Dutch Slough Tidal Marsh Restoration Revised Conceptual Plan

Prepared for

California Department of Water Resources
Reclamation District 2137
California State Coastal Conservancy

Prepared by

ESA PWA (formerly Philip Williams & Associates, Ltd.)
October 18, 2010

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1. INTRODUCTION

The Dutch Slough Tidal Marsh Restoration conceptual design as described in the Conceptual Plan and Feasibility Report (“Feasibility Report”) (PWA 2006) and evaluated in the Environmental Impact Report (EIR) (DWR 2010a) left several elements of the plan broadly defined, deferring refinement for later in the planning and design process. The Management Team, with ESA PWA’s assistance, recently completed refinement of these remaining elements. This report documents the revised conceptual plan, focusing on the elements that have been refined since the Feasibility Report was released. ESA PWA will develop the preliminary and final restoration design based on the revised conceptual design documented in this report.

The Feasibility Report provides detailed documentation of project goals, site conditions, identification and selection of restoration alternatives, technical assessments, and the preferred alternative. The EIR provides documentation of potential project impacts and mitigation measures for all alternatives, consistent with CEQA requirements. The current report assumes that the reader is familiar with the information in the Feasibility Report and EIR and does not repeat this information here.

Figure 1 shows the revised conceptual plan. The conceptual plan has been refined in four areas:

- **Marsh Creek Realignment**. The revised plan provides for restoration of the Marsh Creek delta by realigning Marsh Creek onto the Emerson parcel. (See Figure 1 for parcel locations.) This plan element had previously been one of several under consideration.
- **Phasing of Burroughs**. The revised concept has been reconfigured so that implementation of restoration on the Burroughs parcel can be phased if necessary, and the project would provide relevant (though more limited) adaptive management results in the unlikely event that only Emerson and Gilbert go forward to implementation.
- **Sources of borrow and fill**. The plan includes refinements to reduce the required volume and associated cost of cut and fill. The plan assumes that 200,000 CY of imported fill will be available from the ISD parcel in 2011.
- **Land use for the more subsided “north parcel” areas**. The northern parts of the Emerson, Gilbert, and Burroughs parcels are too deeply subsided to be feasibly restored to tidal marsh. The revised plan provides for tidal open water habitat in north Emerson, managed Black Rail habitat enhancement and subsidence reversal in north Gilbert, and managed upland habitats with enhancements in north Burroughs.

The Management Team used successive rounds of screening to narrow down the full range of options considered in the Feasibility Report to the current version of the conceptual plan. The screening considered: updated site conditions, permitting conditions, fill availability, Delta ecosystem science, limited additional assessment of water quality and geotechnical conditions, and cost. Options screening is documented in PWA 2010a and b.

The project Management Team consists of staff from the California Department of Water Resources (DWR), California State Coastal Conservancy (Conservancy), and Reclamation District 2137 (RD 2137). DWR is the land owner, having purchased the site with funds from California Bay-Delta Authority and the Conservancy. DWR is leading development of the revised conceptual plan and final design with assistance from ESA PWA under contract to RD 2137. MBK Engineers is administering the design contract for RD 2137 and providing design services for the flood protection levee on Burroughs. A Technical Advisory Committee (TAC) provided input on the revised concept. Administration of the TAC is being provided by John Cain.

2. RESTORATION PLAN

The revised conceptual plan (Figure 1) will restore approximately 640 acres of tidal marsh and riparian floodplain habitat, 90 acres of subtidal open water habitat, 100 acres of managed nontidal marsh for Black Rail habitat enhancement and subsidence reversal, and 240 acres of enhanced irrigated pasture. Restoration for these habitat types is summarized below, with additional detail provided in Section 4. Section 4 also describes proposed riparian habitat enhancements along the levees and restored Marsh Creek delta, and potential dune restoration.

The plan requires onsite cut and fill of approximately 1.1 million cubic yards (CY) of material, plus placement of approximately 500,000CY of supplemental fill[1]. Approximately 200,000 CY or more of supplemental fill material will be imported from the ISD property in 2011. Additional fill material will be generated from a combination of imported material (if available) and onsite borrow from the northern, open water part of Emerson. Deep borrow on north Emerson is expected to produce habitat benefits by making the borrow areas too deep to support colonization by non-native submerged aquatic vegetation (SAV).

The location of the flood protection levee on Burroughs has been revised since the Feasibility Report. While the revised location reduces the amount of intertidal marsh area on south Burroughs, it provides additional area on north Burroughs for enhanced Swainson's Hawk foraging habitat and potential seasonal wetland mitigation. The revised alignment also results in significant cost savings through reduced fill placement for levee construction and wetland creation.

2.1 Tidal Marsh and Marsh Creek Delta

Marsh Creek will be re-routed to restore the creek delta on the Emerson parcel, providing seasonal freshwater flows to cue outmigrating salmon into the restored marsh. Creating one large, contiguous marsh habitat connected to Marsh Creek on Emerson is expected to provide significant ecological value. Analysis of available water quality data for Marsh Creek (nutrients and methyl mercury) (Stellar Environmental Solutions, Inc. 2007) and the Sacramento-San Joaquin Delta indicate that the Marsh Creek diversion onto the Emerson Parcel will not detrimentally affect project water quality in terms of nutrients and methyl mercury (see Section 7 for discussion of next steps for water quality monitoring and analysis). The tidal marsh restoration on Gilbert and Burroughs will provide valuable habitat in a way that is consistent with large-scale adaptive management experiments. Diversion of Marsh Creek confounds paired sampling of any adaptive management experiments placed on Emerson, and Emerson will therefore not be considered part of the adaptive management experimental design for the assessment of marsh size and marsh elevation effects.

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[1] Includes fill required for the new east levee, south levees and rehabilitation of the levees on Emerson and Gilbert recently recommended by RD 2137.

The layout of the small, medium, and large low marsh and mid marsh areas on Gilbert and Burroughs has been designed to allow adaptive management experiments to proceed in the event of phased implementation of Burroughs. Though there is strong support for restoring all three parcels at the same time, funding considerations may make it necessary to delay restoration of Burroughs or not restore it all. The marsh areas are configured so the small and medium low marsh and mid marsh areas are on Gilbert, with the large low marsh and mid marsh areas on Burroughs. This allows the experiment for the small- and medium-sized marsh pairs to precede independent of the marsh restoration timing for Burroughs. In the (unlikely) event that Burroughs is not restored, the adaptive management experiment on Gilbert would provide relevant results, but less so than if Burroughs is restored too.

2.2 Black Rail Habitat Enhancement and Subsidence Reversal

The northern part of Gilbert (north Gilbert) will be managed to enhance Black Rail habitat and provide subsidence reversal benefits. Nontidal emergent marsh along the northern edge of north Gilbert currently supports a small population of Black Rails. Brent Gilbert, the former owner's brother and current lessee of this parcel, has observed expansion of the emergent marsh areas over the last few years in response to slightly higher water levels (poor drainage from discontinuing maintenance of the drainage ditches) (P. Quickert, pers. comm.). This suggests that water level management will be effective in establishing additional emergent marsh on north Gilbert.

North Gilbert was considered by the Management Team and the TAC to be a good location for subsidence reversal because of the relatively small extent of land subsidence, especially compared to north Emerson. Most of north Gilbert is three to five feet below the lowest tide levels, meaning that, at current estimates of possible subsidence reversal rates (as high as 2 feet per decade, S. Deverel, pers. comm.), elevation-building to intertidal elevations could possibly be achieved within several decades.

North Gilbert will remain leveed, with managed water levels. A new levee (shown as a habitat levee in Figure 1) will be constructed to isolate north Gilbert from the tidally-inundated south Gilbert. Culverts (e.g., slide-gated, flap-gated) and a discharge pump will be required to manage water levels. Existing water control structures will be used as possible, supplemented with new structures as needed. Any existing water control structures that are no longer needed will be removed and, if possible, salvaged and reused onsite. Limited grading will be used to enhance habitat in portions of north Gilbert. Grading and disturbance in the existing wetlands and Black Rail habitat in north Gilbert will be avoided or limited as possible and required by permits. ESA PWA will refine the design criteria (inundation regime, location within the landscape) for Black Rail habitat and subsidence reversal wetlands during the preliminary design.

2.3 North Burroughs Habitat Enhancement

North Burroughs will be enhanced to provide improved foraging habitat for the State-listed Threatened Swainson's Hawk. Swainson's Hawks forage in low vegetation where they can see their prey organisms (e.g., mice, gophers, ground squirrels, rabbits, large invertebrates, etc.). These prey species flourish in higher vegetation, and are then exposed to predation during and after the habitat is grazed or mowed. To provide optimal foraging for Swainson's Hawks, the pasture and seasonal wetlands in north Burroughs would therefore be periodically mowed or grazed by cattle. Additional fencing and other features to facilitate cattle grazing and improved livestock distribution will be considered during detailed design. In addition to Swainson's Hawk, the irrigated pasture and seasonal wetlands habitat also provide foraging habitat for White-Tailed Kite, Burrowing Owl, Northern Harrier, and numerous passerines.

Riparian trees that have the potential to grow tall, such as Fremont cottonwood (*Populus fremontii*), will be planted along the north side of north Burroughs. Tall trees provide hunting perches and nesting habitat for Swainson's Hawk, White-Tailed Kite, and potentially other raptor species. Loss of tall trees as a result of project implementation was considered a significant impact in the Dutch Slough Restoration Project EIR. Planting new trees in areas consistent with the restoration is expected to fully mitigate the effect of removing raptor nesting habitat.

Restoration of seasonal wetlands on north Burroughs could occur if required as compensation for the loss of seasonal wetlands on other parts of the site. Requirements for compensation for the loss of these seasonal wetlands have not been determined.

2.4 Tidal Open Water

The levee of north Emerson will be breached to Emerson Slough to create subtidal open water. Open water is expected to be highly compatible with public access on Emerson, providing good visibility from the trail and opportunities for canoeing and fishing.

North Emerson is expected to be used as a borrow area, to supply needed fill for levee and intertidal marsh construction. In addition to providing a source of fill, borrow on north Emerson will provide habitat benefits by deepening areas sufficiently to reduce the potential for colonization by undesirable invasive submerged aquatic vegetation (SAV). Currently, north Emerson is at shallow subtidal grades conducive to colonization by invasive SAV once the tides are reintroduced. Because not all of north Emerson is likely to be needed or appropriate for borrow – for example areas near the levees will remain at grade to avoid affecting levee stability, some areas will remain at grade and are expected to support invasive SAV. Given the abundant propagule source for SAV at the adjacent Big Break (e.g., abundant Brazilian waterweed (*Egeria densa*) which readily propagates by fragmentation), and elsewhere in the Delta, the project proposes ongoing maintenance to reduce the extent of invasive SAV, if feasible. The project may conduct limited grading, such as creation of small islands, within the non-borrow areas to provide nesting and roosting habitat for waterfowl.

Several other land use options were considered for north Emerson, the most subsided part of the Dutch Slough site. Fisheries scientists on the TAC and the consultant team do not expect open water on north Emerson to provide benefits to native fish species, but they also do not expect this option to have detrimental effects to native fishes. However, no feasible alternatives for north Emerson were identified that would provide such benefits. Subsidence reversal was considered a possible land use for north Emerson, but was seen as having limited value given the high level of subsidence, and therefore long time frames for achieving elevations appropriate for future intertidal restoration. Open water was selected because it provides public access benefits, is compatible with deep borrow to provide fill for construction, and does not compromise benefits to native species.

3. HABITAT AREAS, HABITAT ELEVATIONS, AND SEA LEVEL RISE

ESA PWA estimated habitat areas and assessed tide levels, habitat elevations, and sea level rise to inform the revised restoration concept.

3.1 Habitat Areas

Table 1 lists estimated habitat acreages for the revised concept (Figure 1).

Table 1. Estimated Restored Habitat Acreages for the Revised Dutch Slough Restoration Concept.

Habitat Type	Emerson	Gilbert	Burroughs[1]	Total
Low marsh	119	61	83	263
Mid marsh[2]	127	60	80	268
High marsh[2]	22	14	4	40
Riparian[3]	20	9	6	35
Habitat levees	*15*	*6*	*4*	*25*
Upland transition	*5*	*3*	*2*	*10*
Native grassland[3]	2	1	1	4
North Emerson subtidal open water	107	-	-	107
North Gilbert managed marsh	-	108	-	108
North Burroughs habitat enhancement	-	-	230	230
Other[4]	29	52	43	124
Total[4]	426	305	447	1,178

Notes:

(1) Acreages for the Burroughs low marsh and north Burroughs habitat enhancement are based on the east (Burroughs) levee alignment shown in Figure 1. See Section 4.9.1 for a discussion of east levee alignment options and associated habitat acreages.

(2) The combined extent of mid and high marsh on Emerson is approximately as shown, though the relative extents of these habitat types has not been determined and may change from the values presented.

(3) Riparian and native grassland habitat lengths are discussed in Sections 4.4 and 4.3, respectively.

(4) Total acreages for each parcel are from DWR (Patty Quickert, pers. comm.). The "other" habitat category is the difference between the subtotal of habitat areas and the total parcel areas. This area includes non-habitat levees and may also result from using different boundaries for estimating habitat areas (e.g., slough areas, City Park boundary).

3.2 Tidal Datums and Inundation Frequency

Table 2 lists tidal datums for Dutch Slough from the Feasibility Report. Tidal datums are published by the National Oceanic and Atmospheric Administration (NOAA 2003) relative to the mean lower low water (MLLW). PWA (2006) converted tidal datums to the National Geodetic Vertical Datum of 1929 (NGVD) based on water level monitoring in lower Marsh Creek and tidal datum calculations by WWR (NHI 2002). See the Feasibility Report for further description. ESA PWA recommends further assessment of the vertical control used for monitoring of tide levels in Dutch Slough and possibly additional monitoring (for approximately two to four weeks) and elevation surveys if needed to confirm site elevations relative to tide levels.

Table 2 Dutch Slough Tidal Datums.

