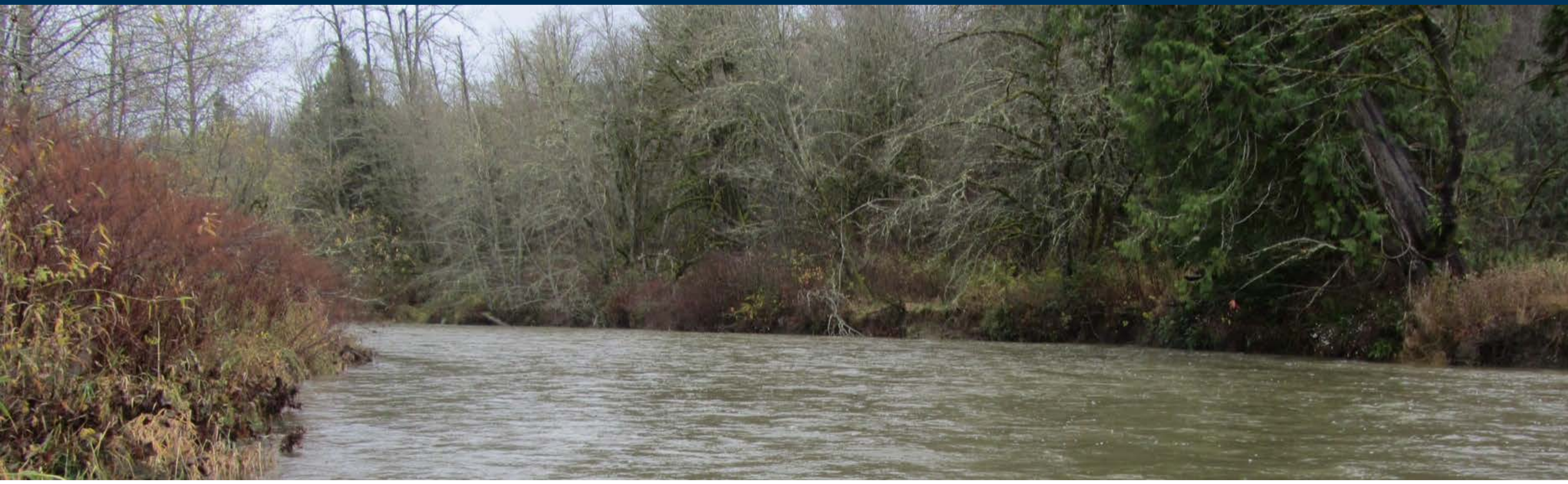

Dungeness River Channel Design Project

60 Percent Design Report

April 2013

Prepared For

Jamestown S'Klallam Tribe

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Jamestown S'Klallam Tribe
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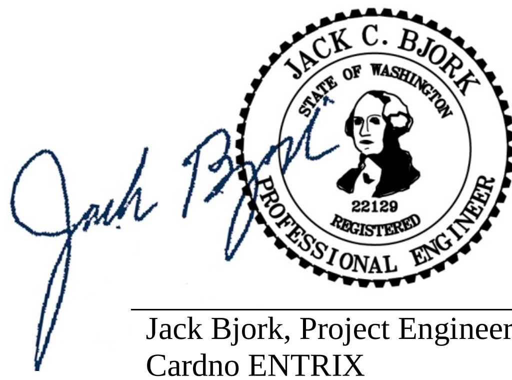
CERTIFICATE OF ENGINEER AND GEOLOGIST

The technical material and data contained in this report were prepared under the supervision and direction of the undersigned, whose seal as a registered professional engineer and a registered professional geologist licensed to practice in the State of Washington are affixed below.



Jack Bjork, Project Engineer
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Chapter 1
Introduction

The Jamestown S'Klallam Tribe (JKT) has engaged Cardno ENTRIX, Inc. to provide technical and engineering support on the Dungeness River Channel Design Project (Project). The overarching purpose of the Project is to reconnect the Dungeness River to its floodplain and restore habitat-forming processes to the lower Dungeness River system. The Project is located between river mile (RM) 0.85 and RM 1.7 (Figure 1-1). This report describes the scientific investigation and technical studies that form the basis for the 60 percent design plans. This design was developed in conjunction with JKT and the Lower Dungeness River Local Stakeholder Group through discussions over the course of the Project. Stakeholders of the Project included Clallam County, Dungeness Farms, U.S. Army Corps of Engineers, North Olympic Peninsula Lead Entity, WDFW, Clallam Conservation District, and WSDOT.

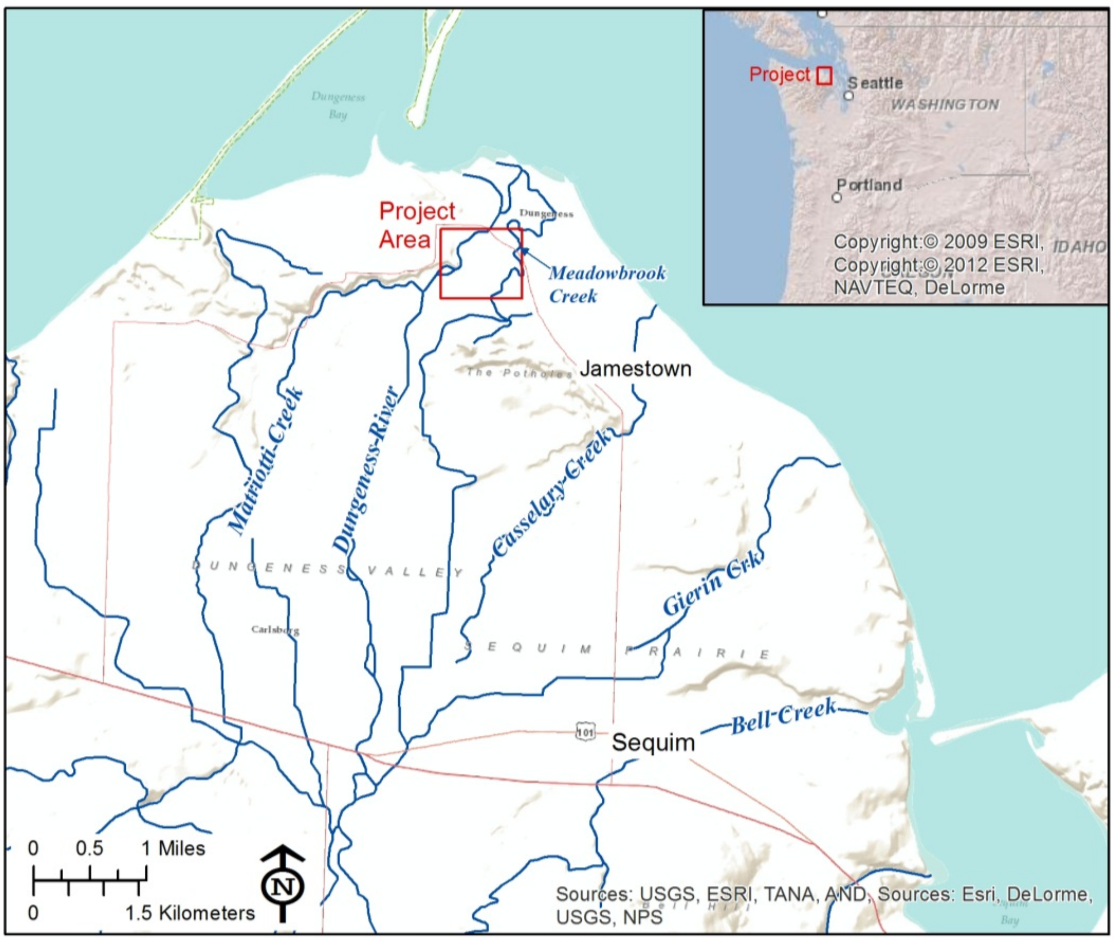

Figure 1-1 Project location in Clallam County, Washington.

The Dungeness River system has been investigated many times over the past two decades. The most relevant studies include the following:

- 1997. Dungeness River Restoration Work Group. *Recommended restoration projects for the Dungeness River*.
- 1999. England, J.F., Jr. *Flood frequency, flow duration, and trend analyses, Dungeness River geomorphology investigation, Dungeness River, Washington*.
- 1999. Haring, D. *Salmon and steelhead habitat limiting factors, WRIA 18*.
- 2001. Federal Emergency Management Agency (FEMA). *Flood Insurance Study, Clallam County, Washington--Unincorporated Areas*.
- 2002. United States Bureau of Reclamation (BOR). *Physical Processes, Human Impacts and Restoration Issues of the Lower Dungeness River*.
- 2003. Rot, B. *The Evolving Dungeness River: Juvenile Salmon and Their Use of Side Channel Habitat, A Comparison of Data Collected 1997/1998 vs. 1999/2000*.
- 2005. Elwha-Dungeness Planning Unit. *Elwha-Dungeness Watershed Plan, Water Resource Inventory Area 18 (WRIA 18) and Sequim Bay in West WRIA 17*.
- 2005. Collins, B. *Historical geomorphology and ecology of the Dungeness River delta and nearshore environments from the Dungeness Spit to Washington Harbor*.
- 2006. Wright, J. *Technical Memorandum: Updated Flood Frequency Analyses - Dungeness River, Washington – Geomorphology Investigation*.
- 2007. BOR (United States Bureau of Reclamation). *Technical Report: Numerical Modeling Study of Levee Setback Alternatives for Lower Dungeness River, Washington*.
- 2008. Rot, B. and Edens, P. *Delineation of the Dungeness River Channel Migration Zone: River Mouth to Canyon Creek.*
- 2009. Dungeness Flood Hazard Advisory Committee. *Dungeness Comprehensive Flood Hazard Management Plan*.

The BOR evaluated several levee setback alternatives in 2006 and 2007 (BOR 2007). From this study, the Jamestown S'Klallam Tribe and other stakeholders selected two setback levee alignments that would involve properties that had been acquired or were expected to be acquired by Clallam County, Washington Department of Fish and Wildlife (WDFW), and the Washington State Department of Transportation (WSDOT). The WSDOT property was acquired for the purpose of wetland mitigation for a different project.

The Cardno ENTRIX investigation was funded by a grant from the Environmental Protection Agency. Concurrent with this investigation, the U.S. Army Corps of Engineers (USACE) has been completing a feasibility study and 15 percent design of the levee setback project. The planned completion date for the feasibility study is late 2013. The existing levee was constructed by the USACE in the 1960s, and if the project is feasible, approved, and funded, the USACE is expected to complete the final design and construction.

1.1 Background

The Dungeness River basin extends northward from its headwaters in the glaciated alpine terrain of the northeastern Olympic Mountains toward the Strait of Juan de Fuca. The basin encompasses 198 mi^2 with a total of 7,770 feet of relief. Major tributaries include the Gray Wolf River, Canyon Creek, and Matriotti Creek. After emerging from the steep canyons of the upper basin, the Dungeness River flows through a broad alluvial valley in the lower 10 miles, where land use is a mixture of agriculture, forest, and rural/urban development near the city of Sequim (DFHAC 2009).

The Dungeness River supports seven species of salmonids: spring Chinook (*Oncorhynchus tshawytscha*), summer/fall pink (*O. gorbuscha*), coho (*O. kisutch*), chum (*O. keta*), steelhead (*O. mykiss*), and char (*Salvelinus confluentus*) (Haring 1999). Chinook, summer chum, and steelhead are listed as threatened under the federal Endangered Species Act (NOAA 2013). The Washington Department of Fish and Wildlife has listed the upper Dungeness pink as depressed and the lower river pink as critical (WDFW 2002). While efforts have been made for salmon recovery, spawning conditions and habitat quality have been diminished by irrigation water withdrawals, fill and construction on floodplains, riparian forest clearing, and gravel extraction (EDPU 2005; Haring 1999).

The Dungeness River floodplain between the mouth and RM 10.8 has been greatly modified from historical conditions due to channelization, diking, constrictions at bridges, accelerated downcutting in some reaches, and sediment accumulation in others (Haring 1999). Levees and dikes have disconnected the river from the floodplain, preventing the dissipation of stream energy and the storage of sediment during high flows (Collins 2005). The side channels in the floodplain historically provided very productive salmonid spawning and rearing habitat, including flow refugia, abundant food sources, and high groundwater contributions. The loss of side-channel habitat may play a key role in the decline of salmon populations in the lower river, such as the lower river pink, and thus restoration of side channel habitat is a high priority for recovery efforts (EDPU 2005). Spawning habitat for Chinook and pink salmon are also severely limited in the lower 10.8 miles of the river, primarily due to scour of redds at even moderate flows (Haring 1999).

The reach of the lower Dungeness River between the Schoolhouse Bridge at RM 0.85 and Matriotti Creek at RM 1.9 (including the Project site) was rated poor for riparian, floodplain, pool, large woody debris (LWD), and substrate habitat factors in 1999 limiting factor analysis (Haring 1999). Most of this reach is diked or leveed, and the LWD present at that time primarily consisted of small pieces outside of the active channel (Haring 1999). The lack of stable LWD increases flow velocities and contributes to decreased pool depth and frequency, sediment storage and stability, and side channel habitat (EDPU 2005; Haring 1999). Although the limiting factor analysis was conducted in 1999, it is likely that the habitat limitations continue to this day.

1.2 Project Goals and Objectives

The Jamestown S'Klallam Tribe goal for the Dungeness River is for salmon to return to harvestable levels in support of the cultural heritage and economic resources of the tribe (Rot 2003). Consistent with this goal, the Dungeness River Restoration Workgroup developed a salmonid habitat restoration strategy for the lower 10.8 miles of the Dungeness River that includes the following action recommendations that are applicable to the scope and location of the Project (DRRW 1997):

- Restore functional channel and floodplain in the lower 2.6 miles by addressing dikes and constrictions;
- Re-establish riparian vegetation and adjacent upland vegetation;
- Increase LWD quantity and habitat diversity until full riparian function can be restored;
- Manage sediment for channel stabilization and to reduce the risk of flooding; and
- Construct and/or protect existing side channels.

The objectives of the Project are to reconnect the Dungeness River to its floodplain and enhance habitat-forming processes from RM 0.85 to 1.7, while not increasing flood risk for nearby property owners or disturbing adjacent floodplain vegetation that has recently planted as part of an associated restoration effort.

Chapter 2 Site Assessment

2.1 Hydrology

Several hydrologic analyses have been conducted for the Dungeness River watershed in the last three decades. The analyses included flood frequency, flow duration, and stream flow trends for the Dungeness River.

In 1985 FEMA published a Flood Insurance Study for unincorporated areas within Clallam County, Washington. The study included a hydrologic analysis establishing the effective hydrology of the Dungeness watershed. The effective hydrology is the hydrology approved by FEMA and used in flood insurance studies that remains in effect for the watershed until a revision is adopted. The study was revised in February, 2001 with no alteration of the effective hydrology (FEMA 2001).

The BOR completed an analysis (England 1999) that was used in the evaluation of the physical processes of and human impacts on the Dungeness River (BOR 2002). This analysis was based on the United States Geological Survey (USGS) stream gaging station data from the Dungeness River near Sequim, Washington (station number 12048000). The gage has a period of record from June 1923 to September 1930 and from June 1937 until the present. Flood frequency estimates were made for three variables: annual instantaneous peak discharge estimates, annual maximum mean daily flows, and annual maximum three-day mean flows. The data was assumed to follow a log-Pearson Type III distribution. The method of moments was used to estimate the log-Pearson Type III parameters for peak discharge estimates.

In January 2006 an updated flood-frequency analysis for the same Dungeness River gage was performed (Wright 2006). This information was used in the development of a numerical modeling study for levee setback alternatives (BOR 2007).

In 2011, Cardno ENTRIX performed a second update of the flood-frequency analysis at the same Dungeness River gage to include the data through 2010 (Appendix A). The update was performed using the HEC-SSP Version 2.0 software developed by the USACE Hydrologic Engineering Center. The software was developed in accordance with procedures and methodologies presented in Bulletin No. 17B of the Hydrology Subcommittee of BOR (USGS 1981). Flood frequencies calculated for each of the analyses summarized above are presented in Table 2-1. The expected annual exceedance probabilities of 10 percent and 1 percent were applied for the hydraulic simulations.

Table 2-1 Peak discharge for the 2-, 10-, 100- and 200-year flood flows.

Annual Exceedance Probability	Recurrence Interval	Peak Discharge (cfs)			
		FEMA 1985	BOR 2002	BOR 2007	Cardno ENTRIX 2011
	Calibration Flow (Jan. 2002)	NA	NA	7,610	7,610
50	2-Year	NA	2,990	3,060	3,090
20	5-Year	NA	4,690	4,800	4,760
10	10-Year	6,640	5,780	5,910	5,820
1	100-Year	11,000	8,960	9,080	8,780
0.5	200-Year	NA	NA	NA	9,560

2.2 Geological Setting

The general geology of the lower Dungeness River is characterized by Pleistocene glacial deposits and more recent Holocene alluvial sediments (Figure 2-1). Within the Project reach the entire valley bottom is mapped by the Washington State Department of Natural Resources (WDNR) as Holocene alluvium. There is a natural constriction in the valley at the downstream end of the Project reach (RM 0.85) at the Schoolhouse Bridge, formed by a dissected upland deposit through which the Dungeness River has eroded. This higher deposit is composed of Pleistocene glaciomarine drift overlying continental glacial drift. These glacial remnants form the highlands in the general vicinity of the Project reach. The current Dungeness River flows along the toe of the glaciomarine plain to west from the downstream end of the Bebee Levee (RM 1.55) to the Schoolhouse Bridge (RM 0.85). While more resistant to erosion than the modern alluvium, the glaciomarine unit has a scalloped margin where the river flows along it, suggesting that some erosion of the unit has occurred in the past.

Since deglaciation about 16,000 years ago (Porter and Swanson 1998), the Dungeness River has carved and subsequently abandoned three successive paleochannels; the present-day Bell Creek, Gierin Creek, and Casselary Creek drainages pass through the sites of these paleochannels (Collins 2005). Older river fan deposits in the southeastern part of the modern delta indicate that the ancient river outlet was in that part of the delta prior to a large avulsion (Collins 2005). In addition, the morphology of the delta suggests that the Dungeness River flowed into Dungeness Bay at the present location of Meadowbrook Creek several hundred years ago, building a delta in that location (Collins 2005). In the mid-19th century, the Dungeness delta was east of the present location; by 1870 the river delta was in its current position, having evolved through natural avulsion, human modifications, fluvial deposition, coastal erosion, and longshore sediment transport (Collins 2005).

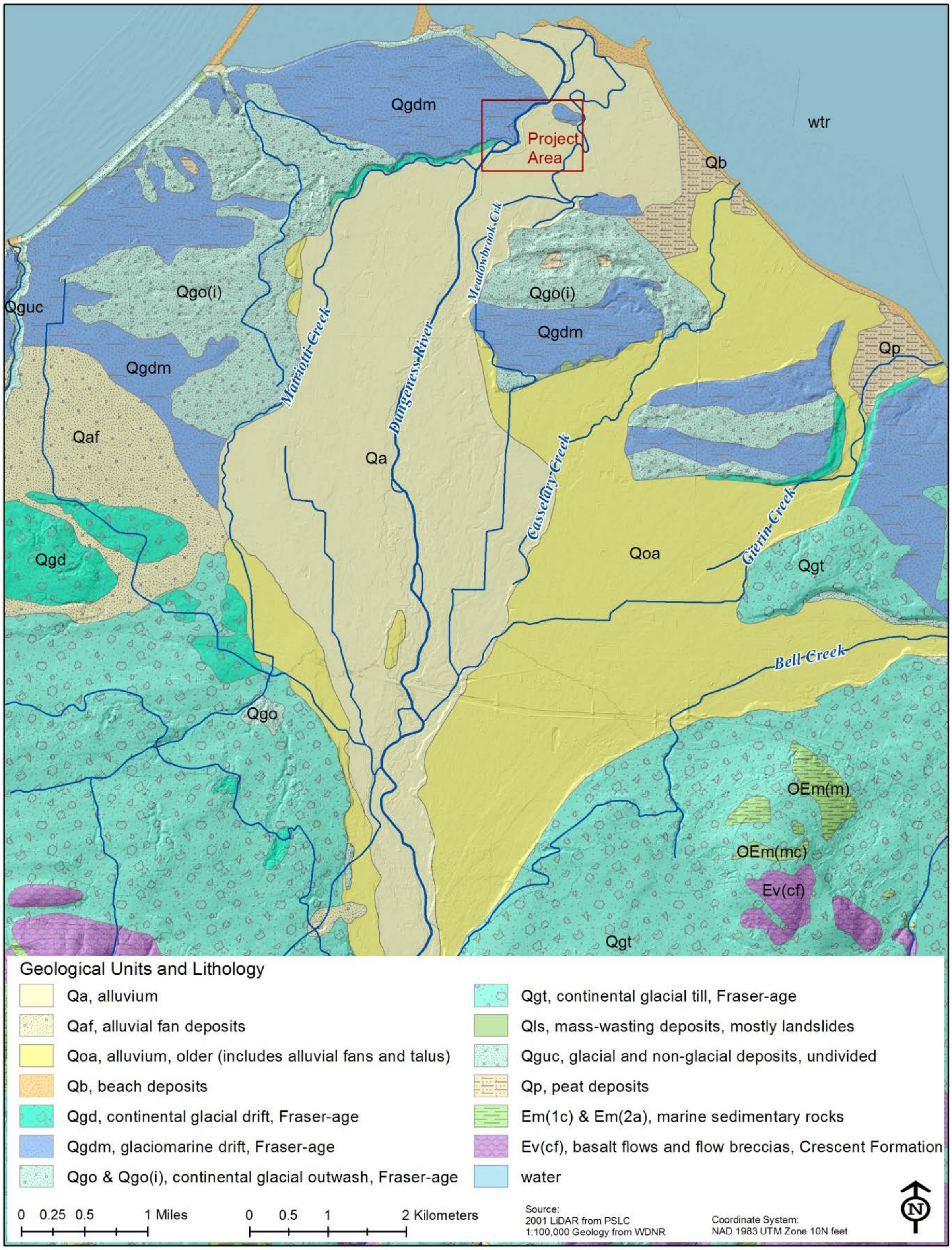

Figure 2-1 Geologic map of the Project area, from WDNR 1:100,000 digital geological map. Fraser-age deposits are those of the last ice-sheet glaciation, which occupied the entire Puget Lowland from about 18,000–16,000 years ago.

2.3 Historical Modifications

The first Schoolhouse Bridge was constructed between the time of an 1859 GLO map and a 1914 USACE map. Construction of the bridge resulted in confinement of natural channel migration, but more significant channel confinement within the Project reach was initiated with construction of levees to protect property and infrastructure from flooding. In 1963 the USACE constructed a right (or east) bank levee from RM 2.6 to the outlet at Dungeness Bay (Collins 2005). The left (or west) bank levee (known as the Bebee Levee or the Olympic Game Farm Levee) was constructed in 1994 and extends from about RM 1.55 in the Project reach to RM 2.6 (BOR 2002). Both of these levees have some armoring along their inboard toe, inhibiting natural channel migration. Shortly following completion of the right bank USACE levee, the Schoolhouse Road Bridge was relocated approximately 200 feet downstream from its original location. The 200-foot overall length appears to be similar to the earlier bridge from comparison of the historic maps and more recent aerial photos.

In addition to reduced channel migration, levee construction resulted in the isolation of large areas of historic floodplain and side channel habitat. The loss of off-channel habitat is exacerbated by the lack of high-flow refugia for rearing salmonids that is the result of the confined river system flowing deeper and faster than the pre-levee channel system. The levees also reduce groundwater input to the river and prevent LWD recruitment. Within the Project reach, major side channels isolated from the mainstem channel as a result of levee construction include the right bank side channel from RM 1.2 to 1.6 and the left bank side channel from RM 1.5 to 2.1. In addition to these major side channels, a mainstem channel thread has been isolated at the downstream end of the Bebee Levee at RM 1.55.

Along with anthropogenic confinement of the river, significant land use changes have occurred within the lower river. Pre-European settlement near the Dungeness River began in 1851, and was focused along the coastal plain and glacial bluffs (Collins 2005). Conversion of the coastal lowlands for agriculture began shortly after settlement began, with diking, diversions and clearing of forests. The loss of riparian vegetation decreased LWD recruitment, bank stability, stream shading, and sources for the terrestrial macroinvertebrates that salmonids feed on. The lower river floodplain in the Project area has been identified as a key restoration site by the Dungeness River Restoration Work Group, targeted for levee removal or setback and reforestation (DFHAC 2009).

Other human modifications of the historical era include water diversions and gravel mining. The Dungeness irrigation system operates five diversions between RM 6.9 and 11.1 (DFHAC 2009). Water users maintain the diversions—several of the intakes are armored and the channel has been modified in some cases to ensure low-flow water supply (DFHAC 2009). Gravel was mined along the lower Dungeness River until the mid-1990s for commercial use and to address concerns about channel aggradation (DFHAC 2009).

2.4 Geomorphic Site Assessment

2.4.1 Channel and Floodplain Conditions

In the approximately 10 lowermost miles of the Dungeness River, the channel traverses a glacial plain through which channel slopes are about 1 percent. While the lower Dungeness River upstream of the Project reach is braided, shallow and about 300 feet wide, within the Project reach the river is a sinuous, single-thread channel about 70 feet wide, with a narrow adjacent floodplain and channel slope of about 0.5 percent. Currently the channel is confined between two levees from the upstream end of the Project reach at RM 1.7 to the downstream end of the left bank levee at RM 1.55. The confining USACE right bank levee continues downstream beyond the Project boundary at the Schoolhouse Bridge (RM 0.85), and the left bank of the river is confined by resistant Pleistocene glaciomarine drift deposits. The river meanders within these constraints, forming narrow alternating floodplains with unvegetated longitudinal and point bar deposits at their margins. These floodplains support a mature riparian forest of cottonwood and mixed conifers. Multiple side channels of varying size and hydrology are present within the constrained floodplain; most are intermittent to ephemeral in nature.

In order to identify the relationship of the floodplain to the main channel, a Height Above Water Surface (HAWS) map was produced (Figure 2-2). We adapted the methodology of Jones (2006) and used the 2008 LiDAR data combined with 2001 LiDAR from the Puget Sound LiDAR Consortium in a digital elevation model (DEM). The 2008 LiDAR was flown on March 8, 2008 during flows of 182 cfs. The 2001 LiDAR was included for coverage of areas of the floodplain outside the river corridor flown in 2008. We digitized a series of valley-spanning cross-sections and recorded the elevation nearest to the edge of the water surface as determined in the 2010 aerial photograph. The cross section water-surface elevations from the LiDAR were used to generate a water-surface raster that was then subtracted from the LiDAR dataset. This resulted in a DEM of ground surface elevations relative to the water surface of the main channel at one-foot resolution. Negative values in this HAWS raster represent locations where the floodplain is below the water surface in the main channel, while positive values represent areas of a higher floodplain. Due to the nature of DEM generation, the absolute accuracy of any interpolated DEM is variable, and the accuracy of any given grid cell is related to its distance from the data points used to generate it. For this reason, the HAWS map should be used as a relative comparison of topography and not for absolute measure of topographic relief.

By displaying differences in the elevation between the water surface of the Dungeness River and the surrounding ground surface, the HAWS map highlights relict side channels east of the levee that have been disconnected from the main stem. It also reveals an area east of the levee between RM 1.6 and 1.8 where ground-surface elevations are below that of the water surface in the mainstem. This area has been used for agricultural fields since the earliest aerial photograph in 1942, but it could have been part of an off-channel wetland complex or an abandoned main channel location prior to the historical record. The 1926 USGS survey map does show a branch of the main channel in this location.

At the upstream end of the Project area (RM 1.4), an area of high ground on the right bank floodplain occurs within the current levee. As seen in Figure 2-2, this area is 4 to 6 feet above the water surface in the channel. This sediment was most likely deposited here as a result of the hydraulic losses that occurred when the right bank levee confined the river and forced it into a sharp turn toward the north.

