HERRERA

TECHNICAL MEMORANDUM

Date: July 18, 2017

To: John Featherstone, City of Shoreline

From: Ian Mostrenko and Mark Ewbank

Subject: Concept Design Evaluation of Fish Passage Improvements in Lower Boeing Creek

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CONTENTS

APPENDICES

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2200 Sixth Avenue | Suite 1100 | Seattle, Washington | 98121 | p 206 441 9080 | f 206 441 9108
PORTLAND, OR | MISSOULA, MT | OLYMPIA, WA | BELLINGHAM, WA

TABLES

FIGURES

Introduction

Potential upstream fish passage for salmonids is blocked by several features in the reach of Boeing Creek between Hidden Lake and the Puget Sound shoreline. In May 2016, Shoreline City Council authorized staff to pursue a Hidden Lake Dam Removal Project approach including assessment of potential fish passage improvements downstream of Hidden Lake to best serve the long-term overall health of Boeing Creek, and also to enhance competitiveness for fish passage-related grant funding for these planned improvements. Accomplishing fish passage restoration from Puget Sound to a point upstream of Hidden Lake will require restoring fish passage in three general areas: 1) the lower reach of Boeing Creek downstream of Northwest Innis Arden Way, 2) the creek crossing of Northwest Innis Arden Way, and 3) the lake area upstream of Northwest Innis Arden Way.

This memorandum documents analyses of a conceptual approach for restoring fish passage in the lower reach of the creek from Puget Sound to the downstream side of the Northwest Innis Arden Way crossing, and implications of fish passage improvements downstream of the roadway on the Hidden Lake Dam Removal Project and eventual replacement of existing creek culverts beneath Northwest Innis Arden Way. Figure 1 shows the extents of the creek that are the subject of this memorandum, which coincide with the “Innis Arden Reach” and “Lower Reach” as documented in the Boeing Creek Basin Plan (Windward et al. 2013).

Existing Conditions in Lower Boeing Creek

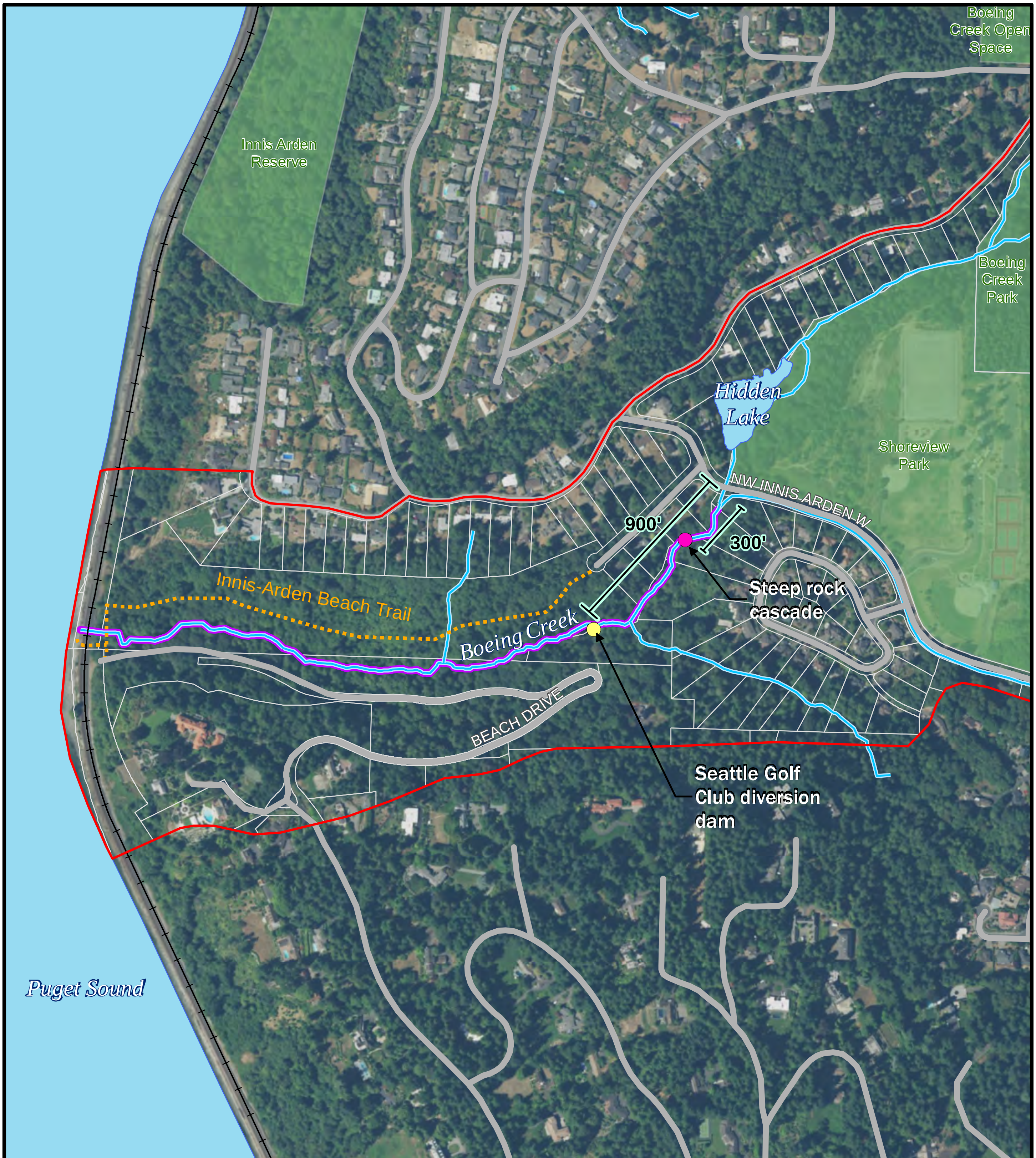
Between Northwest Innis Arden Way and the Puget Sound shoreline, Boeing Creek flows through a natural channel amid a forested ravine area. While those are generally favorable characteristics for good quality fish habitat, potential upstream fish passage is completely prevented by constructed impoundments in two places: 1) a steep rock cascade approximately 300 feet downstream of the road (Figure 2), and 2) a dam made of sheet pile approximately 900 feet downstream of the road, that formerly served to divert water for the Seattle Golf Club (Figure 3). Both of these features create an abrupt drop in the channel elevation of approximately 12 to 13 feet. A third major fish passage barrier is a more gently sloped but longer rock cascade extending from the outlet of twin Boeing Creek culverts beneath Northwest Innis Arden Way. If fish migrating upstream could make it to the outlet of the twin culverts beneath the road, the culverts themselves would pose a significant barrier to upstream passage because they create shallow and high-velocity flow conditions most of the time. The dam impounding Hidden Lake represents a fifth major fish passage barrier in the system. Additionally, due to extensive development in the watershed upstream of Hidden Lake, the creek’s natural hydrology has been altered and resultant high flows during larger storm events have eroded the channel in several places, creating smaller obstacles to fish passage, degrading habitat quality, and inducing hillslope instability on several private properties downstream of Hidden Lake.

