MILL CREEK FISH PASSAGE CONCEPTUAL DESIGNS

FINAL REPORT

Prepared for

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1 INTRODUCTION

This study builds on a recently completed fish passage assessment of Mill Creek in Walla Walla, WA. Conceptual designs are developed for Reach Types 1, 3, 4, 5, 6, 9 and 10. A detailed description of the hydraulics and fish passage problems associated with these Reach Types was documented in the report "Mill Creek Fish Passage Assessment" (P. Powers, B. Burns, K. Bates, J. Kidder 2009). The 2009 study will be referenced as the "Assessment Report". The Assessment Report identified 12 unique Reach Types between river mile 4.8 (Gose Street) and river mile 10.6 (Division Dam). This segment of Mill Creek is referred to as the Mill Creek Flood Control Channel. The Assessment Report developed conceptual designs for Reach Types 1, 7 and 8. The Assessment Report report can be found at: http://tristatesteelheaders.com/millCreekFishPassageAssessment.pdf.

1.1 Summary

For the concrete flume portion of the Mill Creek Flood Control Channel, the 2009 Assessment Report developed design options for fish passage correction based on retrofits to the existing concrete flume. This study takes a step back, and looks at the possibilities for fish passage correction by also rebuilding the flume and making retrofits with resting pools and/or using the existing condition. The existing conditions have some level of fish passage. These design approaches were applied in detail to Reach Type 3 and evaluated by the Mill Creek Work Group (MCWG) based on passability, cost, flood impacts and maintenance. Reach Type 3 is the dominant Reach Type in the concrete flume, 7260 feet out of a total of 10,920 feet. The selected design option was the retrofit roughened channel with resting pools. To better understand the hydraulics of the roughened channel design, and how fish passage will be affected over a long distance, it was decided to build a 1:8 scale model of the existing and roughened channel design. The roughened channel concept was also then applied to designs for Reach Type 6.

For the sill portion of the flood control channel (Reach Type 1 from the Assessment Report), a conceptual design was developed for a typical 70 foot long concrete sill. In some sections of Reach Type 1 the sills are 500 feet long. The MCWG expressed the need for a conceptual design of a low flow channel in these areas to address other issues such as water quality and stranding. Also, some of the channel sills are sheet pile with unknown dimensions and fish passage conditions. This study evaluates the different type, shape and channel conditions of all the sills (not addressed in the Assessment Report). Conceptual designs and costs were developed for six different segments of Reach Type 1.

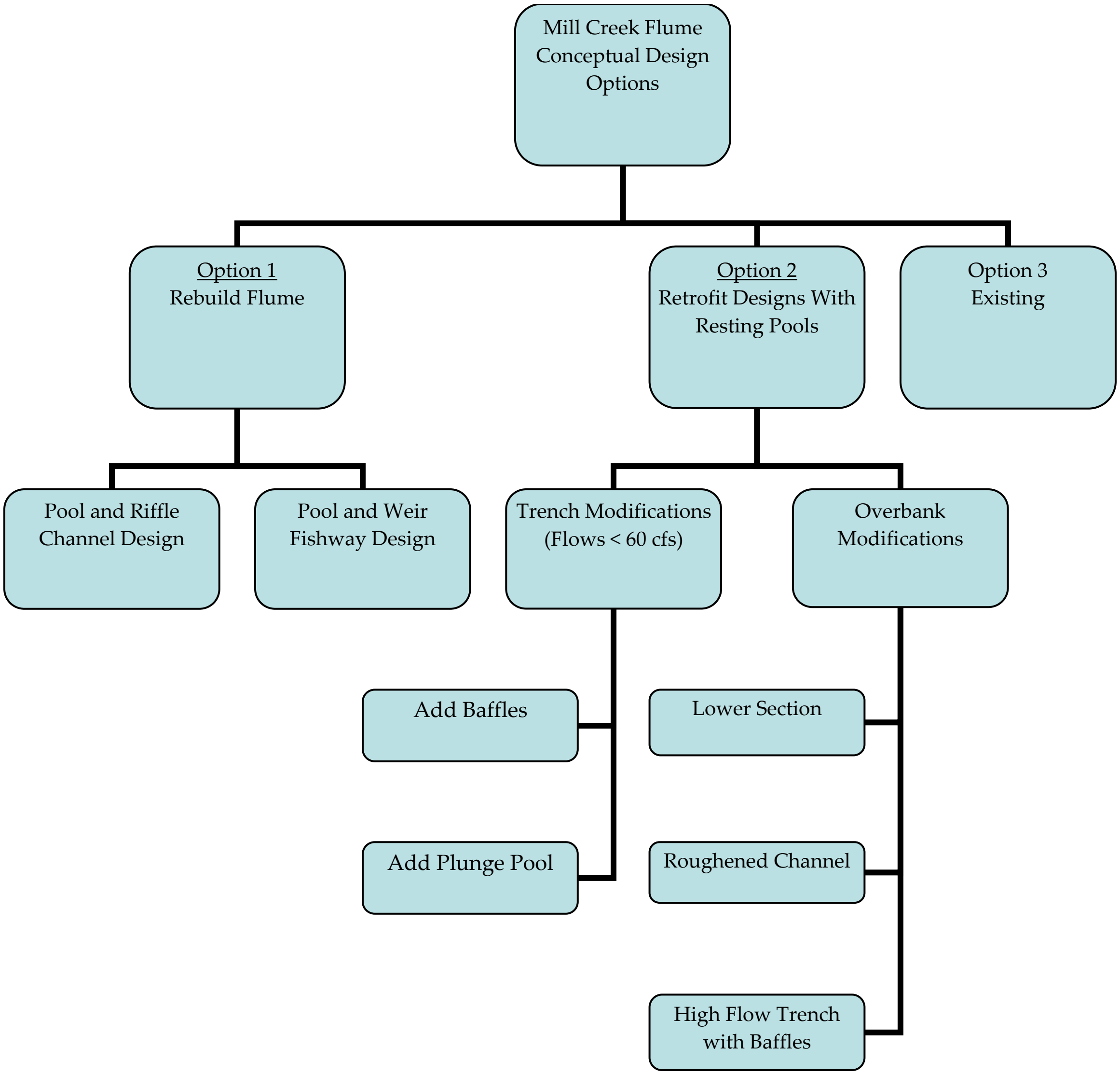
1.2 Funding

Funding was provided to the Tri-State Steelheaders through a grant from The National Fish and Wildlife Foundation – Community Salmon Fund for the Snake River titled "Mill Creek Flood Control Fish Passage Design". The Confederated Tribes of the Umatilla Indian Reservation was a partner on the grant providing match dollars. Direction for the study and decisions on preferred design options was provided by the MCWG.

2 FLUME CONCEPTUAL DESIGN OPTIONS

Three design concepts were considered for correction of fish passage in the concrete flume section. The first (Option 1) is a rebuild of the flume channel within the existing walls. The second (Option 2) includes various retrofit designs of the trench and overbank areas with resting pools, and the third (Option 3) is the existing conditions. A flow chart for the design options is shown in Figure 2-1 and described in more detail below.

Figure 2-1: Flow chart of conceptual design options for the Mill Creek Concrete Flume.



2.1 Option 1 – Rebuild Flume

This option includes designs for fish passage in which separate resting pools are not needed as resting opportunities for fish are part of the design. The assumed constraints are working within the existing concrete walls which define the path of Mill Creek through the City of Walla Walla, maintaining the integrity of a flood control channel, and not increasing flood water surface elevations. This design option will require a modification to how the existing flume is maintained. Different vehicles and/or access to the flume would need to be revisited. Two designs were considered 1) a pool and riffle design and 2) a pool a weir fishway design. The pool and riffle design would function much like a natural stream with pools for resting areas and riffles to provide grade control. The pools would be spaced every 150 to 200 feet. The riffles would be sloped two to three percent. The overall slope would be maintained at one percent. Average water velocity at the high fish passage design flow would be 2 to 3 fps. All construction would be concrete, and the riffles would be formed by natural roughness set within the concrete. There are narrow sections of the flume (at bridge crossings) where this design may not work.

The pool and weir design would function as a 28 foot wide pool and weir fishway. The existing baffles would become weirs, spaced 60 feet. The height of the weirs would be 2.6 feet. The trench and a portion of the overbank areas would be removed from the channel, and a concrete fishway would be formed and poured back in place. Design drawings are provided in Appendix A-2 through A-5.

2.2 Option 2 – Retrofit Trench and Overbank areas

This option includes retrofitting the trench and overbank areas to improve passage. Fish passability is calculated using the energetics model which was developed in the Assessment Report. This model compares fish swimming ability against hydraulics and calculates the energy left for a fish attempting to pass. To model the existing conditions using HEC RAS, the Manning's n values for the trench (0.018) and overbank (0.024) were calibrated from field measurements. For Option 2 designs, modifications are made to the cross section and roughness and fish passage is calculated based on assumptions for roughness values. Even though the surface is identical (concrete), the differing values from the trench and overbank represent inversely the proportion of flow in the trench versus the overbank. To ensure fish passage success over a long distance, these designs may require physical modeling or the construction of smaller pilot projects, which could be field tested.

2.3 Option 3 - Existing

Option 3 (existing conditions) was included, because the Assessment Report documented some existing passage, and constrictions in the channel such as bridge piers and center walls may limit the extent of modifying the channel using an Option 2 design.

3 DESIGN CRITERIA

3.1 Fish Passage Calculations

Chapter 5 of the Assessment Report identifies the design flows and process for calculating fish passage and checking flood flows. The design flows analyzed are 10, 92, 194 and 320 cfs. The fish species include Bull Trout, Steelhead and Spring Chinook. Fish size ranges from 7 inches for the smallest Bull Trout to 30 inches for Steelhead. Swimming speeds, fish length and depth are shown in Table 3-1.

Table 3-1: Fish swimming speeds, fish length and depth used in the energetics model to assess fish passage from the Assessment Report.

Species *Design Flow(cfs)*	**Fish Length (in)**	**Fish Depth (in)**	**Maximum Swimming Speed (fps)**		
			Sustained	Prolonged	Burst
Steelhead *10, 92, 320 cfs*	22	4.8	1.8	9.2	27.5
	30	6.6	2.5	12.5	37.5
Spring Chinook *10, 92, 320 cfs*	24	5.2	2	10	30
	29	6.2	2.4	12.1	36.3
Bull Trout *10, 92, 194 cfs*	7	1.1	0.6	2.9	8.8
	17	2.5	1.4	7.1	21.3

In addition, the results of the energetics model are compared to Washington State Department of Fish and Wildlife's WAC 220-110-070 and Fish Passage Design at Road Culvert Manual (2003) for maximum swimming distance versus fish species and velocity.

The limiting design criteria from Table 3-1, is the 0.6 fps sustained swimming speed and the 2.9 fps prolonged swimming speed for the 7 inch Bull Trout at 194 cfs. The energetics model uses the sustained swimming speed as the velocity where a fish could swim to recover energy. The prolonged swimming speed is most often used for passage, but a fish can only maintain this for a limited amount of time, and the faster they swim the time to fatigue is shorter. To use the energetics model correctly, one must know the velocity a fish is swimming against. In the concrete flume it has been observed and measured that velocity varies across the section (high in the trench, lower in the overbank areas). For a 7 inch fish, which may be using the low velocity boundary layer along the edge to migrate, one must know the actual velocities for each design to calculate passage. For this study it is assumed that this velocity (termed V_{occ}, or occupied velocity) is calculated as 0.9 times the average velocity in the fish passage corridor. For designs which modify the smooth concrete surface to a rough surface, this is a conservative design assumption.

Two other design variables are water depth and hydraulic drop. For water depth the minimum depth for passage is 0.8 feet, and for hydraulic drop, the maximum drop is 0.8 feet.

3.2 Flood Flows

For the flood flow analysis the U.S. Army Corp of Engineers (Corps) recommended 3500 cfs as the design flow. Table 3-2, lists the peak flood flows for Mill Creek below the Division Dam and upstream of Bennington Dam. The Mannings n roughness value was set to 0.011 for the before and after condition.

Table 3-2: Mill Creek peak flood flows for stream gage stations above Bennington Dam and below the Division Dam.

Return Period (yrs)	Mill Creek Peak Discharge (cfs)	
	Gage 14013700 (U/S Bennington Dam)	Gage 14015000 (D/S Division Dam)
1	1050	950
2	1945	2100
50	2800	3200
100	3190	3500

3.3 Flood Control Channel Maintenance

Walla Walla County has a Policy (adopted November 29, 1983) for maintenance of the Mill Creek Flood Control Channel. Access for trucks and workers is required to both sides of the concrete flume. Workers access the flume at the upstream end near Roosevelt Street; drive a small one ton dump truck up and down the channel, clearing overhanging brush, removing trees and debris from the channel. They cross the channel trench by placing wooden planks. Any changes to the existing channel need to accommodate the annual maintenance.

4 REACH TYPE 3

4.1 Existing Hydraulics and Fish Passage

Reach Type 3 is a trapezoidal shaped channel. The trench is 9 feet wide by 1 foot 8 inches deep. The concrete baffles are 12 inches high and 6 feet long and spaced 60 feet on center. The channel slope is one percent. A drawing of the existing conditions is provided in Appendix A-1. There are five different segments. The first segment (960 feet long) extends from 9^{th} to 6^{th} Street. The second (360 feet long) extends from 6^{th} to 5^{th} Street. The third segment (660 feet long) starts upstream of 5^{th} Avenue and extends underground to 3^{rd} Avenue. The fourth segment (5160 feet long) runds from just downstream of Park Street to the Roosevelt Bridge, and the last segment (120 feet long), extends from the Roosevelt Bridge upstream to the Reach Type 11 Transition at the very upstream end of the concrete flume.

At flows less than 20 cfs, most of the Reach Type 3 is a barrier due to shallow depths, although some small fish have been observed passing. At 20 cfs, all of the Reach Types within the concrete flume have similar hydraulic and passage problems. There is some fish passage at flows in the 20 to 60 cfs range, as the existing baffles are effective at increasing the depth and maintaining a low velocity. Above 60 to 70 cfs, the depth in the flume overwhelms the effectiveness of the baffles, velocity increases and passage is limited. Around 200 cfs, the flow in the overbank area is deep enough to allow some level of passage. Above 300 cfs, this passage is reduced as there is now enough flow in the overbank to increase the velocities (see Photo 4.1). The Assessment Report calculated a fish passability index of 37 percent for Reach Type 3.

Photo 4-1: Reach Type 3 just upstream of 9th Street at flows of 10, 70, 200 and 370 cfs.

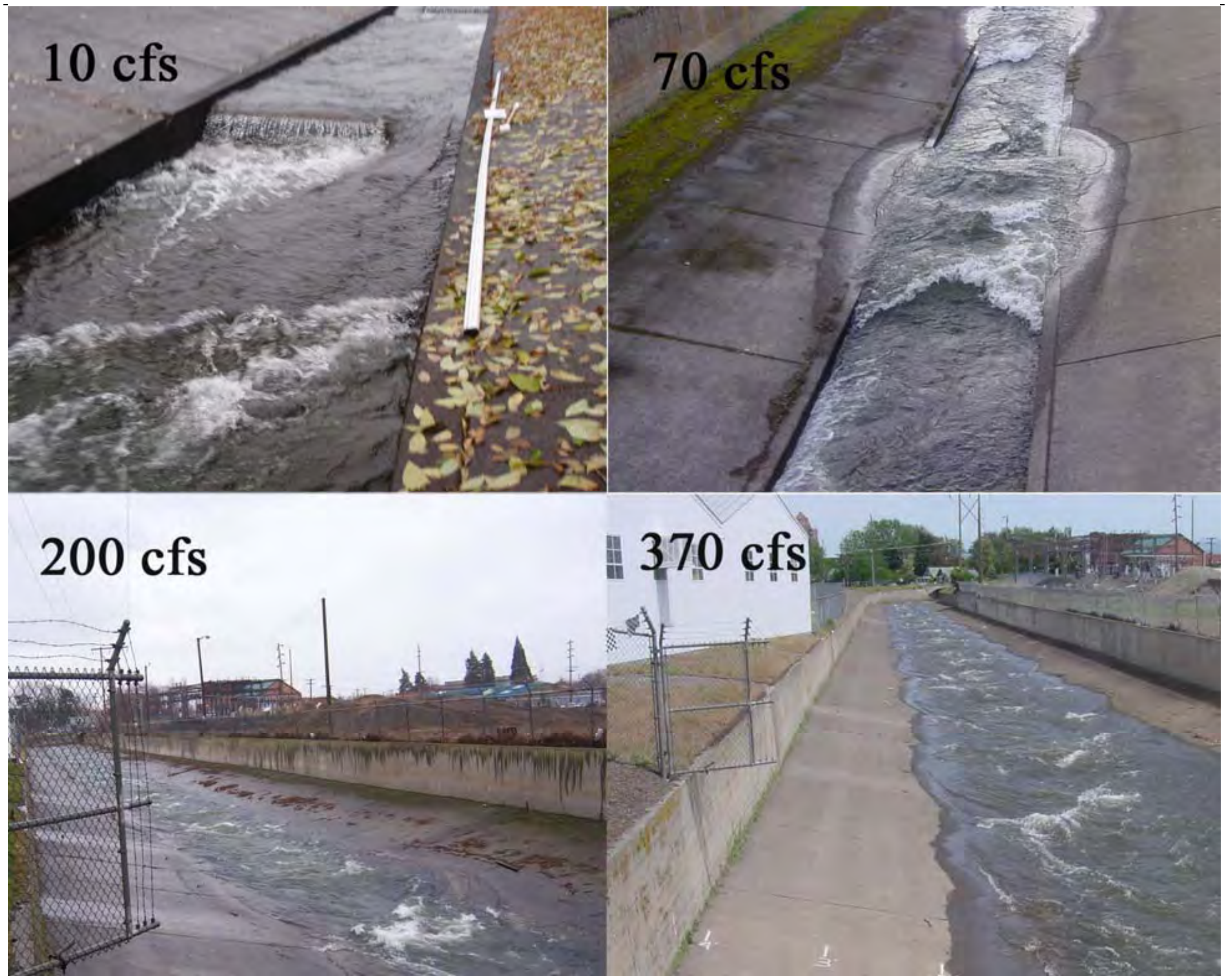


Figure 4-1 is a fish passage summary for Reach Type 3. From Figure 4-1, *Fail* means the fish ran out of energy. *Fail, depth* means the fish could not pass due to the shallow depth. *Rest to pass* means that while the fish was swimming upstream they encountered a velocity equal to or less than their sustained swimming speed and they rested to recover energy. It was assumed fish never recovered their energy to 100 percent. A 50 percent conservative value was used. The velocities in Figure 4-1 are the Q/A (flow divided by cross sectional area). At 92 cfs the velocity in the overbank is denoted as N/A, because the depth in the overbank was less than 0.8 feet. This was the minimum depth criteria established in the Assessment Report for fish to use the overbank area for passage.

Figure 4-1: Reach Type 3 existing fish passability calculated using the Energetics Model.

Species	Size (in)	Flow (cfs) 10 cfs	92 cfs	194 cfs	320 cfs
Steelhead	22	40 ft, then fail, depth	95 ft, then fail	850 ft, then fail	380 ft, then fail
	30	20 ft, then fail, depth	100 ft, then fail	520 feet, then rest to pass	300 feet, then rest to pass
Chinook	24	20 ft, then fail, depth	105 ft, then fail	900 ft, then fail	420 ft, then fail
	29	20 ft, then fail, depth	100 ft, then fail	525 feet, then rest to pass	500 ft, then fail
Bull Trout	7	25 ft, then fail	20 ft, then fail	30 ft, then fail	
	17	60 feet, then rest to pass	20 ft, then fail	50 ft, then fail	
		Velocity (fps)			
Total Cross Section		4.2	7.4	6.7	7.7
Overbank		N/A	N/A	3	3.5

4.2 Option 1 – Pool and Weir Design

This design will widen and lower the existing trench to create a pool and weir fishway based on accepted fish passage design criteria. The drop over each weir would be 0.6 feet. The fishway would be 28 feet wide. The depth at 10 cfs would be 2.2 feet, and the depth at 320 cfs would be 5.3 feet. At approximately 185 cfs, the plunging flow would transition to streaming flow. Above 185 cfs, passage would need to be calculated as fish swimming using the energetics model. A drawing and hydraulic calculations are provided in Appendix A-2, with an isometric view in Appendix A-3. The 100 year flood was not modeled for this design.

4.3 Option 1 – Pool and Riffle Design

For this design a 30 to 40 foot wide section would be removed from the flume, and a pool and riffle channel would be created. A drawing is provided in Appendix A-4, with an isometric view in Appendix A-5. Fish passage would be provided by fish swimming up the riffle and resting in the pools. The riffles would be 2 to 3 percent slope, 70 feet long and 30 feet wide. This design would provide good passage at high and low flow. The riffle is wide enough to keep the velocities low with boundary layers for passage on both sides. The 100 year flood was not modeled for this design.

4.4 Option 2 - Adding Plunge Pools and Baffles Design

This design option only addresses low flow by increasing the depth to provide passage. Adding plunge pools consists of lowering the floor of the concrete flume just downstream of the baffles to eliminate the super-critical flow, high velocity and shallow depth area. The concrete floor would be cut out and lowered a minimum of 12 inches for a distance of 15 to

20 feet downstream of each baffle. For the adding baffle design, baffles would be spaced every 20 feet (the existing spacing is 60 feet), and the height of the baffle would be reduce to 0.8 feet (existing is 1.0 foot), and the length would be increased to 6.5 feet (existing is 6.0 feet). A profile drawing is shown in Appendix A-6, with isometric views of the plunge pool and baffle designs shown in Appendix A-7 and A-8 respectively. Figure 4-2 is the fish passage summary for adding Plunge Pools. For Steelhead the limiting flow is 92 cfs. Steelhead can pass 210 feet before they fail. Resting pools would need to be added at some specified distance. Bates (2003) provides a table relating culvert length, velocity and fish species. For Steelhead at 4.0 fps, a culvert length of 100 to 200 feet is recommended. The fish passage energetics model calculates a steelhead would have 56% of their energy left at 100 feet. Therefore, a resting pool spacing of 120 feet (which matches the interval of baffle spacing (60 feet) is recommended. Adding baffles provides a similar level of passage improvement. The 100 year flood (3500 cfs) was modeled for this design. The result was an average change in water surface elevations of -0.01 feet for the plunge pool design and 0.02 for the baffle design compared to the existing condition.

Figure 4-2: Fish Passage results from adding a plunge pool downstream of the existing baffles.

		Flow (cfs)			
Species	**Size (in)**	**10 cfs**	**92 cfs**	**194 cfs**	**320 cfs**
Steelhead	22	525 feet, then rest to pass	210 ft, then fail	1300 feet, then rest to pass	860 ft, then fail
	30	750 feet, then rest to pass	210 ft, then fail	1300 feet, then rest to pass	500 feet, then rest to pass
Chinook	24	585 feet, then rest to pass	160 ft, then fail	1300 feet, then rest to pass	500 feet, then rest to pass
	29	750 feet, then rest to pass	180 ft, then fail	1300 feet, then rest to pass	500 feet, then rest to pass
Bull Trout	7	160 feet, then fail	20 ft, then fail	60 ft, then fail	
	17	180 feet, then rest to pass	20 ft, then fail	90 feet, then rest to pass	
		Velocity (fps)			
Total Cross Section		2.0	4.0	4.7	5.3
Overbank				2.1	2.2

4.5 Option 2 - Lowered Section Design

The concept for the Lowered Section design is based on increasing the depth in one overbank area and providing an opportunity for fish to this lower velocity area. The design removes a section (7 feet) from the overbank area, and lowers it 0.7 feet. It provides more depth in the overbank area so at the 92 cfs design flow fish can pass in the overbank area. This design would be done in combination with either the plunge pool or adding baffles. A drawing and isometric sketch is provided in Appendix A-9 and A-10 respectively. This design improves on the plunge pool and baffle design at 92 cfs, where Steelhead could only pass 210 feet. They can now pass over 1400 feet by swimming in the increased depth of the overbank area. An option to this design is to add a wedge of concrete on the opposite overbank area to reduce the likelihood that fish would try to pass in that area. A vertical wall along the trench area would likely have very high velocities and fish would be discouraged from using that side.

The 100 year flood (3500 cfs) was modeled for this design. The result was an average change in water surface elevation of -0.14 feet compared to the existing condition.

4.6 Option 2 - Roughened Channel Design

The roughened channel design option is similar to the Lowered Section design, except roughness is added to the new section. Roughness decreases velocity, which will increase the flood stage if not accounted for, so the section was lowered 1.2 feet instead of 0.7 feet (as in the Lowered Section design). A Mannings n value of 0.032 was selected for the model based on roughness heights varying from 3 inches to 9 inches. Fish passage calculations now show a Steelhead at 92 cfs can now pass over 2300 feet. The 100 year flood (3500 cfs) was modeled for this design. The result was an average change in water surface elevation of -0.17 feet compared to the existing condition.

4.7 Option 2 – High Flow Trench with Baffles

This design is based on the concept of adding another trench higher in the water column so when the existing trench becomes impassable, fish could pass at higher flows through the new trench. The design is shown in Appendix A-13, with an isometric view shown in Appendix A-14. At 92 cfs, there would be a very shallow area along the waters edge where water spills (0.6 foot drop) over the baffle. For fish passage the design would function similar to a pool and chute fishway (high velocity in the center, low velocity along the margins). Passage calculations with the energetics model shows at 92 cfs a Steelhead could pass 950 feet.

The 100 year flood (3500 cfs) was modeled for this design. The result was an average change in water surface elevation of -0.03 feet compared to the existing condition, but at the revised baffle locations the increase was as much as 0.33 feet.

4.8 Cost Estimates and Passage Comparisons

Costs were developed for each design option. For comparison purposes to other Reach Types the costs were developed for a given length and then divided by the length for a unit cost per foot. Costs included mobilization, access and water management, concrete demolition, concrete form and pour, contingencies, taxes, engineering and project management. Detailed cost estimate forms are provided in Appendix D. Figure 4-3 shows the cost comparison for all of the design options.

Figure 4-3: Construction costs per foot of channel length for design options developed for Reach Type 3.

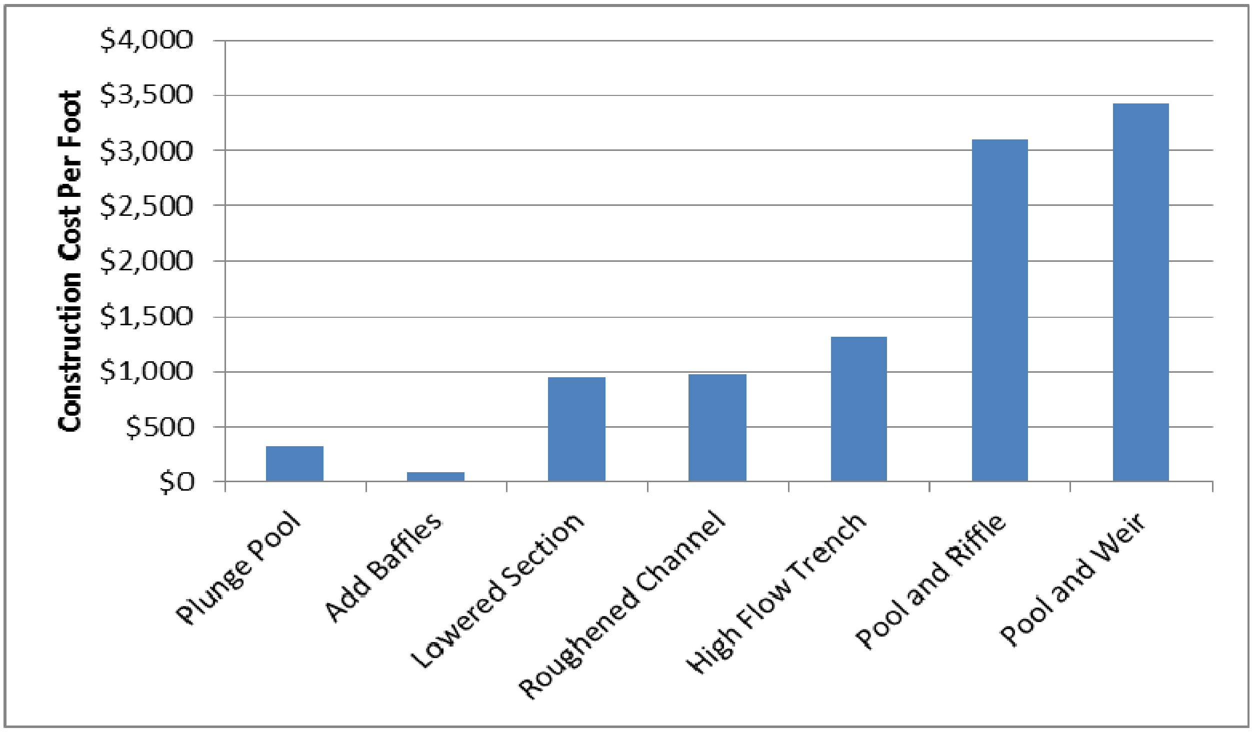


Figure 4-4 shows a fish passage comparison at 92 cfs for the Option 2 designs. Given the unit cost comparison from Figure 4-3, the passability calculations from Figure 4-4, maintenance and flooding concerns, the Mill Creek Work Group (MCWG) selected the Roughened Channel design as the preferred design option. In addition, the group decided

Figure 4-4: Fish passage comparison for the Option 2 (Retrofit) designs in Reach Type 3.

		Design Geometry				
Species	**Size (in)**	**Exisiting**	**Plunge Pool**	**Lowered Section**	**Roughened Channel**	**Highflow Trench**
Steelhead	22	95 ft, then fail	210 ft, then fail	1424 feet, then rest to pass	2325 feet, then rest to pass	950 feet, then rest to pass
	30	100 ft, then fail	210 ft, then fail	1364 feet, then rest to pass	Passable	940 feet, then rest to pass
Chinook	24	105 ft, then fail	160 ft, then fail	1425 feet, then rest to pass	2324 feet, then rest to pass	940 feet, then rest to pass
	29	100 ft, then fail	180 ft, then fail	1380 feet, then rest to pass	2100 feet, then rest to pass	950 feet, then rest to pass
Bull Trout	7	20 ft, then fail	20 ft, then fail	90 ft, then fail	120 ft, then fail	106 ft, then fail
	17	10 ft, then fail	20 ft, then fail	150 feet, then rest to pass	160 feet, then rest to pass	160 feet, then rest to pass
		Velocity (fps)				
Total Cross Section		7.4	4.0	4.0	3.6	3.2
Overbank		N/A	N/A	1.9	1.6	2.4

to vary the complexity of the design by using both a combination of plunge pools and adding baffles for low flow passage. Resting pools will be added as needed based on calculations from the energetics model and WDFW fish passage criteria. The selected Reach Type 3 Conceptual Design is shown in Appendix A-15. The total estimated cost for correction of the 7260 feet of Reach Type 3 is $6.9 million.

Before fish passage correction is applied to a long distance of channel, it is recommended that a physical model be constructed to better understand the flow interaction and distribution between the trench and overbank area for the lowered and roughened portion. The physical model should provide Mannings n roughness values and depths which can then be used in the HEC RAS model, and energetics model for final passability calculations and location of resting pools. Resting pools should also be tested to verify the shape and size and to ensure the resting area is effective for fish.

5 REACH TYPE 6

5.1 Existing Hydraulics and Fish Passage

Reach Type 6 has a nine foot wide trench and baffles similar to other reaches but the overbank area is flat (as compared to the 5:1 slope for Reach Type 3). A detailed plan view, sections, hydraulics and fish passability estimates are provided in Appendix B-2. Reach Type 6 is located within the concrete flume between sections which have piers, double walls, etc. There are four segments of Reach Type 6, although only one has significant length (300 feet) between Colville Street and Spokane Street. This segment was modeled for hydraulics and fish passability using HEC RAS and the Fish Passage Energetics Model. Low flows within the trench are identical to Reach Type 3. At higher discharges the flow spreads out over the flat overbank area, and the overall depth in the trench is less (as compared to Reach Type 3), which results in lower velocities for the same flow. For example; at 194 cfs, the average velocity in Reach Type 3 is 6.7 fps compared to 5.6 fps for Reach Type 6.

Photo 5-1 – Reach Type 6 at flows of 6, 72, 148 and 370 cfs. View is downstream with Colville Street in the background. Depth in the overbank area at 148 cfs is 0.3 to 0.4 feet.

The Assessment Report calculated an overall passability of 36% (59% for Steelhead, 50% for Spring Chinook, and 0% for Bull Trout). Additional hydraulic modeling from this study suggests the passability is lower. Additional cross sections were added to the original HEC RAS Model for better definition of the supercritical flow downstream of each baffle. A passage summary of existing conditions is provided in the Appendix B-2. At 10 cfs all the flow is in the trench. The depth varies from 0.2 to 0.9 feet, and the velocity varies from 1.2 to

6.9 fps. Passability is limited by depth, except for the 7 inch Bull Trout, which is limited by stamina (swimming speed and time). At 92 cfs, flow spreads out into the overbank area. The flow depth varies in the overbank area from 0.0 to 0.4 feet. The variable depth in the overbank area is a result of the variable depth in the trench which is created by the hydraulic jump downstream of each baffle. The depth is too shallow in the overbank area so fish must pass through the trench. Velocities in the trench at 92 cfs vary from 4.0 to 8.0 fps. Using the fish passage energetics model, Steelhead and Chinook can only swim 30 to 80 feet before failing, and Bull Trout even less. At 194 cfs, velocities in the trench range from 6.1 to 7.9 fps. Depth in the overbank area varies from 0.4 to 0.7, and the velocities range from 3.3 to 4.4 fps. Fish passage is still limited to the trench but velocities are too high. At 320 cfs, the depth is now sufficient in the overbank area but velocities have increased to 4.9 to 5.8 fps. Steelhead and Chinook can pass further but still are limited to 60 to 120 feet. Fish passability calculations assume no resting areas, but there are areas with broken concrete and uneven walls which may provide some resting and passage, especially at the toe of the walls where some vegetation and concrete roughness exists. The author has observed steelhead swimming through similar concrete flumes, by hugging the wall and finding resting pockets.

