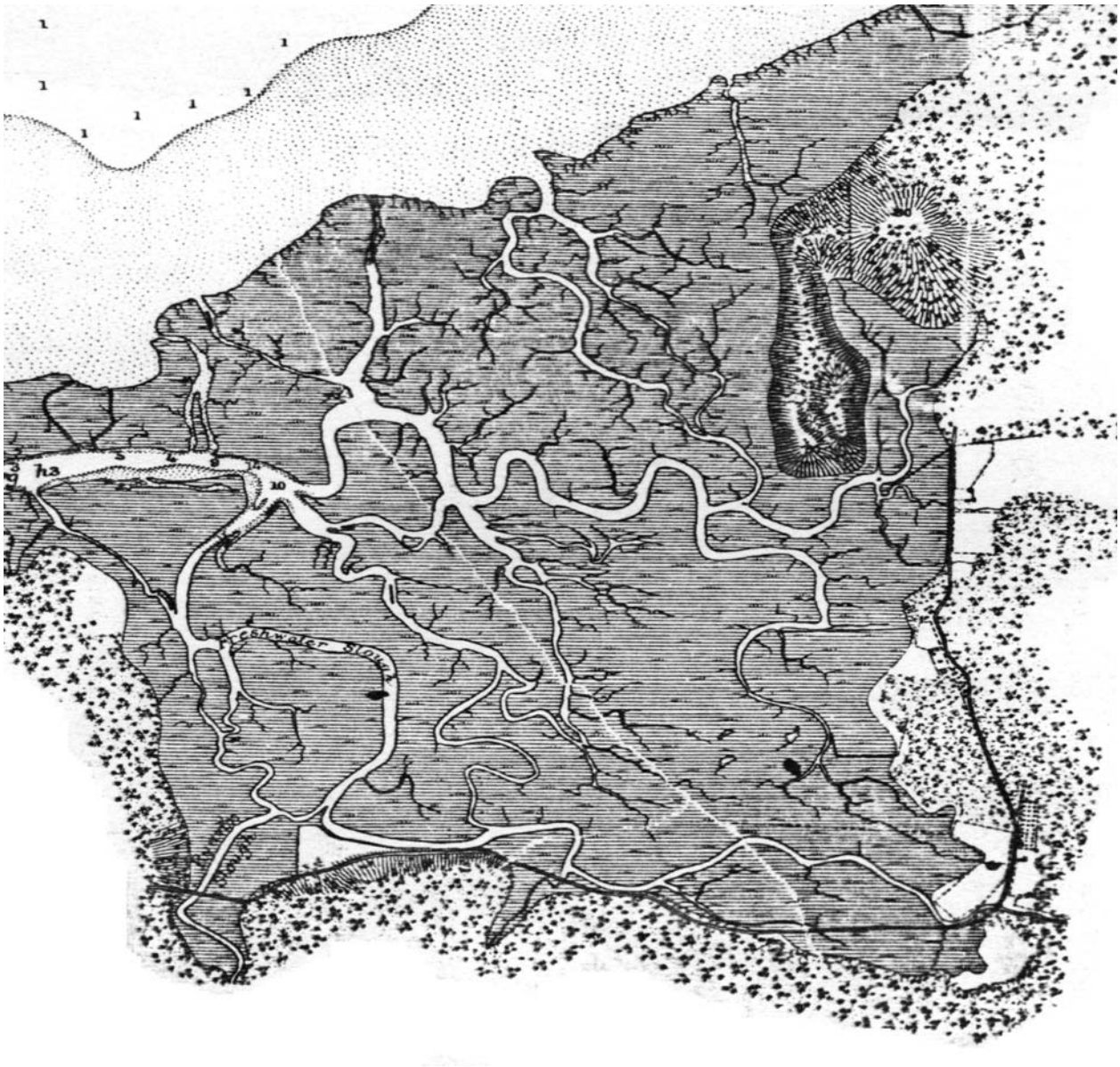

FRESHWATER SLOUGH
ESTUARY REHABILITATION PROJECT

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1 FRESHWATER SLOUGH ESTUARY REHABILITATION PROJECT

1.1 Background

In 2001, Rick Storre of Freshwater Farms proposed restoring estuarine and tidal marsh functions to a portion of his property bordering Freshwater Slough downstream of Three Corners (Figure 1). In response, project goals and objectives were developed using initial funding provided by Redwood Community Action Agency (RCAA) Natural Resources Division. McBain and Trush was then awarded a grant from the California Department of Fish and Game California Coastal Salmon Recovery Program to develop a conceptual design for estuary and marsh restoration at the site. In the interim, a portion (54 acres) of Rick Storre's 75 acre parcel has been subdivided and sold to the Northcoast Regional Land Trust with funding provided by the Department of Fish and Game and the California Coastal Conservancy.

This project (The Freshwater Slough Estuary Rehabilitation Project) collected baseline data needed to develop the conceptual design, then developed a conceptual plan to restore tidal hydrology, tidal marsh functions, and fish access and habitat to approximately 40 acres of pastureland adjacent to Freshwater Slough. The project has also developed cost estimates for project implementation.

