Pekin Brook Floodplain Mapping and Calais Town Hall Alternatives Analysis

Calais, Vermont
September 22, 2016

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Prepared for:
Town of Calais
Calais Historic Preservation Commission
3120 Pekin Brook Road
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MMI #5884-01-3

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1.0 INTRODUCTION

1.1 Background

The historic town hall in Calais, Vermont is in need of repairs. The building sits in a Federal Emergency Management Agency (FEMA) designated approximate (Zone A) special flood hazard area (SFHA). As part of this study, a detailed hydraulic analysis has been conduction to evaluate the limits and elevation of the base flood (i.e., the 1% annual exceedance probability flood or the 100-year flood in Calais). The detailed analysis was used to guide alternatives and understand regulatory feasibility.

1.2 Channel Geomorphology

Channel dimension measurements were made at the project site. The bankfull channel width of Pekin Brook is 22 feet, and the bankfull channel depth is 2 feet. The bankfull channel width of Elmslie Brook is 9 feet, and the bankfull channel depth is 1 foot.

The profile of Pekin Brook indicates that the culvert crossing under Kent Hill Road is located at a break in channel slope, which increases the risk of structure clogging. The channel approaching the culvert is a steep, narrow, mountainous stream and features high sediment bedload and woody debris. The channel sediment is primarily cobble and boulders, with bedrock grade control upstream. Survey data collected shows that sediment deposition has occurred at the culvert inlet, indicating that the culvert is not capable of fully passing the bedload. Based on the setting and high sediment bedload, the culvert is susceptible to clogging during floods. The culvert has clogged in the past during flooding.

Pekin Brook was assessed in 2007 (SGA T3.07). Bankfull dimensions are not present. The mean slope of the reach over 1,500 feet was 5.3%, and the channel was found to be a step-pool system with a cobble bed (channel type B) (VTANR, 2009). This assessment information matches the steeper parts of the channel upstream of the culvert yet differs from the floodplain channel in the project area.

1.3 Structure Geomorphic Compatibility

Geomorphic compatibility screening (Schiff et al., 2008) is a tool used to indicate how well a structure fits the channel that it crosses. The geomorphic compatibility score is made up of five variables:

- Percent bankfull width (structure width/bankfull channel width x 100)
- Sediment and debris continuity – upstream deposits and downstream scour
- Structure slope versus channel slope and break in valley slope
- Approach angle
- Bank armoring and erosion upstream and downstream

Both culverts under Kent Hill Road were found to be mostly incompatible with current channel form and process having a moderate to high risk of structure failure. "Re-design and replacement planning should be initiated to improve geomorphic compatibility" (Schiff et al., 2008).

Percent bankfull width measurements show that the Pekin Brook culvert width is only 55% of the measured channel width while the Elmslie Brook width is 75% of the channel width. The culverts are fundamentally undersized relative to the stream channel.

2.0 HYDROLOGY

Peak flow rates were estimated using statistical analysis of United States Geological Survey (USGS) stream gage data and two different sets of regional regression equations. The drainage area calculated as 11.2 square miles at the Pekin Brook culvert and 12.6 square miles to the downstream limit of the study reach.

Statistical analysis of annual peak flow gage data obtained from regional USGS streamflow gage stations was used to estimate peak flow rates (USGS, 1982). Estimated peak flows at the gages were scaled to the study area by watershed. Gages were selected based on proximity to the Pekin Brook study area and similarities in watershed characteristics (Table 1).

TABLE 1
Scaled Peak Flow Estimates Based on Gage Analysis (cfs)

	Recurrence Interval				
USGS Stream Gage	**2-year**	**10-year**	**50-year**	**100-year**	**500-year**
Scaled from Bryant Brook (USGS 04288400)	468	736	936	1,013	1,180
Scaled from Pope Brook (USGS 01135150)	426	796	1,401	1,774	3,036
Scaled from East Orange Branch (USGS 0113980)	337	667	1,025	1,196	1,646
Scaled from Bailey Brook (USGS 04290700)	298	551	886	1,069	1,615

Estimated peak flow rates were obtained from the *StreamStats* interactive website based on regional regression equations for the State of Vermont published by the USGS (Olson, 2002) (Table 2).

TABLE 2
Peak Flow Estimates Based on USGS *StreamStats* (cfs)

Recurrence Interval				
2-year	**10-year**	**50-year**	**100-year**	**500-year**
318	628	987	1,160	1,640

Peak flow rates were estimated based on the analysis outlined in a report published by the New England Transportation Consortium under the Federal Highway Administration (Jacobs, 2010) (Table 3). The report is titled *Estimating the Magnitude of Peak Flows for Steep Gradient Streams in New England* and uses regression equations to estimate peak flows for streams with a channel slope greater than 50 feet per mile (or approximately 1%). Although the lower portion of Pekin Brook downstream of the town hall does not meet the slope criteria, the upper channel has a slope greater than 1%, and almost all of the contributing watershed is located upstream of Kent Hill Road.

TABLE 3
Peak Flow Estimates Based on Steep Streams Regression Equations (cfs)

Recurrence Interval				
2-year	**10-year**	**50-year**	**100-year**	**500-year**
345	731	1,190	1,414	2,142

The results of the hydrologic analysis for the Pekin Brook study area indicate that there is generally good agreement between methods for the 2-year and 10-year floods; however, the results are more variable for the larger infrequent floods. For this analysis, the largest peak flow rates were used as a conservative approach (Table 4).

TABLE 4
Design Peak Flow Rates (cfs)

Recurrence Interval				
2-year	**10-year**	**50-year**	**100-year**	**500-year**
468	796	1,401	1,774	3,036

3.0 HYDRAULIC MODELING

3.1 Model Introduction

Hydraulic modeling was performed to map the floodplain and to determine the based flood elevation at Calais Town Hall. The *Hydrologic Engineering Center River Analysis System* (HEC-RAS) (USACE, 2016) computer software was used for this study to compute flood profiles for multiple flow conditions, including both subcritical (i.e., slow, tranquil, and deep) and supercritical (i.e., fast, turbulent, and shallow) flow. Common FEMA methods were followed so that map amendments can be performed in the future with the data from this study.

3.2 Model Setup

3.2.1 Survey

Field survey of channel cross sections, channel profile, some floodplain, and some nearby infrastructure was conducted in July 2016 by Little River Survey of Stowe, Vermont. The survey cross sections were located to define the channel, floodplain, and culverts.

The field survey collected references the North American Vertical Datum of 1988 (NAVD88) with units of feet. The Vermont State Planes, North American Datum of 1983 (NAD83) in units of feet was used as the horizontal datum.

3.2.2 Geometry

Pekin Brook was modeled as a single reach beginning at a point approximately 1,000 feet downstream of Kent Hill Road. The model extends up through the Kent Hill Road crossing to a point approximately 250 feet upstream for a total of 1,300 feet. The study reach includes the two culvert crossings at Kent Hill Road as well as the Calais Town Hall building positioned between Pekin Brook and Elmslie Brook.

The hydraulic roughness (i.e., Manning's N) is determined at each cross section location by the substrate on the channel bed, the surface of structures, the type of vegetation present on the channel banks, and the land cover on the floodplains. Higher N values indicate more hydraulic roughness that slows flow and dissipates energy. N values used to define the roughness in the channel ranged from 0.045 to 0.050, representing a cobble and gravel stream with some boulders and debris. N values used on the overbank areas and floodplains ranged from 0.06 to 0.08 in developed areas to 0.12 in areas with heavy vegetation and brush or forested areas.

3.2.3 Model Analysis and Boundary Conditions

The hydraulic model was performed in steady state mode, meaning one estimated peak flow value was used to evaluate the flood conditions for each storm event without variation over time. The model was executed using a subcritical flow regime, which computes the most conservative flood profiles and is the FEMA standard for inundation-based studies such as this.

The upstream and downstream boundary conditions were set to normal flow associated with a channel slope of 0.015 feet/feet (1.5%) at the upstream model limit and a slope of 0.0013 feet/feet (0.13%) at the downstream limit.

3.3 Model Validation

Model validation was primarily based on the 1984 flood and other information about local flood patterns. There were no known high water marks to reference for model validation. Flood levels in 1984 reportedly reached approximately 28 inches above the first floor inside the town hall. The RAS model indicates that the depth of flooding at the town hall would be approximately 8 inches during the base flood; however, the modeling results are based on clear flow (i.e., no sediment and debris clogging at the culvert) and do not account for erosional hazards that appear to have happened during the 1984 flood where water was directed at the town hall once the roadway washed out and sediment filled the channel.

3.4 Existing Conditions Hydraulic Evaluation

The existing conditions model was first utilized to evaluate the base flood at the culverts, over the road, around the town hall, and away from the site. Two models were prepared, one to evaluate inundation flooding typically associated with FEMA floodplain analysis and a second to evaluate erosional hazard flooding should a roadway washout occur (Appendix A).

3.4.1 Channel and Floodplains

The results of the hydraulic modeling indicate that the Pekin Brook and Elmslie Brook channels within the study area can generally pass the 10-year flood before beginning to access the floodplains located downstream of Kent Hill Road. This finding suggests that out-of-bank flows have a 10% chance of occurring each year. Historic encroachments into the floodplain along Kent Hill Road, North Calais Road, and Elmslie Road have reduced flood storage.

The town hall property is situated on a slight rise adjacent to Pekin Brook and was likely placed on fill. The location of the town hall building increases its risk to flooding due to inundation as well as erosion hazards. A berm is also present along Pekin Brook at the right top of bank (looking downstream) reportedly built in an effort to protect the town hall building.

3.4.2 Culverts

There are two culverts located under Kent Hill Road within the study reach. The Pekin Brook culvert is 12 feet wide by 8 feet high while the Elmslie Brook culvert is approximately 7.5 feet wide by 6 feet high. Both culverts are closed-bottom, corrugated metal pipe arches. The approach and exit channels at both culverts are generally well aligned with the crossing. Each culvert has a perched outlet with a scour hole at the downstream end.

Hydraulic modeling results of existing conditions indicate that floodwaters build behind the Kent Hill Road embankment before overtopping the low point in the roadway profile. Survey data indicates that the low point is located almost directly in front of the town hall building at elevation 767 feet NAVD88. The model estimates that overtopping occurs during the 50-year and larger floods, assuming clear flow

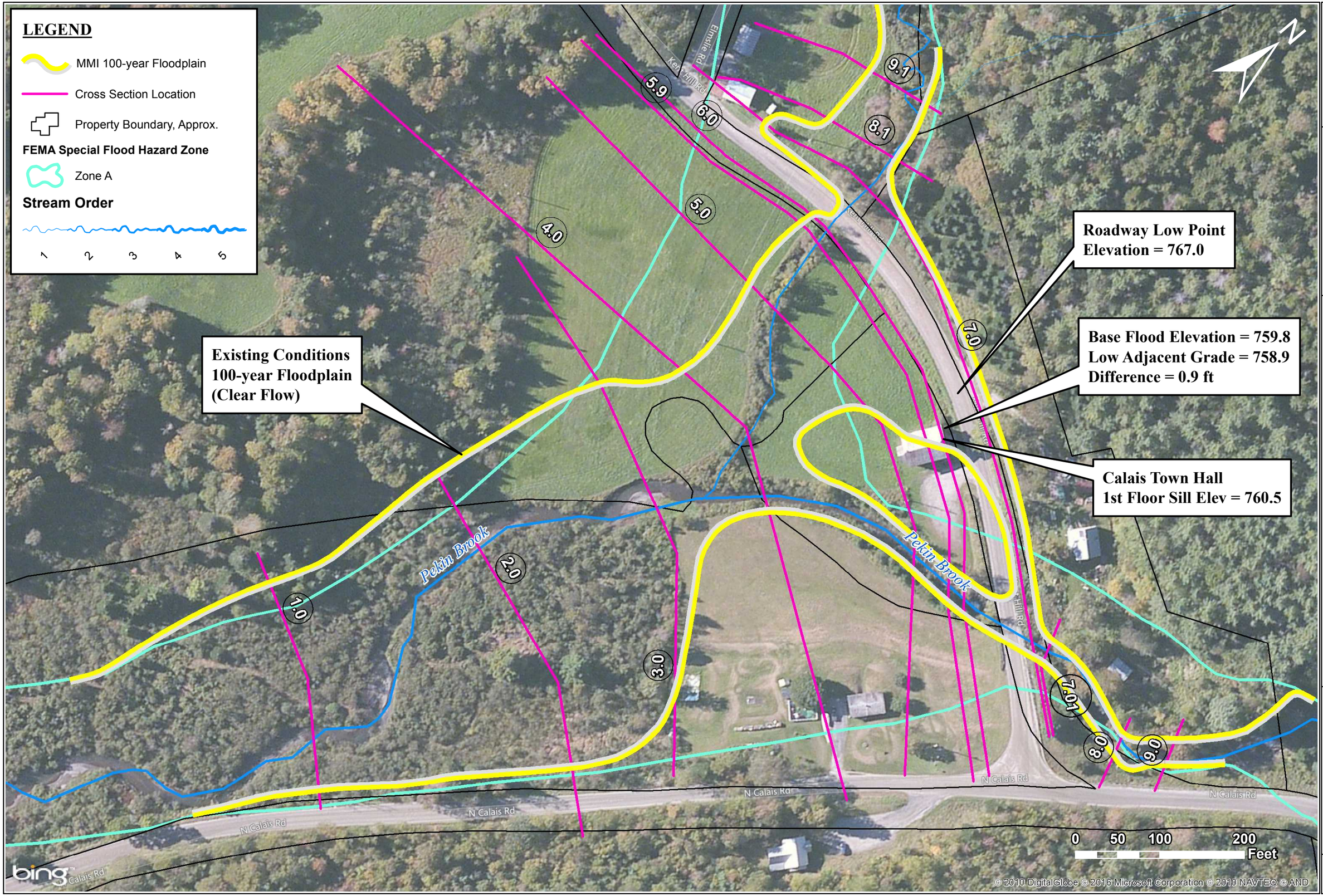
conditions (i.e., no clogging of the culverts). When overtopping of the roadway occurs, floodwaters would flow down the roadway embankment toward the town hall and across the floodplain making its way back toward the channel. The flow path back to the channel is directed toward the town hall by an elevated parking lot adjacent to the building and the berm along Pekin Brook. Roadway overtopping primarily floods the north and west sides of the town hall building.

Flooding at the town hall occurs differently if the Pekin Brook culvert was to clog and the roadway wash out. Under this scenario, flooding would occur at the east and south sides of the town hall building, similar to what reportedly occurred during the 1984 flood. Material washed away from the roadway embankment would fill the channel and scour hole downstream of the culvert, and floodwaters would access the floodplain flowing toward the town hall.

3.4.3 Floodplain Mapping and Base Flood Elevation (BFE)

FEMA has designated an area of the floodplain adjacent to Pekin and Elmslie Brooks as an approximate Zone A SHFA that is defined as an area subject to flooding during the 100-year or base flood. Floodplain boundaries based on the results of the hydraulic analysis of Pekin Brook have been prepared. Two floodplain maps depicting base flood limits were prepared, the first assuming inundation-style flooding with roadway overtopping (Figure 1) and the second assuming that the culvert is clogged by sediment and debris and the roadway washed out (Figure 2). Under each scenario, the floodplain mapping depicts that the town hall building is at risk of damage from the base flood.

The base flood elevation under existing conditions assuming inundation flooding (i.e., roadway is overtopped) was calculated as elevation 759.8 (feet NAVD88). Assuming the culvert clogs and the roadway washes away, the estimated base flood elevation would be elevation 760.3 (feet NAVD88). The low adjacent grade along the building was surveyed at elevation 758.9 (feet NAVD88).



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SOURCE(S):
Vermont Center for Geographic Information
Federal Emergency Management Agency
Bing Maps Aerial

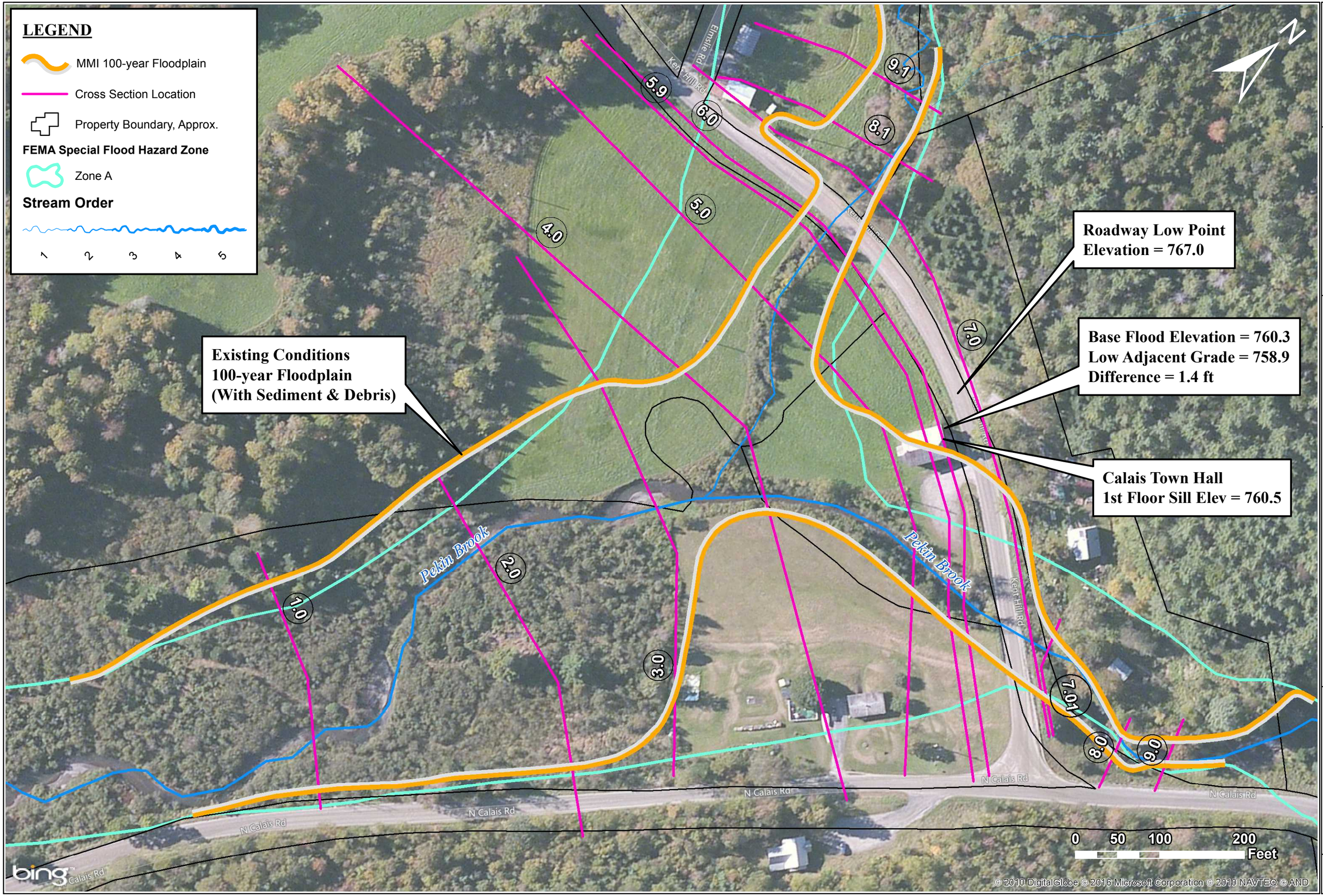
FLOODPLAIN MAP - CLEAR FLOW CONDITIONS

CALAIS TOWN HALL
BASE FLOOD ELEVATION DETERMINATION

CALAIS, VERMONT

Map By: BMC
MMI#: 5884401
MXD: Calais_FPmap_ClearFlow_v2.mxd
1st Version: August 2, 2016
Revision: September 15, 2016
Scale: 1" = 100'

FIGURE 1



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SOURCE(S):
Vermont Center for Geographic Information
Federal Emergency Management Agency
Bing Maps Aerial

FLOODPLAIN MAP - WITH SEDIMENT AND DEBRIS

CALAIS TOWN HALL
BASE FLOOD ELEVATION DETERMINATION

CALAIS, VERMONT

Map By: BMC
MMI#: 5884-01
MXD: Calais_FPmap_ClearFlow_v2.mxd
1st Version: August 2, 2016
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Scale: 1" = 100'

FIGURE 2

4.0 ALTERNATIVES ANALYSIS

4.1 Overview

The goal of the alternatives analysis was to reduce damage frequency and increase public safety. Eight alternatives were evaluated to meet the following objectives:

- Reduce flood hazards.
- Reduce erosion hazards.
- Naturalize debris and sediment transport.
- Limit water quality and habitat impacts.
- Increase regulatory feasibility.
- Minimize implementation costs.
- Minimize maintenance costs.

The alternatives generally included the following:

- No action (maintain existing conditions)
- Site fill and building elevation (~3 feet)
- Partial site fill and building elevation (~3 feet)
- Partial site fill and building elevation (~6 feet)
- Enlarge Pekin Brook culvert only (width = 22 feet)
- Enlarge both culverts (width = 22 feet and 12 feet)
- Elevate building and floodproof (~3 feet)
- Elevate (~2 feet), floodproof, and enlarge both culverts

The results of the alternatives analysis are summarized in an alternatives matrix (Table 5).

TABLE 5
Alternatives Matrix

LEGEND

Excellent	Good	Fair	Poor

Modeling ID	Description	Reduce Flood Hazard	Reduce Erosion Hazard	Naturalize Debris / Sediment Transport	Limit WQ / Ecological Impacts	Regulatory Feasibility	Comparative Implementation Cost	Comparative Maintenance Cost	Preferred
Alt 1	No Action - (Maintain Existing Conditions)	Poor	Poor	Fair	Excellent	Excellent	Excellent	Fair	
Alt 2A	Site Fill and Building Elevation (~3 ft)	Good	Fair	Fair	Fair	Fair	Fair	Fair	
Alt 2B	Partial Site Fill and Building Elevation (~3 ft)	Good	Fair	Fair	Fair	Fair	Fair	Fair	
Alt 2C	Partial Site Fill and Building Elevation (~6 ft)	Excellent	Fair	Fair	Poor	Fair	Fair	Fair	
Alt 3A	Enlarge Pekin Brook Culvert Only (width = 22 ft)	Excellent	Good	Good	Good	Excellent	Good	Good	
Alt 3B	Enlarge Both Culverts (Width = 22 ft & 12 ft)	Excellent	Good	Good	Good	Excellent	Fair	Excellent	
Alt 4	Elevate Building and Floodproof (~3 ft)	Good	Fair	Fair	Fair	Good	Fair	Good	
Alt 5	Elevate (~2 ft), Floodproof, and Enlarge Both Culverts	Excellent	Good	Good	Good	Excellent	Fair	Good	√

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4.2 Alternatives Evaluation

Hydraulic modeling was performed for each alternative. The primary focus of the alternatives analysis was to evaluate potential improvements in vulnerability due to the base flood or 100-year flood as well as erosion hazard vulnerability. Each of the alternatives is described below followed by a list of pros and cons.

Alternative 1 is the no action alternative. No changes would be made to the existing conditions.

PROS	CONS
• No short-term costs	• Continued flood vulnerability
• Easy to do	• Erosion hazards remain

Alternative 2A consists of elevating the building on approximately 3 feet of floodplain fill. The fill would extend from the riverbank to the building so that the parking lot would also be elevated.

PROS	CONS
• Reduces flood vulnerability	• Filling in floodplain
	• Increases erosion vulnerability
	• No change to sediment and wood transport
	• Roadway overtopping continues
	• Need compensatory flood storage to offset fill placement

Alternative 2B consists of elevating the building on approximately 3 feet of floodplain fill; however, the fill would be just under the building and not extend to the bank of Pekin Brook. The existing parking area would remain unchanged. This alternative would require less floodplain fill compared to Alternative 2A.

PROS	CONS
• Reduces flood vulnerability	• Filling in floodplain
• Less filling in floodplain compared to Alternative 2A	• Increases erosion vulnerability
• Less erosion vulnerability compared to Alternative 2A	• No change to sediment and wood transport
	• Roadway overtopping continues
	• Need compensatory flood storage to offset fill placement

Alternative 2C consists of elevating the building on approximately 6 feet of floodplain fill to get it above the base flood levels when roadway overtopping occurs. The fill would be just under the building and not extend to the bank of Pekin Brook or into the existing parking lot. Raising the building by this amount would make access to the building difficult.

PROS	CONS
• Further reduces flood vulnerability compared to Alternatives 2A and 2B.	• Filling in floodplain
• Less erosion vulnerability compared to Alternatives 2A and 2B	• Increases erosion vulnerability
	• No change to sediment and wood transport
	• Building access more difficult
	• Roadway overtopping continues
	• Need compensatory flood storage to offset fill placement

Alternative 3A consists of enlarging the Pekin Brook culvert under Kent Hill Road. The culvert proposed would be 22 feet wide by 11 feet high. The width was selected to match the nearby channel bankfull width measured in the field.

PROS	CONS
• Reduces flood vulnerability	• Potential for backwater flooding remains
• Reduces erosion vulnerability	
• Improves sediment and debris transport	
• Roadway does not overtop during base flood	
• No floodplain fill and thus limited impacts	
• Simple permitting	

Alternative 3B consists of enlarging both the Pekin Brook and Elmslie Brook culverts. Similar to Alternative 3A, the Pekin Brook culvert would be 22 feet wide by 11 feet high. The existing Pekin Brook culvert (12 feet wide by 8 feet tall) would be reused as the replacement structure at the Elmslie Brook crossing. Both culverts would provide a width equal to or greater than the field-measured channel bankfull width.

PROS	CONS
• Reduces flood vulnerability	• Potential for backwater flooding remains
• Reduces erosion vulnerability	
• Improves sediment and debris transport under road	
• Roadway does not overtop during base flood	
• No floodplain fill and thus limited impacts	
• Simple permitting	
• Reusing existing culvert from Pekin Brook for Elmslie Brook means increasing benefit for limited cost	

Alternative 4 consists of elevating the building in place and installing floodproofing rather than placing fill in the floodplain. Although the portion of the building below the base flood elevation would be resistant to flooding, the building could potentially be surrounded by water limiting access should the base flood occur.