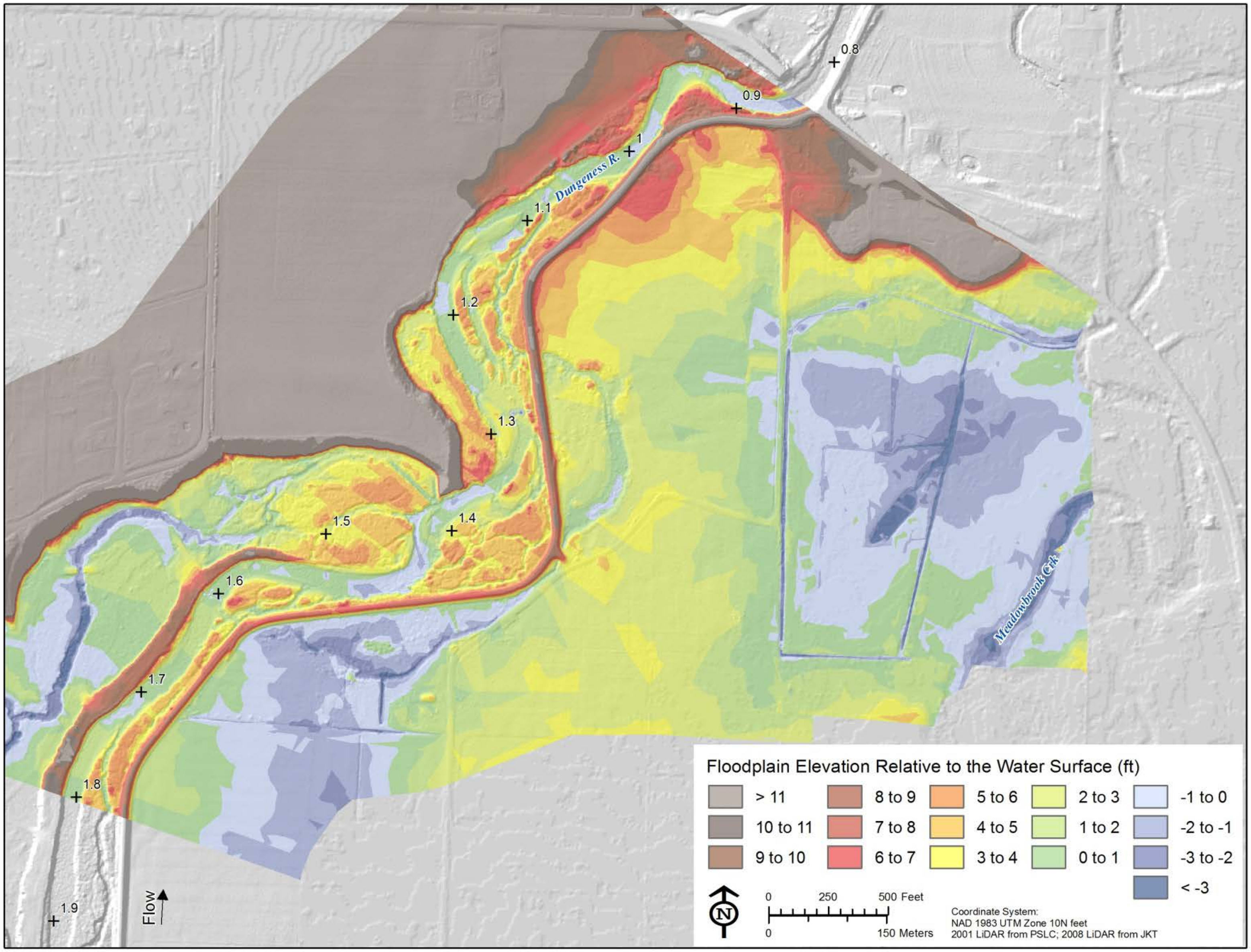

Figure 2-2 Elevations of the floodplain relative to the main stem Dungeness River water surface. Blue zones represent areas at or below water-surface elevation.

2.4.2 Channel Migration and Planform Changes

Several lines of evidence have been used to examine historical channel planform and the resultant impacts from artificial confinement beginning in the early 1960s. Historical maps and aerial photographs were compiled for the Project reach and georeferenced as necessary to make direct comparison possible. Maps from 1859, 1909, 1926, and 1938, and aerial photographs from 1942, 1965, 1975, 1985, 1995, 2000, 2005, and 2010 were evaluated to determine changes in channel planform, including mainstem migration, side-channel presence, floodplain connection, instream islands, and bars. In addition to the historical maps and aerial photographs, bare earth hillshade maps were generated from the 2001 and 2008 LiDAR to examine relict channel and floodplain features both within the confined and unconfined historic channel system. This historical imagery is included in Appendix B.

These data demonstrate the simplification of channel form that resulted from levee construction in the 1960s. The reach-level channel migration rates were measured from the channel centerline perpendicular to the adjacent floodplain slope at four locations covering the Project area. The results show that channel movement was dramatically more active prior to construction of the right bank levee (rates between 4 and 37 feet per year) than the subsequent rates for the confined channel (between 2 and 5 feet per year) (Table 2-2).

Table 2-2 Channel migration analysis for the Dungeness River in the Project reach.

Start	End	Distance Migrated (ft)				Time Period Average Rate (ft/yr)	Notes
1859	1912	315	105	270	63	4	
1912	1926	435	192	502	216	24	
1926	1938	500	333	718	146	37	
1938	1942	108	165	113	50	27	
1942	1965	83	130	66	42	3	RB Levee Constructed
1965	1975	48	61	26	0	3	
1975	1985	43	18	16	0	2	LB Levee Constructed
1985	1994	50	58	17	17	4	
1994	2000	52	13	0	0	3	
2000	2005	34	8	19	41	5	
Reach Average Rate (Pre-Levee Installation 1859 - 1938)						23	

The 1859 and 1909 to 1914 channel delineations were corrected during registration to match the topographic and geological constraints of the site. The channel on these early maps appeared to be on top of the left bank glacial terrace; however, there is no indication in the LiDAR topography that the river could ever have been at this location in recent time. In addition, the plotted channel directly downstream matched the outline of the terrace at RM 1.4; thus, these (imprecise) channel locations were shifted to the south to better align with the topographic data.

With nearly a century of mapped channel locations available, a historical reconstruction of channel positions is possible (Figure 2-3). In the earliest large-scale USACE map (1909), the river had a single-thread, meandering planform, but in a 1910 land classification map the river was depicted as fairly straight through the Project reach. In the 1917 map the channel had a wide meander at the Matriotti Creek confluence, and downstream the channel gradually meandered toward the north.

The channel planform changed significantly between the 1917 and 1938 maps. The meander at the Matriotti Creek confluence pointed to the east in 1938 rather than to the west as depicted in the 1917 map. The channel downstream of the creek confluence was more sinuous and was located directly against the Pleistocene glaciomarine drift unit on the left bank. The channel appeared to cross East Anderson Road farther to the east than in the 1917 map, likely a result of a significant channel avulsion downstream in the river delta.

Features such as side channels, bank locations, and islands are more readily identified in the 1942 aerial photo than in the earlier maps. The 1942 aerial photo showed a large instream island at the Matriotti Creek confluence that was not depicted on any of the earlier maps. Overall the channel location was not significantly different than in the 1938 map, with the channel becoming slightly more sinuous.

The 1963 aerial photograph is the earliest image with the right bank USACE levee visible. The channel had changed little from the 1942 aerial image, with the exception of a shortened meander at RM 1.13. The 1965 aerial showed little to no change from the 1963 aerial, except for the new alignment and Schoolhouse Road Bridge at the downstream end of the Project reach. The channel split around the island at the Matriotti Creek confluence visible in the 1965 aerial photo shifted toward the east branch in the 1975 aerial photo. There appeared to still be a channel present along the west branch; however, the unvegetated channel width was 20 to 40 feet, much less than the east branch at 65 to 100 feet wide.

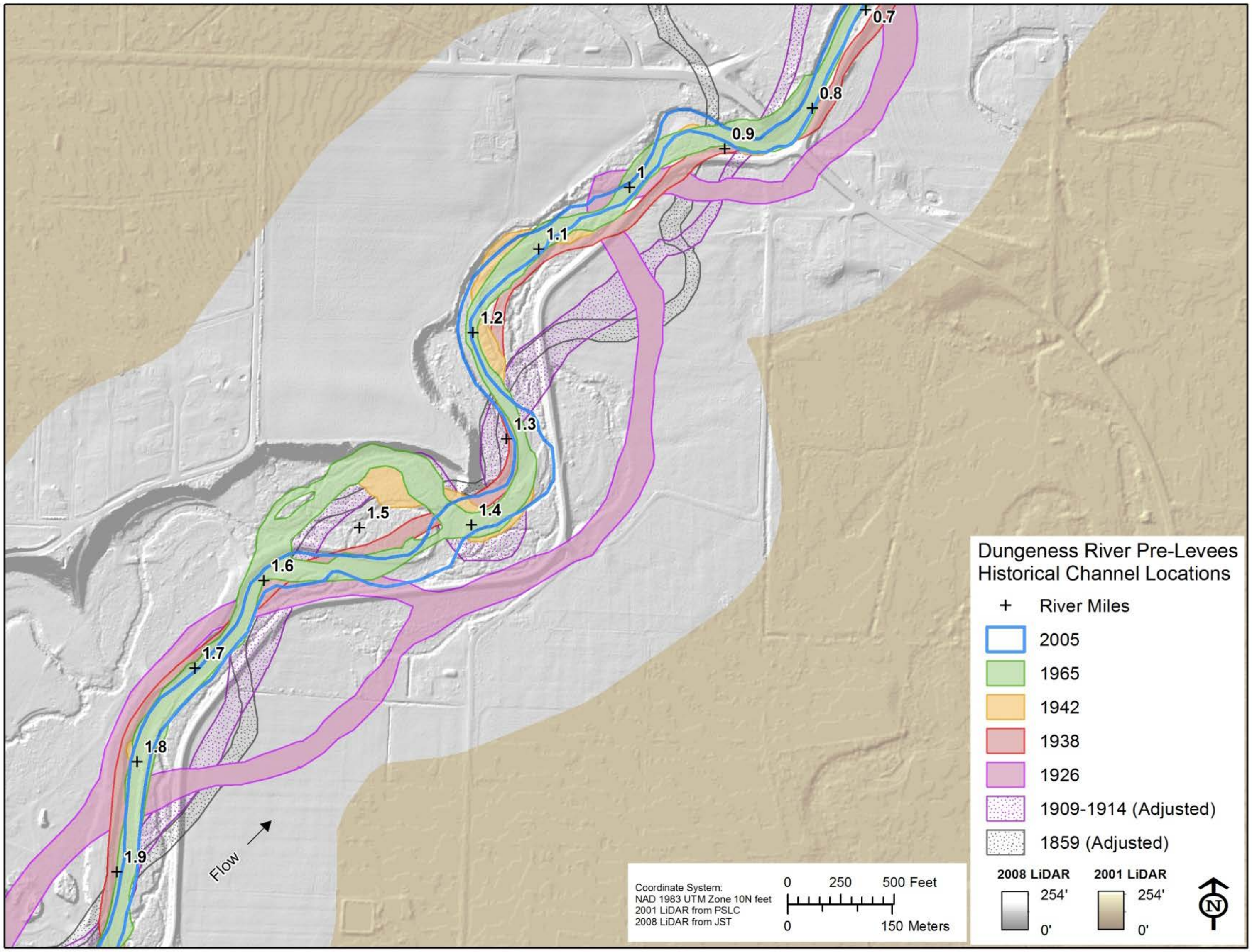

Figure 2-3 Location of historical channels prior to the influence of levee construction in the 1960s. The 1859 and 1909-1914 channel locations were adjusted during registration to match topographic data. The background LiDAR was flown in 2008 along the river corridor and in 2001 outside the corridor.

By the 1985 aerial photo the west branch around the island appeared to have been largely abandoned by the mainstem and likely functioned as an intermittent side channel. Between 1985 and 1995 three meander bends migrated significantly: at RM 0.95, 1.34 and 1.5 (Figure 2-4). Two of these meander migrations (RM 1.34 and 1.5) resulted in the channel impinging on the USACE levee. The downstream meander migrated approximately 40 feet westward into the Pleistocene glaciomarine drift. The mainstem channel impinged on the USACE levee for approximately 200 lineal feet (LF) at the RM 1.34 meander, while the channel impinged on the RM 1.5 meander for approximately 120 LF in 1995.

No significant changes in the channel were observed between the 1995 and 2000 aerial photos. The RM 1.5 meander migrated downstream between 2000 and 2005, resulting in approximately 325 LF of channel directly against the USACE levee. The RM 1.34 meander bend migrated downstream as well, but its movement was away (westward) from the USACE levee and a vegetated bar developed along the levee margin. The 2010 aerial photo showed that the RM 1.5 meander bend has continued to migrate downstream and has begun to build a gravel bar along the levee margin on the upstream end. The RM 1.34 meander bend moved back toward the USACE levee and is directly against it for approximately 140 LF.

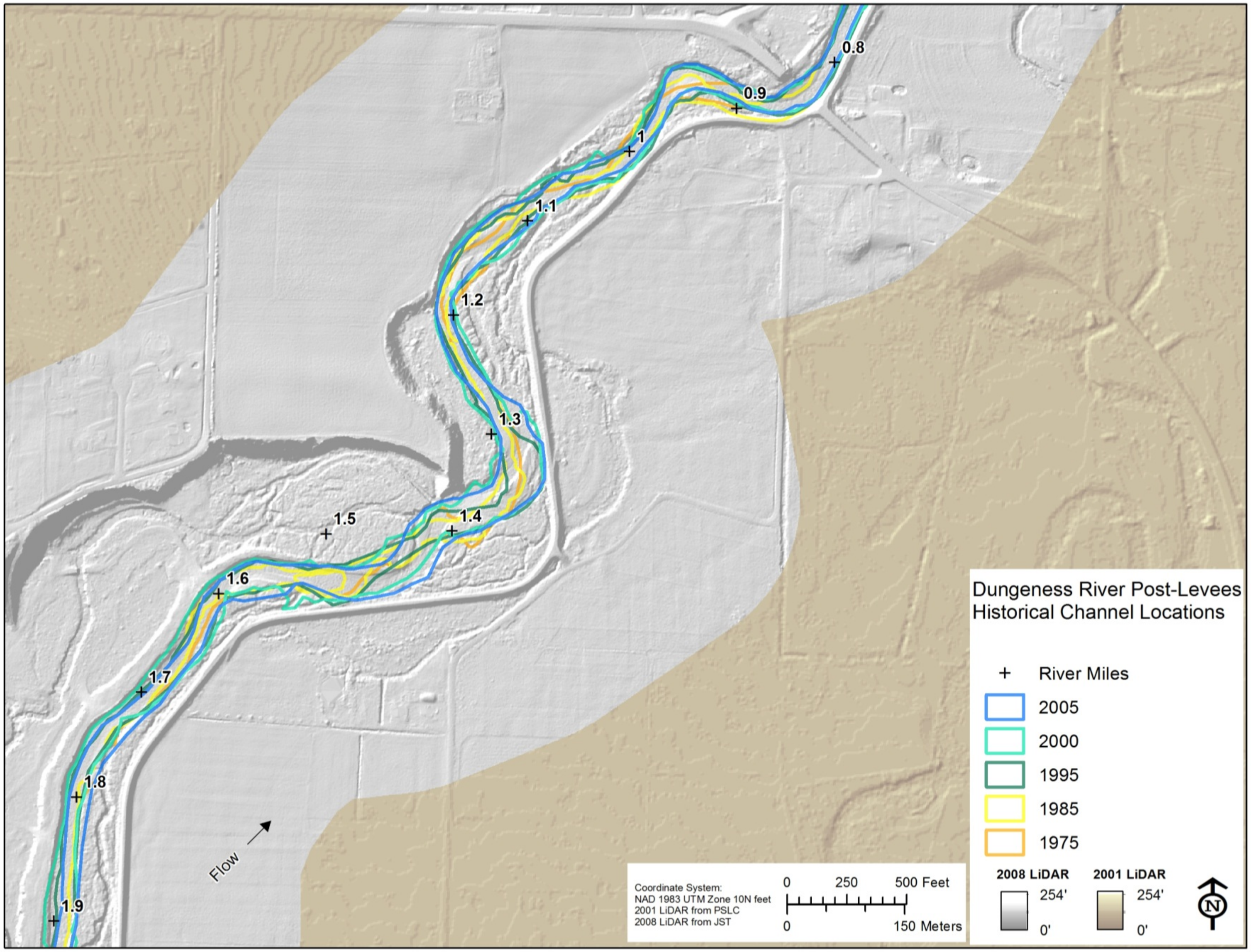

Figure 2-4 Location of historical channels since levee construction in the 1960s. The background LiDAR was flown in 2008 along the river corridor and in 2001 outside the corridor.

2.4.3 Aggradation and Channel Geometry Changes

The accumulation of sediment in the channel can decrease river capacity for carrying flood flows, increasing the potential for flooding and inducing channel migration through gravel bar deposition. While the channel bed elevations in other parts of the Dungeness River have been stable or degrading in the last three decades, the bed in the lower river has expressed zones of both degradation and aggradation, likely due to the interplay of the natural topography and human modifications (Haring 1999). Between 1960 and 1996, the channel and floodplain within the dikes at the Schoolhouse Bridge aggraded significantly (Haring 1999). As a consequence, the levees in this area that had been built to contain the 200-year recurrence interval flood with freeboard were projected to contain only about a 10-year flow (4,500 cfs) with 2.5 feet of freeboard (DFHAC 2009). However, the January 2002 flood (with a peak flow of 7,610 cfs) did not overtop the levee (DFHAC 2009). Hydraulic modeling completed for this site investigation showed a capacity at flows slightly less than the 100-year flood event with no freeboard.

A series of channel cross sections were surveyed in 1997 and 2010 by the BOR and Northwest Territories, Inc., respectively (Figure 2-5). The data in the Project reach (cross sections 4 through 12) were analyzed to quantify aggradation or degradation of the channel. Cross section 8 was not used in the analysis because the channel changed flow direction between 1997 and 2010 such that the cross section no longer spanned the entire channel. The thalweg (i.e., the deepest point in the channel) and the average bed elevations throughout most of the lower half of the study area had lowered by 2010, with aggradation in the upstream sections. Overall, the measurements showed a small net increase in the total amount of sediment in the channel, equivalent to about 0.08 feet (about an inch, and likely within the range of measurement error) of reach-averaged aggradation over 13 years (Table 2-3 and Figure 2-6).

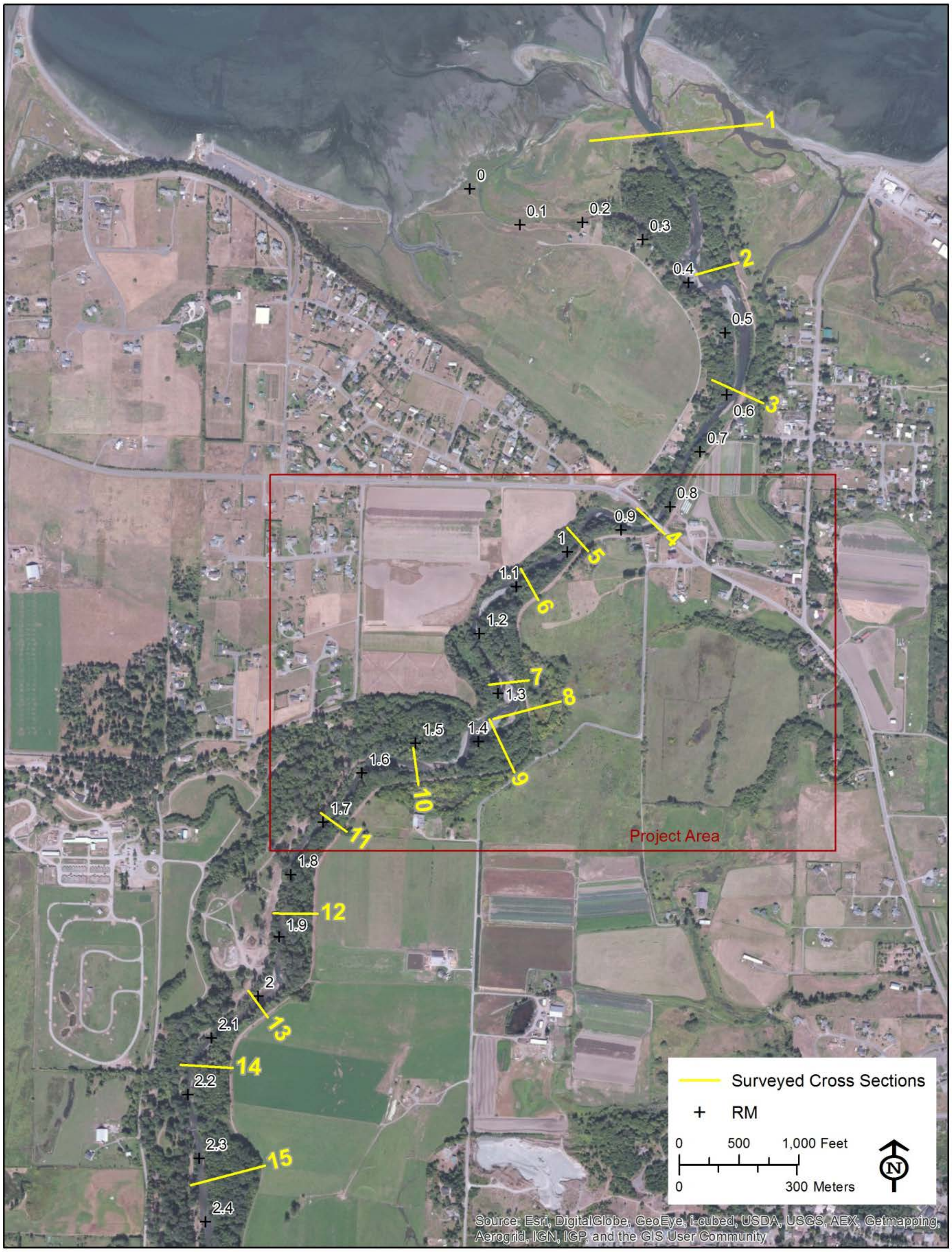

Figure 2-5 Cross sections used in the channel geometry analysis (section 8 excluded; see text).

Table 2-3 Summary of lower Dungeness River cross section survey channel changes from 1997 to 2010. Positive values denote sediment deposition, negative values denote scour.

Cross Section	RM	Thalweg Elevation (ft)		Thalweg Difference 1997 to 2010 (ft)	XS Area Difference 1997-2010 (ft^2)	Volume Difference 1997-2010 (ft^3)
		1997	2010			
4	0.72	10.4	9.9	-0.5	42	18,397
5	0.88	15.2	14.0	-1.2	-106	-75,504
6	0.98	18.3	17.2	-1.1	-15	-13,629
7	1.20	23.1	20.2	-2.9	-310	-260,298
9	1.26	25.4	23.9	-1.5	89	57,202
10	1.32	28.4	29.9	1.5	279	254,454
11	1.47	32.2	34.0	1.8	24	23,105
12	1.65	35.8	36.5	0.7	75	34,694
Average change over 13 years:						+0.08 feet*

* Average volume change per ft^2 of channel using entire interpolated surface area, assuming an average channel width of 80’. Deposition is concentrated in the zone just upstream of the sharp, levee-constrained bend at RM 1.34 (i.e., sections 9–11); what is likely compensatory erosion begins just downstream at section 7.

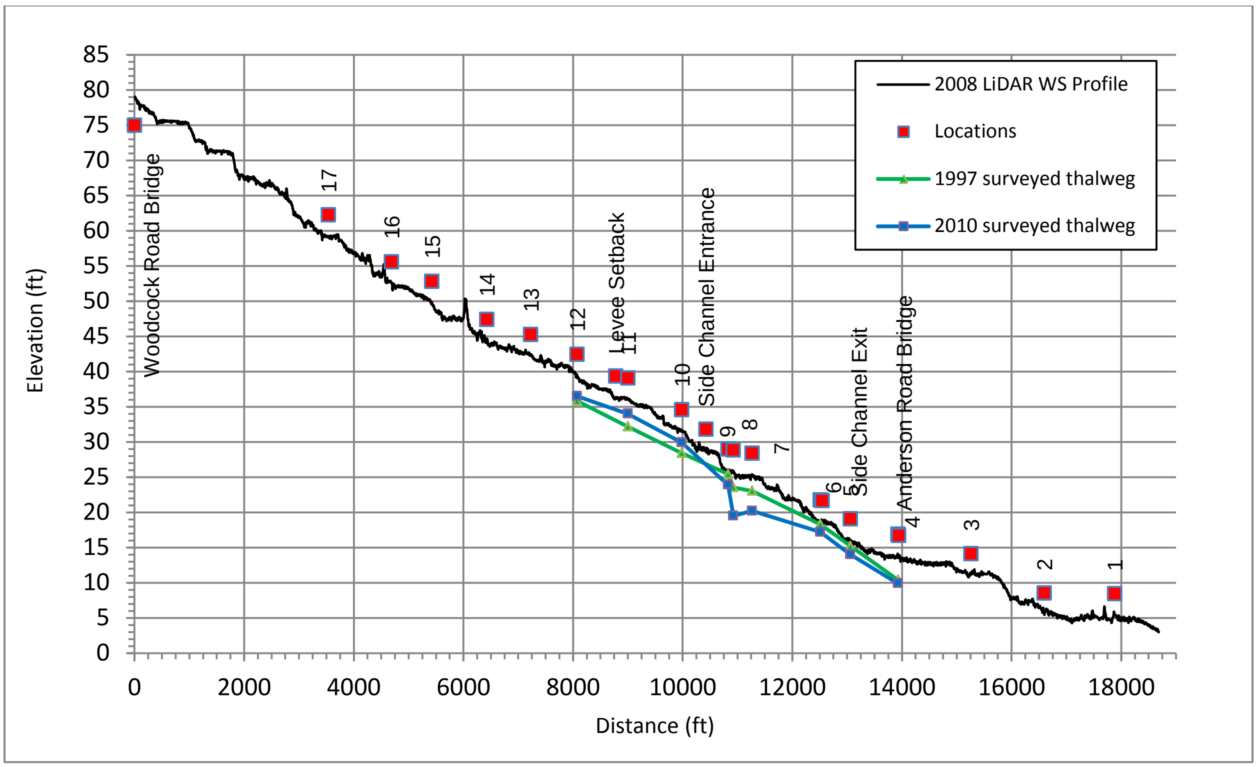

Figure 2-6 Lower Dungeness River water surface profile from March 4, 2008 LiDAR (~182 cfs) with 1997 & 2010 field surveyed thalweg elevations. Aggradation in the upper part of the project reach (sections 10, 11, and 12) are evident; although the thalweg also deepened at section 9, net aggradation occurred here.

Chapter 3 Design Development and Analysis

3.1 Proposed Alternatives

The following concept alternatives were considered in order to restore aquatic habitat and maximize habitat diversity within the Project Area:

1. Levee Setback Along Towne Road;

2. Full Levee Setback; and

3. Levee Setback with Gap.

3.1.1 Levee Setback Along Towne Road

The levee setback along Towne Road option would remove 4,430 linear feet of the existing USACE levee upstream of the Schoolhouse Bridge and reconstruct 4,700 linear feet of new setback levee along the current alignment of Towne Road. Construction of this new setback levee would reconnect approximately 48 acres of floodplain to the Dungeness River. Additionally, an existing side channel would be reconnected to the mainstem of the Dungeness River and 15 engineered log jams (ELJs) would be installed within the mainstem and side channels to provide aquatic habitat and to constrain river lateral migration. This option would require mitigation work and a remapping of the existing FEMA floodway in order to accommodate high flows leaving the mainstem of the Dungeness River by overtopping of the existing levee upstream of the Project Area (Figure 3-1).

