BAIR ISLAND
RESTORATION AND MANAGEMENT PLAN

FINAL EIS/EIR

VOLUME II OF II

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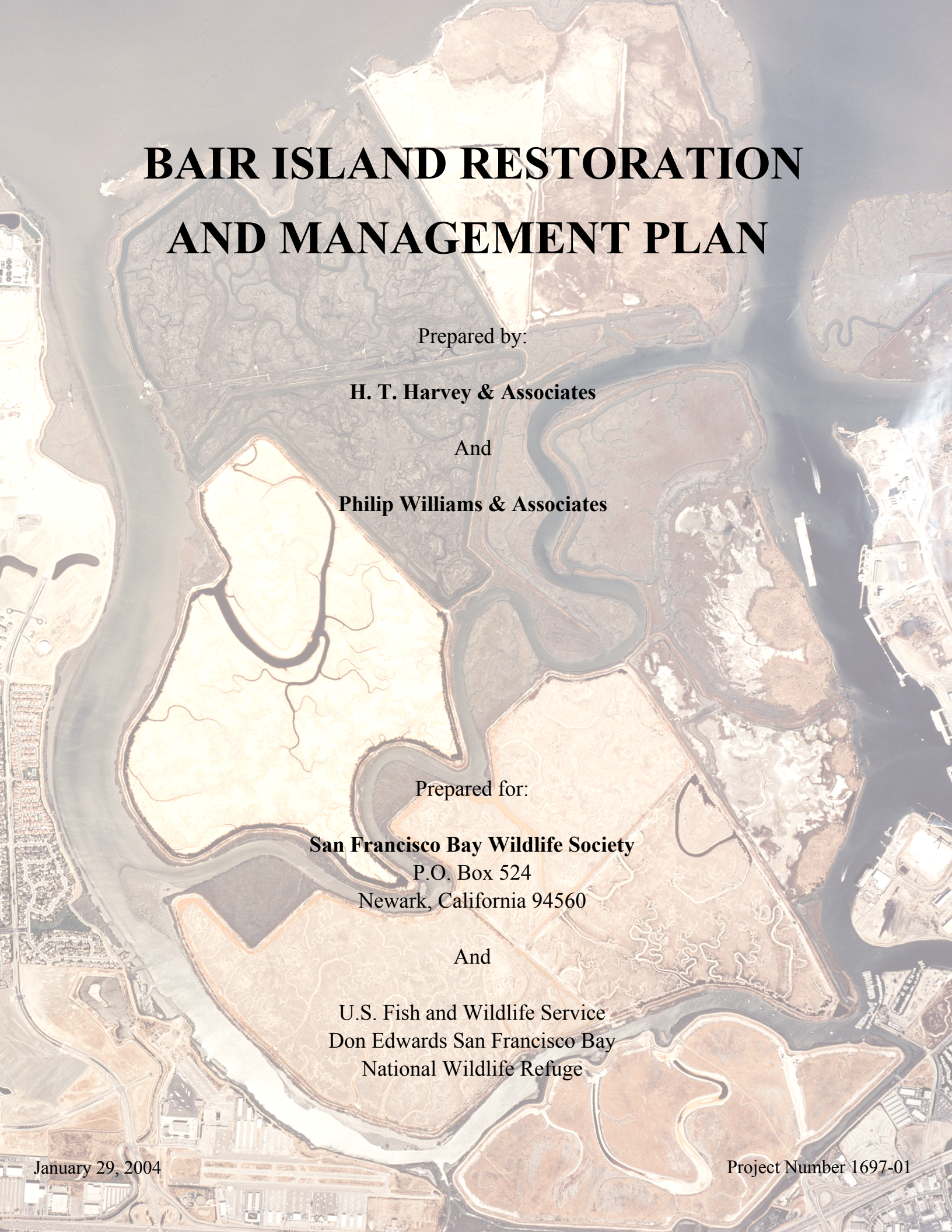
Bair Island Restoration and Management Plan



BAIR ISLAND RESTORATION AND MANAGEMENT PLAN

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And

U.S. Fish and Wildlife Service
Don Edwards San Francisco Bay
National Wildlife Refuge

January 29, 2004

Project Number 1697-01

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1.0 INTRODUCTION

Bair Island is a former tidal salt marsh that is located adjacent to San Francisco Bay in Redwood City, San Mateo County, California (Figure 1). Bair Island has been the target of numerous development proposals through the years, all of which were rejected. The California Department of Fish and Game (CDFG) and the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) both acquired portions of Bair Island over time. In 1997, the Peninsula Open Space Trust (POST) purchased the remaining portions of Bair Island and turned over their interests in the property to these agencies. The San Carlos Airport also retains a portion of Inner Bair Island as a safety zone. In addition, two easements exist on Bair Island, one for the PG&E towers and transmission lines that run throughout the Bair Island complex, the other for the South Bayside System Authority (SBSA) force main that is located underneath most of the southern levee on Inner Bair.

Historically Bair Island was part of a large complex of tidal marshes and mudflats within the drainage of Redwood Creek and Steinberger Slough (Appendix E). Bair Island was diked in the late 1800's and early 1900's for agricultural practices including cattle grazing. Bair Island was converted to salt evaporation ponds by Leslie Salt Company starting in 1946, and remained in production until 1965. The lands were drained and eventually sold to a series of real estate development companies. An EIR was prepared in 1981 for the South Shores Concept Plan that proposed development of Inner and part of Middle Bair Island (EIP 1981). A local referendum in Redwood City finally halted development plans for Bair Island. POST purchased Bair Island in 1997.

This site is a large, restorable complex of former salt evaporators, and has been a major priority for addition to the Refuge since the original boundaries were drawn. The restoration of tidal habitats at Bair Island is ecologically important to South San Francisco Bay. Following restoration, Bair Island will become an integral part of the extensive wetland complex within the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) and adjacent state and privately owned wetlands.

The goal of the restoration design is to restore tidal marshes on Bair Island, thereby minimizing management needs in the future, and providing salt marsh habitat for endangered species such as the California Clapper Rail (*Rallus longirostris obsoletus*) and salt marsh harvest mouse (*Reithrodontomys raviventris raviventris*). This site, once properly restored, can assist with the preservation and perhaps recovery of both species.

The Bair Island complex is divided into three distinct areas separated by slough channels: Inner, Middle and Outer Bair. Inner Bair Island is connected to the mainland and can be directly accessed via Whipple Avenue. It is separated from Middle Bair by Smith Slough, which in turn is separated from Outer Bair by Corkscrew Slough. This Restoration and Management Plan does not cover those privately-owned portions of Bair Island that are outside of the project boundary (Figure 1).

The conceptual plan that is presented in this report includes an overview of the alternatives analysis, the selection of a preferred restoration alternative and the conceptual design for the

preferred alternative. The biological goals and objectives as well as the site opportunities and constraints were used to guide the selection of alternatives. The goals and objectives are committed to the restoration of the natural landscape and structure of Bair Island.

The preferred alternative (Figure 2) would breach the levees on Middle and Outer Bair Islands to allow natural sedimentation processes to restore tidal salt marsh. Additionally, the preferred alternative would use dredged material to raise the elevation of Inner Bair Island as well as protect the San Carlos Airport property and South Bayside System Authority (SBSA) sewer line (Figure 3). Following the placement of dredged material, the levees of Inner Bair Island would be breached to provide tidal action. Modifications to Smith Slough and Corkscrew Slough are included in the restoration design to allow Bair Island to be successfully restored while avoiding the problems of inducing increased siltation in the Redwood Creek shipping channel and increasing tidal currents in Pete's Outer Harbor. Smith Slough would be rerouted to its historic channel alignment, reestablishing the channel meander through Inner Bair. A channel constriction would be constructed in Corkscrew Slough. Expected long-term habitats are shown on Figure 4.

The Bair Island Restoration and Management Plan was prepared by H.T. Harvey & Associates and PWA (Philip Williams & Associates) for the San Francisco Bay Wildlife Society and the U.S. Fish and Wildlife Service Don Edwards San Francisco Bay National Wildlife Refuge. Funding was provided by the San Francisco Bay Wildlife Society, the California Coastal Conservancy, the U.S Fish and Wildlife Service, the California Department of Fish and Game, the Peninsula Open Space Trust, and the California Wildlife Conservation Board. The Plan was developed with the participation and input of the Bair Island Technical Review Team (TRT). The project team wishes to acknowledge the contributions of the TRT, comprising representatives from U.S. Fish and Wildlife Service, Bay Conservation and Development Commission, California Coastal Conservancy, California Department of Fish and Game, National Marine Fisheries Service, Regional Water Quality Control Board, U.S. Geological Survey, U.S. Environmental Protection Agency and U.S. Army Corps of Engineers.

1.1 DEFINITION OF TERMS

Breach
An excavation through an earth levee through which tidal exchange is provided to and from the restored island.

Borrow Ditch
Channels created adjacent to levees by the process of "borrowing" material to create the levee. They tend to be straighter and offer less habitat complexity than natural channels.

Damping (Tidal Damping)
A decrease in tidal range at a location due to frictional losses between the location and the boundary tide.

Cut-off Berm
Earth fill that crosses an existing borrow ditch to inhibit flow.

Fetch (Wind Fetch)
An area of open water over which wind blows to generate waves.

Headcut
An erosion point in a channel that occurs where there is an abrupt drop in the channel bottom elevation in the downstream direction.

MHHW
Mean higher high water.

MLLW
Mean lower low water.

Morphology
Shape and structure of an object.

Muting
Reduction of the tide range caused by undersized inlets or engineering structures that limit the volume of water as the tide wave passes from more open water. The degree of muting is a function of the relative sizes of the inlet and estuary.

NGVD
National Geodetic Vertical Datum. A fixed vertical datum at the mean sea level of 1929. Used in this study for consistency with previous ground surveys. NGVD has been superceded by NAVD88, which came into common use in the San Francisco Bay Area during the course of this study.

SBSA
South Bayside System Authority (owners of sewer line on Inner Bair).

Slough
In general use, a tidal channel. In this project the term may also refer specifically to the major (named) tidal channels between the ponds (e.g., Steinberger Slough, Smith Slough, Corkscrew Slough, etc.).

Subsidence
The consolidation and lowering of a ground elevation.

Thalweg
The deepest point or a line joining the deepest points of a stream channel.

Tidal Frame
The elevation range of the tides.

Tidal Prism
Volume of water that flows into or out of an area during the diurnal tide.

TRT
Bair Island Technical Review Team.

2.0 PROJECT GOALS AND OBJECTIVES

2.1 DEVELOPMENT OF RESTORATION GOALS AND OBJECTIVES

The goals and objectives for the restoration of Bair Island were developed by the San Francisco Bay Wildlife Society (SFBWS) and the U. S. Fish and Wildlife Service (USFWS). These goals and objectives, presented below, are consistent with the policies of the Don Edwards San Francisco Bay National Wildlife Refuge, to which Bair Island now belongs. We assume a 50-year planning horizon, consistent with that used by other San Francisco Bay restoration projects currently in planning.

2.1.1 Goals for the Bair Island Restoration Project

- Restore Bair Island to tidal salt marsh habitat
- Provide habitat for endangered species and other native wildlife
- Enhance the public's appreciation and awareness of the unique resources of Bair Island

2.1.2 Objectives for the Bair Island Restoration Project

- Restore and enhance habitat for the endangered California Clapper Rail and salt marsh harvest mouse
- Create and enhance habitat for the endangered California Least Tern, California sea-blite, and other wetland dependent species, if compatible with restoration for the Clapper Rail and harvest mouse
- Minimize disturbance to sensitive species (e.g., Clapper Rail, harbor seals)
- Provide for control of undesirable species including invasive plants, undesirable predators and mosquitoes
- Enhance the public's awareness of the unique resources at Bair Island by providing opportunities for wildlife-oriented recreation and nature study

2.2 DESCRIPTION OF TARGET HABITATS

The project goals and objectives outline the general target habitats for Bair Island following the completion of site restoration. The target habitat for Bair Island is salt marsh. However, implied within the creation of salt marsh habitat is the creation of interrelated habitats. These interrelated habitats include channels/subtidal zones, tidal mudflats and upland transition zones, all of which are described below.

2.2.1 Tidal Salt Marsh

Tidal salt marsh habitat in San Francisco Bay is located between mean tide level (MTL) and the highest tide. Cordgrass (*Spartina foliosa*) is the dominant plant species in the low marsh located at an elevation between MTL and mean high water (MHW). Pickleweed (*Salicornia virginica*) is the dominant plant species within the middle marsh located at an elevation between MHW and mean higher high water (MHHW). A mix of salt marsh plant species including saltgrass

(*Distichlis spicata*), pickleweed and spearscale (*Atriplex triangularis*) is found in the high marsh located at an elevation between MHHW and the highest tide.

2.2.2 Channels and Subtidal Zone

Channels and subtidal habitat are located at an elevation below mean lower low water (MLLW). Channels are typically imbedded within tidal marshes and vary in width and depth. These areas are entirely unvegetated.

2.2.3 Tidal Mudflats

Tidal mudflats are located between MLLW and MTL and are typically inundated twice daily. These mudflats are unvegetated because of the stresses associated with long periods of inundation and wave energy. Tidal mudflats are typically located adjacent to tidal marshes at the edge of the bay or slough channels.

2.2.4 Upland/Transition Zone

Uplands and the transition zone between upland habitats and the high marsh are located at an elevation above the highest tide. These habitats are typically located on the periphery of tidal salt marshes or occur as levees and are imbedded within the tidal marsh/channel complex. Upland areas adjacent to tidal marshes in San Francisco Bay are typically dominated by herbaceous non-native, salt tolerant plant species.

3.0 SITE DESCRIPTION

3.1 HISTORIC CONDITIONS

3.1.1 Physical

Bair Island is a former tidal salt marsh that has undergone considerable natural and anthropogenic changes. Although existing hydrologic conditions at the site have been substantially modified from historical conditions, some of the existing characteristics are remnants of historic processes and changes, and are best understood within an historic context.

The description of historic conditions at the site is based on a review of existing information, including historic United States Coast and Geodetic Survey (USCGS) maps, United States Geological Survey (USGS) topographic maps, historical aerial photographs, and secondary studies. These studies include: Bair Island Environmental Study (SLC 1977) and Bair Island Ecological Reserve Operations and Maintenance Plan (RTC 1991).

The Natural Landscape. Bair Island was once part of a continuous band of tidal salt marsh wetland fringing the southwest shoreline of southern San Francisco Bay. San Francisco Bay was formed over the past 10,000 years by sea level transgression (Atwater *et al*. 1979). Rising sea levels submerged previously upland valley areas. From the time of initial submergence until large-scale reclamation began approximately 150 years ago, the aerial extent of the Bay's tidal marshes was determined by the interaction of sea level rise, estuarine sedimentation and wind wave erosion.

Initially, the Bay was rapidly submerged by sea levels rising at approximately 10 times the current rate of 1-2 mm/yr. From ~10,000 to 6,000 years before present, the Bay supported only a thin, discontinuous fringe of salt marsh along the expanding perimeter (Atwater et al. 1979). Salt marsh sedimentation and organic accumulation were presumably not able to keep pace with the rise in sea level. Approximately 6,000 years ago sea level rise slowed to its current rate. In the Bay, this allowed marsh accretion to keep pace with submergence. Evidence from Bay marsh cores indicates that during the past 6,000 years a continuous marsh fringe formed around the Bay and expanded landward, as sea level continued to rise.

Human Intervention. A review of historic and recent topographic maps of the area illustrates the changes that have occurred from the 1850s through the present. In 1857, only the bayward two of the three islands that now comprise Bair Island existed as islands; the area that is now Inner Bair was part of the mainland. There were no structures or levees and the entire Bair Island was tidal salt marsh. There were no significant changes between 1857 and 1897, except for a 10-acre area at the confluence of Corkscrew Slough and Redwood Creek, which was diked for use as a fishing village in 1869 (SLC 1977). The 1897 map shows what appears to be Cordilleras Creek discharging to Smith Slough through a small tidal channel on what is now Inner Bair Island. Around the turn of the century, Bair Island was included in several attempts to reclaim marshplain land for agricultural use. A levee around the outer edge of Outer Bair Island,

possibly constructed around 1910 (SLC 1977), is shown in the 1931 map (Appendix E). The descriptive report accompanying this map states, "the area between Steinberger and Redwood Sloughs, some of which was at one time reclaimed land, has again reverted to marsh due to the breaking and overflowing of the confining levees. These marshes lie about one foot below extreme high tide. The area is traversed by numerous small sloughs."

Between 1946 and 1952, Leslie Salt Company partitioned most of Middle and Outer Bair Island with levees for use as salt evaporation ponds (SLC 1977). Salt production on Bair Island was discontinued in 1965, when the ponds were drained and abandoned. Although the date of levee construction for Inner Bair Island is not provided in the existing literature (SLC 1977; RTC 1991), we assume that they were constructed at the same time as the Middle and Outer Bair Island levees (1948-1952). This is consistent with the 1959 USGS topographic map that shows Inner Bair leveed. The 1959 map also shows Smith Slough and the borrow ditches south and southwest of Inner Bair in their current locations. It appears that when Inner Bair Island was leveed, a large meander bend in Smith Slough was cut off and leveed within the island, adding acreage to Inner Bair Island that was formerly part of Middle Bair. The borrow ditches were probably created during construction of the Inner Bair levee.

In 1973, Mobil Oil Estates purchased Bair Island and the Redwood Peninsula, where the Redwood Shores development now stands, from Leslie Salt Company. Much of Outer Bair Island was transferred to the California State Lands Commission (SLC) as part of the transaction or as mitigation for marsh loss during the development of Redwood Shores. Tidal action was restored to a large part of Outer Bair Island in the late 1970's and early 1980's through a series of planned and unplanned levee breaches.

The locations of the major sloughs have remained essentially unchanged between 1857 and the present, based on a comparison of the historic maps with the recent USGS topographic map (USGS 1973). Flow patterns in the sloughs, however, appear to have changed over time. Leveeing decreased tidal flows through the sloughs. In addition, Redwood Creek dredging, which began in 1955 and continues to the present, made Redwood Creek a more efficient tidal conveyance channel. Together, these changes would have had the effect of shifting Corkscrew and Smith Slough tidal flows towards Redwood Creek and making Steinberger Slough shallower from lack of tidal scouring. These results are supported by observations from recent aerial photographs (February 18, 2000). The photographs show that a reach of Steinberger Slough between Smith and Corkscrew Slough is dry at low tides, meaning that Smith Slough and the lower part of Steinberger Slough drain toward Redwood Creek. Also, the existing tidal drainage divide for Corkscrew Slough is in the western part of the channel near Steinberger Slough, meaning that most of Corkscrew Slough drains to Redwood Creek.

As recently as 1975, Steinberger Slough did not drain directly to the Bay at low tide. The USGS topographic map (1959, revised in 1968 and 1973) and old bathymetric maps (NOS 1975) show Steinberger Slough draining at low tide to Bay Slough and from there to Belmont Slough before discharging to the Bay. More recent bathymetric maps (NOS 1989 and NOS 1995) and low-tide aerial photographs (February 2000) show Steinberger Slough discharging directly to the Bay rather than Bay Slough. The former drainage pattern through Bay Slough was probably a remnant feature of the historical marsh. Steinberger and Bay Slough appear to have been one

continuous internal marsh channel that has now become directly connected to the Bay by hundreds of years of sea level rise and shoreline erosion.

The bayward shoreline of Bair Island has experienced both aggradation and erosion, first aggrading from 250 to 1000 feet during the hydraulic mining era (as reflected on the 1857 and 1897 maps), then eroding between 1897 and 1931 and between 1931 and 1959. Relative to its position in 1857, the current shoreline has receded as much as 700 feet in some locations, but has aggraded approximately 200 feet in others. In addition to lateral movement of the marsh edge, the marshplain elevations of areas that were leveed on Inner, Middle, and Outer Bair Islands have subsided (see Existing Conditions section below).

3.1.2 Biological

Historically, Bair Island was part of a large complex of tidal marshes and mudflats located along southern San Francisco Bay. The numerous anthropogenic changes discussed in the previous section have replaced historic tidal salt marsh and fragmented the remaining habitat within the Bair Island complex. Wildlife use on the island complex has shifted over the years as these changes have occurred. In general, wildlife species that were historically supported by Bair Island are still present, only in somewhat diminished diversity and numbers due to the fragmentation and conversion of habitat (see Appendix D for a detailed description of existing wildlife resources). There are, however, some notable changes in nesting habitat on Bair Island.

The federally endangered Least Tern (*Sterna antillarum*) and the state protected Caspian Tern (*Sterna caspia*) both formerly nested on Bair Island. These two tern species have not nested at Bair Island since the early 1980's. Loss of these nesting colonies may have been related to loss of nesting habitat to vegetation encroachment, loss of nesting habitat when tidal action was restored to portions of Outer Bair Island, and depredation by non-native red fox (*Vulpes vulpes regalis*). Currently, a small colony of Forster's Terns (*Sterna forsteri)* occurs in the western portion of Middle Bair Island that moves from year to year.

The same scenario likely is true of the threatened Western Snowy Plover (*Charadrius nivosus nivosus*). Western Snowy Plovers were reported from Bair Island during the breeding season in the 1960s and early 1970s (though no nests were found); they have not been detected since (Page and Stenzel 1981). Black-crowned Night Herons (*Nycticorax nycticorax)*, Great Egrets (*Ardea alba*) and Snowy Egrets (*Egretta thula*) formerly nested on Bair Island, but no longer actively nest on site (Ryan and Parkin 1998). The latter three species, in the process of nesting, eventually destroyed the shrubs and small trees in which they made nests, and since have moved to shrubs nearby at Redwood Shores. Depredation by non-native red foxes likely also played a role in the demise of these nesting species.

3.2 EXISTING CONDITIONS

The following is a brief description of the existing physical and biological conditions at Bair Island. Expanded descriptions of the existing physical conditions can be found in Appendix E and the existing biological conditions in Appendix D.

3.2.1 Physical

Land Use and Infrastructure. The site currently consists of leveed, inactive salt ponds, restored tidal marsh, supra-tidal dredged material disposal areas, and remnant historical marsh (Figure 5). Part of Inner Bair is owned by the San Carlos Airport and maintained as a safety area for emergency landings.

Infrastructure within the area proposed for restoration includes the South Bayside System Authority (SBSA) sewer line, a PG&E transmission tower, and a slide-gated culvert at Inner Bair (Figure 6). The SBSA line runs northwest underneath the Inner Bair Island levee from the Whipple Avenue interchange, across/under the western Inner Bair borrow ditch, and along the San Carlos Airport property. The PG&E transmission tower is located on the Inner Bair levee, near the eastern tip of the island. Infrastructure also includes existing levees (many abandoned), which are discussed in the next sub-section. Adjacent infrastructure includes the Port of Redwood City and Pete's Harbor. Redwood Creek is dredged for use as a shipping channel to service the Port of Redwood City. A part of Pete's Harbor, referred to as the Outer Harbor, is located in Smith Slough east of Inner Bair Island.

Marshplain Topography. Representative elevations for natural marshplains surveyed at Bair Island outboard of the leveed islands average 3.4 feet NGVD (natural pickleweed elevations range between 2.1 and 4.8 feet NGVD), or approximately the local MHW elevation, and represents the target elevation for the restoration of tidal wetlands. In contrast, subsidence has caused marshplains within the leveed salt ponds to lower by several feet below natural marshplain elevations. Inner Bair Island is at about 0.0 feet NGVD, Middle Bair about 1.0 feet NGVD, and Outer Bair at about 1.1 feet NGVD (Appendix E). The total subsidence of these areas from the target elevation, therefore, ranges from about 2.2 to 3.4 feet.

Tidal Characteristics. Tidal characteristics at the Redwood Creek tide gauge are shown in Table 1. Mean tide conditions are from the National Ocean Service (NOS, 2000). The 10- and 100-year estimated high tides are from the U.S. Army Corps of Engineers (USACE, 1984). The published tide data presented in Table 1 were checked for consistency with elevations from the field surveys used in this study (Towill 2000) using a tidal datum analysis based on one month of measured tides. Any future construction work at the site will need to use a vertical datum consistent with the surveys for this planning study (Towill 2000).

Table 1. Tide Characteristics at Redwood Creek, Channel Marker No. 8, San Francisco Bay

	Elevation	
	MLLW (feet)	NGVD (feet)
Estimated 100-Year High Tide	11.2	7.3*
Estimated 10-Year High Tide	10.5	6.6
Mean Higher High Water (MHHW)	8.1	4.0
Mean High Water (MHW)	7.5	3.3
Mean Tide Level (MTL)	4.3	0.2
National Geodetic Vertical Datum , 1929 (NGVD)	4.2	0.0
Mean Low Water (MLW)	1.2	-3.0
Mean Lower Low Water (MLLW)	0.00	-4.2

*Adopted elevation: adopted by the USACE from the smoothed profile of calculated 100-year tides.
Sources: NOS (2000), USACE (1984), PWA tidal datum analysis.
Note: NOS (2000) data are based on tide measurements between 1997 and 2000.

3.2.2 Hydrography

Redwood Creek, Steinberger Slough, Corkscrew Slough, and Smith Slough are the major tidal channels adjacent to Inner, Middle, and Outer Bair Islands. Outer Bair Island is bordered by an approximately 3000-foot wide outboard mudflat that is exposed at low tide. Shallow water continues offshore to the deepwater shipping channel through South San Francisco Bay, approximately 6,000 feet offshore of Outer Bair.

Redwood Creek, because it is dredged for use as a shipping channel, is the largest and deepest of the Bair Island sloughs. Most of the tidal exchange for the Bair Island slough system is through Redwood Creek. Smith Slough and most of Corkscrew Slough drain to Redwood Creek. The southern part of Steinberger Slough, between Smith and Corkscrew Sloughs, drains through Smith Slough to Redwood Creek. The remainder of Steinberger Slough drains directly to the Bay. The western 3000 feet (approximate) of Corkscrew Slough drains to Steinberger Slough and from there to the Bay.

On-site Drainage. Water levels in the inactive salt ponds on Inner, Middle and Outer Bair Islands are controlled by ponding of direct rainfall, evaporation, and levee seepage. Seepage between the ponds and adjacent channels occurs in both directions (into and out of the pond), depending on relative water levels. A slide-gated culvert on Inner Bair may offer some level of drainage connection between the pond interior and Smith Slough. The slide gate and culvert appear to be at least a decade old and have been observed by San Mateo County Mosquito Abatement District staff to be filled with debris (D. Jewell, pers. comm.). During field surveys conducted during March 2000, observed water levels were approximately –0.5 feet NGVD at Inner Bair, 0.1 to 1.3 feet NGVD at Middle Bair (varied by pond and date of survey), and 1.1 feet NGVD at Outer Bair.

Until recently, water in the Middle and Outer Bair salt ponds was siphoned periodically during the rainy season to keep ponding, and associated mosquito production, to a minimum. According to Dennis Jewell, Supervisor with the San Mateo County Mosquito Abatement

District, temporary siphons were used to drain Middle and Outer Bair beginning in the late 1970s or early 1980s (D. Jewell, pers. comm.). Mobil Oil installed and operated the siphons originally, and then the Mosquito Abatement District continued operations. The Mosquito Abatement District siphoned during the rainy season; by June, the ponds would usually be dry. The Mosquito Abatement District discontinued siphon operations at Bair Island in 2000 due to lack of funds and staffing. The siphons are constructed of white PVC pipe and are still visible at the site today (PWA site reconnaissance, March 2000).

It appears that Inner Bair Island has never been siphoned. Siphoning for mosquito control was not used at Inner Bair because the area is easily accessible for other types of mosquito abatement treatment (D. Jewell, pers. comm.). In addition, there are potential vandalism problems associated with storage of siphons at Inner Bair.

Off-site Drainage. Three major creeks—Redwood, Cordilleras, and Pulgas Creeks—convey surface runoff from the hillsides southwest of Bair Island to San Francisco Bay (Figure 5). Redwood Creek continues all the way to the Bay, while Cordilleras and Pulgas Creeks flow into the western Inner Bair borrow ditch and from there to Smith Slough and Steinberger Slough. Smith Slough drains to Redwood Creek and from there to the Bay. The part of Steinberger Slough near Smith Slough drains directly to the Bay only during higher water levels. The storm drain systems of Redwood City and San Carlos discharge storm runoff into Redwood Creek and Pulgas Creek, respectively, through a combination of gravity drainage and pumping. Additionally, there are several areas that discharge directly to the tidal sloughs or to the Bay itself, either via pump stations or gravity drainage.

Redwood Creek. Redwood Creek drains an area of 9.3 square miles, almost entirely within the city limits of Redwood City. The watershed is largely developed, ranging from medium-density residential areas in the hills to high-density residential, commercial, and industrial areas near the Bay.

Cordilleras Creek. Cordilleras Creek drains a 3.6-square mile watershed and forms much of the border between Redwood City and San Carlos. Most of the channel remains in its natural state without significant human alterations. The creek passes through concrete box culverts under Highway 101 before discharging into the western Inner Bair borrow ditch. Tidal influence extends 1000 feet up the creek from the Bay to Redwood High School. Cordilleras Creek is not connected to the main storm drain systems of either Redwood City or San Carlos (CFCCNA, 1999).

Pulgas Creek. Pulgas Creek collects surface runoff from a 3.6-square mile area in central San Carlos and a small part of Belmont (FIA, 1977). It passes through concrete box culverts under Highway 101, approximately 700 feet upstream of its entrance to Steinberger Slough. The creek has been channelized east of Old County Road, and lined with levees east of Highway 101 to protect adjacent areas (primarily the San Carlos Airport) against tidal flooding (FIA, 1977).

Steinberger Slough and San Francisco Bay. There are three main drainage areas northwest of Bair Island that discharge to Steinberger Slough or directly to San Francisco Bay. Storm water runoff from the San Carlos Airport is accommodated by several on-site pump stations (FIA,

1977) that likely drain to Steinberger Slough. Runoff from northern San Carlos and Belmont that drains to a holding pond in Phelps Slough is pumped into Steinberger Slough (KJC, 1986). Runoff from Redwood Shores is routed to a controlled interior lagoon. Some of the flows are collected at pump stations (C. Chang, pers. comm.) and some are stored until they can be released via gravity drainage at low tide to Steinberger Slough or to the Bay (KJC, 1986).

Tidal Flooding. FEMA flood mapping shows Bair Island completely within the 100-year floodplain in a region dominated by tidal flooding. It appears, however, that levee improvements made since the date of FEMA mapping now protect Inner Bair from 100-year flooding. There are no levees along Highway 101 where it parallels the western Inner Bair borrow ditch. The elevation of the highway in this region ranges from 8.6 to 10.9 feet NGVD (Caltrans, 1999), which is higher than the 100-year tide level. The lowest point of the highway infrastructure appears to be part of the Whipple Avenue interchange off-ramp, at an elevation of 6.8 feet NGVD.

Flooding on Regional Creeks. The adjacent watersheds of Redwood, Cordilleras, and Pulgas Creeks experience approximately the same rainfall and tides. Because of these similarities, creek flooding typically occurs during the same storm events. Major surface runoff flooding events on these creeks occurred in 1940, 1955, 1958, 1973, 1982, and 1983 (USACE, 1989).

Redwood Creek. The flood events prior to the 1967 storm drain project seem to be caused largely by high creek flows and the overtopping of channel banks, while later flood events appear to be caused by backed-up storm drain systems and limited culvert capacity (USACE 1989).

Cordilleras Creek. Flooding on Cordilleras Creek is exacerbated by erosion in the upper watershed, resulting in deposition and blockage downstream in the flat, low-lying areas. The more serious flooding on this creek occurs between El Camino Real and Highway 101 (CFCCNA 1999). In more extreme (50- and 100-year) events, flow from Cordilleras Creek backs up at El Camino Real and joins with ponded areas to the northwest created by overflows from Brittan and Pulgas Creeks (Appendix E) (FIA 1977).

Pulgas Creek. Overflow from Pulgas Creek causes flooding in the industrial area between El Camino Real and Highway 101. The pump station at Industrial Road is not large enough to relieve flooding from extreme events in this area (FIA 1977). Flooding in the industrial area is most severe when drainage is limited by high tides. Due to persistent minor flooding in the industrial area, the city plans to install two new culverts under city streets upstream of Highway 101 as part of a long-term flood management initiative (D. Gilbert, pers. comm.). Caltrans recently installed additional culverts under Highway 101 to accommodate the expected higher capacity upstream (S. Goodson, pers. comm.).

Wind Climate. Wind data for Bair Island were collected by USGS for approximately one-year (J. Dingler, pers. comm.). According to these measurements, the primary wind direction is from the west-northwest, with an average wind speed of 6.2 mph. The Bair Island data show seasonal and diurnal patterns typical of San Francisco Bay, where on-shore sea breezes create strong

summer afternoon winds and winter storms bring high velocity, shorter duration winds from the south-southeast.

3.2.3 Biological

In July 2000, an existing biological conditions document was produced to assess and map the existing biological conditions of the Bair Island complex (H. T. Harvey & Associates 2000). During the mapping of Bair Island, seven different habitat types were identified (Figure 7). These included tidal salt marsh, muted tidal salt marsh, diked salt marsh, seasonally ponded wetlands, aquatic/open water (including portions of subtidal and intertidal slough channels that adjoin the site), shell mounds, ruderal upland, and developed. Table 2 lists the quantity (in acres) of each habitat type that is present within the project boundaries of the Bair Island Restoration Project. Each of these habitats is briefly described below, and the locations of the habitats are demarcated on Figure 7.

Table 2. Habitat areas for Inner, Middle and Outer Bair Island.

LOCATION	HABITAT	ACRES
Inner Bair Island	Aquatic	48.71
	Developed	8.47
	Diked Salt Marsh	9.06
	Ruderal Upland	187.89
	Seasonally Ponded Wetland	32.82
	Tidal Salt Marsh	36.90
	Total	**323.83**
Middle Bair Island	Aquatic	112.01
	Diked Salt Marsh	553.64
	Ruderal Upland	38.02
	Tidal Salt Marsh	192.54
	Total	**896.21**
Outer Bair Island	Aquatic	100.21
	Diked Salt Marsh	468.90
	Muted Salt Marsh	51.77
	Ruderal Upland	141.45
	Shell Mounds	5.63
	Tidal Salt Marsh	647.13
	Total	**1415.09**
	Overall Acreage	**2635.13**

Tidal Salt Marsh. Tidal salt marsh occurs along the outboard side of the existing levees, as well as in the former salt ponds in the northwest section of Outer Bair where the levees have been allowed to breach. The tidal salt marsh within these former salt ponds is at a slightly lower elevation than the outboard marshes. This results in a plant community comprising an equal mix of cordgrass (*Spartina foliosa*) and pickleweed (*Salicornia virginica*). The slightly higher elevation outboard marshes are predominantly composed of pickleweed. The outboard marsh

serves as the ideal target habitat for the restoration effort, with the marsh inside the former salt ponds on the west side of Outer Bair providing insight into the evolution of the sites once tidal action is returned.

Other common plant species found in the tidal salt marsh are alkali heath (*Frankenia salina*), saltmarsh dodder (*Cuscuta salina*) and jaumea (*Jaumea carnosa*). Marsh gumplant (*Grindelia stricta* var. *angustifolia*) occurs at higher elevations, as well as along the ecotone between tidal salt marsh and ruderal upland habitat

Tidal salt marsh supports a variety of vertebrate wildlife species, including the federally endangered salt marsh harvest mouse, and the federally endangered California Clapper Rail. Shorebirds such as Willets (*Catoptrophorus semipalmatus*), and dowitchers (*Limnodromus* spp). are likely to occur here as well.

Muted Tidal Salt Marsh. One pond on eastern Outer Bair Island (Figure 7) contains deteriorated flapgate structures that are no longer functional and allow muted tidal action within the small leveed area. This area was leveed off in a failed attempt to protect Least Tern nesting habitat. Currently, the area consists of a mix of cordgrass and pickleweed. Wildlife use is similar to that in tidal salt marsh.

Diked Salt Marsh. This habitat type is largely found on the interior of the former salt ponds on Inner, Middle and Outer Bair Island (Figure 7). These areas will be the primary targets for restoration to tidal salt marsh. The diked salt marsh habitat generally consists of pickleweed interspersed with mudflats and small open water areas. The quality of the habitat between the four former salt ponds is highly variable. The former salt pond on Outer Bair Island has the highest quality habitat with over 50% cover by pickleweed that has moderate vigor. The westernmost pond on Middle Bair has less than 50% cover by pickleweed of moderate to low vigor, while the two remaining diked salt marsh areas on Middle Bair have approximately 30% cover by pickleweed of low vigor (Figure 7). The latter two ponds also have a higher occurrence of brass buttons and bare soil/salt pan. Wildlife use is significantly diminished from that in tidal salt marsh. Clapper Rails are likely to be present in this habitat only along inboard sloughs and channels where sufficient cordgrass is present. Diked salt marsh also represents only poor to moderate quality habitat for salt marsh harvest mice.

Seasonally Ponded Wetlands. These wetlands are located in slightly lower topographic depressions within the levees of Inner Bair Island (Figure 7). The changes in microtopography responsible for small patches of seasonal wetlands are very numerous, and made precise field delineation of all the patches virtually impossible due to time and budgetary constraints. However, soil pits were dug within Inner Bair Island to determine the status of these seasonal wetland areas, and the results were extrapolated to all of Inner Bair using the habitat signatures present on the aerial photography. These wetland areas, supported largely by incident rainfall, were dominated by rabbitsfoot grass (*Polypogon monspeliensis*) and brass buttons (*Cotula coronopifolia*) with patches of pickleweed, spearscale (*Atriplex triangularis*) and alkali heath also occurring throughout. These ponds support feeding shorebirds, such as sandpipers (*Calidris* spp.) and Willets, in winter, as well as waterfowl and gulls.

Aquatic/Open Water. Aquatic habitat occurs within the low-flow channel of the creeks, slough channels and borrow ditches throughout the Bair Island complex. This deep-water habitat does not support either emergent or terrestrial vegetation.

Wildlife likely to occur in this habitat include fish such as the bay ray (*Myliobatis californica*), bay pipefish (*Syngnathus leptorhynchus*), bay goby (*Lepidogobius lepidus*), shiner surfperch (*Cymatogaster aggregata*), starry flounder (*Platichthys stellatus*), and English sole (*Parophrys vetulus*). Birds likely to occur here include Western Grebe (*Aecmophorus occidentalis*), American Coot (*Fulica americana*), gulls, and various waterfowl species, such as scaup (*Aythya* spp.). Harbor seals (*Phoca vitulina*) occur here as well.

Shell Mounds. A few small areas of exposed shell exist along the perimeter of Outer Bair Island along the San Francisco Bay (Figure 7). These areas are largely devoid of vegetation and are readily visible from the ground as well as from the aerial photography. Shell mounds may provide nesting substrate for American Avocets (*Recurvirostra americana*) and Killdeer (*Charadrius vociferus*).

Ruderal Upland. Ruderal habitat is generally characterized by an area of land that receives some sort of natural or anthropogenic disturbance on a regular basis that significantly alters the natural landscape. Ruderal communities are assemblages of plants that thrive in disturbed areas; in the San Francisco Bay area weedy, annual, non-native plants are typically the first species to colonize these sites following a disturbance.

The predominant ruderal species identified at Bair Island include Italian ryegrass (*Lolium multiflorum*), ripgut brome (*Bromus diandrus*), black mustard (*Brassica nigra*), wild radish (*Raphanus sativus*), Mediterranean barley (*Hordeum marinum* ssp. *gussoneanum*), wild oats (*Avena fatua*), yellow star-thistle (*Centaurea solstitialis*), common sow thistle (*Sonchus oleraceus*), bull thistle (*Cirsium vulgare*), bristly ox-tongue (*Picris echioides*), rabbitsfoot grass, brass buttons, alkali heath, and coyote brush (*Baccharis pilularis*).

This habitat may support a variety of songbirds, such as Song Sparrows *(Melospiza melodia*), House Finches (*Carpodacus mexicanus*), and Lesser Goldfinches (*Carduelis psaltria*). Various mammals, including brush rabbits (*Sylvilagus bachmani*) and California voles (*Microtus californicus*) are likely to occur here as well.

Developed. For the purpose of this analysis, developed habitat refers to the unvegetated trails that are present around the perimeter, and across the middle of, Inner Bair Island. The parking lot area adjacent to Whipple Avenue does contain some hardscape material, but the developed areas are mostly compacted soil. These areas do contain sporadic vegetation, generally consisting of ruderal vegetation around the perimeter trail (see Ruderal Upland description) and some brass buttons in the low spots along the trail down the middle of Inner Bair Island. This habitat does not support any significant wildlife.

3.2.4 Special-status Plant Species

The process of identifying special-status plant species for consideration involved two steps. First, a query of special-status plants in the California Natural Diversity Database (CNDDB)

Redwood Point quadrangle, and eight adjoining quads. Second, the California Native Plant Society Inventory (1994) was used to produce a similar list for San Mateo County. The habitat requirements and current distribution for each special-status species were the principal criteria used for inclusion in the list of potentially occurring species on site. Therefore, plants were considered on the basis of their occurrence in the broad categories of marshes and swamps, and valley and foothill grasslands that are most similar to the salt marsh, seasonal wetland, and ruderal habitats on site.

Many of the special-status plant species that occur in San Mateo County are found in habitat types that are not present on site. These habitat types include: dune and prairie habitats, coniferous habitats, woodland habitats, meadow and vernal pool habitats, and scrubs and chaparral habitats, and serpentine environments. In addition, the following sensitive habitats identified by the CDFG Rarefind Database query are not present on site: valley oak woodland, valley needlegrass grassland, and serpentine bunchgrass. A fourth sensitive habitat, northern coastal salt marsh, is prevalent on site.

A total of 41 special-status taxa occur in the area within similar habitats according to the CNPS inventory and the CDFG Rarefind Database. Of these, 37 species were dismissed due to the absence of suitable microhabitats (mostly serpentine substrates), and/or have been regarded as either extirpated from San Mateo County; their distribution has been reduced to historical occurrences, or they are considered extinct. Suitable habitat exists in the project area for only 4 species including: Contra Costa goldfields (*Lasthenia conjugens*), Point Reyes bird's beak (*Cordylanthus maritimus* ssp. *palustris*), Congdon's tarplant (*Hemizonia parryi* ssp. *condonii*), and marsh gumplant (*Grindelia stricta* var. *angustifolia*). Of these, the marsh gumplant was observed on site. Congdon's tarplant, Contra Costa goldfields and the Point Reyes bird's beak have not been observed, and detailed surveys for these species have not been conducted.

California sea-blite (*Suaeda californica*) was one of the species initially considered for the project goals. It is an extremely rare succulent shrub of the upper intertidal zone. In San Luis Obispo County, where the sole remaining natural populations of California sea-blite persist, plants colonize the course substrates of sandy salt marsh edges and marshy beach ridges. Extant populations are discontinuously distributed in a narrow band around Morro Bay in association with pickleweed, saltgrass, rush, and alkali heath. Populations are absent from the more interior portion of the marshlands (USFWS 1994). Relative to the pickleweed-dominated middle marsh plains typical of San Francisco Bay, substrates at favored sites are both well-drained and subject to high-energy waves and tides.

California sea-blite was probably never common in the San Francisco Bay except in the few, long-developed areas of sandy beach interface in Alameda and San Francisco counties (Baye et al 2000). Bair Island is a significant distance from the Bay mouth and is subject only to low-energy wind and waves; the proximity of intertidal mudflats drives the transport and deposition of fine-grained sediments; native plant communities are therefore mudflat colonizers. Sandy substrates suitable for supporting California sea-blite were probably never present on Bair Island. It is therefore very unlikely that an attempt to create a sandy intertidal habitat would succeed, even on Outer Bair, without significant mechanical inputs to fill with dredged sand and prevent fine sediment deposition and mixing. Furthermore, these techniques are incompatible with the

restoration design, which hinges on the natural accumulation of fine sediments on the subsided sites. Therefore, development of habitat for California sea-blite will not be considered further in this restoration plan.

3.2.5 Listed Wildlife Species

Two species listed as Federally Endangered (FE) breed in high density on Outer Bair Island: the California Clapper Rail and salt marsh harvest mouse. The California Clapper Rail breeds only in the fully tidal salt marsh portions of Outer Bair Island. The salt marsh harvest mouse likely occurs on Middle Bair Island also, as there is much pickleweed present. Three listed species occur as seasonal residents, including the Western Snowy Plover (Federally Threatened, FT), California Least Tern (FE) and California Brown Pelican [*Pelecanus occidentalis* (FE)]; and two others, the steelhead [*Oncorhynchus mykiss* (FT)] and chinook salmon [*Oncorhynchus tshawytscha* (FT)], migrate through the area. The California Black Rail (State Threatened and Federal candidate) and Bank Swallow [*Riparia riparia* (State Threatened)] could occur rarely in the study area. The harbor seal, protected under the Marine Mammal Protection Act, hauls out and pups along the banks of Corkscrew Slough. The Alameda Song Sparrow (*Melospiza melodia pusillula*) and Salt Marsh Common Yellowthroat (*Geothlypis trichas sinuosa*) have been candidate species for federal and state listing, and are considered species of special concern by the State of California. The Alameda Song Sparrow is common in the salt marsh of Bair Island; the Salt Marsh Common Yellowthroat is likely sparse owing to a lack of willow thickets and *Scirpus* sp.

California Least Tern was one of the species initially considered for the project goals. These terns formerly nested on diked portions of Outer Bair that are not part of this restoration project. The likelihood of successfully creating breeding habitat in this location is slim, as years of management to preserve the former colony were not successful. In addition, the creation of nesting areas for the Least Tern is not compatible with the natural sedimentation processes necessary for tidal salt marsh development. Tidal salt marsh is the target habitat of this restoration as it serves as the primary habitat for the California Clapper Rail and salt marsh harvest mouse. Therefore, development of habitat for the Least Tern will not be considered further in this restoration plan.

4.0 SITE OPPORTUNITIES AND CONSTRAINTS

The Bair Island complex presents numerous restoration opportunities, including the return of approximately 1400 acres of Inner, Middle and Outer Bair Island to tidal salt marsh habitat. However, the site also offers many constraints to the proposed restoration effort, which range from existing infrastructure to sensitive wildlife species. A comprehensive list of these opportunities and constraints have been compiled in conjunction with the Technical Review Team (TRT), and are presented below.

4.1 PHYSICAL AND GEOMORPHIC OPPORTUNITIES

- *Estuarine sediment supply*. Estuarine sedimentation processes may be used to rebuild the subsided marshplain over time.
- *Natural vegetation processes*. Existing local marsh vegetation is expected to provide a source of seed and propagules for natural colonization of the restored marshes.
- *Existence of antecedent channel network*. Dendritic networks of antecedent channels are present in all the ponds, especially Middle and Outer Bair Islands. Scour is expected to occur first nearest the breaches, gradually headcutting back into the pond interiors. Some channels may need to be excavated in Inner Bair to provide tidal drainage.
- *Fill to elevations conducive for marsh vegetation colonization*. Fill can be used to raise ground elevations and create areas likely to colonize rapidly with marsh vegetation. Redwood Creek dredged material is a potential source of fill.
- *Create recreational and educational areas on Inner Bair Island*.
- *Provide data for future large-scale tidal wetland restoration projects in San Francisco Bay*.

4.2 PHYSICAL AND GEOMORPHIC CONSTRAINTS

- *Subsided ground elevations below vegetation colonization elevations*. The bottom elevations for Inner, Middle, and Outer Bair are subsided below natural marshplain elevations, and most areas are initially too low in the tidal frame for marsh plants to establish or survive. Average marshplain elevations are approximately 0.0 ft NGVD for Inner Bair and 1.0 ft NGVD for Middle and Outer Bair. Emergent marsh requires minimum elevations around 1.0 to 2.0 ft NGVD for seeds to germinate. Figure 8 compares initial elevations of restored tidal marshes in San Francisco Bay to the time it took each site to reach 50 % vegetative cover.
- *Sedimentation rates will limit rates of marsh evolution if fill material is not used*. The mudflats adjacent to Outer Bair Island are the primary source of sediment to the sloughs surrounding Bair Island and will be the primary source for the restored wetlands. Large winter storms deposit suspended sediments on the mudflats. These sediments are then resuspended by wave action and carried into the major sloughs adjacent to Bair Island on each tide. Sediment concentrations are lowest for channels further from the Bay such as Smith Slough. Although the Redwood Creek watershed will supply some sediment to the area, this source is not expected to be significant. Wind wave resuspension could also limit rates of sedimentation, though the extent of this effect is undefined. The islands are

large and high wind fetches could allow sizeable waves to generate within the islands, keeping sediments from depositing and scouring previously deposited sediments.

- *Limitations to natural channel formation*. In general, breaching at the locations of historic channels is expected to help reestablish the antecedent historic channels. The borrow ditches that ring the interior of the diked ponds can short-circuit the tidal flow, drawing tidal energy away from scouring of the historic channels and reestablishment of the natural channel system.
- *SBSA sewer pipeline on Inner Bair Island*. The existing levee over the pipeline will need to be enlarged to protect it from potential wave erosion once the site is breached. Access needs to be provided to the pipeline for regular visual inspections of the pipeline corridor; staging areas also need to be available in the likelihood of future repairs.
- *San Carlos Airport safety zone*. The San Carlos Airport property on Inner Bair Island requires measures to prevent the safety zone from flooding.
- *Induced Deposition in the Redwood Creek shipping channel*. The shipping channel is by far the largest and most efficient channel to convey tidal waters to the restored Inner and Middle Bair Islands. Sediment transport modeling conducted in support of restoration planning indicates that increasing tidal prism through the shipping channel could result in faster siltation of this channel and necessitate more frequent dredging. The restoration plan must avoid or mitigate for these potential impacts.
- *Tidal Velocities in Pete's Outer Harbor*. Hydraulic modeling conducted in support of restoration planning indicates that the most direct restoration approach – simply breaching the islands at historic slough locations – could result in much stronger tidal currents through the Outer Harbor. The restoration plan must avoid or mitigate for these potential impacts.
- *Flooding on Redwood, Pulgas and Cordilleras Creeks.* Significant impacts to flooding on these creeks must be avoided or mitigated.
- *Protection of other infrastructure*. Flood protection levees on Redwood Creek and Steinberger Slough will require protection from potential increased erosion due to any increases in tidal scour. PG&E will need continued access to their towers and maintenance boardwalks.

4.3 BIOLOGICAL OPPORTUNITIES

- *Restore key estuarine ecological processes (e.g., nutrient exchange) by increasing connectivity of the marsh and the Bay*. The interior areas of Bair Island are physically separated from the Bay.
- *Restore approximately 1400 acres of tidal wetland and upland transition habitat.*
- *Convert existing upland to tidal wetland habitat both by lowering portions of the perimeter levees throughout the project site and creating new wetland habitat from upland areas on Inner Bair Island.* Although the majority of Middle and Outer Bair Island are diked wetland habitats, much of Inner Bair Island is upland habitat.
- *Create new areas conducive to seal haul-out and pupping, such as those along Corkscrew Slough.*
- *Maximize topographic relief between upland areas and slough channels to restore habitat diversity via expanded ecotones.*

- *Restore habitat that supports special-status plant and animal species (such as the salt marsh harvest mouse and California Clapper Rail).*
- *Provide data for future large-scale tidal wetland restoration projects in San Francisco Bay.* Since the opportunity exists for tidal wetland restoration in much of the South Bay, the Bair Island Restoration project provides a unique opportunity to gather information that can be applied to the planning, design, and implementation of other large-scale restoration projects.
- *Reduce and manage predation by grading and breaching levees to create barriers to predators.*
- *Create islands within tidal marsh habitat to provide high-tide refugia for target wildlife.*
- *Create seasonal wetland areas.* Opportunities for seasonal or diked wetland habitat creation are present at Inner Bair Island.
- *Reduce mosquito impacts to local communities.*

4.4 BIOLOGICAL CONSTRAINTS

- *Existing seal haul out and pupping area habitat on Corkscrew Slough may be impacted.* Placement of a flow constriction in Corkscrew Slough may affect harbor seal access to haul-out sites in the slough. A barrier located between the two haul-out sites could impede access to at least one of the sites.
- *Ponding of water on Inner Bair may increase bird use, and therefore increase aircraft bird strike potential.* The restoration of seasonal wetland habitat on Inner Bair Island could increase the risk of bird strikes.
- *Creation of habitat for endangered species may impede future maintenance activities along the SBSA sewer line.* The restoration of salt marsh habitat immediately adjacent to the SBSA sewer line could cause future permitting difficulties for maintenance activities.
- *Existing special status-species (especially the salt marsh harvest mouse) habitat on-site will be disturbed by construction activities and flooding of existing habitat.* Much of the area within Middle and Outer Bair Island slated for restoration may currently provide some habitat for the salt marsh harvest mouse. Furthermore, tidal marshes on the outboard side of existing levees may currently support California Clapper Rails and salt marsh harvest mice.
- *Invasion of newly restored habitats by non-native or unwanted organisms.* Non-native cordgrass invasion is a Bay-wide problem and the restoration of Bair Island could contribute to its further expansion.
- *Increase in disturbance to wildlife from recreation and maintenance of recreational infrastructure with changes in habitat on Inner Bair Island.* The restoration of endangered species habitat may not be compatible with some recreational activities.
- *Impacts to existing wetlands from dredge and fill activities, and from increased tidal prism scouring of outboard marshes.*

5.0 DESIGN APPROACH

The restoration design approach is to create an initial site template that will guide the action of natural physical and biological processes after breaching to form a self-sustaining tidal marsh system. The design approach relies as much as possible upon natural estuarine sedimentation and biological succession. This approach is consistent with recommendations by the San Francisco Bay Area Wetlands Ecosystem Goals Project (Goals Project), a collaborative planning effort with input from numerous regional wetland and restoration scientists.

The most direct and simple restoration approach would be to breach each island at several historic channel locations and allow natural estuarine sedimentation and biological succession to gradually create tidal marsh habitat. However, the consideration of several infrastructure constraints (safety considerations for the San Carlos Airport, protection of the SBSA sewer line on Inner Bair, not worsening siltation in the Redwood Creek shipping channel, and avoiding impacts to navigation at Pete's Outer Harbor) made it necessary to include some substantial modifications to this direct and simple approach. The need to address these constraints affected the formulation of restoration alternatives.

Section 5.1 describes the template design approach and provides an overview of tidal marsh evolution after restoration. Section 5.2 describes the infrastructure constraints and solution approaches. Section 5.3 provides an overview of the design features common to many of the restoration alternatives. The information in Sections 5.2 and 5.3 are important background to the alternatives discussion in Section 6.

The design approach also included using hydraulic and sediment transport modeling to assess potential project impacts and evaluation solution approaches. This modeling is described in Appendix A.

5.1 SITE TEMPLATE APPROACH AND EVOLUTION OF RESTORED TIDAL MARSH

The restoration design approach is to create an initial site template that relies primarily on natural estuarine sedimentation to raise subsided site elevations, tidal scour to reestablish antecedent tidal channels, and natural plant colonization to establish marsh vegetation. Direct interventions such as grading and filling are minimized, where possible, in the design. However, any target habitat features that may not evolve on their own or may not evolve as rapidly as needed to meet the habitat goals or site constraints are either included in the design template or given a "jump start" to develop more quickly.

Important to the design approach is an understanding of how tidal habitats will likely evolve over time. The establishment of salt marsh habitat in subsided sites such as Inner, Middle, and Outer Bair Islands requires the accumulation of sediment until mudflats are high enough for plant colonization. Figure 9 illustrates conceptually how the marsh plain for a subsided site is anticipated to evolve in response to estuarine sedimentation, scour, and plant establishment processes. Initially, the site is low in elevation relative to the tidal frame, and consists primarily of intertidal mudflat with vegetation at the higher elevations. As sedimentation raises elevations,

vegetation establishes and tidal flows scour and deepen the channels. Once the mudflats reach a high enough elevation relative to the tidal frame, pioneer plant colonization can occur. A vegetated marsh plain forms through lateral expansion of rhizomes from each established plant on the mudflat, and from plants along the site perimeter. As the marsh plain rises within the tidal frame, estuarine sediment accretions slows exponentially until a marsh plain forms at an elevation within a few decimeters of MHHW (Atwater et al. 1979). The solid line in Figure 10 illustrates conceptually how the marsh plain is anticipated to evolve in response to estuarine sedimentation processes, from subtidal, to intertidal mudflat, to initial mudflat colonization by *Spartina* sp., to ultimately a fully mature vegetated, pickleweed-dominated marsh plain.

The primary determinant of whether a sustainable vegetated marsh will form is whether vertical accumulation of sediment relative to sea level will build up mudflat elevations high enough for emergent vegetation colonization. Elevation gain relative to sea level in any given time period is a function of accumulation, erosion, and relative sea level rise. In general there is a tendency for accumulation processes to decline and for erosive processes to increase as mudflat elevations increase.

Accumulation in subsided restored sites is mainly dependent on estuarine suspended sediment concentrations in the tidal flows feeding the site, and the depth and frequency of tidal inundation. Suspended sediment concentrations in the water column on the incoming tide are influenced by proximity to intertidal mudflats or shallows, wave action, and depth of the water column. Depth and frequency of tidal inundation depend on the mudflat elevation and tides. As mudflats build higher, they are inundated less deeply and less frequently, reducing net sedimentation rates.

Erosion of estuarine sediments is mainly dependent on wind-wave action and tidal currents. Wind-waves are generated when wind blows over a length of water (a distance called the wind "fetch"). Wave height is positively correlated with wind speed, fetch length, and water depth. For a given wave height, erosion is greater in shallow water than in deeper water. Tidal currents are generally quite small except where tidal sloughs are forming.

Relative sea level rise is mainly a function of eustatic (global) sea level rise and local subsidence. Ocean thermal expansion and glacial melting in response to global warming drive global sea level changes. Predictions of global sea level rise range from 0.2 feet to 1.1 feet over the next 50 years. For this study, we used a mid-range estimate of 0.5 feet (IPCC 1996).[1] Based on a 1987 San Francisco Bay Conservation and Development Commission (BCDC) report that characterizes subsidence throughout the San Francisco Bay area, local subsidence at the site is approximately –0.006 feet/year, or –0.3 feet in 50 years. This estimate may be high, however, since it is based on an extrapolation of historic subsidence due to groundwater pumping and tectonic movement. There is evidence to suggest that groundwater pumping has slowed considerably since the period of time upon which the above local subsidence estimate is based (BCDC, 1987).

[1] During the course of this study, updated sea level rise estimates of 0.6 ft over the next 50 years were released (IPCC 2000). These are very close the values used in this study.

In addition to limited sediment supply, two other factors can retard the physical evolution of a subsided restored site to a vegetated marsh: damped tides and internally-generated wind waves. Good marshplain drainage is important to marsh development. Poor drainage from damped tides can limit sediment supply to the restored site and inhibit plant colonization. Internally generated wind waves prevent deposition or resuspend deposited estuarine muds. For wave-exposed sites with long wind fetches, the rate of net mudflat accretion is diminished as it builds in elevation. For some subsided sites with long wind fetches, there is a potential for wind wave action to create permanent intertidal mudflats instead of marshplains (Figure 10) unless the sites are partially filled.

5.1.1 Expected Evolution of Wildlife Communities

Restoration of other tidal marsh sites in the San Francisco Bay area has resulted in expected shifts in wildlife communities. When sites are first exposed to tidal action, mudflats are typically created, resulting in rich invertebrate communities and large numbers of foraging shorebirds, especially during winter. As vegetation develops (e.g., annual pickleweed, and eventually cordgrass), the bird community generally shifts to larger shorebirds, and lower abundance. When mature cordgrass and pickleweed marsh has been established, bird abundance (for many species) and diversity can be quite low, but habitat becomes suitable for the special-status California Clapper Rail and salt marsh harvest mouse, as well as a suite of species found in such tidal marshes.

5.2 APPROACHES FOR ADDRESSING INFRASTRUCTURE CONSTRAINTS

Site conditions and constraints that had a significant effect on the restoration design include: safety requirements of the San Carlos Airport, the SBSA pipeline on Inner Bair, sedimentation in the Redwood Creek shipping channel, and tidal velocities in Pete's Outer Harbor. Each of these constraints and the solution approaches are described below. The restoration alternatives presented in Section 6 use various combinations of these solution approaches.

5.2.1. Safety requirements of the San Carlos Airport

Flood protection for the San Carlos Airport safety zone will require either leveeing and draining the safety zone or filling this area to above tidal elevations (Figure 3). To reduce the potential for bird strike hazards, the restoration approach is to create vegetated marsh habitat on Inner Bair Island and minimize ponded open water areas. Vegetated marsh habitat is not favored by the bird species that pose the greatest strike hazard (see Appendix C).

Natural sedimentation and plant establishment processes would not be expected to result in substantial areas of vegetated marsh at Inner Bair for several decades, or longer. Because this timeframe is not acceptable from a hazard perspective, other approaches are used. Two approaches to creating vegetated marsh are to fill Inner Bair to high intertidal elevations at which vegetation will rapidly establish, or to manage Inner Bair as a muted tidal marsh. In the managed marsh scenario, the depth of ponding on Inner Bair would be limited to depths consistent with vegetation establishment and survival.

5.2.2 SBSA pipeline on Inner Bair

The levee covering the SBSA force main must be protected from wave erosion after restoration. In addition, the SBSA requires continued maintenance access and a means of detecting leaks. The solution approach presumed for the restoration plan is to widen the levee crest. This design constraint will need to be evaluated in more detail in final design.

5.2.3 Redwood Creek Shipping Channel Siltation

Preliminary hydrodynamic and sediment transport modeling indicated that breaching Middle and Inner Bair at the historic channel locations, without including other flow modifications in the design, would result in more rapid sedimentation of the Redwood Creek shipping channel and require more frequent dredging, compared to existing conditions. The restoration approach to prevent this is to restrict tidal flows in Smith and Corkscrew Sloughs, rerouting most or all flow from the restored ponds through Steinberger Slough rather than Redwood Creek.

The rerouting of flows is necessary to avoid drawing large volumes of sediment-laden water through the Redwood Creek shipping channel, where low flow velocities cause the sediment to deposit and rapidly silt in the channel (Appendix B). Because Redwood Creek is dredged and is vastly oversized in comparison to Steinberger Slough (Figure 11), tidal flows to Middle and Inner Bair tend to flow preferentially though Redwood Creek. Even with the larger restored flows, velocities in Redwood Creek are low and sedimentation occurs throughout the tide cycle. Sediment transport modeling results (Appendix B) indicate that the increase in sediment-laden flows through Redwood Creek could result in approximately triple the existing siltation rates in the shipping channel. Existing spatial deposition patterns for the shipping channel are illustrated in Figure 12. The highest sedimentation occurs in a one-mile segment of the dredged channel that includes the junctions of West Point Slough and Corkscrew Slough.

To avoid impacts to the shipping channel, the project must not increase the tidal prism carried through Redwood Creek above existing conditions. Hydrodynamic and cohesive sediment transport modeling results (Appendix B) indicate that when Middle or Inner Bair is breached, flow control structures are required in Smith and Corkscrew Sloughs to limit post-restoration tidal prism. The restoration alternatives include a channel constriction in Corkscrew Slough to route tidal prism from restored Middle Bair to Steinberger Slough, with little flow to Redwood Creek. To be effective, the constriction must be east of the Middle Bair breaches. Realignment of Smith Slough to its historic meander in Inner Bair serves a similar purpose, routing tidal prism from restored Middle and Inner Bair preferentially to Steinberger Slough. See Figure 2 for an illustration of the locations of the flow control structures.

Other solution approaches were considered and rejected based on modeling results. These approaches include: phasing the restoration by pond to allow Steinberger Slough to scour near Outer Bair prior to breaching Middle and Inner Bair, dredging Steinberger Slough, limiting the number and location of breaches, and using seasonal or temporary hydraulic structures/channel realignments.

5.2.4 Pete's Outer Harbor Tidal Currents and Navigation

Preliminary modeling results indicated that if Inner and Middle Bair were restored by breaching at the historic channel locations, without including any flow modifications, velocities at Pete's Outer Harbor will increase from approximately one foot per second (fps) under existing conditions to nearly three fps. Generally accepted marina design guidelines indicate that velocities above one fps pose navigation difficulties for small watercraft. Post-project velocities of up to three fps are likely to be unacceptable to the marina. This increase would likely diminish over time as it is likely that within a few years the channel would scour and widen until it reached a new equilibrium cross section with the tidal flow.

Several solutions approaches to reducing impacts to tidal velocities were considered:

- Widening Smith Slough in the vicinity of the harbor to increase the cross-sectional flow area;
- Constructing a bypass channel through Middle Bair to route flow around Pete's Outer Harbor;
- Breaching Middle Bair only along Corkscrew Slough to reduce tidal flows in Smith Slough;
- Dredging Steinberger Slough;
- Phasing restoration by pond so that Steinberger Slough scours and deepens near Outer Bair before breaching Middle and Inner Bair.
- Constricting flows from Smith and Corkscrew Sloughs to Redwood Creek, thereby directing more flow toward Steinberger Slough.

In the end, constricting flows from Smith and Corkscrew Sloughs to Redwood Creek was the only approach that avoided impacts to both the Redwood Creek shipping channel and Pete's Outer Harbor.

5.3 RESTORATION TEMPLATE DESIGN FEATURES

The site template for the tidal wetland design relies on deposition of sediments from in-flowing waters to fill the subsided sites. As sediments accumulate, natural geomorphic and biological processes will restore tidal wetland function. Dredged material may also be placed on site to accelerate the evolution process. The site template will be established prior to reintroducing tidal action, and will consist of:

- Breaches in the perimeter levees.
- Connector channels in the site interior. These channels will be excavated through interior berms to reconnect segments of historic channel.
- "Cut-off berms" to block tidal flow through the borrow ditches and promote reestablishment of the remnant natural tidal channels. Cut-off berms have been used successfully at the Cooley Landing Marsh Restoration in South San Francisco Bay.
- Excavated channel(s) on Inner Bair to allow for more rapid tidal channel formation following restoration and to connect remnant channels to the primary drainage channels.

Dredged material, if available, will be used to raise the elevation of Inner Bair Island and to construct site features, as needed.

6.0 ANALYSIS OF ALTERNATIVES

Based upon the identified existing site conditions and identified opportunities and constraints a range of restoration alternatives were prepared. A total of six restoration alternatives were prepared and described to the TRT on December 5, 2000. Due to design constraints and through further discussions with personnel from the USFWS, CDFG, and the TRT, a more limited and realistic set of alternatives were developed. These five alternatives are briefly described below. From these five alternatives, one preferred alternative will be carried through in detail to conceptual design. The following discussions assume a 50-year planning horizon, consistent with that used by other San Francisco Bay restoration projects currently in planning.

6.1 ALTERNATIVES

1. No project

For the no project alternative, we assume that USFWS would discontinue on-going levee maintenance at Middle and Outer Bair Island and would not repair any levee breaches. Minimal levee maintenance would occur on Inner Bair Island to protect the existing infrastructure. Eventually, the levees on Middle and Outer Bair will fail and will return to a tidal system. However, the time frame for habitat restoration would be greatly increased, and the timing and location of breaches could not be optimized to maximize benefits to wildlife or to minimize impacts to surrounding infrastructure.

Unmanaged tidal inundation of the Middle and Outer Bair Islands would result in an increased tidal prism that would induce greater siltation within the Redwood Creek shipping channel and higher tidal velocities at Pete's Outer Harbor.

A no project alternative is a necessary part of the environmental review process and will allow comparison of the impacts of implementing the project with those that will occur without the project. Therefore this alternative will be carried forward for further evaluation.

2. Minimal Construction Tidal Marsh Restoration

Alternative 2 maximizes the use of natural processes in the ecological recovery of Bair Island, resulting in what is expected to be the lowest cost alternative that provides for restoration of the entire available 1400-acre area.

Outer and Middle Bair Island. Levees will be breached at historic slough channel locations on Middle and Outer Bair Islands and borrow ditch cutoff berms will be created to prevent tidal capture by the existing borrow ditches. Interior berms and levees will be selectively lowered or removed to the extent possible. Some or all of the levees adjacent to Steinberger Slough would be left in place to provide wind-wave erosion protection for the western shoreline of Steinberger Slough.

Inner Bair Island. Levees will be breached at historic slough channel locations on Inner Bair Island and borrow ditch cutoff berms will be created to prevent tidal capture by the existing

borrow ditches. Fill material will be used to expand the southern levee of Inner Bair Island to adequately protect the SBSA sewer line and to create a cross-levee that protects the San Carlos Airport property on Inner Bair Island. Possible sources of fill material include material excavated from levee breaches and levee crests on all three islands, excavation of the cross-levee on Inner Bair, dredged material from Redwood Creek and imported fill.

The cost of maintaining the Inner Bair levee for public access will increase somewhat over existing conditions due to increased wind-wave erosion and tidal scour. Levees will require maintenance on the inboard and outboard sides. The restored tidal prism would induce greater siltation within the Redwood Creek shipping channel and higher tidal velocities at Pete's Outer Harbor.

From an ecological perspective, this is the most direct restoration approach and it is also the most economical. However, this approach is not feasible from an infrastructure protection perspective. It would likely induce an increased bird strike hazard, Redwood Creek shipping channel siltation, and high tidal velocities at Pete's Outer Harbor. Due to the potential design-related impacts, this alternative will not receive further evaluation.

3. Tidal Marsh Restoration (Recommended Alternative)

Alternative 3 uses dredged material, most likely from Redwood Creek, to raise the marshplain elevation at Inner Bair prior to breaching. The purpose of this approach is to reduce the amount of open water at Inner Bair and to expedite the establishment of emergent marsh. Channel modifications would be made at Smith and Corkscrew Sloughs to mitigate for potential impacts to the Redwood Creek shipping channel and Pete's Outer Harbor. Smith Slough would be realigned to its historic meander through Inner Bair. Corkscrew Slough would be blocked to the east of the Middle Bair breaches.

Dredged material, or other sources of fill, would be used to expand the southern levee of Inner Bair Island to adequately protect the SBSA sewer line and create a cross-levee that protects the San Carlos Airport property on Inner Bair Island. Levees will be breached at historic slough channel locations on Inner Bair Island and borrow ditch cutoff berms will be created to prevent tidal capture by the existing borrow ditches. Although historic slough channels and borrow ditches will be filled with dredged material, differential settlement will result in a lower elevation, and therefore channel development, in these areas. The major drawbacks of dredged material placement are high cost and somewhat impaired tidal channel development.

The restoration approach for Middle and Outer Bair is the same as described in Alternative 2.

Since this alternative meets all of the project's goals and objectives as well as meets the project's design criteria, it is the preferred alternative and will be evaluated in more detail in the following section.

4. Tidal and Managed Marsh Restoration

Alternative 4 would introduce muted tides on Inner Bair Island, allowing the reestablishment of some tidal marsh, while limiting the creation of the open water habitat that would be undesirable from a bird strike hazard perspective. In this approach, a hydraulic structure(s) (e.g., flapgates) would be installed on Inner Bair to allow tidal inundation approximately between mean tide level (the existing marshplain elevation) and mean lower low water. Existing ruderal and seasonally ponded wetland vegetation on the site would likely die back and be replaced by pickleweed and other high marsh vegetation, creating a muted tidal salt marsh. The hydraulic structure(s) would require regular maintenance.

Channel modifications would be made at Smith and Corkscrew Sloughs to mitigate for potential impacts to the Redwood Creek shipping channel and Pete's Outer Harbor. A flow restrictor would be placed in Smith Slough between the two hydraulic structures into Inner Bair Island. It would be similar to the flow restrictor being placed in Corkscrew Slough, except that the flow restrictor in Corkscrew would have a notch for water flows as well as a boat portage.

The restoration approach for Middle and Outer Bair is the same as described in Alternative 2.

This alternative meets most of the project's goals and objectives and meets the project's design criteria. Therefore this alternative will be carried forward for further evaluation.

5. No Restoration of Inner Bair

This alternative consists of no restoration to Inner Bair Island. The restoration approach for Middle and Outer Bair and channel modifications are the same as described in Alternative 4.

This alternative was not chosen for further evaluation due to the overall goal of restoring tidal marsh to as much of Bair Island as possible. Additionally, the restoration of Inner Bair would provide public outreach and educational opportunities.

6.2 RECOMMENDED RESTORATION ALTERNATIVES

This section provides more detailed descriptions of the Bair Island restoration alternatives recommended for further study by the USFWS and CDFG with input from the TRT. The following three alternatives were selected:

Alternative 1: No Project
Alternative 2: Tidal Marsh Restoration
Alternative 3: Tidal and Managed Marsh Restoration

Alternatives 2 and 3 both include the restoration of full tidal action at Middle and Outer Bair; they differ only in their treatment of Inner Bair. The following discussions assume a 50-year planning horizon, consistent with that used by other San Francisco Bay restoration projects currently in planning.

ALTERNATIVE 1: NO PROJECT

In comparing and selecting a project alternative, it is important to understand how the site is likely to evolve if no action is taken. For the no project alternative, the Refuge would discontinue on-going levee maintenance at Middle and Outer Bair Islands and would not repair any levee breaches at these locations. Levees on Middle, and Outer Bair would gradually deteriorate and eventually fail, allowing tidal action. The Refuge would cooperate with San Carlos Airport and the South Bayside System Authority allowing them to maintain the levee on Inner Bair Island that protects the existing safety zone and force main pipeline. However, only minimal maintenance would occur along the Inner Bair Island levee system.

Middle and Outer Bair would likely overtop and begin to breach within the next ten years, since average levee crest elevations on these islands are below the 10-year high-tide elevations. The breaches would erode and widen over time. The existing borrow ditches would capture much of the tidal prism and establishment of the remnant historic channels would be limited. Natural estuarine sedimentation would gradually rebuild the marshplain to elevations at which vegetation could reestablish. Increased tidal flows would scour and deepen the surrounding major sloughs.

If the Inner Bair perimeter levees were allowed to subside (i.e., if they were not maintained) the site would probably breach within the 50-year planning horizon. Minimum levee crest elevations are currently approximately 7.6 feet. Over fifty years, levee subsidence on the order of several feet and sea level rise of approximately 0.5 foot would result in levee crest elevations susceptible to overtopping in a high spring tide or storm surge. Therefore to protect infrastructure located on Inner Bair Island, levee crest elevations of approximately 7.6 feet would need to be maintained. However the trail system on Inner Bair Island would be abandoned.

Unmanaged tidal inundation of the ponds could induce greater siltation within the Redwood Creek shipping channel and higher tidal velocities at Pete's Outer Harbor.

Potential Impacts to Existing Habitats and Wildlife

Middle and Outer Bair would continue to evolve in the period before the levees breach. Habitats that are now sparse to moderate cover of pickleweed may improve somewhat in that time frame. Based on the observations of pond A-11, which has not changed substantially in the past 13 years, that improvement may be negligible (see Figure 6 in Appendix G). When the levees breach, there will be loss of existing poor to moderate quality habitat for the salt marsh harvest mouse.

It is difficult to predict the changes that may occur on Inner Bair Island w/ minimal levee maintenance over a 50 year period. Over the past 13 years, the site has become less saline, dominated by more upland grasses and forbs, and seasonally ponded bare areas have accordingly diminished. If that trend continues, then we would expect continued succession of higher elevation portions of the site toward grass and shrub mixtures, while low-lying areas would likely continue to pond.

Given that scenario, impacts to wildlife habitat include the eventual loss of these ruderal upland areas and seasonal wetlands. There are species currently classified as special status that rely on

these types of habitat, and would be impacted by its loss. Examples include White-tailed Kites (*Elanus leucurus*) and Northern Harriers (*Circus cyaneus*) that nest in the vicinity and forage in the upland habitats. The impacts from the loss of these habitats apply to all the alternatives. When considering this alternative, an additional impact is the delayed timing of the site to evolve from open water to vegetated marsh. Those species that flourish in fully tidal salt marsh habitat, including the federally endangered salt marsh harvest mouse and California Clapper Rail, would benefit within the first few years from the creation of small habitat areas. Large-scale habitat benefits for these species would require upwards of 30 to 50 years.

Potential Creation of Habitat and Benefits to Wildlife

The breaching of outboard levees on Middle and Outer Bair Islands would allow tidal salt marsh to become established. These marshes would evolve over a period of decades. California Clapper Rails, salt marsh harvest mice, fisheries, and the suite of vertebrate and invertebrate species dependent on tidal marshes would benefit. Inner Bair Island levees would be maintained and no new beneficial habitats would be created.

Potential benefits to wildlife include benefits to those species that inhabit salt marsh and would benefit from its eventual restoration, including the salt marsh harvest mouse and the California Clapper Rail. The Alameda Song Sparrow, which is considered a species of special concern by the State of California, is common in the salt marshes of Bair Island and would benefit from further habitat restoration.

Inner Bair currently is at elevations between –0.6 and 1.0 NGVD, and subsided 0.8 feet in about the last 20 years. If the site continues to subside, then it may be several feet below today's elevation in 50 years. The lands are already below mean tide level and, thus with additional subsidence, would be more difficult to drain during the winter months. This would lead to increased water depths and durations in Inner Bair Island following winter storms. Large areas of open water, particularly in a protected area away from wind and waves, are particularly attractive to both shorebirds (at lowest tides) and waterfowl (when the water is deeper). Large flocks of waterbirds could pose a safety hazard for the San Carlos Airport.

ALTERNATIVE 2: TIDAL MARSH RESTORATION

Alternative 2 (the preferred alternative) restores full tidal inundation to Inner, Middle, and Outer Bair. For Middle and Outer Bair, natural estuarine sedimentation will raise the marsh plain surface to allow complete vegetation establishment over time. Restoration will include features to encourage reestablishment of the natural tidal drainage network and discourage the capture of the tidal flows by borrow ditches at these two islands.

At Inner Bair, dredged material, most likely from Redwood Creek, will be used to raise the marsh plain elevation prior to breaching. The purpose of this approach is to reduce bird strike hazards for the San Carlos Airport by reducing the amount of post-breaching open water at Inner Bair. Placement of dredged material has the additional advantage of expediting the establishment of emergent marsh. Potential drawbacks of dredged material placement are cost, and impaired tidal channel development at Inner Bair (as the existing remnant slough system may be covered). Sediment quality would need to be appropriate for wetland reuse.

Channel modifications would be made at Smith and Corkscrew Sloughs to mitigate for potential impacts to the Redwood Creek shipping channel and Pete's Outer Harbor. Smith Slough would be realigned to its historic meander through Inner Bair. Corkscrew Slough would be blocked to the east of the Middle Bair breaches.

Middle and Outer Bair Islands. Levees will be breached at selected historic slough channel locations on Middle and Outer Bair Islands, restoring natural tidal flows. Pickleweed-dominated marsh vegetation will establish quickly in selected areas already at high intertidal elevations. Natural estuarine sedimentation on the lower mudflat areas will gradually build up these areas high enough for cordgrass and pickleweed to establish. Borrow ditch cutoff berms will be created to prevent tidal capture by the existing borrow ditches, allowing the natural channel system to reestablish. Interior berms and levees will be lowered or removed where possible, creating additional tidal habitat. Levees desired for upland refuge habitat or required to protect infrastructure from wind-wave erosion would be left in place.

Based on initial ground elevations and predicted sediment supply, we expect substantial tidal marsh vegetation establishment at Outer Bair within 30 to 50 years and at Middle Bair within approximately 50 years.

Inner Bair Island. Dredged material or other sources of fill would be used to expand the southern levee of Inner Bair Island to adequately protect the SBSA sewer line and create a cross-levee that protects the San Carlos Airport property on Inner Bair Island. Levees will be breached at historic slough channel locations on Inner Bair Island and borrow ditch cutoff berms will be created to prevent tidal capture by the existing borrow ditches. Although historic slough channels and borrow ditches may be filled with dredged material, differential settlement of the dredged material will result in a lower elevation, and therefore channel development may still occur in these areas.

Fill will be used to raise ground levels on Inner Bair from current elevations of approximately 0.0 to between 2.0 and 3.0 feet NGVD, requiring between 400 and 500 thousand cubic yards of fill. This target is close to the 538 thousand cubic yards dredged from Redwood Creek during an average dredging event. Redwood Creek has been dredged eight times between 1977 and 1999, and the average annual accumulation rate is estimated to be 200 thousand cubic yards.

The area within the cross-levee system protecting the San Carlos Airport safety zone, as well as the alignment of the SBSA sewer line, will be filled with dredged material to an elevation that is above MHHW. By creating upland and transitional habitats in these areas, some of the primary constraints associated with reintroducing tidal action to Inner Bair Island are minimized. From the created upland areas, the fill material will gradually slope down to the lower elevations of the restored marsh plain. Fill elevations will be highly varied, ideally providing ample areas of transitional habitat, including upland, seasonal wetland, and supratidal wetland areas. Once the levee is breached, pickleweed and cordgrass should begin to colonize the site and some channel development will occur through natural tidal scour. Pickleweed will be seeded or planted at the higher elevations, and evaluations will be made at that time on the feasibility of active planting of the native cordgrass.

Faber Tract in East Palo Alto and part of Muzzi Marsh in Corte Madera provide examples of the type of habitat that would be created at Inner Bair Island with the addition of dredged material. Both these sites are diked and subsided former tidal marshes that have been filled with dredged material to high intertidal elevations.

Potential Impacts to Existing Habitats and Wildlife

All habitats within Inner Bair Island (aquatic, ruderal, developed, seasonal wetland and diked salt marsh) would be covered with dredged material. By filling the leveed marshplain with dredged material, any wildlife currently using the project area would be impacted. Existing habitats would be lost, as would individuals of species that occur on-site presently. Timing of the deposition of such material should be coordinated to minimize effects on nesting birds, particularly special status species like Burrowing Owls. This is true of all restoration alternatives.

Potential Creation of Habitat and Benefits to Wildlife

Once the material has settled, the perimeter of Inner Bair will be seeded or planted with S*alicornia virginica* and evaluated for potential planting with *Spartina foliosa* or other native wetland vegetation prior to being opened to tidal action. Given that the dredged material has been placed at an appropriate elevation, the site should quickly develop into a tidal salt marsh system, likely to be dominated initially by cordgrass. Transition habitat will also be present along the interior perimeter of the levees.

The benefits to wildlife included in this alternative are many. The immediate sedimentation and planting of vegetation is beneficial as it decreases the delay in vegetation colonization of the marsh. The restoration process is thus expedited and organisms that use tidal salt marsh, particularly the salt marsh harvest mouse and California Clapper Rail, will colonize Inner Bair Island more rapidly. California Clapper Rails are most abundant in extensive salt marshes dominated by cordgrass, pickleweed, and marsh gumplant associated with numerous secondary tidal channels (Harvey 1980). In addition, the area will be less attractive to waterfowl once the vegetation becomes established. Increasing the elevation of the marshplain immediately, instead of waiting for natural sedimentation, decreases the depth and duration of the pooling of water on the site. Water that is shallow (a few inches) will be less attractive to large flocks of waterfowl (particularly ducks), and thus will decrease the bird-strike hazard to the adjacent airport. However, this area will be attractive to various species of wading shorebirds, such as godwits and sandpipers, during the restoration process, as they forage in shallow water. These birds pose less of a risk to the airport due to their small mass and tendency to fly very close to the water. The presence of ponding water will attract some waterbirds, and it is not possible to go through the restoration process without waterbird use of the area. This alternative minimizes the use by those species that are most hazardous to aircraft by decreasing the depth of the water, and increasing the rate that vegetation becomes established.

ALTERNATIVE 3: TIDAL AND MANAGED MARSH RESTORATION

Alternative 3 restores full tidal inundation to Middle and Outer Bair, and creates managed wetlands at Inner Bair. This alternative allows the reestablishment of some salt marsh habitat on

Inner Bair Island, while limiting the creation of the open water habitat that would be undesirable from a bird strike hazard perspective. The restoration approach for Middle and Outer Bair is the same as described in Alternative 2.

Channel modifications would be made at Smith and Corkscrew Sloughs to mitigate for potential impacts to the Redwood Creek shipping channel and Pete's Outer Harbor. Unlike Alternative 2, most of the tidal flows along Smith Slough would be routed through a hydraulic structure in Smith Slough not through the historic meander. However, potential impacts to flood hazards would be identical to those under Tidal Marsh Alternative since the partial block along Smith Slough would be sized to convey the same amount of flood flows as the breach to Inner Bair in Alternative 2. The channel modification along Corkscrew Slough would be identical to Alternative 2.

Inner Bair Island. Hydraulic control structures would be installed on Inner Bair to allow water management of the site. These structures would allow tidal inundation between approximately MLLW and MTL (the existing marshplain elevation). A managed complex of diked salt marsh, uplands and shallow seasonal wetlands is contemplated. Rainfall would contribute to ponding on the site, and would be augmented by tidal inflows on a managed basis. Existing ruderal vegetation on the site would likely die back and be replaced by pickleweed, creating salt marsh. Existing seasonal wetlands will likely remain vegetated, while deeper channels (e.g., former sloughs and borrow ditches) will remain ponded. The main disadvantages of this alternative are the initial and the on-going costs of maintaining a managed system and that it does not meet all of the project's habitat goals (e.g., restoring tidal marsh to as much of Bair Island as possible).

Water management remains to be developed, but flexibility would allow a range of management from muted tidal to occasionally flooded. Tidal inflow to Inner Bair could occur periodically except during the highest tides, to prevent high water levels and open water ponding. Water could drain from the site as frequently as each tide cycle. The hydraulic control structure will be designed for flexibility, allowing the water level management regime to be adaptively managed in response to monitoring results. Several types of hydraulic structures could be used to achieve the desired hydrology. Slide-flap gated culverts could be left in the open position most of the time, then manually closed during high tide events to allow outflow only. Alternately, float-activated gates (such as those at Shell Marsh in Martinez) could eliminate the need for manual gate closure. Floats would mechanically close the inflow culverts when water levels in Smith Slough were high. Flashboard weirs could be used in combination with gated culverts to adjust the frequency of tidal flooding and depth of on-site ponding. Pumps may need to be installed to facilitate drainage, should unusual ponding occur. Hydraulic modeling would be used to refine the hydraulic structure design.

Regular maintenance will be required to maintain the hydraulic structures in working order. Water level control will require some form on on-going active management. Maintaining public access after breaching will require periodic levee repair.

New Chicago Marsh, a managed pickleweed marshplain in Alviso, provides an example of the type of habitat that would be created on Inner Bair under this alternative. New Chicago Marsh is a diked and deeply subsided former tidal marsh managed by the U.S. Fish & Wildlife Service for

pickleweed and salt marsh harvest mouse habitat. Although pumps are used at New Chicago Marsh to drain rainwater and seepage, the use of pumps could be avoided at Inner Bair because Inner Bair is not as deeply subsided.

Potential Impacts to Existing Habitats and Wildlife

The degree of flooding at Inner Bair Island under this alternative will have to be closely monitored and adaptively managed in the first two years. Ideal muted tidal conditions will avoid significant ponding and will result in a more gradual shift from existing habitats on Inner Bair to a muted tidal marsh/managed system. As outlined in the previous alternatives, the loss of existing habitats on Inner Bair Island would be considered an impact to those wildlife species utilizing those habitats. However, those impacts would not be as abrupt under this alternative, due to the more gradual shift in habitats anticipated in a managed system.

Potential Creation of Habitat and Benefits to Wildlife

The resulting muted tidal marsh habitat may lead to an increased area that remains flooded, and a greater likelihood for the formation of small ponds surrounded by vegetation. Dominant plant species would include pickleweed (*Salicornia virginica*), interspersed with areas of open water in those areas that are currently open water (remnant slough channels and borrow ditches). This alternative will likely result in a mosaic of habitats ranging from open water, mudflats and salt marsh at the lower elevations, to seasonal wetlands and upland areas along the perimeter and at the higher elevations.

This type of habitat is ideal for waterfowl and shorebirds, as it provides smaller protected areas for birds to gather, in addition to providing shelter and foraging opportunities. The seasonal wetlands and upland areas along the perimeter provide excellent nesting habitat for many waterbirds that require areas of dry land to nest. The creation and enhancement of managed marshes is in fact used by management agencies to increase waterfowl use for hunting and conservation. Therefore, the creation of a managed wetland adjacent to the San Carlos Airport Safety Zone will have to be closely monitored and managed to avoid significantly increasing the abundance of hazardous wildlife.

This alternative would ultimately result in a diked salt marsh, and therefore would provide habitat for the salt marsh harvest mouse.

6.3 DEVELOPMENT OF PUBLIC USE ALTERNATIVES

This section contains brief descriptions of five draft public use alternatives intended to represent the range of options for public use on Inner Bair Island. These public use alternatives provide a broad range of potential uses yet are physically compatible with all of the restoration alternatives. From this pool of alternatives, three alternatives were selected that will be carried forward into the environmental review process.

ALTERNATIVE 1. NO ACTION/NO PUBLIC USE

- In the short term, limited public use consistent with protection of wildlife habitat and public safety
- In the long term, public use on Bair Island would be eliminated as the infrastructure deteriorates
- No public access to Inner, Middle, or Outer Bair Islands
- No use of motorized water vehicles permitted in Smith or Corkscrew Sloughs
- Close Refuge's Bair Island parking lot on Bair Island Road

A no project/no action alternative is required for the environmental review process. Therefore, this alternative was selected for further evaluation.

ALTERNATIVE 2. MAXIMIZE PUBLIC USE

- Full loop trail on Inner Bair and Airport levees
- Educational and interpretive signage on trail, orientation kiosks and wildlife viewing platform on Inner Bair
- Restrooms will be provided
- Hunting per regulations on Middle and Outer Bair
    - Fishing by boat in sloughs and from docks on Islands
- Pets allowed off-leash
- Unlimited boat use in sloughs
- Middle and Outer Bair open to public use on remaining levees with boat access and boat docks
- Maintain Refuge's Bair Island parking lot on Bair Island Road

Due to the high level of disturbance to wildlife and the incompatibility with some of the project's goals this alternative was not selected for further evaluation.

ALTERNATIVE 3. RESTRICTED PUBLIC USE

- Trail access will extend from the Refuge entrance at Whipple Avenue to the north around the San Carlos Airport levee
- Regulatory and interpretive signs, orientation kiosk and one viewing/environmental education platform will be provided
- Restrooms will be provided
- Fishing from boats in Corkscrew and Smith sloughs but not from land
- No pets will be allowed
- No access to Middle and Outer Bair Islands except by specific Refuge approval
- Boating will be allowed in Smith and Corkscrew Sloughs with seasonal closure to all boats, and a 5-mph speed limit/no wake zone at all times.
- Maintain Refuge's Bair Island parking lot on Bair Island Road
- Hunting of waterfowl on Middle and Outer Bair will be permitted per federal, state and local regulations

This alternative will be carried forward for further evaluation.

ALTERNATIVE 4. MODERATE PUBLIC USE

- Trail access will extend from the Refuge entrance at Whipple Avenue to the north around the San Carlos Airport levee and to an observation point on Smith Slough and to the south towards Pete's Harbor to an observation point on Smith Slough
- Regulatory and interpretive signs, orientation kiosk and viewing/environmental education platform will be provided at each end of the trail at Smith Slough
- Restrooms will be provided
- Fishing from boats in Corkscrew and Smith sloughs but not from land
- Pets (dogs only) will be allowed on a 6-foot leash on designated trails for a test period of 3 months
- Public access would only be allowed on Middle and Outer Bair Islands by Refuge-guided trips and by boat to a viewing platform on Middle Bair at the flow restrictor on Corkscrew Slough
- Boating will be allowed in Smith and Corkscrew Sloughs with a 5-mph speed limit/ no wake zone at all times
- Maintain Refuge's Bair Island parking lot on Bair Island Road
- Hunting of waterfowl on Outer Bair will be permitted per federal, state, and local regulations

This is the preferred alternative. This alternative will be carried forward for further evaluation.

ALTERNATIVE 5. MODERATE PUBLIC USE/NO PETS

- Trail access will extend from the Refuge entrance at Whipple Avenue to the north around the San Carlos Airport levee and to an observation point on Smith Slough and to the south towards Pete's Harbor to an observation point on Smith Slough
- Regulatory and interpretive signs, orientation kiosk and viewing/environmental education platform will be provided
- Restrooms will be provided
- Fishing from boats in Corkscrew and Smith sloughs but not from land
- No pets will be allowed
- Public access would only be allowed on Middle and Outer Bair Islands by Refuge-guided trips and by boat to a viewing platform on Middle Bair at the flow restrictor on Corkscrew Slough.
- Boating will be allowed in Smith and Corkscrew Sloughs with restricted access areas close to shore and a 5-mph speed limit at all times.
- Maintain Refuge's Bair Island parking lot on Bair Island Road
- Hunting of waterfowl on Outer Bair will be permitted per federal, state, and local regulations

This alternative was not selected and will not receive further evaluation.

6.4 RECOMMENDED PUBLIC USE ALTERNATIVES

Below are the modified public use alternatives that will be carried through the environmental review process. The Refuge and the TRT determined that these alternatives provide the most appropriate balance of public uses and natural resources protection on Bair Island.

ALTERNATIVE 1: NO ACTION

In the short term (approximately 5 years), this alternative will allow limited public use consistent with protection of wildlife habitat and public safety. In the long term, the Refuge would eliminate public use on Bair Island as the infrastructure deteriorates (trails, signs, gates, levees, etc.) that would require additional action or maintenance for public access by the Refuge. No public access to Inner, Middle, or Outer Bair Islands will be allowed in the long term. Boating will be allowed in Smith and Corkscrew Sloughs, however it may become difficult over time as the levees degrade along the slough channels. Although levees on Inner Bair Island would require some routine maintenance, the trail system would not be maintained. Therefore, after approximately five years, no trails will be accessible to the public.

In the short term, pets (dogs only) will be allowed on Inner Bair Island on a 6-foot leash and on designated trails for a test period of 3 months to determine the compliance with Refuge public use regulations concerning dog access. In the long term, pets will be prohibited on Bair Island as the infrastructure deteriorates. The Refuge's Bair Island parking lot on Bair Island Road will be closed. No additional infrastructure (e.g., kiosks) will be constructed.

ALTERNATIVE 2: RESTRICTED PUBLIC ACCESS

Public Access will be allowed only on Outer and Middle Bair Island by Refuge guided trips and other specific exceptions that are approved by a Refuge Special Use Permit as well as to a single viewing platform located on Middle Bair Island. This viewing platform will only be accessible by boat. Access on Inner Bair Island will be allowed along a portion of the existing 3-mile loop trail located on the existing levee. Public Access will extend from the Refuge entrance at Whipple Avenue to the north around the San Carlos Airport levee and to an observation point on with a wildlife viewing platform on Smith Slough near a levee break. No access will be allowed on the levee trail to the South towards Pete's Harbor. Sanitary facilities will be provided. No pets will be allowed on Inner Bair Island. Jogging and bicycling will be permitted.

Fishing from boats in Corkscrew and Smith Sloughs will be allowed however fishing will not be permitted from land. Hunting of waterfowl on Outer and Middle Bair Islands will be allowed per federal, state and city regulations. Boating will be permitted with a speed limit of "no wake zone, maximum 5 mph for motorized water vehicles" and in Smith and Corkscrew Sloughs. No motorized vehicle access will be allowed within areas currently inside the exiting levee. Seasonal closures to all boat access will be implemented to protect sensitive species (i.e., harbor seals).

An orientation kiosk and a viewing/environmental education platform will be provided. Regulatory and interpretive signs will be located at the orientation kiosk. The Refuge's Bair Island parking lot on Bair Island Road will be maintained.

ALTERNATIVE 3: MODERATE PUBLIC ACCESS (RECOMMENDED ALTERNATIVE)

Public Access will be allowed only on Outer and Middle Bair Island by Refuge guided trips and other specific exceptions that are approved by a Refuge Special Use Permit as well as to a single viewing platform located on Middle Bair Island. This viewing platform will only be accessible by boat. Access on Inner Bair Island will be allowed along an extensive portion of the existing 3-mile loop trail located on the existing levee. Public Access will extend from the Refuge entrance at Whipple Avenue to the north around the San Carlos Airport levee and to an observation point on Smith Slough near a levee break. Access will also be allowed on the levee trail to the South towards Pete's Harbor to an observation point on Smith Slough near a levee break. Sanitary facilities will be provided. Pets (dogs only) will be allowed on Inner Bair Island on a 6-foot leash and on designated trails for a test period of 3 months to determine compliance with Refuge public use regulations concerning dog access (see Appendix D for the proposed Dog Use Monitoring Program). Jogging and bicycling will be permitted.

Fishing from boats in Corkscrew and Smith Sloughs will be allowed, however fishing will not be permitted from land. Hunting of waterfowl on Outer and Middle Bair Islands will be allowed per federal, state and city regulations. Boating will be permitted with speed limits of "no wake zone, maximum 5 mph for motorized water vehicles" in Smith and Corkscrew Slough. No motorized vehicle access will be allowed within areas currently inside the exiting levee.

An orientation kiosk and two viewing/environmental education platforms at each end of Inner Bair Island trail at Smith Slough will be provided. Regulatory and interpretive signs will be located at the orientation kiosk. The Refuge's Bair Island parking lot on Bair Island Road will be maintained.

Access (both on trail and by boat) has been limited in this recommended alternative to protect sensitive wildlife species at Bair Island. This is based upon a large volume of research conducted on the effects of various recreational activities on wildlife. Recreation is becoming more of a concern as human use of wild areas increases, and the size of those areas decreases. Thus, humans and wildlife are more and more likely to come into contact.

Waterbirds, both shorebirds and waterfowl, vary dramatically according to species in how they react to human presence. During the non-breeding season, birds such as mallards and gulls tend to have a relatively high threshold of disturbance. However, during the breeding season most wildlife is very protective of nests and offspring, and their tolerance to disturbance drops. Even during the non-breeding season, disturbance may have an equally detrimental effect on the animals although not as obvious an effect. It has been demonstrated that human activity in wild areas is correlated with declines of breeding populations in birds (Knight and Gutzwiller 1995).

Activities involving rapid movement and loud noise (e.g., power-boating, water skiing) have been found to rank the highest in level of disturbance to waterbirds (Mathews 1982). Some documented impacts of motorboats include shoreline degradation, disruption of nesting and feeding resulting in a loss of production, as well as displacement of birds. Not only can the noise be a disturbance and cause a bird to flush, but the bow waves can tip over exposed nests. Motorboats can flush waterbirds and interrupt feeding for a much longer period than can quieter,

slower activities (such as canoeing and kayaking). Therefore, to decrease the level of disturbance, all motorized vehicles (i.e., motorboats, personal water crafts, jet boats and hovercrafts) will be subject to speed limits of "no wake zone, maximum 5 mph for motorized water vehicles" in Smith and Corkscrew Sloughs. No motorized vehicles will be allowed within areas currently inside the exiting levee.

6.5 SUMMARY

Through a series of meetings, the Refuge staff, the CDFG and the TRT reviewed the Draft Restoration and Public Use Alternatives. From these meeting, modifications were made to the Draft Alternatives and a consensus was reached on the Alternatives outlined below.

RECOMMENDED RESTORATION ALTERNATIVES:

Alternative 1: No Project
Alternative 2: Tidal Marsh Restoration
Alternative 3: Tidal and Managed Marsh Restoration

RECOMMENDED PUBLIC USE ALTERNATIVES:

Alternative 1: No Action/No Public Use
Alternative 2: Restricted Public Access
Alternative 3: Moderate Public Access

7.0 PREFERRED ALTERNATIVE

7.1 INTRODUCTION

The Tidal Marsh Restoration is the preferred alternative design based upon its ability to maximize the potential for the restoration of tidal salt marsh habitat over most of the project area and provide protection for the infrastructure located on or adjacent to Inner Bair Island. This design meets all of the project's goals and objectives and provides the best opportunity for maximizing the desired ecological functions of the site.

Based upon the geomorphic approach to wetland restoration design, it is anticipated that habitat and ecological functions of the site will gradually change over time. Tidal salt marsh habitat will eventually become the dominant, long-term habitat type on Bair Island. However, Middle and Outer Bair will initially consist of subtidal and intertidal habitats. The use of dredged material and planting on Inner Bair Island will expedite the development of emergent tidal marsh, it is anticipated that initially the site will be rapidly colonized by wetland vegetation.

This section describes expected habitat evolution (Section 7.2), conceptual restoration design and design features (Section 7.3), infrastructure protection (Section 7.4), public use features (Section 7.5), dredged material placement (Section 7.6), phasing/breach timing (Section 7.7), anticipated construction methods (Section 7.8), and preliminary cost estimates for implementing the restoration project (Section 7.9).

7.2 EXPECTED HABITATS AND SITE EVOLUTION

After restoration, Inner, Middle, and Outer Bair are expected to evolve from predominantly tidal mudflat to tidal salt marsh habitat. Inner Bair is expected to colonize rapidly with wetland vegetation (including cordgrass), with substantial areas of vegetated marsh developing within the first 5 to 10 years on the dredged material fill. Dredged material will be used also to create areas of upland habitat and extended transitional zones between tidal marsh and upland habitats. Pickleweed will be present along the fringes of the levees and the lower elevations of the transition zone. The establishment of pickleweed-dominated marsh on Inner Bair will require an additional 10 to 15 years.

Colonization of emergent marsh vegetation at Middle and Outer Bair, which will initially be lower in elevation than Inner Bair (after dredged material is placed), will take longer. Initially following breaching, the ground elevations will generally be too low in the tidal frame for marsh plants to establish or survive at Middle or Outer Bair. Upland habitat will remain on the existing levee system. The site will be predominately intertidal mudflats with areas of cordgrass. Pickleweed will begin to colonize areas along the interior and perimeter levees. Sediments will gradually accumulate and raise the mudflats of Middle and Outer Bair to intertidal elevations that can be colonized by cordgrass. Later, as sediment continues to build, plant species typically found in 'high marsh' areas such as pickleweed, saltgrass and gumplant will establish.

Based on initial marshplain elevations and suspended sediment supply, we expect significant marsh colonization to occur at Outer Bair within approximately 10 to 50 years, and at Middle Bair within approximately 50 years. Evolution rates will be slower for Middle Bair because it is further from the Bay and the supply of suspended sediment at Middle Bair (25 to 50 mg/l) will be lower than at Outer Bair (50 to 75 mg/l). These evolution estimates are based on long term sedimentation modeling and empirical data from other restored San Francisco Bay tidal marshes (Figure 8). The long-term sedimentation modeling of the number of years required to raise average ground elevations from 1 to 2 ft NGVD (Figure 14 and Appendix C) probably overestimates the time for initial vegetation establishment because it uses average site elevations and does not account for spatial distributions in sediment deposition. In reality, the marshplains are characterized by slight variations in topography and some areas that are initially higher in elevation, such as near the breaches and channel edges, will vegetate more quickly. Also, spatial variations in sedimentation will result in localized areas of vegetated marsh nearest the breaches, where sediments will deposit most rapidly.

Although wind wave action can delay site evolution, features incorporated into the design at least partially offset this type of potential delay. At Inner Bair, filling the site allows vegetation to colonize rapidly, providing resistance to wave erosion. At Outer Bair, wind wave delays are expected to be offset by a relatively high sediment supply. At Middle Bair, the interior levees will be left in place to provide some sheltering benefits. Based on the successful site evolution of Outer Bair Ponds B1 and B2, it is our opinion that Middle and Outer Bair can be successfully restored by reintroducing tidal action. Ponds B1 and B2 are former salt production ponds on Outer Bair that are now restored to tidal marsh (see Appendix F, Figure 6 for exact locations). Middle and Outer Bair are similar to Ponds B1 and B2 in terms of wind fetch and initial site elevation (Figure 13).

The antecedent tidal channels, which are likely filled with somewhat consolidated sediments, are expected to scour and deepen once the ponds are breached. Scour is expected to occur first nearest the breaches, gradually headcutting back into the pond interiors.

Because Steinberger Slough and parts of Smith and Corkscrew Sloughs are initially undersized relative to the large restored tidal prism, tidal damping is predicted in the slough channels and ponds early in site evolution. Modeling of initial restored conditions indicates that low tide drainage in the three ponds is limited to a few tenths of a foot below mean tide level (approximately 0 ft NGVD). In Inner Bair, this is 2 to 3 feet below the initial fill elevation. Therefore, Inner Bair Island will drain adequately during low tides. However, in Middle and Outer Bair, low tide drainage is approximately one foot below the average marshplain elevation. The damping of low tide drainage may somewhat inhibit vegetative growth in areas due to more stressful biogeochemical conditions associated with a greater depth and duration of flooding. Damping may also delay the reestablishment of the antecedent tidal channels inside the ponds. As the slough channels scour and enlarge over time, however, low tide drainage will improve. Damping is expected to be a transitory effect.

The expected habitats at 50 years after construction and their importance to wildlife at Bair Island are discussed below (Figure 4):

Tidal Salt Marsh. Cordgrass (*Spartina foliosa*) will be the dominant plant species in the low marsh while pickleweed (*Salicornia virginica*) will be the dominant plant species within the middle marsh. A mix of salt marsh plant species including saltgrass (*Distichlis spicata*), pickleweed, alkali heath (*Frankenia salina*), jaumea (*Jaumea carnosa*), perennial peppergrass (*Lepidium latifolium*), gumplant (*Grindelia* sp.) and spearscale (*Atriplex triangularis*) is expected in the high marsh.

Potential benefits to wildlife include benefits to those species that inhabit salt marsh and would benefit from its eventual restoration, including the salt marsh harvest mouse and the California Clapper Rail. These two species are completely dependent on salt marsh for habitat, and their numbers would likely increase as a result of the restoration of salt marsh. The Alameda Song Sparrow, which is considered a species of special concern by the State of California, is common in the salt marshes of Bair Island and would also benefit from further habitat restoration. In addition, many other species of waterbirds and shorebirds that use this habitat for foraging and nesting would benefit, including Great Blue Herons, Great Egrets, Snowy Egrets, Black-crowned Night Herons, Forster's Terns, Willets, and other shorebirds.

Channels and Subtidal Zone. Channels are entirely unvegetated and are typically imbedded within tidal marshes and vary in width and depth. Many species of shorebirds will move into the tidal channels to forage in the mud during low tide, much like they will on the mudflats. These birds include the Long-billed Curlew (*Numenius americanus*), American Avocet (*Recurvirostra americana*), and the Black-necked Stilt (*Himantopus mexicanus*).

Tidal Mudflats. Tidal mudflats are typically inundated twice daily and located adjacent to tidal marshes at the edge of the bay or slough channels. Tidal mudflats are not vegetated by emergent plant species.

Tidal mudflats provide important foraging habitat to a number of wildlife species, particularly shorebirds. Many birds will only forage on mudflats, roosting elsewhere during high tides. These birds include the Semipalmated Plovers (*Charadrius semipalmatus*), Marbled Godwits (*Limosa fedoa*), and sandpipers (*Calidris sp.*). Numerous species of gulls also feed on invertebrates that are exposed on mudflats during low tides, including Bonaparte's Gulls (*Larus Philadelphia*), Ring-billed Gulls (*Larus delawarensis*), and California Gulls (*Larus californicus*).

Upland/Transition Zone. These habitats are typically located on the periphery of tidal salt marshes or occur as levees and are imbedded within the tidal marsh/channel complex. Upland areas adjacent to tidal marshes in San Francisco Bay are typically dominated by herbaceous non-native plant species such as perennial peppergrass, sweet fennel (*Foeniculum vulgare*), black mustard (*Brassica nigra*), wild radish (*Raphanus sativus*) and ice plant (*Carpobrotus edulis*). Other species expected to occur in the transition zones include gumplant, saltgrass and alkali heath. The transition zones between upland and salt marsh provide habitat for several special status plant species, including marsh

gumplant (*Grindelia stricta* var. *angustifolia*) and Point Reyes bird's-beak (*Cordylanthus maritimus* ssp. *palustris*).

Though upland areas are not considered critical habitat, they provide crucial refuge and foraging opportunities for both birds and mammals. Many raptor species, such as the White-tailed Kite and Northern Harrier, will regularly forage for small mammals in upland areas. During high tide, many mammals and birds may seek refuge along the edge of the marsh and on the levees, including small mammals and many shorebirds that are waiting out the high tide to continue foraging. Unfortunately, non-native predators such as feral cats and red fox use these areas for cover as they are hunting native wildlife.

A design that will prepare the site for the passive restoration of these habitats on Bair Island is the goal of this alternative.

7.2.1 Non-native Cordgrass (*Spartina alterniflora*) Control

Background. San Francisco Bay contains a native species of cordgrass, Pacific cordgrass (*Spartina foliosa*). The growth of Pacific cordgrass is restricted to the upper intertidal fringes of the Bay's estuaries leaving the mid and lower intertidal mudflats devoid of vegetation (Daehler & Strong 1996). In contrast, smooth cordgrass (*Spartina alterniflora*), a dominant species of Eastern U.S. coastal marshes, is a perennial saltmarsh grass that was introduced to the San Francisco Bay in the 1970's. Since its introduction, smooth cordgrass has invaded low tidal marsh and open mudflats (Grossinger *et al.* 1998). Recent studies have shown that the native cordgrass and introduced smooth cordgrass readily hybridize. Hybridization proceeds in both directions with hybrid plants containing either smooth cordgrass or Pacific cordgrass halotypes (Anttila et al. 2000). Furthermore, it is assumed that there is a very high potential for these hybrids to outcompete Pacific cordgrass both ecologically and genetically within the Bay Area. Therefore, the spread of the hybrid species to other marshes in California could be more threatening to the native species than the initial introductions of smooth cordgrass (Anttila et al. 2000).

The invasion of smooth cordgrass and its hybrid throughout San Francisco Bay has affected, and will continue to affect, the ecology of the Bay in several ways. In some areas open mudflat habitat has been converted to smooth cordgrass meadow. In other areas (i.e., the mouth of Alameda Creek) smooth cordgrass and/or hybrids appear to be encroaching into higher elevation areas currently dominated by pickleweed (*Salicornia virginica*). Research regarding the ecological effects of smooth cordgrass on Bay Area fish and wildlife is still in the early stages. However, studies of benthic invertebrates have shown that buried deposit feeders and predators were at a higher density in smooth cordgrass stands and surface deposit feeders were at a higher density in mudflat habitat (Cordell et al, unpublished conference proceedings 1998). The degree of smooth cordgrass colonization also affects the overall density and trophic character of the benthic macroinvertbrate assemblage (Luiting et al, unpublished conference proceedings 1997). These documented differences in diversity and availability of benthic invertebrate prey resources between uncolonized mudflats and areas of smooth cordgrass may negatively impact larger consumers that feed primarily on the littoral mudflats.

The growth of cordgrass, including the native Pacific cordgrass, introduced smooth cordgrass and hybrids, decreases the rate of tidal flow, causing suspended sediment to precipitate, while dense root mats trap sediment creating a depositional environment. Therefore, the presence of cordgrass can increase sedimentation creating a positive feedback scenario in which these plants increasing the elevation of the microtopography around them thereby reducing the tidal influence on their growth and recruitment.

The California State Coastal Conservancy and the U.S Fish and Wildlife Service are currently finalizing a Programmatic Environmental Impact Statement (EIS)/ Environmental Impact Report (EIR) for the San Francisco Estuary Invasive *Spartina* Control Program (SFEISCP 2002). This control program will address the management and eradication of four non-native *Spartina* species in the bay area. The Coastal Conservancy has determined that 469 acres of San Francisco Bay are currently dominated by the invasive smooth cordgrass and its hybrids (SFEISPC 2002). It is also predicted that the hybrid cordgrass is poised to convert 10,000 to 30,000 acres of unvegetated tidal flats to *Spartina* meadows (ISP 2002). Given the proximity of non-native *Spartina* to the project site, it is likely that some colonization of this invasive species will occur after tidal influence is restored.

Colonization Predictions. Daehler and Strong (1996) predicted the extent (acreage) of invasion by smooth cordgrass in Bodega Harbour, CA (currently no smooth cordgrass is found in this harbour) using relationships between mean tidal range, and growth range of smooth cordgrass on the Atlantic coast (McKee & Patrick 1998). Following the methods outlined by Daehler and Strong (1996) a calculation based on the tide characteristics at Redwood Creek, channel marker No. 8 (Table 1) revealed that the upper threshold of smooth cordgrass growth on Bair Island would be +0.36 ft NGVD. Based on field data and calculations at the project site this upper threshold elevation of +0.36 ft NGVD seems to be too low, with cordgrass growing at a mean elevation of +1 to 2 ft NGVD.

McKee and Patrick's findings (1988) therefore, appear to be inapplicable to the growth elevation of smooth cordgrass on Bair Island. A potential explanation for this is the difference between conditions of the San Francisco Bay and the Atlantic and Gulf of Mexico coasts (i.e., smaller tidal ranges, multiple plant stressors, soil temperature, salinity, presence of predators, competition between plant species) where the relationship between mean tidal range and growth range were first described.

Of interest is the fact that smooth cordgrass is capable of vigorous growth across the entire marsh elevations in its native habitat and appears to be excluded from high-marsh habitats by competition with high-marsh perennials (Bertness & Ellison 1987 and Bertness 1991). Research in New England marshes has also shown that smooth cordgrass is an early colonizer following disturbance and is often displaced by better competitors as time passes (Bertness 1991). Therefore interspecies competition in the San Francisco Bay may influence the elevational range of smooth cordgrass in concert with mean tidal ranges.

It should be assumed that the invasion of smooth cordgrass on Bair Island will vary in extent over time. Initially mudflats on Bair Island will provide a suitable opportunity for the invasion of smooth cordgrass and will require management. However, as native vegetation establishment

progresses and sediment is deposited opportunities for smooth cordgrass propagules will vary spatially throughout the restoration site making the predictions for colonization of the invasive cordgrass on Bair Island very complex. For this reason we propose a variety of control methods be adaptively implemented as the restoration site conditions change over time (see Smooth cordgrass control plan for Bair Island below).

Species Identification. The control of smooth cordgrass in San Francisco Bay is complicated by the fact that field identification of the species is very difficult. Many professional botanists have resorted to genetic testing to differentiate between smooth cordgrass, Pacific cordgrass and the hybrids. For this reason, prior to any smooth cordgrass control or eradication program representative samples of individuals within the area to be treated should be sent for genetic testing. The ISP has resources available for carrying out the genetic testing and may be contacted whenever identification of the species is indiscernible (Contact: Katy Zaremba, Invasive Spartina Project, California Coastal Conservancy at 510-286-4091).

Smooth cordgrass has also evolved a new ecotype in San Francisco Bay (Daehler et al. 1999). A dwarf ecotype with one-fifth the tiller height, tenfold the tiller density and is restricted to growth in the upper zone can be found in San Francisco Bay. The ecological range of the dwarf smooth cordgrass ecotype is similar to that of *Spartina patens*, a dominant plant species of higher elevation salt marshes of the Atlantic and Gulf coasts. Daehler et al (1999), suggest that the absence of *S. patens* from most of San Francisco Bay has allowed the dwarf ecotype of smooth cordgrass to survive and spread.

Potential Non-target Impacts of Smooth Cordgrass Control. The California Clapper Rail *(Rallus longirostris obsoletus)* is a Federal Endangered Species (*Federal Register* 35:1604; October 13, 1970). In south and central San Francisco Bay clapper rails typically inhabit salt marshes dominated by pickleweed and Pacific cordgrass. Although opinions vary on the use of smooth cordgrass habitat by the California Clapper Rail, this species will have to be considered during the planning and implementation of smooth cordgrass control. The California Clapper Rail breeding season extends from February 1 through August 31 in the Bay Area.

As mentioned above, the determination of cordgrass species in the field can be very challenging. For this reason the unintentional removal of the native Pacific cordgrass could be a non-target impact of smooth cordgrass control. Throughout the implementation of a smooth cordgrass control plan on Bair Island genetic testing will be used if the species of cordgrass recruiting within the restoration site is unclear.

Summary of Potential Methods to Control Smooth Cordgrass. Table 3 summarizes a variety of *Spartina* sp. control methods that have been applied in New Zealand, Washington State and the San Francisco Bay Area. These methods may vary from those outlined for use in the San Francisco Estuary Invasive *Spartina* Control Program (SFEISCP 2002).

Table 3. Summary of Potential Methods to Control Smooth Cordgrass

Control Method	Appropriate Setting	Timing	Effectiveness in New Zealand (Shaw & Gosling 1997)	Effectiveness in Willapa Bay, WA (Norman & Patten 1997, Grevstad, 2002)	Effectiveness in San Francisco Bay, CA (ISP 2002)	Applicability to Bair Island
Hand pulling and digging	Seedlings in newly infested areas and small areas (less than 1 acre) of infestation.	Seedling hand removal best done in spring	Not applied in this study	Applied to 1-3 year old clones 97 to 100% effective	If all rhizomes are removed 100% effective	Applicable in areas of new infestation where accessibility permits
Clipping seedheads to prevent pollination and seed dispersal	Isolated clones or small areas where prevention of pollen and seed dispersal will prevent hybridization with native *Spartina.*	Before maturation of seeds in the fall.	Not applied in this study	Not applied in this study	All seeds collected will be prevented from germinating. Not suitable for areas of high infestation.	Undesirable method due to presence of smooth cordgrass throughout the South Bay.
Mechanical smothering and burial	Large areas with machine access	During fall and winter. As close to the period of dormancy as possible	Not applied in this study	Not applied in this study.	No information available	Undesirable due to the redisturbance of channels and native vegetation.
Mechanical ripping of root mass	Meadows and large areas	Any time of year, however facilitated by winter dieback	Not applied in this study	Not applied in this study. However, is reportedly working in Washington	No information available	Undesirable due to the redisturbance of channels and native vegetation.
Biological control with *Planthopper Prokelisia marginata*	Large areas	Any time of year	Not applied in this study	50% reduction in 3 months after introduction	*Planthopper* is known to be present in San Francisco Bay (Strong and Daehler 1955)	Smooth cordgrass in San Francisco Bay likely already exposed, therefore Planthopper could not be introduced.

Control Method	Appropriate Setting	Timing	Effectiveness in New Zealand (Shaw & Gosling 1997)	Effectiveness in Willapa Bay, WA (Norman & Patten 1997, Grevstad, 2002)	Effectiveness in San Francisco Bay, CA (ISP 2002)	Applicability to Bair Island
Mowing	Any size infestation except seedlings	Any time of year, however facilitated by winter dieback. Requires 8-12 repetitions	Not applied in this study	95% kill (average of 2, 3 and 4 mowing regimes)	Multiple mowings are necessary.	Longer growing season in California may make mowing more labor intensive.
Covering	Small to medium size areas with reduced tidal influence to avoid dislodgement	Any time of year, however facilitated by low growth form in the spring	Not applied in this study	Not applied in this study	Successful in patches up to 36-feet in diameter.	Accessibility and sediment making removal of cover material difficult.
Application of glyphosate	Any size infestation	Most effective when plants are flowering or soon after	Was determined to be ineffective at one study site	81% (spray) to 91% (hand wipe) effective	Ranging from 0 to 100% depending on timing relative to plant dormancy, inundation, weather conditions etc.	Applicable if herbicide can be applied from July-August.
Application of haloxyfop-ethoxyethyl ester at 100g/l	Any size infestation	Information not available	This was determined to be the most effective method throughout New Zealand	Not applied in this study	No information available	May harm fish species, therefore unsuitable.

7.2.2 Smooth Cordgrass Control Plan for Bair Island

Efforts throughout San Francisco Bay. As mentioned above, the California State Coastal Conservancy has released the draft EIS/EIR outlining a bay wide control plan for four invasive species of *Spartina*. The following recommended controls for smooth cordgrass within the Bair Island restoration site follows many of the suggestions and methods contained within the bay wide preferred alternative (SFEISCP 2002). If necessary the control methods listed below should be modified to remain consistent with the final approved version of the San Francisco Estuary Invasive *Spartina* Control Program EIS/EIR.

Existing Colonies. The control of smooth cordgrass (including hybrids) on Bair Island will begin prior to the reintroduction of tidal influence. Existing colonies of smooth cordgrass within the restoration site, as well as colonies that are determined as a potential propagule source for vulnerable areas within the restoration site, will be treated with a hand application of a mixture of 4.0 to 5.0% Aquamaster (active ingredient glyphosate) and 0.5 to 1.0% of an EPA approved surfactant for use in aquatic habitats (i.e., Agridex, R-11 or LI-700). A dye (preferably "Blazon Blue Spray Pattern") should also be included in the mixture so that crews know where the herbicide has been applied. The application of herbicides on these existing colonies will be timed to maximize the exposure of the plants to sunlight, reduce exposure to high winds (above 5-10 mph), minimize chances of expected rains within 5 to 6 hours of application, and allow for at least six hours of air exposure during low tide.

Based on research in Willapa Bay, the application of glyphosate using a hand wipe could be the most cost effective method of treatment. This recommendation is based on the fact that the percent kill was slightly higher (91% vs. 81%) and the cost lower ($310/acre vs. $585/acre) when compared to hand spraying (Norman & Patten, unpublished conference proceedings 1997). The application of herbicides will be carried out on an annual basis for three consecutive years using a method that completely covers the plant surface such as a spray or wipe and preferably started at least two years prior to the introduction of tides on Bair Island. The methods that will be used will conform with those outlined in the San Francisco Estuary Invasive Spartina Control Program.

Although measures will be required to protect the California Clapper Rail, the herbicides should be applied when smooth cordgrass colonies are flowering in June-August. However, the Refuge has had success in treatment through September and into early October. If permitting constraints and/or other reasons do not allow for the application of glyphosate until September 1st – January 31st, the smooth cordgrass will be entering its dormant period and the application of glyphosate will likely be less effective. In this scenario, herbicide application may not be the best resource allocation. Consideration should be given to the redirection of resources to preventing new infestations and/or hybridization with native cordgrass (see maintaining open mudflat habitat and adaptive management below).

Maintaining Open Mudflat Habitat. Approximately one year prior to the restoration of tidal influence on Inner Bair Island, dredged material will be placed in Inner Bair Island. Native wetland vegetation will be planted where feasible in this area (see Planting Plan below) in an effort to reduce the area available to smooth cordgrass recruits. In addition to this planting,

newly recruiting smooth cordgrass will be hand pulled and any established non-native cordgrass in close proximity will have seed heads removed to prevent hybridization. Cost-efficacy of hand pulling is lower in the late spring vs. mid-summer (4 cents/stem vs. 12 cents/stem). Unlike herbicide treatment the percent kill is close to 100% (if all rhizomes are removed), regardless of treatment timing (Norman & Patten, unpublished conference proceedings 1997). Therefore, although spring treatment is recommended this type of control can be implemented outside of the clapper rail breading season.

Hand pulling of new smooth cordgrass and hybrid recruits (or herbicide application if this method is chosen) within all of Bair Island will be carried out annually for three years after tidal influence is restored.

Initially it seems logical to set a percentage goal for open mudflat habitat within the Bair Island restoration site (i.e., prior to 1880 it is estimated that 27% of the baylands were open tidal flat habitat – reference: South Bay Subregion in Goals Project 1999). However, because the desired restoration alternative is to allow natural sedimentation and channelization to drive the creation of habitat on Bair Island the elevation of restored areas will not remain consistent over time and opportunities for smooth cordgrass will shift both temporally and spatially. An adaptive management approach will allow the control of smooth cordgrass to focus on maintaining open mudflats at a suitable elevation, and reduce the spread of smooth cordgrass into areas where it will threaten the native vegetation.

Adaptive Management. As part of the Invasive *Spartina* Control Program, smooth cordgrass will be controlled for 2-3 years prior to the first breach in Outer Bair Island at OB1. Three years after tidal influence has been restored to any portion of Bair Island, the extent of smooth cordgrass infestation will be reevaluated and the challenge and feasibility of controlling the introduced cordgrass will be reassessed in relation to conditions in the South Bay and regional efforts of smooth cordgrass control. At this time it may be deemed infeasible to eradicate the invasive species in perpetuity. If this is the case, control may focus on limiting the smooth cordgrass growth to a specific elevation to maintain areas of open mudflat and insure that it is not encroaching on higher marsh habitat.

7.2.3 Planting Plan

Planting of native vegetation is recommended at Inner Bair Island (for bird strike minimization). This revegetation opportunity is afforded by the fact that dredged material will be used on Inner Bair Island to raise the marsh plain elevation to a level appropriate for the immediate establishment of emergent salt marsh. This opportunity only exists on Inner Bair, as we are relying on natural sedimentation processes to restore the marsh plain elevation on Middle and Outer Bair Island.

Planting native vegetation will expedite the development of emergent tidal salt marsh habitat on Inner Bair Island. This will also give the native species a foothold on Inner Bair and help to minimize colonization by the non-native species. It is likely that pickleweed or other wetland starter plantings will be installed at the appropriate elevations around the project perimeter. Planting native cordgrass on Inner Bair Island will depend on the success of the eradication of smooth cordgrass on Outer Bair Island and other nearby sources. If smooth cordgrass is still

growing nearby, no cordgrass will be planted to help facilitate the eradication efforts of the Invasive *Spartina* Control Program.

Inner Bair Island will be planted with native species contract grown from propagules collected from the South Bay and genetically tested to verify species. Plantings will be installed between November 1 and January 30 immediately prior to levee breaching and the restoration of tidal influence. It is likely that portions of Inner Bair cannot be planted due to the unconsolidated nature of the dredged material, which would hamper access to the site's interior. Holes approximately 12 inches wide and 18 inches deep will be dug for the plantings, and they will be installed so that their root crowns are even with the soil surface. All plantings will be irrigated immediately following installation.

Plant Procurement. Container plants will be contract grown. The propagules will be collected from the Bair Island complex or nearby salt marshes in South San Francisco Bay, preferably salvaged from the tidal wetland areas to be impacted by the levee breaches. After plant propagules/plugs, are collected, 6-12 months of growing time is generally required before the plants are ready for installation.

7.3 RESTORATION DESIGN FEATURES

The design includes the following features intended to promote tidal marsh evolution: breaches, channel connectors, borrow ditch cut-off berms, and levee lowering.

- Breaches: Excavations through perimeter levees that open the site to tidal action from surrounding sloughs,
- Channel Connectors: Excavations through internal levees that reestablish some part of the drainage network internally,
- Borrow ditch cut-off berms: Excavated material from breach creation placed on site to block and partially fill borrow ditches, and
- Levee lowering: certain segments of levees that will be lowered to generate fill material for construction of the cut-off berms.
- Channel flow control structures: Flow control structures will be utilized on Smith Slough and Corkscrew Slough to encourage scour of Steinberger Slough, and to prevent increases in flow velocity at Pete's Harbor and siltation in Redwood Creek.

In addition, the restoration design of Inner Bair includes the improvement of certain levees to provide greater protection of existing infrastructure, the construction of new levees and berms to facilitate dredged material placement, and the use of dredged material to create upland and upland transition areas. These features, plus design elements that minimize mosquito breeding, are discussed in greater detail in the following sections.

7.3.1 Breaches

Breach Locations. The number and location of breaches were selected as shown in Figure 2 to achieve a balance between four primary objectives:

(1) to reestablish and rejuvenate the natural preexisting drainage network,
(2) where possible to emphasize the recreation of higher order (larger) tidal channels within the marsh restoration areas,
(3) to avoid breaching Middle and Outer Bair to the east of the channel flow control structures, and
(4) to limit construction costs by limiting the number of breaches and associated cut-off berms.

In support of objectives 1 and 2, we placed breaches at the mouth of each large natural drainage network (breaches OB1, MB1, IB1, and IB2)[2].

Historically lower order[3] channels serving small drainage areas that connected directly to one of the major sloughs surrounding the islands drained much of the site. The reconnection of many small drainages directly to the major sloughs was considered to be cost-prohibitive. For the smaller channels, we included one breach for each collected drainage area of approximately 70 acres or more (OB3, OB4, MB4, MB5). Seventy (70) acres of tidal drainage will allow the formation of at least third order channels and larger. Because of infrastructure constraints (Section 7.4) Middle and Outer Bair could not be breached along the eastern parts of Smith and Corkscrew Sloughs. The southeast part of Middle Bair will drain to breaches to the north and west and this area will tend to experience poorer drainage than the rest of Middle Bair.

Two breaches have been included on Inner Bair Island. The breaches are located at the confluence of the preexisting slough channel and Smith Slough and will reestablish the major historical tidal connections. No additional breaches were included because they would have limited public access to much of the site. Two breaches were incorporated into the design, rather than only one, to create habitat in the area between the two breaches that would be isolated from adjacent upland during high tides. A graded upland transition area between the breaches will also help avoid short-circuiting of flow between the breaches.

A small area of fringe marsh on the outboard side of the levees will be excavated in conjunction with the external breaches; however, this area will be minimal, as the existing fringe marsh forms only a narrow band less than 20 feet wide in most locations.

Breach Cross Sections. Breaches will be sized according to the following design criteria: (1) provide full drainage between the slough and the pond (i.e., minimize muting across the breach), and (2) provide reasonable assurance of achieving uninhibited long-term channel formation. Providing full tidal drainage is important for site evolution since restricted drainage has the

[2] OB = Outer Bair; MB = Middle Bair; IB = Inner Bair; breach numbers are shown in Figure 1).

[3] Channel order is a method of describing the placement of a stream segment with the drainage network. Hierarchical order begins with the smallest of channel segments and increases in order when two channels of the same order connect. Thus, the smallest, singular channels in the system are considered to be first order. When two first order channels join, the subsequent portion of the channel is considered to be second order. A third order channel forms when two second order channels join, and so on. A low order channel, such as a first order channel, joining a higher order channel does not alter the order of the latter. The highest order found in a drainage system is used to define the order of that system. (PWA, 1995)

potential to limit sediment delivery and tidal scour. Sediment delivery on the flood tide is critical to rebuilding the marshplain up to natural pickleweed marsh elevations. Tidal flows scour and reform the remnant tidal channels, recreating the complex tidal channel system and valuable channel-edge habitat.

The importance of reasonably assuring uninhibited channel formation (Criterion #2) is self-evident. Sizing breaches to expected long-term equilibrium depths will promote consistency with this design criterion by preventing compacted levee material or other potential erosion resistant material from inhibiting long-term channel development.

Our estimates of long-term breach dimensions are based on empirical channel relationships developed for the San Francisco Bay estuary. These relationships, referred to as hydraulic geometry, are explained further below. Preliminary sizing is based on expected long-term equilibrium dimensions. Final breach sizing will occur in subsequent design.

Hydraulic Geometry. Hydraulic geometry relationships developed by PWA for the San Francisco Bay area (Appendix 1) were used to size the proposed levee breaches on Bair Island according to their expected long-term dimensions and used to estimate potential temporary breach enlargement in response to tidal scour. The first set of hydraulic geometry relationships relates marsh plain drainage areas or "tidal watersheds" to long-term (equilibrium) channel dimensions (top width and depth) (Figure 15). These were used for breach design on Bair Island. The second set relate tidal prism (the volume of water exchanged between MHHW and MLLW upstream of a given cross section location) to channel dimensions (Figure 16). The channel geometry relationships are derived from data on existing and historic natural tidal marsh systems. The database consists of tidal channel drainage areas, estimated or measured tidal prisms, and correlating channel top widths and depths.

Drainage Areas. Marsh drainage areas and preliminary channel dimensions for the proposed breaches are shown in Table 4. The tributary area of each breach was estimated by visual identification of historic watershed boundaries from aerial photographs and planimeter measurement of watershed areas. Channel top widths and depths were derived directly from the hydraulic geometry relationships; bottom widths were calculated using a side slope of 4:1 (horizontal: vertical), according to the channel top width and depth[4]. Thalweg[5] elevations are calculated by subtracting the depths from a starting elevation of MHHW. Two of the larger drainage networks reestablished in this design (Middle Bair 1 and Outer Bair 1) will be deep enough to provide sub-tidal habitat for a significant length of channel, with depths of approximately 2 feet at MLLW.

[4] In some of the smaller breaches this method yields a calculated negative bottom width. This unrealistic bottom width estimate is a function of the side slope used in the calculation. The side slopes of a natural channel are generally steeper than the 4:1 that can be constructed. In these instances, we used a minimum bottom width of 5 feet and back-calculated a wider top width.

[5] The thalweg is the deepest point in the channel.

Table 4. Expected Long-Term Breach Dimensions

Location	Marsh area (acres)	Top width (ft)	Bottom width (ft)	Depth (ft)	Thalweg el. (ft NGVD)	Water depth at MLLW (ft)
Inner Bair 1	96	84	13	8.9	-4.8	0.9
Inner Bair 2	96	84	13	8.9	-4.8	0.9
Middle Bair 1	277	151	64	11.0	-6.9	3.0
Middle Bair 3	161	112	34	9.8	-5.8	1.9
Middle Bair 4	79	76	8	8.5	-4.5	0.6
Middle Bair 5	81	77	8	8.6	-4.5	0.6
Outer Bair 1	210	130	47	10.4	-6.3	2.4
Outer Bair 3	68	71	5*	8.3	-4.2	0.3
Outer Bair 4	77	75	7	8.5	-4.4	0.5

*Assume a minimum bottom width of 5 feet.
Note: Because of the updates to the design, breach numbers are not consecutive. There is no OB2 or MB2.

Expected Transitional Channel Geometry. Since the site may take many decades to evolve to an equilibrium condition, it is important to have a general understanding of the channel forms and overall marsh morphology that may be present during the transition period between initial breaching and eventual equilibrium. In general, since Inner, Middle and Outer Bair Islands will be below natural marshplain elevations at the time they are breached, this will allow a greater tidal prism to pass through the breaches relative to long-term equilibrium conditions. Since the smaller long-term dimensions were used in preliminarily breach sizing, there may be a tendency for the breaches to scour and enlarge. However, as sedimentation inside the sites begin to raise marsh plain elevations, tidal prism and scour will decrease, and channels will experience deposition, until the system eventually reaches equilibrium. Calculations of breach dimensions based on the large initial tidal prism indicate that top widths could increase to 80 - 200 feet and channel depths to –5 to –10 ft NGVD, or 1 to 6 feet deep at MLLW.

7.3.2 Channel Connectors

Channel connectors will be excavated through interior levees on Middle Bair to allow the reestablishment of historical flow paths between internally leveed areas (Figure 2). On Inner Bair, an excavated channel connecting the southeast corner of the island to the main channel will facilitate complete drainage of the site. Like the breaches, the connectors were sized according to expected long-term equilibrium dimensions using marsh area vs. channel dimension hydraulic geometry relationships.

7.3.3 Cut-off Berms

Excavated material from breach creation will be placed on site to block and partially fill borrow ditches in several locations on Inner Bair, Middle Bair, and Outer Bair (Figure 2). These features, referred to in this report as “cut-off berms,” are designed to direct flow into the historic tidal channels and to prevent the borrow ditches from becoming the primary drainage network after tidal action is restored to the marsh. The cut-off berm prevents flows from draining through the full length of the borrow ditch, but allows the ditch to convey flows from the many low-order

channels on Bair Island (that historically drained directly to the marsh perimeter) to one of the proposed breaches. Because flow is blocked, the perimeter borrow ditches are eventually expected to silt in along some of their length.

In this design, one cut-off berm is located between each pair of breaches. Additional cut-off berms are specified in selected areas. Cut-off berm elevations will be between approximately one foot above the adjacent marshplain elevation (to allow for one foot of settling) and MHHW.

7.3.4 Levee Lowering

Portions of certain levees on Middle and Outer Bair Islands may be lowered to provide a source of fill for construction. The design elevation for levees after lowering will be between approximately 5 and 6 feet NGVD. This will create upland transition habitat and provide wave-breaking function, while still being low enough to serve as a source of fill. The existing levee crests are between approximately 6 and 9 feet NGVD and support primarily non-native upland vegetation such as Italian ryegrass (*Lolium multiflorum*), black mustard, wild radish and ice plant. The total area of levee that is lowered will depend on the amount of fill needed for construction of borrow ditch cut-off berms on Middle and Outer Bair. It is not anticipated to be economical to use this fill for construction of dredged material placement berms and levee improvements on Inner Bair.

Levees will be left in place to (1) promote marshplain evolution and (2) protect levees along the west side of Steinberger Slough from shoreline erosion. The primary wind direction is from the west-northwest, with shorter duration winter storms from the southeast.

7.3.5 Upland and Transitional Habitat Areas

Approximately 22 acres of upland habitat will be created on Inner Bair Island, by filling the area within the San Carlos Airport Safety Zone levees. Although the purpose of the fill is infrastructure protection (Section 7.4), the upland area will provide upland habitat and high tide refugia. Two upland transition areas will be created. One transition zone, approximately 2 acres in area, will surround the eastern side of the San Carlos Airport Safety Zone and the other, approximately 1 acre in area, will extend southward from the levee on the island between the two proposed breaches (Figure 3). Elevations of the transition area will range between 0.25 feet above and below the high spring tide elevation (approximately 5.05 feet NGVD).

7.3.6 Design Elements that Minimize Mosquito Breeding

Bair Island is a known breeding location for the California salt marsh mosquito (*Aedes squamiger*), which will develop extremely dense, pestiferous populations if left untreated (San Mateo County Mosquito Abatement District, 1997). Mosquito control initiatives began in 1990 and include surveillance, siphoning of diked salt ponds, and larvicide and insecticide application from the ground and the air. The restoration of Bair Island should improve conditions by opening five diked salt ponds to tidal action, thus reducing the amount of breeding habitat. The Technical Committee for the Development of Vector Prevention Standards (1986) proposed a series of guidelines for marsh restorations projects. These include providing for free tidal flow through deep channels, adequate levee breaches to ensure proper tidal circulation, and avoiding

the creation of areas that will pond water. All of these design elements were taken into careful consideration at Bair Island.

Also of concern with regards to vector control is the beneficial reuse of dredged material at Inner Bair Island. To minimize potential mosquito breeding habitat, adequate drainage must be provided to dewater the dredged material. As the material consolidates, periodic disking and spreading of the dredged material is also recommended. This serves to prevent mosquito breeding in water that subsequently collects in cracks and depressions in the dredged material (Technical Committee for the Development of Vector Prevention Standards, 1986).

7.4 PUBLIC USE INFRASTRUCTURE DESIGN

Public access to Inner Bair Island will be along an out-and-back trail on the levee tops along the San Carlos Airport Property Levee and the Inner Bair Island levee to viewing/environmental education platforms on Smith Slough (Figure 18). The unpaved trail will extend from the Refuge entrance at Whipple Avenue to the north around the San Carlos Airport levee and to an observation platform near the northern breach. The levee trail will also extend to the south towards Pete's Harbor to an observation platform located south of the southern breach. For the benefit of providing wildlife with a area of refuge from human impacts and to allow boating through the realigned Smith Slough, no public access will be permitted between the two breaches on Inner Bair Island. A small craft portage will be constructed around the flow restrictor in Corkscrew Slough to facilitate boating until head and velocity equalize. There will also be a depth gage in the V-cut of the Corkscrew Slough flow restrictor to enable boaters to estimate available draft for passage. Warning signs will be placed on both sides of the flow restrictor on Corkscrew Slough to warn boaters of their location and how to safely navigate. Interpretive signs will be placed at the Redwood City boat ramp about the flow restrictors in Corkscrew Slough and Smith Slough.

The interpretive signs at the Redwood City boat ramp will also contain information on how to pass the harbor seal haulout sites without disturbing them. An orientation kiosk with regulatory and interpretive signs will be located at the entrance to Inner Bair Island. Wildlife observation platforms with interpretive signs will be built at the small craft portage and the flow restrictor at Corkscrew Slough. The Refuge's existing Bair Island parking lot on Bair Island Road will be maintained, and public sanitary facilities will be provided.

7.5 INFRASTRUCTURE PROTECTION

Infrastructure protection will be required for the San Carlos Airport safety area, the SBSA force main, the Redwood Creek shipping channel, Pete's Outer Harbor, and the public path on Inner Bair.

7.5.1 San Carlos Airport Safety Area

The restoration design of Inner Bair Island must provide protection for existing infrastructure after the site is opened to tidal action. In the case of the San Carlos Airport Safety Zone, the restoration plan includes the construction of a levee around the perimeter of the Airport property that is designed to provide the same level of flood protection to the area as under existing

conditions, while also serving as a dredged material placement berm. This levee has a design elevation of 6.6 feet NGVD and a typical cross section as shown in Figure 17. The U.S. Fish and Wildlife Service and the project team have been in contact with Airport authorities regarding the treatment of the Safety Zone and the decision to fill this area represents a coordinated effort to meet the Airport's needs while providing habitat that fulfills the Bair Island restoration objectives (Appendix C). This area will be filled with dredge material to an elevation that will facilitate the establishment of an upland plant community.

7.5.2 South Bayside System Authority Sewer Line

The portion of the Inner Bair Island levee along the SBSA force main will be improved in order to provide increased protection against erosion and provide inspection and maintenance access to the sewer line after the island is opened to tidal action. The improvement will likely include the extension of the levee toward the inside of the island and will match the existing elevation of approximately 7.5 feet NGVD. This elevation will provide protection against approximately the 100-year high tide (7.3 ft NGVD). The levee improvement, which is being designed with the SBSA, has not been finalized at this time. The Refuge will work with SBSA to develop specifications in a subsequent design phase.

7.5.3 Channel Flow Control Structures

Flow control structures would be constructed at Smith and Corkscrew Sloughs to mitigate for potential impacts to Redwood Creek shipping channel siltation rates and Pete's Outer Harbor tidal velocities. Corkscrew Slough would be blocked to the east of the Middle Bair breaches (see location in Figure 2). This would not necessarily be a complete block; a small notch would be included to allow some flow across the structure. Two design concepts were considered at each location: a quarry stone berm and a linked cellular coffer installation. The natural channel is approximately 300 feet wide with a thalweg of approximately –10 ft NGVD at the selected location. The design assumes a notch approximately 30 feet wide at the top (crest at 5.1 ft NGVD), down to 2 ft below MLHW (0.6 ft NGVD). The structure would tie into high ground on both sides. Final design of the flow restrictors will integrate flexibility so that the structures may be modified after installation in order to ensure that flood hazards are not significantly affected (Appendix H).

Smith Slough would be realigned to its historic meander with a block between the two Inner Bair breaches. The structure would be similar to the structure at Corkscrew Slough, but would not be notched. The eastern Inner Bair breach (IB2) will be sized to convey the same amount of tidal flow as is currently conveyed in Smith Slough at this location. To meet this criterion, the breach will be undersized relative to post-restoration flows and will need armoring to protect it from tidal currents of up to 10 feet/second.

Impacts to boating would occur after levee breaching but reduce over time as conveyance along Steinberger Slough improves due to tidal scour. Immediately after tidal restoration, high velocities and head differences would limit the hours of each day that boats would be able to pass the flow restrictors. This window for boating will gradually increase as tidal sloughs adjust to the restored tidal prism and reach a new equilibrium.

7.5.4 Public Path on Inner Bair

Some parts of the public path on Inner Bair may need to be raised to reduce the frequency of tidal flooding. Approximately half the existing path length is already subject to direct tidal inundation from the adjacent sloughs. Tidal inundation frequency for these areas is not expected to change. The other half of the path is currently protected from tidal flooding by the perimeter levee. This part of the path could be affected. Exact path elevations are not available, but are generally between 6 and 8 feet NGVD (Bohley Maley Associates, no date). This is above the elevations of spring tides (approximately 5.0 feet NGVD, or one foot above MHHW), but below the 5 and 10-year high tides (6.3 and 6.6 ft NGVD, respectively). An updated survey of the existing access trail loop is recommended in subsequent phases of the design to estimate more accurately its current inundation frequency and potential need for raising the trail in selected areas.

Tidal action on the inside of the island will also create some initial increase in erosion from wind wave action, where the maximum fetch length is approximately 4000 feet in the predominant wind direction (west-northwest). The perimeter levees will require monitoring and maintenance to preserve trail access. The potential for erosion will be highest in the short-term, before the marshplain is fully developed, although filling the site to approximately 2.5 feet NGVD will reduce wave action by limiting the water depth. As the marshplain becomes vegetated, wave energy will be dampened by vegetative roughness. Also, as the marshplain rises through sedimentation, the water depth decreases, decreasing the height of waves that form and propagate over the site.

7.5.5 Flood Management for Pulgas and Cordilleras Creeks

Implementation of the Preferred Alternative will redirect flows from Pulgas and Cordilleras Creeks away from the deep Redwood Creek Shipping Channel in order to meet project constraints. This action is expected to increase peak water levels at the Highway 101 crossings by approximately 0.05 ft (less than an inch) during a 100-year flood event, although these changes are expected to diminish over time as Steinberger Slough deepens over the fist months and years. Details of the flood analysis are presented in Appendix H.

7.6 PUBLIC USE PLAN

Prior to the acquisition of Bair Island by the Refuge, Inner Bair Island was privately owned. For many years, the landowners attempted to limit access and prevent trespassing on Inner Bair Island (Don Warren, pers. comm.). However, after many failed attempts to block all public access (including motorcycles and all-terrain vehicles) to Inner Bair Island, the landowners allowed foot access to the levees and pathways on Inner Bair Island. Since acquiring Bair Island, the Refuge has maintained the same level of public access until a public use plan could be generated for the entire Bair Island complex.

Due to the numerous members of the public who utilize Bair Island to walk their dogs, it was determined that Alternative 3 (Moderate Public Access With Pets) would be the preferred public use alternative. Under this alternative, dogs will be allowed on leash and on trail for a test period of 3 months to determine the impacts to wildlife (please see Appendix D for a complete

description of the test period criteria). If owners cannot keep their dogs under control during this trial period and potential impacts to wildlife are considered too great, then dogs will be restricted from Bair Island.