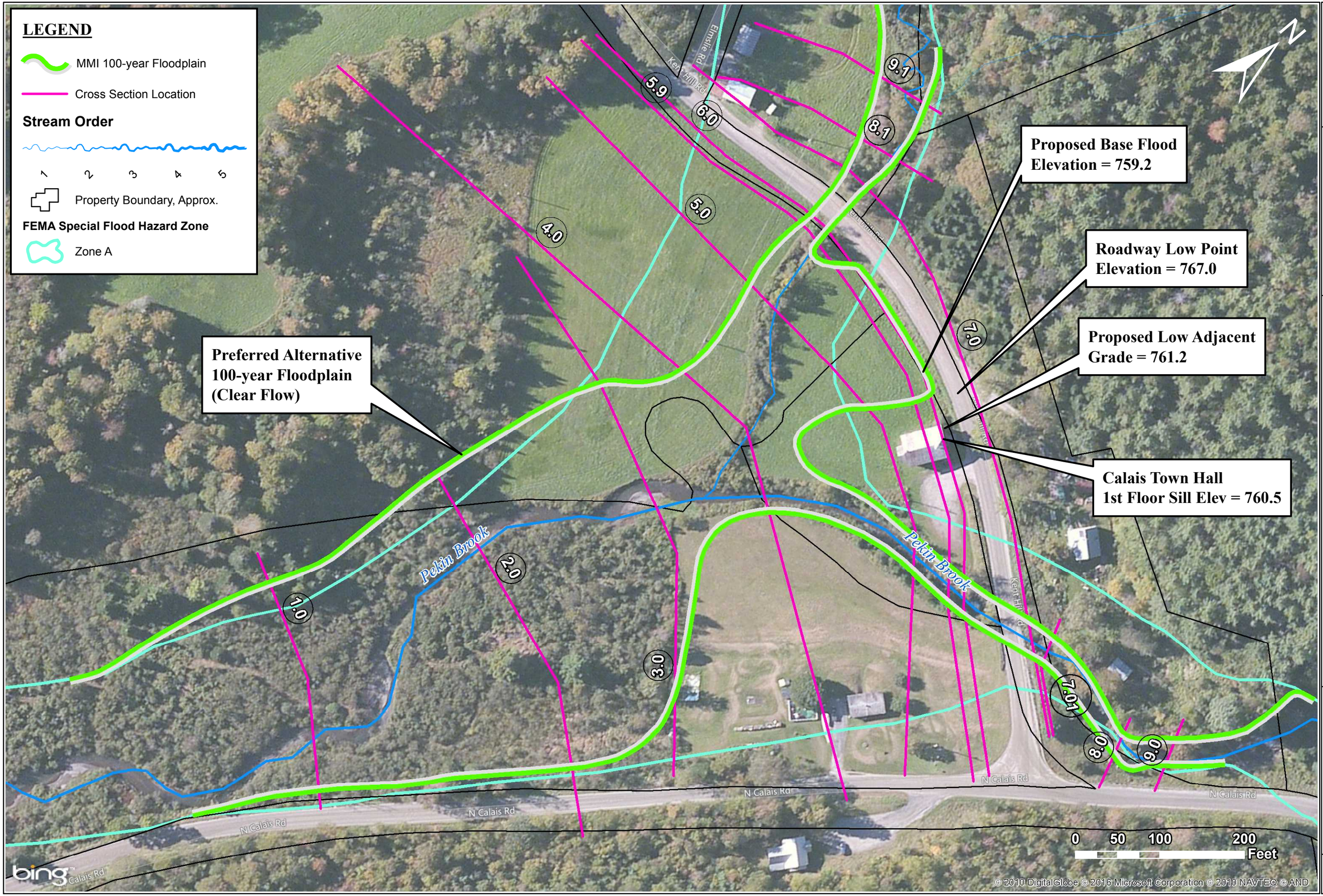
PROS	CONS
• Reduces flood vulnerability	• No change to sediment and wood transport
• No floodplain fill and thus limited impacts	• Roadway overtopping continues
• Simple permitting	• Erosion hazards remain
	• Building potentially surrounded by water during base flood

Alternative 5 consists of elevating the building in place on approximately 2 feet of floodplain fill, installing floodproofing, and increasing the size of both culverts. This alternative combines the proposed conditions of Alternatives 2B, 3B, and 4 and collectively maximize reductions in flood and erosion vulnerability. The existing Pekin Brook culvert (12 feet wide by 8 feet tall) would be reused as the replacement structure at the Elmslie Brook crossing. As part of the building renovation, the new foundation would be designed using standard floodproofing techniques.

PROS	CONS
• Reduces flood vulnerability the most	• May require compensatory flood storage to offset limited fill
• Reduces erosion vulnerability	
• Minimizes floodplain fill	
• Roadway does not overtop during base flood	
• Improves sediment and wood transport	
• Simple permitting	

4.3 The Preferred Alternative

The preferred alternative is to increase the size of the Pekin Brook culvert to the channel bankfull width of 22 feet, to swap the existing Pekin Brook culvert to Elmslie Brook, to elevate the building approximately 2 feet of fill, and to floodproof the lower part of the building up to 2 feet over the proposed base flood elevation. The proposed base flood elevation assuming the preferred alternative is implemented would be 759.2 (feet NAVD88) (Appendix B). Therefore, in order to provide 2 feet of freeboard, the building should be floodproofed up to elevation 761.2 (feet NAVD88). The existing conditions floodplain delineation assuming clear flow has been modified to reflect implementation of the preferred alternative (Figure 3).



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SOURCE(S):
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PREFERRED ALTERNATIVE - CLEAR FLOW CONDITIONS

CALAIS TOWN HALL
BASE FLOOD ELEVATION DETERMINATION

CALAIS, VERMONT

Map By: BMC
MMI#: 5884-01
MXD: PrefAlt_FPmap_ClearFlow.mxd
1st Version: September 15, 2016
Revision:
Scale: 1" = 100'

FIGURE 3

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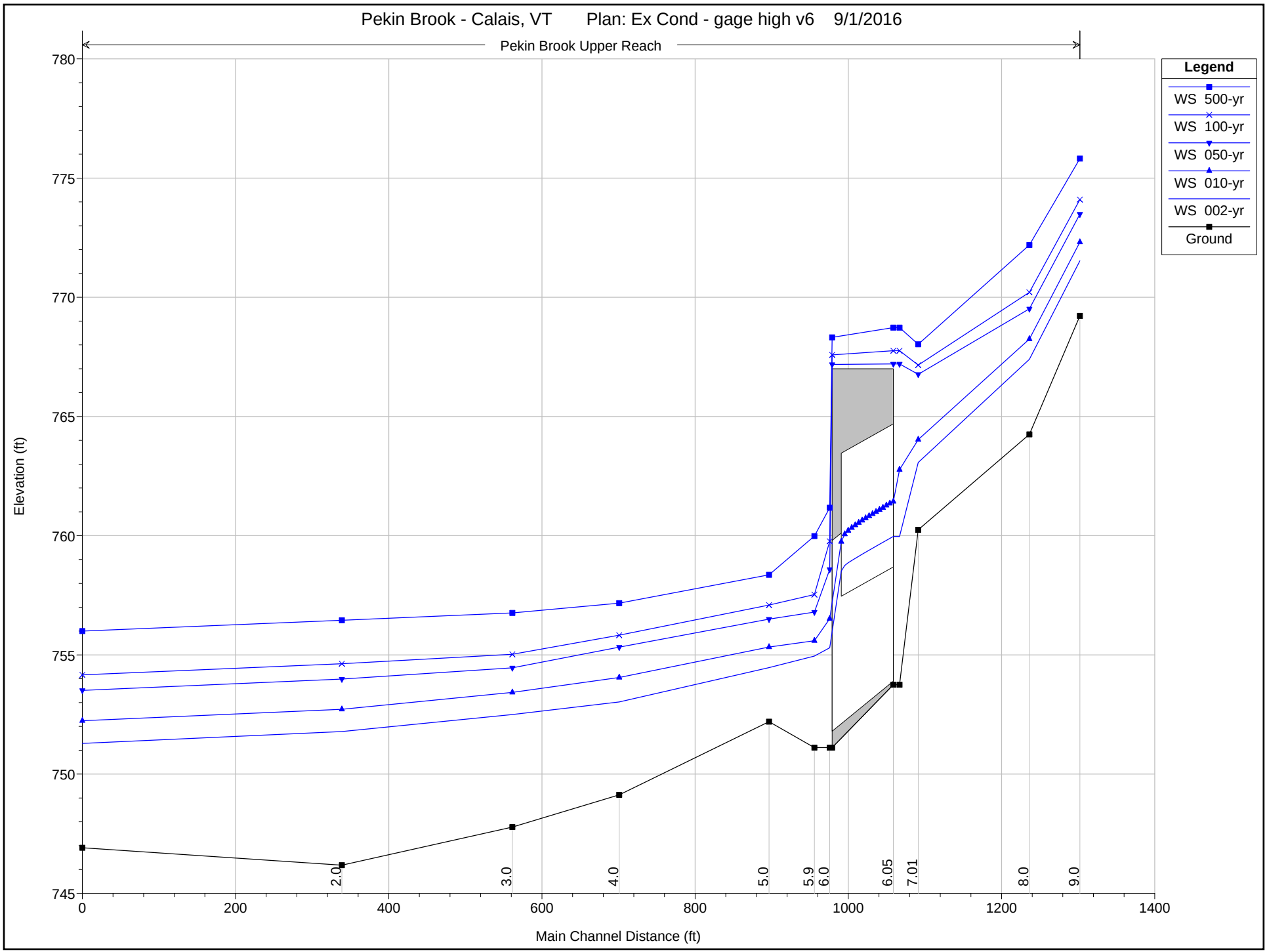
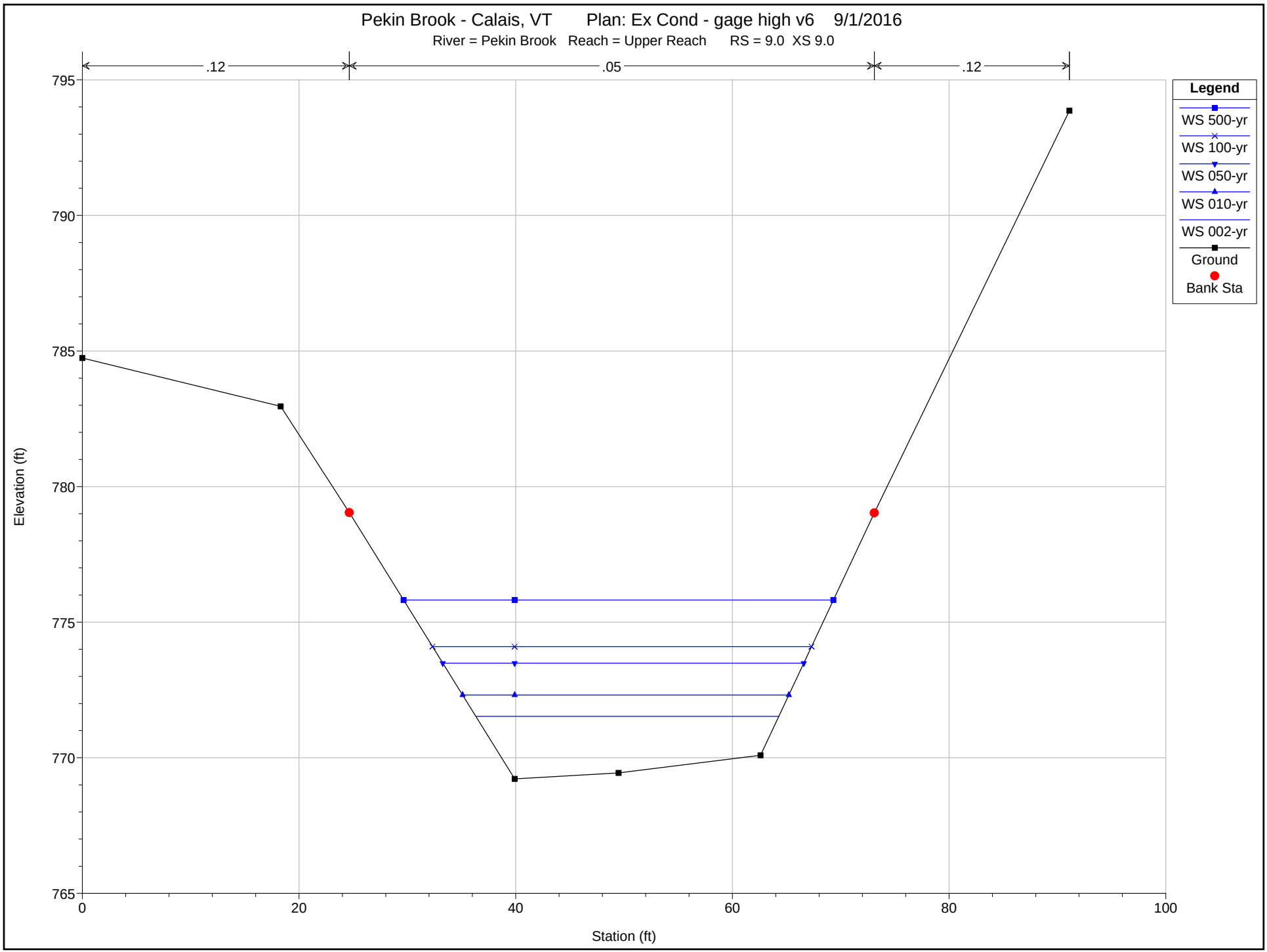
APPENDIX A

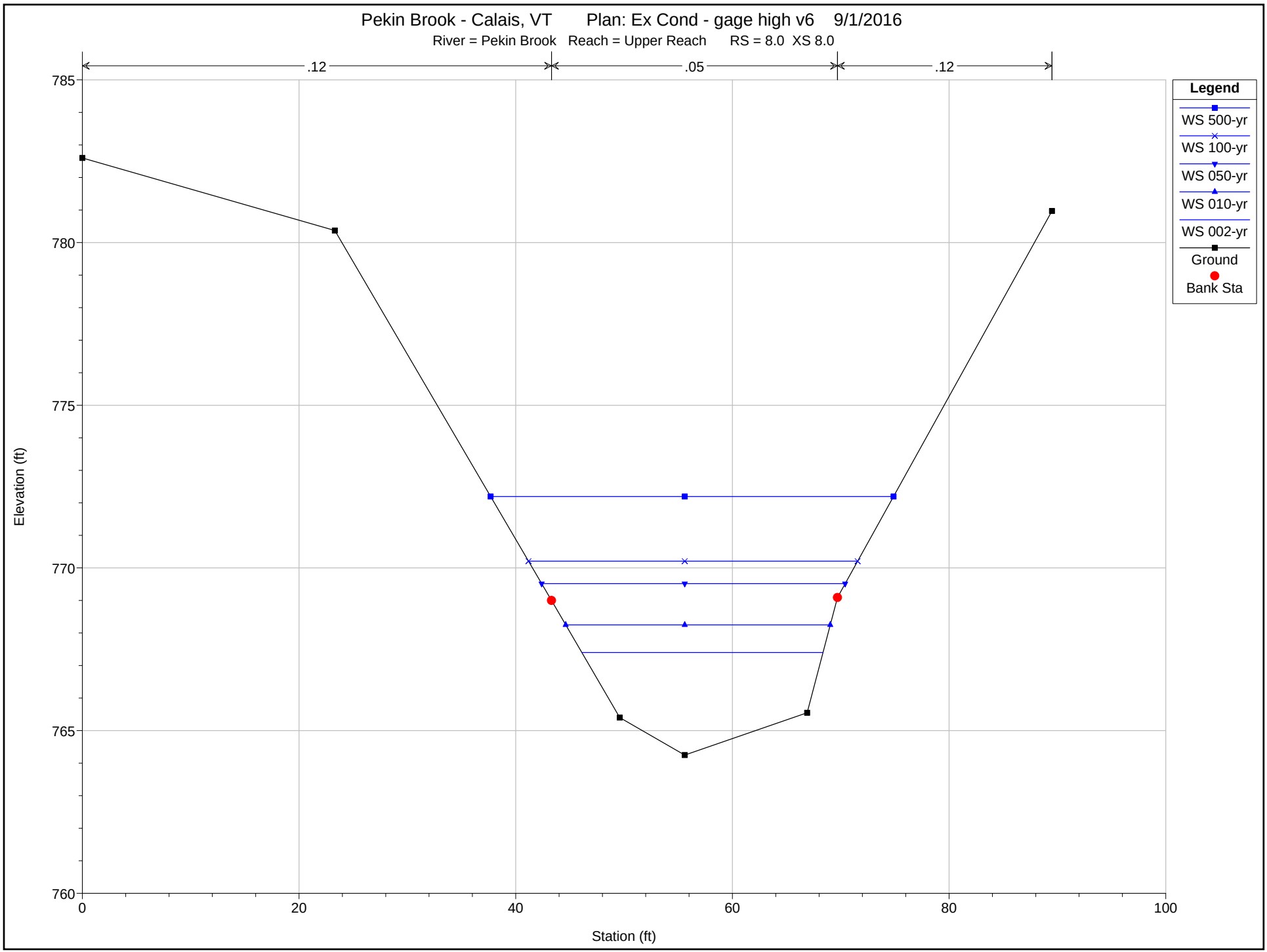
HEC-RAS EXISTING CONDITIONS BASE FLOOD INFORMATION

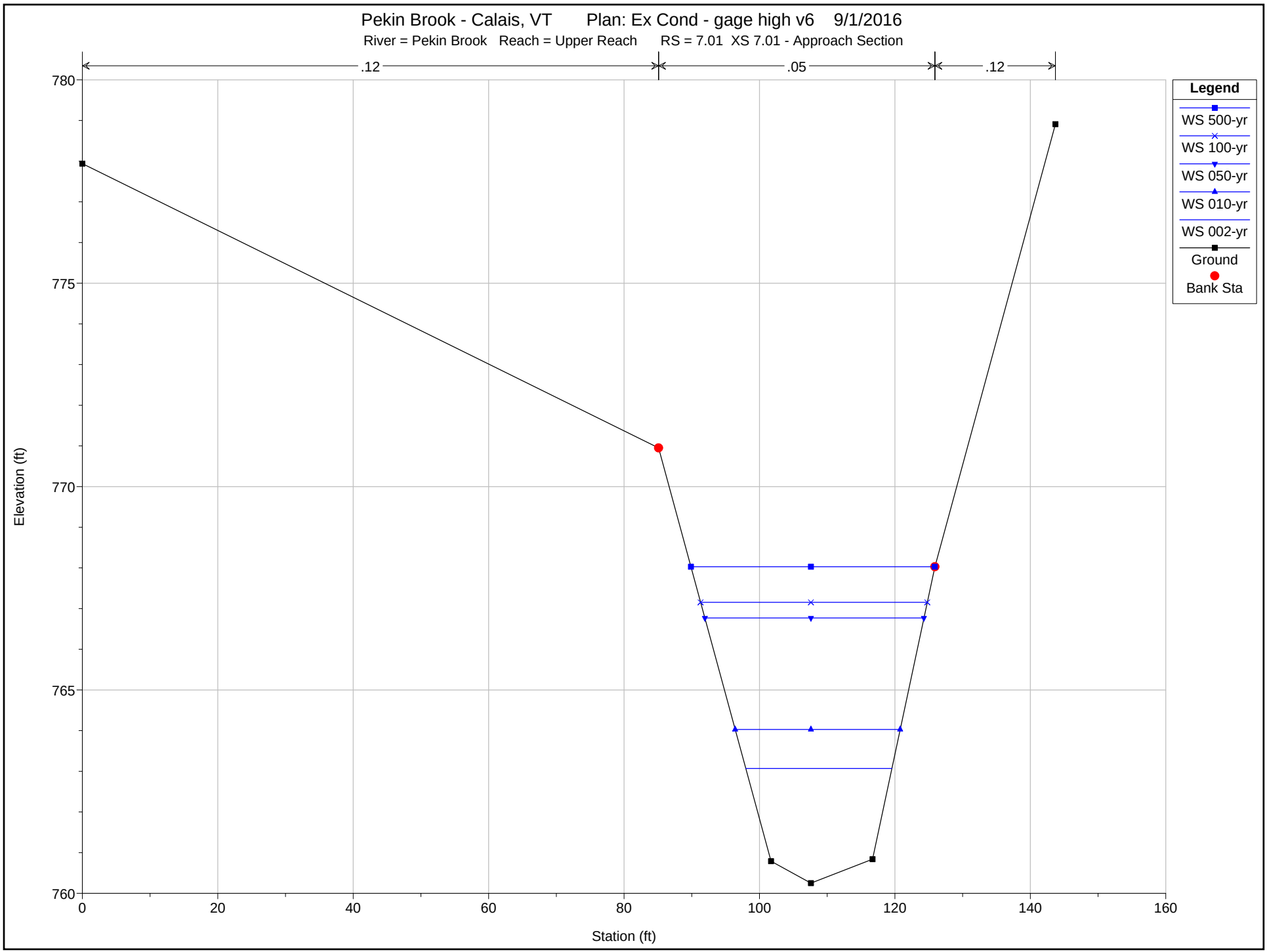
HEC-RAS Plan: Ex Cond v6 River: Pekin Brook Reach: Upper Reach

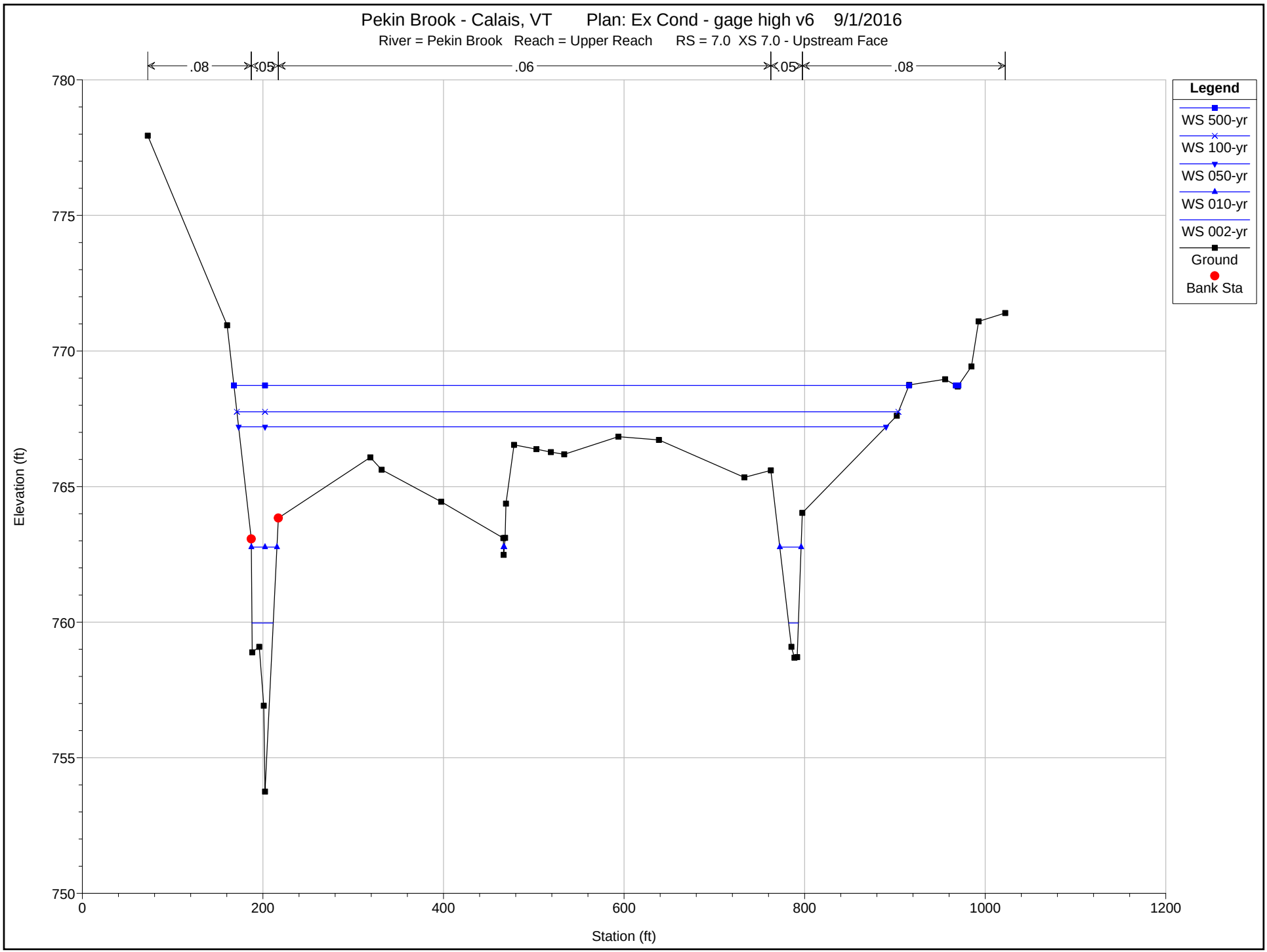
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper Reach	9.0	002-yr	377.00	769.22	771.53	771.53	772.43	0.032381	7.61	49.55	27.98	1.01
Upper Reach	9.0	010-yr	641.00	769.22	772.31	772.31	773.53	0.029779	8.86	72.35	30.12	1.01
Upper Reach	9.0	050-yr	1128.00	769.22	773.49	773.49	775.13	0.027008	10.29	109.62	33.32	1.00
Upper Reach	9.0	100-yr	1429.00	769.22	774.10	774.10	775.96	0.026160	10.95	130.45	34.99	1.00
Upper Reach	9.0	500-yr	2445.00	769.22	775.82	775.82	778.27	0.024423	12.56	194.61	39.68	1.00
Upper Reach	8.0	002-yr	377.00	764.25	767.40	767.27	768.34	0.026507	7.77	48.54	22.26	0.93
Upper Reach	8.0	010-yr	641.00	764.25	768.25	768.22	769.62	0.028340	9.37	68.39	24.42	0.99
Upper Reach	8.0	050-yr	1128.00	764.25	769.52	769.52	771.45	0.026991	11.16	101.45	28.02	1.01
Upper Reach	8.0	100-yr	1429.00	764.25	770.21	770.21	772.42	0.024846	11.96	121.60	30.38	0.99
Upper Reach	8.0	500-yr	2445.00	764.25	772.19	772.19	775.20	0.020999	14.02	188.78	37.19	0.97
Upper Reach	7.01	002-yr	377.00	760.25	763.07	763.07	764.14	0.031493	8.30	45.44	21.58	1.01
Upper Reach	7.01	010-yr	641.00	760.25	764.03	764.03	765.43	0.029286	9.50	67.47	24.37	1.01
Upper Reach	7.01	050-yr	1128.00	760.25	766.77		767.71	0.010694	7.77	145.20	32.35	0.65
Upper Reach	7.01	100-yr	1429.00	760.25	767.15		768.43	0.013634	9.05	157.90	33.48	0.73
Upper Reach	7.01	500-yr	2445.00	760.25	768.03	768.03	770.65	0.024679	12.99	188.28	36.03	1.00
Upper Reach	7.0	002-yr	468.00	753.75	759.97	759.97	760.89	0.032437	7.97	61.97	34.32	0.94
Upper Reach	7.0	010-yr	796.00	753.75	762.77	760.80	763.07	0.004654	4.59	183.02	52.85	0.39
Upper Reach	7.0	050-yr	1401.00	753.75	767.20	761.93	767.22	0.000256	1.68	1552.97	717.14	0.10
Upper Reach	7.0	100-yr	1774.00	753.75	767.76	762.52	767.78	0.000238	1.68	1955.10	732.66	0.10
Upper Reach	7.0	500-yr	3036.00	753.75	768.73	764.67	768.76	0.000302	2.03	2674.02	750.45	0.11
Upper Reach	6.05		Culvert									
Upper Reach	6.0	002-yr	468.00	751.11	755.30		755.77	0.007070	5.52	84.82	27.01	0.55
Upper Reach	6.0	010-yr	796.00	751.11	756.52		757.19	0.007702	6.58	123.39	38.60	0.59
Upper Reach	6.0	050-yr	1401.00	751.11	758.59	756.80	759.28	0.005735	6.83	214.96	51.89	0.53
Upper Reach	6.0	100-yr	1774.00	751.11	759.77	757.53	760.25	0.003867	6.13	436.91	243.05	0.44
Upper Reach	6.0	500-yr	3036.00	751.11	761.17	759.97	761.63	0.003462	6.62	828.05	327.17	0.43
Upper Reach	5.9	002-yr	468.00	751.11	754.95		755.55	0.009759	6.19	75.56	25.82	0.64
Upper Reach	5.9	010-yr	796.00	751.11	755.59		756.74	0.015903	8.57	92.87	28.00	0.83
Upper Reach	5.9	050-yr	1401.00	751.11	756.80	756.80	758.56	0.019370	10.71	134.37	40.19	0.94
Upper Reach	5.9	100-yr	1774.00	751.11	757.53	757.53	759.41	0.018474	11.15	165.40	44.36	0.93
Upper Reach	5.9	500-yr	3036.00	751.11	759.98	759.98	761.16	0.009476	9.73	489.24	247.56	0.69
Upper Reach	5.0	002-yr	468.00	752.20	754.47		754.78	0.010181	4.42	103.86	66.03	0.62
Upper Reach	5.0	010-yr	796.00	752.20	755.33		755.70	0.007316	4.72	163.25	71.82	0.56
Upper Reach	5.0	050-yr	1401.00	752.20	756.50		756.96	0.006110	5.30	256.89	118.85	0.53
Upper Reach	5.0	100-yr	1774.00	752.20	757.09		757.50	0.005546	5.47	349.79	202.69	0.52
Upper Reach	5.0	500-yr	3036.00	752.20	758.36		758.70	0.004780	5.83	710.47	326.58	0.49
Upper Reach	4.0	002-yr	468.00	749.13	753.03		753.32	0.005604	4.56	107.73	45.87	0.50
Upper Reach	4.0	010-yr	796.00	749.13	754.05		754.45	0.005461	5.19	158.22	52.33	0.50
Upper Reach	4.0	050-yr	1401.00	749.13	755.33		755.80	0.005644	6.03	263.20	129.12	0.53
Upper Reach	4.0	100-yr	1774.00	749.13	755.83		756.33	0.005939	6.51	339.71	184.85	0.55
Upper Reach	4.0	500-yr	3036.00	749.13	757.17		757.66	0.005208	7.15	724.55	382.74	0.53
Upper Reach	3.0	002-yr	468.00	747.78	752.50		752.74	0.003004	4.23	159.49	63.46	0.38
Upper Reach	3.0	010-yr	796.00	747.78	753.43		753.81	0.003760	5.48	220.41	68.14	0.44
Upper Reach	3.0	050-yr	1401.00	747.78	754.46	752.97	755.04	0.004868	7.11	386.63	258.30	0.52
Upper Reach	3.0	100-yr	1774.00	747.78	755.02		755.59	0.004578	7.34	555.79	334.60	0.51
Upper Reach	3.0	500-yr	3036.00	747.78	756.76		757.09	0.002729	6.66	1311.73	488.36	0.41
Upper Reach	2.0	002-yr	468.00	746.18	751.79		752.07	0.003039	4.42	141.23	126.85	0.38
Upper Reach	2.0	010-yr	796.00	746.18	752.72		753.04	0.003129	5.14	359.47	298.25	0.40
Upper Reach	2.0	050-yr	1401.00	746.18	753.99		754.23	0.002371	5.19	782.26	367.36	0.36
Upper Reach	2.0	100-yr	1774.00	746.18	754.63		754.84	0.002064	5.17	1026.95	391.42	0.34
Upper Reach	2.0	500-yr	3036.00	746.18	756.45		756.61	0.001511	5.16	1754.42	403.47	0.31
Upper Reach	1.0	002-yr	468.00	746.91	751.29	749.32	751.38	0.001301	2.90	325.03	210.74	0.26
Upper Reach	1.0	010-yr	796.00	746.91	752.24	750.25	752.35	0.001302	3.35	553.77	247.20	0.27
Upper Reach	1.0	050-yr	1401.00	746.91	753.51	751.17	753.64	0.001300	3.90	872.90	253.99	0.28
Upper Reach	1.0	100-yr	1774.00	746.91	754.16	751.63	754.30	0.001301	4.17	1039.30	257.46	0.28
Upper Reach	1.0	500-yr	3036.00	746.91	756.00	752.55	756.17	0.001300	4.88	1520.65	267.24	0.29