	Dutch Slough Tidal Datums	
	Feet MLLW	**Feet NGVD**
100-year Tide Level	6.8	6.5
Mean Higher High Water (MHHW)	3.44	3.15
Mean High Water (MHW)	2.99	2.70
Mean Sea Level (MSL)	1.77	1.48
Mean Tide Level (MTL)	1.76	1.47
Mean Low Water (MLW)	0.52	0.23
Mean Lower Low Water (MLLW)	0.00	-0.29

Sources: NOAA COOPS (2003), WWR (NHI, 2002), and FEMA (1987)

ESA PWA assessed tidal inundation frequency and duration for high tides to inform high marsh and riparian habitat elevations for the revised concept (see Section 3.3). Table 3 summarizes tidal inundation frequency and duration for elevations above MHHW based on USGS tide data collected in Dutch Slough from January 15, 1997 to February 28, 2003 available from the Interagency Ecological Program website (IEP 2005).

Table 3. Approximate Tidal Inundation Frequency and Duration at Dutch Slough.[1]

Elevation (ft NGVD)	Annual inundation frequency (# of times inundated/yr)[2]	Average duration of inundation[3]	Note
7	--	--	
6.5 [(4)]	Less than 0.2	2 hr	100-yr tide level
6 [(5)]	0.6	2 hr	
5.5	1	4 hr	
5	4	4 hr	Proposed high marsh/riparian boundary
4.5	14	3 hr	
4	51	3 hr	
3.5	145	3 hr	
3.2	229	3 hr	MHHW

Notes:

(1) Source: USGS water level record at Dutch Slough from Jan 15, 1997-Feb 28, 2003.
(2) Inundation frequency for the 5-year-long data set is annualized to a 12-month period.
(3) Average duration of inundation is calculated as the total period of inundation for the data set divided by the number of times inundated in the data set.
(4) One water level event exceeded 6.5 ft NGVD during the period of record.
(5) Three water level events exceeded 6.0 ft NGVD during the period of record.

3.3 Habitat Elevations

The habitat elevations used in the revised concept are summarized in Table 4. Note that 5 ft NGVD is used as the boundary between high marsh and riparian, though areas above 4.5 ft NGVD are also expected to support some riparian vegetation given that these areas are tidally inundated only infrequently. The habitat elevations and design for riparian and high marsh areas may be refined during preliminary design.

Table 4 Habitat Elevations.

Habitat	Elevation (ft NGVD)		Note
	Bottom	Top	
Riparian/upland	+5.0	NA	
High marsh	+2.0	+5.0	-1.2 to +1.8 ft MHHW
Mid marsh	+1.0	+2.0	-0.5 to +0.5 ft MTL
Low marsh	-0.8	+0.2	-0.5 to +0.5 ft MLLW
Subtidal open water	NA	-0.8	

NA = not applicable.

3.4 Sea Level Rise

The restoration approach is to lower high-elevation areas of the site to intertidal elevations and use the excavated fill to extend vegetated tidal wetlands into more subsided areas of the site. The restored tidal wetlands using this approach are expected to be relatively sustainable in response to sea level rise over the 50-year planning horizon, with mid marsh more resilient than low marsh (more below). Though the grading approach reduces the area available for wetland transgression with sea level rise ("sea level rise accommodation area"), the total extent of tidal wetlands at Year 50 is expected to be significantly greater than would occur without grading.

3.4.1 Sea-level Rise Scenarios

The State of California Natural Resources Agency (2008) recommends planning for a sea level rise of 1.3 ft (16 inches) in the 50 years between 2000 and 2050. For Dutch Slough planning, we use a sea level rise of 1.7 ft (21 inches) in 50 years, adjusted upward to correspond with the 50 years from 2015 (assumed time of breach) to 2065. ESA PWA calculated the Dutch Slough numbers using the U.S. Army Corps of Engineers' high sea-level rise curve (USACE 2009), adjusted slightly to match the State's recommended 2000-2050 sea-level rise scenarios, then projected forward to the 2015-2065 timeframe. Using the same adjusted USACE (2009) methods to interpolate the rate of sea-level rise, the 1.7 feet of rise corresponds with acceleration in sea level rise from approximately 7 mm/yr in Year 0 (2015) to 15 mm/yr by Year 50 (2065).

Although the Dutch Slough restoration uses a 50-year planning horizon, we provide a 100-year sea level rise scenario for reference. Projected sea-level rise accelerates rapidly between planning Year 50 and 100. The State's recommended sea-level rise scenario for planning purposes is 4.6 ft (55 inches) in 100 years (2000-2100). When adjusted using the method described above, this corresponds with 5.5 ft (66 inches) in the 100 years from 2015 to 2115 (rates increasing to approximately 27 mm/yr by Year 100).

3.4.2 Habitat Responses with Sea Level Rise

Limited observations of restored freshwater wetlands (low and mid marsh) in the Delta indicate accretion rates of 9 to 18 mm/yr sustained over several decades (Orr et al., 2003). Sea-level rise rates that are greater than marsh accretion rates will ultimately result in conversion of vegetated wetlands to open water ("ecological drowning" of wetland vegetation) once marsh elevations fall below elevations at which vegetation can persist. Based on the sea-level rise and marsh accretion rates used in this planning scenario, mid marsh and high marsh are expected to be sustainable over the 50 year planning horizon (though marsh elevations are expected to be somewhat lower relative to tide levels). Low marsh may begin to convert to open water towards the end of the planning horizon. The exact timing of this conversion is difficult to predict. It is unlikely that marsh accretion will keep pace with the higher rate of sea-level rise between Year 50 and Year 100 used in this planning scenario.

By Year 50 (2065), the lower elevation areas of the riparian vegetation that will be planted or establish spontaneously are expected to be regularly inundated by high tides as the result of sea level rise. Riparian vegetation that is tidally inundated during most or all of the growing season will not survive. By Year 50, the lower elevation parts of the riparian area are expected to be gradually replaced by marsh vegetation.

4. RESTORATION DESIGN FEATURES

4.1 Tidal Marsh

4.1.1 Grading

The site will be graded to the habitat elevations for low marsh, mid marsh, and high marsh (see Table 4). In Gilbert and Burroughs, fill will be placed to raise lower-elevation areas to low marsh and mid marsh elevations. Along the southern boundary of the Gilbert parcel, the site grade (approximately 5 ft NGVD) will be lowered to create mid marsh and generate fill material (see Figure 2a and Section 4.3 Upland Transition for more details). Along the southern boundary of the Burroughs parcel, the existing grade (approximately 2 ft NGVD) is appropriate for mid marsh habitat and only the northern part of the Burroughs mid marsh area will be filled (see Figure 2b and Section 4.3).

Marsh drainage divide berms will be constructed between the low marsh and mid marsh areas on Gilbert and Burroughs (Figure 1). The Feasibility Study specified marsh drainage divides with crests at approximately 3.2 ft NGVD (MHHW). Based on recent input from the TAC, the revised conceptual plan includes raising small portions of the marsh drainage divides to approximately 5 ft NGVD or higher to create small upland islands as high tide refugia for Black Rail and other species. The configuration of the small upland islands will be developed in the preliminary design.

On Emerson, the marshplain will be graded to have a gradual slope from upland and high marsh in the south to mid marsh and low marsh in the north. The marshplain will slope from approximately 5 ft NGVD to -0.8 ft NGVD. Tidal channel networks will be constructed in marsh areas on all three parcels.

Once the marshplain and channels are graded, tules are established (see section below), and new flood protection levees are constructed (see Section 4.9), the existing levees will be breached at the mouths of the tidal channel networks to restore tidal flows. Levee breaches and tidal channels will be sized to provide full tidal drainage.

4.1.2 Tule Establishment

After marsh grading and prior to breaching, tules establishment from seed and clonal growth will be encouraged by managing water levels in the marsh areas and select planting. Temporary water control structures and/or pumps will be installed and used to manage water levels as needed. Seeds of common tule (defined as hardstem bulrush, *Schoenoplectus acutus*, formerly *Scirpus acutus*) ripen in late August and September. Starting in early September, the water level in the marsh areas will be raised to and maintained at the surface of the soil, without standing water. From September through November the water level will be maintained at this level to allow seed germination and establishment of roots. Both common tule and California bulrush (*Schoenoplectus californicus*, formerly *Scirpus californicus*) may spontaneously establish from seed. California bulrush typically grows in deeper water than common tule.

Once tules are established, water levels can be fluctuated to control weeds and other less desirable wetland plants because tules are more flood tolerant than most weedy wetland plants. Water level fluctuations can be gradually increased in depth, as the tule plants get taller, up to a depth of 12 inches. Cattails (*Typha* species) are expected to disperse seed widely and establish in large numbers. However, cattails can be controlled by maintaining the water level at sufficient depth (e.g., 12 inches), because tules grow and survive at greater depth than cattails. Tules also tolerate periodic dewatering and the marshes should be drawn down periodically to kill aquatic weeds, such as Brazilian water weed (*Egeria densa*) and others (see Table 5). Once tules have established from seed they will expand by rhizomatous growth and eventually crowd out less desirable plant species.

Water level management is critical in establishing tule marsh. Wetland management is generally described as an adaptive process, not an easily predictable science, and will demand regular bi-weekly attention during the establishment period. A test plot may be helpful for informing the tule establishment approach. It is expected to take several years to establish tule marsh by natural seeding and clonal growth. On Gilbert and Burroughs, the marsh drainage divides will allow water levels to be managed independently in the low marsh and mid marsh areas. On Emerson, water levels could be managed to establish tules first in the low marsh areas, then water levels could be gradually increased to establish tules in the mid marsh and high marsh areas.

Tule plugs may be planted in select locations for two reasons: (1) to establish seed source plants that are strategically distributed throughout the graded marsh plain and (2) for wind-wave dissipation and levee erosion protection around the north Emerson tidal open water. In locations where tule coverage in marsh areas is not adequate to provide wind-wave dissipation and levee erosion protection after breaching, we recommend planting tule plugs along newly graded levee slopes. The plugs will be planted on 5-foot centers, in 2-3 rows. Clumps or plugs of tules will be planted at strategic locations to provide seed sources, if necessary. Given the large size of the tule marsh area, it may become apparent after one growing season that tules do not readily establish in areas that are too far from seed sources. If this is the case, tule clumps or plugs may be planted in these areas as seed source plants.

It is expected that once breaching occurs (e.g., after approximately two to three years of tule establishment), tule marsh will have established with significant coverage. In high marsh areas (above approximately 3.2 feet NGVD), high marsh vegetation will gradually establish after breaching. High marsh is characterized by species that grow in shallower water than common tule, including cattails, common reed (*Phragmites australis*), smartweed (*Polygonum* spp.), rushes (*Juncus* spp.) and sedges (*Carex* spp.). It is expected that these species will establish naturally by dispersal of seed and floating propagules.

Invasive plants that have little or no habitat value and have the ability to spread rapidly will be controlled. These species may include giant reed (*Arundo donax*), tamarisk (*Tamarix* spp.), pampas grass (*Cortaderia selloana*), perennial pepperweed (*Lepidium latifolium*), water primrose (*Ludwigia peploides*), swamp smartweed (*Polypogon amphibium*) and others (see Table 5). Rigorous weed control and monitoring is especially important during the early years following breaching because invasive species disperse quickly, and may compete with and establish sooner than desirable native plants.

Table 5. Major Nonnative Invasive Plants that Could Occur at the Dutch Slough Tidal Marsh Restoration Site and Require Implementation of Control Measures

Habitat	**Common Name**	**Scientific Name**
Aquatic	Brazilian waterweed	*Egeria densa*
Aquatic	Curlyleaf pondweed	*Potamogeton crispus*
Aquatic	Eurasian watermilfoil	*Myriophyllum spicatum*
Aquatic	Water hyacinth	*Eichhornia crassipes*
Tidal marsh	Perennial pepperweed	*Lepidium latipes*
Tidal marsh	Swamp smartweed	*Polygonum amphibium*
Tidal marsh	Water primrose	*Ludwigia peploides, L. hexapetala*
Riparian	Black locust	*Robinia pseudoacacia*
Riparian	Chinese tallow tree	*Triadica sebifera* (= *Sepium sebiferum*)
Riparian	Edible fig	*Ficus carica*
Riparian	Giant dodder	*Cuscuta japonica*
Riparian	Giant reed	*Arundo donax*
Riparian	Himalayan blackberry	*Rubus armeniacus* (= *R. discolor*)
Riparian	Pampas grass	*Cortaderia selloana*
Riparian	Red sesbania	*Sesbania punicea*
Riparian	Tamarisk	*Tamarix* spp.
Riparian	Tree-of-heaven	*Ailanthus altissima*
Riparian/seasonal wetland	Poison hemlock	*Conium maculatum*
Upland grassland	Bermuda grass	*Cynodon dactylon*
Upland grassland	Fennel	*Foeniculum vulgare*
Upland grassland	Yellow Star-thistle	*Centaurea solstitialis*
Upland disturbed (levee road)	Castor bean	*Ricinus communis*
Upland disturbed (levee road)	Russian thistle (tumbleweed)	*Salsola tragus*

4.2 Marsh Creek Riparian Floodplain

A new Marsh Creek distributary channel will be constructed through the Emerson marsh, with low riparian berms or “natural levees” along the channel banks. The existing Marsh Creek levee will be breached at the southwest corner of Emerson to divert Marsh Creek onto Emerson. The existing Marsh Creek channel will remain as is (see Section 4.4 Habitat Levees for a description of re-vegetation along the existing channel).

Figure 1 shows a conceptual sketch of the restored Marsh Creek delta configuration. A detailed layout of the Marsh Creek channel and riparian berms will be developed during preliminary design based on consideration of Marsh Creek hydrology and flooding, geomorphology, fish habitat benefits, and construction constraints. ESA PWA is currently coordinating with the CCCFCWCD to develop an approach to model and analyze how restoring the Marsh Creek delta will affect Marsh Creek flood levels and sediment dynamics. The layout of the Marsh Creek delta shown in Figure 1 may be modified during preliminary design. The purpose of the riparian berms is to benefit fish habitat as described below. Note that historic maps of the site (NHI and Delta Science Center at Big Break, 2002) do not show evidence of riparian berms along Marsh Creek through the historic marsh. Historic maps from similar, though larger, creek/marsh systems (e.g., lower Napa River) show that these systems supported riparian berms.

The goal of riparian berms is to establish riparian scrub and cottonwood-willow riparian forest along Marsh Creek (i.e., low riparian habitat, see Table 6). The riparian vegetation will benefit fish and other aquatic species and functions by shading the creek and lowering summer temperatures, providing organic inputs such as leaves and branches that may fall or hang into the creek, and providing insects and other invertebrates that fall from the vegetation into the creek.

