CREST
Columbia River Estuary Study Taskforce
750 Commercial Street, Room 205, Astoria, Oregon 97103
Phone: (503) 325-0435, Fax: (503) 325-0459
Website: **www.columbiaestuary.org**

To: Tony Grover, Fish and Wildlife Division Director, Northwest Power and Conservation Council; Eric Loudenslager, ISRP chair

From: Micah Russell, CREST Director

Subject: ISRP Review of CREST Estuary Habitat Restoration proposal (#2010-004-00).

May 14th, 2010

CREST has received the ISRP Memorandum 2010-9 dated April 15th that summarizes ISRP review of the CREST Estuary Habitat Restoration proposal (#2010-004-00). What follows is a point-by-point response to each of the seven ISRP requests for more information. Responses indicate where changes can be found in the revised project narrative. The revised narrative and associated appendices are also attached.

We appreciate the opportunity to respond to ISRP questions; we feel the proposal has been strengthened by the following clarifications. Please contact me any time for further discussion.

Micah Russell

CREST Director

503-325-0435, ext.18; mrussell@columbiaestuary.org

Background (as summarized in ISRP Memo 2010-9)

As requested by the Council on March 8, 2010, the ISRP reviewed the Columbia River Estuary Study Taskforce (CREST) Estuary Habitat Restoration proposal (#2010-004-00).

As described in the proposal abstract:

> CREST seeks to continue developing, designing and constructing on-the-ground habitat restoration actions that benefit threatened and endangered salmonid species in the Lower Columbia and Estuary, specifically the 2008 BiOp RPA 37, *Achieving Habitat Quality and Survival Improvement Targets*. This proposal represents a lower river/estuary wide effort to restore mainstem and tidal habitats, acknowledging the interconnected landscapes that comprise the lower river and estuary ecosystems…The restoration actions will benefit threatened and endangered salmonid species in mainstem and tidal habitats that promote diverse estuarine life histories. The project will result in an ecosystem-based habitat restoration program, guided by adaptive management principles, and focused on the improved survival of juvenile salmonids. In the past six years, BPA project dollars have supported and leveraged seven CREST habitat projects that resulted in 86 acres restored and over 18 linear miles of shoreline reconnected or enhanced.

This new project has a close relationship to ongoing work by CREST funded under Grays River Watershed Restoration, Project 2003-013-00 that is due to be closed out in May/June, 2010. The Grays River Watershed Restoration Project focuses on the upper Grays River basin, above tidal influence. The 2008 BiOp prioritizes habitat projects that are in tidally influenced areas of the tributaries. CREST's new habitat project, #2010-004-00, is focused from the mouth of the Columbia River to Bonneville Dam, including the tidally influence areas of the tributaries.

Recommendation

Response requested

1. Clarification of the specific role of CREST in the process of BPA-funded habitat restoration. (see revised proposal page #1-2)

CREST is a long-standing partner with BPA in implementing habitat restoration projects. Over the past decade, CREST has completed at least 1-2 projects per year and has the experience necessary to increase efforts to help implement a significant share of the 2008 Biological Opinion in the estuary. Our relationships with Lower Columbia River communities and landowners, and our experience identifying and implementing projects, will ensure our success as we build our organization's capacity to achieve 2008 BiOp targets.

CREST is a bi-state council-of-governments formed in 1974 to develop a management plan for the Columbia River Estuary, facilitate scientific research (*Columbia River Estuary Data Development Program*), encourage compatible uses of shorelines and serve as a spokesman and steward for the region. Since then, CREST has become a leader in habitat restoration, particularly wetland and floodplain restoration for juvenile salmon. CREST has restored, or is in the process of restoring, 1214 acres and 34 stream miles of habitat, entirely in coordination with public and private landowners. Emphasis on building capacity for restoration activities was recently formalized in the 2010 CREST Strategic Plan. This work has necessitated three distinct but collaborative departments: coastal/estuarine planning, habitat restoration, and ecosystem research and monitoring. CREST also staffs and administers the four watershed councils of the North Coast Watershed Association.

CREST is one of only a few organizations in the Lower Columbia region that has years of experience implementing habitat restoration projects. CREST has previously had two BPA direct-funded projects (Brownsmead #2003– 015– 00 and Grays River #2003- 013- 00), and several BPA projects funded through the Lower Columbia Estuary Partnership. CREST project managers are trained specifically for the challenges of project identification and development, funding acquisition, multi-agency permitting, subcontractor management, construction oversight and ecological monitoring. CREST staff live in the small communities of the estuary and have long-standing relationships with area landowners. This level of communication and trust often leads to valuable project opportunities. As we recognize opportunities on the ground we internally score projects consistently with known BPA ranking criteria and determine project benefit/feasibility prior to submitting proposals to BPA through the selected process. Project selection and prioritization is discussed further in Response #4 below.

CREST believes that these restoration activities are crucial to salmon recovery and economic vitality in the region, and achieve a host of other indirect benefits other species of wildlife, food web functionality, floodplain connectivity, and human concerns (e.g. flood and erosion control). Consequently, we pioneered many of the first restoration projects in the region, including dike breaches. Early projects included dike breaches, tidegate retrofits and culvert removal on the tidal portions of the Lewis and Clark River, as well as reconnection of several miles of tidal habitat in the area of Brownsmead on Blind Slough. One of these projects, Fort Clatsop's South Slough, is being monitored over several years as a model site for determining site evolution for future restoration projects in the area.

As cited in the NOAA Estuary Module, successful estuarine and plume residency by juveniles is critical for fast growth and transition to a salt water environment. CREST has been actively seeking and developing wetland restoration projects that will improve conditions for this critical life-stage and for all 13 Threatened or Endangered salmonid ESUs in the Columbia River basin. The two projects identified in this proposed project for Year 1 implementation will result in juvenile salmon survival benefits that BPA can utilize in meeting their mitigation obligations.

2. More details on the two projects mentioned in the cover letter by Mr. Maslen (Ft. Columbia Tidal Reconnection and Otter Point Restoration). Until the projects have actually been designed, the ISRP cannot determine their technical and scientific merit or whether the projects may benefit Columbia River Basin Fish and Wildlife. (see revised proposal page #14-15)

The Fort Columbia and Otter Point projects are in the final stages of design. Fort Columbia is scheduled for construction in fall, 2010; Otter Point is scheduled for construction in two phases, summer 2010 and 2011. Brief details follow, and the designs and design memorandums for the projects are included as Appendixes D and E.

The Fort Columbia Tidal Reconnection Project will replace an undersized, impassable culvert under US Highway 101, restoring tidal connectivity between the Columbia River and 96 acres of high quality wetland. An estimated twelve of these acres will convert to brackish tidal wetlands, tidal channels will form within the site, and the remainder of the wetland will provide critical off-channel rearing habitat and macrodetrius inputs into the mainstem Columbia River. The site is located immediately opposite of the Columbia River mouth, at approximately RM 6. CREST has managed the project, obtained approval from Washington Department of Fish and Wildlife, Washington Department of Transportation, an easement through Washington State Parks, and is receiving both funding and an easement through Washington State Department of Natural Resources. The project has also been funded through the Washington State Salmon Recovery Funding Board ($740k) and Lower Columbia River Estuary Partnership ($140k). Because of the need to ensure that implementation will guarantee ecological benefits and no flooding threat to the nearby community, a third party engineering review was conducted in Fall 2009 at the request of BPA. This resulted in some additional data collection and minor modifications to the designs.

The Otter Point Restoration Project breaches an unnecessary dike in several strategic locations, reconnecting the Lewis and Clark River, at RM 1, to 33.5 acres of historical wetland and tidal channel habitat. An estimated 21 acres will be enhanced by restoration, with 12 acres converting directly to brackish tidal wetland. Two tidal channel networks will form within the site, and the remainder of the wetland will provide critical off-channel rearing habitat and macrodetrius inputs into the mainstem Columbia River at Youngs Bay. The Lewis and Clark River feeds into the Columbia River estuary at RM 6. CREST has managed the project on behalf of the landowner (National Park Service), obtained approvals from the appropriate state and federal agencies, and is leveraging BPA funds against several other sources, including: National Park Service, NOAA, and the US Fish and Wildlife Service.

A revised proposal for the above two projects could be paired with a document that describes CREST's role in a restoration plan for the entire estuary over the next decade. This comprehensive proposal should (1) deal with the proponent's vision(s), goals, and objectives for the estuary, (2) review accomplishments to date in terms of meeting the goal of restoring 16000 acres, and (3) provide a blueprint for future work. (see revised proposal page #11-12)

CREST's role in the estuary will continue to include regional planning and restoration on a broad scale in the coming 10 years and beyond. Initial funding became available in early 2010 through BPA/LCREP to identify and develop new projects. This additional capacity has already yielded results and has generated new project ideas and opportunities. We anticipate finding and developing numerous and significant new restoration opportunities over the next several years.

CREST's purpose is outlined in its founding Charter, which states that "CREST as a regional estuarine management organization, is to provide local jurisdictions and other groups, agencies, and individuals with assistance in estuarine management, planning and plan implementation". In March 2010, CREST updated this vision with a 3-year Strategic Plan. Goal 2 of the plan calls for securing longer-term funding to sustain staff positions, support restoration project implementation, and add project management capacity. BPA is specifically identified as the principle funder able to provide this direct relationship.

CREST's accomplishments to date, towards the Estuary Partnership's identified Estuary recovery goal of 16,000 acres, is 1214 acres of tidal wetland and riparian habitat and 34 miles of instream habitat.

Project Name	Action	Watershed	Acreage	Miles
Larson Slough	Tidegate Retrofit	L & C	9.0	
Johnson Slough	Tidegate Retrofit	L & C	10.0	
Green Slough	Tidegate Retrofit	L & C	19.0	
Barrett Slough	Tidegate Retrofit	L & C	18.0	
Vera Slough	Tidegate Retrofit	Columbia Estuary	22.0	
L & C Phase I	Dike Breach	L & C	25.0	
Blind Slough	Tidegate Retrofit	Columbia Estuary		7.0
L & C Phase II	Dike Removal	L & C		0.2
South Slough	Dike Breach	L & C	45.0	
Skipanon	Floodplain Reconnection	Skipanon	2.0	
Perkins Ln	Fish Passage	Skipanon		4.0
N.F. Klaskanine	Riparian Plantings	Klaskanine	12.0	
Gorley Springs	Habitat Complexity	Grays River	48.0	1.0
Big Creek	Fish Passage	Big Creek		11.0
CEEEP	Environmental Education			
Chinook Diversion	Diversion Retrofit	Chinook		1.5
Fort Columbia	Fish Passage	Columbia Estuary	96.0	
Otter Point	Dike Breach	L & C	33.5	
Meglar Creek	*Fish Passage*	*Columbia Estuary*		*2.2*
Hungry Harbor	*Fish Passage*	*Columbia Estuary*	*854.0*	*6.0*
Gudmundsen	*Habitat Complexity*	*Grays River*		*0.8*
Sorenson	*Habitat Complexity*	*Grays River*		*0.4*
Gnat Creek	*Dike Breach*	*Columbia Estuary*	*20.5*	
Totals			1214.0	34.0

Upcoming projects italicized.

CREST's future work through the proposed BPA project will focus heavily on meeting recovery goals as stated in the NOAA Estuary Module, as well as the NOAA Fisheries 2008 Biological Opinion. CREST intends to stabilize staffing and increase overall organizational capacity to do this work. In general, projects being targeted are tidal, close in proximity to the mainstem Columbia River, and either large in size or smaller but strategically located to fill a habitat gap.

3. A summary of the analyses completed by the estuary BiOp science group and the ERTG that evaluate the merit of the proposed activities (in 2, above) and a cross-referencing of the proposed work with the analyses.

CREST has not yet received any feedback from the Estuary/Ocean Subgroup for Federal BiOp RME, ERTG, or Estuary Partnership Science Work Group regarding the Fort Columbia Tidal Reconnection Project or the Otter Point Restoration Project. The ERTG facilitator has informed us to expect feedback from the two projects June 2010. The Estuary Partnership Science Workgroup will provide feedback in July 2010.

4. An explanation of the specific methods that CREST uses to identify and prioritize habitat restoration projects. There is a need to demonstrate how the scientific prioritization criteria will be applied to the landscape in general, not just individual projects. How will these criteria be evaluated at multiple sites to decide which sites should be developed into protection and restoration projects? It is not evident from the proposal that recent advances in classifying and mapping estuary habitats (see presentations at the Astoria science/policy exchange www.nwcouncil.org/fw/program/2009spe/Default.asp) have been incorporated into a long-term approach to identify where protection and restoration should be implemented to achieve the three primary objectives. (see revised proposal page #12-14)

To identify and develop projects, CREST strategically analyzes the estuary at both community and landscape levels. We evaluate project opportunities in a formulaic approach that is consistent with BPA ranking systems, as illustrated in Appendix C.

CREST is sometimes contacted by a landowner interested in restoration, often prompted by problems he/she has experienced due to disruption of ecosystem processes, resulting in flooding, erosion, or other impacts to private property. Frequently, a restoration project can be designed to benefit both juvenile salmon and the landowner's interests. More recently, CREST has had limited BPA/LCREP funding to strategically conduct targeted project investigation and development. CREST reviews aerials and LIDAR, conducts site visits, collaborates with other organizations, contacts landowners to assess willingness and creates a list of potential projects. CREST initially evaluates projects for suitability based on known project selection criteria (e.g. Estuary Partnership Science Workgroup). This, along with knowledge of funding priorities (e.g. proximity to mainstem Columbia River) and local knowledge of community support and technical challenges help determine whether a project is worth developing further for the purposes of BPA funding. Top ranked projects are further assessed to determine feasibility and quantify benefits, resulting in a 5-7 page memorandum to be used as background information for presentations and funding applications. At all times, CREST applies scientific criteria from key studies and reports during the project development stage, directly incorporating scientific data during the preliminary review stage to determine project's probable benefits to salmon.

In order to ensure project selection and development yields the highest ecological value and benefit to juvenile salmon, CREST works with several new restoration tools that have become available recently to identify projects strategically. These include the Estuary Partnership's Restoration Prioritization Framework and the University of Washington and US Geological Survey's Columbia River Estuary Ecosystem Classification (CREEC). The Restoration Prioritization Framework uses a disturbance model to identify the optimal locations for restoration and protection projects. Using available GIS layers, the Restoration Prioritization Framework provides an analysis of landscape-scale disturbances to predict the degree to which physical processes will support a specific project within a particular management unit of the estuary. The Estuary Partnership is working with PNNL to refine the model and increase its accuracy.

In 2009, BPA funded an effort to identify priority restoration projects using landscape ecological principles and CREEC as a platform for describing desired future habitat conditions by reach in the estuary. This five-year project uses statistical tools to analyze CREEC landscape classes (historical/present) to help derive metrics for describing optimal juvenile salmonid habitats for each of the eight estuary reaches. The project is supported technically by an expert panel with products vetted through estuary restoration practitioners. CREST participated in the expert panel work session in October, 2009 and will help shape the use of CREEC products as they emerge over the next three years.

CREST also uses a variety of tools to help prioritize potential restoration projects. This includes t-sheets, digital photos and GIS data layers with information on diking extent, tidegate locations, culvert barriers, pile dikes, and dredge material disposal sites. Additionally CREST will incorporate other regional actions, such as the Culvert and Tidegate Inventory completed by Cowlitz Conservation District and the NOAA and Oregon DLCD inventory of tidegates and levees due in 2011.

To summarize, CREST has a strategy in place to utilize selection criteria, regional prioritization tools, LIDAR and GIS layers, and information on community support and project complexity to determine the value of potential projects. What results is a transparent determination of project ranking relative to restoration goals.

5. Specific examples of the significance and consistency of proposed BPA-funded CREST projects with regional programs and how coordination will be achieved. (see revised proposal page #5-6)

CREST is proposing two projects to be constructed in the first year of the proposed BPA project, followed by similar or larger scale, scope, and type of projects through 2018. CREST is working with BPA to estimate the number and type of projects to be implemented during that time period and the anticipated survival benefit units.

Throughout this time period CREST will continue to participate in regional efforts to coordinate estuary restoration efforts, collaborating extensively with the following regional programs: Lower Columbia River Estuary Partnership, Lower Columbia Fish Recovery Board, Lower Columbia Solutions Group, Columbia Land Trust, Oregon Watershed Enhancement Board, and the State of Washington/Action Agency Memorandum of Agreement. Examples of on-going collaboration include CREST participation on the Estuary Partnership's Science Workgroup, Estuary Partnership project development coordination meetings, and the Lower Columbia Solutions Group and its sub-committees. CREST is also managing the LCSG Regional Upland Disposal project. The CREST Director has been working from Portland 2-3 days per week to attend these meetings and strengthen collaborative relationships with partner agencies. CREST staff frequently travel to Portland as well to give project funding presentations, share monitoring data and findings, meet with project permitting authorities, etc.

The Fort Columbia Tidal Reconnection Project and Otter Point Restoration Projects focus on restoring connectivity to historical tidal wetland habitat in the Columbia River Estuary. The NOAA Estuary Module identifies reduced sequences and patterns of habitat availability, which limits the diversity of already simplified salmonid life history patterns. An estimated 62% percent of marshes and 77% of forested wetlands have been lost in the Columbia River estuary (Thomas 1983). Loss of tidal swamps and other forested or vegetated wetlands represents a loss of habitat that ocean-type salmonids use during their estuarine residence. CREST's focus has been and will continue to be restoring these critical habitats. Off-channel habitat availability is also a factor contributing to density-dependant mortality. The module further states that it is possible too many fish are competing for limited habitat and associated resources in the estuary at key times, and that the resulting stressors translate into reduced salmonid survival.

Although they contain different focuses, most plans describing the Lower Columbia River and estuary come to similar conclusions on limiting factors. The Lower Columbia Fish Recovery Board document *Estuary Mainstem Subbasin Plan* describes a substantial loss in historical wetlands and tidal marshes. The Lower Columbia River Estuary Partnership's *Lower Columbia Estuary Comprehensive Conservation and Management Plan*, Chapter 5, identifies as Action 2 "protect, conserve, and enhance identified habitats, particularly wetlands, on the mainstem of the lower Columbia River." The Northwest Power and Conservation Council *Columbia River Basin Fish and Wildlife Program* targets two strategies: reconnecting ecosystem functions and encouragement of continued partnerships.

In addition to continued participation in regional programs, and implementation of projects within the framework of existing plans, all future CREST projects funded by BPA will continue to be reviewed through the Estuary Partnership Science Workgroup for technical merit and BPA Expert Regional Technical Group for assignment of survival benefits. The Science Workgroup may recommend a project based on its overall ecological benefit and the ERTG will subsequently assign the proposed project a salmon survival benefit unit. This information will be evaluated by BPA staff in deciding whether or not to fund the project.

6. An explanation of how the limiting factors described in the Lower Columbia River and Columbia River Estuary Subbasin Plan and RPAs in the 2008 BiOp will be specifically addressed. (see revised proposal page #6)

The Northwest Power and Conservation Council adopted subbasin plans into the Columbia River Basin Fish & Wildlife Program in 2005. Later, in February 2009 the Council completed a two-year process to amend its Columbia River Basin Fish & Wildlife Program. Specific implementation of habitat actions in the estuary, and monitoring and evaluation of these actions, will occur through the adopted Columbia River Estuary and Lower Columbia subbasin plans. The recently completed *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* will be used to guide actions in the estuary and lower Columbia River. CREST has been one of the primary implementers of estuary strategies identified in the Council's Program: 'Habitat restoration work to reconnect ecosystem functions such as removal or lowering of dikes and levees that block access to habitat or installation of fish-friendly tide gates, protection or restoration of riparian areas and off-channel habitat, and removal of pile dikes.

As described by the Lower Columbia River and Columbia River Estuary Subbasin Plan, the limiting factors targeted by CREST are described as:

(1) Limiting Factor 1, availability of preferred habitat. Supported by hypothesis E.H1, E.H2, E.H3, E.H4, E.H6, E.H7, E.H8, E.H9, E.H11, and E.H12
(2) Limiting Factor 2, macrodetrius-based food webs. Supported by hypothesis E.H1, E.H2, E.H3, E.H4, E.H6, E.H8, E.H9, E.H11, and E.H12

(3) Limiting Factor 3, loss of habitat connectivity. Supported by hypothesis E.H1, E.H2, E.H3, E.H4, E.H6, E.H7, E.H8, E.H9, E.H11, and E.H12

In 2007-08, BPA and other agencies of the federal government committed to a number of decisions, documents, and agreements to fund an extensive set of actions over the next ten years to benefit listed and unlisted anadromous and resident fish across the Columbia River Basin. These include estuary habitat improvement actions committed to by the agencies as part of the consultation resulting in the 2008 Biological Opinion for the Federal Columbia River Power System and RPA 37. CREST will be one of the primary organizations to utilize these funds for implementation of on-the-ground restoration projects.

The three primary objectives: (1) increase the availability of preferred habitat; (2) increase the macro-detritus food web; and (3) increase habitat connectivity, need to be developed in a quantitative form. The proponents need to elaborate on the quantitative connection hypothesized between these ecosystem attributes and the survival and capacity of different life-stages and species of salmon in the estuary. (see revised proposal page #16-17)

Specific features CREST is targeting through implementation of the Fort Columbia Tidal Reconnection Site are: improving ecosystem connectivity (restoring passage and tidal connectivity between historic habitats and the mainstem Columbia River), improving habitat connectivity (96 acres of wetland habitat reconnected to tidal, estuary mainstem), replacing an off-channel stream habitat blockage (0% adult passable 24” concrete culvert), gain of historical off-channel habitats (wetland habitat reconnected to tidal, estuary mainstem), improved nutrient exchange (improved nutrient cycling through unrestricted connection to tidal, estuary mainstem), increased availability of preferred habitat (wetland habitat reconnected to tidal, estuary mainstem), and increased macrodetrius inputs (high quality vegetation inputs combined with unrestricted connection to tidal, estuary mainstem).

Limiting factors at Otter Point are addressed by improving ecosystem connectivity (restoring passage and tidal connectivity between historic habitats and a major tributary to the mainstem Columbia River), improving habitat connectivity (33 acres of wetland habitat reconnected to tidal, tributary estuary mainstem), gain of historic off-channel habitats (wetland habitat reconnected to tidal, tributary estuary mainstem), improved nutrient exchange (improved nutrient cycling through unrestricted connection to tidal, tributary estuary mainstem), increased availability of preferred habitat (wetland habitat reconnected to tidal, tributary estuary mainstem), and increased macrodetrius inputs (high quality vegetation inputs combined with unrestricted connection to tidal, tributary estuary mainstem).

CREST is tasked with implementing projects that address the limiting factors identified in the sub-basin plans and other guidance documents. Although we have a robust monitoring program (see Response #7 below) that can quantify the effectiveness of project actions, CREST suggests coordinating, rather than leading, monitoring efforts with entities such as ERTG, NW Science Center, and others as detailed below. Combined, these efforts work to demonstrate a link between the habitat characteristics, established action plans, and salmon survival. Ecosystem research is being performed by a number of other entities, and CREST relies on the ERTG to evaluate projects for salmon survival benefits.

7. Further details on monitoring methods for the two specific projects mentioned in 2 (above). Who will actually decide on the methods? Will the methods be extracted from Roegner et al. (2009), and what is the role of the ERTG in selecting them? Details are requested on the design of the BACI analyses. If cause-effect relationships are being sought, before and after monitoring will require randomization of sites and attention to sample sizes in a power analysis. (see revised proposal page #19-23)

CREST was instrumental in developing the Roegner et al. (2009) standardized monitoring protocols, has on-the-ground experience with all of these methods, and employees biologists for a year-round field crew. To date, methods have been chosen according project type and site conditions, and more often, available funding. Different project types require different monitoring approaches. For example, a dike breach and tidal reconnection requires different monitoring techniques than an Engineered Log Jam installation. At a minimum, CREST strives to perform one year of pre-project monitoring and two years of post-project monitoring with the following metrics: fish utilization, juvenile salmon stock identification (genetics), prey availability and biomass export, vegetation changes, landform and hydrology changes, and water quality. When funding agencies have desired more intensive monitoring techniques for fish habitat utilization and residency time, CREST has also utilized pit tagging, radio telemetry, and fluorescent dyes.

Our research department partners with every major player in estuary research, including National Oceanic and Atmospheric Agency (NOAA), Pacific Northwest National Labs (PNNL), University of Washington, USGS, etc. CREST biologists and wetland specialists conduct research both on contract and for our own projects through grant funding. CREST has a lab for processing fisheries samples. Our monitoring department is active in regional discussions, conferences, and dissemination and analysis of information. CREST has been a partner in both the *Cumulative Effects* study (Army Corps of Engineers funding) and the *Salmon Life Histories, Habitats, and Food Webs in the Columbia River Estuary* study (BPA funding). In addition, CREST is involved with LCREP and PNNL in efforts to conduct a meta-analysis on effectiveness monitoring performed by multiple entities in the region, and continues to participate in Adaptive Management efforts with the Army Corps and others.

CREST will include monitoring as a project action for Science Workgroup and ERTG review. Any suggestions from these groups or other research professionals will be considered. BPA will make final decisions related to funding monitoring efforts as part of annual contract negotiation. CREST assumes that the minimal time and metrics described above will be performed for Fort Columbia and Otter Point projects, but the majority of the proposed project funding will be prioritized for project implementation and development.

In general, CREST evaluates monitoring needs according to a two-tier approach: extensive versus intensive. Extensive monitoring of a few key metrics will broadly cover most projects, whereas select project types may be chosen for intensive monitoring when data on that project type is deemed by CREST and the project reviewers to be deficient or complementary to other studies. As an example, the Fort Columbia Tidal Reconnection site is being monitored extensively for fish species composition and timing, fish size structure, presence/absence of adult fish, landscape change, channel morphology, channel flow volume, hydrology, water temperature, dissolved oxygen, and salinity. Intensive monitoring is proposed with a pit tag array, evaluation of habitat type and area, use of habitat types, winter/summer biomass sampling and flux export to test the hypothesis that the project will benefit out-of-basin stocks and increase macrodetrius availability in the estuary.

Pit-tag arrays are proposed for both Fort Columbia and Otter Point, as we are frequently asked about off-channel habitat use in the estuary by downstream migrants from distant upriver stocks (e.g. mid-Columbia or Snake River). Pit-tag arrays at these locations will be an affordable way to address this question because any fish tagged elsewhere in the Columbia River basin that enters the wetlands will automatically be registered by the array and later uploaded into PTAGIS (Passive Integrated Transponder Tag Information System). CREST staff will work to coordinate as much as possible with related research programs in the estuary (e.g. ACOE telemetry studies).

Through this approach, CREST intends to use quantitative data to produce qualitative assessments indicating direction of habitat outcomes and salmonid usage at specific sites. CREST has identified the following specific metrics for evaluating our effectiveness in targeting the three targeted limiting factors:

1. *Increase the availability of preferred habitat.*
   Extensive: Monitor water surface elevations. Evaluate area inundated.
   Intensive: Delineate habitat type and area. Establish types of use for different areas.
   Example: freshwater tidal wetland, freshwater wetland, brackish wetland.
2. *Increase macrodetrius inputs*
   Extensive: Benthic cores, fall out traps, stomach samples.
   Intensive: Winter/Summer biomass sampling. Flux export, drift and weigh. Invasive species.
3. *Increase habitat connectivity.*
   Extensive: Fish presence/absence.
   Intensive: Number of barriers in the area, percentage remaining to be reconnected. Area, volume, mileage. Floodplain, channel, etc. Continuous randomly selected sampling.

	Tide Gate Removal	Dike Breaching	Culvert Upgrades/ Culvert Installation	Dike Removal	Elevation Adjustment
Extensive	**Case by case**	**Yes**	**Yes**	**Yes**	**Possible**
Water Surface Elevation	X	X	X	X	X
Area Inundated	X	X	X	X	X
Landscape Change		X	X	X	X
Water Quality	X	X	X	X	X
Benthic		X	X	X	

Cores					
Fall Out Traps		X	X	X	
Stomach Samples		X	X	X	
Salmonid performance	X	X	X	X	X
Intensive	**Not used**	**Case by case**	**Case by case**	**Case by case**	**Case by case**
Habitat Type & Area		X	X	X	X
Use of habitat types		X	X	X	X
Winter/Summer biomass sampling		X	X	X	X
Flux export		X	X	X	X
Barriers in area		X	X	X	
Continuous random sampling		X	X	X	
Pit tag array		X	X	X	
Invasive species		X	X	X	X

*Roegner et al (2008), Appendix C

The monitoring approach CREST and our partners employ is Before/After/Reference/Impact, the statistical design recommended in Roegner et al (2009). What results is frequently a 'pass/fail' evaluation of project effectiveness, based on quantitative field data. Sample sizes may be random or targeted, depending on site conditions and project objectives/hypothesis.

CREST is not currently equipped to do a long-term power analysis because of small sample sizes and lack of adequate funding, but will seek the support and advice of statisticians in evaluating and managing data. Whenever possible, CREST data can be used by other researchers performing more intense experimental analyses. Additionally, we will interface with other entities planning research in the region, which include PNAMP, PTAGIS, Corps (acoustics studies & pit tagging) & BPA, Committees, Estuary Partnership Science Work Group, Expert Regional Technical Group, BPA Fish and Wildlife program, Monitoring, Evaluation, Research & Reporting by Council, Estuary R,M&E, Estuary, Ocean, Subgroup Federal RME (Corps/BPA). The Cumulative Effects project (Pacific NW National Labs, Army Corps) will provide a framework for periodic regional evaluation of estuary restoration and adaptive management recommendations. CREST is a contributor to Cumulative Effects Annual Reports; we plan to utilize its approach paper (to be published in June, 2010) for statistical design, and will participate in efforts to utilize this system over the long-term. CREST will also continue to participate as a sponsor and contributor at the Columbia River Estuary Conference held every two years to share scientific advancements.

CREST will coordinate on a project level with the following proposals, targeting RPA actions 58-61.

RPA	Funder	Project Name	Relationship to CREST Proposal
58, 59, 61	USACE	A study of salmonid survival and behavior through the Columbia River estuary Using Acoustic Tags	CREST will conduct intensive monitoring in specific locations, supporting and adding to the body of knowledge being collated by this study.
58, 59, 61	BPA	Historic Habitat Food Web Link	CREST will conduct intensive studies in specific locations to quantify macrodetrius exports, adding to the body of knowledge being collated by this study. CREST was a subcontractor on this project for fish monitoring.
58, 59	USACE	Evaluation of life history diversity, habitat connectivity, and survival benefits associated with habitat restoration actions in the lower Columbia river and estuary	CREST's actions will provide additional study material for this evaluation.
58, 59, 60, 61	BPA	Lower Columbia River Estuary Ecosystem Monitoring	CREST is a subcontractor under this contract and will continue to contribute quality data towards this effort.
59, 60, 61	BPA	Columbia River Estuary Habitat Restoration	CREST has obtained several grants through this source and will continue to seek funds in addition to this proposal for projects as necessary.
59, 60, 61	USACE	Evaluating Cumulative Ecosystem Response to Habitat Restoration Projects in the Lower Columbia River and Estuary	CREST has participated in this effort as a subcontractor and will continue to collaborate with this effort.
60	BPA	Grays River Watershed Assessment	CREST partnered with PNNL on this effort. We will continue to support ongoing geomorphic monitoring in addition to focusing efforts on future

			restoration phases.
60	BPA	Eelgrass Enhancement and Restoration	CREST will collaborate with and incorporate findings from this project into future restoration projects.

The 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (2008 BiOp) is a ten-year operations and configuration plan to mitigate for the adverse effects of the hydrosystem on the 13 listed Columbia/Snake salmon and steelhead under the Endangered Species Act (ESA). The 2008 BiOp provides mitigation actions that are required of the FCRPS action agencies to avoid jeopardy and adverse modification of the critical habitat of ESA listed Columbia River fish. Ongoing projects supported and new projects developed are designed to contribute to hydro, habitat, hatchery and predation management activities required under the 2008 FCRPS Biological Opinion. Additionally, the projects assist the Bonneville Power Administration (BPA) in meeting its protection, mitigation, and enhancement objectives and responsibilities in support of the Columbia Basin Fish and Wildlife Program adopted pursuant of the Northwest Power Act.

Project Title: CREST Estuary Habitat Restoration

Table 1. Proposal Metadata:

Project Number	#2010 – 004 – 00
Title	**CREST Estuary Habitat Restoration**
Proposer	Columbia River Estuary Study Taskforce (CREST)
Brief Description	Restoration of T/E Juvenile Salmon Off-Channel Rearing Habitat
Province(s)	Lower Columbia River and Estuary
Subbasin(s)	Columbia Estuary, Elochoman, Grays, Youngs, Lewis & Clark, Columbia Lower, Cowlitz, Sandy, Lewis, Kalama, Washougal, & Willamette
Contact Name	Micah Russell
Contact email	mrussell@columbiaestuary.org
Projected Start Date	6/1/2010

A. Abstract

CREST is a long-standing partner with BPA in implementing habitat restoration projects. Over the past decade, CREST has completed at least 1-2 projects per year and has the experience necessary to increase efforts to help implement a significant share of the 2008 Biological Opinion in the estuary. Our relationships with Lower Columbia River communities and landowners, and our experience identifying and implementing projects, will ensure our success as we build our organization's capacity to achieve 2008 FCRPS BiOp targets, specifically RPA 37. This RPA states:

> RPA Action 37: "Estuary Habitat Implementation 2010-2018 – Achieving Habitat Quality and Survival Improvement Targets. The AAs will provide funding to implement additional specific projects as needed to achieve the total estuary survival benefits identified in the FCRPS BA."

CREST is a bi-state council-of-governments formed in 1974 to develop a management plan for the Columbia River Estuary, facilitate scientific research (*Columbia River Estuary Data Development Program*), encourage compatible uses of shorelines and serve as a spokesman and steward for the region. Since then, CREST has become a leader in habitat restoration, particularly wetland and floodplain restoration for juvenile

salmon. CREST has restored, or is in the process of restoring, 1214 acres and 34 stream miles of habitat, entirely in coordination with public and private landowners. Emphasis on building capacity for restoration activities was recently formalized in the 2010 CREST Strategic Plan. This work has necessitated three distinct but collaborative departments: coastal/estuarine planning, habitat restoration, and ecosystem research and monitoring. CREST also staffs and administers the four watershed councils of the North Coast Watershed Association.

CREST is one of only a few organizations in the Lower Columbia region that has years of experience implementing habitat restoration projects. CREST has previously had two BPA direct-funded projects (Brownsmead #2003– 015– 00 and Grays River #2003- 013- 00), and several BPA projects funded through the Lower Columbia Estuary Partnership. CREST project managers are trained specifically for the challenges of project identification and development, funding acquisition, multi-agency permitting, subcontractor management, construction oversight and ecological monitoring. CREST staff live in the small communities of the estuary and have long-standing relationships with area landowners. This level of communication and trust often leads to valuable project opportunities. As we recognize opportunities on the ground we internally score projects consistently with known BPA ranking criteria and determine project benefit/feasibility prior to submitting proposals to BPA through the selected process. Project selection and prioritization is discussed further in Appendix C.

CREST believes that these restoration activities are crucial to salmon recovery and economic vitality in the region, and achieve a host of other indirect benefits other species of wildlife, food web functionality, floodplain connectivity, and human concerns (e.g. flood and erosion control). Consequently, we pioneered many of the first restoration projects in the region, including dike breaches. Early projects included dike breaches, tidegate retrofits and culvert removal on the tidal portions of the Lewis and Clark River, as well as reconnection of several miles of tidal habitat in the area of Brownsmead on Blind Slough. One of these projects, Fort Clatsop's South Slough, is being monitored over several years as a model site for determining site evolution for future restoration projects in the area.

As cited in the NOAA Estuary Module, successful estuarine and plume residency by juveniles is critical for fast growth and transition to a salt water environment. CREST has been actively seeking and developing wetland restoration projects that will improve conditions for this critical life-stage for all 13 Threatened or Endangered salmonid ESUs in the Columbia River basin. The two projects identified in this proposed project for Year One implementation will result in juvenile salmon survival benefits that BPA can utilize in meeting their mitigation obligations.

Technical and Scientific Background
CREST has developed this proposal with an objective of restoring estuary habitat critical to the recovery of Threatened/Endangered Columbia River and tributary salmon ESUs. Specific habitat types targeted by CREST are shallow water, peripheral habitats that are adjacent or to the Columbia River mainstem. The recovery of these habitats and their vital importance in the long term health of the salmon resource is described in the following sections. Action effectiveness monitoring will be utilized by CREST to adaptively manage future restoration projects. Scientific review and project selection of

habitat restoration actions funded through this proposal will be driven by a process described in Appendix C.

The Columbia River is historically the world's greatest producer of salmon. The lower Columbia River and Estuary are critical to the viability of all anadromous fish populations for the entire Columbia Basin (NMFS, 2000). Juvenile salmonids, especially juvenile Chinook and coho salmon, reside and feed for lengthy periods in shallow, tidal-fluvial channels and wetlands during their transition from the freshwater to marine environments. In the lower Columbia River and Estuary, historic emergent and forested wetland types with their complex network of dendritic tidal channels and backwater sloughs have been greatly diminished. An estimated 62% percent of marshes and 77% of forested wetlands have been lost in the Columbia River estuary (Thomas 1983). To the extent that survival and productivity of juvenile salmonids is related to interconnected shallow water habitats, the loss of these habitats adversely affect juvenile salmonids in the lower Columbia River.

According to Bottom et al, the most significant changes to the capacity of the Columbia River Estuary to support juvenile salmon are likely the results of habitat loss and recovery of those salmon life histories that depend on shallow-water rearing habitat will require restoration of peripheral estuarine wetlands (Bottom et. al., 2005). Alterations to the historic floodplain and its complex network of shallow waters have created significant limiting factors, presenting substantial restoration opportunities. Recent research describes that even small survival improvements in the estuary and coastal ocean could yield some of the most significant population increases for spring and summer Chinook salmon (Kareiva et al. 2000).

The Lower Columbia River Estuary Partnership (Estuary Partnership) has for several years developed strategies, partnerships, and prioritization plans which have provided a much needed framework for future implementation actions. CREST's efforts have complimented the Estuary Partnership's coordination and planning actions by implementing on-the-ground salmon restoration projects, utilizing our community connections and reputation, staff expertise resulting in high quality habitat restoration projects.

Many of the shallow, peripheral wetlands in this subbasin have been destroyed or impaired by land use activities such as diking, filling, tide gate installation, and shoreline armoring, isolating the lower Columbia River from its extensive historic floodplain. It is estimated that an area of over 80,000 acres of historic floodplain and wetlands are now positioned behind an extensive system of dikes and tide gates, and that urbanization and its associated filling and shoreline armoring account for an additional 20,000 acres of habitat loss (US ACOE, 2003). Extensive loss of historic estuarine wetlands through widespread diking and filling in Northwest estuaries may reduce or eliminate some subyearling migrant life histories that have been linked to the availability of shallow marsh habitats (e.g., Levy and Northcote 1981 and 1982). Historically, juvenile salmon developed strategies to enter the estuary at different times, at different sizes, using unique habitats. As stated in the NOAA Estuary Module, the implication of habitat loss is that the area's habitats must be available through time and space and at sufficient quantities to support more than 150 distinct salmon and steelhead populations.

Jay and Kukulka suggest that the annual Columbia River flow cycle has been dampened and spring-freshet flow to its estuary has been reduced by >40% due to flow regulation by more than 30 major dams, water withdrawal for agriculture, and climate change. During the freshet-season, dikes and flow-alteration together reduce average shallow water habitat in the study-reach (rkm-50 to rkm-90) by 62%. They hypothesize that taken individually, diking has reduced average freshet-season shallow water habitat by 52% and flow-cycle alteration by 29%. These results suggest that dike removal provides a substantial increase in these critical habitats even without flow restoration, greater than for restoration of flow without removal of dikes (Jay and Kukulka, 2003).

While restoration of an entire ecosystem is not generally practical, individual habitat restoration projects have the greatest likelihood of success when they are implemented with an ecosystem perspective, i.e., they are ecosystem-based. Individual restoration projects completed by CREST with ecosystem-wide focus included several dike breaches in the Lewis and Clark River, land acquisitions and dike breaching on the Grays River and Deep Rivers, and other projects which group individual projects into larger, more complex habitat benefits over time.

CREST proposes to target the following primary limiting factors from the Lower Columbia Salmon Recovery 6-year Habitat Work Schedule and Lead Entity Habitat Strategy – Estuary Mainstem River Subbasin which contribute towards the restoration critical habitats:

1. Availability of preferred habitat (juvenile rearing for within and out-of-basin subbasin populations pg A-3)
2. Microdetritus-based food web, increase inputs of macrodetritus to increase productivity in estuary food web, such as was supported by the historic food web (juvenile rearing for within and out-of-basin subbasin populations pg A-4)
3. Loss of habitat connectivity (juvenile rearing for within and out-of-basin subbasin populations pg A-4)

These can also be defined in terms of NOAA Estuary Module identified limiting factors: Reduced In-Channel Habitat Opportunity, Food Web (reduced macrodetrial inputs, increased microdetrital inputs), and Reduced Off-Channel Habitat Opportunity.

The focus of the proposed work will be restoring shallow water in-channel and off-channel rearing habitats and increasing macrodetrius inputs intot he mainstem Columbia River for Threatened/Endangered salmonid populations including the following Lower Columbia basin stocks: Lower Columbia River Fall Chinook, Chum, and Coho as well as Lower Columbia River Spring Chinook, Winter Steelhead, Summer Steelhead, and other out-of-basin stocks utilizing the Columbia River Estuary. This work will also benefit the following out-of-basin Threatened and Endangered including: Snake River Spring/Summer Chinook, Snake River Fall Chinook Salmon, Snake River Sockeye Salmon, Snake River Steelhead, Upper Willamette River Chinook, Upper Willamette River Steelhead, Middle Columbia River Steelhead, Lower Columbia River Steelhead, Lower Columbia River Coho, Lower Columbia River Chinook, Lower Columbia River Chum Salmon, Upper Columbia River Steelhead, and Upper Columbia River Spring Chinook.

CREST's work will primarily focus on the lower 46 miles of the Columbia River and estuary. However, we also propose to work with partners to develop and implement projects to Bonneville Dam and include tidally influenced areas of the tributaries to the Columbia River in both Oregon and Washington. Because of the diversity of project size, location, and type, CREST is proposing to conduct monitoring and evaluation activities in accordance with standard protocols, primarily referencing Monitoring Protocols for Salmon Habitat Restoration Projects in the Lower Columbia River and Estuary, Roegner et al 2009. More detail is provided in *Objectives*.

This proposal is directly proposing to construct two projects in 2010, with an additional three projects in development presently which are a similar or larger scale, scope, and type of project to the Fort Columbia Tidal Reconnection Project and Otter Point Restoration Project. CREST has worked with BPA to identify the upcoming projects, which will be subject to review as detailed below in Objectives, Task 1.

Rationale and significance to regional programs
Several management and prioritization programs have been developed in recent years to assist in managing and directing restoration initiatives in the lower Columbia River and Estuary. Implementation of this proposal will be a step towards significant restoration in the most critical habitats in the lower Columbia River and Estuary.

CREST is proposing two projects to be constructed in the first year of the proposed BPA project, followed by similar or larger scale, scope, and type of projects through 2018. CREST is working with BPA to estimate the number and type of projects to be implemented during that time period and the anticipated survival benefit units.

Throughout this time period CREST will continue to participate in regional efforts to coordinate estuary restoration efforts, collaborating extensively with the following regional programs: Lower Columbia River Estuary Partnership, Lower Columbia Fish Recovery Board, Lower Columbia Solutions Group, Columbia Land Trust, Oregon Watershed Enhancement Board, and the State of Washington/Action Agency Memorandum of Agreement. Examples of on-going collaboration include CREST participation on the Estuary Partnership's Science Workgroup, Estuary Partnership project development coordination meetings, and the Lower Columbia Solutions Group and its sub-committees. CREST is also managing the LCSG Regional Upland Disposal project. The CREST Director has been working from Portland 2-3 days per week to attend these meetings and strengthen collaborative relationships with partner agencies. CREST staff frequently travel to Portland as well to give project funding presentations, share monitoring data and findings, meet with project permitting authorities, etc.

The Fort Columbia Tidal Reconnection Project and Otter Point Restoration Projects focus on restoring connectivity to historical tidal wetland habitat in the Columbia River Estuary. The NOAA Estuary Module identifies reduced sequences and patterns of habitat availability, which limits the diversity of already simplified salmonid life history patterns. An estimated 62% percent of marshes and 77% of forested wetlands have been lost in the Columbia River estuary (Thomas 1983). Loss of tidal swamps and other forested or vegetated wetlands represents a loss of habitat that ocean-type salmonids use during their estuarine residence. CREST's focus has been and will continue to be restoring these critical habitats. Off-channel habitat availability is also a factor contributing to density-dependant mortality. The module further states that it is possible too many fish are competing for limited habitat and associated resources in the estuary at key times, and that the resulting stressors translate into reduced salmonid survival.

Although they contain different focuses, most plans describing the Lower Columbia River and estuary come to similar conclusions on limiting factors. The Lower Columbia Fish Recovery Board document *Estuary Mainstem Subbasin Plan* describes a substantial loss in historical wetlands and tidal marshes. The Lower Columbia River Estuary Partnership's *Lower Columbia Estuary Comprehensive Conservation and Management Plan*, Chapter 5, identifies as Action 2 "protect, conserve, and enhance identified habitats, particularly wetlands, on the mainstem of the lower Columbia River." The Northwest Power and Conservation Council *Columbia River Basin Fish and Wildlife Program* targets two strategies: reconnecting ecosystem functions and encouragement of continued partnerships.

In addition to continued participation in regional programs, and implementation of projects within the framework of existing plans, all future CREST projects funded by BPA will continue to be reviewed through the Estuary Partnership Science Workgroup for technical merit and BPA Expert Regional Technical Group for assignment of survival benefits. The Science Workgroup may recommend a project based on its overall ecological benefit and the ERTG will subsequently assign the proposed project a salmon survival benefit unit. This information will be evaluated by BPA staff in deciding whether or not to fund the project.

The Northwest Power and Conservation Council adopted subbasin plans into the Columbia River Basin Fish & Wildlife Program in 2005. Later, in February 2009 the Council completed a two-year process to amend its Columbia River Basin Fish & Wildlife Program. Specific implementation of habitat actions in the estuary, and monitoring and evaluation of these actions, will occur through the adopted Columbia River Estuary and Lower Columbia subbasin plans. The recently completed *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* will be used to guide actions in the estuary and lower Columbia River. CREST has been one of the primary implementers of estuary strategies identified in the Council's Program: 'Habitat restoration work to reconnect ecosystem functions such as removal or lowering of dikes and levees that block access to habitat or installation of fish-friendly tide gates, protection or restoration of riparian areas and off-channel habitat, and removal of pile dikes.

As described by the Lower Columbia River and Columbia River Estuary Subbasin Plan, the limiting factors targeted by CREST are described as:

(1) Limiting Factor 1, availability of preferred habitat. Supported by hypothesis E.H1, E.H2, E.H3, E.H4, E.H6, E.H7, E.H8, E.H9, E.H11, and E.H12
(2) Limiting Factor 2, macrodetrius-based food webs. Supported by hypothesis E.H1, E.H2, E.H3, E.H4, E.H6, E.H8, E.H9, E.H11, and E.H12
(3) Limiting Factor 3, loss of habitat connectivity. Supported by hypothesis E.H1, E.H2, E.H3, E.H4, E.H6, E.H7, E.H8, E.H9, E.H11, and E.H12

In 2007-08, BPA and other agencies of the federal government committed to a number of decisions, documents, and agreements to fund an extensive set of actions over the next ten years to benefit listed and unlisted anadromous and resident fish across the Columbia River Basin. These include estuary habitat improvement actions committed to by the agencies as part of the consultation resulting in the 2008 Biological Opinion for the Federal Columbia River Power System and RPA 37. CREST will be one of the primary organizations to utilize these funds for implementation of on-the-ground restoration projects.

In detail, the following planning and strategy documents and their relationship to CREST's estuary restoration and project goals:

NOAA Fisheries/Action Agencies' ESA Consultation on Federal Columbia River Power System Operations (NMFS, 2008)
The Action Agencies Estuary Habitat Proposed Action (draft) states that a "key step in conserving and rebuilding Endangered Species Act (ESA)-listed salmon and steelhead is determining the potential benefits that could occur from actions implemented to conserve and improve estuary habitats." Estuary habitat improvements are expected (citing several literature sources) to improve juvenile and adult survival. Estuary habitat improvements (page 5 of the Estuary Habitat Proposed Action) will provide an increase in juvenile salmonid shallow water habitat that would benefit all listed ESUs, with the greatest habitat benefit to those ESUs expressing ocean type life histories.

CREST's projects that specifically target BiOp actions include the Gorley Springs Grays River Restoration Project (completed), Fort Columbia Tidal Reconnection Project and Otter Point Restoration Project.

CREST is proposing the following project types: Enhancement, Restoration, and Creation (of shallow water and off-channel rearing habitats). For Ocean Type and Stream Type life histories, CREST will primarily be targeting the habitat limiting factor, with additional attention to physical characteristics such as temperature and sediment limiting factors. These factors are listed on pages 11 and 12.

NOAA Fisheries/Action Agencies' ESA Consultation on Federal Columbia River
This project will result in a continued coordinated and systematic habitat restoration program with a sound scientific basis to select, implement, and evaluate specific projects. CREST's proposed restoration program will work with the Estuary Partnership's well-developed Science Work Group to ensure estuary goals are being met.

Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan (Lower Columbia Fish Recovery Board, 2004)
The Columbia River Estuary is particularly important for anadromous salmonids, which use it for critical life stages. The estuary serves as a vital transition zone during the physiological acclimation from freshwater to saltwater, it provides juvenile salmonids an opportunity to achieve the critical growth needed to survive in the ocean, and estuarine habitats serve as a productive feeding area, free of marine predators.

CREST staff will evaluate each project in accordance with these criteria as an initial screening activity for sound restoration projects. Through the project identification process, CREST will provide quality projects to the Estuary Partnership Science Work Group to be reviewed for compliance with their Project Selection Criteria, as well as survival benefit analysis associated with RPA 37.

Columbia River Basin Fish and Wildlife Program (NWPPC, 2009)
The Draft Columbia River Basin Fish and Wildlife Program summarizes five key estuary strategies which have been suggested to potentially substantially improve survival benefits. This proposal is designed target the strategies identified in Section V.A, page 32, of the program.

- Habitat restoration work to reconnect ecosystem functions such as removal or lowering of dikes and levees that block access to habitat or installation of fish-friendly tide gates, protection or restoration of riparian areas and off-channel habitat, and removal of pile dikes
- Long-term effectiveness monitoring for various types of habitat restoration projects in the estuary
- Continued evaluation of salmon and steelhead migration and survival rates in the lower Columbia River, the estuary, and the marine environment
- Evaluation of the impact of flow regulation, dredging, and water quality on estuary-area habitat to better understand the relationship between estuary ecology and nearshore plume characteristics and salmon and steelhead productivity, abundance, and diversity
- Recognition and encouragement of continued partnerships in planning, monitoring, evaluating, and implementing activities in the estuary and lower Columbia River

CREST's methods, outlined in Objectives, demonstrate its commitment to critical habitat restoration work, effectiveness monitoring, and partnerships.

Relationships to other projects
CREST is proposing an objective of restoring estuary habitat critical to the recovery of Threatened/Endangered Columbia River and tributary salmon Evolutionarily Significant Units. CREST projects, to which Bonneville Power Administration has contributed, demonstrate work which has been accomplished and additionally the breadth of work necessary to substantively improve habitat. Several dike breach and habitat reconnection projects have been completed will be completed restore 1214 acres and 34 miles of key rearing habitat.

Listed below is a representation of the major habitat restoration implementation accomplished by CREST and its partners in restoring historic functions, with a goal of restoring salmon habitat and reducing limiting factors' influence on salmon production:

CREST Projects With Direct BPA Funding
Blind Slough Restoration Project Brownsmead, Oregon (Project # 2003– 015– 00)
This project restored tidal connection between the Columbia River Estuary and 7 miles of Blind Slough in the community of Brownsmead, Oregon, coordinated with Clatsop County and several private landowners. CREST was the direct grant recipient from Bonneville Power Administration. A portion of the funds supported effectiveness monitoring of water quality, fish use, and elevation monitoring. Results have informed management of restoration work in ongoing tidal reconnection projects in the Columbia River Estuary. Other partners included Clatsop Diking Improvement Company No. 7, Portland District Army Corps of Engineers, Nicolai-Wickiup Watershed Council, and multiple landowners. The project was completed in 2005.

Gorley Springs Restoration Project (Project #2003- 013- 00)
CREST partnered with the Gorley family, Wahkiakum County, and PNNL to propose a habitat-forming process project in the critical Gorley reach of the Grays River. This reach, and adjacent Crazy Johnson Creek (purchased by Columbia Land Trust in 2009), is one of three remaining natural Lower Columbia River Chum spawning locations. CREST installed a series of five engineered log jams, with one non-engineered jam, to increase structural complexity and reduce velocity within an area of approximately 15 acres. The work will facilitate habitat forming processes critical for spawning and egg incubation success. Other partners included Wahkiakum Community Foundation, Columbia Land Trust, Hancock Timber Resource Group, Lower Columbia Fish Recovery Board, Wahkiakum Conservation District, and Rayonier Western Forest Resources. The project was completed in 2009.

BPA Sponsored Partner Projects
LCREP Columbia River and Estuary Habitat Restoration (Project #2003 – 11 – 00)
This project is a multiple year contract that identifies, prioritizes, and monitoring habitat restoration projects in the lower 146 miles of the Columbia River and estuary. The Estuary Partnership uses a prioritized granting process in conjunction with a Science Workgroup to select projects for funding to subcontractors (see Section F, Task 1, below). CREST projects completed through this award include:

South Slough Restoration Project Lewis & Clark, Oregon
In coordination with the National Parks Service, CREST managed the reconnection of 45 acres of tidal wetlands with the lower Lewis and Clark River, a direct tributary into the Young Bay embayment and Lower Columbia Estuary. The project was funded in part by Bonneville Power Administration funding through the Lower Columbia River Estuary Partnership. Other projects completed on the Lewis and Clark River: the City of Seaside Dike Breaches Phases I and II and Vera Slough tide gate retrofit. Other partners included The Conservation Fund, The Nature Conservancy, Destination: The Pacific, LCREP/NOAA, and David Evans & Assoc. The project was completed in 2007.

Wahkiakum CD Skamokawa Creek Dead Slough, Washington
CREST partnered with the Wahkiakum Conservation District with funding from BPA to investigate water quality and options to open 2 miles of historic channel rearing habitat immediately adjacent to Skamokawa Creek and the mainstem Columbia River.

City of Seaside Dike Breach, Lewis and Clark, Oregon
CREST sponsored a two-stage dike breaching project. The City of Seaside Dike Breach was completed in 2005-06 with funding from the Estuary Partnership and BPA. The goal of the project was to restore connectivity to 25 acres of tidal wetland habitat adjacent to the mainstem Lewis and Clark River.

Perkins Lane Culvert Replacement Warrenton, Oregon
CREST, the North Coast Watershed Council, and the Skipanon Watershed Council collaborated to construct a passable culvert and remove invasive species in critical rearing habitat in the Skipanon watershed, a tributary to the Lower Columbia Estuary. Funding was provided by the Estuary Partnership and BPA.

USFWS Preserve and Restore Columbia River Estuary (Project #2003 – 008 – 00)

The project goals included acquiring or restoring 600 acres of tidal emergent marsh, swamp, slough, and riparian forest habitat in the Columbia Estuary to benefit salmon, Columbia white-tailed deer, and other wildlife. Elements included acquisition, fish and vegetation surveys, invasive weed removals, and restoration of tidal marsh. The project was accomplished with BPA, Corps, WDFW, and USFWS funding. This project demonstrates a large partnership working towards mainstem tidal wetland protection and restoration of critical habitats. CREST works closely with these partners in identification and implementation of estuary projects.

WDFW Washington Estuary Accord Plan (Project #2009 – 016 – 00)
The project goal is to plan and develop estuary habitat restoration projects listed in the Washington State Estuary MOA. Six projects have been identified in the preliminary stages of the project with a total of 974 acres to be restored if all projects are completed as proposed. Projects primarily consist of reconnection of historic habitats with active restoration occurring at some sites. Partners include LCFRB and Action Agencies. CREST is working with WDFW to identify and move projects towards implementation.

WDFW BiOp Chum Restoration (Project #2008 – 710 – 00)
The project goals are to assess priority chum salmon habitats, update population abundance, and develop enhancement programs to rebuild LCR chum populations. The Grays River and the Crazy Johnson and Gorley Springs area represent key natural spawning locations and conservation and trapping at the site represent features identified in the program. CREST is collaborating with WDFW scientists to identify historic chum habitat and improve existing habitat.

NOAA Historic Habitat and Food-Web Linkages (Project #2003 – 10 – 00)
The project was developed to reconstruct historic changes in rearing opportunities and food web linkages of salmon in the Columbia River estuary, evaluating the implications of these findings to river flows and restoration of estuarine habitats. This study provides a look into the value of quality and quantity of restored historic habitats, indicating what actions are most effective in improving survival for T/E species. CREST performed juvenile salmon data collection as a subcontractor for this project.

PNNL Eelgrass Enhancement and Restoration (Project #2007 – 513 – 00)
The project evaluated the potential to expand eelgrass habitat in the lower Columbia River estuary. Eelgrass restoration is proposed to enhance feeding, refuge, and rearing habitat for a number of fisheries, including juvenile Pacific salmon. Locating and testing suitable sites for eelgrass enhancement is proposed with experimental plantings in 100 m2 plots. Linked with off-channel habitat restoration, this project provides increased habitat variability for life histories and stages of juvenile salmonids. CREST will be working with PNNL scientists to determine the project's applicability for coordination with this proposal.

Table 1. Relationship to existing projects

Funding Source	**Project #**	**Project Title**	**Relationship (brief)**
BPA	**2003– 015– 00**	**Blind Slough**	Project type representative of Lower Columbia and Estuary habitat availability projects
BPA	**2003 - 013- 00**	**Gorley Springs**	Project type representative of Lower Columbia tributary habitat availability/restoration projects

Funding Source	Project #	Project Title	Relationship (brief)
BPA	**2003– 008 – 00**	**Preserve and Restore Columbia**	Project type representative of Lower Columbia tributary habitat availability/restoration projects
BPA	**2009– 016 – 00**	**Washington Estuary Accord Plan**	Project type representative of Lower Columbia tributary habitat availability/restoration projects
BPA	**2008– 710 – 00**	**BiOp Chum Restoration**	Project type representative of direct salmon population data collection and enhancement.
BPA	**2003– 011 – 00**	**Columbia River and Estuary Habitat**	Project type representative of Lower Columbia tributary habitat availability/restoration projects
BPA	**2003 – 010 – 00**	**Historic Habitat and Food-Web Linkages**	Project type representative of historic condition modeling and hypothesis testing.
BPA	**2007 – 513 - 00**	**Eelgrass Enhancement**	Project type representative of Lower Columbia in-stream habitat availability restoration.

Project History

CREST's role in the estuary has been and will continue to include regional planning and restoration on a broad scale in the coming 10 years and beyond. Initial funding became available in early 2010 through BPA/LCREP to identify and develop new projects. This additional capacity has already yielded results and has generated new project ideas and opportunities. We anticipate finding and developing numerous and significant new restoration opportunities over the next several years.

CREST's purpose is outlined in its founding Charter, which states that "CREST as a regional estuarine management organization, is to provide local jurisdictions and other groups, agencies, and individuals with assistance in estuarine management, planning and plan implementation". In March 2010, CREST updated this vision with a 3-year Strategic Plan. Goal 2 of the plan calls for securing longer-term funding to sustain staff positions, support restoration project implementation, and add project management capacity. BPA is specifically identified as the principle funder able to provide this direct relationship.

CREST's accomplishments to date, towards the Estuary Partnership's identified Estuary recovery goal of 16,000 acres, is 1214 acres of tidal wetland and riparian habitat and 34 miles of instream habitat.

Table 2: CREST Restoration Activities 2002 - 2012

Project Name	Action	Watershed	Acreage	Miles
Larson Slough	Tidegate Retrofit	L & C	9.0	
Johnson Slough	Tidegate Retrofit	L & C	10.0	
Green Slough	Tidegate Retrofit	L & C	19.0	
Barrett Slough	Tidegate Retrofit	L & C	18.0	
Vera Slough	Tidegate Retrofit	Columbia Estuary	22.0	
L & C Phase	Dike Breach	L & C	25.0	

I				
Blind Slough	Tidegate Retrofit	Columbia Estuary		7.0
L & C Phase II	Dike Removal	L & C		0.2
South Slough	Dike Breach	L & C	45.0	
Skipanon	Floodplain Reconnection	Skipanon	2.0	
Perkins Ln	Fish Passage	Skipanon		4.0
N.F. Klaskanine	Riparian Plantings	Klaskanine	12.0	
Gorley Springs	Habitat Complexity	Grays River	48.0	1.0
Big Creek	Fish Passage	Big Creek		11.0
CEEEP	Environmental Education			
Chinook Diversion	Diversion Retrofit	Chinook		1.5
Fort Columbia	Fish Passage	Columbia Estuary	96.0	
Otter Point	Dike Breach	L & C	33.5	
Meglar Creek	*Fish Passage*	*Columbia Estuary*		*2.2*
Hungry Harbor	*Fish Passage*	*Columbia Estuary*	*854.0*	*6.0*
Gudmundsen	*Habitat Complexity*	*Grays River*		*0.8*
Sorenson	*Habitat Complexity*	*Grays River*		*0.4*
Gnat Creek	*Dike Breach*	*Columbia Estuary*	*20.5*	
Totals			1214.0	34.0

Upcoming projects italicized.