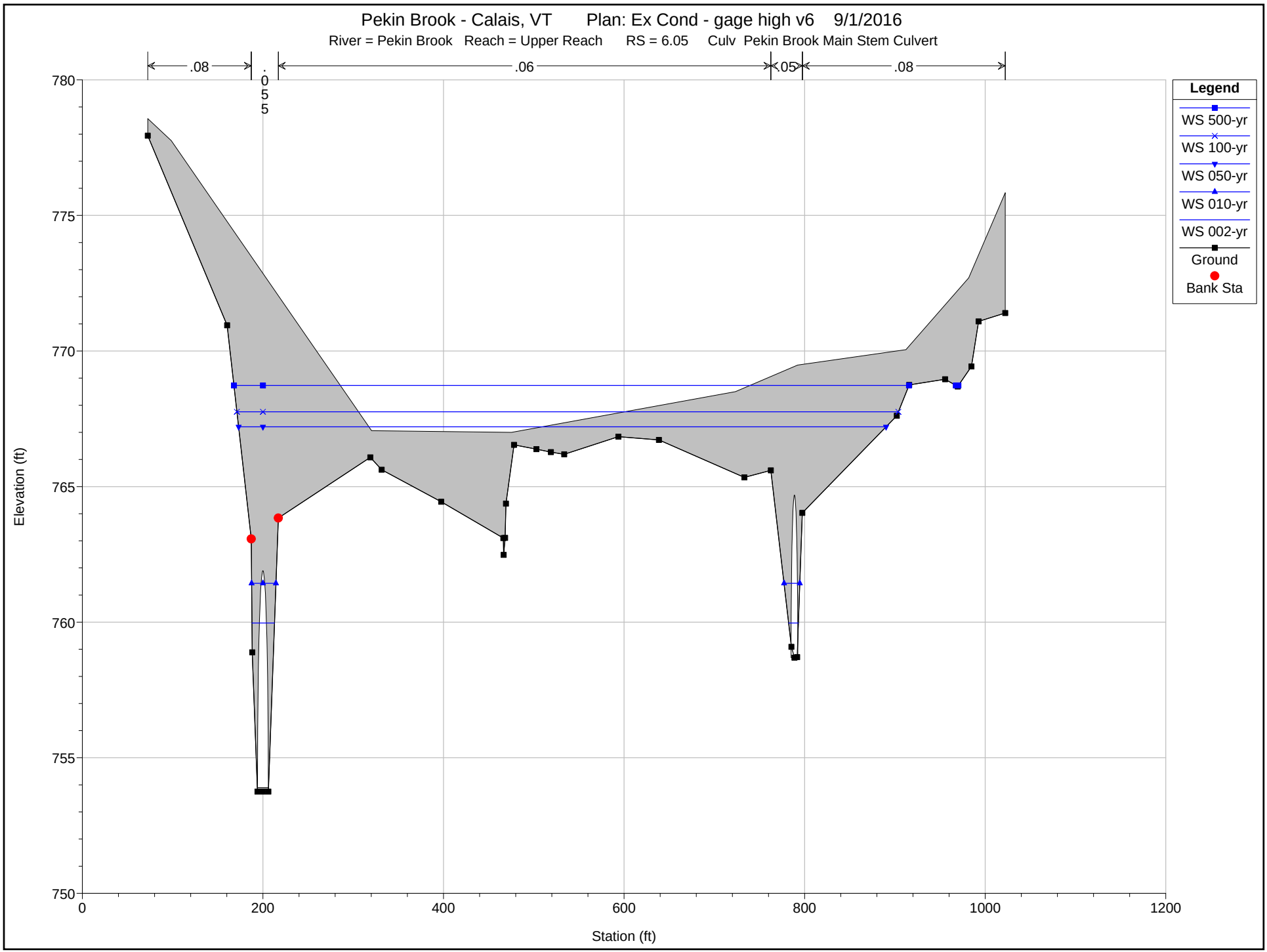

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v6 9/1/2016
Pekin Brook Upper Reach
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Elevation (ft)
Main Channel Distance (ft)
780
775
770
765
760
755
750
745
0
200
400
600
800
1000
1200
1400
2.0
3.0
4.0
5.0
5.9
6.0
6.05
7.01
8.0
9.0

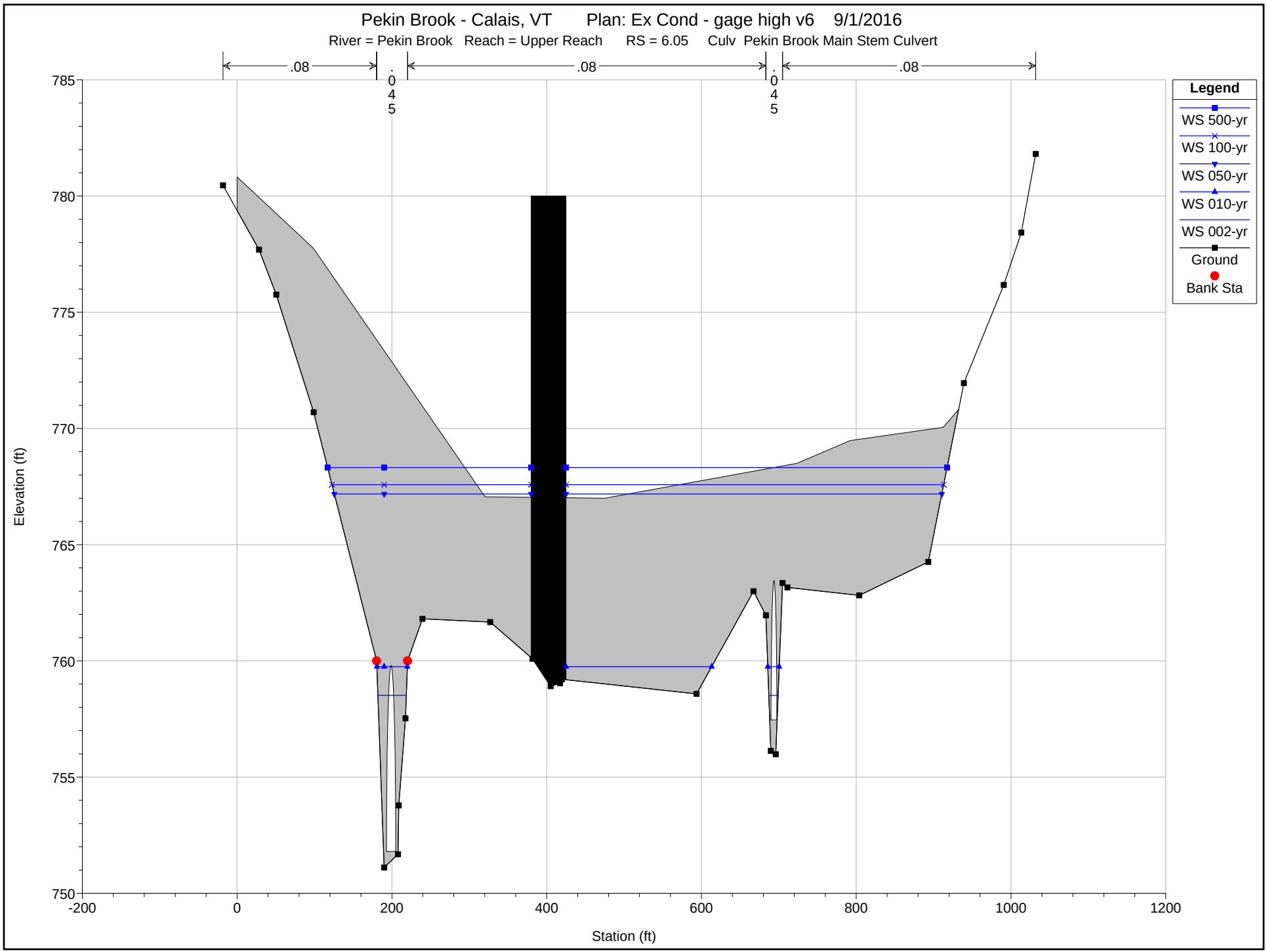

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v6 9/1/2016
River = Pekin Brook Reach = Upper Reach RS = 9.0 XS 9.0
.12
.05
.12
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
795
790
785
780
775
770
765
0
20
40
60
80
100
Station (ft)

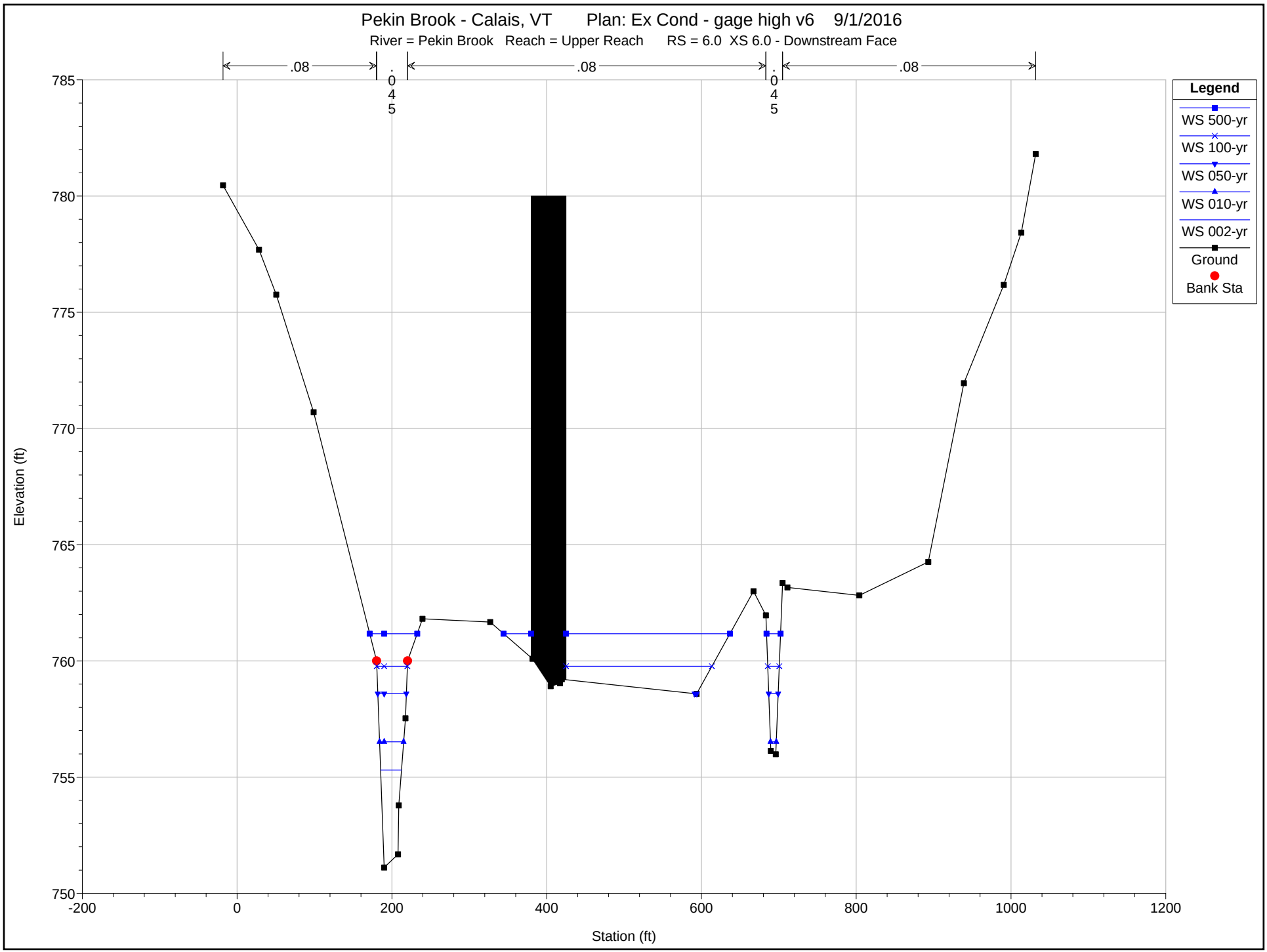

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v6 9/1/2016
River = Pekin Brook Reach = Upper Reach RS = 8.0 XS 8.0
.12
.05
.12
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
785
780
775
770
765
760
0
20
40
60
80
100
Station (ft)

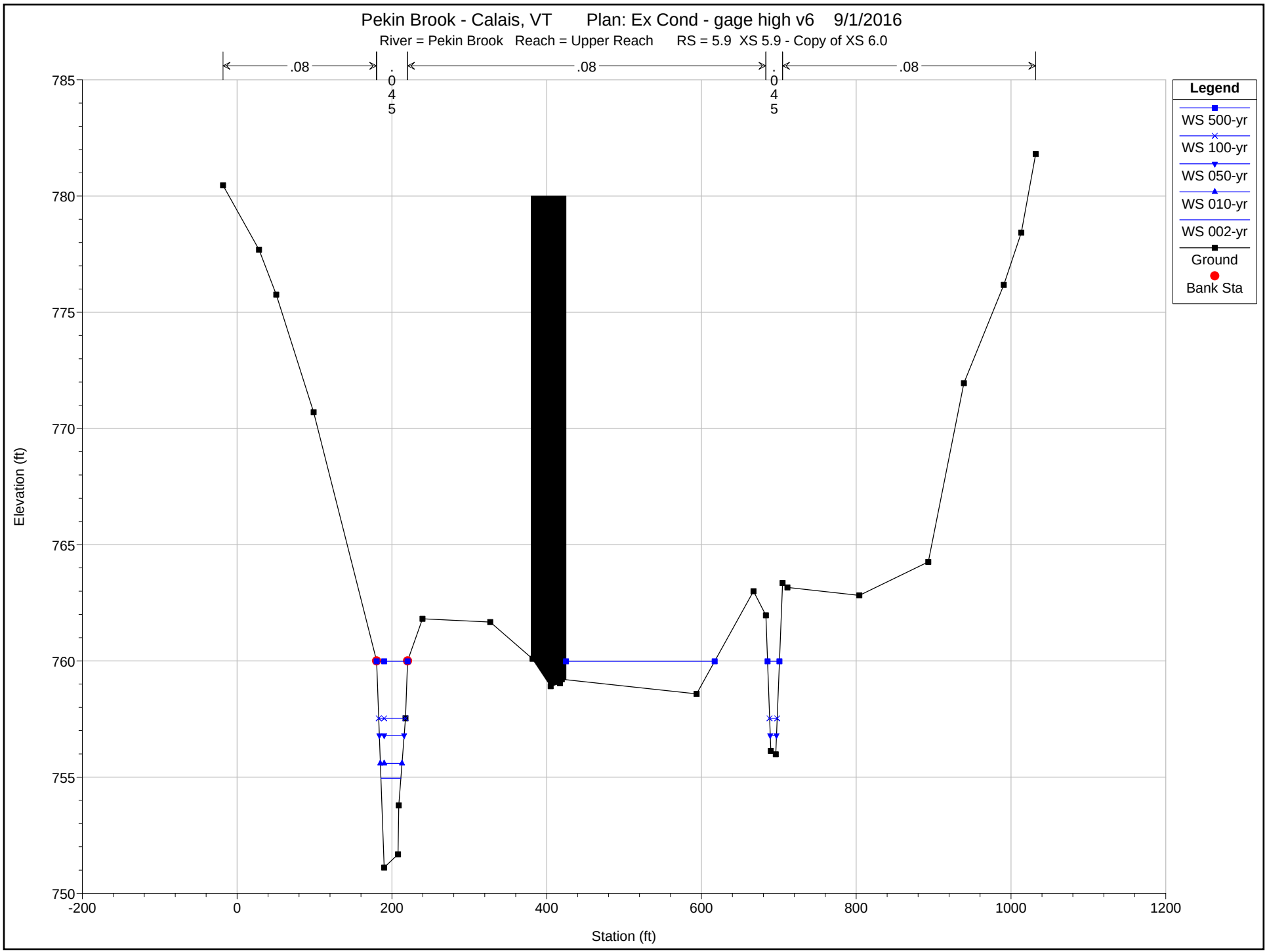

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v6 9/1/2016
River = Pekin Brook Reach = Upper Reach RS = 7.01 XS 7.01 - Approach Section
.12
.05
.12
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
780
775
770
765
760
0
20
40
60
80
100
120
140
160
Station (ft)

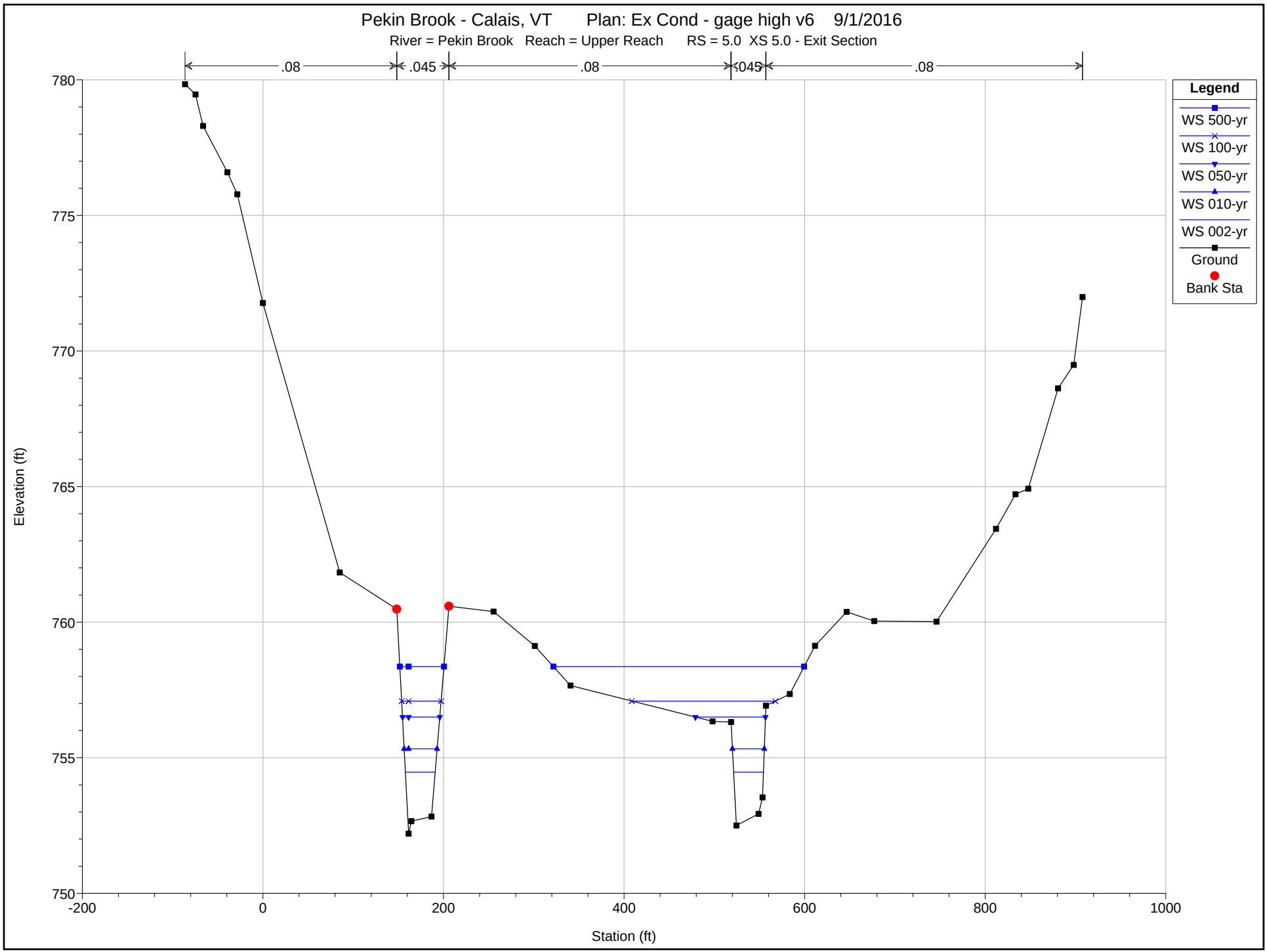

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v6 9/1/2016
River = Pekin Brook Reach = Upper Reach RS = 7.0 XS 7.0 - Upstream Face
.08
.05
.06
.05
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
780
775
770
765
760
755
750
0
200
400
600
800
1000
1200
Station (ft)

