Restoration Design Report
Seasonal and Tidal Wetlands
Hamilton Wetland Restoration Project
Novato, California
Final Draft

January 14, 2008

Executive Summary

The Hamilton Restoration Design Report provides the design basis and desired ecological outcomes for the proposed wetlands restoration project located in Novato, California along central San Pablo Bay within San Francisco Bay. Upon completion of site filling operations which is anticipated for 2014, the Hamilton Wetlands Restoration Project will restore approximately 380 acres of tidal and 81 acres of seasonal wetlands to this ecological sensitive part of San Francisco Bay. This ratio meets the project goals for an approximate 80:20 mix of tidal to seasonal wetlands habitat.

The existing site is below elevations suitable for tidal or seasonal wetlands. As part of this project, site grades will be raised to suitable elevations for restoration through a combination of the importation and placement of dredged sediments and from natural sedimentation.

Breaching of the site to the tides is anticipated to occur in 2015. The site will then evolve towards rich mosaic of habitat types as it develops a full tidal connection to the Bay. In the tidal areas, these habitat types include subtidal habitats, mudflat (low intertidal), mid- and high-intertidal marsh (predominantly cordgrass and pickleweed), tidal channels, tidal ponds, and supertidal pannes. It is anticipated that the tidal areas of the site will reach full maturation after 2030. However, a wide variety of natural factors including the available suspended sediment concentration and global sea level rise could delay this. Throughout the marsh evolution period, the restored wetlands will provide habitat and significant ecological value to a wide variety of flora and fauna. Preliminary modeling of the anticipated marsh evolution indicates that restoration of the tidal areas of the site will take from 15 to 50 years depending on the average suspended sediment concentration into the site.

The restored seasonal wetlands areas will include seasonal ponds (wet in winter and spring), emergent marsh, grassland, and upland transition zone. All of these habitat types provide for important habitat that is rare along SF Bay. The target habitat for the majority of the seasonal wetland would be seasonal, shallowly ponded areas with limited vegetation and pond depths suitable for shorebirds and waterfowl.

Upon completion, the project will provide significant public access and educational opportunities in addition to the ecological benefits. The project showcases the latest advances in wetlands restoration science and will eventually integrate with another large adjacent restoration project to form a significant contiguous block of restored habitat for a variety of special status species.

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1. Introduction

This document provides a description and summary of the design basis and anticipated outcome for the Hamilton Wetland Restoration Project (HWRP), a tidal and seasonal wetland restoration project at the site of the decommissioned Hamilton Army Airfield (HAAF) in Novato California. The HWRP is being undertaken by the U.S. Army Corps of Engineers (USACE) in partnership with The California State Coastal Conservancy (SCC) and with the assistance of the San Francisco Bay Conservation and Development Commission (BCDC). This project is being designed "to create a diverse array of wetland and wildlife habitat types" in accordance with the goals and objectives adopted by the Hamilton Restoration Group (HRG) who oversaw the conceptual plan developed by the SCC in April 1998 (Woodward Clyde et al., 1998). Subsequently the USACE incorporated these goals in its project Feasibility Study (USACE, 1998) and the project EIR/S (Jones and Stokes, 1998) of December 1998.

Since completion of the EIR/S in 1998, on-going efforts have continued to refine the project design under the direction of the USACE and supported by a variety of consultants; in particular, Philip Williams and Associates (PWA), FarWest Restoration Engineering (FRE), Polson Engineering and others. A summary of these design efforts and design modifications is included within this report. In addition, the current project design includes revisions that resulted from site changes (i.e. site topography) as well as revisions that resulted from additional knowledge gained from other restoration projects around SF Bay since the 1998 EIR/S that have been applied to the project.

Placement of dredged sediments at the site is anticipated to be completed in 2013 or 2014 and the site breached to the tides in 2015. The site will provide habitat benefits to a variety of species throughout the dredged sediment placement period. Operation of the site during this period will be described fully in the programmatic dredged sediment operations plan currently in preparation.

2. Project Vision and Goals

2.1 PROJECT VISION

This section presents the overall project vision and establishes a suite of targets for restoration, enhancement, and management. USACE, SCC and the BCDC are proposing to restore tidal and seasonal wetlands at former HAAF. The goal of the project is to provide a diversity of wetlands and wildlife habitat on the site, with a design objective of an approximate 20/80 split between seasonal and tidal wetlands. The HRG, consisting of technical experts, federal and state resource agencies, environmental groups and local interests, guided the development of the restoration plan and agreed upon the project design goals. The dominant seasonal wetlands to be provided will be shallow, brackish to saline seasonal ponds, as described below. The dominant tidal wetlands that will develop will be pickleweed marsh with a dense array of tidal channels and ponds. Restoration of the historic landscape pattern of tidal wetlands at the site (consisting entirely of tidal wetlands with extensive areas of tidal ponds) was determined not to be preferable because it would not provide regionally needed seasonal wetlands habitat.

2.2 PROJECT GOALS AND OBJECTIVES

The habitat objectives were established by the HRG, at its October 8, 1997 meeting, to better define the general percentages of tidal and non-tidal habitats for wetland planning purposes. The objectives were framed as design guidance for the restoration project, but are not strict requirements as would apply to a mitigation project[1]. The goals and objectives are as follows:

Goal:

- To create a diverse array of wetland and wildlife habitats at the HWRP site that benefits a number of endangered species as well as other migratory and resident species.

Objectives:

- To design and engineer a restoration project that stresses simplicity and minimizes need for active management.
- To demonstrate beneficial reuse of dredged material.

[1] Mitigation is required for an existing 12.4 acre seasonal wetland mitigation project on the HAAF site that will be displaced the HWRP.

- To recognize existing site opportunities and constraints, including the runway and remediation of contaminated areas, as integral components of design.
- To ensure no net loss of wetland habitat functions presently provided at the HWRP site.
- To create and maintain wetland habitats that sustain viable wildlife populations, particularly for Bay Area special status species.
- To include buffer areas along the upland perimeter of the project area, particularly adjacent to residential areas, so that wildlife will not be impacted by adjacent land uses. Perimeter buffer areas should also function for upland refuge, foraging, and corridors for some species.
- To be compatible with adjacent land uses and wildlife habitats.
- To provide for public access that is compatible with protection of resource values and regional and local public access policies.
- Creation of a mix of tidal habitats on 80% of the area available for restoration. This mix will consist of subtidal habitats, mudflat (low intertidal), mid- and high-intertidal marsh, channels, tidal ponds, and supertidal pannes.
- Creation of a mix of non-tidal habitats on 20% of the area available for restoration, including seasonal ponds, emergent marsh, grassland, and upland transition. The target habitat for the majority of the seasonal wetland would be seasonal, shallowly ponded areas with limited vegetation.

A subcommittee of the HRG met to discuss seasonal wetland issues on December 8, 1997. The group discussed the lack of availability of fill to raise the elevations of the seasonal wetland area in the natural sedimentation alternative and concluded the following:

- It appeared to be infeasible to create seasonal wetland in two locations (the panhandle and the southeast corner) without supplemental fill.
- The option of making one larger site in the panhandle area was rejected because of the perceived difficulty of constructing a levee across the deep Landfill 26 borrow pit and the subsequent lack of fill for the portion of the borrow pit located in the seasonal wetland.

The mix of habitats within the tidal and non-tidal portions of the project will evolve over time as a result of physical processes and biological succession. The anticipated changes are described in detail in Section 6.

2.3 DESCRIPTION OF TARGET HABITATS

Consistent with the project goal and objectives, the restoration project will create a diverse array of habitats. The habitat types proposed to be created or restored include uplands, seasonal wetland, permanent and ephemeral fresh water and brackish ponds, and tidal wetlands, pannes, and mudflats.

General descriptions of each of the target habitats and more specific information on the wetland and wildlife habitats, including their intended location and extent, are detailed below.

2.3.1 Uplands

Upland areas are non-wetland areas that can be inundated by direct rainfall, with some of the rainfall infiltrating into the soil and the remainder running off as surface flow. Some temporary shallow ponding can occur in upland areas during and immediately following storm events. These ponding events are not at a depth or of duration that allows for the establishment of hydrophytic vegetation or anaerobic (reduced) soil conditions. The upland areas will be grassland habitat (likely a mixture of native and nonnative grasses, forbs, and shrubs) with some peripheral halophytes (salt-tolerant plants). In the transition zone between upland and marsh, a patchwork of vegetation that includes Gumplant (*Grindelia spp*.) pickleweed (*Sarcocornia* and *Salicornia* spp.), alkali heath (*Frankenia salina*), Australian saltbush (*Atriplex semibaccata*), and spearscale (*Atriplex* spp.) will grow at the lowest elevations adjacent to tidal wetlands where soil salinities are elevated.

The upland areas will provide refuge for wildlife displaced by extreme flood events in adjacent wetlands. Furthermore, many organisms associated with wetland habitats will forage and find cover within the more densely vegetated uplands. As well as providing some habitat for vertebrate species from the adjacent wetlands, the uplands are habitat for many reptiles, birds, and mammals that are associated with this environment. The uplands in the HWRP are designed to provide a corridor connecting the grassland and oak woodland on the St. Vincent's and Coast Guard properties to the south with the complex of wetlands around Pacheco Pond.

2.3.2 Seasonal Wetlands

Seasonal wetlands include many different habitat types which form in areas of prolonged seasonal inundation (on the order of weeks to several months) from direct rainfall, surface runoff, high spring tides, or groundwater movement. Ephemeral in nature, seasonal wetlands provide a range of freshwater to hyper saline habitat that offers rich ecological diversity. In the 1990's, the HRG determined that the primary habitat goal for the seasonal wetlands at Hamilton was to provide roosting habitat for shorebirds. The shallow open water areas will provide important high-tide shorebird roosting and foraging habitat as well as habitat for birds that prefer to nest and live in fresh water or brackish environments. Shallow, unvegetated areas will be interspersed with wetland and transitional upland to provide ecotone diversity. Seasonal wetlands were once common at the margins of the bays tidal wetlands but have been greatly reduced by development adjacent to the bay.

2.3.3 Tidal Panne

Natural tidal pannes are shallow and tidally ponded, typically less than 6 inches deep and occur in the high marsh at the landward margin of tidal wetlands or on mature marshplains, distant from channels. Salinities of pannes vary by season but are typically hypersaline, through the concentrating of spring tide saline waters. Surface runoff during the rainy season can lower the salinity of the pannes to nearly fresh water, while high evaporation rates during the dry season can raise salinities well above that of sea water and dry the soil surface. The elevated salinities and saturated soils deter vascular plant growth; therefore, tidal pannes are typically void of emergent wetland vegetation, although the formation of algal mats does occur. Tidal panne habitats support high densities of benthic invertebrates, which provide an important food source for shorebirds and waterfowl.

2.3.4 Tidal Marsh

Tidal marshes of San Francisco Bay are generally located between the mean tide level (MTL) and the highest tide and can be segregated into three habitat types including low marsh, middle marsh, and high transitional marsh. Low marsh habitat, located at an elevation between MTL and mean high water (MHW), is inundated daily and typically is dominated by cordgrass (*Spartina faliosa*). This habitat (cordgrass-dominated low marsh) is usually located along the slough channel edge and at the bayward fringe of the marsh. Middle marsh (the predominant marsh plain) habitat, located between MHW and mean higher high water (MHHW), is inundated numerous times monthly but for a shorter duration than the low marsh. The dominant plant species in the middle marsh is pickleweed (*Sarcocornia pacifica*). High transitional marsh habitat, located between (MHHW) and the highest tide, is inundated infrequently and for a short duration. The dominant plant species in the high marsh are typically a mix of highly salt-tolerant plant species such as pickleweed, spearscale, and salt grass (*Distichlis spicata*).

Tidal wetlands provide a variety of important values and functions. Tidal marshes are highly productive systems and provide food and habitat for numerous vertebrate species, including special-status species such as the California clapper rail (*Rallus longirostris obsoletus*) and the salt marsh harvest mouse (*Reithrodontomys raviventris*). In addition they serve as nurseries for commercially important fish species. Coastal wetlands can provide flood protection for communities located adjacent to the shoreline. Temporary or permanent storage of pollutants by tidal wetlands can improve water quality and shoreline stabilization is naturally improved by coastal wetlands. Finally, some wetlands are hydrologically connected to groundwater and can supplement groundwater supplies by aiding in groundwater recharge. All of these functions are supported by San Francisco Bay's tidal wetlands.

2.3.5 Channels and Subtidal

Channels vary in width, depth, sinuosity and cross sectional geometry. The project will result in the formation of channels that range from less than one foot wide to several hundred feet wide. The small channels drain fully at low tide and expose mudflat. They are embedded in the salt marsh and provide habitat for birds, small fish and aquatic invertebrates. The endangered California clapper rail forages in these channels, seeking cover in the adjacent marsh. The largest channels will provide subtidal habitat for many species of fish including special status species.

Subtidal habitat, located at an elevation below the MLLW level, is inundated during all phases of the daily tide. In mature marsh systems, large subtidal channels provide subtidal habitat for many fish species and epifauna that utilize the tidal channels for part or all of their life histories.

2.3.6 Intertidal Mudflats

Intertidal mudflats, located at an elevation between extra low water (ELW) and MTL, are inundated twice daily. Mudflats are inundated more frequently and for longer durations and at greater depths than the adjacent vegetated marsh. Stresses associated with the frequency and long duration of inundation, as well as wave energy, prevent the establishment of emergent wetland vegetation. Intertidal mudflats are located adjacent to the tidal marshplain primarily along slough channels and between the tidal marsh and the bay. Benthic invertebrate densities are high and intertidal mudflats provide shorebird foraging habitat. When the mudflats are flooded the shallow waters provide habitat for fish and ducks.

2.4 EXPECTED LONG-TERM ECOLOGICAL BENEFITS

Due to loss of habitat several plants and animals found in San Francisco Bay are listed as threatened (T), endangered (E) or are species of concern (S). These include the salt marsh harvest mouse (Reithrodontomys raviventris) (E), California clapper rail (R*allus longirostris obsoletus*) (E), California brown pelican (*Pelecanusoccidentalis*) (E), salt marsh common yellowthroat (*Geothlypis trichas sinuosa*) (S), California least tern (*Sterna antillarum browni*) (E), and salt marsh bird's beak (*Cordylanthus mollis mollis*) (E). Fish species with status include winter run (E) and spring run (T) chinook salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*Oncorhynchus kisutch*) (T) steelhead trout (*Oncorhynchus mykiss*) (T), Sacramento splittail (*Pogonichthys macrolepidotus*) (S), Delta smelt (*Hypomesus transpacificus*) (T), and green sturgeon (*Acipenser medirostris*) (T). The HWRP, through the creation of a diverse array of habitats, will provide much needed habitat for many of these species.

3. Existing Conditions and Setting

3.1 REGIONAL SETTING

The San Francisco Bay estuary is one of the largest and most significant estuaries along the western coast of the United States. Over 40 % of California's land area and 60% of the volume of the state's runoff, drains into the estuary (EPA et al., 1996). The HWRP site is located along the northwestern shore of San Pablo Bay, in the northern reach of the estuary (Figure 1).

San Francisco Bay comprises two major bay components: San Pablo and Suisun bays in the north and San Francisco Bay proper in the south. Although the majority of the tidal marshes in San Francisco Bay have been altered or destroyed, the remaining wetlands and deep water zones continue to provide critical fish and wildlife habitat. The mudflats, wetlands, and deep water habitats provide feeding and roosting areas for migratory birds along the Pacific fly way. Many of the brackish marshes of Suisun Bay are used as over-wintering habitat for waterfowl. Marsh- and wetland-dependent wildlife species such as rails, egrets, herons, and shorebirds use the coastal wetlands for food, cover, and breeding areas. The San Francisco Bay estuary supports several anadromous fisheries including salmon and steelhead. Tidal channels and wetlands are used by fish for spawning and for rearing during early life stages. Fish species of commercial or game importance that use these habitats include Pacific herring (*Clupea harengus pallasi*), English sole (*Parophrys vetulus*) and striped bass (*Morone saxatilis*). Young life stages of Dungeness crab (*Cancer magister*) also use tidal marsh channels.

San Pablo Bay is a large, shallow estuary. Typical water depths in San Pablo Bay are 6 feet at low water. A naturally deeper, periodically dredged, navigational channel of 35 feet extends over the length of the Bay between Point San Pedro and Carquinez Strait. A 3,500-foot-wide expanse of mudflat in San Pablo Bay, adjacent to the project site, is exposed at low tide.

3.2 SITE VICINITY

3.2.1 Adjacent Restoration Projects

There are no completed restoration projects adjacent to the project site. The Bel Marin Keys property is in the project design phase and is planned for restoration to a mixture of tidal and seasonal wetlands.

3.2.2 Adjacent Properties

Adjacent Properties: Adjacent properties are listed in Table 3-1, below and shown on Figure 2.

Table 3-1 ADJACENT PROPERTIES

Site Name	Current Land Use
New Hamilton Partnership	Master Plan for 750,000 sq. ft. of offices, 75,000 sq. ft. of retail space, 845 residential units. Discharge nonpoint source flows to Hamilton. (USACE, 1996)
Bel Marin Keys Unit V California Quartet	Agricultural. A portion drains to Hamilton. (Authorized for restoration to tidal and seasonal wetlands)
Pacheco Pond	Flood control reservoir receiving flow from Pacheco Creek and San Jose Creek. Discharges to Novato Creek.
St Vincent's	Irrigation for reclamation. (Also known as Las Gallinas Valley Sanitary District property.)
Coast Guard	Coast Guard Housing.

3.3 EXISTING SITE CONDITIONS

The HWRP is located 25 miles north of San Francisco on the southeast edge of the City of Novato, Marin County, California. San Pablo Bay is adjacent to the airfield on the southeast side. Properties owned by the St. Vincent Catholic Youth Organization and Las Gallinas Valley Sanitary District lie to the south, while The Bel Marin Keys Unit V (BMKV) property owned by the SCC borders the airfield to the north. (See Figure 2) The Novato Sanitary District's (NSD) sewer outfall pipeline runs along the entire northern boundary of the HAAF parcel, and the NSD operates a dechlorination station next to the pipeline about 1,300 feet west of the bayfront levee on the California State Lands Commission (SLC) property. A power supply line extends from HAAF's pump stations to the dechlorination station. The water supply line along the same route has been abandoned.

The HWRP site consists of three parcels of land; the 644-acre HAAF parcel, the 18-acre Navy Ballfields parcel to the southwest, and the 314-acre SLC property to the Northeast. (See Figure 2) These three parcels occupy approximately 988 acres total, which includes 6 acres of levee easement from the city of Novato. The remainder of the original 2,184-acre air base is outside the project footprint, and has been developed as residential, light industrial and open space areas.

These properties historically supported tidal salt marsh habitat, but levee construction separated the area from the tidal influence of San Pablo Bay. Subsequent natural and artificial processes have resulted in lowered surface elevations.

Natural Environment

The Hamilton Wetlands Restoration project site was historically dominated by tidal salt marsh habitat but was converted in the late 1800s to agricultural land. In 1931 funds were appropriated for the construction of Hamilton Army Airfield, which was in operation until 1974. Prior to the project construction activities, the site was made up mostly of grasslands, seasonal wetlands, and developed areas. The only remaining salt marsh in the project area is outboard of the bayfront levee that defines the developed portions of both the HAAF and SLC sites. Although the habitats present throughout most of the project site area are structurally simple (i.e., lacking the vertical structure that would be provided by trees and shrubs), a significant number of vertebrate species are present in this area, including some special-status species.

Tidal marsh habitat: The HWRP site contains 120 acres of high pickleweed marsh. There are 88 acres of tidal marsh outboard of the HAAF parcel and 32 acres adjacent to the SLC parcel. The pickleweed-dominated tidal salt marsh along San Pablo Bay provides habitat for a number of bird species, including several special status species dependent on such habitats. California clapper rails are known to nest and forage in the outboard marsh and their presence has been recorded in surveys as recently as 2006. Shorebirds, generally present during winter as well as spring and fall migration, feed on mudflats at low tide or around the marshes adjacent to ponds and sloughs. Some water birds occur in both fresh water and saline wetlands, including dabbling ducks and wading birds. Surveys conducted to support the Military's Base Realignment and Closure (BRAC) cleanup activities in the tidal marsh indicate that the salt marsh harvest mouse is present. Numerous individuals were relocated during the cleanup operations. While no surveys have been conducted by the restoration project, we have assumed that the salt marsh harvest mouse is present.

Seasonal Wetland: Prior to initial construction there were 35.5 acres of seasonal wetland on the project site, with 19.5 acres on the HAAF parcel (including the 12.4-acre Landfill 26 wetland mitigation site) and 16 acres on the SLC parcel. The site has been significantly altered since the onset of construction. Some seasonal wetland areas have been destroyed by construction while others have been created by borrow activities. Because of these ongoing changes, the current acreage of existing seasonal wetlands is unknown. The dominant seasonal wetland species on the HWRP site are salt grass, alkali heath (*Frankenia salina),* cattail (*Typha* spp.), salt marsh bulrush (*Scirpus maritimus*), and curly dock (*Rumex crispus*). Seasonal wetlands commonly provide high tide refugia (resting areas during high tide) for shorebirds. In addition, the aquatic invertebrates that inhabit the seasonal wetland pools provide forage for shorebirds. A wetland mitigation site was previously constructed by the Army at the northern end of the runway. The 12.4-acre mitigation site was constructed to replace seasonal wetland losses resulting from Landfill 26 closure activities, but has been significantly altered by HWRP construction activities, primarily consisting of borrow and DDT soil excavation. The mitigation wetland is predominantly emergent marsh dominated by cattail, tules and shallow open water.

Brackish marsh: Cattail and bulrush colonize a total of 4 acres of marshy sections along the perimeter drainage ditch. Common species in the perimeter drainage ditch include threespine stickleback (*Gasterosteus aculeatus*), mosquito fish (*Gambusia affinis)*, marsh wrens, egrets, herons, and red-winged blackbirds. Sections of the perimeter drainage ditch have been scraped and/or filled in preparation for the construction of the remaining perimeter levees.

Grassland: 259 acres of the HAAF parcel (mostly in the revetment area) and nearly the entire SLC parcel are grassland. This habitat is dominated by ruderal (weedy) upland plants such as bristly ox-tongue (*Picris echioides*), yellow star thistle (*Centaurea solstitialis*), wild radish (*Raphanus sativa*), and curly dock (*Rumex crispus*). Additionally, non-native grasses such as Mediterranean barley (*Hordeum marinum*) and perennial ryegrass (*Lolium perenne*) are common throughout the project site. Grassland and ruderal vegetation around the project site supports seed-eating songbirds such as song sparrows (*Melospiza melodia*) and goldfinches (*Carduelis sp*). Northern harriers (*Circus cyaneus*) and burrowing owls (*Athene cunicularia*) use this habitat for nesting. These and other raptors such as red-tailed hawks (*Buteo jamaicencis*) and white-tailed kites (*Elanus caeruleus*) feed on the abundant voles and hares that also populate these areas.

Developed Areas: 284 acres of the project site are developed areas consisting of an airstrip, concrete, asphalt, buildings, and bare ground. These areas provide minimal habitat for wildlife. At present, most of the buildings on the HAAF and Navy Ballfields parcels have been demolished and hauled off. The one remaining building on the HAAF and the structures on the SLC parcel will be demolished in the winter of 2007/2008.

Hazardous, Toxic, and Radiological Wastes (HTRW)

The Hamilton Army Airfield has been in the Base closure process since 1974. Twenty acres of the airfield were considered contaminated with relatively low levels of petroleum hydrocarbons, volatile and semi-volatile compounds, polychlorinated biphenyls, herbicides, pesticides and metals. Soils contaminated by Army activities on the HAAF parcel were concentrated around underground storage tanks (UST's), above ground storage tanks (AST's), an aircraft maintenance facility, transformer and generator sites, a former sewage treatment plant, two burn pits, perimeter drainage ditch sediments, and coastal marsh sediments. A more detailed discussion of site contamination is provided in Chapter 10 of the restoration plan EIS (Jones and Stokes, 1998).

The U.S. Army has implemented a remediation program under the BRAC 1988 process to restore the airfield to a condition protective of human health and the environment for reuse as a wetland area. Further cleanup has been conducted by the HWRP to meet the standards established in the

Main Airfield Parcel Record of Decision/Remedial Action Plan (2003). This cleanup consisted of the relocation of soils containing low-level pesticide contamination to areas in the site that will guarantee at least three feet of clean soil cover, primarily under the northern and southern seasonal wetlands and wildlife corridor areas. A summary of cleanup requirements and actions is provided in Section 5.1.7. Details of the cleanup activity are provided in the 2004 Soil Management Plan for the Hamilton Wetland Restoration Project.

The SLC parcel is being remediated under the Formerly Used Defense Sites (FUDS) program. The SLC parcel was also part of the military complex in the past and has more recently been used by the Novato Police Department for target practice. All contaminants on this parcel will be remediated to support reuse prior to restoration. Potentially contaminated sites include a rifle range, a former firefighting facility, a pistol range, a night firing range, transformers, and miscellaneous underground storage tanks (UST's) and above ground storage tanks (AST's). Several unexploded practice grenades were recently found on this parcel. A combination of confirmatory sampling, toxicity testing, and ecological and human health risk assessments will provide information used to determine final cleanup goals in a focused feasibility study. The timeline for the FUDS remediation is uncertain due to funding constraints and priorities inherent in that program. As a result, the SLC parcel will not be restored until a future date either as part of the Bel Marin Keys portion of the project, currently pending congressional authorization, or on its own.

The HWRP site has been the property of the military since 1930. Prior to that time it was farmed. Pre-WWII farming did not involve the use of significant contaminants and therefore there is no reason to believe that there are any potential concerns other than those resulting from the military use of the site, which is being addressed as part of the BRAC and FUDS efforts described previously. Soil samples taken by the Army to establish background levels at Hamilton for heavy metals are consistent with this analysis. Finally, the project site is a diked historic bayland similar to other diked areas that have been restored to tidal action, such as the nearby Sonoma Baylands Project, and therefore it can be concluded that the site substrate is compatible with the wetlands restoration project

Topography

The HWRP site and the surrounding lands are deeply subsided (Figure 3) as a result of the construction of the outboard levee and pumping of surface water and groundwater, which allowed the underlying Bay Mud to dry and consolidate. Subsidence of up to 7 feet has occurred at the project site since it was diked off from the Bay, and with sea level rise the average elevation of the site is now approximately 8 ft below mature marshplain elevations. Prior to the commencement of construction activities for the HWRP, the site grades were generally below the MTL of 3.9 feet North American Vertical Datum 1988 (NAVD 88) and ranged from +9.6 to -4.4 feet NAVD 88, with a typical ground elevation of -2.4 feet NAVD 88 (Kamman et al., 1998).

Other topographic conditions that existed prior to HWRP construction activities include: the bottom elevations of ditches on the project site were typically at elevations ranging from -8 to -10 feet NAVD 88 on the SLC and HAAF parcels; the Landfill 26 wetland mitigation site ranged from -3 to -5 feet NAVD 88 and the borrow area for this mitigation site was at elevation -8 feet NAVD 88; and the upland mitigation site on the northern part of the runway was at elevations between 4 and 7 feet NAVD 88. The runway is a topographic high area, with elevations ranging from approximately -1 to -4 feet NAVD 88. The outboard tidal marsh is at approximately 6 feet NAVD 88.

The existing topographic data comes from the following sources:

A 2003 survey by USACE that included ground elevation shots and aerial photogrammetry for the entire HWRP,
USACE post-construction (As-built) surveys of levees and berms (2004 to 2008)

Updated topographic surveys have been conducted by USACE since the 2003 survey, following construction of each of the onsite containment levees and berms and the excavation of low-level contaminated soils. These surveys mostly documented the levee and berm features and in some cases also documented borrow pit topography. Borrow excavation has taken place in the panhandle (Northern Seasonal Wetland) as well as in the Tidal Wetland area as shown in Figure 3. The elevations in these borrow areas are typically at approximately -6 ft NAVD 88, or about 4 feet below the pre-borrow grade.

3.3.1 Tides

San Pablo Bay Tides. There are two National Ocean Service (NOS) tide stations near the HWRP site that NOS occupied for short periods of time – Petaluma River Entrance (Station 9415252; not updated by NOS to the current tidal epoch) and Hamilton Air Force Base (AFB) Outside Gauge (Station 9415124; current tidal epoch). In addition, NOS operates the continuously recording Richmond Chevron Oil Pier (Station 9414863) that serves as the closest reference station for establishing new tidal datums for the HWRP. Relevant tidal datums for the HWRP are shown in Table 3-2.

San Pablo Bay is subject to mixed semidiurnal tides[2] with a spring tide range of just over 6-foot. The tidal datum values in Table 3-2 are for current tidal epoch 1983-2001, with ongoing sea level rise these tidal datum will rise relative to the land surface (see section 5.2.3) Bay water levels are also

[2] Mixed semisiurnal - two unequal high tides and two unequal low tides during each day

effected by short term climatic events including El Niño and La Niña events, which influence both oceanographic water levels and Sacramento River run-off to displace Bay tide levels. Figure 4 presents water levels exceeding MHHW for San Pablo Bay at the Richmond Station 8.7 miles southeast of the HAAF (data: water years 1997-2004). Water years 1998 and 1999 encompass El Niño and La Niña events which respectively displace water levels above and below typical ranges. The highest recorded tide at the Richmond Station of 8.65 ft MLLW (2/6/1998) was 2.29 ft higher than predicted tide that day of 6.36 ft MLLW.

Table 3-2 TIDAL CHARACTERISTICS AT HAMILTON ARMY AIRFIELD

Tide	Datum			
	m MLLW	ft MLLW	m NAVD 88	ft NAVD 88
100 year high tide[a]	2.935	9.63	2.999	9.84
10 year high tide[a]	2.630	8.63	2.694	8.84
Mean highest annual tide (observed)[a]	2.399	7.87	2.463	8.08
Mean highest annual tide (measured)[a]	2.258	7.41	2.322	7.62
MHHW[b]	1.842	6.04	1.906	6.25
MHW[b]	1.662	5.45	1.726	5.66
MTL[b]	0.999	3.28	1.063	3.49
MSL[b]	0.986	3.23	1.050	3.44
NGVD 29[b]	0.752	2.47	0.816	2.68
MLW[b]	0.332	0.33	0.396	0.54
MLLW[b]	0.000	0	0.064	0.21
NAVD 88[b]	-0.064	-0.21	0.000	0

Source: [a]Table 2.2. Appendix B – Engineering Appendix, Hamilton Army Airfield Wetlands Restoration Feasibility Study; [b]Hamilton AFB Outside Gauge (Station ID 9415124),

3.3.2 Sedimentation

This section updates the approach used to estimate sedimentation rates for the Feasibility Study design alternatives, and the measures used to compare the alternatives. Considerable uncertainty is associated with estimates of long-term sedimentation rates in wetland systems. The effects of large storm events, the natural variability in sediment supply in San Pablo Bay, changes in sedimentation rates as the site fills, and the differential sedimentation anticipated across the large Hamilton Wetlands Restoration site all introduce uncertainty in sedimentation rate estimates. Three information sources are considered in estimating long-term sedimentation rates at the Hamilton site:

- Measured sedimentation rates in San Pablo Bay
- Predicted long-term sedimentation rates

- Hydrodynamic modeling of post-breach flow and sediment transport

Measured sedimentation in San Pablo Bay

The supply of available sediments to marsh restorations in the region is spatially variable but can generally be described as relatively moderate to high. Measurements in the high turbidity region of the Petaluma River entrance (4 miles north of the HWRP), for instance, typically range between <100 mg/L to 2500 mg/L and on average around.500 mg/L (Ganju et al, 2004). These high suspended sediments are due to a combination of river supply and bay supply which oscillate back and forth, resuspended by tidal currents within a confined estuarine channel (Ganju et al, 2004). As a consequence of being within this high turbidity zone deep sediment sinks such as dredged the Port Sonoma Marina, and Bel Marin Keys (Novato Creek), and initially deeply subsided Petaluma Marsh restoration site have experiences high rates of sedimentation 0.5 – 1.3 ft per year. Direct measurement of suspended sediment at the Petaluma Marsh records suspended sediment values that range between <10 mg/L to 1500 mg/L.

On the open shore of San Pablo Bay suspended sediment concentrations are also relatively high, but lower than estuarine channels (Ganju et al, 2004). The most suitable reference site for the HWRP is the Sonoma Baylands Wetland Demonstration Project (known as Sonoma Baylands), on the open shore just east of the Petaluma River. This restoration site like the HWRP was created by placing dredged material to raise mudflat elevations as well as including wave berms to reduce wave fetch and encourage sedimentation[3]. However, to avoid regulatory agency concerns of impacts to endangered species by dredging through the outboard marsh no connecting tidal channel was constructed. As a consequence sedimentation on site was delayed until natural scour of outboard channel progressed. Now that a full tidal connection has evolved sedimentation rates accelerated with mudflats at an elevation of around 4 ft NAVD 88 gaining up to 0.25 ft / yr. (PWA, 2007). This rate of sedimentation equate to an effective suspended sediment concentration of between 150 and 300 mg/L (PWA unpublished data). It should be noted that in the more wave exposed areas rates of sedimentation have been slower than site average rates (PWA, 2007).

Predicted Long-Term Sedimentation Curves

Suspended sediments brought into the Hamilton site on flood tides will be at a concentration that reflects some combination of two San Pablo Bay sources, the adjacent mudflats and the San Pablo Bay channel.

To gather more information about the change in sedimentation rates that can be expected as the site evolves from a subtidal to an intertidal system, sedimentation curves were developed using a one-

[3] Distribution of wave berms at Sonoma Baylands are at a higher density than at the HWRP and so wave climate will differ accordingly.

dimensional, long-term marsh sedimentation model developed after Krone (1987). The model predicts a mean sedimentation rate across the restoration site as a function of the sediment supply and characteristics, the period of inundation (which changes as a function of the tidal range and the bed elevation), and sea-level rise. A description of the model is presented in Appendix B of the Feasibility study (USACE, 1998). Sedimentation curves generated for a range of suspended sediment concentrations (supply) and initial ground elevations are presented on Figure 5, These curves are updated from the 1998 EIR for sea level rise projections as of 2007 (PWA memo 12/18/07).. The curves are exponential, indicating the highest sedimentation rates will occur immediately after breaching when the depth of water over the marsh plain and the tidal prism is greatest (marsh plain at the lowest elevation). Sedimentation rates will decrease as the depth of water above the marsh plain decreases (as the marsh plain reaches the elevation of mean high higher water).

The family of curves in Figure 5 illustrate the effects of initial site elevations and available sediment supply on the predicted sedimentation rates. The rate of time it takes for the site evolve to vegetated marshplain elevations will depend upon final dredged material elevations, settlement of material, sediment availability from the bay and degree of wave energy across the restoration site.

Figure 5(a) illustrates the variability in sedimentation rates bracketing the expected range of placed dredged material elevations at the HWRP. This family of curves assumes a long-term averaged sediment concentration of 250 mg/L supplied from tidal waters in San Pablo Bay, and insignificant wave resuspension on site. Estimated levels of 'time averaged' available sediment to sheltered areas of the Sonoma Baylands restoration project is around 150 to 300 mg/L (PWA memo 12/18/07). Assuming this sedimentation rate and sediment placed to an elevation of 3.5-4.5 ft NAVD 88 it would take 10 – 15 years for the marsh surface to build up to marshplain (equivalent to MHHW) elevations. The anticipated rate of sedimentation at the HRWP is likely to be an overestimation because of the effects of wave climate inside the site (see next section) and any consolidation of placed dredged material once exposed to tidal drainage.

The family of curves on Figure 5(b) illustrates the variability in sedimentation rates associated with the range of long-term average annual suspended sediment concentrations between 50 mg/L and 350 mg/L. The curves presented bracket the expected range of concentrations occurring in tidal waters in San Pablo Bay, based upon the average site surface elevation described in the1998 Feasibility Study

Spatial Variation in Sedimentation Rates

The sedimentation curves represent average, long-term sedimentation rates across the entire Hamilton Wetlands Restoration site, but do not reflect the spatial distribution of sediments throughout the site. Actual sedimentation rates will not be uniform across this site but will vary depending the redistribution of sediment by waves and tidal currents. Much of the sediment in the water column will be deposited near the inlet at first. Resuspended by waves this sediment will progress to more sheltered areas of the site.

Preliminary hydrodynamic modeling of an earlier HWRP wave berm configuration performed for the USACE (PWA and DHI, 2004) describes sediment to accumulate from mudflat to vegetation colonization elevations across much of the restoration site within ten years. Based upon suspended sediment concentrations of 250 mg/L this study found that highest rates of sedimentation would be found in the vicinity of wave berms with lower rates in more exposed areas, and major channel formation between berms. These results are consistent with monitoring of sedimentation patterns at Sonoma Baylands (PWA, 2007; PWA Memo 12/18/07). -Here, over the period 2002-2006, lowest rates of sediment accumulation (0 ft) were found at a location exposed to a 1200 ft + fetch on the prevailing wind direction; while highest rates (0.25 ft / yr) where found in interior sheltered site locations adjacent to the wave exposed area. Intermediary rates of sedimentation occurred in sheltered locations proximal to the breach and throughout the smaller Pilot Unit. Based upon average sedimentation rates it is calculated that time average effective suspended sediment concentrations are in the range of 150-300 ppm. This may be a slight underestimation of true suspended sediment availability as the calculation is based upon net sedimentation rate and does not account for sediment that is resuspended by waves. It is anticipated that tidal waters will bring similar sediment loads derived from wave resuspension of sediments on San Pablo mudflats to complete building wetlands in the Hamilton wetlands restoration site.

3.3.3 Salinity Regime

The salinity regime in San Pablo Bay adjacent to the HWRP varies considerably by season depending on the degree of Delta outflow. Near-surface salinities in San Pablo Bay frequently approach zero during ebb tides in February and March. During summer months salinities are relatively high and as freshwater from the Delta diminish Bay waters approach full marine salinities.

3.3.4 Climate

The San Francisco Bay Area has a Mediterranean climate with two primary seasons: warm dry summers which extend from mid-April to late October; and mild cool winters. Average summer temperatures (July through September) range form 52 to 78 degrees F; winter temperatures range form 41 to 55 degrees F (NOAA, 1997).

