Project Title: Pile Structure Program

Table 1. Proposal Metadata:

Project Number	2003-011-00
Title	Pile Structure Program
Proposer	Lower Columbia River Estuary Partnership (Estuary Partnership)
Brief Description	Enhance and restore the Lower Columbia River's structure and function for the recovery of federally listed salmonids through the active management of pile structures.
Province(s)	
Subbasin(s)	Lower Columbia River and Estuary
Contact Name	Chris Collins
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Projected Start Date	January 1, 2010 (Implementation)

A. Abstract

The 2008 Federal Columbia River Power System Biological Opinion includes Reasonable and Prudent Alternative 38—Piling and Piling Dike Removal Program. This RPA directs the Action Agencies to work with the Estuary Partnership to develop and implement a piling and pile dike removal program. The program has since evolved to include modifying pile structures to enhance their habitat value and complexity by adding large woody debris.

The geographic extent of the Pile Structure Program (PSP) includes all tidally-influenced portions of the lower Columbia River below Bonneville Dam; however, it will focus on the mainstem. The overarching goal of the PSP is to enhance and restore ecosystem structure and function for the recovery of federally listed salmonids through the active management of pile structures. To attain this goal, the program team developed the following objectives:

1. Develop a plan to remove or modify pile structures that have lower value to navigation channel maintenance, and in which removal or modification will present low-risk to adjacent land use, is cost-effective, and would result in increased ecosystem function.
2. Determine program benefits for juvenile salmonids and the ecosystem through a series of intensively monitored pilot projects.
3. Incorporate best available science and pilot project results into an adaptive management

framework that will guide future management by prioritizing projects with the highest benefits.

The PSP's hypotheses, which form the basis of the pilot project experiments, are organized into five categories: Sediment and Habitat-forming Processes, Habitat Conditions and Food Web, Piscivorous Fish, Piscivorous Birds, and Toxic Contaminant Reduction. These hypotheses are based on the effects listed in the Estuary Module (NOAA Fisheries *in press*) and others that emerged during literature reviews, discussions with scientists, and field visits. Using pilot project findings, future implementation will be adaptively managed to maximize program benefits and address limiting factors.

B. Problem statement: technical and/or scientific background

The lower Columbia River and estuary are critical to the viability of all anadromous fish populations for the entire Columbia Basin (NOAA Fisheries 2000); however, since the mid 1800s, the lower Columbia River below Bonneville Dam has been altered by a variety of anthropogenic impacts. Major changes in the lower river and estuary have resulted from a number of actions, including construction and operation of the hydrosystem, flow diversion, floodplain diking, dredging, and the increased presence of non-native species. Additionally, the system of pile structures constructed by the U.S. Army Corps of Engineers (USACE) and others has modified the lower river. The USACE began constructing pile structures in the lower Columbia River in 1885; however, the majority of the present day system was built during two periods: 1917 to 1923 and 1933 to 1939 (USACE 1987). To date, the USACE has constructed approximately 256 dikes totaling 237,000 linear feet (USACE 1987). Numerous structures constructed by other entities for lumber, shipping and fishing industries, for example, also exist in the lower river and estuary. Due to changes in local hydraulics, sediment processes, access to habitat, and predation, these structures have collectively contributed to the decrease in quantity and quality of habitat available to juvenile salmonids.

To help recover the lower river's ecosystem and the federally listed species it supports, NOAA Fisheries created the *Columbia River Estuary Recovery Plan Module for Salmon and Steelhead* (Estuary Module) (NOAA Fisheries *in press*) and *Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan* (LCR Subbasin Plan) (Estuary Partnership 2004) to identify limiting factors, threats, and management actions to improve ecosystem health, and increase salmonid survival during their residency in the lower river. The Estuary Module identified pilings and pile dikes as having resulted in the following limiting factors:

- impaired sediment accretion and erosion processes (page 4-8, November 5, 2007 draft);
- reduced flow circulation through shallow-water habitats, side-channels, and peripheral bays (page 4-8, November 5, 2007 draft);
- created favorable conditions for predators of salmonids, such as Northern pikeminnow (*Ptychocheilus oregonensis*), smallmouth bass (*Micropterus dolomieu*), and double-crested cormorants (*Phalacrocorax auritus*) (pages 4-8 and 4-11, November 5, 2007 draft);
- reduced edge habitat (page 4-9, November 5, 2007 draft);
- reduced physical access to habitats, e.g., side channels, that are important for refuge and feeding (page 4-3, November 5, 2007 draft); and,
- in those cases where pile structures have been treated with preservatives, release of toxic contaminants (including polycyclic aromatic hydrocarbons) into the water column and

sediment (page 4-12, November 5, 2007 draft).