CREST's future work through the proposed BPA project will focus heavily on meeting recovery goals as stated in the NOAA Estuary Module, as well as the NOAA Fisheries 2008 Biological Opinion. CREST intends to stabilize staffing and increase overall organizational capacity to do this work. In general, projects being targeted are tidal, close in proximity to the mainstem Columbia River, and either large in size or smaller but strategically located to fill a habitat gap.

Biological Objectives, Methods, and Tasks

As identified in the Technical and Scientific Background section, the Lower Columbia Salmon Recovery 6-year Habitat Work Schedule and Lead Entity Habitat Strategy – Estuary Mainstem River Subbasin lists the following factors as limiting factors for juvenile salmon:

1. Availability of preferred habitat (juvenile rearing for within and out-of-basin subbasin populations)

2. Microdetritus-based food web, increase inputs of macrodetritus to increase productivity in estuary food web, such as was supported by the historic food web (juvenile rearing for within and out-of-basin subbasin populations)
3. Loss of habitat connectivity (juvenile rearing for within and out-of-basin subbasin populations)

CREST's objective is to restore estuary habitat critical to the recovery of Threatened/Endangered Columbia River and tributary salmon Evolutionarily Significant Units. We have identified four key tasks to accomplish this objective.

Specific biological objectives, tied to NOAA Estuary Module guidance, are as follows:
1. Increase in-channel habitat opportunities
2. Increase macrodetrial inputs off-channel habitat opportunities
3. Increase off-channel habitat opportunities
4. Restore connectivity between river and floodplain

Methodology
Task 1: Identify and prioritize mainstem and tidal tributary projects in a scientific and systematic manner which will directly benefit ocean- and stream- type salmonids

Associated WE: 99, 114, 119, 185, 132 (described in detail below)

To identify and develop projects, CREST strategically analyzes the estuary at both community and landscape levels. We evaluate project opportunities in a formulaic approach that is consistent with BPA ranking systems, as illustrated in Appendix C.

CREST is sometimes contact by a landowner interested in restoration, often prompted by problems he/she has experienced due to disruption of ecosystem processes, resulting in flooding, erosion, or other impacts to private property. Frequently, a restoration project can be designed to benefit both juvenile salmon and the landowner's interests. More recently, CREST has had limited BPA/LCREP funding to strategically conduct targeted project investigation and development. CREST reviews aerials and LIDAR, conducts site visits, collaborates with other organizations, contacts landowners to assess willingness and creates a list of potential projects. CREST initially evaluates projects for suitability based on known project selection criteria (e.g. Estuary Partnership Science Workgroup). This, along with knowledge of funding priorities (e.g. proximity to mainstem Columbia River) and local knowledge of community support and technical challenges help determine whether a project is worth developing further for the purposes of BPA funding. Top ranked projects are further assessed to determine feasibility and quantify benefits, resulting in a 5-7 page memorandum to be used as background information for presentations and funding applications. At all times, CREST applies scientific criteria from key studies and reports during the project development stage, directly incorporating scientific data during the preliminary review stage to determine project's probable benefits to salmon.

In order to ensure project selection and development yields the highest ecological value and benefit to juvenile salmon, CREST works with several new restoration tools that have become available recently to identify projects strategically. These include the Estuary Partnership's Restoration Prioritization Framework and the University of Washington and US Geological Survey's Columbia River Estuary Ecosystem

Classification (CREEC). The Restoration Prioritization Framework uses a disturbance model to identify the optimal locations for restoration and protection projects. Using available GIS layers, the Restoration Prioritization Framework provides an analysis of landscape-scale disturbances to predict the degree to which physical processes will support a specific project within a particular management unit of the estuary. The Estuary Partnership is working with PNNL to refine the model and increase its accuracy.

In 2009, BPA funded an effort to identify priority restoration projects using landscape ecological principles and CREEC as a platform for describing desired future habitat conditions by reach in the estuary. This five-year project uses statistical tools to analyze CREEC landscape classes (historical/present) to help derive metrics for describing optimal juvenile salmonid habitats for each of the eight estuary reaches. The project is supported technically by an expert panel with products vetted through estuary restoration practitioners. CREST participated in the expert panel work session in October, 2009 and will help shape the use of CREEC products as they emerge over the next three years.

CREST also uses a variety of tools to help prioritize potential restoration projects. This includes t-sheets, digital photos and GIS data layers with information on diking extent, tidegate locations, culvert barriers, pile dikes, and dredge material disposal sites. Additionally CREST will incorporate other regional actions, such as the Culvert and Tidegate Inventory completed by Cowlitz Conservation District and the NOAA and Oregon DLCD inventory of tidegates and levees due in 2011.

CREST has a strategy in place to utilize selection criteria, regional prioritization tools, LIDAR and GIS layers, and information on community support and project complexity to determine the value of potential projects. What results is a transparent determination of project ranking relative to restoration goals. Following this rigorous internal process, CREST submits our projects for review by the Science Work Group and the Expert Regional Technical Panel.

The Estuary Partnership established the Science Work Group, which brought together scientists and technical experts from a numerous fields to provide oversight and advice to the Estuary Partnership, and their partners such as CREST, regarding habitat restoration and monitoring in the lower river and estuary. CREST will utilize the Estuary Partnership's Science Work Group for the first level of scientific review for on-the-ground habitat projects funded through this proposal.

The Estuary Partnership's Science Work Group reviews and ranks the habitat projects, identified by CREST, by utilizing the Estuary Partnership's "Criteria for Identifying and Prioritizing Habitat Protection and Restoration Projects on the Lower Columbia River and Estuary." (Appendix A) The Estuary Partnership's criteria have been reviewed by the Council and the ISRP and include ecosystem, implementation, and monitoring criteria. After the Science Work Group reviews and ranks the CREST habitat projects the Estuary Partnership will provide a written recommendation to BPA.

The second science review is completed by the Expert Regional Technical Group (ERTG), authorized under the 2008 BiOp (RPA 37). The ERTG considers the Science Work Group's recommendation and use the approach originally applied in the 2008 BiOp, as well as all subsequent information on the relationship between actions, habitat and salmon productivity models developed through the FCRPS RM&E. This will produce an estimate for the change in overall estuary habitat and resultant change in ESU survival for all estuary habitat restoration projects they review.

The survival benefit assigned by ERTG will support and inform BPA's project selection decision. Habitat projects will be selected based on meeting BPA's survival benefit targets as required under the 2008 BiOp.

Task 2. Develop construction designs which follow Best Available Science and provide most benefit to species while cost-effective and constructible.

Associated WE: 99, 119, 175, 185, 132 (described in detail below)

CREST conducts all levels of project management, from initial development through to final monitoring. CREST meets with landowners, develops agreements, seeks funding, develops contracts, oversees contracting and engineer selection, oversee engineer performance and product delivery for contract compliance, technical committee set up, meetings, and coordination, permit preparation and oversight, materials purchase, contractor contracting and selection, construction oversight, permit compliance, and post-construction wrap up and reporting.

The Fort Columbia and Otter Point projects, proposed as part of this project, are in the final stages of design in the CREST process. Fort Columbia is scheduled for construction in fall, 2010; Otter Point is scheduled for construction in two phases, summer 2010 and 2011. Brief details follow, and the designs and design memorandums for the projects are included as Appendixes D and E.

The Fort Columbia Tidal Reconnection Project will replace an undersized, impassable culvert under US Highway 101, restoring tidal connectivity between the Columbia River and 96 acres of high quality wetland. An estimated twelve of these acres will convert to brackish tidal wetlands, tidal channels will form within the site, and the remainder of the wetland will provide critical off-channel rearing habitat and macrodetrius inputs into the mainstem Columbia River. The site is located immediately opposite of the Columbia River mouth, at approximately RM 6. CREST has managed the project, obtained approval from Washington Department of Fish and Wildlife, Washington Department of Transportation, an easement through Washington State Parks, and is receiving both funding and an easement through Washington State Department of Natural Resources. The project has also been funded through the Washington State Salmon Recovery Funding Board ($740k) and Lower Columbia River Estuary Partnership ($140k). Because of the need to ensure that implementation will guarantee ecological benefits and no flooding threat to the nearby community, a third party engineering review was conducted in Fall 2009 at the request of BPA. This resulted in some additional data collection and minor modifications to the designs.

The Otter Point Restoration Project breaches an unnecessary dike in several strategic locations, reconnecting the Lewis and Clark River, at RM 1, to 33.5 acres of historical wetland and tidal channel habitat. An estimated 21 acres will be enhanced by restoration, with 12 acres converting directly to brackish tidal wetland. Two tidal channel networks will form within the site, and the remainder of the wetland will provide critical off-channel rearing habitat and macrodetrius inputs into the mainstem Columbia River at Youngs Bay. The Lewis and Clark River feeds into the Columbia River estuary at RM 6. CREST has managed the project on behalf of the landowner (National Park Service), obtained approvals from the appropriate state and federal agencies, and is leveraging BPA funds against several other sources, including: National Park Service, NOAA, and the US Fish and Wildlife Service.

Task 3. Implement restoration projects, substantively improving available fish habitat in the lower Columbia River and Estuary.

Associated WE: 99, 119, 100, 29, 30, 33, 47, 180, 181, 184, 165, 132, 185 (described in detail below)

With funds provided through this proposal, CREST will implement restoration projects each year in the Lower Columbia and Estuary. Projects will include combinations of the following specific activities as increasing in-stream complexity (enhance channel complexity), connecting channels (improved off-channel habitat and roughness), decommissioning roads (decrease sediment inputs), planting vegetation (increased floodplain connectivity and roughness), enhancing floodplains (riparian vegetation and overflow channel development), restoring wetlands (hydraulic connectivity and accessibility) and replacing impassable culverts with passable structures (access to habitat and improved macrodetritus transport). Limiting factors and prioritization of restoration habitat types are described in Section C. Project funds will be matched with non-BPA funds depending on the overall cost of the project and availability of funds within the annual contract. Past cost-share partners include NOAA, USFWS, WDFW, WDNR, OWEB, ODFW, ODEQ, SRFB, and the Estuary Partnership. Lower Columbia and estuary projects will be implemented systematically from bidding through site restoration.

Specific features CREST is targeting through implementation of the Fort Columbia Tidal Reconnection Site are: improving ecosystem connectivity (restoring passage and tidal connectivity between historic habitats and the mainstem Columbia River), improving habitat connectivity (96 acres of wetland habitat reconnected to tidal, estuary mainstem), replacing an off-channel stream habitat blockage (0% adult passable 24" concrete culvert), gain of historical off-channel habitats (wetland habitat reconnected to tidal, estuary mainstem), improved nutrient exchange (improved nutrient cycling through unrestricted connection to tidal, estuary mainstem), increased availability of preferred habitat (wetland habitat reconnected to tidal, estuary mainstem), and increased macrodetrius inputs (high quality vegetation inputs combined with unrestricted connection to tidal, estuary mainstem).

Limiting factors at Otter Point are addressed by improving ecosystem connectivity (restoring passage and tidal connectivity between historic habitats and a major tributary to the mainstem Columbia River), improving habitat connectivity (33 acres of wetland habitat reconnected to tidal, tributary estuary mainstem), gain of historic off-channel habitats (wetland habitat reconnected to tidal, tributary estuary mainstem), improved nutrient exchange (improved nutrient cycling through unrestricted connection to tidal, tributary estuary mainstem), increased availability of preferred habitat (wetland habitat reconnected to tidal, tributary estuary mainstem), and increased macrodetrius inputs (high quality vegetation inputs combined with unrestricted connection to tidal, tributary estuary mainstem).

CREST is tasked with implementing projects that address the limiting factors identified in the sub-basin plans and other guidance documents. Although we have a robust monitoring program (see Task 4 below) that can quantify the effectiveness of project actions, CREST suggests coordinating, rather than leading, monitoring efforts with entities such as ERTG, NW Science Center, and others as detailed below. Combined, these efforts work to demonstrate a link between the habitat characteristics, established action plans, and salmon survival. Ecosystem research is being performed by a number of other entities, and CREST relies on the ERTG to evaluate projects for salmon survival benefits.

Task 4: Monitor and evaluate project effectiveness, quantify benefits and identify areas for improvement.

Associated WE: 119, 157, 162, 159, 185, 132 (described in detail below)

CREST has adopted a two-tiered approach to monitoring: extensive versus intensive. This approach is described in detail in the Monitoring and Evaluation section, below. In brief, most sites will receive extensive monitoring in basic metrics such as landscape, water quality, and fish presence/absence. Intensive monitoring, such as macrodetrius quantification, will be applied to specific project types as identified in Table 3.

Work Elements associated with Tasks 1 – 4

WE 99 –Outreach and Education
CREST follows a broad community outreach and education plan which identifies specific community values and needs and targets the communities with appropriate restoration related information. When working with a specific project, CREST establishes a list of local stakeholders, develops newsletters, lectures, and other materials to provide the community with project information and appropriate educational resources. These efforts have been successful in a number of projects, resulting in higher community involvement and engagement.

WE 114: Identify and Select Projects
Projects are identified either through landowner contact or a strategized process (Appendix C). Projects passing a preliminary, informal review are formally reviewed with a report and budget developed to assess cost/benefit. Projects are proposed to appropriate funders if CREST evaluates the project to have sufficient scientific and biological value.

WE 119 – Manage and Administer Projects
CREST staff provide the full range of management and administration for projects sponsored by CREST. CREST project managers handle all aspects of projects including development, grant writing, selecting design engineer, coordinating engineers efforts, permitting, purchasing materials, outreach and education, selecting contractors, insurance, easements, monitoring, and reporting. CREST financial staff review and invoice for accounts, including up to 50 contracts per month.

WE 100 – Construction Management
Construction management activities include purchasing construction materials, arranging transport to the site, contract development and oversight, coordinating

meetings between contractors and engineers, coordinating construction schedules, overseeing permit compliance, conducting construction site visits, reviewing construction budgets, releasing grant funds for contractor payment, and overseeing whatever elements of construction were not specifically contracted out, which may include fish rescue, temporary erosion and sediment control actions, monitoring, etc.

WE 157 – Collect/Generate/Validate Field and Lab Data
Each project identified by CREST also receives a review for appropriate monitoring activities. These are developed along with the project and proposed for funding. Under this proposal, each project would receive 1-2 years of pre-project monitoring (determined by the length of development time, once identified) and a minimum of 3 years post project monitoring. CREST staff would conduct this work using CREST equipment, equipped with specialized training specific to resources found in the Lower Columbia River and Estuary.

WE 162 – Analyze/Interpret Data
The data will be collected under WE 157 will be completed as described in the Monitoring section below.

WE 159 – Transfer/Consolidate Regionally Standardized Data
The product identified in WE 162 will be available as a source document for other researchers as well as a stand-alone evaluation of project outcomes. Biologists' products will be standardized and broadcast in an appropriate manner.

WE 175 – Produce Designs and/or Specification
CREST subcontracts engineering designs through a competitive RFP process. CREST oversees engineering at each stage, coordinating the design review process, engaging stakeholders, and determining design direction. Engineering is commonly required for the scale and complexity of projects CREST is proposing.

WE 29 – Increase Instream Habitat Complexity and Stabilization
Specific tasks associated with this work element include adding large woody debris or other elements which provide increased habitat for salmonids and ecosystem processes. For the Otter Point project, this work element will be utilized, as CREST installs 46 pieces of large woody debris.

WE 30 – Realign, Connect and/or Create Channel
CREST projects which realign, connect, or create channels under the proposed project will be related to tidal environments, typically either recreating/reconnecting tidal wetland channels, developing side channel habitat, or improving conditions through improved connectivity, water quality, or other functional features. For the Fort Columbia Project, 300 feet of pilot channel will be created for a natural wetland system, with several thousand feet anticipated to develop from the pilot channel. At the Otter Point site, 4,952 feet of channel will be reconnected to the Lewis and Clark River, at River Mile 1.

WE 33 – Decommission Road/Relocate Road
This work element may be used to facilitate restoration of other systems. Decommissioning or relocating roads can reduce sediment and toxins into aquatic systems. The Fort Columbia project will remove approximately 400 feet of historic

roadbed (currently decommissioned), hydraulically reconnecting the culvert inlet location with the majority of the 96 acre wetland site.

WE 47 – Plant Vegetation
CREST recognizes the value of a whole ecosystem, and rarely are projects completed without some element of riparian revegetation. Revegetation plans are incorporated into planning and budgets. The Fort Columbia project will incorporate 3 acres of salt-tolerant riparian species. The Otter Point project will incorporate 13 acres of salt-tolerant as well as upland species plantings.

WE 180 – Enhance Floodplain/Remove, Modify, Breach Dike
Both Fort Columbia Tidal Reconnection and the Otter Point Restoration Project are primarily dike breach projects. The Fort Columbia project will restore connectivity through an un-gated structure to 96 acres of historic tidal and floodplain wetlands. The Otter Point Restoration Project is an enhanced partial levee removal will include two dike breaches and three notches which reconnect 33.5 acres of historic tidal wetland. CREST is evaluating additional projects that include modifying or breaching dikes.

WE 181 – Create, Restore, and/or Enhance Wetlands
WE 180, 181, and 184 are closely correlated. Dike breaching often restores wetlands to historic conditions, when paired with appropriate instream complexity and vegetation planting actions. The Fort Columbia project will restore connectivity through an un-gated structure to 96 acres of historic tidal and floodplain wetlands. The Otter Point Restoration Project is an enhanced partial levee removal will include two dike breaches and three notches which reconnect 33.5 acres of historic tidal wetland. CREST is particularly interested in the wetland type and habitat availability for juvenile salmonids and investigates life history stage use and site location when evaluating potential restoration sites.

WE 184 – Install Fish Passage Structure
Critical habitats along the Lower Columbia River and Estuary are isolated from fish use as a result of inadequate water passage structures. The Fort Columbia project will restore connectivity by replacing a perched, impassable structure with an un-gated structure to 96 acres of historic tidal and floodplain wetlands. Additional projects have been identified and are in the feasibility stage.

WE 165 – Produce Environmental Compliance Documentation
CREST completes all of its own environmental compliance documentation, including Biological Opinions or Environmental Assessments as needed. CREST has a history of working closely with BPA through the direct contracts at Blind Slough and Gorley Springs to complete cultural resources assessments and programmatic endangered species act compliance.

WE 132 – Produce (Annual) Progress Report
CREST staff will develop and complete an annual report in compliance with BPA standards and timelines for each restoration project.

WE 185 – Produce PISCES Status Reports
CREST staff will complete status reports for restoration projects in PISCES in a timely fashion.

Monitoring and Evaluation

CREST was instrumental in developing the Roegner et al. (2009) standardized monitoring protocols, has on-the-ground experience with all of these methods, and employees biologists for a year-round field crew. To date, methods have been chosen according project type and site conditions, and more often, available funding. Different project types require different monitoring approaches. For example, a dike breach and tidal reconnection requires different monitoring techniques than an Engineered Log Jam installation. At a minimum, CREST strives to perform one year of pre-project monitoring and two years of post-project monitoring with the following metrics: fish utilization, juvenile salmon stock identification (genetics), prey availability and biomass export, vegetation changes, landform and hydrology changes, and water quality. When funding agencies have desired more intensive monitoring techniques for fish habitat utilization and residency time, CREST has also utilized pit tagging, radio telemetry, and fluorescent dyes.

Our research department partners with every major player in estuary research, including National Oceanic and Atmospheric Agency (NOAA), Pacific Northwest National Labs (PNNL), University of Washington, USGS, etc. CREST biologists and wetland specialists conduct research both on contract and for our own projects through grant funding. CREST has a lab for processing fisheries samples. Our monitoring department is active in regional discussions, conferences, and dissemination and analysis of information. CREST has been a partner in the Cumulative Effects study (Army Corps of Engineers funding) and the Salmon Life Histories, Habitats, and Food Webs in the Columbia River Estuary study (BPA funding). In addition, CREST is involved with LCREP and PNNL in efforts to conduct a meta-analysis on effectiveness monitoring performed by multiple entities in the region, and continues to participate in Adaptive Management efforts with the Army Corps and others.

CREST will include monitoring as a project action for Science Workgroup and ERTG review. Any suggestions from these groups or other research professionals will be considered. BPA will make final decisions related to funding monitoring efforts as part of annual contract negotiation.
CREST assumes that the minimal time and metrics described above will be performed for Fort Columbia and Otter Point projects, but the majority of the proposed project funding will be prioritized for project implementation and development.

In general, CREST evaluates monitoring needs according to a two-tier approach: extensive versus intensive. Extensive monitoring of a few key metrics will broadly cover most projects, whereas select project types may be chosen for intensive monitoring when data on that project type is deemed by CREST and the project reviewers to be deficient or complementary to other studies. As an example, the Fort Columbia Tidal Reconnection site is being monitored extensively for fish species composition and timing, fish size structure, presence/absence of adult fish, landscape change, channel morphology, channel flow volume, hydrology, water temperature, dissolved oxygen, and salinity. Intensive monitoring is proposed with a pit tag array, evaluation of habitat type and area, use of habitat types, winter/summer biomass sampling and flux export to test the hypothesis that the project will benefit out-of-basin stocks and increase macrodetrius availability in the estuary.

Pit-tag arrays are proposed for both Fort Columbia and Otter Point, as we are frequently asked about off-channel habitat use in the estuary by downstream migrants from distant upriver stocks (e.g. mid-Columbia or Snake River). Pit-tag arrays at these locations will be an affordable way to address this question because any fish tagged elsewhere in the Columbia River basin that enters the wetlands will automatically be registered by the array and later uploaded into PTAGIS (Passive Integrated Transponder Tag Information System). CREST staff will work to coordinate as much as possible with related research programs in the estuary (e.g. ACOE telemetry studies).

Through this approach, CREST intends to seek qualitative results indicating the direction of habitat outcomes and salmonid usage at specific sites. CREST has identified the following specific metrics for evaluating our effectiveness in targeting the three targeted limiting factors:

1. *Increase the availability of preferred habitat.*
   Extensive: Monitor water surface elevations. Evaluate area inundated.
   Intensive: Delineate habitat type and area. Establish types of use for different areas. Example: freshwater tidal wetland, freshwater wetland, brackish wetland.
2. *Increase macrodetrius inputs*
   Extensive: Benthic cores, fall out traps, stomach samples.
   Intensive: Winter/Summer biomass sampling. Flux export, drift and weigh. Invasive species.
3. *Increase habitat connectivity.*
   Extensive: Fish presence/absence.
   Intensive: Number of barriers in the area, percentage remaining to be reconnected. Area, volume, mileage. Floodplain, channel, etc. Continuous randomly selected sampling.

Table 3. Extensive/Intensive Monitoring by Project Type

	Tide Gate Removal	Dike Breaching	Culvert Upgrades/ Culvert Installation	Dike Removal	Elevation Adjustment
Extensive	**Case by case**	**Yes**	**Yes**	**Yes**	**Possible**
Water Surface Elevation	X	X	X	X	X
Area Inundated	X	X	X	X	X
Landscape Change		X	X	X	X
Water Quality	X	X	X	X	X
Benthic Cores		X	X	X	
Fall Out Traps		X	X	X	
Stomach Samples		X	X	X	

Salmonid performance	X	X	X	X	X
Intensive	**Not used**	**Case by case**	**Case by case**	**Case by case**	**Case by case**
Habitat Type & Area		X	X	X	X
Use of habitat types		X	X	X	X
Winter/Summer biomass sampling		X	X	X	X
Flux export		X	X	X	X
Barriers in area		X	X	X	
Continuous random sampling		X	X	X	
Pit tag array		X	X	X	
Invasive species		X	X	X	X

*Roegner et al (2008), Appendix C

The monitoring approach CREST and our partners employ is Before/After/Reference/Impact, the statistical design recommended in Roegner et al (2009). What results is frequently a 'pass/fail' evaluation of project effectiveness, based on quantitative field data. Sample sizes may be random or targeted, depending on site conditions and project objectives/hypothesis.

CREST is not currently equipped to do a long-term power analysis because of small sample sizes and lack of adequate funding, but will seek the support and advice of statisticians in evaluating and managing data. Whenever possible, CREST data can be used by other researchers performing more intense experimental analyses. Additionally, we will interface with other entities planning research in the region, which include PNAMP, PTAGIS, Corps (acoustics studies & pit tagging) & BPA, Committees, Estuary Partnership Science Work Group, Expert Regional Technical Group, BPA Fish and Wildlife program, Monitoring, Evaluation, Research & Reporting by Council, Estuary R,M&E, Estuary, Ocean, Subgroup Federal RME (Corps/BPA). The Cumulative Effects project (Pacific NW National Labs, Army Corps) will provide a framework for periodic regional evaluation of estuary restoration and adaptive management recommendations. CREST is a contributor to Cumulative Effects Annual reports, utilize its approach paper (to be published in June, 2010) for statistical design, and will participate in efforts to utilize this system over the long-term. CREST will also continue to participate as a sponsor and contributor at the Columbia River Estuary Conference held every two years to share scientific advancements.

CREST will coordinate on a project level with the following proposals, targeting RPA actions 58-61.

Table 4. CREST's relationship to RPA scientific studies

RPA	Funder	Project Name	Relationship to CREST Proposal
58, 59, 61	USACE	A study of salmonid survival and behavior through the Columbia River estuary Using Acoustic Tags	CREST will conduct intensive monitoring in specific locations, supporting and adding to the body of knowledge being collated by this study.
58, 59, 61	BPA	Historic Habitat Food Web Link	CREST will conduct intensive studies in specific locations to quantify macrodetrius exports, adding to the body of knowledge being collated by this study. CREST was a subcontractor on this project for fish monitoring.
58, 59	USACE	Evaluation of life history diversity, habitat connectivity, and survival benefits associated with habitat restoration actions in the lower Columbia river and estuary	CREST's actions will provide additional study material for this evaluation.
58, 59, 60, 61	BPA	Lower Columbia River Estuary Ecosystem Monitoring	CREST is a subcontractor under this contract and will continue to contribute quality data towards this effort.
59, 60, 61	BPA	Columbia River Estuary Habitat Restoration	CREST has obtained several grants through this source and will continue to seek funds in addition to this proposal for projects as necessary.
59, 60, 61	USACE	Evaluating Cumulative Ecosystem Response to Habitat Restoration Projects in the Lower Columbia River and Estuary	CREST has participated in this effort as a subcontractor and will continue to collaborate with this effort.
60	BPA	Grays River Watershed Assessment	CREST partnered with PNNL on this effort. We will continue to support ongoing geomorphic monitoring in addition to focusing efforts on future restoration

			phases.
60	BPA	Eelgrass Enhancement and Restoration	CREST will collaborate with and incorporate findings from this project into future restoration projects.

H. Facilities and equipment

CREST will require funds to maintain office and storage space for the employees and equipment utilized to implement this project. Specific equipment required to complete the contract also includes two (2) laptop computers with GIS software, a waterproof digital camera, surveying transom, tripod, and stadia rod, four sets of seining nets and miscellaneous fish sampling equipment, two multi-parameter water quality probes, laminator, desktop printer, and printing supplies.

I. Literature Cited

Bottom et al, 2005. Salmon at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River. U.S. National Marine Fisheries Service, Seattle, WA.

Cameron, AS. Columbia River Estuary Wetland Restoration and Monitoring Findings Report 2007 – 2009. Columbia River Estuary Study Taskforce, Astoria, OR.

Hanrahan, TP, AP Levell, and EV Arntzen. 2008. Monitoring and assessment plan for the Grays River Gorley Springs Restoration Project. PNNL – 18033. Pacific Northwest National Laboratory, Richland, WA

D. A. Jay and T. Kukulka. Revising the paradigm of tidal analysis the uses of non-stationary data. *Ocean Dynamics*, 53(3):110– 125, 2003.

Johnson et al, 2007. Evaluating Cumulative Ecosystem Response to Restoration Projects in the Columbia River Estuary. USACE Portland, OR.

Johnson et al, 2003. An Ecosystem-Based Approach to Habitat Restoration Projects with Emphasis on Salmonids in the Columbia River Estuary.

Kareiva, P. M. Marvier, and M. McClure. 2000. Recovery and management options for spring/summer chinook salmon in the Columbia River Basin. Science 290:977-979.

Levy, D.A. and T.G. Northcote. 1981. The distribution and abundance of juvenile salmon in marsh habitats of the Fraser River estuary. Westwater Research Centre, The University of British Columbia. Technical Report No. 25.

Levy, D.A. and T.G. Northcote. 1982. Effects of estuarine log storage on juvenile salmon. Westwater Research Centre, The University of British Columbia. Technical Report No. 26.

Lower Columbia Fish Recovery Board. 2004. Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan. Longview, WA.

National Marine Fisheries Service. 2004. Biological Opinion, Federal Columbia River Power System. Portland, OR.

National Oceanic & Atmospheric Administration. 2007. Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead. Portland, OR.

Northwest Power Planning Council. 2009. Draft Columbia River Basin Fish and Wildlife Program. Portland, OR.

Roegner et al. 2006. Monitoring Protocols for Salmon Habitat Restoration Projects in the Lower Columbia River Estuary. USACE Portland, OR.

Roni, P. (editor). 2005. Monitoring stream and watershed restoration. American Fisheries Society, Bethesda, MD.

Thomas, D. W. 1983. Changes in Columbia River estuary habitat types over the past century. Columbia River Estuary Data Development Program, Astoria, Oregon. 51 pp.

J. Key personnel

Micah Russell, CREST Director. Oversees staff activities, directs program within CREST and coordinates with partnering entities.
Paula Gerttula, CREST Financial Coordinator. Completes all financial transactions related to the project including receipts payable, receipts billable, and payroll.
Amy Ammer, CREST Habitat Restoration Specialist. Oversees project development, design, outreach, and implementation.
Madeline Dalton, CREST Watershed Coordinator. Oversees project development, design, outreach, and implementation.
April Cameron, CREST Biologist/Ecologist. Reviews environmental documents, develops hypothesis and implements monitoring strategies.
Tim Hanrahan, PNNL Senior Research Scientist. Develops and oversees Grays River Gorley Springs Restoration Project monitoring.

Resumes are provided in Appendix B.

Appendix A. Science Work Group Criteria

Lower Columbia River Estuary Partnership Criteria for Identifying and Prioritizing Habitat Protection and Restoration Projects on the Lower Columbia River and Estuary*

Ecosystem Criteria

1) Habitat Connectivity
This criterion recognizes that habitat connectivity is a landscape level concept. It emphasizes linkages between habitat areas that provide a variety of functions for species at various stages of their life cycle and that gradual alteration of landscapes through natural succession and retrogression allow species that require a variety of habitat components to disperse and survive. In the Lower Columbia, historic changes have limited or cut off species' access to resources needed for their development. Specific emphasis on species with narrow ecological requirements should be considered. Upland habitat areas adjacent to drainage ways, existing protected/restored sites, and areas offering diverse habitat types, function, and successional stages should also be considered.

2) Areas of Historic Habitat Type Loss
Land use activities such as diking, filling, and shoreline hardening have removed many of the shallow, peripheral wetlands along the Lower Columbia, isolating the river from its floodplain. This criterion recognizes that historic wetland types such as emergent and forested wetlands that are particularly important for salmonids and a variety of bird species, have been greatly diminished. These habitats promote networks of physical complexity such as shallow, dendritic channels and backwater sloughs.

3) Improvement in Ecosystem Function
This criterion acknowledges that some restoration actions can result in greater enhancement of ecosystem functions than others. This criterion emphasizes that location of a project may in some cases be more important than size of the project.

4) Adequate Size and Shape
Size refers to reach length and the size of the potential habitat within a reach. In general, larger size enhances habitat stability, increases the number of species that can potentially use the site, makes it easier to find by migratory species, and increases within-habitat complexity.

5) Level of Complexity
This criterion refers to the number and interspersion of different types of habitats within a given restoration reach or area. As the number of habitats increase, so do the number of species that can occupy an area, and the number of functions supported by an area. Higher complexity potentially results in higher biodiversity. It is recognized that some restoration efforts, such as a chum channel, may not strive for habitat complexity.

6) Accessibility For Target Species
Accessibility refers to unencumbered access by Columbia River estuary habitat-dependent aquatic and terrestrial species. Projects that allow or enhance access of these species to important habitats would potentially enhance the feeding, rearing, and

refuge functions of the site are preferred. This criterion acknowledges the need to restore habitat for those threatened and endangered species, both aquatic and terrestrial, whose populations are at precariously low numbers and who might benefit from improved near-shore habitat conditions.

Implementation Criteria

1) Use Natural Processes to Restore and Maintain Structure over Habitat Creation
This criterion recognizes that restoration measures should attempt to re-establish the dynamics of estuarine hydrology, sedimentology, geomorphology and other habitat-forming processes that naturally create and maintain habitat, rather than implanting habitat structures at inappropriate or unsustainable locations. Restoration tasks should initiate or accelerate natural processes. Nearly all manifestations of restoration are accomplished by these processes and not by the direct artifice of the restoration. Complex engineering manipulations to create new habitats or to enhance existing habitats can introduce levels of uncertainty about the ecological impacts of such actions and/or the application of the results to other locations. Restoration methods such as dike, levee, and tide gate removal should receive first priority for restoration since historic habitat features of the surrounding area may still be intact. Areas that require minor alterations and maximize ecosystem function and processes offer a higher certainty of outcomes and may be more cost-effective and self-sustaining. Weight should be given to tidegate improvements with access to quality stream channels where dike breaching is not an option. For purposes of setting natural processes rapidly in motion some artificial manipulation is required, the best ecological engineering practices should be applied in implementing restoration projects, using all available ecological knowledge and maximizing the use of natural processes to achieve goals.

2) Community Support and Participation
Developing partnerships among communities, organizations, individuals and agencies is a critical element to long term estuary restoration success. The following are considerations regarding this criterion:

A. Choose projects with local support that are popular and visible, and have political and environmental education components.

B. Visible, local partners (i.e., those that are technically capable/and can facilitate discussions between local project sponsors and Federal/State agency representatives) are needed to build community support for habitat restoration and protection projects

C. Select habitat restoration and protection projects that are linked to community/watershed councils' goals and objectives

D. Look for synergy with existing projects, spatially and biologically, and those with community support and ecological output. That involvement requires creativity and flexibility on the part of all involved to look for ecological, social, and economics incentives when identifying potential projects

E. Depending on the stakeholder and/or landowner, social and economic considerations may be as important as environmental considerations when choosing potential habitat restoration and protection projects

3) Potential for Self Maintenance and Certainty of Success

Self-maintenance addresses the ability of a site to persist and evolve toward a natural (historical) habitat condition without significant on-going human intervention. Conditions for controlling factors in the reach and in the management unit must be appropriately developed and maintained. Self-maintenance means that the habitat can persist and develop under natural climatic variation, and that the system has a natural degree of resilience to natural perturbations. This criterion relies on needing to know the historical conditions and factors attributed to the current conditions.

4) Potential for Improvement in Ecosystem Function While Avoiding Impacts to Healthy and Functioning Ecosystems
This criterion observes that at times there are competing restoration goals, and while attempting to improve some ecosystem functions, others may be impaired or lost. This criteria stresses that restoration actions should achieve proposed benefits while avoiding the long term or permanent degradation of other ecological functions of natural habitats or broader ecosystems. Restoration actions should avoid replacing one naturally functioning habitat with another, even if the replacement is perceived to benefit salmon. In particular, activities that further reduce the estuarine tidal prism or impair other large-scale estuarine processes (e.g., circulation, salinity intrusion) or attributes should be avoided.

5) Avoid Sites Where Irreversible Change Has Occurred
Many aquatic ecosystems within the Estuary have been so heavily modified that the fundamental processes responsible for historic conditions have been significantly altered, in some cases irrevocably. In the Lower Columbia River, freshwater volume has been reduced or the natural flow cycle altered, inputs of sediments and detritus have changed, and tidal flow has been compromised. In some cases, restoration of historic conditions in their original location or state is simply no longer attainable without restoration of historic processes.

Reconstructing the historical river, tidal floodplain and estuarine structure does not necessarily guarantee restoration success; it only decreases uncertainty. Historic templates often provide the framework for restoration goals, as well as a perspective on how ecosystems have been incrementally degraded. At the minimum, the modified capacities of natural processes to support restoring habitats under present conditions must be well understood to develop realistic restoration goals. In some instances, ecological engineering may be necessary to compensate for diminished processes, but such approaches should be used to initiate self-sustaining restoration rather than as an artificial “fix” requiring long-term maintenance.

6) Capacity of Sponsor/Partnership
Restoration projects are often complex and costly. To effectively implement and monitor a restoration project over the long term it is necessary that the sponsor and project partners have the capacity to successfully manage the project and achieve success. This criterion will consider an organization’s record of project management, its technical expertise, and financial stability.

7) Project Context Within Broader Management and Planning Objectives
This criterion recognizes that within the Lower Columbia system there are a number of management plans and objectives that articulate specific restoration and conservation recommendations. Some of these include; Northwest Power and Conservation

Council's Subbasin Plans, Lower Columbia Fish Recovery Board priorities, Oregon's Coastal and Estuarine Land Conservation Plan, North American Waterfowl Management Plan, and the Columbia Land Trust's Land Conservation Priorities. In evaluating proposed restoration projects, considerations should be made to coordinate with these initiatives to minimize duplication of services or contradictory endeavors.

Monitoring Criteria

1) Monitoring and Evaluation with Relationship to Stated Goals and Objectives
Monitoring and adaptive management are essential components of restoration and habitat management. Restoration activities should be placed in the context of an experimental design strategy. Metrics should be developed that enhance an understanding of the connection between habitat variables and species' needs. Restoration designs should be monitored and, based on the concept of adaptive management, altered if necessary to achieve desired endpoints and to insure that local projects are self-sustaining. Information already available on limiting factors and properly functioning conditions should be included in the site selection and project design. The monitoring information must span both water quality and physical habitat parameters. Determining an appropriate scale is a critical component of developing a monitoring and effectiveness criteria. Goals and biological objectives for restoration should be clearly stated, site specific, measurable and long-term, in many cases greater than 20 years. Performance criteria should derive directly from these goals, and should include both functional and structural elements and be linked to suitable, local reference ("target") habitats. Scientific monitoring based on the established performance criteria is essential to improve restoration techniques and to achieve estuarine restoration goals.

Performance criteria should indicate whether restoration is progressing as intended and how the project may be altered or redesigned to better achieve project goals.

2) Linkages to Reference Site(s)
Determining the effectiveness of restoration activities requires comparison to relatively unaltered reference habitats in close proximity to serve as a "control" for evaluating habitat change. This allows for monitoring the growth, species composition, successional stage and time period of the restoration site in comparison to the reference site and assist in developing performance standards and benchmarks for restoration activities in the estuary. Choosing sites that include an experimental restoration design tied to effectiveness monitoring helps promote a better understanding of the relationship between habitat restoration activities and species response and performance resulting from the restoration activity.

3) Transferability of Results
Projects should be designed as explicit tests of restoration actions that will be evaluated, and, if effective, can be scaled up and applied systematically across the landscape. Restoration results should be evaluated uniformly at individual sites and comprehensively at landscape and ecosystem scales to assess whether the cumulative results of local restoration actions achieve overall recovery goals. The results of monitoring can provide the foundation for more effective restoration methods in future projects.

*Estuary Partnership criteria have been previously reviewed by ISRP.

Micah Russell

750 Commercial St, Rm 205 Astoria, OR 97103 mrussell@columbiaestuary.org
(503) 325 – 0435 www.columbiaestuary.org

Education:
M.S. Oceanography & Coastal Science
(Estuarine Ecology and Fisheries emphasis)
Louisiana State University, Baton Rouge, Louisiana. 2004.
B.S. Environmental Biology
Pacific University, Forest Grove, Oregon. 2001.

Work Experience:
Director [02/08 – present]
Biologist / Ecologist [03/07 – 01/08]
***Columbia River Estuary Study Taskforce (CREST)*, Astoria, Oregon**
Duties:
Administers and directs the activities of CREST -- environmental and resource planning, habitat restoration, and ecosystem monitoring -- on behalf of CREST members (local ports, cities and counties) and other partners. Responsible for ensuring quality services and project management, budgeting, development and facilitation of contracts and grants, interfacing with the board and the public, and organizational strategy and growth. Networks and collaborates extensively with government agencies and non-profit groups to engage pro-actively in regional planning and restoration.

Part-time Instructor (Oceanography): [01/07 – current]]
***Tillamook Bay Community College*, Tillamook, Oregon**
Duties:
Teaches a survey of oceanography (lecture and laboratory) to a diverse group of college students, with an emphasis on understanding the basic principles of geology, chemistry, biology, physics, history, and conservation as they relate to marine science.

Natural Resource Specialist 1 (Recreation): [11/06 – 03/07]
***Oregon Department of Forestry,* Tillamook, Oregon.**
Duties:
Contracted as part of a broad environmental assessment of the Wilson River watershed to inventory and map all dispersed recreational campsites for inclusion in a GIS-based watershed management plan. Collected data and prioritized sites that were heavily impacted, contributed to lower water quality, and degraded salmon habitat. Made recommendations for road closures or other management strategies and coordinated with stakeholders to write work contracts.

Team Leader [06/05 - 08/05]
***Hawaii Youth Conservation Corp.,* Maui, Hawaii.**
Duties:
Supervised a crew of high-school youth in a variety of conservation projects with the purpose of introducing young people to natural resource management. Projects included: invasive plant species removal, native vegetation planting, irrigation installation, erosion control installation, fence construction and removal, feral ungulate snaring, and archaeological site preservation. In charge of logistics, safety, and transportation, while working each week with a different state / federal agency or local conservation group in a different type of wilderness environment.

Oceanography Graduate Researcher [08/02 - 12/04]
***Louisiana State University Coastal Fisheries Institute,* Baton Rouge, Louisiana.**
Duties:
Performed field and laboratory research for a master's thesis in oceanography and fisheries science involving the essential fisheries habitat (EFH) requirements of commercially viable fish in Louisiana estuaries. Biological and environmental data were compiled and analyzed using a variety of statistical computer packages, and subsequently incorporated into scientific reports and a thesis. This project required cooperation between state officials, university colleagues and faculty, and local fishermen. Results were presented orally to all involved parties and the public.

Amy Ammer

750 Commercial St, Rm 205 Astoria, OR 97103 aammer@columbiaestuary.org
(503) 325 – 0435 www.columbiaestuary.org

Education

Oregon State University
Bachelor's Degree – Natural Resources with Policy Emphasis
Relevant Coursework: Management Principles of Salmon in the Northwest, Fish and Wildlife Conservation, Ecological Restoration, Riparian Ecology and Management, Desert Watershed Management (water management principles), Geographical Information Systems in Natural Resources, Natural Resource Decision Making, Environmental Politics and Policy, Rangeland Management Planning, Resource Economics, Statistics, World Soil Resources, Leadership Development, & US and Natural Resource Law

Western Washington University
Bachelor's Degree – English Literature with Geology Minor
Relevant Coursework: Technical Writing, Advanced Technical Writing, Writing and Critical Inquiry, Newswriting, Physical Geology, Historic Geology, Earthquake Geology, Geomorphology, Volcanology, Chemistry, & Anthropology

Work Experience

Habitat Restoration Specialist
Columbia River Estuary Study Taskforce
October 2007 - present
Responsibilities:

- All project management duties, including community outreach, volunteer coordination, and logistics for three habitat restoration projects.
- Specializing in organization of complex, large scale projects with budgets $500,000 and larger.
- Recognized for ability to network within the community and create effective links with community stakeholders.

Planner
Pacific County, Washington
May 2006 – October 2007
Responsibilities:

- Review 30-40 Pacific County planning applications for small to moderate sized projects.
- Conduct primary planning duties for City of Ilwaco including commercial, residential, and environmental reviews.
- Provide quality assistance to the public, present county ordinances to audiences when requested, provide first contact for many landowners to County process.
- Highly successful in developing good working relationships with all demographics of the public served.

Office Assistant 3
Naselle Youth Camp
September 2003 – April 2006
40 hours per week
Responsibilities:

- Provided clerical support for two living units in a medium-security juvenile facility. Total filing and support duties included 60 + residents and 10 – 12 staff.
- Coordinated transportation services for the facility with the state juvenile transportation system at Echo Glenn Children's Center. Received intake information for all juveniles transferred to the facility.
- Collated the Superintendent's Report from supervisor and area reporting. Input commissary inventory data for commodities received by living units.

Madeline Dalton

750 Commercial St, Rm 205 Astoria, OR 97103 mdalton@columbiaestuary.org
(503) 325 – 0435 www.columbiaestuary.org

Education

University of Wisconsin- River Falls

- Bachelor of Science, Environmental Science
- Bachelor of Arts, Spanish and International Studies minor

Work Experience

Watershed Council Coordinator
North Coast Watershed Association/ CREST
2009- Present

- Develop and implement watershed programs and projects
- Compose and develop grant proposals and work plans
- Coordinate and manage ecological restoration and monitoring and research projects
- Manage fiscal grant accounts
- Prepare technical reports
- Facilitate monthly watershed council meetings
- Create community partnerships and recruit volunteers
- Supervise support staff
- Collaborate communication among project partners and stakeholders

Watershed Coordinator
Shakopee Creek Headwaters Project
2007- 2009

- Conducted lake and stream water quality monitoring and data collecting throughout the Shakopee Creek Watershed
- Analyzed, interpreted, and compiled water quality data
- Performed grant budget tracking and reporting
- Composed grant proposals and work plans
- Facilitated monthly meetings for the Shakopee Creek Advisory Committee
- Promoted Best Management Practices through various educational outreach programs and media outlets such as radio, newspaper ads, and informational mailings
- Assisted in the planning and installation of Best Management Practices

Summer Intern
Tonka Equipment Company
2006

- Worked as an assistant technician on a water quality pilot experiment for an oil reclamation site in Gaylord, MI
- Analyzed data collected at municipal water facilities and pilot studies
- Prepared pilot trailers for off-site water filtration study trials
- Researched and led meetings for proper disposal of laboratory chemicals
- Researched and prepared office memos on the use of filtration techniques for Puerto Rican surface water, and substituting Potassium Chloride for Sodium Chloride for drinking water filtration plants
- Developed a new organization system for a newly remodeled, on-site chemistry lab

Paula Gerttula

750 Commercial St, Rm 205 Astoria, OR 97103 pgerttula@columbiaestuary.org
(503) 325 – 0435 www.columbiaestuary.org

Summary of Qualifications

Expertise includes over 30 years of financial management in local governments, non-profits, and the private sector. Extensive experience in administration, customer service and purchasing.

Work Experience

Financial Coordinator
Columbia River Estuary Study Taskforce
December 2003 – Present
Responsibilities:

- Administer all grant and contract files
- Track grant and contract budgets and invoice funders
- Manage an annual budget in excess of $1,500,000
- Responsible for the day to day financial management

Grant Administrator
Sea Resources
May 2000 – December 2003
Responsibilities:

- Administer all grant and contract files
- Manage all financial duties
- Office management

Administrative Assistant
Columbia River Estuary Study Taskforce
April 1997 – May 2000
Responsibilities:

- Bookkeeping, including accounts payable and accounts receivable
- Office management
- Library management

Significant Project History

EPA Brownfields Revolving Loan Fund Grant - $1,000,000

Administered the financial part of this project for the five year period of the grant. In addition to managing the financial part of this project I also helped with the quarterly interim reports and completed all of the final reports.

Fort Clatsop Bridge Project - $706,320

Administered the financial part of this five funder project that took place in the summer of 2007. Coordinated the completion of this project with the Consultant hired by the construction company doing the major part of the work when the project manager left CREST for a position at another organization.

Grays River/Gorley Springs Restoration Project- $761,381

To date I have administered the financial aspect of three grants all funded through BPA for this project.

Blind Slough Restoration Project - $423,225

Managed the financial function of this five grant/four funder project that was completed between the years of 2004 – 2006.

Big Creek Restoration Project - $490,590

Administered the financial part of this project which was comprised of five funders and eight grants from 2005 to 2009.

Timothy P. Hanrahan
Senior Research Scientist
Battelle, Pacific Northwest Division
Pacific Northwest National Laboratory (PNNL)

P.O. Box 999 MS K6-85
Richland, WA 99354
Tel. 509 371 7182
tim.hanrahan@pnl.gov

Employment

Dr. Hanrahan has been a research scientist at PNNL since 1993. In addition to his employment at PNNL, he is an adjunct faculty member in the School of Earth and Environmental Sciences at Washington State University where he teaches *Fundamentals of Environmental Hydrology*.

Education

Ph.D., Environmental Science (fluvial hydrology), Washington State University, Pullman, WA, 2006
M.S., Natural Resource Sciences, Washington State University, Pullman, WA, 1993
B.S., General Sciences, University of Wisconsin, Madison, WI, 1989

Research Interests and Experience

Professional interests and research focus on large river processes, particularly hydrology, hydraulics and water quality, and associated interactions with aquatic organisms and their habitats. Current and recent research includes predicting and assessing aquatic habitat effects resulting from climate change, fluctuating large river flow regimes and hydroelectric dam modifications. Areas of expertise include river hydraulics and sediment transport, assessment and modeling of aquatic habitats, and evaluation of groundwater – surface water interactions in rivers.

Select publications

Hanrahan, T. P. 2008. Effects of river discharge on hyporheic exchange flows in salmon spawning areas of a large gravel-bed river. Hydrological Processes 22(1): 127-141, DOI: 10.1002/hyp.6605.

Geist, D. R., C. J. Murray, T. P. Hanrahan, and Y. Xie. 2008. A model of the effects of flow fluctations on fall Chinook salmon spawning habitat availability in the Columbia River. North American Journal of Fisheries Management 28: 1911-1927, DOI: 10.1577/M07-074.1.

Geist, D. R., E. V. Arntzen, C. J. Murray, K. E. McGrath, Y. J. Bott, and T. P. Hanrahan. 2008. Influence of river level on temperature and hydraulic gradients in chum and fall Chinook salmon spawning areas downstream of Bonneville Dam, Columbia River. North American Journal of Fisheries Management 27: 30-41, DOI: 10.1577/M07-009.1.

Hanrahan, T. P. 2007. Large-scale spatial variability of riverbed temperature gradients in Snake River fall Chinook salmon spawning areas. River Research and Applications 23: 323-341, DOI: 10.1002/rra.982.

Hanrahan, T. P. 2007. Bedform morphology of salmon spawning areas in a large gravel-bed river. Geomorphology 86: 529–536, DOI: 10.1016/j.geomorph.2006.09.017.

Hanrahan, T. P., D. R. Geist, and E. V. Arntzen. 2005. Habitat quality of historic Snake River fall Chinook salmon spawning locations and implications for incubation survival. Part 1: Substrate quality. River Research and Applications 21 (5): 455-467.

Hanrahan, T. P., D. D. Dauble, and D. R. Geist. 2004. An estimate of chinook salmon spawning habitat and redd capacity upstream of a migration barrier in the upper Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 61: 23-33.

Professional Service

- Advisor and preceptor to graduate and undergraduate student interns at the Pacific Northwest National Laboratory
- Advisor to graduate students at Washington State University and University of British Columbia
- Reviewer for proposals submitted to the National Institutes for Water Resources 303(g) program administered for the U. S. Geological Survey
- Reviewer for proposals submitted to the CALFED Bay-Delta Science Program administered by the State of California and the U.S. Department of Interior
- Reviewer for manuscripts submitted to the journals *Advances in Water Research, Hydrogeology Journal, River Research and Applications, Canadian Journal of Fisheries and Aquatic Sciences, New Zealand Journal of Marine and Freshwater Research, Current Zoology, North American Journal of Fisheries Management*
- Judge for Outstanding Student Paper Awards, Hydrology Section of American Geophysical Union

Professional Affiliations and Recognition

Member of the American Geophysical Union (Hydrology Section)
Member of the American Fisheries Society

April Cameron

750 Commercial St, Rm 205 Astoria, OR 97103 acameron@columbiaestuary.org
(503) 325 – 0435 www.columbiaestuary.org

Education
Oregon State University - 1999
BS Biology, Option Marine Biology
BA International Studies, Minor French
Thesis: Temporal and Spatial Variability in the Abundance of Marine Larvae on the Oregon Coast

Work Experience

Biologist/Ecologist
Columbia River Estuary Study Taskforce
2/08 – present
Responsibilities:

- Coordinates biological and ecological research activities, often in collaboration with other agencies.
- Monitors research along the Columbia River's tributaries, where dikes have been breached or tide-gates removed, for example, and vegetation rehabilitated, to restore tidal connectivity and habitat to their natural state
- Collects data on salmonids and other fish communities, water quality, prey, channel morphology, and vegetation, for example, to discern the effectiveness of restorative efforts.
- Obtains scientific collection permits, applies for grants, writes reports for various funding agencies, and processes data and lab samples.

Fisheries Biologist
PSMFC /NOAA – Fish Ecology Division, Pt. Adams Biological Field Station,
5/02 – 2/08
Responsibilities:

- Used of pair-trawls in the upper Columbia River estuary (lower estuary in previous years) to detect PIT-tagged juvenile salmonids for a multi-year study to estimate survival through the hydropower system, and understand migration timing and behavior, for transported versus in-river migrants.
- Routinely run a pontoon barge equipped with scientific gear for daily data collection, to our sample site and back.
- Processed and analyzed all of the trawl data, interpret and synthesize the results, and prepared reports and presentations for funding agencies.
- Applied for scientific collections permits from state and federal entities, and prepare associated annual reports.

Research Assistant
OSU – Lubechenco/Menge Invertebrate Zoology Lab – Department of Zoology
1998
Responsibilities

- Research focused on factors affecting community structure in the Rocky Intertidal
- Monitored barnacle and mussel larval supplies and recruitment, quantified mussel and algal transects, maintained herbivore and predator exclusion experiments, and collected water samples for phytoplankton productivity analyses, along Oregon's rocky intertidal.

Work Related Qualifications
AFEP review, Estuarine Detections of PIT-tagged salmonids presentation, co-presenter 2005, presenter 2006, alternate presenter 2007
Westport GED group, Estuarine Detections of PIT-tagged salmonids presentation and field trip with pair-trawl project, 2006and 2007
Warrenton High School, Estuarine Detections of PIT-tagged salmonids presentation, 2006 and 2007
NWFSC Training: OSHA Hazardous Communication and DOT Material Transport, 2005; Blood borne Pathogen Training, 2006
40-hour "Vessel Operations Training Program", 8-hour "Oregon Boater Education Certification", CCC, Maritime Science Department, 2004
First Aid Basics, CPR and AED, American Red Cross, 2006 (expires 2009)
Open Water Diver Certification, OSU, 1999

Appendix C: Project Identification and Prioritization

Columbia River Estuary Study Taskforce
750 Commercial Street, Room 205, Astoria, Oregon 97103
Phone: (503) 325-0435, Fax: (503) 325-0459
Email: crest@columbiaestuary.org
Website: www.columbiaestuary.org

PROJECT IDENTIFICATION

Step 1: Identification of a Potential Site:

1.A. Landowner Contact – landowner contacts CREST interested in having us evaluate a site. Landowners contact CREST for a variety of reasons, but most commonly because ecosystem processes have been altered, resulting in flooding, erosion, or other impacts to private property. This is the historic method of project identification at CREST because of extremely limited project development funds.

Landowner interest in this case is almost always a specific resource outcome. Landowners are often motivated and engaged, and often an outcome that benefits the landowner's interests and resources is feasible.

OR

1.B. Targeted project identification – CREST reviews aerials, LIDAR, conducts site visits, collaborates with other organizations, creating a list of 'potentials', contacts landowners to assess willingness. CREST will utilize overarching Columbia River Estuary Ecosystem Classification, and Washington and Oregon tidegate and levee assessments to identify additional sites and collaborate with additional entities to ensure maximum landscape scale and ecosystem function restoration.

Step 2: Initial CREST Review

2.A. Science Work Group Criteria – CREST evaluates potential projects based on the existing Science Work Group Criteria and/or other available criteria, permitting ranking to occur. Top ranked projects are further assessed to determine feasibility and quantify benefits.

2.B. Conduct detailed search of existing site information - Include such specifics as:

Location: Where is it in the watershed & what is its relationship to habitat? Proximity to tidal influence? Relationship to other projects?
Size: How large is the potential site? What portion of the site provides habitat benefits? Connectivity to additional habitats & total restoration opportunity?
Condition: Vegetation, systems, etc. Degraded, functioning, highly functional?
Ecological/Biological Value: While not always available at this stage, often some information may indicate the site's use by salmon and/or its ecological value.
Actions: What actions might benefit salmonids at this site?

Cost: Is the first cost estimate appropriate for the expected habitat gain?
Planning: What documents describe this watershed/site? Is it a priority action or site?
Community: Will restoring the site affect neighbors? Is the general trend of the community supportive or not?
Complexity: Factors such as multiple landowners, adjacent low-lying homes, site access, complicated permitting, and other factors may significantly delay or stall the project.
Owner: Is the landowner engaged and supportive of the project?
Funding: Is the site prioritized by funding sources which would adequately cover expected costs?

2.C. Conduct Review of Major Planning & Research Documents – Evaluate the project in terms of existing research and planning documents. For similar types of projects in similar situations this can be streamlined, but conducting this review permits the project manager to determine the site's feasibility for addressing key limiting factors as well as preparing for future funding applications. A partial list of documents to be reviewed includes:

Bottom et al, 2005. Salmon at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River. U.S. National Marine Fisheries Service, Seattle, WA.

Johnson et al, 2003. An Ecosystem-Based Approach to Habitat Restoration Projects with Emphasis on Salmonids in the Columbia River Estuary.

Lower Columbia Fish Recovery Board. 2004. Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan. Longview, WA.

National Marine Fisheries Service. 2004. Biological Opinion, Federal Columbia River Power System. Portland, OR.

National Oceanic & Atmospheric Administration. 2007. Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead. Portland, OR.

Northwest Power Planning Council. 2009. Draft Columbia River Basin Fish and Wildlife Program. Portland, OR.

Roegner et al. 2006. Monitoring Protocols for Salmon Habitat Restoration Projects in the Lower Columbia River Estuary. USACE Portland, OR.

2.D. Develop Preliminary Project Report – CREST will publish an internal report detailing the outcome of the above investigations. It will be developed into a 5-7 page report including maps, photographs, and basic project information and include detailed discussion of potential restoration opportunities at the site. Sections will include:

- Site identification and description
- Discussion of site information, including problem statement
- Discussion of relevance to regional recovery efforts & programs
- Identification of restoration strategies
- Feasibility and associated costs

A basic budget will be provided as an attachment to the preliminary project report.

Step 3: Project Review

3.A. Internal CREST Review – At monthly staff meetings, identified projects will be discussed with all CREST departments, including management, monitoring, planning, and habitat restoration. Cross-department knowledge of site conditions and biological diversity will serve to inform projects' success.

3.B. Estuary Partnership Science Workgroup – CREST will present prioritized projects which have been through the preliminary report and internal CREST review process. Projects will be presented with enough detail for a scientific review to be feasible. If such a review is not yet feasible, as determined by CREST, BPA or the Science Work Group, feasibility study funding will be sought.

3.C. Expert Regional Technical Group – Once a project has been successfully reviewed by the Science Work Group, it will be sent to the ERTG for final review and recommendation to BPA.

Appendix D: Fort Columbia Tidal Reconnection Project

CREST
Columbia River Estuary Study Taskforce

90% Basis of Design

May 2009

Fort Columbia Tidal Reconnection Project

US 101 MP 3.24

Chinook, Washington

Pacific County

TETRA TECH, INC.
1020 SW Taylor Street, Suite 530
Portland, Oregon 97205

(This page intentionally left blank)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

This Basis of Design Report for the Fort Columbia Tidal Reconnection Project (Project) has been prepared for the Columbia River Estuary Study Taskforce (CREST). The overall Project objective is to reestablish connectivity between the Columbia River Estuary (Baker Bay) and a distributary of the Chinook River that flows through a freshwater wetland east of US Highway 101 (US 101). Connectivity would provide tidal slough rearing habitat for juvenile salmonids migrating down the Columbia River and would also reduce stranding of salmonids outmigrating from the Chinook River that enter into the distributary system.

Connectivity is to be enhanced through construction of a fish-passable culvert approximately 450 feet southeast of an existing culvert, along US 101. The existing 24-inch diameter concrete culvert (58 feet in length) is perched within the highway berm at an invert elevation of approximately 8.1 feet NAVD88 (downstream invert of 8.1 feet NAVD88 and upstream invert of 8.79 feet NAVD88). Mean higher high water at this location is estimated to be 8.6 feet NAVD. The proposed fish passage culvert would have an invert of native substrate at an elevation of 2.0 feet NAVD88 with rock protection adjacent to the culvert and below the finish grade to minimize the risk of foundation scour. Current design calls for a nominal 12 foot span by 11 foot total rise precast concrete culvert that is 80 feet in length. This Basis of Design report provides engineering documentation and support for the culvert design plans.