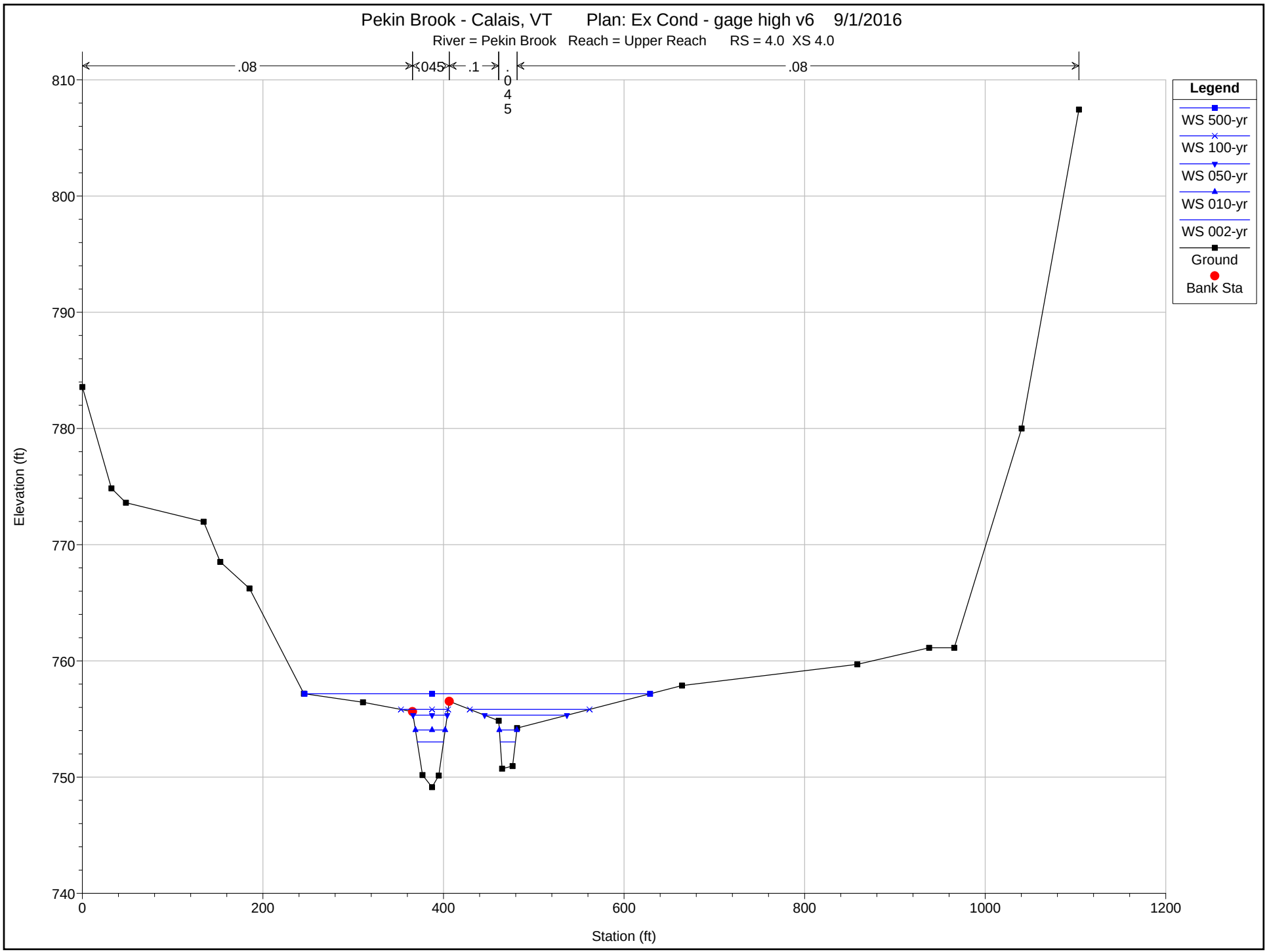

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v6 9/1/2016
River = Pekin Brook Reach = Upper Reach RS = 6.05 Culv Pekin Brook Main Stem Culvert
.08
.055
.06
.05
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
780
775
770
765
760
755
750
0
200
400
600
800
1000
1200
Station (ft)

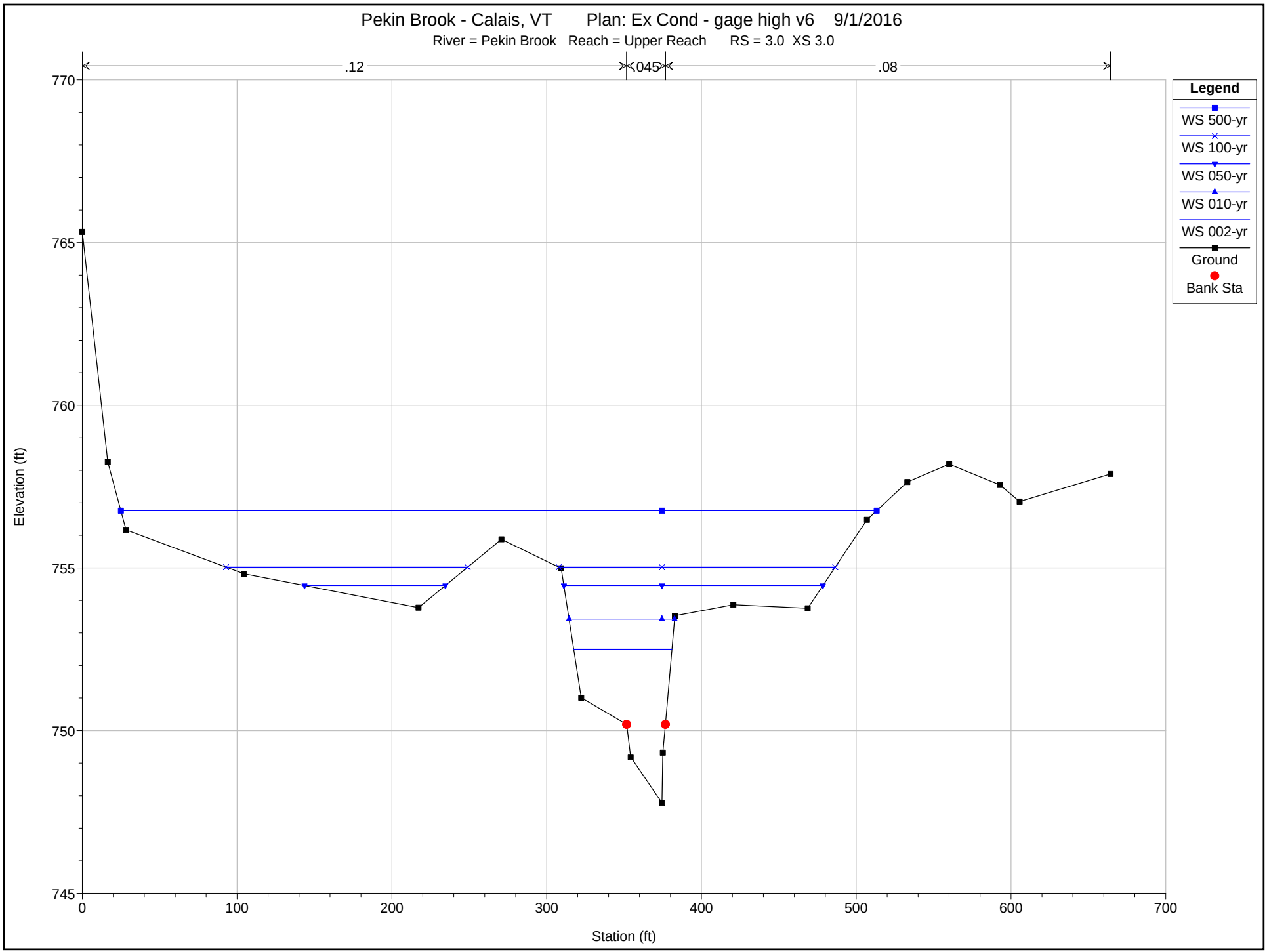

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v6 9/1/2016
River = Pekin Brook Reach = Upper Reach RS = 6.05 Culv Pekin Brook Main Stem Culvert
.08
.045
.08
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
785
780
775
770
765
760
755
750
-200
0
200
400
600
800
1000
1200
Station (ft)

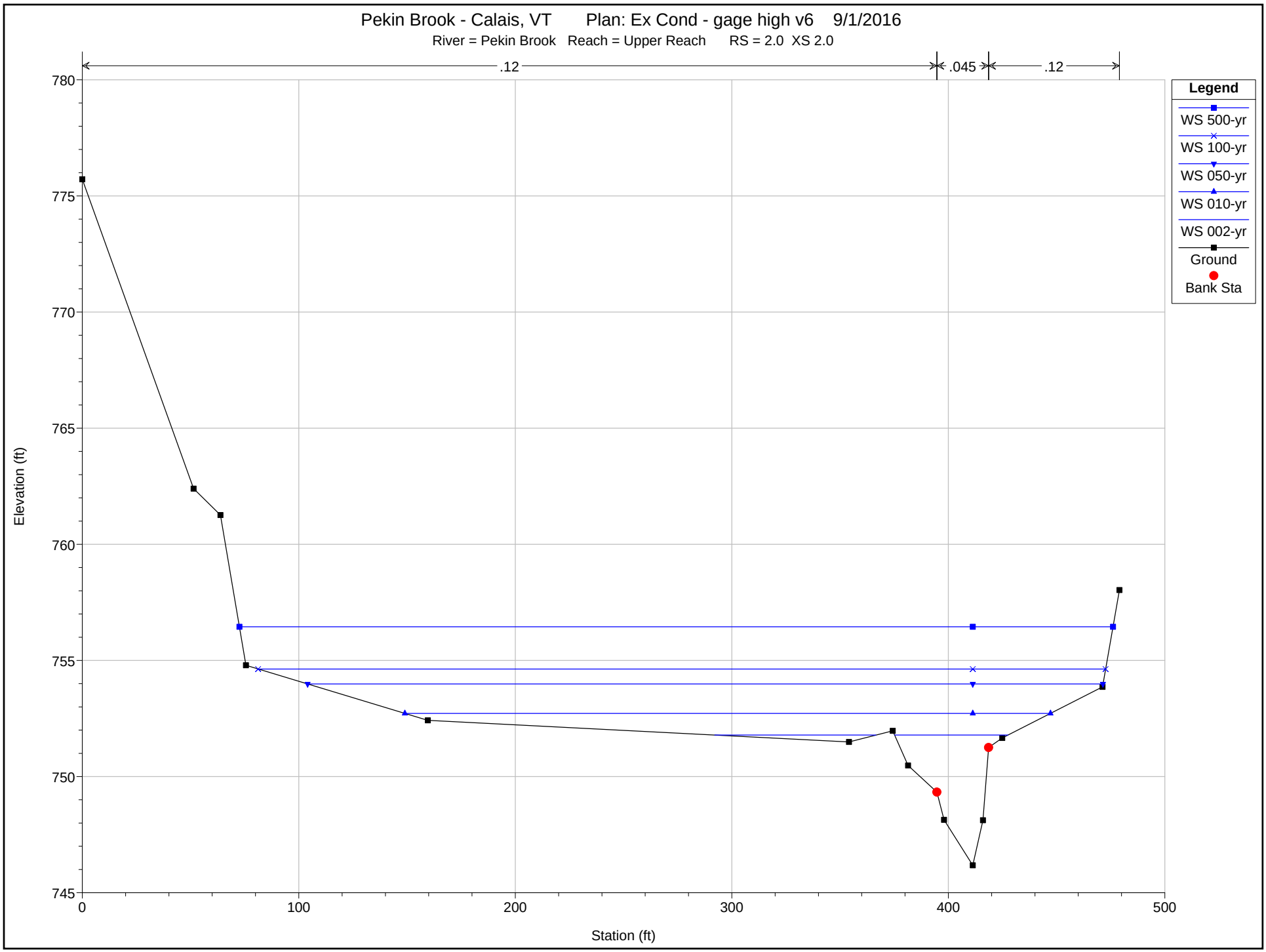

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v6 9/1/2016
River = Pekin Brook Reach = Upper Reach RS = 6.0 XS 6.0 - Downstream Face
.08
.045
.08
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
785
780
775
770
765
760
755
750
-200
0
200
400
600
800
1000
1200
Station (ft)

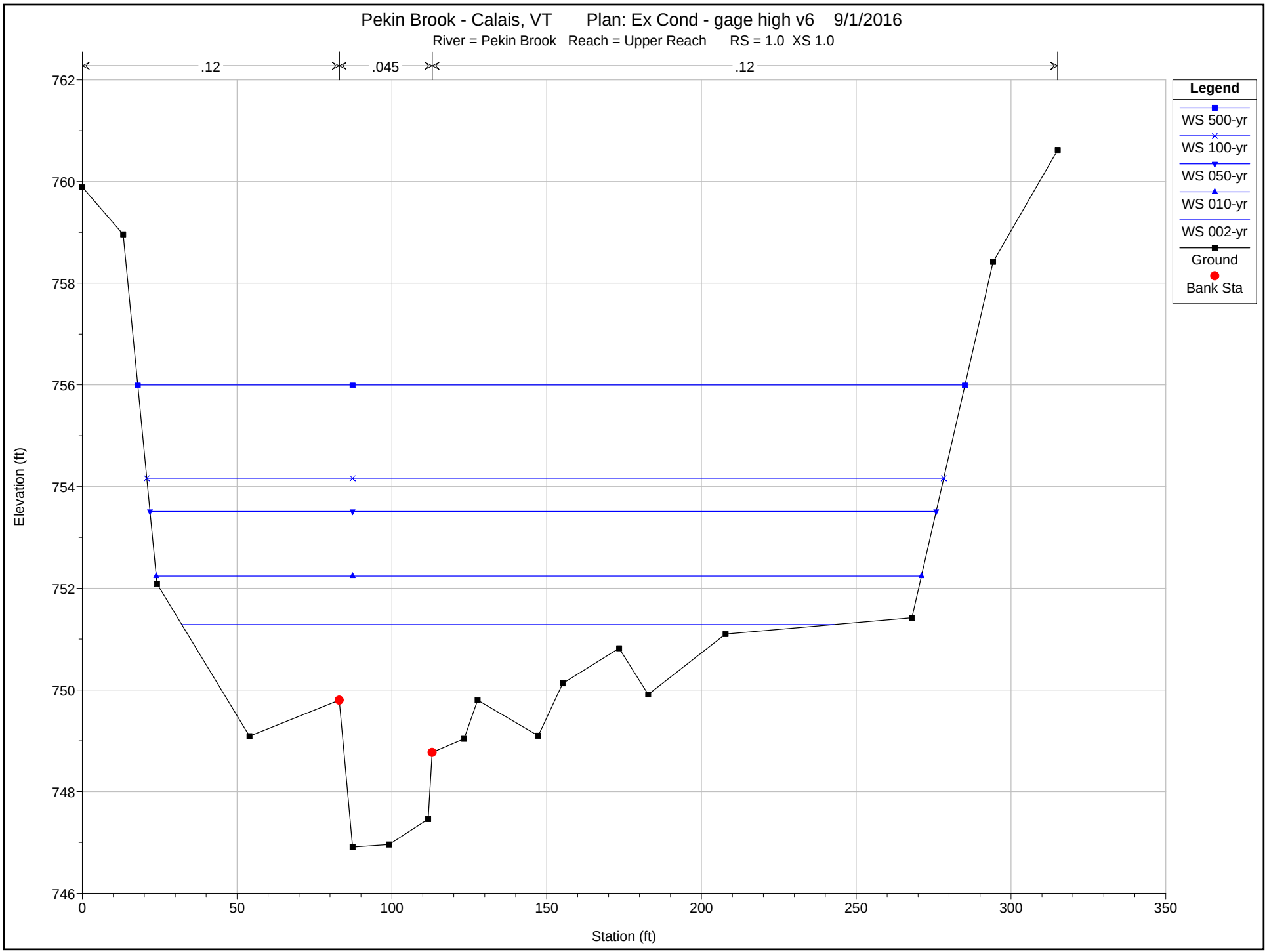

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v6 9/1/2016
River = Pekin Brook Reach = Upper Reach RS = 5.9 XS 5.9 - Copy of XS 6.0
.08
.045
.08
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
785
780
775
770
765
760
755
750
-200
0
200
400
600
800
1000
1200
Station (ft)


Pekin Brook - Calais, VT Plan: Ex Cond - gage high v6 9/1/2016
River = Pekin Brook Reach = Upper Reach RS = 5.0 XS 5.0 - Exit Section
.08
.045
.08
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
780
775
770
765
760
755
750
-200
0
200
400
600
800
1000
Station (ft)


Pekin Brook - Calais, VT Plan: Ex Cond - gage high v6 9/1/2016
River = Pekin Brook Reach = Upper Reach RS = 4.0 XS 4.0
.08
.045
.1
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
810
800
790
780
770
760
750
740
0
200
400
600
800
1000
1200

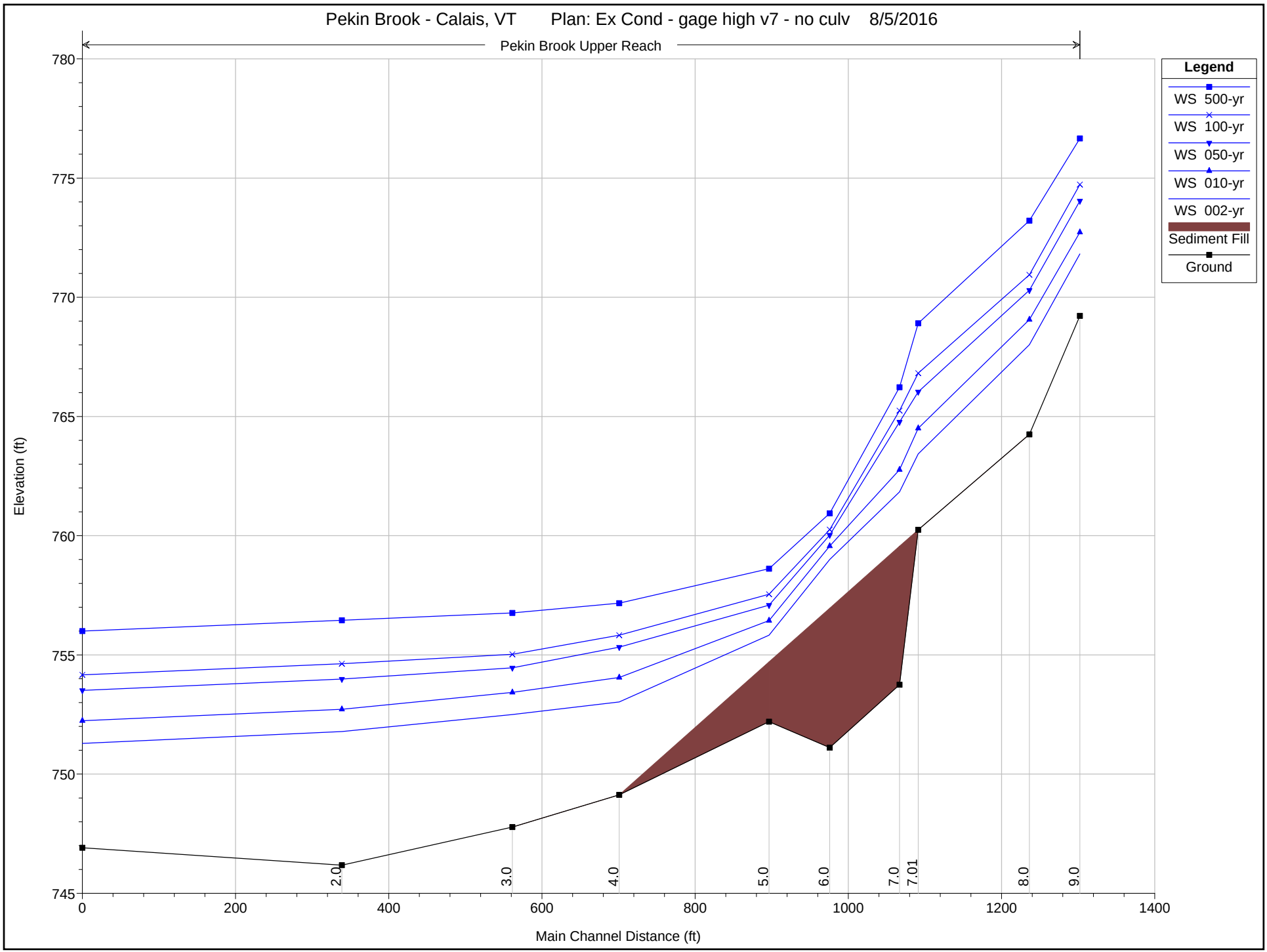

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v6 9/1/2016
River = Pekin Brook Reach = Upper Reach RS = 3.0 XS 3.0
.12
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
770
765
760
755
750
745
0
100
200
300
400
500
600
700
Station (ft)

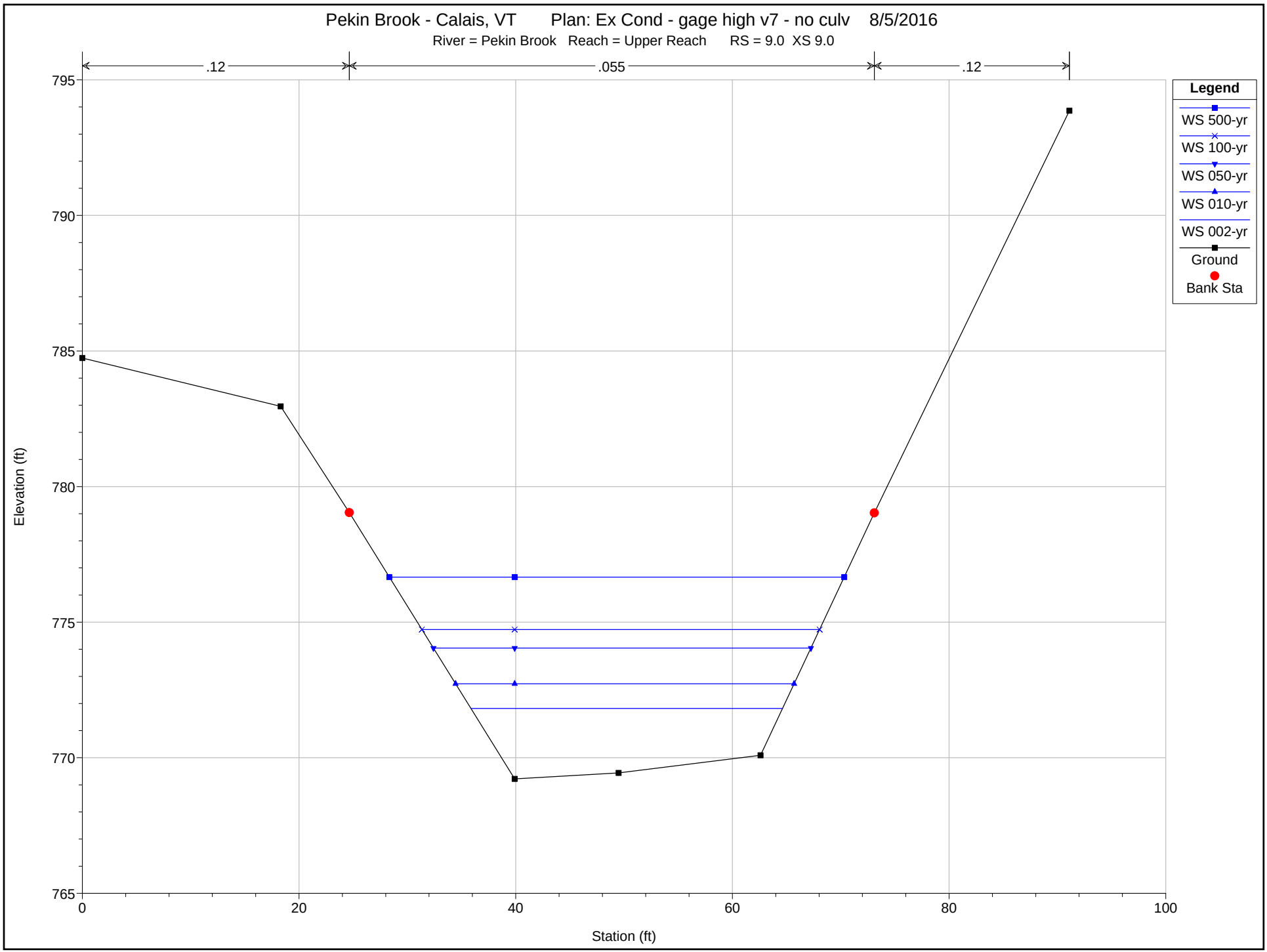

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v6 9/1/2016
River = Pekin Brook Reach = Upper Reach RS = 2.0 XS 2.0
.12
.045
.12
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
780
775
770
765
760
755
750
745
0
100
200
300
400
500
Station (ft)


Pekin Brook - Calais, VT Plan: Ex Cond - gage high v6 9/1/2016
River = Pekin Brook Reach = Upper Reach RS = 1.0 XS 1.0
.12
.045
.12
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
762
760
758
756
754
752
750
748
746
0
50
100
150
200
250
300
350
Station (ft)