For fish to be able to pass unimpeded from Puget Sound upstream through the Hidden Lake area each of these major barriers would have to be removed and a gradually sloped channel would need to be reconstructed for most of that stream channel length. As described later in this memorandum, restoring fish passage for that much stream length is a considerable challenge. This is partly because the land through which the creek flows downstream of Northwest Innis Arden Way is all privately owned, and vehicular access to the creek is currently provided in only one location amid that land at the Seattle Golf Club diversion dam site. The ravine slopes adjacent to the channel are relatively steep for most of the lower creek reach, with minor landsliding evident in several locations.

Anadromous salmonids that historically used and currently use the creek include coho, chum, and Chinook salmon, and cutthroat trout (Windward et al. 2013). Several reaches surveyed in the fall of 2016 contained average gradients of 4 to 5 percent that appeared to be fish passable, but those areas contained tight clusters of at least three to four fallen trees in excess of 48 inches in diameter that have formed complex grade control features. Several adult coho carcasses were observed approximately 700 feet upstream of the creek mouth during a site reconnaissance by Herrera staff on October 27, 2016, so it is apparent that woody debris inducing local channel gradients between 4 to 5 percent are currently not precluding coho passage.

The historical average gradient in the sub-reach of Boeing Creek from the current Seattle Golf Club diversion dam area to the Northwest Innis Arden Way crossing was likely closer to 7 to 8 percent. Based on that channel gradient and the underlying geology, historical fish passage upstream of the diversion dam area was likely intermittent and enabled by complex grade-control features created by dense clustering of very large woody debris. Furthermore, it is likely that the intermittent nature of fish passage in that reach of the creek was also species-dependent. Chinook and chum salmon have been found close to the mouth of the creek (TetraTech/KCM 2004), but recent references/documentation of either of those species in lower Boeing Creek are unknown or unavailable. Altered hydrology, sediment delivery, channel incision, and channel straightening have likely shaped the lower Boeing Creek current channel geometry to be incompatible with these larger salmonid species. With increasing prevalence of pink salmon in Puget Sound, it is possible that pink salmon will use Boeing Creek in the future whereas they have not been documented in the creek in the past.

Taking into account all available information, past and present, the salmonid species that would most likely benefit from fish passage barrier removals as described in this memorandum are coho salmon and sea-run cutthroat trout, and possibly pink salmon as well (if introduced to the creek). Over time, the larger species (Chinook and chum) may reoccupy Boeing Creek after the removal of the Hidden Lake Dam that has impeded downstream sediment delivery and altered channel morphology, but future passage for larger salmonids is uncertain and difficult to predict due to the highly altered hydrology of the basin.



Legend

Project area	Street		
Tax parcel	Stream		
Open water	Lower Boeing Creek Reach		
Park	Steep rock cascade		
Railroad	Seattle Golf Club diversion dam		
Trail			

Figure 1.
Lower Boeing Creek Reach.