1.1. Project Location

The Project is located south of the town of Chinook and north of Fort Columbia State Park in Pacific County, Washington (see Figure 1, also visible on USGS Chinook Quadrangle sheet). An existing culvert is located at Mile Post 3.3 on US 101, south of the Town of Chinook (Tetra Tech 2003). Downstream (seaward) of the existing culvert is a vegetated marsh bench with elevations of approximately +5 to +7 feet NAVD88 (SLS 2005). To avoid excavation of the marsh bench, the proposed culvert is located south of the existing culvert by approximately 450 feet. The proposed location will also provide better connectivity to the tidal channels within Baker Bay.

The proposed culvert will facilitate drainage of a distributary of the Chinook River that begins near the Sea Resources Fish Hatchery water intake (Figure 1). The distributary continues south through a broad, flat and densely vegetated freshwater wetland (approximately 100 acres) until reaching the US 101 culvert. The wetland was historically tidal wetland habitat before construction of the highway, and it has become perched, presumably due to sedimentation related to its disconnection with the estuary. General wetland elevations range from +9 to +12 feet NAVD88 (CREST 2005). Drainage of the wetland is through numerous small, diffuse and poorly defined channels. The wetland is bounded by Houtchen Street and the Chinook River to the north, the adjacent hillside to the east, and the US 101 berm on the west. The main drainage path of the distributary is nearly 5,000 feet in length.

1.2. Project Footprint

Work required to construct the proposed culvert includes excavation of the US 101 roadway and berm to place the culvert, as well as excavation of a starter tidal channel upstream (landward or east) and downstream (seaward or west) of the culvert. This channel will be approximately 220 feet in length. The approximate limits of excavation are shown in Sheet C02 (see Appendix D).

The road work will include widening of the existing roadway (currently 30 foot wide paved section) immediately adjacent to the proposed culvert by 3 feet on each side to conform to current WSDOT standards. The widening will occur over a total distance of approximately 60 to 70 feet along the road. The proposed elevations of the US 101 centerline alignment will match the existing grade (elevation +16.5 NAVD88) with no significant change in elevation.

1.3. Site Topography and Survey

Topography of the site is based on LiDAR data collected in January and February 2005 by the Puget Sound LiDAR Consortium. As part of this Project, verification of this LiDAR dataset was conducted. The verification was performed by field surveying spot elevations using a real-time kinematic global positioning system (RTK GPS) over a two day period in September 2008. The survey was difficult because of the irregular terrain and dense vegetation throughout the wetland, and resulted in collection of several partial transects through the wetland. Transects from the field survey were compared to transects of the LiDAR point data. Results of the LiDAR verification were documented in the Task C Alternatives Analysis Technical Memorandum to CREST (Tetra Tech 2008, included as Appendix A). One finding of the memo is that the LiDAR data appear to be of good quality, but contours are approximately 1 to 2 feet higher in elevation than actual ground surfaces, particularly in the southern region of the wetland. These discrepancies are likely due to the dense vegetation recorded as ‘bare earth’ in the LiDAR dataset. LiDAR elevations of the road surface and other locations outside of the wetland are more accurate, with differences of less than 6 inches on average.

The horizontal datum reference for the Project is Washington State Plane Coordinate System, Zone South, NAD 1983/91. Control points are to be based on WSDOT Monument IDs 6221 and 6222 per the Plans. The vertical reference datum is NAVD 1988 (NAVD88).

1.4. Geotechnical Investigation

A geotechnical investigation was conducted on August 5th and 6th, 2008 by Northwest Geotech, Inc. Two borings to a depth of 61.5 feet each were drilled at the proposed culvert location. Appendix B contains the results of the investigation which provides recommendations for earthwork and excavation, stripping, grubbing of the area to be excavated, seasonal work considerations, subgrade preparation, and cut and fill slopes. The investigation also recommends construction methods, embankment fill material and placement specifications, foundation and allowable soil pressure, expected settlement for footings if they are required, and embedded wall (culvert wingwall) criteria. Results of the geotechnical investigation were incorporated into the Project design.

(This page intentionally left blank)

Figure 1
Fort Columbia Culvert Location and Vicinity Maps

(This page intentionally left blank)

2. DESIGN

This section describes the primary components of the proposed Project, along with associated design standards, criteria, and supporting analyses. The following is a summary of the primary components of the Project:

- ⇒ A precast 12-foot span by 11-foot rise concrete culvert aligned perpendicular to the US 101 centerline. The culvert design considers fish passage criteria and potential flooding risks in the wetland.
- ⇒ The culvert foundation which is to include a cast-in-place (pre-cast may be suitable per CREST, structural and Tetra Tech review) reinforced concrete pile cap supported by driven steel H-piles. This foundation is referred to as "foundation/pile cap." The culvert also includes headwalls and wingwalls.
- ⇒ A 220-foot long starter channel for fish passage that starts approximately 40 feet below (downstream, seaward, or west of) the culvert and continues approximately 100 feet above (upstream, landward, or east of) the culvert. The channel design incorporates passive restoration for connection to and further development of existing drainage channels in the wetland.
- ⇒ A roadway design that includes widening adjacent to the culvert.
- ⇒ Approximately 140 feet of beam guardrails on each side of US 101 to provide safety for vehicles and meet current WSDOT requirements.
- ⇒ Rock slope protection on the seaward (west) side of the US 101 embankment to match and tie-into the existing slope protection.

2.1. Proposed Culvert

The proposed culvert will consist of precast reinforced concrete shallow-arch or three-sided sections furnished by the culvert vendor and to be placed by the contractor. The alignment along the culvert will be at a 90° skew (perpendicular) with US 101. The proposed location is approximately 450 feet southeast along US 101 from the existing culvert. The proposed location was selected to minimize impacts of excavation and grading on the existing marsh bench adjacent to the existing culvert, and to provide better drainage and tidal connection to the tidal channels within Baker Bay.

2.1.1. Fish Passage Analysis

This section describes analysis conducted for the design of the culvert based on fish passage requirements. Culvert size, dimensions, and invert elevation are evaluated. The design approach follows Washington Department of Fish and Wildlife (WDFW) Guiding Principles (WDFW 2003) for water crossing (culvert) design for tidal culverts.

The US Army Corps of Engineers River Analysis System (HEC-RAS) hydraulic model (USACE 2008) was used to model unsteady flows through the culvert and in the wetland. The hydraulic analysis is described in the Task C Technical Memorandum to CREST (Tetra Tech 2008). A key finding of the memorandum is that the proposed culvert exceeds the minimum depth criterion of 0.5 feet 100 percent of the time, and that it meets the maximum velocity criterion, 1.5 ft/s, 85 percent of the time.

2.1.2. Flood Analysis

Existing flooding along the Chinook River and the distributary near the northern border of the wetland (Houtchen Street, Figure 1) is a concern to residents of the Town of Chinook. A flood analysis was conducted to evaluate changes in peak flood elevations as a result of the project. The approach, methods, and results of the analysis are described in the following sections.

The HEC-RAS model (USACE 2008) described in Section 2.1.1 Fish Passage Analysis was used to assess impacts of the proposed culvert on flood elevations in the Project vicinity. The flood analysis compared the existing conditions to the proposed conditions with the goal of evaluating changes in peak water surface elevations (WSEs) within the distributary and wetland. Various tide and upstream inflow conditions were investigated in order to determine which case(s) were critical in affecting peak stages at locations of concern near Houtchen Street.

Tide Data

Three tide gage stations exist near Project site. The tidal benchmark data at these locations are summarized in Table 1. These data were used as the basis for developing downstream tidal boundary conditions applied in the flooding analysis. Primary downstream boundary conditions developed include a Mean Higher High Tide (MHHT) boundary with tidal variations up to +9.0

feet NAVD88, and maximum tide conditions with variations up to +12.0 feet NAVD88. The tidal boundary conditions used in the hydraulic model are shown in Figure 2 and Figure 3.

The Project vertical reference datum is NAVD88. From Table 1, NAVD88 is 0.18 feet above Mean Lower Low Water (MLLW) at Fort Stevens and 0.21 feet below MLLW at Astoria. Because these differences approximately offset, NAVD88 and MLLW were estimated to be equivalent at the Project location. The correlation between NAVD88 and MLLW was not reported (is not known) at the Chinook River station; however, the correlation based on Fort Stevens and Astoria data, i.e. no difference between these datums, was applied and is reflected in Table 1.

Table 1
Comparison of Tidal Datums in the Project Vicinity.

	Fort Stevens Station ID 9439008		Chinook River Station ID 9440573		Astoria (Tongue Pt) Station ID 9439040	
	Elev. in Feet:		Elev. in Feet:		Elev. in Feet:	
TIDAL DATUM:	MLLW	NAVD 88	MLLW	NAVD 88	MLLW	NAVD 88
HIGHEST OBS. WATER LEVEL (06/03/1981 Chinook R.)	NA	NA	9.9	9.9	12.37	12.58
MEAN HIGHER HIGH WATER (MHHW)	8.61	8.43	8.08	8.08	8.61	8.82
MEAN HIGH WATER (MHW)	7.91	7.73	7.4	7.4	7.94	8.15
Mean Diurnal Tide Level	NA	NA	NA	NA	4.31	4.52
MEAN TIDE LEVEL (MTL)	4.60	4.42	4.33	4.33	4.55	4.76
MEAN SEA LEVEL (MSL)	4.54	4.37	NA	NA	4.51	4.72
MEAN LOW WATER (MLW)	1.28	1.11	1.26	1.26	1.17	1.38
NORTH AMERICAN VERTICAL DATUM-1988 (NAVD)	0.18	0.00	0	0	-0.21	0
MEAN LOWER LOW WATER (MLLW)	0.00	-0.18	NA	NA	0	0.21
LOWEST OBSERVED WATER LEVEL (05/06/1981)	NA	NA	-2.48	-2.48	NA	NA

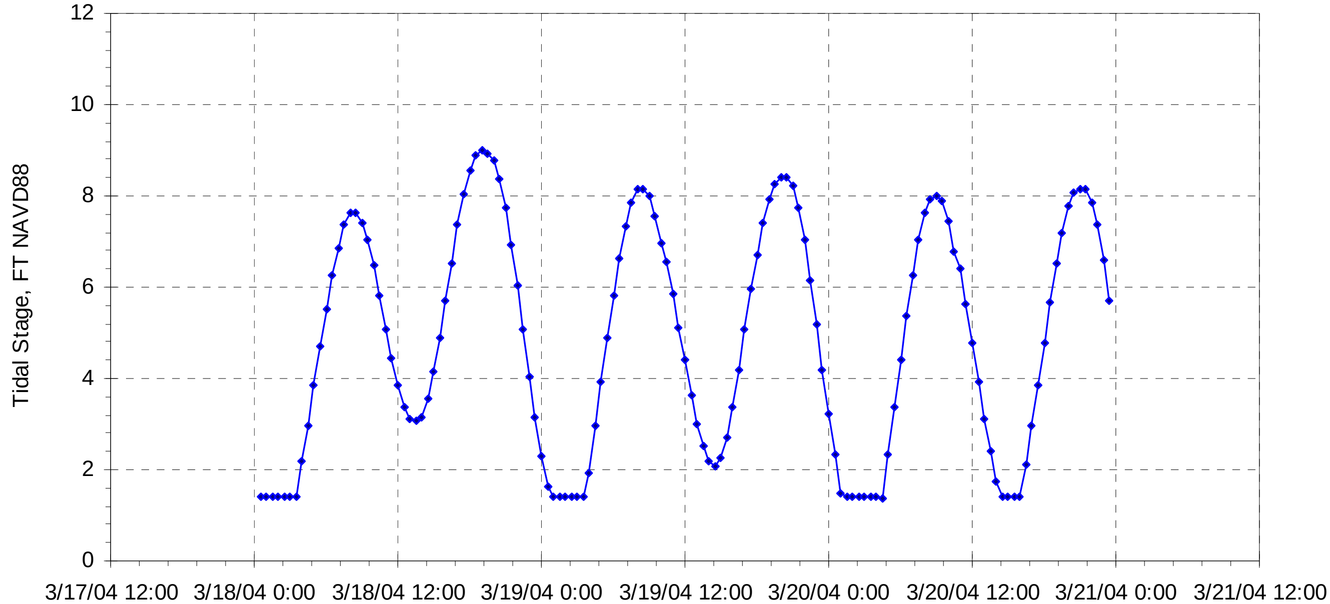


Figure 2
Representative mean higher high tide (MHHT) boundary condition.

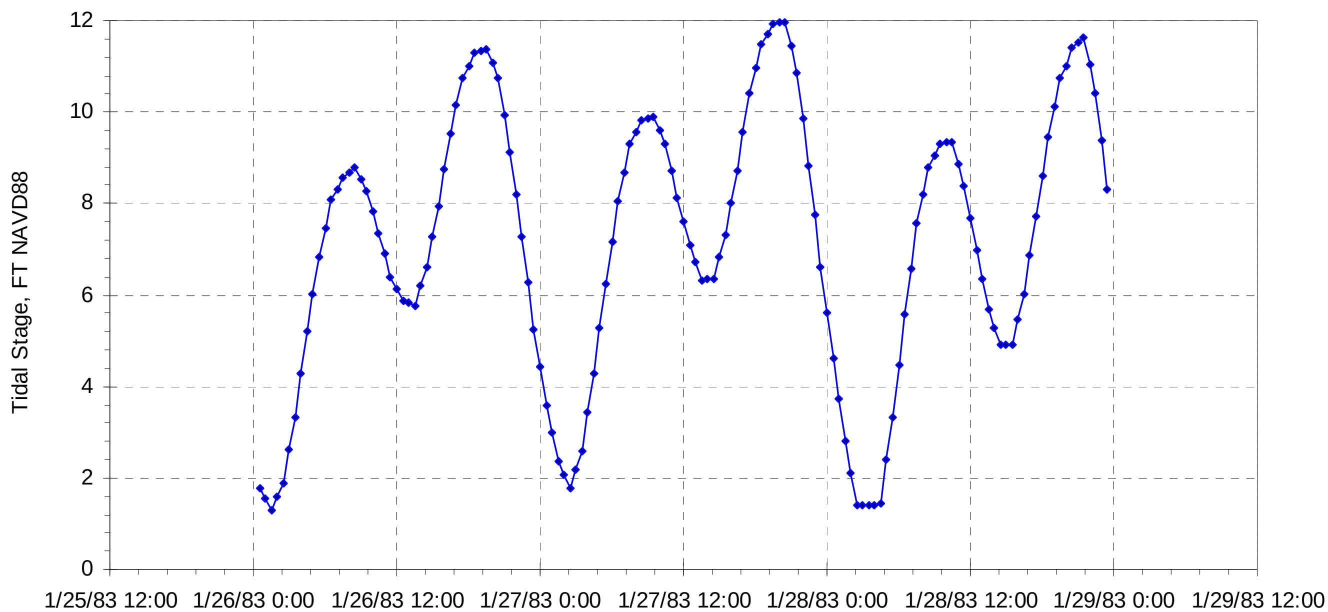


Figure 3
Representative maximum high tide (Max Tide) boundary condition.

Flow Data

Upstream inflows used in the flood analysis were based on hydrologic modeling conducted for the Chinook River (Khangaonkar et al. 2005). The hydrology model simulated baseflow and 100-

year flows at a subwatershed junction in the Chinook River approximately one mile downstream from the distributary ‘breakout’ location. Khangaonkar et al. (2005) estimated the baseflow to be 1 cfs and the 100-year peak discharge to be 220 cfs using the watershed model, HEC-HMS (Hydrologic Modeling System, USACEb 2008).

For the flood analysis of this Project, the distributary “1.01-year event” was estimated to be 5 cfs. The 1.01-year event has a 99 percent chance of being equaled or exceeded in any given year. This value was estimated based on general experience and judgement of the distributary and wetland. This estimate is intended to be somewhat conservative and appropriate for use in combination with the relatively infrequent ‘maximum’ tide boundary condition described in the previous section.

As mentioned, the 100-year peak discharge in the Chinook River downstream of the distributary was estimated to be 220 cfs. For this analysis, the 100-year peak discharge in the river at the distributary ‘breakout’ location was estimated to be 80 percent of the flow at the downstream location, or 180 cfs (rounded). This factor was based on the ratio of drainage areas at the distributary and the downstream subwatershed junction. The actual ‘breakout’ flow into the distributary was then estimated to be 30 percent of the Chinook flow (180 cfs) at the distributary during peak river stages which is 50 cfs (rounded). These values are summarized in Table 1.

Table 2
Estimated Inflow Boundary Conditions for the Distributary

Flow Event / Location	Flow (cfs)
Chinook R. Baseflow Downstream of Distributary[1]	1
Distributary 1.01-Year Flow[2]	5
100-Year Peak Chinook R. Flow Downstream of Distributary[1]	220
100-Year Peak Chinook R. Flow at Distributary[2]	180
100-Year Distributary Flow[2]	50

Notes:
1. Estimated in (Khangaonkar 2005).
2. Estimates developed for this project.

Scenarios were developed to compare existing and proposed WSEs under various tide and inflow boundary combinations. The upstream inflow conditions ranged from the “annual”1.01-year event to the 100-year peak discharge of the Chinook River to represents full avulsion of the river through the distributary and culvert. The model was run in unsteady mode to consider time-variation in the tides, and the inflows were held constant over the three-day simulation periods. The downstream tide conditions include the MHHT and maximum tide variations. These scenarios, labeled Scenario 1 through Scenario 8 for convenience, are summarized in Table 3.

Table 3
Existing and proposed condition simulations conducted for the flood analysis.

Scenario No.	Description
	Existing Conditions
1	1.01-Year Flow (5 cfs) and MHHT
2	100-Year Flow (50 cfs) and MHHT
3	100-Year Chinook Flow (Full Avulsion, 180 cfs) and MHHT
4	1.01-Year Flow (5 cfs) and Max Tide
	Proposed Conditions
5	1.01-Year Flow (5 cfs) and MHHT
6	100-Year Flow (50 cfs) and MHHT
7	100-Year Chinook Flow (Full Avulsion, 180 cfs) and MHHT
8	1.01-Year Flow (5 cfs) and Max Tide

Flood Analysis Results

Results of the flood analysis scenarios are summarized in the following profile plots. These figures show the longitudinal profiles of the water surface and ground elevations along the main distributary drainage, roughly north to south from Houtchen Street to the US 101 roadway embankment. In other words, the profiles are shown looking west towards Baker Bay from the east side of the wetland, with the culvert on the left and Houtchen Street on the right. The ground surface (channel invert in the wetland and tidal mudflat on the downstream-side of the culvert) is shown as the dotted black line in each figure. The black dots are ground surface points in the model, and the gray points represent interpolated ground surface points. In these figures, the existing ground surface is shown for reference. The water surface elevation (WSE) profiles represent the maximum elevation at each location throughout the simulation period; they do not represent results at a particular ‘snapshot’ in time. This is important to note because in reality WSEs will not be at a maximum at all locations simultaneously.

Figure 4 compares the existing conditions under the various tide/inflow conditions. From this plot, the highest WSEs in the wetland distributary resulted from high inflows plus the MHHT conditions (Scenario 3). The 1.01-year inflow plus maximum tide case (Scenario 4) was approximately 1 foot below Scenario 3 throughout the wetland. The main results to be noted from these scenarios were that the existing culvert is undersized and results in (1) muting of tidal inflows in the maximum tide condition (a benefit from a flooding perspective), and (2) insufficient drainage of the wetland particularly under very large inflows.

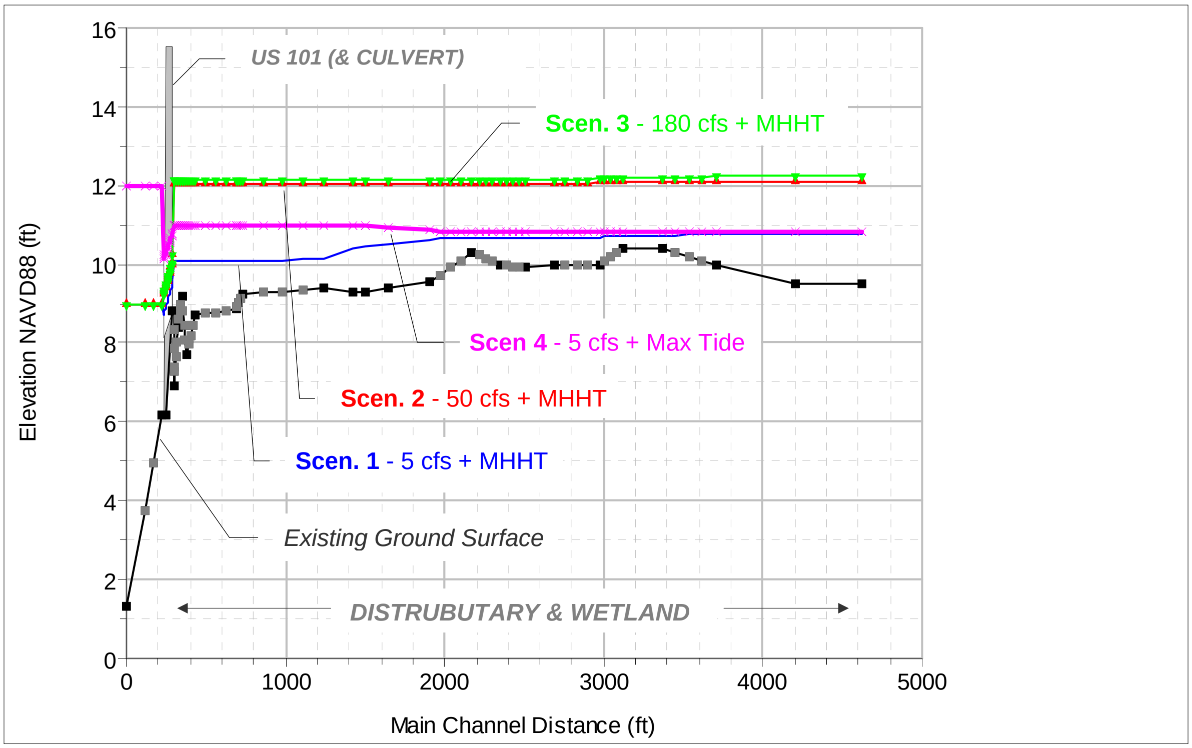


Figure 4
Existing culvert and distributary conditions under various tide/inflow boundary combinations

Figure 5 compares the proposed culvert conditions under the same four boundary conditions. Under proposed conditions, the highest WSEs (at upstream locations near Houtchen Street where flooding is critical) also resulted from the 100-year Chinook flow magnitude plus MHHT scenario (Scenario 7). However, unlike the existing condition which showed significant tidal muting, the highest WSEs in the immediate vicinity of the culvert were due to the 1.01-year flow plus Max Tide scenario (Scenario 8). In Scenario 8, the tide encroached upstream into the wetland approximately 2,000 feet. In the model, tidal elevations did not propagate upstream further because they began to recede again before the water surface could equilibrate throughout the wetland.

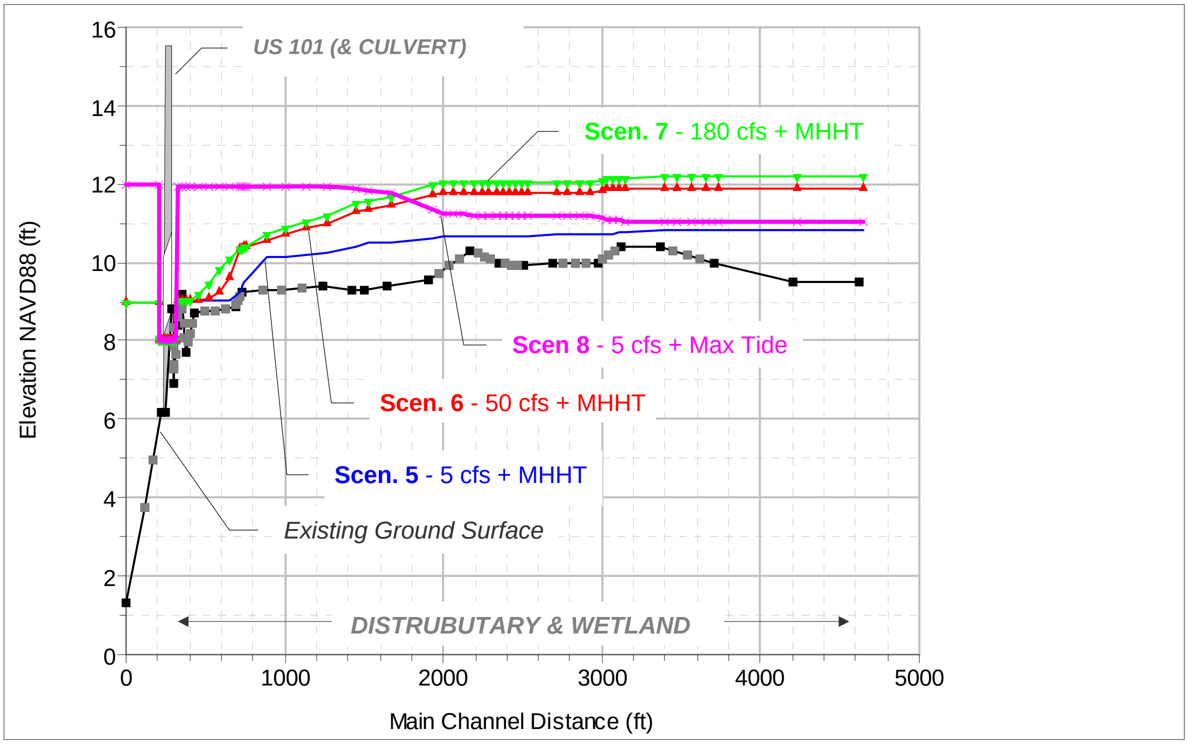


Figure 5
Proposed culvert and distributary conditions under various tide/inflow boundary combinations.

Figure 6 and Figure 7 compare existing and proposed conditions under the 100-year Chinook flow plus MHHT and 1.01-year flow plus Max Tide conditions, respectively. Figure 6 shows that there was no increase in the maximum WSE at any location in the distributary under proposed conditions (Scenario 18) during the estimated 100-year Chinook flow event.

Figure 7 shows that the proposed conditions under 1.01-year flows plus Max Tides caused a higher WSE than existing conditions in the vicinity of the culvert. This result may not be critical to overall flood concerns because peak WSEs near the culvert do not translate into equally high WSEs upstream near structures such as Sea Resources Fish Hatchery, Houtchen Street, and nearby neighborhoods. In addition, existing WSEs under the 100-year Chinook flow plus MHHT conditions (Scenario 3) were higher than proposed WSEs under the max tide conditions (Scenario 8). Results of Scenario 3 showed WSEs of approximately +12 feet NAVD88, versus Scenario 8 which showed elevations of slightly less than 12 feet. Therefore, under all scenarios, the proposed maximum water levels near critical locations (i.e., Houtchen Street) were lower than those under existing conditions.

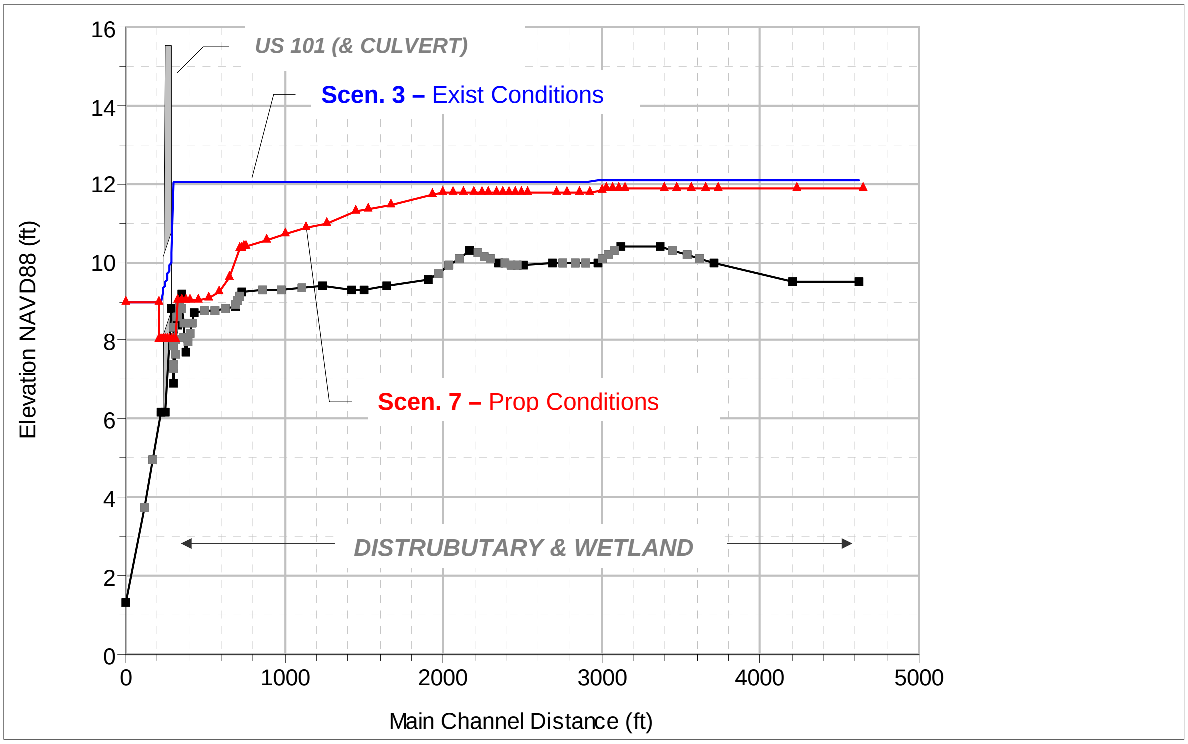


Figure 6
Existing and Proposed conditions under the 100-Year Chinook Flow (full avulsion) and MHHT boundary condition.

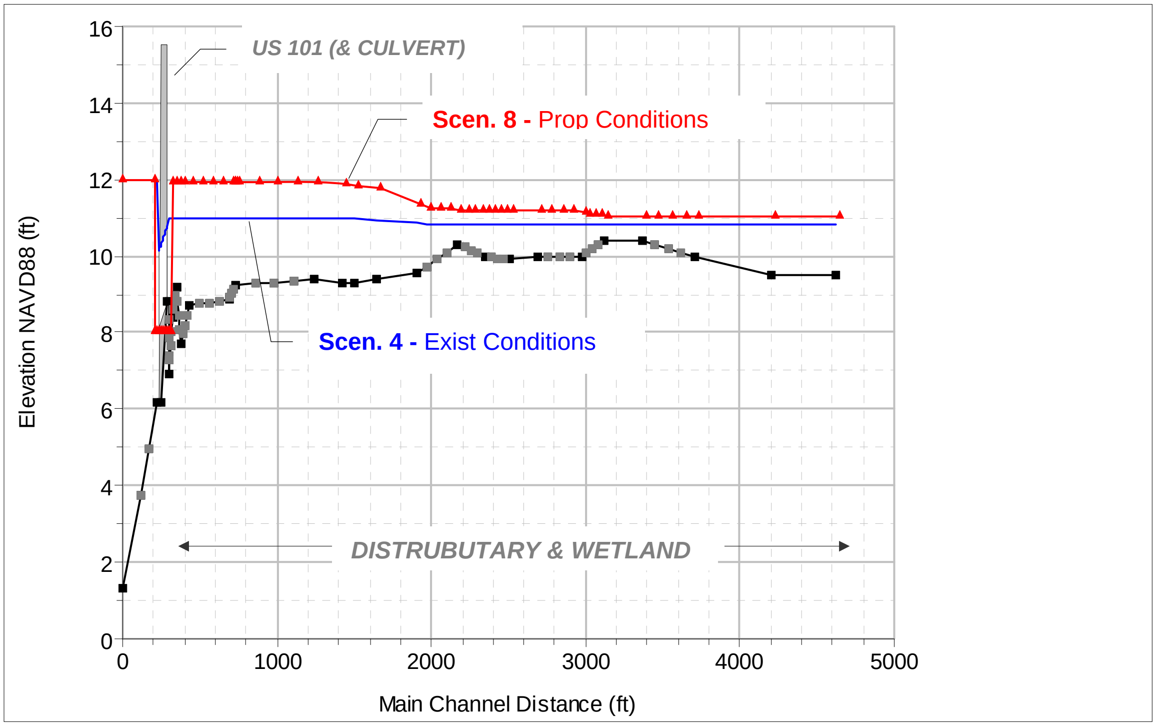


Figure 7
Existing and Proposed conditions under the 1.01-Year Flow and Max Tide boundary condition.

2.2. Culvert Foundation, Headwalls and Wingwalls

The foundation for the culvert includes a cast-in-place (CIP) reinforced concrete footings (footings/pile cap), supported by driven steel H-piles. A precast concrete footing/pile cap may be substituted for the CIP footing/pile cap by the contractor if approved by CREST, its engineer, and WSDOT. Design of the CIP concrete footing/pile cap and piles was based on the following standards:

- ⇒ AASHTO LRFD 4th and 17th Editions
- ⇒ AISC 9th Edition
- ⇒ ACI 318-08

Primary assumptions of the design include no seismic loading, and average undrained shear strength (Cu) of 750 PSI. The arrangement and layout of the culvert, foundation/pile cap and piles are as shown on the plans. The piles and pile cap are designed to support each side of the 80-foot long concrete culvert. Reactions at the pile cap from the earth dead loads and lateral earth pressures acting on the culvert were calculated. The live load from an HL-93 live load was also distributed to the culvert and the reactions calculated. The vertical and lateral reactions were then applied to the pile cap as a uniform distributed load.

Foundation recommendations in the geotechnical report include the allowable bearing capacity (80 tons) for an HP12x63 pile bearing in the weathered basalt bedrock. This size was selected, and the pile analyzed using LPILE v. 4.0. The pile cap was analyzed as a multi-span beam and concrete reinforcement designed in accordance with ACI 318-08. The culvert connection to the pipe cap was assumed as a 6-inch deep pocket with the culvert grouted in place.

The culvert end sections include provisions for fitting precast concrete headwalls and wingwalls, to be furnished by the precast concrete culvert vendor. The height of the headwalls was sized to contain the roadway fill over the culvert sections and is to be as shown on the plans. The wingwalls are to be precast concrete and were sized to match the height of the headwalls and to support the roadway embankment. The precast elements shall be designed in accordance with the "Standard Specifications for Highway Bridges" 17th Edition, adopted by the American Association of State Highway and Transportation Officials, 1996, as amended by the 1997, 1998, 1999, and 2000 Interim Revisions.

2.3. Culvert Channel

The proposed culvert channel begins 138 feet upstream (landward or east) of the US 101 centerline, and continues 82 feet downstream (seaward or west), including the section of the channel through the culvert. The proposed channel includes three sections or types based on its material composition, e.g. riprap or larger rock, or native substrate) and purpose:

(a.) Type A – channel with native substrate bottom and rock slope protection (heavy loose riprap) along the sideslopes to tie into the adjacent rock slope embankment. This rock provides protection against wind-wave erosion on the west side of the US 101 roadway embankment. The Type A channel also has heavy loose riprap below the native substrate surface to provide protection for the culvert footings on the west end of the channel,

(b.) Type B – a rock and native substrate section to provide scour protection for the culvert foundation, and

(c.) Type C - a native substrate section upstream of the culvert where foundation protection is not required.

These channel types are described in more detail in the following sections.

2.3.1. Channel Substrate and Composition

The first channel type, **Type A** – native substrate and wave protection rock channel, is located downstream of the culvert where the channel is exposed to wind-generated waves of Baker Bay. The rock used for channel Type A is to match the size, gradation , and finish grade of the rock slope protection used on the seaward embankment of US 101.The purpose of this channel type is to protect against the relatively large erosional forces of waves breaking and running onto the channel bottom. This channel type includes heavy loose riprap (per Section 2.3.2 below), a 6 inch base layer of rock spalls (drain or bedding rock) and a geotextile fabric to minimize loss of soils below the rock layer. Rock protection is to extend up the sideslopes of the channel from the bottom, and is to match the existing embankment rock protection where this channel daylights.

A one-foot thick layer of native substrate material is specified at the finish grade surface along the channel bottom of the Type A Channel to mimic a natural tidal channel. The channel bottom surface is expected to be highly dynamic with sands and silts will constantly being deposited and scoured from portions of this channel depending on the tide, outflow from the culvert, occurrences of storms, and general sediment transport and deposition within Baker Bay.

The rock and native substrate channel, **Type B**, is located primarily within the culvert. The purpose of the rock component of this channel type is to protect the culvert foundation from scour. This channel type also includes a natural substrate surface overlaying riprap which serves as scour protection for the culvert footing/pile cap. It is expected that natural substrate would naturally deposit on top of the riprap over time after construction. However, to facilitate natural function of the channel immediately after construction, backfilling the culvert channel with native sand and silt materials is specified.

The third channel type, **Type C** – native substrate channel, is comprised of native substrate with no underlying rock protection. This channel is located upstream of the culvert within the wetland, and is very broad. These sections will be excavated to finish grade, and thus the bed material will consist of the native sands and silt soils of the existing wetland. Depending on the appropriate elevation with respect to the tidal range, portions of this channel will be hydro-seeded and revegetated per the plans.

To provide scour protection at the upstream end of the culvert and along the foundations of the wingwalls on the east end of the culvert, a continuous and integrated layer of rock will be 'buried' below the finish grade of the Type B Channel. This rock layer is to be two-feet thick, include geotextile fabric, similar to the Type B rock protection, and is to form a continuous layer with the Channel Type B roc k protection.

2.3.2. Riprap Culvert Protection

The maximum velocities encountered under the proposed condition scenarios (see Table 3, Section 2.1.2) range from approximately -2 ft/s (inflow, flood tide) to 6.1 ft/s (outflow, ebb tide). The higher velocity of 6.1 ft/s occurs during outflow in Scenario 7 which involves the 100-year full Chinook flow if it were to fully avulse into the distributary.

Design of the "light-loose riprap" protection component of the rock and native substrate channel type is based on permissible shear stress and permissible velocity methods for the calculation of the median rock size, D50, originally documented by Norman (1975) in the Federal Highway Administration Hydraulic Engineering Circular 15 (HEC 15) and summarized by USACE (2001). According to USACE (2001) riprap with a D50 of 9 inches provides scour protection against velocities ranging from 7 to 11 ft/s. To account for uncertainties in the hydraulic modeling assumptions and results, impinging velocities at the wall of the culvert, and other uncertainties, a riprap with median diameter of 12 inches is specified. This rock size protects against velocities in the range of 10 to 13 ft/s. The thickness of the rock protection is to be 2 feet, and geotextile is to be used below the rock layer to minimize loss of soils below the riprap. The riprap gradations, summarized in Table 4, are based on standard gradation tables in USACE (2004) and fall within the bounds of WSDOT Specification 9-13.1(2) for "light-loose riprap."

Table 4
Light Loose Riprap (Rock and Natural Substrate Channel) and Heavy Loose Riprap (Rock Slope Protection, Section 2.4.2) Gradations.

Light Loose Riprap		Heavy Loose Riprap	
Sieve Size (in.)	Percent Passing (%)	Sieve Size (in.)	Percent Passing (%)
14 – 20	100	28 - 42	100
10 - 12	50	22 – 26	50
8 – 10	15	16 - 20	15
3	5	6	5

Tidal Scour

To check against scour from potential tidal velocities within the culvert that is expected to increase over time as the tidal prism within the wetland increases (due to natural formation of the drainage channels), an analysis of the peak tidal flow hydraulics was conducted. This analysis used a basic tidal hydraulic method to estimate the peak tidal discharge through an estuary or embayment. This method yields conservative (high) estimates of the peak tidal flow because it assumes no muting of the tidal flow (through the culvert).Thus it usually predicts higher flows than other methods such as hydraulic modeling or assumptions of orifice flow, etc. (USFHA 2004). The basic assumption with this method is that the entire estuary (wetland) fills and empties simultaneously with the tide. This is usually not the case, but it can be reasonable for smaller waterways. This equation for peak flow is given in Equation (1):

$$Q_{peak} = \frac{\pi \cdot Vol}{\Delta t} \qquad \text{Equation (1)}$$

Where

Q_{peak} = maximum discharge during a tidal cycle, cubic feet per second (cfs)

π = the constant Pi (3.14), dimensionless

Vol = volume of water in the wetland upstream of the culvert between high and low tides (tidal prism), ft^3

Δt = time period successive high and low tides, seconds (s)

With this method, the peak discharge was assumed to occur midway through the tidal variation. Results of this analysis are shown in Table 5. This table summarizes hydraulic parameters for four ‘volume’ cases:

- ⇒ the wetland volume immediately after construction per the plans (smallest volume);
- ⇒ the volume of a hypothetical evolved channel that is 5,000 feet long by 5 feet wide by 4 feet deep;
- ⇒ the volume of a hypothetical triangular prism (wedge) that has a 1,000 foot radius, 45 degree arc angle, and average depth of 4 feet (equivalent to 1000 foot by 200 foot (4.5 acres) by 4 foot rectangular prism); and
- ⇒ a case where these volumes are summed.

The intent of these cases was to demonstrate how representative volumes and corresponding hydraulics compare for several scenarios of channel formation. It is not known precisely how the wetland ground surface and drainage channels will evolve over time. Thus these cases represent an ‘order-of-magnitude’ evaluation of channel hydraulics under potential changes in the wetland tidal prism.

The parameters shown in the table include the flow computed from Equation (1), tidal volumes assumed, the tidal period of 6 hours for a semi-diurnal tide, the depth of flow in the culvert, and the corresponding maximum velocity in the culvert. The depth of flow in the culvert corresponds to a mean tide level of approximately +4 feet NAVD88. The velocity was calculated by dividing the peak flow by the flow area (water depth times culvert width). The results indicate that for all cases, the maximum culvert velocity is significantly less than the peak velocity under the 100-year flow conditions. This provides some assurance that significant wetland evolution (lowering in elevation) will be required before channel velocities approach the design velocity used to size the scour protection rock in the culvert.

Table 5
Estimates of flow and velocity in the culvert using peak tidal flow hydraulic methods.

Parameter	Immediately Post-Construction	Evolved Channel (5000'x5'x4')	Evolved Triang. Prism (1000' by 4' Ave. Depth)	**Sum Total**
Max. Flow, cfs	3.1	14.5	114.3	**131.9**
Volume, ft3	21,000	100,000	786,000	**907,000**
(Volume, ac-ft)	0.5	2.3	18.0	**20.8**
Tidal Cycle, hrs.	6	6	6	**6**
Flow Depth, ft	2.0	2.0	2.0	**2.0**
Culvert Width, ft	12	12	12	**12**
Max. Velocity, ft/s	**0.1**	**0.6**	**4.8**	**5.5**

2.3.3. Geomorphology and Passive Restoration

The recommended approach to tidal reconnection involves passive restoration. This approach includes excavating a starter channel upstream from the proposed culvert into the wetland. The starter channel will connect to the existing small, diffuse drainage paths within the wetland. The general size and extents of the channel are intended to balance immediate (post-construction) habitat benefits with costs and impacts on the existing wetland. The slope of the drainage channel is steep relative to typical tidal channels which are generally nearly flat. Accordingly, the channel is expected to erode in the upstream direction over time, and eventually reach a dynamic equilibrium slope given the existing wetland substrate, vegetation, and hydrology. By this process, the sedimentation that occurred in the area after the tidal marsh was effectively isolated from tidal interaction will be reversed.

General rates of channel formation were estimated to better understand if channel evolution would likely occur quickly such as within a season, or longer term such as several years or decades. Two scenarios were developed to examine the sensitivity of formation rates to different potential channel dimensions. The scenarios both included multiple (five) drainage channels because it is likely that there will be more than one drainage path through the wetland into the starter channel. The scenarios assumed width to depth ratios of 2 and 5 based on observations made during the LiDAR verification field survey and other site visits. The scenarios were:

⇒ Multiple channels (5) with an approximate width to depth ratio of 2,

⇒ Multiple channels (5) with an approximate width to depth of 5.

Flow Duration

To calculate rates of channel formation within the wetland, a flow-duration curve for the distributary was estimated. A flow-duration curve shows the percent of time that a flow is at or above a particular magnitude. It is based on average daily flows, and it is required to integrate erosion rates over time to estimate the average rate of erosion.

Flow data are not available for the Chinook River or the wetland distributary. Thus a nearby station was used as a surrogate. The nearest USGS station is Bear Branch (USGS No. 12009500), located approximately five miles northwest of the Chinook River distributary. Bear Branch runs northwest before joining Bear River which drains to Willapa Bay to the north. The subdrainage area above this gage is 11.7 square miles, approximately 4 times larger than the estimated drainage area to the distributary (2.9 square miles). The elevation of the datum at the gage is +15.0 feet MSL (NGVD29), approximately the same elevation as the distributary location on the Chinook River. The topography appears similar, as Bear Branch and the Chinook River both begin on Bear Ridge, a low range that runs predominately north-south between the towns of Naselle and Chinook. The mean annual precipitation at Bear Branch is 87 inches per year, compared to 79 inches per year estimated at the distributary (USGS 2009). Because of these similarities and the proximity of these drainages to one another, it seems reasonable to use the Bear Branch flow-duration relationship to develop the same curve for the distributary.

The USGS has developed correlations of peak flow magnitudes between gaged and ungaged basins within various hydrologic regions in Washington (Knowles and Sumioka 2001; Sumioka et al. 1998). However, similar correlations for lower, more common flows such as average daily events have not been developed. Hence a simple correlation between flow durations of Bear Branch and the distributary was applied. This method uses the ratio of tributary areas to scale flows for the distributary. The ratio of tributary areas of the Chinook River at the distributary location and Bear Branch is 0.25 (2.9 square miles divided by 11.7 square miles). Additionally, for this channel formation analysis it was assumed that 20% of the Chinook River breaks out into the distributary during common, daily flows. This assumption is conservatively high and actual rates are expected to be lower. Figure 8 shows the flow-duration curve for Bear Branch, and the calculated curves for the Chinook River (for reference) and the distributary. These values are also summarized in Table 6.

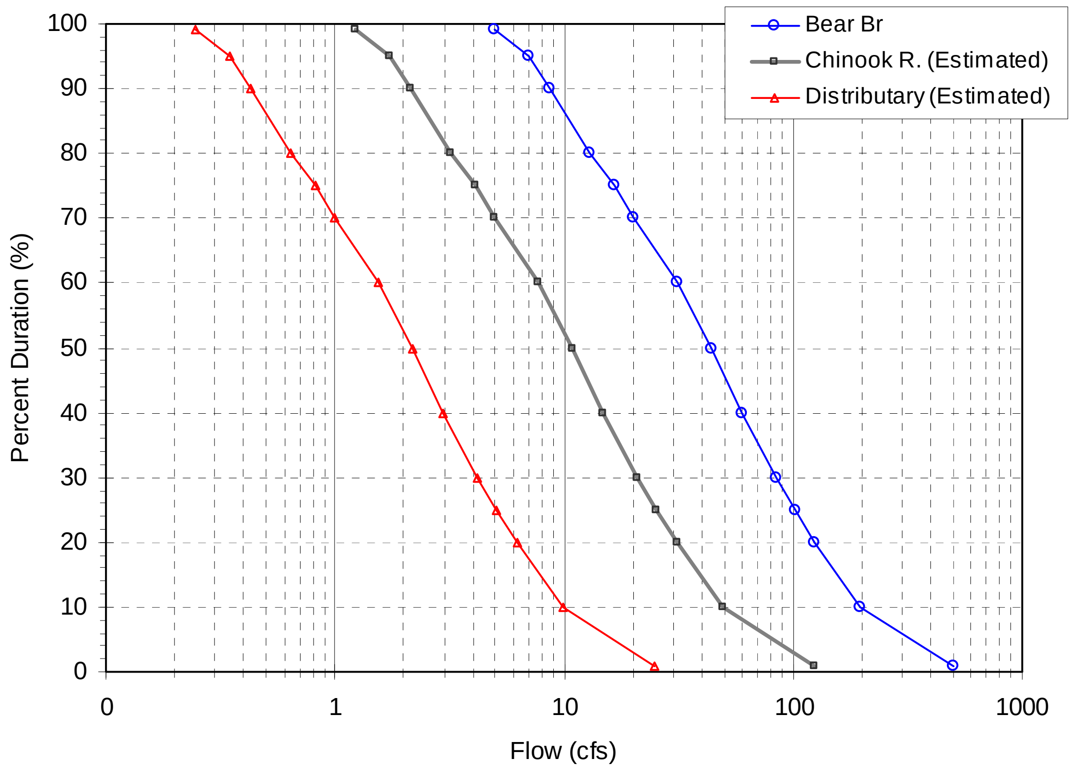


Figure 8
Flow frequency curves for Bear Branch gage and estimated curves for the Chinook River and the distributary.

Table 6
Flow duration for Bear Branch and the Chinook River Distributary.

Percent Duration	Bear Branch Flows (cfs)	Chinook R. Flows (cfs)	Distributary Flows (cfs)
1	499.9	123.9	24.8
10	198.0	49.1	9.8
20	125.0	31.0	6.2
25	102.0	25.3	5.1
30	85.0	21.1	4.2
40	60.0	14.9	3.0
50	44.0	10.9	2.2
60	31.0	7.7	1.5
70	20.0	5.0	1.0
75	16.5	4.1	0.8
80	13.0	3.2	0.6
90	8.7	2.2	0.4
95	7.0	1.7	0.3
99	5.0	1.2	0.2

Hydraulics

Hydraulics calculations were then performed for the discrete flow levels in the distributary as shown in Table 6. Normal depths were calculated using Manning's Equation, and the channel bottom slope was varied until velocities became critical to represent erosion rates at the point of channel extension where flows transition from the relatively flat wetland topography to the over-steepened starter channel. A roughness coefficient of 0.07 was applied to represent well-established vegetation in the wetland. A steep sideslope of 0.2 horizontal to 1 vertical (0.2H:1V) was assumed to represent small tidal channels that generally have steep banks.

Incipient Motion and Channel Bed Erosion

Once the hydraulic characteristics were calculated, incipient motion assumptions were used to predict the rate at which channel erosion would take place. Incipient motion is generally defined as the threshold condition above which the hydraulic forces acting on the grain of sediment particles would initiate motion of the grain. For this analysis, a bed material resistance 'n' value of 0.015 was assumed; this value corresponds to a particle diameter of 0.007 feet (2.2 mm). This value was used to calculate the Darcy-Weisbach friction factor, f, as a function of the hydraulic radius for the various flow levels considered. The hydraulic bed shear stress was then calculated based on the friction factor and square of the velocity.

Channel bottom erosion rates were estimated using the Meyer Peter-Muller bed load transport formulation. The classic form of this equation includes the difference between the applied hydraulic bed shear stress and Shields critical bed shear (Shields parameter of 0.03 assumed), raised to the power of 1.5. The daily erosion rate was integrated over the top width of the drainage channels and also across the flow-duration range using incremental differences between duration-flow values.

Results

Results of the channel formation rate analysis are summarized in Table 7. Ranges in velocities, shear stresses and erosion rates correspond to the range in distributary flows shown in Table 6: 0.2 cfs (99% flow) to 24.8 cfs (1% flow). For example, under the case with a width-to-depth ratio of 2, the velocities of the 99% flow and 1% flow were 1.4 ft/s and 5.4 ft/s, respectively. Overall, the results were insensitive to the different channel configurations. Estimated rates of erosion ranged from 1,700 to 1,800 tons per year (1,200 to 1,300 cubic yards per year). These rates are slightly less than half of the volume of drainage channels that would be eroded over time. Thus, the theoretical time for channel formation to occur was estimated to be over two years.

The estimated time for channel formation is described as ‘theoretical’ because in reality several other factors not considered in the analysis affect rates of erosion. These include the dense wetland vegetation which could slow erosion processes significantly. In addition the actual rate of erosion would likely decrease as the channel evolved and the bed slope decreased. Conversely, significant erosion and channel formation could result from infrequent, large peak flows through the distributary. Channel formation over several relatively ‘low-flow’ years could be equaled or exceeded by one or a series of peak flows in any given year. The general nature of sediment transport and channel erosion is irregular and difficult to predict accurately.

In summary, channel formation could occur over the course of several years, possibly up to a decade or even longer. Under particularly large and infrequent flows that could occur in any given year, this duration could be shortened. The wetland has been effectively disconnected for at least 80 years. It is reasonable to expect that processes that would reverse the effects of this disconnection could require a significant period of time.

Table 7
Summary results of channel formation-rate analysis

Channel Configuration Assumed	Velocity Range, ft/s	Shear Stress Range, lb/ft^2	Annual Erosion Rate, tons/yr (CY/yr)	Estimated Theoretical Time for Channel Formation
Multiple Channels (5), W/D=2	1.4 – 5.4	0.03 – 0.23	1,700 (1,200)	Over 2 years
Multiple Channels (5), W/D=5	1.3 – 5.4	0.02 – 0.22	1,800 (1,300)	Over 2 years

2.4. Roadway Design

The proposed horizontal alignment of the US 101 centerline is to follow that of the existing centerline. The proposed centerline is currently based on a georeferenced aerial photograph of the site because this section of US 101 has not been surveyed and no other definition currently exists. The (horizontal) resolution of the aerial photograph is estimated to be approximately five feet. The vertical alignment of the roadway is not expected to require modification to meet culvert cover requirements. The proposed roadway section will be widened to a 38-foot top width (36 foot paved width) adjacent to the culvert in order to conform to current WSDOT standards, as shown on the plans. The US 101 surface will be hot mix asphalt (HMA) pavement, and the roadway berm will have a 10:1 side slope on the east embankment and a 4:1 side slope on the west embankment. Fill material for the roadway embankment would be imported and compacted to a maximum dry density per the Geotechnical Report (Appendix B), before placing the surfacing base course and HMA pavement as shown on the plans.

At the roadway widening a metal guardrail will be installed above the culvert. Drainage from the roadway surface will sheet flow down the revegetated and rock slope embankments where it will infiltrate. The increase in impervious area due to the pavement widening is approximately 340 square feet.

2.4.1. Guardrail Design

Guardrail will be placed on both sides of the roadway at the culvert crossing and will extend a distance of approximately 70 feet beyond the culvert on each side with offset returns. Design details of the guardrail are to follow WSDOT Standard Plan C-22.40-01..

2.4.2. Roadway Embankment – Rock Slope Protection

The west side of the US 101 roadway embankment is exposed to wind-wave action from Baker Bay. This side of the embankment is to include a rock slope protection as shown on the plans. The side slope of the embankment is to vary by location on the embankment: 2H:1V above the headwall and wingwalls; and match the existing embankment slope beyond the limits of the culvert structures and channel. Per the recommendation of WSDOT during design review meetings, the rock slope protection is based on the heavy loose riprap called for in the WSDOT US 101 Fort Columbia Vic. Realignment project (WSDOT 2004). This project involved a culvert channel located along US 101 approximately one mile south of the proposed culvert. The heavy loose riprap specified was a two-foot nominal size. The gradation specified in the plans conforms to the WSDOT heavy loose riprap specification, and is appropriate for the layer thickness of 4 feet including a 6 inch layer of base rock. Geotextile fabric will be used below the base rock to minimize loss of embankment fill material.

3. CONSTRUCTION

This section describes the estimated construction costs and construction schedule. Assumptions and details of the cost and schedule estimates are outlined in the following sections.

3.1. Cost Estimate

The total construction cost is estimated to be $876,000, and the direct cost subtotal is $581,778. The unit costs were developed based on recent quotes from material and structure vendors, reference cost information form recent and nearby projects, WSDOT standard unit costs, and engineering experience. Table 8 summarizes the construction cost estimate for the proposed Project.

The estimate includes a 15 percent allowance to reflect design and engineering uncertainties representative of this 90% level of design. A State of Washington sales tax of 9% was also applied. Construction engineering and contingencies (for potential weather delays, construction uncertainties, etc.) of 20% total were also factored into the total cost. Cost are in 2009 dollars and do not include an escalation factor to adjust costs if the Project is not built in 2009. Also not included are costs associated with easements, land acquisition, operation and maintenance (expected to be minimal) and permits. The quantity calculations corresponding to the cost estimate are contained in Appendix C.

3.2. Construction Schedule

A construction schedule is presented in Table 9. The schedule is based on construction of half of the Project at a time in order to keep one lane of US 101 open throughout construction. The schedule refers to an “East Construction Duration” and a “West Construction Duration” to reflect construction phases to be completed separately. Primary assumptions included one eight-hour shift per day because the work may occur in November when daylight is limited, and a five-day work week. Other work rate details, assumptions, and allowances are described in the column “Notes” in the table

The total construction duration was estimated to be 8 weeks, approximately 38 days (rounded up). Construction on the east side of the road was estimated to occur over approximately 22 days, and west construction would take nearly 16 days. This schedule assumed work rates that are realistic but somewhat higher than typical because of the desire to minimize traffic obstruction. However, work rates are not excessive such that additional costs (for specialty equipment, contractors, etc.) would be incurred.

Some work activities were assumed to take place concurrently with other activities. These concurrent activity durations do not affect the overall construction duration. For example, it was assumed Item 3.6, “Placement channel rock” in the culvert, could occur while the culvert foundation concrete was curing. Concurrent work items are denoted by italic text.

Table 8
Total Construction Cost Estimate.

STD ITEM NO.	UNIT	WORK ITEM	NO. OF UNITS	UNIT COST	TOTAL COST	NOTE / TYPE
		SECTION 1: PREPARATION				
0001	LS	MOBILIZATION	5%		$27,704	Std Item
0025	AC	CLEARING AND GRUBBING	0.2	$5,000	$1,000	Std Item
		SECTION 2: GRADING				
0310	CY	ROADWAY EXCAVATION INCL. HAUL	1,449	$20	$28,986	Std Item
0408	TON	SELECT BORROW INCL HAUL	400	$15	$6,000	Std Item
0470	CY	EMBANKMENT COMPACTION	498	$5	$2,489	Std Item
		SECTION 4: DRAINAGE				
1040	CY	CHANNEL EXCAVATION INCL. HAUL	1,640	$30	$49,200	Amendment Item
1073	TON	LIGHT LOOSE RIPRAP	240	$45	$10,780	Std Item
1075	TON	HEAVY LOOSE RIPRAP	560	$60	$33,600	Std Item
--	LS	DEWATERING SYSTEM	1	$20,000	$20,000	Special Provision
GSP	LF	PRECAST CONCRETE CULVERT (3-SIDED)	80	$1,220	$97,600	GSP 6-023281.GR6
		SECTION 8: STRUCTURE				
4006	CY	STRUCTURE EXCAVATION CLASS A INCL HAUL	335	$30	$10,050	Std Item
4013	LS	SHORING (COFFERDAM CONSTRUCTION)	1	$39,000	$39,000	Std Item
4025	CY	GRAVEL BACKFILL FOR WALL	72	$70	$5,023	Std Item
4090	LF	FURNISHING ST. PILING	547	$30	$16,410	Std Item
4095	EA	DRIVING ST. PILING	18	$2,222	$40,000	Std Item
4150	LB	ST. REINF. BAR FOR RETAINING WALL	18,419	$1.00	$18,419	Std Item
4151	LB	ST. REINF. BAR FOR PILE CAP FOOTING	9,097	$1.00	$9,097	Std Item
4202	CY	CONC. CLASS 4000 FOR PILE CAP FOOTING	56	$300	$16,800	Std Item
4139	CY	CONC CLASS 4000 FOR RETAINING WALL	113	$350	$39,550	Std Item
		SECTION 9: SURFACING				
5100	TON	CRUSHED SURFACING BASE COURSE	67	$55	$3,667	Std Item
		SECTION 14: HOT MIX ASPHALT				
5767	TON	HMA CL 1/2 IN PG 64-22	95	$135	$12,858	Std Item
		SECTION 17: EROSION CONTROL AND PLANTING				
6403	DAY	ESC LEAD	15	$100	$1,500	Std Item
6463	LF	CHECK DAM	20	$20	$400	Std Item
6468	SY	STABILIZED CONSTRUCTION ENTRANCE	60	$30	$1,800	Std Item
6373	LF	SILT FENCE	210	$5	$1,050	Std Item
6490	EST	EROSION/WATER POLLUTION CONTROL	1	$30,000	$30,000	Std Item
6414	AC	SEEDING, FERTILIZING, AND MULCHING	0.2	$6,500	$1,300	Std Item
6400	CY	TOPSOIL TYPE C	5	$45	$225	Std Item
		SECTION 18: TRAFFIC				
6751	LF	BEAM GUARDRAIL TYPE 1	280	$30	$8,400	Std Item
6717	EA	BEAM GUARDRAIL NON-FLARED TERMINAL	4	$3,000	$12,000	Std Item
6771	EA	BEAM GUARDRAIL ANCHOR TYPE 1	4	$1,000	$4,000	Std Item
6806	LF	PAINT LINE	210	$2	$420	Std Item
6973	LS	OTHER TEMPORARY TRAFFIC CONTROL	1	$2,000	$2,000	Std Item
6980	HR	FLAGGERS AND SPOTTERS	310	$45	$13,950	Std Item
6992	HR	OTHER TRAFFIC CONTROL LABOR	80	$45	$3,600	Std Item
6982	SF	CONSTRUCTION SIGNS CLASS A	70	$20	$1,400	Std Item
		SECTION 20: BUILDING				
8082	LS	FORMWORK	1	$11,500	$11,500	Technical Spec
		Construction Item Subtotal			***$581,778***	
		Design Allowance	15%		$87,267	
		Subtotal - total project			***$669,045***	
		Sales Tax	9%		$60,214	
		Subtotal			***$729,259***	
		Construction Engineering	15%		$109,389	
		Construction Contingencies	5%		$36,463	
		CONSTRUCTION TOTAL			**$876,000**	(Rounded)

Table 9
Estimated Construction Schedule.