HEC-RAS Plan: Ex Cond v7 River: Pekin Brook Reach: Upper Reach

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)	
Upper Reach	9.0	002-yr	468.00	769.22	771.82	771.82	772.84	0.037849	8.10	57.76	28.77	1.01
Upper Reach	9.0	010-yr	796.00	769.22	772.73	772.73	774.09	0.034335	9.36	85.05	31.25	1.00
Upper Reach	9.0	050-yr	1401.00	769.22	774.04	774.04	775.89	0.031733	10.90	128.56	34.84	1.00
Upper Reach	9.0	100-yr	1774.00	769.22	774.73	774.73	776.82	0.030774	11.59	153.11	36.71	1.00
Upper Reach	9.0	500-yr	3036.00	769.22	776.66	776.66	779.39	0.028791	13.25	229.08	41.98	1.00
Upper Reach	8.0	002-yr	468.00	764.25	768.01		768.88	0.023558	7.47	62.62	23.81	0.81
Upper Reach	8.0	010-yr	796.00	764.25	769.06	768.70	770.30	0.024737	8.93	89.09	26.49	0.86
Upper Reach	8.0	050-yr	1401.00	764.25	770.30	770.14	772.34	0.027005	11.48	124.38	30.70	0.94
Upper Reach	8.0	100-yr	1774.00	764.25	770.94	770.94	773.44	0.027783	12.71	144.88	32.90	0.98
Upper Reach	8.0	500-yr	3036.00	764.25	773.21	773.21	776.55	0.023519	14.86	228.48	40.69	0.95
Upper Reach	7.01	002-yr	468.00	760.25	763.43	763.43	764.62	0.036870	8.77	53.39	22.62	1.01
Upper Reach	7.01	010-yr	796.00	760.25	764.51	764.51	766.07	0.034451	10.02	79.43	25.76	1.01
Upper Reach	7.01	050-yr	1401.00	760.25	766.03	766.03	768.08	0.032108	11.47	122.19	30.21	1.01
Upper Reach	7.01	100-yr	1774.00	760.25	766.82	766.82	769.09	0.031091	12.09	146.73	32.49	1.00
Upper Reach	7.01	500-yr	3036.00	760.25	768.91	768.91	771.85	0.028649	13.76	221.25	38.90	1.00
Upper Reach	7.0	002-yr	468.00	759.56	761.84	761.84	762.90	0.038986	8.28	56.55	26.77	1.00
Upper Reach	7.0	010-yr	796.00	759.56	762.77	762.77	764.23	0.036360	9.69	82.30	29.22	1.00
Upper Reach	7.0	050-yr	1401.00	759.56	764.77	764.77	765.72	0.014702	8.45	242.55	169.63	0.69
Upper Reach	7.0	100-yr	1774.00	759.56	765.25	765.25	766.16	0.013615	8.68	336.15	221.72	0.67
Upper Reach	7.0	500-yr	3036.00	759.56	766.23	766.23	767.11	0.013121	9.56	599.69	300.41	0.68
Upper Reach	6.0	002-yr	468.00	756.96	759.00	759.00	759.57	0.015467	6.17	98.36	161.21	0.79
Upper Reach	6.0	010-yr	796.00	756.96	759.56	759.56	760.06	0.012441	6.41	216.63	224.28	0.73
Upper Reach	6.0	050-yr	1401.00	756.96	760.03	760.03	760.67	0.015409	7.86	322.70	233.46	0.83
Upper Reach	6.0	100-yr	1774.00	756.96	760.26	760.26	760.98	0.016508	8.58	377.60	245.58	0.87
Upper Reach	6.0	500-yr	3036.00	756.96	760.94	760.94	761.84	0.017630	10.15	560.80	292.85	0.93
Upper Reach	5.0	002-yr	468.00	754.71	755.83	755.83	756.36	0.029309	5.79	79.68	75.16	1.00
Upper Reach	5.0	010-yr	796.00	754.71	756.44	756.44	757.02	0.019109	6.11	129.96	111.53	0.86
Upper Reach	5.0	050-yr	1401.00	754.71	757.09	757.06	757.70	0.017989	7.17	228.72	201.84	0.87
Upper Reach	5.0	100-yr	1774.00	754.71	757.55	757.34	758.04	0.013643	6.92	340.22	277.88	0.78
Upper Reach	5.0	500-yr	3036.00	754.71	758.61		759.00	0.008724	6.64	674.38	338.42	0.65
Upper Reach	4.0	002-yr	468.00	749.13	753.03		753.32	0.005604	4.56	107.73	45.87	0.50
Upper Reach	4.0	010-yr	796.00	749.13	754.05		754.45	0.005461	5.19	158.22	52.33	0.50
Upper Reach	4.0	050-yr	1401.00	749.13	755.33		755.80	0.005644	6.03	263.20	129.12	0.53
Upper Reach	4.0	100-yr	1774.00	749.13	755.83		756.33	0.005939	6.51	339.72	184.85	0.55
Upper Reach	4.0	500-yr	3036.00	749.13	757.17		757.66	0.005209	7.15	724.51	382.72	0.53
Upper Reach	3.0	002-yr	468.00	747.78	752.50		752.74	0.003004	4.23	159.49	63.46	0.38
Upper Reach	3.0	010-yr	796.00	747.78	753.43		753.81	0.003760	5.48	220.41	68.14	0.44
Upper Reach	3.0	050-yr	1401.00	747.78	754.46	752.97	755.04	0.004868	7.11	386.63	258.30	0.52
Upper Reach	3.0	100-yr	1774.00	747.78	755.02		755.59	0.004578	7.34	555.73	334.57	0.51
Upper Reach	3.0	500-yr	3036.00	747.78	756.76		757.09	0.002730	6.66	1311.67	488.35	0.41
Upper Reach	2.0	002-yr	468.00	746.18	751.79		752.07	0.003039	4.42	141.23	126.85	0.38
Upper Reach	2.0	010-yr	796.00	746.18	752.72		753.04	0.003129	5.14	359.45	298.25	0.40
Upper Reach	2.0	050-yr	1401.00	746.18	753.99		754.23	0.002371	5.19	782.24	367.35	0.36
Upper Reach	2.0	100-yr	1774.00	746.18	754.63		754.84	0.002065	5.17	1026.81	391.41	0.34
Upper Reach	2.0	500-yr	3036.00	746.18	756.45		756.61	0.001511	5.16	1754.40	403.47	0.31
Upper Reach	1.0	002-yr	468.00	746.91	751.29	749.32	751.38	0.001301	2.90	325.03	210.74	0.26
Upper Reach	1.0	010-yr	796.00	746.91	752.24	750.25	752.35	0.001302	3.35	553.77	247.20	0.27
Upper Reach	1.0	050-yr	1401.00	746.91	753.51	751.17	753.64	0.001300	3.90	872.90	253.99	0.28
Upper Reach	1.0	100-yr	1774.00	746.91	754.16	751.63	754.30	0.001301	4.17	1039.30	257.46	0.28
Upper Reach	1.0	500-yr	3036.00	746.91	756.00	752.55	756.17	0.001300	4.88	1520.65	267.24	0.29


Pekin Brook - Calais, VT Plan: Ex Cond - gage high v7 - no culv 8/5/2016
Pekin Brook Upper Reach
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Sediment Fill
Ground
Elevation (ft)
Main Channel Distance (ft)
780
775
770
765
760
755
750
745
0
200
400
600
800
1000
1200
1400
2.0
3.0
4.0
5.0
6.0
7.0
7.01
8.0
9.0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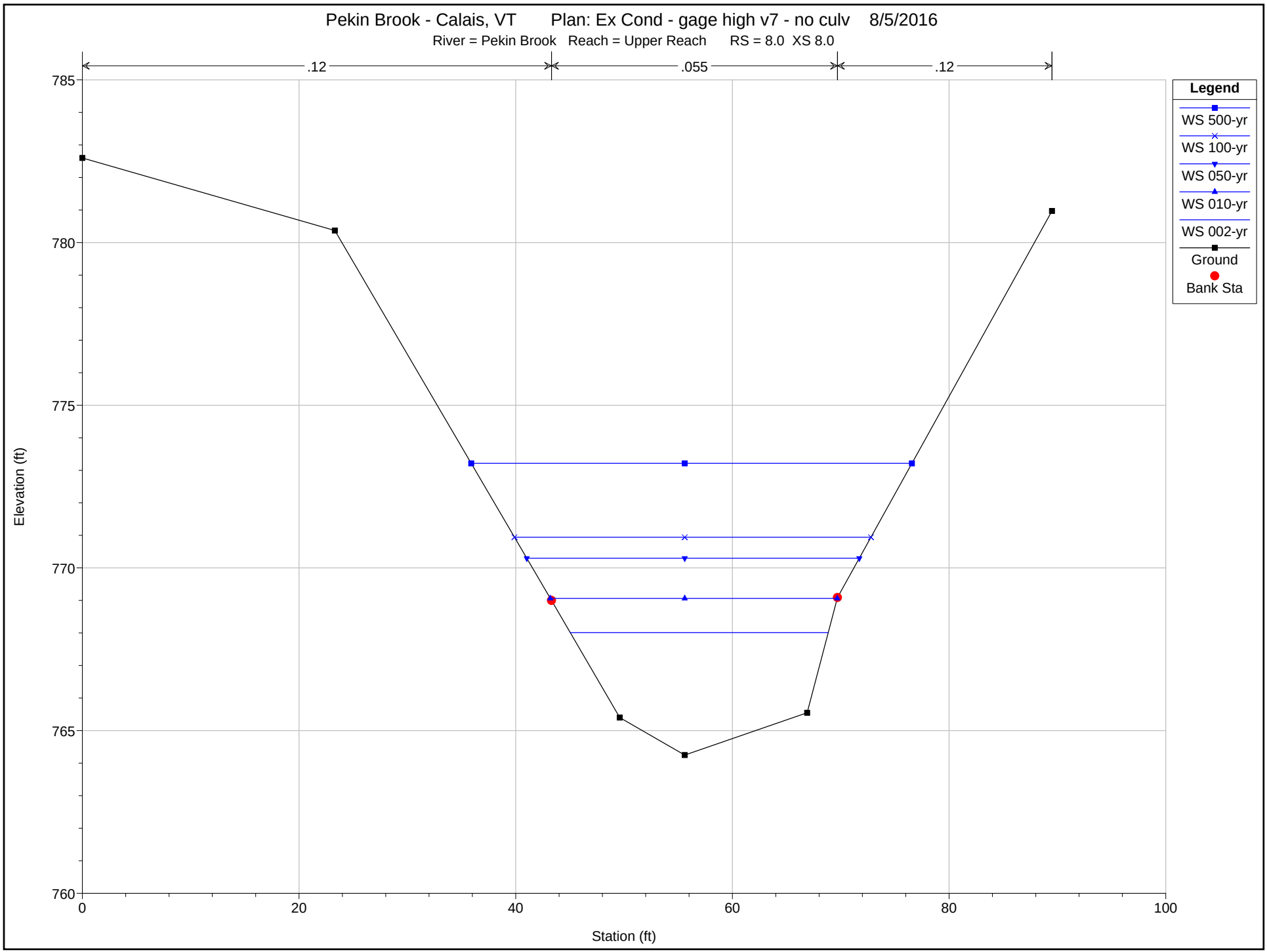
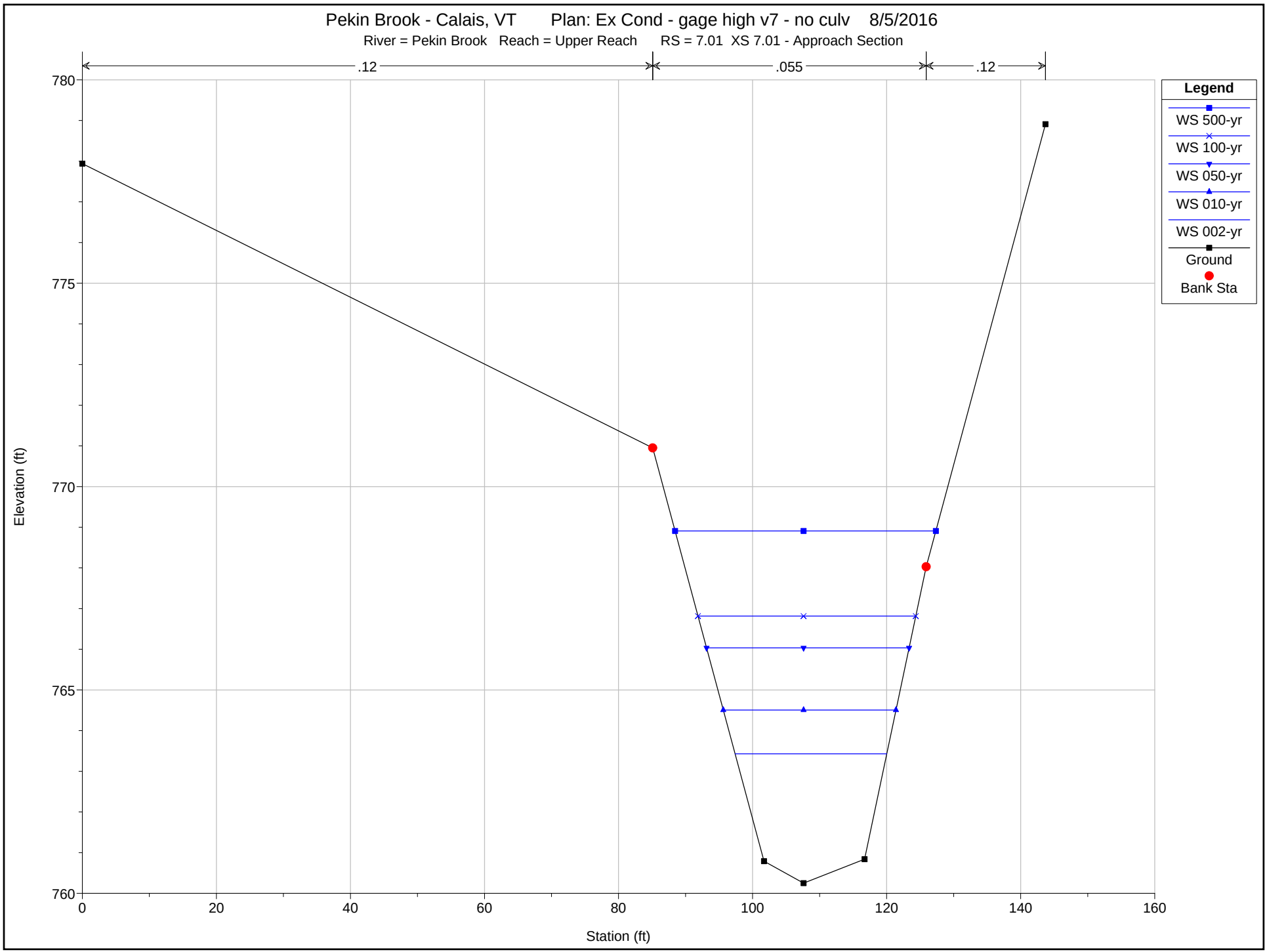
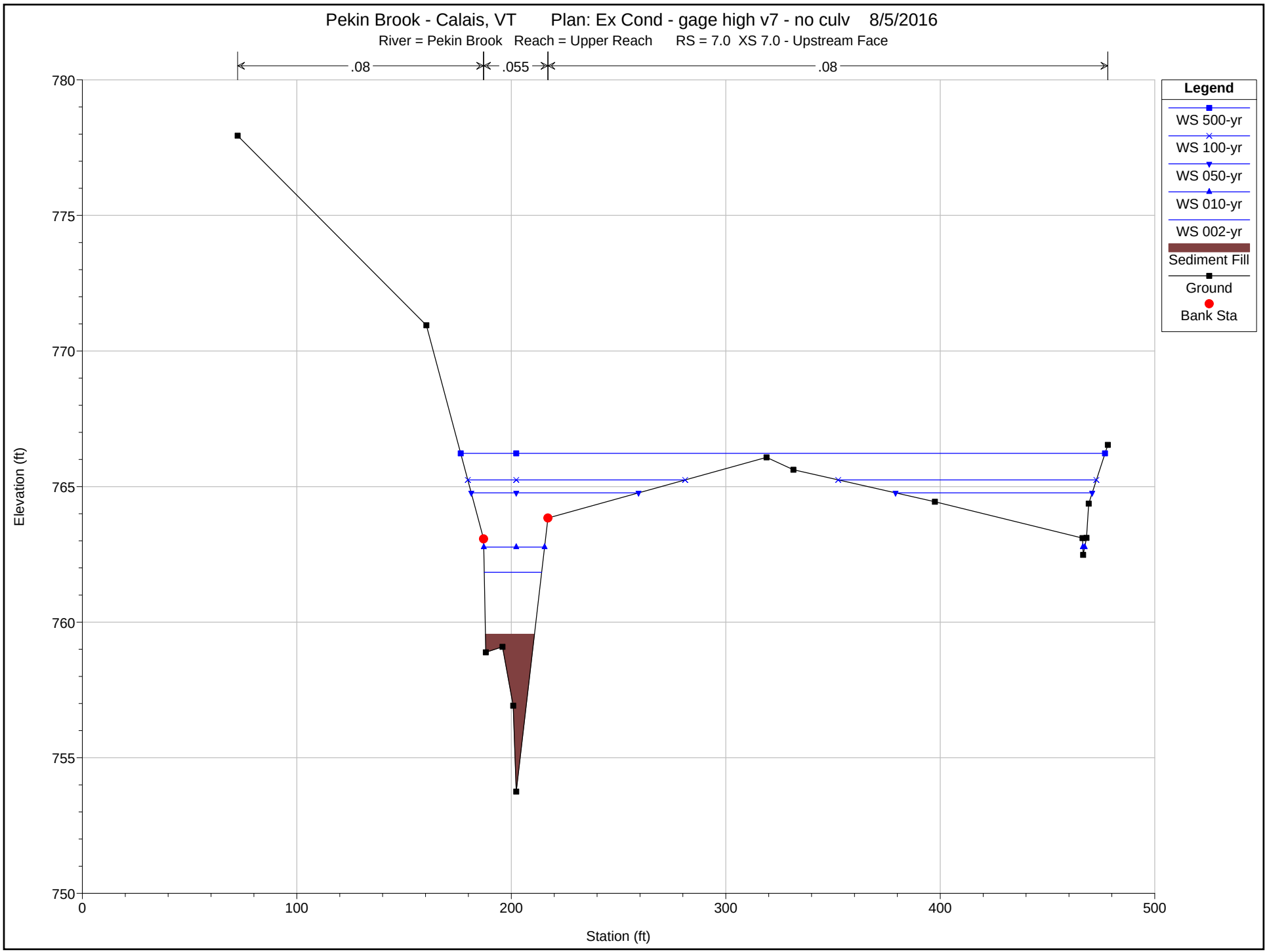
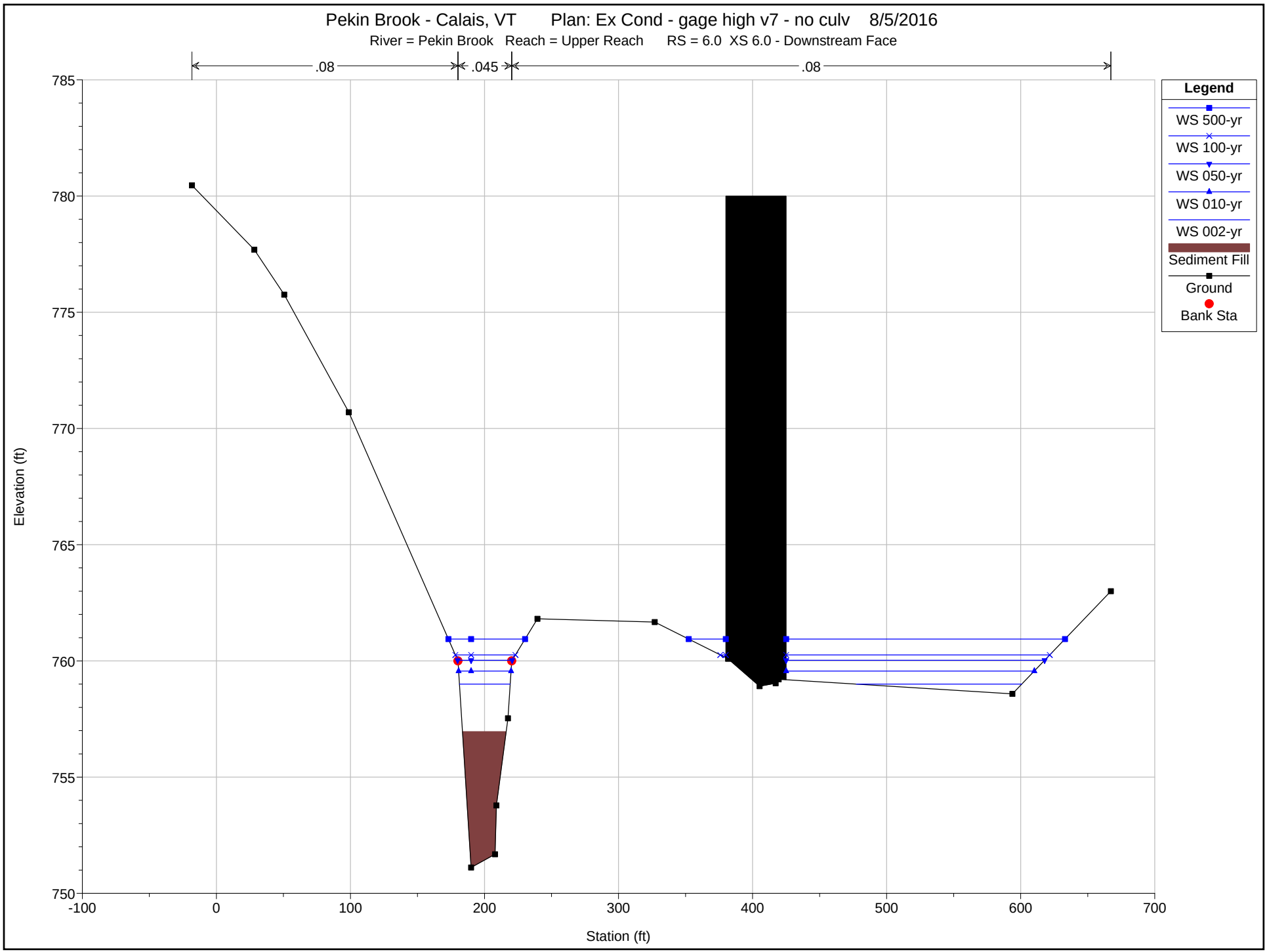
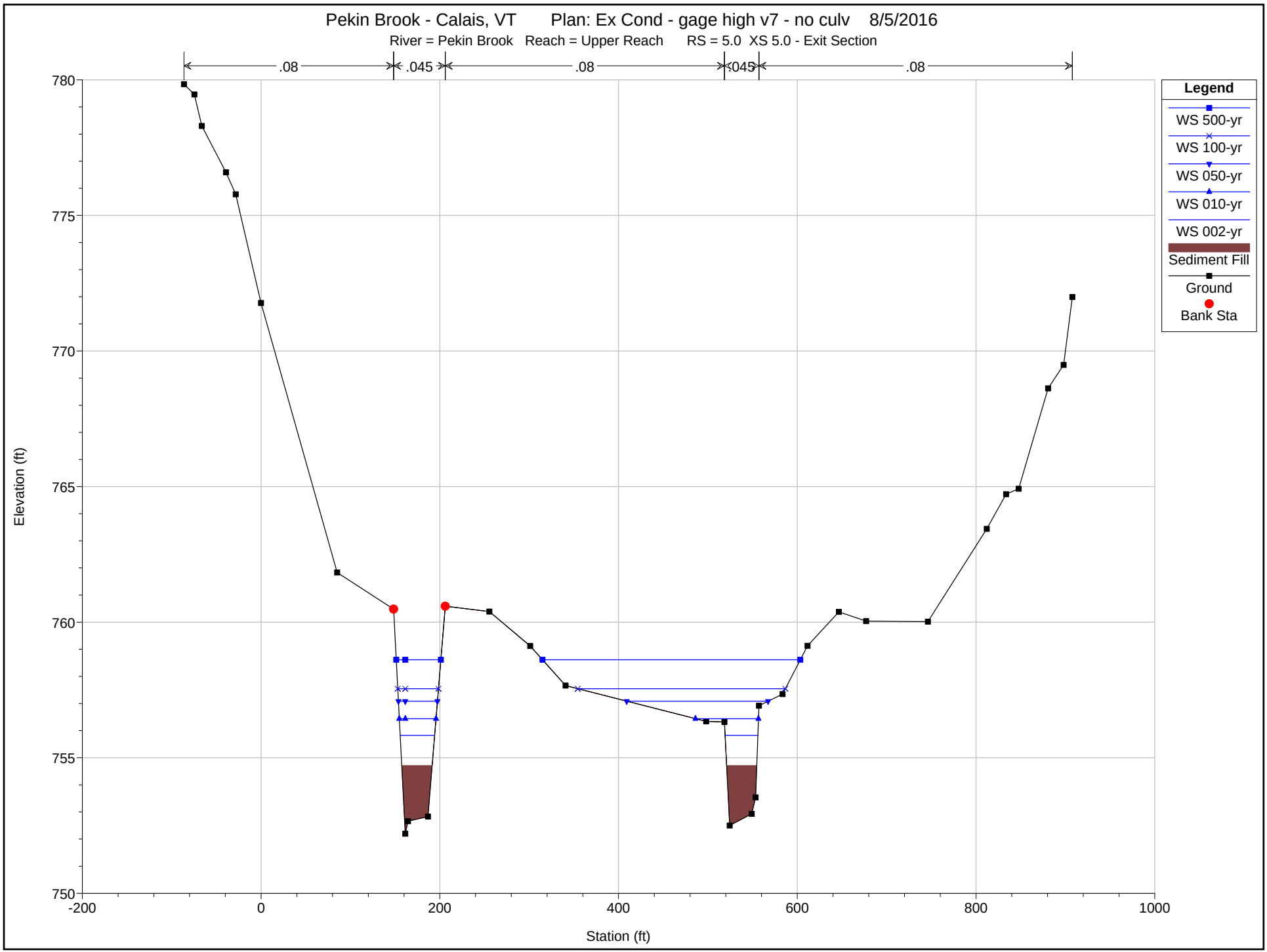
River = Pekin Brook Reach = Upper Reach RS = 9.0 XS 9.0
.12
.055
.12
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
795
790
785
780
775
770
765
0
20
40
60
80
100
Station (ft)

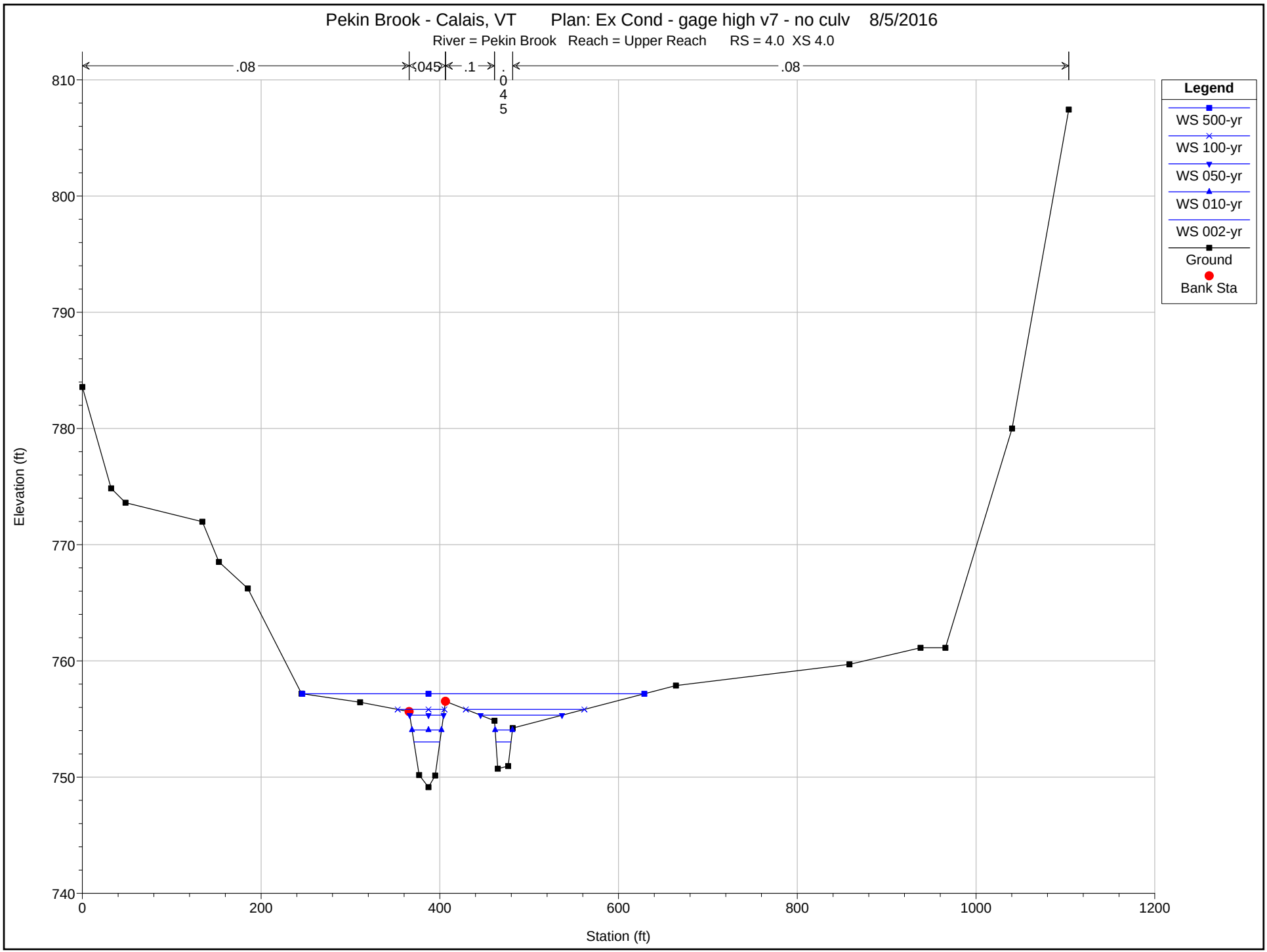

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v7 - no culv 8/5/2016
River = Pekin Brook Reach = Upper Reach RS = 8.0 XS 8.0
.12
.055
.12
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
785
780
775
770
765
760
0
20
40
60
80
100
Station (ft)