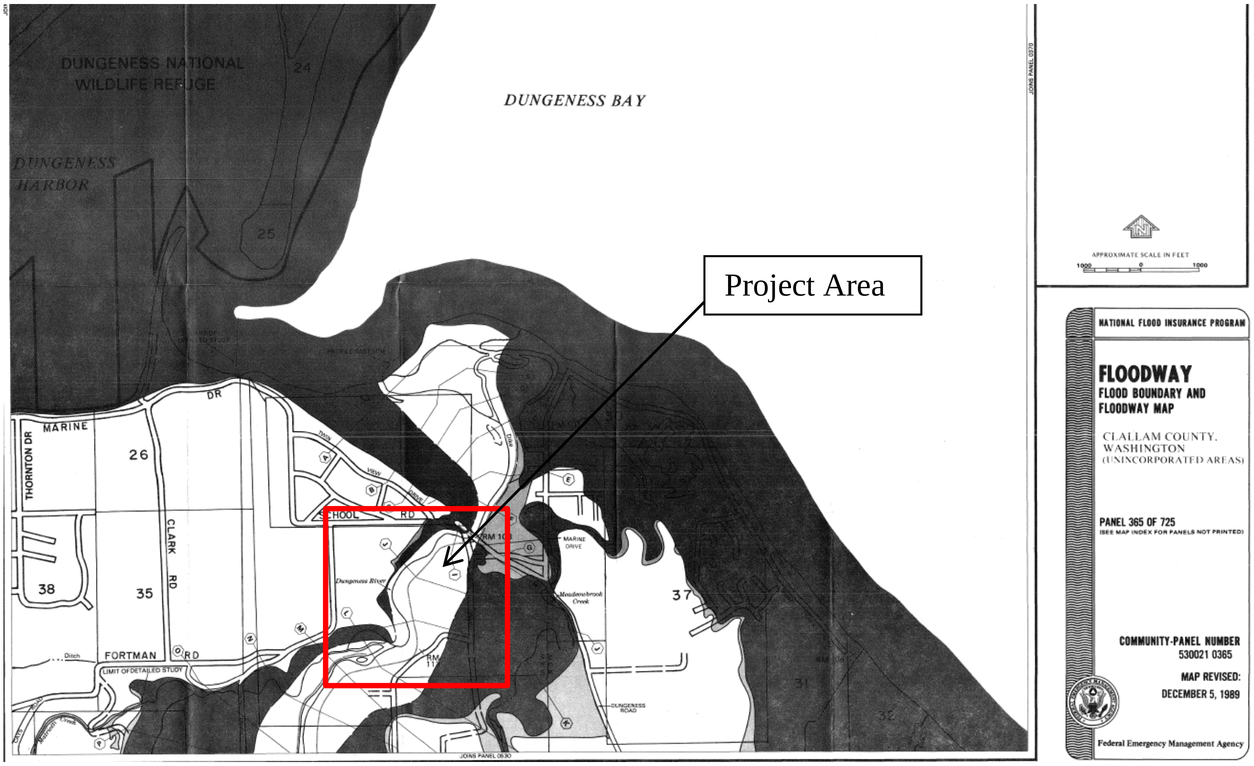

Figure 3-1 The existing FEMA Floodway shown as a white zone along the river in the vicinity of Project Area (FEMA 2001).

3.1.2 Full Levee Setback

The full levee setback option would also remove 4,430 linear feet of the existing USACE levee upstream of the Schoolhouse Bridge and reconstruct 6,320 linear feet of new setback levee along the break in topography separating the Dungeness River from the Meadowbrook Creek drainage. This new setback levee would reconnect 116 acres of floodplain to the Dungeness River including 23 acres of wetland recently restored by the Washington State Department of Transportation (WSDOT). An existing side channel would be reconnected to the mainstem of the Dungeness River and 15 ELJs would be installed within the mainstem and side channels to provide aquatic habitat and to constrain river lateral migration. Towne Road would be removed and a new high flow return channel would also be constructed in order to allow flood water to drain back to the Dungeness River and prevent fish stranding in the relatively low-lying WSDOT mitigation wetland. As in the Towne Road levee setback, this option would require mitigation and a remapping of the existing FEMA floodway in order to accommodate high flows leaving the mainstem of the Dungeness River by overtopping of the existing levee upstream of the Project Area.

3.1.3 Levee Setback with Gap

The levee setback with gap option is similar to the full setback option. Under this option, the FEMA floodway constraint is addressed by leaving a gap in the proposed levee near the upstream end in order to allow high flows which overtop the existing levee upstream of the Project Area to return to the main flow. In order to prevent additional flow loss to areas outside of the levee system, the length of existing USACE levee removed will be reduced to 2,600 linear feet. The new setback levee would run 4,720 linear feet and would reconnect 98 acres of floodplain to the Dungeness River, including the 23 acres of wetland recently restored by WSDOT. A portion of Towne Road would be removed and a portion of an existing side channel would be reconnected to the mainstem of the Dungeness River. Fifteeen ELJs would be installed within the mainstem and side channels to provide aquatic habitat and to constrain river lateral migration. A new high flow return channel would also be constructed in order to allow flood water to drain back to the Dungeness River and prevent fish stranding in the relatively low-lying WSDOT mitigation wetland.

3.2 Selected Alternative

The 60 percent design was based on the levee setback with gap option. The design plans are included in Appendix C. This design includes the reconnection of 98 acres of floodplain and 1,100 linear feet of side channel habitat. It would include the construction of 15 ELJs and removal of 3,125 linear feet of Towne Road. Additionally, 1,070 linear feet of new high flow return channel will be constructed to prevent fish stranding in the WSDOT wetland and allow flood flows to return to the Dungeness River.

While the new levee will actually be designed by the USACE in the future, a proposed 4,720-foot long levee alignment has been included in the 60 percent design plans that ties into existing high ground near Anderson Road and Schoolhouse Bridge. Some of this land is currently privately owned and acquisition of property would be required in order to construct this levee. Within the WSDOT wetland, the levee alignment has been selected to avoid impacts to the proposed wetland and Meadowbrook Creek. South of the wetland, the levee has been extended on to private property (Forbes parcel) under the assumption that this property will soon be acquired. The levee is tied into existing high ground on the Forbes property before continuing west towards Towne Road where a gap has been left in order to provide high flow return access. The levee cross section was developed via conversations with USACE and provides a 12-foot wide top width with 2.5:1 side slopes. The levee height has been set to contain the 100-year flood event with 2 feet of freeboard. A rock face and toe has been provided in the portion of the levee near the Schoolhouse Bridge in order to prevent scour of the levee toe.

The 2,600 linear feet of the existing USACE levee would be removed upstream of Schoolhouse Bridge. The material would be salvaged and used to construct the new setback levee. Towne Road would be terminated near the north end of the removed levee in order to provide maintenance access to the remaining portion of the existing USACE levee. Access gates would be installed at all access points to the new and old levees. Additionally, a gravel access road would be provided along the south portion of the new levee in order to allow continued access to a private property that will be cut off from Towne Road by the Project. Finally, existing power poles will be relocated, and a new gravel parking area will be provided at the intersection of Towne Road and the new levee access path in order to provide parking for recreational access.

A summary of the proposed levee setback and restoration construction activities is contained in Figure 3-2.

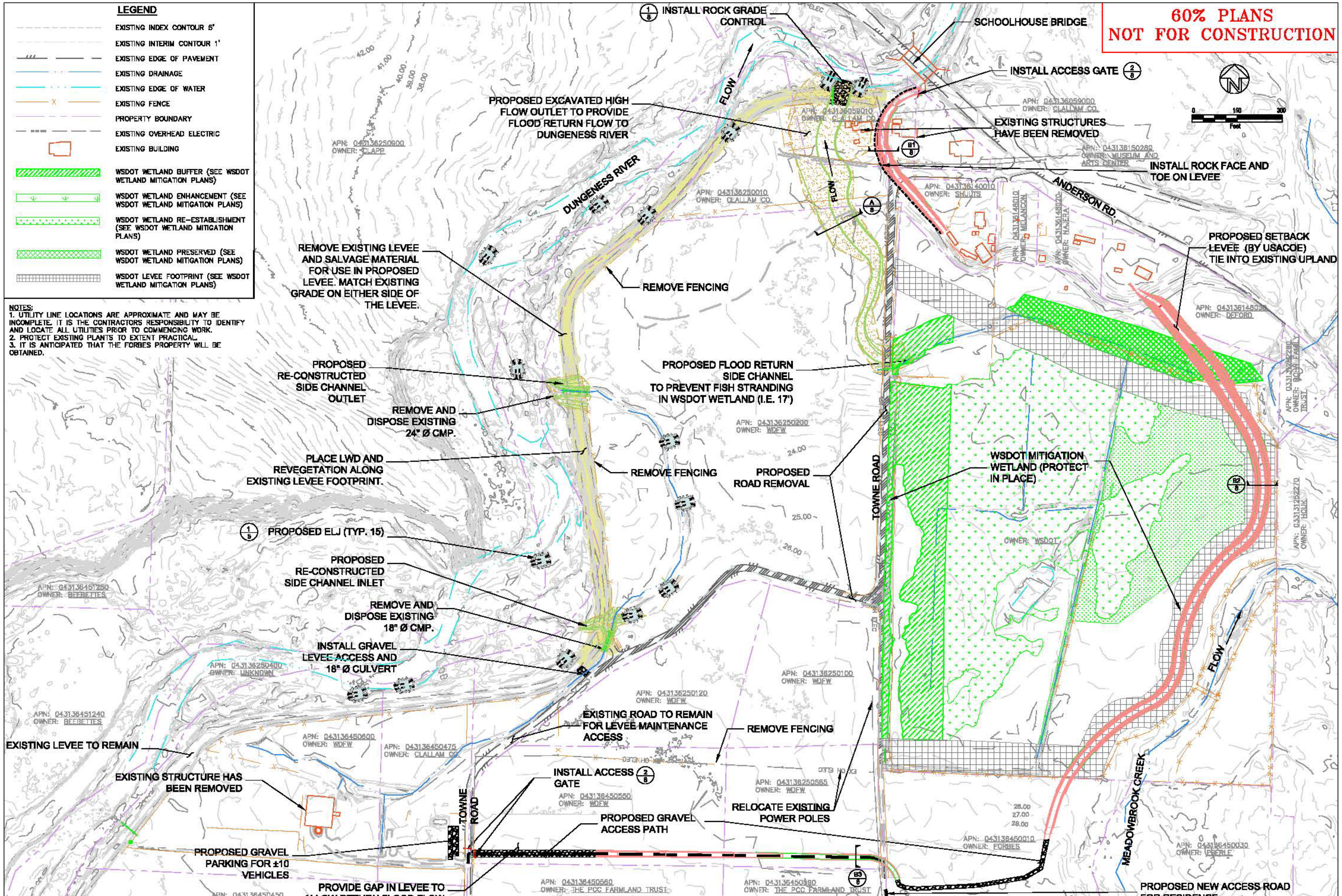

Figure 3-2 Proposed 60% Setback Levee and Habitat Restoration Plan.

3.3 Cost

Construction costs for the work depicted in the 60 percent design plans were developed using material quantities taken from the design plans and unit costs estimated from similar projects constructed recently within the region. Based on this data, construction costs for the setback levee portion of the work (to be completed by USACE) would be approximately $2.8 million. This work would include levee removal, road removal, setback levee construction, residential access road construction, parking area construction, power line relocation, and access gate installation. Construction costs for habitat restoration work would be approximately $1.2 million and include side channel reconnection, flood return channel construction, and ELJ construction. Costs include state sales tax and 20 percent contingency. The construction cost estimates based on the 60 percent design plans, including quantities of earthwork, are shown in Appendix D.

3.4 Design Analysis

3.4.1 Hydraulic Modeling

Cardno ENTRIX conducted an investigation into the lower Dungeness River hydraulics using a two-dimensional (2-D) model. This work updated a 2007 BOR 2-D model using GSTAR-W and a WEST Consultants 2012 Adaptive Hydraulics model (AdH) 2-D model in order to include recent bathymetric and topographic changes due to channel migration. The USACE AdH Version 4.1 modeling software was used and the model revised the location of the proposed levee setback.

The 60 percent designs presented in this report differ in a number of significant ways from the proposed conditions modeled by BOR. The model boundaries were established using the extent of flooding from the 100-year event as estimated in the 2007 BOR study. The model extent consisted of the lower 2.8 miles of the Dungeness River, beginning just upstream of the start of the existing USACE levee on the right bank. The primary area of interest lies between RM 0.8 and 1.8 (Figure 3-3). The details and results of the updated hydraulic model developed by Cardno ENTRIX are described below.

Figure 3-3 The 2-D hydraulic model of the lower Dungeness River with extent of the model outlined in yellow.

3.4.2 Model Development

The model mesh consisted of a minimum of 4 cells across the channel, with finer resolution in the locations of existing and proposed levees and decreased resolution toward the edges of the model domain. A figure illustrating the model mesh is included in Appendix E.

The model geometry for existing conditions was based on a combination of surveyed cross sections of the river and Light Detection and Ranging (LiDAR) data for the overbank areas. The LiDAR data was flown in 2008 for the JKT and the cross sections were surveyed in 1997 and 2010. Although the 1997 cross sections cover more of the river than the 2010 survey, channel migration rendered several of the 1997 cross sections obsolete. The 1997 and 2010 cross sections were combined to establish the most realistic boundary conditions. These cross sections were approximately 1,000 feet apart; additional cross sections were interpolated 10 feet apart between the survey locations to roughly match the resolution of the mesh in the channel. These data were interpolated into a mesh suitable for use in AdH modeling. The proposed condition model was developed by adjusting topographic elevations to reflect the removal or addition of levees and interpolating this onto the model mesh.

3.4.3 Model Parameters

The model parameters were based on the BOR model and calibrated using observations. The model used the BOR downstream boundary condition of a water depth of 9.1 feet, typical of the daily high tide. Although the Dungeness River experiences tidal fluctuations near the outlet to the Strait of Juan de Fuca, the area of interest upstream of the Schoolhouse Bridge is not tidally influenced, and thus the downstream boundary was considered to be constant. The upstream boundary conditions were based on the Cardno ENTRIX hydrologic analysis of the USGS station 12048000 data on the Dungeness River (Table 3-1).

The AdH model was calibrated to the flood event of January 7, 2002 that had a peak discharge of 7,610 cubic feet per second (cfs). The model results were compared to aerial imagery of the flooding extent and the BOR model results. The roughness coefficients (Manning's *n*) used in the BOR model were applied and the mesh was further refined during calibration. Table 3-1 shows the Manning's roughness coefficients used in the model for different areas with different materials. The spatial extent of the roughness values are shown in a figure in Appendix E.

Table 3-1 Manning's roughness coefficients (*n*) used to model existing and proposed conditions.

Classification	Manning's *n*
Channel	0.033
Bars and Bare Ground	0.033
Grasses	0.040
Vegetation	0.060

3.4.4 Results

The existing and proposed conditions were modeled for the 10-year and 100-year flood flows. An initial one-minute time step was used (and modified dynamically by the model in order to achieve solution convergence) and the models were run to steady state. In the existing condition model, the levees on the east side of the river were overtopped for the 100-year flood event by less than 0.1 foot of water depth and by flows in the range of 100 cfs. The 10-year flow was contained within the levees. Results of the existing conditions model are shown in Figures 3-4 through 3-7.

The results of the proposed conditions model are shown in Figures 3-8 through 3-11.Under the proposed conditions with the levee set back to the east, the 100-year flow did not overtop the levee. For all the modeled flows, velocities in the channel were lower under proposed conditions than existing conditions in the Project area. The differences between existing and proposed conditions increased as flows increased. The proposed conditions model also showed that the minor levee overtopping in the 100-year flood was eliminated. Furthermore, the flows that travelled around the remnant levee did not exit the floodplain, i.e. flows did not go south through the gap in the levee. It should be noted that 2-D models can produce isolated spots that appear to be underwater that are outside the actual modeled flow extent; these artificial remnants can be ignored. Additionally, depths less than 0.1 feet and velocities less than 0.5 feet per second are not shown in the model results figures.

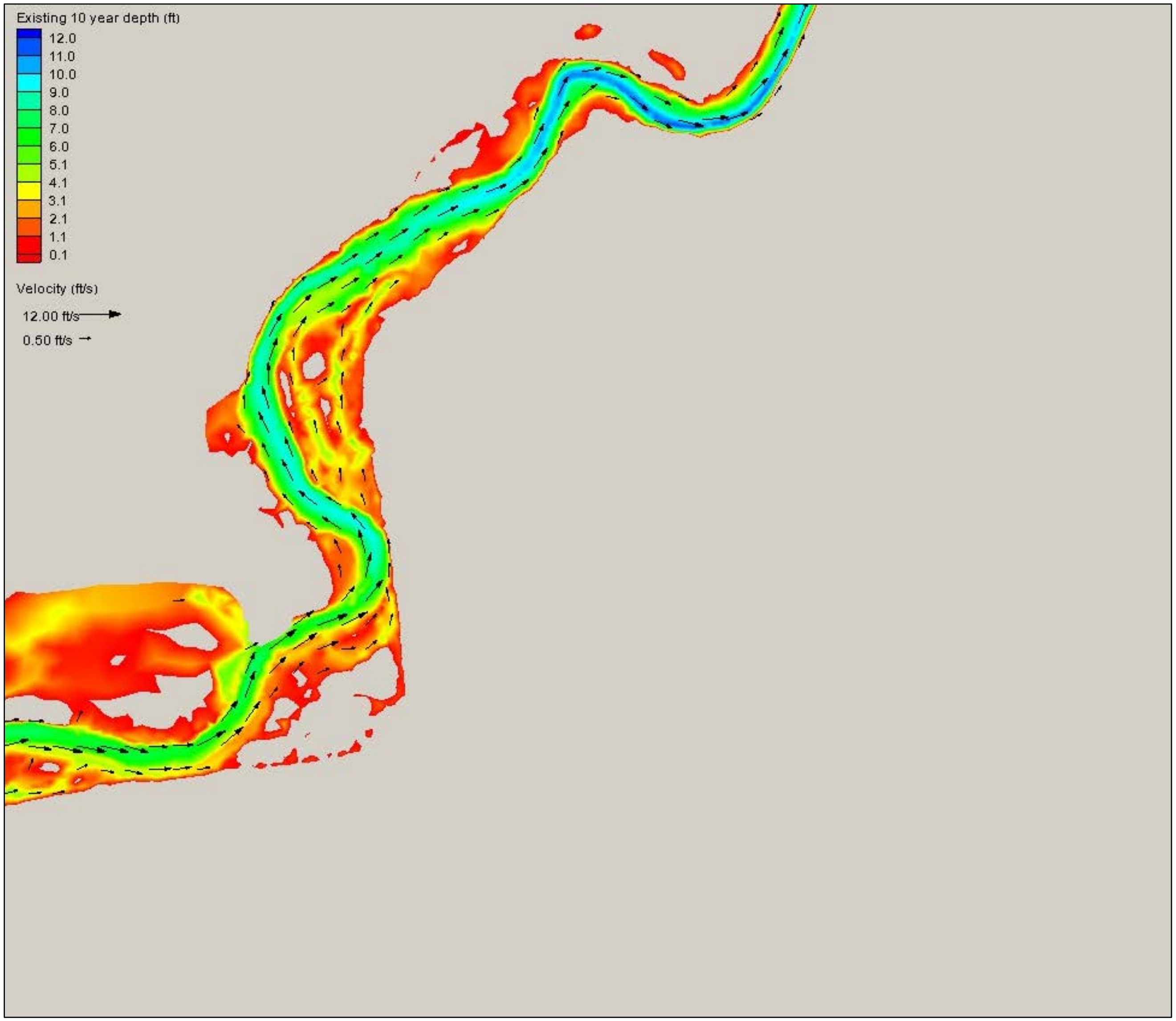

Figure 3-4 The existing conditions 10-year flow model of water depths (ft) and velocity vectors (ft/s). Areas with no vector arrows indicate velocities of less than 0.5 ft/s and depths less than 0.1 ft are not shown.

Figure 3-5 The existing conditions 10-year flow model of velocities (ft/s). Areas with no vector arrows indicate velocities of less than 0.5 ft/s and velocities less than 0.1 ft/s are not shown.

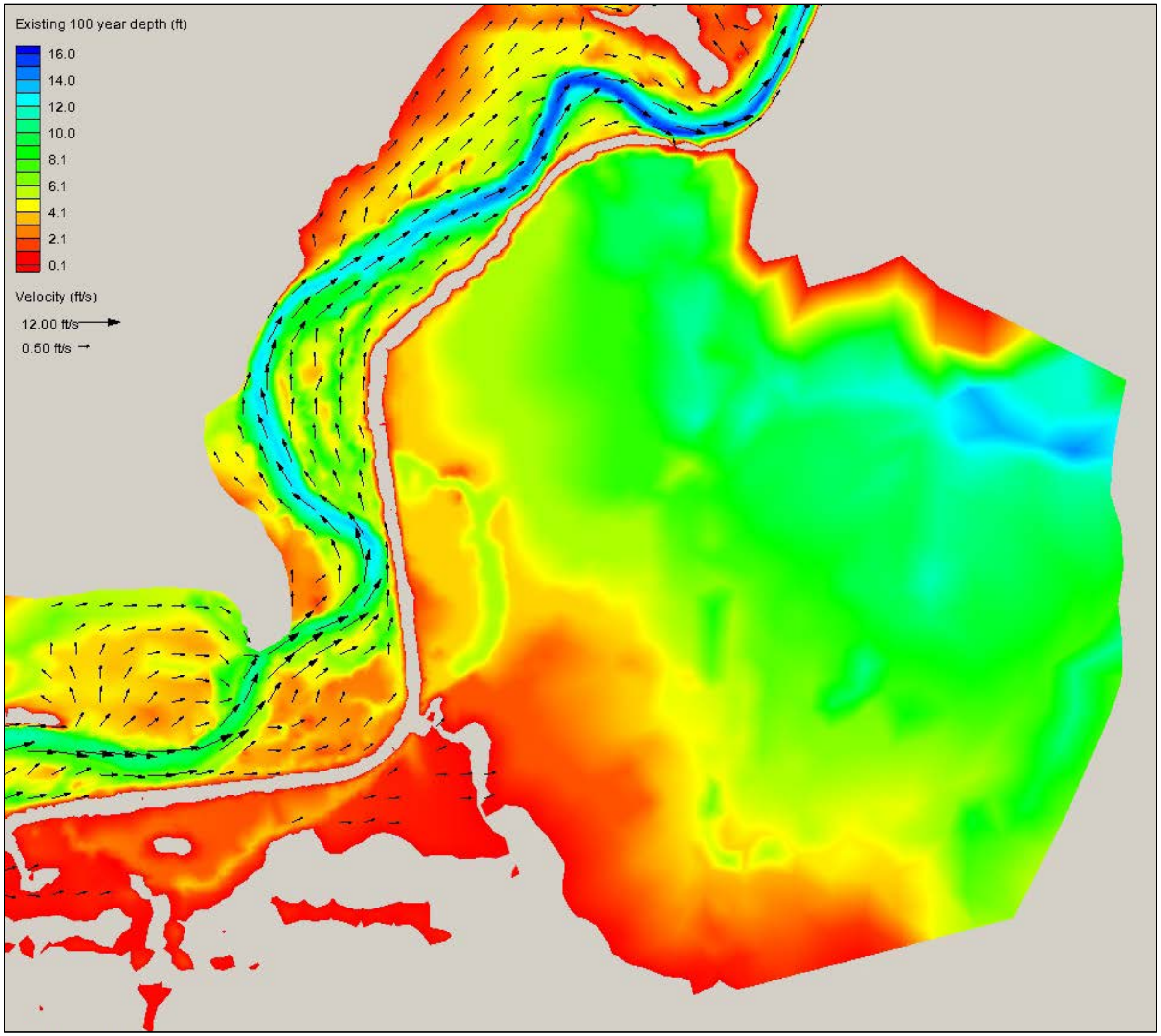

Figure 3-6 The existing conditions 100-year flow model water depths (ft) and velocity vectors (ft/s). The area east of the levee reflects ponding and a small amount of flow exits the floodplain to the right of the figure. Areas with no vector arrows indicate velocities of less than 0.5 ft/s and depths less than 0.1 ft are not shown.

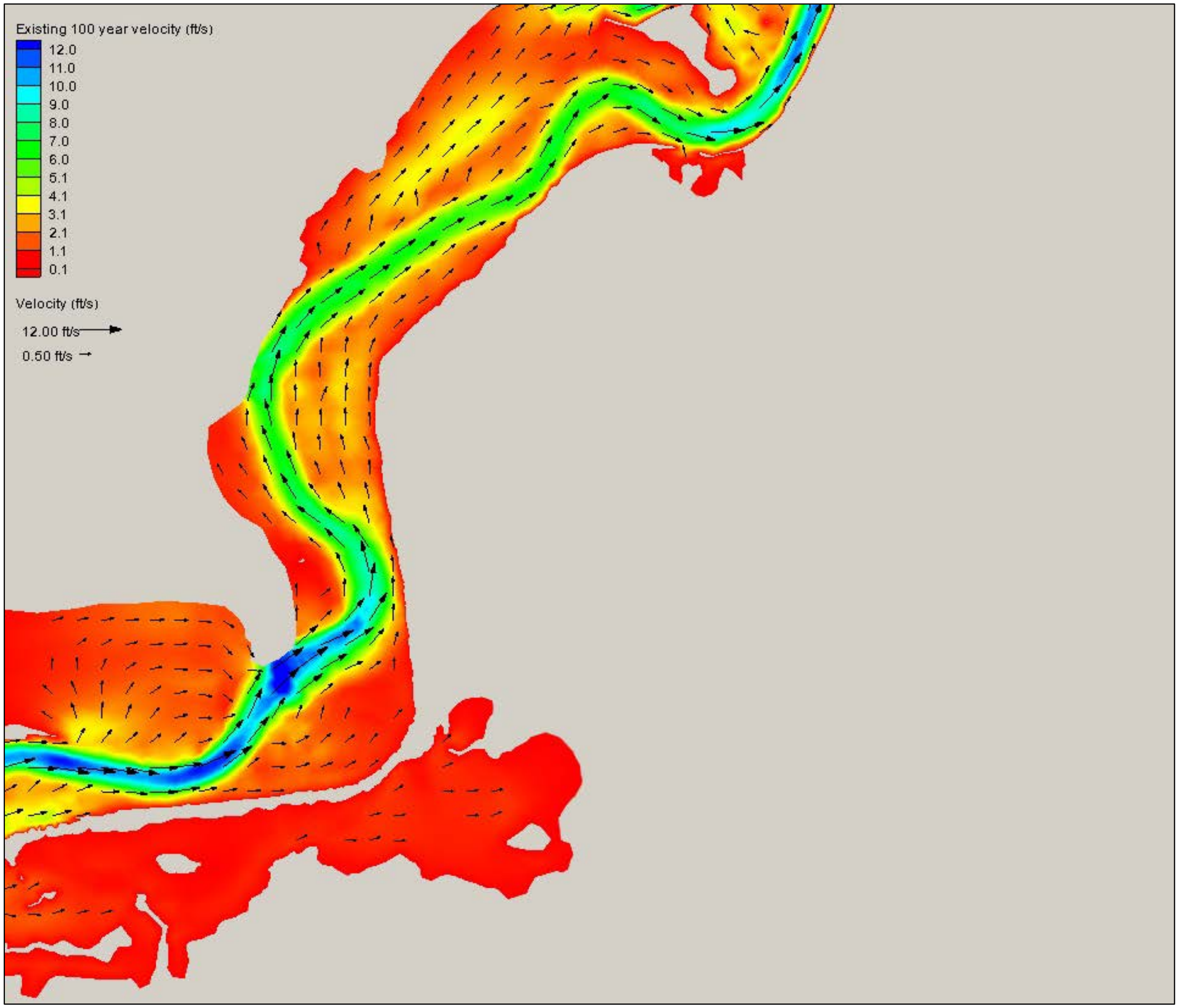

Figure 3-7 The existing conditions 100-year flow model velocities (ft/s). Areas with no vector arrows indicate velocities of less than 0.5 ft/s and velocities less than 0.1 ft/s are not shown.