1.2 Project Setting

The project site is along Freshwater Slough, approximately 2 miles to the Northeast of Eureka, CA (Figure 1). Freshwater Creek drains a 30 square mile watershed, and becomes Freshwater Slough before it flows into the Eureka Slough and eventually Humboldt Bay. The lowermost 8,500 ft of Freshwater Slough, beginning at the Highway 101 bridge crossing Eureka Slough, are tidally influenced (i.e., the ecotone) or estuarine. The project area is located along Freshwater Slough (Figure 2), beginning at station 131+00 (i.e., 13,100 ft upstream of the confluence with Eureka Slough), and extends upstream an additional 4,000 ft almost to the Three Corners area (Figure 1). The project area is an 80 acre pasture isolated between Freshwater Slough to the north, and Myrtle Avenue to the south. Extensive agricultural wetlands extend to the southeast of the project site, south of Myrtle Avenue (Figure 3). These agricultural wetlands are hydrologically linked to the 75 acre pasture by a 130 ft wide causeway under Myrtle avenue, and by a 4 ft diameter culvert that drains Wood Creek under Myrtle Avenue. Prior to diking and land conversion, the project area was historically a transitional area between freshwater aquatic habitats and brackish habitats. Currently, the majority of lands adjacent to Freshwater Slough within the ecotone are diked and protected from tidal influence with tidegates.

The Wood Creek watershed is less than 1 square mile, and the creek flows north and under Myrtle Avenue, entering the 80 acre pasture, then turning west and flowing 2,300 ft before draining into Freshwater Slough at the western end of the pasture (Figure 4). Wood Creek is a perennial stream, but there is no blue-line section on the 1972 USGS quad map. A considerable amount of seepage from the bordering hillsides contribute flow to Wood Creek and the surrounding wetland pasture. Wood Creek has an old wooden tidegate at the confluence with Freshwater Slough (Figure 5) that allows outflow from Wood Creek but prevents water from entering from Freshwater Slough. There are two additional Waterman tidegates adjacent to the Wood Creek tidegate that help drain surface runoff from the pasture. The upper approximately 700 ft of stream channel is heavily aggraded and has become choked with marsh vegetation, primarily cattail (*Typha latifolia*). The lower 1,400 ft of Wood Creek transitions from creek to subtidal slough channel, has well-developed vertical and undercut mud banks, and is bordered by extensive sedge and other freshwater marsh vegetation (Figure 6). This portion of channel appears to receive enough flow to prevent the channel from aggrading, and/or sediment is trapped upstream at the "delta" deposited below the Wood Creek culvert. There are several smaller slough-like channels that connect to Wood Creek, draining the pasture to the north of the creek.

At least five rare, threatened, or endangered, (RTE) amphibian or fish species live in Freshwater Creek. Three listed salmonid species – steelhead, coho, and Chinook – spawn in the watershed, and juveniles are

known to rear in the lower creek and slough (Mike Wallace, unpublished CDFG reports). Additionally, foothill yellow-legged frog and northern red-legged frog occupy freshwater marsh habitats.

1.3 The Importance of Tidal Marshes

The protection and restoration of tidal freshwater marshes, upper estuarine salt marshes, and the corridors linking these habitats may play a vital role in increasing the productivity of estuaries for juvenile salmonids, and for increasing salmonid abundance in general. Scientists have long recognized high productivity associated with tidal marshes. The seminal work on energy budgets by Teal (1962) at a Sapelo Island salt marsh, Georgia, demonstrated that primary production was greater than community respiration (P/R>1) and excess production was exported from the marsh to the surrounding estuarine areas. A recent review of this "outwelling hypothesis" by Odum (2000) substantiated this view that salt marshes are energetic "hot spots" and that excess production may result in the export of organic matter and nutrients from marshes to the sea, thus contributing to enrichment of coastal waters. The outwelling process is likely intermittent, associated with rain storms and high spring tides (Odum 2000). Teal and Howes (2000) also concluded the notion of "excess" marsh production has been supported by subsequent research, but that "overlapping food webs" has replaced "organic matter and energy" as the principle export mechanism.

Tidal marshes thus have ecological value beyond their borders. In addition to the surplus production, marshes perform numerous vital ecological functions, including:

- cycling of plant nutrients, nitrogen, and phosphorus
- prevention of degradation of estuarine habitats from nutrient pollution
- flood peak attenuation
- habitat for numerous estuarine and marine fish species
- abundant biomass production
- bird and waterfowl habitat

We include several contiguous habitats in our definition of tidal marshes (Figure 7): the irregularly flooded marsh surface (including vegetated and non-vegetated areas), the regularly flooded intertidal surface, intertidal marsh creeks, and small subtidal marsh creeks that often form an intricate network of drainage channels. Although highly interconnected, this area is distinct from the open waters of slough channels and the bay, which should be considered estuarine.