Scale: 1" = 600'

0 300 600 1,200 Feet

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USDA, Aerial (2015)

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Figure 2. Looking Upstream at Steep Rock Cascade Between Northwest Innis Arden Way and Seattle Golf Club Diversion Dam.

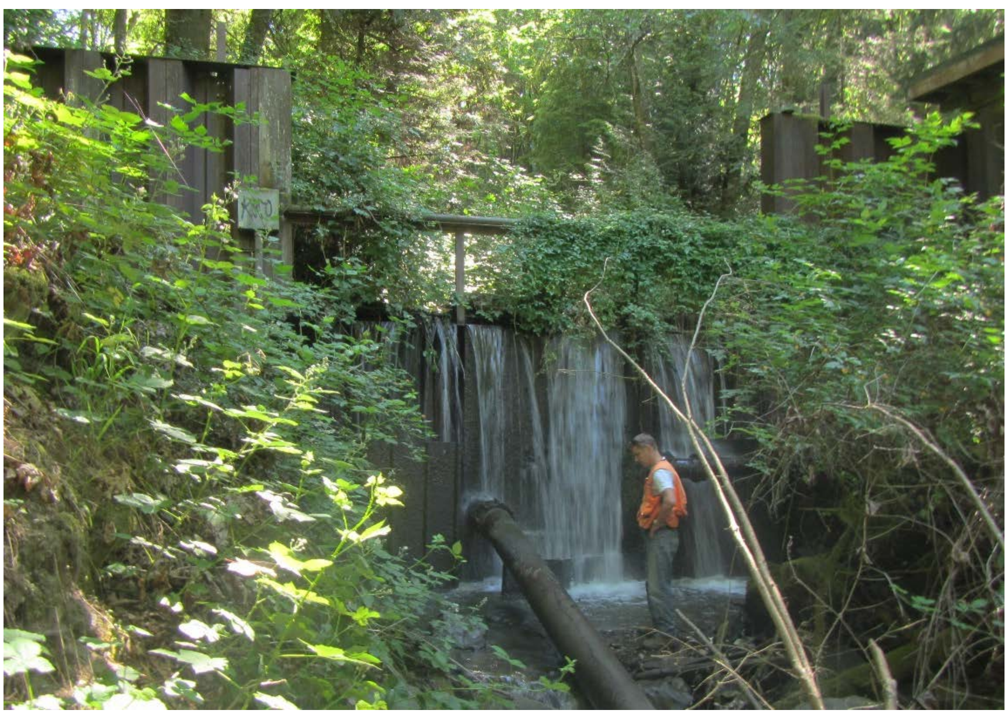


Figure 3. Looking Upstream at Seattle Golf Club Diversion Dam.

Fish passage analysis and design requires a reasonably accurate understanding of both high flood flow magnitudes for channel stability and low flows for fish passage. Flow estimates were obtained from several sources. Flood flow estimates were obtained from the Boeing Creek Basin Plan (Windward et al. 2013). Smaller flows such as the 10 percent exceedance and average annual flow required for assessing maximum permissible velocities for fish passage were estimated by Herrera using gage data collected in 1992 and 1993 by King County (King County Hydrologic Information Center) and data collected by Herrera in 2016 and 2017 at a flow gaging site upstream of Hidden Lake. Table 1 lists flow rates for various frequencies used in the analyses documented in this memo.

Table 1. Boeing Creek Flow Rates Used for Fish Passage Concept Design Analysis Downstream of Hidden Lake.

Frequency	Flow Rate (cfs)	Design Importance
100-year	227.3	Channel Stability
25-year	160.5	Channel Geometry and Stability
2-year	72.1	Channel Geometry (Stage 2)
10 Percent Exceedance	5.4	Fish Passage
Average Annual	3.7	Channel Geometry (Stage 1)/Fish Passage

cfs – cubic feet per second

Design Concept for Fish Passage Upstream to Northwest Innis Arden Way

Based on recent reconnaissance of the entire length of Boeing Creek downstream of Northwest Innis Arden Way, it appears that the best, sustainable instream habitat conditions (with pools, suitable spawning substrate, no channel downcutting or otherwise significantly unstable banks, and woody debris retention) coincide with sections of the channel having a longitudinal slope of about 2 percent or less. Therefore, a concept for restoring fish passage throughout the lower reach of the creek should seek to preserve as much of the channel length as possible with a slope of 2 percent maximum. By doing that, accomplishing a “smoothing out” of the currently disjointed longitudinal profile would require creation of some steeper sections interspersed with flatter (2 percent maximum slope) sections. The overall elevation drop from the entrance to the culverts on the north (Hidden Lake) side of Northwest Innis Arden Way to the Puget Sound shoreline is 160 feet over a total distance of approximately 3,300 feet, equating to an average channel slope of 4.8 percent in the study reach for fish passage improvements downstream of Hidden Lake. However, a large portion of the elevation change (85 feet) occurs in the 900 feet of stream length between Northwest Innis Arden Way and the downstream side of the Seattle Golf Club diversion dam, with an average slope of 9.5 percent in that sub-reach.

