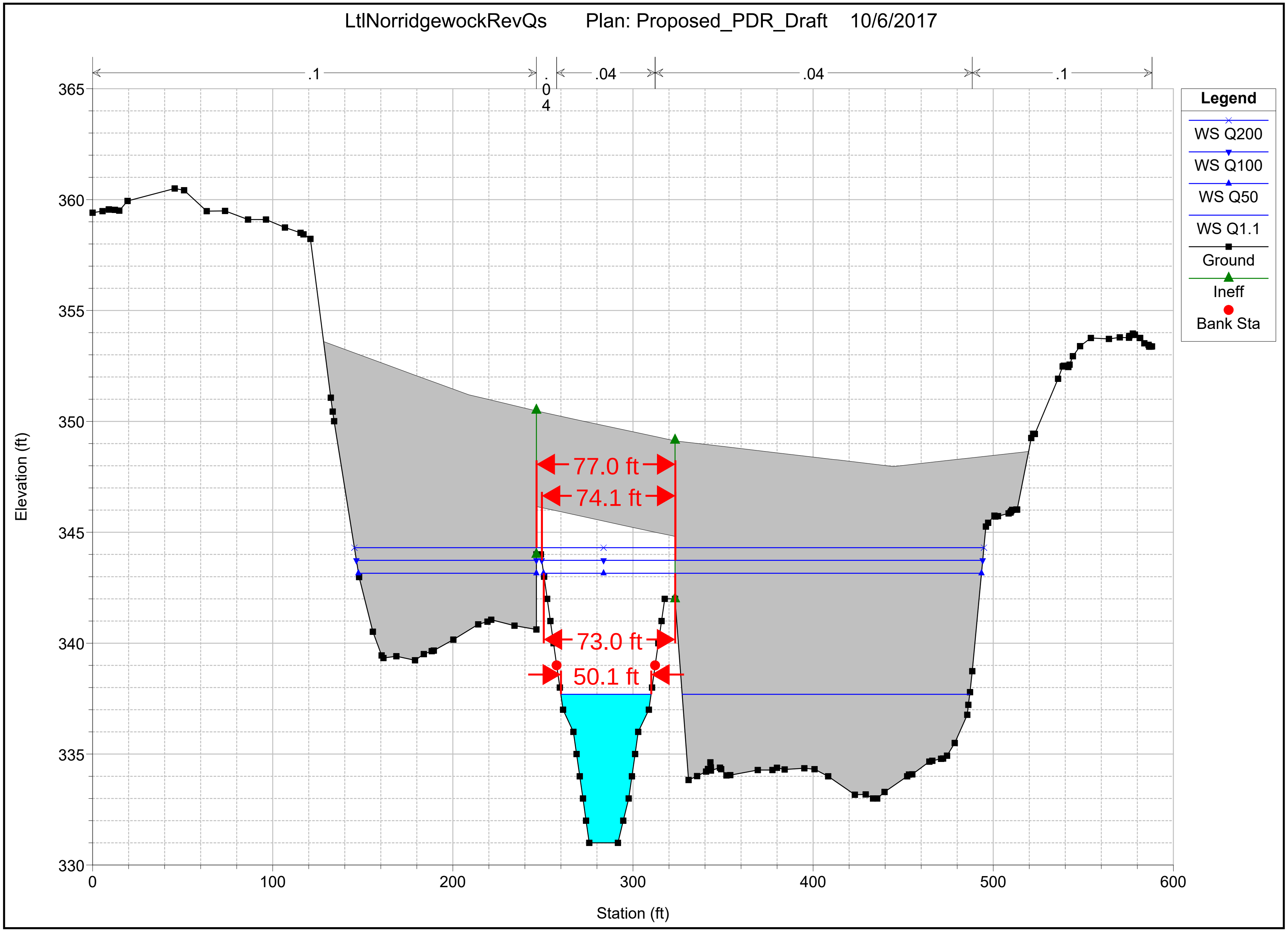
PROPOSED CONDITIONS
Cross-Sections



PROPOSED CONDITIONS
Cross-Sections



PROPOSED CONDITIONS
Flood Top Widths
at Bridge Cross-Section



NOTES AND ASSUMPTIONS

References:

1. FHWA HEC 18, 5th Edition, Publication No. FHWA-HIF-12-003
2. FHWA HEC 15, 3rd Edition, Publication No. FHWA-NHI-05-114

- Scour is to be analyzed per FHWA Hydraulic Engineering Circular (HEC) 18.
- Proposed hydraulic data including flood velocity and elevations are taken from Proposed HEC-RAS Model. Copies of Tables and Cross-sections used are attached.
- Measurements were taken from HEC-RAS Cross-sections and Plans in conjunction with AutoCAD.
- The proposed bridge's hydraulic opening was designed for a 100 Year Flood Frequency. Per the MaineDOT Bridge Design Guide the 500 Year Flood is suggested as a check. The Riprap Revetment is to be designed for the 100 Year Flood Frequency and the 500 Year Flood Frequency is to be used as a check.

HEC-RAS TABLES

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)	
StreamCL	2385.65	Q100	2684.00	330.51	344.59		344.71	0.000306	3.02	1298.37	188.57	0.16
StreamCL	1604.26	Q100	2684.00	331.09	344.24		344.41	0.000487	3.61	1374.03	359.29	0.19
StreamCL	1283.94	Q100	2684.00	330.84	344.18		344.25	0.000327	2.76	1716.04	322.12	0.16
StreamCL	1112.94	Q100	2684.00	330.72	344.12		344.19	0.000331	2.92	1980.67	330.28	0.16
StreamCL	1034.95	Q100	2684.00	331.10	343.92	337.29	344.15	0.000556	3.81	715.06	348.31	0.22
StreamCL	982		Bridge									
StreamCL	904.43	Q100	2684.00	322.63	343.83	329.79	343.91	0.000099	2.34	1199.49	248.77	0.10
StreamCL	838.83	Q100	2684.00	331.46	343.39	337.82	343.77	0.001005	4.96	540.79	287.79	0.29
StreamCL	686.02	Q100	2684.00	328.62	343.51		343.58	0.000233	2.47	1738.52	292.55	0.14
StreamCL	419.2	Q100	2684.00	331.59	343.24	338.25	343.47	0.000736	4.33	1121.03	213.97	0.25
StreamCL	216.64	Q100	2684.00	331.38	343.06	337.80	343.31	0.000786	4.33	970.43	190.41	0.25
StreamCL	31.36	Q100	2684.00	331.88	343.00		343.12	0.000596	3.49	1290.73	251.64	0.22
StreamCL	-121.5	Q100	2684.00	331.36	342.87		343.02	0.000523	3.54	1148.41	212.87	0.20
StreamCL	-459.58	Q100	2684.00	331.35	342.25		342.67	0.001519	5.74	873.01	240.59	0.33
StreamCL	-980.34	Q100	2684.00	331.03	341.92		342.05	0.000739	3.75	1346.76	326.59	0.23
StreamCL	-1650.77	Q100	2684.00	330.91	341.70	334.17	341.79	0.000217	2.42	1400.99	266.65	0.14
StreamCL	-1948.51	Q100	2684.00	331.11	341.63	338.49	341.69	0.000430	2.87	1939.46	473.48	0.18

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
StreamCL	1112.94	Q100	344.19	344.12		0.03	0.01	330.28	629.33	1443.57	611.10	2.92
StreamCL	1034.95	Q100	344.15	343.92	337.29	0.02	0.04	348.31	10.93	2673.07		3.81
StreamCL	982 BR U	Q100	344.09	343.74	338.02	0.02	0.00	74.07	35.16	2597.02	51.82	4.84
StreamCL	982 BR D	Q100	344.07	343.71	338.02	0.02	0.14	71.60	34.83	2604.03	45.14	4.87
StreamCL	904.43	Q100	343.91	343.83	329.79	0.05	0.09	248.77	56.05	2627.95		2.34
StreamCL	838.83	Q100	343.77	343.39	337.82	0.06	0.12	287.79		2684.00		4.96

HEC-RAS TABLES (CONT.)

Cross Section Output

File Type Options Help

River: StreamCL Profile: Q100
Reach StreamCL RS: 1283.94 Plan: Prop

Plan: Prop StreamCL StreamCL RS: 1283.94 Profile: Q100

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	344.25	Wt. n-Val.	0.070	0.040	0.070
Vel Head (ft)	0.07	Reach Len. (ft)	171.00	171.00	171.00
W.S. Elev (ft)	344.18	Flow Area (sq ft)	663.02	500.34	552.69
Crit W.S. (ft)		Area (sq ft)	663.02	500.34	552.69
E.G. Slope (ft/ft)	0.000327	Flow (cfs)	812.96	1381.78	489.26
Q Total (cfs)	2684.00	Top Width (ft)	113.89	53.41	154.82
Top Width (ft)	322.12	Avg. Vel. (ft/s)	1.23	2.76	0.89
Vel Total (ft/s)	1.56	Hydr. Depth (ft)	5.82	9.37	3.57
Max Chl Dpth (ft)	13.34	Conv. (cfs)	44959.7	76417.8	27058.2
Conv. Total (cfs)	148435.7	Wetted Per. (ft)	116.12	60.02	157.79
Length Wtd. (ft)	171.00	Shear (lb/sq ft)	0.12	0.17	0.07
Min Ch El (ft)	330.84	Stream Power (lb/ft s)	0.14	0.47	0.06
Alpha	1.85	Cum Volume (acre-ft)	31.70	48.44	26.69
Frctn Loss (ft)	0.06	Cum SA (acres)	9.40	5.01	6.79
C & E Loss (ft)	0.00				

Cross Section Output

File Type Options Help

River: StreamCL Profile: Q100
Reach StreamCL RS: 982 BR U Plan: Prop

Plan: Prop StreamCL StreamCL RS: 982 BR U Profile: Q100

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	344.09	Wt. n-Val.	0.040	0.040	0.040
Vel Head (ft)	0.35	Reach Len. (ft)	27.33	27.33	27.33
W.S. Elev (ft)	343.74	Flow Area (sq ft)	19.71	536.58	27.07
Crit W.S. (ft)	338.02	Area (sq ft)	19.71	536.58	27.13
E.G. Slope (ft/ft)	0.000881	Flow (cfs)	35.16	2597.02	51.82
Q Total (cfs)	2684.00	Top Width (ft)	8.32	54.68	11.07
Top Width (ft)	74.07	Avg. Vel. (ft/s)	1.78	4.84	1.91
Vel Total (ft/s)	4.60	Hydr. Depth (ft)	2.37	9.81	2.45
Max Chl Dpth (ft)	12.74	Conv. (cfs)	1184.4	87495.5	1745.9
Conv. Total (cfs)	90425.9	Wetted Per. (ft)	9.57	58.35	11.83
Length Wtd. (ft)	27.33	Shear (lb/sq ft)	0.11	0.51	0.13
Min Ch El (ft)	331.00	Stream Power (lb/ft s)	0.20	2.45	0.24
Alpha	1.08	Cum Volume (acre-ft)	28.07	43.18	23.22
Frctn Loss (ft)	0.02	Cum SA (acres)	8.77	4.46	5.96
C & E Loss (ft)	0.00				

GEOMETRY DATA
Left Approach (Q100)

Upstream Bridge Water Surface Elevation:	$WSEL_{BR} := 343.74\ ft$	Refer to HEC-RAS
Station of Face of Abutment:	$STA_{abut.left} := 246.37\ ft$	Refer to HEC-RAS
Station of Overbank or Proposed Toe:	$STA_{BR.LOB} := 257.65\ ft$	Refer to HEC-RAS
Station of WSEL @ outer edge of cross-section:	$STA_{WSEL.LOB} := 146.44\ ft$	Refer to HEC-RAS
Abutment Set Back Distance:	$L_{SBR.L} := \left\|STA_{BR.LOB} - STA_{abut.left}\right\| = 11.280\ ft$	
Length of Left Approach:	$L_{left.appraoch} := \left\|STA_{WSEL.LOB} - STA_{abut.left}\right\| = 99.930\ ft$	

Right Approach

Upstream Bridge Water Surface Elevation:	$WSEL_{BR} = 343.740\ ft$	Refer to HEC-RAS
Station of Face of Abutment:	$STA_{abut.right} := 323.37\ ft$	Refer to HEC-RAS
Station of Overbank or Proposed Toe:	$STA_{BR.ROB} := 339.0\ ft$	Refer to HEC-RAS
Station of WSEL @ outer edge of cross-section:	$STA_{WSEL.ROB} := 494.17\ ft$	Refer to HEC-RAS
Abutment Set Back Distance:	$L_{SBR.R} := \left\|STA_{BR.ROB} - STA_{abut.right}\right\| = 15.630\ ft$	
Length of Right Approach:	$L_{right.appraoch} := \left\|STA_{WSEL.ROB} - STA_{abut.right}\right\| = 170.800\ ft$	

HYDRAULIC DATA
Upstream Cross-Section (12+83)

Upstream Left Overbank Discharge: $Q_{US.LOB} := 812.96 \frac{ft^3}{s}$ HEC-RAS Tables

Upstream Main Channel Discharge: $Q_{US.Main} := 1381.78 \frac{ft^3}{s}$ HEC-RAS Tables

Upstream Right Overbank Discharge: $Q_{US.ROB} := 489.26 \frac{ft^3}{s}$ HEC-RAS Tables

Upstream Left Overbank Flow Area: $A_{US.LOB} := 663.02\ ft^2$ HEC-RAS Tables

Upstream Main Channel Flow Area: $A_{US.Main} := 500.34\ ft^2$ HEC-RAS Tables

Upstream Right Overbank Flow Area: $A_{US.ROB} := 552.69\ ft^2$ HEC-RAS Tables

Top Width of Left Overbank: $TW_{US.LOB} := 113.89\ ft$ HEC-RAS Tables

Top Width of Main Channel: $TW_{US.Main} := 53.41\ ft$ HEC-RAS Tables

Top Width of Right Overbank: $TW_{US.ROB} := 154.82\ ft$ HEC-RAS Tables

Average Flow Depth of Entire Channel: $y_{US} := \frac{\left(A_{US.LOB} + A_{US.Main} + A_{US.ROB}\right)}{\left(TW_{US.LOB} + TW_{US.Main} + TW_{US.ROB}\right)} = 5.327\ ft$

Average Main Channel Flow Depth: $y_{US.Main} := \frac{A_{US.Main}}{TW_{US.Main}} = 9.368\ ft$

Average Left Overbank Flow Depth: $y_{US.LOB} := \frac{A_{US.LOB}}{TW_{US.LOB}} = 5.822\ ft$

Average Right Overbank Flow Depth: $y_{US.ROB} := \frac{A_{US.ROB}}{TW_{US.ROB}} = 3.570\ ft$

Left Overbank Manning's n: $n_{US.LOB} := 0.07$

Right Overbank Manning's n: $n_{US.ROB} := 0.07$

Upstream Energy Grade Line Slope: $S_{1.US} := 0.000327 \frac{ft}{ft}$

HYDRAULIC DATA (CONT.)
Bridge Cross-Section (US, 9+82)

Bridge Left Overbank Discharge:	$Q_{BR.LOB} := 35.16 \frac{ft^3}{s}$	HEC-RAS Tables
Bridge Main Channel Discharge:	$Q_{BR.Main} := 2597.02 \frac{ft^3}{s}$	HEC-RAS Tables
Bridge Right Overbank Discharge:	$Q_{BR.ROB} := 51.82 \frac{ft^3}{s}$	HEC-RAS Tables
Bridge Left Overbank Flow Area:	$A_{BR.LOB} := 19.71\ ft^2$	HEC-RAS Tables
Bridge Main Channel Flow Area:	$A_{BR.Main} := 536.58\ ft^2$	HEC-RAS Tables
Bridge Right Overbank Flow Area:	$A_{BR.ROB} := 27.13\ ft^2$	HEC-RAS Tables
Top Width of Main Channel:	$TW_{BR.Main} := 54.68\ ft$	HEC-RAS Tables
Top Width of Left Overbank:	$TW_{BR.LOB} := 8.32\ ft$	HEC-RAS Tables
Top Width of Right Overbank:	$TW_{BR.ROB} := 11.07\ ft$	HEC-RAS Tables

Average Flow Depth of Entire Channel:

$$y_{BR} := \frac{\left(A_{BR.LOB} + A_{BR.Main} + A_{BR.ROB}\right)}{\left(TW_{BR.LOB} + TW_{BR.Main} + TW_{BR.ROB}\right)} = 7.877\ ft$$

Average Main Channel Flow Depth:

$$y_{BR.Main} := \frac{A_{BR.Main}}{TW_{BR.Main}} = 9.813\ ft$$

Max Main Channel Flow Depth:

$$y_{BR.Main.Max} := 12.74\ ft$$

Energy Grade Line Slope at Bridge:

$$S_{1.BR} := 0.000881 \frac{ft}{ft}$$

HYDRAULIC DATA (CONT.)
Bridge Contraction Scour Variables

Depth in Contracted Section before Scour: $y_{BR.Main} = 9.813\ ft$

Average Depth in Upstream Main Channel: $y_{US.Main} = 9.368\ ft$

Top Width of Upstream Main Channel: $TW_{US.Main} = 53.410\ ft$

Top Width of Contracted Section Main Channel: $TW_{BR.Main} = 54.680\ ft$

Flow in Upstream Main Channel Transporting Sediment: $Q_{US.Main} = 1381.780\ \frac{ft^3}{s}$

Flow in Contracted Channel: $Q_{BR.Main} = 2597.020\ \frac{ft^3}{s}$

Average Velocity in Upstream (Main) Channel Transporting Sediment: $V_{US.Main} := \frac{Q_{US.Main}}{A_{US.Main}} = 2.762\ \frac{ft}{s}$

Max Upstream Main Channel Flow Depth: $y_{US.Main.Max} := 13.34\ ft$

Shear Velocity in Upstream Channel: $V'_{Main} := \sqrt{g \cdot y_{US.Main} \cdot S_{1.US}} = 0.314\ \frac{ft}{s}$

MATERIAL DATA
Main Channel

Median Diameter of Bed Material: $D_{50.Main} := 0.10\ mm$ Per MaineDOT Gradation Report of Site Soil Sample

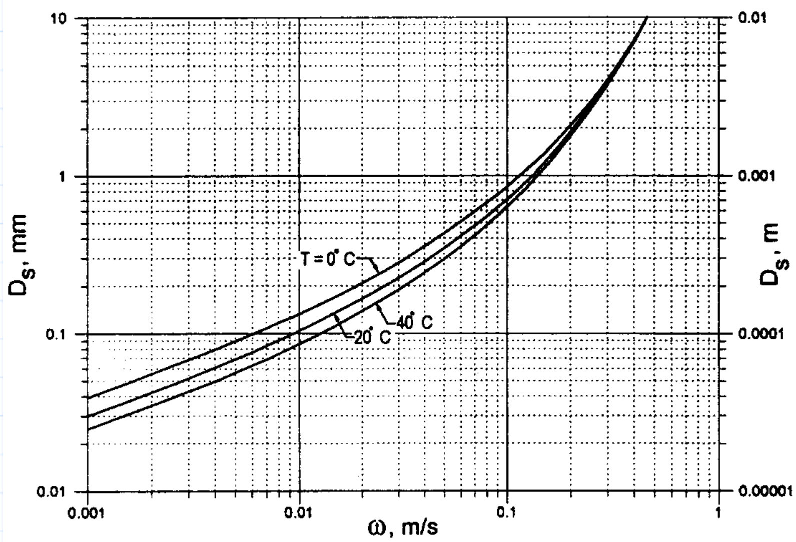
Diameter of the smallest nontransportable particle: $D_{m.Main} := 1.25 \cdot D_{50.Main} = 0.125\ mm$

Note: If D50< 0.2mm, use 0.2mm for clear-water scour

Water Unit Weight: $\gamma_w := 62.4\ \frac{lb}{ft^3}$

Particle Unit Weight: $\gamma_s := 2.65 \cdot \gamma_w = 165.360\ \frac{lb}{ft^3}$

D50 Fall Velocity @ 20C: $\omega_{Main} := 0.01\ \frac{m}{sec}$ Ref. 1, Fig. 6.8 (as seen below)



English Unit Constant for Critical Velocity Eq.: $K_{u\_c} := 11.17$

Critical Velocity that Bed Material of Size D50 and smaller will be transported: $V_{c.Main} := K_{u\_c} \cdot y_{US.Main}^{\frac{1}{6}} \cdot \left(D_{50.Main}\right)^{\frac{1}{3}} \cdot \frac{ft^{\left(\frac{1}{2}\right)}}{sec}$ Ref. 1, Eq. 6.1

$V_{c.Main} = 1.119\ \frac{ft}{s}$

CONTRACTION SCOUR

Main Channel

English Unit Constant for Clear-Water Scour: $K_{u\_clear} := 0.0077$

Check if Live-Bed or Clear-Water Scour is present:

$$check\_cont\_scour := \begin{cases} \text{if } V_{c.Main} > V_{US.Main} & \text{"Clear-Water Scour "} \\ \text{else if } V_{US.Main} > V_{c.Main} & \text{"Live-Bed Scour"} \end{cases} = \text{"Live-Bed Scour"}$$

Exponent determined for Live-Bed Contraction Scour:

V*/T	k1	Mode of Bed Material Transport
<0.50	0.59	Mostly contact bed material discharge
0.50 to 2.0	0.64	Some suspended bed material discharge
>2.0	0.69	Mostly suspended bed material discharge

$$k_1 := \begin{cases} \text{if } \frac{V'_{Main}}{\omega_{Main}} < 0.50 & 0.59 \\ \text{else if } 0.50 \le \frac{V'_{Main}}{\omega_{Main}} \le 2.0 & 0.64 \\ \text{else if } \frac{V'_{Main}}{\omega_{Main}} > 2.0 & 0.69 \end{cases} = 0.690$$

Ref. 1, Art. 6.3

Average Equilibrium Depth in Contracted Section: Ref. 1, Eq. 6.2 & 6.4

$$y_{2\_main} := \begin{cases} \text{if } V_{c.Main} > V_{US.Main} & \left(\frac{K_{u\_clear} \cdot Q_{BR.Main}^2}{\left(\max\left(D_{m.Main}, 0.2\ mm\right)\right)^{\frac{2}{3}} \cdot TW_{BR.Main}^2} \cdot \frac{sec^2}{ft} \right)^{\frac{3}{7}} \\ \text{else if } V_{US.Main} > V_{c.Main} & y_{US.Main} \cdot \left(\left(\frac{Q_{BR.Main}}{Q_{US.Main}} \right)^{\frac{6}{7}} \cdot \left(\frac{TW_{US.Main}}{TW_{BR.Main}} \right)^{k_1} \right) \end{cases}$$

$y_{2\_main} = 15.830\ ft$

Contraction Scour Depth: Ref. 1, Eq. 6.3 & 6.5

$y_{s.main} := y_{2\_main} - y_{BR.Main}$

$y_{s.main} = 6.017\ ft$

TOTAL SCOUR

NCHRP 24-20 Abutment Scour Approach

Refer to Ref. 1, Section 8.6.3

Left Abutment Variables:

Set-Back Ratio: $SBR_{Left} := \frac{L_{SBR.L}}{y_{BR.Main}} = 1.149$

Upstream Floodplain Width: $TW_{US.LOB} = 113.890\ ft$

Projected Approach Length: $L_{left.appraoch} = 99.930\ ft$

Check if the Live-Bed or Clear-Water Contraction Scour is present:

$$check\_NCHRP\_scour\_left := \text{if } \frac{L_{left.appraoch}}{TW_{US.LOB}} \ge 0.75 \;\; \| \text{“Live-Bed Scour ”} \;\; \text{else} \;\; \| \text{“Clear Water Scour”}$$

$$check\_NCHRP\_scour\_left = \text{“Live-Bed Scour ”}$$

Right Abutment Variables:

Set-Back Ratio: $SBR_{Right} := \frac{L_{SBR.R}}{y_{BR.Main}} = 1.593$

Upstream Floodplain Width: $TW_{US.ROB} = 154.820\ ft$

Projected Approach Length: $L_{right.appraoch} = 170.800\ ft$

Check if the Live-Bed or Clear-Water Contraction Scour is present:

$$check\_NCHRP\_scour\_right := \text{if } \frac{L_{right.appraoch}}{TW_{US.ROB}} \ge 0.75 \;\; \| \text{“Live-Bed Scour ”} \;\; \text{else} \;\; \| \text{“Clear Water Scour”}$$

$$check\_NCHRP\_scour\_right = \text{“Live-Bed Scour ”}$$

TOTAL SCOUR (CONT.)
NCHRP 24-20 Abutment Scour Approach (Cont.)

Bridge Cross-Section Unit Discharges for Live-Bed Scour:

Bridge Channel Unit Discharge:

$$q_{2.live} := \frac{Q_{BR.Main} + Q_{BR.ROB} + Q_{BR.LOB}}{TW_{BR.Main} + TW_{BR.ROB} + TW_{BR.LOB}} = 36.236 \ \frac{ft^2}{s}$$

Upstream Cross-Section Unit Discharges:

Upstream Channel Unit Discharge:

$$q_{1.live} := \frac{Q_{US.Main}}{TW_{US.Main}} = 25.871 \ \frac{ft^2}{s}$$

TOTAL SCOUR (CONT.)
NCHRP 24-20 Abutment Scour Approach (Cont.)
Left Abutment Live-Bed Scour:

Unit Discharge Ratio: $\frac{q_{2.live}}{q_{1.live}} = 1.401$

Flow Depth Including Live-Bed Scour: $y_c := y_{US.Main} \cdot \left(\frac{q_{2.live}}{q_{1.live}}\right)^{\frac{6}{7}} = 12.504\ ft$ — Ref. 1, Eq. 8.5

Scour Amplification Factor for Live-Bed Conditions: $\alpha_{A.left} := 1.60$ — Ref. 1, Fig. 8.9 (As seen Below)

Maximum Flow Depth Resulting from Abutment Scour: $y_{max.left} := \alpha_{A.left} \cdot y_c$ — Ref. 1, Eq. 8.3

$y_{max.left} = 20.007\ ft$

Abutment Scour Depth: $y_{s.NCHRP.live.left} := y_{max.left} - y_{BR.Main.Max}$ — Ref. 1, Eq. 8.4

$y_{s.NCHRP.live.left} = 7.267\ ft$

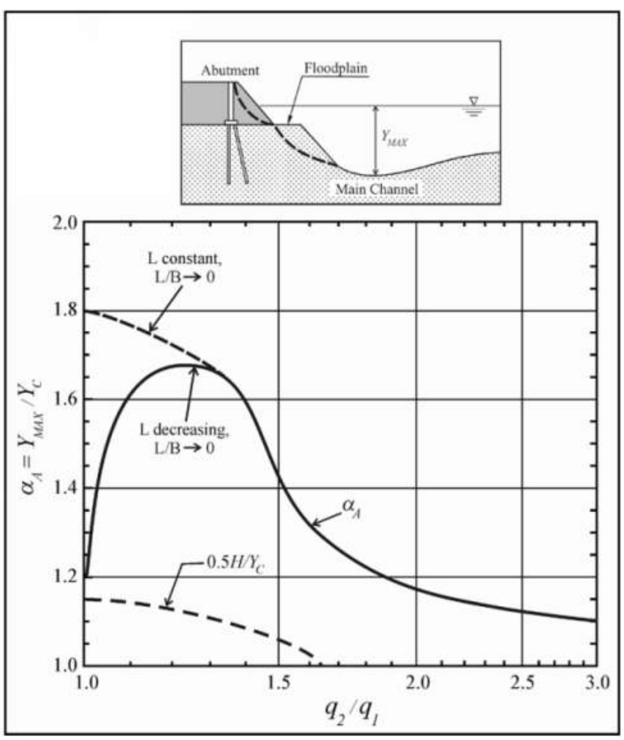


Figure 8.9. Scour amplification factor for spill-through abutments and live-bed conditions (NCHRP 2010b).

TOTAL SCOUR (CONT.)

NCHRP 24-20 Abutment Scour Approach (Cont.)

Right Abutment Live-Bed Scour:

Unit Discharge Ratio: $\frac{q_{2.live}}{q_{1.live}} = 1.401$

Flow Depth Including Live-Bed Scour: $y_c := y_{US.Main} \cdot \left(\frac{q_{2.live}}{q_{1.live}}\right)^{\frac{6}{7}} = 12.504\ ft$ — Ref. 1, Eq. 8.5

Scour Amplification Factor for Live-Bed Conditions: $\alpha_{A.right} := 1.60$ — Ref. 1, Fig. 8.10 (As seen Below)

Maximum Flow Depth: $y_{max.right} := \alpha_{A.right} \cdot y_c$ — Ref. 1, Eq. 8.3

$y_{max.right} = 20.007\ ft$

Abutment Scour Depth: $y_{s.NCHRP.live.right} := y_{max.right} - y_{BR.Main.Max}$ — Ref. 1, Eq. 8.4

$y_{s.NCHRP.live.right} = 7.267\ ft$

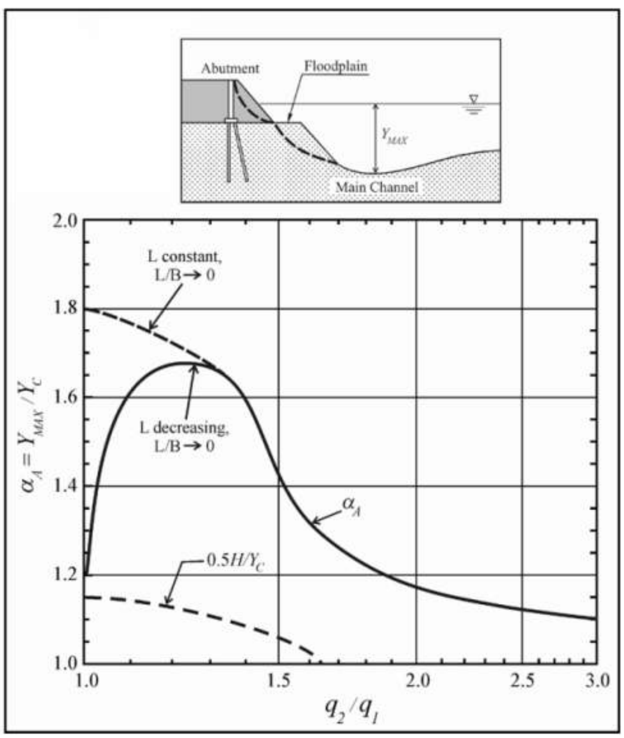


Figure 8.9. Scour amplification factor for spill-through abutments and live-bed conditions (NCHRP 2010b).

SUMMARY

Main Channel

Contraction Scour: $y_{s.main} = 6.017\ ft$

Left Abutment

Local Scour (NCHRP): $check\_NCHRP\_scour\_left =$ "Live-Bed Scour "

Local Scour: $y_{s.NCHRP.live.left} = 7.267\ ft$

Right Abutment

Total Scour (NCHRP): $check\_NCHRP\_scour\_right =$ "Live-Bed Scour "

Local Scour: $y_{s.NCHRP.live.right} = 7.267\ ft$

Bottom Elevation of Scour Pool

Channel Thawleg Elevation: $El_{Thawleg} := 331.0\ ft$

Max Scour Depth: $Max_{scour} := \max\left(y_{s.main}, y_{s.NCHRP.live.left}, y_{s.NCHRP.live.right}\right)$

$Max_{scour} = 7.267\ ft$

Scour Pool Elevation: $Scour_{el} := El_{Thawleg} - Max_{scour}$

$Scour_{el} = 323.733\ ft$

NOTES AND ASSUMPTIONS

References:

1. FHWA HEC 18, 5th Edition, Publication No. FHWA-HIF-12-003
2. FHWA HEC 15, 3rd Edition, Publication No. FHWA-NHI-05-114

- Scour is to be analyzed per FHWA Hydraulic Engineering Circular (HEC) 18.
- Proposed hydraulic data including flood velocity and elevations are taken from Proposed HEC-RAS Model. Copies of Tables and Cross-sections used are attached.
- Measurements were taken from HEC-RAS Cross-sections and Plans in conjunction with AutoCAD.
- The proposed bridge's hydraulic opening was designed for a 100 Year Flood Frequency. Per the MaineDOT Bridge Design Guide the 500 Year Flood is suggested as a check. The Riprap Revetment is to be designed for the 100 Year Flood Frequency and the 500 Year Flood Frequency is to be used as a check.

HEC-RAS TABLES

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
StreamCL	2385.65	Q500	3691.00	330.51	346.10		346.26	0.000355	3.53	1602.18	208.99	0.17
StreamCL	1604.26	Q500	3691.00	331.09	345.76		345.94	0.000471	3.88	1951.09	396.51	0.20
StreamCL	1283.94	Q500	3691.00	330.84	345.71		345.79	0.000319	3.02	2262.99	393.30	0.16
StreamCL	1112.94	Q500	3691.00	330.72	345.64		345.73	0.000346	3.29	2514.32	372.49	0.17
StreamCL	1034.95	Q500	3691.00	331.10	345.35	338.22	345.67	0.000660	4.55	825.17	353.36	0.24
StreamCL	982		Bridge									
StreamCL	904.43	Q500	3691.00	322.63	345.22	330.99	345.35	0.000143	2.96	1306.46	257.33	0.12
StreamCL	838.83	Q500	3691.00	331.46	344.58	338.91	345.15	0.001277	6.06	609.27	292.85	0.33
StreamCL	686.02	Q500	3691.00	328.62	344.78		344.88	0.000266	2.87	2114.30	296.21	0.15
StreamCL	419.2	Q500	3691.00	331.59	344.47	339.59	344.75	0.000825	4.97	1385.57	217.24	0.27
StreamCL	216.64	Q500	3691.00	331.38	344.25	338.96	344.57	0.000896	5.01	1198.90	193.58	0.28
StreamCL	31.36	Q500	3691.00	331.88	344.21		344.35	0.000611	3.87	1596.13	255.25	0.22
StreamCL	-121.5	Q500	3691.00	331.36	344.04		344.24	0.000596	4.08	1400.58	216.81	0.22
StreamCL	-459.58	Q500	3691.00	331.35	343.37		343.84	0.001613	6.38	1147.11	247.75	0.35
StreamCL	-980.34	Q500	3691.00	331.03	343.08		343.22	0.000693	3.97	1729.35	330.13	0.23
StreamCL	-1650.77	Q500	3691.00	330.91	342.82	334.86	342.94	0.000271	2.91	1701.49	272.59	0.15
StreamCL	-1948.51	Q500	3691.00	331.11	342.75	339.11	342.82	0.000431	3.13	2518.20	555.64	0.18

Reach	River Sta	Profile	E.G. Elev (ft)	W.S. Elev (ft)	Crit W.S. (ft)	Frctn Loss (ft)	C & E Loss (ft)	Top Width (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Vel Chnl (ft/s)
StreamCL	1112.94	Q500	345.73	345.64		0.04	0.02	372.49	888.12	1877.57	925.31	3.29
StreamCL	1034.95	Q500	345.67	345.35	338.22	0.02	0.05	353.36	21.29	3669.71		4.55
StreamCL	982 BR U	Q500	345.60	345.09	339.13	0.03	0.00	60.78	80.99	3535.59	74.42	5.79
StreamCL	982 BR D	Q500	345.56	345.05	339.14	0.02	0.19	63.35	84.55	3543.34	63.11	5.82
StreamCL	904.43	Q500	345.35	345.22	330.99	0.07	0.13	257.33	90.05	3600.95		2.96
StreamCL	838.83	Q500	345.15	344.58	338.91	0.08	0.19	292.85		3691.00		6.06

HEC-RAS TABLES (CONT.)