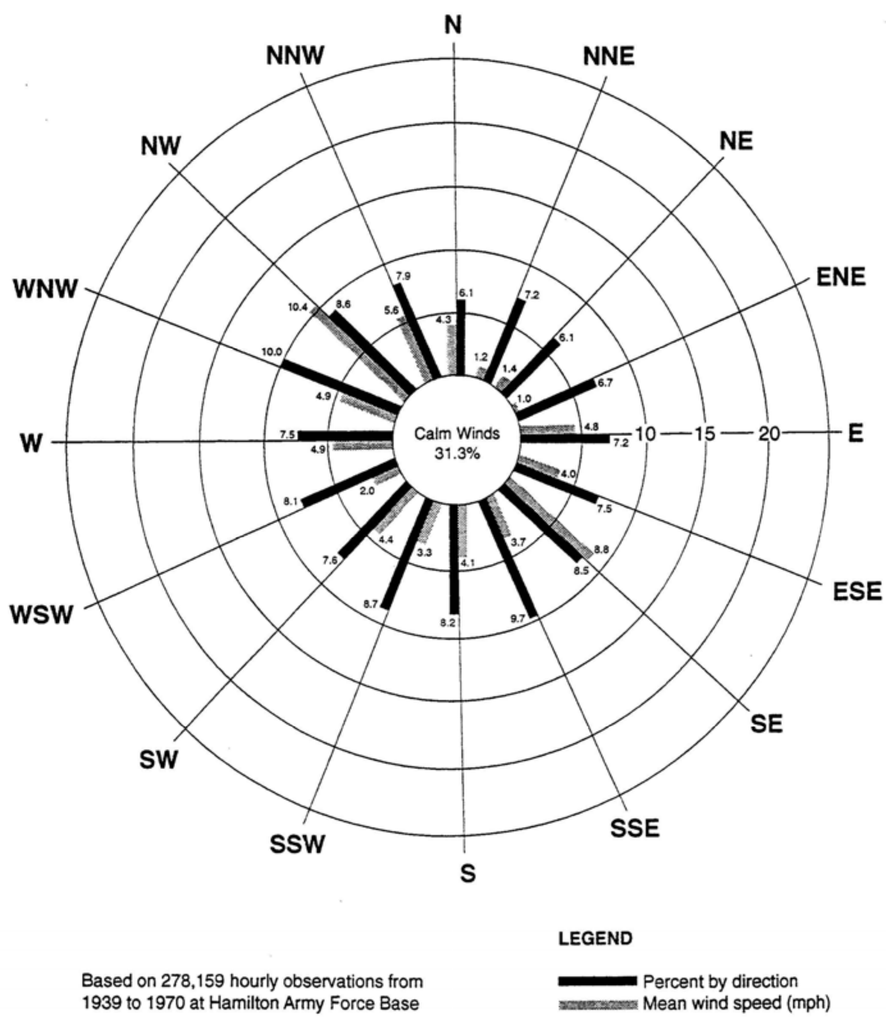
Rainfall patterns vary throughout the San Francisco Bay Area estuary as a function of geographic features. Mean annual rainfall at the site is approximately 26 inches per year, with annual precipitation ranging from 14.5 to 37.5 inches in the 1 in 10 dry and wet years respectively. Rainfall is concentrated in the winter season with 90% of the annual rainfall occurring between November and March. Mean marsh evapotranspiration at the site is approximately 49.3 inches per year (Blaney and Muckel 1955). In an average year, direct precipitation exceeds evapotranspiration from

November through March and evapotranspiration exceeds direct precipitation from April through October.

Winds blow predominately from the northwest and southwest, parallel to the runway. Mean wind speeds are 7.4 knots to the southeast and 7.5 knots to the northwest (DWR, 1978). Table 3-3 below presents extreme wind speeds for return periods ranging from 2 to 50 years. The data in Table 3-3 below are based on PWA analysis using peak gust data at HAAF over a 24-year period of record (DWR, 1978). Average wind speed and direction are presented in the table and wind rose below.

Table 3-3 Wind Speeds at the HAAF

Return Period (years)	Estimated Extreme Wind Speed (mph)
2	55.2
5	63.8
10	69.5
25	76.7
30	82



Source: California Air Resources Board 1984.

3.3.5 Subsurface Hydrology in Diked Baylands

The shallow groundwater at the proposed wetland restoration site has a high salinity because of the historic influence of San Pablo Bay. Groundwater is of poor quality and is not used as a potable water source. A deep, higher-quality aquifer is present at an unknown depth. Because of the prevalence of Bay muds, runoff is unlikely to recharge the deeper groundwater under the wetland restoration site. Groundwater may be influenced by freshwater levels in Pacheco Pond and may be less saline in near the pond. The general direction of groundwater flow is to the east (Woodward-Clyde 1985). However, the low transmissivity of Bay muds greatly reduces the movement of shallow groundwater into San Pablo Bay. Groundwater also discharges to the interior drainage channels and is pumped to San Pablo Bay.

3.3.6 Storm Water Drainage

Regional drainage features are shown on Figure 6. Pacheco Creek traverses the southwestern side of the overall Hamilton area. Pacheco Creek drains into Pacheco Pond, located adjacent to the base's northwestern boundary. Arroyo San Jose, a slightly larger stream draining a 5.4-square-mile area, also drains into Pacheco Pond, but does not cross base property. Pacheco Pond provides temporary storage prior to draining through flap-gates to Novato Creek, which is fully tidal at its confluence with the Pacheco Pond outflow. Although Pacheco Creek, Arroyo San Jose, Novato Creek, and Pacheco Pond are not connected to the HAAF site drainage during average runoff conditions, they become important sources of flow to the site during flood conditions. This issue is discussed further in the following local hydrology section.

Surface water runoff from the areas west of the project site is carried by Pacheco Creek and Arroyo San Jose. Historically, these streams were part of a network of natural channels that drained through the low-lying area, where Pacheco Pond is now located, to Novato Creek. Pacheco Creek and Arroyo San Jose both have their headwaters on Big Rock Ridge, at elevations of 1,300–1,600 feet NGVD. Pacheco Creek has a watershed area of 1.9 square miles and Arroyo San Jose has a watershed area of 5.4 square miles, which is a tributary to Pacheco Pond. Pacheco Pond drains to Novato Creek through a leveed channel with a flap gate outlet (Bissell & Karn/Greiner 1993 and unpublished Corps data). Figure 6 shows regional drainage features in the area.

The HAAF, SLC, and BMKV parcels and the St. Vincent's property (located south of the HAAF parcel) are all served by local drainage facilities, including drains, channels, culverts, and pump stations with outfalls into San Pablo Bay. Ground elevations in these areas are generally from 0 to -4 feet NGVD, several feet below the mean higher high water elevation of 3.4 feet. The general pattern of drainage on and near the project site is shown in Figure 7. Major drainage features and hydrologic resources in the project area are described briefly below.

Pacheco Creek: Pacheco Creek originates on Big Rock Ridge 3 miles west of HAAF at an elevation of 1,300 feet. The creek crosses U.S. Highway 101 near the Alameda del Prado/Nave Drive, and crosses Nave Drive, Marin Valley Road, Bolling Drive, Main Entrance Road, and State Access Road in a series of culverts. The computed 10-year and 100-year peak discharges for Pacheco Creek are 470 and 770 cubic feet per second (cfs), respectively (Bissell & Karn/Greiner 1993). With the exception of low-lying areas near Ammo Hill, the 10-year peak discharge is contained within the creek banks, culverts, and road crossings in the vicinity of the project site. The capacity of Pacheco Creek is substantially lower near the southern and western sides of Ammo Hill than it is upstream, resulting in overflow of the banks during even low flows near Ammo Hill.

The peak 100-year discharge exceeds the channel and culvert capacities in several locations, including Bolling Road, Main Entrance Road, and the area near Ammo Hill. The 100-year peak discharge would also flood the areas between Bunker Hill and Ammo Hill that are at elevations less than 10 feet. The creek passes between Ammo Hill and Bel Marin Keys Industrial Park before discharging into Pacheco Pond.

The Army recently completed construction of a berm around a portion of Landfill 26. The purpose of the berm is to protect the landfill from overflow from Pacheco Creek up to the 100-year flood.

Arroyo San Jose: Arroyo San Jose also originates on Big Rock Ridge 5 miles west of the HAAF parcel at an elevation of 1,600 feet. The creek crosses U.S. Highway 101 near the Ignacio Boulevard/Bel Marin Keys Boulevard interchange and discharges into Pacheco Pond. Arroyo San Jose has a watershed of 5.4 square miles, and the computed 10-year and 100-year peak discharges are 1,200 and 2,300 cfs, respectively (Bissell & Karn/Greiner 1993). The 10-year peak discharge is contained within the channel banks and road crossings between U.S. Highway 101 and Pacheco Pond. High tides on San Pablo Bay raise the water surface elevation in Pacheco Pond and affect water surface elevations in the lower portion of Arroyo San Jose and Pacheco Creek. The 100-year peak discharge would cause flooding in the Los Robles Mobile Home Park and the Bel Marin Keys Industrial Park if accompanied by a high tide on San Pablo Bay (Bissell & Karn/Greiner 1993). At lower tides, the 100-year peak discharge is not expected to cause flooding in these areas.

Pacheco Pond: Both Pacheco Creek and Arroyo San Jose discharge into Pacheco Pond (also called Ignacio Reservoir). This reservoir was built by the Marin County Flood Control and Water Conservation District (MCFCWCD) and is operated jointly by MCFCWCD and the California Department of Fish and Game. The reservoir occupies 120 acres and has a storage capacity of 480 acre-feet (unpublished Corps data). The reservoir discharges to Novato Creek through a leveed channel with a flap gate at the outlet. The outlet is located at the Bel Marin Keys Boulevard bridge. High tides in San Pablo Bay prevent outflow from Pacheco Pond and may cause flow reversal in the outlet channel if the flap gates do not operate properly (Bissell & Karn/Greiner 1993). Ground elevations near the reservoir are near mean sea level.

The reservoir was constructed to provide flood protection by providing storage for discharges from Pacheco Creek and Arroyo San Jose. However, the storage capacity of the reservoir is not always adequate to provide 100-year flood protection and prevent overflow of the reservoir. For example, during a high tide of 7 feet, the reservoir would need a capacity of 600 acre-feet to accommodate 100-year inflows from Pacheco Creek and Arroyo San Jose (unpublished Corps data). The reservoir is also operated to provide freshwater wetland and wildlife habitat. Flashboards are used at the outlet to control water levels during nonflood periods.

Two 24-inch siphons were installed by the U.S. Air Force to provide an overflow from the reservoir onto the HAAF parcel (Bissell & Karn/Greiner 1993). The siphons were designed to prevent overtopping and damage to the airfield levee, but they are no longer operational. According to the draft restoration plan, the reservoir instead overtops levees to flow into agricultural fields north of the reservoir, into Novato Creek, and into the BMKV parcel. Low points in the levees between Pacheco Pond and Novato Creek, and between the reservoir and agricultural lands to the northeast, are 6.2 feet and 8.0 feet, respectively.

Bel Marin Keys V: The BMKV parcel is currently in agricultural use and is drained by a system of channels. Under normal runoff conditions, most of the runoff from the parcel drains to a pump station at the northeast corner of the property that discharges to San Pablo Bay. 100 acres drain to the channel system on the SLC parcel to the east. Until recently these flows were conveyed by gravity to the HAAF perimeter ditch system through two 24-inch culverts (described above).

Under flood conditions (greater than 10-year events, according to the draft restoration plan), the BMKV parcel once received overflows from Ignacio Reservoir and from the HAAF parcel through a levee gap 2,000 feet southeast of the northwest corner of the HAAF property. The construction of the N1 portion of the perimeter levee system in 2005 eliminated this potential for overflow. Flood overflows cause ponding on the BMKV parcel under current conditions and leave the property by overflowing the drainage divide between the BMKV and SLC parcels.

California State Lands Commission (SLC) Parcel: The SLC parcel historically drained to the HAAF perimeter ditch system through a network of channels on the SLC parcel. Flows in the channel system were conveyed to the HAAF perimeter ditch system near the Novato Sanitary district (NSD) dechlorination facility through two 24-inch pipes. These pipes are no longer functional and water now ponds on the parcel. Currently there is no discharge from the SLC property.

St. Vincent's Property: The St. Vincent's property south of HAAF is served by a system of drainage channels that discharge through a pump station to San Pablo Bay. In general, ground elevations on the St. Vincent's property drain away from HAAF, and most of this property does not contribute flows to the perimeter ditch system. However, a channel along the northern boundary of the St. Vincent's property intercepts flows from the western portion of the former DOD housing and Long Point peninsula area. The former DOD housing remains in use, but has been converted to non-military housing. A portion of the St. Vincent's property also drains to this channel. In addition, overflows from the drainage system on the St. Vincent's property may flow to this channel during periods of high runoff. The channel until recently carried flows to a culvert crossing of the HAAF perimeter levee near the southwestern corner of the airfield and then into the perimeter ditch (unpublished Corps data). As part of the BRAC closure the connection to the HAAF parcel was capped and the owners of the St Vincent's property were compensated to increase the capacity of their pump station to handle the increased potential for ponding. The connection to the HAAF perimeter drainage ditch has now been permanently blocked by the new southern portion of the perimeter levee. The channel carrying flows from the former DOD housing area may also overtop onto the St. Vincent's property, where these flows are intercepted by the St. Vincent's property drainage system and conveyed to the associated pump station.

<u>Hamilton Army Airfield Drainage:</u> Drainage from the HAAF parcel is collected in a perimeter ditch system and conveyed to two pump stations on the margin of San Pablo Bay. The drainage system is described in detail in an engineering evaluation of the ditch system prepared by International Technology Corporation for the Corps (USACE 1997). Drainage subareas for the HAAF parcel are delineated in the Flood and Drainage Baseline Study (unpublished Corps data).

Prior to 2001 the perimeter ditch system was drained by three pump stations on the margin of San Pablo Bay, Buildings 35, 39, and 41. These pump stations had a combined capacity of 230 cfs and outlet into an outboard slough that connects to San Pablo Bay. Building 41 and its associated pumps were demolished and remediated as part of the BRAC closure in 2001. The remaining diesel and electric pumps in Buildings 35 and 39 have a combined output capacity of 110 cfs. In the Late fall of 2007 the restoration project will take the diesel pump off line and add two vertical turbine pumps bringing the output capacity to 165 cfs.

In addition to the HAAF parcel, the perimeter ditch system receives drainage from several adjacent areas:

- drainage from the New Hamilton Partnership development, the eastern portion of the former DOD housing area, and other areas adjacent to the west side of the airfield that are conveyed to the ditch in two outfalls, one near Reservoir Hill (west outfall) and one near the southwest corner of the airfield (east outfall);

- drainage from the area of Landfill 26 and Ammo Hill that, is conveyed to the ditch system through a 48-inch culvert. This culvert is being capped in the fall of 2007 prior to the placement of dredged material in the panhandle area. In addition, drainage from POL hill and a small portion of the New Hamilton Partners housing is conveyed in a ditch that turns into a culvert under the access road. This culvert continues along the site perimeter and connects to the HAAF perimeter drainage ditch (which now no longer drains the panhandle area) at the northwest corner of the site. This culvert will also be plugged on the HAAF parcel prior to dredged material placement. Once these culverts are blocked, water will pond on the Landfill 26 parcel and city property against the Bulge levee. As part of the BRAC closure, the Army has committed to providing an alternate source of conveyance of this drainage onto the HAAF site. Currently, the Army plans to construct a pump house near the Bulge levee to convey any ponded water.

Mean Runoff Conditions. During an average storm, the HAAF site accepts local surface runoff from approximately 600 acres of adjacent property: the Landfill 26 and Reservoir Hill areas, NHP, and other base property. Storm water from the NHP properties is lifted onto the HAAF site at two pump stations. Other discharges to the HAAF site occur by gravity flow either over land or in underground storm drains. Figure 7 shows the locations of surface inflow to the HAAF site and Table 3-4 shows the mean monthly volume of inflow.

Table 3-4 Mean Monthly Surface Inflow to the Site from Offsite Areas

	Landfill 26	North Reservoir Hill	New Hamilton Partners West Outfall	New Hamilton Partners East Outfall	Other Base Property	Total Offsite Areas
Area (acres)	102	38	30	197	216	583
Monthly Surface Inflow (acre-feet)						
Oct	3.85	1.43	1.13	7.43	8.15	21.99
Nov	6.93	2.58	2.04	13.38	14.68	39.61
Dec	13.20	4.92	3.88	25.50	27.96	75.45
Jan	14.78	5.51	4.35	28.55	31.30	84.49
Feb	13.62	5.08	4.01	26.31	28.85	77.86
Mar	9.35	3.48	2.75	18.07	19.81	53.47
Apr	4.77	1.78	1.40	9.21	10.10	27.26
May	1.19	0.44	0.35	2.29	2.51	6.78
Jun	0.26	0.10	0.08	0.51	0.56	1.51
Jul	0.00	0.00	0.00	0.00	0.00	0.00
Aug	0.05	0.02	0.02	0.10	0.11	0.30
Sep	0.53	0.20	0.16	1.02	1.12	3.01
Total	**68.54**	**25.53**	**20.16**	**132.37**	**145.14**	**391.73**

Figure 8 shows local monthly precipitation and marsh evapotranspiration. In a mean rainfall year, direct precipitation exceeds evapotranspiration[4] from November through March and evapotranspiration exceeds direct precipitation from April through October. Mean annual rainfall at the HAAF site is approximately 26 inches per year, with annual precipitation ranging from 14.5 inches to 37.5 inches in the 1-in-10 dry and wet years, respectively (NOAA, 1997).

Flood Conditions. During moderate and large storm events (greater than or equal to approximately the 10-year storm), regional flooding results in additional sources of inflow to the HAAF site. These sources are shown on Figure 7. Pacheco Creek overtops its banks, flowing around the Landfill 26 area and into the northwestern part of the HAAF site. High flows in Pacheco Creek and Arroyo San Jose raise water levels in Pacheco Pond, causing the reservoir to overtop surrounding levees. Pacheco Pond used to overflow to HAAF through two 24-inch siphons, but these siphons are no longer operational.

At flood stage, Pacheco Pond overflows into agricultural fields to the north of the reservoir (levee low point is approximately 5.6 feet NGVD), into Novato Creek (levee low point is approximately 6.2 feet NGVD), and into the BMKV property (levee low point is approximately 6.6 feet NGVD). Overflow elevations are based on topographic data collected by PWA (1998, work in progress) and Hunter Surveying (Hunter Surveying, 1997), and have been confirmed by observations of recent flooding (L. Fredrickson, pers. comm.). During flooding, Pacheco Pond overflow and direct rainfall collect on the BMKV property, forming large ponds. Ponded water discharges to the HWRP site via overflow of the drainage divide between BMKV and the SLC site

3.3.7 Geology

The Hamilton Field site lies within the San Francisco-Marin structural block of the northern Coastal Range geomorphic province of California. The Coastal Range province is characterized by a series of nearly parallel mountain ranges and alluviated valleys that trend obliquely to the coastline in a northwesterly direction. The geologic units are composed of a heterogeneous mixture of intrusive, extrusive, metamorphic, and sedimentary rock types, which exhibit varying degrees of tectonic deformation.

The site is located within a region characterized by the seismically active San Andreas fault system, which is the principal tectonic element of the North American/Pacific plate boundary in California. In the San Francisco Bay Area, seismic slip is partitioned onto subsidiary structures, such as the San Andreas, Hayward and Calaveras faults, that are distributed across the Coast Ranges province.

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[4] Evapotranspiration is the total water loss due to evaporation from open water and transpiration from plant growth.

Figure 9 shows the major active faults in the San Francisco Bay area. Many of these faults have been active in historical time, while earthquakes on other major faults have not bee recorded.
The San Andreas and Hayward faults have the highest slip rates and are the most seismically active of any faults in the Bay Area. Other important earthquake sources that are capable of producing large-magnitude earthquakes are the San Gregorio, Calaveras, Rodgers Creek, and Greenville fault zones. The approximate distances between major faults and the project area, as well as other fault characteristics, are summarized below.

Major Faults Relevant to the Hamilton Field Site			
Fault Name and Type	Fault Length (km)	Horizontal Distance to Hamilton Field Site (miles)	Maximum Moment Magnitude (Mw)
San Andreas Right Lateral strike slip (rl-ss)	470	12	7.9
San Gregorio (rl-ss)	129	12	7.7
Hayward (rl-ss)	86	6	7.2
Rodgers Creek (rl-ss)	63	5.5	7.1
Calaveras (rl-ss)	52	33	7.0
Concord-Green Valley (rl-ss)	66	18.5	7.1

Historically, the most active components of the fault system are: the San Andreas fault, source of the 1906 Magnitude 8.2 earthquake and 1989 Magnitude 7.1 (Loma Prieta) earthquake; the Hayward fault, source of the 1836 and 1869 earthquakes; and the Calaveras fault, source of the 1911 Magnitude 6 and 1984 Magnitude 6.2 earthquakes. There are no known reports of damage or ground movements associated with the Loma Prieta earthquake at the project site.

3.3.8 Soils

The Hamilton Field site was reclaimed from low-lying tidal mashes adjacent to San Pablo Bay. Site grading produced fills consisting of up to 5 feet of gravelly sands, sands, and clays within the airstrip and the levee areas. In localized areas near the levees, and in areas along the deeper utility lines, fills of up to 10 feet in thickness can be found. Beneath the fill are natural, fine-grained, bay and marshland deposits commonly known as Bay Mud.

The Bay Mud typically consists of normally consolidated and lightly overconsolidated, highly plastic clays. Variable amounts of organic material (including interlayers of peat) and numerous small shell fragments are commonly incorporated into the Bay Mud. Stream and channel deposits, occurring as discontinuous lenses of silt and sand containing gravels locally, interfinger with the Bay Mud in areas near the hillsides along the western perimeter of the air field.

The Bay Mud is soft and plastic when wet but tends to shrink, harden, and become brittle when dried. Therefore, the Bay Mud in this area can locally be described as having an upper layer of stiff, desiccated Bay Mud (0 to 5 feet in thickness) and a lower horizon of soft and saturated Bay Mud. These two layers are termed “Bay Mud Crust” and “Bay Mud.” The Bay Mud thickness increases generally to the east across the site towards San Pablo Bay. The thickness of the Bay Mud is highly variable, ranging from a few feet near the northwest part of the property to more than 70 feet in the vicinity of the outboard levee.

The Bay Mud layer is underlain by thick deposits of very stiff clays. Over most of the site there appears to be a relatively thin layer of very stiff to hard clay that may be of alluvial origin. Below this layer is an extensive deposit of Old Bay Clay (also known as Yerba Buena Mud) of variable thickness. The thickness of the Old Bay Clay increases from west to east towards San Pablo Bay. The higher relief areas to the west and south of the Hamilton Field site are generally underlain by sandstone and shale bedrock from the Franciscan Complex of Jurassic to Cretaceous age. This unit apparently underlies the fill, the Bay Mud, and other geologically young sedimentary deposits beneath the site. A clayey weathering horizon typically develops on the bedrock foundation at the contact with the overlying deposits. Alluvial/Colluvial deposits, composed of sands and silts, are also present in some areas between the Bay Mud and the bedrock. These materials are thought to have been deposited in channels eroded into the bedrock. More recent alluvial deposits interfinger with the Bay Mud along the margins of the intertidal zone.

3.3.9 Geotechnical Considerations

The area of the proposed wetland restoration is presently below sea level (typical elevation -5 feet) and is protected from tidal inundation by flood control levees along San Pablo Bay and a system of drainage trenches and pumps. The water table is typically located several feet below the surface, and is seasonally variable. As shown on Figure 10, the area is underlain, below a thin near-surface "crust", by soft marine clays known as Bay Mud to depths which vary from up to 70 feet near San Pablo Bay to 30 feet and less in the northwestern end of the site. The crust is composed of desiccated Bay Mud over the entire area and, in many locations, especially on the HAAF site, by a few feet of granular fill and, in the runway and taxiway areas, pavement.

Bay Mud is a plastic silty clay, with high compressibility, low shear strength, and generally low permeability. Bay Mud is underlain by much stronger and less compressible, competent soils. New fill loads placed on top of areas underlain with Bay Mud cause compression of the mud, which in turn requires more fill to be placed. This compression also causes uneven settlement of the surface.

Depending on the depth of the soft Bay Mud, the settlement may take from 10 to as much as 50 years to develop. Figure 11 illustrates the anticipated settlement estimates based on past Bay Mud settlement history. It also distinguishes between large-area loads and more localized loads, such as applied by newly built and modified levees, which cause somewhat smaller settlements.

Fills applied over limited areas, such as levee fills, cause shear stresses in the Bay Mud that, should they exceed the soil's shear strength, will cause stability failures. Therefore, new levees have been designed with geometries that provide adequate stability, which, in some cases, required stabilizing berms.

As part of the wetlands restoration project, new levees and berms have been or will be constructed to contain approximately 7 million cubic yards of wetland fill material dredged from all around the San Francisco Bay area and to replace the flood control currently provided by the outboard levee once it is breached. Key design consideration for the USACE include the potential impacts of the new embankment and wetland fill on the existing levees as well as on the residential and commercial properties that have been constructed very close to the project limit.

Another key concern is the site elevations which have subsided six to seven feet below mean sea level. The subsidence is considered the results of diking and the presence of soft, highly compressible marine clays locally known as Bay Mud. Due primarily to its high compressibility and low strength, the soft Bay Mud poses considerable challenges to the development of the site as a wetland due to the difficulty in predicting the settlement and stability of the levees, berms and dredged fills that are part of this project.

3.3.10 Existing Infrastructure

The following sections describe the site infrastructure prior to the HWRP site construction. They are shown in Figure 31.

Runway: Within the HAAF parcel, the approximately 3-foot-thick concrete runway slopes gently downward for 6000 feet from northwest to southeast and extends over the length of HAAF's southern side. Various taxiways and aprons are associated with the runway.

Revetment Area: The revetment area is located in HAAF's northeastern quadrant and is transected by concrete-paved taxiways that connect 28 circular revetment turnouts. Twenty-four of the revetment turnouts are paved with concrete and the remainder are asphalt (Woodward Clyde, 1996). Many of the revetments have been removed during the BRAC cleanup and others have been removed by the wetland project. Remaining taxiways that lie in the path of the predicted deeper tidal channels will be removed in 2008 prior to the placement of dredged material in those areas.

Structures: The HAAF parcel contained twelve small outbuildings associated with the airstrip and revetments. The hangar was removed as part of the BRAC process, while the most of the remaining buildings were demolished and removed by this project in 2004. Building 82 will be demolished along with the SLC parcel structures in the winter of 2007 and the remaining airfield pumphouses will be demolished after dredged material placement when they are no longer needed by the project.

Structures on the SLC parcel include two buildings associated with the antenna array, buildings associated with the shooting range, and two other small outbuildings. These buildings are scheduled for demolition in the winter of 2007. The Novato Sanitary District's (NSD) dechlorination facility will be demolished at a later date.

Utilities: A six-inch diameter fuel pipeline, formerly used to supply storage tanks that were present on the site, transects the airfield and extends 18,000 feet into the bay. This pipeline has been closed. The pipeline portion lying on upland area has been removed and the remaining portion lying in the bay has been abandoned in place.

Power supply lines to the pump stations run along the outboard levee from the south. A new power supply line from the PG&E towers on the BMKV property is being constructed to supply the pump stations and offloader.

The Novato Sanitary District's sewer outfall pipeline runs along the entire northern boundary of the HAAF site, including a recently abandoned dechlorination station next to the pipeline about 1,300 feet west of the levee. A power supply line extends from the HAAF pump stations to the dechlorination station. The water supply line along the same route has been abandoned. Antenna installations and associated cables are on the SLC site. Other facilities are also on that site including above-ground fuel tanks, transformers, target practice ranges, and burn pits. The SLC parcel is presently being investigated under the FUDS (Formerly Utilized Defense Sites) program, and any needed environmental remediation would be implemented subsequently. This infrastructure that is not associated with the FUDS cleanup is scheduled for demolition and removal in the spring of 2008.

3.3.11 Special Status, Culturally Significant, and Invasive Species

Special-Status Species: Table 3-5 lists the special-status wildlife species known to occur within the project site. A complete list of potential special-status species is contained in the EIS (Jones and Stokes, 1998). Four of the seven species utilize wetland habitat and two of the raptors forage in wetlands and grassland. A survey was conducted for special-status plant species and none were identified (USACE, 1996). No trapping has been conducted to determine the presence of the salt marsh harvest mouse; however, this study assumes that the mouse is present in the existing pickleweed marsh.

Table 3-5 Special-status species observed at Hamilton Army Airbase

Common and Latin Name	Status	Habitat
California clapper rail (*Rallus longirostris obsoletus*)	State and federal endangered	Cordgrass marsh, tidal sloughs
California black rail (*Laterallus jamicensis coturniculus*)	State threatened	Pickleweed marsh and grasses at edge of marsh
San Pablo song sparrow (*Melospiza melodia samuelis*)	State species of special concern	Tidal marsh
Salt marsh common yellowthroat (*Geothlypis trichas sinuosa*)	State species of special concern	Salt marsh and fresh water emergent marsh
Northern harrier (*Circus cyaneus*)	State species of special concern	Marshes and grasslands for foraging
Short-eared owl (*Asio flammeus*)	State species of special concern	Marshes and grasslands for foraging
Burrowing owl (*Athene cunicularia*)	State species of special concern	Grassland with ground squirrel burrows
Salt marsh harvest mouse *(Reithrodontomys raviventris)*	State and federal endangered	Tidal Marsh

3.3.12 Existing Jurisdictional Wetlands and Waters in Diked Baylands

A USACE certified wetland jurisdictional delineation of 87 acres on the HAAF site is in effect until February 23, 1999. This delineation has not been updated. A wetland delineation, identifying 16 acres of jurisdictional waters of the United States, was performed in January 1998 on the interior portions of the SLC site, and currently is in the process of being certified by the Corps. A delineation defines the area of wetlands and waters of the U.S. that are subject to the USACE's jurisdiction, pursuant to Section 10 of the Rivers and Harbors Act of 1899, and Section 404 of the Clean Water Act (33 USC 1344). A delineation does not define the functions and values of the wetlands, waters, or other non-delineated areas that may provide value to wetland-associated species. The functions and values of the site have been identified as part of a Habitat Evaluation Procedure conducted by the U.S. Fish and Wildlife Service (FWS).

3.3.13 Cultural Resources

The HAAF parcel has been surveyed for cultural resources, and no known prehistoric or historic archaeological resources are present on either of the parcel (Archaeological Consulting and Research Services 1979a, 1979b; Chavez 1986; Environmental Science Associates 1993). The HAAF parcel includes elements of the former Hamilton Army Airfield Historic District, but as it is currently delineated (Figure 14-1), no portions of the proposed revised Hamilton Historic District are in the APE for the Hamilton Wetland Restoration Project (PAR Environmental Services 1998). Although the potential for these parcels to contain prehistoric or historic resources is considered low, resources may exist beneath the surface.

The SLC parcel has not been surveyed for cultural resources. Remnants of the site's previous use as an Air Force antenna field are scattered throughout the site, including an array of seven 50-foot-tall poles topped by antennas, a concrete operations building, a concrete generator building, a paved parking area, and numerous concrete footings. In addition, in the southeastern corner of the area is the former Air Force rifle range. Because the SLC parcel was formerly part of San Pablo Bay, it is highly unlikely that prehistoric resources are present on the site; however, offshore archaeological resources (e.g., fishing camps, wharves, sunken ships and boats) could be present.

4. Planning, Design and Permitting Process

This section describes the planning and implementation context for this Preliminary Restoration Plan.

4.1 PARTIES UNDERTAKING THE RESTORATION PROJECT

The project sponsors include the USACE and the SCC. The USACE is the federal sponsor providing 75% of the project costs the Conservancy is the state sponsor providing the remaining 25% of costs. The project design was developed by the USACE and SCC with technical assistance from BCDC, and several contractors working for both USACE and the SCC, including Polson Engineering, Philip Williams and Associated (PWA), FarWest Restoration Engineering, Moffat and Nichol, 2M and Bruce Pavlik, as well as many others who have provided advice and technical expertise.

4.2 PLANNING PROCESS

The initial Hamilton Restoration Plan was developed jointly by the SCC and BCDC. Coordination with other agencies has been performed throughout this study to ensure that problems, concerns and opportunities that could be addressed through water and related land resources planning received the broadest possible attention. The Hamilton Restoration Group (HRG) was formed including Federal, State and local agencies, environmental groups and local citizens. The HRG met regularly to identify and resolve issues related to wetland restoration at Hamilton Army Airfield. Input from the HRG was solicited by the SCC's consultant team and was incorporated into the design. The team completed the *Draft Hamilton Wetlands Conceptual Restoration Plan* in April of 1998 (Woodward-Clyde, 1998).

The USACE, San Francisco District prepared a Section 204 *Initial Appraisal of the Hamilton Army Airfield Wetland Restoration Project* in accordance with the Water Resources Development Act of 1992. This report was submitted to the Commander, USACE in December 1997. In that same month, Headquarters approved the appraisal as the reconnaissance level document providing the basis for proceeding into the feasibility phase of planning under the General Investigations program. A Feasibility cost sharing agreement was executed between USACE and the SCC on April 8, 1998.

During the feasibility phase, the project team completed a Feasibility Report (USACE, 1998) and National Environmental Policy Act (NEPA)/California Environmental Quality Act (CEQA) documentation (Jones and Stokes, 1998). The EIR/EIS solicited comment from the public at large and government agencies. These comments were considered and incorporated into the design as feasible.

4.3 PERMITS

In 2005, the SCC and USACE applied for and received waste discharge requirements from the San Francisco Bay Regional Water Quality Control Board (SFRWQCB) (Board Order No. R2-2005-0034, dated July 20, 2005) and a permit (BCDC Permit No. M23-05, dated April 10, 2006) and consistency determination (BCDC CN No. 05-07, dated September 7, 2005) from BCDC. In addition, USACE consulted with the U.S. Fish and Wildlife Service (FWS) and NOAA Fisheries Service (NOAA) regarding potential effects of the project on endangered species as required by the Federal Endangered Species Act and the Magnuson-Stevenson Act. The FWS issued a biological opinion (BO) on July 20, 2005 and NOAA issued biological opinion and Essential Fish Habitat recommendations on August 9, 2005. Each of the authorizations contains terms and conditions for the project that require specific actions or changes to the HWRP as described in the 1998 Feasibility Study. The feasibility level project design has been modified to meet the terms and conditions, and the project team continues to complete the required actions as necessary during construction of the site.

5. Opportunities and Constraints

This section describes the key project opportunities and constraints that were incorporated into the project design. In general, the HWRP offers the opportunity to expand and enhance a contiguous band of tidal and seasonal wetlands adjacent to San Pablo Bay. A large, complex tidal marsh system, dominated by pickleweed and cordgrass is anticipated for the project. The site also provides the opportunity to create extensive seasonal wetland and upland habitats, as well as transitional zones between these habitats. However, there are several constraints that had to be accounted for in the project design, as described below.

5.1 KEY FACTORS

The HWRP PDT identified six key factors that are important to address with the project design:

1. Ecological Resource Opportunities
2. Impacts to Existing Wetlands and Habitat
3. Reduce Impacts of Aquatic Dredged Material Disposal
4. Flood Protection Constraints
5. Infrastructure Constraints
6. Invasive Pest Species Constraints
7. Containment of DDT soils
8. Public Access Opportunities

Each of these factors is discussed in the following sections.

5.1.1 Ecological Resources Opportunities

The large size of the Hamilton Wetlands Restoration site allows for creation of a diverse, complex, and self-sustaining wetlands system with a habitat continuum from upland to tidal wetlands, providing rare transitional habitat and seasonal wetlands along SF Bay. The project design has incorporated a wide variety of restoration elements including seasonal and tidal wetlands along with tidal panes and transition habitat. The site also abuts a large undeveloped diked historic baylands (Bel Marin Keys V, approx 1,600 acres). As this site is incorporated into the project, this would provide for a very large 2,500-acre area of contiguous wetland.

The location of the project site adjacent to San Pablo Bay is an opportunity because of the adjacent source of tidal waters, sediments, nutrients, and colonizing plants and animals. The site is also adjacent to the migratory pathway of anadromous fish through the estuary. The project can provide critical habitat areas for these fish. In addition, there are existing large areas of tidal mash and riparian environments within close proximity to the site to provide cumulative habitat benefits. The extent of subsidence allows natural sedimentation to create a tidal wetlands with a high density of smaller channels. These smaller channels provide significant habitat benefits. Therefore, targer channel complexity in combination with the size of the site provide for greatly enhanced biological function and value.

Fresh water flows into this site at three locations (the NHP west and east outfalls, and the panhandle drainage) and may be used to augment seasonal wetland habitat to provide local variability in salinity and habitat composition, thus increasing habitat values.

5.1.2 Impacts to Existing Wetlands and Habitat

Mature tidal marsh lying between the HWRP site and San Pablo Bay (the 'outboard marsh') will be impacted by construction of a pilot tidal channel through the marsh during breach construction. The design has minimized these impacts through the construction of a pilot channel and allowing natural erosion to enlarge the channel to the required dimensions. If the anticipated channel dimensions are not achieved through natural erosion, additional excavation may be undertaken in consultation with the regulatory agencies.

Endangered and special-status species occur within and adjacent to the HWRP site. Construction impacts to these species must be minimized, therefore protection measures and monitoring of these species are incorporated in all construction and dredging contracts.

5.1.3 Reduce Impacts of Aquatic Dredge Fill Disposal

The project design calls for dredged sediment to speed up restoration at the site. Beneficial reuse of dredged sediments is a cornerstone of the LTMS process developed for San Francisco Bay. At completion, the HWRP will beneficially reuse approximately 10 million cubic yards of dredged sediment to restore bay habitats and thereby reduce the volume of aquatic fill by this amount.

5.1.4 Flood Protection Constraints

The design provides for flood protection for adjacent properties that currently drain to the HWRP site. A perimeter flood protection levee has been constructed for tidal flood protection.

Surface water management, detention, and drainage from adjacent properties (Landfill 26, the NHP West outfall, Pacheco Pond, and Reservoir Hill) have been integrated in the project design and will be maintained during site construction and filling period.