Analysis of the creek valley topography from upstream of Hidden Lake to Puget Sound shows that the average slope over that length is (and likely historically was) about 5.4 percent, without accounting for local variations in the natural channel alignment that would have effectively flattened the gradient for native fish passage. That slope is not too steep, yet is fairly challenging, for naturally passable conditions for coho salmon and sea-run cutthroat, particularly for returning spawners and juveniles that have yet to outmigrate to Puget Sound. Furthermore, the historical channel gradient was most likely flatter in the lower reach approaching Puget Sound and steeper than 5.4 percent from present-day Northwest Innis Arden Way to the Seattle Golf Club diversion dam area (as described previously), meaning that upstream salmonid passage was intermittent and sometimes blocked or impeded by steeper conditions as the channel adjusted to large floods, sediment delivery, and downed trees in the channel. Restoring fish passage in Boeing Creek should have these types of historical channel characteristics in mind.

Design Approach

There are many design options that could be used to create fish-passable conditions in lower Boeing Creek, all of which would require some form of fixed channel grade control (such as via a series of weirs, a hardened bed, and/or porous dams that emulate small beaver dams) to maintain the necessary water surface depth and velocity for swimmable conditions under a wide range of flows. Given the considerable length of Boeing Creek that would need to be modified to create continuous fish passage from near the mouth of the creek to Northwest Innis Arden Way, and the associated high cost of those modifications, it is preferable to use a design approach that is durable, inherently redundant to be able to “self heal” when shifting of the channel bed inevitably occurs over time, and not prone to failing if one or more step-pool elevation drops (such as a weir) were to blow out or be undermined.

The historical channel was probably dominated by large wood clusters that would “self heal” over time with respect to channel gradient, but those adjustments would be slow and would create intermittent fish passage barriers that could persist over many years. As such, restoration of historical conditions would not provide continuous passage. Furthermore, re-creating historical conditions is unrealistic because importing hundreds of trees/logs more than 4 feet in diameter is not feasible. The use of smaller-sized logs to create a gradual channel gradient would require hundreds of small grade-control step structures, which have been found to be prone to failure, especially in steeper gradient systems, and they typically cannot “self heal” due to the size of available wood. To avoid necessitating a continuous sequence of over 100 engineered small step-pool drops through the length of lower Boeing Creek, the concept design described herein follows the roughened channel design approach presented in the Washington Department of Fish and Wildlife’s (WDFW’s) Water Crossing Design Guidelines (Barnard et al. 2013).

Roughened channels use large rock (e.g., boulders or riprap) mixed with smaller cobbles, gravel, and sediment to create hardened substrate that resists deformation under high-flow conditions while creating numerous micro-scale pathways for flow conveyance and fish passage under low-flow conditions and also providing substrate suitable for spawning in many locations. Figure 4 shows an example of a recently constructed roughened channel in Coal Creek in the city of Bellevue, Washington. That project created over 400 feet length of roughened channel extending from a new roadway culvert through a section of channel where there were previously a series of weirs that impeded upstream fish passage. The average slope of the roughened channel segments in Coal Creek is 5 percent, and those are interspersed with 1.4 percent slope segments. The 1.4 percent riffle segments emulate the natural channel gradient in Coal Creek to support formation of pools and riffles that are vital for fish resting. The average gradient in the entire restored Coal Creek reach is approximately 3.8 percent, which is flatter than the reach of Boeing Creek described herein.

Figure 4. Roughened Channel Section in Coal Creek, Bellevue, Washington.

Channel Profile and Typical Cross Sections Analysis

Topographic survey was collected in fall 2016 throughout lower Boeing Creek to support this analysis. Greater topographic resolution was obtained in the vicinity of the Seattle Golf Club diversion dam. Representative cross-sections were obtained at intervals between Northwest Innis Arden Way and the diversion dam area, and from downstream of the diversion dam to near the BNSF Railway crossing. Numerous channel bed elevation points were obtained to enable creating an accurate thalweg elevation profile for the entire reach downstream of Hidden Lake.

As stated above, the topographic data indicate an average slope of 9.5 percent in the 900 feet of Boeing Creek length extending through the two major fish passage barriers (steep rock cascade and the Seattle Golf Club diversion dam) downstream of the Northwest Innis Arden Way culverts. A continuous slope of 9.5 percent is steeper than historical conditions in this reach of Boeing Creek and is approaching the upper limit for a roughened channel (personal communication with Channing Syms [e-mail], WDFW, March 24, 2017) in a fish passage culvert context. Thus, fish passage would not be achievable with a continuous slope of 9.5 percent over much of the 900 feet of length due to fish exhaustion without the benefit of pools for resting.

Therefore, a “stair-step” profile approach would be necessary to provide periodic resting areas and possibly even areas that would support spawning. The natural gradient segments in a stepped streambed profile would be constructed at 2 percent grade to mimic the natural and sustainable gradient of the pool-riffle areas observed in the creek downstream of the Seattle Golf Club diversion dam.