Cross Section Output

File Type Options Help

River: StreamCL Profile: Q500

Reach StreamCL RS: 1283.94 Plan: Prop

Plan: Prop StreamCL StreamCL RS: 1283.94 Profile: Q500

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	345.79	Wt. n-Val.	0.070	0.040	0.070
Vel Head (ft)	0.08	Reach Len. (ft)	171.00	171.00	171.00
W.S. Elev (ft)	345.71	Flow Area (sq ft)	839.15	582.01	841.84
Crit W.S. (ft)		Area (sq ft)	839.15	582.01	841.84
E.G. Slope (ft/ft)	0.000319	Flow (cfs)	1168.96	1755.97	766.06
Q Total (cfs)	3691.00	Top Width (ft)	116.49	53.41	223.40
Top Width (ft)	393.30	Avg. Vel. (ft/s)	1.39	3.02	0.91
Vel Total (ft/s)	1.63	Hydr. Depth (ft)	7.20	10.90	3.77
Max Chl Dpth (ft)	14.87	Conv. (cfs)	65450.5	98317.4	42892.1
Conv. Total (cfs)	206659.9	Wetted Per. (ft)	119.14	60.02	226.39
Length Wtd. (ft)	171.00	Shear (lb/sq ft)	0.14	0.19	0.07
Min Ch El (ft)	330.84	Stream Power (lb/ft s)	0.20	0.58	0.07
Alpha	1.92	Cum Volume (acre-ft)	43.16	54.51	35.31
Frctn Loss (ft)	0.06	Cum SA (acres)	9.88	5.00	7.17
C & E Loss (ft)	0.00				

Cross Section Output

File Type Options Help

River: StreamCL Profile: Q500

Reach StreamCL RS: 982 BR U Plan: Prop

Plan: Prop StreamCL StreamCL RS: 982 BR U Profile: Q500

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	345.60	Wt. n-Val.	0.040	0.040	0.040
Vel Head (ft)	0.50	Reach Len. (ft)	27.33	27.33	27.33
W.S. Elev (ft)	345.09	Flow Area (sq ft)	34.28	610.58	40.02
Crit W.S. (ft)	339.13	Area (sq ft)	34.28	610.58	40.12
E.G. Slope (ft/ft)	0.001189	Flow (cfs)	80.99	3535.59	74.42
Q Total (cfs)	3691.00	Top Width (ft)	11.26	49.51	
Top Width (ft)	60.78	Avg. Vel. (ft/s)	2.36	5.79	1.86
Vel Total (ft/s)	5.39	Hydr. Depth (ft)	3.04	12.33	
Max Chl Dpth (ft)	14.09	Conv. (cfs)	2349.0	102551.8	2158.7
Conv. Total (cfs)	107059.5	Wetted Per. (ft)	13.69	63.51	22.87
Length Wtd. (ft)	27.33	Shear (lb/sq ft)	0.19	0.71	0.13
Min Ch El (ft)	331.00	Stream Power (lb/ft s)	0.44	4.13	0.24
Alpha	1.11	Cum Volume (acre-ft)	38.57	48.46	30.38
Frctn Loss (ft)	0.03	Cum SA (acres)	9.23	4.45	6.09
C & E Loss (ft)	0.00				

GEOMETRY DATA
Left Approach (Q500)

Upstream Bridge Water Surface Elevation:	$WSEL_{BR} := 345.09\ ft$	Refer to HEC-RAS
Station of Face of Abutment:	$STA_{abut.left} := 246.37\ ft$	Refer to HEC-RAS
Station of Overbank or Proposed Toe:	$STA_{BR.LOB} := 257.65\ ft$	Refer to HEC-RAS
Station of WSEL @ outer edge of cross-section:	$STA_{WSEL.LOB} := 143.76\ ft$	Refer to HEC-RAS
Abutment Set Back Distance:	$L_{SBR.L} := \left\|STA_{BR.LOB} - STA_{abut.left}\right\| = 11.280\ ft$	
Length of Left Approach:	$L_{left.appraoch} := \left\|STA_{WSEL.LOB} - STA_{abut.left}\right\| = 102.610\ ft$	

Right Approach

Upstream Bridge Water Surface Elevation:	$WSEL_{BR} = 345.090\ ft$	Refer to HEC-RAS
Station of Face of Abutment:	$STA_{abut.right} := 323.37\ ft$	Refer to HEC-RAS
Station of Overbank or Proposed Toe:	$STA_{BR.ROB} := 312.33\ ft$	Refer to HEC-RAS
Station of WSEL @ outer edge of cross-section:	$STA_{WSEL.ROB} := 495.76\ ft$	Refer to HEC-RAS
Abutment Set Back Distance:	$L_{SBR.R} := \left\|STA_{BR.ROB} - STA_{abut.right}\right\| = 11.040\ ft$	
Length of Right Approach:	$L_{right.appraoch} := \left\|STA_{WSEL.ROB} - STA_{abut.right}\right\| = 172.390\ ft$	

HYDRAULIC DATA
Upstream Cross-Section (12+83)

Upstream Left Overbank Discharge:	$Q_{US.LOB} := 1168.96 \frac{ft^3}{s}$	HEC-RAS Tables
Upstream Main Channel Discharge:	$Q_{US.Main} := 1755.97 \frac{ft^3}{s}$	HEC-RAS Tables
Upstream Right Overbank Discharge:	$Q_{US.ROB} := 766.06 \frac{ft^3}{s}$	HEC-RAS Tables
Upstream Left Overbank Flow Area:	$A_{US.LOB} := 839.15\ ft^2$	HEC-RAS Tables
Upstream Main Channel Flow Area:	$A_{US.Main} := 582.01\ ft^2$	HEC-RAS Tables
Upstream Right Overbank Flow Area:	$A_{US.ROB} := 841.84\ ft^2$	HEC-RAS Tables
Top Width of Left Overbank:	$TW_{US.LOB} := 116.49\ ft$	HEC-RAS Tables
Top Width of Main Channel:	$TW_{US.Main} := 53.41\ ft$	HEC-RAS Tables
Top Width of Right Overbank:	$TW_{US.ROB} := 223.40\ ft$	HEC-RAS Tables

Average Flow Depth of Entire Channel: $y_{US} := \frac{(A_{US.LOB} + A_{US.Main} + A_{US.ROB})}{(TW_{US.LOB} + TW_{US.Main} + TW_{US.ROB})} = 5.754\ ft$

Average Main Channel Flow Depth: $y_{US.Main} := \frac{A_{US.Main}}{TW_{US.Main}} = 10.897\ ft$

Average Left Overbank Flow Depth: $y_{US.LOB} := \frac{A_{US.LOB}}{TW_{US.LOB}} = 7.204\ ft$

Average Right Overbank Flow Depth: $y_{US.ROB} := \frac{A_{US.ROB}}{TW_{US.ROB}} = 3.768\ ft$

Left Overbank Manning's n: $n_{US.LOB} := 0.07$

Right Overbank Manning's n: $n_{US.ROB} := 0.07$

Upstream Energy Grade Line Slope: $S_{1.US} := 0.000319 \frac{ft}{ft}$

HYDRAULIC DATA (CONT.)
Bridge Cross-Section (9+82)

Bridge Left Overbank Discharge:	$Q_{BR.LOB} := 80.99 \frac{ft^3}{s}$	HEC-RAS Tables
Bridge Main Channel Discharge:	$Q_{BR.Main} := 3535.59 \frac{ft^3}{s}$	HEC-RAS Tables
Bridge Right Overbank Discharge:	$Q_{BR.ROB} := 74.42 \frac{ft^3}{s}$	HEC-RAS Tables
Bridge Left Overbank Flow Area:	$A_{BR.LOB} := 34.28\ ft^2$	HEC-RAS Tables
Bridge Main Channel Flow Area:	$A_{BR.Main} := 610.58\ ft^2$	HEC-RAS Tables
Bridge Right Overbank Flow Area:	$A_{BR.ROB} := 40.12\ ft^2$	HEC-RAS Tables
Top Width of Main Channel:	$TW_{BR.Main} := 49.51\ ft$	HEC-RAS Tables
Top Width of Left Overbank:	$TW_{BR.LOB} := 11.26\ ft$	HEC-RAS Tables

Top Width of Right Overbank: $TW_{BR.ROB} := STA_{abut.right} - STA_{BR.ROB} = 11.040\ ft$

Average Flow Depth of Entire Channel: $$y_{BR} := \frac{\left(A_{BR.LOB} + A_{BR.Main} + A_{BR.ROB}\right)}{\left(TW_{BR.LOB} + TW_{BR.Main} + TW_{BR.ROB}\right)} = 9.539\ ft$$

Average Main Channel Flow Depth: $$y_{BR.Main} := \frac{A_{BR.Main}}{TW_{BR.Main}} = 12.332\ ft$$

Max Main Channel Flow Depth: $y_{BR.Main.Max} := 14.09\ ft$

Energy Grade Line Slope at Bridge: $S_{1.BR} := 0.001189 \frac{ft}{ft}$

HYDRAULIC DATA (CONT.)
Bridge Contraction Scour Variables

Depth in Contracted Section before Scour: $y_{BR.Main} = 12.332\ ft$

Average Depth in Upstream Main Channel: $y_{US.Main} = 10.897\ ft$

Top Width of Upstream Main Channel: $TW_{US.Main} = 53.410\ ft$

Top Width of Contracted Section Main Channel: $TW_{BR.Main} = 49.510\ ft$

Flow in Upstream Main Channel Transporting Sediment: $Q_{US.Main} = 1755.970\ \frac{ft^3}{s}$

Flow in Contracted Channel: $Q_{BR.Main} = 3535.590\ \frac{ft^3}{s}$

Average Velocity in Upstream (Main) Channel Transporting Sediment: $V_{US.Main} := \frac{Q_{US.Main}}{A_{US.Main}} = 3.017\ \frac{ft}{s}$

Max Upstream Main Channel Flow Depth: $y_{US.Main.Max} := 14.87\ ft$

Shear Velocity in Upstream Channel: $V'_{Main} := \sqrt{g \cdot y_{US.Main} \cdot S_{1.US}} = 0.334\ \frac{ft}{s}$

MATERIAL DATA
Main Channel

Median Diameter of Bed Material: $D_{50.Main} := 0.10\ mm$ — Per MaineDOT Gradation Report of Site Soil Sample

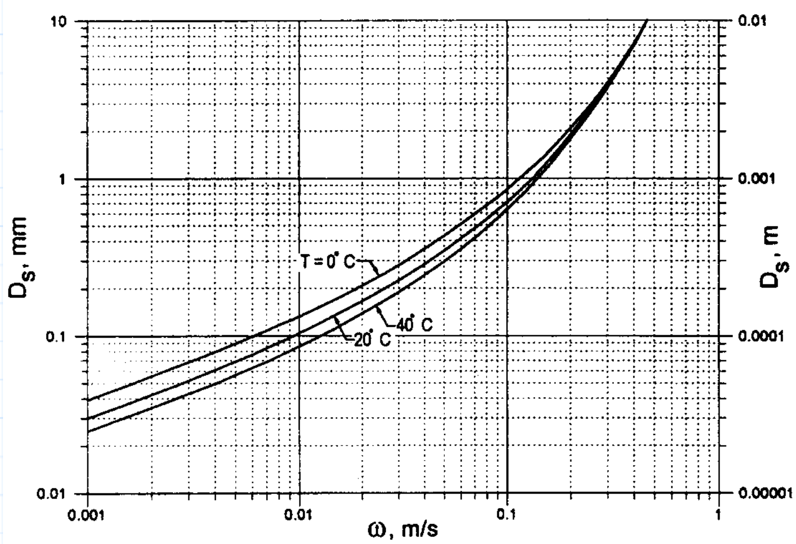
Diameter of the smallest nontransportable particle: $D_{m.Main} := 1.25 \cdot D_{50.Main} = 0.125\ mm$

Note: If D50< 0.2mm, use 0.2mm for clear-water scour

Water Unit Weight: $\gamma_w := 62.4\ \frac{lb}{ft^3}$

Particle Unit Weight: $\gamma_s := 2.65 \cdot \gamma_w = 165.360\ \frac{lb}{ft^3}$

D50 Fall Velocity @ 20C: $\omega_{Main} := 0.01\ \frac{m}{sec}$ — Ref. 1, Fig. 6.8 (as seen below)



English Unit Constant for Critical Velocity Eq.: $K_{u\_c} := 11.17$

Critical Velocity that Bed Material of Size D50 and smaller will be transported: $V_{c.Main} := K_{u\_c} \cdot y_{US.Main}^{\frac{1}{6}} \cdot (D_{50.Main})^{\frac{1}{3}} \cdot \frac{ft^{\left(\frac{1}{2}\right)}}{sec}$ — Ref. 1, Eq. 6.1

$V_{c.Main} = 1.147\ \frac{ft}{s}$

CONTRACTION SCOUR
Main Channel

English Unit Constant for Clear-Water Scour:

$$K_{u\_clear} := 0.0077$$

Check if Live-Bed or Clear-Water Scour is present:

$$check\_cont\_scour := \begin{cases} \text{if } V_{c.Main} > V_{US.Main} & \text{"Clear-Water Scour "} \\ \text{else if } V_{US.Main} > V_{c.Main} & \text{"Live-Bed Scour"} \end{cases} = \text{"Live-Bed Scour"}$$

Exponent determined for Live-Bed Contraction Scour:

V∗/T	k₁	Mode of Bed Material Transport
<0.50	0.59	Mostly contact bed material discharge
0.50 to 2.0	0.64	Some suspended bed material discharge
>2.0	0.69	Mostly suspended bed material discharge

$$k_1 := \begin{cases} \text{if } \frac{V'_{Main}}{\omega_{Main}} < 0.50 & 0.59 \\ \text{else if } 0.50 \le \frac{V'_{Main}}{\omega_{Main}} \le 2.0 & 0.64 \\ \text{else if } \frac{V'_{Main}}{\omega_{Main}} > 2.0 & 0.69 \end{cases} = 0.690$$

Ref. 1, Art. 6.3

Average Equilibrium Depth in Contracted Section:

Ref. 1, Eq. 6.2 & 6.4

$$y_{2\_main} := \begin{cases} \text{if } V_{c.Main} > V_{US.Main} & \left(\frac{K_{u\_clear} \cdot Q_{BR.Main}^{2}}{\left(\max\left(D_{m.Main}, 0.2\ mm\right)\right)^{\frac{2}{3}} \cdot TW_{BR.Main}^{2}} \cdot \frac{sec^2}{ft} \right)^{\frac{3}{7}} \\ \text{else if } V_{US.Main} > V_{c.Main} & y_{US.Main} \cdot \left(\left(\frac{Q_{BR.Main}}{Q_{US.Main}}\right)^{\frac{6}{7}} \cdot \left(\frac{TW_{US.Main}}{TW_{BR.Main}}\right)^{k_1} \right) \end{cases}$$

$$y_{2\_main} = 20.920\ ft$$

Contraction Scour Depth:

$$y_{s.main} := y_{2\_main} - y_{BR.Main}$$

Ref. 1, Eq. 6.3 & 6.5

$$y_{s.main} = 8.587\ ft$$

TOTAL SCOUR

NCHRP 24-20 Abutment Scour Approach

Refer to Ref. 1, Section 8.6.3

Left Abutment Variables:

Set-Back Ratio: $SBR_{Left} := \frac{L_{SBR.L}}{y_{BR.Main}} = 0.915$

Upstream Floodplain Width: $TW_{US.LOB} = 116.490\ ft$

Projected Approach Length: $L_{left.appraoch} = 102.610\ ft$

Check if the Live-Bed or Clear-Water Contraction Scour is present:

$$check\_NCHRP\_scour\_left := \text{if } \frac{L_{left.appraoch}}{TW_{US.LOB}} \geq 0.75 \;\; \text{“Live-Bed Scour ”} \;\; \text{else} \;\; \text{“Clear Water Scour”}$$

$check\_NCHRP\_scour\_left =$ “Live-Bed Scour ”

Right Abutment Variables:

Set-Back Ratio: $SBR_{Right} := \frac{L_{SBR.R}}{y_{BR.Main}} = 0.895$

Upstream Floodplain Width: $TW_{US.ROB} = 223.400\ ft$

Projected Approach Length: $L_{right.appraoch} = 172.390\ ft$

Check if the Live-Bed or Clear-Water Contraction Scour is present:

$$check\_NCHRP\_scour\_right := \text{if } \frac{L_{right.appraoch}}{TW_{US.ROB}} \geq 0.75 \;\; \text{“Live-Bed Scour ”} \;\; \text{else} \;\; \text{“Clear Water Scour”}$$

$check\_NCHRP\_scour\_right =$ “Live-Bed Scour ”

TOTAL SCOUR (CONT.)
NCHRP 24-20 Abutment Scour Approach (Cont.)

Bridge Cross-Section Unit Discharges for Live-Bed Scour:

Bridge Channel Unit Discharge: $q_{2.live} := \dfrac{Q_{BR.Main} + Q_{BR.ROB} + Q_{BR.LOB}}{TW_{BR.Main} + TW_{BR.ROB} + TW_{BR.LOB}} = 51.400\ \dfrac{ft^2}{s}$

Upstream Cross-Section Unit Discharges:

Upstream Channel Unit Discharge: $q_{1.live} := \dfrac{Q_{US.Main}}{TW_{US.Main}} = 32.877\ \dfrac{ft^2}{s}$

TOTAL SCOUR (CONT.)
NCHRP 24-20 Abutment Scour Approach (Cont.)
Left Abutment Live-Bed Scour:

Unit Discharge Ratio: $\frac{q_{2.live}}{q_{1.live}} = 1.563$

Flow Depth Including Live-Bed Scour: $y_c := y_{US.Main} \cdot \left(\frac{q_{2.live}}{q_{1.live}}\right)^{\frac{6}{7}} = 15.983\ ft$ — Ref. 1, Eq. 8.5

Scour Amplification Factor for Live-Bed Conditions: $\alpha_{A.left} := 1.35$ — Ref. 1, Fig. 8.9 (As seen Below)

Maximum Flow Depth Resulting from Abutment Scour: $y_{max.left} := \alpha_{A.left} \cdot y_c$ — Ref. 1, Eq. 8.3

$y_{max.left} = 21.577\ ft$

Abutment Scour Depth: $y_{s.NCHRP.live.left} := y_{max.left} - y_{BR.Main.Max}$ — Ref. 1, Eq. 8.4

$y_{s.NCHRP.live.left} = 7.487\ ft$

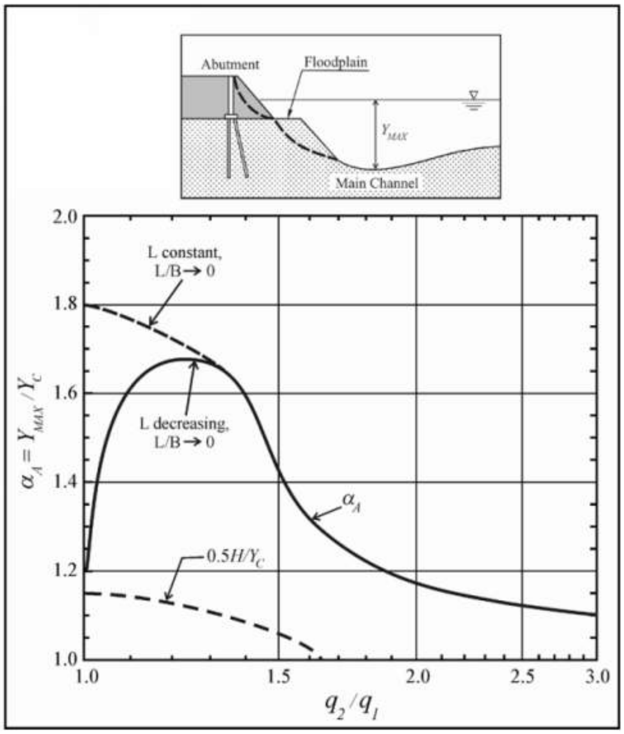


Figure 8.9. Scour amplification factor for spill-through abutments and live-bed conditions (NCHRP 2010b).

TOTAL SCOUR (CONT.)

NCHRP 24-20 Abutment Scour Approach (Cont.)

Right Abutment Live-Bed Scour:

Unit Discharge Ratio: $\frac{q_{2.live}}{q_{1.live}} = 1.563$

Flow Depth Including Live-Bed Scour: $y_c := y_{US.Main} \cdot \left(\frac{q_{2.live}}{q_{1.live}}\right)^{\frac{6}{7}} = 15.983\ ft$ — Ref. 1, Eq. 8.5

Scour Amplification Factor for Live-Bed Conditions: $\alpha_{A.right} := 1.35$ — Ref. 1, Fig. 8.10 (As seen Below)

Maximum Flow Depth: $y_{max.right} := \alpha_{A.right} \cdot y_c$ — Ref. 1, Eq. 8.3

$y_{max.right} = 21.577\ ft$

Abutment Scour Depth: $y_{s.NCHRP.live.right} := y_{max.right} - y_{BR.Main.Max}$ — Ref. 1, Eq. 8.4

$y_{s.NCHRP.live.right} = 7.487\ ft$

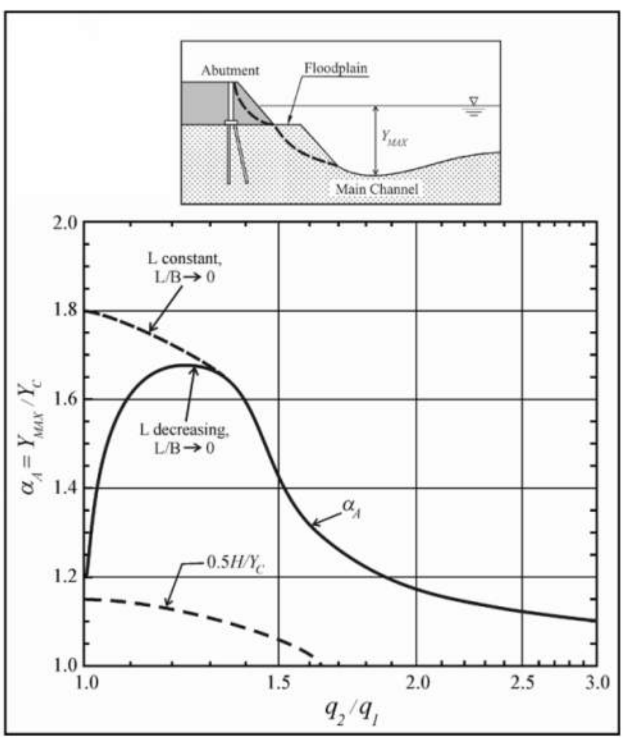


Figure 8.9. Scour amplification factor for spill-through abutments and live-bed conditions (NCHRP 2010b).

SUMMARY

Main Channel

Contraction Scour: $y_{s.main} = 8.587\ ft$

Left Abutment

Local Scour (NCHRP): $check\_NCHRP\_scour\_left =$ "Live-Bed Scour "

Local Scour: $y_{s.NCHRP.live.left} = 7.487\ ft$

Right Abutment

Total Scour (NCHRP): $check\_NCHRP\_scour\_right =$ "Live-Bed Scour "

Local Scour: $y_{s.NCHRP.live.right} = 7.487\ ft$

Bottom Elevation of Scour Pool

Channel Thawleg Elevation: $El_{Thawleg} := 331.0\ ft$

Max Scour Depth: $Max_{scour} := \max\left(y_{s.main}, y_{s.NCHRP.live.left}, y_{s.NCHRP.live.right}\right)$

$Max_{scour} = 8.587\ ft$

Scour Pool Elevation: $Scour_{el} := El_{Thawleg} - Max_{scour}$

$Scour_{el} = 322.413\ ft$

NOTES AND ASSUMPTIONS

References:

1. FHWA HEC 23 Vol. 1, 3rd Edition, Publication No. FHWA-NHI-09-111
2. FHWA HEC 23 Vol. 2, 3rd Edition, Publication No. FHWA-NHI-09-112
3. FHWA HEC 18, 5th Edition, Publication No. FHWA-HIF-12-003
4. MaineDOT Standard Specifications, 2014

- Rock riprap revetment shall be designed to resist scour and protect the abutments per the set-back ratio (SBR) approach detailed in the "Design Guideline 14" in the FHWA Hydraulic Engineering Circular (HEC) 23.
- Proposed hydraulic data including flood velocity and elevations are taken from Proposed HEC-RAS Model. Copies of Tables and Cross-sections used are attached.
- Rock riprap sizes shall meet those as detailed in Section 703 of the MaineDOT Standard Specifications.
- The proposed bridge's hydraulic opening was designed for a 100 Year Flood Frequency. Per the MaineDOT Bridge Design Guide the 500 Year Flood is suggested as a check. The Riprap Revetment is to be designed for the 100 Year Flood Frequency and the 500 Year Flood Frequency is to be used as a check.

HEC-RAS TABLES

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)	
StreamCL	2385.65	Q100	2684.00	330.51	344.59		344.71	0.000306	3.02	1298.37	188.57	0.16
StreamCL	1604.26	Q100	2684.00	331.09	344.24		344.41	0.000487	3.61	1374.03	359.29	0.19
StreamCL	1283.94	Q100	2684.00	330.84	344.18		344.25	0.000327	2.76	1716.04	322.12	0.16
StreamCL	1112.94	Q100	2684.00	330.72	344.12		344.19	0.000331	2.92	1980.67	330.28	0.16
StreamCL	1034.95	Q100	2684.00	331.10	343.92	337.29	344.15	0.000556	3.81	715.06	348.31	0.22
StreamCL	982		Bridge									
StreamCL	904.43	Q100	2684.00	322.63	343.83	329.79	343.91	0.000099	2.34	1199.49	248.77	0.10
StreamCL	838.83	Q100	2684.00	331.46	343.39	337.82	343.77	0.001005	4.96	540.79	287.79	0.29
StreamCL	686.02	Q100	2684.00	328.62	343.51		343.58	0.000233	2.47	1738.52	292.55	0.14
StreamCL	419.2	Q100	2684.00	331.59	343.24	338.25	343.47	0.000736	4.33	1121.03	213.97	0.25
StreamCL	216.64	Q100	2684.00	331.38	343.06	337.80	343.31	0.000786	4.33	970.43	190.41	0.25
StreamCL	31.36	Q100	2684.00	331.88	343.00		343.12	0.000596	3.49	1290.73	251.64	0.22
StreamCL	-121.5	Q100	2684.00	331.36	342.87		343.02	0.000523	3.54	1148.41	212.87	0.20
StreamCL	-459.58	Q100	2684.00	331.35	342.25		342.67	0.001519	5.74	873.01	240.59	0.33
StreamCL	-980.34	Q100	2684.00	331.03	341.92		342.05	0.000739	3.75	1346.76	326.59	0.23
StreamCL	-1650.77	Q100	2684.00	330.91	341.70	334.17	341.79	0.000217	2.42	1400.99	266.65	0.14
StreamCL	-1948.51	Q100	2684.00	331.11	341.63	338.49	341.69	0.000430	2.87	1939.46	473.48	0.18

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
StreamCL	1112.94	Q100	344.19	344.12		0.03	0.01	330.28	629.33	1443.57	611.10	2.92
StreamCL	1034.95	Q100	344.15	343.92	337.29	0.02	0.04	348.31	10.93	2673.07		3.81
StreamCL	982 BR U	Q100	344.09	343.74	338.02	0.02	0.00	74.07	35.16	2597.02	51.82	4.84
StreamCL	982 BR D	Q100	344.07	343.71	338.02	0.02	0.14	71.60	34.83	2604.03	45.14	4.87
StreamCL	904.43	Q100	343.91	343.83	329.79	0.05	0.09	248.77	56.05	2627.95		2.34
StreamCL	838.83	Q100	343.77	343.39	337.82	0.06	0.12	287.79		2684.00		4.96

HEC-RAS TABLES (CONT.)

Cross Section Output

File Type Options Help

River: StreamCL Profile: Q100
Reach StreamCL RS: 1283.94 Plan: Prop

Plan: Prop StreamCL StreamCL RS: 1283.94 Profile: Q100

E.G. Elev (ft)	344.25	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.07	Wt. n-Val.	0.070	0.040	0.070
W.S. Elev (ft)	344.18	Reach Len. (ft)	171.00	171.00	171.00
Crit W.S. (ft)		Flow Area (sq ft)	663.02	500.34	552.69
E.G. Slope (ft/ft)	0.000327	Area (sq ft)	663.02	500.34	552.69
Q Total (cfs)	2684.00	Flow (cfs)	812.96	1381.78	489.26
Top Width (ft)	322.12	Top Width (ft)	113.89	53.41	154.82
Vel Total (ft/s)	1.56	Avg. Vel. (ft/s)	1.23	2.76	0.89
Max Chl Dpth (ft)	13.34	Hydr. Depth (ft)	5.82	9.37	3.57
Conv. Total (cfs)	148435.7	Conv. (cfs)	44959.7	76417.8	27058.2
Length Wtd. (ft)	171.00	Wetted Per. (ft)	116.12	60.02	157.79
Min Ch El (ft)	330.84	Shear (lb/sq ft)	0.12	0.17	0.07
Alpha	1.85	Stream Power (lb/ft s)	0.14	0.47	0.06
Frctn Loss (ft)	0.06	Cum Volume (acre-ft)	31.70	48.44	26.69
C & E Loss (ft)	0.00	Cum SA (acres)	9.40	5.01	6.79

Cross Section Output

File Type Options Help

River: StreamCL Profile: Q100
Reach StreamCL RS: 982 BR U Plan: Prop

Plan: Prop StreamCL StreamCL RS: 982 BR U Profile: Q100

E.G. Elev (ft)	344.09	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.35	Wt. n-Val.	0.040	0.040	0.040
W.S. Elev (ft)	343.74	Reach Len. (ft)	27.33	27.33	27.33
Crit W.S. (ft)	338.02	Flow Area (sq ft)	19.71	536.58	27.07
E.G. Slope (ft/ft)	0.000881	Area (sq ft)	19.71	536.58	27.13
Q Total (cfs)	2684.00	Flow (cfs)	35.16	2597.02	51.82
Top Width (ft)	74.07	Top Width (ft)	8.32	54.68	11.07
Vel Total (ft/s)	4.60	Avg. Vel. (ft/s)	1.78	4.84	1.91
Max Chl Dpth (ft)	12.74	Hydr. Depth (ft)	2.37	9.81	2.45
Conv. Total (cfs)	90425.9	Conv. (cfs)	1184.4	87495.5	1745.9
Length Wtd. (ft)	27.33	Wetted Per. (ft)	9.57	58.35	11.83
Min Ch El (ft)	331.00	Shear (lb/sq ft)	0.11	0.51	0.13
Alpha	1.08	Stream Power (lb/ft s)	0.20	2.45	0.24
Frctn Loss (ft)	0.02	Cum Volume (acre-ft)	28.07	43.18	23.22
C & E Loss (ft)	0.00	Cum SA (acres)	8.77	4.46	5.96

MATERIAL, GEOMETRY DATA AND CONSTANTS

Specific Gravity of Riprap: $S_s := 2.60$

Gravitational Acceleration: $g = 32.174\ \frac{ft}{s^2}$

Vertical Wall or Spill-through Abutment? $abut := \text{"Spill"}$

- Enter "Vertical" if Vertical Wall or "Spill" if Spill-through

MaineDOT Riprap Sizes

	Median size	Maximum size	
Plain Riprap:	$D_{50\_plain} := 9\ in$	$D_{100\_plain} := 12\ in$	Ref. 4, Section 703.26
Heavy Riprap:	$D_{50\_heavy} := 24\ in$	$D_{100\_heavy} := 48\ in$	Ref. 4, Section 703.28
Stone Blanket:	$D_{50\_blanket} := 24\ in$	$D_{100\_blanket} := 66\ in$	Ref. 4, Section 703.27

Left Abutment Geometry

Station of Overbank or Proposed Toe: $STA_{BR.LOB} := 257.65\ ft$ Refer to HEC-RAS

Station of tip of Abutment: $STA_{abut.left} := 246.37\ ft$ Refer to HEC-RAS

Abutment Set Back Distance: $L_{SBR.L} := \left| STA_{BR.LOB} - STA_{abut.left} \right| = 11.280\ ft$

Right Abutment Geometry

Station of Overbank or Proposed Toe: $STA_{BR.ROB} := 339.0\ ft$ Refer to HEC-RAS

Station of tip of Abutment: $STA_{abut.right} := 323.37\ ft$ Refer to HEC-RAS

Abutment Set Back Distance: $L_{SBR.R} := \left| STA_{BR.ROB} - STA_{abut.right} \right| = 15.630\ ft$

HYDRAULIC DATA
Upstream Cross-Section (12+83)

Upstream Water Surface Elevation (*Use Max. El. Immediately Upstream/ Downstream of Bridge, Sta. 9+82): $WSEL_{Q50} := 343.15\ ft$ HEC-RAS

Upstream Left Overbank Discharge: $Q_{US.LOB} := 812.96\ \frac{ft^3}{s}$ HEC-RAS

Upstream Main Channel Discharge: $Q_{US.Main} := 1381.78\ \frac{ft^3}{s}$ HEC-RAS

Upstream Right Overbank Discharge: $Q_{US.ROB} := 489.26\ \frac{ft^3}{s}$ HEC-RAS

Upstream Left Overbank Flow Area: $A_{US.LOB} := 663.02\ ft^2$ HEC-RAS

Upstream Main Channel Flow Area: $A_{US.Main} := 500.34\ ft^2$ HEC-RAS

Upstream Right Overbank Flow Area: $A_{US.ROB} := 552.69\ ft^2$ HEC-RAS

Top Width of Left Overbank: $TW_{US.LOB} := 113.89\ ft$ HEC-RAS

Top Width of Main Channel: $TW_{US.Main} := 53.41\ ft$ HEC-RAS

Top Width of Right Overbank: $TW_{US.ROB} := 154.82\ ft$ HEC-RAS

Average Flow Depth of Entire Channel: $y_{US} := \frac{(A_{US.LOB} + A_{US.Main} + A_{US.ROB})}{(TW_{US.LOB} + TW_{US.Main} + TW_{US.ROB})} = 5.327\ ft$

Average Main Channel Flow Depth: $y_{US.Main} := \frac{A_{US.Main}}{TW_{US.Main}} = 9.368\ ft$

Average Left Overbank Flow Depth: $y_{US.LOB} := \frac{A_{US.LOB}}{TW_{US.LOB}} = 5.822\ ft$

Average Right Overbank Flow Depth: $y_{US.ROB} := \frac{A_{US.ROB}}{TW_{US.ROB}} = 3.570\ ft$

HYDRAULIC DATA (CONT.)
Bridge Cross-Section (US, 9+82)

Bridge Left Overbank Discharge: $Q_{BR.LOB} := 35.16 \frac{ft^3}{s}$ HEC-RAS

Bridge Main Channel Discharge: $Q_{BR.Main} := 2597.02 \frac{ft^3}{s}$ HEC-RAS

Bridge Right Overbank Discharge: $Q_{BR.ROB} := 51.82 \frac{ft^3}{s}$ HEC-RAS

Bridge Left Overbank Flow Area: $A_{BR.LOB} := 19.71\ ft^2$ HEC-RAS

Bridge Main Channel Flow Area: $A_{BR.Main} := 536.58\ ft^2$ HEC-RAS

Bridge Right Overbank Flow Area: $A_{BR.ROB} := 27.13\ ft^2$ HEC-RAS

Top Width of Main Channel: $TW_{BR.Main} := 54.68\ ft$

Top Width of Left Overbank: $TW_{BR.LOB} := 8.32\ ft$

Top Width of Right Overbank: $TW_{BR.ROB} := 11.07\ ft$

Average Flow Depth of Entire Channel: $$y_{BR} := \frac{\left(A_{BR.LOB} + A_{BR.Main} + A_{BR.ROB}\right)}{\left(TW_{BR.LOB} + TW_{BR.Main} + TW_{BR.ROB}\right)} = 7.877\ ft$$

Average Main Channel Flow Depth: $$y_{BR.Main} := \frac{A_{BR.Main}}{TW_{BR.Main}} = 9.813\ ft$$

Average Left Overbank Flow Depth: $$y_{BR.LOB} := \frac{A_{BR.LOB}}{TW_{BR.LOB}} = 2.369\ ft$$

Average Right Overbank Flow Depth: $$y_{BR.ROB} := \frac{A_{BR.ROB}}{TW_{BR.ROB}} = 2.451\ ft$$

SIZE ABUTMENT RIPRAP

1. Determine Set-back Ratios

Left Abutment Set-back Ratio: $SBR_{Left} := \frac{L_{SBR.L}}{y_{BR.Main}} = 1.149$

Right Abutment Set-back Ratio: $SBR_{Right} := \frac{L_{SBR.R}}{y_{BR.Main}} = 1.593$

Left Abutment

2a. Determine Left Abutment Characteristic Velocity per HEC-23 DG 14, SBR Approach

$$V_{left} := \begin{cases} \frac{(Q_{US.Main} + Q_{US.LOB} + Q_{US.ROB})}{(A_{BR.Main} + A_{BR.LOB} + A_{BR.ROB})} & \text{if } SBR_{Left} \le 5 \wedge SBR_{Right} \le 5 \\ \frac{(Q_{US.Main} + Q_{US.LOB})}{(A_{BR.Main} + A_{BR.LOB})} & \text{else if } SBR_{Left} \le 5 \wedge SBR_{Right} > 5 \\ \frac{(Q_{US.LOB})}{(A_{BR.LOB})} & \text{else if } SBR_{Left} > 5 \end{cases}$$

$V_{left} = 4.600 \ \frac{ft}{s}$

Bridge Main Channel Velocity: $V_{BR.Main} := \frac{Q_{BR.Main}}{A_{BR.Main}} = 4.840 \ \frac{ft}{s}$

Compare Characteristic Velocity computed above to Main Channel Velocity through Bridge:

$$V_{left} := \text{if } SBR_{Left} > 5 \ \Big\| \ \text{if } V_{left} > V_{BR.Main} \ \| \ V_{BR.Main} \quad \text{else} \ \| \ V_{left}$$

Left Abutment Characteristic Velocity: $V_{left} = 4.600 \ \frac{ft}{s}$

SIZE ABUTMENT RIPRAP (CONT.)
Left Abutment (Cont.)

3a. Determine the Froude Number

Froude Number:

$$F_{r.left} := \frac{V_{left}}{\left(g \cdot y_{BR.LOB}\right)^{0.5}} \qquad F_{r.left} = 0.527$$

4a. Determine Velocity Multiplier

Velocity Multiplier:

$$k_{left} := \begin{cases} 1.02 & \text{if } abut = \text{"Vertical"} \land F_{r.left} \le 0.8 \\ 0.89 & \text{else if } abut = \text{"Spill"} \land F_{r.left} \le 0.8 \\ 0.69 & \text{else if } abut = \text{"Vertical"} \land F_{r.left} > 0.8 \\ 0.61 & \text{else if } abut = \text{"Spill"} \land F_{r.left} > 0.8 \end{cases} \qquad k_{left} = 0.890$$

5a. Compute Required Riprap Size

$$Equation_{left} := \begin{cases} \text{"HEC 23 Eq. 14.1"} & \text{if } F_{r.left} \le 0.80 \\ \text{"HEC 23 Eq. 14.2"} & \text{else} \end{cases} \qquad Equation_{left} = \text{"HEC 23 Eq. 14.1"}$$

Required D50:

$$D_{50.left} := \begin{cases} y_{BR.LOB} \cdot \left(\frac{k_{left}}{\left(S_s - 1\right)} \cdot \frac{V_{left}^{\,2}}{g \cdot y_{BR.LOB}}\right) & \text{if } F_{r.left} \le 0.80 \\ \left(y_{BR.LOB} \cdot \left(\frac{k_{left}}{\left(S_s - 1\right)} \cdot \left(\frac{V_{left}^{\,2}}{g \cdot y_{BR.LOB}}\right)^{0.14}\right)\right) & \text{else} \end{cases} \qquad D_{50.left} = 4.391 \ in$$

SIZE ABUTMENT RIPRAP (CONT.)

Left Abutment (Cont.)

5a. Compute Required Riprap Size (Cont.)