Tidal marshes and estuaries also play a key role in the life histories of several salmonid species. These habitats provide the spatial salinity gradient necessary during the physiological adaptation from freshwater to saltwater, as well as a rich foraging environment that offers a last opportunity for growth before ocean entrance (Healey 1982). In addition, tidal marshes and estuaries may be an important refuge from predation. Most of these functions are poorly understood, however.

Reimers (1973) demonstrated that Chinook salmon (*Oncorhynchus tshawytscha*) juveniles from the Sixes River, Oregon, that reared initially in freshwater and then moved to the estuary experienced higher growth rates than fish rearing exclusively in freshwater, and eventually represented about 90% of the returning spawners. The average size of juveniles entering the estuary was about 90 mm, while an additional 40 mm was added during estuary rearing. The largest juveniles had the highest survival. Based on these results, freshwater and estuarine rearing were considered to be equally important. Shreffler et al. (1990) showed that a restored wetland within the Puyallup River estuary provided productive foraging habitat for migrating juvenile chum (*Oncorhynchus keta*) and fall-run chinook salmon. Their study demonstrated a highly selective detritus-based food chain (detritus-chironimids-juvenile salmon) within the restored tidal marsh. Juvenile chum foraging in the Skagit River delta also fed primarily on chironomid pupae and adults, and chironomids dominated the diets of all 29 fish species collected in tidal marshes of the lower Fraser River (Northcote et al. 1979). Sogard (1992) noted that estuaries are vital nursery grounds for juvenile fishes, and vegetated habitats within estuaries (e.g., tidal marshes) tend to harbor higher densities and higher growth rates for many fish species than unvegetated substrates.

Despite extensive degradation of estuarine and tidal marsh habitats, most efforts to reverse the dramatic declines in salmonid stocks in the Pacific Northwest have focused almost exclusively on freshwater habitat protection and restoration, and harvest regulation.

A recent study of coho salmon (Oncorhynchus kisutch) utilization of the lower estuary and several marshes adjacent to Winchester Creek, South Slough, Oregon (Miller and Sadro 2003) has provided additional evidence of the importance of tidal marshes and the estuary to juvenile salmon life history. This research focused on the stream-estuary "ecotone", defined as the area extending from the upper limit of tidal influence downstream to the area where the channel becomes bordered by mudflats, and including all tidal channels and fringing marsh habitats that are accessible to fish for at least some portion of the tidal cycle. Miller and Sadro (2003) and other studies (cite) have documented the downstream migration of sub-yearling (age-0) and yearling (age-1) coho salmon to the stream-estuary ecotone and lower mainstem reaches, suggesting that a portion of juvenile production in many systems may take advantage of rearing opportunities provided by the ecotone. Merrell and Koski (1978) have further suggested that the benefits (to juvenile production) of rearing in the ecotone are proportional to the extent of this habitat within the system, meaning that any expanse of this habitat would translate directly to increased production.

The South Slough study (Miller and Sadro 2003) is particularly important because of the strong physiographic similarities between South Slough and Freshwater Slough (Eureka, CA). The South Slough (Winchester Creek) ecotone is described as a deeply entrenched stream channel surrounded by sedge and bulrush, with tidal flux ranging up to approximately 1 m, and salinity ranging from 0% to 10% during low streamflow periods (upper reach), transitioning to the lower slough channel with tidal flux up to 3.3 m and salinities ranging from 0% during high runoff to 32% during low streamflow periods (lower reach). Several fringing marshes were studied, including Dalton Marsh, a restored salt marsh that was reconnected to the main channel by removal of a dike and tidegates, and the channel reconstructed to facilitate stream runoff through the marsh. Age-0 coho were captured in Dalton Marsh beginning in April 1999, and remained for several weeks (up to at least 52 days) before emigrating by mid-June. The spring age-0 coho sampled in Dalton Marsh had the highest growth rates of all fish they sampled, equivalent to 0.44 mm/d, compared to an estimated 0.16 mm/d for fish that reared in the upper watershed of Winchester Creek. In general, estuarine residence times for age-0 coho ranged up to 159 d.

1.4 Freshwater Slough Ecotone

The Freshwater Slough ecotone (henceforth referred to as the Freshwater ecotone or the ecotone) extends roughly from the Freshwater Slough confluence with Eureka Slough upstream to approximately the Howard Heights Bridge located nearly 2 miles upstream of Myrtle Avenue at Three Corners. Tidal influence has been documented to Howard Heights Bridge, and salt water pockets are occasionally observed above the Humboldt Fish Action Council weir (upstream of Three Corners) during high summer tides (WBWAC 2005). The slough between Three Corners and Devoy Road gradually loses all salinity. The reach from Devoy Road to Park Street is a transitional tidal area with a highly variable salinity regime, and the slough gradually becomes more marine from Park Street to Humboldt Bay.

The Freshwater ecotone and surrounding lands were historically an expansive, dendritic network of tidal slough channels, salt marshes, and brackish marshes (Figure 8). Mapping conducted in 1886 by the US Coast and Geodetic Survey indicated salt marsh as far inland as the present location of Myrtle Avenue, although the upper extremes of this area likely transitioned to lower salinities characteristic of brackish marshes. The ecotone was seasonally dominated by runoff from Freshwater Creek which supported extensive perennial and seasonal wetlands surrounding salt and brackish marsh lands. The delineation between freshwater and brackish marshes was likely not distinct. Barnhart et al. (1992) note that Humboldt Bay is the only area between San Francisco Bay and Coos Bay containing appreciable acreage of salt marsh, and its flora is distinct from central and southern California marshes.