5.1.5 Infrastructure Constraints

The site design has to accommodate existing infrastructure remaining from the site's past use as an air force base. In particular, there is the airplane runway which will be buried under dredged fill. Tidal channels may not form to their equilibrium dimensions in areas where erosion resistant surfaces (e.g., the runway, pavement, or containment areas) prevent downcutting. These impacts have been minimized in the site design by using wave berms to direct the largest tidal channels away from paved areas and by excavating concrete in the paths of the major tidal channels.

5.1.6 Invasive Pest Species

Tidal action will be restored to the site once dredged material placement is complete. Seeds and propagules of salt marsh plant species will colonize areas around the fringe of the tidal area almost immediately. Other areas will colonize as sedimentation processes create the target elevations. In addition to desired species such as pickleweed, smooth-leaved cordgrass, jaumea and gumplant, other invasive species have the potential to colonize. This problem is inherent in all restoration projects. The invasive species of greatest concern are eastern cordgrass (*Spartina alterniflora*) and hybrid (*Spartina alterniflora* × *Spartina foliosa*) crosses between eastern cordgrass and the native species. Both of these grow taller and denser than the native species and are able to out compete it for space. Neither *Spartina alterniflora* nor the hybrid cross have been identified in the immediate area, but have recently been identified in the Petaluma River and further south in San Rafael. It is possible that invasive cordgrass could colonize the outboard marsh in the 8 years remaining before the placement of dredged material is complete.

The restoration project will incorporate measures to prevent the establishment of invasive cordgrass on the project site. Initially the outboard marsh will be surveyed for the presence of S. *alterniflora* or hybrids. If either are found, they will be eradicated prior to breach. The Monitoring and Adaptive Management Plan (AMP) will include monitoring and eradication of any invasive cordgrass that may become established on site.

Invasive cordgrass eradication is still in experimental stages in the Bay area. While physical methods have met with limited success, recent uses of approved herbicides (Imazapyr) have yielded promising results. Eradication methods employed by the project will be consistent with the methods employed region-wide, whatever those may be at the time.

The AMP will also monitor for other problematic invasive salt marsh species such as *Lepidium* and will contain measures for eradication if necessary.

5.1.7 Containment of DDT- and PAH- Containing Soils

The HAAF has been in the Base Realignment and Closure (BRAC) process since 1988. Hamilton Airfield had a number of contaminated sites, which were identified in the Record of Decision/Remedial Action Plan (ROD/RAP) (August 2003), co-authored by the Department of Army, the California Department of Toxic Substances Control (DTSC), and the Regional Water Quality Control Board (RWQCB). The ROD/RAP classified the HAAF sites according to the required actions using four alternatives: Alternative 1, no further action necessary, Alternatives 2, excavation and offsite disposal (by BRAC), Alternative 3, manage in situ with monitoring and maintenance (by BRAC), and Alternative 4, manage on site as part of the HWRP. The Alternative 2, and 3 sites were to be handled by the US Army BRAC program under the CERCLA process. However, there were several Alternative 4 sites containing low levels of PAHs and/or DDTs contamination that were the responsibility of the HWRP. The residual levels of DDTs and PAHs were thought to be from application or construction materials and were not considered to be eligible for action by the US Army BRAC program under the CERCLA process. Since these residual levels of DDTs and PAHs were determined to potentially impact the proposed wetland habitat, the responsibility of addressing these residual contaminants was assigned to the US Army Corps of Engineers as part of the HWRP. In addition to, and in conjunction with the ROD/RAP, the USFWS issued a Biological Opinion (BO) and the RWQCB issued a Site Cleanup Requirement (SCR) to guide the HWRP management of the DDT and PAH containing soils. The USFWS also issued a second BO for the HWRP activities on the Main Airfield BRAC Parcel.

The Corps developed a Soil Management Plan (SMP) in 2004 to describe the Corps' methods for complying with the ROD/RAP, BO and RWQCB order. The SMP included a plan to relocate soil material with residual levels of DDTs and/or PAHs from the tidal wetland area to the seasonal wetland area of the project site except for three areas. The three areas are in the tidal wetland and are located at the periphery of the site where 3 feet of cover can be maintained in accordance with the ROD/RAP. Since there will be no tidal scouring in the seasonal wetland area, 3 feet of cover will be placed and maintained over these soils with the residual levels of DDTs and PAHs. This will provide protection for the wetland habitat and endangered species. The RWQCB also issued Board Order No. R2-2005-0034 which provided Waste Discharge Requirements (WDR) for the HWRP. The 3 feet of cover will be constructed by importing dredged material from the San Francisco Bay area that meets the Dredged Material Acceptance Criteria of the WDR and the USFWS July 20, 2005 BO..

All of the DDT/PAH containing soils (apart from the three exempted sites) within the Tidal Wetland area were excavated and moved to the Seasonal Wetland areas in 2004. Two other soil movements not contained in the original SMP were added and will be covered by addendums to the SMP. The first is in the Northern Seasonal Wetland, which contained several areas of low-level

DDT that were within the footprint of the future tidal/drainage channel. These areas were excavated in 2007 and taken off site to be used as surcharge by the Barker Pacific Group (BPG) under an agreement with the SCC and will be returned to the Southern Seasonal Wetland in 2008. The second area, which as of December 2007 is the only remaining DDT-containing soils that still require excavation and movement, is in the Southern Seasonal Wetland in areas where a future tidal/drainage channel will be located. These soils will likely be moved (with approval of an additional SMP addendum by the RWQCB) by Summer 2008.

Figure 3 summarizes the areas where low level DDT was excavated or will be excavated as well as the areas where these DDT soils were placed or will be placed.

RELEVENT DOCUMENTS

a. San Francisco Bay RWQCB Order R2-2003-0076 – Site Cleanup Requirements (SCR) for Hamilton, adopted on August 20, 2003.
b. Record of Decision / Remedial Action Plan (ROD/RAP) dated August 2003 for the Main Airfield Parcel at Hamilton.
c. US Fish and Wildlife‘s Endangered Species Formal Consultation (Biological Opinion) dated August 22, 2003 and amended by a US Fish and Wildlife letter dated Sep 10, 2003.
d. Morphologic Modeling of a Maximum Containment Design by Philip Williams & Associates (PWA)
e. Results of Area-Wide DDT Site Investigation Report by the US Army Corps of Engineers, Sacramento District plus Addendum.
f. PAH investigation near the Main Runway by the US Army Corps of Engineers, Sacramento District.
g. San Francisco Bay RWQCB Order R2-2005-0034 – Waste Discharge Requirements and Water Quality Certification, Hamilton Wetland Restoration Project, Novato, Marin County, adopted on July 20, 2005.
h. US Fish and Wildlife‘s Endangered Species Formal Consultation (Biological Opinion) dated July 20, 2005.

5.1.8 Public Access Opportunities

The proposed project includes providing public access to the Bay as part of the Bay Trail as shown in Figure 35. Originally, the Bay Trail plan showed the trail alignment along the bay front levee, connecting the Las Gallinas property's informal trail to the south to the Bel Marin Keys Unit V parcel along the bay front to the north. This alignment posed several problems identified as the project design was further developed. As designed, the project included breaching the bay front levee to allow tidal access to the site. In addition, the bay front levee would either be degraded or be allowed to subside over time, returning it to tidal marsh. These two factors made the bay front trail alignment infeasible. In addition, this trail alignment had the greatest potential to impact wildlife at the site. For these and other reasons, the Bay Trail was realigned along the western edge of the site, connecting to the Bay Trail at Bel Marin Keys Parcel V in the north along Pacheco Pond. The southern portion of the trail currently does not connect to the Las Gallinas property as required by the Terms and Conditions the U.S. Fish and Wildlife Service Biological Opinion, but rather ends in an overlook 700 feet from the tidal marsh in the southwestern corner of the site. Section 7 below discusses public access in more detail.

5.2 ADDITIONAL CONSIDERATIONS

5.2.1 Adjacent Properties and Land Uses

The project is bordered on the south by the Las Gallinas wastewater spray fields, to the west by residential properties, including the officers' residences for the U.S. Coast Guard, and to the northwest by Reservoir Hill, a small landfill, Ammo Hill and Pacheco Pond, a flood control and wildlife area. To the northeast lies Bel Marin Keys parcel V, an abandoned antenna field and the Bel Marin Keys Community Service District (a residential community surrounded by locked lagoons). Las Galinas wastewater spray fields and Bel Marin Keys parcel V (currently in hay production), Pacheco Pond and Ammo Hill represent large undeveloped tracts of land that serve some human needs, but also provide a large swath of habitat for many terrestrial native and non native species. The creation of the wildlife corridor within the restoration project will allow continued movement between these areas for a number of species. In addition, portions of these areas are also considered areas that would benefit from future restoration, particularly Bel Marin Keys parcel V, which has just been authorized through the Water Resources Development Act of 2007. If this parcel is added to the Hamilton project, it will constitute 2600 acres of tidal and seasonal wetlands rimmed with transitional habitat.

Restoring a large tidal wetland adjacent to residential areas also presents challenges and opportunities. Because residences were built so close to the airfield, disturbance from construction is a major concern. The project has addressed these concerns by minimizing dust by watering down dirt roads. Trucks are not allowed to idle adjacent to any residences, and construction hours conform to the City of Novato ordinances. A challenge for the project includes maintaining public safety on the site. Many of the neighbors have long used the Airfield for recreational purposes and wish to continue to do so during the project construction period. This is a major safety hazard for the public as large construction vehicles are moving throughout the site. Currently the public has been noticed that the project is under construction and entering the site is dangerous and considered trespassing. Signs and fencing have been placed in entry areas to alert the public to safety issues and that the site is off limits. A security guard has also been hired to direct traffic and to maintain closure of the site. This continues to be an ongoing challenge.

Public access trails have been developed and are scheduled to be open to the public in areas that are complete and safe for use. These trails will be phased in as the project progresses. Currently there are trails adjacent to the site, with Reservoir Hill trail offering a view of the entire project from a safe vantage point. Having the site adjacent to residences also offers opportunities. Many people have expressed interest in the project and it is likely that a pool of volunteers can be developed to assist with the planting of the seasonal wetlands and potentially monitoring of the success of these areas in the future. It is also likely that have a close-knit community nearby they will assist with maintaining the public areas for others in the future. There is also the opportunity to develop a interpretive center adjacent to the project, and with public support of the project it could become a reality that would a wonderful resource for Bay Area students.

The landfill area is shown in the Marin General Plan as a park. If this park is developed it will be an additional resource for recreational activities that are more appropriate in a park setting. It may replace some of the recreational space lost to the restoration project.

Lastly, the abandoned antenna field immediately adjacent to Hamilton is contaminated with lead and other heavy metals. It is currently considered a constraint as the clean up progress has been slow. It is currently under scoping and is scheduled for clean up in 25 years, well beyond the timeframe for restoring this area. The restoration project will either have to build support for cleaning up this area sooner, or develop plan to contain the contaminants on site, or restore the areas around it.

5.2.2 Utility Corridors (Novato San District, pipeline easements)

The Novato Sanitary District (NSD) operates a buried, pressurized (8 psi pressure), 54-inch-diameter, reinforced concrete sewer outfall that runs parallel and to the north (and east) side of the property line in an easement 20 feet wide. According to available records the NSD sewer was constructed in 1971. The centerline of the NSD sewer is located approximately 40 feet outboard of the centerline of the previous North-1 Levee. Because of the location and proximity of the new N-1 levee relative to the NSD outfall pipe, there was concern that significant lateral deformations would begin to develop that could impact the NSD sewer. To address this concern, the N-1 levee was constructed in stages with the first stage (Stage 1 fill) constructed to an elevation of +9.5 feet NAVD 88. A setback distance was also provided between the NSD sewer and the N-1 Levee to minimize potential movement of the NSD sewer. In addition, an instrumentation plan was implemented for monitoring pore pressures, settlement and lateral movement during and after construction of the N-1 levee. To date, the measured ground movement near the NSD sewer remains below the maximum acceptable limit. A similar set of procedures, with setbacks, staging, and instrumentation and monitoring are being followed for the current construction of the N-2 levee.

5.2.3 Future Sea-Level Rise

Sea level is rising in San Francisco Bay at a rate that is higher than at any time in the past 5000 years. Measurements at the Presidio tide gauge record average rates sea level rise of 1.12 mm / yr between 1854 and 1905, and 2.54 mm / yr between 1906 – 1999 (NOAA, 2001). This rate is slightly higher than IPCC (IPCC, 2007) estimates of sea level rise globally at less than 1.8 mm / yr during the 20th century because of tectonic effects. At the end of the 20th century the rate of global sea level rise increased, with between 1993 and 2006 measurements of 3.3 mm/ yr being recorded (IPCC, 2007). IPCC (2007) predictions suggest a global rate of sea level rise ranging over 1990 levels by 180 mm and 580 mm by 2100, with mid range values of 200 mm and 430 mm. However, these numbers have received considerable criticism since publication. The IPCC recognize that there understanding of glacial and ice sheet processes is less well refined than direct warming effects on ocean volume. A number of modeling studies as well as direct monitoring of ice bodies suggest that the IPCC (2007) report underestimates the contribution of melt water (Overpeck et al., 2006; Rahmstorf, 2006; Meier et al, 2007). Meier et al (2007) for example estimate ice melting may contribute between 78 ± 21 mm to 160 ± 65 mm by 2050 and 167 ± 44 mm to 560 ± 230 mm by 2100. This extend of glacial melt induced sea level rise would be in addition to the contribution due to sea warming which IPCC (2007) estimate to be between 180 ± 30 mm and 280 ± 120 mm by 2100.

5.2.4 Mercury Methylation

In recent years, scientific study has revealed that wetting and drying of soils, particularly in wetlands promotes production of methylated mercury, which is bioavailable to animals foraging in wetlands. Scientific study has also shown that mercury in animals and humans can cause neurological, developmental and reproductive harm. Because the project purpose is to restore the airfield to tidal action and to create seasonal wetlands in the northern and southern portion of the site, it seems likely that the project will produce methylated mercury. The supplemental environmental impact statement and report identified this issue as an unavoidable adverse impact of the project. The permitting agencies have required the development and implementation of a methyl mercury monitoring plan. This plan will be developed shortly after this restoration plan and will be vetted by a technical advisory committee.

While methyated mercury is a serious issue, it is unclear how much methylated mercury the site will produce. This is due in large part to the cyclic nature of the methylation process in that mercury both methylates and demethylates in tidal marshes. A major scientific question is whether there is a way to increase the demethytlation process within the habitat. Several scientists are examining this question and attempting to develop adaptive management measures to this end. In the event that such measures are developed and feasible at Hamilton, it is likely that they would be implemented at the project site. In addition, the Corps, through the Environmental Research and Development Center has been researching mercury methylation at Hamilton and Bel Marin Keys parcel V and has determined that methylation already occurs both on the site in drainage ditches and adjacent to the site in the fringing tidal marsh. Their continued research in development of appropriate monitoring methods will be helpful to the restoration project.

5.2.5 Mosquito Production

Wetland areas can create conditions favorable to the breeding of mosquitoes. I n addition to providing a nuisance to the human population, mosquitoes can be vectors for diseases such as West Nile virus. Due to the close proximity of the HWRP to residential areas, the project's potential for mosquito production has been carefully considered by the design team.

The design team is coordinating with representatives of the Marin/Sonoma Mosquito and Vector Control District to identify areas of concern and the potential for the minimization of mosquito production. The District's opinion is that the tidal portion of the site does not pose a significant risk of excessive mosquito production, especially of the type that carry West Nile virus. The District expressed concern that the seasonal wetland areas have the potential to generate problem mosquitoes. As a result, the design of the seasonal wetland areas allows for the management of mosquito production through control of water levels if necessary. Mosquito management is discussed in more detail in Section 8.1.2.

6. Habitat Restoration Design

This section describes the design of the various habitat types that will be created as part of the HWRP. It is separated into three sections, Seasonal Wetlands, which also includes tidal pannes and storm water drainage corridors; Tidal Wetlands; and Wildlife Corridor.

6.1 DESIGN OVERVIEW

The Hamilton Wetlands Restoration Project is divided in to three main design elements: Seasonal Wetland areas (including the Panhandle or Northern Seasonal Wetland, and Southern Seasonal Wetland), Tidal Wetland area, and Wildlife Corridor. Tidal Panne habitat is included within the seasonal wetland design. The design of transitional ecotone [5]is included within each major design element. Description of the preliminary design for the seasonal wetlands is provided in section 6.2, and conceptual design for the tidal wetland and wildlife corridor in sections 6.3 and 6.4, respectively.

A fourth major design element is the inclusion of public access via construction of a length of bay running from the Northern Seasonal Wetland, along the Wildlife Corridor to the Southern Seasonal Wetland (See section 7). In time this trail will connect with other sections on adjacent lands.

As of December 2007 all land has been purchased and construction is in an advanced stage in preparation for receiving dredged material from the Port of Oakland in late 2007 or early 2008. An estimated schedule of the remaining construction tasks and a design checklist for the construction of each habitat type is given in Appendix A.

6.1.1 DESIGN EVOLUTION

The process of successful restoration design is to set in place a design template (the initial shaping of the site) which guides the evolution of the wetland to a mature state via a combination of ecological succession and natural physical processes (See PWA and BMP, in prep a). The design is such that ecological value will be achieved as soon as the site is breached and connected to the Bay. The site will, however, follow an evolutionary path towards ecological maturity, which will take 20 year or more to achieve with respect to final elevation and vegetation. It should also be noted that the project will provide habitat benefits for shorebirds and waterfowl during the approximate 8 year period that the site is receiving dredged sediments.

5 A transition area between two distinct habitats, where the ranges of the organisms in each bordering habitat overlap, and where there are organisms unique to the transition area.

The evolution of wetlands at the HWRP at breach (T+0 yrs), breach + 20 years (T+20) and breach + 50 years (T+50) are schematically described in Figure 12 through Figure 14, respectively. The excavation of a pilot channel through the outboard salt marsh and breaching the outboard levee will, over time, bring full exchange between the Bay and the HWRP as the channel widens and deepens[6]. After breaching the levee, the tidal exchange will import sediment, which will raise site grades above the constructed mudflat surfaces (i.e. placed dredged material). Scour and deposition of sediments on site will create a channel network drainage system. Tides will also bring with them seeds of salt tolerant vegetation from adjacent salt marshes that will establish at the proper site elevations and wind-wave energy and substrate conditions. Over time, sediments will accumulate and vegetation will colonize across the site, creating a diverse array of habitat types. The rate at which the tidal wetlands area will evolve will depend upon the amount of wave energy within the site, the rate at which sediments are supplied from San Pablo Bay and the initial elevation of the placed dredged material.

The Seasonal Wetlands and the Wildlife Corridor are graded to specific elevations at or above high tide water levels. These areas will primarily evolve through vegetation and associated habitat changes. The ecology of these areas will be enhanced by the planting of native founder species, which will accelerate natural succession and provide a footing for preferred species.

Over time, as the seasonal wetlands and uplands settle and sea level rises, tidal inundation will become more frequent and lower areas of seasonal wetland will progressively evolve into tidal marsh pannes. In the Southern seasonal wetland area no adaptive management is proposed and as frequency of inundation increases, these seasonal wetlands will convert to tidal pannes and salt marshplain over several decades. At the Panhandle site, provision is made for active adaptive management of ponded water levels if desired. Inundation frequency and duration can be controlled in the Panhandle Seasonal Wetland by progressively adjusting the elevation of the weir in the culvert water control structures. Thus, through active management, the depth and duration of seasonal ponds might be prolonged. Alternatively, should monitoring determine that the ecological value of the seasonal wetland is declining with time the water control structures provide a range of potential adaptive management actions, including the ability to alter overflow and water level regimes. Ultimately, the Panhandle area might be maintained as seasonal ponds, or with increasing water depths associated with subsidence, converted to a muted tidal lagoon (through adjustment to the water control structures) or converted to tidal marsh (through removal of control structures). The seasonal wetland sites are graded such that future tidal channels should not scour deep enough to expose sediments containing residual DDT and PAHs placed within a portion of the seasonal wetland ponds (as per Consistency Determination CN No.07-05).

[6] Potentially, by not excavating through the expansive outboard mudflat low water levels within the HWRP may remain perched 1-2 ft above outboard low water levels. The economic and permitting implications of dredging the outboard mudflat have been recognized as a constraint within the design and the need for any further outboard mudflat dredging requirements will be monitored under an adaptive management plan.

The seasonal and tidal wetland areas will follow complimentary evolutionary trajectories. For example, for shorebirds the critical elements to support shorebird populations are feeding and roosting sites in proximity to intertidal mudflats. It is anticipated that during the early years of site development the tidal wetland area will dominantly consist of intertidal mudflat habitat. This habitat, over the first five or so years, will develop a diverse invertebrate ecology to feed shorebird populations (Atkinson et al., 2004; PWA, 2007). The rate at which invertebrates colonize will depend upon species and dispersal mechanisms. Over these early years, during which the tidal wetlands consists mainly of rich mudflat feeding habitat, the primary ecological function that the seasonal wetland will perform will be to provide safe roosting sites. In the Panhandle areas this will be achieved through creation of low island refugia within the seasonal pond complex. As the adjacent tidal wetlands evolve from predominantly mudflat to predominantly salt marsh habitat then creation of feeding habitat for shorebirds within the seasonal wetland complex will be of increasing value. With site subsidence, the lower areas of the seasonal wetland complex will fall within the tidal range. Eventually, with continuous subsidence and sea level rise, it is anticipated that most of the seasonal wetland areas will convert to vegetated tidal marsh, although there may still be fringing seasonal wetlands along the edge of the tidal marsh as naturally found around the Bay.

6.1.2 CONSTRUCTED ELEMENTS

A system of levees and berms have been or are being constructed to; contain the site features, prevent flooding of adjacent properties by replacing the flood protection of the existing bayfront levee, improve water quality during dredged material placement, reduce wave fetch in order to protect the perimeter levees and promote sedimentation after breach. A list of these constructed features follows and Figure 15 shows their plan locations.

1. The 7,200-foot-long **New Hamilton Partnership (NHP) Levee,** located on the western perimeter of the site, was constructed by the City of Novato to provide flood protection for the adjacent residential development. (Status: constructed in 1996 and raised in 2007). The USACE was concerned about the impacts of the construction that the new levees and wetland fill would have on the existing NHP Levee as well as on the residential structures. Estimates provided by consultants to the City of Novato (Geomatrix, 1998) had concluded that the construction of the wetlands might cause settlements of one to two inches to the existing structures, resulting from placement of 10 feet of new fill. Thicker fills obviously would cause significantly more settlement. To address this concern, the USACE contracted URS to conduct a study of the potential effects of levees and wetland fills on the adjacent properties. The NHP Levee Test Fill study was constructed, designed and monitored to evaluate the response of the existing NHP Levee and the surrounding ground to the placement of new fill for the construction of the planned wetlands (URS Corporation/ARUP, 2005a, 2005b, and 2005c).

2. The **Bulge Levee** extends between the north end of the NHPL Levee and the west end of the Pacheco Pond Levee. It is approximately 2,200 feet long, and was constructed in an area that is relatively flat. (Status: constructed in 2004).

3. The **Pacheco Pond Levee**. This segment was lapped against the south slope of the existing Pacheco Pond Levee. It is approximately 1,200 feet long. (Status: constructed in 2004).

4. The **North Levee** consists of two subsegments. The western segment is referred to as the North-1 Levee (**N-1**). It is approximately 4,000 feet long and extends from the east end of the Pacheco Pond Levee to the western end of the second segment of the North Levee, which is referred to as the North-2 Levee. (Status: constructed in 2005). The second segment of the North Levee, **N-2**, is approximately 5,200 feet long and extends from the southeast end of the N-1 Levee to the existing eastern outboard levee. (Status: Nearly complete as of Dec 2007).

5. The **South Levee** consists of two subsegments: (1) A short segment approximately 400 feet long, oriented in the north-south direction, referred to as the South-1 Levee. It extends between a rock outcrop at Long Point, at the south end, and the west end of the second subsegment of the South Levee. (2) The second segment of this levee is oriented in the east-west direction and is approximately 2,400 feet long, running between and parallel to two existing drainage ditches. The easternmost 700 feet of the South Levee has an intertidal bench to protect if from wave action (Status: Western 700 feet mostly complete, remaining portions were mostly completed but doe to construction complications will need to be completed in the Summer of 2008).

6. The Northern Seasonal Wetland **Containment Berm** was constructed under the same contract as the N-1 Levee to complete Cell 1. It is approximately 1,500 ft long and ties into the NHP levee on the southwestern end and the N-1 levee on the northeastern end. (Status: Constructed in 2005)

7. The **Tidal Panne Berm** is a containment berm that is approximately 1,500 ft long and ties into the Northern Seasonal wetland on the southwestern end and the N-2 levee on the northeastern end. (Status: Constructed in 2007)

8. The **Wildlife Corridor Berm** is a containment berm that spans about 6,600 ft between the NHP levee in the southeast and the Northern Seasonal Wetland Containment Berm in the northwest. (Status: Constructed in 2006)

9. The **Southern Seasonal Wetland Containment Berm** is a containment berm that spans approximately 1,300 ft between the Wildlife Corridor Berm and the South Levee. (Status: Nearly complete as of Dec 2007)

10. There are seven **Intertidal Berms** that are oriented in various directions within the Tidal Wetland area. They range from about 550 ft to 1,400 ft long. (Status: Berms 1 and 4 constructed in summer 2007, remaining berms constructed in fall 2007).

11. There are three **Extension Berms** that were included so that Cell 4 could be closed off for earlier dredged material placement. They connect Intertidal Berms 1 and 4 to each other and to the N-2 Levee and the Wildlife Corridor Berm.

12. **Settling Basin #1** consists of a ring-berm and was constructed in the northeast corner of the HAAF to be used as a secondary settling basin for decant water from the dredged material placement. It was located directly adjacent to the future breach location. (Status: Constructed in 2007).

6.2 SEASONAL WETLANDS

Approximately 52 acres of functioning seasonal ponds will be created within the 105 acres of the Panhandle and 29 acres within the 41 acre Southern portion of the Hamilton restoration site (Design Drawings: Figure 16 to Figure 24). Four habitat types will be constructed with dredged material in these areas: uplands, seasonal ponds, tidal pannes and stormwater drainage corridors (Habitat Plans: Figure 25 to Figure 27). Over a number of decades, as the dredged material settles and subsides, and sea level rises, the actual acreage of the non-tidal habitats will gradually decrease and lower elevations will transition to tidal wetland habitat. The seasonal ponds and wetlands will be interspersed across the non-tidal portion of the site as the result of topographic variability.

We recognize that this design approach using seasonal tidal overflows is experimental and that no passively managed, artificially constructed seasonal wetland system has so far persisted for more than a few decades. Therefore, we have adopted two design approaches: The Northern Seasonal Wetland, which will include water control structures to maximize potential of meeting habitat requirements and provide for adaptive management; and the Southern Seasonal Wetland, which will be graded to offer a transition of habitat from freshwater to saline defined by sill elevation relative to tidal waters. By adopting two design approaches, habitat diversity will be maximized across the Hamilton site. Though both wetland areas are design to operate with minimal management, both will include structures for draining the ponds should it be required for mosquito abatement purposes.

6.2.1 Design goals and objectives

Goal:

> *The HRG determined that the habitat goal for the seasonal wetlands is to provide shorebird habitat. The shallow water open water areas will provide important high tide shorebird roosting and foraging habitat for birds and small mammals that prefer to nest and live in freshwater and brackish environments. The shallowly unvegetated areas will be interspersed with seasonal wetlands containing brackish to saline ponds. These ponds will help to meet the goals of providing seasonal wetlands habitat.*
>
> (Woodward-Clyde et al., 1998)

Objectives:

Specific objectives for the seasonal wetlands are as follows:

- Maximize area of unvegetated shallow water habitat (<4 inches water depth) for shorebird feeding in the migratory period.
- Maximize unvegetated area for shorebird roosting in migratory period.
- Provide suitable feeding and roosting habitat in wet and dry years, and during El Niño and la Niña climatic events.
- Provide heterogeneity of habitat to accommodate variability in ecosystem processes.
- Provide for longevity of habitat function over decadal timescales, anticipating site subsidence and sea level rise.
- Incorporate ability to minimize mosquito breeding habitat.
- Minimize need for active management wherever possible.

6.2.2 Status and references

6.2.2.1 Design Documentation

The basis of the seasonal wetland design can be found in Seasonal Wetland Preliminary Design report (PWA, 2005) and updated in a subsequent memo specific to the Southern Seasonal Wetland; PWA 2007). A biological description of anticipated habitat including planting strategy and monitoring and adaptive management can be found PWA and BMP (in prep b), and ecological reference site material in PWA et al. (in prep).

6.2.2.2 Construction Status

The levees and berms for the northern seasonal wetland containment cell (cell 1) have been built and fill placement is anticipated for late 2007. The Wildlife Corridor Berm, which provides for material placement in Cell 2, comprising the wildlife corridor and northern part of the southern seasonal wetland, has been constructed. Borrow has been taken from on site. Dredged material is anticipated to arrive late 2007- early 2008. The Southern Seasonal Wetland Containment berm, which will contain the southern areas of the southern seasonal wetland is in design phase and will be constructed by summer 2008.

6.2.2.3 Design Linkages

The following list identifies design components that either exert an impact upon the seasonal wetland design should their construction be modified or may require design modification should changes to the seasonal wetland design occur. Any design modifications must take in to account linkages between seasonal wetland and tidal wetland design elements.

- Seasonal wetland functioning requires appropriate hydraulic connection to tidal wetland
- Seasonal wetland functioning requires appropriate water ponding capacity of surface soils.
- Location of landfill 26 pump station will influence Northern Seasonal Wetland Design
- Dredged material availability will potentially influence seasonal wetland grading plan
- Dredged material grain size will influence water ponding capacity
- Bay trail location will influence transitional habitat and potentially floodplain area in Northern Seasonal Wetland Stormwater Water Drainage Channel Area.
- Burial of low level-DDT soil requires 3ft of cover material and isolation from the path of channels should lateral scour or down cutting occur.

6.2.2.4 Tasks to be completed during final design:

- The location for the Landfill 26 pump has yet to be determined. In the existing preliminary design (PWA, 2005) this structure was anticipated to be located at the NW end of the Stormwater Drainage Channel. Other potential locations exist. Pump station location and Northern Seasonal Wetland drainage corridor design should be integrated.

- Management of water on land by Landfill 26. Currently, drains to the panhandle area through a culvert in the bulge levee. With material placement in the Northern Seasonal Wetland this conduit will become inoperable. Alternative management approaches for water ponded behind the NHP levee have yet to be defined.
- Agreement of approach to integrated Stormwater inflow from NHP East pump station to southern seasonal wetlands has yet to be completed.
- Bay trail location to be determined and preliminary design completed.

Design Strategy

The development and maintenance of pannes and ponds suitable for shorebird roosting and feeding as distinct features in the wetland landscape largely depends upon water and salt balance (PWA, 2005; PWA and BMP., in prep). Unlike sedimentation processes that dominate formation and vegetation succession in tidal wetlands, the storage processes for water and salt dominate formation and succession in seasonal wetlands. Plant species that colonize and persist along the margins of pannes must not only tolerate prolonged inundation, and at elevations susceptible to tidal flooding, the resulting high levels of soil salinity.

The overall design strategy used for the seasonal wetlands was to create a series of ponds at various elevations to allow for a range of tidal inundation. Because the creation of sustainable seasonal wetlands using dredged material is experimental, two approaches to wetland creation have been adopted. In the Northern Seasonal Wetland, water control structures have been included to provide for optimization of water and salt inflow. In the Southern Seasonal Wetland, a more natural, open system governed by tidal inundation has been adopted.

The design approach takes into account vertical tolerance of up to two feet due to the long-term settlement of the dredged material placed on the site, and long term sea level rise. The amount of settlement can vary at different locations and is difficult to predict. Therefore, a series of ponds are graded at different elevations to provide heterogeneity and resilience of the desired habitat to these anticipated variable changes. The intent is to provide at any given time in the migration season a range of salinities and ponded water depths on site.

6.2.3 Design criteria

The templates for the northern and southern seasonal wetlands incorporate the following design criteria based upon the conceptual model for seasonal wetland functioning (PWA, 2005).

6.2.3.1 Ponding Depth

The optimum water depth for shorebirds feeding and roosting is less than four inches. The extent of this habitat will be maximized through the migratory season, and be available at varying water elevations.

6.2.3.2 Ponding Period

Shallow water habitat should be maintained where possible from October through April to support migratory shorebirds and incidental benefits for wintering waterfowl.

6.2.3.3 Vegetation Control by Salinity to Sustain Roosting and Feeding Habitat

Field assessments confirm that concentrating salts in the pond water column results in increased soil salinities as ponds desiccate during spring/summer months (PWA 2005, Appendix E). As this occurs, the build up of salts in soils, accompanied by the seasonal, prolonged wetting and drying will restrict vegetation colonization. Water salinities >50 ppt are found to increase soil salinities sufficiently to preclude vegetation encroachment on a portion of the site with prolonged flooding, and these high salinities will be most effective in precluding vegetation early in the growing season (May - July).

6.2.3.4 Habitat Resilience

Rainfall and tidal water elevation may vary considerably from year to year, especially between El Niño (wet) and la Niña (dry) climatic events. The duration of ponding will be determined by the occurrence of rainfall and or high tide inundation. The lower pannes will be inundated by tides even in the driest years, providing shallow water habitat. The site will provide habitat in extreme wet and dry years. Ponds should be graded to allow shallow-water feeding and unvegetated roosting habitat during these events of climatic variability. Additionally, extreme high tide conditions should not damage the integrity of the seasonal wetland pond margins, sills or any water control structures.

6.2.3.5 Habitat Persistence

The site is designed to sustain unvegetated, shallow-water, seasonally flooded areas for a period of 20-50 years. This capacity will be met by providing an adequate supply of salt to brackish ponds and by providing site-wide topographical heterogeneity to accommodate long-term sea level rise. The habitat is expected to ultimately transition to tidal marsh habitat over several decades.

6.2.3.6 Allowance for Settlement

The final grades in the seasonal wetlands should include topographic heterogeneity to accommodate differential and absolute settlement during and after construction. Simple water control structures are incorporated to increase water management capacity, as needed.

6.2.3.7 Scale of Habitat Areas

The design will provide shallowly flooded regions of greater than 4 acres in size; recognized to be of particular value as shorebird habitat.

6.2.3.8 Mosquito Control

The capacity to drain individual ponds after the shorebird migratory season will be included in the design wherever practical as an option for adaptive management to mitigate any arising mosquito breeding concern.

6.2.3.9 Tidal Channel Scour

Buried soils in the northern seasonal wetland requiring a minimum thickness of 3 feet of cap cover will be protected from tidal scour while in the seasonal wetland system. Tidal/stormwater drainage channels should be located to not erode the cap material when the northern site eventually converts to tidal wetland.

6.2.3.10 Stormwater Management

Stormwater from the local catchment will be conveyed past the seasonal wetland areas via drainage channels.

6.2.3.11 Impermeable Mud Cap

An impermeable surface is required to pond water within the seasonal pannes. Should pond water seep in to the soils at rates higher than 0.17 in./day salts will be lost resulting in desired bare ground areas becoming vegetated.

6.2.3.12 Stormwater Drainage Channel thalweg depths

Channel thalweg shall not cut to a depth as to expose underlying concrete surfaces.

6.2.3.13 Adaptive Management

The design for the northern seasonal wetland will accommodate adaptive management for habitat improvement should monitoring data identify failure to meet design objectives. Should the pannes in the southern seasonal wetland not function as intended, then the water control structures for mosquito abatement may be removed to create extensive areas of high marsh mid to high intertidal transitional ecotone.

6.2.4 Preliminary grading plan

The grading plans for the Northern and Southern Seasonal Wetlands are provided in Figure 16 to Figure 24 and artistic impressions in Figure 25 to Figure 28.

6.2.5 Description of habitat features

The following habitat features are included in the design.

6.2.5.1 Upland and transitional habitat

Uplands and transitional habtiats will exist around the margins of the seasonal wetlands and will be scattered through the seasonal wetland complex (Figure 25 and Figure 26). They will provide roosting and nesting habitat for many bird species. The upland areas will be inundated by direct rainfall, with some of the rainfall infiltrating into the soil and the remainder running off as surface flow to the ponds. Some temporary shallow ponding occurs in the upland areas during and immediately following storm events. These ponding events are not of a depth or duration that allows for the establishment of hydrophytic vegetation or anaerobic soil conditions. The upland areas will be grassed habitat (likely a mix of native and non-native grasses, forbs and shrubs). In the ecotone between the upland and marsh, a patchwork of vegetation that includes pickleweed (*Salicornia* spp.), alkali heath (*Frankenia salina*), Australian saltbush (*Atriplex semibaccata*) and spearscale (*Atriplex* spp.*)* will grow at the lowest elevations adjacent to tidally influenced wetlands where soil salinities are elevated. Native plants including perennial shrubs such as Coyote Bush (*Baccharis pilularis*) and Toyon (*Heteromeles arbutifolia)* will be selectively planted to encourage ecological diversity on upland and transitional areas. A non-native species, Brassbutton (*Cotula spp.)* has been found to occupy a niche in transitional wetland / upland habitat in San Pablo Bay and is most likely to occur at the Hamilton Wetlands Restoration Site.

6.2.5.2 Seasonal Wetland pannes/ponds

Seasonal wetlands will be created in shallow depressions (pannes) ranging in size from less than 3 acres to over 10 acres. Pannes will pond water for prolonged periods (on the order of several weeks to several months) from seasonal, direct rainfall and high spring tides. The heterogeneous topography, with depressions of varying sill elevations relative to tidal waters, will create a diverse ecology across the two seasonal wetland areas. Pannes with sill elevations higher than 7.5 ft NAVD 88 will largely be freshwater habitat. Pannes below this elevation will be subject to infrequent tidal inundation and will concentrate salts, thus precluding or limiting salt-intolerant vegetation.

6.2.5.3 Tidal Pannes

Tidal pannes will be graded as low depressions at the tidal edge of the seasonal wetlands areas above MHHW (6.3 ft NAVD 88). The pannes will consist of shallow (0.5 foot deep) mud-lined depressions within the transitional slope at the outer margin of the seasonal wetlands areas. Their sill elevations between 6.5 ft NAVD 88 and 7.0 ft NAVD 88 will allow for tidal water influx. The hydrological regime in the tidal pannes will include: (1) year round infrequent tidal inundation during higher monthly tides (spring tides); and (2) seasonal freshwater input from direct rainfall from adjacent areas. Tidal pannes may dry between spring tides during the summer and fall dry season and may remain inundated during some or all of the winter and spring rainy season. Consequently, surface water and soil salinities tend to vary from nearly fresh to hypersaline, resulting in environmental stresses that limit vegetation colonization. Because tidal pannes occupy the topographic transition between tidal marshes and non-tidal habitats, both total acreage and actual location of tidal pannes will change with time due to subsidence and sea level rise.

