Cardno ENTRIX

Shaping the Future

Deschutes River Restoration Project – 1120 Road

Concept Design Report

October 2014

Prepared For

South Puget Sound Salmon Enhancement Group

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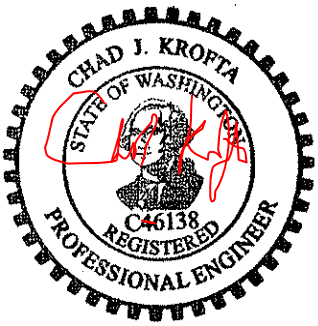

Chad Krofta, PE

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Chapter 1 Introduction

The South Puget Sound Salmon Enhancement Group (SPSSEG) has engaged Cardno ENTRIX for science and engineering services in support of the Deschutes River Restoration Project - 1120 Road (Project). The Project site includes approximately 1,500 linear feet of river channel located at approximately river mile 33 of the Deschutes River adjacent to Weyerhaeuser Road 1120 in the Vail Tree Farm near the town of Rainier in Thurston County, Washington (Figure 1-1). This report presents the preliminary investigation of existing site conditions and potential options for installation of new aquatic habitat enhancement work. The purpose of this report is to provide a basic description of the river, known impacts to salmonid habitat within the Project site, describe the basic geomorphic processes in areas of degraded habitat and recommend potential restoration solutions for enhancing critical aquatic habitat for salmonids.

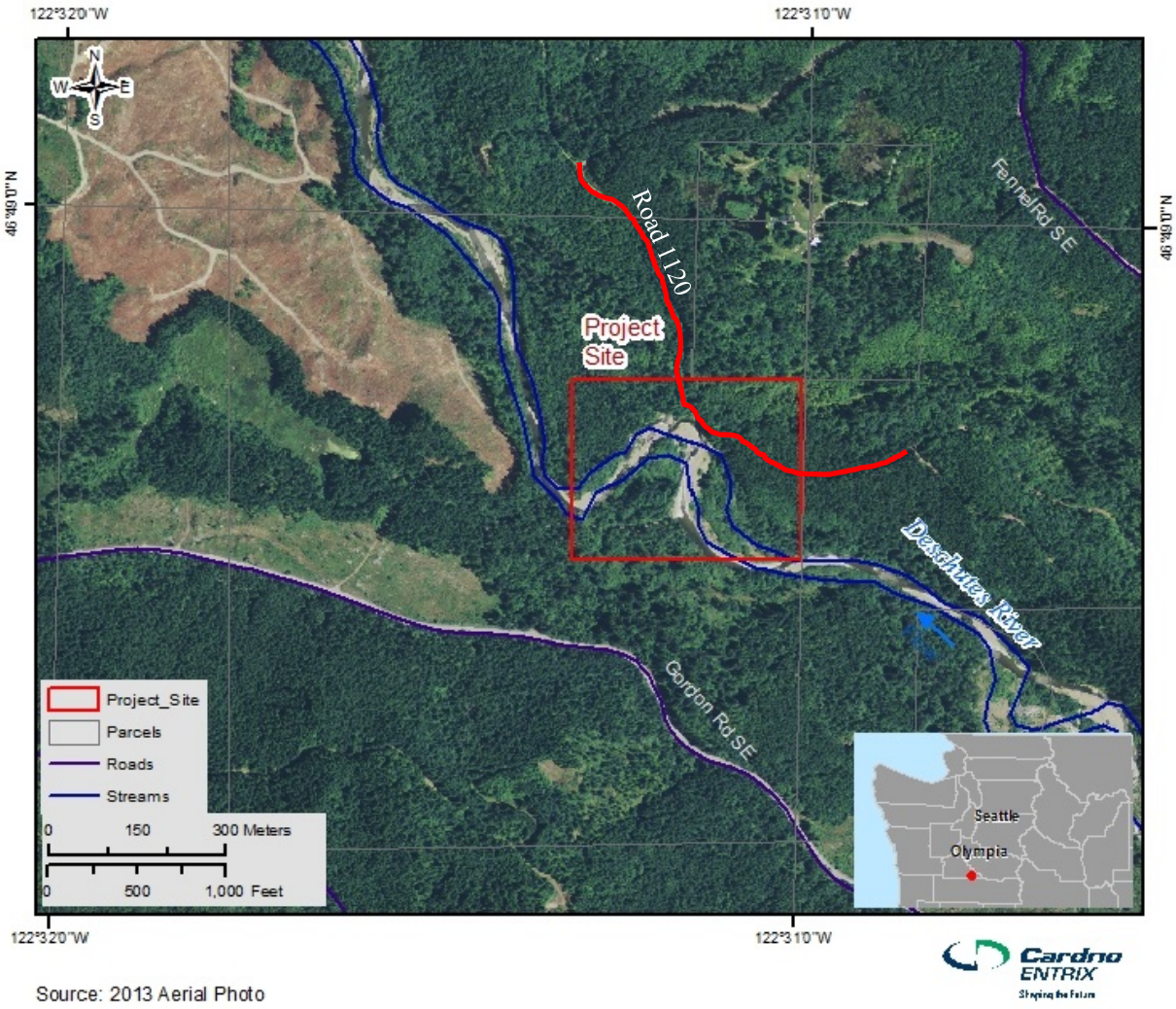


Figure 1-1: Project Area Location Map

Chapter 2 Site Description

2.1 Watershed Characteristics

The Deschutes River watershed is made up of 143 streams totaling 256 linear miles. Its catchment begins at elevation 3,870 feet on Cougar Mountain and encompasses approximately 170 square miles, 62 square miles at the Project Area (See Figure 2-1), of the Cascade foothills draining to the north and west and ending at sea level at Capitol Lake in Olympia, Thurston County, Washington. The main stem of the Deschutes River flows 52 miles before reaching Capitol Lake and eventually the Budd Inlet of the Puget Sound. The primary land use within the basin (and Project Area) is commercial forestry with residential properties and agricultural land located in the lower region of the basin.

