

Technical Memorandum

Date: June 18, 2012

Project Number: 1870.01/MM101

To: Walter T. Pereyra, PhD

From: Glen S. Anderson, P.E.

Project: Zaccuse Creek

Subject: To Provide Design Guidance for Culvert Replacement Projects and Possible Realignment and Re-grading of Zaccuse Creek Upstream of the Culvert Replacement Projects.

Background and Authorization

Glen Anderson of R2 Resource Consultants, Inc. (R2) attended a site visit to Zaccuse Creek on December 19, 2011, as a consultant for Mr. Pereyra to discuss possible projects to improve fish passage on Zaccuse Creek and open new habitat for Kokanee in the creek. The site visit was attended by parties interested in these projects. The main goal of the visit was to bring together the agencies responsible for the culverts (City of Sammamish and King County), Mr. Pereyra (property owner), and technical people with specific knowledge regarding fish passage to discuss the problem on-site. Timing was important because in order to include these projects as part of the upcoming capital budgeting process, some upfront planning was needed. Also, all of the parties must plan together and agree on a concept due to the fact that the culverts are very close to one another; meaning any change to one will impact the others, so a coordinated effort was needed to have a successful project. In addition to the culverts, any realignment or restoration of the reach through Mr. Pereyra's property, just upstream of the culverts would also need to be designed in coordination with the culvert replacements.

In order to keep the process on track R2 Resource Consultants was hired by Mr. Pereyra to do a stream survey and conceptual design for the fish passage and stream restoration projects, which will act as a guide for the overall design process, specifically intended to make sure the components of the overall design worked together.

Stream Survey

A stream survey was conducted on April 13, 2012 by Glen Anderson and Tim Sullivan of R2. The survey was conducted from just downstream of Sammamish Shore Lane Drive in the

upstream direction for approximately 1,300 feet. The lower 600 feet and the upper 400 feet were surveyed using a total station. A section approximately 300 feet long through thick blackberries and other brush was not conducive to total station surveying, so a hand held GPS was used. Elevations were surveyed between the two total station surveys using an auto level. The horizontal alignment of the two surveyed sections was fit using the aerial photos and had held GPS waypoints.

The data collected consisted of the following:

- Creek Centerline Bed Elevations
- Culvert Invert Elevations
- Water Surface Elevations
- Creek Cross Sections
- Locations of Roads and Fence Lines for reference
- Bank full Widths
- Pebble Count

Results

Note: This survey was a reconnaissance level stream survey, not a property or infrastructure survey. The results should not be used for any purpose other than as a starting point to guide fish passage design projects. A final design will need to be done for all of the fish passage recommendations given in this memo. The lower portion of the creek, including the three (3) culverts and up to Station 6+00 was surveyed using the total station, so alignment and elevation will be more accurate than the portion in the wooded area upstream. No survey control was used so all of the location and elevation information is relative. Elevations use an arbitrary datum which set the first setup point on the trail to Elevation 100' and the horizontal location was best-fit using the GPS waypoints and aerial photography to fit the survey.

Reach Descriptions

There were several distinct stream reaches with boundaries caused by man-made obstructions, vegetation changes and the overall basin slope. The overall stream slope surveyed over 1,300 feet was 3.97%, with slopes from less than 2% to over 30% in that length. Approximately 730 feet of the main channel of Zaccuse Creek flows through Mr. Pereyra's property, from approximately Station 2+50 to 9+80. Drawing 1 (attached) shows both the plan view and channel profile of the surveyed creek length. Below is a brief description of the distinct reaches that were identified during the survey;

Reach 1 (Below the Culverts)

This reach is a straight incised reach 77 feet long with a slope of 1.87% and hardened banks on both sides with rock walls. On the downstream end is a 5'-6" wide CMP culvert (width measured at the bed elevation) with a gravel bottom, which passes under private property. The upstream end of this culvert marks the downstream end of the survey.



Figure 1. Surveying Zaccuse Creek Center Line at the Upstream End of the 5'-6" Corrugated Metal Pipe (CMP) Culvert, at the Downstream End of the Survey (Station 0+00).



Figure 2. Looking Upstream Through Reach 1 with Riprap Banks on Both Sides.

Reach 2 (3-Culverts)

This reach includes the three culverts of interest under Shore Lane Drive, Sammamish Trail and Sammamish Parkway. The overall length is 173 feet with a slope of 3.94%.