Minimum Maine Riprap Class to specify:

$$Maine\_Riprap_{left} := \begin{cases} \text{if } D_{50.left} \le D_{50\_plain} & \text{"Plain Riprap, D50 = 9in"} \\ \text{else if } D_{50.left} \le D_{50\_heavy} & \text{"Heavy Riprap, D50 = 24in "} \\ \text{else} & \text{"Refer to HEC-23 Stone Classes and recommend SP "} \end{cases}$$

$$Maine\_Riprap_{left} = \text{"Plain Riprap, D50 = 9in"}$$

- Plain Riprap is to be called out on the plans. Therefore, determine the required thickness of the stone fill. Use **D50 = 9in, D100 = 12in.**

Proposed Median Diameter: $D_{50.left} := 9\ in$

Proposed Maximum Diameter: $D_{100.left} := 12\ in$

6a. Determine the Extent of the Riprap Apron

Minimum Thickness:

$$t_{min.left} := \begin{cases} \text{if } D_{50.left} \le D_{50\_plain} & 3\ ft \\ \text{else if } D_{50.left} \le D_{50\_heavy} & 4\ ft \end{cases}$$

MaineDOT Standard Detail Sheet 610(03)

$$t_{min.left} = 3.000\ ft$$

$$t_{left} := \textbf{if}\left(t_{min.left} \ge D_{100.left}, t_{min.left}, D_{100.left}\right)$$

$$t_{left} = 3.000\ ft$$

SIZE ABUTMENT RIPRAP (CONT.)
Left Abutment (Cont.)
6a. Determine the Extent of the Riprap Apron (Cont.)

- Per the guidelines in HEC 23, the apron shall extend from the toe 2 times the depth of flow or 25', whichever is less.

Length of Apron: $l_{apron} := min\left(2 \cdot y_{BR.LOB}, 25\ ft\right)$ Measured from Face of Abutment

$l_{apron} = 4.738\ ft$

$l_{apron.left} := 5\ ft$

Top Elevation of Riprap: $El_{riprap} := WSEL_{Q50} = 343.150\ ft$

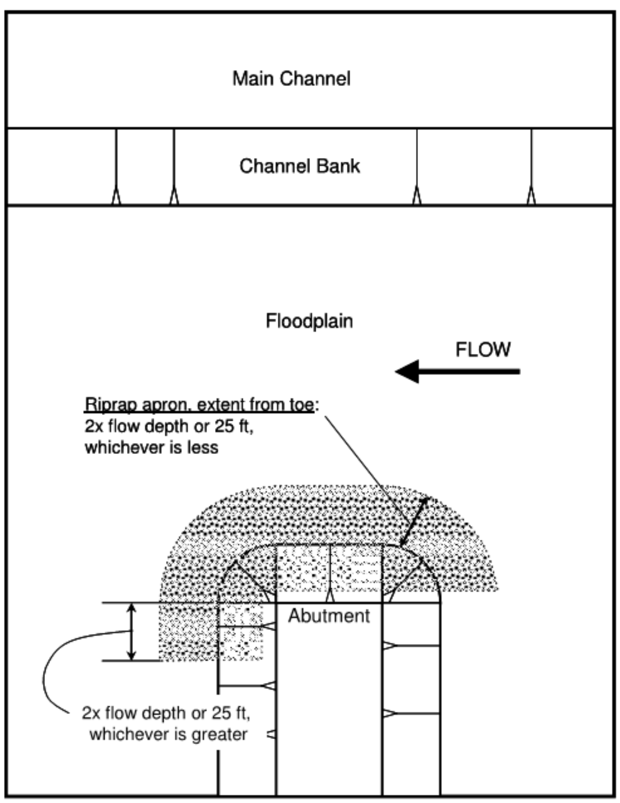


Figure 14.7. Plan view of the extent of rock riprap apron (Lagasse et al. 2006).

SIZE ABUTMENT RIPRAP (CONT.)
Right Abutment

2b. Determine Right Abutment Characteristic Velocity per HEC-23 DG 14, SBR Approach

$$V_{right} := \text{if } SBR_{Right} \le 5 \wedge SBR_{Left} \le 5 \;\; \frac{(Q_{US.Main} + Q_{US.LOB} + Q_{US.ROB})}{(A_{BR.Main} + A_{BR.LOB} + A_{BR.ROB})}$$
$$\text{else if } SBR_{Right} \le 5 \wedge SBR_{Left} > 5 \;\; \frac{(Q_{US.Main} + Q_{US.ROB})}{(A_{BR.Main} + A_{BR.ROB})}$$
$$\text{else if } SBR_{Right} > 5 \;\; \frac{(Q_{US.ROB})}{(A_{BR.ROB})}$$

$$V_{right} = 4.600 \ \frac{ft}{s}$$

Bridge Main Channel Velocity: $V_{BR.Main} = 4.840 \ \frac{ft}{s}$

Compare Characteristic Velocity computed above to Main Channel Velocity through Bridge:

$$V_{right} := \text{if } SBR_{Right} > 5 \;\; \left(\text{if } V_{right} > V_{BR.Main} \;\; V_{BR.Main} \right) \;\; \text{else} \;\; V_{right}$$

Right Abutment Characteristic Velocity: $V_{right} = 4.600 \ \frac{ft}{s}$

3b. Determine the Froude Number

Froude Number: $F_{r.right} := \frac{V_{right}}{(g \cdot y_{BR.ROB})^{0.5}}$ $\quad F_{r.right} = 0.518$

SIZE ABUTMENT RIPRAP (CONT.)
Right Abutment (Cont.)

4b. Determine Velocity Multiplier

Velocity Multiplier:

$$k_{right} := \begin{cases} \text{if } abut = \text{"Vertical"} \wedge F_{r.right} \le 0.8 \\ \quad 1.02 \\ \text{else if } abut = \text{"Spill"} \wedge F_{r.right} \le 0.8 \\ \quad 0.89 \\ \text{else if } abut = \text{"Vertical"} \wedge F_{r.right} > 0.8 \\ \quad 0.69 \\ \text{else if } abut = \text{"Spill"} \wedge F_{r.right} > 0.8 \\ \quad 0.61 \end{cases}$$

$$k_{right} = 0.890$$

5b. Compute Required Riprap Size

$$Equation_{right} := \begin{cases} \text{if } F_{r.right} \le 0.80 \\ \quad \text{"HEC 23 Eq. 14.1"} \\ \text{else} \\ \quad \text{"HEC 23 Eq. 14.2"} \end{cases}$$

$$Equation_{right} = \text{"HEC 23 Eq. 14.1"}$$

Required D50:

$$D_{50.right} := \begin{cases} \text{if } F_{r.right} \le 0.80 \\ \quad y_{BR.ROB} \cdot \left(\dfrac{k_{right}}{(S_s - 1)} \cdot \dfrac{V_{right}^{2}}{g \cdot y_{BR.ROB}} \right) \\ \text{else} \\ \quad \left(y_{BR.ROB} \cdot \left(\dfrac{k_{right}}{(S_s - 1)} \cdot \left(\dfrac{V_{right}^{2}}{g \cdot y_{BR.ROB}} \right)^{0.14} \right) \right) \end{cases}$$

$$D_{50.right} = 4.391 \; in$$

SIZE ABUTMENT RIPRAP (CONT.)
Right Abutment (Cont.)
5b. Compute Required Riprap Size (Cont.)

Minimum MaineDOT Stone Fill to specify:

$Maine\_Riprap_{right}$:= if $D_{50.right} \le D_{50\_plain}$
  "Plain Riprap, D50 = 9in"
else if $D_{50.right} \le D_{50\_heavy}$
  "Heavy Riprap, D50 = 24in "
else
  "Refer to HEC-23 Stone Classes and recommend SP "

$Maine\_Riprap_{right}$ = "Plain Riprap, D50 = 9in"

- Plain Riprap is to be called out on the plans. Therefore, determine the required thickness of the stone fill. **Use D50 = 9in, D100 = 12in**

Proposed Median Diameter: $D_{50.right} := 9\ in$

Proposed Maximum Diameter: $D_{100.right} := 12\ in$

6b. Determine the Extent of the Riprap Apron

Minimum Thickness:

$t_{min.right}$:= if $D_{50.right} \le D_{50\_plain}$
  $3\ ft$
else if $D_{50.right} \le D_{50\_heavy}$
  $4\ ft$

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$t_{min.right} = 3.000\ ft$

$t_{right} := \textbf{if}\left(t_{min.right} \ge D_{100.right}, t_{min.right}, D_{100.right}\right)$

$t_{right} = 3.000\ ft$

SIZE ABUTMENT RIPRAP (CONT.)

Right Abutment (Cont.)

6b. Determine the Extent of the Riprap Apron (Cont.)

- Per the guidelines in HEC 23, the apron shall extend from the toe 2 times the depth of flow or 25', whichever is less.

Length of Apron: $l_{apron} := min(2 \cdot y_{BR.ROB}, 25\ ft)$ Measured from Face of Abutment

$l_{apron} = 4.902\ ft$

$l_{apron.right} := 5\ ft$

Top Elevation of Riprap: $El_{riprap} = 343.150\ ft$

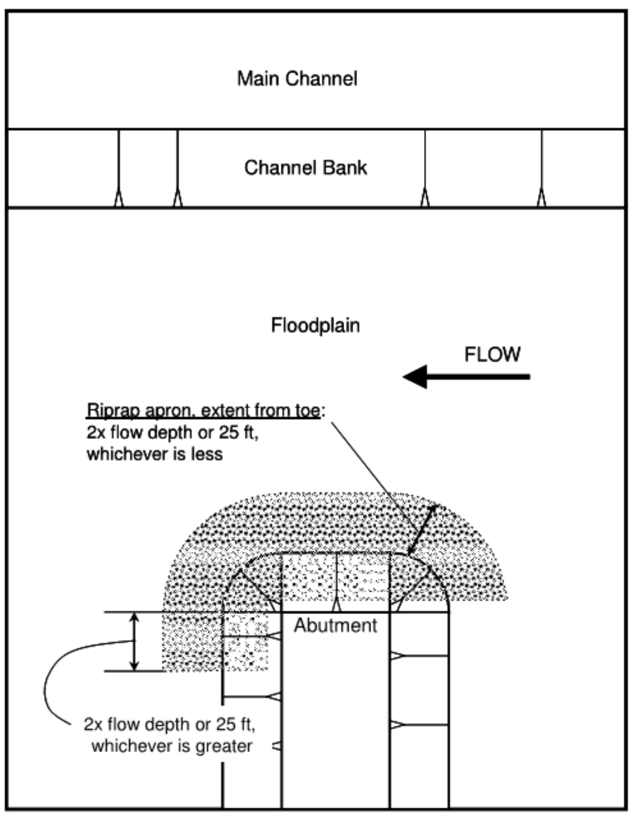

Figure 14.7. Plan view of the extent of rock riprap apron (Lagasse et al. 2006).

SUMMARY

Left Abutment

Median Stone Size: $D_{50.left} = 9.000\ in$ (Plain Riprap)

Riprap Mattress Thickness: $t_{left} = 3.000\ ft$

Apron Length: $l_{apron.left} = 5.000\ ft$ Measured from Face of Abutment

Top Elevation of Riprap: $El_{riprap} = 343.150\ ft$

Right Abutment

Median Stone Size: $D_{50.right} = 9.000\ in$ (Plain Riprap)

Riprap Mattress Thickness: $t_{right} = 3.000\ ft$

Apron Length: $l_{apron.right} = 5.000\ ft$ Measured from Face of Abutment

Top Elevation of Riprap: $El_{riprap} = 343.150\ ft$

NOTES AND ASSUMPTIONS

References:

1. FHWA HEC 23 Vol. 1, 3rd Edition, Publication No. FHWA-NHI-09-111
2. FHWA HEC 23 Vol. 2, 3rd Edition, Publication No. FHWA-NHI-09-112
3. FHWA HEC 18, 5th Edition, Publication No. FHWA-HIF-12-003
4. MaineDOT Standard Specifications, 2014

- Rock riprap revetment shall be designed to resist scour and protect the abutments per the set-back ratio (SBR) approach detailed in the "Design Guideline 14" in the FHWA Hydraulic Engineering Circular (HEC) 23.
- Proposed hydraulic data including flood velocity and elevations are taken from Proposed HEC-RAS Model. Copies of Tables and Cross-sections used are attached.
- Rock riprap sizes shall meet those as detailed in Section 703 of the MaineDOT Standard Specifications.
- The proposed bridge's hydraulic opening was designed for a 100 Year Flood Frequency. Per the MaineDOT Bridge Design Guide the 500 Year Flood is suggested as a check. The Riprap Revetment is to be designed for the 100 Year Flood Frequency and the 500 Year Flood Frequency is to be used as a check.

HEC-RAS TABLES

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)	
StreamCL	2385.65	Q500	3691.00	330.51	346.10		346.26	0.000355	3.53	1602.18	208.99	0.17
StreamCL	1604.26	Q500	3691.00	331.09	345.76		345.94	0.000471	3.88	1951.09	396.51	0.20
StreamCL	1283.94	Q500	3691.00	330.84	345.71		345.79	0.000319	3.02	2262.99	393.30	0.16
StreamCL	1112.94	Q500	3691.00	330.72	345.64		345.73	0.000346	3.29	2514.32	372.49	0.17
StreamCL	1034.95	Q500	3691.00	331.10	345.35	338.22	345.67	0.000660	4.55	825.17	353.36	0.24
StreamCL	982		Bridge									
StreamCL	904.43	Q500	3691.00	322.63	345.22	330.99	345.35	0.000143	2.96	1306.46	257.33	0.12
StreamCL	838.83	Q500	3691.00	331.46	344.58	338.91	345.15	0.001277	6.06	609.27	292.85	0.33
StreamCL	686.02	Q500	3691.00	328.62	344.78		344.88	0.000266	2.87	2114.30	296.21	0.15
StreamCL	419.2	Q500	3691.00	331.59	344.47	339.59	344.75	0.000825	4.97	1385.57	217.24	0.27
StreamCL	216.64	Q500	3691.00	331.38	344.25	338.96	344.57	0.000896	5.01	1198.90	193.58	0.28
StreamCL	31.36	Q500	3691.00	331.88	344.21		344.35	0.000611	3.87	1596.13	255.25	0.22
StreamCL	-121.5	Q500	3691.00	331.36	344.04		344.24	0.000596	4.08	1400.58	216.81	0.22
StreamCL	-459.58	Q500	3691.00	331.35	343.37		343.84	0.001613	6.38	1147.11	247.75	0.35
StreamCL	-980.34	Q500	3691.00	331.03	343.08		343.22	0.000693	3.97	1729.35	330.13	0.23
StreamCL	-1650.77	Q500	3691.00	330.91	342.82	334.86	342.94	0.000271	2.91	1701.49	272.59	0.15
StreamCL	-1948.51	Q500	3691.00	331.11	342.75	339.11	342.82	0.000431	3.13	2518.20	555.64	0.18

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
StreamCL	1112.94	Q500	345.73	345.64		0.04	0.02	372.49	888.12	1877.57	925.31	3.29
StreamCL	1034.95	Q500	345.67	345.35	338.22	0.02	0.05	353.36	21.29	3669.71		4.55
StreamCL	982 BR U	Q500	345.60	345.09	339.13	0.03	0.00	60.78	80.99	3535.59	74.42	5.79
StreamCL	982 BR D	Q500	345.56	345.05	339.14	0.02	0.19	63.35	84.55	3543.34	63.11	5.82
StreamCL	904.43	Q500	345.35	345.22	330.99	0.07	0.13	257.33	90.05	3600.95		2.96
StreamCL	838.83	Q500	345.15	344.58	338.91	0.08	0.19	292.85		3691.00		6.06

HEC-RAS TABLES (CONT.)

Cross Section Output

File Type Options Help

River: StreamCL Profile: Q500
Reach: StreamCL RS: 1283.94 Plan: Prop

Plan: Prop StreamCL StreamCL RS: 1283.94 Profile: Q500

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	345.79	Wt. n-Val.	0.070	0.040	0.070
Vel Head (ft)	0.08	Reach Len. (ft)	171.00	171.00	171.00
W.S. Elev (ft)	345.71	Flow Area (sq ft)	839.15	582.01	841.84
Crit W.S. (ft)		Area (sq ft)	839.15	582.01	841.84
E.G. Slope (ft/ft)	0.000319	Flow (cfs)	1168.96	1755.97	766.06
Q Total (cfs)	3691.00	Top Width (ft)	116.49	53.41	223.40
Top Width (ft)	393.30	Avg. Vel. (ft/s)	1.39	3.02	0.91
Vel Total (ft/s)	1.63	Hydr. Depth (ft)	7.20	10.90	3.77
Max Chl Dpth (ft)	14.87	Conv. (cfs)	65450.5	98317.4	42892.1
Conv. Total (cfs)	206659.9	Wetted Per. (ft)	119.14	60.02	226.39
Length Wtd. (ft)	171.00	Shear (lb/sq ft)	0.14	0.19	0.07
Min Ch El (ft)	330.84	Stream Power (lb/ft s)	0.20	0.58	0.07
Alpha	1.92	Cum Volume (acre-ft)	43.16	54.51	35.31
Frctn Loss (ft)	0.06	Cum SA (acres)	9.88	5.00	7.17
C & E Loss (ft)	0.00				

Cross Section Output

File Type Options Help

River: StreamCL Profile: Q500
Reach: StreamCL RS: 982 BR U Plan: Prop

Plan: Prop StreamCL StreamCL RS: 982 BR U Profile: Q500

		Element	Left OB	Channel	Right OB
E.G. Elev (ft)	345.60	Wt. n-Val.	0.040	0.040	0.040
Vel Head (ft)	0.50	Reach Len. (ft)	27.33	27.33	27.33
W.S. Elev (ft)	345.09	Flow Area (sq ft)	34.28	610.58	40.02
Crit W.S. (ft)	339.13	Area (sq ft)	34.28	610.58	40.12
E.G. Slope (ft/ft)	0.001189	Flow (cfs)	80.99	3535.59	74.42
Q Total (cfs)	3691.00	Top Width (ft)	11.26	49.51	
Top Width (ft)	60.78	Avg. Vel. (ft/s)	2.36	5.79	1.86
Vel Total (ft/s)	5.39	Hydr. Depth (ft)	3.04	12.33	
Max Chl Dpth (ft)	14.09	Conv. (cfs)	2349.0	102551.8	2158.7
Conv. Total (cfs)	107059.5	Wetted Per. (ft)	13.69	63.51	22.87
Length Wtd. (ft)	27.33	Shear (lb/sq ft)	0.19	0.71	0.13
Min Ch El (ft)	331.00	Stream Power (lb/ft s)	0.44	4.13	0.24
Alpha	1.11	Cum Volume (acre-ft)	38.57	48.46	30.38
Frctn Loss (ft)	0.03	Cum SA (acres)	9.23	4.45	6.09
C & E Loss (ft)	0.00				

MATERIAL, GEOMETRY DATA AND CONSTANTS

Specific Gravity of Riprap: $S_s := 2.60$

Gravitational Acceleration: $g = 32.174 \frac{ft}{s^2}$

Vertical Wall or Spill-through Abutment? $abut := \text{"Spill"}$

- Enter "Vertical" if Vertical Wall or "Spill" if Spill-through

MaineDOT Riprap Sizes

	Median size	Maximum size	
Plain Riprap:	$D_{50\_plain} := 9\ in$	$D_{100\_plain} := 12\ in$	Ref. 4, Section 703.26
Heavy Riprap:	$D_{50\_heavy} := 24\ in$	$D_{100\_heavy} := 48\ in$	Ref. 4, Section 703.28
Stone Blanket:	$D_{50\_blanket} := 24\ in$	$D_{100\_blanket} := 66\ in$	Ref. 4, Section 703.27

Left Abutment Geometry

Station of Overbank or Proposed Toe: $STA_{BR.LOB} := 257.65\ ft$ Refer to HEC-RAS

Station of tip of Abutment: $STA_{abut.left} := 246.37\ ft$ Refer to HEC-RAS

Abutment Set Back Distance: $L_{SBR.L} := \left|STA_{BR.LOB} - STA_{abut.left}\right| = 11.280\ ft$

Right Abutment Geometry

Station of Overbank or Proposed Toe: $STA_{BR.ROB} := 312.33\ ft$ Refer to HEC-RAS

Station of tip of Abutment: $STA_{abut.right} := 232.37\ ft$ Refer to HEC-RAS

Abutment Set Back Distance: $L_{SBR.R} := \left|STA_{BR.ROB} - STA_{abut.right}\right| = 79.960\ ft$

HYDRAULIC DATA
Upstream Cross-Section (12+83)

Upstream Water Surface Elevation (*Use Max. El. Immediately Upstream/ Downstream of Bridge, Sta. 9+82): $WSEL_{Q50} := 343.15\ ft$ HEC-RAS

Upstream Left Overbank Discharge: $Q_{US.LOB} := 1168.96\ \frac{ft^3}{s}$ HEC-RAS

Upstream Main Channel Discharge: $Q_{US.Main} := 1755.97\ \frac{ft^3}{s}$ HEC-RAS

Upstream Right Overbank Discharge: $Q_{US.ROB} := 766.06\ \frac{ft^3}{s}$ HEC-RAS

Upstream Left Overbank Flow Area: $A_{US.LOB} := 839.15\ ft^2$ HEC-RAS

Upstream Main Channel Flow Area: $A_{US.Main} := 582.01\ ft^2$ HEC-RAS

Upstream Right Overbank Flow Area: $A_{US.ROB} := 841.84\ ft^2$ HEC-RAS

Top Width of Left Overbank: $TW_{US.LOB} := 116.49\ ft$ HEC-RAS

Top Width of Main Channel: $TW_{US.Main} := 53.41\ ft$ HEC-RAS

Top Width of Right Overbank: $TW_{US.ROB} := 223.40\ ft$ HEC-RAS

Average Flow Depth of Entire Channel: $y_{US} := \frac{\left(A_{US.LOB} + A_{US.Main} + A_{US.ROB}\right)}{\left(TW_{US.LOB} + TW_{US.Main} + TW_{US.ROB}\right)} = 5.754\ ft$

Average Main Channel Flow Depth: $y_{US.Main} := \frac{A_{US.Main}}{TW_{US.Main}} = 10.897\ ft$

Average Left Overbank Flow Depth: $y_{US.LOB} := \frac{A_{US.LOB}}{TW_{US.LOB}} = 7.204\ ft$

Average Right Overbank Flow Depth: $y_{US.ROB} := \frac{A_{US.ROB}}{TW_{US.ROB}} = 3.768\ ft$

HYDRAULIC DATA (CONT.)
Bridge Cross-Section (US, 9+82)

Bridge Left Overbank Discharge:	$Q_{BR.LOB} := 80.99 \frac{ft^3}{s}$	HEC-RAS
Bridge Main Channel Discharge:	$Q_{BR.Main} := 3535.59 \frac{ft^3}{s}$	HEC-RAS
Bridge Right Overbank Discharge:	$Q_{BR.ROB} := 74.42 \frac{ft^3}{s}$	HEC-RAS
Bridge Left Overbank Flow Area:	$A_{BR.LOB} := 34.28\ ft^2$	HEC-RAS
Bridge Main Channel Flow Area:	$A_{BR.Main} := 610.58\ ft^2$	HEC-RAS
Bridge Right Overbank Flow Area:	$A_{BR.ROB} := 40.12\ ft^2$	HEC-RAS
Top Width of Main Channel:	$TW_{BR.Main} := 49.51\ ft$	
Top Width of Left Overbank:	$TW_{BR.LOB} := 11.26\ ft$	
Top Width of Right Overbank:	$TW_{BR.ROB} := 11.04\ ft$	

Average Flow Depth of Entire Channel:

$$y_{BR} := \frac{\left(A_{BR.LOB} + A_{BR.Main} + A_{BR.ROB}\right)}{\left(TW_{BR.LOB} + TW_{BR.Main} + TW_{BR.ROB}\right)} = 9.539\ ft$$

Average Main Channel Flow Depth:

$$y_{BR.Main} := \frac{A_{BR.Main}}{TW_{BR.Main}} = 12.332\ ft$$

Average Left Overbank Flow Depth:

$$y_{BR.LOB} := \frac{A_{BR.LOB}}{TW_{BR.LOB}} = 3.044\ ft$$

Average Right Overbank Flow Depth:

$$y_{BR.ROB} := \frac{A_{BR.ROB}}{TW_{BR.ROB}} = 3.634\ ft$$

SIZE ABUTMENT RIPRAP

1. Determine Set-back Ratios

Left Abutment Set-back Ratio: $SBR_{Left} := \frac{L_{SBR.L}}{y_{BR.Main}} = 0.915$

Right Abutment Set-back Ratio: $SBR_{Right} := \frac{L_{SBR.R}}{y_{BR.Main}} = 6.484$

Left Abutment

2a. Determine Left Abutment Characteristic Velocity per HEC-23 DG 14, SBR Approach

$$V_{left} := \text{if } SBR_{Left} \le 5 \wedge SBR_{Right} \le 5 \;\; \frac{(Q_{US.Main} + Q_{US.LOB} + Q_{US.ROB})}{(A_{BR.Main} + A_{BR.LOB} + A_{BR.ROB})}$$
$$\text{else if } SBR_{Left} \le 5 \wedge SBR_{Right} > 5 \;\; \frac{(Q_{US.Main} + Q_{US.LOB})}{(A_{BR.Main} + A_{BR.LOB})}$$
$$\text{else if } SBR_{Left} > 5 \;\; \frac{(Q_{US.LOB})}{(A_{BR.LOB})}$$

$V_{left} = 4.536 \, \frac{ft}{s}$

Bridge Main Channel Velocity: $V_{BR.Main} := \frac{Q_{BR.Main}}{A_{BR.Main}} = 5.791 \, \frac{ft}{s}$

Compare Characteristic Velocity computed above to Main Channel Velocity through Bridge:

$$V_{left} := \text{if } SBR_{Left} > 5 \;\; \left(\text{if } V_{left} > V_{BR.Main} \;\; V_{BR.Main} \right) \;\; \text{else } V_{left}$$

Left Abutment Characteristic Velocity: $V_{left} = 4.536 \, \frac{ft}{s}$

SIZE ABUTMENT RIPRAP (CONT.)
Left Abutment (Cont.)

3a. Determine the Froude Number

Froude Number:

$$F_{r.left} := \frac{V_{left}}{\left(g \cdot y_{BR.LOB}\right)^{0.5}}$$

$$F_{r.left} = 0.458$$

4a. Determine Velocity Multiplier

Velocity Multiplier:

$$k_{left} := \begin{cases} 1.02 & \text{if } abut = \text{"Vertical"} \wedge F_{r.left} \le 0.8 \\ 0.89 & \text{else if } abut = \text{"Spill"} \wedge F_{r.left} \le 0.8 \\ 0.69 & \text{else if } abut = \text{"Vertical"} \wedge F_{r.left} > 0.8 \\ 0.61 & \text{else if } abut = \text{"Spill"} \wedge F_{r.left} > 0.8 \end{cases}$$

$$k_{left} = 0.890$$

5a. Compute Required Riprap Size

$$Equation_{left} := \begin{cases} \text{"HEC 23 Eq. 14.1"} & \text{if } F_{r.left} \le 0.80 \\ \text{"HEC 23 Eq. 14.2"} & \text{else} \end{cases}$$

$$Equation_{left} = \text{"HEC 23 Eq. 14.1"}$$

Required D50:

$$D_{50.left} := \begin{cases} y_{BR.LOB} \cdot \left(\frac{k_{left}}{(S_s - 1)} \cdot \frac{V_{left}^2}{g \cdot y_{BR.LOB}}\right) & \text{if } F_{r.left} \le 0.80 \\ \left(y_{BR.LOB} \cdot \left(\frac{k_{left}}{(S_s - 1)} \cdot \left(\frac{V_{left}^2}{g \cdot y_{BR.LOB}}\right)^{0.14}\right)\right) & \text{else} \end{cases}$$

$$D_{50.left} = 4.268 \ in$$

SIZE ABUTMENT RIPRAP (CONT.)

Left Abutment (Cont.)

5a. Compute Required Riprap Size (Cont.)

Minimum Maine Riprap Class to specify:

$$Maine\_Riprap_{left} := \text{if } D_{50.left} \le D_{50\_plain}$$
$$\quad \text{“Plain Riprap, D50 = 9in”}$$
$$\text{else if } D_{50.left} \le D_{50\_heavy}$$
$$\quad \text{“Heavy Riprap, D50 = 24in ”}$$
$$\text{else}$$
$$\quad \text{“Refer to HEC-23 Stone Classes and recommend SP ”}$$

$$Maine\_Riprap_{left} = \text{“Plain Riprap, D50 = 9in”}$$

- Plain Riprap is to be called out on the plans. Therefore, determine the required thickness of the stone fill. Use **D50 = 9in, D100 = 12in.**

Proposed Median Diameter: $D_{50.left} := 9\ in$

Proposed Maximum Diameter: $D_{100.left} := 12\ in$

6a. Determine the Extent of the Riprap Apron

Minimum Thickness:

$$t_{min.left} := \text{if } D_{50.left} \le D_{50\_plain}$$
$$\quad 3\ ft$$
$$\text{else if } D_{50.left} \le D_{50\_heavy}$$
$$\quad 4\ ft$$

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$$t_{min.left} = 3.000\ ft$$

$$t_{left} := \textbf{if}\left(t_{min.left} \ge D_{100.left}, t_{min.left}, D_{100.left}\right)$$

$$t_{left} = 3.000\ ft$$

SIZE ABUTMENT RIPRAP (CONT.)

Left Abutment (Cont.)

6a. Determine the Extent of the Riprap Apron (Cont.)

- Per the guidelines in HEC 23, the apron shall extend from the toe 2 times the depth of flow or 25', whichever is less.

Length of Apron: $l_{apron} := min\left(2 \cdot y_{BR.LOB}, 25\ ft\right)$ Measured from Face of Abutment

$l_{apron} = 6.089\ ft$

$l_{apron.left} := 6\ ft$

Top Elevation of Riprap: $El_{riprap} := WSEL_{Q50} = 343.150\ ft$

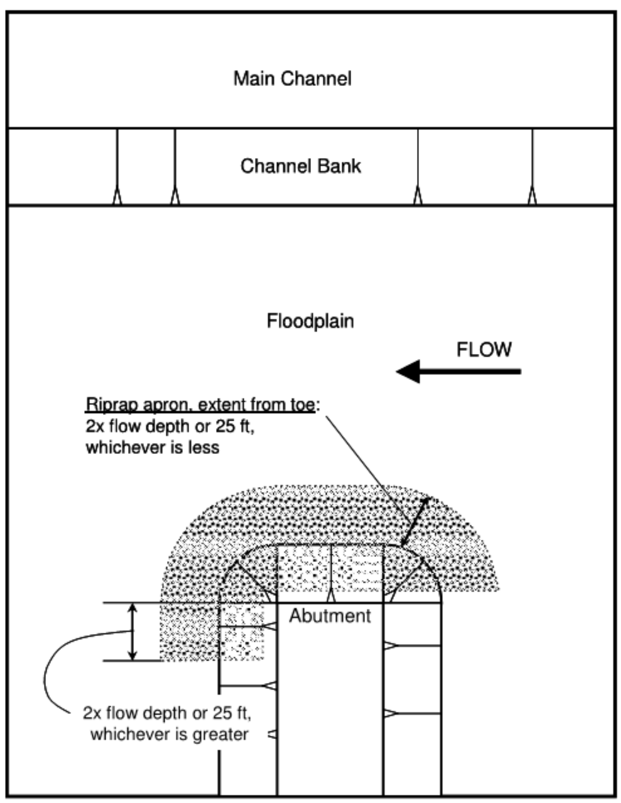


Figure 14.7. Plan view of the extent of rock riprap apron (Lagasse et al. 2006).

SIZE ABUTMENT RIPRAP (CONT.)
Right Abutment

2b. Determine Right Abutment Characteristic Velocity per HEC-23 DG 14, SBR Approach

$$V_{right} := \begin{cases} \dfrac{(Q_{US.Main}+Q_{US.LOB}+Q_{US.ROB})}{(A_{BR.Main}+A_{BR.LOB}+A_{BR.ROB})} & \text{if } SBR_{Right} \le 5 \wedge SBR_{Left} \le 5 \\ \dfrac{(Q_{US.Main}+Q_{US.ROB})}{(A_{BR.Main}+A_{BR.ROB})} & \text{else if } SBR_{Right} \le 5 \wedge SBR_{Left} > 5 \\ \dfrac{(Q_{US.ROB})}{(A_{BR.ROB})} & \text{else if } SBR_{Right} > 5 \end{cases}$$

$$V_{right} = 19.094\ \frac{ft}{s}$$

Bridge Main Channel Velocity: $V_{BR.Main} = 5.791\ \frac{ft}{s}$

Compare Characteristic Velocity computed above to Main Channel Velocity through Bridge:

$$V_{right} := \begin{cases} \begin{cases} V_{BR.Main} & \text{if } V_{right} > V_{BR.Main} \end{cases} & \text{if } SBR_{Right} > 5 \\ V_{right} & \text{else} \end{cases}$$

Right Abutment Characteristic Velocity: $V_{right} = 5.791\ \frac{ft}{s}$

3b. Determine the Froude Number

Froude Number: $F_{r.right} := \dfrac{V_{right}}{(g \cdot y_{BR.ROB})^{0.5}}$ $F_{r.right} = 0.536$

SIZE ABUTMENT RIPRAP (CONT.)
Right Abutment (Cont.)

4b. Determine Velocity Multiplier

Velocity Multiplier:

$$k_{right} := \begin{cases} 1.02 & \text{if } abut = \text{"Vertical"} \wedge F_{r.right} \le 0.8 \\ 0.89 & \text{else if } abut = \text{"Spill"} \wedge F_{r.right} \le 0.8 \\ 0.69 & \text{else if } abut = \text{"Vertical"} \wedge F_{r.right} > 0.8 \\ 0.61 & \text{else if } abut = \text{"Spill"} \wedge F_{r.right} > 0.8 \end{cases}$$

$$k_{right} = 0.890$$

5b. Compute Required Riprap Size

$$Equation_{right} := \begin{cases} \text{"HEC 23 Eq. 14.1"} & \text{if } F_{r.right} \le 0.80 \\ \text{"HEC 23 Eq. 14.2"} & \text{else} \end{cases}$$

$$Equation_{right} = \text{"HEC 23 Eq. 14.1"}$$

Required D50:

$$D_{50.right} := \begin{cases} y_{BR.ROB} \cdot \left(\frac{k_{right}}{(S_s - 1)} \cdot \frac{V_{right}^{2}}{g \cdot y_{BR.ROB}} \right) & \text{if } F_{r.right} \le 0.80 \\ \left(y_{BR.ROB} \cdot \left(\frac{k_{right}}{(S_s - 1)} \cdot \left(\frac{V_{right}^{2}}{g \cdot y_{BR.ROB}} \right)^{0.14} \right) \right) & \text{else} \end{cases}$$

$$D_{50.right} = 6.956\ in$$

SIZE ABUTMENT RIPRAP (CONT.)
Right Abutment (Cont.)
5b. Compute Required Riprap Size (Cont.)

Minimum MaineDOT Stone Fill to specify:

$$Maine\_Riprap_{right} := \begin{cases} \text{if } D_{50.right} \le D_{50\_plain} & \text{“Plain Riprap, D50 = 9in”} \\ \text{else if } D_{50.right} \le D_{50\_heavy} & \text{“Heavy Riprap, D50 = 24in ”} \\ \text{else} & \text{“Refer to HEC-23 Stone Classes and recommend SP ”} \end{cases}$$

$$Maine\_Riprap_{right} = \text{“Plain Riprap, D50 = 9in”}$$

- Plain Riprap is to be called out on the plans. Therefore, determine the required thickness of the stone fill. **Use D50 = 9in, D100 = 12in**

Proposed Median Diameter: $D_{50.right} := 9\ in$

Proposed Maximum Diameter: $D_{100.right} := 12\ in$

6b. Determine the Extent of the Riprap Apron

Minimum Thickness:

$$t_{min.right} := \begin{cases} \text{if } D_{50.right} \le D_{50\_plain} & 3\ ft \\ \text{else if } D_{50.right} \le D_{50\_heavy} & 4\ ft \end{cases}$$

MaineDOT Standard Detail Sheet 610(03)

$$t_{min.right} = 3.000\ ft$$

$$t_{right} := \textbf{if}\left(t_{min.right} \ge D_{100.right}, t_{min.right}, D_{100.right}\right)$$

$$t_{right} = 3.000\ ft$$

SIZE ABUTMENT RIPRAP (CONT.)
Right Abutment (Cont.)
6b. Determine the Extent of the Riprap Apron (Cont.)

- Per the guidelines in HEC 23, the apron shall extend from the toe 2 times the depth of flow or 25', whichever is less.

Length of Apron: $l_{apron} := min\left(2 \cdot y_{BR.ROB}, 25\ ft\right)$ Measured from Face of Abutment

$l_{apron} = 7.268\ ft$

$l_{apron.right} := 8\ ft$

Top Elevation of Riprap: $El_{riprap} = 343.150\ ft$

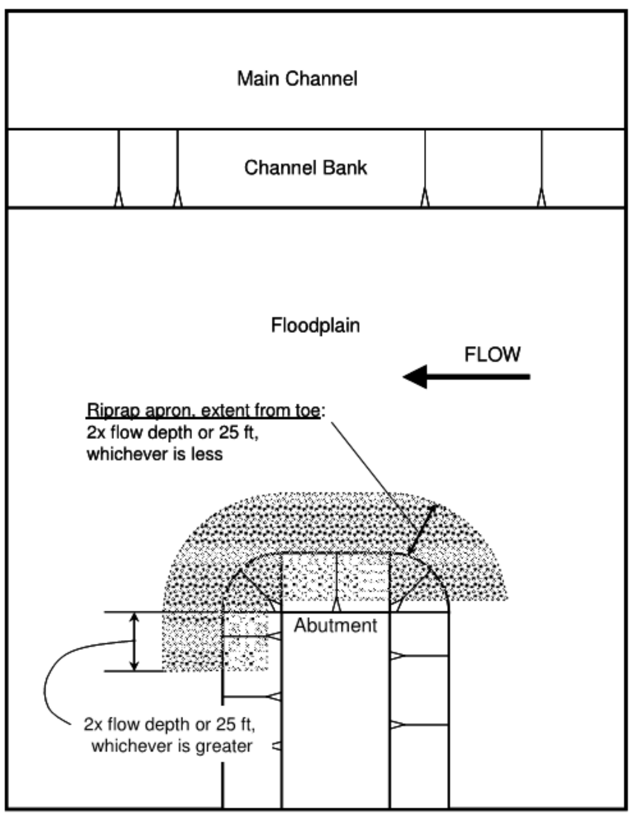


Figure 14.7. Plan view of the extent of rock riprap apron (Lagasse et al. 2006).