Using the topographic survey data, an alternating sequence of 100-foot-long steeper cascade segments and 50-foot-long 2 percent pool-riffle segments was iteratively laid out to assess extents of bank excavation and channel fill that would be required, while attempting to yield a channel bed elevation at the Northwest Innis Arden Way crossing that would be compatible with tying into a fish-passage channel through the Hidden Lake area. After laying out several iterations, it was determined that using a 10 percent slope in the steeper cascade segments of the roughened channel could accomplish fish-passable conditions for the length of creek under consideration while minimizing disturbance of good quality habitat that extends to the creek mouth from a point about 325 feet downstream of the Seattle Golf Club diversion dam. The creek profile and cross-sections in Appendix A reflect an alternating 10 percent/2 percent grade for cascade and pool-riffle segments, respectively, along approximately 1,050 linear feet of rebuilt channel. Within that 1,050 feet of length, a total of 700 feet length would be comprised of a roughened channel at 10 percent slope and a total of 350 feet length would be comprised of a natural (non-roughened) channel with 2 percent slope.

Cost Estimates for Construction and Long-term Inspections and Maintenance

The elevation profile and cross-sections in Appendix A were used to create a three-dimensional surface in CAD with which to compare to a three-dimensional surface of the existing channel bed and banks to yield estimates of the total excavation volume and fill volume that would be required. The construction cost estimate covers the length of channel from the downstream end of the conceptual design to approximately Station 11+20 (see the plan and profile drawings in Appendix A), which is the approximate location where channel modifications associated with eventual culvert replacements for the Northwest Innis Arden Way crossing would tie into the channel bed and banks downstream of the road. The Washington Department of Fish and Wildlife (WDFW) roughened channel design guidance (Barnard et al. 2013) includes sizing of the mix of boulders, cobbles, gravel, and sediment needed to remain stable while promoting fish passage under low-flow conditions given the prevailing flow regime of a stream system. The flow data presented in Table 1 were applied to that design guidance to derive estimated sizes of the larger boulders on down to the smaller substrate that would be required in each of the 10 percent and 2 percent sections of the channel, and thus to enable deriving quantity estimates for different size classes of streambed material that would have to be imported for channel construction. (An important point to note is that the existing Boeing Creek channel contains very few larger boulders and cobbles, in part because the creek’s natural development did not cut through geology creating such material.)

Construction Cost

The quantity estimates for channel excavation, channel fill (using excavated material), and imported streambed rock form the backbone of the planning-level construction cost estimate presented in Appendix B. In addition to the earthwork and streambed material import, the cost estimate includes other major items of work that could be expected for successful construction and to facilitate long-term inspections and maintenance (and required to satisfy anticipated permit conditions, described in more detail below). Suitable access for construction amid privately owned properties represents a significant challenge for ultimately implementing the fish passage improvements described herein, and triggers a corresponding high cost. The construction cost estimate in Appendix B includes creating the permanent access roadway(s), but does not include any costs associated with property easements or acquisitions.

It is anticipated that a condition of obtaining a Hydraulic Project Approval permit for the project from WDFW would be providing and maintaining suitable access for the life of the project (e.g., decades) to enable inspections and repairs as necessary to ensure fish passability (personal communication with Larry Fisher [e-mail], WDFW, April 6, 2017). If a section of the channel deforms considerably and compromises fish passage, repair would most likely have to be done with heavy equipment, necessitating a small roadway(s) for permanent access.,

A contingency of 50 percent is added to the estimate to account for unforeseen cost issues, which is typical for concept design development. Additionally, the cost estimate in Appendix B includes permitting and design costs.

Long-term Inspection and Maintenance Costs

For planning purposes, it is assumed that annual inspections would be performed in the dry season via the permanent access road along the creek. These inspections would be done to determine if there are any local areas along the modified creek length that are not suitable for fish passage due to creek bed or bank erosion in the preceding wet season, and if so to outline the extent of repair needed (including any repairs that may be needed to the access road to enable equipment and vehicles to complete the channel repairs). This type of inspection work, including documentation and coordination of it, is estimated to cost $500 per year (2017 dollars) on average.

It is difficult to accurately estimate long-term maintenance costs to assure sufficient fish passage conditions along the length of modified creek channel. Thus, some simplifying assumptions are necessary, as follows:

- Repair work would be needed every 3 to 5 years

- The repair would not require importing streambed/bank rock, but would require shifting rock in the channel, and repositioning one or more downed trees, using heavy equipment to restore original "as-built" channel conditions
- Minor access road clearing and maintenance/upkeep would coincide with mobilizing to complete creek channel repairs
- Repair work would require a crew of two laborers, a small truck, and an excavator, for one week. This crew cost equates to about $25,000 per repair effort (in 2017 dollars), including a modest contingency for unforeseen issues. In addition, repair work would require technical and administrative oversight to assure it is done adequately and documented clearly; these oversight and administration costs are estimated to be $5,000 per repair cycle (in 2017 dollars).

Assuming a project design life of 75 years, the cumulative maintenance and repair costs could thus be on the order of $500,000 to $700,000 (2017 dollars), including the costs of routine annual inspections and oversight and administration of periodic repair work.