5.2 Roughened Channel Design

The roughened channel design concept selected for Reach Type 3 was applied to Reach Type 6 (see Appendix B-3). The design consists of cutting out a section of overbank area and forming it back with roughness which will increase the depth and decrease the velocity. For low flow, plunge pools were added below the baffles. Resting pools were added at a spacing determined from the fish passage energetics model (see Appendix B-3). Because the overbank area is flat the geometric shape of the roughened channel portion is different from the Reach Type 3. Several layouts were modeled using a cross section analyzer spreadsheet to achieve the best conditions for passage. The overbank width is about 17 feet. Maintenance vehicles need a minimum width of about 10 feet, this leaves only 7 feet in some locations for the roughened channel. At 92 cfs a Steelhead could swim 580 feet, compared to 80 feet for the existing conditions.

The rectangular channel shape allows the flow to spread out more frequently over a wider area as compared to Reach Type 3. There could be times when fish are swimming near the far right bank and have to cross the high velocity trench before they find the roughened channel section on the left side. The 100 year flood (3500 cfs) was modeled for this design. The result was an average change in water surface elevation of -0.09 feet compared to the existing condition.

5.3 Roughened Channel Design Both Sides

An alternative to the roughened channel on one side would be to have an additional roughened channel on the other side and/or resting pools. Ideally resting pools should be located in alignment with the roughened channel. A conceptual design showing roughened channels on both sides with a combination of plunge pools and resting pools to address low flow is shown in Appendix B-4.

5.4 Cost Estimates and Passage Comparisons

Costs were developed for the Reach Type 6 design similar to methods used for Reach Type 3. For the Roughened Channel Design shown in Appendix B-3, the total cost was $258,000 or $906 per foot of channel length. For the Roughened Channel design on both sides the cost was $453,000 or $1,600 per foot. The passage analysis comparison is shown in Figure 5-1. In Appendix B-3 and B-4 (Sheet 3 of 3); a fish passage corridor is identified within the overbank area. Actual velocity may be different in the the fish passage corridor, but the HEC RAS model only calculated three separate flow areas, therefore the passage calculations may be conservative.

It is recommended that a physical model be constructed of the Reach Type 6 roughened channel designs to better clarify the actual velocity in the fish passage corridor and the flow interaction with the overbank area and trench. The implications of fish moving back and forth across the channel and the flow interactions with the passage corridor and resting pools is critical to understand before a final design can be completed. The concept and cost should be sufficient at this point to proceed to preliminary design, assuming the physical model study data will guide the final passage calculations.

Figure 5-1: Reach Type 6 Conceptual Design Passage Comparison for Steelhead and Spring Chinook at 320 cfs.

Species	Size (in)	Design Geometry		
		Exisiting	Roughened Channel One Side	Roughened Channel Both Sides
Steelhead	22	60 ft, fail	120 ft, fail	160 ft, fail
	30	120 ft, fail	180 ft, fail	215 ft, fail
Chinook	24	80 ft, fail	160 ft, fail	175 ft, fail
	29	105 ft, fail	200 ft, fail	215 ft, fail
		Velocity (fps)		
Total Cross Section		6.7	5.2	5.3
Overbank		5.2	4.3	4.3

6 TRANSITION REACH TYPES 4, 5, 9 AND 10

Fish Passage correction for Reach Types 4, 5, 9 and 10 will likely occur during correction of longer Reach Types. For example, when preliminary designs are developed for Reach Type 3, Reach Types 4 and 10 may be included. The following descriptions should be considered for each Reach Type segment.

6.1 Reach Type 4

Reach Type 4 is a trapezoidal channel similar to Reach Type 3, but there is either a bridge pier or center guide wall which splits the channel in the center. The main difference in terms of cross section geometry is the height of the trench wall increases from 1'-8" to 1'-9 1/4". This additional 1-1/4 inch in trench wall height doesn't allow flow out into the overbank as frequently as Reach Type 3, which results in higher velocities for Reach Type 4. There are three segments within the concrete flume, one at the 6th Avenue Bridge, one at the 5th Avenue Bridge and one downstream of Park Street. Starting downstream, the segment length for the 6th Avenue Bridge is only 120 feet long, the length for 5th Avenue is 60 feet and the segment downstream of Park Street is 480 feet long. The Assessment Report calculated passability of 37% for Reach Type 4.

Conceptual designs for this reach would be similar to Reach Type 3 using the roughened channel and baffle modifications with resting pools. These areas would be good areas for resting pools as some cover is provided for fish due to the bridge crossings. The designs will have to be modified to accommodate flume maintenance. The bridge pier and footings result in a increased overall trench width, but the outside flume walls do not change so there is less open width in the overbank area.

For the 480 foot segment with a divider wall, it may be possible to eliminate the baffles on one side and provide fish passage on only one side. The design concept would be to have a high velocity/sheet flow barrier on one side. Fish would be blocked from moving up one side. This could also increase channel flood flow capacity.

6.2 Reach Types 5 and 9

Reach Type 5 is a transition from a 5:1 sloped overbank area to a rectangular or flat overbank area. Reach Type 9 is the opposite (Flat overbank to 5:1 sloped overbank). The CORPS drawings refer to this segment as a side slope transition. There are two segments. The first is under 3rd Street. The length of the transition is 178 feet. Reach 3 is the downstream control and upstream is Reach Type 7. The trench through this segment is the same as all Reach Types. Depth of flow in the overbank area is more for Reach Type 3 versus Reach Type 7. The conceptual design will combine the designs developed for Reach Type 3 and 6, transitioning the roughened channel section from a sloping section to a flat section. Reach Type 9 starts upstream of Palouse Street. The transition from a flat overbank area to a sloped overbank area is 168 feet long. The downstream control is Reach Type 7 and the upstream control is Reach Type 4.

6.3 Reach Type 10

Reach Type 10 is a combination of Reach Type 3 and 4. It was singled out in the Assessment Report because there is one location where the spacing of the baffles is 100 feet, instead of 60 feet. The conceptual design would be the same as Reach Type 3. Reach Type 10 (Roosevelt Street) is a good example of a location where installing a new bridge would eliminate the pier and footing, which would improve fish passage and reduce local flood elevations. The 1948 Corps drawings for this location show a 3 to 4 foot head loss through the bridge pier at 5400 cfs.

7 REACH TYPE 1 CHANNEL SILLS

The Assessment Report identified the channel sills as 59, 42 and 89% passable for Steelhead, Spring Chinook and Bull Trout respectively. Water depth at low flow was identified as the main problem. The analysis used a generic 70 foot wide concrete sill for the calculations. The conceptual design developed for the Assessment Report was to remove a 16 foot wide section of the sill, and form and pour a low flow slot. If the drop over the sill was 0.8 feet or less, a single weir was proposed. If the drop was greater than 0.8 feet, two weirs in the form of a fishway or a roughened channel were proposed.

This report analyzed all the sills in more detail, by looking at aerial photos for changes in channel features, measuring the actual channel width, hydraulic drops and plunge pool depths and making a more complete passage assessment. In addition, the MCWG emphasized the need for the development of concepts for a "low flow channel" in the wide section of Reach Type 1. Concerns are that water quality and fish stranding may play a larger role than just fish passage.

After review of the different sills lengths and channel features in Reach Type 1 is was decided a further classification was needed to break out channel features. Reach Type 1 (channel sills) was split into six segments (labeled A through F) and referenced in terms of the unique channel segments and river mile within the center of that segment. Historical aerial photos of each segment are provided in Appendix C. Table 7-1 is a summary of the segment types, river mile, and description and cross street location. A detailed discussion of each segment follows with recommendations for fish passage correction.

Table 7-1 Reach Type 1 Channel Sill Segments by Mill Creek River Mile, Description and Cross Street Location

Segment	Description	Cross Street Location
A (RM 5.4)	Sheet Pile – confined channel	Goes Street to Myra Road Bridge
B (RM 6.3)	Concrete – confined channel	Myra Road Bridge to 9th
C (RM 9.2)	Concrete – wide channel – heavily vegetated	Wilbur
D (RM 9.5)	Concrete – wide Channel – open water	Union
E (RM 9.8)	Concrete – confined to wide – depositional	Merrill
F (RM 10.4)	Concrete – confined channel	Tausick to Division Dam

7.1 Reach Type 1 – Segment A Channel Sills RM 5.4

This segment is a mile long and starts at Goes Street and ends just upstream of the new bridge on Myra Road. There are 77 sills in this reach. Just upstream of Gose Street there are 2 concrete sills, which were recently constructed to backwater a 3 foot drop over one sheet pile weir. These concrete weirs have a low flow notch in the center and drops of one foot. Upstream of the first sheet pile weir is a concrete sill with one foot of drop. This sill is eroded on the downstream end. The remaining sills are sheet pile weirs. A survey was completed for a series of four sheet pile weirs to document typical dimensions. Each Sheet pile weir has a low flow notch 3 to 4 inches deep and 13.6 feet wide. Drop over the sheet pile weirs range from 0.6 to 0.9 feet. Length of the weirs range from 60 to 63 feet. Appendix C-1 provides a series of aerial photos from 1996 to 2009. Very little channel change can be observed of the 13 year period.

Because of the low flow notches the sheetpile weirs in Segment A are passable. Correction should only be applied to the one concrete sill. The drop is greater than 0.8 feet, so a pool and weir fishway design is recommended.

Photo 7-1: Mill Creek Reach Type 1 Segment A (sheetpile weirs) at 5 and 78 cfs.

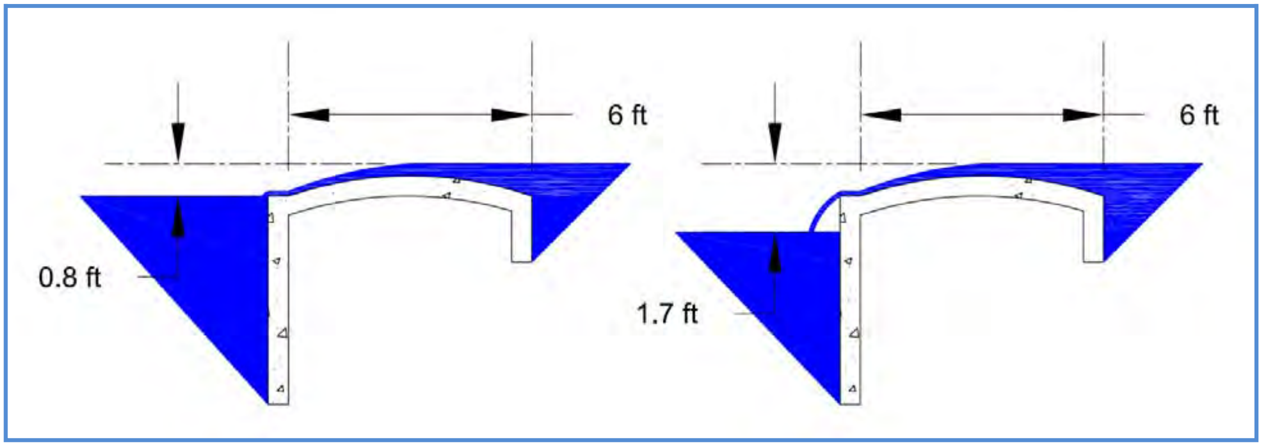
7.2 Reach Type 1 – Segment B Channel Sills RM 6.3

This segment starts just upstream of the newly constructed Myra Road Crossing where the sills transition from sheet pile to concrete and extends to 9th Street at the outlet of the concrete flume (Reach Type 2 Transition). There are 9 sheet pile sills in this segment. The concrete sills are 6 feet wide (in the direction of the flow), shaped is an arc with a radius of 9.2 feet. The vertical rise of the arc is 0.5 feet. Most of the sills have an additional concrete cutoff wall on the downstream side which extends 5 feet below the top of the sill. The wall thickness varies from 6 to 8 inches. Drops over the sills vary from 0.6 to 1.0 feet. For drops less than 0.8 feet, fish can pass by swimming over the sill if the flow depth is adequate. For drops greater than 0.8 feet, water flows over the sill end, and is then projected out by the cutoff wall into the plunge pool (See Figure 7-1).

Photo 7-2: Reach Type 1 Segment B Concrete Sill. Flow is 5 cfs.

The Assessment Report concluded that the sills became passable at flows around 100 cfs. Survey of the channel and subsequent modeling showed the channel to be narrower than the actual drawings and the depth over the sill and backwater from downstream much greater. For Steelhead and Spring Chinook, the sills become passable around 30 to 40 cfs. This is not true for the wide sills with drops greater than one foot. Appendix C-2 shows aerial photos from 1996 to 2009. Very little channel change can be observed in the 13 year period.

Figure 7-1 – Concrete sill dimensions showing watersurface profiles for drops of 0.8 and 1.7 feet.



7.3 Reach Type 1 Segment C Channel Sills RM 9.2

This segment runs from the Reach Type 11 Transition just upstream of Roosevelt Street (STA 216+91) in Walla Walla, to Union Street (where the channel is very wide and was excavated in 2002). Vegetation plays a significant role in this segment. Hydraulic drops over the sills in this section vary from 1.0 to 1.8 feet. Passage routes for fish are variable. In some places vegetation has confined the flow to one location which has scoured the channel. Sill lengths vary from 145 to 228 feet. Elevations across the top of the sills vary as much as 0.6 feet, but are typically within 0.2 feet. Appendix C-3 shows a series of aerial photos for this reach with very little change over time. The vegetation is prominent at lower flows but appears to flatten down at higher flows. This segment is within the area identified by the MCWG where the preferred conceptual design is a low flow channel, as opposed to correcting fish passage for each sill.

Photo 7-3: Concrete Sill in Segment C RM 9.2 showing vegetation which controls lower flows of the sill.

7.4 Reach Type 1 Segment D RM 9.5

This segment is best identified by the wide open bodies of water, which are the remnants of channel excavation in 2002. The County manages this segment as a sediment retention basin. The aerial photos in Appendix C-4 show the basin being partially full in the summer of 1996, after a 4190 cfs flood in February1996, and excavation in 2002. The current condition still has large open water areas, although the depth is very shallow. Surveys of this reach identified the following: hydraulic drops over the sills range from 1.5 to 2.2 feet, the longest sill is 524 feet and plunge pools are 2 to 3 feet deep. A HEC-RAS model was developed for this segment. The bed and water surface profiles are shown in Figure 7-2. There is four feet of freeboard at the 3500 cfs (100 year flood event).

Photo 7-4: Reach Type 1 Segment D. View is downstream.

Understanding the potential of gravel transport in this segment and segments upstream and down is an important design consideration. The shear stress in this segment is very low. At the two year flood of 2100 cfs, the shear stress is only 0.5 lbs/sq ft. Gravel 1.5 inches and larger would tolerate this shear stress. Pebble counts were taken in this segment and the D_{50} gravel size was calculated at 1.5 inches. As a comparison, the D_{50} gravel size in Mill Creek below the Blue Creek confluence (RM 16.9, where Mill Creek is a natural channel) was measured at 2.3 inches (USDA, 2010). These calculations confirm the geomorphology of this segment as a deposition area, which will only pass gravel less than 1.5 inches at a two year flood.

Fish passage was calculated for this segment (see Figure 7-5). At 10 and 92 cfs, the sills are not passable to Steelhead and Spring Chinook due to the shallow water depth, but Bull Trout can pass. Passage assumes fish jump onto the downstream end of the sill and then swim over to pass. While physically possible it may take fish many attempts to successfully pass. In general passage through this reach is very poor and should be a high priority for correction.

The conceptual design developed is a low flow channel with grade control at the sills (see Appendix C-7). The length is 5500 feet which would cover segments C, D and E. The channel width would vary from 12 feet at the toe to a top width of 24 feet. The concept is to excavate a channel, slope the banks and allow the stream power to shape and maintain the channel. Grade control at each sill would be either a concrete fishway or a roughened channel. The fishway would have two drops and function as a pool and weir/pool and chute fishway. The width would be 24 feet. At flows of 60 cfs and less there would be no spill over the sills. Above 60 cfs, there would be flow over the sill, and at 325 cfs, there would be 217 cfs going over the sill and 108 cfs in the fishway. Flows in the fishway above this point exceed the pool and weir fishway energy dissipation criteria and transition to streaming flow.

The roughened channel option would be 24 feet wide at the top, 42 feet long and a 4 percent slope. The channel shape would include a low flow thalweg. Bed material would be angular rock riprap with a size range from 3 to 18 inches. Average velocity would range from 2 to 3 fps, based on a calculation with Mannings n equal to 0.075.

Maintenance of the channel will likely be required over time. When a large flood in Mill Creek transports sediment downstream and into Segment D, the deposition could block or partially block flow into the low flow channel. Sediment transport above the site and below Bennington Dam is unknown. Likely at some extreme flood, there will be sediment transport downstream. The design concept for the channel is to be self-maintaining due to the high percentage of flow, size and drop structure elevation. Major maintenance will likely coincide with the need to remove sediment from the overall channel.

Figure 7-3: Reach Type 1 Segment D (Wide Open Area) HEC RAS water surface profile for 10, 92, 194, 320 and 3500 cfs.

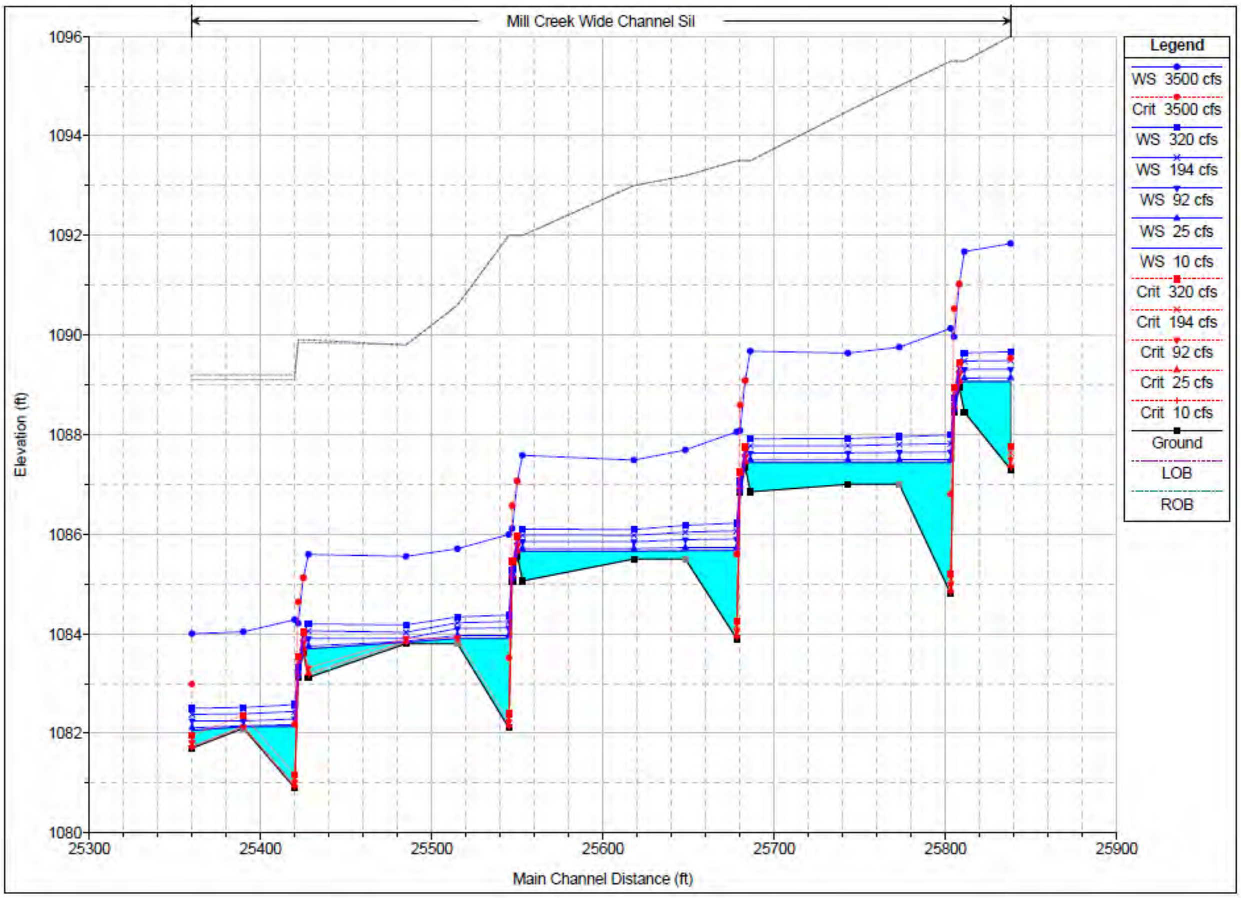


Figure 7-2: Fish Passability calculations for Reach Type 1 Segment D (Wide Open Area)

Fish Species	Size (in)	Flow (cfs) 10	92	194	320
Steelhead	22	Fail, depth	Fail, depth	Rest to pass	Rest to pass
	30	Fail, depth	Fail, depth	Fail, depth	Rest to pass
Spring Chinook	24	Fail, depth	Fail, depth	Rest to pass	Rest to pass
	29	Fail, depth	Fail, depth	Rest to pass	Rest to pass
Bull Trout	7	Rest to pass	Rest to pass	Rest to pass	
	17	Fail, depth	Rest to pass	Rest to pass	
Hydraulic Drop (ft)		1.7	1.7	1.7	1.7
Depth D/S End Sill (ft)		0.02	0.06	0.11	0.16
Velocity End Sill (fps)		5.20	6.20	6.6	6.9

7.5 Reach Type 1 Segment E RM 9.8

This segment is a transition from a very narrow confined (Segment F upstream) to a very wide Segment D. It is a depositional channel, and the first place for gravel to settle out. The drops are less than those in Segment D. Some sills are almost buried with sediment (See Photo 7-5). Passage is less of a problem in this segment compared to Segment D downstream. The low flow channel design will extend through this segment. The upstream end of the low flow channel will be 14 feet wide and increase in width to 24 feet wide incrementally in the downstream direction. This will form the transition from Segment F.

Photo 7-5: Reach Type 1 Segment E Depositional Area – Sill is partially buried from gravel accumulation.

7.6 Reach Type 1 Segment F RM 10.6

Segment F starts at the upstream end of the depositional reach (Segment E) and ends at the Division Dam. This segment of sills is characterized by a very narrow, confined channel. Drops range from 0.4 to 1.4 feet, with the average being 0.8 feet. In most areas the channel is 20 feet narrower than as noted on the Corps drawings. The shear stress is higher in this confined segment, compared to the wide depositional area in Segment D. Pebble counts were performed in this segment. The D_{50} size was 3 inches (as compared to 1.5 inches for Segment D). The D_{85} was 4.5 inches (as compared to 3 inches for Segment D). At the two year flood (2100 cfs) the shear stress is 0.7 lbs/sq ft. Gravel sizes 2 inches and larger would be stable at the two year flood event.

Photo 7-6: Reach Type 1 Sill in Segment F (above Tausick Way).

The Corps completed a 1:10 scale model study (Copeland, 1986) of a 40 feet wide section of flume. Their objective was to study scour downstream of the sills. The D_{50} material used was 3 inches. The model was filled to the top of the sills with gravel and then flow introduced. At 3500 cfs, the final scour depth was 5 feet below the top of the sill on the downstream end.

Data from the HEC RAS model was used to calculate fish passage for the four design flows. The passage summary table is shown in Figure 7.5. The sills are passable at 92 cfs. The 7

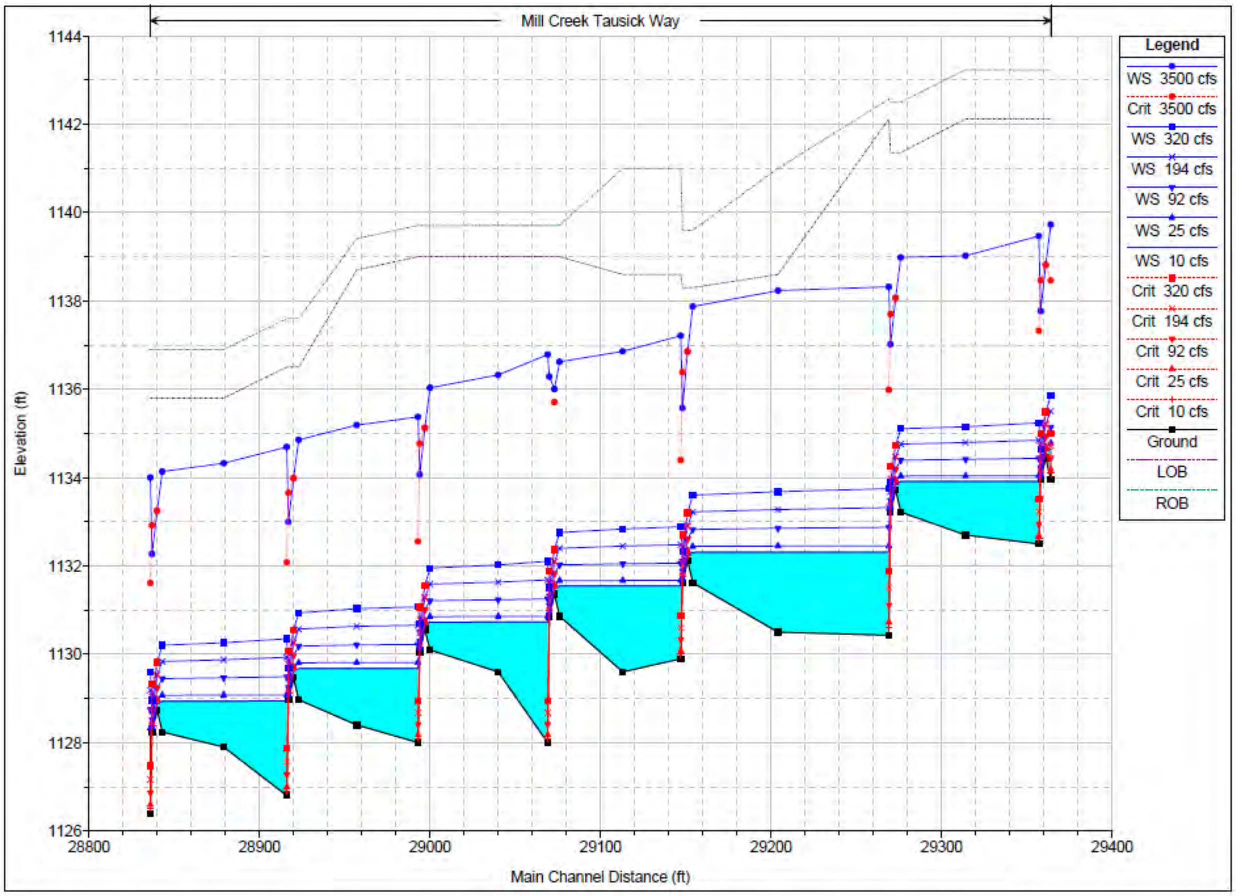
Figure 7-5: Fish Passage Analysis for Reach Type 1 Segment F (Tausick Way)

Fish Species	Size (in)	Flow (cfs) 10	92	194	320
Steelhead	22	Fail, depth	Rest to pass	Rest to pass	Rest to pass
	30	Fail, depth	Rest to pass	Rest to pass	Rest to pass
Spring Chinook	24	Fail, depth	Rest to pass	Rest to pass	Rest to pass
	29	Fail, depth	Rest to pass	Rest to pass	Rest to pass
Bull Trout	7	Rest to pass	Fail, stamina	Fail, stamina	
	17	Rest to pass	Rest to pass	Rest to pass	
Hydraulic Drop (ft)		0.7 to 1.6	0.7 to 1.5	0.6 to 1.4	0.6 to 1.4
Depth D/S End Sill (ft)		0.07	0.27	0.43	0.7
Velocity End Sill (fps)		5.85	7.50	8.3	9.1

inch Bull Trout fails because of high velocities between the channel sills. This was a surprising finding, but points out the potential passage limitation of a confined channel. In reality, there is a lot of vegetation and roughness along the waters edge which would provide lower velocities for small fish.

For correction, the design proposed is similar to the Reach Type 1 Conceptual Design from the Assessment Report. For drops 0.8 feet or less, a low flow slot will be created. For drops greater than 0.8 feet, a two step pool and weir fishway will be constructed. The Assessment Report included a design for a roughened channel. Based on the additional data collected it is recommended the roughened channel concept not be used in the confined channel segments. Given the scour, shear stress and velocities the design would too often be subject to movement.

Figure 7-4: Reach Type 1 Segment F HEC RAS Water Surface Profiles at 10, 92, 194, 320 and 3500 cfs.



7.7 Reach Type 1 Cost Estimates

Table 7-2 is a summary of the conceptual designs and cost estimates for fish passage improvement by segment in Reach Type 1. For example, Segment B has a total of 62 concrete sills, 46 with drops 0.8 feet or less, and 16 with drops greater than 0.8 feet. For the sills with drops less than 0.8 feet, the unit cost for correction is $21,300. Applying a cost reduction of 30 percent for correction of multiple sills the total cost would be $686,000. For the sills with drops greater than 0.8 feet, the unit cost for a fishway would be $28,300. Reducing the unit cost by 30 percent for multiple installations results in a cost of $317,000. Therefore the total cost for Segment B would be $1,003,000. For the low flow channel design is was assumed the fishways would be needed for most of Segment E where the low flow channel is transitioning from 14 to 24 feet wide. This will likely be the key location for sediment deposition and it would be easier to excavate around a solid concrete structure versus a rock channel.

Table 7-2: Reach Type 1 proposed conceptual designs and cost estimates by segment.

	Low Flow Slot (no.)	Pool and Weir Fishway (no.)	Low flow Channel w/Fishway (ft)	Low Flow Channel w/Roughened Channel (ft)	Cost Estimate by Segment
Segment A		1			$28,300
Segment B	46	16			$1,003,000
Segment C				3210	$1,052,000
Segment D				2050	$ 672,000
Segment E			490		$220,000
Segment F	35	26			$1,037,000
Total Cost					**$4, 012,300**

8 OTHER DESIGN ISSUES

8.1 Concrete Flume Width and Bridge Clearance Issues

The width of the concrete flume is variable. In Reach Type 2 the width is 50 feet, but at the Otis Street Bridge the width is only 37 feet. Clearance is another design issue, especially for maintenance vehicles. At Palouse Street the clearance is 11.3 feet, but at the 6th Avenue Bridge the clearance is only 6.7 feet. Clearance was calculated as the vertical distance from the overbank area to the bottom of the bridge a distance of 10 feet back from the trench wall. The height of the dump truck used for maintenance is 6.8 feet, so there are some existing clearance issues. Figures 8-1 and 8-2 provide the flume width and clearance at all bridge crossings. Some of this data was confirmed by measuring and some were some are taken from the 1948 Corps drawings.

Figure 8-1: Width of the Concrete Flume noted between the walls at Bridge locations.

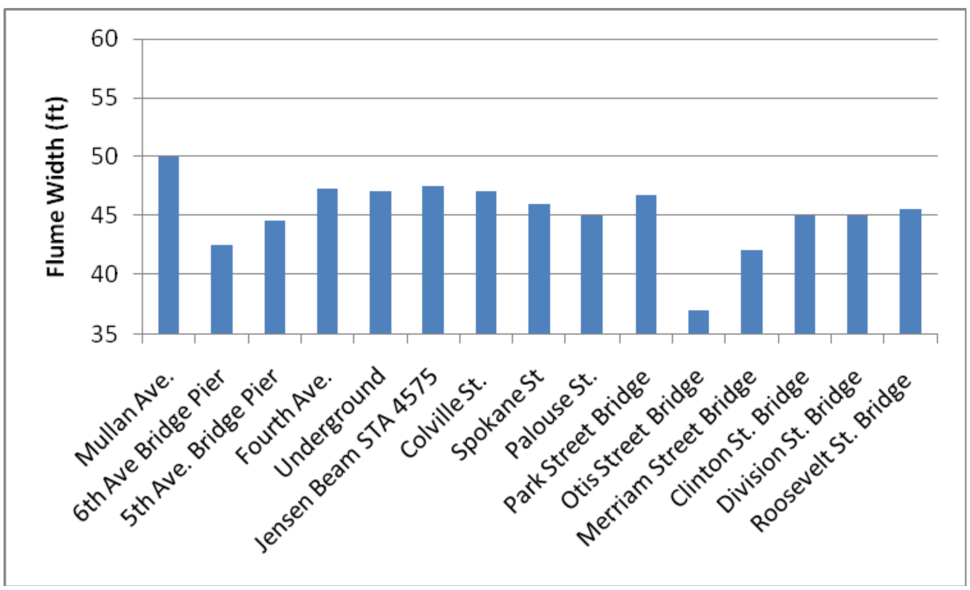
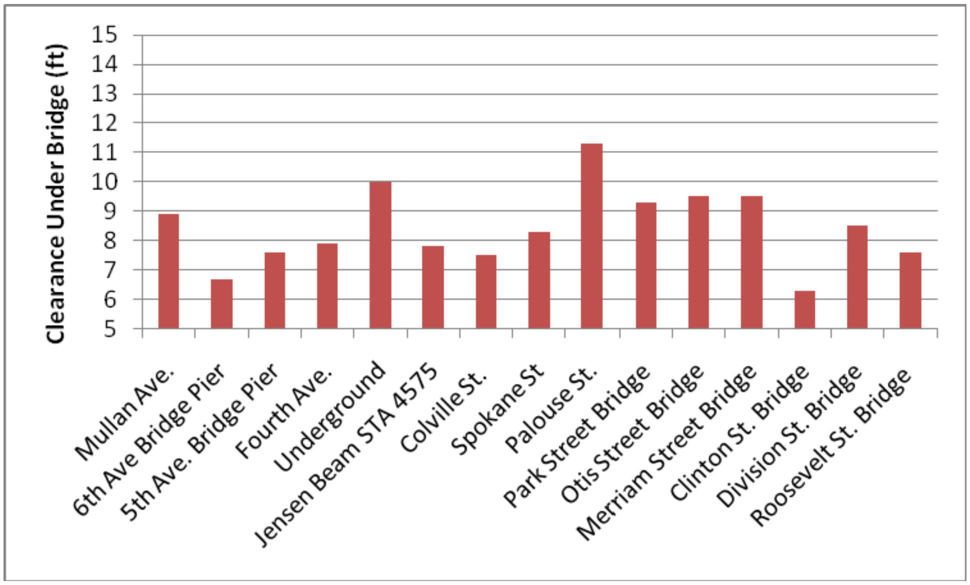


Figure 8-2: Clearance under Bridge Crossings within the Concrete Flume section of Mill Creek.