SUMMARY

Left Abutment

Median Stone Size: $D_{50.left} = 9.000\ in$ (Plain Riprap)

Riprap Mattress Thickness: $t_{left} = 3.000\ ft$

Apron Length: $l_{apron.left} = 6.000\ ft$ Measured from Face of Abutment

Top Elevation of Riprap: $El_{riprap} = 343.150\ ft$

Right Abutment

Median Stone Size: $D_{50.right} = 9.000\ in$ (Plain Riprap)

Riprap Mattress Thickness: $t_{right} = 3.000\ ft$

Apron Length: $l_{apron.right} = 8.000\ ft$ Measured from Face of Abutment

Top Elevation of Riprap: $El_{riprap} = 343.150\ ft$

HYDRAULIC ANALYSIS FOR NEXT BEAMS

Hoyle, Tanner & Associates, Inc.

PROJECT NO.	923403.04 Sheet 1 of 1
DESCRIPTION	WIN 021688.00: Dutch Gap Br. over Little Norridgewock Stream
TASK	Freeboard Comparison
CALCULATED BY	KMH **DATE** 5/2/18
CHECKED BY	AML **DATE** 5/11/18
REVIEWED BY	SMH **DATE** 5/14/18

150 Dow Street
Manchester, NH 03101
K:\923403_04\4-Design\Bridge\Hydraulics\2 - Hydraulics\Freeboard Table.docx

Freeboard Comparison – Steel Girder vs. NEXT Beam

The purpose of this calculation is to revise the steel girder freeboard clearances for the above-referenced project, as presented in the 2/22/18 PDR, and to determine the freeboard of precast concrete NEXT beams.

		Elevations				
Flow Event	**Flow**[1] cfs	**Water Surface**[2] ft	**Steel Girder Low Chord**[3] ft	**NEXT Beam Low Chord**[4] ft	**Steel Girder Freeboard**[5] ft	**NEXT Beam Freeboard**[6] ft
Q25	1925	342.56	344.23	343.97	1.7	1.4
Q50	2293	343.15	344.23	343.97	1.1	0.8
Q100	2684	343.74	344.23	343.97	0.5	0.2

[1] Flows based on the revised flow set determined using the "just overtopping" flow of the existing conditions model.
- Bottom of stream bed elevation at 332' (based on inverts of existing culverts).
- Minor adjustments to the streambed elevation (upstream and/or downstream) do not have a significant impact to the water surface elevations.

[2] Water surface elevations from the PDR dated 2/22/18. Water surface elevations presented in the table above are subject to slight changes using the final channel geometry of the selected alternative. The channel section geometry (i.e. wildlife shelf widths and elevations, Q1.1 flow width, stream bottom elevation, etc.) will be modified from that presented in the PDR based on input from ENV team members during design. Design water surface values are expected to vary no more than about ± 0.05 feet from that shown after these refinements are completed.

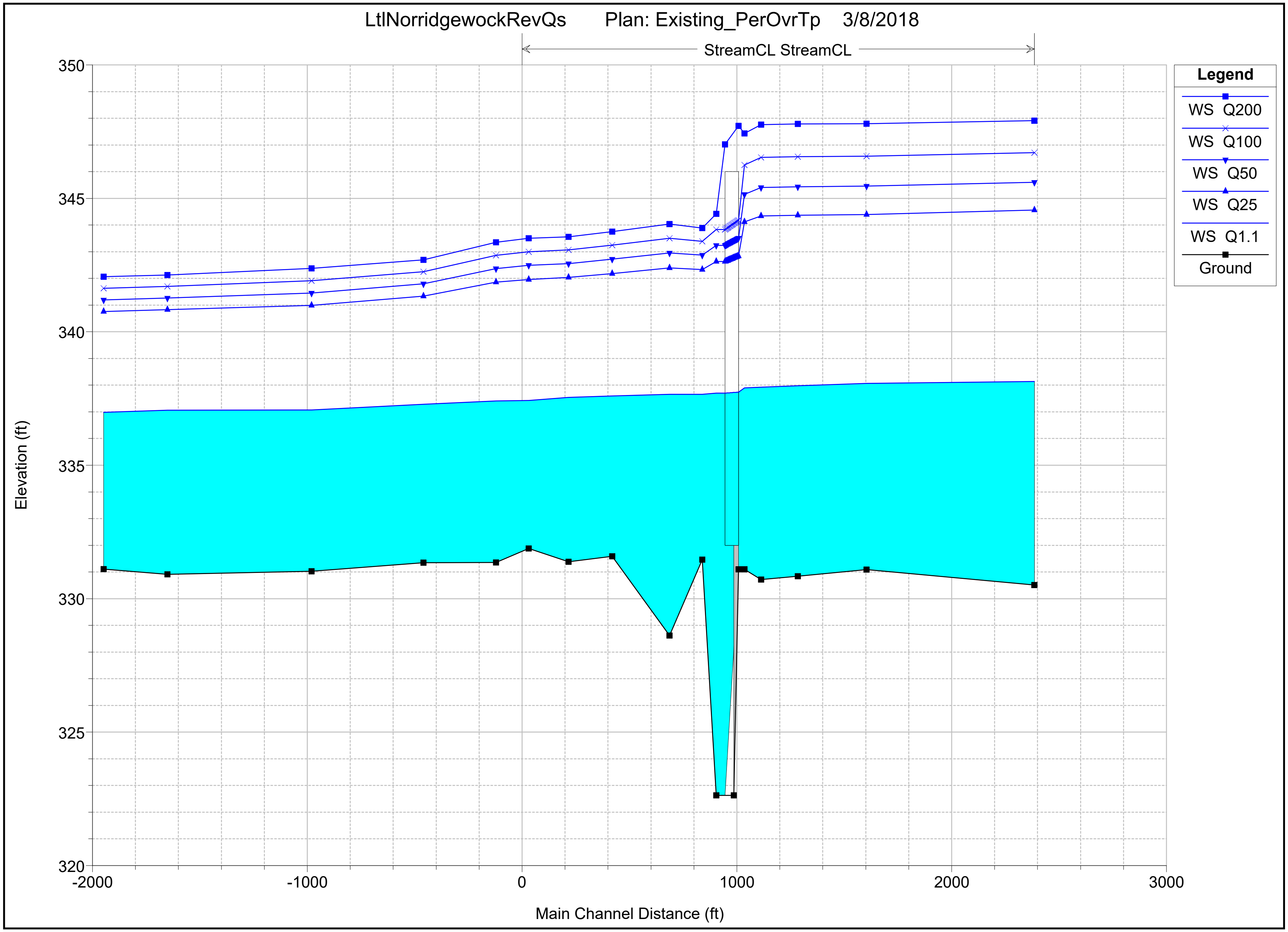
[3] Steel girder low chord elevation at Sta. 14+35.75 (based on 80' span) (alternative presented in PDR). Low chord elevation for the steel alternative presented in the 2/22/18 PDR is updated herein. Elevation 344.81' was presented in PDR dated 2/22/18.

[4] NEXT Beam low chord elevation at Sta. 14+40.75 (based on 75' span) assuming 2" residual camber and blocking.

[5] Corrected freeboard clearance; PDR to be updated with these revised values.

[6] Freeboard for the NEXT Beams is approximately 0.3' less than that of the steel girder alternative.

EXISTING CONDITIONS
Water Surface Profile



EXISTING CONDITIONS
Standard Table 1

HEC-RAS Plan: Ex_OvrTp River: StreamCL Reach: StreamCL

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)	
StreamCL	2385.65	Q1.1	324.00	330.51	338.14		338.15	0.000058	0.90	358.25	53.08	0.06
StreamCL	2385.65	Q25	1925.00	330.51	344.56		344.62	0.000159	2.17	1293.55	188.39	0.11
StreamCL	2385.65	Q50	2293.00	330.51	345.61		345.68	0.000160	2.31	1500.04	205.36	0.11
StreamCL	2385.65	Q100	2684.00	330.51	346.71		346.79	0.000157	2.41	1732.70	220.24	0.11
StreamCL	2385.65	Q200	3100.00	330.51	347.91		347.99	0.000154	2.53	2022.68	253.89	0.12
StreamCL	1604.26	Q1.1	324.00	331.09	338.06		338.09	0.000130	1.19	271.46	50.64	0.09
StreamCL	1604.26	Q25	1925.00	331.09	344.39		344.47	0.000233	2.52	1429.62	363.05	0.14
StreamCL	1604.26	Q50	2293.00	331.09	345.46		345.53	0.000207	2.53	1830.36	389.03	0.13
StreamCL	1604.26	Q100	2684.00	331.09	346.58		346.65	0.000180	2.50	2283.71	416.42	0.12
StreamCL	1604.26	Q200	3100.00	331.09	347.80		347.86	0.000153	2.45	2808.64	446.04	0.11
StreamCL	1283.94	Q1.1	324.00	330.84	337.98		338.02	0.000316	1.73	195.36	90.68	0.14
StreamCL	1283.94	Q25	1925.00	330.84	344.36		344.40	0.000155	1.93	1776.26	330.71	0.11
StreamCL	1283.94	Q50	2293.00	330.84	345.43		345.47	0.000138	1.95	2156.31	380.47	0.11
StreamCL	1283.94	Q100	2684.00	330.84	346.56		346.60	0.000117	1.92	2610.68	413.64	0.10
StreamCL	1283.94	Q200	3100.00	330.84	347.79		347.81	0.000096	1.86	3125.21	428.37	0.09
StreamCL	1112.94	Q1.1	324.00	330.72	337.92		337.96	0.000398	1.64	285.59	176.43	0.15
StreamCL	1112.94	Q25	1925.00	330.72	344.34		344.37	0.000155	2.03	2053.27	334.56	0.11
StreamCL	1112.94	Q50	2293.00	330.72	345.40		345.44	0.000147	2.11	2427.29	369.98	0.11
StreamCL	1112.94	Q100	2684.00	330.72	346.54		346.57	0.000131	2.12	2853.00	381.99	0.11
StreamCL	1112.94	Q200	3100.00	330.72	347.76		347.80	0.000115	2.12	3327.62	393.90	0.10
StreamCL	1034.95	Q1.1	324.00	331.10	337.90	333.80	337.94	0.000240	1.55	209.18	225.72	0.12
StreamCL	1034.95	Q25	1925.00	331.10	344.12	337.01	344.33	0.000504	3.71	518.43	348.94	0.21
StreamCL	1034.95	Q50	2293.00	331.10	345.15	337.52	345.40	0.000518	4.02	571.02	352.18	0.21
StreamCL	1034.95	Q100	2684.00	331.10	346.25	338.00	346.53	0.000520	4.28	626.85	372.36	0.22
StreamCL	1034.95	Q200	3100.00	331.10	347.43	338.53	347.75	0.000510	4.51	687.50	377.60	0.22
StreamCL	982		Culvert									
StreamCL	904.43	Q1.1	324.00	322.63	337.70	325.27	337.70	0.000007	0.43	771.18	210.42	0.02
StreamCL	904.43	Q25	1925.00	322.63	342.63	328.75	342.67	0.000061	1.71	1166.10	241.38	0.08
StreamCL	904.43	Q50	2293.00	322.63	343.24	329.27	343.30	0.000076	1.95	1215.01	245.22	0.09
StreamCL	904.43	Q100	2684.00	322.63	343.84	329.79	343.91	0.000091	2.20	1262.75	248.83	0.10
StreamCL	904.43	Q200	3100.00	322.63	344.42	330.32	344.51	0.000108	2.45	1309.72	252.25	0.11
StreamCL	838.83	Q1.1	324.00	331.46	337.66	334.12	337.69	0.000252	1.48	218.39	51.50	0.13
StreamCL	838.83	Q25	1925.00	331.46	342.33	336.87	342.58	0.000769	4.01	479.96	282.73	0.24
StreamCL	838.83	Q50	2293.00	331.46	342.87	337.35	343.18	0.000886	4.49	510.99	285.58	0.27
StreamCL	838.83	Q100	2684.00	331.46	343.39	337.82	343.77	0.001005	4.96	540.79	287.79	0.29
StreamCL	838.83	Q200	3100.00	331.46	343.89	338.28	344.35	0.001128	5.44	569.59	289.92	0.31
StreamCL	686.02	Q1.1	324.00	328.62	337.66		337.67	0.000049	0.82	418.00	111.19	0.06
StreamCL	686.02	Q25	1925.00	328.62	342.39		342.45	0.000197	2.10	1414.53	289.35	0.13
StreamCL	686.02	Q50	2293.00	328.62	342.96		343.03	0.000215	2.29	1578.63	290.97	0.13
StreamCL	686.02	Q100	2684.00	328.62	343.51		343.58	0.000233	2.47	1738.52	292.55	0.14
StreamCL	686.02	Q200	3100.00	328.62	344.04		344.13	0.000249	2.65	1895.45	294.08	0.15
StreamCL	419.2	Q1.1	324.00	331.59	337.59	333.56	337.64	0.000365	1.68	202.64	69.40	0.15
StreamCL	419.2	Q25	1925.00	331.59	342.18	337.31	342.35	0.000637	3.72	894.43	210.83	0.23
StreamCL	419.2	Q50	2293.00	331.59	342.72	337.90	342.92	0.000688	4.03	1009.15	212.57	0.24
StreamCL	419.2	Q100	2684.00	331.59	343.24	338.25	343.47	0.000736	4.33	1121.03	213.97	0.25
StreamCL	419.2	Q200	3100.00	331.59	343.75	338.91	344.00	0.000783	4.62	1230.79	215.33	0.26
StreamCL	216.64	Q1.1	324.00	331.38	337.54	333.49	337.57	0.000244	1.50	228.52	67.23	0.13
StreamCL	216.64	Q25	1925.00	331.38	342.03	336.77	342.22	0.000664	3.67	775.71	187.40	0.23
StreamCL	216.64	Q50	2293.00	331.38	342.56	337.30	342.77	0.000727	4.00	874.26	189.11	0.24
StreamCL	216.64	Q100	2684.00	331.38	343.06	337.80	343.31	0.000786	4.33	970.43	190.41	0.25
StreamCL	216.64	Q200	3100.00	331.38	343.56	338.32	343.84	0.000843	4.64	1064.65	191.68	0.26
StreamCL	31.36	Q1.1	324.00	331.88	337.43		337.50	0.000607	2.10	176.83	99.93	0.19
StreamCL	31.36	Q25	1925.00	331.88	341.96		342.06	0.000576	3.13	1030.52	248.63	0.21
StreamCL	31.36	Q50	2293.00	331.88	342.49		342.60	0.000586	3.31	1162.23	250.28	0.21
StreamCL	31.36	Q100	2684.00	331.88	343.00		343.12	0.000596	3.49	1290.73	251.64	0.22
StreamCL	31.36	Q200	3100.00	331.88	343.50		343.63	0.000609	3.67	1416.49	253.09	0.22
StreamCL	-121.5	Q1.1	324.00	331.36	337.40		337.43	0.000178	1.24	266.07	72.00	0.10
StreamCL	-121.5	Q25	1925.00	331.36	341.86		341.98	0.000439	3.01	936.02	209.20	0.18
StreamCL	-121.5	Q50	2293.00	331.36	342.37		342.51	0.000482	3.28	1043.38	210.99	0.19
StreamCL	-121.5	Q100	2684.00	331.36	342.87		343.02	0.000523	3.54	1148.41	212.87	0.20
StreamCL	-121.5	Q200	3100.00	331.36	343.35		343.53	0.000562	3.79	1251.60	215.05	0.21
StreamCL	-459.58	Q1.1	324.00	331.35	337.29		337.34	0.000343	1.82	178.07	42.17	0.14

HEC-RAS Plan: Ex_OvrTp River: StreamCL Reach: StreamCL (Continued)

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)	
StreamCL	-459.58	Q25	1925.00	331.35	341.34		341.68	0.001315	4.98	657.27	232.14	0.31
StreamCL	-459.58	Q50	2293.00	331.35	341.80		342.18	0.001427	5.37	764.81	236.31	0.32
StreamCL	-459.58	Q100	2684.00	331.35	342.25		342.67	0.001519	5.74	873.01	240.59	0.33
StreamCL	-459.58	Q200	3100.00	331.35	342.70		343.14	0.001598	6.07	980.85	243.44	0.35
StreamCL	-980.34	Q1.1	324.00	331.03	337.07		337.13	0.000471	1.96	167.29	65.36	0.17
StreamCL	-980.34	Q25	1925.00	331.03	340.99		341.11	0.000744	3.47	1043.94	323.37	0.23
StreamCL	-980.34	Q50	2293.00	331.03	341.45		341.58	0.000742	3.61	1195.95	324.91	0.23
StreamCL	-980.34	Q100	2684.00	331.03	341.92		342.05	0.000739	3.75	1346.76	326.59	0.23
StreamCL	-980.34	Q200	3100.00	331.03	342.37		342.51	0.000738	3.89	1495.63	327.98	0.23
StreamCL	-1650.77	Q1.1	324.00	330.91	337.06	331.95	337.07	0.000027	0.57	565.00	104.95	0.04
StreamCL	-1650.77	Q25	1925.00	330.91	340.83	333.59	340.89	0.000158	1.94	1176.21	248.54	0.11
StreamCL	-1650.77	Q50	2293.00	330.91	341.27	333.88	341.34	0.000187	2.19	1287.14	257.87	0.13
StreamCL	-1650.77	Q100	2684.00	330.91	341.70	334.17	341.79	0.000217	2.42	1400.99	266.65	0.14
StreamCL	-1650.77	Q200	3100.00	330.91	342.13	334.47	342.23	0.000246	2.65	1515.30	269.13	0.15
StreamCL	-1948.51	Q1.1	324.00	331.11	336.98	333.05	337.04	0.000430	1.95	192.60	97.41	0.16
StreamCL	-1948.51	Q25	1925.00	331.11	340.76	337.81	340.82	0.000430	2.66	1529.23	466.72	0.17
StreamCL	-1948.51	Q50	2293.00	331.11	341.20	338.18	341.26	0.000431	2.77	1734.30	469.71	0.18
StreamCL	-1948.51	Q100	2684.00	331.11	341.63	338.49	341.69	0.000430	2.87	1939.47	473.48	0.18
StreamCL	-1948.51	Q200	3100.00	331.11	342.06	338.72	342.12	0.000430	2.97	2145.23	506.24	0.18

EXISTING CONDITIONS
Standard Table 2

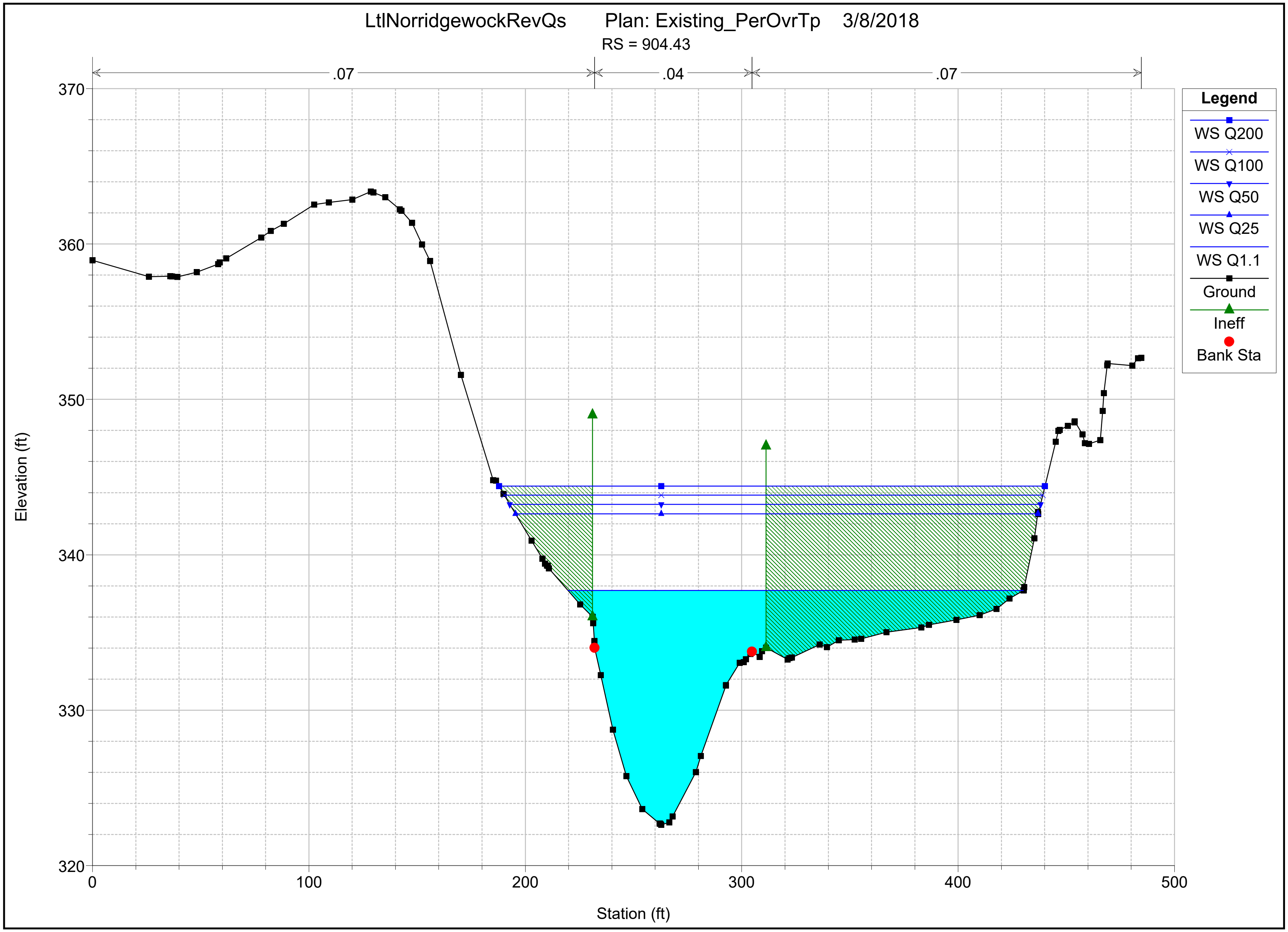
HEC-RAS Plan: Ex_OvrTp River: StreamCL Reach: StreamCL

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
			(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
StreamCL	2385.65	Q1.1	338.15	338.14	0.01	0.07	0.00		324.00		53.08
StreamCL	2385.65	Q25	344.62	344.56	0.06	0.15	0.00	3.12	1661.12	260.76	188.39
StreamCL	2385.65	Q50	345.68	345.61	0.07	0.14	0.00	6.25	1923.27	363.48	205.36
StreamCL	2385.65	Q100	346.79	346.71	0.07	0.13	0.00	15.60	2187.71	480.69	220.24
StreamCL	2385.65	Q200	347.99	347.91	0.08	0.12	0.01	30.76	2493.66	575.59	253.89
StreamCL	1604.26	Q1.1	338.09	338.06	0.02	0.06	0.00		324.00		50.64
StreamCL	1604.26	Q25	344.47	344.39	0.08	0.06	0.01	2.59	1580.59	341.82	363.05
StreamCL	1604.26	Q50	345.53	345.46	0.08	0.05	0.01	4.81	1740.39	547.80	389.03
StreamCL	1604.26	Q100	346.65	346.58	0.07	0.05	0.01	7.90	1887.64	788.46	416.42
StreamCL	1604.26	Q200	347.86	347.80	0.06	0.04	0.01	11.99	2023.68	1064.33	446.04
StreamCL	1283.94	Q1.1	338.02	337.98	0.05	0.06	0.00	0.63	322.96	0.41	90.68
StreamCL	1283.94	Q25	344.40	344.36	0.03	0.03	0.00	588.08	982.24	354.67	330.71
StreamCL	1283.94	Q50	345.47	345.43	0.03	0.02	0.00	723.07	1107.17	462.76	380.47
StreamCL	1283.94	Q100	346.60	346.56	0.03	0.02	0.00	847.12	1207.12	629.76	413.64
StreamCL	1283.94	Q200	347.81	347.79	0.03	0.02	0.00	963.71	1290.95	845.35	428.37
StreamCL	1112.94	Q1.1	337.96	337.92	0.04	0.02	0.00	24.75	295.28	3.96	176.43
StreamCL	1112.94	Q25	344.37	344.34	0.04	0.02	0.02	453.22	1025.41	446.37	334.56
StreamCL	1112.94	Q50	345.44	345.40	0.04	0.02	0.02	552.46	1180.02	560.52	369.98
StreamCL	1112.94	Q100	346.57	346.54	0.04	0.02	0.02	642.82	1310.44	730.74	381.99
StreamCL	1112.94	Q200	347.80	347.76	0.04	0.02	0.03	740.41	1440.42	919.17	393.90
StreamCL	1034.95	Q1.1	337.94	337.90	0.04				324.00		225.72
StreamCL	1034.95	Q25	344.33	344.12	0.21				1925.00		348.94
StreamCL	1034.95	Q50	345.40	345.15	0.25				2293.00		352.18
StreamCL	1034.95	Q100	346.53	346.25	0.28				2684.00		372.36
StreamCL	1034.95	Q200	347.75	347.43	0.32				3100.00		377.60
StreamCL	982		Culvert								
StreamCL	904.43	Q1.1	337.70	337.70	0.00	0.00	0.01	0.14	320.38	3.48	210.42
StreamCL	904.43	Q25	342.67	342.63	0.04	0.03	0.06	2.66	1882.08	40.26	241.38
StreamCL	904.43	Q50	343.30	343.24	0.06	0.04	0.08	3.38	2239.55	50.07	245.22
StreamCL	904.43	Q100	343.91	343.84	0.07	0.05	0.09	4.19	2618.93	60.88	248.83
StreamCL	904.43	Q200	344.51	344.42	0.09	0.06	0.11	5.09	3022.17	72.74	252.25
StreamCL	838.83	Q1.1	337.69	337.66	0.03	0.01	0.01		324.00		51.50
StreamCL	838.83	Q25	342.58	342.33	0.25	0.05	0.08		1925.00		282.73
StreamCL	838.83	Q50	343.18	342.87	0.31	0.06	0.10		2293.00		285.58
StreamCL	838.83	Q100	343.77	343.39	0.38	0.06	0.12		2684.00		287.79
StreamCL	838.83	Q200	344.35	343.89	0.46	0.07	0.15		3100.00		289.92
StreamCL	686.02	Q1.1	337.67	337.66	0.01	0.03	0.00	1.60	322.40		111.19
StreamCL	686.02	Q25	342.45	342.39	0.06	0.09	0.01	283.82	1639.70	1.48	289.35
StreamCL	686.02	Q50	343.03	342.96	0.07	0.09	0.01	387.47	1903.15	2.39	290.97
StreamCL	686.02	Q100	343.58	343.51	0.08	0.10	0.01	503.65	2176.79	3.56	292.55
StreamCL	686.02	Q200	344.13	344.04	0.09	0.11	0.02	632.44	2462.54	5.02	294.08
StreamCL	419.2	Q1.1	337.64	337.59	0.04	0.06	0.00	2.19	321.78	0.03	69.40
StreamCL	419.2	Q25	342.35	342.18	0.18	0.13	0.00	205.08	1543.49	176.42	210.83
StreamCL	419.2	Q50	342.92	342.72	0.20	0.14	0.00	258.19	1778.46	256.35	212.57
StreamCL	419.2	Q100	343.47	343.24	0.22	0.15	0.00	315.46	2020.55	347.99	213.97
StreamCL	419.2	Q200	344.00	343.75	0.25	0.16	0.00	377.16	2272.02	450.82	215.33
StreamCL	216.64	Q1.1	337.57	337.54	0.03	0.07	0.01		321.30	2.70	67.23
StreamCL	216.64	Q25	342.22	342.03	0.19	0.11	0.04	56.86	1691.43	176.71	187.40
StreamCL	216.64	Q50	342.77	342.56	0.22	0.12	0.05	95.89	1966.04	231.07	189.11
StreamCL	216.64	Q100	343.31	343.06	0.25	0.13	0.06	143.16	2249.89	290.95	190.41
StreamCL	216.64	Q200	343.84	343.56	0.28	0.13	0.07	198.09	2545.52	356.38	191.68
StreamCL	31.36	Q1.1	337.50	337.43	0.07	0.05	0.02	8.12	315.88		99.93
StreamCL	31.36	Q25	342.06	341.96	0.10	0.08	0.01	753.86	1167.00	4.14	248.63
StreamCL	31.36	Q50	342.60	342.49	0.11	0.08	0.01	956.95	1327.87	8.18	250.28
StreamCL	31.36	Q100	343.12	343.00	0.12	0.09	0.01	1175.95	1494.82	13.24	251.64
StreamCL	31.36	Q200	343.63	343.50	0.13	0.09	0.01	1410.67	1670.00	19.32	253.09
StreamCL	-121.5	Q1.1	337.43	337.40	0.02	0.08	0.01		323.18	0.82	72.00

HEC-RAS Plan: Ex_OvrTp   River: StreamCL   Reach: StreamCL (Continued)

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
			(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
StreamCL	-121.5	Q25	341.98	341.86	0.12	0.24	0.07	79.99	1618.03	226.97	209.20
StreamCL	-121.5	Q50	342.51	342.37	0.14	0.26	0.07	106.87	1866.53	319.60	210.99
StreamCL	-121.5	Q100	343.02	342.87	0.16	0.28	0.08	136.83	2122.64	424.54	212.87
StreamCL	-121.5	Q200	343.53	343.35	0.18	0.30	0.08	168.96	2388.85	542.19	215.05
StreamCL	-459.58	Q1.1	337.34	337.29	0.05	0.21	0.00	0.00	324.00		42.17
StreamCL	-459.58	Q25	341.68	341.34	0.34	0.50	0.07	235.76	1685.11	4.13	232.14
StreamCL	-459.58	Q50	342.18	341.80	0.38	0.52	0.08	364.23	1922.10	6.67	236.31
StreamCL	-459.58	Q100	342.67	342.25	0.41	0.53	0.09	515.60	2158.43	9.97	240.59
StreamCL	-459.58	Q200	343.14	342.70	0.45	0.54	0.09	689.82	2396.10	14.08	243.44
StreamCL	-980.34	Q1.1	337.13	337.07	0.06	0.05	0.02	0.04	323.76	0.20	65.36
StreamCL	-980.34	Q25	341.11	340.99	0.12	0.20	0.02	247.37	1165.21	512.42	323.37
StreamCL	-980.34	Q50	341.58	341.45	0.12	0.22	0.02	331.72	1292.23	669.04	324.91
StreamCL	-980.34	Q100	342.05	341.92	0.13	0.24	0.01	424.03	1421.48	838.49	326.59
StreamCL	-980.34	Q200	342.51	342.37	0.13	0.26	0.01	523.83	1554.88	1021.29	327.98
StreamCL	-1650.77	Q1.1	337.07	337.06	0.01	0.02	0.01	0.00	324.00		104.95
StreamCL	-1650.77	Q25	340.89	340.83	0.06	0.07	0.00	47.34	1874.07	3.59	248.54
StreamCL	-1650.77	Q50	341.34	341.27	0.07	0.08	0.00	76.73	2210.43	5.84	257.87
StreamCL	-1650.77	Q100	341.79	341.70	0.09	0.09	0.01	114.45	2560.77	8.78	266.65
StreamCL	-1650.77	Q200	342.23	342.13	0.10	0.09	0.01	163.67	2923.88	12.45	269.13
StreamCL	-1948.51	Q1.1	337.04	336.98	0.06			4.07	313.98	5.94	97.41
StreamCL	-1948.51	Q25	340.82	340.76	0.06			492.61	866.67	565.72	466.72
StreamCL	-1948.51	Q50	341.26	341.20	0.06			631.63	955.38	705.99	469.71
StreamCL	-1948.51	Q100	341.69	341.63	0.06			781.20	1045.99	856.81	473.48
StreamCL	-1948.51	Q200	342.12	342.06	0.06			943.73	1139.05	1017.22	506.24

EXISTING CONDITIONS
Cross-Sections



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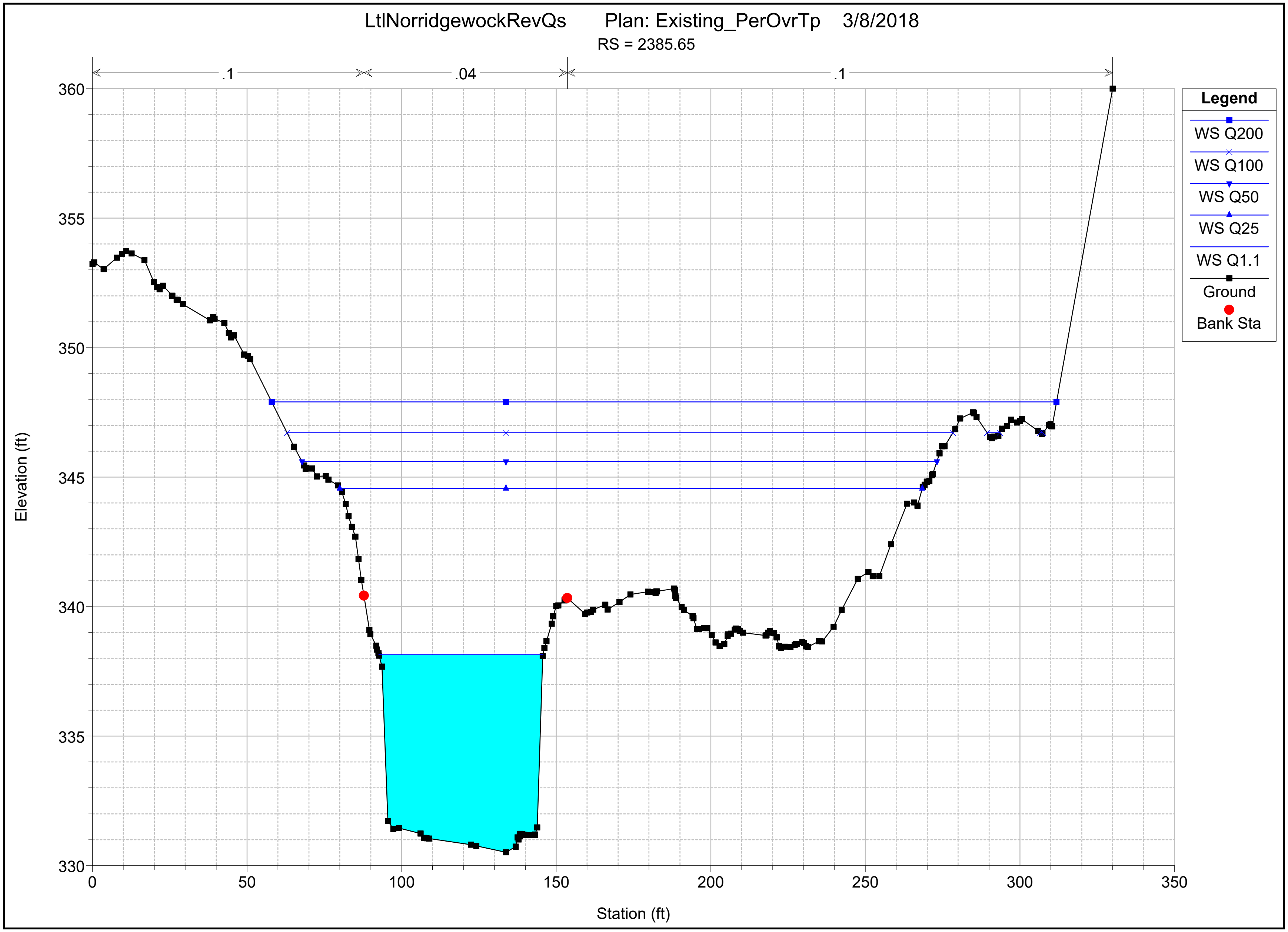
Cross-Sections



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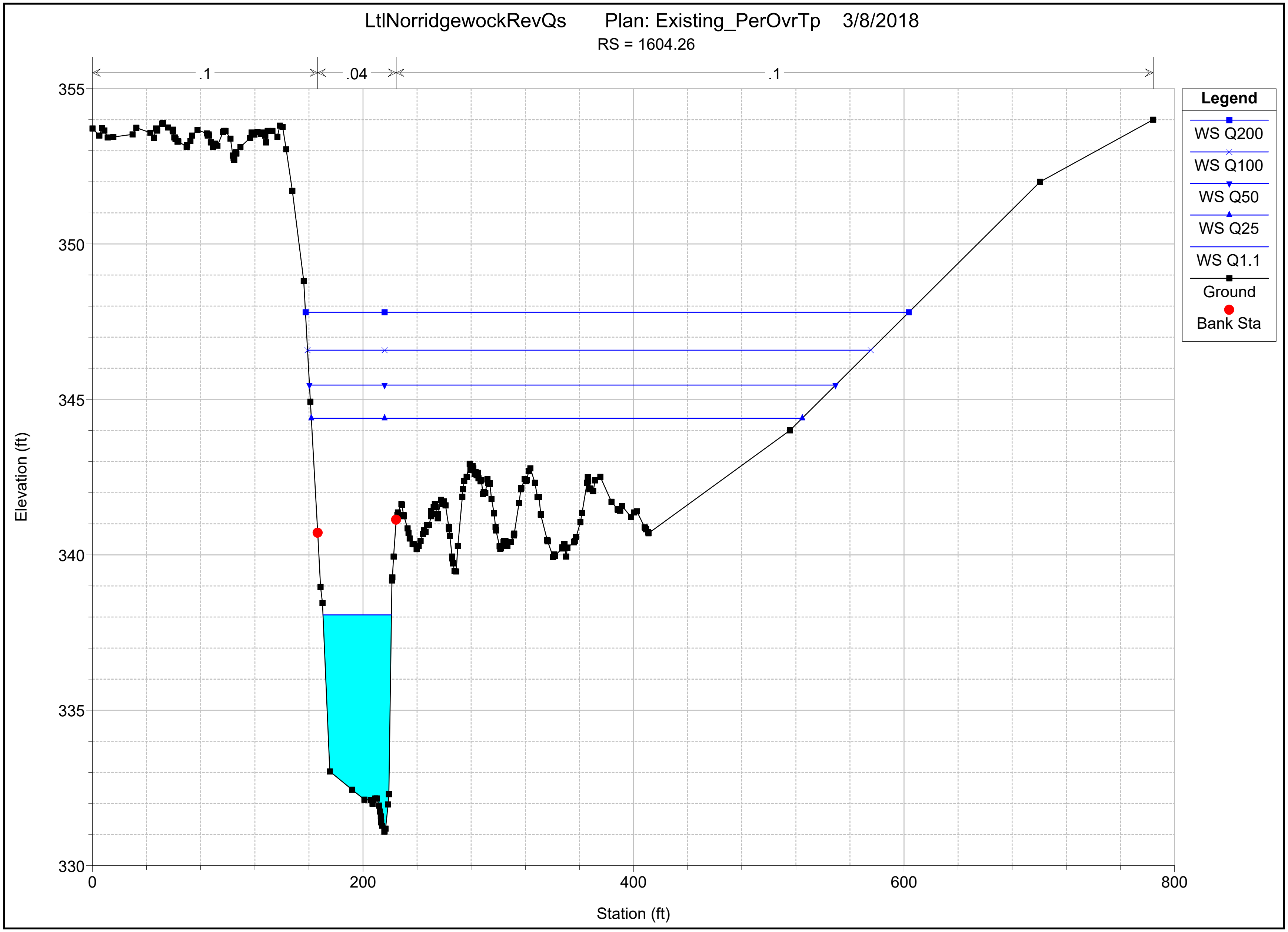