Figure 3. Broken Timber and Pipe Across Inlet to Culvert #1.



Figure 4. Drop at Downstream End of Culvert #2.



Figure 5. Steep Water Surface Drop into Entrance of Culvert #2 Caused by Bedload Buildup Upstream of Culvert Entrance.



Figure 6. Drop at Downstream End of Culvert #3.



Figure 7. Zaccuse Creek Turns 90 Degrees from Drainage Ditch Along Parkway to Enter Culvert #3.

Reach 3 (Influenced by Culverts)

The reach immediately upstream of the culverts is a low gradient sandy bottom channel with some braiding indicating sediment deposition. The overall length is 350 feet with a slope of 2.45%. The first 150 feet flows next to the Parkway in a drainage ditch. In the next 200 feet there were multiple channels with some that disappear and emerge from thick blackberry mats. Not all channels were able to be followed or surveyed in this area. This is the most likely reach targeted for realignment and restoration work.



Figure 8. Zaccuse Creek Flowing in Drainage Ditch Along Parkway.



Figure 9. Multiple Channels in Low Gradient Depositional Area Influenced by the Culverts.



Figure 10. Channel choked with Vegetation in Low Gradient Depositional Reach Upstream of Culverts.

Reach 4 (Upstream of Culvert Influence and Below Falls)

This reach consists of a gravel bottom channel approximately 355 feet long at 3.68%. The channel is generally straight and follows the overall land slope in this area. Small deciduous trees, bushes and blackberries cover the banks, but the channel is mostly clear of obstructions. We were unable to survey this reach with the total station. This section was walked with a hand held GPS and machete to clear a walking path in the creek bed. It is not clear whether 100% of the creek flow is represented in this reach because there are multiple small side channels above and below that were not fully mapped. However, flow measurements were taken to check if a significant flow were bypassing this channel. Flow was measured upstream at 12+50, downstream at 0+50, and in Reach 4 at 7+50 with no discernible difference in flow. This suggests that any side channels that might bypass this reach carry a small amount of flow. The possibility of future changes in channel location must be considered for any channel design in Reach 3 and 4.



Figure 11. Relatively Straight Channel with Gravel Substrate in Reach 4, outside of the immediate Influence of the Culverts.

Reach 5 (Falls)

This reach consists of a steep section of creek (falls) where the bed elevation falls 5.2 feet over a horizontal distance of 17 feet. The falls are located near the eastern edge of Mr. Pereyra's property. The canyon walls formed by the falls contain a gravel/sand mixture which appears to provide a significant source of gravels for the reaches immediately downstream. The falls are formed as the creek transitions from a heavily forested section upstream with significant root structures of large cedars and other trees, to a section with less root structure to support the creek bed consisting of mainly small trees, bushes and blackberries.



Figure 12. Looking up at the Falls where Zaccuse Creek is Cutting Through the Root Supported Substrate as it Emerges from the Forested Area Upstream.



Figure 13. Standing at the Base of the Falls, Looking Downstream through the Cut Banks Left Behind as the Head-cut Moves Upstream.

Reach 6 (Upstream of the Falls): The survey continued upstream for another 327 feet to capture the bed characteristics of the forested reach upstream of Mr. Pereyra's property. This reach consists of a steeper gradient creek bed, which is at least partially supported by the root structure of the forest. There were some depositional areas with predominantly sandy beds followed by steep areas with large gravel beds and tree roots exposed. There were significant logs across the creek and other woody debris in the channel and the abandoned side channels. Two (2) discernible side channels were reported in this reach, with one of them large enough to have been the main channel at some point in the past. Sediment deposition and wind fall may have caused the creek to jump channels, and the same process could result in the creek forming a new channel, or returning to one of the old channels, at some point in the future.



Figure 14. Reach 6, Looking Downstream at the top of the Falls.



Figure 15. Sandy Depositional Area in Reach 6, with Woody Debris in the Creek.



Figure 16. Gravel Bed Side Channel in Reach 6, with Woody Debris Crossing the Side Channel Entrance.



Figure 17. Near the Upstream end of Reach 6, Gravel Bed with Slope of ~5%.



Figure 18. Wood Foot Bridge Crossing Zaccuse Creek at the Upstream end of the Survey.

