Bolinas Lagoon Ecosystem Restoration Project Draft Feasibility Study Marin County, California, June 2002

VOLUME I

Draft Feasability Study

DRAFT EIS/EIR (available as a separate volume for the KRIS edition)

Bolinas Lagoon Ecosystem Restoration Project
Draft Feasibility Study
Marin County, California

EXECUTIVE SUMMARY

1.0 Introduction

The Bolinas Lagoon Ecosystem Restoration Feasibility Study, which was prepared by the US Army Corps of Engineers (Corps) and the non-Federal sponsor Marin County Open Space District (MCOSD), identifies a feasible project to restore nearly 600 acres of subtidal and intertidal habitat in Bolinas Lagoon by removing approximately 1.5 million cubic yards (cy) of sediment. The purpose of this study is to identify the problem in Bolinas Lagoon, identify the opportunities for restoration and constraints to project development, develop planning objectives for the study, and develop a solution that addresses those planning objectives. The overall goal of the project is to find viable alternatives that provide long term benefits to the lagoon ecosystem while minimizing adverse, short term impacts.

2.0 Measures and Alternatives Considered

Restoration measures considered in this study include wet sediment dredging and dry sediment excavation activities in the North Basin, Main Channel, Pine Gulch Creek Delta, Kent Island, Bolinas Channel, Highway One Fill Areas, South Lagoon Channel, Dipsea Road and Seadrift Lagoon. These measures were geographically grouped into North, Central and South. The Central and South alternatives were modified to include other variations, resulting in two alternatives for both. When these alternatives were combined to make alternative plans, all possible combinations were considered and then screened according to the evaluation criteria developed during the planning process. The final array of alternative plans included twelve different combinations of the above restoration measures.

The National Ecosystem Restoration (NER) Plan is the North, Central (Estuarine) and South (No Seadrift) alternative plan and the Locally Preferred Plan (LPP) is the North, Central (Riparian) and South (No Seadrift) alternative plan. Both plans are comprehensive restoration plans addressing all areas of the lagoon, and only differ with respect to excavation in Pine Gulch Creek Delta. The Estuarine plan removes 7 of 17 acres of riparian habitat, whereas the Riparian plan removes no riparian habitat. Because the Recommended Plan will not be identified until the Final Feasibility Report, the public will have the opportunity to comment on the NER Plan and the LPP and make suggestions for further refinement.

A watershed study, the *Bolinas Lagoon Watershed Study: Input Sediment Budget* (2001) in Appendix A of the Environmental Impact Statement/Environmental Impact Report (EIS/EIR), was conducted during the Feasibility Study to identify sources of sediment and potential areas for sediment control and/or restoration in the watershed. The results of the study concluded that, although historical land management practices had been the cause of increased sedimentation in the lagoon in the past, the watershed is in the process of healing due to better land management practices, and there are few places where restoration would be advisable at this time. Future watershed activities will be coordinated by a Bolinas Lagoon Watershed Council, individual property owners, or others.

The environmental impacts will be beneficial in the long term, although there will be some unavoidable adverse impacts in the short term, such as an increase in turbidity and noise disturbance during construction. Monitoring and adaptive management, which will be conducted before, during and after construction, will inform the implementation process and help reduce unexpected impacts. The removal of sediment in Bolinas Lagoon will improve the quantity and quality of subtidal and intertidal habitat for the diverse groups of species that rely on Bolinas Lagoon, including a variety of threatened, endangered, rare and special status species.

3.0 Recommendations

The NER Plan includes the North Basin, Main Channel, Bolinas Channel, Kent Island, Pine Gulch Creek Delta: Estuarine Option, Highway One Fills, Dipsea Road and South Lagoon Channel components. The total project first cost of the NER Plan is $101,553,000. Cost sharing for ecosystem restoration projects is 65% Federal and 35% non-Federal (local sponsor), for a total of $66,009,450 Federal and $35,543,550 non-Federal. The LPP includes the North Basin, Main Channel, Bolinas Channel, Kent Island, Pine Gulch Creek Delta: Riparian Option, Highway One Fills, Dipsea Road and South Lagoon Channel components. The LPP Plan has a total project first cost of $100,716,000. Cost sharing for ecosystem restoration projects is 65% Federal and 35% non-Federal (local sponsor), for a total of $65,465,400 Federal and $35,250,600 non-Federal. For either plan, the costs associated with the Lands, Easements, Rights-of-Way, Relocations and Disposal Areas (LERRD), which would be paid for in full by the local sponsor as part of their 35% share, are expected to be minimal. The entire non-Federal cost share would be financed in cash. Based on continuing coordination with the local sponsor, results of the public review and public involvement process, and continuing refined evaluation of the ecosystem restoration alternatives, a Recommended Plan will be identified in the Final Feasibility Report.