During the very high tides that flood these pannes, ducks and larger waders might forage in these areas. Shorebirds may find some prey in these areas, particularly after inundation by very high tides, although most of the use of this habitat type would be by roosting gulls, egrets and shorebirds during normal high tide, when their preferred foraging areas are inundated (Woodward Clyde et al., 1998).

6.2.5.4 Stormwater Drainage Corridor

Drainage channels will convey stormwater discharge from the NHP outfalls (east and west) and Landfill 26 through to the tidal marsh and San Pablo Bay. These channels will bypass the seasonal pond areas and may create habitat for bulrush (*Bolboschoenus maritimus* syn. *Scirpus maritimus*), cattails (*Typha* spp.), and rush (*Juncus* spp.), as well as pickleweed (*Sarcocornia pacifica*). This habitat will transition to tidal salt marsh species as salinities increase down channel. The emergent vegetation will provide habitat for songbirds and small mammals.

6.2.6 Description of design elements

6.2.6.1 Northern Seasonal Wetland

Approximately 105 acres of seasonal wetlands include: vegetated transitional upland, freshwater pond, brackish to saline pond and saline tidal panne habitats that will be sustained by a combination of rainfall runoff and salts introduced by tidal waters. In all, the site consists of a series of seven shallow ponds ranging in target sill elevations from 6.0 ft NAVD 88 to 7.0 ft NAVD 88. Grading plans at typical cross sections are detailed in Figure 17 to Figure 19 and Figure 22

Pannes and Ponds

Under target conditions at T_0 (time of outboard levee breach and site tidal connection) it is anticipated that the site will be managed with a tidal exchange through the lower water control structure set with an overflow sill elevation of 6.0 ft NAVD 88. The grading plan includes 13.4 acres of seasonal ponds with sill elevations of 7.0 ft NAVD 88 or higher. These ponds are anticipated to receive very limited influx saline tidal waters and so have low water salinities (0-2 ppt). Ponds 3 through 6 (total area 38.5 cares) will receive sufficient tidal influx to raise salinities to concentrations in excess of 10 ppt during winter flood season with salinities exceeding 50 ppt during the summer desiccation phase. Pond 2 will be intermediate between these two conditions – the salinity of which will be sensitive to annual variability and soil infiltration rates (PWA 2005, Appendix C). It is anticipated that ponds with a sill elevation over 6.0 ft NAVD 88 will dry during summer months with the exception of occasional short (2 week duration), summer flooding events. The large, deeper pond will contain island refugia for shorebirds.

Table 6-1 Northern Seasonal Wetland Pond Characteristics at T_0

	Sill Elevation	Max Depth	Incremental Inundated Pond Area by Depth (Acres)						Total Pond Area
	(feet NAVD 88)	*(inches)*	*(0-4")*	*(4-8")*	*(8-12")*	*(12-16")*	*(16-20")*	*(20-24")*	*(acres)*
Pond 1a	7.0	12.0	1.1	1.1	1.7	0.0	0.0	0.0	**3.9**
Pond 1b	7.0	12.0	1.1	1.5	2.0	0.0	0.0	0.0	**4.6**
Pond 2	6.5	18.0	0.6	0.2	0.2	2.1	1.8	0.0	**4.9**
Pond 3	6.0	9.6	0.7	0.7	1.0	0.0	0.0	0.0	**2.4**
Pond 4	6.0	9.6	4.0	4.2	1.3	0.0	0.0	0.0	**9.5**
Pond 5	6.0	9.6	1.1	0.9	0.4	0.0	0.0	0.0	**2.4**
Pond 6	6.0	21.0	2.7	2.6	2.7	2.0	10.2	4.0	**24.2**
Total	**-**	**-**	**11.3**	**11.2**	**9.3**	**4.1**	**12.0**	**4.0**	**51.9**

Stormwater Drainage Corridor

A stormwater channel with vegetated tidal marshplain will transfer stormwater discharge from the local catchment through to the tidal marsh (Figure 17). This channel will provide transitional habitat associated with salinity changes from the stormwater outflow to the tidal marsh. The stormwater discharge channel will be isolated from the seasonal wetland by the 'separator' berm which will host the upper water control structure at Pond 1 and Pond 6.

The drainage corridor will be created from the excavation of fill material and oversized to allow for sedimentation to create a natural channel edge. The channel will be graded in to the first placement of sands upon which subsequent muds will be floated.

Underlying paving obstructions to the channel thalweg will be removed over the length of the channel excluding the main runway in the tidal wetland area.

Containment Berms

The Containment Berm has been constructed between the N-1 levee and the NHP Levee creating cell 1 to contain dredged material for the northern seasonal wetland (Figure 15). This berm is constructed to an elevation of 9.5 ft NAVD 88 with side slopes 2:1. Outboard, the Tidal Panne Berm was constructed to an elevation of 9.0 ft NAVD 88 to create cell 1A. Material in cell 1A (mud cover over sands) will be placed to create a transitional slope into the tidal wetland. Mud-lined tidal pannes (0.5 - 1 ft deep) will be graded in to this slope with sill elevations between 5.5 to 6.5 NAVD 88. The Panne berm will be graded down to 5.5 ft NAVD 88 at time of breach and material side cast into the tidal wetland.

At site connection prior to breach, the Containment Berm will be lowered to 8.5 ft NAVD 88 between the water control structure and the N-1 Levee, notched down to 1 ft NAVD 88 between the Wildlife Corridor Berm and the tidal panne berm to connect the stormwater drainage channel to the tidal wetland area, and graded down to Wildlife Corridor elevations (between +6.2 and +8.8 NAVD 88) between the Wildlife Corridor Berm and the NHP Levee.

Separator Berm

The separator berm will be graded with a gentle slope (ranging from 12:1: to 20:1) to provide transitional ecotone and will have a crest elevation of 8.5 ft NAVD 88.

Water Control Structures

The Northern Seasonal Wetland will include two types of water control structures to support tidal water and salt transfer (details in Figure 19).

Lower Water Control Structure. This structure will consist of two pipes (30") with adjustable flapgates and a flashboard weir (length 10 feet). Under normal operation the sill elevation will be maintained at 6.0 ft NAVD 88. This elevation is adjustable to accommodate improved hydrologic performance under differential settlement of the site and adaptive management.

Upper Water Control Structure. A single flashboard weir, 75-foot long weir consisting of 8-foot sections, will provide adaptive management flooding capacity to the highest pond (Pond 1). It is anticipated that the weir elevation on this structure will be maintained high (8.5 ft NAVD 88) under normal site operation. Should adaptive management actions require flooding the upper pond areas with salt water this weir may be lowered to an elevation of 7.0 ft NAVD 88 allowing salt water to fill ponds 1 and 2.

Simple hand-pull stop gates are included in the design (PWA, 2005) to drain each pond for the purposes of Mosquito abatement adaptive management (Figure 22).

6.2.6.2 Southern Seasonal Wetland

Approximately 41 acres of seasonal wetland complex include: vegetated traditional upland, freshwater pond, seasonal brackish to saline ponds and saline tidal pond habitats that will be sustained by a combination of rainfall run-off and tidal waters, the balance depending upon sill elevation. A series of five ponds, ranging in target sill elevations from 6.5 ft NAVD 88 to 7.5 ft NAVD 88 with depths up to 2 feet to provide habitat for both waterfowl as well as shorebirds. Water and salt balance modeling (PWA, 2005) indicates that a range of pond and panne habitat will be created. Grading plans at typical cross sections are detailed in Figure 20, Figure 21 and Figure 23

Ponds

Ponds 1 and 4 with a sill elevation of 6.5 ft NAVD 88 are the lowest depressions in the Southern Seasonal Wetland complex and will function as tidal ponds. These features will hold water year round though water levels will draw down between spring tides in spring through autumn months. Salinities will typically be high 20 – 50 ppt depending upon season, though potential decreases to near zero salinity during high rain fall winters are possible. It is anticipated that the ponds will hold saturated, unvegetated soils with a rich invertebrate population fringed by pickleweed which transition upslope to ecotone species.

Ponds 2 and 3 with sill elevations at 7.0 NAVD 88 will flood throughout the winter months with a combination of rainfall and tidal high spring tide waters; and during summer months ponds may cyclically flood and desiccate with pulses of tidal waters brought by high spring tides. Salinities will vary generally exceeding 10 ppt during winter months but rising to over 30 ppt and attaining higher than 50 ppt as summer waters dry down. It is anticipated that the ponds will hold unvegetated soils in the panne base fringed by pickleweed which will transition upslope to ecotone species

Pond 5 will have a sill elevation of 7.5 ft NAVD 88 and is anticipated to receive rainfall and very occasional influx of tidal waters and thus have low water salinities of generally less that 20 ppt through winter months, and depending upon soil infiltration rates, could potentially increase as the pond dries in late spring. Species such as bull rush, pickleweed and brassbutton will ring this feature, potentially extending down to near pond bottom elevations. With rising sea level, increased salinities will limit vegetation in this pond, thus increasing habitat for shorebirds displaced from lower ponds.

Table 6-2 describes the topography of seasonal ponds.

Table 6-2 Southern Seasonal Wetland Pond Characteristics

	Sill Elevation	Max Depth	Incremental Inundated Pond Area by Depth (Acres)							Total Pond Area
	(feet NAVD 88)	*(inches)*	*(0-4")*	*(4-8")*	*(8-12")*	*(12-16")*	*(16-20")*	*(20-24")*	*(24"+)*	*(acres)*
Pond 1	6.50	6.0	1.5	1.6	-	-	-	-	-	**3.1**
Pond 2	7.00	18.0	3.0	2.9	2.8	2.7	4.0	-	-	**15.4**
Pond 3	7.00	18.0	0.7	0.5	0.4	0.3	0.6	-	-	**2.4**
Pond 4	6.50	24.0	0.9	0.8	0.7	0.6	0.5	0.8	-	**4.4**
Pond 5	7.50	24.0	0.6	0.5	0.5	0.4	0.3	0.7	-	**3.0**
Total	**-**	**-**	**6.6**	**6.4**	**4.4**	**4.0**	**5.4**	**1.6**	**-**	**28.3**

Stormwater Drainage Corridor

A stormwater swale with vegetated tidal marshplain and channel will transfer discharge from the NHP East Outfall through the seasonal wetland complex to the tidal wetland area (Figure 20). This channel will provide transitional habitat associated with salinity changes from the stormwater outflow to the tidal marsh. The constructed swale will have an upstream elevation of 5 ft NAVD 88 at the pump outflow and slope down to 3.75 ft NAVD 88 at the seasonal wetlands. As such, the swale will be subject to tidal flows and will, over time, build up to form a vegetated marshplain surface with an elevation at MHHW. A shallow channel will meander through the swale with a thalweg depth 1 ft below floodplain elevation. Two grade controls will limit lower elevation of the channel thalweg across the buried paved area.

The drainage corridor will be created from the excavation of fill material and oversized to allow for sedimentation to create a natural channel edge. The channel will be graded in to the first placement of sands upon which subsequent muds will be floated. The margins of the constructed swale will gently transition to higher areas of the seasonal wetlands at a slope of 20:1, providing transitional ecotone.

Containment Berms

The Wildlife Corridor Berm has been constructed adjacent to the NHP levee creating Cell 2 to contain dredged material for the Wildlife Corridor and the northern area of the Southern Seasonal Wetland. A second berm, the South Seasonal Wetland Containment Berm, will create a cell bounded by the Wildlife Corridor Berm, the South Levee, and the high ground near the boundary between the Navy Ballfields Property and the Coast Guard Property. This berm is due to be constructed by

Late 2007. All berms will be constructed to an elevation of 9.5 ft NAVD 88 with side slopes 2:1. Berm locations are shown in Figure 15.

Prior to breach, the Wildlife Corridor Berm and South Seasonal Wetland Berm will be graded down (Table 6-3). Material from berm lowering will be cast in to the tidal wetlands area, to elevations no higher than the lowered berm, to create irregular edge topography.

Table 6-3 Graded elevations of Wildlife Corridor and South Seasonal Wetland Berms

Location	Elevation Ft (NAVD 88)
Wildlife Corridor Berm	
North of Pond 1	5.5
Pond 1	6.5
Pond 2	7.0
South Seasonal Wetland Berm	
Stormwater Channel	2.75
Pond 4	6.5

Water Control Structures

Simple hand pull-stop gates are included in the design to drain each pond for the purpose of mosquito abatement adaptive management (Figure 23).

Grade Control Structures

Two grade control structures are included in the design to hold the stormwater channel thalweg above the buried paved surface (Figure 20 and Figure 24).

Floodplain Cutoff Wall. A grouted rock wall will be constructed prior to dredged material placement to set upstream floodplain and channel elevations. The surface of this structure will follow the topography of wetland design.

South Seasonal Wetland Berm. This berm will be excavated to an elevation of 2 ft NAVD 88 over the 300ft extent of section bordering the stormwater channel. The remainder of the South Seasonal Wetland Containment Berm will be graded to provide transition between the seasonal ponds and the tidal marsh.

Stormwater Dissipation Structure

The velocity of stormwater flow exiting the NPH East Pumps Station should be reduced to limit scour of the downstream channel. A grouted ramp with irregular surface will extend 200 ft from the pump station concrete apron (subject to agreement by City of Novato).

6.2.6.3 Elements common to both seasonal wetland designs

Pond bottom substrate

The following paragraphs describe an empirical basis for the design of "mud" cap liner in the unvegetated seasonally ponded areas of the Northern and Southern Seasonal Wetlands.

Based on the water and salt balance modeling analysis the capacity of the ponds to retain salts and water is dependent on water infiltration rates in to soils (PWA, 2005; Appendix B and C). The analysis found that shallow water can be maintained in the ponded areas lined with low-permeability soils throughout the winter months from October to April should percolation of water in to soils at a rate not exceeding 0.17 in. / day.

It was beyond the capacity of the PWA hydraulic model to predict soils drying and cracking responses to desiccation. Soil desiccation cracks may act as preferential pathways for water and salts to be lost by percolation down to subsurface soil layers. To investigate the potential for cracking, the UCACE undertook an analysis of Bay Mud (dredged material) soil cracking potential, based upon soil cover thickness of 2 to 3 feet as specified in the Seasonal Wetlands Preliminary Design Report by PWA (2005).

To verify the adequacy of the Bay Mud cover thickness for the purpose of seasonally ponding water, relevant site-specific geotechnical soil characteristics were summarized in Table 6-4 below and evaluated. Hydrogeologic conditions were also evaluated. The project design includes working and compaction of the imported bay mud sediments to reduce cracking of mud following drying of pond bottom soils during the summer months.

Table 6-4 Summary of selected properties for Bay Mud dredged material relevant to formation of desiccation cracks.

Location	Material Description	UCS	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Estimated Thickness of Crust (feet)
Port of Oakland, Middle Harbor (1)	Gray Clay with Sand (Young Bay Mud)	CH	58	26	32	0.8
Bel Marin Keys Unit V (2)	Brown Clayey Silt (Desiccated Bay Mud Crust)	MH-CH	63	37	26	2.0

Reference: (1) Soil Test Results, Feb 16, 2000 ERDC Memo to USACE San Francisco District. (2) Miller Pacific Engineering Group, Geotechnical Investigation Bel Marin Keys Unit 5, December 21, 1995. Properties of desiccated Bay Mud crust are included for relative comparison purposes only.

6.2.7 Design Changes Since the EIR/EIS

The areal extent of seasonal and tidal panne wetland types remains as described in the Feasibility/ EIR/EIS studies (USACE, 1998., Jones and Stokes, 1998). Specific design elements have been modified including:

- Relocation of the stormwater drainage channel in Northern Seasonal Wetland to border the NHP levee.
- Inclusion of water control structures at the Northern Seasonal Wetland for adaptive management purposes.
- Relocation of low level DDT soil (< 1000 ppb) within the drainage channel paths to locations underneath the seasonal ponds and beneath at least 3 ft of cover material.
- Inclusions of simple water structures for mosquito abatement.
- Grading and site preparation to create seasonal ponds.

6.3 TIDAL WETLANDS

The most extensive habitat type for the HWRP is tidal wetland. It is anticipated that about 378 acres of tidal marshplain will be created with deep primary channels and a network of smaller channels in about 30 years after the outboard marsh is breached. Site evolution will be aided with the beneficial use of dredged material and inclusion of wave berms to encourage sedimentation and provide interim high tide ecotone and refugia. Private and city-owned property surrounding the project site will be protected by flood control levees

6.3.1 Design goals and objectives

6.3.1.1 Goal

Promote the development of a naturally evolving, ecologically functioning and persistent tidal wetland system (Kamman et al, 1998).

Objectives
Short term habitat objectives for tidal wetlands are to satisfy the mitigation requirements associated with converting the project site to tidal wetlands. A bench constructed along the N2 and South perimeter levees [and wave berms] will provide rapid colonization by tidal marsh plant species.

Long-term objectives for tidal wetlands are to maximize the acreage and habitat quality for clapper rail, black rail, salt marsh harvest mice, anadromous fish, and other sensitive species indigenous to the North Bay tidal wetlands. This entails:

- Establishment of a well-developed system of tidal channels and dense, tall salt marsh vegetation;
- Minimal occurrence of weeds in wetland areas;
- Adequate high tide refugia bordering the marsh
- Minimal access for predators; and
- Minimal disturbance due to people and dogs.

(Kamman et al, 1998)

6.3.2 Status and references

6.3.2.1 Design Documentation

The physical basis of the tidal wetland design can be found in *Conceptual Design for Tidal Wetland Restoration for the Hamilton Army Airfield Focused Feasibility Study* [volume I] and *Technical Appendices* [Volume II] (Kamman et al, 1998) and the *Hamilton Army Airfield Wetland Restoration Feasibility Study* (USACE, 1998). Subsequent documents focus upon specific aspects of tidal wetlands design, updating the conceptual design including PWA Memorandum 5/26/05 *Refined Designs for Internal Berms and Benches* and PWA Memorandum 6/1/07 *Future Tidal Channel Dimension Predictive Information.* A number of finalized (non public) study documents exist which aid interpretation of site evolutions. These include the *Hamilton Wetland Restoration*: *Morphologic Modeling of a Maximum Containment Berm Design.* (PWA and DHI, 2004).

A biological description of anticipated habitat including planting strategy, monitoring and adaptive management can be found in the PWA and BMP *Management Plan for Habitat Creation at the Hamilton Wetland Restoration Project, Marin County, California* (PWA and BMP, in prep).

To support the tidal wetland design for the HWRP, the Sonoma Baylands Wetland Demonstration Project provides a comparable reference site for tidal wetlands created with dredged material. This site has been monitored annually since creation and tidal connection in 1996. Each annual report contains and updates data from previous years. The most recent monitoring report includes data from 1996 through 2006 (PWA, 2007). A revised version of the tidal wetland dredged material placement plan has been provided in a memorandum: PWA Draft Memorandum 12/18/07. *HWRP Tidal Wetland Area: Conceptual Grading Plan and Design of Transitional Edge.* .

6.3.2.2 Design Linkages

The following list identifies design components that either exert an impact upon the seasonal wetland design should their construction be modified or may require design modification should changes to the seasonal wetland design occur. Any design modifications must take in to account linkages between seasonal wetland and tidal wetland design elements.

- Insufficient supply of dredged material to attain design elevations will lengthen time frame of site evolution to mature marsh through natural sedimentation. The resulting delay in formation of expansive vegetated marsh establishment will allow increased wave activity against berms and levees. Assessment of implications will be required prior to breaching the site.
- Site functioning requires full hydraulic connection to San Pablo Bay.
- Site preparation requires management of water levels to sustain fully saturated dredged material.
- Interim water management will be required to prevent low dissolved oxygen and excess salinization during summer months.

6.3.2.3 Tasks to be completed:

- Update base map to include recent borrow and construction.
- Recalculate dredged material quantities and projections of sedimentation based upon additional settlement of deeper material placement.
- Review intertidal berm design. There is potential to increase physical separation for predator management by notching lowered length of berm. Possibly eliminate all low elevation connections to the perimeter levees.
- Review interim water management approach used to keep dredged material under water.
- Determine preferred placements of dredged material pipe outflow
- Calculate containment berm breach dimensions for seasonal wetland margins

6.3.3 Design approach

Tidal wetlands restoration is based upon the construction of a design template that sets the wetland upon an evolutionary pathway toward a desired and sustainable outcome. Elements of the design template are described in section 6.3.6 and include flood protection levees with wave erosion benches, placed unconsolidated clean dredged material, temporary cells to hold this material, wave berms, borrow pits and breach and outboard channel excavation. The wetland design template, consisting of the arranged design elements and graded surface, will be prepared prior to breaching the bay-front levee. Once the levee is breached, the template directs tidal circulation patterns and through interactions with sedimentation from the bay and scour by tides and currents encourages the evolution of a natural marsh, so restoring biological habitat and functions.

A critical element of the design template is the need to place and store dredged material under water for a period of up to 6 years. It is estimated that 3.6 million cubic yards of material will be required to raise the tidal area to a preferred target elevation of no higher than 4.5. ft NAVD 88 (1-1.5 ft below marsh plain elevations). Should sufficient volumes not be available to attain this elevation, the time frame for tidal wetland evolution to vegetated marsh will be extended. The dredged material will be held in bermed cells and maintained below water until breach. Once material placement is complete, the cells will be connected, and the outboard levee will be lowered to high marsh plain elevations and breached in a single location to allow full tidal connection to the Bay. Because borrow material has been excavated from the site to build levees and berms, the depth of soft sediment in most areas should be sufficiently deep as to not impair natural channel formation. In critical areas where the main tidal channel will form, concrete and aggregate base will be excavated, with the exception of a portion of the main runway between the Northern Seasonal Wetland and the Tidal Wetland near the current Nina's Pond. Contaminated soils (low-level DDT and PAH containing soils) as well as borrow for levee and berm construction have been removed from the tidal wetlands area and have created additional space for natural channel formation, with less obstruction from stiff soil surfaces.

There is potential that some dredged material bearing sands will be offered to the HWRP. The tidal wetlands conceptual design has been updated to identify areas suitable for sand placement (around tidal wetlands margins), areas which would be beneficial if construction sequencing permits (e.g. mid-site shoals), and areas where sand would not be acceptable (where sands might intersect with the thalweg of tidal channels). There is potential to use sands to enhance ecotone at the tidal wetland edge and encourage vegetation establishment early during the restoration evolution. All sand will be placed at elevations which will be, in time, be buried beneath bay muds. Historically, sands, from the Sacramento River and reworked by rising sea level, will have contributed to the evolution of natural marshes in San Pablo Bay and so the incorporation of sands in the HWRP is within keeping of once existing regional environmental conditions.

6.3.4 Design criteria

6.3.4.1 Habitat evolution

The tidal wetlands area should evolve into a complex of vegetated, high, mid and low marsh as well as channel and mudflat habitat through the placement of dredged material followed by natural sedimentation, vegetation colonization and channel formation.

6.3.4.2 Habitat resilience

Tidal wetlands should be resilient against sea level rise and infrequent high energy storm events.

6.3.4.3 Full tidal connection

A full connection should be reestablished to allow full tidal exchange with natural tidal circulation, sedimentation and ecological processes.

6.3.4.4 Minimize impacts to endangered species in outboard marsh

Connection of the restoration site should be via a single breach and excavated channel that will cut through the outboard marsh.

6.3.4.5 Natural channel evolution

With reestablishment of tidal exchange, channels should be restored across the mudflat area and incorporated in to the evolving vegetated marsh. Within the physical constraints of the site (Intertidal berms, remaining concrete and stiff soils, drainage channel locations) the channels should form and evolve naturally.

6.3.4.6 Wave climate optimized to encourage marsh evolution

Internal wave climate should be sustained at a level adequate to encourage natural disturbance dynamics and habitat diversity but not unduly limit sedimentation

6.3.4.7 Stormwater management

Stormwater from adjacent lands should be conveyed through the seasonal wetlands, then through the tidal wetland to San Pablo Bay.

6.3.4.8 Support endangered species

Once the tidal wetlands has evolved to long term equilibrium marshplain elevations the site should support local species of concern including but not exclusive to the endangered breeding clapper rails and salt marsh harvest mouse.

6.3.4.9 Development of upper marsh transitional ecotone

Transitional edge ecotone should be created along the perimeter of the tidal wetlands.

6.3.5 Preliminary grading plan

A preliminary grading plan is provided in Figure 29.

6.3.6 Design elements

This section of the Hamilton Wetlands Restoration Plan will summarize project features that will be constructed to enhance tidal wetland formation and provide flood control to surrounding properties. The restoration plan for the 360 acre tidal wetland area includes the following:

6.3.6.1 Flood protection levees.

The flood control levees surrounding the project restoration will be designed to provide a 100-year level of protection to developed areas. Levees protecting future restoration areas (BMK-V) are not required for flood safety and may be built to a lower level of protection (design has not been finalized). Levee elevations are designed to protect against wind waves and tides in exposed areas and against tides only in protected areas. Current design elevations are presented in Table 6-5. Location and typical levee cross-sections are presented on Figure 15 and Figure 30.

Table 6-5 Levee Elevations for 100-year Level of Protection (USACE Memo 2005, updated December 2007)

Levee Elevations for 100-year Level of Protection All units are in feet and all elevations assume a datum on NAVD 88				
	Location			
	South Levee Wave exposed	South Levee Wave Protected	N-2 levee Wave exposed	N-1, Bulge, Pacheco Levees Wave protected
100-year tide elevation (1983 analysis)	9.1	9.1	9.1	9.1
Sea level rise (1983-2050)	0.5	0.5	0.5	0.5
Wind set-up	0.5	0.5	0.5	0.5
100-year still water elevation	10.1	10.1	10.1	10.1
Estimated wave run-up	0.9	Wave protected	0.9	Wave protected
Freeboard	1.0	1.0	1.0	1.0
Levee elevation for 100-year level of protection	12.0	11.1	12.0	11.1

Wave characteristics. Maximum wind from critical directions NW or SE is 45 miles per hour (10-year event). Wave run-up heights were calculated for fetch lengths of 2,500 feet (with berm condition) and 5,400 feet (with berm conditions). Run-up values were 0.7 and 0.9 feet.

6.3.6.2 Intertidal benches (erosion control) to protect the flood control levees.

Intertidal benches will be constructed on the restoration area side (outboard) of the N-2 levee and the easternmost 700 feet of the South levee (Figure 15). These benches have been designed to protect flood control levees from wind wave erosion. The benches will range in elevation from 4.0 feet NAVD 88 near the new tidal wetland and slope up to the flood control levees where they will tie into the levees at 9.0 feet NAVD 88. The slope of the bench extends approximately 55 feet from the face of the levee to the restored wetland. Salt tolerant vegetation will be encouraged to grow on the benches prior to breaching to increase protection of levee from waves. It is anticipated that the benches will progressively erode over time. Typical perimeter levee with bench cross-sections are presented on Figure 30.

6.3.6.3 Containment cells

The tidal wetland area is divided into two containment cells, Cell 4 and the remaining area which is referred to simply as Tidal Wetland area and will be bulk filled. Some filling has already occurred in the Tidal Wetland by the Bel Marin Keys Community Service District (BMKCSD) into two previous borrow areas that were referred to as Cell 3 and a smaller area to the east. The containment cells have been or will be constructed to hold dredged material until sufficient volumes of sediment have been placed to establish the site template (Figure 29). Through appropriate water management this material will be kept under water over the period of holding. Prior to breach of the outboard levee the cells in the tidal wetland area will be connected by excavation of sections of connecting berms to provide for tidal channel formation.

6.3.6.4 Infrastructure removal

Where possible, existing infrastructure will be removed to allow for channel formation. Figure 31 shows the location of existing infrastructure and highlights structures that have been or will be removed prior to placement of dredged material.

6.3.6.5 Intertidal (Wave) berms

The intertidal, or wave berms are intended as temporary features to reduce wind and wave fetch, direct tidal flows away from levees, and create low velocity regions that encourage sedimentation. They are expected to gradually erode or be covered in sediment and settle as the marsh builds up to marsh plain elevations and should eventually disappear or be covered by marsh sediment and vegetation. The wave berms will be constructed to 7.1 feet NAVD 88 and are then expected to subside to an elevation of 6.1 feet NAVD 88 at the time the outboard levee is breached. With a crest elevation set to 6.1 ft NAVD 88 (just below MHHW) at time of breach the intertidal berms will be elevated above the immediate post-breach mudflat and forming low marsh. In a restored wetland, edge habitat is limited. It is anticipated that the berms will be capture seeds brought in by tides from nearby marshes and will be colonized by species such as pickleweed, salt grass, jaumea, alkali heath and gum plant. In doing so they will act as nucleation areas, providing a seed source for the accreting marsh. It is also anticipated that the berms will provide high tide roosting sites for shorebirds and other avian species such as the American White Pelican (*Pelecanus erythrorhynchos*), a California Species of Concern observed to roost on wave berms at the Sonoma Baylands wetlands restoration site.

There is, however, concern that that the berms will provide an access route to the interior of the marsh for mammalian predators. To minimize this potential, the intertidal berms will be separated from the perimeter levee by a 250ft long foot gap. This low section is designed to limit predator access to the project site. Dredged material will be placed at the gaps between the inter-tidal berms and perimeter levees so that its final elevation at the time of breach is 3.7 feet NAVD 88.

One exception will be the gap between inter-tidal berm 6 and the N-2 levee. For this location a low elevation (constructed to 4.5 feet NAVD 88 and will settle to 3.7 feet NAVD 88 at the time of breach) connector berm will be constructed as a way to minimize erosion of the N-2 levee. The connector berm will be constructed with a 50 wide notch at elevation 0.0 feet NAVD 88 at the inter-tidal berm end. The notch will direct the erosive tidal flows towards the inter-tidal berm and away from the N-2 levee.

A plan view of the inter-tidal berm locations is presented on Figure 15. Inter-tidal berm cross-sections are presented on Figure 30.

6.3.6.6 Dredged material placement by location and type

Dredged material to be delivered to the tidal wetland restoration area may consist of both sand and bay mud. However the placement of sand is restricted to certain locations so that it does not block slough pathways to the seasonal wetlands or to the location of the outboard breach. The recommended locations will provide for optimum tidal slough formation. Sand placement will be limited to the areas shown on Figure x and to elevations specified below and on the figure. Sand will be primarily placed near the perimeter levees and wildlife corridor. Secondary locations for sand placement will be along the edges of the intertidal berms and in areas below the expected tidal slough scour depths. It should be noted that the tidal wetland was originally designed assuming the placement of bay mud only and that lower than expected quantities of sand will not have a negative impact on the restoration plan.

Dredged material will be placed within the tidal restoration area to meet elevation requirements, to avoid excessive mounding and to allow for sufficient clarification of water prior to decanting over the outflow weirs. The dredge sediment will move according to its size gradation. Sand will tend to remain at the perimeter of the tidal wetland area and will tend to form a sloped topography as it flows towards the center of the tidal wetlands. Sand elevations near the perimeter of the will be placed no higher than 4.5 feet NAVD 88. The average elevation of the placed sand will be 4.0 to 4.5 feet NAVD 88. The placed sand will form uneven conical landforms that will provide additional protection against wave erosion at the perimeter levees, direct the formation of tidal sloughs and provide diversity in habitat.

Fine material (bay mud) will tend to flow towards the center and across the tidal wetland area. Fine material will be placed at elevations from 2.5 to 4.5 feet depending upon the availability of material. The fine material is expected to self level at its final elevation.

It is critical that all dredged material is placed at elevations not exceeding 4.5 feet NAVD 88. Dredged material elevations above 4.5 feet may limit the natural formation of tidal slough geometry and its associated habitat formation.

6.3.6.7 Tidal inflow structures to maintain water coverage of the placed dredged material.

Dredged material placement will occur over a period of 6 years as suitable sediment becomes available. Throughout this time the material will be maintained in a saturated state to prevent excessive consolidation and desiccation of dredged sediments. To prevent desiccation an adjustable tidal weir structure will be built, or pumps would be installed to sustain a constant water surface elevation that can be maintained between dredged material placement cycles.

6.3.6.8 Connection to seasonal wetlands

Flow paths will be designed to allow decant water to flow from the seasonal wetlands though the tidal marsh restoration area and to the settling basin before it is returned to the bay at the outboard pump station. These flow paths are needed to prevent flooding of the entire tidal marsh area. During the time that the north seasonal wetland and wildlife corridor cells filled other parts of the restoration area will be under construction. These areas will need to remain dry during their construction period.

A series of culverts, cells, weirs and a settling basin will be linked to provide a decant water path from the north seasonal wetland and the wildlife corridor to the bay front pump station.

All earthwork and concrete removal is scheduled to be completed by the time wildlife corridor and north seasonal are filled to their design elevations. Dredged material placement from this point onward will be placed in the south seasonal wetland and tidal marsh area. Decant water from this fill placement will flow overland with no defined path to the settling basin before it is discharged in the bay.

6.3.6.9 Lowering of outboard levee

The Feasibility Study recommends and the permit requires lowering the outboard levee to marshplain elevations prior to breach. However, some potential exists that an extreme event during the early phase of site evolution could impact the integrity of features on the site. In addition, potential exists for over bank flow to scour through the lowered levee thus increasing the number of tidal connections through the outboard marsh. A conservative approach would be to delay lowering the outboard levee until site evolution has progressed sufficiently as to establish expansive marshes, which would act to dampen wave energy inside the restoration site. This approach will be reviewed and a request to amend the existing permit will be made if postponing the lowering of the outboard levee is judged to be the best option.

Vegetated marshes outboard of the HWRP are progressively eroding. In time, with rising sea level the outboard levee eventually erode thus increasing the connectivity of the restoration site and San Pablo Bay.

6.3.6.10 Outboard levee breaching

At project completion the project area will be opened to tidal inflow via a single breach in the outboard levee and a pilot channel cut through the outboard marsh. The dimensions of these excavations are based on data presented in the 1998 Feasibility study. Additional studies completed by PWA in 2002 and 2006 indicate that channel dimensions for a given tidal prism are somewhat smaller than those predicted from data used in the 1998 study. The dimensions presented below in Table 6-6 are the permitted dimensions that are based on the 1998 Feasibility Study and should provide a full tidal exchange between the bay and the restoration site. The outboard levee cut dimensions will provide full tidal exchange (~1,250 acre feet) for the initial restoration area conditions. The channel top width is expected to narrow as the marsh matures and the tidal prism is reduced (~300 acre feet). The initial outboard tidal marsh pilot channel, the breach location and pilot channel and their associated cross-sections are presented on Figure 32. All material excavated for the levee breach and pilot channel which meets the chemical testing criteria established in the 2005 Biological Opinion will be placed in the marsh restoration area. Material that does not meet the criteria will be disposed of at a suitable site elsewhere. Regardless of the availability of dredged material, the levee breach will be completed no later than 8 years after dredged material placement begins.

On going studies will investigate the possibility of cutting an additional pilot channel through the mudflat. A channel through the mud flat will allow complete emptying of the marsh area during the lowest tides. On going design studies will analyze the possibility of constructing a pilot channel through the outboard mudflats before the levee is breached or making the construction of a mudflat channel part of an adaptive management plan.

Table 6-6 **Breach and outboard pilot channel dimensions**

	Levee Breach	**Outboard Marsh Pilot Channel**
Cross-sectional Area (ft^2)	2,500	1,600
Channel bottom elevation (ft NAVD 88)	-5.9	-5.9
Channel Top Width (ft)	280	165
Channel Bottom Width (ft)	155	40
Channel Side Slope (V:H)	1:4	1:5 – 1:10
Channel Length (ft)	200	800
Channel Excavation Volume (yd^3)	25,500	24,900
Channel Surface Area (acres)	1.2	3.0

6.3.7 Design Changes since EIR/EIS

- DDT soils have been relocated from tidal wetlands area for burial beneath 3 ft of cover in Wildlife Corridor and Seasonal Wetlands areas Figure 3.
- Design changes have been made to the inter-tidal berms since their initial 1998 Feasibility Study design. The total length of the inter-tidal berm system and crest elevation has been reduced (see Table 6-7). The berms are constructed features not naturally found in a tidal marsh therefore efforts were made to reduce the constructed lengths of the berms. With the shorter berm length wave activity will increase redistribution of sediment, though extending by a number of years the time line over which exposed areas of the site will develop marsh plain. With reduced berm length wave activity will also increase along any exposed areas of perimeter levees.

Table 6-7 Changes to inter-tidal berm elevations and total berm lengths

Study	Total length of all berms (feet)	Design elevation at breach (feet - NAVD 88)
1998 Feasibility (updated)	9,000*	6.6
2004 Maximum Containment Design (MCD)	14,300	6.1
2007 Design	7,800	6.1
* As stated in the 2004 MCD report		

6.3.8 Anticipated tidal wetland evolution

When the outboard levee is breached tides will enter a relatively open and gently sloping sand and mud surface. Tidal slough formation will begin at high velocity areas between intertidal berms and the outboard levee breach. The slough channel will scour to the long-term equilibrium widths and depths as presented in Table 6-8 below. As the channels scour and form meanders suspended sediment will deposit on the channel overbanks to create a tidal marsh at full equilibrium. Actual values in Table 6-8 are based on relationships developed by PWA in their September 2002 study *Hydraulic Design: A Geomorphic Design Tool for Tidal Marsh Channel Evolution in Wetland Restoration Projects* (Williams et al, 2002). Drainage sub-basins and concentration points are presented on Figure 31.

When the outboard levee is breached the average elevation of fill placed in the in the tidal restoration area is estimated to be between 3.0 and 4.0 feet NAVD 88. The most recent analysis of long term surveys of Sonoma Baylands (a wetland restoration site 3.5 miles to the northeast) indicates that a deposition rate of 2 inches per year of suspended bay mud can be expected at the Hamilton site.