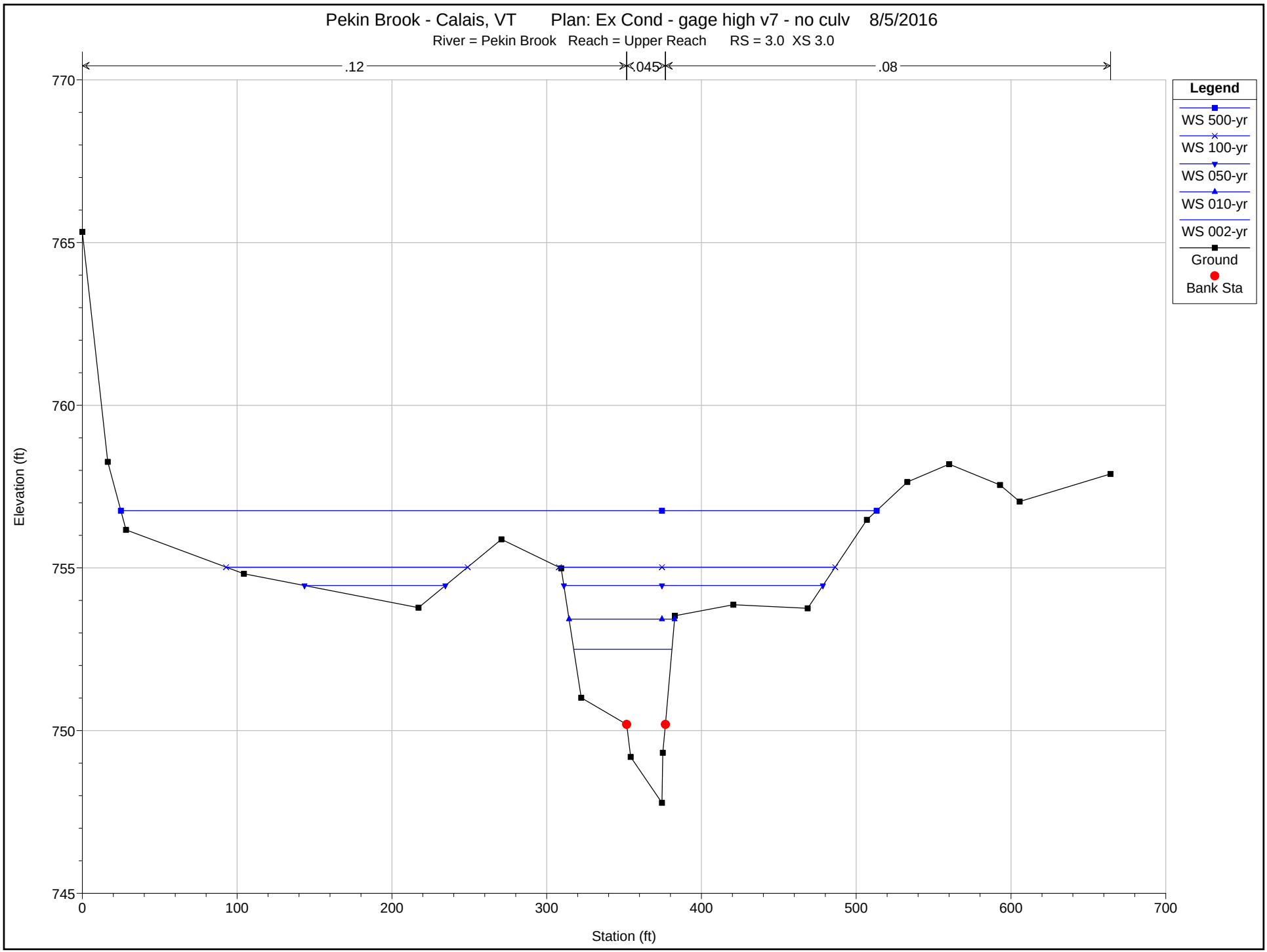

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v7 - no culv 8/5/2016
River = Pekin Brook Reach = Upper Reach RS = 7.01 XS 7.01 - Approach Section
.12
.055
.12
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
780
775
770
765
760
0
20
40
60
80
100
120
140
160
Station (ft)

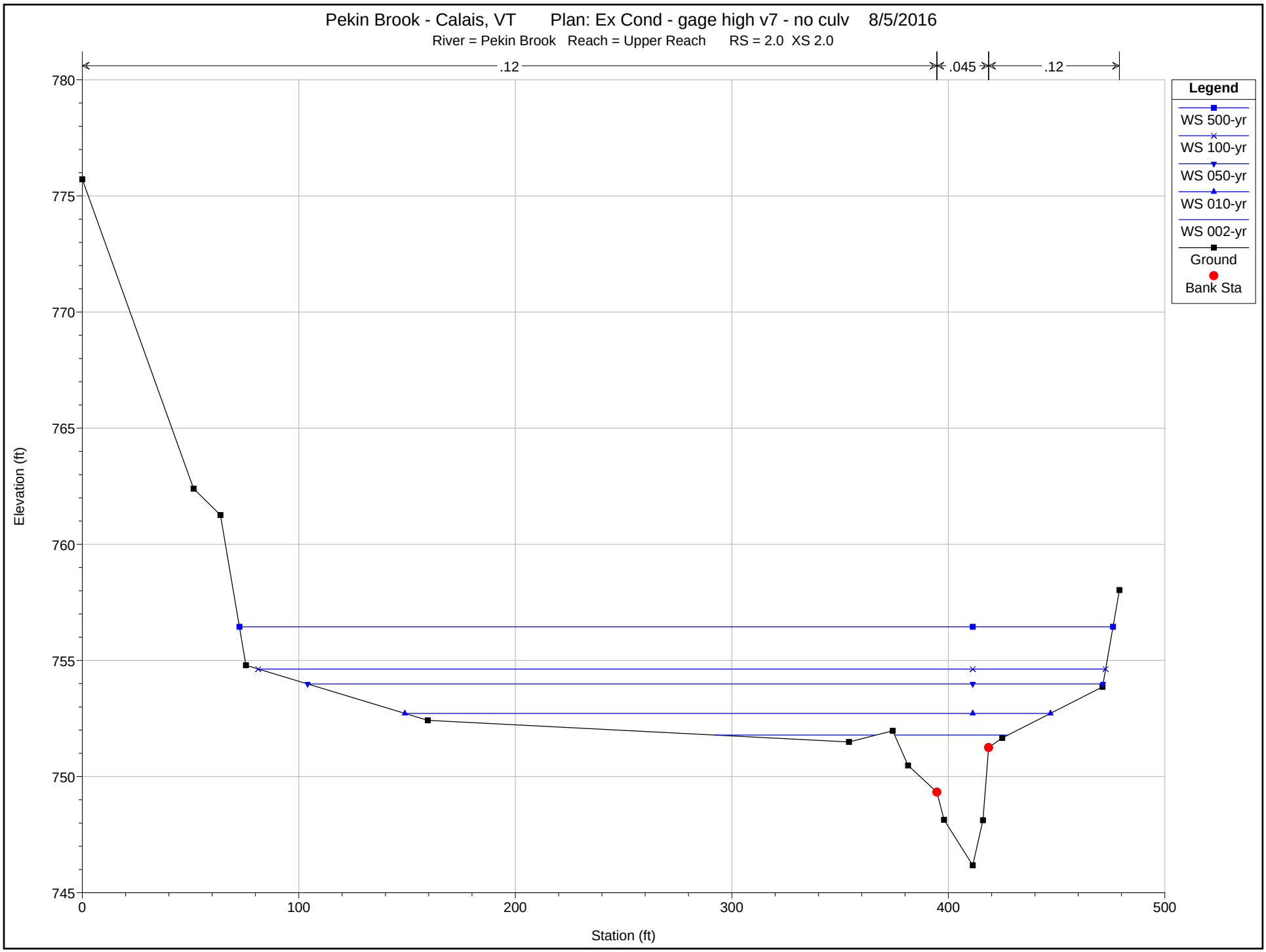

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v7 - no culv 8/5/2016
River = Pekin Brook Reach = Upper Reach RS = 7.0 XS 7.0 - Upstream Face
.08
.055
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Sediment Fill
Ground
Bank Sta
Elevation (ft)
780
775
770
765
760
755
750
0
100
200
300
400
500
Station (ft)

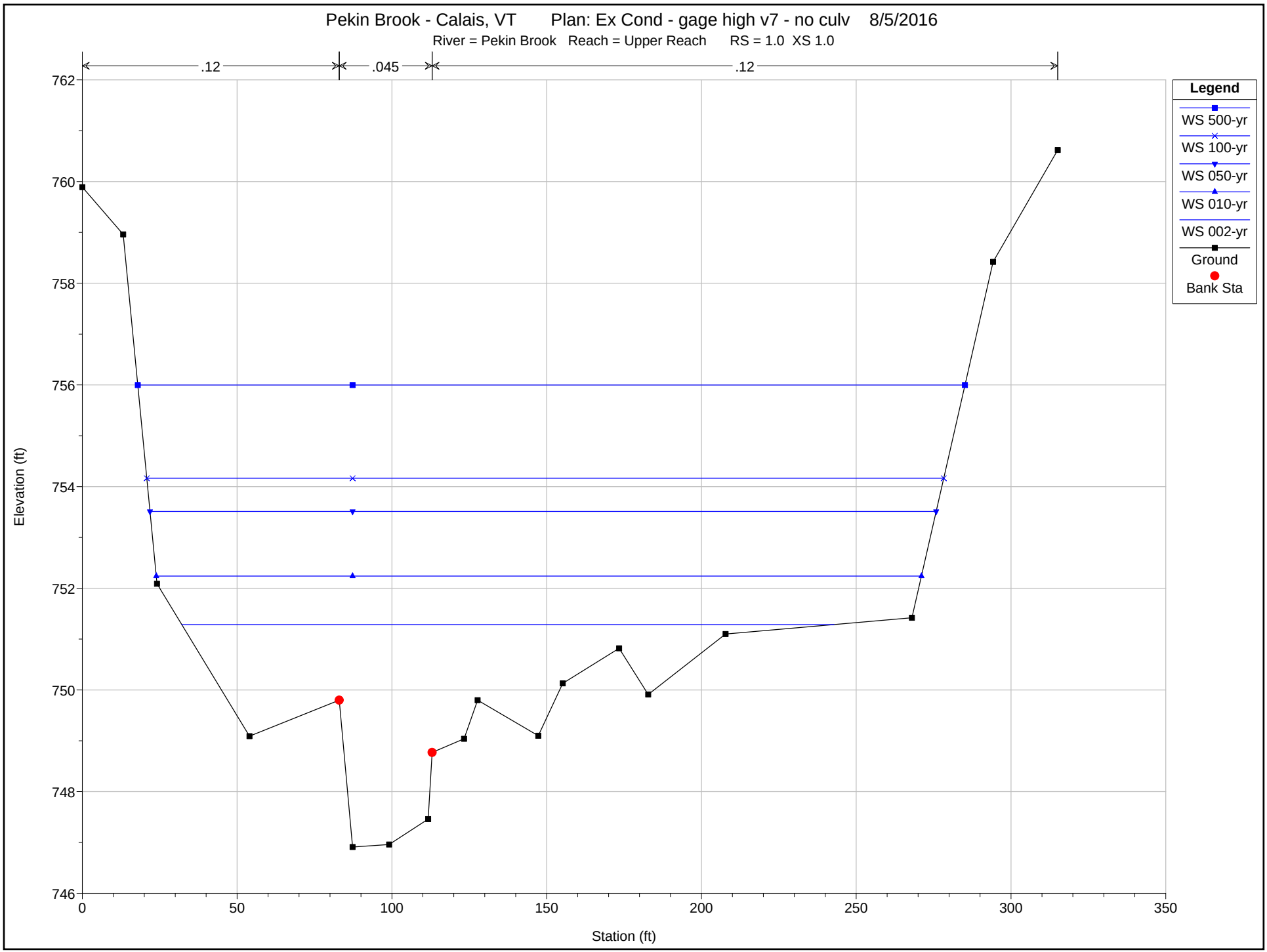

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v7 - no culv 8/5/2016
River = Pekin Brook Reach = Upper Reach RS = 6.0 XS 6.0 - Downstream Face
.08
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Sediment Fill
Ground
Bank Sta
Elevation (ft)
785
780
775
770
765
760
755
750
-100
0
100
200
300
400
500
600
700
Station (ft)


Pekin Brook - Calais, VT Plan: Ex Cond - gage high v7 - no culv 8/5/2016
River = Pekin Brook Reach = Upper Reach RS = 5.0 XS 5.0 - Exit Section
.08
.045
.08
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Sediment Fill
Ground
Bank Sta
Elevation (ft)
780
775
770
765
760
755
750
-200
0
200
400
600
800
1000
Station (ft)


Pekin Brook - Calais, VT Plan: Ex Cond - gage high v7 - no culv 8/5/2016
River = Pekin Brook Reach = Upper Reach RS = 4.0 XS 4.0
.08
.045
.1
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
810
800
790
780
770
760
750
740
0
200
400
600
800
1000
1200


Pekin Brook - Calais, VT Plan: Ex Cond - gage high v7 - no culv 8/5/2016
River = Pekin Brook Reach = Upper Reach RS = 3.0 XS 3.0
.12
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
770
765
760
755
750
745
0
100
200
300
400
500
600
700
Station (ft)


Pekin Brook - Calais, VT Plan: Ex Cond - gage high v7 - no culv 8/5/2016
River = Pekin Brook Reach = Upper Reach RS = 2.0 XS 2.0
.12
.045
.12
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
780
775
770
765
760
755
750
745
0
100
200
300
400
500
Station (ft)

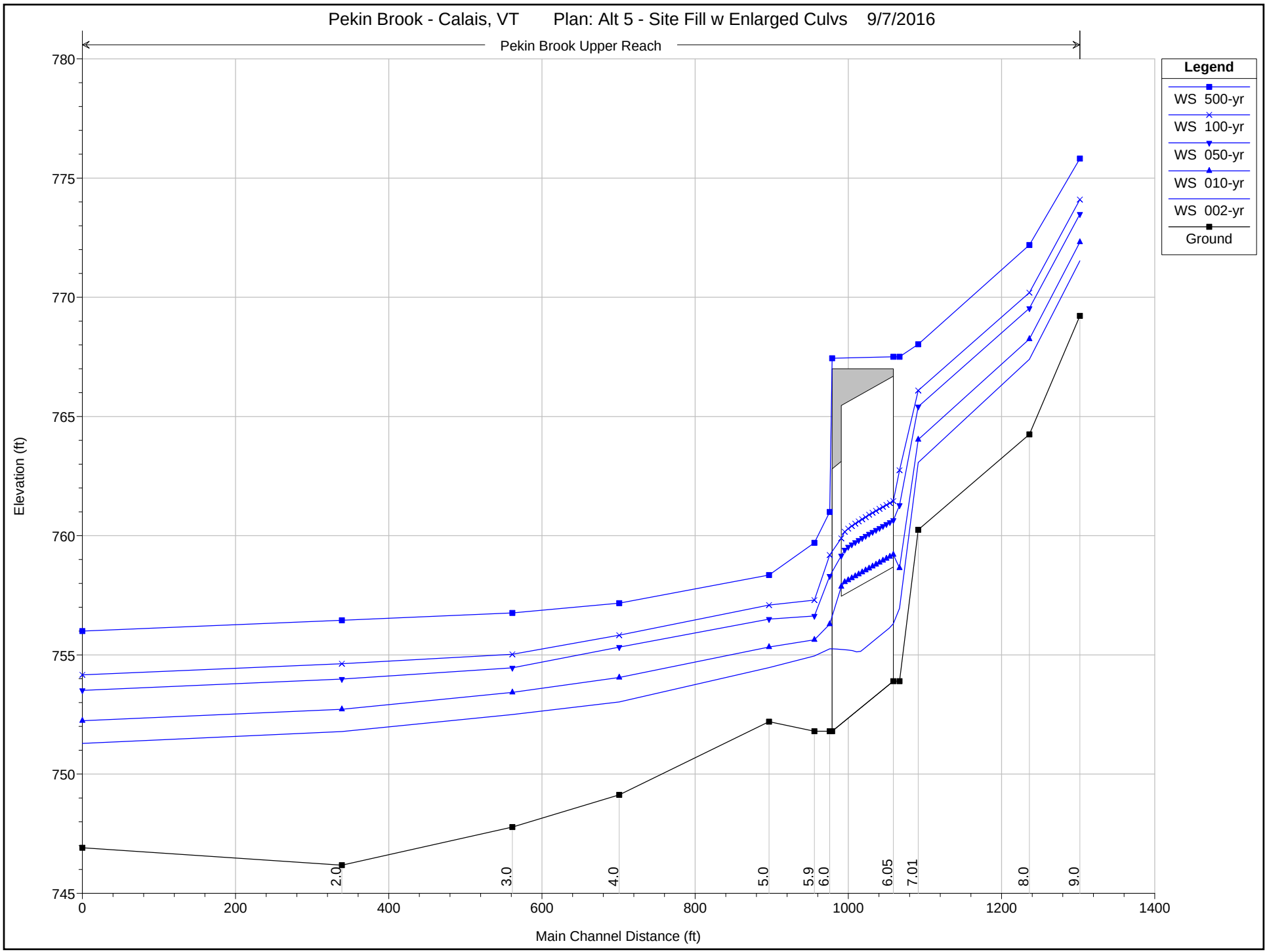

Pekin Brook - Calais, VT Plan: Ex Cond - gage high v7 - no culv 8/5/2016
River = Pekin Brook Reach = Upper Reach RS = 1.0 XS 1.0
.12
.045
.12
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
762
760
758
756
754
752
750
748
746
0
50
100
150
200
250
300
350
Station (ft)

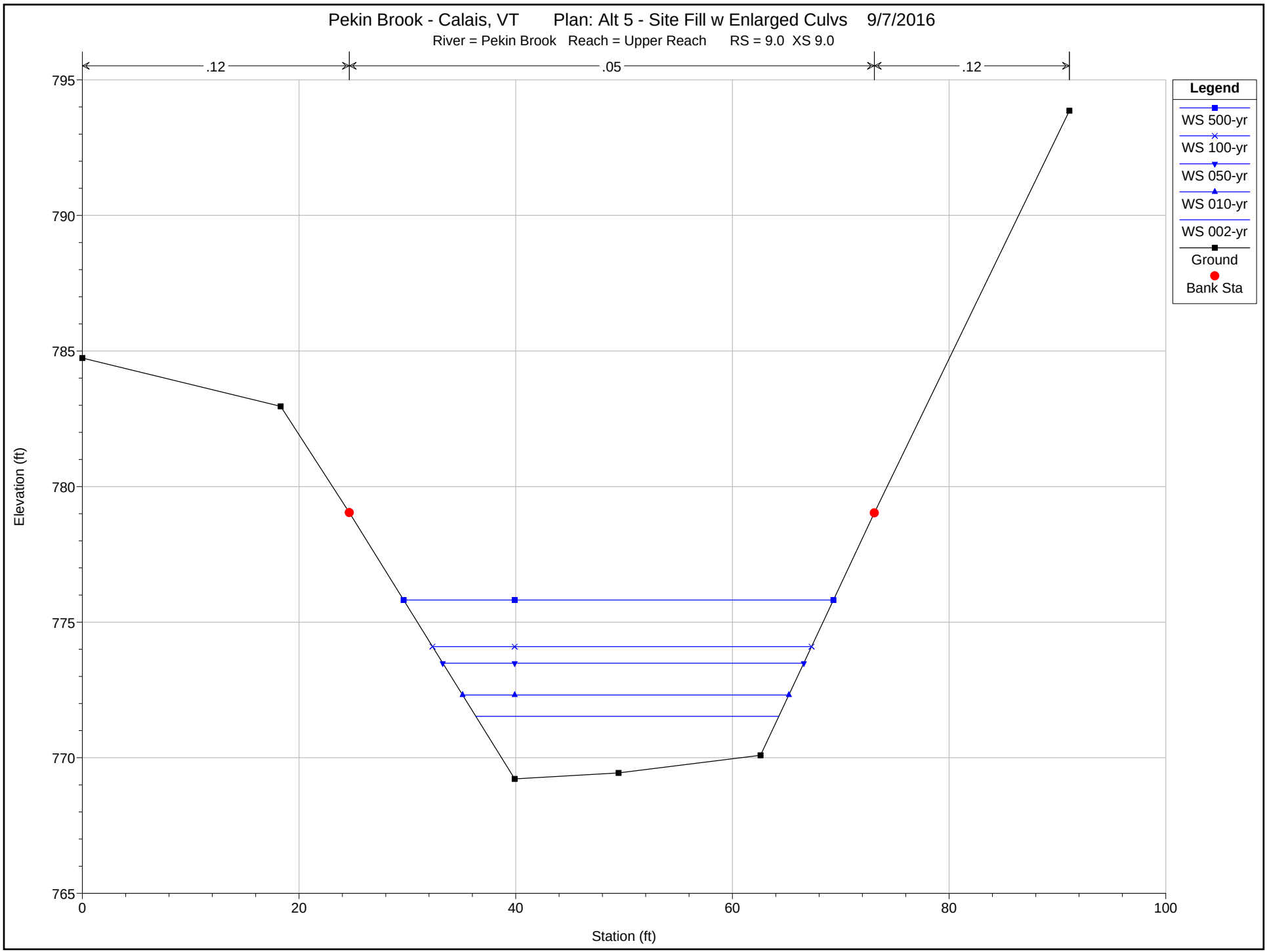
APPENDIX B

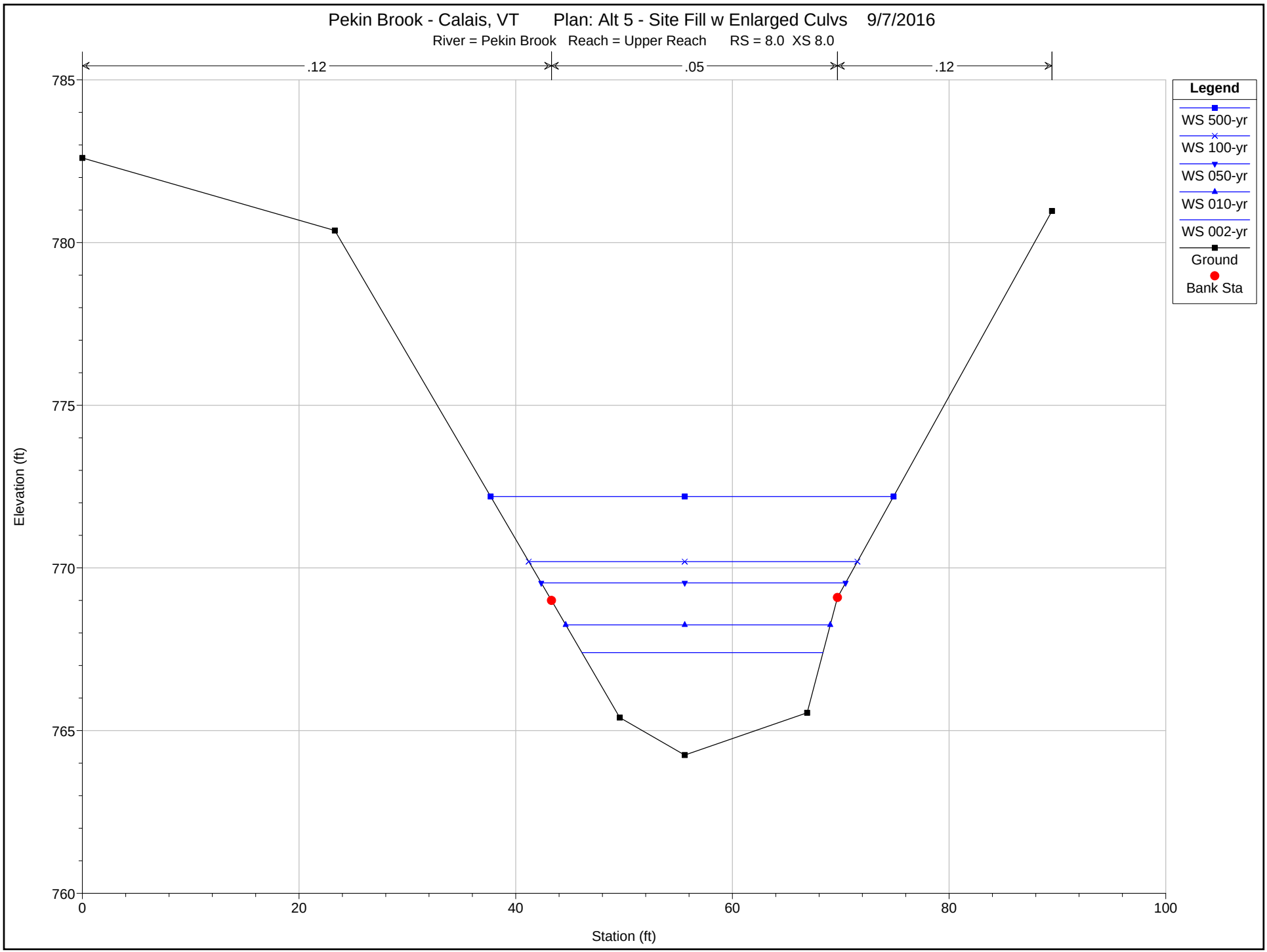
HEC-RAS PREFERRED ALTERNATIVE BASE FLOOD INFORMATION

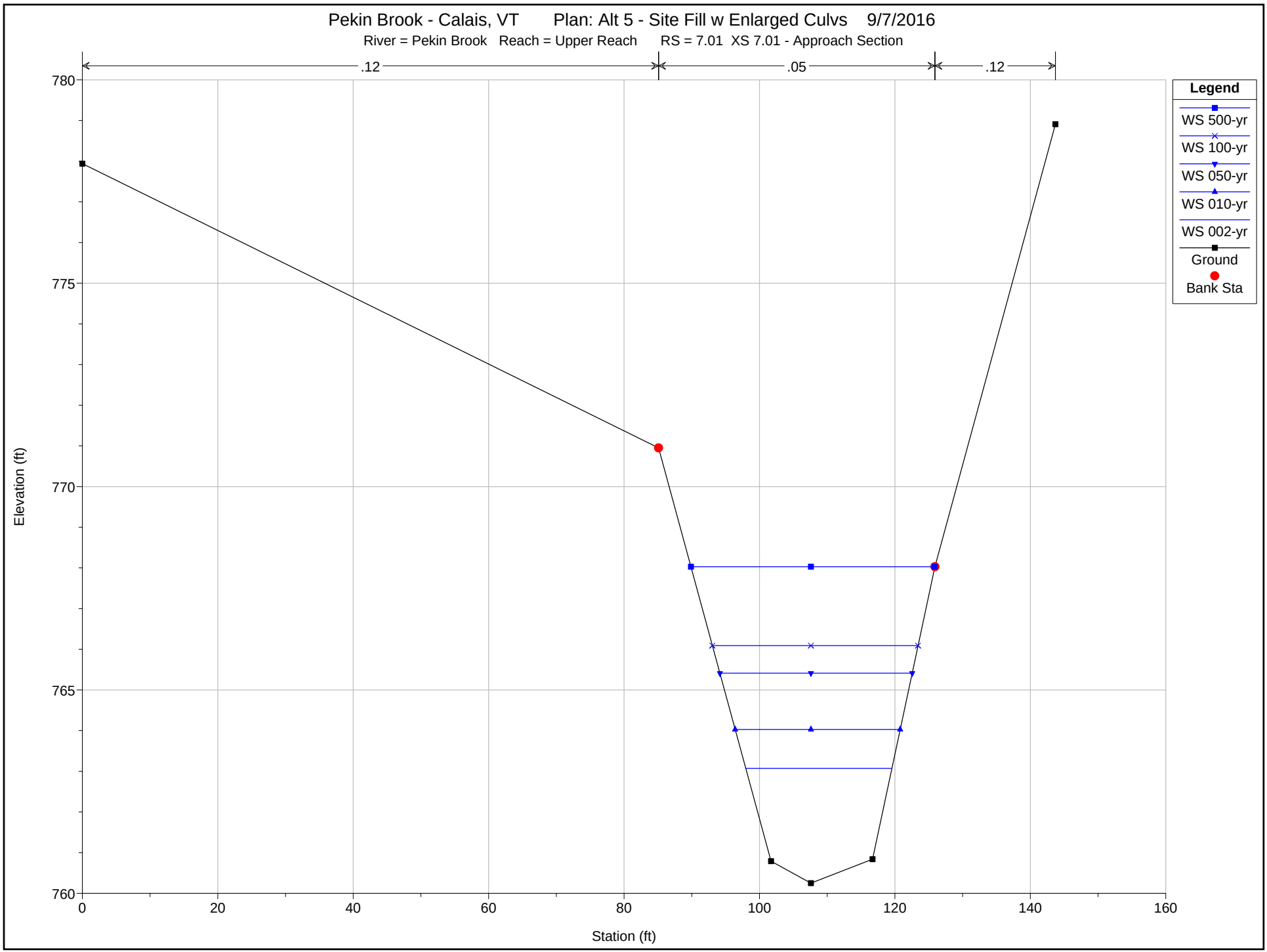
HEC-RAS Plan: Alt 5 River: Pekin Brook Reach: Upper Reach