Public access to Inner Bair Island will be along an out-and-back trail on the levee tops along the San Carlos Airport Property Levee and the Inner Bair Island levee to two viewing/environmental education platforms on Smith Slough (Figure 18). For the benefit of wildlife using Inner and Middle Bair Island and to allow boat passage through the realigned Smith Slough, no public access will be permitted along the rest of Smith Slough. An orientation kiosk with regulatory and interpretive signs will be located at the entrance to Inner Bair Island. The Refuge's Bair Island parking lot on Bair Island Road will be maintained, a trail from the parking lot to Inner Bair Island will be established and public sanitary facilities will be provided. The Refuge will work with Caltrans to close the existing dirt parking area along Whipple Avenue once the trail from the Refuge's parking lot to the Inner Bair Island trailhead is upgraded and made safer for public use. Following the implementation of the entire trail system, there will be a net increase in the total length of trails on and adjacent to Inner Bair Island as the trail from the parking lot to the levee trail will be added to the system. The length of trail that will be added to the system is twice as long as the trail section that will be removed.

There will be no Public Access to Outer and Middle Bair Island except by Refuge guided trips and other specific exceptions that are approved by a Refuge Special Use Permit, and to a single viewing platform, accessible only by boat, located on Middle Bair Island. Fishing from boats in Smith and Corkscrew Sloughs will be allowed, however fishing will not be permitted from land. Hunting of waterfowl on Outer and Middle Bair Islands will be permitted as per federal, state and city regulations.

Access (both on trail and by boat) has been limited in this preferred alternative to protect sensitive wildlife species at Bair Island. This is based upon a large volume of research conducted on the effects of various recreational activities on wildlife (Burger 1981, Pfister et al. 1992, Rogers and Smith 1995, Burger 1998, Suryan and Harvey 1999, Schummer and Eddleman 2000, Rodgers and Scwikert 2002). Recreation is becoming more of a concern as human use of wild areas increases, and the size of those areas decreases. Thus, humans and wildlife are more and more likely to come into contact.

Waterbirds, both shorebirds and waterfowl, vary dramatically according to species in how they react to human presence. During the non-breeding season, birds such as mallards and gulls tend to have a relatively high threshold of disturbance. However, during the breeding season most wildlife is very protective of nests and offspring, and their tolerance to disturbance drops. Even during the non-breeding season, disturbance may have an equally detrimental effect on the animals although not as obvious an effect. It has been demonstrated that human activity in wild areas is correlated with declines of breeding populations in birds (Knight and Gutzwiller 1995).

Activities involving rapid movement and loud noise (e.g., power-boating, water skiing) have been found to rank the highest in level of disturbance to waterbirds (Mathews 1982). Some documented impacts of motorboats include shoreline degradation, disruption of nesting and feeding resulting in a loss of production, as well as displacement of birds. Not only can the noise

be a disturbance and cause a bird to flush, but the bow waves can flood exposed nests. Motorboats can flush waterbirds and interrupt feeding for a much longer period than can quieter, slower activities (such as canoeing and kayaking). Therefore, to decrease the level of disturbance, all motorized vehicles (i.e., motorboats, personal water crafts, jet boats and hovercrafts) will be subject to "no wake zone, maximum 5 mph for motorized water vehicles" in Smith and Corkscrew Slough. No motorized vehicles will be allowed within areas currently inside the exiting levee.

7.7 DREDGED MATERIAL PLACEMENT

7.7.1 Background Discussion

Dredged material will be placed on the majority of Inner Bair to encourage rapid site development and limit the potential for increased bird strike hazard at the adjacent San Carlos Airport. The two basic methods for delivering dredged material for fill to a beneficial reuse site such as Inner Bair Island are hydraulically and mechanically. Hydraulic dredging/delivery is mixing the sediment with large quantities of water and pumping it into the site through a pipeline as slurry. Typical slurry densities are 10-20% sediment and 80-90% water. The process water is then decanted, after the sediments have settled out, and returned to the Bay.

Mechanical dredging/delivery would typically involve excavating the material with a clamshell or excavator dredge and placing the material in a barge, transporting the barge to Inner Bair Island and using a clamshell dredge to take the material out of the barge and place it onto the Island. Alternatively, the barge could be hydraulically off-loaded onto Bair Island. However, both of these methods are significantly more equipment and labor intensive and therefore, substantially more expensive than, hydraulic dredging with direct material placement in the fill areas.

If the dredging area was located nearby, such as the Redwood City Harbor, a hydraulic dredge could dredge the material and pump it directly into the site. If the dredging area were distant (virtually any project except Redwood City Harbor) the material would need to be transported to the site in a barge and off-loaded.

Due to the large surface area, fill depths and grades necessary to create the desired tidal wetland habitat and additional material needed for transitional and upland habitat creation areas, the hydraulic placement of fill is likely the more feasible and cost effective construction alternative for the majority of fill required for the project. This assumes the use of fine-grained dredged materials, such as the material from Redwood City Harbor. However, there may be opportunities to receive mechanically placed material early in the project and use that material for levee and berm construction, or later in the project and use the material for the upper layers or transitional habitat areas.

7.7.2 Areas Requiring Filling

The three basic areas that require filling are: the Airport Safety Zone; the tidal wetland restoration area inside the remnant slough channel; and the tidal wetland restoration area outside/surrounding the remnant slough channel (Figure 3).

Three significant design objectives guided the development of this plan for placement of dredged material: (1) keeping fill out of the existing major remnant sloughs; (2) minimizing the potential for dredged material to migrate out into Smith Slough after breaching the exterior levees of Inner Bair Island; and (3) dividing the site into dredged material placement cells to accommodate the receipt of dredged material from two separate mobilization events (the expected need for two mobilizations is discussed later). In addition it is recognized that the sediment quality of available dredged materials must be suitable for wetland use.

To meet the design objectives, internal berms on Inner Bair Island are proposed to control the lateral extent of dredged material placement (Figure 3). These internal berms would be constructed prior to any placement of dredged material with conventional land based heavy equipment such as scrapers, dozers, graders and trucks. This report assumes that these berms would primarily be constructed from native soil material borrowed from within the areas of Inner Bair to be filled. The SBSA levee improvements will also be constructed with on-site material prior to dredged material placement.

The borrow areas for the levee and berm materials should not be directly adjacent to the levees/berms. The borrow areas should be shallow excavations (1 to 2 foot maximum) spread over relatively large areas. This is desirable to preclude having large differences in the fill depths within the upland and tidal habitat areas that will result in relatively large differential settlement over time.

7.7.3 Conceptual Hydraulic Filling and Process Water Management Plan

Dredged material placement will occur within the interior levees and berms (discussed above) to contain the hydraulically placed fills. Decanting weirs placed in these levees and berms would be used to control material placement elevations, de-watering operations and discharge water quality.

In the San Carlos Airport Safety Zone, care should be taken during implementation in order to avoid creating conditions that might attract birds. If the dredge material utilized contains significant numbers of invertebrates (such as polychaete worms, clams or snails), we would expect gulls to be attracted. This would likely last only a few days after each supra-tidal application of dredge spoil that contained invertebrates. The density of foraging gulls would be roughly proportional to the density of invertebrates. This has been observed during the dredging operations at Oakland City Harbor. We would not expect further foraging after any invertebrates had died or been eaten (a few days to a week maximum), as invertebrates are not likely to colonize supra-tidal dewatering mud.

We would expect shorebirds to be attracted to any ponding water in depressions formed in the dredge spoils. Care should be taken to apply the dredge in such a way as to minimize the formation of depressions. Any depressions that do form should be filled with dredge material as soon as possible. Other birds should not be attracted to the dewatering dredge spoil as either loafing or foraging habitat. Once dewatered, non-native grasses and other invasive forbs would likely colonize the site. We would recommend seeding the area with native grasses, forbs, shrubs and possibly peripheral halophytes such as alkali heath (*Frankenia salina*), salt grass (*Distichlis spicata*), and marsh gumplant (*Grindelia stricta*).

Tidal Wetland Areas. The required design elevation (approximately +2.5 feet NGVD) for Inner Bair Island tidal wetland habitats will initially require the placement of 2 to 3 feet of fill. This depth of fill could likely be placed in one filling sequence. Typically the fill would be maintained in a saturated condition for six months to one year to allow for consolidation. After this period, the fill is typically stable enough that the introduction of tidal action will not cause massive erosion or fill movement problems. The current regional practice for tidal wetland fills is to keep them saturated to prevent potential undesirable chemical and pH changes and to prevent problems from wind blown dust/material movement.

For the tidal wetland areas on Inner Bair, the decanting weirs would be placed in the berms protecting the remnant slough channel. A discharge weir would be located in the northern levee (along Smith Slough) at the future breach location. The remnant slough area, protected by the berms, would provide a storage and settling area for process water. The process water would be discharged from the remnant slough into Smith Slough though the discharge weir located in the northern levee. The discharge weir would be high enough to prevent high tides from entering Inner Bair while still being low enough to allow process water to flow out of Inner Bair.

Upland Area. To meet the required design elevation (approximately +6.6 feet NGVD) for the San Carlos Airport Safety Zone upland habitat area, 7 to 8 feet of fill will be placed. Sequential filling with two or more lifts will likely be required to achieve a stable fill configuration in this area. The initial lift(s) of material will attain a more stable configuration if they are allowed to thoroughly dry and desiccate prior to additional material placement. Further geotechnical and design analysis of specific site and fill material characteristics will be required to produce a specific fill plan for this area.

7.7.4 Dredged Material Volumes

At this stage of design analysis, only preliminary, gross fill volumes for the proposed restoration areas are available. To refine these fill estimate volumes further, additional geotechnical investigation and design analysis are required. Based on the preliminary calculated gross fill volumes, approximate dredged material volume requirements were developed for the tidal and upland fill areas. These approximate dredged material volumes are presented in Table 5 below and assume that:

- The tidal wetland areas could be filled in a single lift and the material always remains saturated;
- The upland area fills will be placed in multiple lifts and thoroughly dried between lifts; and
- Fine-grained sediments such as young bay mud from Redwood City Harbor are used.

Table 5. Approximate Fine Grained Dredged Material Volume Requirements

Area	Approximate Dredged Material Required In Situ (cubic yards)
Tidal Area A - Inside Remnant Slough	200,000
Tidal Area B - Outside Remnant Slough	600,000
Airport Safety Zone - Upland	250,000
TOTAL	**1,050,000**

7.7.5 Dredged Material Sources and Timing

Redwood City Harbor is the closest frequently dredged area to Inner Bair Island. All other currently known potential sources of dredged materials are significantly further away. Therefore, the Redwood City Harbor is likely the only source of dredged material that is close enough to be directly hydraulically placed on the site (economically).

Redwood City Harbor typically has a Corps of Engineers maintenance-dredging event every three years. The last maintenance-dredging event was in 1999. The next scheduled event is in FY 2005 (October 2004 – September 2005). Volumes from dredging events within the last 20 years have ranged from 250,000 to 970,000 cubic yards. The average dredging volume is approximately 600,000 cubic yards. The planning volume for future maintenance dredging events currently used by the LTMS is 430,000 cubic yards. In addition, the Port of Redwood City plans to dredge the berths themselves, and expects to dredge 35,000- 40,000 cubic yards in 2004.

Given the current estimate of dredged material volumes required for Inner Bair, it would likely take at least the next two maintenance dredging events at Redwood City Harbor to fully construct this project. Depending on the actual volume dredged during these events additional material supplies may also be required.

Bair Island is not the only wetland project interested in receiving dredged materials from the Redwood City Harbor. The Hamilton Wetlands Restoration project (Novato, CA) and the Montezuma Wetlands project (Solano County, CA) are also planning to receive future dredged materials from Federal maintenance dredging projects, including the Redwood City Harbor project.

Other potential dredging projects that could provide dredged materials to this project include:

- Port of Oakland – 50 ft Deepening project (2001 to 2005)
- San Leandro Marina Maintenance
- Port of Oakland Maintenance Dredging (annual)
- Port of San Francisco Maintenance Dredging (annual)
- Foster City Lagoons
- Other Federal and private dredging projects north of the Bay Bridge.

The economic, social, and political acceptability of these potential sources, as well as the dredged material physical and chemical suitability for this project, will need to be determined if they are considered.

7.7.6 Dredged Sediment Quality

Any dredged materials used as fill for tidal wetlands restoration are typically required to meet the wetland cover material criteria and guidelines in effect at the time of project approval. Revision of these guidelines has been underway in the San Francisco Bay region for some time and proposed new guidelines are currently under an extended review by state and federal regulatory agencies and the public. Therefore, the specific chemical and physical criteria or guidelines for dredged materials are not currently known.

The dredged materials from the federal maintenance dredging of the Redwood City Harbor have historically met all testing standards for in-bay disposal. These standards are similar, though not identical, to the standards for wetland cover. Corps of Engineers staff familiar with the maintenance dredging of the Redwood City Harbor have indicated that, based on historic testing, they would expect future maintenance dredging sediments to be suitable for wetland cover material uses (Snitz, pers. comm.)

Dredged materials from other locations would need to be evaluated on a case-by-case and site-by-site basis to determine their potential suitability for use at Inner Bair. This analysis would be based on historic and/or current sediment testing and analysis.

7.7.7 Dredged Material Placement Costs

The actual costs to the Bair Island project for large volumes of dredged material fill on Inner Bair Island could be highly variable and dependent on many source specific factors. The major source specific factors include:

- The dredged material location and timing of dredging relative to the Bair Island project;
- The equipment and labor required to place the dredged material on Inner Bair Island as opposed to the cost of other available placement locations for that material;
- Cost sharing options and/or funding sources available for the beneficial reuse of dredged material from the specific source project;
- The cost of planning, permitting and environmental compliance associated with the source project material being placed on Inner Bair Island;
- Site preparation costs associated with dredged material placement on inner Bair Island;
- The costs (economic and non-economic) associated with the political and social implications of using dredged material from the source project.

Given the level of uncertainty regarding the source(s) of dredged material and site specific design at the current level of project development, it is not possible or appropriate to develop a specific cost estimate or per cubic yard cost (with any reasonable level of certainty) for the dredged material placement on Inner Bair Island. However, the estimated dredged material placement costs from regional studies and other wetland restoration projects can be used as approximate indicators of the typical costs for similar projects in this region. Additionally,

several potential sources of dredged material can be discussed relative to the potential funding and cost sharing opportunities for the beneficial reuse of their dredged materials on Inner Bair Island.

Redwood City Harbor Maintenance Dredging. As discussed above, this Federal maintenance-dredging project is located the closest to Inner Bair and is likely the preferable source of dredged material for beneficial reuse on Inner Bair Island. Currently, this U.S. Army Corps of Engineers (Corps) maintenance dredging projects with in-Bay dredged material disposal at Alcatraz site is 100% federally funded by the Harbor Maintenance Trust Fund. It is unlikely that any increased cost (above the cost to dispose at Alcatraz) would be federally funded through the existing maintenance dredging authorization.

Under Section 204 of the Water Resources Development Act of 1996 (WRDA-96) projects for the beneficial reuse of dredged materials for habitat restoration can be authorized and funded on a cost shared basis. The cost-sharing ratio is typically 65% federal and 35% non-federal. For the Redwood City Harbor project the non-federal sponsor is the Port of Redwood City. The Bair Island project could work with the Port of Redwood City to fund a Corps Section 204 project. The Corps, throughout the Long Term Management Strategy (LTMS) project and the Dredged Material Management Office, are very interested in beneficial reuse projects for dredged material that reduce in-Bay disposal.

Once the Inner Bair Island design is refined, detailed cost estimates could be developed to compare the cost of the existing maintenance dredging and in-Bay disposal with dredging and direct placement on Inner Bair Island. If placement on Inner Bair Island could be shown to be less costly, the project could possible be federally funded as a value engineering initiative. This could reduce or eliminate the cost for dredged material placement to the Bair Island project.

Port of Oakland –50 Foot Deepening Project and Maintenance Dredging. Due to the schedule for the Port of Oakland –50 Foot Deepening project and the completed environmental documentation and existing dredge material reuse plans, it is unlikely that any significant dredge material would be available for the Inner Bair Island project (Cardoza, pers. comm.). However, ongoing berth dredging (non-federal) and channel maintenance dredging (federal) may be available within required time frame.

Regional Dredged Material Placement Costs for Restoration Projects. Several recent studies in the San Francisco Bay region, including the LTMS, have looked at the cost of beneficial reuse projects (primarily wetland restoration) relative to the cost of existing in-Bay or ocean disposal of dredged materials. Typically the beneficial reuse project is expected to fund the "incremental cost" of dredged material placement, which is the cost increase due to beneficial reuse instead of traditional in-Bay or ocean disposal. The LTMS studies (LTMS, April 1996) found a range approximately $-0.70 to $+8.50 per cubic yard for the incremental cost for dredged materials going to wetland restoration instead of in-Bay or ocean disposal. Other studies for specific projects in the San Francisco Bay region have found incremental cost within the LTMS range, although primarily positive incremental costs.

Proposed Incremental Dredged Material Cost for This Report. Given the location and timing of nearby dredging and wetland restoration projects in the region as well as regional

regulatory trends and other factors, it is likely that the cost (incremental cost) to this project could range upwards of $3.00 to $6.00 per cubic yard for dredged material placement. The distinct potential exists for the Bair Island project to receive dredged material at no cost and/or to receive financial assistance with project design and site construction. However, to be conservative at this level of design it is suggested that an incremental cost of $5.00 per cubic yard be used until further design developments and dredged material supply investigations can be completed. Additionally, it is suggested that a mobilization and demobilization cost of $110,000 per dredged material placement event be used.

7.8 PHASING / BREACH TIMING

Outer Bair will be restored first, followed by Inner and Middle Bair. Full restoration of Outer Bair is preferred and can be implemented as soon as the internal pond features and the flow restrictor along Corkscrew Slough are constructed. If desired to expedite restoration, permitting and construction, Outer Bair could be partially restored prior to construction of the flow restrictor by breaching to Steinberger Slough only (OB1 and OB4, see Figure 2). However, this would require eliminating at least one ditch block to ensure that Outer Bair drains adequately at low tide. Outer Bair could be breached to Steinberger Slough (at OB3) later in construction, once the flow restrictor along Corkscrew Slough has been installed.

Breaching of Inner and Middle must wait until after both channel flow control structures are in place. If Inner and Middle Bair were to be breached before the control structures were constructed, the result would be high velocities at Pete's Harbor and some additional silting of the shipping channel, though this second effect will be limited in extent and duration. To avoid flooding problems, the Smith Slough control structure will be installed after dredged material placement on Inner Bair is complete. It may be possible to refine the design later to provide for earlier phased breaching of parts of Middle Bair to Corkscrew Slough. Channel flow control structures will be constructed during the dry season, to reduce the potential for flood risks before Inner and Middle Bair are breached.

7.9 ANTICIPATED CONSTRUCTION METHODS

This section provides anticipated construction methods and structure detail that was used as the basis for the preliminary volume and cost estimates in Section 7.9. Preliminary dimensions for the design features are shown in Table 6. These construction methods are preliminary and will be refined during further design development. For cut and fill balance, bulking is assumed to approximately offset losses.

Table 6. Preliminary Dimensions by Design Element

Fill Activities	Design Elevation After Settlement (ft NGVD)	Design Width (ft)	Side Slope (horizontal: vertical)
SBSA levee improvement	+7.5 crest	20 top	4:1 inboard
Safety Zone levee	+8.6 crest	16 top	5:1
Dredged material placement berms	+4.5 crest	12 top	4:1
Transition habitat areas	+4.1 to +5.8 top	NA	15:1
Cut-off berms	+2 to +4	12 top	5:1
Dredged material for tidal wetland	+2.5 top	--	--
Dredged material for upland	+6.6 top	--	--
Excavation Activities			
Breaches	Per Table 2	Per Table 2	4:1
Starter channels	3 deep from surface	10 bottom	2:1
Channel connectors	Per hydraulic geometry calculations	Per hydraulic geometry calculations	4:1
Levee lowering	+6 top	--	--

7.9.1 Inner Bair

Work items to be completed on Inner Bair Island include the following (Figure 3):

- Excavation of levee breaches and an interior "starter" channel,
- Structural fill, including installation of cut-off berms, improvements to the existing perimeter levee (adjacent to SBSA force main), a new levee, and dredged material containment berms, and
- Dredged material placement.

Given the combination of adequate land access and limited number of breaches, it is assumed that the Inner Bair excavation and fill activities will be completed with land-based equipment suitable for use in the marsh environment. A combination of land-based and floating equipment will be required to complete the dredged material placement. Site preparation activity may include clearing of debris, improvement of land access and pumping of the site to obtain favorable working conditions.

The basic sequence of construction (following mobilization and site preparation) will likely proceed as follows:

1. Structural fill (levees, dredged material placement berms, transition habitat areas and cut-off berms),

2. Placement of dredged material (which will be phased over multiple work seasons), and
3. Breach of perimeter levees and excavation of starter channels.

Levees. Proposed levee work includes installation of a ring levee around the San Carlos Airport Safety Zone and improvements to the existing perimeter levee that contains the SBSA force sewer main. A combination of local borrow activity and import of fill from off-site will be required to provide fill for levee work. While surplus fill material could be generated by borrow from Middle and Outer Bair, the lack of land access between Inner and Middle/Outer Bair likely precludes cost effective transport.

The levee foundations will be prepared by removal of vegetation and placement of a geo-fabric over the levee footprint. Fill will be installed in lifts. Fill compaction will be attained by routing equipment over each lift (method compaction).

For this estimate, the following assumptions have been made:

- SBSA levee improvement – In the absence of detailed design criteria for the improved levee cross-section at this stage in the design, we presume an additional 20-foot top width installed against the existing perimeter levee. This is approximately double the existing levee top width. The crest elevation will match existing crest elevation after an estimated 3.5 feet of settlement.
- Airport Safety Zone Levee –crest elevation is the upland design elevation plus 2 feet. Offsite import of fill material. Assumes 3.5 feet of settlement.

Import of fill material has been assumed given unknowns such as suitability of marshplain soils as structural fill, and SBSA's preferred improved levee configuration. Additionally, excessive borrow of on-site marshplain material for use as fill will increase the quantity of dredged material required to attain design elevations.

Dredged Material Placement Berms. Dredged material placement berms will be installed to prevent migration of dredged material into the large remnant channel in the center of Inner Bair. These berms will be constructed adjacent to but offset from either side of the channel (Figure 17). Fill for the dredged material placement berms will be generated by local borrow. Construction of the berms will be similar in nature to levees described above. Crest elevation at the tidal wetland fill design elevation plus 2 feet.

Transition Habitat Areas. Transition habitat areas will be installed with fill in two locations: adjacent to the airport safety zone levee and adjacent to the existing perimeter levee between the breach locations. These berms will be extensions of the respective levee cross sections. Fill for transition habitat areas will be generated by local borrow. Construction of the berms will be similar in nature to levees described above.

Cut-off Berms. Construction of the berms will be similar to levees described above. The crest elevation will range between marshplain and mean higher high water elevations. An elevation of +4 feet NGVD was used to calculate initial estimates of cut-off berm fill volume. These "neat

line" estimates were then doubled to account for potentially significant construction period consolidation (approximately 1.5 feet of settlement) and other issues. Fill material will be generated by local borrow.

Dredged Material Placement. Dredged material will be placed in the airport safety zone and tidal wetland areas of Inner Bair Island. Dredged material will be placed within containment berms and levees to limit material migration and allow decanting to occur. Dredged material will likely be placed at Inner Bair over the course of two distinct dredging cycles. See Section 7.6 for additional information. We assume that two mobilization and demobilizations will be required.

Breaches. Breaches will be excavated at the locations shown in Figure 3. Initially, inboard and outboard daylight channels will be excavated and the levee crest will be lowered to a practical level of approximately +6 feet NGVD (to include freeboard to prevent high tides from entering the site). Some of the excavated material may be used as fill material for other improvements, depending on construction phasing and suitability of the material for such use. The balance of the material from the initial excavation will be disposed on-site. This operation will involve transport of the material and spreading.

When timing (considering tides, status of other site activities) is appropriate for final breach at each location, the remaining material will be excavated. A portion of excavated material from the final breach may be disposed by sidecasting, however, some on-site disposal, requiring multiple handling steps, may also be required.

Given the limited number of breaches (2) for Inner Bair and available land access, breaching activity will be handled as a dry operation with land-based equipment. Outboard daylight channel length is limited by assumed construction methods (long-reach excavator sitting on marsh pads, etc) to approximately 50 feet outboard of existing levees. Longer channels could be excavated with higher cost, but are not expected to be required at this time.

Interior Starter Channels. An interior "starter" channel will be excavated, located as shown in Figure 3. Starter channel excavation will occur prior to placement of dredged material. Excavation spoil will be disposed locally by spreading.

7.9.2 Middle and Outer Bair

Work items to be completed on Middle and Outer Bair Island include the following:

- Excavation of levee breaches and channel connectors,
- Structural fill for installation of cut-off berms, and
- Levee lowering.

Given the combination of remote (water only) access and multiple breach locations, it is assumed that the Middle and Outer Bair excavation and fill activities will be completed with a combination of floating, amphibious and land-based equipment. Water only access will likely require construction of temporary landings at Middle and Outer Bair for transfer of barge-

transported equipment. Temporary landing construction may include such items as installation of sheet and fender piles, and grading. Site preparation activity may include clearing of debris and pumping of the site to obtain favorable working conditions.
The basic sequence of construction (following mobilization and site preparation) will likely proceed as follows:

1. Earthwork required to install structural fills, including lowering levees as required to generate fill material,
2. Excavation of channel connectors, and inboard and outboard daylight channels at breach locations, and
3. Final breach of perimeter levees.

Cut-off Berms. Dimensions and assumptions are as per Inner Bair. Fill will be generated by perimeter levee lowering and breach excavation. The foundations will be prepared by removal of vegetation and placement of a geo-fabric over the berm footprint. Fill will be installed in lifts. Fill compaction will be attained by routing equipment over each lift (method compaction).

Breaches. Breach excavation on Outer and Middle Bair will be accomplished in a sequence and manner generally consistent with the breaches on Inner Bair, described above. Given the multiple breach locations for Middle and Outer Bair, maintaining a dry operation during breaching activity will not be possible. It is likely that the final breach excavations will be accomplished by floating equipment.

Channel Connectors. Channel connectors are excavations through interior levees to facilitate tidal circulation on Middle and Outer Bair. Assumptions are similar to those for breaches discussed above. Channel connector excavation will occur prior to commencement of perimeter levee breaching activity.

Levee Lowering. Levee lowering will be conducted as required to generate fill for cut-off berm installation on each respective island. Some lengths of the levees along the east side of Steinberger Slough will be retained to provide shoreline erosion protection for the flood control levee along the west side of the slough. Restoring tidal inundation to Middle and Outer Bair introduces the potential for wind waves generated onsite to propagate off-site and cause shoreline erosion. Although the potential for worsening shoreline erosion is considered to be small even if the levees along the east side of Steinberger Slough were lowered to marsh elevations, retaining parts of these levees will provide additional shoreline protection.

Generally, levee lowering will be limited to approximately +6 feet NGVD. This limited lowering will provide a freeboard above high tides in order to maintain dry conditions for construction prior to levee breaching. Obtaining fill material solely by levee lowering represents an extreme scenario. Fill material may also be generated in undetermined quantities by salvage of breach excavation spoils.

In order to generate fill required for the Outer Bair cutoff berms, approximately 12,000 LF will need to be lowered to +6 feet NGVD or approximately 6,000 LF lowered to +5 feet NGVD. These lengths represent 60% and 30% respectively of the approximately 20,000 LF total Outer

Bair levee length. To generate fill required for the Middle Bair cutoff berms, approximately 24,000 LF will need to be lowered to +6 feet NGVD or approximately 12,000 LF lowered to +5 feet NGVD. These lengths represent 71% and 35% respectively of the approximately 34,000 LF total Middle Bair levee length. Fill material can be generated by lowering the existing levees to +6 feet NGVD at a rate of approximately 0.5 cubic yards per lineal foot (CY/LF), or to +5 feet NGVD at a rate of approximately 1 CY/LF.

7.9.3 Channel Flow Control Structures

Smith Slough and Corkscrew Slough Flow Control Structures. The preliminary design concepts for these two structures are similar, except that a small notch is included in the Corkscrew Slough structure to allow some flow to and from Redwood Creek, matching existing flow conditions. Two design concepts were considered at each of these locations: a quarry stone berm installation and a linked cellular coffer installation. The notch included at the Corkscrew Slough location will allow flows at tide levels above elevation +0.6 ft NGVD (2 feet below mean lower high water), with top width of 30 feet. The remaining crest length for the Corkscrew slough structure and the entire crest length of the Smith Slough structure are set at elevation +5.1 ft NGVD.

Design concepts were limited to the structures described above because of the anticipated high head differences across the structure (up to 4 feet and higher) and long lengths across the width of the channel (approximately 300 feet). Other structures may be considered during design refinement. Design inputs and evaluation criteria to be considered include soil conditions and structure settlement, hydrostatic loads, seismic issues, design life, factor of safety against failure and connection with adjacent lands. Design refinement may result in adjustments to estimated structure costs approaching 30 %.

The flow restrictors will be designed so they can be modified, if needed, installation as part of the adaptive management program. The quarry stone berm could be modified by adding or removing stone. Modifications to the linked cellular coffer installation would be more difficult, but may potentially include cutting sections from the steel sheetpile wall or driving it deeper. Options to increase the flexibility of these concepts will be incorporated in subsequent stages of final design.

Inner Bair Breach Armoring. Velocities of up to 10 feet per second are anticipated in breach IB2. A quarry stone armor blanket was developed to guard against erosion at this location. The armor blanket is configured with finish grades matching the design configuration for the breach. The armor blanket assumes a four-foot layer of graded stone with median weight of 1000 pounds placed over a geosynthetic filter fabric that will reduce deformation of the armor due to differential settling and piping of underlying soils.

Potential Impacts from Flow Control Structures. Placement of a barrier in Corkscrew Slough may affect harbor seal access to haul-out sites in the slough (Figure 4). The proposed barrier would be between two currently used haul-out locations, potentially impeding access to at least one of the sites. However, haul-out sites themselves will not be affected. In addition, boat access may be compromised during low tides, or when water exchange through the structure is at its peak.

7.10 PRELIMINARY VOLUME AND COST ESTIMATE

The preliminary quantity and cost estimates for the proposed work items are summarized in Table 7. *These estimates are preliminary and subject to revision.* The preliminary cost estimate is intended to provide an approximation of total project costs appropriate for the conceptual design stage. Costs for individual restoration components have been used to support cost/benefit decisions reflected in the conceptual design. Reductions in the estimated quantities and costs are possible through design optimization. The preliminary excavation and fill volumes and cost estimates will be refined in subsequent phases of design development based on refinement of design objectives, additional topographic and geotechnical data and analysis, and further design development.

The preliminary cost – including final design, permitting, construction, ongoing monitoring and maintenance – is approximately $21M, or $13,700/acre averaged for the entire site. Restoration costs are significantly higher for Inner Bair Island ($49,500/acre) than for Middle Bair ($6,000/acre) and Outer Bair ($2,000/acre). These include the costs of dredged material placement. If the Bair Island restoration project receives dredged material at no cost, the total project cost could be reduced to $13M (an $8M reduction).

The volumes are estimated in place. Cost estimates are based on bid results from similar projects, consultation with construction contractors and engineering judgment. A contingency of 20% has been added to the estimate of total project cost to cover circumstances and design issues not readily apparent at the current stage of project development. The contingency also provides safety against construction cost fluctuations possible in the local heavy construction market.

We assume offsite import of fill material for the SBSA levee improvements and safety zone levee. The cost assumes $16/CY for purchase of fill material and delivery to site, which includes $5/CY for purchase of material and cost of transport for 2-hour roundtrip delivery cycle. The cost of levee installation/improvement could be reduced if import material is available for less than $16/CY delivered to the site and/or if increased use of on-site material is practical. Also, cross sections can be optimized with additional information and design development. Supply of fill for levee work is an issue that will require further investigation.

Project performance monitoring costs assume monitoring at 0, 1, 3, 5, and 10 years after construction. Long-term maintenance costs for public access facilities, new levees, and the three structures described above were estimated by assuming that maintenance would be required approximately 10, 20 and 40 years after project completion. For each of these events, repairs costing 7.5% of the original construction costs were assumed. As an exception, additional long-term maintenance costs were added to the public access facilities to account for possible trails maintenance even though no improvements to the existing trail surfaces are currently planned.

Table 7. Preliminary Volume and Cost Estimate (in 2003 dollars)

ITEM	DESCRIPTION		QUANTITY	UNITS	UNIT PRICE	TOTAL
1	Mobilization, Site Preparation, & Demobilization					
	A. Outer Bair		1	LS	160,000	$160,000
	B. Middle Bair		1	LS	160,000	$160,000
	C. Inner Bair		1	LS	160,000	$160,000
2	Cut-off Berms					
	A. Outer Bair (4 total)		4,800	CY	43	$206,000
	B. Middle Bair (5 total)		7,500	CY	43	$323,000
	C. Inner Bair (4 total)		8,000	CY	22	$176,000
3	Breaches					
	A. Outer Bair (3 total)		6,000	CY	43	$258,000
	B. Middle Bair (4 total)		8,000	CY	43	$344,000
	C. Inner Bair (2 total)		4,000	CY	22	$88,000
	D. Armor Breach IB2		1,500	CY	150	$225,000
4	Channel Connectors					
	A. Middle Bair (4 total)		4,000	CY	43	$172,000
5	Channel Flow Control Structures					
	A. Corkscrew Slough Structure		1	LS	1,500,000	$1,500,000
	B. Boat Portage at Corkscrew Slough Structure		1	LS	100,000	100,000
	C. Smith Slough Structure		1	LS	1,500,000	$1,500,000
6	Misc. Earthwork at Inner Bair					
	1.	Improve Sewer Levee	35,000	CY	27	$945,000
	2.	Airport Safety Zone Levee	40,000	CY	27	$1,080,000
	3.	Interior Channel Excavation	6,000	CY	9	$54,000
	4.	Transition Habitat Between Breaches	30,000	CY	11	$330,000
	5.	Transition Habitat at Airport Safety Zone	12,000	CY	11	$132,000
7	Dredge Material Placement at Inner Bair*					
	1.	Dredge Material Testing for Two Dredge Episodes	2	EA	40,000	$60,000
	2.	Mobilization & Demobilization for Dredge Material Placement	2	EA	110,000	$220,000
	2.	Airport Safety Zone	250,000	CY	5	$1,250,000
	3.	Tidal Wetland Area	800,000	CY	5	$4,000,000
	4.	Tidal Wetland Dredge Material Placement Berms	60,000	CY	11	$660,000
8	Planting at Inner Bair		10	acres	8,000	$80,000
9	Public Access Facilities					
	1.	Observation Platforms at Inner Bair	2	EA	75,000	$150,000

ITEM	DESCRIPTION		QUANTITY	UNITS	UNIT PRICE	TOTAL
	2.	Observation Platform at Corkscrew Slough	1	EA	95,000	$95,000
	3.	Chemical Toilets	2	EA	10,000	$20,000
	4.	Cement Pad and Fence around Toilets	1	EA	20,000	$20,000
	5.	Interpretive and Orientation Signs	17	EA	7,500	$127,500
	6.	Regulatory Signs	8	EA	5,000	$25,000
	7.	Warning Signs for Flow Restirctors	4	EA	6,000	$24,000
	8.	Directional Signs for Inner Bair Trail and Corkscrew Portage	4	EA	75	$300
	9.	'Area Closed' Signs	20	EA	20	$400
	10.	Interpretive/Orientation Kiosk	1	EA	10,000	$10,000
10	Permitting and Final Design					
	1.	Permitting	1	EA	20,000	$20,000
	2.	Final Design	1	EA	1,000,000	$1,000,000
11	Monitoring		10	years	60,000	$600,000
12	50-year Maintenance Costs					
	1.	Airport Safety Zone Levee	50	years	4,800	$240,000
	2.	Sewer Levee	50	years	4,300	$215,000
	3.	Breach IB2 Armor	50	years	1,000	$50,000
	4.	Corkscrew Slough Structure	50	years	6,000	$300,000
	5.	Smith Slough Structure	50	years	6,000	$300,000
	6.	Public Access & Trails	50	years	900	$45,000
	7.	*Spartina alterniflora* eradication	5	years	50,000	$250,000
	8.	Predator management	10	years	2500	25,000
Sub-Total			---	---	---	$17,700,200
Contingency (20 % of Project Total)			---	---	---	$3,540,040
Estimated Total Cost			---	---	---	$21,240,240

For detailed explanation of dredged material placement costs, see Section 7.6.

8.0 SITE MAINTENANCE, MONITORING AND ADAPTIVE MANAGEMENT

The restoration of Bair Island has been designed to minimize the necessity of long-term intervention by management personnel. However, some site maintenance will be required for infrastructure protection and to ensure successful restoration of Bair Island to tidal salt marsh habitat that is dominated by native vegetation. Additionally, monitoring of – and possible changes to – the flow control structures will be carried out to ensure that flood hazards do not exceed their expected levels after project implementation.

To protect infrastructure, regular inspections and maintenance will be conducted for the airport safety zone levee, SBSA sewer line levee, flow control structures, and public access facilities. Although no project impacts are expected, the Steinberger Slough levees adjacent to Redwood Shores will also be monitored and maintained as needed.

The successful eradication of smooth cordgrass for Bair Island will require ongoing maintenance as outlined in Section 7.2.1. Other non-native species such as perennial peppergrass (*Lepidium latifolium*), yellow star-thistle (*Centaurea solstitalis*), and ice plant (*Carpobrotus edulis*) are also prevalent on portions of Bair Island. However, the majority of these plant species are naturalized in California, and only perennial peppergrass poses a threat to the marsh plain itself. Eradication programs for species besides smooth cordgrass should be evaluated as an adaptive management strategy if site evolution monitoring illustrates a problem with a particular species. At that time, colonization rates can be determined and the appropriate eradication method for that species applied. However, at this time only smooth cordgrass is anticipated to be a significant threat to the habitat integrity.

The Proposed Action is expected to increase peak flood water levels at the Highway 101 crossings of Pulgas and Cordilleras Creeks during a 100-year flood event by approximately 0.05 ft due to construction of the flow control structures in Smith and Corkscrew Sloughs (PWA 2003). These increases are expected to decrease over the first months and years following project implementation as tidal scour increases conveyance along Steinberger Slough. To manage the uncertainties associated with the hydraulic characteristics of the flow control structures and morphological adjustments along the slough, the Proposed Action includes monitoring of water surface elevations and flow velocities to evaluate whether the structures are functioning per the design criteria given in the Restoration and Management Plan and incorporated into the model used to estimate impacts to flood hazards. The USFWS will be responsible for adjustments to the structures after construction that may be needed to meet the design criteria. The structures will be designed to allow adjustments (such as the addition or removal of rip-rap, or adjustment of weir elevations) for flexibility of post-construction management.

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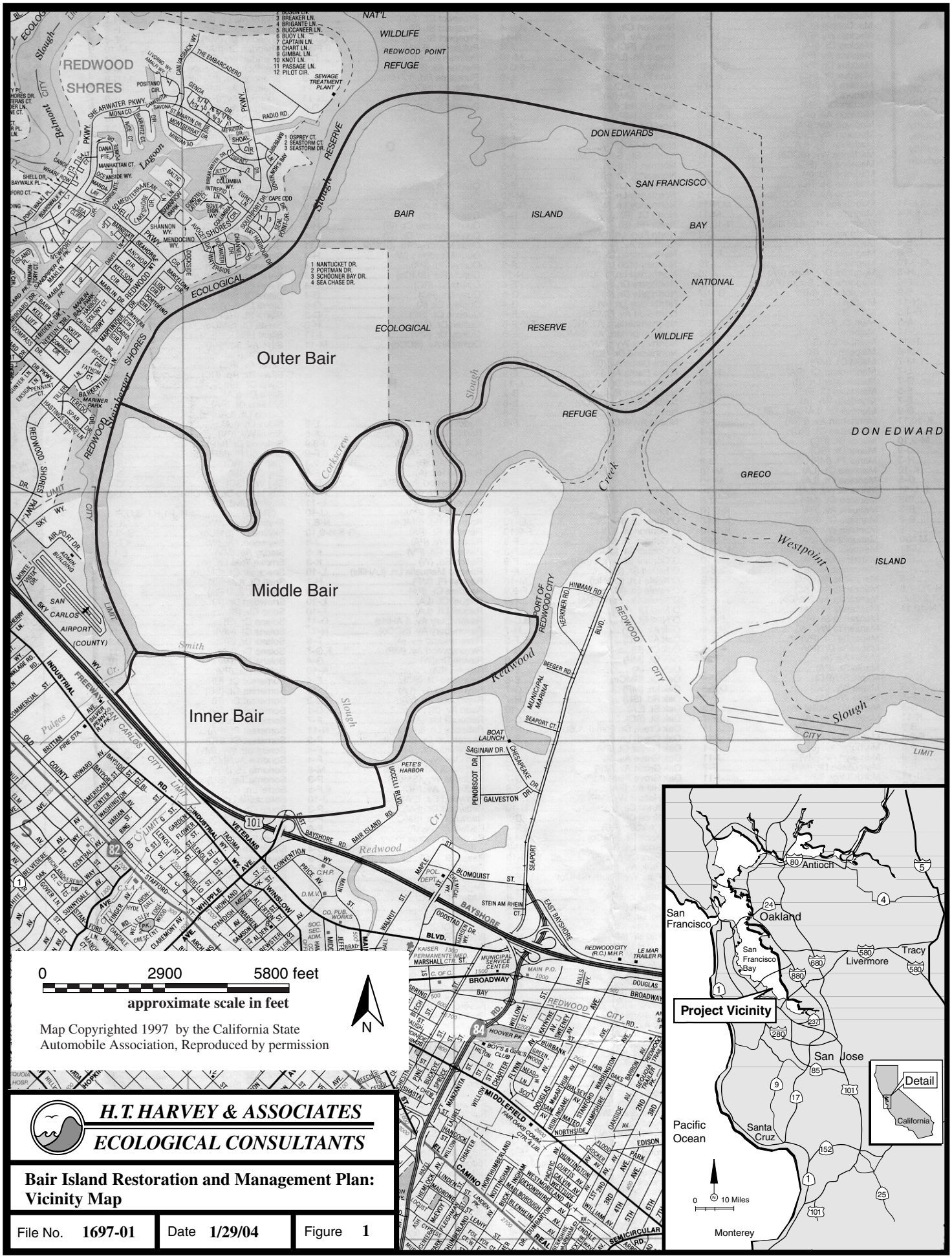
APPENDIX A.
REPORT FIGURES



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H.T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

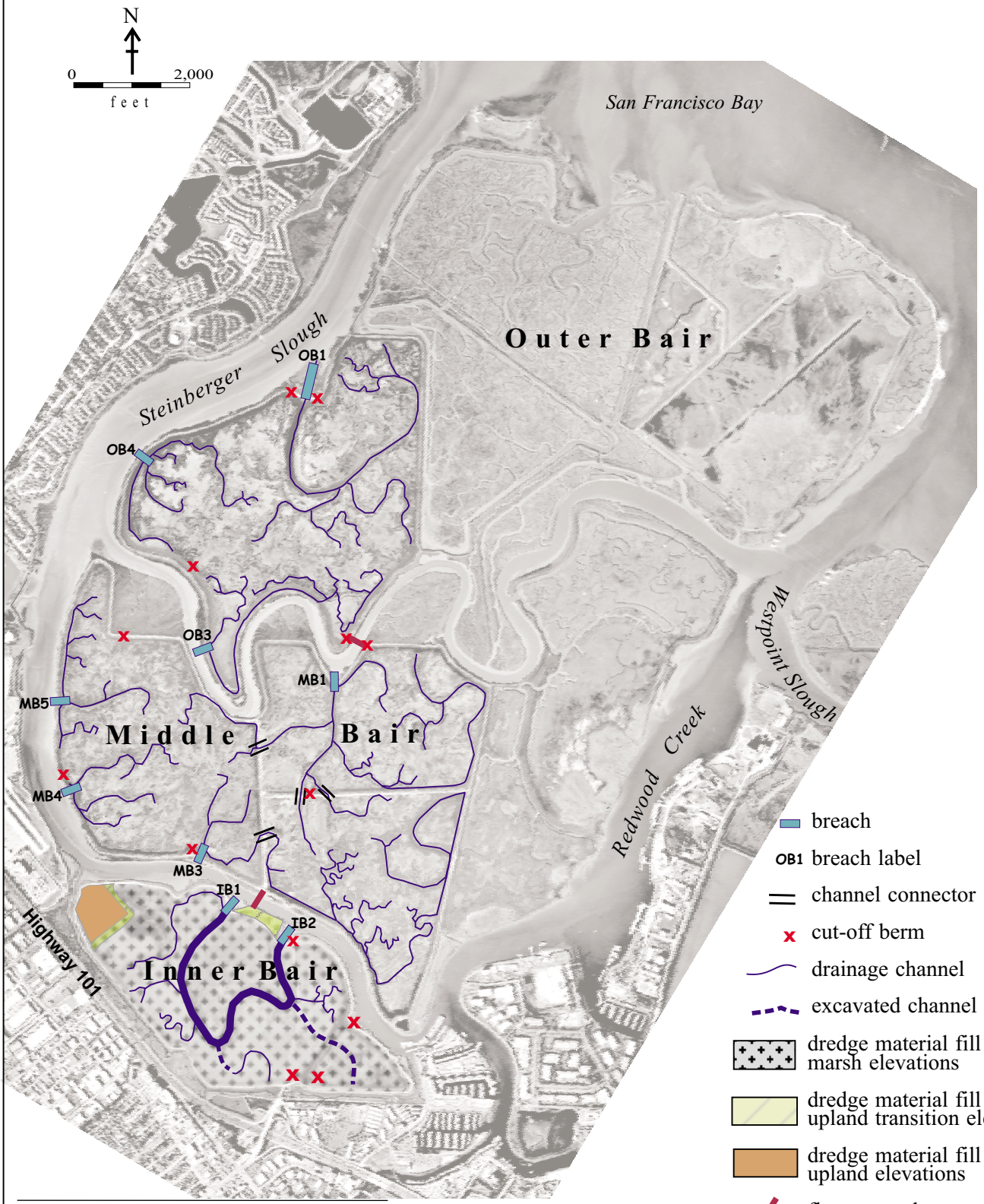
Bair Island Restoration and Management Plan: Vicinity Map

File No. **1697-01**	Date **1/29/04**	Figure **1**

figure 2

Bair Island

Recommended Alternative: Restoration Plan



See figure 19 for Inner Bair detail

Basemap: aerial photograph (2/18/00)

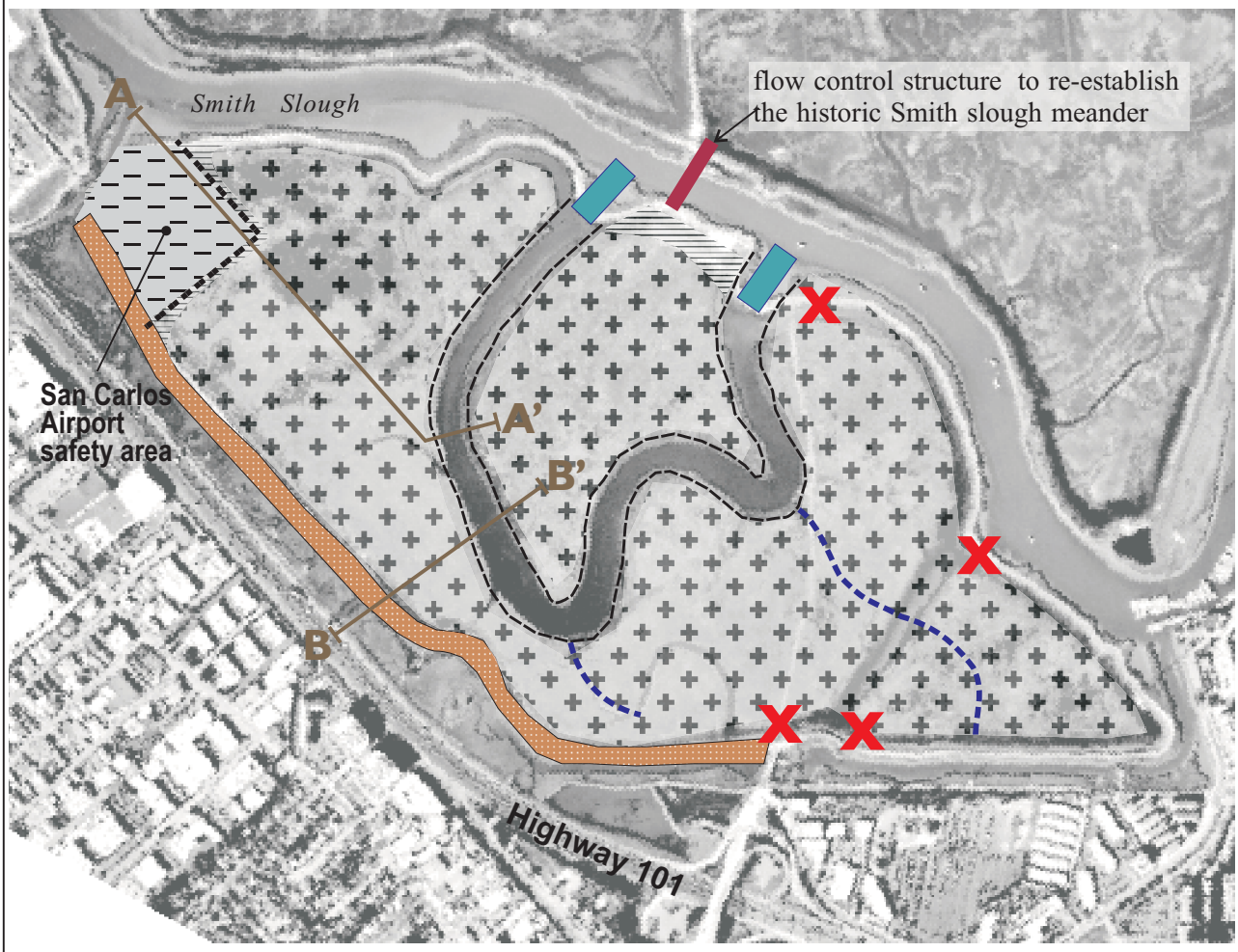
1413 \ nov13, 02 \ fig 14 Rest_Plan.cdr

PWA

figure 3

Bair Island

Recommended Alternative: Restoration Plan Inner Bair Detail



- dredge material fill to upland elevations
- dredge material fill to upland transition elevations
- dredged material fill to tidal marsh elevations
- San Carlos Airport safety zone levee
- dredged material placement berms
- SBSA sewer line levee
- breach
- cut-off berm
- excavated channel

N

feet

0 1,000 2,000

Note: See figure 17 for Transects A-A' and B-B'

PWA

1413 nov 2000\fig3Inner BairDetL.cdr

figure 4

Bair Island

Recommended Alternative: Long-Term Conditions

Basemap: aerial photograph (2/18/00)

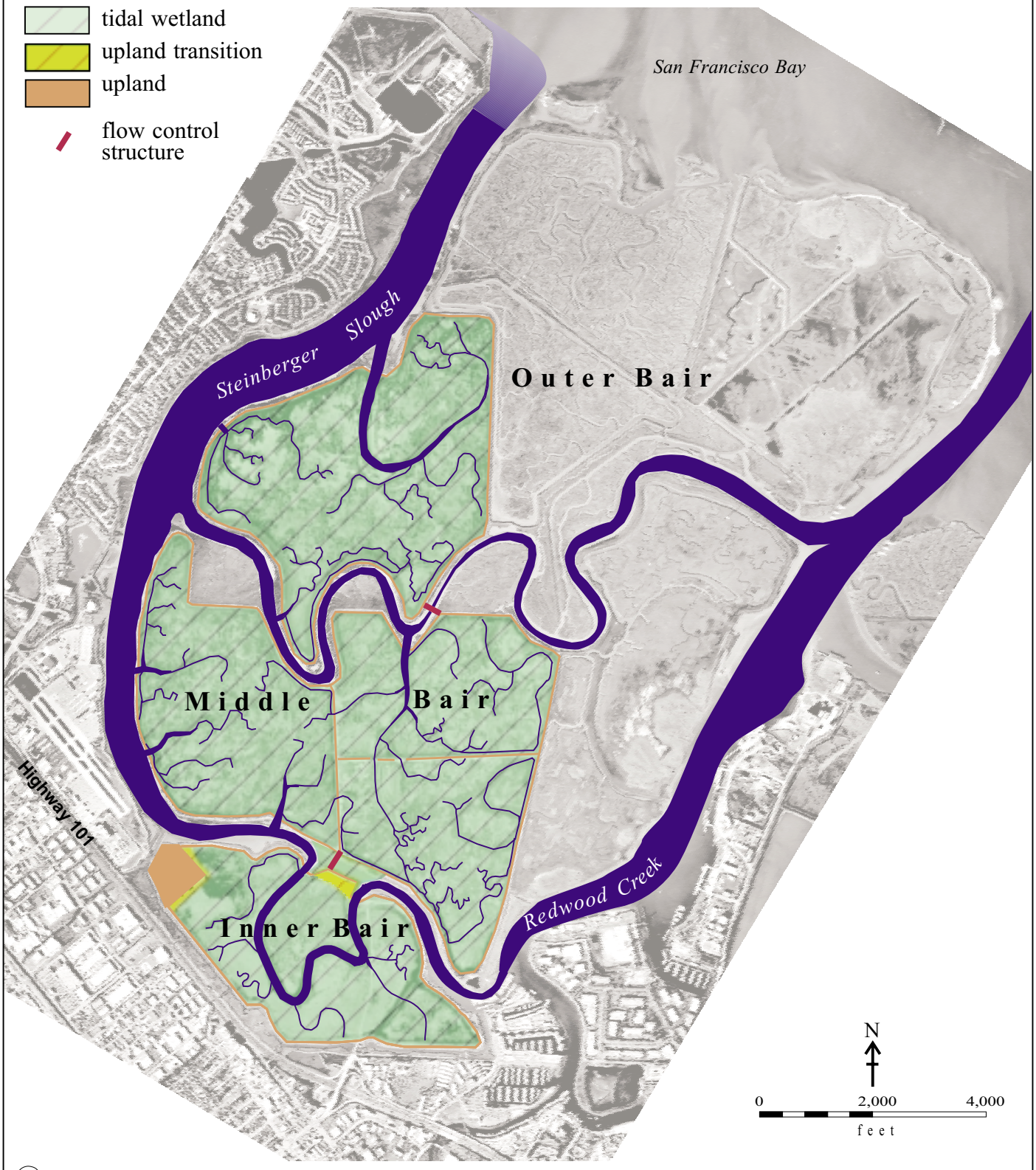


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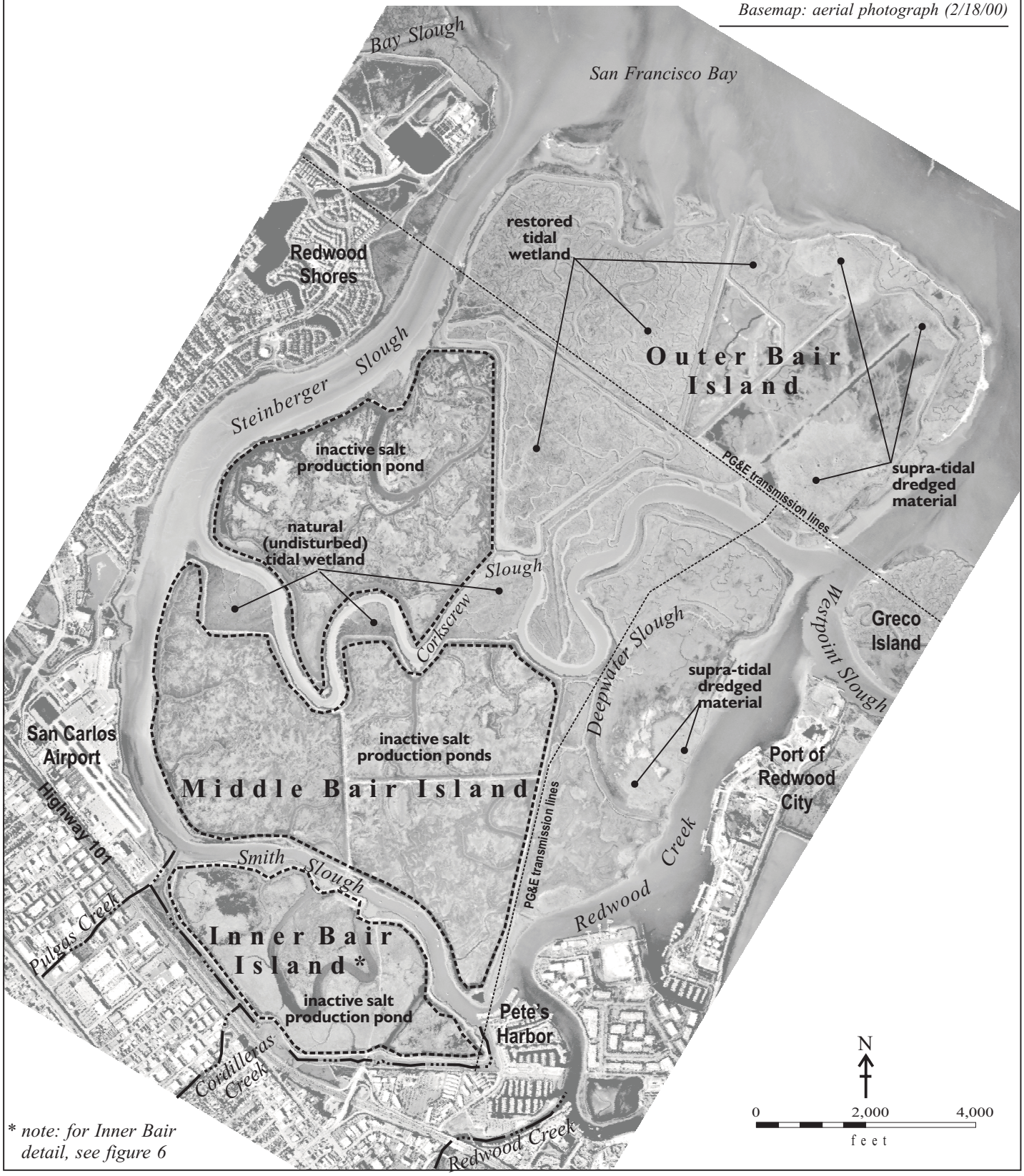
figure 5

Bair Island

Existing Conditions

Basemap: aerial photograph (2/18/00)



* *note: for Inner Bair detail, see figure 6*

1413 \ R&M Plan Aug02\ ExistingCond photo2.cdr

PWA

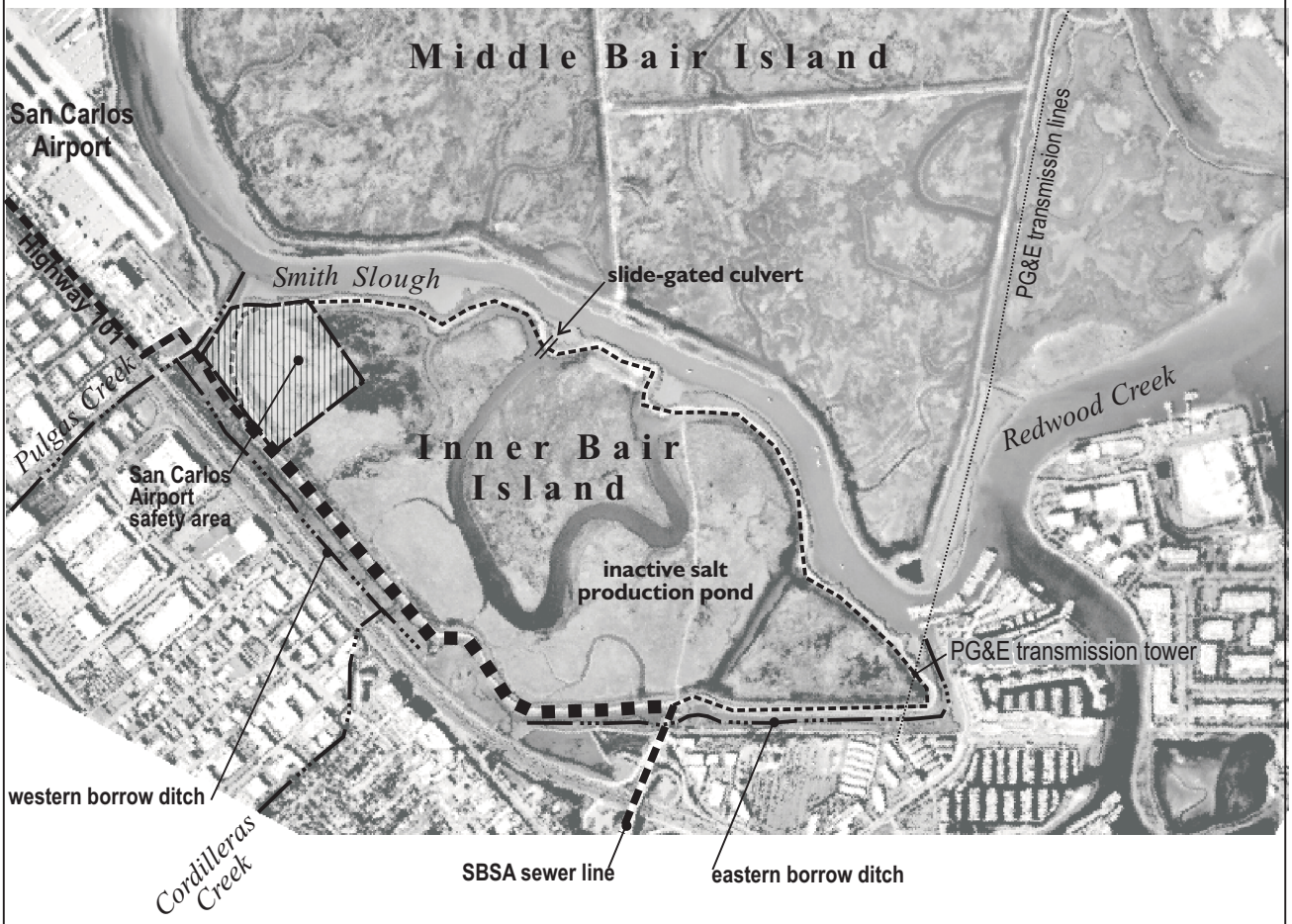
figure 6

Bair Island

Existing Conditions, Inner Bair Detail

Basemap: aerial photograph (2/18/00)

channels
levees
SBSA sewer line
SBSA sewer line under levee



N

0 2,000 4,000

feet

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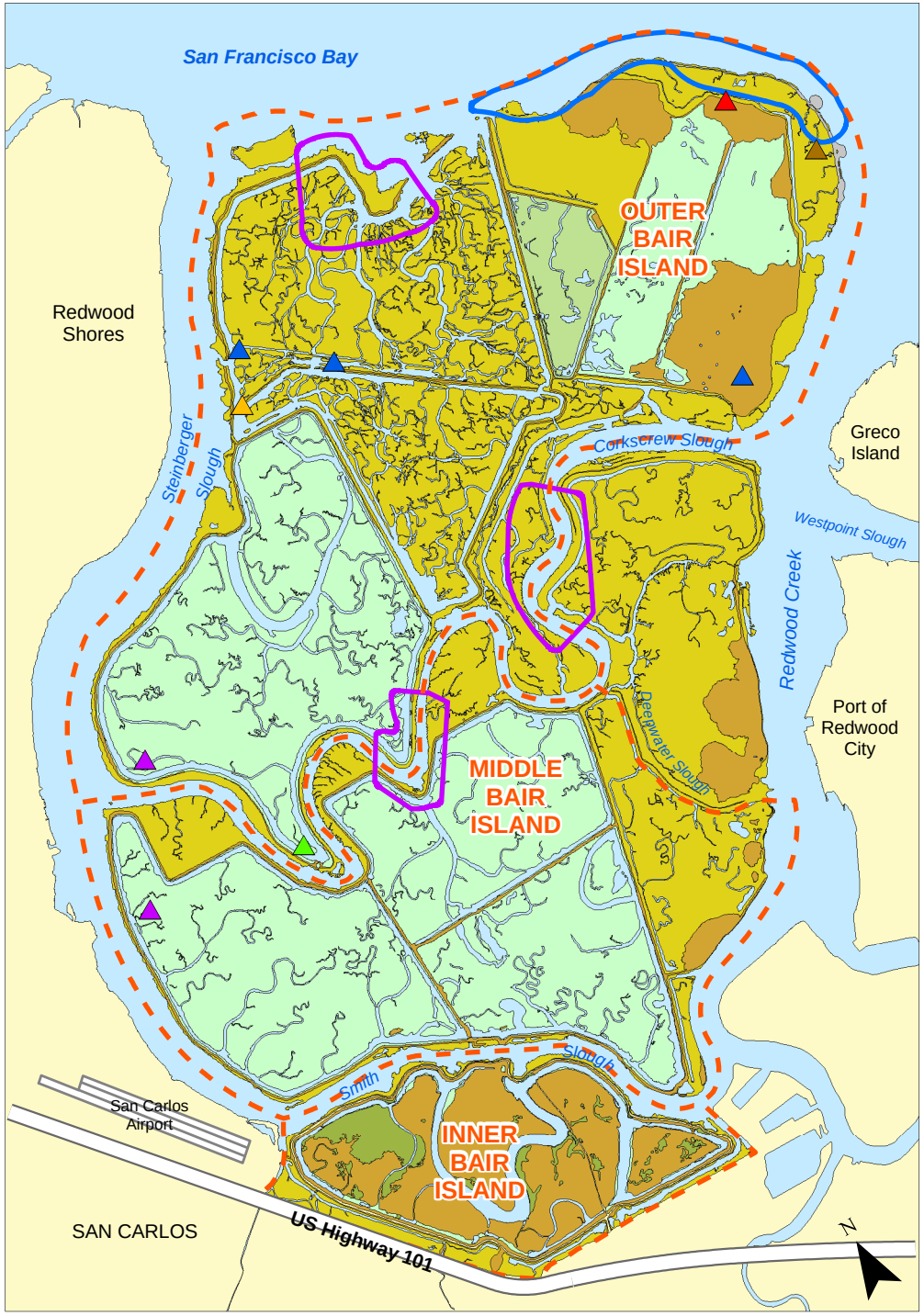
Bair Island Restoration Project
Figure 7: Habitat Map (1/29/04)



Project Boundaries

LOCATIONS OF WILDLIFE USE:

- Existing Brown Pelican Roost
- Existing Double-crested Cormorant/ Great Blue Heron Nests
- Existing White-tailed Kite Nest
- Potential Caspian Tern Colony
- Potential Forster's Tern/ American Avocet Colonies
- Previous Forster's Tern Colony
- Harbor Seal Haul-out Location
- Potential Snowy Plover Nesting Habitat

EXISTING HABITATS (2000):

- Aquatic
- Developed

INNER BAIR ISLAND: 8.47 acres MIDDLE BAIR ISLAND: 0.00 acres OUTER BAIR ISLAND: 0.00 acres

- Shell Mounds

INNER BAIR ISLAND: 0.00 acres MIDDLE BAIR ISLAND: 0.00 acres OUTER BAIR ISLAND: 5.63 acres

- Ruderal Upland

INNER BAIR ISLAND: 187.89 acres MIDDLE BAIR ISLAND: 38.02 acres OUTER BAIR ISLAND: 141.45 acres

- Diked Salt Marsh

INNER BAIR ISLAND: 9.06 acres MIDDLE BAIR ISLAND: 553.64 acres OUTER BAIR ISLAND: 468.90 acres

- Muted Salt Marsh

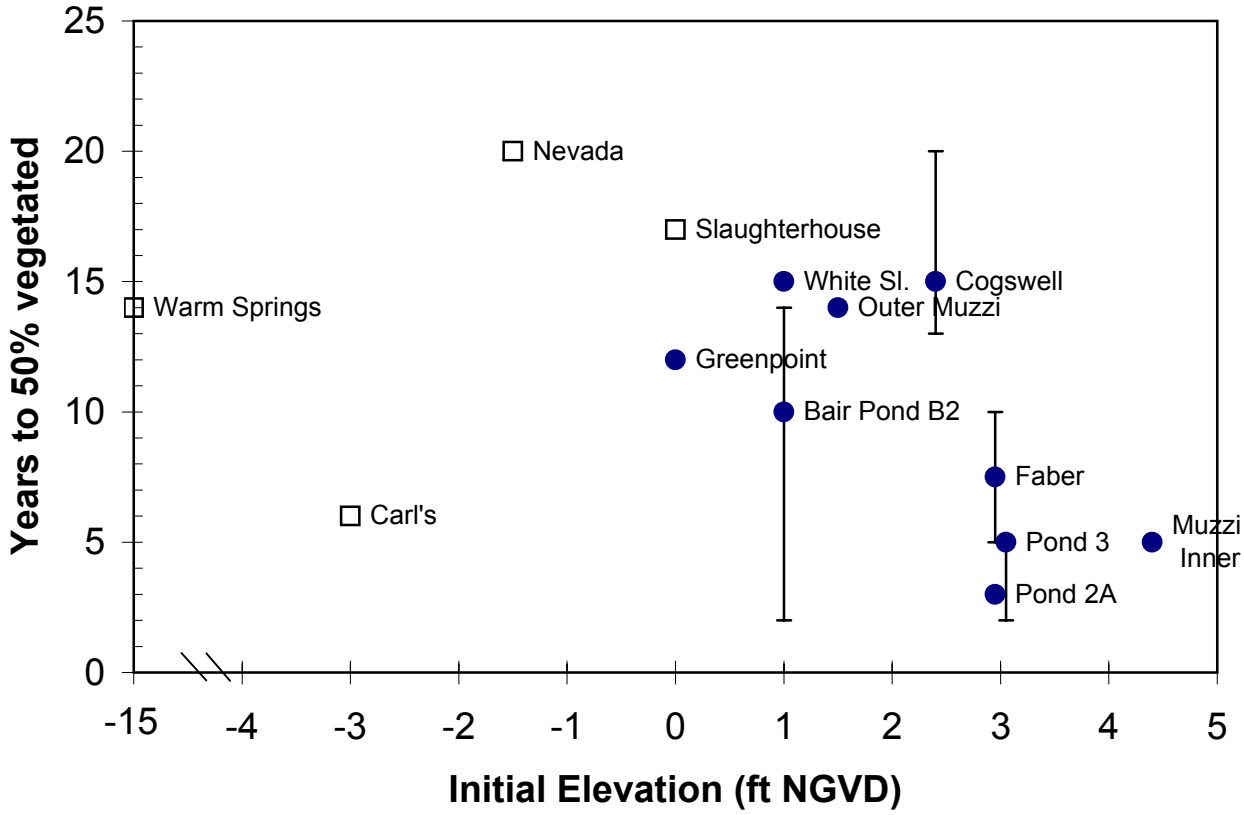
INNER BAIR ISLAND: 0.00 acres MIDDLE BAIR ISLAND: 0.00 acres OUTER BAIR ISLAND: 51.77 acres

- Seasonally Ponded Wetland

INNER BAIR ISLAND: 32.82 acres MIDDLE BAIR ISLAND: 0.00 acres OUTER BAIR ISLAND: 0.00 acres

- Tidal Salt Marsh

INNER BAIR ISLAND: 36.90 acres MIDDLE BAIR ISLAND: 192.54 acres OUTER BAIR ISLAND: 647.13 acres



● Age when 50% vegetated

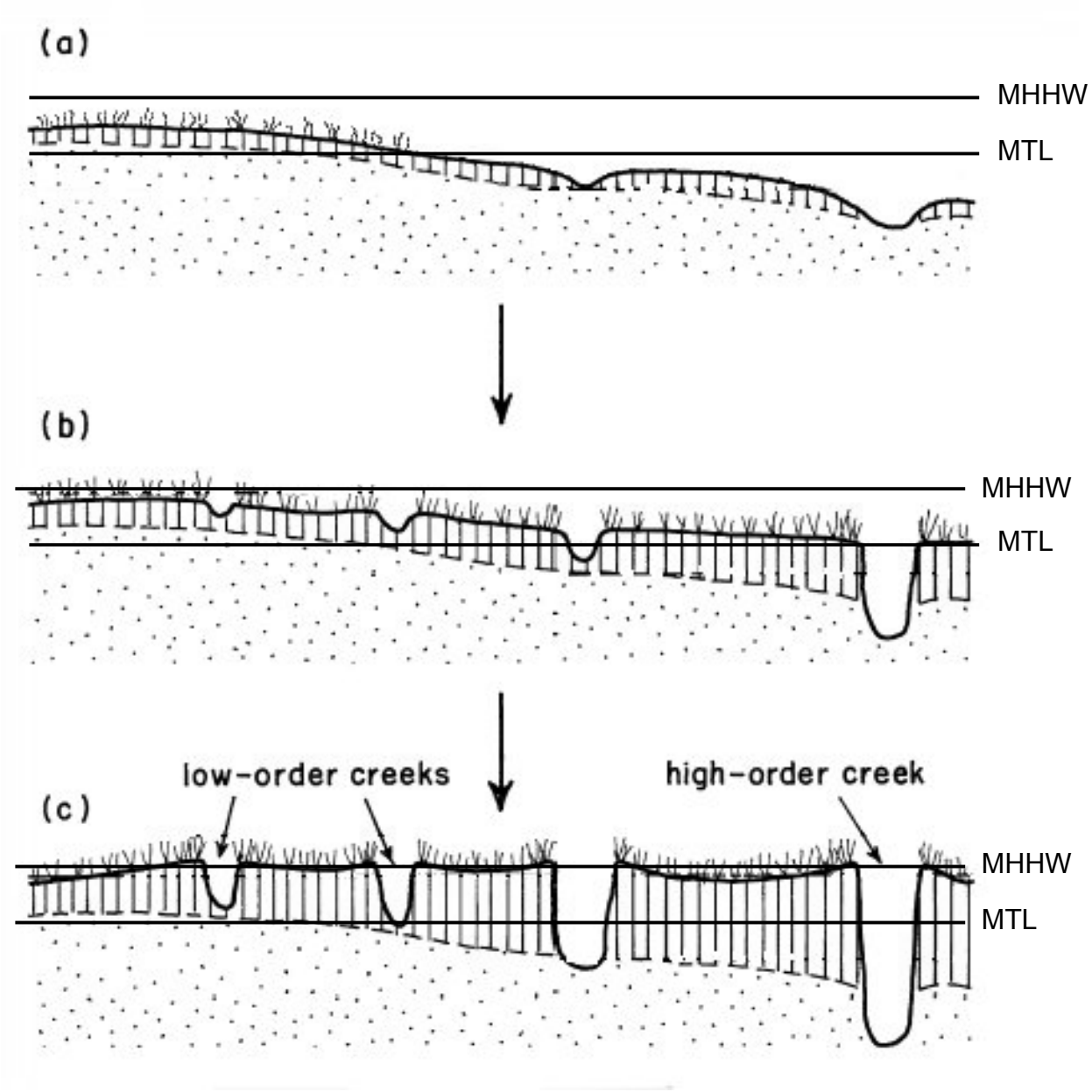
□ Current age if not vegetated (as of Year 2000)

Note: Symbols show most likely estimate; error bars show range.

figure 8

Number of Years for marshplain vegetation to establish versus initial elevation

PWA



A. Young marsh, emergent vegetation & intertidal mudflat
B. Developing marsh, vegetation colonization & channel formation
C. Mature marsh, vegetated marsh plain & channel drainage system

MHHW = mean higher high water
MTL = mean tide level

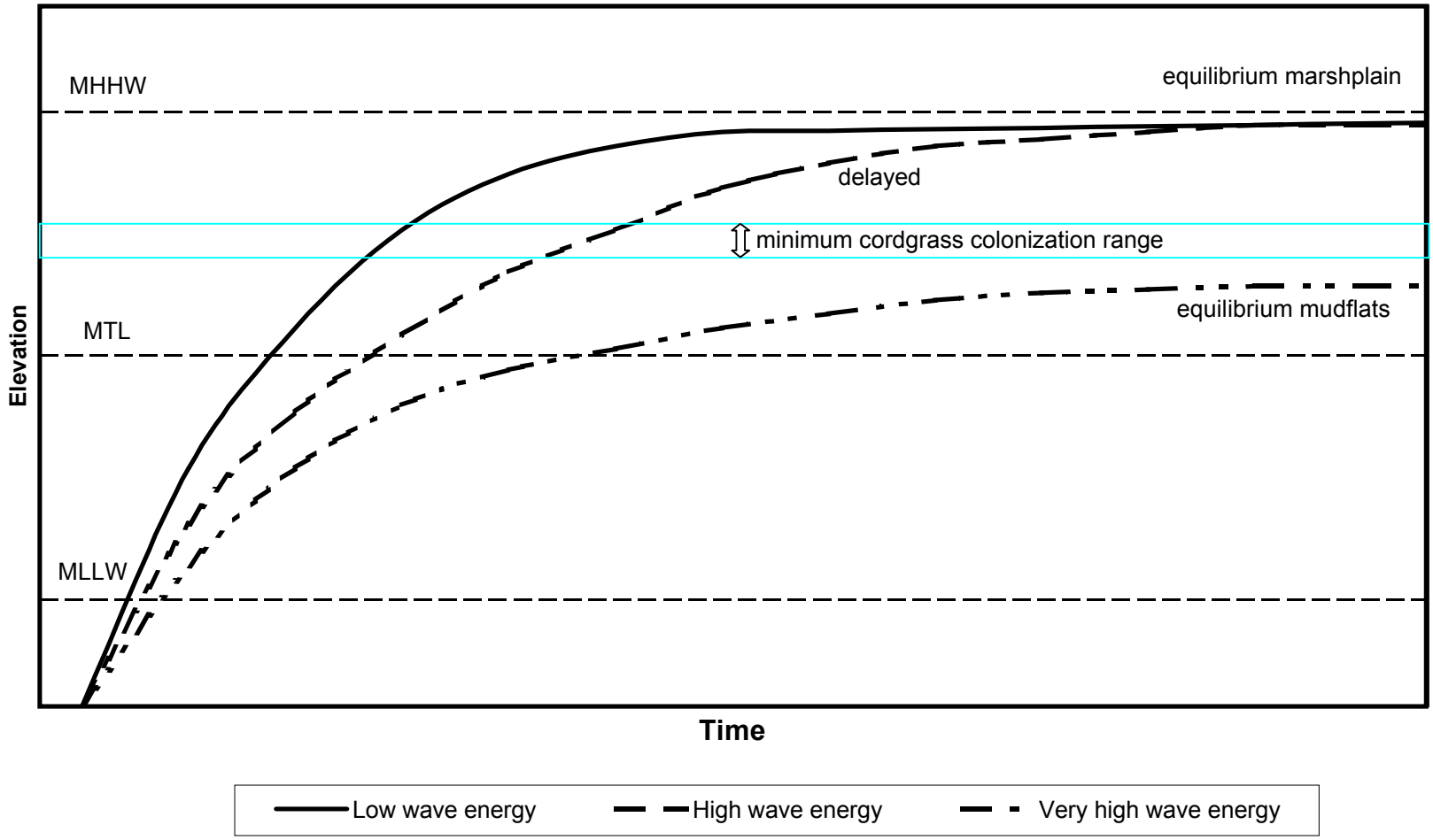
figure 9

Bair Island Restorartion

Schematic of Marsh Evolution

PWA #1591

PWA



Note:
MHHW: Mean Higher High Water
MTL: Mean Tide Level
MLLW: Mean Lower Low Water

figure 10

Tidal marshplain evolution with time since breaching

PWA

PWA #:1413-11

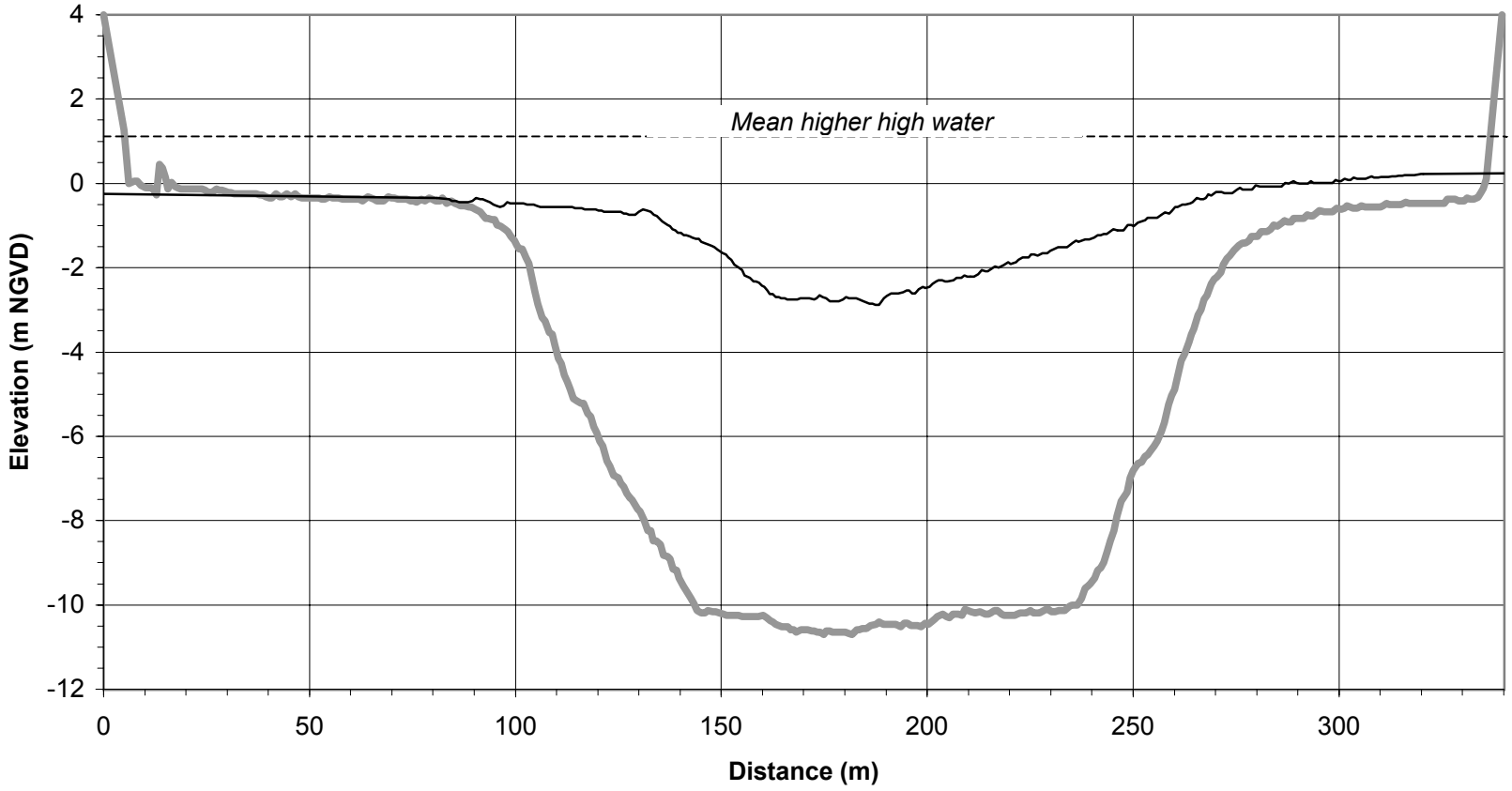


figure 11

Bair Island Restoration

Comparison of Redwood Creek and Steinberger Slough Cross-Sections

PWA

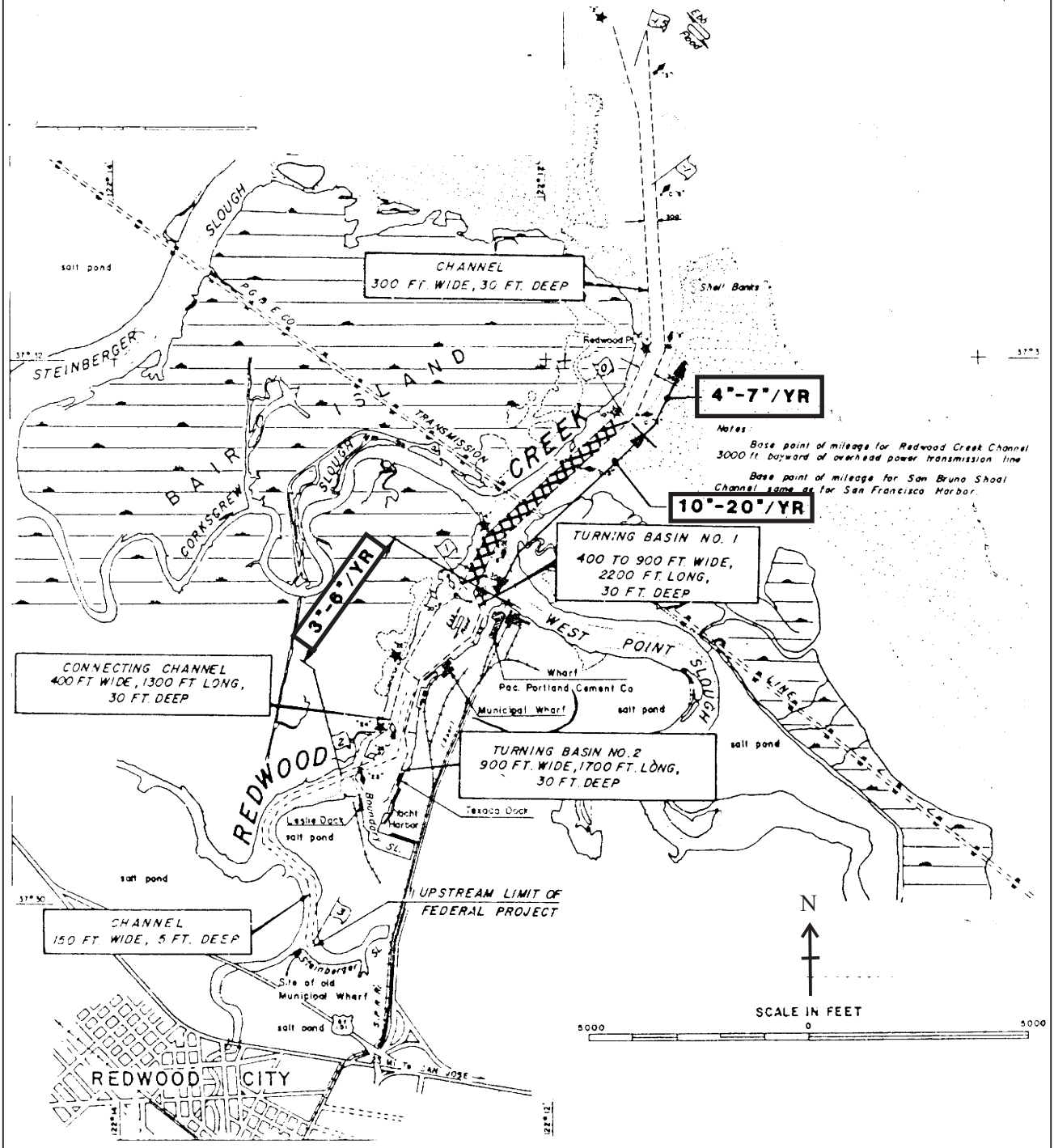
PWA #:1413

figure 12

Bair Island
Redwood Creek Shipping Channel
Average Siltation Rates

source: USACE (1972)

= location where significant shoaling occurs



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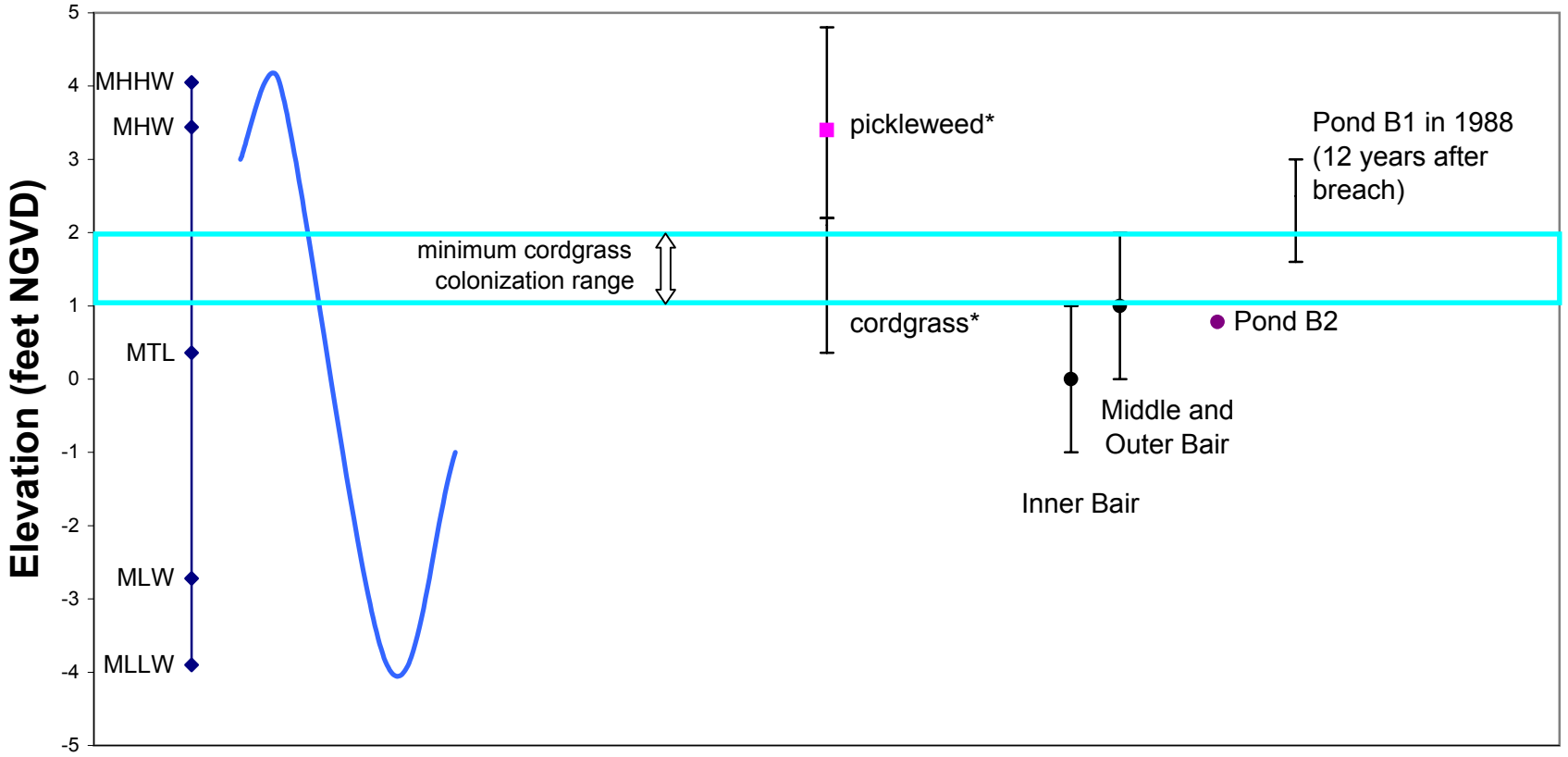


* elevation range for natural marsh areas of Bair Island

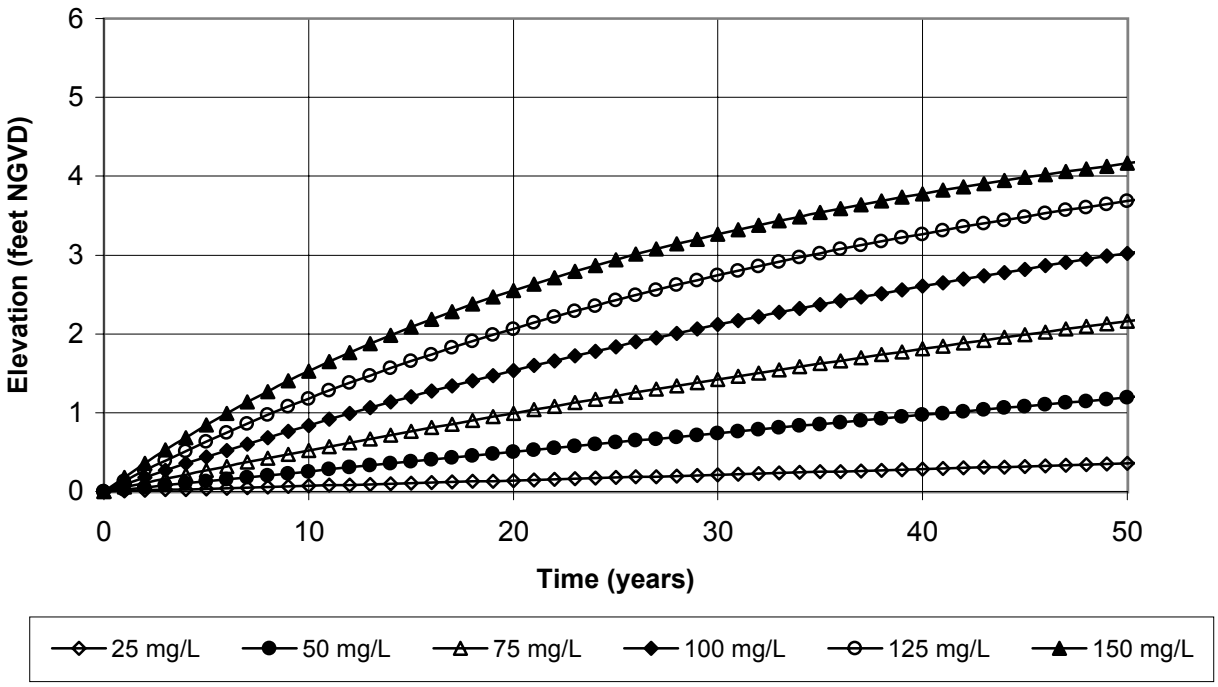
Note: MHHW = mean higher high water; MHW = mean high water; MTL = mean tide level; MLW = mean low water; MLLW = mean lower low water.

figure 13

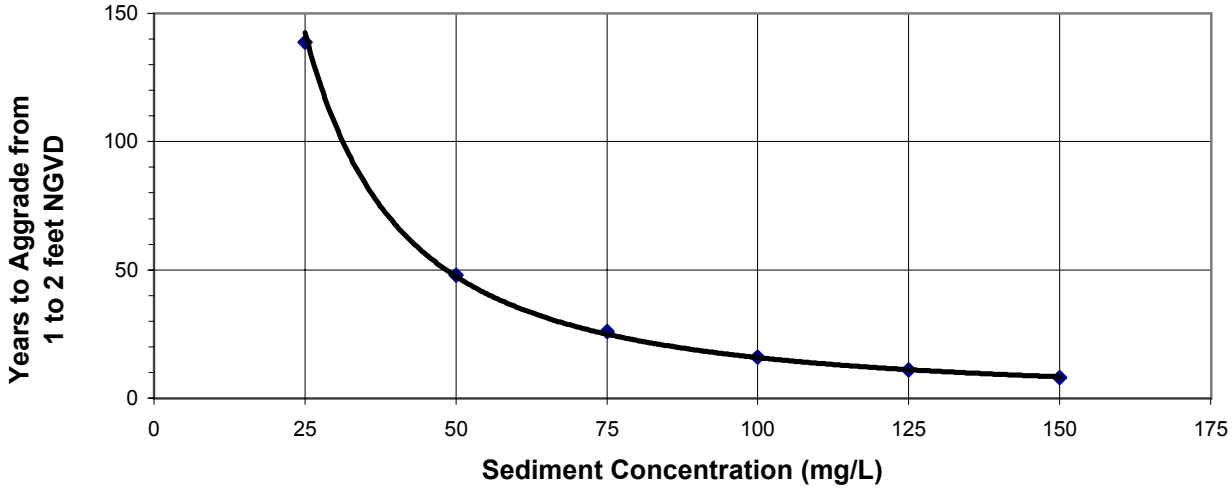
Bair Island Restoration

Marshplain Elevations Relative to Tides and Vegetation Ranges

PWA | PWA#: 1413



a. Sedimentation Curves for Various Suspended Sediment Concentrations



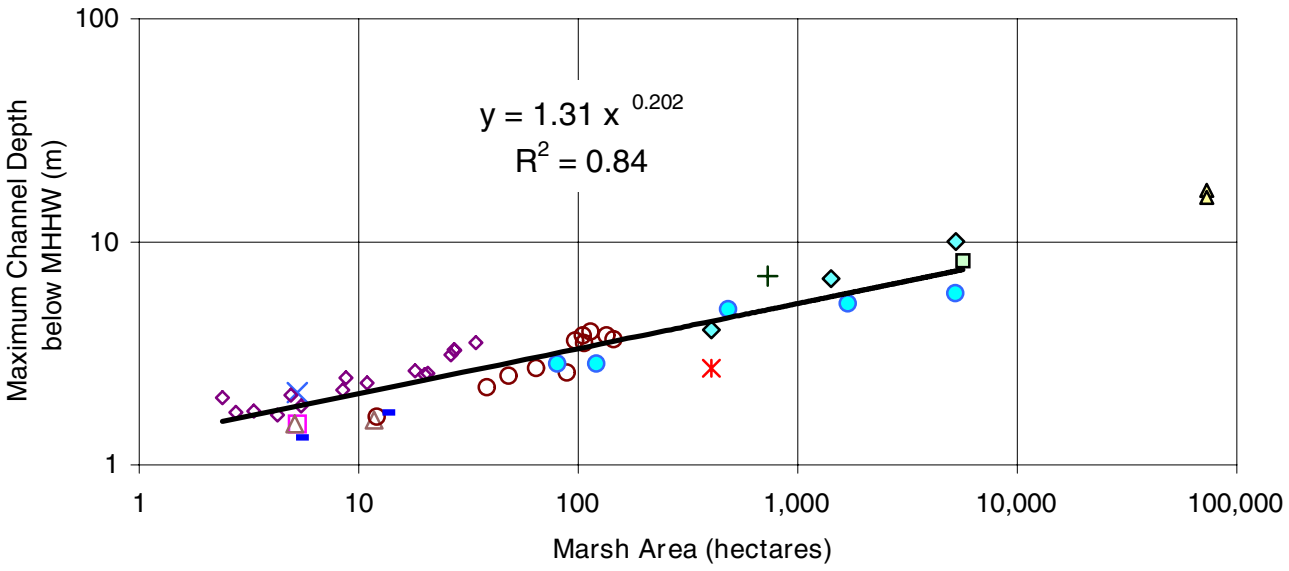
b. Time for Sedimentation from 1 to 2 Feet NGVD vs Suspended Sediment Concentration

Note:
dry density of inorganic material = 550 kg/m3 (consolidated conditions)
Sea level rise = 0.5 foot/50 years
Mean monthly tide from Redwood Creek Channel Marker 8

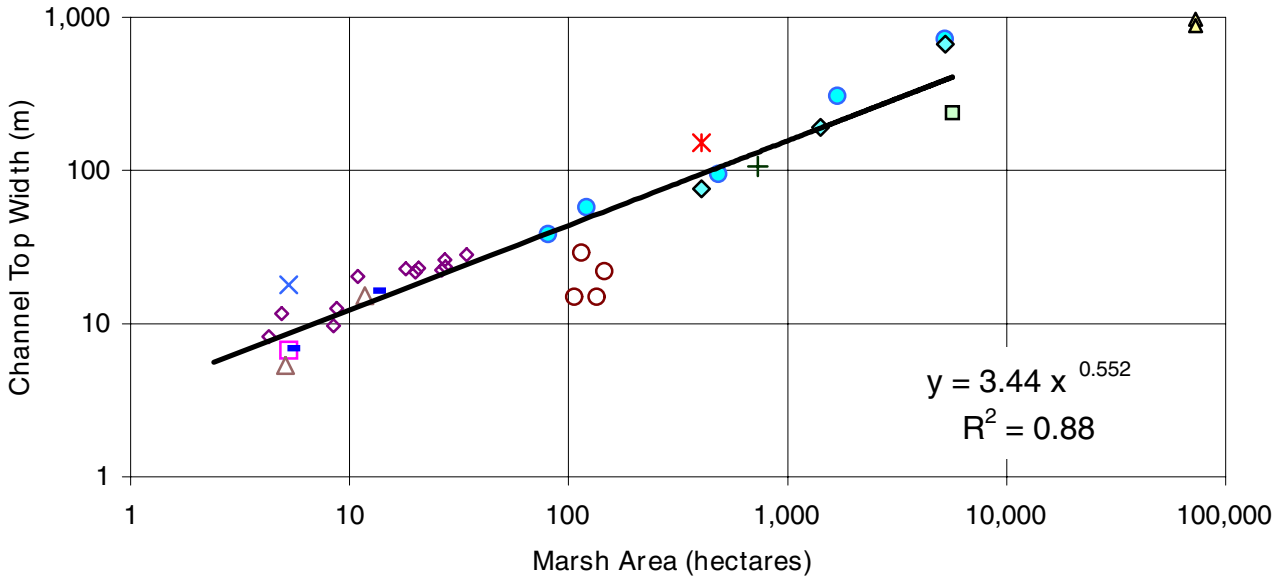
figure 14

Long-Term Sedimentation Variation with Sediment Supply

PWA



a. Channel depth as a function of marsh area.



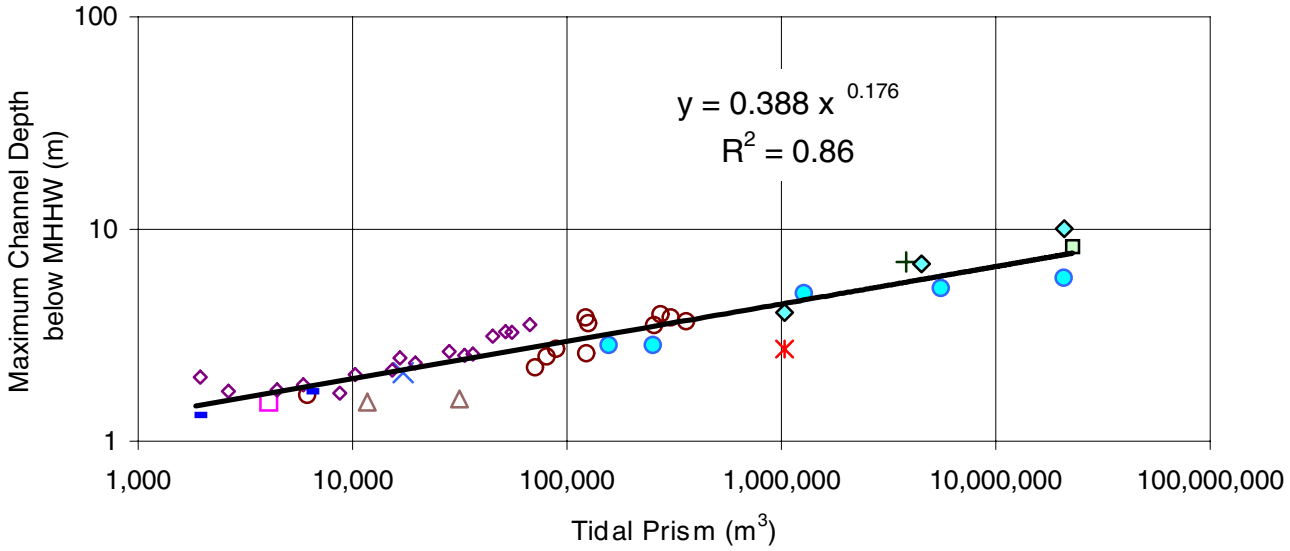
b. Channel width as a function of marsh area.

China Camp Marsh	Heerdt Marsh
Laumeister Tract	Newark Slough
Petaluma Marsh	Ravenswood Slough (historic)
Wildcat Creek	Petaluma Historic
Napa Historic	Sonoma Historic
Gallinas Historic	San Joaquin Historic

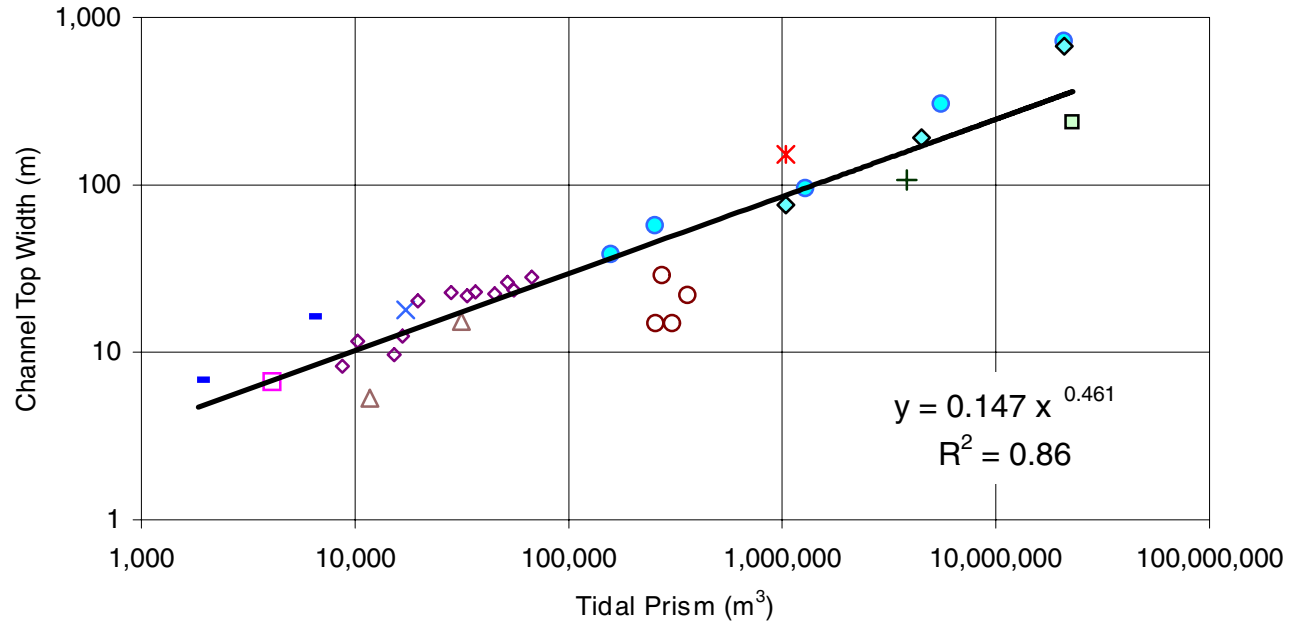
figure 15

Hydraulic Geometry
Marsh Area Relationships

PWA



a. Channel depth as a function of tidal prism.



b. Channel width as a function of tidal prism.

China Camp Marsh	Heerdt Marsh
Laumeister Tract	Newark Slough
Petaluma Marsh	Ravenswood Slough (historic)
Wildcat Creek	Petaluma Historic
Napa Historic	Sonoma Historic
Gallinas Historic	

figure 16

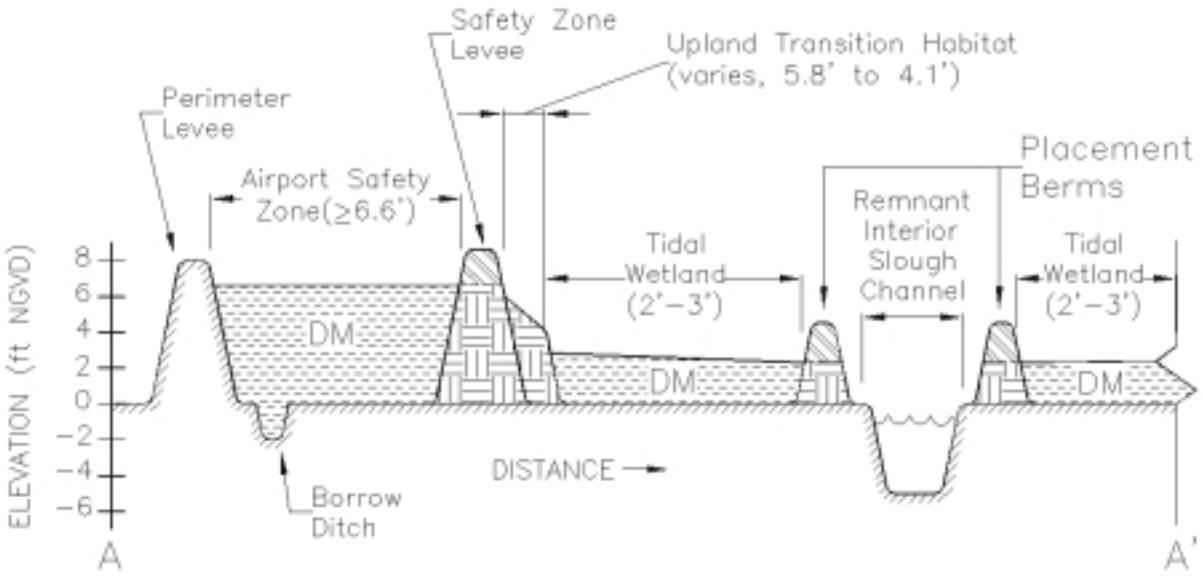
Hydraulic Geometry
Tidal Prism Relationships

PWA

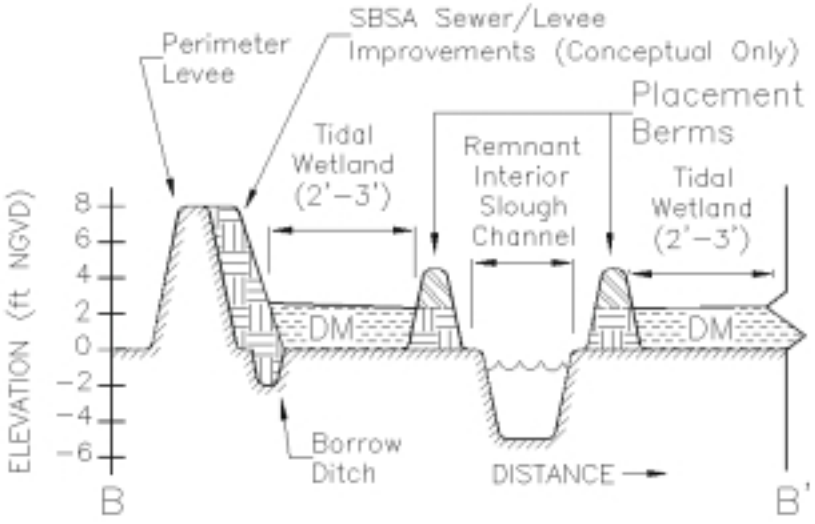
figure 17

Bair Island Restoration

Transects A and B from Inner Bair Detail

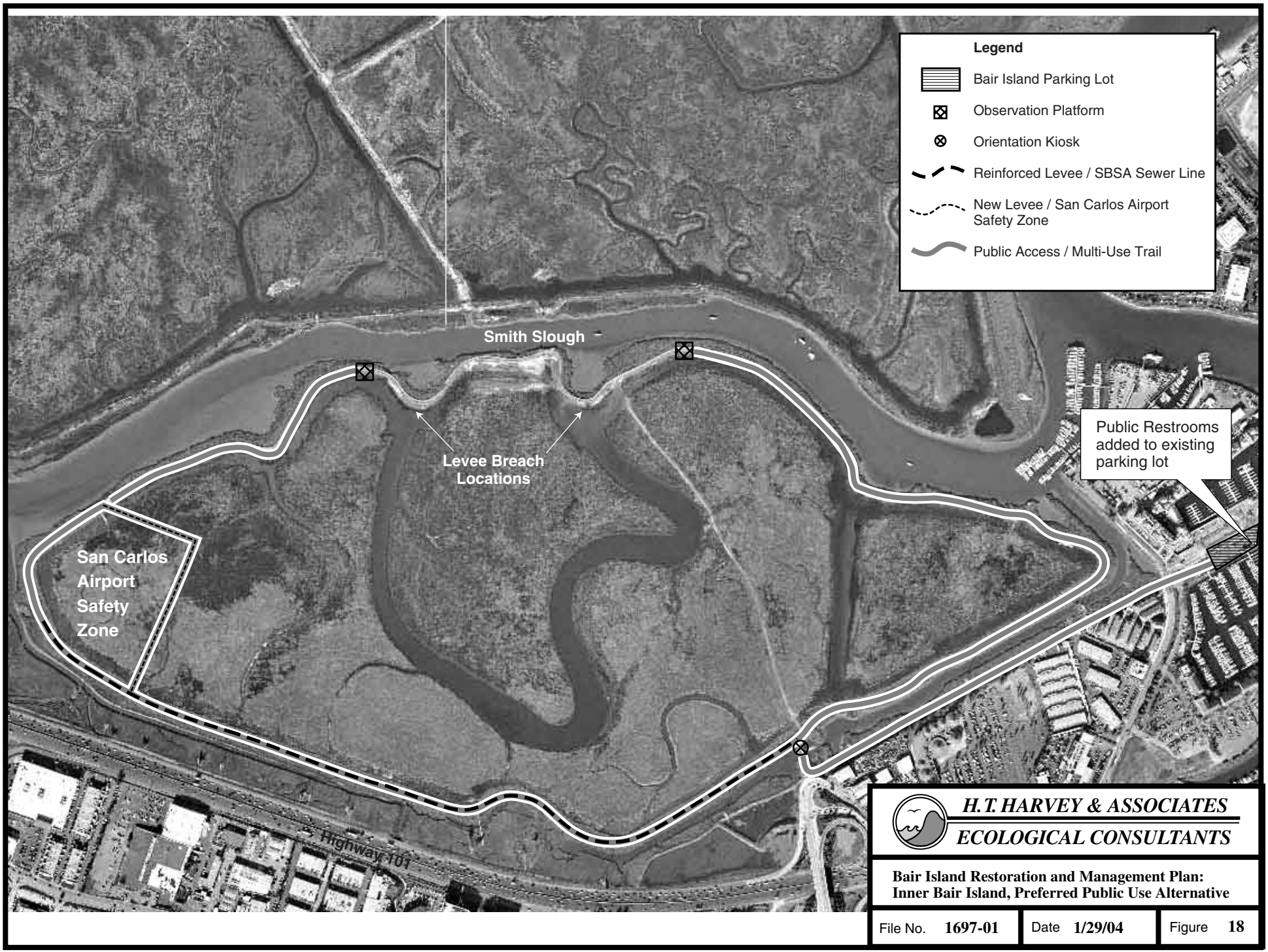


TRANSECT A–A' (NTS)



TRANSECT B–B' (NTS)

Projects\1413_Bair_CM1+2\R&M_Plan_Aug02\figs Transcts-A_B-InnrBairDetail.cdr



H.T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

Bair Island Restoration and Management Plan:
Inner Bair Island, Preferred Public Use Alternative

File No. **1697-01**	Date **1/29/04**	Figure **18**

APPENDIX B.
HYDRODYNAMIC MODELING

BAIR ISLAND RESTORATION AND MANAGEMENT PLAN

APPENDIX B: HYDRODYNAMIC AND SEDIMENT TRANSPORT MODELING

1. INTRODUCTION

Numerical modeling was conducted by PWA to assist in the development and evaluation of restoration alternatives at Bair Island. This modeling effort included hydrodynamic simulations of water levels and currents, as well as cohesive sediment transport (CST) modeling. The numerical model proved useful in identifying constraints associated with the restoration plan and developing modifications to the restoration design. The following constraints were identified through model runs and significantly affected design development:

1. Potential for increased sedimentation in the Redwood Creek Shipping Channel,
2. Potential for increased tidal currents at Pete's Harbor, and
3. Sufficient sediment supply to the breached islands.

This appendix summarizes the modeling effort and presents key findings from the analysis. A description of the numerical schemes employed in the hydrodynamic and sediment transport models are given.

2. CONCLUSIONS AND RECOMMENDATIONS

- A series of numerical simulations was carried out in order to refine the restoration alternative, and led to the August 2002 recommended restoration plan shown in Figure 2 of the main text and described in the main body of this report. Project elements include construction of a flow constriction along Corkscrew Slough, re-establishment of the historic meander along Smith Slough, and breaching only to the Steinberger Slough part of the system. These elements are intended to minimize any increase of tidal prism conveyed through Redwood Creek thereby avoiding impacts to the shipping channel and Pete's Outer Harbor (see below). Model results indicate that under this restoration configuration the tidal prism after breaching is approximately equal to existing conditions, and that impacts to Pete's Harbor and Redwood Creek will be minimal. This configuration also improves estuarine sediment supply to the interior sections of the slough network through Steinberger Slough.

- The Redwood Creek tidal channel is greatly oversized due to regular dredging needed to maintain the deep-draft navigation to the Port of Redwood City. Because it is hydraulically more efficient, Redwood Creek has captured a large portion of the tidal prism that would normally scour Steinberger Slough. This has lead to substantial shoaling along Steinberger Slough.

- Numerical simulation indicates that without flow control structures designed to re-route the flow to Steinberger Slough, most of the new tidal prism created by breaching of Middle and Inner Bair Islands will be supplied through Redwood Creek. Increases in the amount of tidal flow passing through Redwood Creek will lead to additional sedimentation in the shipping channel and increased frequency of dredging. Hydrodynamic modeling indicates that under the preferred restoration alternative, the tidal prism and velocity along the shipping channel will remain similar to existing conditions and prevent additional shoaling along Redwood Creek.

- Under existing conditions, tidal currents at Pete's Outer Harbor are at the high end of the range generally considered acceptable for boat navigation. Peak velocities are about 0.4 m/sec. Hydrodynamic modeling indicates that without any realignment of the existing flow routes with flow control structures, restoration of Middle and Inner Bair Islands to tidal action may triple peak tidal currents at Pete's Outer Harbor. This is primarily due to the fact that much of the tidal prism developed after breaching of the islands will be conveyed through Smith Slough and Redwood Creek and will pass through Pete's Outer Harbor. Hydrodynamic modeling indicates that peak tidal currents will remain at about existing levels with re-establishment of the historic Smith Slough meander and a channel block along Corkscrew Slough.

- Hydrodynamic modeling indicates that most of the tidal prism associated with the recommended restoration plan will be routed through Steinberger Slough. Besides minimizing potential project-related impacts to Pete's Outer Harbor and Redwood Creek, this routing will increase the scour potential along Steinberger Slough and reverse the shoaling observed over the past decades. Although the major source of sediment for marshplain establishment will come from the Bay, some of the material eroded along Steinberger Slough is also expected to deposit in the restored islands.

- Under existing conditions, most of the water discharged during flood events from Pulgas and Cordilleras Creeks is ultimately routed through Redwood Creek and into the Bay. Preliminary model simulations indicate that flow re-alignment designed to address the Pete's Harbor velocity and Port sedimentation issues will also restrict conveyance of flood discharges from the watershed. This will need to be addressed in the design.

- Numerical modeling shows that low tide elevations at the confluence of Steinberger and Smith Sloughs are elevated. Low-tide drainage will improve as Steinberger Slough scours. Although results from the modeled long-term scenario indicate that the tidal signal remains muted, actual drainage is likely to be better as the actual equilibrium geometry may be different than that assumed in the model.

3. DISCUSSION OF THE NUMERICAL MODEL

The flowing sections describe the numerical schemes employed in the model, selection of boundary data, and schematization of the slough-island system.

3.1 DESCRIPTION OF THE NUMERICAL SCHEMES

MIKE 11 is a software package for the simulation of flows, water quality and sediment transport in water bodies that are one-dimensional in nature. Although the actual flow is three-dimensional, most of the movement of water in the tidal slough network follows the longitudinal axis of the channels. Therefore, application of a 1-D model was used to characterize the general flow patterns, and efficiencies in the one-dimensional scheme allowed for a variety of modifications to be tested during the development of the restoration design.

Two modules were employed in the current modeling effort: the hydrodynamic (HD) and cohesive sediment transport (CST) modules. The numerical schemes of each of these modules is described below.

3.1.1 Hydrodynamic (HD) Module

The hydrodynamic module of MIKE 11 HD solves the vertically integrated equations of conservation of continuity and momentum (the 'Saint Venant' equations), based on the following assumptions:

- the water is incompressible and homogeneous;
- the bottom-slope is small;
- the wave lengths are large compared to the water depth. This ensures that vertical accelerations can be neglected and a hydrostatic pressure gradient may be assumed; and
- the flow is sub-critical (super-critical flow is modeled, but more restrictive conditions must be applied).

Discharge and water level are reported at computational points throughout the model domain. Additional parameters such as bed shear stress and cross-sectionally averaged velocity are also reported. It is important to note that since MIKE 11 is a one-dimensional model, these quantities are sectionally-averaged and may differ from point measurements collected from field surveys. Further details of the numerical scheme may be found in the MIKE 11 Reference Manual (DHI, 2001).

3.1.2 Cohesive Sediment Transport (CST) Module

The transport of suspended sediment is modeled with the advection-dispersion equation due to the low settling velocities of fine sediments. The processes of erosion and deposition are modeled as source and sink terms, respectively, in the advection-dispersion equation. The erosion rate depends on local hydraulic conditions whereas the deposition rate additionally depends on the concentration of suspended sediment. The subsections below describe how the processes of settling, deposition, erosion and consolidation are implemented in the CST model.

Estuarial sediment beds are typically composed of flow-deposited cohesive material and occur in one of three states: stationary suspension; partially consolidated beds; and fully-consolidated beds. Initial model calibration was carried out using a single-layer homogeneous consolidated bed model. Re-calibration using a multi-layer model in order to account for vertical variations in density and shear strength found in layered beds was originally expected to improve the fit between simulated and measured SSC. However, additional hydrodynamic modeling was substituted for re-calibration of the sediment transport model and changes in sedimentation were inferred from surrogate hydrodynamic parameters (see Section 4 for further discussion).

3.1.2.1 Settling

The settling velocity of sediment flocs in the deposition equation is dependent on the suspended sediment concentration. In saline water, attractive forces cause sediment particles to "stick together" (i.e. flocculate) and form flocs. Below a certain threshold concentration (approximately 10,000 mg/L), the settling velocity of flocs increases with concentration. For concentrations above this threshold, the settling velocity of flocs is reduced by the upward flow of displaced liquid. This phenomena is called hindered settling.

The more advanced multi-layer MIKE 11 CST model uses two different flow regimes to simulate the settling of sediments, separated by a user-defined suspended sediment concentration that divides flocculating suspensions from suspensions with hindered settling. These two regimes of settling velocity are expressed in the numerical model by:

$w_s = kc^m$ for flocculating suspensions *(c < C-offset)*

$w_s = w_o(1-c)^\gamma$ for hindered-settling suspension *(c > C-offset)*

where,

w_s	= settling velocity
w_o	= free settling velocity of individual flocs
k, m, and γ	= coefficients based empirical data and model calibration
c	= suspended sediment concentration
C-offset	= the concentration above which hindered settling reduces the settling velocity

The single-layer CST model that was applied to the initial calibration has a more simple description of settling. In this model, no flocculation is included in the settling velocity and only one flow regime is allowed (no hindering settling).

3.1.2.2 Deposition

Deposition is modeled as a sink term in the advection-dispersion (AD) equation in MIKE 11 CST, with the rate of deposition given by:

$$S_d = w_s c\left(1 - \frac{\tau_b}{t_{cd}}\right), \quad \text{for } \tau_b \le \tau_{cd}$$

where,

S_d = The rate of deposition (kg/m^2/s)
w_s = Mean settling velocity of the suspended particles and sediment flocs (m/s)
c = Suspended sediment concentration (kg/m^3)
τ_b = Bed shear stress (N/m^2)
τ_{cd} = Critical shear stress for deposition (N/m^2).

The bed shear stress is a function of the roughness, water depth and velocity and is computed from the HD model.

3.1.2.3 Erosion

Erosion is modeled as a source term in the advection-dispersion (AD) equation in MIKE 11 CST, with the rate of deposition given by:

$$S_e = E_o\left(\frac{\tau_b}{t_{ce}} - 1\right), \quad \text{for } \tau_b \ge \tau_{ce}$$

where,

S_e = The rate of erosion (kg/m^2/s)
E_o = Erosion rate coefficient (kg/m^2/s)
τ_b = Bed shear stress (N/m^2)
τ_{ce} = Critical shear stress for erosion (N/m^2).

The critical shear stress for erosion increases with depth for each successive bed layer. The first layer of sediment is the weakest while the bottom-most layer is the strongest or most resistant to erosion.

3.2 DESCRIPTION OF INPUT DATA

Geometric representation of the tidal slough network and restored islands were needed to construct a numerical model of the system. Additionally, boundary data were required to drive the hydrodynamic and sediment transport models, and data from interior locations were used for calibration. The paragraphs

below describe the bathymetric, hydrodynamic, and suspended sediment data used in the modeling effort. Much of this data was collected during an extensive field monitoring program by PWA, which is described in detail in a previous memorandum.

3.2.1 Bathymetry and Geometric Representation

Model bathymetry was constructed using a combination of marshplain topography and slough channel hydrography from both existing sources and surveys conducted for this study. Existing topographic information for the site consists of 1981 topographic maps of Inner and Middle Bair Islands (BKFA 1981), 1993 surveys of levee crest elevations on Inner Bair (Bohley Maley Associates, 1993), and surveys conducted for this study. Hydrographic information for the site consists of NOS bathymetric maps (NOS 1995) and field surveys conducted for this study. For the current study, PWA surveyed elevations of marshplain transects and cross-sections of levees, borrow ditches, and channels of Inner, Middle, and Outer Bair Islands in February and March, 2000. Towill surveyed 30 cross-sections of the major slough channels (Redwood Creek, Steinberger Slough, Smith Slough, and Corkscrew Slough) in February 2000. The locations of the both surveys and cross-section plots are included in Appendix E.

Figure B-1 shows the plan view of the slough network included in the model setup, and includes the existing tidal sloughs as well as the interiors of the restored islands. Note that the restored islands are schematically represented in the MIKE11 model by a network of inter-linking prismatic channels. These channels approximately model the drainage area of the restored islands with one-dimensional channels that simulate the resistance and travel time of water over the two-dimensional marshplain. The prismatic channels are sized to accurately represent the tidal prism of each drainage area. The channels are inter-connected within the interior of the restored islands. A prismatic channel connected to one breach can "transfer" water to another channel connected to another breach, such that the flow of water through the interior of the island is simulated. The channel cross-sections have wide gently-sloped marshplains connected to parabolic channels, which model the interior channels and low water drainage. Figure B-2 shows a typical cross-section for a prismatic channel representing the interior of the restored islands.

3.2.2 Tidal Boundary Condition

As part of the PWA field monitoring program, continuous signals of water surface elevation were collected at 6 platforms throughout the slough network (locations shown in Figure B-3) for approximately 30 days by vented pressure transducers (except at Platform 2 where a non-vented pressure transducer was used). The measured data from Platform 1 and 6 were applied as boundary conditions at the bayward limits of Redwood Creek and Steinberger Sloughs for both model calibration and production runs. Week-long time series from these two stations are shown in Figures B-4 and are representative of the longer record. Note the differences in low water drainage, presumably due to the shallow depth of Steinberger Slough.

3.2.3 Suspended Sediment Concentration (SSC)

Continuous point measurements of suspended sediment concentration (SSC) were collected as part of the PWA field data collection program and used during the calibration of the sediment transport model. However, a synthetic time series that was more representative of the long-term average conditions in south bay was applied as boundary conditions for the production runs. The synthetic time series is based on an approach by Schoellhamer (Schoellhamer 2001) and contains a semidiurnal component that is modified by the spring/neap cycle. Long-term mean values of measured SSC collected in the South Bay were used to establish the average values.

3.3 CALIBRATION

Measured water surface elevations, velocity, and SSC data collected during the monitoring program were compared to simulated values for the existing conditions scenario for a range of input parameters to determine the best correlation or model calibration. Bed roughness (Manning's 'n') was adjusted in the hydrodynamic model in order to optimize the match between measured and simulated water levels and velocities. Calibration of the single-layer sediment transport model setting the settling velocity to 0.05 mm/s and varying the parameters in the erosion and deposition expressions. This included the erosion rate coefficient (E_o), critical stresses for the initiation of erosion and deposition (τ_{ce} and τ_{cd}).

3.3.1 Water Surface Elevation

Figures B-5 through B-10 compare simulated and measured water surface elevations at the six monitoring stations throughout Bair Island. In general, the comparison is extremely good with model results tracking the field data in both phase and magnitude. Results from Platform 3 for the seven-day period covered in Figure B-7 are typical. For this case, the root-mean-squared (RMS) difference between modeled and measured water levels is only 71 mm (approximately 2% of the tidal range). Additionally, elevations of high and low waters that are important in determining the extents of tidal inundation are well predicted by the model.

3.3.2 Velocity

Figures B-11 through B-16 compare simulated and measured currents at the monitoring platforms. These plots indicate that currents simulated by the hydrodynamic model match the measured point velocities fairly well. In particular, the modeled and measured currents at Platform 3 have an RMS difference of 0.07 m/sec for the eight-day period shown in Figure B-13. Peak currents play an important role in erosion of bed sediments and are well predicted by the model. For the results shown in Figure B-13 (Platform 3) the peak currents have an RMS difference of 0.04 m/sec (approximately 10% of the peak values).

The measured time-histories were from point current velocities. These were confirmed to be representative of the average velocity through the slough. Discharge and cross-section area from acoustic Doppler current profiler (ADCP) measurements were used to compute the average velocity. These

computations indicate that the measured point current measurements are representative of average flows in the slough and can be used to calibrate the vertically- and laterally-averaged flows computed by the model.

3.3.3 Suspended Sediment Concentration (SSC)

Continuous point measurements of suspended sediment concentration (SSC) were made at the each of the 6 platforms for approximately 30 days using OBS instruments and used to calibrate the sediment transport model. However, significant biofouling limited the amount of useful data collected by the OBS instruments over the monitoring period. Figure B-17 shows clean SSC time series for Platforms 1, 2 and 3 over a 7-day period. Figure B-18 shows OBS data over the same period for Platforms 4, 5 and 6. Collection of OBS data at Platforms 4, 5 and 6 was particularly difficult at low water due to the shallow depths of upstream portions of Steinberger and Corkscrew Sloughs.

Simulated and measured SSCs over a 3-day period as well as the simulated WSE at each of the platforms are plotted in Figures B-19 through B-24 for the single-layer model calibration. The ambient values of SSC match well, but differences between the simulated and measured peak values are evident. However, rough estimate of the amount of net sedimentation over lower Redwood Creek was close to the typical yearly deposition rates based on recorded dredge volumes.

An attempt to recalibrate the CST model with the multi-layer module did not provide a better fit within the time available, and further refinement of the sedimentation model was not pursued for two reasons. Firstly, other methods were available for analysis of the restoration alternatives. Secondly, and more importantly, refinement of the CST model is not expected to change the restoration plan since design modifications implemented to meet constraints at Pete's Harbor and maintain existing tidal prism through Redwood Creek (a surrogate indicator of sedimentation in lower Redwood Creek) already maximize the sediment delivery to the Middle and Outer Bair.

4. RESTORATION MODELING

4.1 APPROACH

4.1.1 Evaluation of the November 2000 Recommended Alternative

The initial version of the restoration design, developed in November 2000, consisted of filling Inner Bair with dredged material and breaching each island at several historic channel locations. It was similar to the recommended alternative (described in Section 5 of the main report) but without flow control structures in Smith and Corkscrew Sloughs. Modeling was used to assess the performance of the November 2000 alternative and the following design issues were identified:

- Potential to increase sedimentation in the Redwood Creek Shipping channel,
- Potential to increase tidal velocities in Pete's Outer Harbor, and
- Potential for low sediment supply to the restoration site, particularly Middle Bair.

4.1.2 Evaluation of the Design Modifications

The November 2000 alternative was refined through a series of model runs which simulated various changes to the restoration plan. In order to make this optimization process tractable, key independent and dependent variables were identified at the beginning of the modeling exercise. Permutations to the restoration plan were constructed by adjusting the following independent variables in the model set-up:

- Number of breaches,
- Phasing of breaches,
- Channel enlargement at Pete's Outer Harbor,
- By-pass channel around Pete's Outer Harbor,
- Dredging of Steinberger Slough, and
- Use of flow control structures in the sloughs.

The effectiveness of each design modification was assessed by examining key dependent parameters. These dependent parameters were selected based upon the design issues listed above and consisted of the following:

- Average tidal prism at Redwood Creek and Steinberger Slough,
- Peak velocity at Pete's Outer Harbor,
- Low tide drainage in Steinberger Slough,
- Net transport of suspended sediment through the sloughs, and
- Sediment accumulation in the restored islands.

The run catalogue (Table B-1) identifies the potential design solutions/modifications tested in each simulation. These potential design solutions tested in the model are described below.

4.1.2.1 Sedimentation in the Redwood Creek Shipping Channel

The potential for increased sedimentation in Redwood Creek for the November 2000 alternative is due to the fact that the restored tidal flows to and from Middle and Inner Bair Islands draw largely from the shipping channel rather than Steinberger Slough. As the Redwood Creek shipping channel is dredged and vastly oversized in relation to its tidal flow, it serves as an effective sediment trap. The sediment transport modeling suggests that the November 2000 alternative would result in an approximate three-fold increase in the rate of sedimentation within the shipping channel (see results in Section 4.2) due to an increase in the flow of sediment-laden water through Redwood Creek.

Initial sediment transport simulations indicated that increases in flow through Redwood Creek resulted in increased shoaling along the shipping channel. Therefore, the design criteria used in the development of design modifications was to match tidal prism through Redwood Creek and direct flow through Steinberger Slough. The potential design solutions developed to resolve this issue include:

- constricting flows in Smith and Corkscrew Sloughs using flow control structures,
- altering the number, size, and location of breaches to preferentially breach to Steinberger and Corkscrew Sloughs,
- dredging Steinberger Slough, and
- phasing restoration so that Outer and Middle Bair scour and deepen Steinberger Slough before breaching Inner Bair.

Section 5 of the main report provides descriptions of the proposed flow control structures.

4.1.2.2 Tidal Velocities at Pete's Outer Harbor

The above design approach and solutions were also applied to address the potential for increases in tidal velocities at Pete's Outer Harbor. Results from the modeling of the November 2000 alternative show an increase in velocities at Outer Pete's Harbor from approximately one foot per second (fps) under existing conditions to nearly three fps (see results in Section 4.3). Generally accepted marina design guidelines indicate that velocities above 1 fps pose navigation difficulties for small watercraft and post-project velocities of up to 3 fps are therefore not likely to be acceptable to the marina. Although the increase in velocities would diminish over time as the channel scours and the islands fill with sediment, there are design solutions to expedite or avoid this process. The design solutions discussed above in reference to sedimentation in the Redwood Creek shipping channel (Section 4.1.1) serve to direct increased tidal flows preferentially towards Steinberger and Corkscrew Sloughs and away from Redwood Creek and Smith Slough, thus reducing tidal flows and velocities at Pete's Outer Harbor. Additional design solutions for Pete's Outer Harbor include:

- Widening Smith Slough in the vicinity of the harbor to increase the cross-sectional flow area and
- Constructing a bypass channel through Middle Bair to route flow around Pete's Outer Harbor.

4.1.2.3 Sediment Supply to the Restoration Site

The phenomena of increased sedimentation rates in the Redwood Creek shipping channel for the November 2000 alternative has the added ramification of potentially decreasing sediment supply to the restoration site, particularly Middle and Inner Bair Islands. The primary sediment sources for natural estuarine deposition at Inner, Middle, and Outer Bair Islands are the shallow mudflats of San Francisco Bay. When sediment derived from this source is conveyed to the restoration site through Redwood Creek, sediment that would otherwise be available for deposition within the restoration site settles out in the oversized shipping channel. Restored areas that draw flow and sediments largely from Redwood Creek, such as Middle and Inner Bair Islands in the November 2000 alternative, will have a lower sediment supply than areas that draw directly from the Bay or Steinberger Slough. Decreased sediment supply will delay site evolution and vegetation. This is more of an issue for Middle Bair than Inner Bair, since Middle Bair relies on estuarine sedimentation rather than dredge material for habitat evolution. By directing tidal flows away from Redwood Creek and towards Steinberger Slough, the same design solutions employed to resolve the Redwood Creek shipping channel siltation issue have the effect of resolving the sediment supply issue as well.

4.1.3 August 2002 Recommended Alternative

After testing the various design solutions in a series of model runs listed in Table B-1, we arrived at a new recommended alternative. The design solution for the recommended alternative, referred to here as the August 2002 Recommended Alternative, is to include flow control structures in Smith and Corkscrew Sloughs and to eliminate one Middle Bair breach such that tidal exchange to this island is provided only from the Steinberger Slough side of the flow control structures.

4.2 RESULTS

Model results for key performance indicators are listed by model run in Tables B-1 and B-2 for hydrodynamics and sediment transport, respectively. This section compares model results for existing conditions and both the November 2000 and August 2002 alternatives for the following performance parameters:

- Sedimentation in the Redwood Creek shipping channel,
- Velocities at Pete's Outer Harbor, and
- Sediment supply to the restored islands.

Overall, the refined design presented here (August 2002 Alternative) has successfully resolved potential problems with the previous November 2000 Alternative.

4.2.1 Sedimentation in the Redwood Creek Shipping Channel

Sediment transport modeling indicates that the November 2000 alternative would result in approximately three times the existing rates of siltation rates in the shipping channel (Table B-2). Since initial sediment transport simulations (Runs 1-7) indicated that an increase in tidal prism results in increased siltation rates, the design criteria was to match restored tidal prism with existing tidal prism in the shipping channel. In the later runs (Runs 8-15), tidal prism through Redwood Creek was used as an indicator for potential sediment accumulation in the channel. Using a hydrodynamic design criterion (tidal prism) rather than a sediment transport criterion (siltation rates) allowed us to model and analyze each run more quickly and therefore to increase the total number of scenarios modeled within the scope of the study. Tidal prism at the mouth of Steinberger Slough is shown on Table B-2 and was used as a preliminary measure of project performance. For the August 2002 Alternative (Run 15X), we also conducted a more detailed comparison of tidal prisms at several Redwood Creek cross-section locations.

For the August 2002 Alternative, model results show that tidal prism in Redwood Creek shipping channel is about 15% less than under existing conditions. Sedimentation rates in the shipping channel are therefore expected to remain unchanged or decrease slightly. This is supported by the sediment transport modeling results for Runs 5 and 6, which are similar in configuration to the August 2002 alternative. These results show no increase in sediment accumulation in Redwood Creek.

4.2.2 Velocities at Pete's Outer Harbor

Peak tidal velocities at Pete's Outer Harbor of approximately 1.2 to 1.3 m/s were modeled for the November 2000 Alternative, which are over three times greater than existing peak velocities as shown in Figure B-24. For the August 2002 Alternative, model results indicate that the tidal prism passing through Redwood does not increase, therefore peak velocities are about the same as existing conditions.

4.2.3 Sediment Supply to the Restored Islands

The hydrodynamic modeling results for the August 2002 Alternative indicate that most of the water supplied to the restored islands will be conveyed through Steinberger Slough, avoiding the losses of sediment to the Redwood Creek sediment "sink." Although sediment transport modeling was not conducted for the August 2002 alternative (hydrodynamic modeling only), results for Runs 5 and 6, which are similar in configuration to the August 2002 alternative, are available. These results indicate initial sedimentation rates of approximately 15 mm/yr for Outer Bair, 5 to 9 mm/yr for Middle Bair, and 0 to 1 mm/yr for Inner Bair.

4.2.4 Other Considerations

Hydrodynamic simulations of the August 2002 Alternative indicate elevated low water levels at the upstream reaches of Steinberger Slough. Figure B-25 plots water level time series from the confluence of Steinberger and Smith Sloughs for existing conditions as well as restored conditions.

The impacts of elevated low waters on flooding is being examined in a separate task, and results from that analysis will be forthcoming in a technical memorandum. However, these effects are expected to be temporary until sufficient scouring occurs along Steinberger Slough and within the channels in the interior of the islands.

REFERENCES

Danish Hydraulic Institute (DHI) 2001. MIKE 11 General Reference Manual.

Schoellhamer, David H. 2001. Singular Spectrum Analysis for Time Series with Missing Data, Geophysical Research Letters.