The riparian berms will be constructed to approximately 5 ft NGVD or higher and planted with riparian vegetation. Riparian berm heights, widths and side slopes will be detailed during preliminary design. The riparian berms will be planted with herbaceous plants, shrubs, and trees of the low riparian zone, as shown in Table 6. Riparian plants (especially willows) are also expected to establish spontaneously. If invasive riparian species establish (see Table 5), they should be controlled.

During the first two to three years after planting, the riparian trees and shrubs will be irrigated during the dry part of the year to support the roots of young plants until they reach the groundwater level. A low water use system (e.g., drip emitters or flood bubblers) connected to a pump will be used.

Table 6. Plant Material for the Dutch Slough Tidal Marsh Restoration Project

Common Name	***Scientific Name***	***Life Form***	***Average Spacing***[1]	***Size***
Low and Mid Marsh				
California bulrush	*Schoenoplectus californicus*	Herbaceous	5 feet O. C.[2]	TreeBand
Common tule	*Schoenoplectus acutus*	Herbaceous	5 feet O. C. [2]	TreeBand
Low Riparian – Willow Scrub – Cottonwood-Willow Riparian Forest				
Fremont cottonwood	*Populus fremontii*	Large tree	20 feet O.C.	Treepot4
Black willow	*Salix gooddingii*	Large tree	20 feet O.C.	Treepot4
White alder	*Alnus rhombifolia*	Tree	20 feet O.C.	Treepot4
Buttonbush	*Cephalanthus occidentalis*	Shrub	8 feet O. C.	Treepot4
Arroyo willow	*Salix lasiolepis*	Large shrub	8 feet O. C.	Treepot4
Narrow-leaved willow	*Salix exigua*	Large shrub	8 feet O. C.	Treepot4
Slough sedge	Carex obnupta	Herbaceous	2 feet O.C.	TreeBand
Deergrass	*Muhlenbergia rigens*	Herbaceous	2 feet O.C.	TreeBand
Creeping wildrye	*Leymus triticoides*	Herbaceous	2 feet O.C.	TreeBand
Hairgrass	*Deschampsia caespitosa*	Herbaceous	2 feet O.C.	TreeBand
Meadow barley	*Hordeum branchyantherum*	Herbaceous	Seeded	TreeBand
Mid Riparian – Mixed Riparian Forest				
Black willow	*Salix gooddingii*	Tree	20 feet O.C.	Treepot4
Fremont cottonwood	*Populus fremontii*	Tree	20 feet O.C.	Treepot4
Black walnut	*Juglans californica* var. *hindsii*	Tree	20 feet O.C.	Treepot4
Valley oak	*Quercus lobata*	Large Tree	20 feet O.C.	Treepot4
Coast live oak	*Quercus agrifolia*	Large Tree	20 feet O.C.	Treepot4
Boxelder	*Acer negundo*	Tree	15 feet O.C.	Treepot4
Oregon ash	*Fraxinus latifolia*	Tree	15 feet O.C.	Treepot4
Wild rose	*Rosa californica*	Shrub	8 feet O. C.	DeePot
California grape	*Vitis californica*	Vine	8 feet O. C.	DeePot
Mugwort	*Artemisia douglasiana*	Herbaceous	Seeded	Seed
Creeping wildrye	*Leymus triticoides*	Herbaceous	2 feet O.C.	TreeBand
Southern Flood Control Levee - Upland Perennial Grassland				
California onion grass	*Melica californica*	Herbaceous	Seeded	Seed
Hairgrass	*Deschampsia caespitosa*	Herbaceous	Seeded	Seed
Creeping wildrye	*Leymus triticoides*	Herbaceous	Seeded	Seed
Blue wildrye	*Elymus glaucus*	Herbaceous	Seeded	Seed
Purple needlegrass	*Nasella pulchra*	Herbaceous	Seeded	Seed

Note:
[1]O.C. = on-center
[2]Low and mid marsh areas will only be planted (at 5 feet O.C.) on the Emerson habitat levee marsh wind-wave dissipation bench (see Section 4.4) and possibly other areas where plantings may be needed for levee erosion protection. Marsh vegetation (tules) will be established through water level management in other marsh as described in Section 4.1.2.

4.3 Upland Transition

Along the southern boundary of the site, an upland transition zone between the marsh and the south levee (see Section 4.9.2) will be graded and planted. Figures 2a and 2b show typical sections for grading the upland transition on Gilbert and Burroughs, respectively (see Figure 3 for section locations). The upland transition zone will consist of a riparian zone or bench, with a sloped transition down to high marsh and mid marsh. The width of the riparian bench will vary from approximately 10 to 60 ft, and the riparian/high marsh edge will undulate irregularly (as shown conceptually in Figure 1). The average elevation of the riparian bench will be approximately 5 ft NGVD, but may be designed to vary and slope, with higher elevations in wider upland transition areas. The high marsh slope will vary from approximately 10:1 to 20:1[2] from 5 ft NGVD to the mid marshplain (average elevation of 1.5 ft NGVD), with a 20- to 40 ft-wide high marsh transition zone above MHHW. The water-side slope of the south levee will be seeded with native grasses as described below.

On Gilbert (Figure 2a), the existing grade (approximately 5 ft NGVD) is suitable for the riparian bench and the high marsh transitional slope will be excavated down to the mid marshplain. On Burroughs (Figure 2b), the existing grade is lower (approximately 2 to 3 ft NGVD) and fill will be placed to construct the upland transition.

The height of the riparian bench is limited to 5 ft NGVD in the revised concept to limit the amount of fill required; however, at this low elevation, the time over which the riparian habitat will be sustainable with sea-level rise will be limited. With 2.1 ft of sea level rise by 2065, riparian at 5 ft NGVD would be inundated by MHHW (5.3 ft NGVD with 2.1 ft of sea level rise) (Figures 2a and 2b). The riparian may therefore not persist and may be converted to marsh. Future phases of the design will consider raising certain upland transition areas to high elevations (e.g., Gilbert) and eliminating upland transition in lower areas (e.g., Burroughs) to balance cost and benefits over time. Note that the existing riparian vegetation along the irrigation ditch berms between the Burroughs mid marsh and low marsh areas is at about 5 ft NGVD. The existing riparian may therefore persist for some period after tidal restoration, and the additional benefit of upland transition along south Burroughs may therefore be less important.

Riparian scrub and cottonwood-willow riparian forest will be planted on the riparian bench. Narrower and lower elevation portions of the bench will be planted with riparian scrub (Table 6). Wider and higher elevation portions will be planted with cottonwood willow riparian forest (Table 6). The minimum distance between the nearest trees and the toe of the south levee will be selected with input from RD 2137. Planted species will be chosen from Table 6 and the species composition tolerance will be adjusted to soil conditions. The high marsh zone is expected to establish by natural recruitment with cattails, common reed, smartweed and other species after tidal restoration (Figure 2). The installed plants will be irrigated as needed during the dry part of the year using a low water use system (e.g., drip emitters; flood bubblers) connected to a pump.

[2] All slopes in this report are given as the ratio of horizontal to vertical distance.

The water-side slope of the south levee will be seeded with native perennial grassland species using specially designed equipment for levees (i.e., a “ridger-roller-seeder”), which can be successfully used to plant “fluffy” seed of native grasses on a 3:1 slope. (This slope is too steep for operation of native grass drills, e.g., Truax range drill.) Prior to seeding, levee and berm slopes require soil tillage (disk or tine harrow; ring roller) to create a favorable seedbed and to remove competing weeds. Grasses adapted to higher soil moisture will be planted on the lower part of the slope and plants adapted to drier environments on the upper part (see Table 6). It is not anticipated that irrigation of the levee slope is required, if seeding occurs in the fall (September – October).

For the Burroughs east flood control levee, a similar upland transition zone should be considered in the levee design, with adjustments appropriate for flood protection levee maintenance and the lower site grades (e.g., offset between the levee toe and tree plantings or eliminating the riparian bench).

4.4 Habitat levees

Portions of the existing perimeter levees will be re-graded and/or planted with riparian vegetation to restore riparian “habitat levees” (Figure 3). In addition to providing riparian habitat for terrestrial species, habitat levee riparian vegetation will provide shading and organic input to both the restored marsh (woody vegetation interface along marsh, on the marsh-side of levees) and open water channels (woody vegetation interface along open water, on the open water side of levees). The locations and extent of planting may be less than described below if needed to reduce project implementation costs. Refinements to the planting plan will be evaluated during final design.

Riparian vegetation will be planted on levee slopes adjacent to restored tidal marsh and open water channels providing habitat for target native fish (Little Dutch Slough and Dutch Slough, as possible). Since Emerson Slough is not expected to provide significant habitat for target native fish, planting along Emerson Slough will occur only along the public access trail, where the riparian vegetation will shade the trail and be a public access amenity.

In addition, a new levee (cross-levee) will be constructed between south Gilbert and the north Gilbert managed marsh to allow for water level management in north Gilbert. A new berm will be constructed between south Emerson and the north Emerson tidal open water as a drainage divide to limit the hydraulic connection, channel formation, and fish access between these two areas. The new levee and berm may also be planted with riparian vegetation and/or native grassland.

The flood protection function of the existing perimeter levees will be replaced by the new east and south levees (see Section 4.9). As shown in Figure 3, the habitat levees will have the following functions after restoration:

- The Emerson levee will serve as a public access trail and a maintenance vehicle access road. The north Emerson levee will also dissipate wind-waves within the north Emerson subtidal open water area to prevent erosion of the levee/trail and the adjacent Jersey Island Rd. levee. Riparian vegetation will be planted on both sides of the levee.

- The Gilbert levee will serve as a managed marsh levee around north Gilbert and a maintenance vehicle access road, except for the levee section between the restored marsh and Little Dutch Slough, which will be breached and will provide habitat only (see bullet below). The inboard side (marsh side) of the west Gilbert levee (between Emerson Slough and the restored marsh) will be planted. The outboard side (slough side) of the north Gilbert levee will be planted along Dutch Slough and Little Dutch Slough.
- The Little Dutch Slough habitat levees (portions of the Gilbert and Burroughs levee between Little Dutch Slough and the restored marsh) will be planted on the inboard and outboard slopes, and the crown if possible. The Little Dutch Slough habitat levee design will depend on Little Dutch Slough dredging (see Section 4.5) and the sequencing of construction and levee breaching.
- The northern portion of the Burroughs levee will remain as is.

The habitat levees will be graded as needed to allow riparian planting. In a related project, RD 2137 is planning to grade/improve the existing Gilbert and Emerson levees (excluding the Marsh Creek levee) for both short- and long-term maintenance and for the Emerson public access trail. The habitat levee design will be coordinated with RD 2137's levee improvement design, and the grading approach for habitat levees will be developed during preliminary design. A possible conceptual grading approach for the north Emerson levee is discussed below.

Figure 4 shows a typical section of RD 2137's proposed levee improvement for the north Emerson levee (see Figure 3 for section location). Figure 4 also shows a possible grading concept proposed for the purposes of creating habitat levees. On the outboard (slough) side of the levee, the lower levee slope would be approximately 1.5:1, with rip-rap armor up to approximately 5 ft NGVD to protect the steeper slope from wind-wave and boat-wake erosion. The upper slope on both sides of the levee would be flatter (approximately 3:1 or flatter) to allow riparian planting, with riparian widths of approximately 14 ft. On the inboard (subtidal open water) side of the levee, a wind-wave dissipation bench would be graded to extend over the range of tide and wave runup elevations (from approximately -0.5 ft NGVD to 5 ft NGVD) at a shallow slope (e.g., 7:1), with a steeper slope (e.g., 2:1) below low tide levels down to existing grade. The bench dimensions will be refined during preliminary design based on a wind-wave generation and dissipation analysis. The wind-wave dissipation bench will be planted with tule plugs as described in Section 4.1.2. The levee slope from approximately 4.5 ft NGVD (including the upper part of the wave dissipation bench) to approximately 8 feet NGVD will be planted with low riparian zone plants (Table 6). Above 8 feet, the levees will be planted with mid riparian species.

Trees will be planted along both side slopes of the Emerson levee/trail to provide shade for public access along the trail. Upland riparian trees will include black walnut, Valley oak, coast live oak, boxelder, and Oregon ash. The trees will be installed in patches where space is available. Along the marsh edge, riparian scrub species (shrubs) will be planted closest to the marsh. Farther up the lower slope, cottonwood, alder, and willow species will be planted. On the mid to upper slopes and along the top of levees, mixed riparian forest species will be installed (Table 6). Along the waterside of the levees, the emphasis will be on planting trees to maximize shade and aquatic cover (e.g., branches hanging in and over the water), with some understory shrubs and grasses.

For the Gilbert and Emerson habitat levees, riparian plant species for habitat levee planting will be selected from Table 6 according to the soil substrate conditions of the levee. The existing Gilbert and Emerson levee soils vary widely in texture and water-holding capacity in the upper 5 ft, from sandy loam to clay, and peat (Hultgren-Tillis Engineers 2009). There is overlap in species between the lower and mid riparian zones because of the variable range of soil and drought tolerance of the plant species. Because the levees have existing (weedy) vegetation, weed control should be implemented at least one year before planting. Weeds should be killed prior to seed set in spring, and again in summer and fall, to deplete the seed bank. Weeds can be controlled using herbicide (e.g., Rodeo), mechanical disking or mowing. Preference would be given to disking or mowing, but if levee slopes are too steep (e.g., > 3:1), or if existing planted vegetation is in the way, herbicide application may be necessary. The riparian plantings will be irrigated during the dry part of the year with a drip irrigation system connected to a pump. A trail or road should be maintained along the levee crown to allow vehicular maintenance access to the plantings and irrigation system.

The Little Dutch Slough habitat levees may be graded and lowered to approximately 5 ft NGVD. In this case, riparian scrub would be established along the marsh edge. The remainder of the levee slope within the riparian zone, including the levee top, will be planted with cottonwood-willow riparian forest species. Plantings on lowered levees are not likely to require irrigation; however, a foot path should be maintained along the top of the lowered levees to facilitate maintenance access.

Table 7 summarizes lengths, widths, and acreages for riparian habitat levees, as well as the Marsh Creek riparian berms (see Section 4.2) and upland transition riparian bench (see Section 4.3).