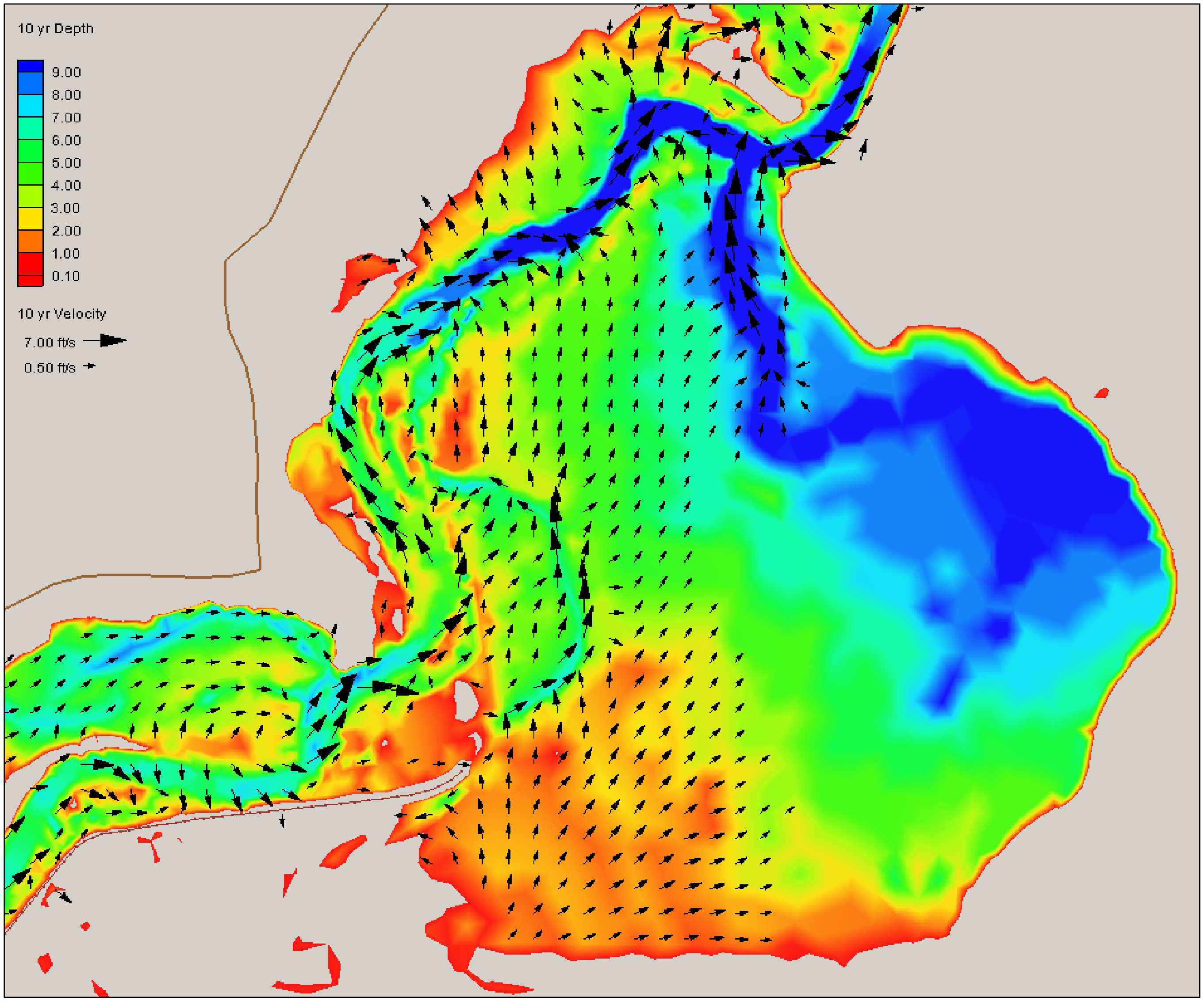

Figure 3-8 The proposed conditions 10-year flow model water depths (ft) and velocity vectors (ft/s). Areas with no vector arrows indicate velocities of less than 0.5 ft/s and depths less than 0.1 ft are not shown.

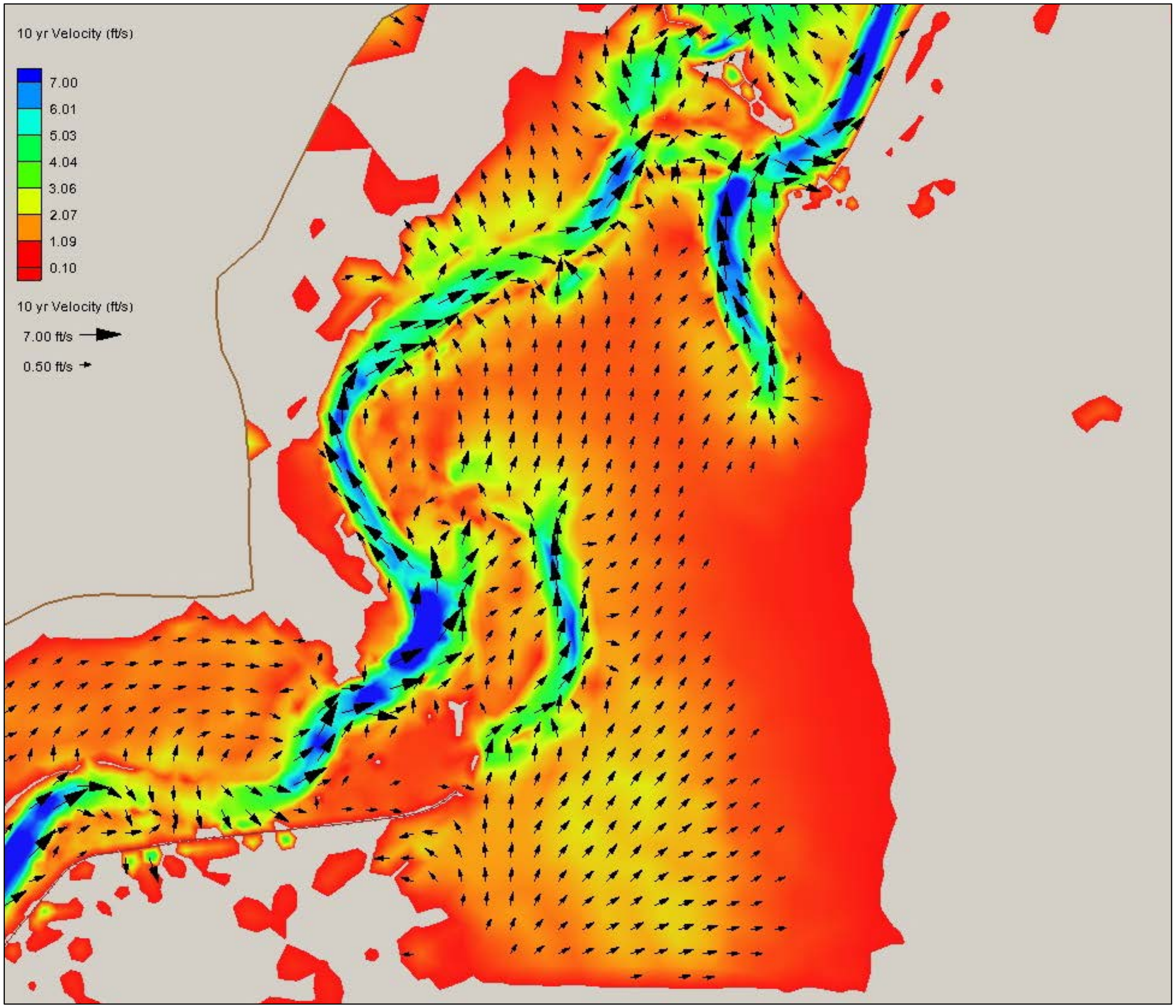

Figure 3-9 The proposed conditions 10-year model flow velocities (ft/s). Areas with no vector arrows indicate velocities of less than 0.5 ft/s and velocities less than 0.1 ft/s are not shown.

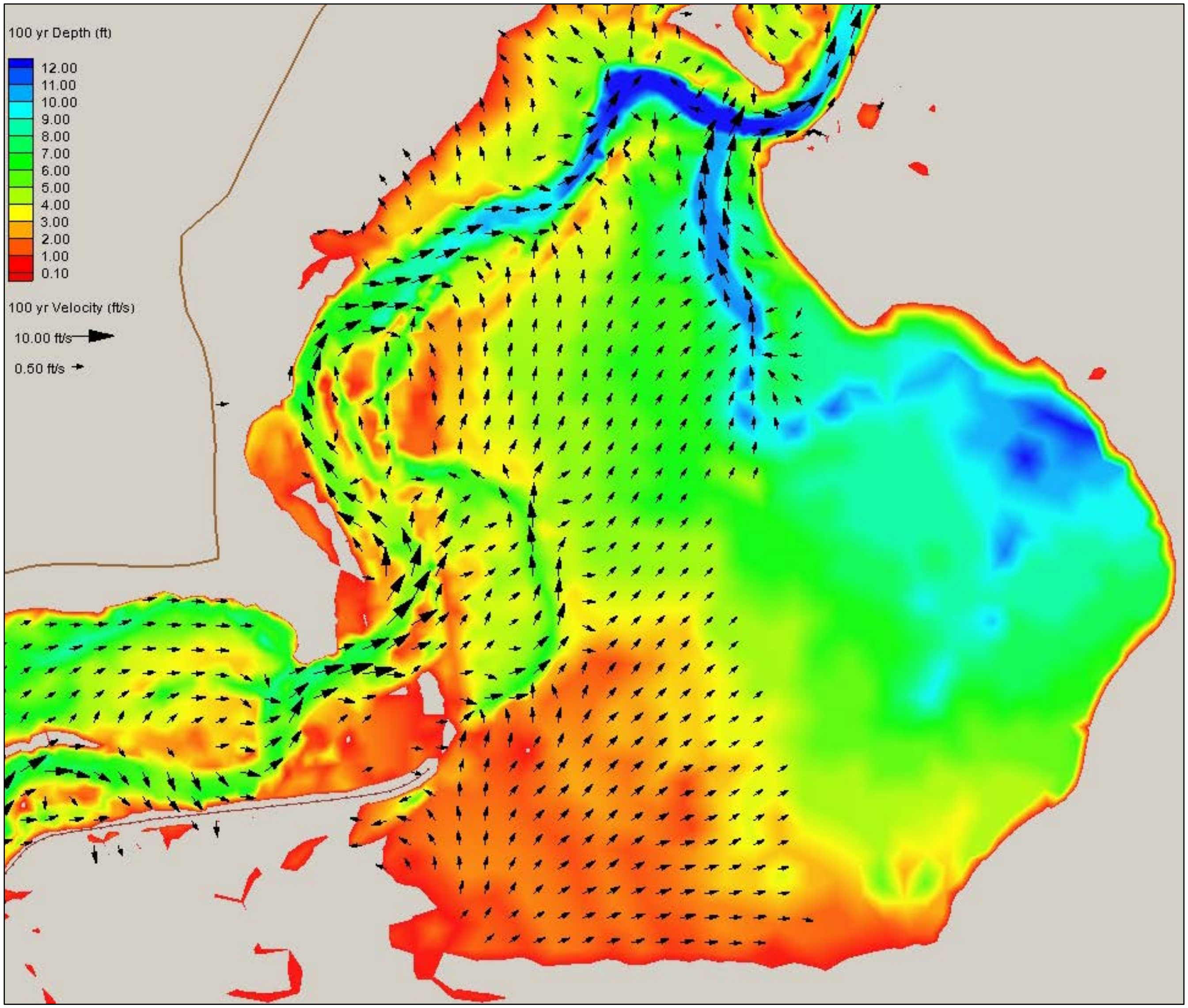

Figure 3-10 The proposed conditions at the 100-year flow modeled water depths (ft) and velocity vectors (ft/s). Areas with no vector arrows indicate velocities of less than 0.5 ft/s and depths less than 0.1 ft are not shown.

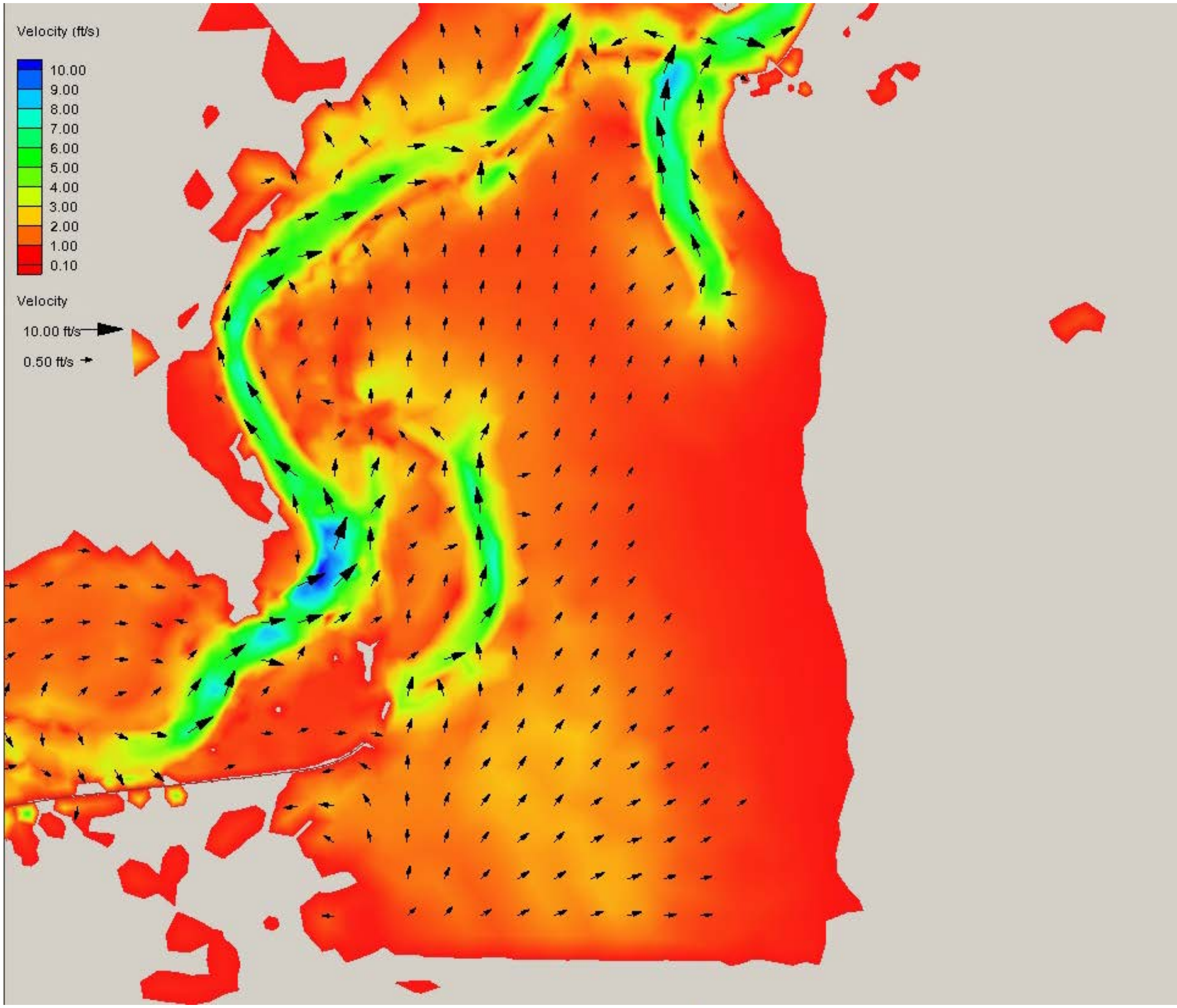

Figure 3-11 The proposed conditions at the 100-year flow model velocities (ft/s). Areas with no vector arrows indicate velocities of less than 0.5 ft/s and velocities less than 0.1 ft/s are not shown.

3.5 Geomorphic Effect of the Proposed Project

3.5.1 Predicted Channel Planform

To predict the channel pattern we expect the Dungeness River to establish once the levee is set back, the channel pattern threshold analysis of Eaton et al. (2010) was applied by plotting the channel slope and dimensionless formative discharge. This type of analysis uses reach-scale models that relate discharge, sediment supply, and bed material grain size to channel geometry using simplified representations of the underlying physics. Thus the formative discharge (the flow at which the river can do geomorphic work) is developed as a dimensionless value so that the exact channel dimensions are not needed.

Substrate sampling reported by the BOR (2002) showed a reach-average median grain size of very coarse gravel and a channel slope of 0.004 for the 2-year flood event. Based on this data, the Dungeness River in the Project reach falls within the anabranching channel planform category (Eaton et al. 2010) (Figure 3-12). While the river hydrology is not expected to change as a result of the levee setback, channel slope and median grain size are both likely to adjust to reflect the additional floodplain storage. These adjustments would likely result in a reduction of both the channel slope and the median grain size as channel velocities and transport capacity decrease. The combined effect of a reduction in channel slope (driving predicted channel planform toward a single-thread planform) and median grain size (driving predicted channel planform toward braided) yield an indeterminate outcome for a qualitative analysis, but the relatively modest changes anticipated for both parameters suggest that no change in the fundamental character of the river is likely. This is consistent with the historical (pre-levee) channel patterns in this reach as described by Collins (2005), which the post-project channel is more likely to resemble than at present.

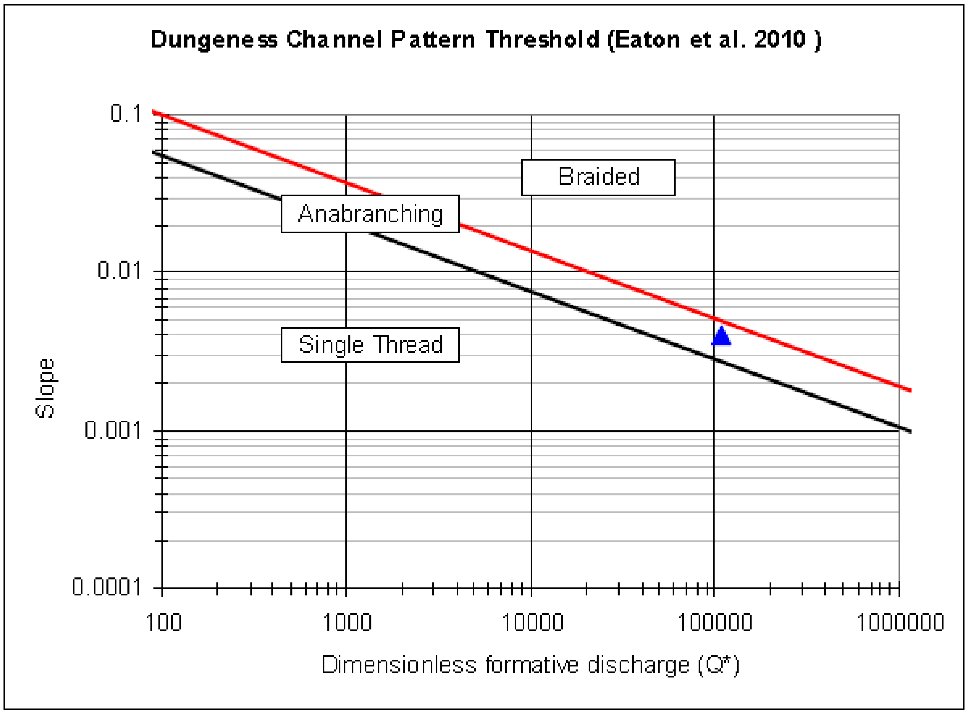

Figure 3-12 Channel slope, discharge, and planform, after Eaton et al. (2010).

3.5.2 Lateral Migration and Avulsion

The channel within the Project reach has historically occupied several tracts over the period of record, with periods when instream islands where present. Channel migration rates prior to levee construction were significantly higher and several meander bends were truncated by the construction of the USACE levee. Once the levee is removed it is likely that the channel will meander or avulse into the newly available floodplain. As long as infrastructure or private property is not threatened, a return to a dynamic channel would be beneficial for ecological function. The occupation of remnant side-channels and the formation of new floodplain channels would help restore geomorphic function and habitat-forming processes in the Project reach.

Removal of the right-bank levee would allow the river to re-occupy the historical meander bend between RM 1.0 and 1.5. Continued growth and downstream translation of this bend, at rates approximating that of the pre-levee period, is to be expected, but there is no credible risk that migration alone could bring the active channel against the new eastern setback levee within the 75-year design period. The reach average channel migration rate before the construction of the levees was 20 feet per year and the distance to the levee at its closest point to the current channel is 2,000 feet. While this meander bend was observed to migrate at a maximum distance of approximately 700 feet in the 12 years between 1926 and 1938, the river moved toward the west during this period. The historical record shows the river channel switching between westward and eastward migration, while remaining within an approximately 1,000-foot wide tract beside the glacial terrace to the west.

The results of the 2D model can provide a more apt prediction of future conditions than the historical record because of the other modifications in place in the watershed that will influence geomorphic processes beyond the presence of levees in the floodplain. As seen in Figures 3-8 through 3-11, flows slow down considerably as water depths increase adjacent to the setback levee. At the 10-year and 100-year flows, the water velocities at the levee drop to less than 0.5 foot per second.

While the footprint of the removed levee will be unvegetated following construction, some of the floodplain adjacent to these cutoff meander bends supports riparian forest. The riparian vegetation will not completely hinder channel migration into these areas, but it will help to impede its progress by increasing boundary shear stress. In addition, channel migration that does occur in the forested floodplain will provide a source of LWD into the river.

Another potential concern is that of channel avulsion to the northeast, where the river reoccupies its path of a few hundred years' prior (Collins 2005) and seeks to rejoin the current alignment of Meadowbrook Creek. The 2D model results indicate that the flow paths and velocities of the 10-year and 100-year flood events will not likely result in a channel avulsion that would threaten the setback levee. Floodplain flow paths generally trend toward the north and the direction of the wetland outflow channel. This channel will locally be lined with rock to prevent headcutting. As described above, the flow velocities in the floodplain drop as water depths increase, indicating that shear stresses will not be sufficient to create a new main channel and trigger an avulsion.

The area of high ground on the right bank floodplain seen in the HAWS map at RM 1.35 to 1.45 (Figure 2-2) may form an artificial impediment to floodplain connectivity. Once the levee is removed, the river could erode through this area over time, but it may instead exploit another remnant side channel closer to river at RM 1.25. In order for the river to re-occupy the larger remnant side channel in the short-term, we recommend exploring the option of connecting the side channel to the river at RM 1.4 through this high ground. The high ground is a legacy of the levee that may persist for some time even after the levee itself is removed, because flow depths and velocities probably will lack sufficient shear stress to erode the material.

3.5.3 Flooding and Aggradation

The setback levee will allow flood flows back onto the floodplain, making critical off-channel habitat available to fish and other aquatic wildlife. The reforestation of the right bank floodplain will increase roughness and decrease boundary shear stress, which will promote sediment deposition and could increase flood elevations. In addition, long-term aggradation is to be expected in this area due to its location in the depositional zone of the Dungeness River delta, although recent rates may more fully reflect increased sediment delivery from logging in the upper watershed earlier in the 20^{th} century, and inefficiencies in sediment transport imposed by localized channel constrictions.

However, the Dungeness River has shown areas of channel lowering as well as of aggradation. Channel degradation could hinder the connection between the river and its floodplain during relatively frequent, low-magnitude flood events. Additional channel aggradation in these areas could help restore floodplain connectivity and recover the conditions needed for sustaining a floodplain-wetland complex. Flooding outside of the intended floodplain, however, is not expected to occur up to the 100-year flood frequency because of the large added floodplain area and proposed 2 feet of freeboard at this design flow.