Table 6-8 Approximate Mature Marsh Dimensions of Internal Slough Channels

Concentration Point	Sub-basins Drained	Estimated contributing area (acres)	Estimated Tidal Prism* (acre-feet)	Channel Top-width at MHHW (feet)	Channel Cross-section area below MHHW (sq. feet)	Channel Thalweg Elevation (feet)	Local Runway/Paved Elevation (feet)
1	1,2,3,4,5,6, 7,8,9	400	290	190	1311	-5.8	No pavement
2	2,3,4,5,6,7, 8,9	350	250	175	1184	-5.5	No pavement
3	3,4,5	187	120	125	731	-4.1	No pavement
4	4,5	115	68	95	504	-3.1	-1.0
5	5	48	24	53	250	-1.6	-0.2
6	6	37	18	50	210	-1.3	No pavement
7	7,8,9	100	58	88	454	-2.9	No pavement
8	8,9	55	28	62	281	-1.8	No pavement
9	9	8	3	21	64	1.0	-2.5

6.4 *WILDLIFE CORRIDOR AREA*

The project design includes a wildlife corridor connecting the Las Gallinas open space to the south of the site to the Bel Marin Keys Parcel V, Pacheco Pond, and Novato Creek to the north. In addition, the wildlife corridor connects the western portion of the site to some extent with adjacent Ammo and Reservoir Hills. The corridor is designed to provide habitat, connections between seasonal wetlands, high tide refugia and buffers between human uses and wildlife habitat.

The location of the Wildlife Corridor is provided in Figure 12 and typical cross section in Figure 33.

6.4.1 Status and references

6.4.1.1 Design Documentation

The Wildlife Corridor concept is described in the Draft *Hamilton Wetlands Conceptual Restoration Plan* (Woodward-Clyde et al, 1998) and incorporated into the Feasibility Study (USACE, 1998). This concept was later incorporated into permitting documentation. The basis for design is described in this document. A biological description of anticipated habitat including, planting strategy, monitoring and adaptive management can be found PWA and BMP (in prep). An assessment of impacts to the NHP levee is analyzed in USACE Memorandum 12/1/2006 *New Hamilton Partnership Levee: Seepage and Stability Analysis, Hamilton Wetlands Restoration Project, Novato, California.*

6.4.1.2 Construction Status

Containment berm for Cell 2 which provides for material placement in the wildlife corridor and northern part of the southern seasonal wetland has been constructed. Dredged material is anticipated to arrive early 2008.

6.4.1.3 Design Linkages

The following list identified design components that either exert an impact upon the Wildlife Corridor design should their construction be modified (or is yet to be define) or may require design modification should changes to the Wildlife Corridor design occur.

- Containment berm lowering and grading of tidal wetlands transitional ecotone.
- Dredged material placement elevations

6.4.1.4 Tasks to be completed:

- Construction approach of northern end of wildlife Corridor (inboard of Cell 1 Containment Berm

6.4.2 Design Strategy

The Wildlife Corridor, which is the northwestern portion of containment Cell 2, is bordered by the Wildlife Corridor Berm to the east, a small potion of the Northern Seasonal Wetland Containment Cell on the northern end, the Southern Seasonal Wetland to the southeast and the NHP Levee to the west.

Hydraulic fill will be placed in cell 2 and against the existing NHP levee to create upland shrub and grasslands, as well as high intertidal transitional wetlands. Slurried dredged material will be placed from a pipe on the Wildlife Corridor Berm and excess water will be decanted through one or more standpipe weirs outletting through the Wildlife Corridor Berm to the east. The hydraulic fill is expected to consist primarily of sandy material dredged from the San Antonio Formation of the Port of Oakland deepening project. The fill contains varying amounts of fine-grained material.

During construction the average operating water elevation will be approximately 8.7 ft NAVD 88, with a maximum of 9.7 ft NAVD 88 near the end of material placement.

Once material has been placed the cell will be drained and site graded to create a 125:1 slope from the edge of the Bay Trail (Preliminary design yet to be completed) against the NHP levee. Dredged material will be placed to an elevation of 7.4 ft NAVD 88 to allow for an average surface elevation of 6.2 – 8.8 ft NAVD 88 after grading.

Once graded fill elevations will range from 8.5 ft NAVD 88 at the Bay Trail to 5.5. ft NAVD 88 at the Wildlife Corridor Berm. The Wildlife Corridor will be hydroseeded with a mix of native grasses and planted with founder perennial shrubs (i.e. Toyon and Coyote Bush - Figure 33).

Prior to breaching the Wildlife Corridor Berm will be graded down to 5.5 ft NAVD 88. In doing so road surface material will be removed from the site will berm material will be side cast in to the tidal wetlands area (Figure 34).

6.4.3 Design criteria

6.4.3.1 High permeability material at surface

A high permeability surface material is required to provide for a soil that will favor native over non-native plant colonization.

6.4.3.2 Gradual Grading of Transitional Ecotone

The grade of the Wildlife Corridor will provide a gradual transition in habitat traversing mid marsh elevations through high marsh ecotone to upland grasslands.

6.4.3.3 Irregular edge

Excess fill material will be cast into the tidal wetland to create irregular edge.

6.4.4 Preliminary grading plan

The preliminary grading plan is provided in Figure 29

6.4.5 Design elements

6.4.5.1 Wildlife Corridor Berm

The Wildlife Corridor Berm has been build to an elevation of 9.5 ft NAVD 88 to contain placed material within Cell 2. This berm will provide road access for the southern margin of the HWRP during construction. Prior to breaching, the road surface will be removed and the berm lowered to provide a transitional slope into the tidal wetland as in figure 33. Non-road material will be side cast into the tidal wetlands area to create irregular edge.

6.4.5.2 Graded placed material

Fill in the wildlife corridor will be graded to a typical slope of 125H:1V from an elevation of 8.8 ft NAVD 88 at the edge of the Bay Trail (against the NHP levee) to 6.2 ft NAVD 88 against the Wildlife Corridor Berm.

6.4.6 Design changes since EIR/EIS

The design criteria were established for the wildlife corridor after the EIR/EIS was completed and are described in this document.

6.4.7 Anticipated wildlife corridor evolution

Prior to breach the Wildlife Corridor and Wildlife Corridor Containment Berm will have been graded to design specifications, and the 125:1 slope hydroseeded with native grasses and planted with founder native shrubs. Excess material from the slope and berm grading will have been sidecast to create an irregular edge.

Upon breach, and establishment of a full tidal connection, high tides will flood the lower levels of the Wildlife Corridor bringing salts and seeds, as well as disturbance by waves. Transitional ecotone will evolve along the Wildlife Corridor with patches of high marsh species (such as salt grass and gum plant and Frankenia) at lower slope elevations grading into upland grass species with elevation. Figure 33 provides a schematic representation of the mature Wildlife Corridor grade and botany at maturity. Extreme high tides will flood upper areas of the Wildlife Corridor. Over time, with sea level rise and an increase of flood frequency at a given elevation, salt marsh will transgress across the lower areas of the Wildlife corridor and the transitional ecotone will move upslope.

7. Public Access, Bay Trail, and Interpretive Facilities

Public access to the project and to the Bay has been included in the project design since the inception of the project. The 2.66 miles of public access provided by the project has been incorporated in the 400-mile planned Bay Trail and will complete the connection from Las Gallinas Valley Sanitary District property in the south to the Bel Marin Keys V Parcel in the north (2M et al, 2005). The project design includes five site overlooks, the trail itself, and a variety of buffers for wildlife protection. The public access will open in phases as different aspects of site construction are completed.

7.1 DESIGN GOALS AND OBJECTIVES

The project design includes seven public access goals. These goals include:

1. The trail and related facilities should provide access to the project shoreline for passive recreation and education opportunities for all residents of the City of Novato and visitors.

2. The trail should direct attention to the project and the qualities of the timelessness that tidal environments impart.

3. The public access will include focal points along its route to portray the distinctive habitat improvements created by the project.

4. The trail will be developed and managed in away that enhances water quality, open space, and natural resource values while minimizing conflicts between the public access and habitat conditions.

5. The trail will be developed and managed in a way that minimizes conflicts between public access and adjacent residential land uses, and that considers its proximity to Coast Guard facilities and related homeland security requirements.

6. Improvements to the trail will be designed and constructed for structural, integrity, function, safety, efficiency and fiscal conservancy in long term maintenance and operations.

7. Development and management of the trail will provide safe public use opportunities and will not preclude long-term construction access needs, emergency access, and maintenance access to nearby facilities.

7.2 EXISTING PUBLIC ACCESS

The greater Hamilton Community includes a number of existing public access opportunities that complement the project's trail and overlooks. There is an informal trail to the top of Ammo Hill to the northwest of the site that provides views to the project, Novato Creek, Bel Marin Keys Parcel V and the Bay. Reservoir Hill, also adjacent to the northwest side of the site, has a connector trail from the western side of the hill, over the top, and then down the eastern side where it will connect to the Bay Trail once this section is completed. Like Ammo Hill, Reservoir Hill has views to the site, adjacent properties to the north and south, as well as San Pablo Bay. At the top of Reservoir Hill there are benches and viewing scopes that have been installed by the City of Novato.

There is a community park adjacent to the south end of the City of Novato levee. This park has playing fields, portable restrooms, a playground and trash, recycling facilities and parking spaces. When the southern portion of the Bay Trail is complete, there will be an access point to the trail at this point.

7.3 DESIGN STRATEGY

The project's public access design strategy balances the desired public access with the protection of wildlife habitat, and minimizes the exposure of the tidal marsh to human intrusion to protect endangered species that are anticipated and those that already inhabit the adjacent fringe tidal marsh. The trail and interpretive overlooks were designed to allow the public to view both the seasonal and tidal marsh, as well as the wildlife corridor while buffering the inhabitants' view of the public. Buffering techniques that were used include distance, vegetative buffers, tidal sloughs, fencing and elevation changes along the perimeter levees. The trail and interpretive overlooks are aligned along the southern, western and northern perimeter of the site.

Constructing public access adjacent to seasonal and tidal marshes require elevations that avoid regular tidal inundation of the trail and overlooks. While the trail is located at the upland edge of the site, at an elevation of 9 feet NAVD 88, some extreme tides or storm events may flood the trail periodically. In addition, as sea level rises, the tidal inundation may increase over time.

7.4 DESIGN ELEMENTS

The following trail and overlook description begins at the northern corner of the site and continues along the perimeter to the southeastern corner of the site. The trail will consist of a twelve-foot-wide, paved path between two, two-foot-wide shoulders of compacted soil vegetated with native herbaceous plants along the entire alignment. The soil beneath the trail will be compacted to 85% to ensure stability. The elevation of the trail is 9 feet NAVD 88 except at the approaches to access points. The placement of the trail at this elevation will preclude inundation from all but the highest tides or rainfall The trail width and design is consistent with Bay Trail guidelines for multi-use trails and will accommodate two-way foot or bicycle traffic. Figure 35 depicts the trail segments described below.

7.4.1 Segment A

This portion of the trail is located along the southeastern side of Pacheco Pond levee. Because the trail is located between two sensitive habitats, Pacheco Pond to the northwest and the seasonal wetlands to the southeast, two wildlife protective measures will be employed. The northwest side of the Pacheco Pond levee will have a native plant vegetated buffer to shield this existing habitat from construction activities and members of the public who have strayed from the trail. On the southeast side of the trail a 1.5-foot-high native plant vegetated berm will be created to minimize wildlife's view of the trail and the public. A post and cable fence will be erected between the trail and the top of the levee as a safety precaution. Limiting access to the top of the levee is an important safety consideration due to construction activities in this area for several years. More restrictive fencing would preclude the passage of wildlife between these two habitats.

7.4.2 Segment B

In the area of the City of Novato levee, the trail runs along the levee, below the crown to the east. There is a splash wall on top of the City of Novato levee that separates the project and the trail from the adjacent residences. A four-foot high fence approximately 20 feet from the trail edge will create a barrier between the public access and the wildlife corridor. This fence would allow small mammals safe use of the wildlife corridor. At the Graystone pumping station a foot bridge approximately six feet wide will allow the public to safely pass over stormwater outfall flows.

A trail access point will be added adjacent to the Army Hangers now used as business buildings. This access point will be connected to the parking lot and the trail via two ramps up to and down from the levee crown. The base of these ramps will be compacted soil with a twelve foot wide paved section consistent with the connecting trail.

7.4.3 Segment C

This portion of the trail connects from the southern end of the City of Novato levee to the south levee. The trail will be place on compacted dredged sediment adjacent to the coast guard property along the oak forest habitat on adjacent Coast Guard Hill. The trail will follow the contour of the hillside. Similar to Segment C, a four-foot high fence would be erected to prevent the public and their dogs from entering the wildlife areas. In addition to provide visual screening for the wildlife, a native vegetated swale will be created on the eastern side of the fence. A second stormwater pumping station exists along this portion of the trail. A second foot bridge approximately six feet wide constructed over the outflow pipes will allow the public to safely pass over this area.

The South Hamilton Park community trail will connect segment D at the junction of the trail and the City of Novato Levee. There are approximately 36 parking spaces and restrooms publicly available at the community park.

7.4.4 Section D

This portion of the trail connects from the southern end of the City of Novato levee to the south levee. The trail will be place on compacted dredged sediment adjacent to the coast guard property along the oak forest habitat on adjacent Coast Guard Hill. The trail will follow the contour of the hillside. Similar to Segment C, a four-foot high fence would be erected to prevent the public and their dogs from entering the wildlife areas. In addition to provide visual screening for the wildlife, a native vegetated swale will be created on the eastern side of the fence. A second stormwater pumping station exists along this portion of the trail. A second foot bridge approximately six feet wide constructed over the outflow pipes will allow the public to safely pass over this area.

The South Hamilton Park community trail will connect segment D at the junction of the trail and the City of Novato Levee. There are approximately 36 parking spaces and restrooms publicly available at the community park.

7.4.5 Section E

The last portion of the trail follows along the southern (inboard) side of the South Levee six feet below the levee crown to its end 700 feet short of the bayfront levee. This portion of the trail is adjacent to habitat intended for waterfowl use, and therefore, necessitates reduced visibility to the ponds. (Waterfowl are actively hunted by humans, and therefore are flushed easily). A four-foot-high fence would be erected to dissuade humans and their pets from climbing over the levee to the wetland site. At the junction between Segment D and E, there will be a gap in the fence to allow mammals and other wildlife to pass between the Las Gallinas property and the project. The levee is designed to include a sixteen-foot wide bench and ramp up to the viewing platform at the end of the trail.

7.4.6 Interpretive Overlooks

Five interpretive overlooks will be built on additional compacted fill. They will be located at the terminus of the trail at Pacheco Pond, near the ramp at Segments B and C, and at the eastern and western terminus of the South Levee. The viewing platforms at Pacheco Pond and the two sites along the south levee will include viewing scopes, and opaque enclosures from the railing height down to grade. All five viewing areas will have seating and interpretive signs about wildlife, wetlands and the restoration process.

8. SITE MANAGEMENT, MONITORING AND MAINTENANCE

This section summarized management, monitoring and maintenance after construction is complete. A detailed description of post-construction habitat monitoring and adaptive management is provided in PWA and BMP (in prep) *Management Plan for Habitat Creation at the Hamilton Wetlands Restoration Project, Marin County, California* (PWA and BMP, in prep b). An overall site Operations Plan for the period during construction will be developed in early 2008.

8.1 SEASONAL WETLANDS MANAGEMENT AND MONITORING PROGRAM

Management of seasonal wetland habitat will focus on actions that influence water storage and salt storage (PWA and BMP, in prep a). Storage of water from precipitation or occasional spring tides will increase pond area, depth and hydroperiod within constructed basins. Storage of salt from spring tides and evaporation of pond water will increase soil salinity of pannes and other areas surrounding the basin. Water and salt storage will dictate vegetation succession in seasonal wetland areas. The Northern Seasonal Wetland includes weir structures that offer the opportunity to manage water levels and influence inundation with saline waters. The Southern Seasonal Wetland does not include weir structures for management of pond water levels, other than the structures intended for mosquito abatement.

There will be two major components for monitoring in the Northern Seasonal Wetland. One component will be physical (pond hydrology, water and soil salinity): three replicate pond stations for measuring inundation and six replicate panne stations for measuring water and soil salinity. The other component will be biological (vegetation succession and bird activity): use of 160 "test polygons" that will be outplanted with propagules of acceptable plant species (founders).

8.1.1 Storm Water

Stormwater discharge channels are sized to convey discharge from NHP East and West levees, as well as from Landfill 26 pump station (in planning), during low and high tides. Both Northern and Southern Seasonal Wetland Stormwater Channels lie at intertidal elevations providing for the establishment of channel dimensions in equilibrium with tidal and stormwater flow hydrology. The low flow channel may meander with time within the bounds of the wider floodplain.

8.1.2 Mosquito Control

As in natural settings, both Northern and Southern Seasonal Wetlands are designed to flood, depending upon elevation, in response to seasonal rainfall events and spring high tides. As such, wetlands above summer high tides will tend to be dry from early summer through to late autumn.

Lower wetlands and tidal pannes will be subject to tidal flooding and thus hold water of varying duration through summer months.

Should mosquito management be necessary, it is provided on two levels in the design. Tidal flooding to the Northern Seasonal Wetland is controlled via a single water control structure with weir boards. Closure of this structure during the spring will result in dry pannes during the summer months. All ponds in the Northern and Southern Seasonal Wetlands will have small water control structures that provide for drainage. However, it should be noted that draining the ponds will compromise the capacity to control vegetation and may impact ecological function. Adjustment to management practices should be taken with the oversight of a Technical Advisory Group (PWA and BMP, in press).

8.1.3 Adaptive Management of Seasonal Wetlands

Controlling vegetation succession in the seasonal wetlands is a major objective for adaptive management. In the Northern Seasonal Wetland, the operation of water control structures will be adjusted to ensure that the composition and structure of developing vegetation and succession can be actively controlled by managing water and salt storage. There are two water control structures. A lower structure provides for control of tidal inflows and setting of water elevations relative to site grades. At the rear of the site (at Pond 1) there is a second weir structure that allows for tidal connection to higher ponds should adaptive management be required for control of vegetation.

Once a preferred mode of operation of the lower structure is selected, this structure may be left without adjustment or be adjusted on an infrequent basis. Over the longer term, this structure may be adjusted to accommodate changing hydrology and salt supply associated with rising sea level. Based upon monitoring and direction by a Technical Advisory Group, the management of the northern seasonal wetland may be modified to a muted tidal system should rising sea level or subsidence create a situation in which management of a seasonal wetland becomes untenable. A final adaptive management option will be to remove the water control structure and allow full tidal access to the site and the restoration of tidal marsh.

The hydrology of the Southern Seasonal Wetland is set by the elevation of pond sills relative to tidal elevations. Day to day adaptive management of water levels is not part of this design.

8.2 TIDAL WETLAND MANAGEMENT AND MONITORING PROGRAM

After the outer level is breached (2014), and sediment accumulates and raises site elevations, the tidal wetland is expected to progressively develop from mudflat to vegetated tidal marsh, with a mosaic of subtidal, intertidal, channel and marshplain habitats. The ecological trajectory of these tidal wetlands will depend upon the restoration of full tidal action, the final elevation of placed dredged material, the amount and rate of self-weight consolidation of dredged material with time, the supply of sediment from San Pablo Bay and the effectiveness of constructed wave berms at dampening wind-wave energy. Development of mudflat to marshplain will be fastest if average suspended sediment concentrations from the bay area high, if amount of dredged material autocompaction will be low and if wind wave energy is moderate. As the maximum elevation of site fill will be no higher than 1.5 ft below MHHW channels formation will progress rapidly across the site.

There will be two major components to implementing the monitoring program within the tidal wetlands (PWA and BMP, in prep b). One component will be physical, focused on sedimentation, tidal hydrology, channel development and the subsidence of berms. The other component will be biological, including vegetation, weeds, fish, birds and special status species. The parameters that will be measured are similar to those employed by other tidal wetlands projects (USACE, 1994) but adapted to the HWRP. Thus, they directly reflect suggested success criteria (PWA & BMP, Table 4) that allow the evaluation of management actions, the developmental trajectories of essential habitat elements and the final assessment of project goals.

8.2.1 Vegetation Management and Non-Native Invasive Vegetation Control

All areas of the tidal wetland system (including top elevations of wave berms) will lie at elevations within the range of tidal flooding. Tidal waters will supply salts to displace non salt tolerant vegetation. Should invasive *spartina* species invade the tidal wetlands area, control with an appropriate aquatic herbicide will be required.

8.2.2 Mosquito Control

The tidal wetlands area will be subject to full tidal connection reducing considerably if not eliminating the likely requirement for mosquito control.

8.2.3 Adaptive Management of Tidal Wetlands

It is not anticipated that ‘fine-tuning’ of site-development from mudflats to marshplain will be necessary. However, it should be noted that internally generated waves may reduce the rate of marsh build up in exposed areas of the site. If monitoring indicates that the site is not accumulating sediment and rising at an acceptable rate or extent, several remedial actions may be taken. If it is determined that the breach was undersized and is limiting tidal exchange, additional excavation may be performed. Should sediment availability be low or wave energy excessively high, supplemental addition of sediment may be warranted. Should channel formation be limited or their structure failing to provide the ecological function observed in natural reference marshes, appropriate approaches, such as micro-dredging, might be deployed.

Beyond alterations to the breach dimensions, other post-construction management actions affecting hydrology could be too expensive or outcome uncertain to deploy. For this reason the restoration of the tidal marshes is 'front-loaded' by the design and construction phases. These phases seek to provide a site template with an acceptable geomorphic and ecological trajectory that responds to long-term changes in estuary wide hydrology and sediment dynamics.

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2. *Refined designs for internal berms and benches, HAAF wetlands restoration project*, PWA 2005
3. *Inter-tidal Berms - wave heights and tide velocities,* Corps 2007
4. *Reference for tidal slough formation used for the 1998 Feasibility study. PWA design study?*

10. FIGURES

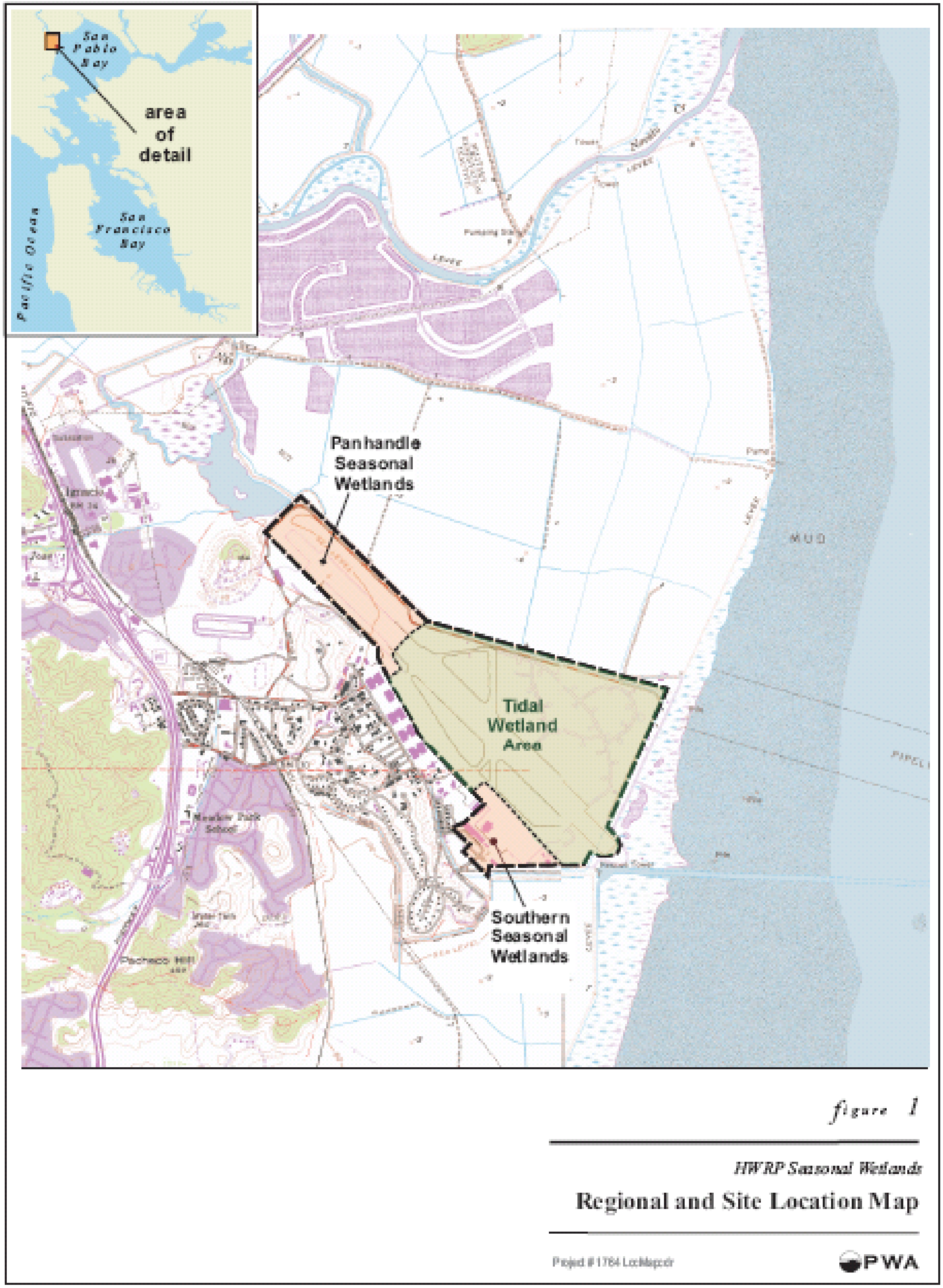


Figure 1. Vicinity Map and Regional Restoration Context

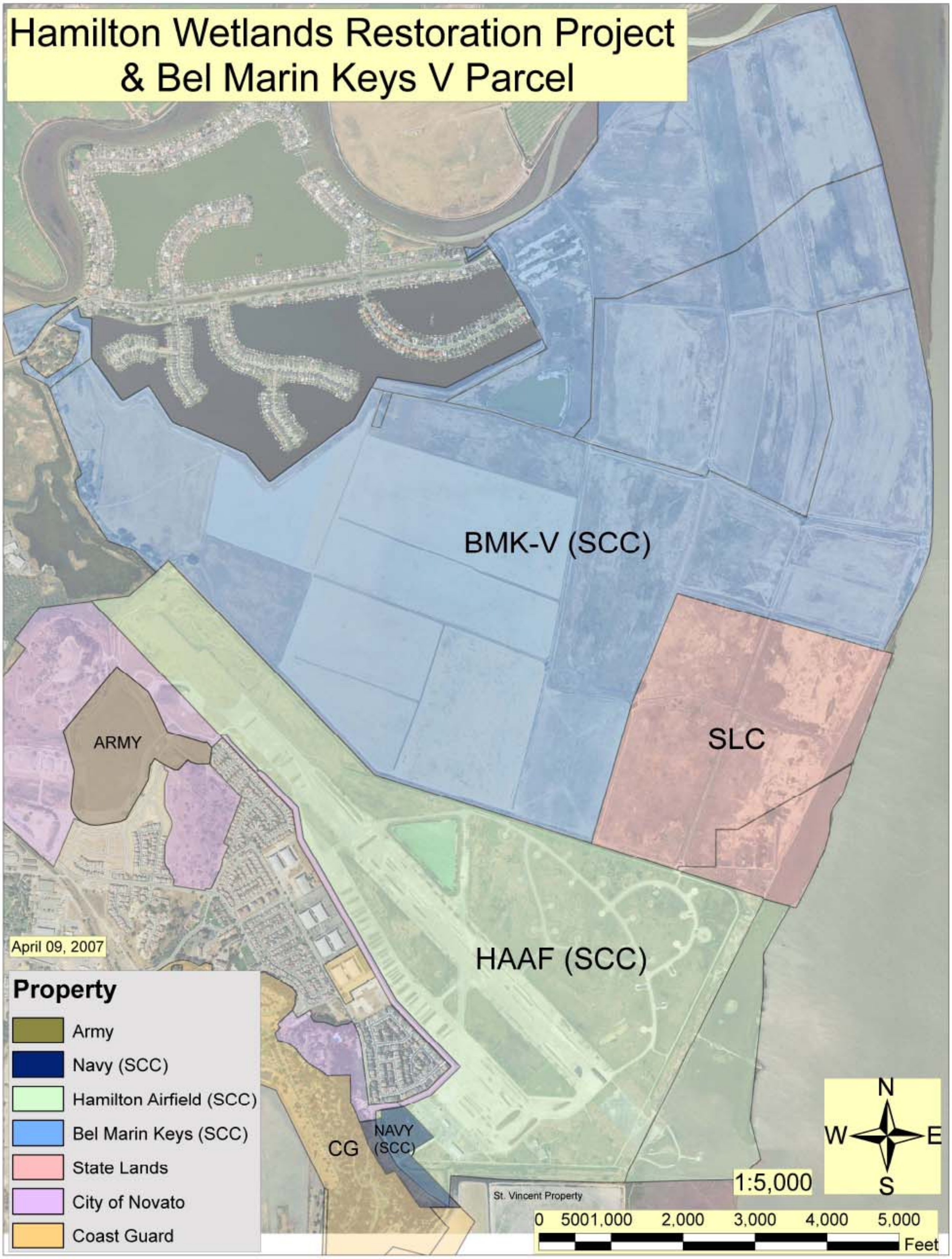


Figure 2. Surrounding Land Uses

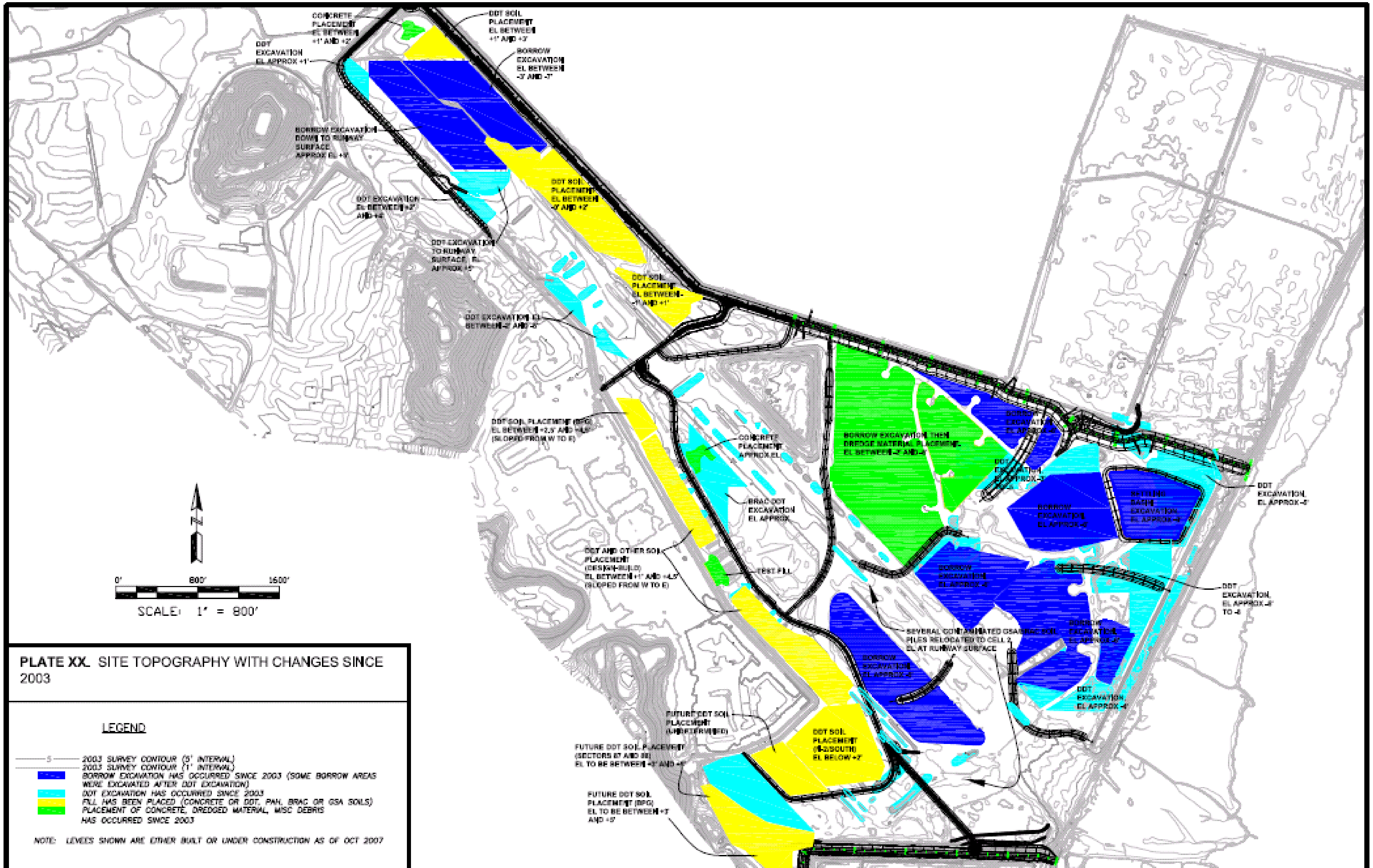


Figure 3. Site Topography and Excavations

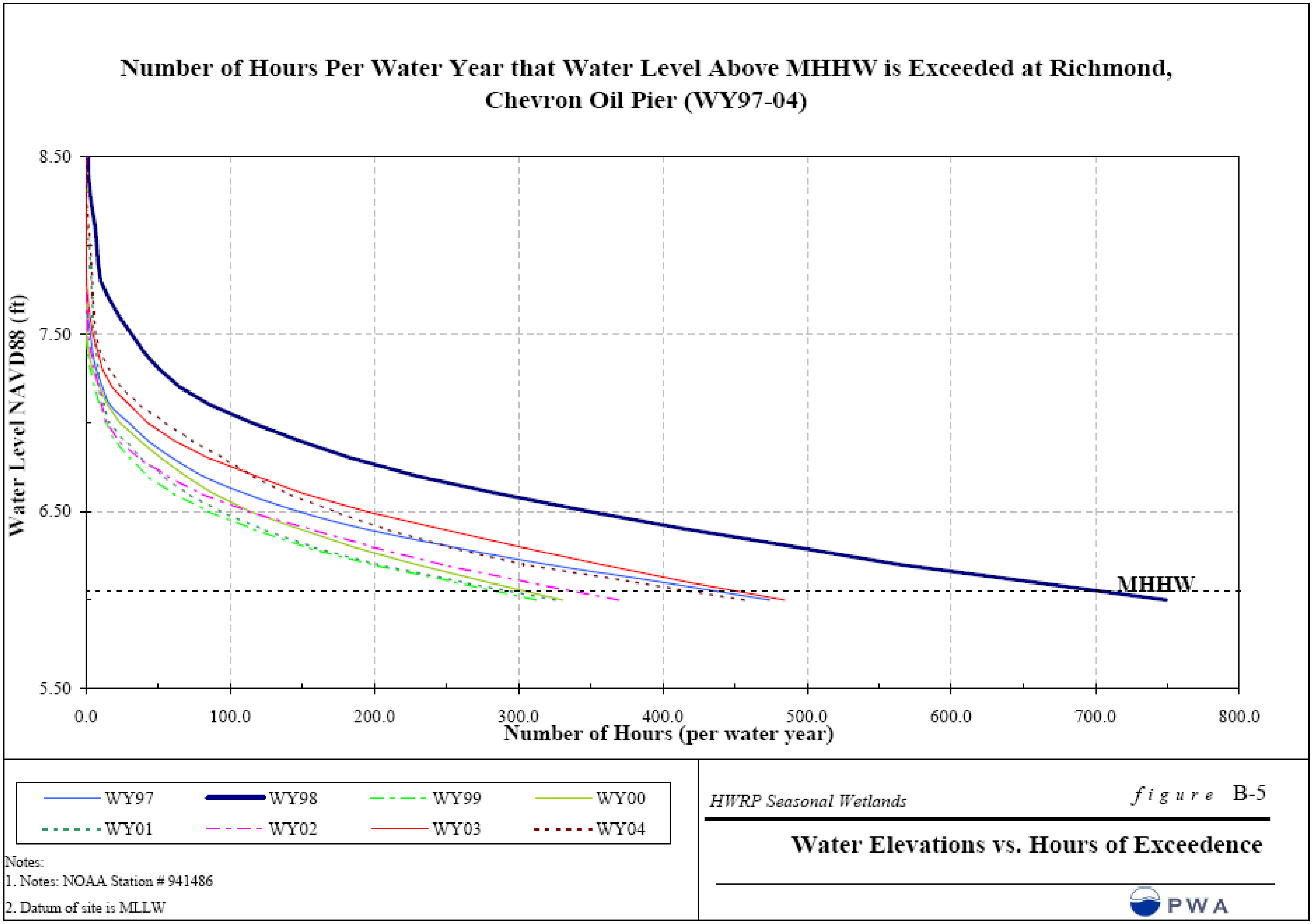
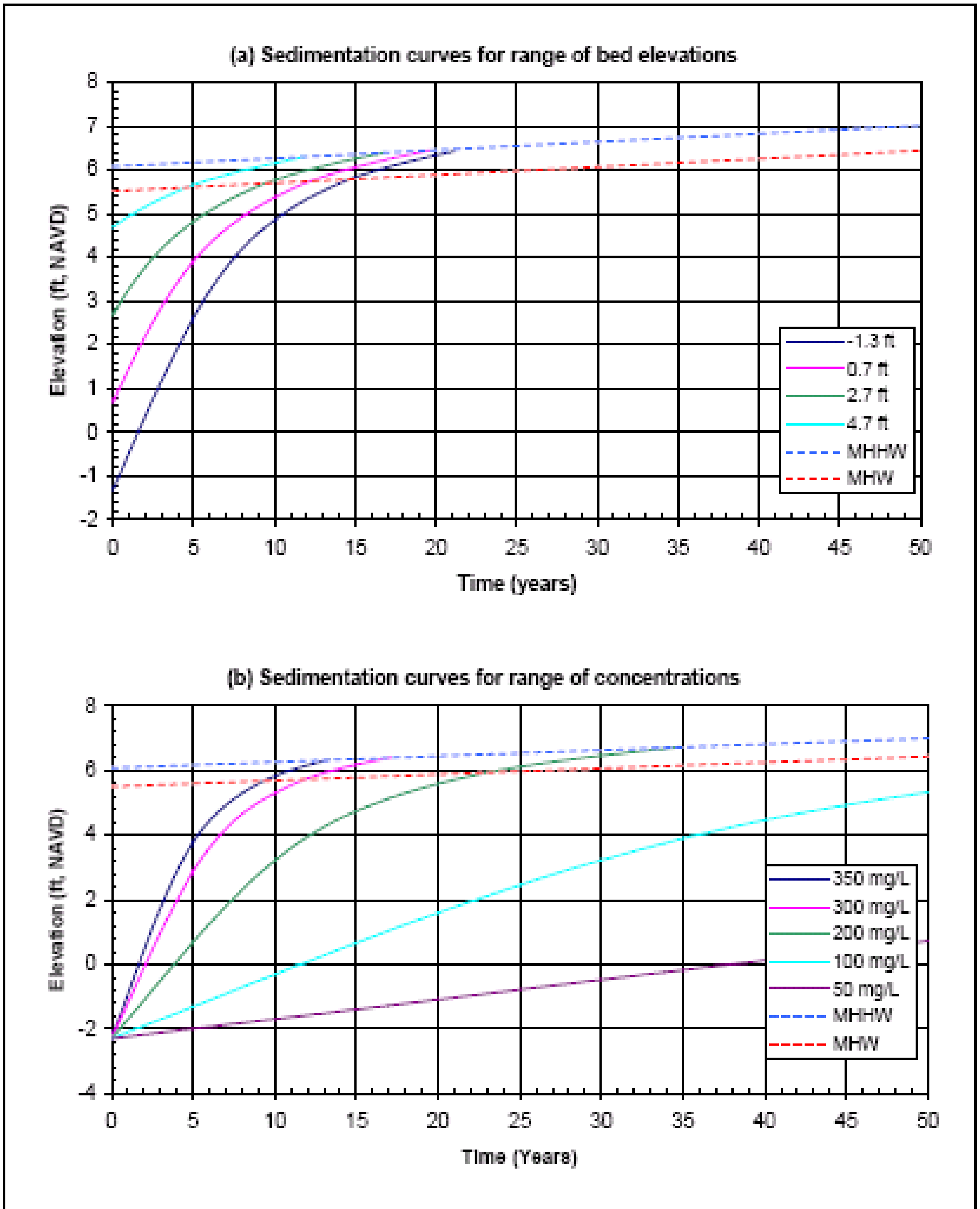