Table 7. Riparian Habitat Levee and Upland Transition Zone Lengths and Areas.

	Riparian Habitat Length		Width	Area
	Feet	Miles	Feet	Acres
Emerson	**27,270**	**5.2**		**19.8**
Perimeter levee/trail	12,550	2.4	30	8.6
New north/south Emerson levee	4,510	0.9	34	3.5
Marsh Creek riparian berms	4,590	0.9	30	3.2
Upland transition/south levee	5,620	1.1	35	4.5
Gilbert	**15,440**	**2.9**		**9.4**
Perimeter levee	4,810	0.9	15	1.7
Little Dutch Slough levee	4,190	0.8	30	2.9
New north/south Gilbert levee	2,630	0.5	30	1.8
Upland transition/south levee	3,810	0.7	35	3.1
Burroughs	**9,080**	**1.7**		**6.6**
Little Dutch Slough levee	3,300	0.6	30	2.3
Existing canal levee to remain[1]	2,750	0.5	30	1.9
Upland transition/south levee	3,030	0.6	35	2.4
Total	**51,790**	**9.8**		**35.9**

Note: If needed to reduce project implementation costs, the locations and extents of planting may be less than shown in this table. Refinements to the planting plan will be evaluated during final design.

4.5 Little Dutch Slough Dredging

The narrow southern reach of Little Dutch Slough is undersized to convey restored tidal flows and will therefore be dredged to reduce the potential for poor low tide drainage in the restored marsh areas (PWA 2003). ESA PWA estimated equilibrium channel dimensions and modeled tidal drainage with deepening of Little Dutch Slough for the Feasibility Report. The revised concept includes two options for dredging Little Dutch Slough described below.

Figure 5a shows the option of deepening Little Dutch Slough by about 3 ft by dredging or excavating the channel bottom between the existing levees. Hydraulic modeling showed that slough deepening improved low tide drainage, but the deepened channel would still be undersized compared to equilibrium channel dimensions. The velocity of tidal flows in the deepened channel are therefore expected to be high compared to tidal flows in natural or equilibrium channels, which may affect fish habitat. The existing compacted levees are not expected to erode over time (to equilibrium channel dimensions) in response to tidal flows.

Figure 5b shows the option of enlarging Little Dutch Slough to equilibrium channel dimensions by dredging the channel and removing portions of the Little Dutch Slough levees. The levee would be removed on one side of the channel. A meandering channel could be constructed by removing levee sections on the outside of the channel meander bends (i.e., alternating levee removal on both sides of the channel). As shown in Figure 5b, marsh drainage divide berms could be constructed (up to MHHW) between the channel and the adjacent low or mid marsh to encourage tidal flows through the restored channel networks (rather than having tidal flows to Little Dutch Slough over the low and mid marshplain, which would likely scour new, unintended channels that could complicate adaptive management experiments).

Dredging the wider northern reach of Little Dutch Slough may improve tidal drainage somewhat, but the channel may scour over time and may not need to be dredged. Future phases of the design may consider including dredging northern Little Dutch Slough as an additive bid item.

The preferred option for dredging Little Dutch Slough will be selected in future design phases based on cost considerations and input from the Management Team. Additional hydrodynamic modeling is recommended in future design phases to check that the design provides adequate low tide drainage, as poor low tide drainage could affect tule survival in low marsh areas.

4.6 Dunes

The restoration plan identifies two areas for possible dune restoration corresponding with locations of sandy soils. USFWS staff, of the Antioch Dunes National Wildlife Refuge, is interested in creating more of this type of habitat in the region and have raised the possibility of providing ongoing maintenance for restored dunes at Dutch Slough. The Dutch Slough restoration project may include dune restoration, provided that USFWS approves the action, assists with the design, and agrees to perform ongoing maintenance. Otherwise, the areas identified for dune restoration will be restored to marsh. The Management Team is coordinating with USFWS on potential dune restoration.

4.7 North Burroughs Enhancements

4.7.1 Irrigated Pasture

As described in Section 2.3, the management of irrigated pasture and seasonal wetlands on north Burroughs will be optimized for Swainson’s Hawk’s foraging and will remain subject to cattle grazing or be mowed as hay crops. In the event of continued cattle grazing, existing fences should remain intact and be maintained. The new leveed areas should be fenced. Access to drinking water and the corral should remain and be maintained. Additional pasture fencing, salt licks, and livestock water sources should be considered in the detailed management plan. These amenities, as well as sequenced rotation grazing, will improve livestock distribution to ensure a uniform rather than selective grazed condition.

In addition to Swainson’s Hawk, the irrigated pasture and seasonal wetland habitat also provide foraging habitat for the White-Tailed Kite, a California Species of Special Concern and Fully Protected species, that forages on the Dutch Slough site, and for Burrowing Owl, a California Species of Special Concern, that has not been reported from the site, but that has been found in surrounding areas. Other California Species of Special Concern that would benefit from this habitat are Northern Harrier, Tricolored Blackbirds, Loggerhead Shrikes, and Horned Lark.

Conditions suitable for ground squirrels should be maintained on the site because ground squirrels are prey animals for the above mentioned raptors, and because their burrows provide habitat for Burrowing Owls, reptiles, and other species.

4.7.2 Tall Riparian Trees

Swainson's Hawks have been observed nesting on the south part of the Burroughs parcel and using the tall riparian trees along the north side of the Burroughs parcel. Swainson's Hawk and White-Tailed Kite are known to nest in tall trees. Swainson's Hawks and other raptors also prefer tall trees overlooking foraging habitat as hunting perches. A number of tall trees within the parcel interior that provide potential nesting habitat for these species will be removed to implement the project. This impact was considered significant in the Dutch Slough Restoration Project EIR prior to mitigation actions which, when implemented, will reduce it to less than significant levels.

As described in Section 2.3, riparian trees that have the potential to grow tall (e.g., 30 – 60 feet), in particular Fremont cottonwood (*Populus fremontii*), are proposed for planting along the north side of north Burroughs. Tall trees will provide nesting habitat for Swainson's Hawk, White-Tailed Kite and potentially other raptor species, and would reduce the effect of removal of raptor nesting habitat.

The riparian trees will be irrigated during the dry part of the year (approximately April – October) with a low water use system (e.g., drip emitters or flood bubblers) during the first three years after planting. The drip system will be provided with surface water using an electric (if near remaining power lines) or diesel operated pump.

4.7.3 Seasonal Wetland

North Burroughs may provide opportunities for restoration of seasonal wetland. The restoration project would potentially convert 2.2 acres of alkali meadow and 17.2 of seasonal wetlands and ponds to open water and tidal marsh. If necessary, compensation for the loss of these seasonal wetlands could potentially be accomplished by seasonal wetland restoration on north Burroughs. Whether this restoration would be required will be discussed with the U.S. Army Corps of Engineers (USACE Regulatory Branch), U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Game (DFG). The project creates many more acres of wetlands than will be impacted. Many of the affected seasonal wetlands and ponds provide poor quality habitat, because of high organic matter content (eutrophic and a turbid water) and a predominance of non-native species. The seasonal ponds (and puddles) were sampled for listed branchiopods (fairy shrimp) in the winter of 2009/2010 and none were found. The biologists who sampled the seasonal ponds considered the likelihood that listed branchiopods would occur in these aquatic habitats low, although two seasons of sampling are required by the USFWS to demonstrate that listed branchiopods are absent. The second season of sampling will occur in winter 2010/2011.

North Burroughs supports areas with hydric soil (Shima Muck) that currently do not support wetlands. The hydrology and management of these areas could be altered to create seasonal wetlands, if desired.

Seasonal wetlands could be created by grading shallow depressional areas and placing soils salvaged from seasonal wetland areas on Emerson and Burroughs (DWR 2010b). Constructed seasonal wetlands and ponds would require exclusion fencing to allow optimization of grazing intensity. A moderate amount of grazing would be most beneficial to these areas, with the exception of the plant establishment period, when absence of grazing will be best.

4.8 Water Control Structures

Water control structures such as gated culverts and pumps will be required for the north Gilbert managed marsh, north Burroughs, and to drain storm water from the City Park site. The MT will coordinate with the City on the drainage plan for the park site. Temporary water control structures will also be required for tule establishment on the restored marshplain (see Section 4.1.2). Existing water control structures and pumps will be used as possible. The preliminary design will identify pumps and other water control structures to retain, remove, and/or relocate.

4.9 Flood Protection Levees

4.9.1 East Levee (Burroughs)

The new east levee will be constructed along Jersey Island Road and through Burroughs, and will connect to the existing Burroughs levee along Little Dutch Slough (Figure 1). The RD 2137 engineers will design the east levee.

The design level of flood protection and crest elevation for the east levee has not been determined. The new levee must, at a minimum, provide for the same level of flood protection as currently exists. DWR is looking into whether a higher design level of flood protection is required and/or desirable given the potential for future residential development to the east.

4.9.2 South Levee

The south levee will be designed and constructed to protect the CCWD right of way, the City Park site, and areas south of the site from flooding. The Management Team has agreed to protect the CCWD right of way from the 100-year flood level (after the CCWD canal is encased in a pipeline and the canal embankments are removed). The Management Team will coordinate with the City to determine the level of flood protection required for the City Park site. The south levee will maintain or improve the existing level of flood protection for areas south of the site. The existing development south of Emerson is protected by a FEMA-certified levee located south of the CCWD canal, and it is expected that future urban development immediately south of the Dutch Slough project site will construct similar levees.

As shown in Figure 1, the south levee will follow the southern site boundary and the northern City Park boundary. At the end of Emerson Slough and Sellers Road, the existing grade of the road was recently raised and is expected to provide the required level of flood protection (N. Hershey, MBK, pers. comm.). The south levee will therefore tie into the end of Sellers Road. At Little Dutch Slough, the south levee will tie into the ends of the CCWD canal embankment on either side of Little Dutch Slough. Levees will be extended to the south along Little Dutch Slough to tie into existing high ground. A second option is for the south levee to cross Little Dutch Slough, with a flap-gated culvert to maintain Little Dutch Slough drainage.

Figures 2a and 2b show conceptual cross-sections for the south levee for Gilbert and Burroughs, respectively. The levee crest elevation assumed for the revised concept is 9 ft NGVD, which will be refined in future phases of the design. The low point of the existing perimeter levees is about 9 ft NGVD. At this elevation, the south levee would provide “in-kind” flood protection to maintain the existing level of protection. This elevation would also provide 2 ft of freeboard above the 100-year water level, which is 7.0 ft NGVD per RD 2137 (K. Tillis, Hultgren Tillis Engineers, pers. comm.) and FEMA (1987) base flood elevation.

The south levee will be constructed so that the levee can be raised in the future to accommodate sea level rise. The levee will be constructed with a wider base and crown to allow the levee to be raised by placing fill material on the levee crown. For example, as shown in Figures 2a and 2b, the levee would be constructed with a top width of 22 ft at 9 ft NGVD so that the levee could be raised to 10 ft NGVD and maintain a 16-ft top width. A levee elevation of approximately 10 ft NGVD allows 0.9 ft of freeboard above a future 100 year water level of 9.1 ft NGVD (i.e., present 100-year water level of 7 ft NGVD, plus 2.1 ft of sea level rise). Note that 3:1 levee side slopes are assumed for the revised concept.

The south levee will be offset from the property line to provide an access and maintenance road behind the levee. The area behind the south levee also allows the south levee to be raised higher to accommodate higher levels of sea level rise in the future as shown in Figures 2a and 2b.

4.10 Other Infrastructure Protection

Marsh Creek Flood Control Channel. The CCFCWCD currently owns and maintains the Marsh Creek levees for flood protection. With the restoration of Emerson, the west Emerson levee will no longer be needed for flood protection. DWR plans to buy the west levee from CCFCWCD so that the levee can be used as a public access trail and habitat levee. As mentioned in Section 4.2, ESA PWA is coordinating with CCFCWCD to develop an approach for analyzing the effect of the Marsh Creek delta restoration on Marsh Creek flood level and sediment dynamics.

ISD pipeline relocation. As described in the 2006 Feasibility Report, the ISD pipeline along the west and north side of Emerson will be relocated from the inboard toe of the levee into the levee crown. The Management Team is currently coordinating with ISD on an agreement for the pipeline relocation.

CCWD Canal. As described in the EIR, the levees surrounding the restored marshes will not be breached until the CCWD canal is encased in a pipe to avoid potential groundwater seepage impacts. In the preliminary design, the project will need to confirm that tule establishment can proceed prior to encasement, as this is likely to raise groundwater levels. The Management Team will coordinate with CCWD regarding the timing of tule establishment.

Power and gas facilities. A plan for moving or decommissioning PG&E's gas distribution lines and power distribution lines, equipment, and transformers as needed for the restoration will be developed during preliminary design with assistance from the Management Team and RD 2137 engineers. Further coordination with PG&E is recommended to develop the plan and estimate costs. There are also several closed gas wells owned by Venoco that need to be sealed prior to fill placement or grading.

4.11 Public Access

The Emerson levee will be maintained as a public access trail. Three bridges will be installed: one at the southwest corner of Emerson where Marsh Creek enters the site, one along the northern boundary of Emerson where Marsh Creek exits the site, and one over the breach connecting the open water area with Emerson Slough (Figure 1). The bridges will be designed for maintenance vehicle access, as well as public access.

4.12 Priorities for Using Additional Fill (the "Dessert Menu")

ESA PWA worked with the Management Team to identify a prioritized list of fill uses – aka the "dessert menu" – that specifies, in order of priority, where the project would use any additional fill (above 460,000 CY) if it were to become available during design and/or construction. The Management Team priorities, selected with input from the TAC, are to: (1) reduce deep borrow on Emerson, (2) increase the extent of marsh on Burroughs, (3) increase the extent of marsh on Gilbert, (4) create additional high marsh, and (5) create islands within the marsh and/or open water areas. Incrementally increasing the extent of marsh on Burroughs is expected to be more cost effective than on Gilbert, so ranks as a higher priority. The timing of fill availability relative to the construction schedule will affect which priorities are pursued. For example, once construction of the cross levee on Gilbert is completed, expansion of marsh on Gilbert would no longer be considered.