Bankfull Width

A bank full width was measured at several locations in the creek in order to determine a reasonable value to use in a realigned creek section and in culvert design. Due to the impacted nature of Zaccuse Creek and the distinct reaches surveyed, some judgment was needed to determine an appropriate value for design. The measured bank full widths varied from 4.2 feet in the incised reaches to 5.8 feet in the more natural gravel bottom reaches to over 8 feet in the braided depositional areas. Since the culverts will be designed at a slope between 3 and 4%, with gravel beds, it is appropriate to use the section of creek which is most similar to the likely design slope and substrate as our reference reach for design. Because of this, the bank full width in the natural flowing gravel bottom reach of 5.8 feet was used, and rounded up to a bank full width of 6.0 feet for design purposes. It should be noted that this is already wider than the CMP culvert installed at the downstream end of the survey, and should serve as a good design value for the new culverts to allow semi-natural processes to take place in the creek bed through the culverts.

Pebble Count

A pebble count was conducted to aid in design of a streambed gravel mix for bed material placed in a new culvert and a re-graded section of creek. A free flowing area, which does not have root structure support, should be used as a reference reach for the pebble count. Reach 4 and 6 both have gravel substrate sections, from station 6+00 to 13+00, with an average slope of 4.98%. A reference reach was selected at the upstream end of Reach 6 for a pebble count. We selected a gravel reach section that appeared to be unaffected by root structures. This reach should have a stable gravel size distribution for this channel in the absence of root structural support. The slope is slightly greater than the culvert reach slope, so the gravel sizes reported in the pebble count results should be conservative for design. This pebble count can be used as a guide for design; it should be noted however, that these are preliminary results which would need to be refined and verified before any final design work can proceed on these projects. The results of the pebble count are reported below in Table 1, below.

Table 1. Pebble Count Results for Zaccuse Creek.

	Diameter	
	(cm)	(in)
D ₁₆	1.0	0.4
D ₅₀	2.5	1.0
D ₈₄	7.0	2.8
D ₁₀₀	16.0	6.3

Culvert Assessment

Barrier Determination

Those familiar with Zaccuse Creek know that the three culverts in question are together a fish passage barrier, and we trust the experience of the local property owners and Kokanee experts that the culverts taken together act as a complete barrier to fish passage, but to verify this anecdotal evidence we need to look at the existing culverts and determine if they are each fish passage barriers. The culverts were surveyed and water surface elevations and velocities were measured. These measurements are reported in Table 2. In order to determine if each culvert individually is a barrier we used the collected data and applied it to the WDFW Fish Passage Barrier Assessment Table and the Barrier Analysis Flow Chart, copied in as Figures 19 and 20. Using these criteria all 3 culverts are at least partial passage barriers and should be replaced. It should be noted that if 1 or 2 of the culverts are replaced and not the other(s) that the culvert(s) that are not replaced will become debris barrier(s) if not fish passage barrier(s). Also, the continuity of the creek processes would be affected if all culverts are not replaced.

Table 2. Existing Culvert Summary Table with Barrier Determination.

Culvert #	Description	Location	Slope ft/ft	Dimensions	Length ft (m)	Water Surface Drop ft (m)	Flow Depth ft (m)	Water Velocity fps (mps)	Passability Ratings Summary (using criteria in Table 3)	Barrier (Y/N)
#1	Bottomless Concrete Box Culvert	E. Lk. Samm. Shore Lane NE	0.019	1'-11" W x 3'- 1" H	9.3 (2.8)	n/a	0.6 (0.18)	1.53 (0.47)	1.0, 0.67, 1.0, 1.0	Y
#2	Concrete Circular Pipe	E. Lk. Samm. Trail	0.027	36" Diameter	33 (10.1)	0.8 (0.24)	0.20 (0.06)	7.22 (2.2)	0.67, 0.33, 0.33, 0.33	Y
#3	Concrete Circular Pipe	E. Lk. Samm. Parkway	0.029	30" Diameter	55 (16.8)	0.5 (0.15)	0.25 (0.08)	6.36 (1.9)	1.0, 0.33, 0.33, 0.33	Y

Table 3. Criteria for assigning passability to culverts that are assessed as barriers. When more than one parameter applies, use the more restrictive passability value (Table 3.3 WDFW).