ATTACHMENTS

Table B-1. Summary of Modeling Runs and Hydrodynamic Results
Table B-2. Summary of Modeling Runs and Sediment Transport Results

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Figure B-25. Modeled Velocity at Pete's Harbor
Figure B-26. Water Surface Elevations in Restored Islands, August 2002 Recommended Alternative

BAIR ISLAND RESTORATION

TABLE B-1. Summary of Modeling Runs and Hydrodynamic Results

RUN ID	Description	Time	Site Evolution Simulated	DESIGN MODIFICATION INCLUDED IN RUN						HYDRODYNAMIC RESULTS			
				# breaches	phasing	Channel Enlargement at Pete's Outer Harbor	Pete's Harbor Bypass Channel	Dredge Steinberger	Locations of flow control structures	Elevation of LLW at Smith @ Stein. Sl [m NGVD]	Peak Velocity at Pete's Outer Harbor [m/s]	Tidal Prism [M m^3]	
												Redwood Creek	Steinberger Slough
1	Existing Conditions	t (0)	none	none	n.a.	none	none	none	none	-1.62	0.38	5.8	1.1
3	November 2000 Recommended Alternative, initial conditions	t (0)	none	12	simultaneous	none	none	none	none	-1.54	1.28	8.0	2.1
4	November 2000 Recommended Alternative, long-term conditions	t (X)	long-term slough scour	12	simultaneous	none	none	none	none	-1.54	1.20	7.9	2.3
5	Restoration with channel blocks and one MB breach to east of Corkscrew block	t (0)	none	12	simultaneous	none	none	none	Smith Sl. (east of MB3) and Corkscrew Sl. (between OB2 and MB2)	0.28	0.04	4.9	2.7
6	Restoration with channel blocks	t (0)	none	12	simultaneous	none	none	none	Smith Sl. (east of MB3) and Corkscrew Sl. (east of MB2)	0.35	0.05	4.6	2.5
7	Phased breaching of Middle Bair	t (MB)	marshplain sedimentation at Inner and Outer Bair	12	MB breached after OB and IB reach pickleweed elevation	none	none	none	none	-1.56	1.08	7.4	1.6
8	Widening Smith Sl. At Pete's Harbor	t (0)	none	12	simultaneous	yes, small	none	none	none	-1.55	0.79	7.6	2.1
9	Restoration with channel block at Inner Bair and Wide/Deep of Smith Sl.	t (0)	none	12	simultaneous	yes	none	none	Smith Slough between IB1 and IB2	-0.46	0.37	6.5	2.7
10	Re-establish Meander Thru Inner Bair + Wide/Deep of Smith Sl. + block at Corkscrew Sl.	t (0)	none	12	simultaneous	yes	none	none	Smith Sl. (between IB1 & IB2) and Corkscrew Sl. (east of MB2)	0.01	0.39	5.5	2.7
11	Re-establish Meander Thru Inner Bair + Wide/Deep of Smith Sl. + block at Corkscrew Sl.	t (X)	long-term slough scour	12	simultaneous	yes	none	none	Smith Sl. (between IB1 & IB2) and Corkscrew Sl. (east of MB2)	-0.16	0.4	5.5	3.1
12a	Only breach MB to Corkscrew with block in Smith Slough	t (0)	none	9	simultaneous	yes	none	none	Smith Slough between IB1 and IB2	-0.34	0.21	7.3	1.4
12b	Only breach MB to Corkscrew	t (0)	none	9	simultaneous	none	none	none	none	-1.48	0.48	7.1	1.6
13a	Dredge Steinberger	t(0)	none	12	simultaneous	none	none	mouth to upstream of Corkscrew	none	-1.30	1.15	7.8	2.5
13b	Dredge Steinberger with channel blocks	t(0)	none	12	simultaneous	none	none	mouth to upstream of Corkscrew	Smith Sl. (between IB1 & IB2) and Corkscrew Sl. (east of MB2)	-1.00	0.69	6.7	4.0
13c	Long Dredge of Steinberger with channel blocks	t(0)	none	12	simultaneous	none	none	mouth to Smith	Smith Sl. (between IB1 & IB2) and Corkscrew Sl. (east of MB2)	-1.02	0.68	5.5	4.3
14a	By-Pass Pete's Harbor with blocks	t(0)	none	12	simultaneous	yes	bypass channel	none	Smith Sl. (between IB1 & IB2) and Corkscrew Sl. (east of MB2)	0.05	0.49	9.0	2.7
14b	By-Pass Pete's Harbor without blocks	t(0)	none	12	simultaneous	none	bypass channel	none	none	-1.63	0.57	8.6	2.1
15a	August 2002 Recommended Alternative, initial conditions	t(0)	none	11	simultaneous	none	none	none	Smith Sl. (between IB1 & IB2) and Corkscrew Sl. (east of MB2)	0.24	0.42	5.0	2.6
15b	August 2002 Recommended Alternative, with dredging	t(x)	none	11	simultaneous	none	none	mouth to Smith	Smith Sl. (between IB1 & IB2) and Corkscrew Sl. (east of MB2)	-1.06	0.39	5.0	4.3
15x	August 2002 Recommended Alternative, long-term conditions	t(x)	long-term slough scour	11	simultaneous	none	none	none	Smith Sl. (between IB1 & IB2) and Corkscrew Sl. (east of MB2)	0.06	0.42	5.0	3.6

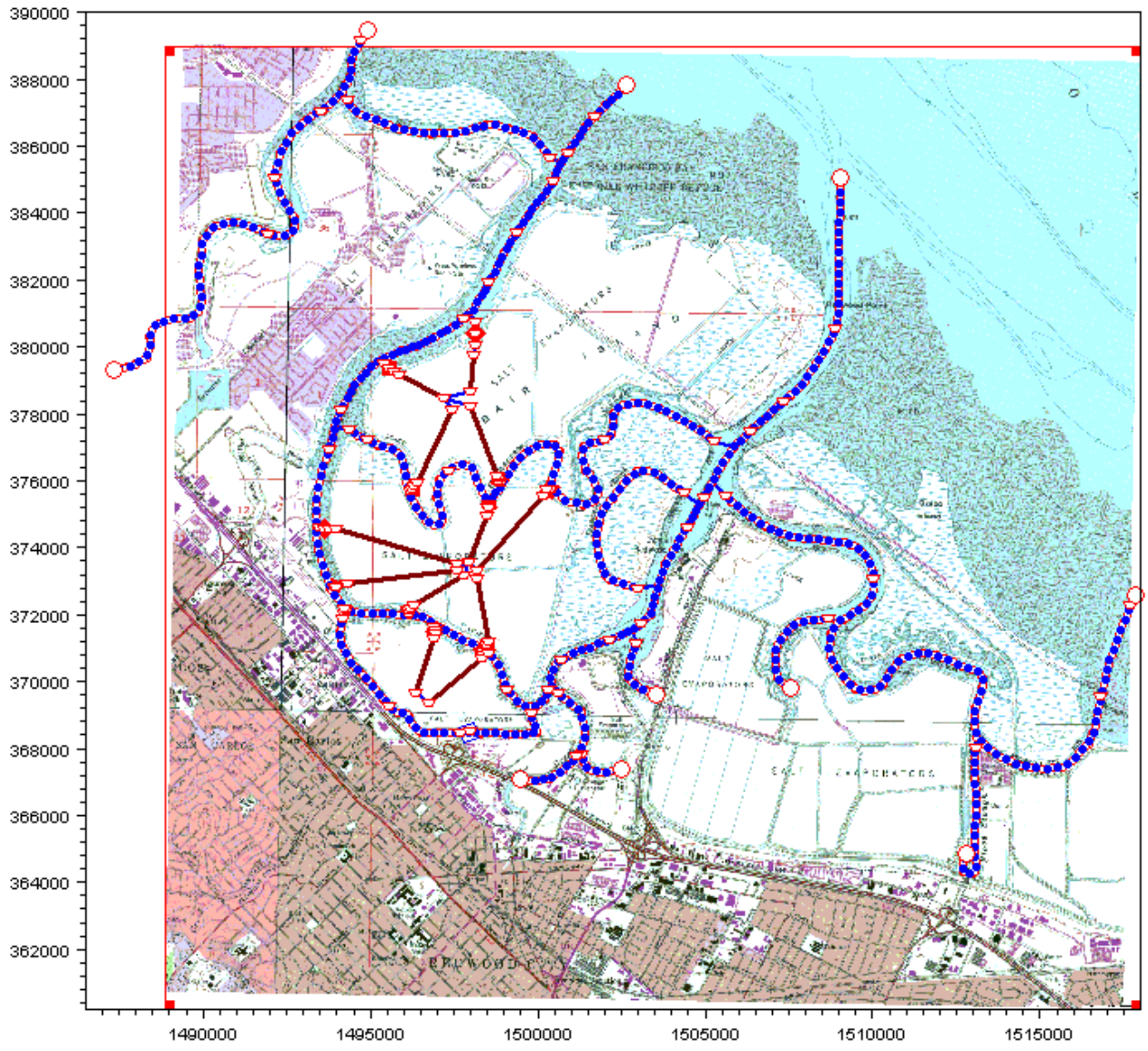
Note: Tidal prism determined by computed cumulative discharge from 6/17/2001 22:00 to 6/18/2001 23:00
LLW = lower low water, taken as LLW SMITH @ STEINBERGER on 6/23
For Runs 3-14, MB3 breach is east of IB2; for Run 15, there are no Middle Bair breaches east of IB2 and MB3 is west of IB1.
IB = Inner Bair; MB = Middle Bair; OB = Outer Bair

BAIR ISLAND RESTORATION

TABLE B-2. Summary of Modeling Runs and Sediment Transport Results

RUN ID	Description	Time	SEDIMENT TRANSPORT RESULTS								
			Sedimentation Rates (mm/yr)			Tidal Prism [M m^3] (for reference)		Sediment Transport [M kg/yr]			Sediment Accumulation in Lower Redwood Creek [M kg/yr]
			Outer Bair	Middle Bair	Inner Bair	Redwood Creek	Steinberger Slough	Smith @ RC	Stein @ Bay	Cork @ RC	Project
1	Existing Conditions	t (0)	n.a.	n.a.	n.a.	5.8	1.1	6.2	5.0	2.8	33
3	November 2000 Recommended Alternative, initial conditions	t (0)	28	12	5	8.0	2.1	18.1	33.4	9.0	106
4	November 2000 Recommended Alternative, long-term conditions	t (X)	25	13	7	7.9	2.3	19.2	32.4	11.7	96
5	Restoration with channel blocks and one MB breach to east of Corkscrew block	t (0)	15	9	0	4.9	2.7	0.3	43.5	13.2	31
6	Restoration with channel blocks	t (0)	15	5	1	4.6	2.5	0.4	52.5	1.7	30
7	Phased breaching of Middle Bair	t (MB)	7	10	1	7.4	1.6	14.6	17.1	9.7	97
8	Widening Smith Sl. At Pete's Harbor	t (0)	n.a.	n.a.	n.a.	7.6	2.1	n.a.	n.a.	n.a.	n.a.
9	Restoration with channel block at Inner Bair and Wide/Deep of Smith Slough	t (0)	n.a.	n.a.	n.a.	6.5	2.7	n.a.	n.a.	n.a.	n.a.
10	Re-establish Meander Thru Inner Bair + Wide/Deep of Smith Sl. + block at Corkscrew Sl.	t (0)	n.a.	n.a.	n.a.	5.5	2.7	n.a.	n.a.	n.a.	n.a.
11	Re-establish Meander Thru Inner Bair + Wide/Deep of Smith Sl. + block at Corkscrew Sl.	t (X)	n.a.	n.a.	n.a.	5.5	3.1	n.a.	n.a.	n.a.	n.a.
12a	Only breach MB to Corkscrew with block in Smith Slough	t (0)	n.a.	n.a.	n.a.	7.3	1.4	n.a.	n.a.	n.a.	n.a.
12b	Only breach MB to Corkscrew	t (0)	n.a.	n.a.	n.a.	7.1	1.6	n.a.	n.a.	n.a.	n.a.
13a	Dredge Steinberger	t(0)	n.a.	n.a.	n.a.	7.8	2.5	n.a.	n.a.	n.a.	n.a.
13b	Dredge Steinberger with channel blocks	t(0)	n.a.	n.a.	n.a.	6.7	4.0	n.a.	n.a.	n.a.	n.a.
13c	Long Dredge of Steinberger with channel blocks	t(0)	n.a.	n.a.	n.a.	5.5	4.3	n.a.	n.a.	n.a.	n.a.
14a	By-Pass Pete's Harbor with blocks	t(0)	n.a.	n.a.	n.a.	9.0	2.7	n.a.	n.a.	n.a.	n.a.
14b	By-Pass Pete's Harbor without blocks	t(0)	n.a.	n.a.	n.a.	8.6	2.1	n.a.	n.a.	n.a.	n.a.
15a	August 2002 Recommended Alternative	t(0)	n.a.	n.a.	n.a.	5.0	2.6	n.a.	n.a.	n.a.	n.a.
15b	August 2002 Recommended Alternative	t(x)	n.a.	n.a.	n.a.	5.0	4.3	n.a.	n.a.	n.a.	n.a.
15x	August 2002 Recommended Alternative	t(x)	n.a.	n.a.	n.a.	5.0	3.6	n.a.	n.a.	n.a.	n.a.

Note: Tidal prism determined by computed cumulative discharge from 6/17/2001 22:00 to 6/18/2001 23:00
LLW = lower low water, taken as LLW SMITH @ STEINBERGER on 6/23
For Runs 3-14, MB3 breach is east of IB2; for Run 15, there are no Middle Bair breaches east of IB2 and MB3 is west of IB1.
IB = Inner Bair; MB = Middle Bair; OB = Outer Bair



NOTES: Planview of network of 1D channels used in numerical model. Tidal sloughs are constructed directly from surveyed bathymetery. Restored interiors of Outer, Middle and Inner Bair Islands are idealized by prismatic channels and are based to topographic surveys, draignage areas, and breach configuration.

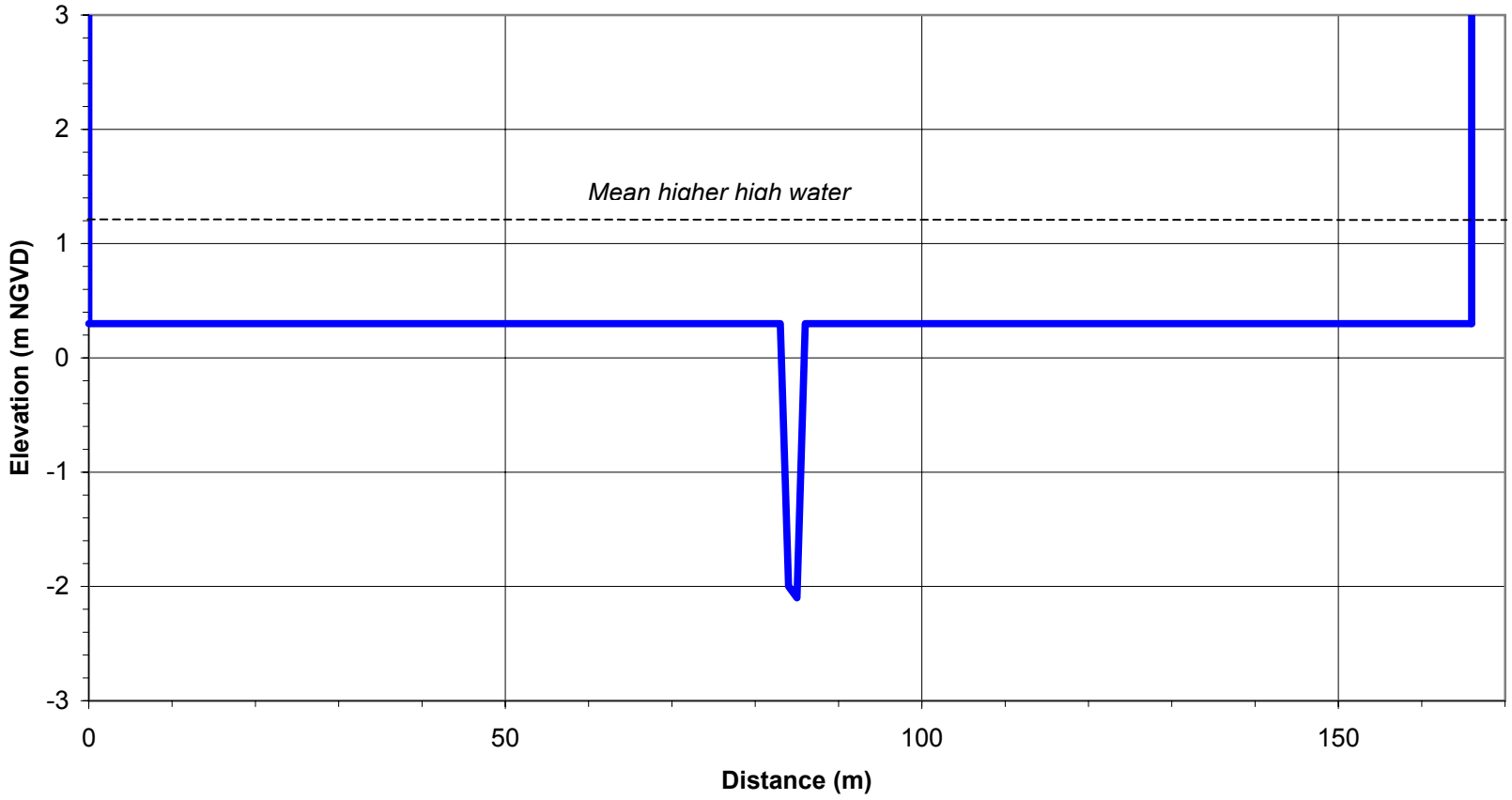
Figure B-1

Bair Island Restoration

MIKE11 Model Layout

PWA

PWA #: 1413.01



NOTES: Pond elevation is based on average elevation, with length and width selected to match drainage area.

figure B-2

Bair Island Restoration

Example of Pond Interior Prismatic Channel Cross-Section

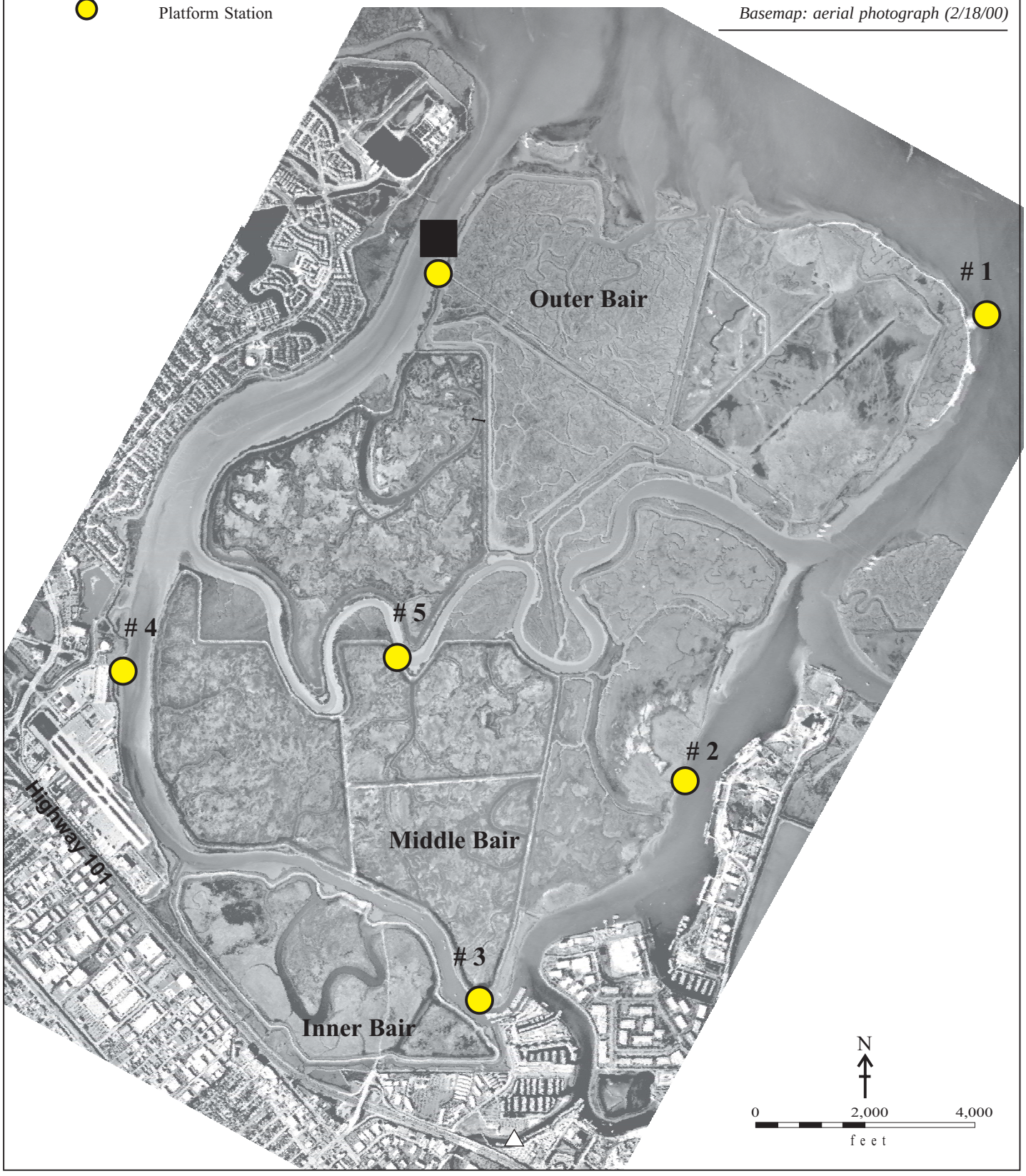
PWA

PWA #:1413

Figure B-3

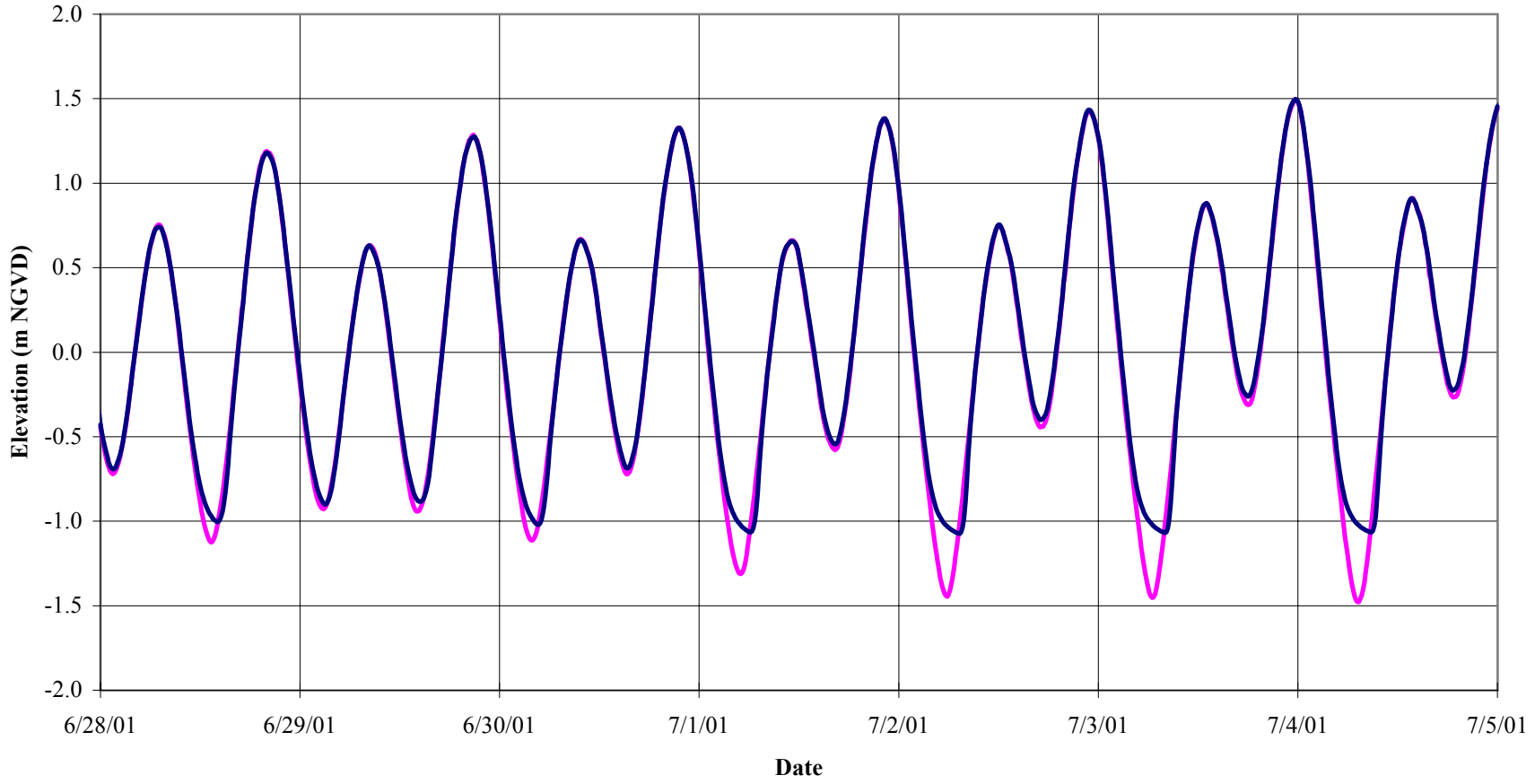
Field Survey Locations

Basemap: aerial photograph (2/18/00)



1413 fieldwork.cdr

PWA



Platform 1, Redwood Creek — Platform 6, Steinberger Slough

Source: PWA flield survey (vented pressure transducer)

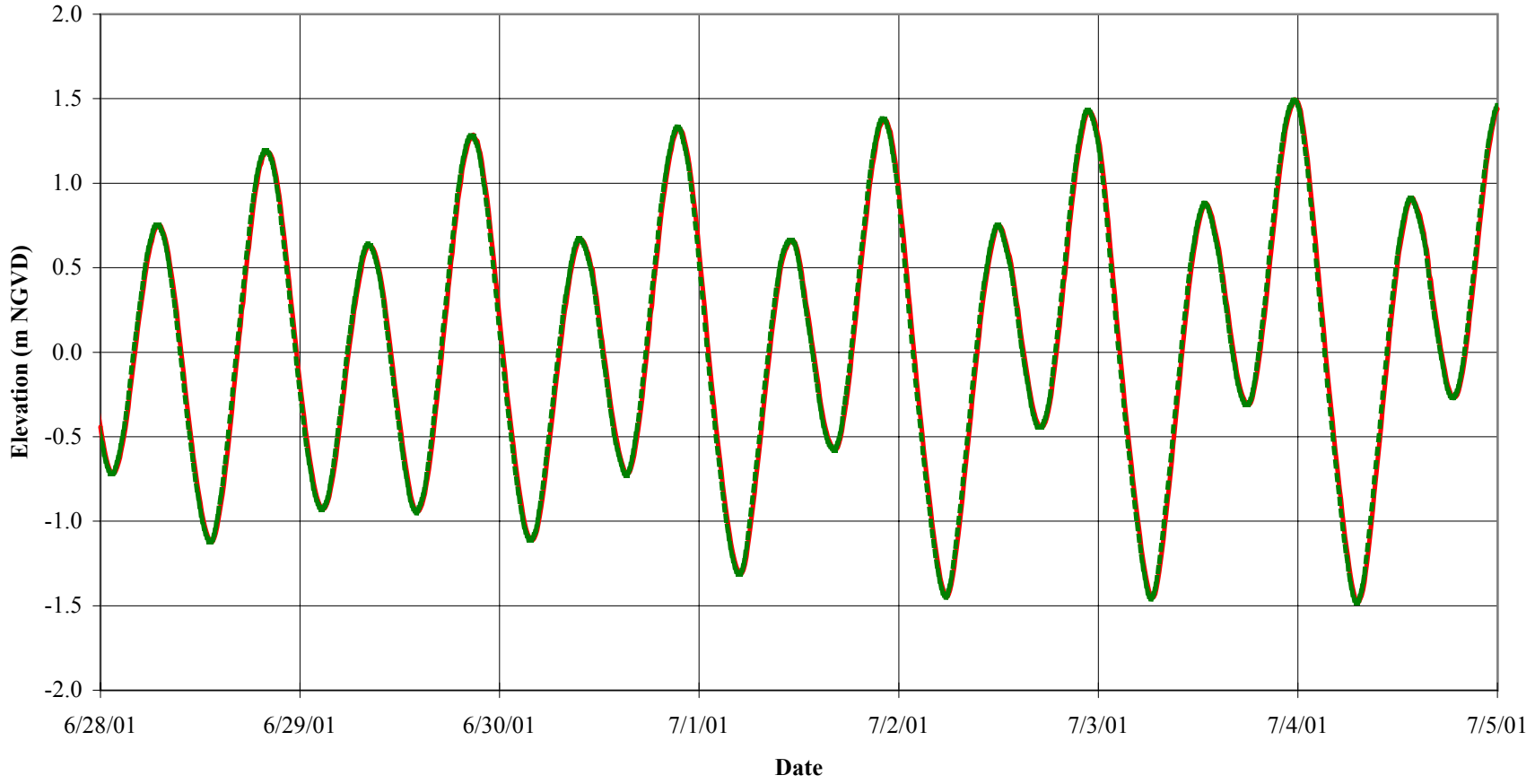
Figure B-4

Bair Island Restoration

Water Surface Eleivations (Boundary Conditions)

PWA

PWA #: 1413.01



Measured

Simulated

Source: PWA flield survey (vented pressure transducer) and numerical simulation

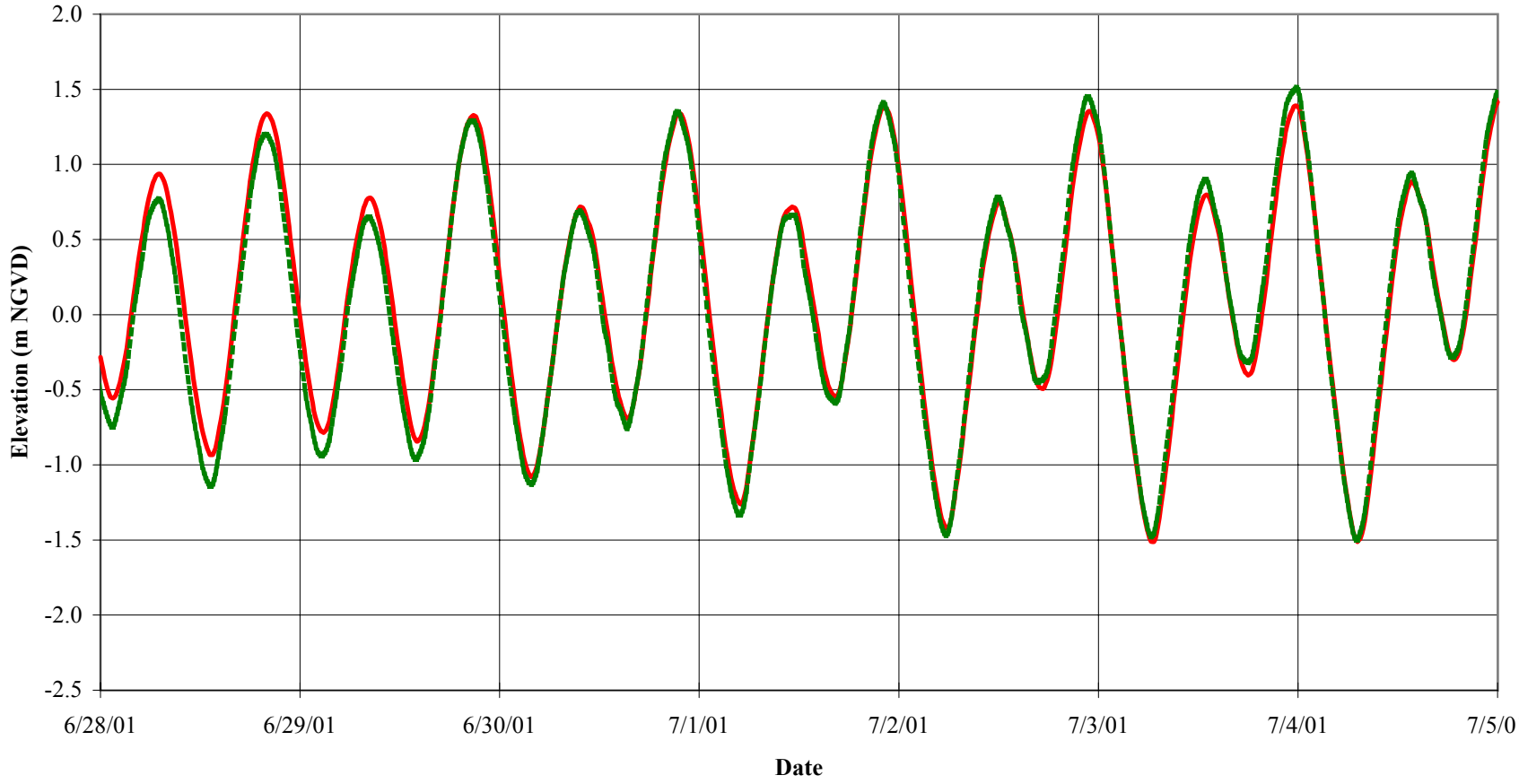
Figure B-5

Bair Island Restoration

Water Surface Elevations Platform 1

PWA

PWA #: 1413.01



Measured

Simulated

Source: PWA flield survey (unvented pressure transducer) and numerical simulation

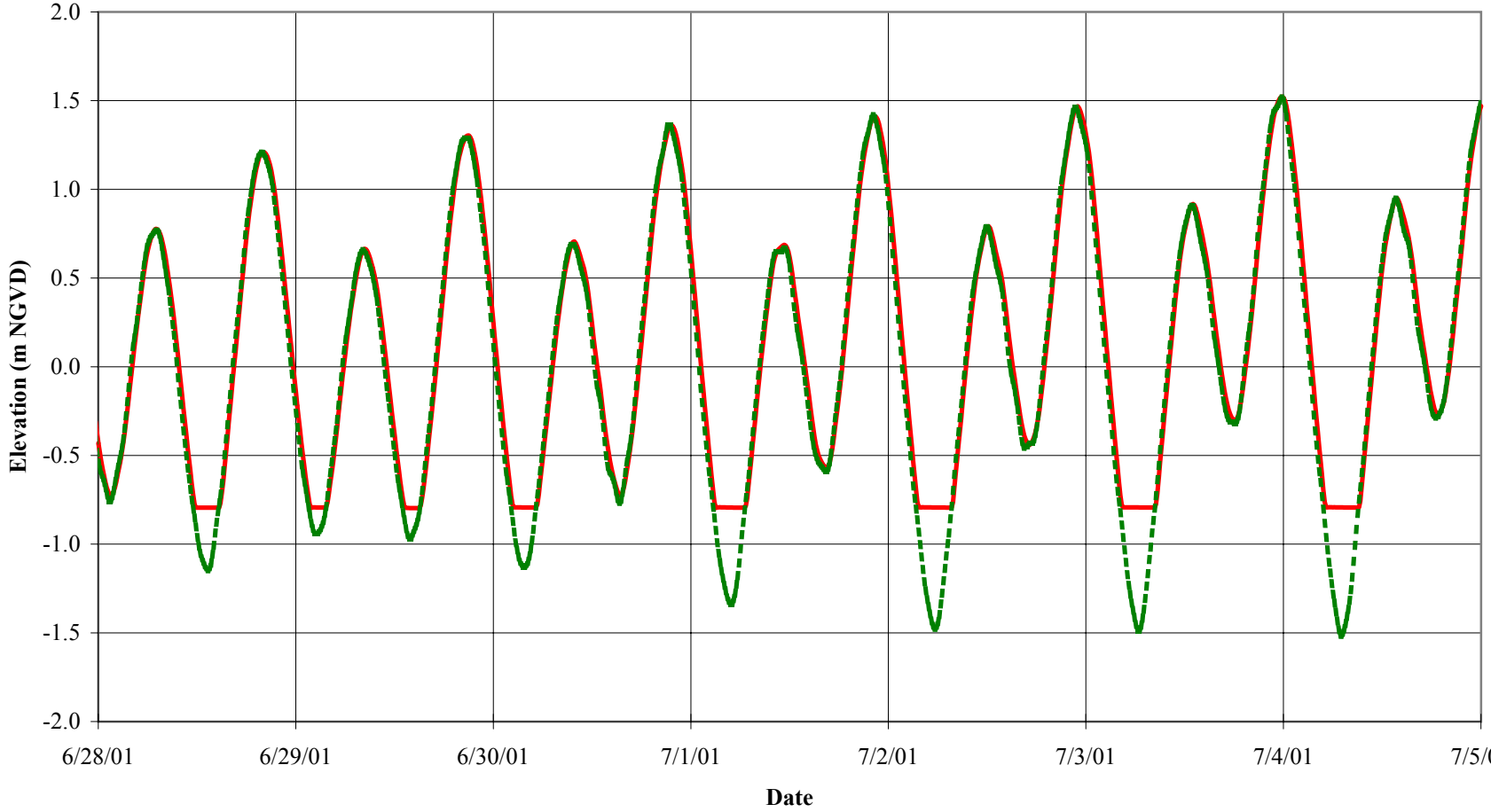
Figure B-6

Bair Island Restoration

Water Surface Elevations Platform 2

PWA

PWA #: 1413.01



Measured

Simulated

Source: PWA flield survey (vented pressure transducer) and numerical simulation

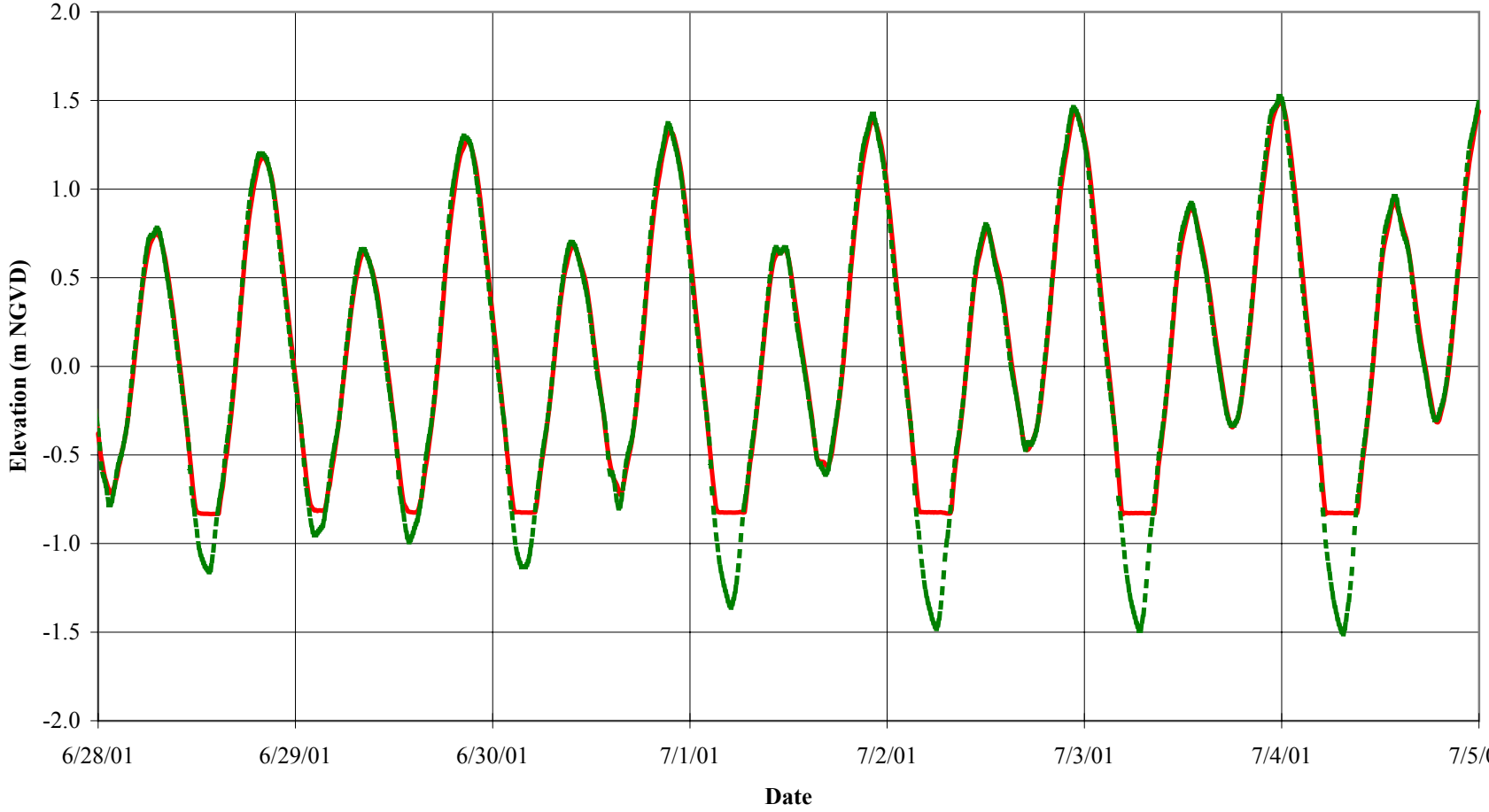
Figure B-7

Bair Island Restoration

Water Surface Elevations Platform 3

PWA

PWA #: 1413.01



Measured

Simulated

Source: PWA flield survey (vented pressure transducer) and numerical simulation

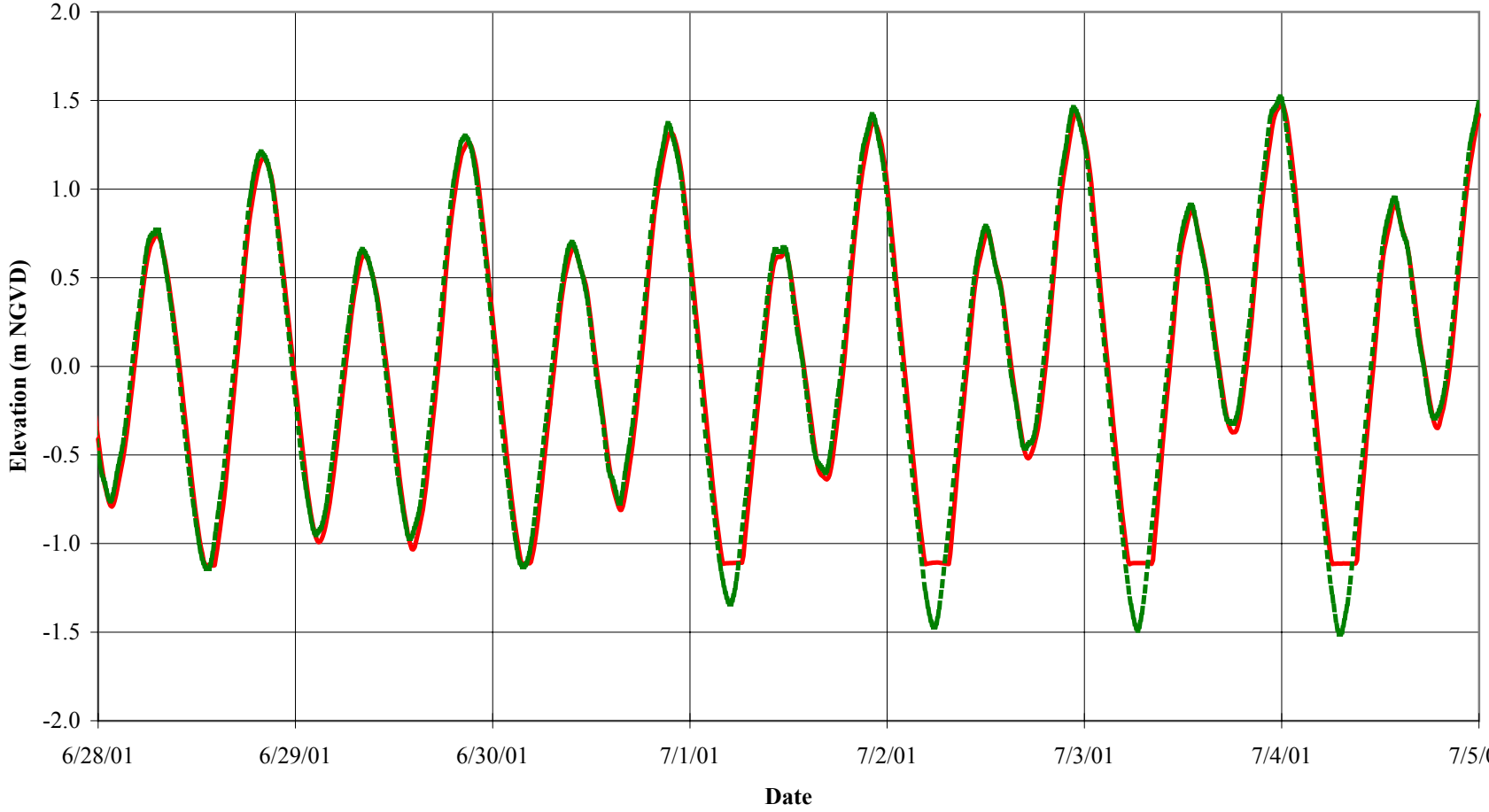
Figure B-8

Bair Island Restoration

Water Surface Elevations Platform 4

PWA

PWA #: 1413.01



Measured

Simulated

Source: PWA flield survey (vented pressure transducer) and numerical simulation

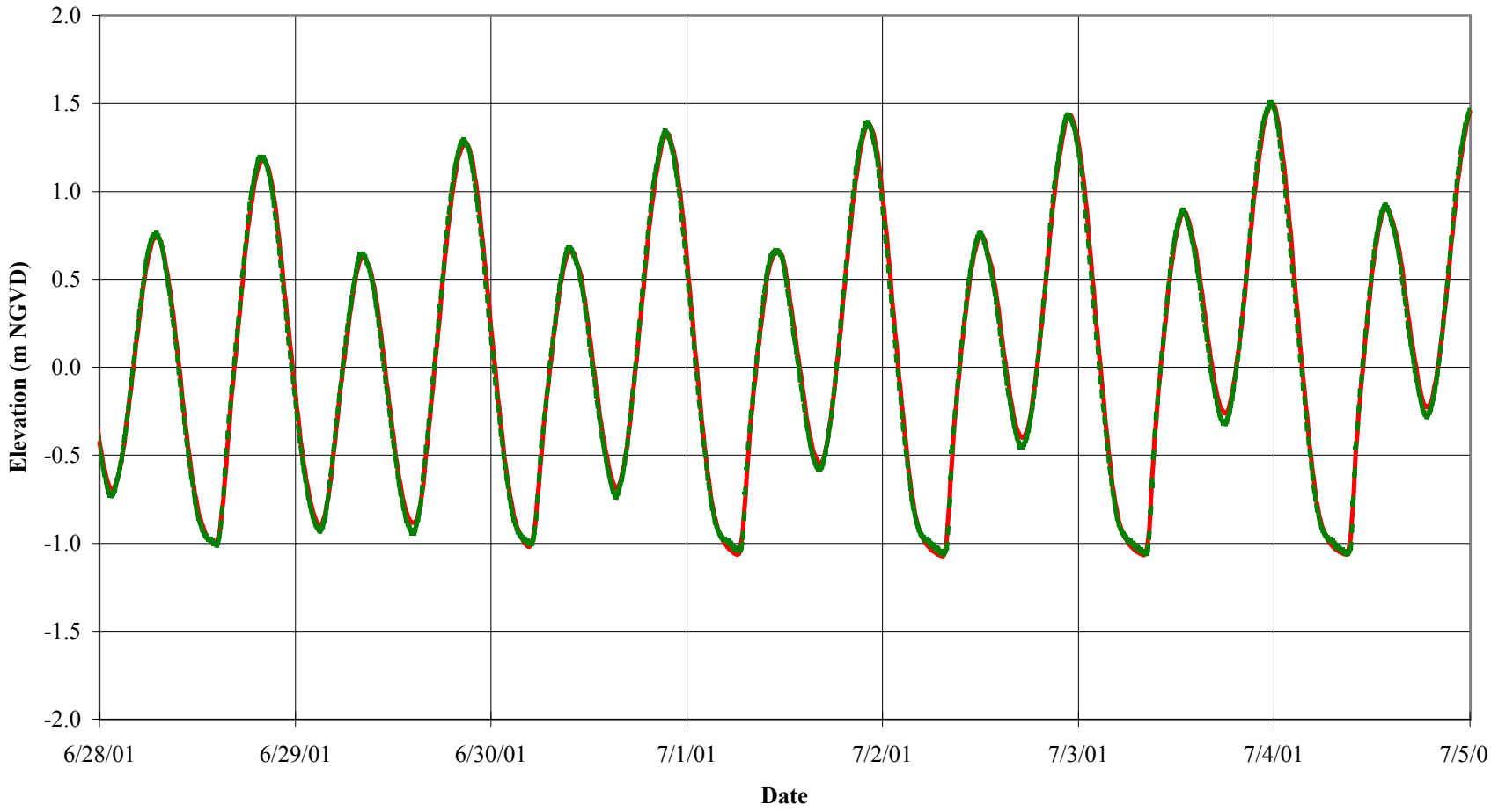
Figure B-9

Bair Island Restoration

Water Surface Elevations Platform 5

PWA

PWA #: 1413.01



Measured

Simulated

Source: PWA flield survey (vented pressure transducer) and numerical simulation

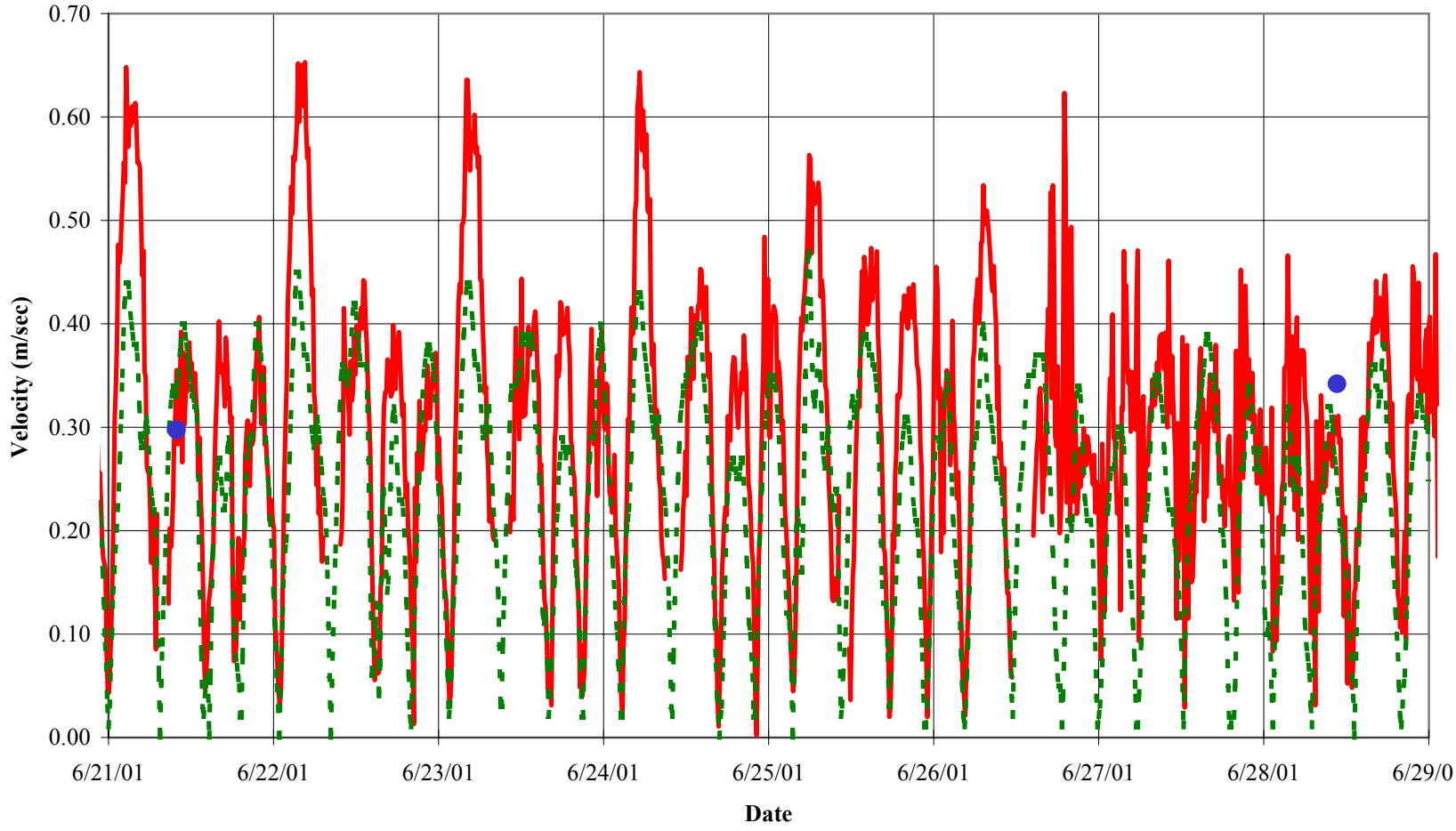
Figure B-10

Bair Island Restoration

Water Surface Elevations Platform 6

PWA

PWA #: 1413.01



Point Data Simulated ADCP Data

Source: PWA field survey (pt vel measurements) and numerical simulation

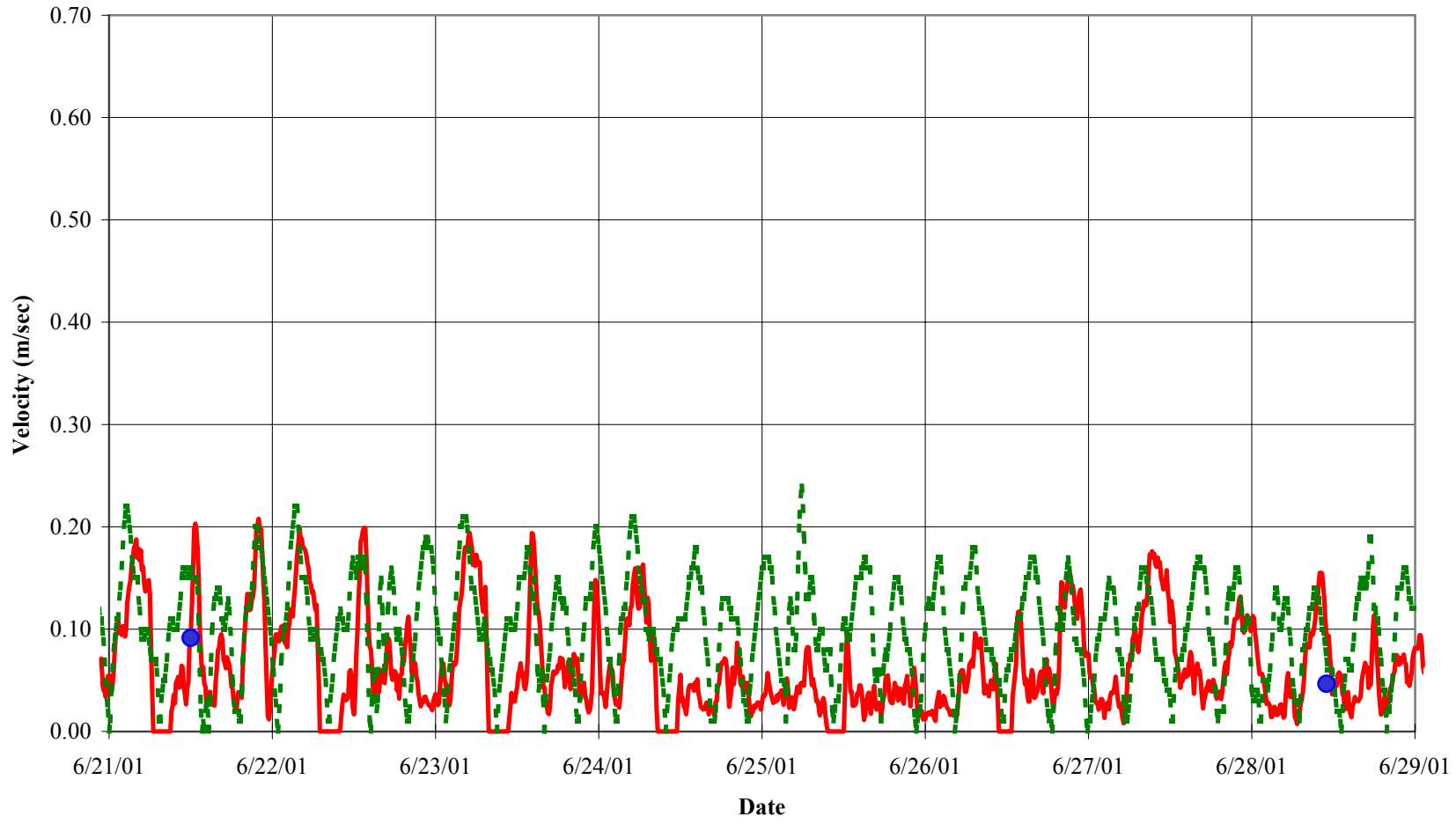
Figure B-11

Bair Island Restoration

Measured vs. Simulated Current Velocity
Platform 1

PWA

PWA #: 1413.01



Point Data Simulated ADCP Data

Source: PWA field survey (pt vel measurements) and numerical simulation

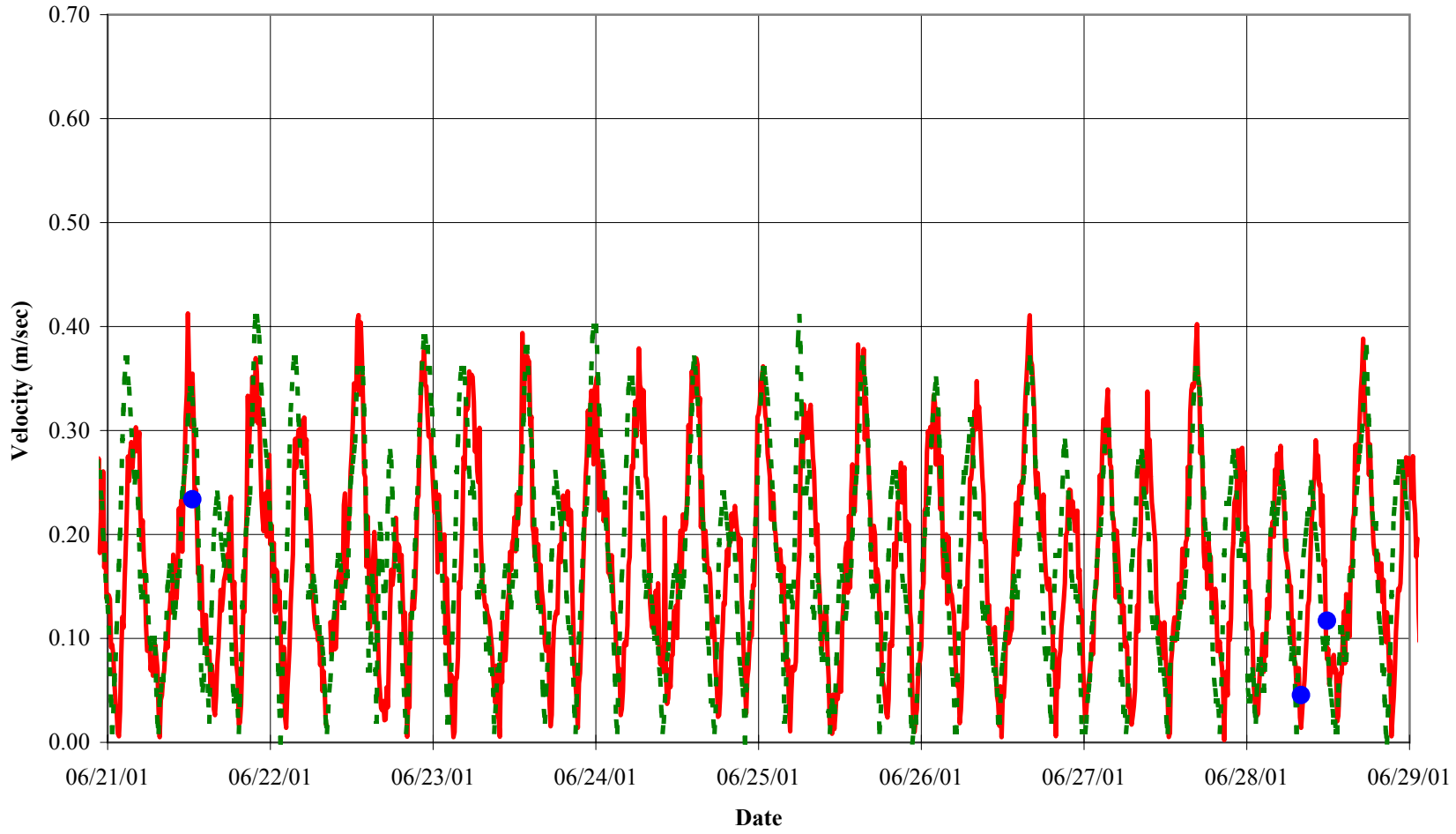
Figure B-12

Bair Island Restoration

Measured vs. Simulated Current Velocity
Platform 2

PWA

PWA #: 1413.01



Point Data Simulated ADCP Data

Source: PWA field survey (pt vel measurements) and numerical simulation

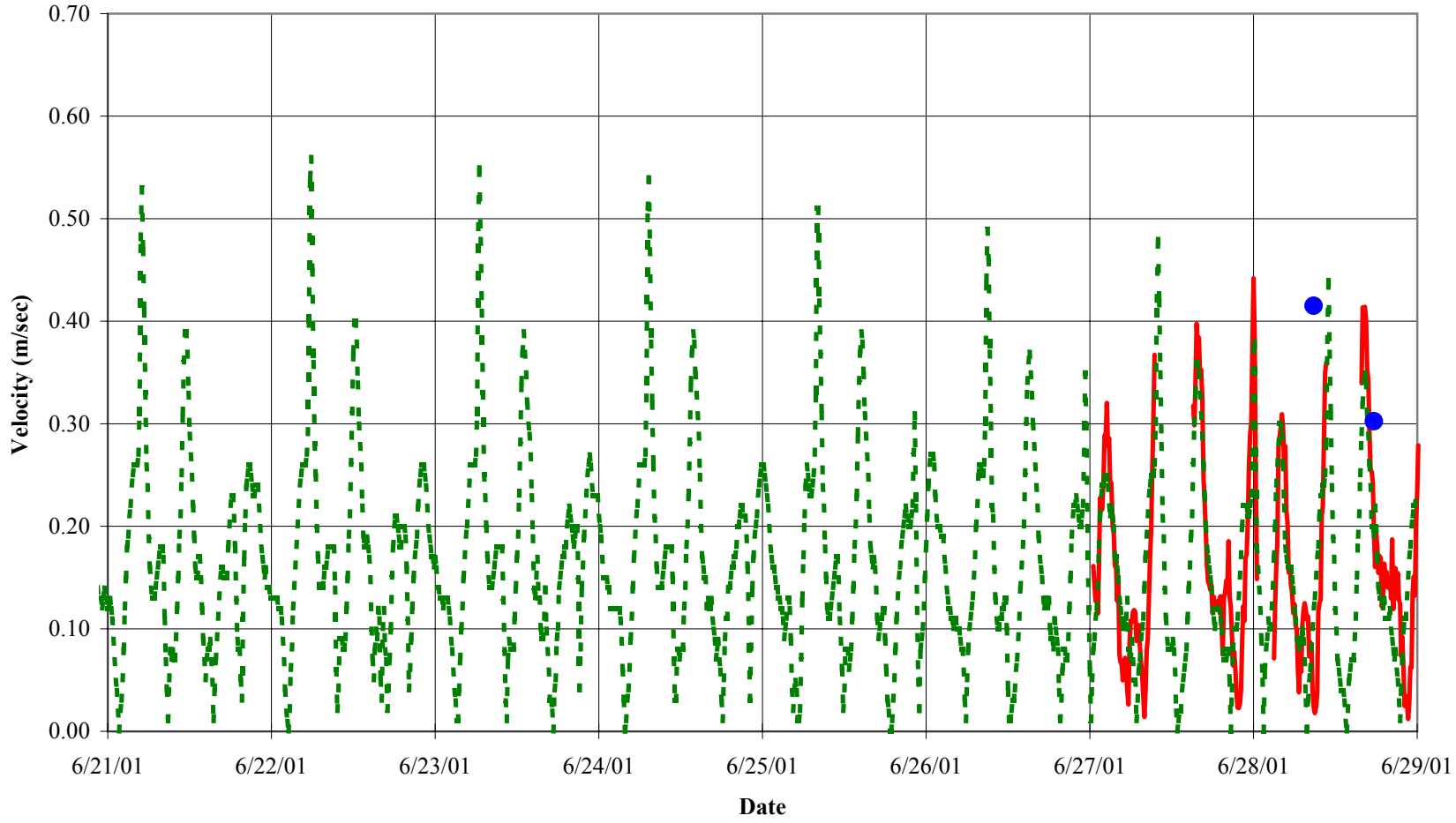
Figure B-13

Bair Island Restoration

Measured vs. Simulated Current Velocity
Platform 3

PWA

PWA #: 1413.01



Point Data Simulated ADCP Data

Source: PWA field survey (pt vel measurements) and numerical simulation

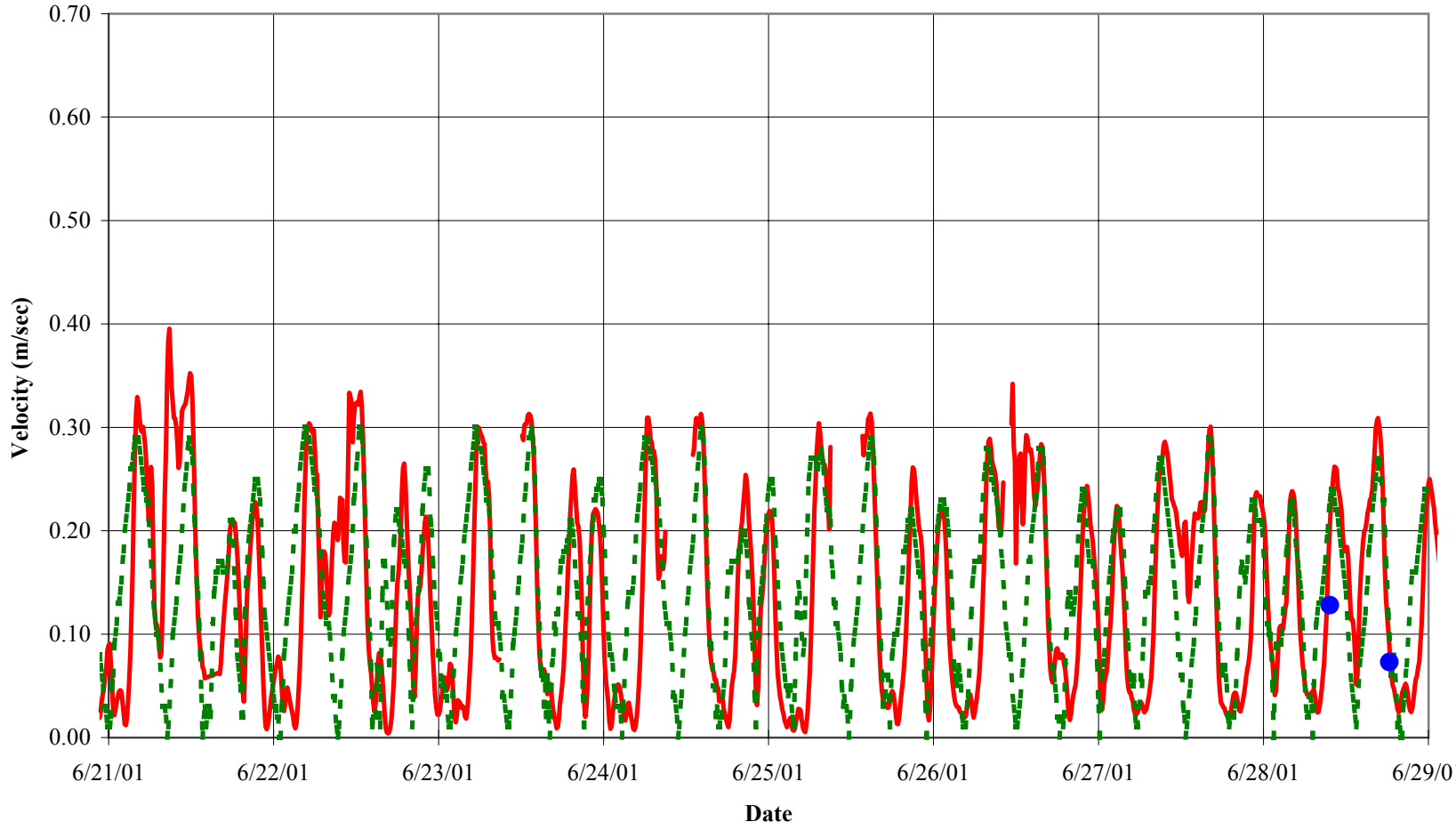
Figure B-14

Bair Island Restoration

Measured vs. Simulated Current Velocity
Platform 4

PWA

PWA #: 1413.01



Point Data Simulated ADCP Data

Source: PWA field survey (pt vel measurements) and numerical simulation

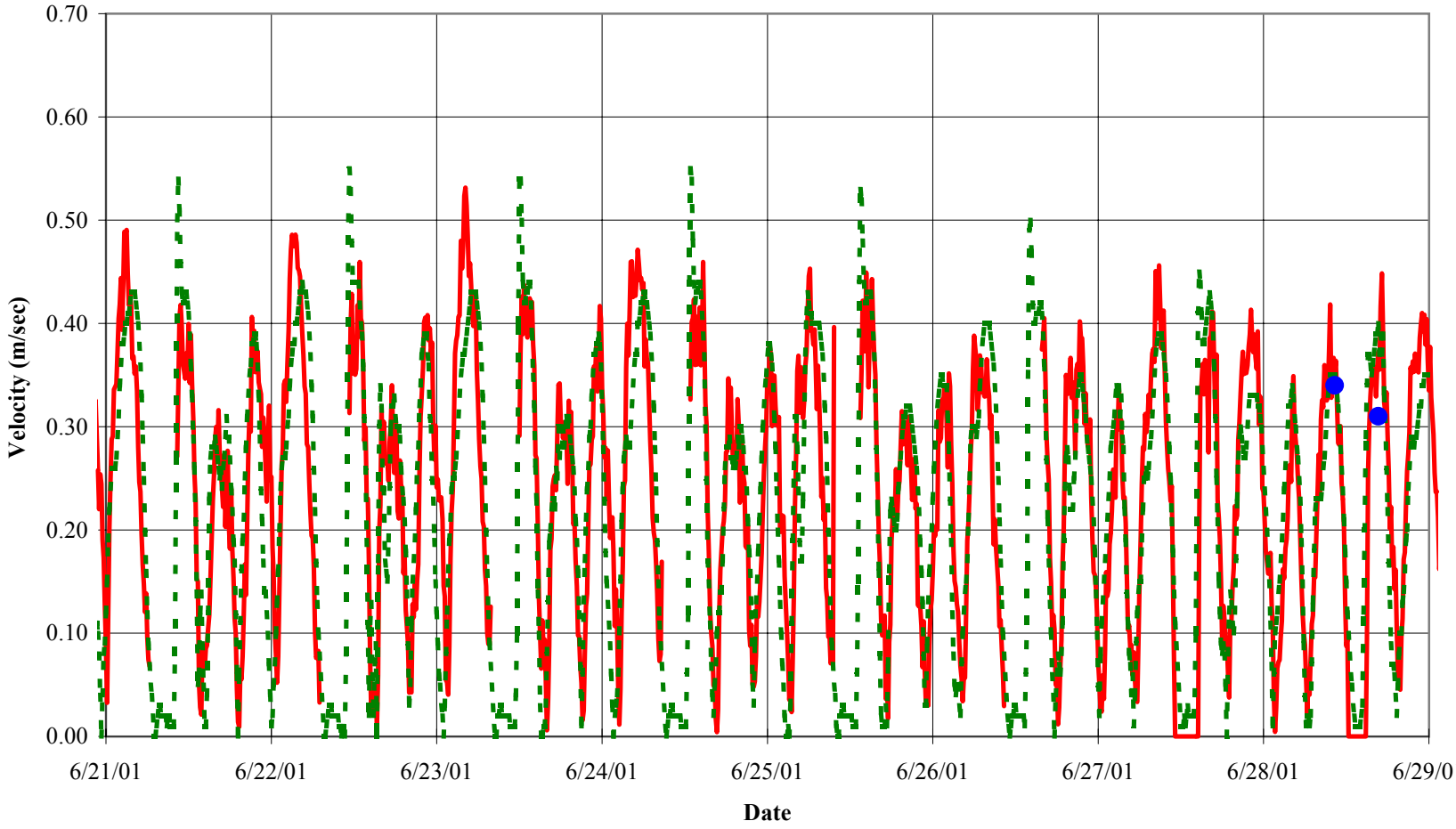
Figure B-15

Bair Island Restoration

Measured vs. Simulated Current Velocity
Platform 5

PWA

PWA #: 1413.01



Point Data Simulated ADCP Data

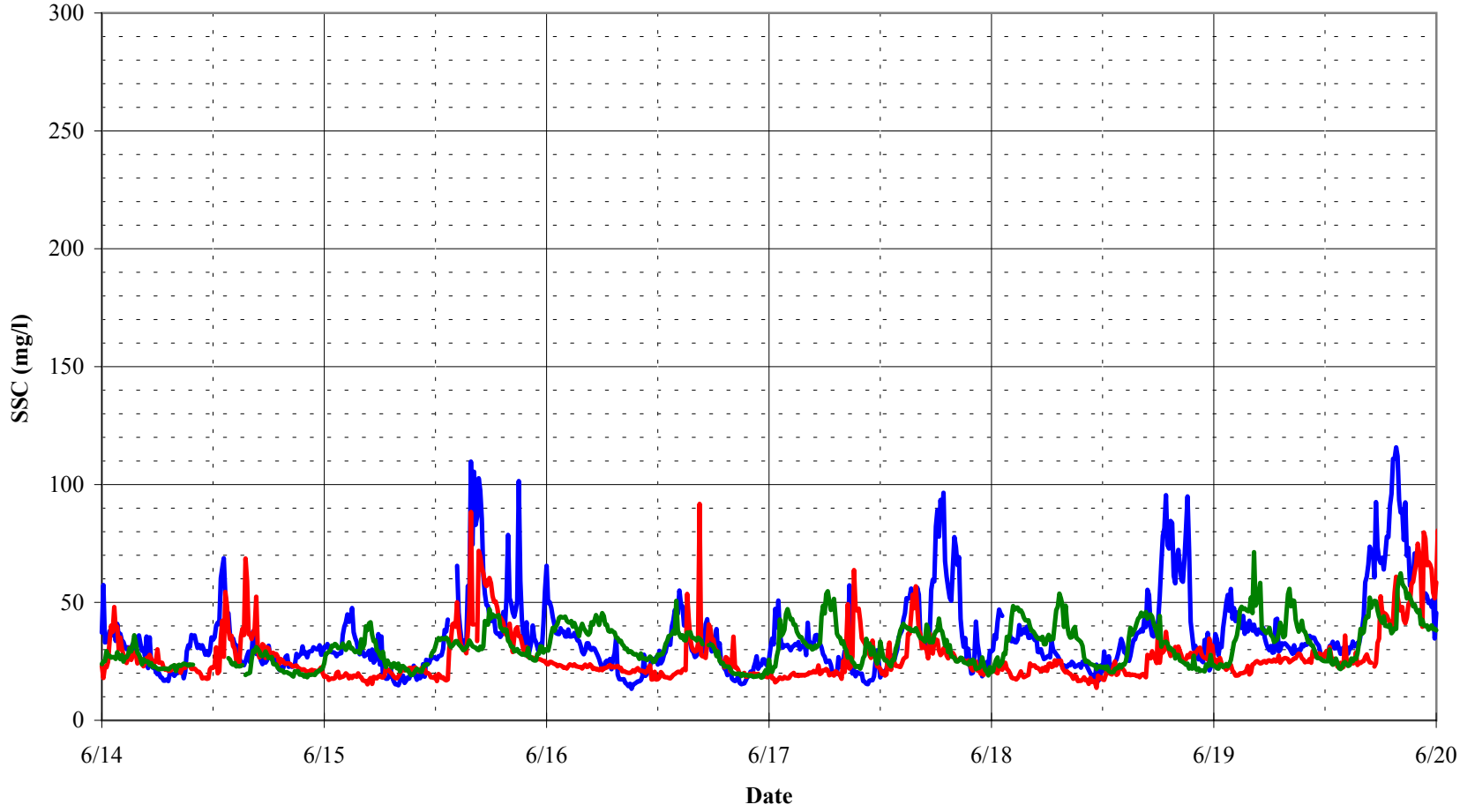
Source: PWA field survey (pt vel measurements) and numerical simulation

Figure B-16

Measured vs. Simulated Current Velocity
Platform 6

PWA

PWA #: 1413.01



Plat. #1 Plat #2 Plat #3

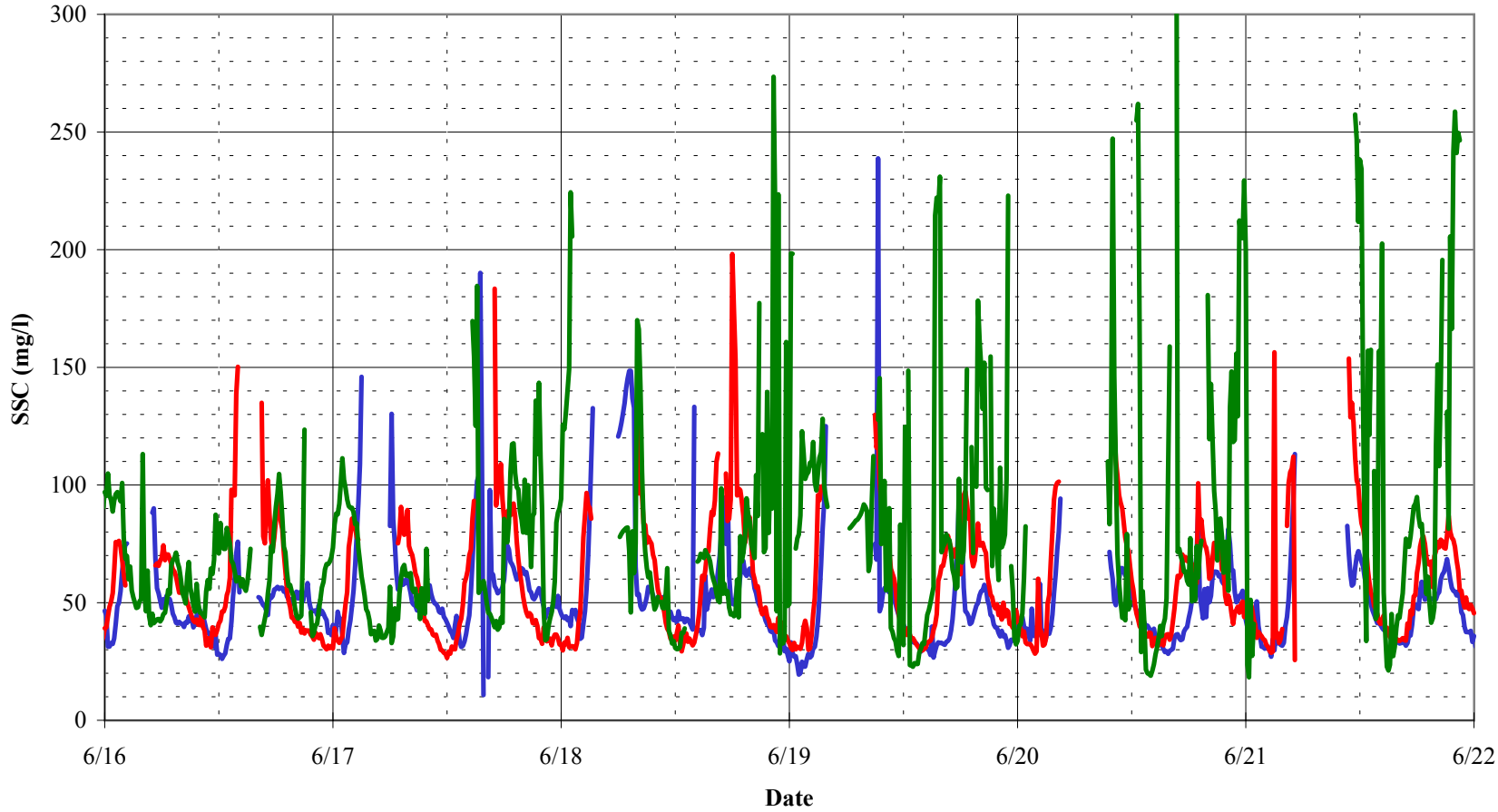
Source: PWA field survey

Figure B-17

Suspended Sediment Concentrations
Platforms 1, 2 and 3

PWA

PWA #: 1413.01



Plat #4 Plat #5 Plat. #6

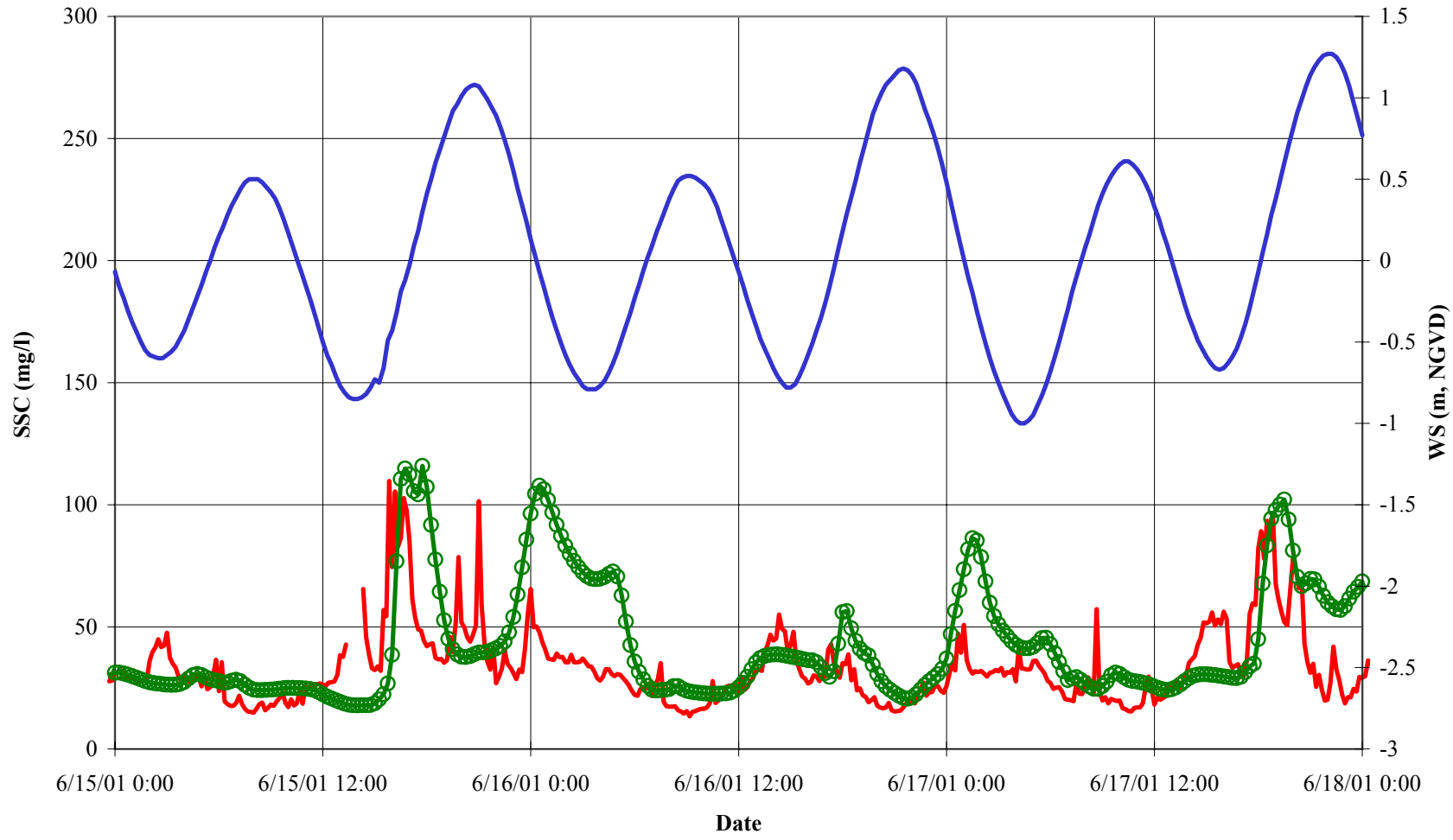
Source: PWA field survey
Note: Signals noisy at low tide due to shallow water depth

Figure B-18

Suspended Sediment Concentrations
Platforms 4, 5 and 6

PWA

PWA #: 1413.01



Measured Simulated WSE

Source: PWA field survey

Figure B-19

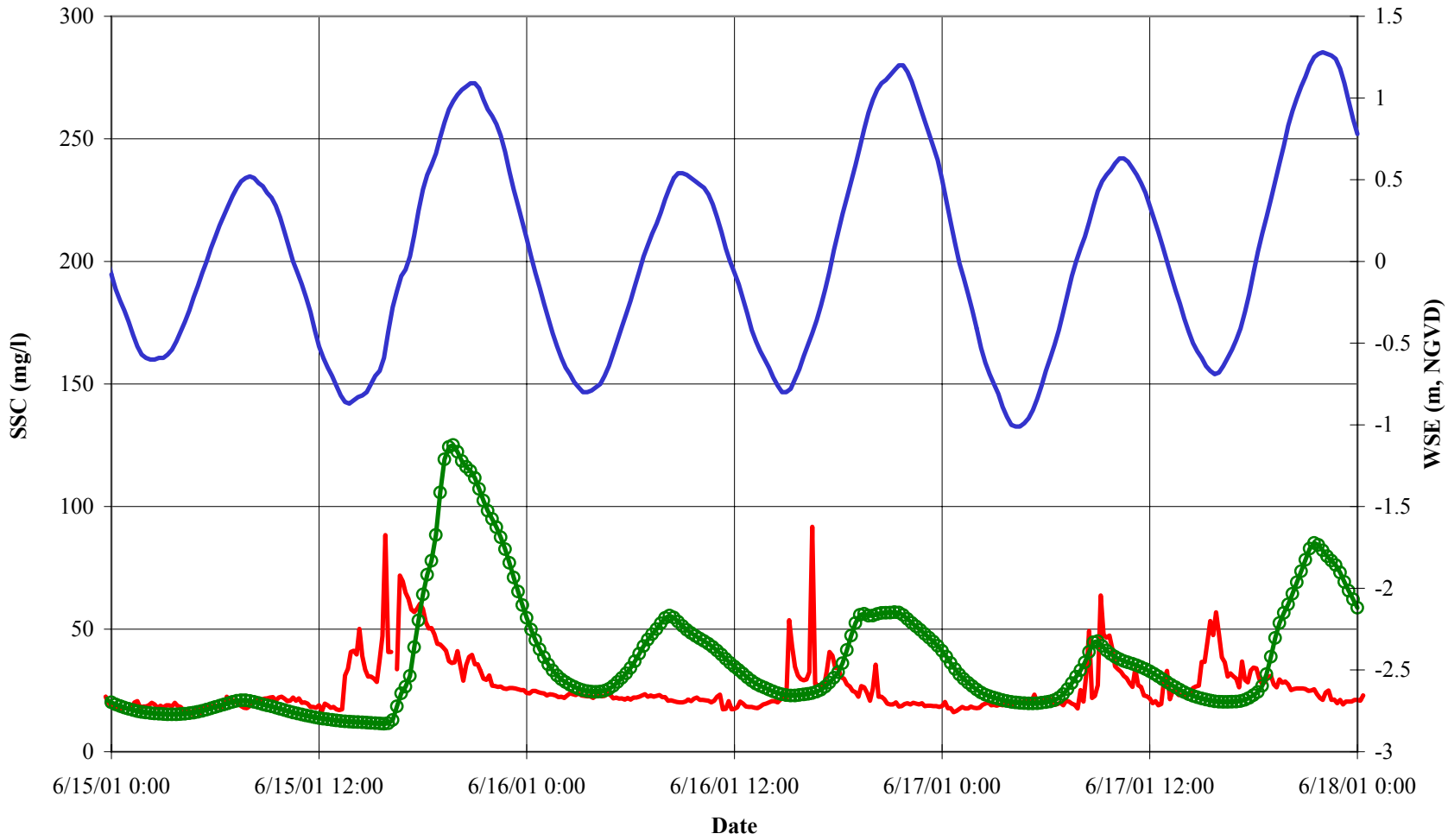
Bair Island Restoration

Suspended Sediment Concentrations

Platform 1

PWA

PWA #: 1413.01



Measured Simulated WSE

Source: PWA field survey

Figure B-20

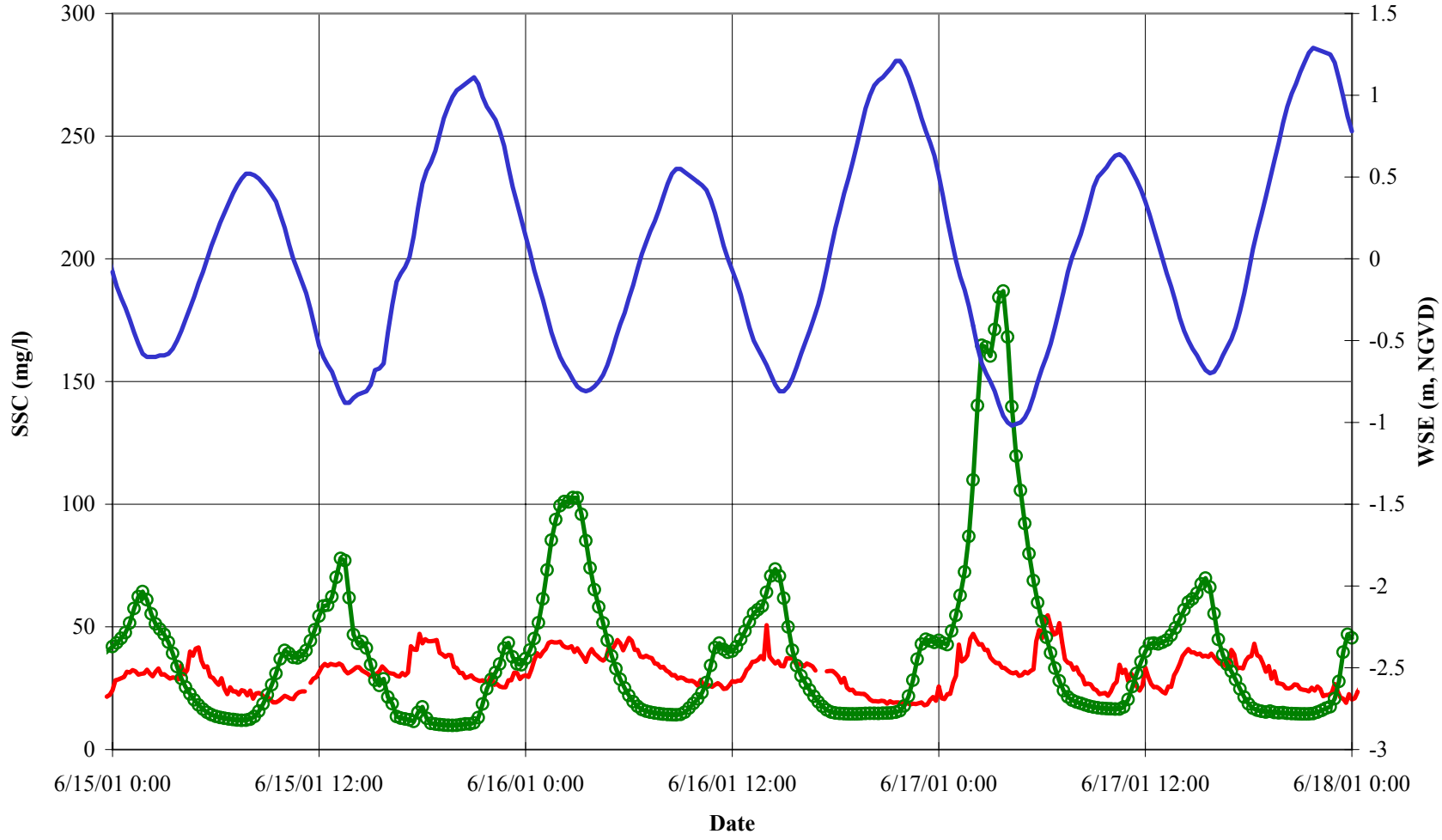
Bair Island Restoration

Suspended Sediment Concentrations

Platform 2

PWA

PWA #: 1413.01



Source: PWA field survey

Figure B-21

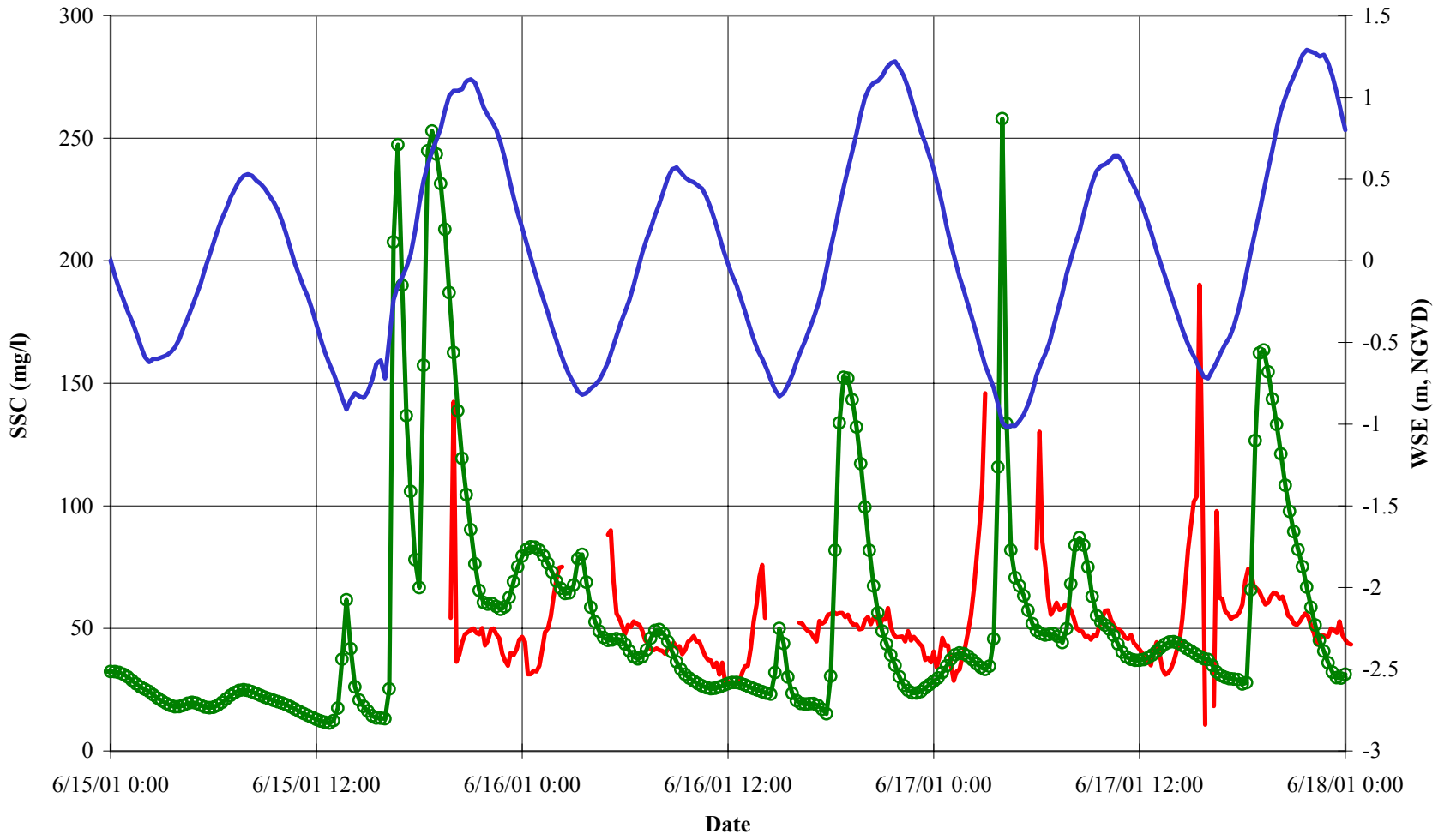
Bair Island Restoration

Suspended Sediment Concentrations

Platform 3

PWA

PWA #: 1413.01



Measured Simulated WSE

Source: PWA field survey

Note: Signals noisy at low tide due to shallow water depth

Figure B-22

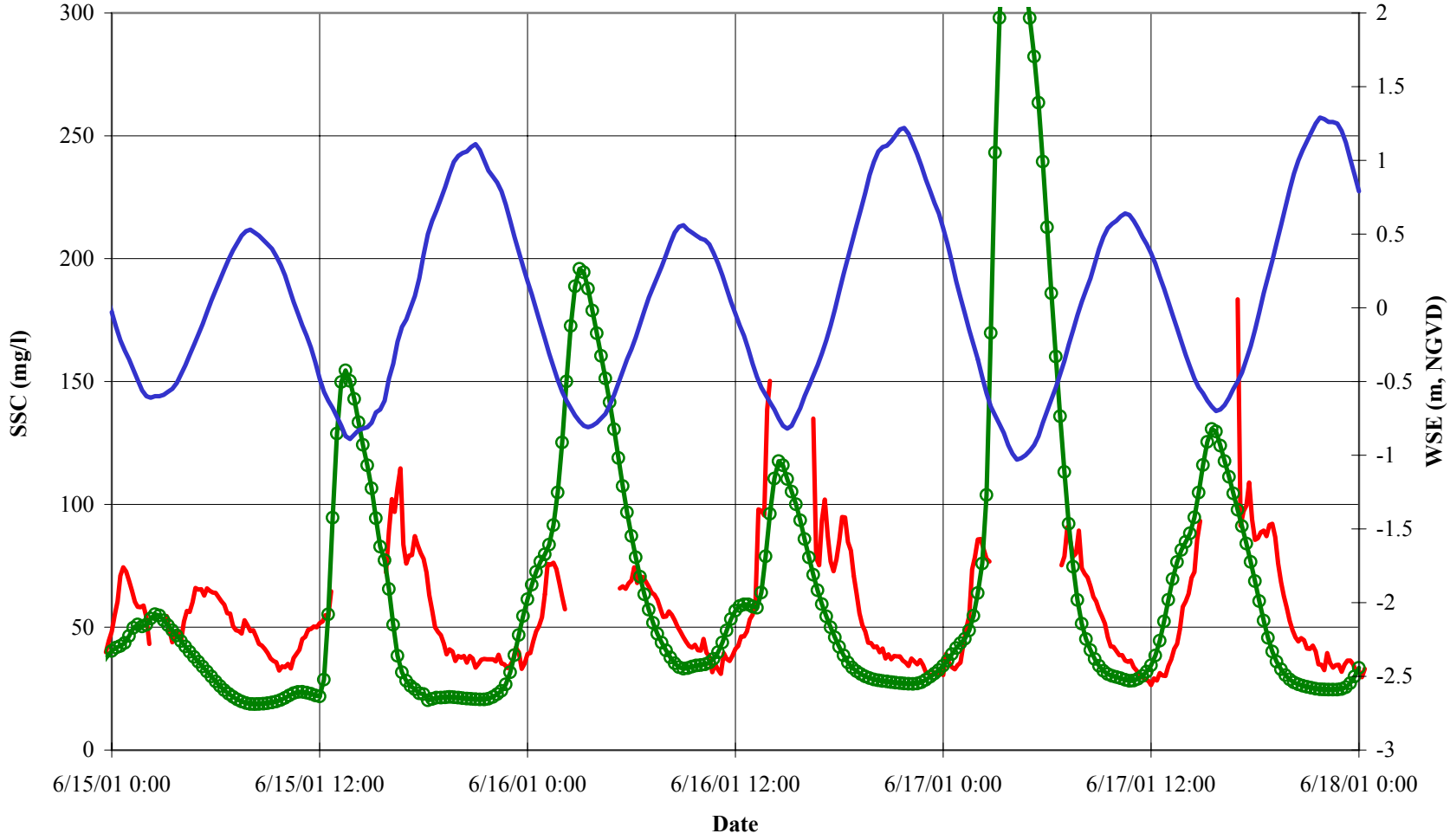
Bair Island Restoration

Suspended Sediment Concentrations

Platform 4

PWA

PWA #: 1413.01



Measured | Simulated | WSE

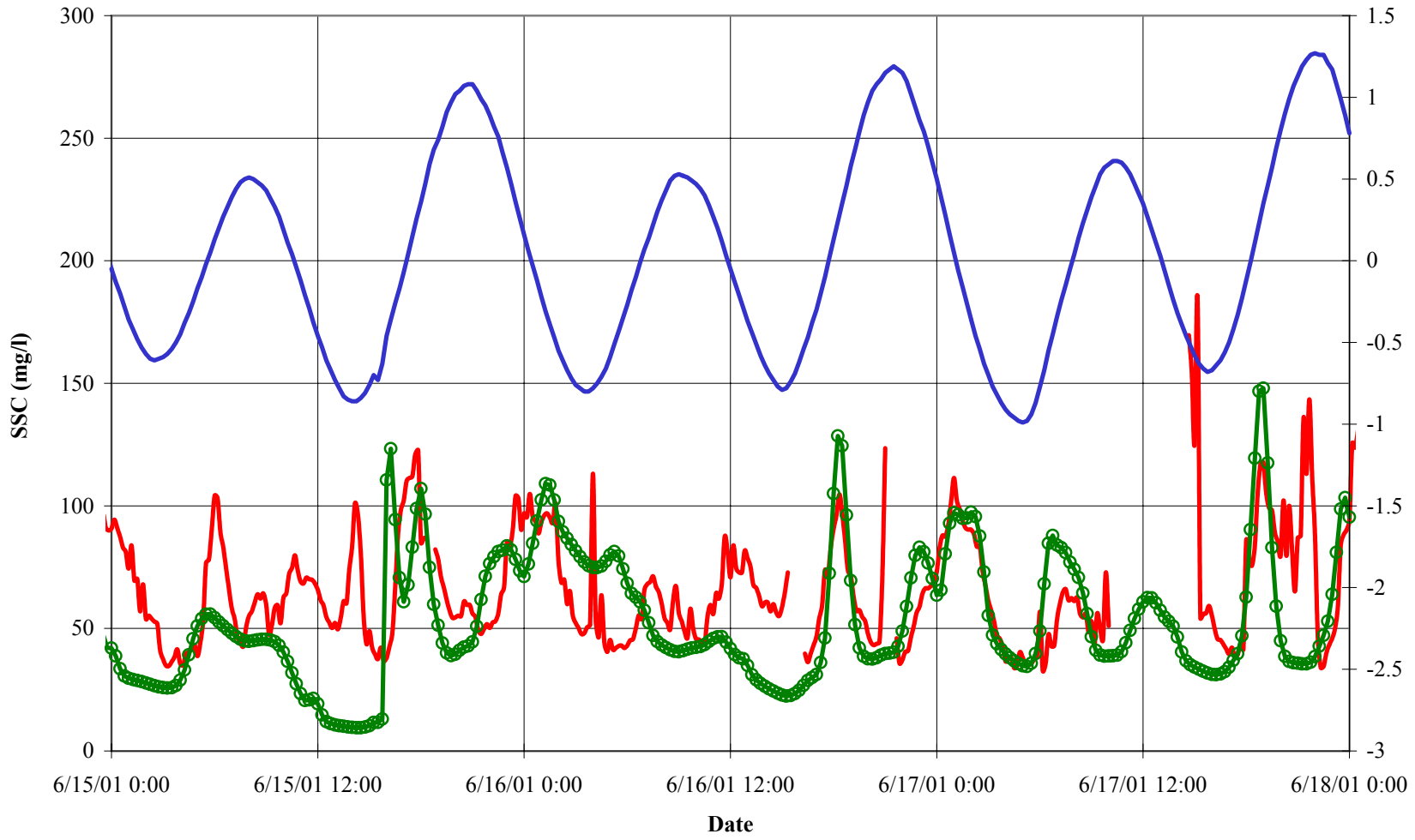
Source: PWA field survey
Note: Signals noisy at low tide due to shallow water depth

Figure B-23

Bair Island Restoration
Suspended Sediment Concentrations
Platform 5

PWA

PWA #: 1413.01



Measured Simulated WSE

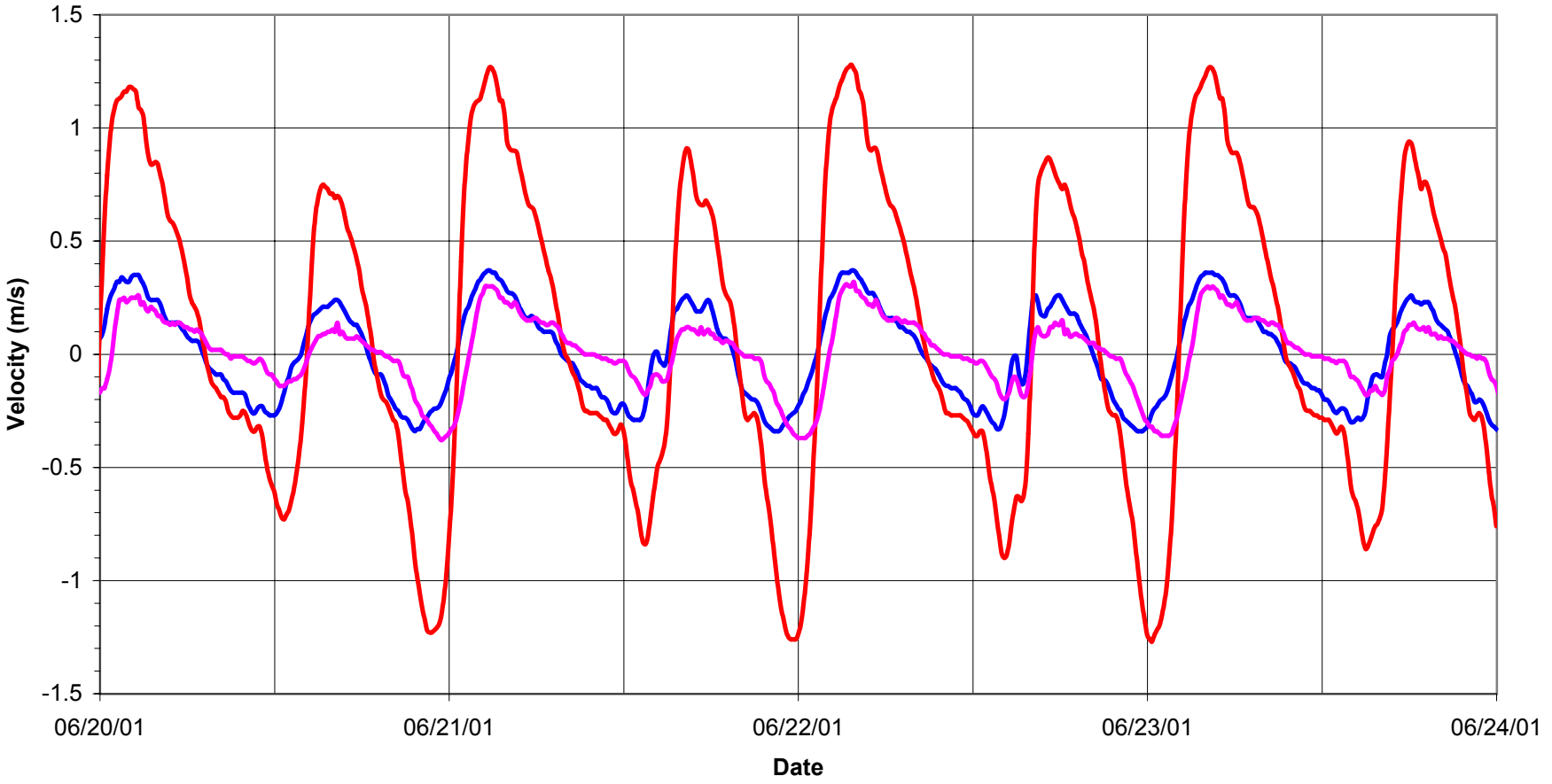
Source: PWA field survey
Note: Signals noisy at low tide due to shallow water depth

Figure B-24

Bair Island Restoration
Suspended Sediment Concentrations
Platform 6

PWA

PWA #: 1413.01



Existing Conditions

Nov. 2000 Recommended Alternative

Aug. 2002 Recommended Alternative

Figure B-25

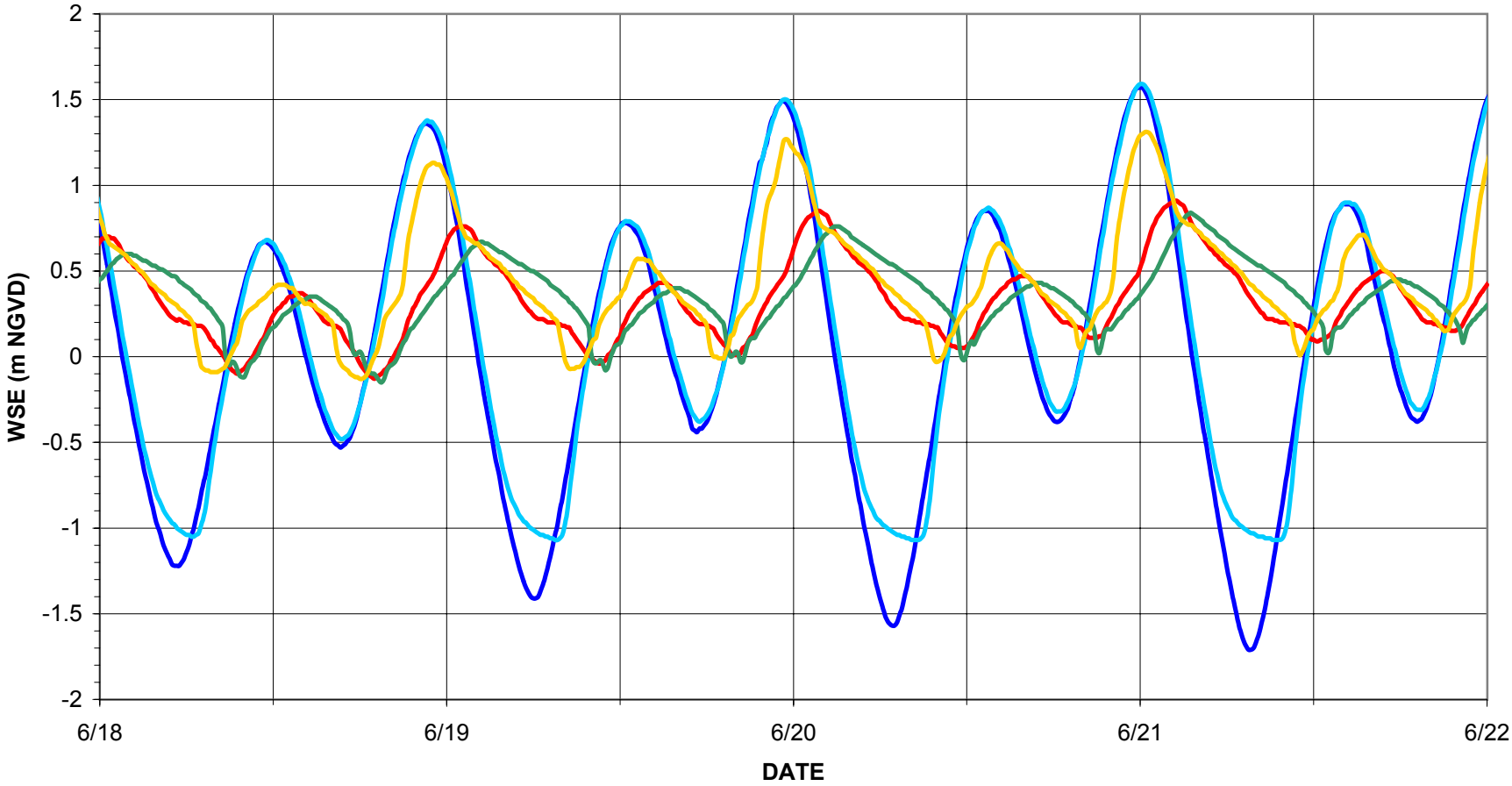
Bair Island Restoration

Modeled Velocity at Pete's Harbor

PWA

PWA #: 1413.01

C:\DonD\JOBS\1413_BairIsland\RecALt\BigSmithA-25_PetesVelocity-allRUNS.xls



Redwook Creek (mouth)
Steinberger Slough (mouth)
Outer Bair
Middle Bair
Inner Bair

Figure B-26

Bair Island Restoration

Water Surface Elevations in System, August 2002 Recommended Alternative

PWA

PWA #: 1413.01

P:\Projects\1413.01 Bair II\Task_11.3_Modeling\SedXportA-26_WSEinISLANDS-RUNS3-9-15.xls

APPENDIX C.
BIRD STRIKE CONSTRAINTS AND DESIGN CRITERIA

BIRD-STRIKE ISSUES AT INNER BAIR ISLAND

Inner Bair Island is adjacent to San Carlos Airport, which lies immediately to the northwest (Figure 1). A portion of Inner Bair Island is within the San Carlos Airport Safety Zone (SCASZ), in line with the airport runway. Concern has been expressed by San Carlos Airport about the potential for restoration activities at Inner Bair Island to increase bird use of the area, thereby increasing the possibility of bird-strikes in the SCASZ.

The FAA Advisory Circular number 150/5200-33 recommends a distance of 5,000 feet between the airport and new wildlife attractants such as wetlands. The circular also provides for exceptions to the recommended distance when the wetland in consideration provides "unique ecological functions, such as critical habitat for threatened or endangered species." The goal of the Bair Island restoration project is to provide habitat for the California Clapper Rail and the salt marsh harvest mouse, and therefore clearly falls within the outlined exceptions. In addition, the airport is surrounded by existing aquatic and wetland habitat that already serves as an attractant to wildlife. However, we are concerned about the potential for bird strikes at San Carlos airport, and have been in communication with airport personnel, as well as the FAA and USDA Wildlife Services to work to minimize the attractiveness of Inner Bair Island within the SCASZ to wildlife that pose the greatest threat to airport safety.

Design criteria for the restoration of Inner Bair Island have largely been driven by these concerns. As a result, the preferred alternative outlined in the body of this report includes a levee around the entire airport safety zone, thereby not allowing tidal action into that area and the conversion of that area to uplands by the use of dredge spoil. The particulars of the implementation, which take into account every foreseeable feature that might attract birds, is summarized in Section 7.7.3. The evolution of tidal marsh on the remainder of Inner Bair will be accelerated by the beneficial use of dredged material to raise the marshplain elevation to reduce the amount of open water and expedite the formation of emergent marsh. The resulting wetland system should actually be less attractive to wildlife species that pose the greatest threat to aircraft at San Carlos Airport.

BACKGROUND INFORMATION ON BIRD-STRIKES

The FAA annually compiles bird-strike data from airports around the United States (Cleary et al. 2002). Between 1990 and 2001, 39,177 bird-strikes resulting in six fatalities were reported to the FAA. Most strikes occurred during approach or on the take-off run, and most strikes occurred on the ground (41%), or below 100 ft. (14%). Most strikes occurred in late summer or fall. 9% of all strikes in the U.S. occurred in California.

We summarized bird strike data (Cleary et al. 2002) for those species that are likely to occur in the San Francisco Bay area (Table 8). It should be noted that a large percentage of wildlife strikes are also caused by mammals, particularly deer. The greatest concern is to avoid bird-strikes that cause an effect-on-flight (EOF) of the aircraft. The majority of strikes causing EOF were with gulls (*Larus* spp.), followed in frequency by waterfowl and raptors. Strikes with waterfowl were most likely to cause injury, followed by raptors and gulls.

Table 8. Bird-strike Data 1990-2001 for Species Likely to Occur in the San Francisco Bay Area, from Cleary et al. (2002).

Bird Taxa	Strikes Resulting in EOF	Strikes Resulting in Damage	Strikes Resulting in Injury or Fatality	Total Number of Strikes
Gulls	624	782	7	4501
Waterfowl	395	837	31	1834
Raptors	274	443	16	1996
Blackbirds	69	66		873
Starlings	55	41		876
Herons & Egrets	54	60	1	448
Sparrows	48	27		1204
Shorebirds	38	29		672
Crows and Jays	28	33		310
Owls	20	42	1	368
Swallows	16	9		513
Pelicans	10	15	1	26
Meadowlarks	9	4		227
Cormorants	3	8	1	20
Loons and Grebes	2	4	1	7
Rails and Coots	1	3	1	20
Terns	1	4		46

Data area sorted by strikes resulting in effect-on-flight (EOF).

CURRENT POTENTIAL FOR BIRD STRIKES AT SAN CARLOS AIRPORT

The channel between San Carlos Airport and Inner Bair Island (approximately 50 m across) provides some habitat for waterfowl and gulls, primarily in winter. The margins of this channel also provide foraging habitat for shorebirds, and herons and egrets. This habitat is closest to the runway, thus wildlife here pose the greatest threat to aircraft during low-elevation approach or take-off. South of this channel, Inner Bair Island is predominantly ruderal grassland. Bird species using this habitat include raptors (e.g., Red-tailed Hawks and Turkey Vultures) and songbirds (e.g., swallows). Raptors currently pose a bird-strike threat in this habitat. In addition, ponding within the SCASZ on Inner Bair Island does occur each winter.

Between September 1990 and September 1999, there have been 39 bird strikes recorded at San Carlos Airport (FAA files, as of June 13, 2001 as reported in the San Carlos Master Plan EIR). The majority of these strikes took place on or over the runway, and not over Inner Bair Island. In addition, most of the strikes involved pigeons (28 of the 39 reported strikes), and not birds associated with the nearby wetland or aquatic habitats. Other birds struck included gulls (4), Canada geese (3), ducks (1) and three (3) unknown birds. These strikes resulted in a total of 6 precautionary landings and 3 aborted takeoffs, while the rest of the strikes had no effect on the flight of the aircraft (San Carlos Master Plan EIR).

However, in conversations with airport personnel, it appears that bird strikes may occur more frequently than are reported. Anecdotal accounts indicate that an incident involving a bird occurs approximately once every two weeks. Gulls were indicated as the bird of primary concern to airport personnel.

In addition, the Sequoia Audubon Society conducts bird surveys of Inner Bair Island. During their surveys from December 2000 to August 2001, the survey personnel were asked to note any time a bird was flushed during landing or take off of a plane at San Carlos Airport. The only birds in the vicinity of the airport observed as flushing were 6 pairs of mallards (two pairs from Pulgas Creek, and 3 pairs from the area between Inner Bair and Highway 101) and numerous Canada Geese on one occasion from Inner Bair Island.

POTENTIAL FOR BIRD STRIKES AFTER RESTORATION

Restoration of Inner Bair Island will not affect the channel between the airport and inner Bair Island, or the northern portion of Inner Bair Island that is to be used as an emergency landing area for San Carlos Airport. Bird communities in these areas will not be affected. The SCASZ will be leveed and filled to an elevation that supports upland habitat, thereby reducing the amount of winter ponding in those portions of Inner Bair Island closest to the runway.

The remainder of Inner Bair Island will be restored to tidal salt marsh. Bird communities are expected to shift immediately after tidal action is restored. Small shorebirds are likely to use newly inundated areas for foraging, and as vegetation develops over the next several years, the bird community will likely shift to low numbers of rails, large shorebirds, and herons and egrets. This habitat is not likely to support songbirds or raptors. Thus, the restoration of Inner Bair Island to tidal salt marsh has the potential to reduce bird-strikes near San Carlos Airport by reducing the number of raptors, gulls and waterfowl using the area.

APPENDIX D.
DOG USE MONITORING PROGRAM

DOG USE MONITORING PROGRAM FOR INNER BAIR ISLAND

PURPOSE

The purpose of monitoring visitor compliance with the Refuge's established Dog Rules is to determine whether allowing dogs on Inner Bair Island will cause unacceptable impacts to wildlife, including endangered species, and Refuge visitors. It is assumed that if dog owners follow the Refuge's established rules for dogs, the dogs will not cause unacceptable impacts.

DOG RULES

1. Dogs will be on a 6-foot leash;
2. Dogs will stay on the established trails; not in vegetation or in water;
3. Owners will pick up their dogs' waste;
4. Dogs will be under control; not jump on, bark at, or otherwise disturb Refuge visitors.

PROTOCOL

Refuge Staff and Volunteers in uniform will conduct a one-month outreach period before the test is started to inform Bair Island visitors of the dog rules.

Compliance with the Bair Island dog rules will then be tested for a 3-month period. Refuge staff without uniforms will walk the Inner Bair Island trails four times a week for 2 hours each visit. The visits will be made at various times of the day and week. During each week, three compliance checks will be made on weekends when Bair Island receives most of its visitation and one compliance check will be conducted on a weekday. Compliance checks will be rotated among morning and afternoon/evening hours, with a focus on before and after work hours when visitation on weekdays is the highest. Therefore, data will be compiled for weekend and weekday mornings, afternoons/evening periods (i.e., Week One: Compliance checks will be done on Sunday morning, Sunday afternoon/evening, Monday morning, and Saturday morning. Week Two: Compliance checks will be done Sunday afternoon/evening, Tuesday afternoon/evening, Saturday morning and afternoon/evening.). Staff will record the number of owners with dog(s). If any of the owners' dog(s) are seen violating the dog rules, it will be recorded and the data filed at Refuge Headquarters.

COMPLIANCE STANDARD

No research has been done on disturbance of wildlife by dogs at Bair Island. However, observations of dog disturbance of wildlife at other locations indicates that it is highly likely that dogs can have a detrimental impact on wildlife. On numerous occasions at the Corte Madera Ecological Preserve, clapper rails have been observed seeking refuge from dogs entering tidal marshes from adjacent levees with public access (USFWS 1997). Dogs have been documented to be a disproportionate source of disturbance of wildlife near Devereux Slough in Santa Barbara County (Lafferty 2001). Impacts from disturbance range from lethal to reduced opportunities to forage or rest, which could have cumulative impacts on reproduction and survivorship. Because

of the lack of research addressing the issue, it is not possible to pinpoint what level of disturbance of wildlife would be acceptable. However, because of the anticipated presence of endangered species in the restored tidal marshes of Inner Bair Island, the disturbance threshold must be conservative.

The USFWS believes that more than one dog being off the trail each day would cause an unacceptable disturbance to wildlife, including endangered species. The USFWS also believes that more than 2 dogs per day not using a 6-foot leash, disturbing Refuge visitors, or not having their waste picked up will cause unacceptable impacts to wildlife and/or Refuge visitors.

Bair Island Visitor Use Surveys estimated that 250,000 people visit Inner Bair Island each year. Thirty-eight percent (38%) of these visitors bring at least one dog which results in a minimum of 95,000 dog visits each year or 260 dogs per day. One dog off the trail each day would result in a minimum of 365 dog impacts to Refuge wildlife each year and would amount to approximately 0.5% of the dogs using the Refuge trail. If two dogs per day are off their leash, disturbing visitors and/or not having their waste picked up, that will result in a minimum of 730 impacts to wildlife/visitors per year or approximately 0.76% of the dogs using the Refuge trail. Therefore, the maximum percentage of dog owner violations that would be acceptable during the test period would be 0.5% for dogs off the trail and 0.76% for dogs not using a 6-foot leash, disturbing Refuge visitors, or not having their waste picked up. The percentage will be calculated by dividing the number of dog violations by the number of visitors with dogs. A group of visitors walking one dog will be counted as one owner with a dog. A visitor with multiple dogs will be counted as one owner with a dog. Any of these owners seen allowing the dogs to violate the rules would be counted as one violation.

RETEST OPTION

If the Dog Use Monitoring Program demonstrates that dog owners are meeting the compliance standard, dog use will continue to be allowed on Inner Bair Island. If, at a later date, the Refuge Manager believes that compliance with the dog rules has declined, the Refuge will conduct another dog use outreach and monitoring program. Based on the results of this later test, the Refuge may continue to allow dog use or close Bair Island to dog use.

APPENDIX E.
LONG-TERM SEDIMENTATION MODELING

BAIR ISLAND RESTORATION AND MANAGEMENT PLAN
APPENDIX E

LONG TERM SEDIMENTATION MODELING

1.0 INTRODUCTION

The FORTRAN program "MARSH98" estimates the long term sedimentation of constructed and natural marshes and marshplains. The program, proprietary to PWA, utilizes Krone's (1987) approach of marshplain modeling.

2.0 BACKGROUND

According to Krone (1987), the elevation of a marshplain rises at rates that depend on the (1) availability of suspended sediment and (2) depth and periods of inundation by high tides. When the level of an evolving marsh surface is low with respect to the tidal range, sedimentation rates may be high if the suspended sediment supply is ample. However, as the marsh surface aggrades through the tidal range, the frequency and duration of flooding by high tides is diminished so that the rate of sediment accumulation declines.

As laid out by Krone (1987), MARSH 98 calculates the amount of suspended sediment that deposits during each period of tidal inundation and sums that amount of deposition over the period of record.

3.0 METHODS

MARSH 98 is based on methods devised by Professor R.B. Krone of UC Davis and reported in his 1987 paper (Krone, 1987). The algorithm is centered around the mass balance of suspended sediment throughout the water column. The equation for this balance is:

On the flood tide when $\frac{d\eta}{dt} \geq 0$,

$$(\eta - z)\frac{dC}{dt} = -V_s C + (C_o - C)\frac{d\eta}{dt}$$

On the ebb tide when $\frac{d\eta}{dt} < 0$,

$$(\eta - z)\frac{dC}{dt} = -V_s C$$

where:

η = Water surface elevation,
z = Marshplain elevation,
C = Suspended sediment concentration,
t = Time,
V_s = Settling velocity, and
C_o = Ambient suspended sediment concentration of flood laden waters.

The major underlying assumption with the mass balance equation is that all material that settles to the bed becomes permanent marshplain material and is not scoured by ebb currents, large waves, or storm conditions. The settling velocity for suspended particles has the following relationship:

$$V_s = KC^{4/3}$$

where:

V_s = Settling velocity,
K = A constant (0.00011 when units are S.I. Metric), and
C = Suspended sediment concentration.

Accumulation of material on the bed is determined by the following equation:

$$\Delta z = \frac{\int V_s C dt}{C_d}$$

where:

Δz = Change in bed elevation,
V_s = Settling velocity,
C = Suspended sediment concentration, and
C_d = Dry density of inorganic material in the deposit.

On the flood tide, the storage of suspended sediment in the water column is affected by (1) re-supply from the sediment laden flood waters (inflow), and (2) deposition to the marsh surface (outflow)— the suspended sediment concentration is affected by both of these processes. On the ebb tide, the storage is affected by (1) ebb waters that remove sediment (outflow), and (2) deposition on the marsh surface (outflow)— the suspended sediment concentration is only affected by the depositional process. MARSH98 can perform the mass balance when the marsh surface is subtidal (always submerged) or intertidal (submerged only part of the time) and can transition between the two states.

Using a series of successively correcting and approximating half- and full-step advances, the algorithm moves the solution forward through time. The technique is very similar to how a second order Runge-Kutta ODE integrator would integrate the equations and advance the solution in time. The exact numerical recipe is laid out by Krone in his 1987 paper.

4.0 REFERENCES

Krone, R.B. "A Method for Simulating Historic Marsh Elevations." *Coastal Sediments '87. Proceedings of the Specialty Conference on Quantitative Approaches to Coastal Sediment Processes*. New Orleans, LA. May 12-14. 1987. 316-323.

Krone, R.B. "Simulation of Marsh Growth Under Rising Sea Levels." *Hydraulics and Hydrology in the Small Computer Age. Proceedings of the Specialty Conference, Hydraulics Division, ASCE*. Lake Buena Vista, FL. August 12-17. 1985. 106-115.

R.B. Krone & Associates. *Tidal Marsh Restoration at Bel Marin Keys*. Prepared for California Quartet, Ltd. January 17, 1996.

APPENDIX F.
EXISTING BIOLOGICAL CONDITIONS ASSESSMENT
(BOUND SEPARATELY)

APPENDIX G.
EXISTING HYDROLOGIC CONDITIONS ASSESSMENT
(BOUND SEPARATELY)

APPENDIX H.
BAIR ISLAND PRELIMINARY FLOOD ASSESSMENT

PWA
PHILIP WILLIAMS & ASSOCIATES
CONSULTANTS IN HYDROLOGY
720 CALIFORNIA ST., 6TH FLOOR, SAN FRANCISCO, CA 94108
TEL 415.262.2300 FAX 415.262.2303
SFO@PWA-LTD.COM

MEMORANDUM

DATE: September 19, 2003

TO: Clyde Morris, USFWS
John Bourgeois, HTH

FROM: Don Danmeier
Michelle Orr

RE: **BAIR ISLAND PRELIMINARY FLOOD ASSESMENT - REVISED**
PWA Ref. 1413 – CM 1+2

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1 INTRODUCTION

Tidal hydrodynamic modeling carried out by PWA during the development of the restoration plan for Bair Island (HTH 2002) showed elevated low tide drainage in the upstream reaches of Steinberger Slough. These elevated low tides were a direct result of re-routing flows within the slough network, which was necessary to meet other project constraints but which has the potential to worsen flooding in the watershed. Therefore, PWA carried out additional numerical modeling of extreme flood events in order to assess the extents of project-related changes to flood hazards along Pulgas and Cordilleras Creeks. This memo summarizes the methods and results from the flood assessment.

2 CONCLUSIONS

The present flood analysis consisted of modeling water levels at the downstream limits of Pulgas and Cordilleras Creeks under various flood events. Previous flood studies for Caltrans and FEMA were reviewed to establish appropriate combinations of bay tides and creek flows. The preliminary flood assessment lead to the following conclusions:

- Short-Term Flood Hazards. Based on the flood modeling, the proposed action is expected to increase peak water levels at Highway 101 by approximately 1.5 cm (0.05 ft; less than an inch) during a 100-year flood event. This estimate is for initial conditions immediately after breaching and is expected to decrease as Steinberger Slough deepens over the first months and years. The magnitude of this change is expected to decrease with distance upstream from

Highway 101, although the flood assessment did not extend to these upstream areas. Increases in peak water levels were less for more frequent flood events (i.e., the 10- and 50-year events).

- Long-Term Flood Hazards. In the long-term, the proposed restoration project is expected to increase peak flood water levels by 1.2 cm (0.04 ft) during a 100-year flood event. This is a slight decrease compared to the initial 1.56 cm (0.05 ft) increase in water levels immediately following project construction. Flood impacts decrease over time because increases in Steinberger Slough conveyance more than offset decreases in marshplain (i.e., floodplain) conveyance. However, even in the "worst case" with no scour along Steinberger Slough, peak flood water levels during a 100-year flood event are expected to increase by only 1.8 cm (0.06 ft).

- Managing for Uncertainties. One source of uncertainty in the above peak water level increase estimate is how closely the actual hydraulic characteristics of the flow control structures placed in Corkscrew and Smith Sloughs will match those simulated in the modeling. Flood performance will be affected if the flow control structures allow more or less flow than modeled. To address this uncertainty, USFWS will monitor the performance of and adaptively manage the flow control structures as needed. Modifications to the structures will be made if post-project measurements of tidal flows indicate that the flow control structures are not functioning per the design criteria given in the Restoration and Management Plan and incorporated into the model.

3 APPROACH AND FLOOD CRITERIA

3.1 APPROACH

PWA carried out a series of hydrodynamic model runs as part of the restoration design development that lead to the August 2002 Alternative. Flow control structures included in the revised restoration design have the effect of raising water levels along the upstream reach of Steinberger Slough during low tide, as shown in Figure 1. These changes in water levels are expected to persist until sufficient scour of Steinberger Slough occurs to fully convey the tidal prism that would otherwise pass through the over-sized Redwood Creek Shipping Channel. Modifications to the restoration design that improved the low tide drainage were not apparent without impacts to other project constraints such as increased tidal currents at Pete's Outer Harbor and increased sedimentation along lower Redwood Creek. Poor low-water drainage is often an indication of restricted channel conveyance which may affect flood flows. Therefore, PWA carried out a set of additional simulations in order to better understand the potential flood impacts associated with the August 2002 Alternative. The intent of this analysis was to quantify the potential flood impacts for preliminary assessment and to screen possible mitigation measures.

3.2 FLOOD HAZARD CRITERIA

Although the tidal hydrodynamic model runs carried out in the development of the restoration design showed changes in the average and low tide water levels along sections of Steinberger Slough, flood impacts were not immediately clear since extreme high tides are often the cause of flooding in coastal areas. Therefore, PWA revised the flood hazard criteria and carried out further analysis in order to examine the extent of project-induced changes in water levels during extreme events.

PWA adopted flood criteria used in previous studies that consisted of certain combinations of steady-state creek flows and bay tides. The two most recent flood studies of Pulgas Cordilleras Creeks are an analysis of both creeks for the Federal Emergency Management Agency (FEMA, 1981) and a separate study of Pulgas Creek for Caltrans (Peterson 2000). Both reports are discussed in PWA 2000, along with descriptions of the existing flooding and drainage of the watershed.

Estimates of various creek flows and bay tides are listed, respectively, in Tables 1 and 2. Additional information was collected to characterize the 1.6-year creek flow for Pulgas Creek, which was found to be 755 cfs (Peterson 2000).

TABLE 1. Estimated Creek Flows

Location		Drainage Area (sq. mi.)	Q_{10} (cfs)	Q_{30} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)	Source
Redwood Creek	USGS Gauge	1.82	--	720	--	--	KJC (1986)
	Broadway	8.8	1800	--	3200	3800	FEMA (1981)
	Highway 101[1]	9.3	1900	--	3300	4000	FEMA (1981)
Cordilleras Creek	El Camino Real	3.3	470	--	940	1170	FEMA (1981)
	Highway 101	3.6	525	--	700[2]	850[2]	FEMA (1981)
Pulgas Creek	Highway 101	3.6	1005	--	1460	1820	FIA (1977)[3]

Notes:
[1]KJC (1986) lists a 30-year peak flow of 1800 cfs at Veteran's Blvd just upstream of Highway 101. This flow is approximately equal to the 10-year peak flow FEMA values at Broadway and Highway 101, 1300 and 1700 feet upstream and downstream, respectively. It is likely that this discrepancy results from different methods of analysis used in the two studies.
[2]The flows at El Camino Real are higher than those downstream at Highway 101. This discrepancy is caused by a diversion of high flows from Cordilleras Creek to Pulgas Creek that FEMA factored into its analysis for the 50- and 100-year flows (E. Boscacci, pers. comm.). KJC (1986) lists a 30-year peak flow of 1000 cfs at Highway 101. This flow, which is significantly higher than the FEMA values at Highway 101, indicates that the diversion of high flows was likely not included in the KJC analysis, but the discrepancy may also be the result of different methods of analysis.
[3]The flow values were not listed in the 1977 San Carlos FIS (FIA, 1977), but were obtained from FIS back-up data. The 50- and 100-year flows include diverted flows from Cordilleras Creek (E. Boscacci, pers. comm.).

Q_N is the creek flow with a return period of N years.

TABLE 2. Estimated Bay Tides

Event	Water Surface Elevation (ft NGVD)	Agency
Highest Expected Tide	7.1	Caltrans (Peterson 2000)
Highest Annual Tide	5.1	FEMA (FEMA 1981)
Mean Sea Level	0.0	Caltrans (Peterson 2000)

4 MODEL RUNS AND RESULTS

We carried out a series of steady-state model runs to calculate water surface elevations with and without project for various combinations of tides and creek flows. Table 3 lists the complete run catalog, input conditions, and results. As noted in the table, some runs were directed at examining various mitigation measures. Consistent with the previously cited FEMA and Caltrans findings, our results indicate that flood water levels are mostly driven by the bay tides, with creek flows of secondary importance.

4.1 EFFECT OF THE PROJECT ON PEAK FLOOD WATER LEVELS

Numerical simulations using with- and without-project conditions lead to the following findings:

- In general, changes in water level were greater when FEMA criteria were applied to flood events than when Caltrans criteria were used. However, the highest absolute water surface elevations were simulated by Caltrans criteria that combined the highest expected tide with relatively low creek flows.

- Project-related changes in water levels for 10- and 50-yr events were less than those generated by 100-yr events.

- Model results indicate that water level changes due to the project under long-term conditions may be overstated unless sea level rise and scour of the sloughs are taken into account. Long-term scenarios modeled in this study accounted for changes in flood conveyance due to sedimentation on the marshplain, although sea level rise and channel scour were included in some runs.

- Various combinations of tides and creek flows were examined, and modeling indicates that high tides govern the water levels throughout the system. This is consistent with previous analysis (FEMA 1981, Peterson 2000). The highest water surface elevations were simulated under 100-yr Caltrans criteria, which included the highest expected tide (HET) as a boundary condition.

- Our analysis tested several approaches to further reducing project-related potential flood increases, such as dredging Steinberger Slough, routing some flow through the Inner Bair borrow

ditch, and additional levee lowering (see Runs 8 through 13). Dredging along the length of Steinberger Slough would reduce greatly reduce flood impacts, with model results indicating only a 0.3 cm (0.01 ft or 0.12 inches) increase in water level. Adding culverts and dredging along the borrow ditch between Inner Bair and Highway 101 is not expected to significantly improve flooding, and would be complicated by the existing sewer line. Assuming levee overtopping, through levee subsidence or extensive levee lowering, long-term impacts were found to be only 0.7 cm (0.28 inches) due to the additional conveyance of the marshplain.

- Levee lowering associated with the proposed restoration actions lowers peak flood water levels, especially in the long-term, by increasing the conveyance of the marshplain.

The 100-yr flood event based on FEMA criteria consisted of 100-yr creek flows applied simultaneously with the highest annual tide (HAT). Results from applying this criteria indicate higher project-related impacts than when using Caltrans criteria. Model results from Run 5 show short-term (immediately after breaching) increases in water level of about 0.05 ft. In the long term, increased conveyance due to scouring along Steinberger Slough are partially offset by reduced conveyance through Middle and Outer Bair Island as marshplain sedimentation. Simulations indicate that under these conditions, long-term project-induced changes may increase flood water levels by 0.04 ft. Predictions of long-term flood impacts are less certain than predictions of short-term impacts because of uncertainties in future slough erosion and marshplain sedimentation. However, we estimate a "worst case" potential increase in peak flood levels of 0.06 ft for long-term conditions. This scenario assumes no scour of Steinberger Slough and full marshplain sedimentation in the restored ponds.

Project-related changes in water levels decrease with creek flow. For example, Run 4 shows that short-term increases in peak flood water levels are limited to 0.03 ft during a 10-year flood events.

4.2 MONITORING AND ADAPTIVE MANAGEMENT

One source of uncertainty in the above peak water level increase estimate is how closely the actual hydraulic characteristics of the flow control structures placed in Corkscrew and Smith Sloughs will match those simulated in the modeling. Flood performance will be affected if the flow control structures allow more or less flow than modeled. To address this uncertainty, the proposed restoration action includes performance monitoring and adaptive management of the flow control structures as needed. The monitoring plan (HTH 2003) includes measurement of tide elevations and flow velocities at Year 0, immediately after project implementation. The measurements will be used to evaluate whether the structures are functioning per the design criteria given in the Restoration and Management Plan and incorporated into the model. The USFWS will be responsible for adjustments to the structures after construction that may be needed to meet the design criteria. The structures will be designed to allow adjustments (such as the addition or removal of rip-rap, or adjustment of weir elevations) for flexibility of post-construction management. Monitoring will continue on a yearly basis through Year 3 to ensure that flood hazards decrease in time as tidal scour along Steinberger Slough increases downstream conveyance.

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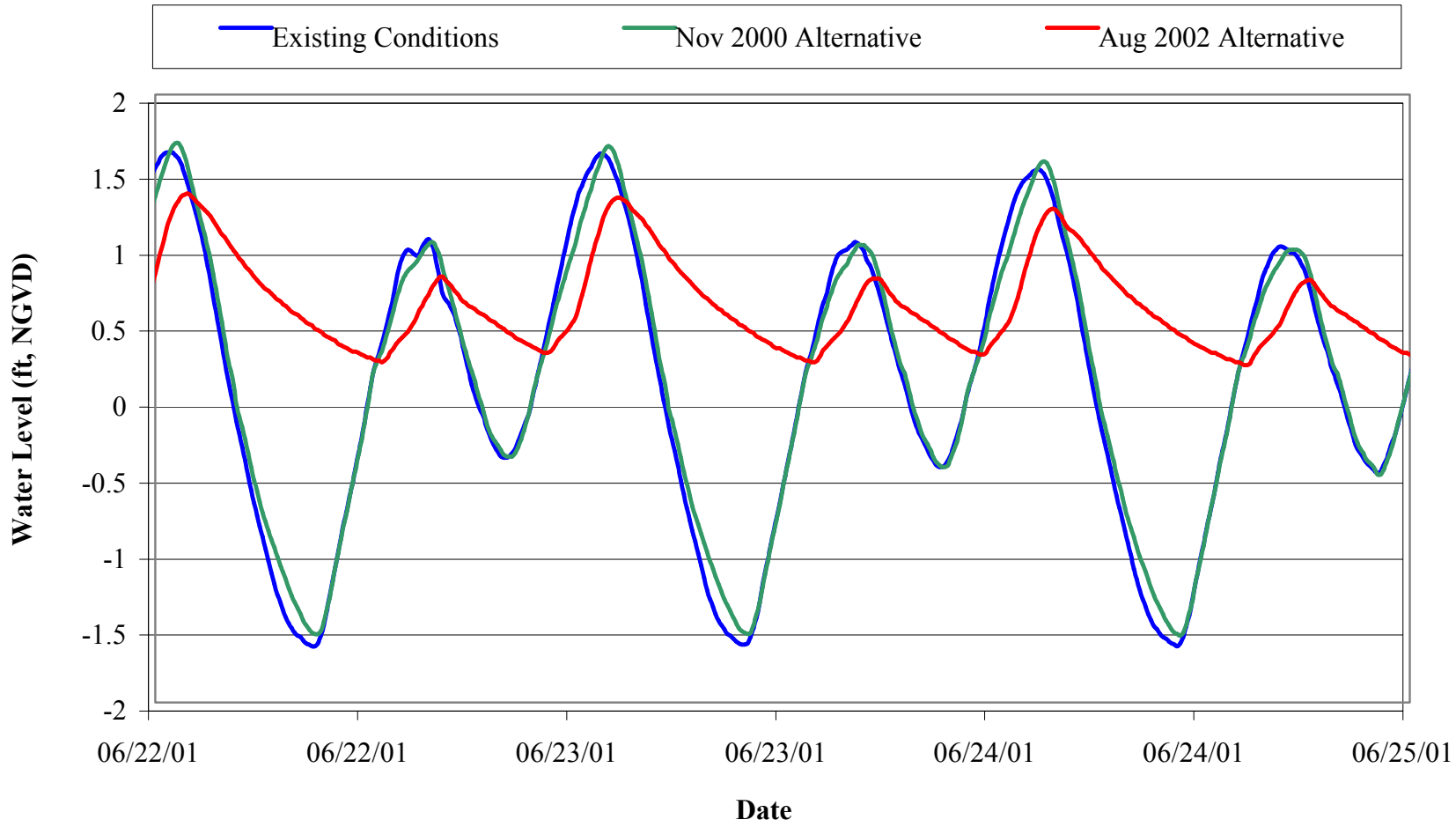
ATTACHMENTS

Figure 1. Water Levels in Steinberger Slough over Representative Tide Cycle.
Table 3. Run Catalog and Changes to Flood Water Levels.



Notes: Simulated water levels in Steinberger Slough at confluence with Smith Slough with no creek flows. In Aug 2002 Alternative, flow restrictions along Corkscrew and Smith Sloughs limit conveyence until Stienberger Slough scours adequately.

Source: Numerical simulation.

figure 1

Bair Island Restoration - Flood Analysis

Tides at Stienberger Slough - No Creek FLows

P:\1413_Bair_CM1+2\FloodAnalysisWSE_FloodGraph.xls

Table 3. Run Catalog and Changes to Flood Water Levels at the Mouths of Pulgas and Cordilleras Creeks

Run	Project Features Modeled	Changes in Morphology Modeled	Flood Event	Design Storms		Modeled Water Levels (m NGVD)			Difference in Water Levels		Comments
				Discharge	Tides	Existing Conditions	Initial Conditions with Project	Long Term Conditions with Project	Initial Conditions with Project	Long Term Conditions with Project	
1	Basic*	Ponds elevation at MHHW and no slough scour.	Caltrans 100-yr	Q1.6 at Pulgas Q10 at Cordilleras	HET (2.16 m NGVD)	Pulgas = 2.163 Cord. = 2.166	Pulgas = 2.166 Cord. = 2.170	Pulgas = 2.166 Cord. = 2.170	Pulgas 0.3 cm Cord. 0.4 cm	Pulgas 0.3 cm Cord. 0.4 cm	Increases over exisiting condtions is small due to high HET tide level
2	Basic	Ponds elevation at MHHW and no slough scour.	Caltrans 100-yr	Q100	MSL (O NGVD)	Pulgas = 0.593 Cord. = 0.702	Pulgas = 0.816 Cord. = 0.887	Pulgas = 0.933 Cord. = 0.989	Pulgas 22.3 cm Cord. 18.5 cm	Pulgas 34.0 cm Cord. 28.7 cm	Increases over exisitng conditions are larger with MSL
3	Basic	Ponds elevation at MHHW and no slough scour.	FEMA 50-yr	Q50	HAT (1.555 NGVD)	Pulgas =1.557 Cord. = 1.571	Pulgas =1.569 Cord. = 1.583	Pulgas =1.579 Cord. = 1.592	Pulgas 1.2 cm Cord. 1.2 cm	Pulgas 2.2 cm Cord. 2.1 cm	Long term increases of about 2 cm (approx. 1 inch)
4	Basic	Ponds elevation at MHHW and no slough scour.	FEMA 10-yr	Q10	HAT (1.555 NGVD)	Pulgas =1.555 Cord. = 1.563	Pulgas =1.563 Cord. = 1.571	Pulgas =1.567 Cord. = 1.575	Pulgas 0.8 cm Cord. 0.8 cm	Pulgas 1.2 cm Cord. 1.2 cm	Long term increases of about 1 cm (approx 0.5 inch)
5	Basic and project-related levee lowering is included in the numerical model. This represents most likely short-term conditions, and worst long-term conditions.	Ponds elevation at MHHW and no slough scour.	FEMA 100-yr	Q100	HAT (1.555 NGVD)	Pulgas =1.561 Cord. = 1.578	Pulgas =1.576 Cord. = 1.591	Pulgas =1.579 Cord. = 1.595	Pulgas 1.5 cm Cord. 1.3 cm	Pulgas 1.8 cm Cord. 1.7 cm	Assumes levee lowering but no change in Stein Sl.
6 - no SLR	Basic	Ponds elevation at MHHW and sections of Steinberger and Corkscrew deepened based on hydraulic geometry.	FEMA 100-yr	Q100	HAT (1.555 NGVD)	Pulgas =1.561 Cord. = 1.578	n.m.	Pulgas =1.584 Cord. = 1.600	n.m.	Pulgas 2.3 cm Cord. 2.2 cm	less than 1 inch increase under long-term (assumes deeper Stein Sl.)
6 - SLR	Basic and project-related levee lowering is included in the numerical model. This represents most likely long-term conditions.	Ponds elevation at MHHW and sections of Steinberger and Corkscrew deepened based on hydraulic geometry. Assume 50 years of SLR	FEMA 100-yr	Q100	HAT + SLR (1.715 NGVD)	Pulgas =1.715 Cord. = 1.728	n.m.	Pulgas =1.727 Cord. = 1.739	n.m.	Pulgas 1.2 cm Cord. 1.1 cm	approx 0.5 inch increase under long-term (assumes deeper Stein Sl., SLR, and levee lowering)
7	Basic	Ponds elevation at MHHW. Assume levees along Steinberger Slough failed/subsided to MHW.	FEMA 100-yr	Q100	HAT (1.555 NGVD)	Pulgas =1.561 Cord. = 1.578	n.m.	Pulgas =1.568 Cord. = 1.585	n.m.	Pulgas 0.7 cm Cord. 0.7 cm	less than 1 in increase. Sheet flow over marshes add to conveyence thru Steinberger Slough
8	Basic plus levees along Steinberger Slough lowered to MHHW (MM).	n.m	FEMA 100-yr	Q100	HAT (1.555 NGVD)	Pulgas =1.561 Cord. = 1.578	Pulgas =1.562 Cord. = 1.578	n.m.	neglible impacts	n.m.	less than 1 in increase. Sheet flow over marshes add to conveyence thru Steinberger Slough
9	Basic plus dredge Steinberger Slough to -4 m NGVD (MM).	Ponds elevation at MHHW.	FEMA 100-yr	Q100	HAT (1.555 NGVD)	Pulgas =1.561 Cord. = 1.578	Pulgas =1.564 Cord. = 1.580	Pulgas =1.564 Cord. = 1.581	Pulgas 0.3 cm Cord. 0.2 cm	Pulgas 0.3 cm Cord. 0.3 cm	negligible impacts
10	Basic plus cut thru high marsh between Inner Bair and Hwy 101 (approx 650-ft long, 50-ft wide, and 0.0 ft NGVD deep) with 1 existing culvert (MM)	Ponds elevation at MHHW.	FEMA 100-yr	Q100	HAT (1.555 NGVD)	Pulgas =1.561 Cord. = 1.578	n.m.	Pulgas =1.594 Cord. = 1.609	n.m.	Pulgas 3.3 cm Cord. 3.1 cm	approx 1 inch impacts near Pulgas, less near Cordilleras
11	Basic plus cut thru high marsh between Inner Bair and Hwy 101 (approx 650-ft long, 50-ft wide, and 1.5 ft NGVD deep) with 1 existing culvert (MM).	Ponds elevation at MHHW.	FEMA 100-yr	Q100	HAT (1.555 NGVD)	Pulgas =1.561 Cord. = 1.578	n.m.	Pulgas =1.594 Cord. = 1.609	n.m.	Pulgas 3.3 cm Cord. 3.1 cm	approx 1 inch impacts near Pulgas, less near Cordilleras
12	Basinc plus cut thru high marsh between Inner Bair and Hwy 101 (approx 650-ft long, 50-ft wide, and 0.5 m NGVD deep) with 2 culverts (MM).	Ponds elevation at MHHW.	FEMA 100-yr	Q100	HAT (1.555 NGVD)	Pulgas =1.561 Cord. = 1.578	n.m.	Pulgas = 1.592 Cord. = 1.606	n.m.	Pulgas 3.1 cm Cord. 2.8 cm	approx 1 inch impacts near Pulgas, less near Cordilleras
13	Basic plus cut thru high marsh between Inner Bair and Hwy 101 (approx 650-ft long, 50-ft wide, and 1.5 m NGVD deep) with 10 culverts (MM).	Ponds elevation at MHHW.	FEMA 100-yr	Q100	HAT (1.555 NGVD)	Pulgas =1.561 Cord. = 1.578	n.m.	Pulgas = 1.590 Cord. = 1.584	n.m.	Pulgas 2.9 cm Cord. 0.6 cm	< 1 inch impacts near Pulgas, less near Cordilleras

NOTES: n.m. = not modeled
HET = highest expected tide
HAT = highest annual tide
MSL = mean sea level
SLR = sea level rise
Basic = channel alignment and breaches from Aug 2002 Alternative but NOT levee lowering. All with-project runs include flow control structures in Smith and Corkscrew Sloughs and levee breaches per R&M Plan (HTH and PWA 2002).
MM = mitigation measure. Applied to Runs 8 - 13.