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Appendix A

Hydrology Flood Frequency Analysis

Appendix A

Bulletin 17B Frequency Analysis
07 Apr 2011 01:38 PM

--- Input Data ---

Analysis Name: 12048000 Station K
Description: Period of record: 1924 - 2010

Data Set Name: DUNGENESS RIVER-SEQUIM, WA-FLOW-ANNUAL PEAK
DSS File Name: T:\Geomorph\ALL_PROJECTS\Dungeness_42549003\Analysis\Hydrology\Dungeness\Dungeness.dss
DSS Pathname: /DUNGENESS RIVER/SEQUIM, WA/FLOW-ANNUAL PEAK/01jan1900/IR-CENTURY/USGS/

Report File Name:
T:\Geomorph\ALL_PROJECTS\Dungeness_42549003\Analysis\Hydrology\Dungeness\Bulletin17bResults\12048000_Station_K\12048000_Station_K.rpt
XML File Name:
T:\Geomorph\ALL_PROJECTS\Dungeness_42549003\Analysis\Hydrology\Dungeness\Bulletin17bResults\12048000_Station_K\12048000_Station_K.xml

Start Date:
End Date:

Skew Option: Use Station Skew
Regional Skew: -Infinity
Regional Skew MSE: -Infinity

Plotting Position Type: Median

Upper Confidence Level: 0.05
Lower Confidence Level: 0.95

Use non-standard frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 4.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0

Display ordinate values using 1 digits in fraction part of value

--- End of Input Data ---

<< Low Outlier Test >>

Based on 80 events, 10 percent outlier test deviate K(N) = 2.94
Computed low outlier test value = 568

0 low outlier(s) identified below test value of 568

<< High Outlier Test >>

Based on 80 events, 10 percent outlier test deviate K(N) = 2.94
Computed high outlier test value = 15,174.19

0 high outlier(s) identified above test value of 15,174.19

--- Final Results ---

<< Plotting Positions >>
DUNGENESS RIVER-SEQUIM, WA-FLOW-ANNUAL PEAK

Events Analyzed				Ordered Events			
Day Mon Year	FLOW CFS		Rank	Water Year	FLOW CFS	Median Plot Pos
11 Feb 1924	6,340.0		1	2002	7,610.0	0.87
19 Nov 1924	3,120.0		2	1991	7,120.0	2.11
23 Dec 1925	740.0		3	1950	6,820.0	3.36
01 Dec 1926	2,860.0		4	1956	6,750.0	4.60
12 Jan 1928	1,400.0		5	1986	6,560.0	5.85
15 Jun 1929	1,000.0		6	1924	6,340.0	7.09
20 Feb 1930	920.0		7	1997	5,990.0	8.33
28 Dec 1937	5,380.0		8	2004	5,920.0	9.58
01 Jan 1939	3,850.0		9	1961	5,900.0	10.82
15 Dec 1939	4,010.0		10	1984	5,510.0	12.06
17 Jan 1941	2,400.0		11	1938	5,380.0	13.31
02 Dec 1941	4,120.0		12	1980	5,350.0	14.55
26 May 1943	1,010.0		13	1976	5,150.0	15.80
03 Dec 1943	1,520.0		14	1992	5,090.0	17.04
07 Feb 1945	3,380.0		15	1995	4,850.0	18.28
14 Jun 1946	1,200.0		16	1960	4,800.0	19.53
12 Feb 1947	2,530.0		17	1999	4,640.0	20.77
19 Oct 1947	2,790.0		18	1951	4,600.0	22.01
01 Dec 1948	2,820.0		19	1996	4,500.0	23.26
27 Nov 1949	6,820.0		20	1974	4,320.0	24.50
09 Feb 1951	4,600.0		21	1942	4,120.0	25.75
30 Apr 1952	1,860.0		22	1981	4,040.0	26.99
12 Jan 1953	2,480.0		23	1940	4,010.0	28.23
05 Jan 1954	3,990.0		24	1954	3,990.0	29.48
18 Nov 1954	3,570.0		25	1968	3,920.0	30.72
03 Nov 1955	6,750.0		26	2010	3,900.0	31.97
09 Dec 1956	3,880.0		27	1957	3,880.0	33.21
24 Feb 1958	2,330.0		28	1939	3,850.0	34.45
29 Apr 1959	2,900.0		29	1983	3,710.0	35.70
29 Jan 1960	4,800.0		30	2008	3,690.0	36.94
15 Jan 1961	5,900.0		31	1963	3,670.0	38.18
03 Jan 1962	1,380.0		32	1990	3,650.0	39.43
04 Feb 1963	3,670.0		33	1973	3,630.0	40.67
22 Oct 1963	2,630.0		34	2005	3,620.0	41.92
30 Nov 1964	1,850.0		35	1955	3,570.0	43.16
06 May 1966	1,370.0		36	1972	3,500.0	44.40
13 Dec 1966	2,960.0		37	2000	3,490.0	45.65
14 Jan 1968	3,920.0		38	1945	3,380.0	46.89
24 May 1969	1,660.0		39	2003	3,330.0	48.13
13 Dec 1969	1,850.0		40	1988	3,300.0	49.38
23 Jun 1971	1,480.0		41	1994	3,240.0	50.62
05 Mar 1972	3,500.0		42	1982	3,240.0	51.87
26 Dec 1972	3,630.0		43	1987	3,220.0	53.11
16 Jan 1974	4,320.0		44	1925	3,120.0	54.35
21 Dec 1974	2,170.0		45	2006	3,090.0	55.60
03 Dec 1975	5,150.0		46	1998	2,970.0	56.84
07 Jun 1977	973.0		47	1967	2,960.0	58.08
01 Nov 1977	2,440.0		48	1959	2,900.0	59.33
04 Nov 1978	1,460.0		49	1927	2,860.0	60.57
17 Dec 1979	5,350.0		50	1949	2,820.0	61.82
26 Dec 1980	4,040.0		51	1948	2,790.0	63.06
05 Dec 1981	3,240.0		52	1964	2,630.0	64.30
03 Dec 1982	3,710.0		53	2007	2,530.0	65.55
15 Nov 1983	5,510.0		54	1947	2,530.0	66.79
03 Nov 1984	1,610.0		55	1953	2,480.0	68.03
18 Jan 1986	6,560.0		56	1978	2,440.0	69.28
23 Nov 1986	3,220.0		57	1941	2,400.0	70.52
09 Dec 1987	3,300.0		58	2009	2,350.0	71.77
05 Nov 1988	1,300.0		59	1958	2,330.0	73.01
04 Dec 1989	3,650.0		60	1975	2,170.0	74.25
24 Nov 1990	7,120.0		61	1952	1,860.0	75.50
31 Jan 1992	5,090.0		62	1970	1,850.0	76.74
25 Jan 1993	1,610.0		63	1965	1,850.0	77.99
10 Dec 1993	3,240.0		64	1969	1,660.0	79.23
20 Dec 1994	4,850.0		65	1993	1,610.0	80.47
13 Dec 1995	4,500.0		66	1985	1,610.0	81.72
19 Mar 1997	5,990.0		67	1944	1,520.0	82.96
30 Oct 1997	2,970.0		68	1971	1,480.0	84.20
13 Dec 1998	4,640.0		69	1979	1,460.0	85.45
11 Nov 1999	3,490.0		70	1928	1,400.0	86.69
24 May 2001	938.0		71	1962	1,380.0	87.94
07 Jan 2002	7,610.0		72	1966	1,370.0	89.18
13 Mar 2003	3,330.0		73	1989	1,300.0	90.42
20 Oct 2003	5,920.0		74	1946	1,200.0	91.67

10 Dec 2004	3,620.0	75	1943	1,010.0	92.91
25 Dec 2005	3,090.0	76	1929	1,000.0	94.15
06 Nov 2006	2,530.0	77	1977	973.0	95.40
04 Dec 2007	3,690.0	78	2001	938.0	96.64
08 Jan 2009	2,350.0	79	1930	920.0	97.89
12 Jan 2010	3,900.0	80	1926	740.0	99.13

<< Skew Weighting >>

Based on 80 events, mean-square error of station skew = 0.098
Mean-square error of regional skew = -?

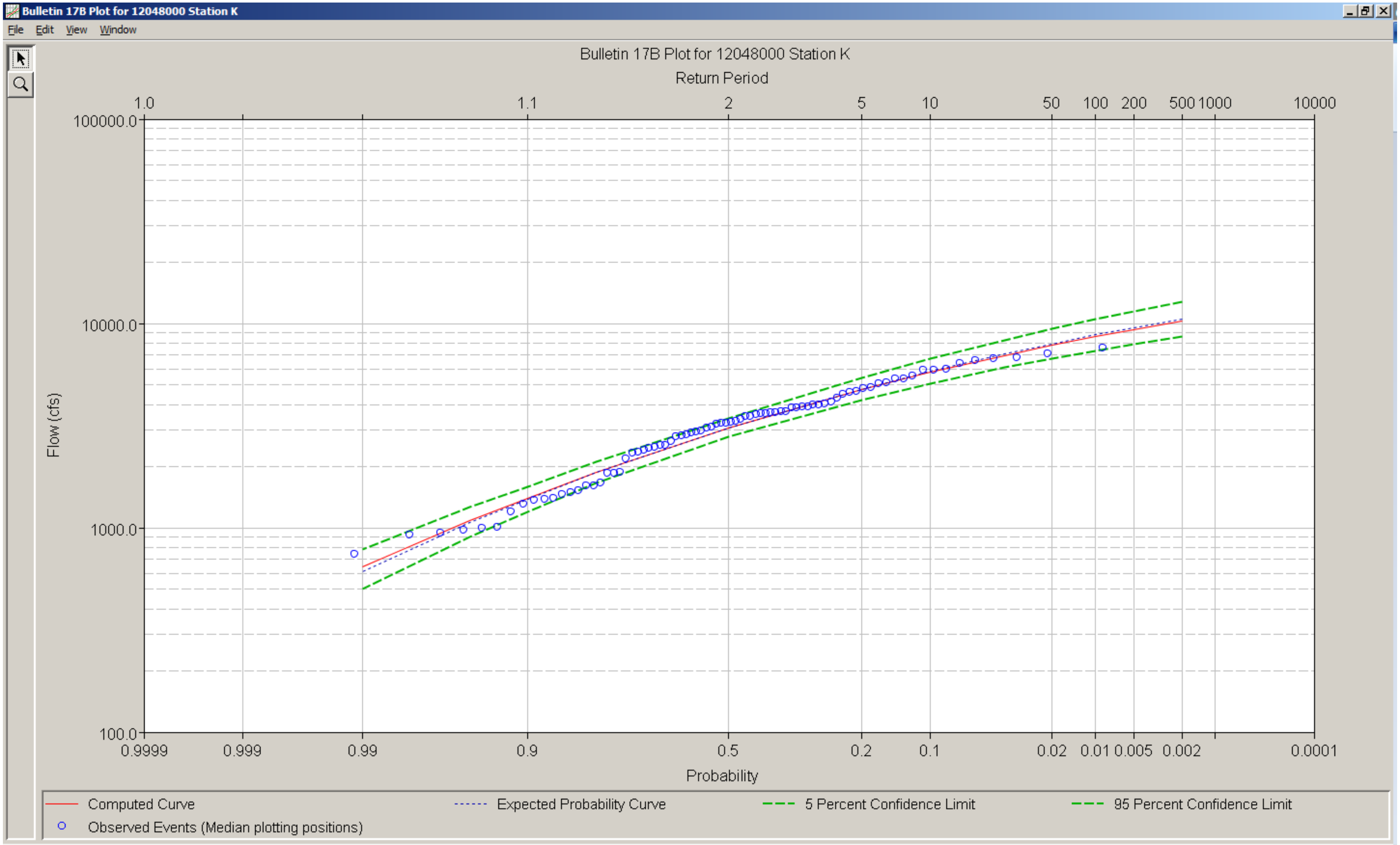
<< Frequency Curve >>
DUNGENESS RIVER-SEQUIM, WA-FLOW-ANNUAL PEAK

Computed Curve FLOW, CFS	Expected Probability FLOW, CFS	Percent Chance Exceedance	Confidence Limits 0.05 FLOW, CFS	Confidence Limits 0.95 FLOW, CFS
10,236.0	10,549.4	0.2	12,725.4	8,599.8
9,332.1	9,563.5	0.5	11,463.9	7,909.0
8,599.8	8,778.9	1.0	10,455.6	7,343.2
7,819.6	7,950.2	2.0	9,396.1	6,733.6
6,983.7	7,073.4	4.0	8,279.4	6,071.4
5,770.5	5,815.5	10.0	6,697.8	5,090.1
4,738.3	4,759.3	20.0	5,396.2	4,230.7
3,087.0	3,087.0	50.0	3,427.8	2,784.9
1,872.8	1,860.6	80.0	2,094.4	1,648.6
1,400.0	1,381.5	90.0	1,594.6	1,197.9
1,083.7	1,060.3	95.0	1,260.3	900.0
644.2	611.9	99.0	787.2	500.0

<< Systematic Statistics >>
DUNGENESS RIVER-SEQUIM, WA-FLOW-ANNUAL PEAK

Log Transform: FLOW, CFS		Number of Events	
Mean	3.468	Historic Events	0
Standard Dev	0.243	High Outliers	0
Station Skew	-0.542	Low Outliers	0
Regional Skew	---	Zero Events	0
Weighted Skew	---	Missing Events	0
Adopted Skew	-0.542	Systematic Events	80

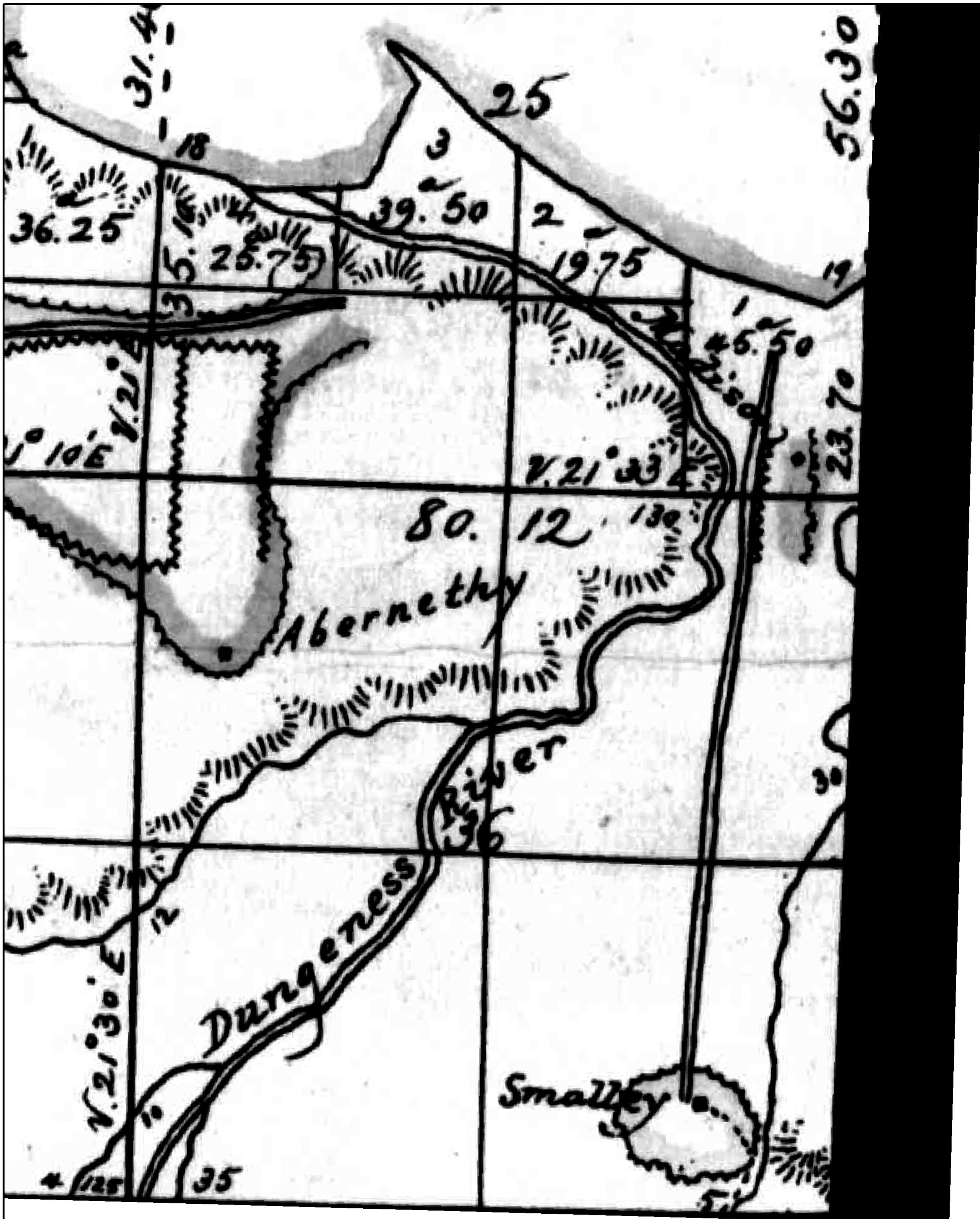
--- End of Analytical Frequency Curve ---


Bulletin 17B Plot for 12048000 Station K
File Edit View Window
Bulletin 17B Plot for 12048000 Station K
Return Period
1.0
1.1
2
5
10
50
100
200
500
1000
10000
100000.0
10000.0
1000.0
100.0
Flow (cfs)
0.9999
0.999
0.99
0.9
0.5
0.2
0.1
0.02
0.01
0.005
0.002
0.0001
Probability
Computed Curve
Expected Probability Curve
5 Percent Confidence Limit
95 Percent Confidence Limit
Observed Events (Median plotting positions)

Appendix B

Historical Imagery

Appendix B



1859 GLO Plat Map

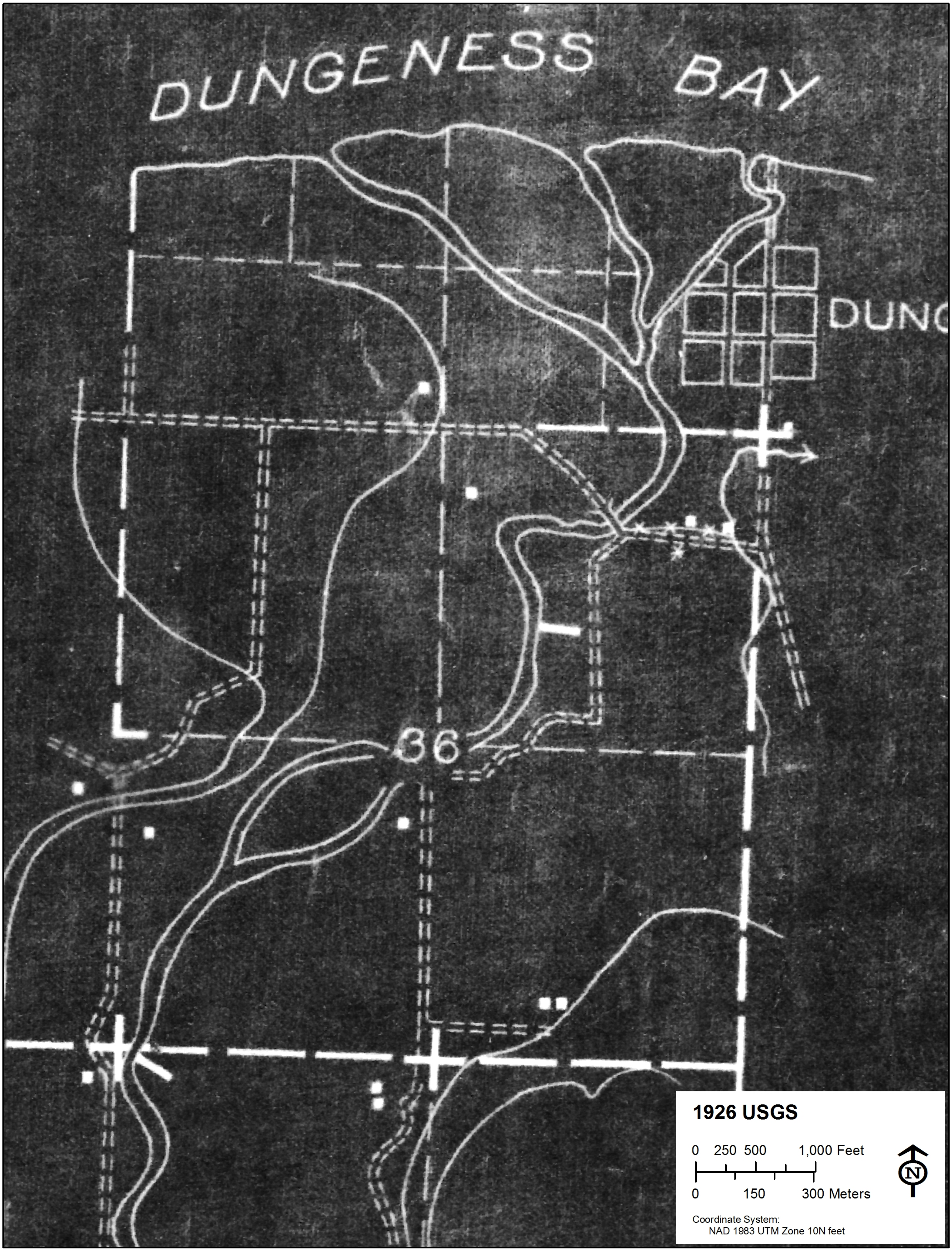
0 250 500 1,000 Feet

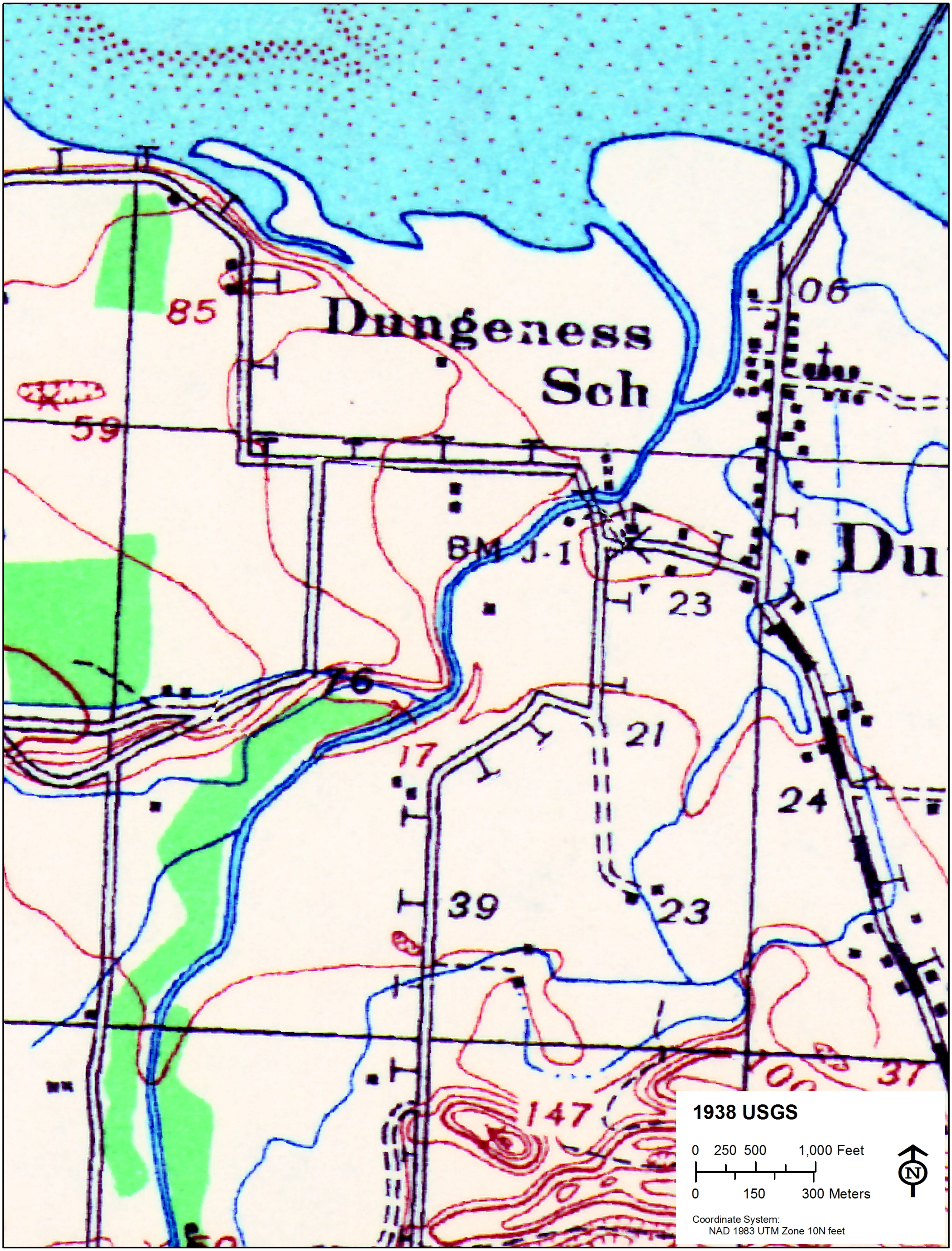
0 150 300 Meters

N

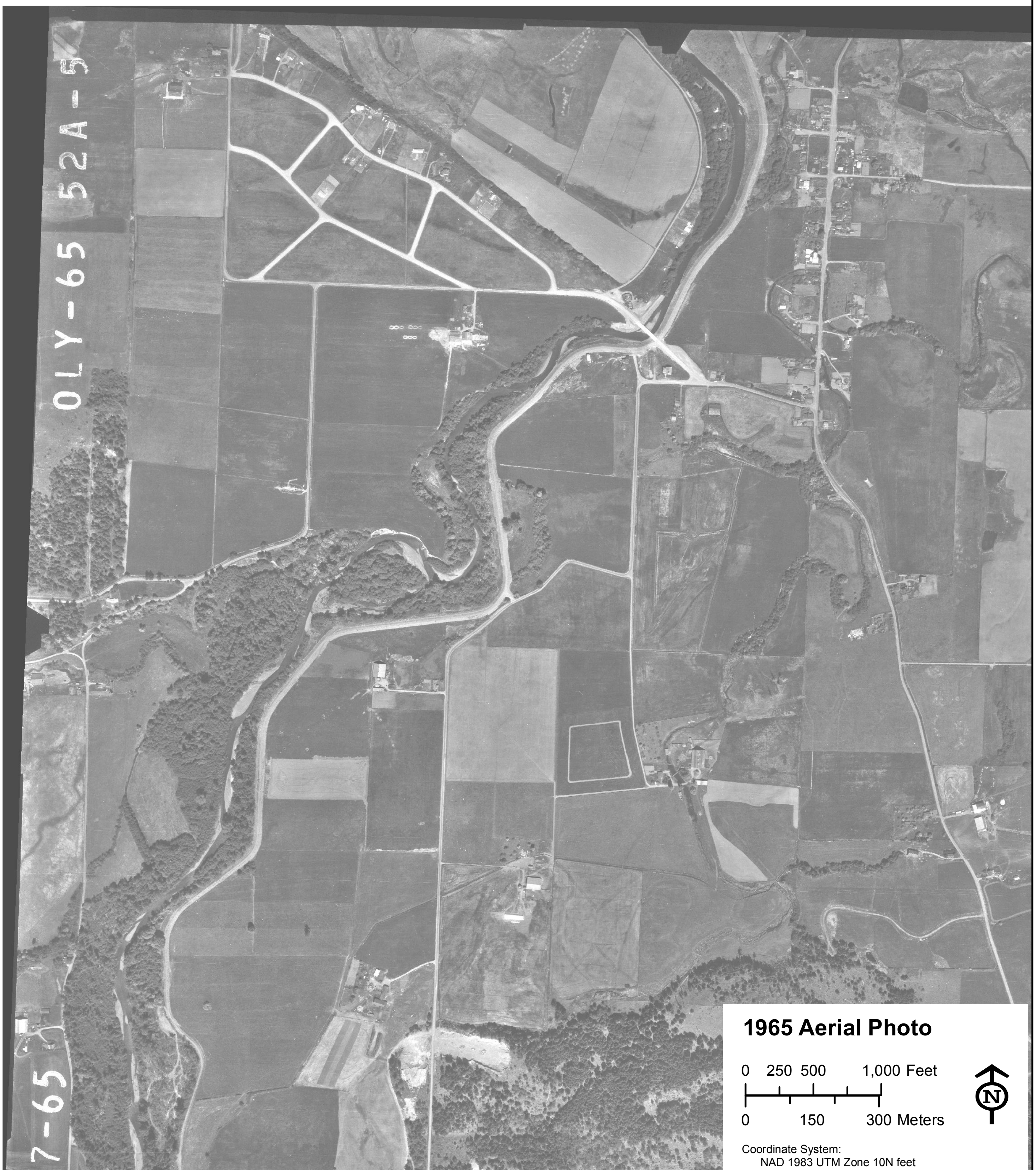
Coordinate System:
NAD 1983 UTM Zone 10N feet


Du
1909-1914 USACE Map
0 250 500 1,000 Feet
0 150 300 Meters
N
Coordinate System:
NAD 1983 UTM Zone 10N feet


DUNGENESS BAY
DUNG
36
1926 USGS
0 250 500 1,000 Feet
0 150 300 Meters
N
Coordinate System:
NAD 1983 UTM Zone 10N feet


Dungeness
Sch
Du
BM J-1
85
59
76
17
39
23
21
24
23
147
1938 USGS
0 250 500 1,000 Feet
0 150 300 Meters
N
Coordinate System:
NAD 1983 UTM Zone 10N feet


1942 Aerial Photo
0 250 500 1,000 Feet
0 150 300 Meters
N
Coordinate System:
NAD 1983 UTM Zone 10N feet


OLY-65 52A-5
7-65
1965 Aerial Photo
0 250 500 1,000 Feet
0 150 300 Meters
N
Coordinate System:
NAD 1983 UTM Zone 10N feet

26 | 25
35 | 36
25 | 30
26 | 31
35 | 36
2 | 1
36 | 31
1 | 6
D
1975 Aerial Photo
0 250 500 1,000 Feet
0 150 300 Meters
N
Coordinate System:
NAD 1983 UTM Zone 10N feet

1995 Aerial Photo
0 250 500 1,000 Feet
0 150 300 Meters
N
Coordinate System:
NAD 1983 UTM Zone 10N feet


2000 Aerial Photo
0 250 500 1,000 Feet
0 150 300 Meters
N
Coordinate System:
NAD 1983 UTM Zone 10N feet

2005 Aerial Photo
0 250 500 1,000 Feet
0 150 300 Meters
N
Coordinate System:
NAD 1983 UTM Zone 10N feet

2010 Aerial Photo

0 250 500 1,000 Feet

0 150 300 Meters

Coordinate System:
NAD 1983 UTM Zone 10N feet

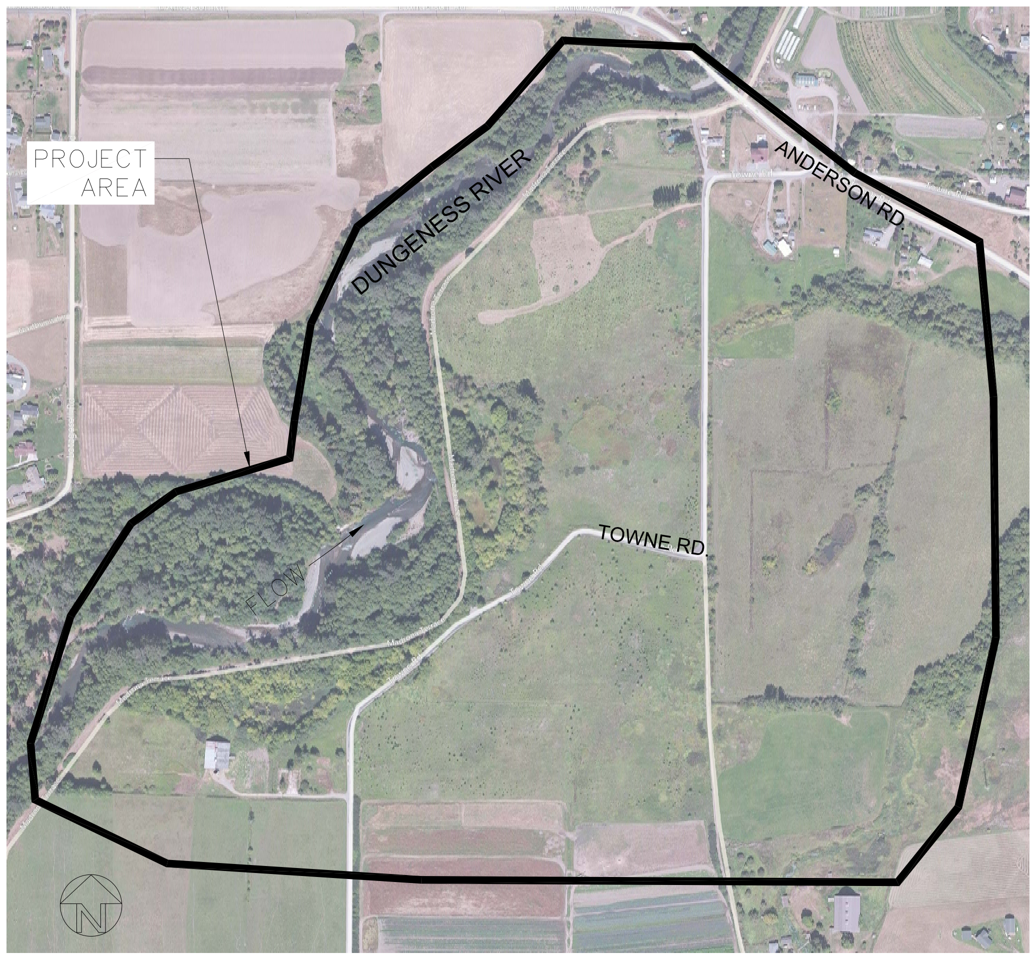
Appendix C

60 Percent Design Plans

JAMESTOWN S'KLALLAM TRIBE

DUNGENESS LEVEE SETBACK RESTORATION PROJECT

APRIL 2013



VICINITY MAP
N.T.S.