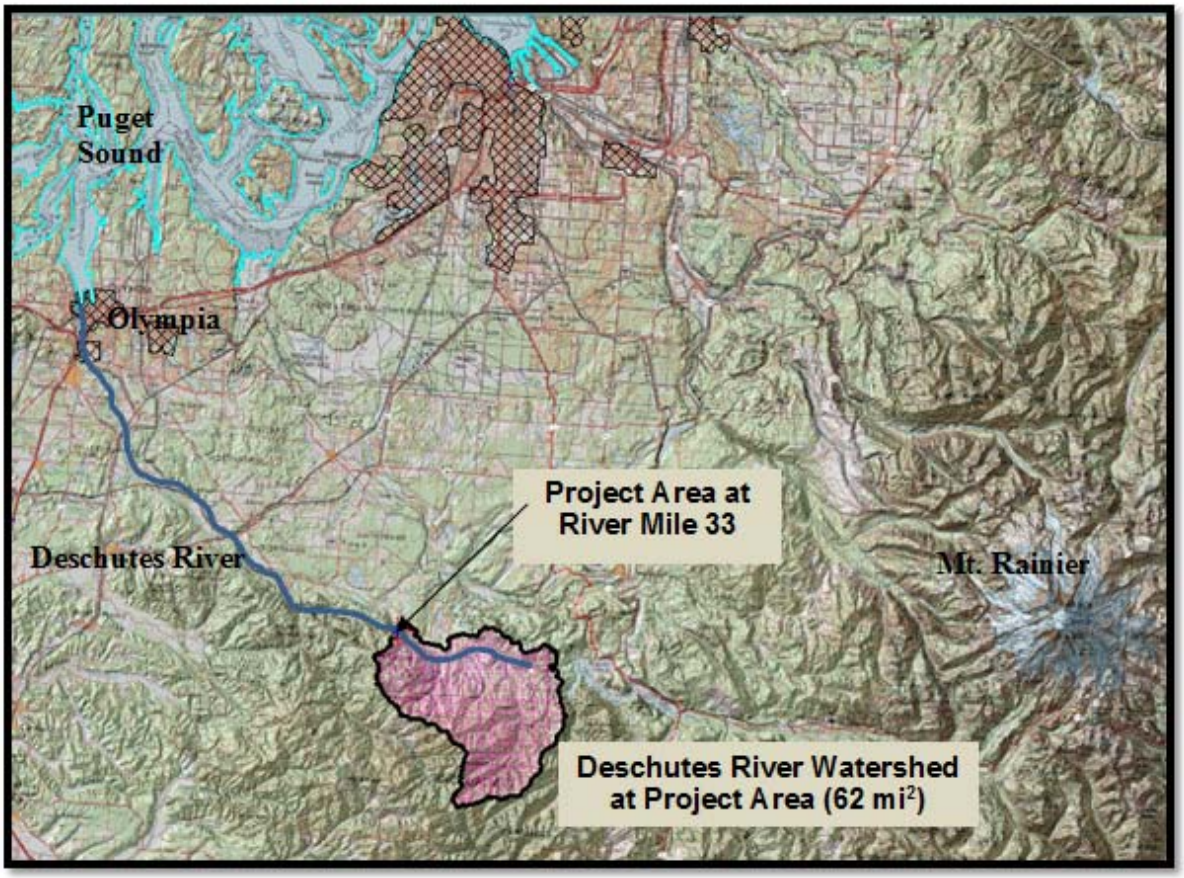


Figure 2-1: Deschutes River Watershed at the Project Area (USGS 2014)

The climate in the vicinity of the Project Area is characterized by cool, dry summers and mild, wet winters. Due to the varied relief within the watershed, temperature and precipitation varies with elevation, but overall temperatures average 60 to 70 degrees Fahrenheit in the summer and 30 to 40 degrees Fahrenheit in the winter. Precipitation within the basin falls primarily as rainfall with some snow at high elevations, resulting in peak flows during the winter months

when heavier precipitation occurs. According to the USGS (2014), the average annual precipitation within the Deschutes River watershed is approximately 60.5 inches (63.7 inches at the Project Area). Portions of the Project site are within the Federal Emergency Management Agency (FEMA) 100-year floodplain (Figure 2-2). The map depicted in Figure 2-2 is the FEMA Flood Insurance Rate Map (FIRM) which is based on a hydraulic model completed by FEMA in 2012. A revised FEMA hydraulic model is currently under development.

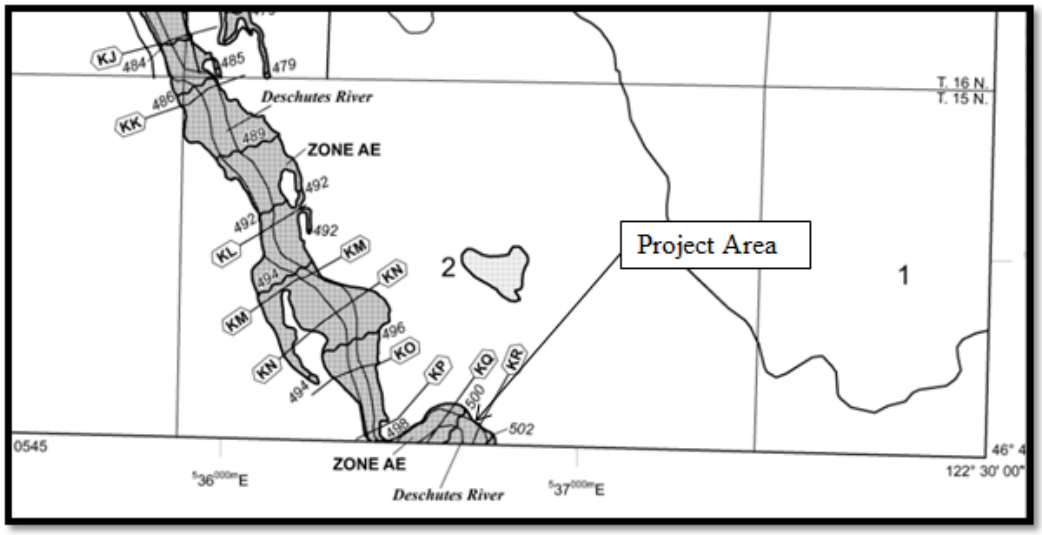


Figure 2-2: Effective FEMA FIRM for the Project Area (FEMA 2012)

Application of the USGS regression equations for Washington State indicates that peak flood flow magnitudes within the Deschutes River system at the Project site range from approximately 1,760 cubic feet per second (cfs) at the 2 year recurrence interval (flows with a 50% probability of occurring in any given year) to 5,040 cfs at the 100 year recurrence interval (1% probability in any given year). FEMA reports the 100 year recurrence interval event to be 7,150 cfs at Vail Loop Road (8 miles downstream of Project Area). The USGS has maintained a flow gauge on the Deschutes River (Gage #12079000) located approximately 8 miles downstream of the Project Reach (90 square mile watershed) at the crossing of Vail Loop Road SE since 1949. Further analysis of this data could yield improved estimates of peak flood flow rates at the Project site. Furthermore, additional detailed hydraulic modeling could provide information about flow depths, velocities, and other hydraulic parameters critical for gaining a detailed understanding of site specific scour, erosion, sediment transport, and large woody debris (LWD) transport.

2.2 Geology, Soils, & Geomorphology

The Deschutes River is separated into several geological and geomorphic domains. Tumwater Falls at River Mile (RM) 2 and Deschutes Falls at RM 41 form natural geological breaks. Above Deschutes Falls, the river is incising through weathered bedrock in steep valleys comprised of Tertiary volcanics: andesite, basalt, flow breccias, siltstones and sandstones (Schuster 2005). Between the two falls (RM 2 to RM 41) and including the Project Area, the river flows through a glacial drift plain (Raines 2005). In the lower 15 RM the river flows through a post-glacial

channel in unconsolidated sands and silts (known as the Tumwater Sands) that were deposited after glacial recession (Raines 2005).