Commonly Used Acronyms

ACR	Audubon Canyon Ranch
ASA(CW)	Assistant Secretary of the Army for Civil Works
BLTAC	Bolinas Lagoon Technical Advisory Committee
CEQA	California Environmental Quality Act
DFG	Department of Fish and Game
EQ	Environmental Quality
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FCSA	Feasibility Cost Sharing Agreement
GFNMS	Gulf of the Farallones National Marine Sanctuary
GGNRA	Golden Gate National Recreation Area
GIS	Geographical Information System
HAAF	Hamilton Army Air Field
HEEP	Habitat Evaluation Expert Panel
HEP	Habitat Evaluation Procedures
HQUSACE	Headquarters, US Army Corps of Engineers
ICA	Incremental Cost Analysis
IDC	Interest During Construction
LERRD	Lands, Easements, Rights-of-Way, Relocations and Disposal Areas
LPP	Locally Preferred Plan
MCOSD	Marin County Open Space District
MHW	Mean High Water
MLLW	Mean Lower Low Water
MSL	Mean Sea Level
NED	National Economic Development

NER	National Ecosystem Restoration
NER Plan	National Ecosystem Restoration Plan
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
O&M	Operations & Maintenance
OMB	Office of Management and Budget
OMRR&R	Operation, Maintenance, Repair, Replacement and Rehabilitation
OSE	Other Social Effects
PCA	Project Cooperation Agreement
PED	Pre-construction, Engineering and Design
PMP	Project Management Plan
PRBO	Point Reyes Bird Observatory
PRNS	Point Reyes National Seashore
RED	Regional Economic Development
RWQCB	Regional Water Quality Control Board
SFDODS	San Francisco Deep Ocean Disposal Site
SLC	State Lands Commission
SPD	South Pacific Division, US Army Corps of Engineers
SPN	San Francisco District, US Army Corps of Engineers
USGS	United States Geological Survey
USFWS	United States Fish & Wildlife Service
WRDA	Water Resources Development Act

1.0 INTRODUCTION

This chapter provides basic background for the Bolinas Lagoon Ecosystem Restoration Feasibility Study, which is a study that has been cost shared by the U.S. Army Corps of Engineers (Corps) and Marin County Open Space District (MCOSD). It lists the steps in the Corps planning process, and relates them to the organization of this report.

1.1 Study Authority

It was resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives on March 7, 1996 that the Secretary of the Army review the report of the Chief of Engineers, *Channel to Bolinas, California*, published as House Document 537, Sixty-fourth Congress First Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time in the interest of ecosystem protection, enhancement, and restoration and related purposes at Bolinas Lagoon, California.

The Federal objective of project planning is defined in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G) approved in April 2000. Guidance for conducting U.S. Army Corps of Engineers' civil works planning studies is presented in the revised Engineering Regulation 1105-2-100, *Planning Guidance Notebook*, dated April 22, 2000.

1.2 Study Purpose and Scope

The purpose of Civil Works ecosystem restoration activities is to restore significant ecosystem function, structure, and dynamic processes that have been degraded. Ecosystem restoration efforts involve a comprehensive examination of the problems contributing to the system degradation, and the development of alternative means for their solution. The intent of restoration is to reestablish the attributes of a natural, functioning, and self-regulating system.

This study considers what can be done in Bolinas Lagoon to restore degraded areas, and ensure the future health of the estuarine habitats and the species dependent on those habitats. It also identifies the Federal interest in an ecosystem restoration project of that purpose. This study is unique in that although the system has been degraded to some extent by past human activities, the lagoon still provides important habitat to many rare, protected, threatened and endangered species and serves as an important stopover point along the Pacific Flyway for migrating waterfowl.

