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**Project Overview**

In 2006 the Elkhorn Slough National Estuarine Research Reserve’s (ESNERR) Tidal Wetland Project (TWP) began a planning process for restoration of Parsons Slough. Consideration of multiple factors led to the conclusion that the project most able to advance the goals of the Tidal Wetland Project Strategic Plan (http://www.elkhornslough.org/tidalwetland/strategic_plan.htm) and the Parsons Slough Restoration Plan (http://www.elkhornslough.org/tidalwetland/parsons.htm) is the construction of an adjustable submerged tidal barrier (a sill) at the mouth of Parsons Slough. TWP, with funding assistance from NOAA, is moving forward with design, permitting, construction and adaptive management of the Parsons Slough Sill Project (project). The implementation of the proposed project is expected to provide a moderate reduction in energy compared to the existing tidal regime, while maintaining sufficient tidal exchange and flushing to provide acceptable water quality. The crest of the structure would be adjustable over a range of conditions to enable optimization among multiple management objectives. This document summarizes goals, objectives and performance requirements for the proposed adjustable sill to inform the design and permitting process.

**Goals and Objectives**

The Parsons Slough Restoration Project Team, with membership from the Science Panel and Strategic Planning Team set multiple goals for the project. The planning process identified substantial barriers to achieving the top goal of restoring salt marsh in Parsons Slough, but the proposed project could advance the other goals in a timely and cost effective manner.

**Parsons Slough Restoration Project goals**

**Goal 1:** To restore and enhance intertidal marsh habitats and functions within the Parsons Slough tidal wetland complex while addressing the needs of special-status species, estuarine-dependent species, and ongoing human uses.

**Goal 2:** To support the ecological recovery of the larger Elkhorn Slough system to the extent possible while meeting Goal 1.

**Goal 3:** To conserve high quality subtidal and intertidal estuarine habitats and functions within the Parsons Slough tidal wetland complex.

**Findings of the planning process**

Goal 1, restoration of salt marsh, does not appear feasible in the near term for technical and economic reasons, which are detailed in the Draft Parsons Slough Restoration Plan (http://www.elkhornslough.org/tidalwetland/parsons.htm). However, supporting ecologic recovery of Elkhorn Slough while conserving high quality subtidal and intertidal habitat in Parsons Slough (Goals 2 and 3) could be advanced by building a submerged tidal barrier (a sill) at the mouth of Parsons Slough.
Ecologic goals – Parsons Slough Sill

- Promote recovery of soft subtidal sediments by reducing peak current velocities and tidal scour in Elkhorn Slough, particularly in Parsons Slough and in Lower Elkhorn Slough from Parsons Slough to Moss Landing Harbor
- Promote the recovery of salt marsh in Elkhorn Slough by (1) increasing the retention of sediment in the estuary, making sediment more available to build marshes deposition on the marsh plain, and by (2) reducing the run up of water at the head of the slough through the reduction in tidal scour
- Improve or sustain ecosystem health with respect to dissolved oxygen and other indicators of eutrophication in Parsons Slough
- Accommodate the movement of fish and wildlife in and out of Parsons Slough, specifically sea otters, harbor seals, flatfish and sharks and rays

Management goals – Parsons Slough Sill

- Adjustment of the structure will be feasible with existing equipment and staff resources.
- The structure will function with minimal maintenance for at least 30 years, with a lifespan of at least 50 years.
- The structure can be dismantled if its effects are determined to be undesirable.
- Structural failure will not endanger life or property.
- The structure will enable tidal range in Parsons Slough to be managed from unrestricted to a 30 percent reduction compared to existing conditions

Structure Details

Concept

The present conceptual design for the sill includes a base constructed of 12 and 24-inch diameter rock. Alternative construction methods and materials (e.g., sheet piling) are also being considered. The top of the sill will consist of an adjustable crest. The width and elevation of the crest must be adjustable using panels, stop logs supported by steel posts, or other materials which can be added or removed using hand labor or a boat-mounted hoist. Figure 1 provides a conceptual drawing of the proposed structure.
Performance and Configurations
The proposed structure would block about 75% of the present channel cross-sectional area. A starting point for the invert elevation of the adjustable portion is -1.5 meters (-5 feet) NAVD 88. The opening of the sill could be configured a variety of ways. The base assumption has been that the structure would be a linear feature perpendicular to the channel. Other configurations may warrant exploration, for example, to reduce ebb dominance. An investigation of alternatives for the structure was led by Moffatt and Nichol. The full and half channel width alternatives are discussed in the Draft Parsons Slough Restoration Plan, Section 4. The ‘Narrow’ option was evaluated in a letter report (http://www.elkhornslough.org/tidalwetland/downloads/6266_Parsons_Modeling_Results_3-9-09.doc). They found that the width of the sill crest has a marked effect on tidal exchange.