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APPENDIX B

B-1 Bair Island Restoration Monitoring Plan
B-2 Bair Island USFWS Biological Opinion
B-3 Mitigation Monitoring and Reporting Program

APPENDIX B-1

Bair Island Restoration Monitoring Plan

BAIR ISLAND RESTORATION PROJECT MONITORING PLAN

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Don Edwards San Francisco Bay
National Wildlife Refuge
San Francisco Bay Wildlife Society

April 5, 2004

Project Number 1697-01

BAIR ISLAND RESTORATION PROJECT
MONITORING PLAN

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April 5, 2004 Project # 1697-02

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1.0 INTRODUCTION

Bair Island is located adjacent to the San Francisco Bay in Redwood City, San Mateo County, California (Figure 1). Historically, Bair Island was part of a large complex of tidal marshes and mud flats within the drainage of Bay and Belmont Sloughs (PWA 2000). Bair Island was diked in the late 1800's and early 1900's for agricultural practices including cattle grazing. The island was converted to salt evaporation ponds by Leslie Salt Company starting in 1946, and remained in salt production until 1965. The lands were drained and eventually sold to a series of real estate development companies.

The California Department of Fish and Game (CDFG) and the Don Edwards San Francisco Bay National Wildlife Refuge (hereafter, "Refuge") both acquired portions of Bair Island over time. In 1997, the Peninsula Open Space Trust (POST) purchased the remaining portions of Bair Island and turned over their interest in the property to these agencies. The San Carlos Airport also retains a portion of Inner Bair Island as a safety zone. In addition, two easements exist on Bair Island for PG&E towers and transmission lines that run throughout the Bair Island complex and the South Bay System Authority (SBSA) force main that runs underneath most of the southern part of the levee on Inner Bair.

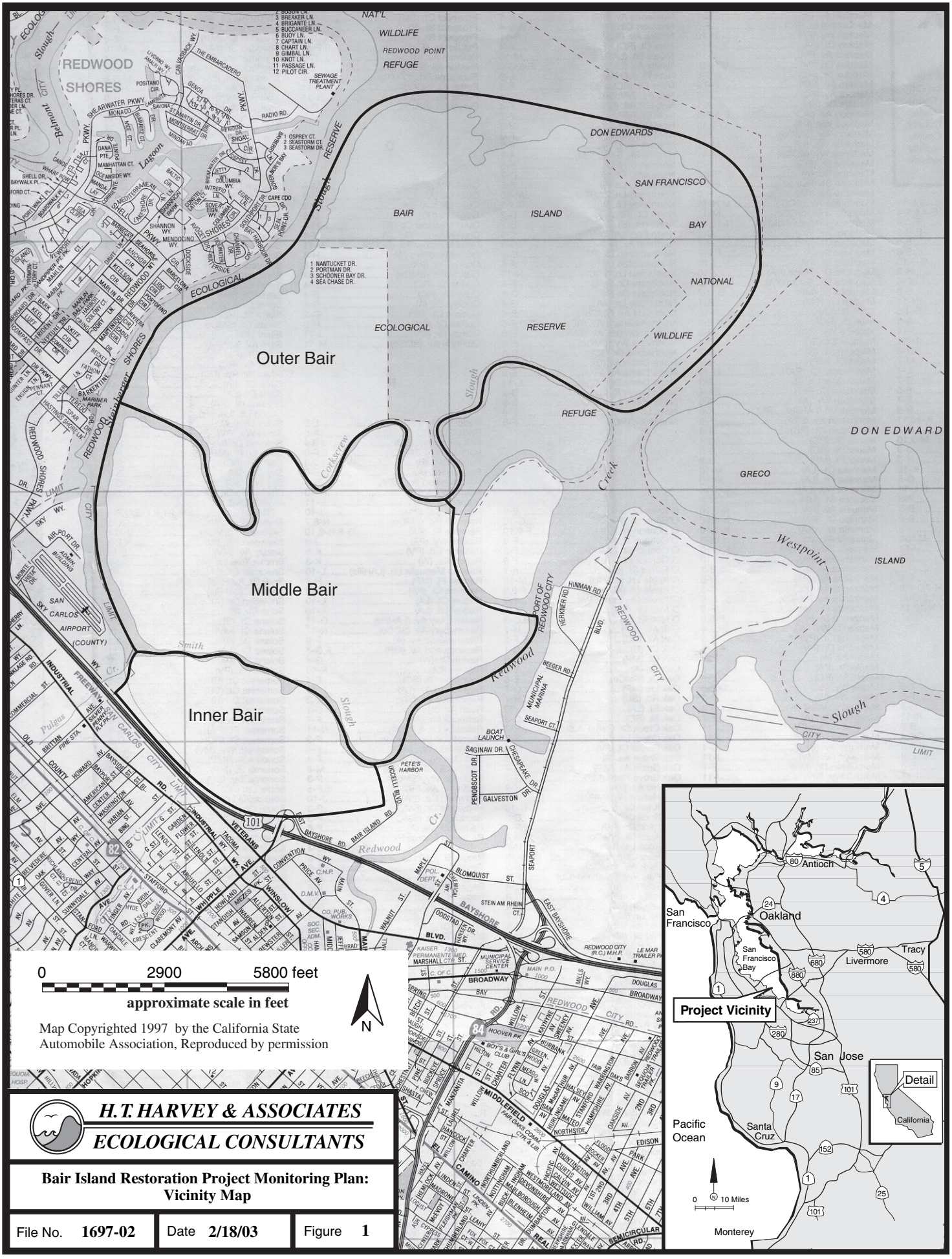
This site is a large, restorable complex of former salt evaporators, and has been a major priority for addition to the Refuge since the original boundaries were drawn. The restoration of tidal habitats at Bair Island is ecologically important to South San Francisco Bay. Following restoration, Bair Island will become an integral part of the extensive wetland complex within the Refuge and adjacent state and privately owned wetlands.

In addition to restoring 1400 acres of tidal wetlands to the much depleted South San Francisco Bay (SFB) tidal-marsh complex, the restoration activities planned for Bair Island provide a unique opportunity for documenting the effects and chronology of events that evolve during the implementation of a tidal salt-marsh restoration. Although similar restoration projects have occurred within the SFB (Cooley Landing, Warm Springs), project development has not been documented to the extent that a specific set of guidelines could be produced for use during subsequent restoration projects. Therefore, the restoration plan, while primarily describing the steps required to produce a successful salt-marsh restoration, also provides a monitoring plan and the testing of hypotheses. These efforts will track the development of the tidal marsh as well as providing valuable information for future restoration projects.

1.1 PROJECT GOALS AND OBJECTIVES

The San Francisco Bay Wildlife Society (SFBWS) and the U. S. Fish and Wildlife Service (USFWS) developed goals and objectives for restoration of Bair Island. These goals and objectives, presented below, are consistent with the policies of the Don Edwards San Francisco Bay National Wildlife Refuge, to which Bair Island now belongs.

We assume a 50-year planning horizon, consistent with that used by other San Francisco Bay restoration projects currently in planning.



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Bair Island Restoration Project Monitoring Plan: Vicinity Map

File No. **1697-02**	Date **2/18/03**	Figure **1**

Goals of the Bair Island Restoration Project

- Restore Bair Island to native tidal salt-marsh habitat.
- Provide habitat for endangered and other natives species.
- Enhance the public's appreciation and awareness of the unique resources of Bair Island.

Objectives for the Bair Island Restoration Project

- Restore and enhance habitat for the endangered California Clapper Rail (*Rallus longirostris obsoletus*) and salt marsh harvest mouse (*Reithrodontomys raviventris*).
- Create and enhance habitat for the endangered California Least Tern (*Sterna antillarum*), California sea-blite (*Suaeda californica*), and other wetland dependent species, if compatible with restoration for the Clapper Rail and harvest mouse.
- Minimize disturbance to sensitive species (e.g., Clapper Rails, harbor seals [*Phoca vitulina*]).
- Provide the control of undesirable species including invasive plants, undesirable predators, and mosquitoes.
- Enhance the public's awareness of the unique resources at Bair Island by providing opportunities for wildlife-oriented recreation and nature study.

1.2 PROPOSED RESTORATION DESIGN

The proposed action restores full tidal inundation to Inner, Middle, and Outer Bair. For Middle and Outer Bair, natural estuarine sedimentation will raise the marshplain surface to allow complete vegetation establishment over time. Restoration will include features to encourage reestablishment of the natural tidal drainage network and discourage the capture of tidal flows by borrow ditches at these two islands. At Inner Bair, dredged material, most likely from Redwood Creek, will be used to raise the marsh plain elevation prior to breaching. Placement of dredged material has the additional advantage of expediting the establishment of emergent marsh vegetation.

Channel modifications would be made at Smith and Corkscrew sloughs to minimize project related effects on high sedimentation rates in the Redwood Creek shipping channel and flow velocities at Pete's Outer Harbor. These channel modifications include the realignment of Smith Slough to its historic meander through Inner Bair and the partial blocking of Corkscrew Slough to the east of the Middle Bair breaches. For details of these project design features please see the Bair Island Restoration and Management Plan (H.T. Harvey & Associates 2002).

Middle and Outer Bair Islands. Levees will be breached at selected historic slough channel locations on Middle and Outer Bair islands, restoring natural tidal flows. Pickleweed-dominated marsh vegetation will establish quickly in areas already at high intertidal elevations. Natural estuarine sedimentation on the lower mud-flat areas will gradually build up these areas to elevations high enough for the establishment of cordgrass and pickleweed. Borrow-ditch cutoff berms will be created to prevent tidal capture by the existing borrow ditches, allowing the natural channel system to re-establish. Interior berms and levees will be lowered or removed where possible, creating additional tidal habitat. Levees desired for upland refuge habitat or required to protect infrastructure from wind-wave erosion would be left in place.

Based on initial ground elevations and predicted sediment supply, some vegetation colonization will begin immediately following restoration implementation. Most of this marsh formation will occur along the perimeter of the restoration areas, along historic slough channels or on higher elevation areas. Substantial tidal marsh vegetation establishment is expected at Outer Bair within 30 to 50 years and at Middle Bair within approximately 50 years.

Inner Bair Island. Dredged material, or other sources of fill, would be used to expand the southern levee of Inner Bair Island to adequately protect the SBSA sewer line and create a cross-levee that protects the San Carlos Airport property on Inner Bair Island. Levees will be breached at historic slough channel locations on Inner Bair Island and borrow ditch cutoff berms will be created to prevent tidal capture by the existing borrow ditches. Although historic slough channels and borrow ditches may be filled with dredged material, differential settlement of the dredged material will result in a lower elevation, and therefore channel development may still occur in these areas.

Fill will be used to raise ground levels on Inner Bair from current elevations of approximately 0.0 to between 2.0 and 3.0 feet NGVD, requiring between 400 – 500,000 cubic yards of fill. This target is close to the 538,000 cubic yards dredged from Redwood Creek during an average dredging event. Redwood Creek has been dredged eight times between 1977 and 1999, and the average annual accumulation rate is estimated to be 200,000 cubic yards.

The area within the cross-levee system protecting the San Carlos Airport safety zone, as well as the alignment of the SBSA sewer line, will be filled with dredged material to an elevation that is above MHHW. By creating upland and transitional habitats in these areas, some of the primary constraints associated with reintroducing tidal action to Inner Bair Island are minimized. From the created upland areas, the fill material will gradually slope down to the lower elevations of the restored marshplain. Fill elevations will be highly varied, ideally providing ample areas of transitional habitat, including upland, seasonal wetland, and supratidal wetland areas. The lower elevations will be high enough for pickleweed and cordgrass to immediately colonize once the site is breached, but low enough to allow some channel development through natural tidal scour. A limited number of perennial pickleweed starter plantings will be installed. Potential drawbacks of dredged material placement are cost and impaired tidal channel development at Inner Bair (as the existing remnant slough system may be covered). Sediment quality would also need to be appropriate for wetland reuse.

No public access will be allowed on Outer and Middle Bair Island except by Refuge guided trips and other specific exceptions that are approved by a Refuge Special Use Permit. Public access for pedestrians and bicyclists will be allowed along a 2.7-mile levee trail on Inner Bair. This trail will be provided along the perimeter of Inner Bair, running from the Refuge's parking lot near Pete's Harbor. An orientation kiosk and viewing/environmental education platforms will be provided at the ends of the levee trail, adjacent to Smith Slough.

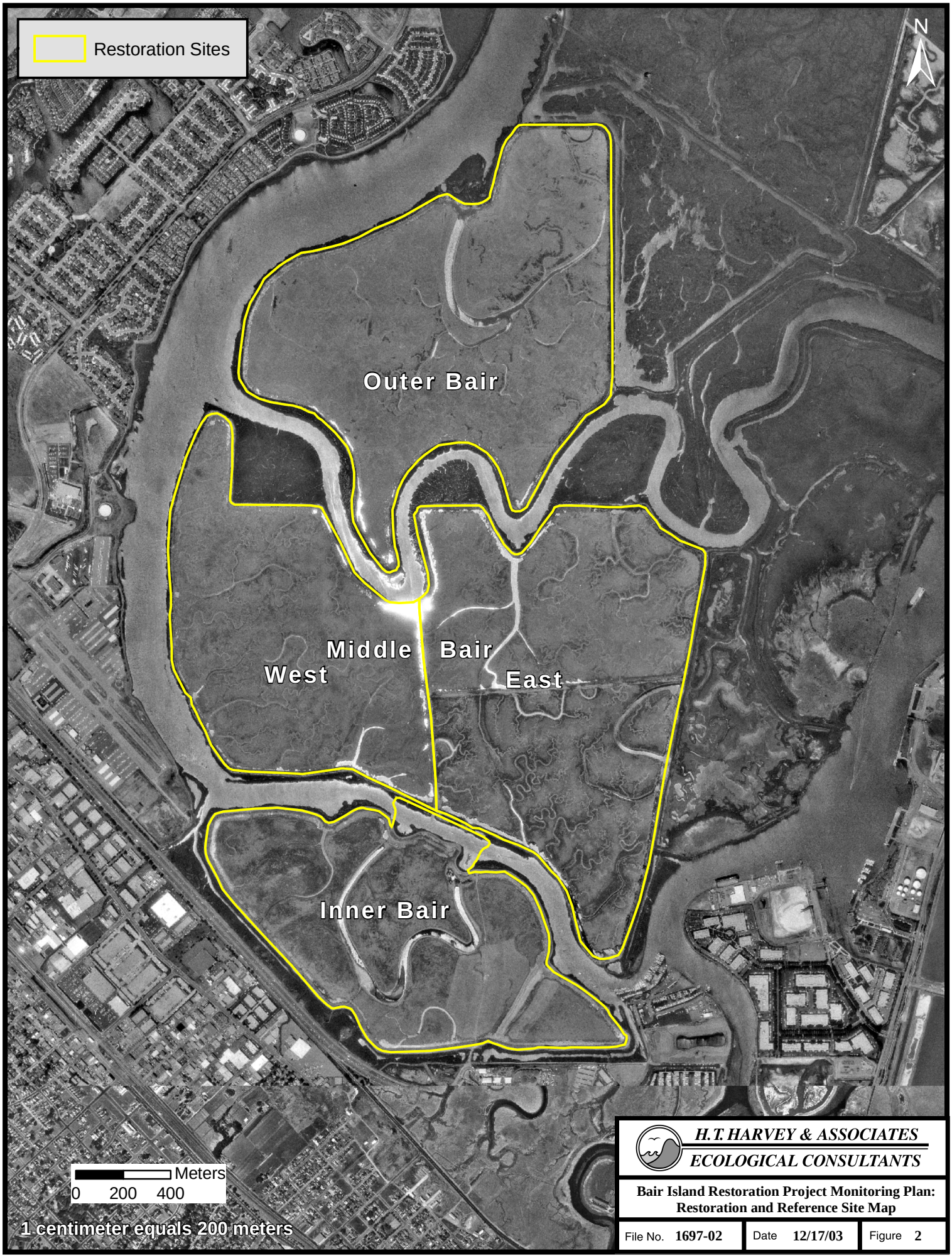
Fishing from boats in Smith, Corkscrew and Steinberger Sloughs and Redwood Creek will be allowed, however fishing will not be permitted from land. Hunting of waterfowl on Outer Bair Island will be allowed per state regulations.

1.3 PROJECT TIMELINE

It is anticipated that Bair Island Restoration project will be implemented in 2005. The project is large scale and therefore will be implemented over a period of several years.

1.4 MONITORING OBJECTIVES

The objectives for the monitoring program are to ensure the restoration meets the project's objectives by achieving the goals stated above. Adaptive management decisions based on monitoring data will increase the potential for project success, especially since tidal restoration at Bair Island will be implemented in phases. One additional objective is to provide data for future, tidal, salt-marsh restoration projects in San Francisco Bay.



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Bair Island Restoration Project Monitoring Plan: Restoration and Reference Site Map

File No. 1697-02	Date 12/17/03	Figure 2

2.0 MONITORING ELEMENTS

Specific monitoring elements that will provide information for evaluating the evolution of site functions have been identified. These monitoring elements have been selected as pertinent indicators of progress towards the project's specific goals and objectives.

2.1 MONITORING LIMITATIONS/ASSUMPTIONS

There are no specific performance criteria for the Bair Island Restoration project. However, the restoration project was designed to achieve overall objectives of restoring Bair Island to native tidal salt-marsh habitat, and providing habitat for endangered species (California Clapper Rails and salt marsh harvest mice). Monitoring of the restoration project will facilitate evaluation of the project's progress towards achieving those objectives.

Certain elements of the plan, especially some of the physical elements, will be discontinued, once there is a clear indication that the site is evolving in the predicted fashion, as described below. It is likely that the distinct subsections, or "ponds" (Inner Bair, Middle Bair East, Middle Bair West, and Outer Bair), within this restoration will achieve their objectives in different time frames. Therefore, this monitoring program will end within each pond once California Clapper Rails and salt marsh harvest mice have colonized that unit.

2.2 PHYSICAL ELEMENTS

Physical monitoring will be carried out at specified intervals to help to understand how the physical system is responding to the restoration design implementation and to determine if any intervention is required. This part of the monitoring program includes several geomorphic and hydrologic elements that will be monitored by a qualified engineer or geomorphologist. Monitoring locations are shown in Figure 3 and 4. The monitoring schedule and frequency are described in Table 1 of Section 4. The exact locations of the monitoring data will be determined by Global Positioning Systems (GPS) to facilitate accurate mapping.

Tidal Circulation. Water levels and drainage patterns will be monitored in the tidal sloughs and inside the restored ponds to evaluate hydrologic functions at the site. Tidal circulation is important since characteristics of the hydroperiod affect vegetation colonization, sediment delivery to the marshplain, ecologic functions of the site, and drainage of adjacent low-lying areas.

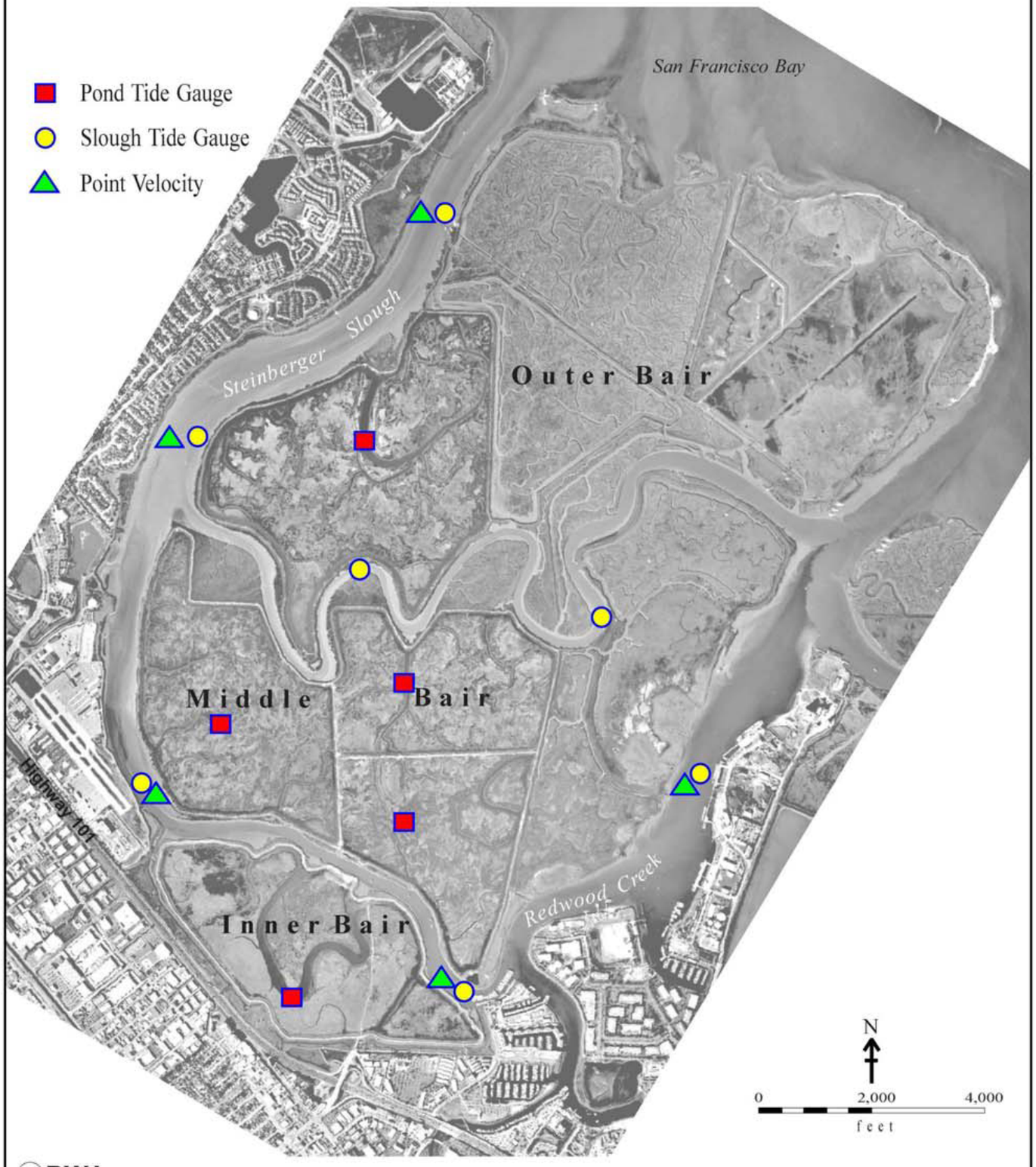
Tidal damping conditions in slough channels and restored ponds are expected during initial tidal restoration of Middle Bair because parts of the slough network will be initially undersized and because the new flow-control structures will reduce the amount of tidal flow routed through Redwood Creek. Initially, Inner Bair, Middle Bair, and the upstream reach of Steinberger Slough are not expected to drain completely at low tide. However, low-tide drainage is expected to improve as the sloughs deepen and internal drainage networks inside the ponds develop.

figure 3

Bair Island

Monitoring Stations: Tide Gauges & Current Velocities

Basemap: aerial photograph (2/18/00)



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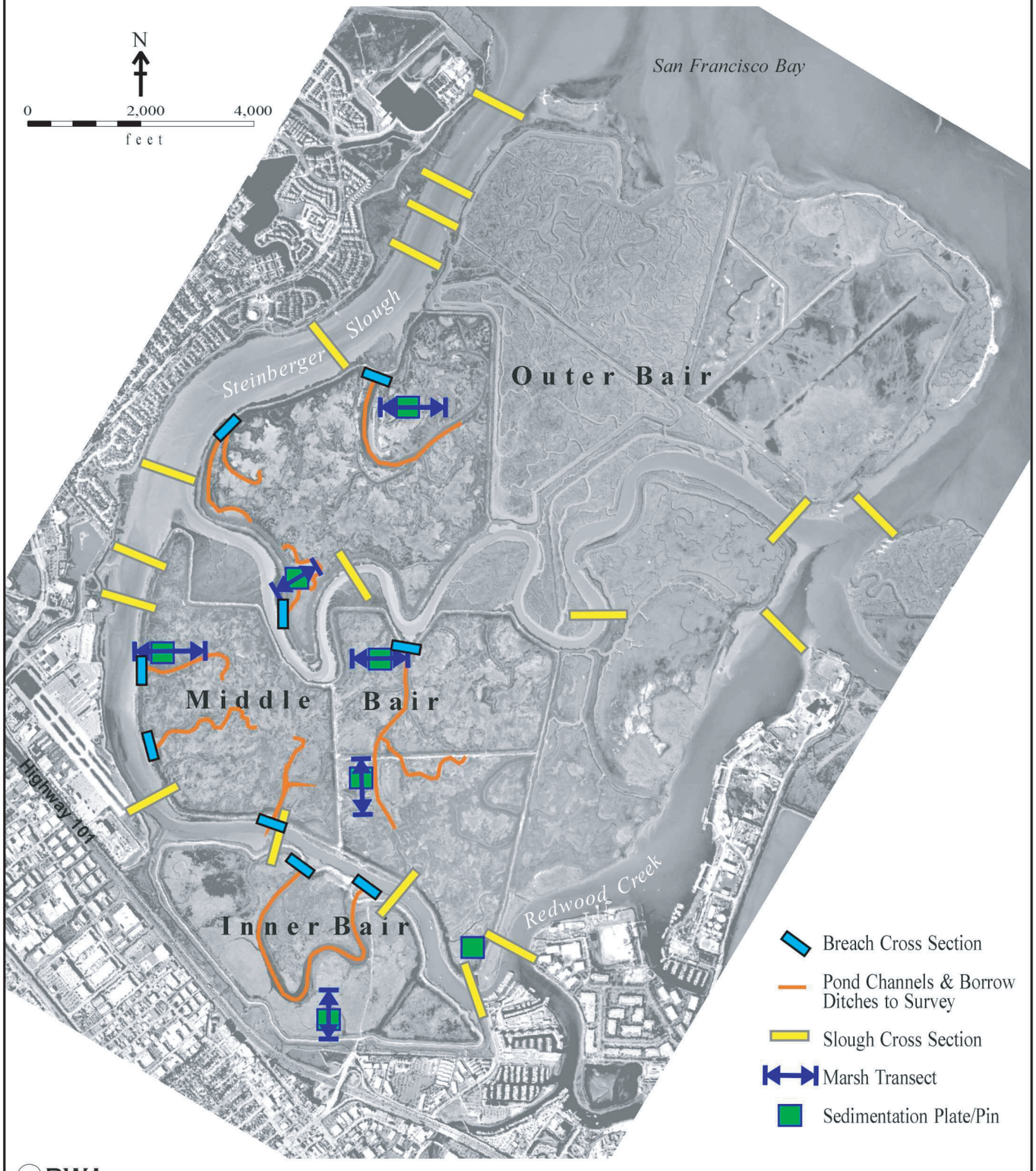
PWA

figure 4

Bair Island

Monitoring Stations: Slough and Marsh Morphology

Basemap: aerial photograph (2/18/00)



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Water-level elevations will be measured continuously over a spring neap cycle (about 14 days) concurrently at locations within the slough network and inside Outer, Middle, and Inner Bair Islands. Water-surface elevation data will be used to determine whether tidal damping is present inside the sloughs and ponds. If the monitoring team concludes that tidal dampening is present and poses a significant threat to site development, then remedial measures will be developed and proposed in the monitoring reports. Internal levees, ditch blocks, under-sized sloughs, and slow re-establishment of the historic pond channels are examples of conditions that may contribute to inadequate low-water elevation drainage.

Slough Morphology. The goal of the slough morphology monitoring is to understand how the existing looped slough networks of Redwood Creek, Steinberger Slough, Corkscrew Slough, and Smith Slough (Figure 4) are responding to the tidal restoration project. Increased tidal flows are expected to erode sections of Steinberger Slough, while decreased flows due to flow-control structures are expected to cause siltation in other portions of the slough system. These trends of erosion and siltation will influence water levels at the site and conveyance of flood flows from Pulgas and Cordilleras Creeks.

Steinberger Slough is currently undersized to convey the additional tidal prism associated with restoration of Inner, Middle, and Outer Bair, and is expected to deepen as increased tidal flows scour sediment. Bed erosion is likely to occur preferentially along the thalweg, where velocities are greatest, resulting in improved low-water drainage in the upstream reaches of the slough and in areas of Middle Bair that drain to Steinberger Slough. Increased conveyance along Steinberger Slough will be necessary to offset decreases in conveyance associated with rerouting streamflow from Pulgas and Cordilleras Creeks that presently discharge to San Francisco Bay through Redwood Creek. Targeted cross sections of Steinberger Slough will be surveyed more frequently than other parts of the slough network to assess morphological changes that affect its ability to route flood flows. This more frequent flood assessment will include numerical modeling to establish changes in flood conveyance along Steinberger Slough, as described in the EIR/S.

As described in PWA (2003), a revised flood assessment may be required if monitoring of water levels indicates that the channel restrictors are not performing as expected (i.e., the amount of tidal flows in the Redwood Creek and Smith Slough are significantly higher than existing conditions). If a revised flood assessment is required, cross sections will be surveyed along Steinberger Slough, at the locations shown in Figure 4. Significantly fewer (approximately half) cross sections will required if a revised flood assessment is not required. Data form cross sections along Smith and Corkscrew Sloughs will also be collected, although less frequently. Additionally, cross section data will also be collected along Redwood Creek to document whether or not tidal restoration of Bair Island has increased the shoaling rate along the Shipping Channel. Cross sections will be surveyed before restoration (Year 0) at every monitoring station to establish baseline conditions and at the time intervals shown in Table 2 in Section 4.

Satellite imagery collected for habitat evolution (see below) will also be used to assess morphological changes along Steinberger Slough, especially at its mouth where substantial erosion through the outboard mudflat is expected.

Marsh Morphology. The morphology of the restored marshplain will be monitored to measure whether the site is evolving along the expected trajectory. Since it is expected to take many

decades for the site to reach elevations close to those of natural marshes, monitoring will provide data that can be used to estimate the rate of evolution and the functions of the restored wetland in its transitional state. Components of the marsh monitoring include:

1. Pond Drainage Network. In the current pond configuration, historic pond channels and some of the borrow ditches in the interior of the ponds are expected to capture most of the tidal flows onto the marshplain, therefore the restoration design includes channel connectors and "cut-off berms" to allow for adequate drainage without the borrow ditches becoming the primary drainage network. In order to track slough development during restoration, approximately one to five cross sections of each selected remnant channel will be surveyed. Figure 4 shows the pond channels recommended for survey, although the exact location and number of cross sections may be modified depending on how the restoration project is implemented (e.g., phasing) or adaptively managed as the site evolves. Longitudinal profiles will also be collected along the main interior channels identified in Figure 4. "Cut-off berms" will be visually inspected to evaluate whether they are performing adequately (not undermined by excessive erosion) and whether any maintenance is required. One cross section will be collected from a borrow ditch adjacent to each of the primary pond channels. Additionally, aerial photography collected for habitat mapping will be used to assess the evolution of the interior pond drainage system.

2. Marshplain Evolution. Tracking the development of the restored marshplain will be a key monitoring element, given the overall goals of the restoration project. Sedimentation plates/pins will be installed prior to breaching and inspected after restoration to determine rates of estuarine deposition. Stations will be installed throughout Outer, Middle and Inner Bair islands to determine how sedimentation rates vary with distance from levee breaches and among the three ponds. Additionally, vegetation-elevation transects approximately 500 – 1,000 feet long will be surveyed to verify sedimentation rates and further characterize marshplain evolution, particularly the natural levee formation behind the interior pond channels.

3. Breaches. Since Middle and Outer Bair Islands will be below natural marshplain elevations at the time they are breached, a greater amount of tidal prism will initially pass through the levee breaches relative to long-term conditions. Therefore, there may be a tendency for the breaches to scour and enlarge, since they were sized based on the expected long-term conditions. Cross sections of each of the nine levee breaches included in the Recommended Alternative will be measured to determine the rate of breach widening and deepening.

4. Remnant Levee. Although some levees on Middle and Outer Bair will be lowered to provide a source of fill for construction, outboard and interior levees will largely be left in place to serve as wave breaks to promote marshplain evolution and provide upland refugia for marsh wildlife. Levees will be inspected for evidence of wind-wave erosion by aerial photography, and the linear distance of intact levees will be estimated.

Tidal-Current Velocities. The potential for increased tidal-current velocities at Pete's Harbor was identified as a significant project constraint early in the restoration design development. Specific elements were included in the design to facilitate tidal restoration without raising peak

velocities at the harbor. Point-current meters will be used to measure tidal currents before and following tidal restoration to confirm velocities are not significantly higher following restoration. Additional current meters will be deployed along Steinberger and Corkscrew Sloughs to correlate velocities with rates of erosion and downcutting. Figure 3 shows the locations of each tidal-current station. Tidal-currents will be measured over a complete spring neap cycle and timed to coincide with measurements of water level elevations.

Infrastructure. Flow-control structures along Smith and Corkscrew Sloughs will be visually inspected to assess structural integrity and to confirm that these elements are functioning as expected. The structural integrity and hydraulic performance of the flow-control structures are essential to project success, since the structures limit sedimentation along the Redwood Creek Shipping Channel and enhance the supply of sediment-laden water to Middle and Outer Bair islands. The armored breach along the historic meander of Smith Slough (IB1) will also be inspected at the same time as the flow control structures. As described in the Restoration and Management Plan (HTH & PWA 2003), adjustments to the flow control structures and armored breach will be made as part of an adaptive management program to ensure the restoration plan does not adversely affect flood hazards or the shipping channel. Trails will also be visually inspected to assess their structural integrity.

Monitoring Schedule. Monitoring of physical elements should follow the schedule summarized in Table 1 in Section 4. Note that some of the monitoring elements can be discontinued early, if data indicate that performance is satisfactory.

2.3 BIOLOGICAL ELEMENTS

Habitat Mapping. To determine ratios of intertidal habitats to each other and to open water, satellite imagery (*e.g.* IKONOS) will be obtained for the project area. The image will be collected in June or July, during a low solar angle, and minus tide. To ensure comparisons across years, all image capture will occur at a similar tidal elevation. The monitoring schedule and frequency are described in Table 1 of Section 4. It is essential that the type of image and parameters of the images stay essentially the same both within and across years to spatially analyze the data. The imaging for the first five years will primarily be used to help monitor physical changes on the marsh plains, as little vegetation colonization is expected in that period.

Habitats will be mapped on a dominant species basis, primarily to detect colonization by native cordgrass and pickleweed. Non-native cordgrass will also be mapped, where it can be detected on the satellite images. The images will be interpreted and mapped preliminarily, then ground truthed from levee locations and by boat.

Vegetation. More detailed plant sampling will occur along the established transects only after the aerial mapping has detected the beginning of colonization. Specifically, when habitat mapping indicates that the percent cover of vegetation on the marsh plain in a given pond (Inner, Middle East, Middle West, or Outer Bair) equals or exceeds 10%, then more detailed sampling will be conducted. That sampling will occur thereafter every 5 years until successful colonization of each pond by CCR and SMHM is confirmed. Plant-species composition and relative abundance will be determined in minimum one square meter quadrats arranged along the vegetation/elevation transects shown on Figure 4. Quadrat sampling will correspond with elevational data points collected on the transects.

The best timing for vegetation sampling is July or August, however this period conflicts with protections afforded to the California Clapper Rail during the breeding season. Therefore, it is understood that sampling may not occur until September of each year. The monitoring schedule and frequency are described in Table 1 of Section 4.

Invasive Cordgrass. The San Francisco Estuary Invasive *Spartina* Control Program proposes to implement a coordinated, region-wide eradication program, comprising a number of on-the-ground treatment techniques to stave off invasion of non-native cordgrass from the eastern United States. The Control Program would be focused within the nearly 40,000 acres of tidal marsh and 29,000 acres of tidal flats that comprise the shoreline areas of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, Sonoma, and Sacramento counties. One of the initial targets of the program includes Bair Island. It is assumed that all invasive cordgrass monitoring and eradication will be coordinated through this control program.

However, if invasive cordgrass is suspected and/or identified along an established vegetation transect or during general site reconnaissance, the location of the invasive cordgrass will be mapped and reported to the Control Program. The project proponents are working closely with the San Francisco Bay Invasive *Spartina* Control Program to ensure that any activities at Bair Island are consistent with the goals and procedures of the bay-wide eradication program.

Adaptive Management. Three years after tidal influence has been restored to Bair Island the extent of the invasive smooth cordgrass (*Spartina alterniflora* and its hybrids) infestation will be re-evaluated and the challenge and feasibility of eradicating the introduced cordgrass will be re-assessed in relation to conditions in the South Bay and Control Program's regional efforts of smooth cordgrass control. At this time it may be deemed infeasible to eradicate the invasive species in perpetuity. If this is the case, efforts may focus on controlling smooth cordgrass spread, maintaining areas of open mudflat and insuring that it is not encroaching on higher marsh habitat.

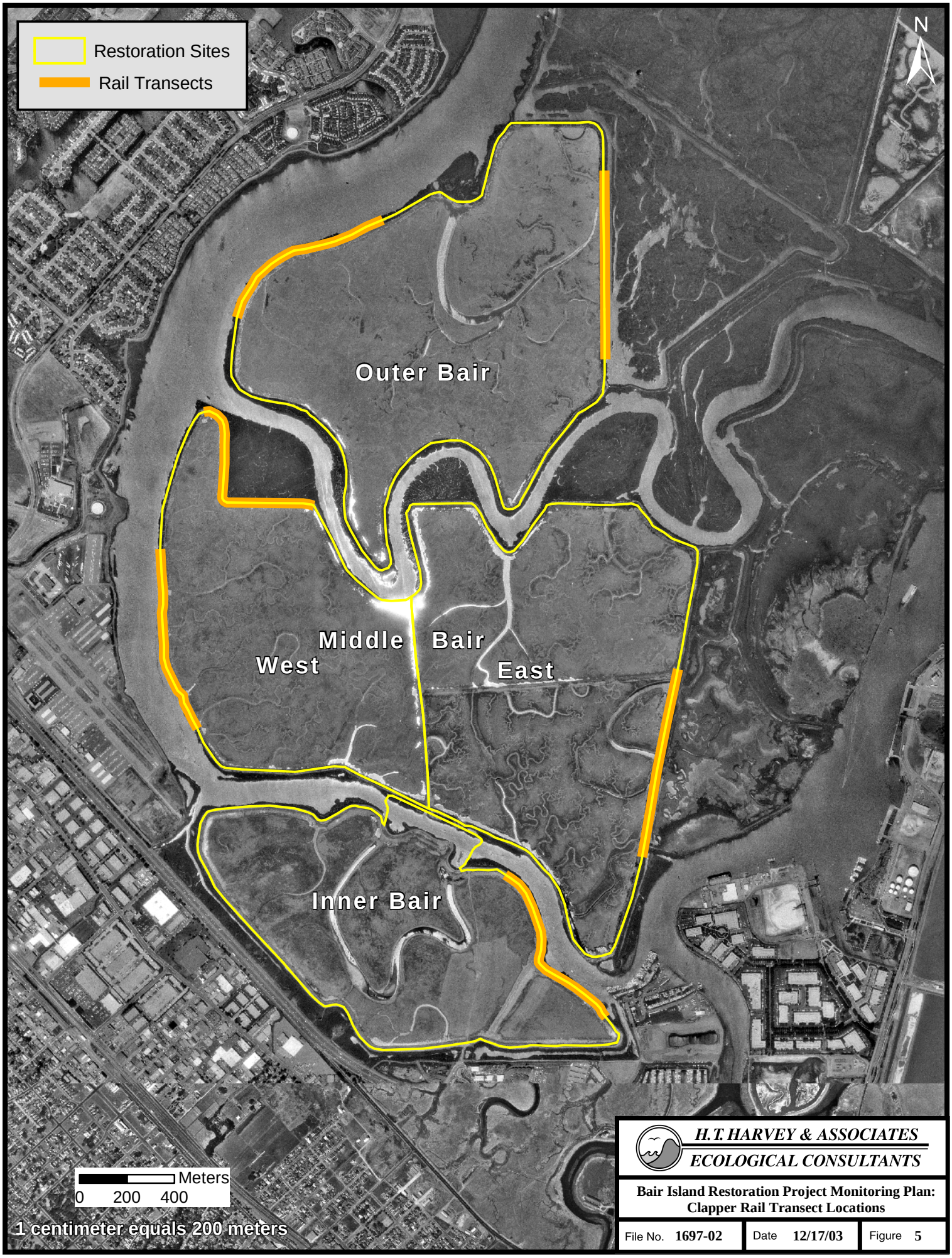
California Clapper Rail. A primary goal of the restoration of Bair Island is the creation of habitat for California Clapper Rails. Clapper Rails currently breed on the restored portion of Outer Bair Island. Clapper Rails also breed on nearby Greco Island.

Studies of radio-tagged individuals representing three other subspecies, including the Louisiana, Light-footed, and Yuma Clapper rails (*R. l. saturatus*, *R. l. levipes*, and *R. l. yumanensis*, respectively; Roth et al. 1972, Zembal et al. 1989, Conway et al. 1993) have shown that these rails have relatively small home ranges ("territories" - 0.04 – 1.66 ha), but that their territories change seasonally, being significantly larger during the nonbreeding period than during the breeding season. These rails are most vocally active during the early breeding season (March to May) and least active during winter (Conway et al. 1993). The latter is the only study that we are aware of that examines seasonal vocalizations of this species, but the seasonality noted by these authors is consistent with that of another species, the California Black Rail (*Rallus jamaciensis corturniculus*; Spear et al. 1999). In addition, detection probability in the California Black Rail, and likely the Clapper Rail as well, is related to several environmental factors including time of day, air temperature, cloud cover, tide height, moon phase, and season (Spear et al. 1999). Except for time of day (see below), we are not aware of such studies having been conducted for the Clapper Rail.

The objective of the Clapper Rail surveys at Bair Island is to determine presence and estimate densities. Breeding season surveys will be conducted every five years beginning when vegetation monitoring detects 30% cover and continue until the USFWS determines that a sustainable population of Clapper Rails breeds in the restored areas. A target breeding season density can be 0.33 rails per hectare of marsh habitat, a mean density derived from an extensive study of breeding California Clapper Rails conducted in 13 marshes in the South Bay in 1989 (H. T. Harvey and Associates 1989). The USFWS will also use the monitoring data to track the rail population in the restored habitats and implement adaptive management as determined necessary by the Service. Once the USFWS determines that a sufficiently robust breeding population of California Clapper Rails is established in the restored areas, the Service will continue monitoring the areas via winter high-tide surveys. Breeding season surveys should be conducted between February 15 and April 15. As noted above, this period coincides with the first part of the breeding season when rails are most vocal and detectability rates are likely at a maximum which, in turn, maximizes the accuracy of density estimates derived from survey data.

Clapper Rails will be surveyed at Outer, Middle-east, Middle-west and Inner Bair Island using 800 m long (0.5 miles) transects positioned on the diked levees (Figure 5). Each transect will consist of 5 stations at 200 m intervals. Each of the 30 stations will be marked with a flagged rebar post with the transect and station numbers labeled on the flagging. Placement of transects within each survey area will be determined based on optimum habitat quality at that time. Surveys will be conducted on each transect three times, with surveys at least one week apart. During each survey session, multiple observers can survey more than one transect simultaneously, as long as: 1) there is not more than one observer assigned to any given section and, 2) they are spaced far enough apart so that call-broadcasts (details below) cannot be detected by any of the other observers involved. Thus, it is likely that a total of three observers could conduct surveys simultaneously. In the past we have found that the problem of an observer mistaking the other's recorded calls for a rail can be avoided by choosing transects separated by distances >2000 feet (about 0.4 miles).

Surveys will be conducted using pre-recorded "duet" calls of the California Clapper Rail. Each observer will need an ESA section 10a1A "recovery permit" to broadcast rail vocalizations, as the activity constitutes "harassment" of a Federally-listed species. These permits are available from the U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, 2800 Cottage Way, Room W-2605, Sacramento, CA 95825. Obtaining these permits well before survey implementation will be very important because without the use of broadcasts, considerably more time will be required for "listening" at each station and rail densities are more likely to be underestimated. Even more critical would be the unrecoverable loss of the standardized survey protocol (a must for population trends analyses) that will occur if broadcasts are used in some years but not others.



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Bair Island Restoration Project Monitoring Plan: Clapper Rail Transect Locations

File No. 1697-02	Date 12/17/03	Figure 5

The calls will be broadcast at each station for one minute, with four sequences of duet or clapper calls repeated during the playback minute. Each observer will require a high-quality cassette (or CD or MP3) player equipped with a stereo-amplified speaker system capable of broadcasting between 80-90 dB at 1-meter in front of the speaker, and a high quality recording to broadcast rail calls. The same audio setup played at a standardized decibel rating will be used on every survey. For each survey, starting points at either end of all transects will be alternated. Morning surveys should not be initiated earlier than 0.75 hours before sunrise or end more than 1.25 hrs thereafter, and evening surveys should begin no earlier than 1.5 hrs before sunset and end no later than 0.75 hours following sunset (Zembal et al. 1989, Spear et al. 1999). An hour should be adequate to complete the survey along each transect if observers spend no more than 10 minutes at each station.

Following Kepler and Scott (1981), observers will be trained to estimate detection distance. These training sessions will be conducted prior to surveys using a recorder playing rail vocalizations at various distances from the observers. Each detected Clapper Rail will be counted and the distance to each bird will be estimated. The distance from observers at which rail detection probabilities decrease will be established using standard equations. This information will then be used to calculated Clapper Rail densities. Thus, both direct-count and density data will exist for each area surveyed.

Weather conditions, including wind speed and direction, air temperature and cloud cover will be recorded at the beginning of each survey. Surveys should be discontinued when winds are >15 knots. Surveys will not be conducted when tides are greater than 4.5 feet NGVD as measured at the Golden Gate. Except for wind speed, it will not be possible to control for the effects of other environmental variables that affect rail detection probability (e.g., tide height, air temperature, cloud cover, and moon phase) due to logistic constraints imposed on the scheduling of rail surveys. But by recording these variables during surveys, it will be possible to make the required adjustments during the analyses of Clapper Rail density (see below).

When a Clapper Rail is detected during surveys, data recorded will include date, time, station number, type of call, compass bearing and estimated distance to the calling bird. Distance estimates will pertain to the first call elicited by a rail. Simultaneous vocalizations and distances between call locations will be used to distinguish individuals.

Post restoration, monitoring will begin at any one of the four subsections only after the vegetation targets area reached. They will continue at the specific transect until CCR densities reach the target level (Table 1, Section 4)

Salt Marsh Harvest Mouse. The objective of the SMHM monitoring is to achieve a consistency in catch within each restored pond so that we can reasonably assume that SMHM are establishing a viable population within the restored portions of Bair Island. We considered a variety of trapping programs and techniques while designing the monitoring element for the SMHM. For example, protocols collected by SFEI (2002) included both random and non-random protocols for monitoring salt marsh harvest mice; the former, with its random assignment of trapping locations, allows for detailed statistical analysis of such parameters as microhabitat use but requires large numbers of trap nights and is time, effort and cost intensive. The latter protocol, i.e., using non-random techniques such as grids and/or lines of traps, can be used to ascertain presence and absence of salt marsh harvest mice and provide qualitative data as

to relative usage of various areas by the mouse. Non-random techniques, however, are not amenable to most statistical analyses but require fewer trap nights, and less time, effort and cost.

We propose to use the non-random method because of the number of areas and trap nights to be monitored, the concentration of traps needed to trap this species when it is present in low numbers, and the narrow time window available for trapping (i.e., when Clapper Rails are not nesting and nighttime tides are low). Therefore, the trapping protocol is designed to detect the colonization of the restored marsh by SMHM, and the establishment of a population within the restored area. A population will be considered established when relative densities, as judged by capture efficiency (capture per unit effort, CPUE), approximate other marshes in the south bay area. Data collected by Shellhammer and Duke (in preparation) indicates that 3 captures per 100 trap nights would be a reasonable indication that a population had established itself on the restored marsh plain.

Monitoring will commence when pickleweed cover reaches at least 75% cover over at least 10% of the developing marshplains within any subsection (i.e., Inner, East and West Middle, Outer) of Bair Island (see Vegetation monitoring element). While dense patches of pickleweed over 10% of any given pond is far less than its projected final distribution, this represents 30 to 140 acres, depending upon the pond. Trapping will occur initially only in the section with the best potential habitat and will be conducted on the marsh plain. Special precautions need to be observed in order to trap on the marsh plain. Trapping will have to occur in a neap tide window in the fall when the marsh plain supporting pickleweed will not be inundated for the 4-day window of trapping.

Because these sites are large and there is likely considerable spatial variation in mouse abundance, two grids (lines) of 50 traps (spaced 10 m apart, 100 total traps) will be established within each pond, within the best available habitat. If possible, the grids will overlap with vegetation/elevation transects established on the marsh plain. Each grid will be trapped for four nights. Trapping will continue every five years until SMHM are captured on the restored marsh plain and in sufficient numbers (see below) to conclude that the population is established.

All trapping will be conducted using Sherman live-traps. Live traps will be supplied with nesting material and baited, and each trap will be placed on a small wooden board to shield nesting material (cotton batting) from wicking moisture from the substrate. A second board should be placed on top of any trap not sufficiently covered by vegetation. Trapping dates will be selected to avoid inclement weather, and be based on periods when overnight tides will be least likely to inundate set traps. Traps will be checked each morning at dawn, closed and removed (if necessary) during the day, and reset one hour before sunset.

Trapping will be conducted by trained and permitted biologists following all federal and state permitting guidelines. All small mammal species will be identified and sexed while salt marsh harvest mice will also be weighed and marked to allow assessment of recapture on subsequent trap-nights during the trap session. Methods described in Shellhammer (1984), and the Don Edwards San Francisco Bay NWR protocol will be used to identify *Reithrodontomys* mice to species whenever possible.

Each trap will be marked with the transect and trap number and GPS units will be used to record the location for each trap. Each time a mouse is trapped the transect and trap number will also be

recorded. Vegetation data will be recorded at each trap site within each grid. Minimum vegetation data collected will be species present, percent plant cover by species, maximum plant height by species. All vegetation data will be collected within a 1-m^2 quadrant. The southeast corner of the quadrat will be located on the trap site.

Introduced Predators. Introduced predators such as the non-native red fox (*Vulpes vulpes regalis*) can have significant negative effects on nesting birds, including California Clapper Rails. Restoration of Clapper Rails cannot occur without concurrent management of non-native predators, thus red foxes and other mammalian predators will continue to be trapped at Bair Island following guidelines in the USFWS (1991) Predator Management Plan and Final EA. Although no formal monitoring will be established for introduced predators, if Clapper Rail surveys or other anecdotal evidence suggests that introduced predators are present at Bair Island, a monitoring program should be established following the methods of Albertson (1995).

3.0 DATA ANALYSIS

3.1 ANALYSIS OF PHYSICAL DATA

Analysis of field data collected during each monitoring event will be conducted as soon as possible to allow for further sampling if discrepancies in the original data set are encountered. Data analysis will include preparation of graphs and tables, and comparisons with previous monitoring events to evaluate site progress. Specifically, analysis of the physical data will include the tasks described below.

Tidal Circulation. Data from the tide gauges will be presented graphically and compared with tides in San Francisco Bay to assess the degree of tidal muting throughout the slough system and ponds. In particular, the low-water elevation during spring and neap tides will be examined at the monitoring locations. Tide signals from the gauges installed inside the restored ponds will be compared to marshplain elevations to determine frequency, duration, and depth of flooding. An assessment regarding the adequacy of site drainage in relation to habitat development will be made.

Slough Morphology. Measured cross-sections will be presented graphically, and the rates of downcutting and widening will be documented. Data collected from the point current meters will be compared to rates of erosion/sedimentation along the sloughs. The amount of slough expansion following tidal restoration will be important in assessing the risk of flooding along Pulgas and Cordilleras Creeks (briefly discussed below and detailed in the EIR/S).

Marsh Morphology. Marshplain sedimentation rates collected from the sedimentation plates/pins will be used to assess if the site is evolving as expected, and to estimate the time required to reach a mature marshplain elevation. Data will be tabulated for each of the monitoring locations to document the variability in sedimentation rates throughout the site. Transect data will be presented graphically and compared to elevations required for vegetation colonization.

Data for breach cross-sections will be presented graphically, and rates of widening and downcutting will be determined. Data from tide gauges installed in the restored sites will also be examined to explain adjustments in breach geometry.

Tidal-Current Velocities. Data from the point-current meters will be presented graphically, and peak spring and neap velocities will be noted. Peak tidal current velocities collected at Pete's Harbor will be compared to pre-project conditions to assess whether tidal restoration at Bair Island has resulted in higher tidal currents and more difficult navigation conditions.

Current velocities along Redwood Creek will also be compared to pre-project conditions to determine if more sediment-laden Bay water is being drawn through the shipping channel. Some natural variability is expected due to differences in tidal forcing at the time of monitoring and timing of dredging activity, and surveyed cross sections along Redwood Creek will supplement the assessment of increased shoaling in the shipping channel.

Since monitoring of velocities at Pete's Harbor and along Redwood Creek will be carried out to

document the need for mitigation, a more detailed description of the data analysis is provided in the EIR/S documents.

Peak tidal current velocities collected along Steinberger and Corkscrew sloughs will be documented and compared to the observed rates of erosion/deposition to help define erosion thresholds.

Performance of Hydraulic Structures. Measured tidal currents collected from Pete's Harbor, Redwood Creek, and Corkscrew Slough (east of the flow control structure) will be compared to pre-project conditions to determine if flow-control structures are functioning properly. Specifically, measured tidal currents and surveyed cross sections will be used to assess the effectiveness of flow-control structures in limiting tidal flows through Redwood Creek and routing the additional tidal prism through Steinberger Slough.

Flood-Risk Assessment. An annual flood-risk assessment will be conducted by examining the low water drainage along Steinberger Slough and supplemented by numerical modeling. Although bed erosion is expected to improve low-water drainage and conveyance, the initially undersized cross sections of Steinberger Slough are expected to increase flood hazards in the short-term. Since the annual flood assessment will be carried out to monitor for mitigation of increased flood hazards, the assessment is detailed in the EIR/S documents.

Trail Assessment. Visual inspections of the constructed trails will be used to assess: (1) if trail cover is appropriate for the level of traffic, (2) if public safety and access have been maintained, and (3) how off-trail use is adversely affecting wildlife habitat and the possible need for trail re-alignment.

3.2 ANALYSIS OF BIOLOGICAL DATA

Habitat Mapping. Habitat mapping data will be analyzed in GIS to determine the area of each habitat type and changes in habitats through time. The percent change in habitats through time will be analyzed using a spatial analysis program. This analysis will allow project managers to track the development of habitats.

Vegetative Cover. The sampling unit to be analyzed will be a species' relative cover value, by transect. These data will be used to trigger sampling for SMHM and CCR.

Invasive Cordgrass Monitoring. Non-native cordgrass stands identified during sampling will be reported directly to the San Francisco Bay Invasive *Spartina* Control Program.

California Clapper Rail. Estimating abundance of rails from call playback surveys requires the determination of the maximum range within which rails are detected with equal probability (see Buckland et al. 1993). The expected number of detections increases in proportion with πr^2, where r is the distance between the observer broadcasting the calls and the outer edge of the survey zone (i.e., the radius of the circular survey zone), and π is the constant, 3.1416. Conformance in the number of rail detections with this relationship as r is increased indicates that rails are being detected at the farther distances as well as they are at closer ones. Conversely, a breakdown in the relationship caused by a decrease in rail detections at larger distances indicates that detection probability is being negatively affected by the increase in r,

either because the observer is hearing fewer of the responding rails, or because fewer rails at those greater distances are responding to the broadcasts.

An example of avian density calculations is given below, assuming that the detection range cutoff is 50 m. The density for each transect survey will be calculated from the equation:

$$d = \frac{n}{(\pi)\,(50^2)\,(5)},$$

where d = the number of birds of species a per meter^2, n = number of detections within 50 m, π = 3.1416, and 5 is the number of stations per transect. Annual mean density of species a $\pm$ the standard error can then be calculated by averaging density across x transects conducted per year. An abundance estimate, then, is the density times the surface area of the marsh for which an estimate is desired.

Salt Marsh Harvest Mouse. The sampling unit will be catch per unit effort (CPUE) per grid. CPUE will be compared among the different subsections of Bair Island, and with other historic and current data from South San Francisco Bay, but 3% CPUE is the initial target. Changes in mouse densities between sampling years will be analyzed qualitatively. Relative plant abundance and plant height will also be qualitatively compared to SMHM densities. Due to sampling design limitations, no statistical tests are planned for SMHM density estimates.

Introduced Predators. No analyses are planned for predator observations.

4.0 MONITORING TIMELINE

All monitoring elements described in Section 2 should occur at the frequency listed in Table 1. Selected monitoring can be discontinued if data indicate that site evolution and/or the hydraulic structures are performing as expected, as discussed below. Efforts will be made to coordinate and consolidate monitoring effort once the monitoring triggers have been attained.

Table 1. Monitoring Frequency of Physical Elements

ELEMENT	FREQUENCY	NUMBER OF STATIONS/GAUGES/TRANSECTS*
Tidal Circulation	Years 0, 1, 2, 5, 10, 15, 20***	7 tide gauges in the slough system and 5 gauges in the Outer, Middle and Inner Bair Islands.
Slough Morphology**	Years 0, 1, 2, 5, 10, 15, 20.	18 cross sections throughout slough network.
Targeted Survey of Steinberger Slough	Annually, to be discontinued once flood assessment indicates that conveyance has been restored (see text)	3 tide gauges and 9 cross sections along Steinberger Slough (to assess changes in flood conveyance).
Marsh Morphology	Years 0, 1, 5, 10, 15, and 20	9 levee breaches, 6 transects, and 7 sedimentation plates/pins.
Current Velocities	Years 0, 1, 2, 5, 10, 15, 20 ***	5 current meters.
Infrastructure	Flow control structures and armored breach immediately after construction and significant rainfall events during the first year, then twice a year (before and after the rainy season). Trail annually.	2 flow control structures, 1 armored breach, and trails along Inner Bair Island.
Habitat Mapping	Years 0, 1, 5, every 5 years until CCR and SMHM monitoring criteria are met	Satellite imagery, field-truthed and produced in GIS
Vegetation	Variable depending upon site evolution. Begins when habitat mapping detects 10% cover, then every 5 years thereafter until CCR and SMHM monitoring criteria are met	6 transects, corresponding to marsh morphology transects.
Invasive Cordgrass	See Vegetation (above)	N/A
California Clapper Rail	Breeding season surveys initiated when vegetation cover in restored areas	Call playback surveys will be conducted along transects on the levees of the restoration site.

ELEMENT	FREQUENCY	NUMBER OF STATIONS/GAUGES/TRANSECTS*
	reaches 30%. Then once every five years until breeding densities reach 0.33 rails/hectare, or the USFWS determines that an adequate breeding population has been established. Thereafter, winter high-tide surveys will be conducted.	
Salt Marsh Harvest Mouse	Begins when dense pickleweed covers 10% in any given pond. Then every 5 years until CPUE = 3%	Two grids on Inner and Outer Bair; four grids on Middle Bair.

* Approximate numbers only. The precise number of monitoring stations may vary depending on data collected during the previous monitoring events.
** See also targeted surveys of Steinberger Slough.
*** See text for discussion of performance criteria for early termination of these surveys.

Low-water drainage is expected to improve as tidal scour deepens Steinberger Slough and a channel drainage networks are established inside the Outer and Middle Bair Islands. Therefore, monitoring of water surface elevations can be discontinued once the full tidal range is developed.

Monitoring of current velocities at Pete's Harbor and Redwood Creek can be discontinued after Outer, Middle, and Inner Bair Islands have been breached, once the data indicate that peak tidal currents to do not significantly exceed pre-project conditions. Monitoring of velocities along Steinberger Slough should continue as long as morphological changes of the slough are observed.

As discussed in the EIR/S, assessments of conveyance of flood flows from Pulgas and Cordilleras Creeks will be carried out every year. Targeted surveys along Steinberger Slough will not be needed once these annual flood assessments demonstrate that scour along this reach of the slough network has increased flood conveyance to pre-project levels.

Note that more detailed descriptions of the flood and Pete's Harbor assessments are provided in the EIR/S.

5.0 PERFORMANCE EXPECTATIONS

Measuring performance of the restoration relative to expectations will increase the likelihood that long-term habitat goals will be met through adaptive management. Since Bair Island is not a mitigation site, it does not need to strictly conform to a particular set of standards. However, the expectations listed in Table 3 will be used to guide evaluation of site evolution. Expectations for meeting non-habitat related mitigation requirements are documented in the EIR/S and are not included here.

Table 2. Performance Expectations

MONITORING ELEMENT	PERFORMANCE EXPECTATIONS (HYPOTHESES)
Tidal circulation and Slough Morphology	Inner Bair, Middle Bair, and the upstream reach of Steinberger Slough are not expected to drain completely at low tide initially. However, drainage will improve as Steinberger Slough deepens and drainage systems inside the ponds develop. The range of high and low tides throughout the site will be similar to those in South San Francisco Bay by approximately Years 5 - 10. This expectation relies on engineering judgment based on rates of tidal slough scour in similar systems. Rates of tidal slough scour erosion are generally difficult to predict with certainty and no site-specific predictions have been prepared for Bair Island. We consider the time frame above (5-10 years) to be conservative, and the actual time for full tidal drainage may be less.
Marsh morphology	The ponds will evolve to more closely resemble a natural marsh. However, rates of colonization of emergent marsh vegetation will vary due to spatial differences in suspended sediment concentration, initial muting of the tide range, and differences in existing elevations within the ponds. Expected habitats and site evolution are described more fully in Section 7.2 of the Restoration and Management Plan.
Current Velocities	Pre- and post-project velocities are expected to be similar east of the flow control structures. Velocities west of the structures are expected to increase.
Tidal marsh vegetation	Inner Bair will rapidly colonize with cordgrass and pickleweed (*Salicornia* sp.), with substantial areas of vegetated marsh forming by the end of Year 5. Inner Bair will likely transition into a perennial pickleweed (*Salicornia virginica*) dominated marsh by the end of Year 15. Outer Bair will be mostly vegetated in 10 to 25 years. Plant establishment at Middle Bair will take longer, with a vegetated marsh forming in 25 to 50 years.
Transition/Upland vegetation	In order to provide high-tide refugia for the salt marsh harvest mouse, the transition and upland vegetation should evolve to provide adequate plant cover. The total acreage of these habitats will depend upon the amount of area created in Inner Bair by the beneficial use of dredge material and by differential subsidence of levees and berms throughout the restoration areas.

MONITORING ELEMENT	PERFORMANCE EXPECTATIONS (HYPOTHESES)
California Clapper Rail	It is anticipated that Clapper Rails will be present in all restored areas of Bair Island once appropriate habitat becomes established. Densities should reach levels comparable to those of known Clapper Rail populations in other marshes on San Francisco Bay (0.33 rails/hectare during the breeding season; after H. T. Harvey and Associates 1990). We anticipate that these levels would be achieved within 20 years of the establishment of appropriate habitat.
Salt Marsh Harvest Mouse	It is anticipated that salt marsh harvest mice will be present in all restored areas of Bair Island once appropriate habitat becomes established. CPUE is expected to exceed 3% within 20 years of the establishment of appropriate habitat.

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H.T. HARVEY & ASSOCIATES

ECOLOGICAL CONSULTANTS

APPENDIX B-2

Bair Island USFWS Biological Opinion

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

IN REPLY REFER TO:
1-1-05-F-0121

Memorandum

To: Project Leader, San Francisco Bay National Wildlife Refuge Complex, Newark, California

From: Field Supervisor, Sacramento Fish and Wildlife Office, Sacramento, California

Subject: Endangered Species Consultation for the Proposed Bair Island Restoration and Management Plan, Don Edwards San Francisco Bay National Wildlife Refuge, San Mateo County, California

This memorandum is in response to your March 14, 2005 request that the Sacramento Fish and Wildlife Office (SFWO) concur with your determination that the proposed restoration and management activities (proposed project) outlined in the Biological Evaluation and draft EIS/EIR for Bair Island, Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) in San Mateo County, California, are not likely to adversely affect the endangered California clapper rail (*Rallus longirostris obsoletus*) (clapper rail) and the endangered salt marsh harvest mouse (*Reithrodontomys raviventris*) (harvest mouse), and will have no effect on the endangered California brown pelican (*Pelecanus occidentalis californicus*), the endangered California least tern (*Sterna antillarum browni*), and the threatened western snowy plover (*Charadrius alexandrinus nivosus*). This response is in accordance with section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S. C. 1531 *et seq*.). Your request was received in our office on March 16, 2005, and additional information was provided to the SFWO through meetings and correspondence subsequent to that date.

Your analysis identifies initial short-term adverse effects to the clapper rail and harvest mouse that will occur while implementing the early stages of restoration that will create long-term benefits to both species and their habitats. Therefore, the SFWO is issuing this biological opinion (opinion) for those two species. The SFWO recognizes that you have determined that the proposed action will have no effect upon the California brown pelican, the California least tern, and the western snowy plover, and therefore these species will not be addressed further.

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This opinion is based on information provided in the following documents: (1) the Refuge's March 14, 2005 Biological Evaluation and January 12, 2006 action description; (2) the Refuge's August 2004 Bair Island Restoration and Management Plan (Draft EIS/EIR); and (3) meeting notes, correspondence, and electronic mail concerning the proposed action between the SFWO, the Refuge, and interested or involved parties. This opinion also is based on other relevant published and unpublished studies, and communications on the distribution and abundance of the clapper rail and harvest mouse, and information available to the SFWO.

Consultation History

November 2004-February 2005:	The Refuge and the SFWO negotiated the Bair Island Trail alignment and defined points of agreement.
March 16, 2005:	The Refuge requested informal consultation for the proposed action.
May 18, 2005:	Staff from the SFWO met with Refuge staff to discuss the proposed action and conduct a site visit of Bair Island.
June 15, 2005:	SFWO staff met with Refuge staff to clarify several outstanding questions regarding modifications to the original proposed action.
June 27, 2005:	The Refuge provided an updated map of the revised proposed action on Inner Bair Island.
July 27, 2005:	The SFWO requested a meeting to discuss details of the proposed action.
August 24, 2005:	The SFWO, Refuge, and consultants met to discuss information needed to initiate consultation, including details of the proposed action and species occurrences. Action items were generated and a follow-up meeting to collaboratively write the description of the action was scheduled.
September 20, 2005:	SFWO staff and Refuge staff developed a draft description of the proposed action.
October 17, 2005:	SFWO submitted draft description of the action to the Refuge and consultants for final review.
December 6, 2005:	SFWO, Refuge, and consultants met at the refuge to discuss contaminants issues and to receive draft comments.
December 13, 2005:	SFWO and Refuge reached concensus on contaminants criteria.
January 12, 2006:	Refuge submitted final description of the action to the SFWO.

BIOLOGICAL OPINION

Description of Proposed Action

The Refuge is proposing adoption of a restoration and management plan to restore approximately 1,400 acres of former salt evaporators on the Bair Island complex to tidal salt marsh (Figure 1). Following restoration, Bair Island will become an integral part of the extensive wetland complex within south San Francisco Bay. The purpose of the restoration activities proposed is to restore high quality tidal marsh habitat to Inner, Middle, and Outer Bair Island, thereby enhancing habitat for special status species, migratory waterfowl, and shorebirds.

The following tasks will be performed to prepare Bair Island for restoration, after *Spartina alterniflora* control is deemed successful by the Refuge in the project vicinity:

1. Phase 1. Breach Outer Bair Island to Steinberger Slough at OB1 (fall 2006).

2. Phase 2. Inner Bair Island elevation increase (fall 2006-fall 2009).

3. Phase 3. Build flow restrictors/blocks in Corkscrew and Smith Sloughs (summer 2010). Breach Outer, Middle, and Inner Bair Islands (fall 2010).

4. Phase 4. Public Access improvements on Inner Bair Island (late summer 2006 and late fall 2010).

Phase 1: Outer Bair Levee Breach

Beginning in September 2006 (or 2007 if *Spartina* control requires another year) excavation will begin at OB1 to remove material in preparation for breaching the levee. Under the guidance of a qualified biologist, a maximum of 1.54 acres of existing pickleweed plants will be hand-removed with a weed-eater prior to mechanical ground disturbance. The weed-eater will start in the middle and work outward to avoid trapping mice in the last remaining area to be removed. An amphibious excavator or bulldozer (transported by raft or helicopter) will be used to excavate material from the salt marsh outside of the levee to create the new channel for tidal flows. The excavated substrate will be used to create two ditch blocks in the borrow ditches at OB1 and in the eastern borrow ditch of Outer Bair Island. If additional material is required to block the borrow ditches, up to 12,000 linear feet (0.55 acres) of the levee on the western edge of Outer Bair Island along Steinberger Slough may be graded to a height no lower than +6 feet NGVD (after pickleweed removal). The new tidal channel will be excavated through the existing pickleweed mass from Steinberger Slough towards the levee with the last block left in place until low tide to ease excavation and minimize sediment transport. This process is anticipated to require two weeks to a month, however, a larger block of time has been allocated. Phase 1 will be completed by the end of January 2007 (or 2008). Outer Bair Island will be exposed to tidal action at OB1; the northeast cell will remain diked salt marsh, and additional breaches (OB3 and OB4) will occur in phase 3.

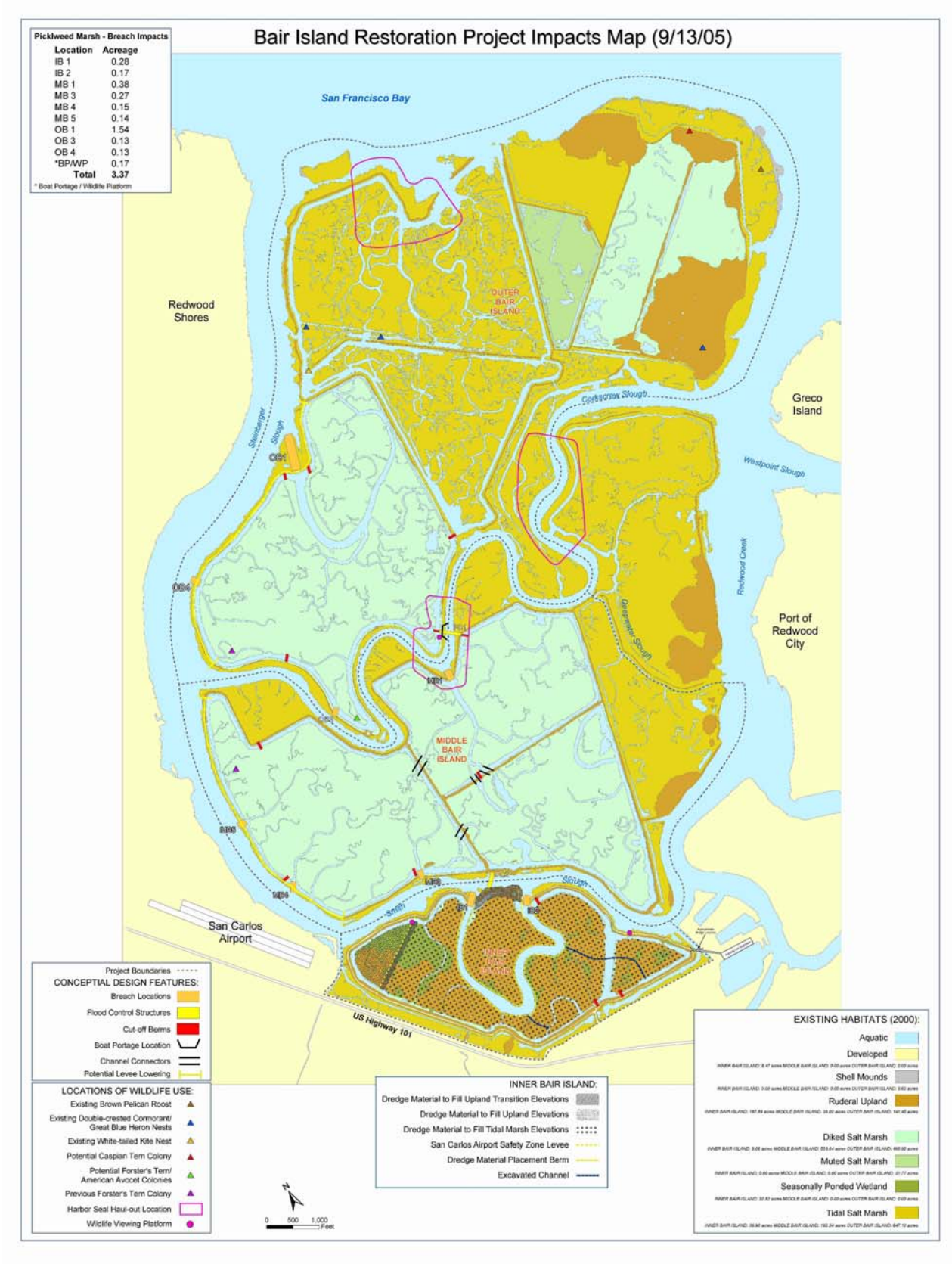

Figure 1. Bair Island Restoration Plan. (Map provided courtesy H.T. Harvey & Associates)

Phase 2: Inner Bair Elevation Increase

Beginning in August 2006, Inner Bair Island will be prepared to receive dredge material. Most, if not all, fill material will come from maintenance dredging of the Redwood Creek Shipping Channel (SFWO file #1-1-04-F-0199). Corps dredging will occur in three separate cycles, June-December 2007, 2008, and 2009, assuming that three cycles will provide enough material to raise Inner Bair to desired elevations (+6.6 feet NGVD at the airport safety zone with +8.6 feet NGVD levee and +2.5 feet NGVD on the remainder of Inner Bair Island with +4.5 feet NGVD berms). All dredged material proposed for upland and wetland placement at Bair Island will either 1) meet the qualifications set forth in the Regional Water Quality Control Board's (RWQCB) waste discharge requirements (Tentative Order), approved with respect to chemical and biological suitability for uplands and wetlands by the Dredged Material Management Office (DMMO), or 2) it will not exceed ambient conditions based upon the mean of samples taken at Steinberger Slough, the Bay near Outer Bair, and the Redwood Creek dredging location. If the above-mentioned thresholds are not attained and the material is approved for use by the RWQCB, consultation will be reinitiated to analyze the potential effects of the contaminated material to listed species.

Primarily bay muds dredged by the Corps of Engineers at Redwood Creek are anticipated to be used as bulk fill for the increase in surface elevation. In addition, dredged material could come from a variety of permitted non-Federal dredging operations, provided the material meets the above-listed criteria. Water quality standards will be specified in the waste discharge requirement stipulated by the RWQCB for water discharged from Bair Island into San Francisco Bay. The discharge standards for the decant water will have to meet RWQCB's standards for water quality parameters such as total suspended solids before the water could be discharged to San Francisco Bay. Evaluating impacts associated with dredging and transporting material to the off-loader will be the responsibility of the sponsor of each dredging project.

The preparation work for Phase 2 will include the following stages:

1. Widening the existing levee on the south side of Inner Bair Island to prevent future resource impacts from South Bay System Authority forced main line (sewer pipeline) maintenance activities. Trucks with fill material will access the levee via the Whipple Avenue entrance. Fill material that meets contaminants criteria will be obtained from outside sources or from scraping surface material from the ruderal upland area of Inner Bair Island. The material will be placed along the existing levee to widen it an additional 10-20 feet. Wave action along the borrow ditch will be buffered by a bench-step design (similar to that at San Pablo Bay NWR) or a very gradual slope creating a wide transition zone. A three foot berm (of fill material) or symbolic fence (posts with single-line cable) will be placed along the inside edge of the new levee surface to serve as a barrier to public access.

2. Building a levee to separate the San Carlos Airport Safety Zone from the rest of Inner Bair Island. The Safety Zone levee will be constructed with a +8.6 foot NGVD crest and design width of 16' and 5:1 slope. Using a bulldozer (or similar equipment), surface material will be scraped from the ruderal upland area of Inner Bair and

compacted to form the new levee structure. Additional material (meeting contaminants criteria) may be obtained from outside sources. A three foot berm (of fill material) or symbolic fence (posts with single-line cable) will be placed along both edges of the new levee surface to serve as barriers for public use.

3. Building a berm along both sides of the former Smith Slough channel, creating pilot channels, and placing ditch blocks. Using a bulldozer (or similar equipment), pilot channels for future channels will be excavated across the ruderal upland from the historic Smith Slough channel to the borrow ditch. Additional surface material from the ruderal upland of Inner Bair Island will be scraped and pushed to form small berms at approximately +4.5 feet NGVD along the edges of the historic Smith Slough channel. Three ditch blocks will be placed in borrow ditches. The berms will serve to capture fill material for surface elevation and the pilot channels and ditch blocks will facilitate channel development upon breaching. Surface contours will be graded to create upland refugia and transitional habitat (at least 10:1 slope). This stage will be completed before the rainy season begins in October or November.

4. Crossing the levee with the dredge pipeline and creating three or four temporary wiers to decant the fill material. Pipes (8”-22” diameter) will be installed beginning June 15 of 2007 to transport dredge material from the Redwood Creek shipping channel. Locations for pipe crossings will be chosen based upon existing levee conditions and fill needs and will be constructed simultaneously with the weirs using a backhoe (or similar equipment). Up to 0.002 acres of pickleweed habitat could be impacted, so plants will be hand-removed (as described above) prior to ground disturbing activities. Decant weirs will either be of compacted levee material (a gradual dip in the surface), or of vertical pipe design.

The placement of shipping channel dredge material from Redwood Creek is anticipated to begin in the summer of 2007. Approximately 7-8 feet of dredge material will be placed in the Airport Safety Zone first, to achieve a design elevation of +6.6 feet NGVD. Material will be placed in two lifts (2007 and 2008) to allow proper compaction and settling. If the available material is limited, more than two lifts may be required. After the Airport Safety Zone fill is settling, 2-3 feet of dredge material will be added to the Refuge portion of Inner Bair Island to achieve the design elevation of +2.5 feet NGVD. A layer of water, as a constituent of the dredged material slurry, will be maintained on top of the dredged material at all times to prevent undesirable compaction and acidification of the material until the outboard levees are breached. The number of dredging cycles needed to raise the elevation will depend upon the quantity of material available. At the end of each dredging cycle, transfer pipes will be removed and weirs will be modified to accommodate winter rains and tidal flows.

Phase 3: Flow Restrictors and Breaches

Beginning in mid-June of 2010, flow restrictors (in Corkscrew Slough and at IB2) and a flow block (in Smith Slough) will be constructed using water- and land-based heavy equipment. The Corkscrew Slough structure will be approximately 300 feet long, 30 feet wide, and will crest at +5.1 with a 30 foot notch in the center to allow a limited flow of water and small boat passage at

high tide. Corkscrew Slough will be posted as a 5 mph no wake zone to further minimize impacts from recreational boating. The flow restrictor berm will be constructed of quarry stone or of linked cellular coffers. If quarry stone is used, it will be placed directly into the channel. Linked cellular coffers will be driven into the slough with a vibrator mounted on a barge and then the cells will be filled with dirt/rock after cell placement. Adjacent to the flow restrictor structure, a portage will be built on the existing Outer Bair levee to facilitate small boat passage at low tide. A 15 x 15 foot wooden observation platform and interpretive signs will be placed at levee-level extending west from the levee surface, over the existing borrow ditch. A ditch block will be placed across the Outer Bair Island borrow ditch at the flow restrictor site, as well as in the borrow ditch between OB3 and OB4.

The flow block at Smith Slough will also be approximately 300 feet long of either quarry stone or linked cellular coffers, but will not have the notch to allow flow at high tides. This block, in concert with breaches at IB1 and IB2, will force water to flow through the historical Smith Slough channel, presently a part of Inner Bair Island. To prevent unacceptable velocity or widening in the newly-opened Smith Slough channel, a flow restrictor will be placed at the IB2 breach location. This flow restrictor will be of a design that does not provide habitat or access for terrestrial predators. A predator resistant fence will also be installed at the channel block. The levee between IB1 and the western observation platform will be lowered to approximately +2.5 NGVD. Under the guidance of a qualified biologist, a maximum of 0.02 acres of existing pickleweed plants will be hand-removed with a weed-eater prior to mechanical ground disturbance.

Using an amphibious excavator (or similar equipment), four ditch blocks will be placed in borrow ditches and four channel connectors will be excavated across internal levees of Middle Bair Island. Material for the ditch blocks may be obtained after pickleweed removal from the levee along Steinberger Slough, if needed (up to 0.55 acres, not to fall below +6 feet NGVD).

Beginning in mid-June 2010 and subsequent to flow restrictor/block installation, ditch block installation, and internal levee breaching, the remaining breaches will be excavated using amphibious excavators (or similar equipment). These breaches include: OB4, OB3, MB1, MB3, MB4, MB5. Clapper rail counts will be conducted prior to construction following Service protocols.

Phase 4: Public Access Improvements on Inner Bair Island

As early as July 2006, an ADA pedestrian bridge will be constructed at the eastern edge of Inner Bair Island at Pete's Harbor. At the present time the bridge design is in development; however, the Refuge will coordinate with the SFWO regarding a "predator resistant" design and monitoring strategy. The trail is presently a 3-mile loop; at completion it will be a shorter out-and-back trail with no public access along most of Smith Slough. The trail base will be upgraded to meet ADA standards and the parking lot at Pete's Harbor will be expanded to accommodate school buses. Interpretive signs will be installed along the trail and two 30x15 foot observation platforms will be constructed on the levee overlooking Smith Slough. It is likely that trail improvements along the western side of Inner Bair Island will not occur until 2010 due to the sequence of actions that must occur to prepare the area for restored tidal flows.

Beginning in 2006, dog walkers will be required to use a 6-foot leash. If compliance standards are not met during a three month trial period, dog use will be eliminated. Although the Whipple Avenue access point will remain available for emergency use, the main entry point to Inner Bair Island will be the new pedestrian bridge at Pete's Harbor.

Motorized and non-motorized recreational boat use will continue in Smith Slough, but with a new 5 mph speed limit "no wake zone" restriction.

Sometime in the near future, the City of Redwood City is planning to construct a second bridge connecting the San Carlos Airport Safety Zone to the northern end of Inner Bair Island. Upon completion, bicycle use will be eliminated on the Inner Bair Island trail.

Future Habitat Conditions

The main habitat type targeted for restoration on Bair Island is tidal wetland. It is anticipated that approximately 1400 acres of tidal marsh will be created with deep primary channels and smaller denser channels in about 30 years after the outboard levees are breached. Fill elevations are planned to be 1 to 1.5 feet below marsh plain elevations to allow sediments borne on the tides to naturally accrete, completing the filling of the tidal wetland area and the final development of tidal channels. Site preparation, including the placement and consolidation of dredged material, is estimated to require five to eight years to complete and will terminate with the breaching of the outboard levees. The minimum amount of time that any fill material will consolidate will be one year before breaching of the outboard levee. Prior to breaching and lowering the outboard levee, the dredged material will be kept wet to prevent excessive consolidation and allow suitable tidal channel development after the levee is breached. Tidal channel formation will be monitored after the levee is breached and corrective measures will be implemented if necessary to ensure adequate channel formation. The specific measures to be undertaken will be developed in the preparation of the monitoring and adaptive management plan for the proposed action and may include mechanically dredging in areas where inadequate channel formation occurs.

When the restoration project reaches maturity, the restored tidal marsh is anticipated to have elevations between mean sea level and extreme high tide and features similar to nearby tidal marshes such as at Greco Island. Existing salt marsh is expected to remain in place. Primary tidal channels will have a mud bottom with a natural equilibrium and depth determined by the tidal prism. The edges of the channels will be colonized and vegetated with Pacific cordgrass (*Spartina foliosa*), pickleweed (*Salicornia virginica*), and gumplant (*Grindelia stricta* var. *angustifolia*). The restored tidal marsh area will receive natural tidal action from San Francisco Bay through the primary channels. Dendritic intertidal channels are anticipated to form naturally and be interspersed with expanses of pickleweed. The edges of the tidal channels will support native cordgrass, as well as gumplant. The mature restored marsh is expected to support low, middle and high marsh areas, and tidal mudflats.

Tidal ponds, which are shallow (less than one foot in depth) and receive water from rainfall and monthly extreme tides, are natural, unvegetated ponds which form within tidal marsh plains. These ponds are not connected with tidal channels, so the water evaporates and can become

hypersaline during the summer and fall. Tidal ponds are expected to form as a feature of the mature restored tidal marsh. The project design does not include plans to specifically construct these features, but due to the underlying site topography, they are likely to form within 50 years and add habitat diversity to the tidal marsh area.

Proposed Conservation Measures

The following conservation measures are proposed as part of the proposed action to directly or indirectly minimize or eliminate potential adverse effects to clapper rails and/or harvest mice:

1. Operation of construction equipment within tidal marsh areas will be avoided during the clapper rail breeding season from February 1 through August 31 each year (except potentially at OB3 and FC1). If breeding rails are determined to be present at OB3 or FC1, construction will not occur within 700 feet of an identified calling center. If the intervening distance across a major slough channel or across a substantial barrier between the rail calling center and OB3 or FC1 is greater than 200 feet, then construction may proceed at that location within the breeding season.

2. To minimize or avoid the loss of individual harvest mice from construction activities in the tidal marsh areas, pickleweed vegetation will be hand-removed with a weed-eater (moving from the center outward) prior to excavation activities. A qualified biologist will be present during pickleweed removal activities. Silt fences will be erected adjacent to construction areas to define and isolate potential mouse habitat.

3. A qualified botanist will conduct an assessment of areas subject to construction activities and recommend specific measures to control the spread of non-native plant species.

4. The restored wetland areas will be monitored for infestation by non-native cordgrasses (*Spartina* spp.), perennial pepperweed (*Lepidium latifolium*), and other invasive, non-native plant species. All infestations occurring within the wetlands will be controlled and removed to the extent feasible without substantially hindering or harming the establishment of native vegetation in the restoring wetlands. A long-term monitoring plan will be developed and remain in effect until tidal marsh habitat is established. The plan will be developed in coordination with the SFWO.

5. The Refuge, in consultation with the SFWO and wetland restoration experts outside the Service, will develop and implement a monitoring and adaptive management program to determine the rate of tidal wetland restoration and quantity and quality of the wetlands established. A monitoring program will be designed to determine whether tidal marsh is developing at the estimated rate of development. Monitoring of the development of the restored areas is intended to enable the Refuge, in coordination with the SFWO, to assess the success of

habitat development and, if necessary, make decisions regarding corrective measures. Key elements of the plan will include:

a. measuring the extent of tidal marsh habitat development to ensure that sufficient habitat is restored to replace the amount of tidal marsh habitat lost by the proposed action at a minimum 2:1 ratio;
b. monitoring habitat parameters such as tidal current at Pete's Harbor, wave characteristics, suspended sediment concentrations, sediment rates and distribution, marsh elevations, mudflat elevations, extent and location of tidal marsh vegetation, composition and density of vegetation, characteristics of subtidal channel and marsh surface sediments, and San Francisco Bay shoreline characteristics;
c. monitoring locations, including the interior and perimeter of the restored tidal wetlands, subtidal channels, and sloughs;
d. comparing predicted and measured restoration development;
e. analyzing monitoring data to identify possible reasons for differences between predicted and measured or observed conditions; and
f. recommending remedial actions to be implemented if restoration does not proceed as designed.

Action Area

The action area is defined in 50 CFR § 402.02, as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." For the proposed action, the action area encompasses the Bair Island complex (Inner, Middle, and Outer Bair Islands), Smith Slough, Corkscrew Slough, Steinberger Slough, and Redwood Creek in the vicinity of Pete's Harbor. The action area also includes the parking lot and access point at the southeast end of Inner Bair Island near Pete's Harbor, and the Whipple Avenue emergency vehicle access point.

Status of the Species

California Clapper Rail

The clapper rail was federally listed as endangered in 1970 (35 **FR** 16047). Critical habitat has not been proposed or designated. This subspecies is one of three subspecies in California listed as endangered under the Act. The other subspecies include the light-footed clapper rail (*R. l. levipes*) which is found in tidal marshes in southern California and northwestern Baja California, and the Yuma clapper rail (*R. l. yumanensis*) which is restricted to the Colorado River basin. A detailed account of the taxonomy, ecology, and biology of the clapper rail is presented in the *Salt Marsh Harvest Mouse & California Clapper Rail Recovery Plan* (Service 1984) (Recovery Plan) and the references cited therein. The clapper rail is a fully protected species under California law (See California Fish and Game Code Section 3511).

The clapper rail is endemic to tidally influenced salt and brackish marshes of California. Historically, the clapper rail occurred in tidal marshes along California's coast from Morro Bay,

San Luis Obispo County, to Humboldt Bay, Humboldt County. Currently, clapper rails are known to occur in tidal marshes in the San Francisco Estuary (San Francisco, San Pablo, Grizzly, Suisun and Honker bays).

The California clapper rail is distinguishable from other rails by its large body size of 13-19 inches from bill to tail, and weighs approximately 8.8-12.3 ounces. It has an orange bill, a rufous breast, black and white barred flanks, and white under tail coverts (Albertson and Evens 2000). Clapper rails are sexually dimorphic; the males are slightly larger than females (Garcia 1995). Juveniles have a pale bill and dark plumage. Clapper rails are capable of producing several vocalizations, most common of which is a series of keks or claps.

Clapper rails are typically found in the intertidal zone and sloughs of salt and brackish marshes dominated by pickleweed, Pacific cord grass, gumplant, saltgrass (*Distichlis spicata*), jaumea (*Jaumea carnosa*), and adjacent upland refugia. They may also occupy habitats with other vegetative components, which include, but are not limited to bulrush *(Scirpus americanus* and *S. maritimus*), cattails (*Typha* spp.), and Baltic rush (*Juncus balticus*).

Evens and Page (1983) concluded from research in a northern San Francisco Bay marsh that the clapper rail breeding season, including pair bonding and nest construction, may begin as early as February. Field observations in south San Francisco Bay marshes suggest that pair formation also occurs in February in some areas (J. Takekawa, pers. comm.). The end of the breeding season is typically defined as the end of August, which corresponds with the time when eggs laid during renesting attempts have hatched and young are mobile. Harvey (1988) and Foerster *et al.* (1990) reported mean clutch sizes of 7.27 and 7.47 for clapper rails, respectively. The clapper rail builds a bowl shaped platform nest of marsh vegetation and detritus (DeGroot 1927, Foerster *et al.* 1990, Garcia 1995). The clapper rail typically feeds on benthic invertebrates, but its diet is wide ranging, and includes seeds, and occasionally small mammals such as the salt marsh harvest mouse.

An estimated 40,191 acres of tidal marshes remained in 1988 of the 189,931 acres of tidal marsh that historically occurred in the Estuary; this represents a 79 percent reduction from historical conditions (Goals Project 1999). Furthermore, a number of factors influencing remaining tidal marshes limit their habitat values for clapper rails. Much of the east San Francisco Bay shoreline from San Leandro to Dumbarton Bridge is rapidly eroding, and many marshes along this shoreline could lose their clapper rail populations in the future, if they have not already. In addition, an estimated 600 acres of former salt marsh along Coyote Creek, Alviso Slough, and Guadalupe Slough, has been converted to fresh- and brackish-water vegetation due to freshwater discharge from wastewater facilities in the southern part of San Francisco Bay and is of lower quality for clapper rails. This conversion has at least temporarily stabilized as a result of the drought since the early 1990s. The introduction of non-native, invasive plant species such as smooth cordgrass (*Spartina alterniflora*) and its hybrids into tidal wetlands within the Estuary is potentially impacting clapper rails by reducing the amount of foraging habitat within tidal channels. The suitability of many marshes for clapper rails is further limited, and in some cases precluded, by their small size, fragmentation, and lack of tidal channel systems and other micro-habitat features. These limitations render much of the remaining tidal marsh acreage unsuitable or of low value for the species.

Throughout the San Francisco Estuary, the remaining clapper rail population is impacted by a suite of mammalian and avian predators. At least 12 native and 3 non-native predator species are known to prey on various life stages of the clapper rail (Albertson 1995). Artificially high local populations of native predators, especially raccoons (*Procyon lotor*) and skunks (*Mephitis mephitis*), result as development occur in the habitat of these predators around the San Pablo and San Francisco bay margins (J. Takekawa, pers. comm.). Encroaching development not only displaces lower order predators from their natural habitat, but also adversely affects higher order predators, such as coyotes, which would normally limit population levels of lower order native and non-native predators, especially red foxes (Albertson 1995). Hunting intensity and efficiency by raptors on clapper rails also is increased by electric power transmission lines, which cris-cross tidal marshes and provide otherwise-limited hunting perches and nesting opportunities (J. Takekawa, pers. comm.). Non-native Norway rats (*Rattus norvegicus*) long have been known to be effective predators of clapper rail nests (DeGroot 1927, Harvey 1988, Foerster *et al*. 1990). Placement of shoreline riprap, levees, buildings, and landfills favor rat populations, which results in greater predation pressure on clapper rails in certain marshes. Raven (*Corvus corax*) populations have recently increased dramatically within the Estuary and evidence of egg predation by this species has been detected (Joy Albertson, pers. comm.). Feral cats also represent another predation threat on adult and young clapper rails near residential areas and landfills (Joy Albertson, pers. comm.). These predation impacts are exacerbated by a reduction in high marsh and natural high tide cover in marshes. DeGroot (1927) noted that rails were extremely vulnerable to predation by raptors during high tide events when they were forced to seek refuge in exposed locations. Similarly, Johnston (1956, 1957) and Fisler (1965) observed heightened predator activity in marshes coinciding with extreme high tides. Evens and Page (1986) also documented the susceptibility of black rails (*Laterallus jamaicensis coturniculus*) to predation during extreme high tides. More recently, rail predation was noted in west Marin during extreme high tides in 2005 (Giselle Downard, pers. comm.). Trails that run along the transition zone where marsh meets upland are a hazard to marsh species that depend on this habitat for refuge during high tides. Rails and other wildlife hide within any available cover in the transition zone, and as people approach, the birds flush and attract predators. There is an abundance of falcons, raptors, egrets, and herons during high tides that opportunistically take advantage of the flushed prey.

The proliferation of non-native red foxes into tidal marshes of southern San Francisco Bay since 1986 has had a profound effect on clapper rail populations. As a result of the rapid decline and almost complete elimination of clapper rail populations in certain marshes, the Refuge implemented a predator management plan in 1991 (Foerster and Takekawa 1991) with an ultimate goal of increasing rail population levels and nesting success through management of red fox predation. This program initially was successful in increasing the south San Francisco Bay populations from an all-time low (see below); however, it has been difficult to effectively conduct predator management over such a large area as the south San Francisco Bay, especially with the many constraints associated with conducting the work in urban environments (J. Takekawa, pers. comm.).

Mercury accumulation in eggs is perhaps the most significant contaminant problem affecting clapper rails in the Estuary, with south San Francisco Bay containing the highest mercury levels.

Mercury is extremely toxic to embryos and has a long biological half-life. The SFWO collected data from 1991 and 1992 on mercury concentrations in rail eggs in the southern portion of the estuary and found that the current accumulation of mercury in rail eggs occurs at potentially harmful levels. The percentage of non-viable eggs ranged from 24 to 38 percent (mean = 29 percent) (Service, unpubl. data).

The clapper rail was listed as endangered primarily as a result of habitat loss. The factors described above have contributed to the more recent population reduction, which has occurred since the mid-1980s. Although many factors are at work, predation by native and non-native predators, in conjunction with historic habitat loss and fragmentation, are the current known primary threats. With historic populations at Humboldt Bay, Elkhorn Slough, and Morro Bay now extirpated, the San Francisco Estuary represents the last stronghold and breeding population of this subspecies.

Although Gill (1978) may have overestimated the total clapper rail population in the mid-1970s at 4,200 to 5,900 birds, surveys conducted by the Department and the Service estimated that the clapper rail population approximated 1,500 birds in the mid-1980s (Harvey 1988). A conservative estimate of the population in north San Francisco, San Pablo, and Suisun bays, was 195 to 282 pairs based on a synoptic survey conducted in 1992-93 (Collins *et al.* 1994). In 2004, Avocet Research Associates conducted surveys within San Pablo Bay and estimated about 200 pairs of clapper rails in that area. These surveys did not include some marshes in north central San Francisco Bay and Suisun Bay that were surveyed in 1992-93. Between the surveys conducted in 1992-93 and 2004, several population centers in San Pablo Bay have declined precipitously. The population in the White Slough tidal marshes on the west side of the Napa River declined from an estimated 16-23 pairs as recent as 2000 to an estimated 2-5 pairs in 2002 and 3-5 pairs in 2004, while the population in the Sonoma Creek marshes declined from 13 pairs in 1992 to no pairs in 2001 and 2004 (Avocet Research Associates 2004).

In 1988, the total rail population was estimated to be 700 individuals, with 400 to 500 rails in south San Francisco Bay (Foerster 1989). The total rail population reached an estimated all-time historical low of about 500 birds in 1991, with about 300 rails in south San Francisco Bay (Service unpubl. data). In response to predator management, the south San Francisco Bay rail population rebounded from this lowest population estimate to an estimated 650 to 700 individuals in 1997-98 (Service unpubl. data). Subsequently, the south San Francisco Bay population declined again the following year to about 500 individuals and remained at that level through early 2002 (Service unpubl. data). However, the south San Francisco Bay population declined further in 2002-2003 and was estimated to be 400-500 individuals (Service unpubl. data), which represented the lowest estimated population level in this area since the late 1980's and early 1990’s. The south San Francisco Bay population apparently increased slightly in 2004 with the population estimated at 500 individuals (Service unpubl. data).

In the area immediately northwest of Bair Island, across Steinberger Slough on the Redwood Shores peninsula and Bird Island, clapper rails have been observed in low numbers since 1985 (Service unpublished data) (Figure 2). The tidal marsh complex made up of Bird Island, the shoreline marsh, and old lock remnants likely support a small, self-sustaining clapper rail population, with most observations occurring along an elevated portion of marsh habitat at the northeast end of the island.

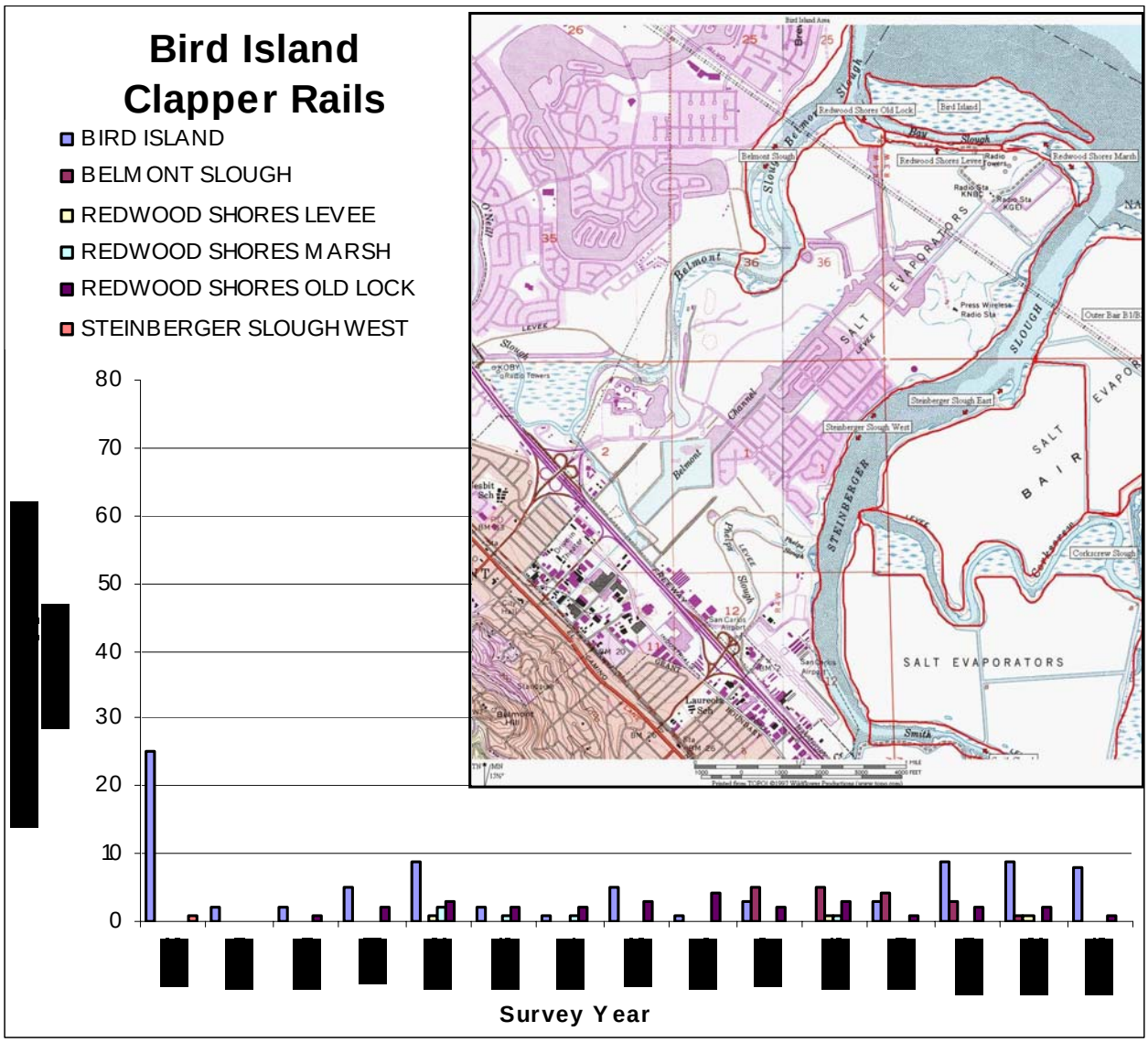

Figure 2. Survey data for clapper rails on Bird Island. Surveys were not conducted at each location every year.

Greco Island, east of Bair Island, maintains the greatest number of clapper rails in the Bair Island vicinity (J. Albertson, pers. comm.). Population numbers peaked in the early 1990s with the greatest number of observations at the Greco East Bulb and Greco South Arm (Figure 3).

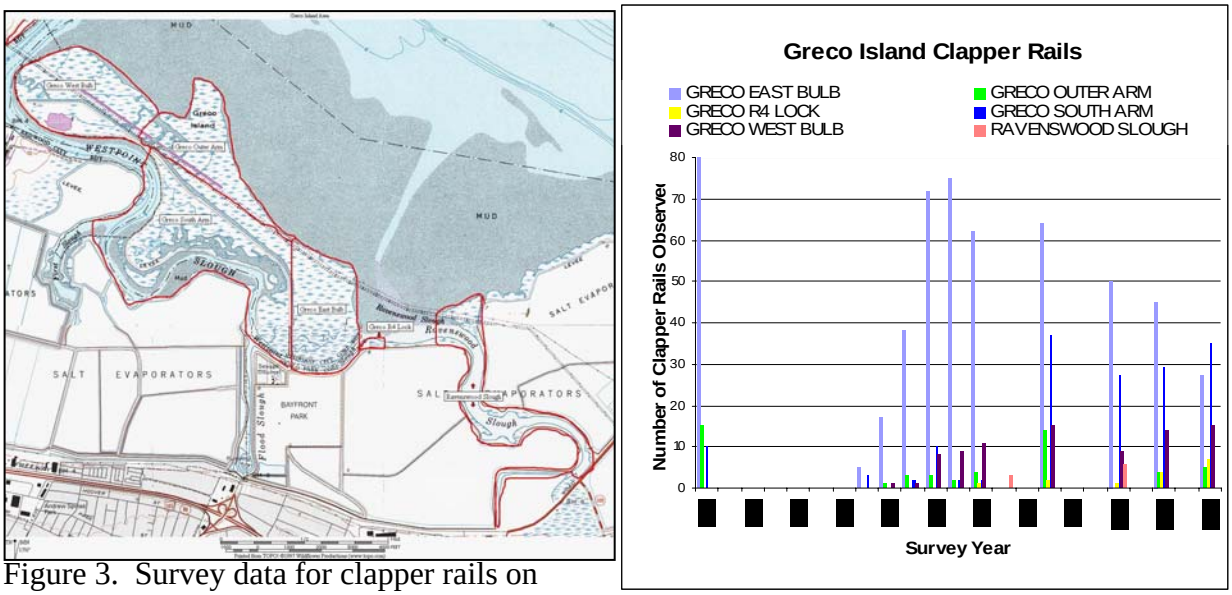

Figure 3. Survey data for clapper rails on Greco Island. Surveys were not conducted at each location every year.

Dispersal or movements by clapper rails in California occurs between and outside of marshes (Orr 1939; Zembal *et al*. 1985; San Francisco Bay Bird Observatory 1986; Page and Evens 1987; Albertson 1995). Eddleman (1989) identified movements by Yuma clapper rails outside of their territories as juvenile dispersal; dispersal by an unmated individual bird; and shifts in home ranges after the breeding, in the winter, and during high water periods; and attributed these movements to a search for more suitable habitat where territories, mates, food, or safe refuge were better available. Juvenile dispersal apparently constitutes the main type of long distance movements by light-footed clapper rails, while adult birds tend to stay within territories once they are established (Zembal and Massey 1988, Zembal *et al.* 1989, Ledig 1990; Zembal 1990, Zembal 1994, Zembal *et al.* 1996, Zembal *et al.* 1997, Zembal *et al.* 1998). Similarly, clapper rails tend to stay within established territories or home ranges year-round (San Francisco Bay Bird Observatory 1986; Albertson 1995). Zembal and Massey (1988) noted that three of six telemetered light-footed clapper rails that moved extensively were preyed upon within a relatively short period of time. By comparison, seven other birds that remained sedentary within established territories were not preyed upon during the telemetry period.

Clapper rails vary in their sensitivity to human disturbance, both individually and between marshes. Certain types of disturbances have occurred within or adjacent to some marsh areas for a long time and certain clapper rails appear to have habituated or become tolerant of these disturbances, while others appear to habituate over time or are unable to habituate to these disturbances at all. For example, certain clapper rails in Palo Alto Baylands Nature Preserve appear to be somewhat tolerant of the relatively common pedestrian traffic on the public boardwalk that dissects the marsh. Clapper rail nests have been documented within 10 feet of

trails in Elsie Romer and Cogswell marshes in Alameda County, and within 65 feet of a busy street near White Slough (Solano County). In contrast, Albertson (1995) documented a clapper rail abandoning its territory in Laumeister Marsh in south San Francisco Bay, shortly after a repair crew worked on a nearby transmission tower. The bird did not establish a stable territory within the duration of the breeding season, but eventually moved closer to its original home range several months after the disturbance. As a result of this territorial abandonment, the opportunity for successful reproduction during the breeding season was eliminated (J. Takekawa, pers. comm.). Clapper rails in Laumeister Marsh have little contact with people, and are apparently quite sensitive to human-related disturbance. On numerous occasions at the Corte Madera Ecological Preserve, rails have been observed seeking refuge from unrestrained dogs entering tidal marshes from adjacent levees with public access (J. Garcia, pers. comm. 1994). These disturbances have occurred despite the presence of signs notifying users that they are entering sensitive wildlife species areas and that pets must be under restraint while in the preserve area. Similarly, along the Redwood Shores Peninsula in San Mateo County, fences and signs installed to prevent access into areas with endangered species habitat have been repeatedly vandalized and people continue to enter the prohibited areas beyond the fences and signs (Popper and Bennett 2005).

Evens and Page (1983) documented 4 rail breeding territories along the Greenbrae boardwalk in the Corte Madera Ecological Preserve. In 1993, no rail breeding territories were discovered along the boardwalk even though rail habitat conditions remained unchanged (J. Garcia, pers. comm.). This territorial abandonment is attributed to an increase in domestic and feral dogs and cats along the boardwalk resulting from new residents moving into nearby residential areas since 1983 (J. Garcia, pers. comm.). According to Harvey (1980) and Foerster et al. (1990), predators, especially rats, accounted for nest losses of 24 to 29 percent in certain South Bay marshes.

Clapper rail reactions to disturbance may vary with season, however both breeding and non-breeding seasons are critical times. Disturbance during the nonbreeding season may primarily affect survival of adult and subadult rails. Adult clapper rail mortality is greatest during the winter (Albertson 1995; Eddleman 1989), and primarily due to predation (Albertson 1995). Human-related disturbance of clapper rails in the winter, particularly during high tide and storm events, may increase the birds' vulnerability to predators. The presence of people and their pets in the high marsh plain or near upland areas during winter high tides may prevent rails from leaving the lower marsh plain (Evens and Page 1983). Rails that remain in the marsh plain during inundation are vulnerable to predation due to minimal vegetative cover available (Evens and Page 1986). A population viability analysis under development for clapper rails identifies changes in adult survivorship as causing the greatest change in the population growth rate (M. Johnson, pers. comm). Another model also indicates that adult survivorship of clapper rails is the primary demographic variable for maintaining a stable population or causing the population to either increase or decline (Foin *et al*. 1997). These models indicate that survival of adult birds has the strongest effect on the perpetuation or extinction of the overall population.

Salt Marsh Harvest Mouse

The harvest mouse was federally listed as endangered in 1970 (35 **FR** 16047). Critical habitat has not been proposed or designated. A detailed account of the taxonomy, ecology, and biology of the harvest mouse is presented in the Recovery Plan (Service 1984) and the references cited therein. The harvest mouse is a fully protected species under California law (See California Fish and Game Code Section 4700).

The harvest mouse is a rodent endemic to the salt and brackish marshes of the San Francisco Estuary and adjacent tidally influenced areas. The harvest mouse closely resembles the western harvest mouse (*R. megalotis*). The harvest mouse typically weighs about 0.35 ounce, has a head and body length ranging from 2.7-2.9 inches, a tail length ranging from 2.6-3.2 inches, and a hind foot length of about 0.7 inch (Fisler 1965). As stated in the recovery plan, the harvest mouse, when compared to the western harvest mouse, have darker ears, belly and back, and a slightly thicker, less pointed and unicolored tail. The harvest mouse is further distinguished taxonomically into the northern and southern subspecies, *R. raviventris halicoetes* and *R. raviventris raviventris*, respectively. Of the two subspecies, *R. r. halicoetes* more closely resembles *R. megalotis*, and can be difficult to differentiate in the field; body color and color of ventral hairs as well as the thickness and shape of the tail have been used to distinguish the two.

The harvest mouse has evolved to a life in tidal marshes. Specifically, they have evolved to depend mainly on dense pickleweed as their primary cover and food source and may utilize a broader source of food and cover that includes saltgrass (*Distichlis spicata*) and other vegetation typically found in the salt and brackish marshes of this region. In natural systems, harvest mice can be found in the middle tidal marsh and upland transition zones. Upland refugia is an essential habitat component during high tide events. Harvest mice are highly dependent on cover, and open areas as small as 10 meters wide may act as barriers to movement (Shellhammer 1978, as cited in Service 1984). The harvest mouse does not burrow. It has been noted that the northern subspecies may build nests of loose grasses.

As described by Fisler (1965), male harvest mice are reproductively active from April through September, but may appear active throughout the year. Females are reproductively active from March to November, and have a mean litter size of approximately four offspring.

The historic range of the species included tidal marshes within the San Francisco and San Pablo bays, east to the Collinsville-Antioch areas. Agriculture and urbanization has claimed much of the former historic tidal marshes, resulting in a 79 percent reduction in the amount of tidal marshes in these areas (Goals Project 1999). At present, the distribution of the northern subspecies occurs along Suisun and San Pablo Bays north of Point Pinole in Contra Costa County and Point Pedro in Marin County. The southern subspecies is found in marshes in Corte Madera, Richmond, and South San Francisco Bay mostly south of the San Mateo Bridge (Highway 92).

Harvest mice may be affected by mercury and PCBs in the intertidal zone. Clark *et al*. (1992) found that harvest mice were captured only at sites where concentrations of mercury or PCBs were below specific levels in house mice (*Mus musculus*). Their results seem to suggest a

southern source of mercury contamination, with mercury an order of magnitude higher in livers of house mice at Calveras Point than at any other point measured in San Francisco Bay.

Environmental Baseline

Historically, Bair Island was part of a large complex of tidal marshes and mudflats within the drainage of the San Francisco Bay and Belmont Sloughs. Bair Island was diked in the late 1800s and early 1900s for agricultural uses, including cattle grazing, and subsequently converted to salt evaporation ponds starting in 1946. Following the end of salt production in 1965, the lands were drained and sold to a series of real estate development companies until the City of Redwood City halted all development plans for Bair Island. The levees on Middle and Outer Bair Islands have not been maintained since 1965 and several natural breaches occurred approximately 20 years ago resulting in a return of some areas to cordgrass tidal marsh. The Refuge and the CDFG both acquired portions of Bair Island over time. A Memorandum of Understanding (MOU) was signed in 1997 by CDFG and the Refuge agreeing that all CDFG lands on Bair Island would be operated and managed by the Refuge as a part of the Don Edwards San Francisco Bay National Wildlife Refuge. The Refuge coordinates annually with the US Department of Agriculture, Animal and Plant Health Inspection Service (USDA APHIS) California Wildlife Services to maximize effectiveness of the predator control program on refuge lands (Interagency Agreement #11640-3-H-002A). Presently, USDA APHIS California Wildlife Services actively scouts for predators on Outer Bair Island and at potential source population sites. They work with refuge personnel to ensure that predator control efforts are prioritized for listed species protection. Small parcels of land on Middle Bair Island along Redwood Creek remain in private ownership. A small area of the bayward mudflat of Outer Bair Island is privately owned. Two parcels on the east side of Middle Bair are held in private interest, as well as the southeast corner across from Pete's Harbor. The San Carlos Airport also retains a portion of Inner Bair Island as a flight safety zone. In addition, two easements exist on Bair Island: (1) for the PG&E towers and transmission lines that run throughout the site, and (2) for the South Bayside System Authority (SBSA) sanitary sewer force main that runs underneath most of the southern part of the levee on Inner Bair Island.

The Bair Island complex is divided into three distinct areas separated by slough channels: Inner, Middle, and Outer Bair Islands. Inner Bair Island is connected to the mainland by an emergency vehicle access road at Whipple Avenue. Inner Bair Island is separated from Middle Bair Island by Smith Slough, which in turn is separated from Outer Bair Island by Corkscrew Slough. Smith Slough no longer follows its historical meandering channel; it has been cut off to flow a shorter distance between Inner and Middle Bair islands. Redwood Creek and Steinberger Slough are the major tidal channels adjacent to the Bair Island complex. Redwood Creek has sufficient capacity for frequent motorized boat traffic, particularly with respect to the high industrial use at the Port of Redwood City. Redwood Creek is a deepwater port, dredged to 40' and used by large recreational boats, motor boats, sailboats, and commercial ships entering the industrial warfs at Westpoint Slough. Steinberger Slough experiences recreational boat traffic, although not at low tide when the channel is not navigable. Smaller recreational watercraft regularly traverse Corkscrew Slough and Smith Slough to travel between Steinberger Slough and Redwood Creek.

The levees on Inner Bair Island are maintained and the 3.3 mile perimeter loop levee trail is currently open to bicyclists and pedestrians with dogs under voice control. In the dry season, a cross-pond trail from the Whipple Avenue trailhead to the levee along Smith Slough is traversable. Until June 2003, pedestrians and bicyclists reached the trailhead to the Inner Bair levees from an unpaved area used for parking at the end of Whipple Avenue. Because Caltrans has closed this area to parking and a commuter bicycle trail has been completed along US Highway 101, visitors are now directed to park at the existing Refuge parking lot along Bair Island Road and walk the connector trail to the trailhead at the end of Whipple Avenue.

Baseline noise conditions at Bair Island vary greatly with respect to sources and timing. Because of the nature of the land uses in the area and volume and diversity of vehicular traffic they attract, the area along US Highway 101 is a generally noisy urban area (Figure 4). Major noise sources are numerous, including railroad, small aircraft from San Carlos airport, commercial aircraft approaching and departing San Francisco International Airport, local commercial and industrial activities, and the automobile and truck traffic they generate (County of San Mateo 2002).

San Francisco International Airport is the world's seventh busiest airport and the majority of arriving and departing jets are directed over the waters of San Francisco Bay. Different weather conditions impact flight paths and clouds or fog can trap noise that on a clear day would more easily disperse. The San Carlos airport serves smaller, lower-flying aircraft and is located immediately west of Middle Bair Island with Inner Bair Island directly under the runway flight path. Arrival and departure flight paths, based upon air traffic control radar data, frequently loop directly over Bair Island. Departure, when the aircraft mass must be lifted, takes the most power overall and is the noisiest (San Mateo County 2002). Maximum noise contribution from flight departures ranges from 94.6 dB at 200' to 59.6 dB at 10,000' (San Mateo County 2002).

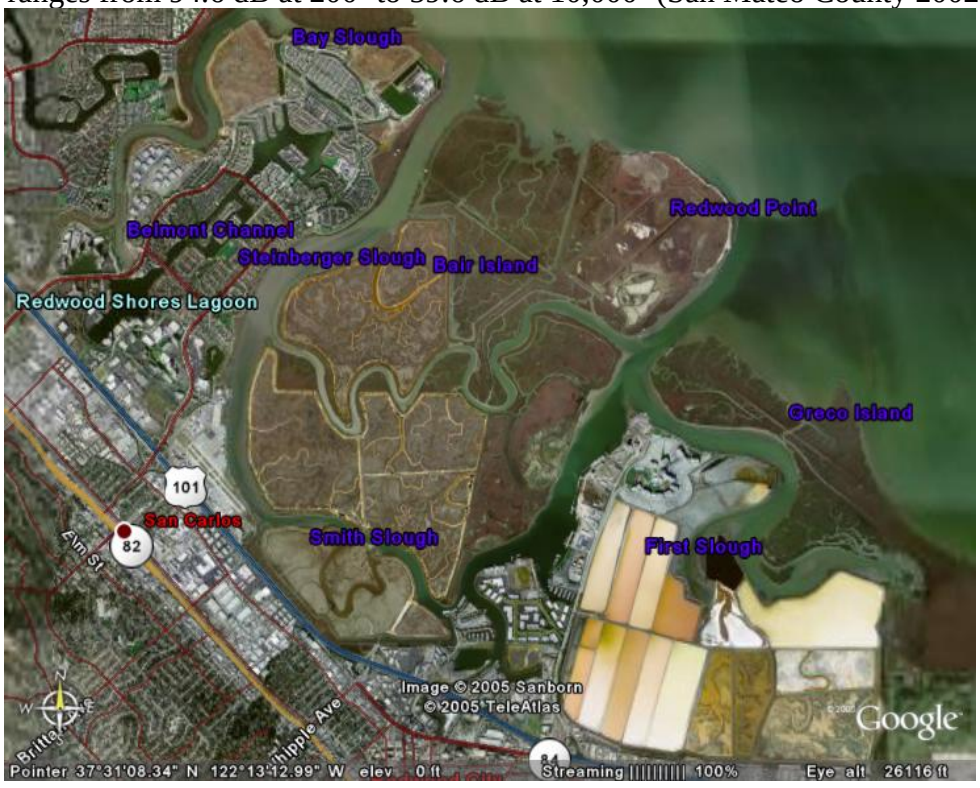

Figure 4. Land use in the Bair Island vicinity results in a relatively noisy urban environment.

The City of Redwood City calculated Community Noise Equivalent Levels (CNEL) at Pete's Harbor, just southeast of Bair Island, in January 2002 (City of Redwood City 2003). The average CNEL during a 24 hour period was <60 dB. Construction activities proposed for the Marina Shores Village project were estimated to range from 65-105 dB at 50' and included earth moving, materials handling, and impact equipment (City of Redwood City 2003).

US Highway 101 is within 500 feet of Inner Bair Island and is the source of constant vehicular traffic noise, peaking at weekday rush hours and all day on Saturday and Sunday. Traffic helicopters patrol the US Highway 101 corridor by Bair Island. Recreational and commercial boat use contributes to the noise load experienced at Bair Island as well as periodic dredging activities in Redwood Creek to maintain the shipping channel. When prevailing winds from the northwest are strong, anthropogenic noise is buffered in a southeasterly direction.

California Clapper Rail

California clapper rails are known to occur in the tidal marshes along Outer Bair Island in south San Francisco Bay. Surveys conducted periodically since 1985 have documented clapper rail presence on Bair Island (Figure 5). Most observations occurred in the tidal marshes along Corkscrew Slough and Outer Bair B1/B2 restoration. A high of 21 clapper rails were observed on Outer Bair B1/B2 restoration in 1999 and 2004, however in 2005 the number observed was seven. Across ten years of surveys, the average number of clapper rails observed at Outer Bair B1/B2 Restoration was 7.3. Clapper rails were observed in the 72 acres of tidal marsh habitat along Corkscrew Slough in surveys between 1992 and 1999, but have not been observed there recently, despite suitable habitat conditions in the undiked marsh thumbs. It is possible that clapper rails still use the area for foraging or juvenile dispersal, but species presence could not be confirmed on survey days. More recently, clapper rails appear to have shifted away from Corkscrew Slough to the central portion (B1/B2 Restoration) of Outer Bair Island. At the present time, clapper rails are using the marsh habitat that has become vegetated cordgrass marsh due to the levee breaching events of twenty years ago. Because the B1/B2 Restoration cell of Outer Bair Island is exposed to tidal influence, tidal channels and cordgrass marsh developed within ten years of the breach event. Juvenile clapper rails are known to disperse several miles from that area to both Bird and Greco islands, and the birds move back and forth fairly regularly (J. Albertson, pers. comm.).

The Recovery Plan (Service 1984) identifies the recovery objectives or conservation needs of the clapper rail. The fundamental tenet of the Recovery Plan is to preserve and increase existing populations of the clapper rail to assure the survival of this species. To accomplish this, the Recovery Plan identifies the preservation and restoration of essential habitat areas throughout the Estuary that are important in meeting the recovery objectives for this species. Inner, Middle, and Outer Bair islands have been identified as habitat essential to the survival and recovery of the clapper rail. This designation represents the area's highest potential for habitat restoration, as well as existing habitat value on about 1,380 acres of tidal marsh and non-tidal wetlands managed by the Refuge or CDFG. The Recovery Plan (Service 1984) designates Inner Bair

Island and parts of Middle and Outer Bair islands as a “Priority 1” area for restoration as habitat essential for the survival and recovery of the clapper rail (Recovery Task 1224). As defined in

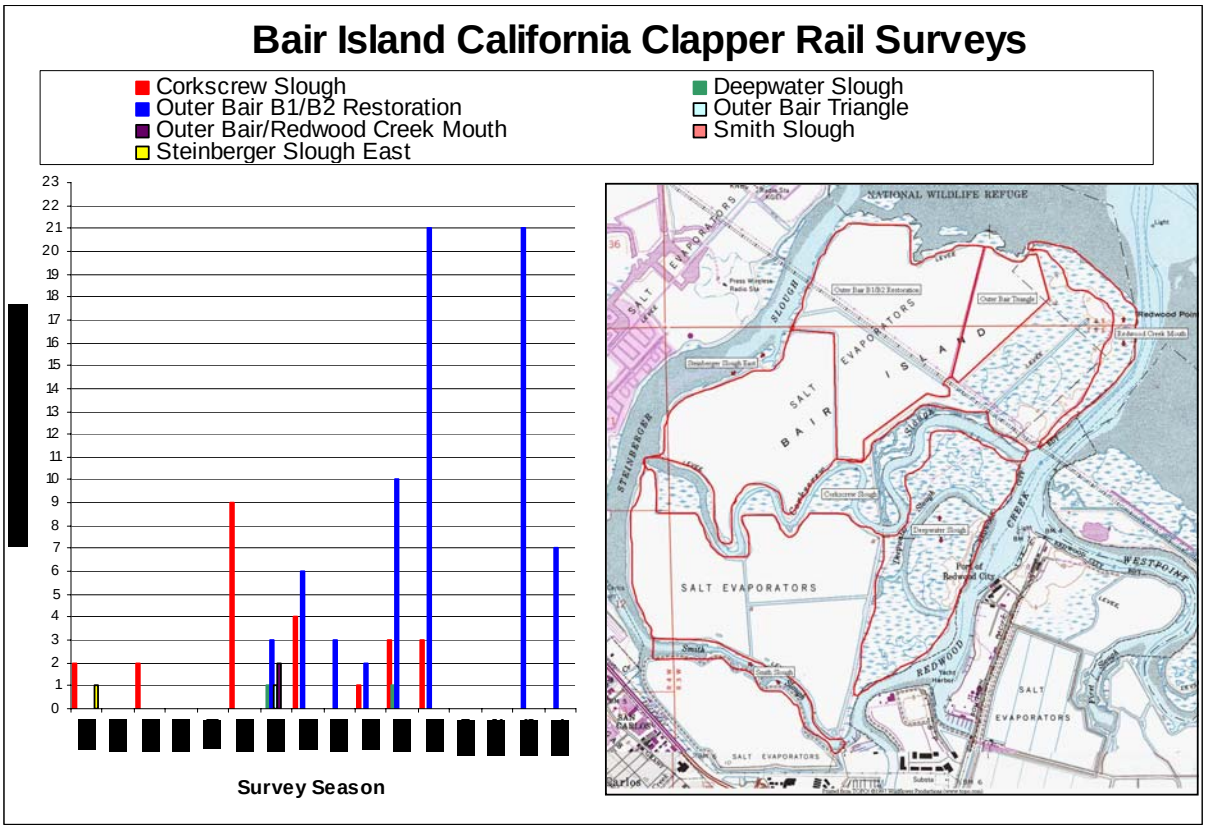

Figure 5. California Clapper Rail survey results on Bair Island, 1985-2004 (Service unpubl. data).

the Recovery Plan, “Priority 1” actions must be completed to avert an irreversible population decline or extinction of the clapper rail. Because of the continuing threats to clapper rails and the current low population levels rangewide, maintaining existing tidal marsh habitat and restoring additional optimal habitat on or adjacent to Bair Island are important elements to ensuring the survival and recovery of this species.

Salt Marsh Harvest Mouse

Although no surveys for harvest mice have been conducted within the action area, the naturally restored areas dominated by pickleweed provide approximately 1000 acres of low quality and approximately 1500 acres of suitable habitat for this species (C. Morris, pers. comm.). This is especially true of the naturally restored tidal marsh areas on the eastern portion of Outer Bair and southern portion of Middle Bair islands. The diked former salt ponds B3, A9, A10, and A11 on Outer Bair and Middle Bair contain patchier cover, less dense pickleweed, and are entirely flooded during winter rain events. Flooding forces mice to the higher elevation levees where they are exposed to extreme levels of predation, and therefore, it is unlikely that the diked marsh supports substantial numbers of mice, except along the high marsh edges. The large cell that makes up Inner Bair Island contains little suitable habitat, except along waterways and standing water. At this time, harvest mice are not assumed to be present in the central part of the island

due to poor habitat conditions and pickleweed absence. However, suitable tidal marsh habitat occurs at the Inner Bair Island bridge crossing, along a small area outboard of the airport levee along Steinberger Slough, and along the outboard side of Inner Bair Island, where harvest mouse presence is assumed. Suitable tidal marsh habitat also occurs around the periphery of Inner Bair Island (San Mateo County Bay Trail Route Access Improvement Project Biological Assessment 1996).

Live trapping studies in 1992 determined the presence of harvest mice in the vicinity of Redwood Shores (San Mateo County Bay Trail Route Access Improvement Project Biological Assessment 1996). Suitable habitat for the harvest mouse occurs on Bird Island, in tidal marshes along the levee, and within a diked non-tidal wetland inboard of the exterior levee in the northwest corner of the Redwood Shores peninsula. Harvest mice are likely to use levees to cross between outboard tidal marshes and inboard non-tidal wetlands, especially during extreme high tides (San Mateo County Bay Trail Route Access Improvement Project Biological Assessment 1996).

Similar to the clapper rail, the preservation and growth of existing populations of the harvest mouse is considered important to assuring the survival of this species. The Recovery Plan (Service 1984) identifies Bair Island as essential habitat area to be preserved or restored throughout the Estuary to meet the recovery objectives for this species. Because of the continuing threats to harvest mice, maintaining existing tidal marsh habitat and restoring additional optimal habitat on or adjacent to Bair Island are important elements to ensuring the survival and recovery of this species.

Effects of the Proposed Action

The proposed action will: (1) eliminate up to 5 acres of suitable habitat available for clapper rails and harvest mice on Inner, Middle, and Outer Bair islands in the short-term and restore approximately 1400 acres of tidal marsh habitat over the long-term (50 years); (2) harass and displace clapper rails and harvest mice due to construction and maintenance activities; and (3) maintain or reduce disturbance to clapper rails and harvest mice as a result of public access.

Habitat Loss and Restoration

The proposed action will restore approximately 1400 acres of tidal marsh habitat on Inner, Middle, and Outer Bair islands to tidal action. To achieve this restoration, the proposed excavation of channels through levees at breach points will permanently eliminate up to 5 acres of suitable habitat currently available for clapper rails and harvest mice, depending on additional material needed to create ditch blocks. Approximately 600 acres of sparsely vegetated seasonal marsh habitat on Middle Bair Island and 500 acres on Outer Bair Island will become tidal marsh. Although the seasonal marsh habitat loss will be permanent, the establishment of tidal influence should result in restored tidal habitat over the entire 1400 acres for clapper rails and harvest mice.

Clapper rails and harvest mice could be harmed if the action area is colonized by non-native, invasive plant species, especially perennial pepperweed and non-native cordgrasses. If these

non-native plant species establish within the proposed tidal marsh restoration areas, they could reduce the habitat value for clapper rails and harvest mice by out-competing, and preventing or limiting, the establishment of native tidal marsh plant species. A key factor in the project's success will be the Refuge's ability to control invasive plant species prior to the breaching of the first levee at OB1. If non-native cordgrasses have not been controlled through the ongoing eradication program, breaching may be postponed until that time when the Refuge determines invasive species will not colonize the newly created habitat.

As Inner Bair Island progresses through the annual dredge material placement cycles, it is anticipated that pickleweed will begin to establish. By the second and third years of elevation increase, some pickleweed may be inundated by the new dredge material lift. Although this could be considered additional habitat loss for harvest mice, it is unlikely that the pickleweed will have reached a density suitable for mouse occupancy. To minimize the potential for effects related to contaminated dredge material placement, dredge material will meet qualifications set forth in the Regional Water Quality Control Board's waste discharge requirements approved with respect to chemical and biological suitability for uplands and wetlands by the Dredge Material Management Office, or the material will not exceed ambient conditions based upon the mean of samples taken at Steinberger Slough, the Bay near Outer Bair, and the Redwood Creek dredging location.

New access will be provided to Inner Bair Island via a new pedestrian bridge, but it is not anticipated that predators will benefit from this new access point due to design features deterring predator passage. Failure of the predator guards likely could result in easy access over the slough and borrow ditch for terrestrial predators of clapper rails and harvest mice. Regardless, predators may still swim the short distance to Inner Bair Island, and most of the perimeter levee will be maintained for trail and pipeline use. The new upland area (the airport safety zone) will provide a larger expanse of terrestrial habitat that could be used as refugia by predators. Predator access to Middle and Outer Bair islands will not be facilitated due to the proposed action. The flow restrictor design at IB2 will discourage terrestrial predator movement and will not include materials that may provide habitat for rats. As long as terrestrial predators cannot cross the IB2 structure, access to Middle and Outer Bair islands will be limited to only those animals willing to swim across the Smith and Corkscrew Slough channels (or those that can fly).

Suitable clapper rail habitat will increase as tidal channels develop and vegetation becomes established. Benefits to harvest mice will begin within the first few years as pickleweed encroaches into new areas under tidal influence. Successful implementation of the proposed action is expected to restore approximately 1400 acres of tidal marsh habitat within 50 years after initiation of construction work for the proposed action. Establishment of this habitat is likely to substantially benefit clapper rails and harvest mice, and to assist with their recovery within San Francisco Bay and rangewide.

Construction-related Effects

In addition to potential effects from habitat loss, the proposed action is likely to result in disturbance in several ways to clapper rails and harvest mice within tidal marsh habitat. These disturbances are likely to result from work activities associated with creating the channels to

provide tidal circulation into the restored tidal wetlands, breaching the outboard levees, and construction of other elements of the proposed action. Disturbances such as noise and excavation of habitat from construction, operational, and maintenance activities of the existing levee and pipeline on Inner Bair Island could also result in abandonment of habitat or direct mortality of clapper rails and harvest mice.

To avoid or minimize disturbance effects to breeding clapper rails during Phase 1 construction activities, the Refuge proposes to begin construction in September 2006 and complete activities by the end of January 2007 (avoiding operation of construction equipment during the February 1-August 31 breeding season). The OB1 breach will take two to four weeks of daytime operation of a weed-eater and excavator. If the amphibious excavator is brought to the site by helicopter, this disturbance would vary from ambient air traffic disturbance from the San Carlos Airport and helicopter activity along US Highway 101 by virtue of being directly over habitat at a low elevation. This disturbance would be very temporary in nature, limited to the unloading and loading of the excavator at the beginning and end of OB1 breaching. Because of baseline noise conditions, the sound from construction/excavation activities (not including the helicopter) is anticipated to attenuate at a distance no greater than approximately 0.25 miles, depending on weather (J. Bradley, pers. comm.). Backhoes, graders, and bulldozers operate at approximately 75-95 dB at 50' (less in intensity to intermittent flight departures from San Carlos Airport). Under common windy conditions, heavy equipment noise will be buffered and carried in a southeasterly direction, away from occupied clapper rail habitat (Figure 6).

Figure 6. Phase 1, OB1 breach site. Radius line represents 0.25 miles, estimated to be the area of sound impact from the OB1 breaching activity. Arrows represent prevailing wind direction.

Phase 2 activities take place on Inner Bair Island, at least 0.75 miles from the 1999 clapper rail observations in Corkscrew Slough and over 2.2 miles from the most recent observations on Outer Bair Island. Sound disturbances (large equipment work and dredge material placement) will be buffered by ambient noise, prevailing winds, and several levees between the source and the clapper rails.

Phase 3 activities will occur on the western cell of Outer Bair Island, in and around Corkscrew Slough, and throughout Middle Bair Island, beginning in mid-June 2010 (Figure 7). Although Phase 3 occurs near the 72 acres of previously occupied cordgrass habitat, observations have not been documented in this vicinity since 1999, and breeding is not presumed to be occurring within 1.5 miles of the nearest activity. The timing of this phase overlaps with the end of the clapper rail breeding season and that of juvenile clapper rail dispersal and foraging; therefore, it is possible that clapper rails may disperse to suitable habitat in the central area of Corkscrew Slough from Outer Bair breeding sites. However, it is more likely that young clapper rails would travel to Greco or Bird islands due to project activities in the central area.

Beginning in 2006, recreational boat disturbance in Corkscrew and Smith Sloughs will be reduced by posted speed limits and no wake zones. Through-traffic will be limited in 2010 by the flow restrictors. Upon completion of construction activities, boating disturbances in the Corkscrew and Smith Slough areas will be maintained at this reduced level. However, boating use in Steinberger Slough is anticipated to increase as the channel scours and a deeper channel provides navigable water. A wildlife viewing platform will be centrally located at FCI at a height no greater than that of the current levee, to reduce disturbance from recreational wildlife observers. If deemed necessary by the Refuge, the SFWO, or the Interagency restoration monitoring team, blinds may be added at a future date to further shield clapper rails from human disturbance. Safety railing on the viewing platform will be constructed in a manner that does not provide perching opportunities for predatory birds.

Figure 7. Areas of disturbance from Phase 3 construction activities. White circles represent 0.25 radius disturbance zones during the June-December 2010 construction period. The red circle represents the most recent documented clapper rail observations. Clapper rails were observed in Corkscrew Slough as recent as 1999.

Construction activities have, as much as possible, been scheduled to occur after the clapper rail breeding season. However, if modifications to the schedule are required (potentially at OB3 and FC1), construction activities and preconstruction surveys would be highly disruptive to rail breeding activities. Construction activities could cause short-term effects such as failure to breed, nest abandonment, lower numbers of eggs, juvenile abandonment, and overall lower juvenile survivorship. Nest surveys could cause moderate to extensive destruction of habitat. If individuals and/or nests are not located within 700 feet of the limits of construction, construction will proceed. If individuals and/or nests are located within 700 feet of the limits of construction, the Refuge will consult with the SFWO to determine what, if any, additional measures may be needed to allow construction to proceed. Because clapper rail nests are not easy to detect within marsh vegetation and surveys to detect them can be disruptive and destructive, current survey protocols to detect presence or absence of rails breeding within tidal marshes involve the establishment and use of listening stations adjacent to or in habitat areas. These survey methods have no effect to habitat, while providing information on locating clapper rail breeding territories within tidal marsh habitat. A high sensitivity to disturbance could exist with clapper rails within the Outer Bair tidal marsh where human access activity is presently limited. Successful reproduction may not occur during the construction years, but may resume after construction is completed.

Construction activities conducted during the clapper rail non-breeding season could also result in harassment, harm, or mortality of clapper rails that occur in Corkscrew Slough and the Outer Bair tidal marsh. Clapper rails could be forced to adjust the boundaries of their territories or to disperse to other habitat areas within this area or to other nearby or distant tidal marshes. The Refuge will conduct construction activities in Corkscrew Slough and the tidal marsh during the end of the breeding season (from June 15 through August 31) when completing Phase 3. Although surveys will be conducted and certain precautions will be followed, survey and construction activities still could result in harassment, injury, or mortality of clapper rails. Disturbances from these activities could cause individual clapper rails to abandon their nests or reduce the ability of adults to properly care for their eggs (less likely at this late date) or young. Displaced individuals and their eggs or young could be subjected to injury or mortality from starvation, physiological stress, and increased predation. Clapper rails disturbed by work activities also could be subjected to predation if they increase their movements within the Bair Island tidal marsh or disperse to other nearby or distant tidal wetlands.

The Refuge's proposal to minimize construction activities in the tidal marsh during the breeding season does not assure that clapper rails dispersed within or away from this area would establish new breeding territories and successfully breed. Clapper rails forced to disperse as a result would need to either maintain existing pair bonds or develop new pair bonds and establish new breeding territories in other suitable habitat areas. The ability of these rails to reestablish new breeding territories would be hampered by the fact that clapper rails maintain year-round home ranges and defend established breeding territories from intrusions by other clapper rails. As observed in the Laumeister Marsh example, clapper rails could be forced to move considerable distances in search of unoccupied suitable habitat. Such movement by rails from established territories is likely to significantly increase the risk of predation and mortality. The farther rails must range in search of other suitable habitat outside of the Bair Island tidal marsh, the more vulnerable they are to predation.

Survivorship of clapper rails displaced from the Bair Island tidal marsh would be less than if they are allowed to remain in established and familiar territories within this area. Increased movements by clapper rails would result in lower survivorship through increased exposure to predators (Zembal and Massey 1988; Eddleman 1989; Albertson 1995). Loss of any female rails would be compounded by the loss of potential future progeny. Reduced survival of adult clapper rails would impact the long-term viability of the population.

Based on the distance from proposed activities to the nearest known occupied habitat, and the number of rails observed at the most recent survey, the SFWO anticipates that all clapper rails located in the 72 acres
of suitable habitat along Corkscrew Slough may be disturbed by construction noise. The likelihood that rails will be forced to disperse away from the Bair Island tidal marsh or along the outboard levee is low, therefore reducing the likelihood that they would be harmed or killed. Because nearby suitable habitat patches (Bird and Greco islands) are presently available along the south bay margins, dispersing juvenile birds should move away from the action area, not towards it, where habitat is not suitable.

Construction and maintenance activities within the tidal marsh and along the outboard levee could affect individual harvest mice through habitat removal, increased disturbance, and temporary habitat destruction. Increased levels of disturbance to harvest mice will result from noise, vibrations from equipment, and construction activities. Operation of construction equipment and associated loss of habitat will result in displacement of harvest mice from protective cover and their territories/home ranges (through noise and vibrations) and/or direct injury or mortality (through crushing). These disturbances are likely to disrupt normal behavior patterns of breeding, foraging, sheltering, and dispersal, and are likely to result in the displacement of harvest mice from their territory/home range in the areas where their habitat is destroyed. Displaced harvest mice may have to compete for resources in occupied habitat, and may be more vulnerable to predators. Disturbance to females during the period of March through November may mean abandonment or failure of the current litter. Thus, displaced harvest mice may suffer from increased predation, competition, mortality, and reduced reproductive success. The Refuge proposes to minimize direct mortality of individual harvest mice from project activities by hand-removing pickleweed with a weed-eater from the center-outward, in the presence of a qualified biologist, and placing a barrier fence to identify sensitive species habitat for construction workers 20 feet from the construction boundaries in and adjacent to the tidal marsh after the vegetation is removed. Up to 5.0 acres of suitable harvest mouse habitat will be removed during the implementation of the action, and all mice in that area will be displaced. Individual mice may be harmed by significantly impairing essential behavior patterns including breeding, feeding, or sheltering. Additionally, as Inner Bair Island receives dredge material to increase elevation, pickleweed may become established between lift cycles. This picklweed will then be inundated by successive dredge material lifts; however it is not anticipated to achieve adequate density in one year to become suitable harvest mouse habitat.

Disturbance and Predation Effects from Public Access

Human activity and associated pet use will be funneled onto the trail from Pete's Harbor and the Whipple Avenue access point and should decrease from current levels, because the trail will no longer be a loop. Interpretive displays will inform the public about the potential to disturb listed species and their habitat. The ability to manage or control potential disturbances in adjacent habitat areas from recreational human activity may not be effectively regulated or controlled, even with the measures proposed by the Refuge to maintain public use and activities along the developed trail.

Visual and physical barriers along the periphery of the trail may have limited effect in deterring human or pet disturbance because they can be easily crossed. Continued dog use will be dependent upon compliance with new leash restrictions; non-compliance will result in the Refuge removing dog-walking from Bair Island recreational use. During the non-compliant period, harvest mice could be harmed, harassed, or killed by dogs, and pickleweed habitat could be trampled.

If the new pedestrian bridge successfully deters predators, the public access trail should not result in an increase in predator pressure on clapper rails and harvest mice in restored and existing tidal marshes. Predator access is presently facilitated by the right-of-way access point at Whipple Avenue although efforts are underway to minimize predator access there (restrictive

fencing and gate). Small predatory mammals, including rats, feral and domestic cats, skunks, and raccoons, likely will continue to emanate from nearby residential and commercial development, and can swim across the borrow ditch to reach Inner Bair Island; however, except for rats, it is unlikely that predators would swim across Smith Slough or Corkscrew Slough (each approximately 300' wide) to reach Middle and Outer Bair Islands. Increases in the number of domestic and feral animals could cause territorial abandonment by clapper rails in adjacent tidal marshes.

Rats and cats entering the action area could become prey for higher order predators such as red foxes and raccoons, as well as becoming predators to endangered species. Therefore, the carrying capacities for higher and lower order predators in the action area could increase above current levels.

The effects described above could be most problematic after suitable habitat is established on Inner Bair Island and if the flow restrictors provide terrestrial connectivity that presently does not exist. Although new terrestrial connectivity will be created between Inner and Middle Bair islands, this path is in a location that was historically connected to Middle Bair Island. The opening of the historic Smith Slough channel will isolate that path from Inner Bair Island. A total of nine levee breaches will serve to disconnect many terrestrial pathways for predators, and annual coordination with USDA APHIS California Wildlife Services will maintain priority predator control.

Human disturbance from recreation use will be reduced through no wake, 5 mph limits in Corkscrew and Smith Sloughs. Flow restrictors and blocks will deter through-boating traffic. The new boat portage and observation deck at Corkscrew Slough will provide a new public access point, however effects from human disturbance will be limited by clear boundaries and interpretive displays to educate the public on endangered species and their habitat. Current public use is not controlled in Corkscrew Slough, and therefore the net effect should result in less human disturbance across the entire area.

Recreational trail use on Inner Bair could result in the flushing of birds at high tides, increasing predator success (once clapper rails become established in the new tidal marsh habitat). Currently, clapper rails are not present in this area, and therefore, trail use is not affecting predator success. As the tidal marsh develops over the long-term, clapper rails are anticipated to colonize the restoring habitat, and the net effect would be consistent with recovery goals for the species. Clapper rails moving into the Inner Bair tidal marsh would be exposed to baseline recreational trail use, and by design, large expanses of suitable habitat will be available for refugia.