5. CONSTRUCTION VOLUMES, COSTS, AND PHASING

Planning-level construction cost and quantity estimates for the revised conceptual design are presented by parcel in Tables 8 and 9. The cost estimate is intended to provide an approximation of total project costs based on the conceptual level of design and has an approximate accuracy of –30% to +50%.

Based on design refinements, we have provided preliminary quantity and cost estimates for several design features previously not included in the 2006 Feasibility Report, which are:

- Obtaining and transporting imported fill material to the site.
- North Gilbert Black Rail enhancement and subsidence reversal managed marsh. (The Feasibility Report estimate excluded costs for open water management options on all parcels.)
- Marsh creek riparian floodplain features (e.g., Marsh Creek levee breach, riparian berms).
- New flood control levee along the south boundary of the site (south levee).
- Revegetation refinements, including costs for 3-year riparian and upland plant establishment maintenance and temporary irrigation.
- Improvements to the existing levees on Emerson and Gilbert for levee stability as recommended in the Hultgren-Tillis Engineers report to RD 2137 (HTE 2009). In some cases, the levee configuration proposed by Hultgren-Tillis Engineers was modified to be compatible with the revised restoration concept (e.g. Emerson levee along Dutch Slough, per Figure 4).
- Improvements to the Emerson perimeter levee for public safety, including removing armoring debris and/or grading to flatten levee side slopes. At this stage, we have included a $4,000,000 allowance to cover potential improvements. (The *total* cost will be estimated in a future phase; the *project* cost will depend on the cost-sharing agreement between DWR and the City of Oakley.)

The design refinement that provided the largest cost savings is the revised levee alignment on the Burroughs parcel. This not only significantly reduced the cost of the new east levee, but also reduced the volume of marshplain fill needed.

Table 10 compares the revised construction cost estimate with the previous estimate presented in the Feasibility Report. As shown in this table, overall project costs have increased by almost $10 million, roughly 35%, mostly due to addition of items listed above. A more detailed explanation of cost changes is provided in Table 10.

Table 8. Conceptual Construction Cost Estimate

	Description	Units	Unit Cost	Emerson Parcel	Gilbert Parcel	Burroughs Parcel	Total
1	**Site Preparation**						**$3,175,000**
A.	Mobilization (5%)	lump sum	$ 1	$677,821	$271,690	$281,928	$1,231,000
B.	Vegetation Clearing	acres	$ 800	$232,000	$116,000	$136,000	$484,000
C.	Demolition	each	$ 20,000	$40,000	$140,000	$380,000	$560,000
D.	Construction Survey	lump sum	$ 300,000	$300,000	$300,000	$300,000	$900,000
2	**Utilities Relocation**						**$528,000**
A.	Ironhouse Pipeline Relocation	linear feet	$ 95	$456,000	$0	$0	$456,000
B.	Marsh Creek Levee Road Resurfacing	sf	$ 24	$72,000	$0	$0	$72,000
3	**Public Access Improvements - Emerson**						**$4,480,000**
A.	Footbridge	square feet	$ 100	$480,000	$0	$0	$480,000
B.	Perimeter Levee - Outboard Armor Removal/Grading (allowance)	lump sum	$ 4,000,000	$4,000,000	$0	$0	$4,000,000
4	**Marsh Creation - Excavation & Transport**						**$5,792,000**
A.	Upland Excavation (Onsite Borrow)	cubic yards	$3.00	$2,716,716	$318,904	$527,189	$3,563,000
B.	Main Channel Excavation	cubic yards	$4.00	$52,800	$32,000	$48,000	$133,000
C.	Tributary Channel Excavation	cubic yards	$4.00	$96,000	$60,000	$88,000	$244,000
D.	Open Water Excavation (Deep Borrow)	cubic yards	$5.00	$1,451,838	$0	$0	$1,452,000
E.	Breaches	each	$ 50,000	$100,000	$200,000	$100,000	$400,000
5	**Marshplain Creation - Fill Placement**						**$3,005,000**
A.	Fill Placement (Onsite Borrow)	cubic yards	$2.00	$857,445	$404,955	$238,270	$1,501,000
B.	Fill Placement (Deep Borrow)	cubic yards	$2.00	$464,588	$0	$0	$465,000
C.	Fill Placement (Imported)	cubic yards	$2.00	$0	$360,000	$0	$360,000
D.	Marsh Drainage Divides	cubic yards	$2.00	$0	$42,230	$0	$42,000
E.	North Emerson Cross-Berm/Wave Break	cubic yards	$4.00	$331,629	$0	$0	$332,000
F.	Perimeter Levee Stability Berm/Wave Break (Emerson)	cubic yards	$4.00	$239,547	$0	$0	$240,000
G.	Marsh Creek Riparian Berms	cubic yards	$2.00	$65,025	$0	$0	$65,000
6	**North Gilbert Managed Marsh**						**$927,000**
A.	North Gilbert Cross-Levee	cubic yards	$4.00	$0	$175,685	$0	$176,000
B.	Perimeter Levee Improvements	cubic yards	$4.00	$0	$146,094	$0	$146,000
C.	Water Control Structures	each	75,000	$0	$150,000	$0	$150,000
D.	Pump Station (allowance)	lump sum	100,000	$0	$100,000	$0	$100,000
E.	Power Line Relocation (allowance)	lump sum	200,000	$0	$200,000	$0	$200,000
F.	Access Road - Aggregate Base Surfacing	ton	$ 25	$0	$155,000	$0	$155,000
7	**Habitat Levee Grading**						**$284,000**
A.	Levee Slope Fill	cubic yards	2.00	$31,540	$24,678	$15,413	$72,000
B.	Levee Lowering	linear feet	25.00	$0	$129,750	$82,000	$212,000
8	**Revegetation & Irrigation**						**$2,023,000**
A.	Site Preparation (Weed Control & Soil Prep)	acre	$ 6,600	$157,603	$71,385	$76,928	$306,000
B.	Riparian Habitat (Habitat Levees) - Container Plants	each	$ 10	$429,089	$177,931	$184,835	$792,000
C.	Riparian Habitat (Upland Transition Zone) - Container Plants	each	$ 10	$177,931	$85,716	$68,168	$332,000
D.	Riparian Habitat (N Burroughs) - Container Plants	each	$ 12	$0	$0	$2,248	$2,000
E.	Riparian Habitat (Habitat Levees) - Seeding & Mulching	acre	$ 2,000	$30,649	$12,709	$13,202	$57,000
F.	Riparian Habitat (Upland Transition Zone) - Seeding & Mulching	acre	$ 2,000	$12,709	$6,123	$4,869	$24,000
G.	Native Grassland - Seeding & Mulching	acre	$ 2,000	$4,400	$2,800	$1,800	$9,000
H.	Dune Revegetation	acre	$ 10,000	$100,000	$0	$0	$100,000
I.	Temporary Drip Irrigation System	acre	$ 10,000	$216,793	$94,160	$90,358	$401,000
9	**Tule Pre-establishment**						**$995,000**
A.	Marsh Revegetation	acres	$ 750	$201,352	$101,533	$124,500	$427,000
B.	Water Control Structures	each	$ 40,000	$120,000	$200,000	$80,000	$400,000
C.	Water Level Management	years	$ 24,000	$48,000	$72,000	$48,000	$168,000
10	**Little Dutch Slough Dredging (Deepening Option)**	cubic yards	$ 37	$0	$0	$118,400	**$118,000**
11	**New East Levee - Burroughs**						**$2,039,000**
A.	Foundation Excavation & Compaction	cubic yards	$ 4	$0	$0	$102,552	$103,000
B.	Levee Fill Placement	cubic yards	$ 4	$0	$0	$259,200	$259,000
C.	Outboard Wave Dissipation Bench	cubic yards	$ 2	$0	$0	$53,575	$54,000
D.	Groundwater Cut-Off Wall (allowance)	lump sum	$ 1,500,000	$0	$0	$1,500,000	$1,500,000
E.	Aggregate Base Surfacing	ton	$ 25	$0	$0	$122,500	$123,000
12	**New South Levees**						**$251,000**
A.	Foundation Excavation & Compaction	cubic yards	$ 4	$24,978	$16,933	$13,467	$55,000
B.	Levee Fill Placement	cubic yards	$ 4	$45,793	$41,204	$109,080	$196,000
13	**ISD Borrow Location**						**$1,496,000**
A.	Clearing	acres	$ 800	$0	$16,000	$0	$16,000
B.	Purchase, Excavation & Transportation	cubic yards	$ 7	$0	$1,400,000	$0	$1,400,000
C.	Seeding & Mulching	acres	$ 4,000	$0	$80,000	$0	$80,000
14	**Other Imported Fill**						
A.	Levee Improvement Fill - unidentified source	cubic yards	$ 15	$0	$0	$750,000	**$750,000**
15	**Plant Establishment Maintenance**						**$3,245,000**
A.	Plant Maintenance Events	lump sum	$ 78	$780,000	$585,000	$546,000	$1,911,000
B.	Weeding Events	lump sum	$ 9	$180,000	$135,000	$108,000	$423,000
C.	Irrigation Events	lump sum	$ 78	$390,000	$273,000	$234,000	$897,000
D.	Plant Establishment Documentation	lump sum	$ 1	$5,000	$4,500	$4,000	$14,000
	Sub-total			**$15,589,000**	**$6,703,000**	**$6,812,000**	**$29,108,000**
	Construction Contingencies (25%)			$3,897,000	$1,676,000	$1,703,000	$7,276,000
	Planning and Design (10%)			$1,559,000	$670,000	$681,000	$2,910,000
	TOTAL			**$21,045,000**	**$9,049,000**	**$9,196,000**	**$39,294,000**

Table 9. Conceptual Construction Quantity Estimate

	Description	Units	Emerson Parcel	Gilbert Parcel	Burroughs Parcel	Total
1	**Site Preparation**					
A.	Mobilization (5%)	lump sum	1	1	1	
B.	Vegetation Clearing	acres	290	145	170	**605**
C.	Demolition	each	2	7	19	**28**
D.	Construction Survey	lump sum	1	1	1	
2	**Utilities Relocation**					
A.	Ironhouse Pipeline Relocation	linear feet	4,800			**4,800**
B.	Marsh Creek Levee Road Resurfacing	sf	3,000			**3,000**
3	**Public Access Improvements - Emerson**					
A.	Footbridge	square feet	4,800	0	0	**4,800**
B.	Perimeter Levee - Outboard Armor Removal/Grading	lump sum	1	0	0	**1**
4	**Marsh Creation - Excavation & Transport**					
A.	Upland Excavation (Onsite Borrow)	cubic yards	905,572	106,301	175,730	**1,187,603**
B.	Main Channel Excavation	cubic yards	13,200	8,000	12,000	**33,200**
C.	Tributary Channel Excavation	cubic yards	24,000	15,000	22,000	**61,000**
D.	Open Water Excavation (Deep Borrow)	cubic yards	290,368	0	0	**290,368**
E.	Breaches	each	2	4	2	**8**
5	**Marshplain Creation - Fill Placement**					
A.	Fill Placement (Onsite Borrow)	cubic yards	428,723	202,477	119,135	**750,335**
B.	Fill Placement (Deep Borrow)	cubic yards	232,294	0	0	**232,294**
C.	Fill Placement (Imported)	cubic yards	0	180,000	0	**180,000**
D.	Marsh Drainage Divides	cubic yards	0	21,115	0	**21,115**
E.	North Emerson Cross-Berm/Wave Break	cubic yards	82,907	0	0	**82,907**
F.	Perimeter Levee Stability Berm/Wave Break (Emerson)	cubic yards	59,887	0	0	**59,887**
G.	Marsh Creek Riparian Berms	cubic yards	32,513	0	0	**32,513**
6	**North Gilbert Managed Marsh**					
A.	North Gilbert Cross-Levee	cubic yards	0	43,921	0	**43,921**
B.	Perimeter Levee Improvements	cubic yards	0	36,523	0	**36,523**
C.	Water Control Structures	each	0	2	0	**2**
D.	Pump Station (allowance)	lump sum	0	1	0	
E.	Power Line Relocation (allowance)	lump sum	0	1	0	
F.	Access Road - Aggregate Base Surfacing	ton	0	6,200	0	**6,200**
7	**Habitat Levee Grading**					
A.	Levee Slope Fill	cubic yards	15,770	12,339	7,706	**35,815**
B.	Levee Lowering	linear feet	0	5,190	3,280	**8,470**
8	**Revegetation & Irrigation**					
A.	Site Preparation (Weed Control & Soil Prep)	acre	24	11	12	**46**
B.	Riparian Habitat (Levees) - Container Plants	each	42,909	17,793	18,483	**79,185**
C.	Riparian Habitat (Upland) - Container Plants	each	17,793	8,572	6,817	**33,182**
D.	Riparian Habitat (N Burroughs) - Container Plants	each	0	0	187	**187**
E.	Riparian Habitat (Levees) - Seeding & Mulching	acre	15	6	7	**28**
F.	Riparian Habitat (Upland) - Seeding & Mulching	acres	6	3	2	**12**
G.	Native Grassland - Seeding & Mulching	acres	2	1	1	**5**
H.	Dune Revegetation	acre	10	0	0	**10**
I.	Temporary Drip Irrigation System	acre	22	9	9	**40**
9	**Tule Pre-establishment**					
A.	Marsh Revegetation	acres	268	135	166	**570**
B.	Water Control Structures	each	3	5	2	**10**
C.	Water Level Management	years	2	3	2	**7**
10	**Little Dutch Slough Dredging (Deepening Option)**	cubic yards			3,200	**3,200**
11	**New East Levee - Burroughs**					
A.	Foundation Excavation & Compaction	cubic yards	0	0	25,638	**25,638**
B.	Levee Fill Placement	cubic yards	0	0	64,800	**64,800**
C.	Outboard Wave Dissipation Bench	cubic yards	0	0	26,787	**26,787**
D.	Groundwater Cut-Off Wall (allowance)	lump sum	0	0	1	
E.	Aggregate Base Surfacing	ton	0	0	4,900	**4,900**
12	**New South Levees**					
A.	Foundation Excavation & Compaction	cubic yards	6,244	4,233	3,367	**13,844**
B.	Levee Fill Placement	cubic yards	11,448	10,301	27,270	**49,019**
13	**ISD Borrow Location**					
A.	Clearing	acres		20		**20**
B.	Purchase, Excavation & Transportation	cubic yards		200,000		**200,000**
C.	Seeding & Mulching	acres		20		**20**
14	**Other Imported Fill**					
A.	Levee Improvement Fill - unidentified source	cubic yards	0	0	50,000	**50,000**
15	**Plant Establishment Maintenance**					
A.	Plant Maintenance Events	lump sum	10,000	7,500	7,000	
B.	Weeding Events	lump sum	20,000	15,000	12,000	
C.	Irrigation Events	lump sum	5,000	3,500	3,000	
D.	Plant Establishment Documentation	lump sum	5,000	4,500	4,000	