The conceptual designs presented may need to be modified at bridge crossings. One Reach Type 3 design option was to lower a section of the overbank area. This design could also improve the movement of maintenance vehicles by providing more clearance. For narrow segments of the flume the width of the roughened channel sections may need to be reduced to accommodate vehicle passage down the overbank area. These design details will need to be modeled during the project preliminary design phase.

8.2 Roughness and Velocity for Roughened Channel Design

Fish passage through the Roughened Channel is a function of the water velocity. The velocity was calculated in the HEC RAS model by proportioning out cross section segments and assigning each a Mannings n roughness value. It is critical to understand the proportion of flow in each segment, flow patterns and transitions to resting pools which would provide fish optimum conditions to remain in the Roughened Channel area, rest, recover and continue swimming upstream.

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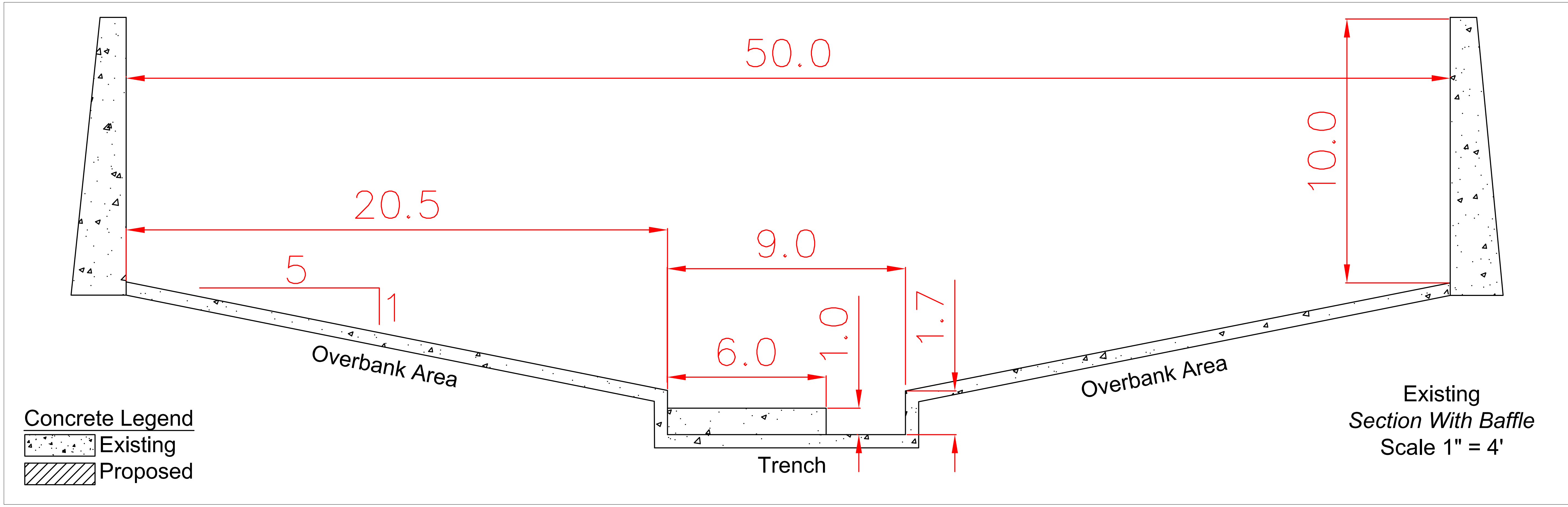
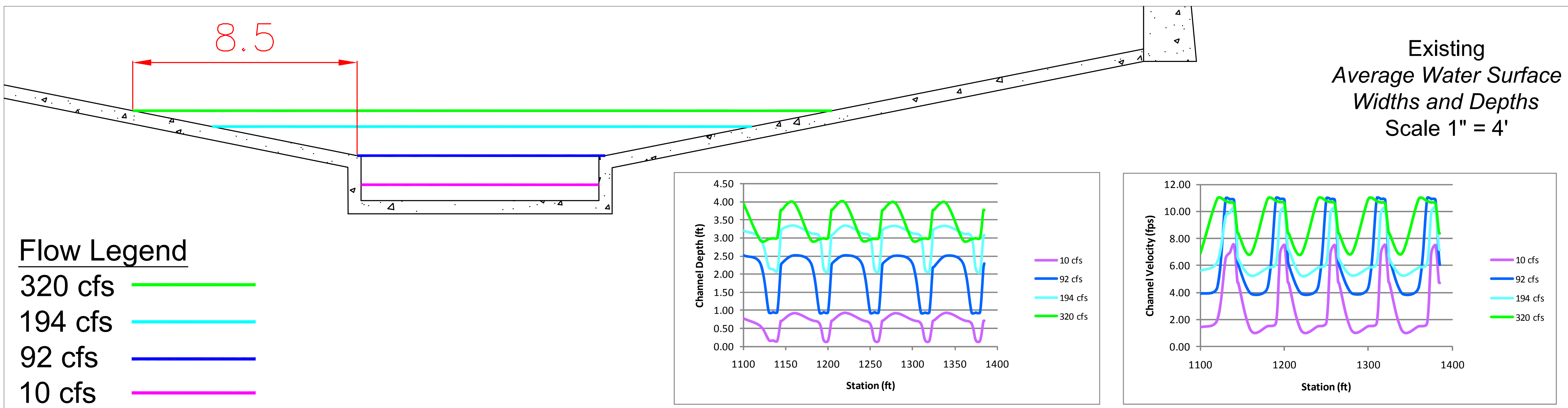
Appendix A: Reach Type 3 Conceptual Designs

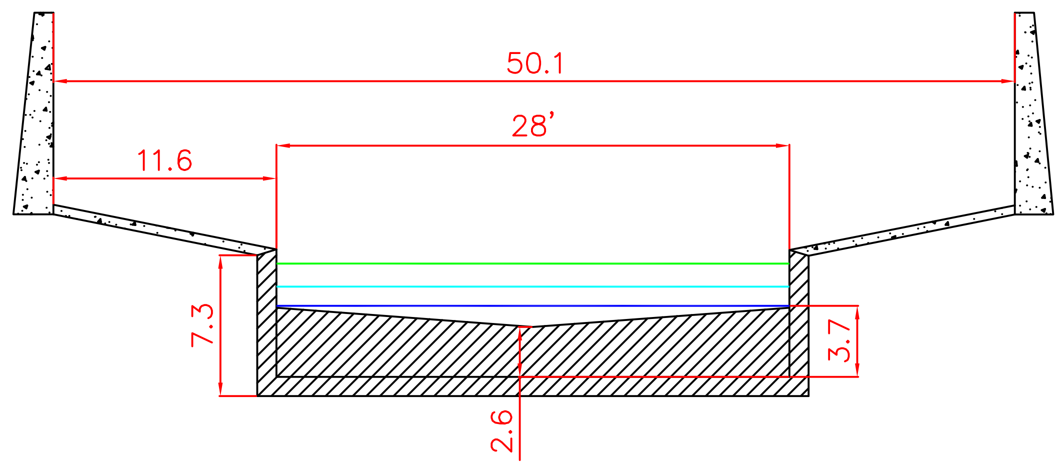
Appendix A-1: Existing Sections



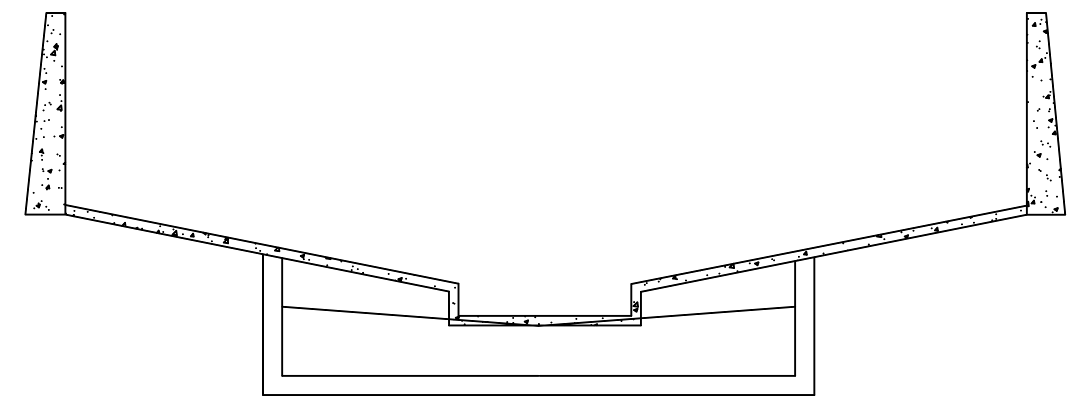


Appendix A-1: Reach Type 3 - Existing

Appendix A-2: Option 1 – Pool and Weir Design



Scale 1" = 10'



Pool and Weir Section
Within Existing
Scale 1" = 10'

Width = 28 ft, Channel Slope = 1%, Weir Spacing = 60 ft, Drop Over Weirs = 0.6 ft, Weir Height = 2.6 ft, Effective Pool Length = 20 ft

Head (H1)	WSEL US	Submerged Weir (Coef)	Flow	Depth 5' US	Depth 40' US	Depth Plunge Pool	Velocity 5' US	Velocity 40' US	Velocity Plunge Pool	Pool Volume	EDF
3.3	105.9	0.60	**320**	5.9	5.5	5.3	1.9	2.1	2.2	2968.0	4.03
2.13	104.73	0.70	**194**	4.7	4.3	4.1	1.5	1.6	1.7	2312.8	3.14
1.12	103.72	0.86	**92**	3.7	3.3	3.1	0.9	1.0	1.1	1747.2	1.97
0.23	102.83		**10**	2.8	2.4	2.2	0.1	0.1	0.2	1248.8	0.30
Streaming Flow (cfs):			185								

(yellow) Equals Calculations

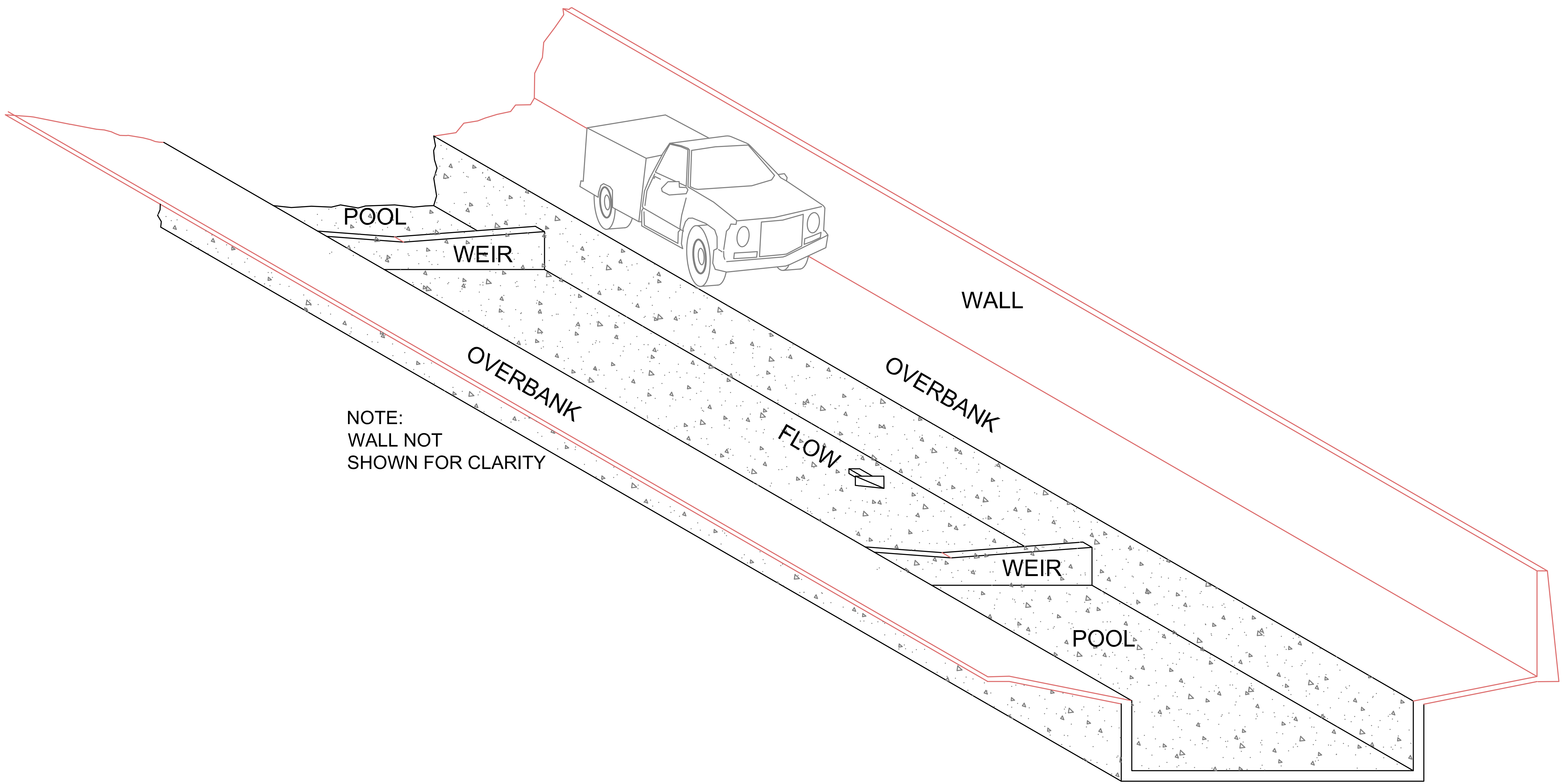
(purple) Indicates weir calculations may not be accurate due to streaming flow

Flow Legend

- 320 cfs (green)
- 194 cfs (cyan)
- 92 cfs (blue)
- 10 cfs (magenta)

Appendix A-2: Reach Type 3 - Option 1 Pool and Weir Design

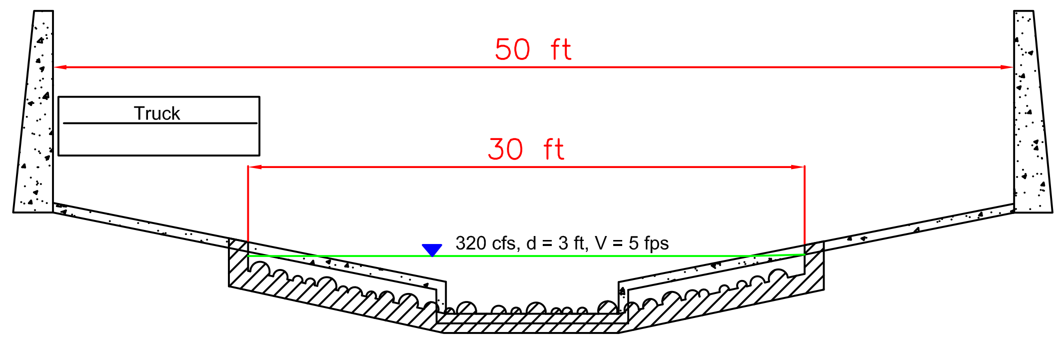
Appendix A-3: Option 1 – Pool and Weir Isometric



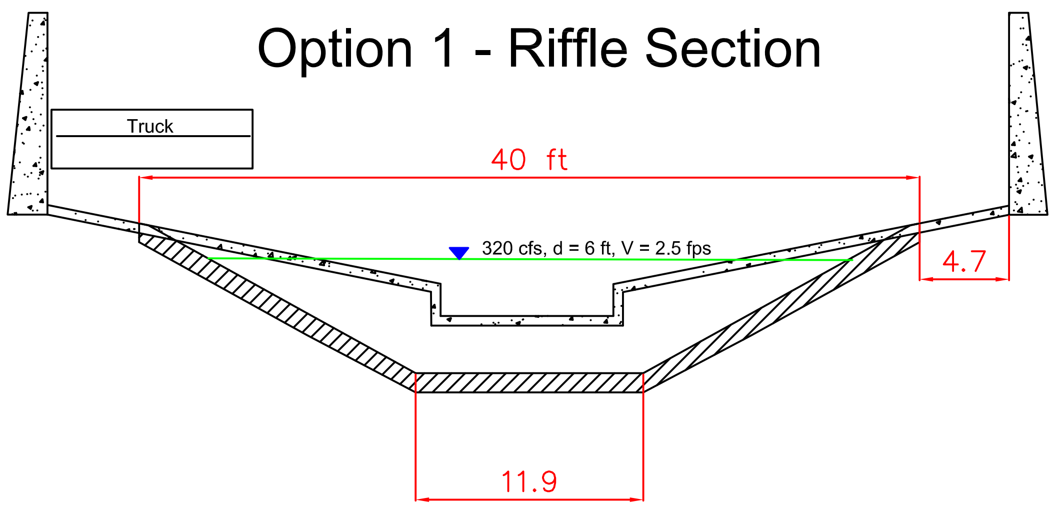
Scale 1" = 10'

Appendix A-3: Reach Type 3 - Pool and Weir Isometric

Appendix A-4: Option 1 – Pool and Riffle Plan Design

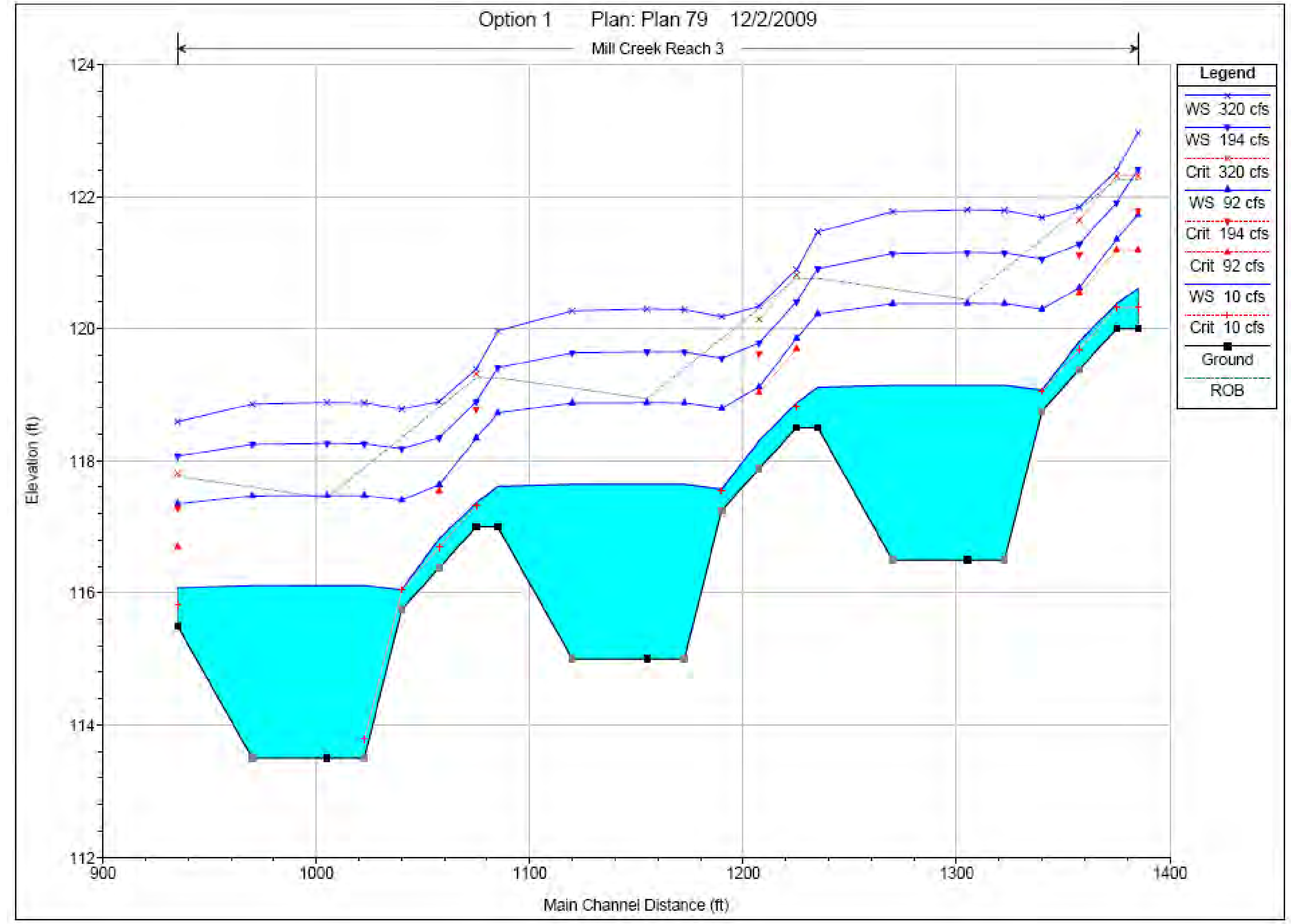


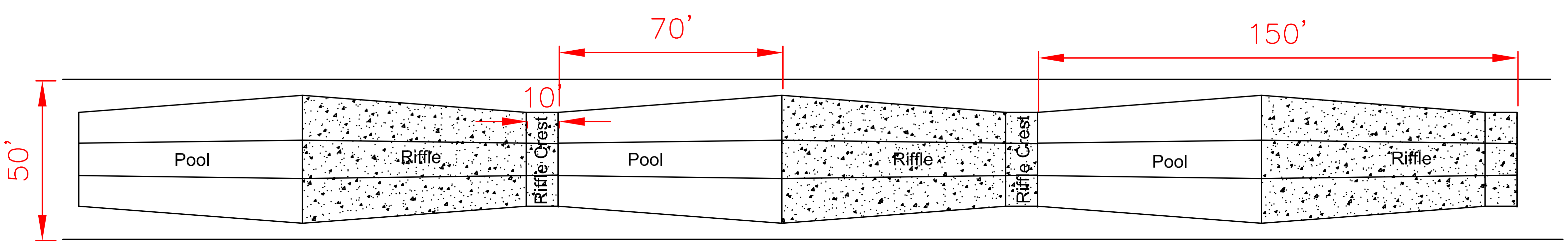
Option 1 - Riffle Section



Option 1 - Pool Section

Scale 1" = 10'



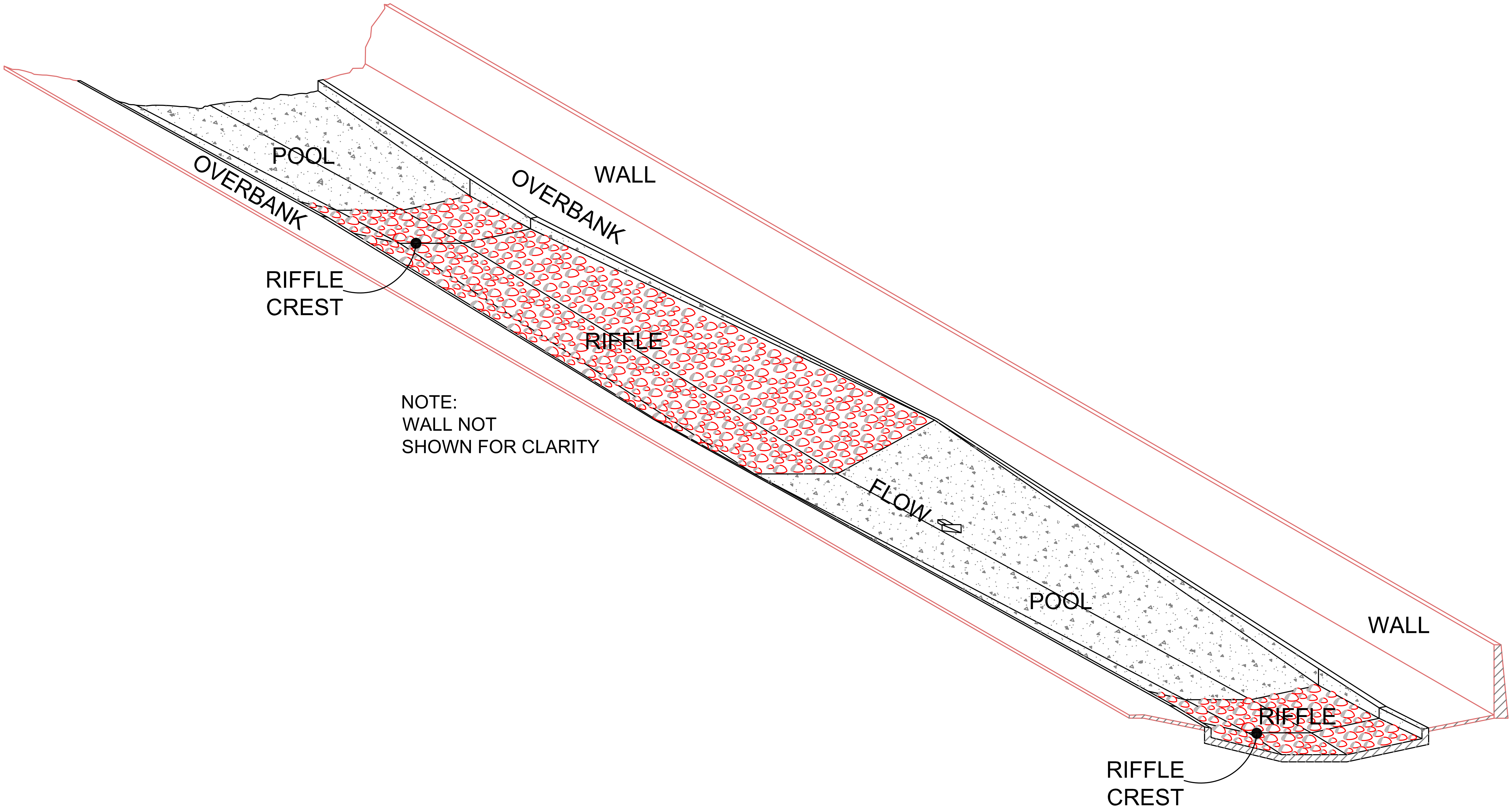


Plan View Layout

Scale 1" = 40'

Appendix A-4: Reach Type 3 - Option 1 Pool and Riffle Design

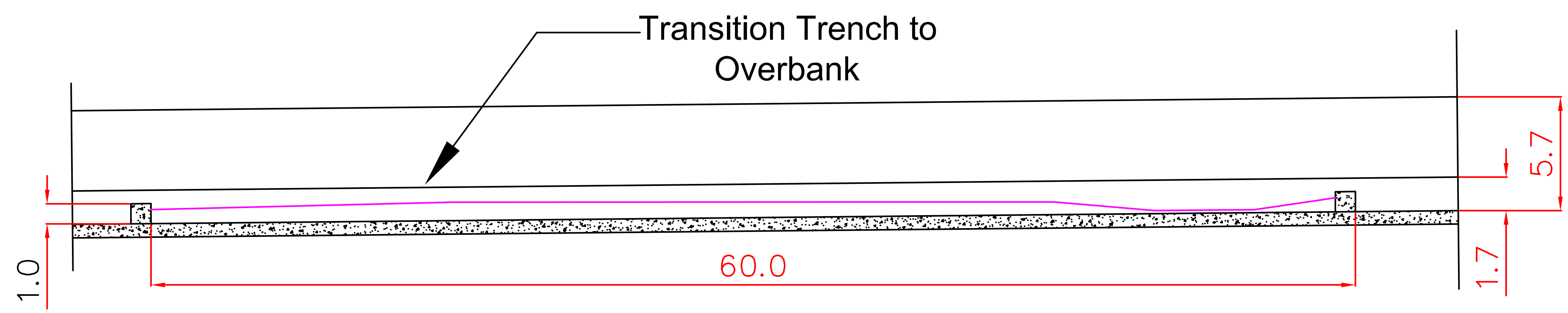
Appendix A-5: Option 1 – Pool and Riffle Isometric



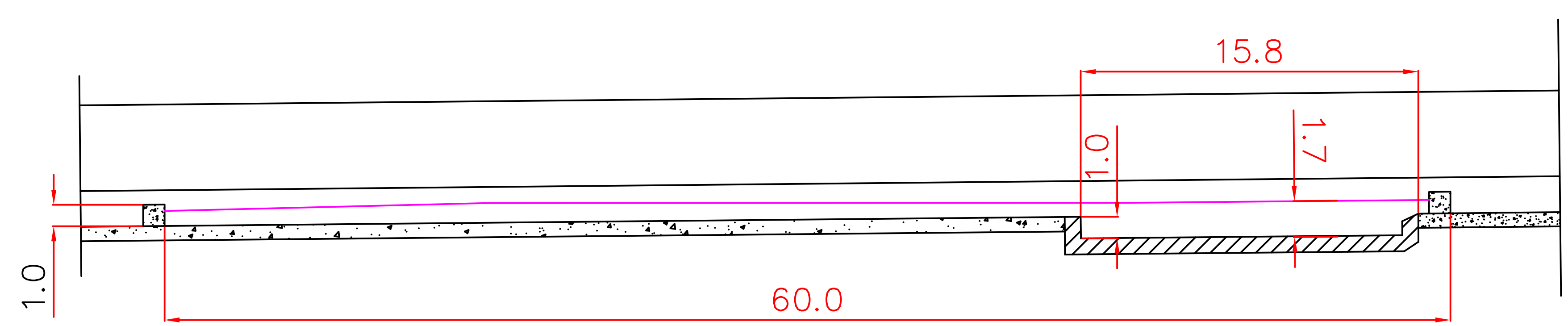
Scale 1" = 15'

Appendix A-5: Reach Type 3 - Option 1 Pool and Riffle Isometric

Appendix A-6: Option 2 - Plunge Pool and Baffles Design



Existing Baffles
Profile
Scale 1" = 8'



Plunge Pool
Profile
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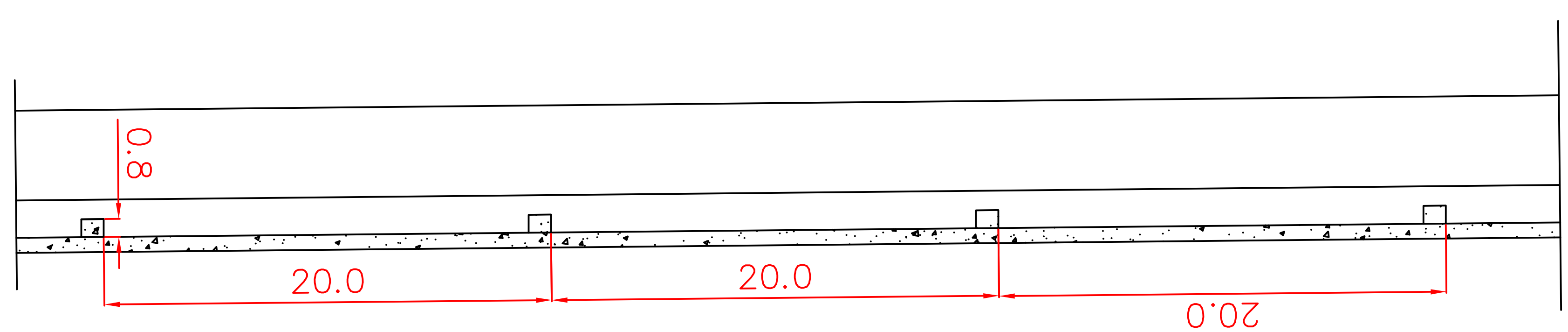
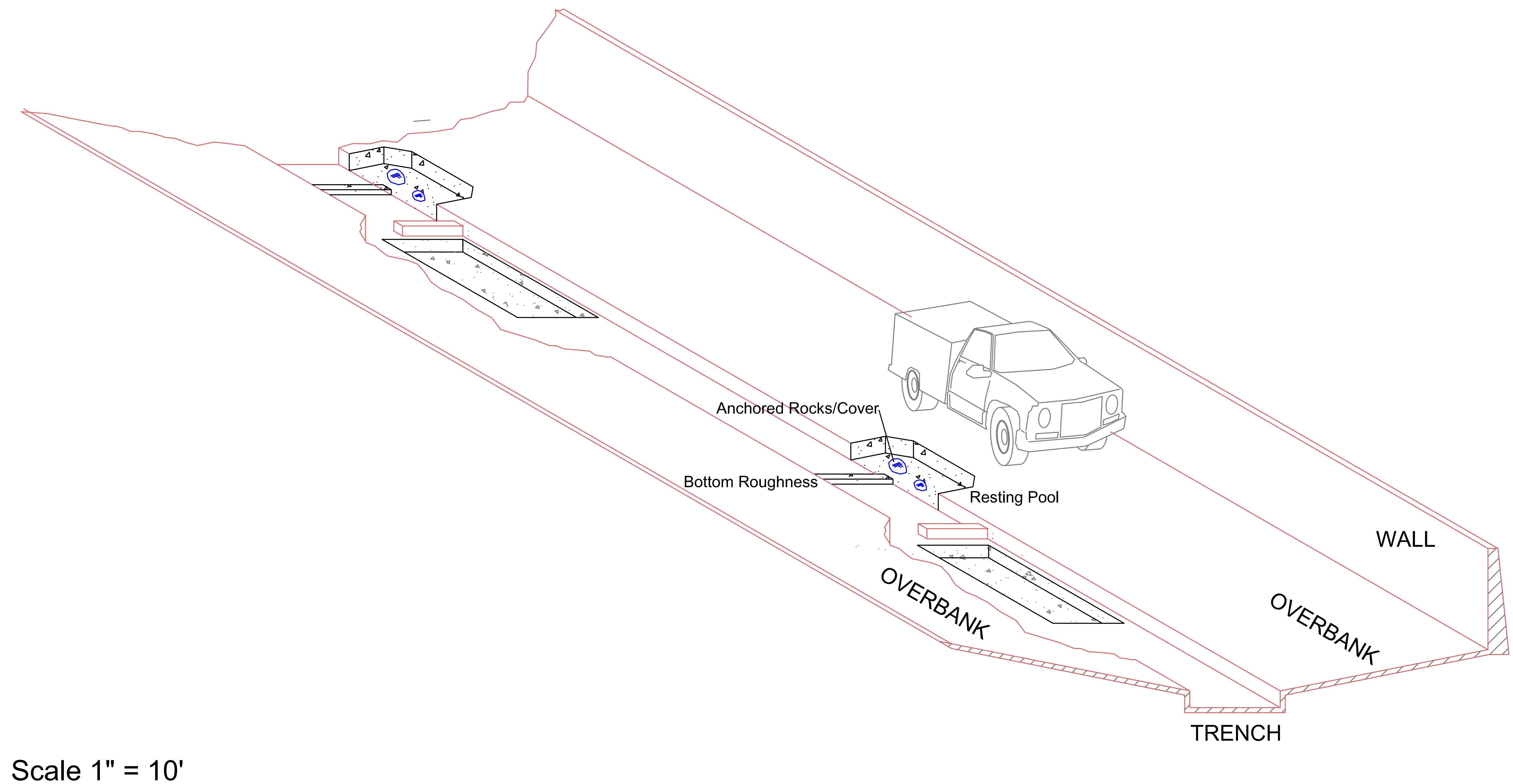


