Ash Way/Maple Road Flood Protection

Alternative Analysis Report

Prepared for: Snohomish County Public Works

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WHPacific, Inc.

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I. Introduction

Snohomish County and the City of Lynnwood are working together to address flooding in the vicinity of the intersection of Maple Road and Ash Way. Maple Road from the intersection with Ash Way to the east under SR 525 Bridge and southeast alongside the Washington Department of Transportation (WSDOT) detention pond floods frequently. This flooding forces multiple road closures per year negatively impacting access into the City and emergency vehicle response times. Settlement has also been a significant issue in this area resulting in extreme pavement cross slopes.

Snohomish County retained WHPacific to evaluate site conditions, alternative solutions, and recommend a solution. This analysis involves the following:

1) Evaluate storm water movement and depth through hydrologic and hydraulic modeling.
2) Review available geologic and geotechnical information
3) Evaluate the pros and cons of the following four alternatives:

    i) Traditional Approach – The traditional approach is to remove the existing pavement, import gravel borrow to rebuild the roadway embankment and repave.
    ii) Lightweight Fill – This approach involves over excavating the roadway and replacing most of the excavated material with Geofoam to reduce the weight of the roadway over the peat.
    iii) Pile-Supported Road – This approach involves the installation of a combination of piles, pile caps, grade beams, and structural slab to support the roadway over the area of peat.
    iv) Railroad Ballast – This approach generally involves over excavating the roadway embankment and replacing some of the excavated material with railroad ballast. The void space within the ballast provides unit weight that is 70 percent of granular fill according to Snohomish County geotechnical staff.

4) Evaluate the life cycle cost (cost to construct the improvement and maintenance)

A typical section sketch of each of the alternatives is included in the Preliminary Plan Exhibits. Please see Appendix C.

Existing Conditions

The project area and vicinity are wet and marshy. Hydraulically, there is very little difference in grade between Swamp Creek and the surface water in the vicinity of the intersection of Ash Way and Maple Road. The intersection area generally drains through storm pipes, culverts and surface flow toward Swamp Creek and adjacent wetlands.

During relatively moderate rain events Swamp Creek swells, increasing tail water on storm pipes and culverts and reducing flow capacity. This situation causes frequent flooding making these roads impassable as seen in the photo 1 below.

Photo 1: Ash Way/Maple Road intersection flooding.

Ground settlement is also an issue. The area is underlain with peat up to 30 feet thick. Peat is very compressible, and its settlement rate will be high at the onset of loading, but due to continual decay, slow settlement can continue indefinitely. The weight of Ash Way and Maple Road pavements compresses the peat causing settlement. Pile supported structures such as the SR525 Bridge and the King County Metro Sewer have not settled. Settlement is very pronounced as can be seen in the photo 2 below where the road and surrounding ground have settled below the pile caps of the SR 525 Bridge.

Photo 2: Settlement occurring around pier caps of SR 525 and ponding in low points adjacent to Maple Road.

Utilities in the area have added to the complexity of settlement in the area. A pile supported 36-inch King County Metro Sewer pipe line runs down the middle of Maple Road under the SR 525 Bridge. This sewer line supports the middle of the road while the remaining road has settled resulting in extreme pavement cross slope as seen in the photo 3 below.

Photo 3: King County Metro Sewer supports the middle of Maple Road while the rest of the road settles.

II. Roadway Design Criteria

A specific set of roadway design criteria was developed for this project based on an evaluation of three sources of design guidelines and standards. These include the Snohomish County Engineering Design and Development Standards (EDDS), American Association of State Highway and Transportation Officials (AASHTO), Washington State Department of Transportation Design Manual, Local Agency Guidelines, and the Snohomish County Drainage Manual. The project design criteria are presented in the following table.

	Ash Way	**Maple Road**
Roadway Type	Collector	Collector
Min. Design Speed	35 m.p.h.	35 m.p.h.
Max. Posted Speed	35 m.p.h.	35 m.p.h.
Max. Super-Elevation Rate	6%	6%
Min. Horizontal Curvature (Radius) *	320’	320’
Max. Grade	10%	10%
Min. Curb Radius	25’	25’
Bike Lane Width	5’	5’
Min. Pavement Width (curbed section)	36’	36’
Min. Pavement Width (non-curbed section)	36’	36’
Clear Zone (curbed section)	2’	2’
Clear Zone (non-curbed section)	10’	10’
Roadway Structure Clearance	16.5’	16.5’
Min. Roadway Structure Design Live Load	HL-93	HL-93

*Some of the existing roadway curves are less than standard and are currently posted with a reduced speed limit sign.

III. Storm Drainage

WHPacific evaluated the stormwater conveyance within the project study limits using the HECRAS water surface profile model. This work was performed as follows:

1. Review of the HECRAS model developed by PACE Engineers, June 2012.
2. Reevaluation of existing conditions.
3. Evaluation of proposed conditions.
4. Received upstream flow rates from nhc Consultants, calculated using HSPF.
5. Adjusted models to convergence or near convergence.

From our review of the PACE HECRAS model we found that inflow rates (upstream off site flows coming into project area) used in the model were incorrect. The model needed to be revised with new inflow rates to evaluate the stormwater conveyance and proposed road improvements. Several revisions were made to update the existing HECRAS model, including:

- Used Swamp Creek tail-water elevations provided by Snohomish County (See Drainage Report, Appendix D)
- WHPacific changed the flow routes in the model to more accurately simulate observed flooding conditions. This included the condition that once flood waters rise above the road surface, then more water flows over the roadway than through culverts.
- WHPacific changed to design flows to used updated upstream design flows analyzed by Northwest Hydraulic Consultants (NHC) in conjunction with this project.

Existing Conditions

From the updated model results we determined that the majority of the tributary runoff from west of Ash Way flows to the Ash Way/Maple Road intersection and then flows over the road at a depth of up to 1.6 feet over the center of the road for the 100 year storm event. (See Table 1, Summary of Existing Condition HECRAS Model Results, in the Storm Drainage Report in Appendix D). This occurs because the intersection is the low point in the road, the existing culverts are partially plugged with sediment, the WSDOT pond creates a tailwater condition, and Swamp Creek itself creates a high tailwater condition.

Floodwaters discharge from the intersection in three different directions: about 7 cfs (25-year) flows southerly to the 42" culvert under SR 525, 23 cfs flows due east on the south side of Maple Road to the WSDOT Pond, and 34 cfs flows northeasterly across Maple Road to Swamp Creek.

Currently some of the flood waters from the intersection drains to the WSDOT detention pond. We analyzed the performance of this pond; specifically the effect of the existing 24" outflow pipe. NHC Consultants and Snohomish County asked if enlarging the outlet pipe would alleviate upstream flooding. So, WHPacific analyzed the system with both larger and smaller pipes. We found that changing the size of the pipe had very little effect (less than 0.4') on upstream water elevations. This is due to the high tailwater of Swamp Creek adjacent to all of Maple Road, and the overflow spillway elevation of the WSDOT detention pond.

The model is consistent with our observations.

See Appendix D for additional detail.

The 25-year water level of Swamp Creek immediately east of the intersection is 349.94, while the roadway pavement elevation is just 350.0. Cleaning out or upsizing the existing culverts will not significantly lower flooding of the roadway because of the high tailwater effect of Swamp Creek so the road must also be raised.

Proposed Conditions

Once the road is raised, it becomes necessary to also increase the capacity of the drainage system so that upstream flooding does not significantly increase. Box culverts are proposed to increase the capacity of the drainage system to allow water to pass under the road, rather than flowing over the intersection. The proposed condition model indicates the net result to be only a minor change (0.2' +/-) in upstream water levels.

The intent of these improvements is to provide a roadway pavement that is 6-inches above the 25-year storm flood elevation (proposed condition). The 6-inch freeboard dimension is used to provide a factor of safety due to the many variables inherent in modeling a complex drainage system. Model results were collaborated with field observations during previous flood events. The proposed improvements include:

- Raising the roadways of Ash Way, Maple Road, and Alder Road so the edge of pavement is 6-inches above the 25-year storm event elevation which varies depending on location. Centerline elevation will vary depending upon pavement cross slope (super elevated or normal crown). See Profile drawings provided in Appendix A.
- Constructing new swales north and south of Maple Road; east of the intersection to increase capacity.
- Constructing new culverts north and south of the intersection to route flow under Ash Way and Maple Road and discharge directly to the Swamp Creek wetland system.
    - The new swales and culverts are required to alleviate flooding due to raising of the intersection.
    - The proposed flood elevations will remain similar (within 0.2') to the existing condition.
- Removing sediment from the existing culverts.

The new swales will require excavation and replanting, so will impact existing wetlands on the immediate South-east and north-east quadrants of the Maple/Ash intersection. The east bound swale on the north side of Maple will pass under the WSDOT bridge, north of the pier caps and discharge to the Swamp Creek wetland system, north of Maple Road. The specific location has not been determined and will require additional topographic survey and wetland delineation. These impacts will require mitigation, to be determined.

See Appendix B for Concept Plans and Appendix C for Typical Sections.

IV. Geotechnical Investigation

WHPacific retained Landau Associates to review available geologic and geotechnical information for the project area and provide geotechnical input to the development of alternative

approaches to raise the roadway grades of Ash Way and Maple Road. Geotechnical reports previously prepared for the area by others consistently indicate that the project area soils are composed of a surficial layer of fill material underlain by peat (up to 33 feet thick) which is underlain with glacial till. WSDOT borings advanced in the vicinity of the SR 525 overpass encountered very dense glacial till at depths ranging from 37 to 42 feet below the ground surface.

Peat is very compressible. The weight of roadway pavements and embankment material consolidates the peat causing settlement. The portion of Maple Road underlain with peat that was built in 1983 has undergone significant settlement. This settlement is likely to continue.

These geotechnical reports also indicate an abundance of groundwater. The depth of the groundwater in the project area generally has been reported at 0 to 5 feet below the surface. Groundwater depths vary significantly with season and location. In the vicinity of the SR 525 overpass groundwater under artesian pressure was encountered. Excavation below 5 feet will likely require aggressive dewatering systems such as well points or deep wells.

Roadway Reconstruction Alternatives

1) Traditional Approach – The traditional approach to simply remove the existing pavement, import gravel borrow to rebuild the roadway embankment and repave. This will add additional weight when the road is raised. This will cause the peat layer to consolidate further resulting in roadway settlement and pavement deformation.

2) Lightweight Fill – Geofoam is 100 times lighter than conventional fill and can be used to reduce vertical loading and future settlement. For this project, we estimate that about 4.5 feet of geofoam plus 5.5 feet of overlying soil would be needed to raise the grades of the road 2 feet. This would not increase the weight of the embankment but would provide enough weight to prevent uplifting from buoyancy. This form of construction would very likely need dewatering. This method stabilizes settlement but does NOT eliminate it. By maintaining the same weight, the road will continue to settle at its current rate.

3) Pile-Supported Road – A combination of piles, pile caps, grade beams, and structural slab could be used to reconstruct the roadway over the peat. Pile would be driven down to approximately 37 to 42 feet below the ground surface through the peat to the stable glacial till layer. This method would eliminate settlement. Specialized equipment to drive pile with limited overhead clearance will be needed for parts of the work under SR 525.

4) Railroad Ballast – This approach generally involves over excavating the roadway embankment approximately to a depth of 4.6 feet. A combination layer of non-woven geotextile fabric, sand, geogrid would then be placed followed by railroad ballast. This Ballast system would be 6.7 feet thick to raise the grades of the road 2 feet. The void space in the ballast resulting from this form of construction is lighter than traditional granular embankment construction. Snohomish County geotechnical staff determined the unit weight of ballast is 70 percent of gravel borrow. This method of construction results in stabilizing the settlement rate such that it maintains its current rate of settlement.

See Appendix E for the Geotechnical Report.

V. Cost Summary

The costs associated with the 4 alternatives were developed and evaluated. These costs include the Initial Construction costs and the Annual Maintenance Costs.

Initial Construction Costs

The following table summarizes the initial construction costs for each of the alternatives. For more details concerning the quantity calculations and assumptions see Appendix F.

Construction Cost Estimates

ITEM NO.	DESCRIPTION	QTY.	UNIT	ALT #1 Traditional UNIT COST	ALT #1 Traditional TOTAL COST	ALT 2 Geofoam QTY.	UNIT	UNIT COST	TOTAL COST	ALT #3 Railroad Ballast QTY.	UNIT	UNIT COST	TOTAL COST	ATL #4 Pin Piles QTY.	UNIT	UNIT COST	TOTAL COST
1	ROADWAY SURVEYING	1	LS	$ 15,000.00	$ 15,000.00	1	LS	$ 20,000.00	$ 20,000.00	1	LS	$ 15,000.00	$ 15,000.00	1	LS	$ 25,000.00	$ 25,000.00
2	SPCC PLAN	1	EA	$ 1,000.00	$ 1,000.00	1	EA	$ 1,000.00	$ 1,000.00	1	EA	$ 1,000.00	$ 1,000.00	1	EA	$ 1,000.00	$ 1,000.00
3	POTHOLING EXISTING UTILITIES	1	LS	$ 7,500.00	$ 7,500.00	1	LS	$ 7,500.00	$ 7,500.00	1	LS	$ 7,500.00	$ 7,500.00	1	LS	$ 7,500.00	$ 7,500.00
4	UNANTICIPATED SITE WORK	1	EST	$ 30,000.00	$ 30,000.00	1	EST	$ 100,000.00	$ 100,000.00	1	EST	$ 35,000.00	$ 35,000.00	1	EST	$ 150,000.00	$ 150,000.00
5	MOBILIZATION	1	LS	$ 60,000.00	$ 60,000.00	1	LS	$ 190,000.00	$ 190,000.00	1	LS	$ 125,000.00	$ 125,000.00	1	LS	$ 330,000.00	$ 330,000.00
6	PROJECT TEMPORARY TRAFFIC CONTROL	1	LS	$ 20,000.00	$ 20,000.00	1	LS	$ 20,000.00	$ 20,000.00	1	LS	$ 20,000.00	$ 20,000.00	1	LS	$ 20,000.00	$ 20,000.00
7	ROADWAY EXCAVATION INCL. HAUL	1,400	CY	$ 30.00	$ 42,000.00	14,000	CY	$ 30.00	$ 420,000.00	5,700	CY	$ 30.00	$ 171,000.00	0	CY	$ 30.00	$ -
8	GRAVEL BORROW INCL. HAUL	4,500	TON	$ 22.00	$ 99,000.00	13,000	TON	$ 20.00	$ 260,000.00	0	TON	$ 22.00	$ -	0	TON	$ 22.00	$ -
9	DITCH EXCAVATION INCL. HAUL	1,200	CY	$ 30.00	$ 36,000.00	1,200	CY	$ 30.00	$ 36,000.00	1,200	CY	$ 30.00	$ 36,000.00	1,200	CY	$ 30.00	$ 36,000.00
10	CRUSHED SURFACING TOP COURSE	800	TON	$ 30.00	$ 24,000.00	800	TON	$ 30.00	$ 24,000.00	800	TON	$ 30.00	$ 24,000.00	800	TON	$ 30.00	$ 24,000.00
11	HMA CL. 1/2" PG 64-22	1,100	TON	$ 90.00	$ 99,000.00	1,100	TON	$ 90.00	$ 99,000.00	1,100	TON	$ 90.00	$ 99,000.00	1,100	TON	$ 90.00	$ 99,000.00
12	CULVERT PIPE 36 IN. DIAM.	75	LF	$ 90.00	$ 6,750.00	75	LF	$ 90.00	$ 6,750.00	75	LF	$ 90.00	$ 6,750.00	75	LF	$ 90.00	$ 6,750.00
13	4' X 8' Reinforced Concrete Box Culvert	2	EA	$ 80,000.00	$ 160,000.00	2	EA	$ 80,000.00	$ 160,000.00	2	EA	$ 80,000.00	$ 160,000.00	2	EA	$ 80,000.00	$ 160,000.00
14	Relocate Existing Waterline	40	LF	$ 100.00	$ 4,000.00	400	LF	$ 100.00	$ 40,000.00	40	LF	$ 100.00	$ 4,000.00	40	LF	$ 100.00	$ 4,000.00
15	SILT FENCE	1,900	LF	$ 5.00	$ 9,500.00	1,900	LF	$ 5.00	$ 9,500.00	1,900	LF	$ 5.00	$ 9,500.00	1,900	LF	$ 5.00	$ 9,500.00
16	EROSION/WATER POLLUTION CONTROL	1	LS	$ 15,000.00	$ 15,000.00	1	LS	$ 15,000.00	$ 15,000.00	1	LS	$ 15,000.00	$ 15,000.00	1	LS	$ 15,000.00	$ 15,000.00
17	CEMENT CONC. TRAFFIC CURB AND GUTTER	250	LF	$ 30.00	$ 7,500.00	250	LF	$ 30.00	$ 7,500.00	250	LF	$ 30.00	$ 7,500.00	250	LF	$ 30.00	$ 7,500.00
18	CEMENT CONC. SIDEWALK	110	SY	$ 90.00	$ 9,900.00	110	SY	$ 90.00	$ 9,900.00	110	SY	$ 90.00	$ 9,900.00	110	SY	$ 90.00	$ 9,900.00
19	CEMENT CONC. CURB RAMP	1	EA	$ 1,200.00	$ 1,200.00	1	EA	$ 1,200.00	$ 1,200.00	1	EA	$ 1,200.00	$ 1,200.00	1	EA	$ 1,200.00	$ 1,200.00
20	PAINTED striping/Signing	2,850	LF	$ 1.00	$ 2,850.00	2,850	LF	$ 1.00	$ 2,850.00	2,850	LF	$ 1.00	$ 2,850.00	2,850	LF	$ 1.00	$ 2,850.00
21									$ -				$ -				$ -
22	Dewatering					1	LS	$ 70,000.00	$ 70,000.00	1	LS	$ 60,000.00	$ 60,000.00	1	LS	$ 20,000.00	$ 20,000.00
23	Shoring					1	LS	$ 50,000.00	$ 50,000.00	1	LS	$ 30,000.00	$ 30,000.00	1	LS	$ 5,000.00	$ 5,000.00
24	Geofoam					7,000	CY	$ 100.00	$ 700,000.00				$ -				
25																	
26	Railroad Ballast									18,000	Ton	$ 25.00	$ 450,000.00				
27	Geo-Grid									17,000	SY	$ 2.00	$ 34,000.00				
28	Geofabric									17,000	SY	$ 3.00	$ 51,000.00				
29																	
30	Pin piles													2,650	EA	$ 640.00	$ 1,696,000.00
31	Reinforced Slab													4,700.0	SY	$ 265.00	$ 1,245,500.00
32																	
33																	
34					$ -												
				SUBTOTAL	**$ 650,200.00**			**SUBTOTAL**	**$ 2,250,200.00**			**SUBTOTAL**	**$ 1,375,200.00**			**SUBTOTAL**	**$ 3,875,700.00**
	CONTINGENCY			**20%**	**$ 130,040.00**			**25%**	**$ 562,550.00**			**20%**	**$ 275,040.00**			**25%**	**$ 968,925.00**
	CONSTRUCTION TOTAL				**$ 780,240.00**				**$ 2,812,750.00**				**$ 1,650,240.00**				**$ 4,844,625.00**
	CONSTRUCTION MANAGEMENT			**12%**	**$ 93,628.80**			**15%**	**$ 421,912.50**			**12%**	**$ 198,028.80**			**10%**	**$ 484,462.50**
	WELTAND MITIGATION			**LS**	**$ 100,000.00**			**LS**	**$ 100,000.00**			**LS**	**$ 100,000.00**			**LS**	**$ 100,000.00**
	DESIGN ENGINEERING			**15%**	**$117,036.00**			**15%**	**$ 421,912.50**			**15%**	**$ 247,536.00**			**15%**	**$ 726,693.75**
	TOTAL ESTIMATED COSTS				**$ 1,090,904.80**				**$ 3,756,575.00**				**$ 2,195,804.80**				**$ 6,155,781.25**

Annualized Capital Cost and Annual Maintenance Cost

The annualized capital cost is the initial construction cost

The annual maintenance costs take into account the expected settlement rate and the associated repaving costs. In addition we have provided the Annualized Capital Cost based on the construction cost and the expected life span of the alternatives.

The Annual Maintenance Costs and the annualized capital costs have been converted to today's dollars then added to provide the Equivalent Uniform Annual Cost (EUAC). These costs are summarized in the following table.

Annual Maintenance Costs Summary

Alt. #	Description	Construction Cost	Estimated Settlement Rate	Settlement Triggering Maint.	Pavement Overlay Interval	Pavt. Overlay Cost	Life Span No. years	A/P i=0.06,	Annualized Capital Cost	Annual Maintenance Cost	Equivalent Uniform Annual Cost EUAC
		P $	(in/year)	(in)	years	$				$	
1	Traditional	$780,240	2	6	3	$44,800	15	0.1030	$80,364.72	$14,933.33	**$95,298.05**
2	Geofoam	$2,812,750	1	6	6	$44,800	35	0.0690	$194,079.75	$7,466.67	**$201,546.42**
3	Piles - Pin Piles	$4,844,625	0.15	6	40	$44,800	100	0.0602	$291,646.43	$1,120.00	**$292,766.43**
4	Railroad Ballast	$1,650,240	1	6	6	$44,800	35	0.0690	$113,866.56	$7,466.67	**$121,333.23**

Settlement Rate - The actual settlement rates are unknown. For this analysis 1993 record drawings and a recent survey of the project area were used to estimate settlement. Since Maple road was constructed approximately 17 inches of settlement in 19 years has occurred along the edge of pavement in some areas. We recognize that initial loading will create a higher settlement rate, which will decrease over time, but, past and future rates are very difficult to predict, especially without additional data. So, for simplicity of this alternatives analysis we have estimated an average settlement rate of about 1 inch of per year. Though the actual magnitude of settlement has decreased over the 19 year period and will continue to decrease over time if no new load is applied, for the sake of simplicity, we have assumed for this analysis that the average rate of settlement (1 inch per year) will continue for the Geofoam and Ballast Alternatives provided there is no increase in weight following reconstruction of the roadway.

For this analysis we have assumed the same rate of settlement (1 inch per year) to continue for the GeoFoam and Ballast Alternatives with no increase in weight following reconstruction. The Traditional Alternative will continue to add weight with each repair increasing the settlement rate expected. Zero settlement was assumed for the Pile Alternative. (See page 3-1 of the Geotechnical Report, Appendix F)

A/P i=0.06 – This factor is used to develop the annualized cost based on Present Value using an interest rate of 6 percent.

Public Economic Costs

There are also costs that the public bears when the roadway is closed for construction and flooding. If maintenance work or repair work is not performed timely because of budgetary or other reasons then there can also be additional cost due to road closures for flooding. These costs are real but difficult to quantify.

Maple Road Alder Way Costs

Further costs were developed for the parts of Maple Road and Alder Road in the vicinity of the Swamp Creek crossing. Costs were developed for improvements to raise the roads above the 10-year and the 25-year flood levels.

Cost Estimate for Other Sections of Maple and Alder Roads				10 year					25 year
ITEM NO.	DESCRIPTION	QTY.	UNIT	UNIT COST	TOTAL COST	QTY.	UNIT	UNIT COST	TOTAL COST
1	ROADWAY SURVEYING	1	LS	$ 2,500.00	$ 2,500.00	1	LS	$5,000.00	$5,000.00
2	SPCC PLAN	1	EA	$ 500.00	$ 500.00	1	EA	$500.00	$500.00
3	POTHOLING EXISTING UTILITIES	1	LS	$ 1,200.00	$ 1,200.00	1	LS	$2,400.00	$2,400.00
4	UNANTICIPATED SITE WORK	1	EST	$ 2,000.00	$ 2,000.00	1	EST	$5,000.00	$5,000.00
5	MOBILIZATION	1	LS	$ 7,000.00	$ 7,000.00	1	LS	$14,000.00	$14,000.00
6	PROJECT TEMPORARY TRAFFIC CONTROL	1	LS	$ 5,000.00	$ 5,000.00	1	LS	$7,500.00	$7,500.00
7	ROADWAY EXCAVATION INCL. HAUL	450	CY	$ 30.00	$ 13,500.00	950	CY	$30.00	$28,500.00
8	GRAVEL BORROW INCL. HAUL	450	TON	$ 22.00	$ 9,900.00	650	TON	$22.00	$14,300.00
9	DITCH EXCAVATION INCL. HAUL	20	CY	$ 30.00	$ 600.00	125	CY	$30.00	$3,750.00
10	CRUSHED SURFACING TOP COURSE	150	TON	$ 30.00	$ 4,500.00	370	TON	$30.00	$11,100.00
11	HMA CL. 1/2" PG 64-22	200	TON	$ 90.00	$ 18,000.00	500	TON	$90.00	$45,000.00
12	SILT FENCE	450	LF	$ 5.00	$ 2,250.00	1,200	LF	$5.00	$6,000.00
13	EROSION/WATER POLLUTION CONTROL	1	LS	$ 3,500.00	$ 3,500.00	1	LS	$5,000.00	$5,000.00
14	PAINTED striping	600	LF	$ 1.00	$ 600.00	1,700	LF	$1.00	$1,700.00
				SUBTOTAL	$ 71,050				$149,750
	CONTINGENCY			15%	$ 10,657.50			15%	$14,975.00
	CONSTRUCTION TOTAL				$ 81,707.50				$164,725.00
	CONSTRUCTION MANAGEMENT			12%	$ 9,804.90			12%	$19,767.00
	DESIGN ENGINEERING			12%	$ 9,804.90			12%	$19,767.00
	TOTAL ESTIMATED COSTS				$ 101,317.30				$204,259.00

VI. Summary of Findings

To address the two primary issues of flooding and settlement the roadway must be raised and the conveyance system improved. The following summarizes our analysis for improving the stormwater conveyance system and our assessment of alternatives for raising the road.

Conveyance System - When the roadways are raised they will back up more water on the west side of Ash Way without an improvement in the existing conveyance system. This is because the roadway in effect acts as a dike or a weir as flood waters spill over the roadway. As the roadway elevation is increased stormwater will back up to greater depths without additional conveyance capacity.

Three additional culverts will be needed to convey this stormwater under Ash Way and Maple roads in the vicinity of the SR 525 overpass to the Swamp Creek system. Water that currently flows over the top of the road during flood events will now pass through the new culverts. This improvement will maintain the same existing ponding depth on the west side of Ash Way during storm events.

Raising the Roadway – The 4 alternative approaches to raising the roadway provide a range of benefits. Judging criteria and a rating system were prepared to provide a relative ranking of the alternatives. The rating matrix below summarizes the relative benefits of each of the 4 alternative approaches.

Rating is 1 to 10. Ten being positive (less cost, little impact, better performance)

Alternative	**1) Traditional**	**2) GeoFoam**	**3) Pile**	**4) RR Ballast**
Settlement potential	2	5	10	5
Constructability	8	4	2	6
Dewatering	9	2	8	5
Life Span	1	7	10	6
Initial Cost	10	3	1	6
Maintenance Cost	1	6	10	5
Public Costs due to road closures	2	6	8	4
Environmental Impact/Permits	6	4	6	4
Right-of-Way Acquisition	5	5	5	5
Utility Conflict	10	8	4	8
Total	**54**	**50**	**64**	**56**

Settlement Potential – The pile alternative provides the best protection against settlement. The GeoFoam and Ballast alternatives in this analysis are designed to perform equally well by not adding any more weight to what exists now. The Traditional Alternative will settle more than the other alternatives because of the added weight from successive repairs.

Constructability – The Traditional Alternative is the easiest to construct and requires less specialized contractor capabilities than the other 3 alternatives. The pile alternative requires the most specialized equipment and crew to construct it.

Dewatering – The groundwater is shallow in the project area. Over excavation on the order of seven to eight feet will be required for the RR Ballast and GeoFoam alternatives respectively. The greater the over excavation the more sophisticated dewatering system will be required. The Traditional Alternative may require over excavation and subsequent dewatering to obtain adequate compaction of the roadway embankment. The Pile Alternative will also require some excavation to construct grade beams and slabs.

Life Span – The Pile Alternative is expected to last 60 years before needing to be replaced or significant repair. The GeoFoam Alternative and the Ballast Alternative are expected to have shorter life spans because settlement continues. The Traditional Alternative is expected to result in continued settlement and require reconstruction much more frequently than any of the other alternatives because this approach will continue to add more and more weight to bear on the peat.

Initial Cost – The Pile Alternative has the greatest initial cost because of the high cost to construct the structural elements of this alternative (pile, reinforce concrete slabs and beams).

Though the RR Ballast Alternative will require over excavation, it will not require as much over-excavation as will the GeoFoam Alternative. This, and the cost of the GeoFoam, is the primary reason we anticipate the GeoFoam Alternative will be more expensive than the RR Ballast Alternative.

The Traditional Alternative will have the lowest initial cost because it is the simplest construction method and will require little dewatering.

Maintenance Cost – The Pile Alternative has very low maintenance cost and partially offset its high initial cost. The other alternatives require more maintenance because of normal deterioration of the roadway pavement and expected continued settlement. The Traditional Alternative will have the greatest amount of maintenance costs because it is expected to settle significantly more than the other alternatives.

Public Costs Due to Road Closures – All of the alternatives will require road closures to varying degrees. The Pile Alternative will have a longer initial closure for construction. However no other closures are expected during the life of the structure. The Traditional Alternative will have shorter but much more frequent closures during each reconstruction. The GeoFoam and Ballast Alternatives will require more moderate closures than the Traditional Alternative because settlement is expected to be less.

Environmental Impact/Permits – All of the alternatives are expected to have similar environmental impacts and require the same permits. The horizontal footprint of each of the alternatives is the same. Drainage improvements for each of the alternatives would be the same. Raising the roadway will result in additional fill materials impacting wetlands, waterways and buffers adjacent to the road.

Wetlands and certain waterways are regulated by federal, state, and local governmental agencies and compliance with one agency does not necessarily fulfill permitting requirements of any other agencies. The following is a list of permits anticipated for each of the alternatives.

1) WSDOT - A general permit will be required for placing new ditches and for enlarging the outlet structure of their pond. WSDOT structures will need to review plans and reports to ensure that any work will not advisedly affect the SR 525 structure.

2) SEPA and Critical areas compliance from the City of Lynnwood or Snohomish County.

3) Hydraulic Project Approval (HPA) from Washington Department of Fish and Wildlife

4) Section 404 Clean Water Act permitting from the U.S. Army Corps of Engineers

5) Section 401 Water Quality Certification from Washington State Department of Ecology.

Right-of-Way Acquisition – All of the alternatives will have similar needs for right-of-way and easements because the horizontal footprint of the improvements and the drainage improvements are very similar.

Utility Conflict – There are a variety of utilities in the vicinity of the project area including:

- **King County Metro** has a 36 inch diameter reinforced concrete gravity sanitary sewer with 10 to 12 feet of cover in Maple Road. King County is concerned about settlement and movement of pipe during construction. They will review Plans and reports. Most likely will require that the pipe be TV'd before and after construction and monitored during construction for settlement.
- **Alderwood Water and Sewer District** has an existing 12 inch water line in Ash Way. Alderwood plans to abandon this line according to staff.
- **SnoPUD** has an underground power line located on east side of the intersection of Ash Way and Maple road that at this time does not appear to be of concern. It will have to be located and watched during construction.
- **City of Lynnwood** has a street light on the south side of Maple Road west of Ash Way. The City also has a water line along Ashway.

VII. Recommendations

From our conceptual level of analysis of the 4 alternatives we recommend proceeding with the Pile Alternative. We believe this provides the County and the City the most benefit because the pile supported roadway will not settle and will provide long lasting desirable performance. However, the Pile Alternative has the greatest initial cost.

The Ballast Alternative would be the next best choice. It can provide a similar level of protection against settlement as the Light Weight Fill Alternative but cost less. The Ballast Alternative is expected to continue to settle but at a slower rate than the Traditional Alternative but it will still require more frequent maintenance than the Pile Alternative.

APPENDIX A

WHPacific, Inc.

SV01 Survey North

SV02 Survey South

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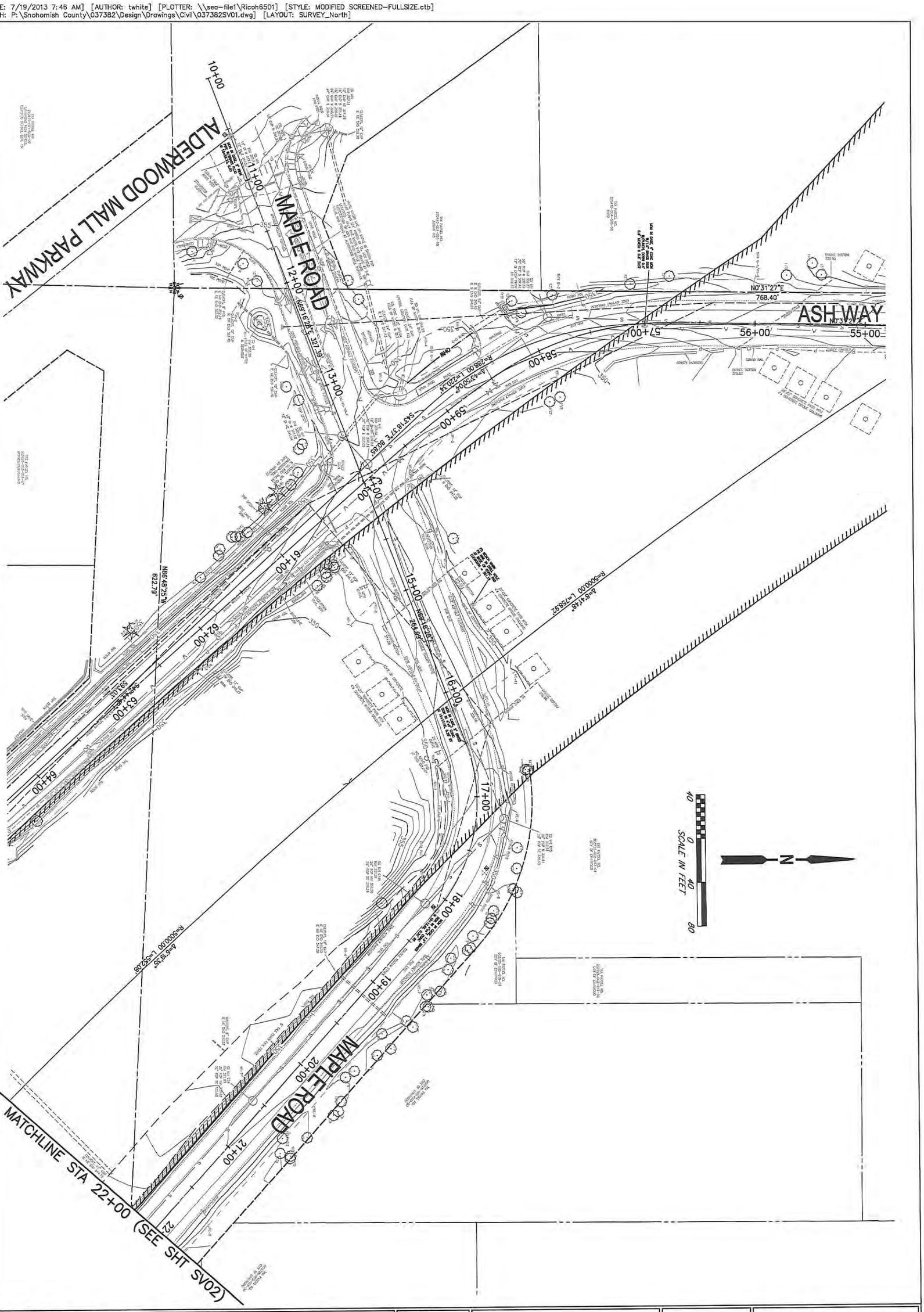

SHEET NUMBER			
SV01	SURVEY NORTH MAPLE ROAD AND ASH WAY SNOHOMISH COUNTY STORM DRAINAGE		
	PROJECT NUMBER 037382	DRAWING FILE NAME 037382SV01	SCALE 1"=40'

SHEET INFO	
DESIGNED	CPC
DRAWN	CPC/TTW
CHECKED	SJR
APPROVED	MSV
LAST EDIT	7/19/2013
PLOT DATE	7/19/2013
SUBMITTAL	

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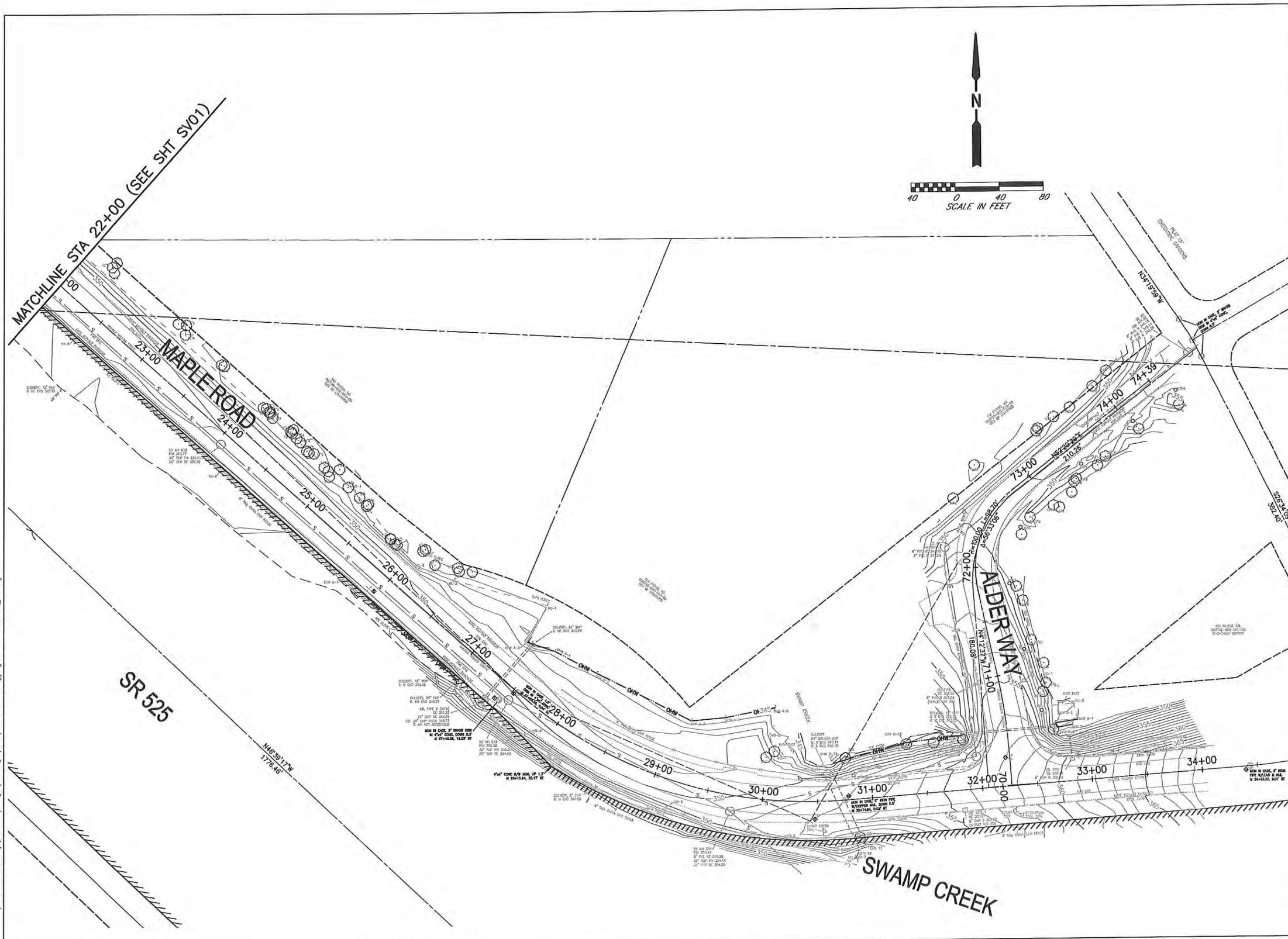

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APPROVED	MSV
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PLOT DATE	7/19/2013
SUBMITTAL	

SURVEY SOUTH
MAPLE ROAD AND ALDER WAY
SNOHOMISH COUNTY
STORM DRAINAGE

SCALE 1"=40'

PROJECT NUMBER 037382

DRAWING FILE NAME 037382SV01

SHEET NUMBER
SV02

[DATE: 7/19/2013 5:15 AM] [AUTHOR: twhite] [PLOTTER: \\sea-file1\Ricoh6501] [STYLE: MODIFIED SCREENED-FULLSIZE.ctb]
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APPENDIX B

WHPACIFIC, Inc.

Preliminary Plan Exhibits

EX01 Not Used

EX02 Plan Option North

EX03 Plan Option South

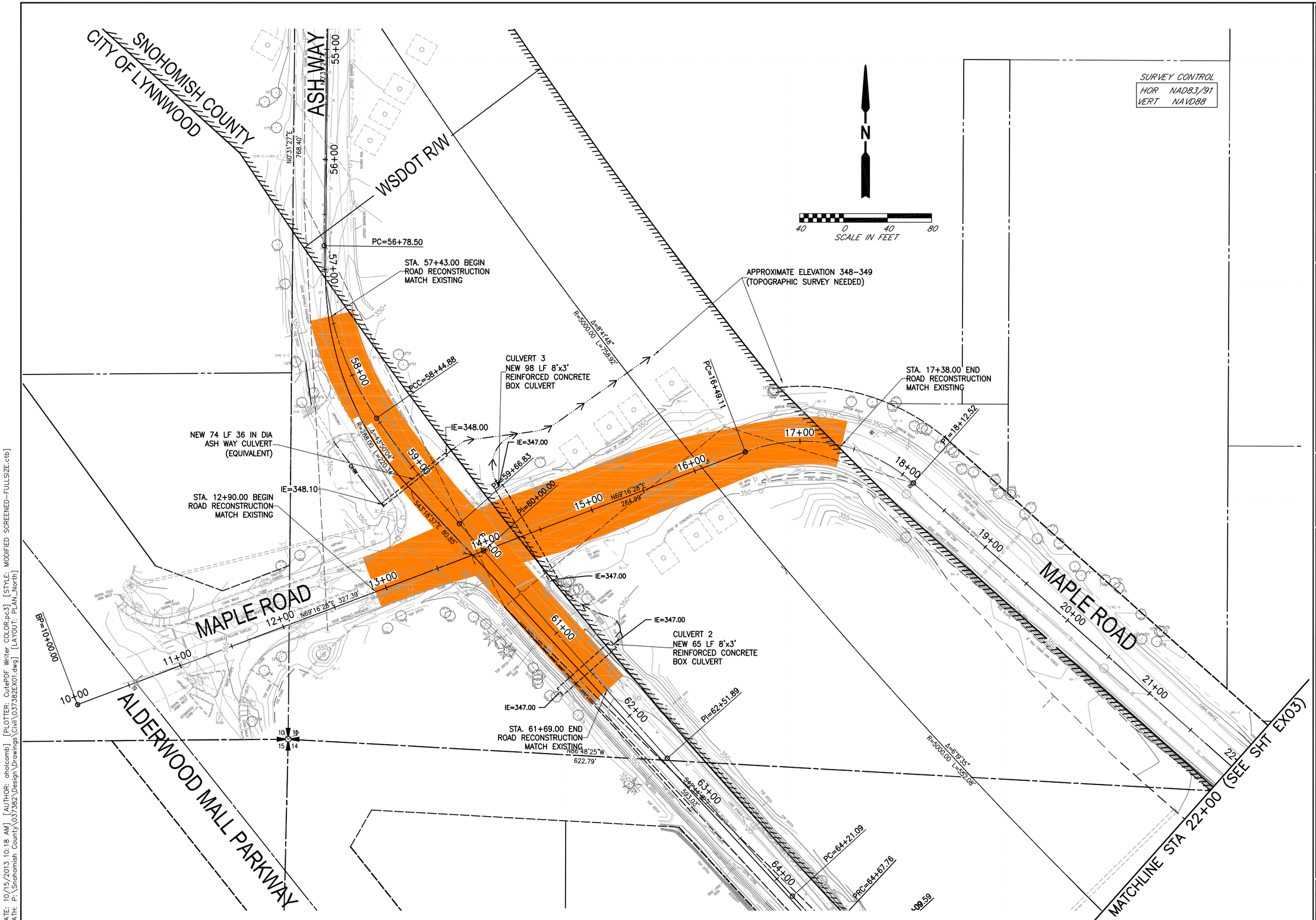
EX04 Profile Option North

EX05 Profile Options South (25 year)

EX06 Profile Options South (10 year)

EX07 Side Sections Roadway

EX08 Side Sections Culverts



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APPROVED	MJS
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PLOT DATE	10/15/2013
SUBMITTAL	

PLAN OPTION NORTH
INTERSECTION MAPLE ROAD & ASH WAY
SNOHOMISH COUNTY
STORM DRAINAGE

SCALE 1"=40'

PROJECT NUMBER 037382

DRAWING FILE NAME 037382EX01

SHEET NUMBER EX02

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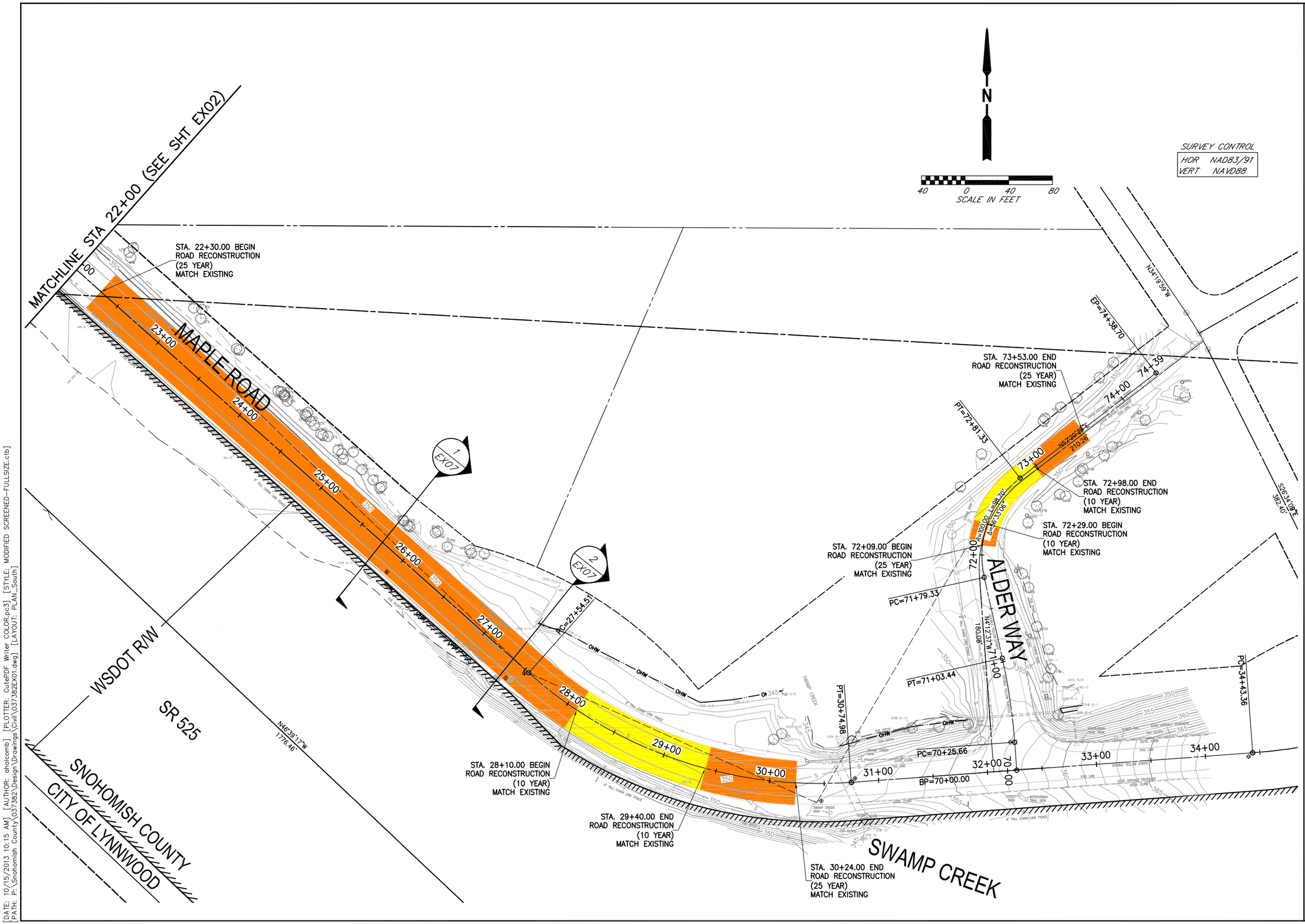

SURVEY CONTROL

HOR	NAD83/91
VERT	NAVD88

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PLAN OPTIONS SOUTH
MAPLE ROAD AND 180TH STREET SW
SNOHOMISH COUNTY
STORM DRAINAGE

SCALE 1"=40'

PROJECT NUMBER 037382

DRAWING FILE NAME 037382EX01

SHEET NUMBER
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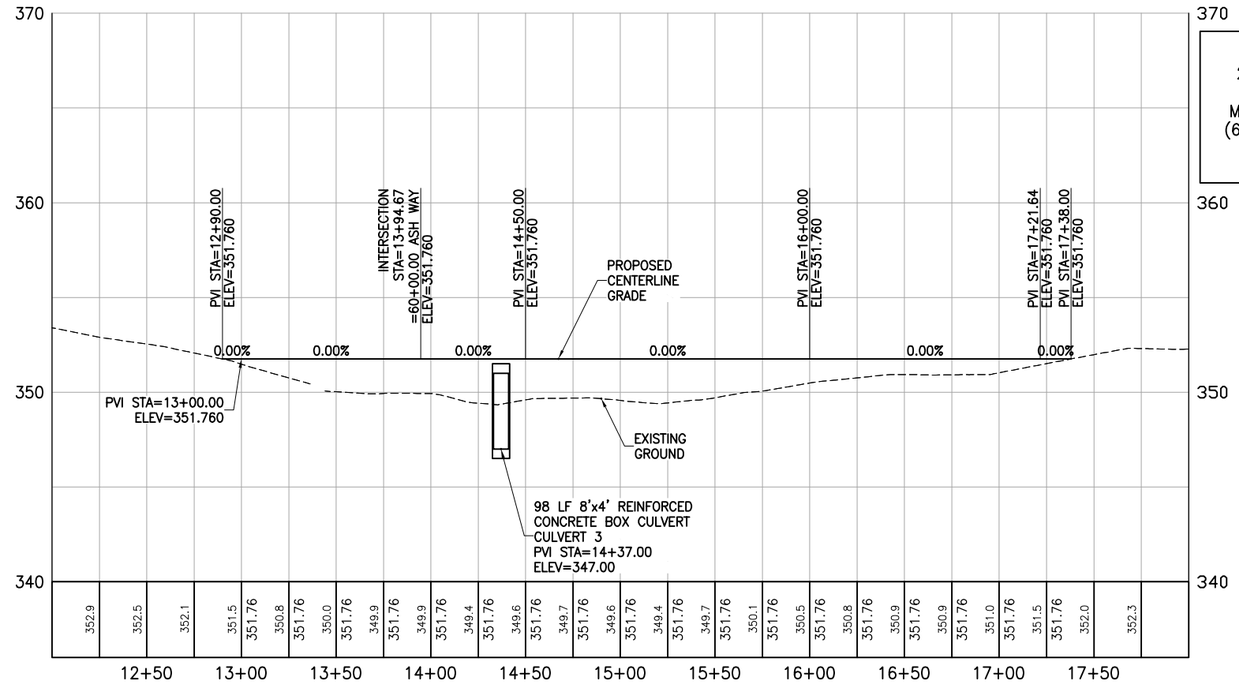
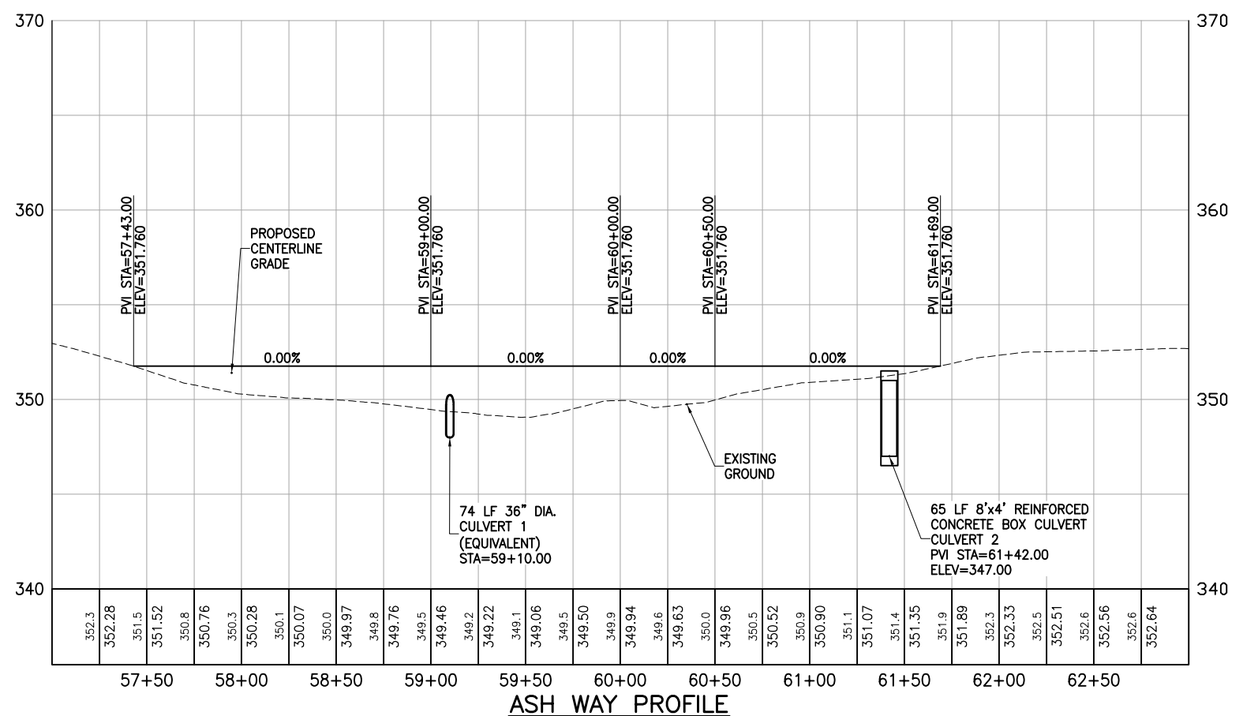


25 YR WATER LEVEL = 350.86

MINIMUM ROAD (E/P) = 351.36
(6" ABOVE 25 YR WATER LEVEL)

MAPLE ROAD PROFILE

SCALE:
HORIZONTAL 1"=40'
VERTICAL 1"=4'



ASH WAY PROFILE

SCALE:
HORIZONTAL 1"=40'
VERTICAL 1"=4'

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PLOT DATE	8/16/2013
SUBMITTAL	

PROFILE OPTION NORTH
INTERSECTION MAPLE ROAD & ASH WAY
SNOHOMISH COUNTY
STORM DRAINAGE

SCALE: H 1"=40' V 1"=4'

PROJECT NUMBER: 037382
DRAWING FILE NAME: 037382EX02

SHEET NUMBER
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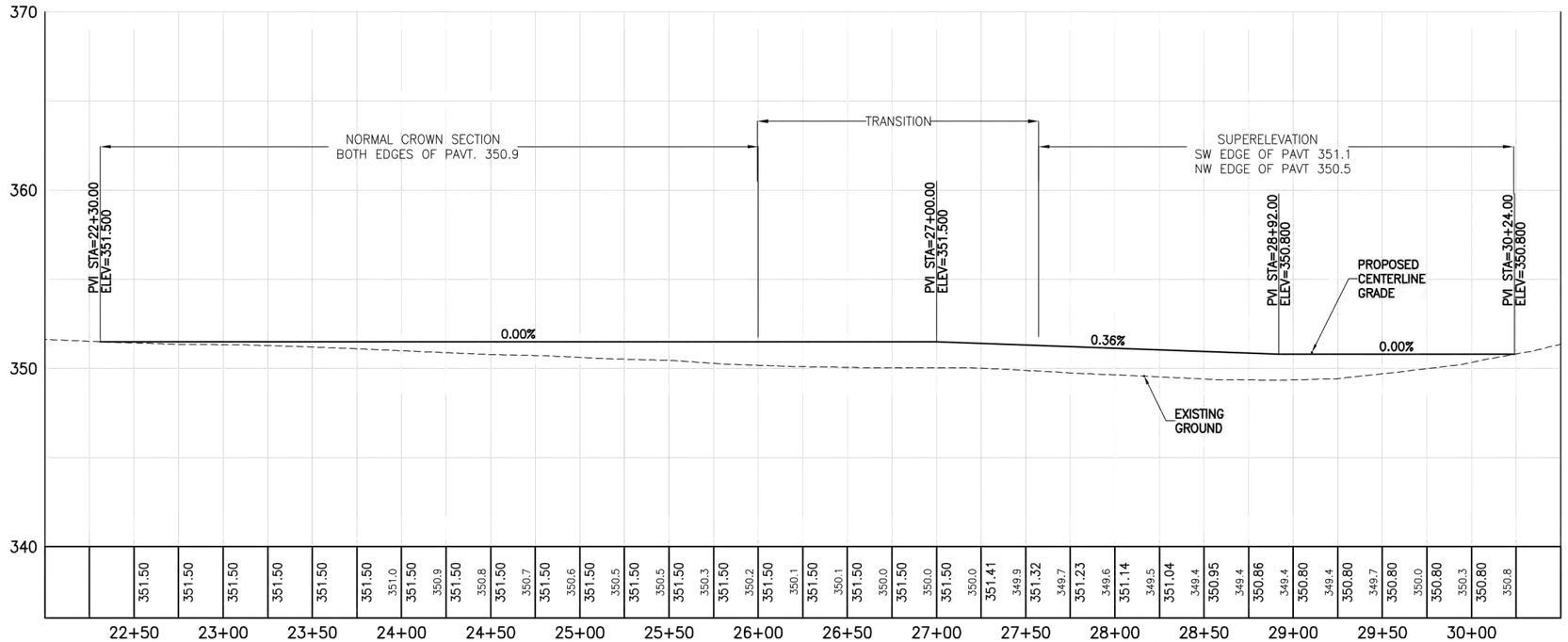


MAPLE ROAD PROFILE (25 YEAR)

SCALE:
HORIZONTAL 1"=40'
VERTICAL 1"=4'

NE

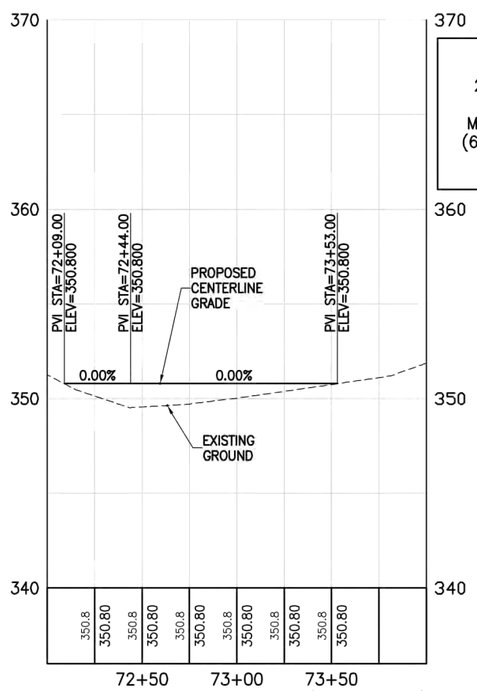
25 YR WATER LEVEL = 350.0

MINIMUM ROAD (E/P) = 350.5
(6" ABOVE 25 YR WATER LEVEL)

SW

25 YR WATER LEVEL = 350.4

MINIMUM ROAD (E/P) = 350.9
(6" ABOVE 25 YR WATER LEVEL)



25 YR WATER LEVEL = 350.0

MINIMUM ROAD (E/P) = 350.5
(6" ABOVE 25 YR WATER LEVEL)

ALDER WAY PROFILE (25 YEAR)

SCALE:
HORIZONTAL 1"=40'
VERTICAL 1"=4'

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APPROVED	MJS
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PLOT DATE	11/18/2013
SUBMITTAL	

PROFILE OPTIONS SOUTH - 25 YR
MAPLE ROAD AND 180TH STREET SW
SNOHOMISH COUNTY
STORM DRAINAGE

PROJECT NUMBER 037382
DRAWING FILE NAME 037382EX02
SCALE H 1"=40' V 1"=4'

SHEET NUMBER
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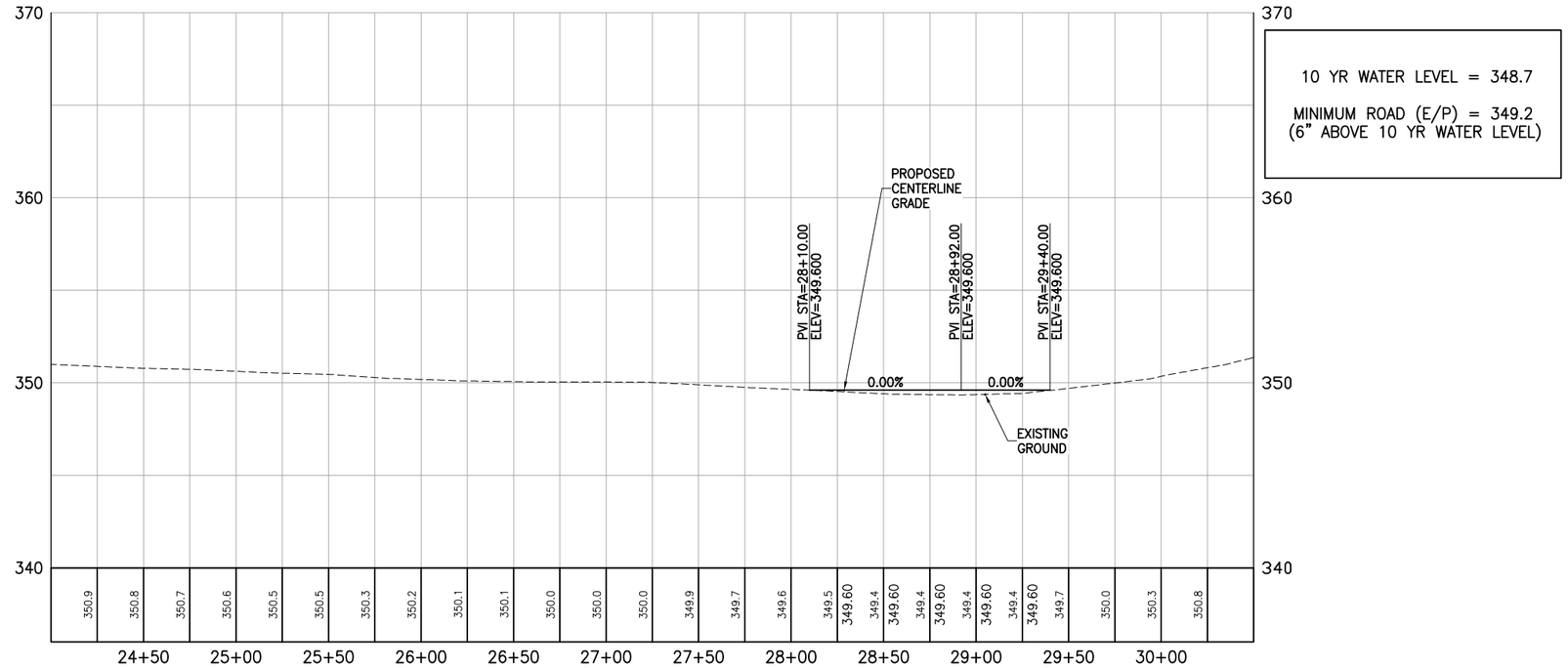

MAPLE ROAD PROFILE (10 YEAR)

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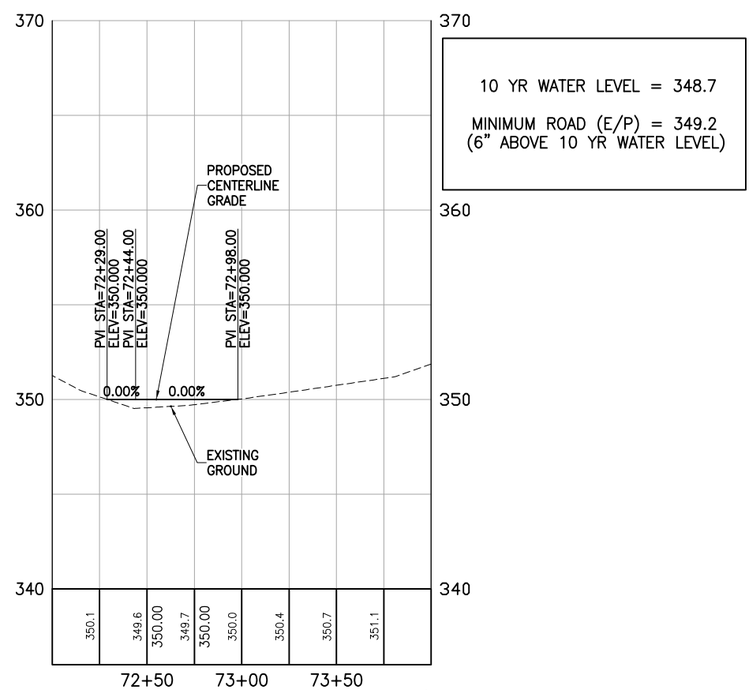
VERTICAL 1"=4'



ALDER WAY PROFILE (10 YEAR)

SCALE:
HORIZONTAL 1"=40'
VERTICAL 1"=4'

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APPROVED	MJS	
LAST EDIT	8/16/2013	
PLOT DATE	8/16/2013	
SUBMITTAL		

PROFILE OPTIONS SOUTH - 10YR
MAPLE ROAD AND 180TH STREET SW
SNOHOMISH COUNTY
STORM DRAINAGE

PROJECT NUMBER 037382
DRAWING FILE NAME 037382EX02
SCALE H 1"=40' V 1"=4'

SHEET NUMBER
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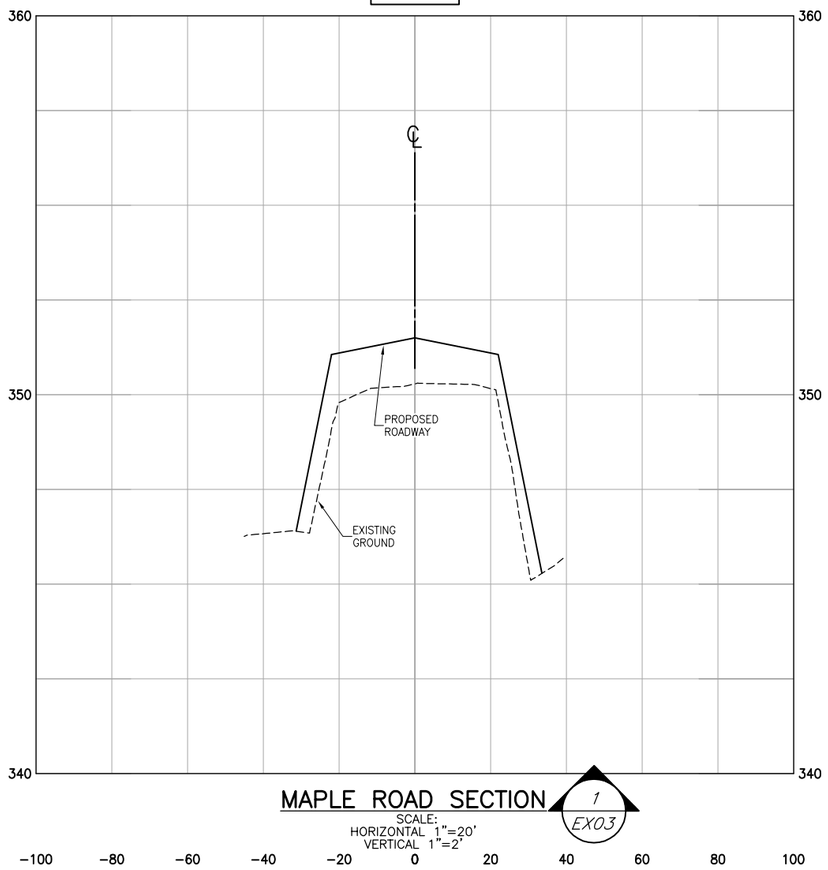
25+75.00



MAPLE ROAD SECTION 1 EX03

SCALE:
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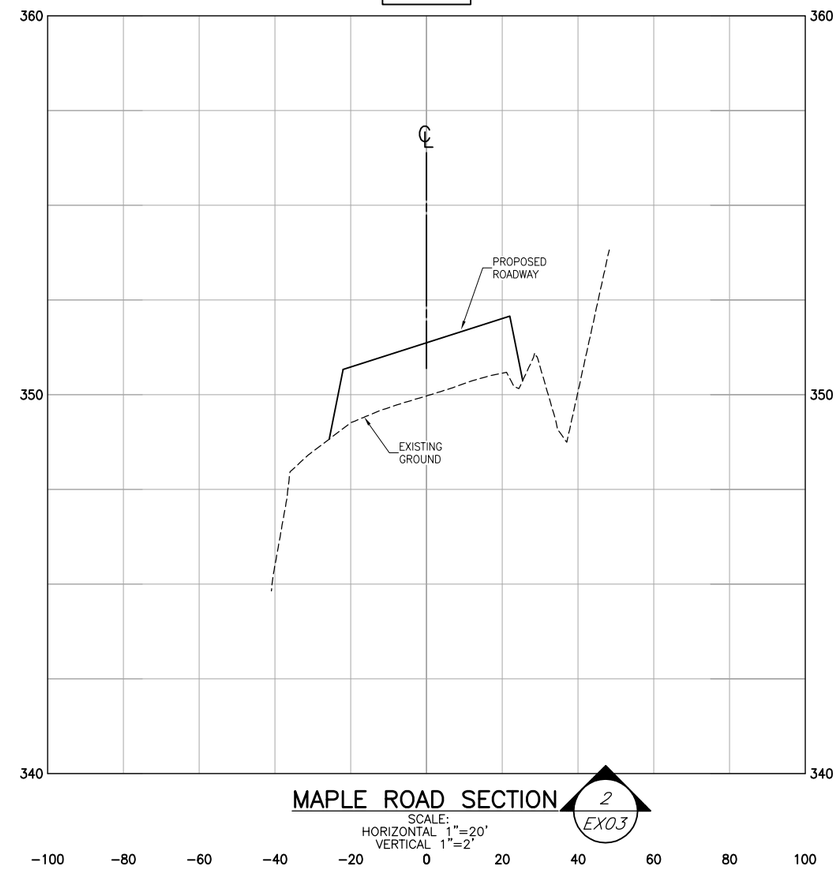
VERTICAL 1"=2'

27+35.37



MAPLE ROAD SECTION 2 EX03

SCALE:
HORIZONTAL 1"=20'
VERTICAL 1"=2'

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SITE SECTIONS
ROADWAY
SNOHOMISH COUNTY
STORM DRAINAGE

SCALE AS NOTED

PROJECT NUMBER 037382

DRAWING FILE NAME 037382EX02

SHEET NUMBER
EX07

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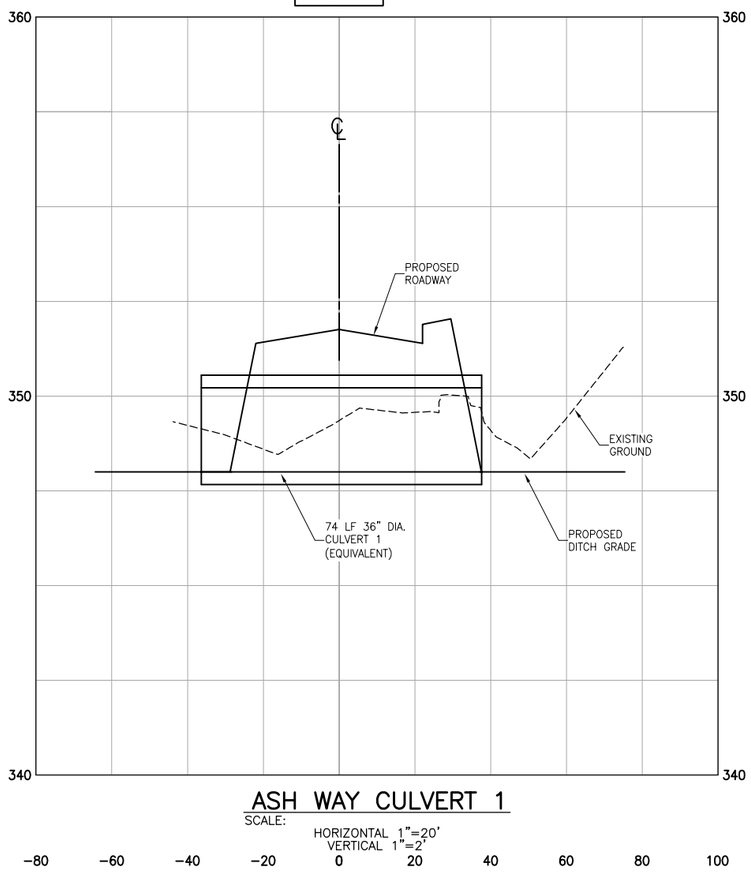
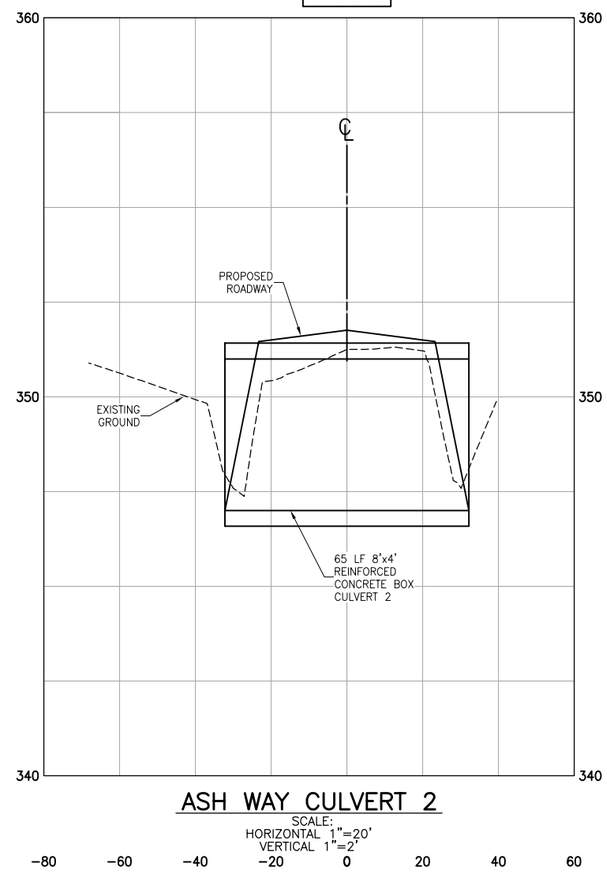
59+10.00



ASH WAY CULVERT 1

SCALE:
HORIZONTAL 1"=20'
VERTICAL 1"=2'

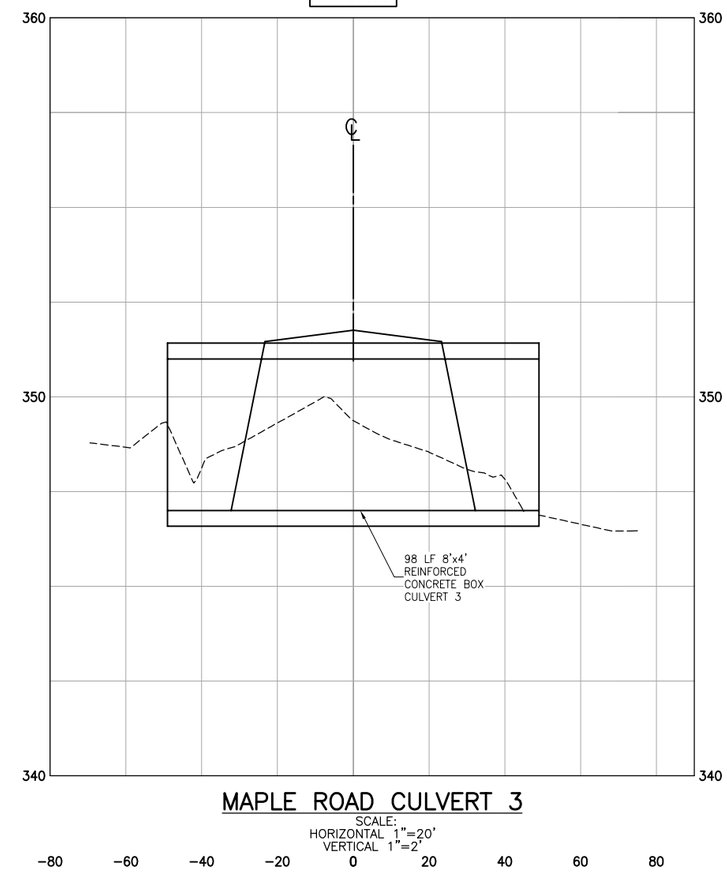
61+42.00



ASH WAY CULVERT 2

SCALE:
HORIZONTAL 1"=20'
VERTICAL 1"=2'

14+37.00



MAPLE ROAD CULVERT 3

SCALE:
HORIZONTAL 1"=20'
VERTICAL 1"=2'

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SITE SECTIONS
CULVERTS 1 & 2
SNOHOMISH COUNTY
STORM DRAINAGE

SCALE: AS NOTED

PROJECT NUMBER: 037382

DRAWING FILE NAME: 037382EX02

SHEET NUMBER
EX08

[DATE: 8/16/2013 12:01 PM] [AUTHOR: twhite] [PLOTTER: CutePDF Writer.pc3] [STYLE: MODIFIED SCREENED-FULLSIZE.ctb]
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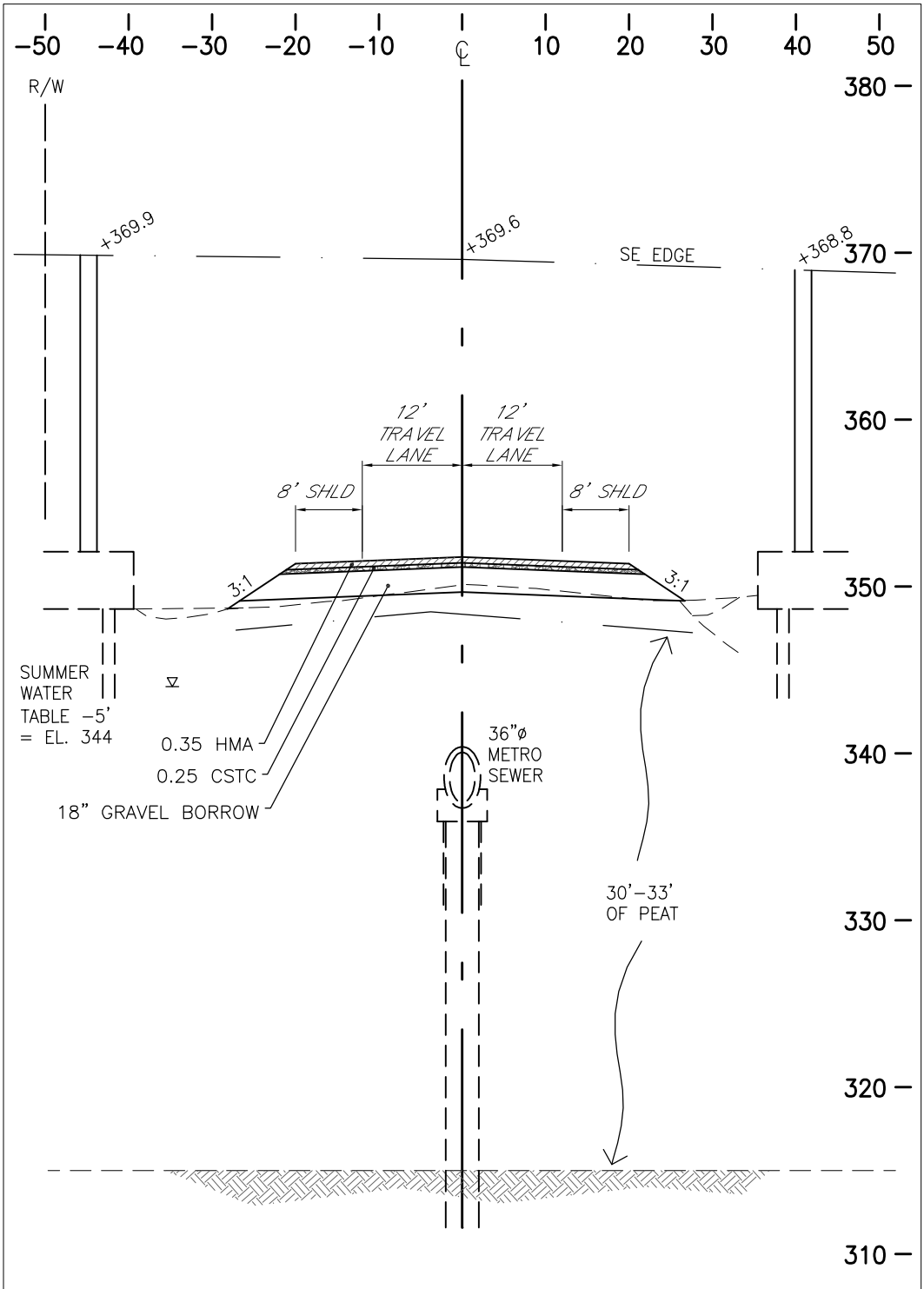
APPENDIX C

WHPacific, Inc.