To address limiting factors such as these to juvenile salmon, the Estuary Module lists 23 management actions including CRE-8: Remove Pilings and Pile Dikes with Low Economic Value when Removal Clearly Would Improve Ecosystem Health.

During the development of Federal Columbia River Power System Hydropower Biological Opinion Remand (NOAA Fisheries 2008), the Bonneville Power Administration (BPA), U.S. Army Corps of Engineers (US ACE), and the Bureau of Reclamation (herein referred to as the Action Agencies) reviewed the Estuary Module's management actions for their potential applicability to off-site mitigation for operation of the Columbia River hydropower system. The Action Agencies incorporated CRE-8 into the 2008 Federal Columbia River Power System Biological Opinion (2008 BiOp) because of the assumed benefits for juvenile salmonids in addressing the threats described above in the mainstem of the lower river and estuary. Hence, the 2008 BiOp includes RPA 38—Piling and Piling Dike Removal Program to increase access to productive habitat and to reduce avian predation (NOAA 2008). The RPA further directs the Action Agencies to work with the Estuary Partnership to develop a plan for strategic removal of structures that have lower value to navigation channel maintenance and in which removal will present low-risk to adjacent land use, support increased ecosystem function, and is cost-effective. The program team of the Estuary Partnership and Action Agencies has broadened the initial concept of pile structure removal first identified in the Estuary Module to include potentially modifying pile structures by adding large wood, for instance, to increase structure and complexity to benefit juvenile salmonids. In this larger view, comprehensive pile structure management becomes the focus of the Pile Structure Program (PSP) rather than one specific restoration technique.

The removal or modification of pile structures is an untested restoration technique for ecosystem restoration and salmonid recovery in the lower Columbia River estuary. As a result, the program team believes it is important to establish a strong scientific foundation for this new program. Currently, this scientific approach includes the review of existing literature, the creation of hypotheses, applied research to test these hypotheses, careful selection of pilot projects for experimentation and monitoring to determine effectiveness and guide future efforts. The program team envisions a phased scientific approach to guide implementation of the PSP that consists of two major phases—Phase 1: Inventory, Characterization, and Pilot Projects and Phase 2: Implementation. Phase 1 involves developing a pile structure classification system, creating the pile structure inventory, developing program hypotheses, identifying potential pilot projects, and initial development of a monitoring plan and associated protocols. Phase 2 will utilize Phase 1 results to inform design and implementation so that projects provide the greatest possible ecosystem benefit, particularly to juvenile salmonids. Both Phases 1 and 2 will include pre and post project and action effectiveness monitoring to assess both short and long term benefits to juvenile salmonids and the lower Columbia River ecosystem. The Program will also involve adaptive management, best management practices, permit coordination, community needs and involvement, and reporting.

An important first step of pile structure management is understanding the population (i.e., number and types) of pile structures present in the lower Columbia River estuary. Over the past three years, the program team developed a digitized pile structure inventory of the study area. The inventory currently includes over 550 pile structures that represent private and public pile structures from historical cannery structures to US ACE pile dikes still in use today. The majority of structures were identified using digital shoreline videography, digital orthography photos, and field trips. The remainder were identified using the US ACE's VE Report developed to evaluate Corps pile dike

maintenance needs (USACE 1987). A GIS data layer for the entire inventory was developed and is maintained by the Estuary Partnership; it will be updated as new information becomes available through field reconnaissance and other efforts.

As part of its Phase 1 activities, the Estuary Partnership classified all of the pile structures in the program's database using these categories. Through field reconnaissance during the summer of 2008, the program team developed a system for grouping pile structures into the following distinct classes:

- 1) **Pile Fields** are groups of pilings used for a variety of purposes, such as to support over-water structures like docks and moorages, to tether log rafts, and to build residential, commercial, and industrial structures. Larger groupings of pilings are referred to as pile fields. For the PSP, pile fields are loosely categorized by low, medium, and high density fields. Figure 1 provides examples of the three categories of pile fields.
- 2) **Training Dikes** are oriented parallel to the river. Their primary purpose is to protect dredged material from eroding into the navigation channel or other undesirable locations. Training dikes are typically linear and in some cases have short perpendicular wings to deflect flows and distribute energy. Training dikes are considered pile dikes and have been extensively used by the Army Corps. Figure 2 shows a typical training dike.
- 3) **Spur Dikes** are constructed perpendicular to the mainstem channel, functionally reducing the width and increasing the depth of the river's thalweg (Figure 3). This reduction in river width causes an increase in flow velocities in the navigation channel, and a decrease in velocity immediately upstream and downstream of the spur dike. In some cases, spur dikes are used to reduce the cross section of the river and provide a low-velocity condition downstream where dredged materials can be deposited and held in place.
- 4) **Transverse Dikes** are linear pile structures that cross an embayment or side channel and are frequently associated with a spur or training dike and dredge material placement. Transverse dikes frequently are created when a spur dike, or less frequently a training dike, is constructed and then dredge material placed near the middle or channel end of the dike, thereby creating an embayment in between the mainland and area of dredge material. They also may be created when dredge material is placed in association with a training dike. In many cases, shallow water and marsh habitats are formed due to the construction of the dike and placement of dredge material. Transverse dikes are considered a subset of spur and transverse dikes. Figure 4 shows a typical transverse dike.

Figure 1. Pile Field Classes

High Density Pile
Field

Medium Density Pile
Field

Low Density Pile
Field

Figure 2. Typical Training Dike

Figure 3. Typical Spur Dike

Figure 4. Transverse Dike

Although the Estuary Module identifies potential impacts to juvenile salmonids associated with pile structures, the potential benefits that may be realized through modification of pile structures are largely untested. Consequently, it is important to establish a scientific foundation that will quantify benefits (or impacts) of various restoration approaches. The PSP's scientific approach includes review and inclusion of existing literature, the creation of hypotheses, applied research to test hypotheses (including careful selection of pilot projects for experimentation), and monitoring to determine effectiveness and guide future efforts.

As a first step in this process, the program team developed a set of hypotheses that addresses the full suite of potential benefits and impacts of various pile structure management techniques. The hypotheses, which form the scientific foundation of the PSP, are based on existing literature, site visits, and extensive discussions with researchers and environmental professionals. The hypotheses are organized into five major categories, each of which is detailed below.

Category 1: Sediment - and Habitat-forming Processes and Conditions Hypotheses

Hypothesis 1A: Local sediment processes can be enhanced by removing/modifying pile structures.

Hypothesis 1B: Flow circulation patterns in embayments can be increased through pile structure removal.

Hypothesis 1C: Nearby salmonid habitat can be enhanced through pile structure management (e.g., removal or modification/reduction).

Hypothesis 1D: Targeted pile structure removal or modification in areas upstream of embayments or tidal marsh habitats will improve juvenile salmonid access to these sites.

Hypothesis 1E: Pile structures are allowing sediment accretion and creating shallow water habitat (in some cases in conjunction with dredge material placement).

Habitat-forming processes and resulting conditions in the mainstem are dependent upon factors that influence sediment supply and where erosion and accretion occur. This balance between erosion and accretion influences bathymetry which in turn determines the size, quality, and location of habitats for salmonids and other species contributing to the lower river's food web. Pile structures are designed to store or remove sediments at discrete locations to meet specific needs, such as maintaining the navigation channel or maintaining the position of dredged materials. Because pile structures were not designed to protect or enhance habitat conditions, they may have contributed to degradation of wetlands and other sediment-dependent ecosystem features in some circumstances. However, in other cases the structures may be helping to create new habitats by establishing conditions suitable for fine sediment accretion. The active management of pile structures may be one of the more useful tools available to restoration practitioners looking to enhance habitat-forming processes.

Category 2: Habitat Conditions and Food Web Contributions Hypotheses

Hypothesis 2A: Pile structures can collect available large woody debris that can be used by juveniles for refugia from predators.

Hypothesis 2B: Pile structures can be enhanced to collect and retain available large woody debris to create more complex rearing habitat.

Hypothesis 2C: Decaying pile structures can contribute macrodetritus to the food web or provide substrate for desirable plants that provide macrodetritus and insect prey.

In the larger context, large woody debris (LWD) is nearly absent in the lower river due to historical removal of wood in tributaries and above Bonneville Dam. In some cases, pile structures may trap available woody debris as it moves downstream and may provide some of the complexity that LWD provided historically (Figure 5).