Parameter	Value	Range	Passability
Water Surface Drop	≥0.24 meters	≥0.24 m & <0.5 m	0.67
		≥0.5 m & <1.0 m	0.33
		≥1.0 m	0
Slope (Culverts ≤18.3 meters length)	≥1.0%	≥1.0% & <2.0%	0.67
		≥2.0% & <4.0%	0.33
		≥4.0%	0
Slope (Culvert >18.3 meters length)	≥1.0%	≥1.0% & <2.0%	0.33
		≥2.0%	0
Velocity (Level B Result)	Exceeds WAC 220-110-070 velocity criterion for 15 cm (6 inch) trout <u>Culvert Length (m) Velocity (mps)</u> <30.5 ≤1.22 30.5-61.0 ≤0.91 >61.0 ≤0.61	<0.61 mps over criterion for 15 cm trout	0.67
		≥0.61 mps over criterion for 15 cm trout	0.33
Depth (Level B Result)	<0.30 meters	≥0.15 m & <0.30 m	0.67
		≥0.05 m & <0.15 m	0.33
		<0.05 m	0
Tidegate or Floodgate	Gate Style	Flap gate	0
		Self-regulating	0.33

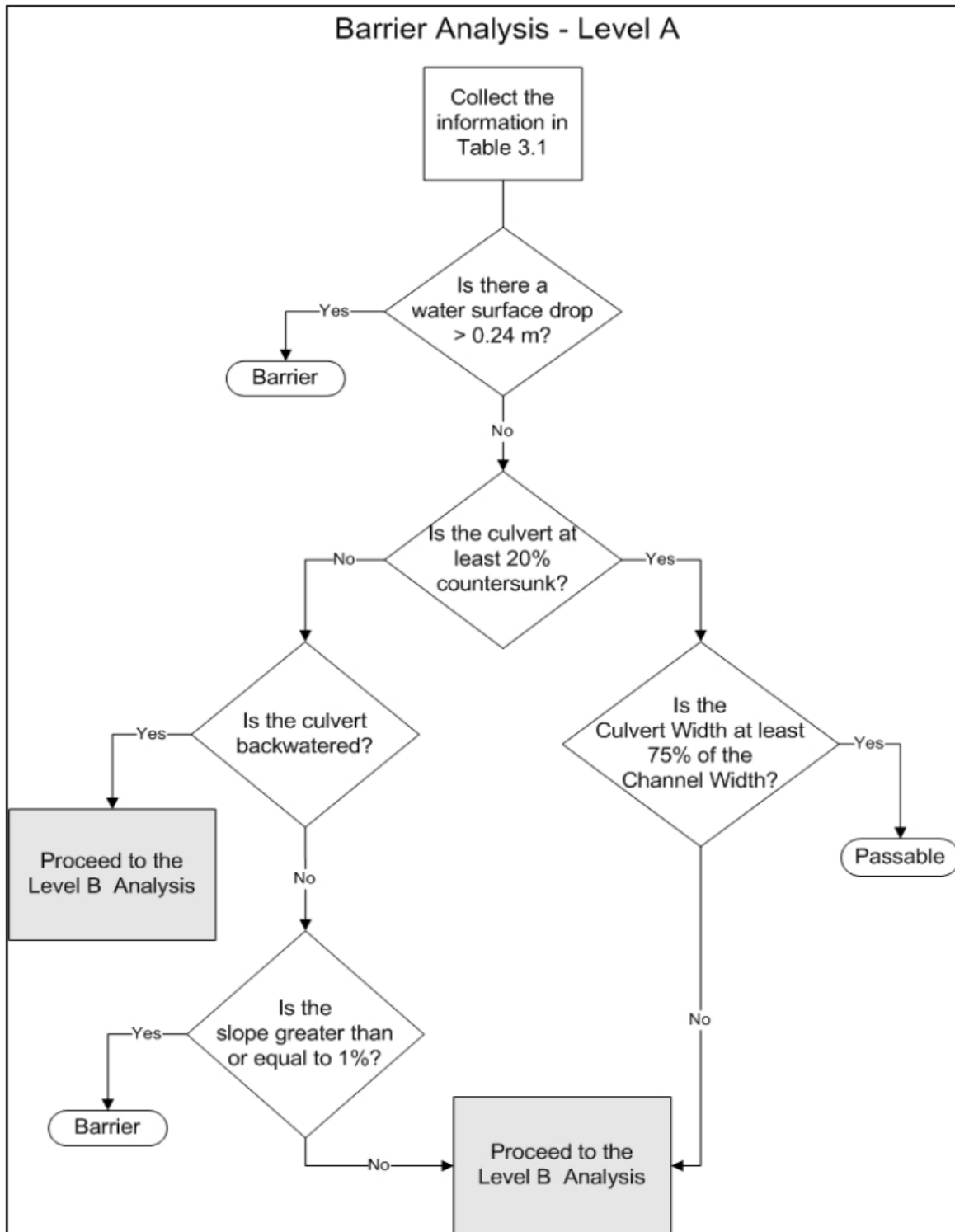


Figure 19. Flow Chart of the Level A Culvert Analysis.

Development of Conceptual Design for Fish Passage Improvements

The stream survey and culvert assessments were performed with the goal of providing guidance to the different culvert owners and property owners, so they can coordinate their individual efforts for fish passage on Zaccuse Creek. We have determined that all of the culverts are at least partial fish passage barriers, and that together they act as a total barrier to upstream fish passage. There are many possible culvert designs for each culvert to be replaced, and these designs should be coordinated for a successful overall project. In order to reduce the degrees of freedom in the design combinations, we have made some assumptions to simplify the design recommendations.

Assumptions:

1. The first assumption is that the horizontal locations (plan view) of the culverts will not change. This will minimize the channel realignment, utility movement, easement locations, property encumbrances etc., and will generally simplify the alternatives and minimize costs.
2. The second assumption is that all three culverts will be of similar design (slope, width, bed shape, and bed material).
3. The third assumption is that the WDFW Stream Simulation Design will be used, and results will be shared and used for all 3 culverts.

Discussion of Culvert Slopes and Elevations