Figure 4. High Tide Water Elevations in San Pablo Bay at Richmond Tide Station (1997-2004)



Notes: (a) Ambient sediment concentration of 250 mg/L
(a) and (b) Cd = 350 mg/L, Mean monthly tide from Petaluma River Entrance (NOAA #9415252), Rate of sea level rise = 5.67 mm/yr. Selected starting elevations reflect re-run of 1998 feasibility study analyses.
Source: MARSH98 Sedimentation Model

figure 5
Hamilton Wetlands

MARSH98 Sedimentation Curves

PWA Ref# 1764.03 PWA

P:\Projects\1764.03_Hamilton_Restoration_Plan\Memos\Tidal_Wetland_Dredge_Matl_Plan\Sedimentation Analysis\Hamilton Marsh 98 Results REVISED.xls\Figure 2-1

Figure 5. Sedimentation Curves

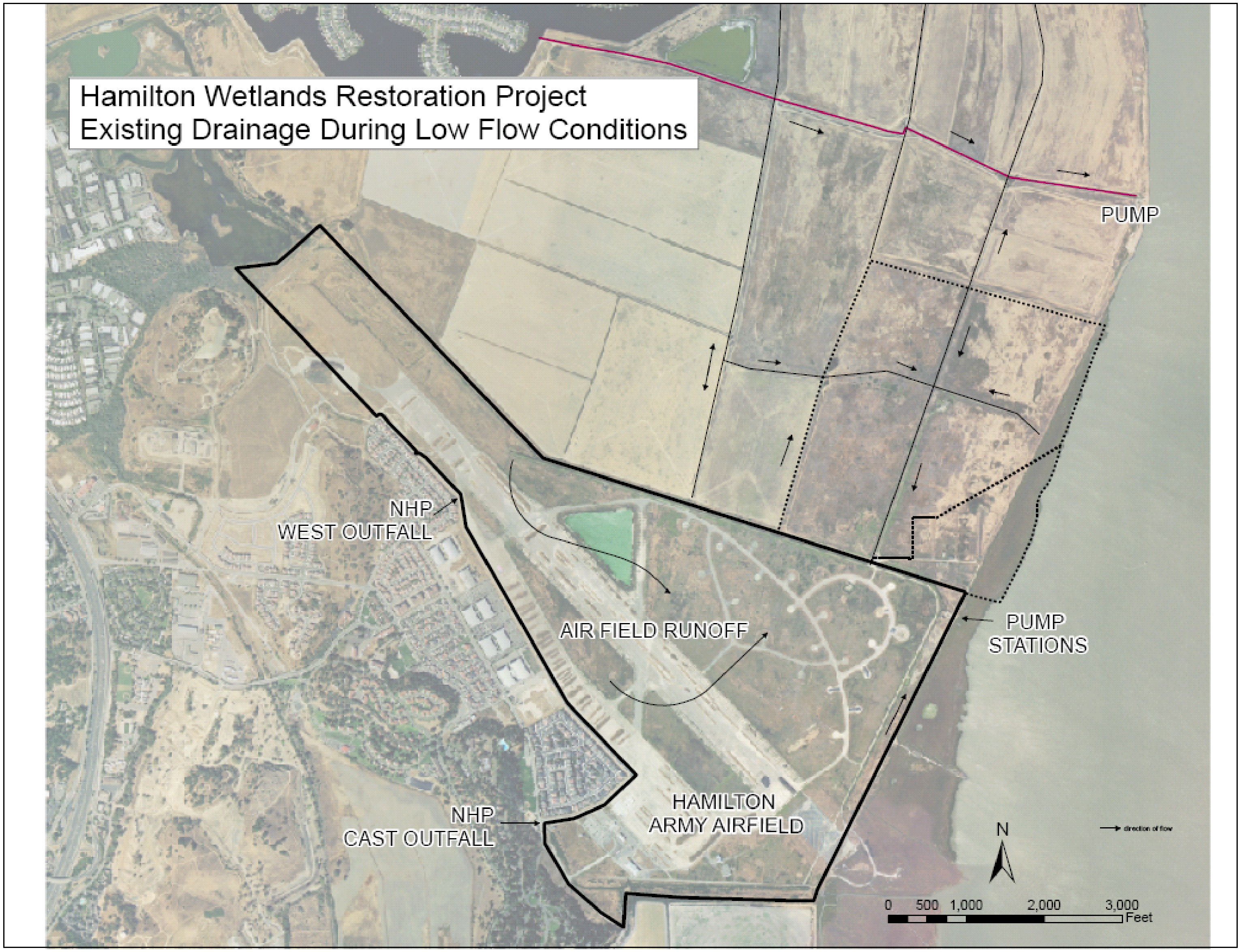


Figure 6. Regional Drainage Features

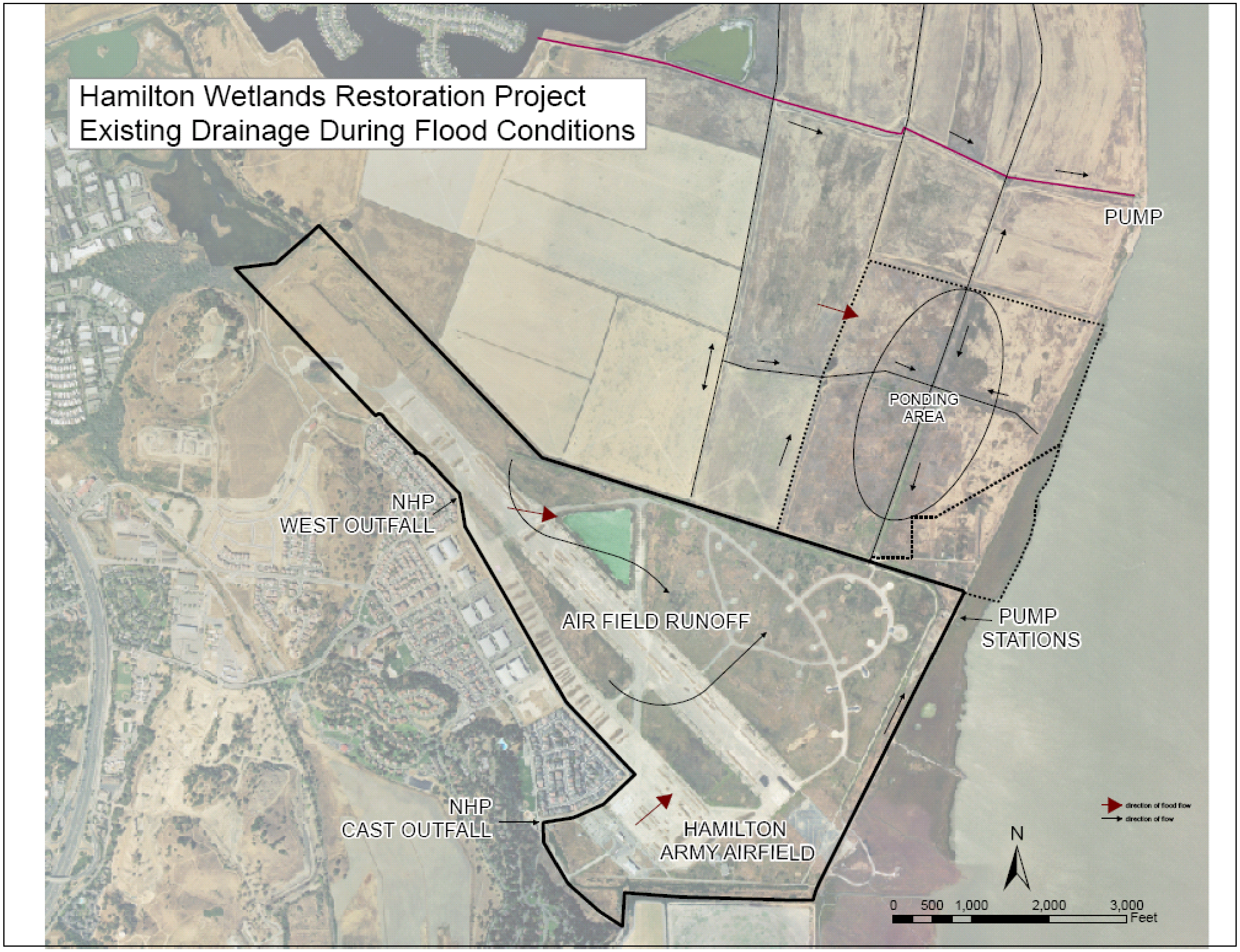
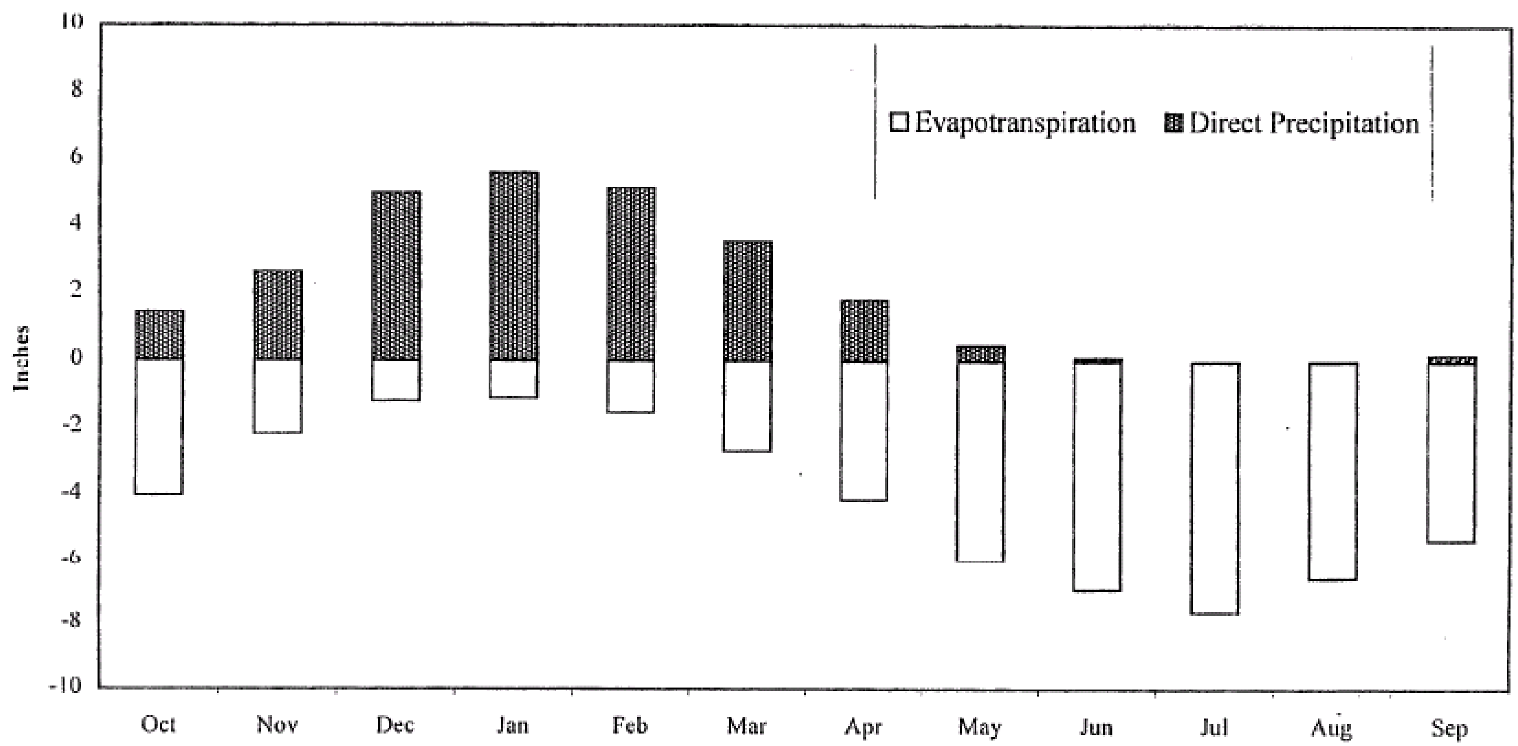


Figure 7 Location of Surface Inflow to Site



Notes: Evapotranspiration is the total water loss due to evaporation from open water and transpiration from plant growth. Evapotranspiration presented here is the average of lake evaporation and marsh vegetation evapotranspiration.

Sources: Precipitation from NOAA National Climate Data Center, Hamilton AFB Station, 29-year period of record. Evapotranspiration for Hamilton Field from "Evaporation and Evapotranspiration Investigations in the San Francisco Bay Area," Blankey and Muckel, Transactions American Geophysical Union, Vol. 36., No. 5, October 1955, pp. 817-818.

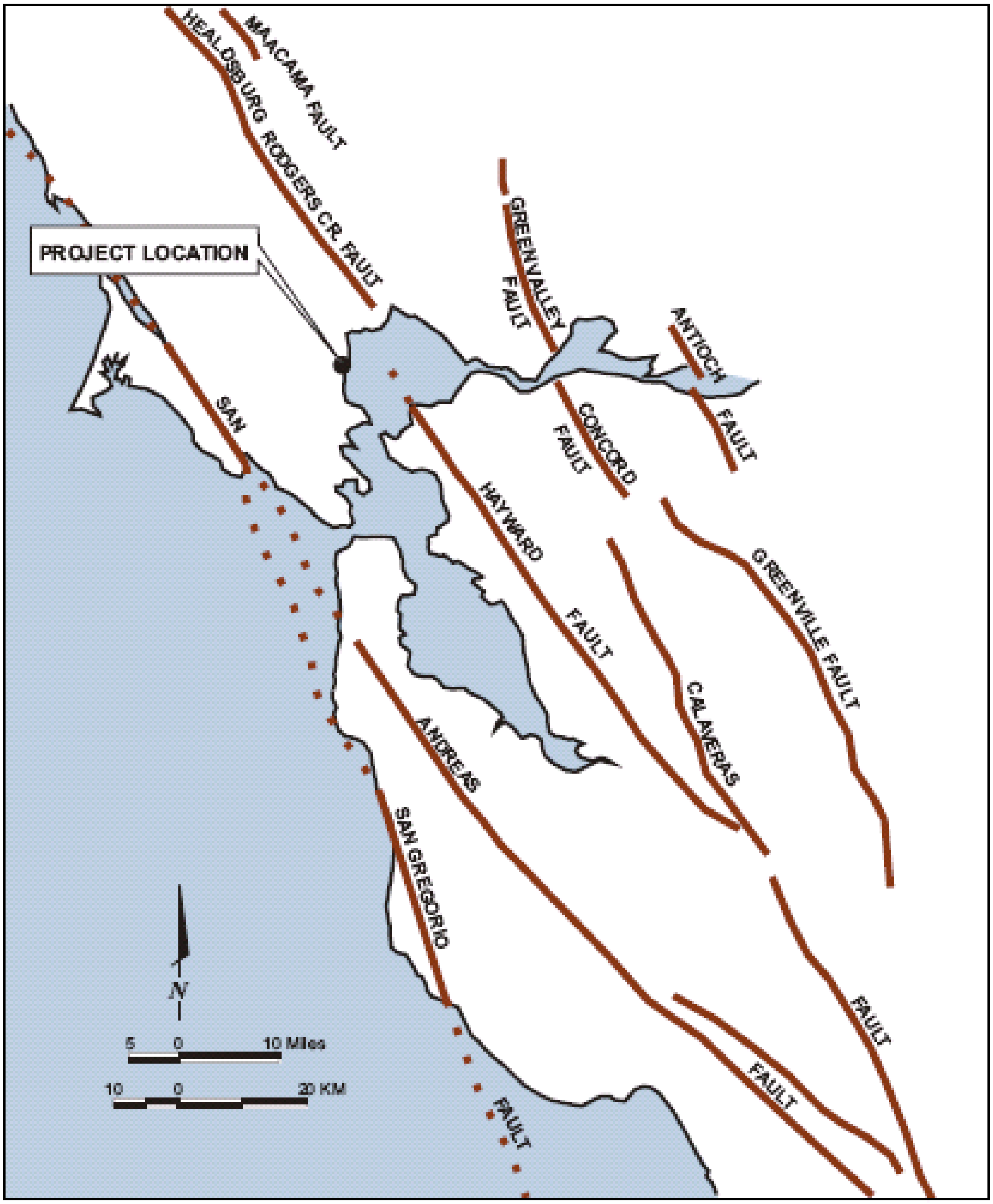
figure 3-5
Hamilton Wetlands Restoration Plan

Water balance for a mean rainfall year

PWA Ref# 1764.03

PWA

Figure 8 Monthly Precipitation and Evapotranspiration



Source: California Division of Mines and Geology, Special Publication 78 (1987)

ACTIVE FAULTS
IN THE SAN FRANCISCO BAY AREA

Hamilton Army Air Field
Wetlands Restoration Project
US Army Corps of Engineers
Novato, California

March 2003
28066444

URS

PLATE 5

Figure 9 Regional Faults

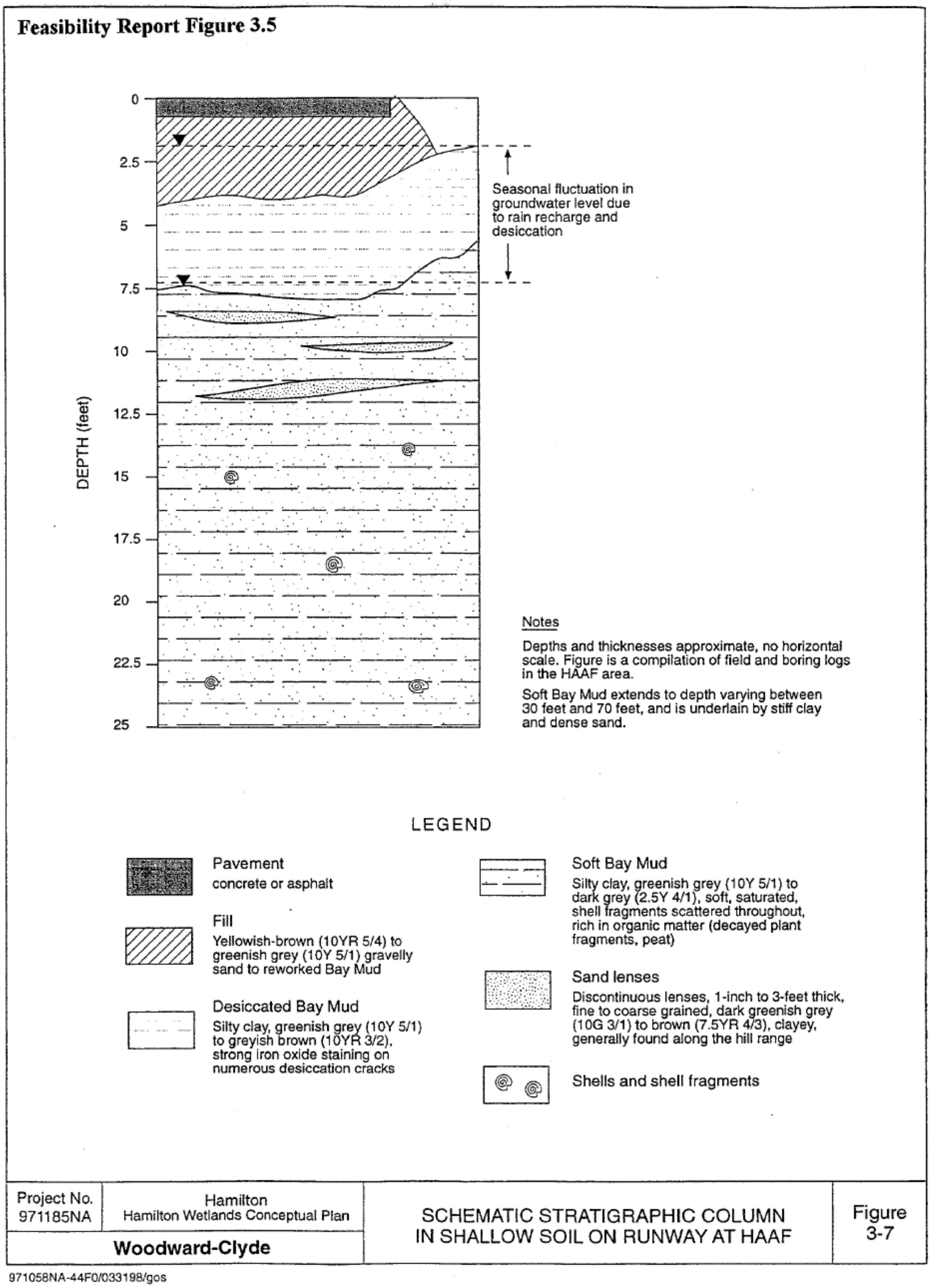
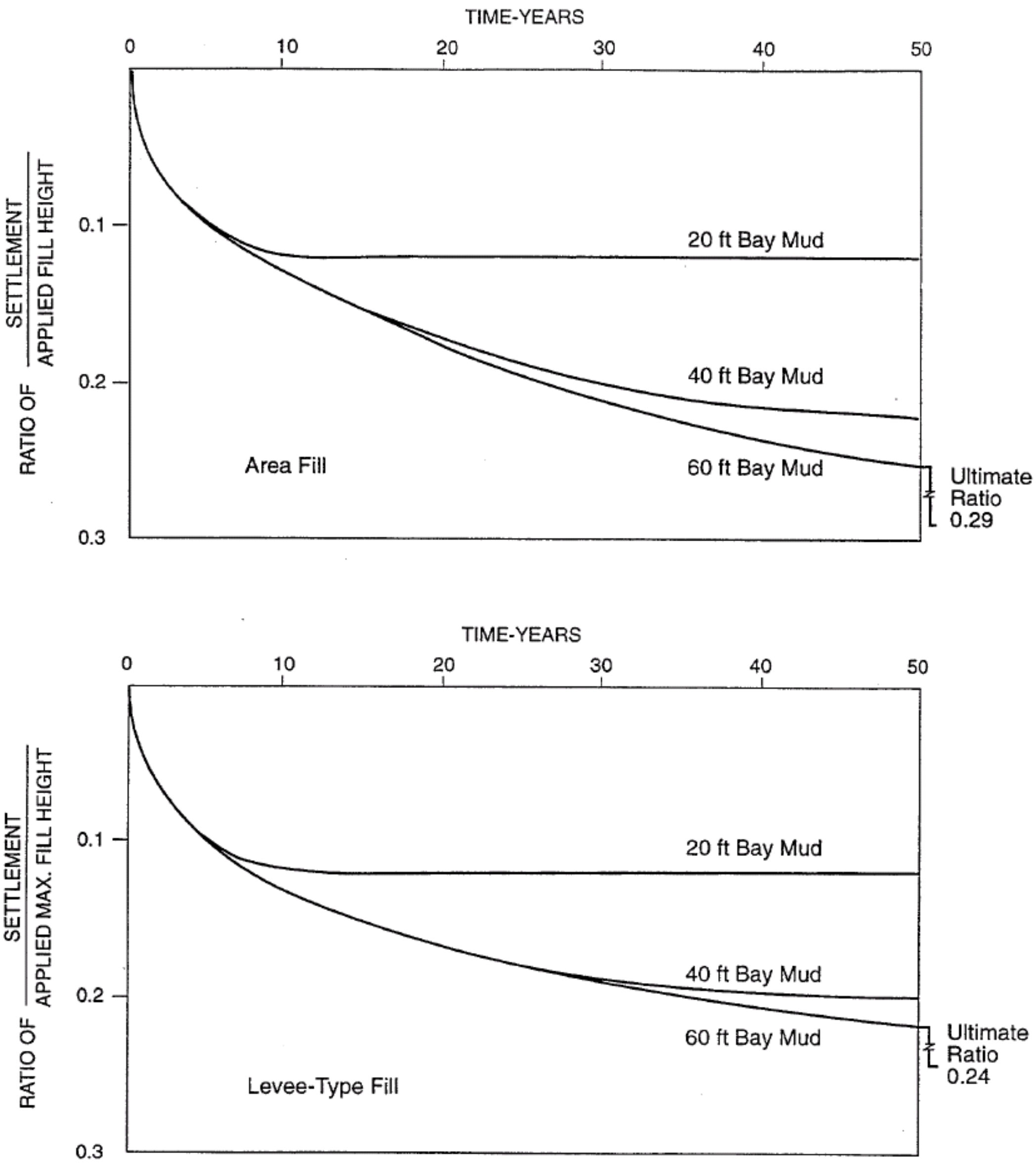


Figure 10 Site Stratigraphy

Feasibility Report Figure 3.6



Note:
The figure depicts settlements as a fraction of the applied fill height.
For instance, for an area fill, at a location with 60 feet of Bay Mud,
the expected settlement after 30 years is 20% of the applied fill depth.

Project No. 971185NA	Hamilton Hamilton Wetlands Conceptual Plan	CONCEPTUAL SETTLEMENT ESTIMATES	Figure 3-8
Woodward-Clyde			