Figure 5: Large Woody Debris Recruited by a Lower Columbia River Pile Structure

Pile structures may also contribute directly to the lower river ecosystem food web. As untreated pilings decay, they may contribute macrodetritus directly to the system. Additionally, the rotting upper sections of the pilings provide a medium for plants to grow in (Figure 6). Plants hanging over the river may contribute litter (macrodetritus) and also insect prey, both of which are important sources of food for juvenile salmonids. The proximity of such structures to shallow habitats and other sources of prey and macrodetritus likely determine if such input is of significance.

Figure 6: Vegetation Growth on a Lower Columbia River Pile Structure

Category 3: Piscivorous Fish Hypotheses

Hypothesis 3A: Pikeminnow or other piscivorous fish species are using conditions created by pile structures (flow-disrupted shallow areas downstream of the structures) to prey on juvenile salmonids.

Hypothesis 3B: Piscivorous fish are using the main-channel end of pile dikes to increase their predator efficiency on juvenile salmonids migrating along the edge of the channel.

Hypothesis 3C: Removal of pile structures will reduce piscivorous fish predation on salmonids in the vicinity of the removal site.

Native Northern pikeminnow and exotic bass (*Micropterus spp.*) and walleye (*Sander vitreus*) all reside in the lower river and prey on juvenile salmonids. Zimmerman (1999) found that smallmouth bass and pikeminnow below Bonneville Dam consumed 1.1 and 1.6 juvenile salmonids, respectively, per predator per day during the June/July juvenile salmonid outmigration. A recent City of Portland study examined the movement patterns, habitat preferences, and diet of northern pikeminnow, smallmouth bass, and walleye on the lower Willamette River. Its results indicated that after being relocated, all three species had a strong preference for pilings or floating structures (49 percent of walleye, 19 percent of pikeminnow, and 17 percent of smallmouth bass relocated to a piling or other structure) (Friesen 2005). Although the stomach contents of these individuals did not show juvenile salmonids as prey, no large adults were captured, and for most species, it is the larger individuals that consume juvenile salmonids. This result illustrates a need to further test the piscivorous fish hypotheses by expanding studies on larger individuals to determine if larger piscivores prefer pile structures for habitat. This is particularly important as pile structures often provide habitat for piscivores that not only may be adjacent to juvenile salmonid habitat, but also may occur in areas where it was not present historically. This may allow piscivores to artificially concentrate in areas where juvenile salmonids are present in large numbers.

Category 4: Piscivorous Birds Hypotheses

Hypothesis 4A: Double-crested cormorants and other piscivorous birds are preying on juvenile salmonids when using pile structures for perches.

Hypothesis 4B: Removal of pile structures will reduce avian predation on salmonids in the vicinity of the removal site.

Compared to the other PSP hypotheses, the relationship between double-crested cormorants, juvenile salmonid predation, and perching habitats is relatively well researched and understood. Cormorants use pilings, pile dikes, navigation aids, and other structures as resting areas. However, they dive from the water's surface and hunt their prey underwater. Removing pile structures in the vicinity of cormorants' nesting and hunting areas may help reduce their colony size or hunting efficiency in areas that juvenile salmonids rear or migrate. The effectiveness of this restoration technique could be reduced by the sheer number of potential perches in the lower river, e.g., trees, rocks, and channel navigation markers. Thus, a key uncertainty for these hypotheses is whether removing pilings will be effective for reducing predation by double-crested cormorants.

Category 5: Toxic Contaminant Reduction Hypotheses

Hypothesis 5A: Removing creosote and copper treated pilings will help reduce the quantity of Polycyclic Aromatic Hydrocarbons (PAHs), copper, and/or other toxic contaminants that are released slowly into the estuarine environment.

Hypothesis 5B: During removal of treated pilings, a pulse of contaminants will not be released into the water column.

Hypothesis 5C: During and immediately following removal of untreated and treated pilings, legacy contaminants bound in buried layers of sediment will not be released.

Hypothesis 5D: Following removal of untreated and treated pilings, legacy contaminants bound in buried layers of sediment will not be released.