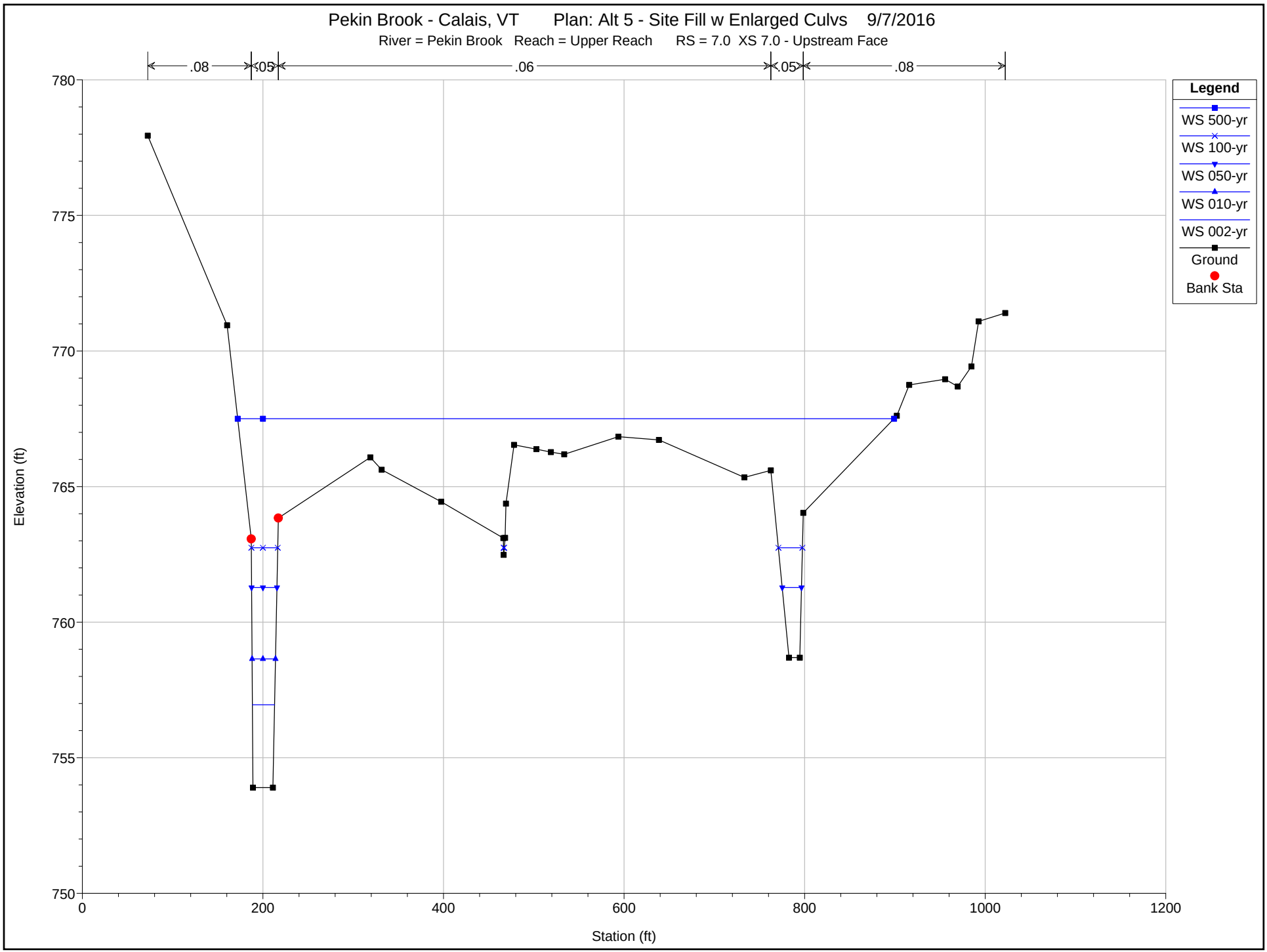
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Upper Reach	9.0	002-yr	377.00	769.22	771.53	771.53	772.43	0.032363	7.61	49.56	27.98	1.01
Upper Reach	9.0	010-yr	641.00	769.22	772.31	772.31	773.53	0.029802	8.86	72.33	30.12	1.01
Upper Reach	9.0	050-yr	1128.00	769.22	773.49	773.49	775.13	0.027011	10.29	109.62	33.32	1.00
Upper Reach	9.0	100-yr	1429.00	769.22	774.10	774.10	775.96	0.026158	10.95	130.45	34.99	1.00
Upper Reach	9.0	500-yr	2445.00	769.22	775.82	775.82	778.27	0.024423	12.56	194.61	39.68	1.00
Upper Reach	8.0	002-yr	377.00	764.25	767.40	767.27	768.34	0.026518	7.77	48.54	22.26	0.93
Upper Reach	8.0	010-yr	641.00	764.25	768.25	768.22	769.61	0.028375	9.38	68.36	24.42	0.99
Upper Reach	8.0	050-yr	1128.00	764.25	769.54	769.54	771.45	0.026464	11.09	102.09	28.10	1.00
Upper Reach	8.0	100-yr	1429.00	764.25	770.19	770.19	772.42	0.025083	11.99	121.22	30.34	1.00
Upper Reach	8.0	500-yr	2445.00	764.25	772.19	772.19	775.20	0.020999	14.02	188.78	37.19	0.97
Upper Reach	7.01	002-yr	377.00	760.25	763.07	763.07	764.14	0.031466	8.29	45.45	21.58	1.01
Upper Reach	7.01	010-yr	641.00	760.25	764.03	764.03	765.43	0.029252	9.50	67.50	24.37	1.01
Upper Reach	7.01	050-yr	1128.00	760.25	765.41	765.41	767.24	0.026904	10.85	103.99	28.40	1.00
Upper Reach	7.01	100-yr	1429.00	760.25	766.09	766.09	768.16	0.026566	11.53	123.90	30.38	1.01
Upper Reach	7.01	500-yr	2445.00	760.25	768.03	768.03	770.65	0.024679	12.99	188.28	36.03	1.00
Upper Reach	7.0	002-yr	468.00	753.90	756.95	756.27	757.63	0.014680	6.59	71.04	24.51	0.68
Upper Reach	7.0	010-yr	796.00	753.90	758.65	757.26	759.41	0.010423	7.00	113.67	25.90	0.59
Upper Reach	7.0	050-yr	1401.00	753.90	761.28	759.06	761.91	0.006188	6.68	227.72	49.42	0.46
Upper Reach	7.0	100-yr	1774.00	753.90	762.75	759.92	763.30	0.004691	6.32	305.29	56.75	0.40
Upper Reach	7.0	500-yr	3036.00	753.90	767.50	761.80	767.57	0.000603	3.06	1899.28	726.95	0.15
Upper Reach	6.05		Culvert									
Upper Reach	6.0	002-yr	468.00	751.80	755.25		755.68	0.006500	5.23	89.43	29.80	0.53
Upper Reach	6.0	010-yr	796.00	751.80	756.29		756.95	0.007585	6.52	124.43	44.49	0.59
Upper Reach	6.0	050-yr	1401.00	751.80	758.31	756.63	758.97	0.005416	6.71	221.62	51.85	0.52
Upper Reach	6.0	100-yr	1774.00	751.80	759.19	757.30	759.84	0.004947	6.86	322.96	215.47	0.50
Upper Reach	6.0	500-yr	3036.00	751.80	761.00	759.70	761.49	0.003520	6.73	758.31	273.46	0.44
Upper Reach	5.9	002-yr	468.00	751.80	754.96		755.48	0.008827	5.80	80.68	29.13	0.61
Upper Reach	5.9	010-yr	796.00	751.80	755.63		756.60	0.013179	7.89	100.89	30.66	0.77
Upper Reach	5.9	050-yr	1401.00	751.80	756.63	756.63	758.29	0.017836	10.40	139.80	45.76	0.91
Upper Reach	5.9	100-yr	1774.00	751.80	757.30	757.30	759.09	0.017221	10.94	171.09	48.23	0.91
Upper Reach	5.9	500-yr	3036.00	751.80	759.70	759.70	760.98	0.009798	10.00	436.39	227.35	0.71
Upper Reach	5.0	002-yr	468.00	752.20	754.47		754.78	0.010181	4.42	103.86	66.03	0.62
Upper Reach	5.0	010-yr	796.00	752.20	755.33		755.70	0.007316	4.72	163.25	71.82	0.56
Upper Reach	5.0	050-yr	1401.00	752.20	756.50		756.96	0.006110	5.30	256.91	118.95	0.53
Upper Reach	5.0	100-yr	1774.00	752.20	757.09		757.50	0.005544	5.47	350.02	203.19	0.52
Upper Reach	5.0	500-yr	3036.00	752.20	758.35		758.70	0.004859	5.87	689.32	292.74	0.50
Upper Reach	4.0	002-yr	468.00	749.13	753.03		753.32	0.005604	4.56	107.73	45.87	0.50
Upper Reach	4.0	010-yr	796.00	749.13	754.05		754.45	0.005461	5.19	158.22	52.33	0.50
Upper Reach	4.0	050-yr	1401.00	749.13	755.33		755.80	0.005644	6.03	263.20	129.12	0.53
Upper Reach	4.0	100-yr	1774.00	749.13	755.83		756.33	0.005939	6.51	339.71	184.85	0.55
Upper Reach	4.0	500-yr	3036.00	749.13	757.17		757.66	0.005208	7.15	724.55	382.74	0.53
Upper Reach	3.0	002-yr	468.00	747.78	752.50		752.74	0.003004	4.23	159.49	63.46	0.38
Upper Reach	3.0	010-yr	796.00	747.78	753.43		753.81	0.003760	5.48	220.41	68.14	0.44
Upper Reach	3.0	050-yr	1401.00	747.78	754.46	752.97	755.04	0.004868	7.11	386.63	258.30	0.52
Upper Reach	3.0	100-yr	1774.00	747.78	755.02		755.59	0.004578	7.34	555.75	334.58	0.51
Upper Reach	3.0	500-yr	3036.00	747.78	756.76		757.09	0.002729	6.66	1311.73	488.36	0.41
Upper Reach	2.0	002-yr	468.00	746.18	751.79		752.07	0.003039	4.42	141.23	126.85	0.38
Upper Reach	2.0	010-yr	796.00	746.18	752.72		753.04	0.003129	5.14	359.47	298.25	0.40
Upper Reach	2.0	050-yr	1401.00	746.18	753.99		754.23	0.002371	5.19	782.26	367.36	0.36
Upper Reach	2.0	100-yr	1774.00	746.18	754.63		754.84	0.002065	5.17	1026.88	391.42	0.34
Upper Reach	2.0	500-yr	3036.00	746.18	756.45		756.61	0.001511	5.16	1754.42	403.47	0.31
Upper Reach	1.0	002-yr	468.00	746.91	751.29	749.32	751.38	0.001301	2.90	325.03	210.74	0.26
Upper Reach	1.0	010-yr	796.00	746.91	752.24	750.25	752.35	0.001302	3.35	553.77	247.20	0.27
Upper Reach	1.0	050-yr	1401.00	746.91	753.51	751.17	753.64	0.001300	3.90	872.90	253.99	0.28
Upper Reach	1.0	100-yr	1774.00	746.91	754.16	751.63	754.30	0.001301	4.17	1039.30	257.46	0.28
Upper Reach	1.0	500-yr	3036.00	746.91	756.00	752.55	756.17	0.001300	4.88	1520.65	267.24	0.29

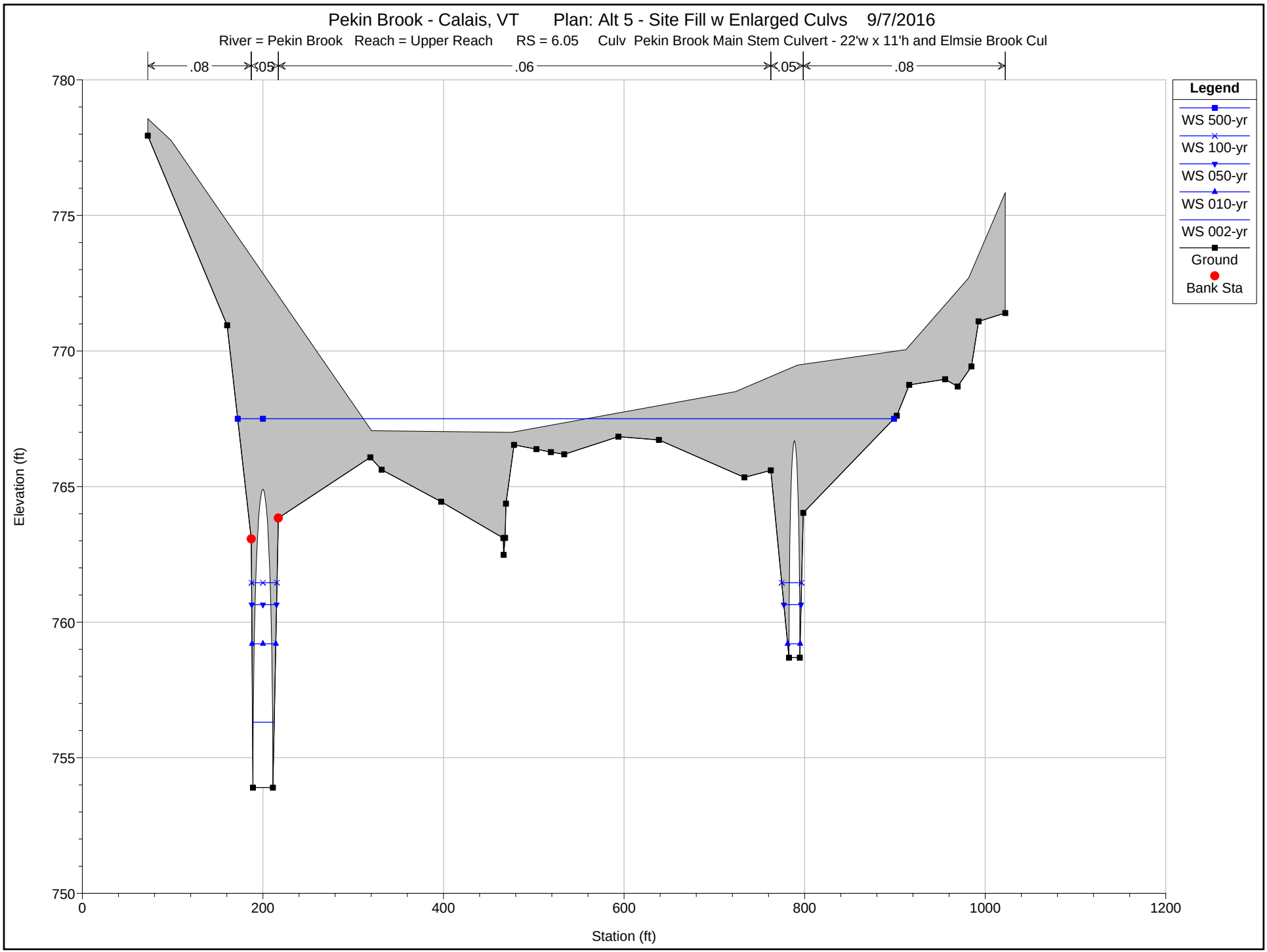

Pekin Brook - Calais, VT Plan: Alt 5 - Site Fill w Enlarged Culvs 9/7/2016
Pekin Brook Upper Reach
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Elevation (ft)
Main Channel Distance (ft)
780
775
770
765
760
755
750
745
0
200
400
600
800
1000
1200
1400
2.0
3.0
4.0
5.0
5.9
6.0
6.05
7.01
8.0
9.0

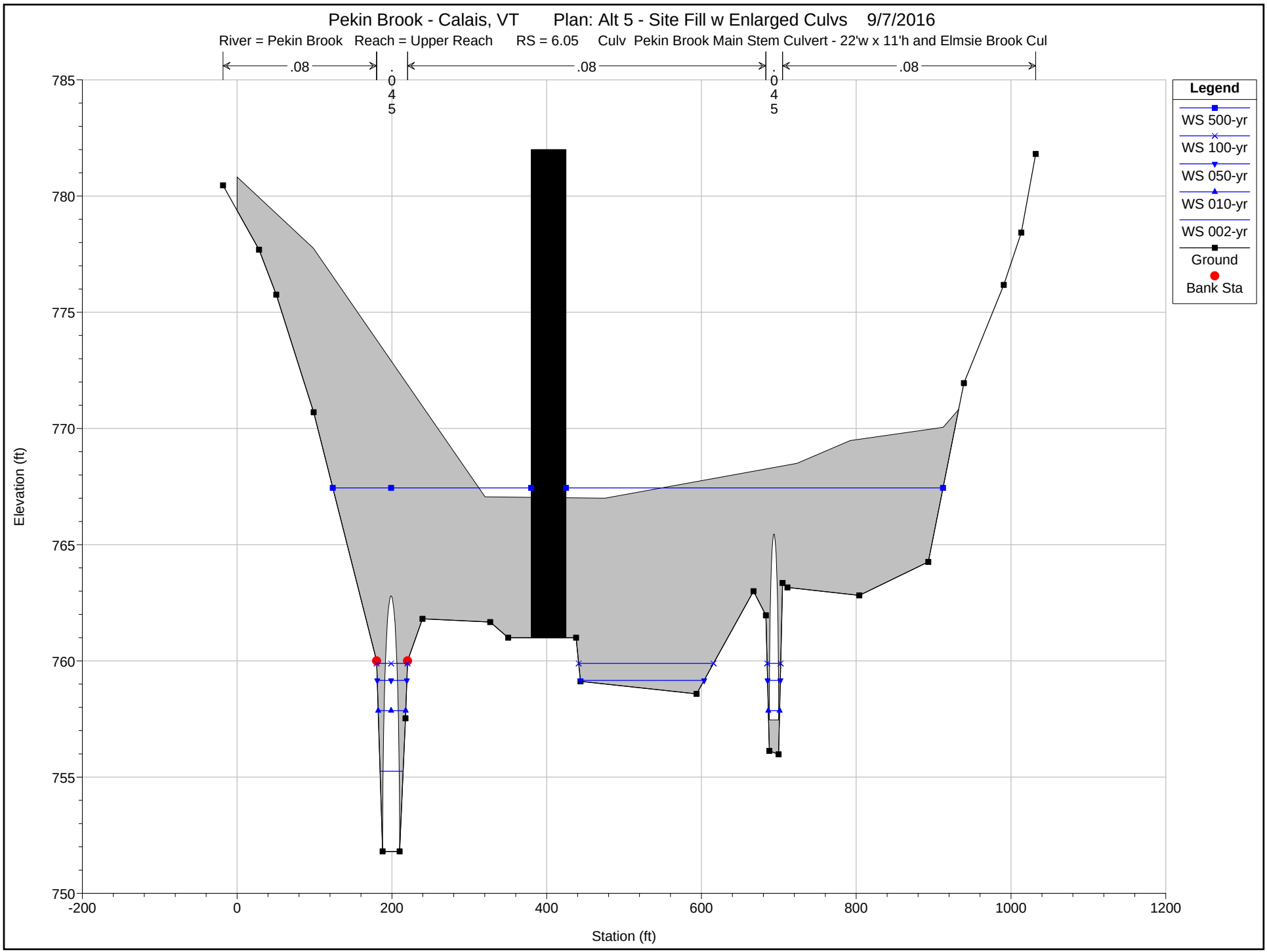

Pekin Brook - Calais, VT Plan: Alt 5 - Site Fill w Enlarged Culvs 9/7/2016
River = Pekin Brook Reach = Upper Reach RS = 9.0 XS 9.0
.12
.05
.12
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
795
790
785
780
775
770
765
0
20
40
60
80
100
Station (ft)

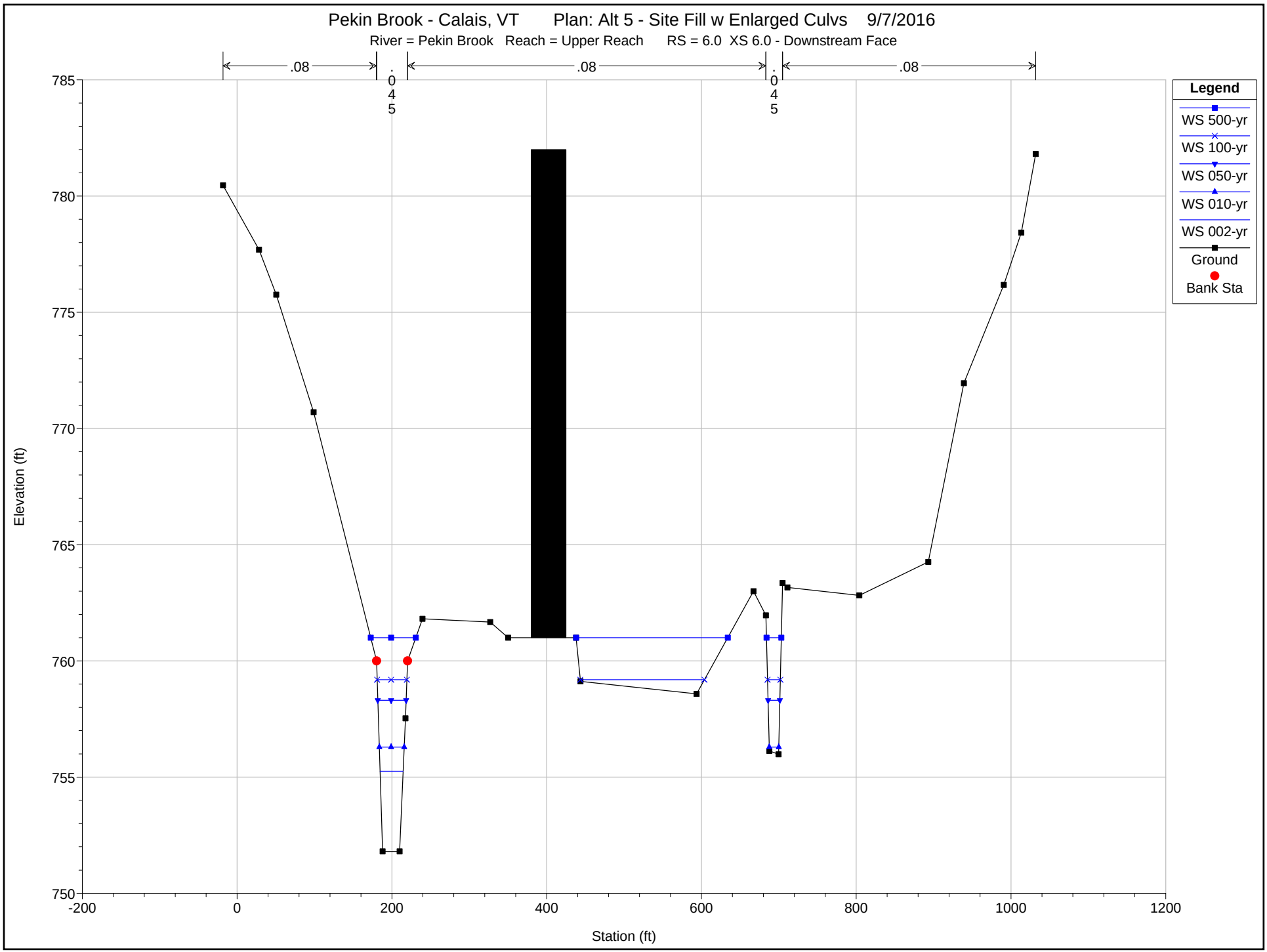

Pekin Brook - Calais, VT Plan: Alt 5 - Site Fill w Enlarged Culvs 9/7/2016
River = Pekin Brook Reach = Upper Reach RS = 8.0 XS 8.0
.12
.05
.12
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
785
780
775
770
765
760
0
20
40
60
80
100
Station (ft)