Table 10. Comparison of Cost Estimates for the Revised Concept and the 2006 Feasibility Report

	Description	Revised Conceptual Design 10/12/10	Original Conceptual Design 5/12/06	Difference	Summary
1.	Site Preparation	$3,175,000	$2,326,000	$849,000	Increased mobilization due to increased total cost and to account for multiple construction phases.
2.	Utilities Relocation	$528,000	$312,000	$216,000	No change.
3	Public Access Improvements - Emerson	$4,480,000	$160,000	$4,320,000	Added $4,000,000 allowance for improvements to Emerson perimeter levee (e.g. armoring removal & grading), plus two additional footbridges on Emerson.
4&5	Marsh Grading	$7,345,000	$7,361,000	($16,000)	Total volumes reduced by ~300,000 (reduced marsh fill on Burroughs, but added Dutch Slough levee improvements on Emerson). Unit prices increased for escalation.
6	North Gilbert Managed Marsh	$927,000	$0	$927,000	New design feature not included in the original conceptual design.
7	Habitat Levee Grading	$284,000	$148,500	$135,500	Refined previous costs.
8	Revegetation & Irrigation	$2,023,000	$1,183,000	$840,000	Doubled riparian habitat area (20 to 40ac, includes habitat levees). Added $400,000 for temporary drip irrigation system.
9	Tule Pre-establishment	$995,000	$1,512,000	($517,000)	Refined costs; reduced water level management costs.
10	Little Dutch Slough Dredging (deepening option)	$118,000	$118,000	$0	No change.
11	New East Levee - Burroughs	$2,039,000	$4,065,500	($2,026,500)	Reduced levee volume by approx 70% and replaced armoring with wave dissipation bench.
12	New South Levees	$251,000	$0	$251,000	New design feature not included in the original conceptual design.
13&14	Fill Material (Deep Borrow and Import)	$3,698,000	$3,786,000	($88,000)	Approximately 100,000 cy less total volume. Refined design assumptions.
15	Plant Establishment Maintenance	$3,245,000	$0	$3,245,000	New item not included in the 2006 Feasiblity Report conceptual design estimate.
	Sub-total	**$29,108,000**	**$20,972,000**	**$8,136,000**	
	Construction Contingencies	$7,276,000	$6,291,600	$984,400	Reduced contingency from 30% to 25% to reflect refinements.
	Design and Permitting (10%)	$2,910,000	$2,097,200	$812,800	Increased design costs assumed to be proportional to increased construction costs.
	SUBTOTAL	**$39,294,000**	**$29,360,800**	**$9,933,200**	

5.1 Earthwork Volumes

Earthwork volumes have been updated to reflect design refinements, and will be further refined following collection of geotechnical and additional topographic data, and further design development. Estimated earthwork volumes for each parcel are summarized in Table 11.

Table 11. Summary Earthwork Quantities.

Description	Emerson Parcel	Gilbert Parcel	Burroughs Parcel	Total
Excavation				
Onsite Marsh Excavation	943,000	129,000	210,000	1,282,000
Losses (10%)	(94,000)	(13,000)	(21,000)	(128,000)
Available Fill Material	**849,000**	**116,000**	**189,000**	**1,154,000**
Fill Placement				
Levee Fill Material *	154,000	91,000	119,000	364,000
Other Fill Material	709,000	416,000	127,000	1,252,000
Total Fill Needed	**863,000**	**507,000**	**246,000**	**1,616,000**
Net Fill Needed	**14,000**	**391,000**	**57,000**	**462,000**

*** Levee fill material includes:**

(1) new South and East levees,

(2) new Gilbert cross-levee,

(3) new Emerson open water berm and

(4) improvements to existing Dutch Slough levees on Emerson and Gilbert. A portion of the material (e.g. stability berms) may not require levee-quality material.

Approximately 460,000 of additional fill material is needed to create marsh areas and construct new levees on the three parcels (530,000 cubic yards including losses). While the exact source and volumes of additional fill material is still uncertain, we have made certain assumptions for cost estimating purposes, in consultation with the Management Team. We have assumed that 200,000 cubic yards of borrow can be obtained from the ISD property, and another 50,000 cubic yards of suitable levee material would be imported from a currently unidentified offsite source. For budgeting purposes, we have assumed that the remainder of fill material (approximately 290,000 cubic yards) will be obtained by excavating the deep open water area on the north end of the Emerson parcel.

Additional fill sources are summarized in Table 12. These assumptions will be refined upon further coordination with ISD and collection of geotechnical data.

Table 12. Assumed Sources of Additional Fill Material.

Fill Material Source	Excavated Volume (cy)	Losses	Net Volume (cy)
ISD Borrow	200,000	10%	180,000
Imported Fill - unidentified source	Not Applicable	0	50,000
Emerson - Deep Borrow	290,000	20%	233,000
Total			**463,000**

5.2 Assumptions and Uncertainties

These planning-level cost and quantity estimates will be refined further in future design phases following collection of geotechnical and additional topographic data, and further design development. Key assumptions and uncertainties for the current estimates are summarized below.

Geotechnical Investigations. No formal assessment of the suitability of on-site soils for use as engineered levee fill has been made to date. For the purpose of the cost estimate, we have included an allowance for importing an additional 50,000 cubic yards of fill material suitable for levee construction. It is assumed that the remainder of fill material for levee construction, as well as marshplain fill, can be obtained through a combination of on-site and near-site (i.e. ISD site) borrow. A comprehensive geotechnical investigation will be undertaken in the next few months to evaluate whether on-site and near-site soils are suitable for levee construction.

Topography. At this stage, available aerial photogrammetry was used to estimate existing site elevations for earthwork calculations. MBK (N. Hershey, pers. comm.) compared topographic surface models from the photogrammetry and the more recent LIDAR topography data, which showed that in the southern half of the site, on average, the LIDAR was generally same elevation or higher than the aerial photogrammetry. In the next design phase, ground survey data will be collected to field verify the accuracy of available topographic data. Any substantial differences from the topography used here could significantly change construction costs.

Earthwork Costs. The majority of implementation costs for the project are for earthwork activities, such as mass grading to create marsh areas and drainage divides, excavating new channels, and constructing the new east flood control levee. As a result, total project costs are sensitive to assumed earthwork volumes and unit prices for earthmoving costs. It is difficult at this stage to accurately estimate earthwork prices; however, the cost estimate includes reasonable assumptions based on the assumed construction approach and costs for similar projects.

Earthmoving Losses. Preliminary earthwork volumes were generally calculated assuming 10% losses between cut and fill volumes. As an exception, 20% volume losses were assumed for deep borrow of peat soils from the northern areas of the Emerson parcel.

Settlement. Subsequent geotechnical recommendations will be used to refine design assumptions currently used to account for expected settlement and consolidation during and after fill placement. At this stage, we have made the following general assumptions regarding settlement:

- Emerson low marsh – 0.5 foot (average over entire area)
- Emerson drainage divide (open water area) – 1 foot
- Gilbert cross-levee (at managed wetland) – 1.5 feet
- Burroughs East levee – 1.2 feet
- South levees – 0 feet
- Emerson low marsh – 0.5 foot (average over entire area)

Imported Fill. As stated above, we have assumed that most of the additional fill material can be obtained from the ISD property the deep open water area on the north end of the Emerson parcel. We assumed that another 50,000 cubic yards of suitable levee material will be imported from a currently unidentified offsite source. The cost of purchasing and importing material from the ISD parcel was estimated by MBK Engineers (based on estimate that to trucking material on public roads would be more cost effective than installing a temporary bridge spanning Marsh Creek).

Revegetation Costs. Planting costs can vary substantially and estimated costs and assumptions are preliminary and subject to refinement with additional site investigation, information, and design refinement. If needed to reduce cost in future phases of the design, the area to be planted with riparian trees and scrubs could be reduced. Also, the riparian planting plan could be modified to include only areas that are saturated close to the soil surface. This approach would substantially reduce the riparian habitat area, and could also eliminate the need for irrigation.

Exclusions. It should be noted that the following items are not included in the estimated costs:

- Installation of public access trail on the Emerson perimeter levee. (Note that the full cost of other public access related features are included in the cost estimate: levee improvements, three footbridges, riparian planting along the part of the trail adjacent to Emerson Slough, and surfacing of the Marsh Creek levee – for ISD maintenance access.)
- Removal and/or relocation of PG&E power and gas distribution infrastructure.
- Any enhancements to the north end of Burroughs, including any seasonal wetland mitigation. (Note that riparian tree planting per Section 4.7.2 is included.)
- Any grading within the north Gilbert managed marsh, if required.
- Dredging the wider downstream reach of Little Dutch Slough or removing portions of the existing levee in the upstream reach (as shown on Figure 5b and described in Section 4.5).

5.3 Phasing and sequencing

The project will be constructed and implemented over several years. Because of the large size of the site and timing of project funding (and possibly project approvals), the three parcels will likely be on different schedules. The recommended construction phasing will be based on several considerations:

Implementation sequence requirements. The basic sequencing of marsh restoration is mass grading, followed by tule establishment and site breaching, taking place over 2 to 3 years. In addition, all levee construction and/or improvements, as well as slough dredging, must occur before breaching. New levees located in subsided areas on soft soils may need to be constructed in phases over two or more years.

Implementation funding. Given the scale of the project, it is expected that project funding will be secured and allocated over several years. Project phasing will need to take into account the expected timing and amount of project funding.

Restoration priorities. We understand that the highest project priority, as established by the Management Team and supported by the TAC, is to provide some large-scale marsh habitat as soon as possible. A secondary priority is to restore tidal inundation to south Gilbert at the same time as at south Burroughs, to facilitate comparison for the adaptive management experiments.

Earthwork Balance. The project requires earthmoving from two or more parcels, which will affect construction phasing. Based on current assumptions, the Emerson Parcel will generate approximately 300,000 cubic yards of surplus material available for export to either Gilbert or Burroughs. (Gilbert and Burroughs parcels require approximately 400,000 cubic yards and 50,000 cubic yards of supplemental material, respectively). Therefore, implementation on Gilbert, and possibly also Burroughs, is linked to some degree with earthmoving on Emerson.

Imported fill availability. A large amount of imported fill (approximately 200,000 cubic yards) is expected to be available for purchase from Ironhouse Sanitary District (ISD) as early as 2011. Any marsh restoration on the adjacent ISD site, which is currently not scheduled, could make additional borrow material available at a low cost.

Related projects. As a condition of the EIR, none of the three site parcels can be breached until the adjacent CCWD canal encasement project is completed. Timing for the canal encasement project is not currently known. Completion of the perimeter trail and levee improvements on the Emerson project is contingent on the City of Oakley's schedule (currently undefined) for public access improvements.

Habitat mitigation requirements. Habitat mitigation requirements, to be finalized during the permitting process, may affect construction sequencing. For example, certain habitat types, such as seasonal wetlands or Swainson's Hawk, may need to be created at a new location prior to impacting existing habitat.

Institutional approvals. There are a number of approvals remaining to be obtained before the project can proceed. The Marsh Creek levee right-of-way, which is the west boundary of the Emerson parcel, needs to be obtained from CCCFCWD. Also, ISD needs to approve relocation of its sanitary sewer into the Marsh Creek levee on the Emerson parcel. In addition, the flood protection design criteria (e.g., urban or agricultural) of the new levees on the east and south site boundaries need to be finalized.

We generally propose that major site grading, which prepares the site for tule cultivation and water level management, be performed on one parcel each year, over three years. Based on this schedule, it would take at least five years for project implementation. The project schedule could easily be prolonged by a year or more due to lack of funding, affordable imported fill or project approvals. In addition, none of the parcels can be breached until the CCWD canal encasement is complete.

The recommended construction phasing depends on several currently unknown factors, including: geotechnical results for soil suitability; project funding and the timing of several factors, including resolution of design criteria for the new east (Burroughs) levee, improvements to the Emerson perimeter levee, and acquisition of the CCCFCWCD right-of-way on Emerson. We will evaluate the various construction phasing scenarios in more detail upon completion of the geotechnical investigation.

For discussion purposes, we have presented one potential phasing scenario in Table 13. This schedule is considered a realistic timeline for the project, leaning toward optimistic. Under this scenario, we have assumed in the first year roughly half of mass grading on Gilbert parcel is performed using onsite borrow and import from the ISD parcel. Grading on Gilbert would be completed in Year 2, using supplemental fill obtained from the Emerson parcel. Optimistically, mass grading of the Burroughs parcel could also be completed in Year 2 using onsite material. The remainder of mass grading on Emerson, and completion of new levees, would be performed over the next two years (Years 3 and 4). If only two years are needed for tule cultivation, the Gilbert and Burroughs parcels could be breached concurrently in Year 4, and Emerson would follow in Year 6.

It should also be noted that we have assumed that year 1 of construction is 2011. This would require obtaining permits, completing final design, and completing public bid within 7 to 9 months of finalizing the conceptual design. It is not clear at this time whether this aggressive schedule is achievable. If not, project construction would begin in 2012, and the schedule in Table 13 would be delayed one year.

Table 13. Example Construction Phasing Scenario

Parcel	2011	2012	2013	2014	2015	2016
Gilbert						
Marsh Excavation	Marsh Ph 1					
Marsh Fill Placement	Marsh Ph 1	Marsh Ph 2	Tule cultivation*/riparian planting	Breaching		
Levees	CrossLevee Ph 1	CrossLevee Ph 2	South Levee			
Managed Wetland		Improvements	Ongoing management/subsidence reversal -->			
Emerson						
Marsh Excavation		Marsh Ph 1 (Gilbert)	Marsh Ph 2			
Marsh Fill Placement			Marsh Ph 2	Marsh Ph3	Tule cultivation*/riparian planting	Breaching
Levees			Berm Ph 1	Berm Ph 2/South Levee		
Open Water Area				Deep borrow		
Infrastructure			ISD sewer		New bridges	Perimeter levee improvements
Burroughs						
Marsh Excavation		Marsh				
Marsh Fill Placement		Marsh	Tule cultivation*/riparian planting	Breaching		
Levees		East levee Ph 1	East levee Ph 2	South levee		
Pasture/Wetlands			Revegetation			
Imported Fill						
ISD Borrow	to Gilbert					
Import Fill			to Burroughs	to Burroughs		

* Tule cultivation may take 2 to 3 years; assumed 2 years for the purposes of this diagram.