Some pilings used in the lower river and other locations were treated with preservation agents to increase their longevity. In most cases, creosote was used to treat pilings, but some newer preservatives use ammoniacal copper, zinc arsenate, and chromated copper arsenate to achieve similar results. An average creosoted marine piling contains about 61 gallons of creosote and has more than 300 chemical constituents (Skagit County Marine Resources Committee 2005), with PAHs being the class of chemicals that is of greatest concern. The copper in substitute preservatives may also be of concern in the lower river. A recent study showed that short-term exposure to dissolved copper impairs juvenile coho's olfactory function and ability to avoid predators; these effects were observed with copper concentrations comparable to those measured in the surface waters of urban and urbanizing watersheds (Sandahl et al. 2007). Copper also is known to disrupt olfaction in Chinook salmon (Hansen et al. 1999a and 1999b) and to affect salmonid growth and development, immune function, and reproduction. Although pilings treated with creosote and other preservatives are present throughout the lower river, they appear to comprise a relatively small percentage of the total pilings. The exception is in urban waterfronts such as Astoria, Longview, Vancouver, and Portland where treated pilings are more common.

In addition to being direct sources of contaminants, some pile fields may have been associated with industries that used toxic materials. For example, metals concentrations at old cannery sites typically are elevated due to disposal of cans in the river. Additionally, pile structures located downstream of contaminant sources may trap and hold toxic-laden sediments. For example, spur dikes decrease velocities immediately downstream creating deposition areas that may trap toxic-laden sediments or assimilate toxics into the pilings themselves. Removing the structures in the former case may allow a pulse of contaminants to enter the water column. Hence, testing of sediments as well as the pilings for toxics is an important first step before removing structures. In some instances, capping or removing contaminated sediments may be advisable prior to removing or modifying pile structures. These tasks likely are outside the scope of the PSP.

The LCR Subbasin Plan identified pile dikes as one component of the navigation system that helped channelize the river and cause a variety of impacts to juvenile salmonids, e.g., decrease circulation in off-channel areas, including Grays Bay. Although it does not identify pile structures as a limiting factor for salmonids in the lower river, several of the program's hypotheses directly address the LCR Subbasin Plan's limiting factors. Table 2 lists the applicable limiting factors and the hypotheses that address them.

Table 2: LCR Subbasin Plan Limiting Factors and Applicable Hypotheses

LCR Subbasin Plan Limiting Factor	Title	Page	Impact	Certainty	Applicable PSP Hypotheses
LF1	Availability of preferred habitat	4-17	High	High	1A, 1C, 1D, 1E, 2A, 2B
LF3	Loss of habitat connectivity	4-18	High	High	1D
LF4	Predation mortality	4-19	Low	Medium	2A, 3A, 3B, 3C, 4A, 4B
LF5	Contaminant exposure	4-19	Medium	Medium	5A, 5B, 5C, 5D
LF6	Interaction with introduced species	4-20	High	High	2A, 3A, 3B, 3C, 4A, 4B
LF9	Loss of LWD recruitment	4-22	High	High	2A, 2B

During the first 4 years of the PSP, the primary objective will be to test the program's hypotheses to quantify the benefits of various approaches to pile structure management and determine how the program can best address the limiting factors identified in the LCR Subbasin Plan. Additional detail regarding how the program team will accomplish this is provided in Sections F and G.

C. Rationale and significance to regional programs

- 1) **Endangered Species Act – Section 7 Consultation Biological Opinion – Federal Columbia River Power System Remand Draft (NOAA Fisheries 2008)**
As outlined in previous sections, RPA 38 of the 2008 BiOp (Piling and Piling Dike Removal Program -- To increase access to productive habitat and to reduce avian predation, the Action Agencies will develop and implement a piling and pile dike removal program) directs the action agencies to develop and implement the PSP. The Program also addresses habitat restoration activities such as RPA 37-- Estuary Habitat Implementation 2010-2018— Achieving Habitat Quality and Survival Improvement Targets.

2) **Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan (Estuary Partnership 2004)**

As detailed in Table 2, pile management projects are anticipated to either directly address or contribute to a number of limiting factors identified in the LCR Subbasin Plan. The PSP also directly addresses or contributes to the objectives and strategies listed below. As detailed in Sections F and G, pilot project monitoring will test PSP hypotheses, quantify project benefits, and help identify those objectives and strategies that can be addressed by the program.