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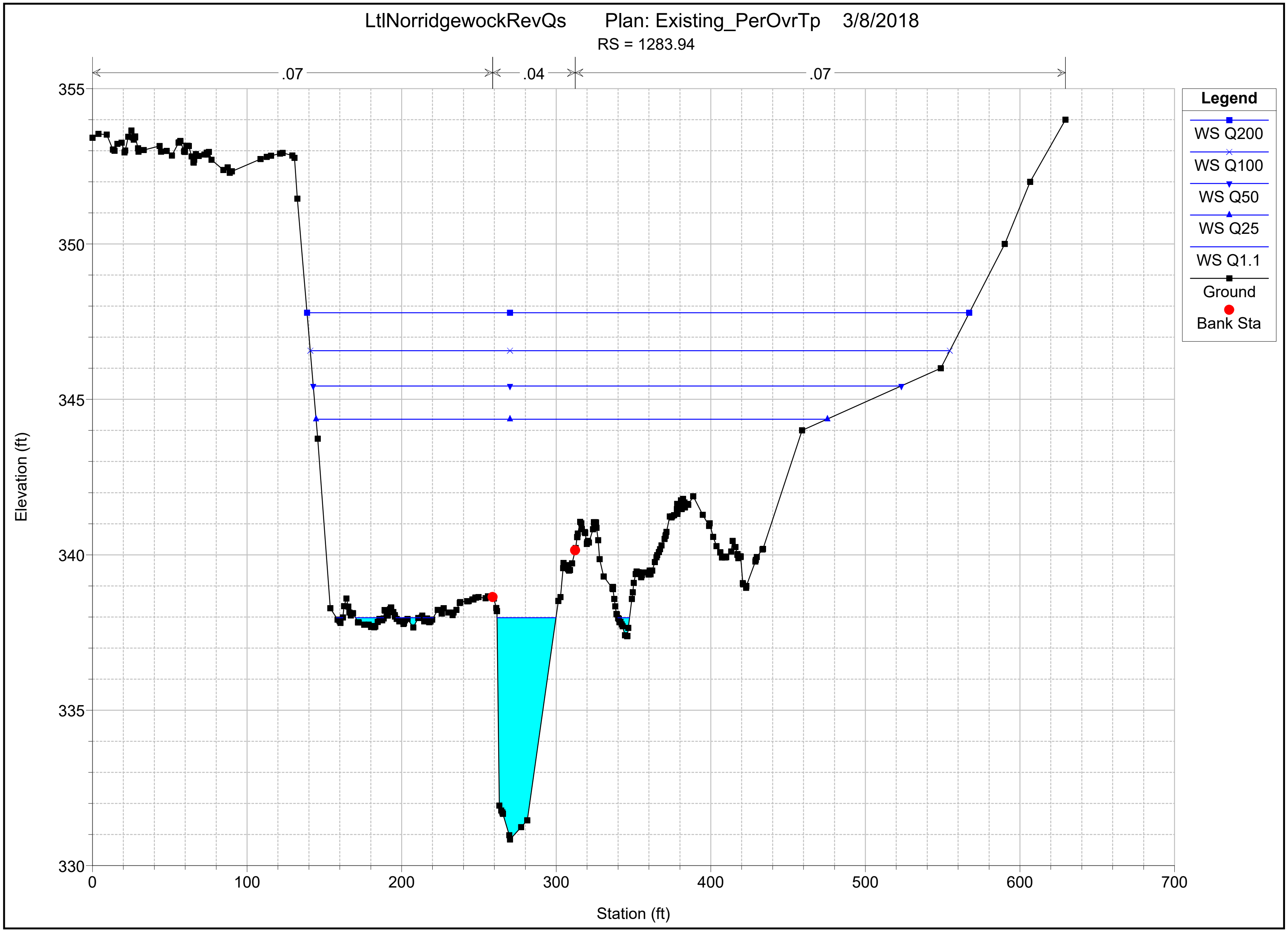

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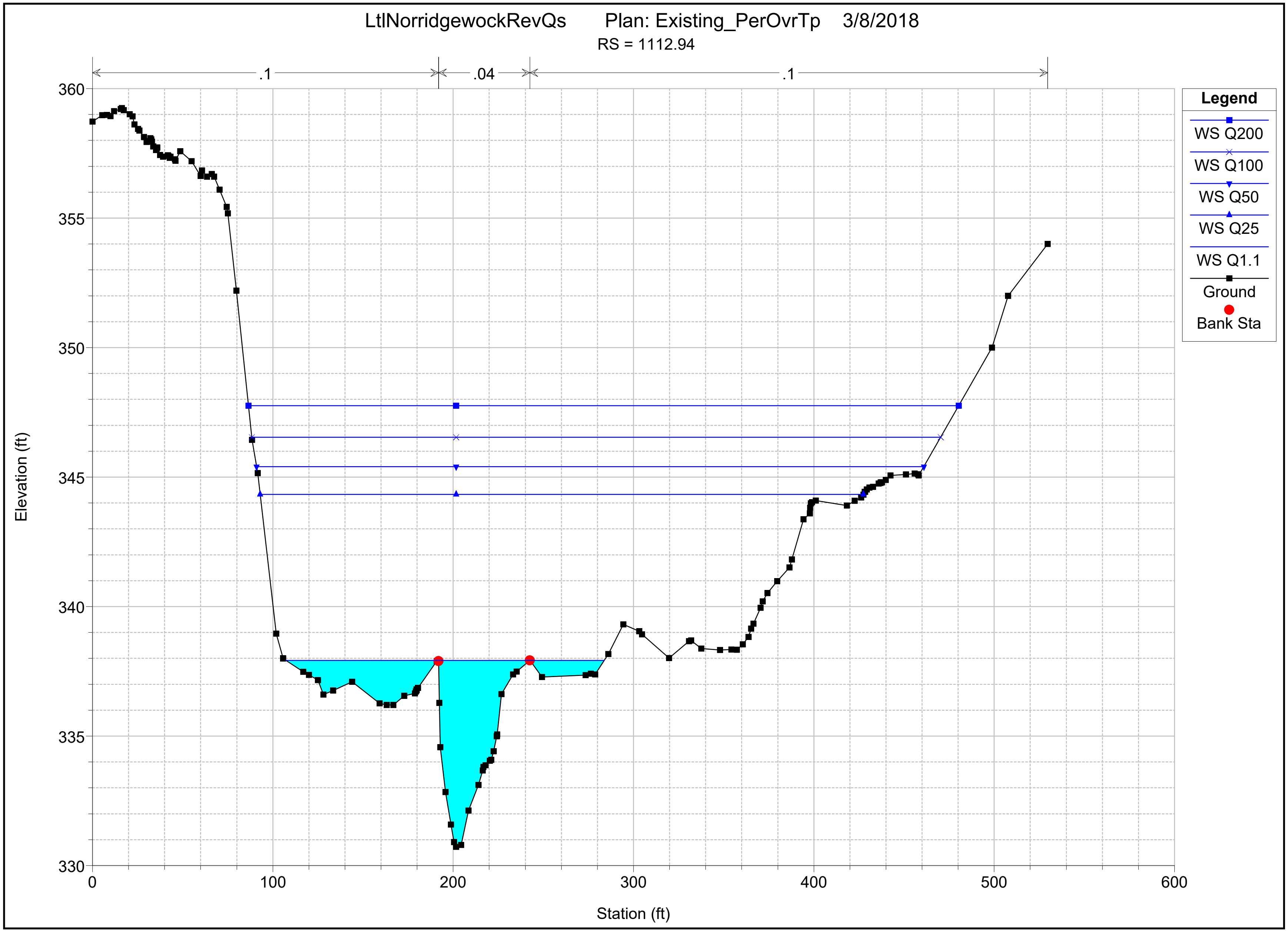

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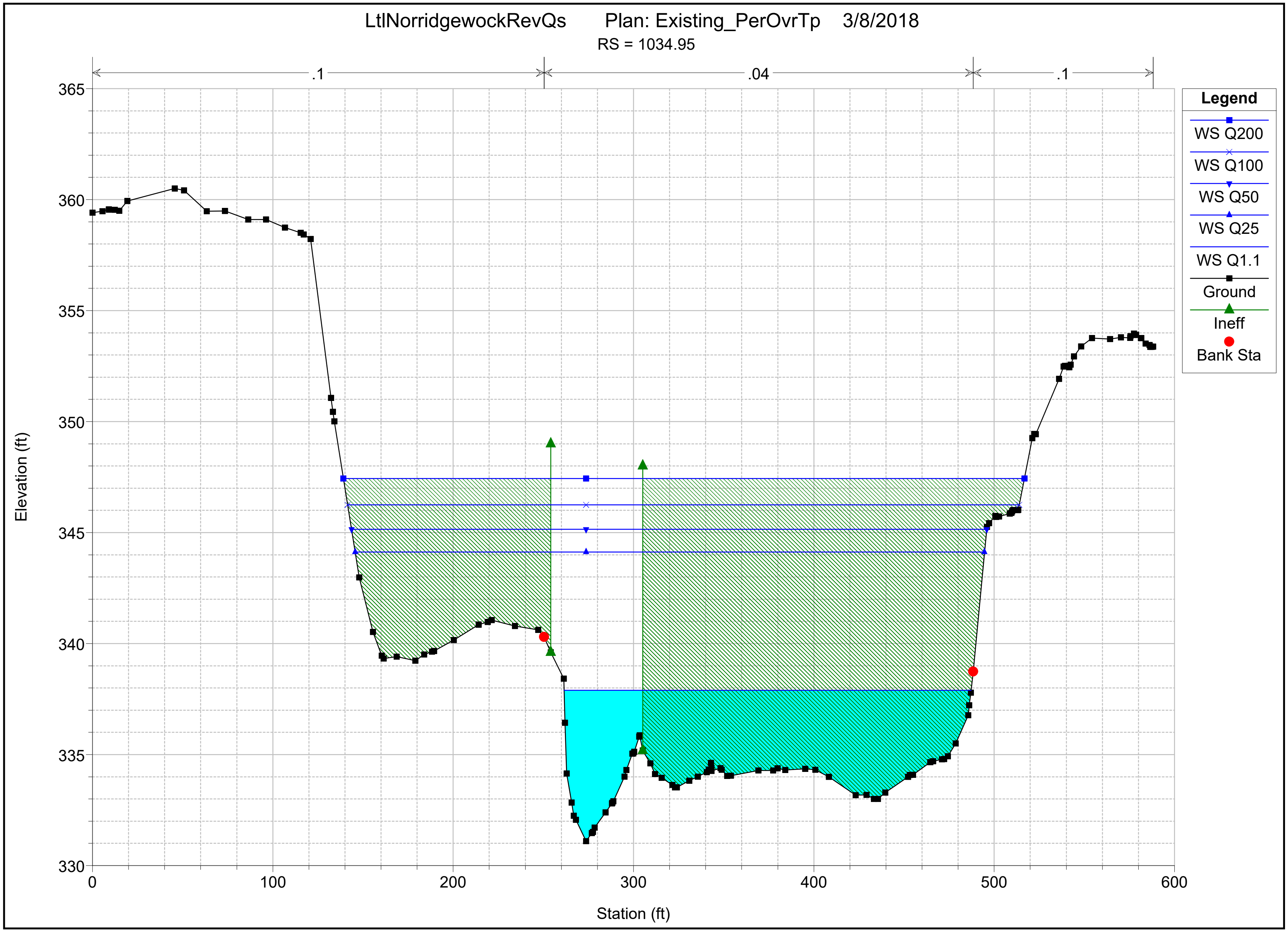

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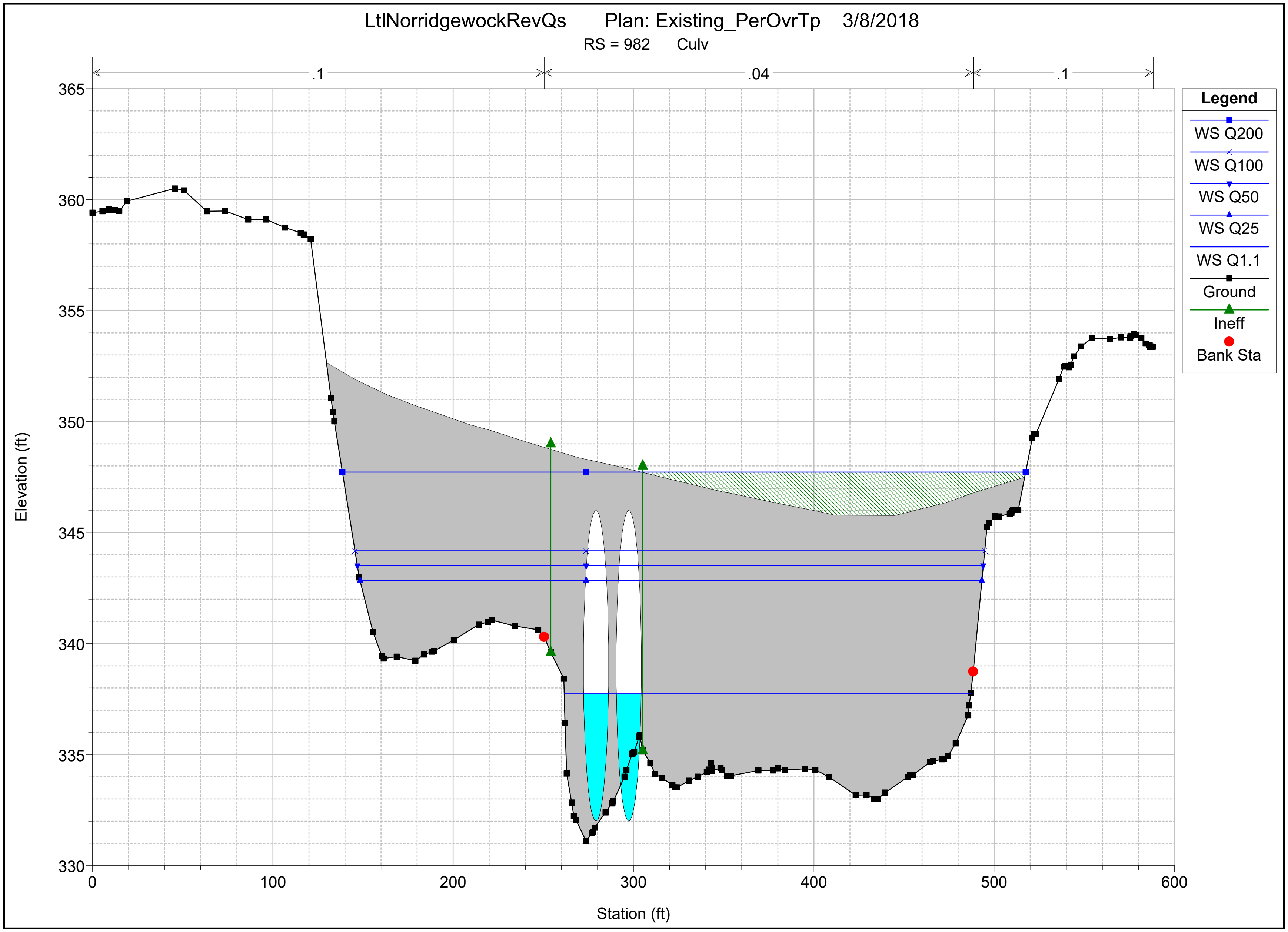

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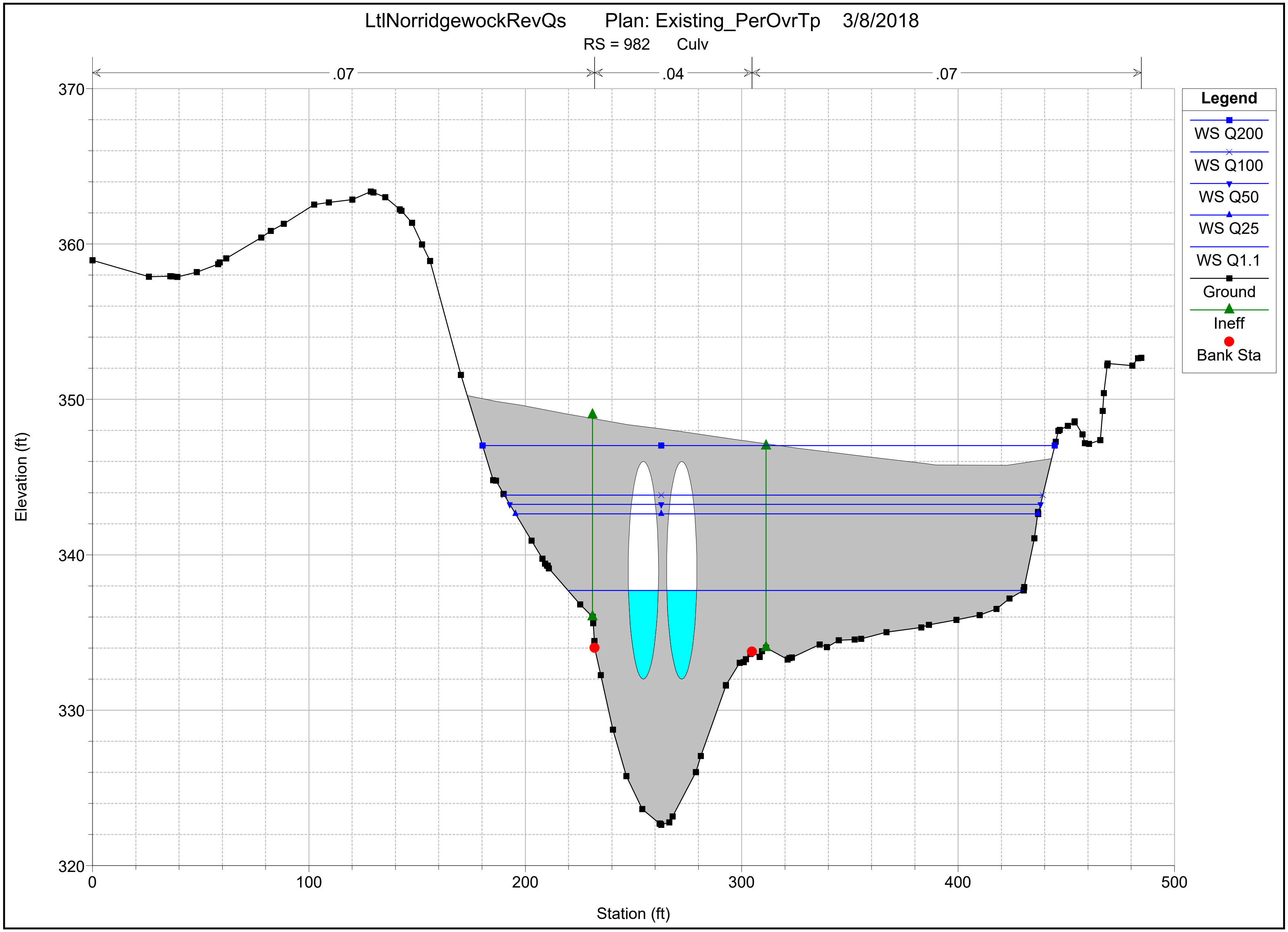

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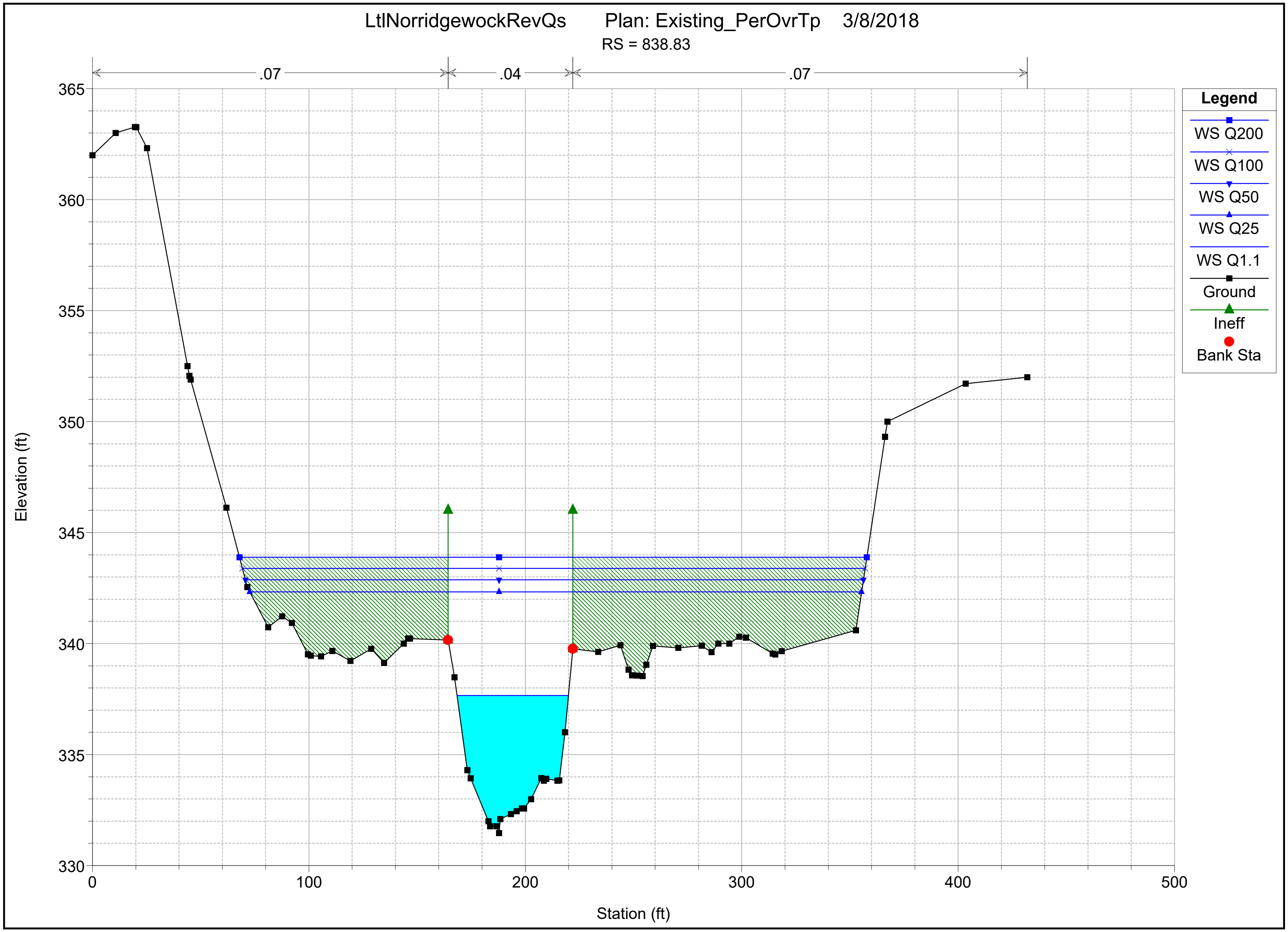

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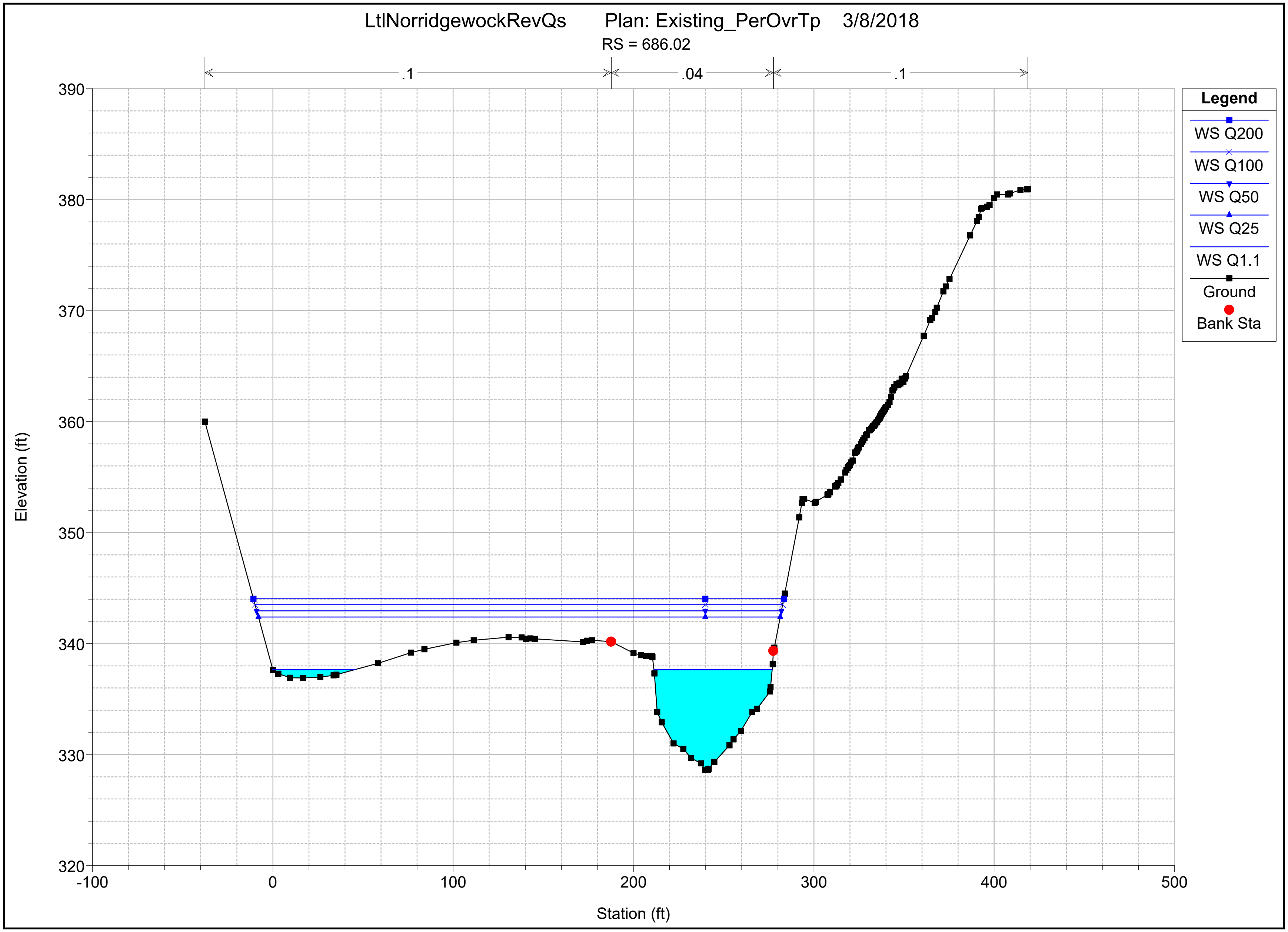

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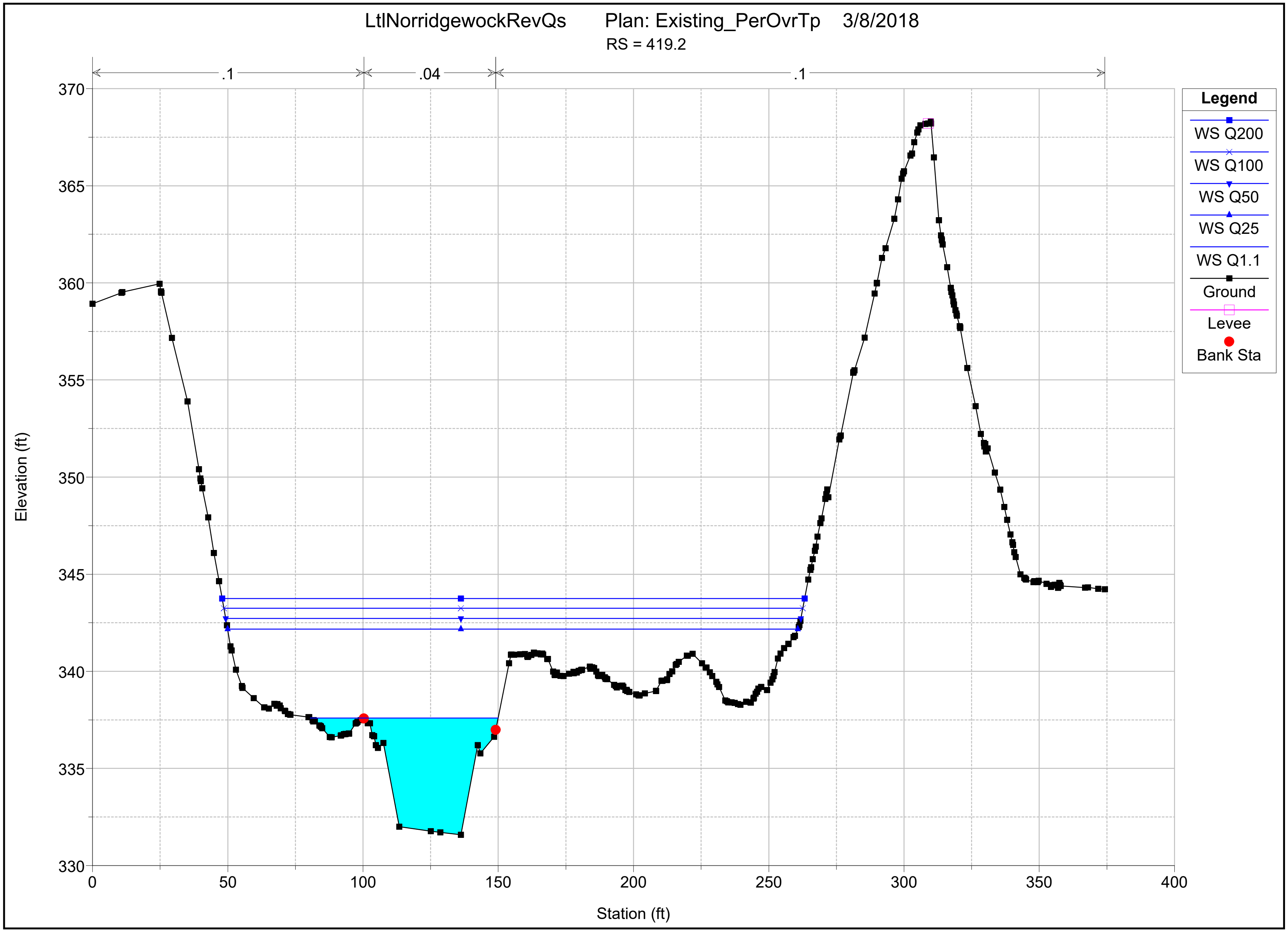

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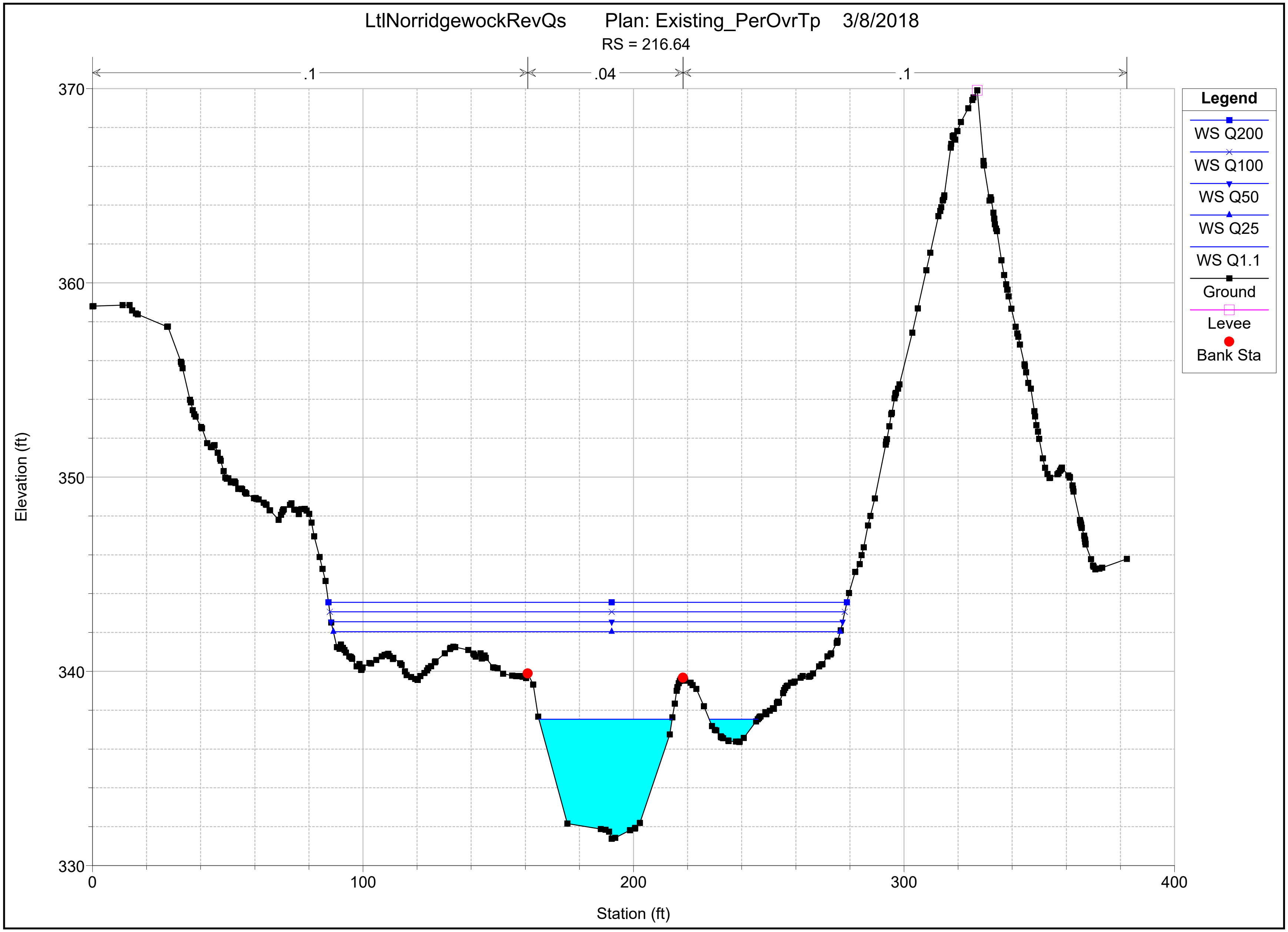

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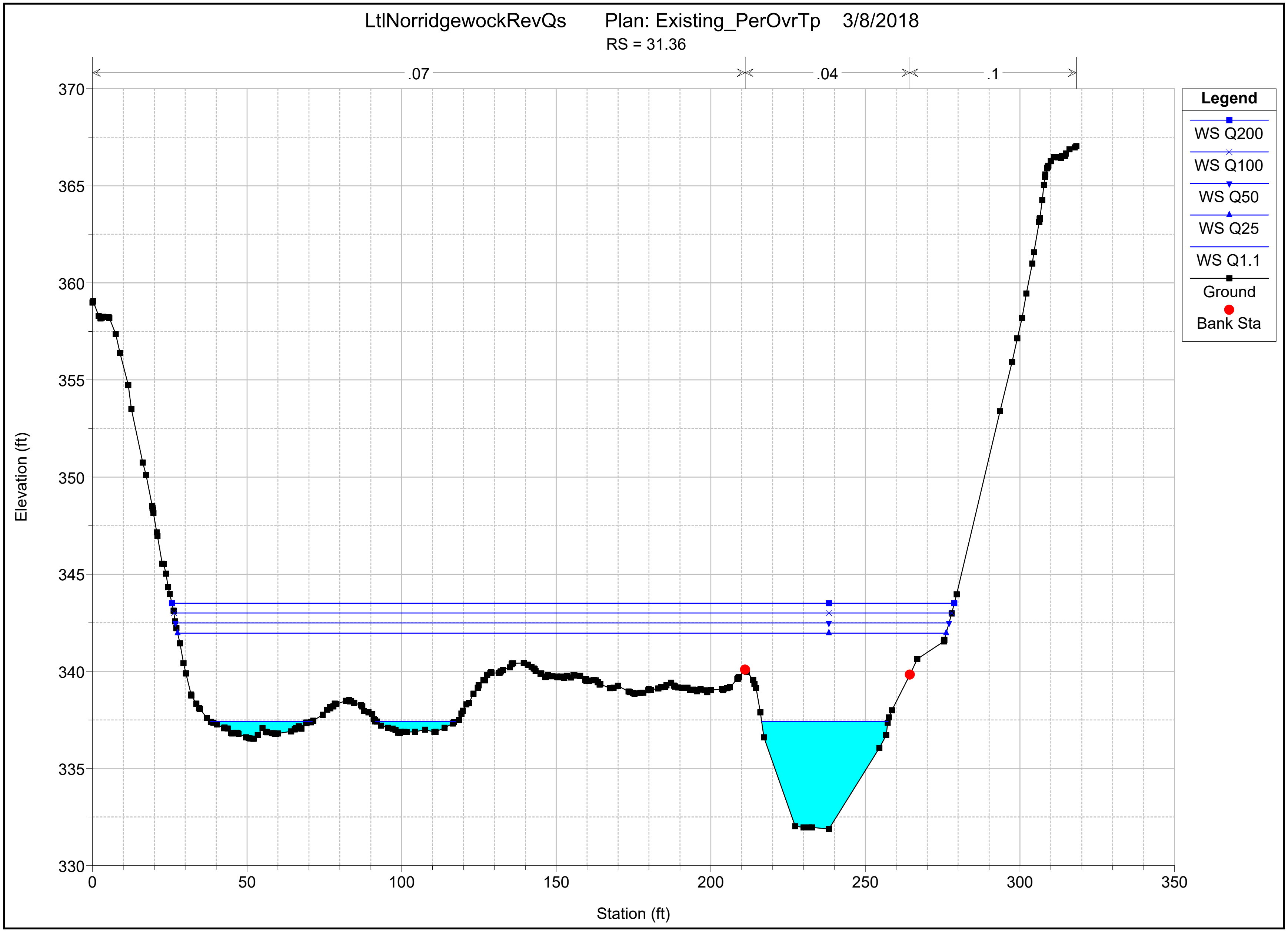