Cumulative Effects

Cumulative effects include the effects of future State, Tribal, local, or private actions affecting listed species and their critical habitat that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

The SFWO is aware of three non-Federal actions which may result in cumulative effects to clapper rails or harvest mice within the action area considered in this opinion:

1. The City of Redwood City plans to construct a pedestrian bridge from the city to the San Carlos Airport safety zone on Inner Bair Island and connect to the Refuge's pedestrian trail. Potential effects that could occur to clapper rails or harvest mice would include increased predator access, increased human disturbance, and loss of suitable habitat within the project footprint. It will be the responsibility of the City to ensure that their action does not result in conditions that may jeopardize the continued existence of clapper rails or harvest mice.
2. PG&E tower and transmission line and their related maintenance activities will continue to occur in the PG&E right-of-way. Such disturbances have been known to result in territory abandonment by clapper rails. Boardwalks can be used as pathways by terrestrial predators, and transmission towers are used by avian predators as perches.
3. The Southside Bay System Authority (SBSA) will continue its sanitary sewer force main maintenance activities on Inner Bair Island. Modifications to the southern levee on Inner Bair Island have been designed to reduce SBSA maintenance needs (excavating or repairing erosion), however the levee will continue to provide upland habitat refugia for Norway rats and terrestrial connectivity for predators near the airport.

Conclusion

After reviewing the current status of the clapper rail and harvest mouse, the environmental baseline for the action area, the effects of the proposed action and cumulative effects, it is the SFWO's biological opinion that the Bair Island restoration project, as proposed, is not likely to jeopardize the continued existence of the California clapper rail and salt marsh harvest mouse. We base this determination on the following: (1) the relatively limited amount of habitat for these species that will be permanently lost; (2) the relatively low number of clapper rails and harvest mice that may be harassed, harmed, or killed; and (3) the large amount of habitat that will be restored with successful implementation of the proposed action. No critical habitat has been proposed or designated for either species, therefore none will be affected.

INCIDENTAL TAKE STATEMENT

Section 9(a)(1) of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened fish and wildlife species without special exemption. Take is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harass is defined by the Service as an intentional or negligent act or omission which creates the likelihood of injury to a listed species by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. Harm is defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by impairing behavioral patterns including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.

Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with this incidental take statement.

The incidental take statement accompanying this opinion exempts take of clapper rails and harvest mice, carried out in accordance with the following reasonable and prudent measures and terms and conditions, from the prohibitions contained in section 9 of the Act. It does not address the restrictions or requirements of other applicable laws. Since the clapper rail and harvest mouse are fully protected species under California law (California Fish and Game Code Sections 3511 and 4700, respectively), the exemption from section 9 of the Act provided by this incidental take statement for these two species does not exempt the Refuge or its contractors from complying with State law.

The measures described below are non-discretionary, and must be implemented by the Refuge. If the RefugeB (1) fails to require to adhere to the terms and conditions of the incidental take statement, and/or (2) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

Amount or Extent of Take

Conservation measures proposed by the Refuge and described above in the "Description of the Proposed Action" section will reduce, but do not eliminate, the potential for incidental taking of clapper rails and harvest mice. The SFWO expects that incidental take of the clapper rail will be difficult to detect or quantify because of the reclusive nature of this species. Similarly, the SFWO anticipates incidental take of individual harvest mice will be difficult to detect because of the variable, unknown size of any resident population over time, and the difficulty of finding killed or injured small mammals. In such instances, acres of habitat lost or impacted are used to quantify take. Therefore, the SFWO anticipates the following levels of take as a result of implementation of the proposed action.

Incidental take of clapper rails is expected in the form of:

> harassment, harm, or mortality of all California clapper rails within 72 acres of suitable habitat due to disturbance from construction-related activities (creating tidal channels, ditch blocks, lowering and breaching of levees, helicopter overflight, constructing flood control structures, boat portage and viewing platforms) and predation between the years 2006 and 2010.

Incidental take of harvest mice is expected in the form of:

harassment, harm, or mortality of all salt marsh harvest mice inhabiting 5.0 acres of suitable tidal marsh habitat due to loss of this habitat during construction activities occurring from 2006 to 2010.

Reasonable and Prudent Measures

The SFWO believes the following reasonable and prudent measures are necessary and appropriate to minimize the impact of take on the clapper rail and harvest mouse:

1. Minimize the potential for harm, harassment, or killing of clapper rails and harvest mice.

2. Minimize the effects of permanent loss and degradation of habitat on clapper rails and harvest mice by habitat restoration and protection.

3. The Refuge shall ensure their compliance with this opinion.

Terms and Conditions

To be exempt from the prohibitions of section 9 of Act, the Refuge must comply with the following terms and conditions, which implement the reasonable prudent measures described above. These terms and conditions are nondiscretionary.

The following terms and conditions implement all of the reasonable and prudent measures:

a. The Refuge shall conduct an employee education program prior to the initiation of construction or maintenance activities within the tidal marsh or along any portion of the outboard levee. The program shall consist of a brief presentation by persons knowledgeable in clapper rail and harvest mouse biology and legislative protection to explain endangered species concerns to contractors and their employees. The program shall include the following: a description of the clapper rail and harvest mouse and their habitat needs; a report of the occurrence of clapper rail and harvest mouse in the project area; an explanation of the status of this species and its protection under the Act; and a list of measures being taken to reduce impacts to these species during project construction and implementation. A fact sheet conveying this information shall be prepared for distribution to the above mentioned people and anyone else who enters the project site.

b. A representative(s) shall be appointed by the Refuge who will be the contact source for any employee or contractor who might inadvertently kill or injure a clapper rail or harvest mouse or who finds a dead, injured, or entrapped individual. The representative(s) shall be identified during the employee education program. The representative’s name and telephone number shall be

provided to the SFWO prior to the initiation of any construction or maintenance activities on Bair Island.

c. The Refuge shall conduct baseline and annual clapper rail surveys in order to quantify the response of the species to the restoration effort. Prior to initiation of the planned work activities, the proposed survey protocol(s) shall be provided to the SFWO for review and approval, and surveys shall be conducted. After the surveys are completed and prior to initiation of the planned work activities, the results of the surveys shall be provided to the SFWO for review to evaluate the appropriateness of work being proposed by the Refuge. Work activities shall not be initiated until after the SFWO has approved the planned work based on the review of the survey results.

d. The Refuge shall conduct predator monitoring, including a strategy to detect the effectiveness of the predator barriers at the new pedestrian bridge and the Whipple Avenue access point. If Norway rats are detected at any location on Bair Island, the Refuge shall immediately conduct rat eradication efforts.

e. The Refuge will submit the name and qualifications of a biologist for approval by the SFWO to be present on-site for any construction or maintenance activities within the tidal marsh or along the crown and bayside slope of the outboard levees. The biologist shall have oversight over implementation of all Terms and Conditions in this opinion, and shall have the authority to stop project activities if any of the requirements associated with these Terms and Conditions are not being fulfilled. If the biologist requests to stop work due to take of any listed species, the SFWO and the Refuge will be notified within one (1) working day via electronic mail or telephone. If requested, during and/or upon completion of construction activities, the biologist and/or representative from the Refuge shall accompany SFWO personnel on an on-site inspection of the action area to review project effects to clapper rails and harvest mice.

f. The Refuge shall prepare and implement an adequate plan that describes how the public access, including restrictions and prohibitions, designed and planned for the action area will be effectively enforced and maintained. This plan shall be subject to review and approval by the SFWO prior to the construction of any segment of the proposed trail.

g. The Refuge shall provide final design drawings of the flow control structures, wildlife viewing platforms, and pedestrian bridge to the SFWO for review and approval to confirm consistency with these criteria prior to their construction.

h. Chemical concentrations and associated sampling plans and activity of dredged material or site soils planned for use on-site shall be reviewed and approved by the SFWO. The data for dredged material proposed for use in the action area shall be provided to the SFWO for review and approval at least 60 calendar days prior to the proposed date of placement of the material.

Reporting Requirements

The Refuge shall provide reports to the SFWO annually (by the end of February for the previous year) to demonstrate the response of clapper rails and pickleweed habitat to the restoration efforts. The SFWO and the Refuge must be notified within 24 hours of the finding of any injured or dead clapper rail or harvest mouse, or any unanticipated damage to clapper rail or harvest mouse habitat associated with the proposed action. Any injured clapper rails and harvest mice must be cared for by a licensed veterinarian or other qualified person such as the biological monitor; any dead individuals should be preserved according to standard museum techniques and held in a secure location. Notification must include the date, time, and precise location of the specimen/incident, and any other pertinent information. The SFWO contact persons are Chris Nagano, Chief, Deputy Assistant Field Supervisor of the SFWO at (916) 414-6648, and Scott Heard, Resident Agent-in-Charge of the SFWO's Law Enforcement Division in Sacramento, California, at (916) 414-6660.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purpose of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities that can be implemented to further the purposes of the Act, such as preservation of endangered species habitat, implementation of recovery actions, or development of information and databases. In order for the SFWO to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the SFWO requests notification of the implementation of any conservation recommendations. We propose the following conservation recommendations:

1. Assist the SFWO in implementing other recovery actions identified within most current recovery plans for the clapper rail and harvest mouse.

2. Encourage or require the use of appropriate California native plant species in revegetation and habitat enhancement efforts associated with projects authorized by the Refuge.

3. Encourage participation of prospective permittees in a program being developed by Federal and State resource agencies to limit and reverse the spread on non-native cordgrass within the San Francisco Bay Estuary.

REINITIATION STATEMENT

This concludes formal consultation on the proposed Bair Island Restoration Project. As provided in 50 CFR § 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, the Refuge must immediately request reinitiation of consultation.

If you have any questions regarding this opinion on the proposed Bair Island Restoration Project, please contact Janice Engle or Ryan Olah of this office at the letterhead address or at (916) 414-6625.

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APPENDIX B-3

Bair Island Mitigation Monitoring and Reporting Program

MITIGATION MONITORING AND REPORTING PROGRAM

BAIR ISLAND RESTORATION
AND
MANAGEMENT PLAN

DON EDWARDS SAN FRANCISCO BAY
NATIONAL WILDLIFE REFUGE
BAIR ISLAND ECOLOGICAL RESERVE

U.S. FISH & WILDLIFE SERVICE
CALIFORNIA DEPARTMENT OF FISH & GAME

June 2006

P R E F A C E

Section 21081 of the California Environmental Quality Act (CEQA) requires a Lead Agency to adopt a Mitigation Monitoring and Reporting Program whenever it approves a project for which measures have been required to mitigate or avoid significant effects on the environment. The purpose of the monitoring and reporting program is to ensure compliance with the mitigation measures during project implementation.

The Final Environmental Impact Report/Statement for the Bair Island Restoration and Management Plan concluded that the implementation of the project could result in significant effects on the environment and mitigation measures were incorporated into the proposed project. This Mitigation Monitoring and Reporting Program addresses those measures in terms of how and when they will be implemented.

MITIGATION MONITORING AND REPORTING PROGRAM BAIR ISLAND RESTORATION AND MANAGEMENT PLAN				
Impact	**Mitigation Measures**	**Timeframe and Responsibility for Implementation**	**Method of Compliance**	**Oversight of Implementation**
CULTURAL RESOURCES				
Implementation of any of the Alternatives could result in a significant impact to buried cultural resources that could be present on the site. (Significant Impact)	Should any cultural deposits be encountered during any phase of the project, work shall halt and the Refuge Manager notified. If human bones are found, the appropriate County authority (Coroner, Sheriff, or Medical Examiner), the Native American Heritage Commission, and the Service's Regional Archaeologist would be contacted immediately. An assessment of the deposits would be made by the Regional Archaeologist, or other similarly qualified individual, before work may resume in the area of discovery. (Less Than Significant Impact with Mitigation)	To be implemented if any significant cultural resources are encountered. Contractors shall stop work, in the immediate area of the findings, and notify the Refuge Manager.	If cultural resources are encountered a report will be submitted by qualified archaeologist to the Refuge Manager.	Refuge Manager U.S. Fish & Wildlife Service California Dept. of Fish & Game
CONSTRUCTION IMPACTS (AIR QUALITY)				
Construction could result in significant air quality impacts associated with dust generation. (Significant Impact)	The Bay Area Air Quality Management District (BAAQMD) has prepared a list of feasible construction dust control measures that can reduce construction impacts to a level that is less than significant. Except when it is raining, the following construction practices would be implemented during construction of any of the alternatives: • Sweep streets daily (preferably with water sweepers) if visible soil material is carried onto adjacent public streets; • Limit traffic speeds on unpaved areas to 15 mph; • Replant vegetation in disturbed areas; • Water or cover all stockpiles of soil that can be blown by the wind;	To be implemented during all phases of construction by the contractors.	All measures are on all construction documents, contracts, and project plans.	Refuge Manager U.S. Fish & Wildlife Service California Dept. of Fish & Game

MITIGATION MONITORING AND REPORTING PROGRAM BAIR ISLAND RESTORATION AND MANAGEMENT PLAN				
Impact	**Mitigation Measures**	**Timeframe and Responsibility for Implementation**	**Method of Compliance**	**Oversight of Implementation**
	• Sweep daily (with water sweepers) the paved access roads, parking areas, and staging areas at construction site. (Less Than Significant Impact with Mitigation)			
CUMULATIVE IMPACTS				
All of the alternatives (including No Action Alternative), along with other tidal restoration projects, could contribute to the creation of additional habitat in the Bay Area that would be susceptible to invasion by Atlantic cordgrass. (Significant Cumulative Impact)	All of the Alternatives including the No Action include controls for non-native *Spartina* species within the Bair Island restoration site and follows many of the suggestions and methods contained within the *Spartina* Control Program. The Bair Island Restoration and Management Plan would be reviewed by California State Coastal Conservancy and the US Fish and Wildlife Service for its consistency with the *Spartina* Control Program. If necessary, the control methods in the Bair Island Restoration and Management Plan would be modified to remain consistent with the final approved version of the San Francisco Estuary Invasive *Spartina* Control Program EIS/EIR. (Less Than Significant Impact with Mitigation)	Implementation is on-going, and will continue after all phases of construction by the San Francisco Estuary Invasive *Spartina* Control Program and/or the Refuge.	Compliance will be consistent with the final approved version of the San Francisco Estuary Invasive *Spartina* Control Program EIS/EIR.	Refuge Manager U.S. Fish & Wildlife Service California Dept. of Fish & Game California State Coastal Conservancy

SOURCE

U.S Fish & Wildlife Service and California Department of Fish & Game, **Bair Island Restoration and Management Plan FEIR,** June 2006.

APPENDIX C

Existing Biological Conditions Report

H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

BAIR ISLAND RESTORATION AND MANAGEMENT PLAN: EXISTING BIOLOGICAL CONDITIONS

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July 05, 2000 Project Number 1697-01

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INTRODUCTION

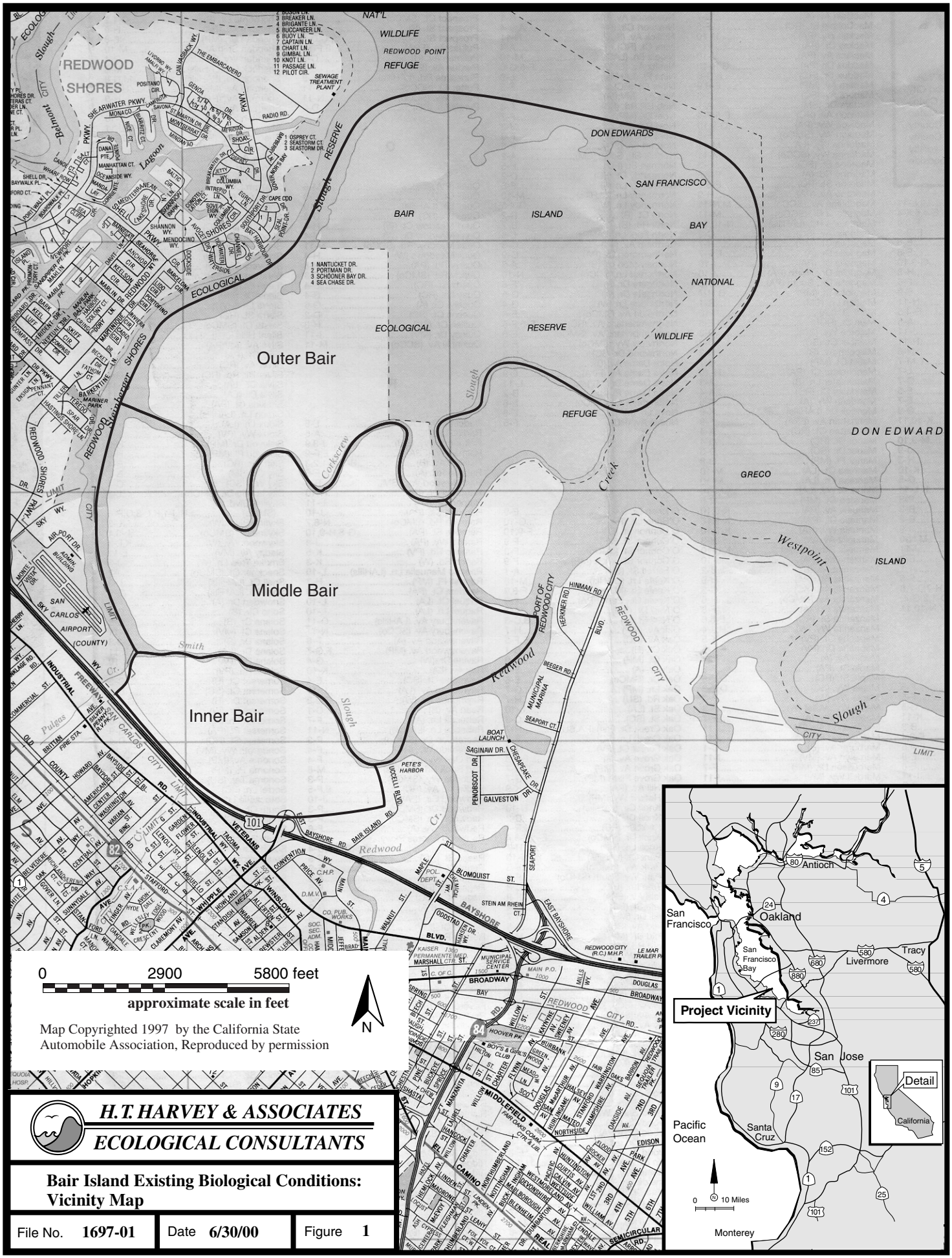
Bair Island is a former tidal salt marsh that is located adjacent to the San Francisco Bay in Redwood City, San Mateo County, California (Figure 1). Due to considerable natural and anthropogenic changes, the Bair Island complex consists of a mosaic of habitats, including tidal salt marsh, mud flats, seasonal wetlands, former diked salt ponds and uplands created from the disposal of dredged material. Bair Island is divided into three distinct areas separated by slough channels: Inner, Middle and Outer Bair (Figure 1). Inner Bair Island is connected to the mainland and can be directly accessed via Whipple Avenue. It is separated from Middle Bair by Smith Slough, which in turn is separated from Outer Bair by Corkscrew Slough (Figure 1). The project boundary for the purposes of the Restoration and Management Plan encompass the majority of Bair Island, with the exception of a portion of Middle Bair Island in the vicinity of Deepwater Slough (Figure 1). The habitats (and acreages) discussed in this document pertain only to those areas within the specified project boundaries.

Bair Island has been the target of numerous development proposals through the years, which were all rejected. The California Department of Fish and Game (CDFG) and the Refuge both acquired portions of Bair Island over time. In 1997, the Peninsula Open Space Trust (POST) purchased the remaining portions of Bair Island and turned over their interests in the property to these agencies. The San Carlos Airport also retains a portion of Inner Bair Island as a safety zone. In addition, two easements exist on Bair Island for both the PG&E towers and transmission lines that run throughout the Bair Island complex, as well as for the South Bay System Authority (SBSA) force main that runs underneath most of the southern part of the levee on Inner Bair.

Historically Bair Island was part of a large complex of tidal marshes and mud flats (Figure 2) within the drainage of Bay and Belmont Sloughs (PWA 2000). Bair Island was diked in the late 1800's and early 1900's for agricultural practices including cattle grazing. Bair Island was converted to salt evaporation ponds by Leslie Salt Company starting in 1946, and remained in production until 1965. The lands were drained and eventually sold to a series of real estate development companies. An EIR was prepared in 1981 for the South Shores Concept Plan that proposed development of Inner and part of Middle Bair Island (EIP 1981). A local referendum in Redwood City finally halted development plans for Bair Island. POST purchased Bair Island in 1997.

This site is a large, restorable complex of former salt evaporators, and has been a major priority for addition to the Refuge since the original boundaries were drawn. The restoration of tidal habitats at Bair Island is ecologically important to South San Francisco Bay. Following restoration, Bair Island will become an integral part of the extensive wetland complex within the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) and adjacent state and privately owned wetlands.

The goal of the restoration design will be to provide a plan that allows for passive restoration of Bair Island, thereby minimizing management needs in the future, but still provide critical salt marsh habitat for endangered species such as the California clapper



Map Copyrighted 1997 by the California State Automobile Association, Reproduced by permission

H.T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

Bair Island Existing Biological Conditions: Vicinity Map

File No. **1697-01**	Date **6/30/00**	Figure **1**

H.T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

Bair Island Existing Biological Conditions:
U.S. Coast Survey 1857

File No. **1697-01**	Date **6/30/00**	Figure **2**

N

0 2000 4000 feet

approximate scale

rail (*Rallus longirostris obsoletus*) and salt marsh harvest mouse (*Reithrodontomys raviventris raviventris*). This site can assist with the preservation and perhaps recovery of both species once properly restored.

The purpose of this document is to assess and map the existing biological conditions of the Bair Island complex. Other existing conditions reports include the existing hydrological conditions prepared by Philip Williams & Associates (Philip Williams & Associates 2000). This study will provide a baseline of information that can be used to develop management objectives, evaluate the opportunities and constraints and provide alternatives to restoring tidal marsh habitat within Bair Island.

EXISTING BIOLOGICAL CONDITIONS

Using aerial photography, existing site conditions were mapped in detail. These include the mapping of habitat types (open water, diked salt marsh, etc.) and wildlife use (determined from both existing information and from a general survey by H. T. Harvey & Associates' wildlife biologists). As part of the habitat mapping a wetland assessment was conducted, which is an important part of understanding potential impacts to existing regulated resources from restoration activities and will likely be necessary during the permit phase.

SURVEY METHODS

Study Area

Bair Island consists of three sub-areas: Inner, Middle and Outer Bair. These areas are separated by slough channels, with only Inner Bair accessible without the use of a boat (Figure 1).

Aerial Photography and Orthorectification

Towill, Inc. acquired the aerial photography in February 2000. Black-and-white, vertical, stereo photography covering the project area and suitable for preparation of digital orthophotography at a scale of 1 inch = 200 feet was acquired at an altitude of 12,000 feet above the mean elevation of the terrain (AMT), resulting in an average scale of 1:24,000 (1 inch = 2000 feet). The photography consists of one line with four exposures (three stereo models) and was acquired during low tide.

Upon completion of the ground (photo) control survey and acquisition of aerial photography, analytical aerotriangulation was performed to extend control throughout the project photography and achieve a network of points sufficient to orient all stereo models. A simultaneous least squares block (bundle) adjustment was performed to obtain final control coordinates.

A black and white digital orthophotography of the project area at a scale of 1 inch = 200 feet with a pixel ground resolution of 1.0 foot (200 pixels per inch) was prepared. Orthophotos cover the entire project area, including perimeter tidal sloughs. Final orthophotos were subdivided into ten (10) conveniently sized tiles. Rectified imagery was clipped at the project limits. The orthophotography was geo-referenced to the project horizontal datum (CCS, Zone 3 NAD 83).

Habitat Mapping and Area Calculations

Field surveys followed a protocol that began with mapping habitat types onto clear acetate overlays placed directly over the digital images of the orthorectified B/W photos. Topographic features, marsh boundaries, and tentative habitat types (based on gray-scale signatures) were mapped in the office prior to field visits. Extensive ground-truthing of the preliminary mapping was then conducted during site visits to the entire Study Area conducted from 14 April to 28 April 2000. Marshes were observed primarily from levee trails, unimproved salt pond levees and Pacific Gas and Electric (PG&E) walkways. Due to lack of access to the interior of most sections of Bair Island, mapping of miscellaneous open water bodies in the interior of individual ponds was not possible. Where possible and when absolutely necessary, habitat types on the interior of the former salt ponds were verified by walking into areas that were not clearly visible from adjacent levees and upland areas.

The field vegetation maps (acetate overlays) were then scanned and electronically digitized. The maps were then overlaid on the digital orthos images. Plant association acreages and color-coded figures for the entire Study Area were generated in GIS (Microstation and ARCVIEW).

Wildlife Survey Methods

Reconnaissance level wildlife surveys were conducted during the same period as the habitat mapping. Observations were made from levees, PG&E walkways, as well as from the boat.

RESULTS

Habitat Types

During the mapping of Bair Island, seven (7) different habitat types were identified. These included tidal salt marsh, muted tidal salt marsh, diked salt marsh, seasonally ponded wetlands, aquatic/open water (including portions of subtidal and intertidal slough channels that adjoin the site), shell mounds, ruderal upland, and developed. Table 1 lists the quantity (in acres) of each habitat type that is present within the project boundaries of the Bair Island Restoration Project. Each of these habitats is briefly described below, and the locations of the habitats are demarcated on Figure 3.

Figure 3. **Habitat map**

Table 1. Habitat areas for Inner, Middle and Outer Bair Island.

LOCATION	HABITAT	ACRES
Inner Bair Island	Aquatic	48.71
	Developed	8.47
	Diked Salt Marsh	9.06
	Ruderal Upland	187.89
	Seasonally Ponded Wetland	32.82
	Tidal Salt Marsh	36.90
	Total	**323.83**
Middle Bair Island	Aquatic	112.01
	Diked Salt Marsh	553.64
	Ruderal Upland	38.02
	Tidal Salt Marsh	192.54
	Total	**896.21**
Outer Bair Island	Aquatic	100.21
	Diked Salt Marsh	468.90
	Muted Salt Marsh	51.77
	Ruderal Upland	141.45
	Shell Mounds	5.63
	Tidal Salt Marsh	647.13
	Total	**1415.09**
	Overall Acreage	**2635.13**

Tidal Salt Marsh. Tidal salt marsh occurs along the outboard side of the existing levees, as well as in the former salt ponds in the northwest section of Outer Bair where the levees have been allowed to breach. The tidal salt marsh within these former salt ponds is at a slightly lower elevation than the outboard marshes. This results in a plant community comprising an equal mix of cordgrass (*Spartina foliosa*) and pickleweed (*Salicornia virginica*). The slightly higher elevation outboard marshes are predominantly composed of pickleweed. The outboard marsh serves as the ideal target habitat for the restoration effort, with the marsh inside the former salt ponds on the west side of Outer Bair providing insight into the evolution of the sites once tidal action is returned.

Other common plant species found in the tidal salt marsh are alkali heath (*Frankenia salina*), saltmarsh dodder (*Cuscuta salina*) and jaumea (*Jaumea carnosa*). Marsh gumplant (*Grindelia stricta* var. *angustifolia*) occurs at higher elevations, as well as along the ecotone between tidal salt marsh and ruderal upland habitat

Muted Tidal Salt Marsh. One pond on eastern Outer Bair Island (Figure 3) contains deteriorated flapgate structures that are no longer functional and allow muted tidal action within the small leveed area. This area (formerly a Least Tern nesting colony) was leveed off in a failed attempt to protect Least Tern nesting habitat. Currently, the area consists of a mix of cordgrass and pickleweed.

Diked Salt Marsh. This habitat type is largely found on the interior of the former salt ponds on Inner, Middle and Outer Bair Island (Figure 3). These areas will be the primary targets for restoration to tidal salt marsh. The diked salt marsh habitat generally consists of pickleweed interspersed with mud flats and small open water areas. The quality of the habitat between the four former salt ponds is highly variable. The former salt pond on Outer Bair Island has the highest quality habitat with over 50% cover by pickleweed that has moderate vigor. The westernmost pond on Middle Bair has less than 50% cover by pickleweed of moderate to low vigor, while the two remaining diked salt marsh areas on Middle Bair have approximately 30% cover by pickleweed of low vigor (Figure 3). The latter two ponds also have a higher occurrence of brass buttons and bare soil/salt pan.

These ponds have subsided between 2.2 and 3.4 feet below the elevation of the tidal salt marsh on the outboard side of the levee (Philip Williams & Associates 2000), and the plants generally appear to have a reduced vigor. The sites' interiors are inaccessible in most places due to the borrow ditch that is located immediately inside of the existing levees. Other common plant species found within the diked salt marsh are cordgrass at lower elevations and alkali heath, brass buttons and saltgrass (*Distichlis spicata*) at the higher elevations.

Seasonally Ponded Wetlands. These wetlands are located in slightly lower topographic depressions within the levees of Inner Bair Island (Figure 3). The changes in microtopography responsible for small patches of seasonal wetlands are very numerous, and made precise field delineation of all the patches virtually impossible due to time and budgetary constraints. However, soil pits were dug within Inner Bair Island to determine the status of these seasonal wetland areas, and the results were extrapolated to all of Inner Bair using the habitat signatures present on the aerial photography. These wetland areas, supported largely by incident rainfall, were dominated by rabbitsfoot grass (*Polypogon monspeliensis*) and brass buttons (*Cotula coronopifolia*) with patches of pickleweed, spearscale (*Atriplex triangularis*) and alkali heath also occurring throughout.

Aquatic/Open Water. Aquatic habitat occurs within the low-flow channel of the creeks, slough channels and borrow ditches throughout the Bair Island complex. This deep-water habitat does not support either emergent or terrestrial vegetation.

Shell Mounds. A few small areas of exposed shell exist along the perimeter of Outer Bair Island along the San Francisco Bay (Figure 3). These areas are largely devoid of vegetation and are readily visible from the ground as well as from the aerial photography.

Ruderal Upland. Ruderal habitat is generally characterized by an area of land that receives some sort of natural or anthropogenic disturbance on a regular basis that significantly alters the natural landscape. Ruderal communities are assemblages of plants that thrive in disturbed areas; in the San Francisco Bay area weedy, annual, non-native plants are typically the first species to colonize these sites following a disturbance.

Ruderal Upland habitat is found in three primary locations on Bair Island. The first area is associated with the levee tops throughout all of Bair Island. Secondly, the majority of

Inner Bair is Ruderal Upland. This habitat is successional, as formerly larger areas of salt panes and less vegetation occurred in the area. Third, there are several other Ruderal Upland areas along the eastern side of Middle and Outer Bair upon spoil material disposal from past dredging of Redwood Creek. Other small, miscellaneous pockets of Ruderal Upland habitat exist throughout the project area, but are generally associated with either the levee system or with dredge spoil disposal (Figure 3).

The predominant ruderal species identified at Bair Island include Italian ryegrass (*Lolium multiflorum*), ripgut brome (*Bromus diandrus*), black mustard (*Brassica nigra*), wild radish (*Raphanus sativus*), Mediterranean barley (*Hordeum marinum* ssp. *gussoneanum*), wild oats (*Avena fatua*), yellow star-thistle (*Centaurea solstitialis*), common sow thistle (*Sonchus oleraceus*), bull thistle (*Cirsium vulgare*), bristly ox-tongue (*Picris echioides*), rabbitsfoot grass, brass buttons, alkali heath, and coyote brush (*Baccharis pilularis*).

Developed. For the purpose of this analysis, developed habitat refers to the unvegetated trails that are present around the perimeter, and across the middle of, Inner Bair Island. The parking lot area adjacent to Whipple Avenue does contain some hardscape material, but the developed areas are mostly compacted soil. These areas do contain sporadic vegetation, generally consisting of ruderal vegetation around the perimeter trail (see Ruderal Upland description) and some brass buttons in the low spots along the trail down the middle of Inner Bair Island.

Dominant species in each habitat types (and jurisdictional designation) are summarized in Table 2.

Table 2. Dominant Species and Jurisdictional Designation, April 2000.

Habitat Type	Dominant Plant Species	Other Common Plant Species Present	USACE Jurisdiction
Tidal Salt Marsh	Pickleweed Cordgrass	Saltgrass Alkali Heath	Historic Section 10, Section 10, Section 404
Muted Tidal Salt Marsh	Pickleweed	Cordgrass	Historic Section 10, Section 404
Diked Salt Marsh	Pickleweed	Alkali Heath Saltgrass Brass Buttons	Historic Section 10, Section 404
Seasonally Ponded Wetlands	Rabbitsfoot Grass Brass Buttons	Pickleweed Alkali Heath	Historic Section 10, Section 404
Aquatic	N/A	N/A	Historic Section 10, Section 10, Section 404
Shell Mounds	N/A	N/A	Historic Section 10, Section 10, Section 404

Habitat Type	Dominant Plant Species	Other Common Plant Species Present	USACE Jurisdiction
Ruderal Upland	Italian Ryegrass Ripgut Brome Wild Radish	Rabbitsfoot Grass Brass Buttons Black Mustard	Historic Section 10
Developed	N/A	N/A	Historic Section 10

Wildlife

Fishes. Fish species that occur in the vicinity, include the bay ray (*Myliobatis californica*), leopard shark (*Triakis semifasciata*), northern anchovy (*Engralis mordax*), bay pipefish (*Syngnathus leptorhynchus*), bay goby (*Lepidogobius lepidus*), shiner surfperch (*Cymatogaster aggregata*), starry flounder (*Platichthys stellatus*), English sole (*Parophrys vetulus*), and striped bass (*Roccus saxatilis*). The steelhead (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*) likely also occur in the vicinity.

Reptiles. Reptile use in the study area is rather limited. Species found within the study area include the common garter snake (*Thamnophis sirtalis*), racer (*Coluber constrictor*), gopher snake (*Pituophis melanoleucus*), western fence lizard (*Sceloporus occidentalis*), and alligator lizard (*Gerrhonotus* spp.), all of which occur along the edge of well vegetated levees, particularly in the vicinity of upland areas (H. T. Harvey & Associates, unpubl. obs).

Mammals and Birds. Considerable information is available for bird occurrences in the study area (see below). However, of the mammals, only rodents have been systematically surveyed. Mammals species known to occur include the opossum (*Didelphis virginiana*), California vole (*Microtus californicus*), California ground squirrel (*Spermophilus beecheyi*), California jack rabbit (*Lepus californicus*), cottontail (*Sylvilagus audubonii*), brush rabbit (*S. bachmani*), pocket gopher (*Thomomys* spp.), the federally endangered salt marsh harvest mouse (*Reithrodontomys raviventris*), salt marsh wandering shrew (*Sorex vagrans halicoetes*), western harvest mouse (*R. megalotis*), house mouse (*Mus musculus*), Norway rat (*Rattus norvegicus*), bats (probably *Myotis* spp. and *Tadarida braziliensis*), striped skunk (*Myphitis mephitis*), and red fox (*Vulpes vulpes*).

The federally endangered salt marsh harvest mouse inhabits areas dominated by pickleweed on Bair Island. It will be addressed in more detail below. Harbor seals, protected under the Marine Mammal Protection Act, haul out and breed in the area of Corkscrew Slough (Kopec and Harvey 1995). As many as 25 animals have been seen, but dedicated surveys have not been conducted. There could be interchange with the larger, more persistent numbers seen at Greco Island nearby.

Predominant bird species recorded during extensive surveys by biologists from the San Francisco Bay Bird Observatory (SFBBO) during summer and fall (Table 3) in order of numerical importance, are: Ring-billed (*Larus delewarensis)* and California Gulls (*Larus*

californicus), American Avocets (*Recurvirostra americanus)*, Black-necked Stilts (*Himantopus mexicanus)*, Least (*Calidris pusilla),* Western Sandpiper (*Calidris mauri)*, Barn (*Hirundo rustica)* and Cliff Swallow (*Hirundo pyrrhonota)*, and Short-billed (*Limnodromus griseus*) and Long-billed Dowitchers (*Limnodromus scolopaceus*). During fall the predominant species have been Least and Western Sandpipers, Ring-billed Gulls, Dowitcher, and American Coots (*Fulica Americana)*. Foraging ducks, shorebirds, herons and egrets are also found.

Table 3. Summary of Results of Bird Surveys Conducted in The South Bay.[a]
The avifauna of Bair Island is similar to this in terms of relative abundance of species. Counts of "0" indicate that the species occurs, but in number too low to have been detected on the surveys. Species seen on brief surveys by H.T. Harvey biologists on two days in April 2000 are shown in bold.

	SUMMER	FALL
Clark's/Western Grebe	0	0.1 (1)
American White Pelican	0.2 (4)	0
California Brown Pelican	0.1 (5)	0
Double-crested Cormorant[b]	0.2 (5)	0
Great Blue Heron	0.2 (4)	0
American Egret[b]	<0.1 (2)	0.1 (1)
Snowy Egret[b]	0.7 (5)	0.4 (2)
Black-crowned Night Heron	<0.1 (1)	0
Mallard[b]	3.4 (20)	0.5 (7)
Northern Pintail[b]	<0.1 (2)	0
Gadwall[b]	1.9 (56)	0
Northern Shoveller[b]	<0.1 (1)	2.1 (37)
Cinnamon Teal[b]	0.1 (4)	0
Green-winged Teal	<0.1 (1)	0
Lesser Scaup[b]	0.1 (5)	0
duck spp.	3.9 (80)	0
California Clapper Rail[b]	0	0
Virginia Rail	0	2.5 (7)
Sora	0.4 (6)	0.3 (2)
American Coot[b]	1.2 (7)	18.6 (35)
Common Moorhen[b]	0.8 (6)	1.1 (2)
American Avocet[b]	19.4 (272)	3.1 (15)
Black-necked Stilt[b]	20.4 (327)	2.0 (10)
Killdeer[b]	1.4 (8)	4.4 (15)
Black-bellied Plover	<0.1 (1)	1.1 (6)
Snowy Plover	0	0
Semipalmated Plover	0.1 (2)	0
Long-billed Curlew	1.0 (15)	0.2 (2)

	SUMMER	FALL
Whimbrel	<0.1 (1)	<0.1 (1)
Marbled Godwit	3.4 (43)	1.5 (11)
Long-billed Dowitcher	1.9 (18)	0.1 (1)
Short-billed Dowitcher	2.7 (15)	0
dowitcher spp.	9.3 (103)	16.1 (80)
Willet	0.8 (9)	0.8 (4)
Greater Yellowlegs	0.4 (7)	0.2 (1)
Lesser Yellowlegs	0.1 (3)	0
yellowlegs spp.	0.2 (3)	0
Dunlin	0.7 (30)	0
Western Sandpiper	6.1 (50)	8.4 (35)
Least Sandpiper	6.6 (52)	17.8 (61)
Western/Least sandpipers	16.2 (80)	91.2 (250)
Wilson's Phalarope	1.6 (13)	0
Red-necked Phalarope	8.6 (380)	0
phalarope spp.	13.2 (580)	0
Herring Gull	0	0.3 (2)
Western Gull	3.9 (73)	2.2 (5)
California Gull	9.0 (78)	4.5 (17)
Ring-billed Gull	14.9 (45)	48.4 (150)
Mew Gull	0	0.1 (1)
gull spp	37.3 (1000)	0.3 (5)
Caspian Tern	<0.1 (1)	0
Forster's Tern[b]	0.3 (8)	0
Turkey Vulture	<0.1 (2)	0
Red-tailed Hawk	0	0.3 (2)
Northern Harrier[b]	0.1 (1)	0.2 (2)
White-tailed Kite[b]	<0.1 (1)	<0.1 (1)
Ring-necked Pheasant	<0.1 (1)	0
Black Phoebe[b]	0.2 (1)	<0.1 (1)
Barn Swallow[b]	10.9 (32)	0
Cliff Swallow[b]	8.1 (100)	0
Violet-green Swallow	0.2 (9)	0
Loggerhead Shrike[b]	<0.1 (2)	0
Mourning Dove[b]	0.3 (2)	0
Marsh Wren[b]	2.9 (26)	1.1 (3)
Brewer's Blackbird[b]	0.1 (1)	0.4 (5)
Song Sparrow[b]	1.3 (6)	1.5 (3)
Savannah Sparrow[b]	0	0.5 (3)

	SUMMER	FALL
Salt Marsh Yellowthroat[b]	0	0.7 (4)
House Finch[b]	0.7 (7)	0

[a] – San Francisco Bay Bird Observatory (SFBBO 1991, 1999). Surveys during summer were from 4 June to 20 September 1989-90; surveys during fall were from 24 September to 26 November 1989-90. In taxonomic order, the average number of birds is given (average counts for each year were added together and divided by two) followed by maximum count (in parentheses; maximum counts are the maximum for the two years).

[b] – Likely or definitely breeds on Bair Island.

The federally endangered California Clapper Rail likely has a healthy, resident population in the tidal salt marshes of Outer Bair Island. Alameda Song Sparrow (*Melospiza melodia maxillaris*), Marsh Wrens (*Cistothorus palustris*), some ducks, primarily the Mallard (*Anas platyrhynchos*) and Gadwall (*Anas strepera*), and Canada Geese (*Branta canadensis*) nest on levees and among higher vegetation throughout the salt marsh. Double-crested Cormorant (*Phalacrocorax auritus)* (up to 100 pair) and Great Blue Herons (*Ardea herodias*) (about 10 pair) nest on PG&E towers located at the northern and southern shores of Outer Bair Island (Figure 3). Black-crowned Night Herons (*Nycticorax nycticorax)*, Great Egrets (*Ardea alba*) and Snowy Egrets (*Egretta thula*) formerly nested on Bair Island, but no longer actively nest on site (Ryan and Parkin 1998). The latter three species, in the process of nesting, eventually destroyed the shrubs and small trees in which they made nests, and since have moved to shrubs nearby at Redwood Shores. The colony at Redwood Shores appeared and grew as the Bair Island colony shrank and disappeared. White-tailed Kites (*Elanus leucurus*) and Northern Harriers (*Circus cyaneus*) nest along the levees of Bair Island. Formerly, the federally endangered Least Tern (*Sterna antillarum*) and the state protected Caspian Tern (*Sterna caspia*) nested on Bair Island, but no longer. These two tern species disappeared when Outer Bair Island was restored to salt marsh. The same scenario likely is true of the threatened Western Snowy Plover (but see below). Currently, a small colony of Forster's Terns (*Sterna forsteri)* occurs in the western portion of Middle Bair Island. The colony moves about year to year. Other nesting species include Black-necked Stilt and American Avocet.

Special-Status Plant Species

When assessing the site's potential habitat suitability for special-status plant species, several factors are generally taken under consideration, including: 1) the proximity and date of known occurrences, 2) the presence and ecological condition of habitats on-site, 3) past and current land use practices, 4) the existence of known associate species, and 4) direct observation of plants as a result of optimally-timed, species-specific surveys. Reconnaissance-level surveys for special status plant species were conducted during habitat mapping surveys between 14 and 28 April 2000 within the project area. Additional species-specific surveys will be necessary to account for potentially occurring plants with later blooming periods.

The special-status plant species that occur regionally in habitats similar to those found in the project area are described below. The process of identifying special-status plant

species for consideration involved two steps. First, a query of special-status plants in the California Natural Diversity Database (CNDDB) Redwood Point quadrangle, and eight adjoining quads. Second, the California Native Plant Society Inventory (1994) was used to produce a similar list for San Mateo County. The habitat requirements and current distribution for each special-status species were the principal criteria used for inclusion in the list of potentially occurring species on site. Therefore, plants were considered on the basis of their occurrence in the broad categories of marshes and swamps, and valley and foothill grasslands that are most similar to the salt marsh, seasonal wetland, and ruderal habitats on site.

Many of the special-status plant species that occur in San Mateo County are found in habitat types that are not present on site. These habitat types include: dune and prairie habitats, coniferous habitats, woodland habitats, meadow and vernal pool habitats, and scrubs and chaparral habitats, and serpentine environments. In addition, the following sensitive habitats identified by the CDFG Rarefind Database query are not present on site: valley oak woodland, valley needlegrass grassland, and serpentine bunchgrass. A fourth sensitive habitat, northern coastal salt marsh, is prevalent on site.

A total of 41 special-status taxa occur in the area within similar habitats according to the CNPS inventory and the CDFG Rarefind Database. Of these, 37 species were dismissed due to the absence of suitable microhabitats (mostly serpentine substrates), and/or have been regarded as either extirpated from San Mateo County; their distribution has been reduced to historical occurrences, or are considered extinct. Suitable habitat exists in the project area for only 4 species including: Contra Costa Goldfields (*Lasthenia conjugens*), Point Reyes bird's beak (*Cordylanthus maritimus* ssp. *palustris*), Congdon's tarplant (*Hemizonia parryi* ssp. *condonii*), and marsh gumplant (*Grindelia stricta* var. *angustifolia*). Of these, the marsh gumplant was observed on site. Congdon's tarplant and the Point Reyes bird's beak have not been observed, and detailed surveys for these species have not been conducted.

Federal or State Endangered or Threatened Species

Contra Costa Goldfields (*Lasthenia conjugens*). Federal Listing Status: Endangered; State Listing Status: None; CNPS List 1B. This annual herb occurs in mesic valley and foothill grasslands, and vernal pools. The blooming period is from March to June. This range of this species is reported to have been reduced to Napa and Solano counties, having been extirpated from five other counties forming its historic range, including Santa Clara County. The DFG rarefind database has only historical reports of this species within the quadrangle search area. However suitable habitat is present on site and known populations occur across the bay in Alameda County.

State Protected or CNPS Species

Point Reyes Bird's-Beak (*Cordylanthus maritimus ssp. palustris*). Federal listing status: Species of Concern; State listing status: None; CNPS List 1B. This annul hemi-parasitic herb occurs in coastal salt marsh. The blooming period extends from June

to October. The range of this species includes San Mateo and 5 other counties in California, and in Oregon, though it is believed to be extirpated from the south bay area. The DFG rarefind database has only historical reports of this species within the Redwood Point quadrangle. However suitable habitat is present on site.

Congdon's Tarplant (*Hemizonia parryi* ssp. *congdonii*). Federal Listing Status: Species of Concern; State Listing Status: None; CNPS List: 1B. This annual herb occurs in valley and foothill grassland, particularly those with alkaline substrates, and in sumps or disturbed areas where water collects. The blooming period extends from June through November. The range of this species has been reduced to Monterey, San Luis Obispo, Santa Clara, and Alameda counties. The DFG rarefind database has only historical reports of this species within the quadrangle search area as close as Mountain View. However suitable habitat is present on site and known populations occur in Alviso.

Marsh Gumplant (*Grindelia stricta* var. *angustifolia*). Federal listing status: None; State listing status: None; CNPS List 4. This perennial herb occurs in coastal salt marsh and tidally influenced areas between sea level and 10 meters. The blooming period extends from August to October. The range of this species includes San Mateo and 9 other counties in California. The DFG rarefind database has no reports of this species within the quadrangle search area, however, suitable habitat is present on site and the species was observed within the tidal salt marsh habitats.

Listed Wildlife Species

Two species listed as Federally Endangered (FE) breed in high density on Outer Bair Island: the California Clapper Rail and salt marsh harvest mouse. The latter likely occurs on Middle Bair Island also, as there is much pickleweed present. Three listed species occur as seasonal residents, including the Western Snowy Plover (Federally Threatened, FT), California Least Tern (FE) and California Brown Pelican (*Pelecanus occidentalis*) FE); and two others, the steelhead (FT) and Chinook salmon (FT), migrate through the area. The California Black Rail (State Threatened and Federal candidate) and Bank Swallow (State Threatened) could occur rarely in the study area. The harbor seal, protected under the Marine Mammal Protection Act, hauls out and pups along the banks of Corkscrew Slough. The Alameda Song Sparrow and Salt Marsh Common Yellowthroat have been candidate species for federal and state listing, and are considered species of special concern by the State of California. The Alameda Song Sparrow is common in the salt marsh of Bair Island; the Salt Marsh Common Yellowthroat is likely sparse owing to a lack of willow thickets and *Scirpus* sp.

California Clapper Rail. The California Clapper Rail breeds in salt and brackish marshes along the edge of San Francisco Bay, and is most abundant in extensive salt marshes dominated by cordgrass, pickleweed, and marsh gumplant associated with numerous secondary tidal channels (Harvey 1980). Within these salt marshes, nests are placed in or under this vegetation as well as saltgrass, or tidal wrack (DeGroot 1927, Evens and Page 1983, Harvey 1980, Foerster et al. 1990). Most foraging occurs on exposed mud along tidal (usually secondary) channels or in vegetation at the edges of

such channels (Shuford 1993). In winter, California Clapper Rails tend to forage primarily in cordgrass-dominated habitat (P. R. Kelly, pers. comm. in Shuford 1993), although tall vegetation at the edges of the upper marsh provides important cover during high winter tides.

Although California Clapper Rails also breed in brackish marshes, especially those dominated by alkali bulrush (*Scirpus robustus*), the importance of these marshes to California Clapper Rails is not well understood (H. T. Harvey & Associates 1989, 1990b, 1991a,b, Collins et al. 1994). No recent breeding-season surveys have been conducted for this species at Bair Island. However, the species was reported there by Gill (1979); other surveys have found them in marshes immediately adjacent to Bair Island (e.g., Harvey 1980). Gill (1979: 43) wrote that, "the Clapper Rail can be expected to inhabit those areas of Bair Island now being restored to tidal marsh." At that time, he was referring to the restoration of Outer Bair Island.

Salt Marsh Harvest Mouse. The salt marsh harvest mouse inhabits pickleweed marshes of the San Francisco Bay. This species is most abundant in deep, dense pickleweed in marshes providing non-submerged refugia during high winter tides (Shellhammer et al. 1982). Although this species makes some use of grasses and salt-tolerant forbs at the upper margins of salt and brackish marshes, it is closely tied to the cover of dense pickleweed, and it makes little use of pure alkali bulrush or cordgrass stands (Wondolleck et al. 1976, Shellhammer 1977). These mice inhabit both marshes that are open to tidal action and diked marshes, provided that suitable pickleweed habitat is present.

Although no recent surveys have been conducted, the areas of Bair Island dominated by pickleweed provide high quality habitat for this species. This is especially true of the tidal marshes of the entire study area, and the muted tidal and diked marshes of Outer Bair. The diked units of Middle Bair contain less pickleweed and are patchier, less dense and less deep. The pickleweed habitats in Middle Bair provide salt marsh harvest mouse habitat that ranges from slightly better than average to non-habitat. The large cell that makes up Inner Bair is mostly non-habitat for the mouse, as pickleweed is found only as strips along waterways and standing water. The overall habitat value of Inner Bair to the mouse is generally poor. Most of the levees between cells in Middle Bair have moderate cover hence it seems likely that salt marsh harvest mice may be able to move between cells, at least sporadically.

Other Listed Species. Other listed species that are found in the vicinity of Bair Island, but which do not breed there, include the Western Snowy Plover (FT), California Least Tern (FE), California Brown Pelican (FE), steelhead (FT), and Chinook salmon (FT).

Snowy Plovers were reported from Bair Island during the breeding season in the 1960s and early 1970s (though no nests were found); they have not been detected since (Page and Stenzel 1981). They do nest in the South Bay, and individuals likely forage at times on the mud flats of Bair Island (see Page and Stenzel 1981). Suitable Snowy Plover nesting habitat does occur now, if freed of human disturbance, on the outer barrier beaches of Outer Bair Island (Figure 1).

Least Terns (and Caspian Terns) once nested in an area on Outer Bair Island, but not since 1984 (former nesting area is now tidal salt marsh; e.g. Naslund et al. 1982, Layne and Harding-Smith 1995). The main post-breeding (fall) staging area of the Least Tern in the South Bay is in the complex of salt ponds immediately north of Moffett Field and, to a lesser extent, in the vicinity of Shoreline Park in Mountain View. Least Terns no doubt forage over the sloughs in the vicinity of Bair Island. Caspian Terns (about 25) were observed courting at a roost site on the outer edge of Bair Island on 26 April 2000 (H.T. Harvey and Associates, unpublished observations). They would likely nest in that vicinity, although the area may receive too much anthropogenic disturbance (kayakers, etc.).

The California Brown Pelican is a regular non-breeding forager in the area. A roost site occurs on the barrier beach along the outer, eastern shore of Bair Island (Figure 3). Species such as the California Black Rail (state threatened and federal candidate) and Bank Swallow (state threatened) may occur rarely, but do not nest in the area.

The Caspian and Forster's terns both are considered by the State as being species of concern owing to restricted habitat. In particular, their colonies are given protected status. The Forster's Tern nests on Middle Bair, and the Caspian Tern once nested, and may nest again, on Outer Bair; see below.

Adult steelhead and Chinook salmon migrate up various creeks and rivers in the South Bay, and foraging smolts of both species after swimming down river frequent areas throughout San Francisco Bay. Likely these fish frequent Redwood Slough and other deep sloughs of Bair Island.

A variety of other special status wildlife species are known from the vicinity and would be expected on-site.

WETLAND TECHNICAL ASSESSMENT

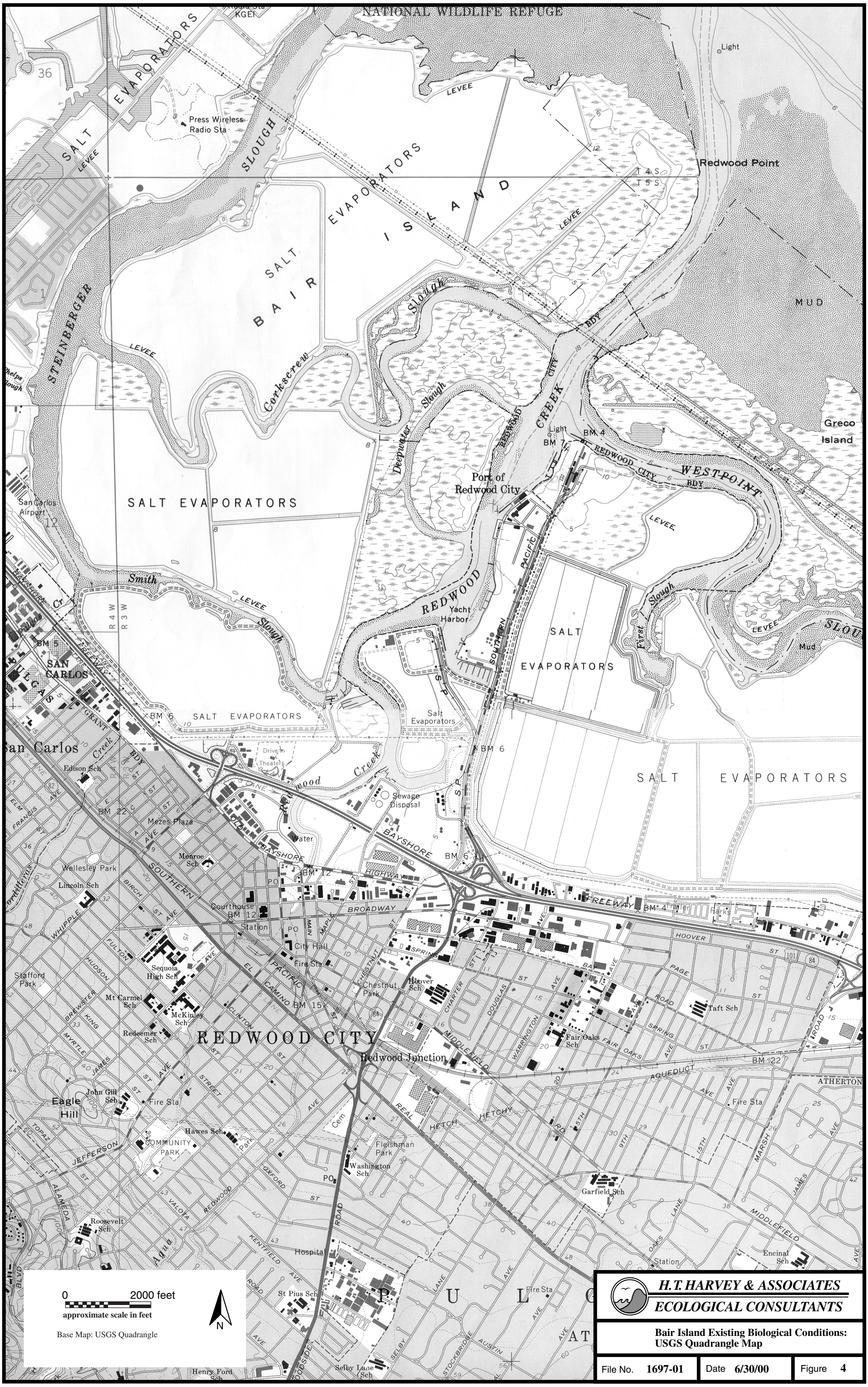
The Bair Island tidal wetland restoration project site occurs within the city limits of Redwood City, San Mateo County, California (Figure 1). The site is situated adjacent to San Francisco Bay just north of the Ravenswood Open Space Preserve. It is located on the Palo Alto and Redwood Point U.S.G.S. Quadrangle Maps (Figure 4).

Bair Island is largely surrounded by water, with the exception of Inner Bair, which is accessible to pedestrians from Whipple Avenue. Bair Island is bordered to the west by Steinberger Slough, to the north by San Francisco Bay, to the east by Redwood Creek, and to the south by Highway 101 (Figure 1). Inner Bair is separated from Middle Bair by Smith Slough and Middle Bair is separated from Outer Bair by Corkscrew Slough (Figure 1). The project site is characterized by tidal, muted and diked salt marsh, mud flats and salt pannes, levees and borrow ditches, as well as historic slough channels.

The project site is underlain predominantly by Reyes clay 0-1% slopes, with some areas of Novato clay, 0-1% slopes (Figure 5). The Reyes clay series are deep, somewhat poorly drained series on reclaimed tidal lands that were at one time used as evaporation or salt producing ponds (Soil Conservation Service; SCS 1991). The Novato clay is characterized by very deep, very poorly-drained soils that formed in alluvium derived from various types of rock (Soil Conservation Service; SCS 1991). The Soil Conservation Service (1992) classifies both the Reyes and Novato series as hydric soils. Average annual precipitation within the project vicinity is 15 inches and occurs primarily during November through April. The average annual temperature as reported for Redwood City is approximately 59.1^{o}F (SCS 1991). The 30-year normal annual temperature as reported from the National Weather Service is 59.3^{o}F for Redwood City (1961-1990). Topography of the site is relatively varied; elevation ranges from approximately –0.8 feet National Geodetic Vertical Datum (NGVD) in the subsided, diked marsh plane, to 9 feet NGVD at the levee crests, to over 11 feet NGVD at some of the spoil deposits (PWA 2000, LSA 1999).

The U. S. Fish and Wildlife Service has described Bair Island using seven different habitat classifications (Figure 6). These habitats include estuarine, intertidal, emergent, regularly flooded (E2EMN), estuarine, intertidal, unconsolidated shore, regularly flooded (E2USN), palustrine, emergent, seasonally flooded, mixohaline, diked/impounded (PEMC3h), palustrine, unconsolidated bottom, permanently flooded, diked/impounded (PUBHh), palustrine, unconsolidated bottom, semi-permanently flooded, diked/impounded (PUBFh), lacustrine, littoral, unconsolidated shore, seasonally flooded, mixohaline, diked/impounded (L2USC3h), and lacustrine, littoral, unconsolidated shore, seasonally flooded, hyperhaline, diked/impounded (L2USC1h).

The project site includes extensive areas that are regulated by Section 10 of the Rivers and Harbors Act of 1899; these include historical and current Section 10 Waters.



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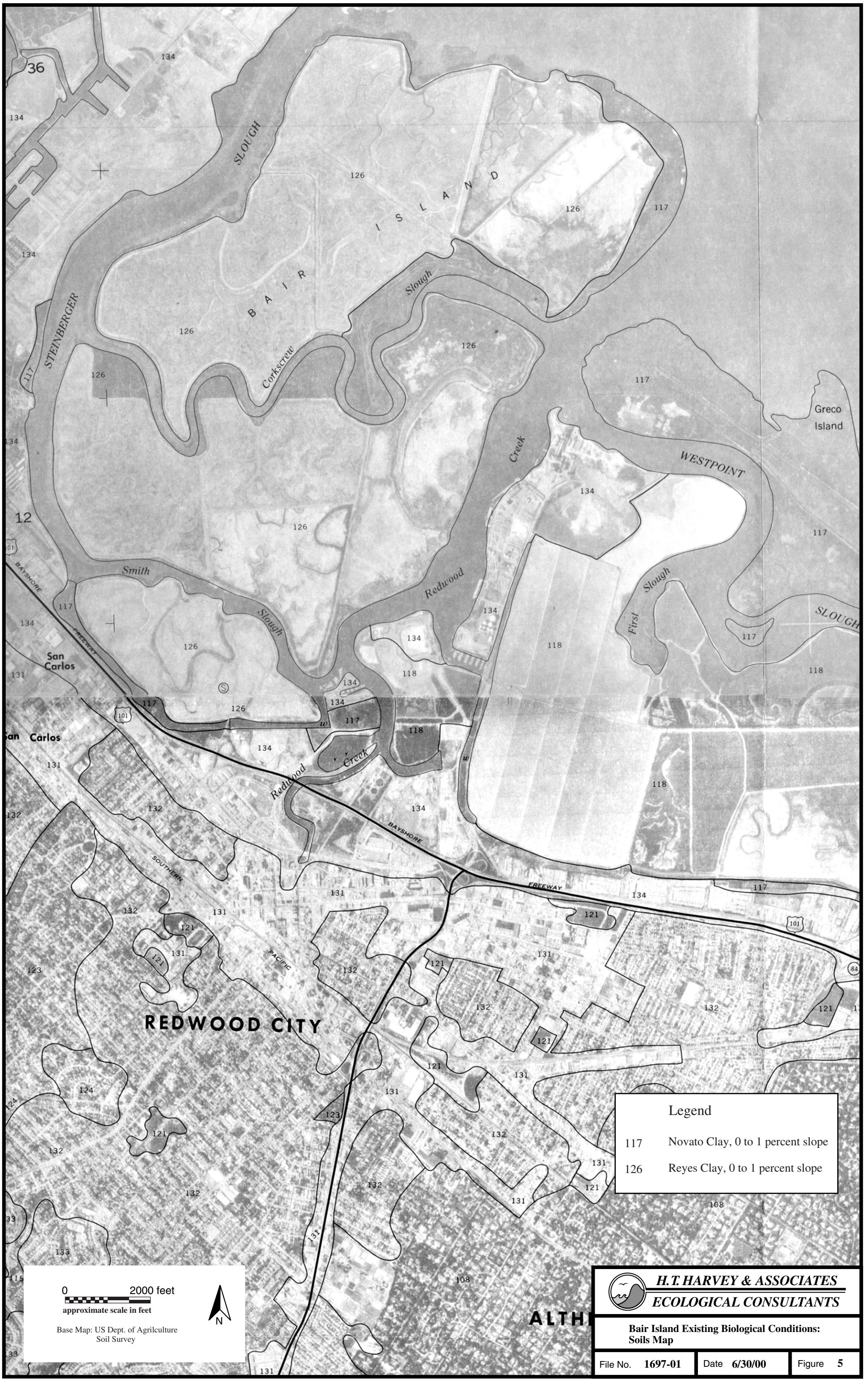
Bair Island Existing Biological Conditions: USGS Quadrangle Map

File No. 1697-01	Date 6/30/00	Figure 4


SLOUGH
BAIR ISLAND
STEINBERGER
Corkscrew
Slough
Creek
WESTPOINT
Greco Island
Smith
Slough
Redwood
First Slough
SLOUGH
San Carlos
Redwood Creek
BAYSHORE FREEWAY
SOUTHERN PACIFIC
REDWOOD CITY
ALTH
Legend
117 Novato Clay, 0 to 1 percent slope
126 Reyes Clay, 0 to 1 percent slope
0 2000 feet
approximate scale in feet
N
Base Map: US Dept. of Agrilculture Soil Survey
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ECOLOGICAL CONSULTANTS
Bair Island Existing Biological Conditions: Soils Map
File No. 1697-01
Date 6/30/00
Figure 5

LEGEND

E2EMN - estuarine, intertidal, emergent, regularly flooded

E2USN - estuarine, intertidal, unconsolidated shore, regularly flooded

PEMC3h - palustrine, emergent, seasonally flooded, mixohaline, diked/impounded

PUBHh - palustrine, unconsolidated bottom, permanently flooded, diked/impounded

PUBFh - palustrine, unconsolidated bottom, semi-permanently flooded, diked/impounded

L2USC3h - lacustrine, littoral, unconsolidated shore, seasonally flooded, mixohaline, diked/impounded

L2USC1h - lacustrine, littoral, unconsolidated shore, seasonally flooded, hyperhaline, diked/impounded

0 2000 feet

approximate scale in feet

Base Map: National Wetlands Inventory Map

N

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Bair Island Existing Biological Conditions: NWI Map

File No. **1697-01** | Date **6/30/00** | Figure **6**

SURVEY PURPOSE

H. T. Harvey & Associates' biologists surveyed all portions of the project site for areas that potentially meet the regulatory definition of Waters of the United States (jurisdictional waters). Development in areas identified as such is subject to the permit requirements of the U. S Army Corps of Engineers (USACE) under Section 404 of the Clean Water Act (1972) and Section 10 of the Rivers and Harbors Act (1899). The primary purpose of our work was to provide a technical assessment of potential jurisdictional waters located within the study area under conditions existing at the time of the survey.

SURVEY METHODS

Habitat mapping of the entire study area was conducted during six (6) visits to Bair Island from April 14 to April 27, 2000. In order to formalize the extent and location of jurisdictional waters, including wetlands within the project area, a routine determination was conducted at eight points thought to be representative of the habitats as established by the mapping effort. A description of these sites was conducted using methodologies approved by the USACE. Personnel included John Bourgeois (wetland restoration ecologist).

Generally, surveys conducted on non-disturbed sites examine the vegetation, soils, and hydrology using the "Routine Determination Method, On-Site Inspection Necessary: (Section D) outlined in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987). This multi-parameter approach to identifying wetlands is based upon the presence of hydrophytic vegetation, hydric soils and wetland hydrology. Although the site has been substantially modified over the years (i.e. diked, drained, etc.) in terms of topography, hydrologic conditions and vegetative cover, these conditions represent the new normal circumstance.

Alternatively, upland sites (non-wetlands) which subsequently developed some characteristics of wetlands, due to intentional or incidental human activities, are examined for wetlands using the techniques described in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987) for "Atypical Situations: Man-Induced Wetlands" (Section F, Subsection 4). The majority of such wetlands involve a significant change in the hydrologic regime, which may either increase or decrease the wetness of an area.

Prior to site surveys, topographic maps and aerial photographs of the study area were obtained form several sources and were reviewed. These sources included the U. S. Geological Survey Map for the Redwood Point and Palo Alto Quadrangles (1991), National Wetlands Inventory Maps for the Redwood Point and Palo Alto Quadrangles (1985), and aerial photographs contained in the *Soil Survey of San Mateo County, Eastern Part, and San Francisco County, California* (SCS 1991).

The boundaries of potential jurisdictional waters located on site were drawn directly as lines and polygons onto an acetate overlay on top of 1-inch : 200-feet black and white aerial photography. Jurisdictional acreages and color-coded figures for the entire Study Area were generated by GIS systems Microstation and ARCVIEW as previously discussed in the habitats section.

A brief overview of the USACE regulations specifically applicable to the identification of jurisdictional waters on the Bair Island Restoration project and general guidance regarding the acquisition of permits for proposed activities within these jurisdictional waters are summarized below.

WATERS OF THE U. S. REGULATIONS OVERVIEW

Areas meeting the regulatory definition of "Waters of the United States" are subject to the regulatory jurisdiction of the U. S. Army Corps of Engineers (USACE). The USACE under provisions of Section 404 of the Clean Water Act (1972) has jurisdiction over "Waters of the United States" (jurisdictional waters). These waters may include all waters used, or potentially used, for interstate commerce, including all waters subject to the ebb and flow of the tide, all interstate waters, all other waters (intrastate lakes, rivers, streams, mud flats, sandflats, playa lakes, natural ponds, etc.), all impoundments of waters otherwise defined as "Waters of the U. S.," tributaries of waters otherwise defined as "Waters of the U. S.," the territorial seas, and wetlands adjacent to "Waters of the U.S." (33 CFR, Part 328, Section 328.3).

Areas not considered to be jurisdictional waters include non-tidal drainage and irrigation ditches excavated on dry land, artificially-irrigated areas, artificial lakes or ponds used for irrigation or stock watering, small artificial water bodies such as swimming pools, and water-filled depressions (33 CFR, Part 328).

WETLAND TECHNICAL ASSESSMENT

Below we provide a detailed description of the methodology used in the identification of the different classes of jurisdictional waters, having the potential of occurring on site, including: A) Section 404 jurisdictional wetlands; B) Section 404 tributary waters; C) Section 404 "other waters"; D) Section 404 Mud flats, and; E) Historical and Current Section 10 Waters.

A) Identification of Section 404 Jurisdictional Wetlands (Special Aquatic Sites)

Surveys were conducted within the study area for areas that meet the technical criteria of jurisdictional wetlands. The vegetation, soils, and hydrology of the site were examined following the guidelines outlined in the "Routine Determination Method" in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987).

The property was examined for topographic features, drainages, alterations to site hydrology and areas of significant recent disturbance by hiking the entire site. A

determination was then made as to whether normal environmental conditions were present at the time of the field surveys. Data were used to document which portions of the site were wetlands. Information obtained in the field was drawn onto a 1-inch : 200-feet black line copy of an aerial photograph of the project site.

Vegetation. Plants observed at each of the sample sites were identified to species using *The Jepson Manual* (Hickman 1993). Additional references included *A California Flora and Supplement* (Munz and Keck 1973), *A Flora of the Marshes of California* (Mason 1969), *Manual of the Grasses of the United States* (Hitchcock 1971), and *Weeds of California* (Robbins, et al. 1970). The wetland indicator status of each species was obtained from the 1987 Wetland Plant List, California (Reed 1988). A list of dominant species for each observation area was made and it was then determined which of the observation areas supported wetland vegetation (Appendix B).

Wetland indicator species are so designated according to their frequency of occurrence in wetlands. For instance, a species with a presumed frequency of occurrence of 67% to 99% in wetlands is designated a facultative wetland indicator species. The wetland indicator groups, indicator symbol and the frequency of occurrence of species within them in wetlands are as follows:

Table 4. Wetland Indicator Status Categories for Vascular Plants.

INDICATOR CATEGORY	SYMBOL	FREQUENCY OF OCCURRENCE
OBLIGATE	OBL	greater than 99%
FACULTATIVE WETLAND	FACW	67 - 99%
FACULTATIVE	FAC	34 - 66%
FACULTATIVE UPLAND	FACU	1 - 33%
UPLAND	UPL	less than 1%

Based upon information contained in *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987).

Obligate and facultative wetland indicator species are hydrophytes that occur "in areas where the frequency and duration of inundation or soil saturation produce permanently or periodically saturated soils of sufficient duration to exert a controlling influence on the plant species present" (Environmental Laboratory 1987). Facultative indicator species may be considered wetland indicator species when found growing in hydric soils that experience periodic saturation.

Soils. Where possible, the top 18 inches of the soil profile was examined for hydric characteristics. Such characteristics include the presence of organic soils (histosols), histic epipedons, aquic or peraquic moisture regime, presence of soil on hydric soil list, mottling indicated by the presence of gleyed or bright spots of colors (in the former case, blue grays; in the latter case, orange red, or red brown) within the soil horizons observed. Mottling of soils usually indicates poor aeration and lack of good drainage. Munsell Soil Notations (Munsell Soil Color Charts, Kollmorgen Instr. Corp. 1990) were recorded for the soil matrix for each soil sample. The last digit of the Munsell Soil Notation refers to the chroma of the sample. This notation consists of numbers beginning with 0 for neutral

grays and increasing at equal intervals to a maximum of about 20. Chroma values of the soil matrix which are one (1) or less, or of two (2) or less when mottling is present, are typical of soils which have developed under anaerobic conditions. In addition, the Field Indicators of Hydric Soils in the United States, Version 4 (USDA, NRCS 1998) was used in the identification of hydric soil features.

In sandy soils, such as alluvial deposits in the bottom of drainage channels, hydric soil indicators include high organic matter content in the surface horizon and streaking of subsurface horizons by organic matter. All soil colors indicated in this report were taken under clear, sunny skies using moistened soil samples.

The *Soil Survey of San Mateo County, Eastern Part, and San Francisco County, California* (SCS 1991) was consulted in order to determine which soil types have been mapped on the project site. Descriptions of soil mapping units and the list of hydric soils in San Mateo County are included in Appendix A.

Hydrology. Each of the sample sites was examined for positive field indicators of wetland hydrology. Such indicators might include visual observation of inundation and/or soil saturation, watermarks on culverts, drift lines, water-borne sediment deposits, water-stained leaves, and drainage patterns within wetlands.

B) Identification of Section 404 "Other Waters"

"Other waters" include lakes, seasonal ponds and seasonal springs. Such areas are identified by the presence of standing or running water and generally lack hydrophytic vegetation. The project site was surveyed for areas meeting the regulatory definition of "other waters."

C) Identification Of Section 404: Mud Flats

Mud flats are special-aquatic sites that are not vegetated. The project site was surveyed for areas meeting the regulatory definition of mud flats.

D) Identification Of Historical And Current Section 10 Waters

Historic maps and aerial photographs that included the project site were reviewed to determine if portions of the site occur within Section 10 waters. This information included: 1) U. S. Fish and Wildlife Service National Wetland Inventory Maps for the Redwood Point and Palo Alto USGS Quadrangles (1985); 2) U. S. Coast and Geodetic Survey Charts for 1857; 3) 1970 aerial photograph from the *Soil Survey of San Mateo County, Eastern Part, and San Francisco County, California* (SCS 1991); and aerial photograph of the project area from February 2000.

Current Section 10 Waters in tidal waters includes tidal channels and adjacent special aquatic sites up to the limit of the mean high water mark (MHW) in areas currently exposed to fully tidal or muted-tidal action.

Historical Section 10 Waters occur behind levees, are currently not exposed to tidal or muted-tidal influence, and meet certain criteria. These criteria include: 1) the area is presently at or below mean high water (MHW); 2) the area was historically at or below MHW in its "unobstructed, natural state", and; 3) there is no evidence that the area was ever above MHW (Calvin Fong Memo, USACE, 1983).

Procedures for determining Historical Section 10 jurisdiction behind levees are as follows:

1. First, determine present MHW for the area in question.
    a. Use surveyed elevation data from the prospective applicant.
    b. If elevation data are not available, use the survey technique for determining MHW on the outboard side of the dike and project the MHW line back to the area in question.
    c. Those areas behind dikes that are presently above MHW are not subject to Section 10 permit requirements (provided they were above MHW prior to 28 January 1972 or were filled to above MHW thereafter under USACE permit) because they are presently at or above MHW.
    d. Those areas that are presently at or below MHW may be subject to Section 10 permit requirements. To determine whether these areas are subject to Section 10, two additional facts must be obtained (which are numbers 2 and 3 of the historical waters definition provided above).
2. The second step is to determine whether those areas presently at or below MHW were historically below MHW before the dikes were built.
    a. If available, use elevation data that were surveyed just prior to or just after the dikes were built. More often then not, this information is not available but potential sources include city and county planning commissions, public works departments, Caltrans, State Lands Commission, etc.
    b. If historic elevation data are not available, use the T-charts of 1850-90 to determine the location of the historic sloughs, if any, in those areas that are presently below MHW. The premise is that the historic sloughs were subject to the ebb and flow of the tides, and thus were below MHW.
    c. Those areas presently below MHW and historically below MHW as determined by elevation data or T-charts would be considered at or below MHW historically.
    d. Areas that were historically below MHW and filled above MHW (as shown by reliable data) but due to subsidence are now below MHW are not subject to Section 10 authority, but may be subject to Section 404 jurisdiction.

The MHW elevation in Redwood Creek was identified at Channel Marker No. 8 by Philip Williams & Associates (PWA 2000) as 3.44 feet NGVD. A table with tide characteristics and elevations (in NGVD and MLLW) is provided in the hydrologic existing conditions report (PWA 2000, Table 6).

SURVEY RESULTS

SUMMARY OF FINDINGS

Historically, the majority of the project area (see Table 1 and Figure 2) was exposed to the full ebb and flow of the tides. These habitats included tidal sloughs and channels, salt marshes above and below the MHW mark, transition zone wetlands extending up to the high tide line, salt pannes, and mud flats. This complex of habitats comprises several different categories of jurisdictional waters including Historical and Current Section 10, and Section 404 waters.

In the absence of reliable elevation data for the study area taken prior to the construction of the levees, the full extent of Historical Section 10 is approximated by the location of the historic sloughs presented in a T-chart taken from 1857 (Figure 2). In contrast, there are approximately 882.20 acres of Current Section 10 jurisdictional waters located within the project boundaries (Figure 7). These include the tidal salt marsh and shell mounds habitat types that are on the outboard side of the levees and are at an elevation at or below MHW. Current Section 10 jurisdictional waters include the majority of Outer Bair Island, as well as waters open to San Francisco Bay such as Corkscrew Slough and Smith Slough.

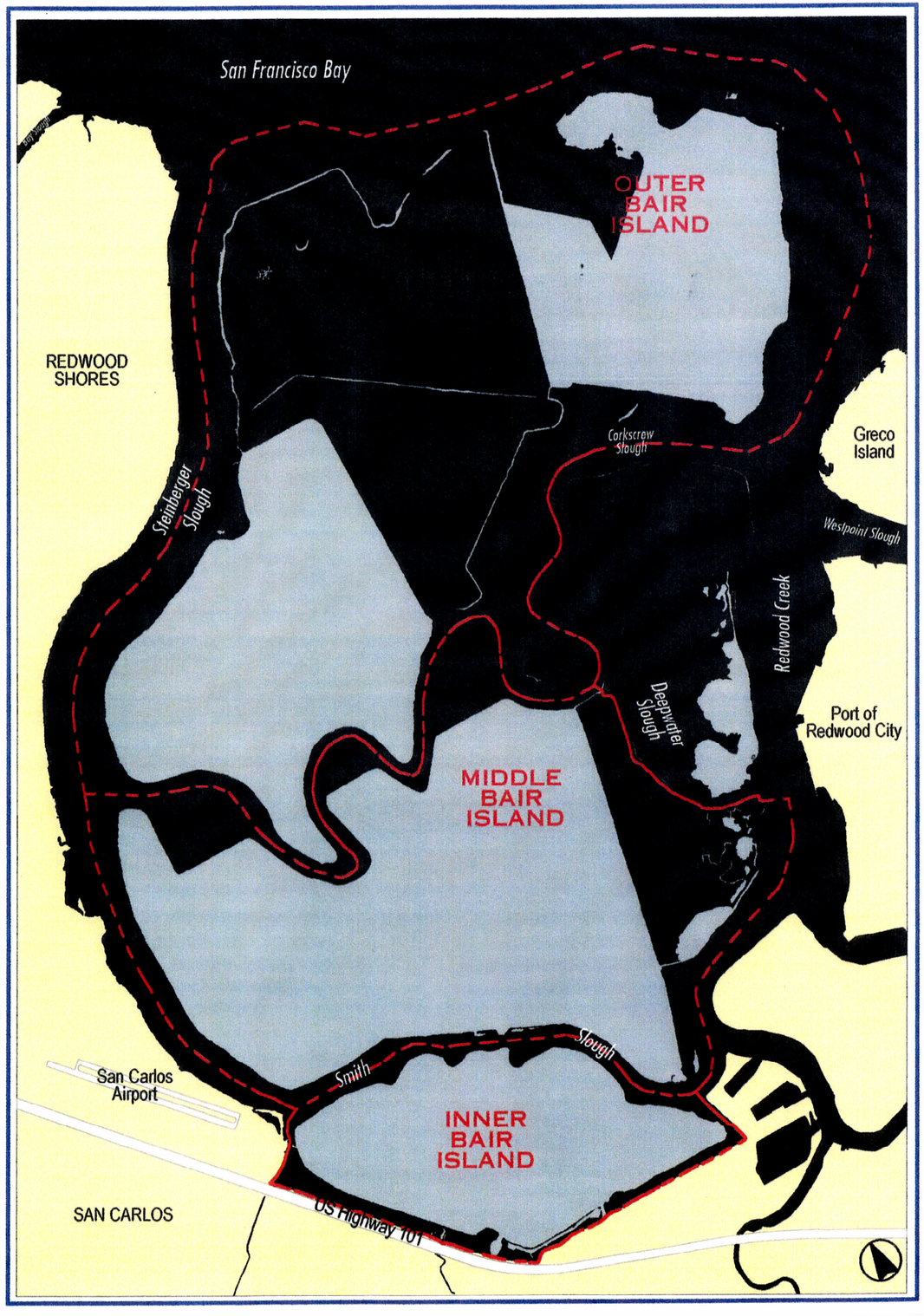
Section 404 waters were identified within the project boundaries and are presented in Figure 8. Approximately 2,259.32 acres of these habitats, including wetlands (1,992.76 acres) and other waters (266.56 acres; shell mounds, mud flats, salt pan and open water) were identified on site.

The remainder of the project site (i.e. uplands; approximately 375.82 acres) met none of the regulatory definitions of jurisdictional waters under Section 404 of the Clean Water Act nor Section 10 of the Rivers and Harbors Act. A summary of habitat acreages for the project site is presented in Table 4.

BAIR ISLAND RESTORATION PROJECT
FIGURE 7. SECTION 10 WATERS MAP

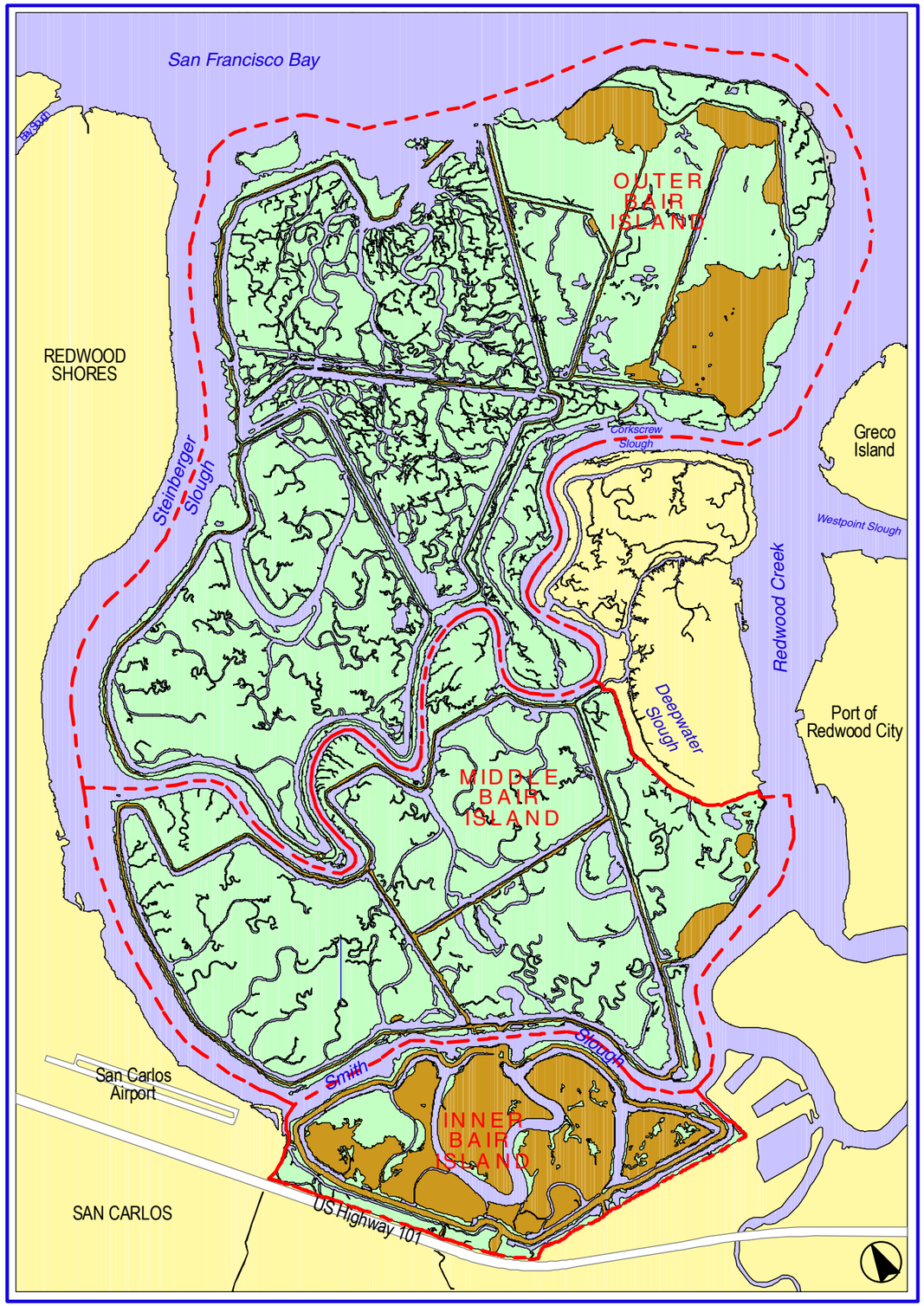
H.T. HARVEY & ASSOCIATES/GEOGRAPHIC COMPUTER TECHNOLOGIES

JUNE 2000 SCALE: 1 inch = 2,000 feet



Historic Section 10 Waters

Current Section 10 Waters



BAIR ISLAND RESTORATION PROJECT
FIGURE 8. WETLAND DELINEATION MAP

H.T. HARVEY & ASSOCIATES / GEOGRAPHIC COMPUTER TECHNOLOGIES

JUNE 2000 SCALE: 1 inch = 2,000 feet

Upland

SECTION 404 WATERS:

Open Water

Shell Mounds

Wetland

Table 5. Jurisdictional Habitat Acreages of the Bair Island Project Site.

HABITATS	ACRES
Upland:	**375.8**
Current Section 10-Jurisdictional Waters: (within project boundary)	**882.2**
Current Section 404-Jurisdictional Waters:	**2,259.3**
-Wetlands (within levees)	1,116.2
-Wetlands (associated with San Francisco Bay)	876.6
-Other Waters within levees (open water, mud flats, salt pannes)	260.9
-Other Waters associated with San Francisco Bay (shell mounds)	5.6
Total USACE Jurisdictional Area:	**2,259.3**

Information pertinent to the identification of jurisdictional waters assembled during the investigations is presented in four appendices located at the back of this report.

- Appendix A--Soils Descriptions
- Appendix B--USACE Data Forms
- Appendix C--Color Photographs

Observations/Rationale/Approach/Assumptions

- Due to several factors, the methodology used to describe and quantify the extent and distribution of potential jurisdictional waters within the defined project boundaries was modified somewhat from the approach commonly employed by following the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987), definitions contained in federal regulations, and guidance provided in Regulatory Guidance Letters. These factors included: limited access to Outer and Middle Bair Islands; minimal direct impacts to these habitats during work intended to reintroduce tidal flows; complexity of habitats driven by varied micro-topographic relief resulting from diking, draining, placement of fill materials in the historical marshes, and differential settlement of these materials over time.

- As described above, the approach on Outer and Middle Bair Islands was to utilize the vegetation signatures on the aerial photographs for mapping these habitats with field verification. This task was conducted with a high degree of certainty as the vast majority of these two islands possess obvious wetland characteristics. The only exceptions are a few areas on the east side of Outer Bair Island that are at an elevation that is beyond tidal influence. These primarily upland habitats are interspersed with depressional wetlands resulting from differential settlement of fill materials. Access to these areas was possible during field surveys and wetland habitats were mapped as shown in Figure 8.

- Inner Bair Island posed the greatest challenge to mapping potential jurisdictional waters as this area is a complex of heterogeneously-distributed upland and wetland habitats. Mapping involved delineating obvious wetland and open water habitats on overlays of the aerial photographs with extensive field verification of those color signatures. It was not possible to use this approach to identify the multitude of minor topographic depressional wetlands that dot the landscape. **It is acknowledged that many wetland depressions were not mapped on Inner Bair Island. Such areas were either too small to accurately identify on the photographs and/or too numerous to include at this level of analysis.**

- Approximately 8 sample points were taken throughout the study areas. Information regarding field characteristics at each of the sample points was entered onto USACE Data Forms presented in Appendix C of this report.

- The 8 sample points were taken in characteristic habitat types identified from field surveys and habitat mapping of the entire Bair Island complex. These sample points were then assumed representative of those habitat types, and jurisdictional boundaries were placed based on the vegetation observed in the field and the habitat signatures on the aerial photography. We feel that this approach is appropriate for the purposes of restoration of these areas.

- Inner Bair consists largely of ruderal, non-native grassland. Diked salt marsh occurs along the edge of the borrow ditches and remnant slough channels. Additional wetlands occur throughout Inner Bair in areas where there are slight topographic depressions. Many of the soil characteristics in regards to color, mottling and gleying, were considered historical in nature and formed during a hydrologic regime that no longer exists today. On the other hand, modifications to topography have led to conditions on site that clearly have wetland hydrology and a predominance of wetland vegetation. Such areas, may have lacked clear hydric soil features only because enough time has not lapsed to allow such features to develop and surveys were not conducted during the rainfall season to directly monitored such features as redox potential in the soil profile. In such areas two parameters, hydrology and vegetation, were used to define wetland habitats as soils characteristics were seen to be unreliable indicators. For clarification, areas that possessed clear field characteristics of surface and/or subsurface hydrology and a predominance of

hydrophytic vegetation without current hydric soil features were included as potential jurisdictional wetlands.

- The vast majority of the project site consists of former salt ponds (Photograph A; Appendix C).

· The outboard side of the levees support bands of tidal salt marsh most of which are dominated by pickleweed (*Salicornia virginica*; Photograph B; Appendix C). All of the dominant plant species observed on site (and their wetland indicator status) can be found in the text of the report.

· Fill material consisting of dredge spoil has been historically deposited along the south side of Middle and Outer Bair, as well as throughout Inner Bair. Dominant plants were mostly upland species such as Italian ryegrass (*Lolium multiflorum*), ripgut brome (*Bromus diandrus*), black mustard (*Brassica nigra*), wild radish (*Raphanus sativus*), Mediterranean barley (*Hordeum marinum* ssp. *gussoneanum*) and wild oats (*Avena fatua*). Remnant hydric soils characteristics were found in some of these areas.

- The portions of the study area targeted for restoration are currently not tidally influenced. The primary source of water is surface runoff during the rainfall season and lateral seepage.

- Much of the area within the levees appears as a degraded marsh with substantial subsidence; existing salt marsh vegetation in these areas, such as pickleweed, generally appear to have a lower vigor and are sometimes covered with salt marsh dodder (*Cuscuta salina*; Photograph C, Appendix C).

AREAS MEETING THE REGULATORY DEFINITION OF JURISDICTIONAL WATERS

A) Identification of Jurisdictional Wetlands (Special Aquatic Sites)

Jurisdictional wetlands located within the levees are shown in Figure 5. The total size of these wetlands is approximately 1,116.19 acres. Field characteristics of hydrophytic vegetation, hydric soils and wetland hydrology were obtained at sample location numbers: 1A, 1C, 2A, 2B, 3A and 3B (Appendix B).

Vegetation. The dominant hydrophytic vegetation observed within wetlands was pickleweed (*Salicornia virginica*; OBL). Other hydrophytic vegetation included, cordgrass (*Spartina foliosa*; OBL) and alkali heath (*Frankenia salina*; FACW+).

Hydrology. Primary indicators of hydrophytic characteristics included inundation, saturated soils within the upper 12 inches, drift lines and surface deposits of salt and sediments. Secondary indicators included surface cracks and oxidized root channels.

Soils. Hydric soil indicators included gleyed soils and soils of low chroma, the presence of mottles, aquic moisture regime and listing on local hydric soils list (SCS 1992). Typical soil chroma values observed included 10YR 3/2 and 5YR 5/1.

Wetland habitats (tidal salt marsh) located on the outboard side of the levees at Bair Island totaled approximately 876.57 acres.

B) Identification of "Other Waters"

The remainder of jurisdictional waters on site, within the levees, were combined into a single category termed "other waters" including open water, salt pan, and mud flat. "Other waters" within the project site total approximately 260.93 acres. These habitats were devoid of vascular vegetation and were inundated.

C) Identification of Historical and Current Section 10 Waters

The entire study area including the levees was once tidal salt marsh situated along the perimeter of San Francisco Bay. Current Section 10 Waters includes those portions of the tract at or below MHW in areas currently exposed to tidal or muted-tidal influcence. These areas total approximately 882.20 acres.

AREAS NOT MEETING THE REGULATORY DEFINITION OF JURISDICTIONAL WATERS

Approximately 375.82 acres of the project site (uplands) did not meet the regulatory definition of jurisdictional waters (Figure 8). Field data were collected at sample location numbers 1B and 3B (Appendix B).

Vegetation characteristic of these upland habitats included: Mediterranean barley (*Hordeum marinum* ssp. *gussoneanum*; FAC), Italian ryegrass (*Lolium multiflorum*; FAC), wild radish (*Raphanus sativus*, UPL) black mustard (*Brassica nigra*; UPL), wild oats (*Avena fatua*, NOL), pickleweed, rabbitfoot grass (*Polypogon monspeliensis*; FACW+), common sow thistle (*Sonchus oleraceus*; NI), alkali heath (*Frankenia grandiflora*; FACW+), salt grass (*Distichlis spicata*, FACW), Italian thistle (*Carduus pycnocephalus*; UPL), ripgut brome (*Bromus diandrus*; UPL), and ice plant (*Carpobrotus edulis*, NOL).

The soils of these upland sites were located on fill material that included native soils dredged from the neighboring borrow ditch. Soil color varied due to the fill material. Typical soil chroma values observed included 10YR 3/3 and 7.5YR 3/4.

Field characteristics of wetland hydrology were entirely absent from these upland areas.

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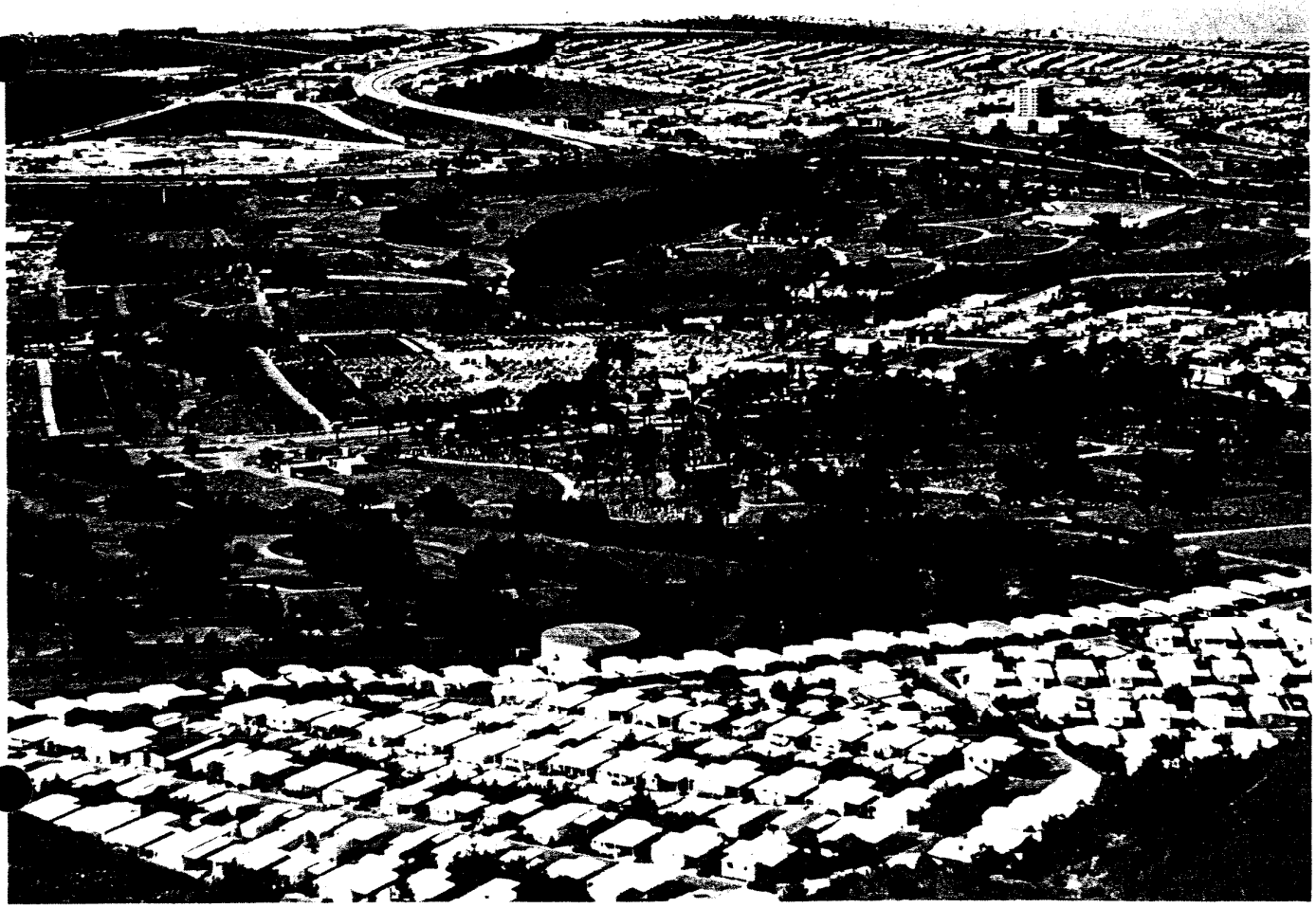
Appendix A.
Soils Descriptions

United States Department of Agriculture

Soil Conservation Service

In cooperation with the Regents of the University of California (Agricultural Experiment Station)

Soil Survey of San Mateo County, Eastern Part, and San Francisco County, California



clay loam, brown (7.5YR 5/4) moist; moderate medium and coarse subangular blocky structure; extremely hard, firm, sticky and plastic; many coarse roots and common fine and medium roots; common fine and medium tubular and interstitial pores; 3 percent angular pebbles 2 to 5 millimeters in diameter; common thin clay films on ped faces, in pores, and as bridges; neutral; gradual wavy boundary.

Bt3—27 to 37 inches; variegated light reddish brown (5YR 6/3) and reddish brown (5YR 5/4) clay, reddish brown (5YR 4/4) moist; moderate medium and coarse subangular blocky structure; extremely hard, firm, sticky and plastic; many coarse roots and few fine and medium roots; common very fine and fine tubular and interstitial pores; 3 percent angular pebbles 2 to 5 millimeters in diameter; common thin clay films on ped faces and in pores; slightly acid; clear wavy boundary.

Cr—37 inches; soft, fractured sandstone; silty clay loam in fractures.

Bedrock is at a depth of 20 to 40 inches. The profile averages 0 to 10 percent gravel. Reaction is slightly acid or neutral throughout the profile. The difference between the mean summer soil temperature and the mean winter soil temperature is less than 9 degrees F.

The A horizon has color of 7/5YR 6/2, 6/3, or 6/4. Moist color is 7/5YR 3/2, 4/2, or 4/4.

The Bt horizon has color of 5YR 5/4, 6/3, or 6/4. Moist color is 5YR 4/4 or 4/6 or 7.5YR 4/6 or 5/4. Texture is clay loam or clay.

Miramar Series

The Miramar series consists of moderately deep, well drained soils on coastal uplands. These soils formed in material weathered from quartz-diorite. Slope ranges from 30 to 75 percent.

Soils of the Miramar series are fine-loamy, mixed, isomesic Pachic Argiustolls.

Typical pedon of Miramar loam, in an area of Scarper-Miramar complex, 30 to 75 percent slopes; about 0.5 mile north of Montara, on California Highway 1; 1,400 feet north and 750 feet east of the intersection of Highway 1 and Martini Creek (not sectionalized); Montara Mountain 7.5' Quadrangle:

A1—0 to 7 inches; dark grayish brown (10YR 4/2) loam, very dark gray (10YR 3/1) moist; strong fine and medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots and few medium roots; many very fine and fine tubular and interstitial pores; 5 percent pebbles 2 to 7 millimeters in diameter; neutral; clear wavy boundary.

A2—7 to 15 inches; dark grayish brown (10YR 4/2) loam, very dark gray (10YR 3/1) moist; moderate coarse subangular blocky structure parting to moderate fine and medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine, fine, and medium roots; common very fine tubular and interstitial pores; 5 percent pebbles 2 to 5 millimeters in diameter; slightly acid; clear wavy boundary.

Bt—15 to 24 inches; brown (10YR 5/3) clay loam, dark brown (10YR 3/3) moist; weak coarse subangular blocky structure; slightly hard, friable, slightly sticky and plastic; few very fine and fine roots; common very fine tubular pores; 5 percent pebbles 2 to 5 millimeters in diameter; slightly acid; clear wavy boundary.

BC—24 to 29 inches; yellowish brown (10YR 5/4) loam, dark brown (10YR 4/3) moist; weak coarse subangular blocky structure; slightly hard, friable, slightly sticky and plastic; few very fine and fine roots; common very fine tubular pores; 5 percent pebbles 2 to 5 millimeters in diameter; slightly acid; clear wavy boundary.

Cr—29 inches; weathered quartz-diorite that slakes in water.

Bedrock is at a depth of 20 to 40 inches. The profile averages 2 to 10 percent gravel. Reaction is slightly acid or neutral throughout the profile. The difference between the mean summer soil temperature and the mean winter soil temperature is less than 9 degrees F.

The A1 horizon has color of 10YR 3/2, 4/2, or 5/2. Moist color is 10YR 2/1, 2/2, 3/1, or 3/2.

The Bt horizon has color of 10YR 3/4, 5/3, 5/4, or 5/6. Moist color is 10YR 3/2 or 3/3. Texture is sandy clay loam or clay loam.

Novato Series

The Novato series consists of very deep, very poorly drained soils in tidal marshes along the margins of San Francisco Bay. These soils formed in alluvium derived from various kinds of rock. Slope ranges from 0 to 1 percent.

Soils of the Novato series are fine, mixed, nonacid, isomesic Typic Hydraquents.

Typical pedon of Novato clay, 0 to 1 percent slopes, near Foster City; 330 feet north on Beach Park

oulevard from its intersection with Foster City oulevard and 150 feet east of Beach Park Boulevard; 75 feet east of asphalt pavement on top of dike (not ctionalized); Redwood Point 7.5' Quadrangle:

Ag—0 to 6 inches; gray (5Y 5/1) clay, dark gray (5Y 4/1) moist; common medium distinct dark yellowish brown (10YR 3/4, moist) mottles; massive; extremely hard, firm, sticky and plastic; many very fine roots; many very fine tubular pores and few fine and medium pores; moderately alkaline; clear irregular boundary.

A2g—6 to 16 inches; light olive gray (5Y 6/2) clay, variegated olive gray (5Y 4/2) and very dark gray (N 3/0) moist; common medium faint dark yellowish brown (10YR 3/4, moist) mottles; massive; extremely hard, firm, sticky and plastic; few very fine roots; moderately alkaline; diffuse smooth boundary.

C1g—16 to 30 inches; gray (5Y 5/1) clay, variegated dark gray (5Y 4/1) and dark greenish gray (5BG 4/1) moist; common medium distinct pale yellow (5Y 8/4, moist) jarosite mottles; massive; extremely hard, firm, sticky and plastic; moderately alkaline; iffuse smooth boundary.

2g—30 to 45 inches; dark gray (10YR 4/1) clay, very dark gray (N 3/0) moist; massive; extremely hard, firm, sticky and plastic; moderately alkaline; diffuse smooth boundary.

C3g—45 to 60 inches; gray (5Y 6/1) clay, very dark gray (N 3/0) moist; massive; extremely hard, firm, sticky and plastic; moderately alkaline.

These soils are saturated with water year round. The value is more than 1. Sulfidic material is below a epth of 20 inches. The content of organic matter decreases irregularly with increasing depth. The profile is strongly alkaline or moderately alkaline throughout nd is noncalcareous.

The Ag horizon has color of 5Y 5/1, 5/2, or 6/2 or of 2.5Y 5/2 or 6/2. Moist color is 5Y 4/1 or 4/2, N 3/0, or 2.5Y 3/2 or 4/2. The horizon has common medium istinct or faint mottles that have color of 10YR 3/4.

The Cg horizon has color of 10YR 4/1, of 5Y 4/2, 5/1, 6/1, or 6/2, or of N 5/0 or 6/0. Moist color is 5Y 4/1 or 6/2, 2.5Y 4/1 or 4/2, N 2/0 or 3/0, or 5BG 4/1. Common medium distinct jarosite mottles that have color of 5Y 8/4 are in most pedons. Texture is silty clay, clay, or ilty clay loam.

Obispo Series

The Obispo series consists of shallow, well drained soils on gently rolling to hilly uplands. These soils formed in material weathered from hard, serpentinitic rock. Slope ranges from 5 to 30 percent.

Soils of the Obispo series are clayey, serpentinitic, thermic Lithic Haploxerolls.

Typical pedon of Obispo clay, 5 to 15 percent slopes; 3,200 feet south on Skyline Boulevard from its intersection with Hayne Road and 10 feet west of Skyline Boulevard (not sectionalized); San Mateo 7.5' Quadrangle:

A1—0 to 4 inches; dark gray (10YR 4/1) clay, very dark gray (10YR 3/1) moist; strong fine granular structure and strong coarse subangular blocky structure; extremely hard, firm, sticky and plastic; many very fine roots; few very fine and fine tubular and interstitial pores; moderately alkaline; clear irregular boundary.

A2—4 to 12 inches; very dark gray (10YR 3/1) clay, very dark brown (10YR 2/2) moist; strong coarse and very coarse subangular blocky structure; extremely hard, firm, sticky and plastic; common very fine roots; few very fine and fine tubular and interstitial pores; moderately alkaline; abrupt irregular boundary.

R—12 inches; hard, serpentinitic rock.

Unweathered serpentine is at a depth of 10 to 20 inches. The profile averages 0 to 10 percent gravel. Unless the soils are irrigated, cracks 0.5 inch to 3.0 inches wide extend to bedrock and remain open in summer until it rains.

The A1 horizon has color of 10YR 3/1 or 4/1. Moist color is 10YR 2/1, 2/2, or 3/1.

The A2 horizon has color of 10YR 3/1 or 4/1. Moist color is 10YR 2/2 or 3/1. Texture is clay or clay loam.

Orthents

Orthents are very shallow to very deep, very poorly drained to excessively drained soils on uplands, including hills and ridgetops; alluvial fans; coastal terraces; flood plains; and tidal flats. These soils formed in alluvium derived from various kinds of rock; sandy coastal deposits; hard and soft sandstone, shale, siltstone, serpentine, and volcanic rock; and various manmade fill material. Slope is 0 to 75 percent.

Reference pedon of Orthents, cut and fill, 15 to 75 percent slopes, at Oceana High School in Pacifica; 750 feet east and 4,200 feet north of the intersection of Highway 1 and Sharp Park Road (not sectionalized); San Francisco South 7.5' Quadrangle:

A—0 to 4 inches; dark yellowish brown (10YR 4/4)

gravelly loam, dark brown (10YR 3/3) moist; strong fine, medium, and coarse subangular blocky structure; hard, firm, sticky and plastic; many very fine roots; slightly acid; clear irregular boundary.

Cr—4 inches; light olive brown (2.5Y 5/4), soft, fractured, slightly metamorphosed sandstone, olive brown (2.5Y 4/4) moist.

These soils are extremely variable. They consist of areas of undisturbed loamy material on coastal terraces; areas that have been mechanically altered for residential and other urban uses and have cuts that have slopes of 3:1 to 1.5:1 and fills that are 0 to 75 feet deep or more; smoothed areas on alluvial fans and plains; reclaimed areas near San Francisco Bay; and areas on the margins of the bay that consist of earthy material, rock fragments, plant matter, and manmade debris.

Reyes Series

The Reyes series consists of very deep, somewhat poorly drained soils that formed in alluvium derived from various kinds of rock. These soils are on reclaimed tidelands along the margins of San Francisco Bay. Slope is 0 to 1 percent.

Soils of the Reyes series are fine, mixed, acid, thermic Sulfic Fluvaquents.

Typical pedon of Reyes clay, 0 to 1 percent slopes; 670 feet north of gate on dirt road at the eastern end of Whipple Avenue, in Redwood City, and 110 feet west of dirt road (not sectionalized); Redwood Point 7.5' Quadrangle:

Ap—0 to 9 inches; gray (10YR 6/1) clay, very dark grayish brown (10YR 3/2) moist; common fine distinct strong brown (7.5YR 5/6, moist) mottles; moderate fine, medium, and coarse subangular blocky structure; extremely hard, friable, slightly sticky and slightly plastic; common very fine roots; many very fine tubular and interstitial pores; strongly acid; clear irregular boundary.

A—9 to 22 inches; gray (5YR 5/1) clay, dark gray (10YR 4/1) moist; many fine distinct dark yellowish brown (10YR 4/6) mottles, yellow (10YR 7/6) moist; moderate fine, medium, and coarse subangular blocky structure; extremely hard, firm, sticky and plastic; common very fine roots; common very fine and fine tubular pores and few medium and coarse interstitial pores; very strongly acid; clear smooth boundary.

Cg—22 to 30 inches; gray (5Y 6/1) clay, dark gray (5Y 4/1) moist; common fine distinct pale yellow (5Y 8/3) jarosite mottles, very pale brown (10YR 7/4) moist; massive; extremely hard, firm, sticky and plastic; few very fine tubular pores and common medium and coarse interstitial pores; very strongly acid; clear smooth boundary.

C2g—30 to 60 inches; gray (5Y 6/1) clay, dark greenish gray (5GY 4/1) moist; few jarosite mottles; massive; extremely hard, firm, sticky and plastic; moderately alkaline.

The content of organic matter in the profile decreases irregularly with increasing depth. These soils are artificially drained. The N value ranges from 0.3 to 0.7. Jarosite mottles are at a depth of 20 to 40 inches.

The A horizon has color of 10YR 5/1, 5/2, 6/1, or 6/2 or of 2.5Y 5/2 or 6/2. Moist color is 10YR 3/2, 3/3, 4/1, or 4/2 or 2.5Y 3/2 or 4/2. The horizon has few to many fine or medium distinct mottles that have color of 5YR 4/3, 4/4, or 4/6, of 7.5YR 4/6 or 5/6, or of 10YR 4/6. Reaction is strongly acid or very strongly acid.

The B horizon has color of 10YR or 5Y 5/1, 5/2, 6/1, or 6/2 or of N 5/0 or 6/0. Moist color is 10YR or 5Y 4/1 or 5/1 or N 4/0 or 5/0. The horizon has distinct or prominent mottles that have hue of 5Y, 2.5Y, 10YR, 7.5YR, or 5YR. Moist value of the mottles commonly is 4, but it is 5 in areas where hue is 5Y or 2.5Y. The lower part of the B horizon has many or common jarosite mottles that have color of 2.5Y 7/6, 8/6, or 8/8 or of 5Y 7/6, 7/8, 8/3, 8/6, or 8/8.

The C horizon has color of 5Y 6/1 or 6/2. Moist color is 5Y 4/1 or 5/1, N 4/0 or 5/0, or 5GY 4/1. The horizon has few or common fine or medium distinct or prominent jarosite mottles. Reaction is very strongly acid to medium acid in drained areas and is moderately alkaline in saturated areas. Texture is clay or silty clay.

Scarper Series

The Scarper series consists of moderately deep, well drained soils on uplands. These soils formed in material weathered from quartz-diorite. Slope ranges from 30 to 75 percent.

Soils of the Scarper series are coarse-loamy, mixed, isomesic Typic Haplustolls.

Typical pedon of Scarper gravelly coarse sandy loam, in an area of Scarper-Miramar complex, 30 to 75 percent slopes; 7,700 feet east and 1,500 feet north of Point Montara Lighthouse (not sectionalized); Montara Mountain 7.5' Quadrangle:

A1—0 to 5 inches; dark grayish brown (10YR 4/2)

Tech Guide Notice #12 4/17/92

HALF MOON BAY, CA Field Office
March, 1992
SECTION II
FIELD OFFICE TECHNICAL GUIDE

HYDRIC SOIL LISTS

USDA - Soil Conservation Service
Davis, California (March 1992)

INTRODUCTION

Hydric soils are developed under sufficiently wet conditions to support growth and regeneration of hydrophytic vegetation. More specifically, hydric soils are ones that meet the definition and criteria developed by the National Technical Committee for Hydric Soils (NTCHS). The criteria are selected soil properties that are documented in Soil Taxonomy (Soil Survey Staff, 1975, 1990) and Soil Interpretations Records (Soil Survey Staff, 1983). The NTCHS is chaired by Soil Conservation Service (SCS). Members include representatives from the U.S. Army Corps of Engineers, U. S. Fish and Wildlife Service, Environmental Protection Agency, Agricultural Experiment Stations, U. S. Forest Service and the Bureau of Land Management.

KINDS OF LISTS OF HYDRIC SOILS

The SCS maintains three kinds of lists of hydric soils.

1. National List of Hydric Soils. This is a listing of soil series mapped in the United States that meet hydric soil criteria. This list includes soil series that may or may not have been drained. Some series, designated as hydric have phases that are not hydric depending on water table, flooding and ponding characteristics. Refer to Soil Survey Area List of Hydric Soil Map Units for specific information. The NTCHS is responsible for reviewing and approving changes to this list. It is contained in the publication "Hydric Soils of the United States, 1985". A second edition was published in December 1987 and a third edition in June 1991. This general list is maintained in a computer file and is updated annually. The most current national list from the computer file may be obtained for the cost of printing from the SCS Project Manager, Statistical Laboratory, Iowa State University, 217 Snedecor Hall, Ames, IA 50011.

2. State List of Hydric Soils. This is a subset of the National List of Hydric Soils for specific states. The California list may be obtained from the SCS State Soil Scientist, 2121-C 2nd Street, Davis, CA 95616.

3. Soil Survey Area List of Hydric Soil Map Units. SCS maintains a local list of hydric soil map units for each soil survey area in the Field Office Technical Guide. Each soil survey area encompasses all or a portion of a county. These are the most specific of the three kinds of lists. They identify the soil map units that contain or may in some delineations contain hydric soils. These lists have the advantage, when used with the local soil survey report map sheets, of indicating the geographic distribution of hydric soils within a given area. A conventional and Special Symbols Legend is attached to the list. These symbols may appear on the soil survey maps. Hydric soils may occur in areas designated by the Water Features symbols.

COLUMNS ON THE SOIL SURVEY AREA LIST OF HYDRIC SOIL MAP UNITS

Map Symbol: A soil map unit symbol is listed for every map unit in the soil survey area. The symbols on the list correspond to the symbols presented in the soil survey report and map sheets.

Map Unit Name: A soil map unit name is listed for every map unit in the soil survey area. The individual components of the soil map unit are listed directly below the map unit name, preceeded by either a "(C)" or "(I)". The "(C)" signifies a major component, which is therefore a part of the map unit name. The "(I)" signifies a component of minor extent – an inclusion – which is not a part of the map unit name.

Hyd?: For each component or inclusion listed, "Y" indicates, yes, the soil is hydric and "N", no, indicates the soil is not hydric.

Hydric Criteria: Codes indicating the NTCHS criteria that are met are listed. (See page 3)

Hydric Landforms: The probable landscape position within the soil map unit delineation is given for each listed hydric soil.

FSA Items: Information required for FSA implementation purposes as per National Food Security Act Manual, Section 512.12, is listed. The entries 1 through 5 signify the following: (1) hydric only because of saturation, (2) support woody vegetation under natural conditions, (3) contain potholes or playas, (4) are seasonally flooded or ponded, and (5) can be farmed under natural conditions without removing woody vegetation or other manipulation.

Footnotes: A number indicates that a footnote pertinent to the listed hydric soil is given on the last page of the hydric soil list. Some footnotes identify soils that have altered conditions, and soil characteristics indicate that hydric soil conditions existed prior to alteration of drainage or flooding. Other footnotes indicate that soil properties range across the hydric soil criteria. On-site investigation may be required.

NOTES ON USES AND LIMITATIONS OF THE LISTS

The lists have a number of agricultural and nonagricultural applications. These include assistance in land-use planning, conservation planning, and assessment of potential wildlife habitat. A combination of hydric soil, hydrophytic vegetation, and hydrology criteria defines wetlands as described in the Federal Manual for Identifying and Delineating Jurisdictional Wetlands (Federal Interagency Committee for Wetland Delineation, 1989). Therefore an area that meets hydric soil criteria must also meet hydrophytic vegetation and wetland hydrology criteria in order for it to be classified as a jurisdictional wetland.

The Soil Survey Area Lists of Hydric Soil Map Units identify hydric soil components and hydric soil inclusions. Inclusions are soil components of minor extent and may need to be located by on-site investigation.

DEFINITION OF HYDRIC SOIL (NTCHS, June, 1991)

A hydric soil is a soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part. The following criteria reflect those soils that meet this definition.

CRITERIA FOR HYDRIC SOILS (NTCHS, June, 1991)

1. All Histosols except Folists, or

2. Soils in Aquic suborder, Aquic subgroups, Albolls suborder, Salorthids great group, Pell great groups of Vertisols, Pachic subgroups, or Cumulic subgroups that are:

a. somewhat poorly drained and have a frequently occurring water table at less than 0.5 (ft) feet from the surface for a significant period (usually more than 2 weeks) during the growing season, or

b. poorly drained or very poorly drained and have either:

(1) a frequently occurring water table at less than 0.5 feet from the surface for a significant period (usually more than 2 weeks) during the growing season if textures are coarse sand, sand, or fine sand in all layers within 20 inches (in), or for other soils

(2) a frequently occurring water table at less than 1.0 foot from the surface for a significant period (usually more than 2 weeks) during the growing season if permeability is equal to or greater than 6.0 in/hr in all layers within 20 inches, or

(3) a frequently occurring water table at less than 1.5 feet from the surface for a significant period (usually more than 2 weeks) during the growing season if permeability is less than 6.0 in/hr in any layer within 20 inches, or

3. Soils that are frequently ponded for long duration or very long duration during the growing season, or

4. Soils that are frequently flooded for long duration or very long duration during the growing season.

FIELD OFFICE OFFICIAL LIST OF HYDRIC SOIL MAP UNITS
FOR
SAN MATEO COUNTY, EASTERN PART, AND SAN FRANCISCO COUNTY, CALIFORNIA

Map Units are listed in alpha-numeric order by map unit symbol. The 'HYDRIC CRITERIA' column refers to criteria defined in 'Hydric Soils of the United States' (USDA Miscellaneous Publication No. 1491 June, 1991.) The 'FSA ITEMS' column contains information needed for Food Security Act determinations required by Section 512.11(h)(4) of the National Food Security Act Manual (August 1991).

March 25, 1992

Soil Survey Area No.: CA689
Soil Survey Name: SAN MATEO COUNTY, EASTERN PART, AND SAN FRANCISCO COUNTY, CALIFORNIA

Map Symbol	Map Unit Name (C) Component (I) Inclusion	Hyd?	Hydric Criteria	Hydric Landforms	FSA Items	Footnotes
101	ACCELERATOR-FAGAN ASSOCIATION, 5 TO 15 PERCENT SLOPES					
	(C) ACCELERATOR	N				
	(C) FAGAN	N				
102	ACCELERATOR-FAGAN-URBAN LAND COMPLEX, 5 TO 15 PERCENT SLOPES					
	(C) ACCELERATOR	N				
	(C) FAGAN	N				
	(C) URBAN LAND	N				
103	ALAMBIGUE SANDY LOAM, 15 TO 75 PERCENT SLOPES					
	(C) ALAMBIGUE	N				
104	ALAMBIGUE-MCGARVEY COMPLEX, 30 TO 75 PERCENT SLOPES					
	(C) ALAMBIGUE	N				
	(C) MCGARVEY	N				
105	BARNABE-CANDLESTICK COMPLEX, 30 TO 75 PERCENT SLOPES					
	(C) BARNABE	N				
	(C) CANDLESTICK	N				
106	BARNABE-ROCK OUTROCK COMPLEX, 15 TO 75 PERCENT SLOPES					
	(C) BARNABE	N				
	(C) ROCK OUTROCK	N				

March 25, 1992

Soil Survey Area No.: CA689
Soil Survey Name: SAN MATEO COUNTY, EASTERN PART, AND SAN FRANCISCO COUNTY, CALIFORNIA

Map Symbol	Map Unit Name (C) Component (I) Inclusion	Hyd?	Hydric Criteria	Hydric Landforms	FSA Items	Footnotes
107	BOTELLA LOAM, 0 TO 5 PERCENT SLOPES					
	(C) BOTELLA	N				
108	BOTELLA-URBAN LAND COMPLEX, 0 TO 5 PERCENT SLOPES					
	(C) BOTELLA	N				
	(C) URBAN LAND	N				
109	CANDLESTICK-BARNABE COMPLEX, 30 TO 50 PERCENT SLOPES					
	(C) BARNABE	N				
	(C) CANDLESTICK	N				
110	CANDLESTICK-KRON-BUR IBURI COMPLEX, 30 TO 75 PERCENT SLO PES					
	(C) BURIBURI	N				
	(C) CANDLESTICK	N				
	(C) KRON	N				
111	CANDLESTICK VARIANT LOAM, 2 TO 15 PERCENT SLOPES					
	(C) CANDLESTICK VARIANT	N				
112	CANDLESTICK VARIANT LOAM, 15 TO 30 PERCENT SLOPES					
	(C) CANDLESTICK VARIANT	N				
113	FAGAN LOAM, 15 TO 50 PERCENT SLOPES					
	(C) FAGAN	N				
114	FRANCISQUITO-URBAN LAND COMPLEX, 5 TO 15 PERCENT SLOPES					
	(C) FRANCISQUITO	N				
	(C) URBAN LAND	N				

March 25, 1992

Soil Survey Area No.: CA689
Soil Survey Name: SAN MATEO COUNTY, EASTERN PART, AND SAN FRANCISCO COUNTY, CALIFORNIA

Map Symbol	Map Unit Name (C) Component (I) Inclusion	Hyd?	Hydric Criteria	Hydric Landforms	FSA Items	Footnotes
115	LOS GATOS LOAM, 30 TO 75 PERCENT SLOPES					
	(C) LOS GATOS	N				
116	MAYMEN GRAVELLY LOAM, 30 TO 50 PERCENT SLOPES					
	(C) MAYMEN	N				
117	NOVATO CLAY, 0 TO 1 PERCENT SLOPES					
	(C) NOVATO	Y	2B3,3	Salt Marsh	4	
118	NOVATO CLAY, 0 TO 1 PERCENT SLOPES PONDED					
	(C) NOVATO	Y	2B3,3	Salt Marsh	4	
119	OBISPO CLAY, 5 TO 15 PERCENT SLOPES					
	(C) OBISPO	N				
120	OBISPO CLAY, 15 TO 30 PERCENT SLOPES					
	(C) OBISPO	N				
121	ORTHENTS, CUT AND FILL, 0 TO 15 PERCENT SLOPES					
	(C) ORTHENTS	N				
122	ORTHENTS, CUT AND FILL, 15 TO 75 PERCENT SLOPES					
	(C) ORTHENTS	N				
123	ORTHENTS, CUT AND FILL-URBAN LAND COMPLEX, 0 TO 5					
	(C) ORTHENTS	N				
	(C) URBAN LAND	N				

March 25, 1992

Soil Survey Area No.: CA689
Soil Survey Name: SAN MATEO COUNTY, EASTERN PART, AND SAN FRANCISCO COUNTY, CALIFORNIA

Map Symbol	Map Unit Name (C) Component (I) Inclusion	Hyd?	Hydric Criteria	Hydric Landforms	FSA Items	Footnotes
124	ORTHENTS, CUT AND FILL-URBAN LAND COMPLEX, 5 TO 75 PERCENT SLOPES					
	(C) ORTHENTS	N				
	(C) URBAN LAND	N				
125	PITS AND DUMPS					
	(C) DUMPS	N				
	(C) PITS	N				
126	REYES CLAY, 0 TO 1 PERCENT SLOPES					
	(C) REYES	Y	2B3	Tidal Marsh	1	1
	(I) UNNAMED	Y	3	Tidal Marsh	4	
127	ROCK OUTCROP-ORTHENTS COMPLEX, 30 TO 75 PERCENT SLOPES					
	(C) ORTHENTS	N				
	(C) ROCK OUTCROP	N				
128	SCARPER-MIRAMAR COMPLEX, 30 TO 75 PERCENT SLOPES					
	(C) MIRAMAR	N				
	(C) SCARPER	N				
129	SIRDRAK SAND, 5 TO 50 PERCENT SLOPES					
	(C) SIRDRAK	N				
	(I) TIDAL FLATS	Y	2A,3,4	Tidal Flat	4	
	(I) BEACHES	Y	2A,3,4	Beach	4	
130	TYPIC ARGIUSTOLLS, LOAMY-URBAN LAND ASSOCIATION, 5 TO 1 5 PERCENT SLOPES					
	(C) TYPIC ARGIUSTOLLS	N				
	(C) URBAN LAND	N				

March 25, 1992

Soil Survey Area No.: CA689
Soil Survey Name: SAN MATEO COUNTY, EASTERN PART, AND SAN FRANCISCO COUNTY, CALIFORNIA

Map Symbol	Map Unit Name (C) Component (I) Inclusion	Hyd?	Hydric Criteria	Hydric Landforms	FSA Items	Footnotes
131	URBAN LAND					
	(C) URBAN LAND	N				
132	URBAN LAND-ORTHENTS, CUT LAND FILL COMPLEX, 0 TO 5 PERCENT SLOPES					
	(C) ORTHENTS	N				
	(C) URBAN LAND	N				
133	URBAN LAND-ORTHENTS, CUT AND FILL COMPLEX, 5 TO 75 PERCENT SLOPES					
	(C) ORTHENTS	N				
	(C) URBAN LAND	N				
134	URBAN LAND-ORTHENTS, RECLAIMED COMPLEX, 0 TO 2 PERCENT SLOPES					
	(C) ORTENTS	N				
	(C) URBAN LAND	N				
	(I) NOVATO	Y	2B3,3	Salt Marsh	4	
135	URBAN LAND-ORTHENTS, SMOOTHED COMPLEX, 5 TO 50 PERCENT SLOPES					
	(C) ORTHENTS	N				
	(C) URBAN LAND	N				
136	URBAN LAND-SIRDRAK COMPLEX, 2 TO 50 PERCENT SLOPES					
	(C) SIRDRAK	N				
	(C) URBAN LAND	N				
137	ZENI-ZENI VARIANT GRAVELLY LOAMS, 30 TO 75 PERCENT SLOPES					
	(C) TAMALPAIS	N				
	(C) ZENI	N				

March 25, 1992

Soil Survey Area No.: CA689
Soil Survey Name: SAN MATEO COUNTY, EASTERN PART, AND SAN FRANCISCO COUNTY, CALIFORNIA

Map Symbol	Map Unit Name (C) Component (I) Inclusion	Hyd?	Hydric Criteria	Hydric Landforms	FSA Items	Footnotes
W	WATER					
	(C) WATER	Y				

Footnotes:

1. Hydrology has been altered in some or all areas of this map unit through drainage and/or protection from flooding. Soil characteristics indicate that hydric soil conditions existed prior to alteration of drainage.

Appendix B.
USACE Data Forms

SOILS

Sample Number
1A

Map Unit Name
(Series and Phase) Fill material on top of Reyes Clay, 0-1% slopes

Taxonomy (Subgroup):Sulfic Fluvaquent

Drainage Class:
Field Observations:
Confirm Mapped Type? Yes (No)

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-12	A	10 YR 3/2	7.5 YR 4/6	few/distinct	clay loam
12-	A	5 YR 5/1	10 YR 4/6	few/distinct	clay

Hydric Soil Indicators:

	Histosol		Concretions
	Histic Epipedon		High Organic Content in Surface Layer in Sandy Soils
	Suffidic Odor		Organic Streaking in Sandy Soils
x	Aquic Moisture Regime		Listed on Local Hydric Soils List
	Reducing Conditions		Listed on National Hydric Soils List
x	Gleyed or Low-Chroma colors		Other (Explain in Remarks

Remarks:
Upper soil layer highly disturbed by fill and likely past disking.

WETLAND DETERMINATION

	(Circle)
Hydrophytic Vegetation Present?	(Yes) No
Wetland Hydrology Present?	(Yes) No
Hydric Soils Present?	(Yes) No

(Circle)

Is this Sampling Point Within a Wetland? (Yes) No

Remarks:
Sample point occurs in pickleweed dominated topographic depression (remnant slough channel).

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Sample Number
1A

Project/Site: Bair Island
Applicant/Owner: San Francisco Bay Wildlife Society
Investigator: J. Bourgeois, P. Boursier

Date: April 27, 2000
County: San Mateo
State: California

Do Normal Circumstances exist on the site? Yes (No)

Is the site significantly disturbed (Atypical Situations?) Yes (No)

Is the area a potential Problem Area? Yes (No)

(If needed, explain on reverse.)

Community ID: Diked Saltmarsh

Transect ID : 1

Plot ID: A

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. *Salicornia virginica*	H	OBL	9.		
2. *Polypogon monspeliensis*	H	FACW+	10.		
3.			11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 100%

Remarks:

HYDROLOGY

Recorded Data (describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other
x No Recorded Data Available

Field Observation:

Depth of Surface Water: --- (in.)

Depth to Free Water in Pit: 12 (in.)

Depth to Saturated Soil 8 (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
x Saturated
_____ Water Marks
X Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

x Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
X FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks:

SOILS

Sample Number
1B

Map Unit Name
(Series and Phase) Fill material on top of Reyes Clay, 0-1% slopes

Drainage Class:
Field Observations:

Taxonomy (Subgroup): Sulfic Fluvaquent

Confirm Mapped Type? Yes (No)

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-24	A	10 YR 3/3	---	none	clay loam
24-	A	5 YR 5/2	10 YR 4/6	few/distinct	clay

Hydric Soil Indicators:

	Histosol		Concretions
	Histic Epipedon		High Organic Content in Surface Layer in Sandy Soils
	Suffidic Odor		Organic Streaking in Sandy Soils
	Aquic Moisture Regime		Listed on Local Hydric Soils List
	Reducing Conditions		Listed on National Hydric Soils List
x	Gleyed or Low-Chroma colors		Other (Explain in Remarks

Remarks:
Deep layer of fill on surface; evidence of disturbance/disking.

WETLAND DETERMINATION

	(Circle)	
Hydrophytic Vegetation Present?	Yes (No)	(Circle)
Wetland Hydrology Present?	Yes (No)	
Hydric Soils Present?	(Yes) No	Is this Sampling Point Within a Wetland? Yes (No)

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Sample Number
1C

Project/Site: Bair Island
Applicant/Owner: San Francisco Bay Wildlife Society
Investigator: J. Bourgeois, P. Boursier

Date: April 27, 2000
County: San Mateo
State: California

Do Normal Circumstances exist on the site? Yes (No)

Is the site significantly disturbed (Atypical Situations?) Yes (No)

Is the area a potential Problem Area? Yes (No)

(If needed, explain on reverse.)

Community ID: Seasonal Wetland

Transect ID : 1

Plot ID: C

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. *Polypogon monspeliensis*	H	FACW+	9.		
2. *Frankenia salina*	H	FACW+	10.		
3.			11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 100%

Remarks:

HYDROLOGY

Recorded Data (describe in Remarks):

- ____ Stream, Lake, or Tide Gauge
- ____ Aerial Photographs
- ____ Other
- x No Recorded Data Available

Field Observation:

- Depth of Surface Water: --- (in.)
- Depth to Free Water in Pit: 18 (in.)
- Depth to Saturated Soil 10 (in.)

Wetland Hydrology Indicators:

Primary Indicators:

- ____ Inundated
- x Saturated
- ____ Water Marks
- ____ Drift Lines
- ____ Sediment Deposits
- ____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

- x Oxidized Root Channels in Upper 12 in.
- ____ Water-Stained Leaves
- ____ Local Soil Survey Data
- X FAC-Neutral Test
- ____ Other (Explain in Remarks)

Remarks:

SOILS

Sample Number
1C

Map Unit Name
(Series and Phase) Fill material on top of Reyes Clay, 0-1% slopes

Taxonomy (Subgroup): Sulfic Fluvaquent

Drainage Class:
Field Observations:
Confirm Mapped Type? Yes (No)

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-12	A	10 YR 3/2	---	none	clay loam
12-	A	5 YR 5/1	10 YR 4/6	few/distinct	clay

Hydric Soil Indicators:

	Histosol		Concretions
	Histic Epipedon		High Organic Content in Surface Layer in Sandy Soils
	Suffidic Odor		Organic Streaking in Sandy Soils
	Aquic Moisture Regime		Listed on Local Hydric Soils List
	Reducing Conditions		Listed on National Hydric Soils List
X	Gleyed or Low-Chroma colors		Other (Explain in Remarks

Remarks:
Evidence of disturbance/disking in upper fill layer.

WETLAND DETERMINATION

	(Circle)	
Hydrophytic Vegetation Present?	(Yes) No	
Wetland Hydrology Present?	(Yes) No	(Circle)
Hydric Soils Present?	(Yes) No	Is this Sampling Point Within a Wetland? (Yes) No

Remarks:
Low point in fill material surface; depressional wetland, close to clay soil layer; seasonally flooded.

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Sample Number
1B

Project/Site: Bair Island
Applicant/Owner: San Francisco Bay Wildlife Society
Investigator: J. Bourgeois, P. Boursier

Date: April 27, 2000
County: San Mateo
State: California

Do Normal Circumstances exist on the site? Yes (No)

Is the site significantly disturbed (Atypical Situations?) Yes (No)

Is the area a potential Problem Area? Yes (No)

(If needed, explain on reverse.)

Community ID: Ruderal Upland

Transect ID : 1

Plot ID: B

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. *Lolium multiflorum*	H	FAC	9.		
2. *Raphanus sativus*	H	UPL	10.		
3.			11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 50%

Remarks:

HYDROLOGY

Recorded Data (describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other
x No Recorded Data Available

Field Observation:

Depth of Surface Water: --- (in.)

Depth to Free Water in Pit: >16 (in.)

Depth to Saturated Soil >16 (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
_____ Saturated
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks: No hydrologic indicators observed.

SOILS

Sample Number
1C

Map Unit Name
(Series and Phase) Fill material on top of Reyes Clay, 0-1% slopes

Taxonomy (Subgroup): Sulfic Fluvaquent

Drainage Class:
Field Observations:
Confirm Mapped Type? Yes (No)

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-12	A	10 YR 3/2	---	none	clay loam
12-	A	5 YR 5/1	10 YR 4/6	few/distinct	clay

Hydric Soil Indicators:

	Histosol		Concretions
	Histic Epipedon		High Organic Content in Surface Layer in Sandy Soils
	Suffidic Odor		Organic Streaking in Sandy Soils
	Aquic Moisture Regime		Listed on Local Hydric Soils List
	Reducing Conditions		Listed on National Hydric Soils List
X	Gleyed or Low-Chroma colors		Other (Explain in Remarks

Remarks:
Evidence of disturbance/disking in upper fill layer.

WETLAND DETERMINATION

	(Circle)		(Circle)
Hydrophytic Vegetation Present?	(Yes) No		
Wetland Hydrology Present?	(Yes) No		
Hydric Soils Present?	(Yes) No	Is this Sampling Point Within a Wetland?	(Yes) No

Remarks:
Low point in fill material surface; depressional wetland, close to clay soil layer; seasonally flooded

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Sample Number
2A

Project/Site: Bair Island
Applicant/Owner: San Francisco Bay Wildlife Society
Investigator: J. Bourgeois, P. Boursier

Date: April 27, 2000
County: San Mateo
State: California

Do Normal Circumstances exist on the site? Yes (No)

Is the site significantly disturbed (Atypical Situations?) Yes (No)

Is the area a potential Problem Area? Yes (No)

(If needed, explain on reverse.)

Community ID: Seasonal Wetland

Transect ID : 2

Plot ID: A

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. *Polypogon monspeliensis*	H	FACW+	9.		
2. *Frankenia salina*	H	FACW+	10.		
3. *Salicornia virginica*	H	OBL	11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 100%

Remarks:

HYDROLOGY

Recorded Data (describe in Remarks):

___ Stream, Lake, or Tide Gauge
___ Aerial Photographs
___ Other
X No Recorded Data Available

Field Observation:

Depth of Surface Water: --- (in.)

Depth to Free Water in Pit: 16 (in.)

Depth to Saturated Soil 10 (in.)

Wetland Hydrology Indicators:

Primary Indicators:

___ Inundated
___ Saturated
___ Water Marks
___ Drift Lines
___ Sediment Deposits
___ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

X Oxidized Root Channels in Upper 12 in.
___ Water-Stained Leaves
___ Local Soil Survey Data
x FAC-Neutral Test
___ Other (Explain in Remarks)

Remarks:

SOILS

Sample Number
2A

Map Unit Name
(Series and Phase) Fill material on top of Reyes Clay, 0-1% slopes

Drainage Class:
Field Observations:
Confirm Mapped Type? Yes (No)

Taxonomy (Subgroup): Sulfic Fluvaquent

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-12	A	10 YR 3/2	10 YR 4/6	many/distinct	clay loam
12-	A	5 YR 5/1	10 YR 4/6	few/distinct	clay

Hydric Soil Indicators:

	Histosol		Concretions
	Histic Epipedon		High Organic Content in Surface Layer in Sandy Soils
	Suffidic Odor		Organic Streaking in Sandy Soils
	Aquic Moisture Regime		Listed on Local Hydric Soils List
	Reducing Conditions		Listed on National Hydric Soils List
x	Gleyed or Low-Chroma colors		Other (Explain in Remarks

Remarks:

WETLAND DETERMINATION

(Circle)

Hydrophytic Vegetation Present? (Yes) No
Wetland Hydrology Present? (Yes) No
Hydric Soils Present? (Yes) No

(Circle)

Is this Sampling Point Within a Wetland? (Yes) No

Remarks:
Low point in fill material surface; depressional wetland, close to clay soil layer; seasonally flooded.

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Sample Number
2B

Project/Site: Bair Island
Applicant/Owner: San Francisco Bay Wildlife Society
Investigator: J. Bourgeois

Date: April 27, 2000
County: San Mateo
State: California

Do Normal Circumstances exist on the site? Yes (No)

Is the site significantly disturbed (Atypical Situations?) Yes (No)

Is the area a potential Problem Area? Yes (No)

(If needed, explain on reverse.)

Community ID: Tidal Saltmarsh

Transect ID : 2

Plot ID: B

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. *Salicornia virginica*	H	OBL	9.		
2.			10.		
3.			11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 100%

Remarks:

HYDROLOGY

Recorded Data (describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other
x No Recorded Data Available

Field Observation:

Depth of Surface Water: --- (in.)

Depth to Free Water in Pit: 6 (in.)

Depth to Saturated Soil 0 (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
X Saturated
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks: Flooded in higher high tides.

SOILS

Sample Number
2B

Map Unit Name
(Series and Phase) Reyes Clay, 0-1% slopes

Taxonomy (Subgroup): Sulfic Fluvaquent

Drainage Class:
Field Observations:
Confirm Mapped Type? Yes (No)

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-8	A1	10 YR 3/2	---	none	clay loam
8-	A2	5 YR 5/1	---	none	clay

Hydric Soil Indicators:

	Histosol		Concretions
	Histic Epipedon		High Organic Content in Surface Layer in Sandy Soils
	Suffidic Odor		Organic Streaking in Sandy Soils
x	Aquic Moisture Regime		Listed on Local Hydric Soils List
	Reducing Conditions		Listed on National Hydric Soils List
x	Gleyed or Low-Chroma colors		Other (Explain in Remarks

Remarks:

WETLAND DETERMINATION

	(Circle)	
Hydrophytic Vegetation Present?	(Yes) No	(Circle)
Wetland Hydrology Present?	(Yes) No	
Hydric Soils Present?	(Yes) No	Is this Sampling Point Within a Wetland? (Yes) No

Remarks:
Tidal saltmarsh.

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Sample Number
3A

Project/Site: Bair Island
Applicant/Owner: San Francisco Bay Wildlife Society
Investigator: J. Bourgeois

Date: April 27, 2000
County: San Mateo
State: California

Do Normal Circumstances exist on the site? Yes (No)

Is the site significantly disturbed (Atypical Situations?) Yes (No)

Is the area a potential Problem Area? Yes (No)

(If needed, explain on reverse.)

Community ID: Diked Saltmarsh

Transect ID : 3

Plot ID: A

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. *Salicornia virginica*	H	OBL	9.		
2.			10.		
3.			11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 100%

Remarks:

HYDROLOGY

Recorded Data (describe in Remarks):

_____ Stream, Lake, or Tide Gauge
_____ Aerial Photographs
_____ Other
x No Recorded Data Available

Field Observation:

Depth of Surface Water: --- (in.)

Depth to Free Water in Pit: 6 (in.)

Depth to Saturated Soil 0 (in.)

Wetland Hydrology Indicators:

Primary Indicators:

_____ Inundated
x Saturated
_____ Water Marks
_____ Drift Lines
_____ Sediment Deposits
_____ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

_____ Oxidized Root Channels in Upper 12 in.
_____ Water-Stained Leaves
_____ Local Soil Survey Data
_____ FAC-Neutral Test
_____ Other (Explain in Remarks)

Remarks:

SOILS

Sample Number
3A

Map Unit Name
(Series and Phase) Reyes Clay, 0-1% slopes

Taxonomy (Subgroup): Sulfic Fluvaquent

Drainage Class:
Field Observations:
Confirm Mapped Type? Yes (No)

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-8	A1	10 YR 3/2	---	none	clay loam
8-	A2	5 YR 5/1	---	none	clay

Hydric Soil Indicators:

	Histosol		Concretions
	Histic Epipedon		High Organic Content in Surface Layer in Sandy Soils
	Suffidic Odor		Organic Streaking in Sandy Soils
x	Aquic Moisture Regime		Listed on Local Hydric Soils List
	Reducing Conditions		Listed on National Hydric Soils List
x	Gleyed or Low-Chroma colors		Other (Explain in Remarks

Remarks:

WETLAND DETERMINATION

	(Circle)	
Hydrophytic Vegetation Present?	(Yes) No	(Circle)
Wetland Hydrology Present?	(Yes) No	
Hydric Soils Present?	(Yes) No	Is this Sampling Point Within a Wetland? (Yes) No

Remarks:
Diked saltmash, degraded; dominated by pickleweed of low to moderate health.

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Sample Number
3B

Project/Site: Bair Island
Applicant/Owner: San Francisco Bay Wildlife Society
Investigator: J. Bourgeois

Date: April 27, 2000
County: San Mateo
State: California

Do Normal Circumstances exist on the site? Yes (No)

Is the site significantly disturbed (Atypical Situations?) Yes (No)

Is the area a potential Problem Area? Yes (No)

(If needed, explain on reverse.)

Community ID: Ruderal Upland

Transect ID : 3

Plot ID: B

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. *Lolium multiflorum*	H	FAC	9.		
2.			10.		
3.			11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 100%

Remarks: Large mono-typic stand of Italian ryegrass, some wild radish in area too.

HYDROLOGY

Recorded Data (describe in Remarks):

___ Stream, Lake, or Tide Gauge
___ Aerial Photographs
___ Other
x No Recorded Data Available

Field Observation:

Depth of Surface Water: --- (in.)

Depth to Free Water in Pit: >16 (in.)

Depth to Saturated Soil >16 (in.)

Wetland Hydrology Indicators:

Primary Indicators:

___ Inundated
___ Saturated
___ Water Marks
___ Drift Lines
___ Sediment Deposits
___ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

___ Oxidized Root Channels in Upper 12 in.
___ Water-Stained Leaves
___ Local Soil Survey Data
___ FAC-Neutral Test
___ Other (Explain in Remarks)

Remarks: No hydrologic indicators observed.

SOILS

Sample Number
3B

Map Unit Name
(Series and Phase) Fill material on top of Reyes Clay, 0-1% slopes

Drainage Class:
Field Observations:
Confirm Mapped Type? Yes (No)

Taxonomy (Subgroup): Sulfic Fluvaquent

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-	A	7.5 YR 3/4	---	none	clay loam

Hydric Soil Indicators:

	Histosol		Concretions
	Histic Epipedon		High Organic Content in Surface Layer in Sandy Soils
	Suffidic Odor		Organic Streaking in Sandy Soils
	Aquic Moisture Regime		Listed on Local Hydric Soils List
	Reducing Conditions		Listed on National Hydric Soils List
	Gleyed or Low-Chroma colors		Other (Explain in Remarks

Remarks:
Hard, dry material.

WETLAND DETERMINATION

	(Circle)
Hydrophytic Vegetation Present?	(Yes) No
Wetland Hydrology Present?	Yes (No)
Hydric Soils Present?	Yes (No)

(Circle)

Is this Sampling Point Within a Wetland? Yes (No)

Remarks:

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Sample Number
3C

Project/Site: Bair Island
Applicant/Owner: San Francisco Bay Wildlife Society
Investigator: J. Bourgeois

Date: April 27, 2000
County: San Mateo
State: California

Do Normal Circumstances exist on the site? Yes (No)

Is the site significantly disturbed (Atypical Situations?) Yes (No)

Is the area a potential Problem Area? Yes (No)

(If needed, explain on reverse.)