Physical Objectives (PO) (Chapter 4, pages 35-39):

- PO1.** Protect existing rearing and spawning habitat to ensure no further net degradation.
- PO2.** Increase shallow water peripheral and side-channel habitats toward historic levels.
- PO3.** Restore connectivity between tributary deltas and the estuary, the river and the floodplain, as well as in-river habitats.
- PO4.** Reduce predation mortality on emigrating salmonid juveniles and migrating adults, developing sturgeon embryos and migrating Pacific lamprey adults.
- PO5.** Reduce contaminant exposure of emigrating salmonid and Pacific lamprey juveniles and sturgeon eggs and juveniles.
- PO19.** Restore spawning and rearing habitat in the Western Oregon tributaries.
- PO22.** Increase the availability of habitat on public lands.

Priority Subbasin strategies the proposal addresses (Chapter 4, pages 42-43):

- Strategy 1:** Protect functioning habitats while also restoring impaired habitats to properly functioning conditions.
- Strategy 2:** Strive to understand, protect, and restore habitat-forming processes in the lower Columbia River mainstem, Western Oregon tributaries, estuary, and plume.
- Strategy 4:** Mitigate small-scale local habitat impacts such that no net loss occurs.
- Strategy 5:** Maximize efficiency of habitat restoration activities by concentrating in currently productive areas with significant scope for improvement, adjacent areas of marginal habitat where realistic levels of improvement can restore conditions suitable for fish, and areas where multiple species benefit.
- Strategy 6:** Utilize a combination of active and passive habitat restoration measures to provide near-term and long-term benefits.
- Strategy 9:** As an interim recovery measure until more suitable habitat conditions are restored for salmon, consider management of predators and predation by selected species where corresponding threats have been exacerbated by human activities.
- Strategy 11:** Use existing processes and programs wherever possible to take maximum advantage of opportunities for efficient implementation of improvement measures.
- Strategy 18:** Open access to productive habitat by removing or mitigating passage barriers.

Strategy 23: Assess the mainstem lower Columbia River and the Columbia River estuary by discrete geographic reaches for restoration and protection priorities, and develop approach for determining expected outcomes of research, monitoring and evaluation activities.

3) Northwest Power and Conservation Council's (NPCC) Draft Columbia River Basin Fish and Wildlife Program (NPCC 2008, Page 55)

The Northwest Power Act directs the NPCC to develop a fish and wildlife program and make periodic major revisions. The 2008 draft program includes a section on the estuary province, whereby according to the draft plan the NPCC supports strategies that protect, enhance, and restore critical habitat and spawning and rearing grounds in the estuary and lower Columbia River. The draft fish and wildlife program has several strategies that overlap with the PSP:

- 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;
- Long-term effectiveness monitoring for various types of habitat restoration projects in the estuary;
- Evaluation of the impact of flow regulation, dredging, and water quality on estuary-area habitat to better understand the relationship between estuary ecology and near-shore 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.

4) 2003 Mainstem Amendments to the Columbia River Basin Fish and Wildlife Program (NPCC 2003)

The PSP directly or indirectly addresses the following biological objectives outlined in the 2003 Mainstem Amendments:

- restore and enhance habitats and ecological functions that connect to protected productive areas to support the expansion of productive populations and to connect weaker and stronger populations, so as to restore more natural population structures (page 11);
- enhance the connections between the mainstem sections of the Columbia and Snake rivers and their floodplains, side channels and riparian zones (page 12);
- reconnect protected and enhanced tributary habitats to protected and enhanced mainstem habitats, especially in the area of productive mainstem populations (page 12);
- expand the complexity and range of mainstem habitats to allow for greater life history and species diversity (page 12); and,
- provide conditions that support the needs of...anadromous and resident species in the lower parts of the mainstem (page 13).

The 2003 Mainstem Amendments also present strategies for achieving these objectives. The strategies are subdivided into separate categories. The PSP relates primarily to measures that fall within the “Mainstem Habitat” category. Specifically, the PSP addresses the following strategies:

- providing appropriate spawning, rearing, and resting flows in the mainstem;
- reconnecting alcoves, sloughs and side channels to the main channel; and,
- adding large woody debris to these systems.

The amendments emphasize that the measures should benefit all species that utilize the mainstem as habitat and not just ESA-listed species.

D. Relationships to other projects

The Estuary Partnership currently is implementing two programs for Bonneville Power Administration (BPA):

- Columbia River Estuary Habitat Restoration – Project #2003-011-00
- Lower Columbia River Estuary Ecosystem Monitoring – Project #2003-007-00

For contracting purposes, the PSP is considered a subset of the Habitat Restoration Program. Although the ecosystem monitoring efforts have focused on the mainstem Columbia River, to date, the vast majority of restoration efforts have occurred along the river’s floodplain and in the tidally influenced portions of its tributaries. Very little restoration has occurred in the mainstem where, due to intensive use for hydropower and navigation, opportunities are limited. Consequently, the PSP represents one of the few opportunities to increase habitat complexity and restore functions in portions of the mainstem Columbia River. It also represents an opportunity to tie mainstem restoration efforts to those occurring on the floodplain and in the tributaries.