Expected Effects of the Sill
Tidal scour
The ‘Full Width’ configuration is not expected to reduce tidal scour in the main channel of Elkhorn Slough, because it does not reduce the tidal prism or substantially reduce main channel velocity. However, it would address tidal scour in Parsons Slough by acting to prevent downcutting, and by retaining sediment.

The ‘Narrow’ configuration would reduce tidal prism and peak ebb current velocity in the Main Channel of Elkhorn Slough. This would likely reduce tidal scour. The degree of this effect has not been modeled. The analysis of the effect of the Parsons Slough project on tidal scour by Philip Williams and Associates (PWA) (http://www.elkhornslough.org/tidalwetland/williams_final_report/index.htm) assumed an 80% reduction in the Parsons Slough tidal prism, but this Narrow configuration would reduce it by about 30%. PWA predicted that the more substantial project would reduce the rate of tidal scour by 40%, so the effect of the most restrictive configuration now considered would likely be less than that.

Upstream of Parsons Slough, ebb tide channel velocities are predicted to increase. This would increase tidal scour in that portion of the slough, though the net effect of the structure would be to substantially decrease tidal scour overall.

Salt marsh viability in Elkhorn Slough
The Parsons Slough sill would have no direct effect on marsh dieback in Elkhorn Slough, but its indirect effects, while beneficial for salt marsh are difficult to quantify. It would help balance the overall sediment budget for the slough, but with different effects in different areas. It would increase the rate that the upper slough drains, which may decrease the duration of inundation in the upper slough, benefitting marsh there.
Habitat types in Parsons Slough

The Full Width configuration would have minimal effects on habitat types in Parsons Slough, as the tidal range would remain unchanged.

The Narrow sill configuration would substantially affect the tidal range in Parsons Slough, eliminating the low end of the tidal range and reducing the high end of the tidal range.

Salt marsh extent in Parsons Slough would increase around the perimeter and on islands. The magnitude of that effect would be in the low tens of acres, depending on the sill configuration.

Minimum water levels in the Parsons Slough complex would increase from – 0.6 meters (-2.0 feet) to +0.6 meters (+2.0 feet) in elevation. This would convert large areas of intertidal mudflat to shallow subtidal habitat. Approximately 200 acres of the intertidal mudflat could be affected. Maximum water levels would be reduced by approximately 0.3 meters (1.0 feet), which would promote the establishment of a band of salt marsh around the periphery of Parsons Slough. The acreage has not been determined, but could be about 20 acres. This habitat type conversion would represent a substantial shift in Elkhorn Slough habitats and whether this tradeoff is acceptable should be addressed by the group.

Effects on species, fish and wildlife habitat use

Harbor seals, sharks and rays use Parsons Slough for pupping, and the area may be important for the conservation of regional populations of these animals. Sea otters also use the area. Consulted experts with respect to sea otters (Lillian Carswell, USFWS) and sharks (Greg Calliet, MLML, and Aaron Carlisle, Hopkins Marine Station), have indicated that while a more restrictive structure may interfere with movement at some times, it would probably not have a significant effect on the populations. However, monitoring and managing the structure to reduce that risk may be warranted. Habitat conversion from intertidal mudflats to subtidal areas may also affect shark populations, as the intertidal mudflats are the preferred foraging areas, based on detailed data analysis by Aaron Carlisle.

Olympia oysters, other invertebrates and communities dependent on them such as shorebirds, may be adversely affected by the conversion of habitat from low intertidal mudflats to shallow subtidal habitats.

For sharks and Olympia oysters, Parsons supports a substantial fraction of the estuary populations.

Effects on water quality in Parsons Slough

The Full Width configuration would have little effect on the residence time of water in Parsons Slough, which generally suggests that the water quality would not be adversely affected. However, the structure could impede the export of algal mats from Parsons Slough, which would result in increased benthic oxygen demand over time. The importance of this effect is unknown.
The Narrow configuration could have several effects on water quality, and would mute the tides to an extent that could impair water quality. The net effect of this configuration on dissolved oxygen and eutrophication is unclear, but could very likely be undesirable. It is affected by several factors:

- It would decrease the tidal prism by 28 percent and increase the residence time of Parsons Slough by 40 percent. This could result in warmer water, higher primary productivity, increased water column and benthic oxygen demand and decreased dissolved oxygen conditions.

- It would also decrease current velocity in Parsons Slough by up to 40 percent and peak tidal range by up to 60 percent, which could increase stratification and reduce dissolved oxygen concentrations near the bed.

- This configuration would convert approximately 200 acres of intertidal mudflat to shallow subtidal habitats. This would increase the average depth of Parsons Slough. The net effect on dissolved oxygen is unclear. The modeling work done by Ken Johnson on the Elkhorn Slough suggests that the deeper water, by providing a larger reservoir of dissolved oxygen, generally results in higher concentrations of water column dissolved oxygen.