Typical Sections



TRADITIONAL APPROACH

SCALE:
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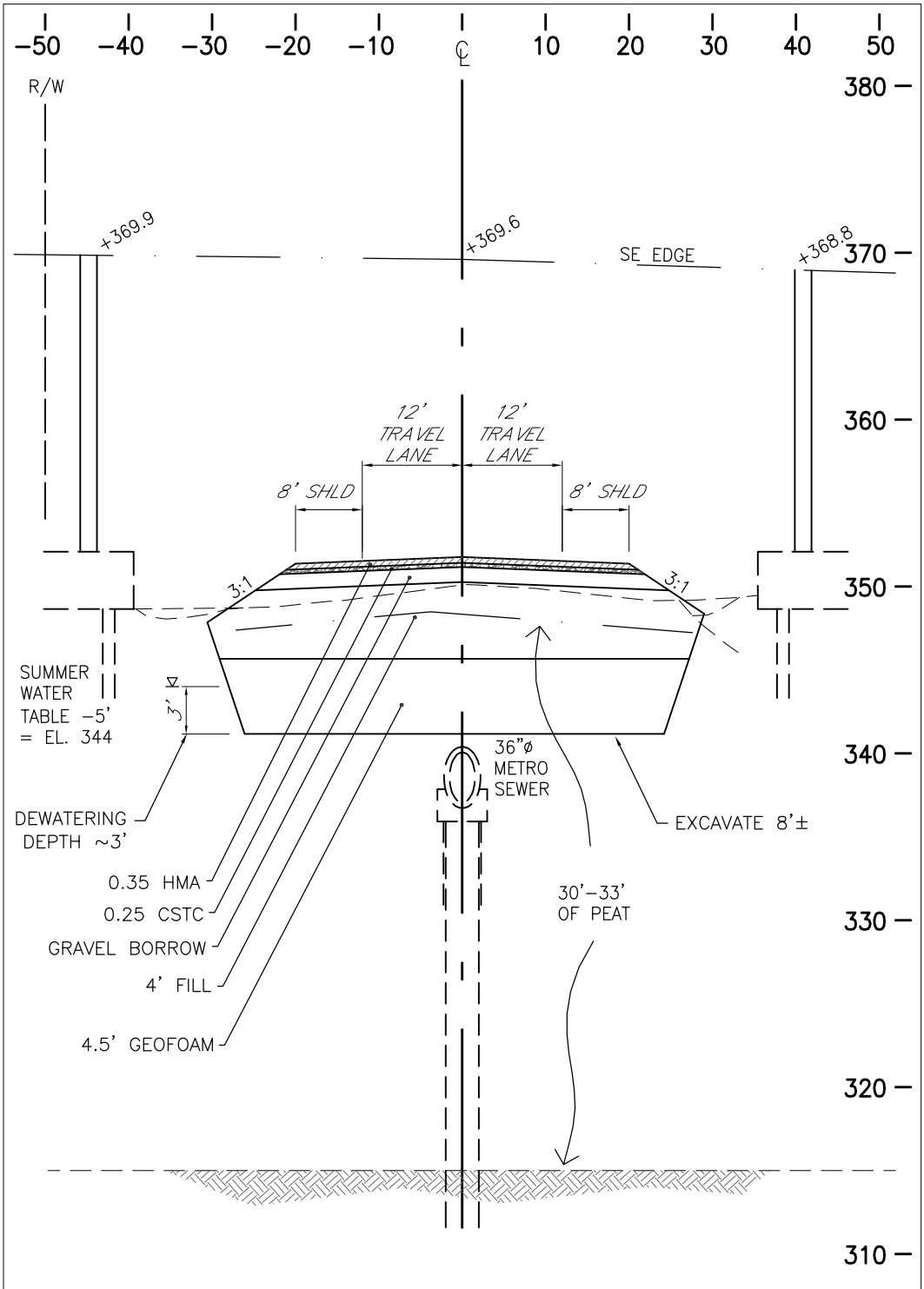
VERTICAL 1" = 10'

EX09



LIGHT WEIGHT FILL (GEOFOAM)

SCALE:
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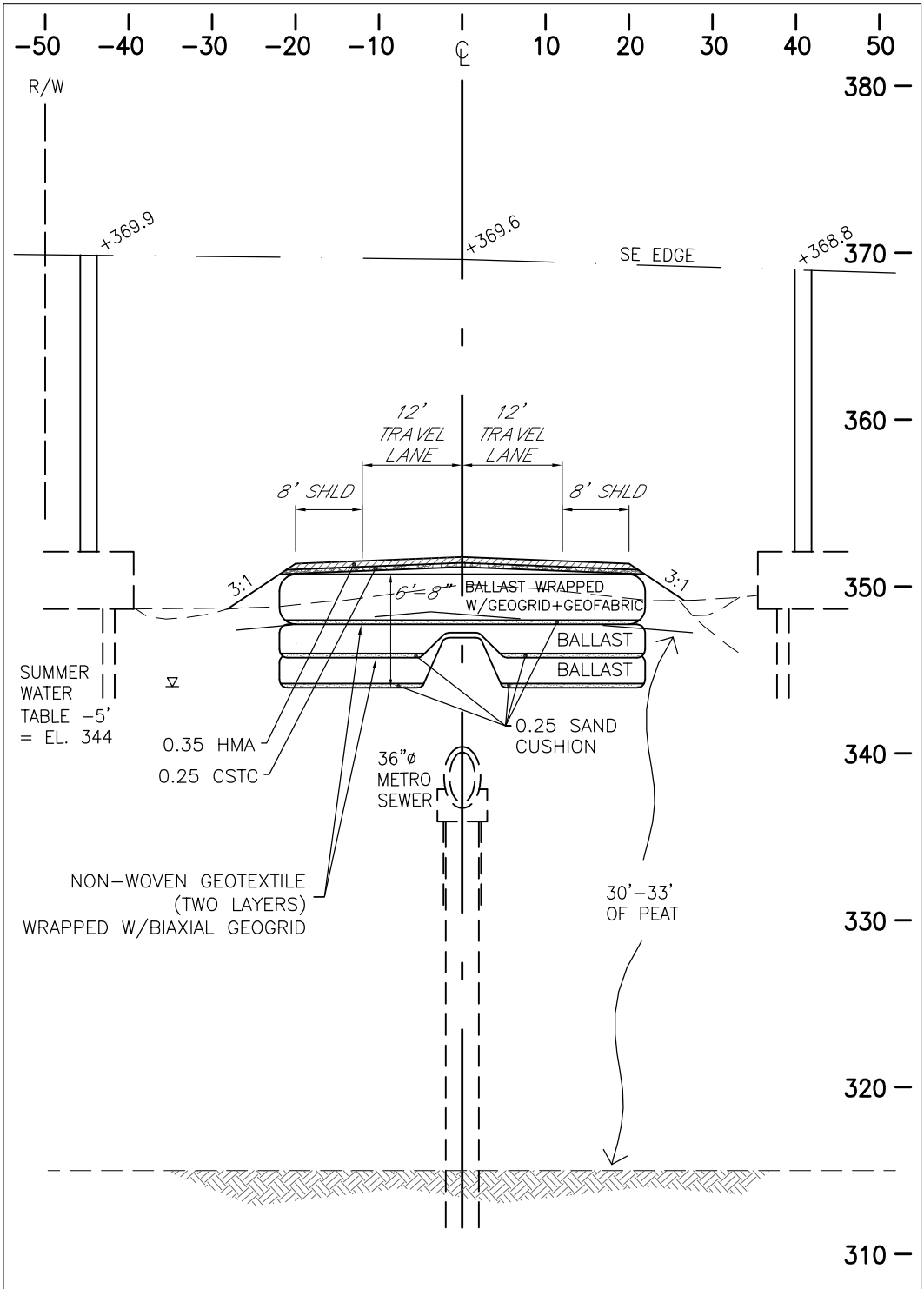
VERTICAL 1" = 10'

EX10



RAILROAD BALLAST

SCALE:
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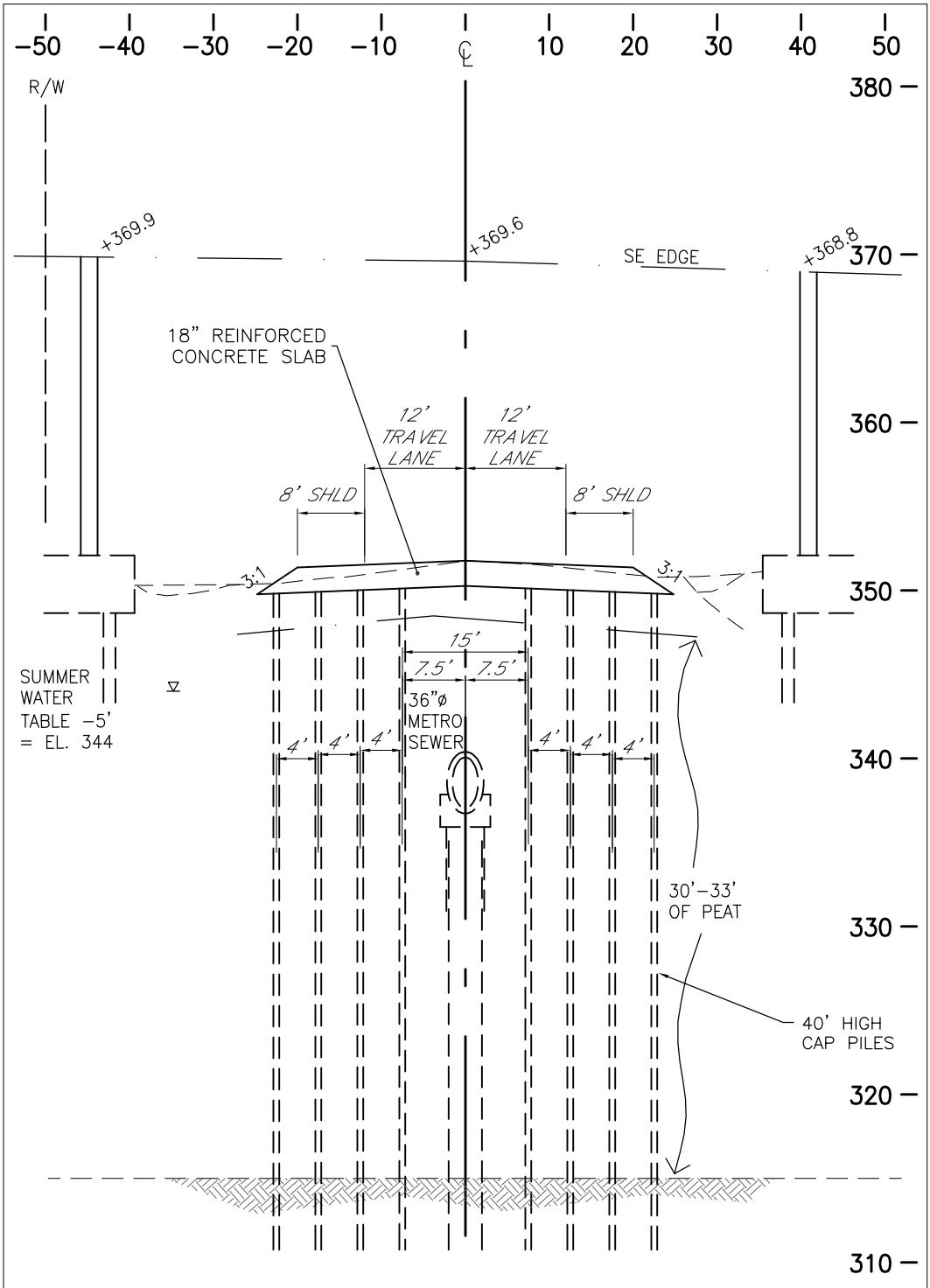
VERTICAL 1" = 10'

EX11



PILE SUPPORTED ROAD

SCALE:
HORIZONTAL 1" = 20'
VERTICAL 1" = 10'

EX12

APPENDIX D

Storm Drainage Report

Summary of Preliminary HECRAS Analysis

The Ash Way and Maple Road Flood Protection project consists of designing roadway improvements to alleviate frequent flooding that occurs along Maple Road from the intersection with Ash Way to the east under the SR 525 bridge and along Maple Road adjacent to the existing Washington Department of Transportation (WSDOT) detention pond located about 700 feet south of the bridge on the east side of SR 525. The preliminary roadway design also included the evaluation of the conveyance of stormwater runoff within the design area. The causes of flooding along this section of Maple Road and stormwater conveyance options were previously studied for the City of Lynnwood by PACE Engineers, Inc. (PACE). The PACE study was documented in the Maple Road and Ash Way Flood Study Technical Memorandum dated June 2012 and resulted in a preferred option to reconstruct the roadway by raising it where needed to provide 10-year flood protection. For this design project, WHPacific used the HECRAS water surface profile model to evaluate the stormwater conveyance within the study limits. This work was performed in three steps;

1. Review of the June 2012 PACE HECRAS model.
2. Reevaluation of existing conditions.
3. Evaluation of proposed conditions.

Below is a summary of the HECRAS analyses performed for each of these three steps, including the modeling results.

Review of the PACE HECRAS Model

The PACE study identified and analyzed several options to reduce flooding along Maple Road. HECRAS was used to evaluate the options, which included storm pipe and ditch maintenance, road reconstruction, and a dike. Prior to analyzing the options, an existing condition HECRAS model was prepared. Swamp Creek tailwater elevations used in the PACE HECRAS model were obtained from the 2002 Snohomish County Drainage Needs Report and are as follows for the storm frequencies evaluated:

- 2 Year – 347.9
- 10 Year – 349.98
- 25 Year – 351.6
- 100 Year – 355.15

A review of the PACE HECRAS model determined that the inflows were incorrectly entered in the model. Due to this error and the high Swamp Creek tailwater conditions, the study determined that there would be no significant difference in the resulting water surface elevations for the existing and proposed options. A recommendation was made to reconstruct Maple Road to provide flood protection by raising the road to 6 inches above the 10-year storm event at the edge of travelled way (elevation 350.5 minimum).

Based on our review, it was concluded that the PACE HECRAS model would need to be revised for use by WHPacific to evaluate the stormwater conveyance and proposed road improvements.

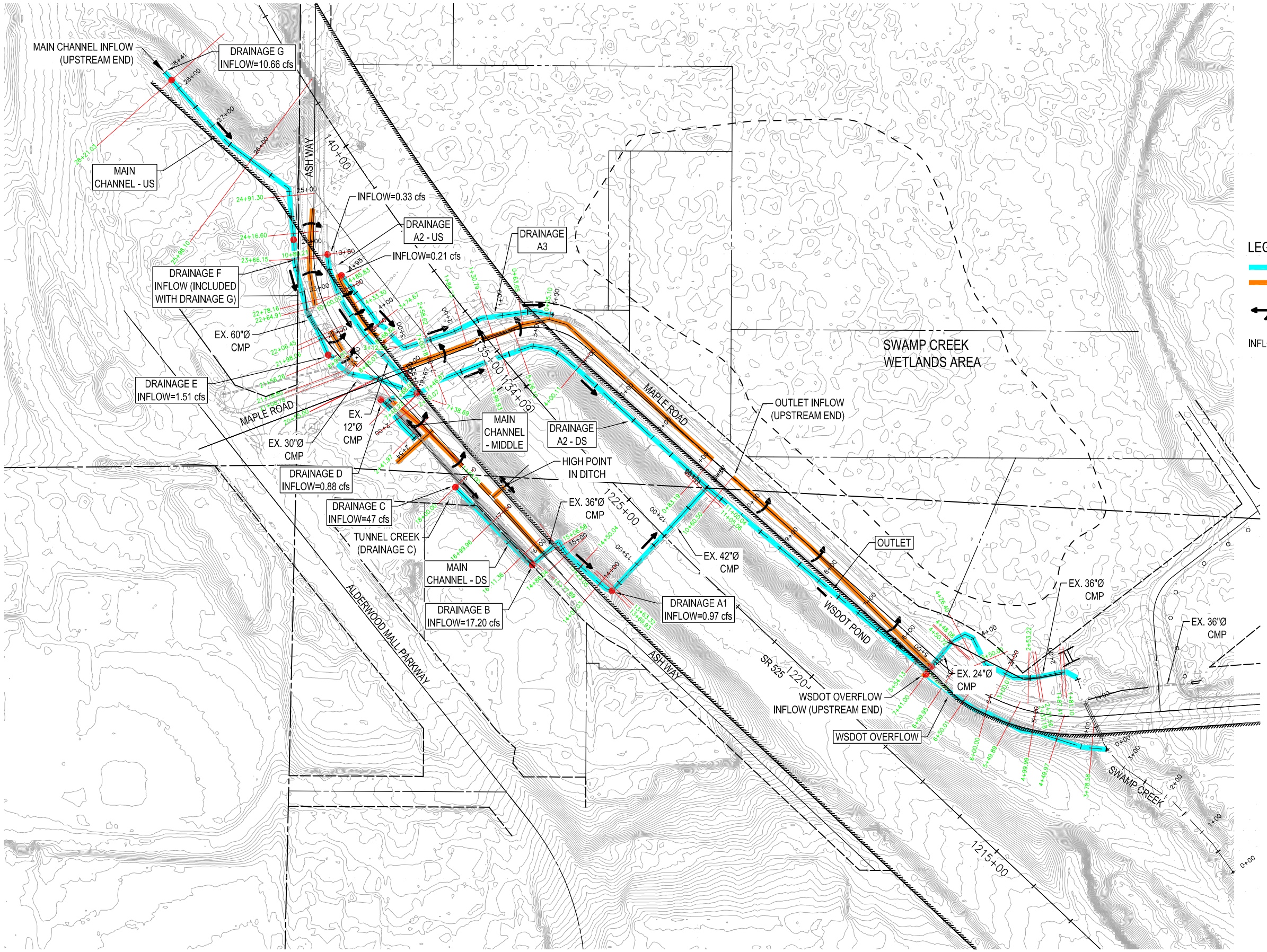
Reevaluation of Existing Conditions

See Figure 1 for a schematic drawing showing the HECRAS routing for the existing condition. The PACE HECRAS model was modified to reevaluate the existing condition hydraulics from about 700 feet north of the Ash Way/Maple Road intersection to Swamp Creek. The following revisions were made when updating the HECRAS model:

1. Swamp Creek Tailwater Elevations – Snohomish County completed a study in 2012 to update the 2, 10, 25, and 100-year water surface profiles for Swamp Creek. The resulting water surface elevations at the Maple Road crossing were determined to be significantly lower than the 2002 Snohomish County Drainage Needs Report study (see Attachment A for 2012 HECRAS output table results). The 2012 Swamp Creek water surface elevations were used as the tailwater elevations in the revised HECRAS model and are as follows for the storm frequencies evaluated:

   <u>Upstream of Maple Road (Swamp Creek Sta. 71+43.918)</u>
   - 2 Year – 346.9
   - 10 Year – 348.26
   - 25 Year – 349.94
   - 100 Year – 350.87

   <u>Downstream of Maple Road (Swamp Creek Sta. 70+43)</u>
   - 2 Year – 346.14
   - 10 Year – 347.02
   - 25 Year – 348.16
   - 100 Year – 349.64



LEGEND:

- HECRAS RIVER REACHES
- HECRAS LATERAL WEIRS
- HECRAS INFLOW LOCATIONS
- EXISTING FLOW DIRECTION ARROWS

INFLOWS = 25-YEAR STORM EVENT

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HECRAS MODEL SCHEMATIC
EXISTING CONDITION
SNOHOMISH COUNTY
STORM DRAINAGE

SCALE: 1"=100'

PROJECT NUMBER: 037382

DRAWING FILE NAME: 037382-HECRAS-EC01

SHEET NUMBER

FIGURE 1

[DATE: 8/16/2013 11:01 AM] [AUTHOR: twhite] [PLOTTER: CutePDF Writer.pc3] [STYLE: MODIFIED SCREENED-FULLSIZE.ctb]
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2. Flow Routing Changes – Observed flooding conditions at the Ash Way and Maple Road intersection indicated that the majority of runoff flows to the intersection, overflows to the southeast corner, and then flows east under the bridge in Drainage A2 to the north end of the Washington Department of Transportation (WSDOT) detention pond located on the east side of SR 525. The HECRAS model was revised to follow this route in addition to allowing portions of the flow to be routed to the existing SR 525 42" CMP culvert and in an existing swale along the north side of Maple Road (Drainage A3).

3. Detention Storage Routing – The PACE HECRAS model included several storage areas to route the effects of detention storage on peak flows. Evaluation of the detention areas indicated that the available storage volumes would not significantly reduce the peak flows. Two of the storage areas (a manhole and catch basin) have very small volumes. The WSDOT Pond has about 2.5 acre-feet of available storage volume, but was only sized to provide detention storage for the local highway drainage basin (about 12 acres), whereas, the majority of the 350± acre tributary drainage basin is tributary to the pond. Observations indicate that the WSDOT Pond fills up quickly during typical storm events. Therefore, it was assumed that the pond would be full during larger storm events and was not included in the HECRAS model.

4. Existing 30" CMP Culvert – The existing 30" CMP culvert across Maple Road, on the west side of the Ash Way/Maple Road intersection, is currently plugged with sediment and water. Therefore, this culvert was not included in the revised HECRAS model. Since the culvert is plugged, water flowing to the west side of the intersection will overtop the road and spill to the southeast corner.

5. Lateral Weirs – Several lateral weirs were included in the PACE HECRAS model to allow flow to spill across the roads and over embankments between channels when overtopped. These weirs (Drainage A2 - US 1040, Main Channel – US 2460, and Main Channel – US 2205) were updated as needed. Additional weirs were included to model the flow spills across Maple Road from the south side to the north side (Drainage A2 - DS 700) and flow spills from the WSDOT Pond area to the Swamp Creek wetland area (Outlet 1059).

   See below for descriptions of three other lateral weirs that were included in the updated HECRAS model to analyze flow splits.

   a. The main inflows to Maple Creek are Tunnel Creek (Drainage C) and runoff from the commercial area (Drainage B), which are tributary to the main channel south of the Ash Way/Maple Road intersection. The existing ditch along the west side

of Ash Way (Main Channel – Middle and Main Channel – DS), south of the intersection is relatively flat. Since the road elevation at the intersection is lower than the road elevation at the existing 36" CMP culvert across Ash Way, water on the west side of Ash Way that cannot flow through the culvert will flow north to the intersection then across Ash Way to the east side of the road. A lateral weir was added to the model (Main Channel – DS 1699) to allow the water surface elevation to "balance" between the Ash Way 36" CMP culvert (Main Channel – DS Section 1699.96) and the southwest corner of the Ash Way/Maple Road intersection (Main Channel – Middle Section 241.97).

b. Similarly, the existing ditch along the east side of Ash Way, south of the intersection is relatively flat and has a high point located between the intersection and the existing 42" CMP culvert across SR 525. Depending on the water surface elevations at the southeast corner of the intersection and ponded at the 42" CMP culvert, water can either flow northerly or southerly in this ditch. A lateral weir (Main Channel – DS 1518) was added to the model to allow the water surface elevation to "balance" between the SR 525 42" CMP culvert (Main Channel – DS Section 1506.58) and the southeast corner of the Ash Way/Maple Road intersection (Drainage A2 – DS Section 746.87).

c. At the WSDOT Pond outlet structure, water initially is routed across Maple Road in an existing 24" CMP pipe. Flows exceeding the capacity of the 24" CMP pipe spill over a weir (Outlet 553) and are routed in a ditch (WSDOT Overflow) along the south side of Maple Road to Swamp Creek. The WSDOT Overflow lateral weir (Outlet 553) was included in the updated existing condition HECRAS model.

6. Design Flows – PACE analyzed future condition flow rates using the WWHM3 hydrologic model for use as inflows to their HECRAS model. The inflow hydrographs were not routed to determine timing or storage effects. Snohomish County retained Northwest Hydraulic Consultants (NHC) to provide an updated runoff analysis for the Maple Creek tributary basins using the HSPF Model (Hydrologic Simulation Program Fortran), including timing and storage effects. Storage effects were included for detention storage areas located within the tributary areas and for inadvertent storage located upstream of culverts due to backwater conditions. Storage effects were not included for the WSDOT Pond.

   Inflows at selected locations were provided for input to the HECRAS model for the 2, 10, 25, and 100-year storm events (see Attachment A for inflows provide by NHC). The routed discharges to Swamp Creek in the table represent the total routed flow from all of

the tributary drainage basins without including inadvertent storage at, or downstream from, the Ash Way/Maple Road intersection (2 yr – 34 cfs, 10 yr – 62 cfs, 25 yr – 73 cfs, 100 yr – 87 cfs).

As described above, several split flow conditions occur through the Maple Road project limits that were analyzed by the updated HECRAS model using lateral weirs. WHPacific provided the updated HECRAS models and results to NHC for their use in defining split flow rating curves for the HSPF model for both the existing and proposed conditions.

7. Model Optimization/Convergence – Several revisions were made to the existing condition HECRAS model per recommendations made by NHC based on their review of the preliminary model results. The revisions included the following:
    - Deleted or turned off the optimization for lateral weirs that resulted in no overflows (Drainage A2 – DS 450, Main Channel – US 2205, Main Channel – Middle – 241, and Main Channel – DS 1735).
    - Shortened lateral weirs that overlapped.
    - Increased the roughness value (n) for ditches to use a value of 0.05.
    - Revised the cross section connecting position for lateral weirs if needed.
    - Added a storage area (Wetlands Area) to represent the tailwater elevation conditions for the Swamp Creek wetlands area. Drainage A3 and the Outlet 1059 lateral weir were connected to outfall to the storage area to simulate the tailwater conditions.
    - Adjusted the lateral weir coefficients as needed to allow the lateral weir model results to converge where possible.
    - Revised the model tolerance limits to be less stringent.

Convergence was obtained for only the 2-year storm event, but the 25-year lateral weir results appear to be reasonable since the water surface elevation does not change when the weir coefficients are adjusted.

In addition, to verify the reasonableness of the model results, WHPacific checked the observed flooding elevation during the December 3, 2007 flood event. Specifically, the water surface elevation was compared at the fire hydrant located along the west side of Ash Way north of the Maple Road intersection (see photo below). The elevation of the 2007 water surface (hydrant flange) was 351.65.

Rainfall in the 2007 storm event was greater than the 100-year storm since 1.8 inches fell on December 2nd, followed by 3.6 inches on December 3rd. Per a study of the 2007 flood event for Snohomish County, the 2007 water surface elevation on Swamp Creek

just upstream of the Maple Road crossing (River Sta. 7143.918) was determined to be 351.15' (0.25' higher than the simulated 100-year storm event).

From the WHPacific existing condition model, the 100-year water surface elevation at the Ash Way/Maple Road intersection is about 0.2' above the Swamp Creek tailwater. Assuming this same relationship for the 2007 flood event, we can estimate the 2007 water surface elevation at the fire hydrant as shown in the calculation below. The difference is about 0.3' between calculated and observed elevations. Given the inherent accuracy of hydrologic and hydraulic modelling, this is a reasonable result and consequently justifies the model.

Swamp Creek (Snohomish County study, Unsteady Results for Dec 2007)	*351.15*
Water elevation drop (100yr) from Intersection to Swamp Creek:	*351.03-350.87 = 0.2'±*
Estimated Water Elevation at Intersection	*351.35*
Actual Observed Elevation at Fire Hydrant	*351.65*
Difference	*0.3'±*

Photo of December 3, 2007 flood event looking southeast
at the Ash Way/Maple Road intersection.

The results of the updated existing condition HECRAS model are provided in Attachment B, including an output table, profiles, and cross sections. See Table 1 for a summary of the existing condition flows and water surface elevations at selected locations. The 25-year existing condition flows are also shown in Figure 3 along with the 25-year proposed condition results at selected locations.

The existing condition HECRAS model results indicate that the majority of the tributary runoff flows to the southwest corner of the Ash Way/Maple Road intersection, then spills across the intersection to the southeast corner, then flows east under the bridge in Drainage A2 to the north end of the WSDOT detention pond and also spills northerly across Maple Road to Drainage A3. At the WSDOT pond, water overtops Maple Road (lateral weir Outlet 1059) in storm events greater than the 25-year and flows into the Swamp Creek wetland area. At the WSDOT Pond outlet structure, flows exceeding the capacity of the 24" CMP culvert spill over a weir (Outlet 553) then flow along the south side of Maple Road to Swamp Creek (WSDOT Overflow). Runoff that spills to Drainage A3 flows to the Swamp Creek wetland area.

Evaluation of Proposed Conditions

The intent of the proposed drainage design for the road improvements is to route the tributary runoff to Swamp Creek or to the Swamp Creek wetland area without water inundating the edge of the roads for the 25-year or more frequent storm events. The existing condition HECRAS model was modified to evaluate the proposed condition hydraulics. See Figure 2 for a schematic drawing showing the HECRAS routing for the proposed condition. The existing condition model was modified as follows to reflect the proposed improvements:

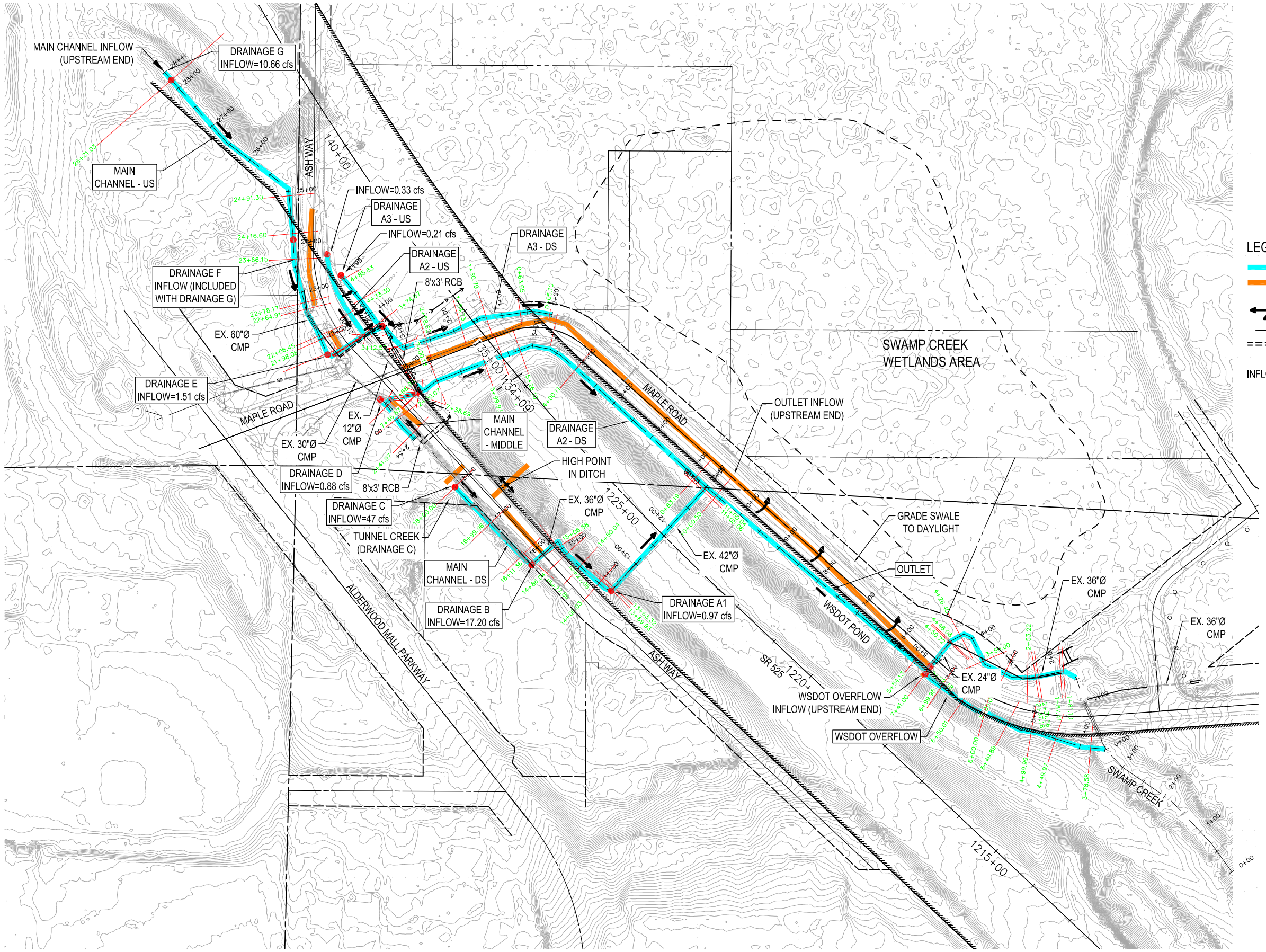
1. Road Elevations Raised – Ash Way and Maple Road were raised per the proposed plans to set the edge of travelled way at or above the 25-year water surface elevation plus 6 inches (elevation 351.36 at the Ash Way/Maple Road intersection, elevation 351.1 along the west side of Maple Road Sta. 24+00 to 30+30, and elevation 350.44 along the northeast side of Maple Road Sta. 24+00 to 30+30). To be conservative, the existing condition elevations were used for design since they are slightly higher than the proposed water surface elevations. When the proposed grading is finalized, the proposed results will be used. The lateral weirs in the model were also raised to the proposed road elevations.

2. Drainage A2 Flow Routing – When Maple Road is regraded as proposed, flow from Drainage A2 will be routed to both the proposed 8' x 3' RCB and to the north end of the WSDOT Pond without overtopping Maple Road in the 25-year storm event.

3. Drainage A3 Realignment – Due to the proposed road regrading, the portion of Drainage A3 along Maple Road is proposed to be realigned to the north. The realigned channel is proposed to be sized to contain the 25-year runoff, minimum, without overtopping Maple Road. The realigned channel will still outfall directly to the Swamp Creek wetland area.

4. Proposed Culvert North of Intersection – About 80 feet north of the Ash Way/Maple Road intersection, a 43¾" x 26⅝" concrete arch pipe is proposed to route runoff from the west side of Ash Way to the realigned Drainage A3 located north of Maple Road. The culvert was sized to route the 25-year runoff without overtopping Ash Way.

5. Proposed Culverts South and East of Intersection – Two 8' x 3' concrete box culverts are proposed south and east of the Ash Way/Maple Road intersection to route runoff from the west side of Ash Way to the north side of Maple Road to the realigned Drainage A3 located north of Maple Road. The culverts were sized to route the 25-year runoff without overtopping Ash Way and Maple Road, and to keep the proposed water surface elevation at approximately the existing elevation at the southwest corner of the intersection.



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LEGEND:

- HECRAS RIVER REACHES
- HECRAS LATERAL WEIRS
- HECRAS INFLOW LOCATIONS
- PROPOSED FLOW DIRECTION ARROWS
- REALIGNED CHANNELS
- PROPOSED CULVERT

INFLOWS = 25-YEAR STORM EVENT

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HECRAS MODEL SCHEMATIC
PROPOSED CONDITION
SNOHOMISH COUNTY
STORM DRAINAGE

SCALE 1"=100'

PROJECT NUMBER 037382

DRAWING FILE NAME 037382-HECRAS-EC02

SHEET NUMBER
FIGURE 2

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6. Existing 60” CMP Culvert Modification – The existing 60” CMP culvert across the driveway located north of the Ash Way/Maple Road intersection is filled with about 4 feet of sediment. For existing conditions, the culvert only has a capacity of about 6 cfs and runoff exceeding the capacity spills across Ash Way to the west side of the road. With the proposed 43¾” x 26⅝” concrete arch pipe culvert, the channel invert downstream of the 60” CMP culvert is proposed to be lowered by about 1 foot. With the lower channel invert, about 1 foot of sediment within the 60” CMP culvert is proposed to be removed toincrease the flow capacity. With the sediment removal, the culvert capacity is increased to about 13.4 cfs and no flow overtops Ash Way.

7. Model Optimization/Convergence –Several revisions were made to the proposed condition HECRAS model per recommendations made by NHC based on their review of the preliminary model results. Convergence was obtained for the 2-year, 10-year, and 25-year storm events. The revisions that were made are similar to the existing condition model revisions as described above.

The results of the proposed condition HECRAS model are provided in Attachment C, including an output table, profiles, and cross sections. See Table 2 for a summary of the proposed condition flows and water surface elevations at selected locations. The 25-year proposed condition flows are also shown in Figure 3 along with the 25-year existing condition results at selected locations.

The proposed condition HECRAS model results indicate that the majority of the tributary runoff flows to the proposed culvert south of the Ash Way/Maple Road intersection, then flows through the proposed culverts under Ash Way and Maple Road to the north side of Maple Road, then outfalls to Drainage A3 and flows east under the bridge to the Swamp Creek wetlands area. East of the Ash Way/Maple Road intersection, flows do not spill across Maple Road as they do for existing conditions. At the WSDOT Pond, 100-year storm event flows do not overtop Maple Road and spill to the Swamp Creek wetland area as they do for existing conditions. At the WSDOT Pond outlet structure, flows exceeding the capacity of the 24” CMP pipe spill over the weir (Outlet 553) then flow along the south side of Maple Road (WSDOT Overflow) to Swamp Creek at a lower rate than for the existing condition, except for the 100-year storm event. Tributary flow to the project area from the north will flow through the proposed culvert north of the intersection, then flows east in Drainage A3 to the Swamp Creek wetland area.

TABLE 1
SUMMARY OF EXISTING CONDITION HECRAS MODEL RESULTS

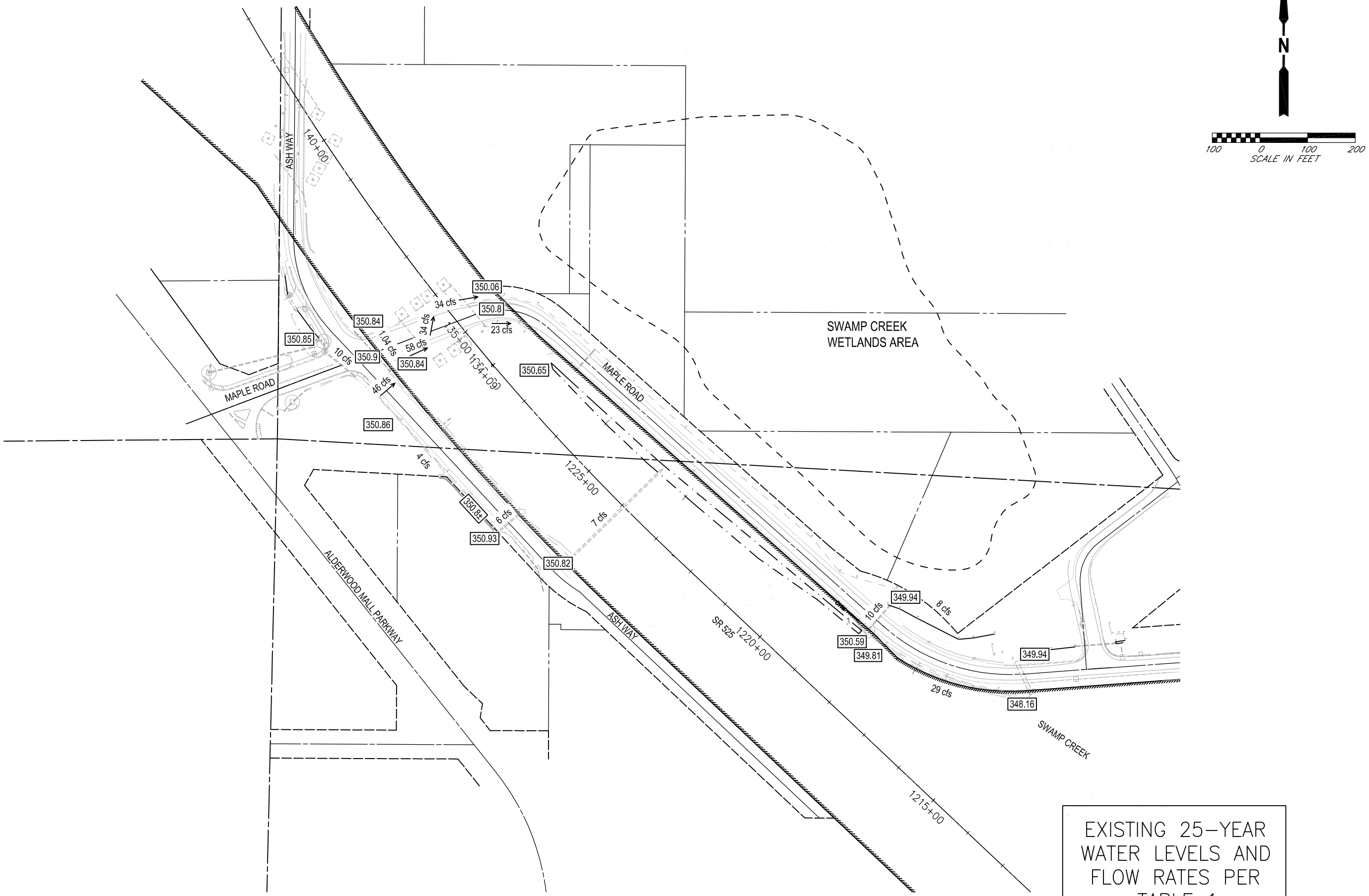
APPROX. ROAD STATION	RIVER REACH	HECRAS MODEL CROSS SECTION NO.	LOCATION	FLOW (cfs)				WATER SURFACE ELEVATION (feet)			
				2 YEAR	10 YEAR	25 YEAR	100 YEAR	2 YEAR	10 YEAR	25 YEAR	100 YEAR
Maple 13+50	Main Channel - US	2055	NW Corner Ash/Maple Intersection	6	9	10	12	350.46	350.74	350.85	351.03
Ash 61+10	Main Channel - Middle	241.97	About 75 feet south of SW Corner Ash/Maple Intersection	19	37	47	62	350.46	350.75	350.86	351.03
Maple 14+30	Drainage A2 - US	865.07	NE Corner Ash/Maple Intersection	0.03	0.42	1.04	2.25	350.46	350.74	350.84	351.03
Maple 14+40	Drainage A2 - DS	746.87	SE Corner Ash/Maple Intersection	24	46	58	75	350.46	350.74	350.84	351.02
Maple 14+40 to 16+80	Drainage A2 - DS	Lateral Weir 700 (Sta. 700.18 - Sta. 526.1)	Maple Road Overflow from Drainage A2 to Drainage A3	4	22	34	54	350.3±	350.7±	350.8±	351.0±
Maple 18+20	Drainage A2 - DS [1]	83.19	North End of WSDOT Pond	18	23	23	24	350.01	350.52	350.65	350.89
Maple 17+20	Drainage A3	63.65	Outfall to Swamp Creek Wetland Area	4	23	34	55	348.69	349.28	350.06	350.87
Ash 61+50 to 64+60	Main Channel - DS/ Main Channel - Middle	Lateral Weir 1699 (Sta. 1699.96 - Sta. 1611.36)	Ditch along west side of Ash Way from Main Channel - DS to Main Channel - Middle	18	36	46	57	350.5±	350.8±	350.9±	351.2±
Ash 64+60	Main Channel - DS [1]	1577.89	Upstream Side of 36" CMP Culvert Across Ash Way	7	6	6	9	350.48	350.80	350.93	351.30
Ash 66+10	Main Channel - DS[1]	1363.32	Upstream Side of 42" CMP Culvert Across SR 525	9	7	7	6	350.33	350.71	350.82	351.04
Maple 20+00 to 27+00	Outlet	Lateral Weir 1059 (Sta. 1060.5 - Sta. 554.13)	Maple Road Overflow from WSDOT Pond to Swamp Creek Wetland Area	0	0	0	11	350.0±	350.5±	350.6±	350.9±
Maple 27+35	Outlet [2]	522.38	Upstream Side of 24" CMP Culvert Across Maple Road at WSDOT Pond Outlet Structure	18	15	10	0.1	349.88	350.43	350.59	350.87
Maple 27+35	Outlet [2]	450.72	Downstream Side of 24" CMP Culvert Across Maple Road	18	15	10	0.1	347.69	348.83	349.94	350.87
Maple 30+00	Outlet [2]	181.1	Outfall to Swamp Creek	18	15	10	0.1	346.90	348.26	349.94	350.87
Maple 27+35	Outlet	Lateral Weir 553 (Sta. 554.13 - Sta. 522.38)	WSDOT Pond to WSDOT Overflow Channel	12	24	29	22	349.03	349.63	349.81	349.92
Maple 30+75	WSDOT Overflow[3]	378.58	Outfall to Swamp Creek	12	24	29	22	346.14	347.02	348.16	349.64

1 Flows are affected by the tailwater for the various storm events so the flows do not always increase along with the storm frequency.
2 The capacity of the Maple Road culvert is affected by tailwater so the flow is reduced as the storm frequency increases.
3 A portion of the 100-year runoff spills across Maple Road along the WSDOT Pond, so the 100-year flow to the WSDOT Overflow is reduced compared to the 25-year flow.
"Red" elevations are the maximum 25-year elevations at the Ash/Maple intersection and along the west and northeast sides of Maple Road adjacent to the WSDOT Pond.
"Blue" locations represent lateral weir overflows.

TABLE 2
SUMMARY OF PROPOSED CONDITION HECRAS MODEL RESULTS

APPROX. ROAD STATION	RIVER REACH	HECRAS MODEL CROSS SECTION NO.	LOCATION	FLOW (cfs)				WATER SURFACE ELEVATION (feet)			
				2 YEAR	10 YEAR	25 YEAR	100 YEAR	2 YEAR	10 YEAR	25 YEAR	100 YEAR
Ash 59+10	Main Channel - US	2148	Upstream Side of 43¾" x 26⅝" Arch Culvert Across Ash Way	6	10	11	14	349.66	350.25	350.62	351.20
Ash 61+50	Main Channel - Middle	241.97	Upstream Side of 8' x 3' RCB Culvert Across Ash Way	17	35	44	61	349.72	350.39	350.76	351.39
Maple 14+30	Main Channel - Middle	45	Downstream Side of 8' x 3' RCB Culvert Across Maple Road	17	35	44	61	349.63	350.19	350.52	351.03
Maple 14+40	Drainage A2 - DS	746.87	Upstream End of Drainage A2 - DS	0.3	0.4	0.5	0.6	349.96	350.61	350.81	351.24
Maple 14+40 to 16+80	Drainage A2 - DS	Lateral Weir 700 (Sta. 700.18 - Sta. 526.1)	Maple Road Overflow from Drainage A2 to Drainage A3	0	0	0	0	349.26	350.10	350.41	350.89
Maple 18+20	Drainage A2 - DS	83.19	North End of WSDOT Pond	1.4	2.3	2.8	4.0	349.26	350.10	350.41	350.89
Maple 17+20	Drainage A3	63.65	Outfall to Swamp Creek Wetland Area	22	43	54	73	348.82	349.09	349.94	350.86
Ash 61+50 to 64+60	Main Channel - DS/ Main Channel - Middle	Lateral Weir 1699 (Sta. 1699.96 - Sta. 1611.36)	Ditch along west side of Ash Way from Main Channel - DS to Main Channel - Middle	16	34	43	57	349.7±	350.4±	350.8±	351.2±
Ash 64+60	Main Channel - DS [1]	1577.89	Upstream Side of 36" CMP Culvert Across Ash Way	9	8	9	10	349.73	350.42	350.78	351.42
Ash 66+10	Main Channel - DS [1]	1363.32	Upstream Side of 42" CMP Culvert Across SR 525	7	6	6	7	349.48	350.24	350.57	351.09
Maple 20+00 to 27+00	Outlet	Lateral Weir 1059 (Sta. 1060.5 - Sta. 554.13)	Maple Road Overflow from WSDOT Pond to Swamp Creek Wetland Area	0	0	0	0	349.2±	350.1±	350.4±	350.9±
Maple 27+35	Outlet [2]	522.38	Upstream Side of 24" CMP Culvert Across Maple Road at WSDOT Pond Outlet Structure	15	14	8	0.1	349.07	350.01	350.36	350.87
Maple 27+35	Outlet [2]	450.72	Downstream Side of 24" CMP Culvert Across Maple Road	15	14	8	0.1	347.48	348.72	349.94	350.87
Maple 30+00	Outlet [2]	181.1	Outfall to Swamp Creek	15	14	8	0.1	346.90	348.26	349.94	350.87
Maple 27+35	Outlet	Lateral Weir 553 (Sta. 554.13 - Sta. 522.38)	WSDOT Pond to WSDOT Overflow Channel	2	14	22	29	348.76	349.16	349.52	350.05
Maple 30+75	WSDOT Overflow	378.58	Outfall to Swamp Creek	2	14	22	29	346.14	347.02	348.16	349.64

1 Flows are affected by the tailwater for the various storm events so the flows do not always increase along with the storm frequency.
2 The capacity of the Maple Road culvert is affected by tailwater so the flow is reduced as the storm frequency increases.
"Red" elevations are the maximum 25-year elevations at the Ash/Maple intersection and along the west and northeast sides of Maple Road adjacent to the WSDOT Pond.
"Blue" locations represent lateral weir overflows.



EXISTING 25-YEAR WATER LEVELS AND FLOW RATES PER TABLE 1

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25 YEAR WATER SURFACE ELEVATIONS
EXISTING CONDITION
SNOHOMISH COUNTY
STORM DRAINAGE

SCALE 1"=100'

PROJECT NUMBER 037382

DRAWING FILE NAME 037382-ELEV-EC3A

SHEET NUMBER

FIGURE 3A

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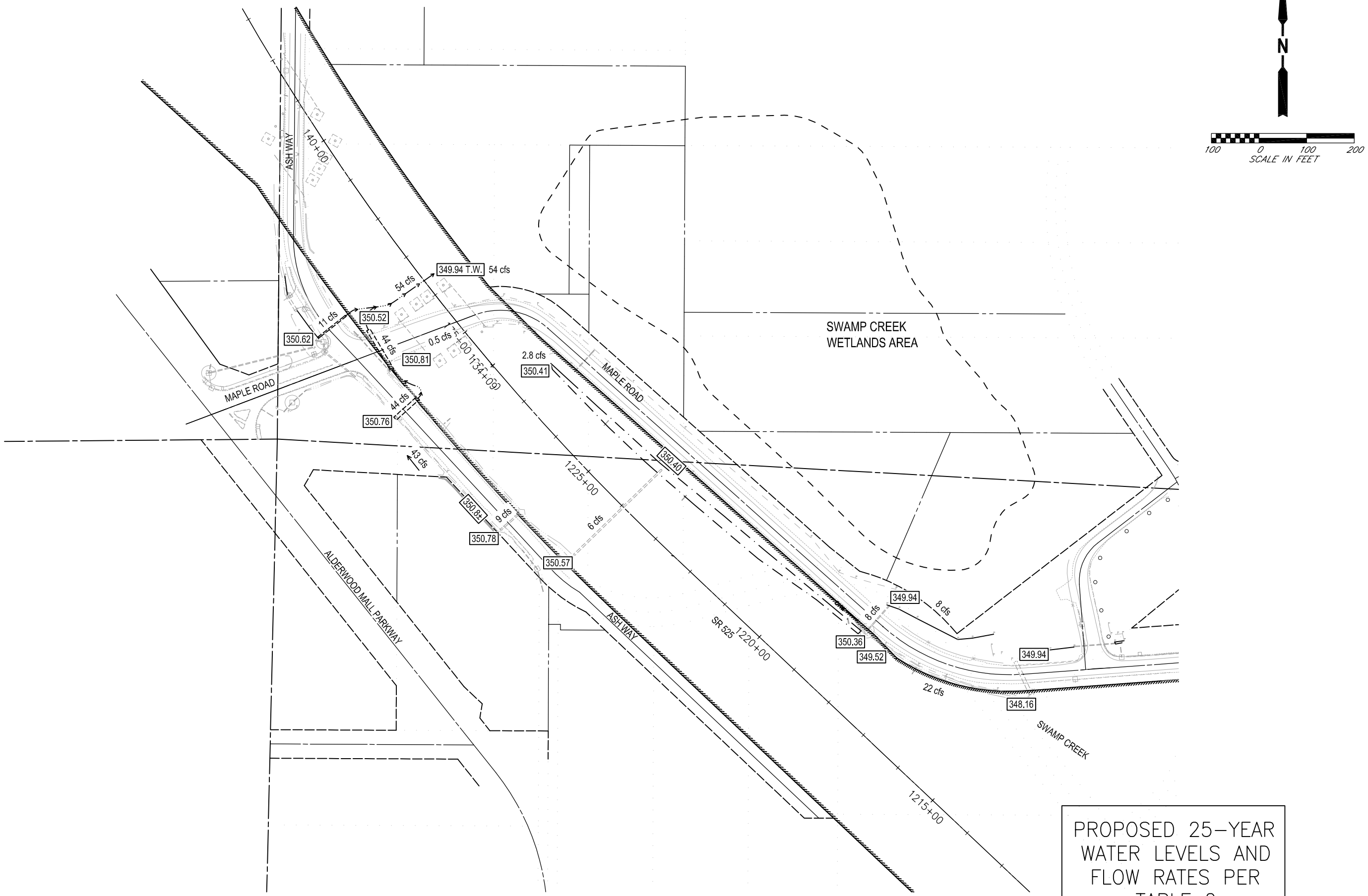

PROPOSED 25-YEAR WATER LEVELS AND FLOW RATES PER TABLE 2

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25 YEAR WATER SURFACE ELEVATIONS
PROPOSED CONDITION
SNOHOMISH COUNTY
STORM DRAINAGE

SCALE 1"=100'

PROJECT NUMBER 037382

DRAWING FILE NAME 037382-ELEV-EC3B

SHEET NUMBER

FIGURE 3B

[DATE: 8/16/2013 1:49 PM] [AUTHOR: twhite] [PLOTTER: CutePDF Writer.pc3] [STYLE: MODIFIED SCREENED-FULLSIZE.ctb]
[PATH: P:\Snohomish County\037382\Design\Drawings\Civil\037382-ELEV-EC3B.dwg] [LAYOUT: 3B]

ATTACHMENT A

TAILWATER AND FLOW INFORMATION

UPDATED Flow Inputs for Maple Road RAS (6/12)
-updated rainfall in hydrologic model to match most recent work by County

HSPF ID	PACE Area (Flow Pt)	Description	Type	2-yr	10-yr	25-yr	100-yr	
COPY 780	E-F-G unrouted (15)	u/s inflow to Maple Creek	Inflow	5.41	8.87	10.66	13.38	
RCHRES 777	n/a (1)	inflow from swales along Maple Rd	Inflow	0.83	1.28	1.51	1.86	
COPY 762	D (2)	local inflow to ditch	Local	0.51	0.76	0.88	1.07	
RCHRES 233	C (3)	Tunnel Creek inflow	Inflow	18.28	39.74	47.00	56.90	
COPY 774	A2/A3 (5 and others)	inflow from area east of Ash Way	Inflow	0.49	0.73	0.86	1.05	(approx split: 24% A3, 38% A2 head, 38% A2 south of Maple)
COPY 759	B (4)	inflow from commercial area	Inflow	8.31	14.04	17.20	22.24	
RCHRES 753	A1 (10)	inflow to south ditch	Inflow	0.51	0.81	0.97	1.22	
COPY 230	n/a (11)	local inflow SR525 and east	Local	4.52	7.00	8.33	10.40	

Routed discharge to Swamp Creek (dummy FTABLEs for Maple Creek)

RCHRES 230		routed d/s Maple Creek flow	Routed	34.00	62.00	73.00	87.00	

2012 SWAMP CREEK HECRAS RESULTS/TAILWATER ELEVATIONS PROVIDED BY SNOHOMISH COUNTY

HEC-RAS Unsteady Flow Results - Swamp Creek near Maple Road (8/2012)

Reach	River Sta	Profile	Plan	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
M2-2	13905.01	03DEC2007 2400	U100yr	310	361.61	365.91		366.04	0.001188	3	157.09	157.15	0.3
M2-2	13905.01	03DEC2007 2400	U25yr	250	361.61	365.49		365.62	0.001396	2.95	103.05	88.23	0.32
M2-2	13905.01	03DEC2007 2400	U10yr	200	361.61	365.12		365.24	0.001457	2.79	82.29	45.15	0.32
M2-2	13905.01	03DEC2007 2400	U2yr	150	361.61	364.7		364.8	0.001465	2.58	64.26	40.07	0.31
M2-2	13704.69	03DEC2007 2400	U100yr	310	361.1	365.81		365.85	0.000377	1.87	293.21	167.37	0.18
M2-2	13704.69	03DEC2007 2400	U25yr	250	361.1	365.38		365.42	0.000427	1.82	225.14	145.89	0.18
M2-2	13704.69	03DEC2007 2400	U10yr	200	361.1	364.99		365.03	0.000477	1.75	173.41	118.57	0.19
M2-2	13704.69	03DEC2007 2400	U2yr	150	361.1	364.56		364.6	0.000518	1.62	129.02	90.7	0.19
M2-2	13675.53	03DEC2007 2400	U100yr	310	361.05	365.68		365.88	0.001232	3.62	87.43	44.88	0.32
M2-2	13675.53	03DEC2007 2400	U25yr	250	361.05	365.27		365.43	0.001151	3.26	78.3	42.3	0.3
M2-2	13675.53	03DEC2007 2400	U10yr	200	361.05	364.89		365.02	0.001064	2.91	70	39.95	0.29
M2-2	13675.53	03DEC2007 2400	U2yr	150	361.05	364.48		364.58	0.000941	2.5	60.95	37.05	0.26
M2-2	13630.99			Culvert at 164th St									
M2-2	13585.45	03DEC2007 2400	U100yr	310	360.98	363.59	363.82	364.88	0.020399	9.16	35.8	24.32	1.15
M2-2	13585.45	03DEC2007 2400	U25yr	250	360.98	363.4	363.54	364.45	0.018802	8.22	31.63	22.35	1.09
M2-2	13585.45	03DEC2007 2400	U10yr	200	360.98	363.23	363.26	364.06	0.016952	7.3	28.03	20.69	1.02
M2-2	13585.45	03DEC2007 2400	U2yr	150	360.98	363.02	362.97	363.64	0.015311	6.32	23.9	18.64	0.95
M2-2	13559.29	03DEC2007 2400	U100yr	310	360.92	363.25		363.47	0.006397	4.51	133.11	162.89	0.64
M2-2	13559.29	03DEC2007 2400	U25yr	250	360.92	363.08		363.29	0.00693	4.35	107.02	150.05	0.65
M2-2	13559.29	03DEC2007 2400	U10yr	200	360.92	362.94		363.14	0.007304	4.15	86.05	142.35	0.66
M2-2	13559.29	03DEC2007 2400	U2yr	150	360.92	362.74	362.62	362.96	0.008637	4.09	59.54	128.34	0.7
M2-2	12883.42	03DEC2007 2400	U100yr	310	356.05	358.53		358.87	0.00802	5.18	93.58	116.31	0.72
M2-2	12883.42	03DEC2007 2400	U25yr	250	356.05	358.36		358.67	0.007981	4.83	75.5	97.99	0.71
M2-2	12883.42	03DEC2007 2400	U10yr	200	356.05	358.15		358.43	0.008539	4.59	57.73	62.93	0.71
M2-2	12883.42	03DEC2007 2400	U2yr	150	356.05	357.94		358.18	0.007976	4.16	46.25	49.18	0.68
M2-2	12315.16	03DEC2007 2400	U100yr	310.01	352.69	355.78		355.93	0.002443	3.53	171.44	222.69	0.42
M2-2	12315.16	03DEC2007 2400	U25yr	249.99	352.69	355.43		355.62	0.003496	3.8	107.53	136.51	0.48
M2-2	12315.16	03DEC2007 2400	U10yr	200	352.69	355.24		355.41	0.00345	3.56	83.47	108.82	0.47
M2-2	12315.16	03DEC2007 2400	U2yr	150	352.69	354.92		355.08	0.003606	3.35	57.1	63.42	0.48
M2-2	11764.68	03DEC2007 2400	U100yr	309.99	351.05	355.03		355.12	0.000645	2.38	139.59	414	0.23
M2-2	11764.68	03DEC2007 2400	U25yr	250	351.05	354.34		354.43	0.000925	2.44	109.33	316.72	0.27
M2-2	11764.68	03DEC2007 2400	U10yr	200	351.05	354.29		354.35	0.000637	2	106.84	305.03	0.22
M2-2	11764.68	03DEC2007 2400	U2yr	150	351.05	353.9		353.94	0.000631	1.78	89.6	233.76	0.21
M2-2	11737.7	03DEC2007 2400	U100yr	309.99	351.18	354.89	353.24	355.09	0.001508	3.63	85.34	271.85	0.35
M2-2	11737.7	03DEC2007 2400	U25yr	250	351.18	354.18	353.02	354.4	0.002202	3.73	66.95	180.5	0.41
M2-2	11737.7	03DEC2007 2400	U10yr	200	351.18	354.19	352.82	354.32	0.001403	2.98	67.04	180.73	0.33
M2-2	11737.7	03DEC2007 2400	U2yr	150	351.18	353.81	352.61	353.92	0.001327	2.61	57.36	159.07	0.31