The PSP is closely coordinated with the existing Habitat Restoration Program and the Ecosystem Monitoring Project. The Estuary Partnership closely coordinates the programs and continually looks for partnering opportunities to leverage funding, coordinate monitoring, and maximize the ecological benefits of individual projects. For example, during selection of PSP pilot project sites, the program team sought to select sites that leverage the benefits of past or planned restoration efforts by including those factors in selection criteria. As a result, two to three structures likely will be removed to improve access to a side channels or tributaries that are being scoped for restoration.

Table 3. Relationship to existing projects

Funding Source	Project #	Project Title	Relationship (brief)
BPA	2003-011-00	Columbia River Estuary Habitat Restoration	The PSP is being implemented as part of the Habitat Restoration Contract. The program team will look for opportunities to leverage the benefits of the two programs by implementing projects that provide joint benefits.
BPA	2003-007-00	Lower Columbia River Estuary Ecosystem Monitoring	The program team will look for opportunities to leverage benefits by utilizing standard monitoring protocols, sharing data, etc.

Through formation and engagement of a pile structure subcommittee, the PSP is being developed and will be implemented in partnership with a variety of organizations including the U.S. Geological Survey (USGS), USACE, BPA, Pacific Northwest National Laboratory (PNNL), and National Marine Fisheries Service (NMFS). Additionally, because pile structure management will require coordination with, and input and approval from, local, state, and federal resource agencies that have regulatory jurisdiction, the program team currently is developing relationships and coordinating with federal and state resource agencies, including NMFS, U.S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, Washington Department of Ecology, Oregon Department of State Lands, Oregon Department of Environmental Quality, Washington Department of Historic Preservation, and Oregon State Historic Preservation Office. Depending on the structure type, proposed management action, and location, permits from and/or consultation with each of these agencies may be required.

E. Project history (for ongoing projects; this includes projects that have been funded with non-BPA funds).

Not applicable. This is a new program.

F. Proposal biological/physical objectives, methods, work elements and metrics.

The overall goal of the PSP is to improve habitat conditions and survival of juvenile salmonids in the mainstem of the lower Columbia River. As stated previously, although there is much speculation regarding the impacts of pile structures and the potential benefits that may be realized through their modification, management of pile structures for ecosystem benefit and salmon recovery is largely untested. Consequently, the program team divided the program's implementation into two separate phases. During Phase I, the primary objective will be to develop and test hypotheses to quantify the benefits of various approaches to pile structure management. To

accomplish this, the program team will implement and intensively monitor a diverse array of pilot projects. Results of these pilot projects will be combined with existing data to develop an adaptive management framework that clearly defines program benefits, details how these benefits address limiting factors identified in the LCR Subbasin Plan and Estuary Module, outlines specific biological, chemical, and physical objectives of future projects, and provides a mechanism for matching action-specific benefits with site specific and basin-wide limiting factors.

The similarities within structure type vary greatly; however, in an effort to maximize the utility of Phase I results, pilot project experiments will be designed to illustrate as many parallels as possible. Where similarities are common, e.g., spur dikes, this will involve the use of control/reference sites. For other structure types that vary greatly in design and setting, e.g., pile fields, comparison studies will rely more on pre- and post-implementation monitoring.

Phase I is anticipated to last 4 years. During its first three years, the program team will address one structure type, implementing 2-3 projects within that category. A proposed schedule is outlined below.

Winter 2009/2010 – 2-3 pile field experiments

Winter 2010/2011 – 3 transverse/training dike experiments

Winter 2011/2012 – 3 spur dike experiments

2012 through 2013 – continued monitoring and development of the adaptive management plan

Prior to implementing each individual project the program team will develop a set of clearly defined project-level objectives. Specific methods used to implement removal/modification projects will vary depending on site conditions; however, the BMPs utilized by the Washington Department of Natural Resources in their Creosote Removal Program (Appendix A) will form the basis of our removal methods. The methods and metrics used to monitor project results and test program hypotheses will be detailed during development of the program's RM&E plan, which is scheduled for completion in August 2009. Additional detail regarding the RM&E plan is provided in Section G.