Based on our interpretation of Raines (2005), the Project Area is located at the extreme southern extents of the Frasier glacial drift plane portion of the river system. Several glacial outwash valleys are present in the vicinity of the Project Area, including the present day Deschutes River valley itself. According to the Washington Dept. of Natural Resources 1:100,000 geological map (Figure 2-3), the river flows through modern river alluvium and glacial outwash sands within the Project Area with andesitic flows comprising the uplands and valley wall to the south. The soils of the Project site are mapped as Chehalis silt loam (NRCS 2014). The typical profile for Chehalis silt loam consists of silt loam underlain by layers of silty clay loam and loam. Silts are fine grained materials with particle diameters less than 0.0025 inches.

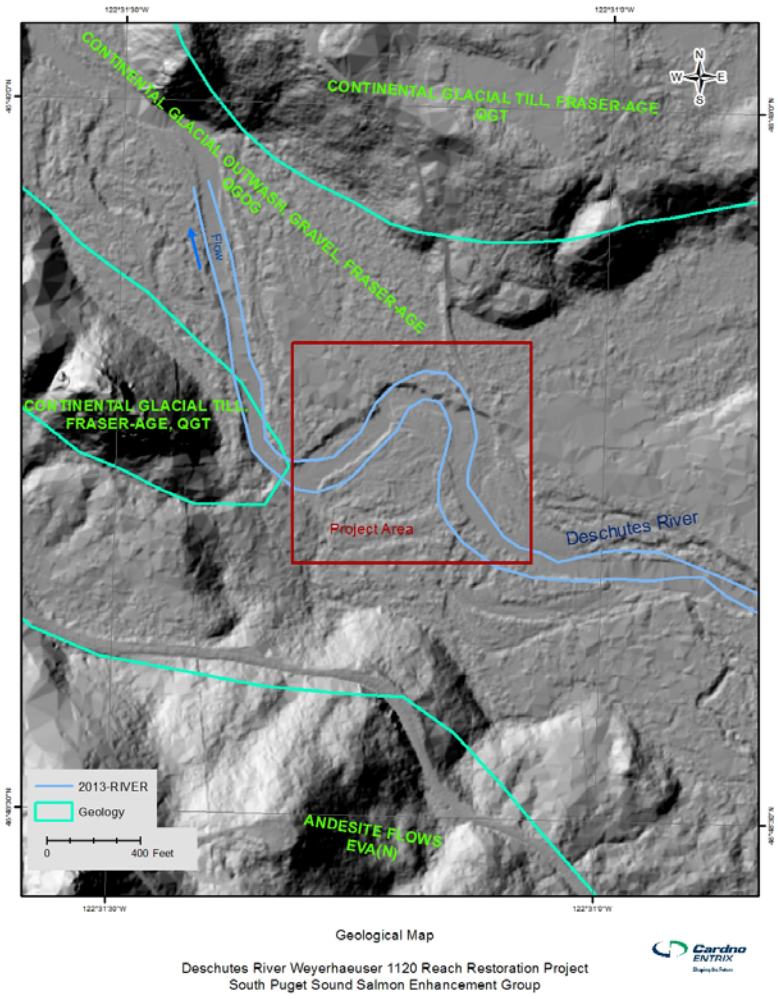
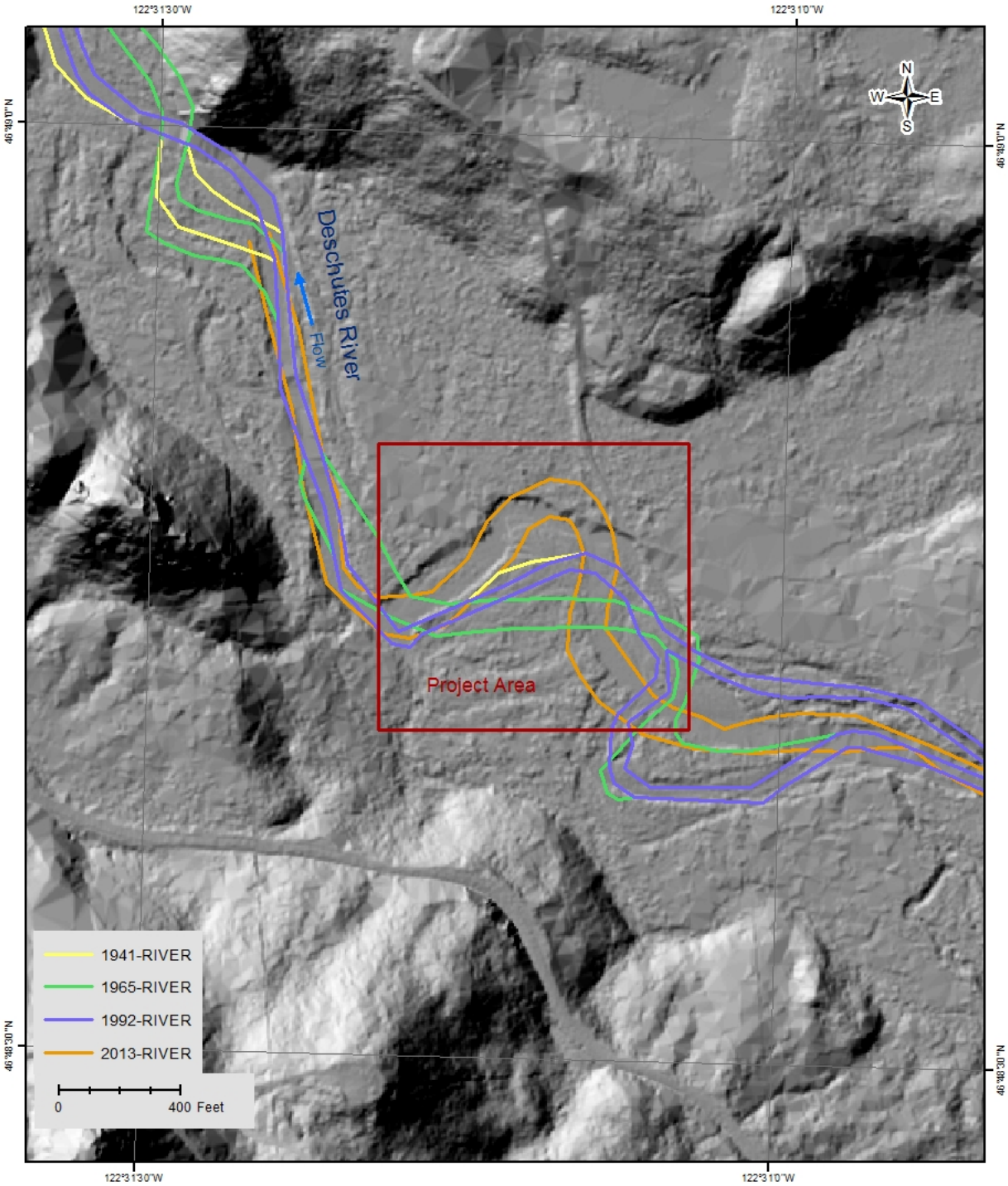


Figure 2-3: Geological map of the Project site (from WDNR).