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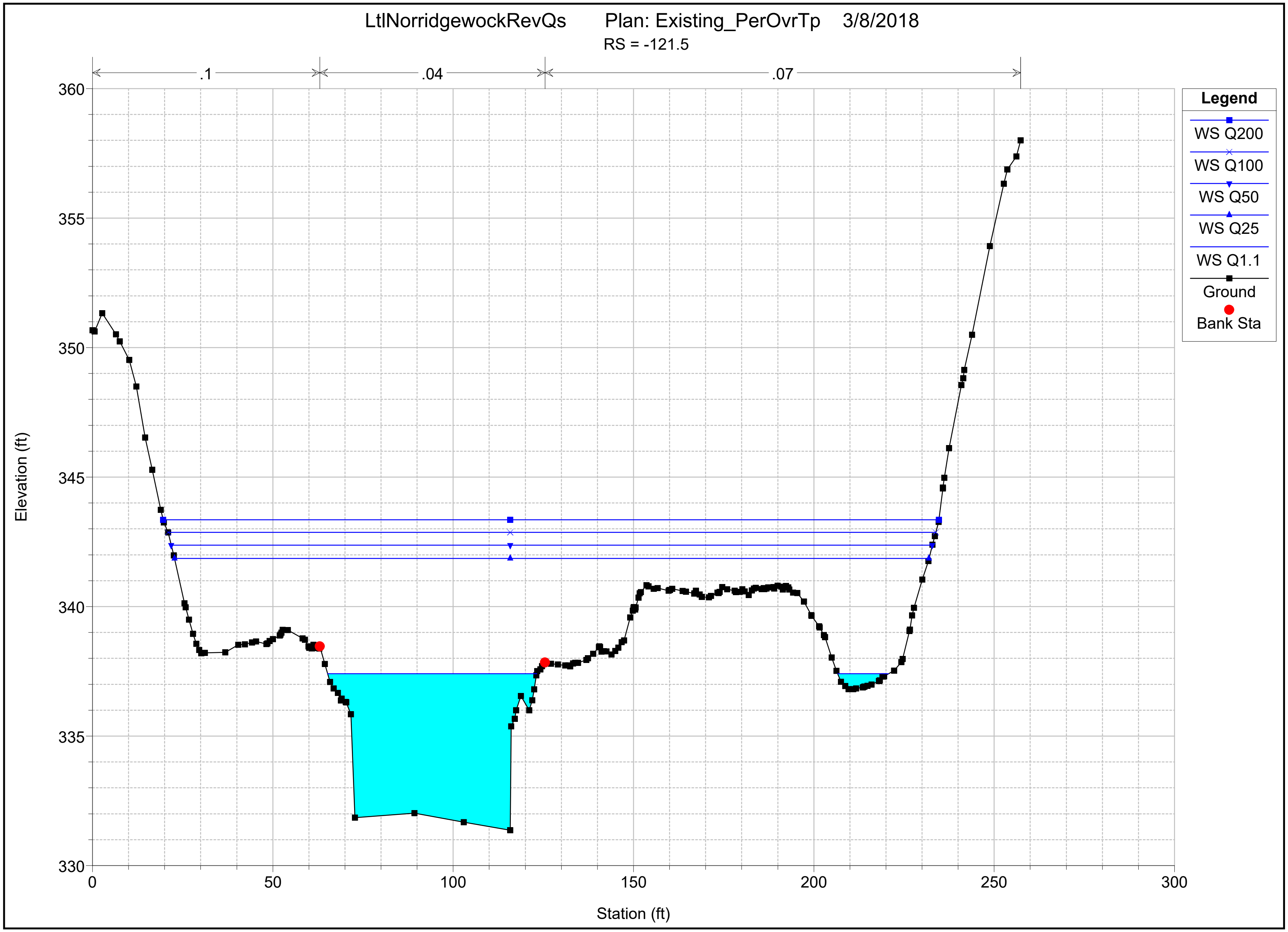

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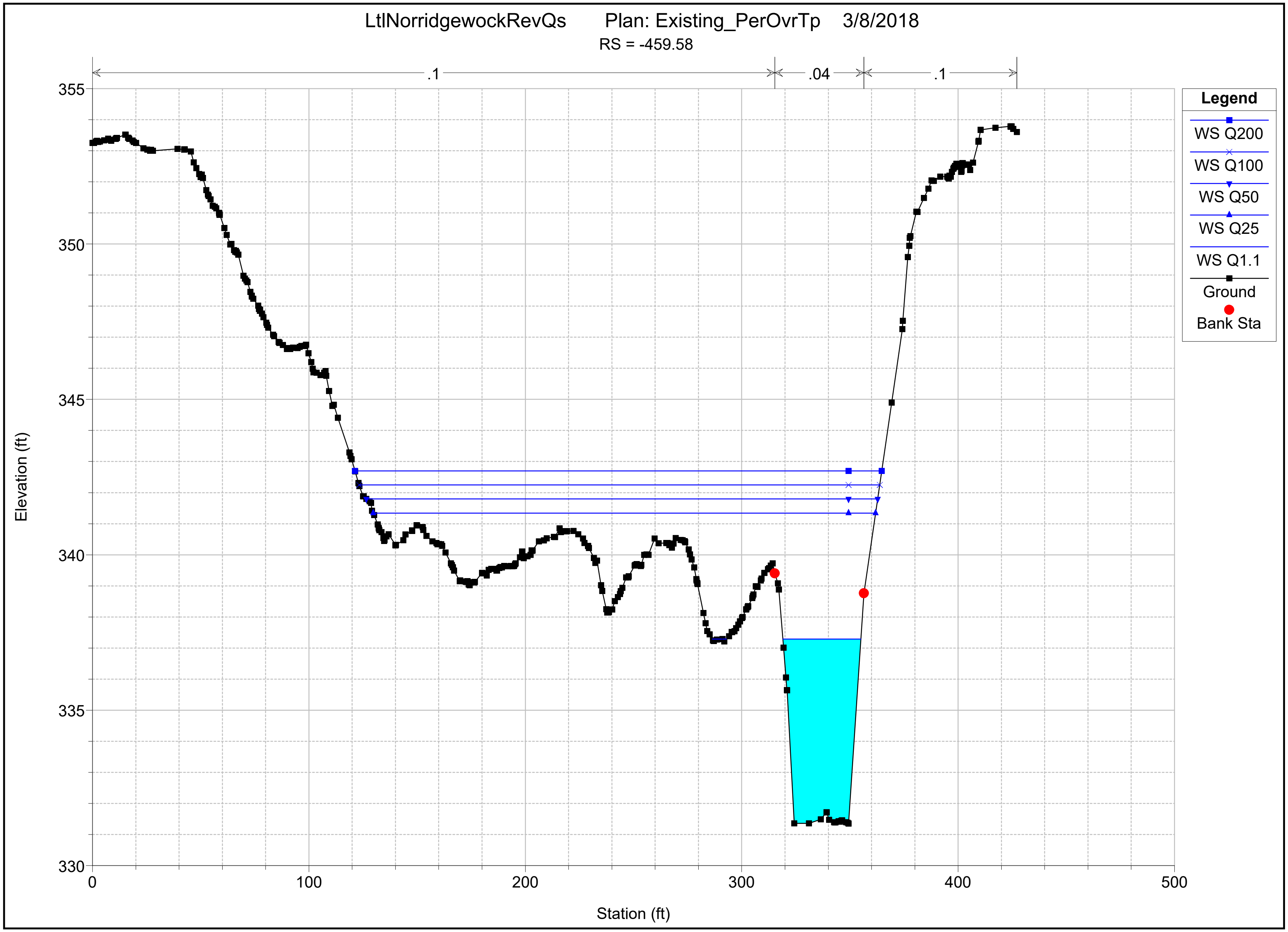

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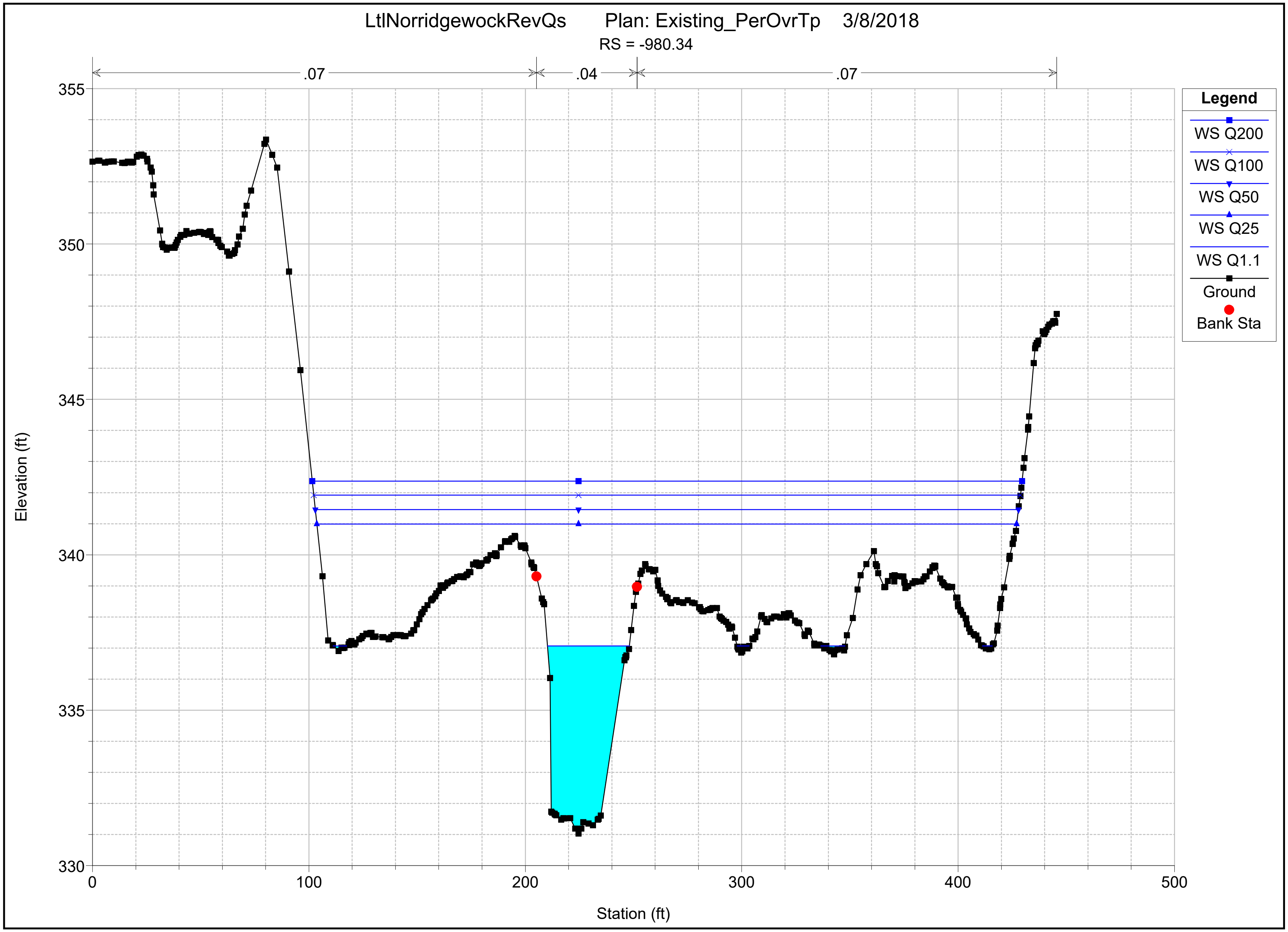

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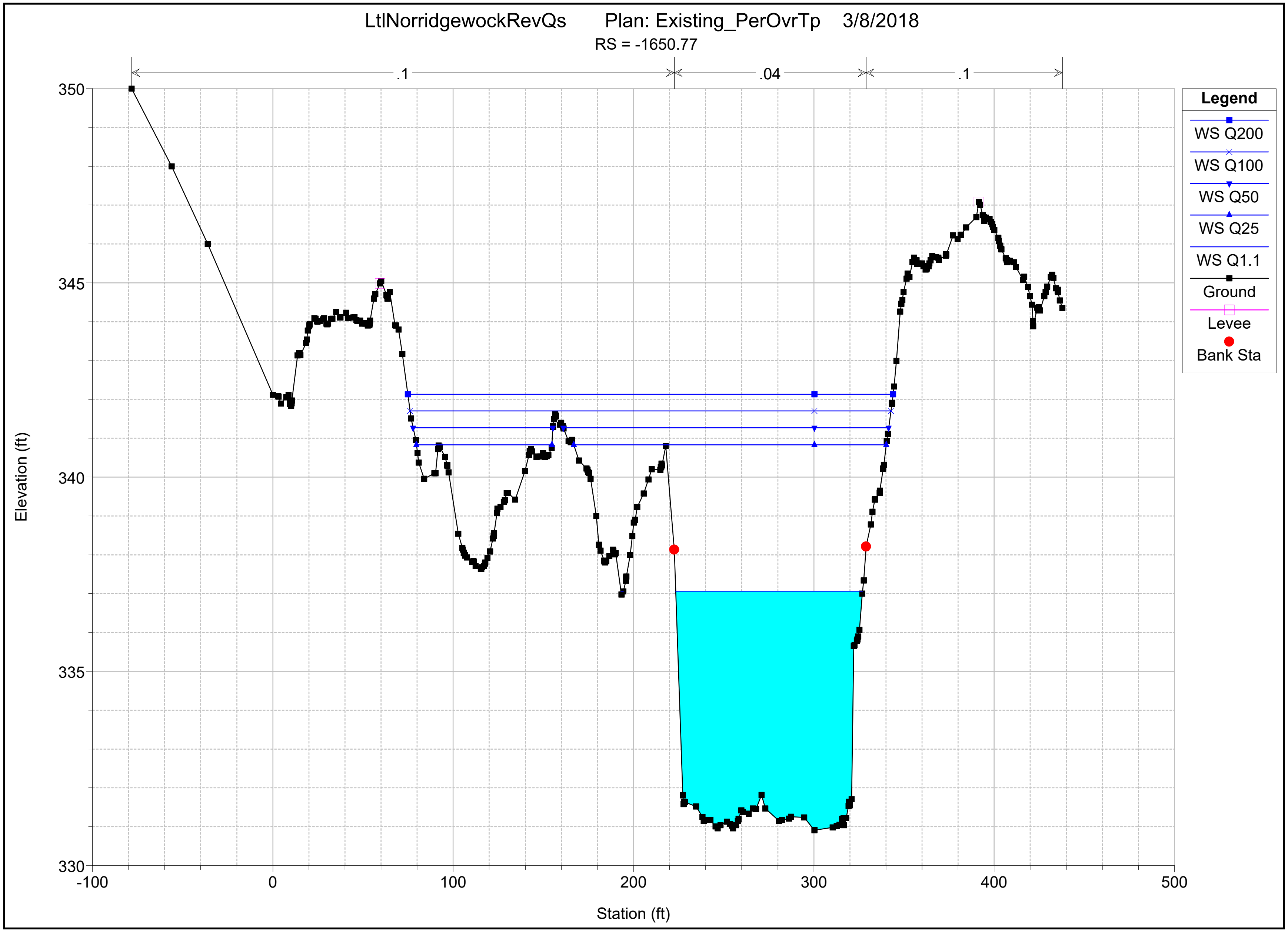

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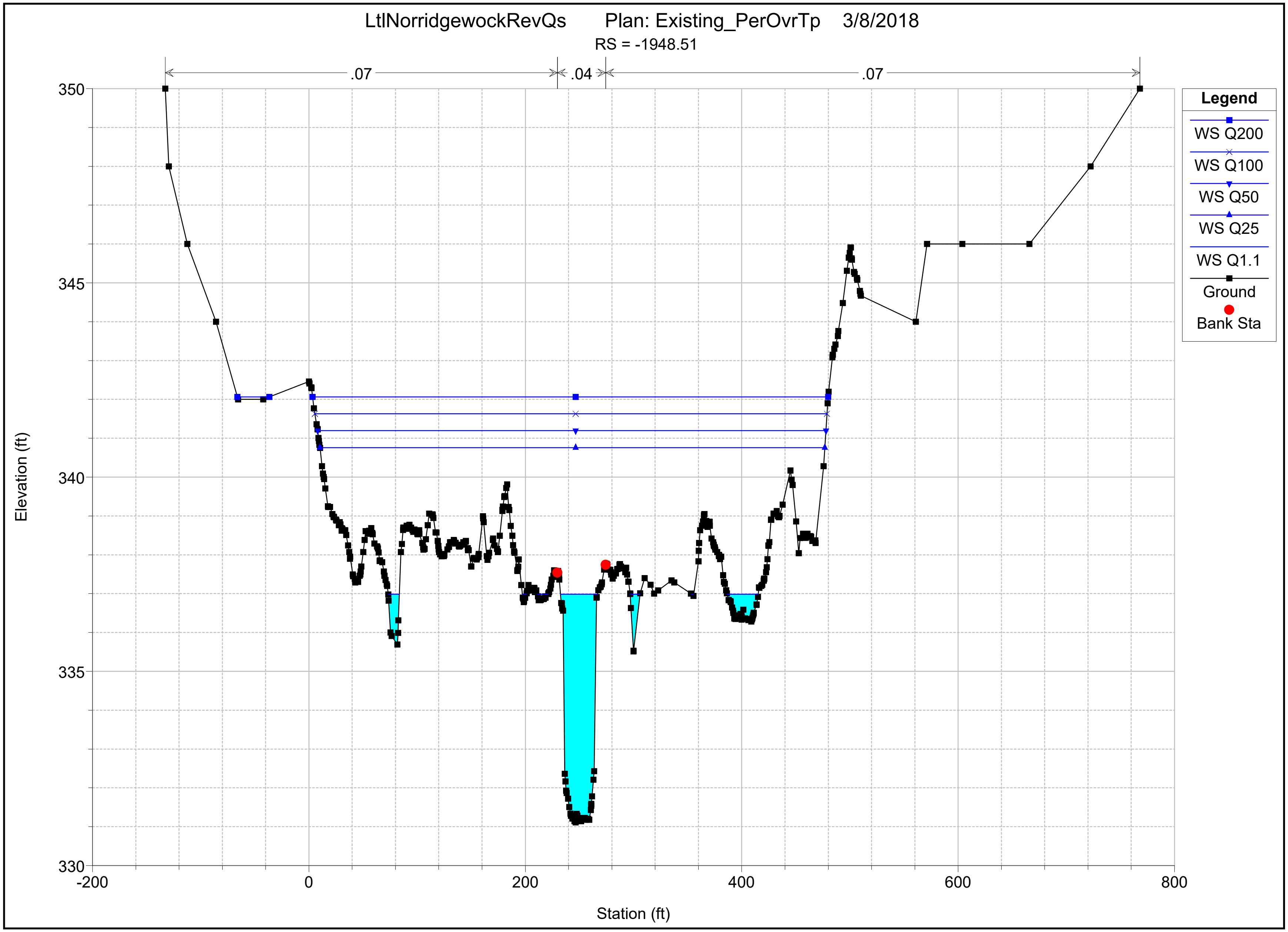
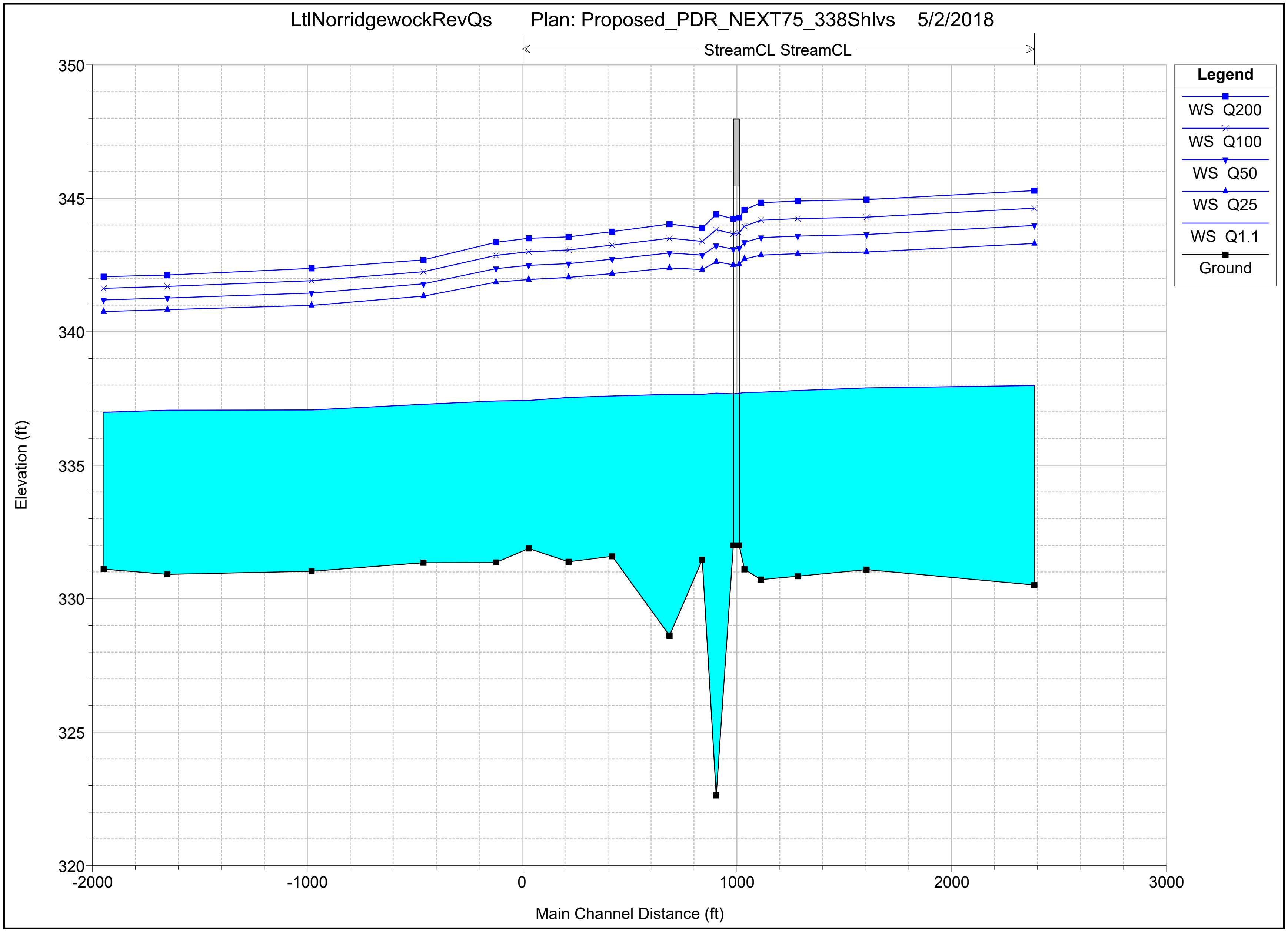
Cross-Sections



PROPOSED CONDITIONS
Water Surface Profile



Dutch Gap Bridge, Chesterville, ME
MaineDOT WIN 021688.00
Hoyle, Tanner & Associates No. 923403.04

Hydraulic Analysis - Proposed Conditions
Six XS Bridge Table

HEC-RAS Plan: NEXT75_338Shlvs River: StreamCL Reach: StreamCL

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Crit W.S.	Frctn Loss	C & E Loss	Top Width	Q Left	Q Channel	Q Right	Vel Chnl
			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft/s)
StreamCL	1112.94	Q1.1	337.78	337.74		0.02	0.01	163.20	20.17	301.58	2.24	1.76
StreamCL	1112.94	Q25	342.93	342.87		0.03	0.01	296.79	428.29	1079.33	417.38	2.50
StreamCL	1112.94	Q50	343.60	343.53		0.03	0.01	302.45	520.05	1242.13	530.82	2.67
StreamCL	1112.94	Q100	344.26	344.18		0.03	0.02	332.19	630.46	1440.25	613.29	2.89
StreamCL	1034.95	Q1.1	337.76	337.73	333.84	0.01	0.01	225.43		324.00		1.27
StreamCL	1034.95	Q25	342.89	342.73	336.60	0.02	0.04	344.28	1.74	1923.26		3.26
StreamCL	1034.95	Q50	343.55	343.35	337.00	0.02	0.05	346.52	2.71	2290.29		3.62
StreamCL	1034.95	Q100	344.21	343.96	337.40	0.02	0.05	348.44	3.87	2680.13		3.97
StreamCL	982 BR U	Q1.1	337.74	337.69	333.86	0.01	0.00	40.79		324.00		1.85
StreamCL	982 BR U	Q25	342.84	342.54	337.48	0.03	0.00	67.32	16.79	1890.77	17.44	4.41
StreamCL	982 BR U	Q50	343.49	343.13	338.28	0.03	0.00	68.36	26.61	2235.06	31.33	4.85
StreamCL	982 BR U	Q100	344.13	343.71	338.77	0.03	0.00	71.50	35.94	2599.43	48.63	5.29
StreamCL	982 BR D	Q1.1	337.73	337.68	333.86	0.00	0.02	40.75		324.00		1.85
StreamCL	982 BR D	Q25	342.81	342.51	337.47	0.01	0.12	67.27	16.53	1891.45	17.02	4.43
StreamCL	982 BR D	Q50	343.46	343.10	338.28	0.02	0.15	68.30	26.24	2236.00	30.76	4.87
StreamCL	982 BR D	Q100	344.10	343.67	338.76	0.02	0.17	71.37	34.89	2601.23	47.88	5.32
StreamCL	904.43	Q1.1	337.70	337.70	325.27	0.00	0.01	210.41	0.67	323.33		0.46
StreamCL	904.43	Q25	342.67	342.62	328.75	0.04	0.06	241.32	26.40	1898.60		1.87
StreamCL	904.43	Q50	343.30	343.23	329.27	0.04	0.07	245.15	34.39	2258.62		2.14
StreamCL	904.43	Q100	343.91	343.82	329.79	0.05	0.09	248.74	43.47	2640.53		2.42
StreamCL	838.83	Q1.1	337.69	337.66	334.12	0.01	0.01	51.50		324.00		1.48
StreamCL	838.83	Q25	342.58	342.33	336.87	0.05	0.08	282.73		1925.00		4.01
StreamCL	838.83	Q50	343.18	342.87	337.35	0.06	0.10	285.58		2293.00		4.49
StreamCL	838.83	Q100	343.77	343.39	337.82	0.06	0.12	287.79		2684.00		4.96

Design Water Surface Elevations

Design Velocities

Minor differences between hydraulic analysis results and final water surface elevations included on plans. Values on plans are slightly higher, indicating slightly more freeboard and slower velocities (less scour potential) for current analysis results. Aaron Lachance, PE - 12/23/18

PROPOSED CONDITIONS
Standard Table 1

HEC-RAS Plan: NEXT75_338Shlvs River: StreamCL Reach: StreamCL

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)	
StreamCL	2385.65	Q1.1	324.00	330.51	337.98	332.10	338.00	0.000062	0.93	349.91	52.64	0.06
StreamCL	2385.65	Q25	1925.00	330.51	343.31	334.65	343.40	0.000249	2.52	1065.01	178.02	0.14
StreamCL	2385.65	Q50	2293.00	330.51	343.98	335.08	344.09	0.000276	2.77	1185.46	183.09	0.15
StreamCL	2385.65	Q100	2684.00	330.51	344.64	335.54	344.76	0.000301	3.00	1308.05	189.01	0.15
StreamCL	2385.65	Q200	3100.00	330.51	345.29	336.00	345.43	0.000324	3.23	1435.83	201.07	0.16
StreamCL	1604.26	Q1.1	324.00	331.09	337.90		337.92	0.000143	1.23	263.17	50.43	0.10
StreamCL	1604.26	Q25	1925.00	331.09	342.99		343.14	0.000457	3.22	949.02	320.22	0.18
StreamCL	1604.26	Q50	2293.00	331.09	343.65		343.80	0.000470	3.41	1166.26	341.83	0.19
StreamCL	1604.26	Q100	2684.00	331.09	344.30		344.46	0.000473	3.57	1395.87	360.78	0.19
StreamCL	1604.26	Q200	3100.00	331.09	344.96		345.12	0.000469	3.70	1638.10	376.81	0.19
StreamCL	1283.94	Q1.1	324.00	330.84	337.80		337.85	0.000350	1.79	182.63	57.60	0.14
StreamCL	1283.94	Q25	1925.00	330.84	342.92		342.99	0.000332	2.53	1326.09	304.92	0.16
StreamCL	1283.94	Q50	2293.00	330.84	343.59		343.65	0.000322	2.63	1529.97	310.32	0.16
StreamCL	1283.94	Q100	2684.00	330.84	344.24		344.31	0.000318	2.74	1736.20	325.02	0.16
StreamCL	1283.94	Q200	3100.00	330.84	344.90		344.97	0.000317	2.86	1959.79	355.61	0.16
StreamCL	1112.94	Q1.1	324.00	330.72	337.74		337.78	0.000453	1.76	254.66	163.20	0.16
StreamCL	1112.94	Q25	1925.00	330.72	342.87		342.93	0.000292	2.50	1603.36	296.79	0.15
StreamCL	1112.94	Q50	2293.00	330.72	343.53		343.60	0.000301	2.67	1800.58	302.45	0.16
StreamCL	1112.94	Q100	2684.00	330.72	344.18		344.26	0.000323	2.89	2001.80	332.19	0.16
StreamCL	1112.94	Q200	3100.00	330.72	344.84		344.92	0.000329	3.05	2222.96	346.43	0.17
StreamCL	1034.95	Q1.1	324.00	331.10	337.73	333.84	337.76	0.000178	1.27	255.81	225.43	0.11
StreamCL	1034.95	Q25	1925.00	331.10	342.73	336.60	342.89	0.000491	3.26	592.09	344.28	0.20
StreamCL	1034.95	Q50	2293.00	331.10	343.35	337.00	343.55	0.000548	3.62	636.66	346.52	0.21
StreamCL	1034.95	Q100	2684.00	331.10	343.96	337.40	344.21	0.000603	3.97	680.31	348.44	0.23
StreamCL	1034.95	Q200	3100.00	331.10	344.57	337.82	344.86	0.000655	4.31	724.08	350.36	0.24
StreamCL	982		Bridge									
StreamCL	904.43	Q1.1	324.00	322.63	337.70	325.27	337.70	0.000007	0.46	712.20	210.41	0.02
StreamCL	904.43	Q25	1925.00	322.63	342.62	328.75	342.67	0.000069	1.87	1063.95	241.32	0.08
StreamCL	904.43	Q50	2293.00	322.63	343.23	329.27	343.30	0.000086	2.14	1107.36	245.15	0.09
StreamCL	904.43	Q100	2684.00	322.63	343.82	329.79	343.91	0.000104	2.42	1149.70	248.74	0.10
StreamCL	904.43	Q200	3100.00	322.63	344.40	330.32	344.51	0.000124	2.70	1191.30	252.13	0.11
StreamCL	838.83	Q1.1	324.00	331.46	337.66	334.12	337.69	0.000252	1.48	218.39	51.50	0.13
StreamCL	838.83	Q25	1925.00	331.46	342.33	336.87	342.58	0.000769	4.01	479.96	282.73	0.24
StreamCL	838.83	Q50	2293.00	331.46	342.87	337.35	343.18	0.000886	4.49	510.99	285.58	0.27
StreamCL	838.83	Q100	2684.00	331.46	343.39	337.82	343.77	0.001005	4.96	540.79	287.79	0.29
StreamCL	838.83	Q200	3100.00	331.46	343.89	338.28	344.35	0.001128	5.44	569.59	289.92	0.31
StreamCL	686.02	Q1.1	324.00	328.62	337.66		337.67	0.000049	0.82	418.00	111.19	0.06
StreamCL	686.02	Q25	1925.00	328.62	342.39		342.45	0.000197	2.10	1414.52	289.35	0.13
StreamCL	686.02	Q50	2293.00	328.62	342.96		343.03	0.000215	2.29	1578.61	290.97	0.13
StreamCL	686.02	Q100	2684.00	328.62	343.51		343.58	0.000233	2.47	1738.52	292.55	0.14
StreamCL	686.02	Q200	3100.00	328.62	344.04		344.13	0.000249	2.65	1895.45	294.08	0.15
StreamCL	419.2	Q1.1	324.00	331.59	337.59	333.56	337.64	0.000365	1.68	202.64	69.40	0.15
StreamCL	419.2	Q25	1925.00	331.59	342.18	337.31	342.35	0.000637	3.72	894.43	210.83	0.23
StreamCL	419.2	Q50	2293.00	331.59	342.72	337.90	342.92	0.000688	4.03	1009.13	212.57	0.24
StreamCL	419.2	Q100	2684.00	331.59	343.24	338.25	343.47	0.000736	4.33	1121.03	213.97	0.25
StreamCL	419.2	Q200	3100.00	331.59	343.75	338.91	344.00	0.000783	4.62	1230.79	215.33	0.26
StreamCL	216.64	Q1.1	324.00	331.38	337.54	333.49	337.57	0.000244	1.50	228.52	67.23	0.13
StreamCL	216.64	Q25	1925.00	331.38	342.03	336.77	342.22	0.000664	3.67	775.71	187.40	0.23
StreamCL	216.64	Q50	2293.00	331.38	342.56	337.30	342.77	0.000727	4.00	874.24	189.11	0.24
StreamCL	216.64	Q100	2684.00	331.38	343.06	337.80	343.31	0.000786	4.33	970.43	190.41	0.25
StreamCL	216.64	Q200	3100.00	331.38	343.56	338.32	343.84	0.000843	4.64	1064.65	191.68	0.26
StreamCL	31.36	Q1.1	324.00	331.88	337.43		337.50	0.000607	2.10	176.83	99.93	0.19
StreamCL	31.36	Q25	1925.00	331.88	341.96		342.06	0.000576	3.13	1030.51	248.63	0.21
StreamCL	31.36	Q50	2293.00	331.88	342.49		342.60	0.000586	3.31	1162.22	250.28	0.21
StreamCL	31.36	Q100	2684.00	331.88	343.00		343.12	0.000596	3.49	1290.73	251.64	0.22
StreamCL	31.36	Q200	3100.00	331.88	343.50		343.63	0.000609	3.67	1416.49	253.09	0.22
StreamCL	-121.5	Q1.1	324.00	331.36	337.40		337.43	0.000178	1.24	266.07	72.00	0.10
StreamCL	-121.5	Q25	1925.00	331.36	341.86		341.98	0.000439	3.01	936.01	209.20	0.18
StreamCL	-121.5	Q50	2293.00	331.36	342.37		342.51	0.000482	3.28	1043.37	210.99	0.19
StreamCL	-121.5	Q100	2684.00	331.36	342.87		343.02	0.000523	3.54	1148.41	212.87	0.20
StreamCL	-121.5	Q200	3100.00	331.36	343.35		343.53	0.000562	3.79	1251.60	215.05	0.21
StreamCL	-459.58	Q1.1	324.00	331.35	337.29		337.34	0.000343	1.82	178.07	42.17	0.14

HEC-RAS Plan: NEXT75_338Shlvs River: StreamCL Reach: StreamCL (Continued)

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)	
StreamCL	-459.58	Q25	1925.00	331.35	341.34		341.68	0.001315	4.98	657.26	232.14	0.31
StreamCL	-459.58	Q50	2293.00	331.35	341.80		342.18	0.001427	5.37	764.80	236.31	0.32
StreamCL	-459.58	Q100	2684.00	331.35	342.25		342.67	0.001519	5.74	873.01	240.59	0.33
StreamCL	-459.58	Q200	3100.00	331.35	342.70		343.14	0.001598	6.07	980.85	243.44	0.35
StreamCL	-980.34	Q1.1	324.00	331.03	337.07		337.13	0.000471	1.96	167.29	65.36	0.17
StreamCL	-980.34	Q25	1925.00	331.03	340.99		341.11	0.000744	3.47	1043.90	323.37	0.23
StreamCL	-980.34	Q50	2293.00	331.03	341.45		341.58	0.000742	3.61	1195.93	324.91	0.23
StreamCL	-980.34	Q100	2684.00	331.03	341.92		342.05	0.000739	3.75	1346.77	326.59	0.23
StreamCL	-980.34	Q200	3100.00	331.03	342.37		342.51	0.000738	3.89	1495.63	327.98	0.23
StreamCL	-1650.77	Q1.1	324.00	330.91	337.06	331.95	337.07	0.000027	0.57	565.00	104.95	0.04
StreamCL	-1650.77	Q25	1925.00	330.91	340.83	333.59	340.89	0.000158	1.94	1176.18	248.54	0.11
StreamCL	-1650.77	Q50	2293.00	330.91	341.27	333.88	341.34	0.000187	2.19	1287.12	257.87	0.13
StreamCL	-1650.77	Q100	2684.00	330.91	341.70	334.17	341.79	0.000217	2.42	1401.01	266.65	0.14
StreamCL	-1650.77	Q200	3100.00	330.91	342.13	334.47	342.23	0.000246	2.65	1515.29	269.13	0.15
StreamCL	-1948.51	Q1.1	324.00	331.11	336.98	333.05	337.04	0.000430	1.95	192.60	97.41	0.16
StreamCL	-1948.51	Q25	1925.00	331.11	340.76	337.83	340.82	0.000430	2.66	1529.17	466.72	0.17
StreamCL	-1948.51	Q50	2293.00	331.11	341.20	338.18	341.26	0.000431	2.77	1734.28	469.71	0.18
StreamCL	-1948.51	Q100	2684.00	331.11	341.63	338.51	341.69	0.000430	2.87	1939.49	473.48	0.18
StreamCL	-1948.51	Q200	3100.00	331.11	342.06	338.68	342.12	0.000430	2.97	2145.22	506.24	0.18