By 1933 (or earlier) much of the tidal wetlands had been isolated from tidal influence by dikes, and converted to pasture. The present configuration of Freshwater Slough and lower Wood Creek was already

established, as indicated in the 1933 USGS quad map (Figure 9). The dramatic loss of tidal marsh lands in Humboldt Bay has been well documented, and tidal marsh declines within the Freshwater ecotone have been no less dramatic. Only 393 of 2833 original hectares of salt marsh remain (Barnhart 1992). By far the largest contributor to the loss of tidal marshes in Humboldt Bay is the diking associated with agricultural development. Dikes extend along both sides of Freshwater Slough upstream to station 145+00 (station 0+00 is at the Freshwater Slough confluence with Eureka Slough). Former tidelands on the north and south banks of Freshwater Slough are nearly all converted to pasture. Only the Park Street marsh (9.5 acres of restored salt marsh) remains as a viable marsh within the Freshwater ecotone.

1.5 Need for Tidal Marsh Restoration.

Given the dramatic loss of tidal marsh lands in Humboldt Bay, and recognizing the importance of these habitats to juvenile salmonids, tidal marsh restoration is a high priority for all of Humboldt Bay and especially within the Freshwater ecotone. Brown et al. (1994) noted that Freshwater Creek had one of the last populations of coho salmon numbering in the hundreds annually in all of northwestern California. Freshwater Creek still supports the largest population of coho salmon within Humboldt Bay, and is identified as a priority watershed in the Recovery Strategy for California Coho Salmon. The Freshwater watershed also supports chinook salmon, coastal cutthroat, and steelhead populations.

1.5.1 The Recovery Strategy for California Coho Salmon

The Recovery Strategy for California Coho Salmon (CDFG 2004) provides a broad-scoped evaluation of the status of coho, their habitats, and recovery needs. The Recovery Strategy cites a number of impairments to salmonid habitat that exist in the Humboldt Bay watershed, including the loss of functioning estuary habitat. The report (citing Sedell et al. 1991) concludes that estuaries are essential habitat of Pacific salmon, including coho salmon.

The Recovery Strategy provides the following ‘Range-Wide Recommendations’:

RW-XXIII-E-01 Restore estuarine habitat and the associated wetlands and sloughs by providing fully functioning habitat. Fully functioning habitat includes:

a. Restoration of historic estuarine areas to maximize available estuarine habitats and tidal prisms;

b. Free passage for adult and juvenile coho salmon to all estuarine areas;

c. Adequate instream structure (cover and complexity);

d. Adequate riparian habitat;

e. Eradication of invasive exotic flora and fauna;

f. Protection of habitat quality by providing suitable water quality and quantity input to estuaries;

g. Protection and restoration of coho salmon prey habitat; and

h. Minimizing artificial breaching and associated potential negative impacts.

The Recovery Strategy provides the following Watershed Recommendations for the Eureka Plain Hydrologic Unit:

EP-HU-02 Support implementation of Humboldt County’s provisions to protect Stream Management Areas and evaluate their effectiveness; recommend revisions as necessary.

EP-HU-03 Work with agencies and landowners, to re-establish estuarine function.

EP-HU-06d In cooperation with willing landowners, restore and maintain historical tidal areas, backwater channels and salt marsh.

1.5.2 Humboldt Bay Watershed Salmon and Steelhead Conservation Plan

The recently completed Humboldt Bay Watershed Salmon and Steelhead Conservation Plan (cite) provides the following goals and objectives for the restoration of tidal marshes and estuarine processes in Humboldt Bay:

GOAL A: Maintain and restore estuary processes that benefit salmonids.

Objectives:

1. Identify changes in estuarine tidal connectivity over the past 100+ years using historic maps, air photo analysis, historic records, and interviews with long-term residents.
2. Identify locations where historic estuary habitat (sloughs, wetlands, stream channels) could be reconnected to the main stem channel.
3. Identify suitable locations for the placement of large woody debris (LWD) to enhance backwater habitat.

2 PROJECT GOALS AND OBJECTIVES

The goal of the Freshwater Slough Estuary Rehabilitation Project (Phase 2) **is to restore tidal hydrology to a tidal marsh (approximately 35 acres) on frequently inundated agricultural lands adjoining the upper Freshwater Slough, and provide access to high quality rearing habitat within the marsh for juvenile salmonids and other fish species.**

2.1 Project Objectives

- Allow tidal inundation (freshwater and low-salinity brackish water) to the tidal marsh area upstream of the existing Wood Creek tidegate structure.
- Restore access to aquatic habitat in tidal slough channels and inundated marsh areas for transient marine fish species and juvenile salmonid species (including listed chinook and coho salmon, and steelhead).
- Increase hydrologic diversity (velocity) and available slack-water refugia during high winter flood events.
- Increase width and area of the saline wedge in Freshwater Slough to reduce the sharp saline gradient experienced by emigrating coho salmon smolts.
- Construct micro-topography indicative of a regionally less-disturbed estuary to maximize natural regeneration of salt, brackish, and freshwater marsh complexes.
- Revegetate restored tidal marsh surfaces to increase diversity of marsh plant species and prohibit colonization by invasive species.
- Improve channel capacity and flood conveyance of tributary channels that drain through the restored tidal marsh into Freshwater Slough.