A rapid geomorphic assessment was completed to examine the processes shaping the environment at the Project site. Geomorphic conditions in the study reach were examined based on a one day site visit conducted by two Cardno staff members (Mr. Jack Bjork, P.E. and Mr.

Dan Elefant) on September 17, 2014. This site visit was supplemented with data obtained from existing reports, topographic data, historic maps and aerial photographs. Data sources included 2002 Light Detection and Ranging (LiDAR) from the Puget Sound LiDAR Consortium (PSLC) and Deschutes River meander data from 1992, 1965 and 1941 obtained from Thurston County. A 2013 aerial photo was also obtained from the U.S. Department of Agriculture National Agricultural Inventory Program (NAIP). The un-vegetated channel from the 2013 aerial photograph was digitized at a scale of 1:3,000 using ArcGIS and compared to data from 1992, 1965, and 1941. This analysis revealed that the Deschutes River has migrated significantly within vicinity of the Project area over the period of record analyzed. Specifically, a larger meander bend within the channel at the Project Area has migrated to the north approximately 150 feet during the period 1965 to 1992 (average of 6 feet/year) and then another 350 feet between 1992 and 2013 (average of 17 feet/year), eroding into the southern embankment of Weyerhaeuser Road 1120 (Figure 2-4). Assuming a conservative (lower bound) average bank length of 250 linear feet and an average silt material bank height of 10 feet as observed during the 2014 site visit, approximately 46,300 CY of silty materials have eroded into the Deschutes River between 1965 and 2013.



Unvegetated Channel Location 1941 to 2013

Deschutes River Weyerhaeuser 1120 Reach Restoration Project
South Puget Sound Salmon Enhancement Group

Figure 2-4: Unvegetated channel in the Project site from 1941 to 2013. Lidar bare earth base map is 2002.

Based on 2002 Lidar topographic data, the average low flow channel within the Project Area has a slope of approximately 0.45% and width (the area frequently disturbed by river flows) of approximately 50 feet. The valley width varies from approximately 400 to 1,200 feet within the Project Area with an average about 1,000 feet. The valley was defined as the land surface that is no more than 10 feet above the channel elevation. The channel confinement (ratio of valley width to channel width) is low; there is little natural topographic restriction to channel movement other than outcrops of andesite, primarily along the southern valley wall. During the site visit, channel bed materials were observed to be primarily gravel and cobbles while bank materials were comprised primarily of silt underlain by alluvial gravel. The silt bank materials are scoured easily and significant lateral channel movement and introduction of fine sediments can be expected if the bank materials are not otherwise restrained by vegetation or other restraining materials such as LWD.

Cardno created a height above water surface (HAWS) map based on the FEMA reported 100 year water surface compared to 2002 Lidar data available from the PSLC. This map is depicted in Figure 2-5. The colored regions on the HAWS map indicate the height of the 2002 Lidar bare earth topography above (or below) the FEMA (2012) 100 year water surface. Clearly visible in these types of maps are channels and other topographic depressions that may convey water. The dark blue band near the southern extents of the Project Area shown in Figure 2-4 indicates the presence of a side channel feature cutting through the point bar region south of the 1120 Road which was also observed in the field. This feature is likely a remnant of the 1965 or earlier Deschutes River channel. Lidar, however, cannot penetrate the water surface. Therefore, bathymetry within the active channel may be several feet lower than depicted in Figure 2-5. Additional ground based topographic and bathymetric data collection can improve the accuracy of future Project Area analyses including analysis of channel bed form and hydraulic function.