PROPOSED CONDITIONS
Standard Table 2

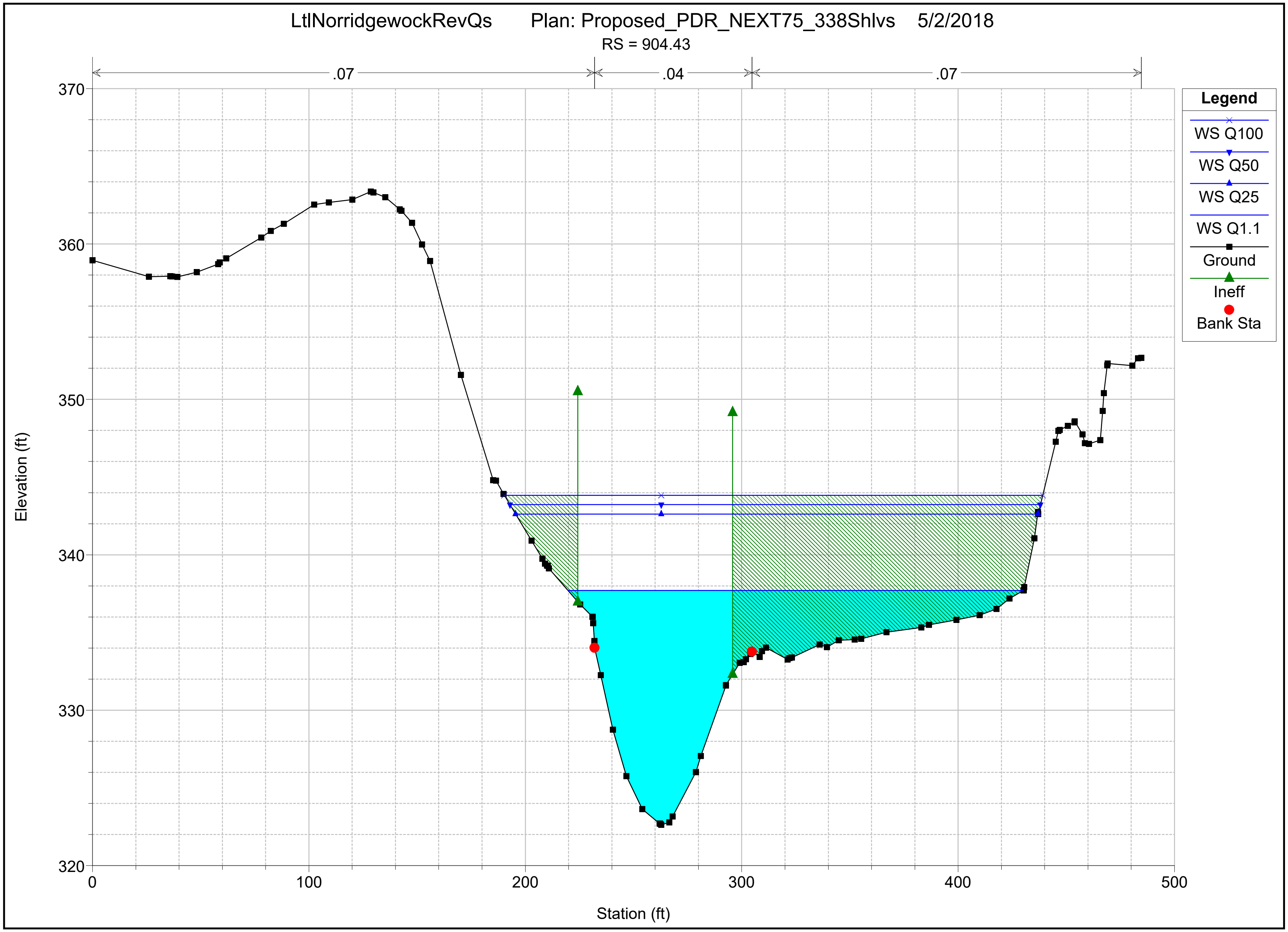
HEC-RAS Plan: NEXT75_338Shlvs River: StreamCL Reach: StreamCL

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
			(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
StreamCL	2385.65	Q1.1	338.00	337.98	0.01	0.07	0.00		324.00		52.64
StreamCL	2385.65	Q25	343.40	343.31	0.09	0.26	0.01	1.31	1721.56	202.13	178.02
StreamCL	2385.65	Q50	344.09	343.98	0.10	0.28	0.01	2.66	2009.67	280.67	183.09
StreamCL	2385.65	Q100	344.76	344.64	0.12	0.29	0.00	4.51	2310.94	368.55	189.01
StreamCL	2385.65	Q200	345.43	345.29	0.14	0.30	0.00	6.68	2623.49	469.84	201.07
StreamCL	1604.26	Q1.1	337.92	337.90	0.02	0.07	0.00		324.00		50.43
StreamCL	1604.26	Q25	343.14	342.99	0.15	0.12	0.03	1.01	1755.80	168.19	320.22
StreamCL	1604.26	Q50	343.80	343.65	0.16	0.12	0.03	2.01	1992.42	298.57	341.83
StreamCL	1604.26	Q100	344.46	344.30	0.16	0.12	0.03	3.45	2219.57	460.99	360.78
StreamCL	1604.26	Q200	345.12	344.96	0.17	0.12	0.03	5.38	2439.93	654.70	376.81
StreamCL	1283.94	Q1.1	337.85	337.80	0.05	0.07	0.00	0.07	323.74	0.19	57.60
StreamCL	1283.94	Q25	342.99	342.92	0.06	0.05	0.00	556.48	1096.10	272.42	304.92
StreamCL	1283.94	Q50	343.65	343.59	0.07	0.05	0.00	679.93	1230.36	382.71	310.32
StreamCL	1283.94	Q100	344.31	344.24	0.07	0.05	0.00	815.41	1377.67	490.91	325.02
StreamCL	1283.94	Q200	344.97	344.90	0.07	0.06	0.00	965.43	1539.59	594.98	355.61
StreamCL	1112.94	Q1.1	337.78	337.74	0.04	0.02	0.01	20.17	301.58	2.24	163.20
StreamCL	1112.94	Q25	342.93	342.87	0.06	0.03	0.01	428.29	1079.33	417.38	296.79
StreamCL	1112.94	Q50	343.60	343.53	0.06	0.03	0.01	520.05	1242.13	530.82	302.45
StreamCL	1112.94	Q100	344.26	344.18	0.08	0.03	0.02	630.46	1440.25	613.29	332.19
StreamCL	1112.94	Q200	344.92	344.84	0.08	0.04	0.02	736.98	1619.56	743.46	346.43
StreamCL	1034.95	Q1.1	337.76	337.73	0.02	0.01	0.01		324.00		225.43
StreamCL	1034.95	Q25	342.89	342.73	0.17	0.02	0.04	1.74	1923.26		344.28
StreamCL	1034.95	Q50	343.55	343.35	0.20	0.02	0.05	2.71	2290.29		346.52
StreamCL	1034.95	Q100	344.21	343.96	0.24	0.02	0.05	3.87	2680.13		348.44
StreamCL	1034.95	Q200	344.86	344.57	0.29	0.02	0.06	5.24	3094.76		350.36
StreamCL	982		Bridge								
StreamCL	904.43	Q1.1	337.70	337.70	0.00	0.00	0.01	0.67	323.33		210.41
StreamCL	904.43	Q25	342.67	342.62	0.05	0.04	0.06	26.40	1898.60		241.32
StreamCL	904.43	Q50	343.30	343.23	0.07	0.04	0.07	34.39	2258.62		245.15
StreamCL	904.43	Q100	343.91	343.82	0.09	0.05	0.09	43.47	2640.53		248.74
StreamCL	904.43	Q200	344.51	344.40	0.11	0.06	0.10	53.72	3046.28		252.13
StreamCL	838.83	Q1.1	337.69	337.66	0.03	0.01	0.01		324.00		51.50
StreamCL	838.83	Q25	342.58	342.33	0.25	0.05	0.08		1925.00		282.73
StreamCL	838.83	Q50	343.18	342.87	0.31	0.06	0.10		2293.00		285.58
StreamCL	838.83	Q100	343.77	343.39	0.38	0.06	0.12		2684.00		287.79
StreamCL	838.83	Q200	344.35	343.89	0.46	0.07	0.15		3100.00		289.92
StreamCL	686.02	Q1.1	337.67	337.66	0.01	0.03	0.00	1.60	322.40		111.19
StreamCL	686.02	Q25	342.45	342.39	0.06	0.09	0.01	283.81	1639.70	1.48	289.35
StreamCL	686.02	Q50	343.03	342.96	0.07	0.09	0.01	387.46	1903.15	2.39	290.97
StreamCL	686.02	Q100	343.58	343.51	0.08	0.10	0.01	503.65	2176.79	3.56	292.55
StreamCL	686.02	Q200	344.13	344.04	0.09	0.11	0.02	632.44	2462.54	5.02	294.08
StreamCL	419.2	Q1.1	337.64	337.59	0.04	0.06	0.00	2.19	321.78	0.03	69.40
StreamCL	419.2	Q25	342.35	342.18	0.18	0.13	0.00	205.08	1543.50	176.42	210.83
StreamCL	419.2	Q50	342.92	342.72	0.20	0.14	0.00	258.19	1778.47	256.34	212.57
StreamCL	419.2	Q100	343.47	343.24	0.22	0.15	0.00	315.46	2020.55	347.99	213.97
StreamCL	419.2	Q200	344.00	343.75	0.25	0.16	0.00	377.16	2272.02	450.82	215.33
StreamCL	216.64	Q1.1	337.57	337.54	0.03	0.07	0.01		321.30	2.70	67.23
StreamCL	216.64	Q25	342.22	342.03	0.19	0.11	0.04	56.86	1691.43	176.71	187.40
StreamCL	216.64	Q50	342.77	342.56	0.22	0.12	0.05	95.88	1966.05	231.07	189.11
StreamCL	216.64	Q100	343.31	343.06	0.25	0.13	0.06	143.16	2249.89	290.95	190.41
StreamCL	216.64	Q200	343.84	343.56	0.28	0.13	0.07	198.09	2545.52	356.38	191.68
StreamCL	31.36	Q1.1	337.50	337.43	0.07	0.05	0.02	8.12	315.88		99.93
StreamCL	31.36	Q25	342.06	341.96	0.10	0.08	0.01	753.86	1167.00	4.14	248.63
StreamCL	31.36	Q50	342.60	342.49	0.11	0.08	0.01	956.95	1327.88	8.18	250.28
StreamCL	31.36	Q100	343.12	343.00	0.12	0.09	0.01	1175.95	1494.82	13.24	251.64
StreamCL	31.36	Q200	343.63	343.50	0.13	0.09	0.01	1410.67	1670.00	19.32	253.09
StreamCL	-121.5	Q1.1	337.43	337.40	0.02	0.08	0.01		323.18	0.82	72.00

HEC-RAS Plan: NEXT75_338Shlvs River: StreamCL Reach: StreamCL (Continued)

Reach	River Sta	Profile	E.G. Elev	W.S. Elev	Vel Head	Frctn Loss	C & E Loss	Q Left	Q Channel	Q Right	Top Width
			(ft)	(ft)	(ft)	(ft)	(ft)	(cfs)	(cfs)	(cfs)	(ft)
StreamCL	-121.5	Q25	341.98	341.86	0.12	0.24	0.07	79.99	1618.04	226.97	209.20
StreamCL	-121.5	Q50	342.51	342.37	0.14	0.26	0.07	106.87	1866.54	319.59	210.99
StreamCL	-121.5	Q100	343.02	342.87	0.16	0.28	0.08	136.83	2122.64	424.54	212.87
StreamCL	-121.5	Q200	343.53	343.35	0.18	0.30	0.08	168.96	2388.85	542.19	215.05
StreamCL	-459.58	Q1.1	337.34	337.29	0.05	0.21	0.00	0.00	324.00		42.17
StreamCL	-459.58	Q25	341.68	341.34	0.34	0.50	0.07	235.75	1685.12	4.13	232.14
StreamCL	-459.58	Q50	342.18	341.80	0.38	0.52	0.08	364.22	1922.11	6.67	236.31
StreamCL	-459.58	Q100	342.67	342.25	0.41	0.53	0.09	515.60	2158.43	9.97	240.59
StreamCL	-459.58	Q200	343.14	342.70	0.45	0.54	0.09	689.82	2396.10	14.08	243.44
StreamCL	-980.34	Q1.1	337.13	337.07	0.06	0.05	0.02	0.04	323.76	0.20	65.36
StreamCL	-980.34	Q25	341.11	340.99	0.12	0.20	0.02	247.36	1165.23	512.41	323.37
StreamCL	-980.34	Q50	341.58	341.45	0.12	0.22	0.02	331.72	1292.24	669.04	324.91
StreamCL	-980.34	Q100	342.05	341.92	0.13	0.24	0.01	424.03	1421.48	838.49	326.59
StreamCL	-980.34	Q200	342.51	342.37	0.13	0.26	0.01	523.83	1554.88	1021.29	327.98
StreamCL	-1650.77	Q1.1	337.07	337.06	0.01	0.02	0.01	0.00	324.00		104.95
StreamCL	-1650.77	Q25	340.89	340.83	0.06	0.07	0.00	47.34	1874.08	3.59	248.54
StreamCL	-1650.77	Q50	341.34	341.27	0.07	0.08	0.00	76.73	2210.44	5.84	257.87
StreamCL	-1650.77	Q100	341.79	341.70	0.09	0.09	0.01	114.45	2560.76	8.78	266.65
StreamCL	-1650.77	Q200	342.23	342.13	0.10	0.09	0.01	163.67	2923.88	12.45	269.13
StreamCL	-1948.51	Q1.1	337.04	336.98	0.06			4.07	313.98	5.94	97.41
StreamCL	-1948.51	Q25	340.82	340.76	0.06			492.60	866.69	565.71	466.72
StreamCL	-1948.51	Q50	341.26	341.20	0.06			631.63	955.40	705.98	469.71
StreamCL	-1948.51	Q100	341.69	341.63	0.06			781.21	1045.99	856.80	473.48
StreamCL	-1948.51	Q200	342.12	342.06	0.06			943.74	1139.06	1017.20	506.24

PROPOSED CONDITIONS
Cross-Sections



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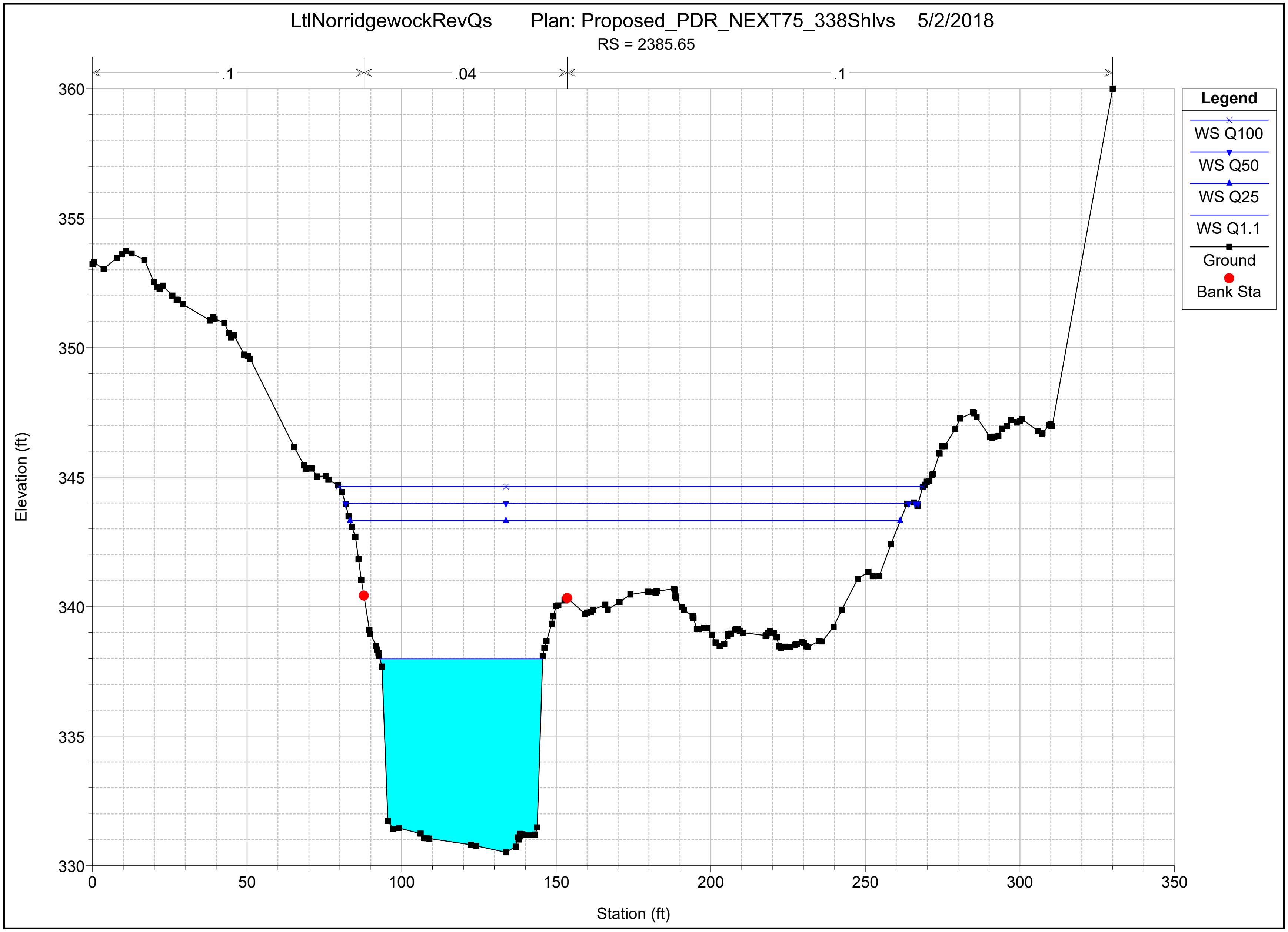
Cross-Sections



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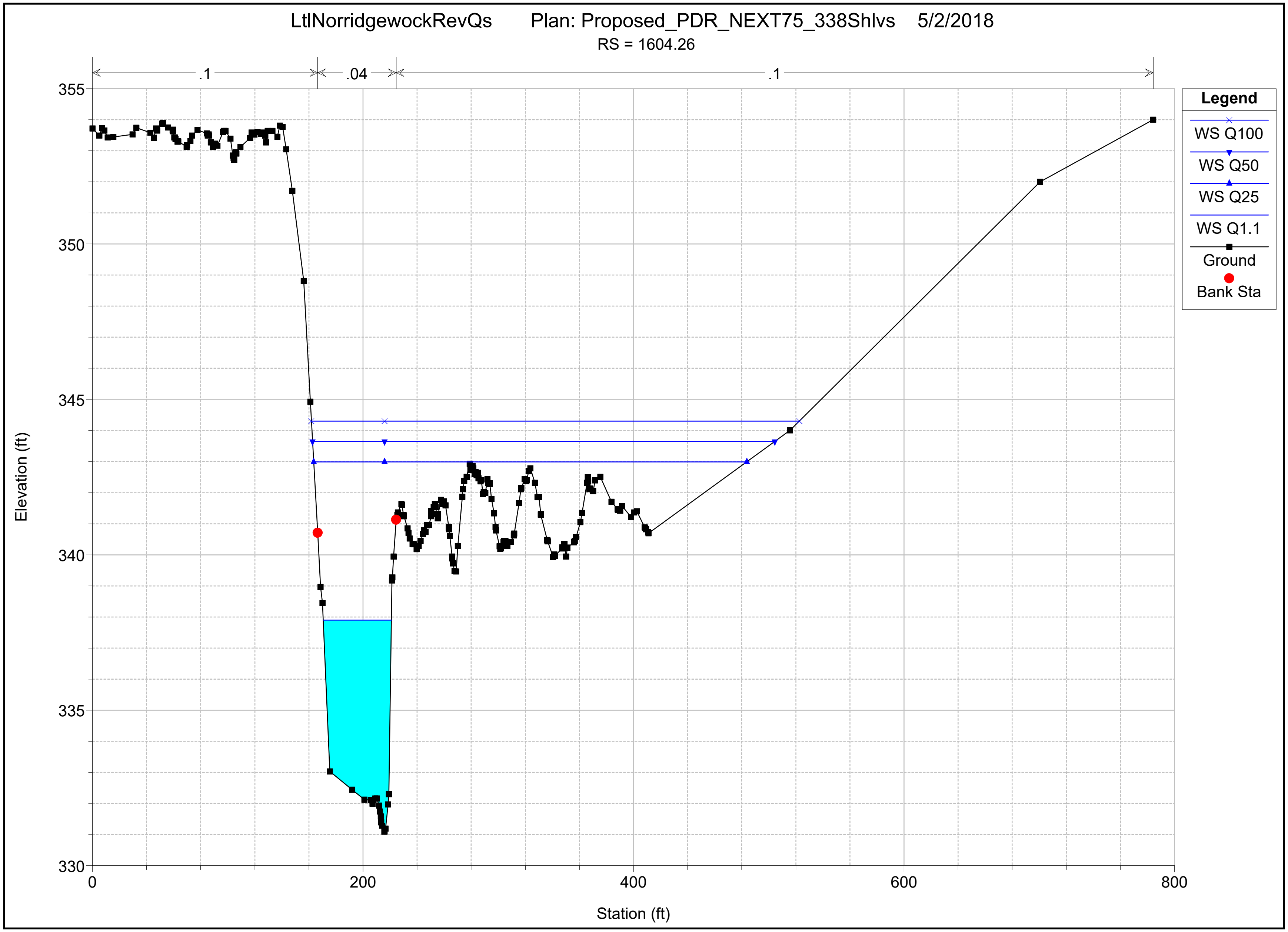

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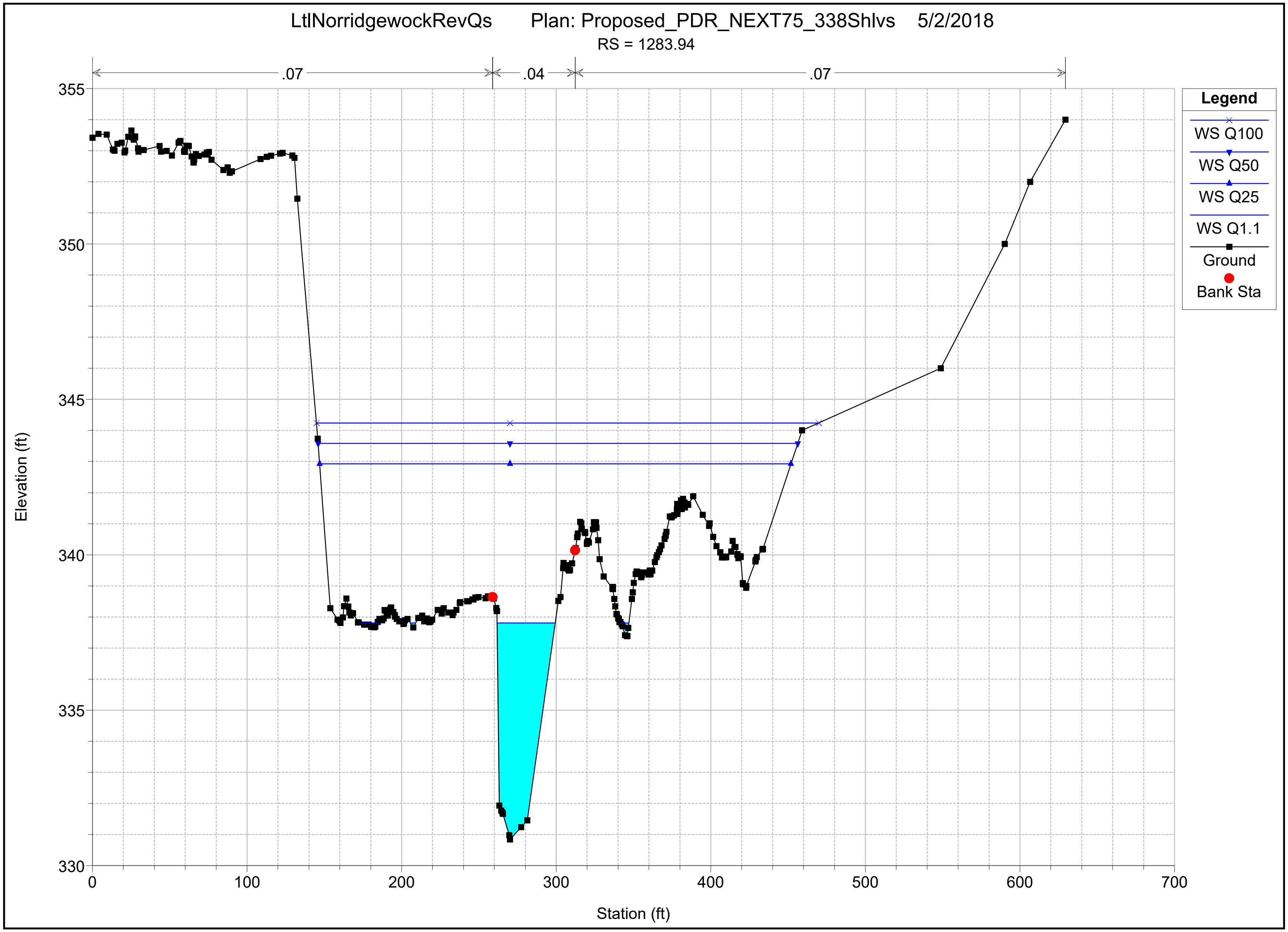
Cross-Sections



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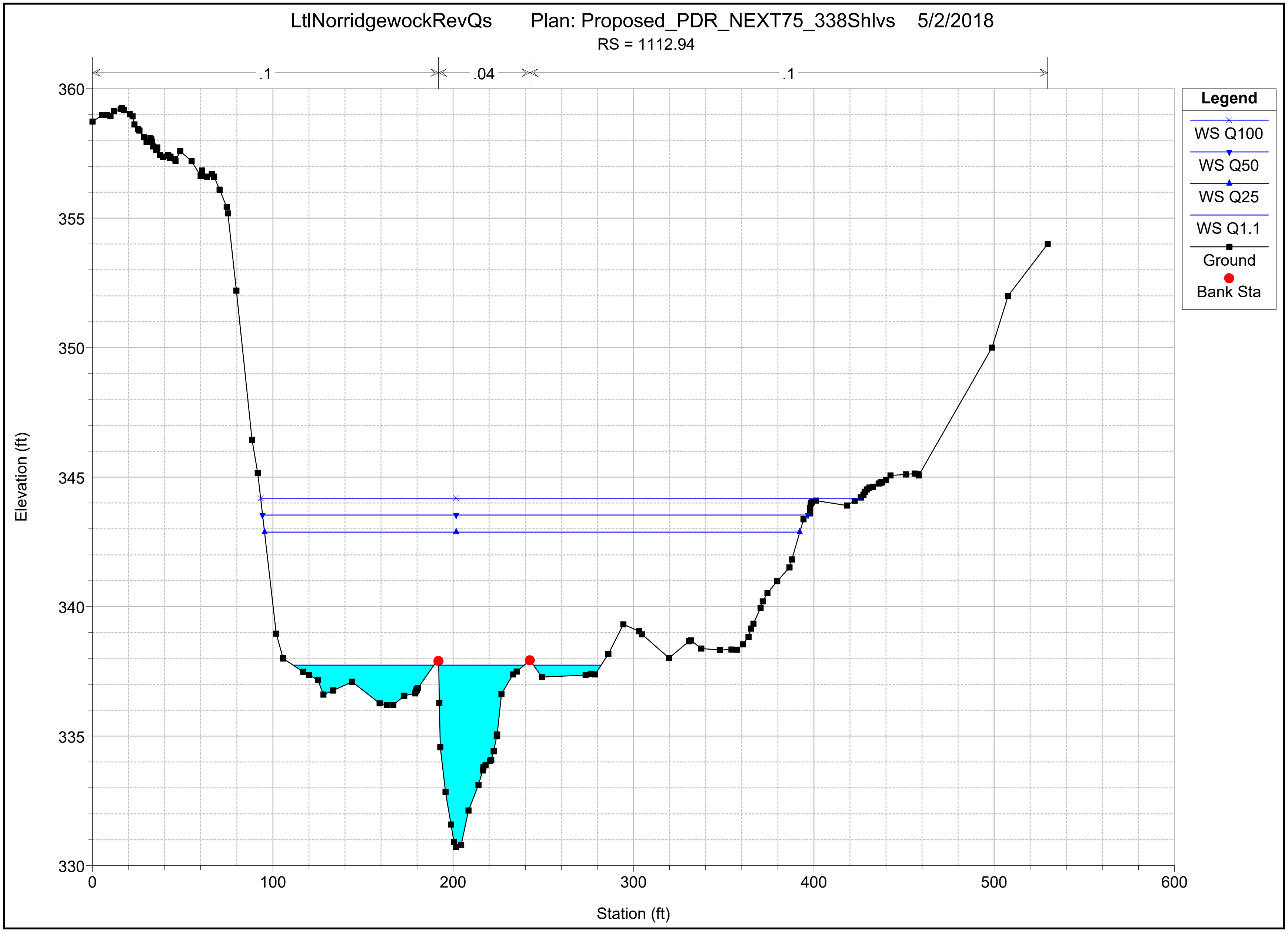
Cross-Sections



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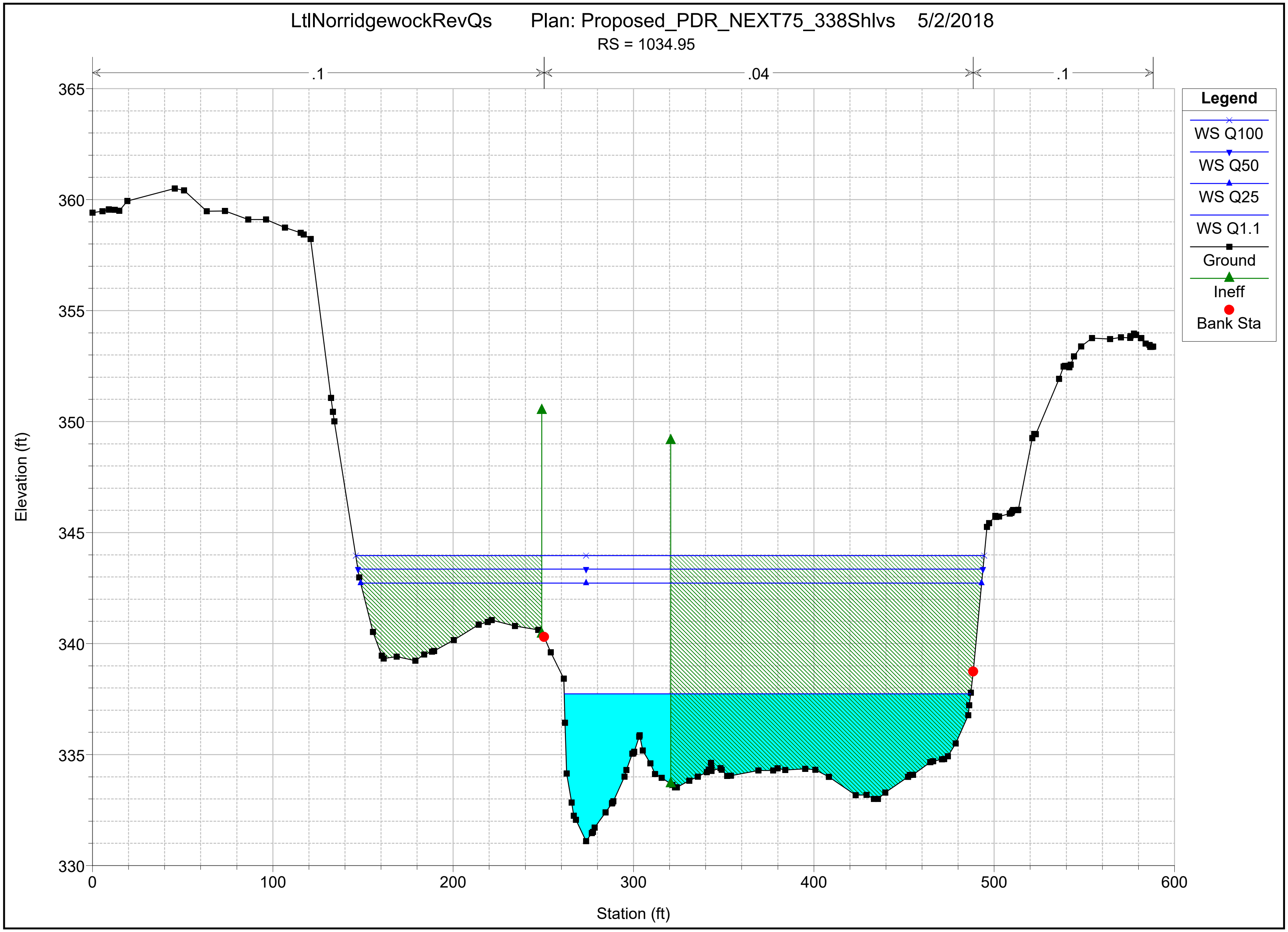
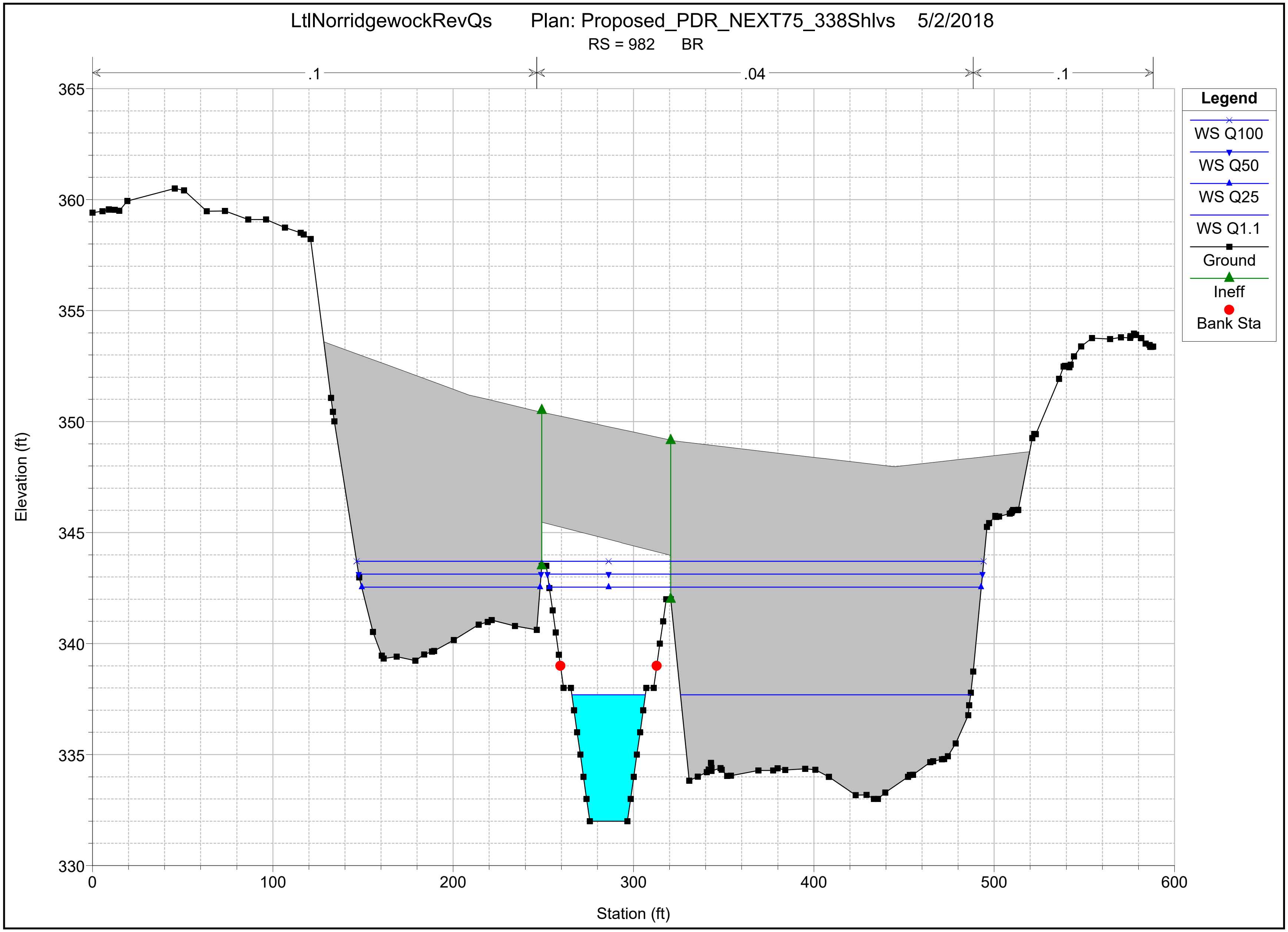
Cross-Sections