2.2 Additional Objectives

The conversion of agricultural wetlands surrounding Humboldt Bay back to tidal marsh and estuarine conditions is a subject receiving much attention recently. Several large parcels that are diked former tidelands have recently been sold to public entities, and other parcels are the subject of restoration projects with the landowner's participation. The support and consent of the landowners –both of the subject parcels and of adjacent parcels – is critically important to our ability to move forward with these and other future marsh restoration projects. An important additional objective of the Freshwater/Wood Creek project, therefore, was that the preferred alternative not only met the ecological goals and objectives, but also met the approval of landowners and other stakeholders (e.g., Humboldt County).

Another objective associated with the Freshwater/Wood Creek project is to restore marsh functions and fish access, monitor to see how well our design worked, and then apply these lessons to the next phase of projects in future years. This programmatic approach to restoration and adaptive management by explicit experimental design of initial projects, intensive monitoring, then application of knowledge gained to subsequent projects, is becoming a key aspect of most, if not all, large-scale restoration programs. Humboldt Bay tidal marsh restoration and agricultural land conversion is well-suited to this approach.

3 FIELD DATA COLLECTION METHODS AND RESULTS

The conceptual rehabilitation design proposes to restore tidal hydrology to a portion of the seasonally inundated pasture adjacent to Freshwater Slough. Four alternative designs were considered during the process of developing the conceptual design. Each alternative would convert the wetland pasture to a tidally influenced brackish-freshwater marsh, but each alternative proposes varying degrees of engineering and construction implementation (e.g., earthworks, existing structure demolition). We conducted an assessment of current conditions and a description of site hydrology to aid in selecting a preferred alternative conceptual design.

3.1 Data Collection: Methods

The following baseline data were collected during the winter season of 2003-04:

Task 1: Physical Site Assessment. We documented the interaction of site topography and channel morphology with stream flows and tide cycles to provide the basis of a conceptual design and feasibility assessment. For task 1, we:

1) obtained a recent aerial photograph (1993) of the site to use as a base map;

2) established longitudinal stationing along Freshwater Creek, which is distance in feet from the Freshwater Slough confluence with Eureka Slough;

3) surveyed topography of the 75 acre pasture with a total station, established five cross sections throughout the project reach, a longitudinal profile in Freshwater Slough, a longitudinal profile in Wood Creek, and a longitudinal profile of the ground surface from the west to east boundaries. Spot elevations on adjacent floodplains and levees were surveyed at locations where streamflows access the site. A total station survey was used instead of an auto-level to provide better topographic data;

5) documented a wide range of water surface elevations at cross sections and at the tidegate to establish relationships between storm-related flooding, tidal action, and site topography;

Task 2. Hydrologic Assessment. The Freshwater ecotone is hydrologically complex; tides and floods interact to create a diversity of hydrologic conditions. We evaluated how floods and tides interact across the site under existing and proposed conditions. Flood frequency, timing, magnitude, stage, and duration are important, and tidal fluctuations also strongly influence stage height in the slough channels and the extent and duration of inundation on surrounding pasture. For task 2, we:

1) Installed staff plates at upstream, middle, and downstream locations within the study reach to document stream water surface elevations;

2) Installed crest stage recorders at staff plate locations to document peak streamflow elevations of individual floods;

3) Installed one continuous stage recorder at the middle staff plate in Freshwater Slough (1,200 ft above the tidegates), so that hydrologic conditions could be quantified in terms of tidal influence, streamflows, and the combination of the two.

5) Measured water salinity (the saline wedge) intrusion at the site under flood flow-high tide conditions;

6) Correlated streamflow stage data at the site with the Redwood Science Laboratory (RSL) gage at Terry Roeloff's house, to assess the role tides play in determining water surface elevations at the project site at baseflows and during flood events.

A simple flood model was developed that calculated the volume of flow through the Wood Creek tidegate weir on Freshwater Slough (with the tidegate removed) during a series of tide cycles. Data from the NOAA North-Spit Humboldt Bay tide station (station 9418767) was converted to tide-stage data at the concrete weir. The model assumed no hydraulic resistance from water flooding the pasture upstream of the weir, thus making the inundation estimate fairly conservative, (i.e, likely an over-estimate of the inundation extent). We estimated inundation at Mean High Water, Mean Higher High Water, and resulting from the December 24, 2003 extreme high tide event.