971058NA-44F0/033198/gos

Figure 11 Settlement Estimates

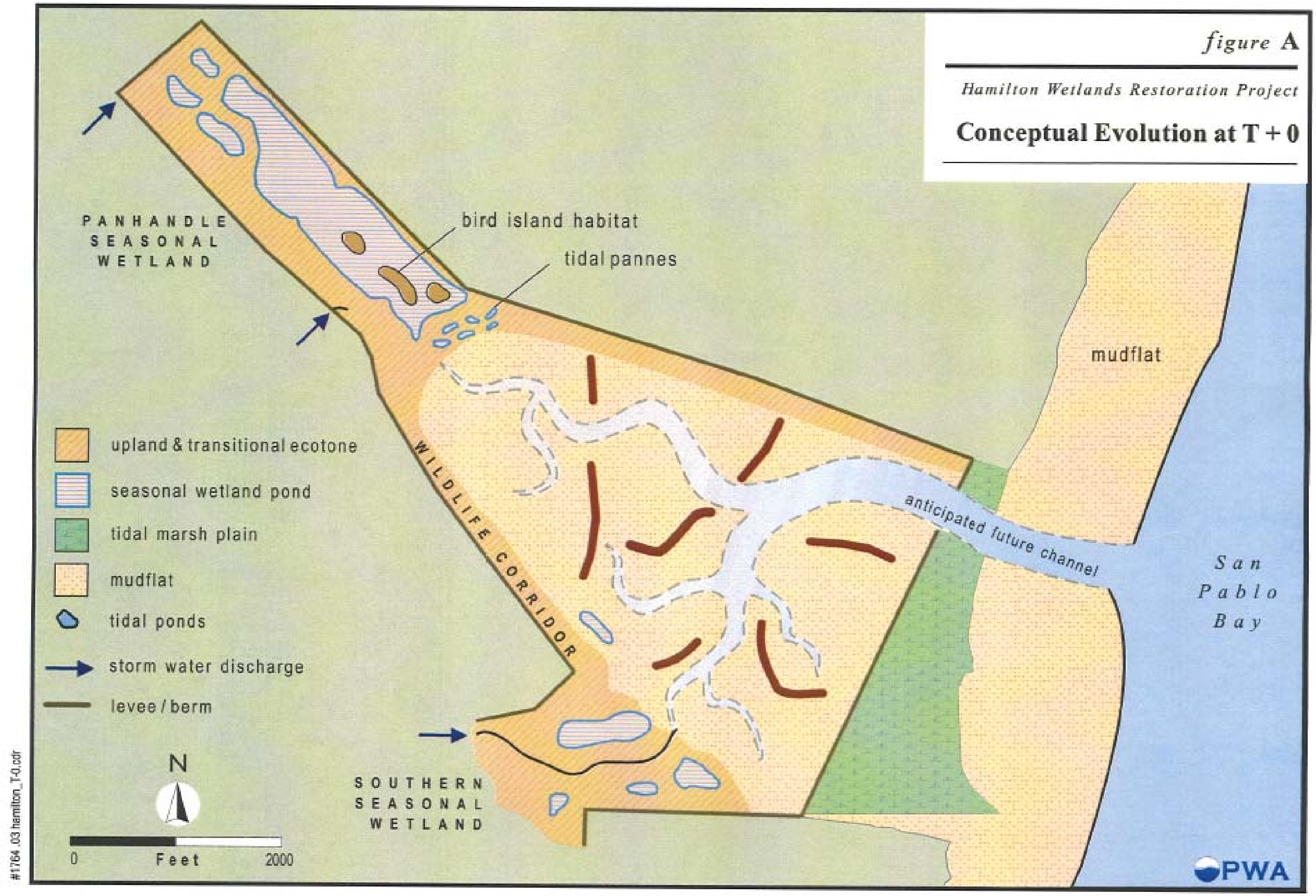


Figure 12 Conceptual Evolution at T+0

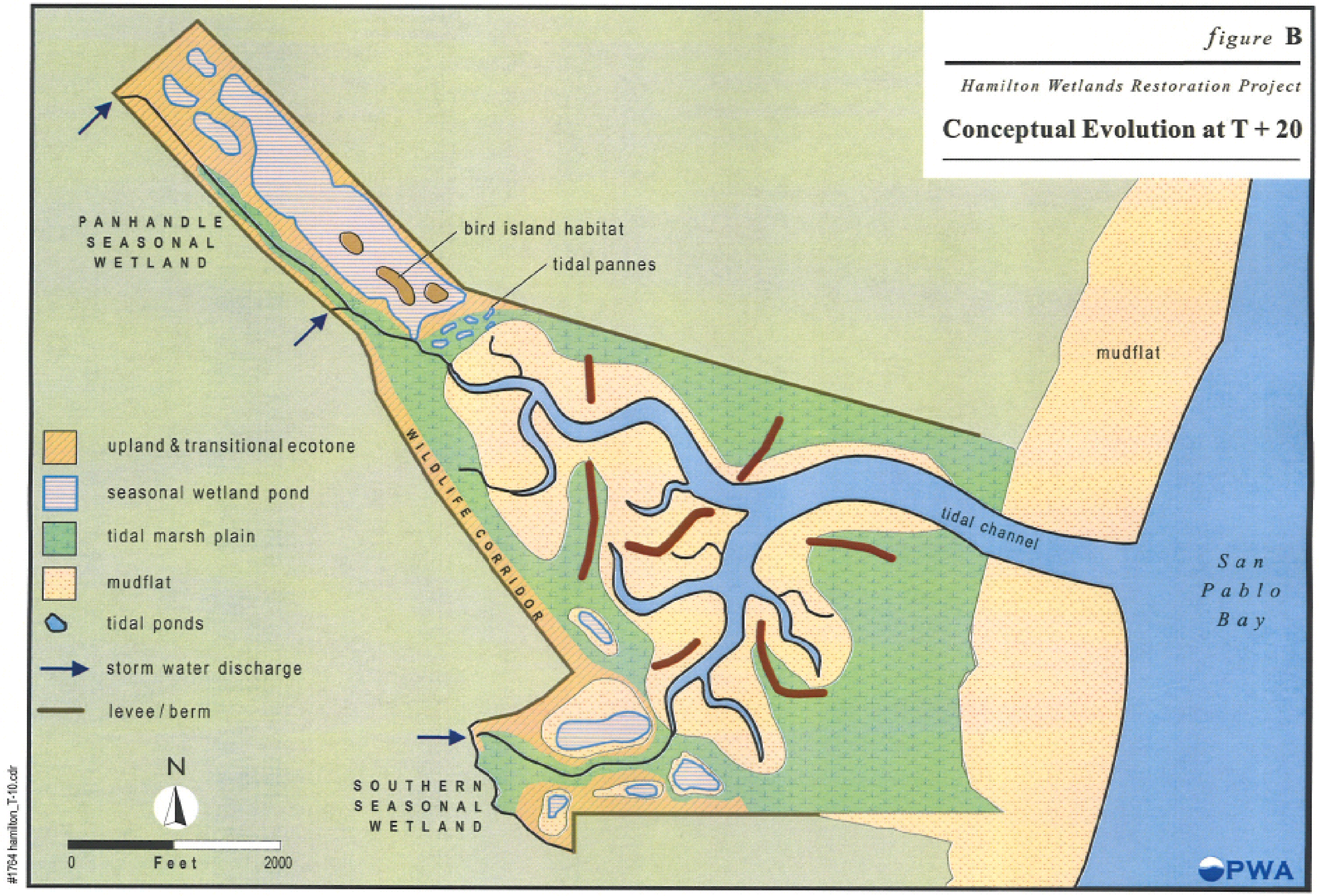


Figure 13 Conceptual Evolution at T+20

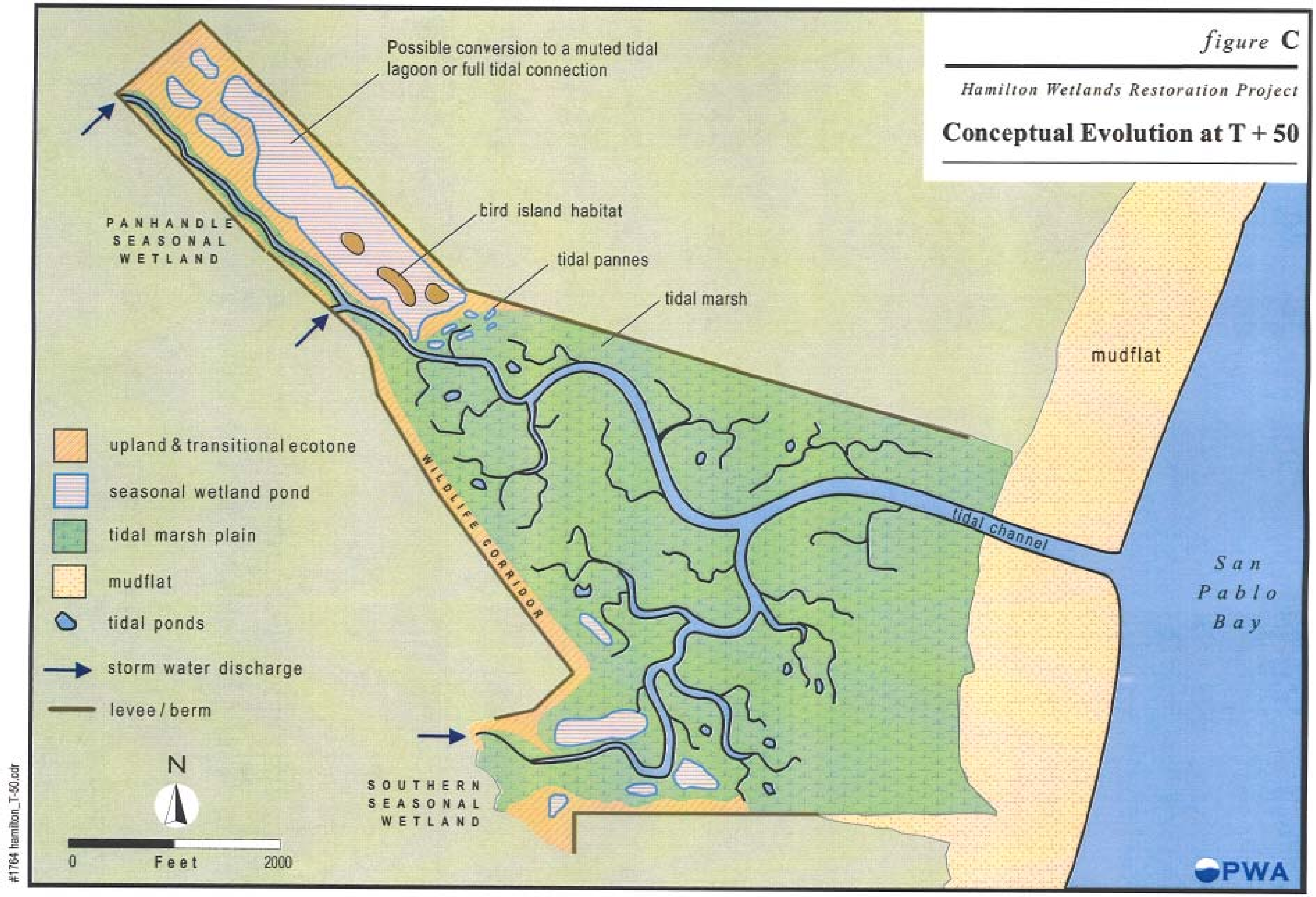


Figure 14 Conceptual Evolution at T+50

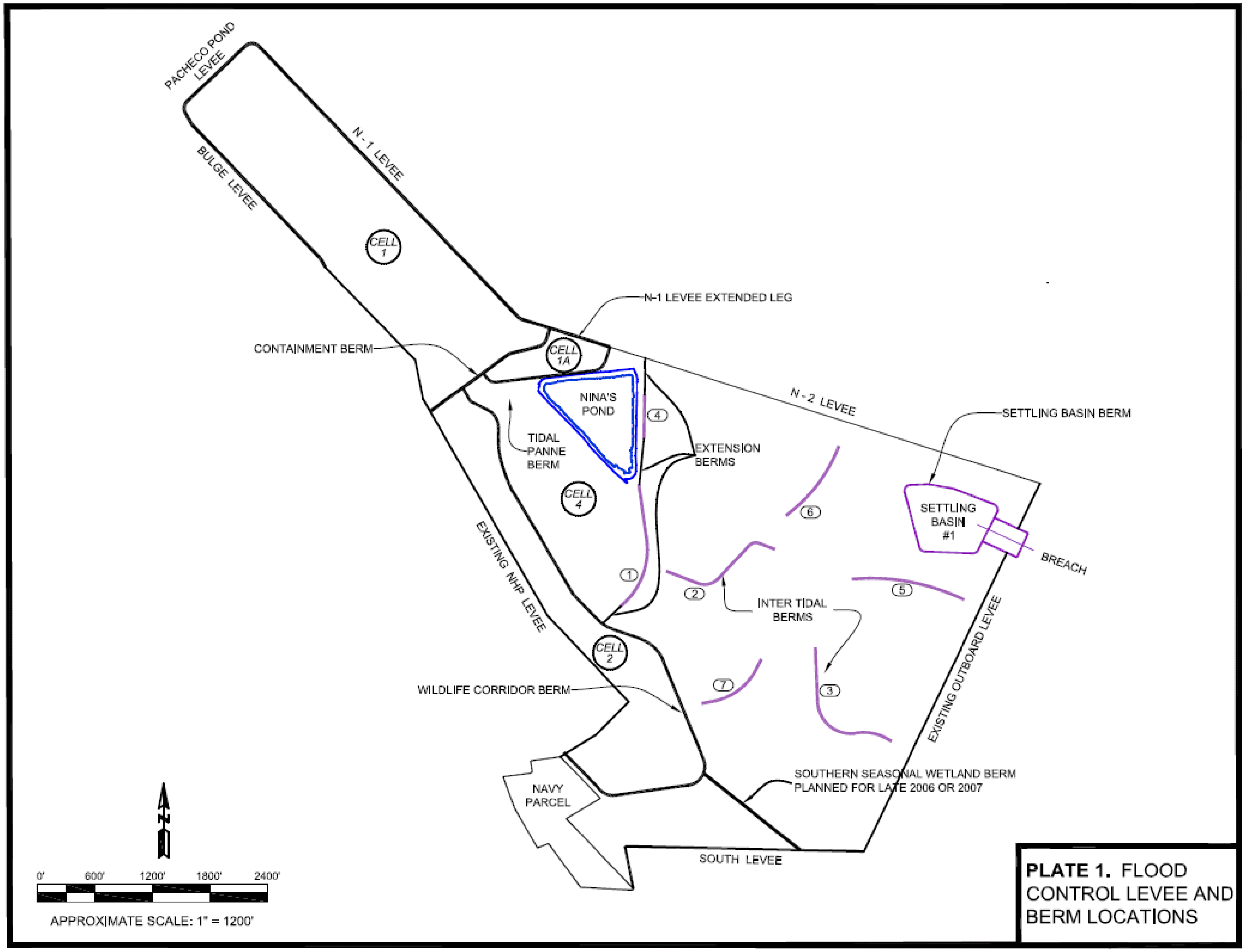
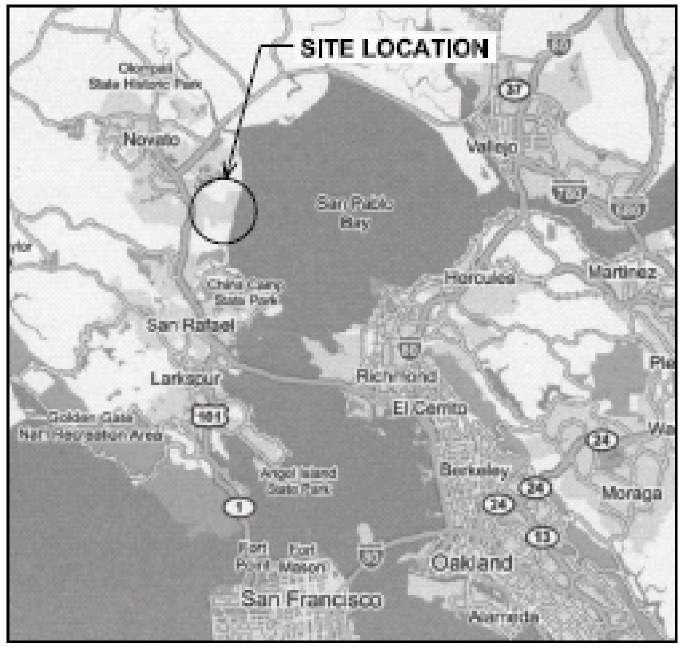
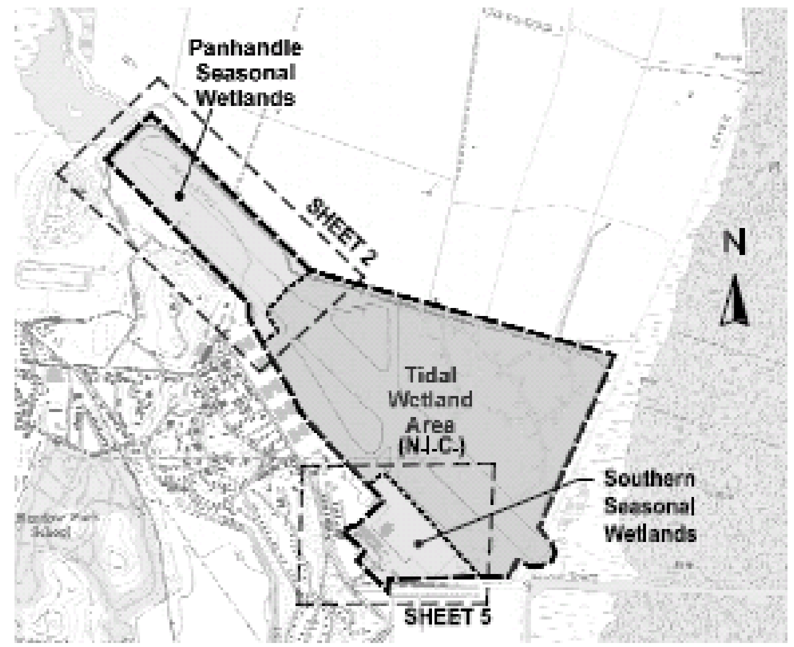


Figure 15 HWRP Levees and Berm

SEASONAL WETLANDS



VICINITY PLAN



SHEET INDEX MAP

LEGEND

- EXISTING CONTOUR
- DESIGN CONTOUR
- EXISTING GRADE
- DESIGN GRADE
- EXISTING / N.I.C
- GRADED DEPRESSIONS
- LOW PERMABILITY FILL (SECTION)
- SANDY FILL (SECTION)
- (DETAIL) — SHEET ON WHICH DETAIL IS TAKEN (TYP.) / SHEET ON WHICH DETAIL IS DRAWN (TYP.)

GENERAL NOTES

1. TOPOGRAPHIC MAPPING PREPARED BY TOWILL, INC. USING PHOTOGRAMMETRIC SURVEYING TECHNIQUES. BASED ON AERIAL PHOTO DATED 6/16/03.
2. ELEVATIONS ARE REFERENCED TO NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).
3. HORIZONTAL CONTROL IS CALIFORNIA STATE PLAN COORDINATE SYSTEM, ZONE 3, IN FEET, NORTH AMERICAN DATUM (NAD 83, 1992).
4. ALL ELEVATION AND HORIZONTAL COORDINATES ARE IN FEET.
5. BASEMAPS, CONTROL AND TOPOGRAPHY PROVIDED BY THE U.S. ARMY CORPS OF ENGINEERS.
6. THESE DRAWINGS ARE FOR THE SEASONAL WETLANDS ONLY. SEE DRAWINGS BY OTHERS FOR LEVEES, DRAIN OUTLETS, SUBGRADE FILL ETC., WHERE DRAWN FEATURES LABELED 'BY OTHERS' ARE APPROXIMATED.

DRAWING LIST

1. TITLE SHEET & INDEX
2. GRADING PLAN - PANHANDLE SITE
3. TYPICAL GRADING SECTIONS - PANHANDLE SITE
4. WATER CONTROL STRUCTURES – PANHANDLE SITE
5. GRADING PLAN – SOUTHERN SITE
6. TYPICAL GRADING SECTIONS - SOUTHERN SITE
7. ADDITIONAL GRADING FOR MOSQUITO ABATEMENT - PANHANDLE SITE
8. ADDITIONAL GRADING FOR MOSQUITO ABATEMENT - SOUTHERN SITE
9. CHANNEL PROFILE – SOUTHERN SITE

ABBREVIATIONS

APPROX.	APPROXIMATE	(N)	NEW
℄	CENTERLINE	NTS	NOT TO SCALE
EL,ELEV.	ELEVATION	PIP	PROTECT IN PLACE
(E),EXIST.	EXISTING	PWA	PHILIP WILLIAMS & ASSOCIATES
EG	EXISTING GRADE	RC	RELATIVE COMPACTION
FG	FINISHED GRADE	3:1	SLOPE, HORIZONTAL:VERTICAL
FT	FOOT, FEET	TYP.	TYPICAL
GB	GRADE BREAK	V/F	VERIFY IN FIELD
MAX.	MAXIMUM		
MIN.	MINIMUM		

35% SUBMITTAL
NOT FOR CONSTRUCTION

EAW / RAF / PLL	05/26/05	California State Coastal Conservancy HAMILTON PROJECT DELIVERY TEAM	MARIN COUNTY HAMILTON WETLAND RESTORATION PROJECT SEASONAL WETLANDS
SC	OCT 2007	PREPARED BY: PWA	TITLE SHEET & INDEX
BB	DEC 2005		SHEET 1 OF 9 — 1 DRAWING NUMBER: C101

Figure 16 Seasonal Wetlands Grading Plan – Cover Sheet and Legend

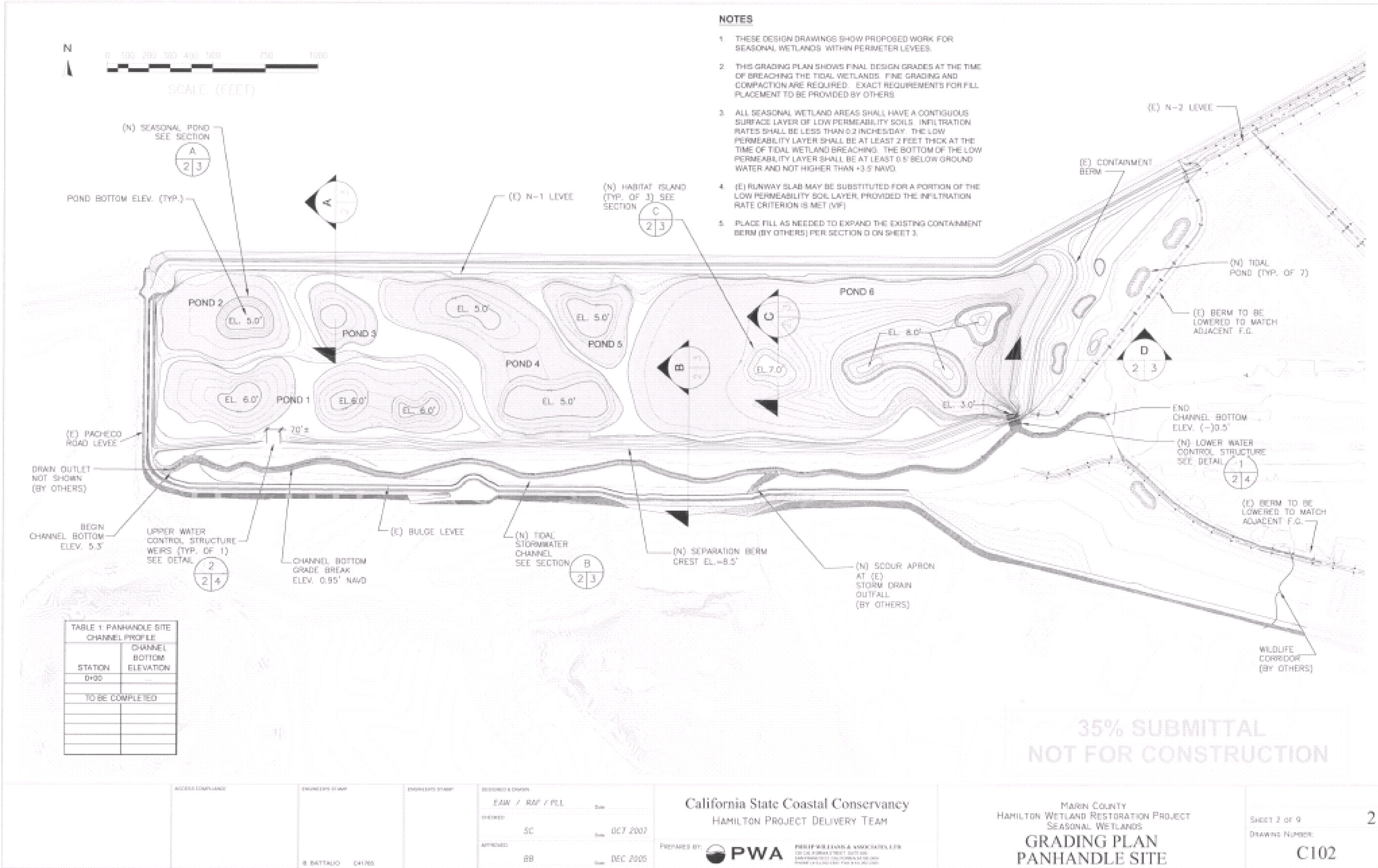


Figure 17 Grading Plan – Panhandle Site (N. Seasonal Wetland)

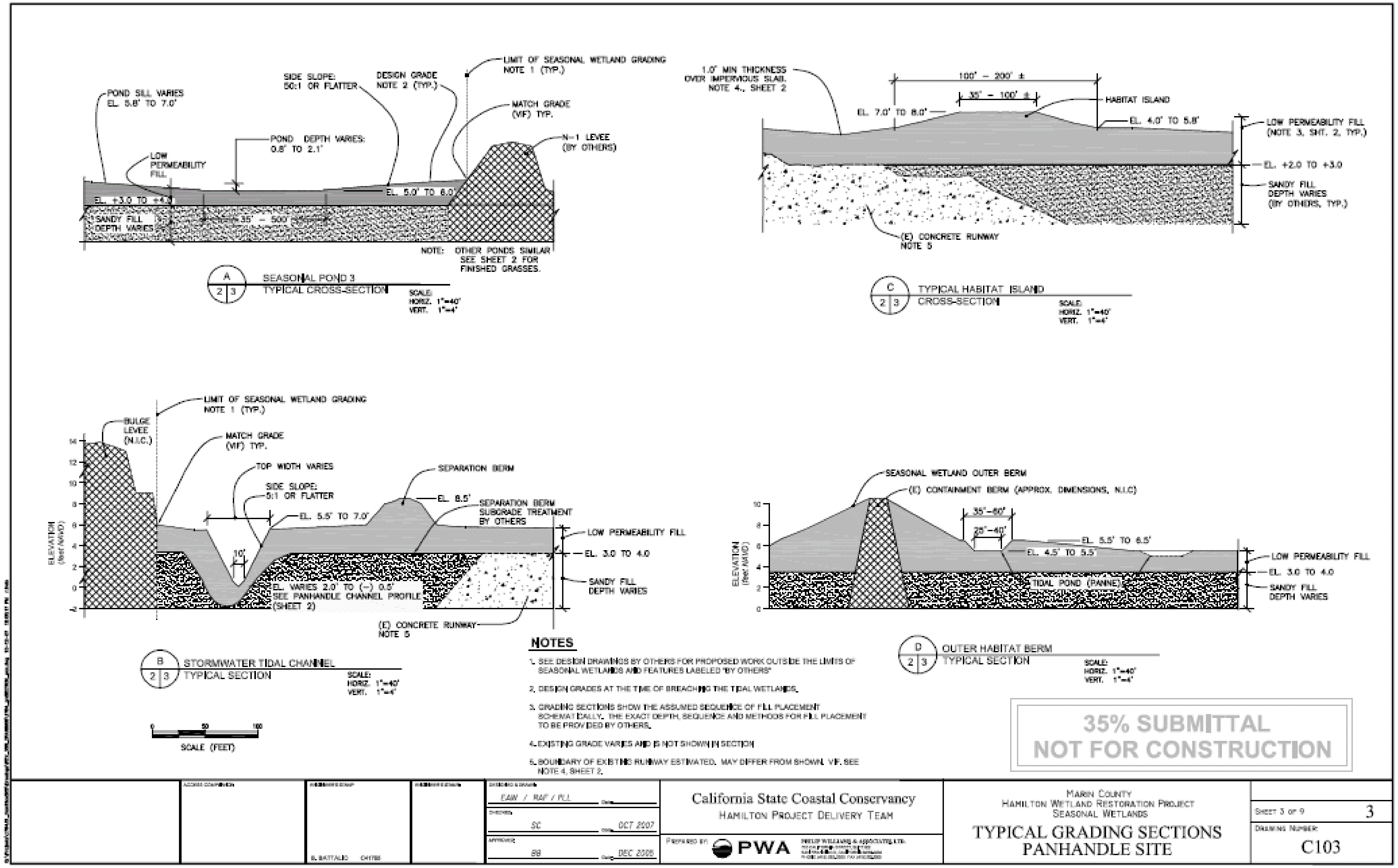


Figure 18 Typical Grading Sections – Panhandle Site (N. Seasonal Wetland)

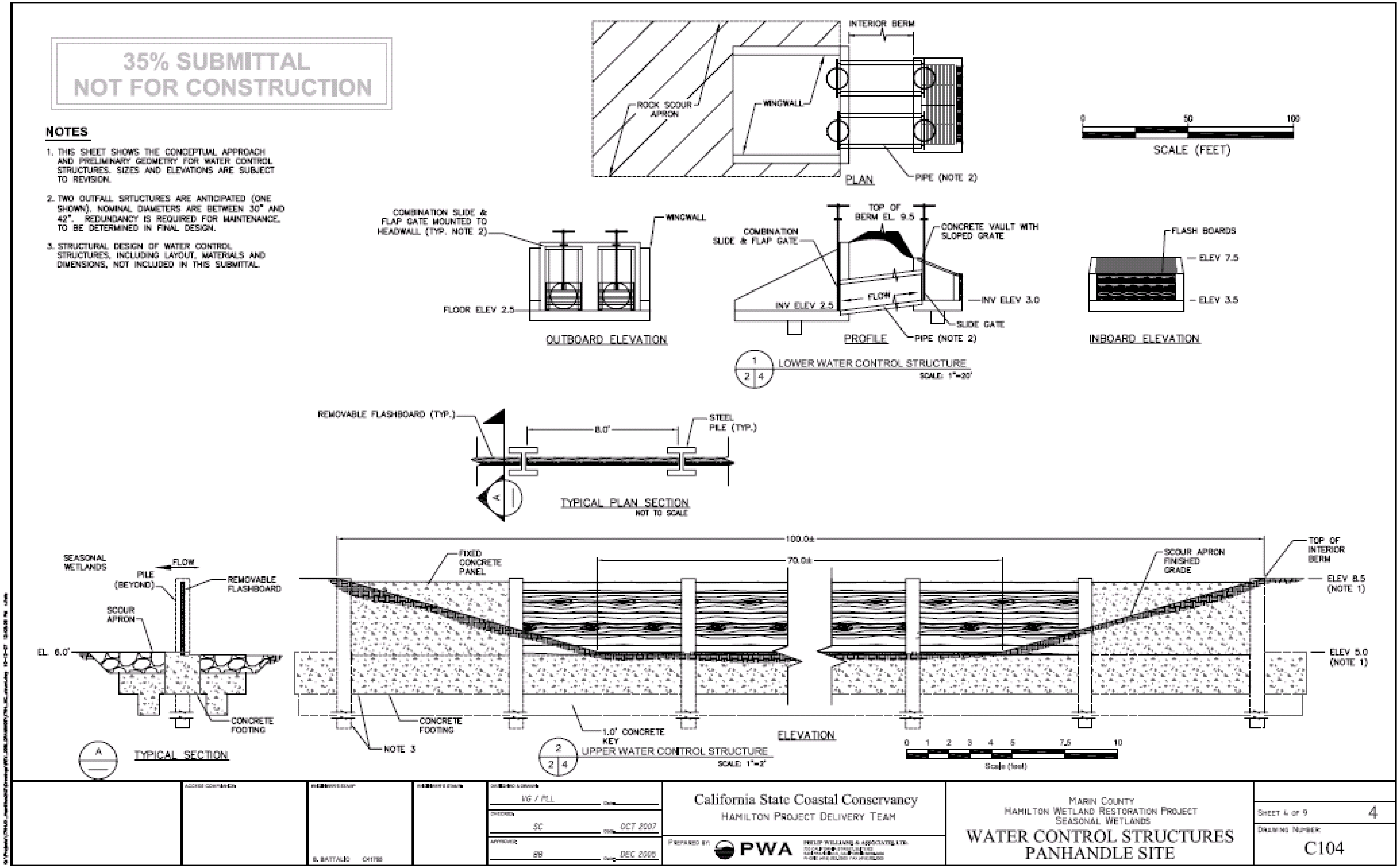


Figure 19 Water Control Structures – Panhandle Site (N. Seasonal Wetland)

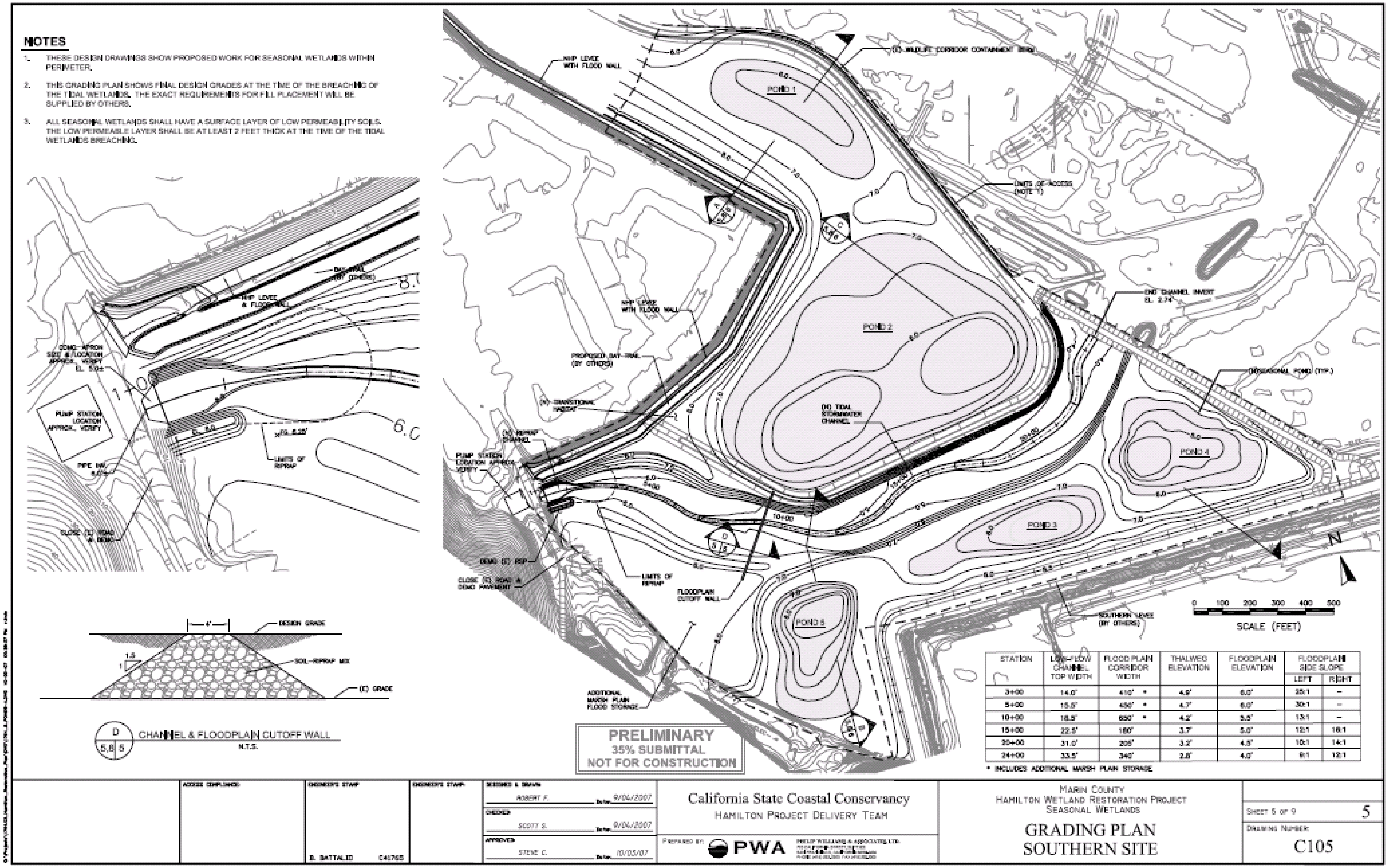


Figure 20 Grading Plan – Southern Site (S. Seasonal Wetland)

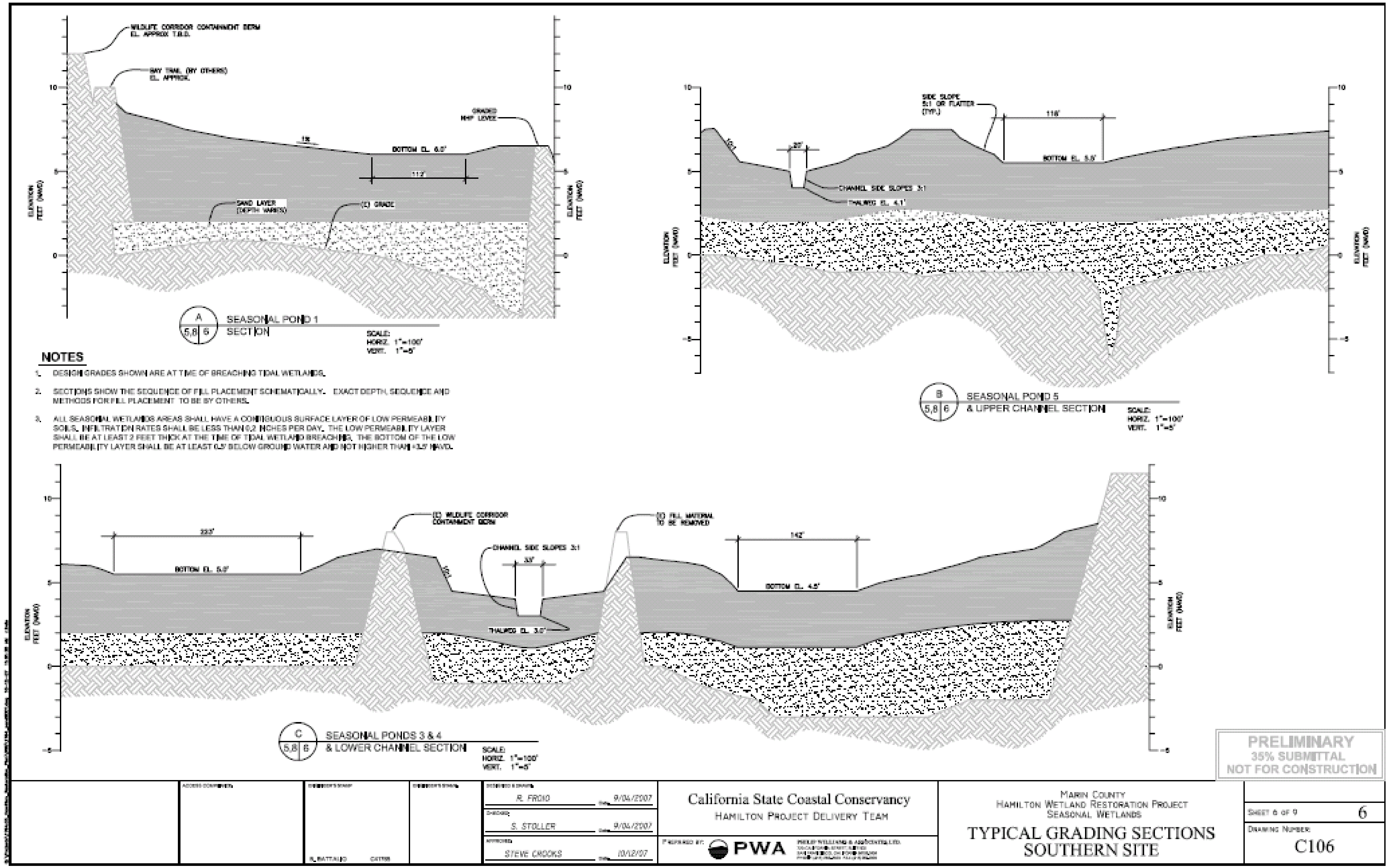


Figure 21 Typical Grading Sections – Southern Site (S. Seasonal Wetland)

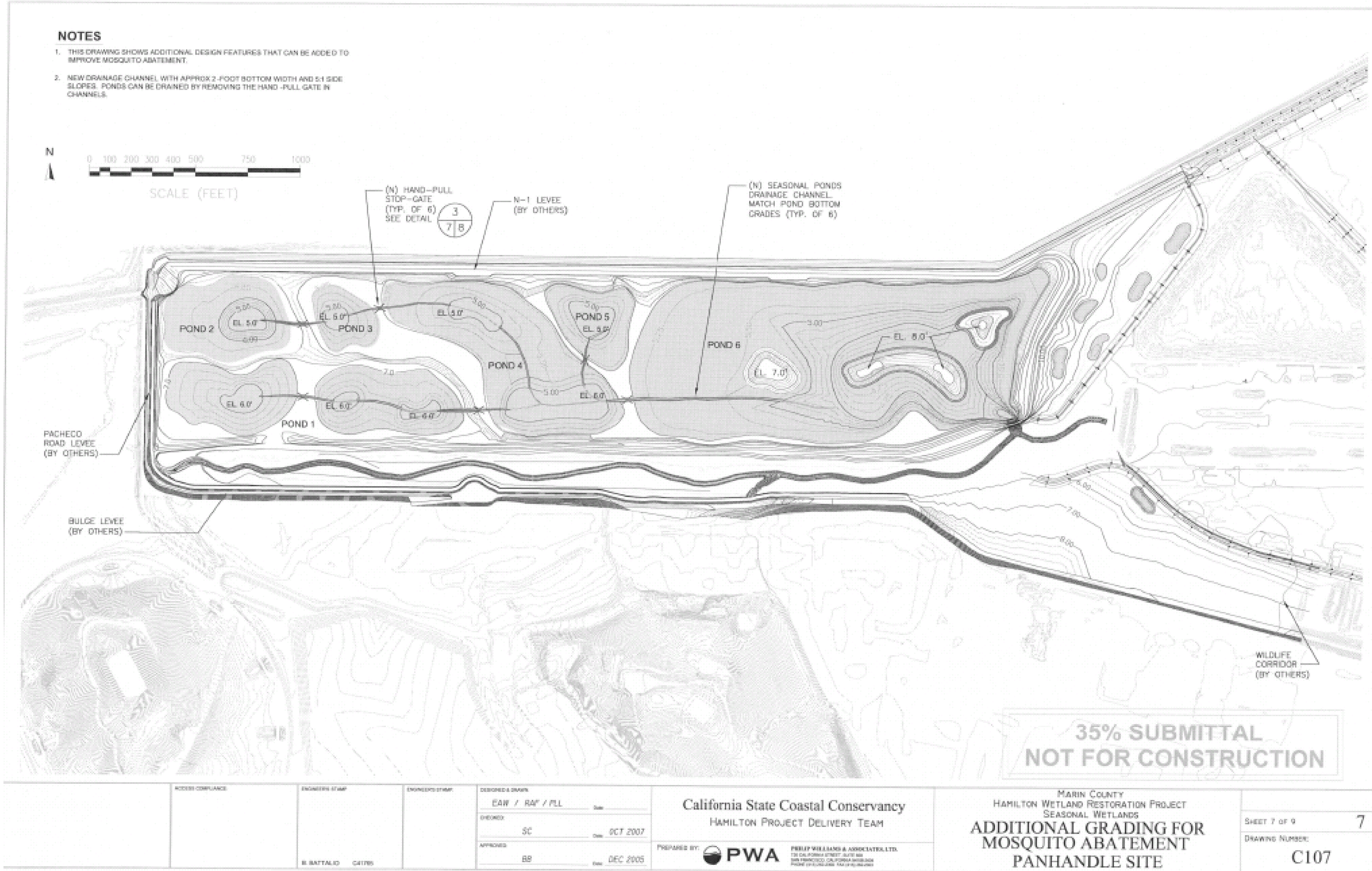
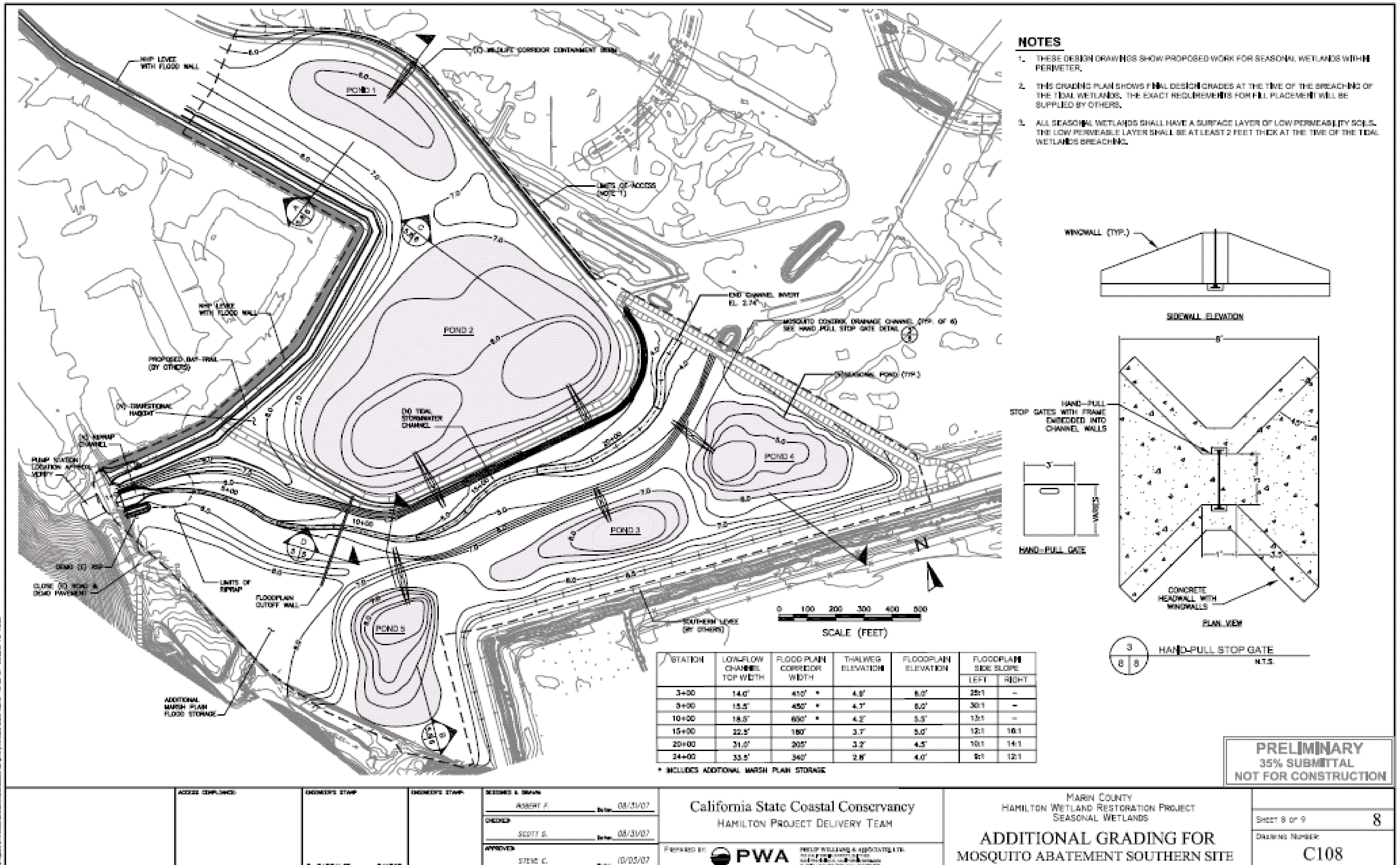


Figure 22 Additional Grading for Mosquito Abatement – Panhandle Site



STATION	LOW-FLOW CHANNEL TOP WIDTH	FLOOD PLAIN CORRIDOR WIDTH	THALWEG ELEVATION	FLOODPLAIN ELEVATION	FLOODPLAIN SIDE SLOPE	
					LEFT	RIGHT
3+00	14.0'	410' *	4.8'	6.0'	25:1	–
8+00	15.5'	450' *	4.7'	6.0'	30:1	–
10+00	18.5'	650' *	4.2'	5.5'	13:1	–
15+00	22.5'	180'	3.7'	5.0'	12:1	16:1
20+00	31.0'	205'	3.2'	4.5'	10:1	14:1
24+00	33.5'	340'	2.8'	4.0'	9:1	12:1