M2-2	11706.82			Bridge at Ash Way										
M2-2	11687.1	03DEC2007	2400	U100yr	309.99	350.54	353.73	354.24	0.00602	5.75	53.93	21.25	0.64	
M2-2	11687.1	03DEC2007	2400	U25yr	250	350.54	353.52	353.91	0.005047	5.05	49.51	20.91	0.58	
M2-2	11687.1	03DEC2007	2400	U10yr	200	350.54	353.28	353.59	0.004444	4.5	44.49	20.52	0.54	
M2-2	11687.1	03DEC2007	2400	U2yr	150	350.54	352.99	353.23	0.003793	3.87	38.74	20.06	0.49	
M2-2	11671.23	03DEC2007	2400	U100yr	309.99	350.54	353.73	354.15	0.005934	5.2	59.57	28.52	0.63	
M2-2	11671.23	03DEC2007	2400	U25yr	250	350.54	353.49	353.83	0.005305	4.72	52.92	26.93	0.59	
M2-2	11671.23	03DEC2007	2400	U10yr	200	350.54	353.22	353.52	0.004927	4.34	46.07	25.2	0.57	
M2-2	11671.23	03DEC2007	2400	U2yr	150	350.54	352.93	353.16	0.004334	3.84	39.01	23.28	0.52	
M2-2	11195.2	03DEC2007	2400	U100yr	310.02	349.8	352.04	352.13	0.0023	2.89	198.18	234.69	0.39	
M2-2	11195.2	03DEC2007	2400	U25yr	250.01	349.8	351.81	351.9	0.002671	2.84	150.29	184.91	0.41	
M2-2	11195.2	03DEC2007	2400	U10yr	199.99	349.8	351.68	351.76	0.00241	2.57	128.69	155.49	0.39	
M2-2	11195.2	03DEC2007	2400	U2yr	150	349.8	351.5	351.56	0.002343	2.33	101.95	133.36	0.37	
M2-2	10505.11	03DEC2007	2400	U100yr	309.95	347.71	351.17	351.18	0.000381	1.49	620.71	653.99	0.17	
M2-2	10505.11	03DEC2007	2400	U25yr	250	347.71	350.63	350.66	0.000927	1.97	329.43	445.06	0.25	
M2-2	10505.11	03DEC2007	2400	U10yr	200.01	347.71	350.19	350.24	0.002099	2.48	172.51	258.93	0.36	
M2-2	10505.11	03DEC2007	2400	U2yr	150	347.71	349.92	349.98	0.002618	2.49	116	175.5	0.39	
M2-2	9069.394	03DEC2007	2400	U100yr	310.07	345.41	350.91	350.92	0.000031	0.66	1229.2	606.68	0.05	**1833 feet upstream of culvert through Flood Control Structure**
M2-2	9069.394	03DEC2007	2400	U25yr	250.19	345.41	350.03	350.03	0.00006	0.8	735.38	484.52	0.07	
M2-2	9069.394	03DEC2007	2400	U10yr	199.98	345.41	348.61	348.64	0.000338	1.4	229.52	220.85	0.16	
M2-2	9069.394	03DEC2007	2400	U2yr	150	345.41	348.02	348.05	0.000598	1.54	135.46	128.06	0.2	
M2-2	8876.738	03DEC2007	2400	U100yr	309.98	344.81	350.91	350.91	0.000021	0.58	1743.88	1146.14	0.05	
M2-2	8876.738	03DEC2007	2400	U25yr	250.21	344.81	350.02	350.02	0.000044	0.73	926.85	618.27	0.06	
M2-2	8876.738	03DEC2007	2400	U10yr	200	344.81	348.57	348.59	0.000222	1.24	381.25	277.2	0.13	
M2-2	8876.738	03DEC2007	2400	U2yr	150.01	344.81	347.95	347.97	0.000405	1.4	227.2	219.99	0.17	
M2-2	8342.521	03DEC2007	2400	U100yr	310.02	343.8	350.9	350.9	0.000003	0.23	3689.67	1109.02	0.02	
M2-2	8342.521	03DEC2007	2400	U25yr	250.37	343.8	350.01	350.01	0.000004	0.25	2730.74	1028.44	0.02	
M2-2	8342.521	03DEC2007	2400	U10yr	200.02	343.8	348.52	348.52	0.000015	0.38	1354.4	801.03	0.04	
M2-2	8342.521	03DEC2007	2400	U2yr	150	343.8	347.86	347.86	0.000024	0.41	883.94	615.97	0.04	
M2-2	7881.413	03DEC2007	2400	U100yr	309.95	343.11	350.9	350.9	0.000003	0.27	3346.1	847.43	0.02	
M2-2	7881.413	03DEC2007	2400	U25yr	250.49	343.11	350.01	350.01	0.000004	0.29	2593.97	830.68	0.02	
M2-2	7881.413	03DEC2007	2400	U10yr	200.01	343.11	348.52	348.52	0.000011	0.38	1467.37	645.4	0.03	
M2-2	7881.413	03DEC2007	2400	U2yr	150	343.11	347.85	347.85	0.000015	0.39	1061.96	574.74	0.04	
M2-2	7451.749	03DEC2007	2400	U100yr	310.13	342.61	350.9	350.9	0.000002	0.22	3452.59	636.77	0.01	**Location of Elevations referenced in 8/2012 SWM memorandum**
M2-2	7451.749	03DEC2007	2400	U25yr	250.57	342.61	350.01	350.01	0.000002	0.21	2891.7	613.8	0.01	
M2-2	7451.749	03DEC2007	2400	U10yr	200.02	342.61	348.52	348.52	0.000004	0.25	2010.1	569.16	0.02	
M2-2	7451.749	03DEC2007	2400	U2yr	150.01	342.61	347.85	347.85	0.000004	0.22	1648.13	523.7	0.02	
M2-2	7400			Lat Struct										
M2-2	7251.2	03DEC2007	2400	U100yr	218.13	341.59	350.9	350.9	0.000006	0.43	1099.5	217.01	0.03	
M2-2	7251.2	03DEC2007	2400	U25yr	243.6	341.59	350	350.01	0.000012	0.57	908.36	207.28	0.04	
M2-2	7251.2	03DEC2007	2400	U10yr	204.63	341.59	348.51	348.52	0.000022	0.66	613.38	181.87	0.05	

M2-2	7251.2	03DEC2007 2400	U2yr	161.73	341.59	347.84	347.85	0.000022	0.62	496.02	168.55	0.05	
M2-2	7236.337	03DEC2007 2400	U100yr	207.13	343.15	350.9	350.91	0.000062	0.95	527.07	279.93	0.08	**Upstream side of culvert through Flood control structure**
M2-2	7236.337	03DEC2007 2400	U25yr	243.6	343.15	349.99	350.01	0.000202	1.5	306.06	226.43	0.13	
M2-2	7236.337	03DEC2007 2400	U10yr	204.63	343.15	348.48	348.55	0.001068	2.5	147.42	145.68	0.28	
M2-2	7236.337	03DEC2007 2400	U2yr	161.73	343.15	347.77	347.92	0.002982	3.32	79.37	124.68	0.45	
M2-2	7223.617			**Culvert at Flood Control Structure**									
M2-2	7202.104	03DEC2007 2400	U100yr	207.13	341.4	350.86	350.89	0.000114	1.42	354.19	228.85	0.1	**Downstream side of culvert through Flood Control structure**
M2-2	7202.104	03DEC2007 2400	U25yr	243.6	341.4	349.92	349.98	0.000337	2.17	195.93	77.81	0.17	
M2-2	7202.104	03DEC2007 2400	U10yr	204.63	341.4	348.24	348.38	0.001291	3.23	92.08	54.55	0.31	
M2-2	7202.104	03DEC2007 2400	U2yr	161.73	341.4	346.85	347.15	0.001251	4.43	36.49	47.65	0.34	
M2-2	7150			Lat Struct									
M2-2	7143.918	03DEC2007 2400	U100yr	202.98	340.4	350.87	350.87	0.000009	0.57	640.82	143.95	0.03	
M2-2	7143.918	03DEC2007 2400	U25yr	243.59	340.4	349.94	349.95	0.000021	0.8	522.56	118.63	0.05	
M2-2	7143.918	03DEC2007 2400	U10yr	204.63	340.4	348.26	348.27	0.000036	0.9	343	96.35	0.06	
M2-2	7143.918	03DEC2007 2400	U2yr	161.72	340.4	346.9	346.91	0.000052	0.94	223.54	74.91	0.07	
M2-2	7132.169	03DEC2007 2400	U100yr	202.97	341.22	350.84	350.9	0.000125	2.02	100.26	173.77	0.12	**Upstream side of Culvert at Maple Road**
M2-2	7132.169	03DEC2007 2400	U25yr	243.59	341.22	349.89	350	0.00026	2.71	89.74	135.53	0.17	
M2-2	7132.169	03DEC2007 2400	U10yr	204.63	341.22	348.2	348.33	0.000397	2.88	71.17	124.16	0.2	
M2-2	7132.169	03DEC2007 2400	U2yr	161.72	341.22	346.83	346.96	0.000548	2.88	56.1	111.89	0.22	
M2-2	7092.777			**Culvert at Maple Road**									
M2-2	7043	03DEC2007 2400	U100yr	202.97	340.94	349.64	349.72	0.000183	2.25	90.02	53.94	0.14	**Downstream side of Culvert at Maple Road**
M2-2	7043	03DEC2007 2400	U25yr	243.59	340.94	348.16	348.33	0.000516	3.31	73.63	45.19	0.23	
M2-2	7043	03DEC2007 2400	U10yr	204.63	340.94	347.02	347.19	0.000677	3.35	61.1	38.38	0.25	
M2-2	7043	03DEC2007 2400	U2yr	161.72	340.94	346.14	346.3	0.000748	3.14	51.51	32.71	0.26	
M2-2	7038.448	03DEC2007 2400	U100yr	202.97	340.94	349.64	349.72	0.000183	2.26	90.01	53.93	0.14	
M2-2	7038.448	03DEC2007 2400	U25yr	243.59	340.94	348.15	348.32	0.000516	3.31	73.61	45.17	0.23	
M2-2	7038.448	03DEC2007 2400	U10yr	204.63	340.94	347.01	347.19	0.000679	3.35	61.07	38.36	0.25	
M2-2	7038.448	03DEC2007 2400	U2yr	161.72	340.94	346.14	346.29	0.00075	3.14	51.47	32.68	0.26	
M2-1	7022.17	03DEC2007 2400	U100yr	330.02	340.94	349.64	349.69	0.000157	1.9	252.72	62.45	0.12	
M2-1	7022.17	03DEC2007 2400	U25yr	270.66	340.94	348.15	348.22	0.000253	2.08	169.39	48.01	0.15	
M2-1	7022.17	03DEC2007 2400	U10yr	220	340.94	347.01	347.08	0.000376	2.18	119.52	39.94	0.18	
M2-1	7022.17	03DEC2007 2400	U2yr	170	340.94	346.14	346.21	0.000472	2.13	87.49	33.25	0.19	
M2-1	6841.417	03DEC2007 2400	U100yr	330.02	341.2	349.64	349.67	0.000083	1.3	271.04	51.41	0.09	
M2-1	6841.417	03DEC2007 2400	U25yr	270.66	341.2	348.14	348.17	0.000139	1.4	198.19	45.96	0.11	
M2-1	6841.417	03DEC2007 2400	U10yr	220	341.2	346.99	347.03	0.000227	1.5	147.64	41.77	0.14	
M2-1	6841.417	03DEC2007 2400	U2yr	170	341.2	346.1	346.14	0.000324	1.52	111.98	38.43	0.16	
M2-1	6748.726	03DEC2007 2400	U100yr	330.02	341.4	349.63	349.66	0.000093	1.34	260.19	50.56	0.1	
M2-1	6748.726	03DEC2007 2400	U25yr	270.66	341.4	348.13	348.16	0.000162	1.47	188.28	45.13	0.12	
M2-1	6748.726	03DEC2007 2400	U10yr	220	341.4	346.96	347	0.00028	1.6	138.21	40.92	0.15	
M2-1	6748.726	03DEC2007 2400	U2yr	170	341.4	346.06	346.11	0.000406	1.65	102.95	36.94	0.17	

M2-1	6730.355	03DEC2007 2400	U100yr	330.02	341.6	349.52	349.67	0.001434	3.06	113.6	68.55	0.33	**Upstream side of Culvert across WSDOT access Road**
M2-1	6730.355	03DEC2007 2400	U25yr	270.66	341.6	348	348.18	0.000601	3.43	79.02	43.96	0.24	
M2-1	6730.355	03DEC2007 2400	U10yr	220	341.6	346.83	347.01	0.000809	3.45	63.82	39.71	0.27	
M2-1	6730.355	03DEC2007 2400	U2yr	170	341.6	345.94	346.11	0.000937	3.25	52.31	34.94	0.29	
M2-1	6707.01			Culvert									
M2-1	6686.492	03DEC2007 2400	U100yr	330.02	341.03	348.17	348.37	0.000536	3.61	91.48	47.09	0.24	**Downstream side of Culvert across WSDOT access Road**
M2-1	6686.492	03DEC2007 2400	U25yr	270.66	341.03	346.98	347.18	0.000668	3.56	76.03	35.93	0.26	
M2-1	6686.492	03DEC2007 2400	U10yr	220	341.03	346.21	346.38	0.000704	3.33	66.06	30.07	0.26	
M2-1	6686.492	03DEC2007 2400	U2yr	170	341.03	345.52	345.65	0.000688	2.98	57	27.75	0.25	
M2-1	6675.191	03DEC2007 2400	U100yr	330.02	341.03	348.29	348.34	0.000219	1.86	191.26	48.25	0.14	
M2-1	6675.191	03DEC2007 2400	U25yr	270.66	341.03	347.1	347.16	0.000331	1.95	140.37	37.05	0.16	
M2-1	6675.191	03DEC2007 2400	U10yr	220	341.03	346.31	346.37	0.000407	1.93	114.13	30.4	0.18	
M2-1	6675.191	03DEC2007 2400	U2yr	170	341.03	345.59	345.64	0.000427	1.83	93.05	28	0.18	
M2-1	6579.737	03DEC2007 2400	U100yr	330.02	341.23	348.28	348.32	0.000195	1.81	225.91	61.15	0.13	
M2-1	6579.737	03DEC2007 2400	U25yr	270.67	341.23	347.07	347.13	0.000308	1.95	157.56	51.99	0.16	
M2-1	6579.737	03DEC2007 2400	U10yr	220	341.23	346.27	346.33	0.000401	1.95	119.41	43.11	0.18	
M2-1	6579.737	03DEC2007 2400	U2yr	170	341.23	345.54	345.6	0.000484	1.89	92.06	34.38	0.19	
M2-1	6494.519	03DEC2007 2400	U100yr	330.02	341.43	348.24	348.3	0.000292	2.03	170.49	44.03	0.16	
M2-1	6494.519	03DEC2007 2400	U25yr	270.67	341.43	347.02	347.09	0.000483	2.19	123.74	32.56	0.19	
M2-1	6494.519	03DEC2007 2400	U10yr	220	341.43	346.21	346.29	0.000595	2.21	99.42	28.75	0.21	
M2-1	6494.519	03DEC2007 2400	U2yr	170	341.43	345.48	345.55	0.000667	2.15	79.19	26.31	0.22	
M2-1	6477.609	03DEC2007 2400	U100yr	330.02	341.57	348.02	348.34	0.001058	4.52	73.07	28.14	0.32	
M2-1	6477.609	03DEC2007 2400	U25yr	270.67	341.57	346.78	347.11	0.001524	4.65	58.15	25.45	0.37	
M2-1	6477.609	03DEC2007 2400	U10yr	220	341.57	345.98	346.3	0.001829	4.53	48.61	23.73	0.4	
M2-1	6477.609	03DEC2007 2400	U2yr	170	341.57	345.27	345.55	0.002075	4.24	40.1	22.2	0.41	
M2-1	6453.197			**Culvert at I-5**									
M2-1	5931.15	03DEC2007 2400	U100yr	330.02	338.32	343.67	344.16	0.002184	5.65	58.43	28.16	0.45	
M2-1	5931.15	03DEC2007 2400	U25yr	270.67	338.32	343.37	343.75	0.00181	4.93	54.88	27.07	0.41	
M2-1	5931.15	03DEC2007 2400	U10yr	220	338.32	343.09	343.37	0.001479	4.27	51.49	26.03	0.36	
M2-1	5931.15	03DEC2007 2400	U2yr	170	338.32	342.76	342.95	0.001157	3.58	47.48	24.85	0.32	
M2-1	5910.535	03DEC2007 2400	U100yr	330.02	338.92	343.89	344.11	0.001688	3.78	88.3	28.81	0.36	
M2-1	5910.535	03DEC2007 2400	U25yr	270.67	338.92	343.52	343.71	0.001652	3.47	78.14	26.36	0.35	
M2-1	5910.535	03DEC2007 2400	U10yr	220	338.92	343.19	343.34	0.001523	3.16	69.66	24.29	0.33	
M2-1	5910.535	03DEC2007 2400	U2yr	170	338.92	342.81	342.93	0.001334	2.8	60.7	23.08	0.3	
M2-1	5876.475	03DEC2007 2400	U100yr	330.02	339.55	343.67	344.05	0.003462	5.13	76.82	29.65	0.5	
M2-1	5876.475	03DEC2007 2400	U25yr	270.67	339.55	343.31	343.65	0.003391	4.79	66.41	28.18	0.49	
M2-1	5876.475	03DEC2007 2400	U10yr	220	339.55	342.99	343.28	0.003258	4.42	57.47	26.85	0.47	
M2-1	5876.475	03DEC2007 2400	U2yr	170	339.55	342.64	342.87	0.003055	3.97	48.3	25.42	0.45	
M2-1	5488.57	03DEC2007 2400	U100yr	330.02	337.88	341.42	342.01	0.007355	6.15	54.61	27.01	0.72	
M2-1	5488.57	03DEC2007 2400	U25yr	270.67	337.88	341.16	341.67	0.007444	5.7	47.79	25.64	0.71	
M2-1	5488.57	03DEC2007 2400	U10yr	220	337.88	340.9	341.35	0.007842	5.33	41.29	24.26	0.71	
M2-1	5488.57	03DEC2007 2400	U2yr	170	337.88	340.63	341	0.007914	4.88	34.84	23.08	0.7	

M2-1	5221.283	03DEC2007 2400	U100yr	330.02	335.78	339.16		339.84	0.009404	6.62	50.99	28.19	0.81
M2-1	5221.283	03DEC2007 2400	U25yr	270.67	335.78	338.91		339.5	0.009785	6.19	44.08	26.07	0.8
M2-1	5221.283	03DEC2007 2400	U10yr	220	335.78	338.65		339.18	0.010432	5.84	37.74	24.06	0.81
M2-1	5221.283	03DEC2007 2400	U2yr	170	335.78	338.42		338.85	0.009772	5.26	32.33	22.4	0.77
M2-1	4539.891	03DEC2007 2400	U100yr	330.02	331.78	335.16		335.46	0.00321	4.4	86.46	67.45	0.49
M2-1	4539.891	03DEC2007 2400	U25yr	270.67	331.78	334.85		335.12	0.003448	4.18	68.98	46.57	0.5
M2-1	4539.891	03DEC2007 2400	U10yr	220	331.78	334.66		334.88	0.0031	3.73	61.34	37.56	0.46
M2-1	4539.891	03DEC2007 2400	U2yr	170	331.78	334.33		334.52	0.003401	3.46	49.64	32.93	0.47
M2-1	4304.62	03DEC2007 2400	U100yr	330.02	330.58	333.69		334.32	0.007141	6.41	54.21	25.34	0.7
M2-1	4304.62	03DEC2007 2400	U25yr	270.67	330.58	333.34		333.92	0.007819	6.1	45.79	23.32	0.72
M2-1	4304.62	03DEC2007 2400	U10yr	220	330.58	332.96		333.52	0.009712	6	37.21	21.73	0.77
M2-1	4304.62	03DEC2007 2400	U2yr	170	330.58	332.7		333.15	0.009508	5.41	31.53	21.31	0.75
M2-1	4215.473	03DEC2007 2400	U100yr	330.03	329.37	333.41	332.24	333.81	0.004015	5.06	65.28	21.9	0.52
M2-1	4215.473	03DEC2007 2400	U25yr	270.67	329.37	333.03	331.98	333.38	0.003998	4.74	57.12	21.36	0.51
M2-1	4215.473	03DEC2007 2400	U10yr	220	329.37	332.39	331.74	332.78	0.005887	5.04	43.64	20.44	0.61
M2-1	4215.473	03DEC2007 2400	U2yr	170	329.37	332.31	331.48	332.57	0.003916	4.04	42.1	20.33	0.49
M2-1	4206.905			Bridge									
M2-1	4198.308	03DEC2007 2400	U100yr	330.03	329.37	332.51		333.3	0.011286	7.17	46.03	20.61	0.85
M2-1	4198.308	03DEC2007 2400	U25yr	270.67	329.37	332.22		332.92	0.011319	6.72	40.31	20.21	0.84
M2-1	4198.308	03DEC2007 2400	U10yr	220	329.37	331.98		332.58	0.011053	6.21	35.44	19.86	0.82
M2-1	4198.308	03DEC2007 2400	U2yr	170	329.37	331.72		332.21	0.010663	5.61	30.29	19.49	0.79
M2-1	3644.938	03DEC2007 2400	U100yr	330.02	324.61	326.94		327.57	0.009529	6.55	58.26	35.5	0.81
M2-1	3644.938	03DEC2007 2400	U25yr	270.67	324.61	326.72		327.27	0.009592	6.09	50.58	34.65	0.8
M2-1	3644.938	03DEC2007 2400	U10yr	220	324.61	326.51		326.99	0.009722	5.65	43.49	33.96	0.79
M2-1	3644.938	03DEC2007 2400	U2yr	170	324.61	326.28		326.69	0.010046	5.17	35.76	32.01	0.78
M2-1	3289.961	03DEC2007 2400	U100yr	330.02	322.01	325.16		325.38	0.002379	3.76	92.91	45.54	0.42
M2-1	3289.961	03DEC2007 2400	U25yr	270.67	322.01	324.96		325.14	0.002123	3.37	84.06	43.76	0.39
M2-1	3289.961	03DEC2007 2400	U10yr	220	322.01	324.65		324.81	0.002315	3.19	70.7	40.93	0.4
M2-1	3289.961	03DEC2007 2400	U2yr	170	322.01	324.41		324.53	0.002135	2.81	61.12	38.78	0.37
M2-1	2813.549	03DEC2007 2400	U100yr	330.02	317.7	320.35	320.64	321.77	0.018433	9.75	39.3	24.84	1.15
M2-1	2813.549	03DEC2007 2400	U25yr	270.67	317.7	320.11	320.33	321.35	0.018511	9.05	33.6	22.72	1.13
M2-1	2813.549	03DEC2007 2400	U10yr	220	317.7	319.88	320.04	320.95	0.018595	8.37	28.7	20.72	1.11
M2-1	2813.549	03DEC2007 2400	U2yr	170	317.7	319.63	319.73	320.51	0.01868	7.58	23.83	18.53	1.09
M2-1	2516.079	03DEC2007 2400	U100yr	330.02	313.34	316.91		317.51	0.005177	6.32	60.61	27.81	0.64
M2-1	2516.079	03DEC2007 2400	U25yr	270.67	313.34	316.38		316.99	0.00679	6.36	47.03	23.74	0.71
M2-1	2516.079	03DEC2007 2400	U10yr	220	313.34	315.91		316.54	0.009235	6.45	36.31	21.36	0.8
M2-1	2516.079	03DEC2007 2400	U2yr	170	313.34	315.63		316.15	0.009081	5.8	30.58	19.98	0.77
M2-1	2493.518	03DEC2007 2400	U100yr	330.02	313.34	316.63		317.37	0.007702	6.93	47.59	30.48	0.75
M2-1	2493.518	03DEC2007 2400	U25yr	270.67	313.34	316.03		316.87	0.012162	7.35	36.84	25.2	0.91
M2-1	2493.518	03DEC2007 2400	U10yr	220	313.34	315.63		316.48	0.015904	7.4	29.71	21.67	1
M2-1	2493.518	03DEC2007 2400	U2yr	170	313.34	315.35		316.08	0.016696	6.85	24.8	19.18	1.01

M2-1	2335.297			Culvert										
M2-1	2137.257	03DEC2007	2400	U100yr	330.02	311.31	314.24	314.27	315.37	0.014758	8.52	38.72	25.74	1.02
M2-1	2137.257	03DEC2007	2400	U25yr	270.67	311.31	314.01	314.01	314.97	0.014517	7.83	34.55	24.62	1
M2-1	2137.257	03DEC2007	2400	U10yr	220	311.31	313.81	313.75	314.6	0.013832	7.11	30.96	23.75	0.96
M2-1	2137.257	03DEC2007	2400	U2yr	170	311.31	313.59		314.21	0.013148	6.31	26.93	22.98	0.91
M2-1	2095.636	03DEC2007	2400	U100yr	330.02	310.3	313.1	313.76	315.21	0.040472	11.67	28.37	17.21	1.58
M2-1	2095.636	03DEC2007	2400	U25yr	270.67	310.3	312.83	313.44	314.82	0.044579	11.32	23.91	15.9	1.62
M2-1	2095.636	03DEC2007	2400	U10yr	220	310.3	312.61	313.16	314.4	0.045802	10.73	20.5	15.05	1.62
M2-1	2095.636	03DEC2007	2400	U2yr	170	310.3	312.36	312.84	313.95	0.048205	10.11	16.81	14.12	1.63
M2-1	2073.148	03DEC2007	2400	U100yr	330.02	309.51	312.5	312.4	313.41	0.013491	7.67	43.04	20.97	0.94
M2-1	2073.148	03DEC2007	2400	U25yr	270.67	309.51	312.19	312.13	313.03	0.014356	7.35	36.8	20.05	0.96
M2-1	2073.148	03DEC2007	2400	U10yr	220	309.51	311.96		312.68	0.014138	6.85	32.11	19.33	0.94
M2-1	2073.148	03DEC2007	2400	U2yr	170	309.51	311.68		312.3	0.014111	6.3	26.98	18.52	0.92
M2-1	1877	03DEC2007	2400	U100yr	330.02	307.13	310.47		311.09	0.007552	6.44	55.98	27.48	0.73
M2-1	1877	03DEC2007	2400	U25yr	270.67	307.13	310.06		310.68	0.009036	6.42	45.15	24.84	0.78
M2-1	1877	03DEC2007	2400	U10yr	220	307.13	309.73		310.32	0.009703	6.2	37.35	22.57	0.8
M2-1	1877	03DEC2007	2400	U2yr	170	307.13	309.33		309.9	0.011267	6.06	28.94	19.85	0.84
M2-1	1754.862	03DEC2007	2400	U100yr	330.02	305.18	310.19		310.46	0.001548	4.3	93.55	30.47	0.36
M2-1	1754.862	03DEC2007	2400	U25yr	270.67	305.18	309.71		309.95	0.001573	4.02	79.44	28.21	0.36
M2-1	1754.862	03DEC2007	2400	U10yr	220	305.18	309.27		309.48	0.001579	3.72	67.51	26.15	0.35
M2-1	1754.862	03DEC2007	2400	U2yr	170	305.18	308.81		308.98	0.001562	3.36	55.76	23.95	0.34
M2-1	1739.73	03DEC2007	2400	U100yr	330.02	305.18	310.12		310.44	0.001776	4.56	75.5	30.13	0.39
M2-1	1739.73	03DEC2007	2400	U25yr	270.67	305.18	309.66		309.92	0.00175	4.19	67.15	27.95	0.38
M2-1	1739.73	03DEC2007	2400	U10yr	220	305.18	309.23		309.46	0.001714	3.84	59.46	25.94	0.36
M2-1	1739.73	03DEC2007	2400	U2yr	170	305.18	308.77		308.95	0.001659	3.43	51.19	23.78	0.35
M2-1	1704.496			Culvert										
M2-1	1656.394	03DEC2007	2400	U100yr	330.02	304.69	308.61		309.35	0.006211	7.02	51.36	38.48	0.7
M2-1	1656.394	03DEC2007	2400	U25yr	270.67	304.69	308.32		308.94	0.005801	6.36	46.2	34.51	0.66
M2-1	1656.394	03DEC2007	2400	U10yr	220	304.69	308.07		308.56	0.005269	5.7	41.65	31.01	0.62
M2-1	1656.394	03DEC2007	2400	U2yr	170	304.69	307.78		308.16	0.004737	5	36.39	26.97	0.58
M2-1	1638.368	03DEC2007	2400	U100yr	330.02	304.69	308.65		309.24	0.005262	6.51	67.51	32.6	0.64
M2-1	1638.368	03DEC2007	2400	U25yr	270.67	304.69	308.3		308.84	0.005449	6.13	56.48	30.93	0.64
M2-1	1638.368	03DEC2007	2400	U10yr	220	304.69	308		308.48	0.005425	5.69	47.54	29.5	0.63
M2-1	1638.368	03DEC2007	2400	U2yr	170	304.69	307.68		308.08	0.00534	5.15	38.35	26.55	0.61
M2-1	1580.516	03DEC2007	2400	U100yr	330.02	305.21	308.67		308.94	0.002458	4.2	94.01	71.27	0.44
M2-1	1580.516	03DEC2007	2400	U25yr	270.67	305.21	308.3		308.54	0.002739	4.03	75.56	49.44	0.45
M2-1	1580.516	03DEC2007	2400	U10yr	220	305.21	307.97		308.19	0.002947	3.81	62.91	36.59	0.46
M2-1	1580.516	03DEC2007	2400	U2yr	170	305.21	307.6		307.79	0.003384	3.59	50.05	33.07	0.48
M2-1	1565.917	03DEC2007	2400	U100yr	330.02	305.21	308.59	307.51	308.89	0.002869	4.47	77.02	38.92	0.47
M2-1	1565.917	03DEC2007	2400	U25yr	270.67	305.21	308.22	307.3	308.5	0.003116	4.23	66.5	36.54	0.48
M2-1	1565.917	03DEC2007	2400	U10yr	220	305.21	307.9	307.11	308.14	0.003335	3.98	57.33	34.46	0.48
M2-1	1565.917	03DEC2007	2400	U2yr	170	305.21	307.52	306.9	307.74	0.003895	3.77	46.57	32.02	0.51

M2-1	1550.4			Bridge										
M2-1	1529.519	03DEC2007	2400	U100yr	330.02	304.9	307.82		308.43	0.006941	6.35	57.92	31.84	0.72
M2-1	1529.519	03DEC2007	2400	U25yr	270.67	304.9	307.56		308.08	0.006965	5.89	50.42	29.97	0.7
M2-1	1529.519	03DEC2007	2400	U10yr	220	304.9	307.34		307.78	0.006572	5.34	44.54	28.47	0.67
M2-1	1529.519	03DEC2007	2400	U2yr	170	304.9	307.08		307.44	0.00644	4.8	37.51	26.62	0.65
M2-1	1502.777	03DEC2007	2400	U100yr	330.02	304.9	307.48	307.39	308.33	0.011689	7.45	48.75	29.45	0.91
M2-1	1502.777	03DEC2007	2400	U25yr	270.67	304.9	307.25	307.14	307.98	0.011713	6.91	42.21	27.84	0.89
M2-1	1502.777	03DEC2007	2400	U10yr	220	304.9	307.01	306.91	307.66	0.012402	6.49	35.74	26.14	0.9
M2-1	1502.777	03DEC2007	2400	U2yr	170	304.9	306.78		307.32	0.012526	5.88	29.84	24.5	0.88
M2-1	962.41	03DEC2007	2400	U100yr	330.02	299.59	303.32		303.7	0.004632	5	69.05	36.37	0.57
M2-1	962.41	03DEC2007	2400	U25yr	270.68	299.59	303.04		303.38	0.004382	4.64	59.59	32.29	0.55
M2-1	962.41	03DEC2007	2400	U10yr	220	299.59	302.76		303.05	0.004189	4.31	51.25	27.3	0.53
M2-1	962.41	03DEC2007	2400	U2yr	170	299.59	302.47		302.7	0.003812	3.87	43.91	23.51	0.5
M2-1	723.1741	03DEC2007	2400	U100yr	330.02	298.88	302.66		302.87	0.002309	3.84	109.27	67.96	0.42
M2-1	723.1741	03DEC2007	2400	U25yr	270.67	298.88	302.37		302.57	0.002398	3.62	90.24	63.81	0.42
M2-1	723.1741	03DEC2007	2400	U10yr	220	298.88	302.08		302.26	0.002539	3.42	73.42	55.74	0.42
M2-1	723.1741	03DEC2007	2400	U2yr	170	298.88	301.78		301.94	0.002632	3.15	57.21	49.9	0.42
M2-1	394.641	03DEC2007	2400	U100yr	330.02	297.06	301.22		301.69	0.00536	5.6	67.31	42.96	0.62
M2-1	394.641	03DEC2007	2400	U25yr	270.67	297.06	300.99		301.38	0.005061	5.1	58.11	37.21	0.6
M2-1	394.641	03DEC2007	2400	U10yr	220	297.06	300.75		301.08	0.004923	4.67	49.71	32.69	0.58
M2-1	394.641	03DEC2007	2400	U2yr	170	297.06	300.49		300.76	0.004657	4.16	41.84	28.6	0.55
M2-1	64.75999	03DEC2007	2400	U100yr	330.02	296.23	299.03	298.69	299.5	0.00831	5.52	60.52	38.45	0.74
M2-1	64.75999	03DEC2007	2400	U25yr	270.68	296.23	298.84	298.48	299.24	0.008064	5.09	53.48	35.83	0.72
M2-1	64.75999	03DEC2007	2400	U10yr	220	296.23	298.61	298.28	298.97	0.008322	4.82	45.73	33.32	0.72
M2-1	64.75999	03DEC2007	2400	U2yr	170	296.23	298.38	298.05	298.69	0.0083	4.45	38.23	30.66	0.7

ATTACHMENT B

EXISTING CONDITION HECRAS MODEL RESULTS

HEC-RAS Plan: WHP Existing

River	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)	
WSDOT Overflow	WSDOT Overflow	741	PF 1	0.00	348.60	349.03	348.77	349.03	0.000000	0.00	0.66	2.32	0.00
WSDOT Overflow	WSDOT Overflow	741	PF 2	0.00	348.60	349.63	348.72	349.63	0.000000	0.00	2.89	5.09	0.00
WSDOT Overflow	WSDOT Overflow	741	PF 3	0.00	348.60	349.81	348.73	349.81	0.000000	0.00	3.92	5.92	0.00
WSDOT Overflow	WSDOT Overflow	741	PF 4	0.00	348.60	349.92	348.71	349.92	0.000000	0.00	4.56	6.28	0.00
WSDOT Overflow	WSDOT Overflow	699.95	PF 1	11.86	346.27	348.95	347.53	348.97	0.001483	0.99	11.93	12.33	0.18
WSDOT Overflow	WSDOT Overflow	699.95	PF 2	24.19	346.27	349.56	347.99	349.58	0.001395	1.17	20.68	16.26	0.18
WSDOT Overflow	WSDOT Overflow	699.95	PF 3	29.11	346.27	349.74	348.13	349.77	0.001365	1.22	23.81	17.36	0.18
WSDOT Overflow	WSDOT Overflow	699.95	PF 4	21.89	346.27	349.89	347.92	349.90	0.000580	0.83	26.39	18.21	0.12
WSDOT Overflow	WSDOT Overflow	650.01	PF 1	11.86	346.18	348.86	347.62	348.88	0.002152	1.06	11.14	13.74	0.21
WSDOT Overflow	WSDOT Overflow	650.01	PF 2	24.19	346.18	349.49	348.08	349.51	0.001445	1.15	21.09	17.71	0.19
WSDOT Overflow	WSDOT Overflow	650.01	PF 3	29.11	346.18	349.68	348.22	349.70	0.001352	1.19	24.55	18.77	0.18
WSDOT Overflow	WSDOT Overflow	650.01	PF 4	21.89	346.18	349.86	348.01	349.87	0.000521	0.78	28.10	19.79	0.12
WSDOT Overflow	WSDOT Overflow	600	PF 1	11.86	346.34	348.70	347.69	348.74	0.003380	1.56	7.59	6.51	0.25
WSDOT Overflow	WSDOT Overflow	600	PF 2	24.19	346.34	349.34	348.14	349.40	0.003867	1.96	12.31	8.33	0.28
WSDOT Overflow	WSDOT Overflow	600	PF 3	29.11	346.34	349.52	348.27	349.59	0.004332	2.09	13.90	9.47	0.30
WSDOT Overflow	WSDOT Overflow	600	PF 4	21.89	346.34	349.80	348.06	349.82	0.001930	1.27	17.20	14.57	0.21
WSDOT Overflow	WSDOT Overflow	549.89	PF 1	11.86	345.94	348.59	347.33	348.61	0.002023	1.32	8.99	6.85	0.20
WSDOT Overflow	WSDOT Overflow	549.89	PF 2	24.19	345.94	349.16	347.78	349.21	0.003866	1.77	13.64	11.88	0.29
WSDOT Overflow	WSDOT Overflow	549.89	PF 3	29.11	345.94	349.32	347.93	349.38	0.004043	1.85	15.70	13.48	0.30
WSDOT Overflow	WSDOT Overflow	549.89	PF 4	21.89	345.94	349.74	347.71	349.75	0.000992	0.99	22.21	17.76	0.16
WSDOT Overflow	WSDOT Overflow	499.99	PF 1	11.86	346.55	348.37	347.79	348.44	0.007731	2.06	5.74	6.61	0.39
WSDOT Overflow	WSDOT Overflow	499.99	PF 2	24.19	346.55	348.81	348.18	348.92	0.009576	2.71	8.94	7.99	0.45
WSDOT Overflow	WSDOT Overflow	499.99	PF 3	29.11	346.55	348.95	348.35	349.08	0.009973	2.90	10.05	8.34	0.46
WSDOT Overflow	WSDOT Overflow	499.99	PF 4	21.89	346.55	349.67	348.12	349.69	0.001384	1.31	16.73	10.19	0.18
WSDOT Overflow	WSDOT Overflow	449.97	PF 1	11.86	346.49	347.92	347.57	347.99	0.008880	2.04	5.82	8.30	0.43
WSDOT Overflow	WSDOT Overflow	449.97	PF 2	24.19	346.49	348.19	347.92	348.32	0.014687	2.96	8.19	9.81	0.57
WSDOT Overflow	WSDOT Overflow	449.97	PF 3	29.11	346.49	348.28	348.03	348.44	0.015624	3.17	9.18	10.38	0.59
WSDOT Overflow	WSDOT Overflow	449.97	PF 4	21.89	346.49	349.64	347.87	349.65	0.000424	0.67	32.78	26.86	0.11
WSDOT Overflow	WSDOT Overflow	378.58	PF 1	11.86	344.97	346.14	346.11	346.50	0.076816	4.80	2.47	4.22	1.11
WSDOT Overflow	WSDOT Overflow	378.58	PF 2	24.19	344.97	347.02	346.59	347.18	0.016065	3.19	7.58	7.40	0.56
WSDOT Overflow	WSDOT Overflow	378.58	PF 3	29.11	344.97	348.16	346.70	348.18	0.001260	1.04	28.00	24.67	0.17
WSDOT Overflow	WSDOT Overflow	378.58	PF 4	21.89	344.97	349.64	346.52	349.64	0.000046	0.30	72.22	34.66	0.04
Outlet	Outlet	1060.5	PF 1	29.80	346.96	350.00	347.60	350.00	0.000050	0.34	88.88	45.22	0.04
Outlet	Outlet	1060.5	PF 2	39.51	346.96	350.52	347.69	350.52	0.000045	0.35	113.44	50.43	0.04
Outlet	Outlet	1060.5	PF 3	38.90	346.96	350.65	347.68	350.65	0.000037	0.33	120.27	51.80	0.04
Outlet	Outlet	1060.5	PF 4	32.44	346.96	350.89	347.58	350.89	0.000020	0.25	132.88	54.46	0.03
Outlet	Outlet	1059		Lat Struct									
Outlet	Outlet	554.13	PF 1	29.80	344.85	349.92	347.11	349.94	0.000746	0.88	33.70	24.10	0.13
Outlet	Outlet	554.13	PF 2	39.51	344.85	350.45	347.38	350.46	0.000484	0.84	47.16	26.66	0.11
Outlet	Outlet	554.13	PF 3	38.88	344.85	350.60	347.37	350.61	0.000368	0.76	51.17	30.73	0.10
Outlet	Outlet	554.13	PF 4	21.89	344.85	350.87	346.85	350.87	0.000075	0.37	59.63	31.40	0.05
Outlet	Outlet	553		Lat Struct									
Outlet	Outlet	522.38	PF 1	17.94	344.59	349.88	345.93	349.90	0.001707	1.30	14.10	10.00	0.10
Outlet	Outlet	522.38	PF 2	15.32	344.59	350.43	345.80	350.45	0.000686	0.89	16.86	10.00	0.07
Outlet	Outlet	522.38	PF 3	9.74	344.59	350.59	345.58	350.59	0.000237	0.53	17.65	10.00	0.04
Outlet	Outlet	522.38	PF 4	0.09	344.59	350.87	344.74	350.87	0.000000	0.00	20.40	10.00	0.00
Outlet	Outlet	487		Culvert									
Outlet	Outlet	450.72	PF 1	17.94	343.59	347.69	344.77	347.69	0.000291	0.54	33.12	59.38	0.08
Outlet	Outlet	450.72	PF 2	15.32	343.59	348.83	344.66	348.83	0.000026	0.23	67.21	100.00	0.03
Outlet	Outlet	450.72	PF 3	9.74	343.59	349.94	344.45	349.94	0.000002	0.07	166.97	100.00	0.01
Outlet	Outlet	450.72	PF 4	0.09	343.59	350.87	343.68	350.87	0.000000	0.00	259.88	100.00	0.00
Outlet	Outlet	448.08	PF 1	17.94	343.59	347.69	344.80	347.69	0.000236	0.51	35.50	65.70	0.08
Outlet	Outlet	448.08	PF 2	15.32	343.59	348.83	344.70	348.83	0.000022	0.22	70.24	100.00	0.03
Outlet	Outlet	448.08	PF 3	9.74	343.59	349.94	344.37	349.94	0.000002	0.09	106.98	100.00	0.01
Outlet	Outlet	448.08	PF 4	0.09	343.59	350.87	343.76	350.87	0.000000	0.00	137.65	100.00	0.00
Outlet	Outlet	426.4	PF 1	17.94	343.59	347.69	344.63	347.69	0.000008	0.14	129.80	100.00	0.02
Outlet	Outlet	426.4	PF 2	15.32	343.59	348.83	344.58	348.83	0.000001	0.08	193.34	100.00	0.01
Outlet	Outlet	426.4	PF 3	9.74	343.59	349.94	344.44	349.94	0.000000	0.04	255.35	100.00	0.00
Outlet	Outlet	426.4	PF 4	0.09	343.59	350.87	343.71	350.87	0.000000	0.00	307.14	100.00	0.00
Outlet	Outlet	350	PF 1	17.94	343.30	347.69	344.27	347.69	0.000012	0.16	122.43	70.11	0.02
Outlet	Outlet	350	PF 2	15.32	343.30	348.83	344.20	348.83	0.000002	0.08	213.40	87.43	0.01

HEC-RAS Plan: WHP Existing (Continued)

River	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)	
Outlet	Outlet	350	PF 3	9.74	343.30	349.94	344.00	349.94	0.000000	0.03	322.11	100.00	0.00
Outlet	Outlet	350	PF 4	0.09	343.30	350.87	343.49	350.87	0.000000	0.00	415.03	100.00	0.00
Outlet	Outlet	300.01	PF 1	17.94	343.00	347.69	344.58	347.69	0.000042	0.25	72.92	49.59	0.03
Outlet	Outlet	300.01	PF 2	15.32	343.00	348.83	344.45	348.83	0.000005	0.11	145.63	74.94	0.01
Outlet	Outlet	300.01	PF 3	9.74	343.00	349.94	344.13	349.94	0.000000	0.05	236.24	82.98	0.00
Outlet	Outlet	300.01	PF 4	0.09	343.00	350.87	343.21	350.87	0.000000	0.00	313.35	82.98	0.00
Outlet	Outlet	253.22	PF 1	17.94	342.80	347.68	343.99	347.68	0.000058	0.33	53.80	33.31	0.04
Outlet	Outlet	253.22	PF 2	15.32	342.80	348.83	343.89	348.83	0.000010	0.17	88.85	45.85	0.02
Outlet	Outlet	253.22	PF 3	9.74	342.80	349.94	343.81	349.94	0.000001	0.07	153.86	73.13	0.01
Outlet	Outlet	253.22	PF 4	0.09	342.80	350.87	342.92	350.87	0.000000	0.00	216.24	73.13	0.00
Outlet	Outlet	237.18	PF 1	17.94	342.60	347.67	344.18	347.68	0.001238	0.95	18.98	15.17	0.15
Outlet	Outlet	237.18	PF 2	15.32	342.60	348.83	344.03	348.83	0.000104	0.35	43.30	27.65	0.05
Outlet	Outlet	237.18	PF 3	9.74	342.60	349.94	343.78	349.94	0.000005	0.11	104.54	65.89	0.01
Outlet	Outlet	237.18	PF 4	0.09	342.60	350.87	342.77	350.87	0.000000	0.00	165.78	65.89	0.00
Outlet	Outlet	231.56	PF 1	17.94	342.59	347.65	343.62	347.67	0.001301	1.18	15.18	3.00	0.09
Outlet	Outlet	231.56	PF 2	15.32	342.59	348.82	343.45	348.83	0.000622	0.80	19.12	14.72	0.07
Outlet	Outlet	231.56	PF 3	9.74	342.59	349.94	343.27	349.94	0.000029	0.16	66.06	64.76	0.02
Outlet	Outlet	231.56	PF 4	0.09	342.59	350.87	342.77	350.87	0.000000	0.00	126.47	64.99	0.00
Outlet	Outlet	200		Culvert									
Outlet	Outlet	187.41	PF 1	17.94	342.37	346.89	343.69	346.91	0.000402	1.05	17.07	17.06	0.09
Outlet	Outlet	187.41	PF 2	15.32	342.37	348.26	343.46	348.26	0.000107	0.66	23.07	64.43	0.05
Outlet	Outlet	187.41	PF 3	9.74	342.37	349.94	343.34	349.94	0.000010	0.12	90.38	68.14	0.02
Outlet	Outlet	187.41	PF 4	0.09	342.37	350.87	342.52	350.87	0.000000	0.00	153.76	68.14	0.00
Outlet	Outlet	181.1	PF 1	17.94	342.37	346.90	343.80	346.90	0.000106	0.37	48.28	40.83	0.05
Outlet	Outlet	181.1	PF 2	15.32	342.37	348.26	343.65	348.26	0.000008	0.14	113.08	85.76	0.02
Outlet	Outlet	181.1	PF 3	9.74	342.37	349.94	343.41	349.94	0.000000	0.05	228.09	85.76	0.00
Outlet	Outlet	181.1	PF 4	0.09	342.37	350.87	342.56	350.87	0.000000	0.00	302.26	85.76	0.00
Main Channel	Main Channel-US	2821.03	PF 1	5.41	358.01	358.51	358.51	358.56	0.021117	1.79	3.02	11.24	0.61
Main Channel	Main Channel-US	2821.03	PF 2	8.87	358.01	358.54	358.54	358.65	0.041562	2.61	3.39	11.91	0.86
Main Channel	Main Channel-US	2821.03	PF 3	10.66	358.01	358.52	358.52	358.70	0.074407	3.41	3.13	11.44	1.15
Main Channel	Main Channel-US	2821.03	PF 4	13.38	358.01	358.60	358.60	358.76	0.054027	3.20	4.18	13.23	1.00
Main Channel	Main Channel-US	2598.1	PF 1	5.41	353.34	353.86	353.61	353.88	0.004647	1.00	5.40	15.44	0.30
Main Channel	Main Channel-US	2598.1	PF 2	8.87	353.34	354.01	353.73	354.03	0.004243	1.13	7.85	17.55	0.30
Main Channel	Main Channel-US	2598.1	PF 3	10.66	353.34	354.07	353.71	354.09	0.004246	1.19	8.94	18.40	0.30
Main Channel	Main Channel-US	2598.1	PF 4	13.38	353.34	354.17	353.79	354.19	0.004000	1.25	10.73	19.77	0.30
Main Channel	Main Channel-US	2491.3	PF 1	5.41	352.19	352.58	352.58	352.68	0.038052	2.61	2.07	6.67	0.83
Main Channel	Main Channel-US	2491.3	PF 2	8.87	352.19	352.65	352.65	352.83	0.053023	3.41	2.60	7.19	1.00
Main Channel	Main Channel-US	2491.3	PF 3	10.66	352.19	352.70	352.70	352.90	0.053826	3.62	2.94	7.51	1.02
Main Channel	Main Channel-US	2491.3	PF 4	13.38	352.19	352.74	352.74	353.00	0.064737	4.13	3.24	7.78	1.13
Main Channel	Main Channel-US	2460		Lat Struct									
Main Channel	Main Channel-US	2416.6	PF 1	5.41	350.20	351.28	350.72	351.30	0.002384	1.07	5.03	7.09	0.22
Main Channel	Main Channel-US	2416.6	PF 2	8.87	350.20	351.55	350.83	351.58	0.002527	1.25	7.11	8.30	0.24
Main Channel	Main Channel-US	2416.6	PF 3	10.66	350.20	351.67	350.88	351.70	0.002821	1.31	8.14	9.68	0.25
Main Channel	Main Channel-US	2416.6	PF 4	13.38	350.20	351.78	351.17	351.81	0.004248	1.41	9.48	14.08	0.30
Main Channel	Main Channel-US	2366.15	PF 1	5.41	349.78	351.19	350.32	351.21	0.001444	0.92	5.88	6.34	0.17
Main Channel	Main Channel-US	2366.15	PF 2	8.87	349.78	351.45	350.41	351.47	0.001955	1.16	7.65	7.31	0.20
Main Channel	Main Channel-US	2366.15	PF 3	10.66	349.78	351.54	350.49	351.56	0.002293	1.29	8.29	7.63	0.22
Main Channel	Main Channel-US	2366.15	PF 4	13.38	349.78	351.61	350.55	351.64	0.003059	1.52	8.83	7.89	0.25
Main Channel	Main Channel-US	2278.17	PF 1	5.41	350.00	351.14	350.34	351.14	0.000375	0.38	16.37	48.94	0.09
Main Channel	Main Channel-US	2278.17	PF 2	8.74	350.00	351.43	350.40	351.43	0.000158	0.33	30.72	49.75	0.06
Main Channel	Main Channel-US	2278.17	PF 3	10.15	350.00	351.52	350.43	351.52	0.000141	0.33	35.19	50.00	0.06
Main Channel	Main Channel-US	2278.17	PF 4	11.94	350.00	351.60	350.46	351.60	0.000143	0.35	38.85	50.20	0.06
Main Channel	Main Channel-US	2264.91	PF 1	5.41	345.40	351.14	350.14	351.14	0.000165	0.28	19.28	23.72	0.05
Main Channel	Main Channel-US	2264.91	PF 2	8.58	345.40	351.43	350.24	351.43	0.000155	0.33	26.04	35.56	0.06
Main Channel	Main Channel-US	2264.91	PF 3	9.77	345.40	351.52	350.28	351.52	0.000153	0.34	29.21	36.34	0.06
Main Channel	Main Channel-US	2264.91	PF 4	11.30	345.40	351.59	350.30	351.59	0.000164	0.37	31.83	36.97	0.06
Main Channel	Main Channel-US	2235		Culvert									
Main Channel	Main Channel-US	2206.45	PF 1	5.41	346.01	350.46	350.14	350.46	0.001459	0.55	9.86	31.53	0.15
Main Channel	Main Channel-US	2206.45	PF 2	8.58	346.01	350.74	350.23	350.74	0.000667	0.49	17.39	35.89	0.11
Main Channel	Main Channel-US	2206.45	PF 3	9.77	346.01	350.85	350.23	350.85	0.000520	0.47	20.59	37.27	0.10
Main Channel	Main Channel-US	2206.45	PF 4	11.30	346.01	351.03	350.21	351.03	0.000326	0.43	26.44	41.31	0.08

HEC-RAS Plan: WHP Existing (Continued)

River	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)	
Main Channel	Main Channel-US	2205		Lat Struct									
Main Channel	Main Channel-US	2198.06	PF 1	5.41	348.00	350.46	348.59	350.46	0.000014	0.14	40.30	34.38	0.02
Main Channel	Main Channel-US	2198.06	PF 2	8.58	348.00	350.74	348.58	350.74	0.000019	0.18	50.47	37.93	0.02
Main Channel	Main Channel-US	2198.06	PF 3	9.77	348.00	350.85	348.65	350.85	0.000020	0.19	54.59	39.28	0.02
Main Channel	Main Channel-US	2198.06	PF 4	11.29	348.00	351.03	348.70	351.03	0.000018	0.19	61.99	41.59	0.02
Main Channel	Main Channel-US	2156.26	PF 1	5.79	348.38	350.46	348.88	350.46	0.000011	0.11	53.31	43.99	0.02
Main Channel	Main Channel-US	2156.26	PF 2	9.16	348.38	350.74	348.91	350.74	0.000014	0.14	66.18	47.54	0.02
Main Channel	Main Channel-US	2156.26	PF 3	10.45	348.38	350.85	348.87	350.85	0.000015	0.15	71.32	48.89	0.02
Main Channel	Main Channel-US	2156.26	PF 4	12.14	348.38	351.03	348.93	351.03	0.000015	0.15	80.49	51.21	0.02
Main Channel	Main Channel-US	2118.8	PF 1	5.77	349.12	350.46	349.42	350.46	0.000031	0.13	45.89	68.47	0.03
Main Channel	Main Channel-US	2118.8	PF 2	9.10	349.12	350.74	349.55	350.74	0.000025	0.14	65.42	70.40	0.03
Main Channel	Main Channel-US	2118.8	PF 3	10.38	349.12	350.85	349.55	350.85	0.000023	0.14	72.96	71.14	0.02
Main Channel	Main Channel-US	2118.8	PF 4	12.06	349.12	351.03	349.58	351.03	0.000018	0.14	86.10	72.00	0.02
Main Channel	Main Channel-US	2108.78	PF 1	5.77	345.50	350.46	346.03	350.46	0.000008	0.08	68.78	63.61	0.01
Main Channel	Main Channel-US	2108.78	PF 2	9.08	345.50	350.74	346.29	350.74	0.000011	0.10	88.93	77.87	0.02
Main Channel	Main Channel-US	2108.78	PF 3	10.36	345.50	350.85	346.26	350.85	0.000010	0.11	97.23	77.95	0.02
Main Channel	Main Channel-US	2108.78	PF 4	12.05	345.50	351.03	346.32	351.03	0.000009	0.11	111.58	78.70	0.02
Main Channel	Main Channel-US	2055	PF 1	5.77	350.00	350.46	350.20	350.46	0.000186	0.21	27.06	70.39	0.06
Main Channel	Main Channel-US	2055	PF 2	9.08	350.00	350.74	350.20	350.74	0.000082	0.19	48.81	84.19	0.04
Main Channel	Main Channel-US	2055	PF 3	10.36	350.00	350.85	350.20	350.85	0.000065	0.18	58.08	89.42	0.04
Main Channel	Main Channel-US	2055	PF 4	12.05	350.00	351.03	350.20	351.03	0.000041	0.16	75.33	98.07	0.03
Main Channel	Main Chan-Middle	241.97	PF 1	0.51	346.73	350.46	346.92	350.46	0.000000	0.01	38.25	24.34	0.00
Main Channel	Main Chan-Middle	241.97	PF 2	0.76	346.73	350.75	346.90	350.75	0.000000	0.02	45.82	28.36	0.00
Main Channel	Main Chan-Middle	241.97	PF 3	0.88	346.73	350.86	346.92	350.86	0.000000	0.02	49.02	29.83	0.00
Main Channel	Main Chan-Middle	241.97	PF 4	1.07	346.73	351.05	346.95	351.05	0.000000	0.02	55.82	40.45	0.00
Main Channel	Main Chan-Middle	200.07	PF 1	18.55	346.07	350.46	346.90	350.46	0.000040	0.35	60.65	32.87	0.04
Main Channel	Main Chan-Middle	200.07	PF 2	37.15	346.07	350.74	347.35	350.75	0.000112	0.61	70.29	35.61	0.06
Main Channel	Main Chan-Middle	200.07	PF 3	46.88	346.07	350.85	347.51	350.86	0.000157	0.73	74.16	36.85	0.07
Main Channel	Main Chan-Middle	200.07	PF 4	61.73	346.07	351.03	347.73	351.04	0.000224	0.89	81.16	40.63	0.09
Main Channel	Main Chan-Middle	168	PF 1	18.55	345.72	350.46	346.51	350.46	0.000045	0.32	58.80	26.71	0.04
Main Channel	Main Chan-Middle	168	PF 2	37.15	345.72	350.74	346.88	350.75	0.000136	0.56	66.75	32.08	0.07
Main Channel	Main Chan-Middle	168	PF 3	46.88	345.72	350.85	347.16	350.85	0.000193	0.67	70.18	33.20	0.08
Main Channel	Main Chan-Middle	168	PF 4	61.73	345.72	351.03	347.26	351.04	0.000260	0.81	76.20	33.68	0.09
Main Channel	Main Chan-Middle	146	PF 1	18.55	350.00	350.45	350.20	350.46	0.000112	0.77	24.11	82.99	0.22
Main Channel	Main Chan-Middle	146	PF 2	37.15	350.00	350.73	350.20	350.74	0.000082	0.88	42.38	105.87	0.20
Main Channel	Main Chan-Middle	146	PF 3	46.88	350.00	350.84	350.34	350.85	0.000081	0.94	49.93	114.49	0.20
Main Channel	Main Chan-Middle	146	PF 4	61.73	350.00	351.02	350.36	351.03	0.000070	0.97	63.93	131.02	0.19
Main Channel	Main Channel-DS	1800	PF 1	18.28	346.61	350.50	347.52	350.51	0.000156	0.49	36.93	20.40	0.06
Main Channel	Main Channel-DS	1800	PF 2	39.74	346.61	350.88	347.73	350.89	0.000518	0.86	46.31	28.57	0.12
Main Channel	Main Channel-DS	1800	PF 3	47.00	346.61	351.02	347.80	351.03	0.000601	0.93	50.37	30.87	0.13
Main Channel	Main Channel-DS	1800	PF 4	56.90	346.61	351.38	348.02	351.39	0.000511	0.91	62.40	35.46	0.12
Main Channel	Main Channel-DS	1699.96	PF 1	18.28	346.84	350.48	347.73	350.49	0.000241	0.57	32.20	18.52	0.08
Main Channel	Main Channel-DS	1699.96	PF 2	39.74	346.84	350.81	348.04	350.83	0.000731	1.02	38.81	21.35	0.13
Main Channel	Main Channel-DS	1699.96	PF 3	47.00	346.84	350.94	348.21	350.96	0.000861	1.13	41.51	22.18	0.15
Main Channel	Main Channel-DS	1699.96	PF 4	56.90	346.84	351.30	348.38	351.32	0.000756	1.14	50.10	24.32	0.14
Main Channel	Main Channel-DS	1699		Lat Struct									
Main Channel	Main Channel-DS	1611.36	PF 1	0.24	346.69	350.48	346.83	350.48	0.000000	0.01	31.57	18.74	0.00
Main Channel	Main Channel-DS	1611.36	PF 2	3.35	346.69	350.81	347.14	350.81	0.000005	0.09	38.07	21.25	0.01
Main Channel	Main Channel-DS	1611.36	PF 3	1.00	346.69	350.93	346.91	350.93	0.000000	0.02	40.81	22.33	0.00
Main Channel	Main Channel-DS	1611.36	PF 4	0.06	346.69	351.30	346.83	351.30	0.000000	0.00	49.46	23.99	0.00
Main Channel	Main Channel-DS	1577.89	PF 1	6.96	346.69	350.48	347.32	350.48	0.000018	0.29	24.28	90.19	0.03
Main Channel	Main Channel-DS	1577.89	PF 2	5.61	346.69	350.80	347.28	350.80	0.000009	0.21	26.56	95.13	0.02
Main Channel	Main Channel-DS	1577.89	PF 3	6.00	346.69	350.93	347.29	350.93	0.000009	0.22	27.44	97.02	0.02
Main Channel	Main Channel-DS	1577.89	PF 4	9.34	346.69	351.30	347.46	351.30	0.000016	0.31	30.03	100.00	0.03
Main Channel	Main Channel-DS	1525		Culvert									
Main Channel	Main Channel-DS	1523.05	PF 1	6.96	346.61	350.34	347.03	350.34	0.000021	0.32	21.77	84.65	0.03
Main Channel	Main Channel-DS	1523.05	PF 2	5.61	346.61	350.71	347.01	350.71	0.000010	0.23	24.02	89.60	0.02
Main Channel	Main Channel-DS	1523.05	PF 3	6.00	346.61	350.83	347.02	350.83	0.000010	0.24	24.69	91.09	0.02
Main Channel	Main Channel-DS	1523.05	PF 4	9.34	346.61	351.05	347.12	351.05	0.000021	0.36	26.02	93.58	0.03
Main Channel	Main Channel-DS	1518		Lat Struct									

HEC-RAS Plan: WHP Existing (Continued)

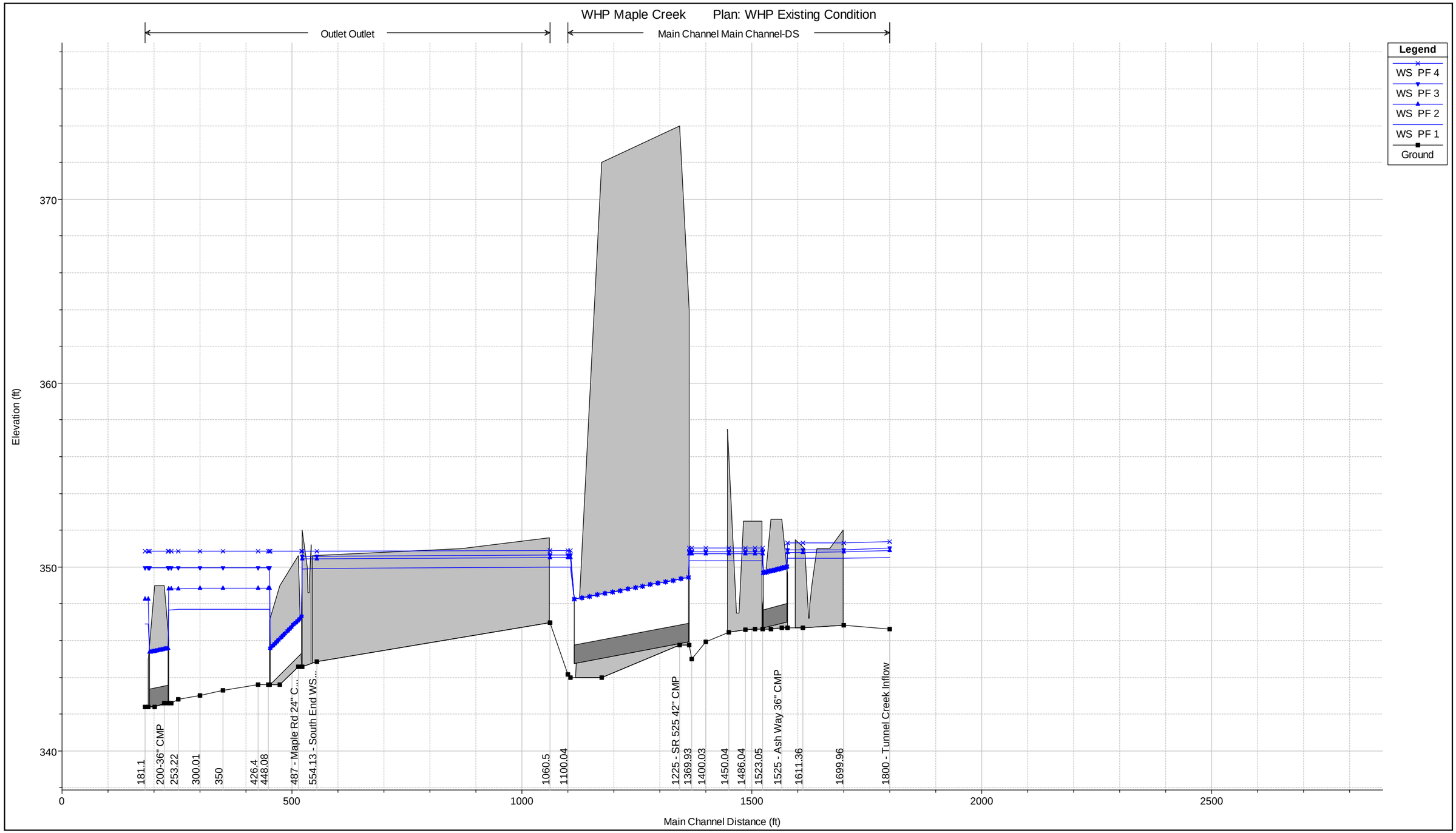
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Main Channel	Main Channel-DS	1506.58	PF 1	6.96	346.61	350.34	347.51	350.34	0.000082	0.34	20.49	11.53	0.04
Main Channel	Main Channel-DS	1506.58	PF 2	5.61	346.61	350.71	347.54	350.71	0.000032	0.22	25.13	13.17	0.03
Main Channel	Main Channel-DS	1506.58	PF 3	6.00	346.61	350.83	347.56	350.83	0.000031	0.23	26.64	13.65	0.03
Main Channel	Main Channel-DS	1506.58	PF 4	9.34	346.61	351.05	347.67	351.05	0.000056	0.31	29.76	14.62	0.04
Main Channel	Main Channel-DS	1486.04	PF 1	6.96	346.60	350.34	347.60	350.34	0.000073	0.33	21.42	10.46	0.04
Main Channel	Main Channel-DS	1486.04	PF 2	5.61	346.60	350.71	347.44	350.71	0.000029	0.22	25.51	11.26	0.03
Main Channel	Main Channel-DS	1486.04	PF 3	6.00	346.60	350.82	347.50	350.83	0.000029	0.22	26.79	11.50	0.03
Main Channel	Main Channel-DS	1486.04	PF 4	9.34	346.60	351.05	347.73	351.05	0.000056	0.32	29.40	12.32	0.04
Main Channel	Main Channel-DS	1450.04	PF 1	8.96	346.46	350.33	347.48	350.33	0.000055	0.30	29.58	14.33	0.04
Main Channel	Main Channel-DS	1450.04	PF 2	6.88	346.46	350.71	347.44	350.71	0.000020	0.20	35.22	15.53	0.02
Main Channel	Main Channel-DS	1450.04	PF 3	6.50	346.46	350.82	347.42	350.82	0.000016	0.18	36.99	15.89	0.02
Main Channel	Main Channel-DS	1450.04	PF 4	6.20	346.46	351.05	347.40	351.05	0.000011	0.15	40.58	16.59	0.02
Main Channel	Main Channel-DS	1400.03	PF 1	8.96	345.92	350.33	346.93	350.33	0.000044	0.24	37.67	21.99	0.03
Main Channel	Main Channel-DS	1400.03	PF 2	6.88	345.92	350.71	346.90	350.71	0.000015	0.15	46.47	24.46	0.02
Main Channel	Main Channel-DS	1400.03	PF 3	6.50	345.92	350.82	346.88	350.82	0.000011	0.13	49.27	25.23	0.02
Main Channel	Main Channel-DS	1400.03	PF 4	6.20	345.92	351.04	346.86	351.04	0.000008	0.11	55.03	26.93	0.01
Main Channel	Main Channel-DS	1369.93	PF 1	8.96	345.00	350.33	345.68	350.33	0.000001	0.06	172.45	87.33	0.01
Main Channel	Main Channel-DS	1369.93	PF 2	6.88	345.00	350.71	345.46	350.71	0.000000	0.04	206.38	90.89	0.00
Main Channel	Main Channel-DS	1369.93	PF 3	6.50	345.00	350.82	345.46	350.82	0.000000	0.03	216.72	92.41	0.00
Main Channel	Main Channel-DS	1369.93	PF 4	6.20	345.00	351.04	345.46	351.04	0.000000	0.03	237.52	96.26	0.00
Main Channel	Main Channel-DS	1363.32	PF 1	8.96	345.76	350.33	346.37	350.33	0.000029	0.43	20.71	87.48	0.04
Main Channel	Main Channel-DS	1363.32	PF 2	6.88	345.76	350.71	346.33	350.71	0.000013	0.31	22.46	89.97	0.02
Main Channel	Main Channel-DS	1363.32	PF 3	6.50	345.76	350.82	346.18	350.82	0.000011	0.28	22.98	90.71	0.02
Main Channel	Main Channel-DS	1363.32	PF 4	6.20	345.76	351.04	346.17	351.04	0.000008	0.26	24.00	97.37	0.02
Main Channel	Main Channel-DS	1225		Culvert									
Main Channel	Main Channel-DS	1105.06	PF 1	8.96	343.99	350.00	344.92	350.01	0.000010	0.28	31.88	100.00	0.02
Main Channel	Main Channel-DS	1105.06	PF 2	6.88	343.99	350.52	344.91	350.52	0.000004	0.20	34.97	100.00	0.01
Main Channel	Main Channel-DS	1105.06	PF 3	6.50	343.99	350.65	344.91	350.65	0.000003	0.18	35.77	100.00	0.01
Main Channel	Main Channel-DS	1105.06	PF 4	6.20	343.99	350.89	344.91	350.89	0.000003	0.17	37.19	100.00	0.01
Main Channel	Main Channel-DS	1100.04	PF 1	8.96	344.15	350.00	344.43	350.00	0.000000	0.02	534.15	100.00	0.00
Main Channel	Main Channel-DS	1100.04	PF 2	6.88	344.15	350.52	344.40	350.52	0.000000	0.01	585.50	100.00	0.00
Main Channel	Main Channel-DS	1100.04	PF 3	6.50	344.15	350.65	344.39	350.65	0.000000	0.01	598.85	100.00	0.00
Main Channel	Main Channel-DS	1100.04	PF 4	6.20	344.15	350.89	344.39	350.89	0.000000	0.01	622.50	100.00	0.00
Drainage A3	Drainage A3	485.83	PF 1	0.12	350.82	350.95	350.95	350.95	0.000373	0.11	1.13	14.15	0.07
Drainage A3	Drainage A3	485.83	PF 2	0.18	350.82	350.95	350.95	350.95	0.000840	0.16	1.13	14.15	0.10
Drainage A3	Drainage A3	485.83	PF 3	0.21	350.82	350.95	350.95	350.95	0.001143	0.19	1.13	14.15	0.12
Drainage A3	Drainage A3	485.83	PF 4	0.25	350.82	350.95	350.95	350.95	0.001620	0.22	1.13	14.15	0.14
Drainage A3	Drainage A3	433.3	PF 1	0.13	350.00	350.19	350.19	350.19	0.000036	0.05	2.67	19.34	0.02
Drainage A3	Drainage A3	433.3	PF 2	0.24	350.00	350.19	350.19	350.19	0.000131	0.09	2.67	19.34	0.04
Drainage A3	Drainage A3	433.3	PF 3	0.32	350.00	350.19	350.19	350.19	0.000223	0.12	2.67	19.34	0.06
Drainage A3	Drainage A3	433.3	PF 4	0.41	350.00	350.92	350.19	350.92	0.000001	0.02	25.92	43.44	0.00
Drainage A3	Drainage A3	374.67	PF 1	0.28	349.11	349.24	349.24	349.24	0.003764	0.33	0.84	10.83	0.21
Drainage A3	Drainage A3	374.67	PF 2	0.46	349.11	349.63	349.24	349.63	0.000016	0.05	8.44	27.31	0.02
Drainage A3	Drainage A3	374.67	PF 3	0.54	349.11	350.15	349.24	350.15	0.000001	0.02	27.13	44.14	0.00
Drainage A3	Drainage A3	374.67	PF 4	0.65	349.11	350.92	349.24	350.92	0.000000	0.01	63.46	50.01	0.00
Drainage A3	Drainage A3	312.59	PF 1	0.31	348.92	349.08	349.08	349.08	0.000227	0.08	3.65	44.39	0.05
Drainage A3	Drainage A3	312.59	PF 2	0.46	348.92	349.63	349.08	349.63	0.000000	0.01	38.23	68.43	0.00
Drainage A3	Drainage A3	312.59	PF 3	0.54	348.92	350.15	349.08	350.15	0.000000	0.01	73.79	68.52	0.00
Drainage A3	Drainage A3	312.59	PF 4	0.65	348.92	350.92	349.08	350.92	0.000000	0.01	126.50	68.65	0.00
Drainage A3	Drainage A3	258.62	PF 1	0.31	348.10	349.00	348.27	349.00	0.000024	0.07	4.34	12.45	0.02
Drainage A3	Drainage A3	258.62	PF 2	0.46	348.10	349.63	348.27	349.63	0.000001	0.02	19.17	30.87	0.01
Drainage A3	Drainage A3	258.62	PF 3	0.54	348.10	350.15	348.38	350.15	0.000000	0.01	37.83	40.71	0.00
Drainage A3	Drainage A3	258.62	PF 4	0.65	348.10	350.92	348.35	350.92	0.000000	0.01	72.77	49.71	0.00
Drainage A3	Drainage A3	184.73	PF 1	4.32	347.81	348.98	348.26	348.98	0.000236	0.31	14.00	25.00	0.07
Drainage A3	Drainage A3	184.73	PF 2	20.92	347.81	349.60	348.70	349.61	0.000528	0.63	33.45	37.97	0.12
Drainage A3	Drainage A3	184.73	PF 3	28.96	347.81	350.13	348.75	350.14	0.000237	0.51	56.41	47.22	0.08
Drainage A3	Drainage A3	184.73	PF 4	42.29	347.81	350.91	348.83	350.91	0.000136	0.41	102.63	78.18	0.06
Drainage A3	Drainage A3	130.79	PF 1	4.32	348.41	348.96	348.67	348.96	0.000862	0.40	10.85	35.12	0.13
Drainage A3	Drainage A3	130.79	PF 2	22.67	348.41	349.57	348.88	349.58	0.000628	0.64	35.66	44.89	0.13
Drainage A3	Drainage A3	130.79	PF 3	34.30	348.41	350.12	349.03	350.12	0.000271	0.55	62.01	50.81	0.09
Drainage A3	Drainage A3	130.79	PF 4	54.21	348.41	350.90	349.13	350.90	0.000178	0.50	108.89	76.22	0.07

HEC-RAS Plan: WHP Existing (Continued)