Discussion

Based upon discussions with Larry Fisher and Channing Syms of WDFW, the overall length and relatively steep slope of the roughened channel concept described above is beyond WDFW's experience in past fish passage projects, and thus represents an unprecedented approach in Washington State that could indicate an inherent risk to long-term success. If a large tree falls into the roughened channel, or other debris forms a local flow blockage, turbulent flow deflected into erodible soil above the rock lining the channel bed and lower bank could readily induce an abrupt elevation drop that is not passable for fish, triggering a need for maintenance action to restore the channel area that outflanked the rock lining. Given the forested land use surrounding the creek, it would be nearly impossible to prevent treefall from partially obstructing the engineered channel. The risks of maintaining "as-constructed" conditions is the reason for anticipating permanent inspection and maintenance access as a condition of the HPA permit.

In addition to technical design challenges and high costs, establishing construction access and long-term access thereafter would likely require acquiring portions of several private properties or negotiating permanent easements on those properties. Currently, downstream of Northwest Innis Arden Way, Boeing Creek flows along the boundaries of eight individually owned parcels, then along the boundaries of three larger parcels owned by the Seattle Golf Club, Innis Arden Club, and the Highlands, Inc., before crossing the BNSF railroad right-of-way and entering the Puget Sound (Figure 1). The City of Shoreline does not own or have easements for any of this reach of Boeing Creek downstream of Northwest Innis Arden Way. It is probably unrealistic to expect that this group of private property owners could collectively manage the long-term inspection and maintenance role and capably fulfill that role to ensure long-term fish-passage success. A key question for the City of Shoreline is, without any ownership of land along the lower stream corridor, whether project construction and/or long-term inspections and maintenance are consistent with the City's overall responsibilities, authority, and resources to pursue.

One consideration that can encourage private property owner willingness to collaborate in large-scale channel improvements for fish passage relates to existing erosion concerns on many of those properties. The roughened channel design approach would provide a stable toe for the creek banks through most of those properties, reducing potential for future bank erosion that can lead to larger-scale slope instability extending inland from the creek. A more predictable creek bank is likely of interest to most of the property owners who would be affected by construction of a long section of roughened channel.

Given that most grant programs targeting removal of fish passage barriers in the Puget Sound region are currently focused on endangered species (e.g., Chinook and steelhead) that would possibly have only marginal benefits from removing fish passage barriers in lower Boeing Creek, the relatively small size of this creek, and the estimated high costs and degree of challenges in implementation and maintenance of a large-scale roughened channel project, the prospects for obtaining grant funding in the near term for the project as described in this memorandum are low. However, there are several relevant grant programs to consider pursuing, and the focus of stream restoration grant programs evolves over time. There is increasing focus on removing fish passage barriers at roadway crossings in Washington State that will lead to large sums of grant money being allocated in the years ahead for fish passage improvement projects. That funding climate for fish passage could improve the chances of grant funds being viable for fish passage improvements in Boeing Creek.

Implications for Hidden Lake Dam Removal Project

The City of Shoreline intends to proceed with modifications to Hidden Lake and the dam impounding it, and to eventually replace the Boeing Creek culverts crossing Northwest Innis Arden Way, in ways that could be compatible with fish-passage improvements in the lower creek. Thus, the roughened-channel design plan and profile design concept presented in Appendix A would seamlessly tie into the modified creek channel on the downstream (south) side of Northwest Innis Arden Way once the existing culverts are replaced. If future efforts eventually lead to fish passage restoration improvements being implemented in lower Boeing Creek, the City's work at and upstream of Northwest Innis Arden Way would allow for fish passage in Boeing Creek from Puget Sound to upstream of the current Hidden Lake configuration.