This study reviews prior research done in the lagoon and contributes to that knowledge by providing information on the unique habitats Bolinas Lagoon provides to many species and a variety of ecological communities. All restoration measures have been designed to improve the quality and long term health of estuarine habitats, which support diverse and important species. Other benefits include recreational and education opportunities and providing the Nation with a natural resource that can be enjoyed for years to come.

1.3 Study Area Description

Bolinas Lagoon is located on the northern California coast, 12 miles northwest of San Francisco and the Golden Gate (Figure 1.1). It is a tidal estuary, connected to Bolinas Bay, approximately three miles long by one mile wide, and 1,100 acres in size, as described in the *Bolinas Lagoon Management Plan Update of 1996* (BLMPU 1996). During low tides, much of the lagoon bottom is exposed; only the deeper channel areas and part of the northern basin are constantly covered with water.

1.4 History of the Investigation

In response to the study authority, the reconnaissance phase of the study was initiated in January 1997. This phase of the study resulted in the finding that there was a Federal interest in continuing the study into the feasibility phase. MCOSD as the local sponsor and the Corps initiated the feasibility phase of the study in January 1998. The feasibility phase study cost was shared equally between the Corps and the sponsor. This report presents the results of both phases of study.

1.5 Study Participants and Coordination

The Corps and MCOSD are responsible for conducting and coordinating this Feasibility Study. The Marin County Open Space District is the local sponsor and, as such, has made fiscal contributions toward completing this study. MCOSD also contributed in-kind services, including surveys and mapping, plan formulation, technical management, financial assessment, real estate studies, independent technical review, and public involvement, including meeting coordination, newsletters and distribution of project information to interested parties. The Gulf of the Farallones National Marine Sanctuary (GFNMS) and Bolinas Lagoon Technical Advisory Committee (BLTAC) have also participated in, and contributed invaluable information towards, the development of the Feasibility Study.

1.6 Public Involvement

Corps study participants have attended quarterly meetings of the Bolinas Lagoon Technical Advisory Committee (BLTAC) to gather and disseminate information on the Feasibility Study. A Habitat Evaluation Expert Panel was convened from August 2000 to March 2001 as a scientific forum to discuss the merits of the various restoration alternatives. Public workshops were held in September 1998, November 1999 and November/December 2000 to review the progress of the feasibility study and to listen to public concerns. Newsletters updating the local communities on project activities are distributed as necessary by MCOSD.