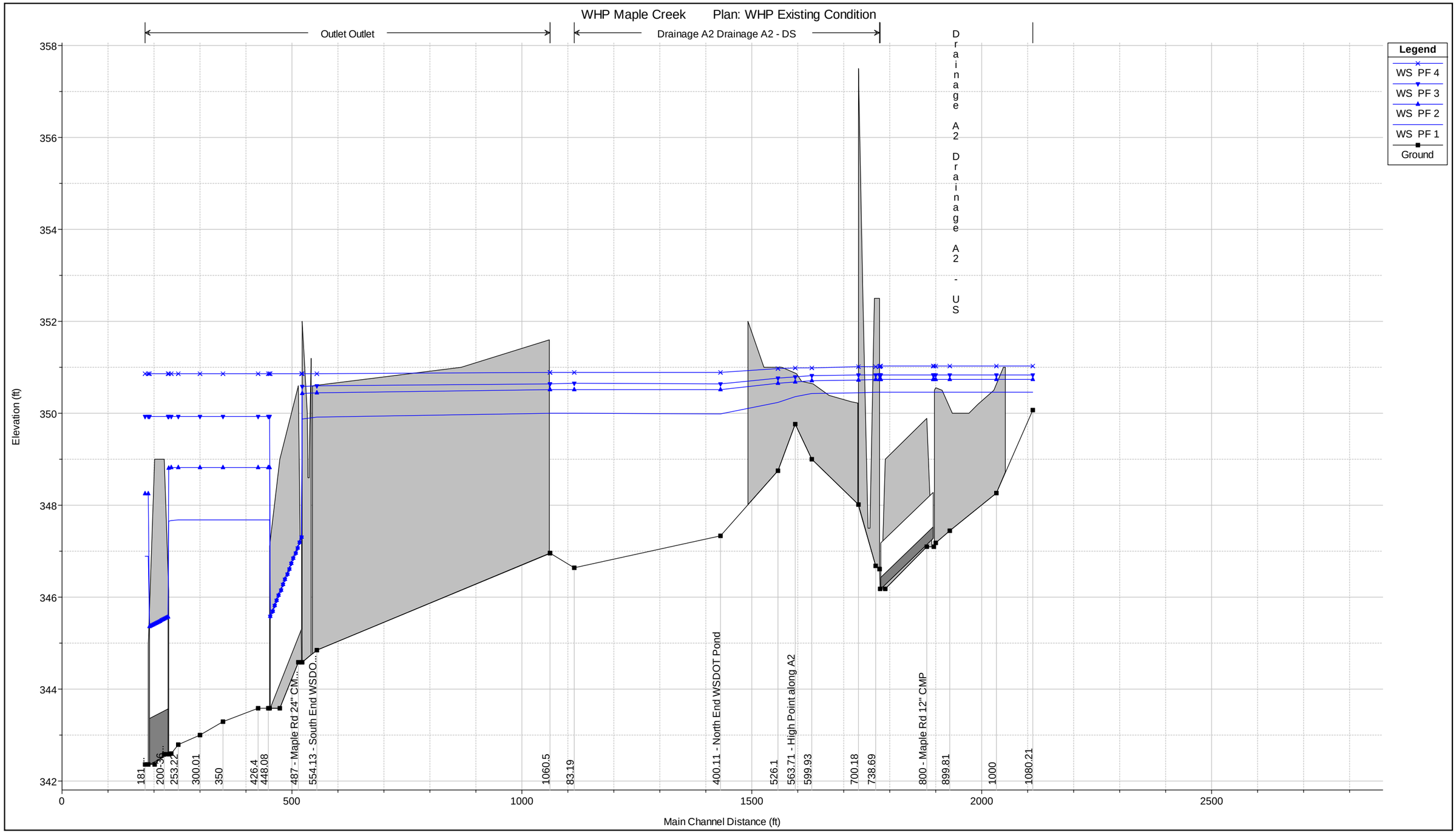
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Drainage A3	Drainage A3	63.65	PF 1	4.32	348.05	348.69	348.48	348.74	0.010122	1.64	2.63	6.03	0.44
Drainage A3	Drainage A3	63.65	PF 2	22.67	348.05	349.28	349.03	349.45	0.018651	3.31	6.85	8.55	0.65
Drainage A3	Drainage A3	63.65	PF 3	34.31	348.05	350.06	349.50	350.08	0.002924	1.22	28.16	41.65	0.26
Drainage A3	Drainage A3	63.65	PF 4	54.81	348.05	350.87	349.72	350.88	0.000545	0.84	64.87	46.47	0.13
Drainage A3	Drainage A3	10		Lat Struct									
Drainage A3	Drainage A3	5.1	PF 1	0.04	347.89	348.03	348.03	348.06	0.149508	1.51	0.02	0.35	1.01
Drainage A3	Drainage A3	5.1	PF 2	0.00	347.89	348.26	348.03	348.26	0.000000	0.00	0.17	0.94	0.00
Drainage A3	Drainage A3	5.1	PF 3	0.00	347.89	349.94	348.03	349.94	0.000000	0.00	6.94	12.48	0.00
Drainage A3	Drainage A3	5.1	PF 4	0.00	347.89	350.86	348.03	350.86	0.000000	0.00	21.58	17.19	0.00
Drainage A2	Drainage A2 - US	1080.21	PF 1	0.19	350.07	350.46	350.28	350.46	0.000378	0.19	1.02	5.54	0.08
Drainage A2	Drainage A2 - US	1080.21	PF 2	0.28	350.07	350.74	350.28	350.74	0.000044	0.08	3.54	13.90	0.03
Drainage A2	Drainage A2 - US	1080.21	PF 3	0.33	350.07	350.84	350.28	350.84	0.000023	0.06	5.24	17.99	0.02
Drainage A2	Drainage A2 - US	1080.21	PF 4	0.40	350.07	351.03	350.28	351.03	0.000008	0.04	9.16	23.64	0.01
Drainage A2	Drainage A2 - US	1040		Lat Struct									
Drainage A2	Drainage A2 - US	1000	PF 1	0.19	348.27	350.46	348.45	350.46	0.000000	0.00	44.87	39.28	0.00
Drainage A2	Drainage A2 - US	1000	PF 2	0.57	348.27	350.74	348.45	350.74	0.000000	0.01	56.87	46.26	0.00
Drainage A2	Drainage A2 - US	1000	PF 3	1.21	348.27	350.84	348.57	350.84	0.000000	0.02	62.46	58.39	0.00
Drainage A2	Drainage A2 - US	1000	PF 4	2.46	348.27	351.03	348.60	351.03	0.000001	0.03	73.66	62.38	0.00
Drainage A2	Drainage A2 - US	899.81	PF 1	0.01	347.45	350.46	347.62	350.46	0.000000	0.00	72.69	41.87	0.00
Drainage A2	Drainage A2 - US	899.81	PF 2	0.29	347.45	350.74	347.62	350.74	0.000000	0.00	84.40	41.87	0.00
Drainage A2	Drainage A2 - US	899.81	PF 3	0.89	347.45	350.84	347.73	350.84	0.000000	0.01	88.86	41.87	0.00
Drainage A2	Drainage A2 - US	899.81	PF 4	2.08	347.45	351.03	347.79	351.03	0.000000	0.02	96.55	41.87	0.00
Drainage A2	Drainage A2 - US	868.82	PF 1	0.03	347.18	350.46	347.30	350.46	0.000000	0.00	85.86	47.77	0.00
Drainage A2	Drainage A2 - US	868.82	PF 2	0.42	347.18	350.74	347.37	350.74	0.000000	0.00	101.04	55.21	0.00
Drainage A2	Drainage A2 - US	868.82	PF 3	1.04	347.18	350.84	347.44	350.84	0.000000	0.01	106.92	55.21	0.00
Drainage A2	Drainage A2 - US	868.82	PF 4	2.25	347.18	351.03	347.54	351.03	0.000000	0.02	117.05	55.21	0.00
Drainage A2	Drainage A2 - US	865.07	PF 1	0.03	347.10	350.46	347.22	350.46	0.000000	0.00	35.11	48.76	0.00
Drainage A2	Drainage A2 - US	865.07	PF 2	0.42	347.10	350.74	347.29	350.74	0.000000	0.01	48.78	48.89	0.00
Drainage A2	Drainage A2 - US	865.07	PF 3	1.04	347.10	350.84	347.36	350.84	0.000000	0.02	53.98	48.89	0.00
Drainage A2	Drainage A2 - US	865.07	PF 4	2.25	347.10	351.03	347.49	351.03	0.000001	0.04	62.96	48.89	0.01
Drainage A2	Drainage A2 - US	800		Culvert									
Drainage A2	Drainage A2 - US	748.22	PF 1	0.03	346.19	350.46	346.36	350.46	0.000000	0.00	113.88	87.86	0.00
Drainage A2	Drainage A2 - US	748.22	PF 2	0.42	346.19	350.74	346.34	350.74	0.000000	0.00	139.30	93.36	0.00
Drainage A2	Drainage A2 - US	748.22	PF 3	1.04	346.19	350.84	346.40	350.84	0.000000	0.00	149.36	95.50	0.00
Drainage A2	Drainage A2 - US	748.22	PF 4	2.25	346.19	351.03	346.58	351.03	0.000000	0.01	167.21	99.19	0.00
Drainage A2	Drainage A2 - DS	746.87	PF 1	24.05	346.61	350.46	347.50	350.46	0.000006	0.12	167.46	89.34	0.01
Drainage A2	Drainage A2 - DS	746.87	PF 2	46.11	346.61	350.74	347.71	350.74	0.000014	0.20	193.09	94.49	0.02
Drainage A2	Drainage A2 - DS	746.87	PF 3	57.67	346.61	350.84	347.73	350.84	0.000018	0.23	203.19	96.76	0.03
Drainage A2	Drainage A2 - DS	746.87	PF 4	75.27	346.61	351.02	347.99	351.03	0.000023	0.28	221.19	100.82	0.03
Drainage A2	Drainage A2 - DS	740		Lat Struct									
Drainage A2	Drainage A2 - DS	738.69	PF 1	22.05	346.69	350.46	347.72	350.46	0.000007	0.13	165.36	97.77	0.02
Drainage A2	Drainage A2 - DS	738.69	PF 2	44.84	346.69	350.74	347.87	350.74	0.000017	0.22	193.46	103.62	0.02
Drainage A2	Drainage A2 - DS	738.69	PF 3	57.17	346.69	350.84	347.91	350.84	0.000023	0.26	204.52	105.48	0.03
Drainage A2	Drainage A2 - DS	738.69	PF 4	78.40	346.69	351.02	348.17	351.03	0.000031	0.31	224.02	108.76	0.03
Drainage A2	Drainage A2 - DS	700.18	PF 1	22.05	348.02	350.45	348.55	350.46	0.000063	0.31	75.52	59.67	0.04
Drainage A2	Drainage A2 - DS	700.18	PF 2	44.84	348.02	350.73	348.73	350.74	0.000144	0.52	92.54	63.93	0.07
Drainage A2	Drainage A2 - DS	700.18	PF 3	57.17	348.02	350.84	348.90	350.84	0.000193	0.62	99.42	68.23	0.08
Drainage A2	Drainage A2 - DS	700.18	PF 4	78.40	348.02	351.01	349.03	351.02	0.000263	0.77	112.21	73.63	0.09
Drainage A2	Drainage A2 - DS	700		Lat Struct									
Drainage A2	Drainage A2 - DS	599.93	PF 1	18.03	349.00	350.44	349.56	350.44	0.000407	0.46	39.36	58.74	0.10
Drainage A2	Drainage A2 - DS	599.93	PF 2	22.78	349.00	350.72	349.63	350.72	0.000220	0.40	56.34	63.69	0.08
Drainage A2	Drainage A2 - DS	599.93	PF 3	25.07	349.00	350.82	349.65	350.82	0.000186	0.40	62.87	63.70	0.07
Drainage A2	Drainage A2 - DS	599.93	PF 4	29.54	349.00	351.00	349.67	351.00	0.000149	0.40	74.23	63.71	0.06
Drainage A2	Drainage A2 - DS	563.71	PF 1	18.03	349.77	350.36	350.22	350.40	0.014444	1.58	11.38	38.50	0.51
Drainage A2	Drainage A2 - DS	563.71	PF 2	22.63	349.77	350.69	350.26	350.70	0.001975	0.83	27.19	54.19	0.21
Drainage A2	Drainage A2 - DS	563.71	PF 3	23.40	349.77	350.80	350.26	350.81	0.001152	0.70	33.31	57.06	0.16
Drainage A2	Drainage A2 - DS	563.71	PF 4	24.44	349.77	350.99	350.26	350.99	0.000514	0.55	44.20	58.95	0.11
Drainage A2	Drainage A2 - DS	526.1	PF 1	18.03	348.76	350.24	349.50	350.25	0.001861	0.97	18.58	28.02	0.21
Drainage A2	Drainage A2 - DS	526.1	PF 2	22.63	348.76	350.65	349.58	350.66	0.000704	0.69	32.84	39.92	0.13
Drainage A2	Drainage A2 - DS	526.1	PF 3	23.40	348.76	350.77	349.59	350.78	0.000516	0.62	37.81	42.75	0.12

HEC-RAS Plan: WHP Existing (Continued)

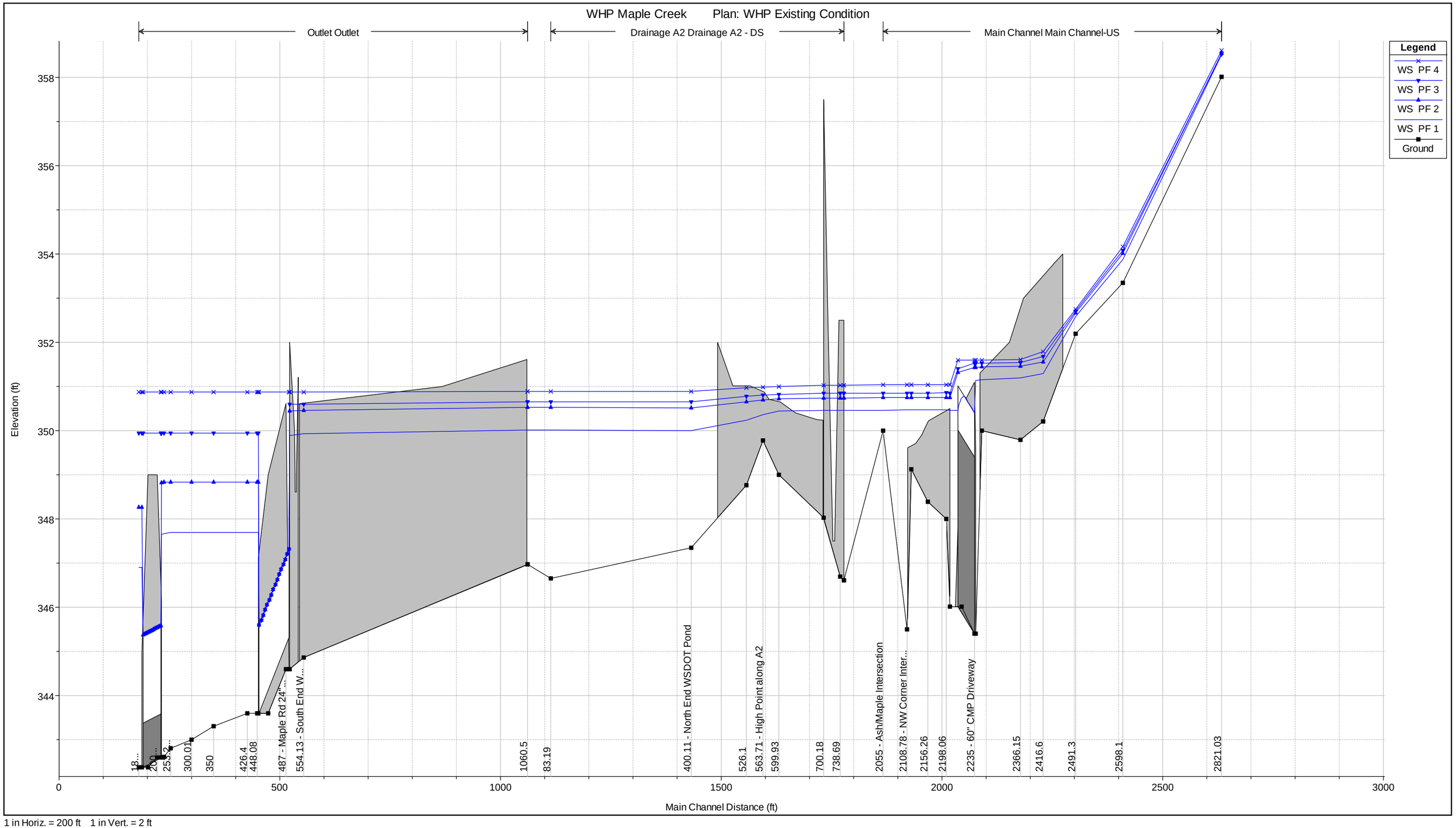
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Drainage A2	Drainage A2 - DS	526.1	PF 4	24.24	348.76	350.97	349.61	350.98	0.000314	0.52	46.75	47.44	0.09
Drainage A2	Drainage A2 - DS	400.11	PF 1	18.03	347.34	350.00	348.71	350.03	0.001762	1.38	13.08	9.75	0.21
Drainage A2	Drainage A2 - DS	400.11	PF 2	22.63	347.34	350.51	348.90	350.54	0.001077	1.22	18.55	11.36	0.17
Drainage A2	Drainage A2 - DS	400.11	PF 3	23.40	347.34	350.65	348.92	350.67	0.001268	1.16	20.23	15.71	0.18
Drainage A2	Drainage A2 - DS	400.11	PF 4	24.24	347.34	350.89	348.94	350.90	0.001125	0.97	25.06	24.00	0.17
Drainage A2	Drainage A2 - DS	83.19	PF 1	18.03	346.64	350.01	347.09	350.01	0.000011	0.17	106.11	45.96	0.02
Drainage A2	Drainage A2 - DS	83.19	PF 2	22.63	346.64	350.52	347.15	350.52	0.000010	0.17	130.89	50.54	0.02
Drainage A2	Drainage A2 - DS	83.19	PF 3	23.40	346.64	350.65	347.16	350.65	0.000009	0.17	137.70	51.65	0.02
Drainage A2	Drainage A2 - DS	83.19	PF 4	24.24	346.64	350.89	347.08	350.89	0.000008	0.16	150.14	53.63	0.02



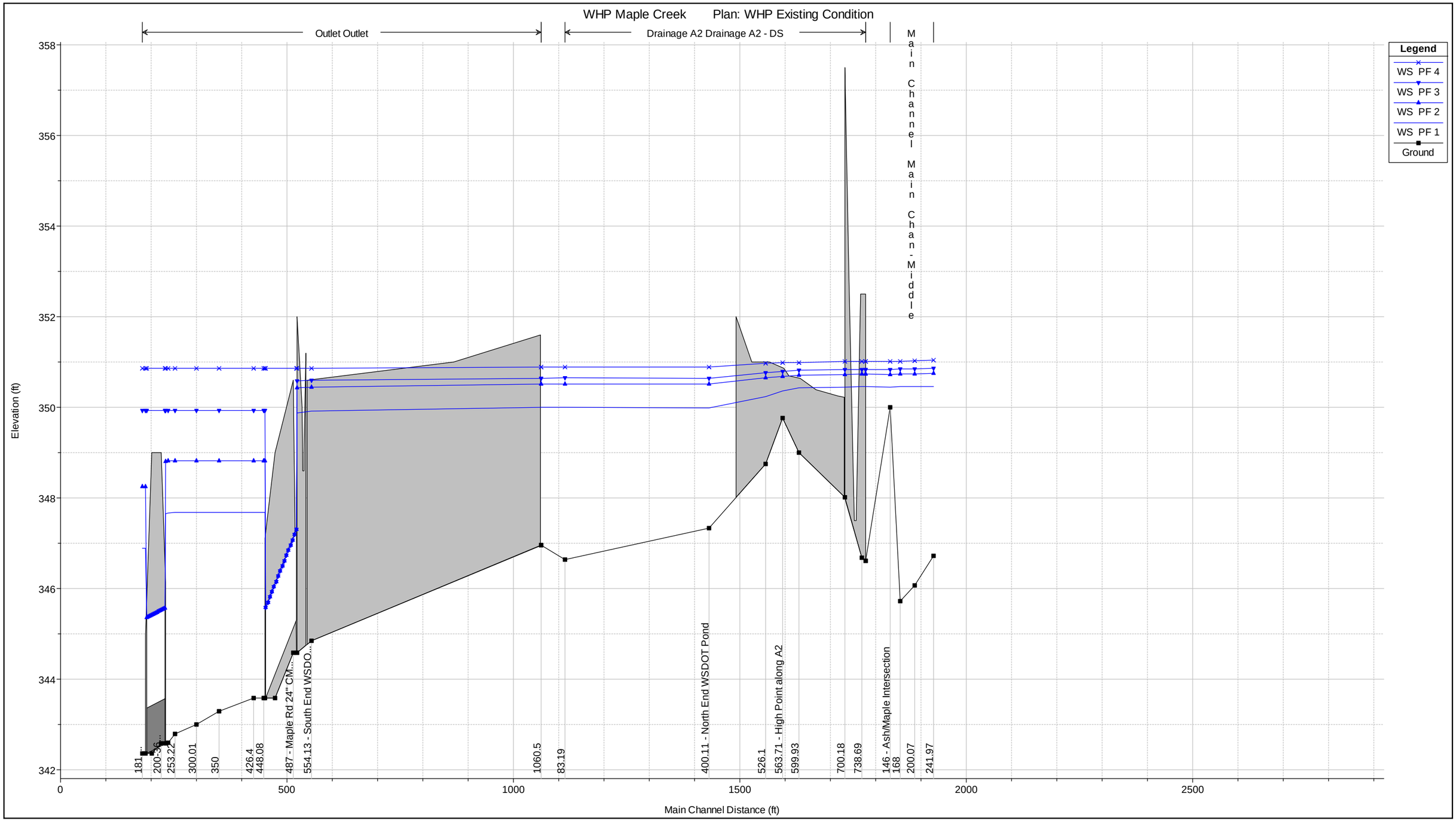
1 in Horiz. = 200 ft 1 in Vert. = 5 ft



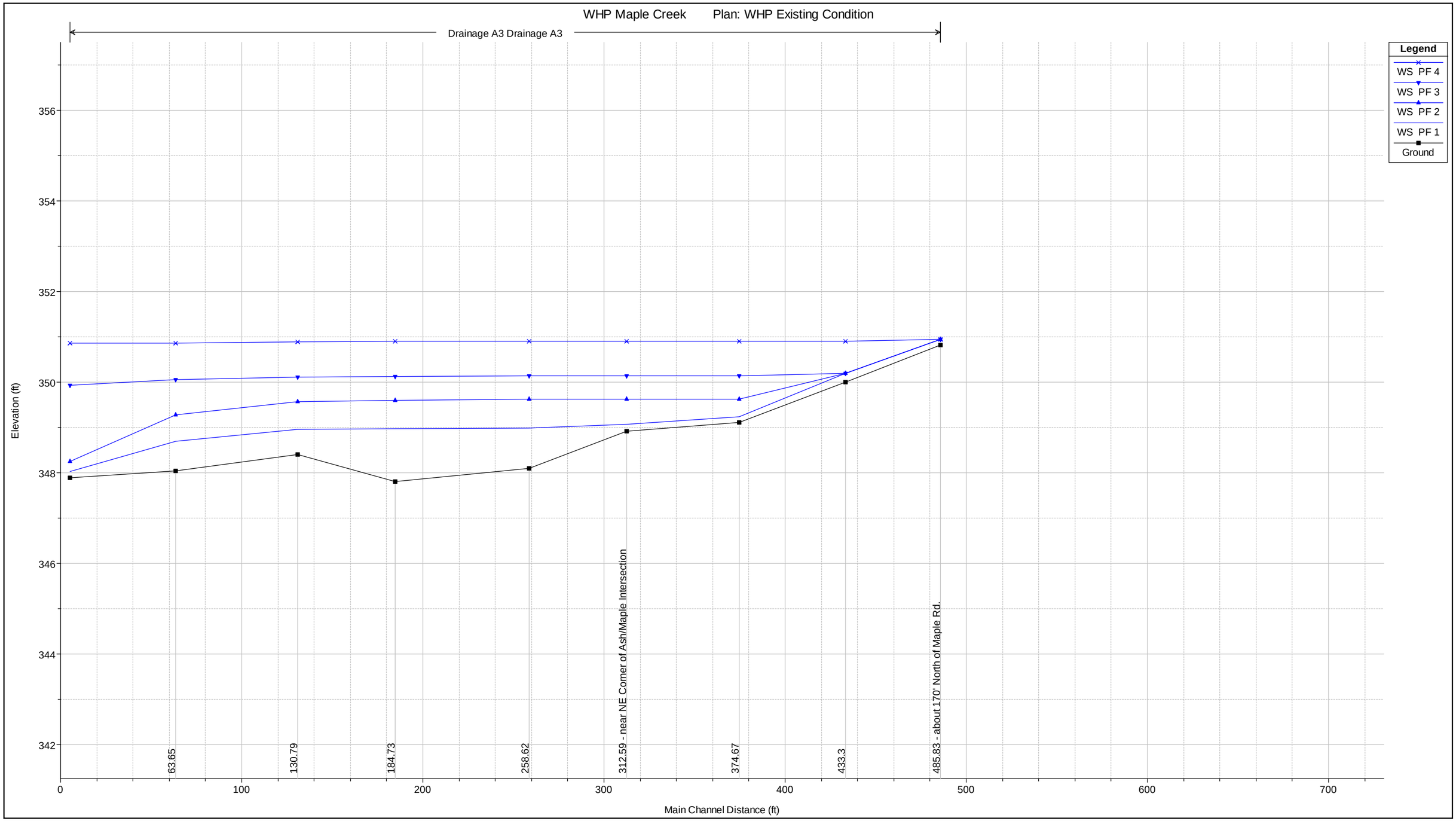
1 in Horiz. = 200 ft 1 in Vert. = 2 ft



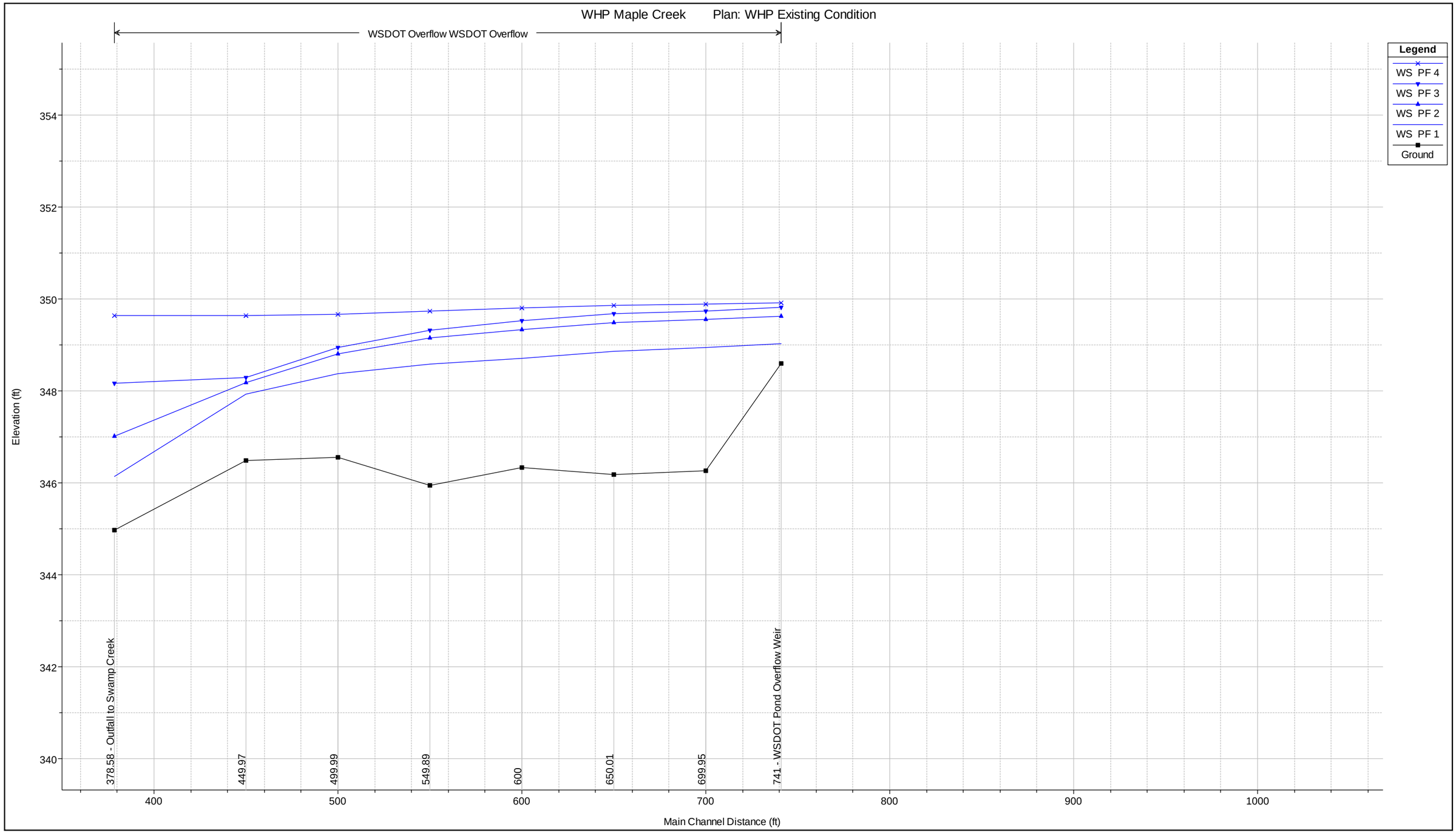
1 in Horiz. = 200 ft 1 in Vert. = 2 ft



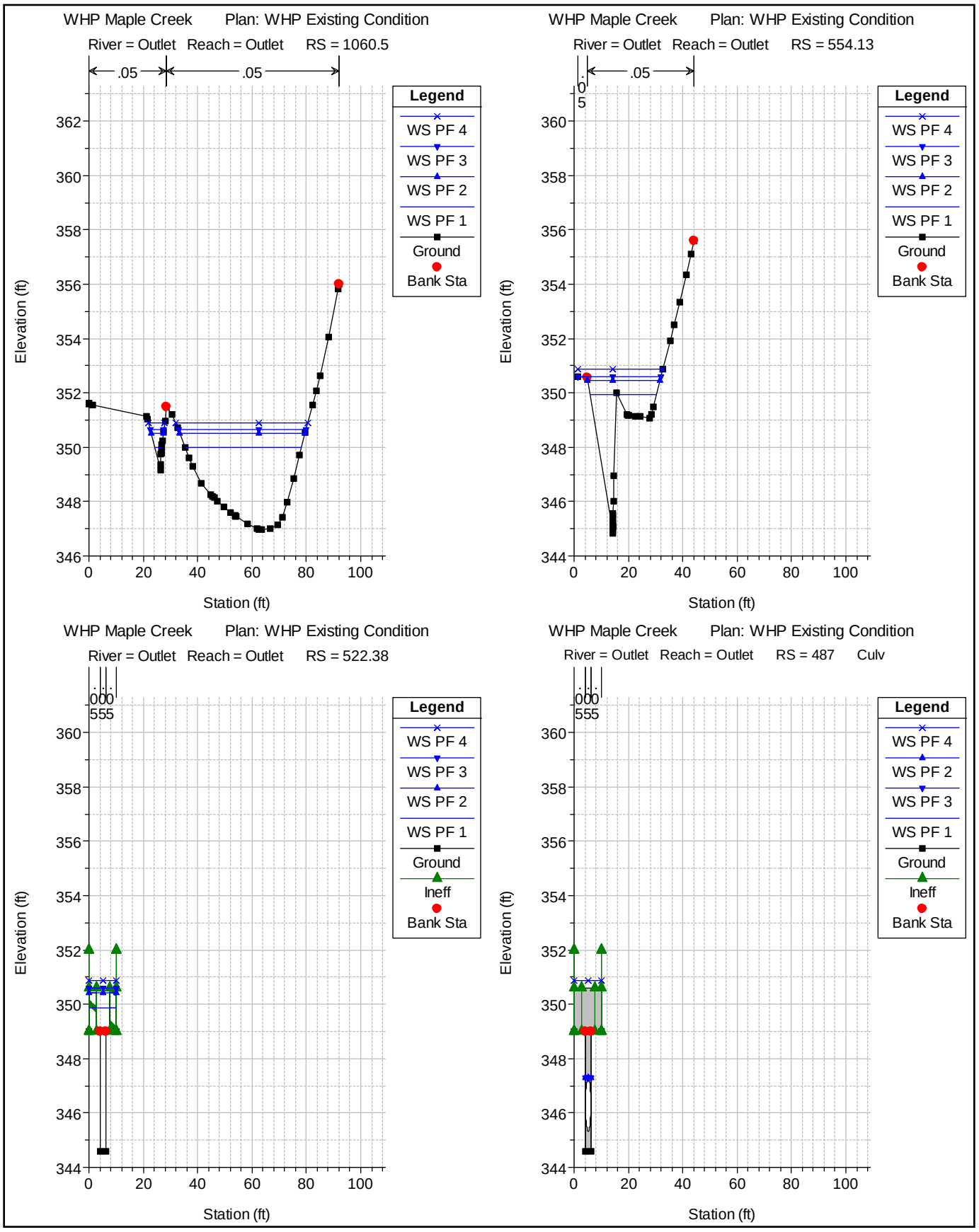
1 in Horiz. = 200 ft 1 in Vert. = 2 ft



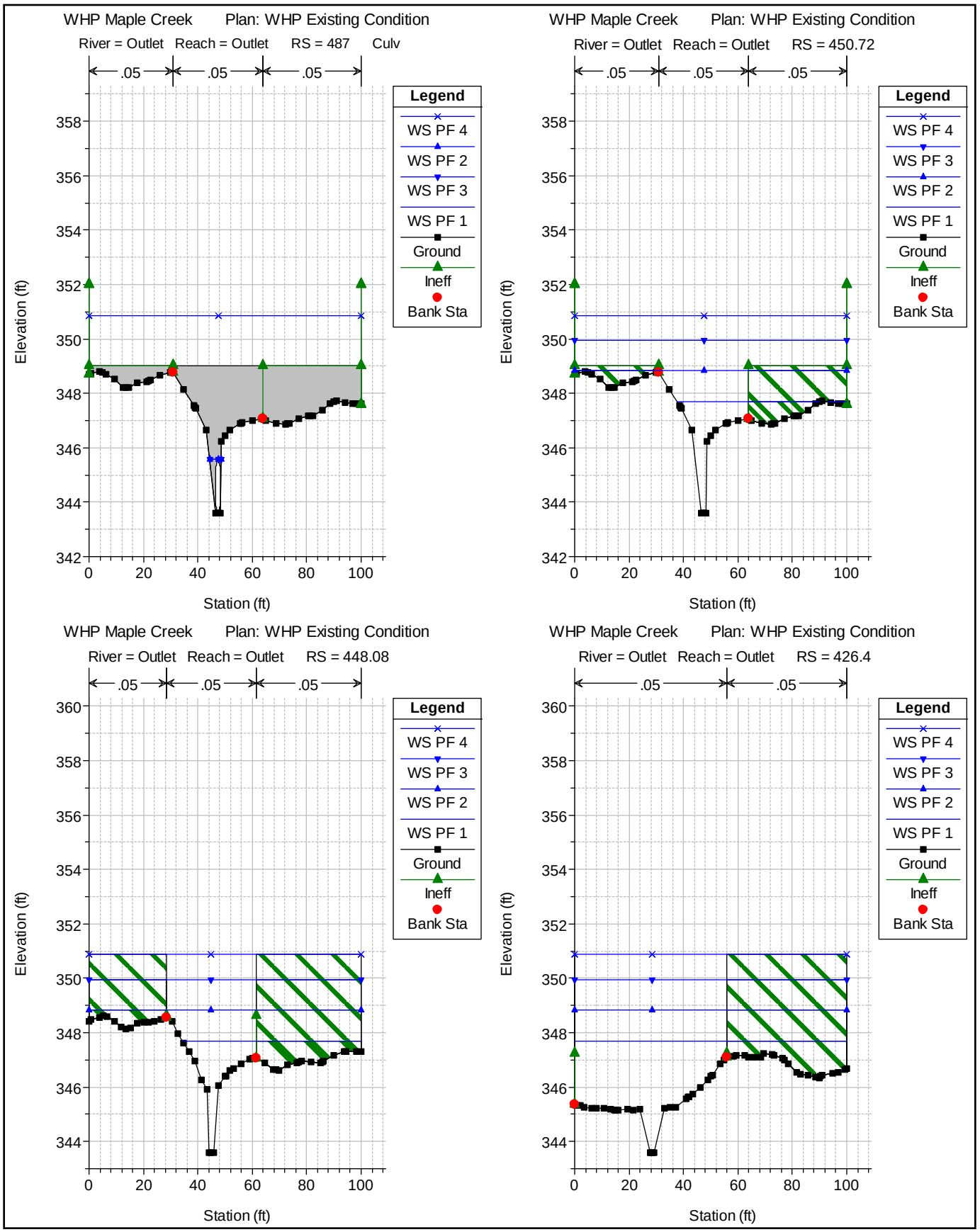
1 in Horiz. = 50 ft 1 in Vert. = 2 ft



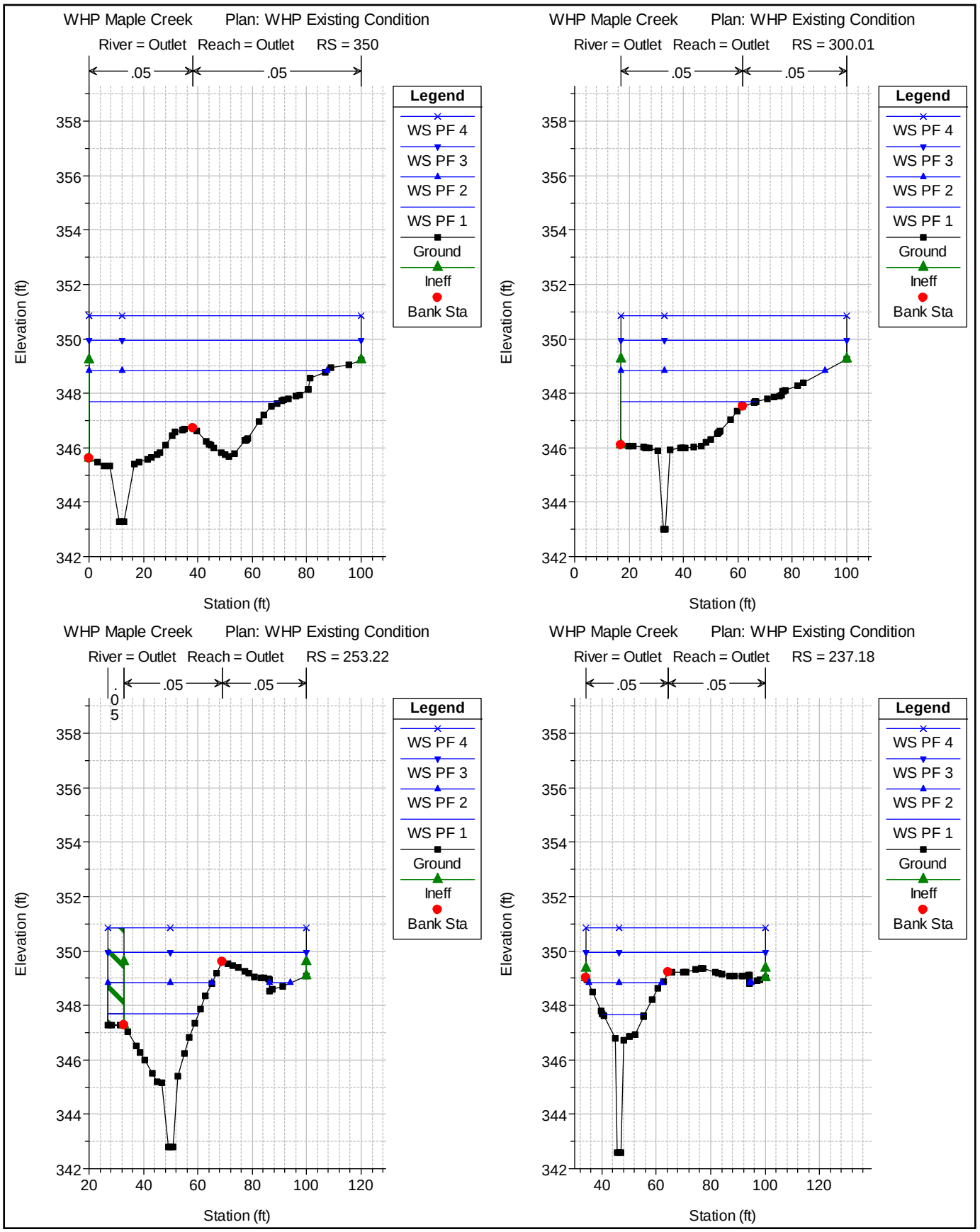
1 in Horiz. = 50 ft 1 in Vert. = 2 ft



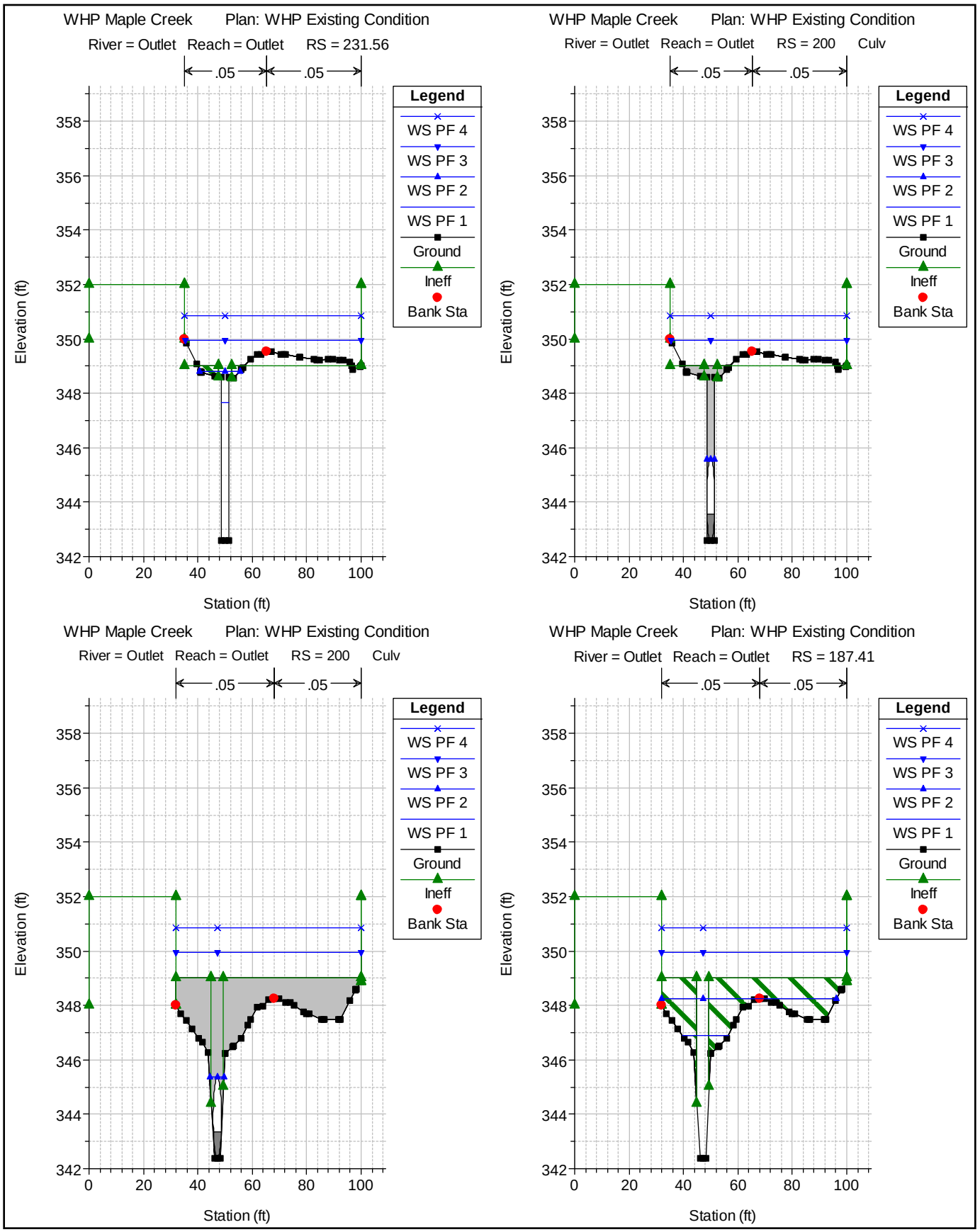
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



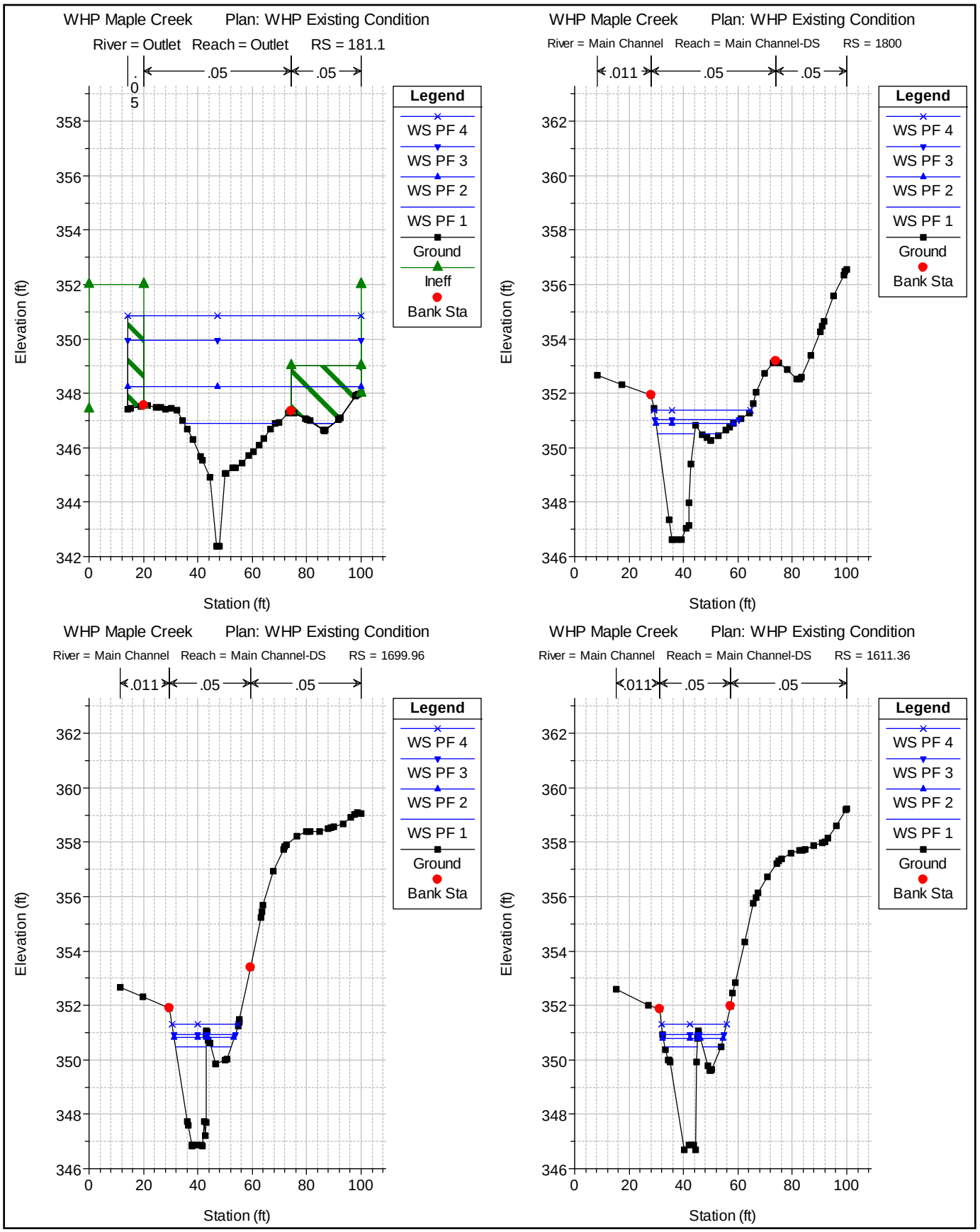
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



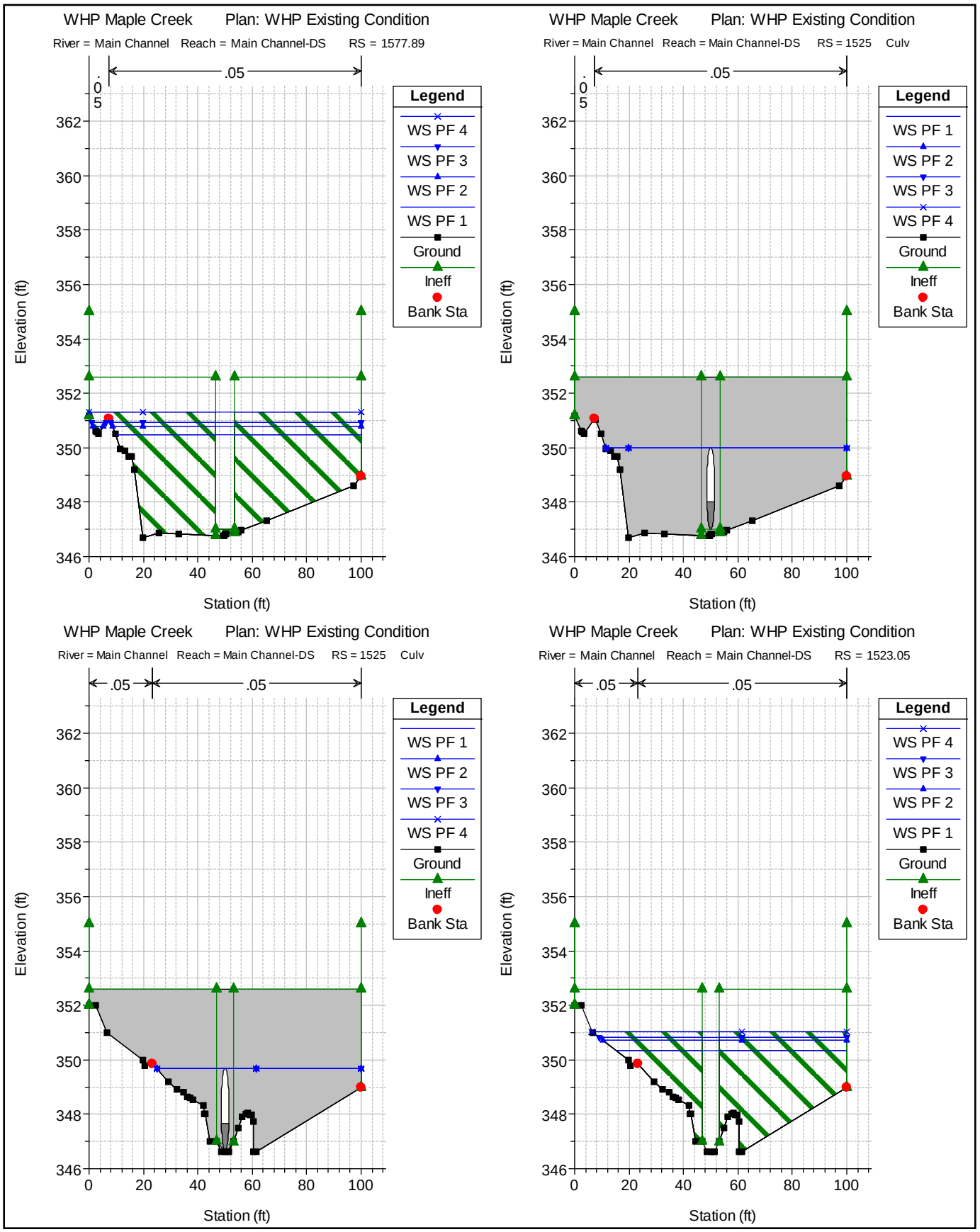
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



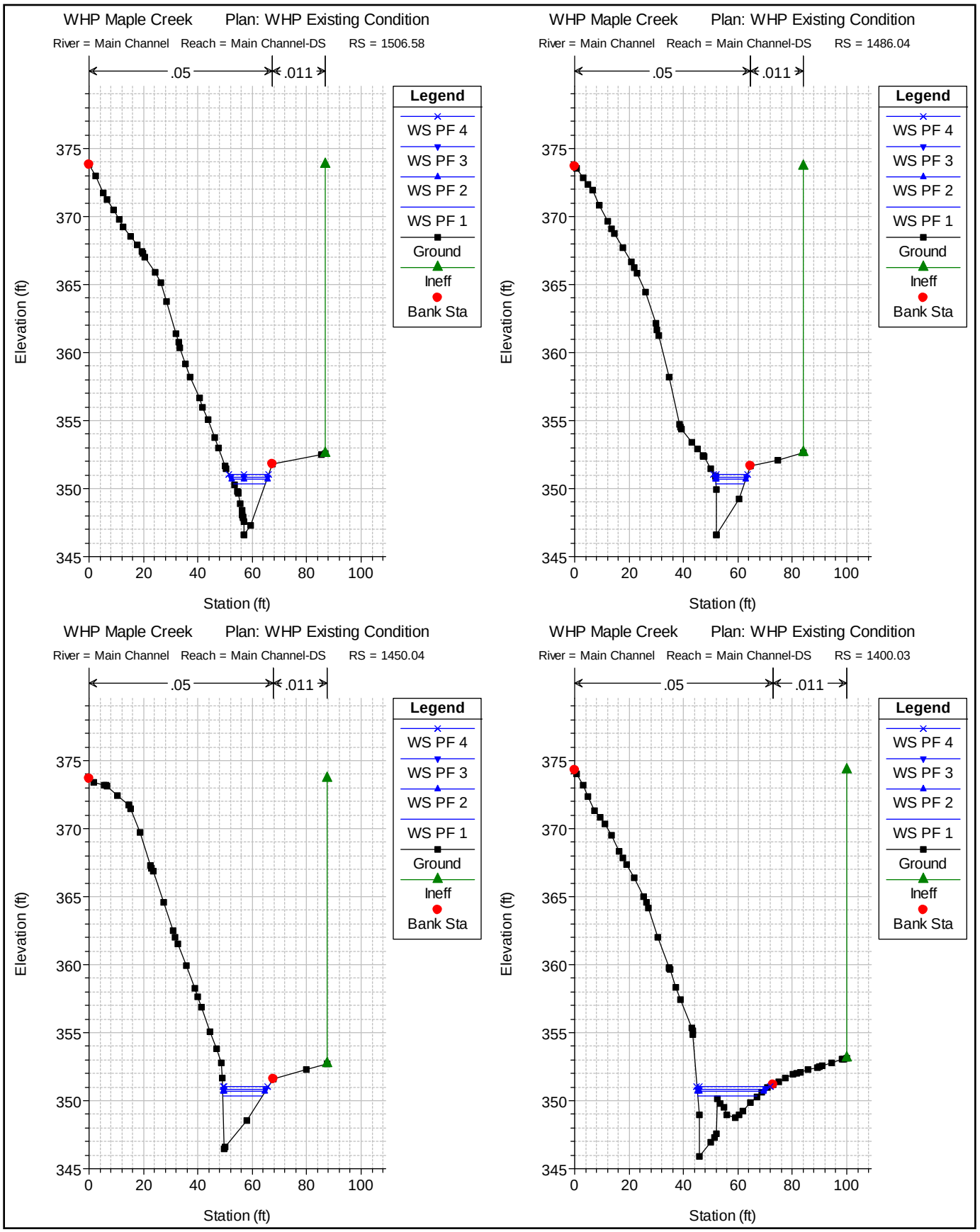
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



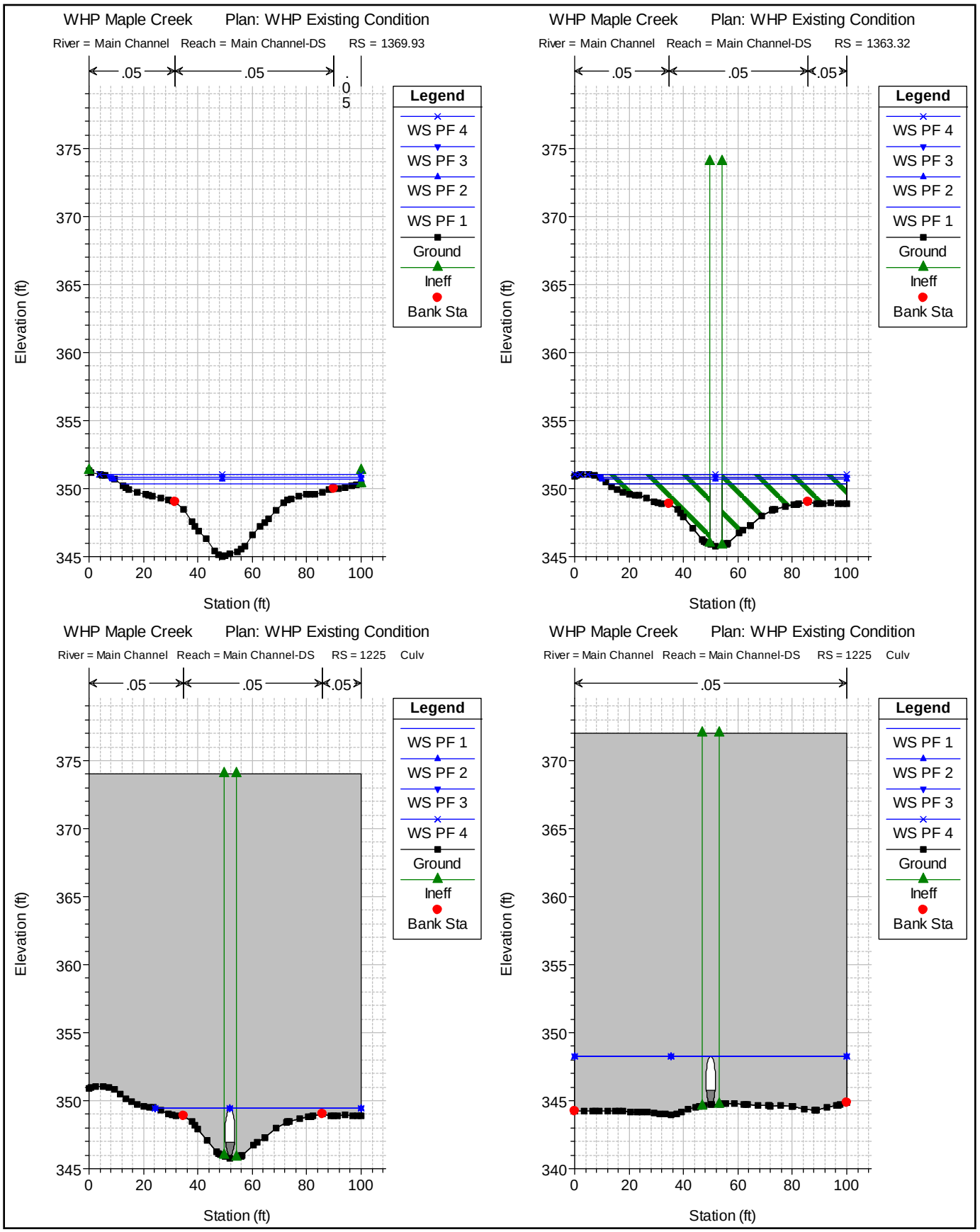
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



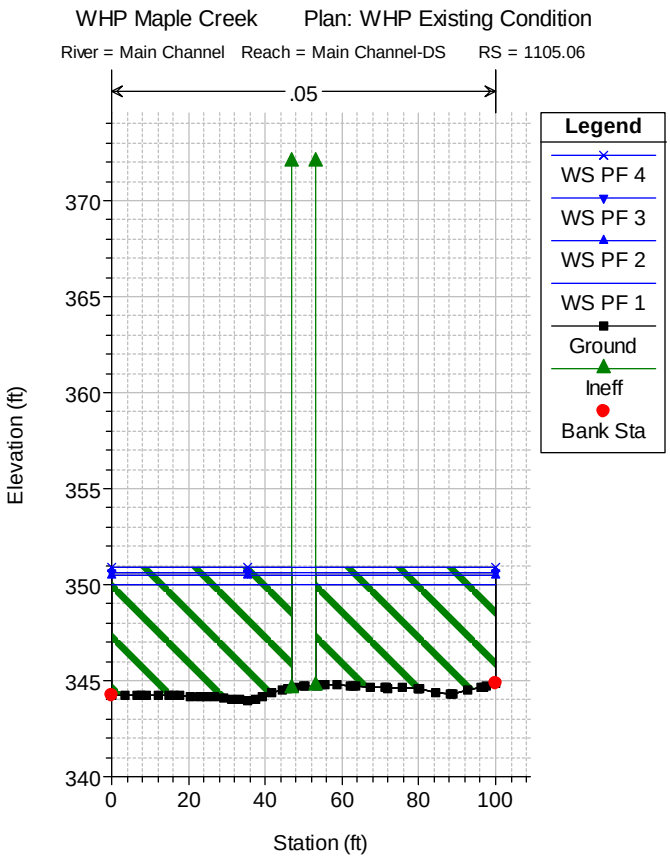
1 in Horiz. = 50 ft 1 in Vert. = 5 ft

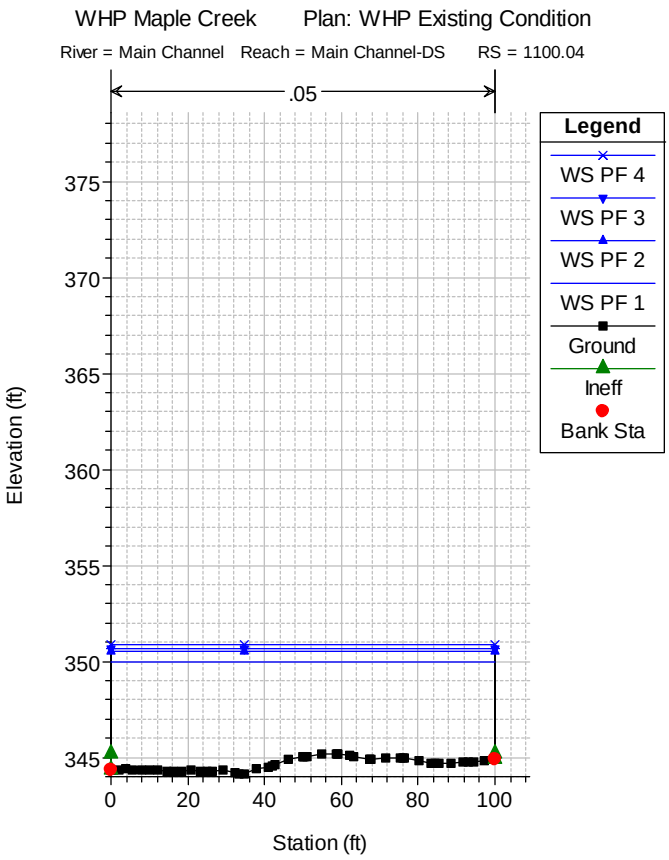


1 in Horiz. = 50 ft 1 in Vert. = 10 ft

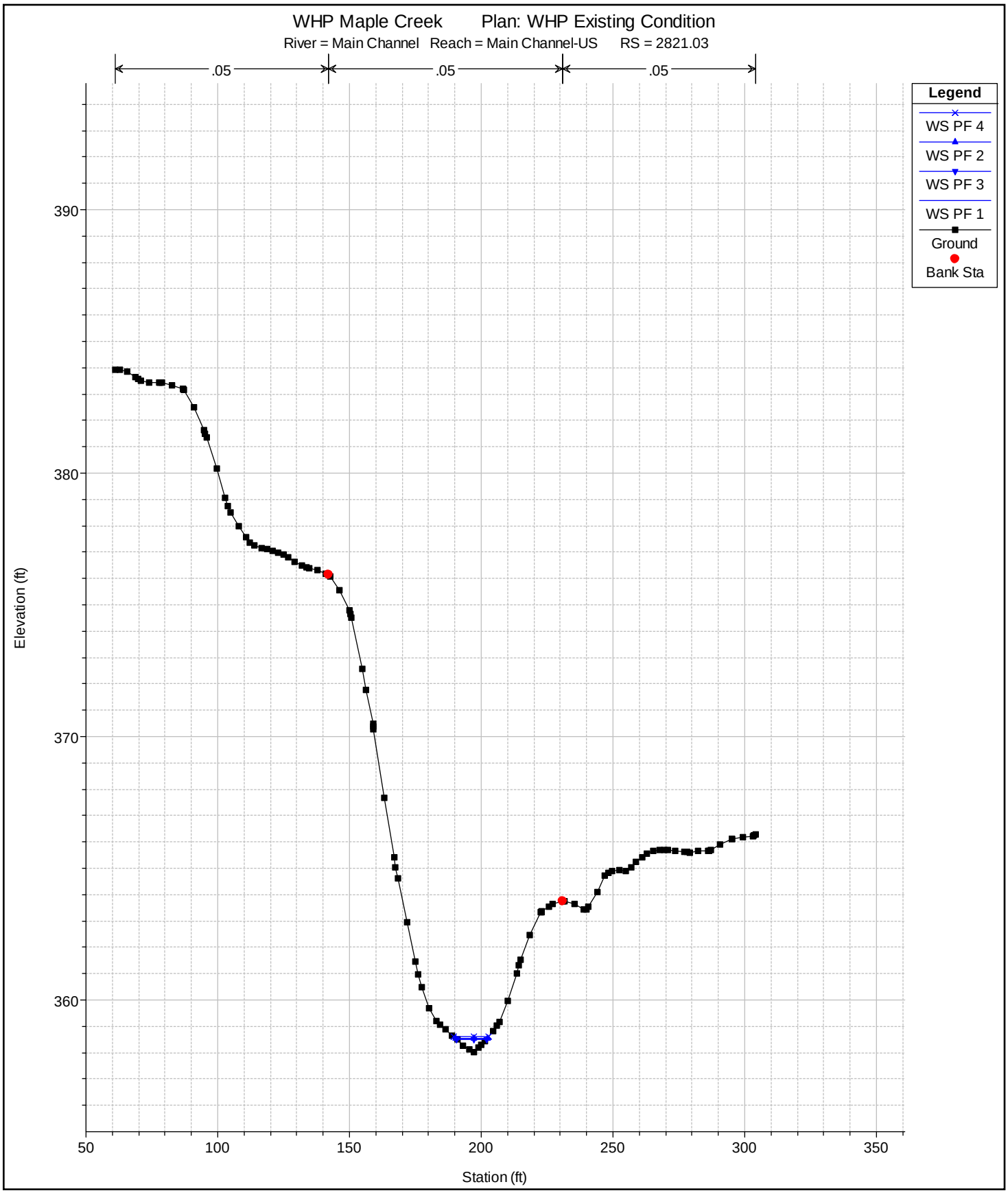


1 in Horiz. = 50 ft 1 in Vert. = 10 ft

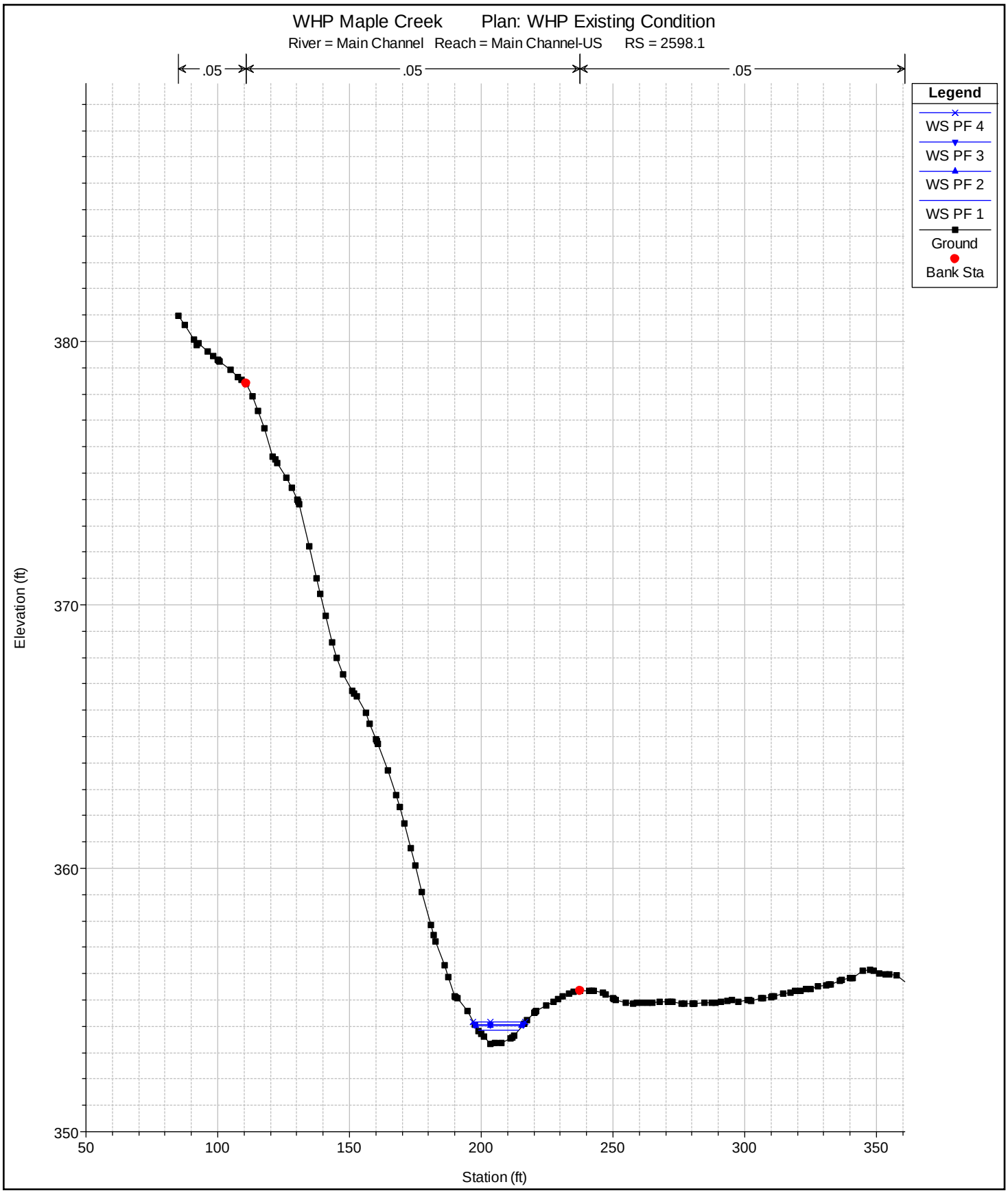




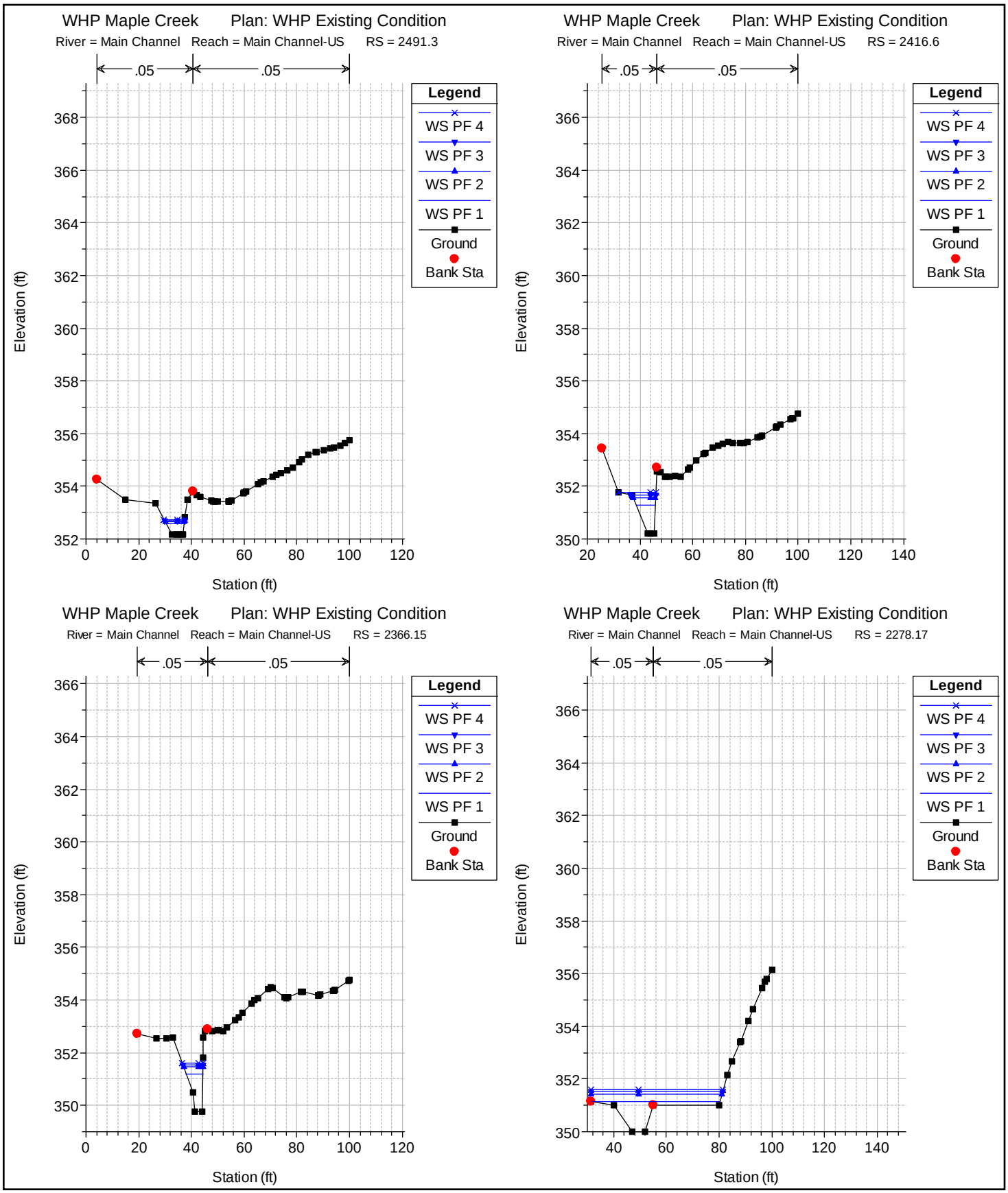
1 in Horiz. = 50 ft 1 in Vert. = 10 ft



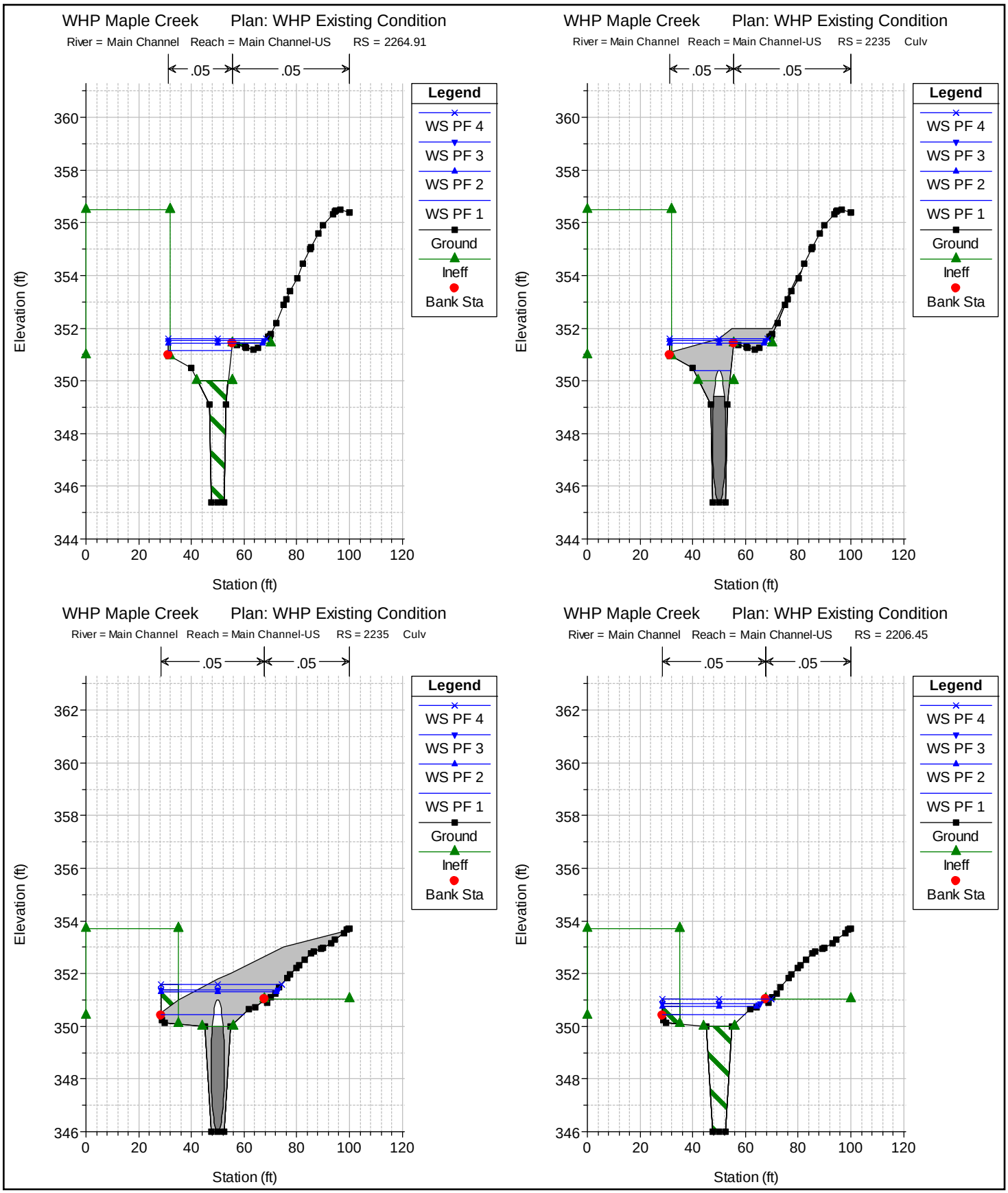
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