The overall surveyed slope through Reach 2 (culvert reach), from the downstream end of Culvert #1 to the upstream end of Culvert #3, is 3.94%. The creek bed is scoured below each of the culverts followed by a deposit of bedload before the creek enters the next culvert. This is due to the very high velocity in the undersized culverts resulting in a concentrated jet exiting the culvert on the downstream end. The water jet scours material from below the culvert and much of this scoured material is deposited a short distance downstream as the water slows before entering the next culvert. This provides the worst case for fish passage because the downstream end of the culvert becomes perched as the bed is scoured in this area, and the upstream end of the culvert becomes partially blocked by bed load from the scour from the next upstream culvert.

The slopes of both Reach 1 and Reach 3, upstream and downstream of the culverts, are lower than the Reach 2 slope. The undersized culverts and road fill have created a low slope

depositional area just upstream of the culverts in Reach 3, where the creek is braided and meanders as it tries to find a path through the sediment that has been deposited in this area. If the culverts are sized to provide enough width so that semi-natural stream processes can take place, including sediment transport, then the tendency of the creek to deposit material in this reach will be reduced to a more natural level, and the braiding and meandering can be eliminated.

The existing slope through Reach 2 is 3.94%, while the slope both upstream and downstream of Reach 2 is significantly lower. In the absence of the road fills and culverts one would expect the slope to decrease in the downstream direction, as the creek nears Lake Sammamish. There is some opportunity for reducing the slope through the culverts by re-grading a portion of Reach 1, or by lowering the upstream invert of Culvert #3. While lowering the invert of Culvert #3 is a possibility, it would be more costly, and more difficult to coordinate with the other projects. Instead we recommend re-grading the upper part of Reach 1 to lower the slope through the culverts. Reach 1 is currently incised with hardened high banks, which would allow for some re-grading (channel fill) without increasing the flooding risk. Below Culvert #1 the bed is slightly scoured and slowly rises in the downstream direction for approximately 34 feet. By extending the creek bed re-grade for 34 feet downstream of Culvert #1 to match the existing bed elevation at that location, the resulting slope would be reduced to 3.41% through the culverts.