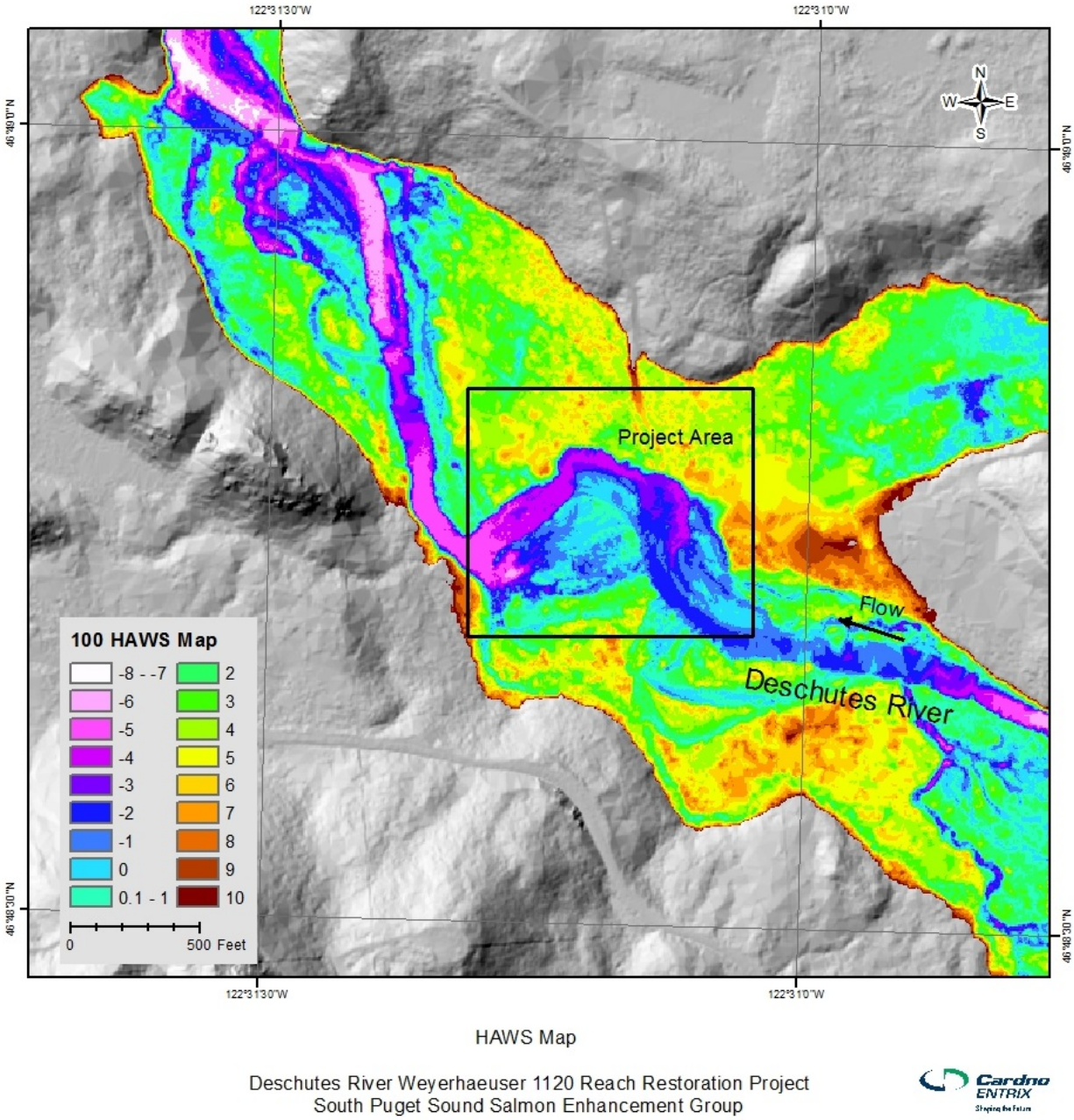


Figure 2-5: Project Area HAWS Map

Large woody debris (LWD) serves a number of important ecological and geomorphic functions. Wood delivered by riparian forests can form snags and logjams that deflect flows and capture sediment. The LWD introduced from riparian forests increases scour pool frequency, habitat complexity, shading of wetted area, adult salmonid holding areas, spawning substrates, hyporheic flow connection, and floodplain connectivity (Fetherston et al. 1995, Latterell 2005; Sedell and Froggatt 1984; Abbe and Montgomery 1996; Montgomery et al. 2003; Abbe and Brooks 2011). Live vegetation increases bank strength through root cohesion and adds hydraulic

roughness to floodplains, while wood recruited to the river partitions shear stress (Abbe and Montgomery 1996; Abbe et al. 2003).

Large woody debris including a beaver dam was observed during the 2014 site visit to be prevalent within the side channel cutting through the point bar to the south of the 1120 Road (Figure 2-6). LWD within the mainstem of the Deschutes River, however, was sparse with the exception of several larger accumulations of LWD located on the inside of the meander bend (left bank) adjacent to a large cut bank (right bank) located near the 1120 Road (Figure 2-7). The large cut bank itself was approximately 200 'long and 12' high on average and consisted of approximately 10' of silty material overlying cobbles and was virtually free of LWD (Figure 2-8). Some road base materials were observed in the upper layers of the cut bank where the river has scoured the 1120 Road. The high cut bank has been designated as "Reach A" of the Project Area (See Concept Plans in Appendix A for map figure). Downstream of the large cut bank the right bank was generally more vegetated with less bank material exposed but was lacking in LWD (Figure 2-9). This reach has been designated as "Reach B" of the Project Area (See Concept Plans in Appendix A for map figure). Additional photos from the site visit are contained in Appendix C.

Figure 2-6: LWD observed blocking the entrance to the side channel during the September 2014 site visit

Figure 2-7: LWD observed on the large point bar adjacent to the 1120 Road during the September 2014 site visit

Figure 2-8: Looking downstream at 12' high cut bank observed adjacent to the 1120 Road during the September 2014 site visit. Note alluvial sandy, cobbley gravel overlain by 5' thicknessof silt. Top 2' is road material. Placed riprap is right foreground. No cover, shade, or LWD along this reach.

Figure 2-9: Looking downstream at Deschutes River downstream of 1120 Road during the September 2014 site visit. Note andesitic bedrock bank and sill in the river on right.

2.3 Land Use

The primary land use in the upper basin (and the Project Area) is commercial forestry with few residential properties. Agricultural land is located in the middle potion and urban development in the lower portion of the basin. At the outlet of the watershed, the estuary has been modified by the creation of Capitol Lake in 1954. A dike and tide gate produced an artificial freshwater impoundment in the estuary which historically had extended from the river outlet into Budd Inlet up to Tumwater Falls (Haring and Konovsky 1999). Because Capitol Lake was historically a narrow tidal basin, little natural flushing occurs and sediment drops out of river water as it fills the basin. Consequently, sedimentation of the lake requires continual management through dredging.

2.4 Limiting Factors for Salmonid Populations

Of the anadromous salmon that utilize the Deschutes River, two are listed under the Endangered Species Act (ESA); the Puget Sound Chinook (*Oncorhynchus tshawytscha*) were listed as threatened in 1999, and steelhead *(O. mykiss*) were listed as threatened in 2007 (NOAA 2011). Coho salmon (*O. kisutch*) were listed as a species of concern in 2004. Anadromous salmonids did not have access to the river until 1954 when a fish ladder was installed at Tumwater Falls, a natural barrier at RM 2; today they utilize the river up to Deschutes Falls at RM 42 (Haring and Konovsky 1999). Although not native to this river, the reduction of salmonid habitat quality and quantity throughout Puget Sound and the resulting decline in populations of Chinook, steelhead and coho creates an imperative for enhancing all available habitat. Coastal cutthroat trout (*O. clarkii*) also occur in the Deschutes River watershed (WDFW 2008).

The key limiting factors for salmon habitat of the Deschutes River above Capitol Lake as identified by Haring and Konovsky (1999) include the following:

- Fine sediment (grain size less than 0.85 millimeter, or silt), which is listed as an impairment under Section 303(d) of the Clean Water Act. Bed materials in the Deschutes regularly exceed the 12 percent limit of fine material for suitable spawning habitat (Haring and Konovsky 1999). Haring and Konovsky (1999) characterized spawning conditions in the Deschutes River above Vail, WA as poor due to elevated fine sediment levels. Fine sediments in streams interfere with salmonid spawning and respiration and can bury redds, fill in pools and reduce penetration of light and hence productivity in the stream. A 12’ high by over 250’ long cut bank of exposed fine grained silts was observed within the Project Area during the September 17, 2014 site visit. Erosion of this bank was contributing to high fine sediment loads in the river.

- Lack of LWD, particularly the large key pieces that form stable log jams that are rare in the Deschutes (Cramer 1997). The majority of Project site adjacent to the 1120 Road was lacking LWD on the September 17, 2014 site visit.

- Significantly impaired riparian conditions due to loss of riparian vegetation.

- Lack of off-channel habitat utilized by juvenile salmonids, particularly coho, for refugia from high flows, high temperatures and predators (Taylor 1999). Only 11 percent of the 343 reaches surveyed by Cramer (1997) had high levels off-channel rearing availability, while 17

percent had medium levels and 72 percent had little or no off-channel rearing availability. An active side channel was identified during the September 17, 2014 site visit. This side channel is currently providing good juvenial habitat in the reach and should not be disturbed.

- Inadequate instream flows, for which the Deschutes River is listed as 303(d) impaired (Thurston County 2010); and
- Elevated water temperatures in the summer due to lack of riparian cover and low flows, also resulting in a 303(d) listing (Thurston County 2010). Watershed Sciences, LLC (2003) found that temperatures within the Project reach (river mile 33) were over 21 degrees Celsius, some of the highest recorded on the Deschutes River.