SHEET TITLE	NUMBER
TITLE SHEET	1
NOTES	2
STAGING, ACCESS AND TESC PLAN	3
PLAN SHEET	4
ELJ DETAIL	5
ELJ SEQUENCING	6
DETAILS - BMPS	7
DETAILS - SITE RESTORATION	8

PROJECT SITE

LOCATION MAP
N.T.S.

60% PLANS
NOT FOR CONSTRUCTION

DATE	REVISIONS

Cardno ENTRIX
801 Second Avenue, Suite 700
Seattle, WA 98104
WWW.ENTRIX.COM

Jamestown S'Klallam Tribe

TITLE SHEET

DUNGENESS LEVEE SETBACK RESTORATION PROJECT

CLALLAM COUNTY, WASHINGTON

DATE:	4/2013
DRAWN BY:	C. KROFTA
CHECKED BY:	J. BRJORK
SCALE:	AS SHOWN
ENTRIX JOB NO.	42549003
FIGURE NO.	1

SHEET 1 of 8

GENERAL NOTES

1. ALL IMPROVEMENTS SHALL BE ACCOMPLISHED UNDER THE APPROVAL, INSPECTION, AND TO THE SATISFACTION OF THE JAMESTOWN S'KLALLAM TRIBE (JKT). IMPROVEMENT CONSTRUCTION SHALL COMPLY WITH THESE PLANS AND THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT) STANDARD PLANS FOR CONSTRUCTION OF ROAD, BRIDGE, AND MUNICIPAL CONSTRUCTION, CURRENT EDITION UNLESS NOTED OTHERWISE. ALL REFERENCES TO THE "STANDARD SPECIFICATIONS" SHALL MEAN THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION (WSDOT) STANDARD SPECIFICATIONS FOR CONSTRUCTION OF LOCAL STREETS AND ROADS, CURRENT EDITION. CONSTRUCTION NOT SPECIFIED ON THESE PLANS SHALL CONFORM TO THE REQUIREMENTS OF THE STANDARD SPECIFICATIONS. THE CONTRACTOR IS OBLIGATED TO BE FAMILIAR WITH APPLICABLE SECTIONS OF THE STANDARD SPECIFICATIONS NOT DISCUSSED IN THE GENERAL NOTES. THE CONTRACT SPECIAL PROVISIONS SHALL SUPERSEDE THOSE OF THE STANDARD SPECIFICATIONS WHERE DISCREPANCIES OCCUR.
2. CONSTRUCTION HOURS SHALL BE MONDAY - SATURDAY BETWEEN 7:30 A.M. AND 6:30 P.M. UNLESS PRIOR APPROVAL IS RECEIVED FROM THE JKT.
3. THE LOCATIONS AND EXTENT OF EXISTING UNDERGROUND UTILITIES IN THE WORK AREA AS SHOWN ARE APPROXIMATE AND ARE NOT NECESSARILY COMPLETE. A REASONABLE EFFORT HAS BEEN MADE TO LOCATE AND DELINEATE EXISTING UTILITIES BASED UPON AVAILABLE RECORDS. THE CONTRACTOR SHALL DETERMINE THE TYPE, LOCATION, SIZE, AND/OR DEPTH OF THE EXISTING UTILITIES WITHIN THE WORK AREA BEFORE COMMENCING WORK. THE CONTRACTOR OR ANY SUBCONTRACTOR FOR THIS CONTRACT SHALL BE FULLY RESPONSIBLE FOR ANY AND ALL DAMAGES WHICH MIGHT BE OCCASIONED BY THE FAILURE TO EXACTLY LOCATE AND PRESERVE ANY AND ALL UNDERGROUND UTILITIES. THE CONTRACTOR SHALL CONTACT UTILITIES UNDERGROUND LOCATION CENTER AT (800) 424-5555 AT LEAST 48 HOURS PRIOR TO ANY CONSTRUCTION. PRIVATE UTILITIES REQUIRE COORDINATION WITH OWNER. SEE SPECIAL PROVISIONS FOR CONTRACTOR NOTIFICATION REQUIREMENTS. THE CONTRACTOR SHALL ASSUME COMPLETE RESPONSIBILITY FOR DAMAGED UTILITIES.
4. UNLESS NOTED OTHERWISE ON THE PLANS, THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE PROTECTION OF ALL EXISTING SURVEY MONUMENTS AND OTHER SURVEY MARKERS DURING CONSTRUCTION.
5. THE CONTRACTOR SHALL PROVIDE, PLACE, AND MAINTAIN ALL LIGHTS, SIGNS, BARRICADES, FLAG PERSONS, PILOT CAR, OR OTHER DEVICES NECESSARY TO CONTROL TRAFFIC THROUGH THE CONSTRUCTION AREA AND FOR PUBLIC SAFETY IN ACCORDANCE WITH THESE PLANS, THE STANDARD SPECIFICATIONS, FEDERAL HIGHWAY ADMINISTRATION (FHWA) MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD) CURRENT EDITION.
6. THE CONTRACTOR AGREES TO ASSUME SOLE AND COMPLETE RESPONSIBILITY FOR JOB SITE CONDITIONS DURING THE COURSE OF CONSTRUCTION OF THIS PROJECT, INCLUDING SAFETY OF ALL PERSONS AND PROPERTY, AND FURTHER AGREES THAT THIS REQUIREMENT SHALL APPLY CONTINUOUSLY AND NOT BE LIMITED TO NORMAL WORKING HOURS IN ACCORDANCE WITH THE PROVISIONS OUTLINED BY THE PROJECT CONTRACT AND STANDARD SPECIFICATIONS.
7. THE CONTRACTOR SHALL MAINTAIN A SET OF PLANS ON THE JOB SHOWING "AS-CONSTRUCTED" CHANGES MADE TO DATE. UPON COMPLETION OF THE PROJECT, THE CONTRACTOR SHALL SUPPLY TO JKT A SET OF PLANS, MARKED UP TO THE SATISFACTION OF THE JKT, REFLECTING THE AS-CONSTRUCTED MODIFICATIONS.
8. AT NO TIME SHALL THE CONTRACTOR UNDERTAKE TO CLOSE OFF ANY EXISTING UTILITY LINES OR OPEN VALVES OR TAKE ANY OTHER ACTION WHICH WOULD AFFECT THE OPERATION OF EXISTING WATER OR SEWER SYSTEMS WITHOUT PRIOR APPROVAL FROM THE PRIVATE UTILITY OWNERS. APPROVAL SHALL BE REQUESTED AT LEAST 48 HOURS IN ADVANCE OF THE TIME THAT THE INTERRUPTION OF THE EXISTING SYSTEM IS REQUIRED. ANY INTERRUPTION OF SERVICE TO ACTIVE WATER OR SEWER SERVICES, INCLUDING FIRE HYDRANTS, WHETHER INTENTIONAL OR NOT, MUST BE KEPT TO A MINIMUM TIME PERIOD. IF SERVICE TO BUILDINGS IS TO BE OFF FOR MORE THAN FOUR HOURS, THE CONTRACTOR MUST ADVISE THE UTILITY DISTRICT.
9. THE CONTRACTOR SHALL BE REQUIRED TO PERFORM PREVENTIVE DUST CONTROL MEASURES TO ENSURE THAT DUST RESULTING FROM THE CONTRACTOR'S PERFORMANCE OF THE WORK IS CONTROLLED IN CONFORMANCE WITH THE STANDARD SPECIFICATIONS AND FEDERAL, STATE, LOCAL, AND PERMIT REQUIREMENTS.
10. THE CONTRACTOR SHALL BE RESPONSIBLE FOR IMPLEMENTING ALL TEMPORARY EROSION CONTROL MEASURES. THE EROSION CONTROL MEASURES SHALL BE IN ACCORDANCE WITH ALL FEDERAL, STATE, AND LOCAL REQUIREMENTS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE MAINTENANCE AND PERFORMANCE OF THE TEMPORARY EROSION CONTROL MEASURES THROUGHOUT THE DURATION OF THE PROJECT. SEE SPECIAL PROVISIONS REGARDING TEMPORARY EROSION CONTROL FACILITY REMOVAL.
11. GRADING LIMITS SHOWN ON THE PLANS DELINEATE BOUNDARIES FOR THE CONTRACTOR'S OPERATIONS. THESE BOUNDARIES SHALL BE CLEARLY DELINEATED PRIOR TO COMMENCEMENT OF CONSTRUCTION. WITHIN THE CONSTRUCTION LIMITS, EXISTING VEGETATION SHALL BE PROTECTED TO THE EXTENT FEASIBLE. ALL EXISTING TREES SHALL BE PROTECTED UNLESS SHOWN ON THE PLANS TO BE REMOVED.
12. WHILE WORKING IN THE RIVER, ALL EXTERNAL GREASE AND OIL SHALL BE PRESSURE-WASHED OFF THE EQUIPMENT PRIOR TO TRANSPORT TO THE SITE. ALL EQUIPMENT SHALL USE VEGETABLE OIL HYDRAULIC FLUID.
13. THE CONTRACTOR SHALL USE ONLY DESIGNATED SPECIFIC SITES FOR STORAGE OF EQUIPMENT AND MATERIALS AS SHOWN ON THESE PLANS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE SECURITY OF ALL EQUIPMENT AND MATERIALS.
14. IT IS THE RESPONSIBILITY OF THE CONTRACTOR AND HIS SUBCONTRACTOR(S) TO EXAMINE THE PROJECT SITE PRIOR TO THE OPENING OF BID PROPOSALS. THE CONTRACTOR SHALL BECOME FAMILIAR WITH THE CONDITIONS UNDER WHICH THE WORK IS TO BE PERFORMED, SUCH AS THE NATURE AND LOCATION OF THE WORK AND THE GENERAL AND LOCAL CONDITIONS, PARTICULARLY THOSE AFFECTING THE AVAILABILITY OF TRANSPORTATION, THE DISPOSAL, HANDLING, AND STORAGE OF MATERIALS, AVAILABILITY OF LABOR, WATER, ELECTRICITY AND ROADS, THE UNCERTAINTIES OF WEATHER, THE CONDITIONS OF THE GROUND, SURFACE AND SUBSURFACE MATERIALS, THE EQUIPMENT AND FACILITIES NEEDED PRIMARILY FOR AND DURING THE PERFORMANCE OF THE WORK, AND THE COSTS THEREOF. ANY FAILURE BY THE CONTRACTOR AND SUBCONTRACTOR(S) TO ACQUAINT HIMSELF WITH ALL THE AVAILABLE INFORMATION WILL NOT RELIEVE HIM FROM RESPONSIBILITY FOR PROPERLY ESTIMATING THE DIFFICULTY AND COST OF SUCCESSFULLY PERFORMING THE WORK. THE CONTRACTOR SHALL BE PREPARED TO WORK WITHIN THE CONSTRAINTS OF THE SITE HYDROLOGY.
15. THE CONTRACTOR SHALL HAVE AN EMERGENCY SPILL KIT ONSITE AT ALL TIMES.
16. ELEVATIONS SHOWN ON THE PLANS FOR PIPE INVERTS, TOPS OF BANKS,THALWEGS ,GRADE CONTROLS, ETC., ARE BASED UPON THE TOPOGRAPHIC INFORMATION SHOWN ON THE PLANS. THE CONTRACTOR SHALL VERIFY ALL NECESSARY SURFACE ELEVATIONS IN THE FIELD AND NOTIFY JKT OF ANY DISCREPANCIES, WHICH MIGHT AFFECT PROPER OPERATION OF THE NEW FACILITIES BEFORE BREAKING GROUND AND PRIOR TO FACILITY INSTALLATION. JKT SHALL BE CONTACTED IN THE EVENT ELEVATIONS ARE INCORRECT SO THAT THE PROPER ADJUSTMENTS CAN BE MADE PRIOR TO THE INSTALLATION OF THE FACILITIES, AS SET FORTH IN THE SPECIAL PROVISIONS.
17. THE CONTRACTOR SHALL OBTAIN AT HIS OWN EXPENSE ALL PERMITS, LICENSES, INSURANCE POLICIES, ETC., NOT ALREADY OBTAINED BY NOSC, AS MAY BE NECESSARY TO COMPLY WITH STATE AND LOCAL LAWS ASSOCIATED WITH THE PERFORMANCE OF THE WORK. SEE SPECIAL PROVISIONS.
18. THE CONTRACTOR IS RESPONSIBLE TO REVIEW THE CONTRACT DOCUMENTS FOR ALL SUBMITTALS REQUIRED FOR NOSC REVIEW AND ACCEPTANCE.
19. THE ENGINEER RESPONSIBLE FOR PREPARATION OF THESE PLANS AND SPECIFICATIONS WILL NOT BE RESPONSIBLE FOR, OR LIABLE FOR UNAUTHORIZED CHANGES TO OR USES OF THESE PLANS. ALL CHANGES TO THE PLANS MUST BE IN WRITING AND MUST BE APPROVED BY THE ENGINEER RESPONSIBLE FOR PREPARATION OF THESE PLANS.
20. NO NATIVE TREES OR WETLAND VEGETATION SHALL BE REMOVED UNLESS THEY ARE SHOWN AND NOTED TO BE REMOVED ON THE PLANS, OR AS DIRECTLY SPECIFIED ON-SITE BY JKT. ALL TREES CONFLICTING WITH GRADING SHALL BE TRIMMED. NO GRADING SHALL TAKE PLACE WITHIN THE DRIP LINE OF TREES NOT TO BE REMOVED UNLESS OTHERWISE APPROVED.
21. IF, DURING CONSTRUCTION, ARCHAEOLOGICAL REMAINS ARE ENCOUNTERED, CONSTRUCTION IN THE VICINITY SHALL BE HALTED, AND THE STATE OFFICE OF HISTORIC PRESERVATION, JKT AND A QUALIFIED ARCHEOLOGIST SHALL BE NOTIFIED IMMEDIATELY. REFER TO INADVERTENT DISCOVERY PLAN IN THE SPECIAL PROVISIONS.
22. PERMIT CONDITIONS MAY CONTAIN SPECIFIC REQUIREMENTS FOR THE CONTROL OF OFF-SITE TURBIDITY FROM PROJECT OPERATIONS. TURBIDITY WILL BE MONITORED ON A FREQUENT BASIS. TURBIDITY AMOUNTS IN EXCESS OF THE PERMITTED AMOUNT AND/OR DURATIONS WILL CAUSE WORK TO BE STOPPED UNTIL IMPROVED PRACTICES ARE IN EFFECT AND THE PROBLEMS CONTROLLED. THE CONTRACTOR IS COMPLETELY RESPONSIBLE FOR ANY PROJECT DELAYS THAT OCCUR BY NATURE OF THIS FAILURE TO ADEQUATELY CONTAIN SEDIMENT ON-SITE.
23. THE CONTRACTOR IS RESPONSIBLE TO ENSURE THAT NO PETROLEUM PRODUCTS, HYDRAULIC FLUID, SEDIMENTS, SEDIMENT-LADEN WATER, CHEMICALS, OR ANY OTHER TOXIC OR DELETERIOUS MATERIALS ARE ALLOWED TO ENTER OR LEACH INTO THE RIVER.
24. THE CONTRACTOR SHALL FOLLOW PROVISIONS SET FORTH IN THE PROJECT PERMITS, AND INSTALL BMP'S TO CONTROL SEDIMENT AND MINIMIZE DISTURBANCE TO EXISTING VEGETATION.
25. BASE TOPOGRAPHY OBTAINED FROM THE FOLLOWING SOURCES AND WAS MERGED BY CARDNO ENTRIX:
 -TOPOGRAPHIC LINES DEPICTED WITHIN WSDOT WETLAND BASED ON 2010 SURVEY CONDUCTED BY WSDOT.
 -TOPOGRAPHIC LINES DEPICTED WITHIN EXISTING LEVEE BASED ON 2011 SURVEY CONDUCTED BY NTI. PORT ANGELES, WA.
 -TOPOGRAPHIC LINES DEPICTED ELSEWHERE BASED ON 6' GRID PUGET SOUND LIDAR CONSORTIUM DATA.
26. THE PLANS SHOW CONSTRUCTION SEQUENCING. THESE ARE PROVIDED TO THE CONTRACTOR FOR CONSIDERATION. CONTRACTOR IS TO USE THIS PLAN OR DEVELOP A NEW PLAN FOR THE ENGINEER'S APPROVAL.

ABBREVIATIONS

APN	ASSESSOR'S PARCEL NUMBER
BMP	BEST MANAGEMENT PRACTICE
CLF	CONSTRUCTION LIMIT FENCE
CMP	CORRUGATED METAL PIPE
ELJ	ENGINEERED LOG JAM
EX	EXISTING
JKT	JAMESTOWN S'KLALLAM TRIBE
MAX	MAXIMUM
MIN	MINIMUM
OC	ON CENTER
TYP	TYPICAL
WSDOT	WA STATE DEPARTMENT OF TRANSPORTATION
YR	YEAR

LEGEND

*NOTE: LEGEND PROVIDED ON SHEET SUPERCEDES THIS LEGEND

EXISTING

- EXISTING INDEX CONTOUR 5'
- EXISTING INTERIM CONTOUR 1'
- EXISTING EDGE OF PAVEMENT
- EXISTING DRAINAGE
- EXISTING EDGE OF WATER
- EXISTING FENCE
- PROPERTY BOUNDARY
- EXISTING OVERHEAD ELECTRIC
- EXISTING BUILDING
- WSDOT WETLAND BUFFER (SEE WSDOT WETLAND MITIGATION PLANS)
- WSDOT WETLAND ENHANCEMENT (SEE WSDOT WETLAND MITIGATION PLANS)
- WSDOT WETLAND RE-ESTABLISHMENT (SEE WSDOT WETLAND MITIGATION PLANS)
- WSDOT WETLAND PRESERVED (SEE WSDOT WETLAND MITIGATION PLANS)
- WSDOT LEVEE FOOTPRINT (SEE WSDOT WETLAND MITIGATION PLANS)

PROPOSED

- PROPOSED TEMPORARY HAUL ROAD
- PROPOSED TEMPORARY STAGING AND STORAGE AREA
- CP-51 — EXISTING SURVEY CONTROL POINT
- 3 / 8 — DETAIL REFERENCE NUMBER / SHEET NUMBER

UTILITIES

STORM DRAIN	CLALLAM COUNTY PUBLIC WORKS, (360) 417-2319
FIBER OPTIC	QWEST, (800) 954-1211

HORIZONTAL AND VERTICAL CONTROL/PROJECTION

VERTICAL CONTROL IS NAVD 88; HORIZONTAL CONTROL IS NAD83 WASHINGTON STATE PLANES, NORTH ZONE, US FOOT.

60% PLANS
NOT FOR CONSTRUCTION

DATE | REVISIONS | SEAL | SEAL

Cardno ENTRIX
801 Second Avenue, Suite 700
Seattle, WA 98104
WWW.ENTRIX.COM

Jamestown S'Klallam Tribe

NOTES

DUNGENESS LEVEE SETBACK RESTORATION PROJECT

CLALLAM COUNTY, WASHINGTON

DATE:	4/2013
DRAWN BY:	C. KROFTA
CHECKED BY:	J. BJORK
SCALE:	AS SHOWN
ENTRIX JOB NO.	42549003
FIGURE NO.	2

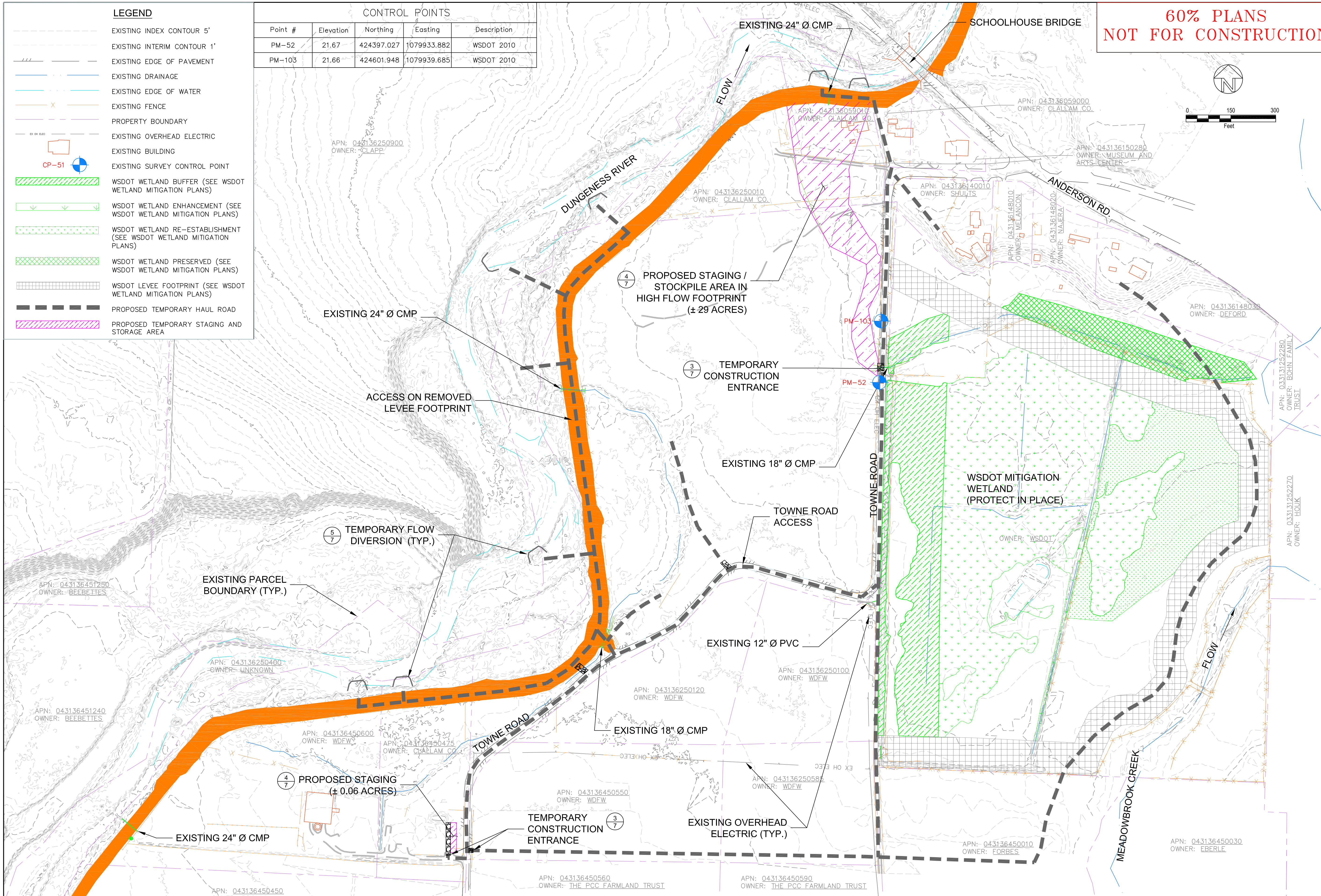
SHEET 2 of 8

LEGEND

- EXISTING INDEX CONTOUR 5'
- EXISTING INTERIM CONTOUR 1'
- EXISTING EDGE OF PAVEMENT
- EXISTING DRAINAGE
- EXISTING EDGE OF WATER
- EXISTING FENCE
- PROPERTY BOUNDARY
- EXISTING OVERHEAD ELECTRIC
- EXISTING BUILDING
- CP-51 EXISTING SURVEY CONTROL POINT
- WSDOT WETLAND BUFFER (SEE WSDOT WETLAND MITIGATION PLANS)
- WSDOT WETLAND ENHANCEMENT (SEE WSDOT WETLAND MITIGATION PLANS)
- WSDOT WETLAND RE-ESTABLISHMENT (SEE WSDOT WETLAND MITIGATION PLANS)
- WSDOT WETLAND PRESERVED (SEE WSDOT WETLAND MITIGATION PLANS)
- WSDOT LEVEE FOOTPRINT (SEE WSDOT WETLAND MITIGATION PLANS)
- PROPOSED TEMPORARY HAUL ROAD
- PROPOSED TEMPORARY STAGING AND STORAGE AREA

CONTROL POINTS

Point #	Elevation	Northing	Easting	Description
PM-52	21.67	424397.027	1079933.882	WSDOT 2010
PM-103	21.66	424601.948	1079939.685	WSDOT 2010