Realigned Channel in Reach 3

A new channel upstream of the culverts should be excavated of roughly the same dimensions and slightly higher slope as the channel through the culverts to create a continuous reach. *(Note: It is advised that any channel design in this reach take into account the existing side channels, and reconnect them to the realigned channel in order to provide some refuge at high flows.)*

Reach 4 upstream can be used as a guide for connecting Reaches 2 and 3 together to create a coordinated project with slopes decreasing in the downstream direction. Reach 4 has an overall slope of 3.68%, and a realigned channel in Reach 3, as shown on Drawing 2, would have a slope of approximately 3.48% extending from the upstream end of Culvert #3 up to approximately station 6+00 on the existing channel. This slope is slightly higher than the proposed 3.14% in the culvert reach just downstream. Drawing 2 (attached) shows the resulting plan and profile for the proposed changes. *(Note: If the upstream invert of Culvert #3 can be lowered by 1 foot then, the channel realignment in Reach 3 would be 29 feet longer at the same slope, allowing for some sinuosity and more channel habitat. Also, the Reach 2 slope through the culverts could be lowered to 2.9% while maintaining the same downstream control elevation).*

Culvert Width

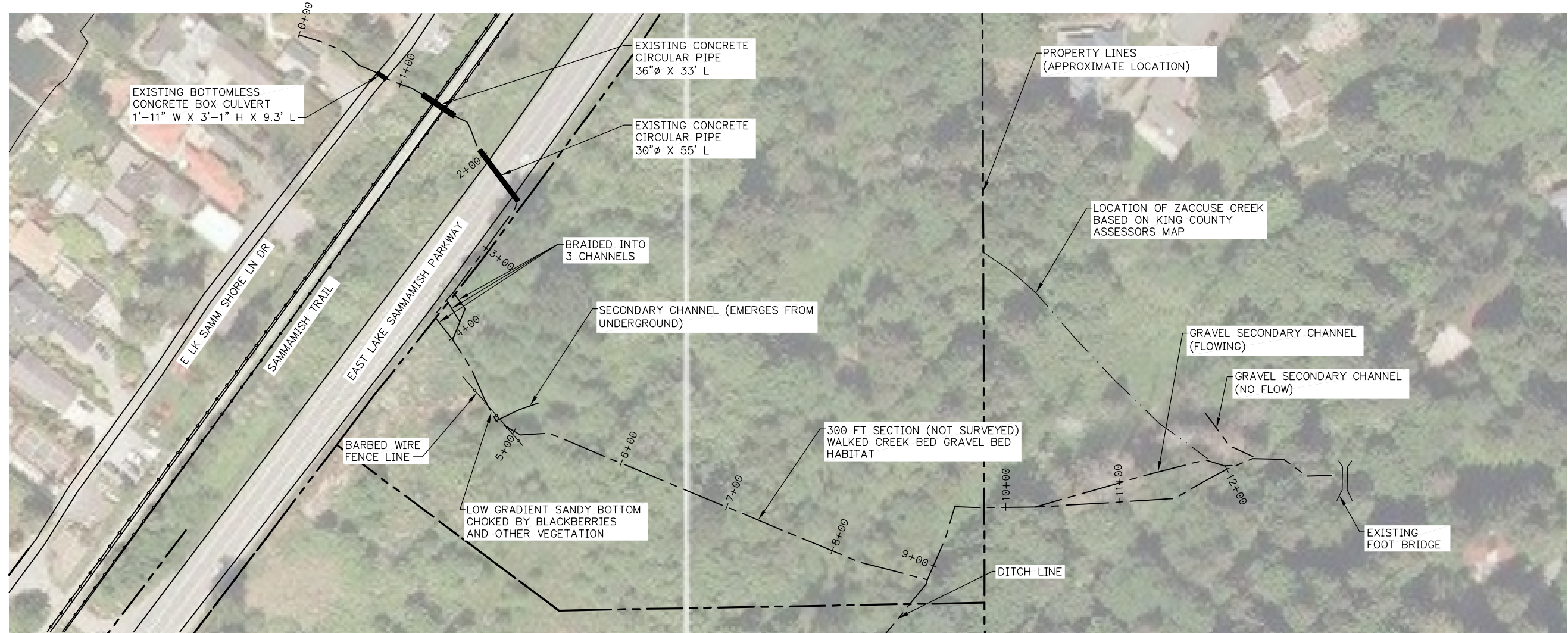
A bankfull width of 5.8 feet was selected from the most representative reference reach for the preliminary design purposes of this memo. Using Equation 4 from Chapter 6 – Stream-Simulation Design Option of WDFW’s “Design of Road Culverts for Fish Passage” a culvert bed width of 10 feet was calculated. It should be noted that this is the culvert width at the bed elevation so the actual culvert width may be larger than 10 feet, depending on the type of culvert used.