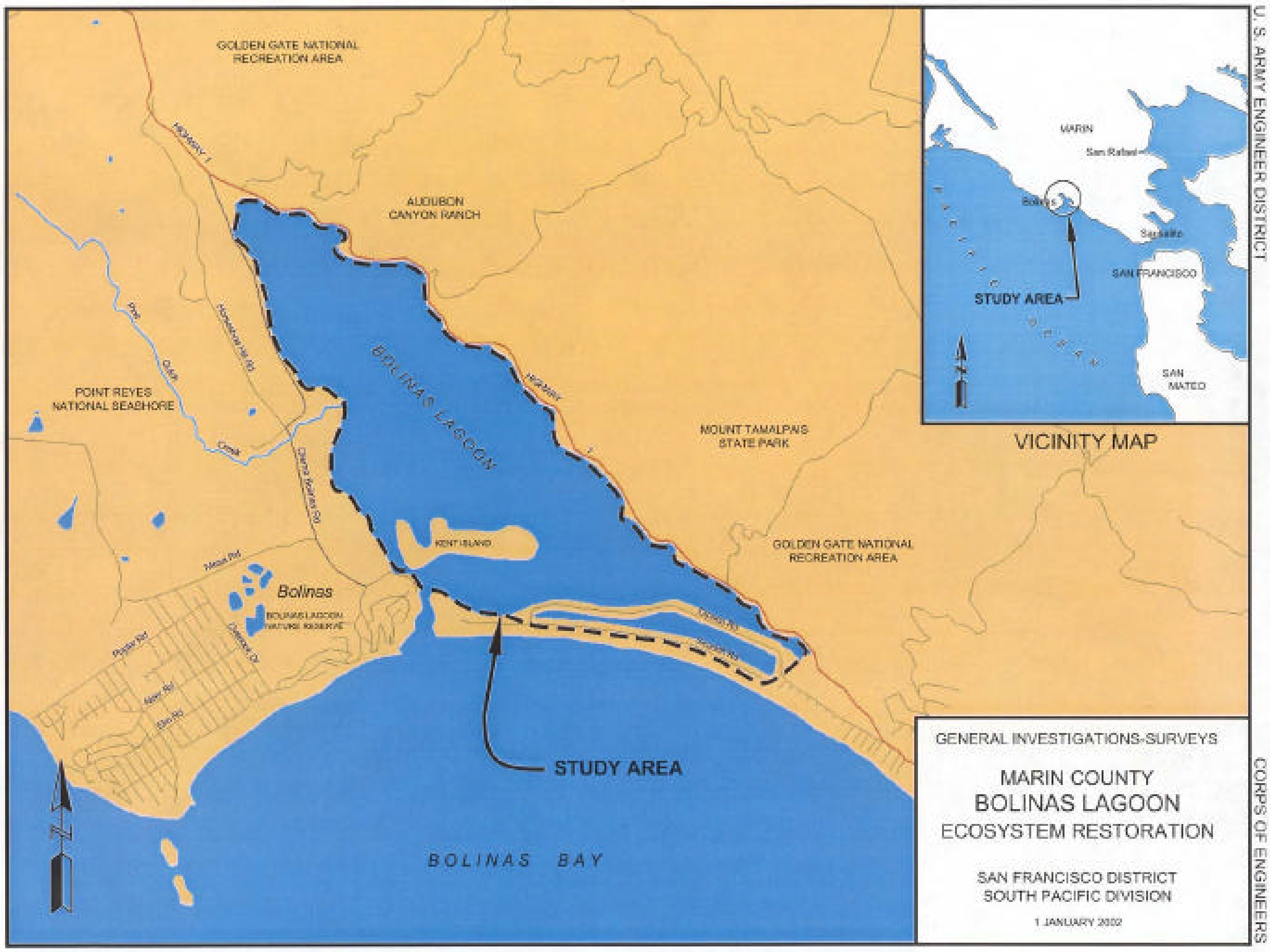


Figure 1.1 Bolinas Lagoon Ecosystem Restoration Project Location Map

1.7 Prior Studies and Reports

Past studies and reports by the USACE for Bolinas Lagoon include:

1. *Report on Preliminary Examination of Channel from the Town of Bolinas California, to the Sea*, 8 January 1916.

2. *Bolinas Channel & Lagoon*, *Review of Reports*, 25 November 1939.

3. *Review Report on Bolinas Channel and Lagoon*, California for Navigation and Appendices, January 1966.

4. *Section 103 Reconnaissance Report for Beach Erosion Control* Bolinas, California, 14 July 1967.

5. *Plan of Survey for Beach Erosion Study*, Bolinas California, March 1972.

6. *Brief Letter - Type Report, Bolinas Channel and Lagoon*, California, 30 April 1974 (In the Interest of Navigation).

7. *Plan of Study for Bolinas Lagoon*, California, U.S. Army Corps of Engineers, San Francisco District, July 1978.

Other significant reports for the study area include:

1. *The Bolinas Lagoon Management Plan Update*, 1996. The Bolinas Lagoon Management Plan Update (BLMP) was prepared by MCOSD in 1996 to reflect the changed environmental, legal, and political conditions in the lagoon since the first plan was written in 1981. The BLMP identifies the primary long term management issues as those involving sedimentation in the lagoon and the expected continued loss of tidal and subtidal habitat.

2. *Gulf of the Farallones National Marine Sanctuary Management Plan*, 1987 (GFNMS 1987). The management goals of the GFNMS Management Plan are identified as follows: 1) "[i]mproved protection of the marine environment and resources of the sanctuary, consistent with the existing policies of regulatory agencies;" 2) the furthering of research to help solve specific management problems, enhance resource protection efforts, and assist in the interpretation of the resource for visitors;" 3) interpretation and education designed to "enhance public awareness and understanding of the sanctuary, and to promote the need for and benefits to long term comprehensive management of its marine resources."

There are no existing (constructed) Corps projects at Bolinas Lagoon.