PROPOSED CONDITIONS
Cross-Sections



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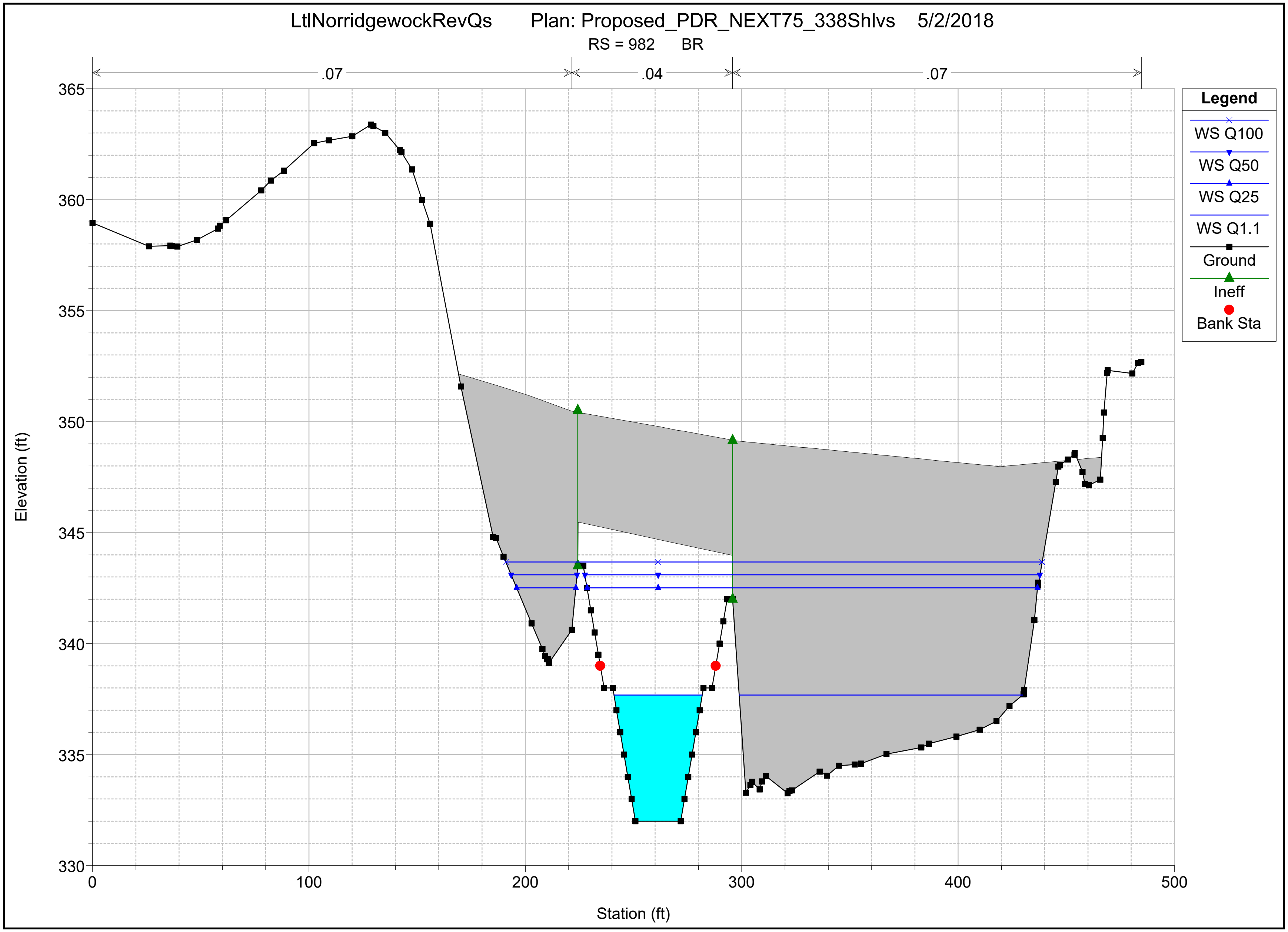
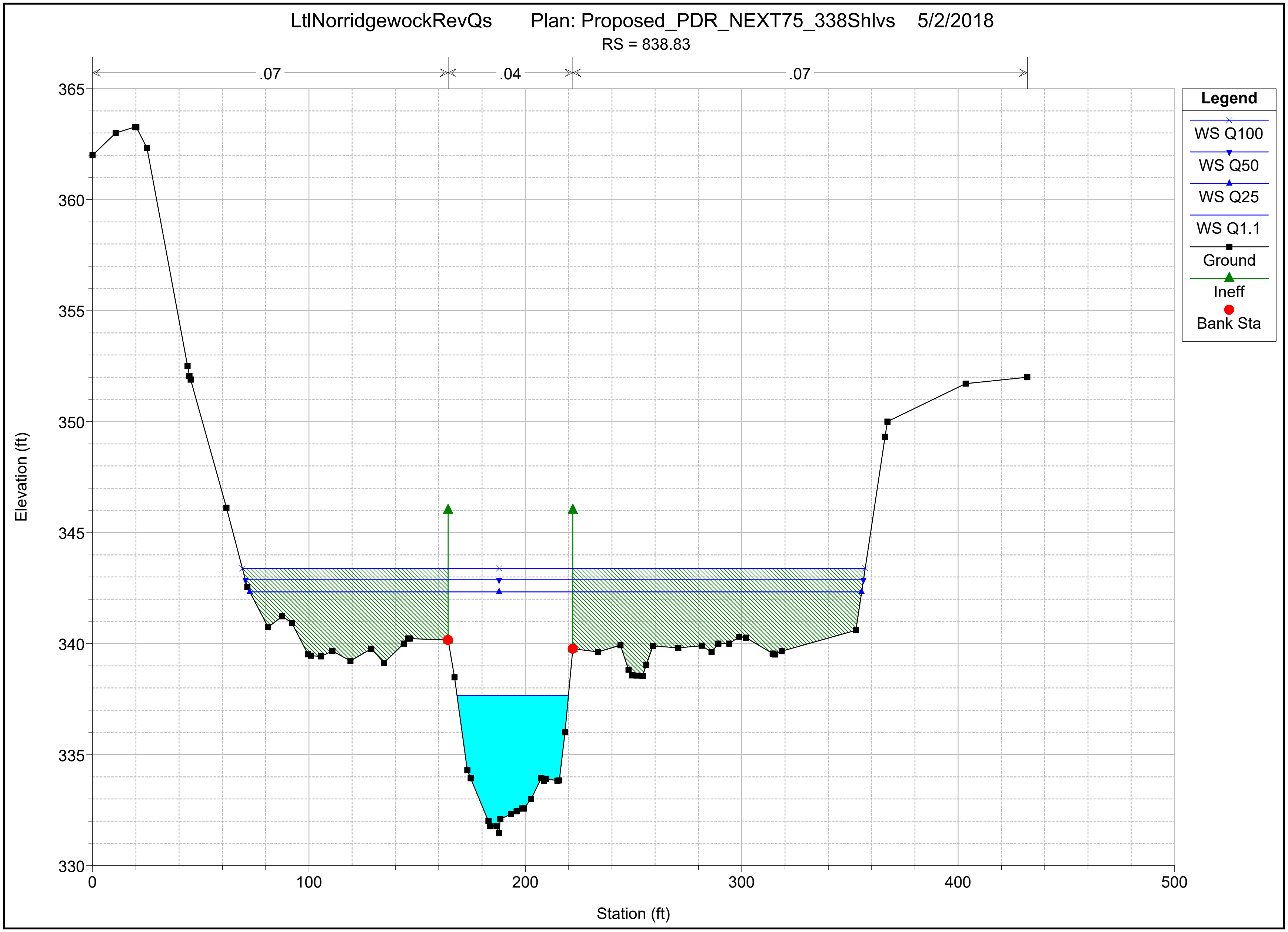
Cross-Sections



PROPOSED CONDITIONS
Cross-Sections



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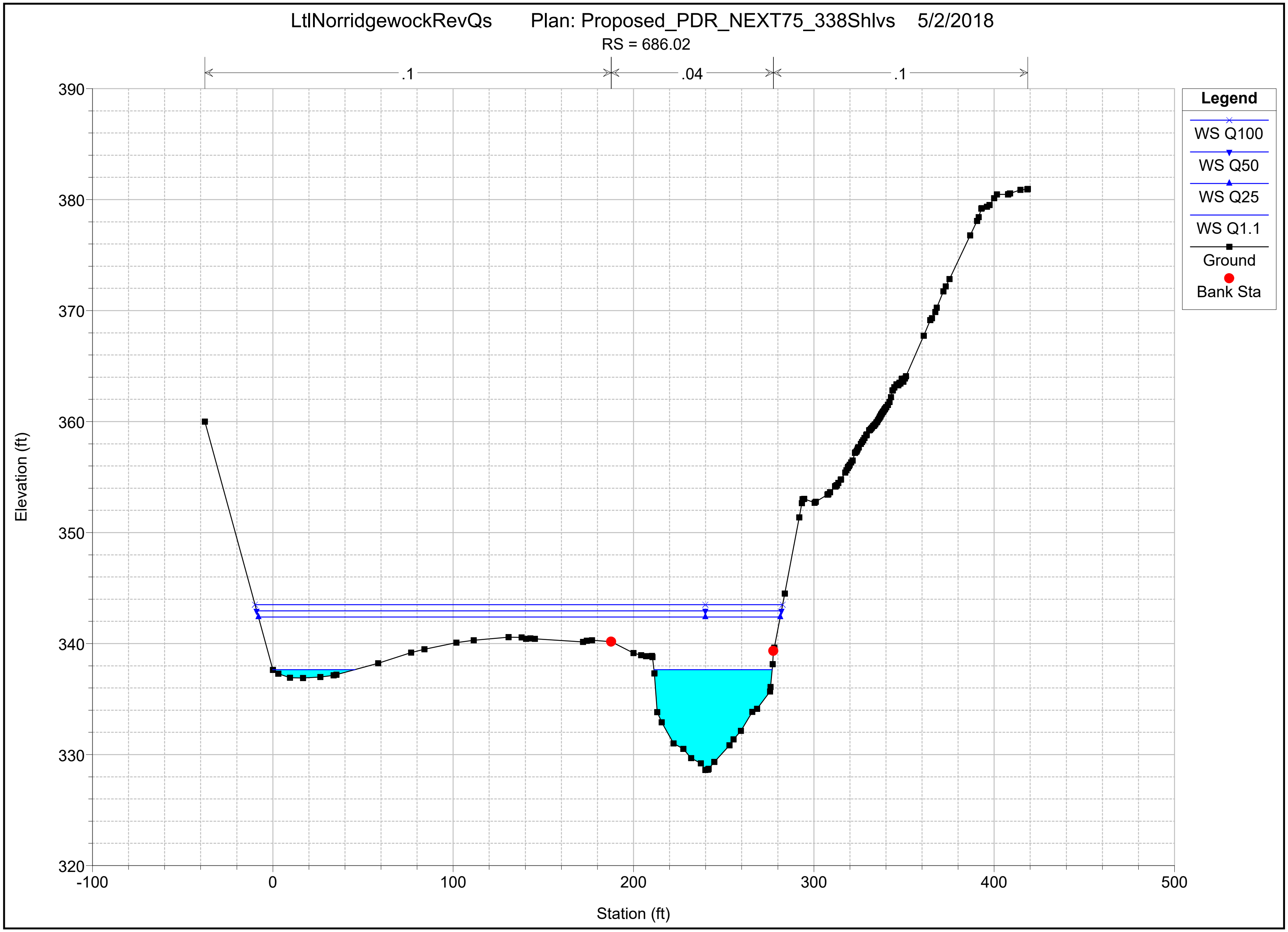
Cross-Sections



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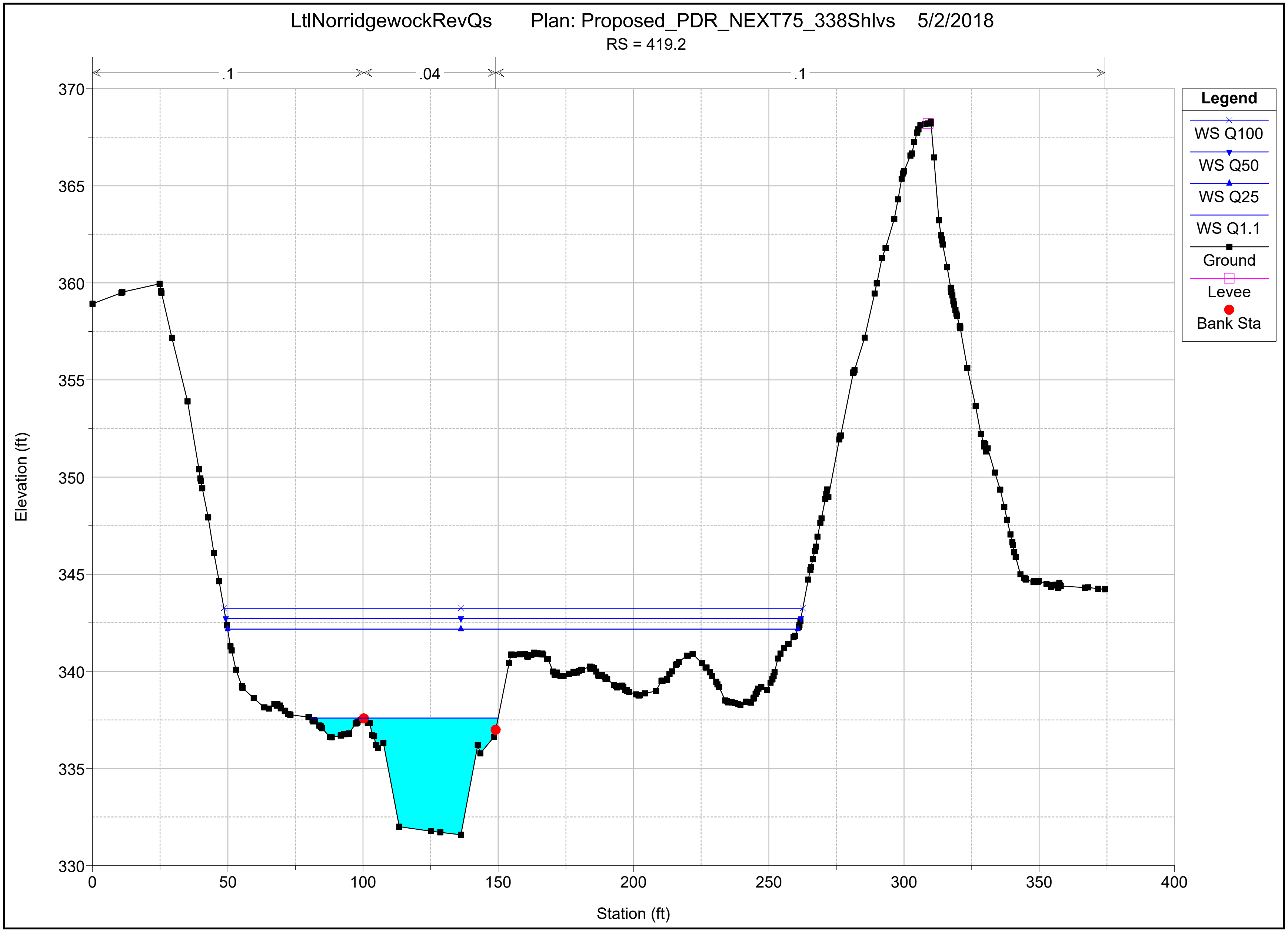

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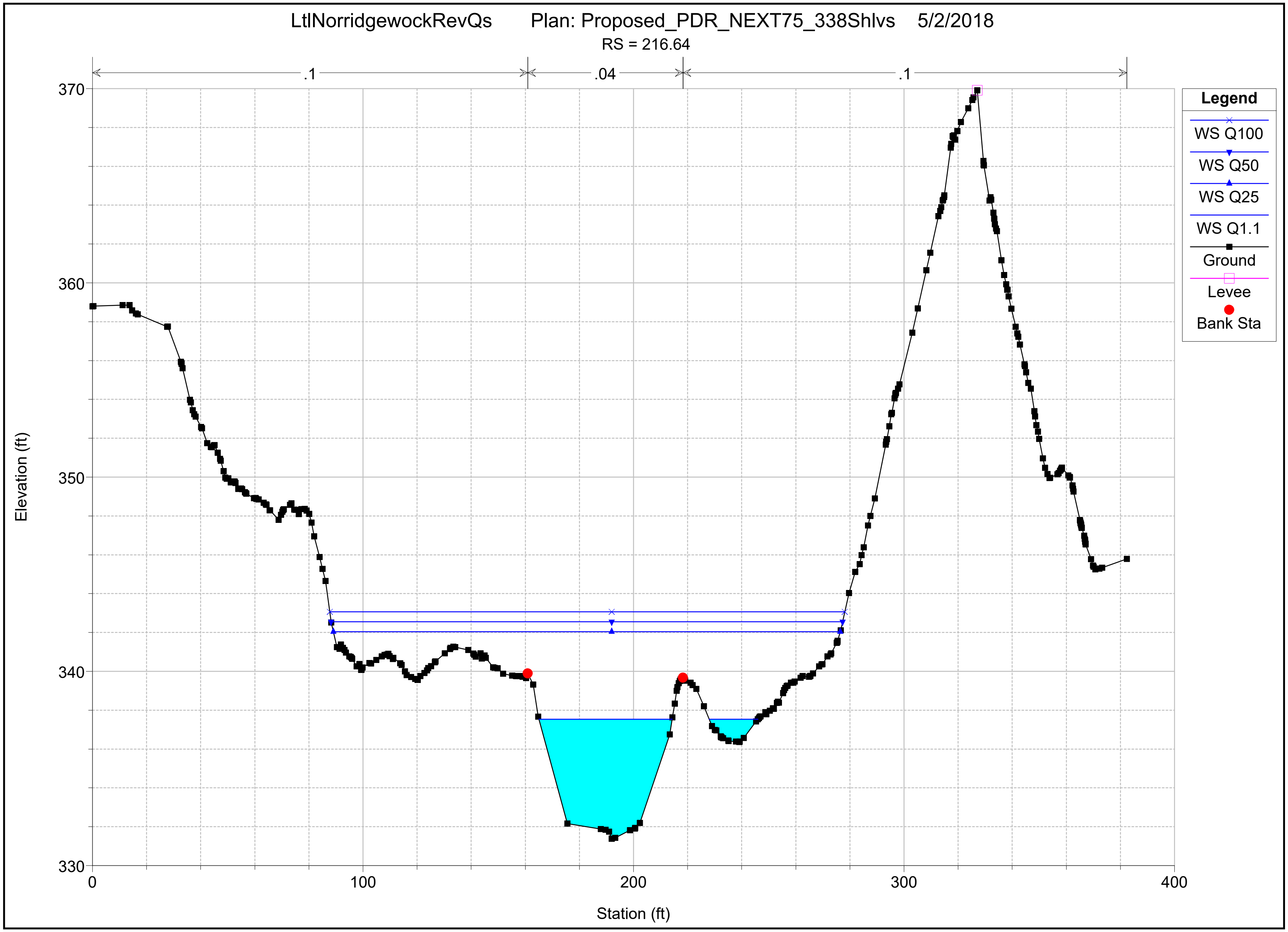

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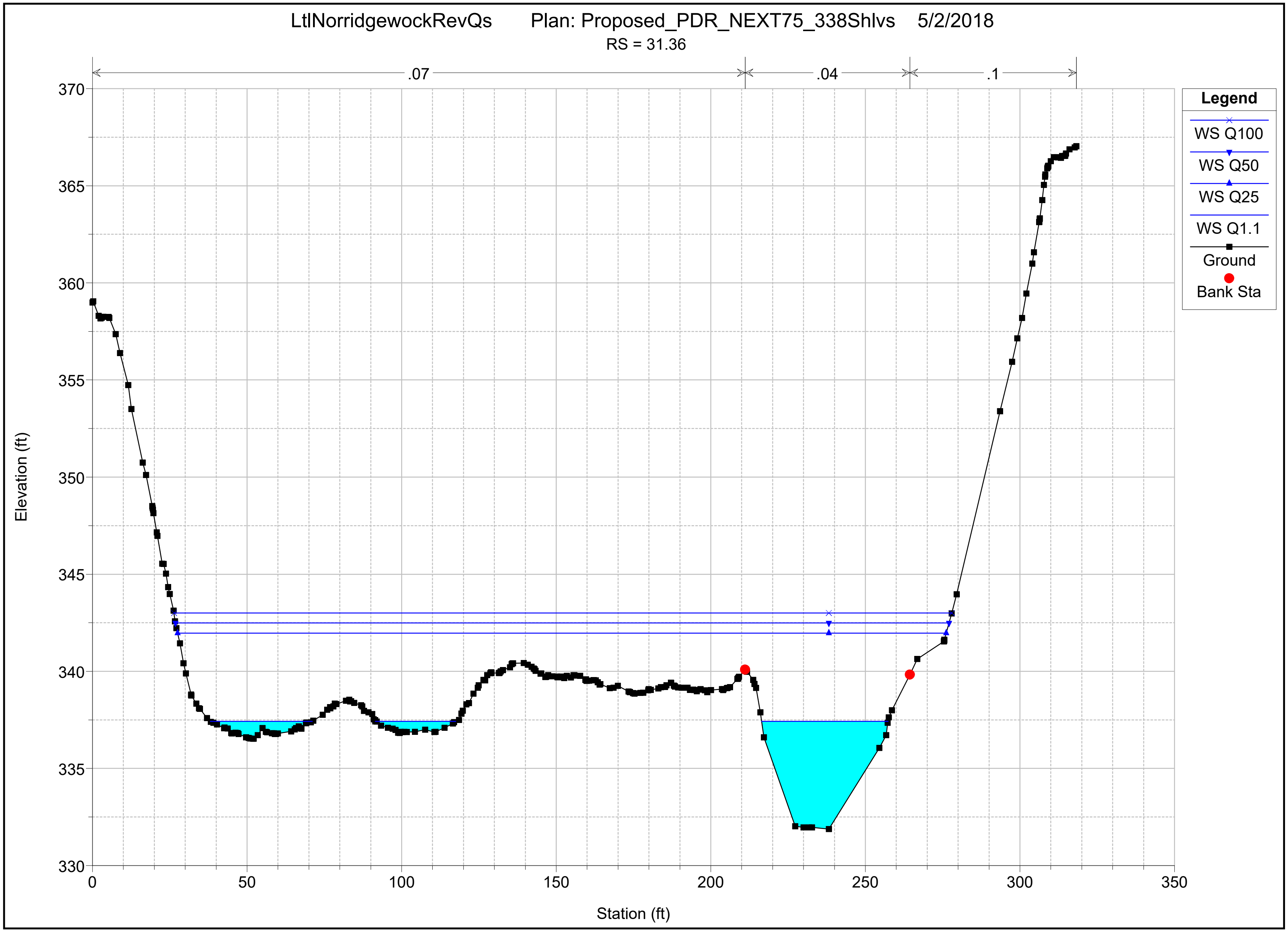
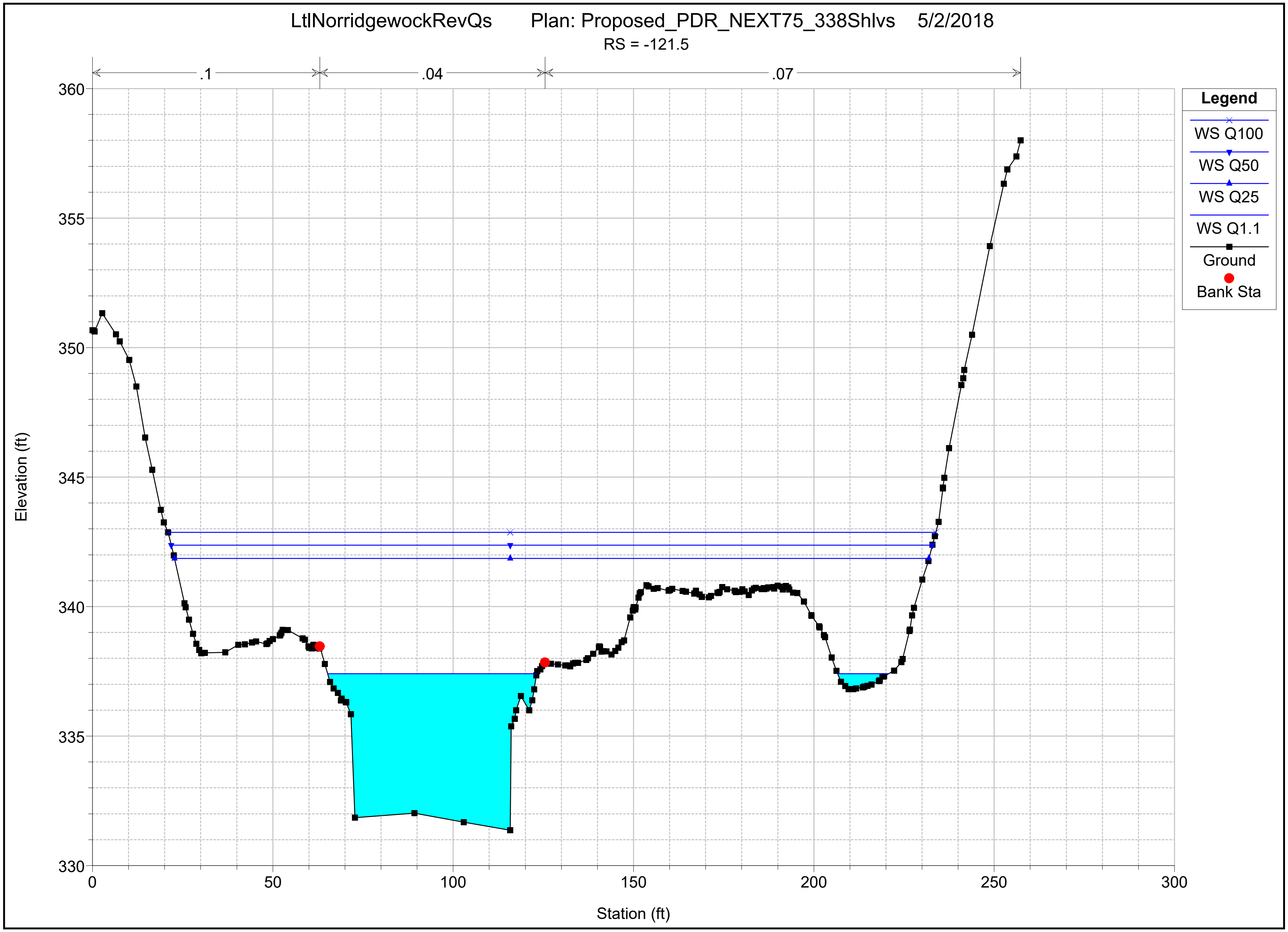
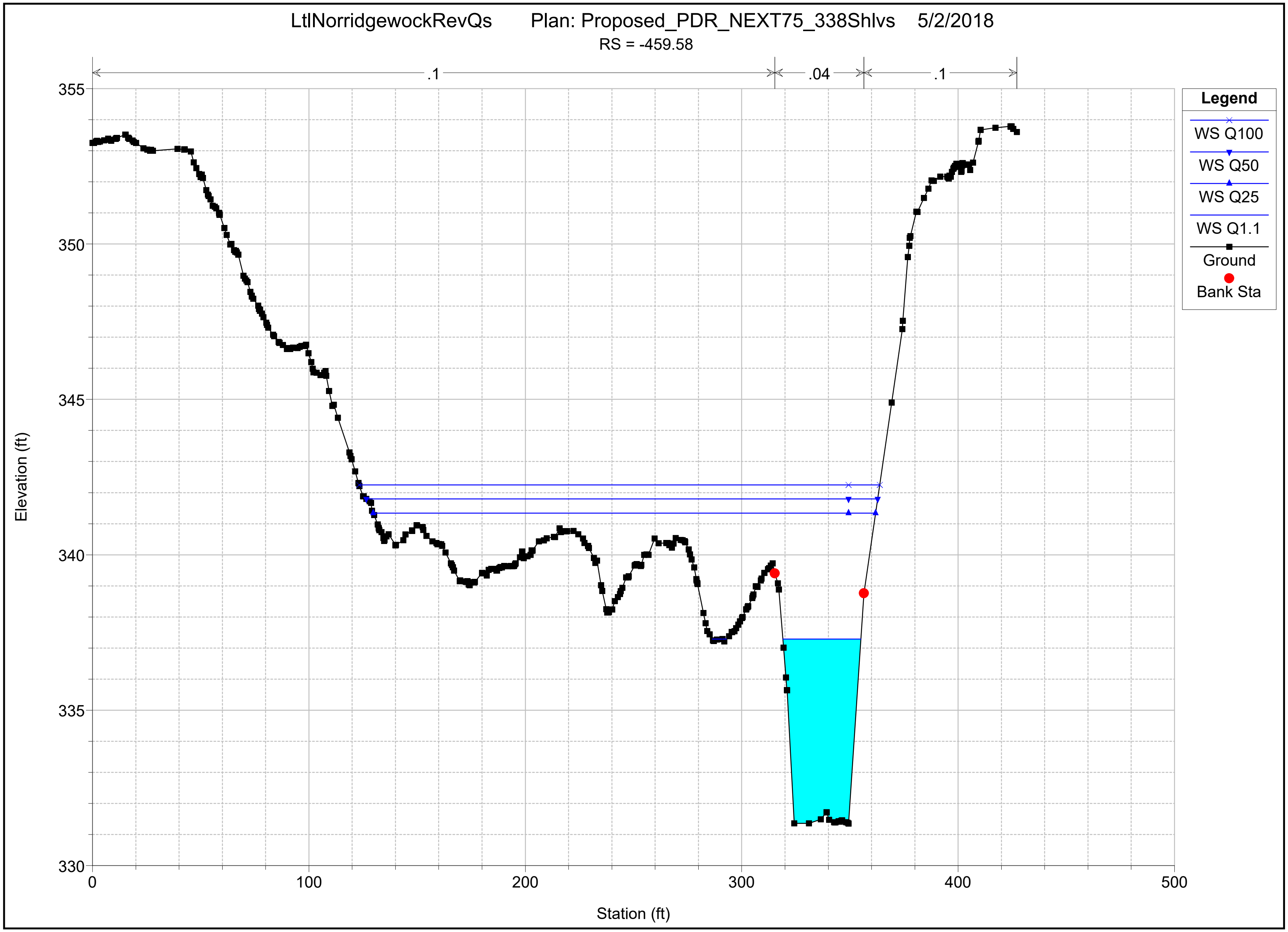
Cross-Sections



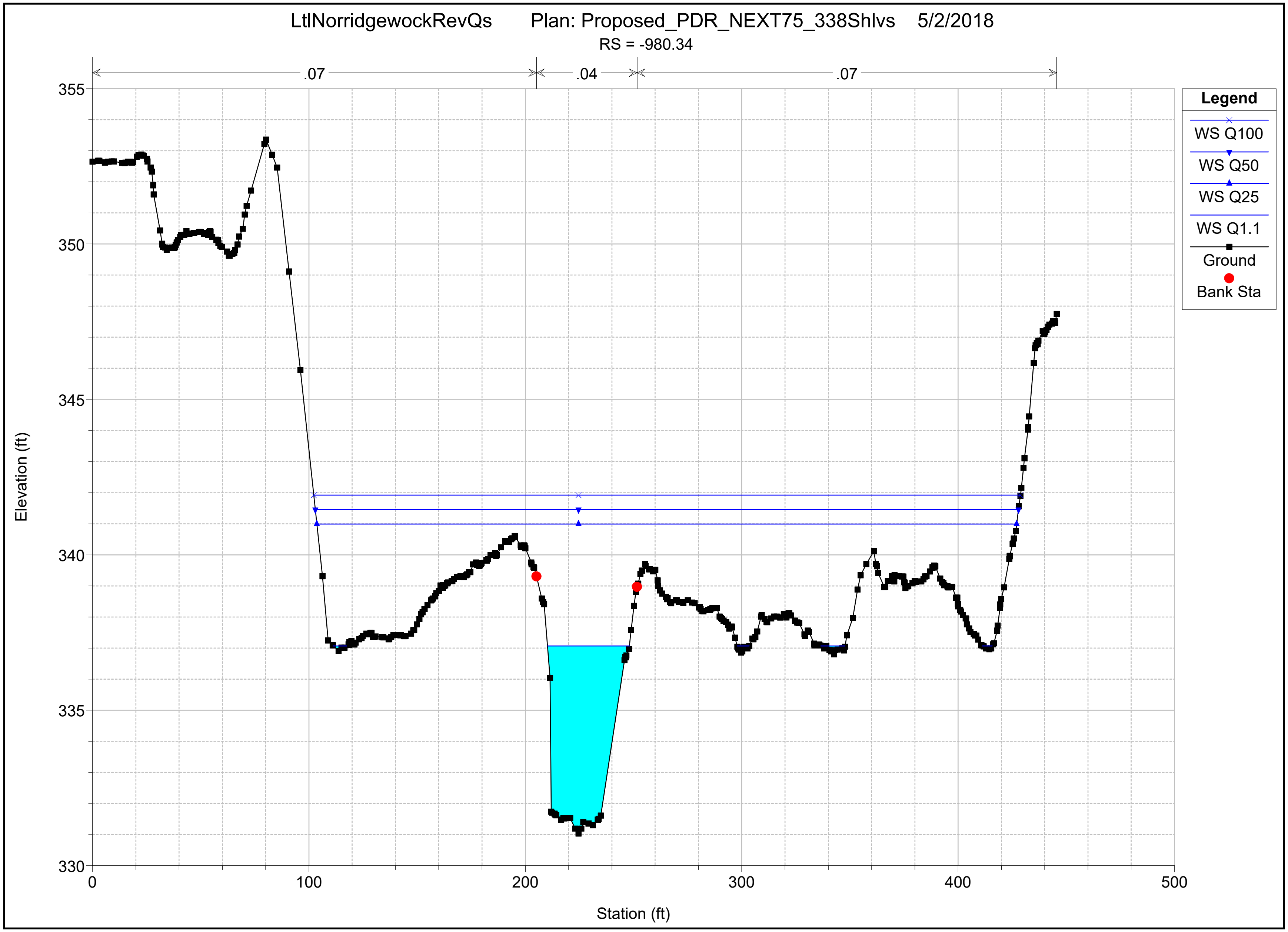
PROPOSED CONDITIONS
Cross-Sections



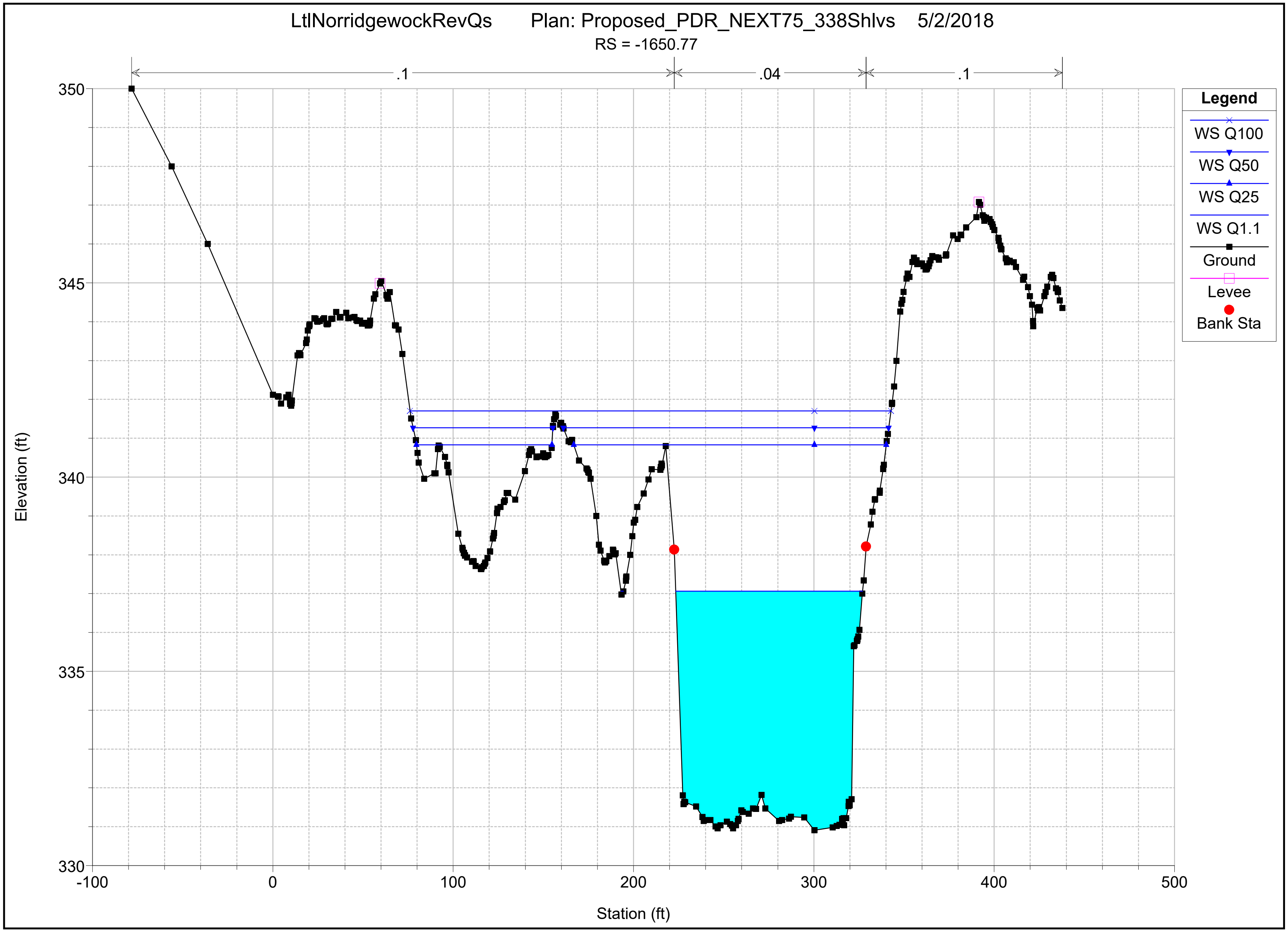
PROPOSED CONDITIONS
Cross-Sections



PROPOSED CONDITIONS
Cross-Sections



PROPOSED CONDITIONS
Cross-Sections



PROPOSED CONDITIONS
Cross-Sections