NO.	DESCRIPTION	QTY	UNIT	RATE QTY	RATE UNIT	DURATION QTY	DURATION UNIT	Notes
0.0	**Misc**							
0.1	Labor shift duration	8	HR					Assumes November work window
1.0	**Site Preparation**							
1.1	Mobilization					2.0	DAY	Allowance
1.3	Install erosion control (concurrent)					0.5	*DAY*	Allowance, concurrent
1.4	Install traffic control (concurrent)					0.5	DAY	Allowance, concurrent
1.2	Clear and Grub					1.0	DAY	Allowance, concurrent
	Subtotal					***4.0***	***DAY***	
2.0	**Excavation - East**							
2.1	Place shoring equipment					2.0	DAY	Allowance for sheeting/piles shoring between N/S lanes
2.2	Excavate east half of roadway	725	CY	120	CY/HR	1.0	DAY	(2) 1-CY excav @ 1 cycle/1 MIN EA = 120 CY/HR, 8 HR SH/DAY
2.3	Excavate east channel	1,213	CY	120	CY/HR	2.0	DAY	
	Subtotal					**5.0**	***DAY***	
3.0	**Culvert & Channel Construction - East**							
3.1	Drive foundation piles	10	EA	4	EA/SH	2.5	DAY	Assume 1 PILE/2.5HR (4 EA/DAY)
3.2	Lay foundation base course	11	CY	2	CY/HR	0.7	DAY	Allowance
3.3	Place foundation forms					1.0	DAY	Assume forms constructed at laydown area (concurrently)
3.4	Place foundation reinforcing steel					1.0	DAY	Allowance - 0.5 DAY per side
3.5	Pour foundation concrete - quick cure					1.5	DAY	1/2 day pour, 24 hr 3k-4k PSI concrete assumed
3.6	*Place channel rock*	84	TN	5	TN/HR	*2.1*	*DAY*	Assume 70% channel rock placed concurrent w/ curing, placed @ 5 TN/HR
3.7	Set Precast Culvert Sections	4	EA	8	EA/SH	0.5	DAY	Includes grouting
3.8	Place remaining channel rock	36	TN	2	TN/HR	2.2	DAY	Assume slower 2 TN/HR RR placement w/in culvert
3.9	*Place precast wing/headwalls*					*2.0*	*DAY*	Allowance, assume concurrent with foundation construction
3.10	Backfill & compact roadway	249	CY	40	CY/HR	0.5	DAY	
3.11	*Place topsoil, mulch, hydroseed*	0.11	AC	1.0	AC/SH	*0.1*	*DAY*	Concurrent w/backfilling
	Subtotal					***10.1***	***DAY***	
4.0	**Road Construction - East**							
4.1	Construct guardrail	140	LF	100	LF/SH	*1.4*	*DAY*	Allowance
4.2	Place base course	33	TN	5	TN/HR	*0.6*	*DAY*	Allowance
4.3	Place HMA	48	TN	10	TN/HR	*0.4*	*DAY*	Allowance
4.4	Road striping	70	LF	60	LF/HR	*0.1*	*DAY*	Allowance
	Subtotal					***2.4***	***DAY***	
	East Construction Duration					**21.5**	**DAY**	Includes site prep
5.0	**Excavation - West**							
5.1	Set up traffic/erosion control					3.0	DAY	Allowance, includes temp lane alignment
5.2	Excavate east half of roadway	725	CY	120	CY/HR	1.0	DAY	(2) 1-CY excav @ 1 cycle/1 MIN EA = 120 CY/HR, 8 HR SH/DAY
5.3	Excavate east channel	123	CY	120	CY/HR	1.0	DAY	
	Subtotal					**5.0**	***DAY***	
6.0	**Culvert & Channel Construction - West**							
6.1	Drive foundation piles	8	EA	4	EA/SH	2.0	DAY	Assume 1 PILE/2.5HR (4 EA/DAY)
6.2	Lay foundation base course	11	CY	2	CY/HR	0.5	DAY	Allowance
6.3	Place foundation forms					1.0	DAY	Assume forms constructed at laydown area (concurrently)
6.4	Place foundation reinforcing steel					1.0	DAY	Allowance - 0.5 DAY per foundation
6.5	Pour foundation concrete - quick cure					1.5	DAY	1/2 day pour, 24 hr 3k-4k PSI concrete assumed
6.6	*Place channel rock*	84	TN	5	TN/HR	*1.4*	*DAY*	Assume 70% channel rock placed concurrent w/ curing, placed @ 5 TN/HR
6.7	Set Precast Culvert Sections	4	EA	8	EA/SH	0.5	DAY	Includes grouting
6.8	Place remaining channel rock	36	TN	2	TN/HR	1.5	DAY	Assume slower 2 TN/HR RR placement w/in culvert
6.9	*Place precast wing/headwalls*					*1.0*	*DAY*	Allowance, assume concurrent with foundation construction
6.10	Backfill & compact roadway	249	CY	40	CY/HR	0.5	DAY	
						8.5	***DAY***	
7.0	**Road Surfacing - West**							
7.1	Construct guardrail	140	LF	100	LF/SH	*1.4*	*DAY*	Allowance
7.2	Place base course	33	TN	5	TN/HR	*0.6*	*DAY*	Allowance
7.3	Place HMA	48	TN	10	TN/HR	*0.4*	*DAY*	Allowance
7.4	Road striping	140	LF	60	LF/HR	*0.2*	*DAY*	Allowance
	Subtotal					***2.5***	***DAY***	
	West Construction Duration					**16.0**	**DAY**	Includes site prep
5.0	**TOTAL DURATION**					**38**	**DAY**	Total work days
						(8	***WKS)***	Rounded-up, assumes 5 day work week

Notes:
1. Italics denotes concurrent work item, not included on critical schedule.
2. Schedule assumes 5 day work week, (1) 8-hour shift per day.

4. REFERENCES

CREST 2006. Fort Columbia Restoration Project Summary. Prepared by A. Whiting, Wetlands Coordinator, Columbia River Estuary Study Taskforce, April, 2006.

USFHA 2004. US Federal Highway Administration, National Highway Institute, Hydraulic Engineering Circular No. 25, Tidal Hydrology, Hydraulics, and Scour at Bridges – First Edition, December 2004.

Khangaonkar T, S. Breithaupt and F. Kristanovich 2005. Restoration of Hydrodynamic and Hydrologic Processes in the Chinook River Estuary, Washington – Feasibility Assessment. Pacific Northwest National Laboratory, Battelle Research Center, Seattle, WA, 2005.

Knowles, S.M. and Sumioka, S.S. 2001, The National Flood-Frequency Program—Methods for Estimating Flood Magnitude and Frequency in Washington, 2001: U.S. Geological Survey Fact Sheet FS-016-01, 4 p.

Norman, J. N. 1975. Design of Stable Channels with Flexible Linings. Hydraulic Engineering Circular 15 (HEC 15), U.S. Dept. of Transportation, Federal Highway Adm., Washington, DC.

Sumioka, S.S., Kresch, D.L., and Kasnick, K.D., 1998, Magnitude and Frequency of Floods in Washington: U.S. Geological Survey Water-Resources Investigations Report 97-4277, 91 p.

Tetra Tech 2003. Southwest Washington Streams, Survey Field Data: Mile Post 3.3 "Chinook Wetland." Wetland Survey for WA State Dept. of Transportation.

Tetra Tech 2008. Technical Memorandum – Phase II Initial Tasks, Task C Alternatives Analysis. Prepared for CREST by Tetra Tech, Portland, October 2008.

USACE. 2008. US Army Corps of Engineers Hydrologic Engineering Center River Analysis System (HEC-RAS) User's Manual, Version 4.0, March 2008.

USACE 2008b. US Army Corps of Engineers Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) User's Manual, Version 3.3, September 2008.

USACE 2004. Hydraulic Design of Flood Control Channels. US Army Corps of Engineers, Engineering Manual, EM 1110-2-1601, June 30, 1994.

USACE 2001. "Stability Thresholds for Stream Restoration Materials," C. Fischenich, EMRRP Technical Notes Collection (ERDC, TN-EMRRP-SR-29), US Army Engineer Research and Development Center, Vicksburg, MS.

USGS 2009. US Geological Survey, Water Resources, National Water Information System (NWIS), StreamStats National Data-Collection Station Information, URL: "http://streamstats.usgs.gov/gages/viewer.htm."

WDFW 2003. Design of Road Culverts for Fish Passage. Washington Department of Fish and Wildlife, 2003.

WSDOT 2004. US 101 Fort Columbia Vic. Realignment (MP 2.46 to MP 1.85) – Contract Provisions and Plans. WSDOT F.A. Project Number STPE-9999(344), Pacific County, Washington, November 2004.

APPENDIX A

TASK C TECHNICAL MEMORANDUM – ALTERNATIVES ANALYSIS

(This page intentionally left blank)

APPENDIX B

GEOTECHNICAL ANALYSIS TECHNICAL MEMORANDUM

(FINAL DRAFT APRIL 2009)

(This page intentionally left blank)

APPENDIX C

QUANTITY TAKE-OFF DATA USED IN COST ESTIMATE

(This page intentionally left blank)

Quantity Take Off Data Used in 90% Cost Estimate

		Dimensions						Total	
No.	Item	Height	Unit	Length	Unit	Width	Unit	Total	Unit
1.0	**Roadway**								
	Crushed base course	0.35	FT	200	LF	36	FT	**66.7**	**TN**
	Paving - HMA	0.5	FT	200	LF	36	FT	**95.2**	**TN**
2.0	**Cofferdam Construction**	15	FT	130	LF			**1950.0**	**SF**
3.0	**Excavation**								
	Roadway Berm	14	FT	43	LF	65	FT	**1449**	**CY**
	Channel - West	9	FT	41	LF	18	FT	123	CY
	Channel - Culvert (overexcav.)	6	FT	84	LF	16	FT	299	CY
	Channel - East							1213	CY
	Subtotal - Channel							**1640**	**CY**
4.0	**Culvert Structure**								
	Foundation								
	CIP culvert footing/pile cap	3	FT	84	LF	3	FT	56.0	CY
	Piles - furnish	18	EA	30.4	LF			547	LF
								17.3	TN
	Piles - install			4	EA/SH			5.0	SH
								$2,222	$/EA
	Culvert								
	Furnish Unit Cost							$1,000	$/LF
	Install Unit Cost	8	SECTS	1	HR/SECT	$8,000	$/SH	$100	$/LF
								1100	**$/LF**
5.0	**Wingwalls, headwalls**								
	Headwall - upstream	5.5	FT	12	LF	1	LF	2.4	
	Wingwalls - upstream (both)	11	FT	40	LF	1.5	LF	83.1	
	Headwall - downstream	3.5	FT	12	LF	1	LF	1.6	
	Wingwalls - downstream (both)	11	FT	12	LF	1.5	LF	24.9	
	Subtotal							**113**	**CY**
	Gravel wall base			476	SF	0.67	FT	12	CY
	Backfill							60	CY
								72	**CY**
6.0	**Erosion protection**								
	Rock slope - downstream	4	FT	70	FT	30	LF	311.1	CY
	Subtotal							**560.0**	**TN**
	Channel - bottom	2	FT	84	LF	13	FT	80.9	TN
	Channel - bottom	2	FT	1190	SF			158.7	TN
	Subtotal							**239.6**	**TN**
7.0	**Backfill and compaction**								
	Roadway berm	5	FT	43	LF	62.5	LF	**497.7**	**CY**
								400.0	**TN**
8.0	**Revegetation**								
	East road embankment					5000	SF	0.11	AC
	West road embankment					1000	SF	0.02	AC
	Subtotal							**0.20**	**AC**

(This page intentionally left blank)

APPENDIX D

90% PLANS

(This page intentionally left blank)

APPENDIX E

90% TECHNICAL SPECIFICATION OUTLINE &

DRAFT TECHNICAL SPECIFICATION

SECTION 6-02.3(28) “PRECAST REINFORCED CONCRETE CULVERT”

(This page intentionally left blank)

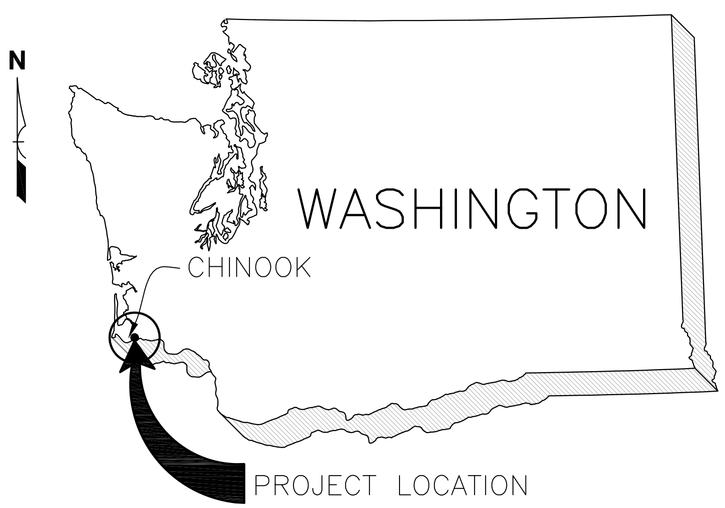
Technical Specification Outline

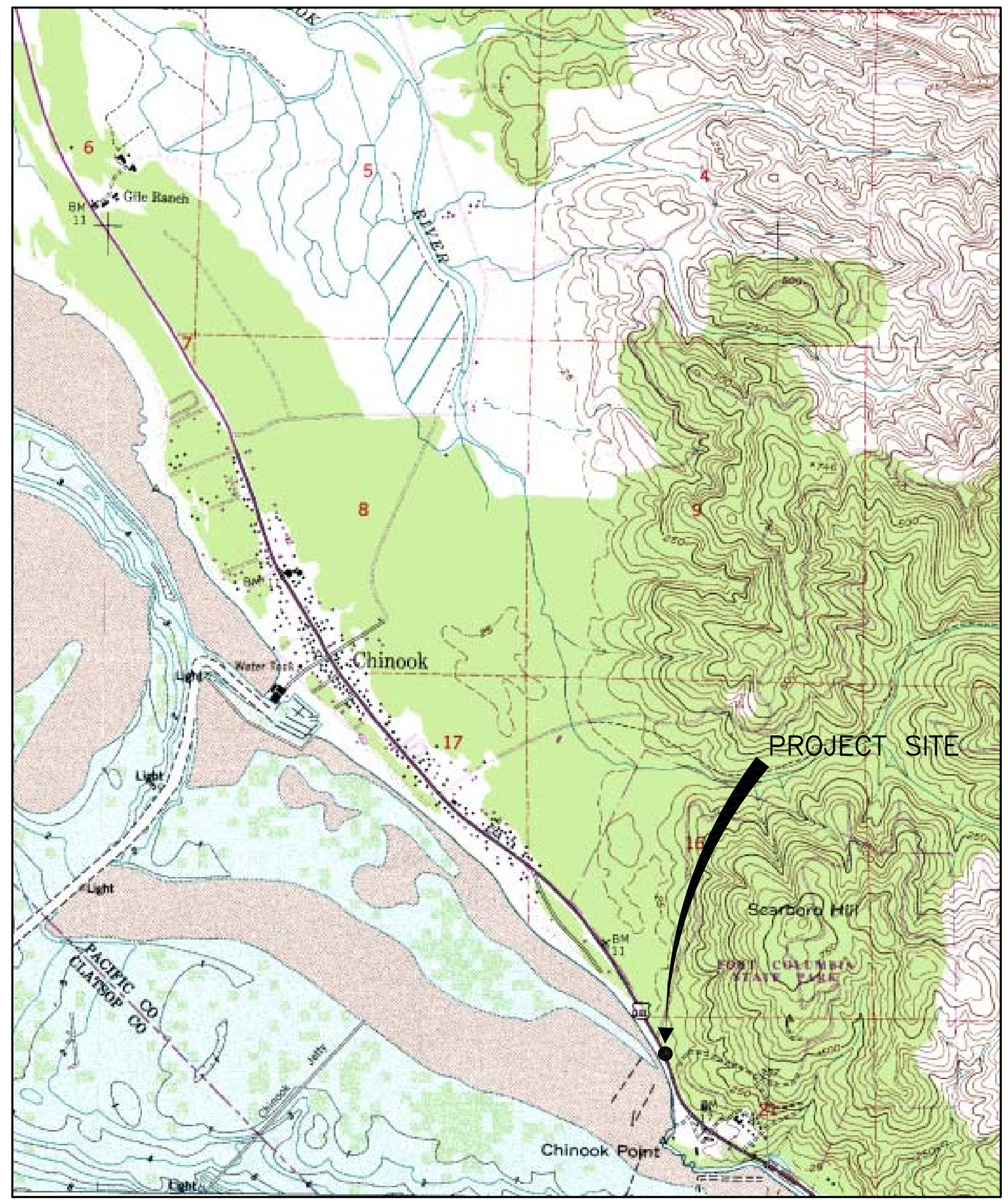
STD ITEM NO.	WORK ITEM	NOTE / TYPE
	SECTION 1: PREPARATION	
0001	MOBILIZATION	Std Item
0025	CLEARING AND GRUBBING	Std Item
	SECTION 2: GRADING	
0310	ROADWAY EXCAVATION INCL. HAUL	Std Item
0408	SELECT BORROW INCL HAUL	Std Item
0470	EMBANKMENT COMPACTION	Std Item
	SECTION 4: DRAINAGE	
1040	CHANNEL EXCAVATION INCL. HAUL	Amendment Item
1073	LIGHT LOOSE RIPRAP	Std Item
1075	HEAVY LOOSE RIPRAP	Std Item
--	DEWATERING SYSTEM	Special Provision
GSP	PRECAST CONCRETE CULVERT (3-SIDED)	GSP 6-02.3(28)
	SECTION 8: STRUCTURE	
4006	STRUCTURE EXCAVATION CLASS A INCL HAUL	Std Item
4013	SHORING (COFFERDAM(	Std Item
4025	GRAVEL BACKFILL FOR WALL	Std Item
4090	FURNISHING ST. PILING	Std Item
4095	DRIVING ST. PILING	Std Item
4150	ST. REINF. BAR FOR RETAINING WALL	Std Item
4151	ST. REINF. BAR FOR PILE CAP FOOTING	Std Item
4202	CONC. CLASS 4000 FOR PILE CAP FOOTING	Std Item
4139	CONC CLASS 4000 FOR RETAINING WALL	Std Item
	SECTION 9: SURFACING	
5100	CRUSHED SURFACING BASE COURSE	Std Item
	SECTION 14: HOT MIX ASPHALT	
5767	HMA CL 1/2 IN PG 64-22	Std Item
	SECTION 17: EROSION CONTROL AND PLANTING	
6403	ESC LEAD	Std Item
6463	CHECK DAM	Std Item

STD ITEM NO.	WORK ITEM	NOTE / TYPE
6468	STABILIZED CONSTRUCTION ENTRANCE	Std Item
6373	SILT FENCE	Std Item
6490	EROSION/WATER POLLUTION CONTROL	Std Item
6414	SEEDING, FERTILIZING, AND MULCHING	Std Item
6400	TOPSOIL TYPE C	Std Item
	SECTION 18: TRAFFIC	
6751	BEAM GUARDRAIL TYPE 1	Std Item
6717	BEAM GUARDRAIL NON-FLARED TERMINAL	Std Item
6771	BEAM GUARDRAIL ANCHOR TYPE 1	Std Item
6806	PAINT LINE	Std Item
6973	OTHER TEMPORARY TRAFFIC CONTROL	Std Item
6980	FLAGGERS AND SPOTTERS	Std Item
6992	OTHER TRAFFIC CONTROL LABOR	Std Item
6982	CONSTRUCTION SIGNS CLASS A	Std Item
	SECTION 20: BUILDING	
8082	FORMWORK	Technical Spec

FORT COLUMBIA TIDAL RECONNECTION PROJECT

US 101 MP 3.24
CHINOOK, WASHINGTON





VICINITY MAP
NOT TO SCALE
N

INDEX TO DRAWINGS

SHEET NO.	DRAWING NO.	DRAWING DESCRIPTION
1	G01	INDEX, VICINITY MAP, AND LOCATION MAP
2	G02	ABBREVIATIONS AND NOTES
3	C01	SITE PLAN
4	C02	PLAN AND PROFILE – CULVERT
5	C03	PLAN AND PROFILE – ROADWAY
6	C04	CROSS SECTIONS – CULVERT
7	C05	CROSS SECTIONS – ROADWAY
8	C06	TBD
9	C07	TBD
10	C08	CHANNEL DETAILS
11	C09	GENERAL CONSTRUCTION
12	S01	STRUCTURAL ELEVATIONS, SECTION & NOTES
13	S02	PILE CAP PLAN & DETAILS

WSDOT – APPROVED FOR CONSTRUCTION

DATE

90% SUBMITTAL

P:\Projects\Fort Columbia Design\T22833 CAD\DWG\SH01_G01_Ft Columbia.dwg

DESIGNED	CJL	MAY 2009
DRAWN	MAR	MAY 2009
CHECKED	YHC	MAY 2009
APPROVED		

TETRA TECH, INC.
1020 Taylor Street, Suite 530
Portland, OR 97205
Phone (503) 223-5388
Fax (503) 228-8631

FORT COLUMBIA TIDAL RECONNECTION PROJECT
CHINOOK, WASHINGTON

INDEX, VICINITY MAP, AND LOCATION MAP

CREST
Columbia River Estuary Study Taskforce
750 COMMERCIAL STREET, ROOM 205
ASTORIA, OREGON 97103
(503) 325-0435

PROJECT NO. T22833
FILE NAME: SH01_G01_FT_COL
DRAWING NO. G01
SHEET 1 OF X

GENERAL CONSTRUCTION NOTES

1. CLEARING AND GRUBBING SHALL BE PERFORMED ACCORDING TO WSDOT STANDARD SPECIFICATION 2–01.3 (1) AND (2).
2. CONTRACTOR IS RESPONSIBLE FOR REPAIR OF ANY UTILITIES DAMAGED DURING CONSTRUCTION. THE LOCATION AND ELEVATIONS OF EXISTING UTILITIES SHOWN ON THESE DRAWINGS ARE BASED UPON THE BEST AVAILABLE INFORMATION AND IS APPROXIMATE AND INCOMPLETE. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO LOCATE ALL EXISTING UTILITIES WHETHER SHOWN HEREON OR NOT AND TO PROTECT THEM FROM DAMAGE. CONTRACTOR SHALL CONTACT LOCAL DIGGER HOTLINE AT 1–800–424–5555 FOR UTILITY LOCATIONS AT LEAST 48 HOURS PRIOR TO START OF CONSTRUCTION TO LOCATE EXISTING UNDERGROUND UTILITIES.
3. FINAL STRIPING SHALL BE DONE IN ACCORDANCE WITH WSDOT STANDARD SPECIFICATION 8–22.1 USING MATERIALS AS SPECIFIED BY WSDOT STANDARD SPECIFICATION 9–08.1.
4. FINAL ROADSIDE CLEANUP SHALL BE IN ACCORDANCE WITH WSDOT STANDARD SPECIFICATION 2–01.3(4)
5. CONTRACTOR SHALL PROVIDE ALL MATERIALS, EQUIPMENT, AND LABOR NECESSARY TO IMPLEMENT THE PLANS AND SPECIFICATIONS.
6. TOPOGRAPHIC CONTOURS ARE BASED ON 2005 LIDAR DATA FROM THE PUGET SOUND LIDAR CONSORTIUM. ACTUAL ELEVATIONS UPSTREAM OF THE CULVERT WITHIN THE WETLAND MAY DIFFER FROM THOSE INDICATED BY THE CONTOURS.
7. CONTRACTOR SHALL HAUL AND DISPOSE OF ALL CONSTRUCTION DEBRIS AND SURPLUS MATERIALS. CONTRACTOR SHALL NOT DISPOSE OF THESE MATERIALS ON–SITE OR ADJACENT TO SITE.
8. THE CONTRACTOR SHALL COMPLY WITH ALL LOCAL, STATE, AND FEDERAL REGULATIONS RELATED TO THE SAFETY OF PERSONNEL AND BY–STANDERS ON THE JOB SITE.
9. THE CONTRACTOR SHALL DEFEND, INDEMNIFY AND HOLD WSDOT, CREST AND THE ENGINEER HARMLESS FROM ANY AND ALL LIABILITY, REAL OR ALLEGED, IN CONNECTION WITH THE PERFORMANCE OF WORK ON THIS PROJECT, EXCEPTING FOR LIABILITY ARISING FROM THE SOLE NEGLIGENCE OF CREST OR THE ENGINEER.
10. DETAILS ARE INTENDED TO SHOW FINAL RESULT OF DESIGN. MINOR MODIFICATIONS MAY BE REQUIRED TO SUIT JOB SITE DIMENSIONS OR CONDITIONS, AND SUCH MODIFICATIONS SHALL BE INCLUDED AS PART OF THE WORK.
11. THE CONTRACTOR SHALL MAKE ALL NECESSARY PROVISIONS TO PROTECT EXISTING IMPROVEMENTS, ROADWAY, DRAINAGE WAYS, CULVERTS, AND VEGETATION UNTIL SUCH ITEMS ARE TO BE DISTURBED OR REMOVED AS INDICATED ON THE CONSTRUCTION DOCUMENTS.
12. REPRESENTATIONS OF TRUE NORTH SHALL NOT BE USED TO IDENTIFY OR ESTABLISH THE BEARING OF TRUE NORTH AT THIS JOB SITE.
13. SIZE, LOCATION AND TYPE OF ANY UNDERGROUND UTILITIES OR IMPROVEMENTS SHALL BE ACCURATELY NOTED AND PLACED ON AS–BUILT DRAWINGS BY THE CONTRACTOR AND ISSUED TO THE ENGINEER AT COMPLETION OF THE PROJECT.
14. ALL WORK ON STATE RIGHT OF WAY SHALL CONFORM TO THE LATEST STANDARDS AND PRACTICE OF THE MOST CURRENT EDITION OF THE "STANDARD SPECIFICATIONS FOR ROAD, BRIDGE AND MUNICIPAL CONSTRUCTION", MOST CURRENT STANDARD PLANS AS PREPARED BY THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION, AND CURRENT VERSION OF THE MUTCD. OTHER NOTES ON THE PLANS SHALL NOT SUPERSEDE THIS NOTE.
15. TO DISRUPT PUBLIC TRAFFIC AS LITTLE AS POSSIBLE, THE CONTRACTOR SHALL PERMIT TRAFFIC TO PASS THROUGH THE WORK ZONE WITH THE LEAST POSSIBLE INCONVENIENCE OR DELAY. THE CONTRACTOR SHALL LIMIT THE TOTAL DELAY, TO THE PUBLIC, TO A MAXIMUM OF 15 MINUTES, DURING TRAVEL THROUGH THE PROJECT. DELAY BEGINS UPON ARRIVAL OF THE FIRST VEHICLE.
16. THE CONTRACTOR SHALL PREPARE A SPILL PREVENTION, CONTROL AND COUNTER MEASURES (SPCC) PLAN PER WSDOT STANDARDS, FOR APPROVAL, PRIOR TO THE BEGINNING OF CONSTRUCTION.
17. THE CONTRACTOR CAN SUBMIT ALTERNATE TRAFFIC CONTROL PLANS FOR APPROVAL TO THE WSDOT OR MAINTENANCE SUPERVISOR (WHOMEVER IS ASSIGNED INSPECTION); PLEASE ALLOW 5 WORKING DAYS FOR REVIEW.
18. WSDOT SHALL BE INVITED TO A PRECONSTRUCTION MEETING.
19. CREST/WSDOT AGREEMENT AND BONDING WILL BE REQUIRED BEFORE WORK WITHIN THE STATE RIGHT OF WAY.
20. AS–BUILT PLANS SHALL BE TURNED INTO WSDOT AT THE CONCLUSION OF THE PROJECT.

STANDARD CIVIL NOTES

1. SLOPES DESIGNATED AS 3:1 ETC., REFER TO THE RATIO OF HORIZONTAL TO VERTICAL DISTANCE.
2. PIPE SIZES SHOWN ARE NOMINAL PIPE DIAMETERS UNLESS OTHERWISE SHOWN.
3. DIMENSIONS FOR EARTHWORK (EXCAVATION, EARTHFILL, ETC.) ARE GIVEN IN FEET AND TENTHS OF FEET.
4. DIMENSIONS FOR STRUCTURAL CONCRETE AND METAL ARE GIVEN IN FEET AND INCHES.
5. ALL SITE WORK SHALL BE AS INDICATED ON THE CONSTRUCTION DOCUMENTS, WHICH INCLUDE THE BASIS OF DESIGN REPORT.
6. DO NOT EXCAVATE OR DISTURB BEYOND THE JOB SITE AREA, UNLESS NOTED OTHERWISE.
7. ALL EXISTING ACTIVE SEWER, WATER, GAS, ELECTRIC, AND OTHER UTILITIES WHERE ENCOUNTERED IN THE WORK, SHALL BE PROTECTED OR RELOCATED AS SHOWN HEREON OR AS DIRECTED BY THE ENGINEER.
8. EXTREME CAUTION SHOULD BE USED BY THE CONTRACTOR WHEN EXCAVATING OR PILE DRIVING AROUND OR NEAR UTILITIES. CONTRACTOR SHALL ENSURE THAT THE WORK CREW HAS BEEN TRAINED.

SURVEY NOTES

1. PROPERTY LINES ARE NOT SHOWN ON THE DRAWINGS. CONTRACTOR SHALL BE RESPONSIBLE FOR ENSURING ALL WORK IS EXECUTED WITHIN THE PROPERTY BOUNDARIES AND REQUIRED SETBACKS.

ABBREVIATIONS

AC–FT	ACRE FEET
APPROX	APPROXIMATE
AVG	AVERAGE
B.M.	BENCH MARK
BOT	BOTTOM
BW	BOTTOM WIDTH
C–C	CENTER–TO–CENTER
C.L.	CENTERLINE, CONTROL LINE
CFS	CUBIC FEET PER SECOND
CHAN	CHANNEL
CJ	CONSTRUCTION JOINT
CLR	CLEAR
CONC	CONCRETE
CP	CONTROL POINT
D	DEGREE, DEGREE OF CURVATURE
DD°MM'SS"	DEGREES, MINUTES, SECONDS
DEPT	DEPARTMENT
DIA, Ø	DIAMETER
DRS	DROP STRUCTURE
DS	DOWNSTREAM
E	EAST
EA	EACH
EG	EXISTING GRADE
EL, ELEV	ELEVATION
ER	ENGINEERING REPORT
ETC	ET CETERA (AND THE LIKE)
EX	EXISTING
FG	FINISHED GRADE
FT	FOOT OR FEET
GB	GRADE BREAK
HVF	HIGH VISIBILITY FENCE
HWY	HIGHWAY
ICC–ES	INTERNATIONAL CODE COUNCIL
IN	INCH OR INCHES
INV	INVERT
L	LENGTH OF CURVE
LB OR LBS	POUND OR POUNDS
LT	LEFT
MAX	MAXIMUM
MI	MILE
MIN	MINIMUM
MISC	MISCELLANEOUS
N	NORTH
NTS	NOT TO SCALE
NO	NUMBER
O.C.	ON CENTER
PC	POINT OF CURVATURE
PERF	PERFORATED
PI	POINT OF INTERSECTION
POB	POINT OF BEGINNING
POE	POINT OF ENDING
PL	PLATE
PROP	PROPOSED
PT	POINT OF TANGENCY
PSI	POUNDS PER SQUARE INCH
PVC	POLYVINYLCHLORIDE
R	RANGE
RAD	RADIUS
RC	REINFORCED CONCRETE
RCP	REINFORCED CONCRETE PIPE
RDWY	ROADWAY
REQ'D	REQUIRED
RT	RIGHT
ROW	RIGHT OF WAY
S	SOUTH; SLOPE
SCH	SCHEDULE
SHT	SHEET
SS	SIDE SLOPE
STA	STATION
STD	STANDARD
STL	STEEL
SQ	SQUARE
T	TANGENT OF CURVE
TBD	TO BE DEVELOPED
TOB	TOP OF BANK
TYP	TYPICAL
UON	UNLESS OTHERWISE NOTED
US	UPSTREAM, UNITED STATES
VAR	VARIES; VARIABLE
W	WEST
WSDOT	WASHINGTON DEPT. OF TRANSPORTATION
W/	WITH
WSE	WATER SURFACE ELEVATION
W/O	WITHOUT
°	DEGREE
@	AT
#	NUMBER
Δ	DELTA ANGLE

EXISTING LEGEND

- MONUMENT FOUND AS NOTED
- CENTERLINE
- +100.00 SPOT ELEV. @ F.G. OR FLOWLINE, UNLESS NOTED OTHERWISE
- FIRE HYDRANT
- SANITARY SEWER MANHOLE
- STORM DRAINAGE MANHOLE
- TELEPHONE MANHOLE
- TELEPHONE RISER
- UTILITY POLE
- WATER METER
- WATER VALVE
- CABLE TV RISER
- CONIFEROUS TREE
- 100 EXISTING MAJOR CONTOURS
- EXISTING MINOR CONTOURS
- EXISTING GROUNDLINE
- EXISTING FENCE
- OH OVERHEAD UTILITY LINE
- Neutral ELECTRICAL NEUTRAL LINE
- UNDERGROUND TELEPHONE

PROPOSED LEGEND

- 100 PROPOSED MAJOR CONTOUR
- PROPOSED MINOR CONTOUR
- CONSTRUCTION WORK LIMITS
- EASEMENT LINE
- PROPOSED STRUCTURE
- PROPOSED FENCE
- FINISHED GROUND
- CUT/FILL LINE
- CENTERLINE
- HIDDEN LINE
- POWER POLE
- POWER POLE GUY ANCHOR
- 5209.2 SPOT ELEVATION
- WATER VALVE/IRRIGATION OUTLET
- W WATER LINE
- STRIPING
- SAWCUT LINE
- PAVEMENT RESTORATION
- X SILT FENCE
- BIO FILTER BAG
- GATE VALVE
- AIR RELEASE VALVE

A — SHEET OR DETAIL

SHEET WHERE SECTION OR DETAIL IS SHOWN

90% SUBMITTAL

DESIGNED	CJL	MAY 2009
DRAWN	MAR	MAY 2009
CHECKED	YHC	MAY 2009
APPROVED		

TETRA TECH, INC.
1020 Taylor Street, Suite 530
Portland, OR 97205
Phone (503) 223-5388
Fax (503) 228-8631

FORT COLUMBIA TIDAL RECONNECTION PROJECT
CHINOOK, WASHINGTON

ABBREVIATIONS AND NOTES

CREST
Columbia River Estuary Study Taskforce
750 COMMERCIAL STREET, ROOM 205
ASTORIA, OREGON 97103
(503) 325-0435

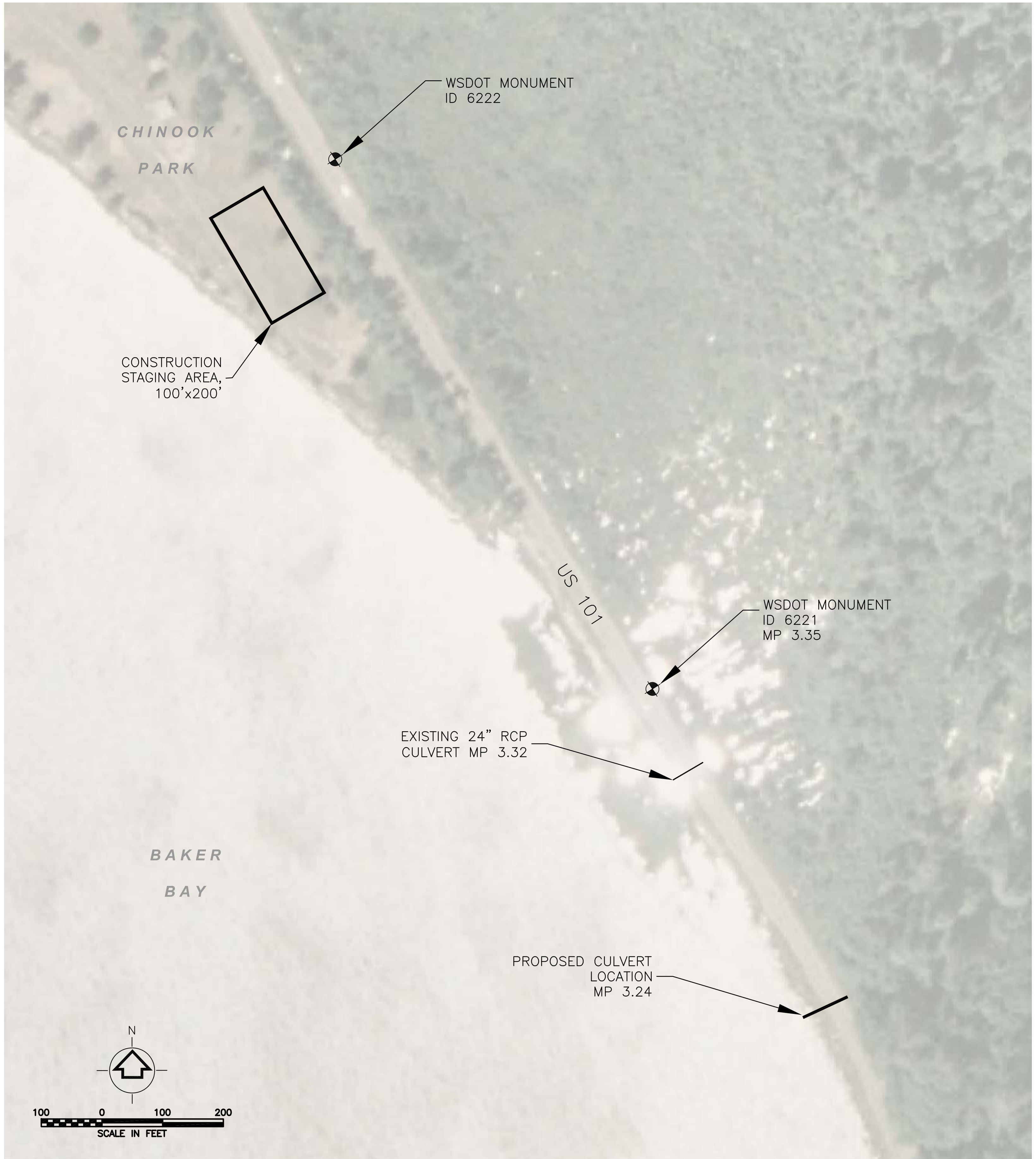
PROJECT NO. T22833

FILE NAME: SH02_G02_FT_COL

DRAWING NO. G02

SHEET 2 OF X

P:\Projects\Fort Columbia Design\T22833 CAD\DWG\SH02_G02_Ft Columbia.dwg



SITE PLAN 1 –

NOTES

1. BASIS OF BEARING: HELD WSDOT MONUMENT ID NUMBERS 6221 AND 6222 WITH A BEARING OF N 30°55'46"W.
2. HORIZONTAL DATUM IS NAD 83/91, WA STATE PLANE ZONE SOUTH.
3. VERTICAL DATUM IS NAVD 88.
4. PROJECT TIDAL DATUMS ARE BASED ON NOAA/NGS DATA PER DESIGN BASIS REPORT.

TIDE LEVEL	ELEVATION, FT NAVD 88
HIGHEST OBSERVED	9.9
MEAN HIGHER HIGH WATER (MHHW)	8.6
MEAN HIGH WATER (MHW)	7.9
MEAN TIDE LEVEL (MTL)	4.6
MEAN SEA LEVEL (MSL)	4.5
MEAN LOW WATER (MLW)	1.3
MEAN LOWER LOW WATER (MLLW)	0
LOWEST OBSERVED WATER LEVEL	−2.5

MONUMENT ID NO	NORTHING	EASTING	ELEVATION, FT NAVD 88
6222	356951.66	773522.16	14.068
6221	356079.24	774044.90	14.600

90% SUBMITTAL

DESIGNED	CJL	MAY 2009
DRAWN	MAR	MAY 2009
CHECKED	YHC	MAY 2009
APPROVED		

TETRA TECH, INC.
1020 Taylor Street, Suite 530
Portland, OR 97205
Phone (503) 223-5388
Fax (503) 228-8631

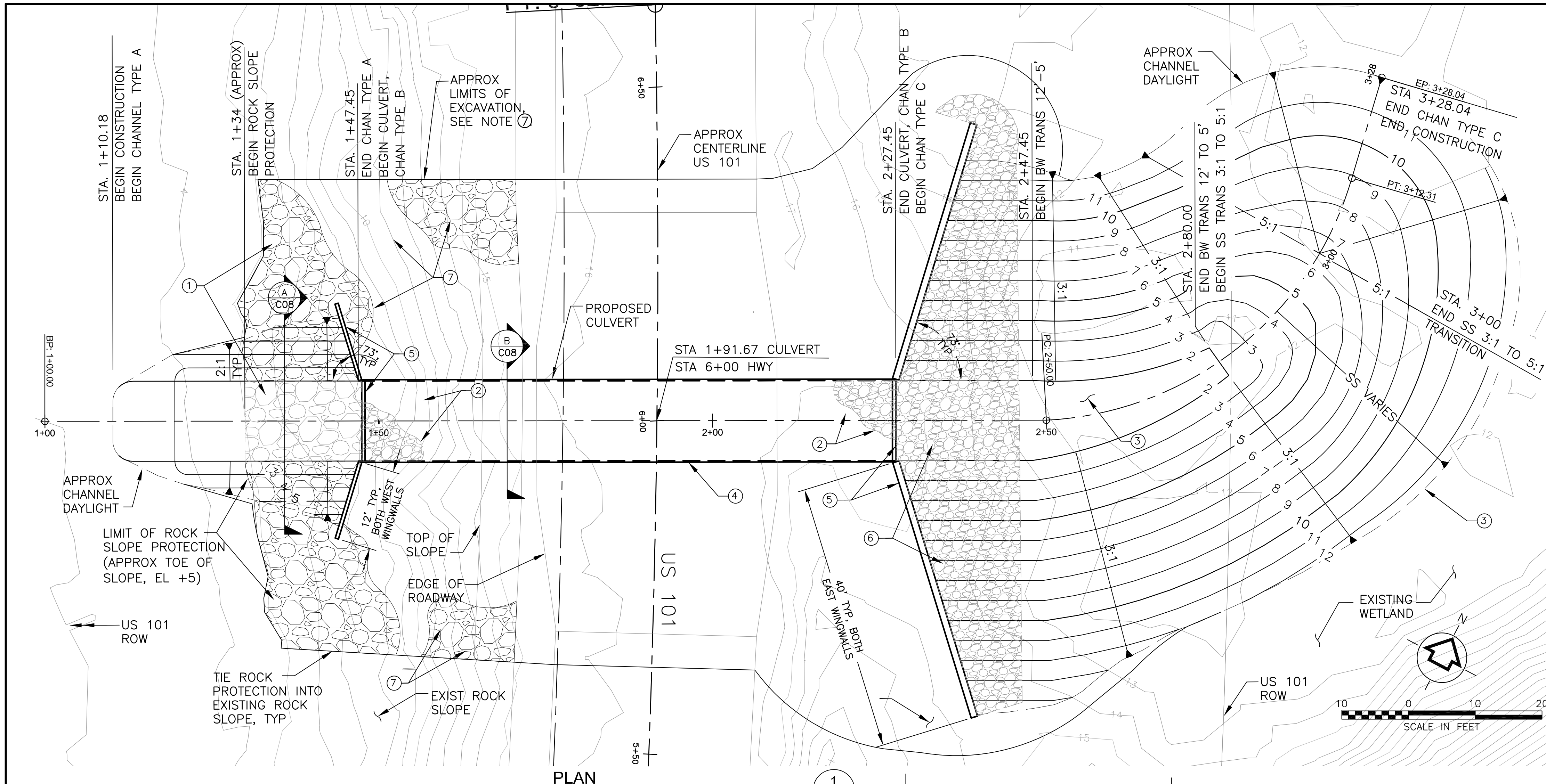
FORT COLUMBIA TIDAL RECONNECTION PROJECT
CHINOOK, WASHINGTON

SITE PLAN

CREST
Columbia River Estuary Study Taskforce
750 COMMERCIAL STREET, ROOM 205
ASTORIA, OREGON 97103
(503) 325-0435

PROJECT NO. T22833
FILE NAME: SH03_C01_FT_COL
DRAWING NO. C01
SHEET 3 OF X

P:\Projects\Fort Columbia Design\T22833 CAD\DWG\SH03_C01_Ft Columbia.dwg



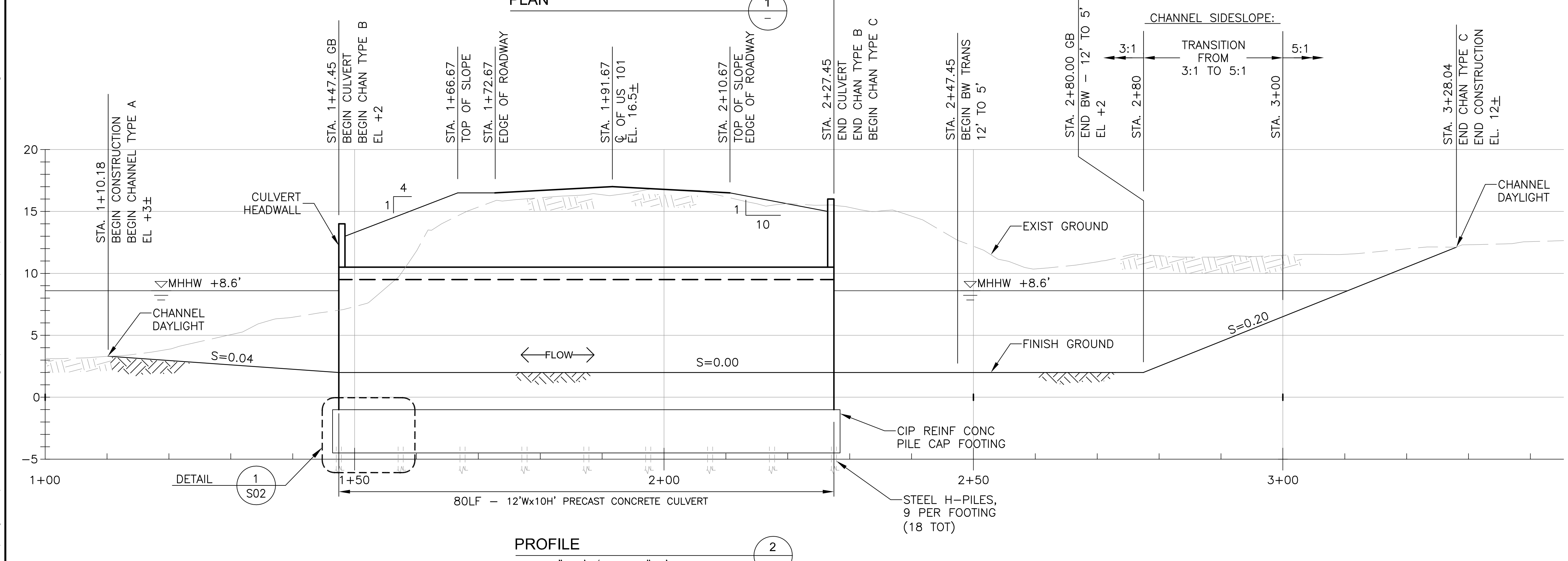
CONSTRUCTION NOTES

1. CONSTRUCT CHANNEL TYPE A, PER PLAN & PROFILE HEREON AND SECTION A ON SHT 10.
2. CONSTRUCT CHANNEL TYPE B, PER PLAN & PROFILE HERON, AND SECTION B ON SHT 10.
3. CONSTRUCT CHANNEL TYPE C, PER PLAN & PROFILE HERON & SECTIONS ON SHT 6.
4. CONSTRUCT PRECAST CONCRETE CULVERT, PER PLAN & PROFILE HEREON, AND DETAILS ON SHTS 12 & 13.
5. CONSTRUCT HEADWALLS AND WINGWALLS, PER PLAN HERON, AND DETAILS ON SHT 12.
6. PLACE SCOUR PROTECTION ROCK FOR CULVERT/WINGWALL FOUNDATIONS.
7. DEMO EXISTING ROCK SLOPE & CONSTRUCT ROCK SLOPE PROTECTION THAT TIES INTO EXISTING ROCK, PER PLAN & PROFILE HEREON AND SECTION A ON SHT 10.

ALIGNMENT – CHANNEL

COORDINATE DATA			
POINT	STA	EASTING	NORTHING
BP1	1+00.00	774252.50	355513.65
PC	2+50.00	774384.92	355584.22
PT	3+12.31	774408.30	355637.75
EP1	3+28.04	774405.17	355653.17

CURVE/	SEGMENT DATA		CURVE DATA		
LINE	BEARING	DISTANCE	DELTA	RADIUS	LENGTH
BP to PC	N 61°56'11" E	150.00'			
PC to PT			70°51'38"	50.38'	62.30'
PT to EP	N 11°27'38" W	15.74'			



PROFILE

HORZ. 1"=10' / VERT. 1"=5'

P:\Projects\Fort Columbia Design\T22833 CAD\DWG\SH04_C02_Ft Columbia.dwg

90% SUBMITTAL

DESIGNED	CJL	MAY 2009
DRAWN	MAR	MAY 2009
CHECKED	YHC	MAY 2009
APPROVED		

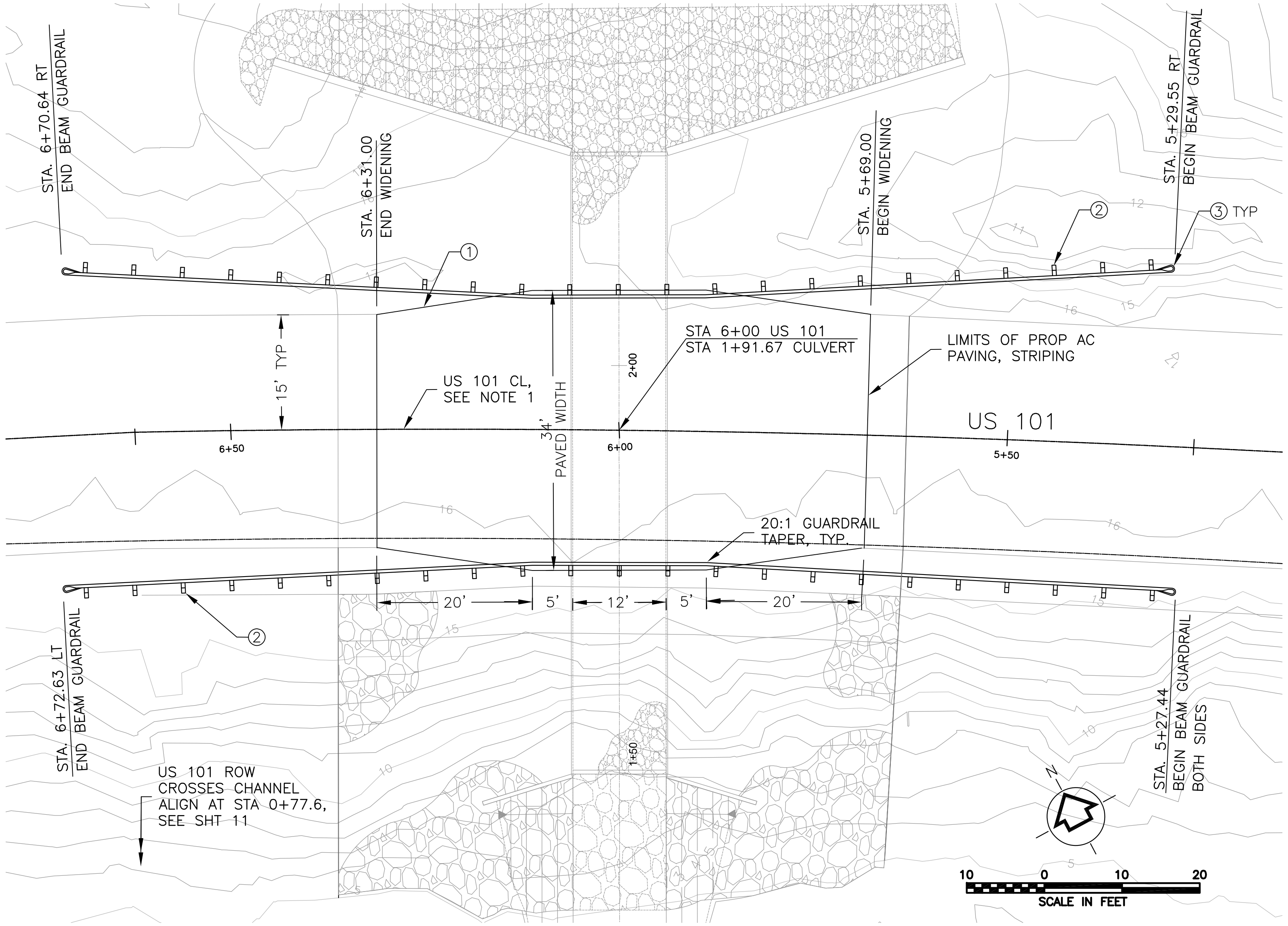
TETRA TECH, INC.
1020 Taylor Street, Suite 530
Portland, OR 97205
Phone (503) 223-5388
Fax (503) 228-8631

FORT COLUMBIA TIDAL RECONNECTION PROJECT
CHINOOK, WASHINGTON

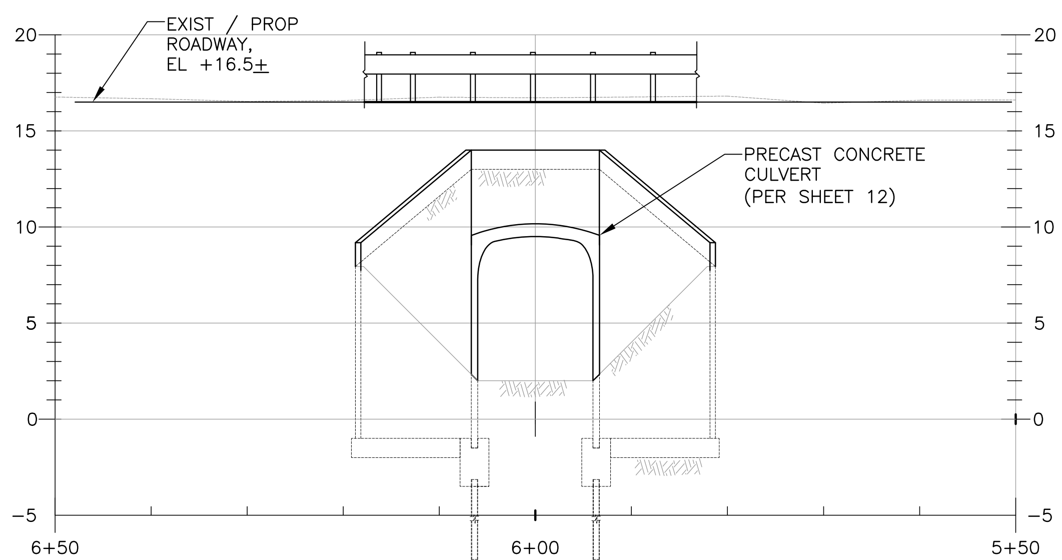
PLAN AND PROFILE – CULVERT

CREST
Columbia River Estuary Study Taskforce
750 COMMERCIAL STREET, ROOM 205
ASTORIA, OREGON 97103
(503) 325-0435

PROJECT NO. T22833
FILE NAME: SH04_C02_FT_COL
DRAWING NO. C02
SHEET 4 OF X



PLAN 1/–



PROFILE 2/–

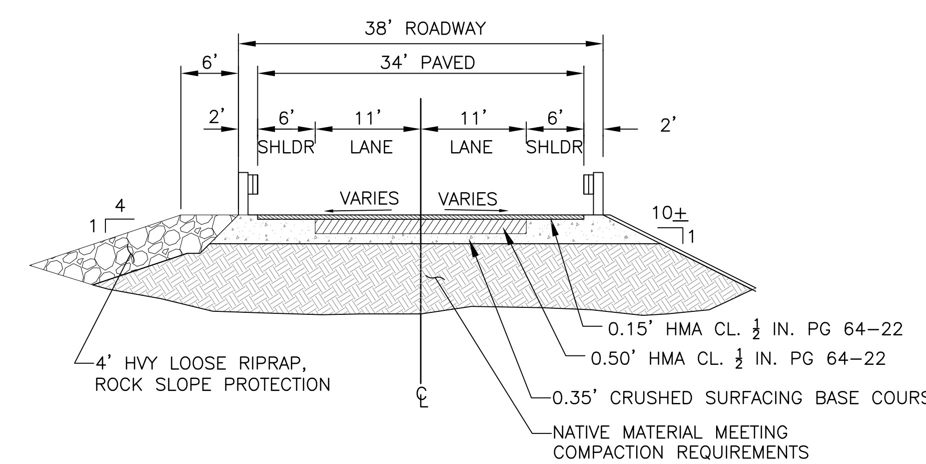
HORZ. 1"–10' / VERT. 1"=5'

CONSTRUCTION NOTES

1. CONSTRUCT PROPOSED ROADWAY (AC PAVING, STRIPING, ETC) PER DETAILS HEREON.
2. INSTALL WSDOT BEAM GUARDRAIL TYPE 31 NON-FLARED TERMINAL PER STANDARD PLAN C-22.40-01, DATED 10-05-07.
3. INSTALL WSDOT BEAM GUARDRAIL ANCHOR TYPE 1 PER STD PLAN C-6, DATED 5/30/97 PER PLAN HEREON.

NOTES

1. PROPOSED US 101 CL HORZ ALIGN BASED ON GEOREFERENCED AERIAL PHOTO. SEE SHT 11 FOR ALIGN GEOMETRY DATA. PROPOSED ALIGN TO FOLLOW EXISTING ALIGN AND MATCH AS SHOWN ON PLAN HEREON.
2. US 101 ROW PER STATEWIDE LAND SURVEYING INC SURVEY CONDUCTED FEB 2009.