3.2 Data Collection: Results

3.2.1 Physical Site Conditions

During 2003 and 2004, we collected physical and hydrologic data and developed a base map (Table 1). We installed a permanent concrete benchmark at the site and assigned an arbitrary elevation of 100 ft. All subsequent surveys were made relative to this benchmarks; in the future this benchmark should be related to the North American Vertical Datum.

The site was surveyed in June 2003 and provided the data needed for developing a topographic 1 foot contour map of the site (Figure 10). The site survey also provided the baseline data needed for illustrating five cross sections and the longitudinal profiles of Freshwater Creek and Wood Creek (Figures 11 and 12). Due to many years of agricultural use, there is little topographic variability, and the historic dendritic channel network has been suppressed.

3.2.2 Hydrologic Conditions

The influence of tidal hydrology on streamflow and the interaction of these with site topography were assessed. On Freshwater Slough a continuous record was taken for two lunar cycles (approximately 2.5 months); measurements of tidal fluctuations were measured every six minutes. The tidal cycle was recorded at cross section 142+94 (Figure 10). This tide data was then calibrated to the NOAA North Spit tide data.

Using the record at the North spit we evaluated tides at the North Spit to derive extreme high tides, Mean Higher High Water (MHHW) and Mean High Water (MHW) exceedence probabilities (Figure 13). We synchronized our measured tidal fluctuations taken at cross section 142+94 to the continuously measured tidal record at the North Spit (Figure 14). Using the exceedence probability relationship and the correlation of the North Spit to the tide data collected at the site we derived the MHHW, MHW elevations for the Freshwater Estuary Site. We overlaid streamflow on the tide cycle data using data collected the Redwood Sciences Laboratory's gage at Terry Roelof's house (Figures 15-16).

During our continuous logging of tidal cycles, the Freshwater Slough site experienced six stream flood events and the highest tide recorded in Humboldt Bay (Figure 15). Stream induced flood events did not occur coincidentally with the high tide of record. We evaluated the influence of streamflow baseflows and flood peaks on tidal influence at the Freshwater estuary site (Figure 15). High tide events without the influence of stream flood peaks are not sufficient to go overbank or cause flooding. Only during flood peaks does water goes overbank and causes flooding (Figure 16).

Wood Creek currently drains during the outgoing tides and during lower high-tide events. During tides higher than the concrete sill of the tidegate, the tidegate closes and Wood Creek backs up until the tide ebbs.

We measured salinity during a high tide event in January 2004; this was a period of high freshwater surface runoff to the estuary. Salinity was depressed throughout the site (Table 2.). Freshwater Slough had the lowest salinity and Wood Creek behind the tidegate had the highest. The salinity concentration measured was at the low end of a brackish estuary bordering on freshwater marsh (Zedler 2000). Further

measurements should be taken during low summer streamflows and high tide events to determine the higher range of salinity experienced at this site.

In summary, the Freshwater Slough site is influenced by tidal elevation fluctuations but typically has low salinities, indicative of the upper estuarine ecotone. Tidal fluctuations are currently restricted to Freshwater Slough, but would be restored to Wood Creek by removal of the tidegate, and with little or no impact associated with salinity upstream of the concrete weir.

4 DEVELOPMENT OF ALTERNATIVE CONCEPTUAL DESIGNS

The Freshwater Slough Estuary Rehabilitation Project (Phase 1) gathered baseline data on site conditions (described above), and developed four alternative conceptual designs, one of which would be implemented in Phase 2. Briefly, the four alternative designs are (see Appendix A for planform maps showing each alternative design):

Alternative 1:

- Remove the wooden tidegate from the concrete weir at the confluence of Wood Creek with Freshwater Slough;

Alternative 2:

- Remove the wooden tidegate from the concrete weir at the confluence of Wood Creek with Freshwater Slough;
- Re-establish channel gradient from Myrtle Avenue culvert outlet (conveying Wood Creek) downstream to the collapsed concrete rubble bridge;
- Remove berms confining Wood Creek along the downstream right bank;

Alternative 3:

- Remove the wooden tidegate from the concrete weir at the confluence of Wood Creek with Freshwater Slough;
- Re-establish channel gradient from Myrtle Avenue Wood Creek culvert outlet downstream to the collapsed concrete rubble bridge;
- Remove berms confining Wood Creek along the downstream right bank;
- Build a concrete weir and side-hinged tidegate structure at Myrtle Ave Wood Creek culvert outlet;
- Build control structure under Myrtle Ave causeway;

Alternative 4:

- Replace the existing wooden tidegate with a muted tide-cycle, fish-friendly tidegate using the existing concrete weir structure ;
- Remove berms confining Wood Creek along the downstream right bank;

The alternative designs used the hydraulic model to gauge the extent of tidal inundation within the proposed 35 acre marsh area and across the entire 80 acre pasture. Based on initial predictions from the model, removal of the tidegate with no further structural modifications would result in regular tidal inundation (55% exceedence) of approximately 5 acres in the western side of the pasture at Mean High Water, and frequent inundation (31% exceedence) of 9 acres at Mean Higher High Water. Less frequent tidal events such as the December 24, 2003 event would inundate approximately 45 acres.