6. OPERATIONS AND MAINTENANCE

The restored tidal marsh and riparian areas are designed to be largely self-maintaining, after the initial period of vegetation establishment. The north parcel areas and levees will require a somewhat higher level of operations and maintenance (O&M). Planning-level annual costs (in 2010 dollars) for the following O&M activities are summarized in Table 14.

Tidal marsh. O&M of tidal marsh areas includes:

- Remove or control the spread of invasive plants within the upper marsh;
- Remove any obstructions from the tidal channels (e.g., debris), if needed;
- Maintain marsh drainage divides between marsh cells;
- Manage for vector control (expected to be minor).

Riparian vegetation. O&M of installed riparian vegetation includes:

- Remove irrigation lines after completion of the establishment period.
- Remove weeds around installed plants;
- Remove invasive plants, using herbicides (e.g., Rodeo) or mechanical means;
- Replace dead plants during the establishment period, if deemed necessary;
- Re-grade eroded levees, if desired.

North Emerson Open Water. O&M of this area includes:

- Maintain the levee between north and south Emerson, e.g., repair any channels that cut through the levee.

North Gilbert Black Rail and subsidence reversal. O&M of this area includes:

- Manage water levels to maintain existing California Black Rail habitat and promote additional tule growth (initial period and ongoing)
- Maintain pumps and other water control structures;
- Control weeds (expected to be minor);
- Maintain the levee between north and south Gilbert, e.g. repair any channels that cut through the levee;
- Manage for vector control.

North Burroughs. O&M of north Burroughs includes:

- Remove or control the spread of invasive plants, using herbicides registered for use near water (e.g., Rodeo) or by mechanical means (mowing, disking);
- Maintain berms, drainages, and water control structures for seasonal wetlands, if needed. (Not included in the O&M cost estimate at this time.)

Flood protection levees. Maintenance includes:

- Maintain the south levee (all parcels) and the east and north levee on Burroughs to flood protection standards
- Levee inspections, grading, vegetation and rodent control, debris removal, drainage structures, seepage control, underwater surveys, slope protection, resurfacing, and fill placement due to settlement/subsidence, as needed.

Former perimeter levee(s). Maintenance includes:

- Maintain former north perimeter levees on Emerson and Gilbert to reduce wind fetch and wave erosion along Dutch Slough
- Maintain the perimeter levee on Emerson and west levee on Gilbert for maintenance access
- Levee inspections, grading, vegetation and rodent control, debris removal, drainage structures, seepage control, underwater surveys, slope protection, resurfacing (e.g., base rock) and possibly fill placement due to settlement/subsidence, as needed.

Performance Monitoring.

- Conduct performance monitoring for permit compliance and other objectives, including establishing baseline conditions and monitoring project performance
- Assume physical and biological monitoring at 0, 1, 3, 5, and 10 years after construction.

Table 14. Planning-Level Annual Operations and Maintenance Costs.

	Description	**Estimated Annual Cost**
1	Tidal Marsh (minimal) and Riparian Habitat (all parcels)	50,000
2	North Emerson Open Water Cross Levee	25,000
3	North Gilbert Wetland	110,000
4	North Gilbert Wetland Cross Levee	50,000
5	North Burroughs Vegetation	20,000
6	South Flood Protection Levees (all parcels)	50,000
7	East Flood Protection Levee (Burroughs)	50,000
8	Former Perimeter Levees (Gilbert and Emerson)	75,000
9	Performance Monitoring (first 10 years only)	200,000
	Total	**630,000**

Additional O&M activities assumed at this stage to be performed and funded by others (subject to verification) are listed below.

Vegetation Establishment Costs: The following maintenance activities expected during the first few years of implementation, are included in the construction costs shown in Table 8.

- Operate water control structures to adjust water level as needed (prior to breaching);

- Maintain watering basins, and operating and maintaining irrigation lines, emitters and pumps during the establishment phase;
- Replace dead plants during the establishment period, if deemed necessary;
- Control beaver damage of plants during the establishment phase.

Public Access. The costs of maintaining public access facilities, such as trails on the habitat levees and the footbridge over the Emerson parcel breach, are not included. It is assumed that the City of Oakley will be responsible for these maintenance costs. It is assumed that the cost of maintaining the Marsh Creek levee road for access to the Ironhouse Sanitary District's pipeline will be part of the cost for maintaining the public access trail.

Adaptive Management. It is assumed that the cost of monitoring large-scale adaptive management experiments and implementing and conducting small-scale experiments will be funded through individual scientific research initiatives.

Dunes. If constructed, restored dune areas may be maintained by USFWS.

Removal of non-native SAV. It is possible that the Department of Boating and Waterways and/or others may perform routine maintenance for removal of non-native SAV and FAV (e.g., *egeria* and water hyacinth) in the north Emerson tidal open water area and tidal channels in the restored marshes on all three parcels. We have not included costs for this activity at this time.

North Burroughs Maintenance. We assume that the grazing land lessee will be responsible for routine maintenance associated with grazing operations. These activities would include maintain fencing, livestock water sources, and corral; and operating and maintaining the irrigation and drainage system (e.g. watering basins, irrigation lines, emitters, culverts and pumps).

7. NEXT STEPS

The following items are recommended for future phases of the Dutch Slough restoration planning and design.

Regulatory agency meetings. Now that the revised conceptual plan has been documented, we recommend that the Management Team schedule meetings with the regulatory agencies. A pre-application meeting with the USACE should be scheduled and wetland mitigation requirements, if any, should be discussed. A meeting should also be scheduled with DFG and the USFWS to discuss special-status species mitigation needs, including mitigation of potential impacts on Swainson's Hawk. A draft wetland delineation has been submitted to the USACE, with a request for verification and preliminary jurisdictional determination.. The conceptual design report should be modified or appended after these agency meetings and wetland verification to incorporate any regulatory requirements that are identified by the agencies.

Project phasing. Section 5 presents two options for project phasing and a series of considerations. Project phasing will need to be decided in coordination with progression of the final design (more below).

Final design. Construction drawings and specifications will be produced at 30% (preliminary design), 50%, and 80% complete. Subsequent to 80% complete, DWR may decide to complete the 100% design documents for bid or may decide to bid the project for design-build. It has not been determined how much of the site (e.g., how many of the three parcels) will proceed to 80% complete at this time, for bid in 2011. It may be desirable to produce a 30% complete design for all three parcels, then carry forward only the Phase 1 design (e.g., Gilbert parcel) to 80% design for construction in 2011.

Design elements will be refined during final design, with revised cost estimates produced at each percent complete submittal. Final design will refine the grading plan, design of water control structures, infrastructure treatment (protection, relocation, abandonment in place, or demolition), construction access, planting, specifications for conformance with permit requirements, and other items. Select design items are highlighted below. This is not an exhaustive list.

- Refine design to protect or abandon onsite infrastructure: ISD sewer line, PG&E lines, gas wells
- Investigate a possible off-site water right to Little Dutch Slough via the existing Burroughs canal and refine the design to maintain water conveyance as needed
- Identify the potential for seepage into the CCWD canal during initial tule establishment, prior to CCWD canal encasement, and mitigate if needed
- Refine the north parcels designs for Emerson, Gilbert, and Burroughs, as these are generally less developed than design for the tidal marsh areas
- Identify/confirm flood protection levee design criteria for the south levee (including the City park) and east levee

- Refine design for sand dunes and establish interagency agreements for maintenance
- Refine Marsh Creek delta restoration, including hydrodynamic modeling of flood flows and coordination with the Contra Costa County Flood Control and Water Conservation District (CCCFCWCD); continue discussions with CCCFCWCD regarding purchase of Marsh Creek levee along west Emerson
- Monitor groundwater elevations and water quality, identify potential for seepage impacts for low lying areas to the south, and identify mitigation measures as needed (groundwater monitoring plan in progress)
- Monitor Marsh Creek water quality. Concerns and questions remain about constituents not determined during previous sampling efforts. Specifically, agricultural and urban pesticides, organic chemicals possibly present in urban runoff and pharmaceuticals and personal care products from the Brentwood waste water treatment plant have not been determined in Marsh Creek water samples, nor has biological toxicity been assessed. Water quality monitoring plans currently in development will include these constituents and toxicity testing to fully assess the water quality impacts of the Marsh Creek diversion.
- Consider installing a tide gage at the mouth of Little Dutch Slough to confirm tide levels relative to land-based topographic survey elevations
- Refine estimates of survival of existing riparian woodland along the canal on south Burroughs
- Model tidal hydrodynamics to inform final design for breaches, slough dredging, tidal channels, water control structures, and potential offsite impacts. Regarding slough dredging, modeling is recommended to assess whether it is necessary to dredge the wider northern reach of Little Dutch Slough (in addition to the narrow south reach) to allow sufficient drainage for low marsh vegetation to survive. Regarding potential offsite impacts, modeling is recommended to assess the potential for open water in north Emerson to cause tidal damping and impede drainage through the culverts at the upstream end of Emerson Slough.
- Consider whether tidal flows and salinities need to be modeled at the regional scale (e.g., in the Delta) to assess potential project impacts. This modeling was recommended in the Feasibility Study, but not required by the EIR.
- Investigate geotechnical conditions to evaluate whether on-site soils and/or ISD fill material are suitable for constructing the new east and south levees and other design features.
- Collect additional topographic data (ground surveys) to check (quality control) the LIDAR topography and refine volume estimates, particularly at locations of breaches, new/improved levees, new water control structures, and any other major grading.
- Confirm the vertical datum to be used for design, NGVD29 or NAVD88. The current standard is NAVD88, and this standard is being used for regional Delta restoration planning and tide data collection. However, previous site surveys are referenced to NGVD.
- Design tidal channels based on geomorphic relationships, construction constraints, fish habitat benefits, and adaptive management experiment considerations. Collect additional data on tidal channel dimensions and planform relationships to marsh area in Delta marshes to inform the geomorphic channel design and marsh-scale adaptive management experiment design (which is

based on the hypothesis that the range in channel depths in larger marshes provide fish greater refuge from predators).

Operations and Maintenance Plan. An O&M plan will be needed to outline requirements for the site (see Section 6).

Adaptive management. Research monitoring plans need to be developed and funding for this research identified.

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9. PREPARERS AND ACKNOWLEDGEMENTS

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Stuart Siegel, Ph.D., Private Consultant
John Takekawa, Ph.D., USGS
Lars Anderson, Ph.D., USDA

The TAC meetings were convened by John Cain, consultant. Sarah Puckett, Natural Heritage Institute, provided coordination with the Friends of Marsh Creek.