TYPICAL ROADWAY SECTION 3/–

NTS

(SECTION LOOKING UP-STATION)

90% SUBMITTAL

P:\Projects\Fort Columbia Design\T22833 CAD\DWG\SH05_C03_Ft Columbia.dwg

DESIGNED	CJL	MAY 2009
DRAWN	MAR	MAY 2009
CHECKED	YHC	MAY 2009
APPROVED		

TETRA TECH, INC.
1020 Taylor Street, Suite 530
Portland, OR 97205
Phone (503) 223-5388
Fax (503) 228-8631

FORT COLUMBIA TIDAL RECONNECTION PROJECT
CHINOOK, WASHINGTON

PLAN AND PROFILE – ROADWAY

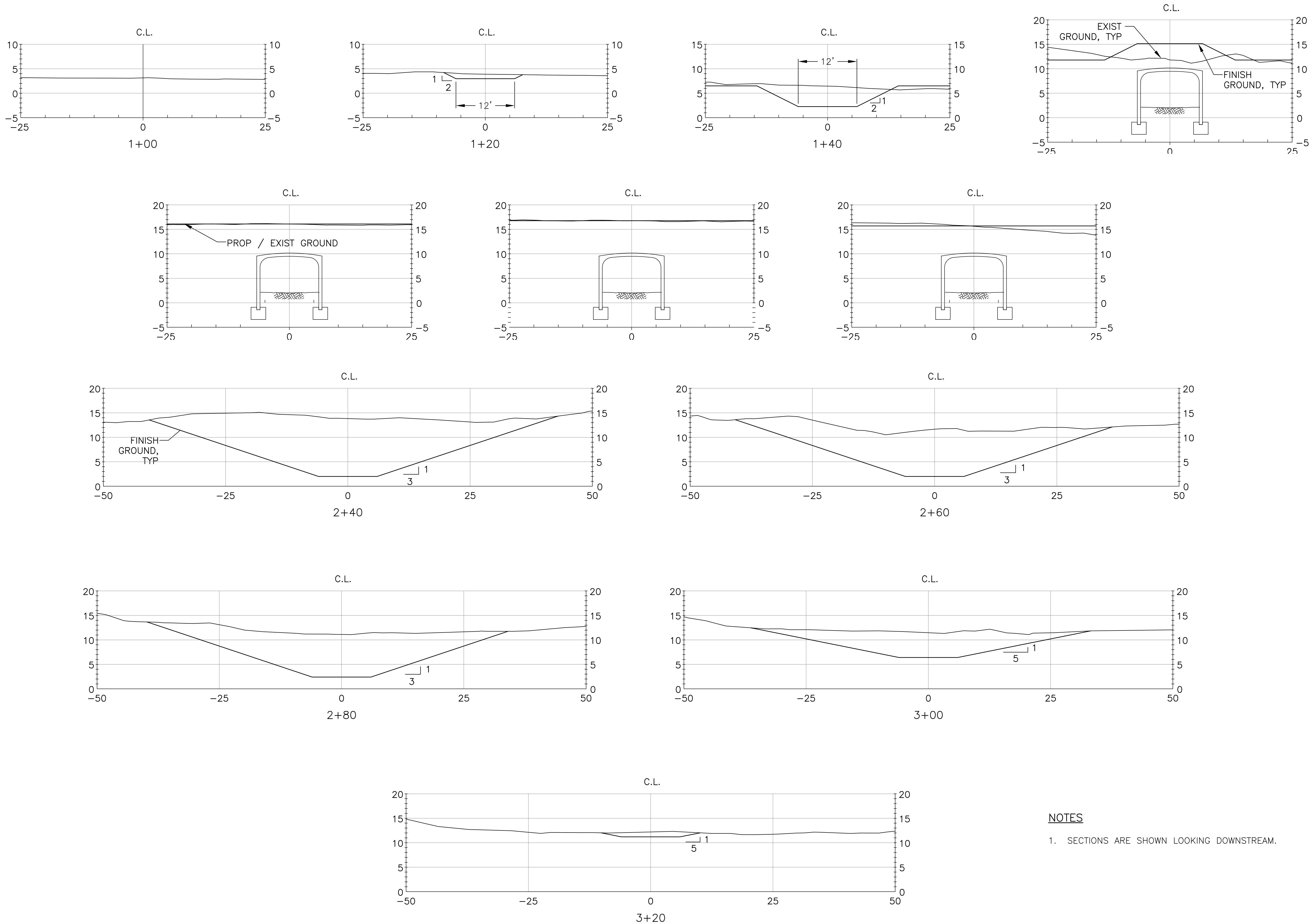
CREST
Columbia River Estuary Study Taskforce
750 COMMERCIAL STREET, ROOM 205
ASTORIA, OREGON 97103
(503) 325-0435

PROJECT NO. T22833

FILE NAME: SH05_C03_FT_COL

DRAWING NO. C03

SHEET 5 OF X



NOTES

1. SECTIONS ARE SHOWN LOOKING DOWNSTREAM.

CROSS SECTIONS (A)

SCALE: 1"=10'

90% SUBMITTAL

DESIGNED	CJL	MAY 2009
DRAWN	MAR	MAY 2009
CHECKED	YHC	MAY 2009
APPROVED		

TETRA TECH, INC.
1020 Taylor Street, Suite 530
Portland, OR 97205
Phone (503) 223-5388
Fax (503) 228-8631

FORT COLUMBIA TIDAL RECONNECTION PROJECT
CHINOOK, WASHINGTON

CROSS SECTIONS – CULVERT

CREST
Columbia River Estuary Study Taskforce
750 COMMERCIAL STREET, ROOM 205
ASTORIA, OREGON 97103
(503) 325-0435

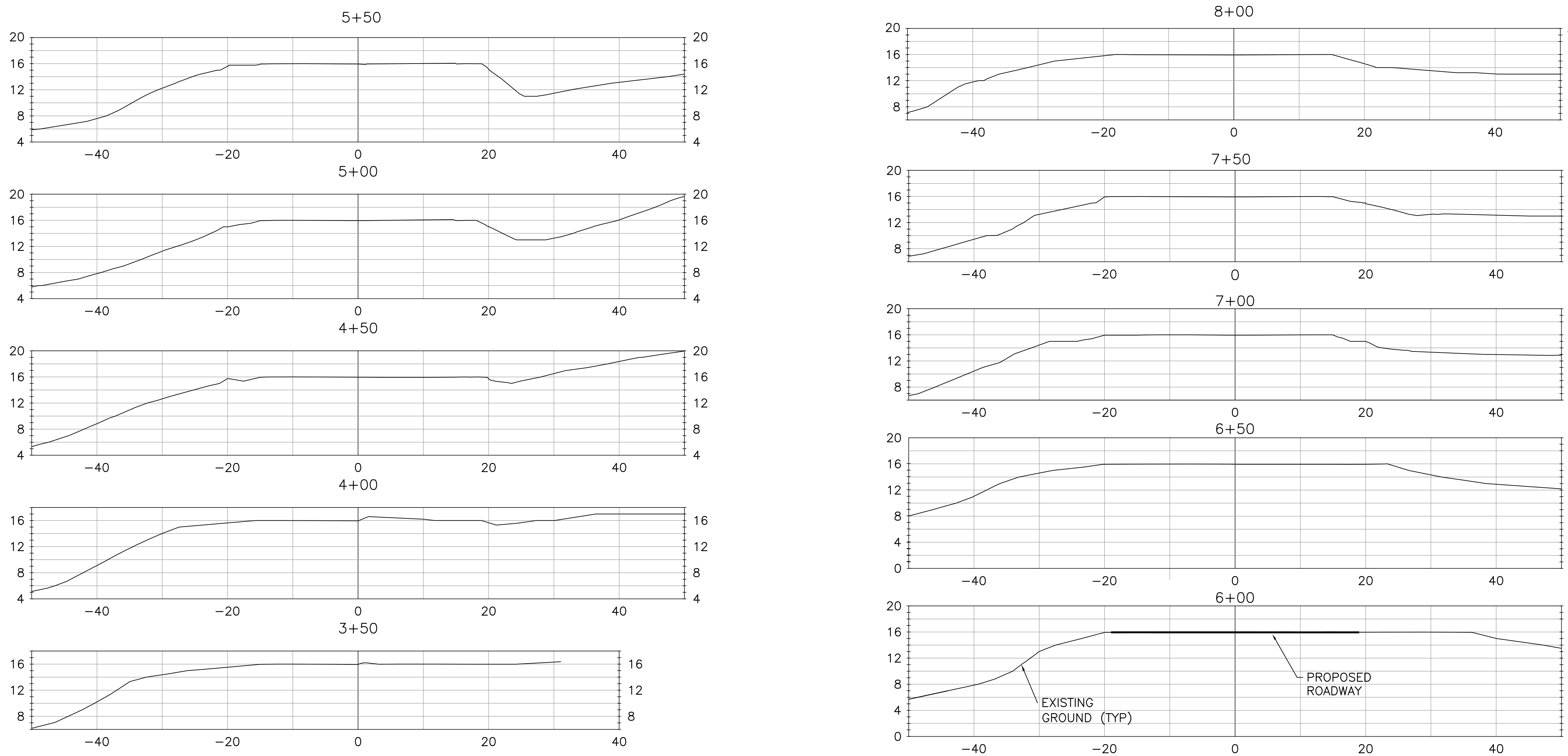
PROJECT NO. T22833

FILE NAME: SH06_C04_FT_COL

DRAWING NO. C04

SHEET 6 OF X

P:\Projects\Fort Columbia Design\T22833 CAD\DWG\SH06_C04_Ft Columbia.dwg



CROSS SECTIONS

HORZ. 1"=10' / VERT. 1"=20'

A
–

NOTES

1. SECTIONS ARE SHOWN LOOKING UP–STATION (NORTHWEST).

90% SUBMITTAL

DESIGNED	CJL	MAY 2009
DRAWN	MAR	MAY 2009
CHECKED	YHC	MAY 2009
APPROVED		

TETRA TECH, INC.
1020 Taylor Street, Suite 530
Portland, OR 97205
Phone (503) 223-5388
Fax (503) 228-8631

FORT COLUMBIA TIDAL RECONNECTION PROJECT
CHINOOK, WASHINGTON

CROSS SECTIONS – ROADWAY

CREST
Columbia River Estuary Study Taskforce
750 COMMERCIAL STREET, ROOM 205
ASTORIA, OREGON 97103
(503) 325-0435

PROJECT NO. T22833

FILE NAME: SH07_C05_FT_COL

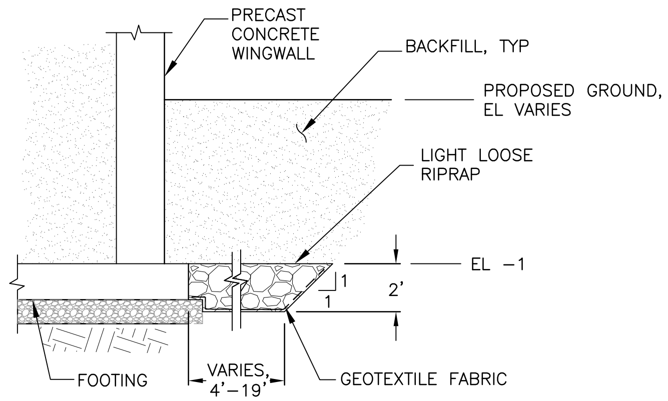
DRAWING NO. C05

SHEET 7 OF X

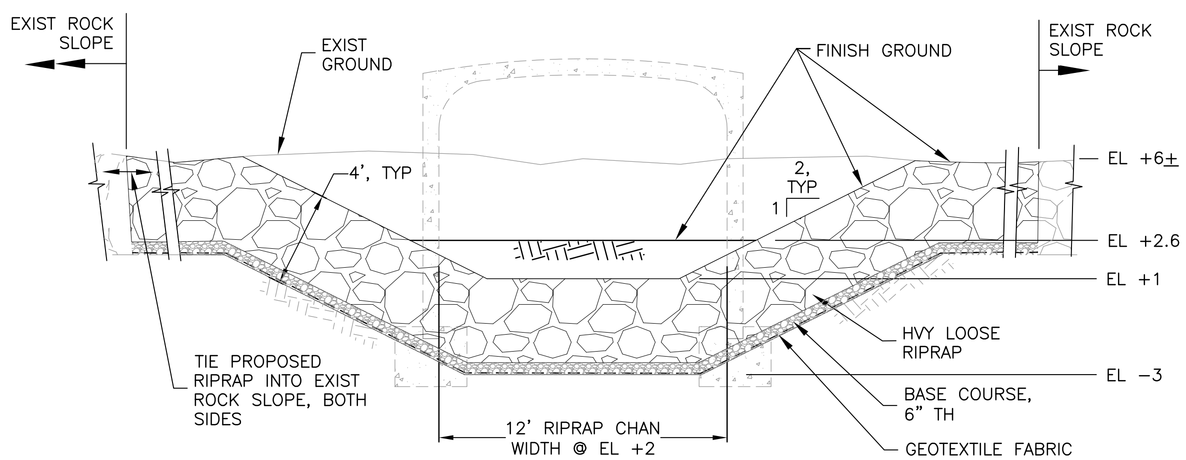
P:\Projects\Fort Columbia Design\T22833 CAD\DWG\SH07_C05_Ft Columbia.dwg

RIPRAP GRADATION

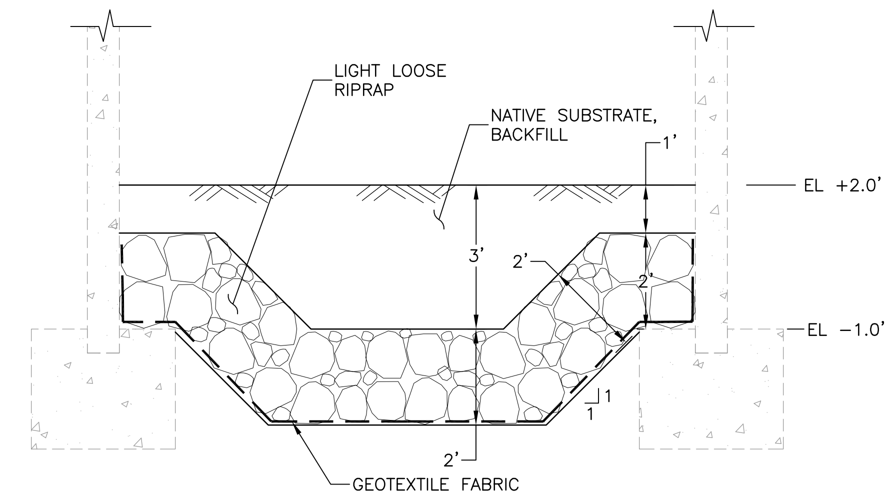
LIGHT LOOSE RIPRAP SIEVE SIZE	LIGHT LOOSE RIPRAP PERCENT PASSING	HEAVY LOOSE RIPRAP SIEVE SIZE	HEAVY LOOSE RIPRAP PERCENT PASSING
14"–20"	100%	28"–42"	100%
10"–12"	50	22"–26"	50
8"–10"	15%	16"–20"	15%
3"	5%	6"	5%



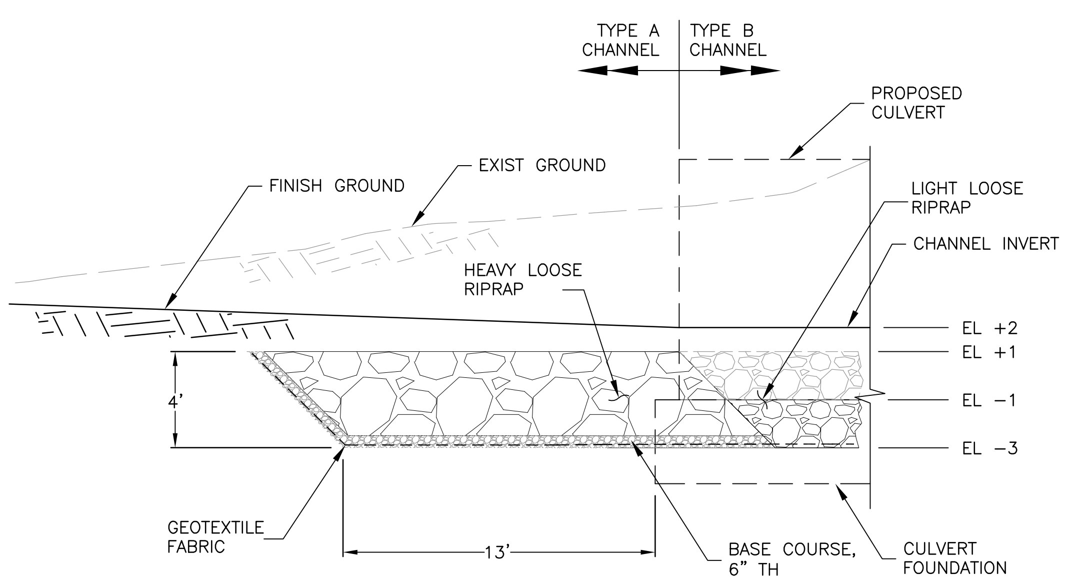
ROCK PROTECTION DETAIL - CULVERT & WINGWALLS (2 / C02)
SCALE: 1"=4"



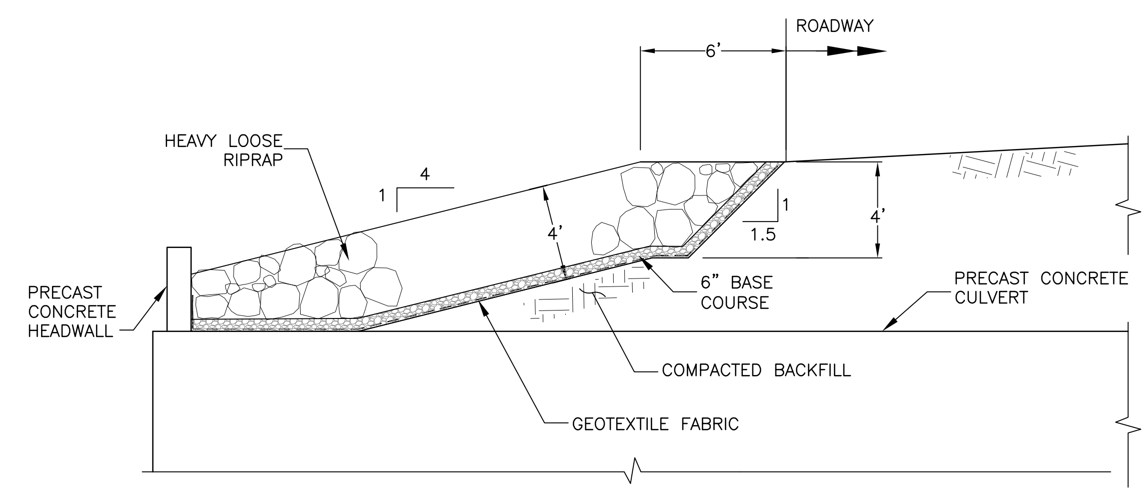
SECTION CHANNEL TYPE A (A / C02)
SCALE: 1"=4"



SECTION CHANNEL TYPE B (B / C02)
STA. 1+47.45 TO STA. 2+27.45 NTS



ROCK PROTECTION DETAIL CHANNEL TYPE A (1 / C02)
SCALE: 1"=4"



ROCK SLOPE PROTECTION DETAIL (3 / C02)
SCALE: 1"=4"

90% SUBMITTAL

DESIGNED	CJL	MAY 2009
DRAWN	MAR	MAY 2009
CHECKED	YHC	MAY 2009
APPROVED		

TETRA TECH, INC.
1020 Taylor Street, Suite 530
Portland, OR 97205
Phone (503) 223-5388
Fax (503) 228-8631

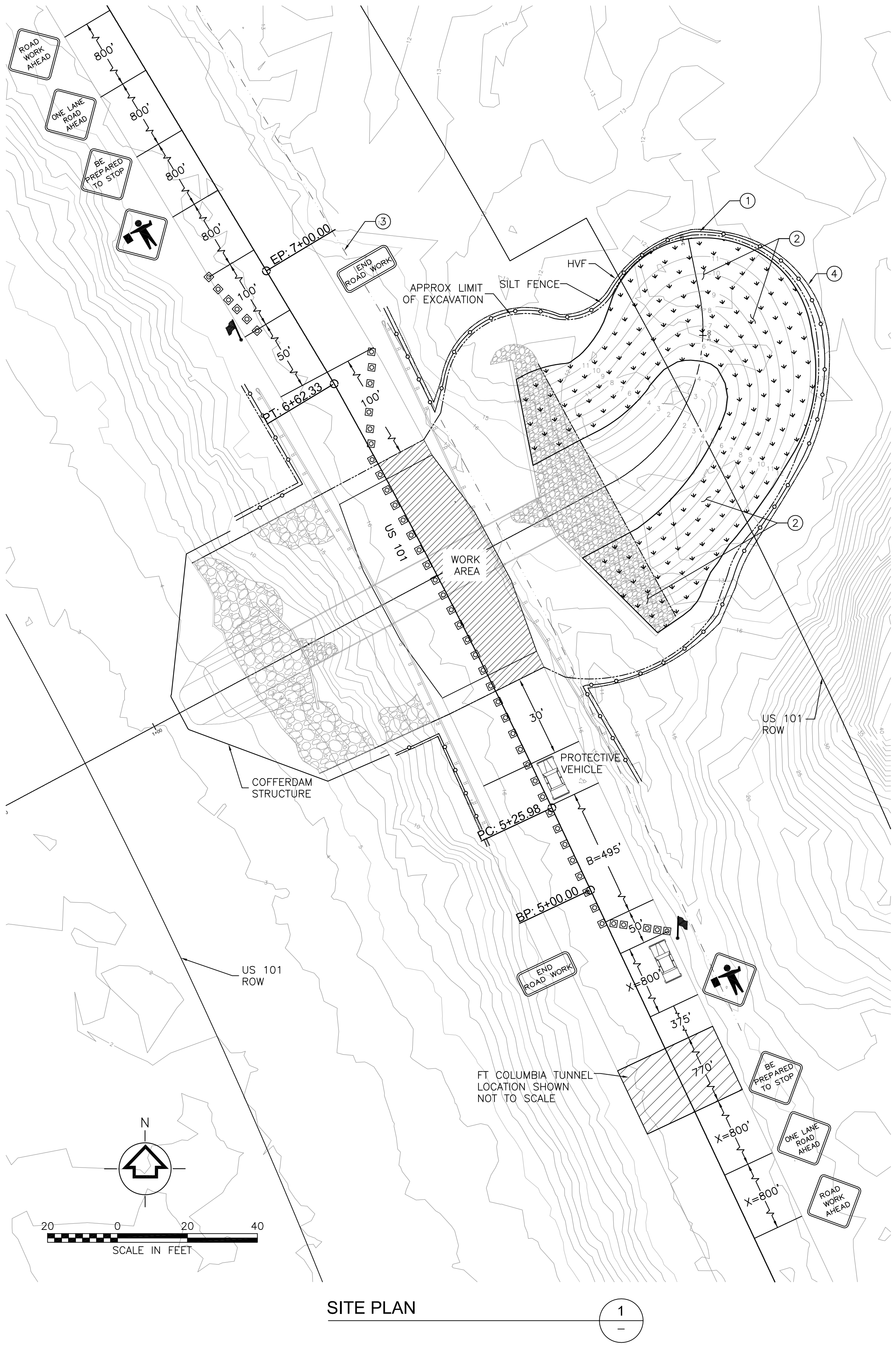
FORT COLUMBIA TIDAL RECONNECTION PROJECT
CHINOOK, WASHINGTON

CHANNEL DETAILS

CREST
Columbia River Estuary Study Taskforce
750 COMMERCIAL STREET, ROOM 205
ASTORIA, OREGON 97103
(503) 325-0435

PROJECT NO. T22833
FILE NAME: SH10_C08_FT_COL
DRAWING NO. C08
SHEET 10 OF X

P:\Projects\Fort Columbia Design\T22833 CAD\DWG\SH10_C08_Ft Columbia.dwg



SITE PLAN 1 / –

EROSION CONTROL NOTES

1. INSTALL SILT FENCE PER WSDOT STANDARD PLAN I-30.10-00
2. AREA TO BE SEEDED AND MULCHED AS SHOWN HEREON AND AS PER THE HYDRO-SEEDING LIST HEREON.

FORT COLUMBIA CULVERT REPLACEMENT		
SCIENTIFIC NAME	COMMON NAME	QUANTITY
CALAMAGROSTIS NUTKAENSIS	PACIFIC REED GRASS	5 LBS/ACRE
DESCHAMPSIA CESPITOSA	TUFTED HAIR GRASS	5 LBS/ACRE
DISTICHLIS SPICATA	SALT GRASS	5 LBS/ACRE
GLYCERIA BOREALIS	NORTHERN MANNAGRASS	2 LBS/ACRE
TORREYOCHLOA PAUCIFLORA	WEAK MANNAGRASS	2 LBS/ACRE
TRIFOLIUM WORMSKJOLDII	MARSH CLOVER	1 LB/ACRE

3. OVERHEAD ELECTRIC, TELEPHONE, FIBER OPTIC UTILITIES TO BE LOCATED. RELOCATE OR PROTECT IN PLACE AS TBD.
4. INSTALL HIGH VISIBILITY FENCE PER WSDOT STANDARD PLAN 1-10.10-00, DATED 08-31-07.

GENERAL NOTES

1. AFTER COMPLETION OF CULVERT AND ROADWAY CONSTRUCTION, CAP EXISTING RCP CULVERT W/CONCRETE PLUG.

EROSION/SEDIMENTATION CONTROL NOTES

GENERAL

1. THIS DRAWING IS FOR GENERAL GUIDANCE ONLY. IT IS THE INTENT OF THESE PLANS AND SPECIFICATIONS TO ENSURE THAT SEDIMENT AND SEDIMENT-LADEN WATER DOES NOT LEAVE THE SITE. THE CONTRACTOR SHALL USE ALL AVAILABLE MEANS TO ACHIEVE THIS RESULT.
2. APPROVAL OF THE EROSION, SEDIMENT AND POLLUTION CONTROL PLAN (ESPCP) DOES NOT CONSTITUTE APPROVAL OF PERMANENT ROAD OR DRAINAGE DESIGN.
3. THE IMPLEMENTATION OF THE ESPCP AND THE CONSTRUCTION, MAINTENANCE, REPLACEMENT AND UPGRADING OF THE ESPCP FACILITIES IS THE RESPONSIBILITY OF THE CONTRACTOR UNTIL ALL CONSTRUCTION IS COMPLETED AND APPROVED AND VEGETATION/LANDSCAPING IS ESTABLISHED.

BEFORE CONSTRUCTION

4. THE ESPCP FACILITIES SHOWN ON THIS SHEET MUST BE CONSTRUCTED IN CONJUNCTION WITH ALL CLEARING AND GRADING ACTIVITIES, AND IN SUCH A MANNER AS TO ENSURE THAT SEDIMENT AND SEDIMENT LADEN WATER DO NOT ENTER THE DRAINAGE SYSTEM, ROADWAYS OR VIOLATE APPLICABLE WATER STANDARDS.
5. STABILIZED CONSTRUCTION ENTRANCES SHALL BE INSTALLED (WHERE NECESSARY) AT THE BEGINNING OF CONSTRUCTION AND MAINTAINED FOR THE DURATION OF THE PROJECT. ADDITIONAL MEASURES, SUCH AS WHEEL WASHES OR HAND BRUSHING, MAY ALSO BE NECESSARY TO ENSURE THAT ALL PAVED AREAS ARE KEPT CLEAN FOR THE DURATION OF THE PROJECT.

DURING CONSTRUCTION

6. THE ESPCP FACILITIES SHOWN ON THIS SHEET ARE THE MINIMUM REQUIREMENTS FOR ANTICIPATED SITE CONDITIONS. DURING THE CONSTRUCTION PERIOD, THESE ESPCP FACILITIES SHALL BE UPGRADED AS NEEDED FOR UNEXPECTED STORM EVENTS AND TO ENSURE THAT SEDIMENT AND SEDIMENT-LADEN WATER DO NOT LEAVE THE SITE.
7. THE ESPCP FACILITIES SHALL BE INSPECTED DAILY BY THE CONTRACTOR AND MAINTAINED AS NECESSARY TO ENSURE THEIR CONTINUED FUNCTIONING.
8. THE ESPCP FACILITIES ON INACTIVE SITES SHALL BE INSPECTED AND MAINTAINED A MINIMUM OF ONCE A WEEK OR WITHIN THE 24 HOURS BEFORE AND AFTER A STORM EVENT.
9. ANY STOCKPILED SOIL MUST BE SECURED AND PROTECTED THROUGHOUT THE PROJECT WITH SOIL STABILIZATION MEASURES INCLUDING SEDIMENT BARRIERS AND PLASTIC SHEETING.

AFTER CONSTRUCTION

10. CONTRACTOR SHALL REMOVE ALL ESPCP FACILITIES AFTER COMPLETION OF CONSTRUCTION.

STANDARD NOTES FOR SILT FENCE

THE FILTER FABRIC SHALL BE PURCHASED IN A CONTINUOUS ROLL CUT TO THE LENGTH OF THE BARRIER TO AVOID USE OF JOINTS. WHEN JOINTS ARE NECESSARY, FILTER CLOTH SHALL BE SPLICED TOGETHER ONLY AT A SUPPORT POST, WITH A MINIMUM 6-INCH OVERLAP, AND BOTH ENDS SECURELY FASTENED TO THE POST.

THE FILTER FABRIC FENCE SHALL BE INSTALLED TO FOLLOW THE CONTOURS WHERE FEASIBLE. THE FENCE POSTS SHALL BE SPACED A MAXIMUM OF 6 FEET APART AND DRIVEN SECURELY INTO THE GROUND A MINIMUM OF 30 INCHES. A TRENCH SHALL BE EXCAVATED, ROUGHLY 8 INCHES WIDE BY 12 INCHES DEEP, UPSLOPE AND ADJACENT TO THE WOOD POST TO ALLOW THE FILTER FABRIC TO BE BURIED.

WHEN STANDARD STRENGTH FILTER FABRIC IS USED, A WIRE SUPPORT FENCE SHALL BE FASTENED SECURELY TO THE UPSLOPE SIDE OF THE POSTS USING HEAVY-DUTY WIRE STAPLES AT LEAST 1 INCH LONG, TIE WIRE OR HOG RINGS. THE WIRE SHALL EXTEND INTO THE TRENCH A MINIMUM OF 4 INCHES AND SHALL NOT EXTEND MORE THAN 36 INCHES ABOVE THE ORIGINAL GROUND SURFACE.

THE STANDARD STRENGTH FILTER FABRIC SHALL BE STAPLED OR WIRED TO THE FENCE, AND 12 INCHES OF THE FABRIC SHALL BE EXTENDED INTO THE TRENCH. THE FABRIC SHALL NOT EXTEND MORE THAN 36 INCHES ABOVE THE ORIGINAL GROUND SURFACE. FILTER FABRIC SHALL NOT BE STAPLED TO EXISTING TREES.

WHEN EXTRA-STRENGTH FILTER FABRIC AND CLOSER POST SPACING ARE USED, THE WIRE MESH SUPPORT FENCE MAY BE ELIMINATED. IN SUCH A CASE, THE FILTER FABRIC IS STAPLED OR WIRED DIRECTLY TO THE POSTS WITH ALL OTHER PROVISIONS OF THE ABOVE STANDARD NOTE FOR STANDARD STRENGTH FILTER FABRIC APPLYING.

SEDIMENT FENCES SHALL BE REMOVED WHEN THEY HAVE SERVED THEIR USEFUL PURPOSE, BUT NOT BEFORE THE UPSLOPE AREA HAS BEEN PERMANENTLY STABILIZED.

SEDIMENT FENCES SHALL BE INSPECTED BY APPLICANT/CONTRACTOR IMMEDIATELY BEFORE AND AFTER EACH RAINFALL AND AT LEAST DAILY DURING PROLONGED RAINFALL. ANY REQUIRED REPAIRS SHALL BE MADE IMMEDIATELY.

AT NO TIME SHALL MORE THAN A ONE FOOT DEPTH SEDIMENT BE ALLOWED TO ACCUMULATE BEHIND A SEDIMENT FENCE, SEDIMENT SHOULD BE REMOVED OR REGRADED INTO SLOPES, AND THE SEDIMENT FENCES REPAIRED AND RE-ESTABLISHED AS NEEDED.

LANE CLOSURE NOTES

1. LANE CLOSURE AND FLAGGER CONTROL TO FOLLOW WSDOT STANDARD PLAN K-20.40-00 UON HEREON.

WATER DIVERSION NOTES

1. CONTRACTOR SHALL BE RESPONSIBLE FOR FINAL DESIGN AND PERFORMANCE OF ANY AND ALL WATER DIVERSIONS.
2. CONTRACTOR SHALL BE RESPONSIBLE FOR ANY DAMAGES OR INJURIES CAUSED BY THE FAILURE OF ANY AND ALL WATER DIVERSIONS.
3. ALL WATER DIVERSION MATERIALS SHALL BE REMOVED FROM THE SITE AT THE COMPLETION OF THE PROJECT.

ALIGNMENT – ROADWAY

COORDINATE DATA			
POINT	STA	EASTING	NORTHING
BP1	5+00.00	774377.24	355466.89
PC	5+25.98	774366.18	355490.40
PT	6+62.33	774303.96	355611.68
EP1	7+00.00	774284.57	355643.97

CURVE / LINE	SEGMENT DATA		CURVE DATA		
	BEARING	DISTANCE	DELTA	RADIUS	LENGTH
BP to PC	N 64°49'22" E	25.98'			
PC to PT			3°57'08"	1966.84'	135.66'
PT to EP	N 59°1'13" E	37.67'			

90% SUBMITTAL

DESIGNED	CJL	MAY 2009
DRAWN	MAR	MAY 2009
CHECKED	YHC	MAY 2009
APPROVED		

TETRA TECH, INC.
1020 Taylor Street, Suite 530
Portland, OR 97205
Phone (503) 223-5388
Fax (503) 228-8631

FORT COLUMBIA TIDAL RECONNECTION PROJECT
CHINOOK, WASHINGTON

GENERAL CONSTRUCTION

CREST
Columbia River Estuary Study Taskforce
750 COMMERCIAL STREET, ROOM 205
ASTORIA, OREGON 97103
(503) 325-0435

PROJECT NO. T22833
FILE NAME: SH11_C09_FT_COL
DRAWING NO. C09
SHEET 11 OF X

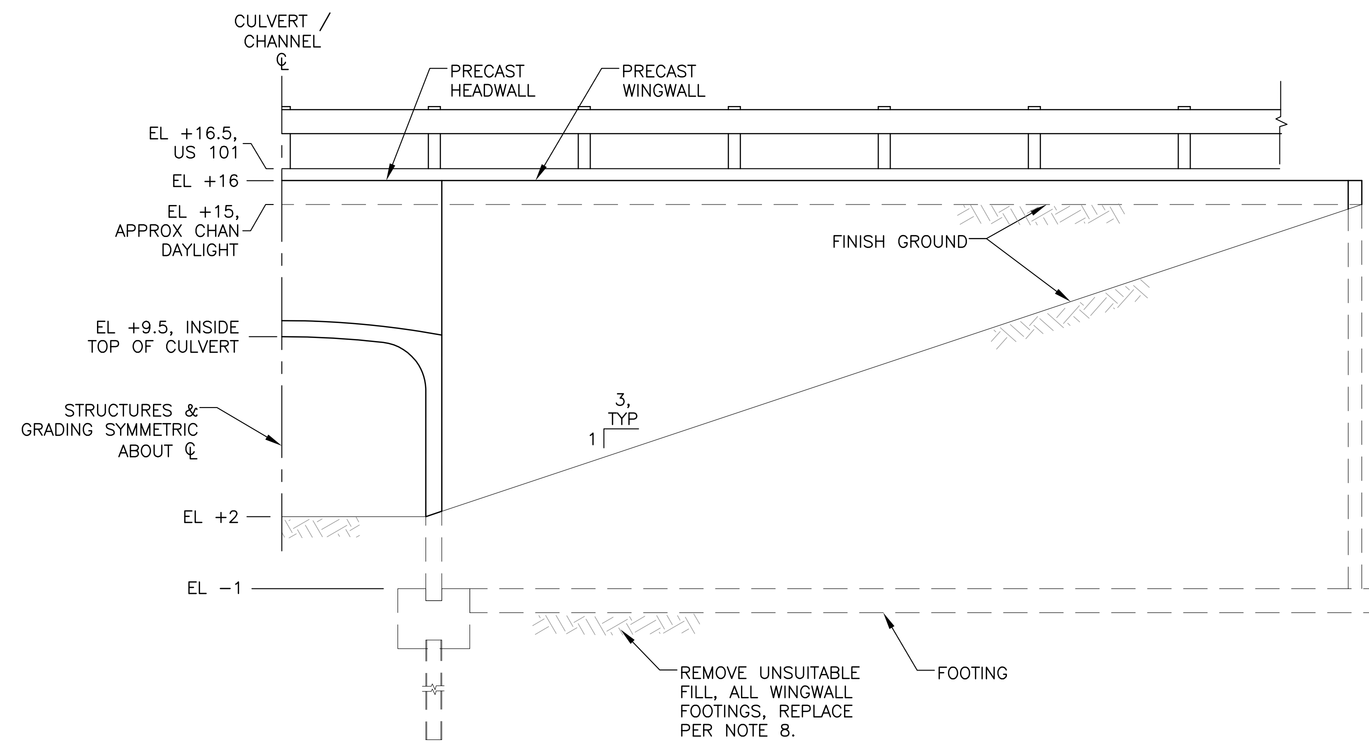
P:\Projects\Fort Columbia Design\T22833 CAD\DWG\SH11_C09_Ft Columbia.dwg

STRUCTURAL NOTES

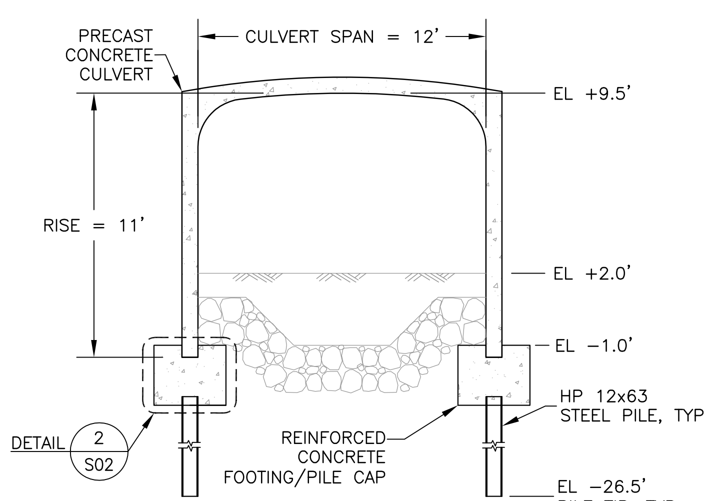
1. CULVERT FOOTING/PILE CAP DESIGN TO BE BASED ON PRECAST CONCRETE CULVERT (3-SIDED SHALLOW ARCH OR 3-SIDED 'BOX') WITH 12' SPAN BY 11' RISE.
2. ASSUMED ALLOWABLE SOIL BEARING OF 5,000 PSF.
3. HIGHWAY DESIGN LOAD SHALL BE HL-93 LIVE LOAD.
4. CONCRETE SHALL CONFORM TO WSDOT STANDARD SPECIFICATION 6-02.3.
5. REINFORCING SHALL CONFORM TO WSDOT STANDARD SPECIFICATION 9-07.
6. PILING SHALL CONFORM TO WSDOT STANDARD SPECIFICATION 6-05.3.
7. MATERIAL PROPERTIES:

   CONCRETE f'c=4000 PSI
   REINFORCING fy= 60 KSI
   HP STEEL PILING A572 GR50.

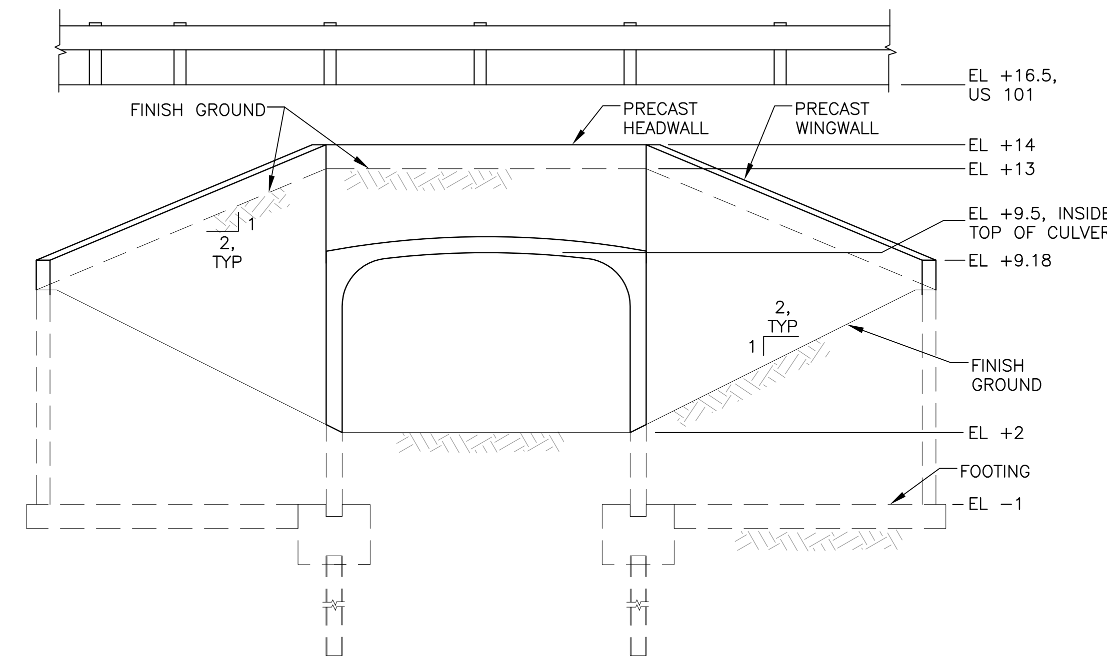
8. REMOVE UNSUITABLE FILL & REPLACE AS PER STRUCTURAL FILL REQUIREMENTS IN GEOTECHNICAL REPORT.



EAST ELEVATION (B/–)
SCALE: 1"=4'



TYPICAL CULVERT SECTION (A/–)
SCALE: 1"=4'



WEST ELEVATION (C/–)
SCALE: 1"=4'

90% SUBMITTAL

DESIGNED	CJL	MAY 2009
DRAWN	MAR	MAY 2009
CHECKED	YHC	MAY 2009
APPROVED		

TETRA TECH, INC.
1020 Taylor Street, Suite 530
Portland, OR 97205
Phone (503) 223-5388
Fax (503) 228-8631

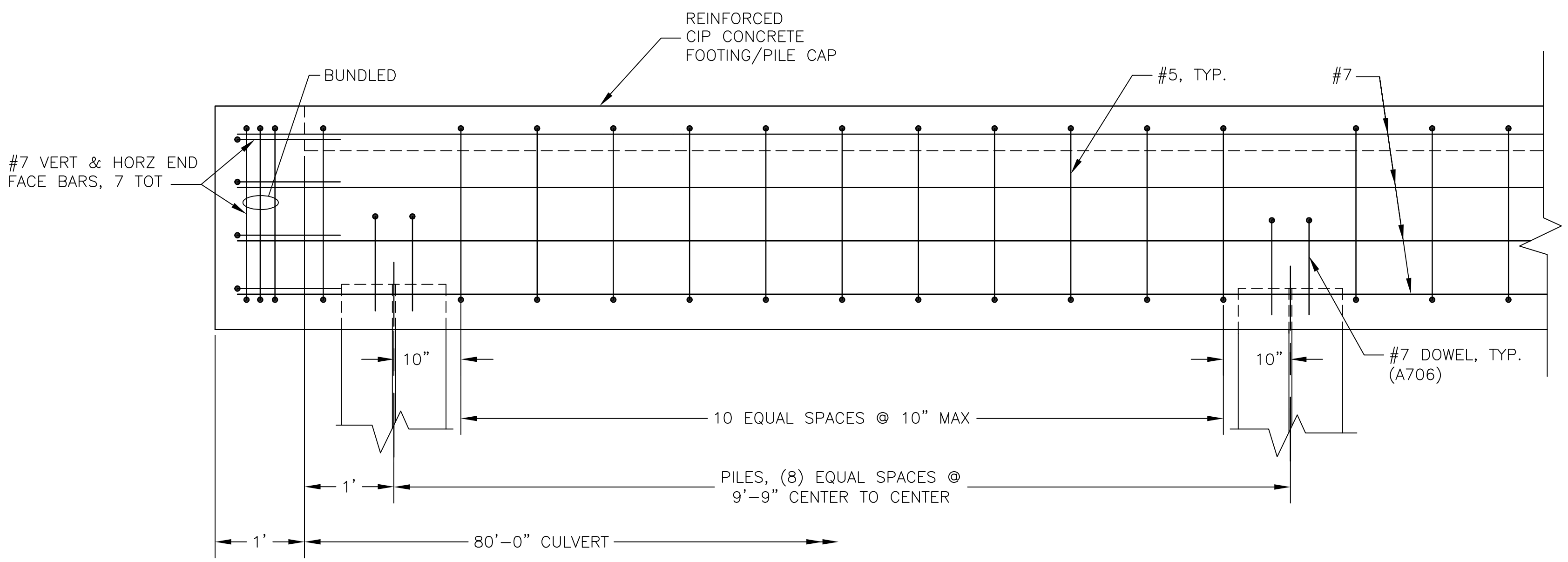
FORT COLUMBIA TIDAL RECONNECTION PROJECT
CHINOOK, WASHINGTON

STRUCTURAL ELEVATIONS, SECTIONS & NOTES

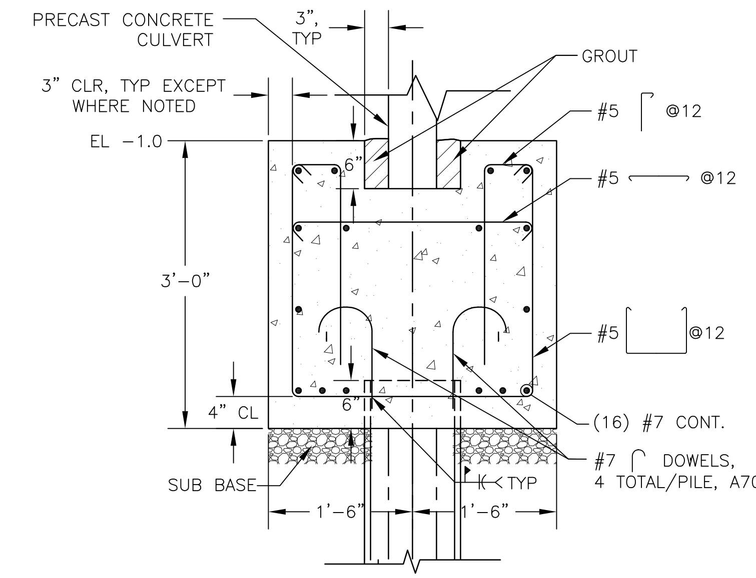
CREST
Columbia River Estuary Study Taskforce
750 COMMERCIAL STREET, ROOM 205
ASTORIA, OREGON 97103
(503) 325-0435

PROJECT NO. T22833
FILE NAME: SH12_S01_FT_COL
DRAWING NO. S01
SHEET 12 OF X

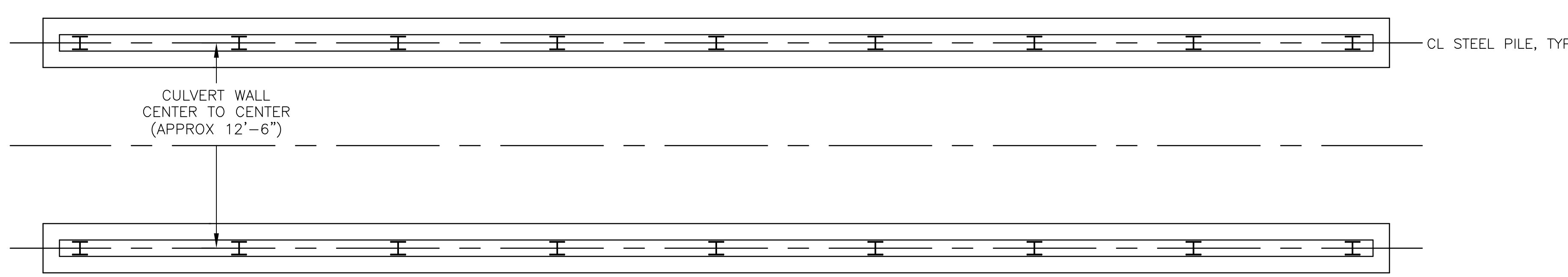
P:\Projects\Fort Columbia Design\T22833 CAD\DWG\SH12_S01_Ft Columbia.dwg



DETAILS
SCALE: 1"=10'
1
C02



DETAILS
SCALE: 1"=10'
2
S01



PILE CAP PLAN
SCALE: 1"=5'
1
S01

90% SUBMITTAL

P:\Projects\Fort Columbia Design\T22833 CAD\DWG\SH13_S02_Ft Columbia.dwg

DESIGNED	CJL	MAY 2009
DRAWN	MAR	MAY 2009
CHECKED	YHC	MAY 2009
APPROVED		

TETRA TECH, INC.
1020 Taylor Street, Suite 530
Portland, OR 97205
Phone (503) 223-5388
Fax (503) 228-8631

FORT COLUMBIA TIDAL RECONNECTION PROJECT
CHINOOK, WASHINGTON

PILE CAP PLAN & DETAILS

CREST
Columbia River Estuary Study Taskforce
750 COMMERCIAL STREET, ROOM 205
ASTORIA, OREGON 97103
(503) 325-0435

PROJECT NO.
T22833

FILE NAME:
SH13_S02_FT_COL

DRAWING NO.
S02

SHEET 13 OF X

TETRA TECH, INC.

TRANSMITTAL

To: Columbia River Estuary Study Taskforce
750 Commercial Street, Room 205
Astoria, Oregon 97103

Date: October 27, 2008

Attention: Amy Ammer, CREST Project Manager

Project Name: Fort Columbia Tidal Reconnection Project – Phase II Initial Tasks

---

Description:

Task C: Alternatives Analysis Memorandum

The attached summary memorandum addresses Task C of the Phase II Initial Tasks of the Fort Columbia Tidal Reconnection Project. The scope of the attached memo includes verification of an existing LiDAR topographic dataset, a brief description of the geotechnical evaluation which is included as an attachment to this memorandum, and an alternatives analysis that evaluates culvert locations, sizes, elevations and describes expected habitat impacts.

We thank you for the opportunity to assist you in supporting the Fort Columbia Project. Let us know if we can be of service in any other way.

Best Regards,

Curtis Loeb
Project Manager

TETRA TECH, INC.
1020 SW Taylor Street
Suite 530
Portland, OR 97205
Tel: 503.223.5388
Fax: 503.228.8631

MEMORANDUM

Date: October 27, 2008

To: CREST, Amy Ammer

Project Name: Fort Columbia Tidal Reconnection Project

Re: Phase II Initial Tasks – Task C, Alternatives Analysis

This technical memorandum analyzes alternative culvert locations and sizes, and their associated projected effects on habitat of the freshwater wetland adjacent to Washington State Highway 101 and Fort Columbia State Park. The purpose of this task is to evaluate alternative design concepts and to provide a basis for advancing the design of the Tidal Reconnection Project.

An existing LiDAR dataset was also evaluated using a site topographic survey that was conducted as part of this task. The LiDAR dataset may be useful to the project as the basis for recommended flooding analysis of the Chinook River and distributary through the wetland. As part of the overall Phase II Initial Tasks scope of work, a geotechnical investigation was also conducted. Results of the geotechnical investigation are summarized in this memo, and the full report is included as Attachment II. Results of these subtasks are described in the following sections.

Background

This Fort Columbia Tidal Reconnection Project (project) is part of a broader effort by CREST to restore the Chinook River Estuary (CREST 2007). The project includes replacing a culvert under Washington State Highway 101 (Hwy 101) between the town of Chinook, WA and Fort Columbia State Park (see Figure 1). The culvert is perched or located at the top of the tidal range (near MHHW), and thus limits freshwater drainage from the Chinook River (distributary) and tidal exchange with the Columbia River Estuary.

The existing Hwy 101 culvert is a 24 inch diameter concrete pipe culvert. The culvert was constructed to drain a distributary of the Chinook River that is located approximately four miles upstream of the mouth of the river. The distributary runs through a freshwater wetland before it reaches the Hwy 101 culvert. Construction of Highway 101 and installation of the culvert disconnected the river and associated floodplain (approximately

96 acres) from the estuary. Since this disconnection, sediment and organic matter from the distributary have deposited in the wetland and raised its general elevation.

Main objectives of the tidal reconnection project are to:

1) Re-establish the connection between the distributary of the Chinook River and its associated wetlands with the greater Columbia River estuary, and

2) Restore access to the tidal wetland for fish and wildlife species.

LiDAR Verification

The purpose of the LiDAR verification subtask is to evaluate the quality and usefulness of the dataset for future analysis and design tasks of the project. LiDAR is a relatively new method of collecting topographic data that utilizes a scanning laser rangefinder mounted in an airplane that flies over swaths of land creating a continuous database of land elevations (PSLC 2008a). LiDAR stands for “Light Distance and Ranging” and produces very high resolution datasets with typically good accuracy. Post-processing routines are used to correct the raw data using algorithms that eliminate vegetative canopy data to determine true land elevations. However, LiDAR data methods are generally still not able to determine land elevations in areas with standing water, i.e., lakes, rivers, ponds, or under dense canopy.

Puget Sound LiDAR

The LiDAR dataset for the Fort Columbia vicinity is available from the Puget Sound LiDAR Consortium (PSLC 2008a). The PSLC is an informal group of local agency and federal researchers committed to supporting LiDAR in the Puget Sound region. Various government agencies support PSLC including the Puget Sound Regional Council, NASA, and the USGS. Pertinent information regarding the PSLC LiDAR coverage of Fort Columbia is summarized in Table 1.

Table 1
Summary of Fort Columbia LiDAR Data (PSLC, 2008a)

Dates of Flight	January 10, 2005 to February 20, 2005
Overall Coverage Set	Lower Columbia R. in OR & WA
Horizontal & Vertical Datums	WA State Plane NAD83 HARN Feet & Feet NAVD88
Suggested Uses	Flood hazards, geologic mapping, hydrologic modeling
Approx. Vertical Accuracy	Less than 1 foot
Source of Data	TerraPoint USA, Inc. (an Ambercore Software company)

A color shade-plot of the PSLC LiDAR dataset indicating elevations through the wetland is shown in Figure 2. This same dataset displayed as a contour map is shown in Figure 3

Verification Ground Survey

To 'ground-truth' the PSLC LiDAR dataset, Tetra Tech conducted a topographic survey of the wetland and vicinity. The survey was completed over three days, September 3, 4 and 23, 2008. The objective of the survey was to take a series of representative topographic points to compare against associated LiDAR data from PSLC. Topographic data were collected with a survey-grade Trimble RTK 5800 with horizontal accuracy of +/- 10 mm and vertical accuracy of +/- 20 mm. The crew collected data along several transects across the wetland and spot elevations at key locations around the culvert. Results of this survey are shown in Figure 4. The field report for the ground survey is included in Attachment I.

Comparisons of survey and LiDAR elevations were made along five transects as shown in Figure 4. Plots of these data along with descriptions at each site are included in the survey report, Attachment I. To illustrate typical variations and differences, Transects 1 and 3 are repeated in Figure 5 and Figure 6, respectively.

Transect 1 is the northern-most transect and data are plotted 'looking downstream' from left to right with respect to the main drainage flow direction of the wetland (i.e., looking primarily south towards the culvert). In other words, east is to the left, and west is to the right. The red line represents the LiDAR dataset, and the blue line shows the ground survey points. Note that the ground survey points were collected at discrete locations at intervals of approximately 20 to 100 feet as necessary to capture grade breaks and as GPS reception allowed. Thus there are locations where comparisons were not possible; these are indicated by dashed lines in Figure 5 and Figure 6 (primarily near the western portion of the wetland adjacent to the roadway embankment where tall trees prohibited GPS signal reception).

In Figure 5 and Figure 6 the ground survey is consistently 2 feet below the LiDAR surface. In locations where there are dense willows, crab apple, conifers or other dense vegetation, the discrepancy is slightly higher, varying from 2.4 to 4.0 feet approximately. At locations with bare earth such as on top of the Hwy 101 embankment, the data show much smaller differences of on the order of 6 inches or less (within the range of accuracy of the LiDAR and ground survey methods). Differences between the datasets are believed to be due to a combination of standing water in the wetland at the time of the survey (January and February 20005) and dense vegetation where the LiDAR accuracy is reduced because of penetration difficulties. The LiDAR was flown in the middle of the winter, when there was likely substantial standing water (presumably 2 feet) in the wetland. The apparent 'humps' in the LiDAR data appear to reflect dense, broad canopy trees and shrubs that were observed during the survey.

Figure 1
Fort Columbia Culvert Location and Vicinity Maps.

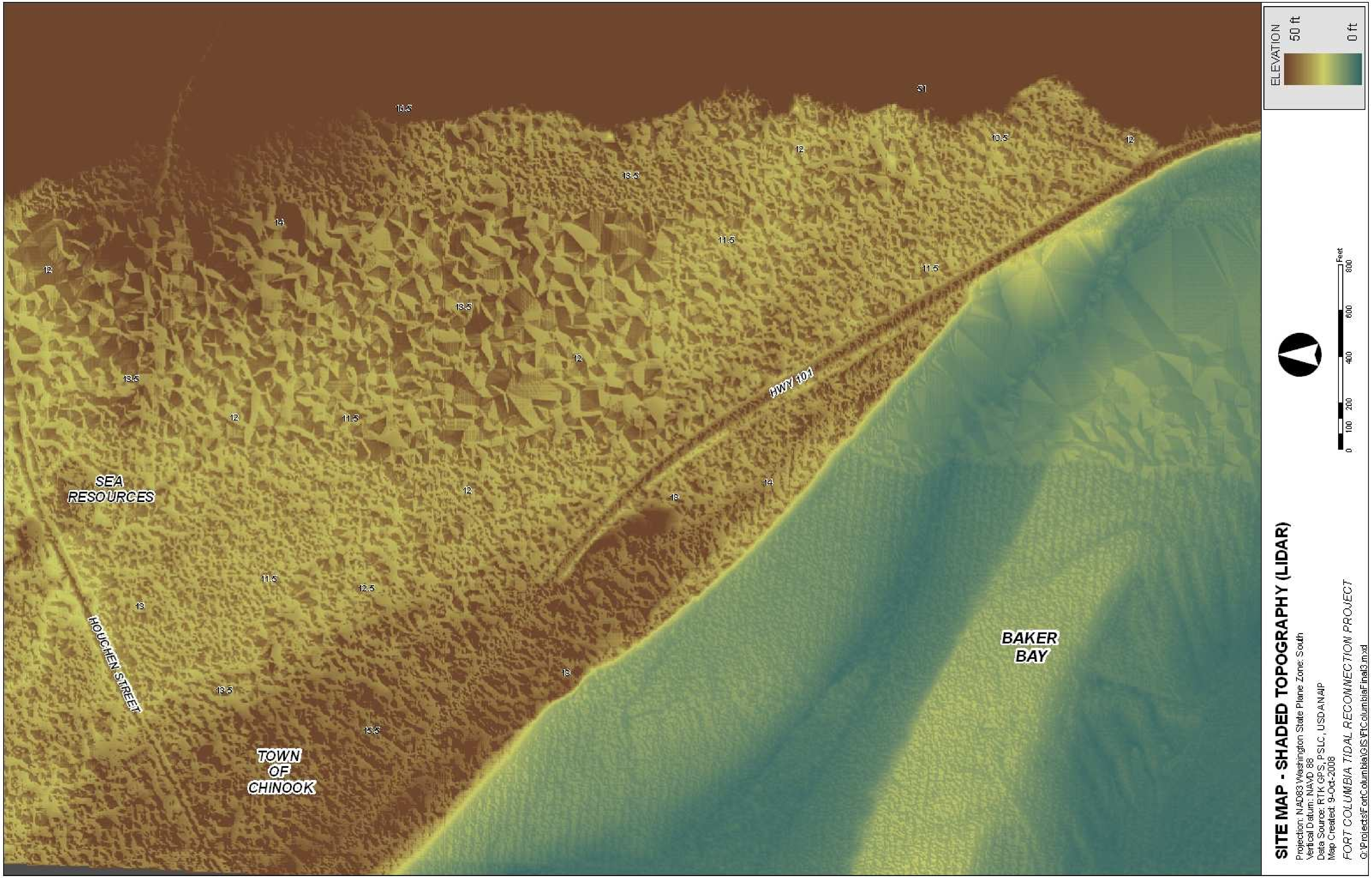


Figure 2
Color Shade-Plot Map of the PSLC LiDAR Data in the Fort Columbia Project Vicinity.

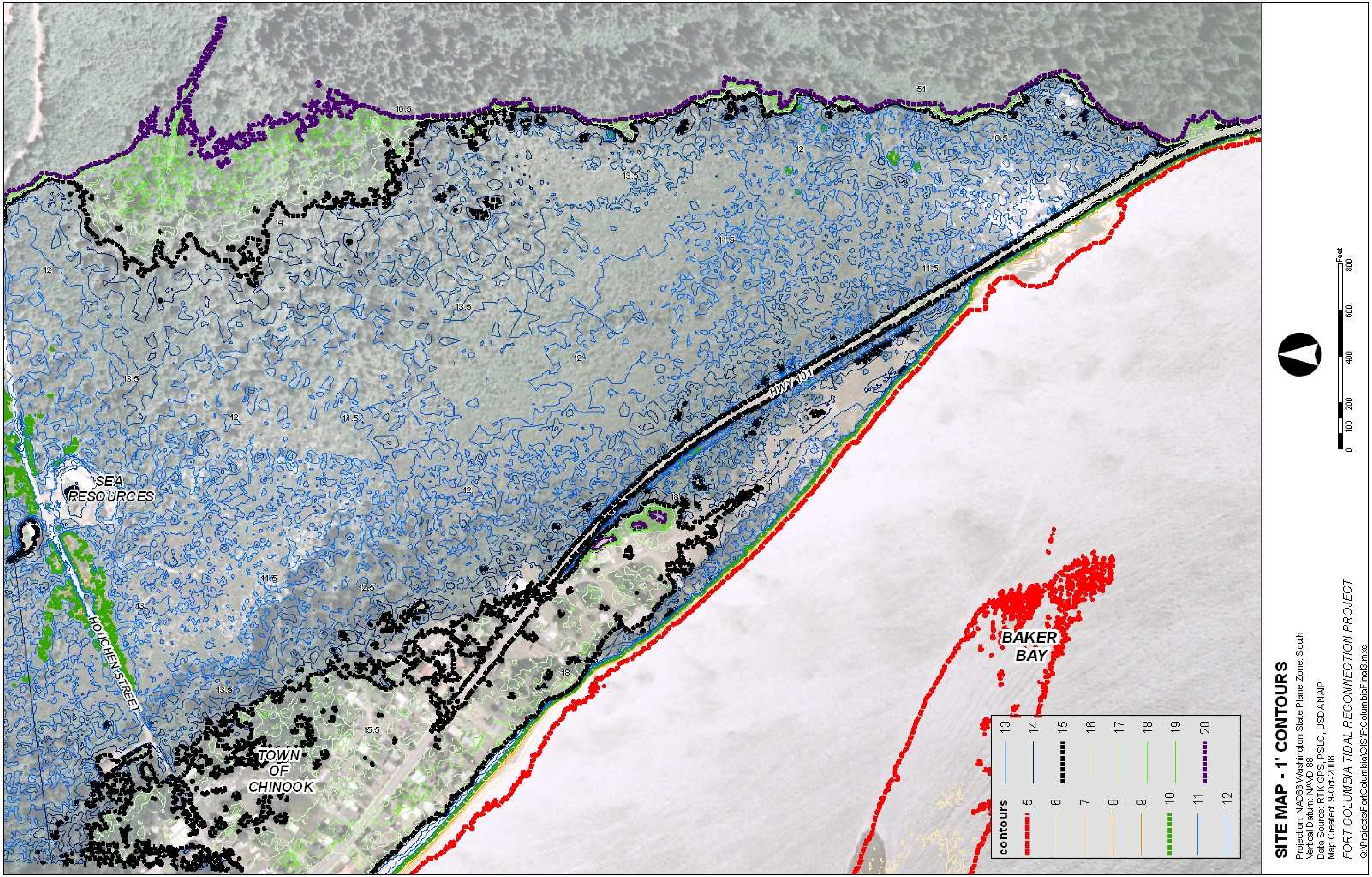


Figure 3
Contour Map of the PSLC LiDAR Data in the Fort Columbia Project Vicinity.