1.8 The Planning Process and Report Organization

The Feasibility Study is the second phase of the Corps of Engineers' planning process, and follows a favorable Reconnaissance Report and the execution of a Feasibility Cost Sharing Agreement between the USACE and the local sponsor. The scope of the Feasibility Study includes review, update and use of the 1997 Reconnaissance Study results and consolidation of information that has been developed since the conclusion of that study. Feasibility Study efforts include new and more detailed information to support the baseline conditions identified in the Reconnaissance Study, a watershed study, a recent bathymetric survey, numerical modeling studies, consolidation of aerial photography, Geographic Information System (GIS) mapping, formation of a Habitat Evaluation Expert Panel to evaluate the ecosystem restoration outputs of alternative plans, and cost effectiveness and incremental cost analyses.

The study begins with the analyses of the historical conditions, existing conditions and 50-year projection of the lagoon's condition without a work project (i.e., Future

Without Project Conditions) to form the baseline condition, and identification of problems and opportunities, goals and objectives. From the existing and historical data gathered, restoration measures (or components) are formulated, and these measures are combined to form a number of alternatives that are later combined to form alternative plans. Plans are compared to the baseline conditions as well as other plans, and from there, a recommended plan is selected. The recommendations listed in this report will serve as the basis for congressional project authorization and, if authorized, will be carried forward to the Pre-construction, Engineering and Design (PED) phase. The scoping process for this study includes participation from numerous groups and individuals throughout the planning process.

This feasibility planning process incorporates six major steps: (1) Specification of water and related land resources problems and opportunities; (2) Inventory, forecast and analysis of water and related land resources conditions within the study area; (3) Formulation of alternative plans; (4) Evaluation of the effects of the alternative plans; (5) Comparison of the alternative plans; and (6) Selection of the recommended plan based upon the comparison of the alternative plans.

The chapter headings and order in this report generally follow this six-step planning process, and appear as follows:

- The second chapter of this report, Problems, Needs and Opportunities, covers the first step in the planning process: specification of water and related land resources problems and opportunities.
- The third chapter of this report, Study Area Description, covers the second step in the planning process: inventory, forecast and analysis of water and related land resources conditions within the study area.
- The fourth chapter in this report, Plan Formulation: Possible Solutions, covers the third step in the planning process: formulation of alternative plans.
- The fifth chapter in this report, Plan Evaluation, covers the fourth step in the planning process: evaluation of the effects of the alternative plans.
- The sixth chapter in this report, Plan Comparison, covers the fifth step in the planning process: comparison of the alternative plans.
- The seventh chapter in this report, Recommendations: The Selected Plans, covers the sixth step of the planning process: selection of the recommended plan based upon the comparison of the alternative plans.

Subsequent chapters cover implementation of the recommended plans, public involvement and agency coordination, and conclusions, recommendations and the list of preparers.

2.0 PROBLEMS, NEEDS AND OPPORTUNITIES

This chapter presents the results of the first step of the planning process: the specification of water and related land resources problems and opportunities in the study area. The chapter concludes with the establishment of planning objectives and planning constraints, which are the basis for the formulation of alternative plans.

2.1 National Objectives

The national or Federal objective of water and related land resources planning is to contribute to national economic development consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to National Economic Development (NED) are increases in the net value of the national output of goods and services expressed in monetary units. Contributions to NED are the direct net benefits that accrue in the planning area and the rest of the nation.

The Corps has added a second national objective for Ecosystem Restoration in response to legislation and administration policy. This objective is to contribute to the nation's ecosystems through ecosystem restoration, with contributions measured by changes in the amounts and values of habitat.

As stated in Engineering Regulation ER-1105-2-100:

> "Ecosystem restoration is one of the primary missions of the Corp of Engineers Civil Works program. The Corps objective in ecosystem restoration planning is to contribute to National Ecosystem Restoration (NER). Contributions to National Ecosystem Restoration (NER outputs) are increases in the net quantity and/or quality of desired ecosystem resources. Measurement of NER is based on changes in ecological resource quality as a function of improvement in habitat quality and/or quantity and expressed quantitatively in physical units or indexes (but not monetary units). These net changes are measured in the planning area and in the rest of the Nation. Single purpose ecosystem restoration plans shall be formulated and evaluated in terms of their net contributions to increases in ecosystem value (NER outputs), expressed in non-monetary units..."