* INCLUDES ADDITIONAL MARSH PLAIN STORAGE

Figure 23 Additional Grading for Mosquito Abatement – Southern Site

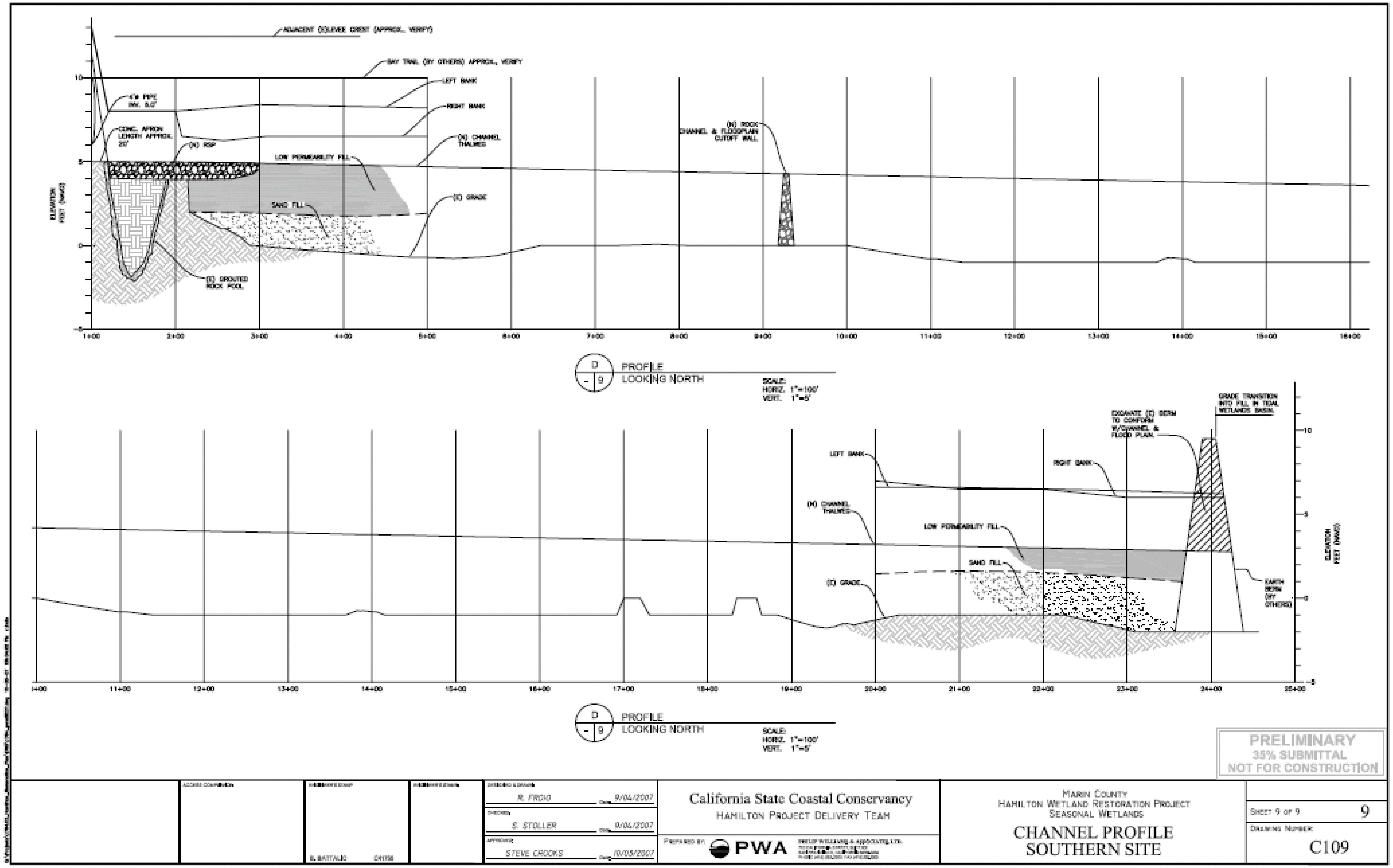


Figure 24 Channel Profile – Southern Site

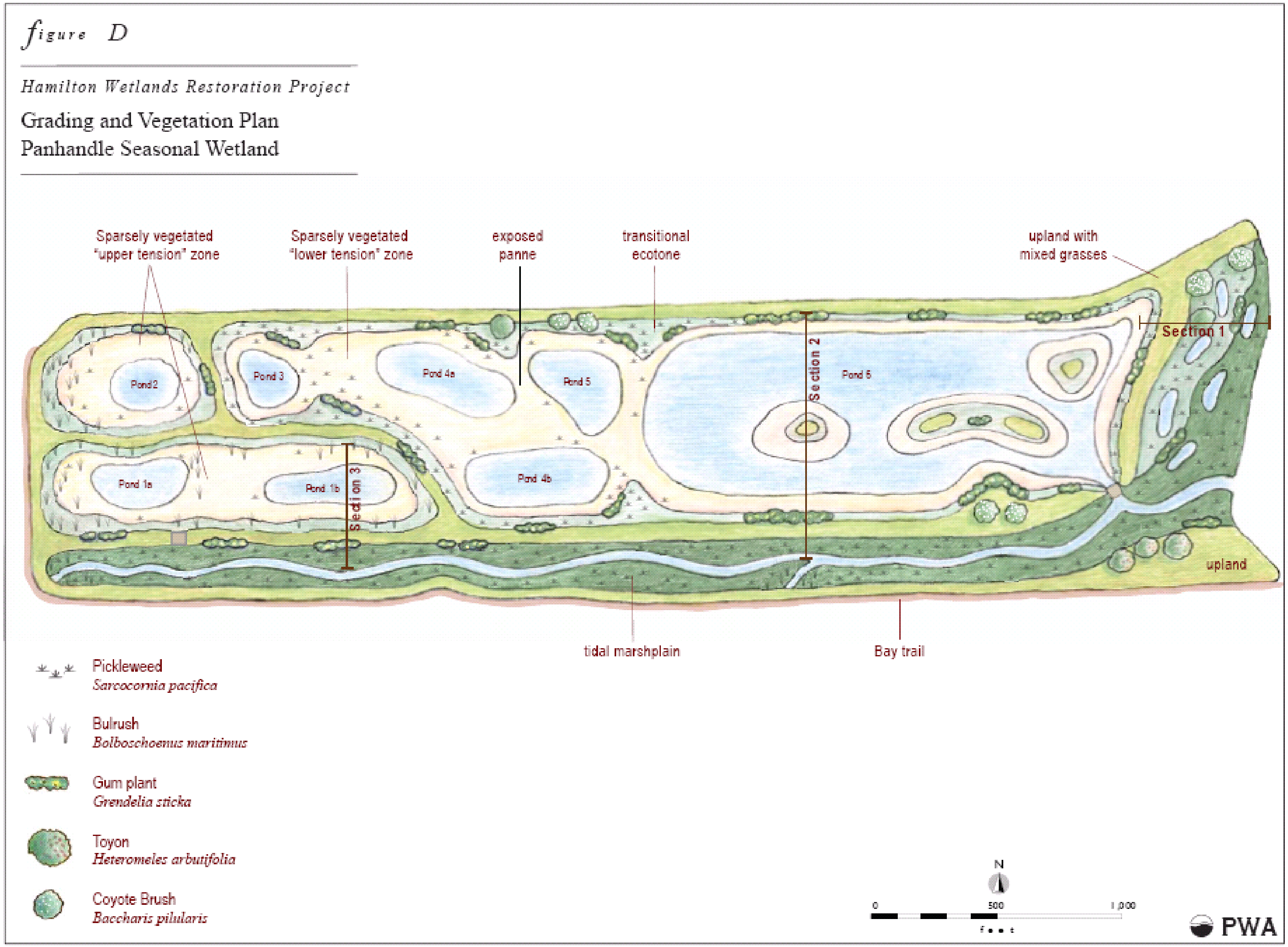


Figure 25 Grading and Vegetation Plan – Panhandle Seasonal Wetland

Figure 26 Grading and Vegetation Plan – Southern Seasonal Wetland Site

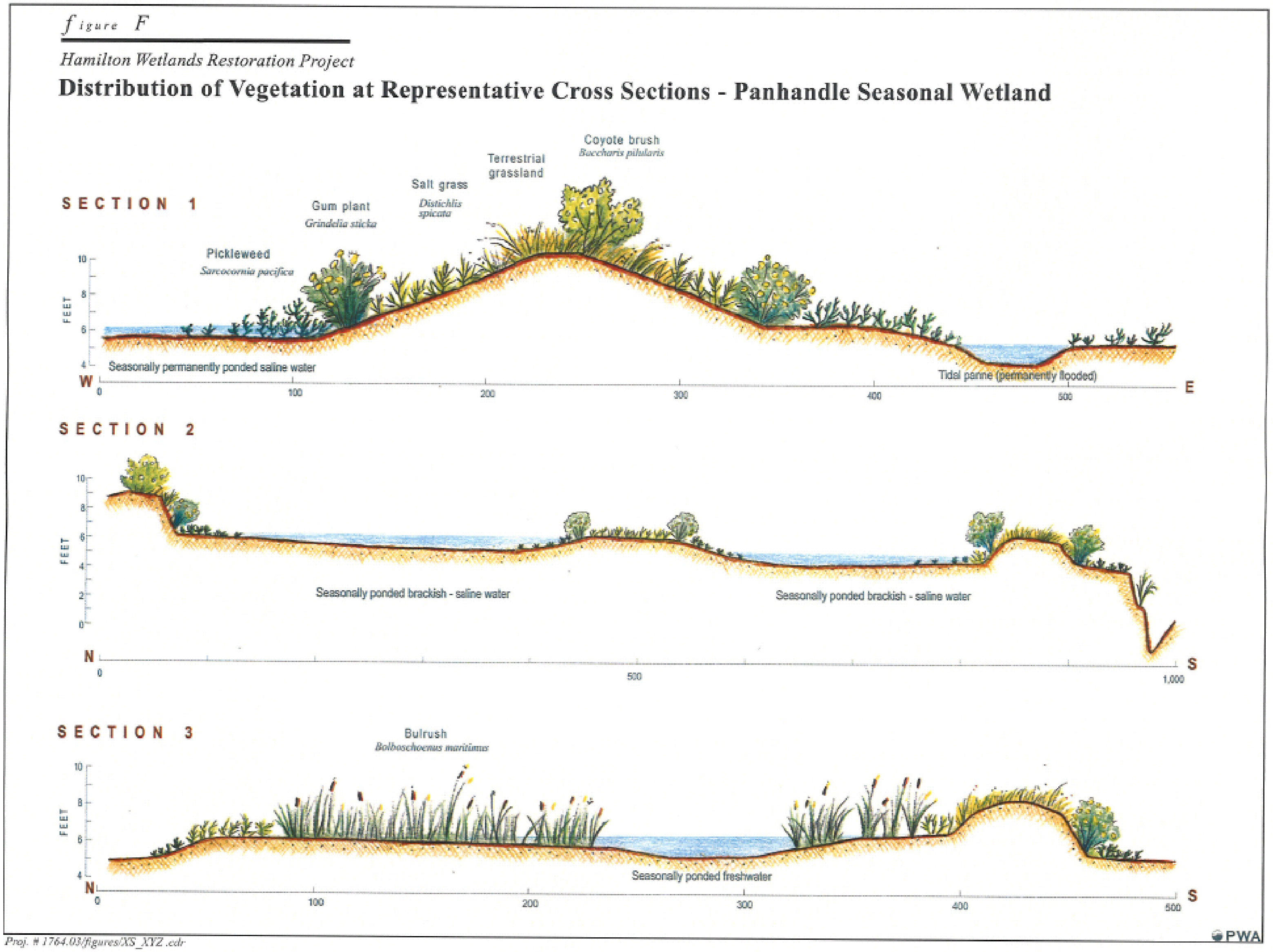


Figure 27 Distribution of Vegetation at Representative Cross Sections - Panhandle Seasonal Wetland

To be Included – Cross Sections will be generally similar to the Northern Seasonal Wetland Sections shown in Figure 27.

Figure 28 Cross Section – Southern Site Seasonal Wetland

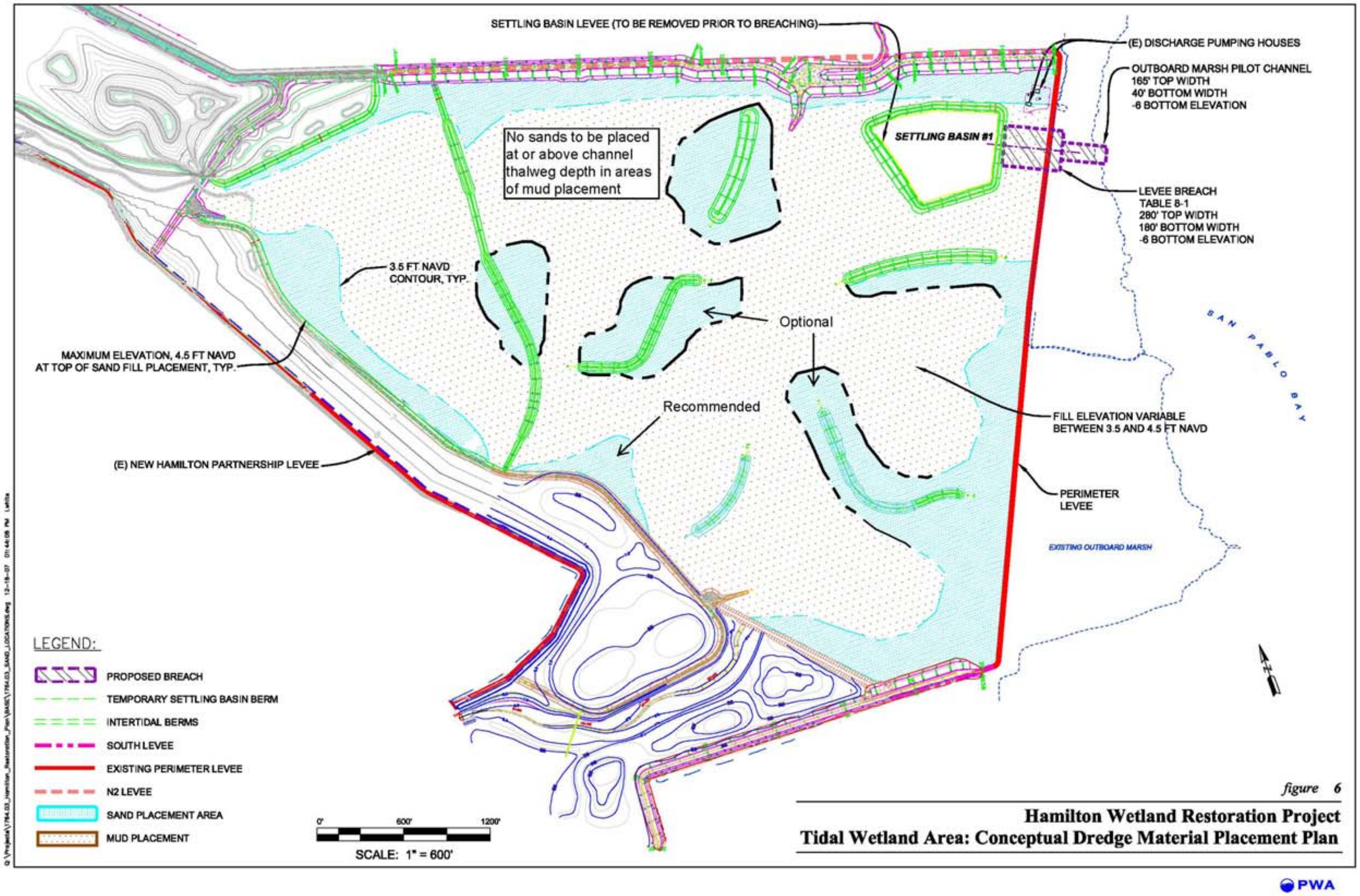
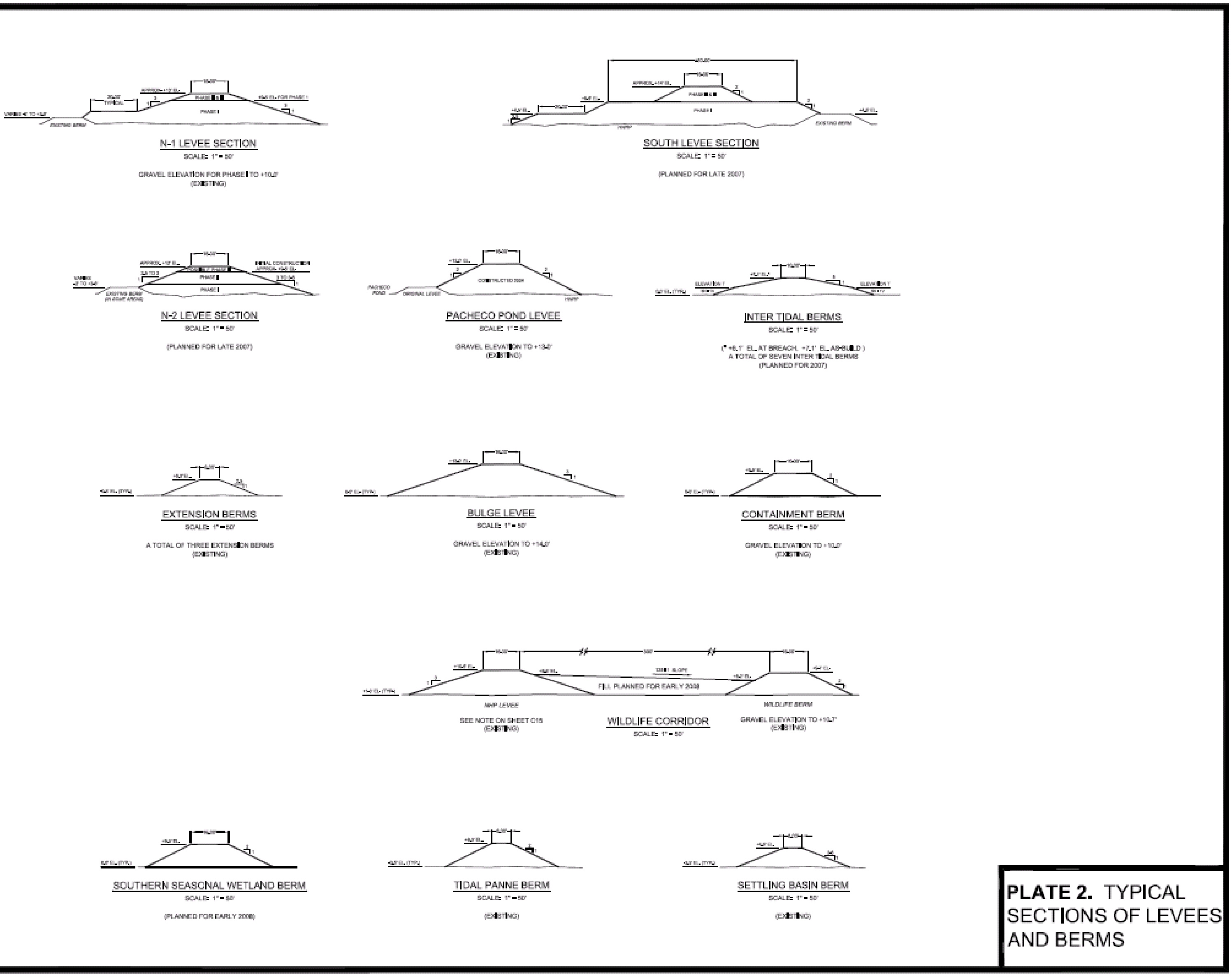


Figure 29 Tidal Wetland and Wildlife Corridor – Preliminary Grading Plan



ure 30. Typical Cross Sections of HWRP Levees and Berms

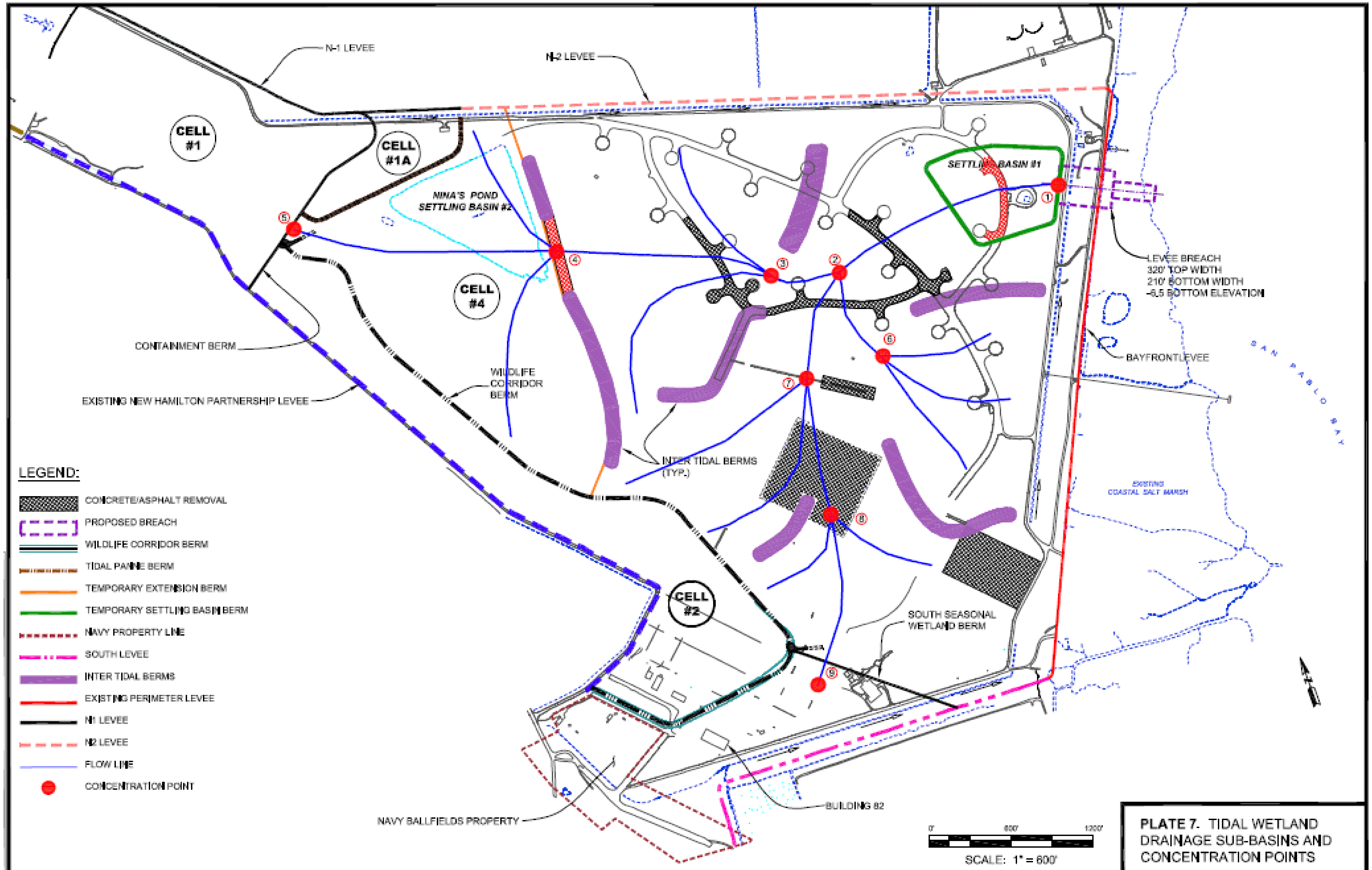
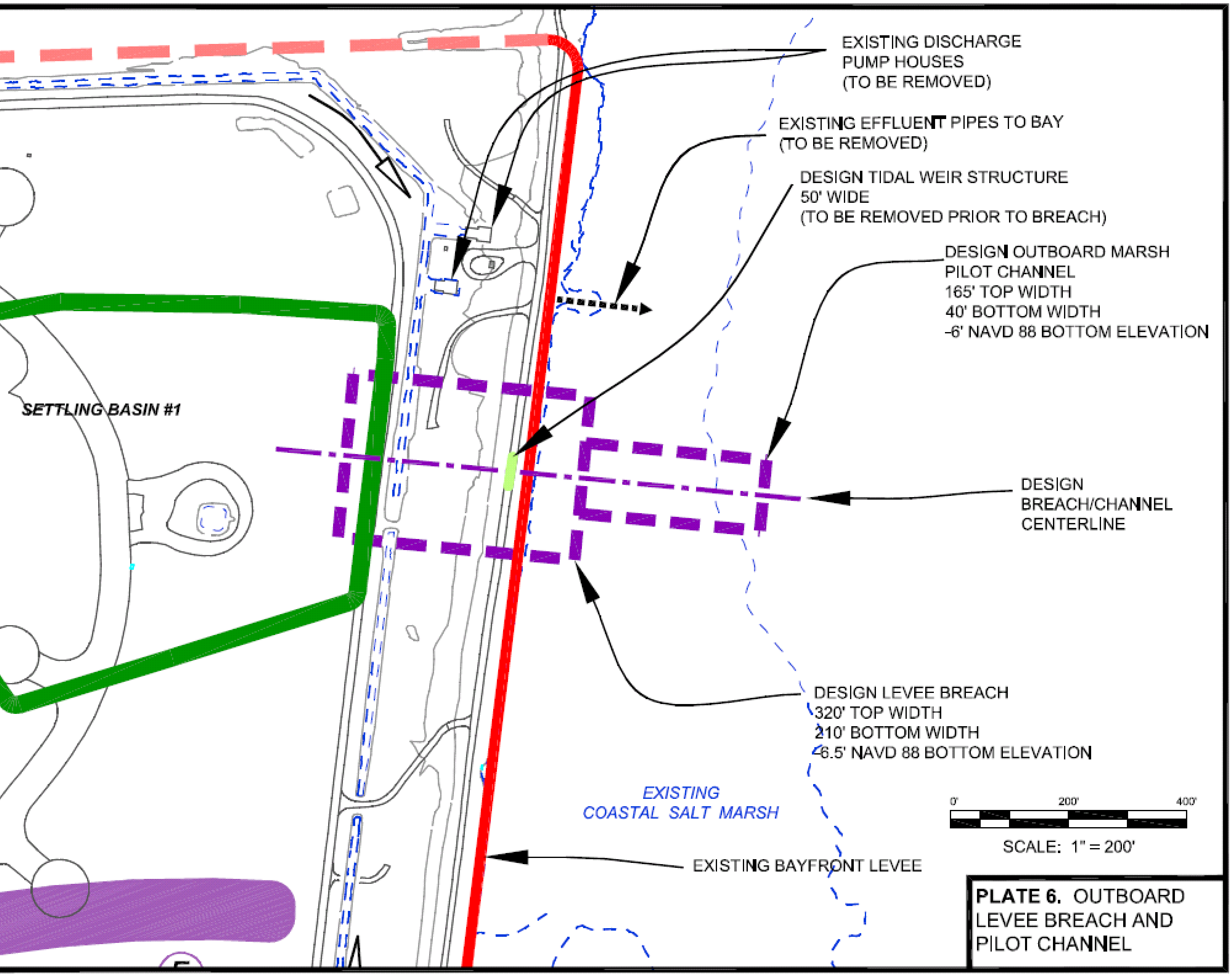
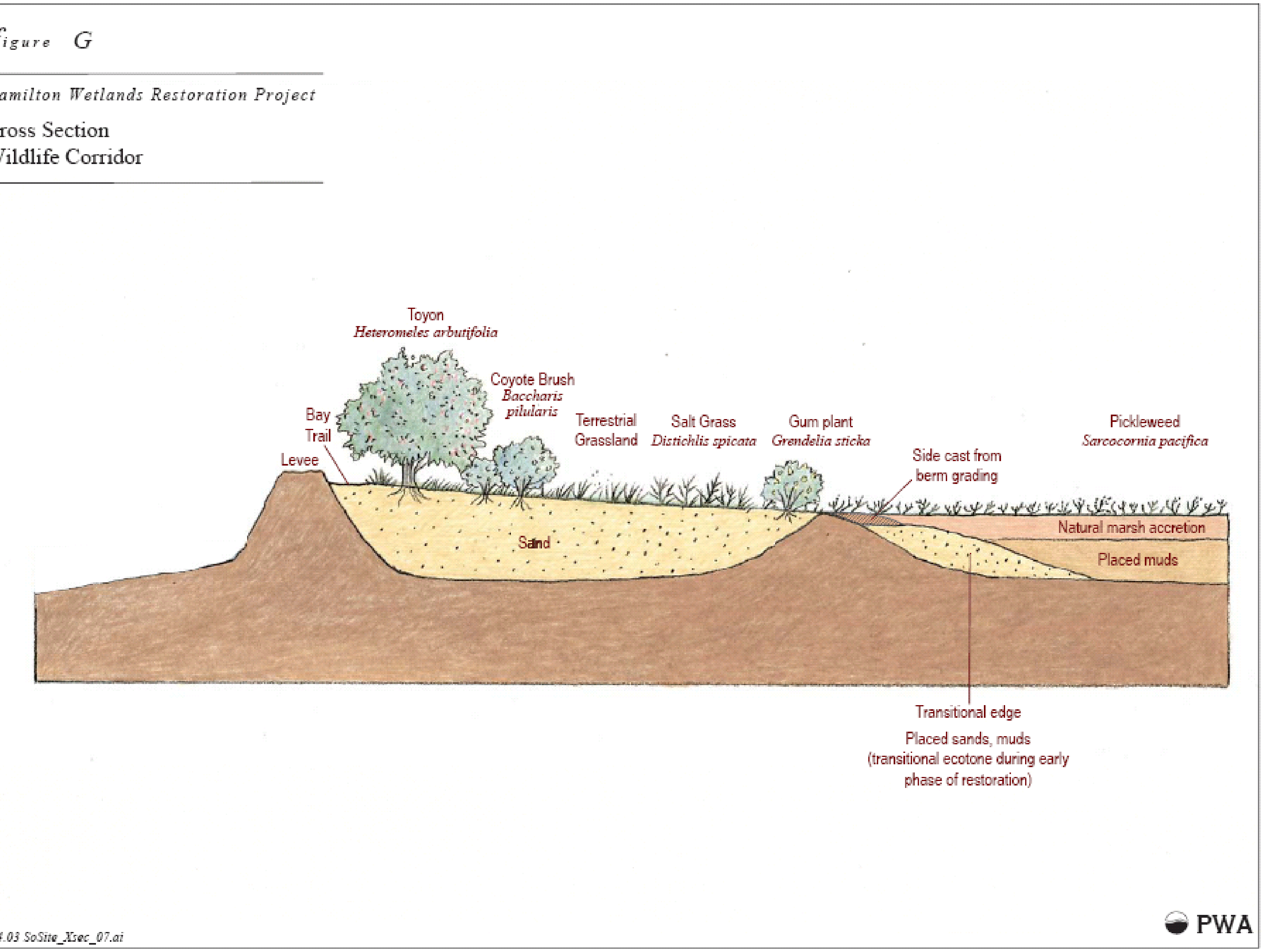


Figure 31 Site Infrastructure Removal and Future Channel Locations



ure 32 Pilot Channel and Breach Characteristics

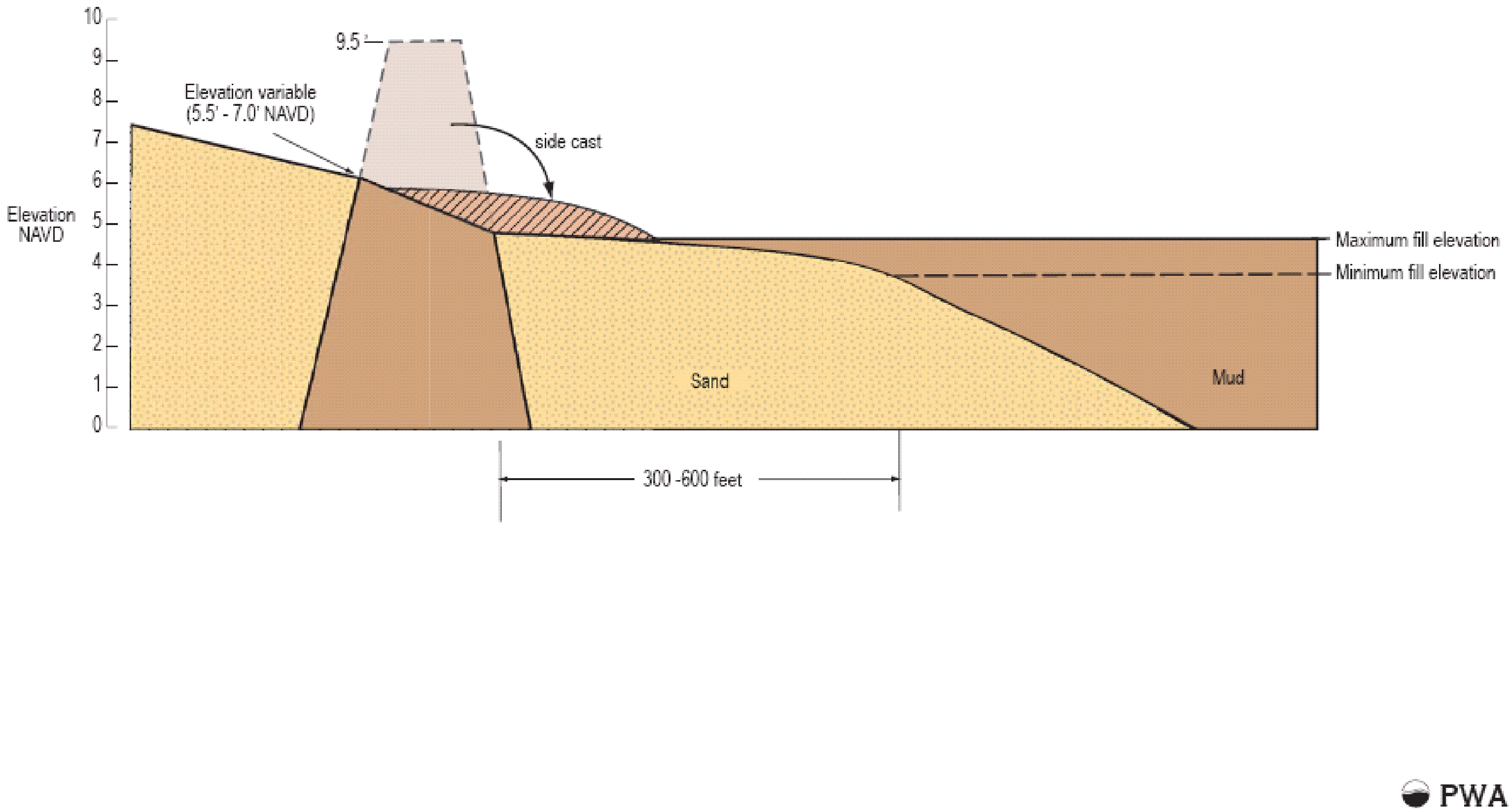


ure 33 Cross Section – Wildlife Corridor

igure H

amilton Wetlands Restoration Project

onceptual Grading Plan for Tidal Wetland Transitional Edge



ure 34 Conceptual Grading Plan for Tidal Wetland Transitional Edge

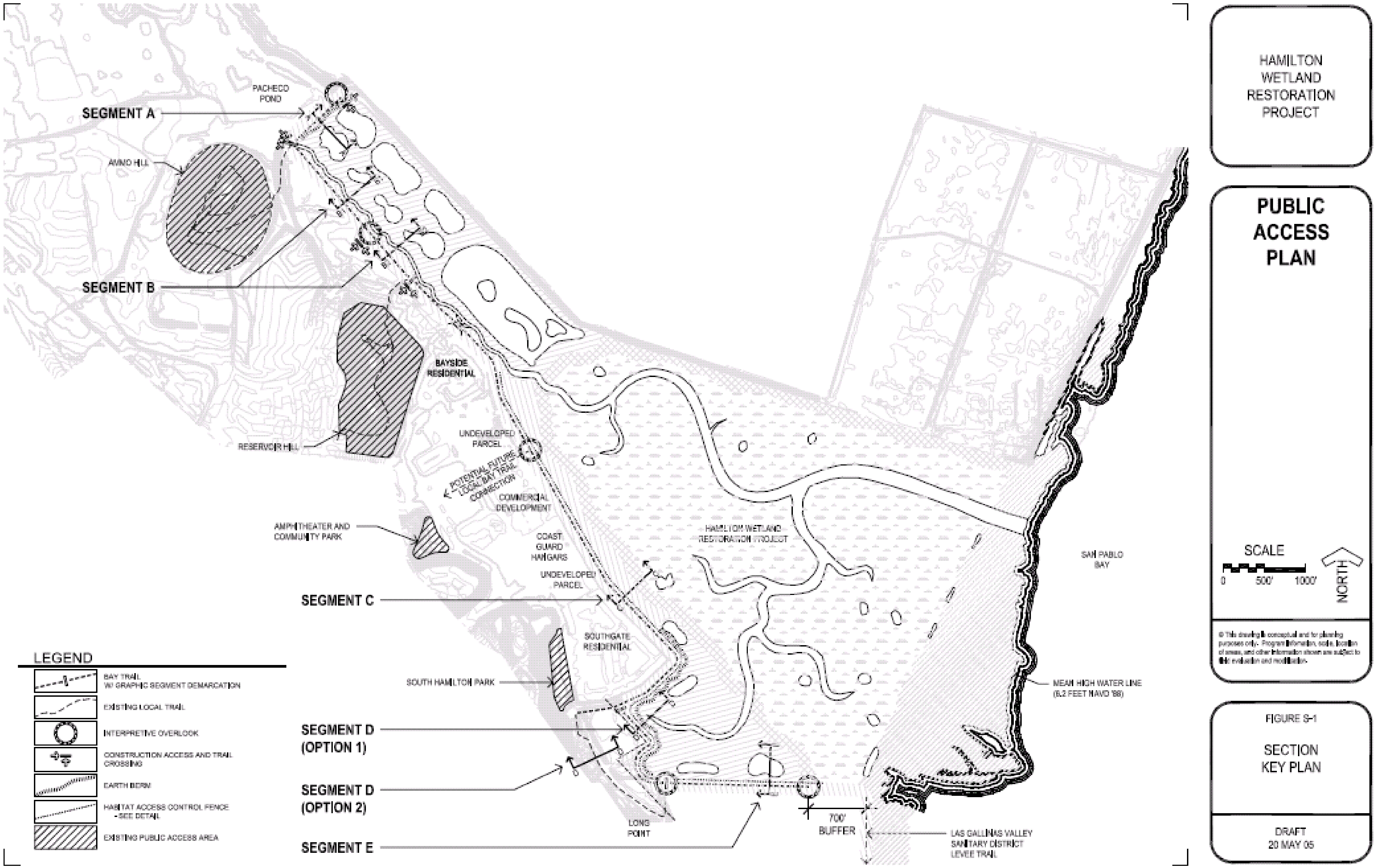


Figure 35 Bay Trail Segments