REFERENCES

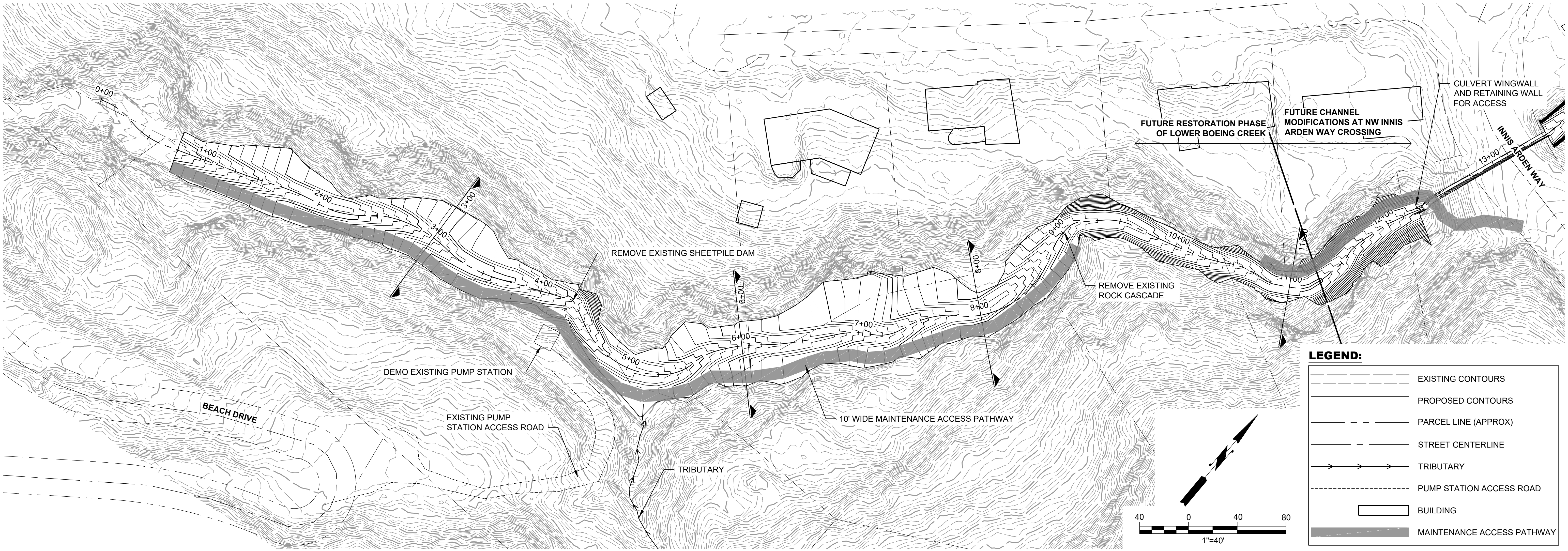
Barnard, R.J., J. Johnson, P. Brooks, K.M. Bates, B. Heiner, J.P. Klavas, D.C. Ponder, P.D. Smith, and P.D. Powers. 2013. Water Crossing Design Guidelines. Washington Department of Fish and Wildlife, Olympia, Washington.

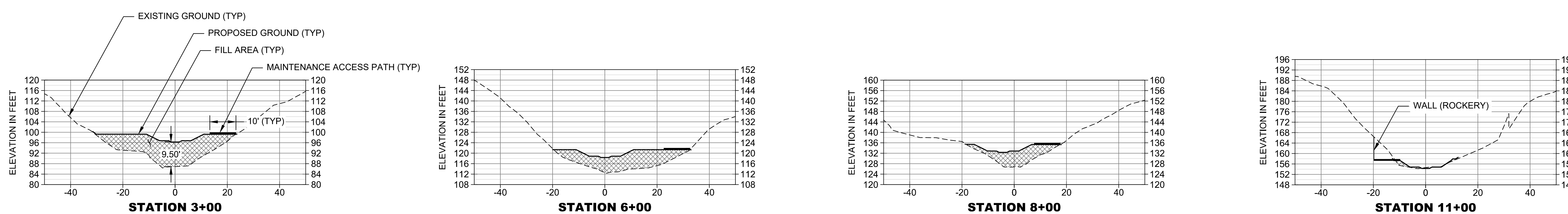
TetraTech/KCM. 2004. Boeing Creek Basin Characterization Report. Prepared for City of Shoreline by TetraTech/KCM, Inc., Seattle, Washington.

Windward Environmental, Osborn Consulting, and The Watershed Company. 2013. Boeing Creek Basin Plan. Prepared for City of Shoreline.

APPENDIX A

Lower Boeing Creek Fish Passage Restoration Plan and Profile Design Concept





CROSS SECTIONS

HORIZ. SCALE: 1"=20'
VERT. SCALE: 1"=20'