Chapter 3 Project Objectives

3.1 Project Objectives

To rehabilitate aquatic habitat, the Project objectives were selected based on the results of the site assessment and the key limiting factors for salmon population recovery for the Deschutes River identified in previous studies (Pacific Groundwater Group 1995; Cramer 1997; Taylor 1999; Haring and Konovsky 1999; Watershed Sciences 2003; Anchor 2008). These objectives are as follows:

1. Address the lack of LWD, particularly stable log jams;
2. Decrease mobilization of fine sediments to the Deschutes River system which interfere with salmonid spawning, respiration and can bury redds.

3.2 Opportunities and Constraints

The conditions found in the Project site present opportunities for restoration of ecological and geomorphic functions within the constraints of the natural and human environment. These opportunities and constraints are summarized below in Table 3-1.

Table 3-1: Opportunities and constraints for the Project site.

Opportunities	Constraints
Unconfined channel provides space for floodplain function and off-channel habitat.	Restoration actions cannot impact forestry operations on adjacent lands.
Existing native riparian vegetation upstream and downstream can provide long-term sources of plant propagules, LWD, and other organic inputs.	Restoration actions cannot increase risk of flooding or erosion.
Glacial outwash gravel ensures supply of appropriate spawning substrate materials.	
Presence of off-channel habitat beneficial for salmonids	
A portion of the existing 1120 Road can be decommissioned and restored.	

Chapter 4 Conceptual Restoration Alternatives

4.1 Conceptual Restoration Alternatives

As depicted in the conceptual design plans contained in Appendix A, the conceptual restoration design includes installation of LWD habitat structures which will reduce the influx of fine sediments to the Deschutes River system and increase the amount of stable LWD within the Project reach. The addition of LWD to the river would address a number of the Project objectives both directly and indirectly. Stable, engineered wood structures would directly resolve the loss of LWD function due to the lack of large key pieces that form stable log jams in the river. LWD would reduce shear stresses on the channel banks and thus reduce the rate at which fine grained materials are mobilized into the Deschutes River system. The structures also offer the following benefits:

- They will immediately add LWD and promote formation of stable wood accumulation in the future as natural wood is captured by the structure.
- They will create cover and shade for salmonids.
- They will increase in-stream habitat complexity.
- They will increase sediment sorting.
- They will serve to increase boundary roughness, decrease flow velocities and partition shear stress, decreasing the input of fine sediment and thus the inundation of spawning gravels with fine grained sediments.

Engineered log jams in similar river systems in the Pacific Northwest have been shown to increase scour pool frequency, habitat complexity, shading of wetted area and floodplain connectivity (McHenry et al. 2007; Fetherston et al. 1995; Abbe and Montgomery 1996; Abbe et al. 1997). They also increase salmonid refugia habitats and spawning substrates through sediment sorting (Pess et al. 2002; Peters et al. 1998; McHenry et al. 2007; QDF 2008; O'Connor et al. 2006). In addition, ELJs stabilize woody debris in active migration zones, retaining natural wood flux to promote further natural log accumulation (Latterell 2005; Abbe and Montgomery 1996). The wood also acts to increase surface area for algae and aquatic insects (McHenry et al. 2007), retain organic matter (Bilby 2003) and salmon carcasses (Cederholm et al. 1985).

The conceptual restoration design includes an LWD habitat structure(s) along the right bank within Reach A, optional installation of self-ballasted habitat LWD within Reach B, and decommissioning and revegetation of a portion of the 1120 Road. The right bank LWD habitat structure could be constructed in a number of ways, either as a continuous structure or as several small engineered log jams (ELJs). Because of private properties and human use downstream, the LWD should not be mobile; stable LWD habitat structures that meet project objectives can be accomplished by any of the followings options (also depicted in the design plans contained in Appendix A):

- Alternative 1: Complex Log Crib Wall: This option consists of a continuous LWD habitat structure embedded within the existing bed and banks of the Deschutes River. The core of the structure would be filled with compacted earth fill, while the embedded LWD would interact with the flow and provide interstitial spaces along the bank edge.
- Alternative 2: LWD Bank Roughening Structure: Under this option, the existing right bank of the Deschutes River would be laid back at a shallow angle and LWD would be placed on the bank face and toe, providing interstitial spaces for aquatic organisms and hydraulic roughness to decrease scouring forces. The LWD would be stabilized with vertical logs and ballasted with boulder pairs strung over top of the logs with chain.
- Alternative 3: Self Ballasted LWD: This option consists of a new patent pending technology where LWD pieces are internally ballasted with native streambed cobble materials or other dense materials. These structures consist of large logs, augured to create an interior chamber which is then filled with dense materials and capped. The self-ballasted LWD pieces can be placed in the river channel without the need for excavation, dewatering, wire, chain, bolts, or external ballast materials. This reduces impacts due to construction as well as long term impacts due to placement of rock and soil fills within the stream channel. Self-ballasted logs can be placed individually or in multiples to form more complex structures and engineered log jams (ELJs) including structures similar to Alternatives 2 and 4.
- Alternative 4: Flow Deflecting ELJs: This option would provide a series of several small ELJs (approximately 25’ x 25’) consisting of woody material and earthen backfill ballast materials. These structures could be designed to be keyed in to the channel bed and banks for added security or installed at the toe of the existing bank without bank embedment to minimize excavation.

4.2 Alternative Evaluation and Preferred Alternative

We recommend pursuing a robust restoration approach that includes installation of the optional self-ballasted LWD within Reach B which can be installed without impacts to the existing banks and vegetation. Conceptual estimated costs (including optional restoration of Reach B, a 30% contingency and state sales tax) are as follows:

- Alternative 1 Complex Log Crib Wall: $544,949
- Alternative 2 LWD Bank Roughening Structure: $473,411
- Alternative 3 Self Ballasted LWD: $466,222
- Alternative 4 Flow Deflecting ELJs: $509,706

Detailed conceptual cost estimates are provided in Appendix B. Any of the restoration alternatives would directly address the Project objectives of improving salmonid habitat in the following ways:

1. The LWD structures would address the lack of stable LWD in the reach.

2. LWD would reduce fine sediment inputs to the Deschutes River system through increased boundary roughness, decreased flow velocities and partitioned shear stress.

3. LWD structures would immediately create and maintain in-stream habitat complexity and pools, providing in-channel holding sites for juvenile salmonids and refugia from high flows, high temperatures and predators.

4. Decommissioning of a portion of the 1120 Road would improve riparian conditions which would provide cover and food sources for salmonids as well as a source for future LWD recruitment.