Add Baffles
Profile
Scale 1" = 8'

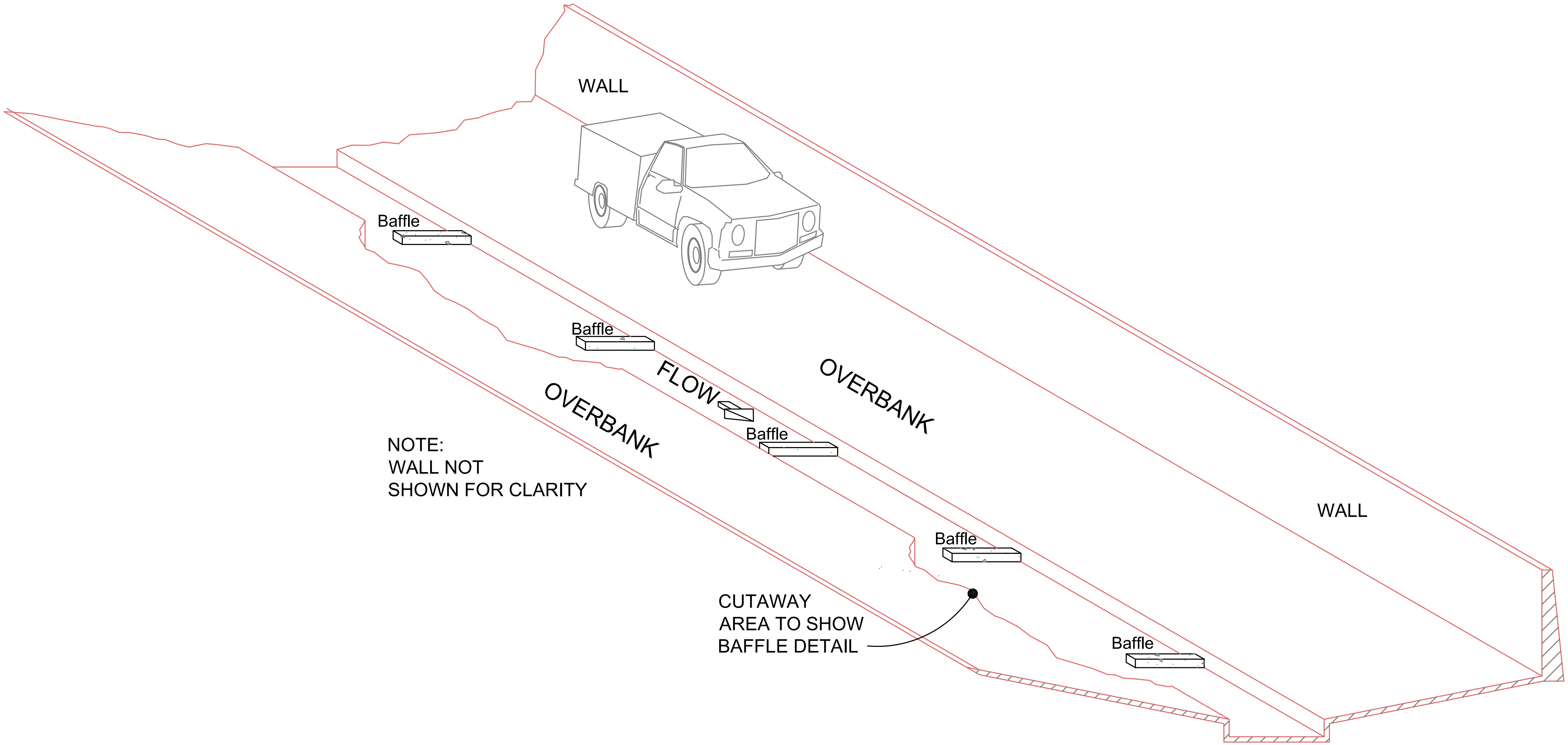
Appendix A-6: Reach Type 3 - Option 2 Plunge Pool and Add Baffles Design

Appendix A-7: Option 2 - Plunge Pool Isometric



Appendix A-7: Reach Type 3 Option 2 Plunge Pool Isometric

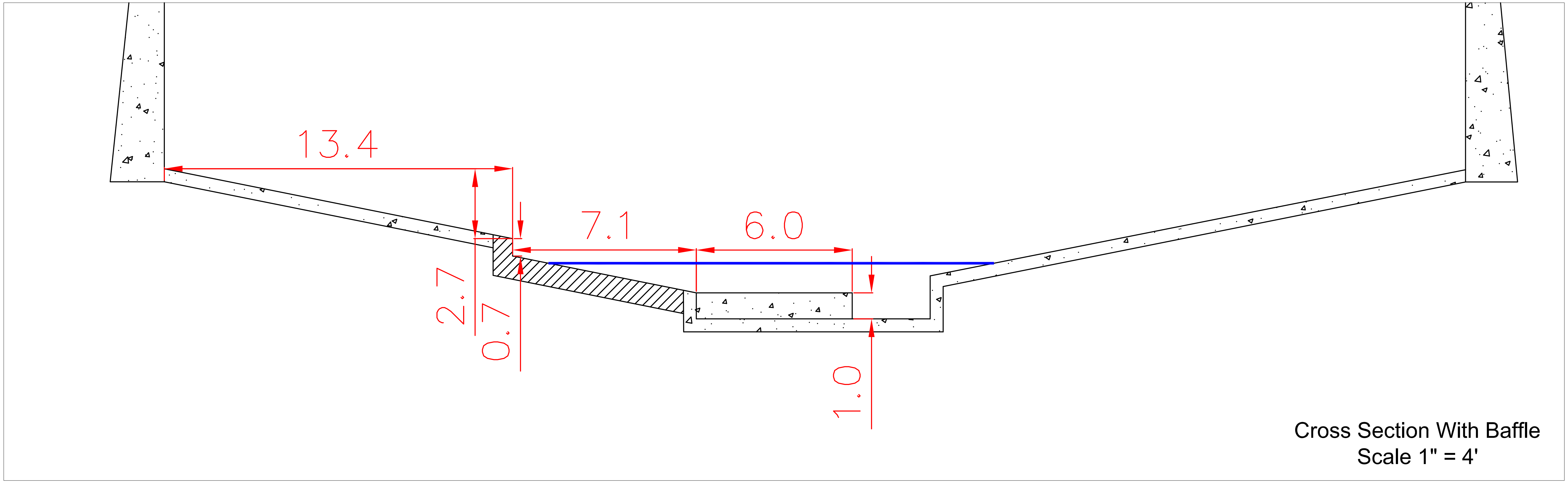
Appendix A-8: Option 2 - Baffle Isometric

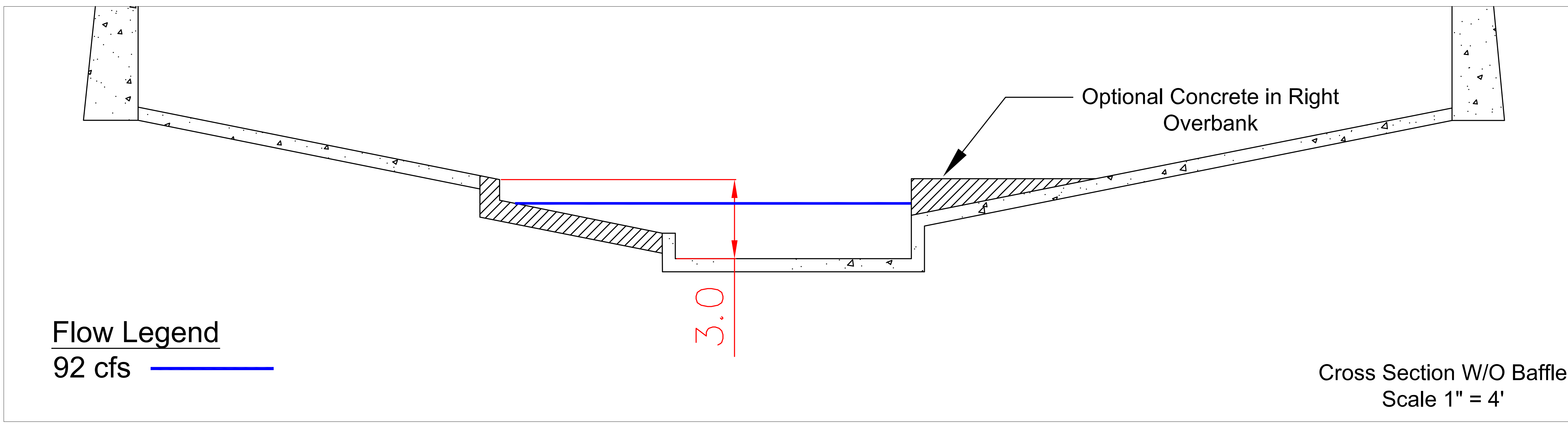


Scale 1" = 10'

Appendix A-8: Reach Type 3 - Option 2 Baffles Isometric

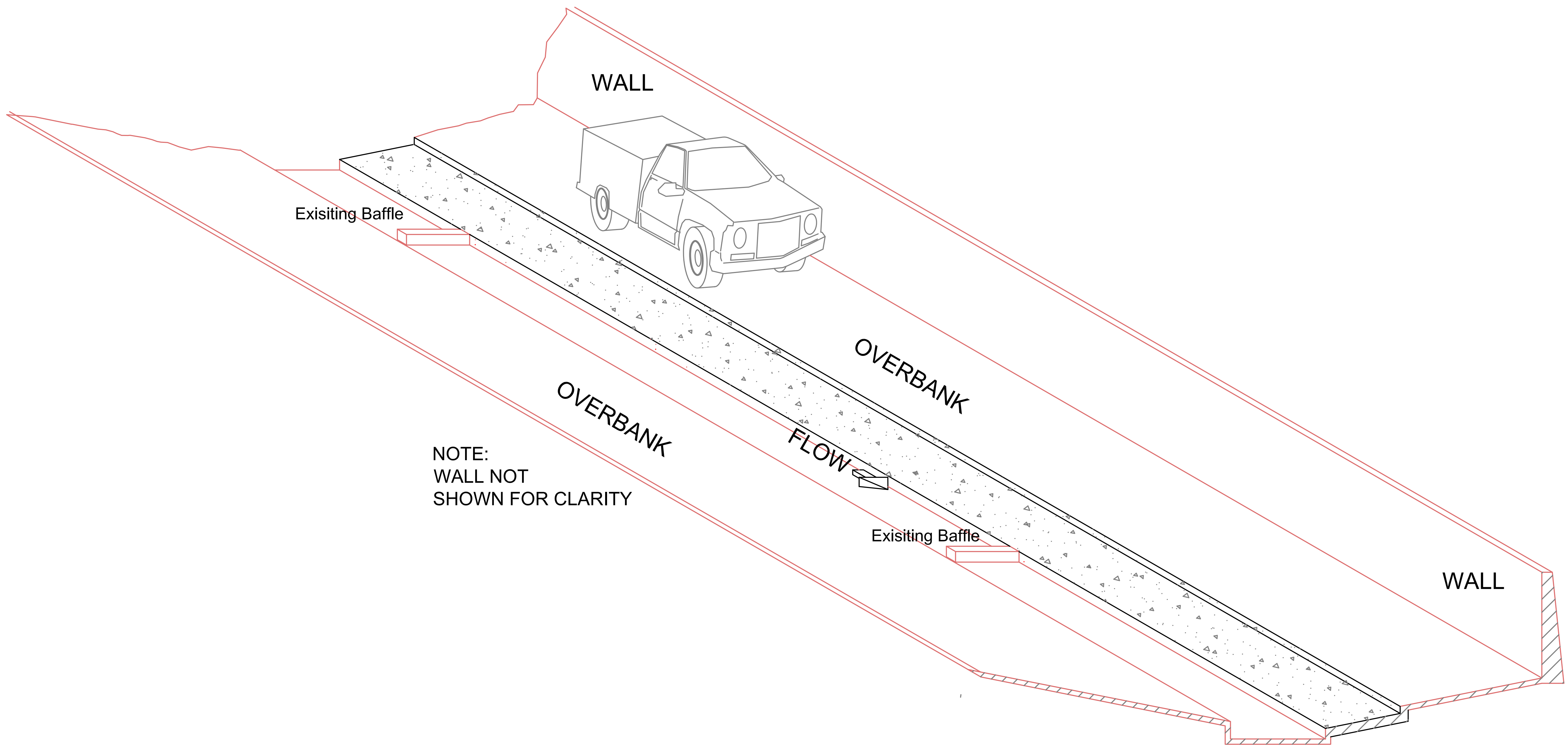
Appendix A-9: Option 2 – Lowered Section Design





Appendix A-9: Reach Type 3 - Option 2 Lowered Section Design

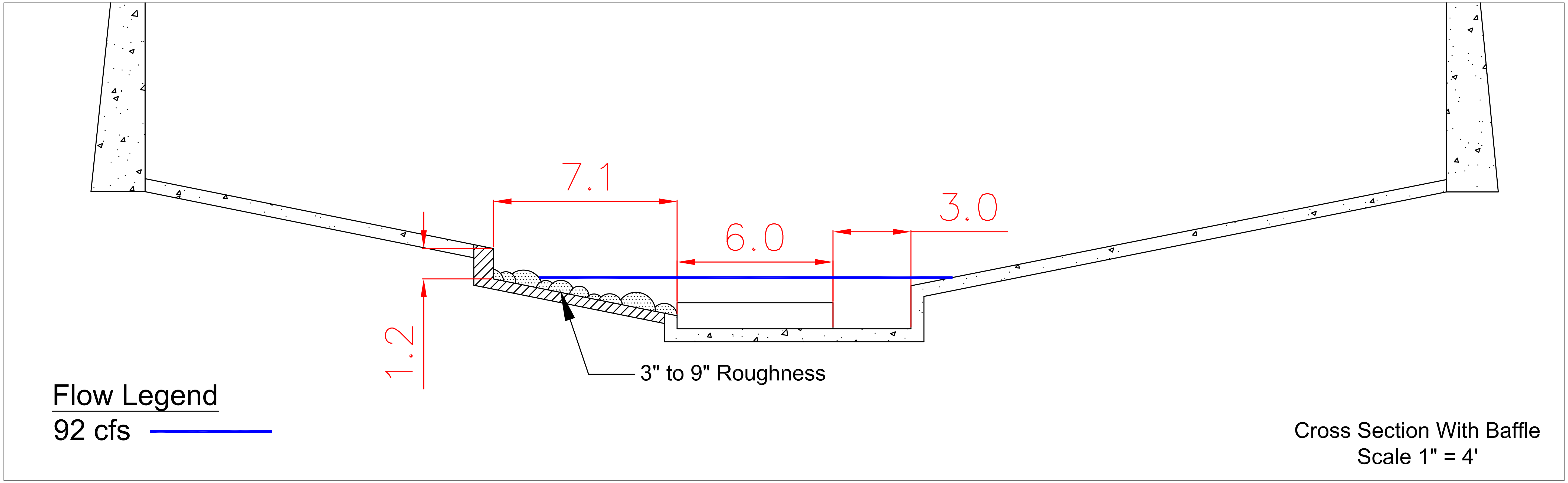
Appendix A-10: Option 2 – Lowered Section Isometric

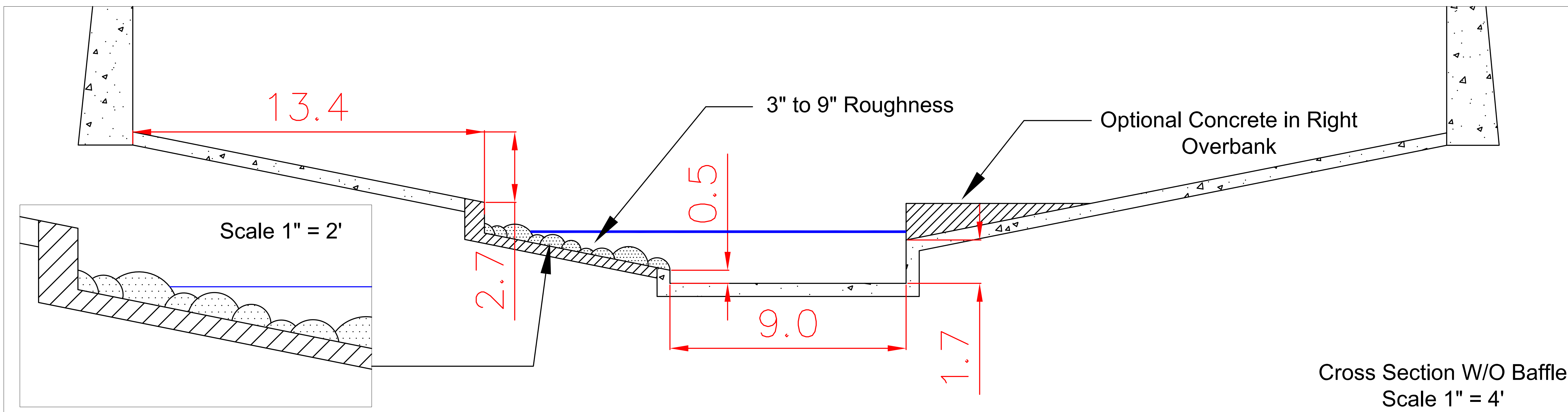


Scale 1" = 10'

Appendix A-10: Reach Type 3 - Option 2 Lowered Section Isometric

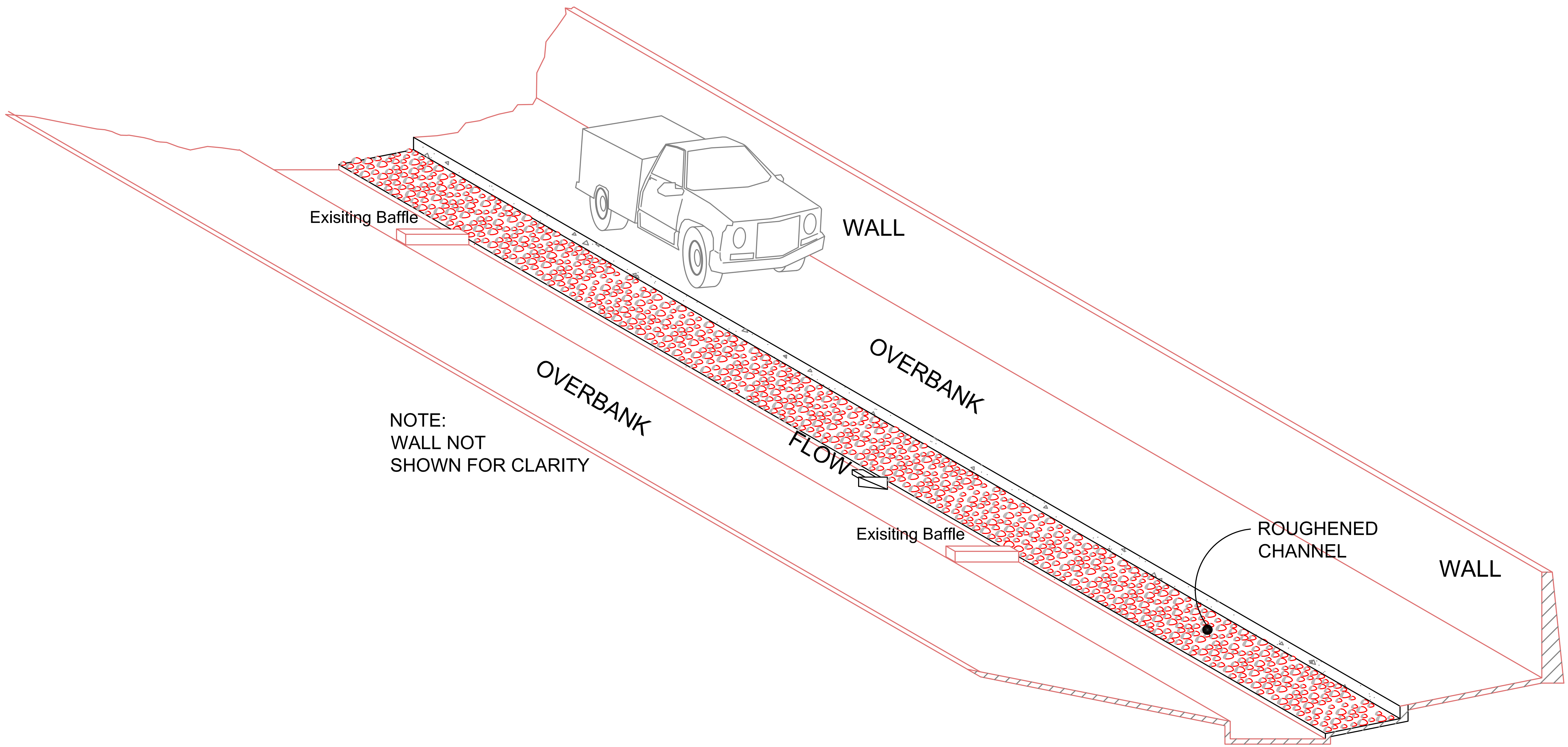
Appendix A-11: Option 2 – Roughened Channel Design





Appendix A-11: Reach Type 3 - Option 2 Roughened Channel Design

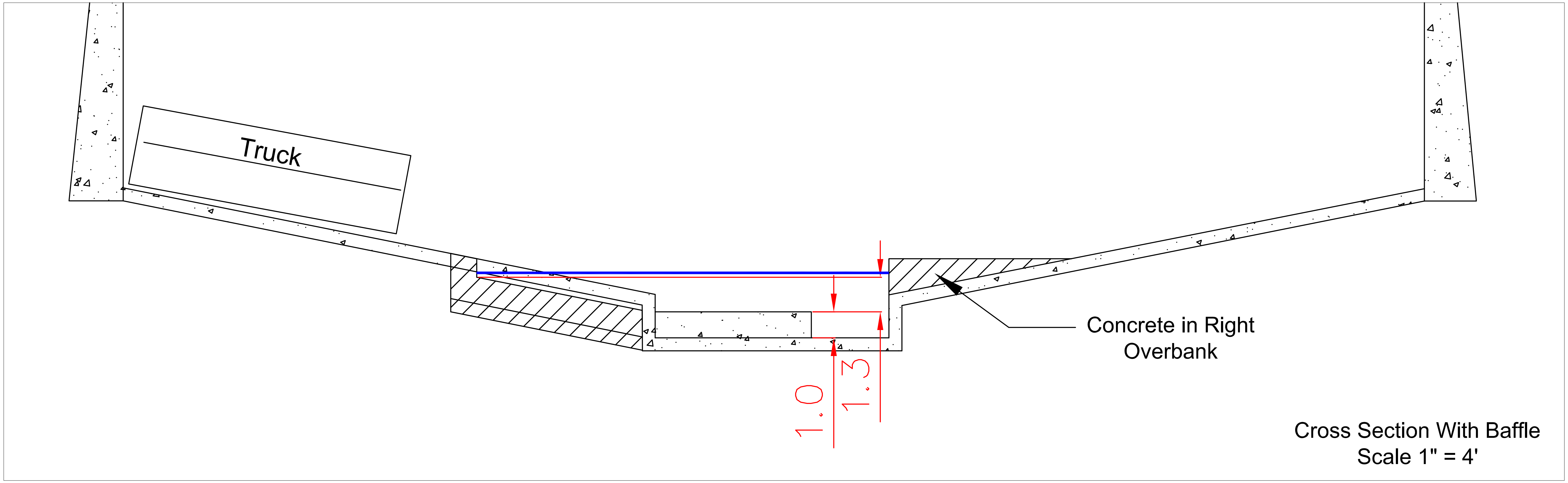
Appendix A-12: Option 2 – Roughened Channel Isometric

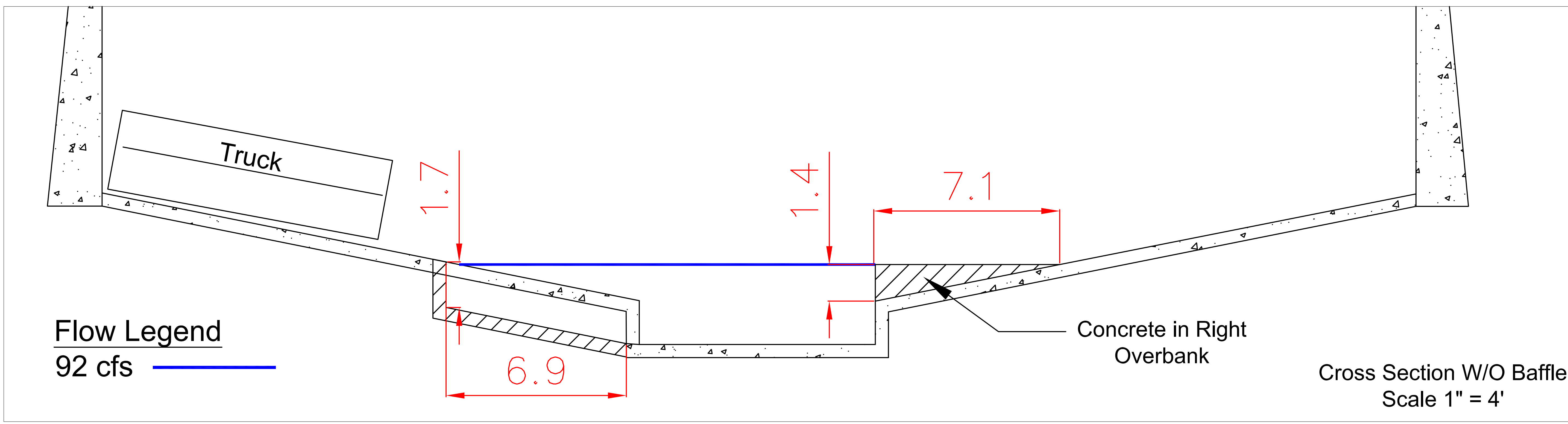


Scale 1" = 10'

Appendix A-12: Reach Type 3 - Roughened Channel Isometric

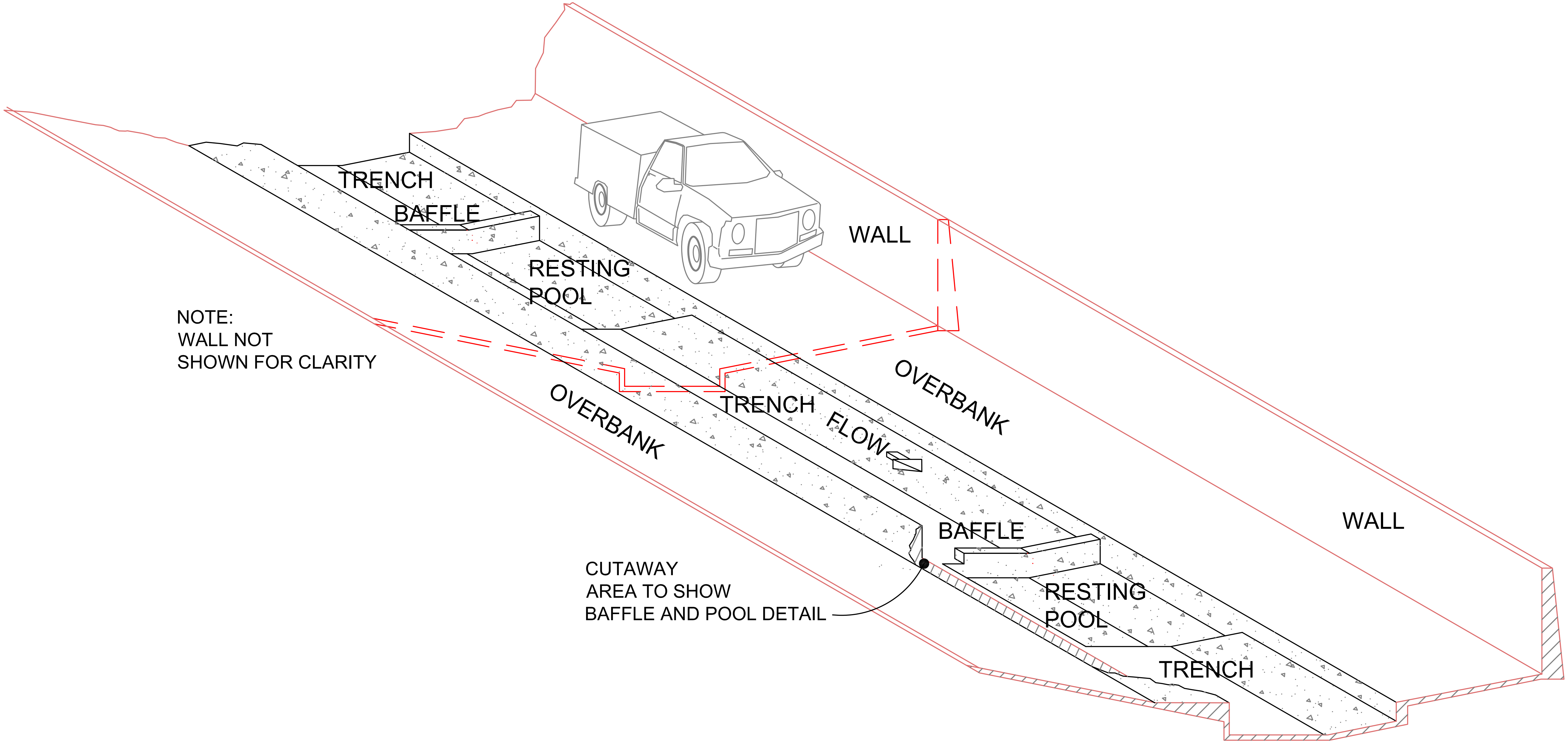
Appendix A-13: Option 2 – High Flow Trench with Baffles Design