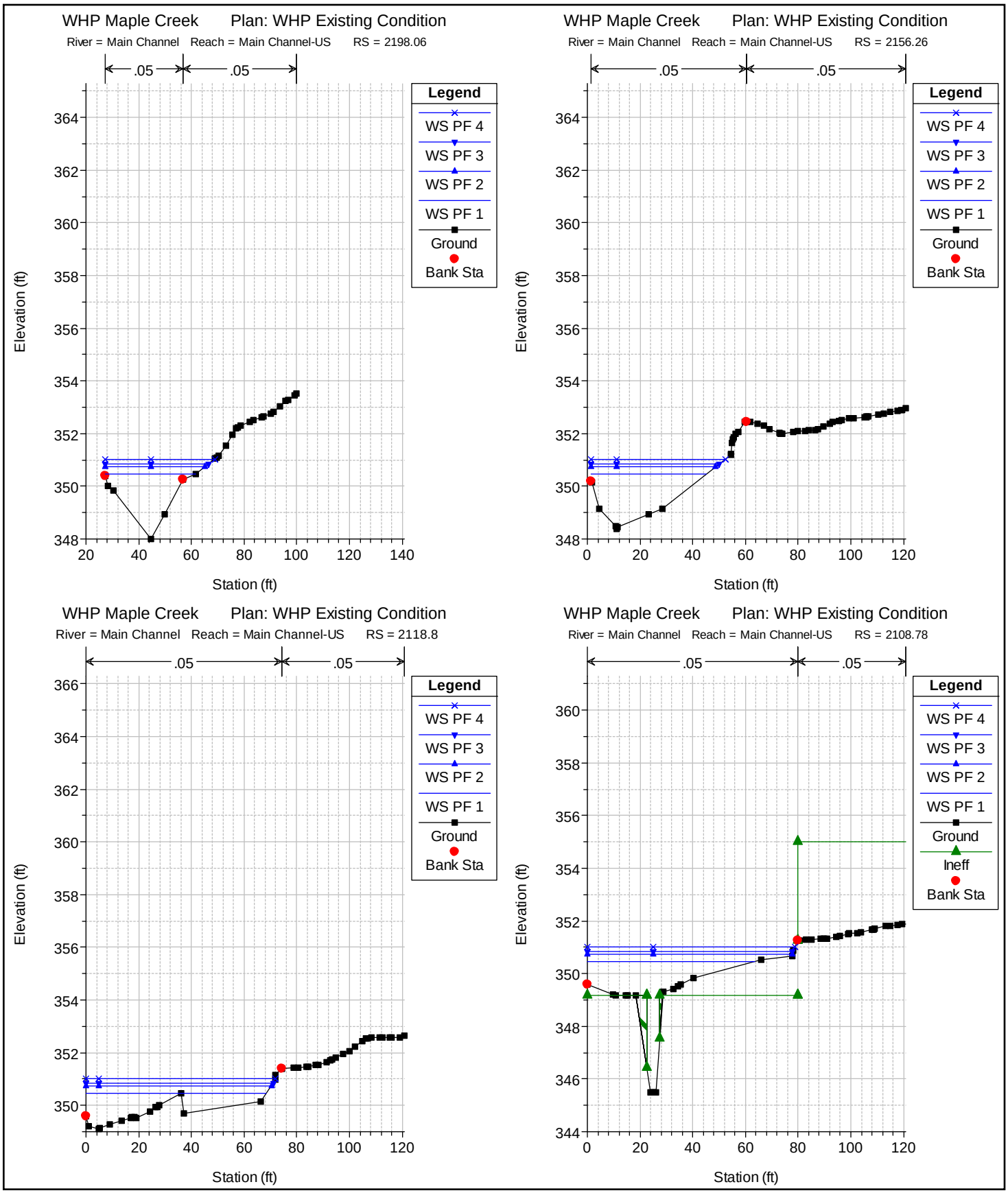
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



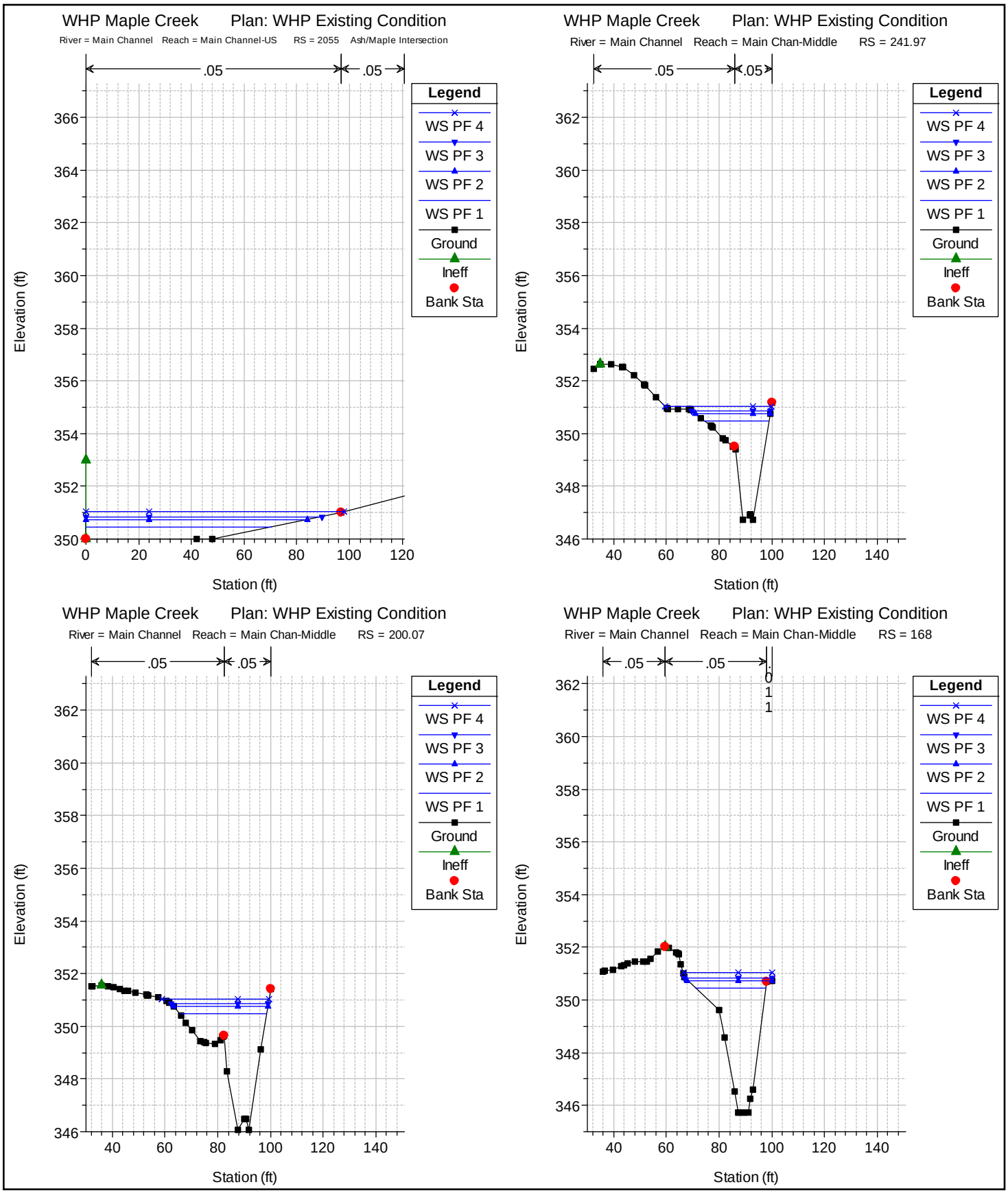
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



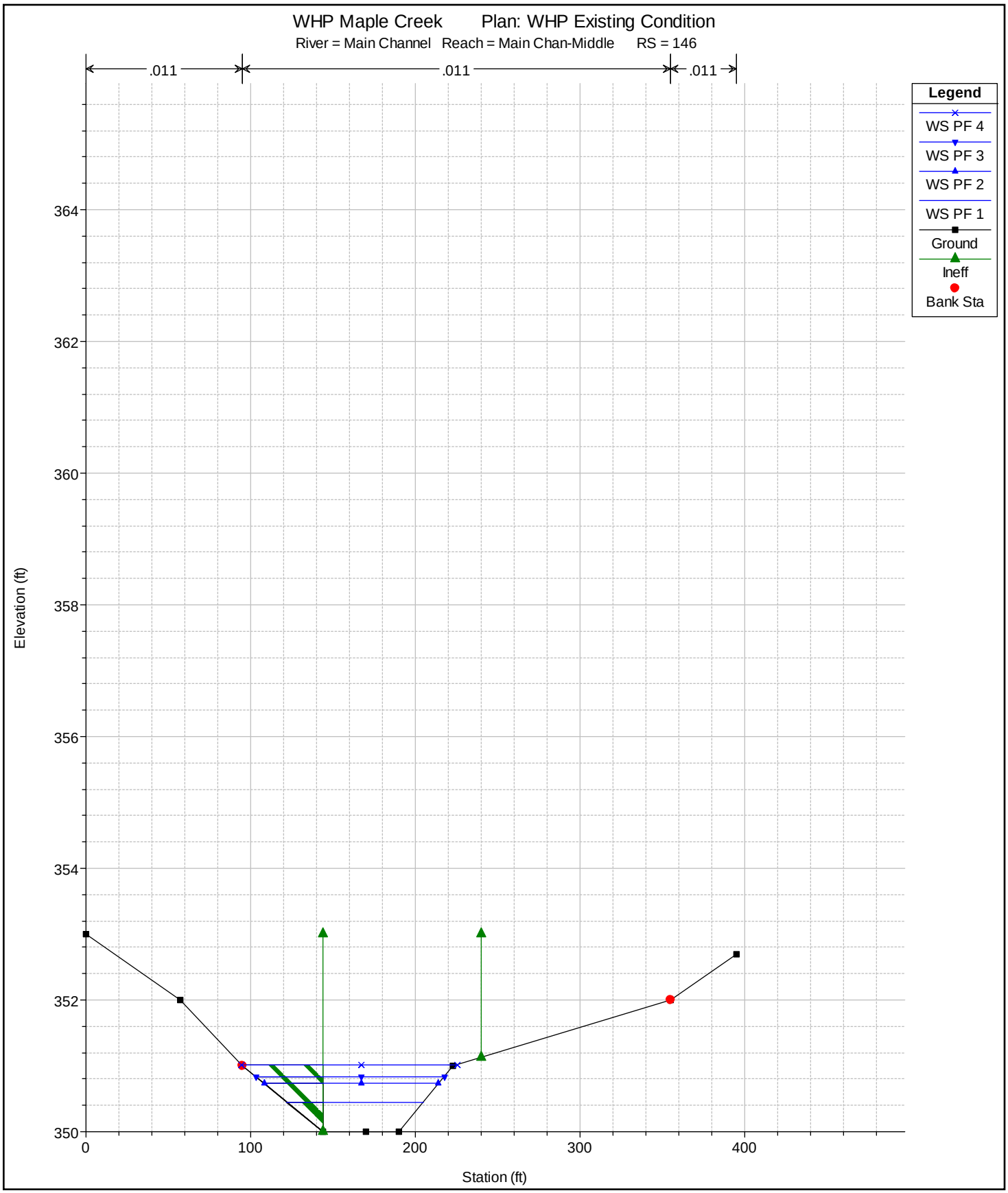
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



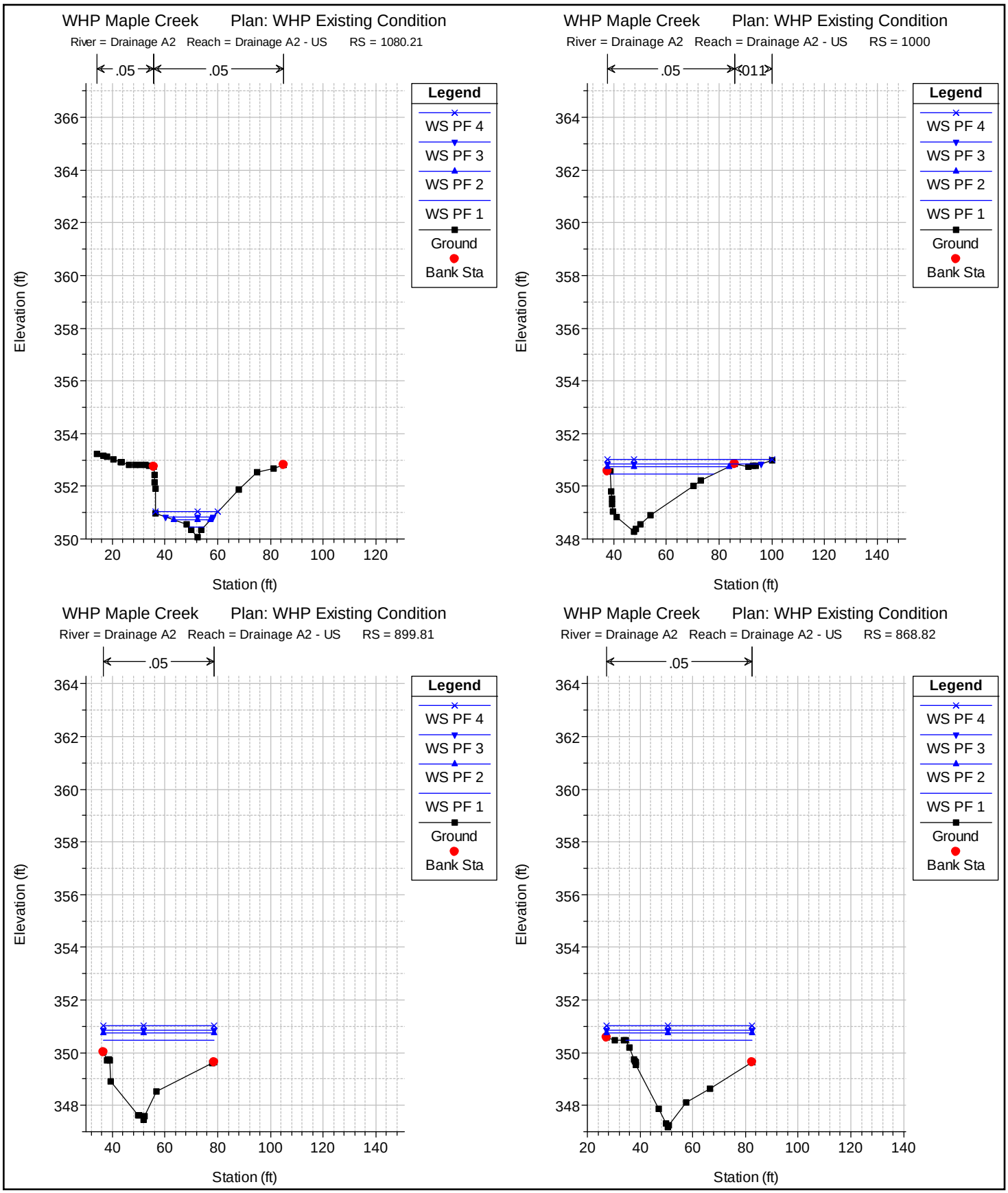
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



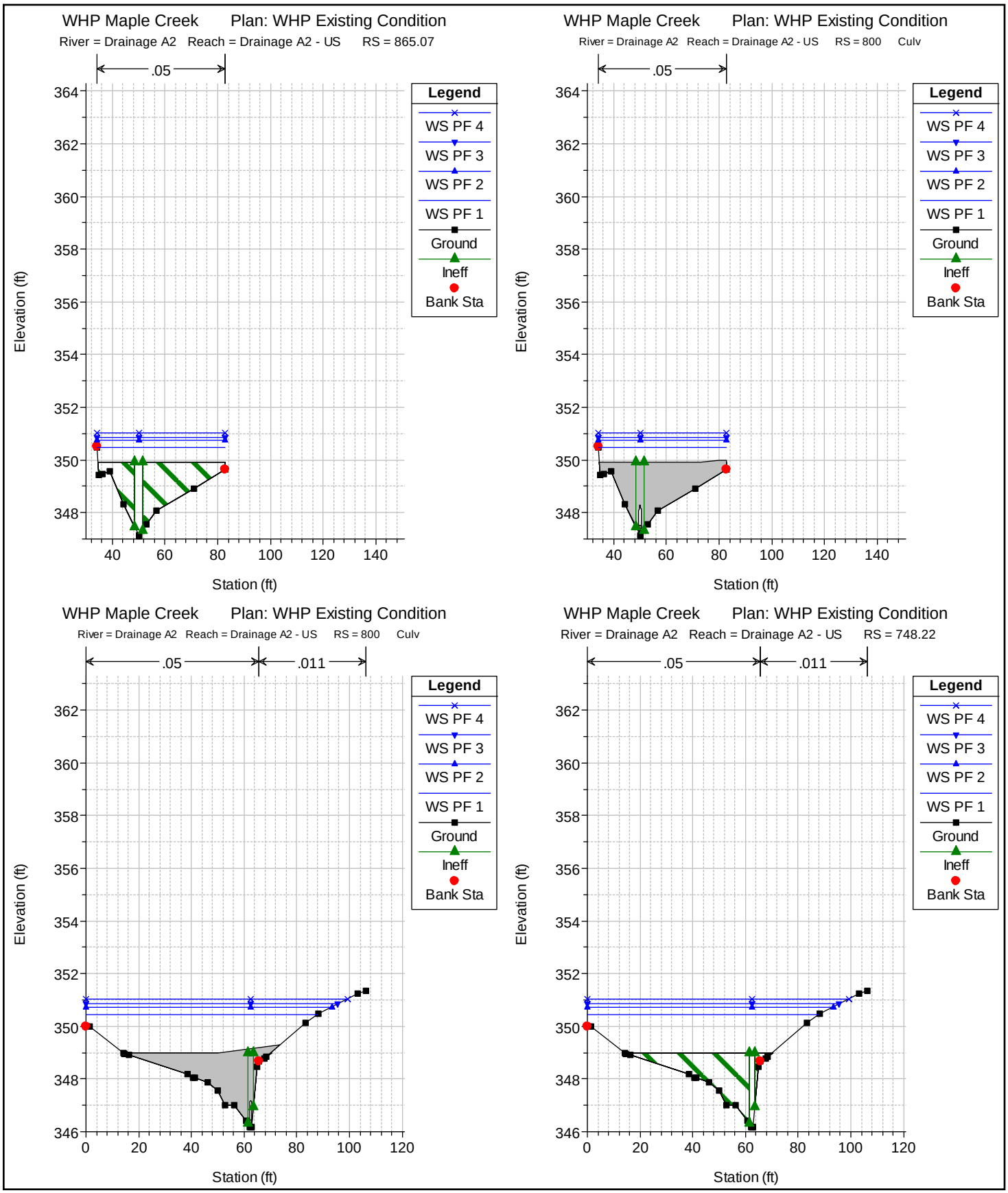
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



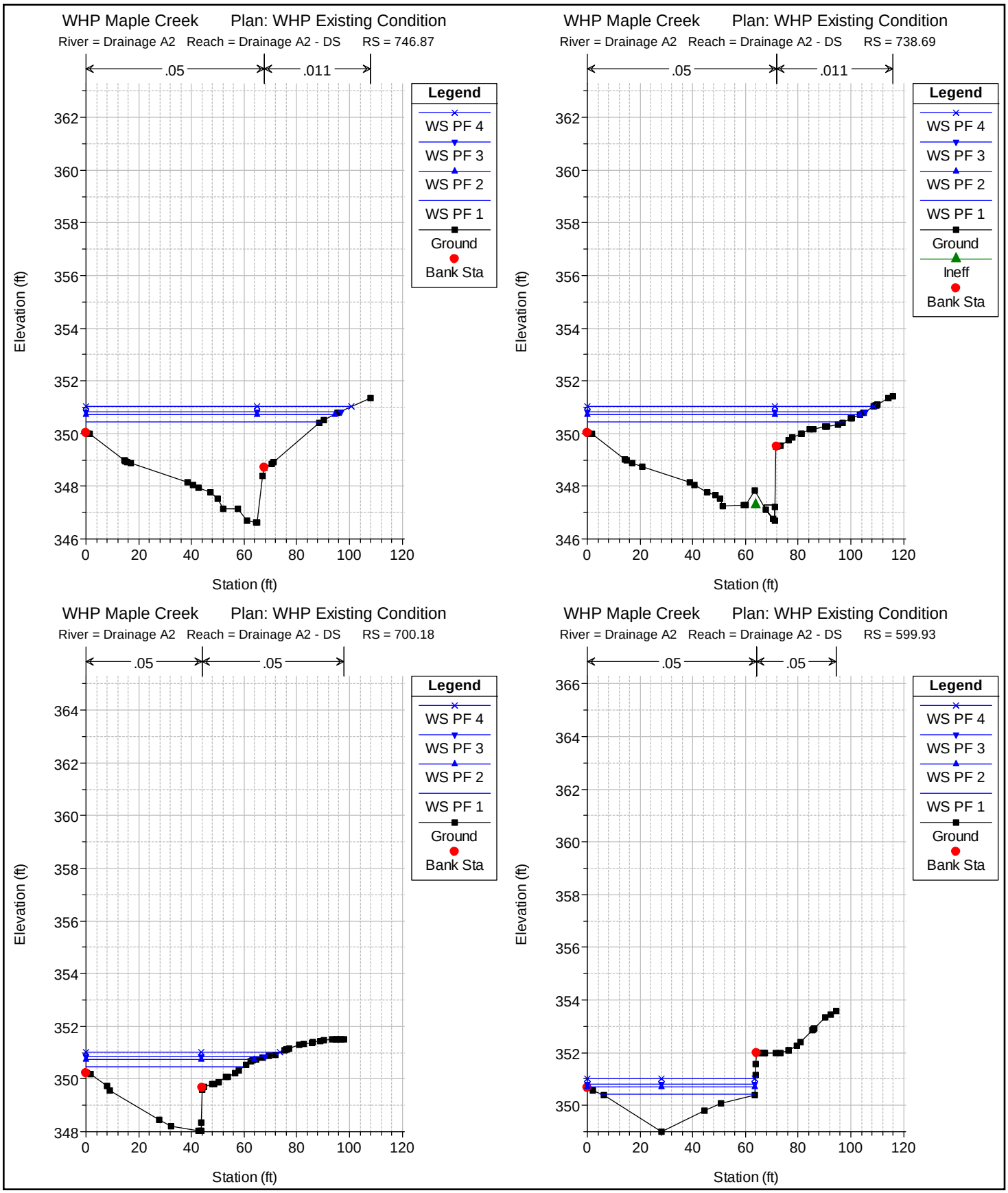
1 in Horiz. = 80 ft 1 in Vert. = 2 ft



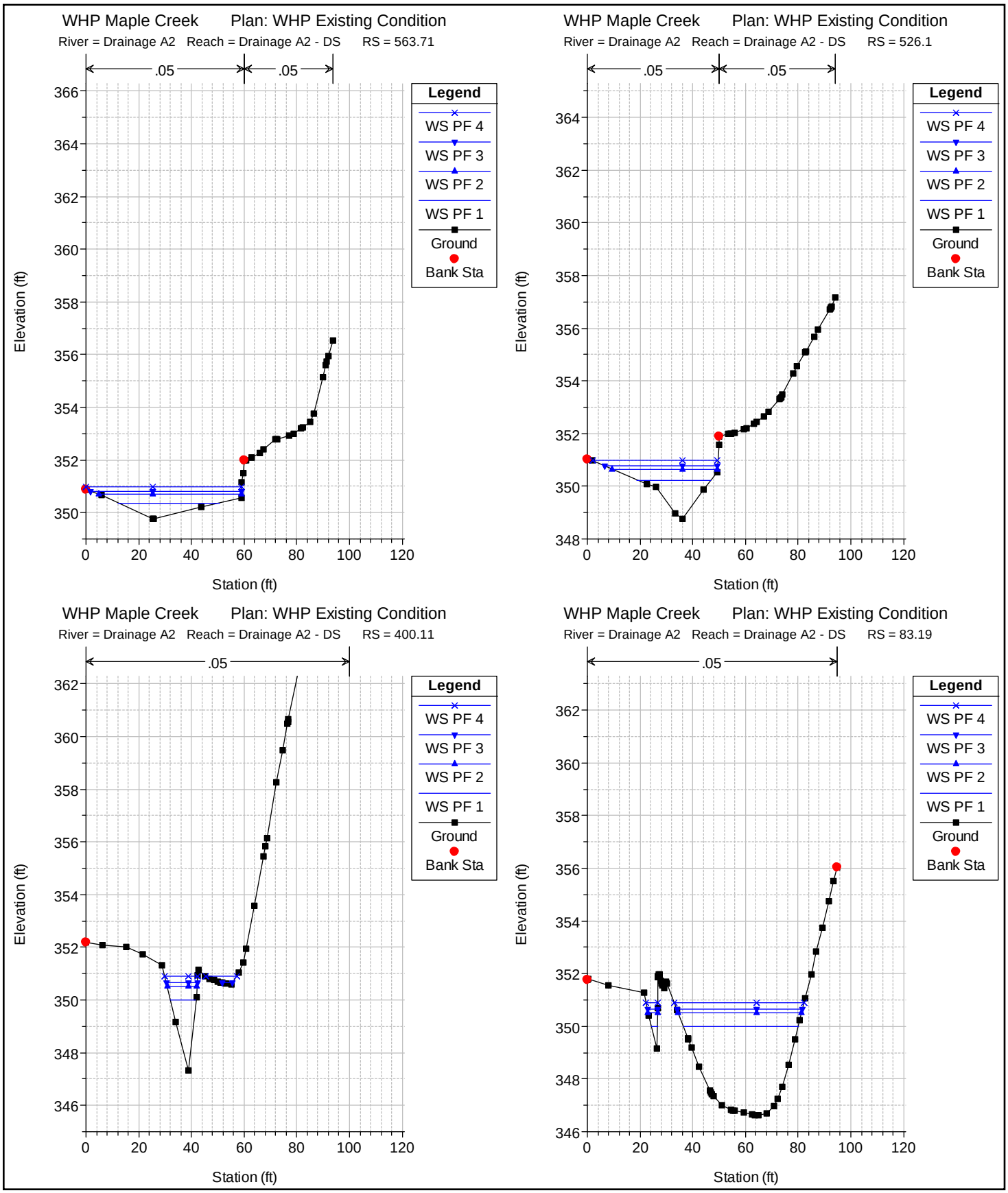
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



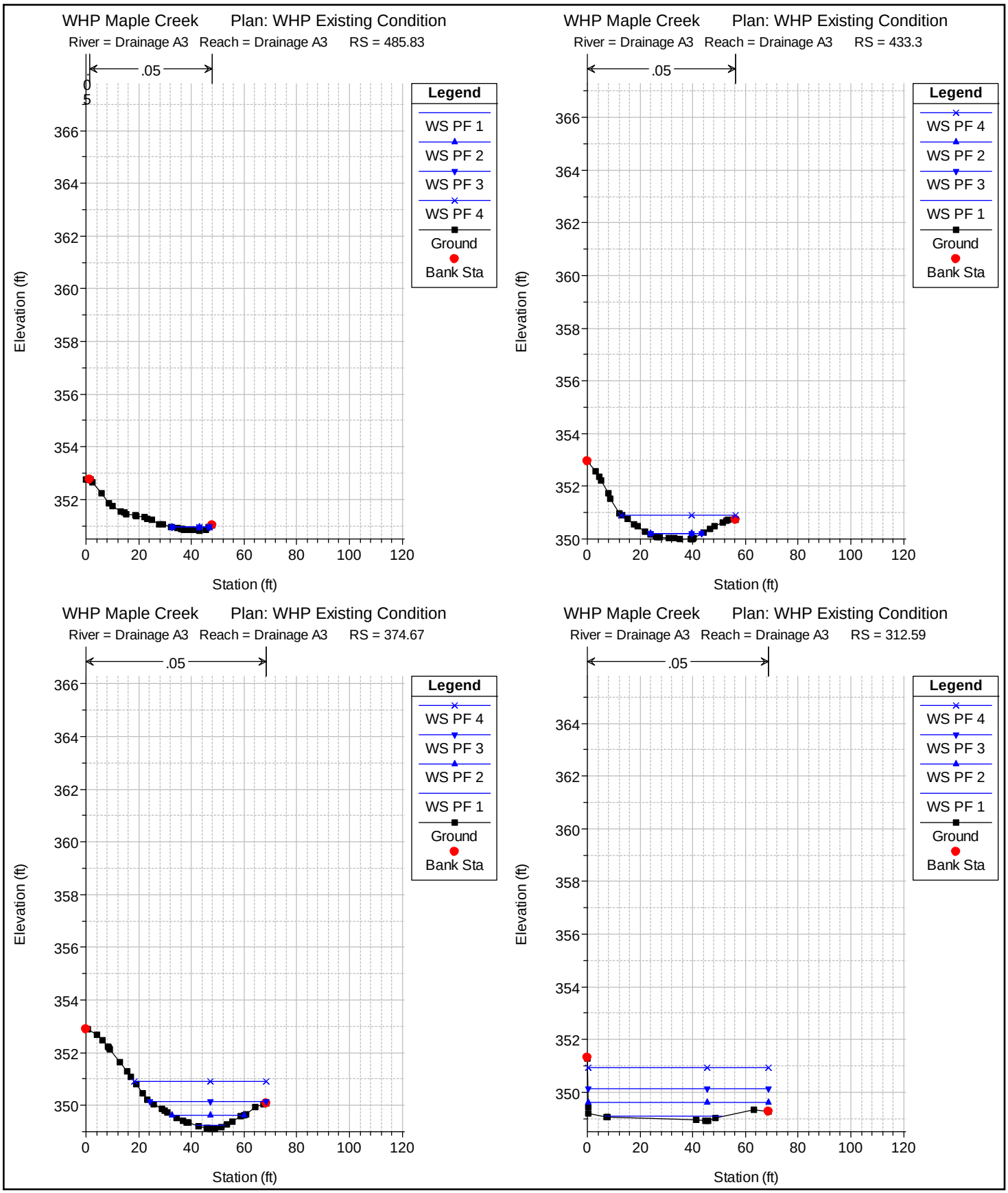
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



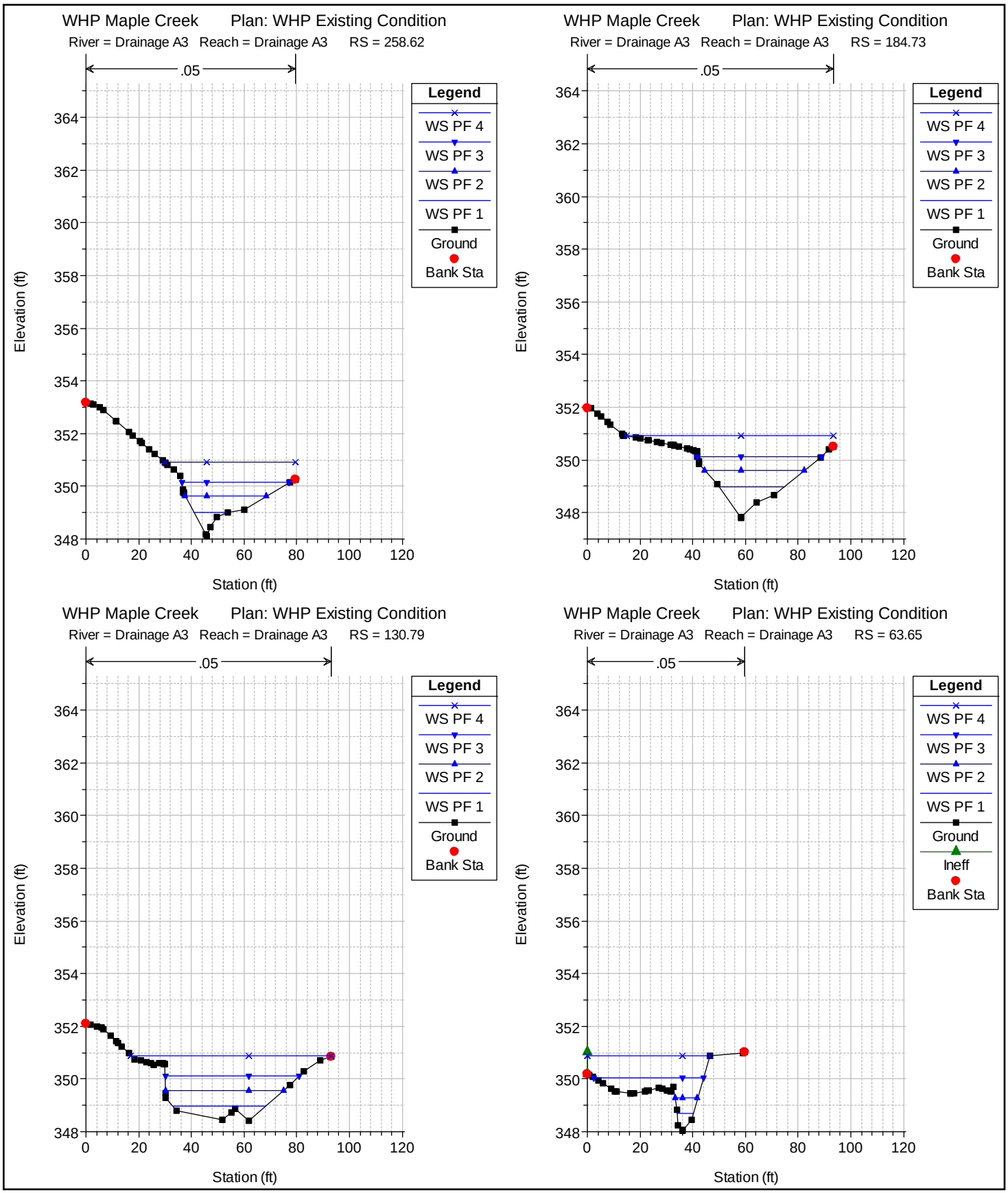
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



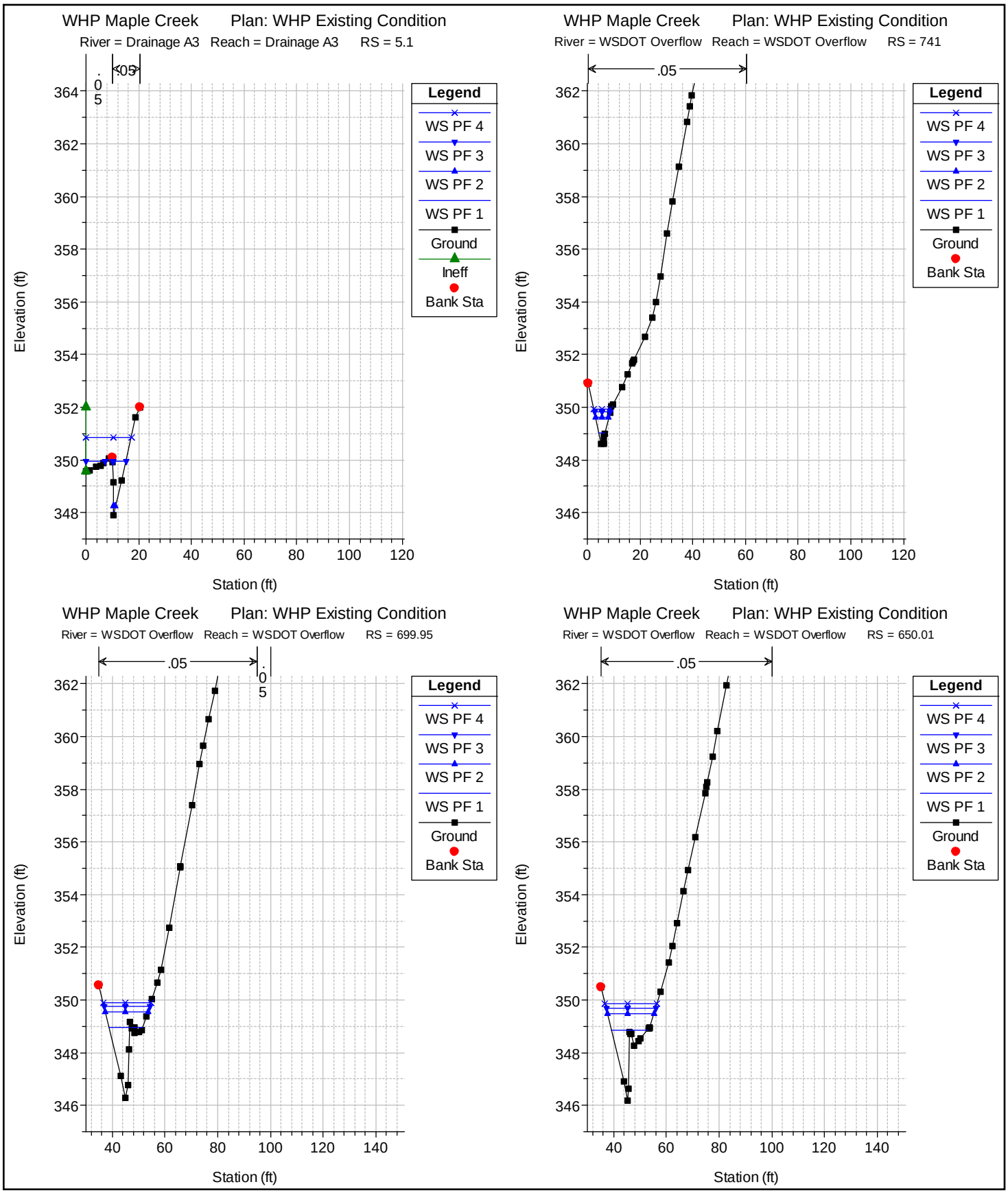
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



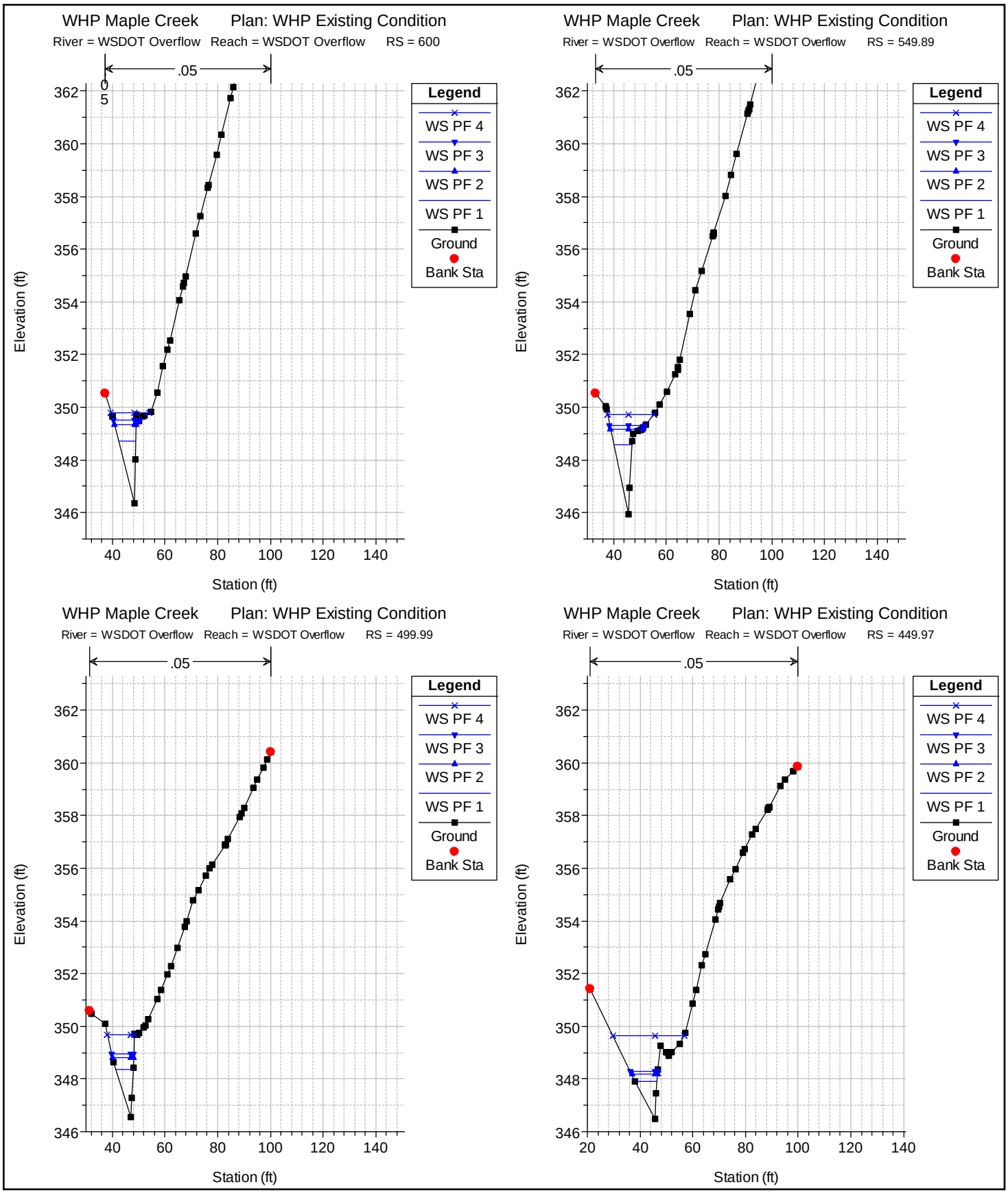
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



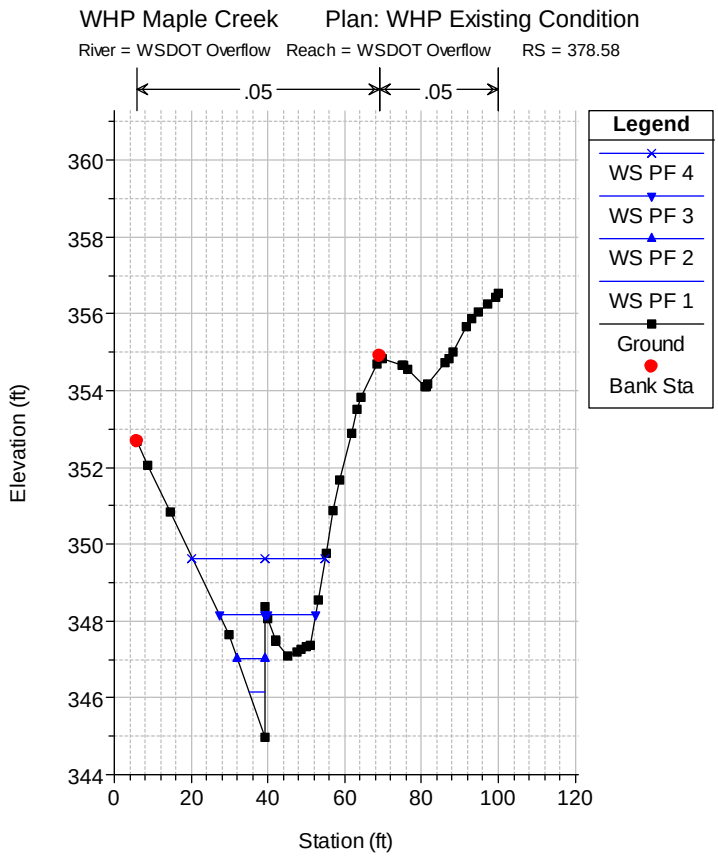
1 in Horiz. = 50 ft 1 in Vert. = 5 ft



1 in Horiz. = 50 ft 1 in Vert. = 5 ft



1 in Horiz. = 50 ft 1 in Vert. = 5 ft



1 in Horiz. = 50 ft 1 in Vert. = 5 ft

ATTACHMENT C

PROPOSED CONDITION HECRAS MODEL RESULTS

HEC-RAS Plan: WHP Conpt Alt7

River	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)	
WSDOT Overflow	WSDOT Overflow	741	PF 1	0.00	348.60	348.76	348.76	348.76	0.000000	0.00	0.18	1.36	0.00
WSDOT Overflow	WSDOT Overflow	741	PF 2	0.00	348.60	349.16	348.78	349.16	0.000000	0.00	1.01	2.94	0.00
WSDOT Overflow	WSDOT Overflow	741	PF 3	0.00	348.60	349.52	348.71	349.52	0.000000	0.00	2.36	4.58	0.00
WSDOT Overflow	WSDOT Overflow	741	PF 4	0.00	348.60	350.05	348.73	350.05	0.000000	0.00	5.45	6.92	0.00
WSDOT Overflow	WSDOT Overflow	699.95	PF 1	2.25	346.27	347.91	346.88	347.91	0.000416	0.49	4.63	5.14	0.09
WSDOT Overflow	WSDOT Overflow	699.95	PF 2	13.98	346.27	349.09	347.62	349.10	0.001463	1.02	13.67	13.42	0.18
WSDOT Overflow	WSDOT Overflow	699.95	PF 3	21.80	346.27	349.44	347.91	349.46	0.001464	1.16	18.86	15.59	0.19
WSDOT Overflow	WSDOT Overflow	699.95	PF 4	28.65	346.27	350.01	348.12	350.03	0.000788	1.00	28.71	18.95	0.14
WSDOT Overflow	WSDOT Overflow	650.01	PF 1	2.25	346.18	347.87	346.90	347.88	0.000920	0.64	3.54	4.33	0.12
WSDOT Overflow	WSDOT Overflow	650.01	PF 2	13.98	346.18	349.00	347.71	349.02	0.001895	1.06	13.18	15.03	0.20
WSDOT Overflow	WSDOT Overflow	650.01	PF 3	21.80	346.18	349.37	348.00	349.39	0.001582	1.15	19.02	17.05	0.19
WSDOT Overflow	WSDOT Overflow	650.01	PF 4	28.65	346.18	349.98	348.21	349.99	0.000712	0.94	30.41	20.43	0.14
WSDOT Overflow	WSDOT Overflow	600	PF 1	2.25	346.34	347.81	347.02	347.82	0.001549	0.77	2.93	3.98	0.16
WSDOT Overflow	WSDOT Overflow	600	PF 2	13.98	346.34	348.85	347.79	348.89	0.003383	1.63	8.59	6.93	0.26
WSDOT Overflow	WSDOT Overflow	600	PF 3	21.80	346.34	349.21	348.06	349.27	0.003974	1.93	11.27	7.96	0.29
WSDOT Overflow	WSDOT Overflow	600	PF 4	28.65	346.34	349.89	348.26	349.93	0.002774	1.54	18.57	15.66	0.25
WSDOT Overflow	WSDOT Overflow	549.89	PF 1	2.25	345.94	347.77	346.62	347.78	0.000530	0.53	4.28	4.71	0.10
WSDOT Overflow	WSDOT Overflow	549.89	PF 2	13.98	345.94	348.73	347.38	348.76	0.002116	1.40	10.01	7.23	0.21
WSDOT Overflow	WSDOT Overflow	549.89	PF 3	21.80	345.94	349.05	347.71	349.09	0.003173	1.75	12.49	9.12	0.26
WSDOT Overflow	WSDOT Overflow	549.89	PF 4	28.65	345.94	349.80	347.92	349.83	0.001490	1.23	23.38	18.37	0.19
WSDOT Overflow	WSDOT Overflow	499.99	PF 1	2.25	346.55	347.70	347.30	347.72	0.003762	1.03	2.18	3.97	0.25
WSDOT Overflow	WSDOT Overflow	499.99	PF 2	13.98	346.55	348.51	347.79	348.58	0.007220	2.10	6.66	7.10	0.38
WSDOT Overflow	WSDOT Overflow	499.99	PF 3	21.80	346.55	348.73	348.12	348.83	0.009625	2.63	8.28	7.77	0.45
WSDOT Overflow	WSDOT Overflow	499.99	PF 4	28.65	346.55	349.69	348.33	349.73	0.002298	1.69	16.92	10.23	0.23
WSDOT Overflow	WSDOT Overflow	449.97	PF 1	2.25	346.49	346.99	346.99	347.15	0.091812	3.25	0.69	2.78	1.15
WSDOT Overflow	WSDOT Overflow	449.97	PF 2	13.98	346.49	347.70	347.52	347.88	0.031049	3.40	4.11	6.91	0.78
WSDOT Overflow	WSDOT Overflow	449.97	PF 3	21.80	346.49	348.23	347.87	348.33	0.010509	2.54	8.58	10.04	0.48
WSDOT Overflow	WSDOT Overflow	449.97	PF 4	28.65	346.49	349.65	348.02	349.66	0.000721	0.87	32.85	26.88	0.14
WSDOT Overflow	WSDOT Overflow	378.58	PF 1	2.25	344.97	346.14	345.63	346.15	0.002775	0.91	2.47	4.22	0.21
WSDOT Overflow	WSDOT Overflow	378.58	PF 2	13.98	344.97	347.02	346.34	347.07	0.005368	1.84	7.58	7.40	0.32
WSDOT Overflow	WSDOT Overflow	378.58	PF 3	21.80	344.97	348.16	346.52	348.17	0.000707	0.78	28.00	24.67	0.13
WSDOT Overflow	WSDOT Overflow	378.58	PF 4	28.65	344.97	349.64	346.69	349.64	0.000079	0.40	72.22	34.66	0.05
Outlet	Outlet	1060.5	PF 1	17.61	346.96	349.25	347.46	349.26	0.000061	0.30	57.79	38.09	0.04
Outlet	Outlet	1060.5	PF 2	27.76	346.96	350.09	347.58	350.10	0.000038	0.30	93.09	46.14	0.04
Outlet	Outlet	1060.5	PF 3	29.59	346.96	350.40	347.60	350.41	0.000029	0.28	107.86	49.31	0.03
Outlet	Outlet	1060.5	PF 4	27.45	346.96	350.89	347.58	350.89	0.000014	0.21	132.98	54.48	0.02
Outlet	Outlet	1059		Lat Struct									
Outlet	Outlet	554.13	PF 1	17.61	344.85	349.15	346.69	349.17	0.001148	0.98	17.90	14.00	0.15
Outlet	Outlet	554.13	PF 2	27.76	344.85	350.04	347.06	350.05	0.000520	0.76	36.47	24.96	0.11
Outlet	Outlet	554.13	PF 3	29.59	344.85	350.36	347.11	350.37	0.000316	0.66	44.82	26.30	0.09
Outlet	Outlet	554.13	PF 4	27.45	344.85	350.87	347.05	350.87	0.000118	0.47	59.63	31.40	0.06

HEC-RAS Plan: WHP Conpt Alt7 (Continued)

River	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)	
Outlet	Outlet	553		Lat Struct									
Outlet	Outlet	522.38	PF 1	15.36	344.59	349.07	345.80	349.10	0.003089	1.55	10.04	10.00	0.13
Outlet	Outlet	522.38	PF 2	13.77	344.59	350.01	345.71	350.03	0.000867	0.94	14.77	10.00	0.07
Outlet	Outlet	522.38	PF 3	7.79	344.59	350.36	345.29	350.36	0.000192	0.46	16.48	10.00	0.04
Outlet	Outlet	522.38	PF 4	0.09	344.59	350.87	344.74	350.87	0.000000	0.00	20.40	10.00	0.00
Outlet	Outlet	487		Culvert									
Outlet	Outlet	450.72	PF 1	15.36	343.59	347.48	344.66	347.48	0.000359	0.55	27.83	47.91	0.09
Outlet	Outlet	450.72	PF 2	13.77	343.59	348.72	344.59	348.72	0.000025	0.22	63.63	91.56	0.03
Outlet	Outlet	450.72	PF 3	7.79	343.59	349.94	344.34	349.94	0.000001	0.06	167.08	100.00	0.01
Outlet	Outlet	450.72	PF 4	0.09	343.59	350.87	343.68	350.87	0.000000	0.00	259.88	100.00	0.00
Outlet	Outlet	448.08	PF 1	15.36	343.59	347.48	344.71	347.48	0.000285	0.51	30.02	64.40	0.08
Outlet	Outlet	448.08	PF 2	13.77	343.59	348.72	344.73	348.72	0.000022	0.21	66.66	100.00	0.03
Outlet	Outlet	448.08	PF 3	7.79	343.59	349.94	344.31	349.94	0.000001	0.07	107.01	100.00	0.01
Outlet	Outlet	448.08	PF 4	0.09	343.59	350.87	343.76	350.87	0.000000	0.00	137.65	100.00	0.00
Outlet	Outlet	426.4	PF 1	15.36	343.59	347.48	344.58	347.48	0.000007	0.13	118.27	100.00	0.02
Outlet	Outlet	426.4	PF 2	13.77	343.59	348.72	344.53	348.72	0.000001	0.07	187.28	100.00	0.01
Outlet	Outlet	426.4	PF 3	7.79	343.59	349.94	344.37	349.94	0.000000	0.03	255.42	100.00	0.00
Outlet	Outlet	426.4	PF 4	0.09	343.59	350.87	343.71	350.87	0.000000	0.00	307.14	100.00	0.00
Outlet	Outlet	350	PF 1	15.36	343.30	347.48	344.20	347.48	0.000012	0.15	108.30	66.58	0.02
Outlet	Outlet	350	PF 2	13.77	343.30	348.72	344.14	348.72	0.000002	0.08	204.00	85.26	0.01
Outlet	Outlet	350	PF 3	7.79	343.30	349.94	343.95	349.94	0.000000	0.03	322.23	100.00	0.00
Outlet	Outlet	350	PF 4	0.09	343.30	350.87	343.49	350.87	0.000000	0.00	415.03	100.00	0.00
Outlet	Outlet	300.01	PF 1	15.36	343.00	347.48	344.45	347.48	0.000048	0.24	63.29	44.30	0.04
Outlet	Outlet	300.01	PF 2	13.77	343.00	348.72	344.36	348.72	0.000004	0.11	137.60	72.91	0.01
Outlet	Outlet	300.01	PF 3	7.79	343.00	349.94	343.95	349.94	0.000000	0.04	236.34	82.98	0.00
Outlet	Outlet	300.01	PF 4	0.09	343.00	350.87	343.21	350.87	0.000000	0.00	313.35	82.98	0.00
Outlet	Outlet	253.22	PF 1	15.36	342.80	347.48	343.90	347.48	0.000059	0.32	48.23	32.53	0.04
Outlet	Outlet	253.22	PF 2	13.77	342.80	348.72	343.75	348.72	0.000009	0.16	84.69	42.78	0.02
Outlet	Outlet	253.22	PF 3	7.79	342.80	349.94	343.48	349.94	0.000001	0.06	153.94	73.13	0.01
Outlet	Outlet	253.22	PF 4	0.09	342.80	350.87	342.92	350.87	0.000000	0.00	216.24	73.13	0.00
Outlet	Outlet	237.18	PF 1	15.36	342.60	347.46	344.03	347.47	0.001384	0.96	16.06	13.08	0.15
Outlet	Outlet	237.18	PF 2	13.77	342.60	348.72	343.94	348.72	0.000100	0.34	40.43	25.75	0.05
Outlet	Outlet	237.18	PF 3	7.79	342.60	349.94	343.70	349.94	0.000003	0.09	104.62	65.89	0.01
Outlet	Outlet	237.18	PF 4	0.09	342.60	350.87	342.77	350.87	0.000000	0.00	165.78	65.89	0.00
Outlet	Outlet	231.56	PF 1	15.36	342.59	347.45	343.46	347.47	0.001048	1.05	14.58	3.00	0.08
Outlet	Outlet	231.56	PF 2	13.77	342.59	348.71	343.43	348.72	0.000553	0.74	18.58	11.16	0.07
Outlet	Outlet	231.56	PF 3	7.79	342.59	349.94	343.10	349.94	0.000018	0.13	66.14	64.76	0.02
Outlet	Outlet	231.56	PF 4	0.09	342.59	350.87	342.77	350.87	0.000000	0.00	126.47	64.99	0.00
Outlet	Outlet	200		Culvert									

HEC-RAS Plan: WHP Conpt Alt7 (Continued)

River	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)	
Outlet	Outlet	187.41	PF 1	15.36	342.37	346.90	343.47	346.91	0.000294	0.90	17.08	17.08	0.08
Outlet	Outlet	187.41	PF 2	13.77	342.37	348.26	343.50	348.26	0.000087	0.60	23.07	64.44	0.05
Outlet	Outlet	187.41	PF 3	7.79	342.37	349.94	343.06	349.94	0.000006	0.09	90.39	68.14	0.01
Outlet	Outlet	187.41	PF 4	0.09	342.37	350.87	342.52	350.87	0.000000	0.00	153.76	68.14	0.00
Outlet	Outlet	181.1	PF 1	15.36	342.37	346.90	343.65	346.90	0.000078	0.32	48.28	40.83	0.05
Outlet	Outlet	181.1	PF 2	13.77	342.37	348.26	343.62	348.26	0.000007	0.12	113.08	85.76	0.01
Outlet	Outlet	181.1	PF 3	7.79	342.37	349.94	343.38	349.94	0.000000	0.04	228.09	85.76	0.00
Outlet	Outlet	181.1	PF 4	0.09	342.37	350.87	342.52	350.87	0.000000	0.00	302.26	85.76	0.00
Main Channel	Main Chan-Middle	241.97	PF 1	0.51	346.73	349.72	346.92	349.72	0.000000	0.02	23.83	14.94	0.00
Main Channel	Main Chan-Middle	241.97	PF 2	0.76	346.73	350.39	346.90	350.39	0.000000	0.02	36.55	23.28	0.00
Main Channel	Main Chan-Middle	241.97	PF 3	0.88	346.73	350.76	346.91	350.76	0.000000	0.02	46.13	28.51	0.00
Main Channel	Main Chan-Middle	241.97	PF 4	1.07	346.73	351.39	346.95	351.39	0.000000	0.02	72.13	62.77	0.00
Main Channel	Main Chan-Middle	241		Lat Struct									
Main Channel	Main Chan-Middle	200.07	PF 1	16.90	346.07	349.72	346.89	349.72	0.000094	0.46	38.77	26.19	0.05
Main Channel	Main Chan-Middle	200.07	PF 2	35.00	346.07	350.38	347.32	350.39	0.000159	0.68	58.37	32.57	0.07
Main Channel	Main Chan-Middle	200.07	PF 3	44.29	346.07	350.75	347.46	350.76	0.000159	0.72	71.04	36.26	0.07
Main Channel	Main Chan-Middle	200.07	PF 4	60.62	346.07	351.38	347.71	351.38	0.000140	0.75	101.72	75.00	0.07
Main Channel	Main Chan-Middle	168	PF 1	16.90	345.72	349.72	346.45	349.72	0.000068	0.40	42.21	17.80	0.05
Main Channel	Main Chan-Middle	168	PF 2	35.00	345.72	350.38	346.95	350.38	0.000172	0.62	56.64	25.72	0.07
Main Channel	Main Chan-Middle	168	PF 3	44.29	345.72	350.75	346.97	350.75	0.000192	0.66	66.95	32.05	0.08
Main Channel	Main Chan-Middle	168	PF 4	60.62	345.72	351.37	347.26	351.38	0.000138	0.63	94.00	62.79	0.07
Main Channel	Main Chan-Middle	166	PF 1	16.90	348.10	349.70	348.77	349.71	0.001168	1.03	16.36	15.47	0.18
Main Channel	Main Chan-Middle	166	PF 2	35.00	348.10	350.35	348.98	350.38	0.001173	1.25	27.93	19.77	0.19
Main Channel	Main Chan-Middle	166	PF 3	44.29	348.10	350.72	349.15	350.75	0.000971	1.24	35.67	22.19	0.17
Main Channel	Main Chan-Middle	166	PF 4	60.62	348.10	351.35	349.35	351.37	0.000659	1.20	50.49	24.00	0.15
Main Channel	Main Chan-Middle	150		Culvert									
Main Channel	Main Chan-Middle	102	PF 1	16.90	348.00	349.67	348.68	349.68	0.001005	0.98	17.17	15.57	0.17
Main Channel	Main Chan-Middle	102	PF 2	35.00	348.00	350.28	348.90	350.30	0.001160	1.26	27.86	19.44	0.18
Main Channel	Main Chan-Middle	102	PF 3	44.29	348.00	350.63	349.06	350.66	0.000999	1.26	35.06	21.66	0.18
Main Channel	Main Chan-Middle	102	PF 4	60.62	348.00	351.20	349.26	351.22	0.000756	1.26	48.27	24.00	0.16
Main Channel	Main Chan-Middle	100	PF 1	16.90	348.00	349.67	348.60	349.68	0.001021	0.99	17.03	15.42	0.17
Main Channel	Main Chan-Middle	100	PF 2	35.00	348.00	350.28	348.90	350.30	0.001181	1.27	27.60	19.23	0.19
Main Channel	Main Chan-Middle	100	PF 3	44.29	348.00	350.63	349.07	350.65	0.001017	1.28	34.72	21.43	0.18
Main Channel	Main Chan-Middle	100	PF 4	60.62	348.00	351.20	349.26	351.22	0.000801	1.26	47.93	24.98	0.16
Main Channel	Main Chan-Middle	75		Culvert									
Main Channel	Main Chan-Middle	45	PF 1	16.90	348.00	349.63	348.60	349.65	0.001110	1.02	16.52	15.21	0.17
Main Channel	Main Chan-Middle	45	PF 2	35.00	348.00	350.19	348.90	350.22	0.001392	1.35	25.97	18.70	0.20
Main Channel	Main Chan-Middle	45	PF 3	44.29	348.00	350.52	349.06	350.55	0.001218	1.36	32.49	20.76	0.19
Main Channel	Main Chan-Middle	45	PF 4	60.62	348.00	351.03	349.27	351.06	0.001016	1.38	43.86	23.94	0.18

HEC-RAS Plan: WHP Conpt Alt7 (Continued)

River	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)	
Main Channel	Main Chan-Middle	30	PF 1	16.90	348.00	349.62	348.60	349.63	0.001161	1.04	16.25	15.10	0.18
Main Channel	Main Chan-Middle	30	PF 2	35.00	348.00	350.17	348.90	350.20	0.001455	1.37	25.55	18.56	0.21
Main Channel	Main Chan-Middle	30	PF 3	44.29	348.00	350.50	349.07	350.53	0.001260	1.38	32.08	20.64	0.20
Main Channel	Main Chan-Middle	30	PF 4	60.62	348.00	351.01	349.20	351.04	0.001041	1.39	43.48	23.84	0.18
Main Channel	Main Channel-US	2821.03	PF 1	5.41	358.01	358.51	358.51	358.56	0.021117	1.79	3.02	11.24	0.61
Main Channel	Main Channel-US	2821.03	PF 2	8.87	358.01	358.54	358.54	358.65	0.041562	2.61	3.39	11.91	0.86
Main Channel	Main Channel-US	2821.03	PF 3	10.66	358.01	358.52	358.52	358.70	0.074407	3.41	3.13	11.44	1.15
Main Channel	Main Channel-US	2821.03	PF 4	13.38	358.01	358.60	358.60	358.76	0.054027	3.20	4.18	13.23	1.00
Main Channel	Main Channel-US	2598.1	PF 1	5.41	353.34	353.86	353.61	353.88	0.004647	1.00	5.40	15.44	0.30
Main Channel	Main Channel-US	2598.1	PF 2	8.87	353.34	354.01	353.73	354.03	0.004243	1.13	7.85	17.55	0.30
Main Channel	Main Channel-US	2598.1	PF 3	10.66	353.34	354.07	353.71	354.09	0.004246	1.19	8.94	18.40	0.30
Main Channel	Main Channel-US	2598.1	PF 4	13.38	353.34	354.17	353.79	354.19	0.004000	1.25	10.73	19.77	0.30
Main Channel	Main Channel-US	2491.3	PF 1	5.41	352.19	352.58	352.58	352.68	0.038052	2.61	2.07	6.67	0.83
Main Channel	Main Channel-US	2491.3	PF 2	8.87	352.19	352.65	352.65	352.83	0.053023	3.41	2.60	7.19	1.00
Main Channel	Main Channel-US	2491.3	PF 3	10.66	352.19	352.70	352.70	352.90	0.053826	3.62	2.94	7.51	1.02
Main Channel	Main Channel-US	2491.3	PF 4	13.38	352.19	352.74	352.74	353.00	0.064737	4.13	3.24	7.78	1.13
Main Channel	Main Channel-US	2460		Lat Struct									
Main Channel	Main Channel-US	2416.6	PF 1	5.41	350.20	351.28	350.72	351.29	0.002447	1.09	4.99	7.05	0.23
Main Channel	Main Channel-US	2416.6	PF 2	8.87	350.20	351.55	350.83	351.57	0.002537	1.25	7.10	8.29	0.24
Main Channel	Main Channel-US	2416.6	PF 3	10.66	350.20	351.68	350.88	351.71	0.002861	1.29	8.24	10.13	0.25
Main Channel	Main Channel-US	2416.6	PF 4	13.38	350.20	351.81	351.17	351.84	0.003719	1.35	9.91	14.21	0.28
Main Channel	Main Channel-US	2366.15	PF 1	5.41	349.78	351.18	350.32	351.20	0.001481	0.93	5.82	6.30	0.17
Main Channel	Main Channel-US	2366.15	PF 2	8.87	349.78	351.45	350.41	351.47	0.001963	1.16	7.64	7.31	0.20
Main Channel	Main Channel-US	2366.15	PF 3	10.66	349.78	351.55	350.49	351.58	0.002225	1.27	8.38	7.68	0.21
Main Channel	Main Channel-US	2366.15	PF 4	13.38	349.78	351.66	350.55	351.69	0.002708	1.45	9.25	8.09	0.24
Main Channel	Main Channel-US	2278.17	PF 1	5.41	350.00	351.13	350.34	351.13	0.000373	0.39	15.78	46.86	0.09
Main Channel	Main Channel-US	2278.17	PF 2	8.87	350.00	351.42	350.40	351.43	0.000207	0.30	31.70	61.07	0.07
Main Channel	Main Channel-US	2278.17	PF 3	10.66	350.00	351.53	350.44	351.53	0.000162	0.30	38.33	61.37	0.06
Main Channel	Main Channel-US	2278.17	PF 4	13.38	350.00	351.65	350.47	351.65	0.000146	0.31	45.51	61.70	0.06
Main Channel	Main Channel-US	2264.91	PF 1	5.41	349.00	351.13	349.29	351.13	0.000037	0.20	27.49	28.00	0.03
Main Channel	Main Channel-US	2264.91	PF 2	8.87	349.00	351.42	349.35	351.42	0.000049	0.26	34.25	46.62	0.04
Main Channel	Main Channel-US	2264.91	PF 3	10.66	349.00	351.53	349.45	351.53	0.000055	0.29	37.99	47.80	0.04
Main Channel	Main Channel-US	2264.91	PF 4	13.38	349.00	351.65	349.52	351.65	0.000066	0.33	42.21	48.81	0.05
Main Channel	Main Channel-US	2235		Culvert									
Main Channel	Main Channel-US	2206.45	PF 1	5.41	348.65	349.67	349.01	349.68	0.001295	0.85	6.36	8.51	0.17
Main Channel	Main Channel-US	2206.45	PF 2	8.87	348.65	350.26	349.20	350.26	0.000800	0.61	14.50	28.97	0.14
Main Channel	Main Channel-US	2206.45	PF 3	10.66	348.65	350.63	349.12	350.63	0.000280	0.45	23.63	37.52	0.08
Main Channel	Main Channel-US	2206.45	PF 4	13.38	348.65	351.20	349.26	351.20	0.000088	0.32	41.94	58.82	0.05
Main Channel	Main Channel-US	2205		Lat Struct									