The alternative designs were presented to stakeholders, agency personnel, Humboldt County maintenance personnel and First District Supervisor, and landowners of the subject property and adjacent property at a public meeting held February 3, 2004. Alternative 2 was selected as the recommended (preferred) alternative. This alternative provides the simplest means of meeting project goals of restoring tidal hydrology and fish access to the restored marsh, while avoiding the unnecessary expense of building new control structures. Other alternatives were less favorable for the following reasons: (1) Alternative 1 did not resolve flood conveyance problems resulting from the aggraded sections of Wood Creek; (2) Alt-3 involved retro-fitting the existing Myrtle Ave county road flood structures with additional structures that may be unnecessary; (3) Alt-4 imposed new structural control (muted tidegate) on tidal hydrology within the restored marsh that also appears unnecessary.

5 PROPOSED RESTORATION PROJECT TASKS

The proposed Freshwater Slough Estuary Rehabilitation Project (Alternative 2) will be implemented with the following tasks:

5.1 Task 1: Engineering Designs

A. Obtain additional hydrologic and hydraulic data. Prior to implementing the Estuary Rehabilitation Project, a 2-dimensional hydraulic model hydraulic model of the site will be developed. Preliminary streamflow and tidal data were collected during the Phase 1 of the Freshwater Slough project; additional data may be required for model development and calibration, including stream discharge and tide-stage data.

B. Build hydraulic model. A 2-dimensional hydraulic model will be prepared that will provide more refined estimates of inundation patterns within Wood Creek and connected slough channels, and across the tidal marsh area. The model will evaluate hydraulic conditions with the wooden flapgate removed, and the concrete weir structure and auxiliary Waterman tidegates left in place (as per design Alternative 2). However, the model can be modified to assess other design options.

C. Develop engineering designs and revegetation plans. This task will develop the design topography, estimate material volumes, and prepare a construction plan for the on-site excavation of the north-bank berm and dredging of Wood Creek. The excavated material would likely need to be removed from the site, but the feasibility of on-site spoiling will be evaluated. The grading plans will limit the construction footprint to the smallest area needed, to minimize compaction and other impacts to the marsh surface. Geotex fabric and crushed rock base may be temporarily installed to protect wet areas and improve access. A revegetation plan will be developed to rehabilitate the areas impacted by construction. This plan will include species, planting densities, and implementation specifications.

5.2 Task 2: Regulatory Compliance (CEQA/NEPA and Regulatory Permits)

The project site is within the designated Coastal Zone, and is not described in the California Salmonid Stream Habitat Restoration Manual. The project will therefore not qualify under the programmatic CEQA document prepared by CDFG. This project will therefore be required to develop the appropriate documentation for CEQA, ESA, and CESA compliance. The following subtasks will therefore fulfill these requirements:

A. Develop formal project description of all project elements, approved by landowner(s). This task will define the project in terms that will allow an impact analysis, and provide a detailed description for permit applications. Prior to submission of permits and regulatory compliance documents, landowner(s) will be required to sign landowner agreement forms in support of the project.

B. Prepare Biological Assessment, apply for ACOE 404 Permit with ESA Section 7 consultations. The project will involve designated wetlands and listed species, both of which will require a Section 404 permit from Army Corp of Engineers. The ACOE Permit will then require consultation with NOAA Fisheries and USFWS, and preparation of biological opinions by the consulting agencies.

C. Prepare and circulate draft and revised CEQA document. The project proponent will identify the lead agency (likely either Humboldt County or CDFG), prepare and circulate an Initial Study identifying impacts resulting from the project, then prepare mitigation and monitoring elements that address significant impacts. The CEQA process will likely lead to a Mitigated Negative Declaration.

D. Prepare and submit applications for regulatory permits. In addition to CEQA/NEPA requirements, the project will require numerous regulatory agency permits. Acquisition of appropriate local, state and federal permits, leases, or easements may involve the following agencies: Humboldt County Public Works, Natural Resources, Humboldt County Planning Department, Humboldt Bay Harbor, Recreation, and Conservation District, California Department of Fish and Game, California Coastal Commission,

Northcoast Regional Water Quality Control Board, Army Corps of Engineers, National Marine Fisheries Service, and United States Fish and Wildlife Service.

E. Develop final mitigation and monitoring plan to guide implementation. Mitigation and monitoring conditions may be imposed by regulatory agencies, and must be implemented as part of the permit agreement. At the completion of the permit acquisition process, these conditions will be summarized and made available to landowners, contractor(s), project managers and engineers, and other stakeholders.

5.3 Task 3: Project Implementation

The following tasks and descriptions are based on implementing Alternative 2 described above. If the conceptual design changes, the following tasks would need to be revised accordingly.

A. Prepare site for equipment access and construction. Construction equipment will be required to implement the project, including a large excavator, backhoe, dump trucks, and other small equipment. An equipment access road will be constructed, and access to the north side of Wood Creek may require a temporary bridge. In-channel excavation may also require a temporary flow diversion, fish removal, and appropriate erosion control measures.