Appendix A-13: Reach Type 3 - Option 2 High Flow Trench With Baffles Design

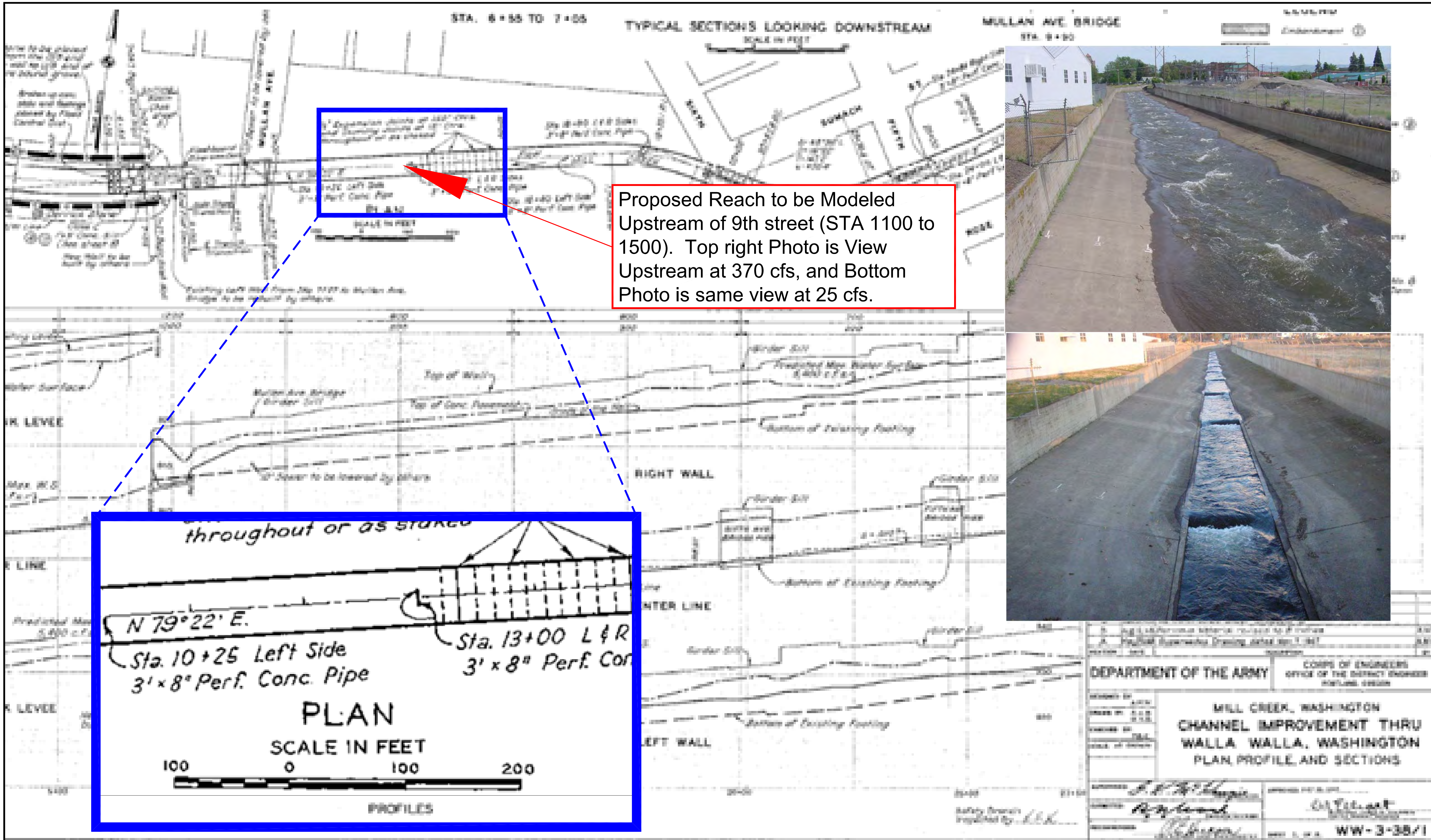
Appendix A-14: Option 2 – High Flow Trench with Baffles Isometric



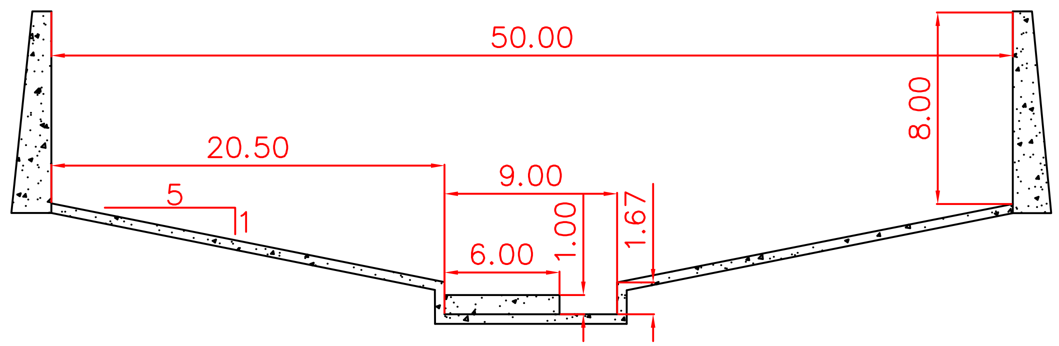
Scale 1" = 10'

Appendix A-14: Reach Type 3 - Option 2 High Flow Trench with Baffles Isometric

Appendix A-15: Selected Reach Type 3 Conceptual Design (5 Sheets)



Appendix A-15: Reach Type 3 Conceptual Design (Sheet 1 of 5)

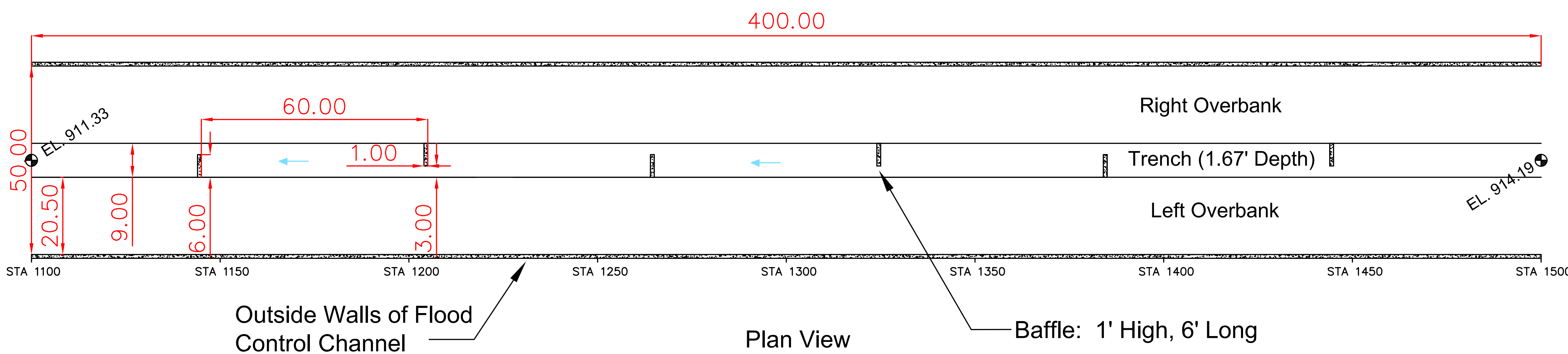


Typical Section
Scale 1" = 10'

Legend

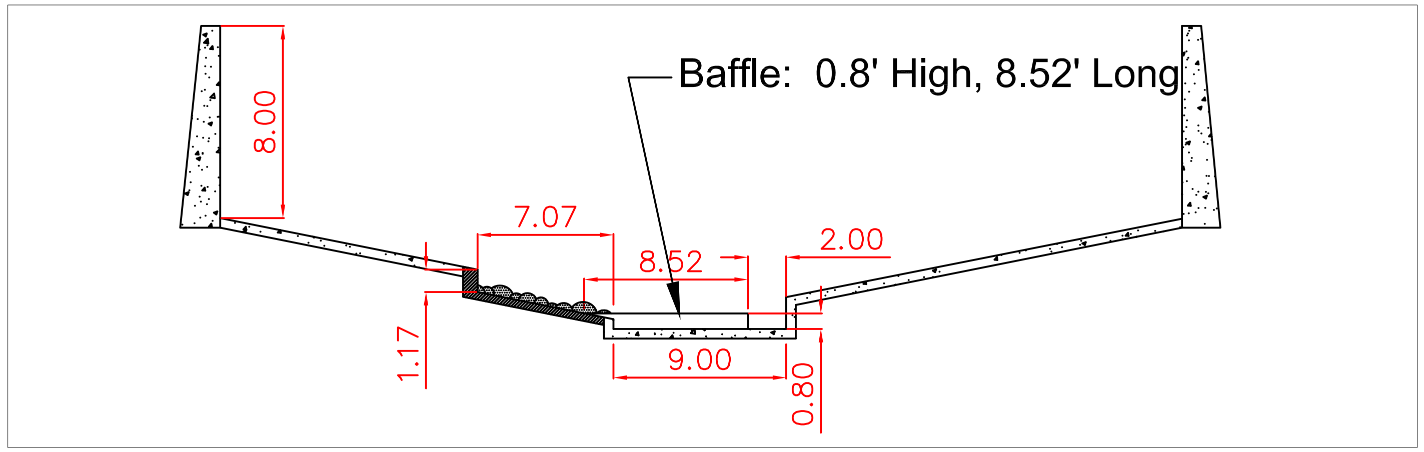
Existing Concrete

17.0 Dimensions in Feet

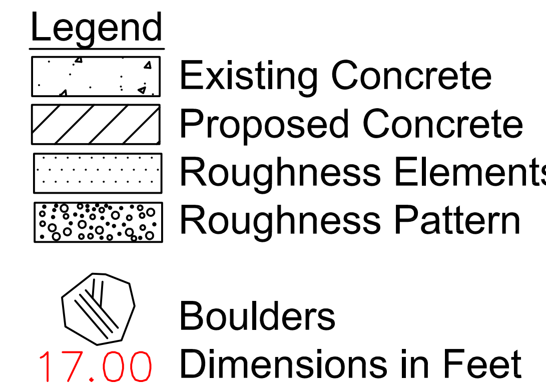


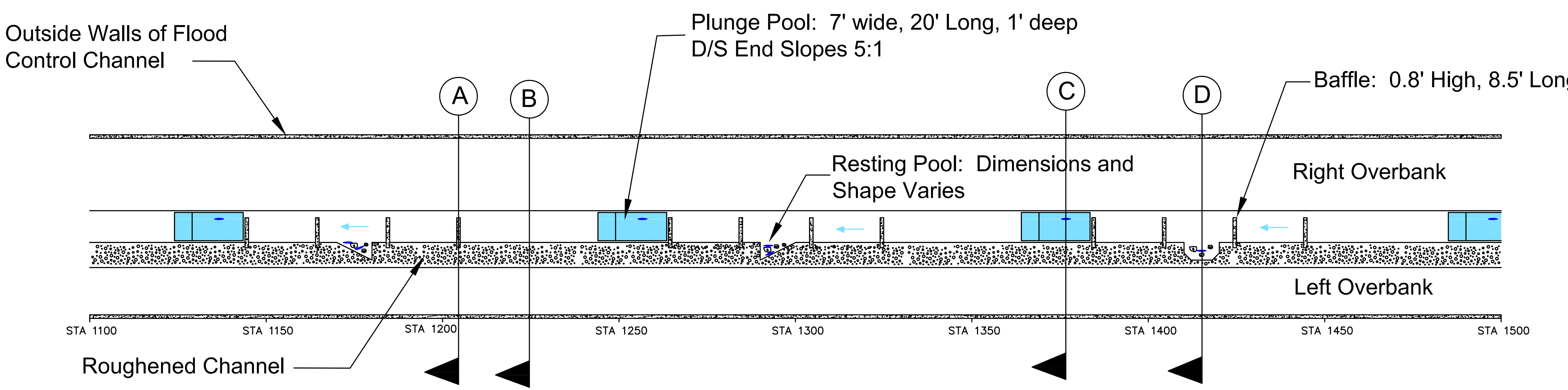
Plan View
Scale 1" = 30'

Appendix A-15: Reach Type 3 Conceptual Design (Sheet 2 of 5)



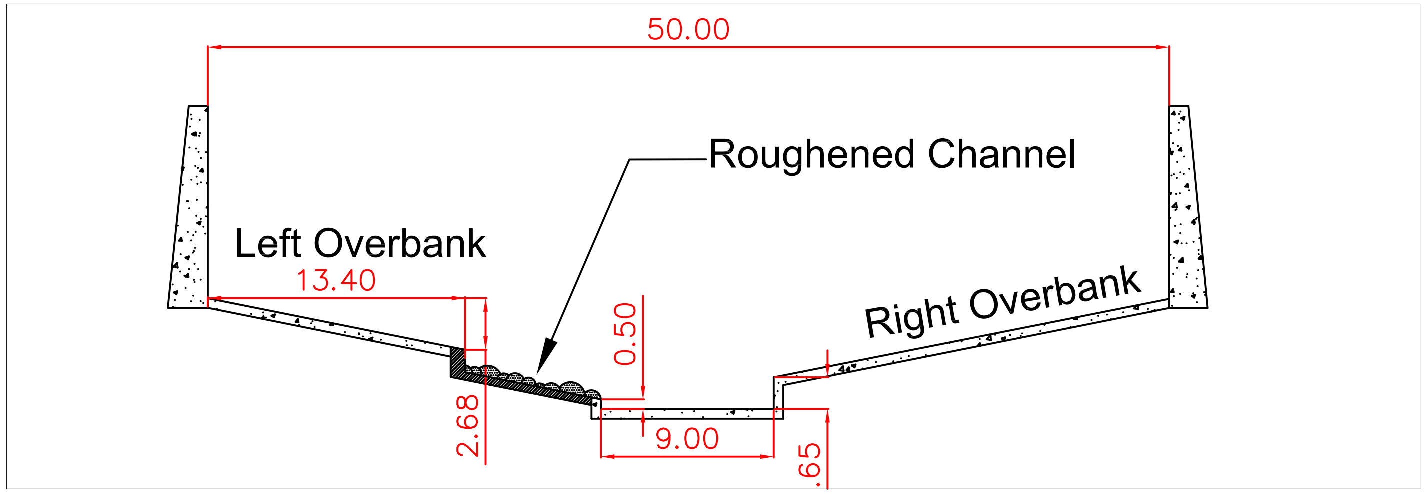
Section A
Scale 1" = 10'



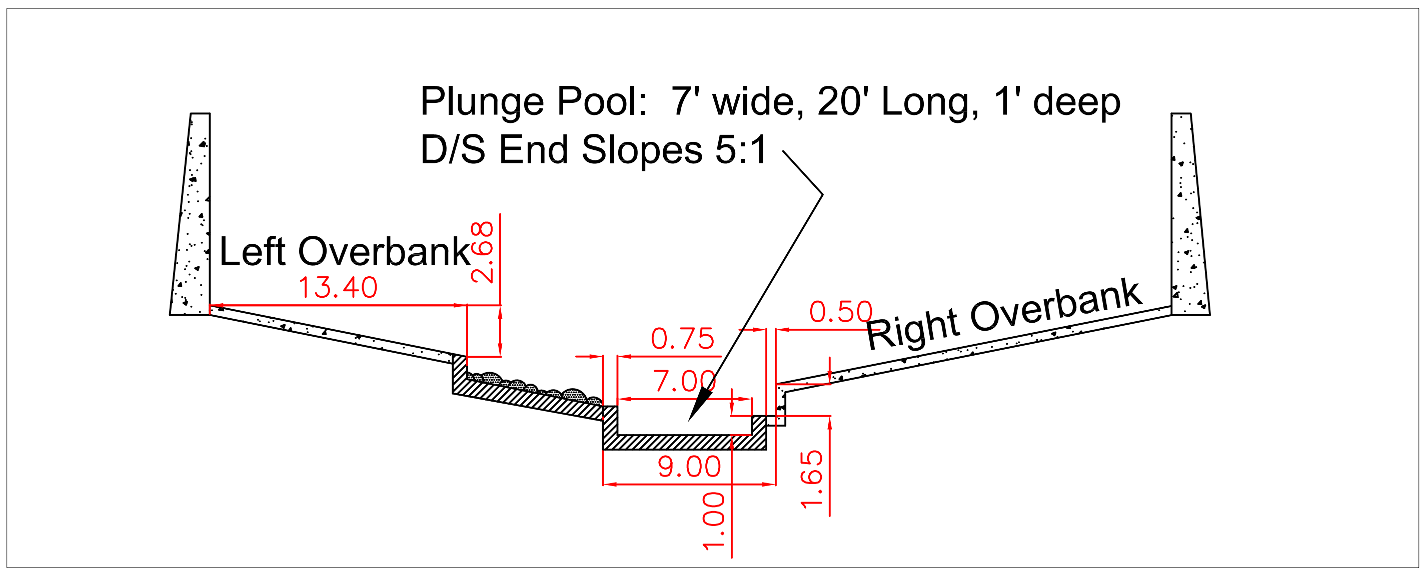


Plan View
Scale 1" = 30'

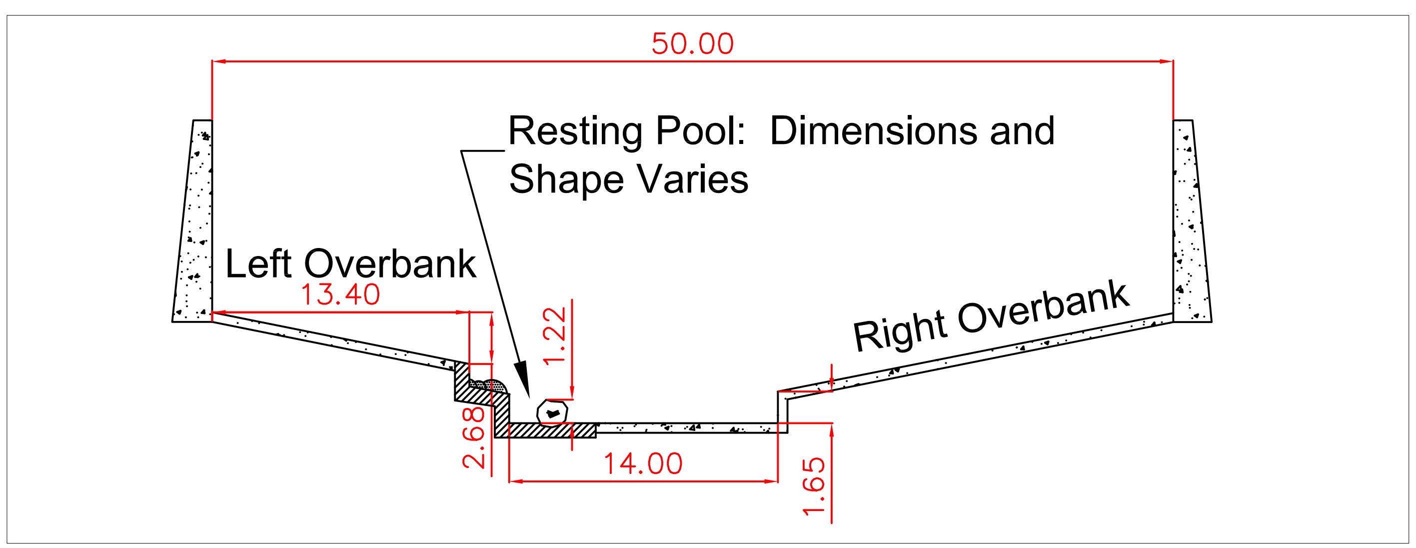
Appendix A-15: Reach Type 3 Conceptual Design (Sheet 3 of 5)



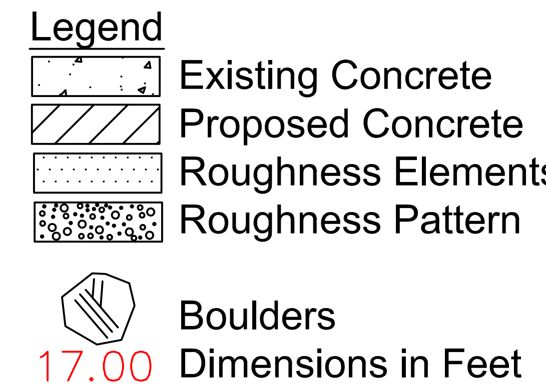
Section B
Scale 1" = 10'



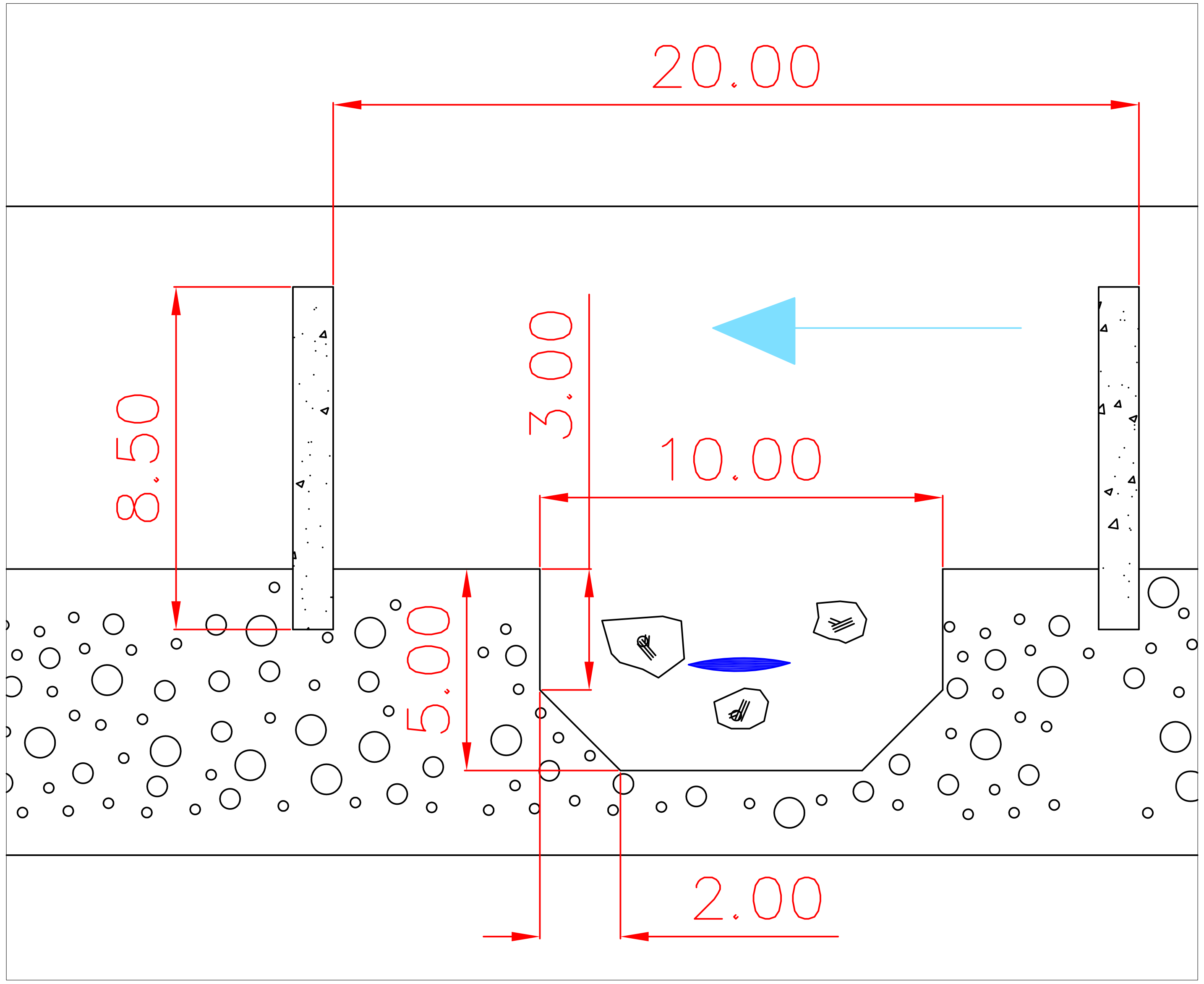
Section C
Scale 1" = 10'



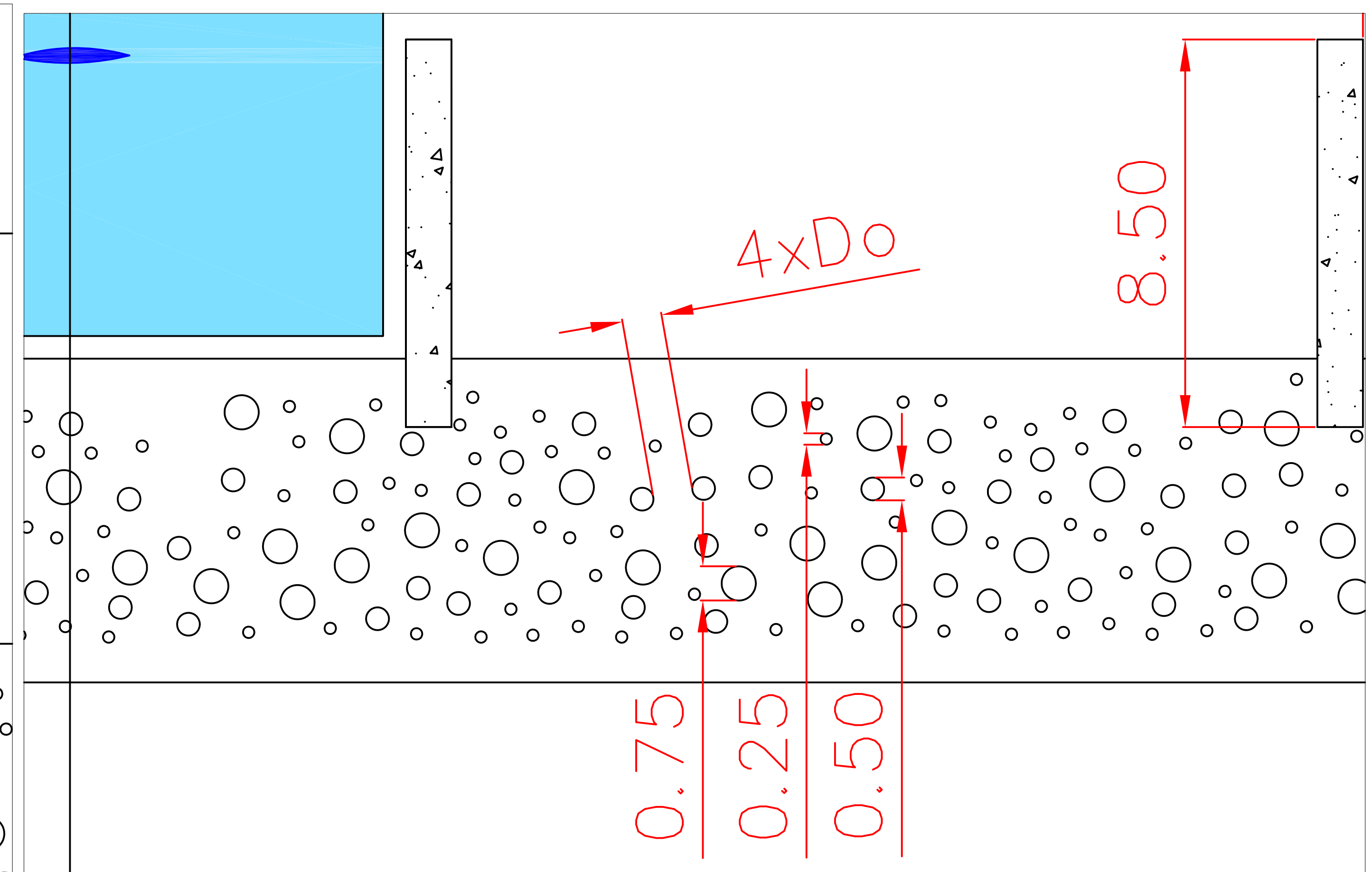
Section D
Scale 1" = 10'



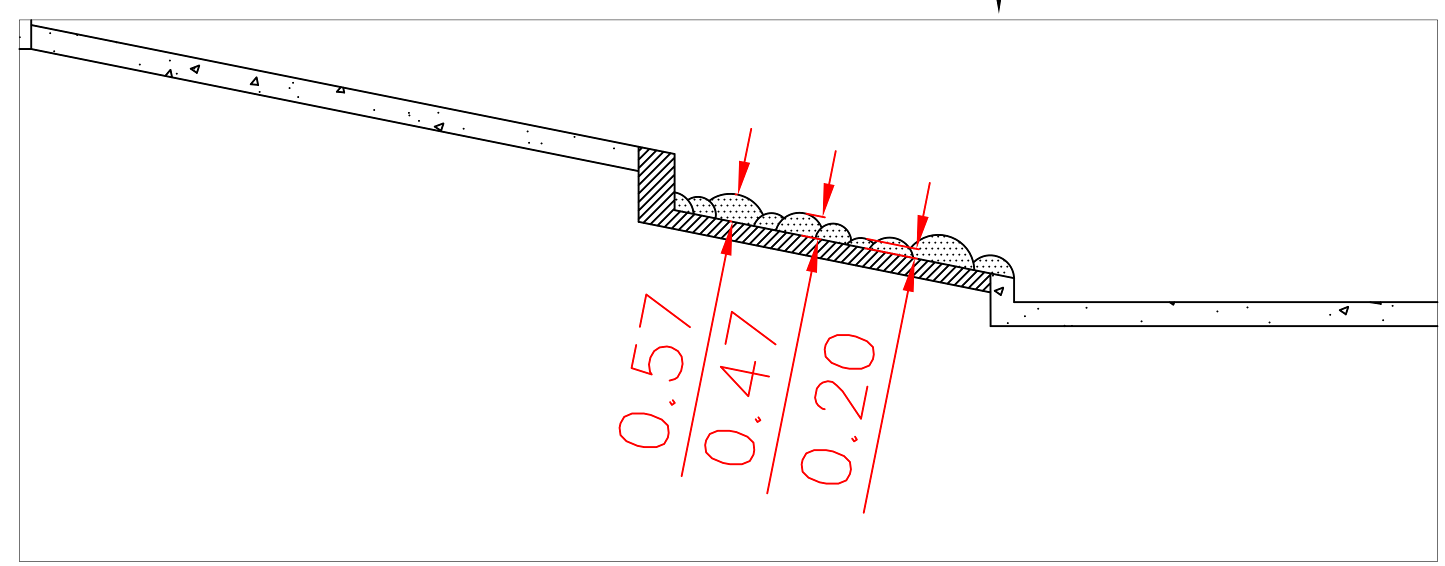
Appendix A-15: Reach Type 3 Conceptual Design (Sheet 4 of 5)



Resting Pool
Scale 1" = 4'



Roughness Size and Spacing
Scale 1" = 4'

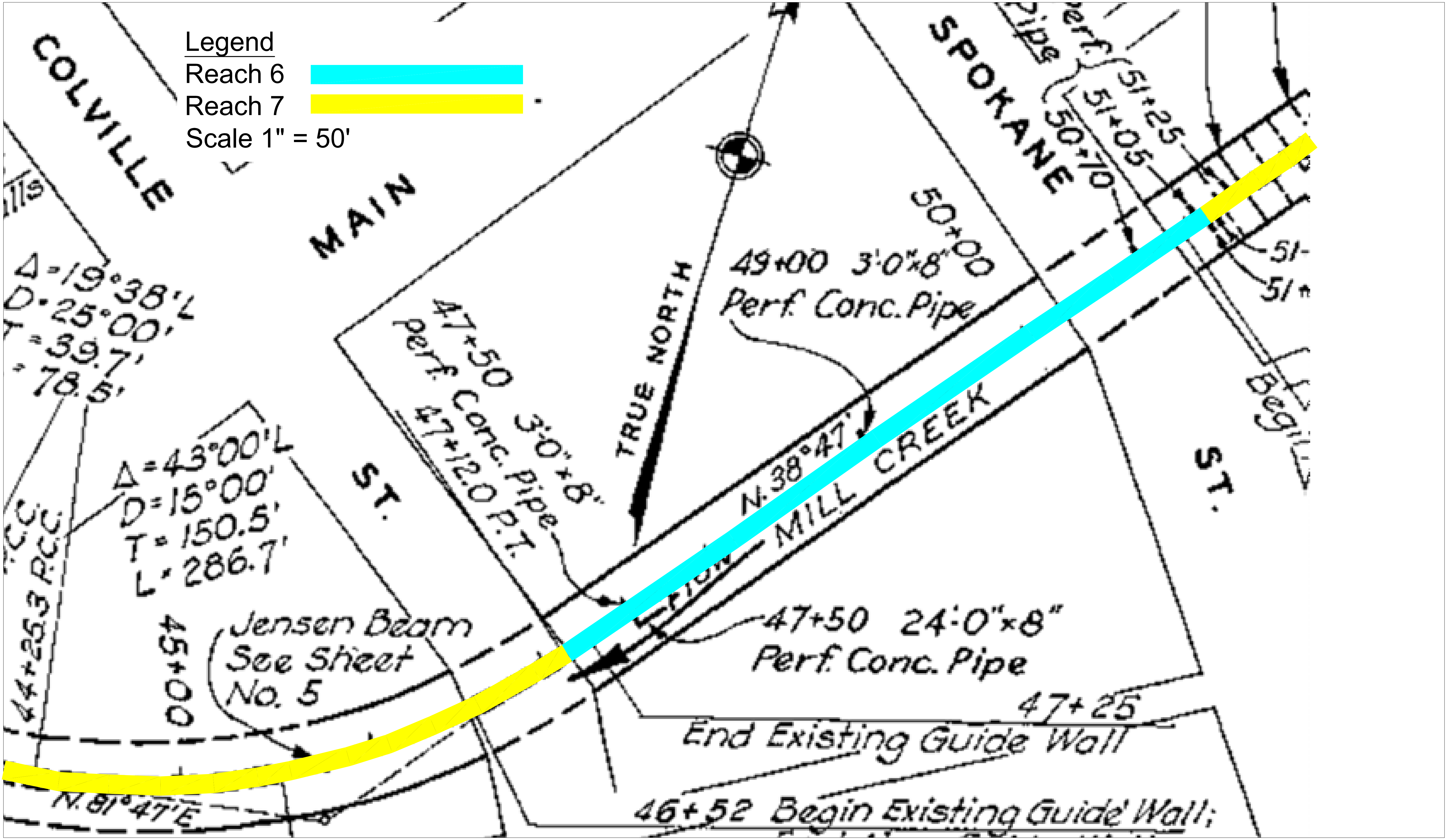


Legend
- Existing Concrete
- Proposed Concrete
- Roughness Elements
- Roughness Pattern
- Boulders
- 17.00 Dimensions in Feet

Appendix A-15: Reach Type 3 Conceptual Design (Sheet 5 of 5)