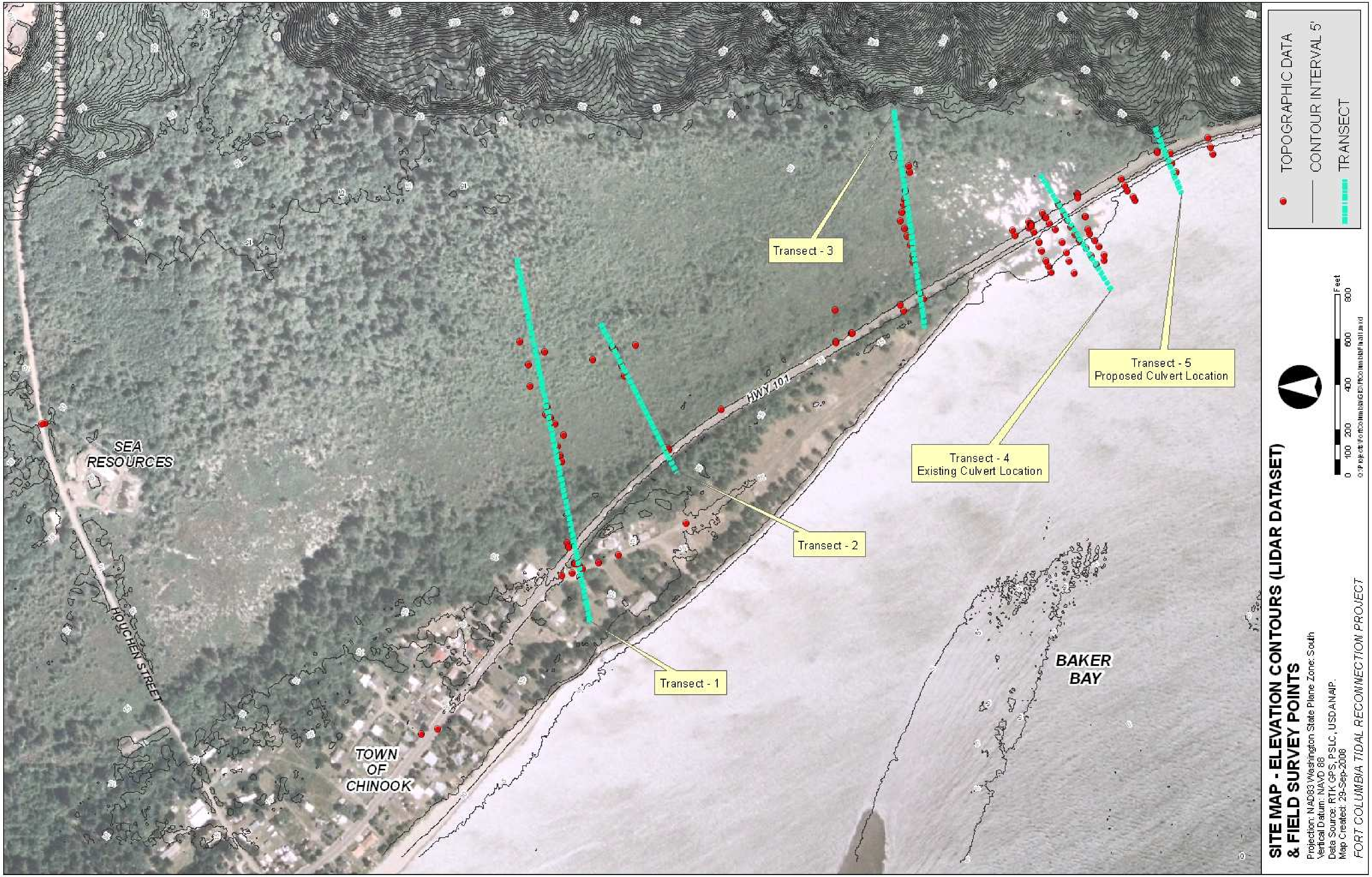


Figure 4
Data Collected Along Transects During the Ground Survey Used to Verify the LiDAR Data.

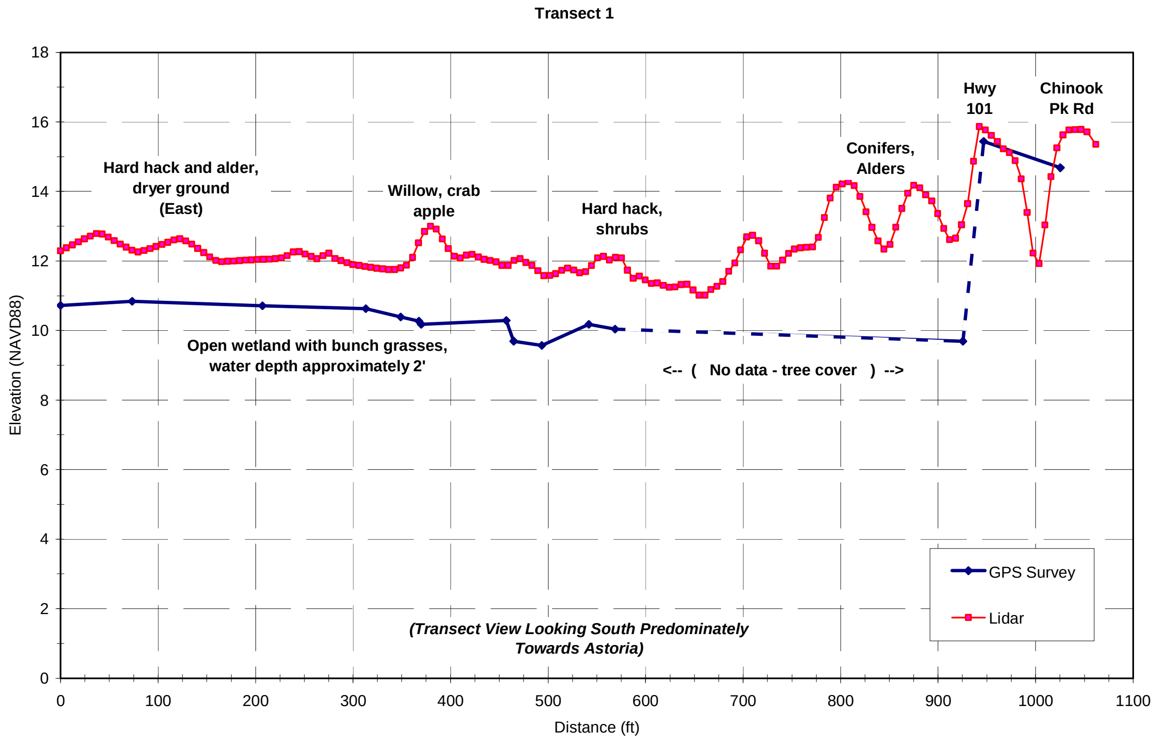


Figure 5
Transect 1 – Comparison of LiDAR Dataset to Ground Survey.

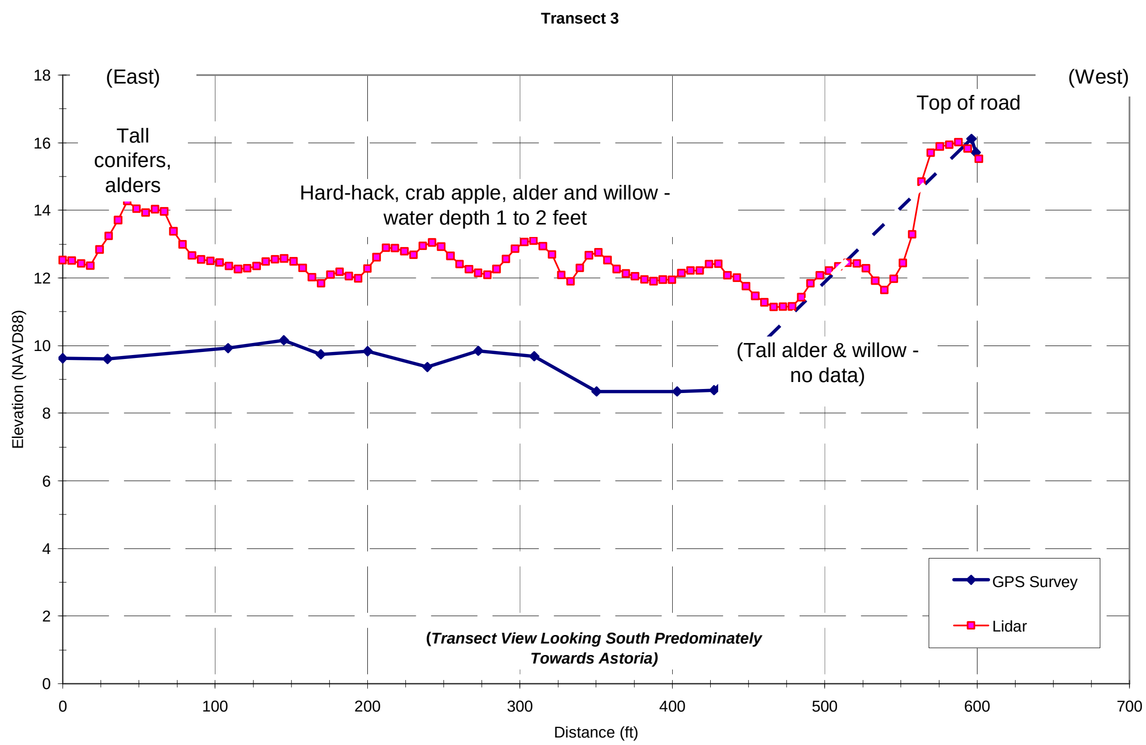


Figure 6
Transect 3 – Comparison of LiDAR Dataset to Ground Survey.

LiDAR Adjustment

The discrepancies between the ground survey and the LiDAR data appear fairly consistent, and the LiDAR data appear to be of high quality (precision and accuracy). Consequently, it is recommended that the LiDAR data be modified for use in subsequent Fort Columbia project design tasks. There are at least two ways that the data can be corrected. The first is to apply a regional elevation adjustment to those areas (land cover types, wetted areas, etc.) to be corrected. The magnitude of the adjustment would be based on the discrepancies noted from the transect comparisons, i.e. generally 2 feet in the downward direction. This method can be effective, but it is also difficult, time consuming and may be somewhat arbitrary because it requires delineation of areas within the wetland to reduce in elevation. In other words, it is difficult to determine where to make the adjustments and where not to. Moreover, 'smoothing' would be required between areas with and without corrections so the resulting terrain surface does not show unnatural drops within the wetland. Smoothing would also be difficult and somewhat arbitrary.

The second method by which elevations may be adjusted involves modifying the sensitivity parameter used when processing the LiDAR data. Varying the sensitivity of the processing routine determines which data are used and which are discarded because they indicate high points, i.e., vegetation or tree canopy. Setting a higher sensitivity parameter would reduce the points that return as bare ground even through they are really vegetative cover. Modifying the sensitivity parameter may result in improved data coverage within densely vegetated areas and possibly in standing water as well.

It is recommended that the second method be used to correct the LiDAR data because it is less expensive, faster and less arbitrary. It would involve a standard processing algorithm that is applied to the entire coverage, and only those points in error would be corrected. Those points along the roadway, already within reasonable tolerances, would not be affected. Using the first method would be more time intensive and more arbitrary in terms of the user selecting which areas to change and those to remain unadjusted. At the time of the writing of this memorandum, the PSLC indicated that they would be willing to look at the LiDAR comparison plots and may be willing to make the necessary corrections at little or no cost to the project (PSLC 2008b). However, it may take a few weeks for PSLC staff to become available to reprocess the data due to prior commitments. Tetra Tech will keep CREST informed of the availability of PSLC and the status of this task in the coming weeks.

Geotechnical Analysis

As part of Task B of the current contract with CREST, a geotechnical investigation was conducted by Tetra Tech's subcontractor, Northwest Geotech, Inc (NGI). A geotechnical investigation was required to assess soil properties and subsurface conditions of the Hwy 101 embankment and foundational soils below the road berm that would support the proposed culvert. The geotechnical investigation presents key findings and provides recommendations on construction methods, culvert foundation requirements, and other considerations.

On August 5 and 6, 2008, NGI drilled two borings through the Hwy 101 road surface to a depth of just over 60 feet. The borings were drilled at the proposed culvert location, approximately 500 feet south of the existing culvert.

The main finding of the investigation was that the selected site was suitable to construct a culvert, given the various stated recommendations and requirements. Recommendations were also made regarding requirements for different culvert types. For example, an open-bottom culvert (shallow arch or similar, see Figure 7 A.) would require pile-supports because soil bearing capacities are likely not adequate to support the culvert and roadway above it. In comparison, a full box culvert (Figure 7 B.) would not require a specially-supported foundation.

Figure 7
Open Bottom (A.) and Full Box Culvert (B.) Examples.

Other findings and recommendations can be found in the full geotechnical report which is included as Attachment II to this memorandum.

Alternatives Analysis

An alternatives analysis was conducted to address outstanding project issues and concerns, refine the design of the culvert as necessary, and quantify expected benefits and other impacts. Some of these issues and questions include:

⇒ Verify that the current design or develop new alternative(s) that acceptably meet WDFW fish passage criteria for tidal culverts and that minimize other costs and undesirable impacts of the project

- ⇒ Consider constructing new culvert southeast of the existing culvert
- ⇒ Determine the extent of the wetland impacted by the project, including tidal intrusion (or tidal prism)
- ⇒ Assess risk of avulsion of Chinook River into wetland and through culvert or bridge.
- ⇒ Determine flood elevations relative to local properties
- ⇒ Assess expected increase in fish habitat and related benefits due to the project
- ⇒ Evaluate the ecological sustainability or change in wetland characteristics to determine habitat complexity, quality and function

The alternative analysis builds on existing data and modeling developed in earlier design stages of the project, as well as new data and information such as historical aerial photographs and communications with relevant stakeholders and community members.

Shoreline History

A qualitative shoreline history analysis was conducted to assess the feasibility of relocating the proposed culvert to avoid excavation of the tidal marsh located on the fringes of Baker Bay adjacent to the current culvert. Constructing the proposed culvert approximately 500 feet south of the existing culvert (along Hwy 101 towards Astoria) would reduce required excavation and possibly other impacts to the marsh and possibly better connect the distributary to Baker Bay (see Figure 8).

The project site is near the head of Baker Bay where it experiences dynamic mechanisms of sediment transport. The sediment transport regime in Baker Bay is likely driven by two processes: shoaling of Columbia River sediments, and wind-wave erosion and re-suspension of fine sediments from storms blowing across the large fetch of Baker Bay. In the latter case, wind-wave action re-suspends fines that are transported primarily west-northwest during ebb tides.

In 2004, the Port of Chinook (Port of POC) dredged about 80,000 cubic yards (CY) from the federal navigation channel (Sand Island Channel) located just to the north of the Project within Baker Bay. In 2006 another 25,000 CY were dredged by the Port in a minor maintenance episode (NWFSC 2008; Port of Chinook- POC 2008). The Port also maintains depths within the harbor where it dredges approximately 20,000 CY annually. From this information, it appears that Baker Bay generally experiences significant deposition of sediments in the vicinity of the project.

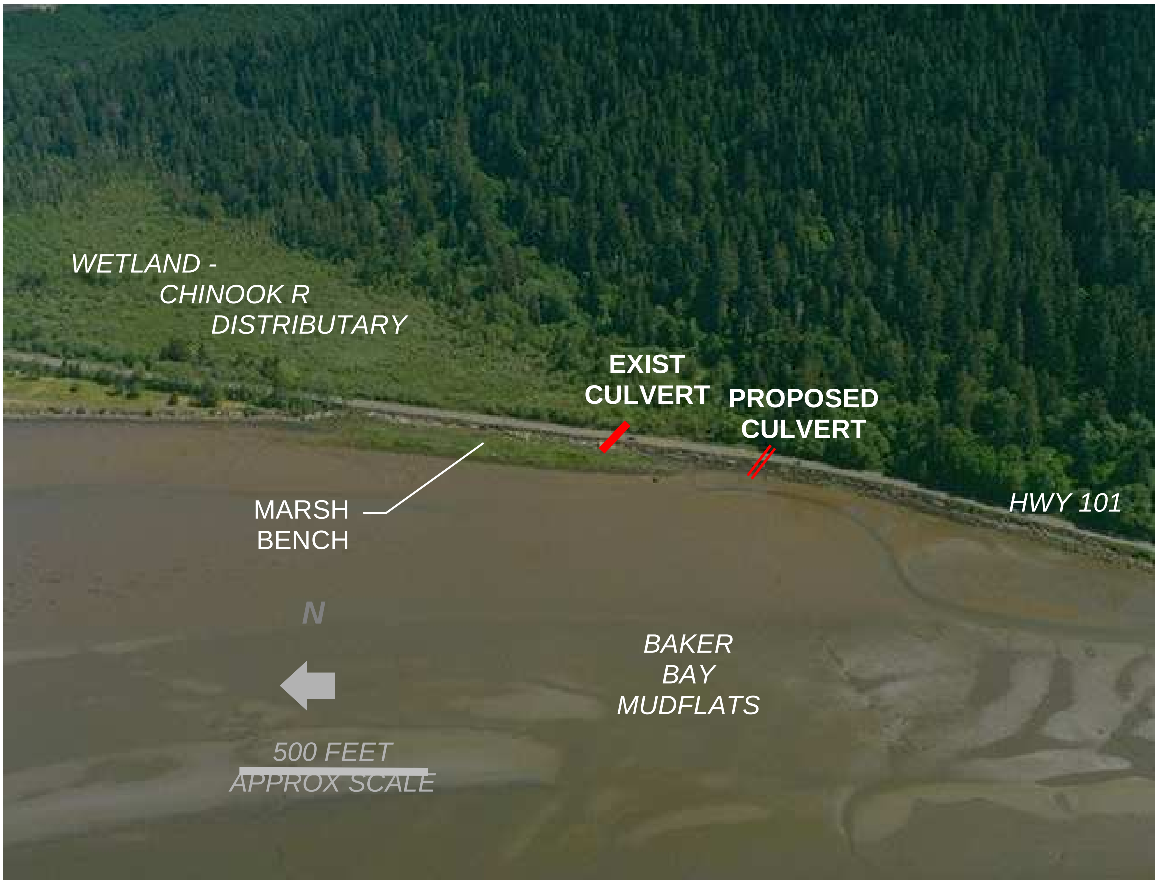


Figure 8
Alternative Culvert Locations.

Amidst the dynamic sedimentation processes within Baker Bay and the larger Columbia River Estuary, a number of channels typically form within the Bay as a result of tidal and freshwater drainage. A tidal channel commonly forms southeast of the existing culvert (see Figure 9, photo C.). Placing the proposed culvert closer to this tidal channel will both reduce the potential excavation necessary to adequately connect the wetland to the Columbia River and also likely help maintain the culvert opening scoured over the long term.

Another observation of the historical shoreline is that the shoreline position adjacent to the wetland is relatively stable. From Figure 9 there does not appear to be gross erosion or accretion of the shoreline or mudflats occurring within Baker Bay near the proposed culvert. This is an indication that relocating the culvert south of the existing location may not pose additional risk in terms of exposure to wind-wave erosion and subsequent culvert wingwall, headwall, or revetment damage. Accordingly, maintenance costs associated with storm damage should not be significantly different than those currently required.

Alternative Culvert Hydraulics and Designs

An analysis of alternative culvert designs was conducted to evaluate the current design (30% design level), and determine if additional refinements are necessary. As part of the previous analysis, culvert hydraulic were characterized by Maul Foster & Alongi (MFA 2005; MFA 2006; MFA 2008). The MFA analysis utilized an unsteady flow HEC-RAS model of the distributary through the wetland and the culvert. The modeling did not include the Chinook River. Distributary inflows were estimated based on flows in the Chinook River (presumably from those developed by Khangaokar, *et al*. 2006), and a percent of the river flow assumed to enter the distributary/wetland. Various downstream tidal boundary conditions were used to represent mean high tide, normal tide, and other tidal sequences. Topographic data used to create model cross section data was developed by photogrammetric methods conducted by Statewide Land Surveying (SLS 2005) through a subcontract with MFA.

The inflow and downstream tidal boundary conditions developed by MFA were used in this alternatives analysis for the sake of consistency and so that direct comparisons of model results could be made. Various culvert parameters were modified in attempt to improve fish passage depths and flow velocities. A summary of the various culvert sizes and elevations under associated alternatives are shown in Table 2.

Table 2
Summary of Existing and Alternative Culvert Characteristics.

Characteristics	*Ref-Ex. Culvert*	Alt 1	Alt 2	Alt 3	Alt 4
Dimensions (W x D)	*24" Dia.*	10' x 6'	10' x 6'	10' x 7'	12' x 7'
Invert elevation, FT NAVD	*8.1'*	6.5'	2.5'	2.0'	2.0'
Gravel substrate depth	*NA*	14"	14"	12"	12"
Net culvert dimensions (Clear Opening W x D)	*NA*	10' x 4.8'	10' x 4.8'	10' x 6'	12' x 6'

Alternatives 1 and 2 were designs considered previously, at the 30% design level. They both included 10 foot wide by 6 foot high (tall) rectangular culvert openings, 14 inches of gravel substrate, but they called for different invert elevations. Based on fish passage analysis done by MFA, Alternative 1 met fish passage criteria (depths greater than 0.5 feet and velocities less than 1.5 ft/s) 30% and 34% of the time, respectively. Alternative 2 was improved and met these criteria 81% and 82% of the time, respectively. The general target for fish passage culverts is 90% exceedance. Consequently, improvements in culvert performance were sought.

,

Figure 9
Historical Photographs of the Shoreline Adjacent to the Fort Columbia Project at (A. 1938, B. 1977, C. 1996, D. 2002, E. 2006).

Two new alternatives, Alternatives 3 and 4 (see Table 2), were developed in an attempt to increase compliance. Alternative 3 includes a 10 foot by 7 foot culvert, 12 inches of gravel substrate, and an invert elevation of 2.0 feet NAVD88. Alternative 4 is similar except it includes a slightly wider 12 foot by 7 foot culvert shape. A HEC-RAS model schematic showing the Alternative 3 culvert is shown in Figure 10.

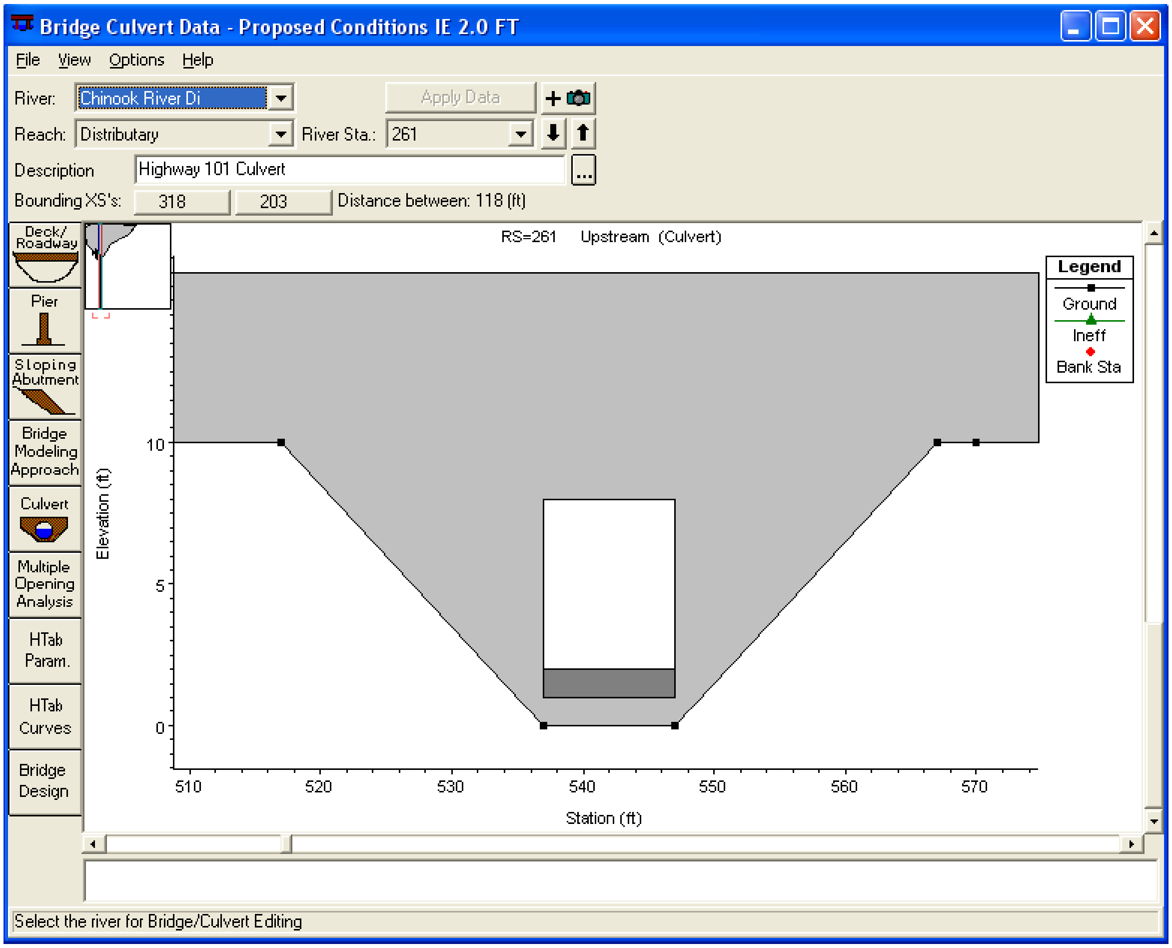


Figure 10
HEC-RAS Model Schematic Showing Alternative 3, 10'x7' Culvert with Invert at Elevation 2.0 FT NAVD88.

Fish passage performance of all alternatives is shown in Table 3. Alternatives 3, which was taller and at a lower elevation than Alternative 2, did represent an improvement with depths greater than 0.5 feet 100% of the time and velocities meeting this criterion 85% of the time.

Alternative 4 was an attempt to attain the velocity criteria more frequently with a 12 foot wide opening. It showed a slight improvement in velocities as shown in Table 3; however, the greater width also reduced water depths below those of either Alternative 2 or 3. Hence, it appears that the culvert design relative to Alternative 3 has reached a point of diminishing returns. Improving performance for one parameter decreases performances in another. There may be other ways of attaining increases in compliance, such as by providing a more diverse substrate, but the design appears to be near optimal given the topographic, flow and tidal boundary condition constraints of the culvert. Per discussions with WDFW staff at the Technical Advisory Committee meeting on October 14, 2008, they recognize that fish passage criteria for culverts does not always conform to tidal situations and that a slightly lower achievement of the criteria is likely to be acceptable. Thus, it is recommended to carry Alternative 3 forward in the next stages of design.

Table 3
Percent Exceedance of Depth and Velocity Criteria of All Alternatives.

Tidal Fish Passage Criteria:	Alt 1 – 10'x6' Invert EL 6.5'	Alt 2 – 10'x6' Invert EL 2.5'	Alt 3 – 10'x7' Invert EL 2.0'	Alt 4 – 12'x7' Invert EL 2.0'
Water Depth > 0.5 ft	30%	81%	100%	76%
Water Depth > 1.5 ft	14%	64%	82%	65%
Velocity < 1.5 ft/s	34%	82%	85%	86%
Velocity < 2.5 ft/s	100%	100%	100%	100%

Flood Impacts

As mentioned, the existing hydraulic model included the distributary, wetland, and culvert, but it did not include the Chinook River itself. To adequately address the impacts of tidal reconnection on flood stages in the river and in the wetland, the model must be revised to include segments of the Chinook River. One impact of tidal reconnection may be that the flood storage capacity of the wetland (if it acts as such) may be diminished due to tidal flows that encroach into the wetland. This interaction between the river and the tide through the wetland is complicated, and must be modeled to assess the impacts of the proposed culvert. It is recommended that the hydraulic model be revised to include the Chinook River and reflect updated LiDAR as one of the first tasks of the continued project design.

Anticipated Impacts on Habitat Vegetation

Based on the alternatives analyzed in the culvert hydraulics section using the HEC-RAS model, the estimated tidal incursion (under mean higher high tides and typical flows) into the wetland is approximately 700 to 800 feet along the main drainage axis. In other words, the tidal stages do not typically encroach upstream into the wetland beyond about 800 feet. This was evaluated based on the elevation of the MHHW and the longitudinal profile of the ground and water surface elevation through the culvert and into the wetland.

This extent of incursion corresponds to an area of approximately 8 to 12 acres, depending on the number and depths of the tidal channels that ultimately form upstream of the culvert. If there is a single main channel that forms upstream of the culvert, although unlikely, the area impacted by brackish tidal flows would be 8 acres or possibly less. If there are numerous shallow tidal channels that together drain towards the culvert, the area of impact could approach 12 acres total. The tidal prism, or volume of water passing through the culvert over one tidal cycle, is approximately 1 acre-foot. The risk of scour and erosion of the wetland upstream of the culvert is estimated to be low because maximum velocities in the vicinity are less than 3 to 4 ft/s. It is estimated that the existing drainage channels within the wetland would not scour away or be silted in, but rather they would be deepened over time. The exact footprint of tidal intrusion is difficult to predict.

Along with the hydrodynamic (flow volume, water depth and velocity) impacts of tidal reconnection, there would be changes in the water quality regime of the wetland near the culvert. To assess changes in water quality (salinity concentrations), observed salinity data from two nearby monitoring stations in Baker Bay and the Columbia River Estuary were analyzed (CORIE 2008). These stations, Chinook River Estuary (CHNKE) and Sand Island (SANDI) are highlighted in Figure 11. The Chinook River station includes real time and historical hourly salinity concentrations from 2002 to 2004. The Sand Island station has data recorded from 1997 to 2008.

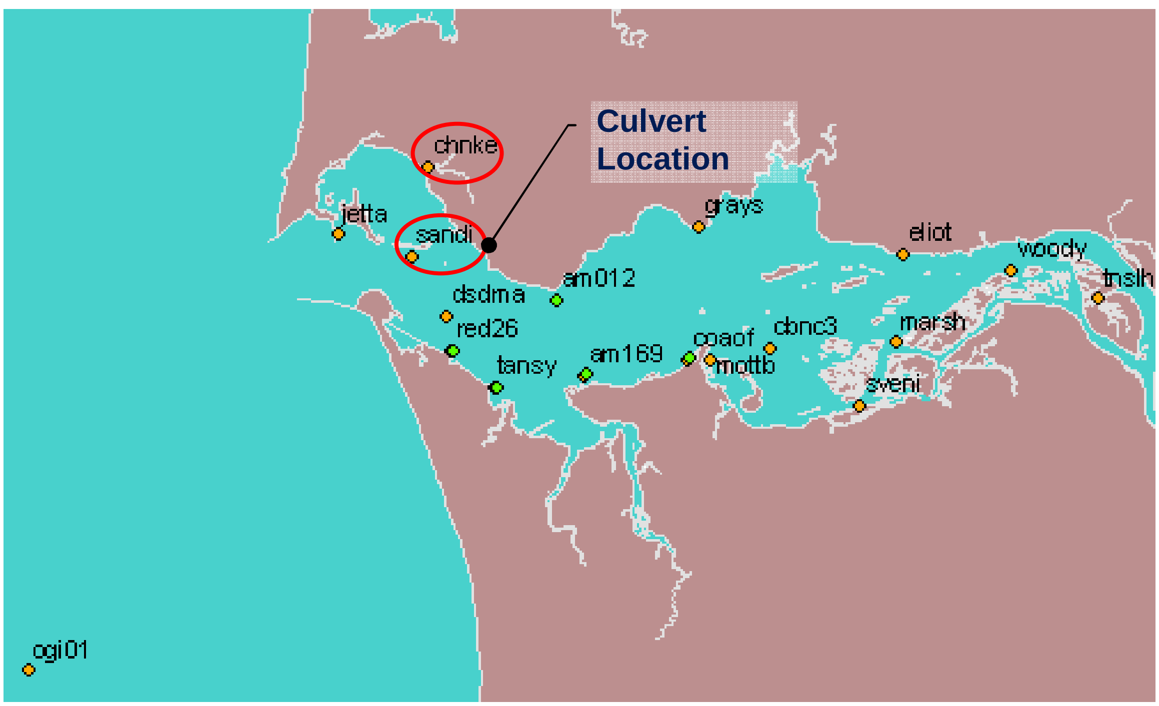


Figure 11
Locations of Sand Island and Chinook River – Estuary Salinity Monitoring Stations.

Salinity concentrations at these two locations are highly dynamic and heavily influenced by tidal fluctuations (seawater concentrations) and freshwater flows in the Columbia River. Summary plots of salinity concentrations (x-axis) displayed as distributions over time (percent of time, y-axis) for the Chinook and Sand Island stations are shown in

Figure 12 and Figure 13, respectively. These plots show data aggregated by season (quarters of year) so that seasonal differences can be compared.

Figure 12 shows that concentrations in Baker Bay near the Chinook River vary from 5 to 25 parts per thousand (ppt) over the year. Concentrations tend toward lower salinities in the winter presumably because of higher freshwater flows from the Chinook River and/or the Columbia River, and concentrations are highest in the summer when they vary between 15 to 25 ppt. The maximum, mean, and minimum concentrations over the period of record are 29.1 ppt, 13.2 ppt, and 0.1 ppt, respectively (CORIE 2008).

At Sand Island, concentrations show a larger variation within each season; concentrations range from nearly entirely freshwater to saltwater. Also, in each season a bi-modal distribution of salinity is apparent. This is believed to be a result of the semi-diurnal tide in the estuary and nearby navigation channel that causes higher frequencies of low and also high salinities as the tide floods and ebbs twice per day. The overall maximum, mean, and minimum concentrations are 32.9 ppt, 18.8 ppt, and 0.0 ppt, respectively (CORIE 2008).

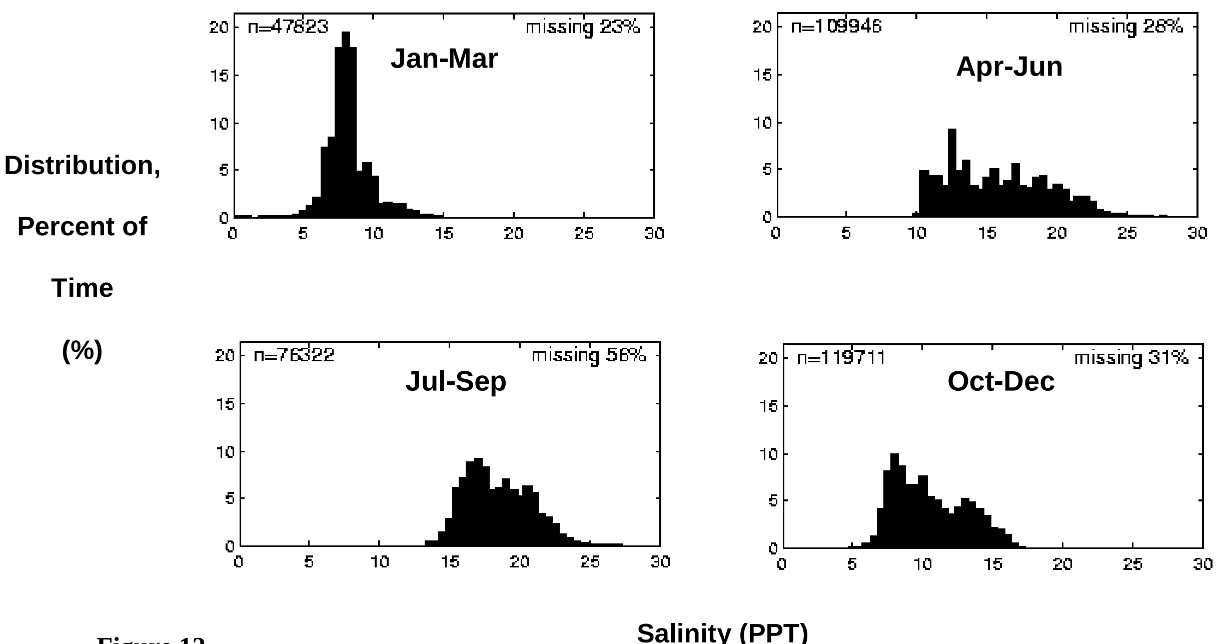


Figure 12
Quarterly Variation in Salinity Concentrations – Chinook River Estuary Monitoring Station.

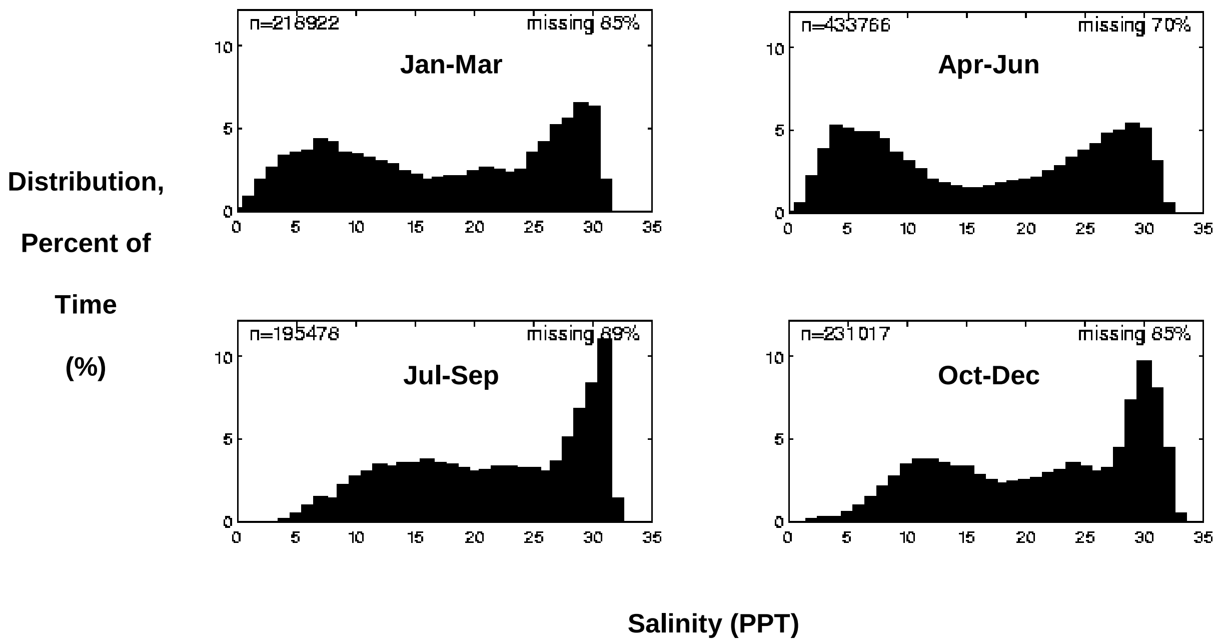


Figure 13
Quarterly Variation in Salinity Concentrations – Sand Island Monitoring Station.

Overall, the expected salinity concentrations in the vicinity of the culvert would be some combination of the patterns at Chinook and Sand Island. There could be a slight bias towards Sand Island (higher salinities and greater tidal variations) because the culvert is slightly closer to the Sand Island station and has lesser freshwater flow volumes than the Chinook River station. Thus, salinities within the wetland due to tidal reconnection would be highly variable over the day, season, and year, with concentrations commonly ranging from freshwater to near-marine levels.

Other Habitat Impacts

Moving the culvert to the proposed location further to the southeast may necessitate some minor excavation on the upstream side in the freshwater wetland area. The ground is slightly higher than the proposed culvert invert and there are a number of alder trees located close to the road. This is not anticipated to be a significant impact on the freshwater wetland as it is likely that this portion of the freshwater community would transition to salt/brackish marsh regardless of the location of the culvert.

The habitat of the existing wetland is likely to change as a result of the culvert replacement. This will not result in a loss of wetlands, but will rather create more habitat diversity by allowing saltwater intrusion into the wetland which will likely convert up to 12 acres of the wetland closest to the culvert to a mix of salt marsh, high marsh, and tidal swamp habitat. This would restore a habitat type that is extremely rare in Baker Bay (tidal swamp), and also provide rearing and refuge opportunities for juvenile salmonids. Research from the Skagit River Delta (Beamer, *et al*. 2005; Beamer and Larsen 2004) indicates that chinook fry and juveniles rear in a variety of delta habitats (that typically includes distributary channels, blind channels, and pocket estuaries) for one to several months prior to migrating out into marine waters. The significant loss of estuarine habitats that has occurred in the Columbia Estuary has likely caused estuarine density dependent effects such as quicker migrations into marine waters and/or reduced growth in estuary habitats. Providing an incremental increase in the diversity of habitats that historically occurred in the Columbia River estuary will help to reduce density dependent effects and also restore the diversity of salmonid rearing strategies and contribute to the recovery of listed stocks.

Summary – Recommendations and Next Steps

Based on the analysis conducted under Tasks A, B and C, the Initial Phase II tasks of the Fort Columbia Project, the following recommendations and next steps have been identified:

⇒ **LiDAR data adjustment**
The available Puget Sound LiDAR Consortium (PSLC) dataset appears consistent and of good quality, but will require adjustment based on comparisons with the ground survey. The adjustments required would be time consuming and somewhat arbitrary if done by typical civil design methods (decrease point elevations by selected increments using drafting software). It is recommended that the PSLC first attempt to correct the data using LiDAR standards and commonly adjusted post-processing parameters. If this does not achieve the desired result, the topography can be adjusted under the next project phase.

⇒ **Geotechnical analysis**
The geotechnical analysis conducted as part of Task B of the Initial Phase II Tasks was successful and provided informative culvert design and construction recommendations. Details of the two borings that were drilled at the proposed culvert location and corresponding analysis can be found in the geotechnical report included in Attachment II.

⇒ **Alternatives Analysis**
The culvert alternatives analysis investigated various culvert locations, sizes, invert elevations and associated impacts on hydrodynamics, habitat and wetland vegetation. It is recommended that the proposed culvert be located approximately 500 feet south (along Hwy 101) of the existing culvert to avoid impacts to the marsh near the existing culvert. Based on historical photographs of the shoreline, this new location appears to provide better connection to Baker Bay, reduces construction impacts, and does not appear to pose higher maintenance costs associated with storm damage to the embankment.

The culvert design that maximizes fish passability appears to be Alternative 3, which calls for a 10 foot by 7 foot rectangular culvert with an invert elevation of 2.0 feet NAVD88. This design exceeds water depth and velocity criteria over 80% of the time under typical tide and flow conditions.

Flood impacts of the proposed culvert have not been adequately addressed by the previous modeling and was not in the scope of this contract. It is recommended that any subsequent design work first assesses changes in the water surface elevation of the Chinook River and wetland, if any, due to the proposed culvert. It is likely that the new culvert will facilitate regular drainage of wetland area, on a twice daily basis.

The area of habitat and vegetation impacted by tidal reconnection is estimated to range from approximately 8 to 12 acres, depending on the depth of water and number of tidal channels that form upstream of the culvert. Salinity levels within this area of the wetland are likely to vary daily and seasonally from freshwater to nearly marine concentrations. The wetland areas affected will result in vegetative community changes, as opposed to a loss of wetlands. Habitat diversity would increase and restore rare tidal swamp habitat. Rearing and refuge opportunities for juvenile salmonids would result, contributing to the recovery of several listed stocks.

References

Beamer, E., A. McBride, C. Greene, R. Henderson, G. Hood, K. Wolf, K. Larsen, C. Rice, and K. Fresh. 2005. Delta and nearshore restoration for the recovery of wild Skagit River chinook salmon: linking estuary restoration to wild chinook salmon populations. Supplement to the Skagit Chinook Recovery Plan.

Beamer, E. and K. Larsen, 2004. The importance of Skagit delta habitat on the growth of wild ocean-type chinook in Skagit Bay: implications for delta restoration. Skagit River System Cooperative.

CORIE, 2008. CORIE Environmental Observation and Forecasting System for the Columbia River, URL: "http://www.stccmop.org/CORIE/about.html." Developed and maintained by the Oregon Graduate Institute School of Science and Engineering, Oregon Health & Science University.

Khangaonkar T., S. Breithaupt & F. Kristanovich, 2006. Restoration of Hydrodynamic and Hydrologic Processes in the Chinook River Estuary, Washington – Feasibility Assessment. Pacific Northwest National Laboratory, Battelle Seattle Research Center, Seattle, WA.

NWFSC, 2008. Northwest Fisheries Science Center, NOAA Fisheries Service, Town of Chinook Community Profile. URL: http://www.nwfsc.noaa.gov/, 2008.

MFA, 2005. Culvert Replacement – Preliminary Plans, Draft 10/20/05. Maul Foster & Alongi, Vancouver, WA.

MFA, 2006. HEC-RAS River Analysis, Software Files and Spreadsheet Results – Fort Columbia Project. Maul Foster & Alongi, Vancouver, WA.

MFA, 2008. Personal Communication, Mr. Michael Rounds, Water Resources Engineer, Maul Foster & Alongi, September 2008.

POC, 2008. Personal communication, Port of Chinook General Manager, September 2008.

PSLC, 2008a. Puget Sound LiDAR Consortium, "http://pugetsoundlidar.ess.washington.edu/".

PSLC, 2008b. Personal communication, Mr. Andy Norton, Puget Sound LiDAR Consortium (Puget Sound Regional Council).

SLS, 2005. Topographic Survey of Culvert Area for Columbia River Estuary Task Force. Survey coordinated by Maul Foster & Alongi, conducted by Statewide Land Surveying, August 15, 2005.

Attachment I –
Fort Columbia Topographic Survey, Field Report.

Dates: Trip 1 - September 3 & 4, 2008; Trip 2 - September 23, 2008
Crew: Tom Smrdel, Jeff Barna
Location: 1-2 miles south of Chinook, WA along Highway 101

The objective of the survey was to take a series of representative topographic points to compare against associated LiDAR data from PSLC. Topographic data were collected with a survey-grade Trimble RTK 5800 with horizontal accuracy of +/- 10mm and vertical accuracy of +/- 20mm. The crew is to collect 3-5 transects across the wetland and spot elevations for the study area through rough, wet terrain.

Trip 1:

Day 1 - Mostly sunny day about 70 degrees, set up base station at Chinook County Park Picnic Area WSDOT survey monument. Setup was straight forward, but there were some limitations of range from the base station due to vegetation, terrain and effectiveness of the internal radio. We were able to complete one full transect and one partial transect with spot elevations before the batteries discharged.

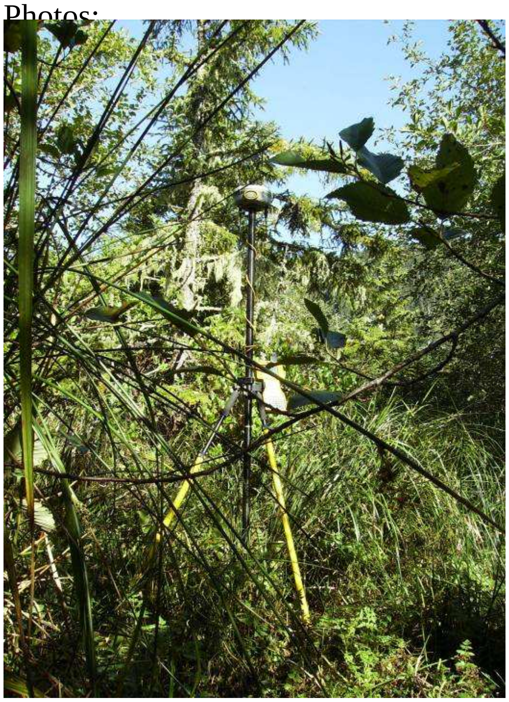
Day 2 – Mostly sunny day, about 70 degrees, set up base station along highway 101, at WSDOT survey monument #11. This bases station location allowed us to reach the mud flats on the west side of the road at low tide. Completed 4 transects near the existing culvert location as well as several points along the road and the toe of the road slope. We were then able to complete the partial transect from the previous day. A third transect was started but due to radio problems we were unable to complete it. We were also unable to collect data from the southern most extent, near the proposed culvert location. We called the day at 1700 hours and returned to Portland.

Trip 2:

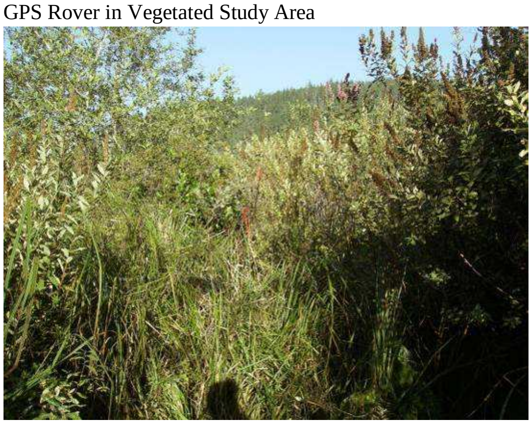
Due to the lack of an external radio as mentioned above, our survey range was extremely limited and a third day in the field was necessary. An external radio was used for the survey Trip 2.

Day 1 – Mostly sunny day about 65 degrees, set up base station at Chinook County Park Picnic Area WSDOT survey monument. After setup, our range improved significantly, we were able to complete a transect through the center of the study area, as well as all missing info near the proposed culvert and additional spot elevations. We attempted to get information in the northern extent of the study area, but due to thick canopy we were unable to do so. We called the day at 1720 hours and returned to Portland. Photos from the field survey are shown below.

Photos:



GPS Rover in Vegetated Study Area



Transect – 1. Looking Northeast.

Transect – 2. Looking East.

Transect – 2. Looking South

Transect – 3. Looking Northeast from Highway

Proposed Culvert Control Point

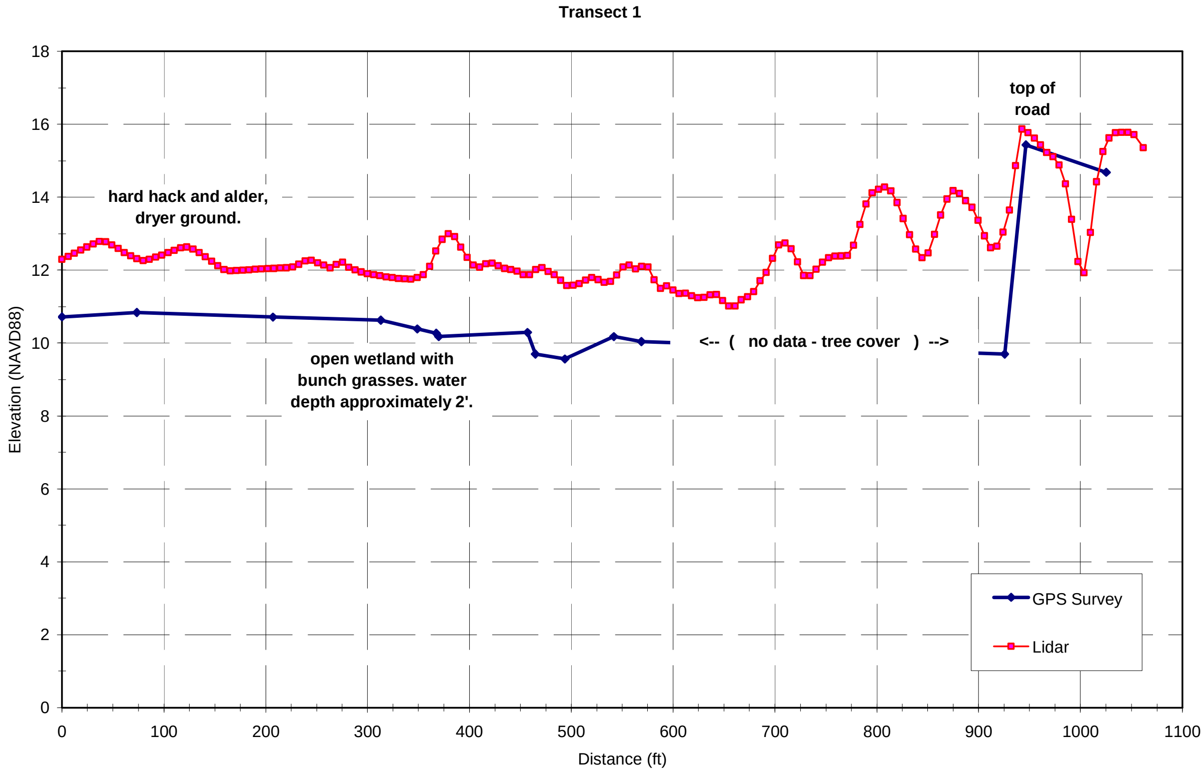
After downloading and reviewing the topographic data, some horizontal corrections were necessary for the first day of surveying. The initial northing and easting were off due to a preliminary information error.

A comparison of WSDOT control point elevations with both the Tetra Tech ground survey and LiDAR dataset are given in the table below. The control points listed below correspond to the WSDOT monument IDs shown in the 'Notes' column in the table.

Table A-1
Comparison of Ground Survey and LiDAR to WSDOT Control Points.

				Differences		
Control Point	Control Point Elev, FT NAVD88	Ground Survey Elev, FT NAVD88	Lidar Elev, FT NAVD88	Control vs. Ground Survey, FT	Control vs. Lidar, FT	Notes
1	14.62	14.64	14.85	-0.02	-0.23	CP1 is nr Chinook Co. Prk (WSDOT ID 5514)
2	14.07	14.07	14.74	0.00	-0.67	CP2 east side Hwy 101 middle of project (WSDOT ID 6222)
3	14.78	14.79	15.09	-0.01	-0.31	CP3 east side Hwy 101 nr exist culvert (WSDOT ID 6221)
			Ave	-0.01	-0.40	

All data points were then compared to the lidar data from PSLC by spatially selecting values that correlate to our field data. These values were then compiled in a spreadsheet and graphically compared with the survey data. They are represented in figures 1 -5 below. Along the major transects, the lidar data is about 2 feet higher than the survey data in the wetland area, which may be attributed to water depth. The points along the road have little variation, and the lidar is deemed credible for the purposes of our study.

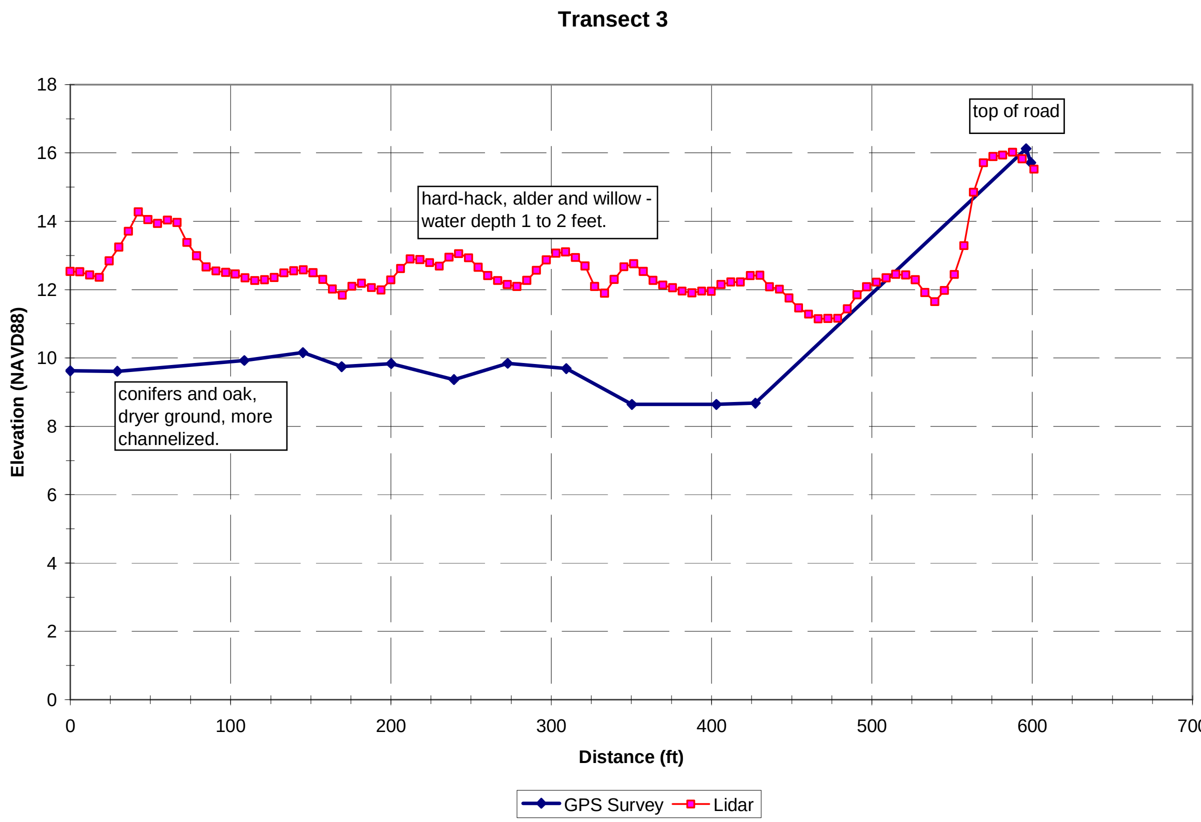


Transect 1:

Terrain consists mostly of bunch grasses less than 3 feet tall, scattered across a braided network of channels through open wetland with a water depth of about 2 feet. In areas with sparse data, tree cover was too heavy to collect points. The difference in elevation can be attributed mostly to water depth, with some variance in vegetation.

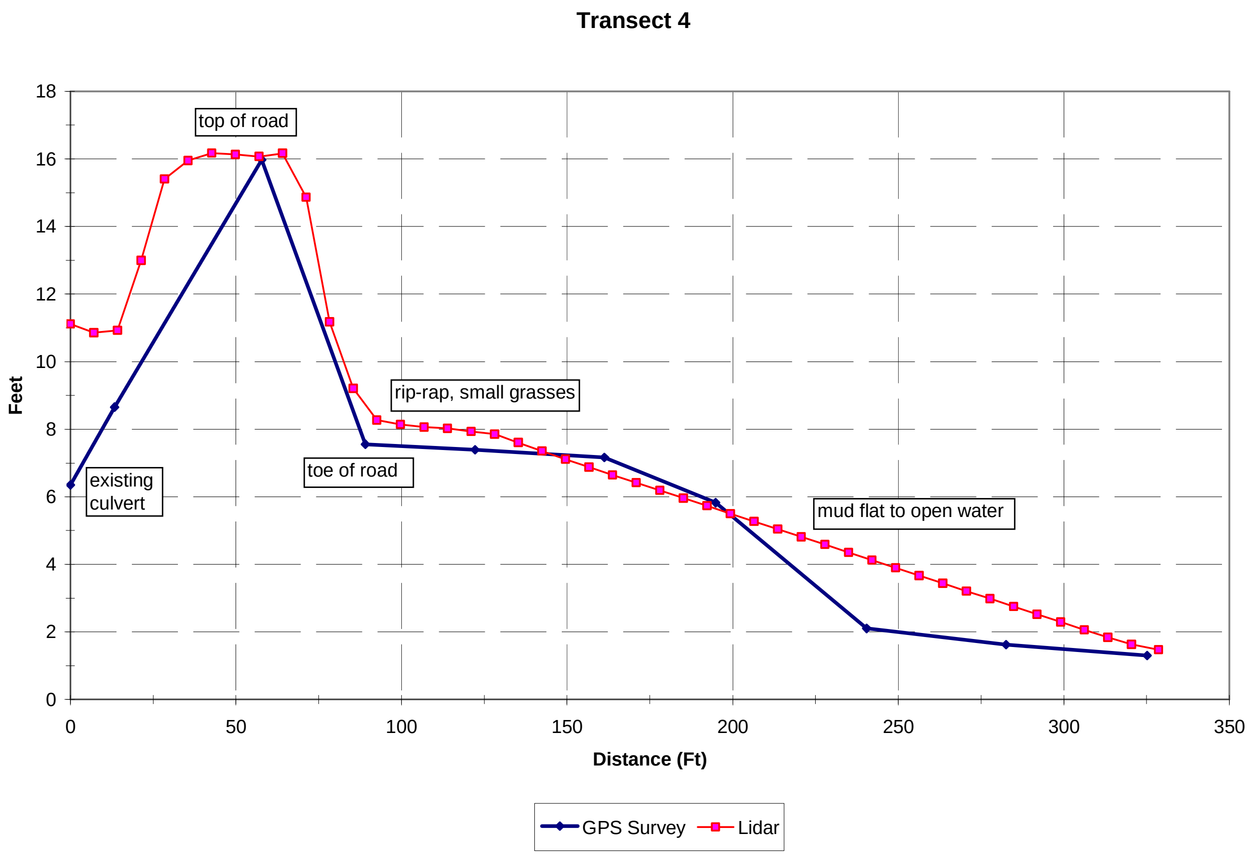
Transect 2:

Terrain consists mostly of hard-hack, about 6 feet in height, with scattered alder and willow trees. Water depth remains about 1.5 to 2 feet in depth with less channelization than the transect 1. The beginning of the transect is on higher ground with less water transitioning into hard-hack. The lack of data can be attributed to radio problem and poor satellite coverage.