B. Remove wooden flapgate from concrete weir structure. This task will remove the wooden flapgate, and will likely be performed at a low tide during summer. A backhoe may assist in moving the flapgate off-site. The flapgate could alternatively be floated down Freshwater Slough to a more accessible location for removal.

C. Excavate berm from north bank of Wood Creek. A 300 ft long berm along the north side of Wood Creek near the confluence with Freshwater Slough reduces the extent of tidal inundation onto the marsh surface to the north of Wood Creek. Approximately 100 yd^3 of material will be removed and hauled off-site. Excavation can likely be accomplished with a backhoe to minimize impacts.

D. Excavate Wood Creek drainage channel. To facilitate improved drainage from upper Wood Creek, approximately 1,500 ft of new slough channels will be excavated from the Wood Creek culvert and the County Road causeway, connected to the existing Wood Creek channel. Approximately 2,000 yd^3 of material will be removed and hauled off-site. Some excavation may be accomplished with backhoe to minimize impacts, but the task will likely require use of a larger excavator. Dump trucks will need to access the excavation area to haul material away. Truck traffic can use the footprint of the proposed new slough channel to minimize the disturbed area.

E. Revegetate excavated channel and disturbed area. The revegetation plan is intended to mitigate for impacts associated with heavy equipment disturbance. Disturbed areas may be ripped with heavy equipment to reduce compaction, then re-planted with grasses, sedges, and riparian hardwood species.

F. Site clean-up, as-built surveys. To complete the project, all temporary materials such as silt fences, road-base rock, geotex fabric, and other materials will be removed from the site. Erosion control measures required by permits will be installed, and surveys of the reconstructed channels will be conducted when excavation work is completed

5.4 Task 4: Monitoring

A. Compliance monitoring. Permitting agencies will require mitigation for short-term project impacts and/or monitoring of specific components of the project. This compliance monitoring is a required part of the project, but the conditions (tasks) are not known until the permits are issued.

B. Performance monitoring. This aspect of monitoring is important to evaluate the success of the project in meeting the project goals and objectives. We recommend three categories of performance monitoring, including (1) vegetation, (2) physical site conditions, and (3) fisheries habitat use.

> *Vegetation monitoring*. This monitoring will include evaluation of the survival success of re-planting, evaluation of invasive species colonization after construction and restoration of tidal exchange, mapping of vegetation cover type to track the transition from inundated agricultural

wetland (pasture) to tidal marsh, and vegetation plots to document species composition and abundance within the restored marsh area.

Physical monitoring. This monitoring will include establishing and surveying cross sections and a longitudinal profile of the reconstructed Wood Creek slough channels to document aggradational trends for maintenance purposes, and installation of permanent water level logger(s) to monitor the extent of inundation and effect of a muted tide prism.

Fisheries monitoring. This monitoring will be conducted at several different levels, and will include (at a minimum) seining and/or fyke net trapping to assess fish species composition and abundance, and fish passage conditions (i.e., water velocity, depth, etc.) through the concrete weir structure. A more detailed monitoring program will evaluate fish use of the restored tidal marsh, residence time and season of use, condition factor, growth rates (relative to other rearing areas such as the upper watershed), and survival to adult spawner (in proportion to other life-history strategies). This information will be valuable in prioritizing future restoration opportunities in the Freshwater ecotone and in Humboldt Bay.

6 PROJECT BUDGET

6.1 Budget

Task 1: Engineering Designs	**$41,400**
A. Obtain hydrologic and hydraulic data	$6,900
B. Build hydraulic model	$17,000
C. Develop engineering designs and revegetation plans	$17,500
Task 2: Regulatory Compliance (CEQA/NEPA and Regulatory Permits)	**$28,750**
A. Prepare environmental site description	$3,000
B. Prepare Biological Assessment	$4,000
C. Prepare draft and revised CEQA document	$4,000
D. Prepare and submit applications for regulatory permits (including fees)	$15,250
E. Develop final mitigation and monitoring plan	$2,500
Task 3: Project Implementation	**$58,400**
A. Engineering oversight of project implementation	$3,400
B. Prepare site for equipment access and construction (mobilization, access, stake-out)	$4,500
C. Remove wooden flapgate from concrete weir structure	$1,000
D. Excavate berm from north bank of Wood Creek, haul material off-site	$3,500
E. Excavate Wood Creek drainage channel, haul material off-site	$24,000
F. Remove defunct bridge structure from Wood Creek	$3,500
G. Revegetate excavated channel and disturbed area	$15,000
H. Site clean-up, as-built surveys	$3,500
Task 4: Monitoring	**$47,500**
A. Compliance monitoring	$7,500
B. Performance monitoring (vegetation, geomorphic, fisheries)	$40,000
TOTAL PROJECT COST	**$176,100**

6.2 Deliverables

The deliverables for this project will include (1) data and results of hydraulic modeling, (2) grading plans and construction engineering designs, revegetation design (3) copies of Biological Assessment, CEQA Initial Study, permit applications, responses from regulatory agencies and final approved permits, mitigation and monitoring plan, (4) as-built surveys, (5) photographic documentation of project implementation, (6) results of post-construction monitoring.

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