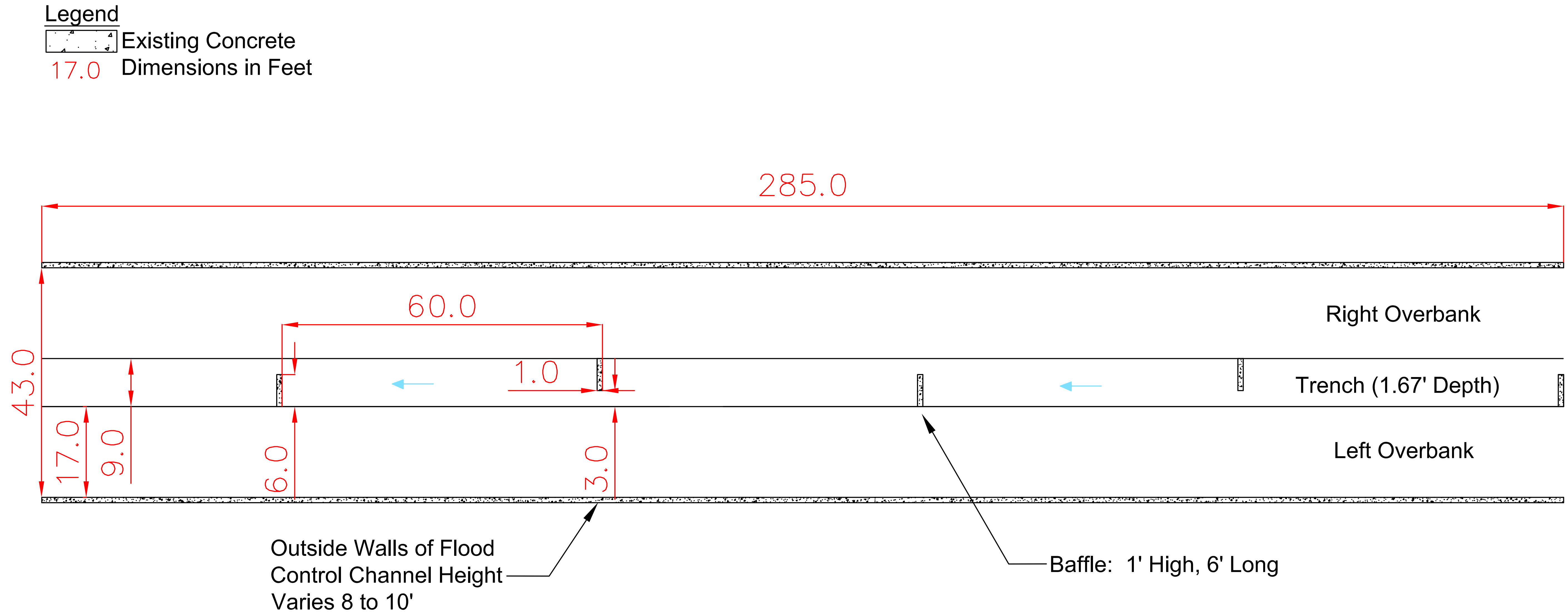
Appendix B: Reach Type 6 Conceptual Designs

Appendix B-1: Reach Type 6 Location – 1948 CORP Drawings



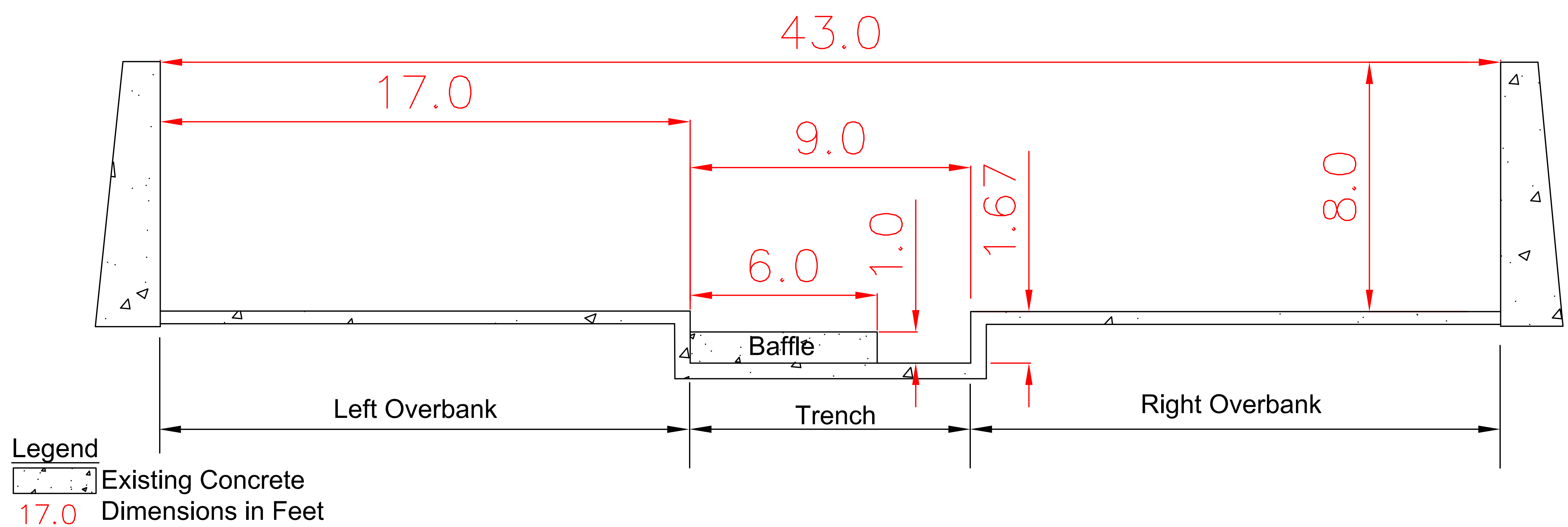
Appendix B-1: Reach Type 6 Location on 1948 CORP Drawing

Appendix B-2: Existing (3 Sheets) – Plan, Sections, Passage Analysis and Hydraulics

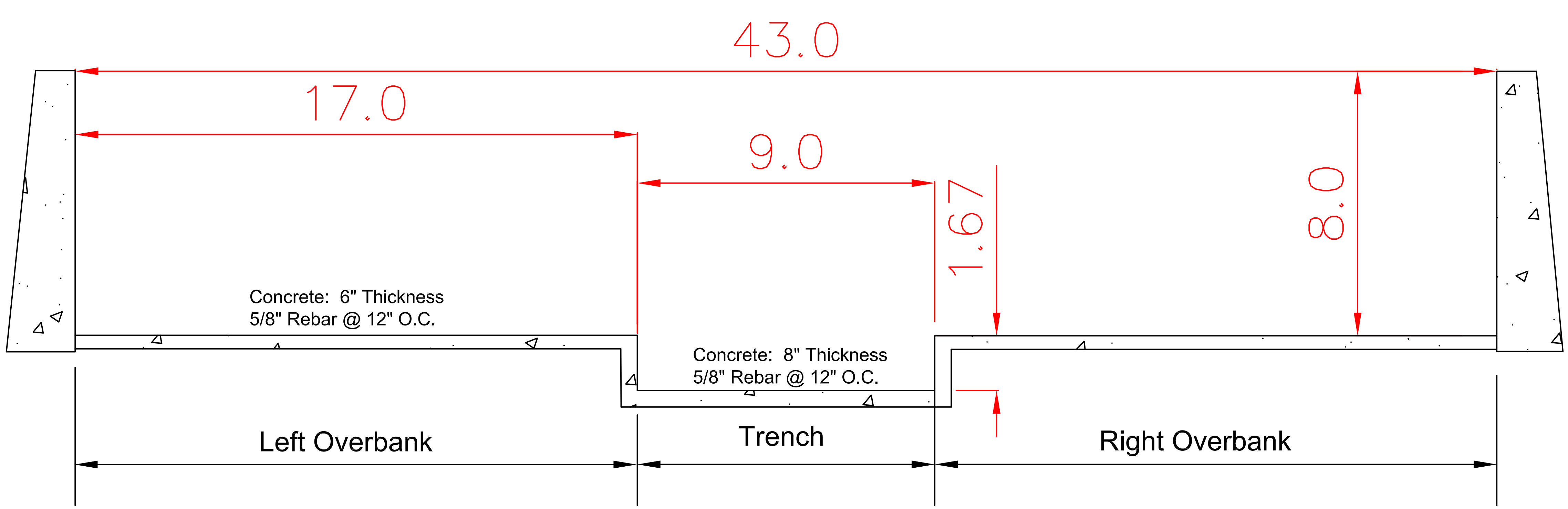


Plan View
Scale 1" = 20'

Appendix B-2: Reach Type 6 Existing - Sheet 1 of 3



Section With Baffle
Scale 1" = 4'

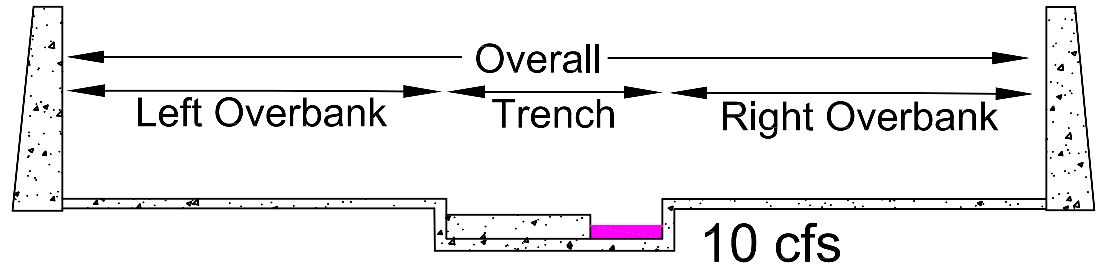


Section Without Baffle
Scale 1" = 4'

Appendix B-2: Reach Type 6 Existing - Sheet 2 of 3

Passage Analysis (Trench)

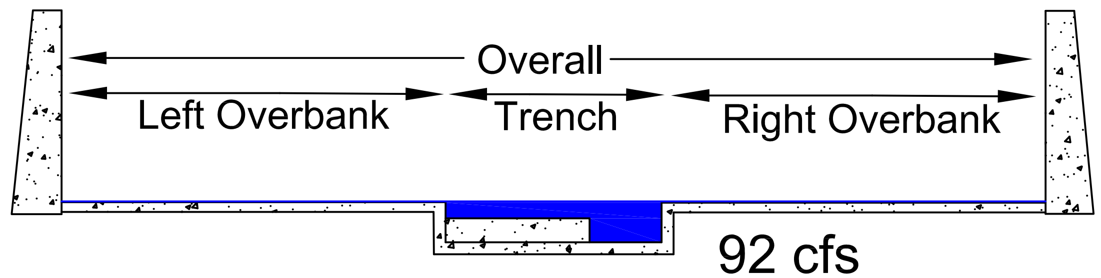
Species	Size (in)	10 cfs
Steelhead	22	120 feet, rest to pass
	30	40 ft, fail, depth
Chinook	24	120 feet, rest to pass
	29	40 ft, fail, depth
Bull Trout	7	60 ft, fail
	17	80 feet, rest to pass



	TRENCH	
	Velocity	Depth
Average	3.25	0.64
Max	6.92	0.94
Min	1.19	0.16

Passage Analysis (Trench)

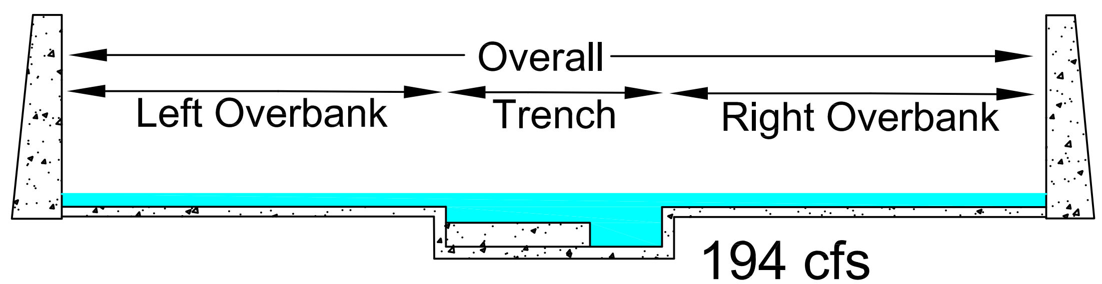
Species	Size (in)	92 cfs
Steelhead	22	80 ft, fail
	30	30 ft, fail
Chinook	24	80 ft, fail
	29	30 ft, fail
Bull Trout	7	20 ft, fail
	17	45 ft, fail



	LEFT OVERBANK		TRENCH		RIGHT OVERBANK		OVERALL
	Velocity	Depth	Velocity	Depth	Velocity	Depth	Velocity
Average	2.19	0.16	6.21	1.67	2.19	0.16	5.74
Max	2.55	0.40	8.02	2.07	2.55	0.40	8.02
Min	1.53	0.00	3.98	1.27	1.53	0.00	3.03

Passage Analysis (Trench)

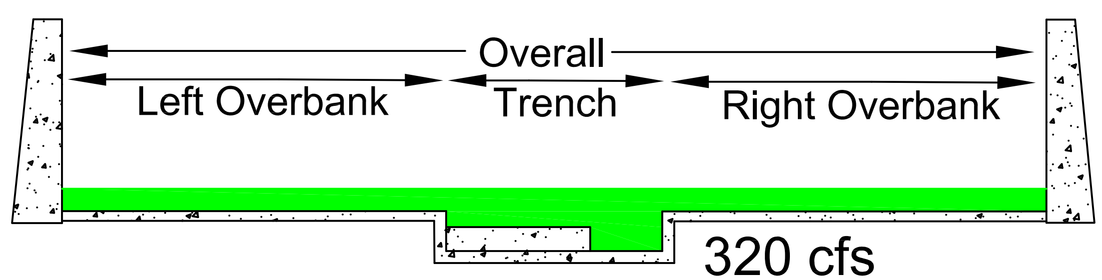
Species	Size (in)	194 cfs
Steelhead	22	80 ft, fail
	30	30 ft, fail
Chinook	24	80 ft, fail
	29	30 ft, fail
Bull Trout	7	20 ft, fail
	17	45 ft, fail



	LEFT OVERBANK		TRENCH		RIGHT OVERBANK		OVERALL
	Velocity	Depth	Velocity	Depth	Velocity	Depth	Velocity
Average	3.56	0.53	7.24	2.20	3.56	0.53	5.55
Max	4.36	0.74	7.90	2.41	4.36	0.74	5.98
Min	3.30	0.43	6.11	2.10	3.30	0.43	4.92

Passage Analysis (Left Overbank)

Species	Size (in)	320 cfs
Steelhead	22	60 ft, fail
	30	120 ft, fail
Chinook	24	80 ft, fail
	29	105 ft, fail
Bull Trout	7	
	17	

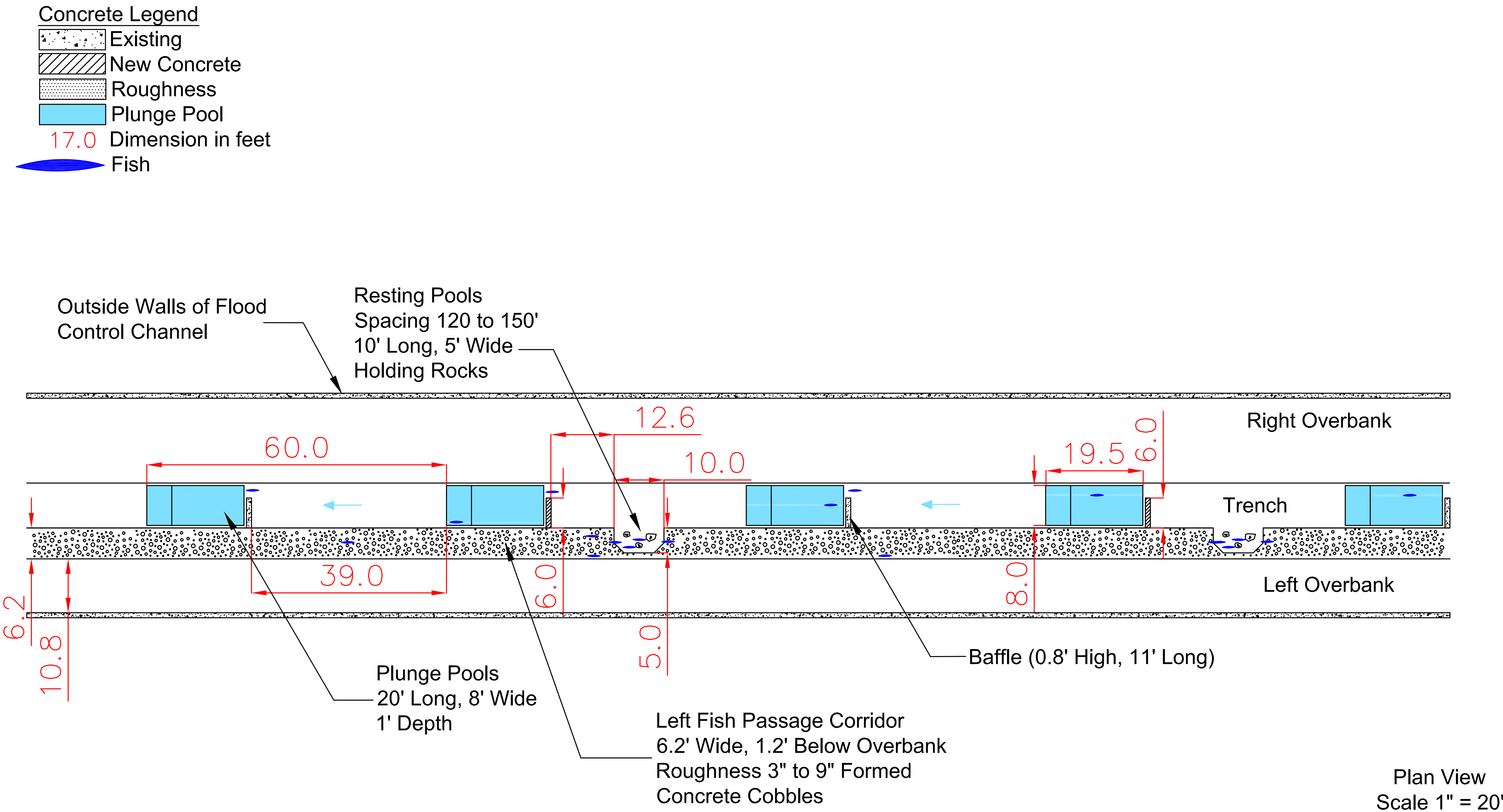


	LEFT OVERBANK		TRENCH		RIGHT OVERBANK		OVERALL
	Velocity	Depth	Velocity	Depth	Velocity	Depth	Velocity
Average	5.16	0.85	8.49	2.69	5.16	0.85	6.65
Max	5.81	1.00	8.94	3.97	5.81	1.00	6.83
Min	4.91	0.78	7.67	2.45	4.91	0.78	6.42

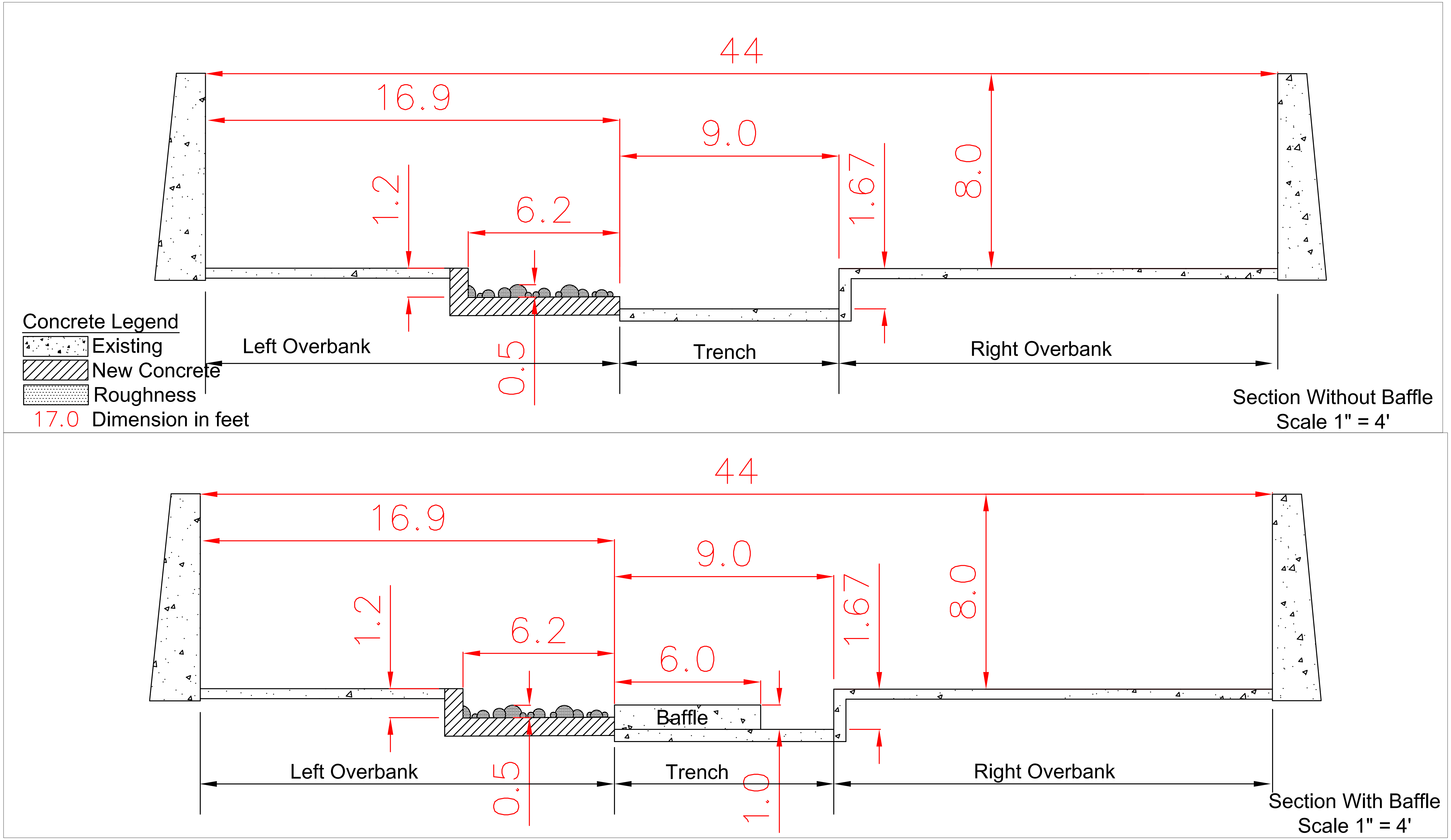
Flow Legend
- 10 cfs
- 92 cfs
- 194 cfs
- 320 cfs

Appendix B-2: Reach Type 6 Existing - Sheet 3 of 3

Appendix B-3: Roughened Channel (3 Sheets) - Plan, Sections, Passage Analysis and Hydraulics



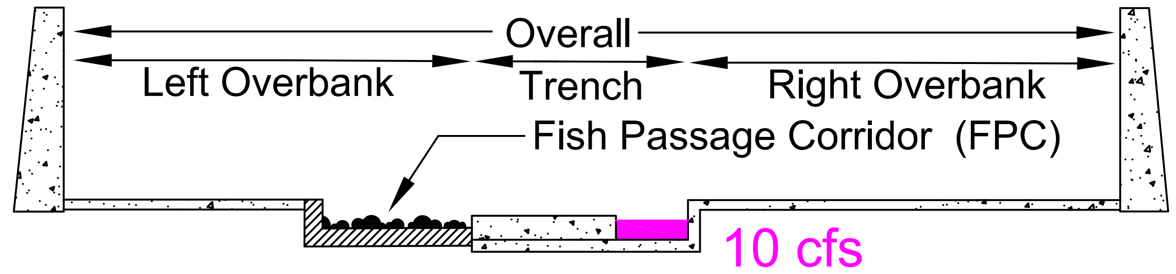
Appendix B-3: Reach Type 6 Roughened Channel - Sheet 1 of 3



Appendix B-3: Reach Type 6 Roughened Channel - Sheet 2 of 3

Passage Analysis (Trench)

Species	Size (in)	10 cfs
Steelhead	22	1000 ft, rest to pass
	30	1100 ft, rest to pass
Chinook	24	1060 ft, rest to pass
	29	1124 ft, rest to pass
Bull Trout	7	150 ft, rest to pass
	17	240 ft, rest to pass

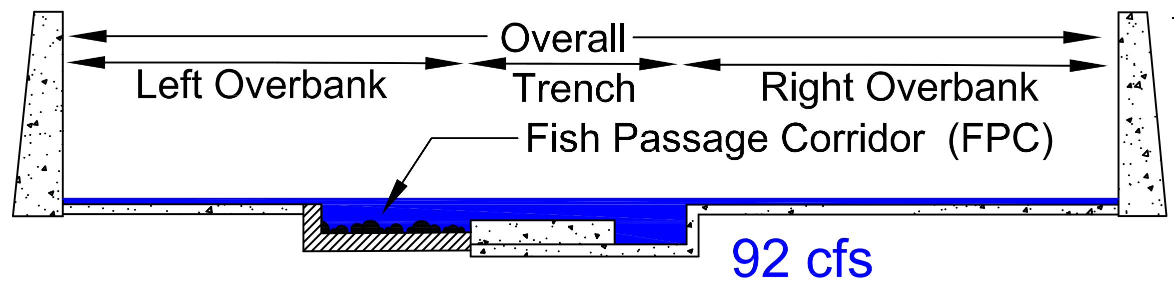


Hydraulics

	TRENCH	
	Velocity	Depth
Average	1.84	1.04
Max	3.99	1.62
Min	0.68	0.57

Passage Analysis (Left Overbank)

Species	Size (in)	92 cfs
Steelhead	22	580 ft, rest to pass
	30	640 ft, rest to pass
Chinook	24	610 ft, rest to pass
	29	700 ft, rest to pass
Bull Trout	7	95 ft, fail
	17	165 ft, rest to pass

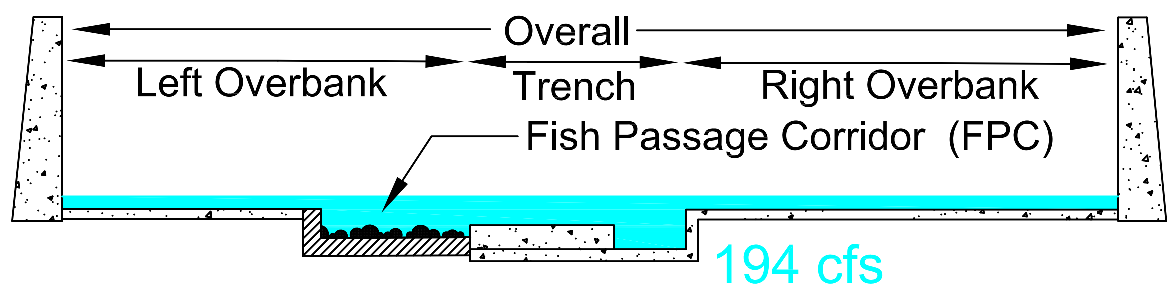


Hydraulics

	LEFT OVERBANK		TRENCH		RIGHT OVERBANK		OVERAL
	Velocity	Depth	Velocity	Depth	Velocity	Depth	Velocity
Ave	2.46	1.27	4.06	2.20	0.84	0.09	3.40
Max	3.75	1.49	5.03	2.82	1.49	0.29	4.22
Min	1.44	1.15	3.07	1.65	0.09	0.00	2.52

Passage Analysis (Left Overbank)

Species	Size (in)	194 cfs
Steelhead	22	400 ft, fail
	30	280 ft, rest to pass
Chinook	24	440 ft, fail
	29	280 ft, rest to pass
Bull Trout	7	60 ft, fail
	17	140 ft, fail

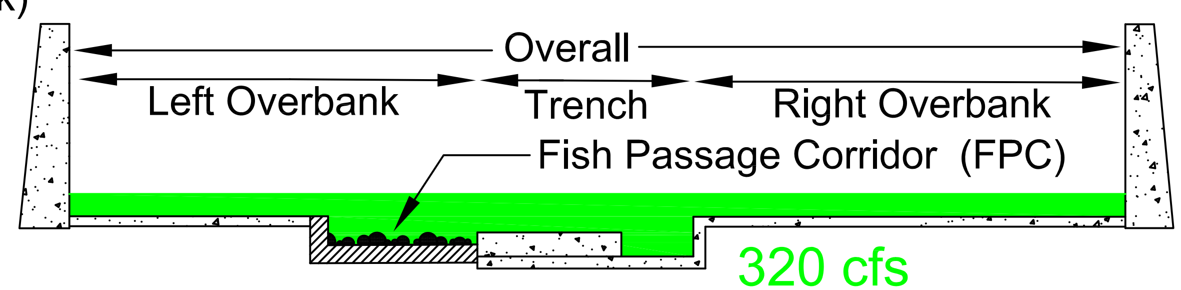


Hydraulics

	LEFT OVERBANK		TRENCH		RIGHT OVERBANK		OVERALL
	Velocity	Depth	Velocity	Depth	Velocity	Depth	Velocity
Ave	3.33	1.74	5.60	2.66	2.54	0.54	4.27
Max	4.53	1.82	7.49	3.32	3.60	0.62	5.66
Min	2.33	1.49	4.53	1.99	1.82	0.29	3.40

Passage Analysis (Left Overbank)

Species	Size (in)	320 cfs
Steelhead	22	120 ft, fail
	30	180 ft, fail
Chinook	24	160 ft, fail
	29	200 ft, fail



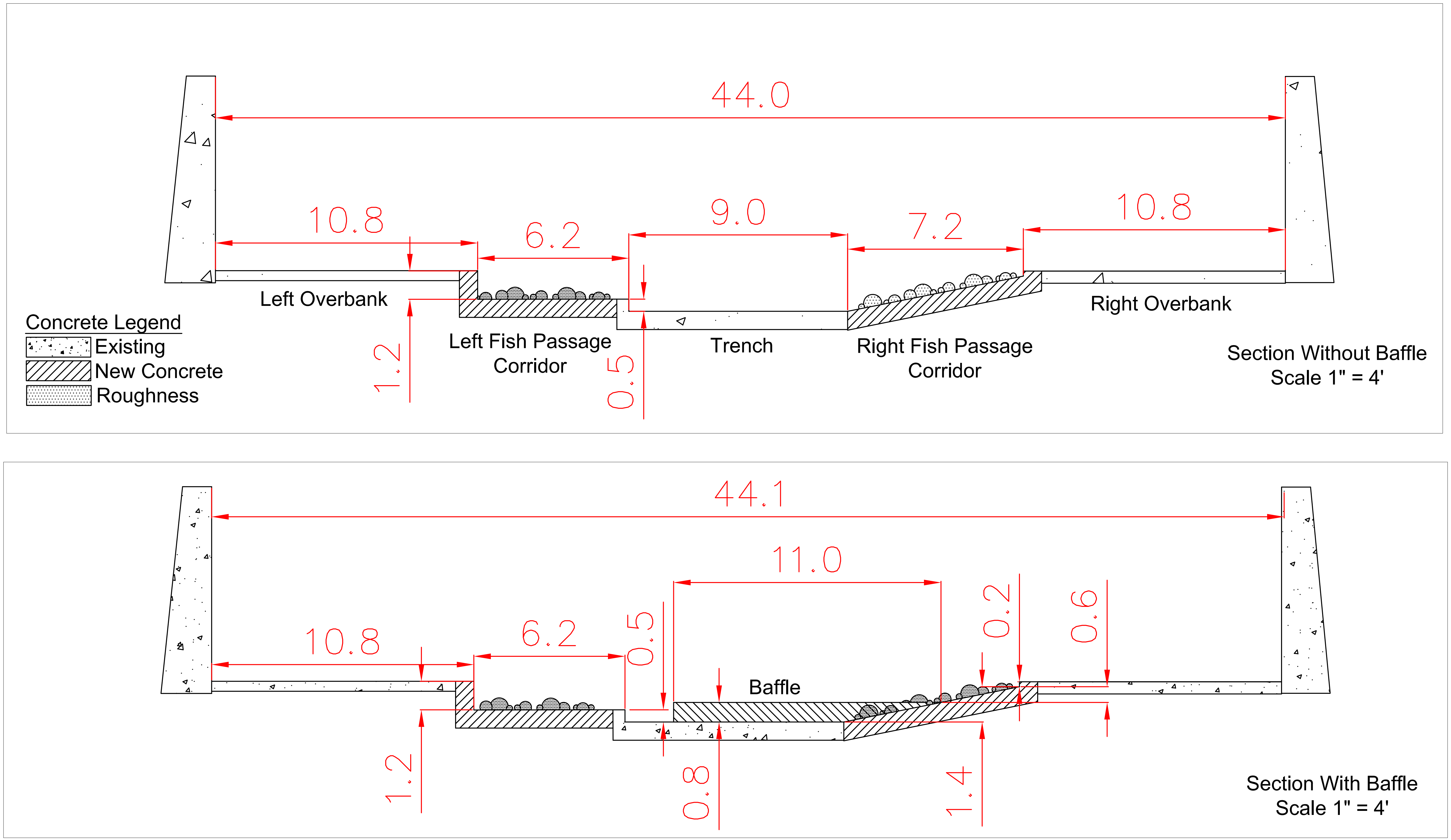
Hydraulics

	LEFT OVERBANK		TRENCH		RIGHT OVERBANK		OVERALL
	Velocity	Depth	Velocity	Depth	Velocity	Depth	Velocity
Ave	4.30	2.12	6.79	3.05	3.90	0.92	5.23
Max	5.53	2.24	8.73	3.74	5.09	1.04	6.48
Min	3.24	1.86	5.70	2.36	3.01	0.66	4.31