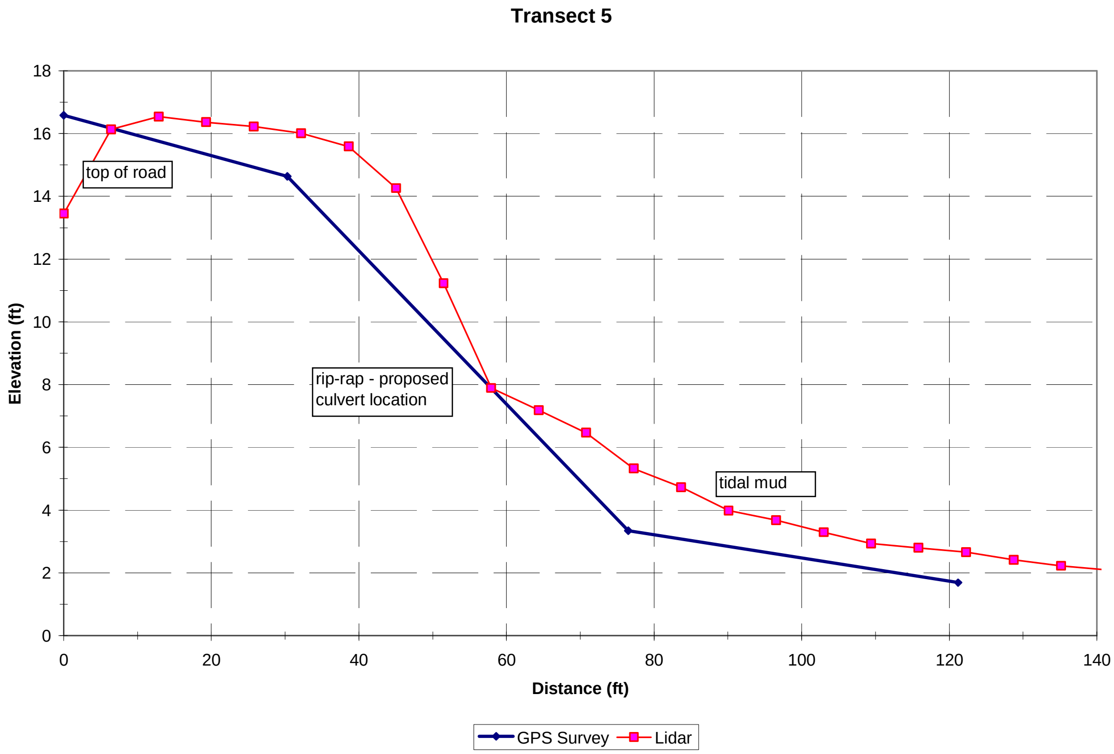
Transect 3:

Terrain consists of conifers and oak trees to mostly hard-hack, with scattered willow and alder trees. Water depth remains at 1 to 2 feet and vegetation is extremely dense. Tree cover is very heavy near the road which prevented data collection until hard-hack was reached. Differences in elevation can be attributed mostly to water depth with some variance in vegetation.



Transect 4:

Terrain is an inter-tidal zone located at the existing culvert. Water depth varied from < 1foot to 4 feet, and the culvert is completely cut off from the inland side by over 2 feet. As a result the water is very stagnant and anaerobic. No data was collected further inland due to extremely dense vegetation. On the west side of the road, rip-rap armors the bank and it transition into some sparse grasses then down into the mud flat. At the time of data collected, water depth was about 1 foot. Differences in elevation can be attributed to vegetation on the right extent and water depth on the left extent.



Transect 5:

The proposed culvert location has a much more direct connection with the tidal zone, there is some rip-rap armoring the bank with no grasses or shelf, as observed at the existing culvert location. This site drops off more sharply is connected to a tidal channel at its lowest point. There is no data east of the road due to extremely dense vegetation; differences may be attributed to water depth and vegetation.

Attachment II –
Geotechnical Investigation

(Northwest Geotech, Inc. Task B Memorandum)

Appendix E: Otter Point Restoration Project

OTTER POINT RESTORATION PROJECT DESIGN SUMMARY

Prepared for the:
Columbia River Estuary Study Taskforce and the National Park Service's Lewis & Clark National Historic Park

CREST
Columbia River Estuary Study Taskforce

NATIONAL PARK SERVICE

HENDERSON LAND SERVICES LLC

August 28, 2008

TABLE OF CONTENTS

PREFACE

THE PARTNERSHIP

The Columbia River Estuary Study Taskforce (CREST) in partnership with the National Park Service and the Young's Bay Watershed Council contracted Henderson Land Services LLC (HLS) for conducting site characterization and developing a Phase I restoration design for the Otter Point Restoration Project near Astoria, Oregon.

Stakeholder agencies, property owners, volunteer organizations, and watershed resource interests have coalesced into a composite study group for restoration of Otter Point, herein called the *Partnership*. Shared perspectives of, and interests within, this area are brought together by the Partnership in development of a long-term vision for the environmental restoration of the Otter Point site and return of this site to natural tidally-influenced conditions representative of this site during the Lewis & Clark Expeditions.

OTTER POINT RESTORATION PROJECT FUNDING

CREST, in partnership with the National Park Service and the Young's Bay Watershed Council, initiated the Otter Point Restoration Project design effort presented herein with funding made available from the Lower Columbia River Estuary Partnership and the Bonneville Power Administration. CREST developed a two-phased approach to implement the Otter Point project, with the completion of Phase I presented in this Design Summary. Final design development will be implemented during Phase II.

INTRODUCTION

HISTORY OF THE OTTER POINT RESTORATION SITE

In November of 1805, the Lewis & Clark Expedition appointed by President Thomas Jefferson reached the Pacific Ocean after crossing the North American continent from the fledgling United States of America. During the winter of 1805-06, the expedition encamped and over-wintered at Fort Clatsop, named for the Clatsop Indians who inhabited this area. A modern replica of Fort Clatsop sits in the approximate location of the historical fort, and is located a short distance south of the Otter Point Restoration Project site. In the years following the Corps of Discovery's departure, the Clatsop Indians briefly occupied the site, but soon the Fort fell into ruin. By the mid-19th century, the site was being used by newly arrived agricultural settlers, who grazed livestock and grew modest crops along the banks of the Lewis & Clark River.

In the intervening years, Otter Point's landscape was altered from tidally-influenced wetland and estuarine habitat into pastureland. Protective levees were constructed along the site's river frontage to reduce the influence of tides from Young's Bay as well as Lewis & Clark River flows. Materials dredged from the bed of Young's Bay and Young's River to improve shipping access and commerce were pumped into the Otter Point site as fill. With these changes to site elevation and hydrology, the Otter Point Restoration site no longer sustained a native vegetation community as experienced by the Lewis & Clark Expedition and early explorers to the Pacific.

The Fort Clatsop Historical Association purchased the Otter Point site in the early 1990s to protect park resources and views, and the land was transferred to National Park Service (NPS) management in 2002 as part of Fort Clatsop National Memorial. In 2004, Fort Clatsop National Memorial was incorporated into the larger Lewis & Clark National Historical Park. Today, this Park is a nationally-significant historical site that receives a quarter million visitors per year. Restoration of Otter Point therefore provides unique opportunities to potentially integrate public access, interpretive, and educational opportunities centered on the restored estuarine habitat adjacent to Fort Clatsop.

NEED FOR DESIGN ALTERNATIVES ANALYSIS

As our communities grow, the preservation of linkages which constitute the continuity of the water cycle becomes ever more critical to our lives and where we live. From the rainfall which refreshes our groundwater, from small streams to great rivers, and onward to the sea, this continuity is the ribbon of life for countless and diverse species.

Once natural resource areas were thought to be only areas for exploration and exploitation, we now know that these areas cleanse and maintain our environment. Wetlands, creeks, and streams retain and gradually release large volumes of water providing flood control important to our urbanized lands. Associated native vegetation trap sediments, consume water-borne pollutants, and most importantly offset the build-up of CO_2 in our air releasing great volumes of oxygen much as rain forests do. Preserving natural resource areas in our developing communities, preventing the isolation of key elements of this cycle, requires forward planning in balancing economic development with a quality of living and environmental vitality.

Otter Point represents a unique opportunity to restore critical tidally-influenced lands along the lower Lewis & Clark River. Wetlands and estuarine lands within the Young's Bay watershed and lower Columbia River estuary are some of the most productive habitat for salmonid production and rearing. Careful analysis of design opportunities and constraints in restoring the approximately 33.5-acre Otter Point site is required to optimize environmental and social/cultural benefits while minimizing implementation costs. Guidance from Partnership members is critical to ensure that the Phase I restoration design presented in this Design Summary are refined to best reflect established project goals.

DESIGN OBJECTIVES

Conceptual design objectives established for Phase I were as follows:

- Increase floodplain connectivity in the lower Lewis & Clark River by reconnecting the Otter Point site to riverine flows and tidal inundation.
- Restore estuarine habitat within Otter Point.
- Increase diversity of habitats within Otter Point.
- Increase off-channel salmonid refugia by re-establishing localized hydraulic connectivity.
- Provide rearing habitat for juvenile salmonids, especially Chinook fry from February through July and chum fingerlings from March through May*.
- Remove/reduce invasive vegetation presence.
- Enhance riparian conditions via strategic native plantings.

- Increase ‘edge’ habitat for smaller mammals and birds.
- Conserve unique Roosevelt Elk habitat.
- Integrate site public access and interpretive opportunities where appropriate.

**“Salmon Life Histories, Habitat and Food Webs in The Columbia River Estuary: An Overview of Research Results, 2002-2006” Draft. March, 2008*

Collectively, the Otter Point Restoration Project’s design objectives are intended to provide multiple ecological benefits including: improved wetland and in-stream complexity, restoration of inter-tidal marsh habitats, improved riparian function, increased large wood recruitment potential, and increased habitat availability for resident and anadromous salmonids as well as other wetland-dependant species. Critical Roosevelt Elk habitat will be retained through general conservation native willow habitat and enhanced through creation of upland spruce cover habitat.

Design development constraints presented by the Otter Point site and adjoining private lands included the following:

- No increase of flood/erosion potential on adjacent private pasture land.
- No impact to limited existing maintenance access to PacifiCorp’s power transmission line alignment which bisects the Otter Point site.
- Maintain vehicular access to NPS’ existing septic drain field from NPS offices into the Otter Point site.
- No disturbance of historic/cultural integrity of the Otter Point site.

RESTORATION SITE ASSESSMENT

EXISTING CONDITIONS

Otter Point is an approximately 33.5-acre site located in T8N, R10W, Section 35 and 36, approximately one mile upstream of the confluence of the Lewis & Clark River and Young’s Bay, within the Lewis & Clark National Historic Park.

The Lower Lewis & Clark River watershed is a 6th field watershed that drains into Young’s Bay on the north coast of Oregon. Young's Bay Watershed is located near the mouth of the Columbia River in the northwest corner of Clatsop County. The Lewis & Clark River flows through state and private forestry lands, residential communities, and farmland into Young's Bay and then the Columbia River Estuary, a nationally-significant estuary, rich in natural resources, supporting some of the largest anadromous fish runs in the world and providing unique habitat for sensitive and endangered species. Past research shows that the Young's Bay Estuary is one of the Lower Columbia's most biodiverse areas.

Supporting several species of salmonids, the Lewis & Clark River’s estuarine wetland habitat has been severely altered due to historic diking and filling activities, which has resulted in a significant loss of this important habitat type as well as altered hydrology, sediment regimes and vegetation types and degraded water quality. Today, Otter Point is largely hydrologically disconnected from Lewis & Clark River flows and estuarine tidal influence, with an altered vegetation community dominated by reed canary grass and willow, a habitat which provides virtually none of its historic value to salmonids.

Limited population information is known about salmonids in the Young's Bay Watershed. Historically, fall Chinook, Coho, steelhead, sea run cutthroat, and chum found their way into backwater refugia associated with the estuarine wetlands and riverine tributaries to spawn. In addition to reduced habitat complexity, the Lewis & Clark River is listed for fecal coliform on the state’s 303(d) inventory of impaired water bodies. Other limiting factors for the water body include: water quantity, spawning gravel quantity and quality, fish passage/migration barriers, riparian stand condition, riparian invasive species, excess sediment deposition, upland habitat fragmentation, and insufficient large wood recruitment (Young’s Bay Watershed Assessment, 2001). These limiting factors reduce salmonid production: altering in-stream biotic structures, limiting the availability of forage, increasing turbidity, reducing cover from predation, restricting off-channel refuge during high water events, and altering salinity gradients. Today, most populations are in decline.

Cultural and Historical Resources

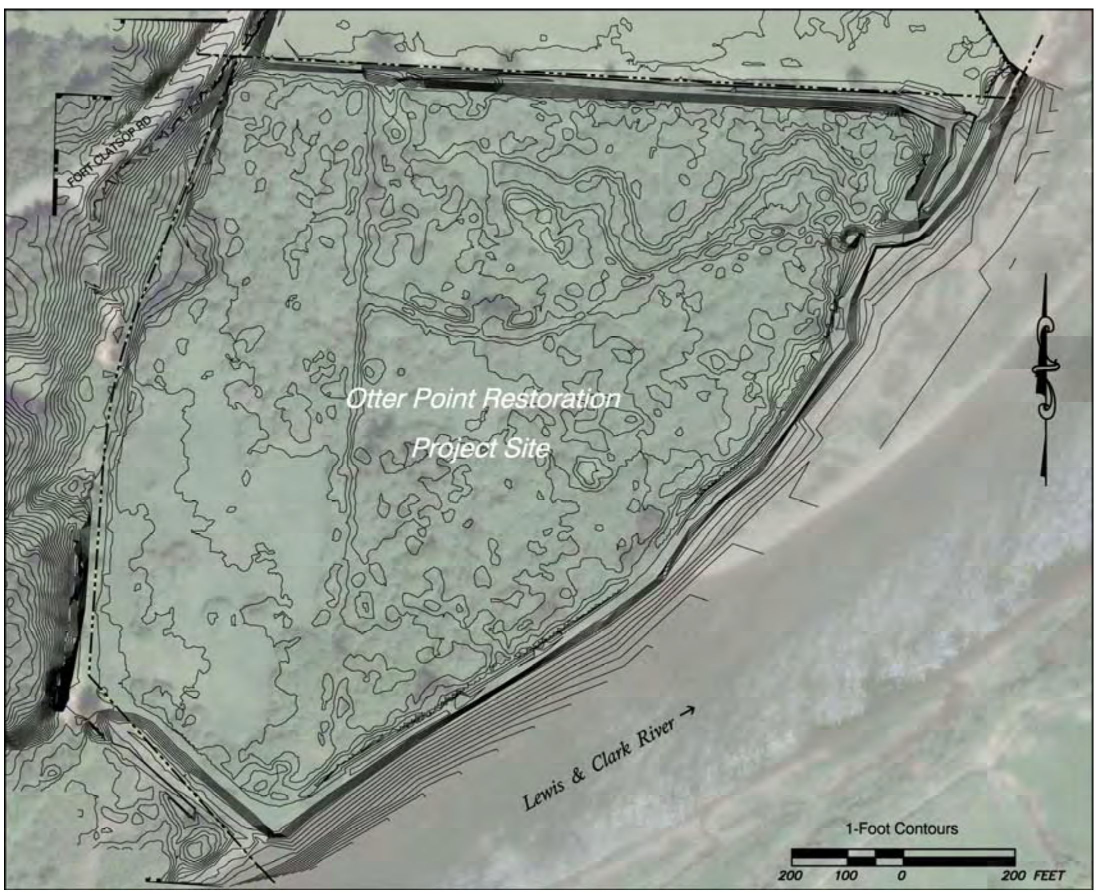
NPS and the HLS team have conducted limited historic research conducted within the study area. No onsite archaeological investigations have yet been conducted at Otter Point though NPS has conducted archeological investigations on adjacent lands. Therefore the cultural and historical resources analysis presented herein is by necessity 'preliminary' (see Appendix I) as it only represents an overview of cultural resource and interpretive mandates that must be considered at the current Phase I level of design. Prior to finalizing the Phase II design, the NPS will need to complete a cultural resources survey of the Otter Point project site.

While archaeological resources have not been documented within the proposed project footprint, the site is anticipated to have a high probability of such resources due to its proximity to the Lewis & Clark River estuary. In addition, the Otter Point project site sits close to documented archaeological sites, including historical sites of national significance associated with the Corps of Discovery and Native American archaeological sites predating and/or contemporary with the Lewis & Clark Expedition. The Clatsop people almost certainly used the wetlands in this area for subsistence and other purposes, including residents of village sites reported in this area, as well as the family of Chief Coboway, who occupied the fort seasonally after the Corps of Discovery's departure. Despite considerable ground disturbance in the last century and a half, archaeological materials might be anticipated along the historic shoreline from these pre-contact and contact-period American Indian communities, homesteading at the Shane ranch that occupied the site in the mid-19th century, and commemorative visitation of the Fort site until roughly 1860. As mandated by relevant cultural resource laws, regulations, NPS policies and guidelines, archaeological clearance would be required on this site prior to ground disturbance – especially along the historical shoreline.

In addition, NPS policies provide strong incentives to preserve or restore the landscape of this historical park to approximate conditions witnessed by the Lewis & Clark Expedition. If configured to replicate historical conditions, marsh areas, springs, and channels that might be restored on the site can contribute to the park's mandate to tell the stories of the Corps of Discovery, and may themselves become the focus of interpretive efforts. So too, restoration strategies that enhance flora and fauna that were integral to the Corps of Discovery story may potentially aid the park in meeting its cultural resource and interpretation mandates, in addition to its natural resource management mandates. As stated in the park's General Management Plan, "Today, management of the cultural landscape focuses on the preservation of both natural and built landscape features as they contribute to the historic scene" (NPS 1995: 76). A preliminary cultural/historical assessment of the project site (see Appendix), conducted as part of this restoration planning effort, has illuminated a number of these issues. Together with the natural resource criteria outlined in this document, these considerations have helped to shape the restoration design proposed in this Design Summary.

Site Boundary and Topography

LiDAR (Light Detection and Ranging) is a remote sensing system used to collect topographic data with aircraft-mounted lasers capable of recording elevation measurements with an optimum vertical precision of 15 centimeters (6 inches). In 2002, the NPS conducted a LiDAR survey over much of Lewis & Clark National Historical Park. In researching available site boundary and topography documentation of the Otter Point site, HLS reviewed the LiDAR data provided by the NPS. Concurrently, HLS conducted initial ground survey of site boundaries and utilities. Differences in excess of 6 inches in elevation were found between the LiDAR and field survey topography, progressively greater in discrepancy nearer the existing vegetated levee and river. HLS therefore conducted ground survey at low tide on multiple transects of the levee into the Lewis & Clark River as well as the existing excavated drainage channels on the northern and southern fringes of the Otter Point site. Both LiDAR and field survey data were then integrated into a baseline data set that established boundaries and topographic conditions for the entire project area. LiDAR, confirmed by field surveys of the Otter Point ground surface, revealed a number of attributes to the site, including no fewer than two historical estuarine channels that formerly traversed the project site.



Site Utilities

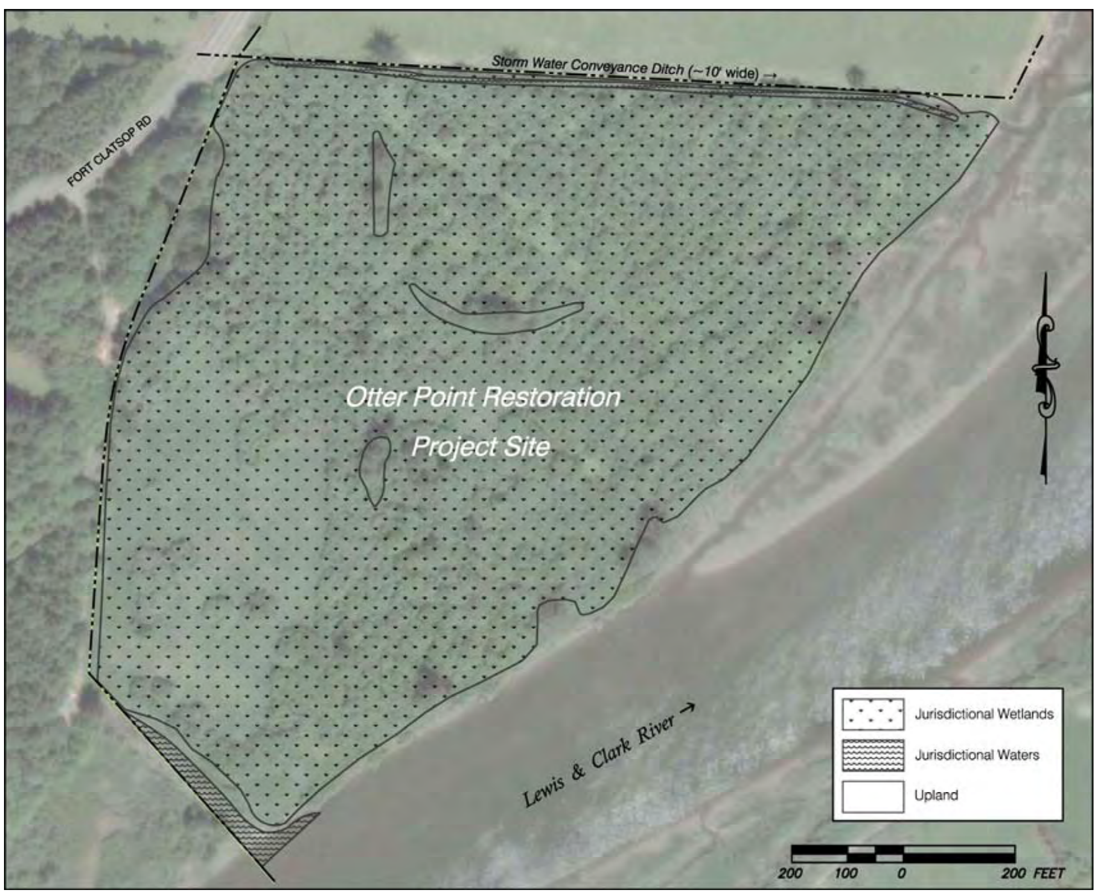
Site utilities and their locations on the project site were researched through county and state records as well as through the use of private locating services. Entering Otter Point along the western boundary is the abandoned road grade of Fort Clatsop Road, maintained today by Lewis & Clark National Historical Park for access to Otter Point and to service the Park's office's septic system field which enters Otter Point immediately west of the abandoned roadway. PacifiCorp (Pacific Power and Light) has a 100-foot wide easement through Otter Point for an area-wide power transmission line serving the communities of Warrenton and Astoria. No other public or private utilities or easements were located on the Otter Point restoration site. PacifiCorp's easement provides for the right of access in maintaining these lines and supporting towers on Otter Point.

Wetland Delineation/Determination

HLS ecologists conducted a field delineation of wetland boundaries within the Otter Point Restoration Project site using the methodology described in the *US Army Corps of Engineers Wetlands Delineation Manual* (Environmental Research Laboratory 1987) based on the concurrent presence of hydrophytic vegetation, hydric soils, and wetland hydrology. The majority of the site was found to meet wetland criteria despite the levees and ditches.

Special attention was paid to delineating boundaries of small, isolated upland areas. Often, these areas were initially identified by the presence of large, potentially upland trees such as Sitka spruce (*Picea sitchensis*).

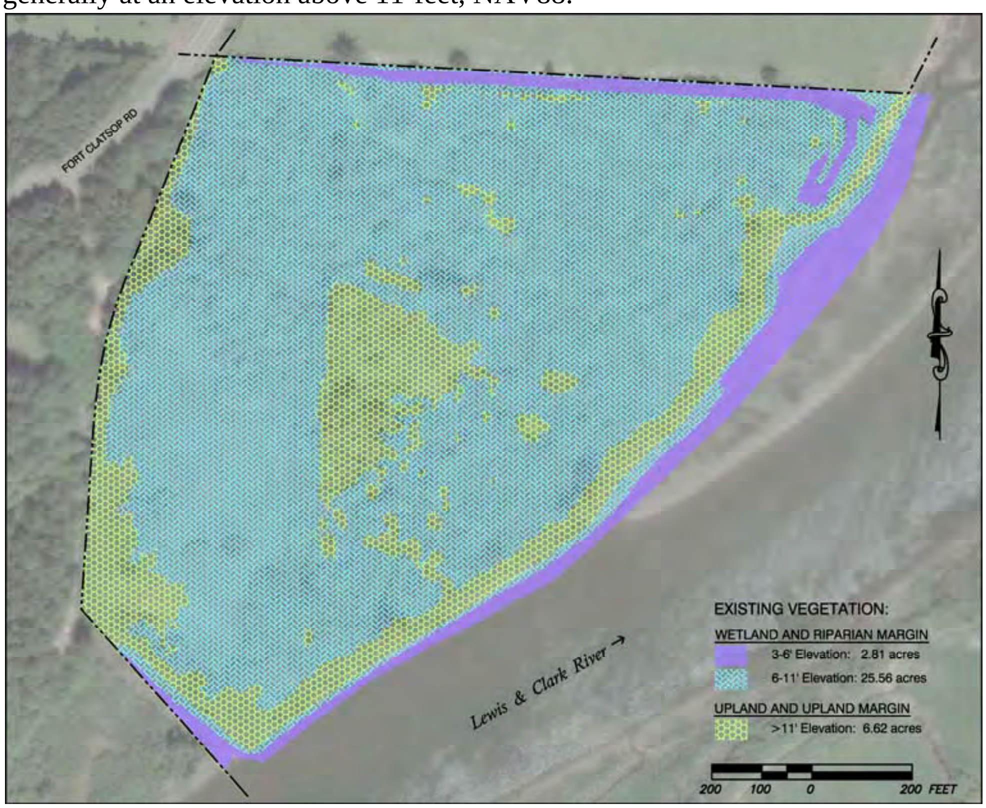
Surface hydrology on the site is mainly supplied by precipitation, but some storm runoff reaches the site by way of culverts under the maintenance road along the west side of the project area. An excavated drainage channel runs along the northern property line and is connected to the Lewis & Clark River by a tide gate. Soils found on site generally concur with soil units mapped by The Natural Resource Conservation Service (NRCS) with the exception of those locations where fill from either excavated drainages or river dredge materials were introduced.



Onsite field investigation located 29.4 acres of potentially jurisdictional wetlands and 0.3 acres of jurisdictional waters connected to the Lewis & Clark River – representing 89% of the total 33.5-acre Otter Point Restoration Project site. Onsite wetlands consisted of palustrine emergent wetlands (PEM) displaying erect, rooted herbaceous hydrophytes dominated by reed canary grass (*Phalaris arundinacea*) and palustrine scrub-shrub wetlands (PSS) dominated by woody vegetation less than 20 feet tall, such as hooker willow (*Salix hookeriana*). A few small areas of palustrine forested wetlands (PFO) were found near previously-disturbed dredge material piles and were dominated by woody upland vegetation taller than 20 feet.

Vegetation Communities

Vegetation on the Otter Point site has been influenced by the historic disturbances mentioned elsewhere in this document. The Lewis & Clark River levee prevents tide waters or river flows (typically below 6 feet in elevation, NAV88) from entering the site, therefore, the majority of the plants identified on site were fresh water wetland species. Reed canary grass was the most widespread invasive plant found throughout the site and inhabited much of the PEM wetland habitat (characterized between 6-feet and 11-feet in elevation). Hooker willow formed almost impenetrable thickets of PSS wetland and stands of Sitka spruce were found on old dredge material piles which accounted for the limited upland vegetation communities within the wetland. The vegetative boundary between upland vegetation stands and wet willow thickets occurred at the drip line of the larger spruce trees, and generally at an elevation above 11-feet, NAV88.



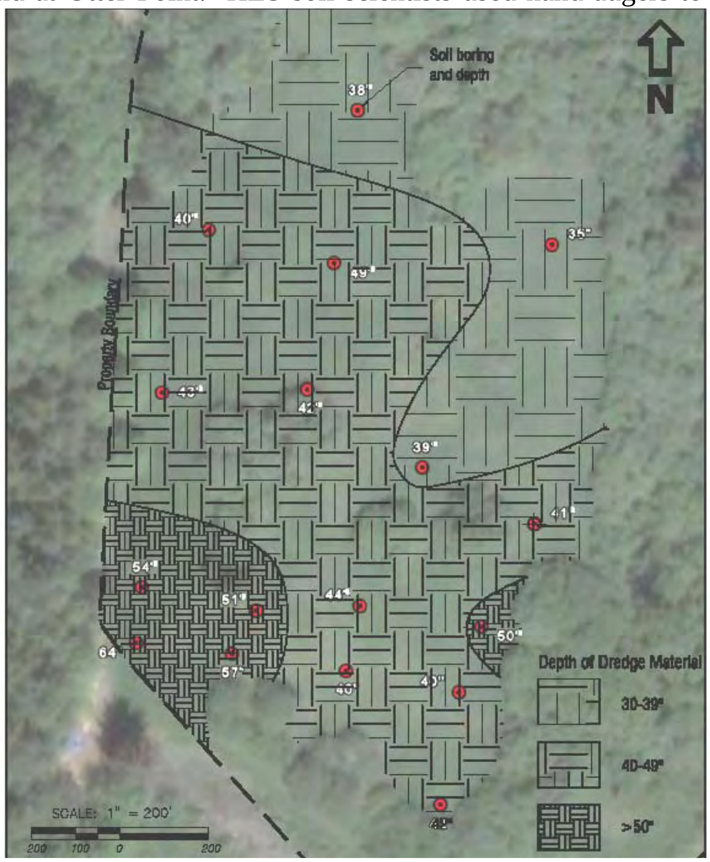
Reference Sites

Relatively undisturbed naturally-vegetated riverine frontage to the Lewis & Clark River can be found immediately to the south of the Otter Point site. As a reference for design communities in the Otter Point restoration effort, HLS characterized the vegetation communities in this reference site by plant communities and by elevation or landscape position of the species within these communities. A second observational reference site is the recently completed passive restoration site at South Clatsop Slough, which is south (upstream) of both Otter Point and HLS' primary reference site. NPS biologists provided review and comments of these HLS reference site characterizations, to insure their compatibility with observations accumulated by NPS staff over a relatively long time horizon.

River Dredge Materials Survey

HLS conducted an investigation to document the presence of dredged material in the reed canary grass-dominated habitat in the southwest corner of the Otter Point restoration site. Previous field research had made HLS aware of the possibility of large amounts of dredged material burying the native ground at Otter Point. HLS soil scientists used hand augers to locate the boundary between native soil and dredged material, easily identifiable by the organic material and change of soil texture. Dredged material ranged from sand to silt and was 20 to 64 inches deep. As HLS augured through the profile, soil texture changed from sand to silt due to translocation of the finer soil particles. A thin (~1-inch) layer of partially decomposed organic material was found just below the dredged material signifying the historic ground surface.

Generally, dredged material was deepest in the southwest corner of Otter Point and shallowest in the northeast. Estimates of dredged material volume within the restoration site exceed 100,000CY.



Baseline Hydraulic and Hydrological Analysis

A hydrodynamic analysis of the Otter Point site –an investigation of the movement of water through the site under different scenarios – was conducted employing a two-dimensional (2D) hydrodynamic model of the proposed restoration area. This analysis served to evaluate tidally-driven inundation of the site in order to provide a baseline for proposed restoration efforts. Evaluation of the Partnership's preferred design against baseline conditions requires hydrodynamic modeling in order to:

- evaluate the water levels, flow velocities, and extent of tidal inundation in the 33.5-acre property being restored.
- evaluate the velocities within the preferred design's restored channels, including the confluence of the channels with the Lewis & Clark River.
- evaluate the proposed northern levee's elevation required to avoid tidal inundation to the adjoining private pasturelands.

Available bathymetric, topographic, and site survey data were compiled and reviewed for use in development of the 2D hydrodynamic model. Site specific tidal information and hydrology data were also compiled and reviewed for use as input to the 2D hydrodynamic model. No field data collection efforts were undertaken and model validation was conducted with preexisting data only.

Water levels in the estuarine portion of the Lewis & Clark River are influenced by the semi-diurnal tide in the Columbia River (mean tide range is more than 6 feet at Astoria, Oregon). Presently, almost the entire Otter Point site is hydrologically disconnected from tidal and riverine influence. Water sources for this site are primarily seeps, springs, and seasonal flows from upslope sources that are impounded by the existing Lewis & Clark River levee. A tide gate at the river terminus of the northern excavated drainage allows for limited outflow of these impounded surface waters.

COMMUNITY LINKAGES

Planning for the Otter Point restoration effort has involved a unique collection of decision-makers, including stakeholder agencies, property owners, volunteer organizations, and watershed resource interests. Stakeholders represented in Phase I design workshops include the NPS, CREST, Young's Bay Watershed Council, Clatsop County Planning, Clatsop County Diking District, Warrenton Trails Association, and PacifiCorp.

Together, representatives of these groups coalesced into a composite study group that has helped set the agenda for the current restoration effort, based on the diverse concerns of these groups regarding both the natural resource values and the community use and significance of the Otter Point site.

A goal of this Partnership is to integrate the preferred design and recommendations presented in this document into the Phase II Final Design and Implementation phases of this design effort. Expanding on this Partnership's contributions after this Phase I design effort, an executive committee could be created from the Partnership members, consisting of representatives of those stakeholders who are most affected by the successful implementation of the Otter Point Restoration Project. Phase II design efforts by the Partnership will provide opportunities for public input in shaping the vision for this unique historical restoration site. Consideration and integration of public comments will help the Partnership refine Phase II restoration design efforts through all future project phases, including project permitting, construction implementation, and effectiveness monitoring.

While there are many community partners who will play a role in this restoration effort, we focus here on two: Lewis & Clark National Historical Park and the community organizers behind the Warrenton Trails System expansion effort.

Lewis & Clark National Historic Park

Lewis & Clark National Historical Park consists of six separate park sites that serve to preserve and commemorate the history of the Corps of Discovery's visit in 1805-06. The park is operated by the NPS, with cooperation from partners, Oregon State Parks and Washington State Parks. Otter Point represents a recently acquired extension of the Fort Clatsop National Memorial component of the larger park. The original Fort Clatsop was constructed by members of the Lewis & Clark Expedition and served as their primary winter quarters from December 1805 through March of 1806. A replica of the fort occupies the site today, alongside a visitor center, set amidst a young Sitka-spruce dominated forest along the banks of the Lewis & Clark River.

As owners and stewards of the Otter Point site, the resource management staff from Lewis & Clark National Historical Park has had a central role in the Otter Point restoration planning process. Staff members originally conceived of the Otter Point restoration project, and have played an active role in shaping the project's goals at every stage of the planning process. Natural and cultural resource managers from the park will continue to play a decisive role in the final planning and construction phases of this restoration effort. Moreover, they will play a central role in caring for the site after construction, through such tasks as monitoring site conditions for adherence to project goals, and interpreting this unique area to park visitors.

Warrenton Trails System

The Warrenton Trails Association, the City of Warrenton, and various partner organizations have been working to consolidate a number of disconnected trail segments into an integrated system of trails. When complete, this Warrenton Trail System will include a 25-mile loop trail that links places of historical interest on public lands throughout the City of Warrenton and adjacent unincorporated portions of Clatsop County. The Warrenton Trail System is planned to connect with Fort Clatsop, in part by following the system of dikes fronting the Lewis & Clark River. The Otter Point restoration project has the potential to facilitate this trail access by incorporating pedestrian pathways into a design that serves to enhance both natural functions and visitor access at the site. Members of the Warrenton Trails Association participated in meetings regarding the design of the Otter Point restoration. We anticipate that this Association will continue to engage in a dialogue with other project partners during final design and construction phases of the project.

RESTORATION DESIGN DEVELOPMENT

In consideration of site design constraints, existing conditions, and Partnership design objectives, two basic design options were evaluated; full removal and partial removal of the existing levee along Otter Point's Lewis & Clark River frontage. These options are briefly summarized below, with more detailed analysis of each alternative in the pages that follow.

FULL LEVEE REMOVAL

Full levee removal is utilized to maximize re-exposure of prior estuarine and riverine lowlands to the estuarine hydrology of the lower Lewis & Clark River. Under this scenario, the levee material is removed at the river or tidal frontage to restore connectivity and periodic flooding of these lowlands. The levee would be reconstructed away from the water and restored lowlands to protect adjacent property and infrastructure.

Removal of the Lewis & Clark River levee would allow for full connectivity of Otter Point with the Lewis & Clark River flows as well as tidal interaction from Young's Bay and the lower Columbia River estuary. In addition, this option would allow for the structural restoration of the shoreline in such a manner that it would approximate the historical shoreline conditions observed by members of the Corps of Discovery. Excavation of the two historic channels, identified through LiDAR survey and verified by field survey, would restore tidally-influenced off-channel salmonid refugia and potential rearing habitat, while also enhancing site surface hydrology. Redirection of freshwater seeps, springs, and seasonal drainages from the adjacent hillside into these channels would provide critical freshwater input to improve salmonid habitat productivity and provide a diversity of salinity gradients, as well as to help flush sediments and maintain channel design grades.

Invasive vegetation, primarily reed canary grass, has developed near-monotypic coverage in areas where historic dredge material from the Lewis & Clark River was deposited and graded. Full levee removal would increase the period of inundation and salinity of these areas, helping to reduce the relative robustness of these monotypic plant communities and restricting their proliferation. Moreover, these monotypic plant communities could be excavated along with underlying soil material, to both reduce the prevalence of reed canary grass and to reduce elevations to a level where this species is unlikely to persist in such concentrations.

Specific to Otter Point's structural integrity, full removal of the Lewis & Clark River levee would not require re-construction of levees at the site's southern or western boundaries. Flooding of the forested riverine/wetland habitat to the south is not deemed environmentally negative and the land west of Otter Point is topographically protected as it elevates rapidly into upland forest. Additionally, these lands to the south and west of Otter Point are federally-owned and located within the Lewis & Clark National Historical Park.

Privately-owned pasturelands north of Otter Point require structural protection from tidal and riverine flood events should the existing levee be removed. Presently, a shallow berm/levee of sidecast material from an excavated drainage provides limited protection of these pasturelands. Without significant structural enhancement of this berm/levee, the private pasturelands to the north could be flooded by periodic tidal and riverine events.

As protection of adjacent private lands is one of the core design objectives in restoration of Otter Point, HLS' design incorporates structural enhancement of the northern berm/levee to an elevation of approximately 14 feet (NAV88) which is consistent with the highest elevation of the existing Lewis & Clark River levee. Levee structural enhancement will utilize excavated materials from the existing river levee. Levee stability will be achieved through compaction (90-95%) of these materials with a minimum side slope of 3:1.

Preliminary estimates of material to be removed from the existing Lewis & Clark River levee is approximately 50,000CY. Enhancement of the northern berm/levee would require approximately 30,000CY, resulting in a net 20,000CY of material required to be removed and disposed of offsite. All levee construction will be within Otter Point's surveyed property boundaries with no impacts to the adjoining private pastureland.

Estimated (2008) construction costs range from $900,000 to $1,100,000.

PARTIAL LEVEE BREACH

Partial breaching of the Lewis & Clark River levee in strategic areas at the northern and southern frontage would allow for some re-connection of surface hydrology throughout the Otter Point restoration site, but would not wholly meet other Partnership design objectives. Partial levee breaching would restore key estuarine functions and values to the site but would not structurally 'restore' Otter Point to historic conditions at the time of the Lewis & Clark Expedition. While the partial levee breach alternative still integrates excavation of the two historic channels to restore tidally-influenced off-channel salmonid refugia and potential rearing habitat, the tidal and riverine influence would not extend completely into the restored site. Remaining portions of the levee would be retained to provide upland 'islands' thus enhancing the structural and biotic diversity of the overall project site.

As with the full levee removal design alternative, redirection of freshwater seeps, springs, and seasonal drainages into these channels would provide critical freshwater input to improve salmonid habitat productivity and provide a diversity of salinity gradients, as well as to help flush sediments and maintain channel design grades. HLS' partial levee breach design also incorporates structural enhancement of the northern berm/levee as previously described. While the landscape will not appear just as it did at the time of Lewis & Clark, it will be restored in such a manner that native habitat types return to the site, while retained levee segment 'islands' provide viewshed buffers between likely pedestrian access points and preexisting development to the north of the park.

Preliminary estimates of material to be removed from the existing Lewis & Clark River levee is approximately 17,000CY. With enhancement of the northern berm/levee requiring approximately 30,000CY, a net 13,000CY of material is required to be imported for proposed levee construction.

Estimated (2008) construction costs range from $600,000 to $700,000.

CONCEPTUAL DESIGN ALTERNATIVES EVALUATION

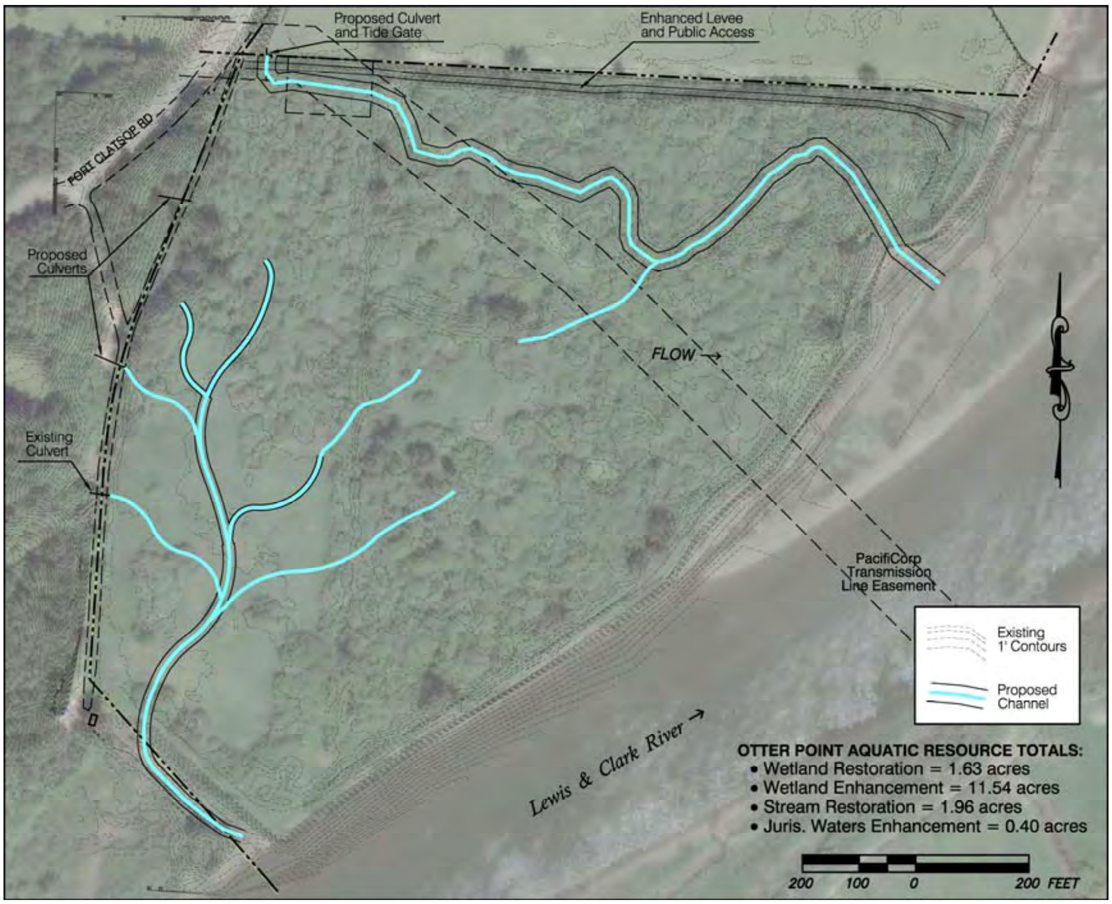
CREST has a strong history of research, planning, and environmental restoration within the Columbia River Estuary. Building upon this practical and applicable experience, CREST with other Partnership members has conducted a thorough evaluation of both design alternatives, including the full and partial levee removal option. Each alternative was evaluated for its ability to meet established design objectives, in addition to each option's overall project feasibility and cost projections.

Each alternative merited specific review and comment from Partnership members. Estimated implementation costs were largely driven by the need to either export and dispose of excavated materials, or import clean fill into the Otter Point site to construct the proposed northern levee. Phase II final design and implementation funds have not yet been secured by CREST. It is anticipated that potential funding of the preferred design presented here will be evaluated on the basis of a cost-benefit analysis that will weigh environmental benefits against project costs.

At the direction of the Partnership, a 'preferred design' alternative was sought that 'balanced' the quantities of excavated materials with the quantities of excavated materials that were to be deposited onsite, especially in the berm on the northern edge of the project site. Partnership members agreed that such a solution was ideal, requiring neither the costly importation nor exportation of materials to or from the site.

PREFERRED RESTORATION DESIGN

The Partnership's preferred restoration design, an enhanced partial levee removal, balances excavation (cut) and fill activities on the Otter Point Restoration Project site. This preferred design restores tidal influence within Otter Point and provides a surface hydrologic connection to the Lewis & Clark River. Restored dendritic tidal channels (totaling 4,952 lineal feet) transecting the site provide tidally-influenced habitat with diverse salinity profiles for salmonid refugia and rearing. Freshwater input from upslope seeps, springs, and intermittent streams is directed into these channels to increase diversity and seasonal productivity of this estuarine habitat. Establishment of small-scale channels and alcoves off of the larger restored channels will provide a diversity of refugia for juvenile salmonids.



With reestablished surface connectivity with upslope seeps, springs and intermittent streams, coupled with the anticipated intersection of channel excavation with ground water *in situ*, juvenile salmonids will be presented with a diversity of salinities throughout the project site; this will allow these fish to undergo osmotic regulation and transition while occupying the restored project site. The juxtaposition of small channels and alcoves with upland margin vegetation on portions of the site will enhance opportunities for macroinvertebrate recruitment – an essential component of juvenile salmonid use of historical estuarine channels that has been lost throughout large portions of the Columbia River estuary.

HLS recommends that the implementation phase Project Manager be given the flexibility in making minor adjustments to the final Phase II design in order to 'field fit' small-scale features such as secondary dendritic channels and alcoves to maximize the functions and values of these structures. It is anticipated that all excavation work will occur within the established in-water work period and will employ best management practices erosion control to minimize any short-term adverse impacts of construction upon salmonid fish.

The monoculture of invasive reed canary grass will be partially removed through both excavation of the rooting zone within this habitat as well as the increased salinity from tidal-influence. Careful disposal and sculpting of placed excavated materials on the improved levee to the north and a number of small 'islands' centered on retained levee segments on the site's eastern edge will provide a diversified structural element and visual interest to the Otter Point site. Conservation of limited Roosevelt elk habitat, primarily native willow and upland spruce cover, and dense plantings of native vegetation in areas disturbed by restoration design implementation will result in a more diverse vegetative community similar to those found on the site historically.

Enhanced species diversity and structural diversity of Otter Point's vegetative community, brought by hydrological reconnection, restored/created topographical diversity through the preferred design's balanced fill concept, and by the planting of native species (see Appendix VII), will significantly increase riparian and estuarine wetland habitat diversity – including critical 'edge' habitat – for native mammals and birds.

WETLAND IMPACTS

Approximately 29.4 acres of the 33.5-acre Otter Point site (88%) are determined as jurisdictional or regulated wetlands. Another 0.3 acres (0.1%) are considered jurisdictional waters connected to the Lewis & Clark River. Oregon's Department of State Lands (ODSL) has formally concurred (June 2008) with HLS' field delineation of wetlands (see Appendix III). Filling of regulated wetlands should be avoided where possible. However, the US Army Corps of Engineers (USACE) and ODSL acknowledge that many environmental restoration efforts occur in habitat that meet jurisdictional criteria as wetlands, yet have a poor or low functional resource and habitat value. Otter Point's reed canary grass areas as well as that of other invasive species or monotypic habitat would be considered as having a low functional environmental value yet are still considered as wetlands. Restoration of these areas could significantly enhance their qualitative environmental value.

Quantitatively, the Partnership's preferred design impacts 4.6 acres of low-value wetlands and 0.03 acres of jurisdictional waters through placed balanced fill. Permitting of proposed restoration excavation and fill activities will likely occur under a Resource Enhancement Permit jointly submitted to the USACE and ODSL (see Appendix IX).

WETLAND RESTORATION AND ENHANCEMENTS

Restoration of Otter Point's historic off-channel habitat and associated stream channel, wetland, riparian, and upland edge habitat equate to approximately 21.0 acres of significant habitat enhancement. Wetlands restored from upland historically-filled through levee construction or dredge materials placement equate to 1.63 acres. Additional habitat enhancements and restoration include 1.96 acres (4,952 lineal feet) of restored tidally-influenced channels as salmonid refugia and rearing habitat, 0.4 acres of enhanced jurisdictional waters, and 11.5 acres of wetland enhancement within existing low-value wetland areas. From hydraulic and hydrological analysis of the preferred design, tidal-influence will extend to 6.5 acres (inclusive of the 1.96 acres of restored channel) of environmentally critical off-channel habitat within the enhanced and restored wetlands (see Appendix VI).

Otter Point **Existing Habitat Condition**	**Otter Point** **Preferred Restoration Design**	**Acreage** **Restored/Enhanced**
Upland Dredge/Levee Fill	Restored Tidal Wetlands	1.63
Low-Quality Fresh Water Wetlands	Restored Tidal Wetlands*	11.5
Low-Quality Fresh Water Wetlands	Restored Off-Channel Habitat*	6.5
Low-Quality Fresh Water Wetlands	Restored Salmon Refugia*	2.0
Excavated Drainage Ditch	Enhanced Jurisdictional Waters	0.4

*NOTE: Some restoration categories listed may overlap in acreage reported (e.g. off-channel habitat and restored tidal channels can be differentiated by elevation, but are reported above by habitat utilization.

BALANCING WETLAND IMPACTS WITH WETLAND RESTORATION AND ENHANCEMENTS

In general, 'no net loss of wetlands' is federally mandated under the 1972 Clean Water Act However, as stated before, restoration of low-quality historically-impacted wetlands may result in a 'net loss of wetland acreage', but may also result in a net gain in environmental function and value of the restored habitat.

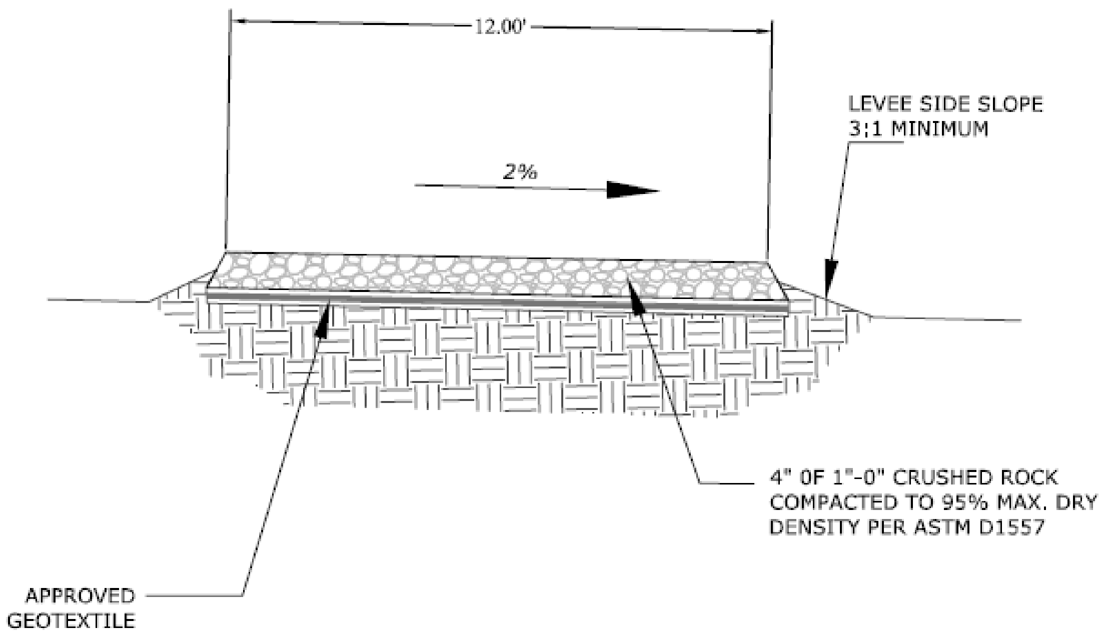
Federal (USACE) and state (ODSL) jurisdictions have recognized this fact and have established specific avenues of permitting such 'resource restoration projects'. CREST's Otter Point Restoration Project will likely be permitted under state and federal resource restoration authorization (see Appendix VIII).

Should reduction of wetland impacts proposed by the Partnership's balanced cut-fill restoration design approach be required by agency permit review, several limited areas of dredge material within the Otter Point site could be partially removed (avoiding impacts to existing spruce trees) to restore additional area to jurisdictional wetland criteria. Additionally, reduction of the upland island habitat footprint would reduce wetland impact from the placed and shaped fill. This latter would require off-site removal and disposal of excavated materials, with a consequent increase to project costs.

Private property to the north of Otter Point will receive increased protection from Lewis & Clark River floods with the enhanced levee inside of Otter Point's northern property line – a point confirmed by meticulous hydrological modeling by HRS staff. A biological treatment swale is designed on the north side of the enhanced levee to treat and carry surface flows from the cattle grazing pasturelands into the head of the northern restored channel. A tide gate placed at the head of this channel will prevent tidal and riverine flows from Otter Point from intrusion into the private pastureland.

The existing PacifiCorp power transmission alignment and easement would remain undisturbed and unchanged unless PacifiCorp elected to re-align the transmission corridor along the enhanced northern levee. Though the preferred design does not impact PacifiCorp's current maintenance access to power transmission towers on the Otter Point site, it neither enhances nor creates improved maintenance access. However, the northern enhanced levee is designed to support a minimum roadway surface width of 12-feet, capable of allowing PacifiCorp maintenance vehicles easy and safe access if the company ever opted to realign their transmission lines along this route.

Additionally, the northern levee will provide approximately 1,400 lineal feet of unique pedestrian access into the Lewis & Clark National Historical Park and the restored Otter Point as well as interpretive opportunities to integrate the project area into the larger Warrenton Trail system. At the discretion of the NPS, further extension of pedestrian access via trails and bridges could be integrated into the Otter Point site to further develop public recreational and interpretive access to such general locations as the existing informal 'overlook' near the southeastern corner of the levee.



The proposed Warrenton Trail system extends public pedestrian access from existing trails up the Lewis & Clark River along the existing levee. Otter Point's enhanced northern levee, at a minimum, could be incorporated into the trail system. A pedestrian trail could readily be incorporated into the levee's surface. Similar to the Park's trail system further south adjacent to the South Clatsop Slough restoration project, the trail could be 6 feet in width, have a compacted (92% minimum) crushed granite or ¼-minus basalt pervious surface, and provide directional and interpretive signage along with possibly benches in carefully located overlooks of the restored Otter Point restoration site.

Should the Lewis & Clark National Historical Park elect to place additional public access trails through Otter Point's wetland areas, although minimized in width, permitting will be required through the Oregon Department of State Lands and the US Army Corps of Engineers (USACE). Compensation, or mitigation, for these minimized and unavoidable wetland impacts would also be required under permit.

Signage for either directional or educational/interpretive purposes is an objective of the Lewis & Clark National Historical Park. The development of interpretive materials for this site is fostered by the unique combination of stakeholders involved with the Otter Point restoration project. For example, the Partnership in conjunction with local school representatives could potentially integrate local student involvement in the interpretive design and depiction of selected vistas, issues, or species of interest to Otter Point's visitors. Such students might be able to participate in such efforts as repeat photography on the restored site, so as to provide content that both aides site monitoring while also being an effective tool in interpreting the site's history and ecology to park visitors.

GEOTECHNICAL RECOMMENDATIONS

The Partnership's preferred restoration design for Otter Point requires breaching the levee located on the northwest bank of the Lewis & Clark River to restore tidal estuarine habitat. Breaching the levee is proposed for several locations. To mitigate the risk of flooding private properties downstream (north) of the project site, the levee along the northern site boundary will be structurally enhanced. This enhancement will involve using dredge spoils obtained adjacent to the existing levee on the riverbank as well as material generated from levee breaching on the eastern edge of the Otter Point site.

As designed by HLS staff, the enhanced northern levee will be approximately 1,300 feet long, with an approximate height of 7 feet above existing grade, and side slopes of approximately 5.7-feet horizontal to 1-foot vertical (5.7H:lV) slopes. Proposed borrow material will be from dredge spoils and the existing Lewis & Clark River levee on the eastern edge of the project site. Based on visual observation of the soil samples, it appears than this material generally consists of fine sand with a varying fraction of particles finer than the U.S. Standard No. 200 Sieve (fines). Some material generated from breaching the existing levee will also be used; this material consists primarily of fines with a varying sand fraction. USACE states that almost any soil is suitable for construction of levees, except very wet, fine-grained soils and highly organic soils. Our preliminary geotechnical study (see Appendix V) provides a professional opinion on the feasibility of using the proposed borrow materials for levee enhancement.

Dredge spoils and materials from the existing Lewis & Clark River levee are too wet in their current condition to achieve required compaction, but will be suitable if dried to within a few percentage points of optimum moisture content. HLS' design anticipates blending the dredge spoil material with fine-grained soils at a ratio so that the fill material contains a minimum of 30 percent passing a U.S. Standard No. 200 Sieve.

Organic material is present in the root zone throughout the restoration portions of Otter Point dominated by reed canary grass. Organic strippings can be blended into proposed structural fill such that the final product contains no more than 10 percent organic content by dry weight. It may be feasible to bury soils with a higher organic content below a depth of 5 feet in the enhanced levee soil matrix, but confirmation of this point will require future analysis. The HLS team therefore proposes that organic materials are to be excavated and used to fill the existing ditch located on the north of the site; the proposed enhanced levee will extend over and above this buried material.

Contamination of existing fill and levee materials on the Otter Point site is negligible. Preliminary environmental testing (see Appendix V) shows that re-use of on-site materials is feasible without the risk of environmental contamination at levels permitted by the Oregon Department of Environmental Quality.

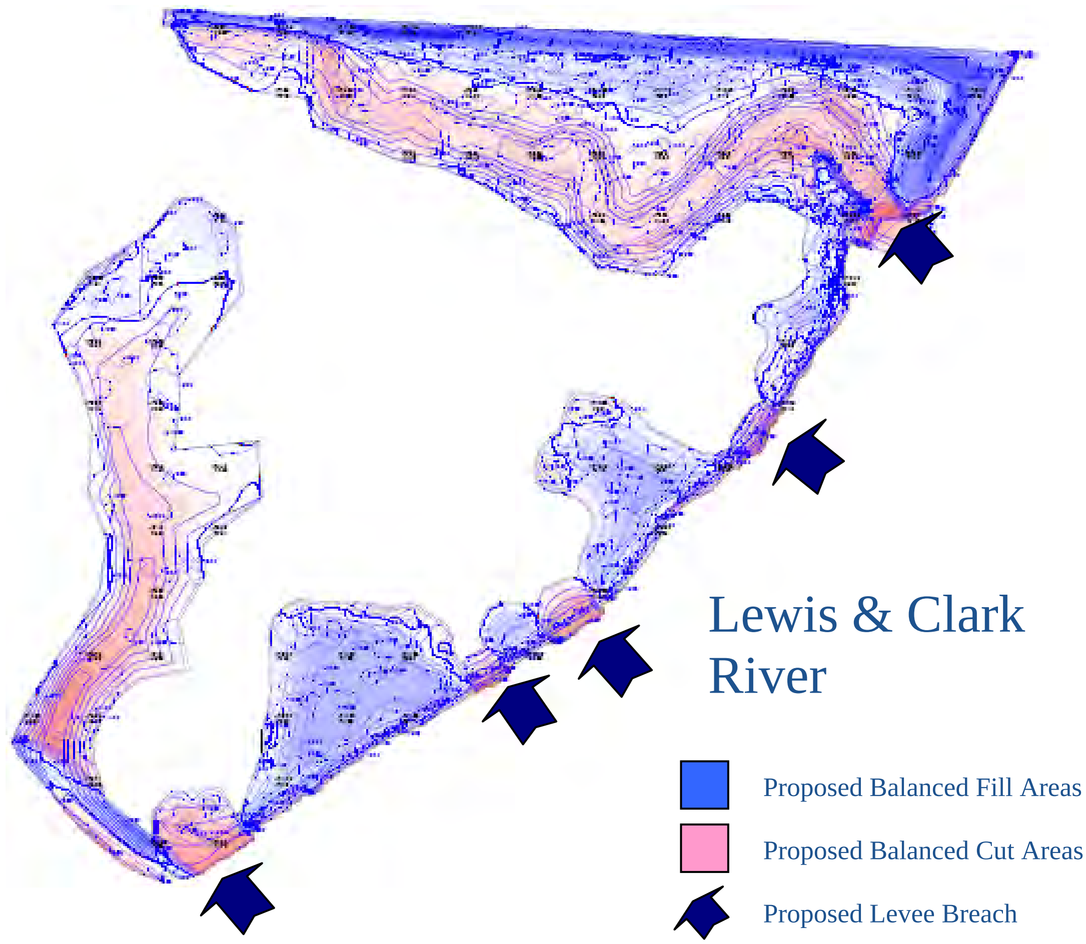
While preliminary testing has yielded encouraging results, additional geotechnical analysis will be required to evaluate the following:

- whether existing foundation soils are capable of supporting the proposed northern levee enhancement.
- determination of the seepage rate beneath and through the enhanced levee.
- stability of the proposed levee slopes under static, seismic, and rapid drawdown (tidal surge) conditions.
- potential for levee slope erosion.