Within Reach A, installation of Alternative 1 would provide robust protection against mobilization of fine sediments in addition to interstitial space for aquatic habitat. Construction would require flow diversion and earthwork within the river channel. Alternative 2 would provide a large amount of interstitial space for aquatic habitat in addition to fine sediment restraint. Excavated soils would require off-site disposal. Alternative 3 provides a large amount of interstitial space for aquatic habitat as well as shear stress reduction which would reduce mobilization of fine sediments. Alternative 3 can be constructed without flow diversion or earthwork within the river channel. Alternative 4 would also provide a large amount of interstitial space for habitat as well as sediment sorting and restraint. Construction of Alternative 4 would require flow diversion and excavation of the channel bed and banks.

Further design analysis should be conducted prior to moving forward with project implementation in order to identify and address project risks as well as further refine project benefits. Additional data may need to be collected in order to perform these analyses as described earlier. Typical design criteria that should be assessed in detail prior to implementation include the following:

- Environmental and Habitat Impact;
- Project Stability and Life Expectancy;
- Infrastructure and Private Property Impact;
- Public Safety and Use Impact;
- Constructability and Construction Impact.

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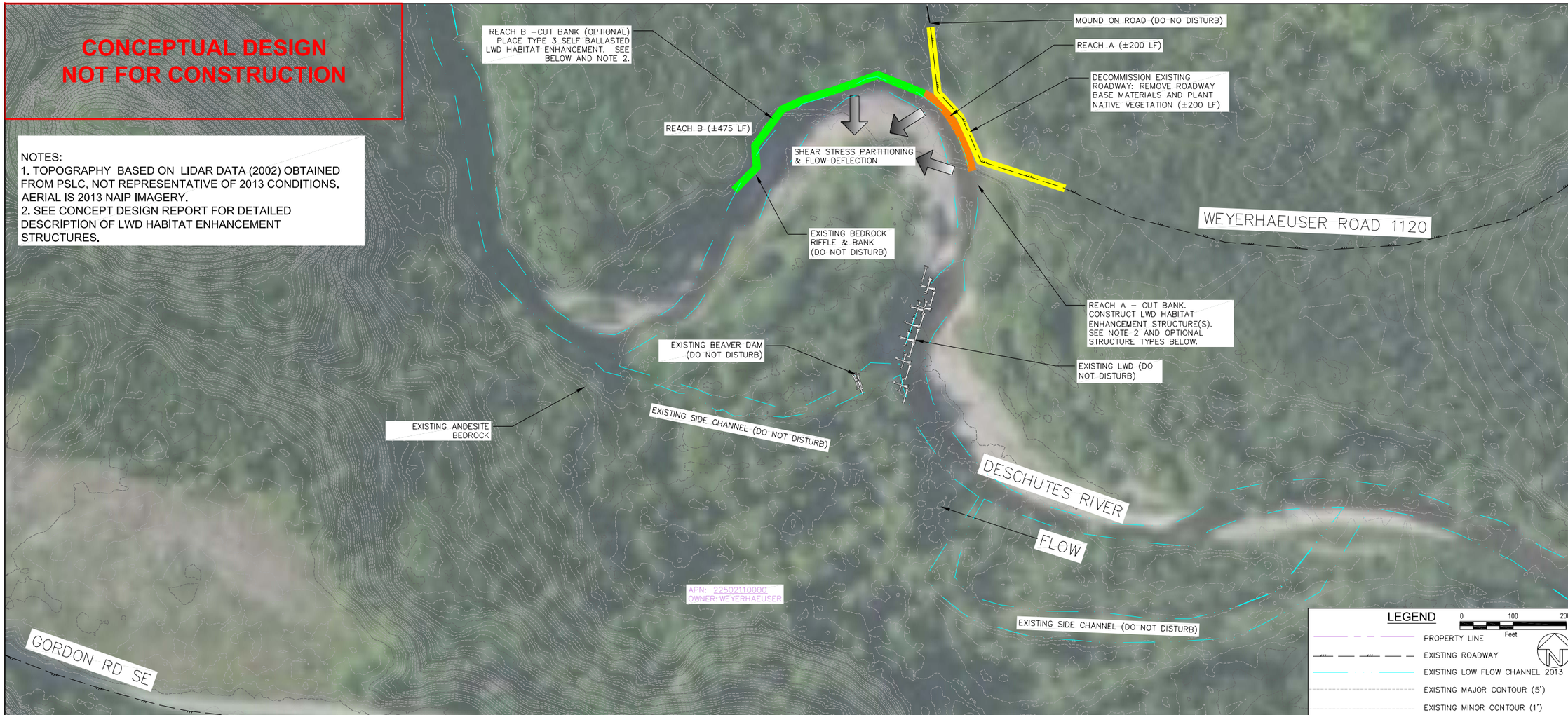
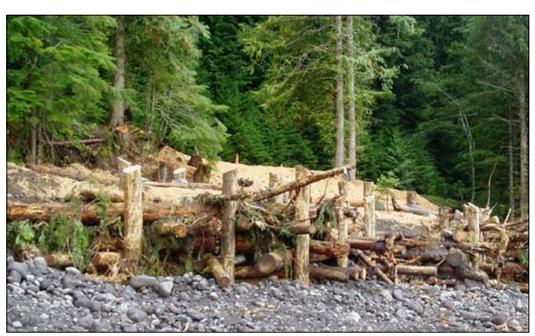
Appendix A

Conceptual Design Plans

CONCEPTUAL DESIGN
NOT FOR CONSTRUCTION

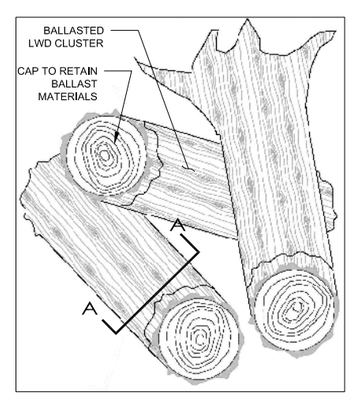
NOTES:
1. TOPOGRAPHY BASED ON LIDAR DATA (2002) OBTAINED FROM PSLC, NOT REPRESENTATIVE OF 2013 CONDITIONS. AERIAL IS 2013 NAIP IMAGERY.
2. SEE CONCEPT DESIGN REPORT FOR DETAILED DESCRIPTION OF LWD HABITAT ENHANCEMENT STRUCTURES.