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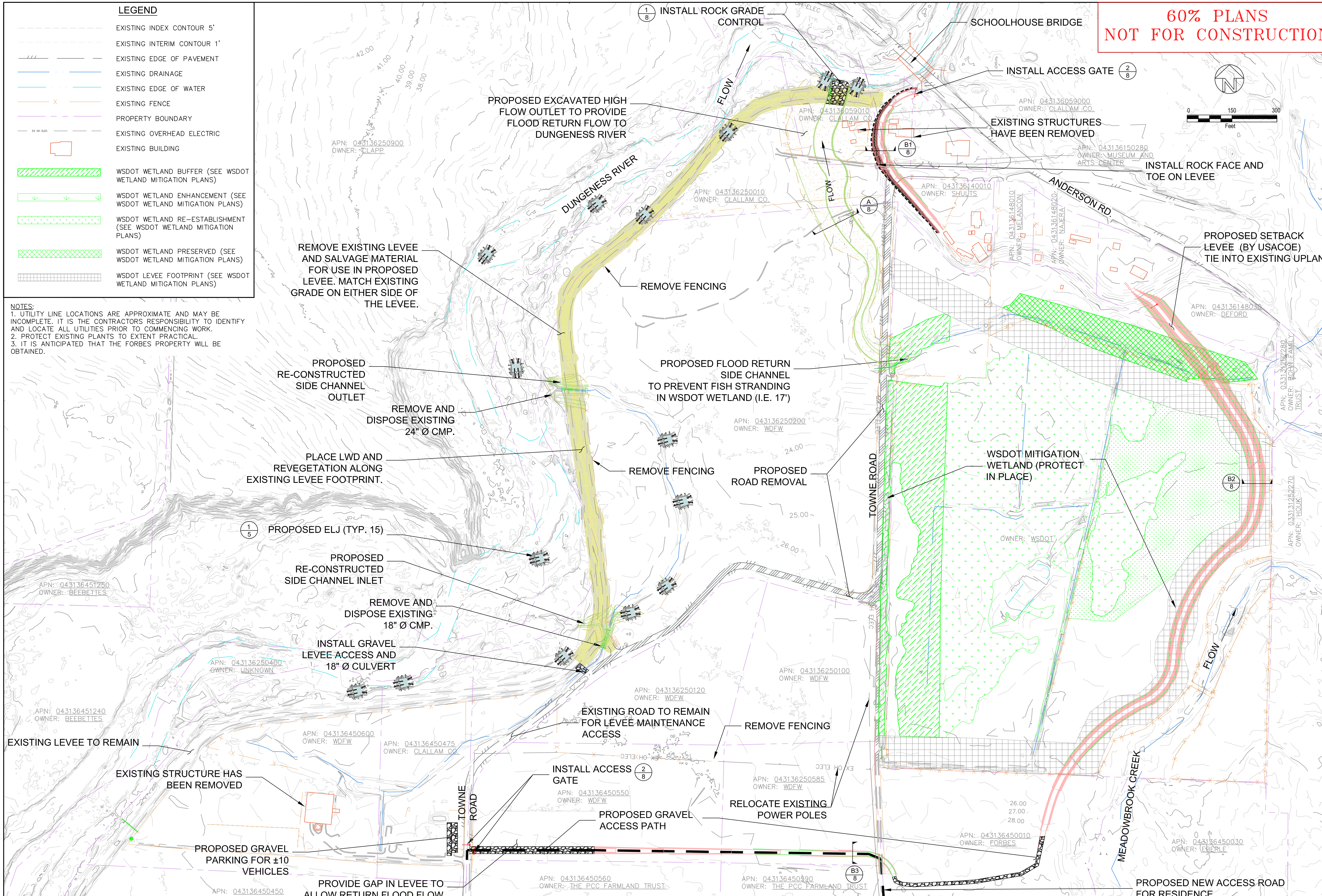
STAGING, ACCESS AND TESC PLAN

DUNGENESS LEVEE SETBACK RESTORATION PROJECT

CLALLAM COUNTY, WASHINGTON

DATE:	4/2013
DRAWN BY:	D. SHAFER
CHECKED BY:	C. KROFTA
SCALE:	AS SHOWN
ENTRIX JOB NO.	42549003
FIGURE NO.	3

SHEET 3 of 8



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Jamestown S'Klallam Tribe

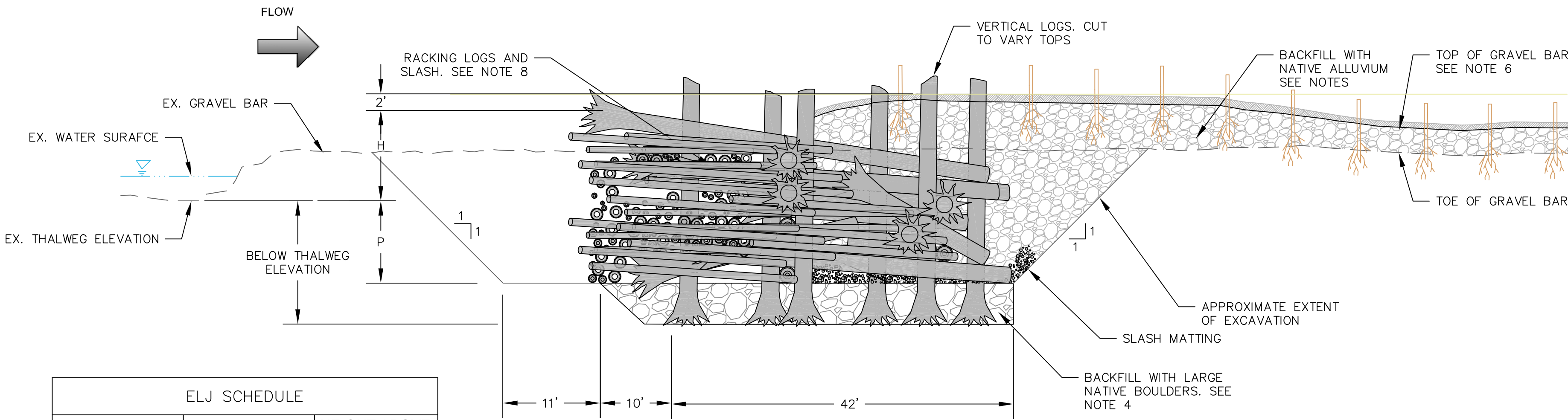
PLAN SHEET

DUNGENESS LEVEE SETBACK RESTORATION PROJECT

CLALLAM COUNTY, WASHINGTON

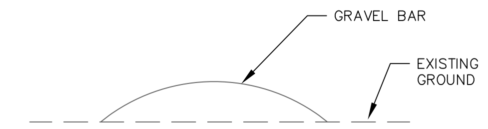
DATE:	4/2013
DRAWN BY:	C. KROFTA
CHECKED BY:	J. BJORK
SCALE:	AS SHOWN
ENTRIX JOB NO.	42549003
FIGURE NO.	4

SHEET 4 of 8



ELJ TYPE I ELEVATION VIEW

SCALE: 1"=20'

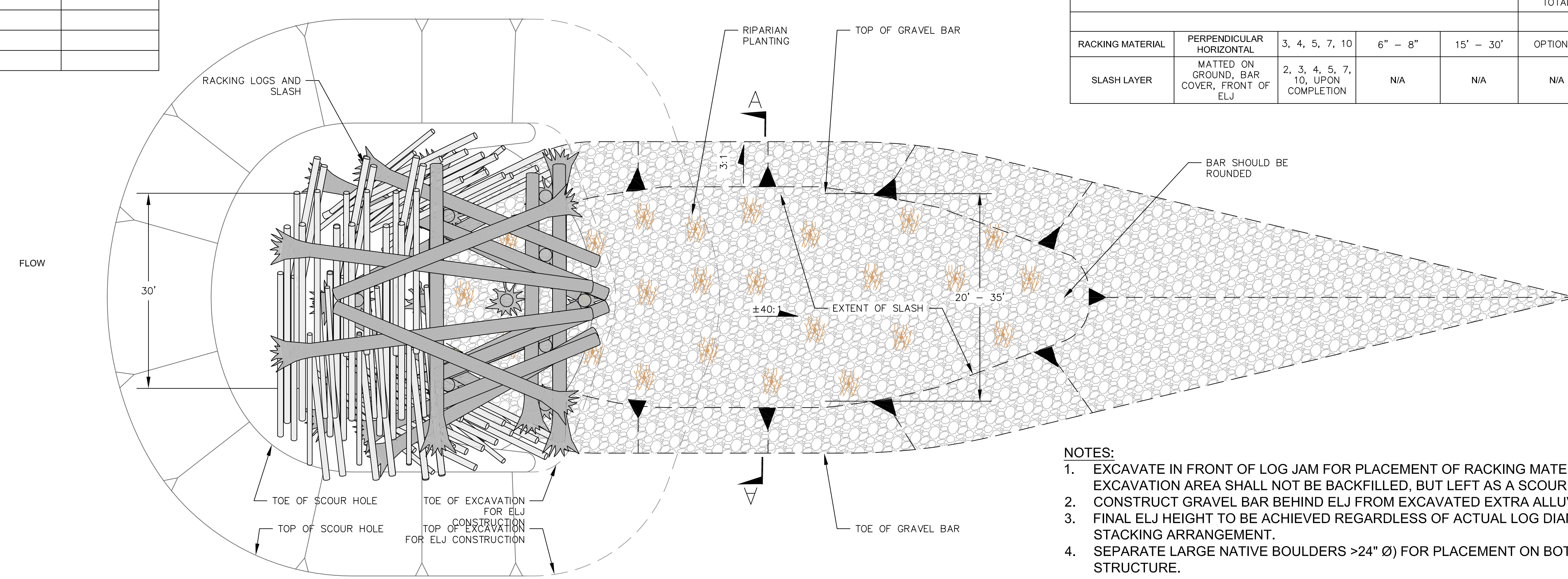


SECTION A-A

NOT TO SCALE

ELJ SCHEDULE		
ELJ NUMBER	POOL DEPTH (P)	HEIGHT ABOVE RIVER BED (H)

ELJ LOG SCHEDULE (PER INDIVIDUAL STRUCTURE)						
TYPE	ORIENTATION TO FLOW	SEQUENCE	MIN. DIAMETER	LENGTH	ROOTWAD	NUMBER
VERTICAL	VERTICAL	1	20" – 24"	30'	YES	10
HORIZONTAL	PERPENDICULAR	1	20" – 24"	30'	NO	1
HORIZONTAL	PERPENDICULAR	4, 5, 7, 10	20" – 24"	40' – 45'	YES	6
HORIZONTAL	PERPENDICULAR	3, 4, 6, 9	20" – 24"	10' – 25' SPACER	NO	4
ANGLED	ANGLED	4, 5, 7	20" – 24"	10' – 25' SPACER	NO	6
ANGLED	ANGLED	4, 6	20" – 24"	30'	YES	6
ANGLED	ANGLED	3, 9,12	20" – 24"	40' – 45'	YES	6
ANGLED	ANGLED	8, 11	20" – 24"	50'	YES	4
					TOTAL	43
RACKING MATERIAL	PERPENDICULAR HORIZONTAL	3, 4, 5, 7, 10	6" – 8"	15' – 30'	OPTIONAL	95 TOTALING 5400 BD FT
SLASH LAYER	MATTED ON GROUND, BAR COVER, FRONT OF ELJ	2, 3, 4, 5, 7, 10, UPON COMPLETION	N/A	N/A	N/A	178 CY



ELJ TYPE I PLAN VIEW

SCALE: 1"=20'

1
5

NOTES:
1. EXCAVATE IN FRONT OF LOG JAM FOR PLACEMENT OF RACKING MATERIAL. RACKED LOG EXCAVATION AREA SHALL NOT BE BACKFILLED, BUT LEFT AS A SCOUR HOLE.
2. CONSTRUCT GRAVEL BAR BEHIND ELJ FROM EXCAVATED EXTRA ALLUVIUM.
3. FINAL ELJ HEIGHT TO BE ACHIEVED REGARDLESS OF ACTUAL LOG DIAMETERS USED OR STACKING ARRANGEMENT.
4. SEPARATE LARGE NATIVE BOULDERS >24" Ø) FOR PLACEMENT ON BOTTOM OF LOG JAM STRUCTURE.
5. PLANT 30 FEET X 100 FEET OF GRAVEL BAR AND ELJ ON 6 FOOT CENTERS WITH COTTONWOOD AND WESTERN RED CEDAR SEEDLINGS PER WSDOT STD PLAN H10.10-00.
6. GRAVEL BAR LENGTH WILL BE DETERMINED BY AMOUNT OF MATERIAL EXCAVATED FOR ELJ AND CHANNELS.MATERIAL SHALL BE LOOSE AND NOT COMPACTED. FINISHED SURFACE SHALL BE IRREGULAR WITH HUMMOCKS AND VARIATIONS OF ±1'.
7. SPACER LOGS WILL BE CUT ON SITE TO FIT.
8. MIX SLASH WITH RACKING LOGS

60% PLANS
NOT FOR CONSTRUCTION

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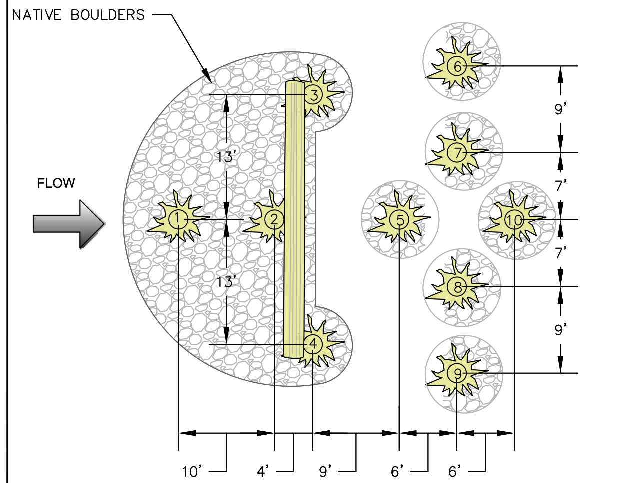
ELJ DETAIL

DUNGENESS LEVEE SETBACK RESTORATION PROJECT

CLALLAM COUNTY, WASHINGTON

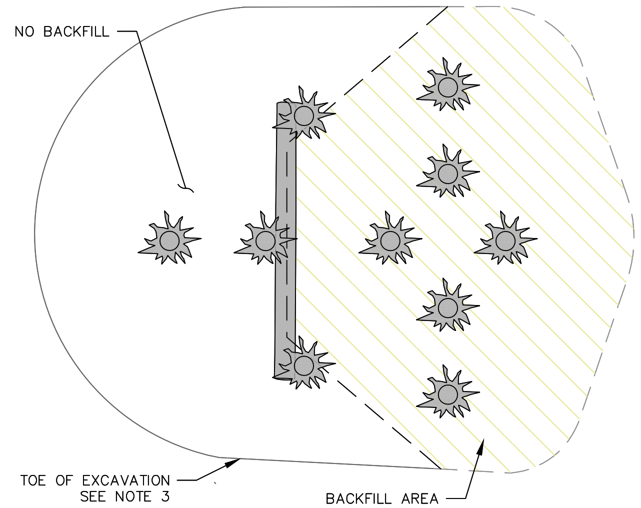
DATE:	4/2013
DRAWN BY:	C. KROFTA
CHECKED BY:	J. BJORK
SCALE:	AS SHOWN
ENTRIX JOB NO.	42549003
FIGURE NO.	5

SHEET 5 of 8



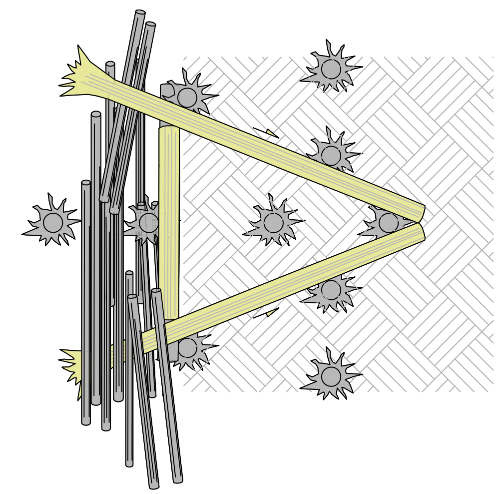
EXCAVATE HOLES FOR TEN VERTICAL LOGS AND A SUMP. PLACE MATERIAL IN GRAVEL BAR. INSTALL ONE HORIZONTAL LOG PERPENDICULAR TO FLOW. BACKFILL WITH LARGER NATIVE BOULDERS.

SEQUENCE 1



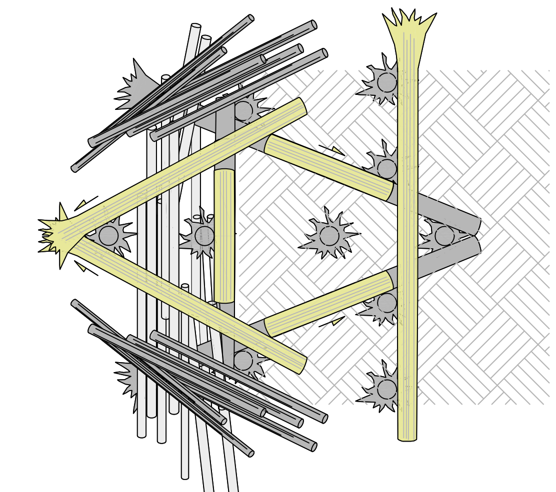
INSTALL APPROX. 1150 SQFT SLASH LAYER

SEQUENCE 2



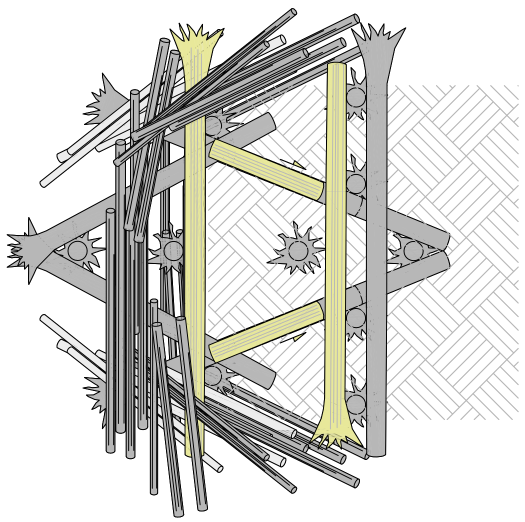
ADD TWO HORIZONTAL LOGS ANGLED TO FLOW ANGLED DOWN TOWARDS THE CENTER OF THE ELJ AND ONE LOG PERPENDICULAR TO FLOW AS SHOWN. ADD RACKING MATERIAL AS SHOWN. PACK SLASH WITHIN RACKING AREA.

SEQUENCE 3



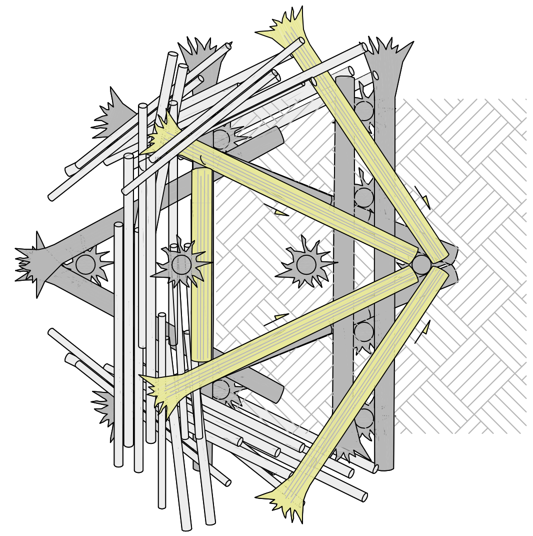
ADD ONE HORIZONTAL LOG PERPENDICULAR TO FLOW. ADD TWO HORIZONTAL LOGS ANGLED TO FLOW ANGLED DOWNSTREAM AWAY FROM CENTER OF ELJ AS SHOWN. ADD 3 SHORT SPACER LOGS AS SHOWN. ADD RACKING MATERIAL AS SHOWN. PACK SLASH WITHIN RACKING AREA.

SEQUENCE 4



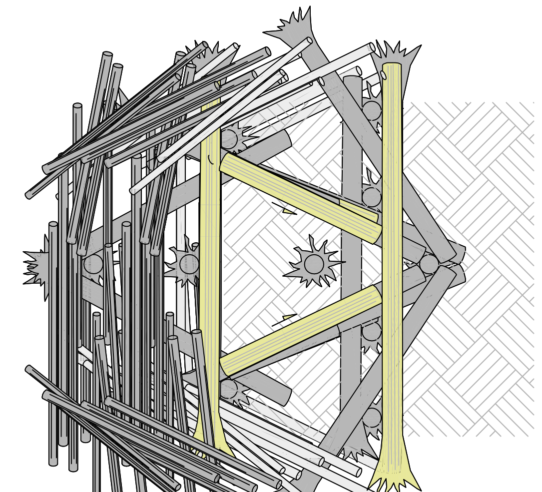
ADD TWO LOGS PERPENDICULAR TO FLOW. ADD 2 SHORT SPACER LOGS. ADD RACKING MATERIAL AS SHOWN. PACK SLASH WITHIN RACKING AREA.

SEQUENCE 5



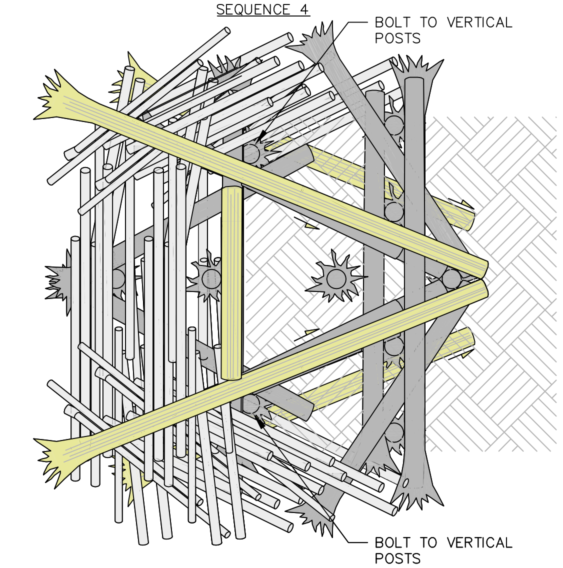
ADD FOUR HORIZONTAL LOGS ANGLED TO FLOW ANGLED DOWN TOWARDS THE CENTER OF THE ELJ AS SHOWN. ADD ONE SPACER LOG PERPENDICULAR TO FLOW.

SEQUENCE 6



ADD TWO HORIZONTAL LOGS PERPENDICULAR TO FLOW. ADD 2 SHORT SPACER LOGS AS SHOWN. ADD RACKING MATERIAL AS SHOWN. PACK SLASH WITHIN RACKING AREA.

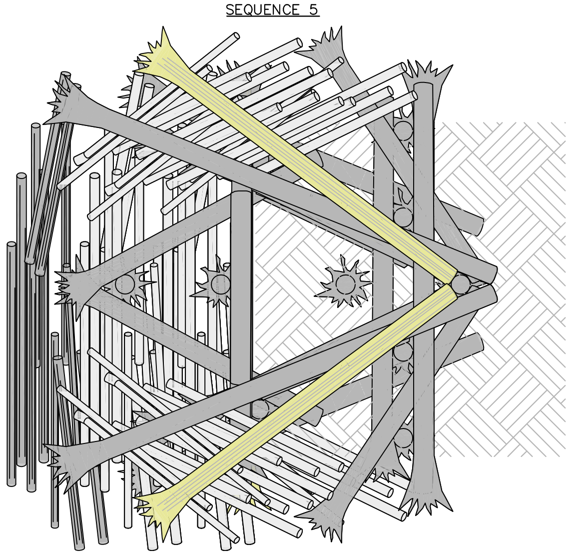
SEQUENCE 7



ADD TWO HORIZONTAL LOGS ANGLED TO FLOW ANGLED DOWN TOWARDS THE CENTER OF THE ELJ AS SHOWN. ADD 1 SHORT SPACER LOG AS SHOWN.

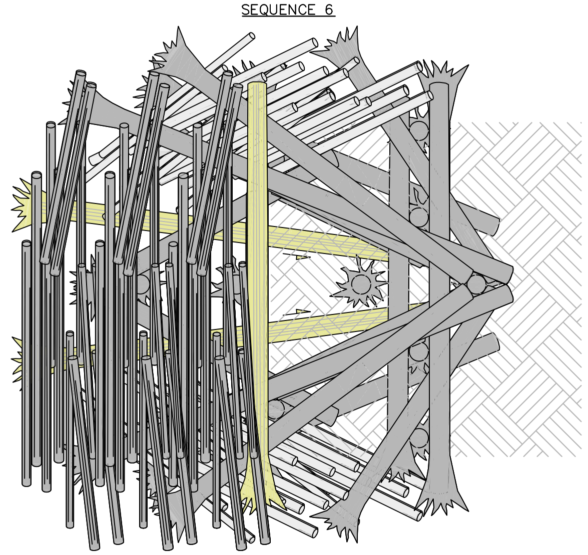
SEQUENCE 8

0 10 20
SCALE: 1"=20'



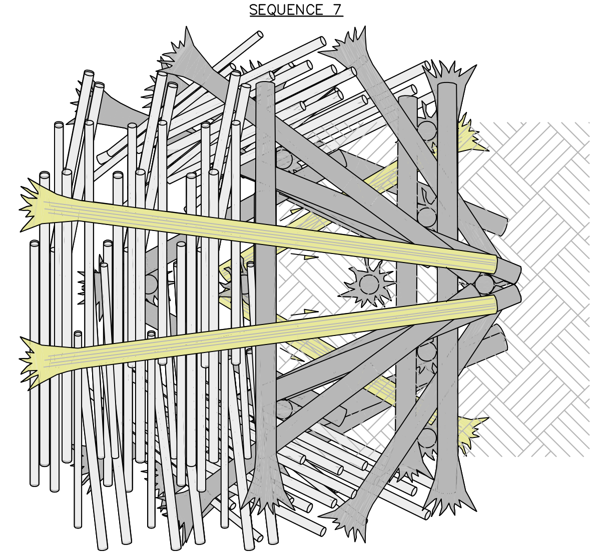
ADD TWO HORIZONTAL LOGS ANGLED TO FLOW ANGLED DOWN TOWARDS THE CENTER OF THE ELJ AS SHOWN.

SEQUENCE 9



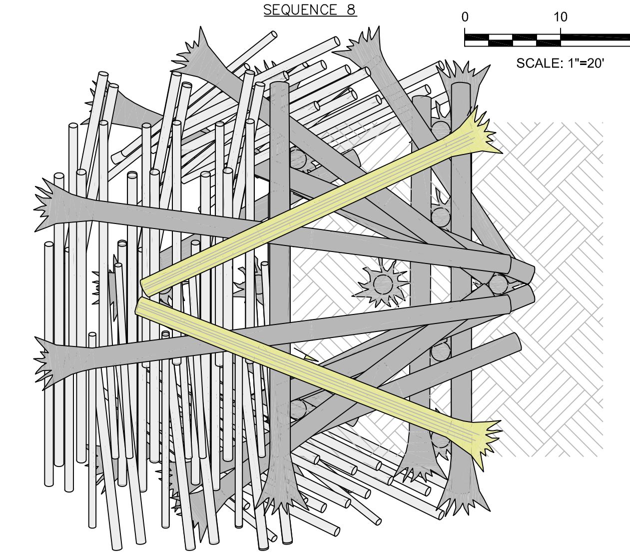
ADD ONE HORIZONTAL LOG PERPENDICULAR TO FLOW. ADD RACKING MATERIAL AS SHOWN. PACK SLASH WITHIN RACKING AREA.

SEQUENCE 10



ADD TWO HORIZONTAL LOGS PARALLEL TO FLOW ANGLED DOWN TOWARDS THE CENTER OF THE ELJ AS SHOWN.

SEQUENCE 11



ADD TWO HORIZONTAL LOGS PERPENDICULAR TO FLOW ANGLED AWAY FROM CENTER OF ELJ AS SHOWN. CABLE AND SECURE UPPERMOST LOGS AS SHOWN TO VERTICAL POST WITH 1" NON-GALVANIZED THREADED STEEL ROD. USE 4" DIA. WASHERS CUT OFF FLUSH WITH LOG.

SEQUENCE 12

NOTES:

1. LOGS INSTALLED DURING PREVIOUS SEQUENCE ARE SHOWN LIGHTER THAN THOSE OF CURRENT SEQUENCE.
2. ARROWS INDICATE DOWNHILL SLOPE ON LOGS.
3. BACKFILL WITH EXCAVATED MATERIAL DURING EACH SEQUENCE, WITHIN APPROXIMATE AREA SHOWN. AREA NOT SHOWN ON ALL SEQUENCES FOR CLARITY.
4. ELJ SEQUENCING MAY VARY FROM ELJ TO ELJ BASED ON SPECIFIC SITE CONDITIONS.