HEC-RAS Plan: WHP Conpt Alt7 (Continued)

River	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)	
Main Channel	Main Channel-US	2198.06	PF 1	5.41	348.57	349.67	348.84	349.67	0.000186	0.33	16.35	21.99	0.07
Main Channel	Main Channel-US	2198.06	PF 2	8.87	348.57	350.26	348.88	350.26	0.000080	0.28	31.65	29.02	0.05
Main Channel	Main Channel-US	2198.06	PF 3	10.66	348.57	350.63	348.92	350.63	0.000042	0.25	44.53	41.14	0.04
Main Channel	Main Channel-US	2198.06	PF 4	13.38	348.57	351.20	348.95	351.20	0.000015	0.18	73.60	59.58	0.02
Main Channel	Main Channel-US	2166	PF 1	5.80	348.15	349.66	348.49	349.66	0.000071	0.22	26.44	31.98	0.04
Main Channel	Main Channel-US	2166	PF 2	9.50	348.15	350.26	348.67	350.26	0.000037	0.20	48.14	42.55	0.03
Main Channel	Main Channel-US	2166	PF 3	11.40	348.15	350.63	348.69	350.63	0.000022	0.17	65.94	53.71	0.03
Main Channel	Main Channel-US	2166	PF 4	14.30	348.15	351.20	348.67	351.20	0.000009	0.13	101.92	71.11	0.02
Main Channel	Main Channel-US	2148	PF 1	5.80	348.10	349.66	348.52	349.66	0.000194	0.40	14.35	14.40	0.07
Main Channel	Main Channel-US	2148	PF 2	9.50	348.10	350.25	348.58	350.26	0.000129	0.39	24.06	18.35	0.06
Main Channel	Main Channel-US	2148	PF 3	11.40	348.10	350.62	348.64	350.62	0.000091	0.36	31.31	20.82	0.05
Main Channel	Main Channel-US	2148	PF 4	14.30	348.10	351.20	348.69	351.20	0.000056	0.32	44.43	24.67	0.04
Main Channel	Main Channel-US	2140		Culvert									
Main Channel	Main Channel-US	2072	PF 1	5.80	348.00	349.62	348.43	349.63	0.000168	0.39	15.06	14.55	0.07
Main Channel	Main Channel-US	2072	PF 2	9.50	348.00	350.18	348.48	350.18	0.000125	0.39	24.19	18.18	0.06
Main Channel	Main Channel-US	2072	PF 3	11.40	348.00	350.52	348.54	350.52	0.000095	0.37	30.65	20.36	0.05
Main Channel	Main Channel-US	2072	PF 4	14.30	348.00	351.03	348.60	351.03	0.000064	0.34	41.98	23.70	0.05
Main Channel	Main Channel-US	2062	PF 1	5.80	347.99	349.62	348.34	349.62	0.000160	0.38	15.38	14.85	0.07
Main Channel	Main Channel-US	2062	PF 2	9.50	347.99	350.18	348.41	350.18	0.000120	0.38	24.70	18.55	0.06
Main Channel	Main Channel-US	2062	PF 3	11.40	347.99	350.52	348.49	350.52	0.000091	0.36	31.29	20.78	0.05
Main Channel	Main Channel-US	2062	PF 4	14.30	347.99	351.03	348.53	351.03	0.000061	0.33	42.87	24.00	0.04
Main Channel	Main Channel-DS	1800	PF 1	18.28	346.61	349.78	347.52	349.79	0.000234	0.68	26.95	11.73	0.08
Main Channel	Main Channel-DS	1800	PF 2	39.74	346.61	350.54	347.73	350.56	0.000722	1.05	37.69	21.25	0.14
Main Channel	Main Channel-DS	1800	PF 3	47.00	346.61	350.89	347.80	350.91	0.000711	1.01	46.70	28.77	0.14
Main Channel	Main Channel-DS	1800	PF 4	56.90	346.61	351.48	348.02	351.49	0.000431	0.86	66.09	35.99	0.11
Main Channel	Main Channel-DS	1699.96	PF 1	18.28	346.84	349.74	347.73	349.76	0.000474	0.86	21.28	9.95	0.10
Main Channel	Main Channel-DS	1699.96	PF 2	39.74	346.84	350.44	348.04	350.46	0.001212	1.27	31.40	18.20	0.17
Main Channel	Main Channel-DS	1699.96	PF 3	47.00	346.84	350.80	348.21	350.82	0.001045	1.22	38.49	21.26	0.16
Main Channel	Main Channel-DS	1699.96	PF 4	56.90	346.84	351.42	348.38	351.44	0.000646	1.08	52.90	24.81	0.13
Main Channel	Main Channel-DS	1699		Lat Struct									
Main Channel	Main Channel-DS	1611.36	PF 1	1.89	346.69	349.74	346.99	349.74	0.000006	0.09	20.41	11.38	0.01
Main Channel	Main Channel-DS	1611.36	PF 2	5.50	346.69	350.42	347.15	350.42	0.000025	0.18	30.46	18.17	0.02
Main Channel	Main Channel-DS	1611.36	PF 3	3.59	346.69	350.79	347.14	350.79	0.000006	0.10	37.68	21.09	0.01
Main Channel	Main Channel-DS	1611.36	PF 4	0.06	346.69	351.42	346.83	351.42	0.000000	0.00	52.24	24.36	0.00
Main Channel	Main Channel-DS	1577.89	PF 1	8.61	346.69	349.73	347.23	349.74	0.000048	0.42	20.48	85.84	0.04
Main Channel	Main Channel-DS	1577.89	PF 2	7.76	346.69	350.42	347.23	350.42	0.000019	0.31	25.27	89.98	0.03
Main Channel	Main Channel-DS	1577.89	PF 3	8.59	346.69	350.78	347.23	350.79	0.000017	0.31	27.83	94.84	0.03
Main Channel	Main Channel-DS	1577.89	PF 4	10.45	346.69	351.42	347.14	351.42	0.000016	0.32	32.24	100.00	0.03
Main Channel	Main Channel-DS	1525		Culvert									

HEC-RAS Plan: WHP Conpt Alt7 (Continued)

River	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)	
Main Channel	Main Channel-DS	1523.05	PF 1	8.61	346.61	349.51	347.09	349.51	0.000077	0.51	16.80	73.63	0.05
Main Channel	Main Channel-DS	1523.05	PF 2	7.76	346.61	350.24	347.04	350.25	0.000029	0.37	21.20	83.40	0.03
Main Channel	Main Channel-DS	1523.05	PF 3	8.59	346.61	350.57	347.09	350.57	0.000026	0.37	23.17	87.72	0.03
Main Channel	Main Channel-DS	1523.05	PF 4	10.45	346.61	351.10	347.15	351.10	0.000025	0.40	26.33	93.78	0.03
Main Channel	Main Channel-DS	1518		Lat Struct									
Main Channel	Main Channel-DS	1506.58	PF 1	8.61	346.61	349.50	347.63	349.51	0.000462	0.70	12.32	8.26	0.10
Main Channel	Main Channel-DS	1506.58	PF 2	7.76	346.61	350.24	347.58	350.24	0.000117	0.40	19.42	11.13	0.05
Main Channel	Main Channel-DS	1506.58	PF 3	8.59	346.61	350.57	347.63	350.57	0.000090	0.37	23.30	12.54	0.05
Main Channel	Main Channel-DS	1506.58	PF 4	10.45	346.61	351.10	347.74	351.10	0.000066	0.34	30.51	14.84	0.04
Main Channel	Main Channel-DS	1486.04	PF 1	8.61	346.60	349.50	347.70	349.50	0.000416	0.65	13.35	8.81	0.09
Main Channel	Main Channel-DS	1486.04	PF 2	7.76	346.60	350.24	347.66	350.24	0.000103	0.38	20.43	10.26	0.05
Main Channel	Main Channel-DS	1486.04	PF 3	8.59	346.60	350.57	347.70	350.57	0.000082	0.36	23.91	10.95	0.04
Main Channel	Main Channel-DS	1486.04	PF 4	10.45	346.60	351.10	347.77	351.10	0.000067	0.35	30.03	12.56	0.04
Main Channel	Main Channel-DS	1450.04	PF 1	7.49	346.46	349.49	347.35	349.49	0.000135	0.40	18.62	11.65	0.06
Main Channel	Main Channel-DS	1450.04	PF 2	5.90	346.46	350.24	347.38	350.24	0.000027	0.21	28.24	14.03	0.03
Main Channel	Main Channel-DS	1450.04	PF 3	6.30	346.46	350.57	347.41	350.57	0.000020	0.19	33.03	15.07	0.02
Main Channel	Main Channel-DS	1450.04	PF 4	7.10	346.46	351.10	347.30	351.10	0.000014	0.17	41.42	16.75	0.02
Main Channel	Main Channel-DS	1400.03	PF 1	7.49	345.92	349.48	346.92	349.49	0.000121	0.34	21.78	14.86	0.05
Main Channel	Main Channel-DS	1400.03	PF 2	5.90	345.92	350.24	346.84	350.24	0.000022	0.17	35.65	21.42	0.02
Main Channel	Main Channel-DS	1400.03	PF 3	6.30	345.92	350.57	346.86	350.57	0.000015	0.15	43.03	23.49	0.02
Main Channel	Main Channel-DS	1400.03	PF 4	7.10	345.92	351.10	346.91	351.10	0.000009	0.13	56.40	27.37	0.02
Main Channel	Main Channel-DS	1369.93	PF 1	7.49	345.00	349.48	345.47	349.48	0.000002	0.07	110.27	55.13	0.01
Main Channel	Main Channel-DS	1369.93	PF 2	5.90	345.00	350.24	345.45	350.24	0.000000	0.04	164.43	84.75	0.00
Main Channel	Main Channel-DS	1369.93	PF 3	6.30	345.00	350.57	345.46	350.57	0.000000	0.04	193.41	89.85	0.00
Main Channel	Main Channel-DS	1369.93	PF 4	7.10	345.00	351.10	345.47	351.10	0.000000	0.03	242.39	97.16	0.00
Main Channel	Main Channel-DS	1363.32	PF 1	7.49	345.76	349.48	346.26	349.48	0.000068	0.58	12.84	76.27	0.05
Main Channel	Main Channel-DS	1363.32	PF 2	5.90	345.76	350.24	346.33	350.24	0.000023	0.38	15.49	86.87	0.03
Main Channel	Main Channel-DS	1363.32	PF 3	6.30	345.76	350.57	346.33	350.57	0.000020	0.38	16.64	89.04	0.03
Main Channel	Main Channel-DS	1363.32	PF 4	7.10	345.76	351.09	346.37	351.09	0.000018	0.38	18.48	100.00	0.03
Main Channel	Main Channel-DS	1225		Culvert									
Main Channel	Main Channel-DS	1105.06	PF 1	7.49	343.99	349.26	344.92	349.26	0.000011	0.27	27.39	100.00	0.02
Main Channel	Main Channel-DS	1105.06	PF 2	5.90	343.99	350.10	344.91	350.10	0.000004	0.18	32.44	100.00	0.01
Main Channel	Main Channel-DS	1105.06	PF 3	6.30	343.99	350.41	344.91	350.41	0.000004	0.18	34.29	100.00	0.01
Main Channel	Main Channel-DS	1105.06	PF 4	7.10	343.99	350.89	344.91	350.89	0.000004	0.19	37.20	100.00	0.01
Main Channel	Main Channel-DS	1100.04	PF 1	7.49	344.15	349.26	344.41	349.26	0.000000	0.02	459.32	100.00	0.00
Main Channel	Main Channel-DS	1100.04	PF 2	5.90	344.15	350.10	344.38	350.10	0.000000	0.01	543.33	100.00	0.00
Main Channel	Main Channel-DS	1100.04	PF 3	6.30	344.15	350.41	344.39	350.41	0.000000	0.01	574.23	100.00	0.00
Main Channel	Main Channel-DS	1100.04	PF 4	7.10	344.15	350.89	344.41	350.89	0.000000	0.01	622.66	100.00	0.00
Drainage A3	Drainage A3 - US	485.83	PF 1	0.12	350.82	350.95	350.95	350.95	0.000373	0.11	1.13	14.15	0.07

HEC-RAS Plan: WHP Conpt Alt7 (Continued)

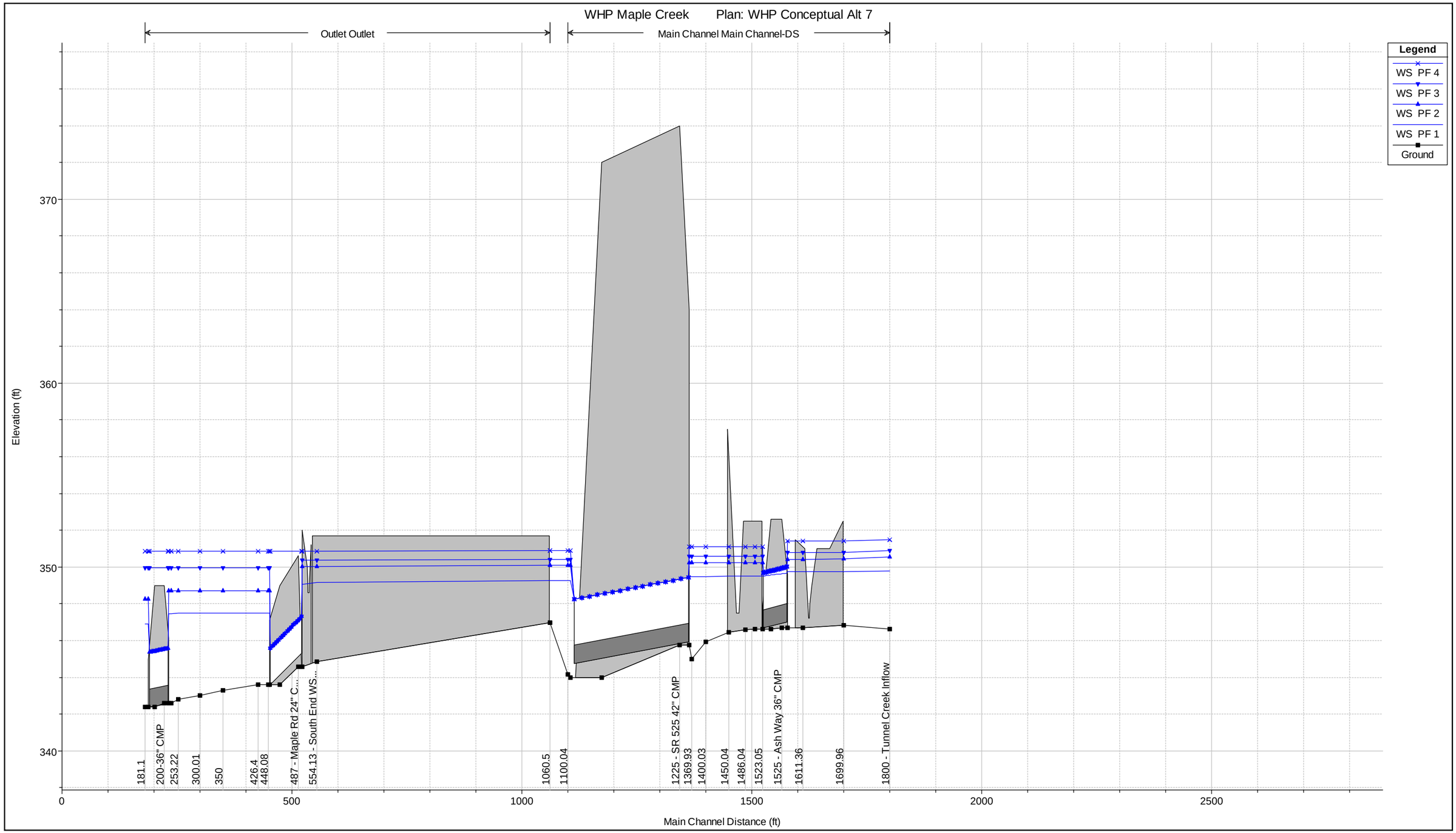
River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Drainage A3	Drainage A3 - US	485.83	PF 2	0.18	350.82	350.95	350.95	350.95	0.000840	0.16	1.13	14.15	0.10
Drainage A3	Drainage A3 - US	485.83	PF 3	0.21	350.82	350.95	350.95	350.95	0.001143	0.19	1.13	14.15	0.12
Drainage A3	Drainage A3 - US	485.83	PF 4	0.25	350.82	351.02	350.95	351.02	0.000207	0.11	2.31	18.05	0.05
Drainage A3	Drainage A3 - US	433.3	PF 1	0.12	350.00	350.19	350.19	350.19	0.000032	0.04	2.67	19.34	0.02
Drainage A3	Drainage A3 - US	433.3	PF 2	0.18	350.00	350.19	350.19	350.19	0.000072	0.07	2.67	19.34	0.03
Drainage A3	Drainage A3 - US	433.3	PF 3	0.21	350.00	350.51	350.19	350.51	0.000002	0.02	10.66	30.71	0.01
Drainage A3	Drainage A3 - US	433.3	PF 4	0.25	350.00	351.02	350.19	351.02	0.000000	0.01	30.70	44.51	0.00
Drainage A3	Drainage A3 - US	374.67	PF 1	0.12	349.11	349.64	349.24	349.64	0.000001	0.01	8.88	27.96	0.00
Drainage A3	Drainage A3 - US	374.67	PF 2	0.18	349.11	350.18	349.24	350.18	0.000000	0.01	28.83	44.66	0.00
Drainage A3	Drainage A3 - US	374.67	PF 3	0.21	349.11	350.51	349.24	350.51	0.000000	0.00	43.88	47.17	0.00
Drainage A3	Drainage A3 - US	374.67	PF 4	0.25	349.11	351.02	349.24	351.02	0.000000	0.00	68.93	50.76	0.00
Drainage A3	Drainage A3 - DS	312.59	PF 1	21.89	348.00	349.57	348.59	349.59	0.001180	1.10	19.96	85.84	0.18
Drainage A3	Drainage A3 - DS	312.59	PF 2	43.24	348.00	350.11	348.84	350.14	0.001450	1.43	30.28	89.18	0.21
Drainage A3	Drainage A3 - DS	312.59	PF 3	54.21	348.00	350.45	348.97	350.48	0.001252	1.44	37.66	91.28	0.20
Drainage A3	Drainage A3 - DS	312.59	PF 4	73.15	348.00	350.97	349.16	351.01	0.001035	1.45	50.29	94.49	0.18
Drainage A3	Drainage A3 - DS	258.62	PF 1	21.89	348.00	349.49	348.60	349.52	0.001527	1.23	17.86	30.33	0.20
Drainage A3	Drainage A3 - DS	258.62	PF 2	43.24	348.00	350.01	348.86	350.05	0.001907	1.61	26.85	37.43	0.24
Drainage A3	Drainage A3 - DS	258.62	PF 3	54.21	348.00	350.37	348.99	350.41	0.001586	1.60	33.80	41.78	0.22
Drainage A3	Drainage A3 - DS	258.62	PF 4	73.15	348.00	350.90	349.18	350.94	0.001276	1.61	45.54	53.10	0.20
Drainage A3	Drainage A3 - DS	184.73	PF 1	21.89	348.00	349.39	348.52	349.41	0.001589	1.25	17.52	36.71	0.21
Drainage A3	Drainage A3 - DS	184.73	PF 2	43.24	348.00	349.86	348.77	349.91	0.002166	1.71	25.23	44.28	0.25
Drainage A3	Drainage A3 - DS	184.73	PF 3	54.21	348.00	350.24	348.92	350.29	0.001725	1.69	32.06	47.70	0.23
Drainage A3	Drainage A3 - DS	184.73	PF 4	73.15	348.00	350.89	349.08	350.89	0.000295	0.80	112.50	80.78	0.10
Drainage A3	Drainage A3 - DS	130.79	PF 1	21.89	348.00	349.27	348.58	349.30	0.002618	1.46	15.04	50.76	0.26
Drainage A3	Drainage A3 - DS	130.79	PF 2	43.24	348.00	349.71	348.84	349.77	0.003312	1.92	22.48	55.68	0.31
Drainage A3	Drainage A3 - DS	130.79	PF 3	54.21	348.00	350.14	348.99	350.19	0.002167	1.76	30.85	60.25	0.25
Drainage A3	Drainage A3 - DS	130.79	PF 4	73.15	348.00	350.88	349.20	350.88	0.000190	0.62	137.03	92.28	0.08
Drainage A3	Drainage A3 - DS	63.65	PF 1	21.89	348.00	348.82	348.58	348.92	0.012964	2.54	8.60	19.32	0.55
Drainage A3	Drainage A3 - DS	63.65	PF 2	43.24	348.00	349.09	348.87	349.28	0.018240	3.53	12.26	22.11	0.68
Drainage A3	Drainage A3 - DS	63.65	PF 3	54.21	348.00	349.94	348.96	350.01	0.003170	2.02	26.87	58.71	0.30
Drainage A3	Drainage A3 - DS	63.65	PF 4	73.15	348.00	350.86	349.15	350.87	0.000232	0.73	128.50	95.30	0.09
Drainage A3	Drainage A3 - DS	10		Lat Struct									
Drainage A3	Drainage A3 - DS	5.1	PF 1	0.01	348.00	348.10	348.10	348.10	0.000006	0.01	0.84	9.14	0.01
Drainage A3	Drainage A3 - DS	5.1	PF 2	0.03	348.00	348.26	348.10	348.26	0.000001	0.01	2.28	10.50	0.00
Drainage A3	Drainage A3 - DS	5.1	PF 3	0.01	348.00	349.94	348.10	349.94	0.000000	0.00	26.81	72.99	0.00
Drainage A3	Drainage A3 - DS	5.1	PF 4	1.20	348.00	350.86	348.10	350.86	0.000000	0.01	117.85	84.69	0.00
Drainage A2	Drainage A2 - US	1080.21	PF 1	0.19	350.07	350.28	350.28	350.28	0.010307	0.66	0.29	2.77	0.36
Drainage A2	Drainage A2 - US	1080.21	PF 2	0.28	350.07	350.28	350.28	350.29	0.022384	0.97	0.29	2.77	0.53
Drainage A2	Drainage A2 - US	1080.21	PF 3	0.33	350.07	350.50	350.28	350.50	0.000641	0.26	1.28	6.27	0.10
Drainage A2	Drainage A2 - US	1080.21	PF 4	0.40	350.07	351.02	350.28	351.02	0.000008	0.04	8.98	23.57	0.01

HEC-RAS Plan: WHP Conpt Alt7 (Continued)

River	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)	
Drainage A2	Drainage A2 - US	1040		Lat Struct									
Drainage A2	Drainage A2 - US	1000	PF 1	0.19	348.27	349.60	348.45	349.60	0.000000	0.01	17.73	25.06	0.00
Drainage A2	Drainage A2 - US	1000	PF 2	0.28	348.27	350.16	348.45	350.16	0.000000	0.01	34.19	33.40	0.00
Drainage A2	Drainage A2 - US	1000	PF 3	0.33	348.27	350.50	348.45	350.50	0.000000	0.01	46.60	40.21	0.00
Drainage A2	Drainage A2 - US	1000	PF 4	0.40	348.27	351.02	348.45	351.02	0.000000	0.01	73.21	62.38	0.00
Drainage A2	Drainage A2 - US	950	PF 1	0.19	347.45	349.60	347.58	349.60	0.000000	0.01	22.89	16.81	0.00
Drainage A2	Drainage A2 - US	950	PF 2	0.28	347.45	350.16	347.58	350.16	0.000000	0.01	33.52	20.36	0.00
Drainage A2	Drainage A2 - US	950	PF 3	0.33	347.45	350.50	347.58	350.50	0.000000	0.01	40.53	20.98	0.00
Drainage A2	Drainage A2 - US	950	PF 4	0.40	347.45	351.02	347.58	351.02	0.000000	0.01	51.67	22.92	0.00
Drainage A2	Drainage A2 - US	905	PF 1	0.19	347.45	349.60	347.58	349.60	0.000000	0.01	22.89	16.81	0.00
Drainage A2	Drainage A2 - US	905	PF 2	0.28	347.45	350.16	347.58	350.16	0.000000	0.01	33.52	20.36	0.00
Drainage A2	Drainage A2 - US	905	PF 3	0.33	347.45	350.50	347.58	350.50	0.000000	0.01	40.53	20.98	0.00
Drainage A2	Drainage A2 - US	905	PF 4	0.40	347.45	351.02	347.58	351.02	0.000000	0.01	51.67	22.92	0.00
Drainage A2	Drainage A2 - DS	746.87	PF 1	0.28	346.61	349.26	346.77	349.26	0.000000	0.00	60.17	44.04	0.00
Drainage A2	Drainage A2 - DS	746.87	PF 2	0.42	346.61	350.10	346.77	350.10	0.000000	0.00	103.37	59.23	0.00
Drainage A2	Drainage A2 - DS	746.87	PF 3	0.49	346.61	350.41	346.77	350.41	0.000000	0.00	122.52	64.85	0.00
Drainage A2	Drainage A2 - DS	746.87	PF 4	0.60	346.61	350.89	346.77	350.89	0.000000	0.00	156.70	77.18	0.00
Drainage A2	Drainage A2 - DS	740		Lat Struct									
Drainage A2	Drainage A2 - DS	738.69	PF 1	1.40	346.69	349.26	347.42	349.26	0.000000	0.02	75.47	55.72	0.00
Drainage A2	Drainage A2 - DS	738.69	PF 2	2.27	346.69	350.10	347.42	350.10	0.000000	0.02	129.94	77.84	0.00
Drainage A2	Drainage A2 - DS	738.69	PF 3	2.77	346.69	350.41	347.42	350.41	0.000000	0.02	156.66	95.49	0.00
Drainage A2	Drainage A2 - DS	738.69	PF 4	3.95	346.69	350.89	347.42	350.89	0.000000	0.02	206.66	111.03	0.00
Drainage A2	Drainage A2 - DS	700.18	PF 1	1.40	348.00	349.26	348.11	349.26	0.000011	0.09	14.88	34.22	0.02
Drainage A2	Drainage A2 - DS	700.18	PF 2	2.27	348.00	350.10	348.16	350.10	0.000004	0.08	30.01	51.75	0.01
Drainage A2	Drainage A2 - DS	700.18	PF 3	2.77	348.00	350.41	348.16	350.41	0.000004	0.08	36.65	59.72	0.01
Drainage A2	Drainage A2 - DS	700.18	PF 4	3.95	348.00	350.89	348.21	350.89	0.000003	0.08	48.22	75.27	0.01
Drainage A2	Drainage A2 - DS	700		Lat Struct									
Drainage A2	Drainage A2 - DS	599.93	PF 1	1.40	348.00	349.26	348.09	349.26	0.000011	0.09	14.86	22.05	0.02
Drainage A2	Drainage A2 - DS	599.93	PF 2	2.27	348.00	350.10	348.16	350.10	0.000004	0.08	30.00	47.96	0.01
Drainage A2	Drainage A2 - DS	599.93	PF 3	2.77	348.00	350.41	348.16	350.41	0.000004	0.08	36.64	63.68	0.01
Drainage A2	Drainage A2 - DS	599.93	PF 4	3.95	348.00	350.89	348.16	350.89	0.000003	0.08	48.22	68.61	0.01
Drainage A2	Drainage A2 - DS	563.71	PF 1	1.40	348.00	349.26	348.12	349.26	0.000013	0.10	13.55	13.49	0.02
Drainage A2	Drainage A2 - DS	563.71	PF 2	2.27	348.00	350.10	348.13	350.10	0.000005	0.09	26.38	32.65	0.01
Drainage A2	Drainage A2 - DS	563.71	PF 3	2.77	348.00	350.41	348.12	350.41	0.000004	0.09	31.87	48.62	0.01
Drainage A2	Drainage A2 - DS	563.71	PF 4	3.95	348.00	350.89	348.16	350.89	0.000004	0.10	41.34	59.06	0.01
Drainage A2	Drainage A2 - DS	526.1	PF 1	1.40	348.00	349.26	348.12	349.26	0.000012	0.10	13.93	22.85	0.02
Drainage A2	Drainage A2 - DS	526.1	PF 2	2.27	348.00	350.10	348.13	350.10	0.000005	0.08	27.44	38.78	0.01
Drainage A2	Drainage A2 - DS	526.1	PF 3	2.77	348.00	350.41	348.13	350.41	0.000004	0.08	33.28	44.32	0.01
Drainage A2	Drainage A2 - DS	526.1	PF 4	3.95	348.00	350.89	348.18	350.89	0.000004	0.09	43.37	50.78	0.01

HEC-RAS Plan: WHP Conpt Alt7 (Continued)

River	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)	
Drainage A2	Drainage A2 - DS	400.11	PF 1	1.40	347.34	349.26	347.98	349.26	0.000061	0.21	6.83	7.12	0.04
Drainage A2	Drainage A2 - DS	400.11	PF 2	2.27	347.34	350.10	347.99	350.10	0.000023	0.16	14.07	10.11	0.02
Drainage A2	Drainage A2 - DS	400.11	PF 3	2.77	347.34	350.41	347.94	350.41	0.000019	0.16	17.34	11.04	0.02
Drainage A2	Drainage A2 - DS	400.11	PF 4	3.95	347.34	350.89	348.12	350.89	0.000030	0.16	25.12	24.06	0.03
Drainage A2	Drainage A2 - DS	395		Lat Struct									
Drainage A2	Drainage A2 - DS	83.19	PF 1	1.40	346.64	349.26	346.78	349.26	0.000000	0.02	74.25	39.15	0.00
Drainage A2	Drainage A2 - DS	83.19	PF 2	2.27	346.64	350.10	346.78	350.10	0.000000	0.02	110.35	46.79	0.00
Drainage A2	Drainage A2 - DS	83.19	PF 3	2.77	346.64	350.41	346.78	350.41	0.000000	0.02	125.23	49.58	0.00
Drainage A2	Drainage A2 - DS	83.19	PF 4	3.95	346.64	350.89	346.87	350.89	0.000000	0.03	150.22	53.64	0.00



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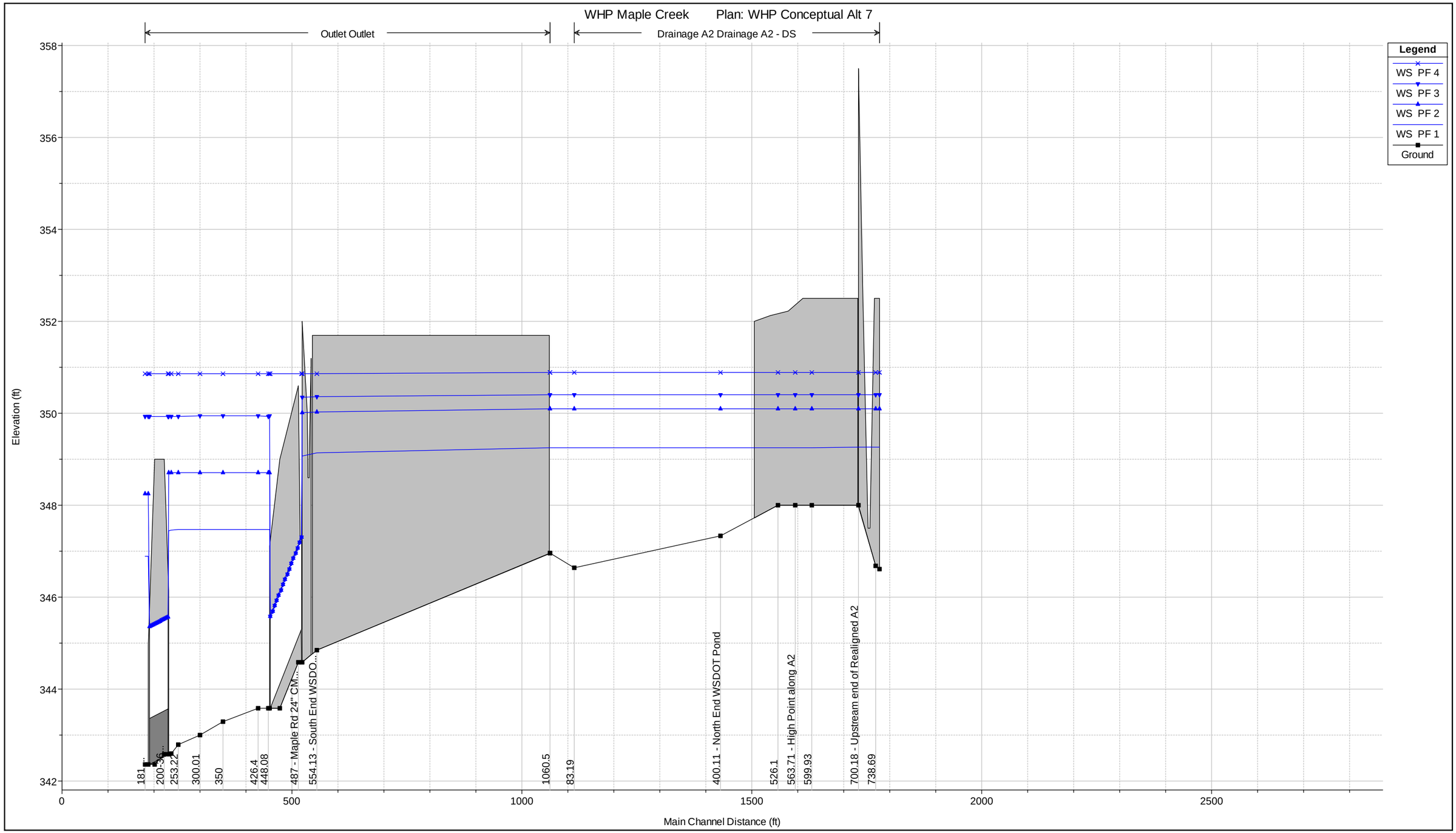

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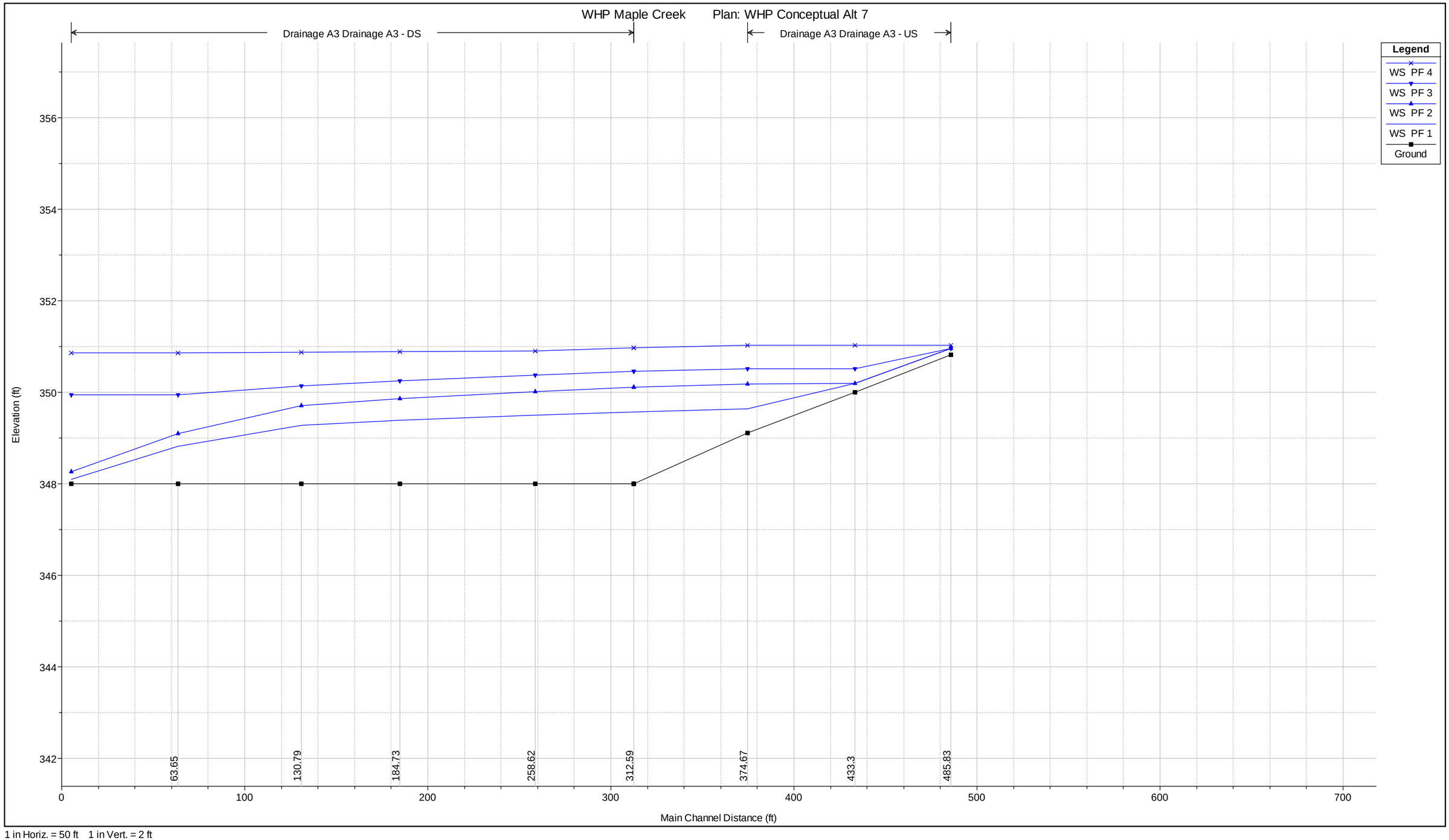

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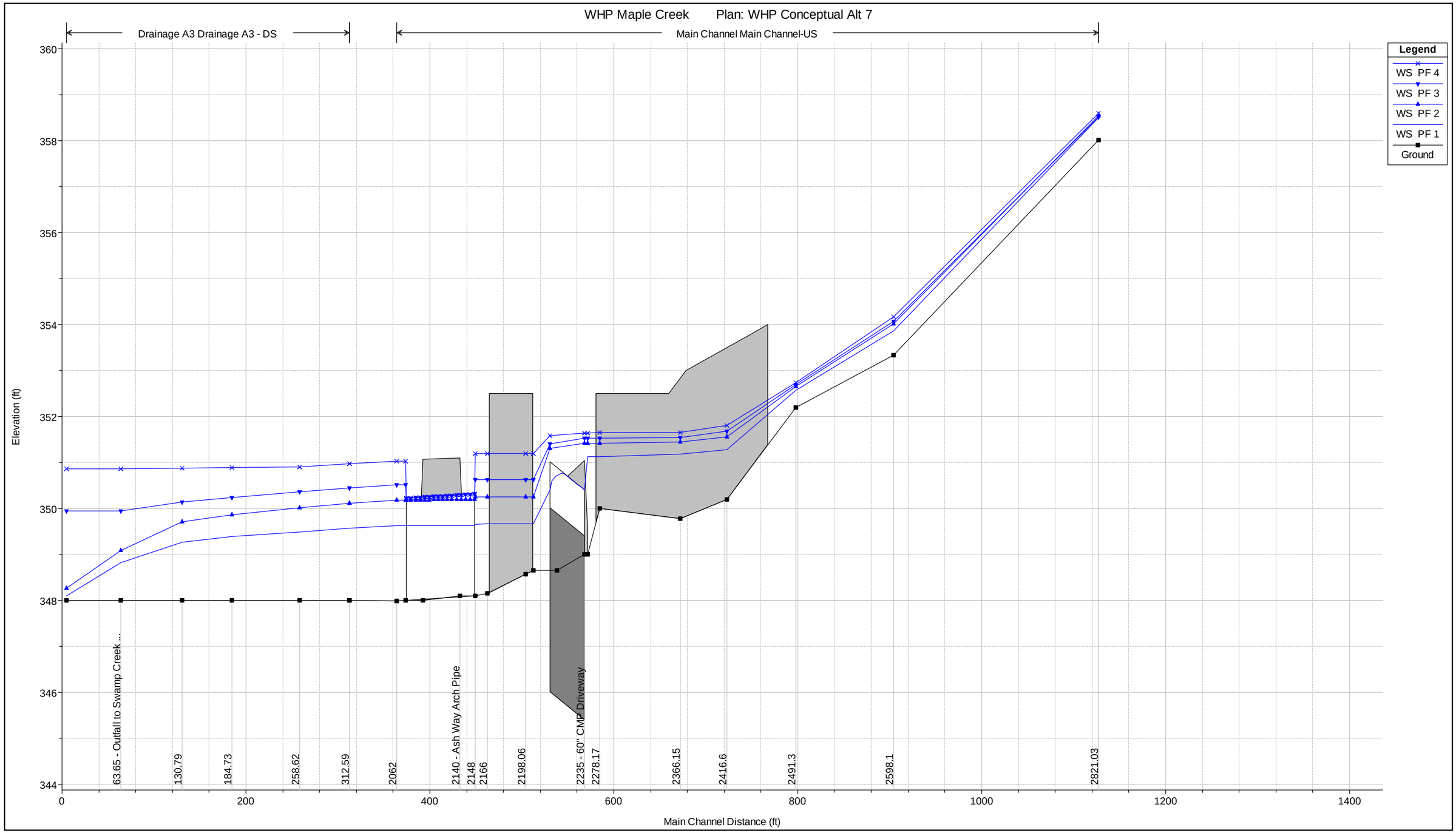

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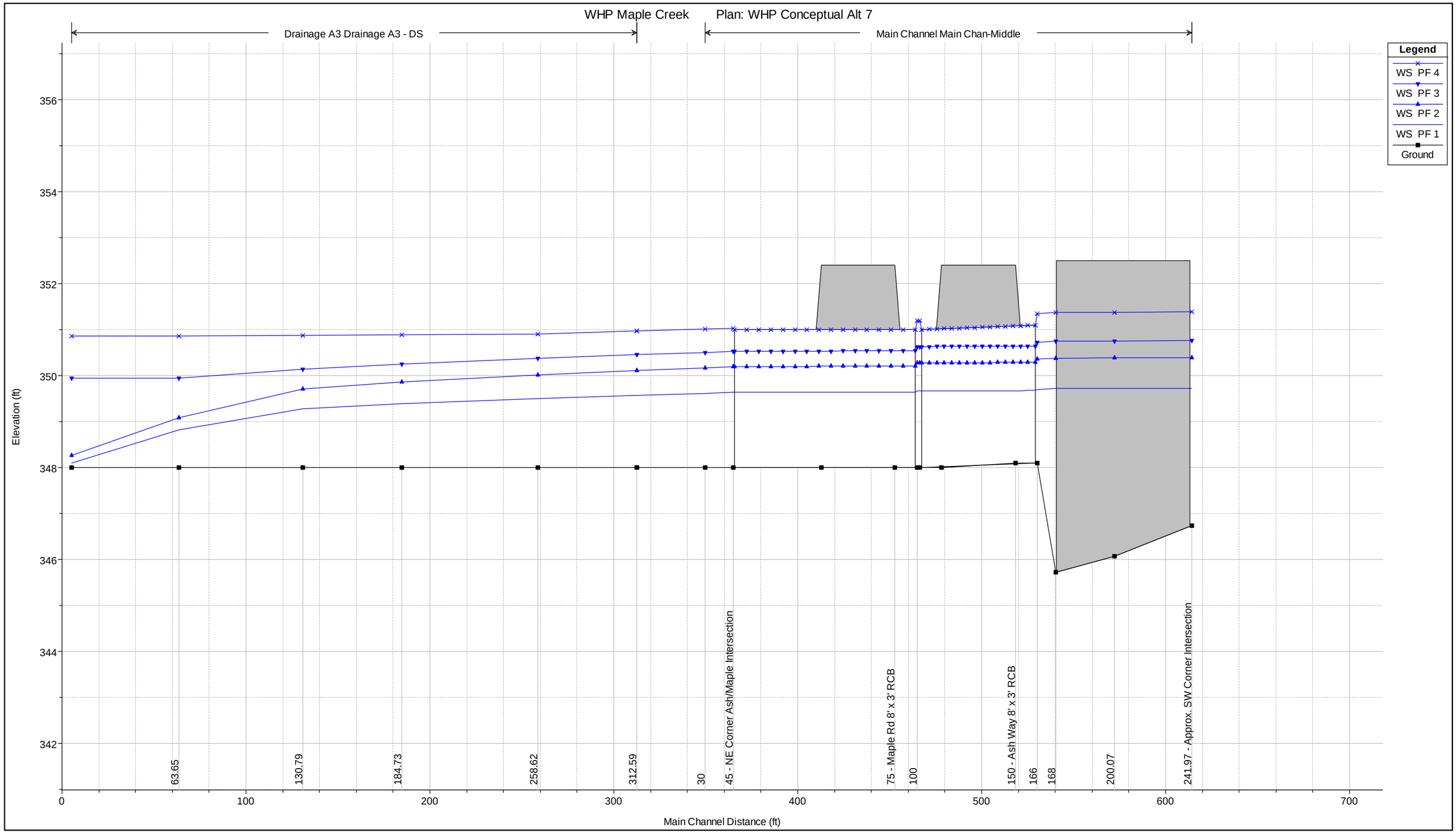

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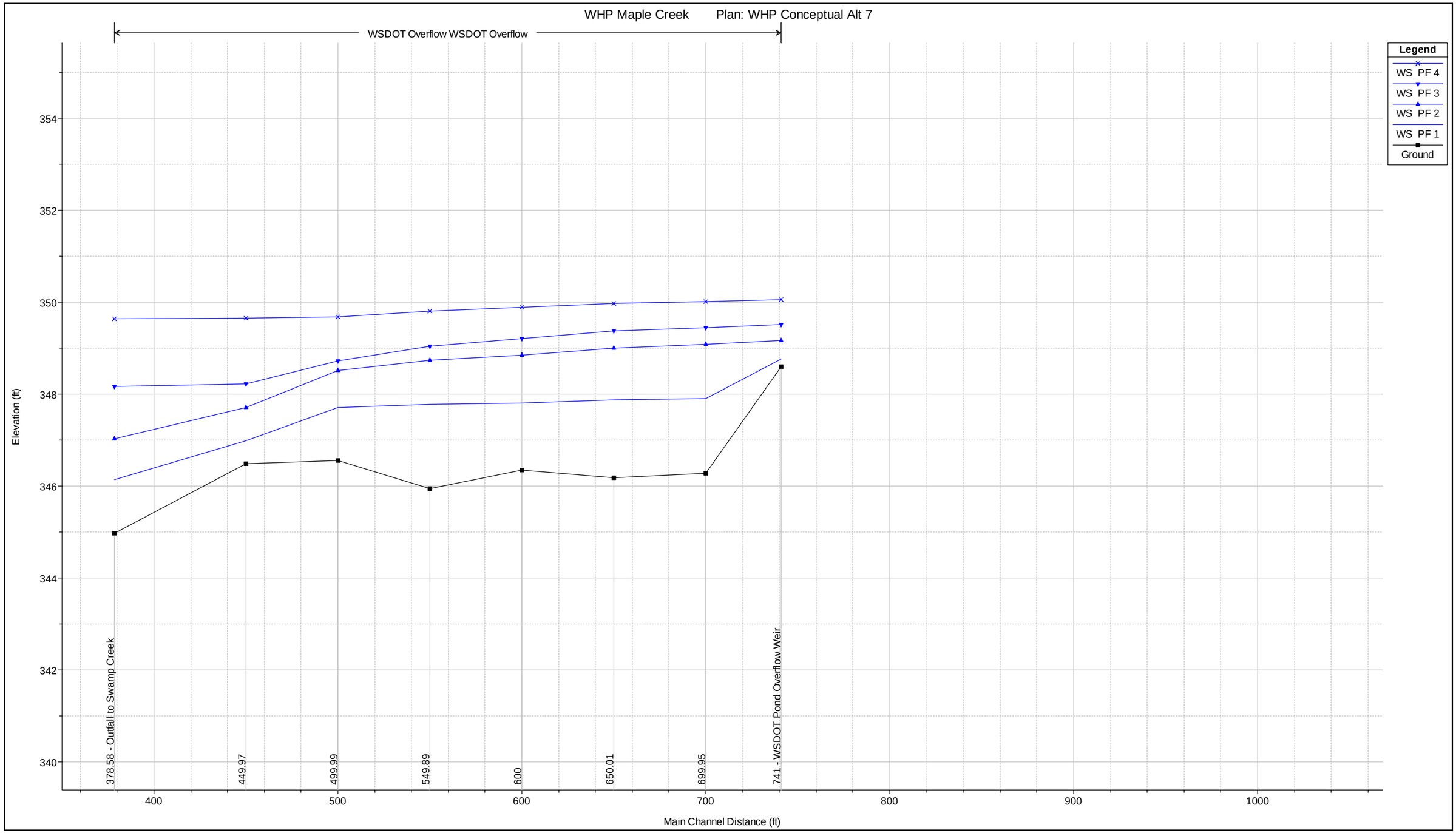

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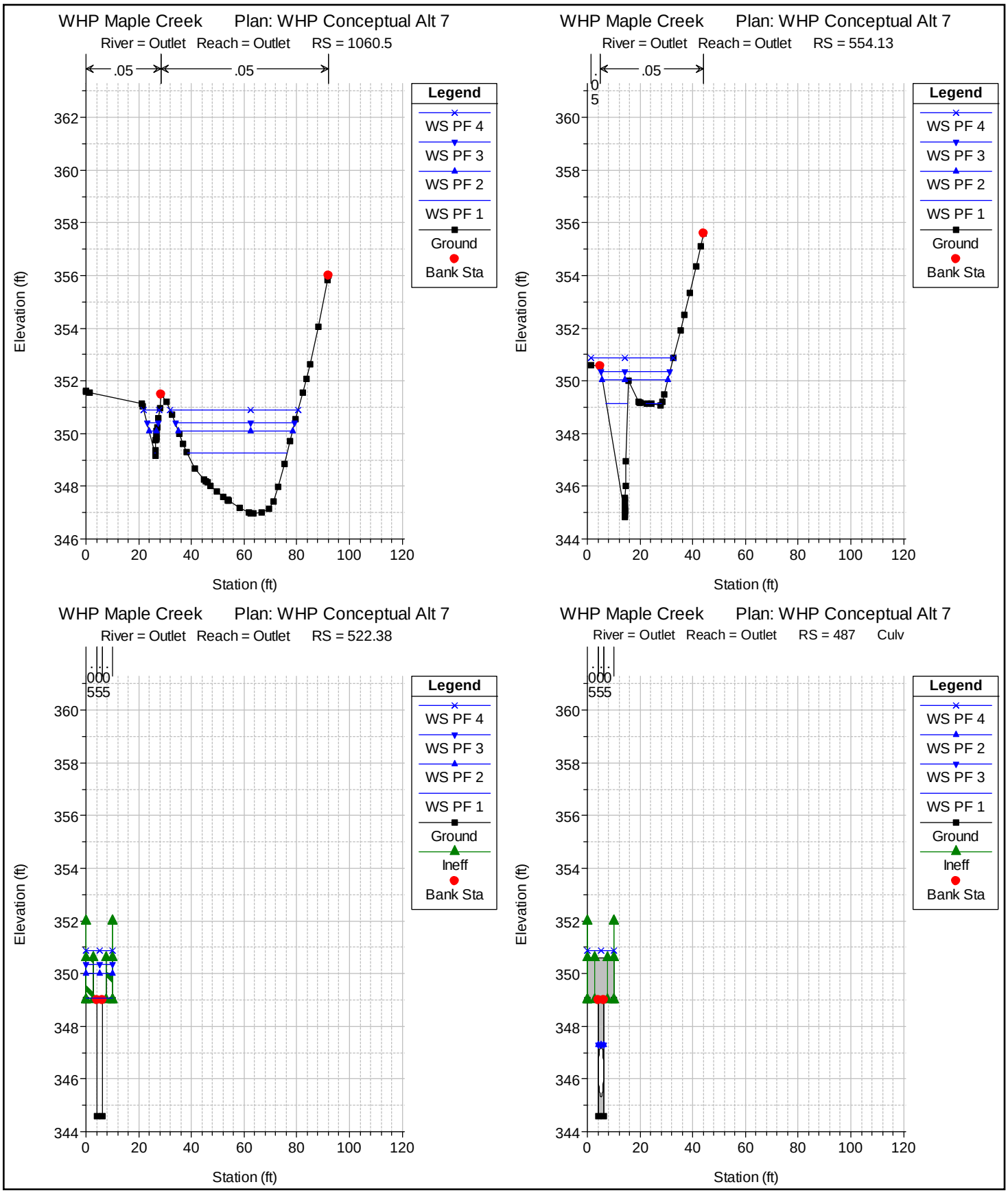

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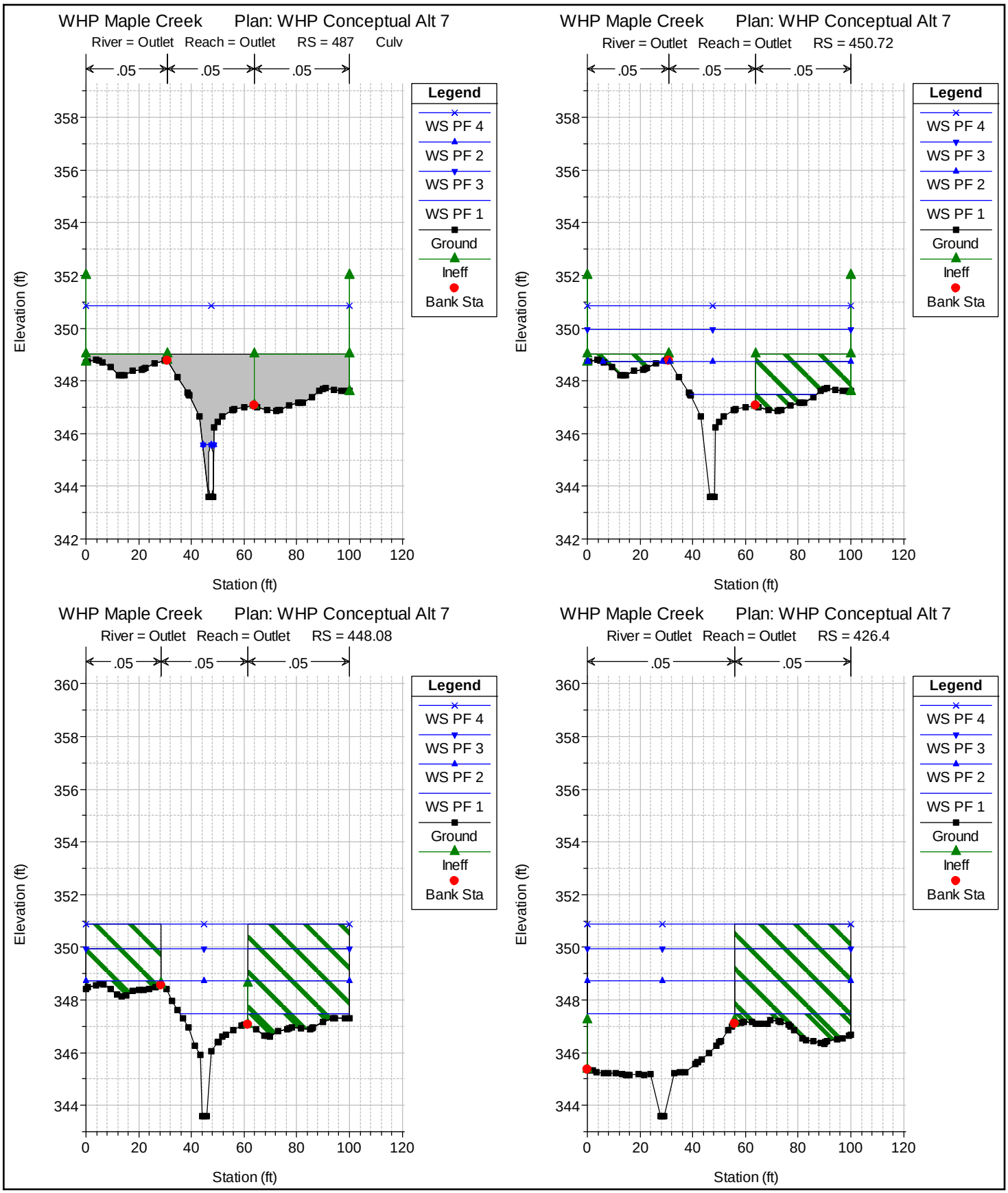

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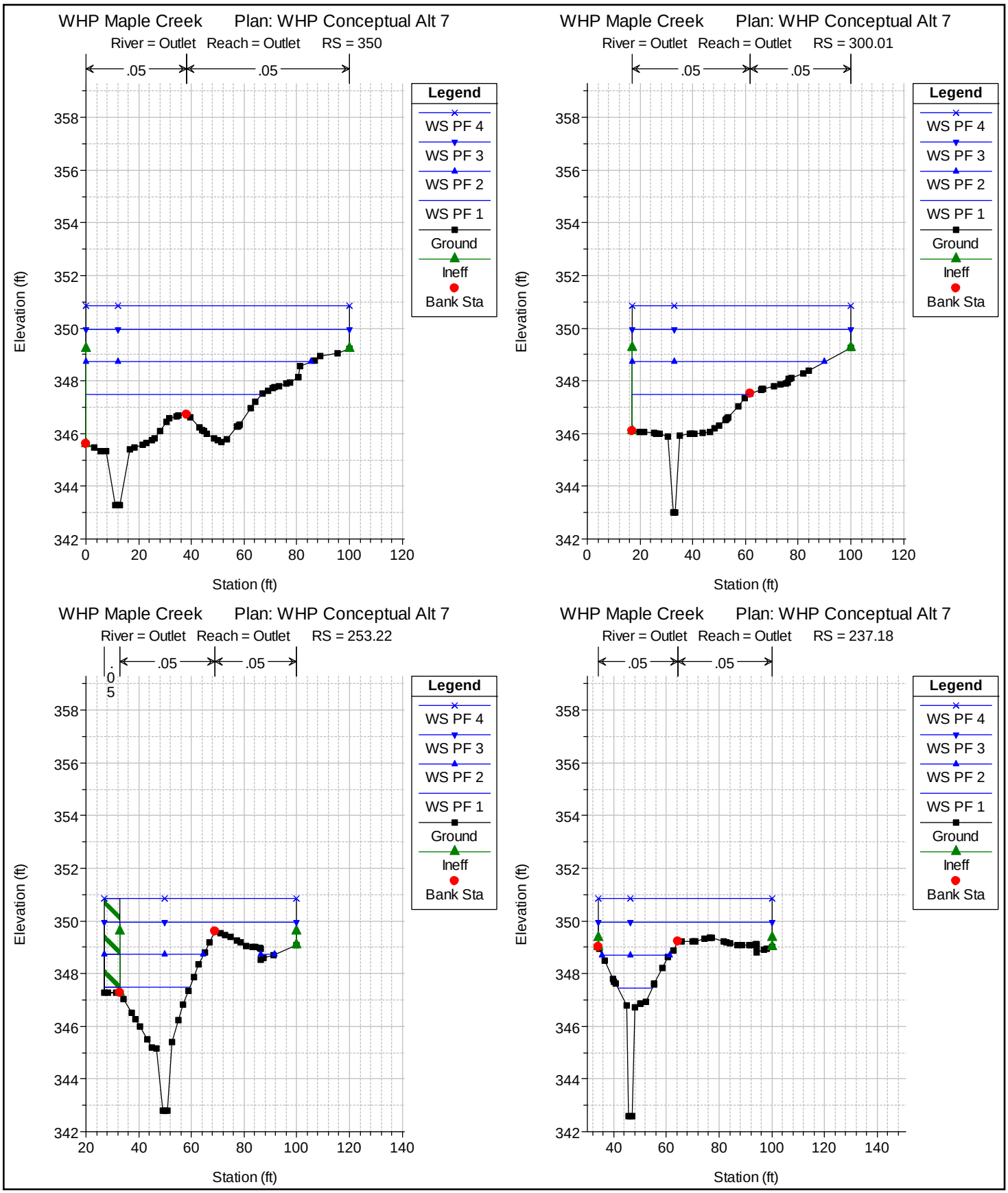

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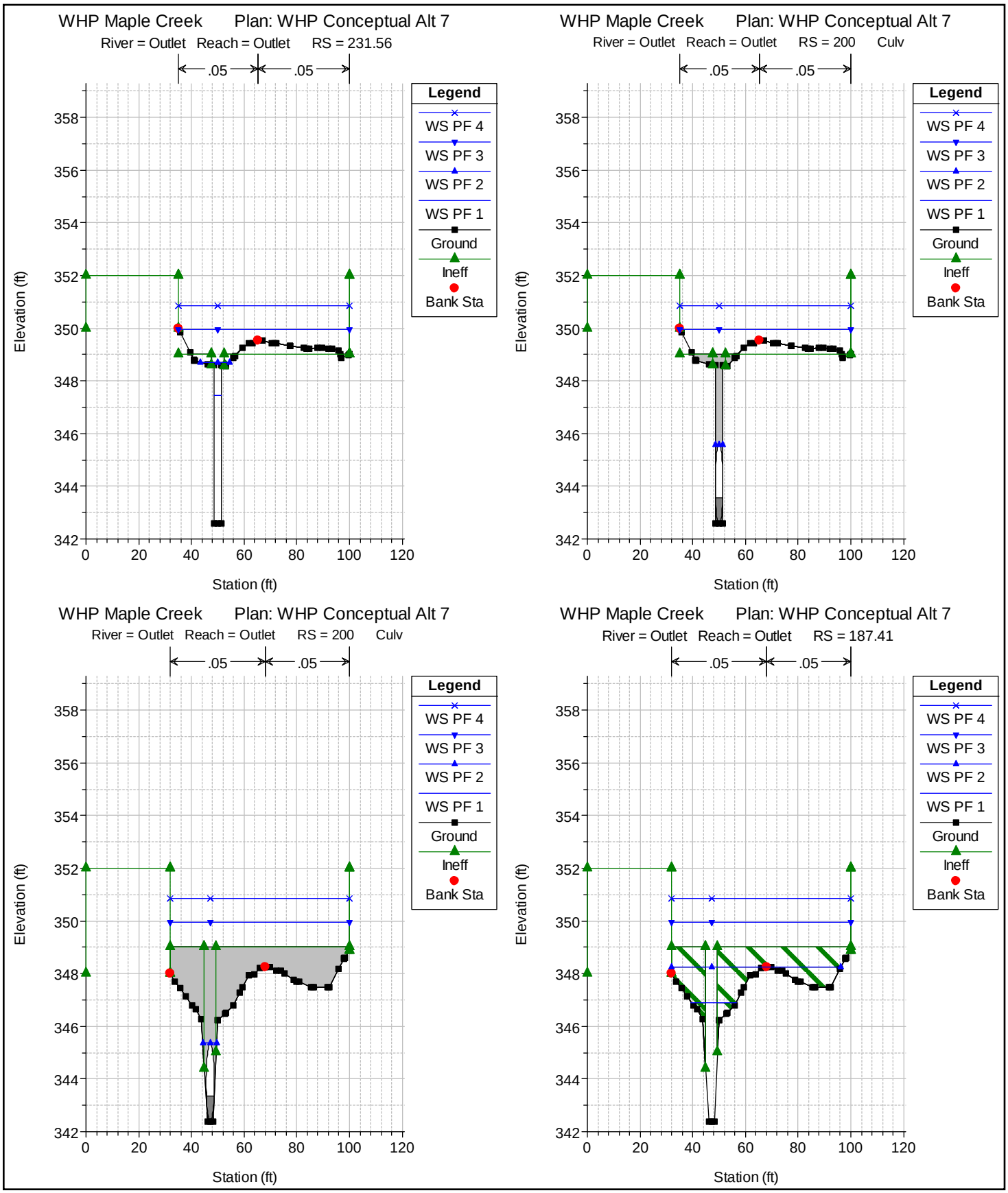

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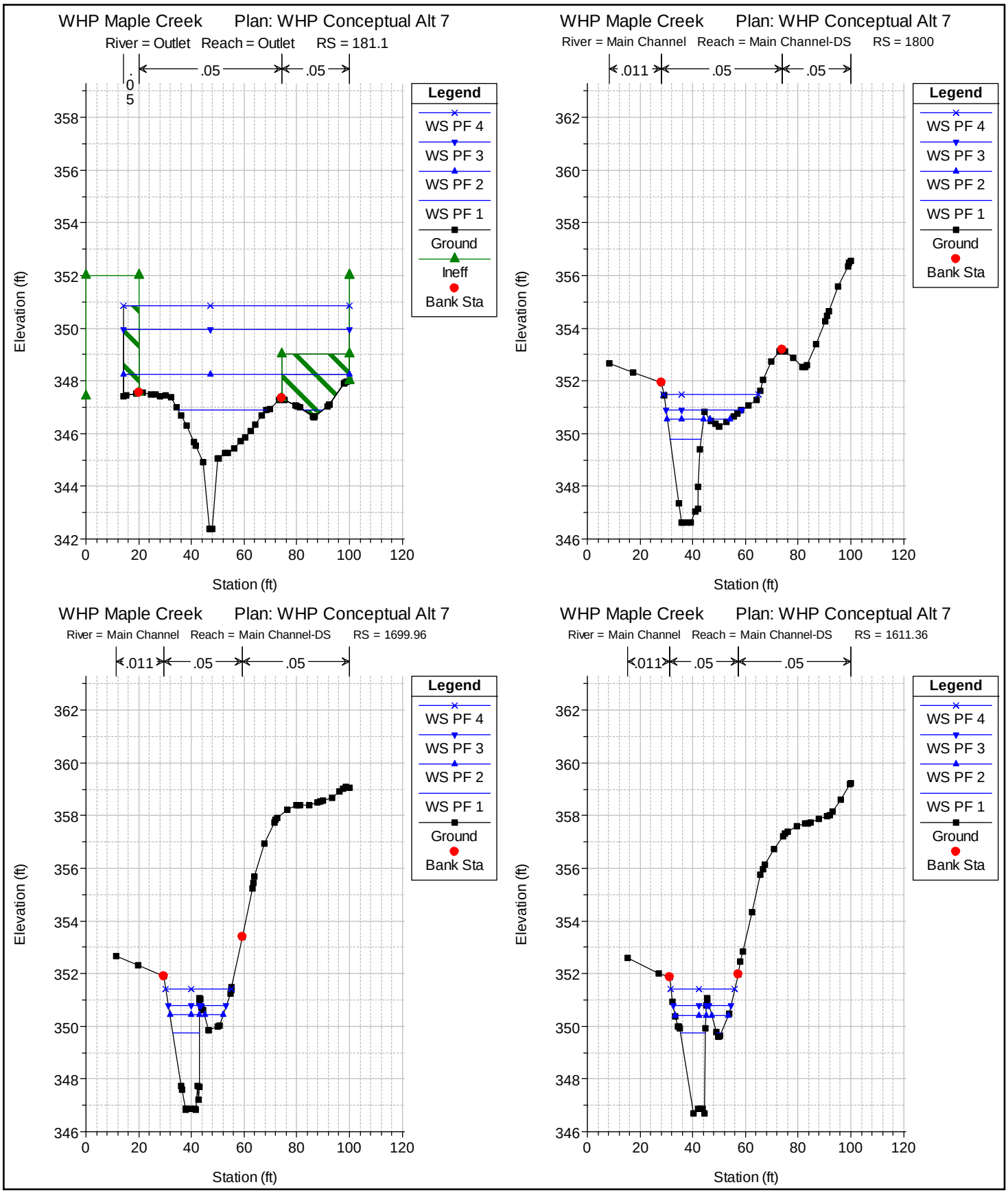

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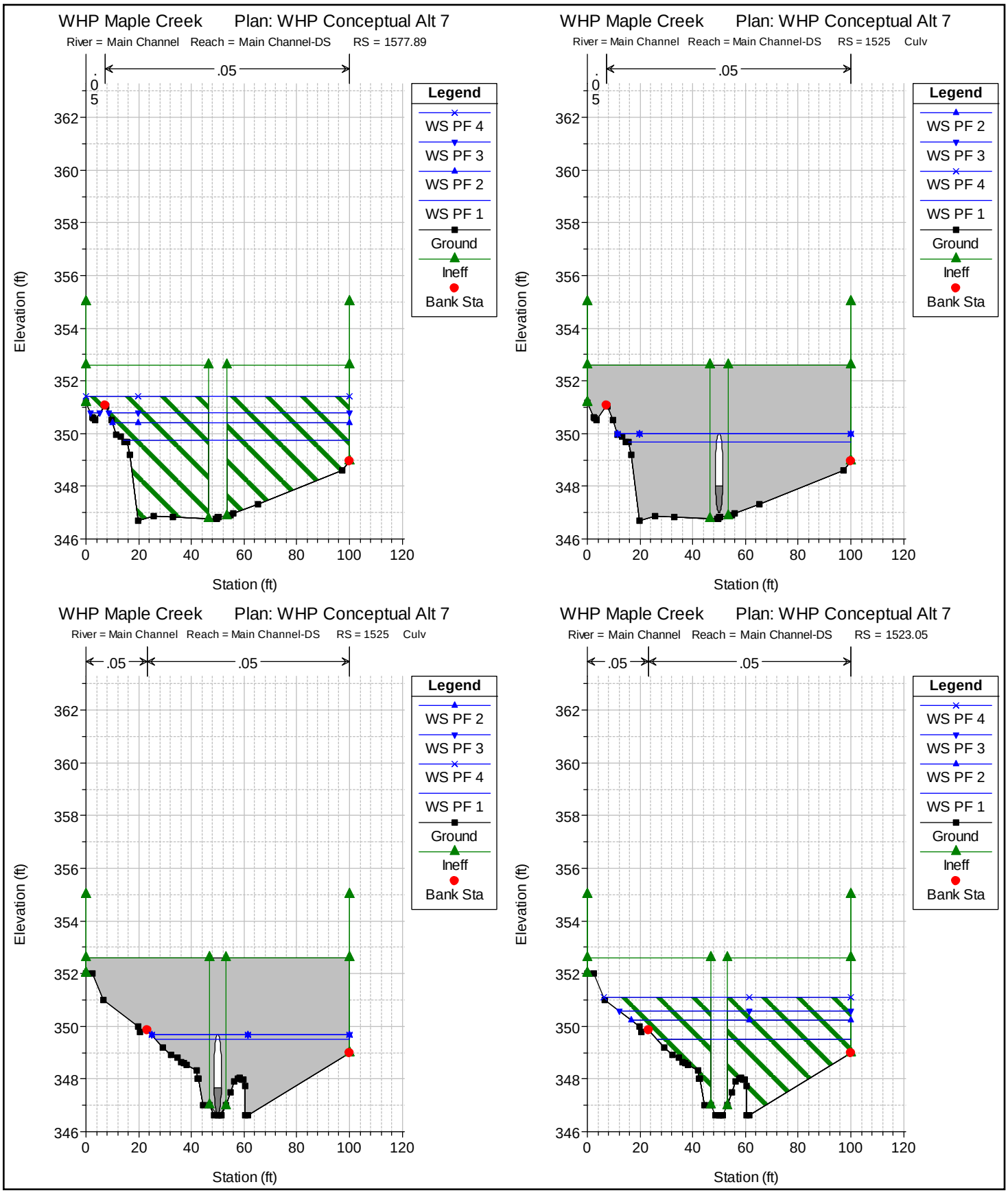