Community ID: Tidal Saltmarsh

Transect ID : 3

Plot ID: C

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. *Salicornia virginica*	H	OBL	9.		
2.			10.		
3.			11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 100%

Remarks:

HYDROLOGY

Recorded Data (describe in Remarks):

___ Stream, Lake, or Tide Gauge
___ Aerial Photographs
___ Other
x No Recorded Data Available

Field Observation:

Depth of Surface Water: --- (in.)

Depth to Free Water in Pit: 6 (in.)

Depth to Saturated Soil 0 (in.)

Remarks: Frequently inundated.

Wetland Hydrology Indicators:

Primary Indicators:

___ Inundated
x Saturated
___ Water Marks
___ Drift Lines
___ Sediment Deposits
___ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):

___ Oxidized Root Channels in Upper 12 in.
___ Water-Stained Leaves
___ Local Soil Survey Data
___ FAC-Neutral Test
___ Other (Explain in Remarks)

Sample Number
3C

SOILS

Map Unit Name
(Series and Phase) Reyes Clay, 0-1% slopes

Taxonomy (Subgroup): Sulfic Fluvaquent

Drainage Class:
Field Observations:
Confirm Mapped Type? Yes (No)

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-8	A1	10 YR 3/2	---	none	clay loam
8-	A2	5 YR 5/1	---	none	clay

Hydric Soil Indicators:

	Histosol		Concretions
	Histic Epipedon		High Organic Content in Surface Layer in Sandy Soils
	Suffidic Odor		Organic Streaking in Sandy Soils
x	Aquic Moisture Regime		Listed on Local Hydric Soils List
	Reducing Conditions		Listed on National Hydric Soils List
x	Gleyed or Low-Chroma colors		Other (Explain in Remarks

Remarks:

WETLAND DETERMINATION

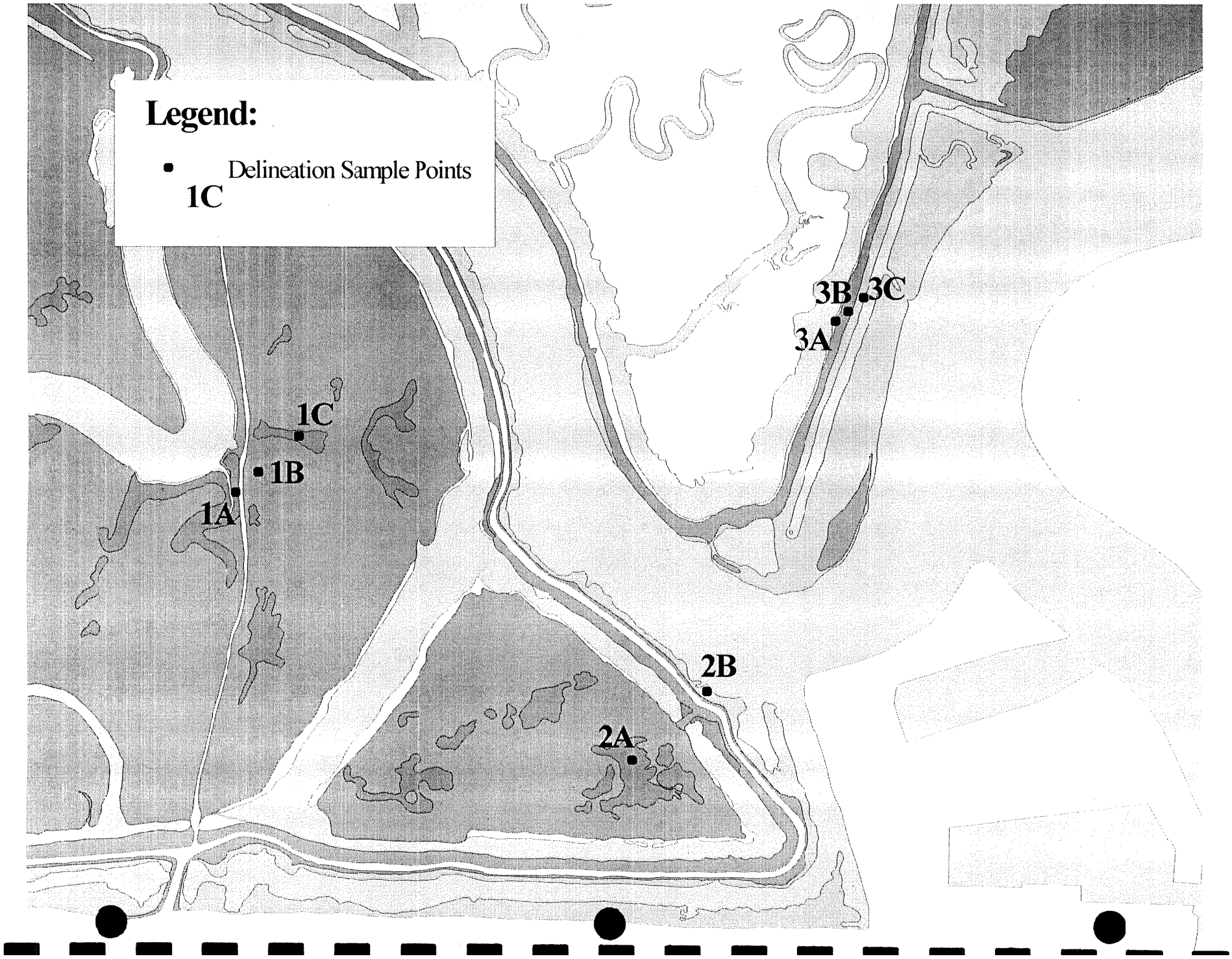
(Circle)

Hydrophytic Vegetation Present? (Yes) No
Wetland Hydrology Present? (Yes) No
Hydric Soils Present? (Yes) No

(Circle)

Is this Sampling Point Within a Wetland? (Yes) No

Remarks:
Tidal saltmarsh.


Legend:
Delineation Sample Points
1C
3B
3C
3A
1C
1B
1A
2B
2A

Appendix C.
Color Photographs

A: Degraded diked salt marsh in former salt pond A11.

B: Canada Goose on outboard tidal marsh.

H.T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

Bair Island Existing Biological Conditions: Appendix C

File No. **1697-01**	Date **6/30/00**	Figure **C-1**

C: Salt marsh dodder.

D: Harbor seals hauled out on Corkscrew Slough.

APPENDIX D

Existing Hydrologic Conditions Assessment

PWA
PHILIP WILLIAMS & ASSOCIATES, LTD
CONSULTANTS IN HYDROLOGY
720 CALIFORNIA STREET, SUITE 600, SAN FRANCISCO, CA 94108-2404
TEL: 415.262.2300 FAX: 415.262.2303
EMAIL: SFO

BAIR ISLAND RESTORATION AND MANAGEMENT PLAN: EXISTING HYDROLOGIC CONDITIONS ASSESSMENT

Prepared for

H.T. Harvey & Associates

Prepared by

Philip Williams & Associates, Ltd.

Revised June 30, 2000

PWA Ref. # 1413, Task 3

P:\Projects\1413_Bair_orig\Task3 ExConds\1413 hydroEC revision v2.doc

02/05/04

Services provided pursuant to this Agreement are intended solely for the use and benefit of H.T. Harvey & Associates and the San Francisco Bay Wildlife Society.

No other person or entity shall be entitled to rely on the services, opinions, recommendations, plans or specifications provided pursuant to this agreement without the express written consent of Philip Williams & Associates, Ltd., 770 Tamalpais Drive, Suite 401, Corte Madera, California 94925.

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1. INTRODUCTION

The San Francisco Bay Wildlife Society is developing a Restoration and Management Plan for 3,200 acres of Federal and State lands on Bair Island, Redwood City, California (Figure 1). The plan includes restoration of 1,400 acres of inactive, leveed salt production ponds ("salt ponds") to tidal wetlands. This report provides background information on existing hydrologic conditions at Bair Island. This study was conducted by Philip Williams & Associates (PWA) for H.T. Harvey & Associates as part of planning and permitting assistance being provided to the San Francisco Bay Wildlife Society (Society) in support the Bair Island Restoration and Management Plan.

Bair Island is a former tidal marsh that currently consists of inactive salt ponds, former salt ponds restored to tidal marsh, supra-tidal dredged material disposal areas, and remnant historic marsh (Figure 2). Bair Island is composed of three islands – Inner, Middle, and Outer Bair Islands – separated by tidal sloughs. The project study area includes the entire Restoration and Management Plan area (Figure 1), with particular emphasis on the 1,400 acres proposed for restoration.

This study and the assessment of existing biological conditions being prepared concurrently by H.T. Harvey are the first of several in support of the Bair Island Restoration and Management Plan. Subsequent studies will include:

- development of management objectives;
- opportunities and constraints analysis,
- development and evaluation of restoration alternatives;
- preparation of Bair Island Restoration and Management Plan; and
- preparation of Bair Island Restoration and Management Plan Environmental Impact Study (EIS)/Environmental Impact Report (EIR).

Hydrodynamic modeling and additional hydrologic and geomorphic analyses will be conducted to assist in the above studies.

2. HISTORIC SITE CONDITIONS

Bair Island is a former tidal salt marsh that has undergone considerable natural and human-induced changes in its evolution. Although existing hydrologic conditions at the site have been substantially modified from historical conditions, some of the existing characteristics are remnants of historic processes and changes, and are best understood within an historic context.

The description of historic conditions at the site is based on a review of existing information, including historic United States Coast and Geodetic Survey (USCGS) maps, United States Geological Survey (USGS) topographic maps, historical aerial photographs, and secondary studies. These studies include: Bair Island Environmental Study (SLC 1977) and Bair Island Ecological Reserve Operations and Maintenance Plan (RTC 1991).

2.1 THE NATURAL LANDSCAPE

Bair Island was once part of a continuous band of tidal salt marsh wetland fringing the southwest shoreline of southern San Francisco Bay. San Francisco Bay was formed over the past 10,000 years by sea level transgression (Atwater *et al*. 1979). Rising sea levels submerged previously upland valley areas. From the time of initial submergence until large-scale reclamation began approximately 150 years ago, the aerial extent of the Bay's tidal marshes was determined by the interaction of sea level rise, estuarine sedimentation and wind wave erosion.

Initially, the Bay was rapidly submerged by sea levels rising at approximately 10 times the current rate of 1-2 mm/yr. From ~10,000 to 6,000 years before present, the Bay supported only a thin, discontinuous fringe of salt marsh along the expanding perimeter (Atwater *et al.* 1979). Salt marsh sedimentation and organic accumulation were presumably not able to keep pace with the rise in sea level. Approximately 6,000 years ago sea level rise slowed to its current rate. In the Bay, this allowed marsh accretion to keep pace with submergence. Evidence from Bay marsh cores indicates that during the past 6,000 years a continuous marsh fringe formed around the Bay and expanded landward, as sea level continued to rise.

2.2 HUMAN INTERVENTION

A review of historic and recent topographic maps of the area illustrates the changes that have occurred from the 1850s through the present. In 1857, only the bayward two of the three islands that now comprise Bair Island existed as islands; the area that is now Inner Bair was part of the mainland (Figure 3). There were no structures or levees and the entire Bair Island was tidal salt marsh. There were no significant changes between 1857 and 1897, except for a 10-acre area at the confluence of Corkscrew Slough and Redwood Creek, which was diked for use as a fishing village in 1869 (SLC 1977). The 1897 map shows what appears to be Cordilleras Creek discharging to Smith Slough through a small tidal channel on what

is now Inner Bair Island. Around the turn of the century, Bair Island was included in several attempts to reclaim marshplain land for agricultural use. A levee around the outer edge of Outer Bair Island, possibly constructed around 1910 (SLC 1977), is shown in the 1931 map (Figure 4). The descriptive report accompanying this map states, "the area between Steinberger and Redwood Sloughs, some of which was at one time reclaimed land, has again reverted to marsh due to the breaking and overflowing of the confining levees. These marshes lie about one foot below extreme high tide. The area is traversed by numerous small sloughs."

Between 1948 and 1952 most of Middle and Outer Bair Island were leveed by Leslie Salt Company for use as salt evaporation ponds (SLC 1977). Salt production on Bair Island was discontinued in 1965, when the ponds were drained and abandoned. Table 1 summarizes the recent history of leveeing and diking for which information is readily available. Pond names and other area locations referenced in Table 1 are shown on Figure 5. Although the date of leveeing for Inner Bair Island is not provided in the existing literature (SLC 1977; RTC 1991), we assume that it was leveed at the same time as Middle and Outer Bair Islands (1948-1952). This is consistent with the 1959 USGS topographic map which shows the Inner Bair leveed. The 1959 map also shows Smith Slough and the borrow ditches south and southwest of Inner Bair in their current locations. It appears that when Inner Bair Island was leveed, a large meander bend in Smith Slough was cut off and leveed within the island, adding acreage to Inner Bair Island which was formerly part of Middle Bair. The borrow ditches were probably created during construction of the Inner Bair levee.

In 1973, Mobil Oil Estates purchased Bair Island and the Redwood Peninsula, where the Redwood Shores development now stands (Figure 5), from Leslie Salt Company. Much of Outer Bair Island was transferred to the California State Lands Commission (SLC) as part of the transaction or as mitigation for marsh loss during the development of Redwood Shores. Tidal action was restored to a large part of Outer Bair Island in the late 1970's and early 1980's through a series of planned and unplanned levee breaches (Table 1).

The locations of the major sloughs have remained essentially unchanged between 1857 and the present, based on a comparison of the historic maps with the recent USGS topographic map (USGS 1973). Flow patterns in the sloughs, however, appear to have changed over time. Leveeing decreased tidal exchange through the sloughs. In addition, Redwood Creek dredging, which began in 1955 and continues to the present, made Redwood Creek a more efficient tidal conveyance channel. Together, these changes would have had the effect of shifting Corkscrew and Smith Slough tidal flows towards Redwood Creek and making Steinberger Slough shallower from lack of tidal scouring. These end results are supported by observations from recent aerial photographs (February 18, 2000). The photographs show that a reach of Steinberger Slough between Smith and Corkscrew Slough is dry at low tides, meaning that Smith Slough and the lower part of Steinberger Slough drain toward Redwood Creek. Also, the existing tidal drainage divide for Corkscrew Slough is in the western part of the channel near Steinberger Slough, meaning that most of Corkscrew Slough drains to Redwood Creek.

As recently as 1975, Steinberger Slough did not drain directly to the Bay at low tide. The USGS topographic map (1959, revised in 1968 and 1973) and old bathymetric maps (NOS 1975) show

Steinberger Slough draining at low tide to Bay Slough and from there to Belmont Slough before discharging to the Bay. More recent bathymetric maps (NOS 1989 and NOS 1995) and low-tide aerial photographs (February 2000) show Steinberger Slough discharging directly to the Bay rather than Bay Slough. The former drainage pattern through Bay Slough was probably a remnant feature of the historical marsh. Steinberger and Bay Slough appear to have been one continuous internal marsh channel which has now become directly connected to the Bay by hundreds of years of sea level rise and shoreline erosion.

The bayward shoreline of Bair Island has experienced both aggradation and erosion, first aggrading from 250 to 1000 feet during the hydraulic mining era (as reflected on the 1857 and 1897 maps), then eroding between 1897 and 1931 and between 1931 and 1959. Relative to its position in 1857, the current shoreline has receded as much as 700 feet in some locations, but has aggraded approximately 200 feet in others.

In addition to lateral movement of the marsh edge, the marshplain elevations of areas that were leveed on Inner, Middle, and Outer Bair Islands have subsided. Subsidence is discussed in Section 3.

TABLE 1. Site History by Sub-Area, 1948 to present

Location	Sub-Area	Date Leveed	Date Breached	Comments
Inner Bair	Pond A-12	1948-1952	NA (not breached)	Inner Bair restoration area. 297 acres.
Middle Bair	Ponds A-9, A-10, and A-11	1948-1952	NA (not breached)	Middle Bair restoration area. Total 779 acres.
	Deepwater Slough and land bounded by it	1965	date unknown	Purchased by Port of Redwood City in 1963 and 1964. The ends of Deepwater Slough (at Redwood Creek) were diked in 1965. Used for dredged material disposal until 1970.
	North of Deepwater Slough	unknown (1965?)	date unknown	May have received dredged material overflow from the area bounded by Deepwater Slough. Appears relatively undisturbed, except for leveeing. No evidence that this area was used for salt production.
	West and South of Deepwater Slough	unknown	date unknown	It appears that dredged material was placed on 5 to 10 acres of this parcel. No levee visible in aerial photographs on the southeast side of the parcel; may never have been leveed. Shows ponding and evidence of disturbed/poor drainage.
Outer Bair	Pond B-1	1948-1952	1976 (unplanned)	Ownership transferred from Mobil Corporation to SLC in 1973. Interior levee between Ponds B-1 and B-2 was breached sometime after 1979, and again in 1983 to allow greater tidal action in Pond B-2. Approximately 310 acres.
	Pond B-2	1948-1952	1979-1983	Mitigation for development on Redwood Peninsula. Interior levee between Ponds B-1 and B-2 was breached sometime after 1979, and again in 1983 to allow greater tidal action in Pond B-2. Approximately 182 acres.
	Pond B-3	1948-1952	NA (not breached)	Outer Bair restoration area. 419 acres.
	Pond VI	1948-1952	1983	Ownership transferred from Mobil Corporation to SLC in 1973. Unplanned breach began in 1983. Interior levee constructed in 1983 to protect least tern nesting sites from tidal inundation. The western levee of Pond VI was repaired and raised in 1986. Approximately 128 acres.
	Eastern Outer Bair	1948-1952	appears not to be breached	Part of this area referred to as Pond VII was used for salt production. The exact location of Pond VII within eastern Outer Bair is unknown. Ownership for part of eastern Outer Bair transferred from Mobil Corporation to SLC in 1973.

Sources: SLC 1977, RTC 1991, and D. Jewell, pers. comm.

NA = not applicable

Note: All of Outer Bair Island except Pond B-3 was leveed and breached between 1897 and 1931.

3. EXISTING SITE CONFIGURATION AND GRADES

Inner, Middle, and Outer Bair Islands are separated by natural and constructed tidal sloughs (Figure 5). Steinberger Slough and the tidal portion of Redwood Creek are located to the west and east of Bair Island, respectively. Corkscrew Slough separates Outer and Middle Bair; Smith Slough separates Middle and Inner Bair. Two borrow ditches separate Inner Bair Island from the mainland.

3.1 LAND USE AND INFRASTRUCTURE

The site consists of leveed inactive salt ponds, restored tidal marsh, supra-tidal dredged material disposal areas, and remnant historical marsh (Figures 2 and 6 and Table 2). Part of Inner Bair (Pond A-12) is owned by the San Carlos Airport and maintained as a safety area for emergency landings (Figure 7).

TABLE 2. Existing Habitat Type by Sub-Area

Location	Sub-Area	Existing Habitat Type	Notes
Inner Bair	Pond A-12	inactive salt pond	Inner Bair restoration area. 297 acres.
Middle Bair	Ponds A-9, A-10, and A-11	inactive salt ponds	Middle Bair restoration area. Total 779 acres.
	Deepwater Slough and land bounded by it	supra-tidal dredged material and poorly-drained high marsh	
	North of Deepwater Slough	tidal marsh (elevation unknown; appears to be high marsh)	
	West and South of Deepwater Slough	tidal marsh (elevation of marsh unknown) and supra-tidal dredged material	
Outer Bair	Pond B-1	young low/mid-elevation tidal marsh	Approximately 310 acres.
	Pond B-2	young low/mid-elevation tidal marsh	Approximately 182 acres.
	Pond B-3	inactive salt pond	Outer Bair restoration area. 419 acres.
	Pond VI	northern part is young low/mid-elevation tidal marsh; southern part is leveed	Approximately 128 acres.
	Eastern Outer Bair	leveed; portions are supra-tidal	relatively little information available

Sources: aerial photographs (February 2000), SLC 1977, RTC 1991, and D. Jewell, pers. comm.

Infrastructure within the area proposed for restoration includes the South Bay System Authority (SBSA) sewer line, a PG&E transmission tower, and a slide-gated culvert, all of which are located on Inner Bair (Figure 7). The SBSA line runs northwest underneath the Inner Bair Island levee from the Whipple Avenue interchange, across/under the western Inner Bair borrow ditch, and along the San Carlos Airport property. The PG&E transmission tower is located just inside of the Inner Bair levee, near the eastern tip of the island. Infrastructure also includes existing levees (many abandoned), which are discussed in the next sub-section.

3.2 TOPOGRAPHY

Existing topographic information for the site consists of 1981 topographic maps of Inner and Middle Bair Islands (BKFA 1981), 1993 surveys of levee crest elevations on Inner Bair (Bohley Maley Associates, 1993), and field surveys conducted for this study. PWA surveyed elevations of marshplain transects and levee/borrow ditch cross-sections in the inactive salt pond areas of Inner, Middle, and Outer Bair Islands in February through April, 2000 (locations shown in Figure 8).

3.2.1 Marshplains

Representative elevations for natural marshplains surveyed at Bair Island outboard of the leveed islands average 3.4 feet NGVD[1], or approximately the local MHW elevation (tides are discussed further in Section 5). Natural pickleweed marshplain elevations range between 2.1 and 4.8 feet NGVD (Table 3).

In contrast, subsidence has caused marshplains within the leveed salt ponds to lower by several feet below natural marshplain elevations (Table 3). Subsidence is caused by decomposition of the organic material that comprises much of marsh soils and by soil consolidation, which is accelerated by de-watering. The degree of subsidence depends on how long a site has been leveed and drained, and how aggressively the site has been drained (i.e., how low water levels were kept). Total subsidence and subsidence since 1981 are shown in Table 3. Total subsidence depths were calculated as the difference between the average natural marshplain elevation and average pond interior elevations from 2000 field surveys (this study). The 1981 to 2000 subsidence depths were calculated as the difference between the 2000 field survey elevations (this study) and those on the 1981 map (BKFA 1981).

[1] National Geodetic Vertical Datum, a fixed vertical datum at the mean sea level of 1929.

TABLE 3. Bair Island Marshplain Elevations

Location	Feature	Average Elevation (feet NGVD)	Minimum Elevation (feet NGVD)	Maximum Elevation (feet NGVD)	Subsidence between 1981 and 2000 (feet)	Total Subsidence (feet)
Inner Bair	Transect T-5	0.1	-0.8	1.0	0.8	3.3
	Safety Zone Transect	0.0	-0.8	0.7	0.8	3.4
Middle Bair	Transect T-4	1.2	0.4	1.9	1.5	2.2
	Transect T-6	0.8	0.1	1.3	2.1	2.6
Outer Bair	Transect T-1	1.1	0.1	2.2	NA	2.3
	Transect T-2	0.0	-0.8	1.4	NA	3.4
Outside of levees	Natural marshplain	3.4	2.2	4.8	---	---

Source: PWA field surveys (2000) and BKFA (1981).
Note: Marshplain elevations exclude channel and levee portions of transects.

3.2.2 Levees

Levees on Inner, Middle, and Outer Bair were originally constructed to contain salt ponds and not necessarily to prevent flooding during large flood events (such as the 100-year flood). The majority of the Middle and Outer Bair levees have not been maintained since the ponds were abandoned in 1965. The Inner Bair levee has been repaired and raised since 1965, primarily to protect the SBSA force main that runs underneath most of the southern part of the levee and to protect the San Carlos Airport safety area. Survey information from Bohley Maley Associates (1993) indicates that the Inner Bair Island perimeter levee elevation was likely raised at least once prior to 1993, by creating a narrower levee on top of the original levee. The survey was performed to aid in the design of a second maintenance project, which would raise the levee to a design elevation of 8.0 feet NGVD by adding another narrow band of material on top of the section that was raised previously (Bohley Maley Associates, 1993). Spot checks of the levee elevation from 2000 PWA surveys indicate that the current levee crest elevation is approximately 8 feet NGVD on Inner Bair Island, excluding the portion of the levee above the force main. PWA's April 2000 surveys of the levee above the force main indicate that the crest elevations are approximately 10 feet NGVD for this portion of the levee.

TABLE 4. Levee Crest Elevations

Location	Data Source	Average Elevation (feet NGVD)	Minimum Elevation (feet NGVD)	Maximum Elevation (feet NGVD)
Inner Bair	1981 survey (BKFA 1981)	~6	5.2	7.8
	1993 survey (Bohley Maley Associates)	~7	5.9	7.9
	2000 survey (this study) excluding the portion of the levee above the force main	7.9	7.6	8.2
	2000 survey (this study) portion of levee above the force main only	9.9	9.4	10.7
Middle Bair	1981 survey (BKFA 1981)	~7	6.1	9.1
	2000 survey (this study)	7.0	6.6	7.8
Outer Bair	2000 survey (this study)	7.6	6.3	8.7

3.3 HYDROGRAPHY

Existing hydrographic information for the site consists of NOS bathymetric maps (NOS 1995) and field surveys conducted for this study. PWA surveyed channel and borrow ditch cross-sections in the inactive salt pond areas of Inner, Middle, and Outer Bair Islands in February and March, 2000 (locations shown in Figure 8). Towill surveyed 30 cross-sections of the major slough channels (Redwood Creek, Steinberger Slough, Smith Slough, and Corkscrew Slough) in February 2000, for the current study.

Redwood Creek, Steinberger Slough, Corkscrew Slough, and Smith Slough are the major tidal channels adjacent to Inner, Middle, and Outer Bair Islands. Outer Bair Island is bordered by an approximately 3000-foot wide outboard mudflat that is exposed at low tide. Shallow water continues offshore to the deepwater shipping channel through South San Francisco Bay, approximately 6,000 feet offshore of Outer Bair.

Redwood Creek is dredged for use as a shipping channel to service the Port of Redwood City (discussed further in Section 8) and is the largest and deepest of the Bair Island sloughs (Table 5). Most of the tidal exchange for the Bair Island slough system is through Redwood Creek. Drainage divides are located in Steinberger Slough just south of its confluence with Corkscrew Slough and in Corkscrew Slough, approximately 3000 feet east of its confluence with Steinberger Slough (Figure 9). The drainage divide areas are dry at low tide.

In light of the drainage divide locations, Smith Slough and most of Corkscrew Slough drain to Redwood Creek. The southern part of Steinberger Slough, between Smith and Corkscrew Sloughs, drains through Smith Slough to Redwood Creek. The remainder of Steinberger Slough drains directly to the Bay. The western 3000 feet of Corkscrew Slough drains to Steinberger Slough and from there to the Bay.

Two borrow ditches adjacent to Inner Bair Island (Figure 7) are minor tidal channels. Cordilleras and Pulgas Creeks empty into the western borrow ditch and from there to Smith Slough. A pump station draining approximately 140 acres empties into the eastern borrow ditch (Linsley Kraeger, 1985). Although it carries less upland runoff, the eastern borrow ditch is deeper and wider than the western borrow ditch.

TABLE 5. Channel Bathymetry

Location		Channel Bottom Elevation (feet NGVD)	Depth at MHHW [H] (feet)	Top Width at MHHW (feet)	Comments
Redwood Creek	at mouth, near Redwood Point	-34.8	38.9	NA*	
	Port of Redwood City	-39.0	43.1	509	Design dredge depth is -33.9 ft NGVD
	south end, near Highway 101	-8.9	12.9	984	
Steinberger Slough	at mouth	-9.2	13.2	656	
	south end, near Smith Slough	-7.62	11.7	390	
Smith Slough	west end	-6.1	10.2	377	
	east end	-13.1	17.2	328	
Corkscrew Slough	west end	-2.6	6.7	308	
	east end	-12.8	16.9	433	
Inner Bair borrow ditches	western	-3.3	7.3	45	
	eastern	-5.9	10.0	141	

H MHHW = Mean Higher High Water

* Channel top of bank is not defined on the west bank.

Source: Towill field surveys (February 2000; this study).

4. WIND CLIMATE

Wind data for Bair Island were collected by USGS for approximately one-year (J. Dingler, pers. comm.). According to these measurements, the primary wind direction is from the west-northwest, with an average wind speed of 6.2 mph. The Bair Island data show seasonal and diurnal patterns typical of San Francisco Bay, where on-shore sea breezes create strong summer afternoon winds and winter storms bring high velocity, shorter duration winds from the south-southeast.

In addition to the USGS data, continuous wind data are available from the NOAA meteorological station located on Wharf 5 at the Port of Redwood City. The period of record extends from August 22, 1997 to the present and consists of hourly recordings of wind speed, wind direction, and wind gust. No summarized information exists for this data set.

5. TIDAL CHARACTERISTICS

5.1 AVERAGE AND EXTREME TIDE ELEVATIONS

Tidal characteristics at the Redwood Creek tide gauge are shown in Table 6. Mean tide conditions are from the National Ocean Service (NOS, 1987). The 10- and 100-year estimated high tides are from the U.S. Army Corps of Engineers (USACE, 1984).

The published tide data presented in Table 6 were checked for consistency with elevations from the 2000 field surveys using a tidal datum analysis. Vertical datum control is important in areas that are subsiding rapidly. Benchmark subsidence and inaccurate vertical control are common difficulties in the tidal marsh environment. Based on preliminary results from this analysis, the published data were found to be consistent with elevations from the current surveys and no vertical correction was necessary. The results of the tidal datum analysis are preliminary and finalized in a subsequent study.

TABLE 6. Tide Characteristics at Redwood Creek, Channel Marker No. 8, San Francisco Bay

	Elevation	
	MLLW (feet)	**NGVD (feet)**
Estimated 100-Year High Tide	11.2	7.3*
Estimated 10-Year High Tide	10.5	6.6
Mean Higher High Water (MHHW)	7.96	4.05
Mean High Water (MHW)	7.35	3.44
Mean Tide Level (MTL)	4.27	0.36
National Geodetic Vertical Datum , 1929 (NGVD)	3.91	0.00
Mean Low Water (MLW)	1.19	-2.72
Mean Lower Low Water (MLLW)	0.00	-3.91

Sources: NOS (1987), USACE (1984), PWA analysis.

Note: Elevations are for the 1960 to 1978 tidal epoch.

*Adopted elevation: adopted by the USACE from the smoothed profile of calculated 100-year tides.

6. EXISTING DRAINAGE

Existing local and regional drainage are important elements of restoration design.[2] Until specific restoration alternatives are developed and evaluated, however, it is not possible to know which details of the existing drainage will be most relevant to the design. Therefore, in preparation of this section of the study, we assume certain project changes associated with the restoration and use these changes to focus the scope of our existing conditions assessment. Existing drainage and potential project impacts will be analyzed in more detail in subsequent phases of the project, once specific restoration alternatives have been developed.

We assume that restoration will re-introduce full tidal action to most, if not all, of the available restoration area. The project will directly affect drainage in the restoration areas and has the potential to affect the elevation-duration characteristics of typical tide cycles in adjacent sloughs.[3] Changes in water levels are expected to be short-term and limited to "typical tides," within approximately the mean diurnal tidal range. During the initial period of site development, typical tides may be muted within the restoration area and adjacent channels. Water levels in the local slough channels may not fall as quickly or drain as low during the ebb tide as under existing conditions. In the long-term, as the local slough channels enlarge and the restored areas fill with sediment, typical tide levels are expected to return to close to existing conditions.

Changes to typical tides could affect drainage in adjacent areas that rely upon low tides for storm discharge. The potential for impact, however, depends upon the type of drainage for each area, described below in Section 6.2.2.

6.1 ON-SITE

Drainage within the Restoration and Management Plan area, in terms of which sub-areas are tidal versus non-tidal, is discussed above in Section 3. This section focuses on detailed drainage for the areas of Bair Island proposed for tidal restoration.

Water levels in the inactive salt ponds on Middle and Outer Bair Islands are controlled by ponding of direct rainfall, evaporation, and levee seepage. Seepage between the ponds and adjacent channels occurs in both directions (into and out of the pond), depending on relative water levels. A slide-gated culvert on Inner Bair appears to offer some level of drainage connection between the pond interior and Smith Slough. We assume that the culvert is functioning to some extent, since water levels in Inner Bair were observed to be lower than in Middle and Outer Bair during recent PWA field surveys. Middle and Outer

[2] Drainage refers to surface runoff during typical (non-extreme) rainfall events or tidal flow during typical diurnal tides. Flooding refers to surface runoff and tide conditions during extreme events. Flooding is discussed separately in Section 7.

[3] Potential project impacts to flooding are discussed separately in Section 7.

Bair ponded water levels remained high following several recent storm events. The slide gate and culvert appear to be at least a decade old and have been observed by San Mateo County Mosquito Abatement District staff to be filled with debris (D. Jewell, pers. comm.). During PWA field surveys conducted during March 2000, observed water levels were approximately –0.5 feet NGVD at Inner Bair, 0.1 to 1.3 feet NGVD at Middle Bair (varied by pond and date of survey), and 1.1 feet NGVD at Outer Bair.

Until recently, water in the Middle and Outer Bair salt ponds was siphoned periodically during the rainy season to keep ponding, and associated mosquito production, to a minimum. According to Dennis Jewell, Supervisor with the San Mateo County Mosquito Abatement District, temporary siphons were used to drain Middle and Outer Bair beginning in the late 1970s or early 1980s (D. Jewell, pers. comm.). Mobil Oil installed and operated the siphons originally, then operations were continued by the Mosquito Abatement District. The Mosquito Abatement District siphoned during the rainy season; by June, the ponds would usually be dry. The Mosquito Abatement District discontinued siphon operations at Bair Island this year due to lack of funds and staffing. The siphons are constructed of white PVC pipe and are still visible at the site today (PWA site reconnaissance, March 2000).

It appears that Inner Bair Island has never been siphoned. Siphoning for mosquito control was not used at Inner Bair because the area is easily accessible for other types of mosquito abatement treatment (D. Jewell, pers. comm.). In addition, there are potential vandalism problems associated with storage of siphons at Inner Bair.

6.2 OFF-SITE

6.2.1 Prior Studies

Existing information reviewed for the off-site drainage section includes FEMA Flood Insurance Studies for the Cities of San Carlos and Redwood City (FIA 1977 and FEMA 1981) and the following reports: *Update of Master Plan for Storm Drainage, Water, and Sanitary Sewer Systems, City of Redwood City* (KJC, 1986); and *Addressing the Problems of Flooding and Drainage Along Cordilleras Creek, Draft Preliminary Report* (CFCCNA, 1999). Additional information was obtained through conversations with engineers from the City of Redwood City Engineering Department (J. Lynch, S. Vorametsanti, and C. Chang, pers.comm.).

6.2.2 Drainage Mechanisms

Drainage of storm water runoff in coastal areas can be categorized according to the following drainage mechanisms: (1) gravity drainage of supra-tidal areas, (2) gravity drainage of diked inter-tidal areas, and (3) pumped drainage of diked inter-tidal areas. Restoration-related changes in typical tide elevations are not expected to significantly affect drainage for adjacent areas relying upon the first and third drainage mechanisms. They could, however, affect gravity drainage of inter-tidal areas (the second mechanism) by reducing the frequency and duration of very low tides, when stored storm water can drain through passive drainage structures to adjacent sloughs.

6.2.3 Regional Drainage Overview

Three major creeks—Redwood, Cordilleras, and Pulgas Creeks—convey surface runoff from the hillsides southwest of Bair Island to San Francisco Bay (Figure 10). Redwood Creek continues all the way to the Bay, while Cordilleras and Pulgas Creeks flow into the western Inner Bair borrow ditch and from there to Smith Slough and Steinberger Slough. Smith Slough drains to Redwood Creek and from there to the Bay. The part of Steinberger Slough near Smith Slough drains directly to the Bay only during higher water levels. The storm drain systems of Redwood City and San Carlos discharge storm runoff into Redwood Creek and Pulgas Creek, respectively, through a combination of gravity drainage and pumping. Additionally, there are several areas that discharge directly to the tidal sloughs or to the Bay itself, either via pump stations or gravity drainage.

Table 7 provides a summary of the drainage mechanisms and flood protection infrastructure for areas adjacent to Bair Island (see Figure 10 for locations). A discussion of this information follows in Sections 6.2.4 through 6.2.7.

6.2.4 Redwood Creek

Redwood Creek drains an area of 9.3 square miles, almost entirely within the city limits of Redwood City. The watershed is largely developed, ranging from medium-density residential areas in the hills to high-density residential, commercial, and industrial areas near the Bay. The Highway 101 bridge over Redwood Creek is built on piers at an elevation well above the 100-year tide (Caltrans, 1999), allowing unrestricted passage of high flows as they drain to the Bay. Redwood City began a major storm drain improvement and channelization project on Redwood Creek in 1967, which extended and enlarged the storm drain system, added pump stations, and lined portions of the creek channel with concrete.

Most of the flows from low-lying areas of the Redwood Creek watershed near the Bay are collected by 9 pump stations, 8 of which discharge directly to Redwood Creek and one of which discharges through flap-gated culverts to a leveed storage basin known as Basin 1 between Highway 101 and Inner Bair Island (Figure 7) (KJC, 1986, J. Lynch, pers. comm., and Fong, 1979). Basin 1 drains through a culvert to the eastern Inner Bair borrow ditch.

Figure 10 indicates the locations of areas adjacent to Bair Island that are discussed below. The area west of Highway 101 within the regional drainage and flooding focus area (Figure 10) drains to pump stations (KJC, 1986). East of 101, the areas that drain to pumps include: the Bair Island Road area from the Whipple Avenue interchange to Docktown Marina and Pete's Harbor, the area bounded by Maple Street, the area between 101 and Bloomquist Street, and the Seaport Center (C. Chang, pers. comm.). A pump station for the Pacific Shores office complex at the northern end of the Port of Redwood City will be installed upon completion of the development (J. Lynch, pers. comm.). The areas that drain to Redwood Creek via gravity drainage include: the area northwest of Maple Street which houses the San Mateo County Women's Correctional Center and Work Furlough Facility, the area north of Bloomquist Street, and the Port of Redwood City (C. Chang, pers. comm.). Information currently available is not sufficiently detailed to indicate the elevations of the gravity-drained areas or culvert characteristics relative to the tides, although we assume most of these areas are intertidal.

TABLE 7. Drainage Mechanisms and Flood Protection Infrastructure Near Bair Island

Watershed	Drainage Area	Drainage Type	Flood Protection Infrastructure	Historical Flooding
Redwood Creek	Port of Redwood City	Inter-tidal gravity drainage	Unknown	None documented
	Pacific Shores Development (future)	Pump (future)	Levee (future)	NA
	Seaport Center	Pump	Levee	None documented
	North of Bloomquist Street	Inter-tidal gravity drainage	Unknown	None documented
	South of Bloomquist Street	Pump	Unknown (borders area north of Bloomquist St.)	None documented
	Maple Street area	Pump	Levee / high ground	1973, 1982, 1983. Caused by levee failure and overtopping.
	Northwest of Maple Street	Inter-tidal and supra-tidal gravity drainage	Levee	1973, 1982, 1983. Caused by levee failure and overtopping.
	Bair Island Road area (from Whipple Ave interchange to Docktown Marina and Pete's Harbor)	Pump	Levee	1982, 1983. Caused by levee failure and overtopping.
	Redwood City east of the Southern Pacific Railroad and west of 101	Pumps	Some areas leveed	1958, 1967, 1973, 1982. Caused by high creek flows, back-ups at Middlefield Rd. culvert.
Cordilleras Creek	West of 101	Inter-tidal gravity drainage	None documented	1958, 1973, 1982, 1983. Caused by high tides and heavy rainfall.
Pulgas Creek	West of 101	Inter-tidal gravity drainage, one pump	None documented	1958, 1973, 1982, 1983, 1986. Caused by high tides and heavy rainfall.
Steinberger Slough and San Francisco Bay	San Carlos Airport	Pumps	Levee	1973. Caused by high tides.
	Northern San Carlos and Belmont	Pumped from Phelps Slough holding pond	Levee (some areas may be supra-tidal)	Not available in sufficient detail to document
	Redwood Shores	Mostly pumps, some inter-tidal gravity drainage	Levee	None documented

Sources: KJC 1986, FIA 1977, FEMA 1981, USACE 1989, C. Chang, J. Lynch and S. Vorametsanti, pers. comm.
Notes:
NA = not applicable
Inter-tidal elevations are for typical tides (range from –3.9 to +4.1 feet NGVD)
See Table 8 for levee elevations.

6.2.5 Cordilleras Creek

Cordilleras Creek drains a 3.6-square mile watershed and forms much of the border between Redwood City and San Carlos. Most of the channel remains in its natural state without significant human alterations. The creek passes through three 12' x 6' concrete box culverts under Highway 101 before discharging into the western Inner Bair borrow ditch. Tidal influence extends 1000 feet up the creek from the Bay to Redwood High School, where the creek makes a 90-degree turn. All of the land bordering the creek is privately owned, and there are no public easements for creek access and maintenance. Cordilleras Creek is not connected to the main storm drain systems of either Redwood City or San Carlos (CFCCNA, 1999).

6.2.6 Pulgas Creek

Pulgas Creek collects surface runoff from a 3.6-square mile area in central San Carlos and a small part of Belmont (FIA, 1977). In its lower watershed, it has been confined to culverts under Arroyo Avenue near Walnut Street, continuing below El Camino Real, the Southern Pacific Railroad embankment, and ending east of Old County Road. It passes through a 12 ft x 6 ft concrete box culvert under Highway 101, approximately 700 feet upstream of its entrance to Steinberger Slough. The creek has been channelized east of Old County Road, and lined with levees east of Highway 101 to protect adjacent areas (primarily the San Carlos Airport) against tidal flooding (FIA, 1977).

There is little information available about the storm drainage network and pump stations in San Carlos. The San Carlos Flood Insurance Study (FIA, 1977) indicates that there is a pump station at Industrial Road that pumps floodwaters from nearby street conduits into the creek. The remainder of the Pulgas Creek drainage area appears to be gravity-drained.

6.2.7 Steinberger Slough and San Francisco Bay

There are three main drainage areas northwest of Bair Island that discharge to Steinberger Slough or directly to San Francisco Bay. Storm water runoff from the San Carlos Airport is accommodated by several on-site pump stations (FIA, 1977) which likely drain to Steinberger Slough. Runoff from northern San Carlos and Belmont that drains to a holding pond in Phelps Slough is pumped into Steinberger Slough (KJC, 1986). Runoff from Redwood Shores is routed to a controlled interior lagoon. Some of the flows are collected at pump stations (C. Chang, pers. comm.) and some are stored until they can be released via gravity drainage at low tide to Steinberger Slough or to the Bay (KJC, 1986).

7. FLOODING

Flooding on and around Bair Island usually occurs in winter or early spring, and is most severe when a large frontal storm coincides with an extreme high tide (FEMA, 1981). A compilation of FEMA Flood Insurance Rate Maps showing the extents of the 100-year floodplain on Bair Island and in the surrounding areas of Redwood City and San Carlos is provided in Figure 10.

As in Section 6, we assume certain project changes associated with the restoration and use these changes to focus the scope of our existing conditions flood assessment. Existing flooding and potential project impacts will be analyzed in more detail in subsequent phases of the project.

The proposed restoration plan has the potential to create short-term changes in typical tide elevations around Bair Island (as discussed in Section 6). These changes would not affect flooding from extreme high tides and would be unlikely to affect high creek flows. They could potentially affect flooding caused by the combination of high tides and high creek flows by increasing the duration of higher tides that impede creek drainage. In the long-term, the capacities of Steinberger and Smith Sloughs may be increased by greater tidal exchange with the restored marsh areas, which could help alleviate flooding in the downstream reaches of Cordilleras and Pulgas Creeks. Flood mechanisms and potential project impacts are discussed in greater detail below.

7.1 ON-SITE

Current FEMA flood mapping shows Bair Island completely within the 100-year floodplain in a region dominated by tidal flooding (Figure 10). It appears, however, that levee improvements made since the date of FEMA mapping now protect Inner Bair from 100-year flooding. The levee around Inner Bair, which protects the San Carlos Airport safety area from tidal inundation, has a design elevation of 8.0 feet NGVD (Bohley Maley Associates, 1993). Spot elevations from recent PWA surveys confirm that current levee crest elevations are at or above approximately 8.0 feet NGVD. This elevation provides protection against approximately the 100-year flood with only a small allowance (0.7 feet) for wave run-up and freeboard. It should be noted that for most of the levee only a 2- to 3-feet portion of the levee width has been raised to this elevation, and the majority of the width of the levee is up to several feet lower (Bohley Maley Associates, 1993). Table 8 provides levee elevations for Inner, Middle, and Outer Bair Islands.

TABLE 8. On-site and Off-site Levee Elevations

Feature	Minimum Elevation (feet NGVD)	Maximum Elevation (feet NGVD)	Comments
Inner Bair Island levees excluding the force main levee	7.6	8.2	Around most of Pond A-12 (PWA, 2000)
Inner Bair force main levee	9.4	10.7	Force main levee survey (PWA, 2000)
Middle Bair Island levees	6.6	7.8	Around Ponds A-9, A-10, and A-11 (PWA 2000)
Outer Bair Island levees	6.3	8.7	Around Pond B-3 (PWA, 2000)
Seaport Center levee	~8.0 (design elevation)	~8.0 (design elevation)	Design elevation = 8.0 feet NGVD (S. Vorametsanti, pers. comm.).
Maple Street area levee / high ground	~6.0	~7.5	Elevations of high ground around the west and north sides of Maple Street (CRCCDD, 1989). Survey performed prior to construction of the Police Department offices in this location. Current elevations may differ.
Pete's Harbor levee	*	*	
PG&E levee	6.2	7.2	Elevations from BKFA (1981). Fong (1979) indicates minimum elevation of 5.6 feet NGVD.
Basin 1 levee	6.7	7.9	Elevations from BKFA (1981). Fong (1979) indicates approximate elevation of 7.0 feet NGVD. Levee elevations may have changed with redesign of Whipple Avenue interchange in 1982 (Caltrans, 1982).
San Carlos Airport levees	7.8	9.2	Elevations known for approximately 1000-foot length where roadway rebuilt out of total 4500-foot levee length (SMC, 1993). Elevations for remainder of levee not readily available from San Carlos Airport or San Mateo County.
Redwood Shores levees	~9.5 (design elevation)	~9.5 (design elevation)	Design elevation = 9.5 feet NGVD, Redwood City in the process of levee maintenance. Most areas raised already, some still need to be raised (S. Vorametsanti, pers. comm.).

*Accounts of historical flooding along Redwood Creek indicate the existence of levees in this area (USACE, 1989). However, after conversations with the City of Redwood City and San Mateo County Public Works Departments, we are unable to locate any information about these levees (S. Vorametsanti, J. Lynch and K. Wick, pers. comm.).

7.2 OFF-SITE

7.2.1 Prior Studies

Existing information reviewed for the off-site flooding section includes the *San Mateo and Northern Alameda Counties Interim San Francisco Bay Shoreline Study* (USACE, 1989), in addition to sources cited previously in Section 6.2.1.

7.2.2 Flooding Mechanisms

Flooding in coastal areas can be categorized according to the following mechanisms: flooding from high tides, flooding from rainfall runoff, and flooding from the combination of high tides and rainfall runoff. For the purposes of this study, tidal flooding is defined as direct flooding from high tides overtopping shoreline levees or high ground. Rainfall runoff flooding is defined as flooding caused by high creek flows exceeding channel or culvert capacity. Flooding caused by the combination of high tides and high rainfall runoff is defined as creek flooding (typically in the downstream reaches) that occurs when high tide levels at the creek mouth create a backwater effect that limits the creek's drainage.

Based on expected project-related changes in tide elevations, the project's zone of influence on regional flooding is limited to areas where creek drainage could experience tidal backwater effects. Therefore, the regional flooding discussion was focused on the area within and a small distance outside of the 100-year tidal flooding zone (elevation 7.3 feet NGVD). In general, this study includes areas below approximately 15 feet NGVD and encompasses the area from Bair Island to approximately the Southern Pacific Railroad in San Carlos and El Camino Real in Redwood City (Figure 10).

7.2.3 Flood Protection Infrastructure

Table 8 provides elevations of the levees on and adjacent to Bair Island. All of the levees for which elevations are readily available protect the areas they surround against the 100-year tide (7.3 feet NGVD, from Table 6), except the remnant salt pond levees on Middle and Outer Bair Island, the levees/high ground around the Maple Street area east of Highway 101, and the Bair Island Road area levee parallel to the eastern Inner Bair borrow ditch. The part of this levee east of the Whipple Avenue interchange is on PG&E property and will be referred to as the PG&E levee; the part west of Whipple Avenue surrounds Basin 1 (Section 6.2.4) and will be referred to as the Basin 1 levee (Figure 7). FEMA maps confirm that the areas with lower levees are within the 100-year floodplain (Figure 10). Jon Lynch, the City Engineer for Redwood City, also identified the Maple Street area as a location that has experienced significant flooding (J. Lynch, pers. comm.). Current FEMA flood mapping shows the Seaport Center completely within the 100-year floodplain (Figure 10). However, levee improvements with a design elevation of 8.0 feet NGVD made since the date of FEMA mapping now protect this area from 100-year flooding (S. Vorametsanti, pers. comm.).

There are no levees along Highway 101 where it parallels the western Inner Bair borrow ditch. The elevation of the highway in this region ranges from 8.6 to 10.9 feet NGVD (Caltrans, 1999), which is higher than the 100-year tide level.

7.2.4 Tidal Flooding

Tidal flooding has been documented in portions of Redwood City and San Carlos near Bair Island in 1973, 1982, 1983, and 1986 (USACE, 1989). Areas east of Highway 101 have experienced the most severe flooding. The storms of January 1973, which involved the combination of high rainfall and tides that were reported to be 100-year elevations in some locations, caused a levee failure at the south end of the San Carlos Airport, flooding an automobile wrecking yard and the southern part of the airport. Levee overtopping and failure caused flooding at Pete's Harbor parking lot, the Docktown Marina offices, and on Bair Island Road in the winter of 1982-1983. Maple Street east of 101 (including the old Redwood City Sewage Treatment Plant, the San Mateo County Work Furlough Facility and Women's Correctional Center, and the Society for the Prevention of Cruelty to Animals facilities) and the area by the old Circle Star Theater (just west of 101) have been flooded by high tides multiple times since records have been kept.

7.2.5 Flooding on Regional Creeks

The adjacent watersheds of Redwood, Cordilleras, and Pulgas Creeks experience approximately the same rainfall and tides. Because of these similarities, creek flooding typically occurs during the same storm events. Major surface runoff flooding events on these creeks occurred in 1940, 1955, 1958, 1973, 1982, and 1983 (USACE, 1989).

7.2.5.1 Redwood Creek

The flood events prior to the 1967 storm drain project seem to be caused largely by high creek flows and the overtopping of channel banks, while later flood events appear to be caused by backed-up storm drain systems and limited culvert capacity (USACE, 1989). According to the Redwood City FIS published in 1981 (FEMA, 1981), the critical overflow point is at Middlefield Road where Redwood Creek enters an underground culvert. The downtown area of Redwood City (including Middlefield Road, Broadway, and Veteran's Blvd) was flooded by storm water backed-up at the Middlefield Road culvert entrance during the January 1973 floods. The ground elevation at this culvert entrance appears to be approximately equal to the 100-year tide level (KJC, 1986), and high tides may contribute to flooding problems by retarding creek drainage.

Estimated flows for various design floods on Redwood Creek are listed in Table 9. A USGS stream gauge was operated from 1959 to 1997 in the upper watershed of Redwood Creek.

TABLE 9. Estimated Creek Flows

Location		Drainage Area (sq. mi.)	Q_{10} (cfs)	Q_{30} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)	Source
Redwood Creek	USGS Gauge	1.82	--	720	--	--	KJC (1986)
	Broadway	8.8	1800	--	3200	3800	FEMA (1981)
	Highway 101[1]	9.3	1900	--	3300	4000	FEMA (1981)
Cordilleras Creek	El Camino Real	3.3	470	--	940	1170	FEMA (1981)
	Highway 101	3.6	525	--	700[2]	850[2]	FEMA (1981)
Pulgas Creek	Highway 101	3.6	1005	--	1460	1820	FIA (1977)[3]

Notes:
[1]KJC (1986) lists a 30-year peak flow of 1800 cfs at Veteran's Blvd just upstream of Highway 101. This flow is approximately equal to the 10-year peak flow FEMA values at Broadway and Highway 101, 1300 and 1700 feet upstream and downstream, respectively. It is likely that this discrepancy results from different methods of analysis used in the two studies.
[2]The flows at El Camino Real are higher than those downstream at Highway 101. This discrepancy is caused by a diversion of high flows from Cordilleras Creek to Pulgas Creek that FEMA factored into its analysis for the 50- and 100-year flows (E. Boscacci, pers. comm.). KJC (1986) lists a 30-year peak flow of 1000 cfs at Highway 101. This flow, which is significantly higher than the FEMA values at Highway 101, indicates that the diversion of high flows was likely not included in the KJC analysis, but the discrepancy may also be the result of different methods of analysis.
[3]The flow values were not listed in the 1977 San Carlos FIS (FIA, 1977), but were obtained from FIS back-up data. The 50- and 100-year flows include diverted flows from Cordilleras Creek (E. Boscacci, pers. comm.).

7.2.5.2 Cordilleras Creek

Flooding on Cordilleras Creek is exacerbated by erosion in the upper watershed, resulting in deposition and blockage downstream in the flat, low-lying areas. The more serious flooding on this creek occurs east of El Camino Real, particularly from the Redwood High School to Industrial Road (CFCCNA, 1999). In more extreme (50- and 100-year) events, flow from Cordilleras Creek backs up at El Camino Real and joins with ponded areas to the northwest created by overflows from Brittan and Pulgas Creeks (Figure 10) (FIA, 1977).

Estimated flows for various design floods on Cordilleras Creek are listed in Table 9. The flows at El Camino Real are higher than those downstream at Highway 101, indicating that the overflow diversion mentioned above was factored into flow calculations for the 50- and 100-year flows.

7.2.5.3 Pulgas Creek

Overflow from Pulgas Creek causes flooding in the industrial area between Highway 101 and El Camino Real. The pump station at Industrial Road is not large enough to relieve flooding from extreme events in this area (FIA 1977). Flooding in the industrial area is most severe when drainage is limited by high tides. Estimated flows for various design floods on Pulgas Creek are listed in Table 9. The 50- and 100-year flows include diverted flows from Cordilleras Creek as discussed in the preceding section (E. Boscacci, pers. comm.).

Due to persistent minor flooding in the industrial area, the city plans to install two new culverts under city streets upstream of Highway 101 as part of a long-term flood management initiative (D. Gilbert, pers. comm.). Caltrans also plans to enlarge the culvert under Highway 101 to accommodate the increased capacity upstream (S. Goodson, pers. comm.).

8. SEDIMENTATION

This section presents regional suspended sediment concentrations and sedimentation estimates for the dredged portion of Redwood Creek. Long-term sedimentation predictions for the project area will be developed during subsequent hydrology and sedimentation analyses.

8.1 REGIONAL SUSPENDED SEDIMENT CONCENTRATIONS

Suspended sediments are predominantly muds carried to the Bay by river flows during large floods. These sediments are deposited and stored in shallow subtidal and intertidal mudflat areas. Wind-wave action and tidal currents re-suspend and redistribute these sediments throughout the year. The mudflats outboard of Bair Island provide a year-round source of sediment inflow to the slough channels surrounding Bair Island. During storm events, the regional creeks are an additional, probably minor, source.

Suspended sediment concentration data for San Francisco Bay are available for a network of USGS monitoring stations. Bair Island is located approximately equidistant between the San Mateo Bridge and Dumbarton Bridge stations. These stations are located in deepwater areas, where suspended sediment concentrations are generally low compared to shallow water areas. Thus, suspended sediment concentrations for these stations (Table 10) provide a lower limit estimate of concentrations expected at Bair Island.

TABLE 10. Suspended Sediment Concentrations for San Mateo and Dumbarton Bridges

	San Mateo Bridge		Dumbarton Bridge	
Year	Mean (mg/l)	Median (mg/l)	Mean (mg/l)	Median (mg/l)
1992-1993	66	53	73	64
1994	63	52	97	86
1995	44	35	98	63
1996	40	25	120	89
1997	58	45	122	106

Note: Data are for mid-depth observations.
Sources: USGS 1995, USGS 1996a, and USGS 1996b.

Local suspended sediment concentration data were collected in Corkscrew Slough by the USGS between 1997 and 1998, but are not available at this time (J. Dingler, pers. comm.). The data are preliminary and are currently undergoing quality control review. According to preliminary review of the data by USGS staff, some or all of the data may be unusable due to damage at the measurement station.

8.2 REDWOOD CREEK DREDGING

Redwood Creek has been dredged approximately every two to four years since 1955. The dredged portion includes a 3.5-mile segment extending from the ship channel in San Francisco Bay to the Redwood City Yacht Harbor (Figure 11). It averages 300 to 400 feet wide with a required dredge depth of -33.9 feet NGVD (–30.0 feet MLLW) (Moffatt & Nichol 1992). There is also a shallow draft channel further upstream from the Yacht Harbor with a dredge depth of -8.9 feet NGVD (-5.0 feet MLLW). It has not been dredged since 1960 due to budgetary constraints. (Larry Graham, USCOE project manager, pers. comm.). Dredged sediments have mostly consisted of silty clay (Moffatt & Nichol 1997).

Past dredge events for the Redwood Creek ship channel are listed on Table 11. Between 1973 and 1999, the channel was dredged eight times. For this entire period, the average annual dredge volume was 200,000 cubic yards/year, which corresponds to a vertical accretion of 10 inches/year, assuming an average dredge area of 3.5 miles by 350 feet. Among the separate dredge episodes, the average annual accretion varied from 3 inches/year (1977) to 20 inches/year (1993).

Moffatt & Nichol (1992) assessed local variation in sedimentation rates between 1984 and 1989 by comparing the 1984 post-dredge and 1989 pre-dredge surveys. Sedimentation varied from 3 inches/year to 20 inches/year of accretion, depending on location (see Figure 11). The highest sedimentation (from 10 to 20 inches/year) occurred in a one-mile segment that includes the junctions of West Point Slough and Corkscrew Slough. This area regularly receives the most sediment accumulation (Larry Graham, USCOE, pers. comm.; Michael J. Giari, Port of Redwood City, pers. comm.). The specific causes of this high sedimentation were not analyzed.

TABLE 11. Dredge Events for the Redwood Creek Ship Channel

Date of dredging	Date of previous dredging	Volume removed (cubic yards)	Average annual volume (CY/yr)	Average annual accumulation (in/yr)[1]
1977	1973	250,000	62,000	0.3
1981	1977	300,000	75,000	0.3
1984[2]	1981	790,000	260,000	1.1
1990	1984	800,000	110,000	0.5
1992[3]	1990	250,000	130,000	1.6
1993	1992	400,000	400,000	1.8
1996	1993	970,000	320,000	1.6
1999	1996	570,000	190,000	1.1
Average:				
1977	1999	4,300,000	200,000	0.8

[1]Accumulation calculated by using a depositional area 3.5-miles long and 350-feet wide.
[2]1984 dredge depth 2 to 8 feet shallower than design dredge depth of –33.9 feet NGVD (Moffatt & Nichol 1992).
[3]In 1992, only a 1-mile segment was dredged, versus 3.5 miles in all other years.
Sources: Moffatt & Nichol 1992, L. Graham, pers. comm.
Note: Design dredge depth is –33.9 feet NGVD (-30.0 feet MLLW).

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Vorametsanti, Peter, Senior Civil Engineer, Redwood City Department of Public Works, January 13, 2000 and April 6, 2000.

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FIGURES

figure 1

Bair Island

Site Location Map

Basemap: USGS topographic map (1959, revised 1968 and 1973)

N

0 5,000

feet

Approximate island boundaries

Everything within these lines is within the Restoration and Management Plan area

Outer Bair Island

Middle Bair Island

Inner Bair Island

Inactive salt production ponds

SAN FRANCISCO BAY NATIONAL WILDLIFE REFUGE

SALT EVAPORATORS

Redwood Point

BELMONT

SAN CARLOS

1413 loc map 2.cdr

PWA

figure 8

Bair Island

Field Survey Locations

Basemap: aerial photograph (2/18/00)

1413 fieldwork II.cdr

PWA

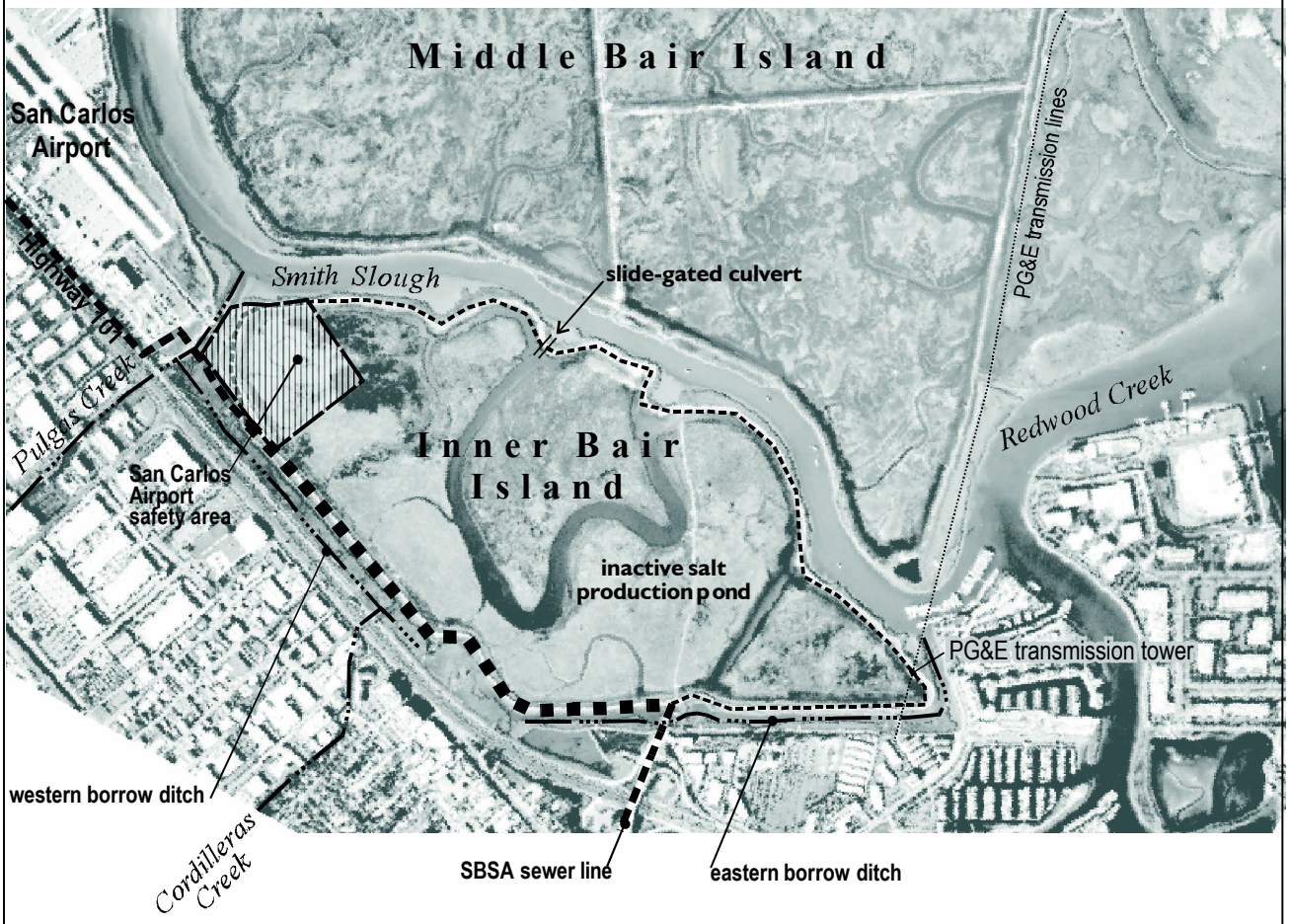
figure 7

Bair Island

Existing Conditions, Inner Bair Detail

Basemap: aerial photograph (2/18/00)

channels
levees
SBSA sewer line
SBSA sewer line under levee



N

0 2,000 4,000

feet

Inner Bair.cdr

PWA

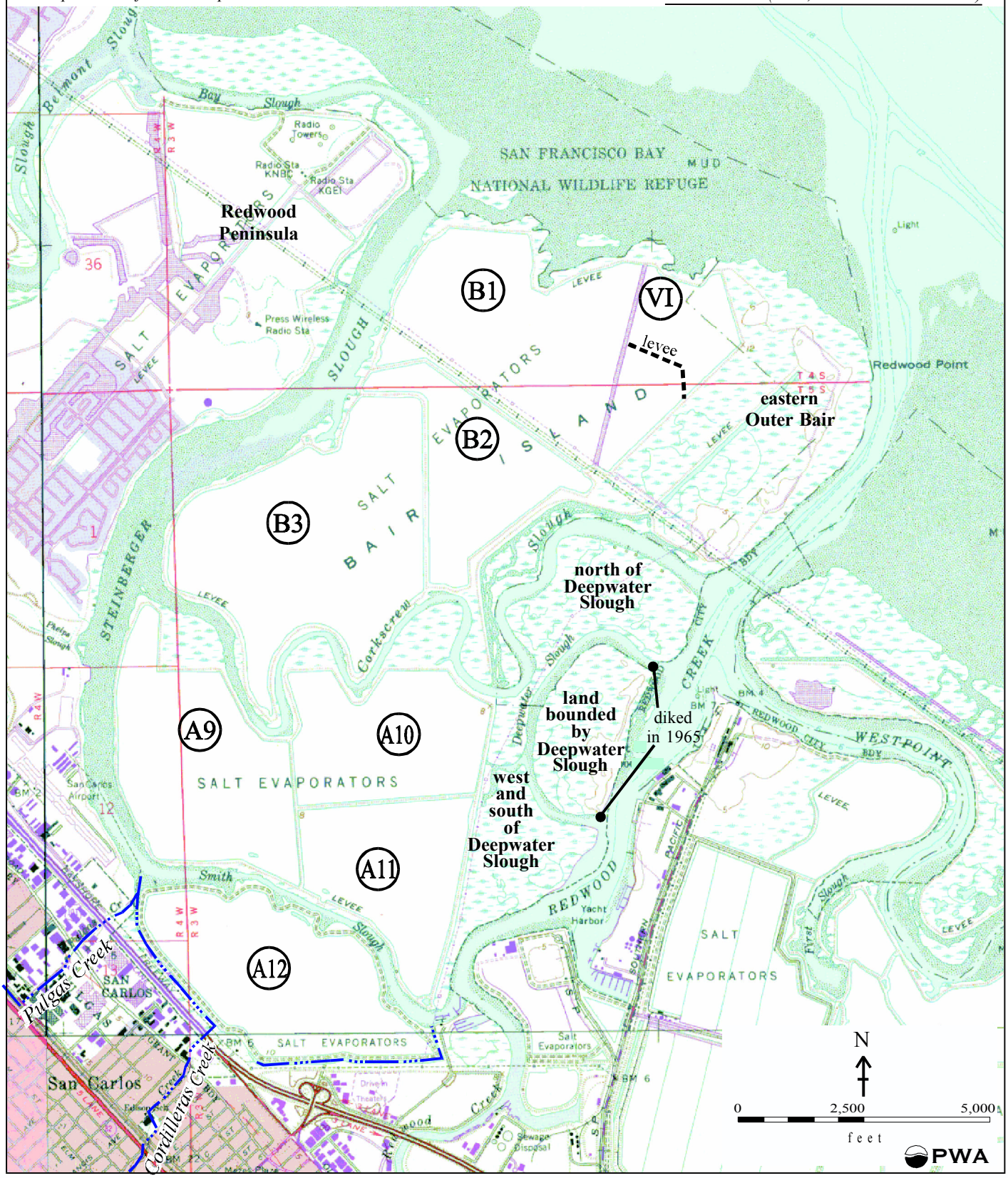
figure 6

Bair Island

Sub-Area Map

Basemap: USGS topographic map (1959, revised 1968 and 1973)

Note:
Number and letter sub-area names correspond with former salt pond names

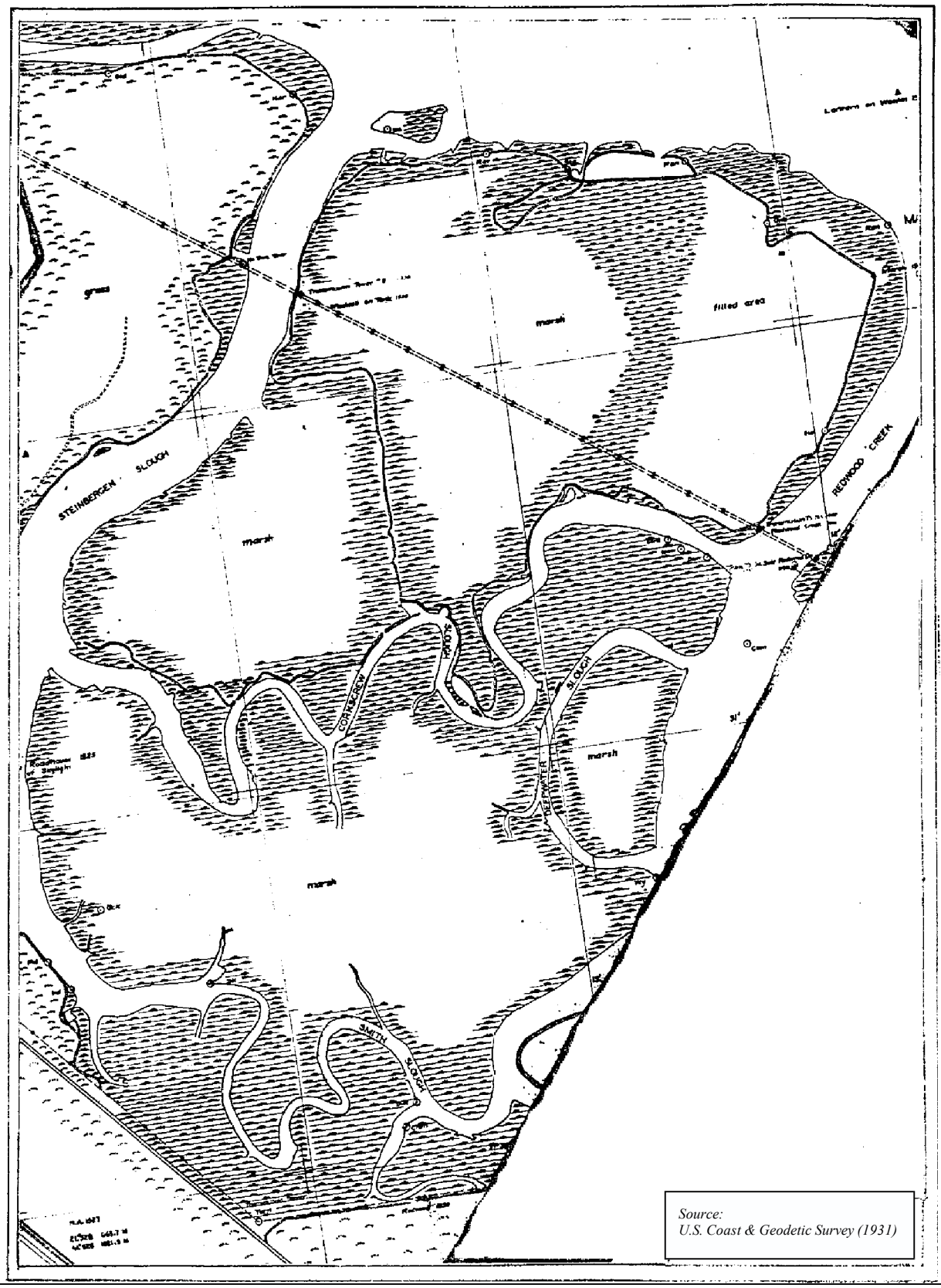


1413 salt ponds.cdr

figure 5

Bair Island

Historic Conditions, 1931



1931map.cdr

PWA

figure 4

Bair Island
Historic Conditions, 1897

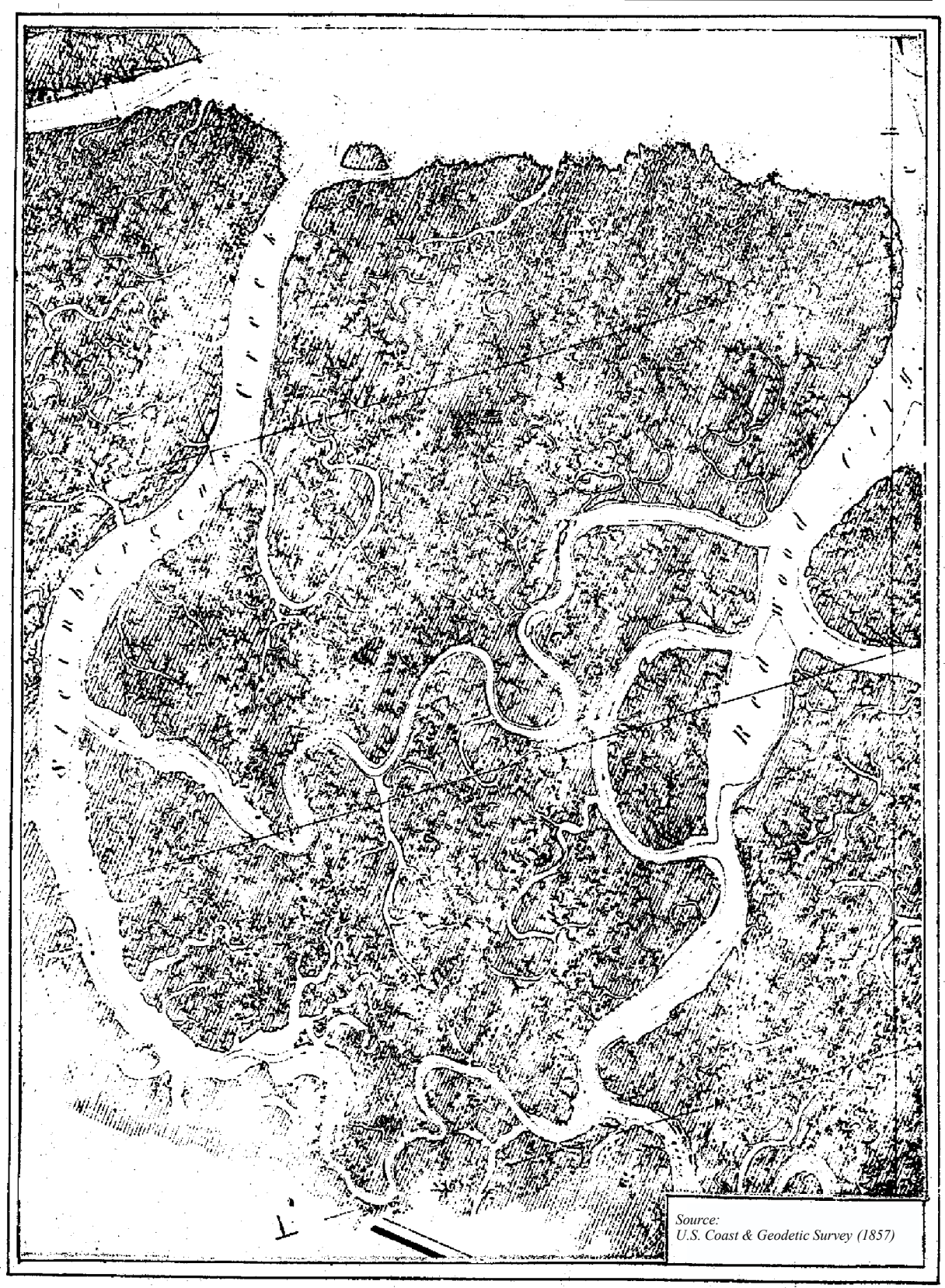
1897map.cdr

PWA

figure 3

Bair Island

Historic Conditions, 1857



1857map.cdr

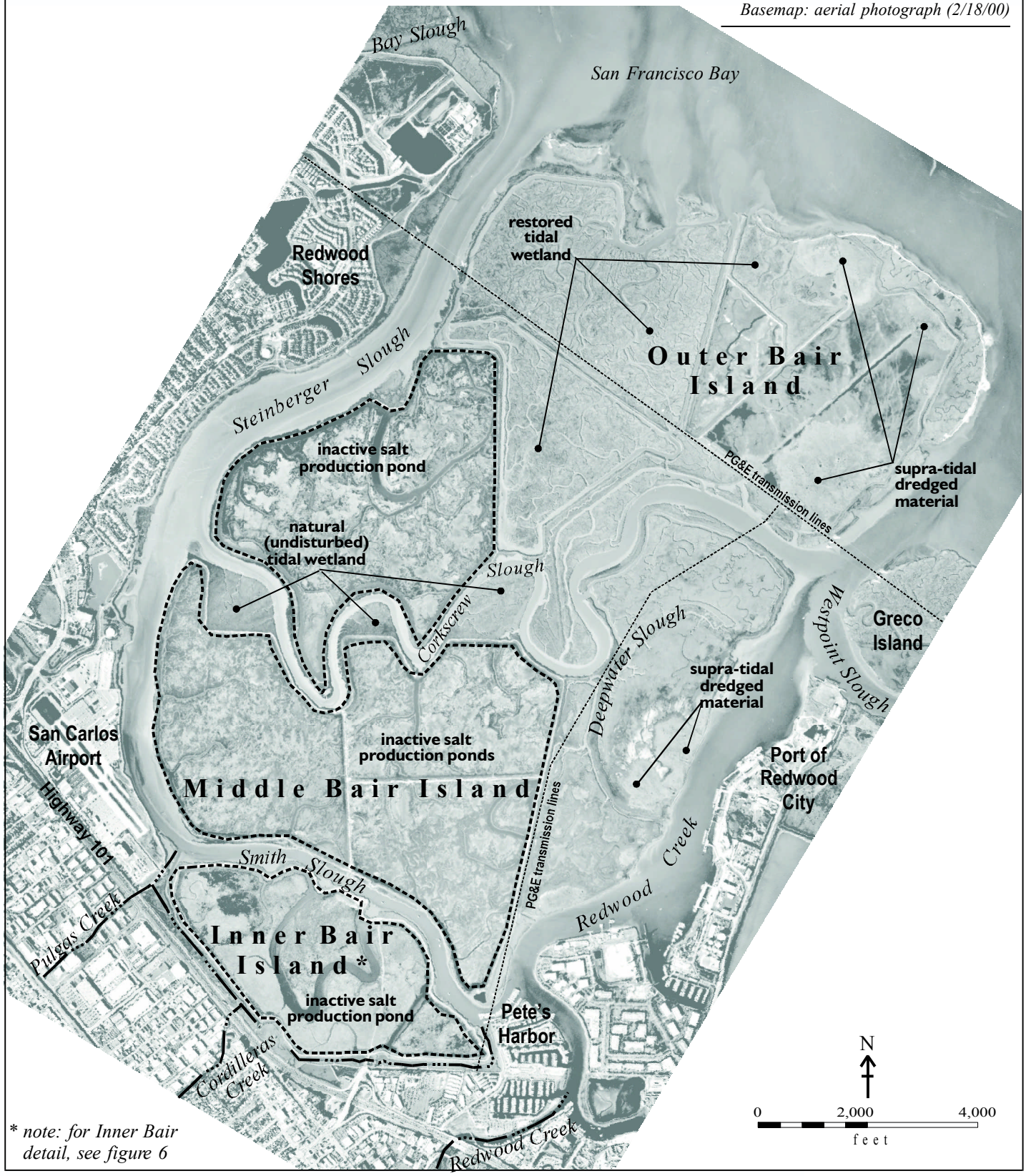
PWA

figure 2

Bair Island

Existing Conditions

Basemap: aerial photograph (2/18/00)



* *note: for Inner Bair detail, see figure 6*

1413 ex cond photo2.cdr

PWA

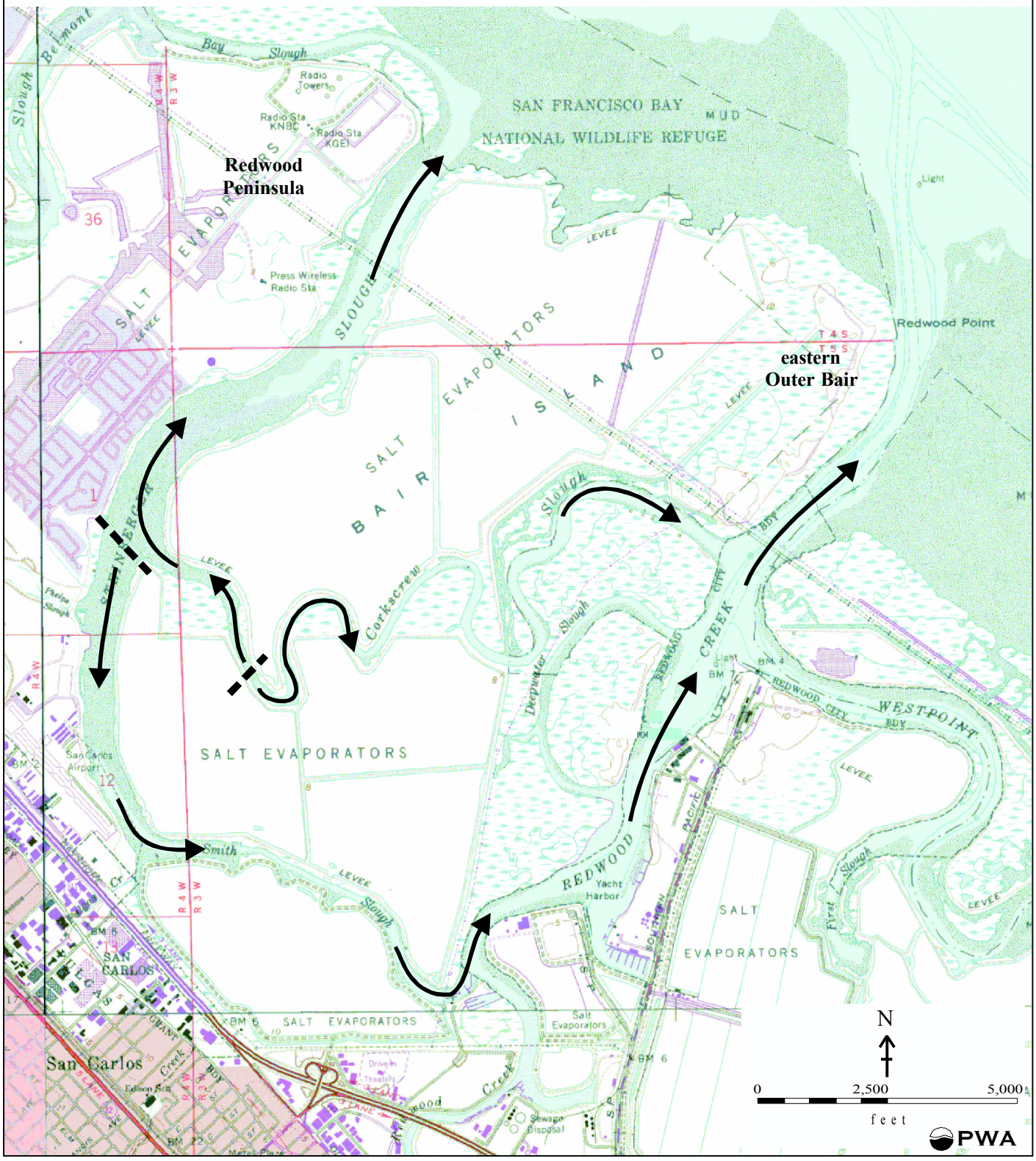
figure 9

drainage divide at low tide
ebb tide flow direction at low tide

Bair Island

Drainage Divides and Flow Directions at Low Tide

Basemap: USGS topographic map (1959, revised 1968 and 1973)



1413 flow direction.cdr

figure 9

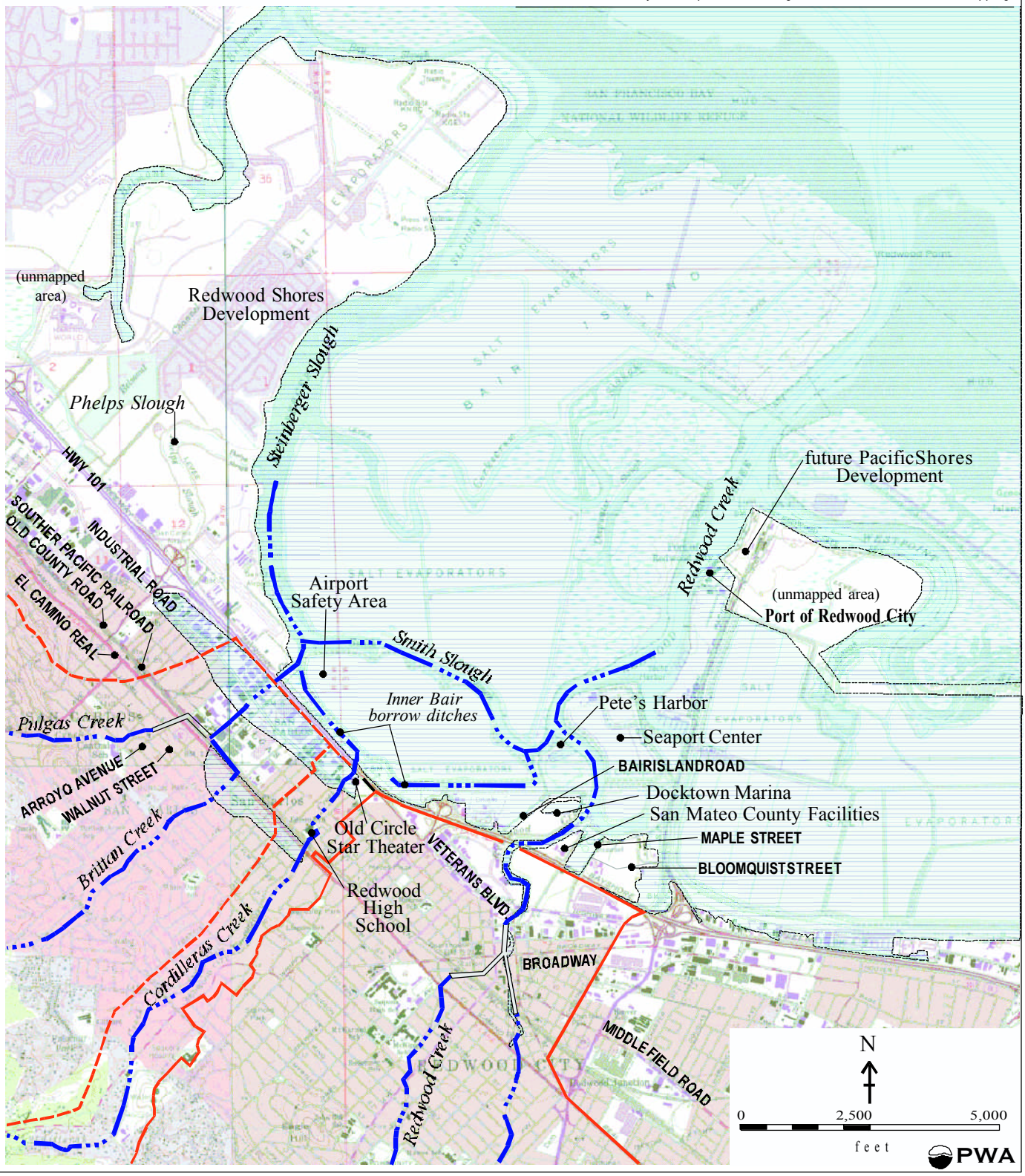
Bair Island

Regional Drainage Map

area inundated by 100 year flood
watershed divide
approximate watershed divide
creeks
culverts

Source: FEMA, Flood Insurance Rate Map; San Carlos (1979), Redwood City (1982)
Basemap: USGS topographic map (1959, revised 1968 and 1973)

Note: Levee improvements on Inner Bair Island & the Seaport Center have removed these areas from the 100-year floodplain. This change is not reflected in current FEMA mapping.



1413 drainage map.cdr

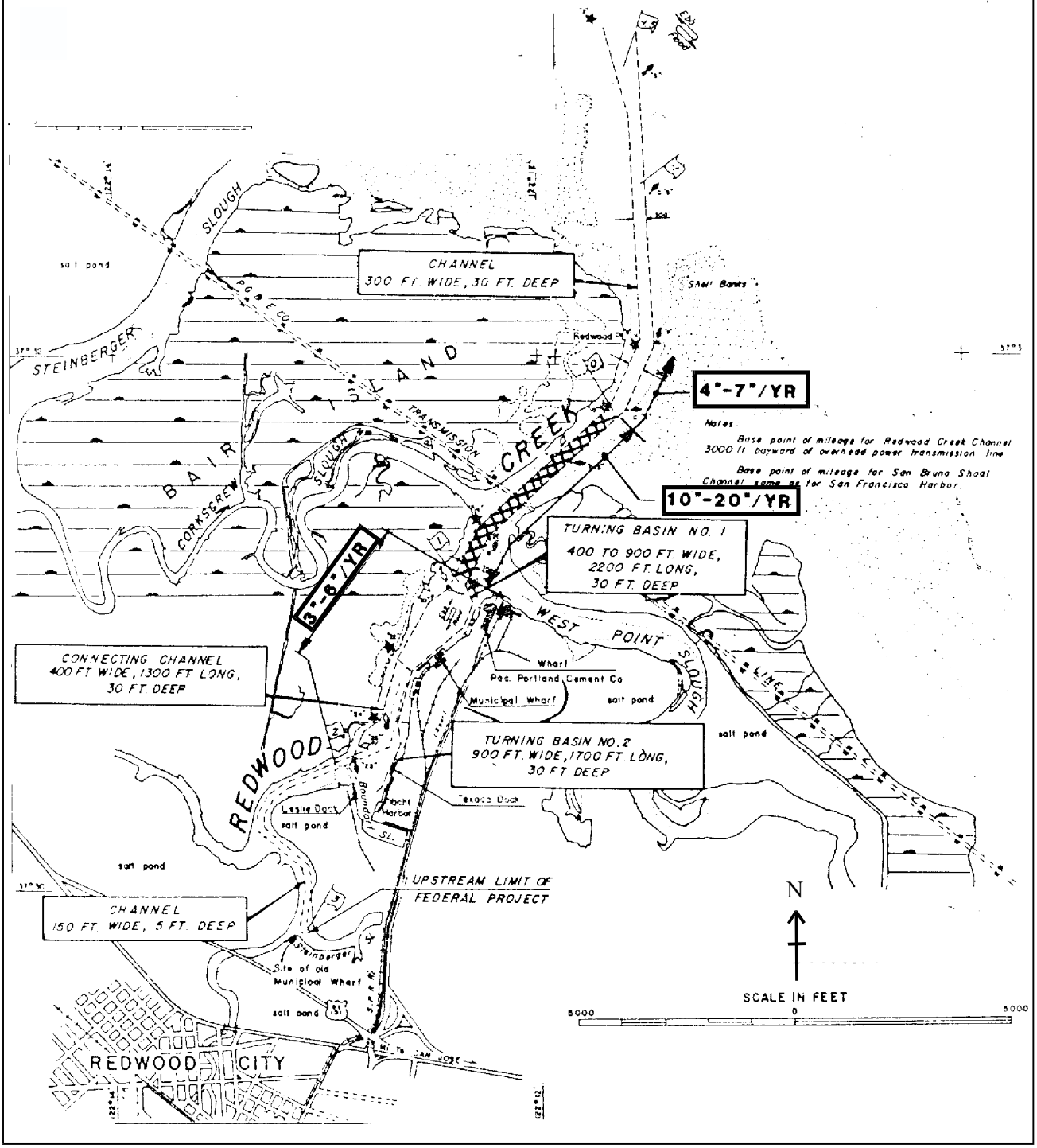
figure 10

Bair Island

Redwood City Harbor Dredging

source: USACE (1972)

= location where significant shoaling occurs



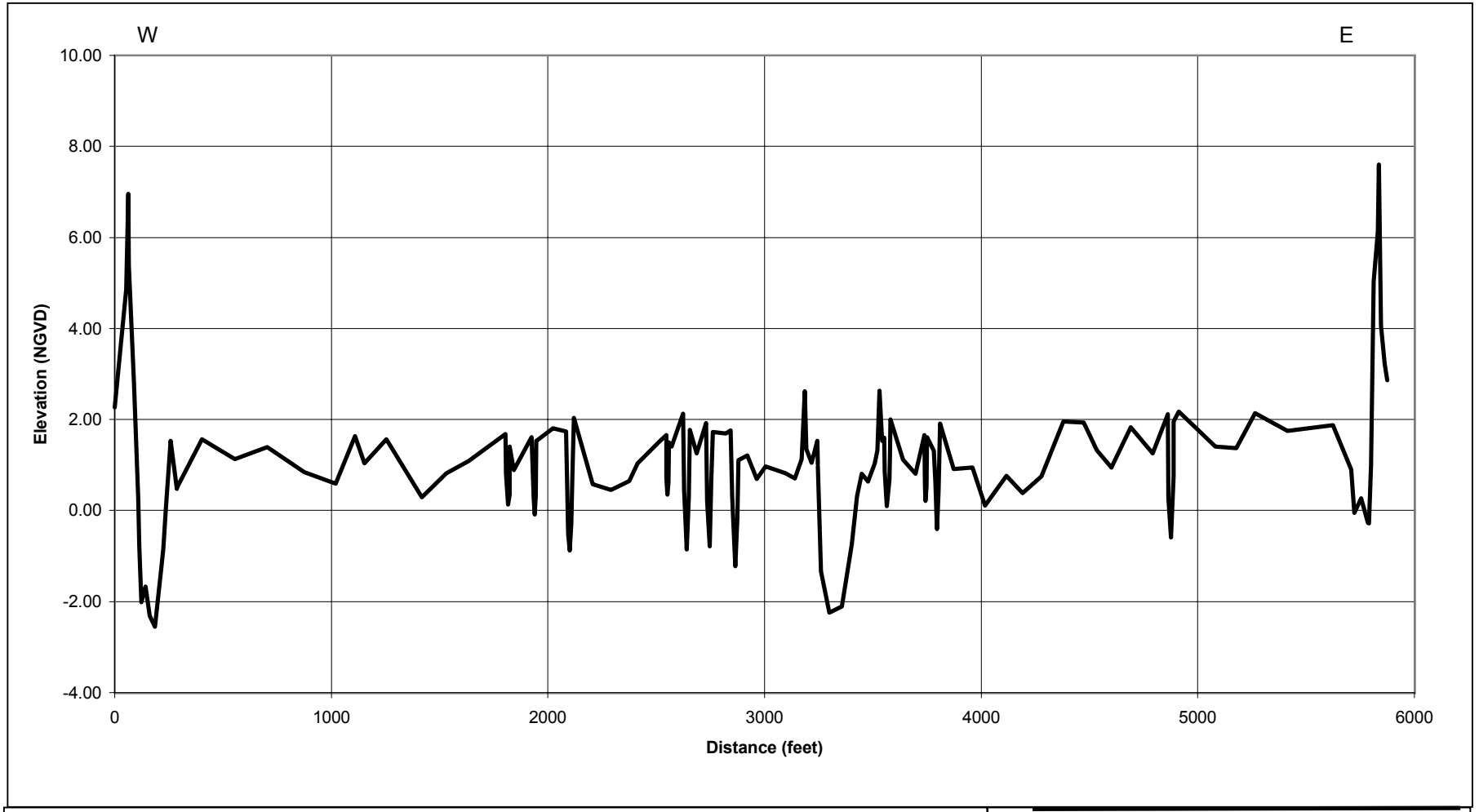
PWA

APPENDIX A
FIELD SURVEYS

- Topographic transects T1 through T6 and Safety Zone transect
- Pond interior channel cross sections 1 through 17
- South Bay System Authority (SBSA) levee cross-sections 1 through XS5
- Hydrographic cross-sections in the major slough channels:
  location map and cross-sections 1 through 30
- Tide measurements for 6 stations

APPENDIX A
FIELD SURVEYS

A-1 Topographic transects T1 through T6 and Safety Zone transect

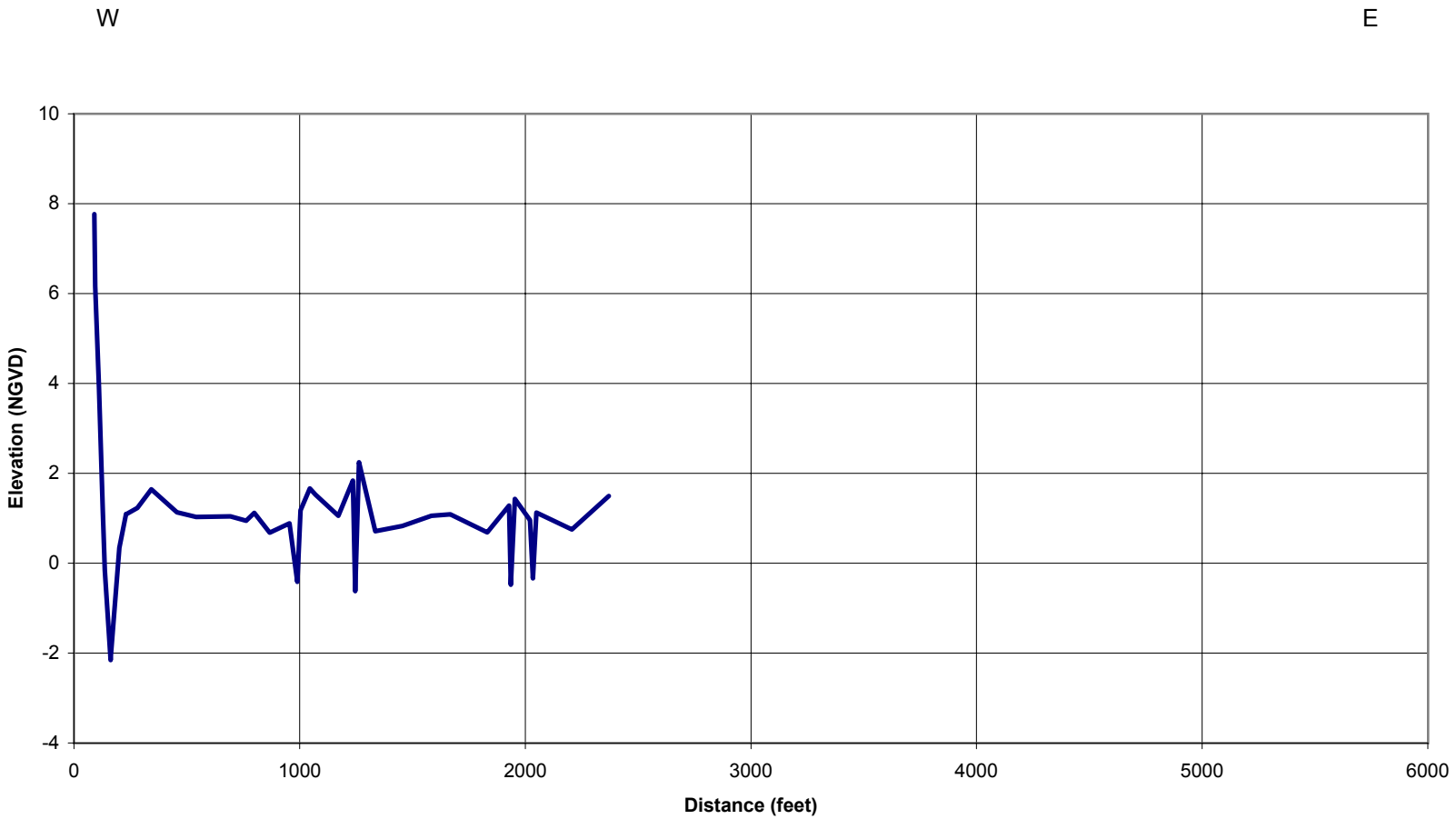


Source: PWA field surveys (March 2000).

BAIR ISLAND
T1

PWA

PWA#: 1413

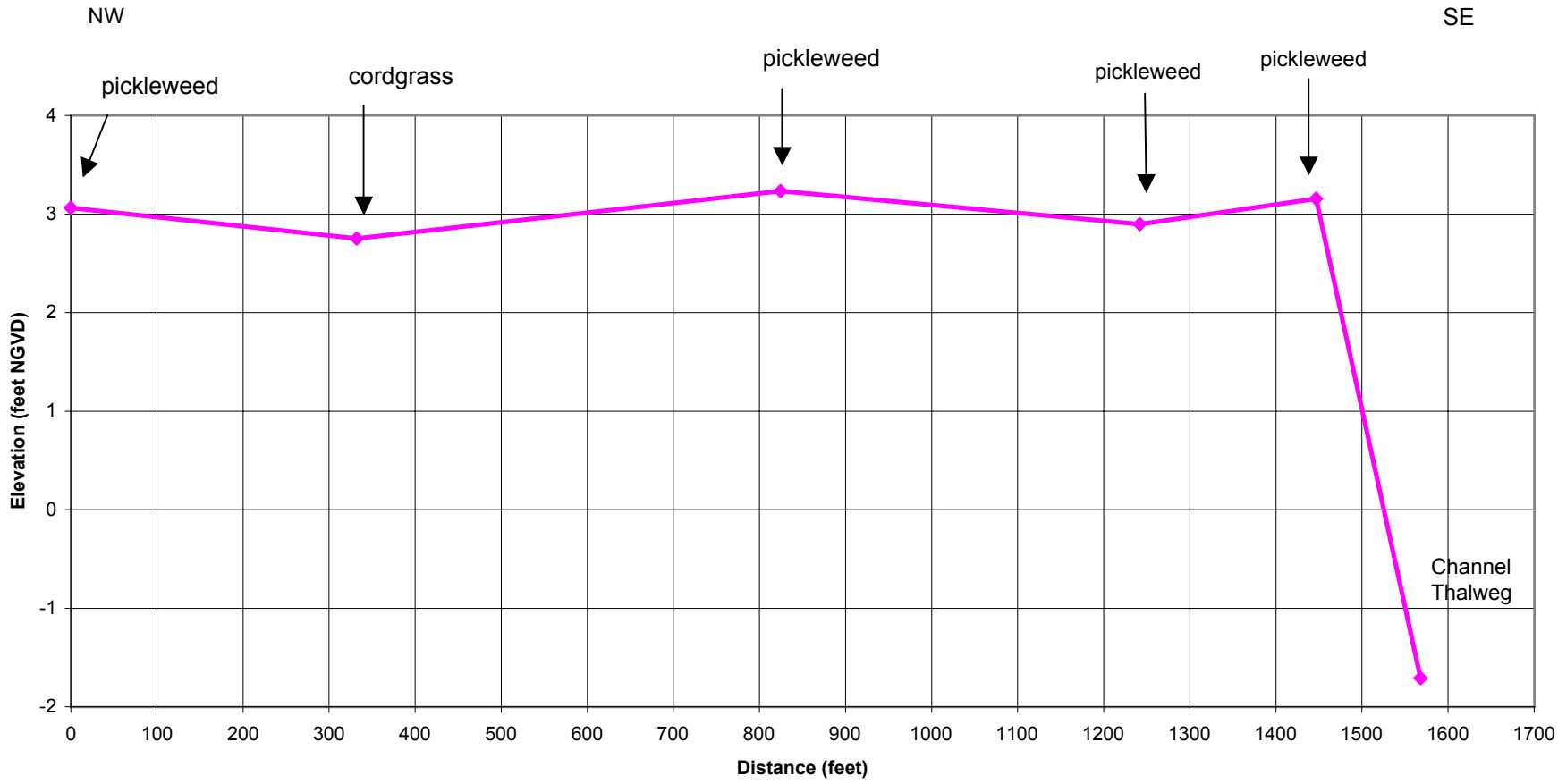


Source: PWA field surveys (July 2000).

BAIR ISLAND
T2

PWA

PWA#: 1413

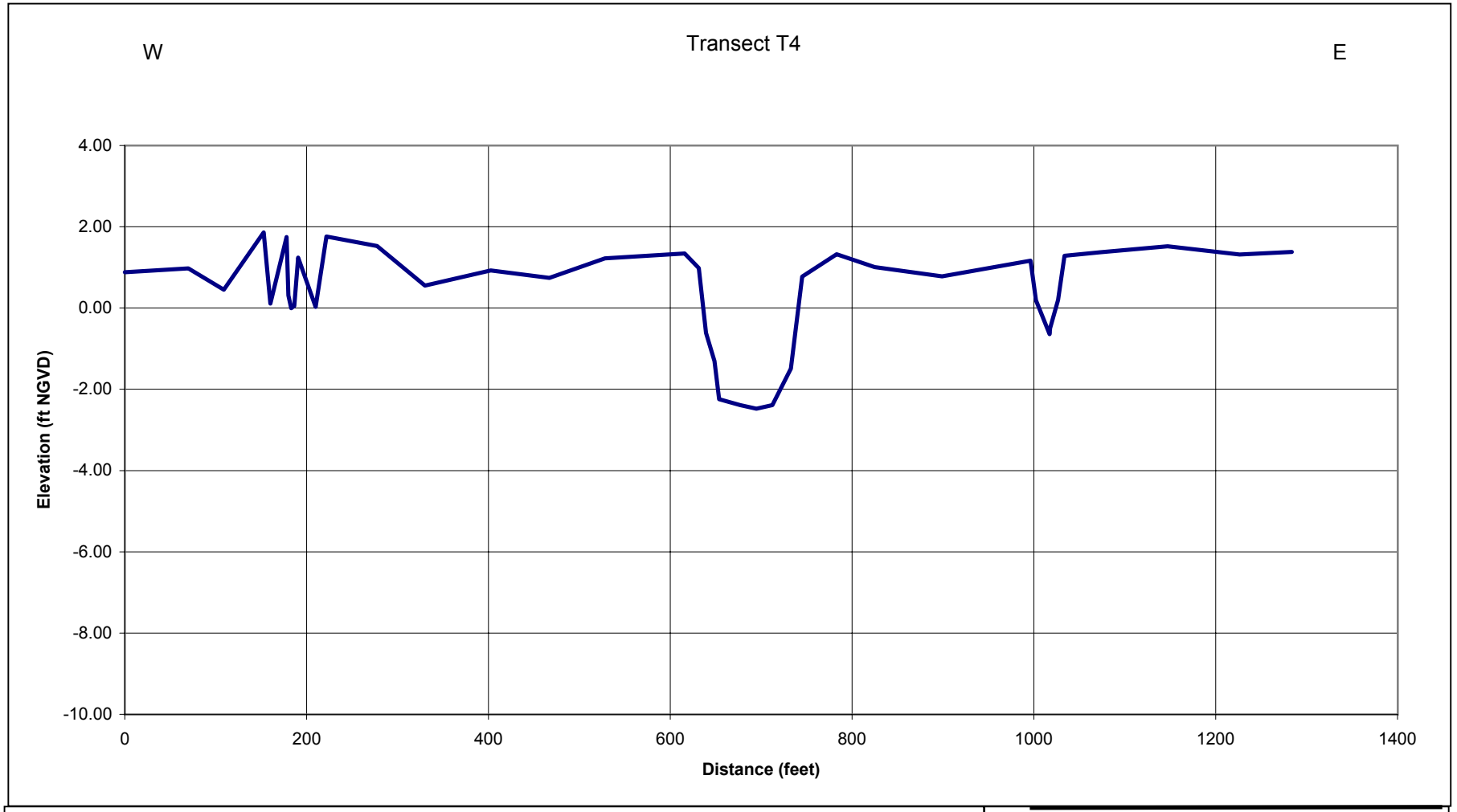


Source: April 19, 2000 PWA survey (this study).
Note: Transect located parallel to and ~10 feet north of power tower boardwalk.

Bair Island
Outer Bair Transect T3 (Pond B-1)

PWA

PWA#: 1413

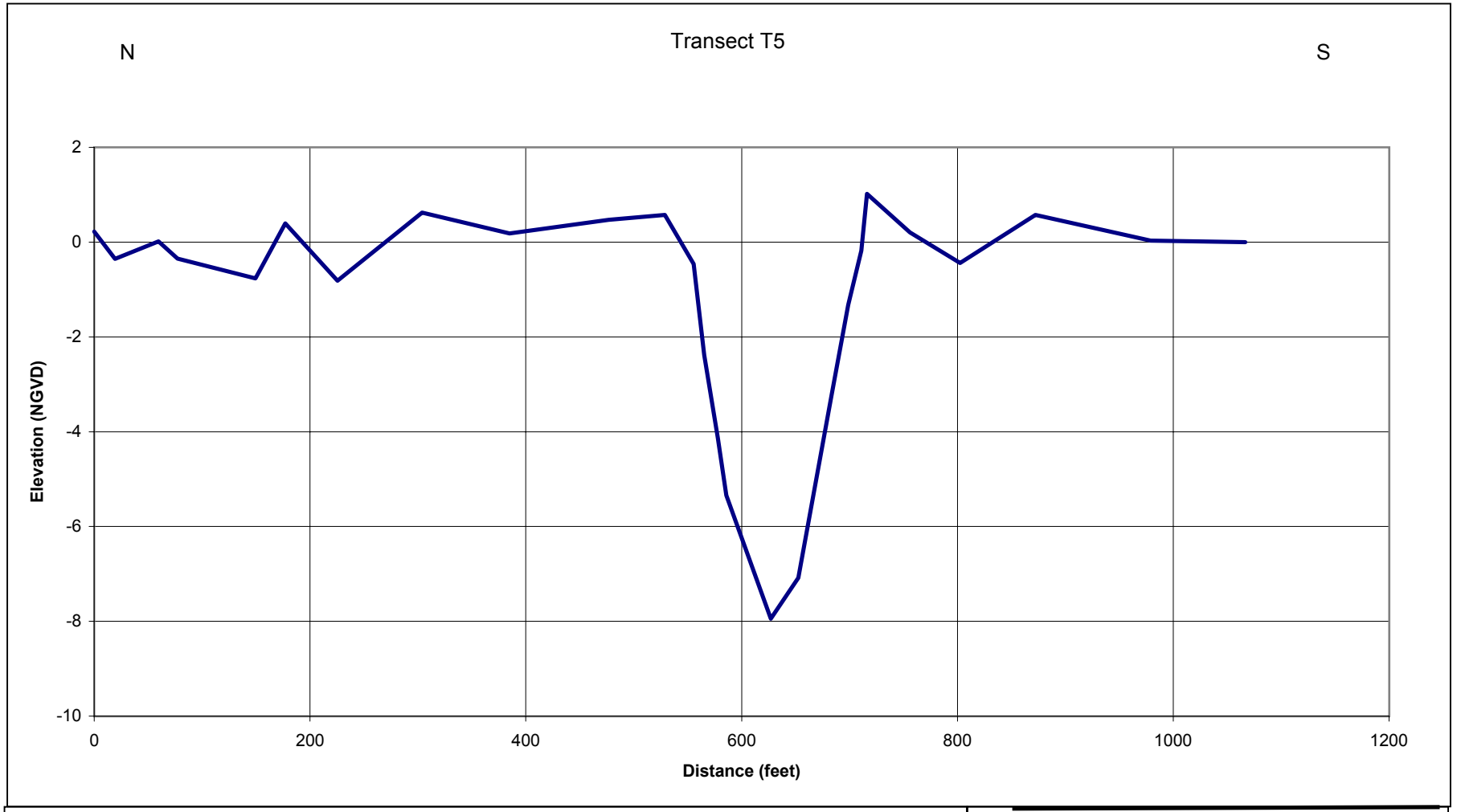


Source: PWA field surveys (March 2000).

BAIR ISLAND
Transect T4

PWA

PWA#: 1413

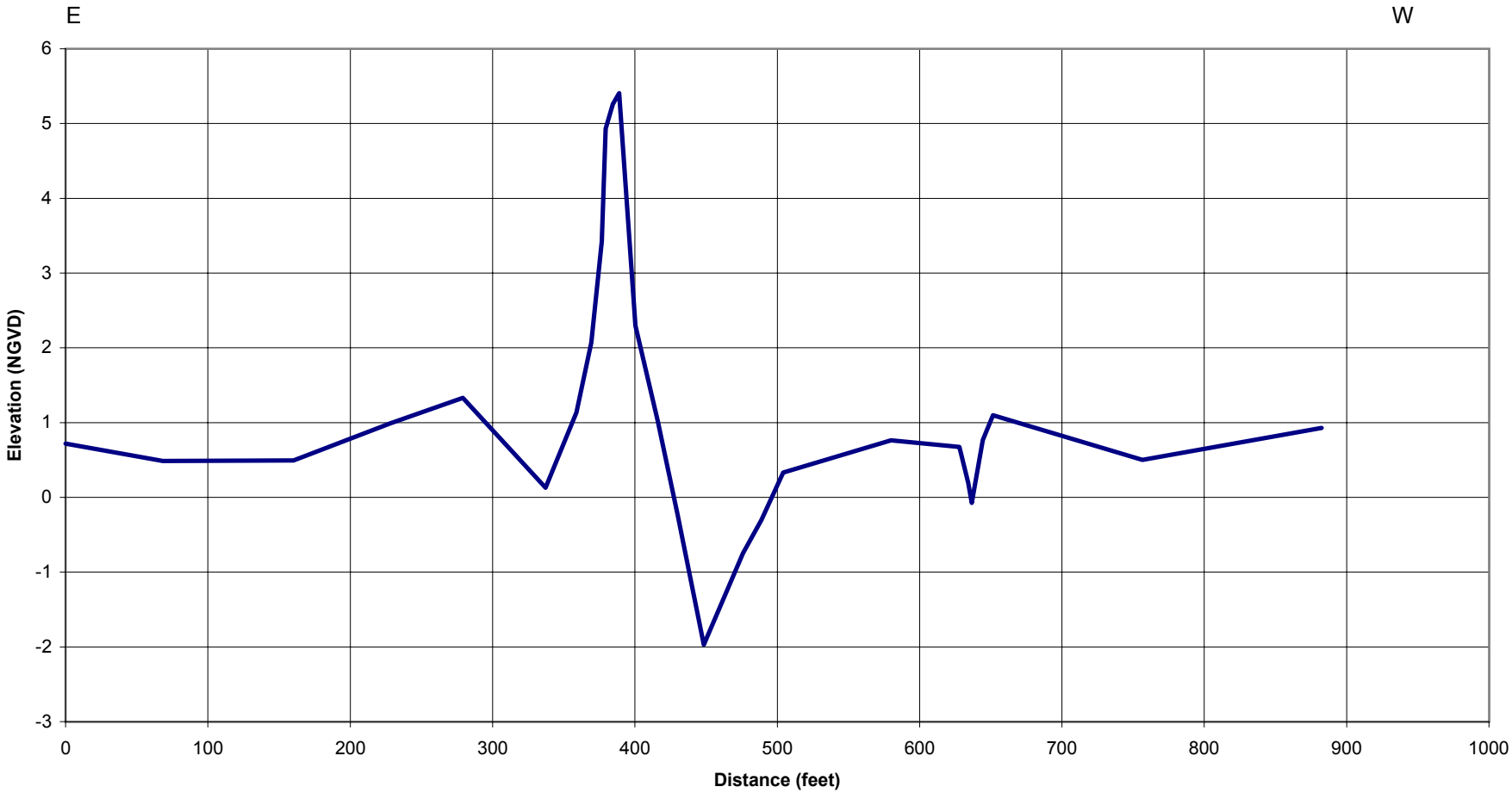


Source: PWA field surveys (March 2000).

BAIR ISLAND
T5

PWA

PWA#: 1413

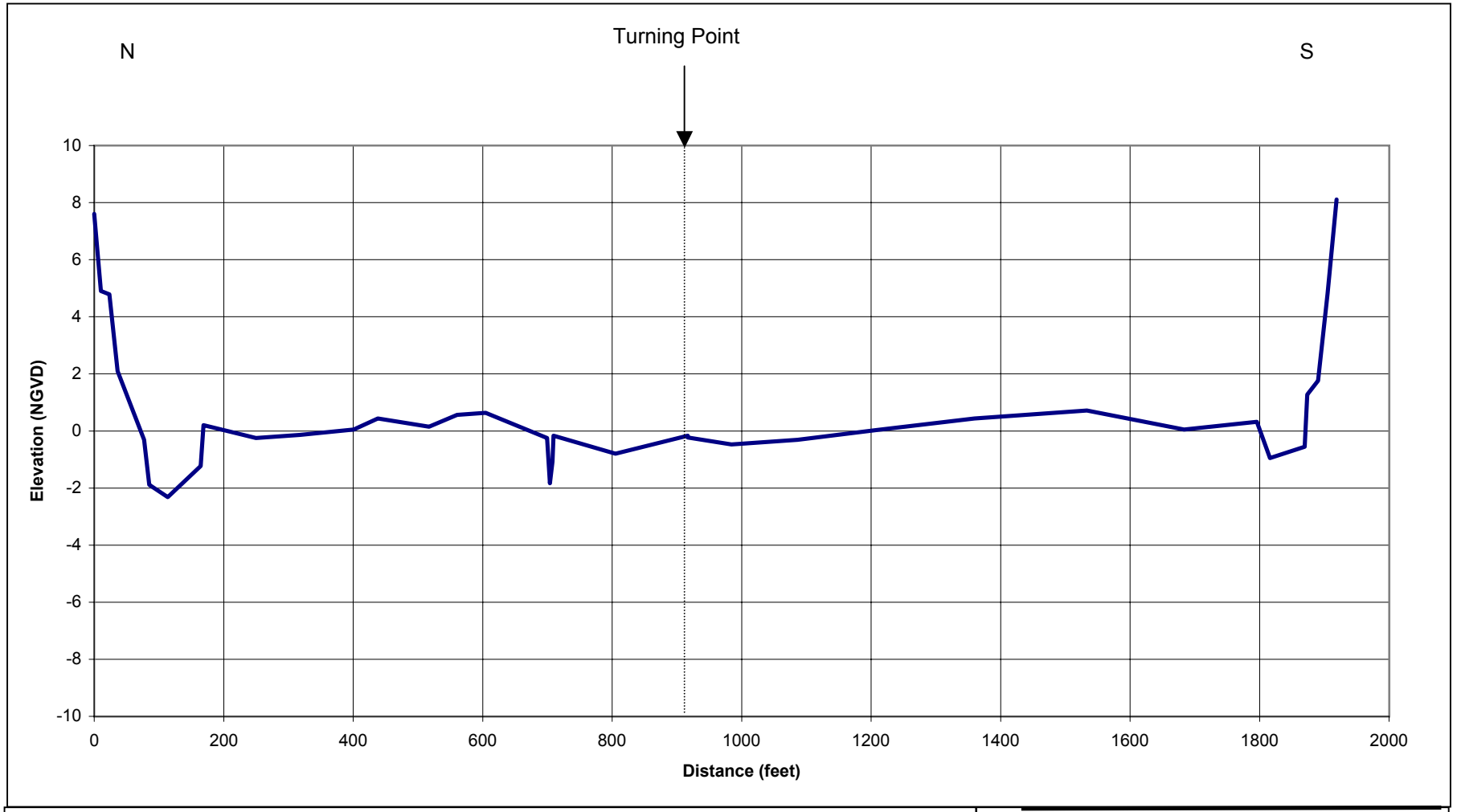


Source: PWA field surveys (March 2000).

BAIR ISLAND
T6

PWA

PWA#: 1413



Source: PWA field surveys (March 2000).

BAIR ISLAND

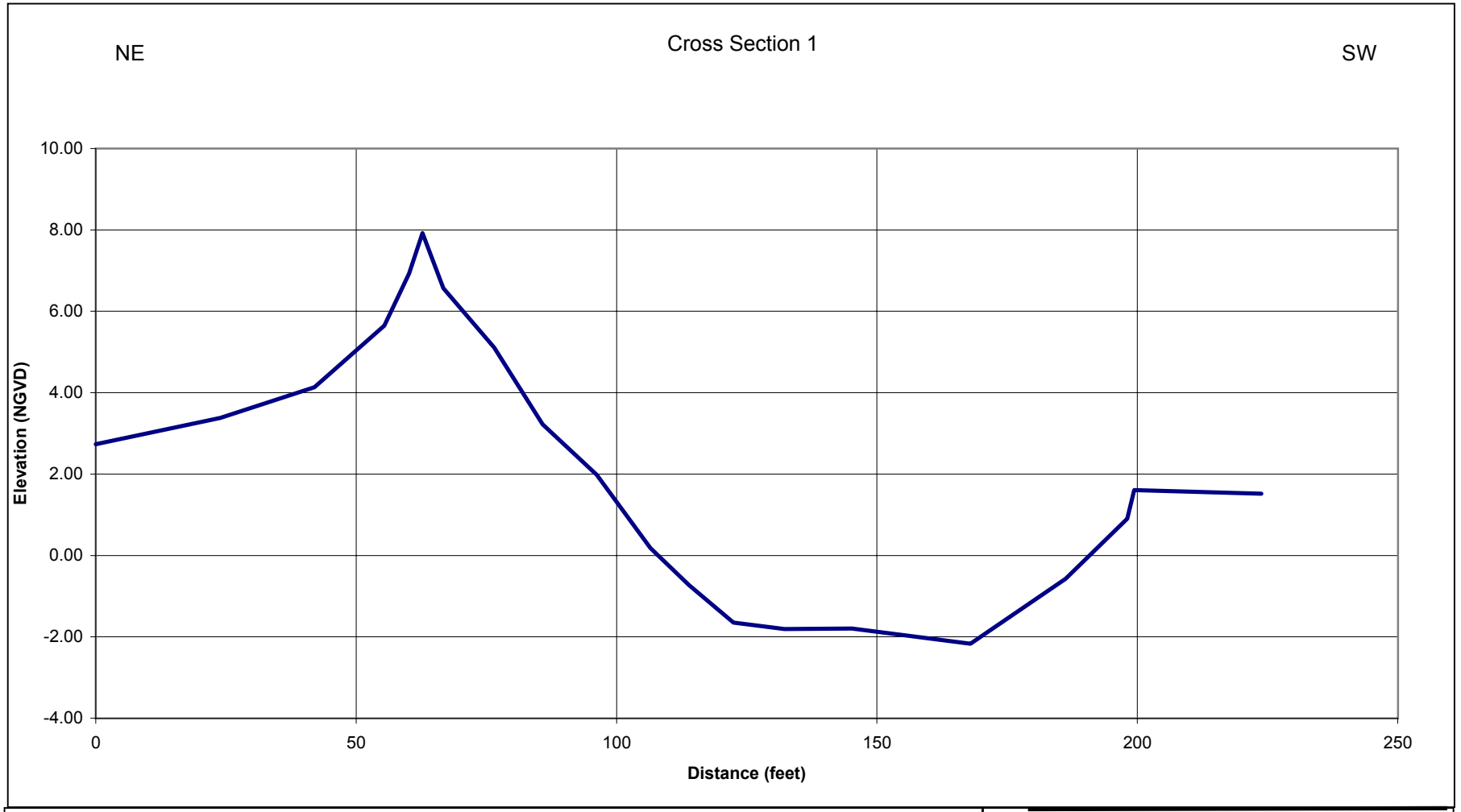
Transect T SZ (Safety Zone)

PWA

PWA#: 1413

APPENDIX A
FIELD SURVEYS

A-2 Pond interior channel cross sections 1 through 17

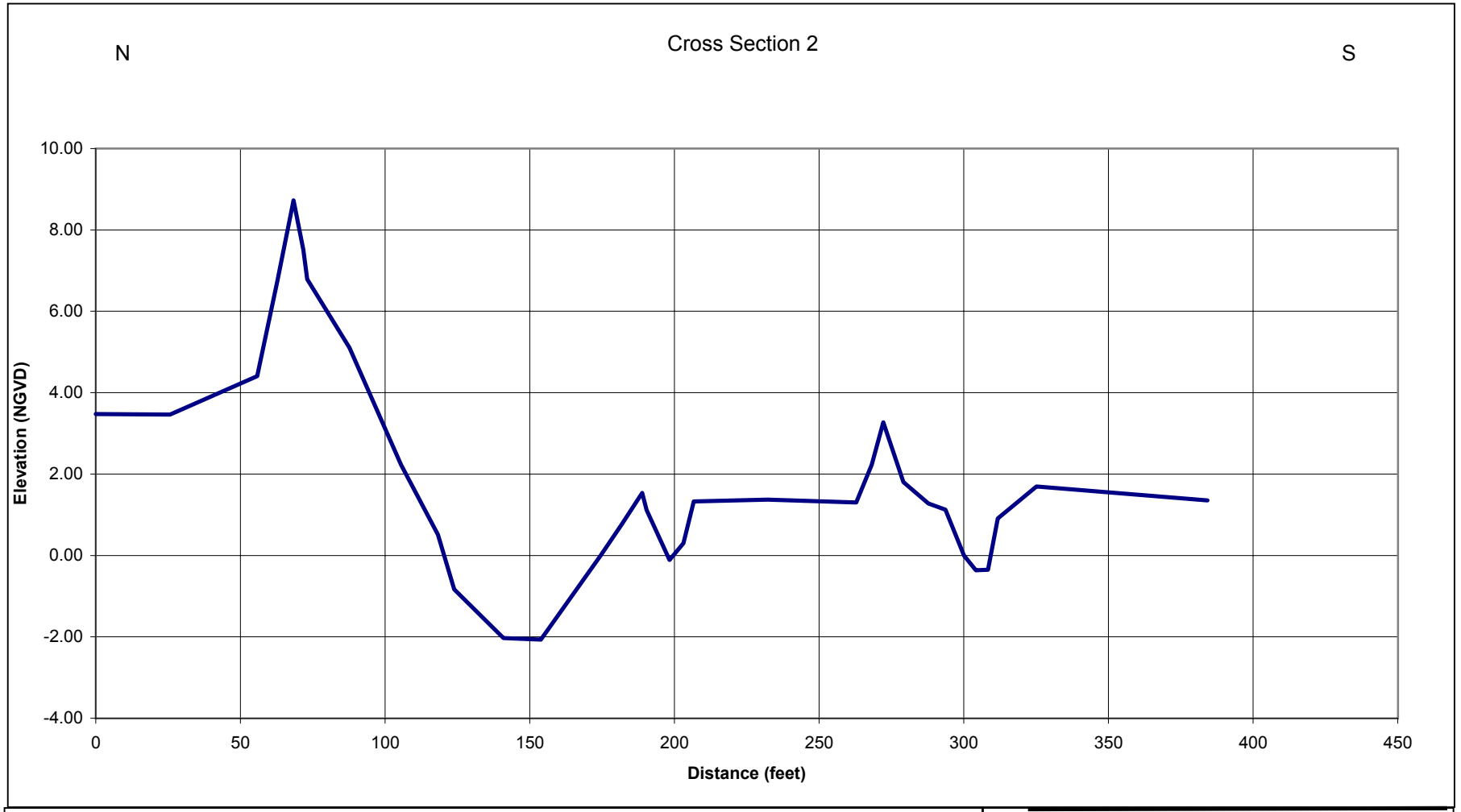


Source: PWA field surveys (March 2000).

BAIR ISLAND
xs 1

PWA

PWA#: 1413

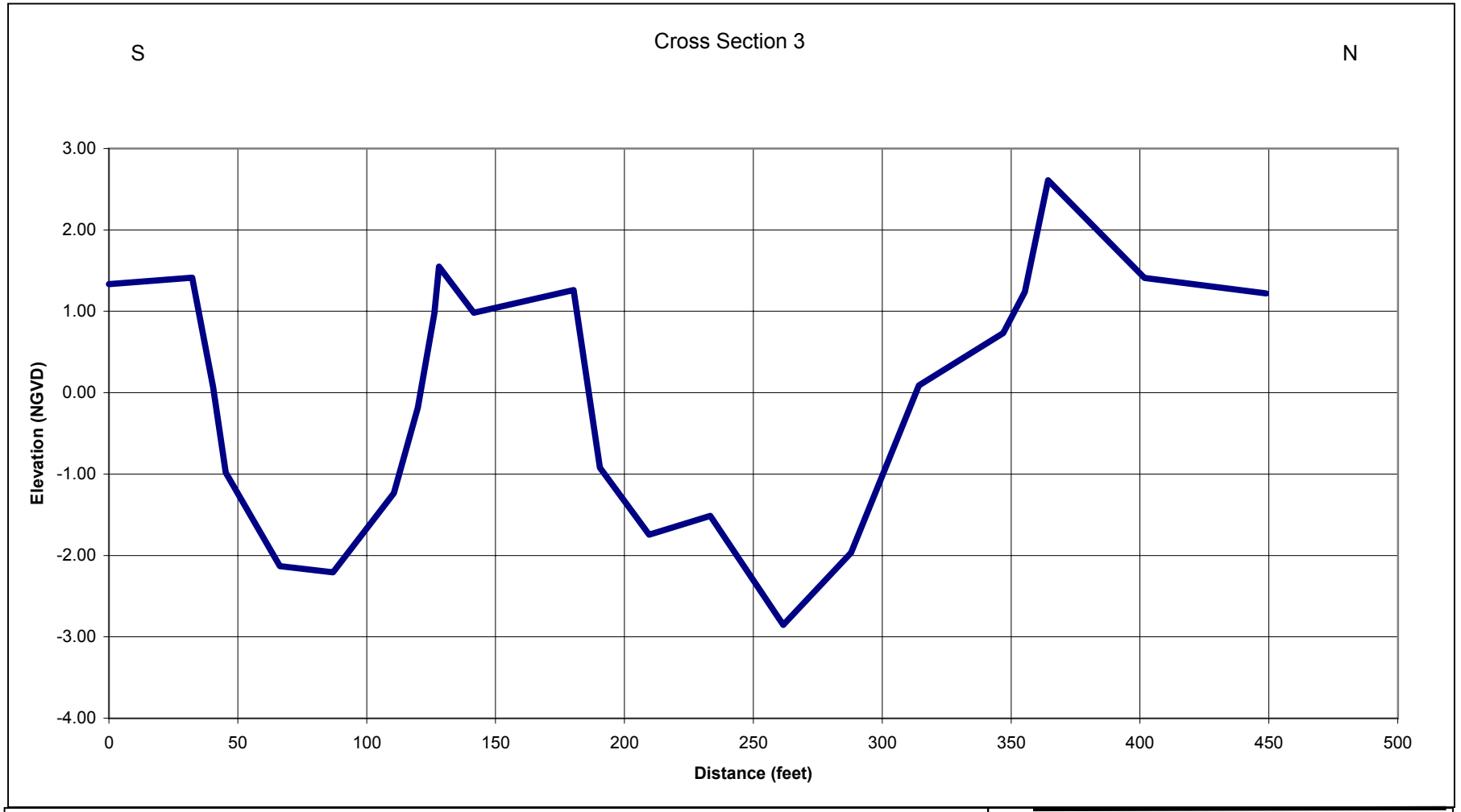


Source: PWA field surveys (March 2000).

BAIR ISLAND
xs 2

PWA

PWA#: 1413

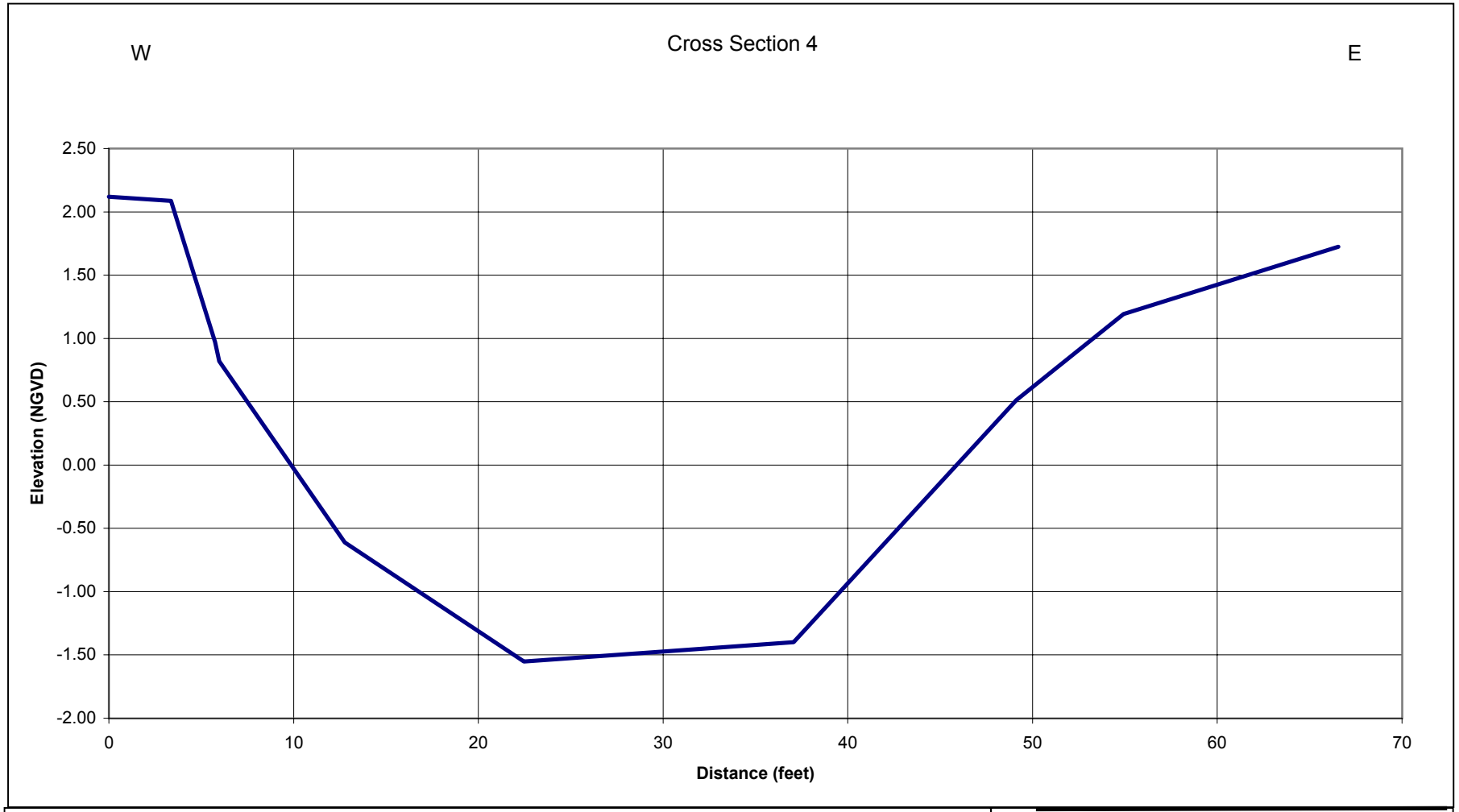


Source: PWA field surveys (March 2000).

BAIR ISLAND
xs 3

PWA

PWA#: 1413

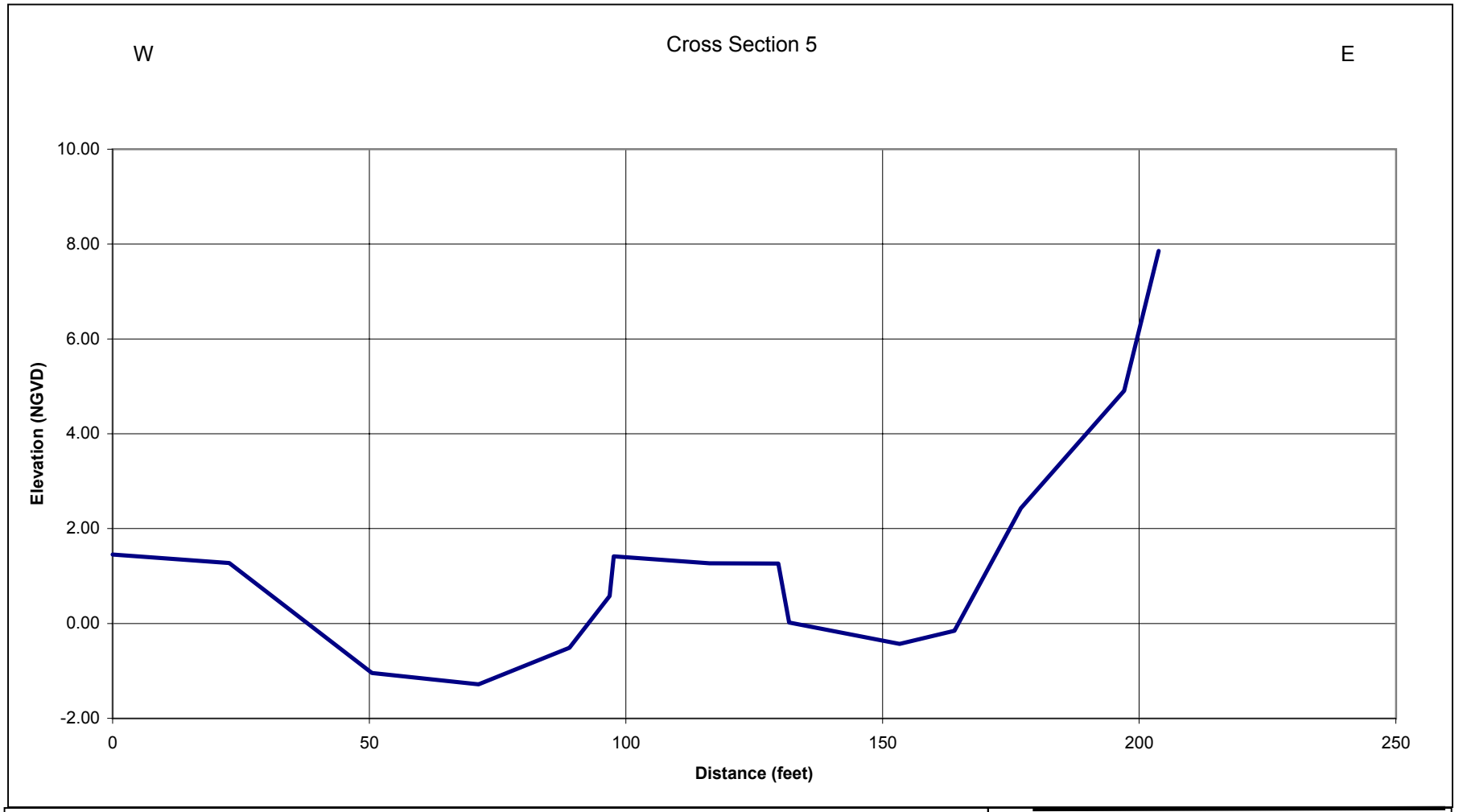


Source: PWA field surveys (March 2000).

BAIR ISLAND
xs 4

PWA

PWA#: 1413

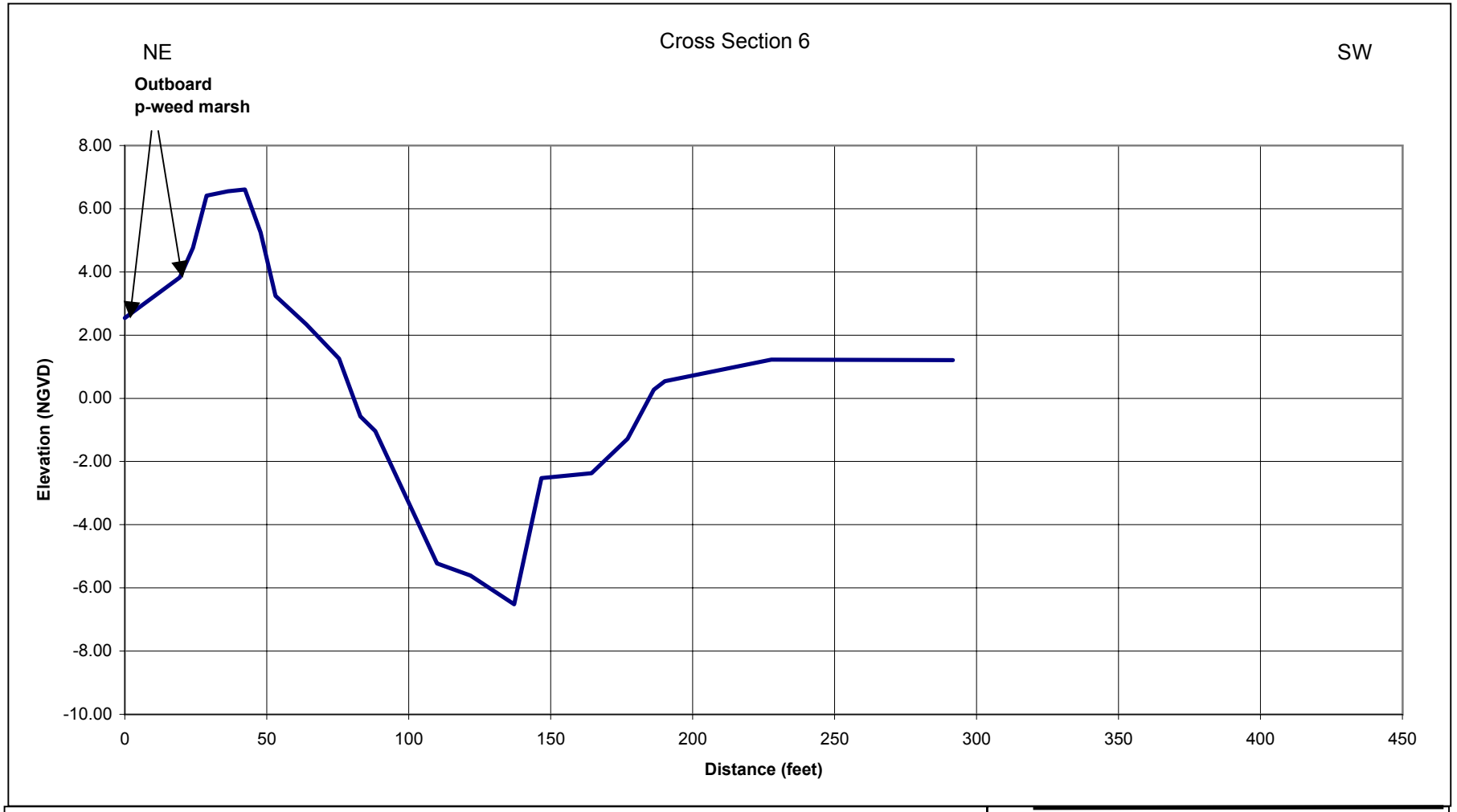


Source: PWA field surveys (March 2000).

BAIR ISLAND
xs 5

PWA

PWA#: 1413

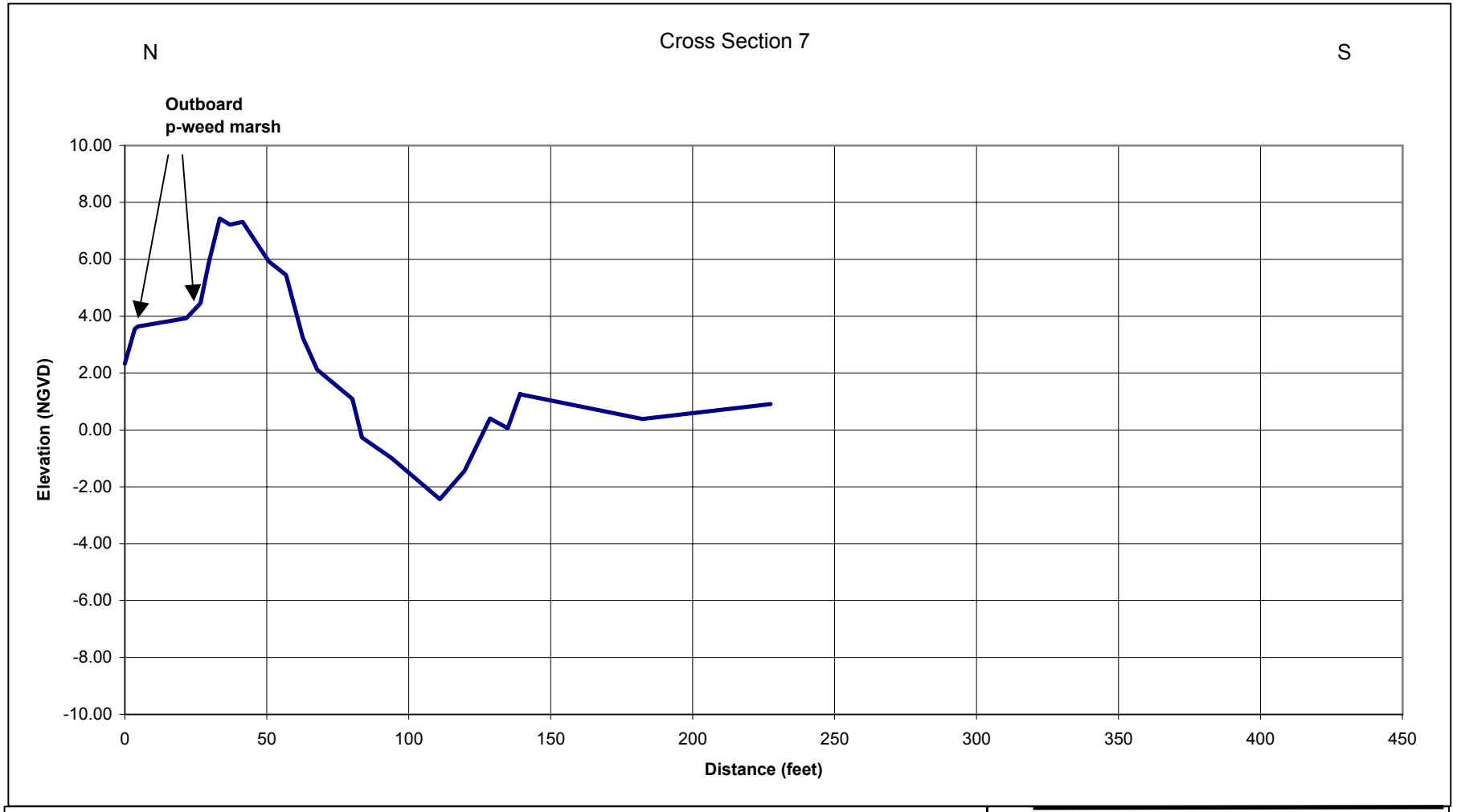


Source: PWA field surveys (March 2000).