2.2 Public Concerns

The Bolinas Lagoon Ecosystem Restoration Study has been guided by the advice and interest of the public through public meetings and workshops, as well as by the Bolinas Lagoon Technical Advisory Committee (BLTAC) which meets quarterly and in special sessions in a public forum, and advises MCOSD on how to manage Bolinas Lagoon. Through these meetings, a number of concerns have been identified. A discussion of public involvement is included in Chapter 8, Public Involvement and Agency Coordination. The public concerns that are related to the establishment of planning objectives and planning constraints, as stated in the EIS/EIR, are:

- That non-invasive sediment input reduction (e.g., restoration in the watershed) be considered as an alternative to dredging the lagoon.

- That at least one of the alternatives include incremental dredging.

- That aesthetics are an important concern to members of the public.

- That rock revetment on the ocean side of the Stinson Beach sand spit may have caused or exacerbated erosion of the sand from the spit, which then moves into the lagoon.

- That the Corps is overly focused on erosion in the upper watershed, instead of in the bottoms of the canyons, on the east side of the lagoon.

- That the study area should include the Bolinas groin.

- That the Corps should open Seadrift Lagoon to full tidal influence, restore Pine Gulch Creek Delta, open up the channel between Kent Island and the town of Bolinas, and remove excess fill from Dipsea Road.

- That residuals of copper sulfate might enter Bolinas Lagoon from Seadrift Lagoon or that there might be future failures of the leach fields along Dipsea Road.

- That the project should be designed to encourage natural processes to scour sediment from the lagoon.

- That adaptive management be used to guide implementation and scope of restoration activities.

2.3 Problems and Opportunities

The evaluation of public concerns reflects a range of needs, which are perceived by the public. This section describes these needs in the context of problems and opportunities that can be addressed through water and related land resource management. The problems and opportunities are based upon the without project conditions that are described in Chapter 3, Study Area Description.

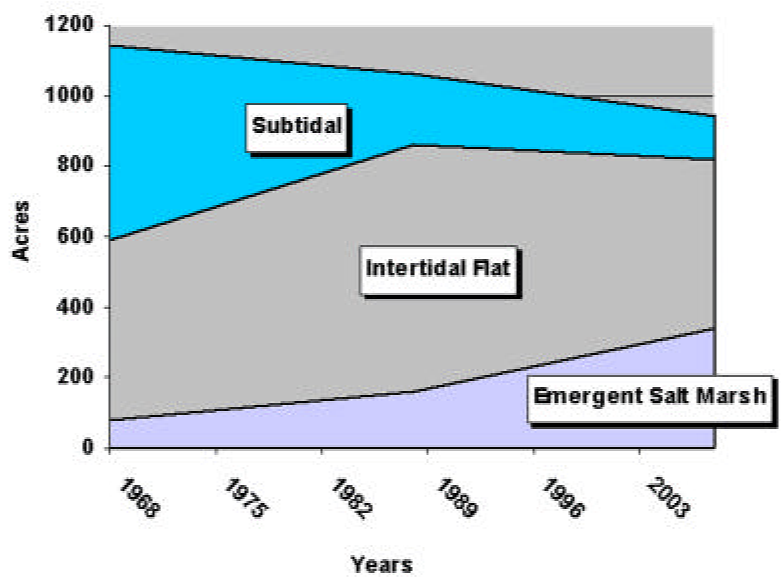
2.3.1 Problem Identification

Lagoons normally have a geologically short life span, accreting more sediment over time than is carried out. Thus, the normal life cycle of a lagoon is to change from an estuary into, first, intertidal wetland habitat, then, as sediment continues to accrete, into upland habitat. Because of its location along the San Andreas Fault line, however, Bolinas Lagoon has had an extended life span. Due to a balance between sedimentation, sea level rise, and tectonic subsidence, the estuarine habitat has been maintained for some 7,000 years (BLMPU 1996). Available information indicates that the "Great San Francisco Earthquake" of 1906 caused about one foot of subsidence in most of the lagoon. It is because of this relationship that Bolinas Lagoon is not, in fact, a lagoon at all. It is an estuary, an estuary that survived several thousand years of human intervention; until Europeans arrived and changed that balance.