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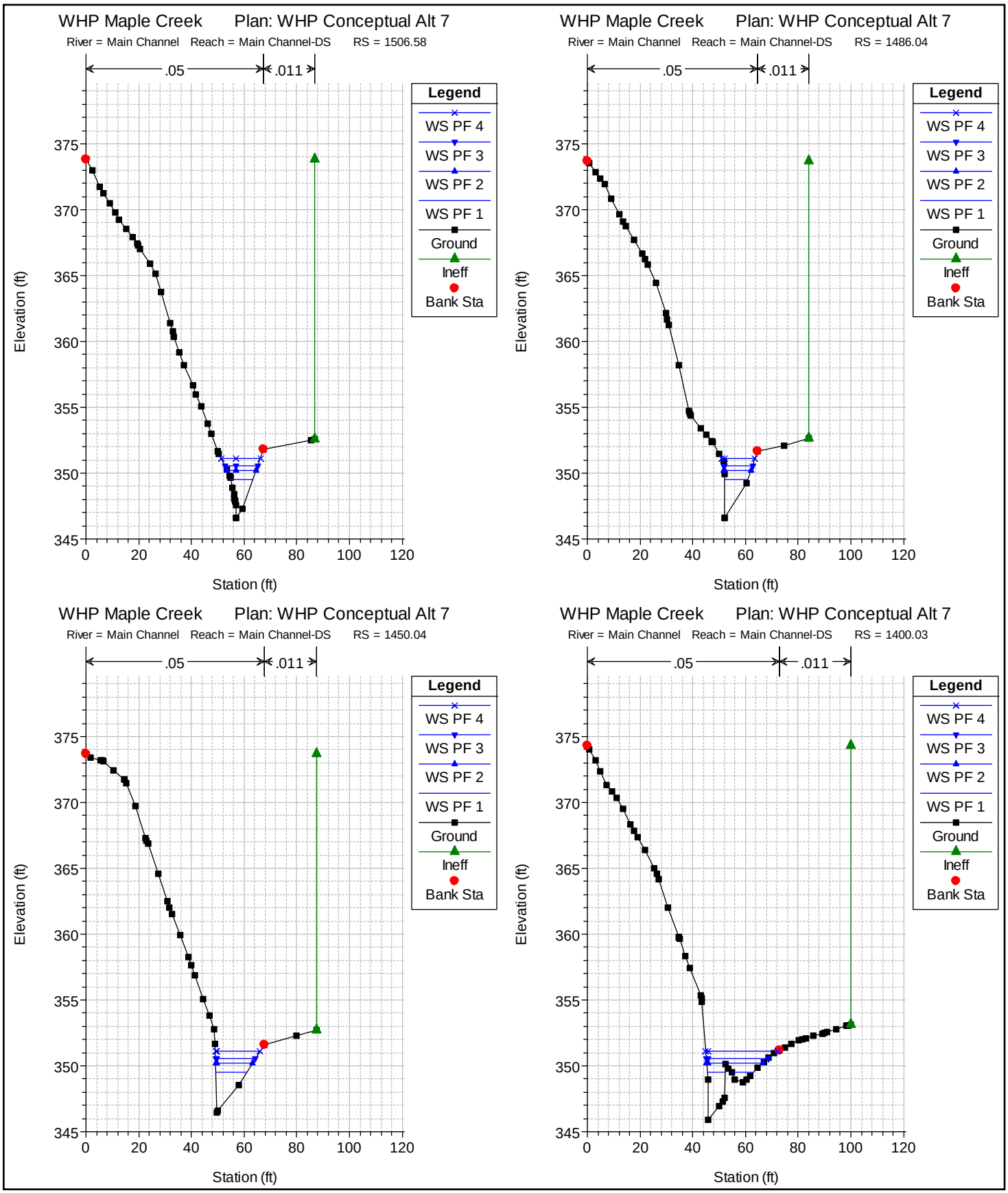

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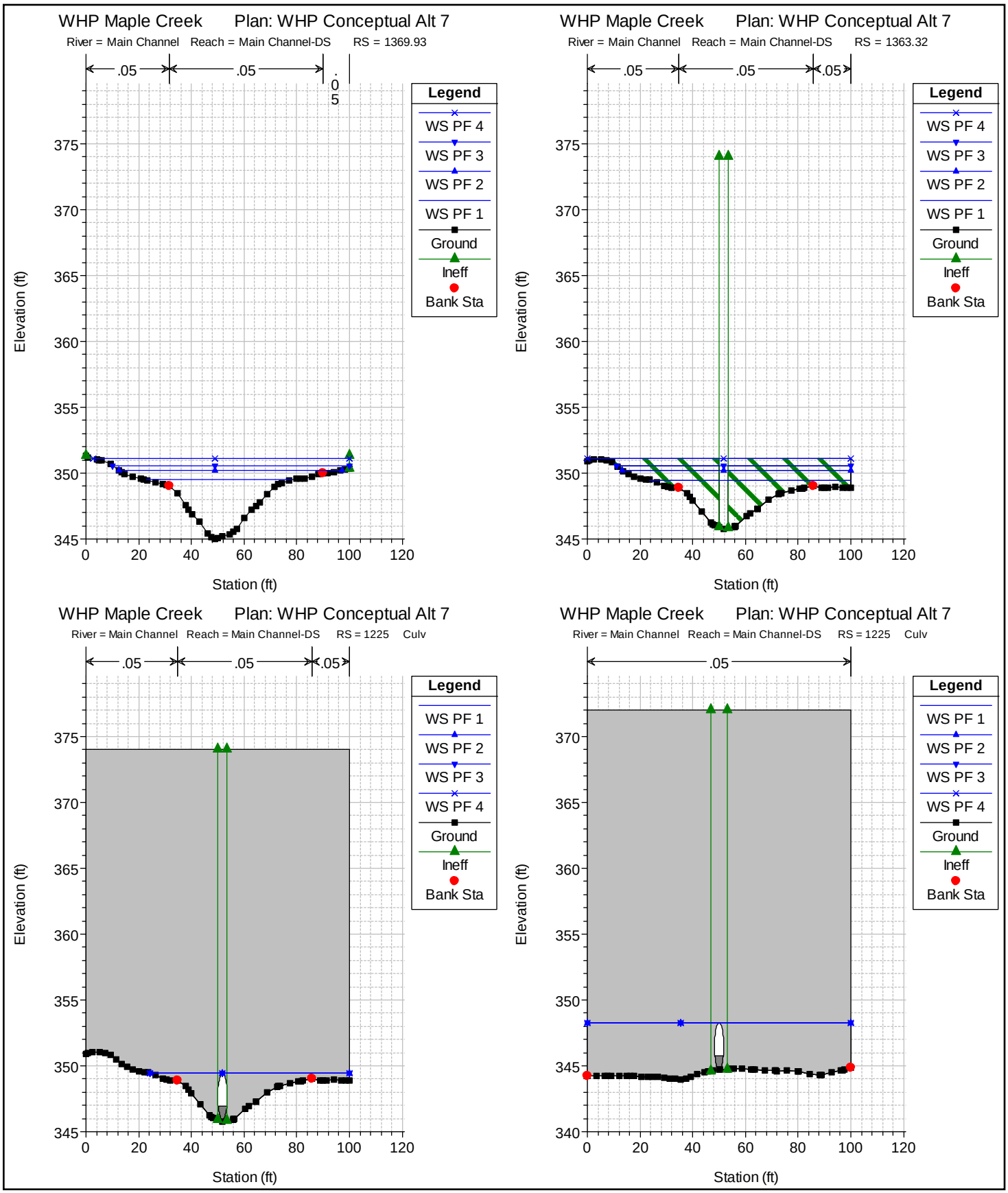

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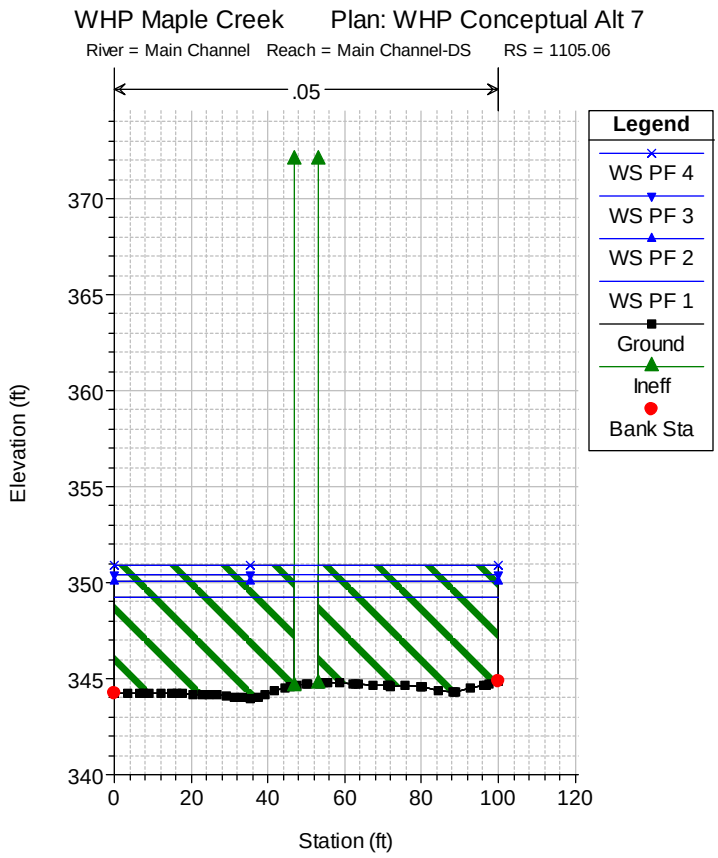

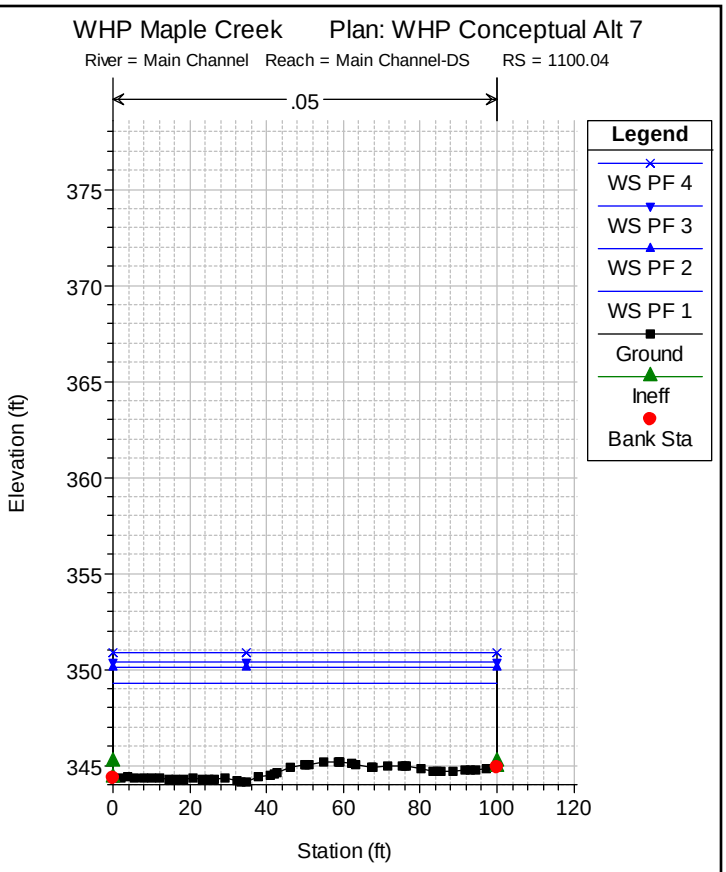

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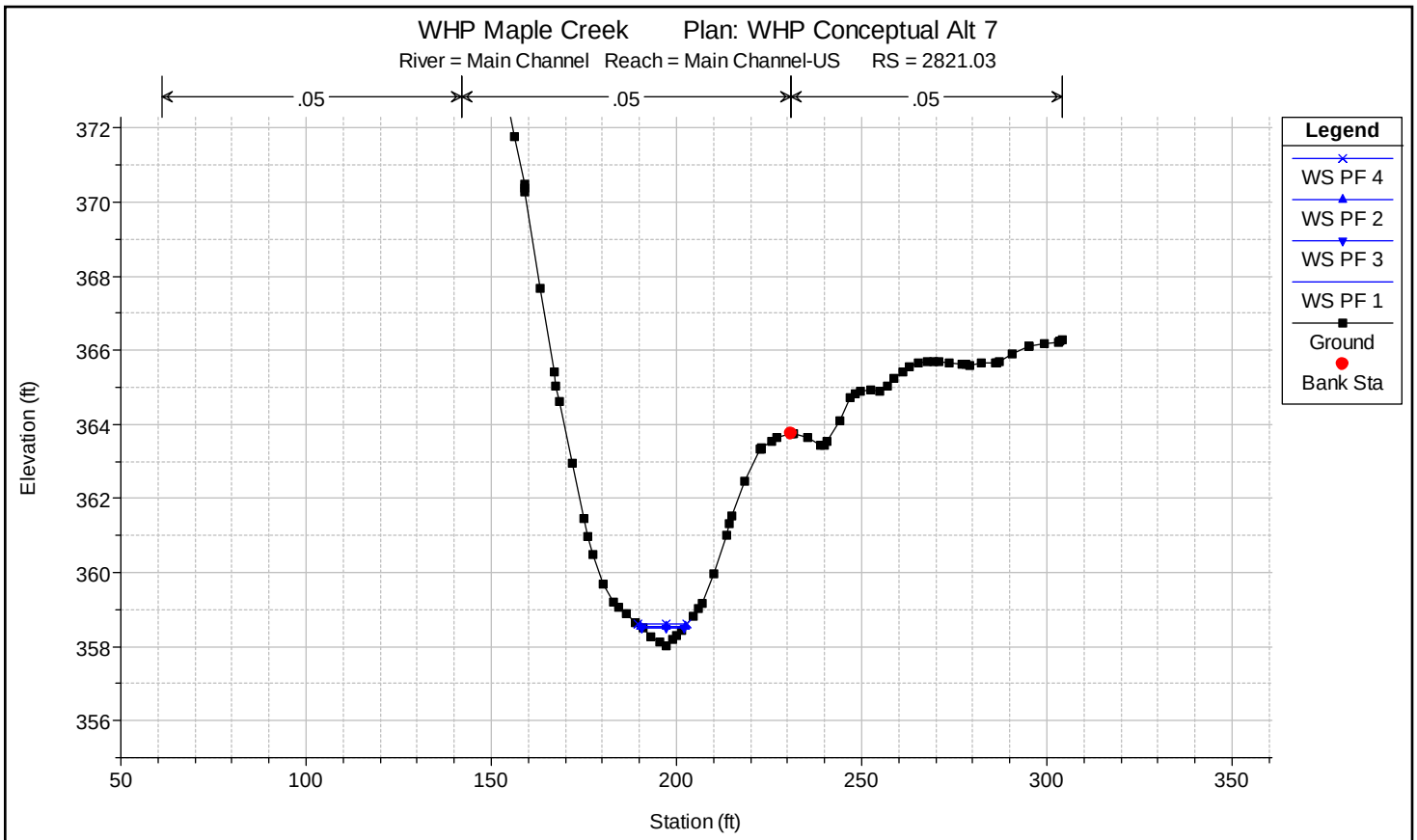

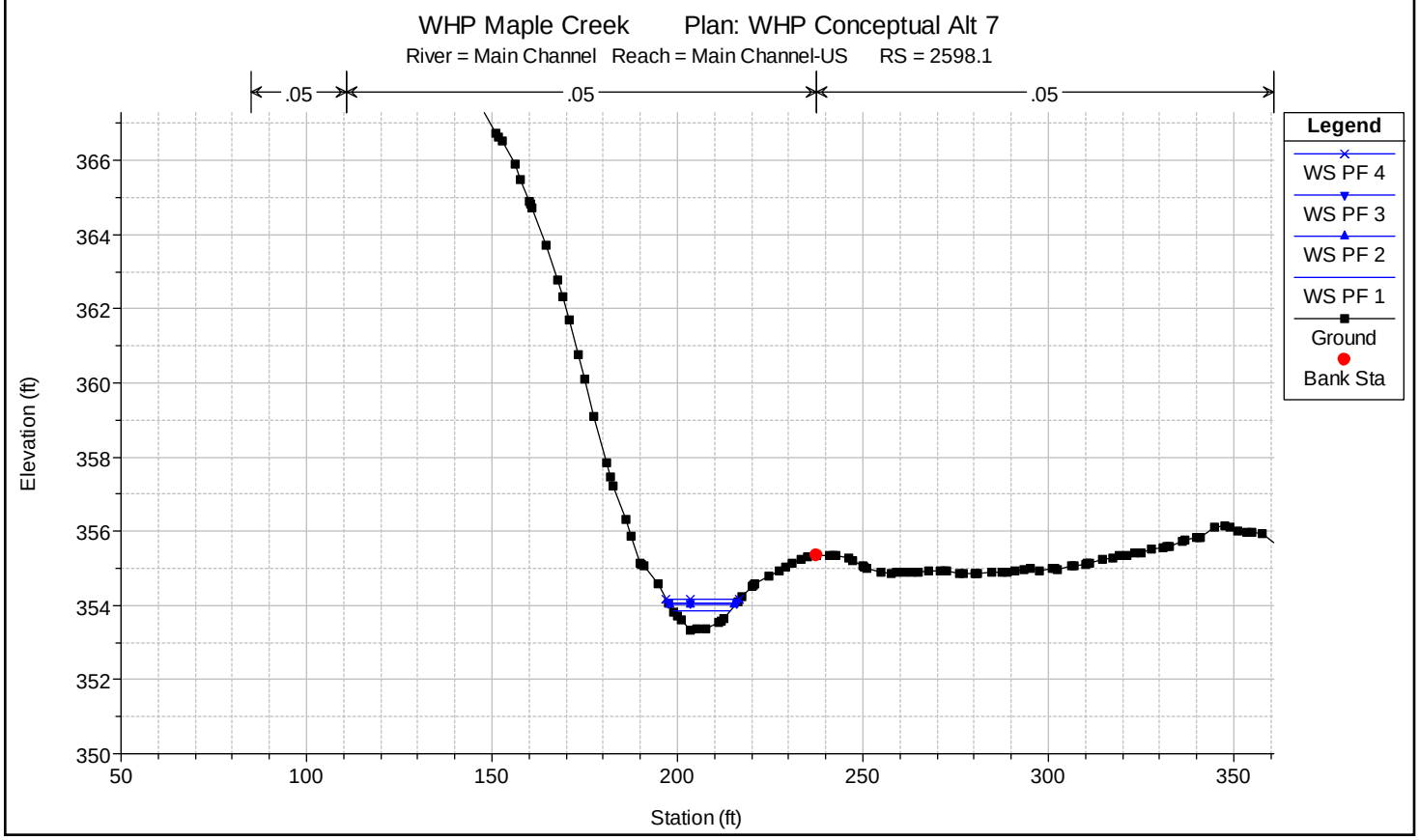

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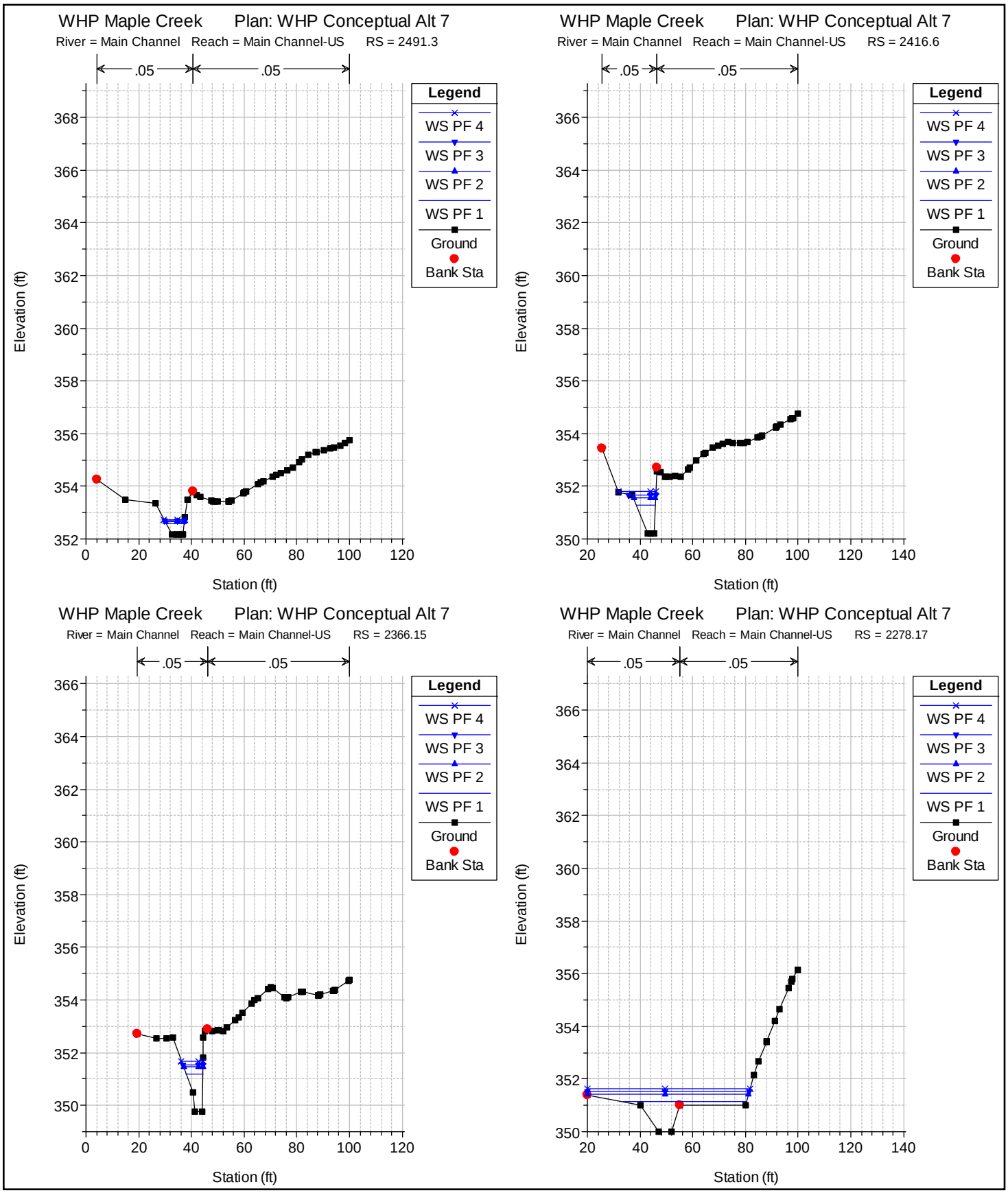

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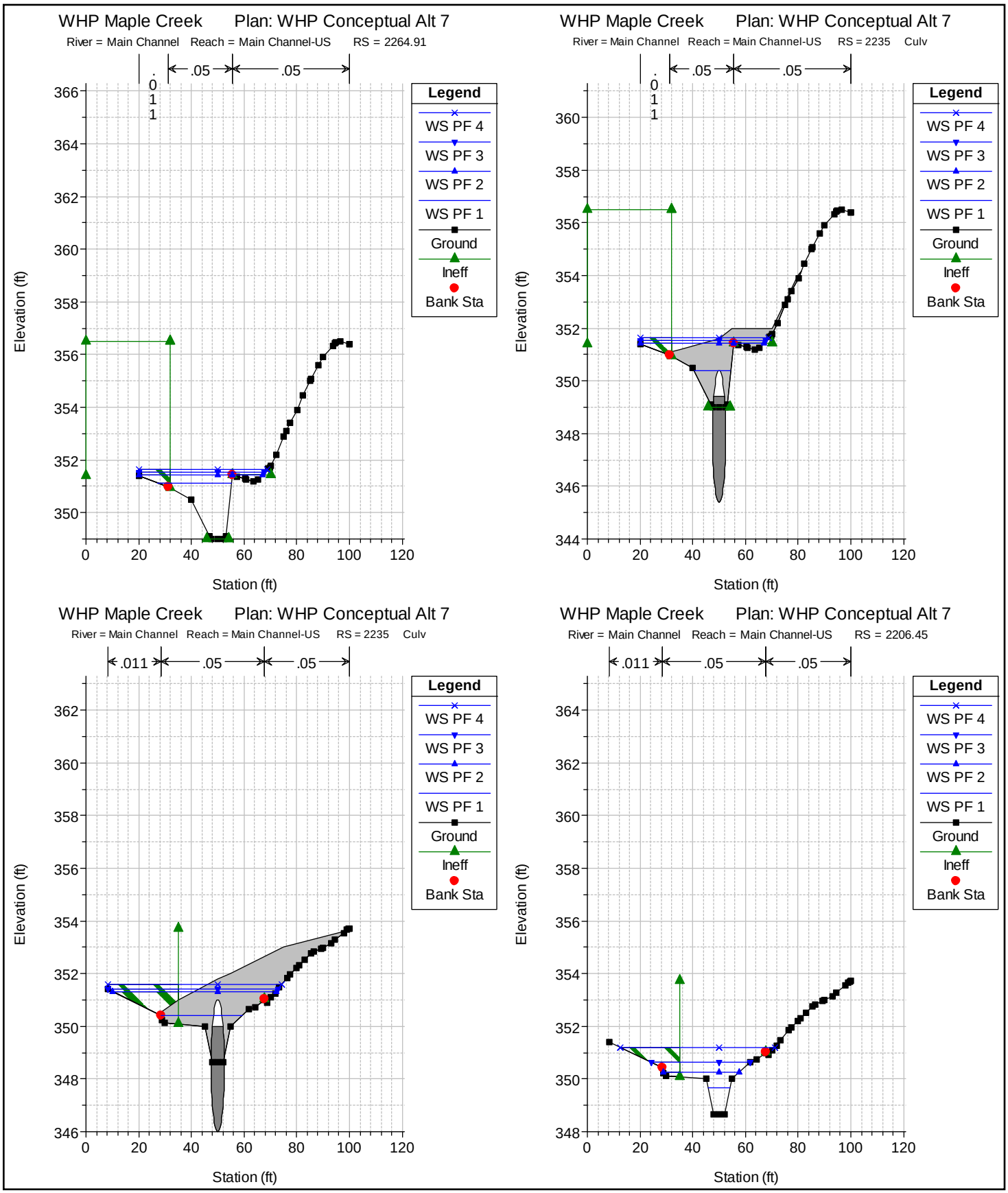

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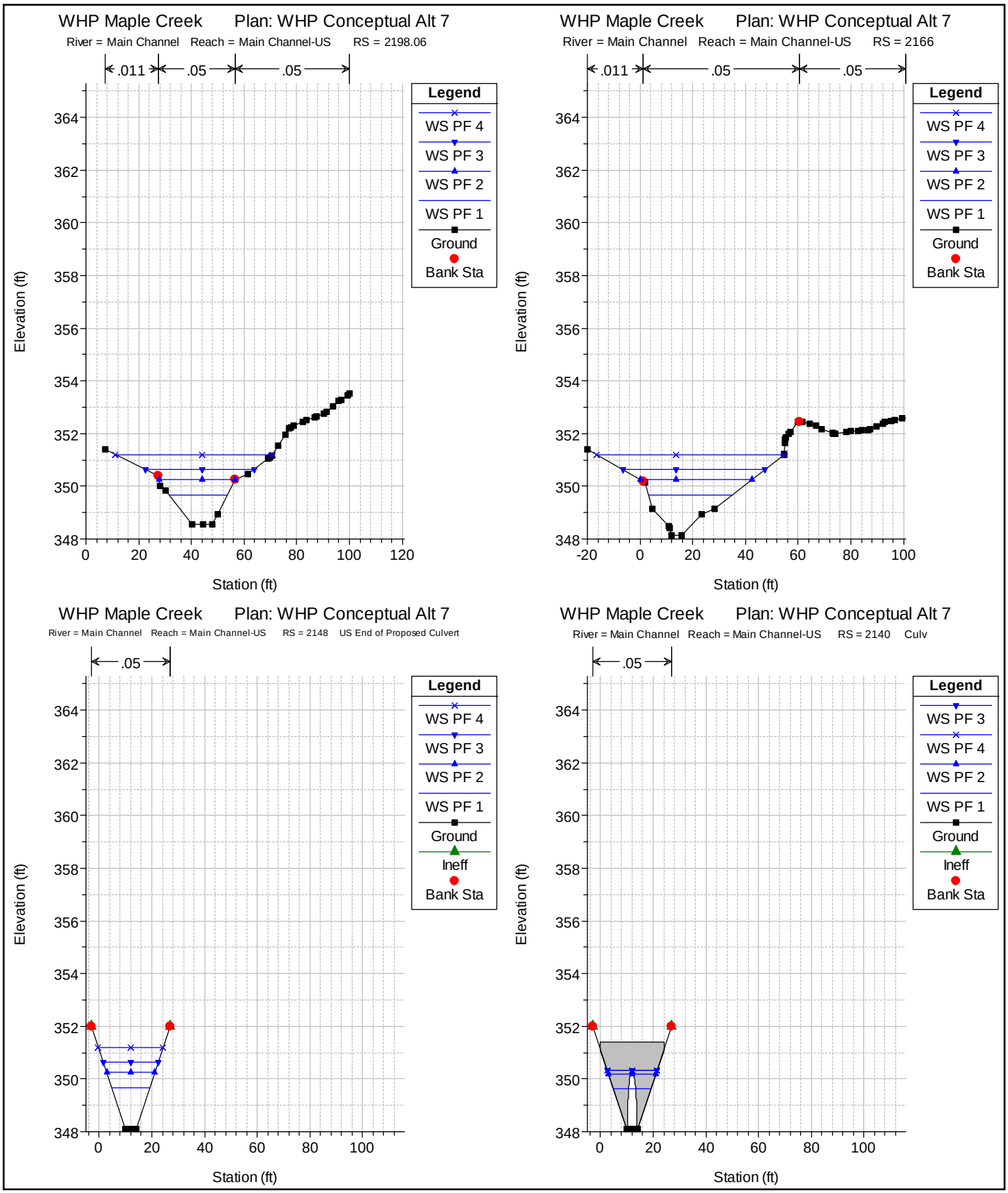

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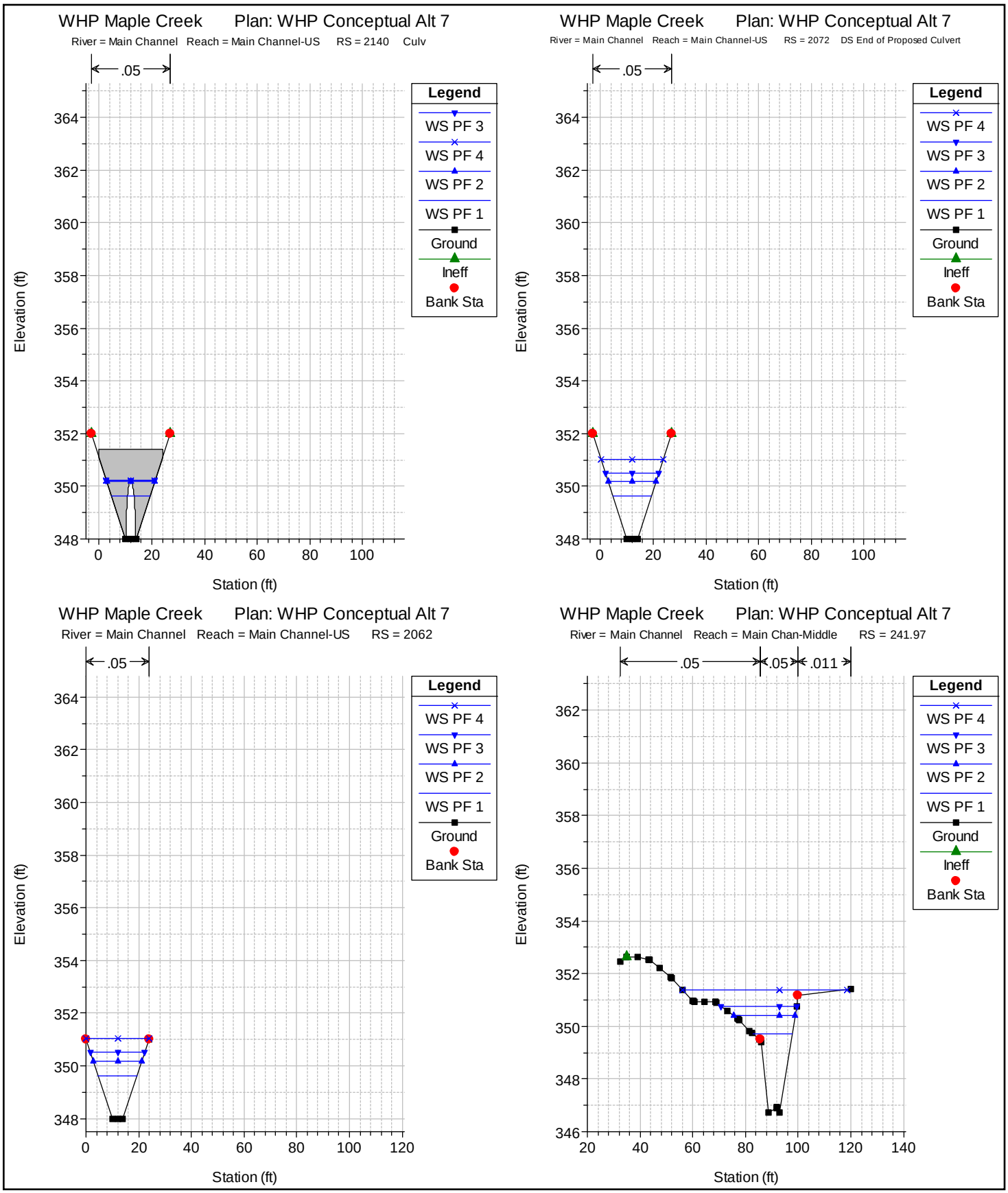

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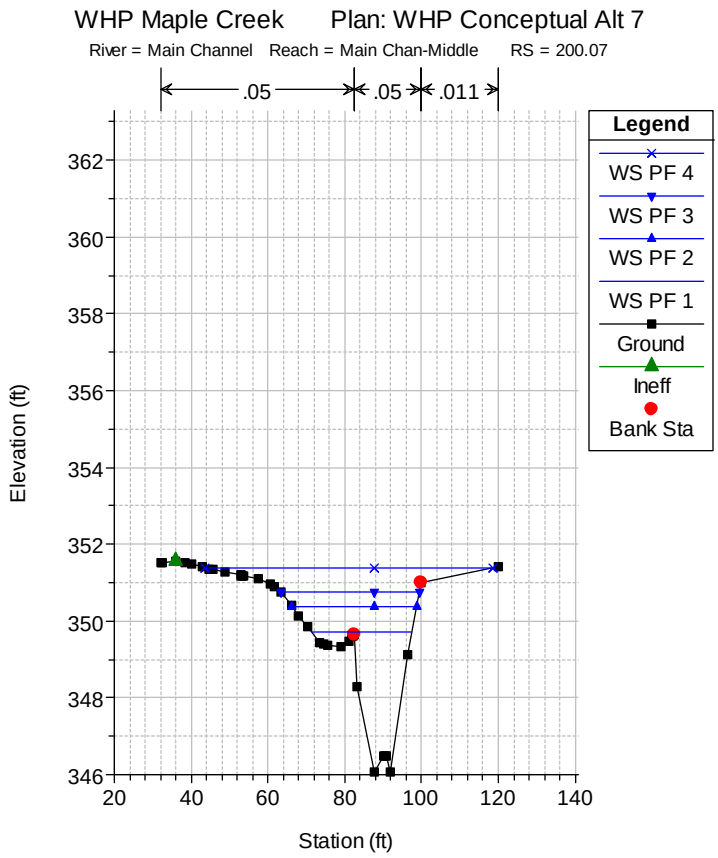

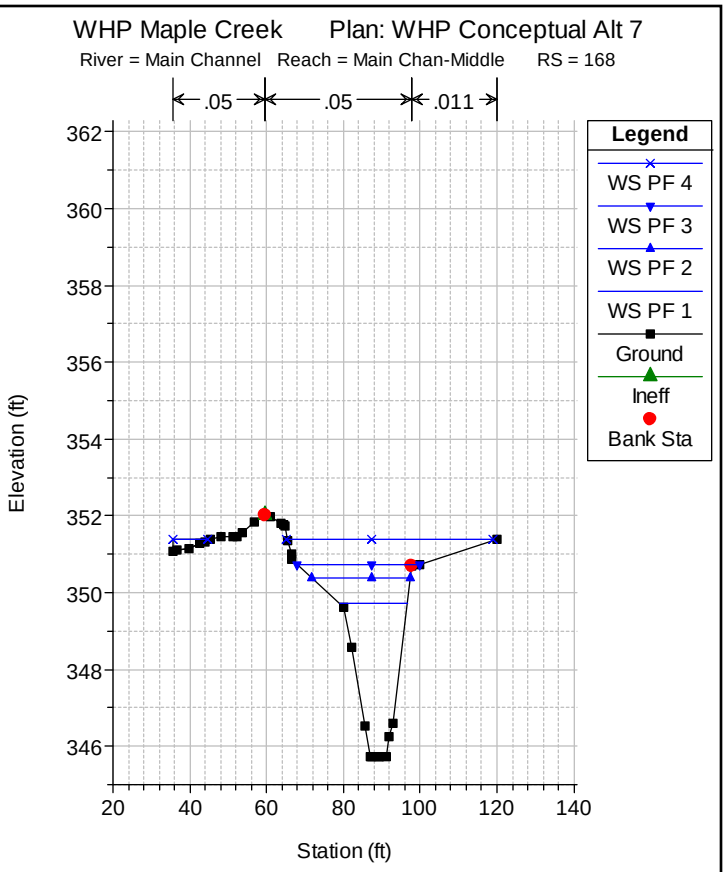

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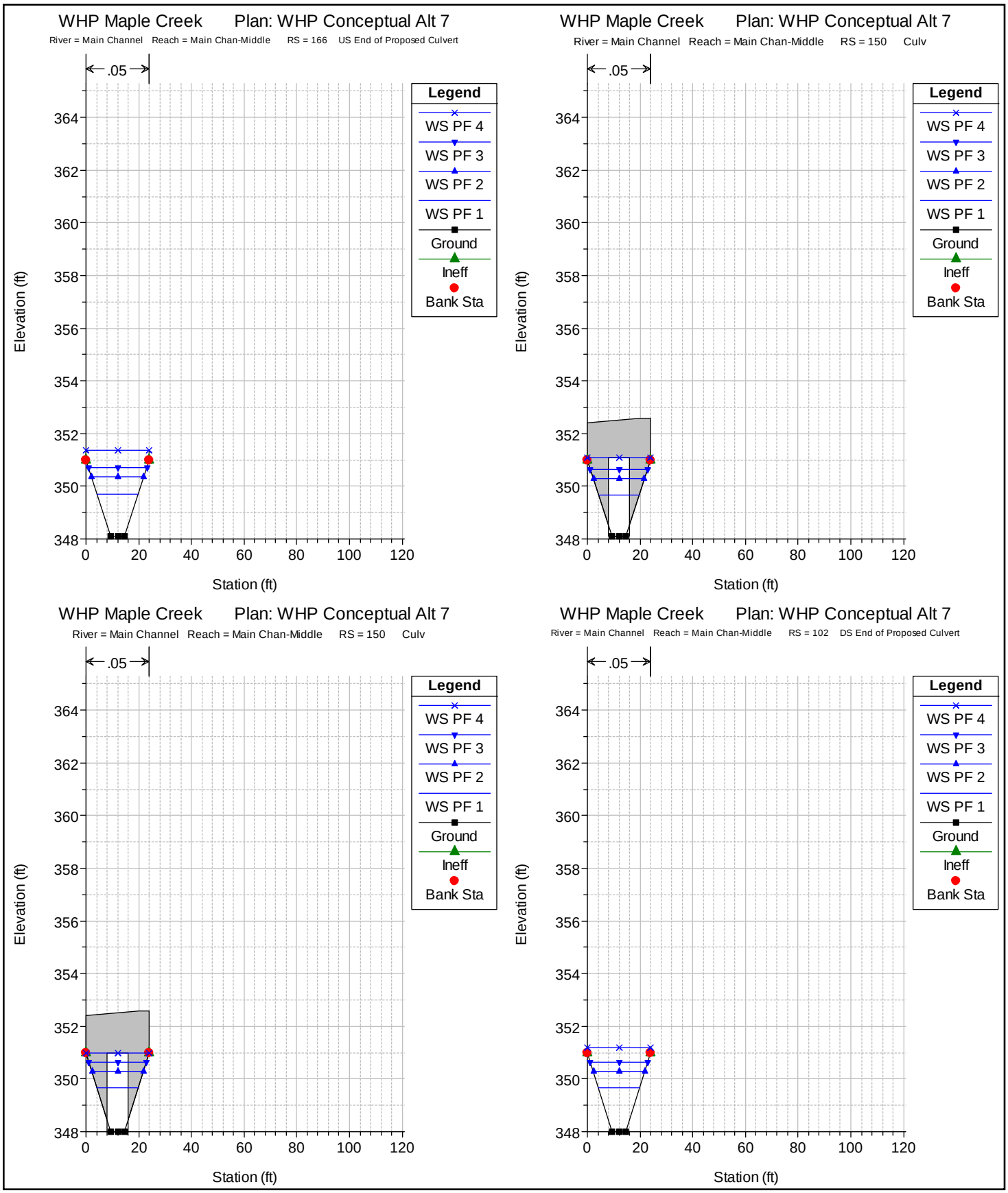

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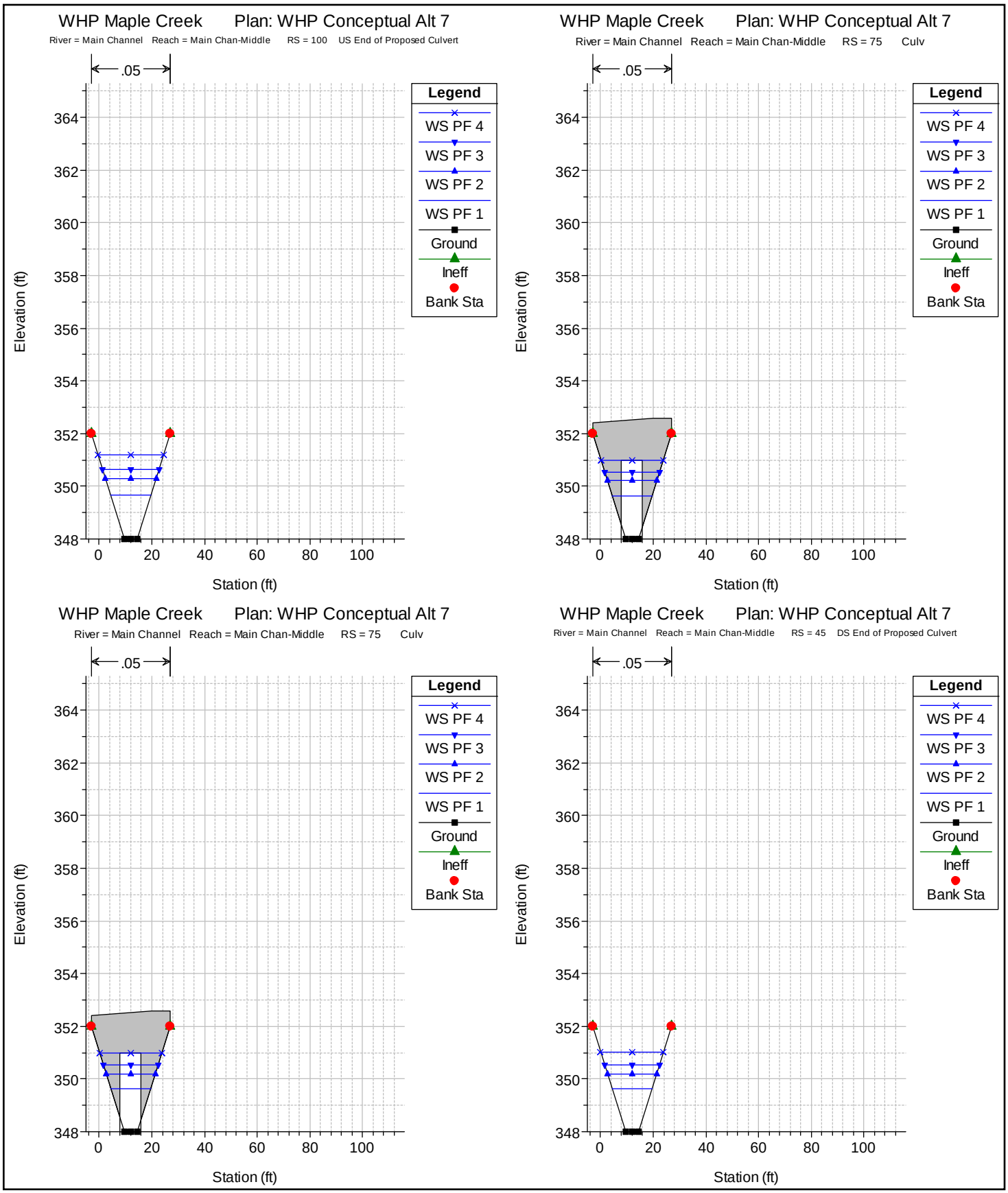

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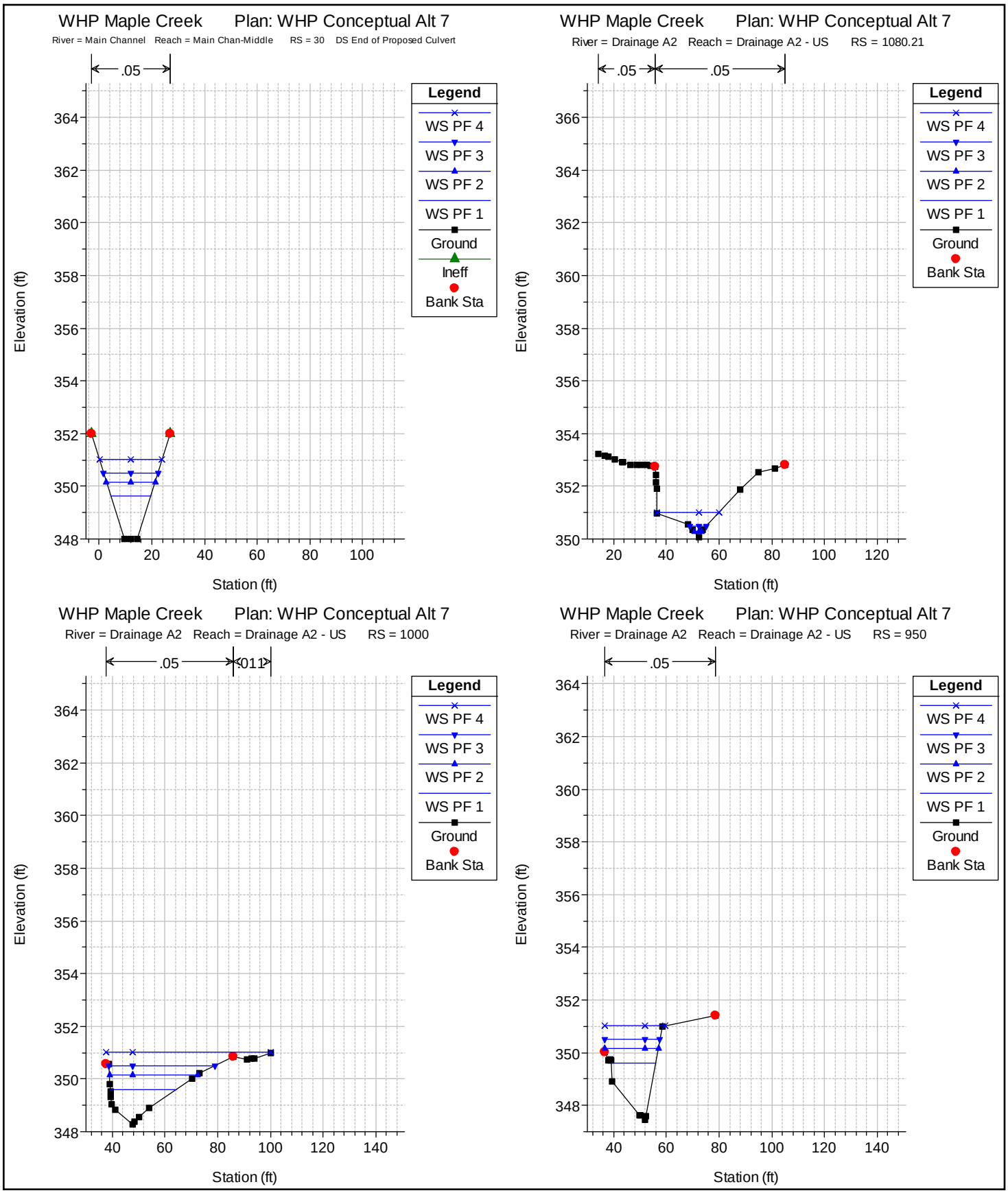

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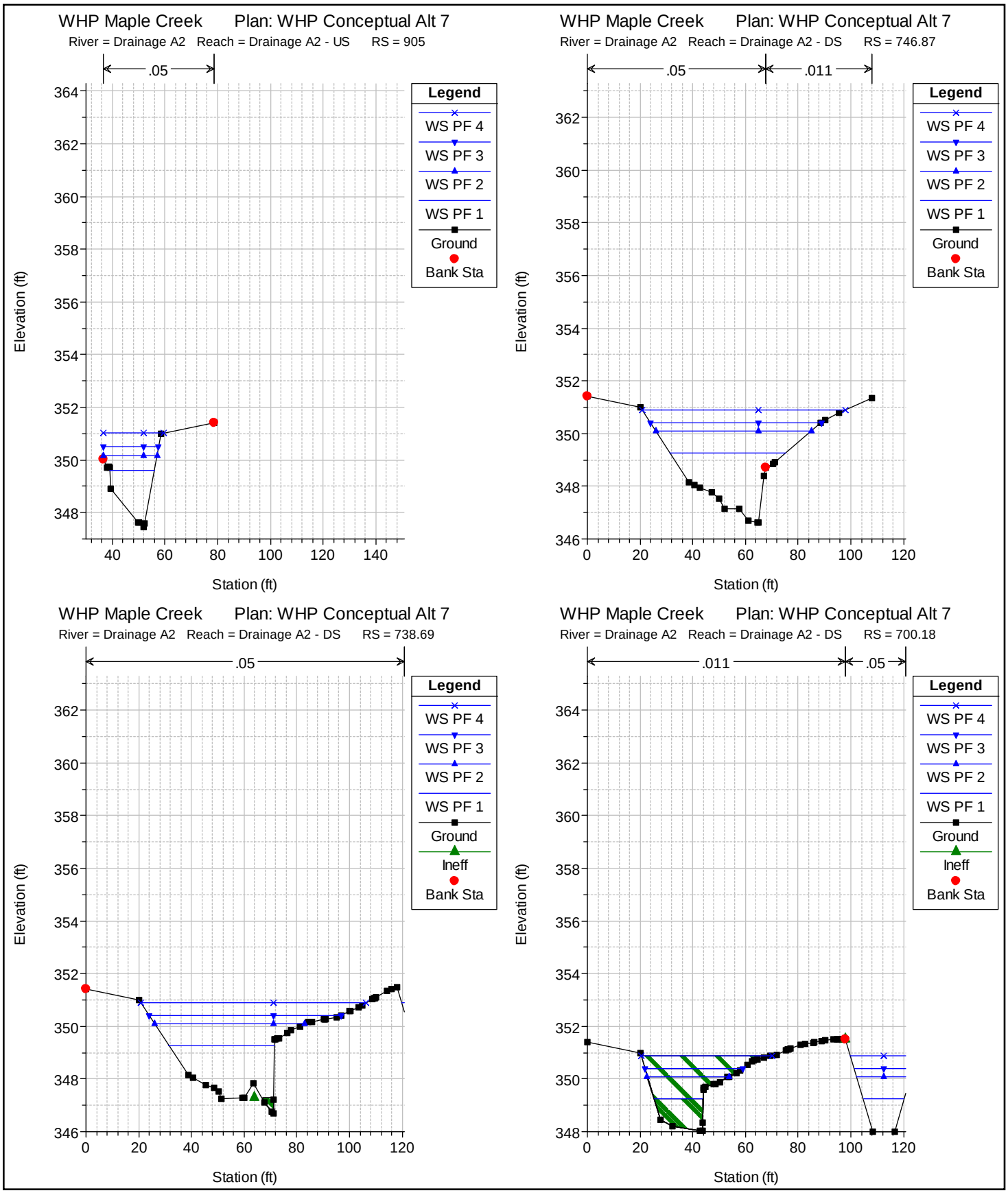

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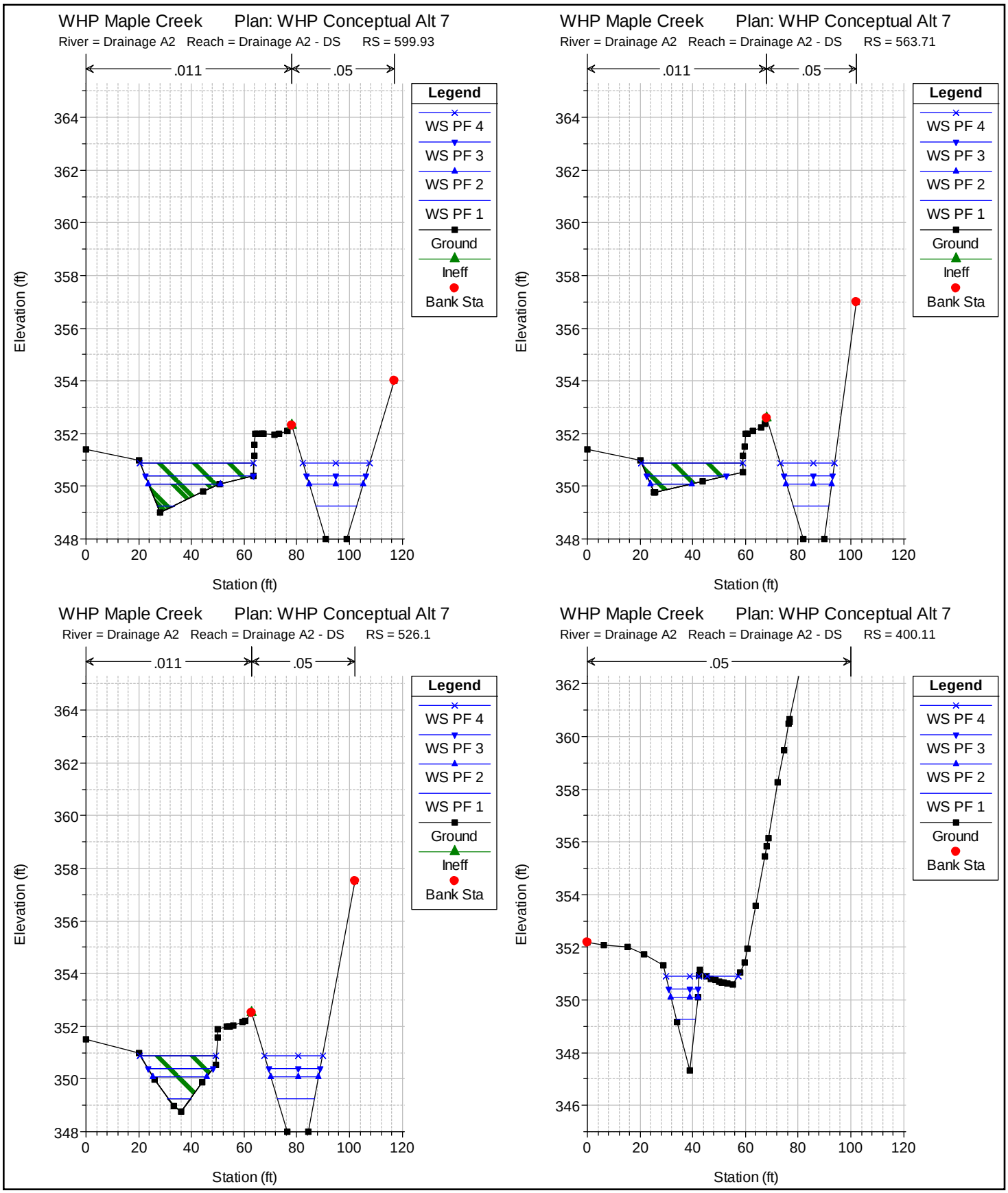

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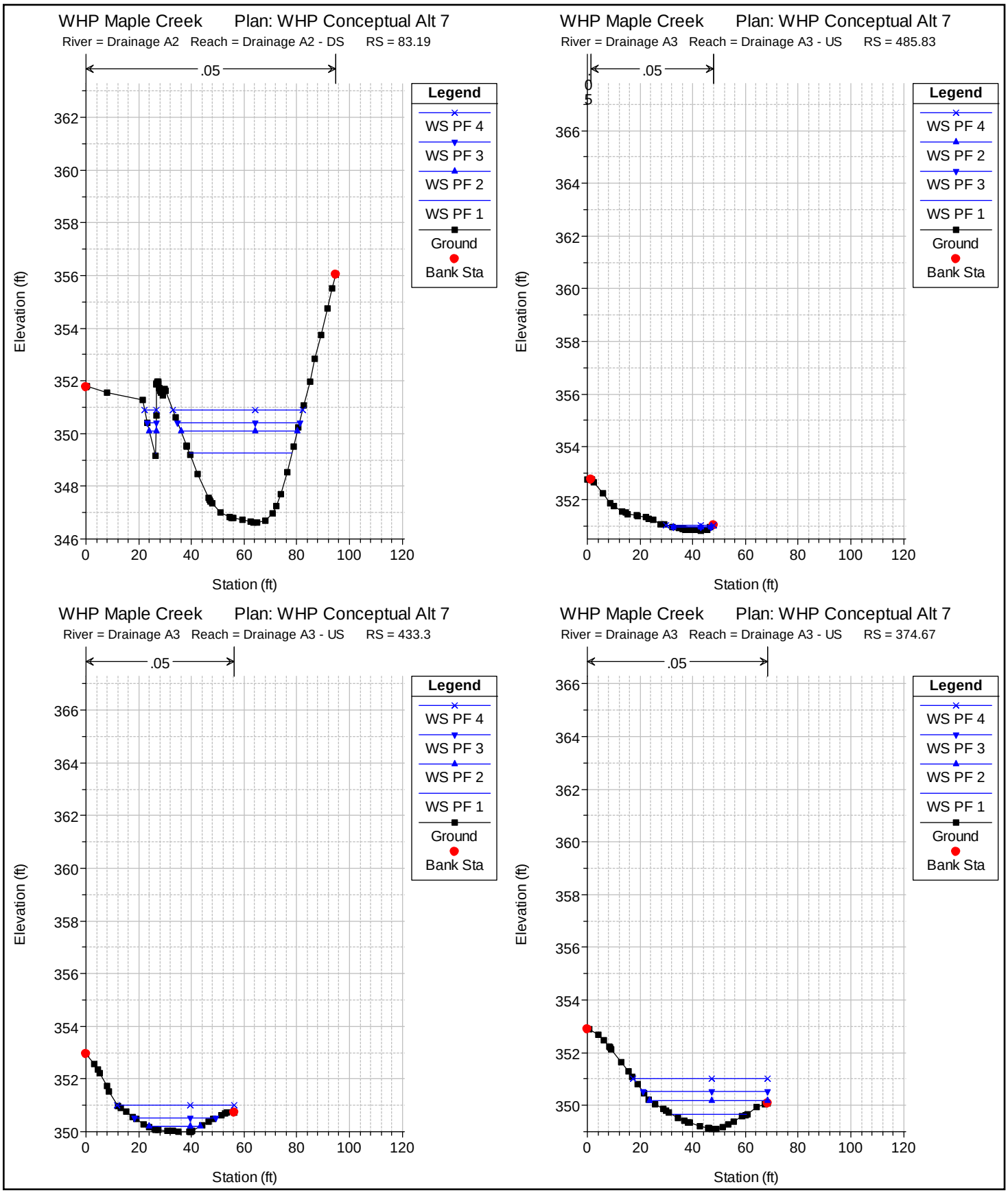

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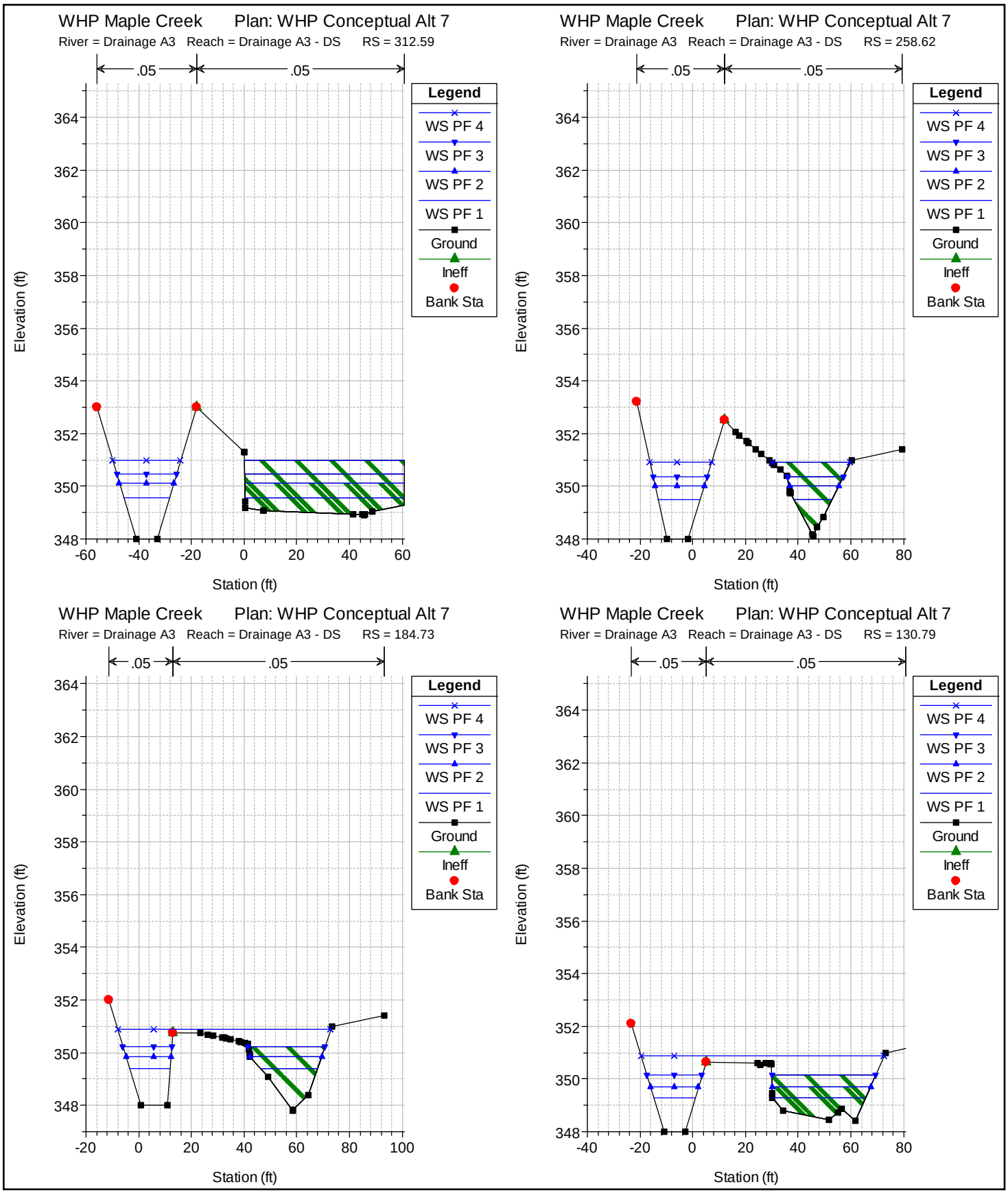

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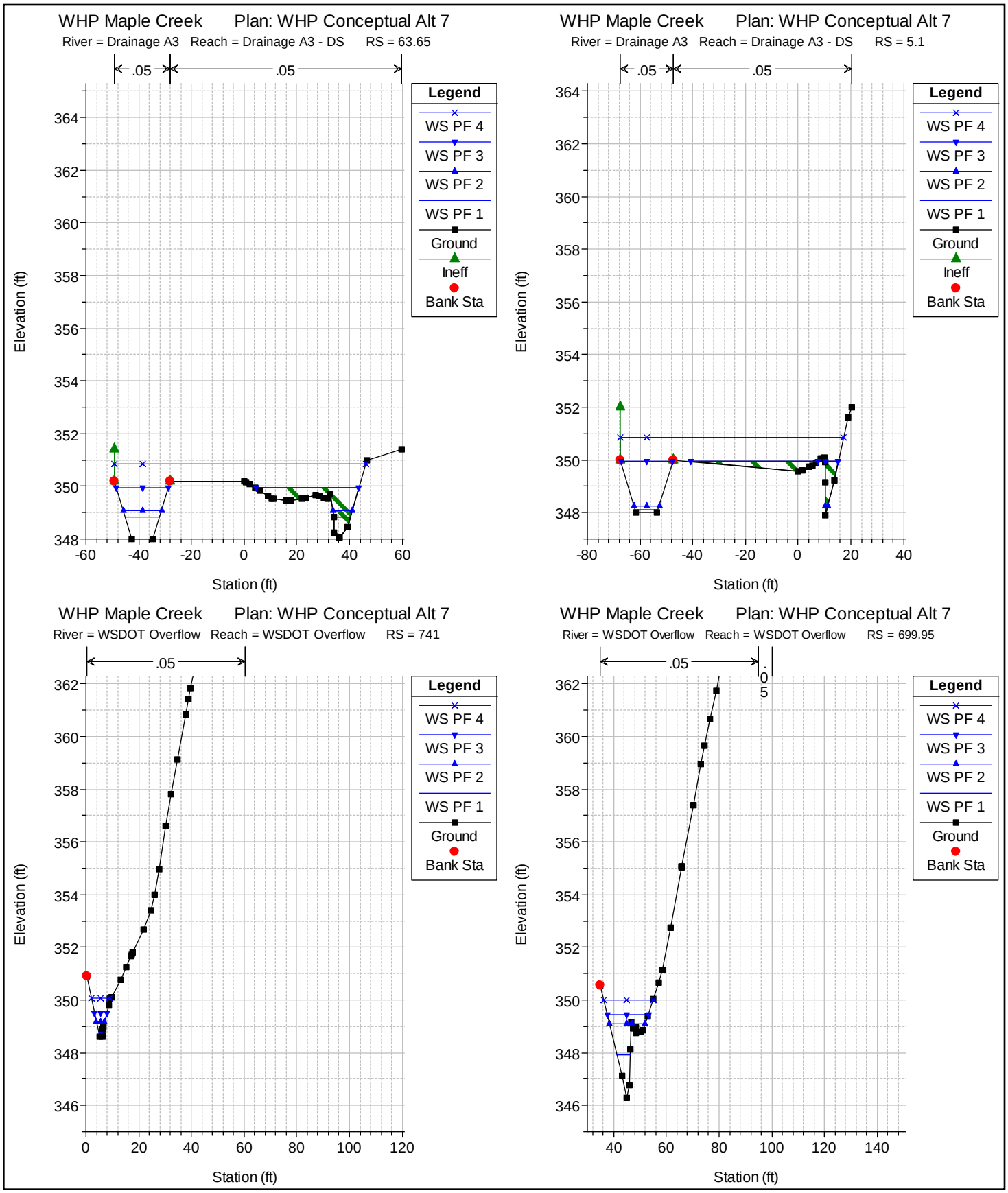

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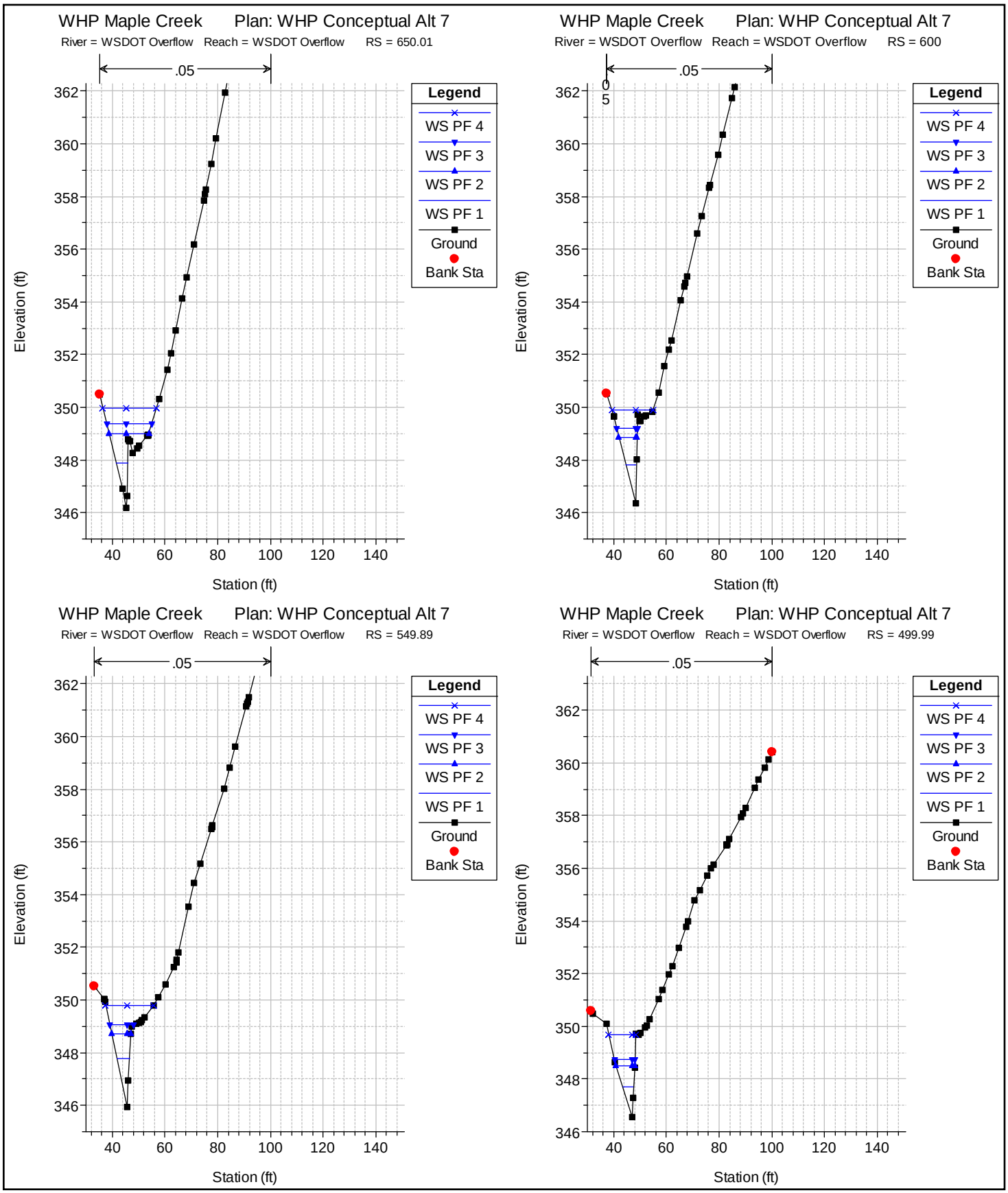

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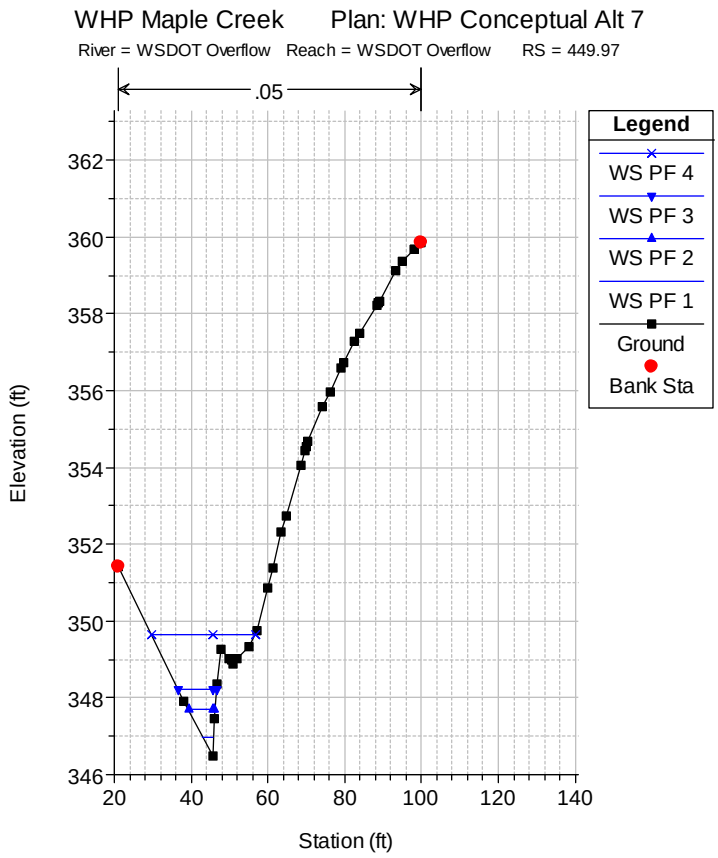

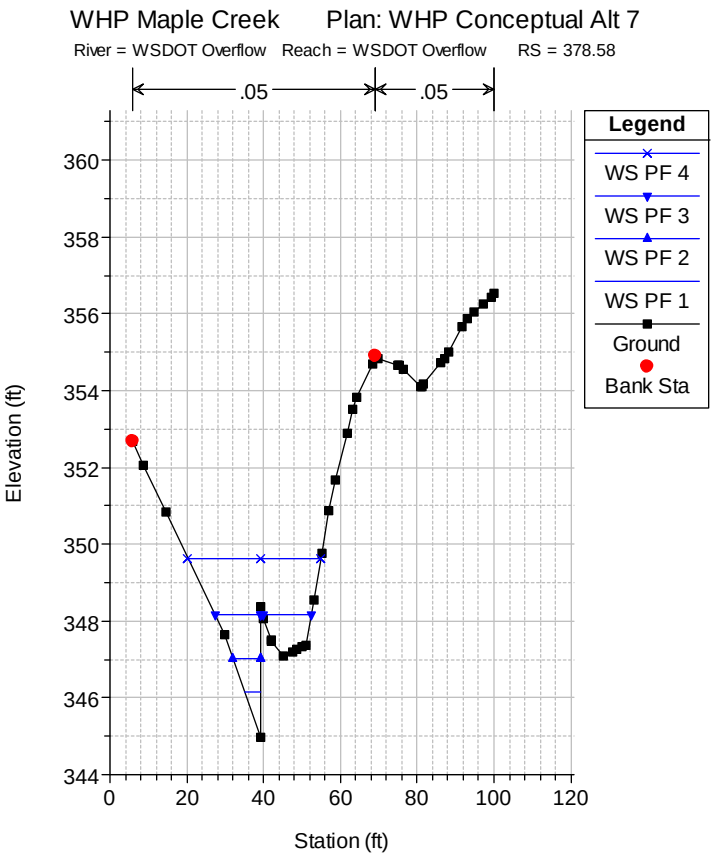

1 in Horiz. = 50 ft 1 in Vert. = 5 ft

APPENDIX E

Landau and Associates

Geotechnical Report

Report
Geotechnical Services
Maple Road High Flow Bypass
Snohomish County, Washington

May 16, 2013

Prepared for

WHPacific, Inc.
12100 NE 195th Street, Suite 300
Bothell, Washington 98011

LANDAU ASSOCIATES
130 2nd Avenue South
Edmonds, WA 98020
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Figure	Title
1	Vicinity Map
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1.0 INTRODUCTION

This report summarizes the results of geotechnical engineering services conducted for Snohomish County's (County) proposed Maple Road High Flow Bypass project. The general project location is shown on the Vicinity Map (Figure 1). The general configuration of the project area is shown on the Site Plan (Figure 2).