During Phase II, the primary objective will be to identify, develop, and implement projects that address the greatest number of limiting factors identified in the LCR Subbasin Plan, i.e., have the greatest benefit to juvenile salmonids and the lower Columbia River ecosystem. This will be accomplished by identifying pile structures that have lower value to navigation channel maintenance, present low-risk to adjacent land use, are cost-effective, and when modified (using the management actions that produced desirable benefits during Phase I pilot projects) would result in the greatest increase in ecosystem structure and function. Phase II is anticipated to continue from 2013 – 2018. The number of projects implemented per year will depend on size and complexity of individual projects and available funding; however, it is anticipated that 2-4 projects would be implemented per year.

G. Monitoring and evaluation

In order to prove or disprove program hypotheses and determine benefits of various pile structure management techniques, the program team will develop a RM&E plan. The PSP RM&E plan will be based on well-established principles, including: 1) coordination, 2) conceptual ecosystem modeling,

3) baseline evaluations for status and hypotheses testing, 4) hypothesis testing to address critical uncertainties, 5) intensive and extensive monitoring for action effectiveness, and 6) adaptive management. PSP RM&E plan will be developed and implemented through the ongoing effort for BiOp implementation, as outlined in *Research, Monitoring and Evaluation for the Federal Columbia River Estuary Program* (Johnson et al. 2008).

The RM&E plan will be divided into three areas: Phase 1 monitoring, Phase 2 monitoring, and links to other monitoring programs. Phase 1 monitoring primarily will involve experimental studies to validate hypotheses and address uncertainties in the knowledge base. At a minimum, pre- and post-project monitoring focused on testing hypotheses will occur; hence, the monitoring plan will include a proposed monitoring design, including parameters and frequency and duration of data collection. Phase 2 monitoring will include pre- and post-project monitoring, action effectiveness monitoring, and monitoring to assess cumulative effects of management actions. The final section of the monitoring plan will describe how monitoring for the PSP will link to other on-going monitoring programs.

The RM&E plan will describe the techniques and metrics required to validate or disprove each category of hypotheses at the different classes of pile structures. Similarly it will describe the techniques and metrics that should be utilized for Phase II effectiveness monitoring. Proposed field procedures will be repeatable and conducted over a sufficient period of time to ensure that the evolution of the site is captured. Linking monitoring for the PSP to established monitoring protocols and programs, such as those developed for the Cumulative Effects of Restoration Project, Estuary Partnership action effectiveness monitoring, and existing research when possible may offer some benefit in cost savings and reduction in duplication for measuring a variety of ecological changes resulting from pile structure manipulations. The RM&E plan also will discuss if it is feasible to use a system of reference sites to establish site performance standards gauging the level of success or failure of future projects.

Physical conditions for measurement would include contaminant presence/absence, flow field, local bathymetry, sediment grain size, and sediment accretion rates, amongst others. Examples of biological parameters include fish species presence/absence, residence times, and fish community structure.

H. Facilities and equipment

The Estuary Partnership is a 501(c)(3) organization that has been working to restore habitat in the lower Columbia River and Estuary for over a decade. The Estuary Partnership has a science team of five solely dedicated to managing all aspects of restoration programs and a modern office with the best available office technology to implement programs. Additionally, we regularly contract with research specialists that have the most advanced equipment required for field sampling and analysis. Contractors that likely will be used for the PSP include USGS (contaminant testing), PNNL (sediment accretion and water quality analyses), and ODFW (piscivorous fish and bird surveys). At this stage, the Estuary Partnership and its subcontractors have the equipment required to complete all anticipated tasks, therefore no equipment acquisitions are anticipated.

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J. Key personnel

Table 4 summarizes the personnel that will be most involved with the PSP. One page resumes for each individual are included in Appendix B.

Table 4: Summary of Project Personnel

Name	Title	Organization	Role on Project	% of Time Dedicated to Project
Chris Collins	Biologist	Estuary Partnership	Program Coordinator	100
Catherine Corbett	Senior Scientist	Estuary Partnership	Program Oversight	20
Blaine Ebberts	Senior Biologist/Technical Manager	USACE	Technical Advisor	10
Gary Johnson	Senior Engineer	PNNL	Technical Advisor	10
Phil Trask	Senior Planner	PC Trask and Associates, Inc.	Technical Advisor	10