BAIR ISLAND
xs 6

PWA

PWA#: 1413

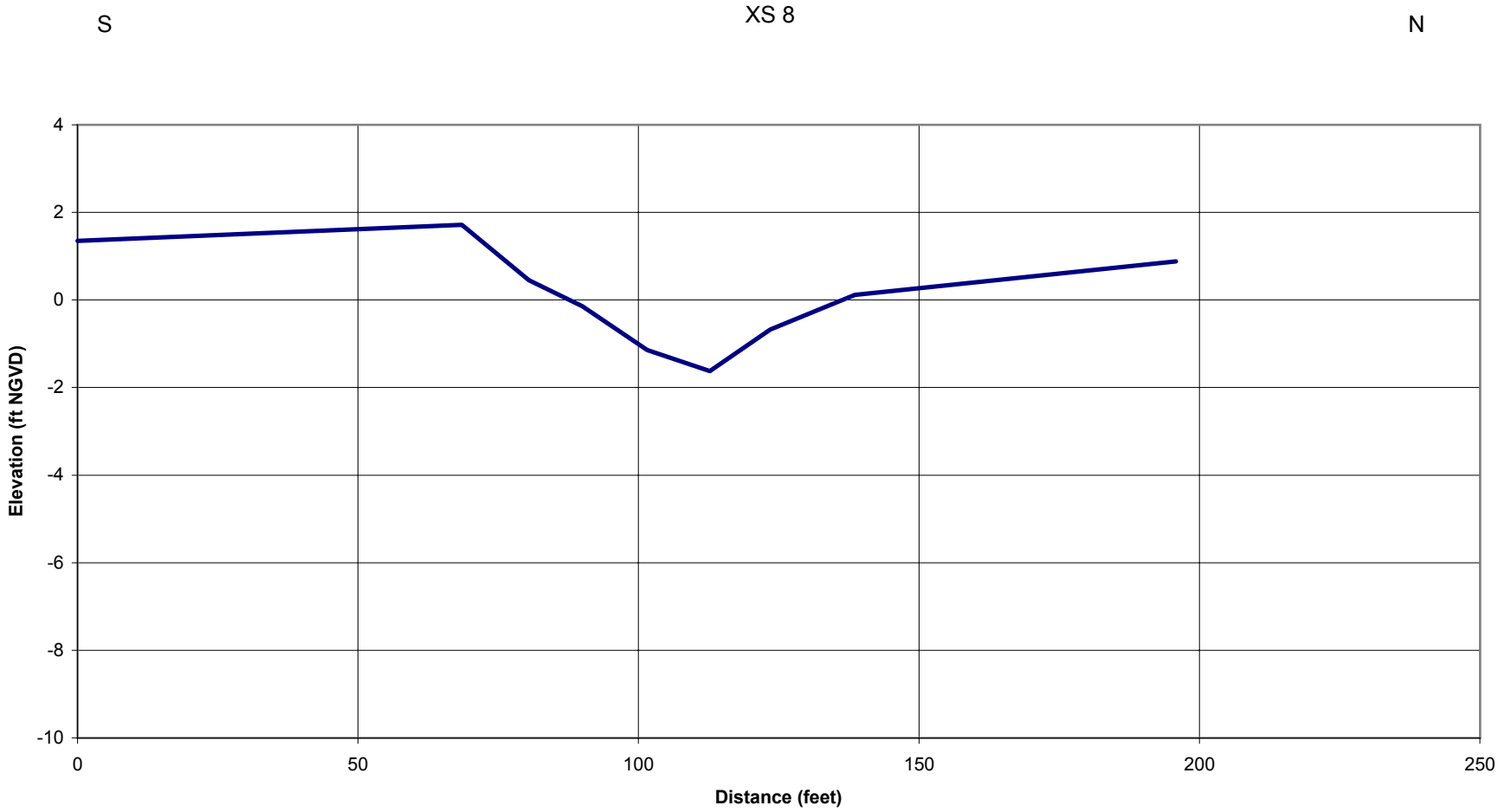


Source: PWA field surveys (March 2000).

BAIR ISLAND
xs 7

PWA

PWA#: 1413

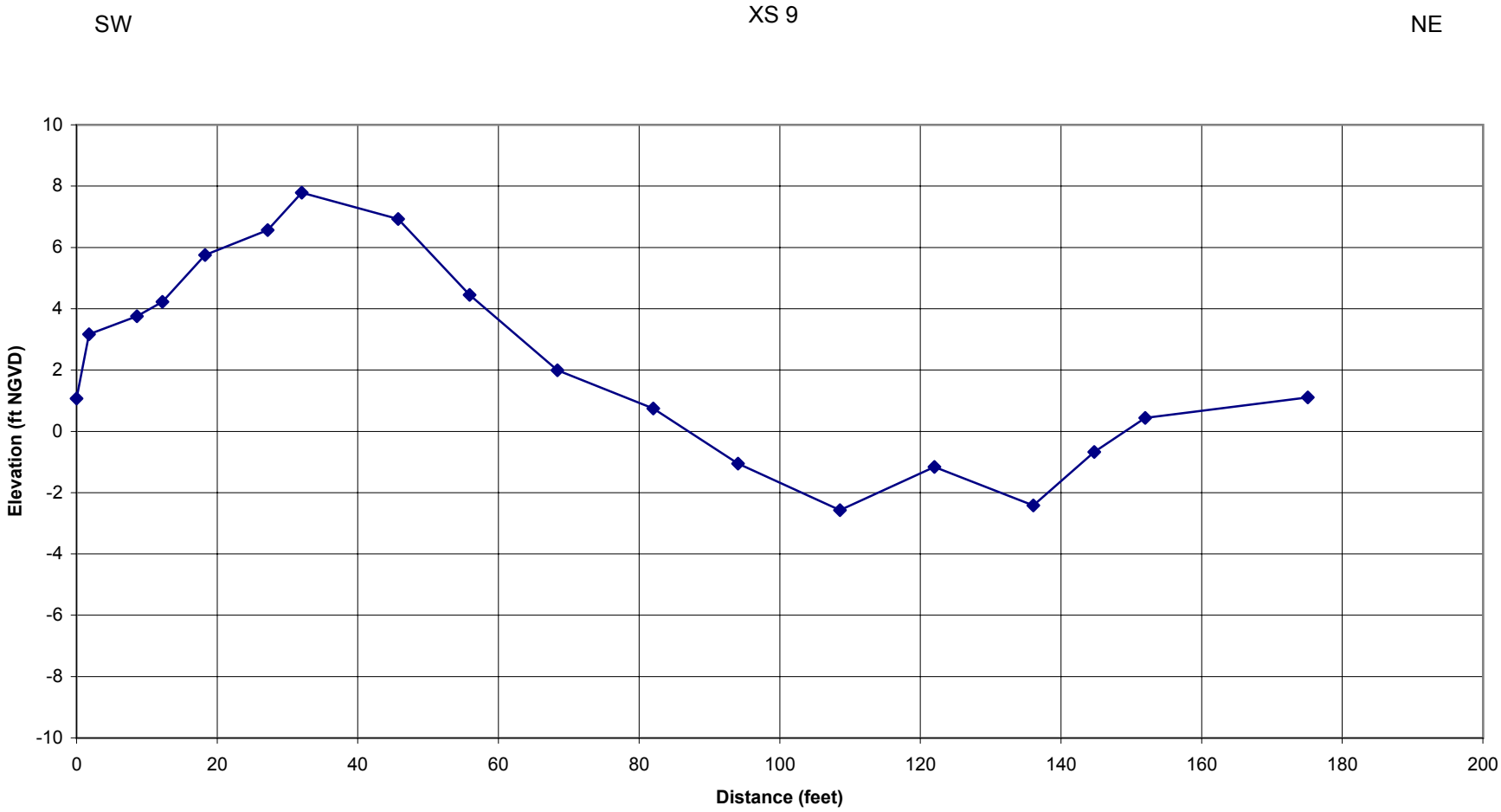


Source: PWA field surveys (March 2000).

BAIR ISLAND
XS 8

PWA

PWA#: 1413

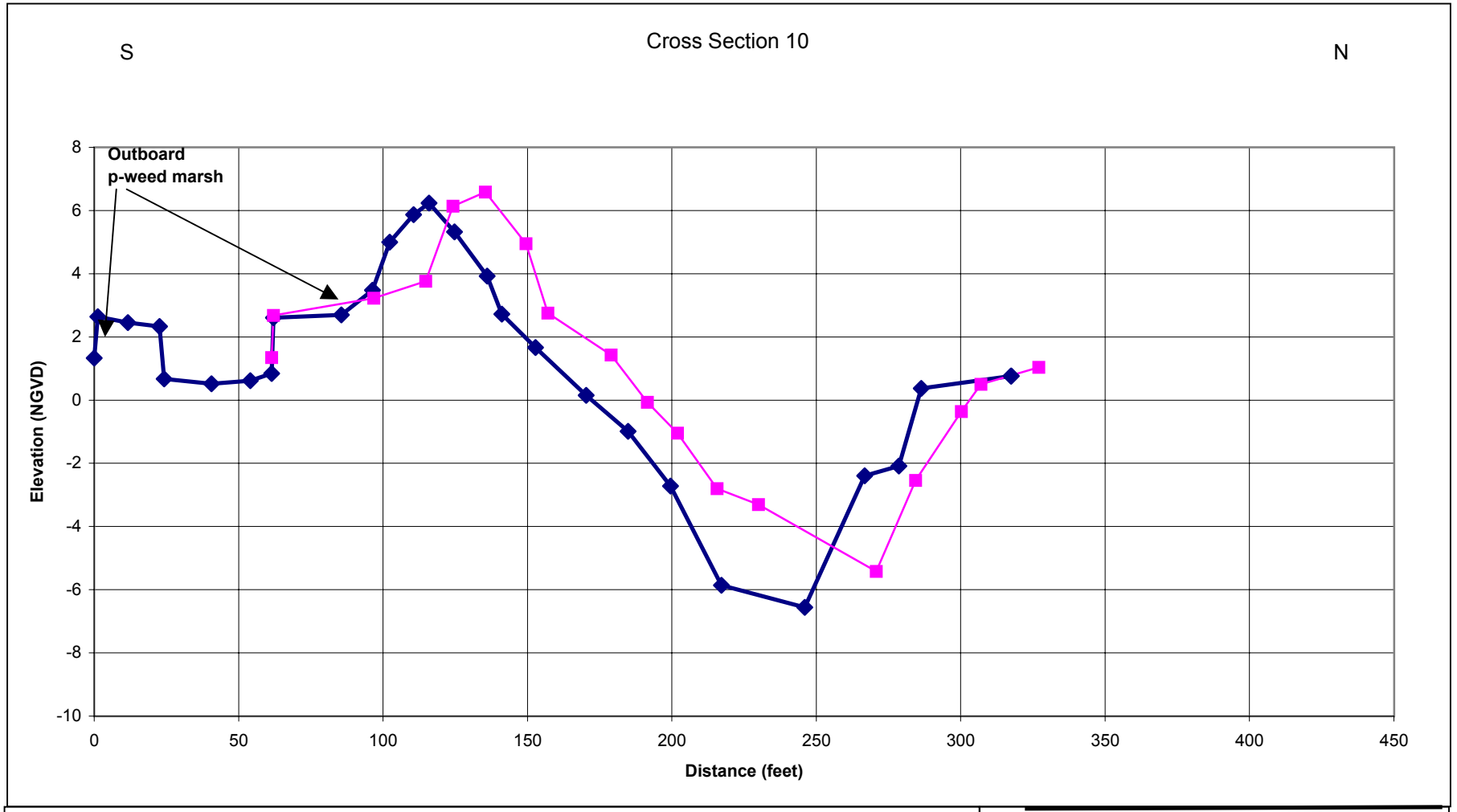


Source: PWA field surveys (March 2000).

BAIR ISLAND
XS 9

PWA

PWA#: 1413

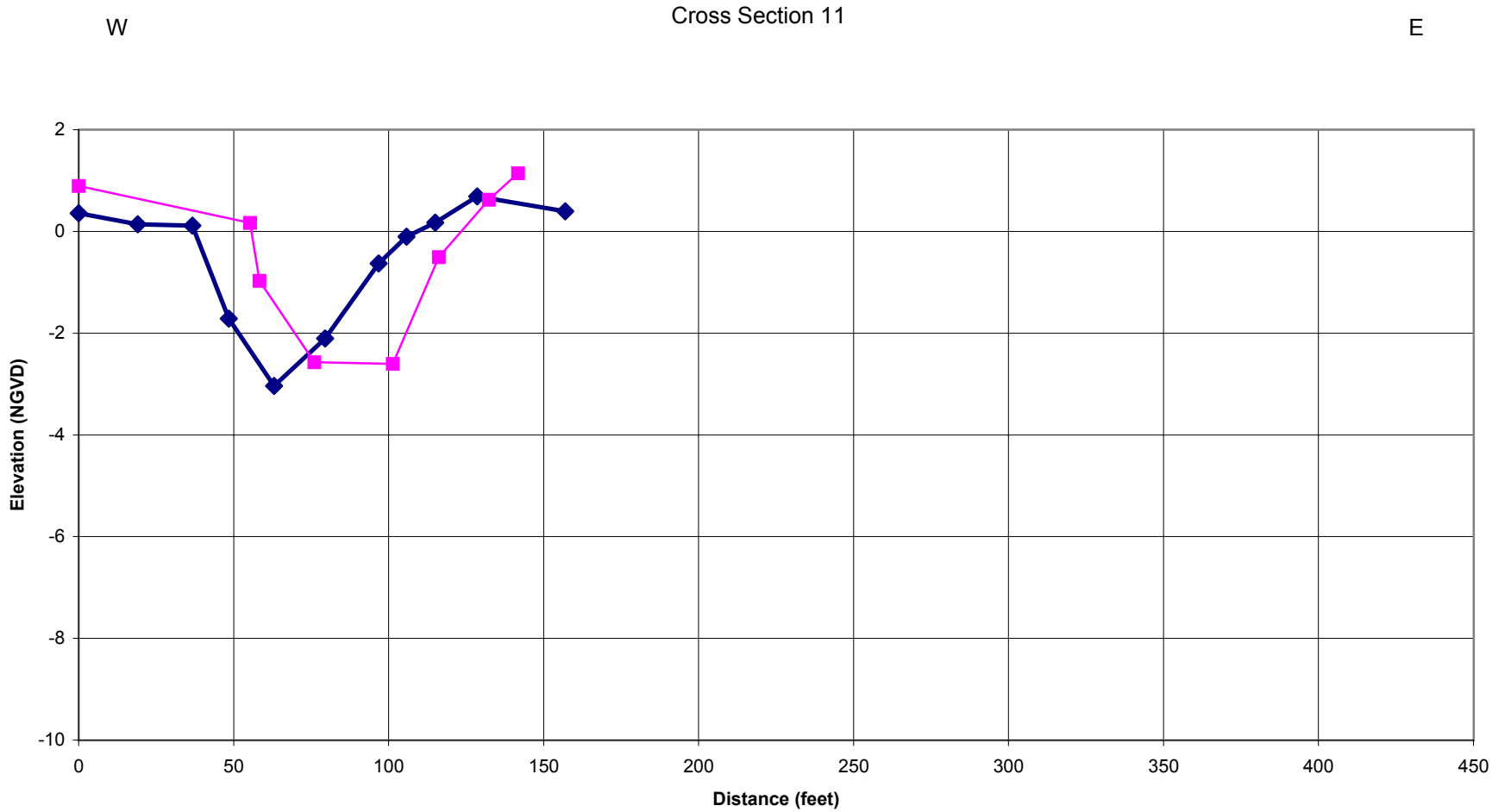


Source: PWA field surveys (March 2000).
Note: Preliminary data; vertical datum confirmation in progress.

BAIR ISLAND
XS 10

PWA

PWA#: 1413

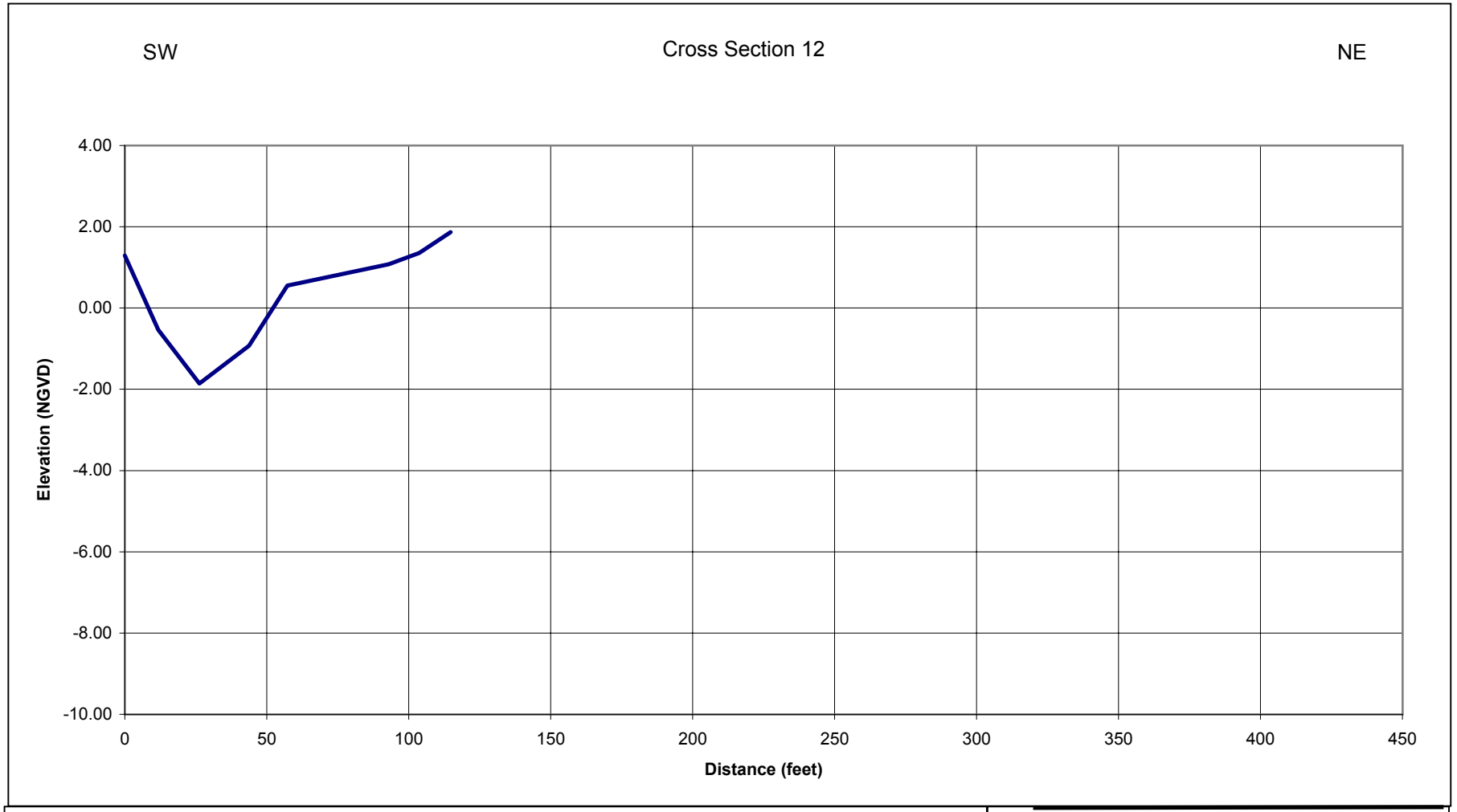


Source: PWA field surveys (March 2000).
Note: Preliminary data; vertical datum confirmation in progress.

BAIR ISLAND
XS 11

PWA

PWA#: 1413

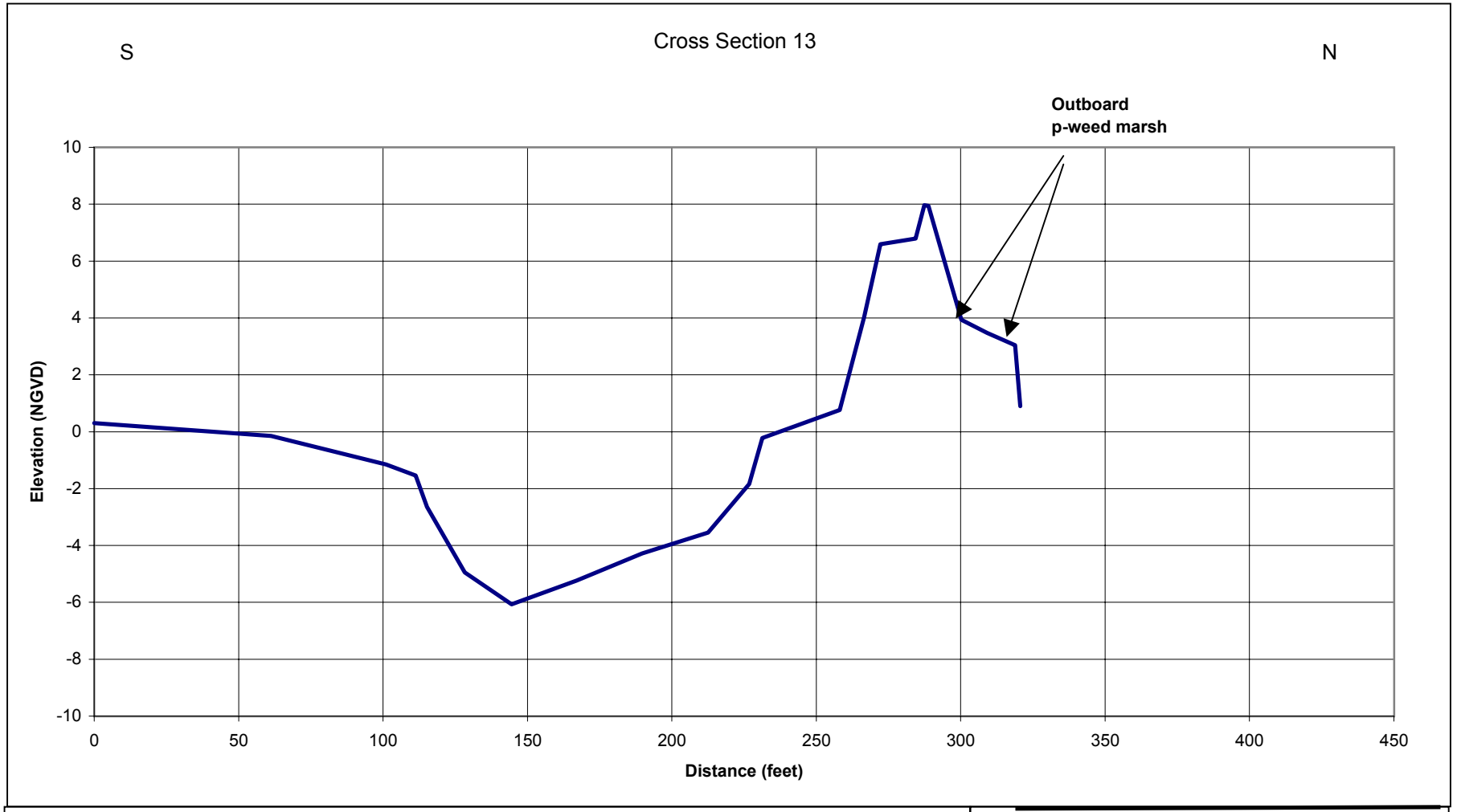


Source: PWA field surveys (March 2000).

BAIR ISLAND
xs 12

PWA

PWA#: 1413

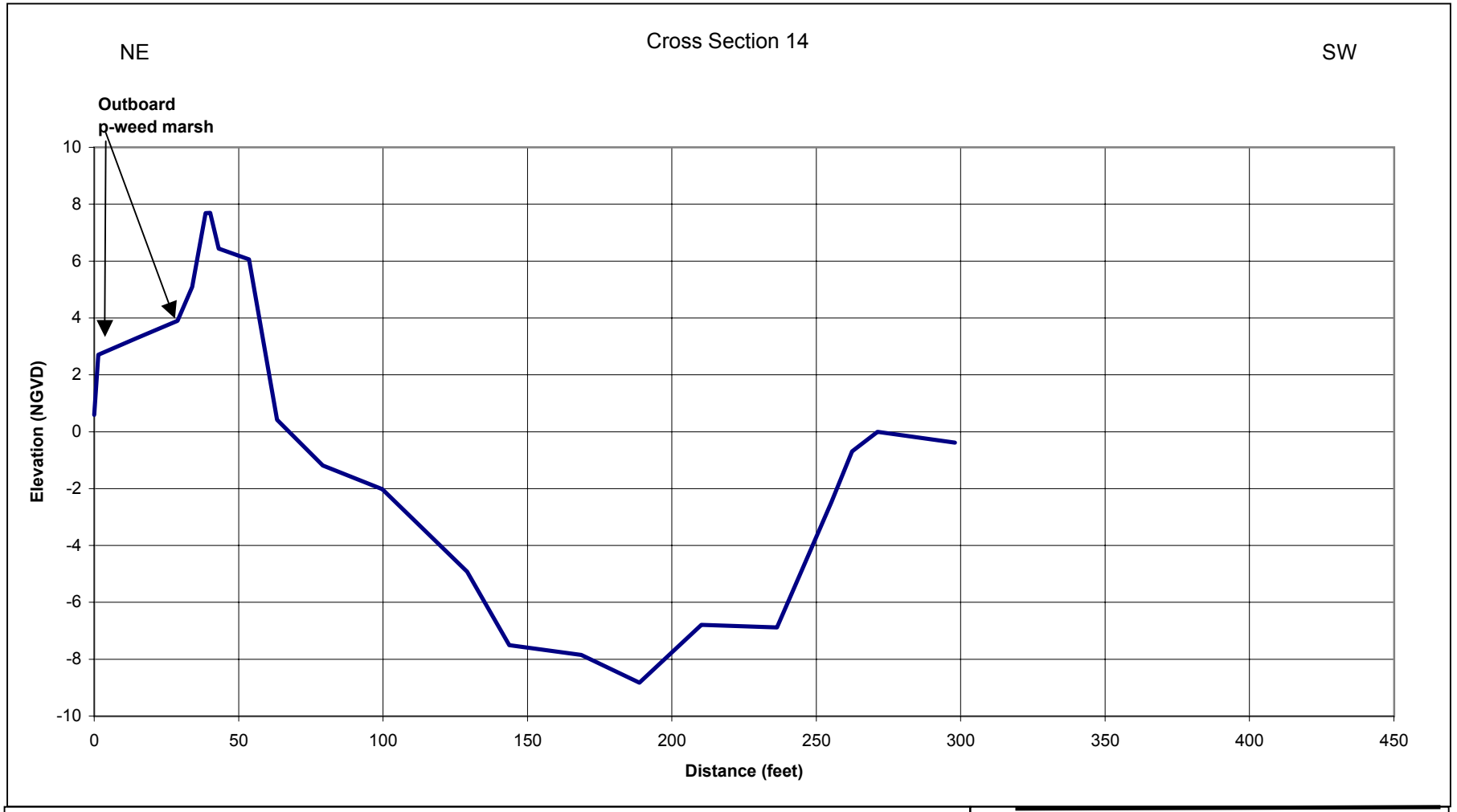


Source: PWA field surveys (March 2000).

BAIR ISLAND
xs 13

PWA

PWA#: 1413

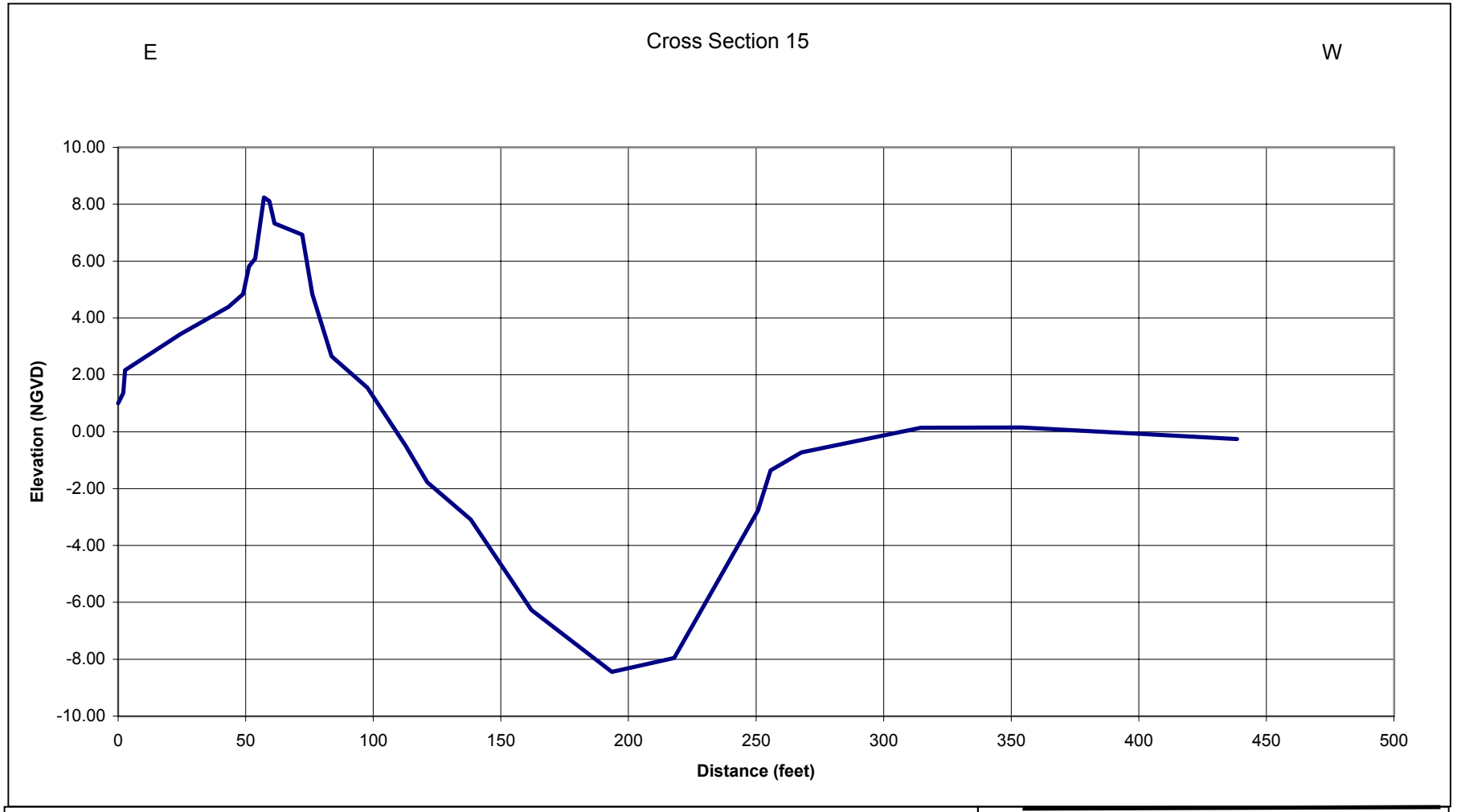


Source: PWA field surveys (March 2000).

BAIR ISLAND
xs 14

PWA

PWA#: 1413

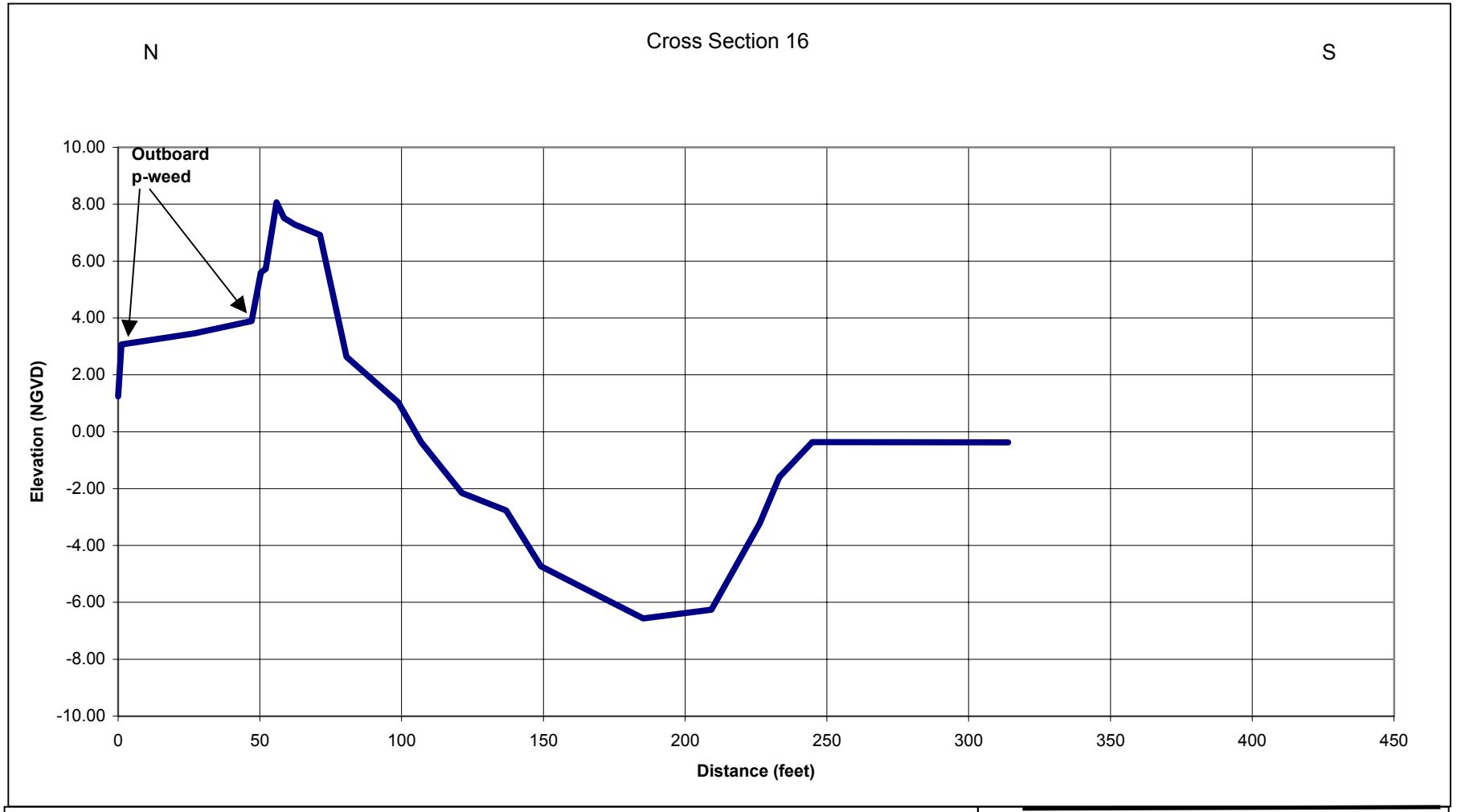


Source: PWA field surveys (March 2000).

BAIR ISLAND
*XS **15***

PWA

PWA#: 1413

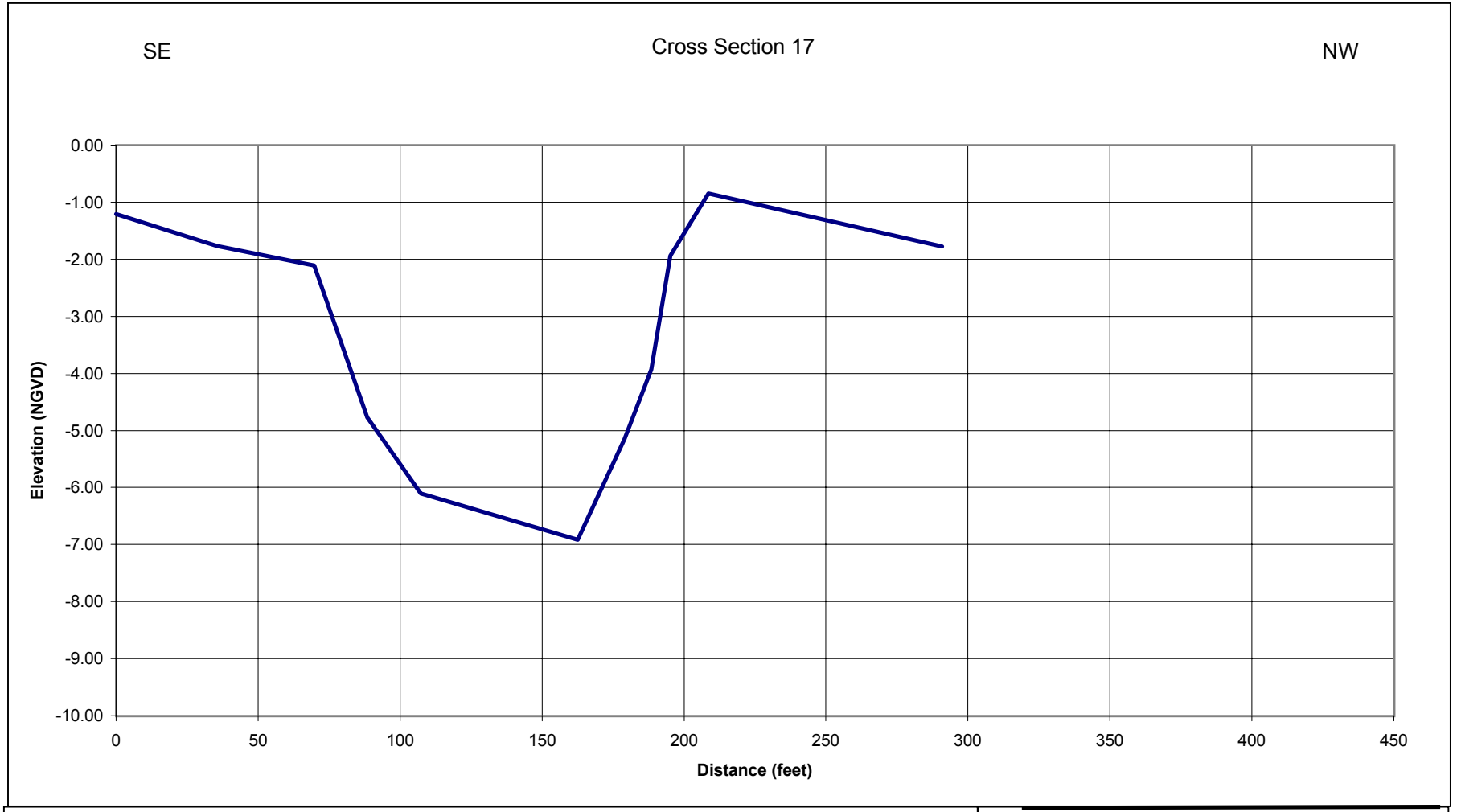


Source: PWA field surveys (March 2000).

BAIR ISLAND
xs 16

PWA

PWA#: 1413



Source: PWA field surveys (March 2000).

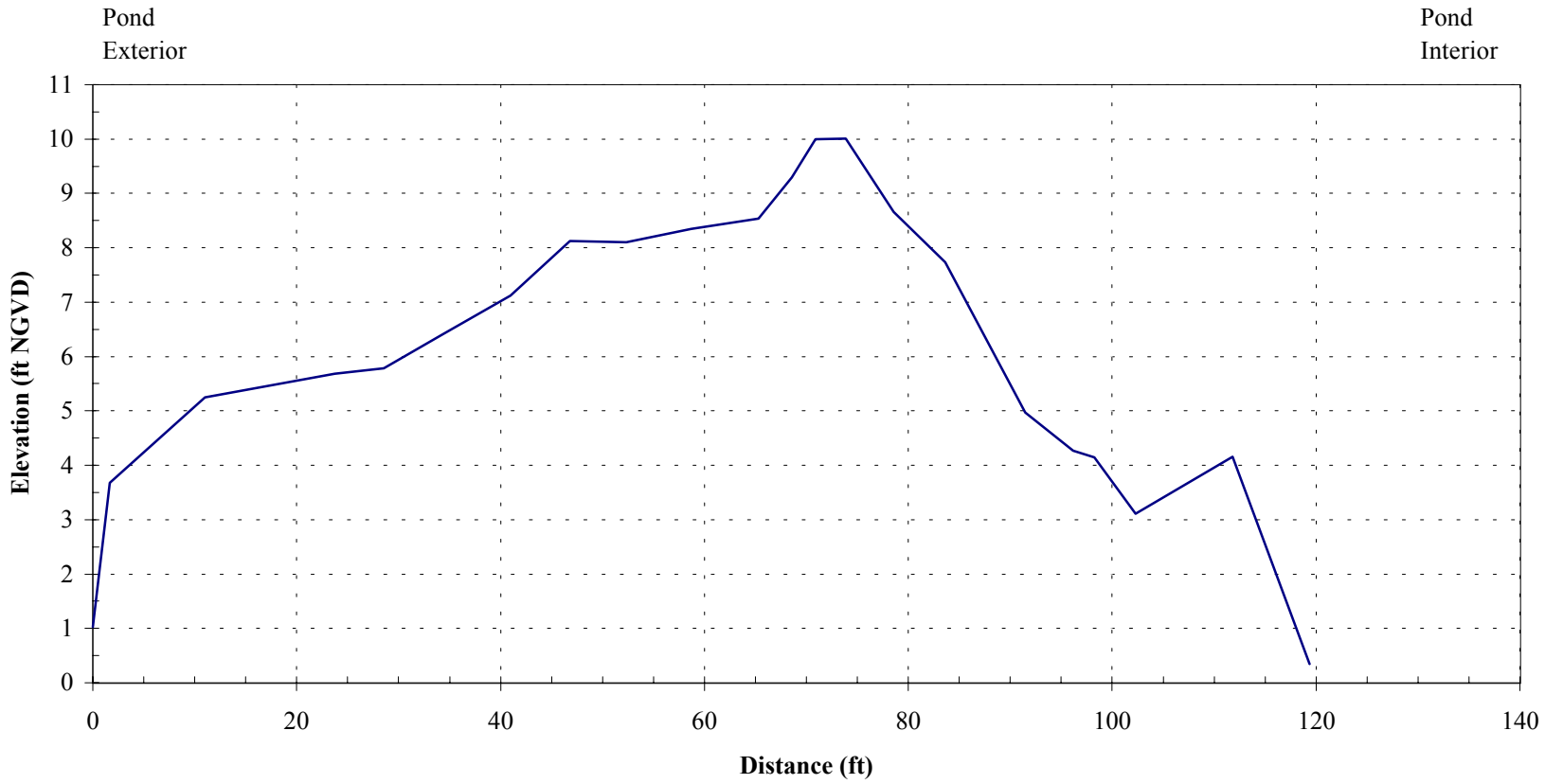
BAIR ISLAND
xs 17

PWA

PWA#: 1413

APPENDIX A
FIELD SURVEYS

A-3 South Bay System Authority (SBSA) levee cross-sections 1 through XS5

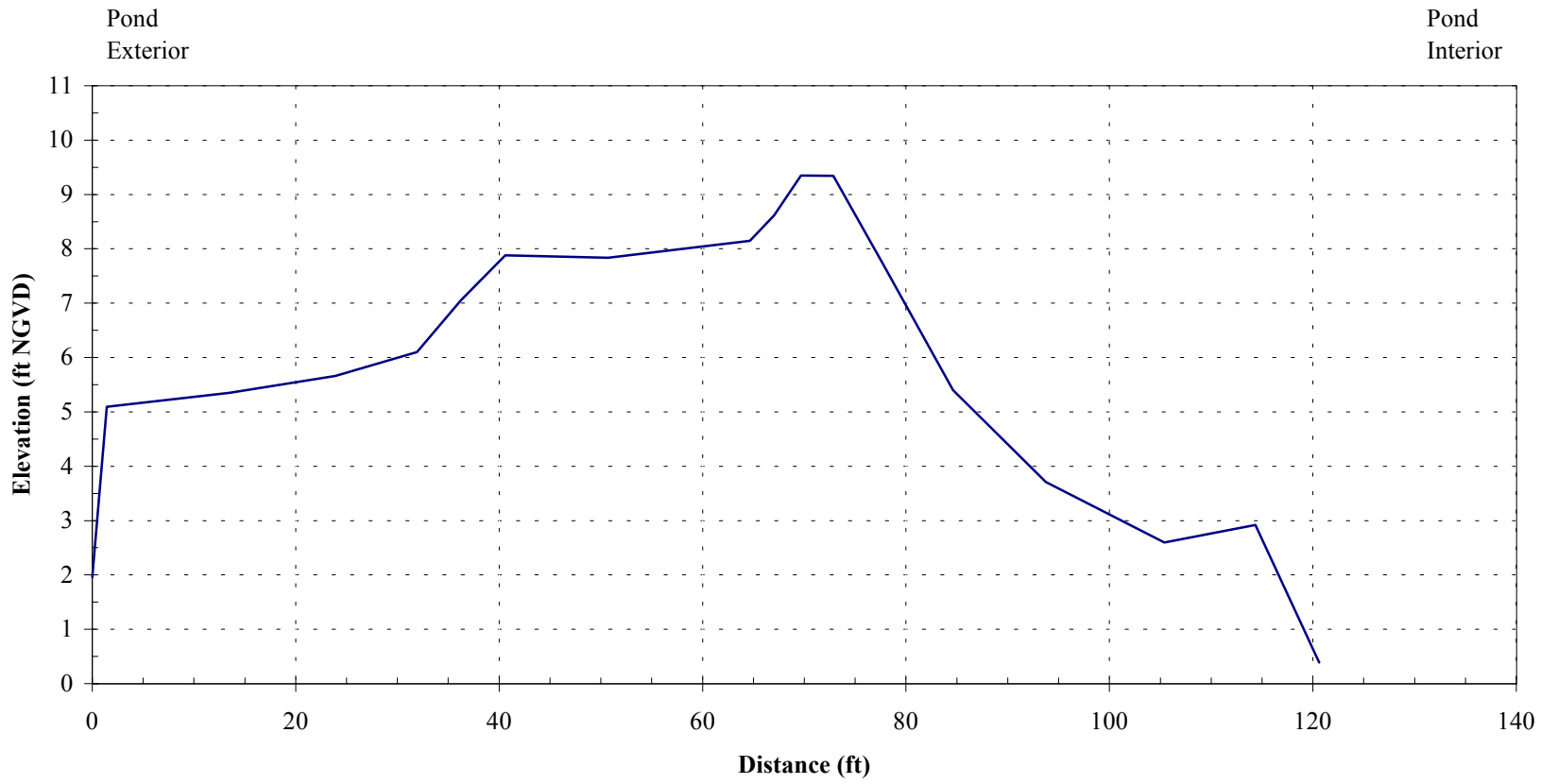


Source: PWA field surveys (04/05/2000)

SBSA Sewer Line
Cross Section 1

PWA

PWA #: 1413



Source: PWA field surveys (04/05/2000)

SBSA Sewer Line
Cross Section 2

PWA

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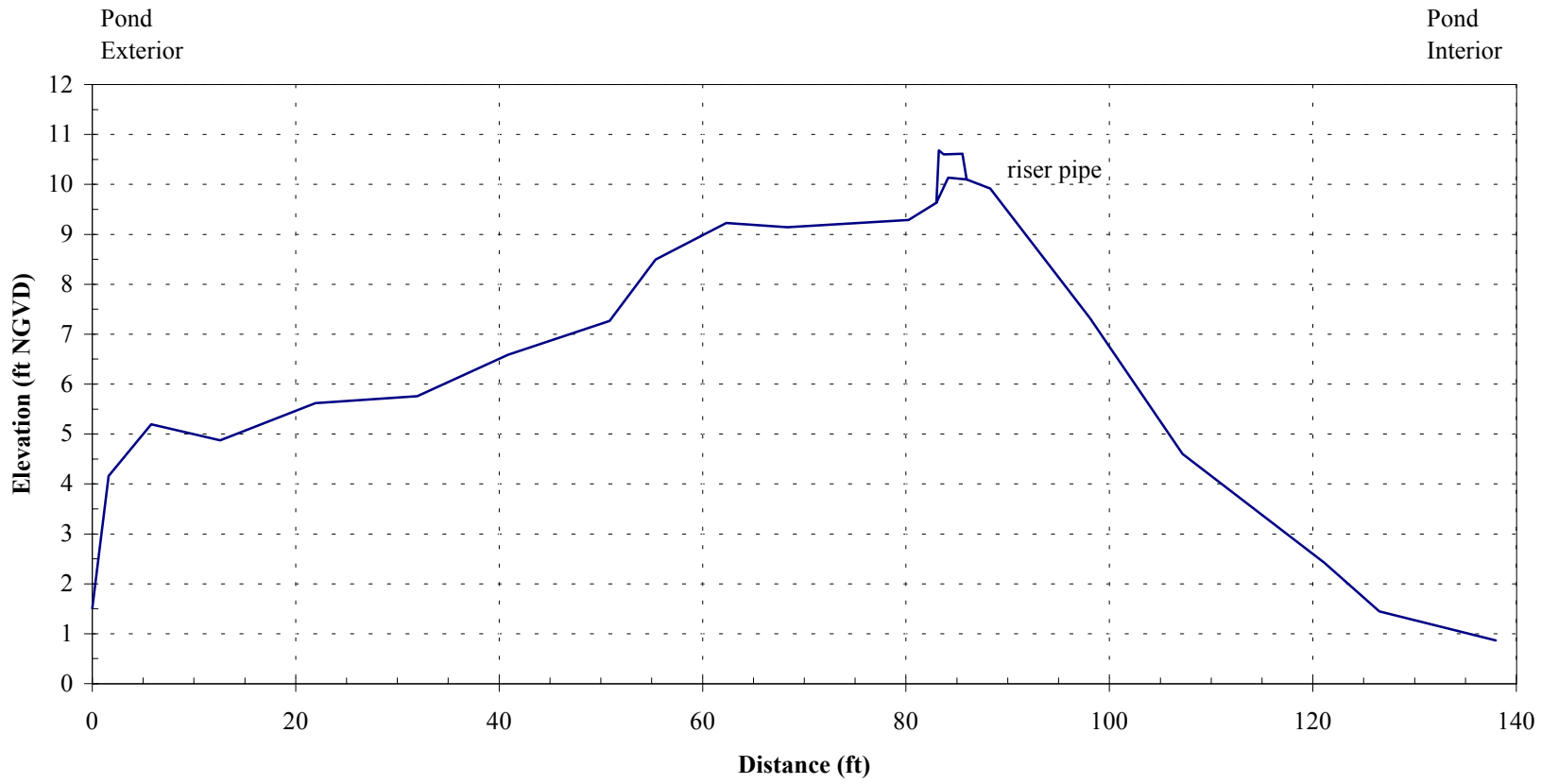
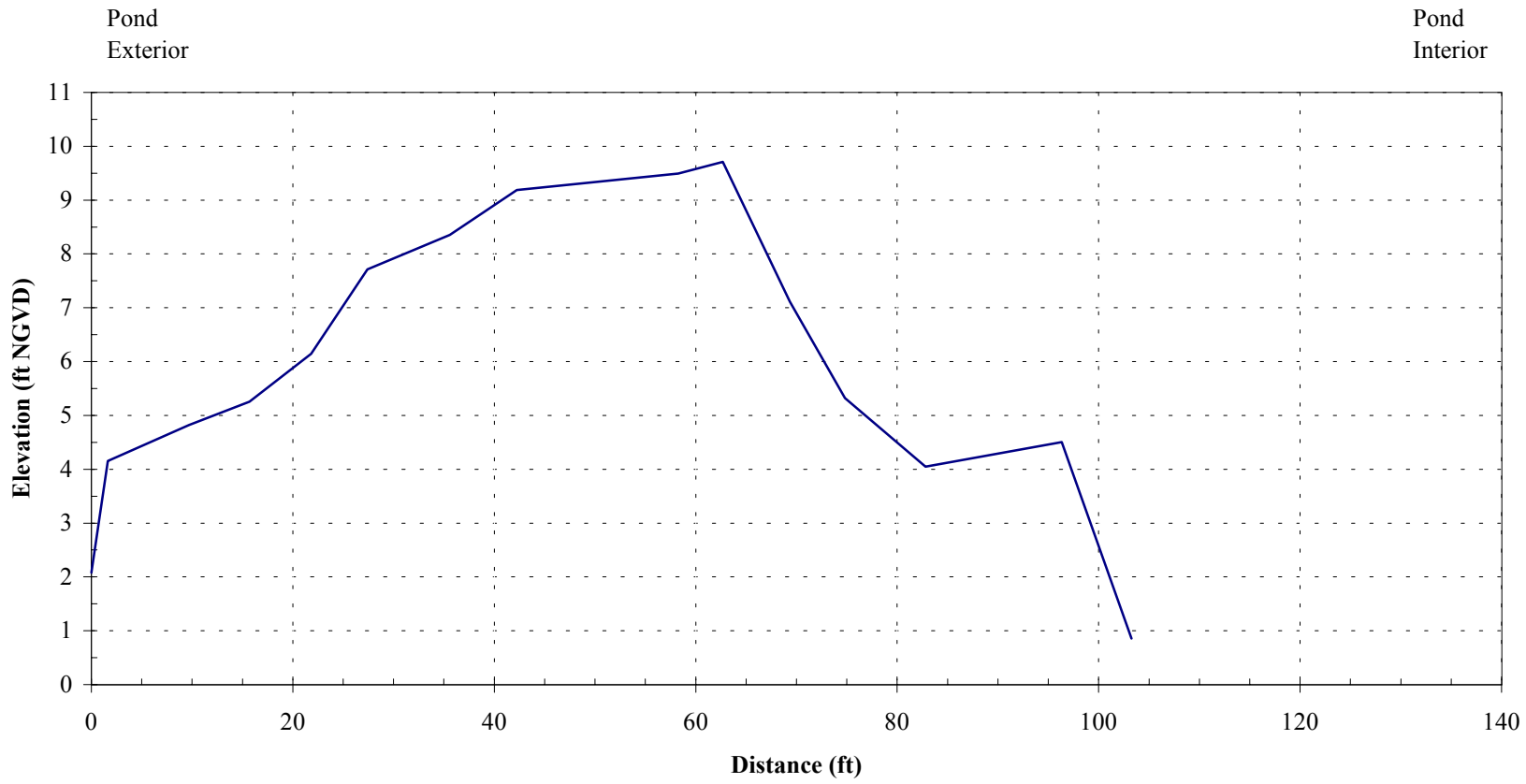


Source: PWA field surveys (04/05/2000)

SBSA Sewer Line
Cross Section 3

PWA

PWA #: 1413

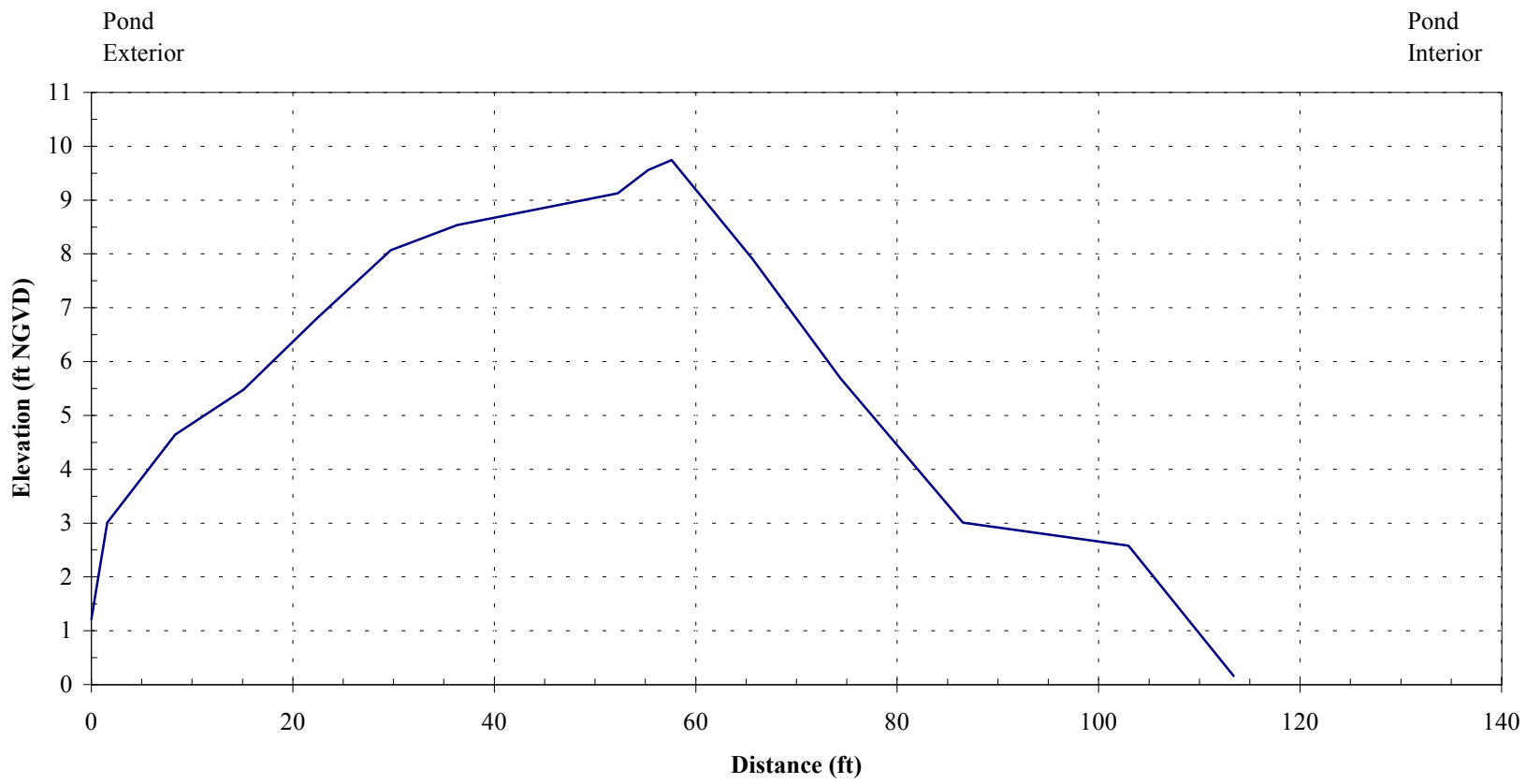


Source: PWA field surveys (04/05/2000)

SBSA Sewer Line
Cross Section 4

PWA

PWA #: 1413



Source: PWA field surveys (04/05/2000)

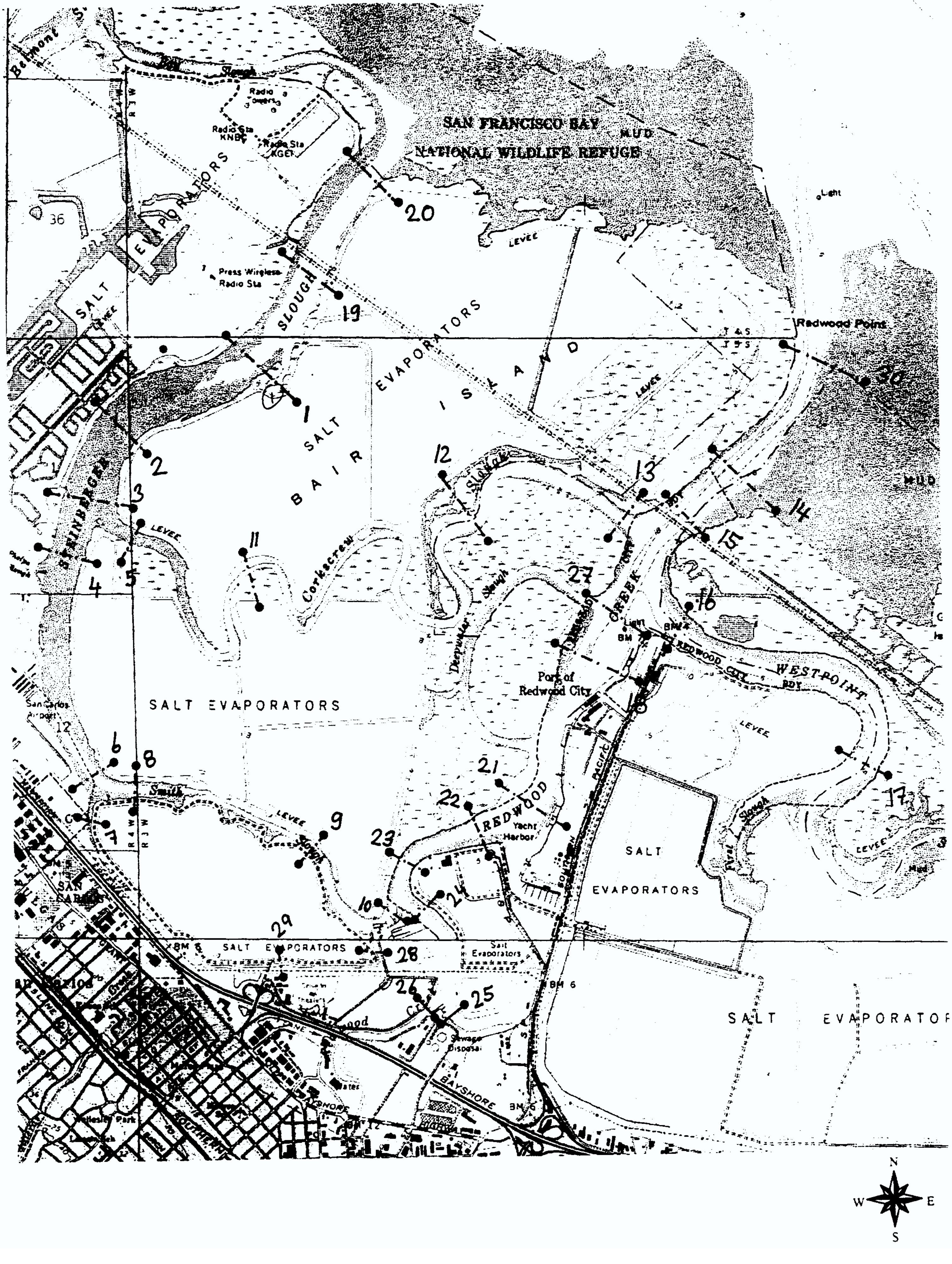
SBSA Sewer Line
Cross Section 5

PWA

PWA #: 1413

APPENDIX A
FIELD SURVEYS

A-4 Hydrographic cross-sections in the major slough channels: location map and cross-sections 1 through 30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MUD
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Slough
Radio Towers
Radio Sta KNBC
Radio Sta KGEI
SALT EVAPORATORS
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SLOUGH
LEVEE
Light
Redwood Point
T 4 S
T 5 S
BAIR ISLAND
STEINBERGER
Corkscrew
Slough
Deepwater Slough
CREEK
Port of Redwood City
REDWOOD CITY BDY
WESTPOINT
San Carlos Airport
Smith
REDWOOD
Yacht Harbor
SOUTHERN PACIFIC
SALT EVAPORATORS
Salt Evaporators
Sewage Disposal
BAYSHORE
BM 6
First Slough
R 4 W
R 3 W
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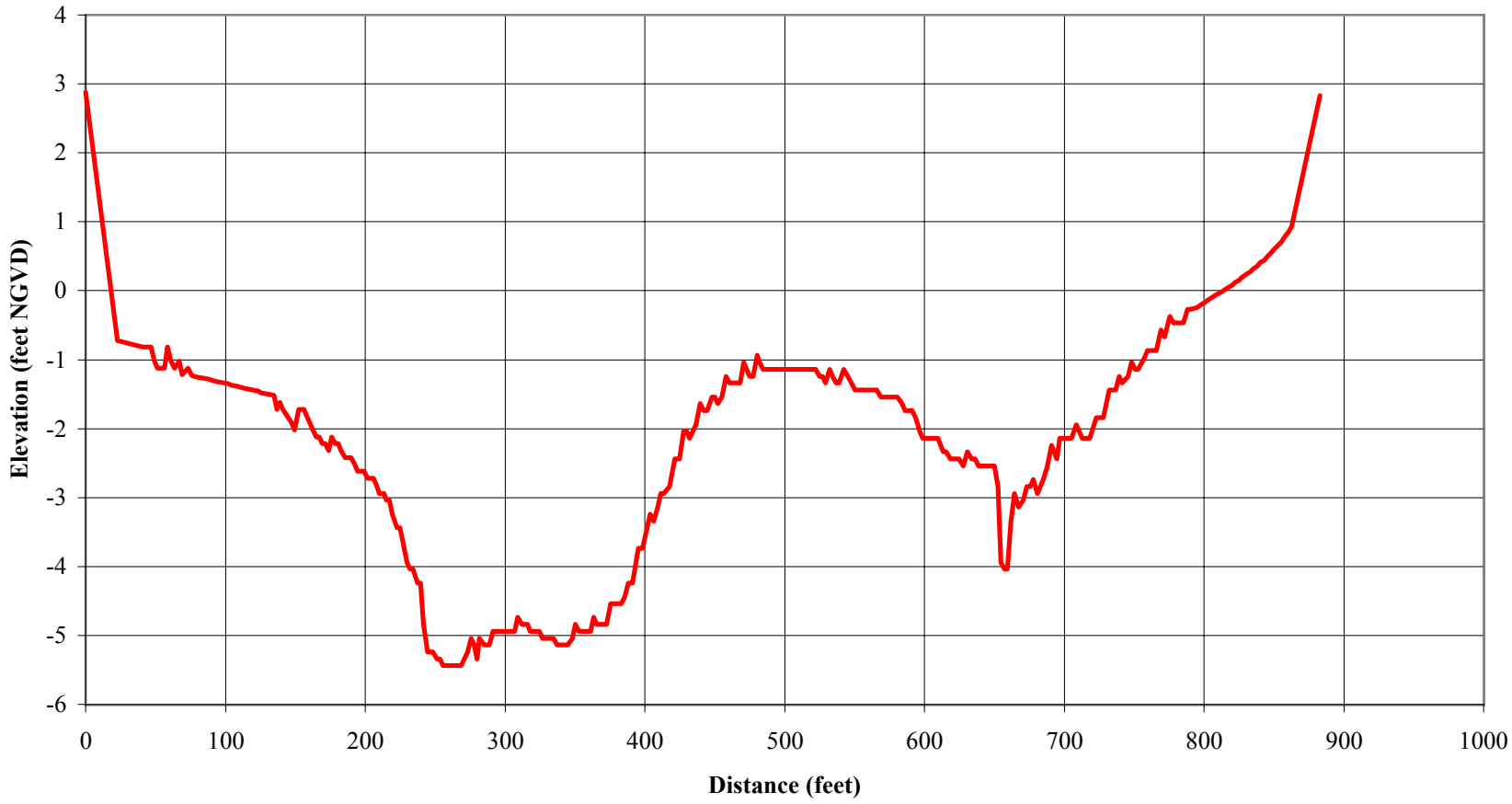


Source: Towill surveys (February 2000).

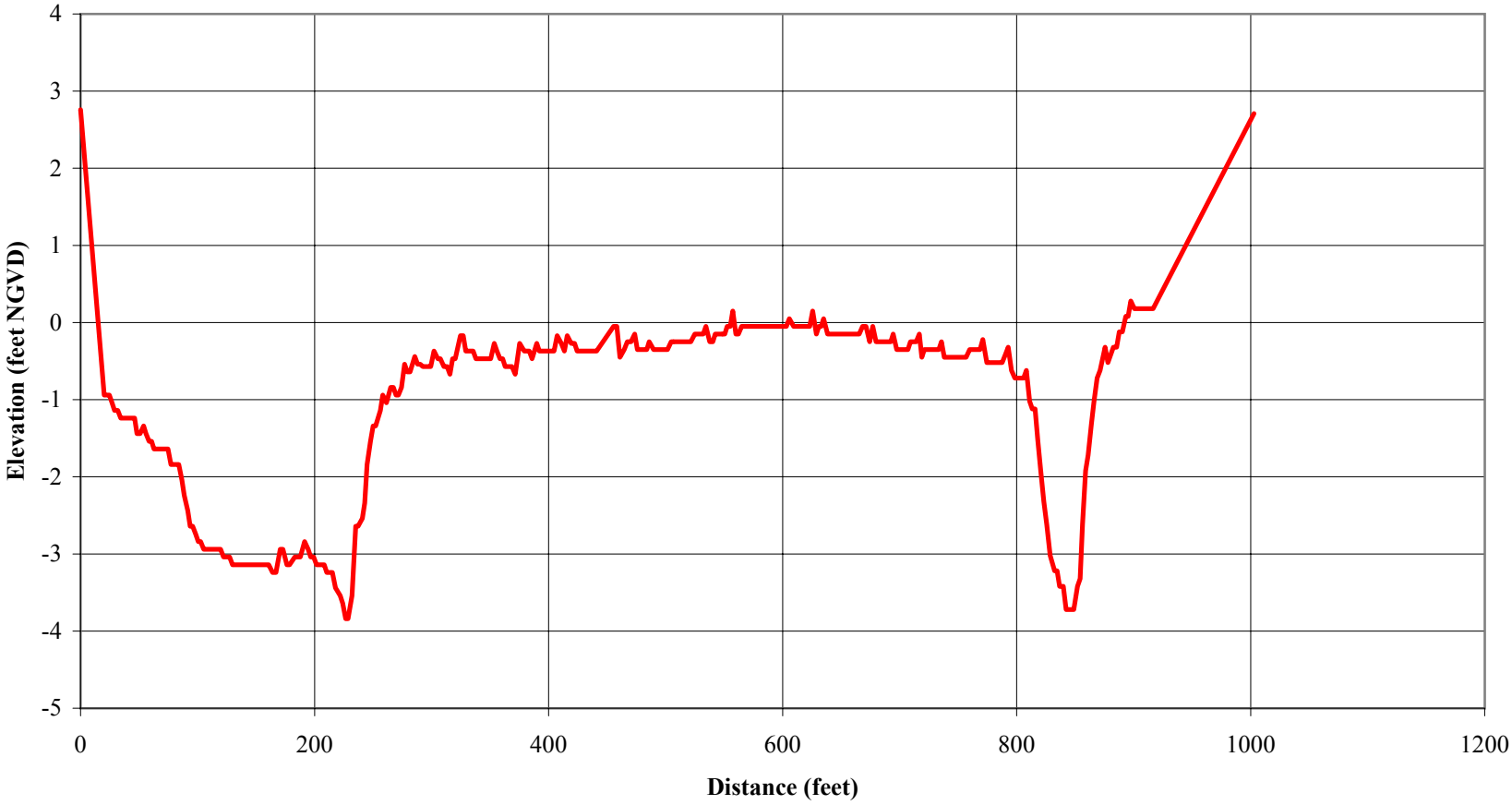
Bair Island

Cross Section 1

PWA

PWA #:1413

towillXS.xls 01 fig 2/6/04



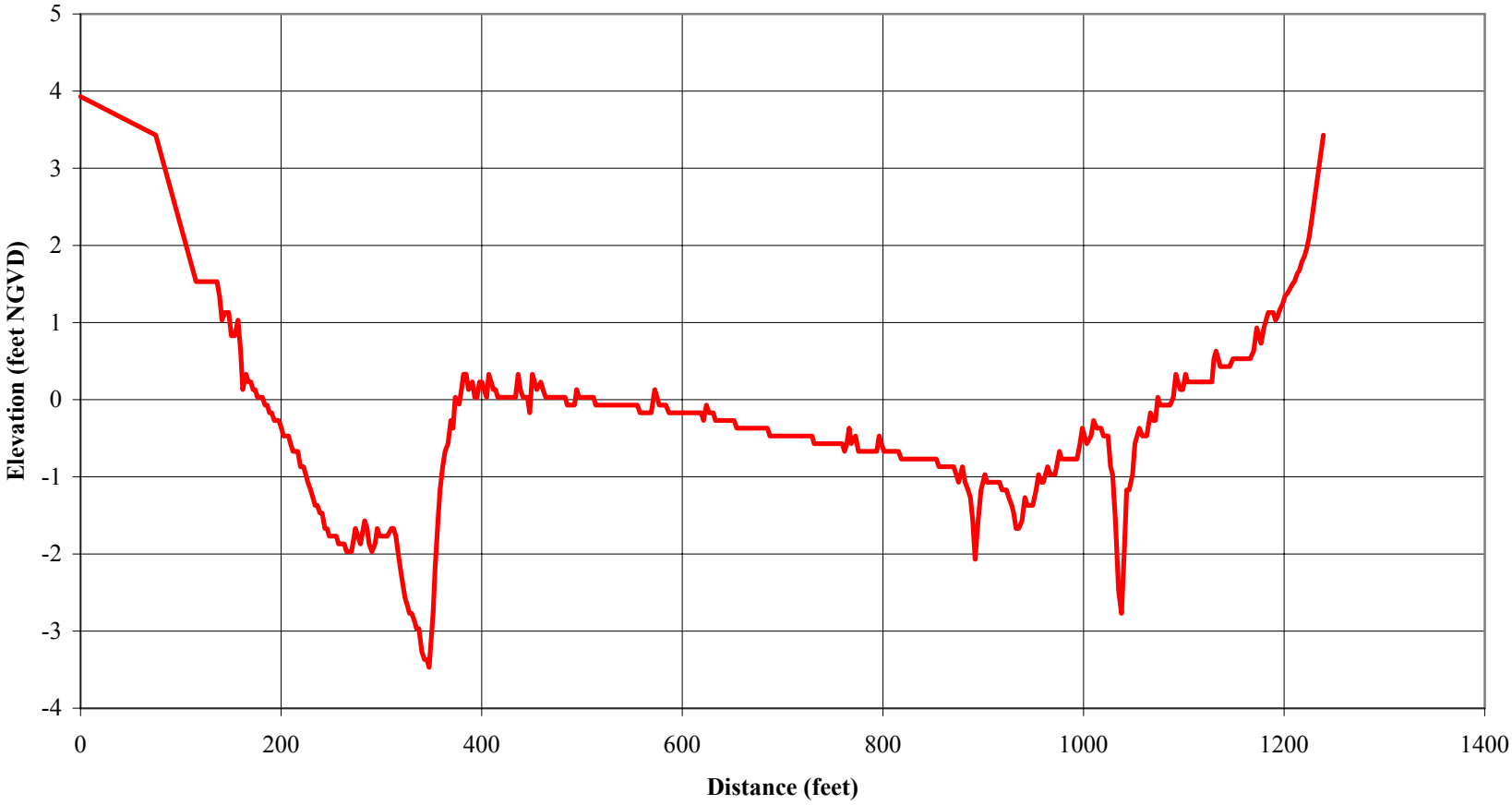
Source: Towill surveys (February 2000).

Bair Island

Cross Section 2

PWA

PWA #:1413



Source: Towill surveys (February 2000).

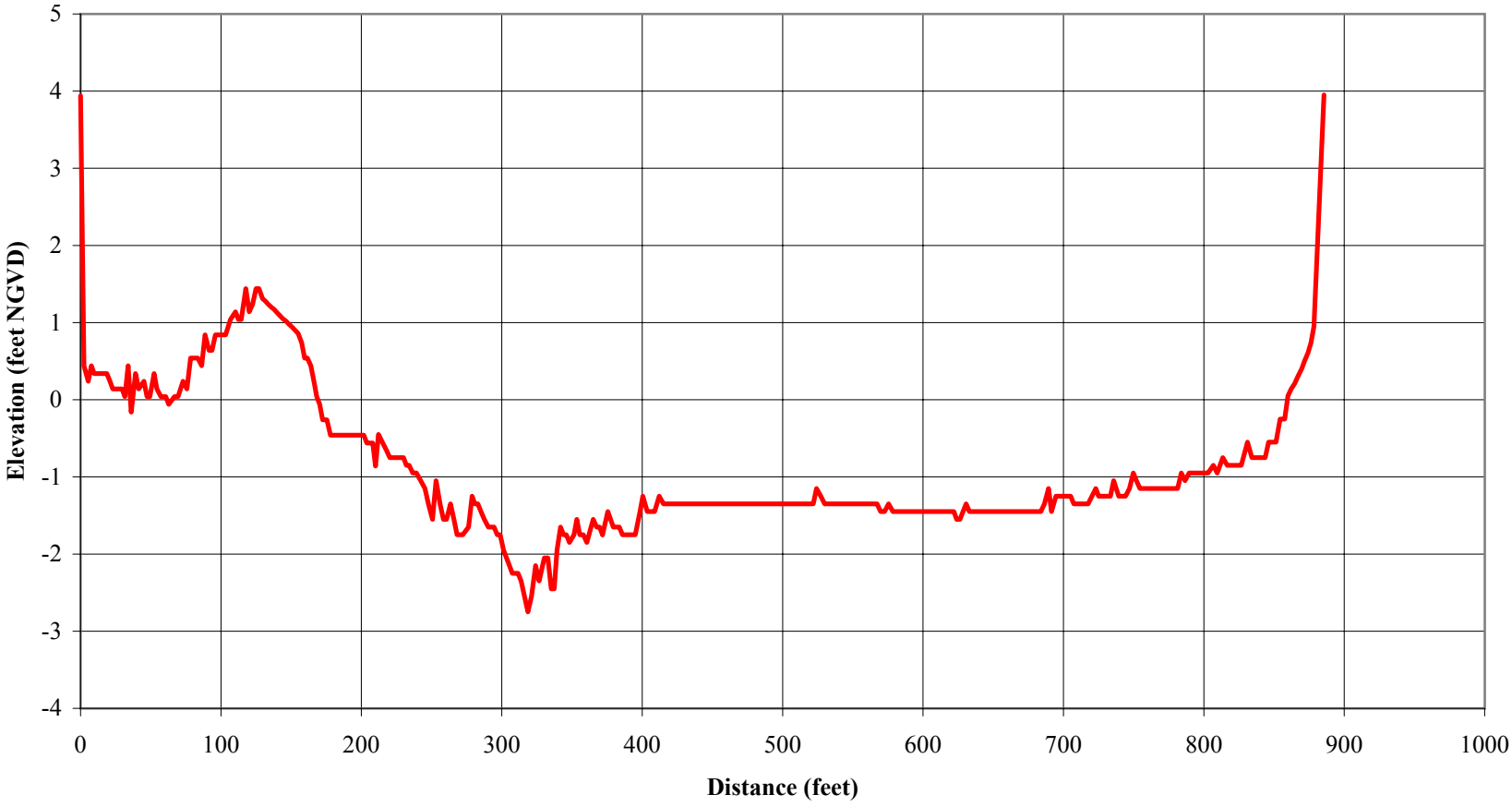
Bair Island

Cross Section 3

PWA

PWA #:1413

towillXS.xls 03 fig 2/6/04



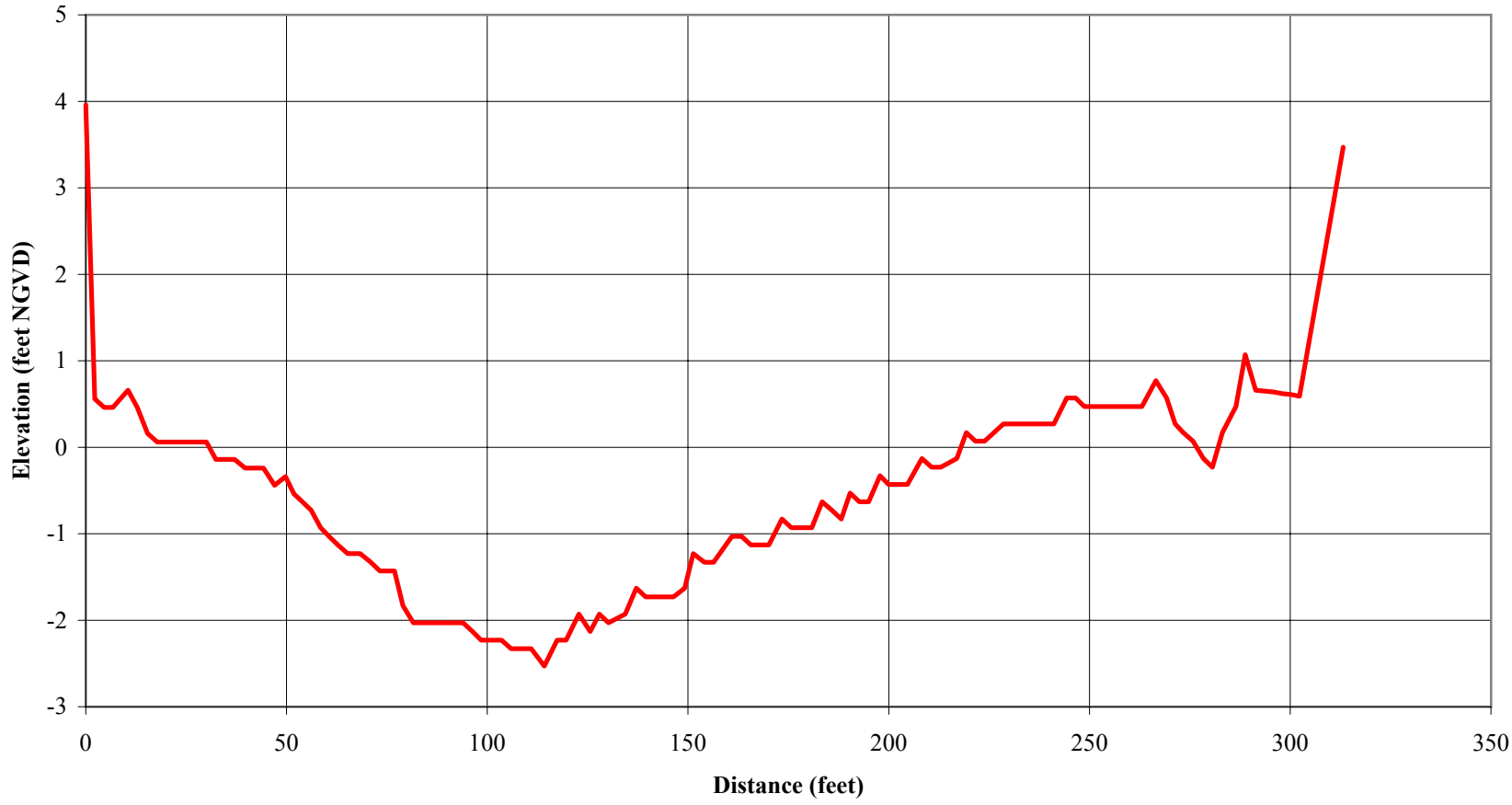
Source: Towill surveys (February 2000).

Bair Island

Cross Section 4

PWA

PWA #:1413



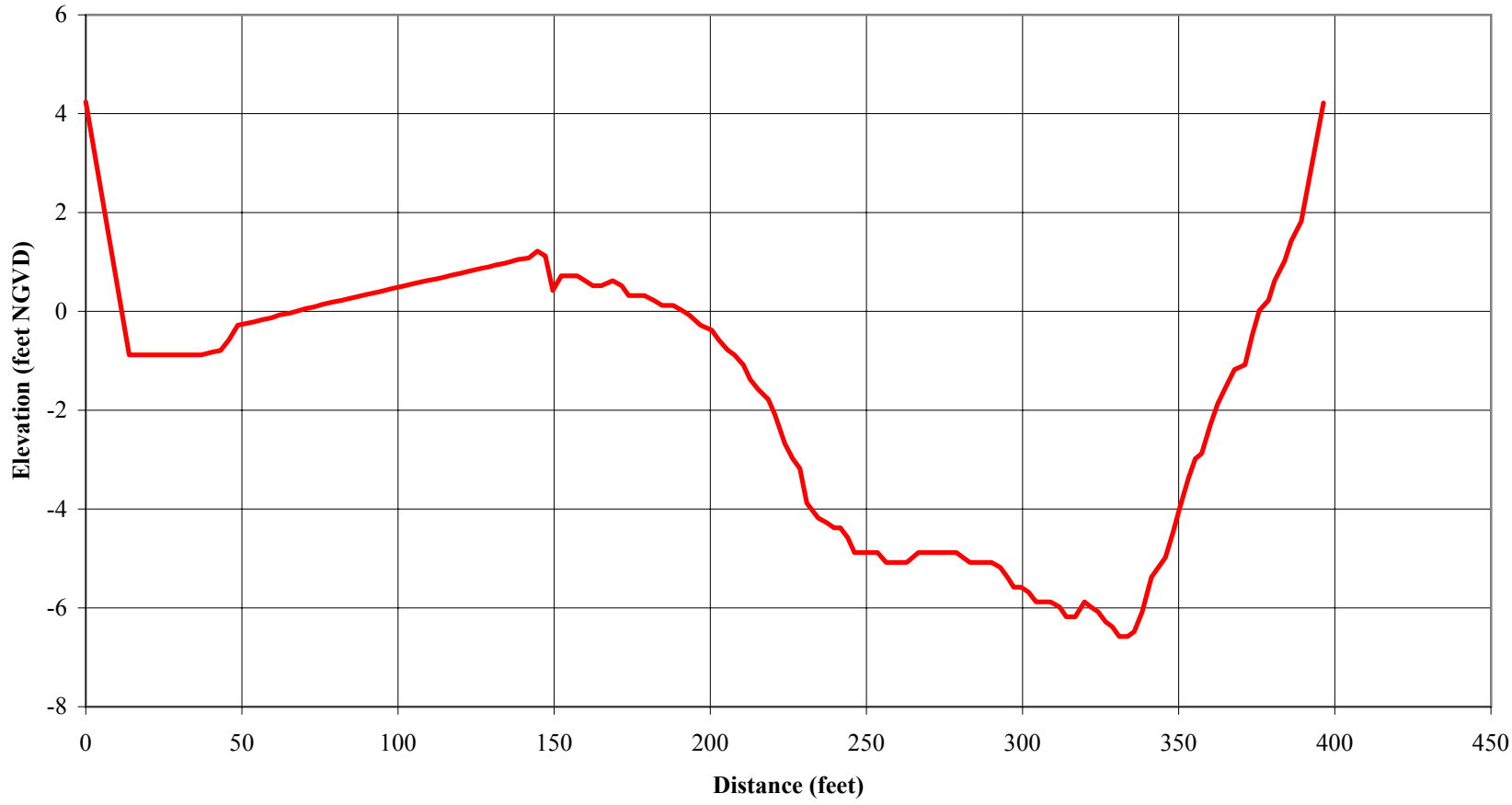
Source: Towill surveys (February 2000).

Bair Island

Cross Section 5

PWA

PWA #:1413



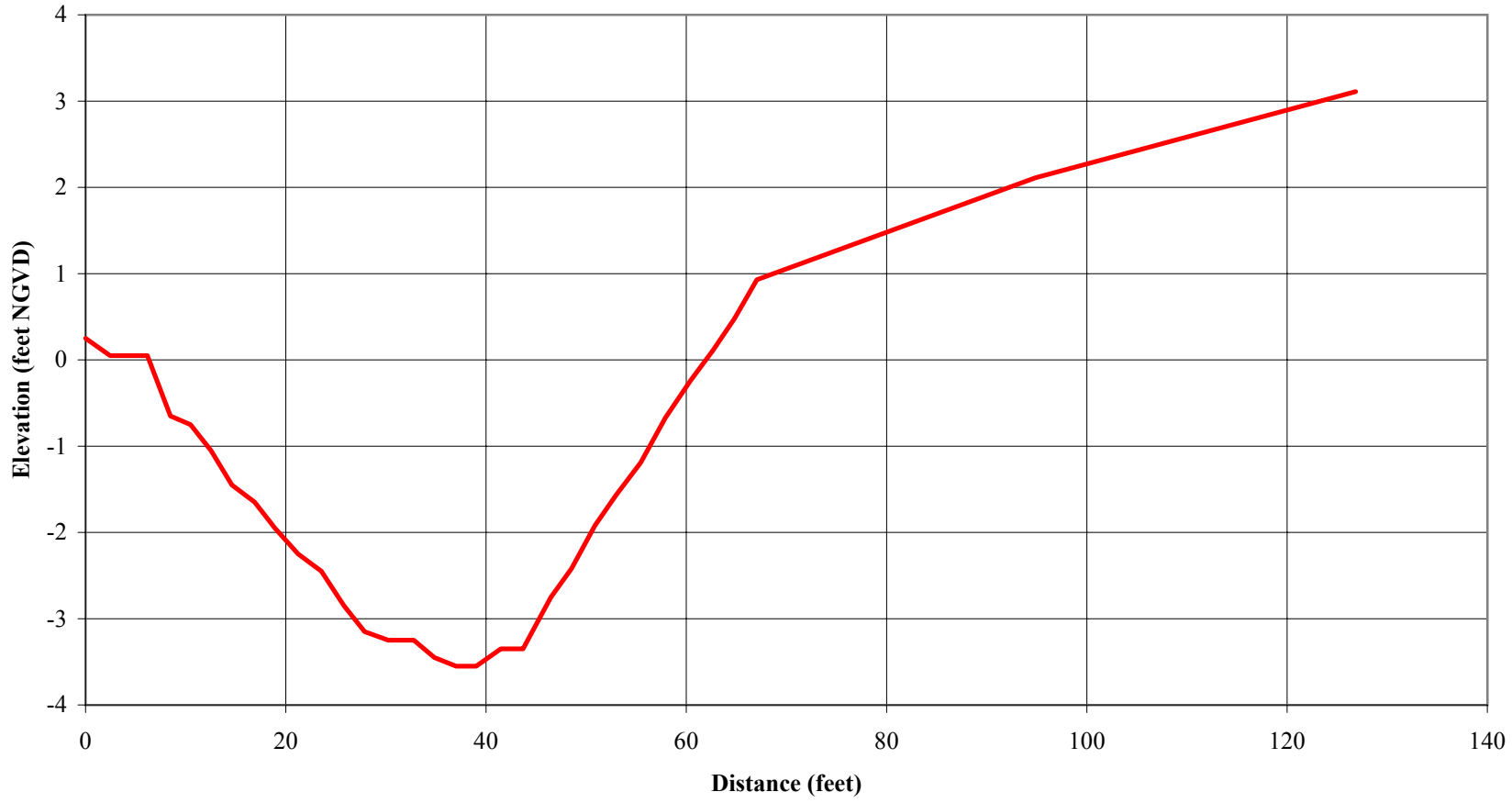
Source: Towill surveys (February 2000).

Bair Island

Cross Section 6

PWA

PWA #:1413



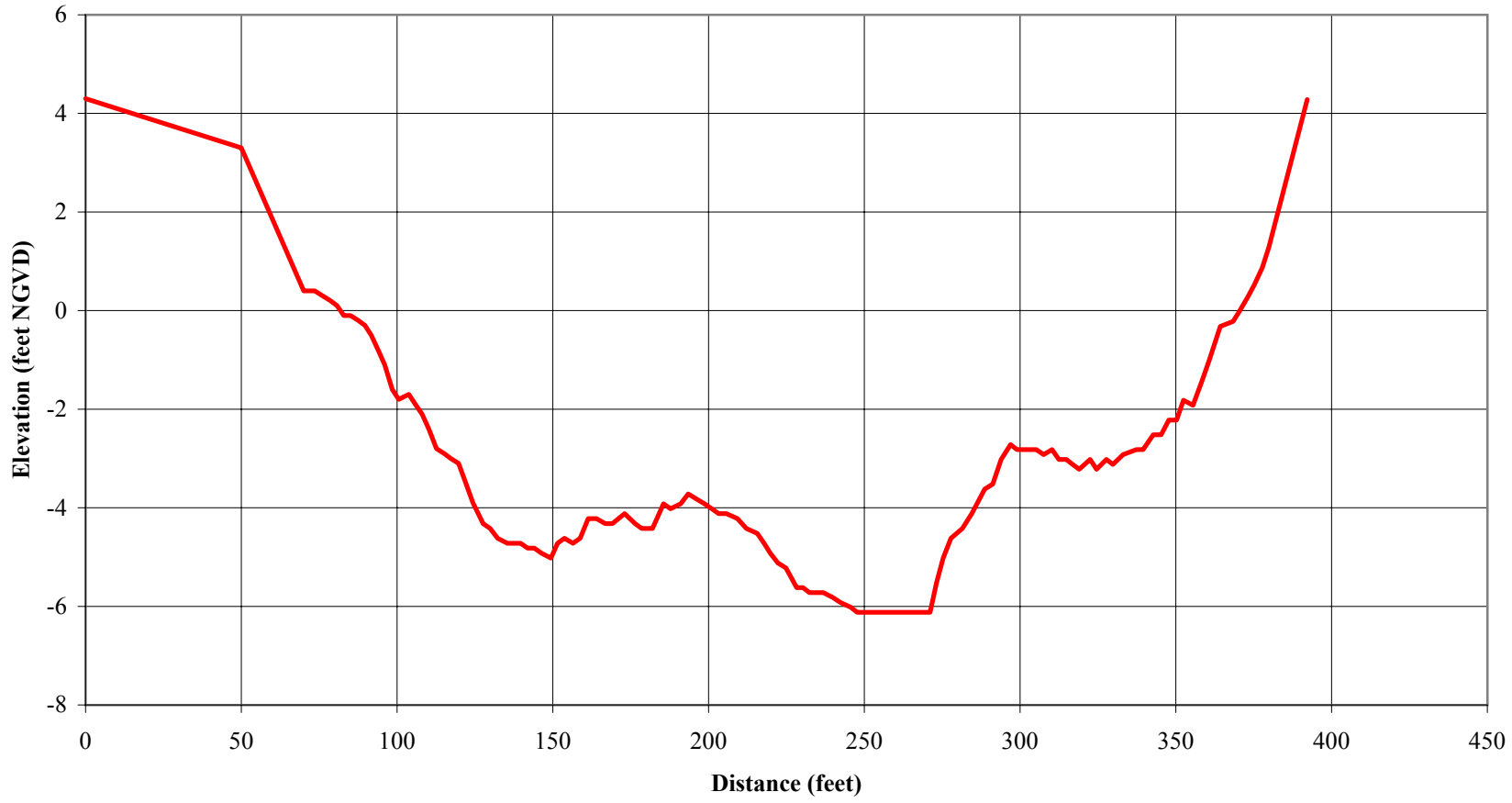
Source: Towill surveys (February 2000).

Bair Island

Cross Section 7

PWA

PWA #:1413



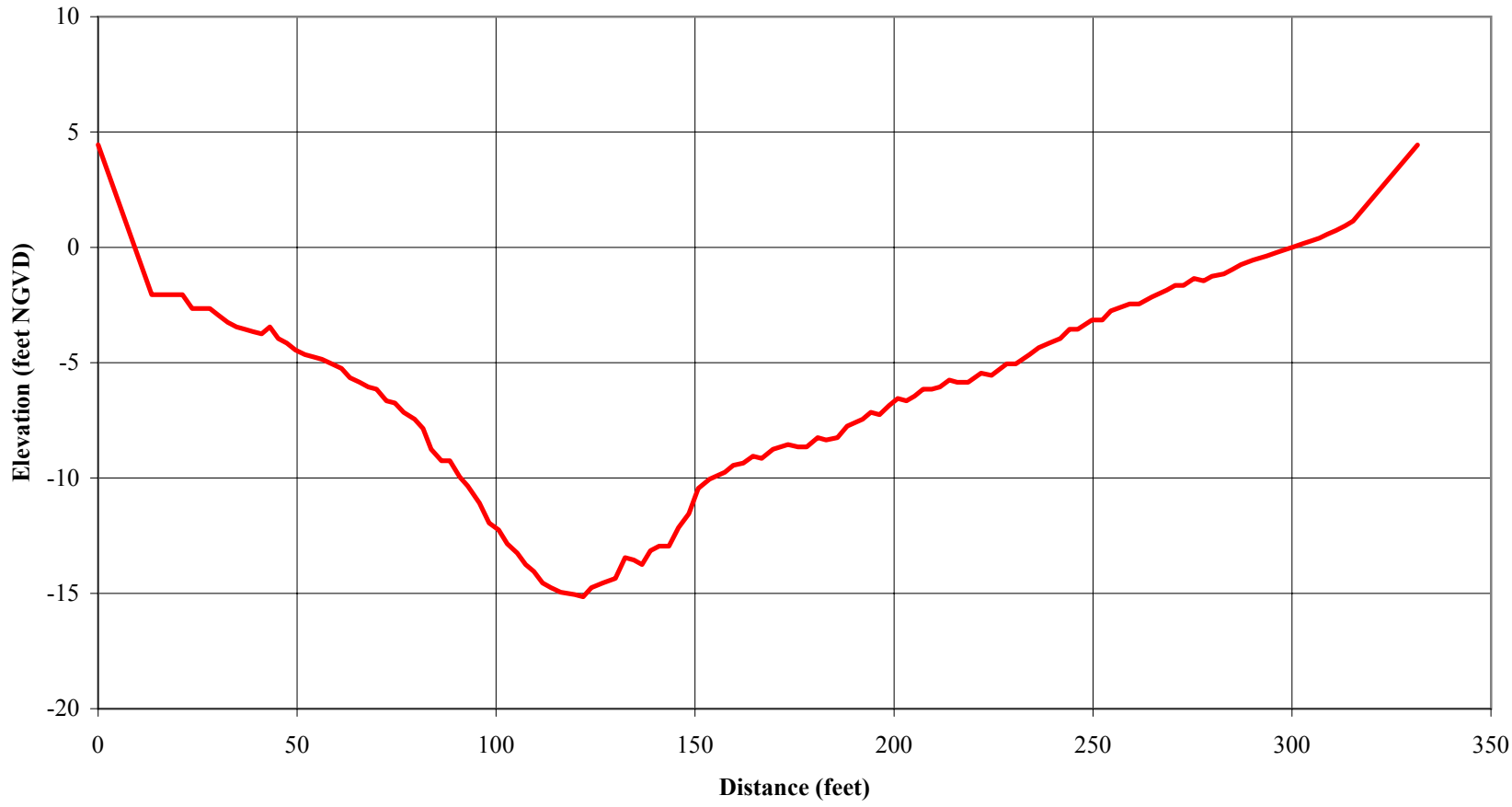
Source: Towill surveys (February 2000).

Bair Island

Cross Section 8

PWA

PWA #:1413



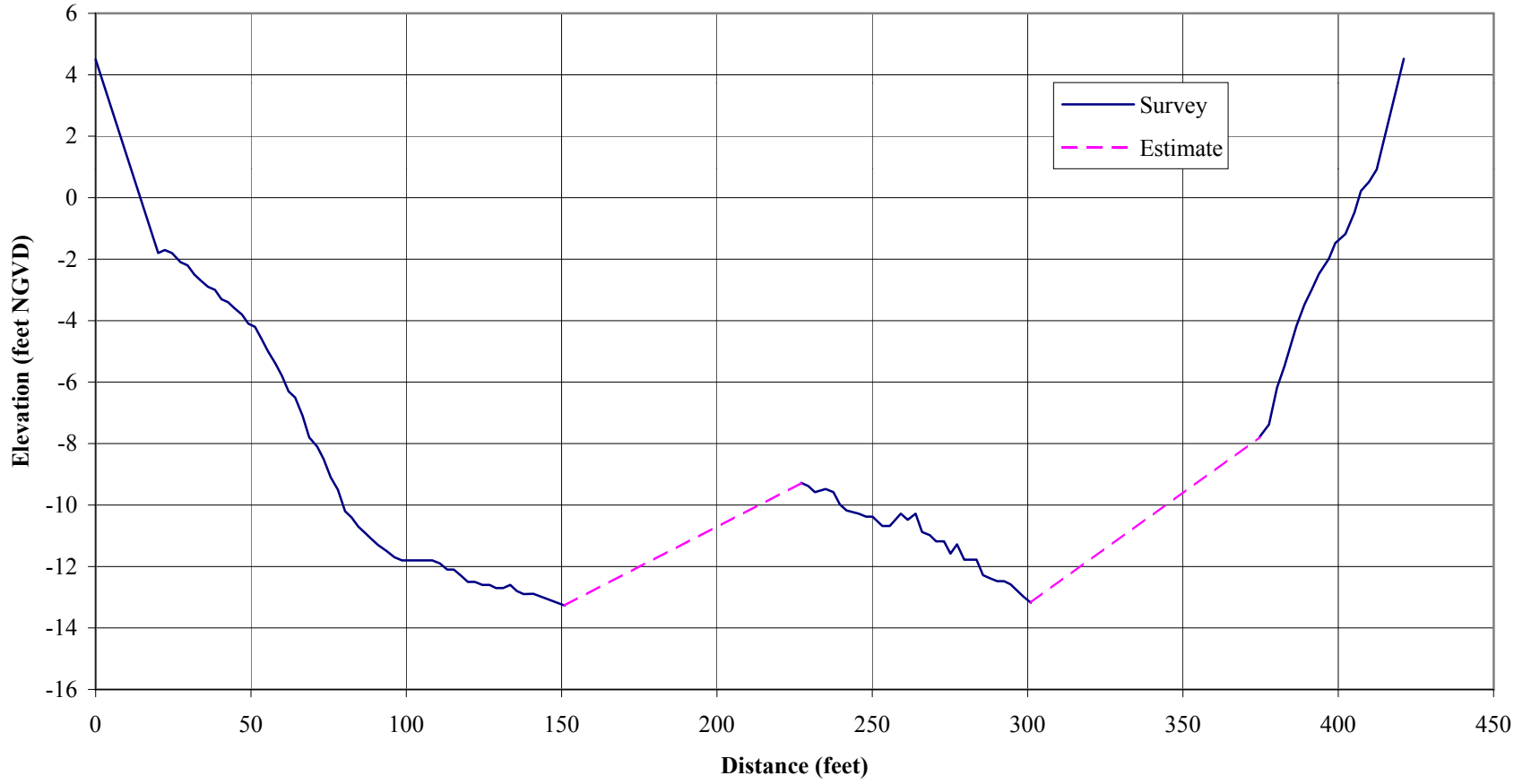
Source: Towill surveys (February 2000).

Bair Island

Cross Section 9

PWA

PWA #:1413



Source: Towill surveys (February 2000).

Note: Parts of the cross-section could not be surveyed because of obstructions (anchored boats). These parts of the cross-section are estimted.

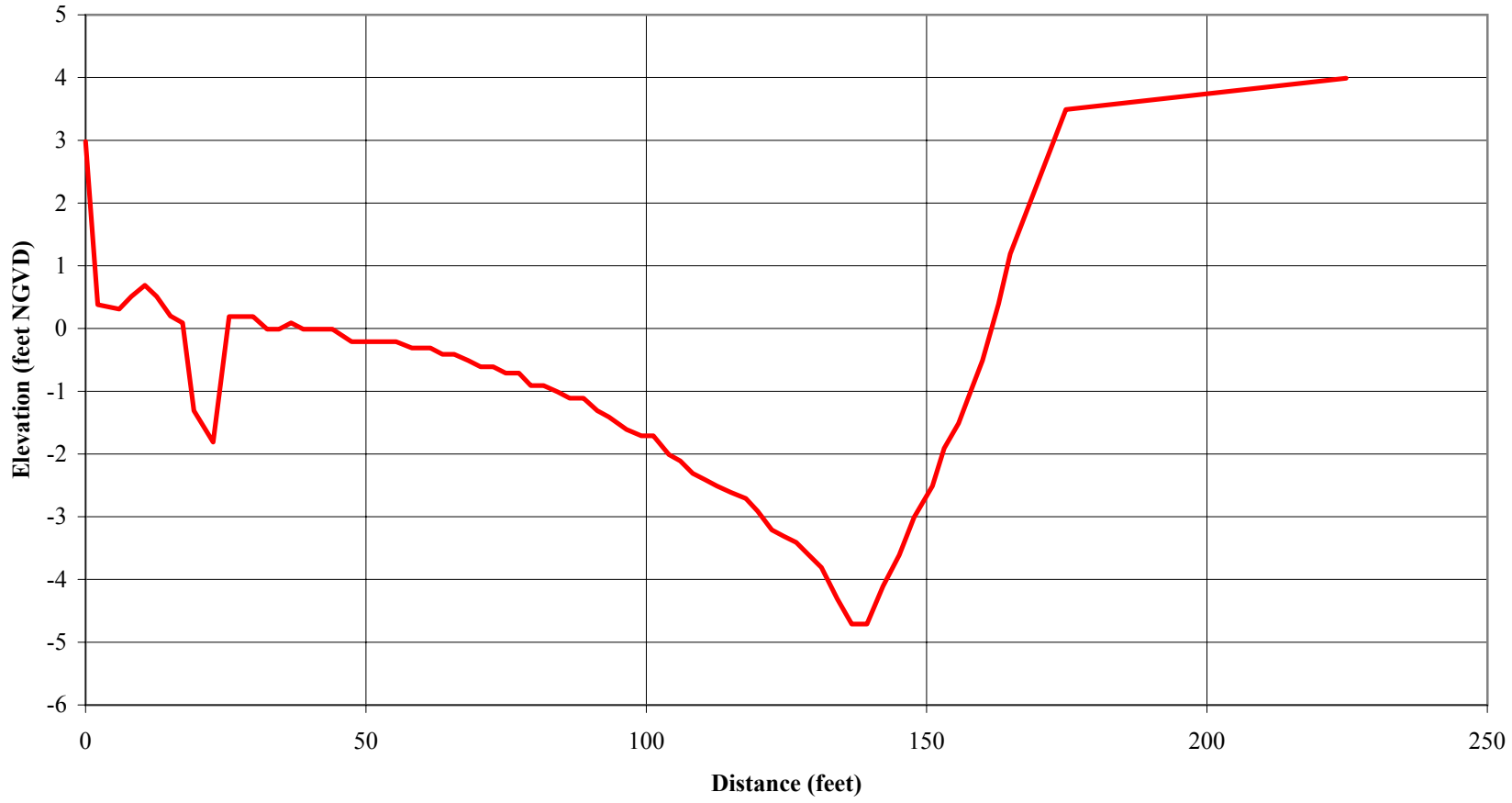
Bair Island

Cross Section 10

PWA

PWA #:1413

towillXS.xls 10 fig 2/6/04



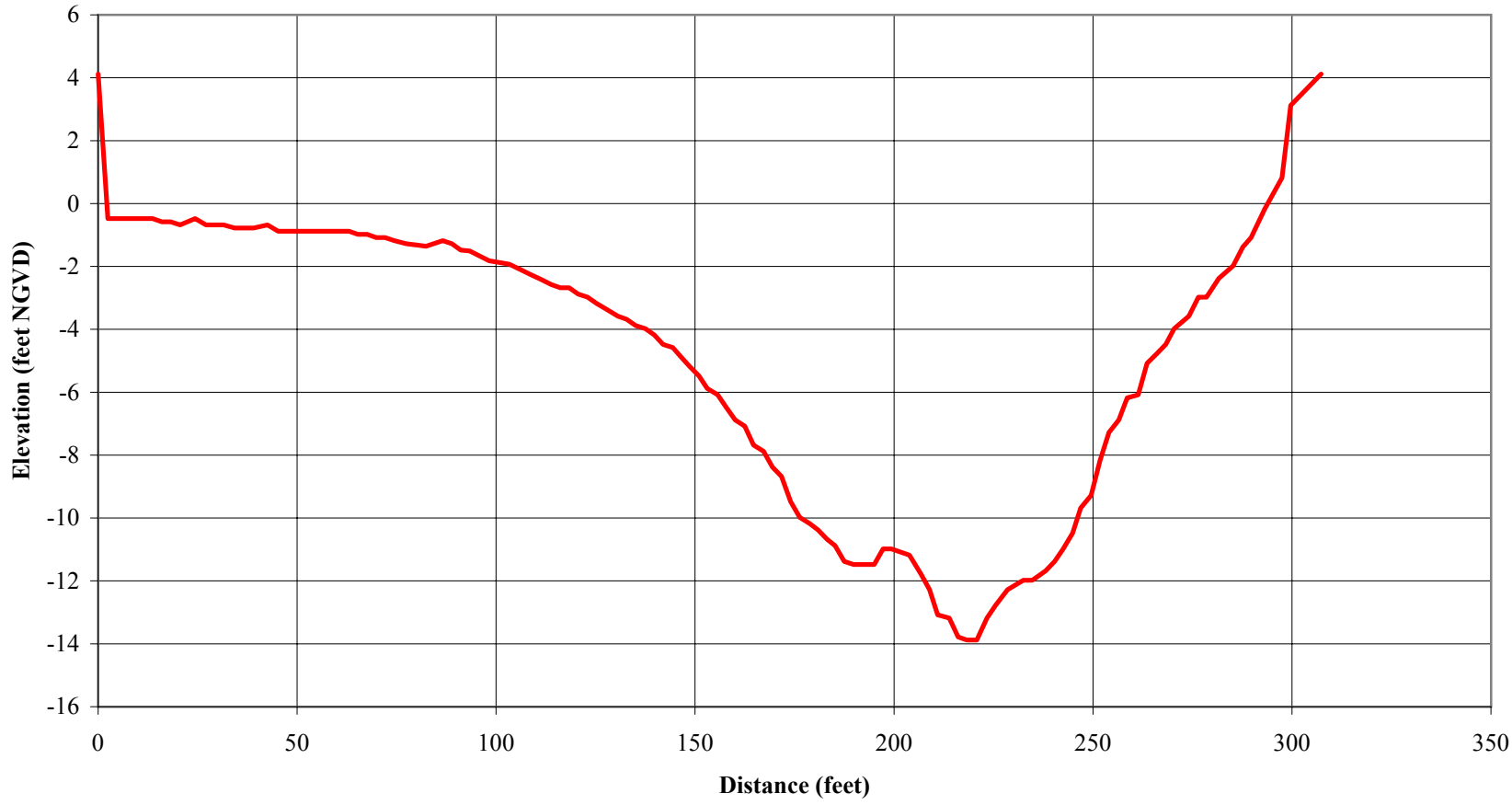
Source: Towill surveys (February 2000).

Bair Island

Cross Section 11

PWA

PWA #:1413



Source: Towill surveys (February 2000).

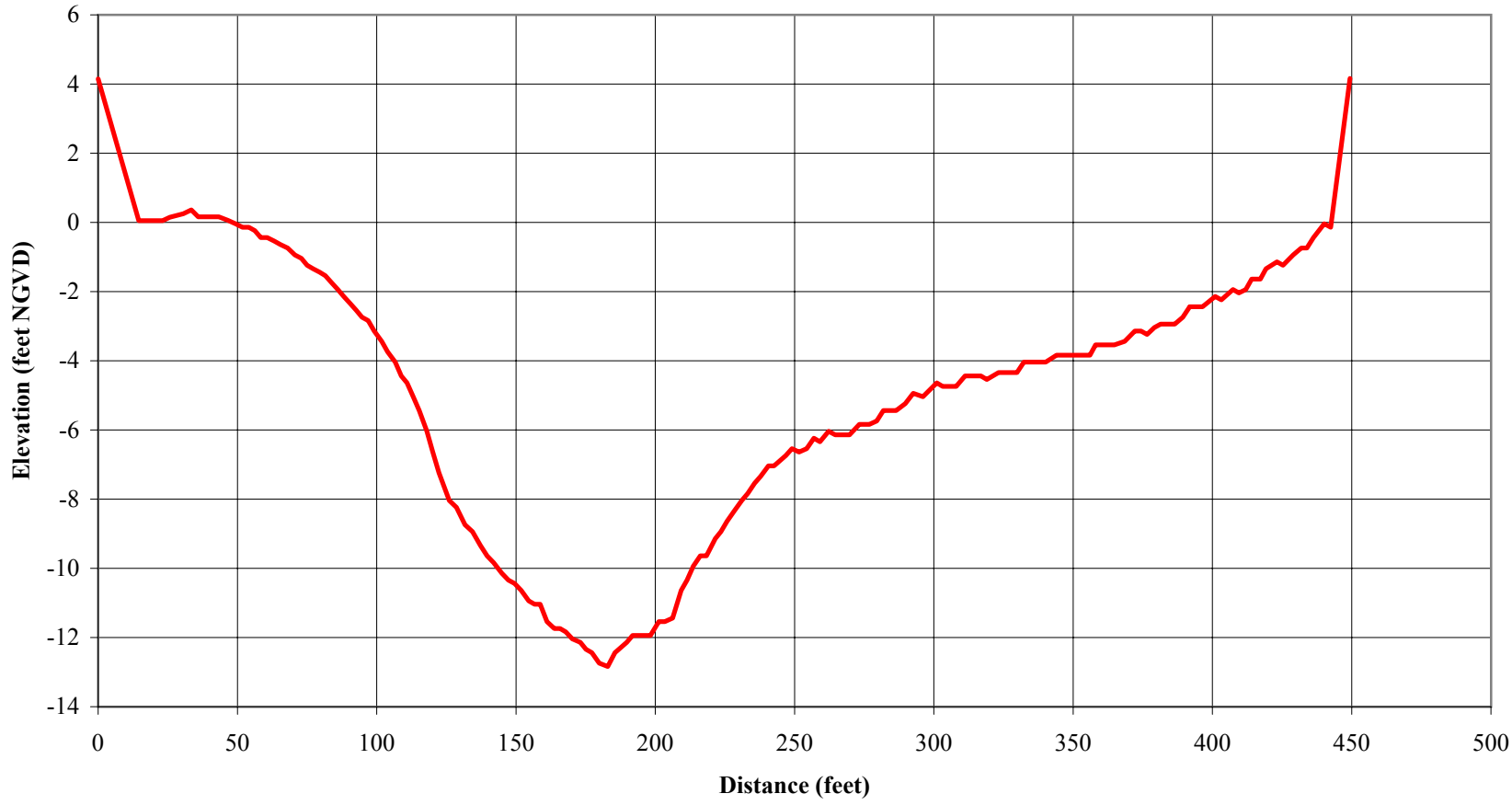
Bair Island

Cross Section 12

PWA

PWA #:1413

towillXS.xls 12 fig 2/6/04



Source: Towill surveys (February 2000).

Bair Island

Cross Section 13

PWA

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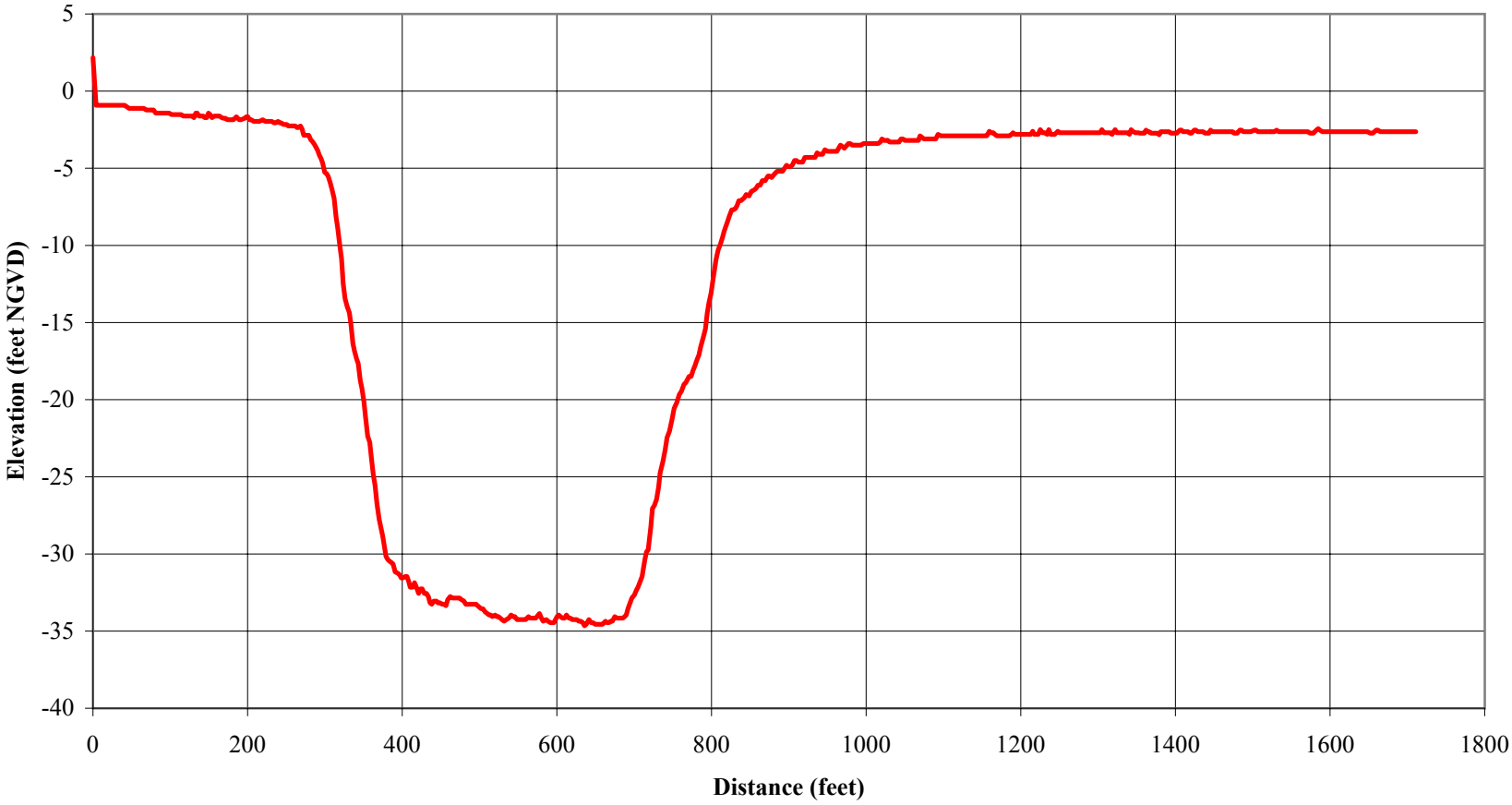

Source: Towill surveys (February 2000).

Bair Island

Cross Section 14

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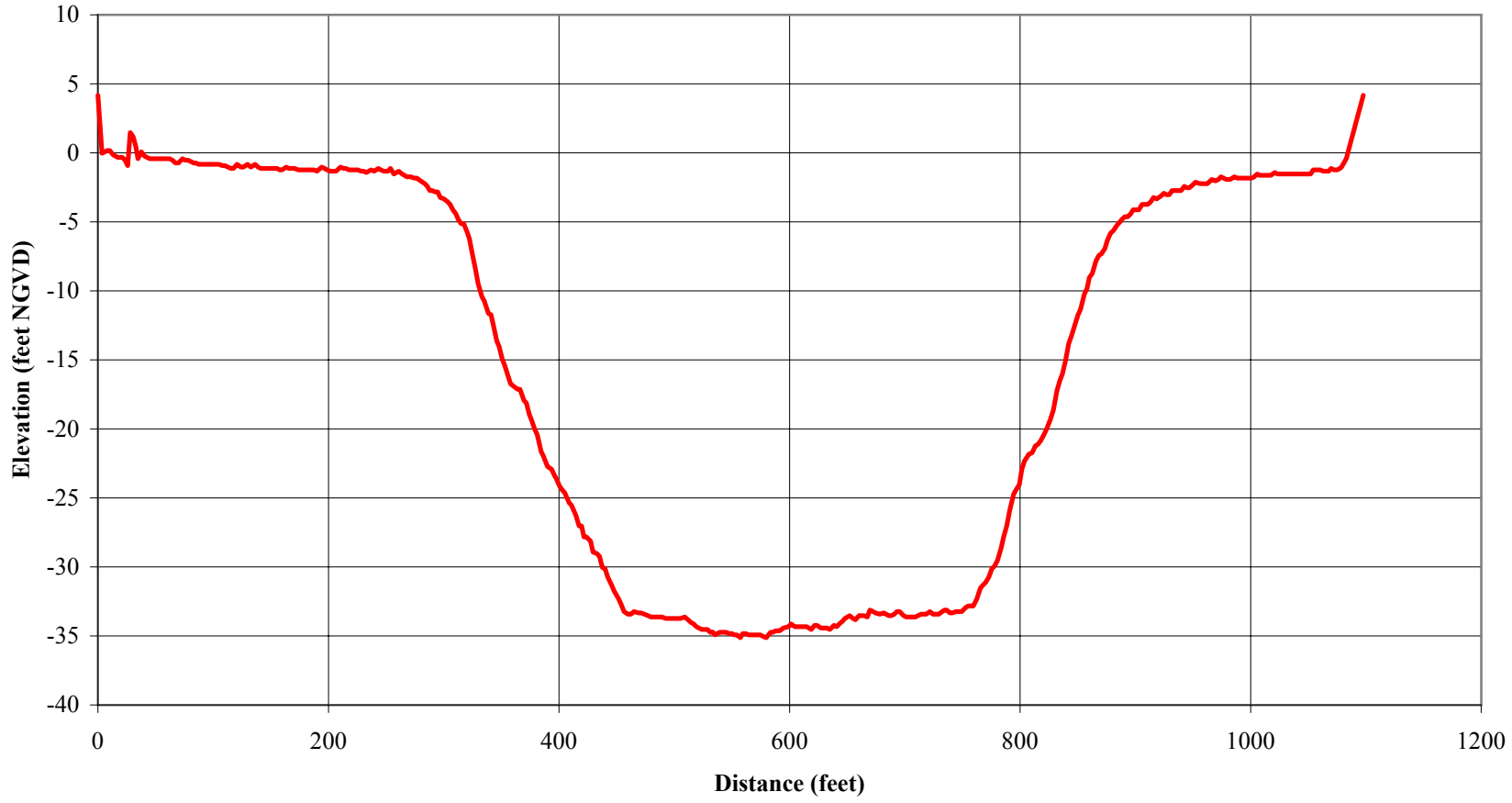


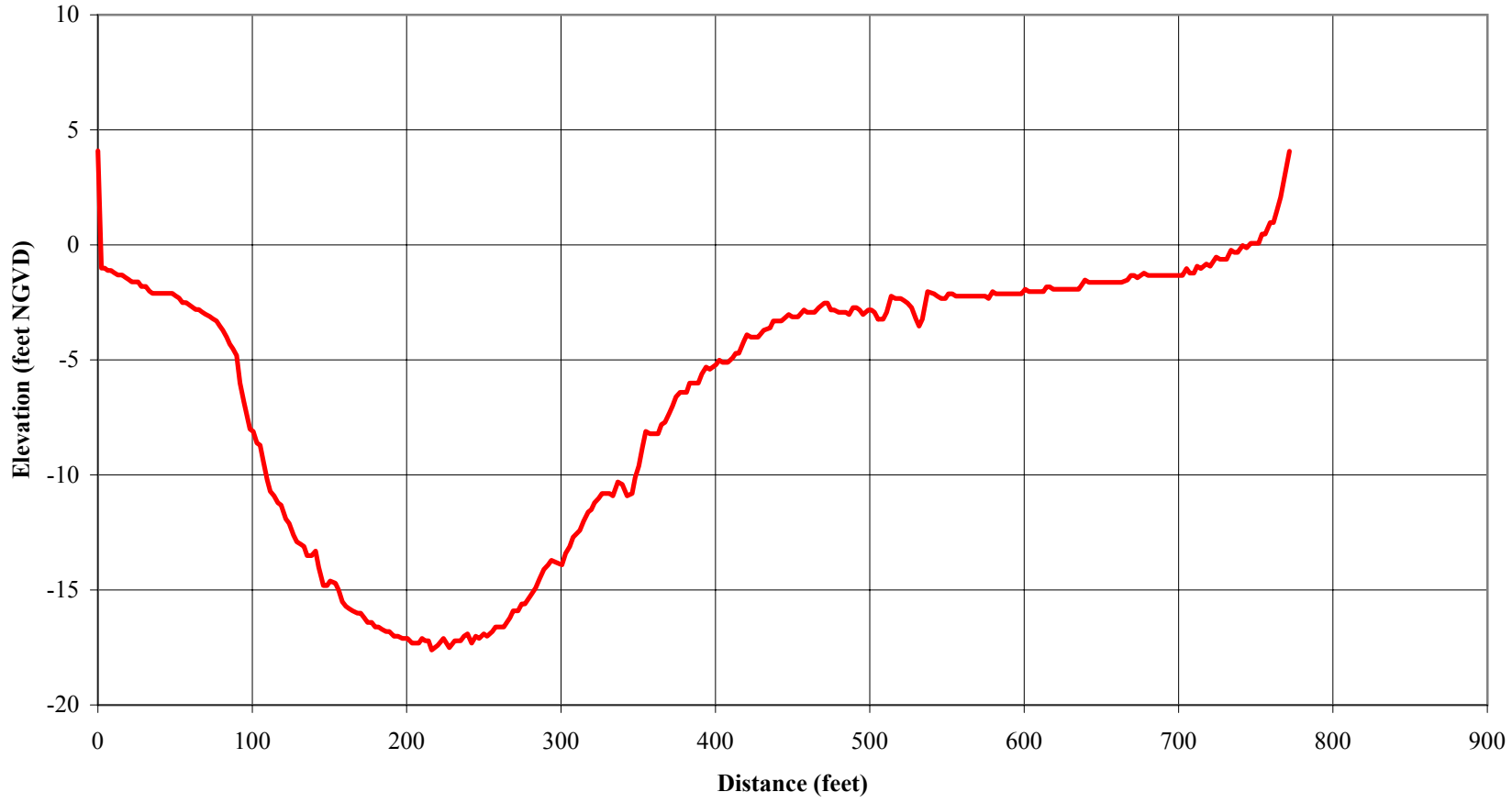
Source: Towill surveys (February 2000).

Bair Island

Cross Section 15

PWA

PWA #:1413



Source: Towill surveys (February 2000).

Bair Island

Cross Section 16

PWA

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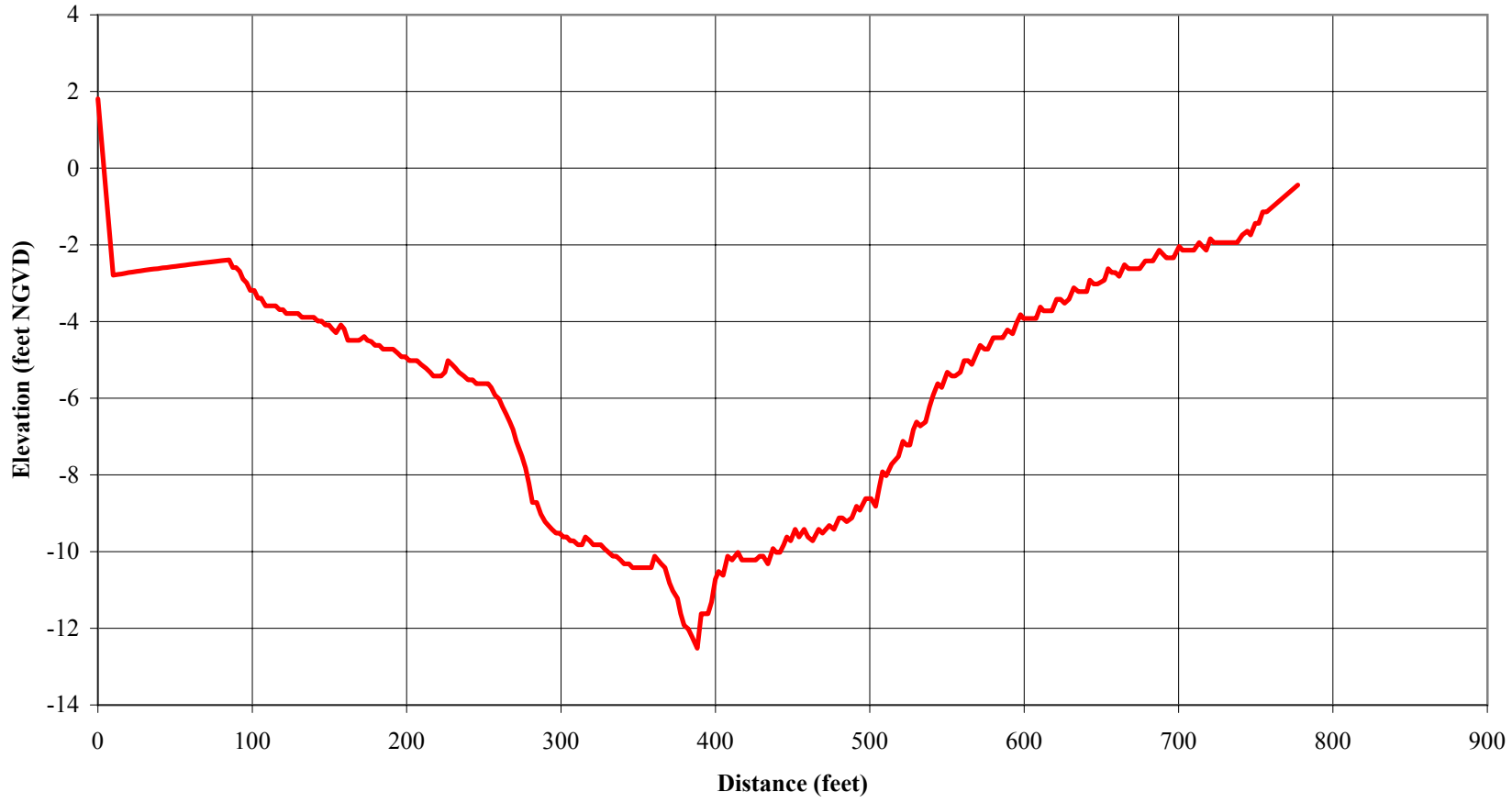


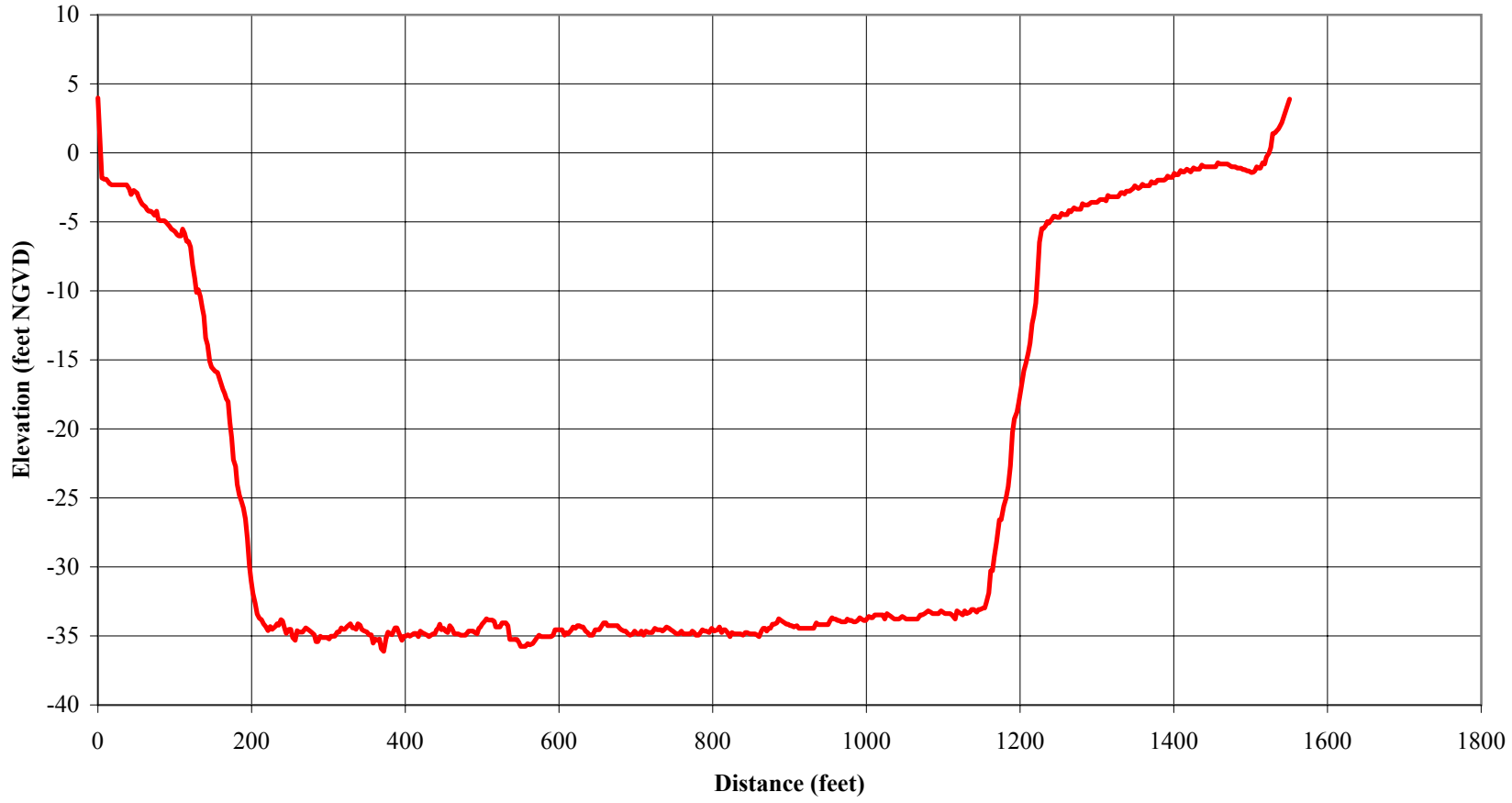
Source: Towill surveys (February 2000).

Bair Island

Cross Section 17

PWA

PWA #:1413



Source: Towill surveys (February 2000).

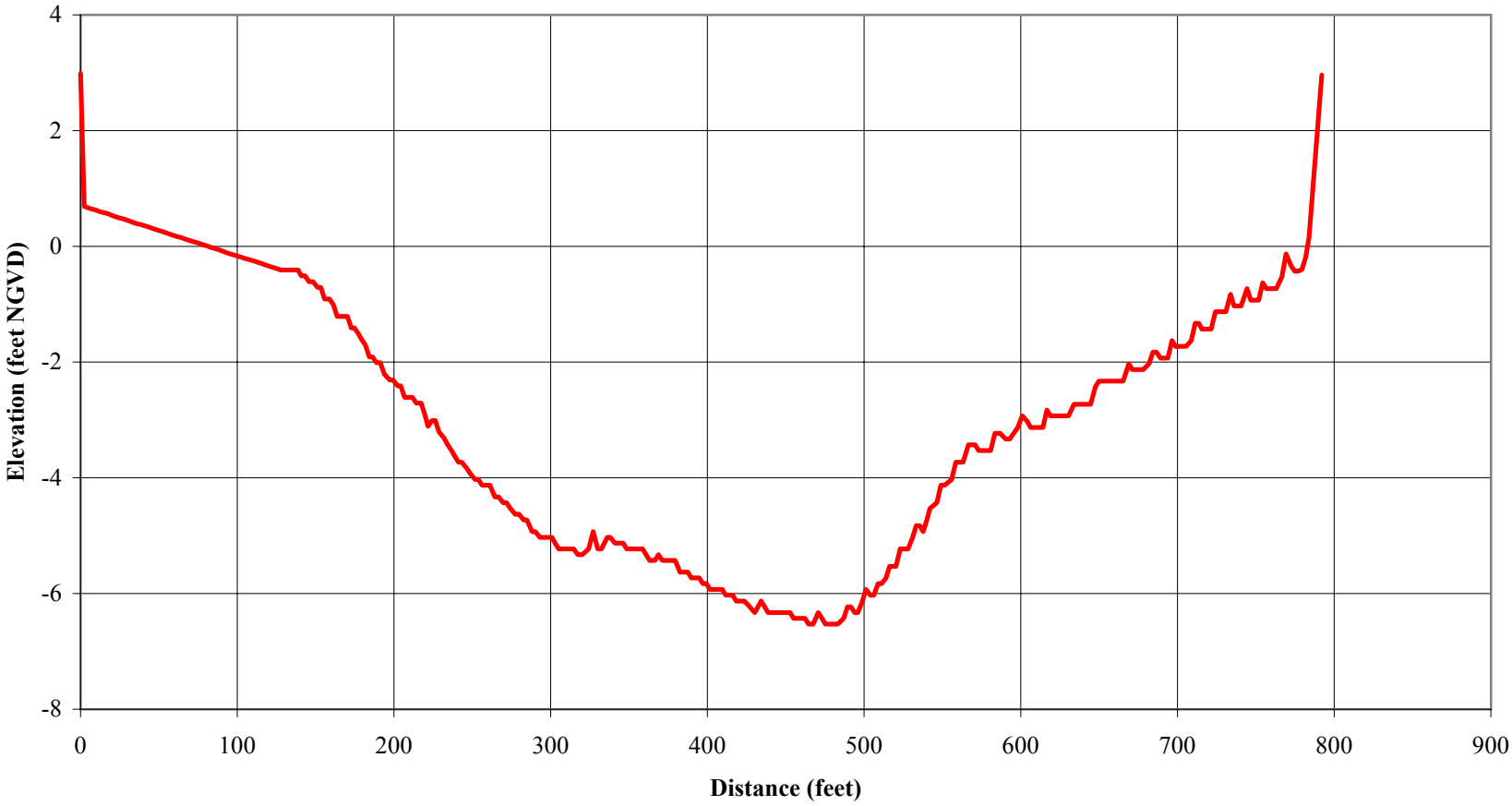
Bair Island

Cross Section 18

PWA

PWA #:1413

towillXS.xls 18 fig 2/6/04



Source: Towill surveys (February 2000).

Bair Island

Cross Section 19

PWA

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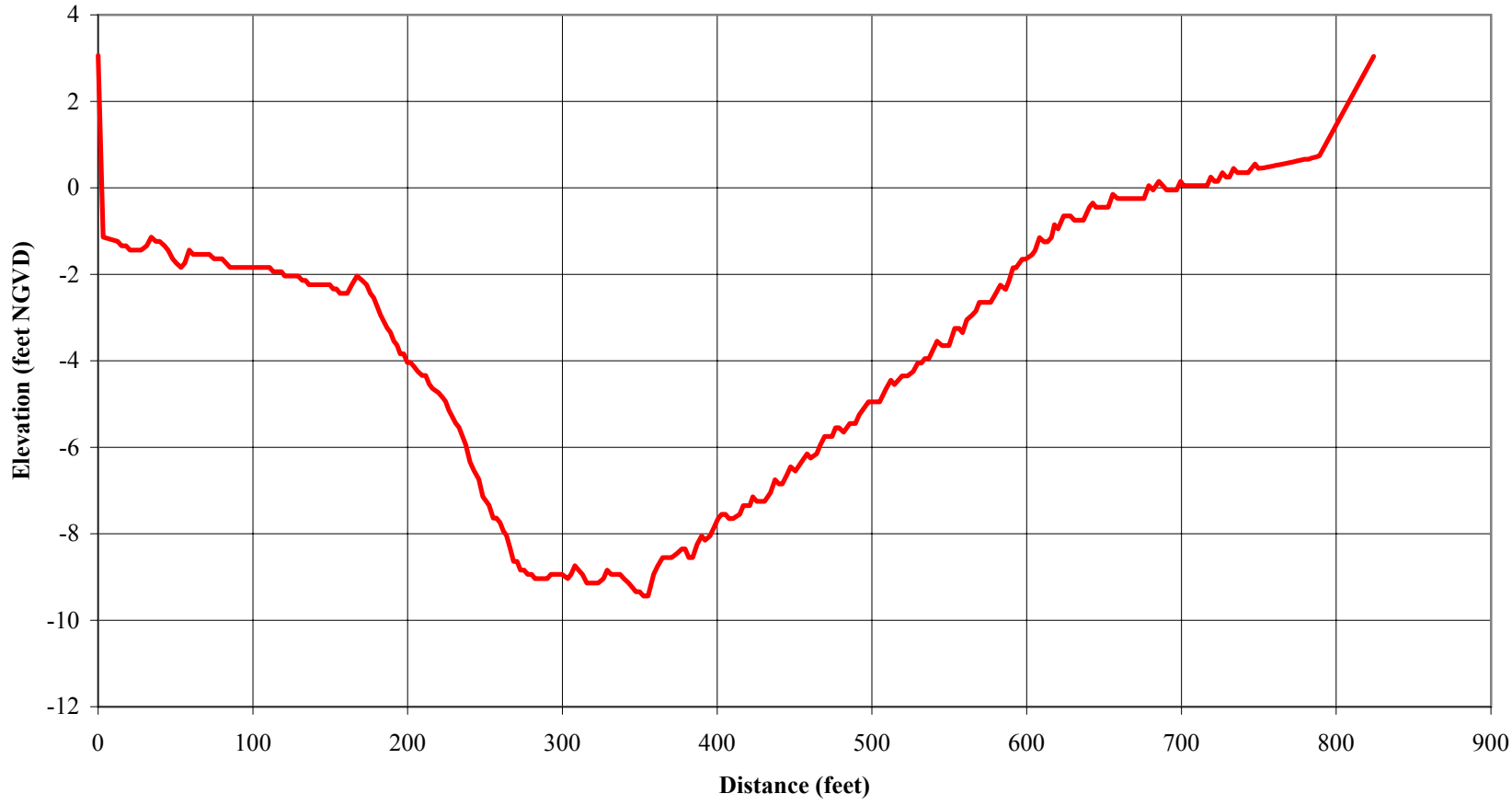


Source: Towill surveys (February 2000).

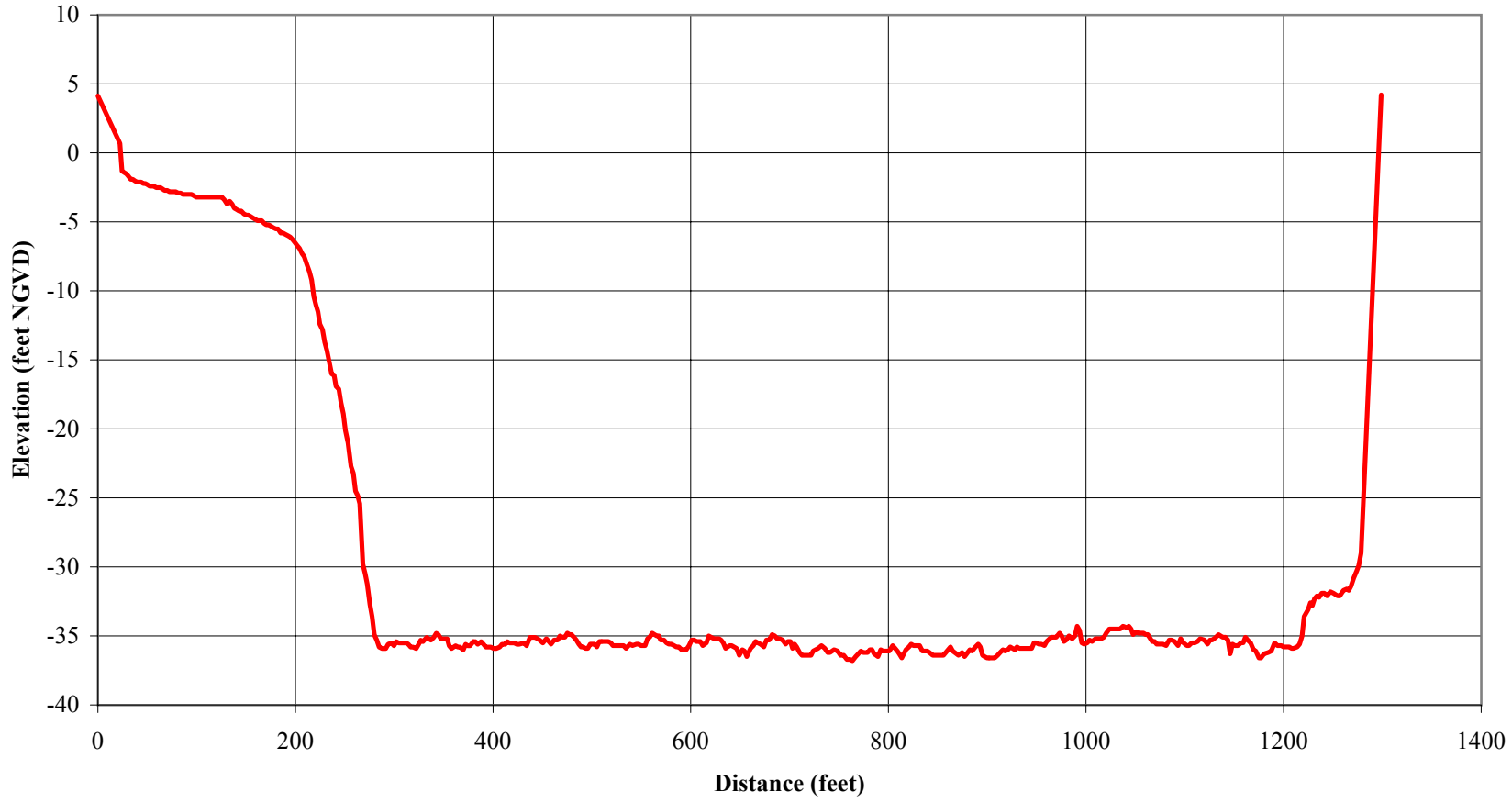
Bair Island

Cross Section 20

PWA

PWA #:1413

towillXS.xls 20 fig 2/6/04



Source: Towill surveys (February 2000).