The information in Table 4 and the design shown on the attached Drawing 2 provide the design recommendations for this memo.

Table 4. Summary Table for Preliminary Culvert Design.

Culvert #	Recommended Culvert Type	Location	Slope ft/ft	Width of Culvert at Bed Elevation ft	Length ft	Bed Invert Elevations ¹	
						Downstream Design/ (Existing)	Upstream Design/ (Existing)
#1	Bottomless Box (3-sided) or Arch Culvert	E. Lk. Samm. Shore Lane NE	0.034	10	10	92.45/(91.55)	92.79/(91.66)
#2	Bottomless Box (3-sided) or Arch Culvert	E. Lk. Samm. Trail	0.034	10	33	93.98/(93.80)	95.10/(94.67)
#3	Bottomless Box (3-sided) or Arch Culvert	E. Lk. Samm. Parkway	0.034	10	55	96.48/(96.74)	98.35/(98.35)

¹ All elevations are based on local datum with survey station #1 set to 100' arbitrarily.

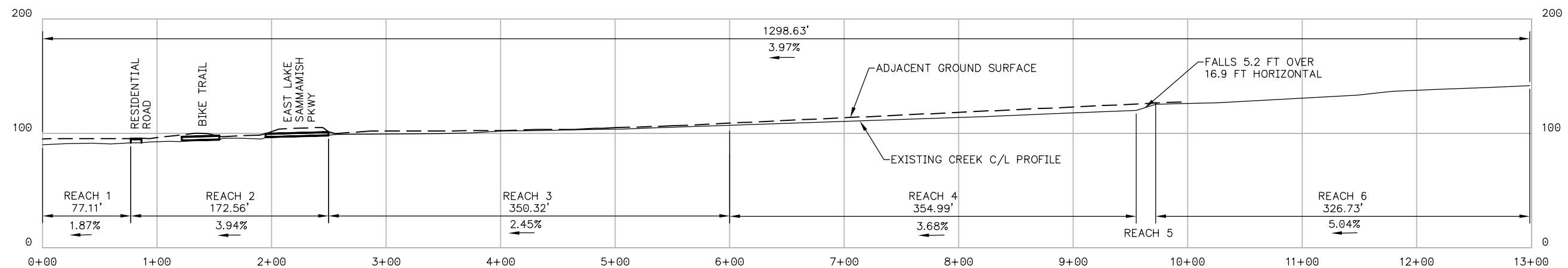


NOTES:

1. SURVEY APRIL 13TH, 2012. ZACCUSE CREK FLOW = 1.0 CFS. HORIZONTAL LOCATION BASED ON BEST FIT TO AERIAL PHOTO. VERTICAL DATUM BASED ON SETUP #1 ON SAMMAMISH TRAIL ARBITRARILY SET TO 100.0'.

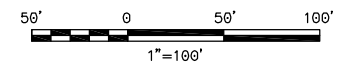
SITE PLAN


SCALE: 1" = 100'