- The same work, however, pointed out that mudflats, when exposed to the atmosphere at low tide exert their benthic oxygen demand on the atmosphere rather than the water column. Under this configuration, the sediment oxygen demand from these former mudflats would be exerted entirely on the water column, which could counter the benefits of a deeper water column.

**Optimization of the structure (adaptive management)**

The concept is that width and depth of the sill opening would be adjusted through an optimization process based on monitoring the achievement of project goals. This would ensure that currents are reduced but high quality existing habitat is not compromised. The structure would be adjusted through different configurations, with monitoring to compare the results against these targets. That process would last for perhaps five years following construction. The best configuration would then be selected based on criteria determined prior to construction. (Formerly, this approach was described as adaptive management, but since that term is somewhat vague, we will use the term optimization instead.)

After that intensive period, annual or seasonal adjustment is presently viewed as undesirable for cost reasons. The most feasible management scheme would settle on a fixed position after this period of adjustment, and then the structure would be left unchanged for several years at a time. Long term changes to conditions or changed management objectives would be the main reason for adjustments during that time. The preferred design would not require frequent operation or maintenance to provide lasting ecologic benefits.

**Additional Resources**

A description of the project, including an initial list of potential impacts is available at [http://www.elkhornslough.org/tidalwetland/downloads/090603_Parsons_Slough_Project](http://www.elkhornslough.org/tidalwetland/downloads/090603_Parsons_Slough_Project)
The proposed project, which includes a single water control structure and no additional sediment additions, was recommended at a June 3, 2009 Joint Meeting of Strategic Planning Team and Science Panel of the Elkhorn Slough Tidal Wetland Project. The management history and photos of the Parsons Slough Marsh Complex can be found at http://www.elkhornslough.org/tidalwetland/twmap06.htm.

The Draft Parsons Slough Wetland Restoration Plan web site includes a Draft Existing Conditions Report that inventories habitats and species occurring in the area. That web page is: http://www.elkhornslough.org/tidalwetland/parsons.htm. On that web page are copies of the Draft Restoration Plan, which includes a CEQA Initial Study Checklist for a separate, larger-scale project entailing sediment addition to restore tidal marsh. That larger-scale project is not proposed at this time.

Additional information about the Elkhorn Slough Tidal Wetland Project can be found at http://www.elkhornslough.org/tidalwetlandproject/index.html. The Tidal Wetland Project Strategic Plan summarizes the outcomes of this planning process, and is posted here: http://www.elkhornslough.org/tidalwetland,strategic_plan.htm.
Figures
FIGURE 1: PROJECT VICINITY MAP.
FIGURE 2: PROJECT LOCATION.
Figure 3. Cross sectional diagram of the adjustable Parsons Slough Sill.

An adjustable section will be built on top of a submerged tidal barrier that is constructed of rock or sheet piling. With the flashboards removed, the structure will provide a cross sectional area similar to pre-development conditions. With the flashboards in place, tidal exchange will be restricted, reducing tidal scour and salt marsh loss. Figure 4 shows a photograph of a similar structure.
Figure 4. Tidal current velocity in Elkhorn Slough under the most restrictive configuration of the sill

This configuration reduces peak velocities by 20 percent in the main channel of Elkhorn Slough, which is expected to substantially reduce tidal scour and salt marsh loss. The least restrictive configuration of the structure would result in a negligible reduction in velocity compared to existing conditions.
Figure 5. Tidal range in Parsons Slough under the most restrictive configuration of the sill

The most restrictive ‘Narrow and Deep’ configuration would reduce the tidal range in Parsons Slough by approximately 50 percent. The least restrictive ‘Full Exchange’ configuration would result in no change in tidal range in Parsons Slough. This ‘full exchange’ configuration would also maintain the existing residence time of water in Parsons Slough.
Figure 6. Water control structure installed in October 2008 by the Elkhorn Slough Foundation which ties into the Union Pacific Railroad track embankment.

At North Azevedo Pond, tidal exchange is managed with this water control structure, which is positioned between a railroad bridge and the adjacent subsided salt marsh. The structure consists of an array of adjustable openings, one of which is shown open. Flashboards may be added or removed, enabling the management of a variety of hydrologic regimes without the use of culverts or traditional tide gates, which interfere with the movement of large fish and marine mammals.

A similar approach is proposed for the Parsons Slough Sill, with the adjustable section built on top of a submerged tidal barrier that is constructed of rock or sheet piling. In both Parsons Slough and North Azevedo Pond, subsidence of the marshes on the inland side of the railroad tracks has created a situation where full tidal exchange results in the drowning of salt marsh vegetation on the inland side and the pronounced scour of tidal channels.

The Union Pacific Railroad approved this project, which was built in part on the Union Pacific right of way. Union Pacific has indicated support for the project concept at Parsons Slough, provided specific design requirements are met.

Fencing in the foreground of the picture is remnant from the historical grazing of the area.
Extent of current SFML bathy/topo data for Parsons Slough Bridge

Data: California State University at Monterey Bay, Sea Floor Mapping Center. March 2009.