This report has been prepared based on our discussions with representatives of WHPacific, Inc. (WHPacific) and the County; our review of reports of past geotechnical studies conducted in the project area by others (Hart Crowser 1993; Hart Crowser 1997; Snohomish County 2010; WSDOT 1980); observations made during our site reconnaissance; our familiarity with geologic conditions within the vicinity of the project area; and our experience on similar projects.

1.1 PROJECT DESCRIPTION

The County and the City of Lynnwood (City) are working together to alleviate flooding in the vicinity of the intersection of Maple Road and Ash Way. This intersection, which is located in the vicinity of the State Route 525 (SR 525) overpass, has been the site of frequent stormwater flooding that results in road closures several times per year. This flooding, which occurs at an intersection that is considered a significant gateway into the City, restricts access into the City and negatively impacts travel time for emergency vehicles.

Potential solutions to the flooding problem include improving culvert and channel conveyance features in the project area. In addition, raising the elevation of a portion of Maple Road and Ash Way has also been considered as a solution to help resolve the flooding problem. At the time this report was prepared, it was understood that the elevation along the shoulders of Maple Road and Ash Way would need to be raised by several feet to alleviate some of the flooding problems. For this approach to be effective, the elevation of Maple Road would need to be raised from Ash Way to a point located about 300 ft west of Alder Way.

Maple Road has settled several feet or more since it was constructed in 1983. It is our understanding that the new grades proposed along Maple Road would not be more than about 2 ft higher than the grades that existed when the roadway was originally constructed.

1.2 SCOPE OF SERVICES

WHPacific retained Landau Associates to review available geologic and geotechnical information for the project area and provide geotechnical input during the development of up to four alternative approaches to raise the grades of Maple Road. Our services were provided in general accordance with the

scope of services outlined in and the terms of a Subconsultant Agreement between WHPacific and Landau Associates dated March 5, 2013. Our scope of services included the following specific tasks:

- Reviewing readily available geologic and geotechnical information and other relevant data for the project area.
- Completing a geologic reconnaissance of the project area and collecting information on the general nature and physical features of the area surrounding the project alignment.
- Providing geotechnical input during the development of up to four alternative approaches to raise the grades of Maple Road and Ash Way and limit impacts to existing facilities in the project area.
- Participating in meetings with the County and City to present the identified alternative approaches for raising the grades of Maple Road.
- Preparing and submitting this written report summarizing our findings, conclusions, and geotechnical recommendations for the project. This report includes:
  - a site plan showing the locations of explorations conducted by others in the project area
  - a discussion of the near-surface soil and groundwater conditions anticipated along the project alignment, including an estimation of the lateral extent of the peat deposit in the project area based on available geotechnical data
  - a qualitative discussion of the possible impacts to existing facilities in the project area (e.g., pile-supported sewer, other underground utilities, SR 525 piles, etc.) that could occur if the grades of Maple Road are raised
  - a discussion related to four alternative approaches that could be used to raise the grades of Maple Road and limit impacts to existing facilities in the project area
  - a discussion of the relative cost, life cycle assessment, maintenance requirements, and constructability issues associated with each of the identified alternative approaches
  - a summary of dewatering methods that will be needed for each alternative
  - identification of further explorations needed to develop geotechnical recommendations to support final design of the selected alternative.

2.0 SITE CONDITIONS

This section discusses the general geologic setting of the project area and describes the surface and subsurface conditions observed along the project alignment at the time of our site reconnaissance. Interpretations of the site conditions are based on the results of our review of available subsurface information collected by others (listed in Section 5.0) and the results of our site reconnaissance.

2.1 GEOLOGIC SETTING

General geologic information for the project area was obtained from the *Geologic Map of the Edmonds East and Part of the Edmonds West Quadrangles, Washington* (Minard 1983), published by the U.S. Geological Survey. According to this source, near-surface deposits in the vicinity of the project site consist of 4 to 11 meters of peat, much of which is described as consisting of good quality sphagnum peat. Peat is generally characterized as a highly compressible, very soft to soft, organic rich deposit that has low shear strength.

Based on information contained on the above referenced geologic map, it is inferred that the peat deposit in the project area is underlain by glacial till. Soil defined as glacial till typically consists of a heterogenous, non-sorted mixture of subrounded boulders, cobbles, gravel, and sand in a matrix of silt and clay. The heterogenous nature of the till is a result of it being mixed and transported before being deposited, overridden, and compacted by the weight of an advancing glacier. This unit typically exhibits low permeability and high shear strength.

Though not indicated on the above-referenced geologic map, fill associated with construction of the existing roadways and highway in the vicinity of the project alignment should be anticipated in the project area.

2.2 SURFACE CONDITIONS

Maple Road crosses under SR 525 at a point located north of Alderwood Mall and west of Interstate 5. The SR 525 overpass, which was constructed in 1983, is supported by a series of columns that are in turn reportedly supported by a number of steel HP 14x89 piles. Adjacent to Maple Road, the gravel backfill that was presumably placed around the pile caps for the columns that support the overpass has settled a vertical distance that appears to be on the order of about 1 to 2 ft. In addition, the portion of Maple Road that is located in the vicinity of the SR 525 overpass has experienced significant differential settlement that has resulted in longitudinal cracks along portions of the pavement section and an accentuated roadway crown that has an elevation that is several feet higher than the elevations along the

shoulders of the roadway. The length of Maple Road that has settled in this manner is estimated to be approximately 350 ft.

In the early 1990s, the Alderwood Water and Wastewater District installed a 36-inch diameter reinforced concrete sewer main beneath the approximate centerline of Maple Road. This sewer main reportedly has an invert that is located about 12 ft below the ground surface (BGS) and is bedded in controlled density fill. In the vicinity of the SR 525 overpass, the sewer main is supported by timber piles. The presence of the pile-supported sewer is likely a contributing factor to the differential settlement along Maple Road and the accentuated roadway crown.

2.3 ANTICIPATED SUBSURFACE SOIL CONDITIONS

Subsurface conditions along the project alignment were interpreted from past exploratory borings completed by others (Hart Crowser 1993; Hart Crowser 1997; Snohomish County 2010; d WSDOT 1980) in the project area. The subsurface conditions described in these reports are generally consistent with one another and by reviewing these reports collectively, we were not able to make any conclusions about the subsurface conditions beyond those that were made by the individual investigators.

Based on our review of the available subsurface information, subsurface conditions along the project alignment are interpreted to consist of up to about 33 ft of peat that is overlain by a surficial layer of fill material and is underlain by interbedded sand, silt, and silty sand. The deepest thickness of peat along Maple Road is anticipated to be located beneath the SR 525 overpass. It should be noted that some of the peat that is reported on the summary logs for the above referenced exploratory borings may have been partially or completely removed when Alderwood Mall Parkway was constructed.

Deeper borings that were advanced by WSDOT in the late 1970s and early 1980s along the alignment of the SR 525 overpass reportedly encountered very dense glacial till at depths ranging from about 37 to 42 ft below the ground surface that existed at the time these explorations were conducted.

2.4 GROUNDWATER

At the times of the previous subsurface investigations that were conducted in September 1979, October 1979, November 1997, January 1980, October 1992, and November 1993, groundwater was reported in all of the exploratory borings that were advanced in the vicinity of the project area. The depths to groundwater reportedly ranged from 0 to about 39 ft BGS. All but two of the previous explorations (HC-104 and HC-105, which are located more than 2,000 ft southeast of the SR 525 overpass) reportedly encountered groundwater within about 5 ft of the ground surface. At the locations of exploratory borings HC-104 and HC-105, the depth to groundwater was reported to be 19 and 39 ft BGS, respectively. Seven of the previous exploratory borings conducted by WSDOT along the alignment of the

SR 525 overpass reportedly encountered groundwater under artesian pressure at depths ranging from about 26 to 65 ft BGS. At these locations, artesian heads ranging from 1 to 20 feet (measured above the ground surface) and artesian flows ranging from a few gallons per hour to up to 1,200 gallons per hour were reported.

It should be noted that the groundwater information reported herein is for the specific dates and locations indicated, and therefore may not necessarily be indicative of other locations and/or times. Furthermore, it is anticipated that groundwater conditions will vary depending on local subsurface conditions, the weather, the level of Swamp Creek, and other factors. It is likely that maximum groundwater levels would occur during the wetter times of the year.

3.0 CONCLUSIONS AND RECOMMENDATIONS

The following sections present geotechnical conclusions and recommendations related to the estimated lateral extent of the peat deposit, settlement consideration, roadway reconstruction alternatives, temporary construction dewatering, and additional subsurface explorations needed to support final design of the selected roadway reconstruction alternative.

3.1 ESTIMATED LATERAL EXTENT OF PEAT DEPOSIT

Based on the available geotechnical information that we reviewed for this project, we estimate that the peat deposit extends west of the intersection of Maple Road and Ash Way (i.e., beyond the western limit of the project alignment). However, some of the peat in the vicinity of this intersection may have been removed during construction of Alderwood Mall Parkway. The peat deposit is present beneath the SR 525 overpass, and the information that we reviewed and summarized on Figure 2 indicates that the eastern limit of the peat deposit is located about 100 ft south of the point where the alignment of Maple Road curves to the southeast and begins paralleling SR 525 (approximately 400 ft east of the intersection of Ash Way and Maple Road). Due to the lack of previous exploratory borings along Ash Way, we are unable to estimate how far north and south along Ash Way the peat deposit extends.

3.2 SETTLEMENT CONSIDERATIONS

When a roadway embankment is constructed over a peat deposit, the peat deposit will undergo consolidation under the weight of the embankment. This consolidation will result in settlement of the embankment. In general, this process of consolidation and settlement will occur in two phases that are referred to as primary consolidation and secondary compression. During the primary consolidation phase, the volume of the peat deposit decreases through the expulsion of water. During the secondary compression phase, the volume of the peat deposit decreases as the individual particles/fibers of the peat deposit are forced together and reorganized to form a denser matrix. The magnitude of settlement associated with primary consolidation of a peat deposit is typically larger than the magnitude of settlement associated with the secondary compression phase. In addition, primary consolidation usually occurs over a period of weeks or months after the load is applied, whereas secondary compression can continue for many years after the primary consolidation phase is completed.

The portion of Maple Road that is underlain by peat has undergone settlement (and is likely still settling) as a result of the weight of the roadway embankment that was placed when the roadway was originally constructed in 1983. Given the amount of time that has passed since the roadway embankment was constructed, it is likely that the settlement that is occurring now is a result of secondary compression

of the peat. If the roadway is reconstructed and the weight of the reconstructed embankment does not exceed the weight of the original embankment, it is estimated that the peat will continue to undergo secondary compression and the magnitude of future roadway settlement will gradually decrease over time. However, if the weight of the reconstructed embankment exceeds the weight of the original embankment, the additional weight of fill could induce additional primary consolidation of the peat, thereby possibly resulting in large primary consolidation settlements (compared to settlements associated with secondary compression) followed by many years of additional secondary compression settlement.

If a pile is driven through a soft, compressible material such as peat, it is possible for the peat to move downwards with respect to the pile. The downward movement (or settlement) of the peat may be caused by the application of a surcharge associated with the placement of additional fill or a lowering of the water table. If the settlement of the peat surrounding a pile is larger than the downward movement of the pile, the shear stresses mobilized along a portion of the pile will act downward and are referred to as negative skin friction. This negative skin friction (or downdrag) will increase the load applied to the pile. In the case of a pile with its tip supported in a hard/dense unyielding layer, the majority of the downward movement of the pile will be due to the compression of the pile (i.e., very little downward movement of the pile will occur). This condition leads to a larger downdrag load on the pile as compared to a pile that has its tip supported in a deformable soil unit that allows downward movement of the pile.

Because the piles that support the sewer main are reportedly embedded in dense glacially consolidated material that will limit the amount of downward pile movement that can occur, if Maple Road is reconstructed and the weight of the reconstructed embankment exceeds the weight of the original embankment, the induced settlement of the peat could impose additional downdrag loads on the piles that support the sewer main. Depending on the location and weight of the new embankment, additional downdrag loads could also be imposed on the steel piles that support the SR 525 overpass. The introduction of additional downdrag loads on these piles would reduce the allowable load carrying capacity of these piles. Furthermore, the additional load from the new roadway fill could possibly distort and/or damage the existing pile-supported sewer main and other nearby utilities that were installed within the roadway prism without pile support.

3.3 ROADWAY RECONSTRUCTION ALTERNATIVES

The following sections present our conclusions and recommendations related to four alternatives that are being considered to raise the grades of Maple Road.

3.3.1 TRADITIONAL APPROACH

The traditional approach to raise the grades of Maple Road would be to simply remove the existing asphalt concrete pavement and place an imported material consisting of well graded sand and gravel (e.g., Gravel Borrow) to the desired pavement subgrade elevations. The advantages of this approach include relatively low initial costs (compared to the other alternatives presented herein) and no need for specialty contractors, specialized construction equipment, or temporary construction dewatering. The disadvantages of this alternative include possible adverse settlement impacts to the pile-supported sewer and overpass (see Section 3.2) and the likely need to periodically repair and/or repave the roadway as the embankment continues to settle as a result of primary consolidation and secondary compression of the underlying compressible peat unit. Because it is anticipated that the Maple Road embankment has not completely settled, it should be noted that these disadvantages apply whether or not the weight of the reconstructed embankment exceeds the weight of the original embankment. However, if the weight of the reconstructed embankment does not exceed the weight of the original embankment, the disadvantages associated with this alternative would be reduced and this alternative would become more attractive in terms of cost and the need for future roadway repairs.

3.3.2 LIGHTWEIGHT FILL

Impacts to the existing pile-supported overpass and sewer associated with settlement induced by new roadway fill could be limited by raising the grades of the roadway using a lightweight fill, such as expanded polystyrene (EPS) geofoam. Because geofoam is approximately 100 times lighter than conventional fill, its use greatly reduces vertical loads and future settlement. Geofoam embankments can be covered with soil to look like normal sloped embankments. Geofoam blocks are typically 3 ft x 4 ft x 8 ft in size. For projects similar to this project, the conventional approach is to overexcavate an amount of soil that is equivalent to the weight of the geofoam and any additional soil (typically a **minimum** of 18 inches) that is used to provide enough weight on top of the EPS geofoam to prevent uplift associated with buoyancy.

For this project, we estimate that about 4.5 ft of geofoam plus 5.5 ft of overlying soil would be needed in order to raise the grades of the road by 2 ft without increasing the weight of the embankment and to prevent uplift (with a factor of safety of about 1.2) associated with buoyancy. This would result in the need for about an 8 ft over-excavation below existing grades. Raising existing road grades by 4 ft would require about 6 ft of geofoam with 7 ft of overlying soil, resulting in the need for about a 9 ft over-excavation below existing grades.

A local example of the use of geofoam for a similar application is the City of Bellevue's SE 8th Street Reconstruction project. The portion of SE 8th Street that was reconstructed is located over a peat

deposit associated with the Mercer Slough. After its original construction, this portion of SE 8th Street settled up to about 4 ft. This settlement caused damage to the pavement section and underground utilities. The approach that the City of Bellevue used to solve this problem was to use lightweight geofoam fill to raise the roadway while limiting the additional weight being applied to the underlying soils. The combination of the geofoam fill, geogrid mesh reinforcement, and a thin layer of base course gravel directly beneath the asphalt surfacing resulted in a roadway section that transmits very little weight to the underlying soils and reduces roadway settlement.

The advantages of the lightweight fill alternative include the ability to raise the grades of the road without imposing any additional loads on the underlying peat deposits, thereby eliminating adverse impacts to the pile-supported sewer and overpass. This alternative also has the advantage of reducing the need to periodically repair and/or repave the roadway as a result of future roadway embankment settlement. The disadvantages of this alternative include higher initial cost to construct (compared to the traditional approach) and the need to overexcavate and export existing roadway embankment fill in order to install the geofoam. Depending on the depth of over-excavation required, the groundwater table could be encountered in the excavations; and because geofoam floats, it would be necessary to temporarily dewater the excavation prior to and during installation of the geofoam.

As noted in Section 3.2, a lowering of the water table in the vicinity of the pile-supported sewer and overpass could induce downdrag loads on these piles. Therefore, if temporary construction dewatering is necessary to facilitate construction of the lightweight fill alternative, it would be prudent to carefully design the temporary dewatering system such that adverse impacts to surrounding existing improvements are limited. One method that could be used to limit adverse impacts would be to dewater from within a relatively watertight shoring system. Dewatering the excavation in this manner would limit the amount of groundwater that would need to be extracted and limit the radius of influence of the dewatering system.

3.3.3 PILE-SUPPORTED ROAD

A combination of piles, pile caps, grade beams, and a structural slab could be used to reconstruct the portion of the roadway that is underlain by peat. Given the width of the existing roadway (about 40 to 60 ft), it is estimated that 2 to 3 rows of high capacity piles oriented parallel to the centerline of the roadway would be required to support the roadway. The required spacing between piles is estimated to be on the order of 15 to 20 ft; however, this spacing would become much closer if low capacity piles (e.g., pin piles) were used to support the structural slab. The available subsurface information that we reviewed suggests that the piles would need to be installed to depths of at least 37 to 42 ft BGS in order to embed the piles in the competent underlying glacial till and provide adequate support for the roadway.

Similar to the lightweight fill alternative, the advantages of the pile-supported road alternative include the ability to raise the grades of the road without imposing any additional loads on the underlying peat deposits, thereby eliminating adverse impacts to the pile-supported sewer and overpass. This alternative also has the advantage of reducing or possibly eliminating the need to periodically repair and/or repave the roadway as a result of roadway embankment settlement. The disadvantages of this alternative include the need for a specialty contractor and specialized construction equipment (including the need for low overhead equipment for pile installation below the highway overpass) and an initial cost to design and construct that is estimated to be greater than the three other alternatives presented herein.

3.3.4 RAILROAD BALLAST

This alternative was proposed by the County and is summarized in a technical memorandum dated June 8, 2010 that the County prepared. Their memorandum describes this alternative as consisting of over-excavating a portion of the existing embankment and replacing it with railroad ballast. The excavation of the existing embankment is described as extending vertically down to a depth of 3.5 ft BGS and horizontally 1 foot beyond the existing pavement edge. Towards the centerline of the roadway, the excavation would step up onto the Alderwood Water and Wastewater District sewer trench backfill to a depth of about 1.5 ft BGS. Prior to the placement of railroad ballast, the entire base of the excavation would be covered with a layer of non-woven drainage geotextile followed by a layer of biaxial geogrid. The County recommended extending the geogrid and geotextile a distance of about 6 ft beyond the edge of the excavation. The County also recommended covering the geogrid and geotextile with 3 inches of sand in order to protect the underlying geosynthetic materials from the angular ballast. After gently placing railroad ballast over the sand cushion to a depth of 2 ft, the County recommended pulling the tails of the geogrid and geotextile over the top of the railroad ballast. A second layer of geogrid and geotextile wrapped railroad ballast (including the sand cushion) would then be similarly constructed on top of the initial layer of railroad ballast. Additional railroad ballast would then be placed on top of the geogrid and geotextile wrapped railroad ballast in order to achieve the desired grades. Once the desired grades are achieved, the ballast would be capped with 0.25 ft of crushed surfacing base course or shoulder ballast before paving with 0.35 ft of hot mix asphalt. It is our understanding that the above described construction method has been reviewed and accepted by both WSDOT and the Alderwood Water and Wastewater District.

It is estimated that the initial cost to construct a railroad ballast supported roadway would be more than the cost of the traditional approach, but significantly less than the cost of the lightweight fill and pile-supported road alternatives. Furthermore, because the unit weight of locally manufactured railroad ballast in about 70 percent of the unit weight of a gravelly sand backfill (Snohomish County 2010), the

use of railroad ballast allows for the embankment to be constructed approximately 40 percent higher without imparting additional load on the underlying peat deposit. The railroad ballast alternative also has the advantage of allowing water to flow through the ballast.

Even if the weight of the roadway embankment is not increased using the railroad ballast alternative, it is anticipated that the peat deposit beneath the reconstructed roadway embankment would continue to undergo settlement as a result of secondary compression of the underlying peat. Depending on the magnitude of this settlement, periodic reconstruction/repaving of the road may or may not be required. Provided the weight of the roadway embankment is not increased, it is our opinion that the magnitude of the secondary compression of the peat that will occur in the future will not be great enough to adversely impact the pile-supported sewer or overpass.

3.4 TEMPORARY CONSTRUCTION DEWATERING

Groundwater was reported in all of the exploratory borings that were advanced by others in the vicinity of the project area. The depths to groundwater reportedly ranged from 0 to about 39 ft BGS, with most of the depths to groundwater being reported to be within about 5 ft of the ground surface (see Section 2.4 for additional information regarding the depths to groundwater that are reported on the summary logs that we reviewed for this project). Based on this information, it is anticipated that temporary construction dewatering would be necessary to raise the grades of Maple Road using the lightweight fill and railroad ballast alternatives, but not the traditional or pile-supported road alternatives. If the maximum depth of excavation required to construct the lightweight fill and railroad ballast alternatives is on the order of about 5 ft and the excavation is completed during the summer and early fall months when groundwater levels are expected to be at their lowest levels, we expect that open sump pumping may be adequate to control groundwater seepage into the excavation. If the maximum depth of excavation exceeds about 5 ft and/or the excavation is completed during the late fall, winter, or spring months, it is anticipated that a more aggressive dewatering system (e.g., well points or deep wells) will likely be required to dewater the excavation due to both the volume of water that is expected to be encountered below this depth and the rate at which the water is expected to flow into the excavation.

3.5 COMPARISON OF RECONSTRUCTION ATLERNATIVES

Four alternatives for reconstructing the roadway were discussed in the previous sections of this report. The following table provides a relative comparison of the cost to design and construct each alternative, potential for post-construction roadway settlement, and anticipated need for periodic roadway maintenance in the future. Each of these items is assigned a relative ranking of 1 through 4, with 1 being

more expensive or more potential for post-construction settlement and need for periodic maintenance, and 4 being less expensive or less potential for settlement and need for maintenance.

Roadway Reconstruction Alternative	Relative Cost to Design and Construct	Potential for Post-Construction Settlement	Anticipated Need for Periodic Roadway Maintenance
Traditional Approach	4	1	1
Lightweight Fill	2	3	3
Pile-Supported Road	1	4	4
Railroad Ballast	3	2	2

3.6 ADDITIONAL SUBSURFACE EXPLORATIONS

Based on the available geotechnical information that we reviewed for this project, we estimate that the eastern limit of the peat deposit along Maple Road is located about 100 ft south of the point where the alignment of Maple Road curves to the southeast and begins paralleling SR 525 (approximately 400 ft east of the intersection of Ash Way and Maple Road). To refine the eastern extent (not depth) of the peat deposit, we recommended advancing two shallow (on the order of about 10 ft in depth) exploratory borings in the vicinity of where the eastern limit of the peat is currently estimated to be located.

The available data that we reviewed suggests that the peat deposit extends west of the intersection of Maple Road and Ash Way (i.e., beyond the western limit of the project alignment). However, some of the peat in the vicinity of this intersection may have been removed during construction of Alderwood Mall Parkway. We therefore recommend advancing one shallow (on the order of about 10 ft in depth) exploratory boring near the western limit of the project alignment to determine if peat is still present along this portion of the project alignment.

Once it is determined how much of Ash Way will need to be raised to help solve the flooding problem, we recommend advancing two deeper (on the order of about 30 ft in depth) borings along Ash Way to confirm if peat is present along the portion of Ash Way that will be raised and to define the depth (not extent) of the peat deposit in that area.

4.0 USE OF THIS REPORT

Landau Associates prepared this report for the exclusive use of WHPacfic, Inc. and Snohomish County for specific application to the design of the proposed Maple Road High Flow Bypass project in Snohomish County, Washington. Use of this report by others or for another project is at the user's sole risk. Landau Associates warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

The conclusions and recommendations contained in this report are based in part upon the subsurface data obtained by others from the explorations that were previously completed in the project area. There may be some variation in subsurface soil and groundwater conditions along the project alignment, and the nature and extent of the variations may not become evident until additional explorations are conducted, or even until construction. Accordingly, a contingency for unanticipated conditions should be included in the preliminary and design phase budgets to accommodate the potential for variability in the ground conditions. As the project enters the design stage, we should be advised so that we can finalize our geotechnical study and review our recommendations to determine if they are consistent with the project plans.

We appreciate the opportunity to provide geotechnical services on this project and look forward to assisting you during the construction phase of the project. If you have any questions or comments regarding the information contained in this report, or if we may be of further service, please call.

LANDAU ASSOCIATES, INC.

Steven R. Wright, P.E.
Principal

SZW/DAP/rgm

STEVEN R. WRIGHT
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32250
REGISTERED
PROFESSIONAL ENGINEER

5/16/13

5.0 REFERENCES

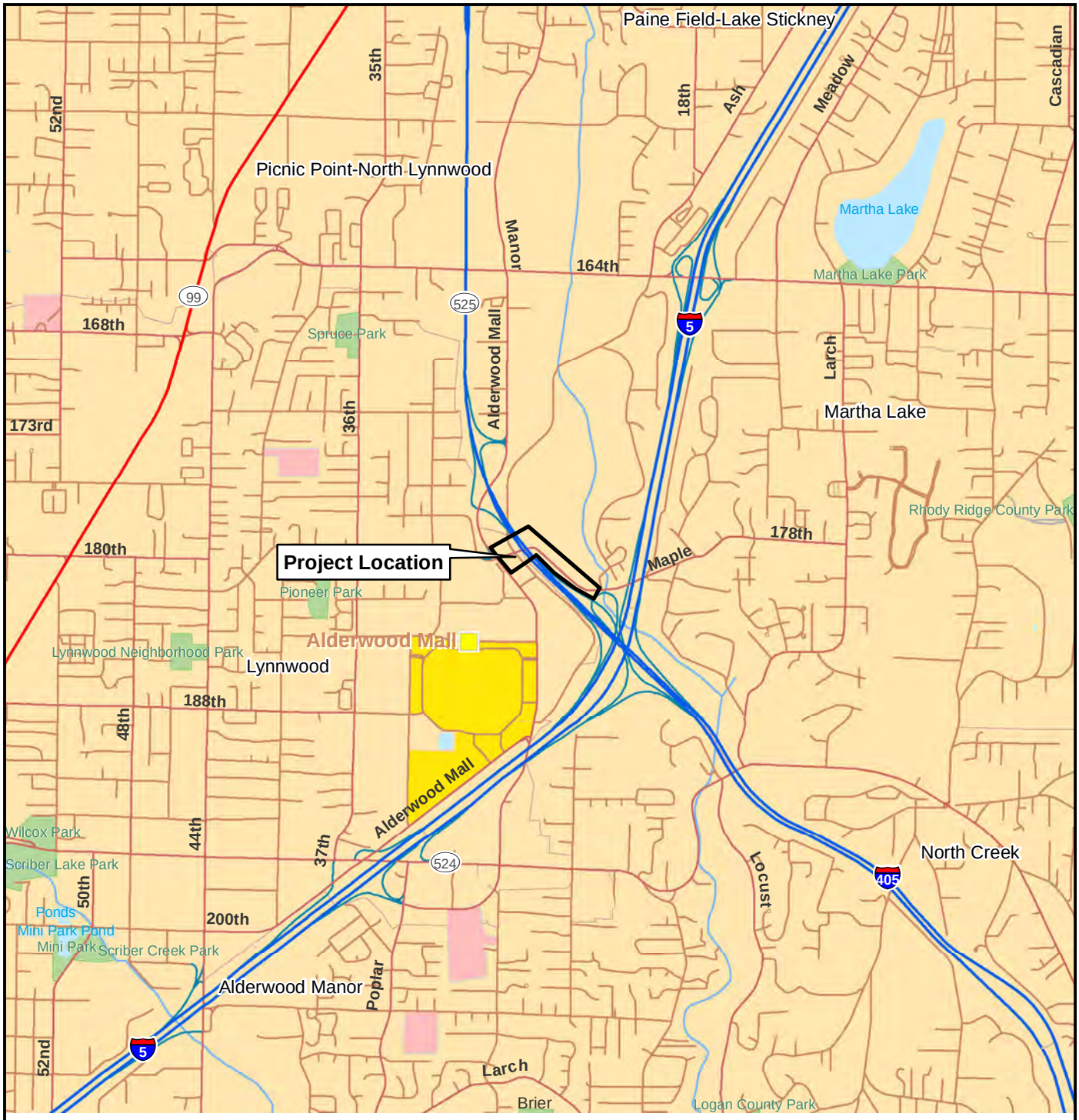
Hart Crowser. 1993. *Geotechnical Engineering Design Study, Swamp Creek Trunk Sewer Project, Phase II, Alderwood Water District*. February 8.

Hart Crowser. 1997. *Geotechnical Engineering Design Study, Swamp Creek Trunk Sewer Project, Maple Road Extension, Alderwood Water District*. June 13.

Minard, J.P. 1983. *Geologic Map of the Edmonds East and Part of the Edmonds West Quadrangles, Washington*. U.S. Geological Survey.

Snohomish County. 2010. *Geotechnical Recommendations, Maple Road at S.R. 525 Overcrossing*. June 8.

Washington State Department of Transportation. 1980. *SR-525, C.S. 3131, L-5793, SR-5 to Ashway Overcrossing, Vicinity Station LC 134+00, Soil Profile and Logs of Test Borings.* June 20.



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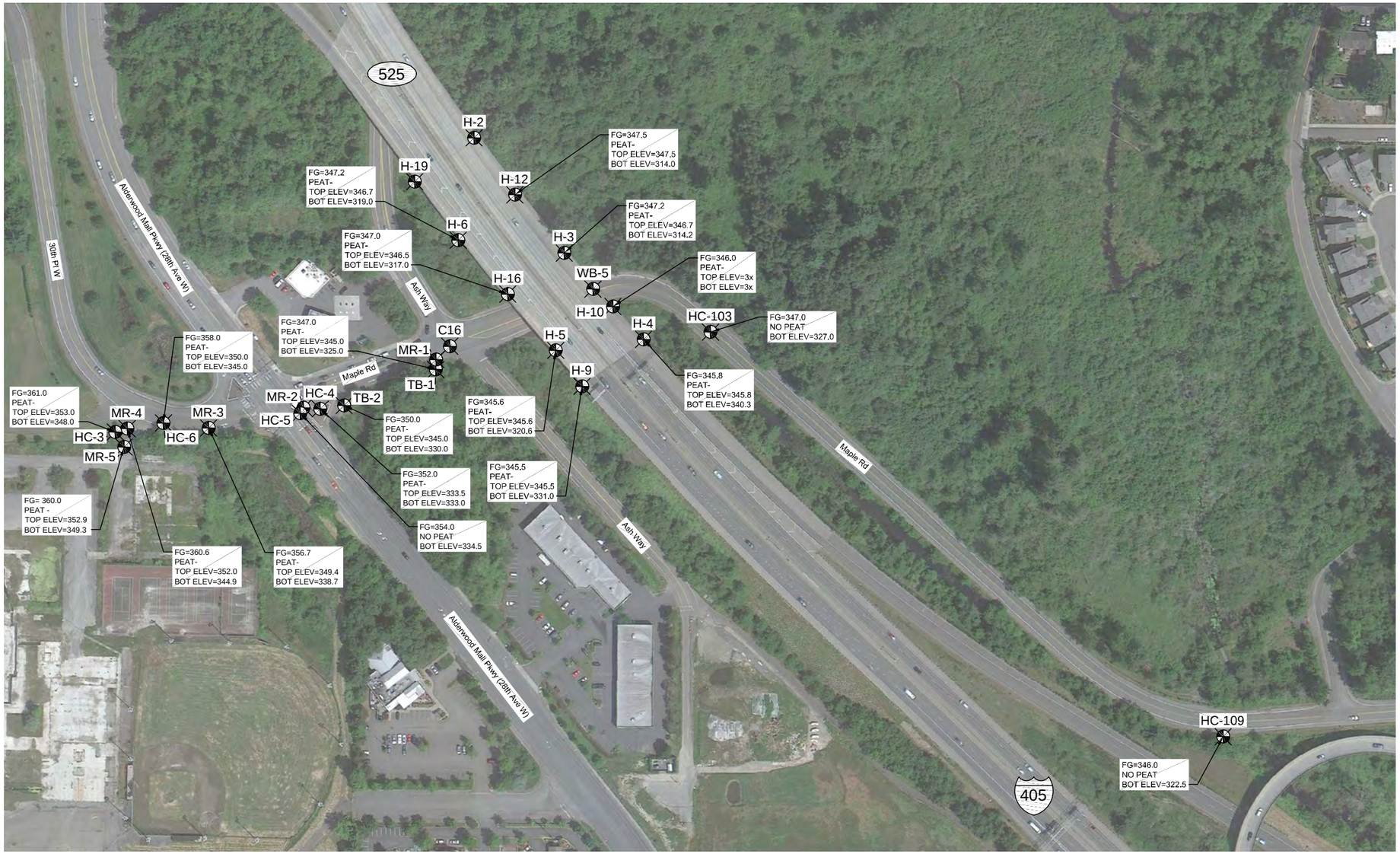
LANDAU ASSOCIATES

Maple Road High Flow Bypass Snohomish County, Washington	**Vicinity Map**	Figure 1



Legend

Approximate location and designation of previous exploration.

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Source: Google Earth Pro 2010

0 200 400
Scale in Feet

LANDAU ASSOCIATES

Maple Road High Flow Bypass Snohomish County, Washington	**Site Plan**	Figure 2

LANDAU ASSOCIATES, INC. | V:\550\070\010.011\Figure No.2.dwg (A) "11x17h" 4/15/2013

APPENDIX F

Cost Estimate and Quantity Calculations

Snohomish County Maple Road & Ash Way

- Cost Estimate Assumptions:
- Roadway Surveying assumed the most effort to establish control with pin piles, followed by geofoam, railroad ballast and last, the traditional option.
- SPCC plan efforts were assumed to be greater with this work site location.
- Potholing existing utilities was assumed to be conducted with the use of a vactor truck.
- Unanticipated Site Work is assumed to be 5% of the construction subtotal and was rounded off.
- Mobilization is assumed to be 10% of the construction subtotal.
- Project Temporary Traffic Control was based upon the assumption that the road would be closed for all alternates. Thus there would be signs, barricades and traffic control devices together with some VMS message boards for notification purposes.
- Ditch Excavation was assumed to be a 600LF ditch, with an 8 foot bottom, 3 foot depth and 3:1 side slopes.
- Box Culverts were assumed to be 4ft in height by 8ft in width, 70LF long as a pre-cast concrete installation together with pre-cast headwalls and wing walls.
- The Pin Pile Alternate was assuming 4-Inch diameter piles to be driven to depths to 40'. For this work they would typically use a 15,000 to 25,000LB mini-excavator with a small high frequency hammer that will deliver about 500 blows per minute. The installer would typically use 21 foot pile sections/lengths. However, if there is a potential conflict with overhead obstructions (such as a bridge at say 14' clearance) or power lines, they would use 8 foot pile lengths with couplers which could be used in locations with a 12' minimum clearance. Then place a ½" thick, 6" x 6" top plate with a smaller I.D. sleeve shop welded to it to "cap" the pile to accommodate a concrete grade beam or slab. We estimated production of 800-900 feet per day, or about 21 piles/day per pile driver machine. The average price would be around $16.00/FT, including typical load testing, and mobilization. Therefore, we arrived at $640 per pile at 40 foot in depth.
- Dewatering for the geofoam alternate was considered the most extensive, followed closely by the railroad ballast alternate. For the geofoam, the base must be free of water to establish a uniform base and avoid floatation of the material prior to it being loaded. The railroad ballast would require adequate preparation for grid, fabric and sand installation.
- Erosion/Water Pollution Control was based upon installation during a typical construction summer season.
- Wetland Mitigation costs were based upon previous typical square footage costs in Snohomish County that disturbed approximately ¼ acre. We assumed .5 of acre would be impacted.
- No hazardous Material removal or handling of contaminated water is included in our estimate.

Project: Ash Way/ Maple Road
Project No.: 37382.0000
Client: Snohomish County
Engineer Estimates

Date: 8/15/2013
By: TC
Checked by

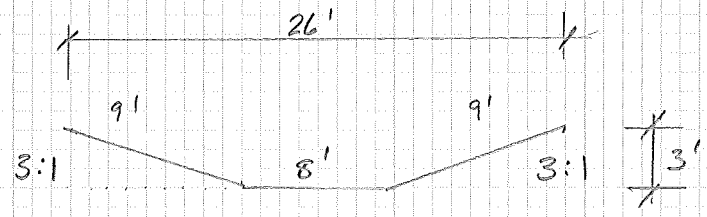
Construction Cost Estimates

ITEM NO.	DESCRIPTION	QTY.	UNIT	ALT #1 Traditional UNIT COST	ALT #1 Traditional TOTAL COST	ALT 2 Geofoam QTY.	UNIT	UNIT COST	TOTAL COST	ALT #3 Railroad Ballast QTY.	UNIT	UNIT COST	TOTAL COST	ATL #4 Pin Piles QTY.	UNIT	UNIT COST	TOTAL COST
1	ROADWAY SURVEYING	1	LS	$ 15,000.00	$ 15,000.00	1	LS	$ 20,000.00	$ 20,000.00	1	LS	$ 15,000.00	$ 15,000.00	1	LS	$ 25,000.00	$ 25,000.00
2	SPCC PLAN	1	EA	$ 1,000.00	$ 1,000.00	1	EA	$ 1,000.00	$ 1,000.00	1	EA	$ 1,000.00	$ 1,000.00	1	EA	$ 1,000.00	$ 1,000.00
3	POTHOLING EXISTING UTILITIES	1	LS	$ 7,500.00	$ 7,500.00	1	LS	$ 7,500.00	$ 7,500.00	1	LS	$ 7,500.00	$ 7,500.00	1	LS	$ 7,500.00	$ 7,500.00
4	UNANTICIPATED SITE WORK	1	EST	$ 30,000.00	$ 30,000.00	1	EST	$ 100,000.00	$ 100,000.00	1	EST	$ 35,000.00	$ 35,000.00	1	EST	$ 150,000.00	$ 150,000.00
5	MOBILIZATION	1	LS	$ 60,000.00	$ 60,000.00	1	LS	$ 190,000.00	$ 190,000.00	1	LS	$ 125,000.00	$ 125,000.00	1	LS	$ 330,000.00	$ 330,000.00
6	PROJECT TEMPORARY TRAFFIC CONTROL	1	LS	$ 20,000.00	$ 20,000.00	1	LS	$ 20,000.00	$ 20,000.00	1	LS	$ 20,000.00	$ 20,000.00	1	LS	$ 20,000.00	$ 20,000.00
7	ROADWAY EXCAVATION INCL. HAUL	1,400	CY	$ 30.00	$ 42,000.00	14,000	CY	$ 30.00	$ 420,000.00	5,700	CY	$ 30.00	$ 171,000.00	0	CY	$ 30.00	$ -
8	GRAVEL BORROW INCL. HAUL	4,500	TON	$ 22.00	$ 99,000.00	13,000	TON	$ 20.00	$ 260,000.00	0	TON	$ 22.00	$ -	0	TON	$ 22.00	$ -
9	DITCH EXCAVATION INCL. HAUL	1,200	CY	$ 30.00	$ 36,000.00	1,200	CY	$ 30.00	$ 36,000.00	1,200	CY	$ 30.00	$ 36,000.00	1,200	CY	$ 30.00	$ 36,000.00
10	CRUSHED SURFACING TOP COURSE	800	TON	$ 30.00	$ 24,000.00	800	TON	$ 30.00	$ 24,000.00	800	TON	$ 30.00	$ 24,000.00	800	TON	$ 30.00	$ 24,000.00
11	HMA CL. 1/2" PG 64-22	1,100	TON	$ 90.00	$ 99,000.00	1,100	TON	$ 90.00	$ 99,000.00	1,100	TON	$ 90.00	$ 99,000.00	1,100	TON	$ 90.00	$ 99,000.00
12	CULVERT PIPE 36 IN. DIAM.	75	LF	$ 90.00	$ 6,750.00	75	LF	$ 90.00	$ 6,750.00	75	LF	$ 90.00	$ 6,750.00	75	LF	$ 90.00	$ 6,750.00
13	Culvert Pipe 48 in. Diam.	65	LF	$ 100.00	$ 6,500.00	65	LF	$ 100.00	$ 6,500.00	65	LF	$ 100.00	$ 6,500.00	65	LF	$ 100.00	$ 6,500.00
14	4' X 8' Reinforced Concrete Box Culvert	2	EA	$ 80,000.00	$ 160,000.00	2	EA	$ 80,000.00	$ 160,000.00	2	EA	$ 80,000.00	$ 160,000.00	2	EA	$ 80,000.00	$ 160,000.00
15	Relocate Existing Waterline	400	LF	$ 100.00	$ 40,000.00	400	LF	$ 100.00	$ 40,000.00	400	LF	$ 100.00	$ 40,000.00	400	LF	$ 100.00	$ 40,000.00
16	SILT FENCE	1,900	LF	$ 5.00	$ 9,500.00	1,900	LF	$ 5.00	$ 9,500.00	1,900	LF	$ 5.00	$ 9,500.00	1,900	LF	$ 5.00	$ 9,500.00
17	EROSION/WATER POLLUTION CONTROL	1	LS	$ 15,000.00	$ 15,000.00	1	LS	$ 15,000.00	$ 15,000.00	1	LS	$ 15,000.00	$ 15,000.00	1	LS	$ 15,000.00	$ 15,000.00
18	CEMENT CONC. TRAFFIC CURB AND GUTTER	250	LF	$ 30.00	$ 7,500.00	250	LF	$ 30.00	$ 7,500.00	250	LF	$ 30.00	$ 7,500.00	250	LF	$ 30.00	$ 7,500.00
19	CEMENT CONC. SIDEWALK	110	SY	$ 90.00	$ 9,900.00	110	SY	$ 90.00	$ 9,900.00	110	SY	$ 90.00	$ 9,900.00	110	SY	$ 90.00	$ 9,900.00
20	CEMENT CONC. CURB RAMP	1	EA	$ 1,200.00	$ 1,200.00	1	EA	$ 1,200.00	$ 1,200.00	1	EA	$ 1,200.00	$ 1,200.00	1	EA	$ 1,200.00	$ 1,200.00
21	PAINTED striping/Signing	2,850	LF	$ 1.00	$ 2,850.00	2,850	LF	$ 1.00	$ 2,850.00	2,850	LF	$ 1.00	$ 2,850.00	2,850	LF	$ 1.00	$ 2,850.00
22									$ -				$ -				$ -
23	Dewatering					1	LS	$ 70,000.00	$ 70,000.00	1	LS	$ 60,000.00	$ 60,000.00	1	LS	$ 20,000.00	$ 20,000.00
24	Shoring					1	LS	$ 50,000.00	$ 50,000.00	1	LS	$ 30,000.00	$ 30,000.00	1	LS	$ 5,000.00	$ 5,000.00
25	Geofoam					7,000	CY	$ 100.00	$ 700,000.00				$ -				
26																	
27	Railroad Ballast									18,000	Ton	$ 25.00	$ 450,000.00				
28	Geo-Grid									17,000	SY	$ 2.00	$ 34,000.00				
29	Geofabric									17,000	SY	$ 3.00	$ 51,000.00				
30																	
31	Pin piles													2,650	EA	$ 640.00	$ 1,696,000.00
32	Reinforced Slab													4,700.0	SY	$ 265.00	$ 1,245,500.00
33																	
34																	
35					$ -												
				SUBTOTAL	$ 692,700.00			SUBTOTAL	$ 2,256,700.00			SUBTOTAL	$ 1,417,700.00			SUBTOTAL	$ 3,918,200.00
	CONTINGENCY			20%	$ 138,540.00			25%	$ 564,175.00			20%	$ 283,540.00			25%	$ 979,550.00
	CONSTRUCTION TOTAL				$ 831,240.00				$ 2,820,875.00				$ 1,701,240.00				$ 4,897,750.00
	CONSTRUCTION MANAGEMENT			12%	$ 99,748.80			15%	$ 423,131.25			12%	$ 204,148.80			10%	$ 489,775.00
	WELTAND MITIGATION			LS	$ 100,000.00			LS	$ 100,000.00			LS	$ 100,000.00			LS	$ 100,000.00
	DESIGN ENGINEERING			15%	$124,686.00			15%	$ 423,131.25			15%	$ 255,186.00			15%	$ 734,662.50
	TOTAL ESTIMATED COSTS				$ 1,155,674.80				$ 3,767,137.50				$ 2,260,574.80				$ 6,222,187.50

WHPacific

SNOHOMISH COUNTY (MAPLE & ASH) 8/15/2013

DITCH EXC. = 600 LF



13.5' + 24 + 13.5 = 51 SF x 600

1,133 CY.

∴ 1,200 CY

RELOCATE EXIST WATERLINE:

ASH	STA	57+48	to	60+00	=	252 LF
MAPLE	STA	12+49	to	14+00	=	151
						403 LF

NEW LIMITS: 8/15/2013

ASH WAY	STA	57+48	to	62+14	=	466 LF
MAPLE RD	STA	12+49	to	17+20	=	471 LF
						937 LF

LESS INTERSECTION

STA 13+50 to 14+25 = -75

862 LF

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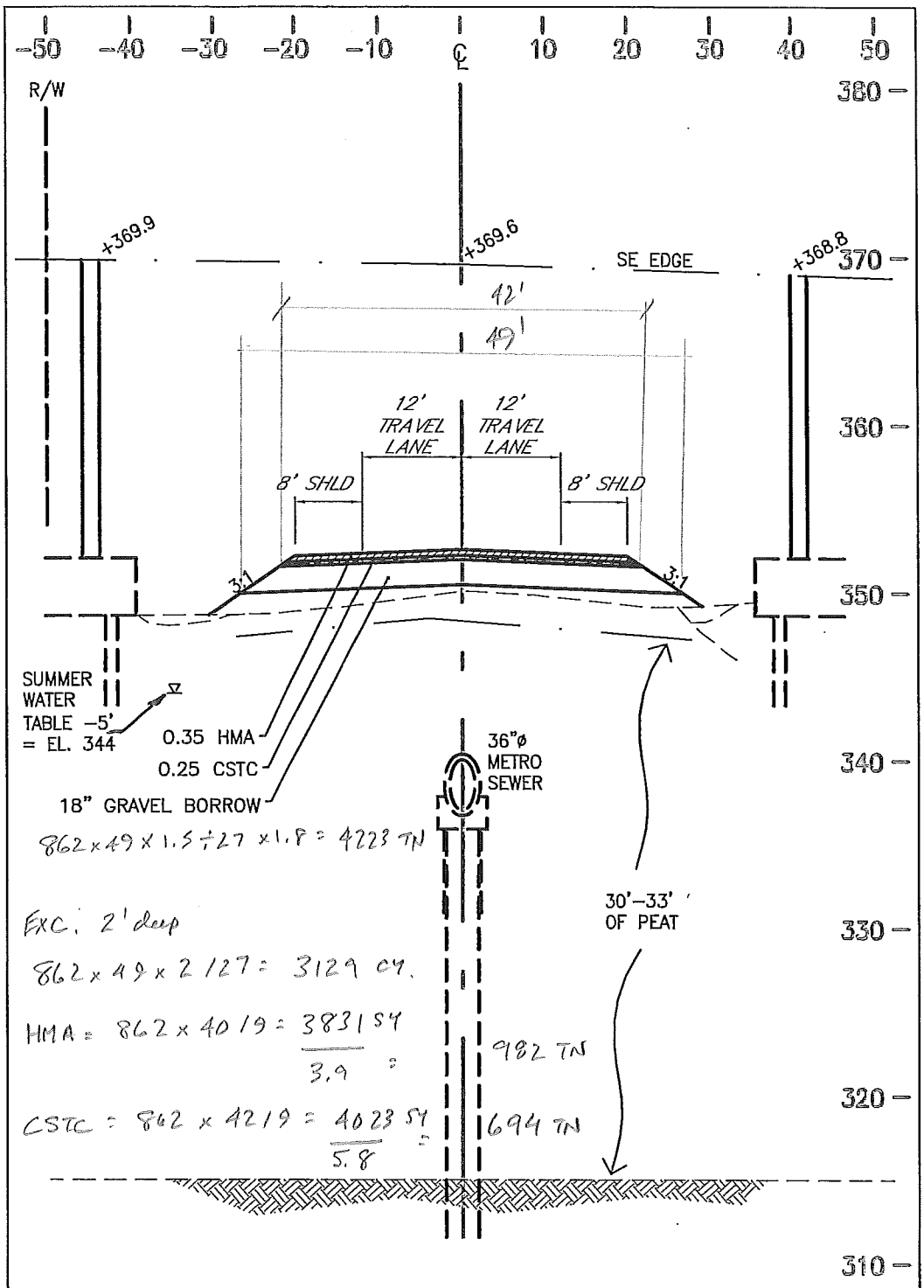
Project _____ Subject _____ Sheet No. _____ of _____

Job No. _____ Prepared by TC Date _____ Checked by _____ Date _____

8/15/2013

862 LF



862 x 49 x 1.5 ÷ 27 x 1.8 = 4223 TN

Assume EXC. 2' deep

862 x 49 x 2 / 27 = 3129 CY.

HMA = 862 x 40 / 9 = 383 SY / 3.9 =

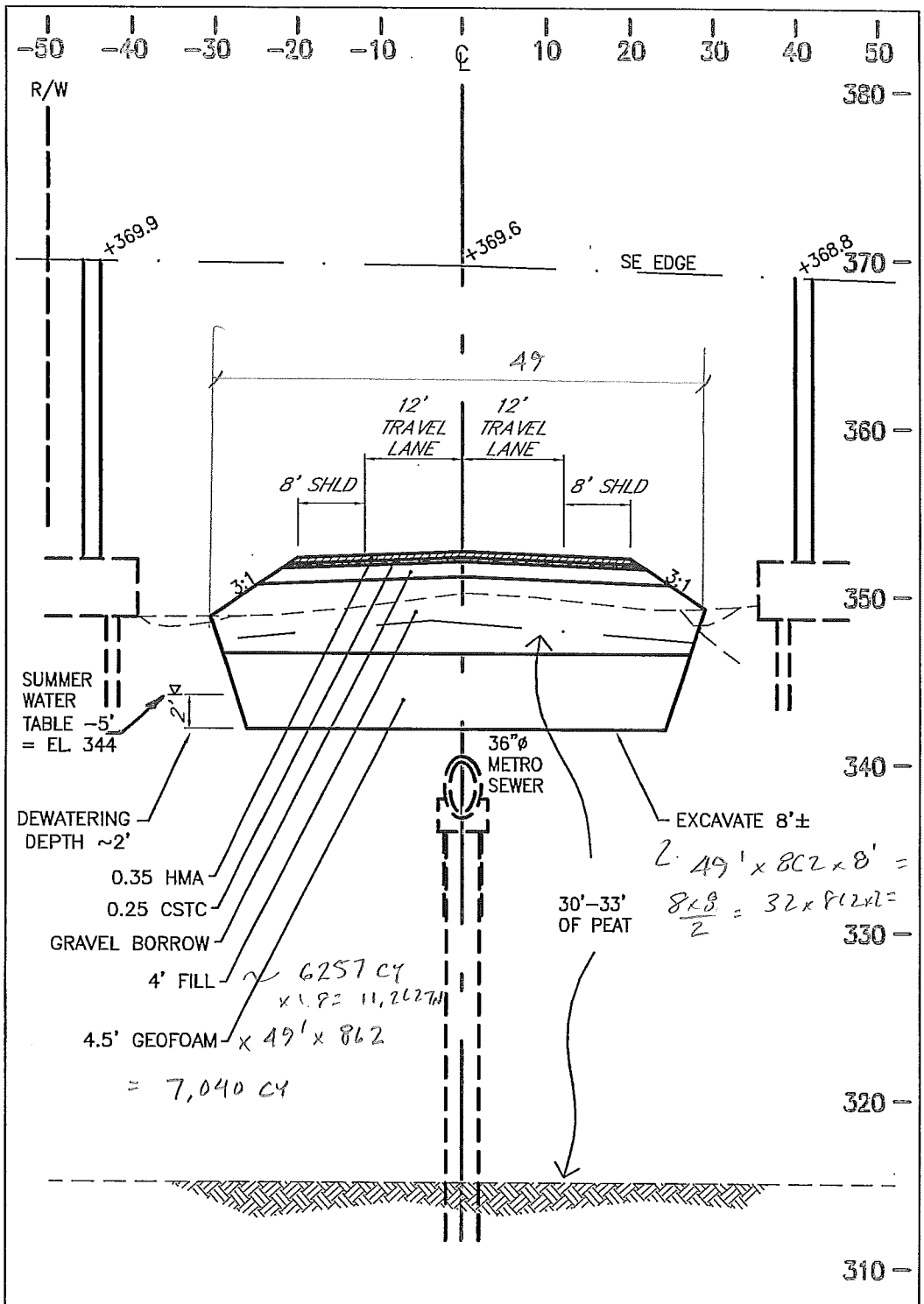
CSTC = 862 x 42 / 9 = 402.3 SY / 5.8 =

TRADITIONAL APPROACH

SCALE:
HORIZONTAL 1" = 20'
VERTICAL 1" = 10'

8/15/2013

862 LF



2 · 49' x 862 x 8' = 12,515 cy

8x8/2 = 32 x 862 x 2 = 2043 cy.

14,558 cy.

6257 cy x 1.8 = 11,262 TN

x 49' x 862

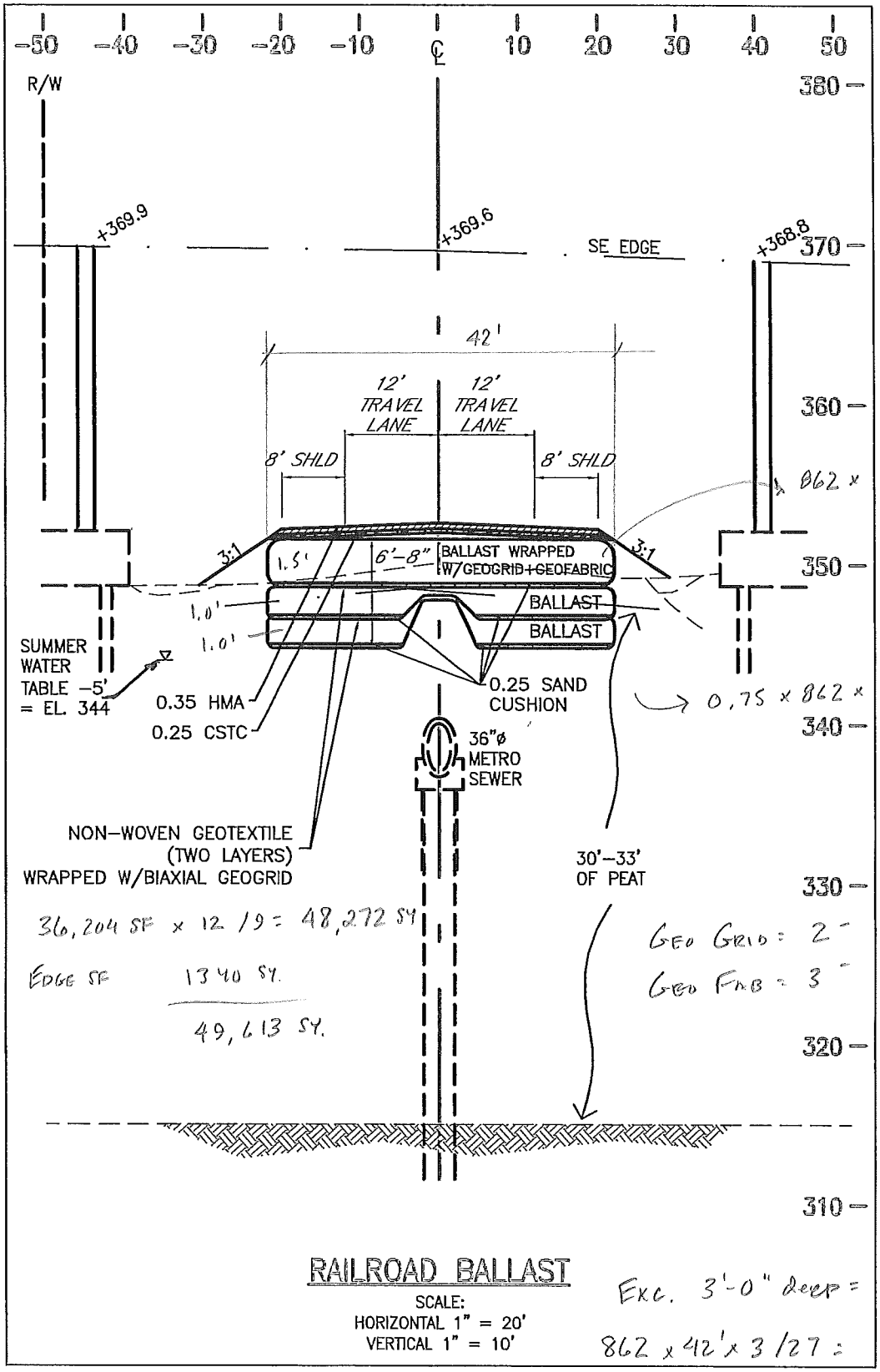
= 7,040 cy

LIGHT WEIGHT FILL (GEOFOAM)

SCALE:
HORIZONTAL 1" = 20'
VERTICAL 1" = 10'

8/15/2013

862 LF @ 42' wide = 36,204 SF



42,238 SF ÷ 100 = 422 PILES @ $2000 = 844,760 (OLD EST.)

8/15/2013

TYP. SECTION = 49' wide

= 42,238 SF ÷ 16 = 2639 PILES

or 4693 SY.

862 LF

2347 CY @ 120

= $281,640

REBAR FRT

84,476 LF

#8 = 2.670

= 225,551 lbs

$676,652

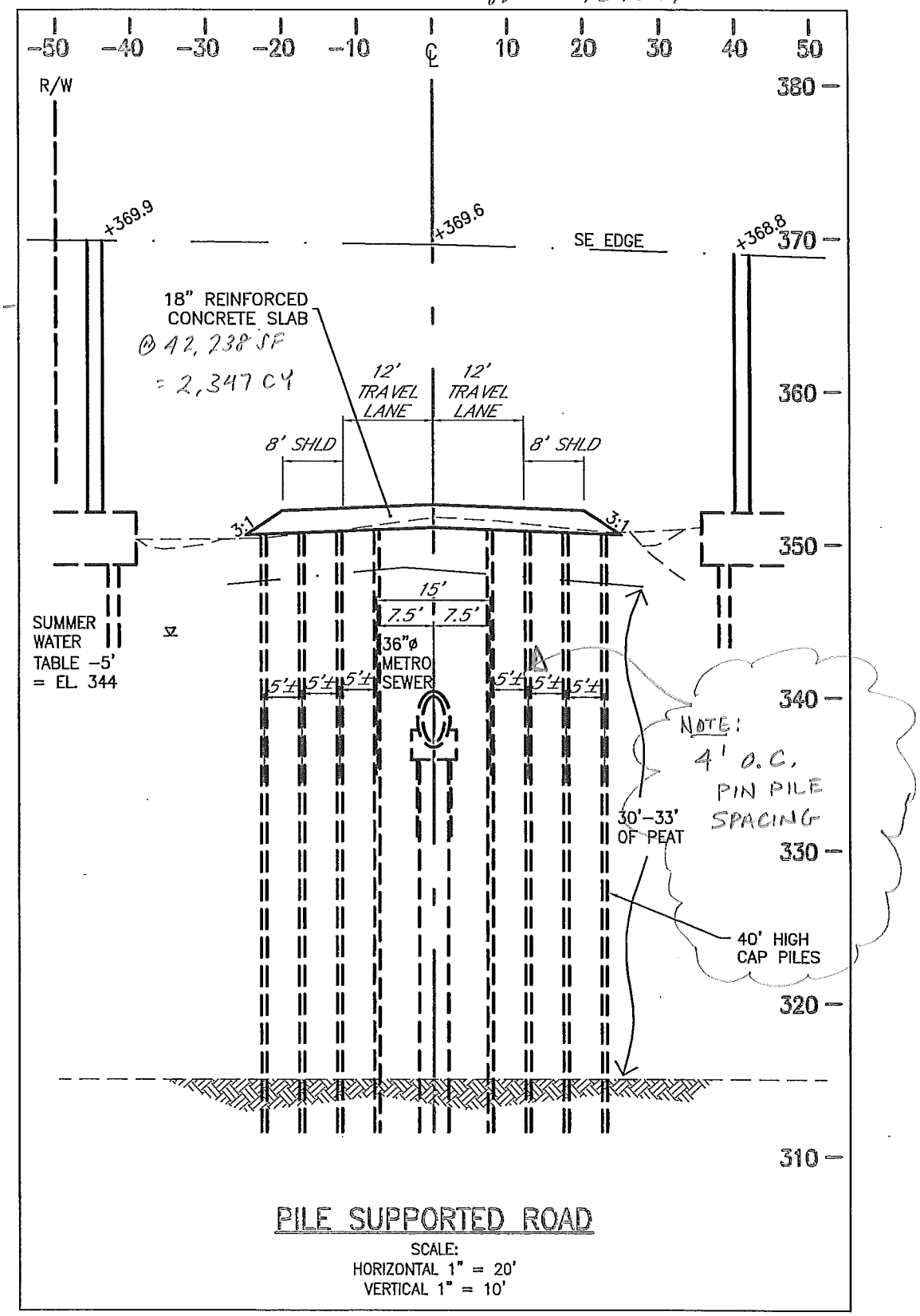
$988,293

+ 30%

1,245,781

4693 SY

= 265.46/SY.



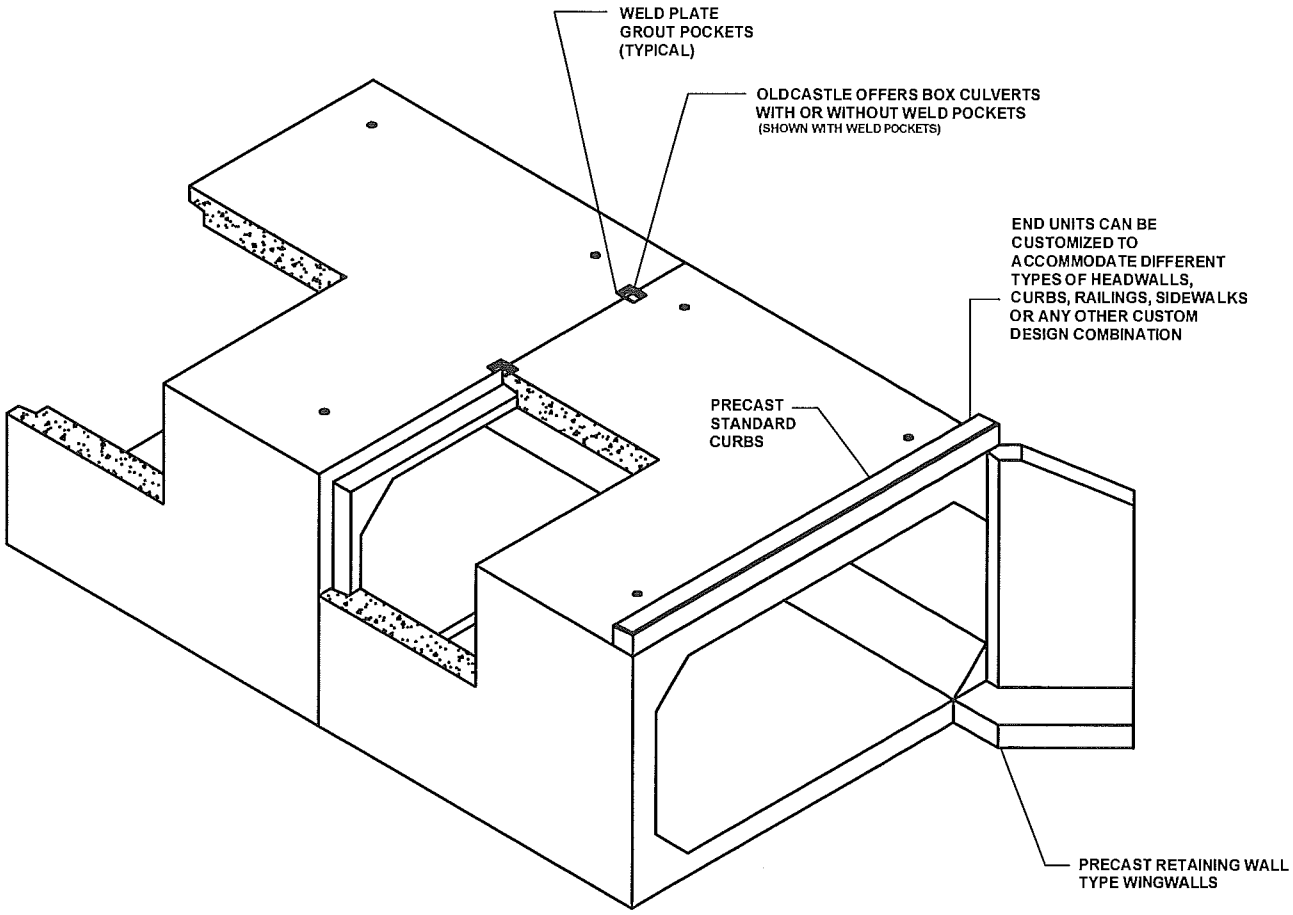
PILE SUPPORTED ROAD

SCALE:
HORIZONTAL 1" = 20'
VERTICAL 1" = 10'

Oldcastle Precast®

BOX CULVERT

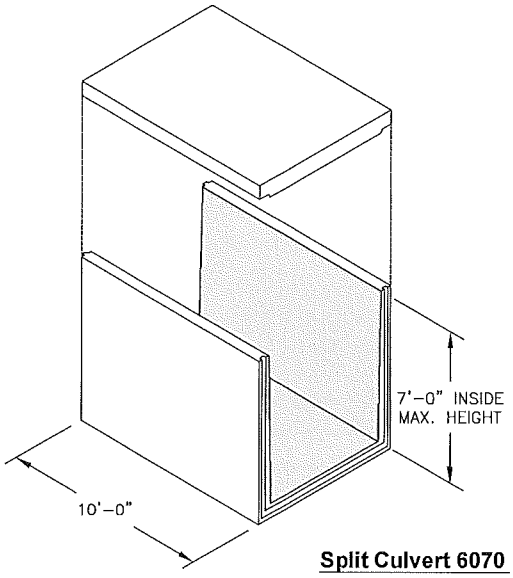
PRODUCTS



TYPICAL
ISOMETRIC BOX CULVERT LAYOUT

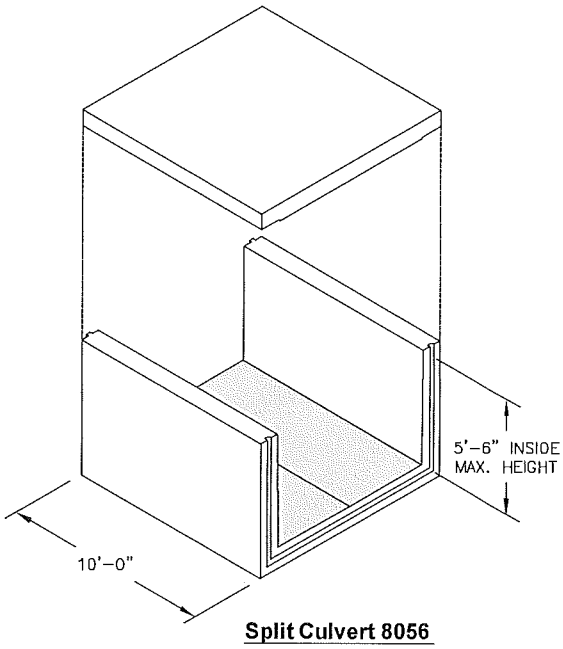
SHOWING BOX CULVERTS SECTIONS
CURBS & WINGWALL
(Retaining Wall Type Wingwall)

SPLIT CULVERTS



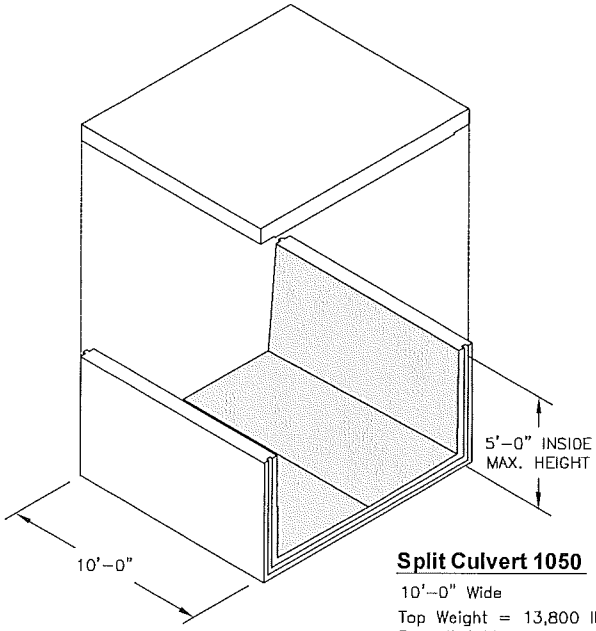
Split Culvert 6070

6'-0" Wide
Top Weight = 8,700 lbs.
Base Weight = 20,500 lbs.



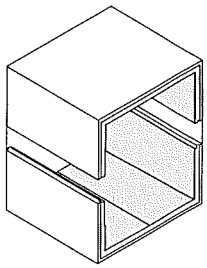
Split Culvert 8056

8'-0" Wide
Top Weight = 9,400 lbs.
Base Weight = 25,200 lbs.



Split Culvert 1050

10'-0" Wide
Top Weight = 13,800 lbs.
Base Weight = 25,100 lbs.



2 Base Option
Available On All Split Culverts

Maximun Inside Height As Shown
Can Be Made To Any Height Shorter Than Maximum
Designed For HS-20 Loads

Oldcastle Precast® Utility Vault PO Box 588, Auburn, Washington 98071-0588 Tel: (253) 839-3500 Fax: (253) 735-4201	**SPLIT CULVERTS** File Name: 010-SPLITCUL2 Issue Date: 2010 www.uvauburn.com	**6070, 8056 & 1050** **Standard Layout** ©2006-2010 Oldcastle Precast, Inc.