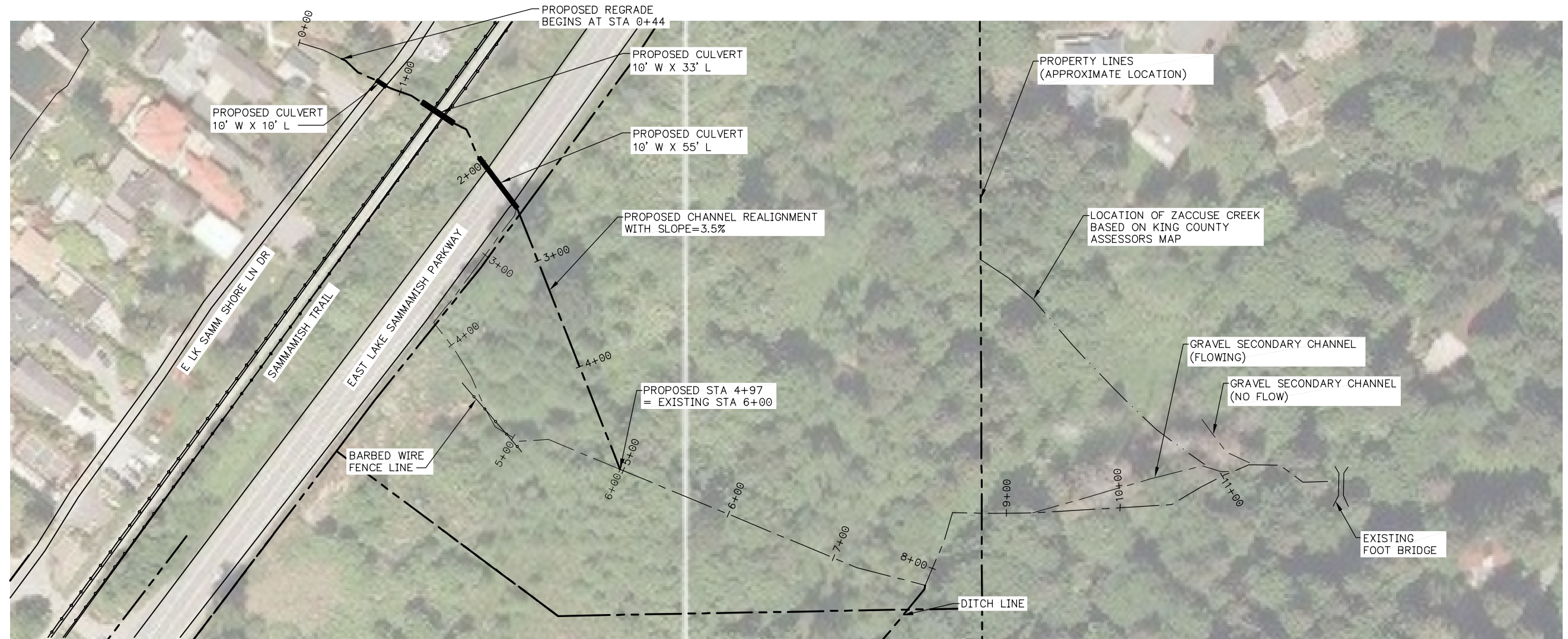


EXISTING CHANNEL PROFILE

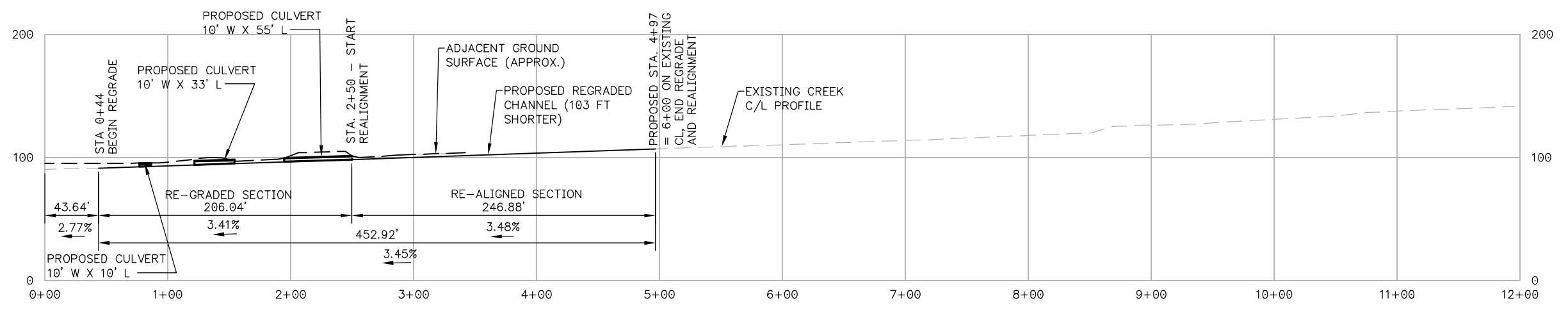
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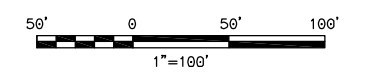
 <p>Resource Consultants, Inc. REDMOND, WA.</p>	<p>PEREYRA ZACCUSE CREEK</p>
	<p>DRAWING 1 EXISTING PLAN AND PROFILE</p>



SITE PLAN
SCALE: 1" = 100'



PROPOSED CHANNEL PROFILE
SCALE: 1" = 100'



Resource Consultants, Inc.
REDMOND, WA.

PEREYRA
ZACCUSE CREEK

DRAWING 2
PROPOSED PLAN AND PROFILE