10. FIGURES

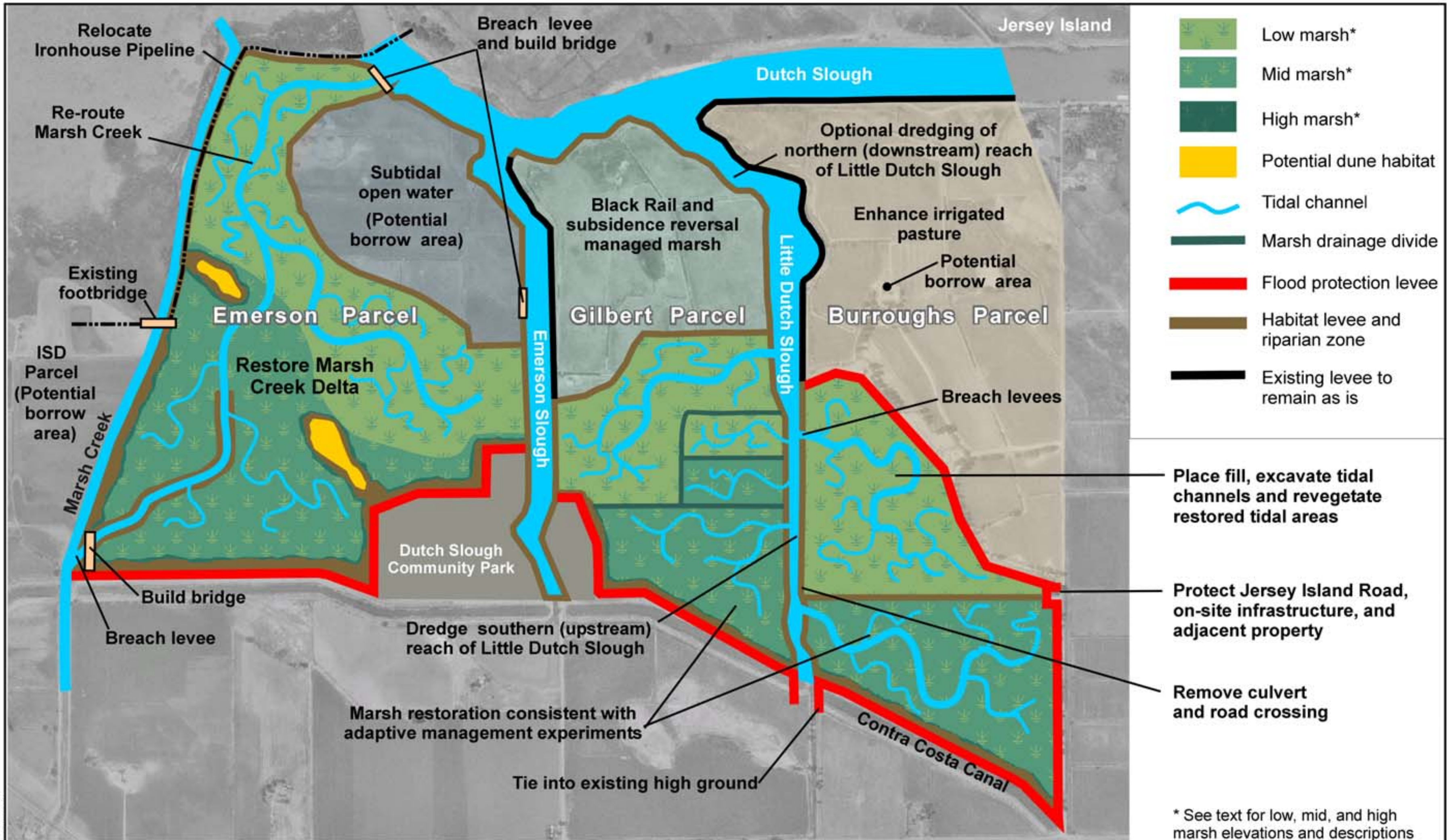


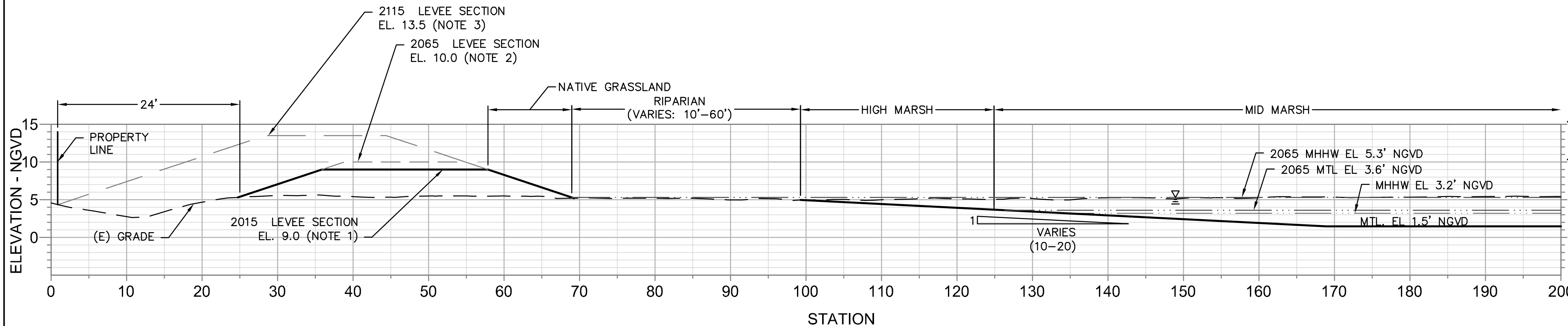
figure 1

Dutch Slough Tidal Marsh Restoration

Conceptual Restoration Plan

PWA

PWA#: 1714 Detail_Alt2.10-13_2010V2.cdr



NOTES:

1. 2015 LEVEE SECTION: 22-FT TOP WIDTH, 3:1 SIDE SLOPES. TOE OFFSET FROM P.L. TO ACCOMODATE 2115 SLR.
2. 2065 LEVEE SECTION: CROWN ADDED TO 2015 LEVEE SECTION. 16-FT TOP WIDTH, 3:1 SIDE SLOPES.
3. 2115 LEVEE SECTION: LEVEE EXPANDED TOWARDS PROPERTY LINE. 16-FT TOP WIDTH, 3:1 SIDE SLOPES.
4. NATIVE GRASSLAND ALONG THE WATER-SIDE FACE OF LEVEE
5. RIPARIAN ZONE AT EL 5'
6. HIGH MARSH EXTENDS FROM EL 5 TO MHHW (EL 3.2)
7. MID MARSH IS BELOW MHHW (EL 3.2)
8. SCALE IS 1" = 20'

figure 2a

DUTCH SLOUGH TIDAL MARSH RESTORATION

SOUTH LEVEE AND UPLAND TRANSITION CROSS-SECTIONS
GILBERT TYPICAL SECTION

PWA

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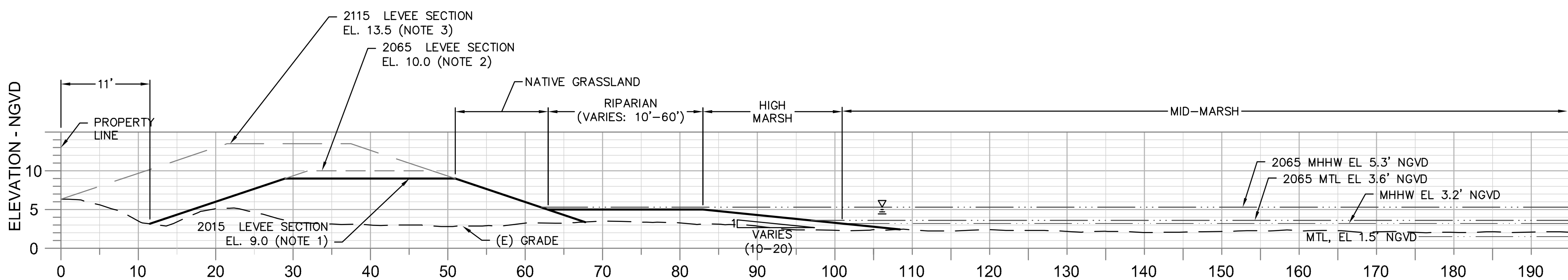

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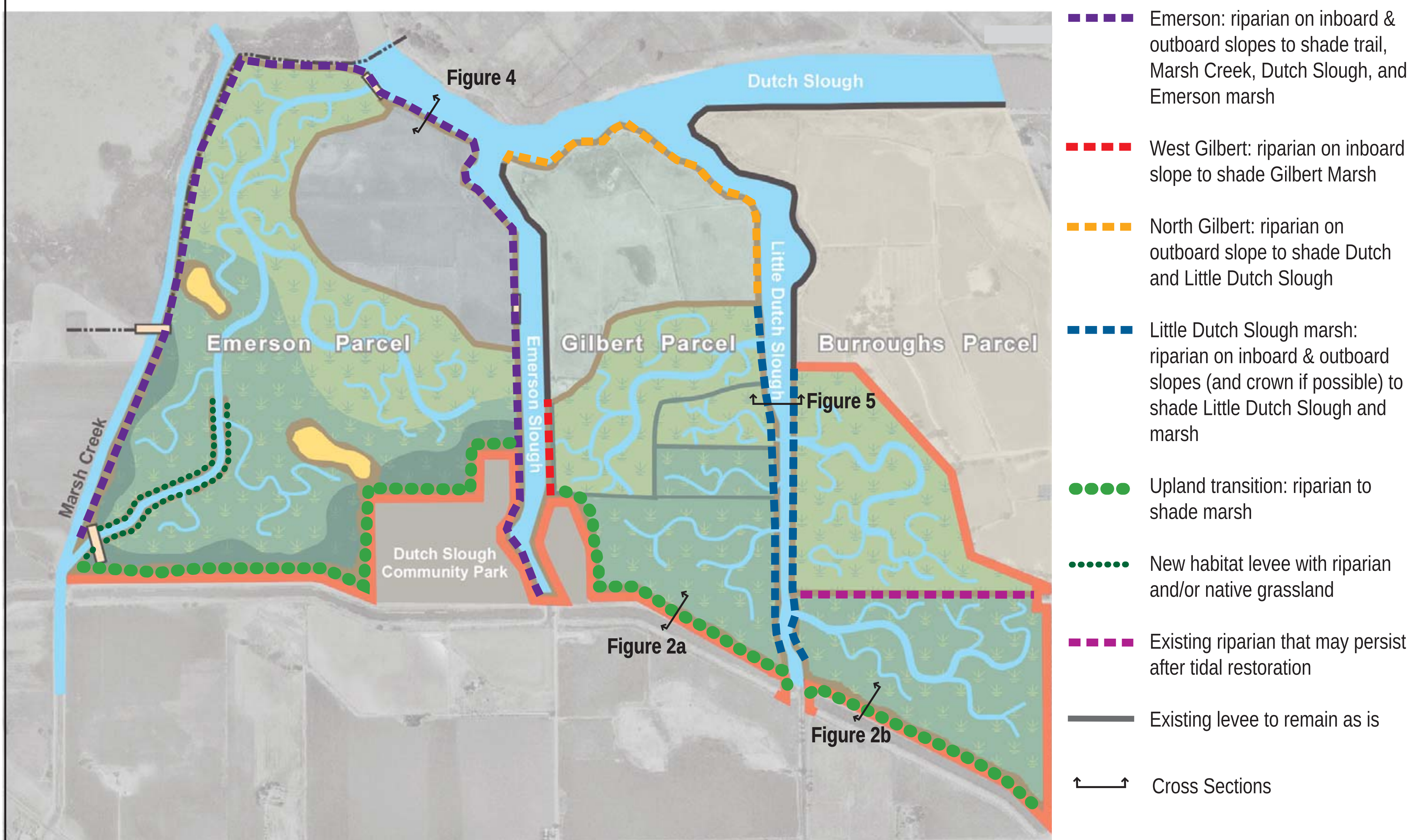
8. SCALE IS 1"=20'

figure 2B

DUTCH SLOUGH TIDAL MARSH RESTORATION

SOUTH LEVEE AND UPLAND TRANSITION CROSS-SECTIONS
BURROUGHS TYPICAL SECTION

PWA



Note: See Figure 1 for base map legend

figure 3

Dutch Slough Tidal Marsh Restoration

Habitat Levees, Riparian Planting Plan, and Section Locations

PWA

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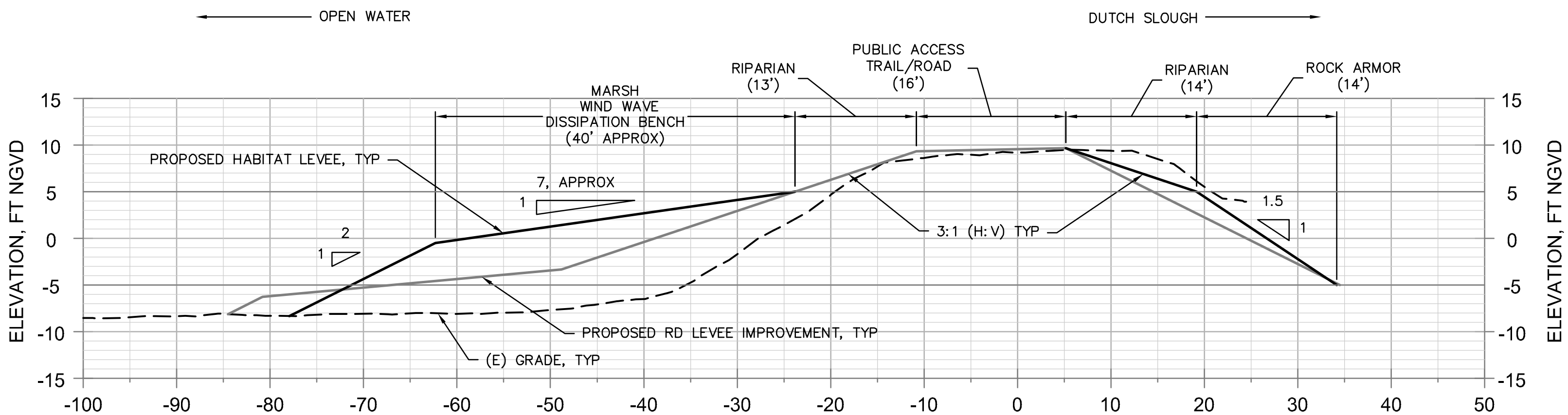
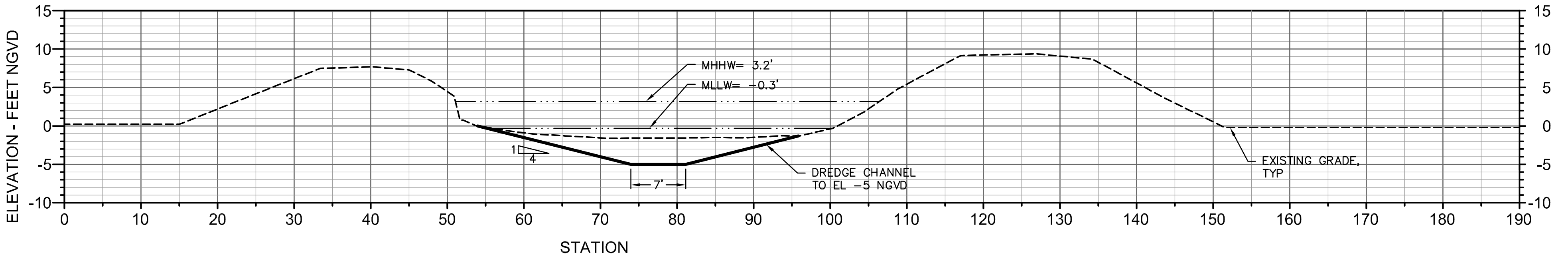


figure 4

DUTCH SLOUGH TIDAL MARSH RESTORATION

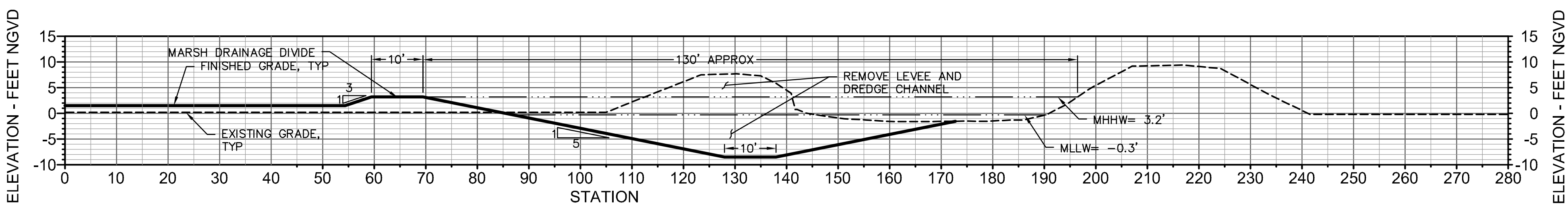
HABITAT LEVEE
EMERSON TYPICAL SECTION

PWA



ALTERNATIVE A: CHANNEL DEEPENING OPTION

NOT TO SCALE



ALTERNATIVE B: CHANNEL WIDENING AND DEEPENING OPTION

NOT TO SCALE

figure 5

DUTCH SLOUGH TIDAL MARSH RESTORATION

LITTLE DUTCH SLOUGH DREDGING
TYPICAL SECTIONS

PWA