HERRERA

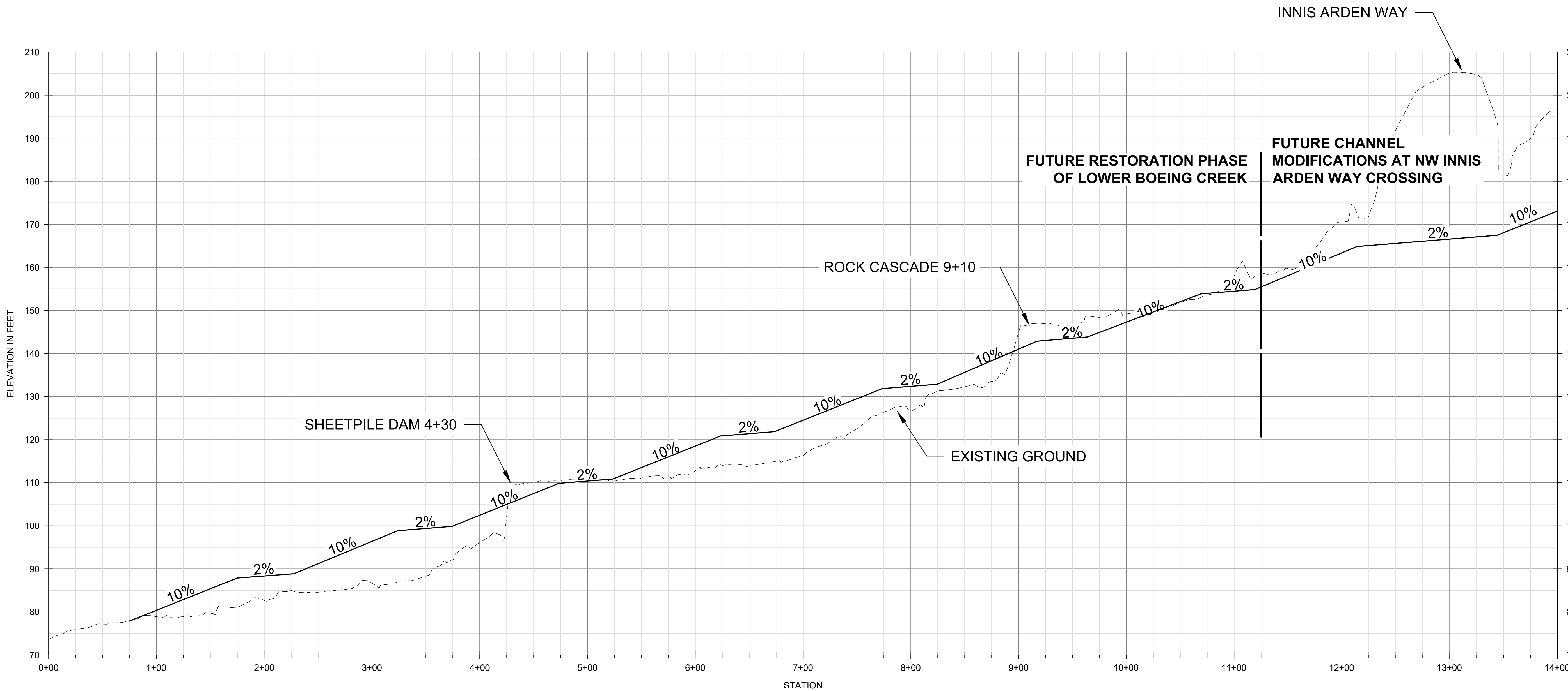
LOWER BOEING CREEK

CONCEPTUAL DESIGN COMPONENTS

DATE: JULY 2017

DRAWING:

SHEET: OF



PROFILE (1 / -)

HORIZ. SCALE: 1"=80'
VERT. SCALE: 1"=20'

HERRERA

LOWER BOEING CREEK

CONCEPTUAL DESIGN PROFILE

DATE: JULY 2017

DRAWING:

SHEET: OF

APPENDIX B

Lower Boeing Creek Fish Passage Restoration Conceptual Cost Estimate

Planning-Level Cost Estimate for Fish Passage Restoration in Lower Boeing Creek

Project: Hidden Lake Dam Removal
Herrera Project 15-05984-000
Client: City of Shoreline

Date Modified: 7/19/2017
Spreadsheet by: I. Mostrenko
Checked by: M. Ewbank
Latest Date Checked: 7/19/2017

Cost Item #	Spec Section	Item Description	Quantity	Unit	Unit Cost	Price	Total Price	Comments
1		Mobilization	1	LS	$ 212,500.00		$ 212,500.00	8% of construction subtotal (Div 2 - Div 8 work items)
2		Temporary Erosion and Sediment	1	LS	$ 120,300.00		$ 120,300.00	Assumes 5% of all other items except water management
3		Water Management	1	LS	$ 130,000.00		$ 130,000.00	Use Coal Creek bid cost, assume 2 phases, like coal creek total
4		Clearing	1.0	AC	$ 19,445.00		$ 19,104.44	WSDOT unit bid analysis, NW Region 2016
5		Removal/staging of LWD	1	LS	$ 42,000.00		$ 42,000.00	See support calcs
6		Access Construction	1950	LF	$ 64.90		$ 126,555.00	See support calcs
7		Access Road Retaining Wall	1	LS	$ 60,000.00		$ 60,000.00	upper 200 feet reach to minimize large cut slope
8		Channel Excavation	2470	CY	$ 40.00		$ 98,800.00	See support calcs, unit assumes double handling and staging
9		Import Alluvial Fill (pit run)	590	CY	$ 60.00		$ 35,400.00	See support calcs, increase unit cost due to acesss/stage space
10		Import Boulders	3820	CY	$ 150.00		$ 573,000.00	See support calcs / add 25% to unit est due to access/staging
11		Import Sediment Gravel/Cobble Material	1910	CY	$ 112.50		$ 214,900.00	See support calcs / add 25% to unit est due to access/staging
12		Channel Construction	5740	CY	$ 190.00		$ 1,090,600.00	See support calcs
13		LWD Placement	14	EA	$ 6,800.00		$ 95,200.00	See support calcs
14		Riparian Restoration	1	AC	$ 50,000.00		$ 50,000.00	
						Construction Subtotal	$ 2,868,359	
						Sales Tax (10.0%)	$ 286,900	
						Construction Total (roundup to 1000's)	$ 3,156,000	
						Contingency (50%)	$ 1,578,000	
						Construction Total with Contingency	$ 4,734,000	
						Permitting	$ 100,000	based on past project experience, high end due to WDFW
						Design	$ 225,000	based on past project experience, channel design
						Construction Management & Administration (20% of Construction Cost)	$ 946,800	
						GRAND TOTAL	$ 6,010,000	