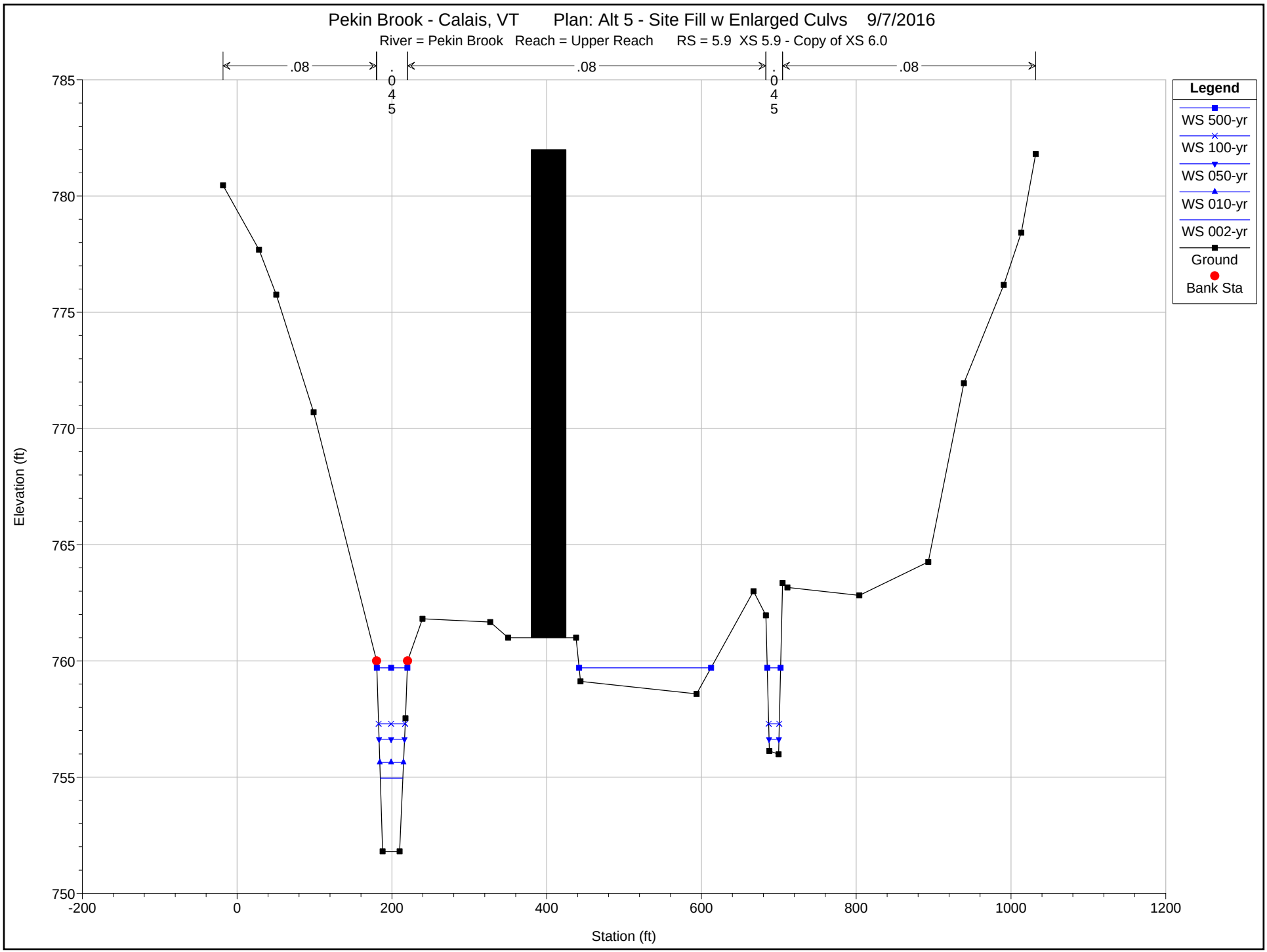

Pekin Brook - Calais, VT Plan: Alt 5 - Site Fill w Enlarged Culvs 9/7/2016
River = Pekin Brook Reach = Upper Reach RS = 7.01 XS 7.01 - Approach Section
.12
.05
.12
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
780
775
770
765
760
0
20
40
60
80
100
120
140
160
Station (ft)

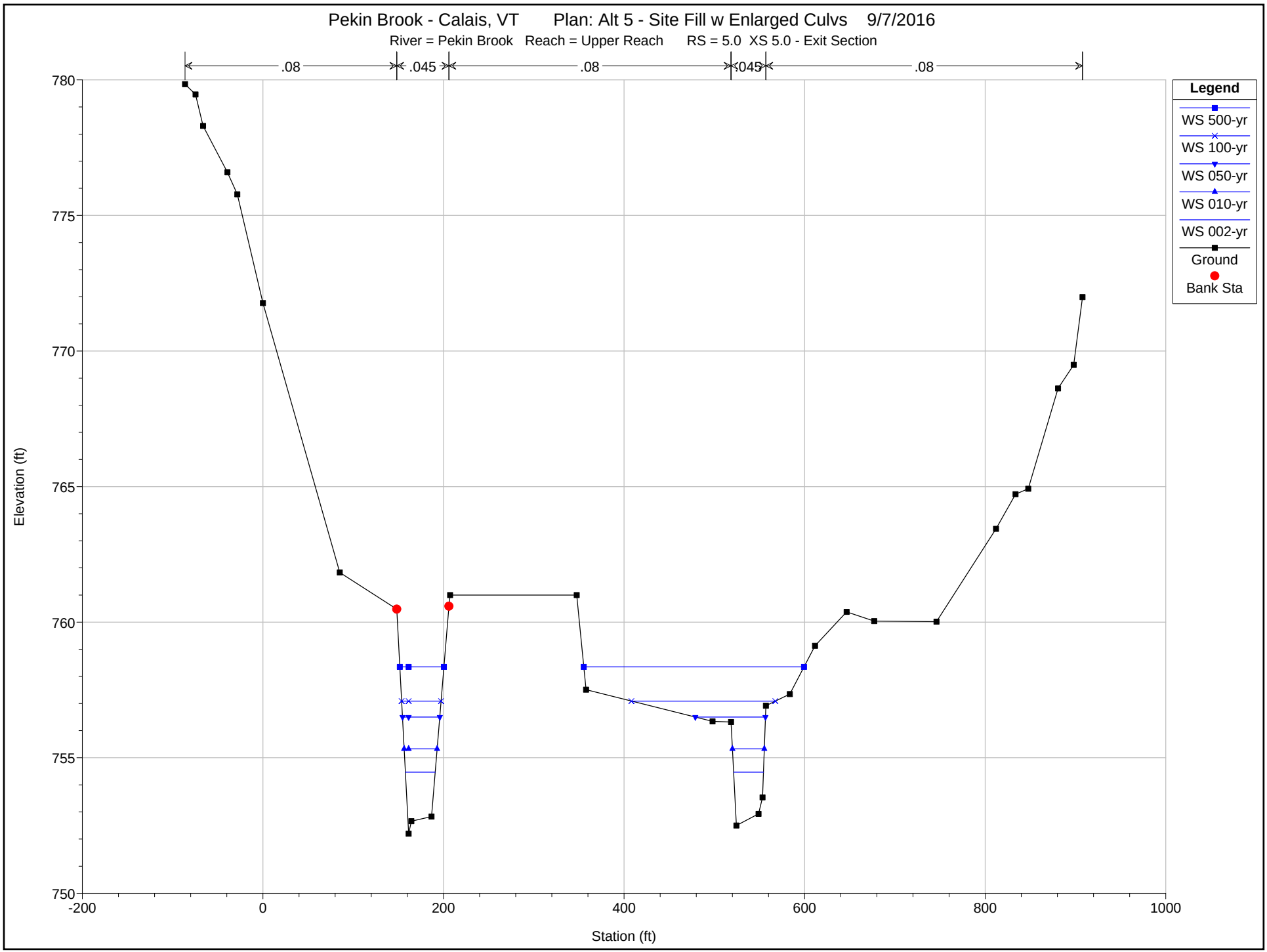

Pekin Brook - Calais, VT Plan: Alt 5 - Site Fill w Enlarged Culvs 9/7/2016
River = Pekin Brook Reach = Upper Reach RS = 7.0 XS 7.0 - Upstream Face
.08
.05
.06
.05
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
780
775
770
765
760
755
750
0
200
400
600
800
1000
1200
Station (ft)

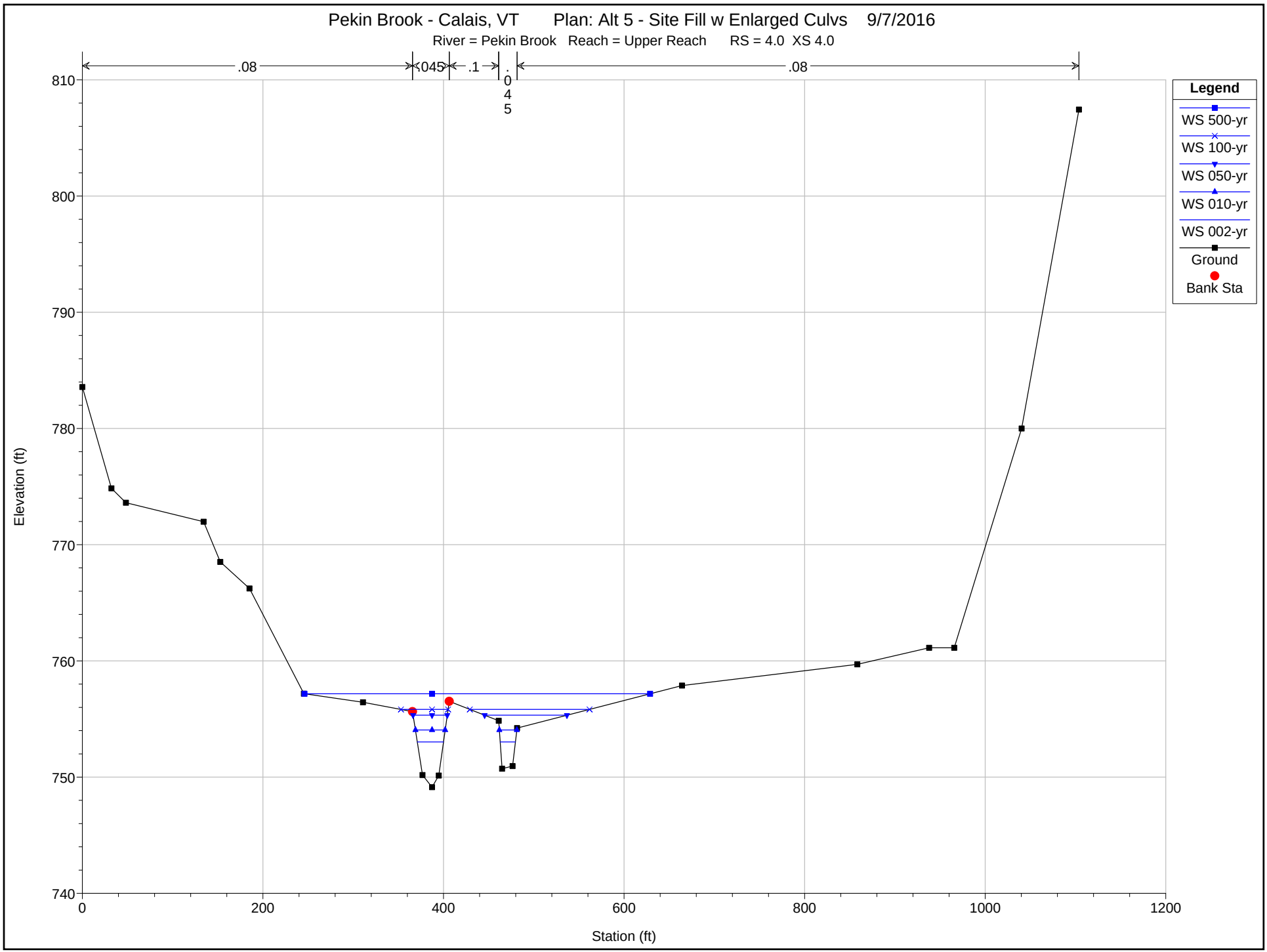

Pekin Brook - Calais, VT Plan: Alt 5 - Site Fill w Enlarged Culvs 9/7/2016
River = Pekin Brook Reach = Upper Reach RS = 6.05 Culv Pekin Brook Main Stem Culvert - 22'w x 11'h and Elmsie Brook Cul
.08
.05
.06
.05
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
780
775
770
765
760
755
750
0
200
400
600
800
1000
1200
Station (ft)

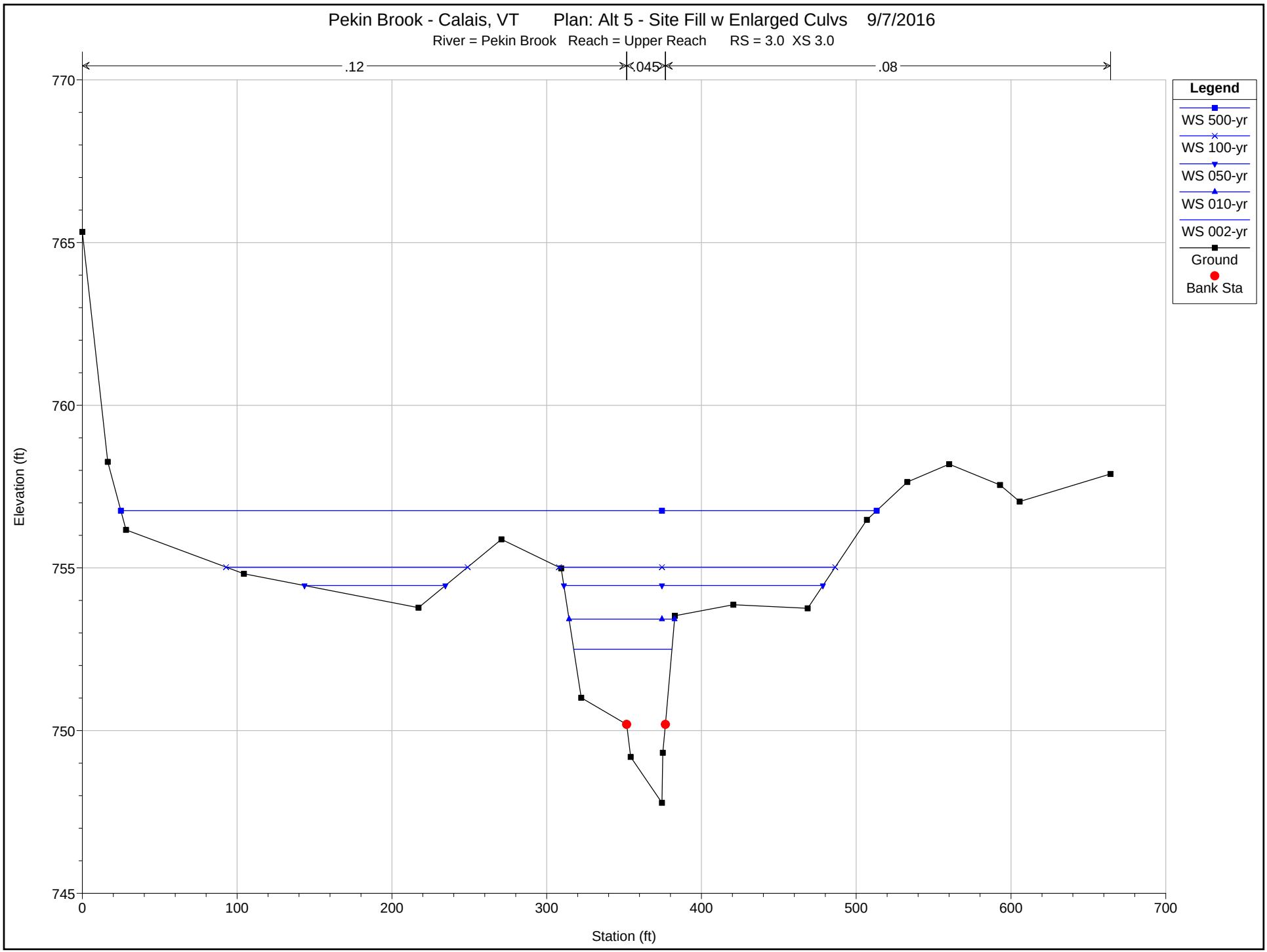

Pekin Brook - Calais, VT Plan: Alt 5 - Site Fill w Enlarged Culvs 9/7/2016
River = Pekin Brook Reach = Upper Reach RS = 6.05 Culv Pekin Brook Main Stem Culvert - 22'w x 11'h and Elmsie Brook Cul
.08
.045
.08
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
785
780
775
770
765
760
755
750
-200
0
200
400
600
800
1000
1200
Station (ft)

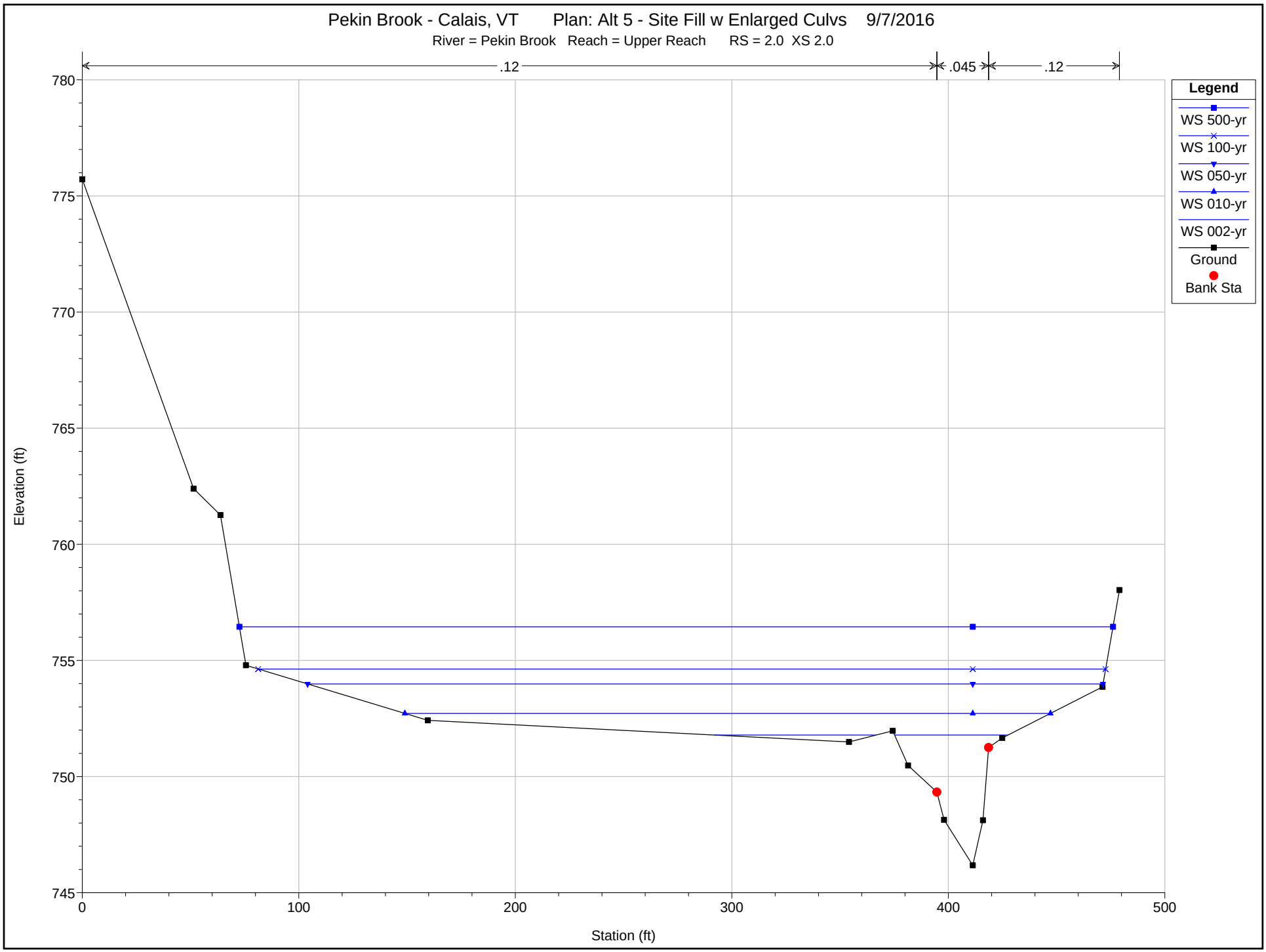

Pekin Brook - Calais, VT Plan: Alt 5 - Site Fill w Enlarged Culvs 9/7/2016
River = Pekin Brook Reach = Upper Reach RS = 6.0 XS 6.0 - Downstream Face
.08
.045
.08
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
785
780
775
770
765
760
755
750
-200
0
200
400
600
800
1000
1200
Station (ft)

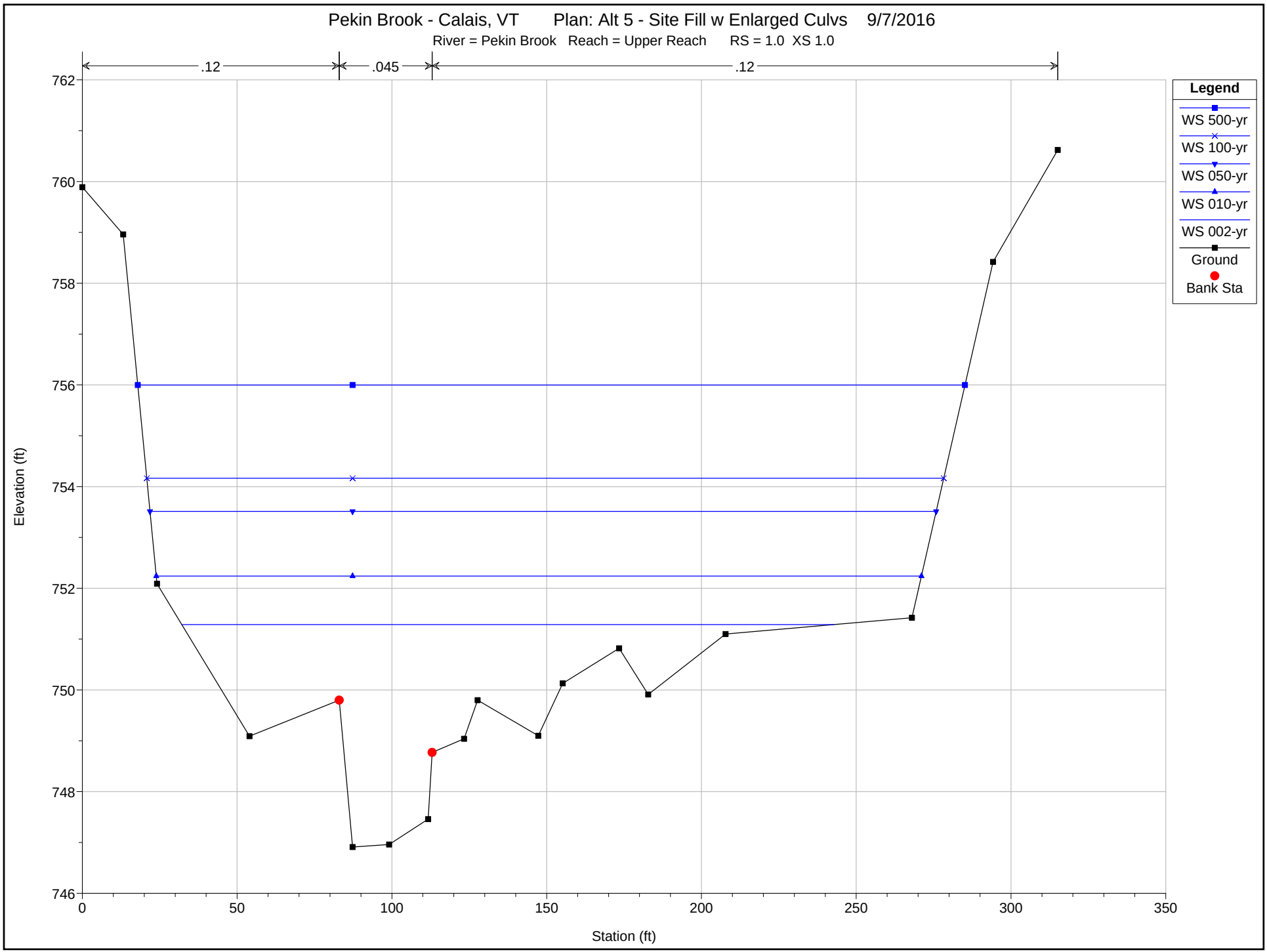

Pekin Brook - Calais, VT Plan: Alt 5 - Site Fill w Enlarged Culvs 9/7/2016
River = Pekin Brook Reach = Upper Reach RS = 5.9 XS 5.9 - Copy of XS 6.0
.08
.045
.08
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
785
780
775
770
765
760
755
750
-200
0
200
400
600
800
1000
1200
Station (ft)


Pekin Brook - Calais, VT Plan: Alt 5 - Site Fill w Enlarged Culvs 9/7/2016
River = Pekin Brook Reach = Upper Reach RS = 5.0 XS 5.0 - Exit Section
.08
.045
.08
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
780
775
770
765
760
755
750
-200
0
200
400
600
800
1000
Station (ft)


Pekin Brook - Calais, VT Plan: Alt 5 - Site Fill w Enlarged Culvs 9/7/2016
River = Pekin Brook Reach = Upper Reach RS = 4.0 XS 4.0
.08
.045
.1
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
810
800
790
780
770
760
750
740
0
200
400
600
800
1000
1200


Pekin Brook - Calais, VT Plan: Alt 5 - Site Fill w Enlarged Culvs 9/7/2016
River = Pekin Brook Reach = Upper Reach RS = 3.0 XS 3.0
.12
.045
.08
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
770
765
760
755
750
745
0
100
200
300
400
500
600
700
Station (ft)


Pekin Brook - Calais, VT Plan: Alt 5 - Site Fill w Enlarged Culvs 9/7/2016
River = Pekin Brook Reach = Upper Reach RS = 2.0 XS 2.0
.12
.045
.12
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
780
775
770
765
760
755
750
745
0
100
200
300
400
500
Station (ft)


Pekin Brook - Calais, VT Plan: Alt 5 - Site Fill w Enlarged Culvs 9/7/2016
River = Pekin Brook Reach = Upper Reach RS = 1.0 XS 1.0
.12
.045
.12
Legend
WS 500-yr
WS 100-yr
WS 050-yr
WS 010-yr
WS 002-yr
Ground
Bank Sta
Elevation (ft)
762
760
758
756
754
752
750
748
746
0
50
100
150
200
250
300
350
Station (ft)