ELJ SEQUENCING

SCALE: 1"=20'

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ELJ SEQUENCING

DUNGENESS LEVEE SETBACK RESTORATION PROJECT

CLALLAM COUNTY, WASHINGTON

DATE:	4/2013
DRAWN BY:	C. KROFTA
CHECKED BY:	J. BJORK
SCALE:	AS SHOWN
ENTRIX JOB NO.	42549003
FIGURE NO.	6

SHEET 6 of 8

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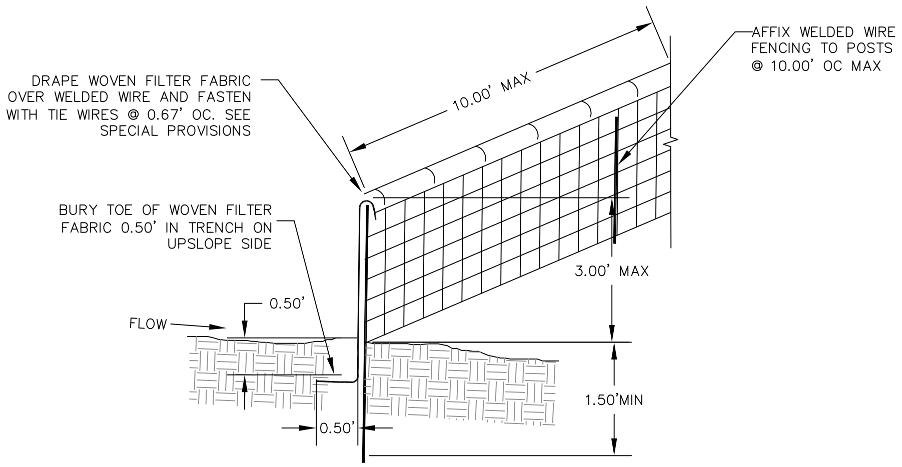


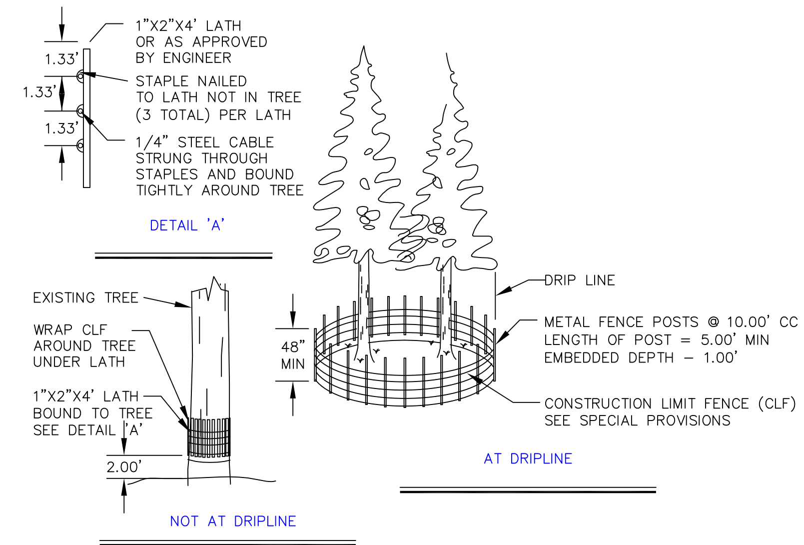
NOTES: 1. CONTRACTOR MAY USE PRE MANUFACTURED SEDIMENT CONTROL FENCE AS APPROVED BY THE ENGINEER. SEE SPECIAL PROVISIONS.

2. PLACE FENCING SUCH THAT STORM RUNOFF CANNOT PASS AROUND OR UNDER FENCE

SILT FENCE

1/7

NOT TO SCALE

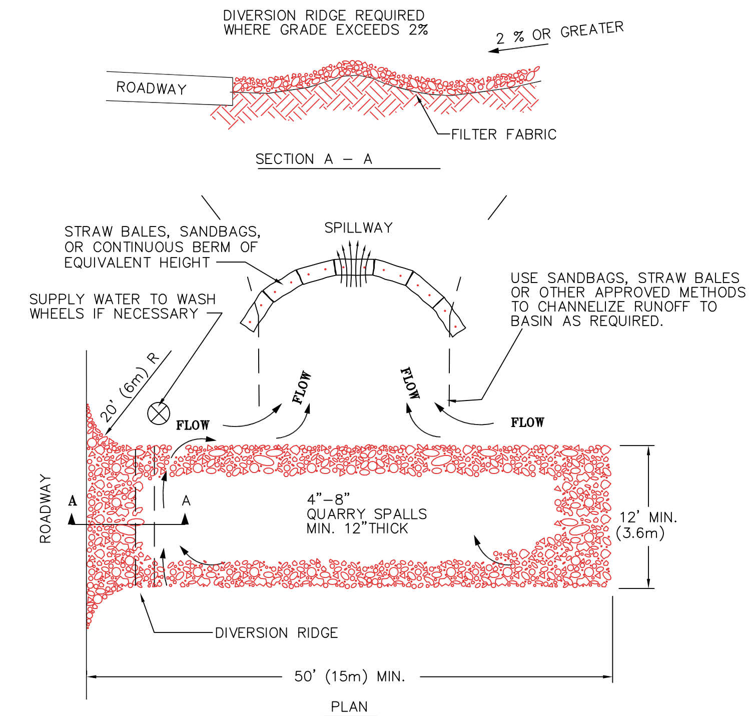


NOTES:
1. CLF AND TREE PROTECTION FENCE SHALL BE A MINIMUM OF 49" HIGH. FOR TREES WITH DRIPLINES THAT OVERHANG THE CONSTRUCTION AREAS, THE LOCATION OF THE TREE PROTECTION FENCE SHALL BE DETERMINED IN THE FIELD BY THE ENGINEER.
2. THE DETAIL SHOWN IS FOR TREE PROTECTION. MATERIAL AND SPACING SHOWN ALSO APPLIES TO CLF.

CONSTRUCTION LIMIT FENCE

2/7

NOT TO SCALE

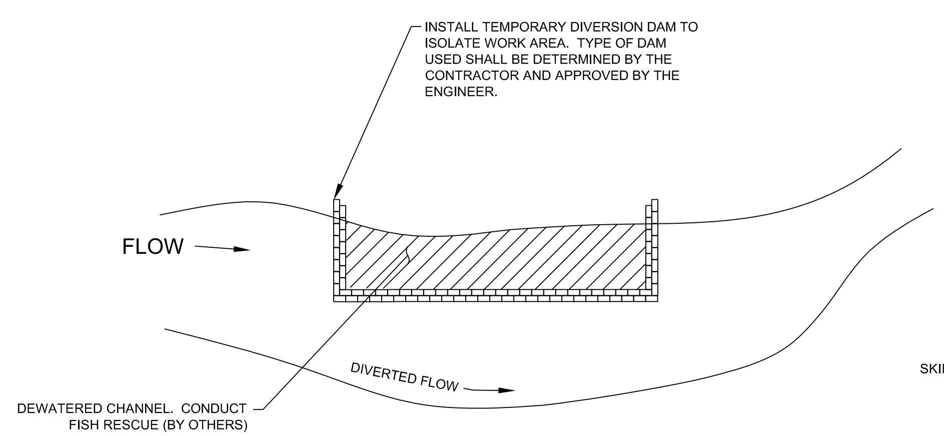


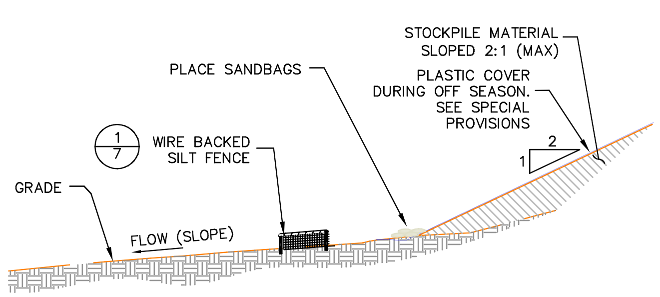
NOTES:
1. THE ENTRANCE SHALL BE MAINTAINED IN A CONDITION THAT WILL PREVENT TRACKING OR FLOWING OF SEDIMENT ONTO PUBLIC RIGHT-OF-WAYS. THIS MAY REQUIRE TOP DRESSING, REPAIR AND/OR CLEANOUT OF ANY MEASURES USED TO TRAP SEDIMENT.
2. WHEN NECESSARY, WHEELS SHALL BE CLEANED PRIOR TO ENTRANCE ONTO PUBLIC RIGHT-OF-WAY.
3. WHEN WASHING IS REQUIRED, IT SHALL BE DONE ON AN AREA STABILIZED WITH CRUSHED STONE THAT DRAINS INTO AN APPROVED SEDIMENT TRAP OR SEDIMENT BASIN.

TEMPORARY STABILIZED CONSTRUCTION ENTRANCE

3/7

NOT TO SCALE



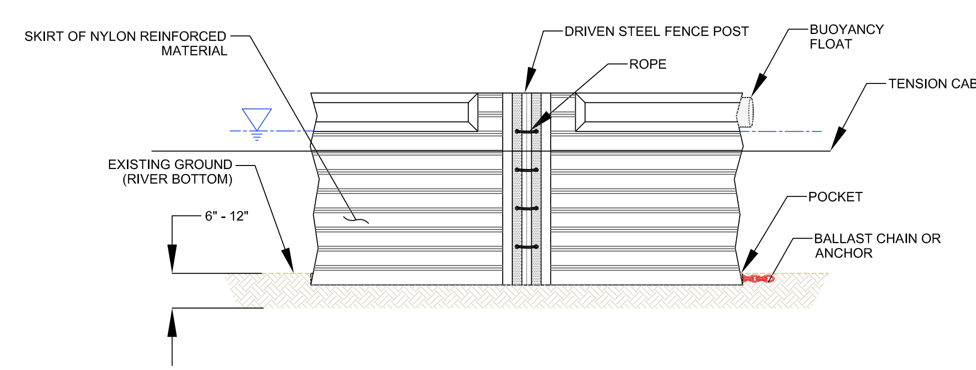


NOTE:
1. CONTRACTOR RESPONSIBLE FOR FINAL DESIGN OF DIVERSION PLAN. FINAL DIVERSION PLAN SHALL BE APPROVED BY THE ENGINEER PRIOR TO IMPLEMENTATION

TEMPORARY DIVERSION

5/7

NOT TO SCALE



TEMPORARY EXPOSED SOIL AND STOCKPILE BMPs

4/7

NOT TO SCALE

SILT BOOM

6/7

NOT TO SCALE

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DETAILS - BMPS

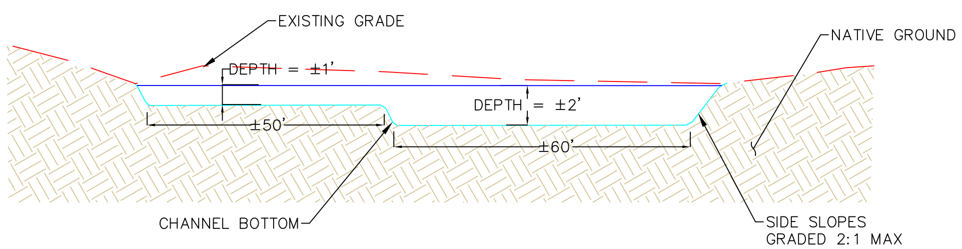
DUNGENESS LEVEE SETBACK RESTORATION PROJECT

CLALLAM COUNTY, WASHINGTON

DATE:	4/2013
DRAWN BY:	C. KROFTA
CHECKED BY:	J. BJORK
SCALE:	AS SHOWN
ENTRIX JOB NO.	42549003
FIGURE NO.	7

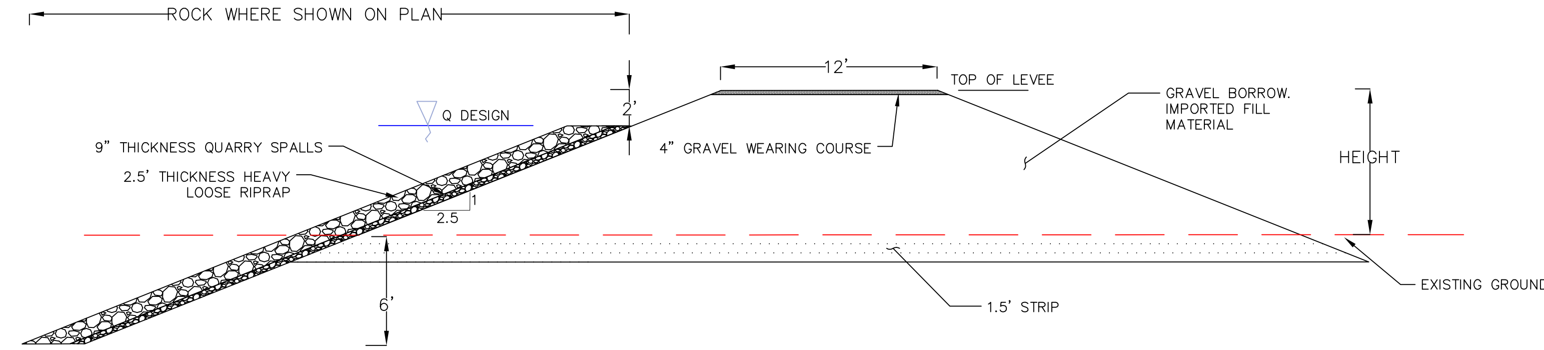
SHEET 7 of 8

LOCATION	TOP LEVEE ELEVATION	APPROX. HEIGHT
B1	29.5	9'
B2	29.8	9'
B3	29.9	3'



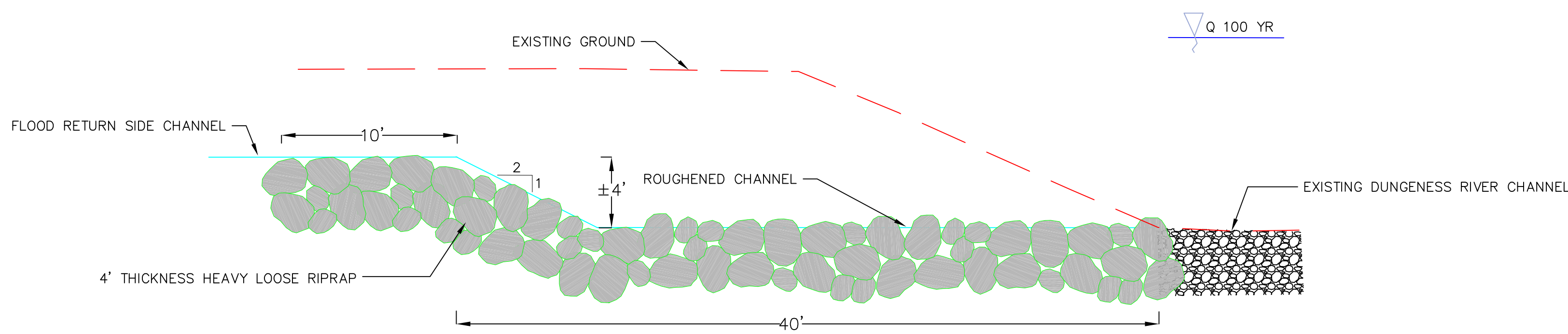
TYPICAL SECTION - HIGH FLOW OUTLET AND FLOOD RETURN CHANNEL (A/8)

NOT TO SCALE



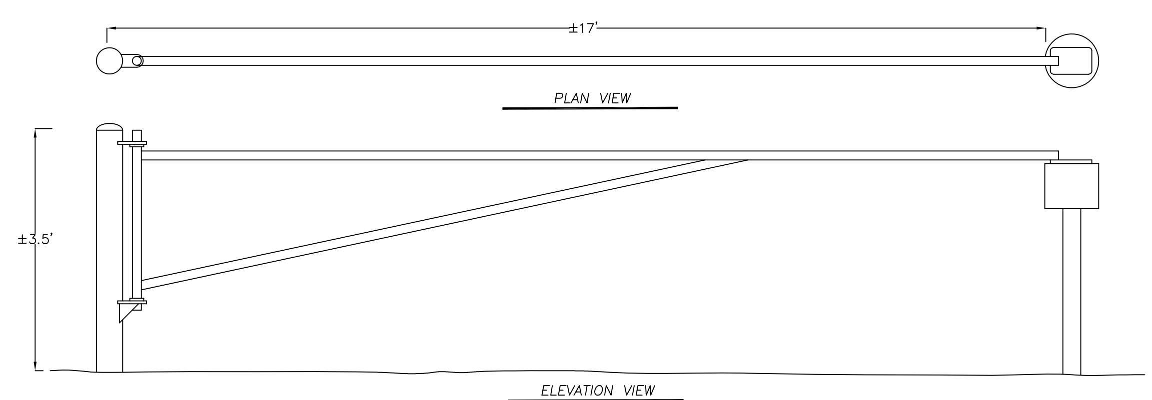
TYPICAL LEVEE CROSS SECTION (B/8)

NOT TO SCALE



RETURN CHANNEL PROFILE (1/8)

NOT TO SCALE



NOTE:
THESE DRAWINGS ARE TYPICAL DRAWINGS AND MAY REQUIRE MINOR MODIFICATION FOR INSTALLATION.

PERMANENT ACCESS GATE (2/8)

NOT TO SCALE

60% PLANS
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DETAILS - SITE RESTORATION

DUNGENESS LEVEE SETBACK RESTORATION PROJECT

CLALLAM COUNTY, WASHINGTON

DATE:	4/2013
DRAWN BY:	C. KROFTA
CHECKED BY:	J. BJORK
SCALE:	AS SHOWN
ENTRIX JOB NO.	42549003
FIGURE NO.	8

SHEET 8 of 8

Appendix D

Construction Cost Estimate

Dungeness Levee Setback Restoration
Engineer's 60% Estimate of Construction Cost
04/30/13

Restoration

Item #	Item Description	Unit	Unit Cost	Quantity	Value
1	Mobilization	LS	$100,000	1	$100,000
2	Construction Staking	LS	$12,000	1	$12,000
3	Traffic Control	LS	$10,000	1	$10,000
4	TESC	LS	$12,000	1	$12,000
5	Clearing and Grubbing	AC	$3,000	7.3	$21,877
6	Diversion/Dewatering	LS	$100,000	1	$100,000
8	Reconstruct Side Channel Inlet and Outlet	LF	$110	300	$33,000
9	Construct Flood Return Channel	LF	$127	1,100	$139,700
10	Engineered Log Jams	EA	$35,000	15	$525,000
				Total Construction (Restoration):	*$953,577*
				Tax (8.4%):	*$81,054*
				Contingency (20%):	*$206,926*
				Total:	***$1,241,558***

Notes:

1. Total CY Excavation for Channel Construction is +/-12,000 CY
2. Construction costs do not include additional property acquisition, final design, permitting, construction management or inspection costs

USACE Levee

Item #	Item Description	Unit	Unit Cost	Quantity	Value
1	Mobilization	LS	$200,000	1	$200,000
2	Construction Staking	LS	$30,000	1	$30,000
3	Traffic Control	LS	$10,000	1	$10,000
4	TESC	LS	$25,000	1	$25,000
5	Clearing and Grubbing	AC	$4,750	7	$34,909
6	Diversion/Dewatering	LS	$5,000	1	$5,000
7	Levee Removal	LF	$125	2,610	$325,661
8	Remove Road	LF	$49	2,150	$105,780
9	Setback Levee	LF	$187	4,720	$881,379
10	Rock Toe	LF	$237	755	$179,086
11	New residential Access Road	LF	$7	2,000	$14,820
12	New Parking Area	SF	$1	8,525	$8,525
13	Powerline Relocation	LF	$75	3,940	$295,500
14	Install Access Gate	EA	$4,200	4	$16,800
				Total Construction (USACE Levee):	*$2,132,460*
				Tax (8.4%):	*$181,259*
				Contingency (20%):	*$462,744*
				Total:	***$2,776,463***

**Notes:*

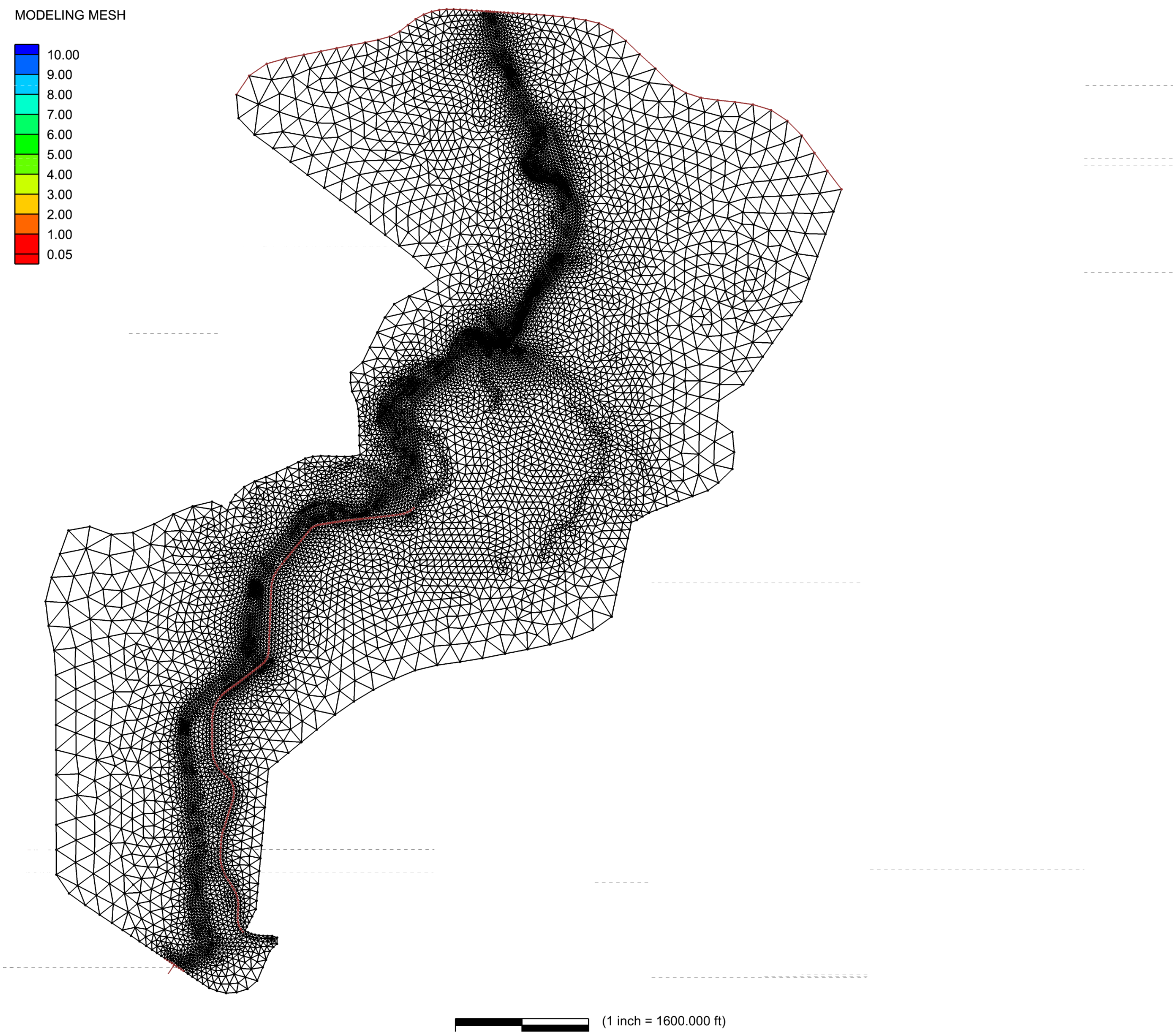
1. Total Fill for New Levee is +/- 36,800 CY,
2. Total Excavation for Levee Removal is +/-19,100 CY

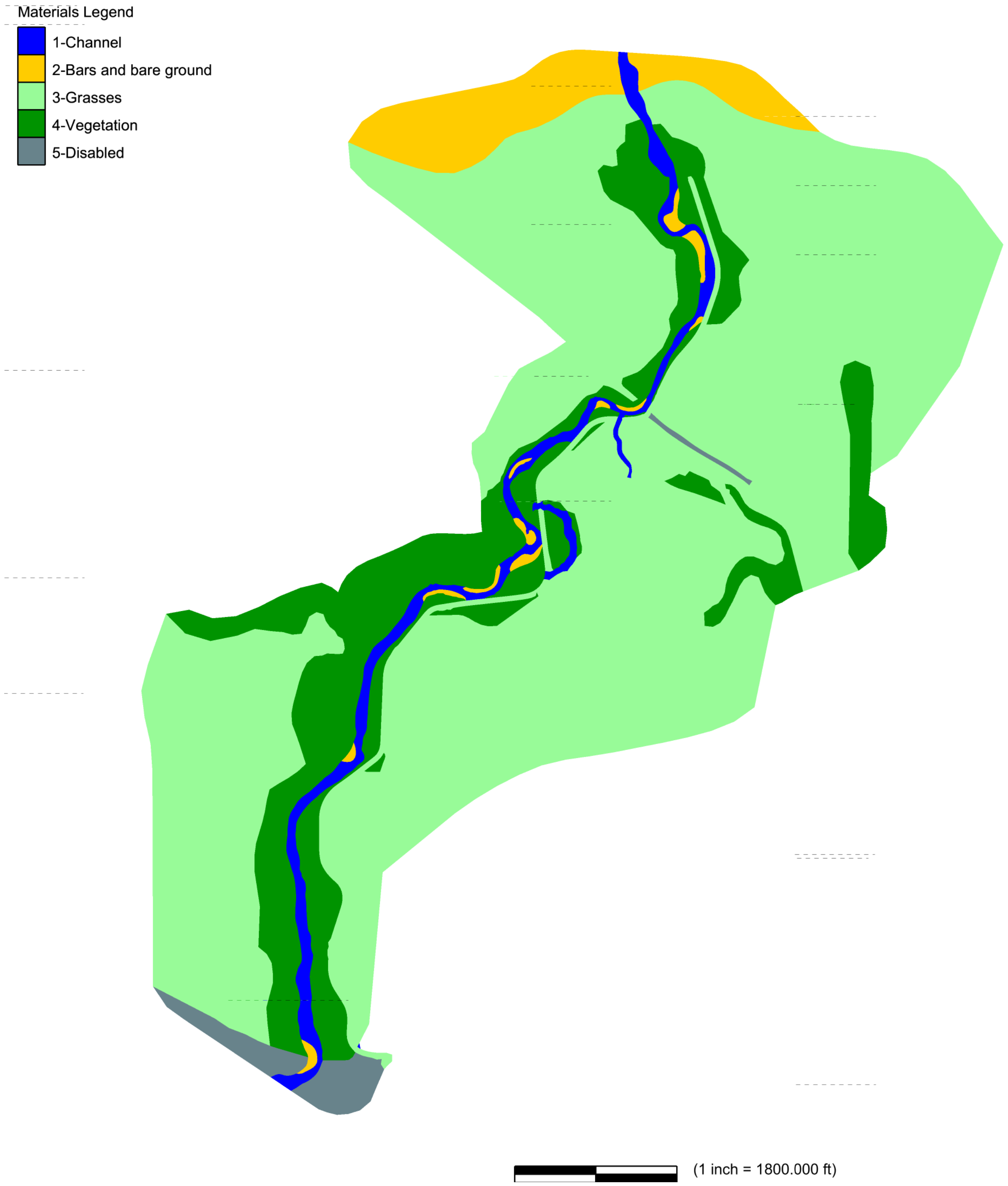
<u>Total Project Cost:</u> ***$4,018,020***

Appendix E

2D Hydraulic Model Data

MODELING MESH




Materials Legend
1-Channel
2-Bars and bare ground
3-Grasses
4-Vegetation
5-Disabled
(1 inch = 1800.000 ft)

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