Bair Island

Cross Section 21

PWA

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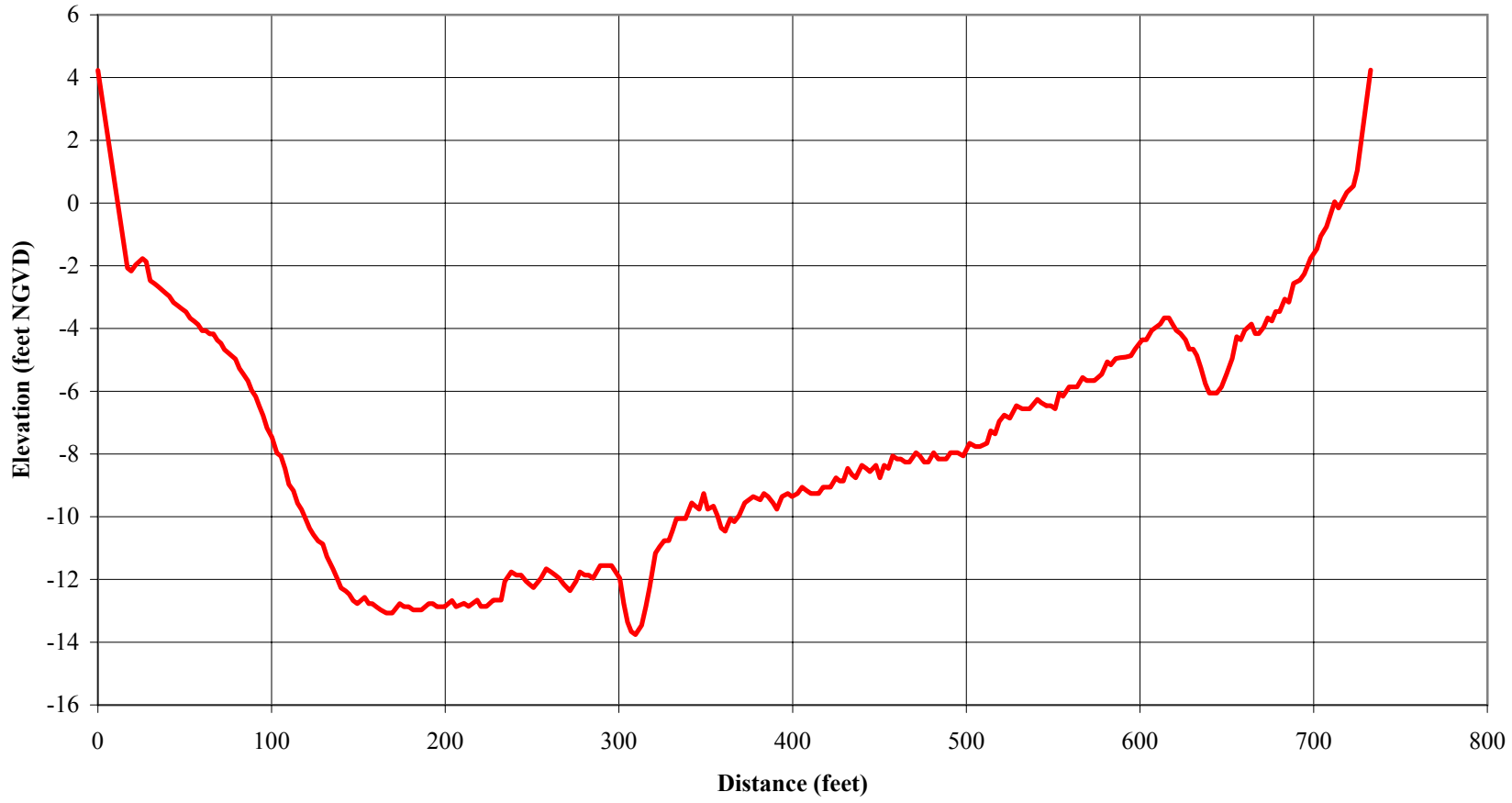


Source: Towill surveys (February 2000).

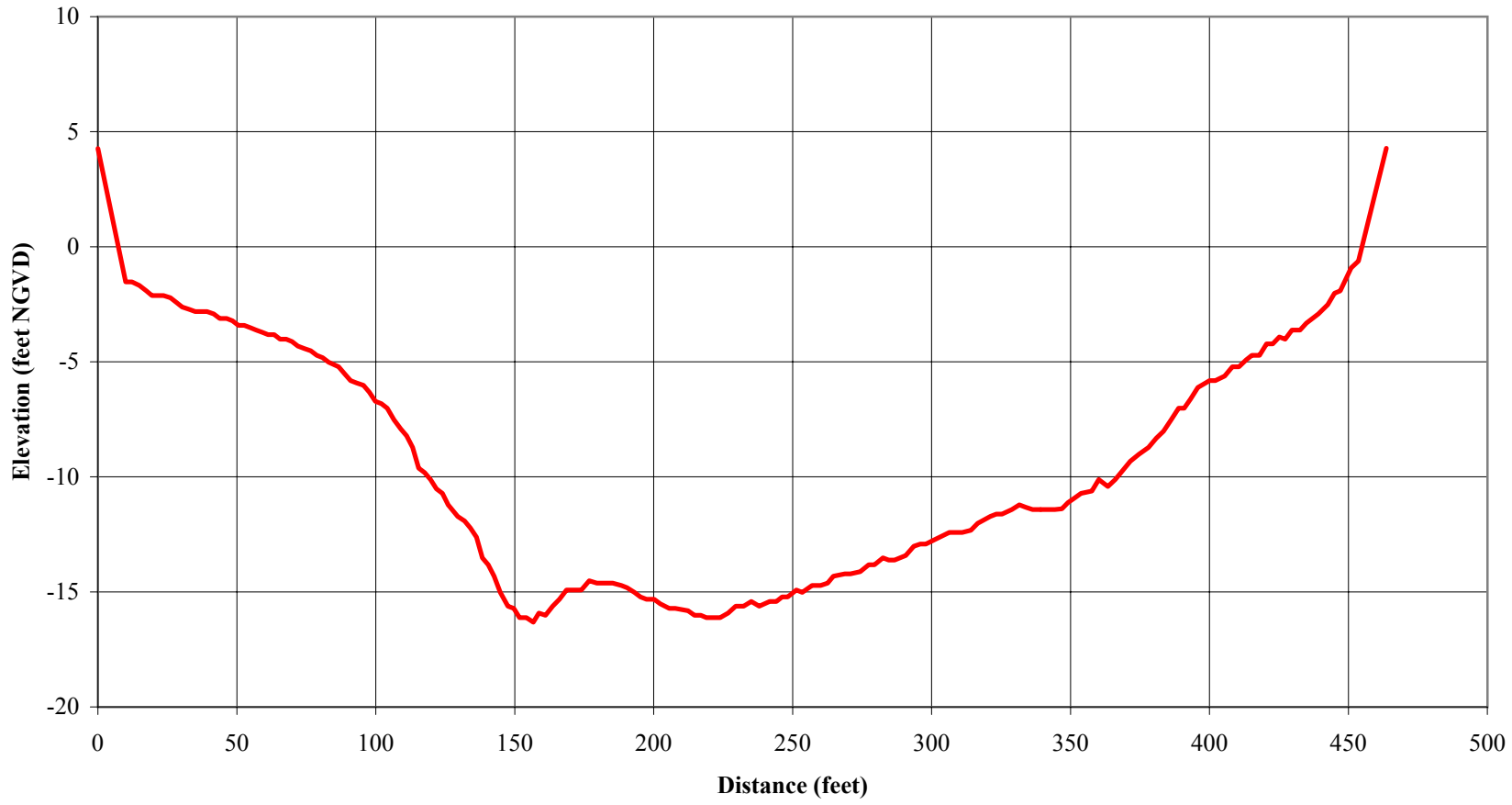
Bair Island

Cross Section 22

PWA

PWA #:1413

towillXS.xls 22 fig 2/6/04



Source: Towill surveys (February 2000).

Bair Island

Cross Section 23

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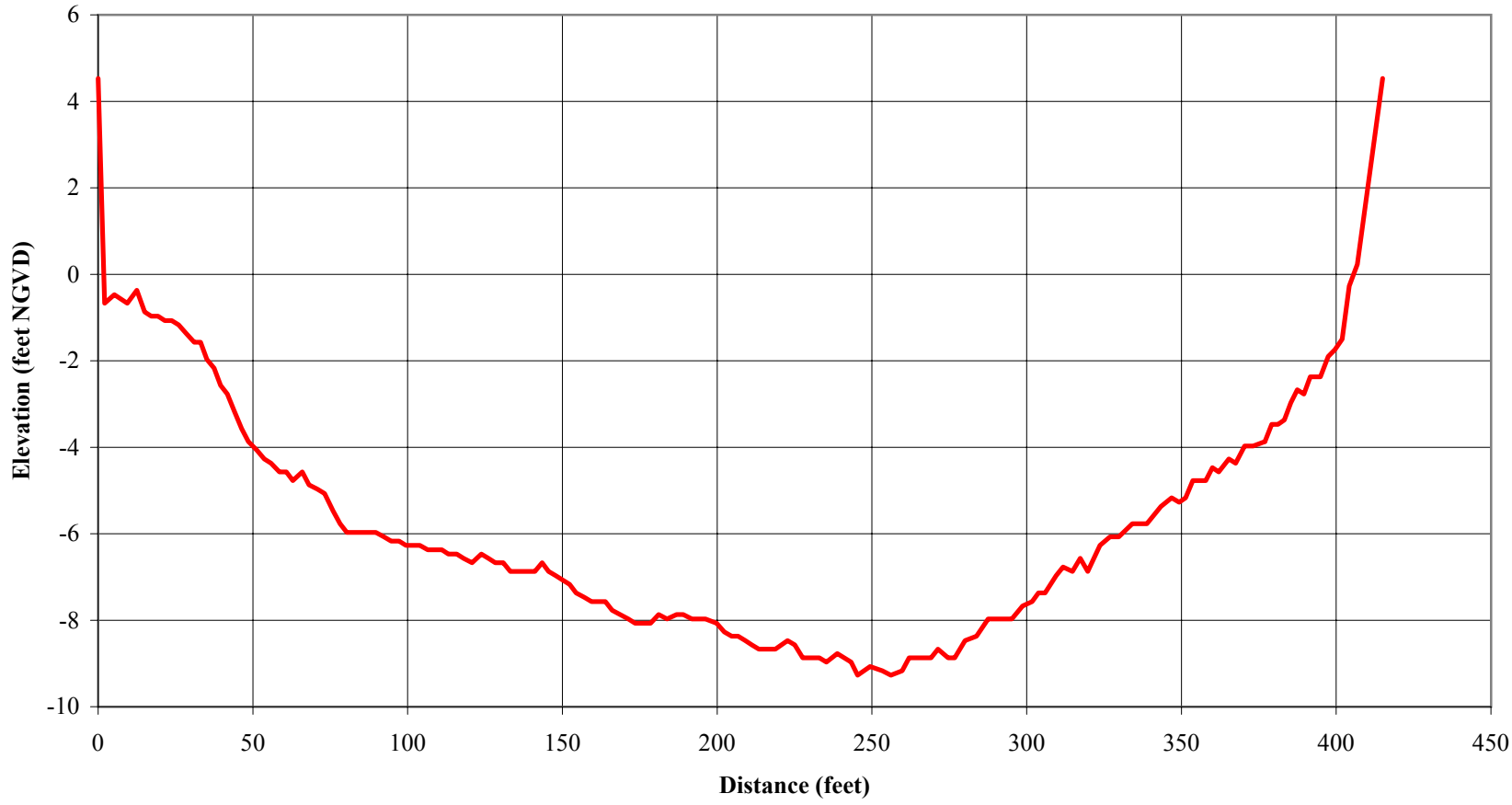

Source: Towill surveys (February 2000).

Bair Island

Cross Section 24

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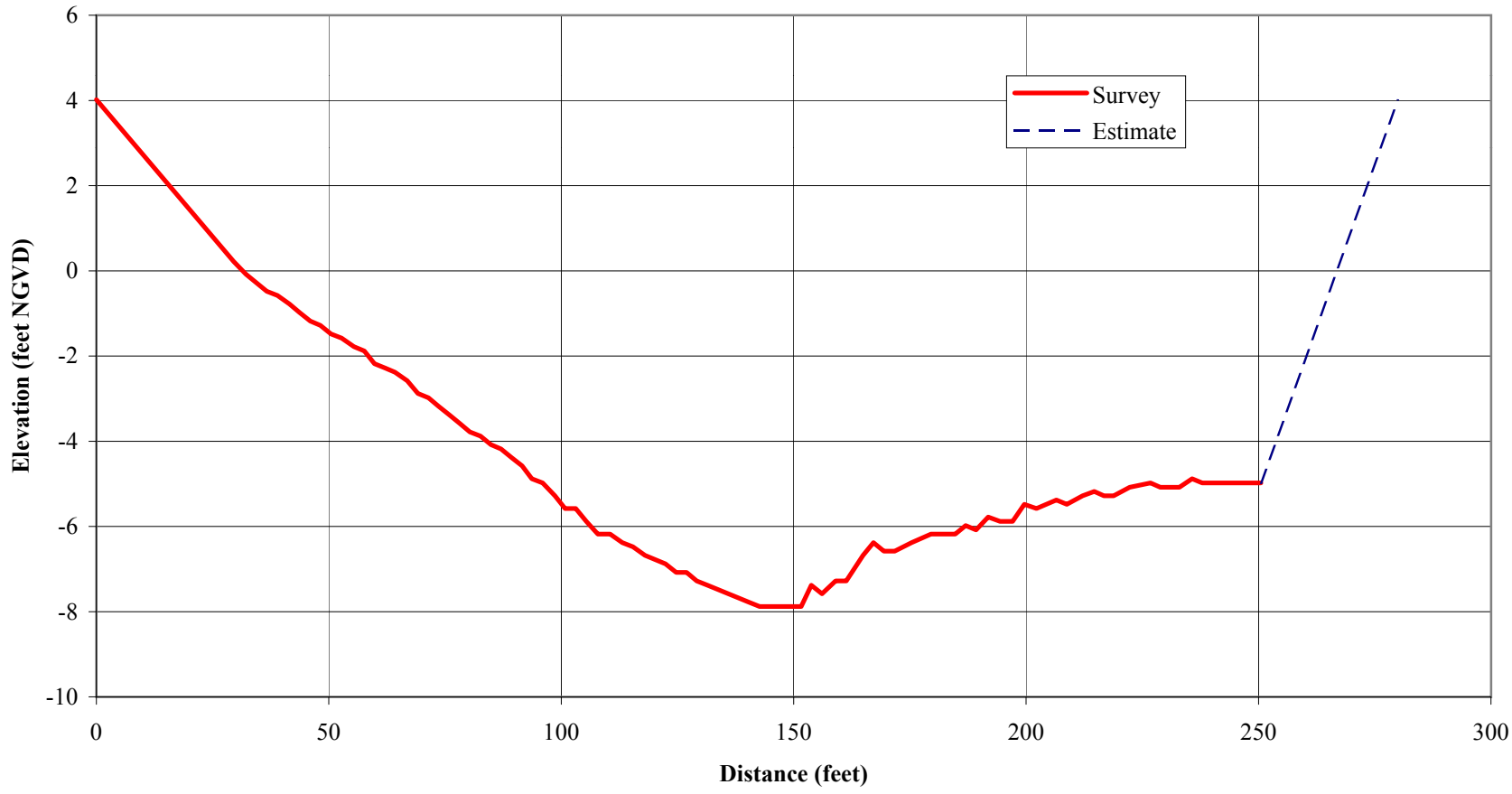

Source: Towill surveys (February 2000).

Bair Island

Cross Section 25

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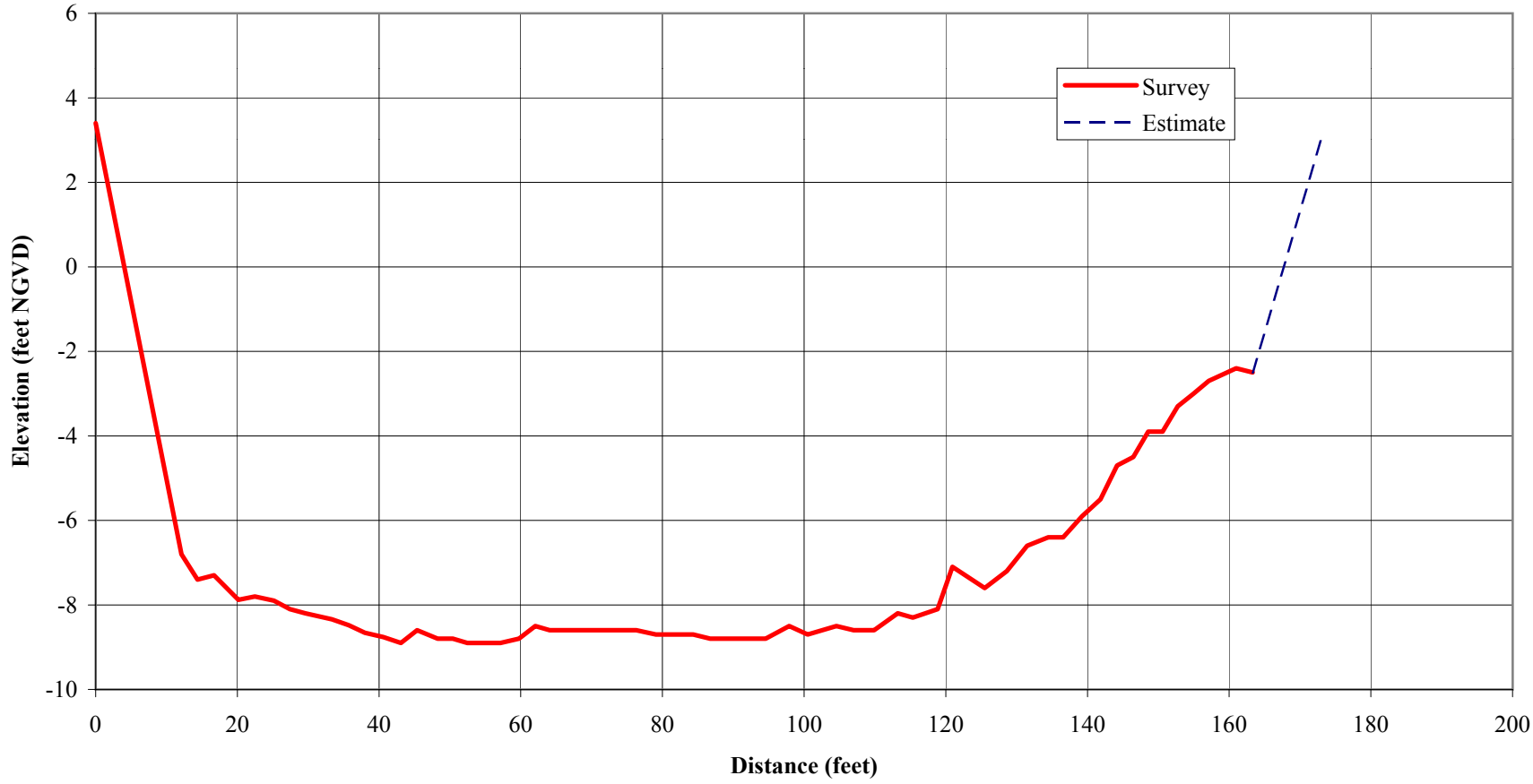


Source: Towill surveys (February 2000).

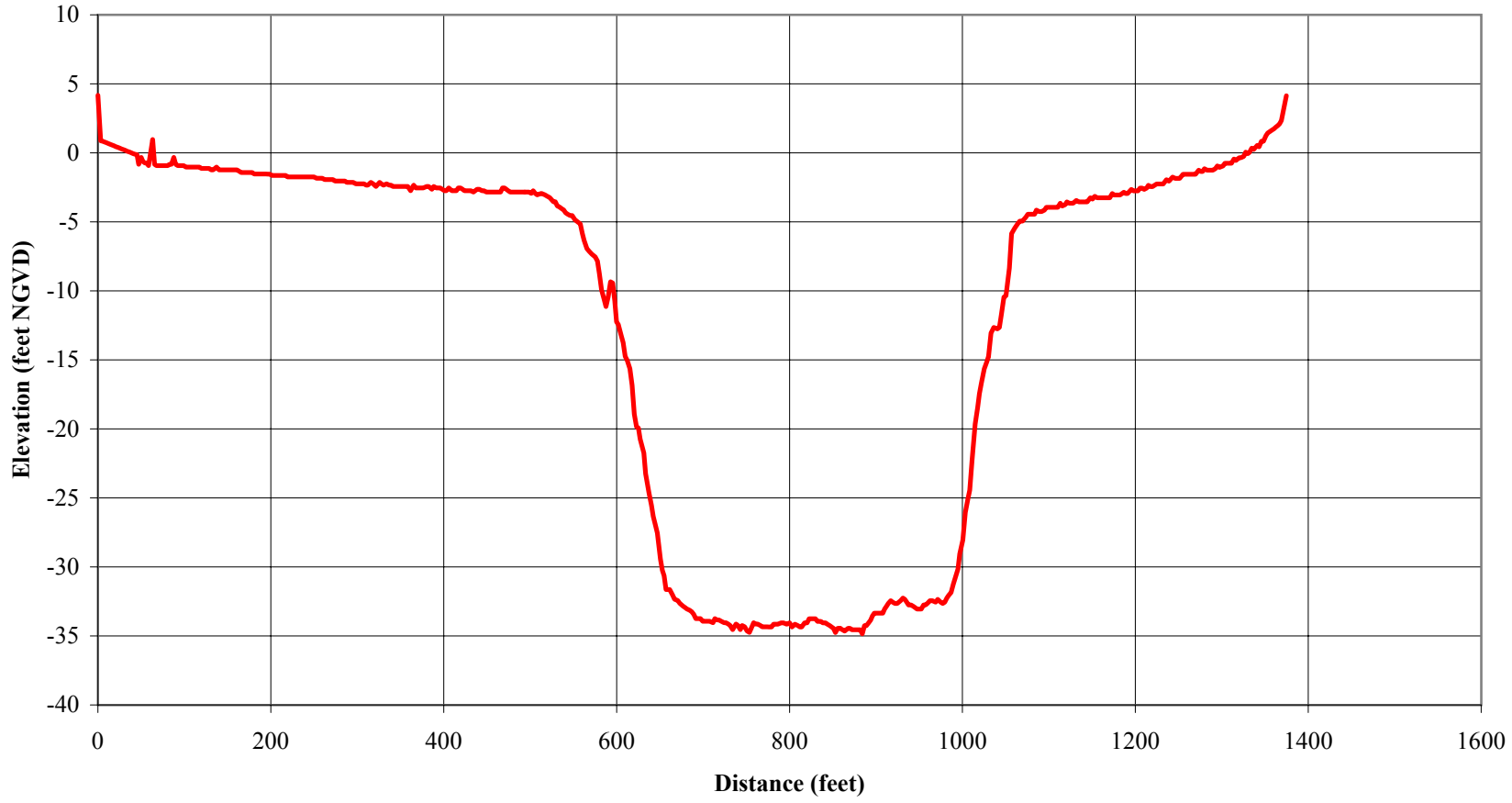
Bair Island

Cross Section 26

PWA

PWA #:1413

towillXS.xls 26 fig 2/6/04



Source: Towill surveys (February 2000).

Bair Island

Cross Section 27

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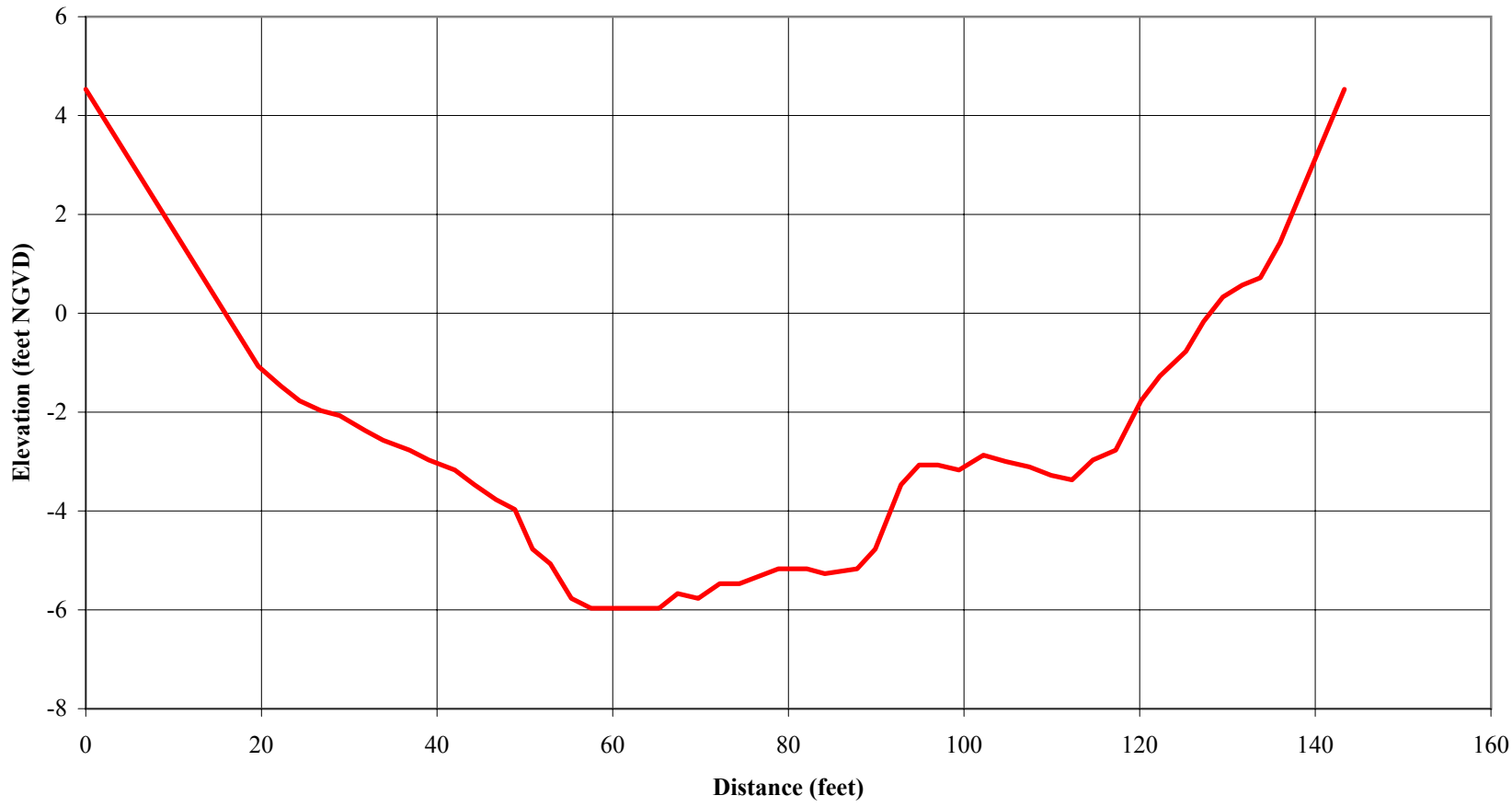


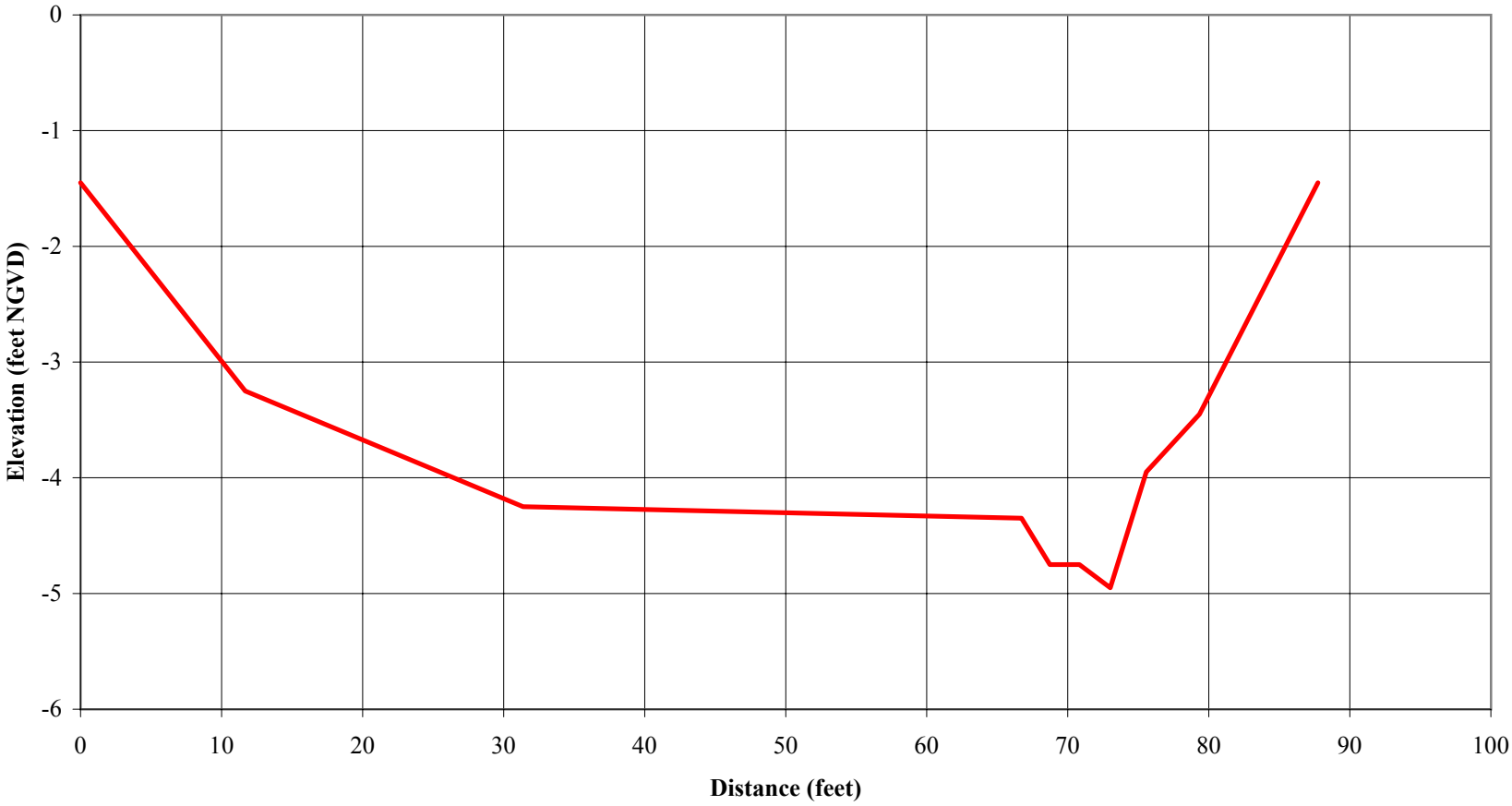
Source: Towill surveys (February 2000).

Bair Island

Cross Section 28

PWA

PWA #:1413



Source: Towill surveys (February 2000).

Bair Island

Cross Section 29

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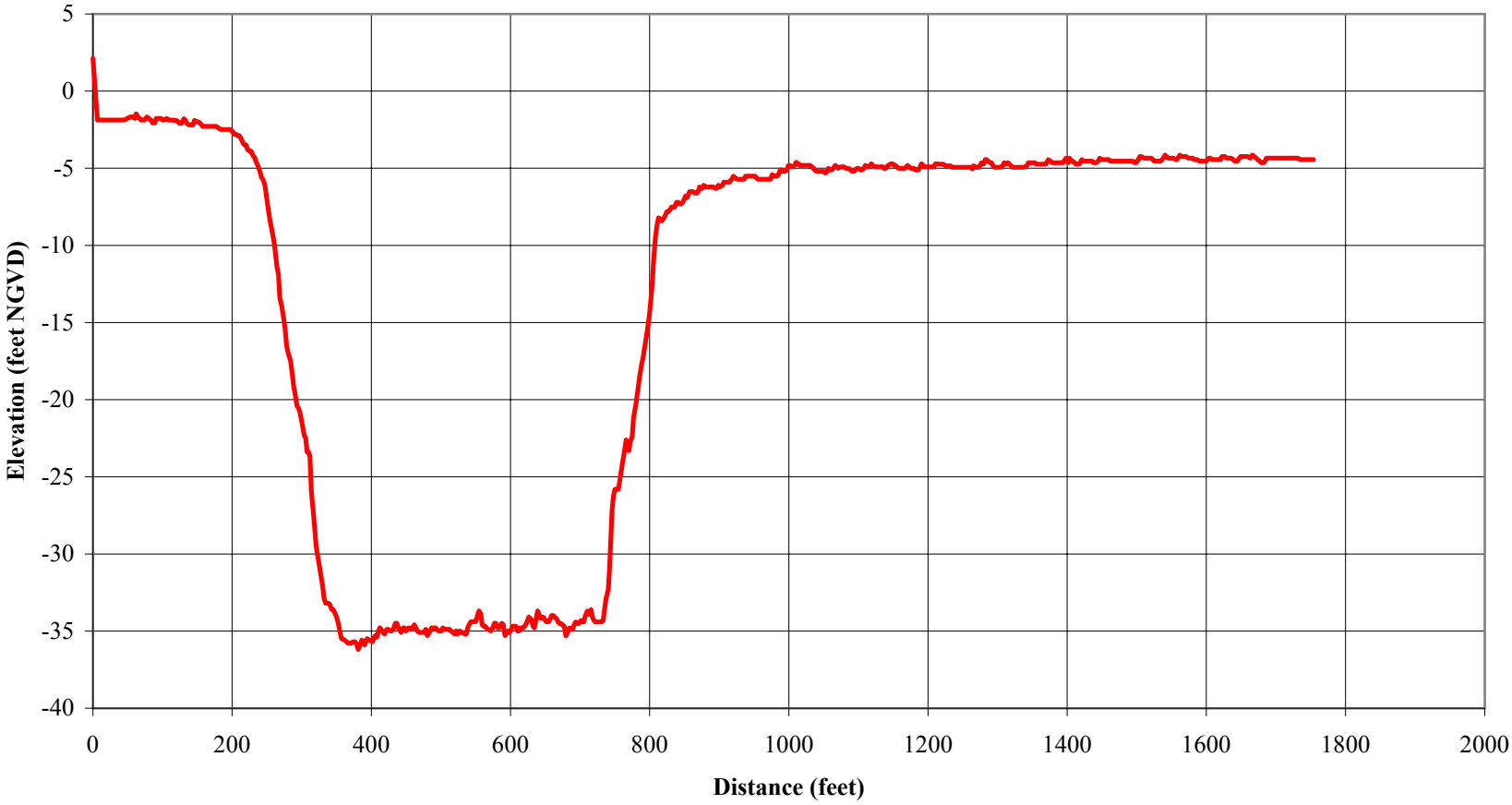


Source: Towill surveys (February 2000).

Bair Island

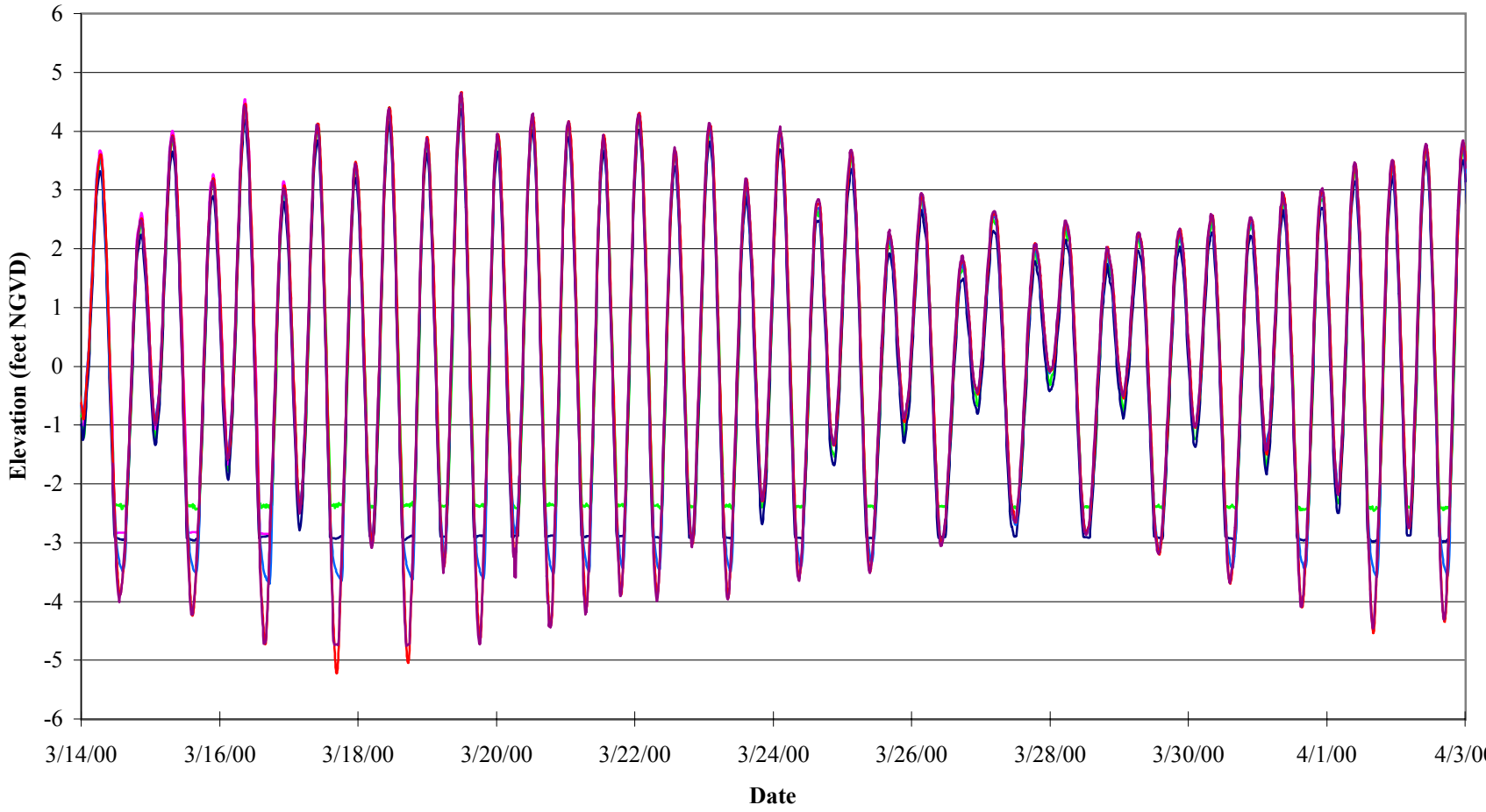
Cross Section 30

PWA

PWA #:1413

APPENDIX A
FIELD SURVEYS

A-5 Tide measurements for 6 stations



Corkscrew Slough
Steinberger Slough Pilings at Airport
Smith Slough Marina
Steinberger Slough Power Tower
Redwood Creek Wharf 5
Redwood Creek Channel Marker 8

Source: PWA field surveys (this study) and NOS (2000)

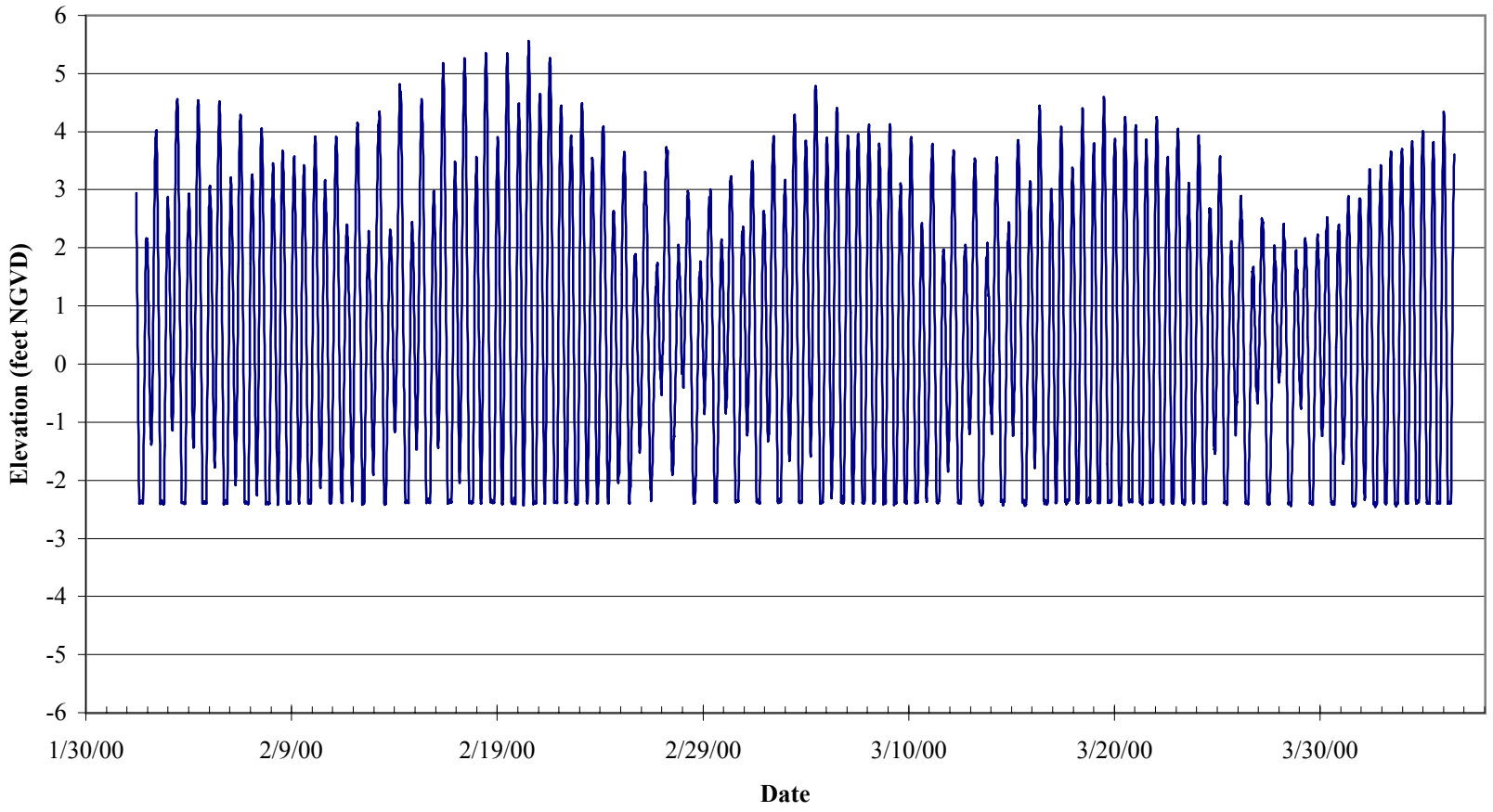
Bair Island

All Tidal Monitoring Stations from March 14 to April 3, 2000

PWA

PWA #: 1413

Projects\1413_Bair_orig\Task2+7_PWA\surveys\tidesall tides june2000.xls all chart 2/6/04



Source: PWA field surveys.

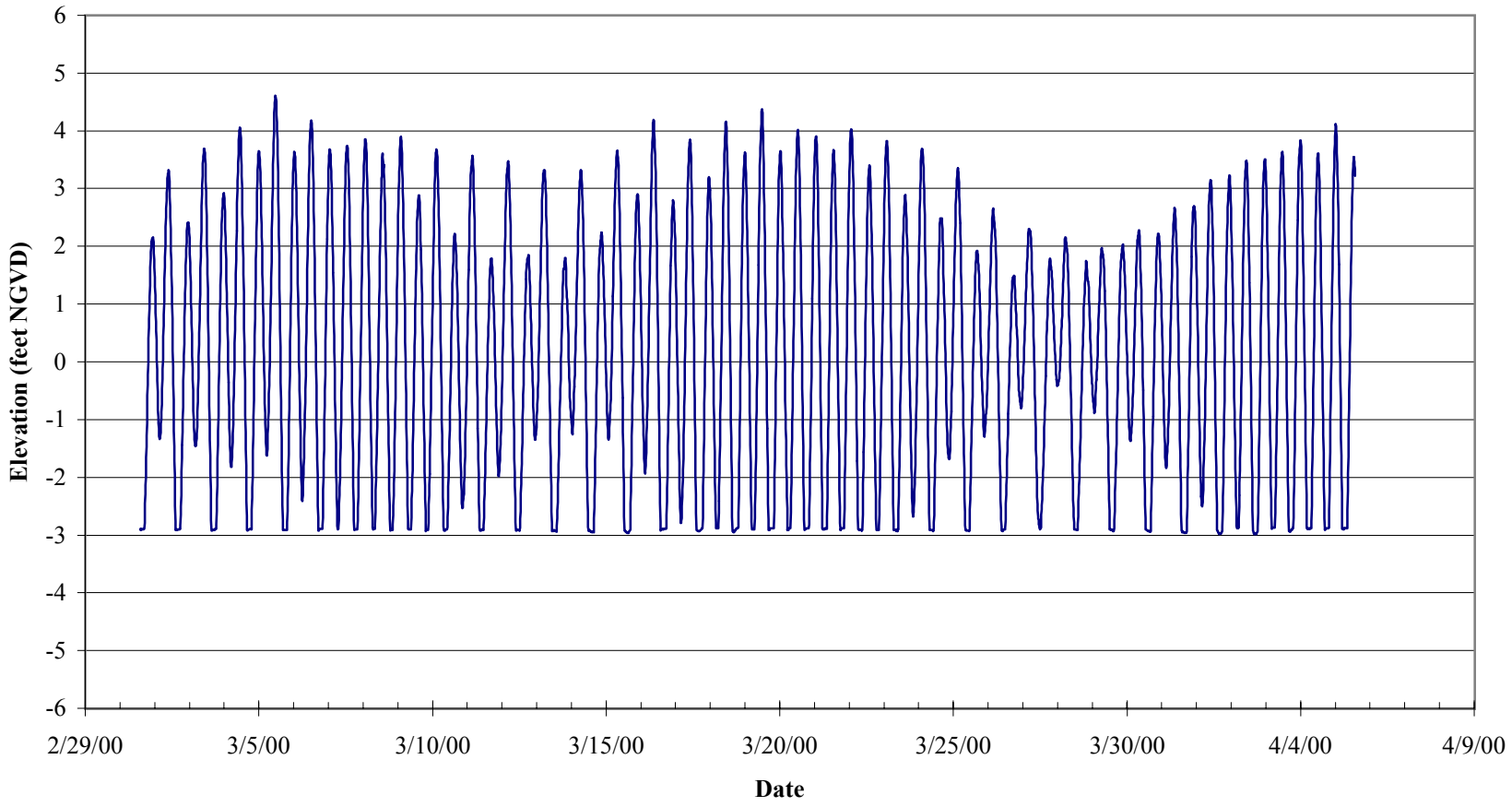
Bair Island

Corkscrew Slough
from February 1 to April 5, 2000

PWA

PWA #: 1413

Projects\1413_Bair_orig\Task2+7_PWAsurveys\tides\ all tides june2000.xls cork chart 2/6/04



Source: PWA field surveys.

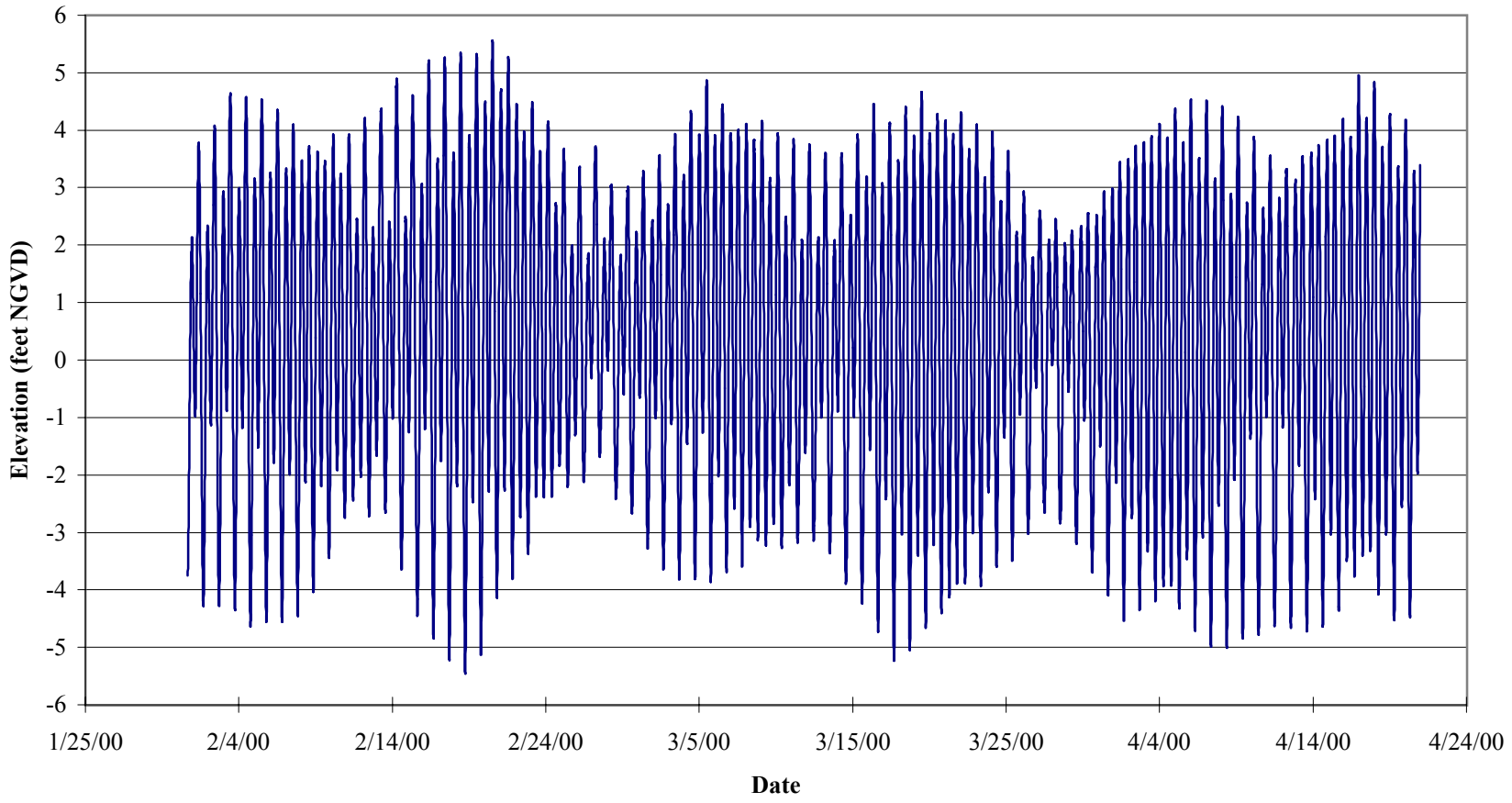
Bair Island

Smith Slough near Pete's Marina
from March 1 to April 5, 2000

PWA

PWA #: 1413

Projects\1413_Bair_orig\Task2+7_PWAsurveys\tides \ all tides june2000.xls marina chart 2/6/04



Source: NOS 2000 and PWA survey (this study).
Note: Tide elevations relative to MLLW are from NOS (2000) at Station 9414523 (Redwood City Wharf 5). Tidal datum conversion from MLLW to NGVD (-4.12 feet) is based on PWA field survey . Other methods of estimating the conversion based on previous published conversion values (NOS 1983) and published benchmark elevation data (NGS 2000) yield different conversion estimates.

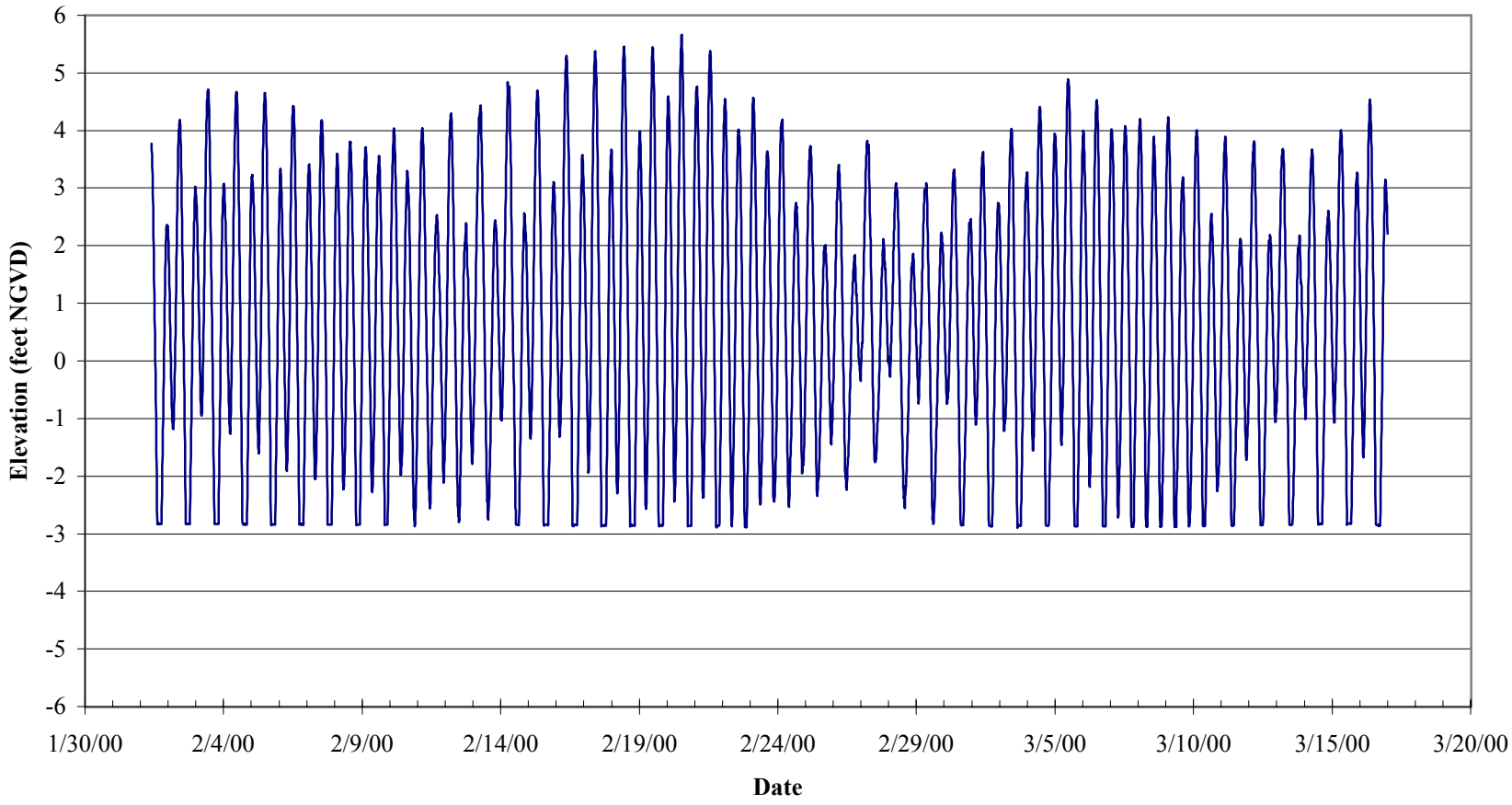
Bair Island

Wharf 5 on Redwood Creek from February 1 to April 20, 2000

PWA

PWA #: 1413

Projects\1413_Bair_orig\Task2+7_PWAsurveys\tides \ all tides june2000.xls wharf5 chart 2/6/04



Source: PWA field surveys.

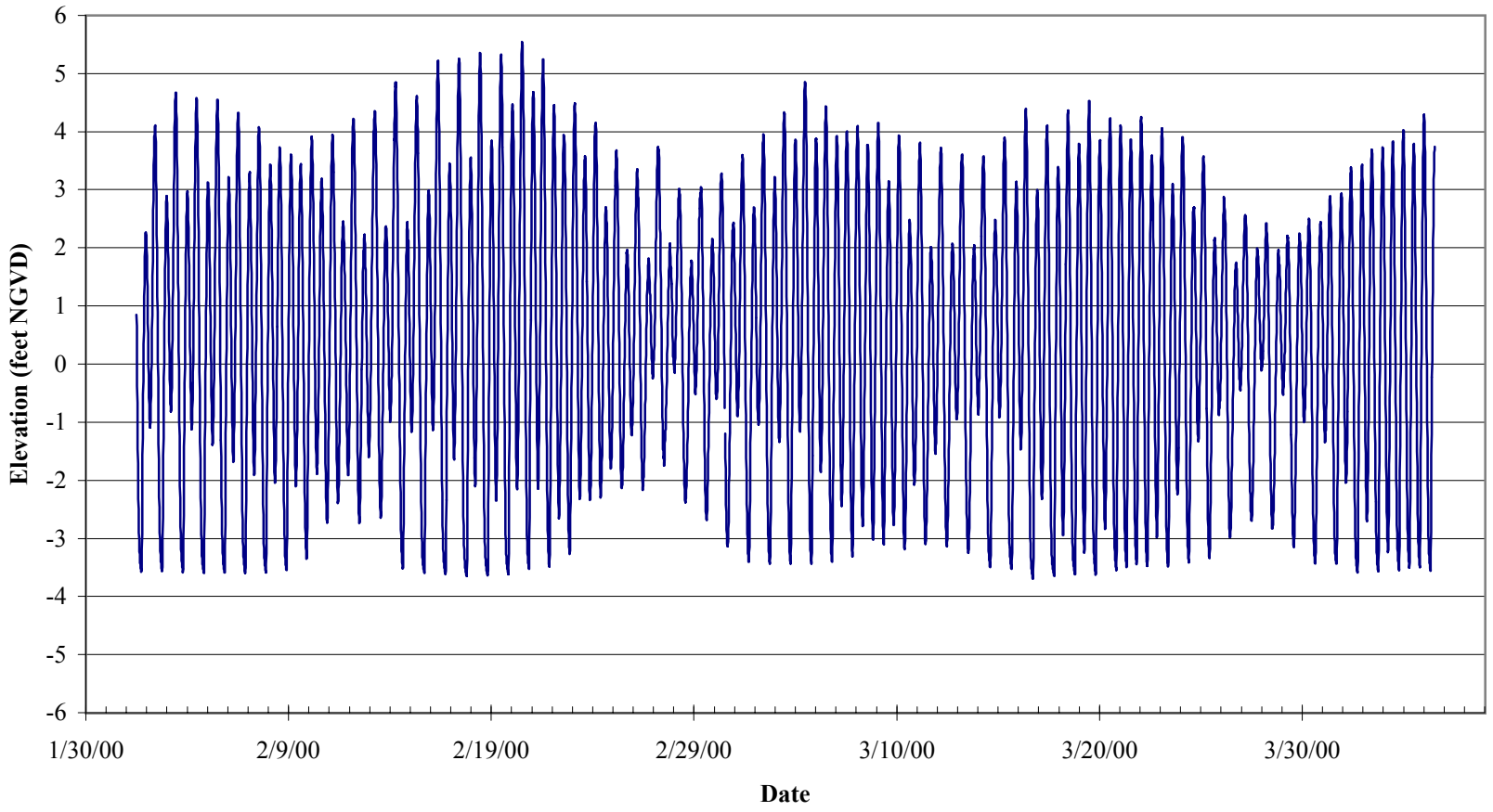
Bair Island

Steinberger Slough Pilings at Airport from February 1 to March 16, 2000

PWA

PWA #: 1413

Projects\1413_Bair_orig\Task2+7_PWAsurveys\tides \ all tides june2000.xls piling chart 2/6/04



Source: PWA field surveys

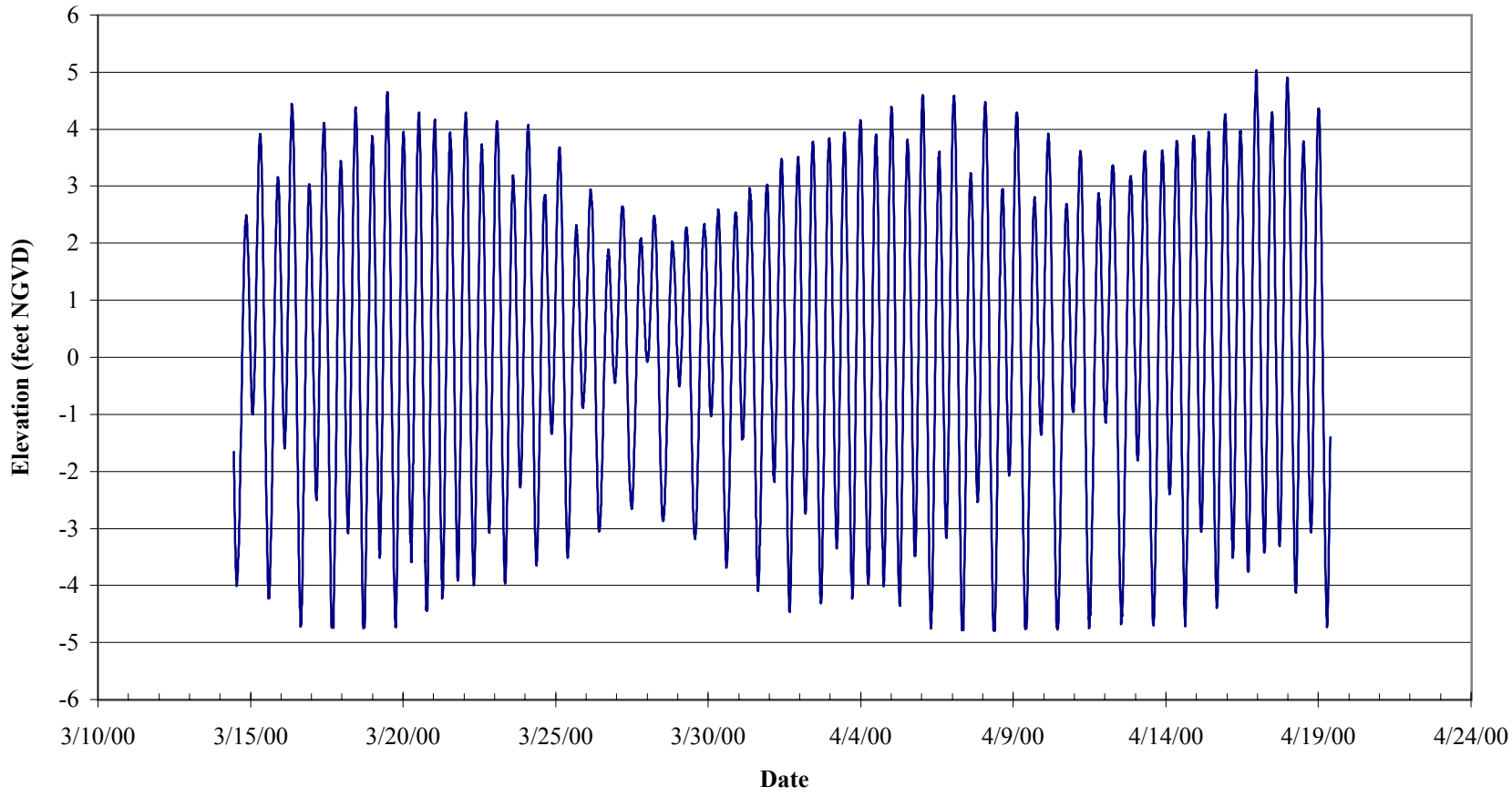
Bair Island

Steinberger Slough Power Tower from February 1 to April 5, 2000

PWA

PWA #: 1413

Projects\1413_Bair_orig\Task2+7_PWAsurveys\tidesall tides june2000.xls power t chart 2/6/04



Source: PWA field surveys.

Bair Island

Channel Marker 8 on Redwood Creek from March 13 to April 19, 2000

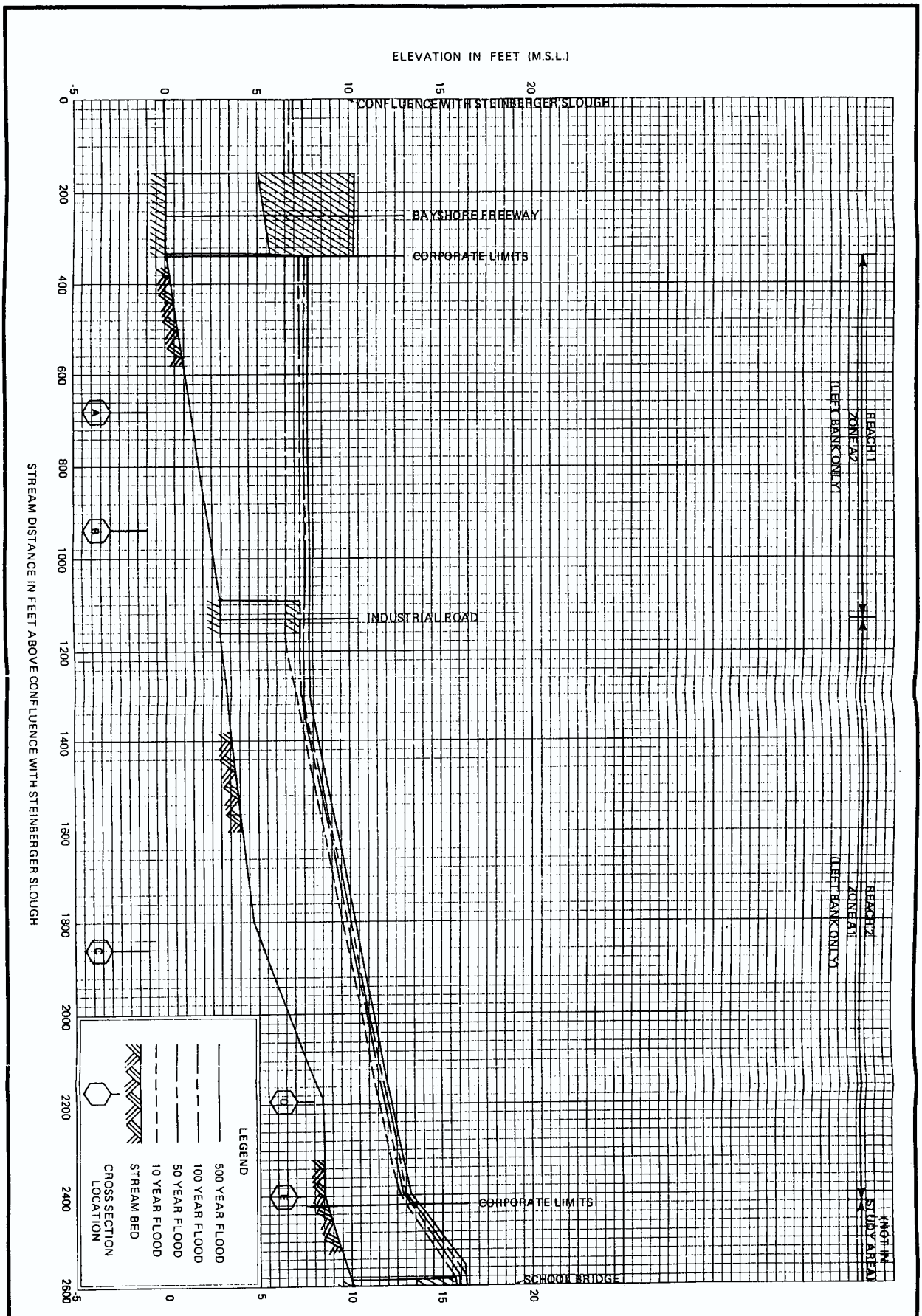
PWA

PWA #: 1413

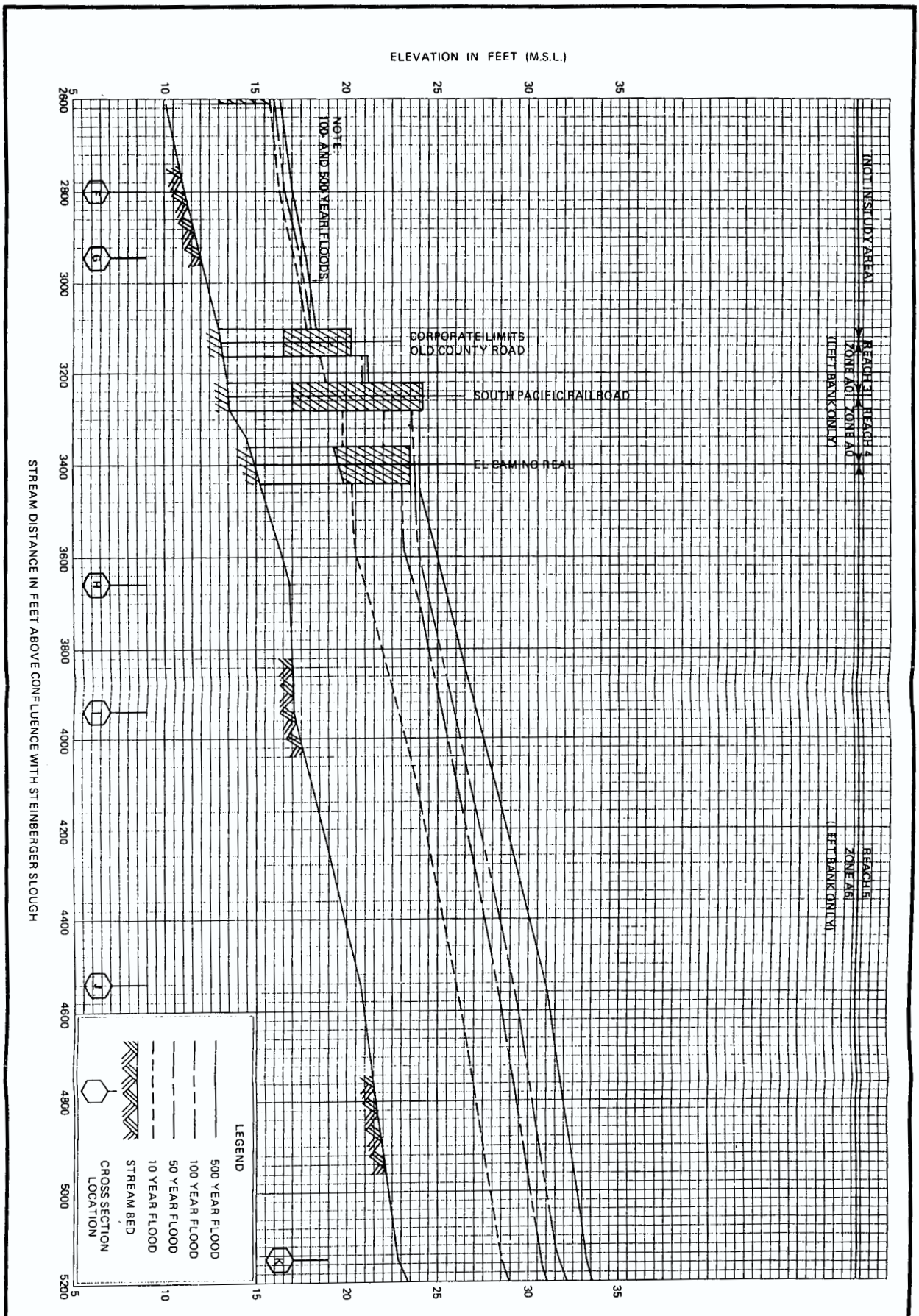
Projects\1413_Bair_orig\Task2+7_PWAsurveys\tides \ all tides june2000.xls ch mark8 chart 2/6/04

APPENDIX B
FEMA 100-YEAR WATER SURFACE ELEVATION PROFILES

- Cordilleras Creek
- Pulgas Creek



01P	DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT Federal Insurance Administration **CITY OF SAN CARLOS, CA** SAN MATEO COUNTY	**FLOOD PROFILES** **CORDILLERAS CREEK**



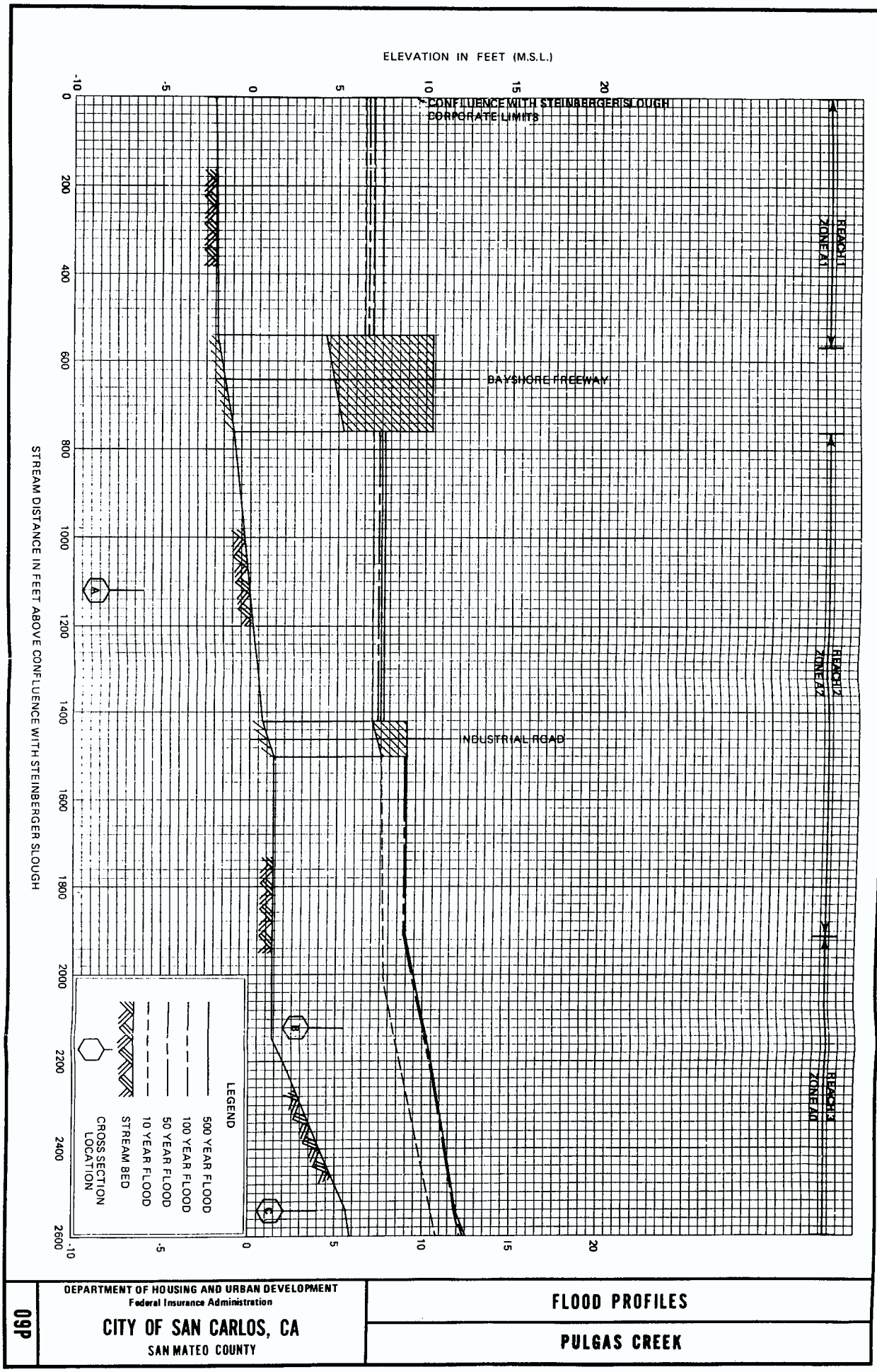
02P

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

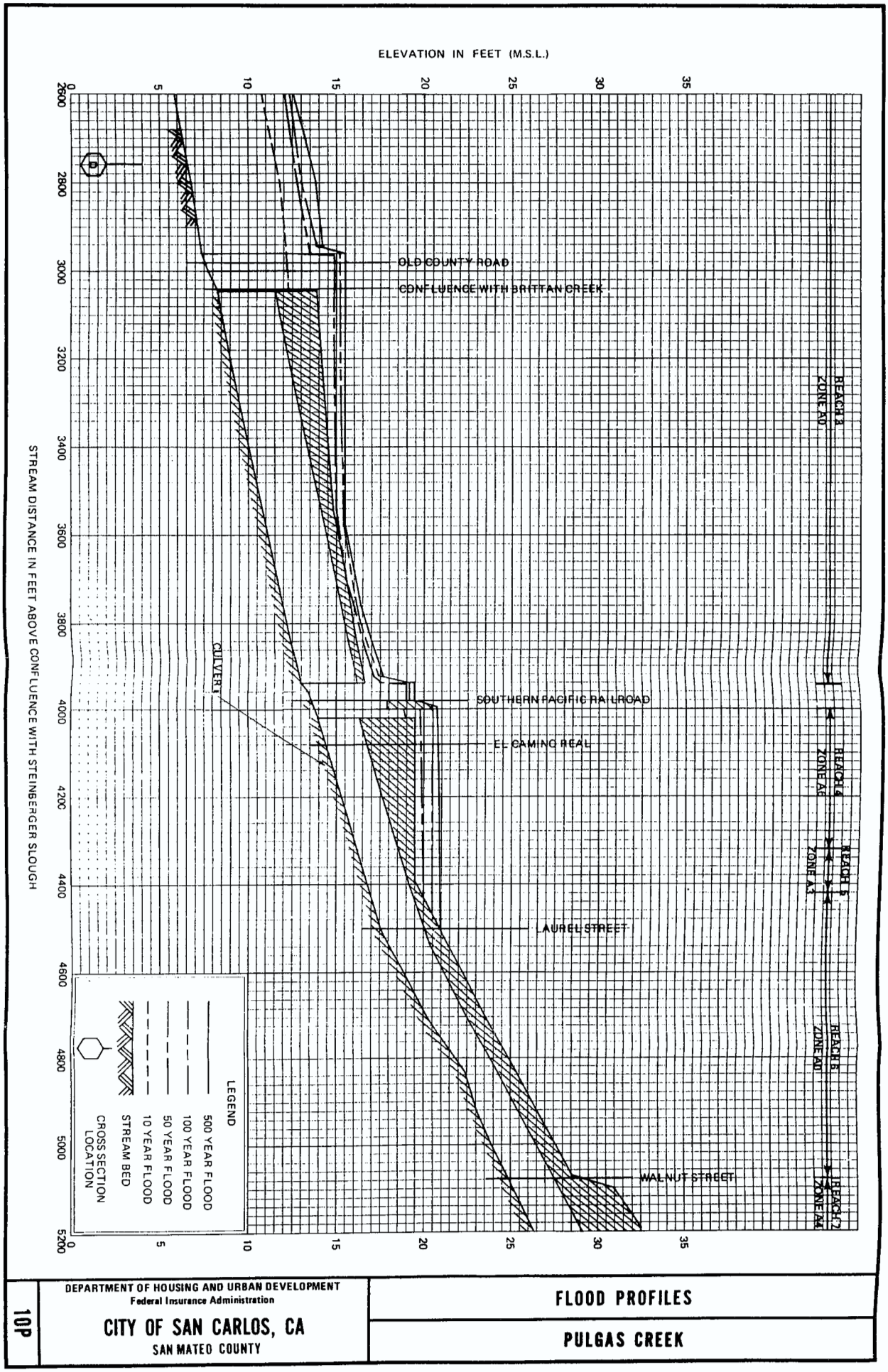
CITY OF SAN CARLOS, CA
SAN MATEO COUNTY

FLOOD PROFILES

CORDILLERAS CREEK



09P	DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT Federal Insurance Administration **CITY OF SAN CARLOS, CA** SAN MATEO COUNTY	**FLOOD PROFILES** **PULGAS CREEK**



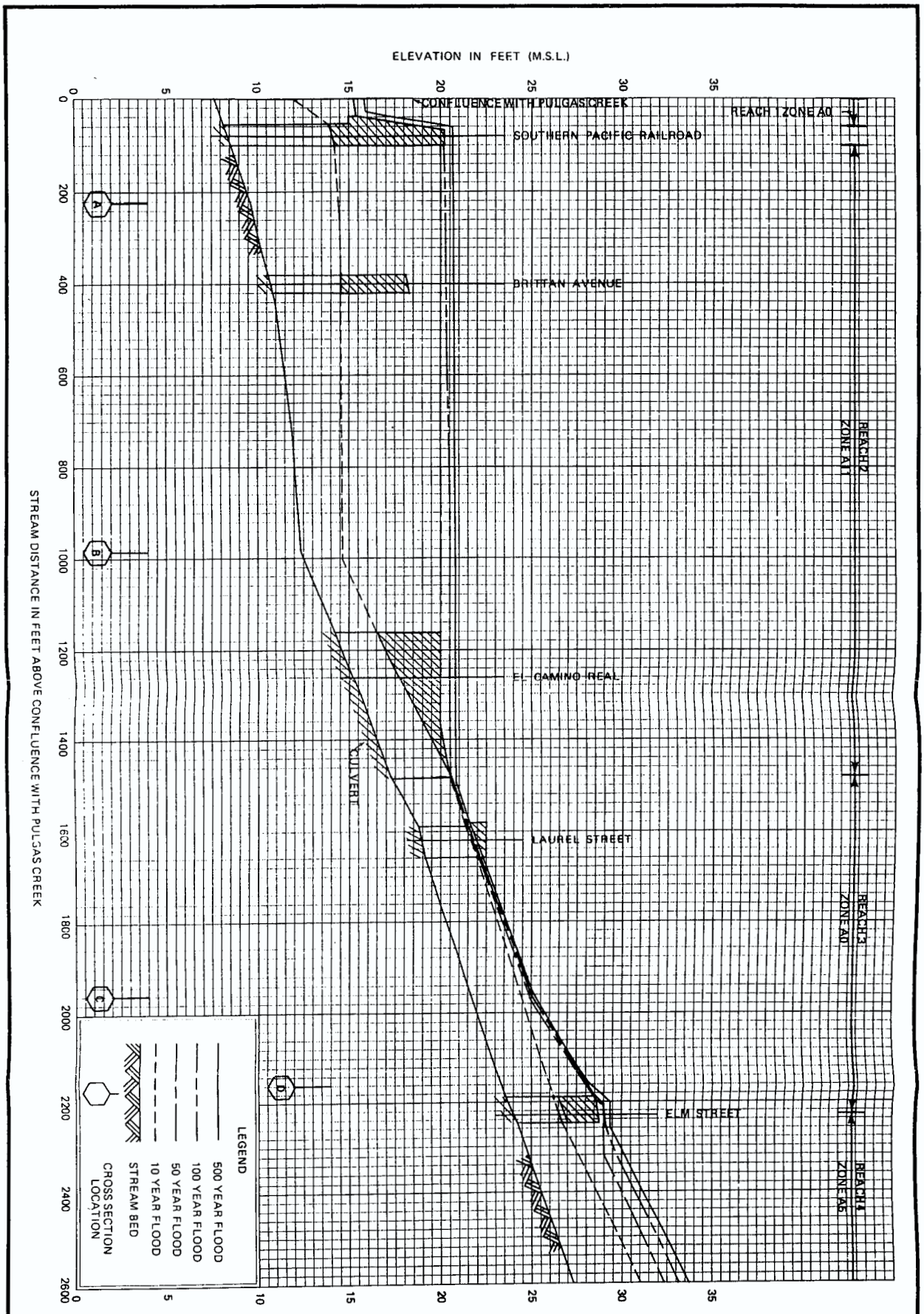
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

CITY OF SAN CARLOS, CA
SAN MATEO COUNTY

FLOOD PROFILES

PULGAS CREEK

10P



05P

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration

CITY OF SAN CARLOS, CA
SAN MATEO COUNTY

FLOOD PROFILES

BRITTAN CREEK

APPENDIX E

Responses to Notices of Intent/Preparation

SAN FRANCISCO BAY TRAIL

FISH & GAME
MAR 12 2003
YOUNTVILLE

March 10, 2003

Mr. Carl Wilcox
Department of Fish and Game, Region 3
P.O. Box 47
Yountville, CA 94599

Subject: Notice of Preparation of a Draft EIS/EIR for the Bair Island Restoration and Management Plan

Dear Mr. Wilcox,

I am writing to provide comments from the San Francisco Bay Trail Project in response to your agency's Notice of Preparation (NOP) of a Draft Environmental Impact Statement (EIS)/Environmental Impact Report (EIR) for the Bair Island Restoration and Management Plan.

The Bay Trail Project is a nonprofit organization administered by the Association of Bay Area Governments (ABAG) that plans, promotes and advocates for implementation of the Bay Trail.

As you know, the Bay Trail is a 400-plus mile regional shared-use pathway planned to encircle San Francisco and San Pablo Bays, linking the shoreline of all nine Bay Area counties. When complete, the Bay Trail will pass through 47 shoreline cities and cross all of the major toll bridges in the region. Over half of the Bay Trail is currently in place.

The Draft EIS/EIR for this project should reference the *Bay Trail Plan*. The *Bay Trail Plan*, which was adopted by ABAG in 1989, includes a future alignment; a set of policies to guide the future selection, design and implementation of routes; and strategies for implementation and financing. The Draft EIS/EIR should identify any inconsistencies with the *Bay Trail Plan* that may result from this project.

The Draft EIS/EIR should also contain a discussion of the existing and proposed Bay Trail alignment within and near the project area (see discussion below and the enclosed map). It should identify any potential impacts to existing or planned public access via the Bay Trail and offer suitable mitigation for such impacts.

In the subject area, the existing Bay Trail alignment follows an unimproved levee trail from the U. S. Fish and Wildlife Service (USFWS) parking lot at the end of Bair Island Road (near Pete's Harbor) to the entrance of inner Bair Island, at Whipple Avenue. The existing Bay Trail alignment then crosses Steinberger Slough and follows the outer levee of inner Bair Island in a northern direction. At Smith Slough, the Bay Trail alignment is planned to cross

Administered by the Association of Bay Area Governments
P.O. Box 2050 • Oakland California 94604-2050
Joseph P. Bort MetroCenter • 101 Eighth Street • Oakland California 94607-4756
Phone: 510•464•7935
Fax: 510•464•7970

Steinberger Slough and follow the shoreline of the San Carlos Airport north, adjacent to Steinberger Slough. I have enclosed a map of the Bay Trail in the South Bay for your reference.

The *Bay Trail Plan* calls for a continuous shoreline trail connection from inner Bair Island to the San Carlos Airport, including a planned connection across Steinberger Slough. The EIS/EIR should take into account this planned alignment and identify how this connection can be maintained within the context of the Bair Island Restoration and Management Plan.

Also, please clarify the physical extent and configuration of the 2.7-mile levee trail noted in the NOP, and identify whether this distance includes the approximately 1 mile levee trail between the USFWS parking lot and the existing entrance at inner Bair Island.

I would like to review the Bair Island Restoration and Management Plan as well as the Draft EIR/EIS for the Bair Island Restoration and Management Plan. Please address copies of the above mentioned documents as well as any other related correspondence on this subject to:

Melissa Barry
ABAG/ San Francisco Bay Trail Project
101 Eighth Street
Oakland, CA 94607

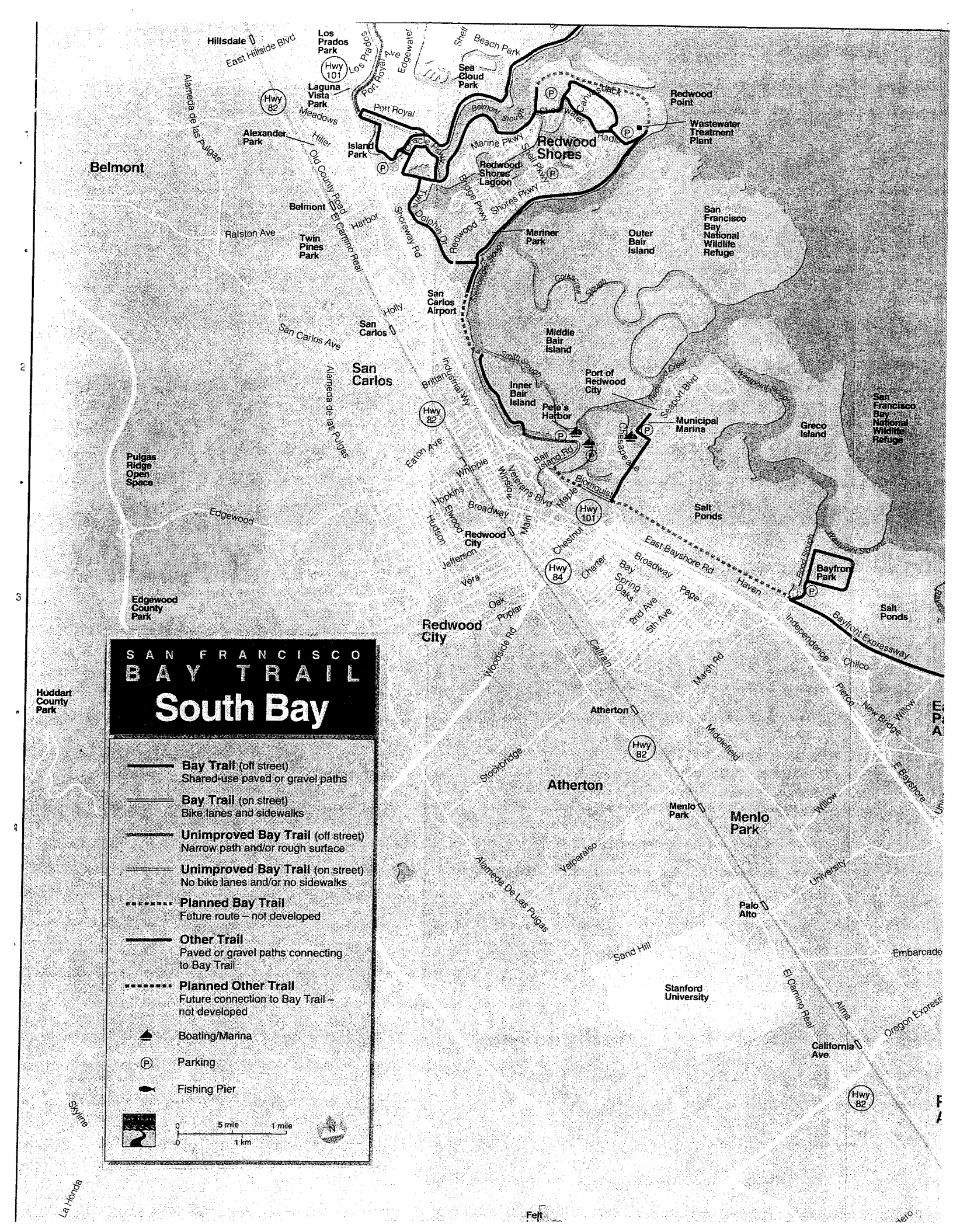
I look forward to ongoing collaboration with you on the matter of public access throughout the planning process for Bair Island. Please feel free to call me at (510) 464-7919 with any questions.

Sincerely,

Melissa Barry

Melissa Barry
Bay Trail Planner

Cc: Tom Huening, Controller, San Mateo County
Colleen Jordan, Member, City Council of Redwood City
Barbara Pierce, Member, City Council of Redwood City
John Hernandez, San Mateo County Trails Advisory Committee
Peter Vorametsanti, Senior Civil Engineer, City of Redwood City


SAN FRANCISCO
BAY TRAIL
South Bay
Bay Trail (off street)
Shared-use paved or gravel paths
Bay Trail (on street)
Bike lanes and sidewalks
Unimproved Bay Trail (off street)
Narrow path and/or rough surface
Unimproved Bay Trail (on street)
No bike lanes and/or no sidewalks
Planned Bay Trail
Future route – not developed
Other Trail
Paved or gravel paths connecting to Bay Trail
Planned Other Trail
Future connection to Bay Trail – not developed
Boating/Marina
Parking
Fishing Pier
0 .5 mile 1 mile
0 1 km
N
Belmont
Hillsdale
East Hillside Blvd
Los Prados Park
Hwy 101
Los Prados
Port Royal Ave
Edgewater
Shell Beach Park
Sea Cloud Park
Laguna Vista Park
Hwy 82
Alameda de las Pulgas
Meadows
Port Royal
Belmont Slough
Redwood Point
Wastewater Treatment Plant
Alexander Park
Hiller
Island Park
Marina Pkwy
Redwood Shores
Redwood Shores Lagoon
Shell Pkwy
Old County Road
Belmont
El Camino Real
Harbor
Shoreway Rd
Bridge Pkwy
Shores Pkwy
N Dolphin Dr
Redwood
Ralston Ave
Twin Pines Park
Mariner Park
Outer Bair Island
San Francisco Bay National Wildlife Refuge
Steinberger Slough
Corkscrew Slough
San Carlos Airport
Holly
San Carlos
San Carlos Ave
Middle Bair Island
South Slough
San Carlos
Industrial Way
Inner Bair Island
Port of Redwood City
Redwood Creek
Seaport Blvd
Westpoint Slough
Pete's Harbor
Municipal Marina
Greco Island
Hwy 82
Eaton Ave
Chesapeake Dr
Bair Island Rd
Pulgas Ridge Open Space
Whipple
Yeterans Blvd
Winslow
Maple
Bloomquist
Hopkins
Broadway
Edgewood
Elwood
Hudson
Redwood City
Main
Hwy 101
Salt Ponds
Chestnut
East Bayshore Rd
Jefferson
Vera
Hwy 84
Charter
Bay
Broadway
Spring
Oaks
Page
Haven
Bayfront Park
Oak
Poplar
2nd Ave
5th Ave
Edgewood County Park
Redwood City
Independence
Bayfront Expressway
Chilco
Woodside Rd
Marsh Rd
Pierce
New Bridge
Willow
Huddart County Park
Atherton
Hwy 82
Middlefield
Stockbridge
Atherton
E Bayshore
Menlo Park
Menlo Park
Willow
Alameda De Las Pulgas
Valparaiso
University
Palo Alto
Sand Hill
Embarcade
Stanford University
El Camino Real
Alma
Oregon Express
California Ave
Hwy 82
Skyline
La Honda
Felt

Department of Toxic Substances Control

Edwin F. Lowry, Director
700 Heinz Avenue, Suite 200
Berkeley, California 94710-2721

Winston H. Hickox
Agency Secretary
California Environmental
Protection Agency

Gray Davis
Governor

FISH & GAME
MAR - 7 2003
YOUNTVILLE

March 6, 2003

Carl Wilcox
Department of Fish and Game, Region 3
P.O. Box 47
Yountville, California 94599

Re: Notice of Preparation – Bair Island Restoration and Management Plan

Dear Mr. Wilcox:

Thank you for the opportunity to comment on the *Notice of Preparation for the Bair Island Restoration and Management Plan* [SCH No. 2003022049]. As you may be aware, the California Department of Toxic Substances Control (DTSC) oversees the cleanup of sites where hazardous substances have been released pursuant to the California Health and Safety Code, Division 20, Chapter 6.8. As a potential Responsible Agency, DTSC is submitting comments to ensure that the environmental documentation prepared for this project to address the California Environmental Quality Act (CEQA) adequately addresses any required remediation activities which may be required to address any hazardous substances release.

The project description does not include a description of the property's past uses, without this information we are unable to determine whether hazardous substances may have been released at the Site. We recommend that a historical assessment of past uses be done and that this information be included in the draft Environmental Impact Report. Based on that information, sampling may be required to determine whether there is an issue which will need to be addressed in the CEQA compliance document. If hazardous substances have been released, they will need to be addressed as part of this project.

For example, if the remediation activities include the need for soil excavation, the CEQA document should include: (1) an assessment of air impacts and health impacts associated with the excavation activities; (2) identification of any applicable local standards which may be exceeded by the excavation activities, including dust levels and noise; (3) transportation impacts from the removal or remedial activities; and (4) risk of upset should be there an accident at the Site.

The energy challenge facing California is real. Every Californian needs to take immediate action to reduce energy consumption. For a list of simple ways you can reduce demand and cut your energy costs, see our Web-site at www.dtsc.ca.gov.

Printed on Recycled Paper

DTSC can assist your agency in overseeing characterization and cleanup activities through our Voluntary Cleanup Program. A fact sheet describing this program is enclosed. We are aware that projects such as this one are typically on a compressed schedule, and in an effort to use the available review time efficiently, we request that DTSC be included in any meetings where issues relevant to our statutory authority are discussed.

If you have any questions please call Ed Gillera of my staff at (510) 540-3826.

Sincerely,

Barbara J. Cook, P.E., Chief
Northern California - Coastal Cleanup
Operations Branch

Enclosures

cc: without enclosures

Governor's Office of Planning and Research
State Clearinghouse
P.O. Box 3044
Sacramento, California 95814-3044

Guenther Moskat
CEQA Tracking Center
Department of Toxic Substances Control
P.O. Box 806
Sacramento, California 95812-0806

State of California
Memorandum

The Resources Agency
Department of Boating and Waterways

Date: February 26, 2003

FISH & GAME
FEB 28 2003
YOUNTVILLE

To: Carl Wilcox
Department of Fish and Game
7329 Silverado Trail
Napa, CA 94558

From: David L. Johnson
Legislation, Public Information and Regulation

Subject: SCH# 2003022049 NOP EIR/EIS Bair Island Restoration and Management Plan

The document is a NOP of an EIR/EIR for the restoration of Bair Island to marsh and habitat by removal of levee, development of recreation access and facilities to control tidal flow in Corkscrew and Smith Sloughs.

Limiting access of boats to the marsh and habitat area will be accomplished through state and federal fish and wildlife regulations to protect the targeted endangered species, however, the construction needed to complete the restoration may involve the use of barges or dredges San Francisco Bay, Corkscrew Slough and Smith Slough. This activity may impose a hazard to navigation since San Francisco Bay, Corkscrew Slough and Smith Slough are navigable waterways.

Therefore, the EIR/EIS should address possible mitigation that may be required to address the possible impact on navigation, such as the promulgation of the dates and location of the proposed construction by local notices to mariners and/or using waterway markers such as signs, lights or buoys to warn or advise boaters in the vicinity.

California Regional Water Quality Control Board
San Francisco Bay Region

Winston H. Hickox
Secretary for Environmental Protection

Internet Address: http://www.swrcb.ca.gov
1515 Clay Street, Suite 1400, Oakland, California 94612
Phone (510) 622-2300 • FAX (510) 622-2460

Gray Davis
Governor

February 19, 2003
File No. 2178.05 (RM)

Mr. Carl Wilcox
Department of Fish and Game, Region 3
7329 Silverado Trail
Napa, CA 94558

FISH & GAME
MAR 10 2003
YOUNTVILLE

Re: Bair Island Restoration and Management Plan (SCH# 2003022049)

Dear Mr. Wilcox:

We have reviewed the Notice of Preparation for the above referenced project and offer the following comments. The project involves the restoration of approximately 1600 acres of diked bayland to tidal marsh and habitat for endangered species. More specifically, the project will involve the breaching of a levee as well as dredging to restore full tidal inundation to Inner, Middle, and Outer Bair Islands. Recreational access and facilities to control tidal flows in Corkscrew and Smith Sloughs will also be developed. These comments are to advise the California Department of Fish and Game of our concerns, so they may be incorporated into the planning and design process at an early date.

The Notice of Preparation discloses that impacts may occur to Bair Island and the surrounding area. This wetland needs to be protected for the Beneficial Uses it offers. Bair Island is considered an estuarine as well as a wildlife habitat because it supports habitats necessary for the survival and successful maintenance of plant or animal species (California clapper rail and the salt marsh harvest mouse) established under state and/or federal law as rare, threatened, or endangered. Furthermore, Bair Island provides water contact and noncontact water recreation. All of these Beneficial Uses are protected under the San Francisco Water Quality Control Plan (Basin Plan).

The Notice of Preparation also indicates that there may be a potential for impacts to aquatic resources including wetland habitat, streams or tributaries, or other waters of the State. A Clean Water Act (CWA) Section 401 water quality certification is required for such impacts/activities. A CWA Section 404 Permit from the U.S. Army Corps of Engineers may also be necessary for projects involving impacts to waters of the U.S.

The Board adopted U.S. EPA's Section 404(b)(1) "Guidelines for Specification of Disposal Sites for Dredge or Fill Material," dated December 24, 1980, in its Basin Plan for determining the circumstance under which filling of wetlands, streams or other waters of the State may be permitted. The Section 404(b)(1) Guidelines prohibit all discharges of fill material into regulated

waters of the United States, unless a discharge, as proposed, constitutes the least environmentally damaging practicable alternative that will achieve the basic project purpose.
The following Guidelines sequence the order in which proposals should be approached: 1) Avoid - avoid impacts to waters; 2) Minimize - modify project to minimize impacts to waters; and, 3) Mitigate – once impacts have been fully minimized, compensate for unavoidable impacts to waters. When it is not possible to avoid water bodies, disturbance should be minimized. Mitigation for lost water body acreage and functions through restoration or creation should only be considered after disturbance has been minimized. Where impacts cannot be avoided, the creation of adequate mitigation habitat to compensate for the loss of water body acreage, functions and values must be provided.

Cumulative and indirect impacts of wetlands must also be prevented. Indirect impacts include deposition of sediments; erosion of substratum; additional water (flooding); reduced water supply or flows; creating a condition of pollution; shading; and watershed degradation. The Environmental Impact Report should also fully describe any runoff from dredged material or urban storm water that may occur, and the potential to impact water quality.

For further information about our regulations and requirements, please refer to the **General Comments** document, which discusses the Regional Board's areas of responsibility, and which should be of assistance to the project sponsor. If you have any questions, please contact me at (510) 622-2474, or via e-mail at AMP@rb2.swrcb.ca.gov; or Andree Breaux at (510) 622-232 and via e-mail at AB@rb2.swrcb.ca.gov.

Sincerely,

Ann M. Powell

Ann Powell
Environmental Scientist

Enclosure: *General Comments*

General Comments

The San Francisco Regional Water Quality Control Board (Regional Board or RWQCB) is charged with the protection of the Waters of the State of California in the San Francisco Bay Region, including wetlands and stormwater quality. The Regional Board is responsible for administering the regulations established by the Federal Clean Water Act. Additionally, the California Water Code establishes broad state authority for regulation of water quality. The San Francisco Bay Basin Water Quality Control Plan (Basin Plan) explains the Regional Board's strategy for regulating water quality. The Basin Plan also describes the range of responses available to the Regional Board with regard to actions and proposed actions that degrade or potentially degrade the beneficial uses of the Waters of the State of California.

NPDES

Water quality degradation is regulated by the Federal National Pollutant Discharge Elimination System (NPDES) Program, established by the Clean Water Act, which controls and reduces pollutants to water bodies from point and nonpoint discharges. In California, the program is administered by the California Regional Water Quality Control Boards. The Regional Board issues NPDES permits for discharges to water bodies in the San Francisco Bay Area, including Municipal (area- or county-wide) Stormwater Discharge Permits.

Projects disturbing more than five acres of land during construction must be covered under the State NPDES General Permit for Discharges of Storm Water Associated with Construction Activity (General Permit). This can be accomplished by filing a Notice of Intent with the State Water Resources Control Board. An NOI and the General Permit can be obtained from the Board at (510) 622-2300. The project sponsor must propose and implement control measures that are consistent with the General Permit and with the recommendations and policies of the local agency and the RWQCB.

Projects that include facilities with discharges of Storm Water Associated with Industrial Activity must be covered under the State NPDES General Permit for Discharges of Storm Water Associated with Industrial Activity. This may be accomplished by filing a Notice of Intent. The project sponsor must propose control measures that are consistent with this, and with recommendations and policies of the local agency and the RWQCB. In a few cases, the project sponsor may apply for (or the RWQCB may require) issuance of an individual (industry- or facility-specific) permit.

The RWQCB's Urban Runoff Management Program requires Bay Area municipalities to develop and implement storm water management plans (SWMPs). The SWMPs must include a program for implementing new development and construction site storm water quality controls. The objective of this component is to ensure that appropriate measures to control pollutants from new development are: considered during the planning phase, before construction begins; implemented during the construction phase; and maintained after construction, throughout the life of the project.

Impacts and Mitigation Measures

Wetlands

Wetlands enhance water quality through such natural functions as flood and erosion control, stream bank stabilization, and filtration and purification of contaminants. Wetlands also provide critical habitats for hundreds of species of fish, birds, and other wildlife, offer open space, and provide many recreational opportunities. Water quality impacts occur in wetlands from construction of structures in waterways, dredging, filling, and altering drainage to wetlands.

The Regional Board must certify that any permit issued by the U.S. Army Corps of Engineers pursuant to Section 404 of the Clean Water Act (covering, dredging, or filling of Waters of the United States, including wetlands) complies with state water quality standards, or waive such certification. Section 401 Water Quality Certification is necessary for all 404 Nationwide permits, reporting and non-reporting, as well as individual permits.

All projects must be evaluated for the presence of jurisdictional wetlands and other Waters of the State. Destruction of or impact to these waters should be avoided. If the proposed project impacts wetlands or other Waters of the State and the project applicant is unable to demonstrate that the project was unable to avoid those adverse impacts, water quality certification will most likely be denied. 401 Certification may also be denied based on significant adverse impacts to wetlands or other Waters of the State. In considering proposals to fill wetlands, the Regional Board has adopted the California Wetlands Conservation Policy (Executive Order W-59-93, signed August 23, 1993). The goals of the Policy include ensuring "no overall net loss and achieving a long-term net gain in the quantity, quality, and permanence of wetlands acreage and values." Under this Policy, the Regional Board also considers the potential post-construction impacts to wetlands and Waters of the State and evaluates the measures proposed to mitigate those impacts (see Storm Water Quality Control, below).

The Regional Board has adopted U.S. EPA's Clean Water Act Section 404(b)(1) "Guidelines for Specification of Disposal Sites for Dredge or Fill Material," dated December 24, 1980, in the Board's Basin Plan for determining the circumstances under which fill may be permitted.

Section 404(b)(1) Guidelines prohibit all discharges of fill material into regulated waters of the United States, unless a discharge, as proposed, constitutes the least environmentally damaging practicable alternative that will achieve the basic project purpose. For non-water dependent projects, the guidelines assume that there are less damaging alternatives, and the applicant must rebut that assumption.

The Section 404(b)(1) Guidelines sequence the order in which proposals should be approached. First, impacts to wetlands or Waters of the State must be avoided to the maximum extent practicable. Second, the remaining impacts must be minimized. Finally, the remaining unavoidable adverse impacts to wetlands or Waters of the State must be mitigated. Mitigation will be preferably in-kind and on-site, with no net destruction of habitat value. A proportionately greater amount of mitigation is required for projects that are out-of-kind and/or off-site. Mitigation will preferably be completed prior to, or at least simultaneous to, the filling or other loss of existing wetlands.

Successful mitigation projects are complex tasks and difficult to achieve. This issue will be strongly considered during agency review of any proposed wetland fill. Wetland features or ponds created as mitigation for the loss of existing jurisdictional wetlands or Waters of the United States cannot be used as storm water treatment controls.

In general, if a proposed project impacts wetlands or Waters of the State and the project applicant is unable to demonstrate that the project was unable to avoid adverse impacts to wetlands or Waters of the State, water quality certification will be denied. 401 Certification may also be denied based on significant adverse impacts to wetlands or other Waters of the State.

Storm Water Quality Control

Storm water is the major source of fresh water to creeks and waterways. Storm water quality is affected by a variety of land uses and the pollutants generated by these activities. Development and construction activities cause both site-specific and cumulative water quality impacts. Water quality degradation may occur during construction due to discharges of sediment, chemicals, and wastes to nearby storm drains or creeks. Water quality degradation may occur after construction is complete, due to discharges of petroleum hydrocarbons, oil, grease, and metals from vehicles, pesticides and fertilizers from landscaping, and bacteria from pets and people. Runoff may be concentrated and storm water flow increased by newly developed impervious surfaces, which will mobilize and transport pollutants deposited on these surfaces to storm drains and creeks. Changes in runoff quantity or velocity may cause erosion or siltation in streams. Cumulatively, these discharges will increase pollutant loads in creeks and wetlands within the local watershed, and ultimately in San Francisco Bay.

To assist municipalities in the Bay Area with complying with an area-wide NPDES Municipal Storm Water Permit or to develop a Baseline Urban Runoff Program (if they are not yet a co-permittee with a Municipal Storm Water Permit), the Regional Board distributed the *Staff Recommendations for New and Redevelopment Control for Storm Water Programs* (Recommendations) in April 1994. The Recommendations describe the Regional Board's expectations of municipalities in protecting storm water quality from impacts due to new and redevelopment projects, including establishing policies and requirements to apply to development areas and projects; initiating appropriate planning, review, approval, and inspection procedures; and using best management practices (BMPs) during construction and post-construction.

Project impacts should be minimized by developing and implementing a Storm Water Pollution Prevention Plan (SWPPP). A SWPPP is required by the State Construction Storm Water General Permit (General Permit). The SWPPP should be consistent with the terms of the General Permit, the Manual of Standards for Erosion & Sedimentation Control Measures by the Association of Bay Area Governments (ABAG), policies and recommendations of the local urban runoff program (city and/or county), and the Recommendations of the RWQCB. SWPPPs should also be required for projects that may have impacts, but which are not required to obtain an NPDES permit. Preparation of a SWPPP should be a condition of development. Implementation of the SWPPP should be enforced during the construction period via appropriate options such as citations, stop work orders, or withholding occupancy permits.

Impacts identified should be avoided and minimized by developing and implementing the types of controls listed below. Explanations of the controls are available in the Regional Board's construction *Field Manual*, available from Friends of the San Francisco Estuary at (510) 286-0924, in BASMAA's *Start at the Source*, and in the *California Storm Water Best Management Practice Handbooks*.

Site Planning

The project should minimize impacts from project development by incorporating appropriate site planning concepts. This should be accomplished by designing and proposing site planning options as early in the project planning phases as possible. Appropriate site planning concepts to include, but are not limited to the following:

- Phase construction to limit areas and periods of impact.
- Minimize directly connected impervious areas.
- Preserve natural topography, existing drainage courses and existing vegetation.
- Locate construction and structures as far as possible from streams, wetlands, drainage areas, etc.
- Provide undeveloped, vegetated buffer zones between development and streams, wetlands, drainage areas, etc.
- Reduce paved area through cluster development, narrower streets, use of porous pavement and/or retaining natural surfaces.
- Minimize the use of gutters and curbs which concentrate and direct runoff to impermeable surfaces.
- Use existing vegetation and create new vegetated areas to promote infiltration.
- Design and lay out communities to reduce reliance on cars.
- Include green areas for people to walk their pets, thereby reducing build-up of bacteria, worms, viruses, nutrients, etc. in impermeable areas, or institute ordinances requiring owners to collect pets' excrement.
- Incorporate low-maintenance landscaping.
- Design and lay out streets and storm drain systems to facilitate easy maintenance and cleaning.
- Consider the need for runoff collection and treatment systems.
- Label storm drains to discourage dumping of pollutants into them

Erosion

The project should minimize erosion and control sediment during and after construction. This should be done by developing and implementing an erosion control plan, or equivalent plan. This plan should be included in the SWPPP. The plan should specify all control measures that will be used or which are anticipated to be used, including, but not limited to, the following:

- Limit access routes and stabilize access points.
- Stabilize denuded areas as soon as possible with seeding, mulching, or other effective methods.
- Protect adjacent properties with vegetative buffer strips, sediment barriers, or other effective methods.
- Delineate clearing limits, easements, setbacks, sensitive areas, vegetation and drainage courses by marking them in the field.
- Stabilize and prevent erosion from temporary conveyance channels and outlets.
- Use sediment controls and filtration to remove sediment from water generated by dewatering or collected on-site during construction. For large sites, stormwater settling basins will often be necessary.

Chemical and Waste Management

The project should minimize impacts from chemicals and wastes used or generated during construction. This should be done by developing and implementing a plan or set of control measures. The plan or control measures should be included in the SWPPP. The plan should specify all control measures that will be used or which are anticipated to be used, including, but not limited to, the following:

- Designate specific areas of the site, away from streams or storm drain inlets, for storage, preparation, and disposal of building materials, chemical products, and wastes.
- Store stockpiled materials and wastes under a roof or plastic sheeting.
- Store containers of paint, chemicals, solvents, and other hazardous materials stored in containers under cover during rainy periods.
- Berm around storage areas to prevent contact with runoff.
- Cover open Dumpsters securely with plastic sheeting, a tarp, or other cover during rainy periods.
- Designate specific areas of the site, away from streams or storm drain inlets, for auto and equipment parking and for routine vehicle and equipment maintenance.
- Routinely maintain all vehicles and heavy equipment to avoid leaks.
- Perform major maintenance, repair, and vehicle and equipment washing off-site, or in designated and controlled areas on-site.
- Collect used motor oil, radiator coolant or other fluids with drip pans or drop cloths.
- Store and label spent fluids carefully prior to recycling or proper disposal.
- Sweep up spilled dry materials (cement, mortar, fertilizers, etc.) immediately--do not use water to wash them away.
- Clean up liquid spills on paved or impermeable surfaces using "dry" cleanup methods (e.g., absorbent materials, cat litter, rags) and dispose of cleanup materials properly.
- Clean up spills on dirt areas by digging up and properly disposing of the soil.
- Keep paint removal wastes, fresh concrete, cement mortars, cleared vegetation, and demolition wastes out of gutters, streams, and storm drains by using proper containment and disposal.

Post-Construction

The project should minimize impacts from pollutants that may be generated by the project following construction, when the project is complete and occupied or in operation. These pollutants may include: sediment, bacteria, metals, solvents, oil, grease, and pesticides, all of which are typically generated during the life of a residential, commercial, or industrial project after construction has ceased. This should be done by developing and implementing a plan and set of control measures. The plan or control measures should be included in the SWPPP.

The plan should specify all control measures that will be used or which are anticipated to be used, including, but not limited to, the source controls and treatment controls listed in the Recommendations. Appropriate control measures are discussed in the Recommendations, in:

- Table 2: Summary of residential post-construction BMP selection
- Table 3: Summary of industrial post-construction BMP selection
- Table 4: Summary of commercial post-construction BMP selection

Additional sources of information that should be consulted for BMP selection include the *California Storm Water Best Management Practice Handbooks;* the Bay Area Preamble to the *California Storm Water Best Management Practice Handbooks and New Development Recommendations*; the BASMAA New Development Subcommittee meetings, minutes, and distributed information; and Regional Board staff. Regional Board staff also have fact sheets and other information available for a variety of structural stormwater treatment controls, such as grassy swales, porous pavement and extended detention ponds.

FLOOD PROGRAM COORDINATION

PUBLIC WORKS SERVICES DEPT AND
ENGINEERING & CONSTRUCTION DIV

CITY HALL
1017 Middlefield Road
Redwood City, CA 94064-0391
Phone: (650) 780-7387
Fax: (650) 780-7309
www.redwoodcity.org

May 18, 2000

Facsimile Transmittal
Mr. Clyde Morris
Refuge Manager
Don Edwards San Francisco Bay Refuge
U.S. Fish & Wildlife Service
P.O. Box 524
Newark, CA 94560

SUBJECT: SCOPING COMMENTS – BAIR ISLAND RESTORATION PLANS

Dear Mr. Morris:

As a part of the environmental assessment process for the Bair Island Restoration, Redwood City would like to request that the EIS analyze the creation a new waterway, tied to Cordilleras Creek, on the east side of Highway 101.

In 1986, Redwood City commissioned the preparation of the "Storm Drainage, Water System, and Sanitary Sewers Master Plan for the City of Redwood City." The document prepared by the consulting firm, Kennedy/Jenks/Chilton recommends the creation of a new waterway and dredging to reopen a portion of the Cordilleras Creek channel that at one time connected Cordilleras to Redwood Creek to the south. Such an analysis should evaluate the potential benefit that the freshwater flow from Cordilleras Creek may have on the wetland restoration process. Additionally, many residents near Cordilleras Creek believe that a mutually beneficial result of wetland enhancement, improved flood protection and creek health is obtainable.

The attached diagram showing the proposed improvements recommended in the Kennedy/Jenks/ Chilton study is provided for your consideration. In the coming fiscal year, Redwood City will initiate a conservation program with creek side property owner participation to improve conditions along Cordilleras Creek. Since Cordilleras Creek flows to the Bair Island area, we ask that consideration of the relationship of the creek to the proposed restoration activity receive thorough evaluation.

If you have questions or would like additional information please contact me at (650) 780-7387 or email me: mharang@redwoodcity.org.

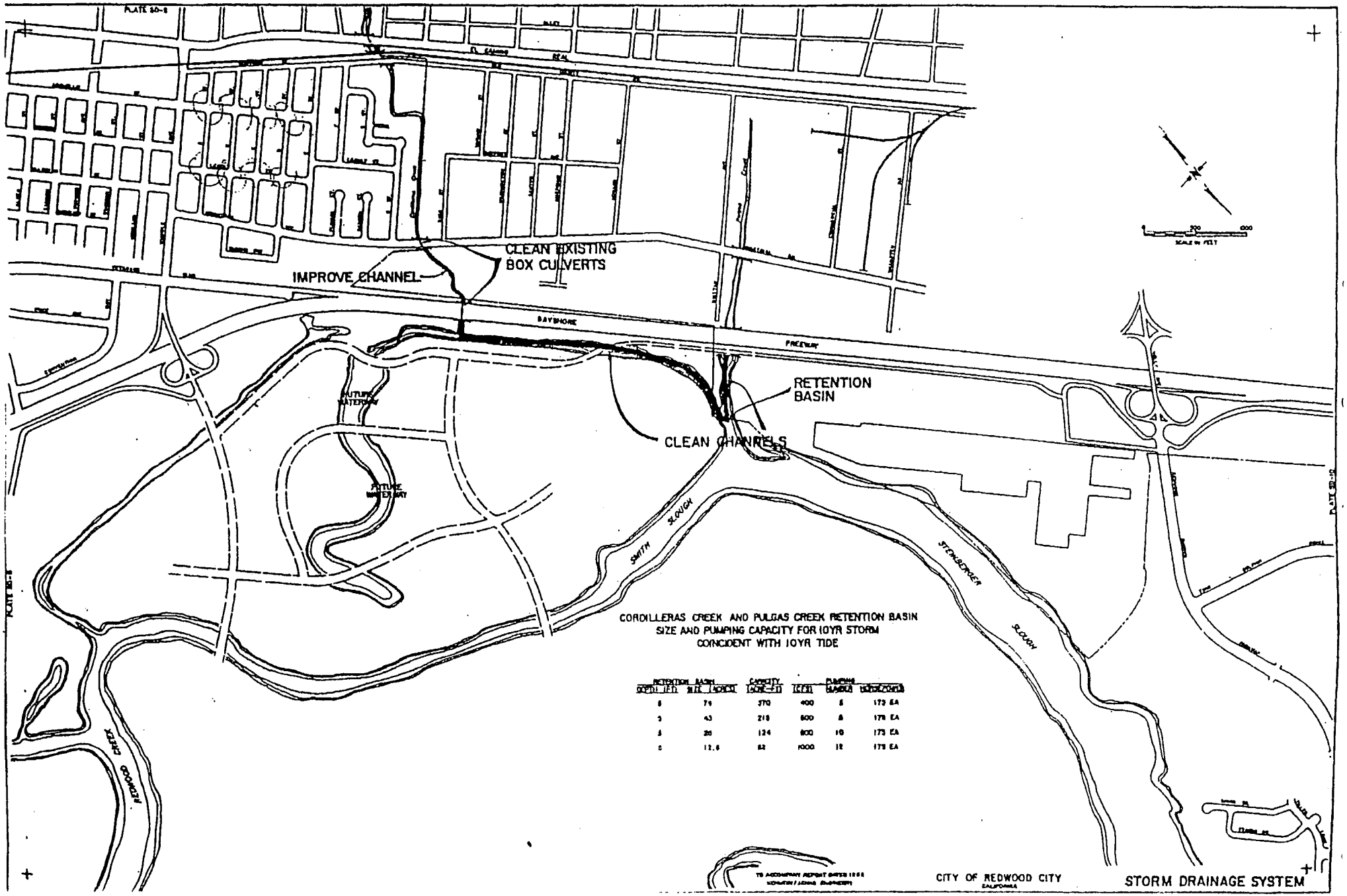
Sincerely,

Marilyn W. Harang

Marilyn W. Harang
Special Projects Coordinator

Enclosure

C:\My Documents\Misc Correspondence\BairIslandScopingLtr.doc


IMPROVE CHANNEL
CLEAN EXISTING BOX CULVERTS
RETENTION BASIN
CLEAN CHANNELS
BAYSHORE
FREEWAY
SMITH SLOUGH
STEINBERGER SLOUGH
REDWOOD CREEK
CORDILLERAS CREEK AND PULGAS CREEK RETENTION BASIN
SIZE AND PUMPING CAPACITY FOR 10YR STORM
COINCIDENT WITH 10YR TIDE
CITY OF REDWOOD CITY
STORM DRAINAGE SYSTEM

FOR WATER QUALITY

SOUTH BAYSIDE SYSTEM AUTHORITY

JOINT POWERS AUTHORITY — *A Public Entity*

1400 Radio Road • Redwood City, California 94065-1220 •

650/591-7121

FAX 650/591-7122

City of Belmont

City of Redwood City

City of San Carlos

West Bay Sanitary District

May 12, 2000
20.109-27

Margaret T. Kolar
Refuge Complex Manager
San Francisco Bay National Wildlife Refuge Complex
P.O. Box 524
Newark, CA 945610

Subject: Bair Island Restoration Plan EIR/EIS

Dear Ms. Kolar:

The South Bayside System Authority (SBSA) provides wastewater treatment services to 210,000 customers in southern San Mateo County. An integral part of the SBSA system is a four-foot diameter pipeline along a levee in what is generally regarded as Inner Bair Island. The SBSA has an existing legal easement that grants right of entry for operation and maintenance of the pipeline.

The title of the property containing a portion of the SBSA pipeline has transferred from private ownership to the Peninsula Open Space Trust (POST), a Menlo Park based land conservation group, with POST then transferring title to the U.S. Fish and Wildlife Service (USFWS). The USFWS plans to designate Blair Island as a part of the Don Edward's San Francisco Bay National Wildlife Refuge. This transfer of title and the intended future use of the land as a wildlife refuge significantly changes the planned uses for this area. Prior to transfer to the Service the land was planned for future commercial and residential development. Development planning would have been coordinated with the existing SBSA easement to provide suitable continuing access to the pipeline. The change in land use planning makes modifications to the access provisions necessary to ensure that SBSA continues to have the ability to serve its customers that depend upon this pipeline. In particular, the easement must provide for sufficient access for operation and maintenance of the pipeline. This is particularly important since there is a history of leaks from the pipeline in this area. It is important that the nature of the levee provide for early detection of leaks, and that an easement of sufficient width is provided to insure necessary rapid access to repair and maintain the pipeline. Repairs to the pipeline require an approximate 100-foot diameter working area. Since the locations of future leaks cannot be predetermined, there needs to be some mechanism in place that allows SBSA to use the required working area.

Additionally, as the USFWS develops its wildlife refuge plan it is important for USFWS and SBSA to work together to create a plan that recognizes and fulfills their separate and mutual needs. This should certainly be the case given the early stage of planning and the nature of the needs, particularly the needs of SBSA. In essence the SBSA needs to protect the integrity of the pipeline and the surrounding levee. If Inner Bair Island is flooded either by tidal action or in a controlled manner such that the levee will be eroded, then the levee needs to be reengineered for those conditions. A reconfiguration of the levee may also be desirable from the standpoint of maintenance, thereby reducing any future concerns of either party.

SBSA has previously provided detailed information to the Service regarding the pipeline location and possible impacts from the change of planned use of the area. We request that the previously submitted information be incorporated into these comments by reference.

The purpose of this letter is continue the dialog with USFWS and to make sure that the interests and needs of the SBSA are incorporated into the USFWS planning process. This will provide the opportunity to meet the objectives of the future wildlife refuge and the public safety, health and welfare duty that the SBSA carries out through its sanitary facilities.

You may contact me at the address above, by direct phone number (650) 594-8411 ext. 124, or email jbewley@sbsa.org for any additional information you may need.

Sincerely,

James B. Bewley
Manager

SAN CARLOS AIRPORT PILOTS' ASSOCIATION
Richard M. Newman, President
P.O. Box 1934
Burlingame, California 94011-1934

(650) 343-6111 Fax
(650) 259-9559

VIA FACSIMILE
(510) 792-5828

May 12, 2000

Mr. Clyde Morris
Refuge Manager
DON EDWARDS SAN FRANCISCO BAY
NATIONAL WILDLIFE REFUGE
P.O. Box 524
Newark, California 94560

Re: Bair Island restoration project

Dear Mr. Morris:

Our association represents over 350 pilots, based at the San Carlos Airport, located immediately adjacent to the Bair Island property, which is proposed for wetlands restoration. We are informed that your office is soliciting comments for use in environmental planning and assessment, in connection with that project.

Though we were unable to attend your public scoping meetings, we have received certain material produced by your agency, from Mr. Gary Petersen, Airports Manager of the County of San Mateo. This letter is intended to present our concerns, with regard to the scope of the environmental and other impacts of your proposals.

We would ask that you consider the following areas of concern to our association:

1. What changes would occur in noise levels in adjacent communities, relative to the generation of noise from water and marsh surfaces, as opposed to the present situation, when low-flying aircraft cross-over the area? In addressing this question, we would ask you to study in particular (but not to the exclusion of other areas), the residential communities in the vicinity of Bair Island Road (new homes) and the neighborhoods near the County Government Center, in Redwood City.
2. What would be the impact on parties currently using the Bair Island area for recreation, with regard to changes in use patterns, concentrations of

people, areas of allowed or restricted access and limitations on use? What changes would occur in the numbers of persons using areas adjacent to the San Carlos Airport, as a result of your project?

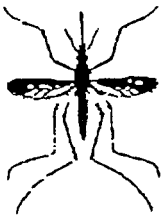
3. We incorporate by reference, the areas of concern raised in letters to you from Mr. Petersen for the County of San Mateo, dated December 16, 1999 and May 8, 2000, with regard to:
   a. Bird activity and other wildlife (including birds or other wildlife interfering with aircraft in flight or on the ground).
   b. Levee integrity, maintenance and useful life.
   c. Maintaining the area known as "Pond A-12" in the present state as an emergency landing area.
   d. FAA notification and involvement in the review process.

Please put our association on your mailing list for all future notices or informational mailings. We appreciate the opportunity to have input at this stage of the review process.

Very truly yours,
SAN CARLOS AIRPORT PILOTS' ASSOCIATION

/s/
Richard M. Newman
President

Cc: Neil Cullen, Director of Public Works, County of San Mateo
Gary Petersen, Airports Manager, County of San Mateo
Mark Larson, Airports Operation Supervisor, County of San Mateo
Dave Carbone, Airport Planner, County of San Mateo
Joe Rodriquez, FAA Airport District Office
Carol Ford, Immediate Past President, San Carlos Airport Pilots' Association



SAN MATEO COUNTY
MOSQUITO ABATEMENT DISTRICT
1351 Rollins Road
Burlingame, California 94010-2409
(650) 344-8592
FAX (650) 344-3843

Clyde Morris, Refuge Manager
Don Edwards San Francisco Bay National Wildlife Refuge
Newark, Ca. 94560

The San Mateo County Mosquito Abatement District would like the following issues addressed by the environmental review of the restoration of Bair Island.

1) The impact restoration alternatives on production of mosquitoes at this site

2) The fiscal and environmental impact of controlling mosquitoes from Bair Island should they reach the surrounding communities

3) The potential public health consequences of encephalitis viruses which may be transmitted by mosquitoes produced on Bair Island.

Our District is strongly in favor of the restoration of Bair Island to tidal salt marsh. At present, large numbers of mosquito larvae develop in rainwater collecting behind the dikes in the former salt pans on Bair Island. Opening the area to full tidal flow would greatly curtail mosquito breeding in these areas. This would reduce the need for application of pesticides to Bair Island and surrounding communities. The District has filed an IPM plan for Bair Island with the US Fish and Wildlife Service and can provide additional information on these issues if needed.

Cordially,

Chindi Peavey

Chindi Peavey
Vector Ecologist
San Mateo Co. Mosquito Abatement District

Environmental Services Agency
Parks & Recreation Division

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DIRECTOR

COUNTY OF SAN MATEO

455 COUNTY CENTER, 4TH FLOOR • REDWOOD CITY • CALIFORNIA 94063-1646

(650) 363-4020
FAX (650) 599-1721

May 12, 2000

Ms. Margaret T. Kohlar
Refuge Complex Manager
San Francisco Bay National Wildlife Refuge
P.O. Box 254
Newark, CA 94560

Dear Ms. Kohlar:

This letter is in relation to the EIR/EIS for Bair Island wetlands restoration.

San Mateo County Parks is in the process of up-dating its Countywide Trails Master Plan. We have identified as a priority completion of the Bay Trail, which proposes to traverse Bair Island. San Mateo County's Board of Supervisors has endorsed the Bay Trail concept as an important resource for our residents.

As someone involved in resources management, I understand the importance of protecting wildlife. I also understand the need for environmental stewardship and the idea of being able to connect people with natural resources and to help them understand them is an important part of our mission. I strongly support the concept of public access and hope that you will work closely with the Bay Trail community at finding a compromise that works for both people as well as wildlife. I would urge you to analyze an alternative that would accommodate hikers and bicyclists along the eastern levy of the inner island. Please find a way of maintaining community access for this important segment of the trail.

Sincerely,

Mary E. Burns
Director

C: San Mateo County Board of Supervisors
John Maltbie, County Manager
San Mateo County Parks and Recreation Commission
San Mateo County Trails Advisory Committee
San Francisco Bay Trail

SEQUOIA AUDUBON SOCIETY INC.
30 W. 39th Avenue #202, San Mateo, CA 94403
(650) 345-3724

Clyde Morris, Refuge Manager
Don Edwards San Francisco Bay National Wildlife Refuge
P.O.Box 524
Newark, CA 94560

Dear Clyde,

Here are the suggestions that Sequoia Audubon has for the restoration plans and the EIS/EIR for Bair Island. Since our mission is the protection of birds and wildlife and their habitats, our comments are focused on those areas.

Sequoia Audubon Society has spent many hours during the last 9 months conducting public use surveys at Inner Bair Island. We have found that the levee system surrounding Inner Bair Island is prized by local residents as one of the few places to take a long walk accompanied by one's dog. We have found that most of the people using this area treat it with respect. But because dogs are not required to be leashed, a small number of them are allowed to enter closed areas, swim in the sloughs and chase small animals. We would like to see the area restricted to joggers, walkers and dog walkers **with dogs on leash and on the levee.**

The cross trail is heavily used because it allows people to choose either a one or two mile loop, instead of the full three miles of the levee system. We suggest that you consider keeping the cross trail but incorporate fences, moats or a boardwalk so as to keep people and dogs out of the areas set aside for wildlife.

Much of the habitat within the levee system of Inner Bair supports a population of raptors and the animals they feed upon (i.e. rabbits, ground squirrels, mice, lizards, etc.). This provides an excellent opportunity for teaching people about these species along with the ability to watch them in action. We would like some of this type of habitat to remain in place, probably down by the airport end of the circuit and, perhaps, including a brackish marsh.

The harbor seals that haul out along the edge of the slough need some protection such as, restricting access to the sloughs during seal pupping time.

Ban personal motorized watercraft (jet skis, etc.)from the sloughs as they are disruptive to wildlife and detrimental to the water environment.

Develop a plan for eradicating non-native plant species that will increase with the increased tidal flows from the bay.

Restore as much as possible of Middle and Outer Bair to its original habitat.

Sincerely,

Robin Winslow Smith

Robin Winslow Smith
President, Sequoia Audubon Society

Department of Public Works

BOARD OF SUPERVISORS
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NEIL R. CULLEN
DIRECTOR

COUNTY OF SAN MATEO

555 COUNTY CENTER, 5TH FLOOR • REDWOOD CITY • CALIFORNIA 94063-1665 • PHONE (650) 363-4100 • FAX (650) 361-8220

May 8, 2000

Mr. Clyde Morris
Don Edwards San Francisco Bay
National Wildlife Refuge
P.O. Box 524
Newark, CA 94560

Dear Mr. Morris:

RE: Follow up to Public Meeting of April 27, 2000 - Bair Island Restoration Project

During the April public meeting you requested that I be sure to submit our concerns regarding the Bair Island Restoration Project. I thought the best way to accomplish this was to summarize our concerns and to attach previous correspondence related to project issues.

Our first concern regards the approximately 36 acres of property owned by the County of San Mateo and managed by San Carlos Airport that are adjacent to Bair Island. This property includes portions of what is commonly referred to as Pond A-12, as well as some levee properties. Any activity that is undertaken to flood our area is unacceptable as this could present a hazard to aircraft that need to utilize this area for emergency landing.

Conversely, we are concerned as to what actions you might take, or structures you might build, to prevent this area from flooding should you continue with the proposal to flood the adjoining property referred to as Pond-A12.

We are also concerned as to what the ultimate effect would be on levees surrounding San Carlos Airport, if all of Bair Island is restored to wetland status. Our questions are hydrological in nature as we are concerned that changes in tidal flow could create a "scouring" action that could quickly erode airport levees.

Finally we are concerned about the potential for attracting wildlife, particularly birds, into areas underneath the final landing approach to Runway 30. A concentration of birds particularly in the Pond A-12 Area could easily create a hazard for landing aircraft. In the past I have provided you with Federal Aviation Administration Advisory Circular 150/5200 33. This document titled *Hazardous Wildlife Attractants on or Near Airports*, discusses concerns associated with changes in wetlands in the vicinity of airports that could increase bird or other wildlife activity.

Section 4-3 of this document describes the process for notifying the FAA of proposed changes in wetlands near airports. We have also provided copies of FAA Form 7460-1, *Notice of Proposed Construction or Alteration* that would be used for informing the FAA of the activities you intend to pursue. We believe it is very important than you pursue this process and work with the FAA to provide for the safest possible restoration of Pond A-12.

If you have questions or comments, or require further information please contact the San Carlos Airport Office at (650) 573-3700.

Very truly yours,

Gary E. Petersen
Airport Manager

cc: Neil Cullen, Director of Public Works
Brian Lee, Manager Programs Services and Engineering Division
Mark Larson, Airport Operations Supervisor
Dave Carbone, Airport Planner
Joe Rodriguez, FAA Airports District Office

Pacific Gas and Electric Company

245 Market Street
San Francisco Ca 94105
Mailing Address
Mail Code N10A
P.O. Box 770000
San Francisco, CA 94177

Date: April 28, 2000

Marge Kolar
Refuge Complex Project Leader
S. F. Bay National Wildlife Refuge Complex
P. O. Box. 524
Newark CA 94560-0524

Re: Comments by Pacific Gas and Electric Company on the Development of a Restoration and Management Plan for Bair Island, Don Edwards San Francisco Bay National Wildlife Refuge.

RECEIVED
MAY 0 1 2000

Dear Ms. Kolar:

On behalf of Pacific Gas and Electric Company (PG&E), I wish to thank you for including me as an invitee to the open house held on April 27, 2000 at 1400 Roosevelt Way in Redwood City. We appreciate the opportunity to comment on the U.S. Fish and Wildlife Service's project to develop a plan for the restoration and management of Bair Island. As you know, PG&E owns and operates several electric transmission tower lines crossing Bair Island. These lines are an important part of the electric grid serving the local area as well as the northern San Francisco peninsula.

At the open house, I had a chance to talk with one of the project consultants and we discussed PG&E's electric lines crossing Bair Island. The consultant was knowledgeable and answered my concerns about the possibility that the breaching of levees may cause the water level to rise in the vicinity of our towers to the point where the steel tower legs would be inundated.

PG&E offers the following comments on the restoration and management project:

- The DEIS/EIR should address potential impacts the project may have on PG&E's current access to its tower lines and the mitigation necessary to resolve the impacts.

- The DEIS/EIR should address potential impacts the project may have on PG&E's current operation and maintenance practices in relation to the tower lines and the mitigation necessary to resolve the impacts.

As the project plan develops, PG&E wishes to remain a part of the planning process. The project team can contact me if it needs information about the electric lines and PG&E's operations and maintenance practices.

Sincerely,

Robert Bonderud
Senior Planner

U.S Department
of Transportation

**Federal Aviation
Administration**

Western-Pacific Region
Airports Division

San Francisco ADO
831 Mitten Road, Suite 210
Burlingame, CA 94010

April 25, 2000

RECEIVED
MAY 01 2000

Ms. Margaret T. Kolar
Refuge Complex Manager
San Francisco Bay National Wildlife Refuge Complex
P. O. Box 524
Newark, CA 94560

Dear Ms. Kolar,:

NOTICE OF INTENT - RESTORATION AND MANAGEMENT PLAN FOR BAIR ISLAND ENVIRONMENTAL IMPACT STATEMENT/ENVIRONMENTAL IMPACT REPORT

Thank you for providing the Federal Aviation Administration (FAA) with a copy of the Open House News Release and Federal Register Notice regarding the Notice of Intent for the environmental analysis of the proposed Bair Island Restoration and Management Plan. Due to the proximity of Bair Island to existing airports within San Mateo County, such as San Carlos Airport and San Francisco International Airport, the FAA requests that it be included on the distribution list for future documents as they become available.

Sincerely,

Joseph R. Rodriguez
Supervisor, Planning and Programming Section

cc:
Gary Petersen, San Mateo County

SAN FRANCISCO BAY TRAIL

Marge —
Clyde — f.u.?
Matt —
Carmen —

April 19, 2000

Margaret T. Kolar, Refuge Complex Manager
Don Edwards San Francisco Bay National Wildlife Refuge
U.S. Fish and Wildlife Service—Region 1
P.O. Box 524
Newark, CA 94560

Subject: Notice of preparation of a draft EIS/EIR for a restoration and management plan for Bair Island

Dear Ms. Kolar:

The San Francisco Bay Trail Project is a nonprofit organization administered by the Association of Bay Area Governments (ABAG) that plans, promotes and advocates for implementation of the Bay Trail. Our organization has appreciated the commitment demonstrated by the U.S. Fish and Wildlife Service (FWS) to an inclusive and participatory planning process for Bair Island, and we have enjoyed our dealings with you and with Clyde Morris of your staff on this process during the past year. Today, I am writing to submit our comments on the FWS's preparation of a draft environmental impact statement/environmental impact report (EIS/EIR) for a restoration and management plan for Bair Island, in response to your recent news release on this subject.

We request that the EIS/EIR consider a restoration and management alternative that permits access through Bair Island's Pond A-12 (also knows as inner Bair Island) to hikers and bicyclists. As you might know, the area east of Highway 101 between San Carlos Airport and Bair Island Road, which includes Pond A-12, is one of the highest-priority gaps in the Bay Trail alignment. We realize, of course, that the issue of public access at Bair Island is a sensitive one, and we believe that the subject EIS/EIR could shed much-needed light on this topic by identifying significant impacts that a public-access alternative could have on Bair Island and devising mitigation measures for any such impacts.

For context, the EIS/EIR should describe the Bay Trail alignment in the vicinity of inner Bair Island, and provide an inventory of existing, planned and proposed segments of the Bay Trail in the area. Enclosed for your reference is a map of the Bay Trail alignment in central San Mateo County. Please note that the original adopted alignment—along the inner edge of Pond A-12, as shown on the Winter 1994 map—was amended in May 1995 by the Bay Trail Project at the request of San Mateo County to travel along the outer edge of Pond A-12.

Administered by the Association of Bay Area Governments
P.O. Box 2050 • Oakland California 94604-2050
Joseph P. Bort MetroCenter • 101 Eighth Street • Oakland California 94607-4756
Phone: 510•464•7935
Fax: 510•464•7970

A Few Facts About The San Francisco Bay Trail

- When complete, the Bay Trail will be a continuous 400-mile recreational corridor that will encircle the entire Bay Area, connecting communities to each other and to the Bay. It will link the shorelines of all nine counties in the Bay Area and 47 of its cities. To date, 210 miles of the Bay Trail, or slightly more than half its ultimate length, has been developed.

- The Bay Trail provides easily accessible recreational opportunities for outdoor enthusiasts, including hikers, joggers, bicyclists and skaters. It also offers a setting for wildlife viewing and environmental education, and it increases public respect and appreciation for the Bay.

- The Bay Trail also has important transportation benefits: it provides a commute alternative for cyclists, and it connects to numerous public transportation facilities, including ferry terminals, light-rail lines, bus stops and Caltrain, Amtrak, and BART stations. Also, the Bay Trail will eventually cross all the major toll bridges in the Bay Area.

- The Bay Trail provides access to commercial, industrial and residential neighborhoods; points of historic, natural and cultural interest; recreational areas like beaches, marinas and fishing piers; and over 130 parks totaling 57,000 acres of open space. It passes through highly urbanized areas like downtown San Francisco as well as remote natural areas like the San Francisco Bay National Wildlife Refuge. Depending on the location of its segments, the Bay Trail consists of paved multi-use paths, dirt trails, bike lanes, sidewalks or signed bike routes.

- State Senate Bill 100, authored by Senator Bill Lockyer and passed into law in 1987 with the endorsement of the entire Bay Area legislative delegation, advanced the concept of a "Ring around the Bay." SB 100 directed the Association of Bay Area Governments (ABAG) to develop an alignment for the Bay Trail as well as funding and implementation plans.

- Implementation of the Bay Trail is being coordinated by the Bay Trail Project, a nonprofit organization housed at ABAG. To carry out its mission, the Project raises funds for trail construction and maintenance, ensures consistency with the adopted Bay Trail Plan, provides technical assistance, enlists public participation in trail-related activities, and publicizes the Bay Trail and its benefits to the region.

To learn more about the Bay Trail, call the Bay Trail Project at 510/464.7935, e-mail us at BayTrail@abag.ca.gov, or visit us at http://baytrail.abag.ca.gov. (April 2000)

Administered by the Association of Bay Area Governments
P.O. Box 2050 • Oakland California 94604-2050
Joseph P. Bort MetroCenter • 101 Eighth Street • Oakland California 94607-4756
Phone: 510•464•7935
Fax: 510•464•7970

East Fort Baker, Marin County
San Francisco Bay Model Visitors' Center, Sausalito
Richardson Bay Wildlife Preserve, Tiburon

Wine Country (Sonoma and Napa Counties):

Hudeman Slough, Sonoma County
Napa Marshes Wildlife Area, Napa County
San Pablo Bay National Wildlife Refuge, Sonoma County

San Pablo Bay (Napa and Solano Counties):

Benicia State Recreation Area
California Maritime Academy, Vallejo
Kennedy Park, City of Napa

Upper East Bay (Contra Costa County):

Martinez Regional Shoreline Park
Point Pinole Regional Shoreline Park, Richmond
Point Isabel Regional Shoreline, Richmond

Central East Bay (Alameda and Contra Costa Counties):

Arrowhead Marsh, Oakland
Lake Merritt, Oakland
Miller/Knox Regional Shoreline, Richmond

Lower East Bay (Alameda County):

Hayward Area Interpretive Center
San Francisco Bay National Wildlife Refuge, Fremont
San Leandro Marina and Hayward Shoreline Trail

South Bay (Santa Clara County):

Alviso Environmental Education Center, San Jose
Palo Alto Baylands Preserve
Shoreline at Mountain View
Sunnyvale Baylands Park

Peninsula (San Mateo County):

Coyote Point Park, Cities of San Mateo and Burlingame
Ravenswood Open Space Preserve, San Mateo County
Redwood Shores Mariner Park, Redwood City
San Mateo County Fishing Pier, Foster City

Chevron

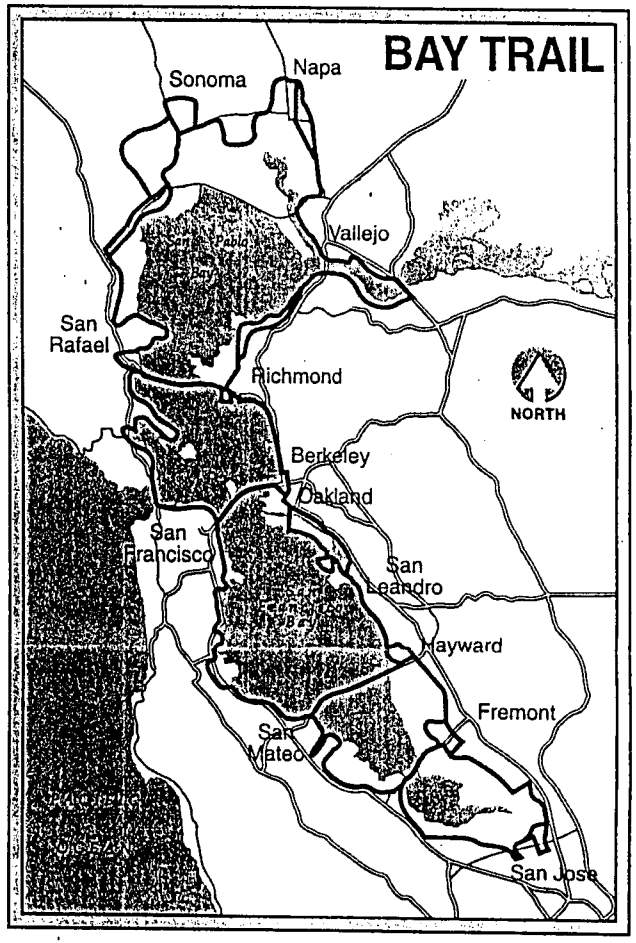
CARGILL SALT

VAN DEN BERGH FOODS COMPANY

Lockheed
Missiles & Space Company, Inc.

Baseline data provided by Etak Inc.
The San Francisco Bay Trail Project is administered and supported by
the Association of Bay Area Governments and the Metropolitan Transportation Commission.

- ✔ Some trails may be closed during nesting season or when muddy. Call the local jurisdiction to get the most recent information.
- ✔ Avoid disturbing wildlife. Enjoy viewing opportunities from a distance.



To Reach the San Francisco Bay Trail Project:
101 Eighth Street (Lake Merritt BART station)
P.O. Box 2050
Oakland, CA 94604
(510) 464-7900

SAN FRANCISCO BAY TRAIL

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