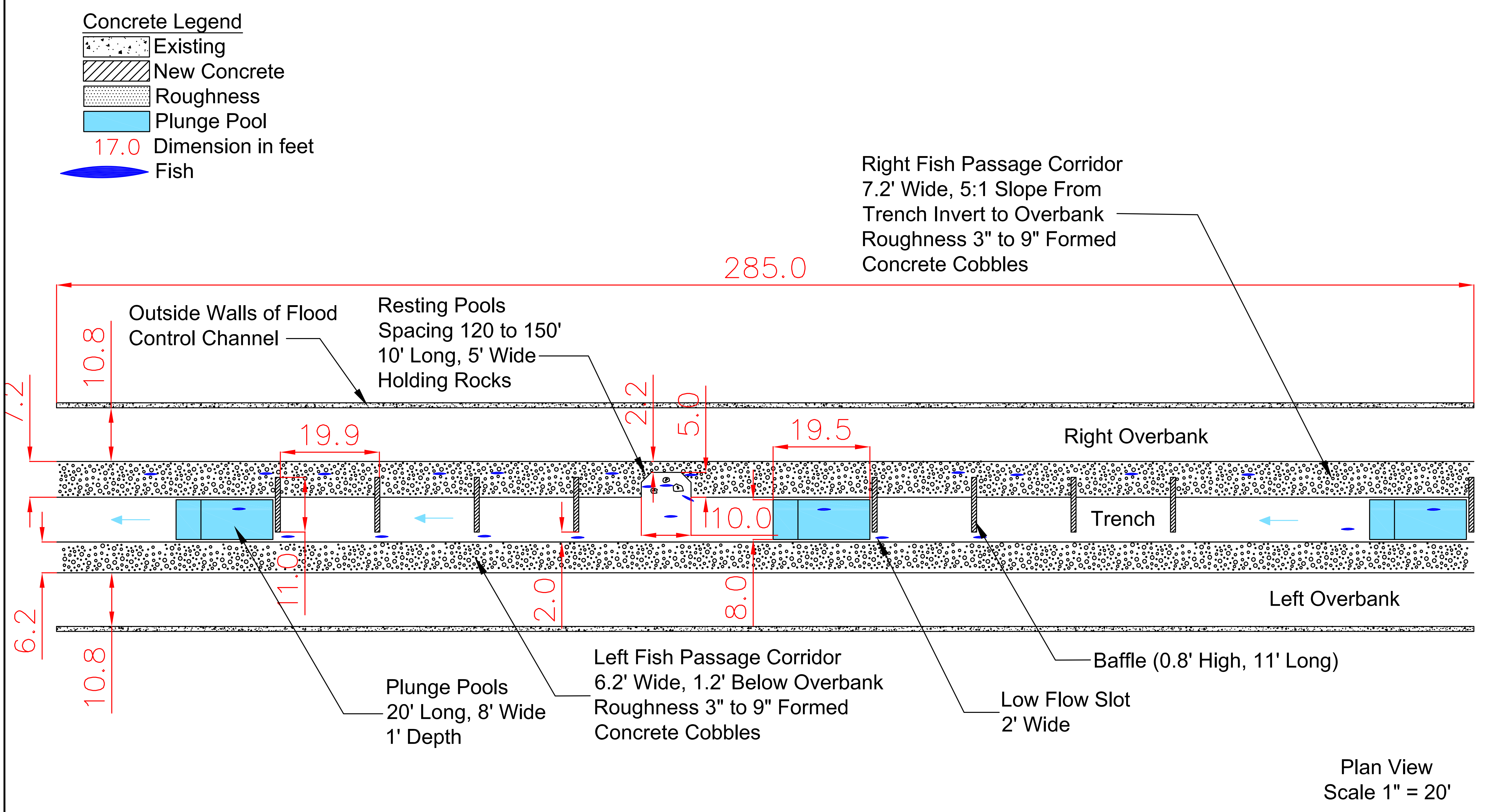
Flow Legend
- 10 cfs
- 92 cfs
- 194 cfs
- 320 cfs

Appendix B-3: Reach Type 6 Roughened Channel - Sheet 3 of 3

Appendix B-4: Roughened Channel Both Sides (3 Sheets) - Plan, Sections, Passage Analysis and Hydraulics



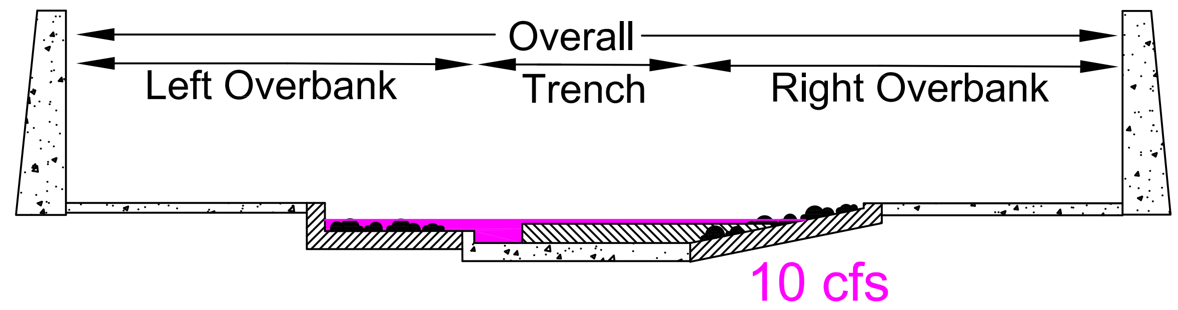
Appendix B-4: Reach Type 6 Roughened Channel - Sheet 2 of 3



Appendix B-4: Reach Type 6 Roughened Channel - Sheet 1 of 3

Passage Analysis (Trench)

Species	Size (in)	10 cfs
Steelhead	22	Passable
	30	Passable
Chinook	24	Passable
	29	Passable
Bull Trout	7	160 ft, rest to pass
	17	260 ft, rest to pass



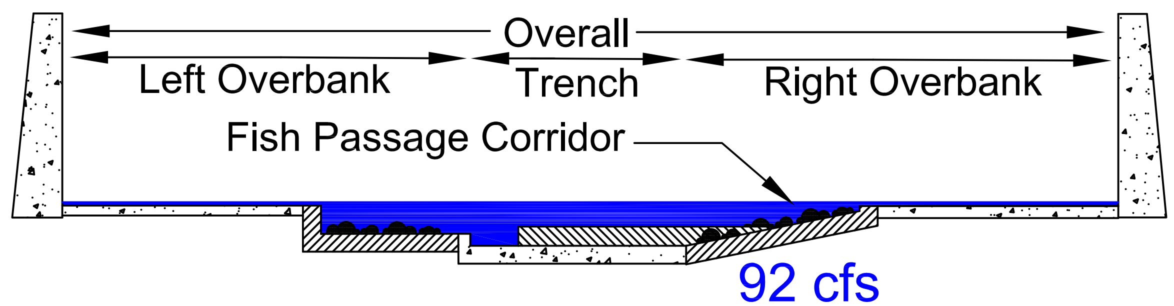
Hydraulics

	TRENCH	
	Velocity	Depth
Ave	1.80	0.96
Max	4.57	1.61
Min	0.67	0.58

Passage Analysis (Right Overbank)

Species	Size (in)	92 cfs
Steelhead	22	Passable
	30	Passable
Chinook	24	Passable
	29	Passable
Bull Trout	7	**95 ft, fail
	17	150 ft, rest to pass

**** = Passable at Vocc/Vave = 0.4**



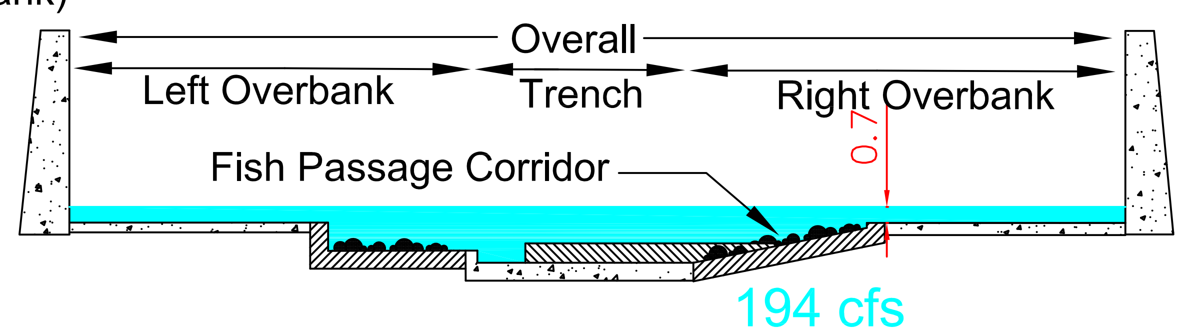
Hydraulics

	LEFT OVERBANK		TRENCH		RIGHT OVERBANK		OVERALL
	Velocity	Depth	Velocity	Depth	Velocity	Depth	Velocity
Ave	3.18	1.08	4.67	1.81	2.65	1.21	3.82
Max	4.78	1.49	5.91	2.74	3.58	1.99	5.00
Min	1.28	0.95	2.90	1.45	1.23	0.71	2.15

Passage Analysis (Right Overbank)

Species	Size (in)	194 cfs
Steelhead	22	Passable
	30	Passable
Chinook	24	Passable
	29	Passable
Bull Trout	7	**55 ft, fail
	17	215 ft, fail

**** = Passable at Vocc/Vave = 0.3**



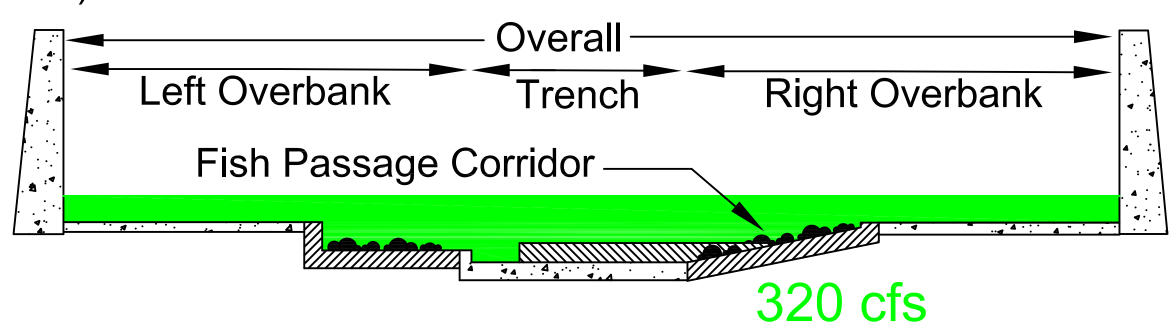
Hydraulics

	LEFT OVERBANK		TRENCH		RIGHT OVERBANK		OVERALL
	Velocity	Depth	Velocity	Depth	Velocity	Depth	Velocity
Ave	3.39	1.59	5.90	2.32	3.16	1.72	4.32
Max	4.29	1.64	6.69	3.13	3.83	2.14	4.84
Min	2.09	1.45	4.70	1.95	2.08	1.30	3.36

Passage Analysis (Right Overbank)

Species	Size (in)	320 cfs
Steelhead	22	***160 ft, fail
	30	215 ft, fail
Chinook	24	175 ft, fail
	29	215 ft, fail

***** Passable at Vocc/Vave = 0.7**



Hydraulics

	LEFT OVERBANK		TRENCH		RIGHT OVERBANK		OVERALL
	Velocity	Depth	Velocity	Depth	Velocity	Depth	Velocity
Ave	4.32	1.94	7.13	2.76	4.24	2.07	5.26
Max	5.28	2.13	7.84	3.97	4.97	2.63	5.90
Min	2.83	1.61	4.75	2.11	2.96	1.53	4.01

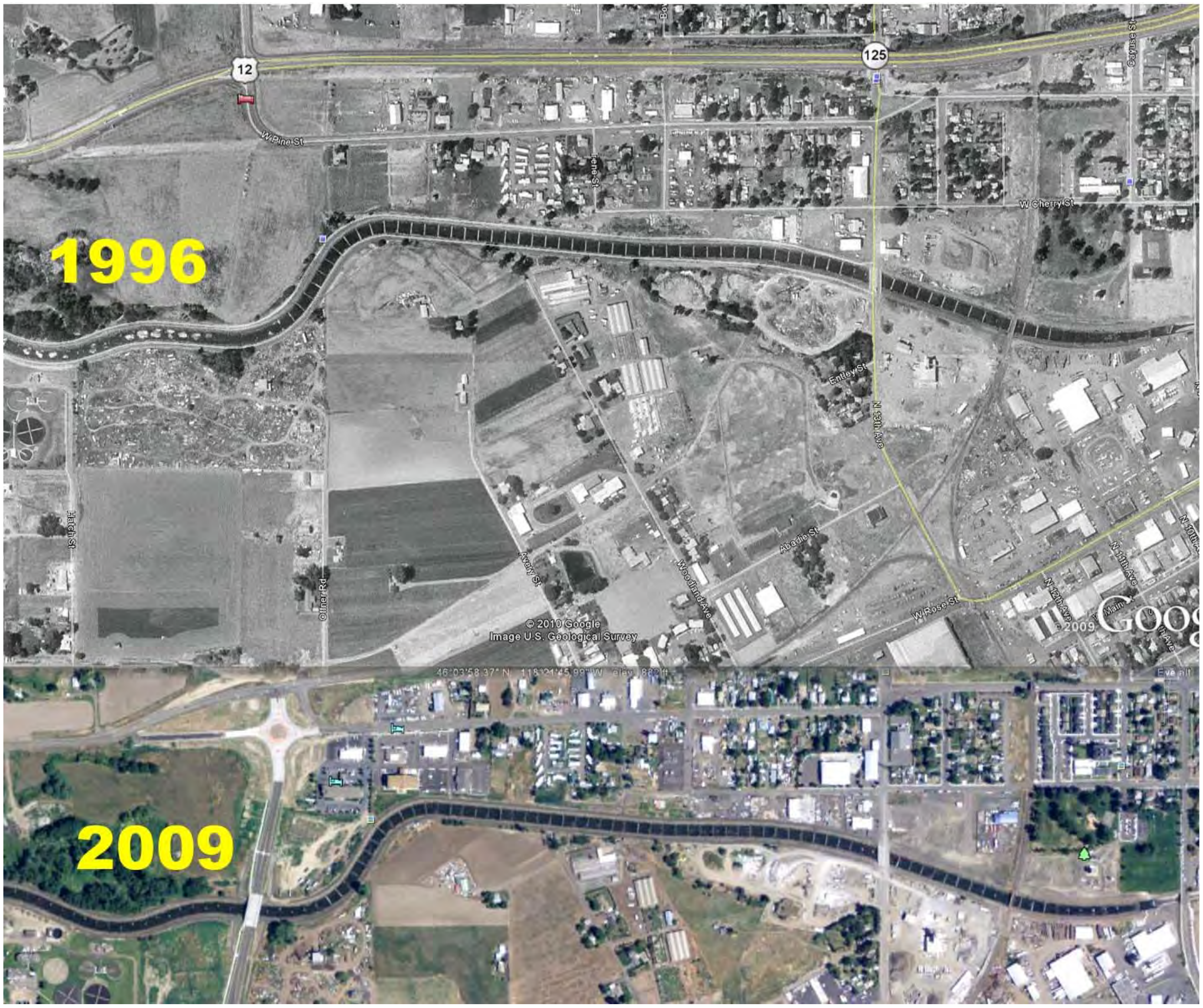
Flow Legend
10 cfs
92 cfs
194 cfs
320 cfs

Appendix B-4: Reach Type 6 Roughened Channel - Sheet 3 of 3

Appendix C: Reach Type 1 Sills – Historical Photos and Designs

Appendix C1: Segment A - RM 5.4 – Sheet Pile Confined Channel

Appendix C2: Segment B - RM 6.3 – Concrete Sills Confined Channel



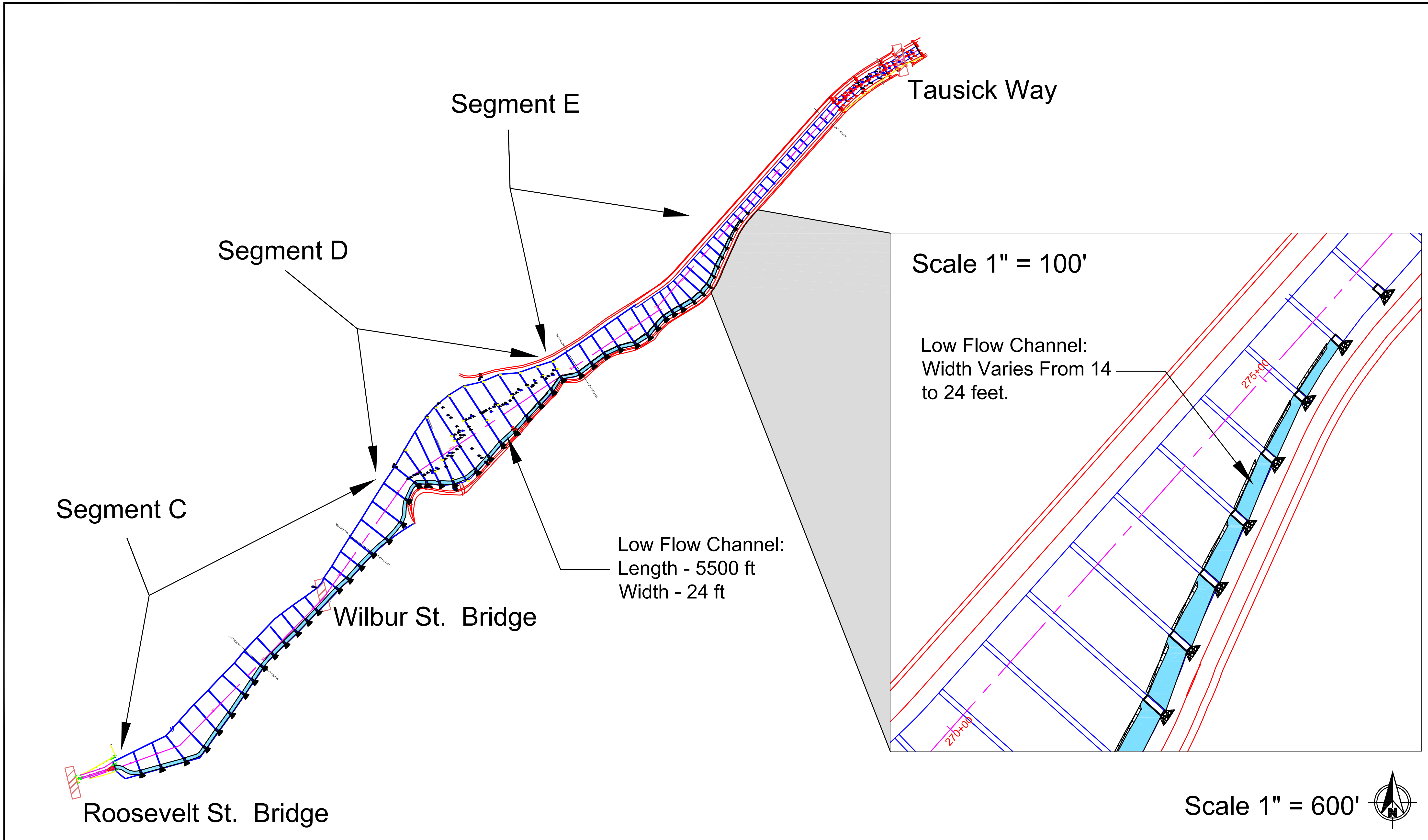
Appendix C3: Segment C - RM – Wide, Heavily Vegetated Channel

Appendix C4: Segment D - RM 9.5 – Wide Channel Open Water

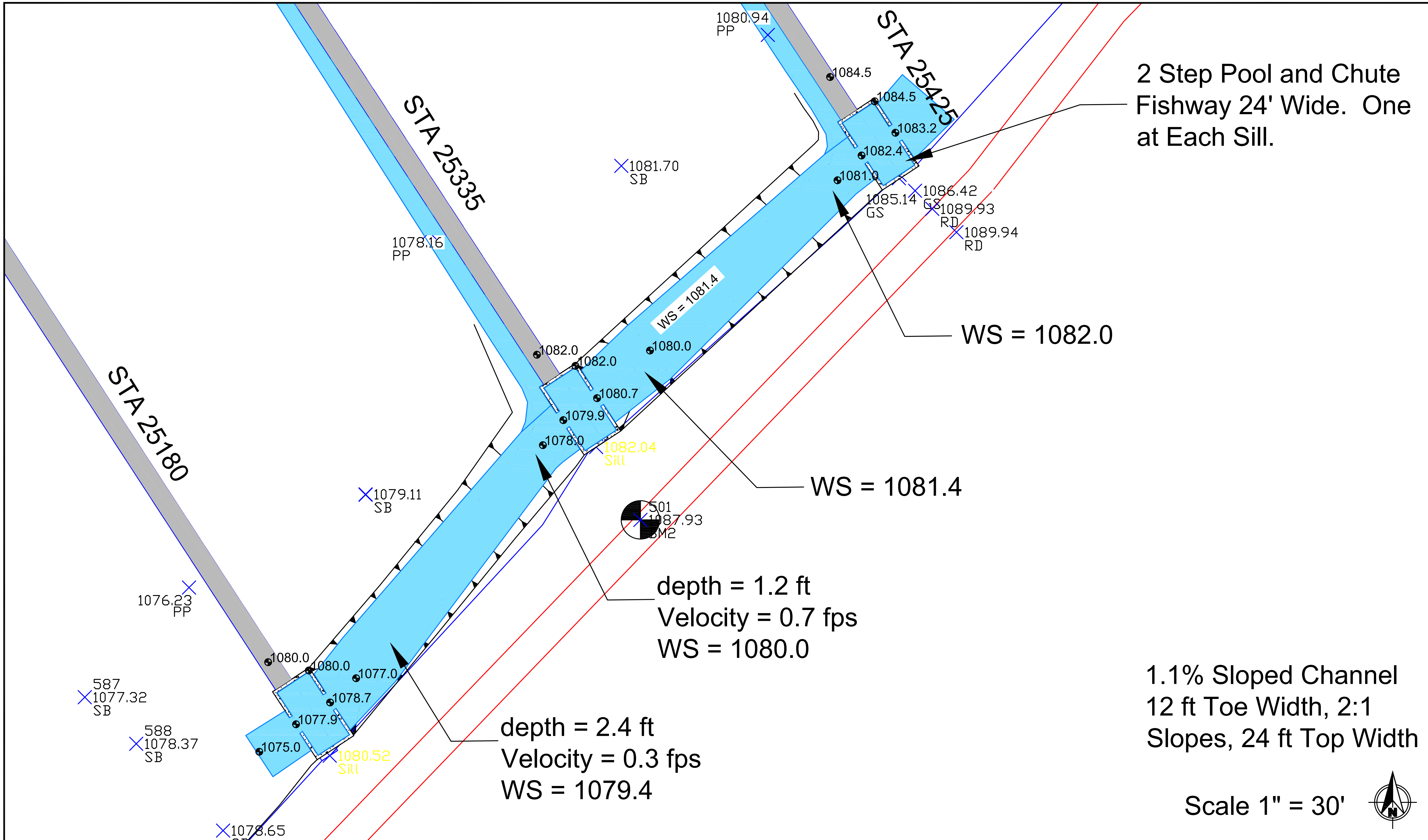
Appendix C5: Segment E - RM 9.8 – Depositional Channel

Appendix C6: Segment F – RM 10.4 - Concrete Sills, Confined Channel

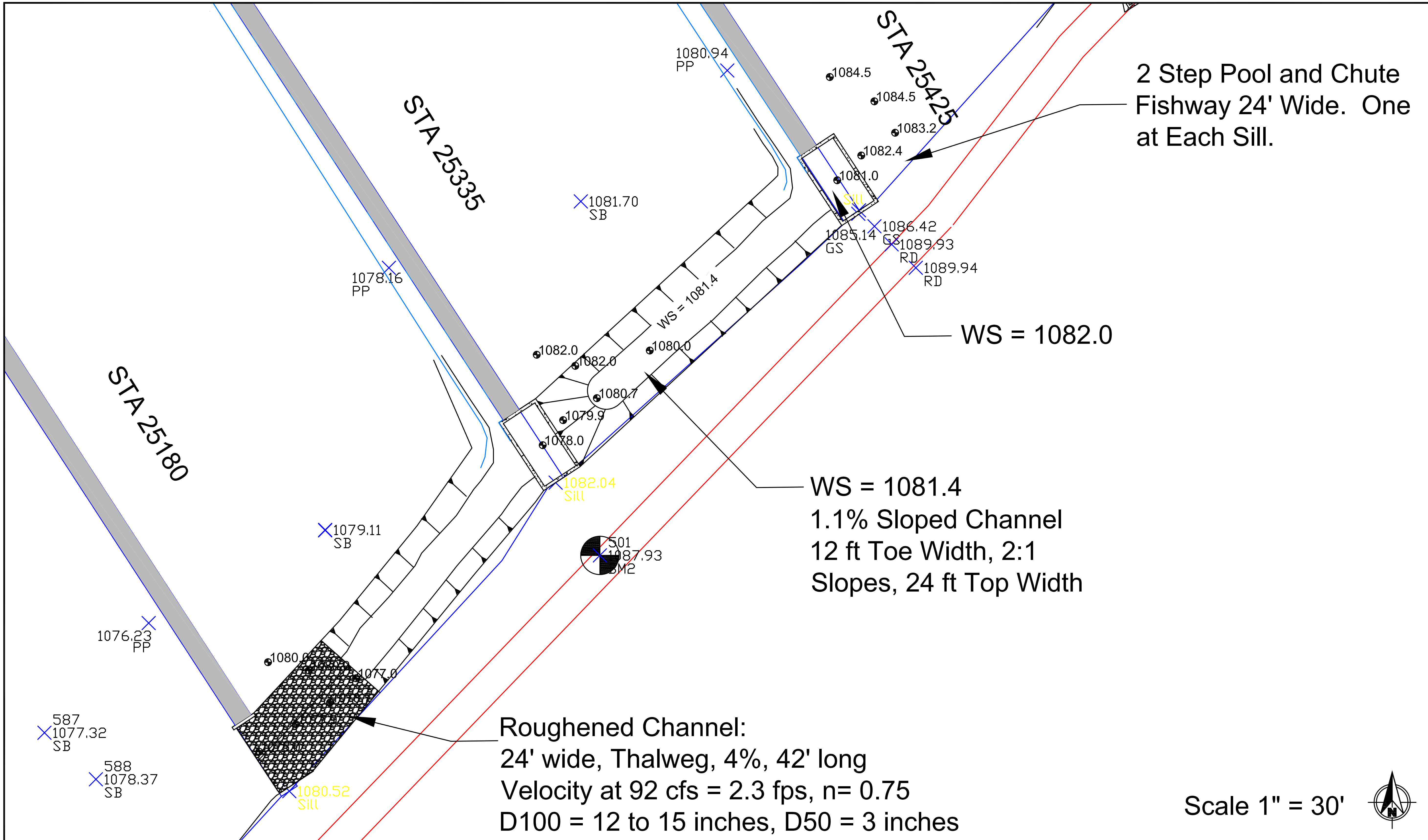
Appendix C-7: Reach Type 1 Segment C, D and E Low Flow Channel Conceptual Design (3 Sheets)



Appendix C-7: Reach Type 1 - Segments C, D and E - Low Flow Channel Conceptual Design (Sheet 1 of 3)



Appendix C-7: Reach Type 1 - Segments C, D and E - Low Flow Channel Conceptual Design (Sheet 2 of 3)



Appendix C-7: Reach Type 1 - Segments C, D and E - Low Flow Channel Conceptual Design (Sheet 3 of 3)

Appendix D-1: Reach Type 3 - Pool and Weir

Mill Creek Fish Passage - Conceptual Design Cost Estimate

Date:	1/20/2010		
By:	P.Powers		
Reach Type:	**3**		
Reach Length:	7260	ft	
Reach Length for Calculations:	60	ft	
Design:	**Option 1: Pool and Weir**		
Design Level:	10%		
Cost Per Foot:	**$3,420**		
Total Cost This Design:	**$17,380,440**	Note: Assumes a 30% cost reduction when applied over entire length	
Addition For Low Flow Correction	**$0**		
Resting Pool Spacing	0	ft	
Addition For Resting Pool Correction	**$0**		
Total Cost For Correction	**$0**		

Description	**Unit**	**Qty**	**t (in)**	**Cost**	**Amount**	**Sub Total**	***Comments***
Mob, Access and Water Management						$17,600	
Mobilization	L.S.	1		$16,000.00	$16,000		*Typically 10% of construction costs*
Access	L.S.	1		$800.00	$800		
Water Management	L.S.	1		$800.00	$800		
Concrete Demolition						$32,820	
Concrete Slab cutting	L.F.	184		$6.00	$1,104		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Wall cutting (plain)	L.F.	0	0	$7.00	$0		*per inch of depth*
Concrete Wall cutting (with rebar)	L.F.	150	7	$11.45	$12,023		*per inch of depth*
Blades	ea.	3		$625.00	$1,875		*12" = $625, 36" = $1750*
Breaking up for Removal	C.Y.	50		$140.00	$6,969		
Remove Whole Pieces	ea.	0		$140.00	$0		*1 to 2.5 cubic yards in size*
Loading Concrete	C.Y.	50		$200.00	$10,000		
Hauling	C.Y.	50		$7.00	$350		
Concrete Disposal	C.Y.	50		$10.00	$500		
Reinforced Concrete Form and Pour						$108,332	
Excavation	C.Y.	449		$15.00	$6,733		
Disposal	C.Y.	449		$20.00	$8,980		*High cost for getting out of flume area*
Subgrade	C.Y.	50		$70.00	$3,500		*Crushed Rock*
Concrete Underpining	C.Y.	4		$2,100.00	$9,333		
Concrete Slabs	C.Y.	67		$700.00	$46,667		
Concrete Walls	C.Y.	34		$900.00	$30,800		
Grouting	S.F.	840		$2.76	$2,318		*Assumes 1/4 C.Y. per foot*
Cobble/Roughness Finish	S.F.	0		$3.00	$0		*$1.73 for exposed agg finish*
Baffles						$0	
Concrete Slab cutting	L.F.	0		$10.78	$0		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Walls	C.Y.	0.0		$900.00	$0		
Resting Pools						$0	
	ea.	0		$10,126.00	$0		
Construction Total						**$158,752**	
Contingency	20%					$31,750	
Sales Tax	7.7%					$14,700	
Engineering	0%					$0	
Project Management	0%					$0	
Project Total						**$205,200**	

Opinions of Probable Construction Cost

In providing opinions of probable construction cost, the Client understands that the Consultant (Waterfall Engineering, L.L.C.) has no control over the cost or availability of labor, equipment or materials, or over market condition or the Contractor's method of pricing, and the consultant's opinions of probable construction costs are made on the basis of the Consultant's professional judgment and experience. The Consultant makes no warranty, express of implied that the bids or the negotiated cost of the Work will not vary from the Consultant's opinion of probable construction cost.

Appendix D-2: Reach Type 3 - Pool and Riffle

Mill Creek Fish Passage - Conceptual Design Cost Estimate

Date:	1/20/2010		
By:	P.Powers		
Reach Type:	**3**		
Reach Length:	7260	ft	
Reach Length for Calculations:	150	ft	
Design:	**Option 1: Pool and Riffle**		
Design Level:	10%		
Cost Per Foot:	**$3,099**		
Total Cost This Design:	**$15,750,812**	Note: Assumes a 30% cost reduction when applied over entire length	
Addition For Low Flow Correction	**$0**		
Resting Pool Spacing	0	ft	
Addition For Resting Pool Correction	**$0**		
Total Cost For Correction	**$0**		

Description	**Unit**	**Qty**	**t (in)**	**Cost**	**Amount**	**Sub Total**	***Comments***
Mob, Access and Water Management						$31,600	
Mobilization	L.S.	1		$30,000.00	$30,000		*Typically 10% of construction costs*
Access	L.S.	1		$800.00	$800		
Water Management	L.S.	1		$800.00	$800		
Concrete Demolition						$77,288	
Concrete Slab cutting	L.F.	388		$6.00	$2,328		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Wall cutting (plain)	L.F.	0	0	$7.00	$0		*per inch of depth*
Concrete Wall cutting (with rebar)	L.F.	150	7	$11.45	$12,023		*per inch of depth*
Blades	ea.	3		$625.00	$1,875		*12" = $625, 36" = $1750*
Breaking up for Removal	C.Y.	171		$140.00	$23,956		
Remove Whole Pieces	ea.	0		$140.00	$0		*1 to 2.5 cubic yards in size*
Loading Concrete	C.Y.	171		$200.00	$34,200		
Hauling	C.Y.	171		$7.00	$1,197		
Concrete Disposal	C.Y.	171		$10.00	$1,710		
Reinforced Concrete Form and Pour						$250,830	
Excavation	C.Y.	894		$15.00	$13,417		
Disposal	C.Y.	894		$20.00	$17,880		*High cost for getting out of flume area*
Subgrade	C.Y.	183		$70.00	$12,833		*Crushed Rock*
Concrete Underpining	C.Y.	6		$2,100.00	$11,667		
Concrete Slabs	C.Y.	244		$700.00	$171,111		*Includes Overbank*
Concrete Walls	C.Y.	17		$900.00	$15,000		
Grouting	S.F.	450		$2.76	$1,242		*Assumes 1/4 C.Y. per foot*
Cobble/Roughness Finish	S.F.	2560		$3.00	$7,680		*$1.73 for exposed agg finish*
Baffles						$0	
Concrete Slab cutting	L.F.	0		$10.78	$0		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Walls	C.Y.	0.0		$900.00	$0		
Resting Pools						$0	
	ea.	0		$10,126.00	$0		
Construction Total						**$359,718**	
Contingency	20%					$71,944	
Sales Tax	7.7%					$33,200	
Engineering	0%					$0	
Project Management	0%					$0	
Project Total						**$464,900**	

Opinions of Probable Construction Cost

In providing opinions of probable construction cost, the Client understands that the Consultant (Waterfall Engineering, L.L.C.) has no control over the cost or availability of labor, equipment or materials, or over market condition or the Contractor's method of pricing, and the consultant's opinions of probable construction costs are made on the basis of the Consultant's professional judgment and experience. The Consultant makes no warranty, express of implied that the bids or the negotiated cost of the Work will not vary from the Consultant's opinion of probable construction cost.