Such additional analysis will require field exploration, geotechnical laboratory testing, and analyses. The U.S Army Corp of Engineers Manual No. I I l0-2-l91 3, *Design and Construction of Levees, April 30, 2000* (USACE 2000) provides guidelines for use in design and construction of levees. In overview, upon preliminary geotechnical review, HLS' proposed northern levee enhancement is structurally feasible as presented in this Design Summary; however, Phase II final design should include specific engineering analyses.

RESTORATION DESIGN TOPOGRAPHICAL DIVERSITY

The topography of the Otter Point site has been historically altered through both levee construction and dredge material placement. Prior to European settlement, Otter Point appears to have been an environment composed of riverine lowlands, salt marsh and freshwater wetlands, and tidally-influenced mud flats. HLS' adjacent primary reference site does represent a relatively undisturbed and more structurally diversified habitat than what is currently found at Otter Point. In this reference site, upland hummock 'islands' are surrounded by saline wetlands and tidally-influenced channels connected to flows from the Lewis & Clark River. The Partnership's preferred design restores a similar diversity of topographical structure to Otter Point by placing and shaping excavated native material adjacent to portions of the levee where spruce trees have become established (typically above the 11-feet NAV88 elevation). These restored and/or enhanced 'islands' will add to the habitat diversity of the Otter Point site, providing such functions as shading and macroinvertebrate recruitment over salmonid-bearing channels, nesting and roosting areas for passerines and waterfowl, and the like. The enhancement of these islands will also provide for placement of excess excavated material over that required for enhancement of the northern levee. Slopes of these shaped upland islands are very gradual (minimum 3:1) providing for establishment of a diversity of native plantings. At the toe of each slope, a broad, shallow swale provides for introduction of freshwater and saline-tolerant native herbaceous species as well as provides opportunities for surface drainage back into the Lewis & Clark River.


Lewis & Clark River
Proposed Balanced Fill Areas
Proposed Balanced Cut Areas
Proposed Levee Breach

HYDRAULIC AND HYDROLOGICAL ANALYSIS

A hydraulic and hydrological analysis (see Appendix VII) was performed to analyze the Partnership's preferred restoration design for Otter Point in the context of projected tidal influence and riverine flows. Potential 2-year and 100-year flood events were projected for the preferred design to understand the possible impacts of floods on the restored site, off-channel habitat, the enhanced northern levee, and the adjacent private pastureland. Flood water depths and velocities were analyzed to determine the extent of wetted surface within Otter Point as well as the potential for erosional scour at the mouths and within the 4,952 lineal feet of restored off-channel habitat.

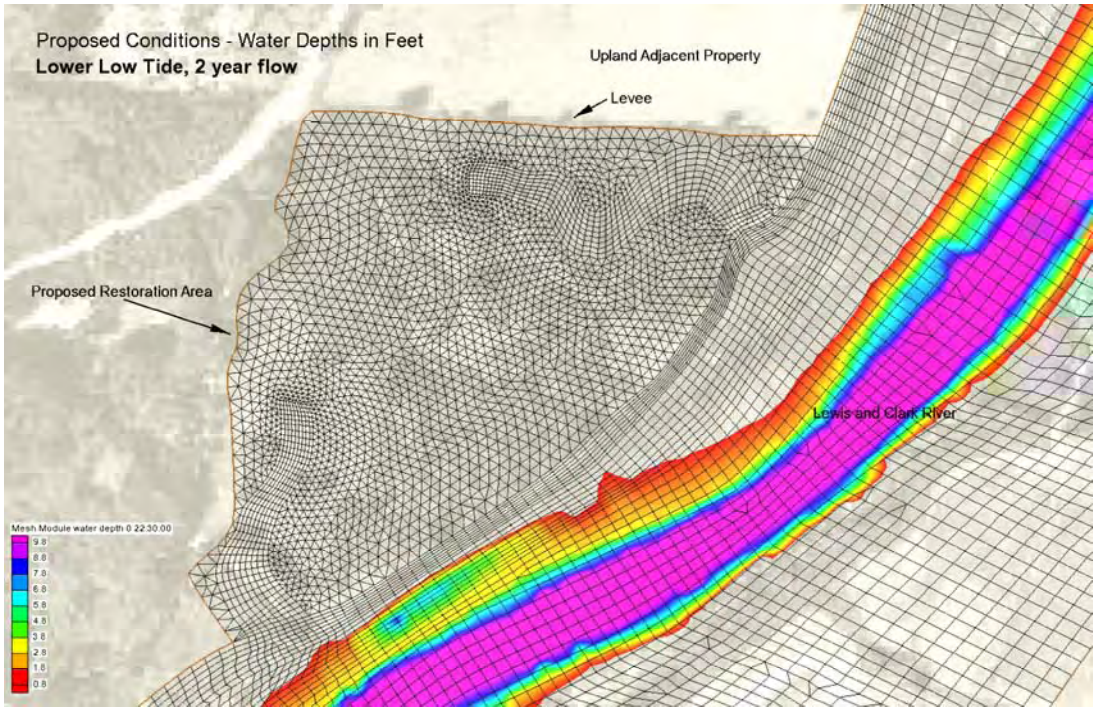
Data utilized for hydraulic and hydrological analysis presented herein may often be generalized or extrapolated from information sources such as US Geological Survey datum. An example would be extrapolation of 100-year flows from data that spans only years or decades of valid collection. However, this uncertainty associated with hydrodynamic modeling and analysis is taken into account through the engineering design of the project. An industry-accepted and appropriate safety factor will necessarily be applied to the design of levees and any other flood control structures to account for uncertainties in both the physical understanding of the project area (lack of data) and within the modeling process itself. However, such potential limitations of data application to specific riverine sites as Otter Point generally result is small changes to water surface elevations in larger tidally-influenced systems as Young's Bay and the lower Columbia River estuary.

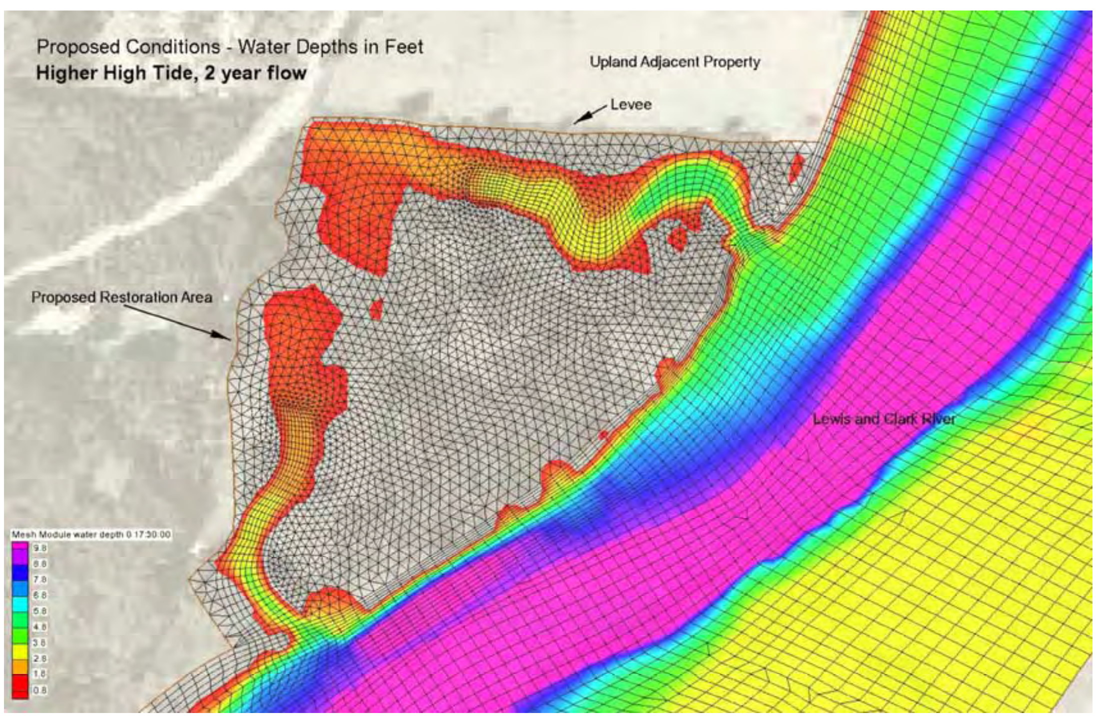
As can be seen from the following graphic analysis of water depths and velocities based upon modeling results of the 2-year and 100-year flows, water surface elevations at Otter Point are dominated by tidal influence with little sensitivity to water surface elevation from flows in the Lewis & Clark River.

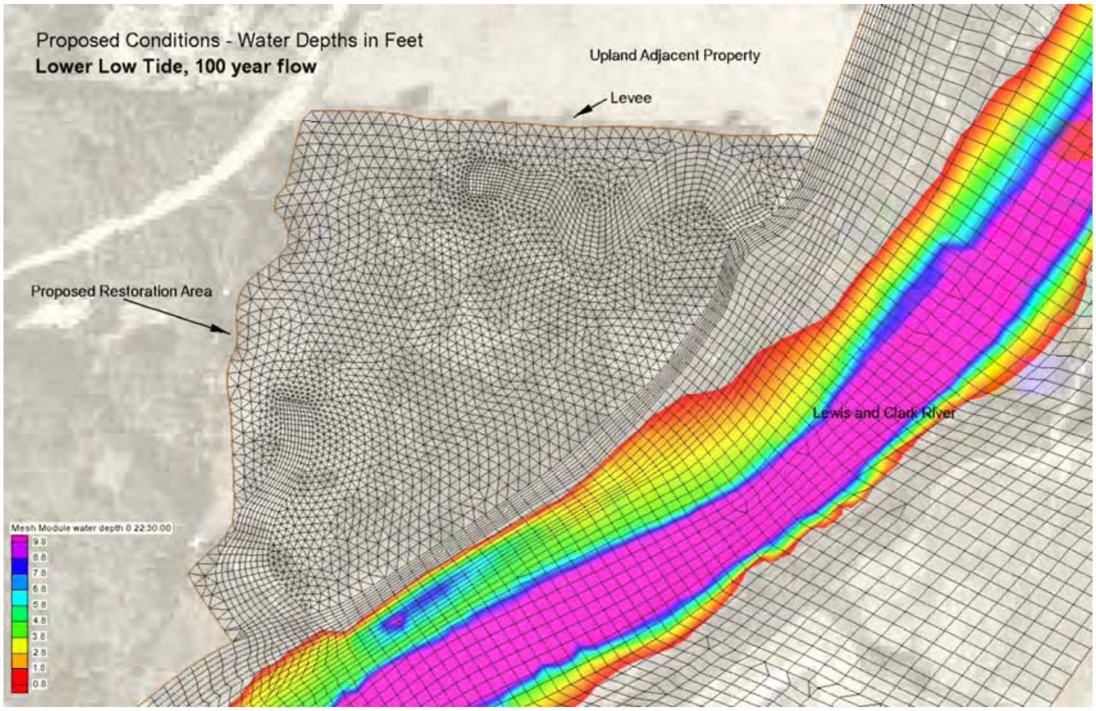
2-Year and 100-Year Water Depths

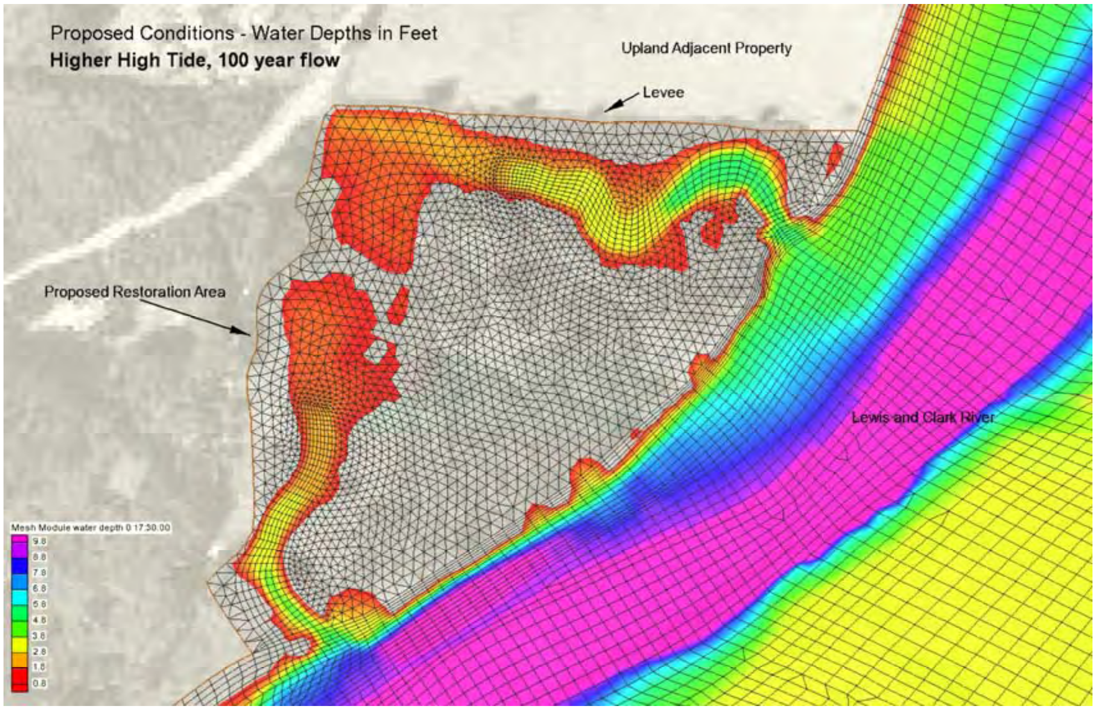
Water depths were projected for 2-year and 100-year flooding events (Higher High Tide combined with a maximum Lewis & Clark River Flow) as they interact with the restored Otter Point site. Peak inflows into the restored off-channel habitat ranged from water depth of approximately 5-feet (NAV88) at the mouths of the southern and northern channels to less than 1-foot at the head of these channels. Positive slope gradients ensure that salmonids utilizing these refugia move into and out of these channels without entrapment.

Water depth variation from projected 2-year events below (Lower Low Tide, Higher High Tide) to comparative 100-year events on the following page is minimal.



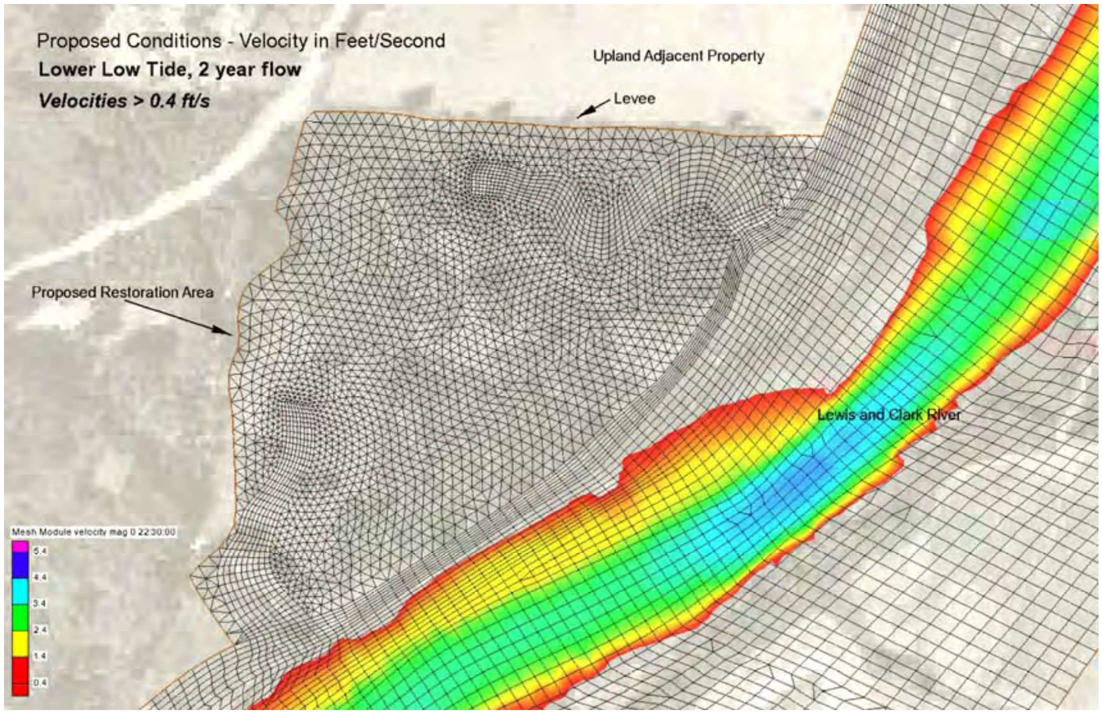


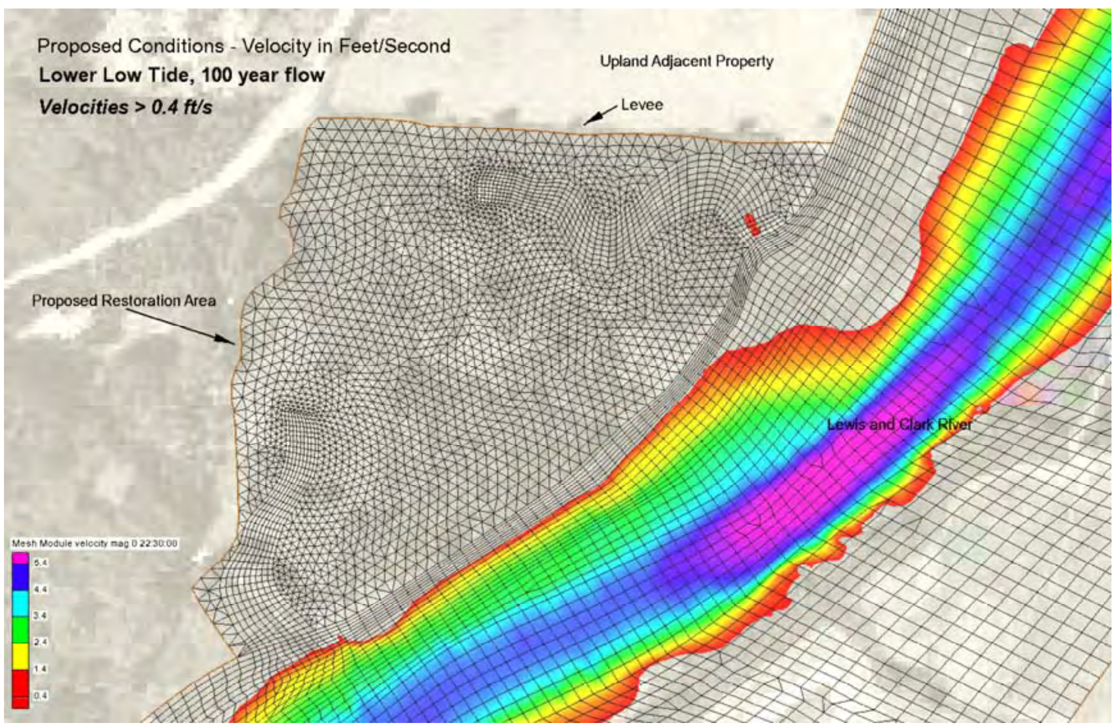

Proposed Conditions - Water Depths in Feet
Lower Low Tide, 100 year flow
Upland Adjacent Property
Levee
Proposed Restoration Area
Lewis and Clark River


Proposed Conditions - Water Depths in Feet
Higher High Tide, 100 year flow
Upland Adjacent Property
Levee
Proposed Restoration Area
Lewis and Clark River

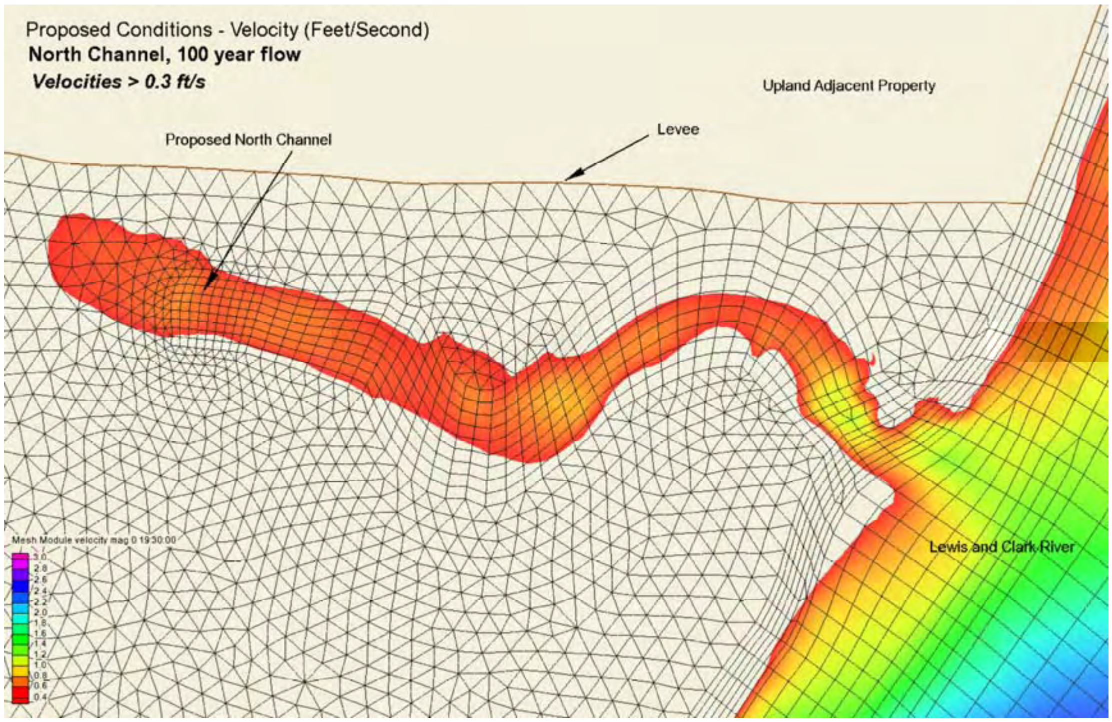
2-Year and 100-Year Velocities

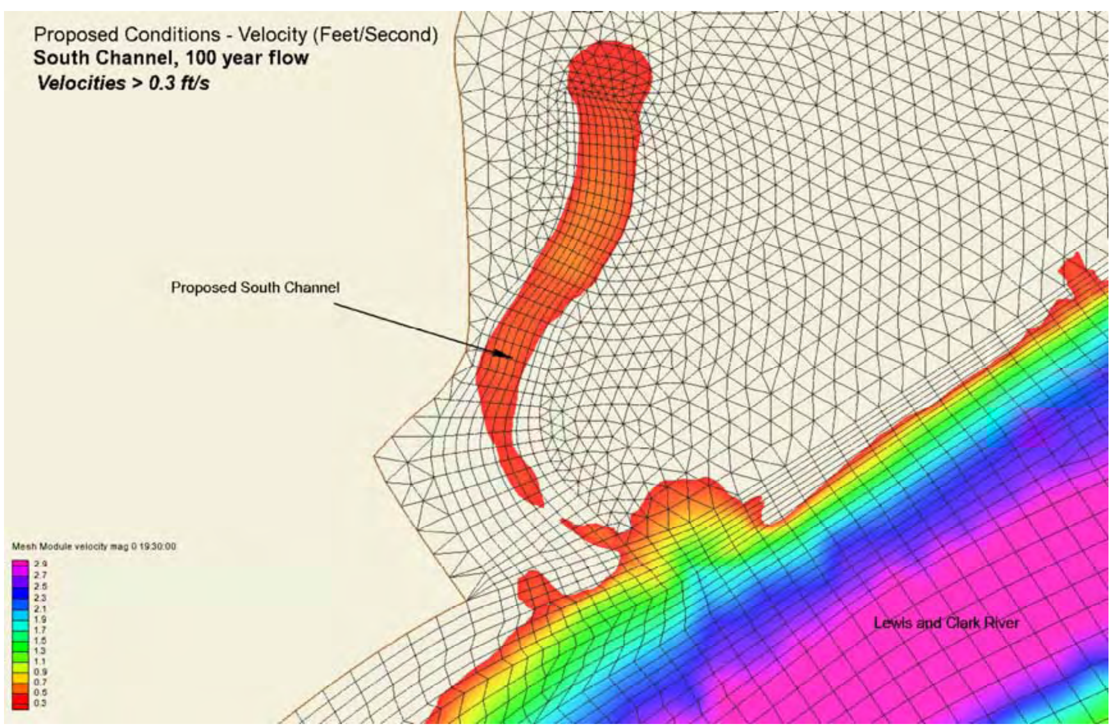
Flow velocities were projected for 2-year and 100-year flooding events (below) as they interact with the restored Otter Point site during lower low tides.



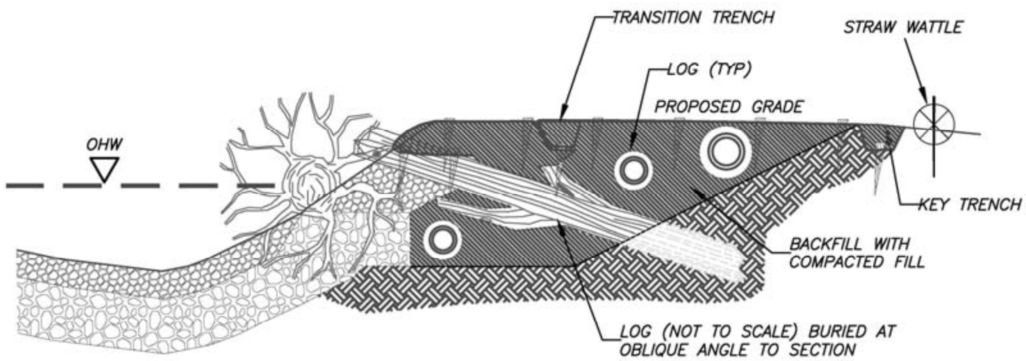


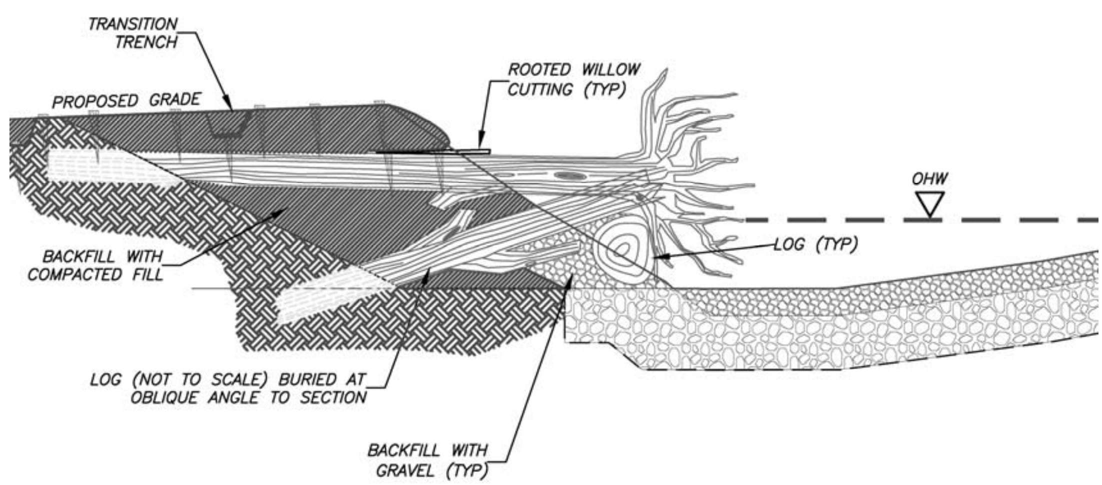
Peak velocities into the restored off-channel habitat during 100-year flooding events ranged from approximately 1-foot per second (fps) at the mouths of the northern channel (yellow) to less than 0.4fps within these channels (orange).





Though 1fps would not be considered an erosive flow resulting in significant scour, it is recommended that the mouths of both southern and northern channels be vegetatively- and structurally-armored. HLS recommends that large coniferous root-wads with a minimum 10-feet bole length attached be embedded (bole embedded, roots out) into the channel mouth embankment at the higher high tide elevation. Saline-tolerant estuarine tidal and wetland vegetation should be planted at highest densities around the mouths of these channels to prevent potential erosion and scour during peak events.



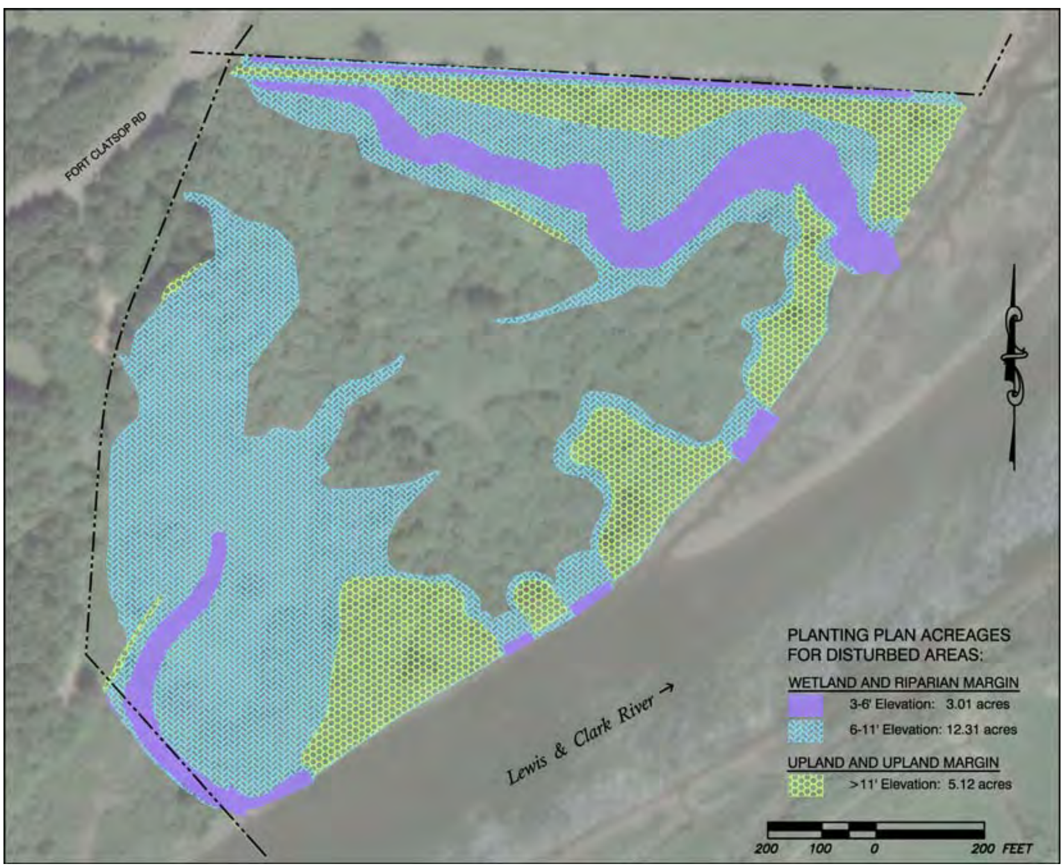


Large wood material is also proposed to be introduced into the restored channels in order to provide habitat for juvenile salmonids and other aquatic species. Typical of tidal channels, large wood is often observed as the channel incises and/or broadens to accommodate flows. HLS similarly proposes that such large wood and root wads be physically embedded into the channel embankments and bottom in locations typical of natural tidal channels. With this approach, low velocity flows in these channels during 100-year flood events will not result in channel scour and erosion.

RESTORED NATIVE VEGETATION COMMUNITIES

Restoration and diversification of Otter Point's native vegetation communities will be achieved, in part, through the reintroduction of site hydrology and salinity, as well as the physical removal of significant areas of reed canary grass.

A diverse range of plant species will be planted and/or seeded on site, each chosen for their appropriateness in achieving overall project goals as well as in providing structural diversity and integrity to the site and interpretive opportunities related to the Lewis & Clark Expedition. While planting and seeding densities are not sufficient to completely revegetate the site, they will provide the structural elements required to secure the site and enhance recruitment of seeds and root fragments occurring naturally in the larger estuary. With time, it is anticipated that the relatively sparse plantings installed at the end of construction will be augmented by a number of volunteer 'pioneer' species. Appropriate site grading and hydrology will insure that the entire plant community will gradually evolve in the direction of self-sustaining native plant communities of the kind identified on the reference sites. This process may take multiple years, and so success must be measured in the years immediately following construction by plant community composition that exhibits change in the direction of desired plant species.



In addition to the proposed planting and seeding, other methods may be required to minimize the presence of invasive plant species on the restoration site. Accordingly, at least two weeks prior to construction HLS proposes that areas with invasive species be chemically-treated (sprayed) in accordance with Park protocols and permit conditions. Reed canary grass removed from the site will be disposed of in a manner that prevents its reestablishment elsewhere on the project site.

Restoration Planting and Seeding Schedule

Restoration plant and seed materials for Otter Point as presented in the following tables were developed from field research and documentation of reference site communities with input from NPS biologists. Approximately 13.7 acres of the Otter Point site (1.63 acres of restored tidal wetlands and 11.54 acres of enhanced wetlands; not including 1.96 acres of restored tidal channels, 0.40 acres of enhanced jurisdictional waters, and 5.49 acres of upland edge habitat) will experience ground disturbance as an outcome of the Partnership's preferred restoration design, and will be the focus of most planting efforts (see Appendix VIII). Densities of plantings are proposed to establish native vegetation communities that may reasonably compete with non-native invasive species and establish root networks that will help rapidly stabilize the overall project site.

Wetland and Riparian Margin Seeding (6-11 feet in elevation, NAV88)

Plant plugs of the following in hydrologically appropriate portions of the Otter Point project site:

Species	Common Name	Area (Ac.)	No. / Acre	Est. Quantity
Carex lyngbyei	Lyngbye's sedge	13.17	1,040	13,697
Carex obnupta	slough sedge	13.17	640	8,429
Scirpus microcarpus	smallfruit bulrush	13.17	1,440	18,965
Salix lasiandra	Pacific willow	13.17	840	11,063
Minimum Planting Density Per Acre			3,960	
Minimum Total Quantity Plantings				52,154

In addition, plant no fewer than 6 of the plant species in the following table planted in appropriate densities in hydrologically appropriate portions of the Otter Point project site:

Species	Common Name	Area (Ac.)	No. / Acre	Est. Quantity
Eleocharis palustris	common spikerush	13.17	840	11,063
Schoenoplectus acutus	hardstem bulrush	13.17	640	8,429
Schoenoplectus tabernaemontani	softstem bulrush	13.17	840	11,063
Juncus balticus var. *balticus*	Baltic rush	13.17	200	2,634
Deschampsia caespitosa	tufted hairgrass	13.17	840	11,063
Sagittaria latifolia	wapato	13.17	840	11,063
Argentina egedii ssp. *egedii*	Pacific silverweed	13.17	840	11,063
Minimum Planting Density Per Acre			4,200	
Minimum Total Quantity Plantings				66,378

Wetland and Riparian Margin Seeding (6-11 feet in elevation, NAV88)

Broadcast seed of the following 3 species in hydrologically appropriate portions of the Otter Point project site:

Species	Common Name	Area (Ac.)	Lbs. / Acre	Est. Quantity
Carex lyngbyei	Lyngbye's sedge	13.17	8	105
Carex obnupta	slough sedge	13.17	8	105
Eleocharis palustris	common spikerush	13.17	6	79
Minimum Seeding Density Per Acre			22	
Minimum Total Lbs. Seed				289

In addition, seed no fewer than 2 of the following plant species to achieve the recommended lbs. seeding per acre:

Species	Common Name	Area (Ac.)	Lbs. / Acre	Est. Quantity
Scirpus microcarpus	smallfruit bulrush	13.17	9	119
Deschampsia caespitosa	tufted hairgrass	13.17	9	119
Juncus balticus var. *balticus*	Baltic rush	13.17	1	13
Sagittaria latifolia	wapato	13.17	1	13
Minimum Seeding Density Per Acre			10	
Minimum Total Lbs. Seed				132

Upland and Upland Margin Plantings (>11 feet in elevation, NAV88)

Plant containerized, native stock, consisting of the following species, in appropriate portions of the Otter Point project site:

Species	Common Name	Area (Ac.)	No. / Acre	Est. Quantity
Picea sitchensis	Sitka spruce	5.49	120	656
Minimum Planting Density Per Acre			120	
Minimum Total Quantity Plantings				656

Species	Common Name	Area (Ac.)	No. / Acre	Est. Quantity
Gaultheria shallon	salal	5.49	136	747
Physocarpus capitatus	ninebark	5.49	136	747
Lonicera involucrata	twinberry	5.49	136	747
Rosa nutkana	Nootka rose	5.49	136	747
Rubus spectabilis	salmonberry	5.49	136	747
Spiraea douglasii	rose spiraea	5.49	136	747
Minimum Planting Density Per Acre			816	
Minimum Total Quantity Plantings				4,482

Upland and Upland Margin Seeding (>11 feet in elevation, NAV88)

Broadcast seed of the following 3 species in hydrologically appropriate portions of the Otter Point project site:

Species	Common Name	Area (Ac.)	Lbs. / Acre	Est. Quantity
Juncus tenuis	slender rush	5.49	6	33
Bromus sitchensis	Sitka brome	5.49	4	22
Deschampsia caespitosa	tufted hairgrass	5.49	6	33
Minimum Seeding Density Per Acre			16	
Minimum Total Lbs. Seed				88

In addition, seed no fewer than 4 of the following plant species to achieve the recommended lbs. seeding per acre:

Species	Common Name	Area (Ac.)	Lbs. / Acre	Est. Quantity
Physocarpus capitatus	ninebark	5.49	4	22
Lonicera involucrata	twinberry	5.49	4	22
Rosa nutkana	Nootka rose	5.49	4	22
Rubus spectabilis	salmonberry	5.49	4	22
Spiraea douglasii	rose spiraea	5.49	4	22
Minimum Seeding Density Per Acre			16	
Minimum Total Lbs. Seed				88

NOTE: If a seed base is needed for seeding dispersal in the upland and upland margin areas, appropriate quantities of the above species can be mixed into a native red fescue (*Festuca rubra* var. *rubra*) seed base.

Enhanced Wetland Functions and Values

HLS ecologists conducted a baseline hydrogeomorphic (HGM) classification (see Appendix VIII) of Otter Point's wetlands to compare wetland functions and values against wetland enhancements and restoration proposed in the Partnership's preferred restoration design.

Existing wetland areas within Otter Point can be generally characterized as a historically altered, Slope/Flat Palustrine Scrub-Shrub & Palustrine Emergent (PSS/PEM) freshwater wetland adjacent to an estuarine system. These wetlands proposed for impact have had significant degradation as a result of historical land use practices such as diking, dredge material deposition, ditching and cattle grazing. Otter Point's natural topography has been significantly altered through the construction of old Fort Clatsop Road, construction of the levee along the Lewis & Clark River, placement and grading of fill material (historic river dredge spoils), and other sidecast fill from the excavated southern and northern drainages.

The Partnership's proposed restoration design will significantly improve Otter Point's baseline HGM classification through onsite wetland enhancement and restoration. Using the HGM Assessment Guidebook for Tidal Wetlands (see Appendix VIII; *Restoration Plan for Otter Point*), HLS ecologists evaluated 12 functions of tidally-influenced wetlands to determine the anticipated improvement in function as a result of the restoration project result in a nearly three-fold increase in overall environmental function (average overall function rating of 0.38 pre-project and average overall function rating of 0.88 post-project).

Proposed restoration will return Otter Point's estuarine and tidal habitat back to its historical HGM: River Sourced Tidal-flat wetlands, River Sourced Tidal PEM wetlands and River Sourced Tidal PSS wetlands.

Upon completion of the Phase II final design, HLS recommends that the HGM classification for the restored Otter Point site be reassessed to provide a baseline of proposed design condition against which project effectiveness monitoring can be conducted.

Effectiveness Monitoring

Post-restoration monitoring is fundamental to understanding how well a project is meeting established environmental design goals and specific performance criteria. Recommended performance monitoring for the Otter Point Restoration Project includes several project-specific methodologies that track the results of on-site restoration activities and Otter Point's interaction with the Lewis & Clark River as part of the lower Columbia River estuary system. In the long term, effective restoration monitoring will inform CREST's project selection and design processes for future habitat restoration efforts.

The number and scope of habitat restoration projects in the lower Columbia River estuary continues to grow. With this growth the need to develop and utilize standardized monitoring methods and protocols has become a priority. For this purpose, standardized monitoring protocols for restoration projects within the lower Columbia River and estuary have been applied to the Otter Point Restoration Project. These protocols and methods were developed and presented in the multi-agency 2008 Report, Monitoring Protocols for Salmon Habitat Restoration Projects in the Lower Columbia River and Estuary.

Monitoring protocols that the Report outlines include:

1. hydrology (water surface elevation);
2. water quality (temperature, salinity, dissolved oxygen);
3. elevation (bathymetry, topography);
4. landscape morphology;
5. plant community (composition, cover, success of plantings); and
6. fish (temporal presence, size/age structure, species).

Environmental design goals for the Otter Point Restoration Project includes increasing vegetative and structural (landscape) diversity, reconnecting Otter Point wetlands to riverine and tidal influence by the Lewis & Clark River, and restoring off-channel juvenile salmonid habitat and refugia. Human interaction and aesthetic design goals were to return the Otter Point site to an approximation of the estuarine habitat along the Lewis & Clark River as seen by members of the Lewis & Clark Expedition. A component of these goals would be inclusion of public pedestrian access without degrading the environment of this unique restoration site on NPS land.

Environmental Design Monitoring Protocols

Though all of the monitoring protocols in the 2008 Report could be effectively adapted to the Otter Point restoration site, protocols selected reflect the specific design intent and performance goals developed for this project.

Water Quality. Water quality monitoring will be descriptive of the design intent to return Otter Point to a more saline environment influenced by riverine and estuarine tidal flows from Young's Bay and the lower Columbia River estuary. Three water quality monitoring locations are recommended, one each in the southern and northern restored estuarine channels respectively; and one at the proposed tide gate at the site's northwestern corner to determine water quality influence into Otter Point from the adjacent watershed and private pastureland. Minimum frequency of water quality sampling at each station should be during high-flow and runoff events to be compared to annual baseline monitoring at each station during in the late spring during potential peak use by juvenile salmonids.

Landscape Morphology. Dynamic alterations of restoration site morphology and vegetation patterns often accompany hydrologic reconnection of sloughs and backwaters with tidal forcing. Enhancing structural diversity and restoring historic back-water channels at Otter Point were primary design goals. With increased exposure to riverine and tidal flows, potential dynamic alteration of design grades throughout the restored wetlands and channels could occur. In most cases, minor changes in grade are not a source of concern, and in some cases can even be desirable, so long as larger project goals are met. Two methodologies are recommended for monitoring the restored estuarine landscape: visual observation and photo documentation of any site erosion within the enhanced wetlands, and channel cross sections located within the restored backwater habitat. A minimum of three cross sections are to be located from top-of-bank to top-of-bank on each of the northern and southern restored channels. Permanent bank pins or stakes are to be placed and surveyed to locate each monitoring cross section for comparison over time. Channel widening, incision, embankment failure, or accretion can be measured by laser level at one-foot intervals along the cross section. Minimum frequency of cross section monitoring should be annual, timed to occur in the late spring after seasonal peak hydrology events.

Plant Community. Changes in the restored site's plant community reflect the effectiveness of overall project design. Vegetative diversity, coverage, vigor and growth of installed plantings, and natural recruitment to the site provide qualitative and quantitative measures of restoration success. Two methodologies are recommended for plant community monitoring: photo-station visual documentation of Otter Point's vegetation communities, and establishment of comparative vegetation transects through these communities. A minimum of one photo stations will be located to document each of the following vegetation communities: tidal flat, restored channel (2), estuarine herbaceous wetland, willow-dominated wetland, and spruce-scrub upland. Vegetation surveys for plant presence, cover, vigor, and recruitment are best conducted in a grid with monitoring transects established along a baseline. Points along these transects may also be surveyed for elevational changes in addition to vegetation. A minimum of six established and surveyed transects should be established for comparison of vegetation community changes over time. Frequency of monitoring along these transects can be annually, recommended to occur in the early fall before leaf-drop. As mentioned elsewhere, photo and vegetation transect monitoring provide welcome opportunities for student involvement and interpretive development, allowing the restoration project to yield benefits well beyond the natural resource enhancements at the site.

Fish. Re-establishing off-channel fish habitat and refugia, primarily for migrating juvenile salmonids, was a cornerstone design objective for restoration of the Otter Point site. Several methods of non-lethal sampling for fish presence can be combined (e.g. seine nets, dip nets, trap nets, etc.) for documentation of fish presence and refugia utilization. Electro-shocking to determine presence of juvenile salmonids is not recommended as fish mortality can result. Consistency between samplings (season, time of day, tide, and methodologies employed) is critical for effectiveness comparisons over time. At a minimum, sampling for presence of fish within the northern and southern restored channels should occur in the late spring during peak migration of juvenile salmonids within the Lewis & Clark River.

Monitoring long-term trends in fish habitat structure and response to estuarine restoration improvements at Otter Point should continue to be adapted and broadened over time as experience dictates. In general fish sampling results from prior lower Columbia River estuary levee breach projects indicate the following:

1) Juvenile salmon and other fish occupy lower Columbia River estuary restoration project sites at the same time they occur in the Columbia River mainstem.
2) Species composition of the juvenile salmonids occupying these restoration sites is similar to that in the mainstem.
3) Relative abundance over time of juvenile salmon at these restoration sites mirrors the general life history characteristics of their respective species.

Fish presence in the restored channels at the Otter Point site would be best understood in relation to these factors, and fish presence data should be assessed and weighted in reference to estuary-wide trends.

Human Interaction and Aesthetic Design Monitoring Protocols

Though perhaps more subjective and less quantifiable, the NPS and Partnership members should consider effectiveness monitoring for both the aesthetic quality of the restoration site through time as well as of human interaction with the restored Otter Point environment. As this site lies within the boundary of the Lewis & Clark National Historical Park, and is adjacent to Fort Clatsop where the Lewis & Clark Expedition encamped, these considerations are of enduring importance to the NPS, with its mandates to manage the cultural landscape and interpretation of the site.

The restored estuarine site's vegetation community and structure was intended to take on an uncontrived and natural visual quality as part of the Otter Point Restoration Project. 'Monitoring' for natural and diversified aesthetics can be accomplished through photo-documentation supported by the environmental component monitoring data. Similarly, public pedestrian use of the public trail designed along the enhanced northern levee, or of other potential trail access routes into the Otter Point site, can be reasonably photo-documented. Such documentation may also serve to document any conflict(s) between public access and Otter Point' restored estuarine environment.

PREFERRED DESIGN BENEFITS

The Partnership's preferred design will provide a wide range of tangible benefits to the Otter Point site. The preferred design will restore tidal influence within Otter Point and a surface hydrologic connection to the Lewis & Clark River. Nearly 5,000 lineal feet (4,952LF) of restored backwater 'off-channel' refugia and rearing habitat for migrating salmonid smolts and other aquatic organisms will meet Partnership salmonid productivity objectives. Restoration of the historic freshwater channel input from the local watershed and riparian habitat reconnected to the Lewis & Clark River will augment the productivity of this off-channel habitat. HGM analysis of the increase in environmental function (see Appendix VIII) of the restored site indicates a nearly three-fold increase in function from existing conditions.

Reduction of the existing monoculture of invasive reed canary grass community will provide a more diversified onsite vegetative community similar to historical conditions as documented in the primary reference site. Enhanced speciation and structural diversity of Otter Point vegetative community will increase habitat diversity, including critical 'edge' habitat for native mammals and birds.

Otter Point's enhanced habitat will also conserve native willow and upland spruce-dominated forest cover for the resident Roosevelt elk herd. This critical habitat has been greatly reduced throughout the floodplain of the Lewis & Clark River, as well as throughout the lower Columbia River estuary.

Privately-owned pasturelands to the north of Otter Point will receive increased protection from Lewis & Clark River floods with the enhanced levee along Otter Point's northern property line. A biological treatment swale will pre-treat surface water runoff from the cattle-grazed pasture just north of the Otter Point site before these waters enter into the head of Otter Point's northern channel.

While the landscape will not appear just as it did at the time of Lewis & Clark, it will be restored in such a manner that native habitat types return to the site, while retained levee segment 'islands' provide viewshed buffers between likely pedestrian access points and preexisting development to the north of the park. Otter Point's enhanced northern levee will provide pedestrian access and possible interpretive opportunities as part of the Warrenton Trail system. PacifiCorp's existing transmission alignment and easement would remain undisturbed and unchanged.

ESTIMATED RESTORATION COSTS

Phase II final design and restoration construction costs are estimated for the Partnership's preferred restoration design at Otter Point. Estimated costs (2008) are will require updating through CREST's Phase II design refinement and must react to permit requirements from reviewing local, state, and federal jurisdictions.

Restoration Construction Element	*Quantity*	*2008 Estimated Costs*
Invasive Vegetation Spray Control @ $2,400/AC*	*6*	*$15,000*
Traffic Control (LS)	*1*	*$1,000*
Clearing & Grubbing @ $1,200/AC	*16*	*$19,200*
Erosion and Sediment Controls Implementation/Maintenance (LS)	*1*	*$6,800*
Remove Existing Tidal Gate (LS)	*1*	*$2,000*
Mass Excavation and Onsite Placement @ $6/CY	*27,500*	*$165,000*
Final Grading/Shaping/Compaction @ $7,500/AC	*15*	*$112,500*
Restored Channel Final Grading/Shaping @ $18/LF	*2,400*	*$43,200*
Install New Self-Regulating Tidal Gate (LS)	*1*	*$8,500*
Northern Levee Tidegate/Access Road Crossing Wingwalls (LS)	*1*	*$15,000*
Northern Levee Access Road/Pedestrian Trail Surface @ $12/LF	*1,360*	*$16,320*
*Install LWD** In-Stream and Floodplain Habitat @ $450/EA*	*20*	*$9,000*
*Install Native Vegetation*** @ $8,500/AC*	*15*	*$127,500*
Subtotal		*$541,020*
Contractor Mobilization/Demobilization @10%	*1*	*$54,102*
ESTIMATED RESTORATION COSTS		*$595,122*

**spray control (1) of invasive species 15 days prior to construction*
***LWD source to be provided by CREST/NPS*
****includes bare-root plantings and native herb/grass hydroseeding of disturbed areas*

Phase 2 Final Design and Permitting	*2008 Estimated Costs*
Phase 2 Design, Engineering, and Permitting @ 10%	*$54,102*
Permitting Fees @ 1%	*$5,410*
Design Contingency @ 3%	*$16,231*
CREST/NPS Construction Management @ 5%	*$27,051*
TOTAL FINAL DESIGN AND RESTORATION COSTS	***$697,916***

FINAL DESIGN RECOMMENDATIONS AND IMPLEMENTATION

PHASE II FINAL DESIGN RECOMMENDATIONS

PacifiCorp's electrical transmission line and easement could be potentially relocated to align with the enhanced northern levee. Costs of engineering design and line reconstruction are outside of present project scope and funding.

In order to reduce project construction costs while maximizing project benefits, the Phase I preferred design 'balances' the proposed Otter Point restoration to minimize or eliminate the need for either disposal of materials offsite or the need to import materials onsite. If a local site was available to re-use additionally-excavated materials at no cost, such as to provide material for the local Diking District, Phase II design refinements could further increase off-channel habitat and reduce the area of enhanced upland 'islands' at Otter Point. Public recreational/education access and interpretive signage opportunities could extend as appropriate from the Warrenton Trail into Otter Point.

Geotechnical

According to the Preliminary Geotechnical Report, the proposed northern levee enhancement is feasible as designed; however, final design should include engineering analyses as outlined above. Geotechnical recommendations are as follows:

1. Re-use of dredge spoils and materials from the existing levees is feasible; however these materials are too wet in their current condition to achieve required compaction.
2. Compaction of between 90 and 95 percent of the maximum dry density, as determined by American Society for Testing and Materials D I 557, will be required to achieve the required soil strength for levee slope stability.
3. Desired engineering specifications can be achieved if these materials are dried to within a few percentage points of optimum moisture content. This can only be achieved during extended periods of dry weather and will require laying the material out over a large staging area, tilling it with an agricultural disc or similar equipment. HLS recommends that the Partnership consider excavating and drying this material onsite during the summer months prior to construction. Covering this material stockpile during summer or early fall rain events may be necessary. If necessary, cement or lime stabilization can be implemented provided it does not violate the project's environmental requirements.
4. Blending the dredge and excavated levee materials requires that the resulting fill material contains a minimum of 30 percent passing a U.S. Standard No. 200 Sieve. Organic stripping can be blended into the proposed fill such that the final product contains no more than l0% organic content by dry weight.

5. It is feasible to bury soils with a higher organic content below a depth of 5 feet. However, future geotechnical analysis is required.
6. Preliminary environmental testing shows that re-use of on-site materials are feasible without the risk of environmental contamination at levels permitted by the Oregon Department of Environmental Quality.
7. Construction should be scheduled for the drier summer months.

Balanced Cut/Fill Approach

Balancing cut and fill quantities for the Otter Point Restoration Project achieves the Partnership's design objectives while minimizing the project's implementation costs. At a minimum, fill is required to construct the enhanced northern levee in order to protect the adjoining private pasturelands. All additional excess excavated material is proposed under the preferred design to construct and shape the restored site's upland islands around retained spruce hummocks and sections of the existing levee not removed.

A design alternative is the variable reduction of this placed and shaped fill, which would reduce fill imprint, but increase project costs due to offsite removal trucking costs and disposal fees. One option discussed within the Partnership to reduce onsite fill and to minimize any corresponding increase in removal and disposal costs is that Clatsop County's Diking District could potentially utilize this excess material to enhance the existing levee along the Lewis & Clark River immediately south of Otter Point within the District's easement on the adjoining private pasturelands. Though offsite removal is still required, potentially this material could be removed, placed, and shaped on the backside of the existing levee for structural support using off-road machinery transferring excavated material from Otter Point.

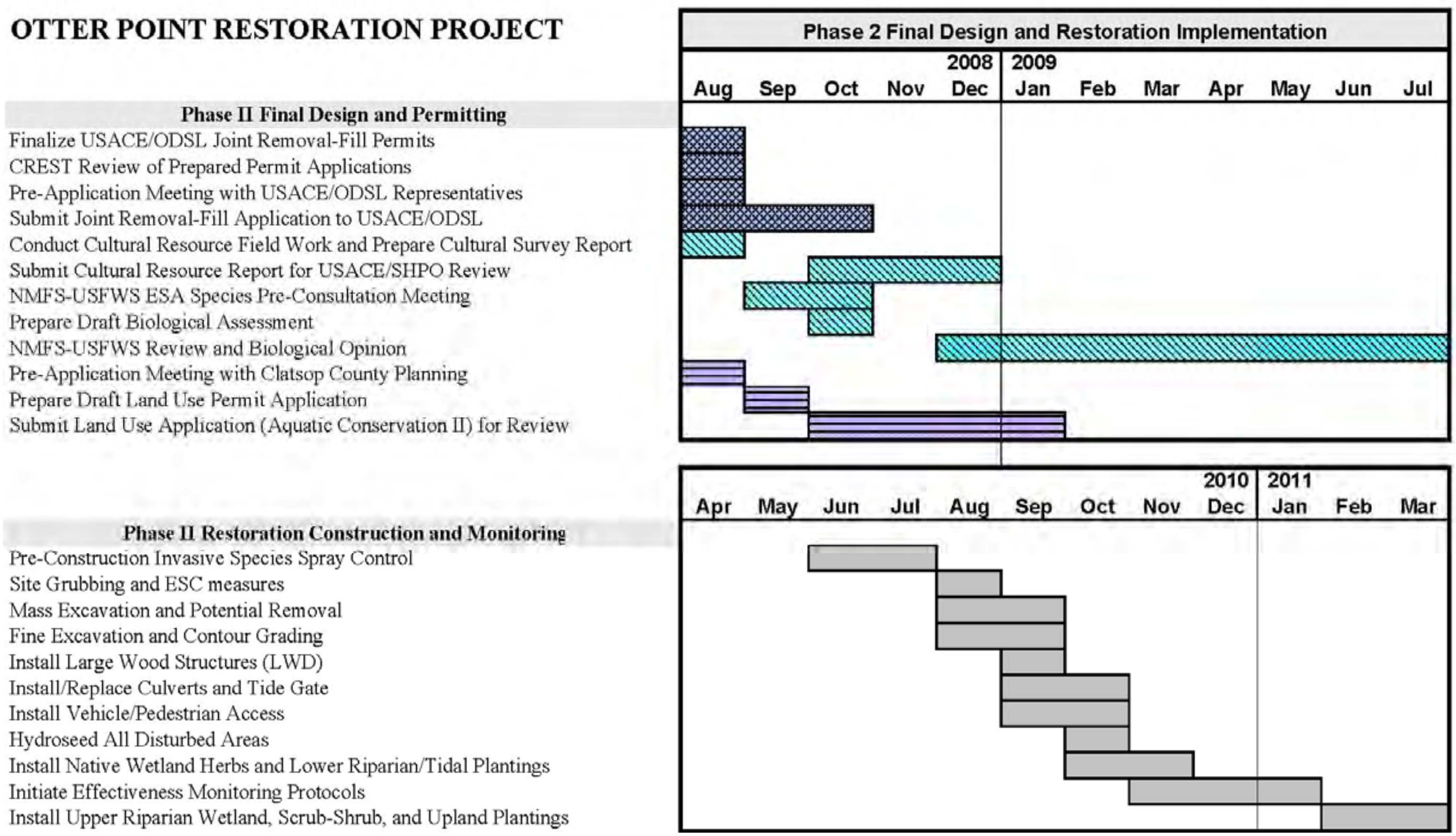
Additionally, reduction of onsite placement of the balanced fill would reduce fill in delineated wetlands at Otter Point.

PacifiCorp's Power Transmission Line and Easement

PacifiCorp's power transmission line and easement through the Otter Point restoration site is neither benefited nor impacted by the Partnership's preferred design presented in this Design Summary. However, PacifiCorp representatives have attended Partnership design workshops and have participated in discussions about relocating several of the existing towers to Otter Point's northern boundary. Besides eliminating the easement and need to access these towers through the restored Otter Point site, this potential alignment would provide PacifiCorp with year-round maintenance access along the enhanced northern levee.

At present however, no funds are available from the Partnership to study this design alternative nor does PacifiCorp elect to provide needed engineering for the new alignment. Should a cooperative agreement develop in the future, this alternative could benefit both resource enhancement and power transmission interests.

PROJECTED IMPLEMENTATION SCHEDULE



APPENDIX I

PRELIMINARY CULTURAL/HISTORICAL ANALYSIS

THIS PAGE DELIBERATELY LEFT BLANK

APPENDIX II

WETLAND DETERMINATION REPORT AND ODSL CONCURRENCE

THIS PAGE DELIBERATELY LEFT BLANK

APPENDIX III

RIVER DREDGE MATERIALS SURVEY

THIS PAGE DELIBERATELY LEFT BLANK

APPENDIX IV

PRELIMINARY GEOTECHNICAL RECOMMENDATIONS

THIS PAGE DELIBERATELY LEFT BLANK

APPENDIX V

BALANCED CUT/FILL ANALYSIS

THIS PAGE DELIBERATELY LEFT BLANK

APPENDIX VI

HYDRAULIC AND HYDROLOGICAL ANALYSIS

THIS PAGE DELIBERATELY LEFT BLANK

APPENDIX VII

RECOMMENDED PLANTING AND SEEDING SCHEDULE

THIS PAGE DELIBERATELY LEFT BLANK

APPENDIX VIII

DRAFT JOINT USACE/ODSL REMOVAL-FILL PERMIT

THIS PAGE DELIBERATELY LEFT BLANK

APPENDIX IX

DRAFT CLATSOP COUNTY LAND USE PERMIT

THIS PAGE DELIBERATELY LEFT BLANK

APPENDIX X

PREFERRED RESTORATION DESIGN SHEETS AND DETAILS

THIS PAGE DELIBERATELY LEFT BLANK

APPENDIX XI

PROJECTED PHASE II FINAL DESIGN AND RESTORATION IMPLEMENTATION COSTS