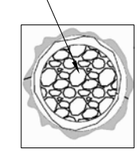




ALTERNATIVE #1- COMPLEX LOG CRIB WALL

ALTERNATIVE #2- LWD BANK ROUGHENING COMPLEX





SECTION A-A

ALTERNATIVE #3*- SELF BALLASTED LWD

*PATENT PENDING

ALTERNATIVE #4- FLOW DEFLECTING ELJS

DATE	REVISIONS

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CONCEPTUAL RESTORATION ALTERNATIVES

DESCHUTES RIVER RESTORATION PROJECT - 1120 ROAD

THURSTON COUNTY, WASHINGTON

DATE:	September 2014
DESIGNED BY:	CK
DRAWN BY:	KB
CHECKED BY:	JB
ENTRIX JOB NO.	E514002000
PLAN NO.	1
SHEET	1 of 1

Appendix B

Cost Estimates

Deschutes River Restoration Project - 1120 Road
Alternative 1 - Complex Log Crib Wall
Engineer's Conceptual Estimate of Construction Cost
09/29/14

Restoration

Item #	***Item Description***	***Unit***	***Unit Cost***	***Quantity***	***Value***
1	Mobilization	LS	$39,000	1	$39,000
2	Construction Staking	LS	$3,500	1	$3,500
3	TESC	LS	$4,000	1	$4,000
4	Clearing and Grubbing	AC	$2,500	0.65	$1,625
5	Diversion/Dewatering	LS	$20,000	1	$20,000
6	Excavate & Dispose Roadway Base Material	LF	$15	450	$6,750
7	Install Complex Log Cribwall	LF	$850	200	$170,000
8	Rip and Revegetate Decommissioned Roadway	LF	$2.5	450	$1,125
9	Install Self Ballasted LWD in Reach B	EA	$950	150	$142,500

Total: *$388,500*

Contingency (30%): *$116,550*

Subtotal: $505,050

Sales Tax (7.9%): *$39,899*

Total Cost: ***$544,949***

**Notes: 1) Construction costs do not include design, permitting, or construction administration costs.*
2) Construction costs do include log purchase

Deschutes River Restoration Project - 1120 Road
Alternative 2 - LWD Bank Roughening Structure
Engineer's Conceptual Estimate of Construction Cost

09/29/14

Restoration

Item #	***Item Description***	***Unit***	***Unit Cost***	***Quantity***	***Value***
1	Mobilization	LS	$34,000	1	$34,000
2	Construction Staking	LS	$3,500	1	$3,500
3	TESC	LS	$3,000	1	$3,000
4	Clearing and Grubbing	AC	$2,500	0.65	$1,625
5	Diversion/Dewatering	LS	$15,000	1	$15,000
6	Excavate & Dispose Roadway Base Material	LF	$15	450	$6,750
7	Install LWD Bank Roughening Structure	LF	$650	200	$130,000
8	Rip and Revegetate Decommissioned Roadway	LF	$2.5	450	$1,125
9	Install Self Ballasted LWD in Reach B	EA	$950	150	$142,500

Total:	*$337,500*
Contingency (30%):	*$101,250*
Subtotal:	$438,750
Sales Tax (7.9%):	*$34,661*
Total Cost:	***$473,411***

**Notes: 1) Construction costs do not include design, permitting, or construction administration costs.*
2) Construction costs do not include temporary or permanent irrigation for plant establishment

Deschutes River Restoration Project - 1120 Road
Alternative 3 - Self Ballasted LWD
Engineer's Conceptual Estimate of Construction Cost
09/29/14

Restoration

Item #	***Item Description***	***Unit***	***Unit Cost***	***Quantity***	***Value***
1	Mobilization	LS	$33,000	1	$33,000
2	Construction Staking	LS	$3,500	1	$3,500
3	TESC	LS	$3,000	1	$3,000
4	Clearing and Grubbing	AC	$2,500	0	$0
5	Diversion/Dewatering	LS	$0	1	$0
6	Excavate & Dispose Roadway Base Material	LF	$15	450	$6,750
7	Install Self Ballasted LWD	EA	$950	150	$142,500
8	Rip and Revegetate Decommissioned Roadway	LF	$2.5	450	$1,125
9	Install Self Ballasted LWD in Reach B	EA	$950	150	$142,500

Total: *$332,375*

Contingency (30%): *$99,713*

Subtotal: $432,088

Sales Tax (7.9%): *$34,135*

Total Cost: ***$466,222***

**Notes: 1) Construction costs do not include design, permitting, or construction administration costs.*
2) Construction costs do not include temporary or permanent irrigation for plant establishment

Deschutes River Restoration Project - 1120 Road
Alternative 4 - Flow Deflecting ELJs
Engineer's Conceptual Estimate of Construction Cost
09/29/14

Restoration

Item #	***Item Description***	***Unit***	***Unit Cost***	***Quantity***	***Value***
1	Mobilization	LS	$36,000	1	$36,000
2	Construction Staking	LS	$3,500	1	$3,500
3	TESC	LS	$3,500	1	$3,500
4	Clearing and Grubbing	AC	$2,500	0	$0
5	Diversion/Dewatering	LS	$20,000	1	$20,000
6	Excavate & Dispose Roadway Base Material	LF	$15	450	$6,750
7	Install Flow Defecting ELJs	EA	$50,000	3	$150,000
8	Rip and Revegetate Decommissioned Roadway	LF	$2.5	450	$1,125
9	Install Self Ballasted LWD in Reach B	EA	$950	150	$142,500

Total: *$363,375*

Contingency (30%): *$109,013*

Subtotal: $472,388

Sales Tax (7.9%): *$37,319*

Total Cost:

$509,706

**Notes: 1) Construction costs do not include design, permitting, or construction administration costs.*
2) Construction costs do not include temporary or permanent irrigation for plant establishment

Appendix C

Site Photographs September 17, 2014

Figure C-1: Right Bank of Deschutes River along 1120 Road looking Downstream. About of roadway width remains. Flow about 20-30 CFS.

Figure C-2: Right Bank of Deschutes River looking down stream along bank erosion at 1120 Road. Note: Gravel/cobble overlain by 5’ of light gray brown silt and 1’-2’ of road bed material.

Figure C-3: From right bank of Deschutes looking upstream 1120 Road out of photo to left. Note: Angular rip rap on left probably placed to protect road.

Figure C-4: From right Bank of Deschutes River looking down stream and west of 1120 Road.

Figure C-5: Right Bank of Deschutes River looking up stream, remainder of 1120 Road is planar feature in background.

Figure C-6: Right side bank of main channel looking upstream, west of 1120 Road. Bank composition similar to those described in Figure 2

Figure C-7: FroY left bank on point bar of Deschutes looking downstream, west of 1120 Road.

Figure C-8: Right bank looking up stream of Deschutes, west/southwest of 1120 Road. Note: bedrock in left of photo and a step forming in middle of photo.

Figure C-9: On left bank looking down stream, west/southwest of 1120 Road. Note: bedrock bank and step in right of photo.

Figure C-10: Rock island of Deschutes River looking up stream, west of 1120 Road.

Figure C-11: On mid channel bar, looking down stream west of 1120 Road.

Figure C-12: From right bank looking up stream toward side channel outlet connection on far bank.

Figure C-13: Side channel looking upstream.

Figure C-14: [ooking upstream at Side channel with large LW5.

Figure C-15: Side channel looking upstream. Beaver dam in lower right corner.

Figure C-16: Side channel looking upstream at south bank.

Figure C-17: Side channel entrance looking downstream at LWD accumulation.

Figure C-18: From right bank looking downstream at point bar. Road 1120 is out of photo to the right.

Figure C-19: On left bank of Deschutes looking downstream.

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