Appendix D-3: Reach Type 3 - Plunge Pool

Mill Creek Fish Passage - Conceptual Design Cost Estimate

Date:	1/20/2010		
By:	P.Powers		
Reach Type:	**3**		
Reach Length:	7260	ft	
Reach Length for Calculations:	60	ft	
Design:	**Option 2: Plunge Pool**		
Design Level:	10%		
Cost Per Foot:	**$323**		
Total Cost This Design:	**$1,643,180**	Note: Assumes a 30% cost reduction when applied over entire length	
Addition For Low Flow Correction	**$0**		
Resting Pool Spacing	60	ft	
Addition For Resting Pool Correction	**$1,225,204**		
Total Cost For Correction	**$2,868,384**		

Description	**Unit**	**Qty**	**t (in)**	**Cost**	**Amount**	**Sub Total**	***Comments***
Mob, Access and Water Management						$3,300	
Mobilization	L.S.	1		$1,700.00	$1,700		*Typically 10% of construction costs*
Access	L.S.	1		$800.00	$800		
Water Management	L.S.	1		$800.00	$800		
Concrete Demolition						$2,311	
Concrete Slab cutting	L.F.	50		$4.84	$242		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Wall cutting (plain)	L.F.	0	0	$7.00	$0		*per inch of depth*
Concrete Wall cutting (with rebar)	L.F.	0	12	$11.45	$0		*per inch of depth*
Blades	ea.	1		$625.00	$625		*12" = $625, 36" = $1750*
Breaking up for Removal	C.Y.	3		$140.00	$373		
Remove Whole Pieces	ea.	3		$140.00	$420		*1 to 2.5 cubic yards in size*
Loading Concrete	C.Y.	3		$200.00	$600		
Hauling	C.Y.	3		$7.00	$21		
Concrete Disposal	C.Y.	3		$10.00	$30		
Reinforced Concrete Form and Pour						$9,028	
Excavation	C.Y.	13		$15.00	$200		
Disposal	C.Y.	13		$20.00	$260		*High cost for getting out of flume area*
Subgrade	C.Y.	4		$70.00	$280		*Crushed Rock*
Concrete Underpining	C.Y.	1		$2,100.00	$3,111		
Concrete Slabs	C.Y.	5		$700.00	$3,733		
Concrete Walls	C.Y.	1		$900.00	$1,333		
Grouting	S.F.	40		$2.76	$110		*Assumes 1/4 C.Y. per foot*
Cobble/Roughness Finish	S.F.	0		$1.73	$0		*$1.73 for exposed agg finish*
Baffles						$386	
Concrete Slab cutting	L.F.	8		$10.78	$86		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Walls	C.Y.	0.3		$900.00	$300		
Resting Pools						$0	
	ea.	0		$10,126.00	$0		
Construction Total						**$15,026**	
Contingency	20%					$3,005	
Sales Tax	7.7%					$1,400	
Engineering	0%					$0	
Project Management	0%					$0	
Project Total						**$19,400**	

Opinions of Probable Construction Cost

In providing opinions of probable construction cost, the Client understands that the Consultant (Waterfall Engineering, L.L.C.) has no control over the cost or availability of labor, equipment or materials, or over market condition or the Contractor's method of pricing, and the consultant's opinions of probable construction costs are made on the basis of the Consultant's professional judgment and experience. The Consultant makes no warranty, express of implied that the bids or the negotiated cost of the Work will not vary from the Consultant's opinion of probable construction cost.

Appendix D-4: Reach Type 3 - Adding Baffles

Mill Creek Fish Passage - Conceptual Design Cost Estimate

Date:	1/20/2010	
By:	P.Powers	
Reach Type:	**3**	
Reach Length:	7260	ft
Reach Length for Calculations:	60	ft
Design:	**Option 2: Add Baffles**	
Design Level:	10%	
Cost Per Foot:	**$87**	
Total Cost This Design:	**$440,440**	Note: Assumes a 30% cost reduction when applied over entire length
Addition For Low Flow Correction	**$0**	
Resting Pool Spacing	60	ft
Addition For Resting Pool Correction	**$1,225,204**	
Total Cost For Correction	**$1,665,644**	

Description	**Unit**	**Qty**	**t (in)**	**Cost**	**Amount**	**Sub Total**	***Comments***
Mob, Access and Water Management						$2,200	
Mobilization	L.S.	1		$600.00	$600		*Typically 10% of construction costs*
Access	L.S.	1		$800.00	$800		
Water Management	L.S.	1		$800.00	$800		
Concrete Demolition						$1,122	
Concrete Slab cutting	L.F.	0		$4.84	$0		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Wall cutting (plain)	L.F.	0	0	$7.00	$0		*per inch of depth*
Concrete Wall cutting (with rebar)	L.F.	0	12	$11.45	$0		*per inch of depth*
Blades	ea.	1		$625.00	$625		*12" = $625, 36" = $1750*
Breaking up for Removal	C.Y.	1		$140.00	$140		
Remove Whole Pieces	ea.	1		$140.00	$140		*1 to 2.5 cubic yards in size*
Loading Concrete	C.Y.	1		$200.00	$200		
Hauling	C.Y.	1		$7.00	$7		
Concrete Disposal	C.Y.	1		$10.00	$10		
Reinforced Concrete Form and Pour						$0	
Excavation	C.Y.	0		$15.00	$0		
Disposal	C.Y.	0		$20.00	$0		*High cost for getting out of flume area*
Subgrade	C.Y.	0		$70.00	$0		*Crushed Rock*
Concrete Underpining	C.Y.	0		$2,100.00	$0		
Concrete Slabs	C.Y.	0		$700.00	$0		
Concrete Walls	C.Y.	0		$900.00	$0		
Grouting	S.F.	0		$2.76	$0		*Assumes 1/4 C.Y. per foot*
Cobble/Roughness Finish	S.F.	0		$1.73	$0		*$1.73 for exposed agg finish*
Baffles						$714	
Concrete Slab cutting	L.F.	18		$10.78	$194		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Walls	C.Y.	0.6		$900.00	$520		
Resting Pools						$0	
	ea.	0		$10,126.00	$0		
Construction Total						**$4,036**	
Contingency	20%					$807	
Sales Tax	7.7%					$400	
Engineering	0%					$0	
Project Management	0%					$0	
Project Total						**$5,200**	

Opinions of Probable Construction Cost

In providing opinions of probable construction cost, the Client understands that the Consultant (Waterfall Engineering, L.L.C.) has no control over the cost or availability of labor, equipment or materials, or over market condition or the Contractor's method of pricing, and the consultant's opinions of probable construction costs are made on the basis of the Consultant's professional judgment and experience. The Consultant makes no warranty, express of implied that the bids or the negotiated cost of the Work will not vary from the Consultant's opinion of probable construction cost.

Appendix D-5: Reach Type 3 - Lowered Section

Mill Creek Fish Passage - Conceptual Design Cost Estimate

Date:	1/20/2010	
By:	P.Powers	
Reach Type:	**3**	
Reach Length:	7260	ft
Reach Length for Calculations:	60	ft
Design:	**Option 2: Lowered Section**	
Design Level:	10%	
Cost Per Foot:	**$948**	
Total Cost This Design:	**$4,819,430**	Note: Assumes a 30% cost reduction when applied over entire length
Addition For Low Flow Correction	**$1,643,180**	
Resting Pool Spacing	300	ft
Addition For Resting Pool Correction	**$245,041**	
Total Cost For Correction	**$6,707,651**	

Description	**Unit**	**Qty**	**t (in)**	**Cost**	**Amount**	**Sub Total**	***Comments***
Mob, Access and Water Management						$6,600	
Mobilization	L.S.	1		$5,000.00	$5,000		*Typically 10% of construction costs*
Access	L.S.	1		$800.00	$800		
Water Management	L.S.	1		$800.00	$800		
Concrete Demolition						$13,705	
Concrete Slab cutting	L.F.	76		$7.00	$532		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Wall cutting (plain)	L.F.	0	0	$7.00	$0		*per inch of depth*
Concrete Wall cutting (with rebar)	L.F.	63	8	$11.45	$5,771		*per inch of depth*
Blades	ea.	3		$625.00	$1,875		*12" = $625, 36" = $1750*
Breaking up for Removal	C.Y.	13		$140.00	$1,867		
Remove Whole Pieces	ea.	6		$140.00	$840		*1 to 2.5 cubic yards in size*
Loading Concrete	C.Y.	13		$200.00	$2,600		
Hauling	C.Y.	13		$7.00	$91		
Concrete Disposal	C.Y.	13		$10.00	$130		
Reinforced Concrete Form and Pour						$23,320	
Excavation	C.Y.	33		$15.00	$500		
Disposal	C.Y.	33		$20.00	$660		*High cost for getting out of flume area*
Subgrade	C.Y.	13		$70.00	$933		*Crushed Rock*
Concrete Underpining	C.Y.	2		$2,100.00	$4,667		
Concrete Slabs	C.Y.	18		$700.00	$12,444		
Concrete Walls	C.Y.	4		$900.00	$4,000		
Grouting	S.F.	42		$2.76	$116		*Assumes 1/4 C.Y. per foot*
Cobble/Roughness Finish	S.F.	0		$1.73	$0		*$1.73 for exposed agg finish*
Baffles						$356	
Concrete Slab cutting	L.F.	8		$10.78	$86		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Walls	C.Y.	0.3		$900.00	$270		
Resting Pools						$0	
	ea.	0		$10,126.00	$0		
Construction Total						**$43,982**	
Contingency	20%					$8,796	
Sales Tax	7.7%					$4,100	
Engineering	0%					$0	
Project Management	0%					$0	
Project Total						**$56,900**	

Opinions of Probable Construction Cost

In providing opinions of probable construction cost, the Client understands that the Consultant (Waterfall Engineering, L.L.C.) has no control over the cost or availability of labor, equipment or materials, or over market condition or the Contractor's method of pricing, and the consultant's opinions of probable construction costs are made on the basis of the Consultant's professional judgment and experience. The Consultant makes no warranty, express of implied that the bids or the negotiated cost of the Work will not vary from the Consultant's opinion of probable construction cost.

Appendix D-6: Reach Type 3 - Roughened Channel

Mill Creek Fish Passage - Conceptual Design Cost Estimate

Date:	1/20/2010	
By:	P.Powers	
Reach Type:	**3**	
Reach Length:	7260	ft
Reach Length for Calculations:	60	ft
Design:	**Option 2: Roughened Channel**	
Design Level:	10%	
Cost Per Foot:	**$980**	
Total Cost This Design:	**$4,980,360**	Note: Assumes a 30% cost reduction when applied over entire length
Addition For Low Flow Correction	**$1,643,180**	
Resting Pool Spacing	300	ft
Addition For Resting Pool Correction	**$245,041**	
Total Cost For Correction	**$6,868,581**	

Description	Unit	Qty	t (in)	Cost	Amount	Sub Total	*Comments*
Mob, Access and Water Management						$6,600	
Mobilization	L.S.	1		$5,000.00	$5,000		*Typically 10% of construction costs*
Access	L.S.	1		$800.00	$800		
Water Management	L.S.	1		$800.00	$800		
Concrete Demolition						$13,705	
Concrete Slab cutting	L.F.	76		$7.00	$532		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Wall cutting (plain)	L.F.	0	0	$7.00	$0		*per inch of depth*
Concrete Wall cutting (with rebar)	L.F.	63	8	$11.45	$5,771		*per inch of depth*
Blades	ea.	3		$625.00	$1,875		*12" = $625, 36" = $1750*
Breaking up for Removal	C.Y.	13		$140.00	$1,867		
Remove Whole Pieces	ea.	6		$140.00	$840		*1 to 2.5 cubic yards in size*
Loading Concrete	C.Y.	13		$200.00	$2,600		
Hauling	C.Y.	13		$7.00	$91		
Concrete Disposal	C.Y.	13		$10.00	$130		
Reinforced Concrete Form and Pour						$24,854	
Excavation	C.Y.	36		$15.00	$533		
Disposal	C.Y.	36		$20.00	$720		*High cost for getting out of flume area*
Subgrade	C.Y.	13		$70.00	$933		*Crushed Rock*
Concrete Underpining	C.Y.	2		$2,100.00	$4,667		
Concrete Slabs	C.Y.	18		$700.00	$12,444		
Concrete Walls	C.Y.	4		$900.00	$4,000		
Grouting	S.F.	42		$2.76	$116		*Assumes 1/4 C.Y. per foot*
Cobble/Roughness Finish	S.F.	480		$3.00	$1,440		*$1.73 for exposed agg finish*
Baffles						$356	
Concrete Slab cutting	L.F.	8		$10.78	$86		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Walls	C.Y.	0.3		$900.00	$270		
Resting Pools						$0	
	ea.	0		$10,126.00	$0		
Construction Total						**$45,515**	
Contingency	20%					$9,103	
Sales Tax	7.7%					$4,200	
Engineering	0%					$0	
Project Management	0%					$0	
Project Total						**$58,800**	

Opinions of Probable Construction Cost

In providing opinions of probable construction cost, the Client understands that the Consultant (Waterfall Engineering, L.L.C.) has no control over the cost or availability of labor, equipment or materials, or over market condition or the Contractor's method of pricing, and the consultant's opinions of probable construction costs are made on the basis of the Consultant's professional judgment and experience. The Consultant makes no warranty, express of implied that the bids or the negotiated cost of the Work will not vary from the Consultant's opinion of probable construction cost.

Appendix D-7: Reach Type 3 - High Flow Trench with Baffles

Mill Creek Fish Passage - Conceptual Design Cost Estimate

Date:	1/20/2010	
By:	P.Powers	
Reach Type:	**3**	
Reach Length:	7260	ft
Reach Length for Calculations:	60	ft
Design:	**Option 2: High Flow Trench With Baffles**	
Design Level:	10%	
Cost Per Foot:	**$1,320**	
Total Cost This Design:	**$6,708,240**	Note: Assumes a 30% cost reduction when applied over entire length
Addition For Low Flow Correction	**$1,643,180**	
Resting Pool Spacing	300	ft
Addition For Resting Pool Correction	**$245,041**	
Total Cost For Correction	**$8,596,461**	

Description	**Unit**	**Qty**	**t (in)**	**Cost**	**Amount**	**Sub Total**	***Comments***
Mob, Access and Water Management						$8,600	
Mobilization	L.S.	1		$7,000.00	$7,000		*Typically 10% of construction costs*
Access	L.S.	1		$800.00	$800		
Water Management	L.S.	1		$800.00	$800		
Concrete Demolition						$15,757	
Concrete Slab cutting	L.F.	76		$7.00	$532		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Wall cutting (plain)	L.F.	0	0	$7.00	$0		*per inch of depth*
Concrete Wall cutting (with rebar)	L.F.	64	8	$11.45	$5,862		*per inch of depth*
Blades	ea.	4		$625.00	$2,500		*12" = $625, 36" = $1750*
Breaking up for Removal	C.Y.	17		$140.00	$2,333		
Remove Whole Pieces	ea.	6		$140.00	$840		*1 to 2.5 cubic yards in size*
Loading Concrete	C.Y.	17		$200.00	$3,400		
Hauling	C.Y.	17		$7.00	$119		
Concrete Disposal	C.Y.	17		$10.00	$170		
Reinforced Concrete Form and Pour						$36,245	
Excavation	C.Y.	42		$15.00	$633		
Disposal	C.Y.	42		$20.00	$840		*High cost for getting out of flume area*
Subgrade	C.Y.	13		$70.00	$933		*Crushed Rock*
Concrete Underpining	C.Y.	4		$2,100.00	$9,333		
Concrete Slabs	C.Y.	28		$700.00	$19,623		*Includes Overbank*
Concrete Walls	C.Y.	5		$900.00	$4,600		
Grouting	S.F.	102		$2.76	$282		*Assumes 1/4 C.Y. per foot*
Cobble/Roughness Finish	S.F.	0		$3.00	$0		*$1.73 for exposed agg finish*
Baffles						$626	
Concrete Slab cutting	L.F.	8		$10.78	$86		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Walls	C.Y.	0.6		$900.00	$540		
Resting Pools						$0	
	ea.	0		$10,126.00	$0		
Construction Total						**$61,228**	
Contingency	20%					$12,246	
Sales Tax	7.7%					$5,700	
Engineering	0%					$0	
Project Management	0%					$0	
Project Total						**$79,200**	

Opinions of Probable Construction Cost

In providing opinions of probable construction cost, the Client understands that the Consultant (Waterfall Engineering, L.L.C.) has no control over the cost or availability of labor, equipment or materials, or over market condition or the Contractor's method of pricing, and the consultant's opinions of probable construction costs are made on the basis of the Consultant's professional judgment and experience. The Consultant makes no warranty, express of implied that the bids or the negotiated cost of the Work will not vary from the Consultant's opinion of probable construction cost.

Appendix D-8: Reach Type 6 – Roughened Channel

Mill Creek Fish Passage - Conceptual Design Cost Estimate

Date:	5/6/2009	
By:	P.Powers	
Reach Type:	**6**	
Reach Length:	285	ft
Reach Length for Calculations:	285	ft
Design:	**Option 2: Roughened Channel Design Both Sides With Plunge Pools, Add Baffles and Resting Pools**	
Design Level:	10%	
Total Cost This Design:	**$258,100**	Note: Assumes no cost reduction when applied over entire length
Add Baffles	**$3,000**	2
Plunge Pools	**$76,000**	5
Resting Pools	**$10,126**	1
Total Cost For Correction	**$347,226**	
Cost Per Foot:	$906	

Description	**Unit**	**Qty**	**t (in)**	**Cost**	**Amount**	**Sub Total**	***Comments***
Mob, Access and Water Management						$38,000	
Mobilization	L.S.	1		$29,000.00	$29,000		*Typically 10% of construction costs*
Access	L.S.	1		$3,000.00	$3,000		
Water Management	L.S.	1		$6,000.00	$6,000		
Concrete Demolition						$50,451	
Concrete Slab cutting	L.F.	285		$8.00	$2,280		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Wall cutting (plain)	L.F.	0	8	$7.00	$0		*per inch of depth*
Concrete Wall cutting (with rebar)	L.F.	285	8	$11.45	$26,106		*per inch of depth*
Blades	ea.	4		$625.00	$2,500		*12" = $625, 36" = $1750*
Breaking up for Removal	C.Y.	45		$140.00	$6,300		
Remove Whole Pieces	ea.	25		$140.00	$3,500		*1 to 2.5 cubic yards in size*
Loading Concrete	C.Y.	45		$200.00	$9,000		
Hauling	C.Y.	45		$7.00	$315		
Concrete Disposal	C.Y.	45		$10.00	$450		
Reinforced Concrete Form and Pour						$77,394	
Excavation	C.Y.	140		$20.00	$2,800		
Disposal	C.Y.	140		$30.00	$4,200		*High cost for getting out of flume area*
Subgrade	C.Y.	35		$70.00	$2,450		*Crushed Rock*
Concrete Underpining	C.Y.	5		$2,100.00	$10,500		
Concrete Slabs	C.Y.	60		$700.00	$42,000		
Concrete Walls	C.Y.	11		$900.00	$9,900		
Grouting	S.F.	150		$2.76	$414		*Assumes 1/4 C.Y. per foot*
Cobble/Roughness Finish	S.F.	1710		$3.00	$5,130		*$1.73 for exposed agg finish*
Construction Total						**$165,845**	
Contingency	20%					$33,169	
Sales Tax	7.7%					$15,300	
Engineering	12%					$23,900	
Project Management	10%					$19,900	
Project Total						**$258,100**	

Opinions of Probable Construction Cost

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Appendix D-9: Reach Type 6 – Roughened Channel Both Sides

Mill Creek Fish Passage - Conceptual Design Cost Estimate

Date:	5/6/2009		
By:	P.Powers		
Reach Type:	**6**		
Reach Length:	285	ft	
Reach Length for Calculations:	285	ft	
Design:	**Option 2: Roughened Channel Design Both Sides With Plunge Pools, Add Baffles and Resting Pools**		
Design Level:	10%		
Total Cost This Design:	**$452,500**	Note: Assumes no cost reduction when applied over entire length	
Add Baffles	**$13,500**	9	
Plunge Pools	**$45,600**	3	
Resting Pools	**$10,126**	1	
Total Cost For Correction	**$521,726**		
Cost Per Foot:	$1,588		

Description	**Unit**	**Qty**	**t (in)**	**Cost**	**Amount**	**Sub Total**	***Comments***
Mob, Access and Water Management						$38,000	
Mobilization	L.S.	1		$29,000.00	$29,000		*Typically 10% of construction costs*
Access	L.S.	1		$3,000.00	$3,000		
Water Management	L.S.	1		$6,000.00	$6,000		
Concrete Demolition						$98,402	
Concrete Slab cutting	L.F.	570		$8.00	$4,560		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Wall cutting (plain)	L.F.	0	8	$7.00	$0		*per inch of depth*
Concrete Wall cutting (with rebar)	L.F.	570	8	$11.45	$52,212		*per inch of depth*
Blades	ea.	4		$625.00	$2,500		*12" = $625, 36" = $1750*
Breaking up for Removal	C.Y.	90		$140.00	$12,600		
Remove Whole Pieces	ea.	50		$140.00	$7,000		*1 to 2.5 cubic yards in size*
Loading Concrete	C.Y.	90		$200.00	$18,000		
Hauling	C.Y.	90		$7.00	$630		
Concrete Disposal	C.Y.	90		$10.00	$900		
Reinforced Concrete Form and Pour						$154,274	
Excavation	C.Y.	280		$20.00	$5,600		
Disposal	C.Y.	280		$30.00	$8,400		*High cost for getting out of flume area*
Subgrade	C.Y.	69		$70.00	$4,830		*Crushed Rock*
Concrete Underpining	C.Y.	10		$2,100.00	$21,000		
Concrete Slabs	C.Y.	119		$700.00	$83,300		
Concrete Walls	C.Y.	21		$900.00	$18,900		
Grouting	S.F.	285		$2.76	$787		*Assumes 1/4 C.Y. per foot*
Cobble/Roughness Finish	S.F.	3819		$3.00	$11,457		*$1.73 for exposed agg finish*
Construction Total						**$290,676**	
Contingency	20%					$58,135	
Sales Tax	7.7%					$26,900	
Engineering	12%					$41,900	
Project Management	10%					$34,900	
Project Total						**$452,500**	

Opinions of Probable Construction Cost

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Appendix D-10: Reach Type 1 – Low Flow Slot

Mill Creek Fish Passage - Conceptual Design Cost Estimate

Date:	9/5/2010	
By:	P.Powers	
Reach Type:	**1**	
Application:	Segment B and F - Low Flow Slot - Drops 0.8' or Less	
Number of Applications:	87	
Slot Width:	14	
Design:	**Remove section of sill and install concrete low flow slot**	
Design Level:	10%	
Cost Per Slot	**$21,300**	
Total Cost This Design:	**$1,297,170**	Assumes 30% Cost Reduction From Scale

Description	Unit	Qty	t (in)	Cost	Amount	Sub Total	*Comments*
Mob, Access and Water Management						$3,300	
Mobilization	L.S.	1		$1,700.00	$1,700		*Typically 10% of construction costs*
Access	L.S.	1		$400.00	$400		
Fish Removal	L.S.	1		$600.00	$600		
Water Management	L.S.	1		$600.00	$600		
Concrete Demolition Remove Wires						$2,605	
Concrete Slab cutting	L.F.	20		$4.84	$97		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Wall cutting (plain)	L.F.	0	8	$7.00	$0		*per inch of depth*
Concrete Wall cutting (with rebar)	L.F.	4	8	$11.45	$366		*per inch of depth*
Blades	ea.	1		$625.00	$625		*12" = $625, 36" = $1750*
Breaking up for Removal	C.Y.	2		$140.00	$249		
Cutting Wire Baskets	L.S.	1		$500.00	$500		
Remove Rock	ea.	5		$25.00	$117		
Loading Concrete	C.Y.	3		$200.00	$600		
Hauling	C.Y.	3		$7.00	$21		
Concrete Disposal	C.Y.	3		$10.00	$30		
Reinforced Concrete Form and Pour						$7,001	
Excavation	C.Y.	8		$15.00	$120		
Disposal	C.Y.	8		$25.00	$200		*High cost for getting out of flume area*
Subgrade	C.Y.	4		$70.00	$280		*Crushed Rock*
Concrete Underpining	C.Y.	0		$2,100.00	$0		
Concrete Slabs	C.Y.	5		$700.00	$3,319		
Concrete Walls	C.Y.	3		$900.00	$3,000		
Grouting	S.F.	30		$2.76	$83		*Assumes 1/4 C.Y. per foot*
Cobble/Roughness Finish	S.F.	0		$1.73	$0		*$1.73 for exposed agg finish*
Construction Total						**$12,906**	
Contingency	20%					$2,581	
Sales Tax	8.0%					$1,200	
A&E	30%					$4,600	
Project Total						**$21,300**	

Opinions of Probable Construction Cost

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Appendix D-11: Reach Type 1 – Fishway

Mill Creek Fish Passage - Conceptual Design Cost Estimate

Date:	9/5/2010
By:	P.Powers
Reach Type:	**1**
Application:	Segment B and F - Drops greater than 0.8 feet
Number of Applications:	45
Fishway Width	14
Design:	**Remove section of sill and install 2 step concrete fishway**
Design Level:	10%
Cost Per Fishway:	**$28,300**
Total Cost This Design:	**$891,450** Assumes 30% Cost Reduction From Scale

Description	**Unit**	**Qty**	**t (in)**	**Cost**	**Amount**	**Sub Total**	***Comments***
Mob, Access and Water Management						$3,800	
Mobilization	L.S.	1		$1,700.00	$1,700		*Typically 10% of construction costs*
Access	L.S.	1		$400.00	$400		
Fish Removal	L.S.	1		$700.00	$700		
Water Management	L.S.	1		$1,000.00	$1,000		
Concrete Demolition Remove Wires						$2,669	
Concrete Slab cutting	L.F.	6		$4.84	$29		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Wall cutting (plain)	L.F.	0	8	$7.00	$0		*per inch of depth*
Concrete Wall cutting (with rebar)	L.F.	4	8	$11.45	$366		*per inch of depth*
Blades	ea.	1		$625.00	$625		*12" = $625, 36" = $1750*
Breaking up for Removal	C.Y.	2		$140.00	$249		
Cutting Wire Baskets	L.S.	1		$500.00	$500		
Remove Rock	ea.	12		$20.00	$249		
Loading Concrete	C.Y.	3		$200.00	$600		
Hauling	C.Y.	3		$7.00	$21		
Concrete Disposal	C.Y.	3		$10.00	$30		
Reinforced Concrete Form and Pour						$10,632	
Excavation	C.Y.	13		$15.00	$200		
Disposal	C.Y.	13		$25.00	$325		*High cost for getting out of flume area*
Subgrade	C.Y.	4		$70.00	$280		*Crushed Rock*
Concrete Underpining	C.Y.	0		$2,100.00	$0		
Concrete Slabs	C.Y.	5		$700.00	$3,733		
Concrete Walls	C.Y.	7		$900.00	$5,983		
Grouting	S.F.	40		$2.76	$110		*Assumes 1/4 C.Y. per foot*
Cobble/Roughness Finish	S.F.	0		$1.73	$0		*$1.73 for exposed agg finish*
Construction Total						**$17,101**	
Contingency	20%					$3,420	
Sales Tax	8.0%					$1,600	
A&E	30%					$6,200	
Project Total						**$28,300**	

Opinions of Probable Construction Cost

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Appendix D-12: Reach Type 1 – Low Flow Channel with Fishways

Mill Creek Fish Passage - Conceptual Design Cost Estimate

Date:	9/5/2010
By:	P.Powers

Reach Type:	**1**	
Application:	Segment C, D and E - 24 Wide Fishways	
Number of Applications:	1	
Fishway Width	24	
Design:	**Remove section of sills and construct low flow channel and Fishways**	
Channel Length:	5500	ft
Design Level:	10%	

Description	Unit	Qty	t (in)	Cost	Amount	Sub Total	*Comments*
Mob, Access and Water Management						$55,500	
Mobilization	L.S.	1		$30,000.00	$30,000		*Typically 10% of construction costs*
Access	L.S.	1		$6,000.00	$6,000		
Fish Removal	L.S.	1		$4,500.00	$4,500		
Water Management	L.S.	1		$15,000.00	$15,000		
Concrete Demolition Remove Wires						$160,884	
Number of Weirs	*49*						
Concrete Slab cutting	L.F.	30		$4.84	$145		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Wall cutting (plain)	L.F.	0	8	$7.00	$0		*per inch of depth*
Concrete Wall cutting (with rebar)	L.F.	24	8	$11.45	$2,198		*per inch of depth*
Blades	ea.	3		$625.00	$1,875		*12" = $625, 36" = $1750*
Breaking up for Removal	C.Y.	3		$140.00	$404		
Cutting Wire Baskets	L.S.	1		$1,000.00	$1,000		
Remove Rock	ea.	21		$20.00	$427		
Loading Concrete	C.Y.	3		$200.00	$600		
Hauling	C.Y.	3		$7.00	$21		
Concrete Disposal	C.Y.	3		$10.00	$30		
Reinforced Concrete Form and Pour						$639,513	
Excavation	C.Y.	31		$15.00	$462		
Disposal	C.Y.	31		$25.00	$775		*High cost for getting out of flume area*
Subgrade	C.Y.	6		$70.00	$420		*Crushed Rock*
Concrete Underpining	C.Y.	0		$2,100.00	$0		
Concrete Slabs	C.Y.	9		$700.00	$6,067		
Concrete Walls	C.Y.	12		$900.00	$10,700		
Grouting	S.F.	80		$2.76	$221		*Assumes 1/4 C.Y. per foot*
Cobble/Roughness Finish	S.F.	0		$1.73	$0		*$1.73 for exposed agg finish*
Channel Excavation						$961,920	
Excavation and Disposal	C.Y.	48		$4.00	$961,920		*Spoil within channel*
Construction Total						$1,817,817	
Contingency	15%					$272,673	
Sales Tax	8.0%					$167,200	
A&E	10%					$209,000	
Project Total						**$2,466,700**	

Opinions of Probable Construction Cost

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Appendix D-13: Reach Type 1 – Low Flow Channel with Roughened Channels

Mill Creek Fish Passage - Conceptual Design Cost Estimate

Date:	9/7/2010			
By:	P.Powers			3442
Reach Type:	**1**			
Application:	Segment C, D and E - 24 Wide Roughened Channel			
Number of Applications:	1			
Roughened Channel Width	24			
Design:	**Remove section of sills and construct low flow channel and Roughened Channel for Drop**			
Channel Length:	5500	ft		
Design Level:	10%			

Description	Unit	Qty	t (in)	Cost	Amount	Sub Total	*Comments*
Mob, Access and Water Management						$55,500	
Mobilization	L.S.	1		$30,000.00	$30,000		*Typically 10% of construction costs*
Access	L.S.	1		$6,000.00	$6,000		
Fish Removal	L.S.	1		$4,500.00	$4,500		
Water Management	L.S.	1		$15,000.00	$15,000		
Concrete Demolition Remove Wires						$160,884	
Number of Weirs	*49*						
Concrete Slab cutting	L.F.	30		$4.84	$145		*Overbank Area, 6" slab, 12" = $10.78, 18" = $16.72*
Concrete Wall cutting (plain)	L.F.	0	8	$7.00	$0		*per inch of depth*
Concrete Wall cutting (with rebar)	L.F.	24	8	$11.45	$2,198		*per inch of depth*
Blades	ea.	3		$625.00	$1,875		*12" = $625, 36" = $1750*
Breaking up for Removal	C.Y.	3		$140.00	$404		
Cutting Wire Baskets	L.S.	1		$1,000.00	$1,000		
Remove Rock	ea.	21		$20.00	$427		
Loading Concrete	C.Y.	3		$200.00	$600		
Hauling	C.Y.	3		$7.00	$21		
Concrete Disposal	C.Y.	3		$10.00	$30		
Reinforced Concrete Form and Pour						$78,005	
Excavation	C.Y.	2		$15.00	$30		
Disposal	C.Y.	2		$25.00	$50		*High cost for getting out of flume area*
Subgrade	C.Y.	1		$70.00	$70		*Crushed Rock*
Concrete Underpining	C.Y.	0		$2,100.00	$0		
Concrete Slabs	C.Y.	0		$700.00	$0		
Concrete Walls	C.Y.	2		$900.00	$2,000		
Grouting	S.F.	45		$2.76	$124		*Assumes 1/4 C.Y. per foot*
Cobble/Roughness Finish	S.F.	0		$1.73	$0		*$1.73 for exposed agg finish*
Channel Excavation/Rough Channel						$1,033,509	
Excavation and Disposal	C.Y.	48		$4.00	$660,864		*Spoil within channel*
Rough Channel Mix	C.Y.	169		$45.00	$372,645		
Construction Total						$1,327,898	
Contingency	15%					$199,185	
Sales Tax	8.0%					$122,200	
A&E	10%					$152,700	
Project Total						**$1,802,000**	

Opinions of Probable Construction Cost

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