Human activities beginning in 1849 initiated a change in the balance, favoring sediment accumulation. Activities such as logging, clearing, and grazing in the watershed, as well as placement of fill material along the edge of the lagoon and the diversion and manipulation of watercourses entering the lagoon have caused a large amount of sediment to enter the lagoon, accelerating the transition from estuarine lagoon to intertidal marsh. Lagoon bathymetries show that between 1968 and 1988, the lagoon lost about 25% of its tidal prism (the amount of water that flows in and out during a normal tidal cycle) and 7% of its estuarine habitats (BLMPU 1996).

Without intervention, Bolinas Lagoon will continue to fill with sediment, resulting in further losses of subtidal estuarine and intertidal habitats. Estimates indicate that "between 1998 and 2008, subtidal habitat area will decrease by 40% (down nearly 80% compared to 1968); intertidal flat area is expected to decrease 30%; emergent salt

Figure 2.1 Bolinas Lagoon Habitat Changes



marsh habitat type area will have increased more than 50% (400% increase compared to 1968); and upland habitat will increase by 11% as estuarine and wetland habitats are converted to uplands" (BLMPU 1996).

Historically, poor watershed management has contributed to higher sediment loads being transported into the lagoon. High sedimentation rates, in combination with the placement of fill material along the edge of the lagoon, have not only caused a direct loss of tidal prism and intertidal subtidal habitats, but have also accelerated the natural shoaling processes in the lagoon.

A decrease in tidal prism results in a loss of subtidal and intertidal habitats, equating to significant changes in habitat conditions for the species that are dependent on those areas. A decline in subtidal habitat, for example, would result in the loss of estuarine plants (e.g., eelgrass), invertebrates and fish species in the lagoon (BLMPU 1996). Steelhead and Coho salmon are two federally listed threatened species that would be detrimentally affected by a loss of subtidal habitat (and access to the watershed's tributaries). Bird diversity would also be affected.

Bird surveys indicate that since 1972, diving birds (e.g., grebes and diving ducks) have decreased, giving rise to birds dependent on the intertidal zone, such as shorebirds and dabbling ducks. This trend is counter to statewide and regional trends. These trends will only continue as long as sediment continues to fill the lagoon. The next transitional phase to occur would be that of intertidal habitat to upland habitat. According to the *Bolinas Lagoon Management Plan Update of 1996*, "By 2008, the Lagoon will likely be a significantly less valuable migration and over-wintering location on the Pacific Flyway, where estuarine habitats have already suffered huge losses and degradation." Other species, like the harbor seals that use Bolinas Lagoon during their pupping season, would also suffer losses in habitat quality and quantity. Given the diversity of wildlife species using the lagoon and its proximity to relatively undisturbed and protected areas, Bolinas Lagoon is a critical element of a unique ecosystem. Although Bolinas Lagoon currently provides important habitat to a variety of species, the value of its habitats will continue to degrade as intertidal and subtidal habitats continue to decline.

A decline in subtidal habitat would have a concomitant loss in intertidal habitat, and vice versa. Similarly, an increase in intertidal habitat would also signify a gain in subtidal habitat. The two are linked. Therefore, although increases in intertidal volume are used as an indicator for "success" for the purposes of this project, it is assumed that while intertidal habitat is increasing, subtidal habitat is also increasing. An increase in both of these habitats correlates to an improvement in the lagoon as an ecosystem.

2.3.2 Opportunities

Because habitat quality and quantity in Bolinas Lagoon have diminished in the recent past, there are many opportunities for restoration in the lagoon via sediment removal. In addition, although a full feasibility-level evaluation for restoration in the watershed is beyond the scope of this study, potential restoration opportunities in the watershed can be identified.

2.4 Planning Objectives

The national objectives are general statements, not specific enough for direct use in plan formulation. The water and related land resource problems and opportunities identified in this study are stated as specific planning objectives to provide focus for the formulation of alternatives. The study team identified the objectives through the Reconnaissance Study effort and from public and agency comments during the Feasibility scoping process. These planning objectives reflect the problems and opportunities, and represent desired positive changes with respect to existing conditions and Without Project Conditions. The planning objectives are specified as follows:

- Restore intertidal and subtidal habitat
- Increase tidal prism
- Reduce the chance for inlet closure
- Identify potential restoration projects in the watershed to reduce the amount of sediment coming into the lagoon

2.5 Planning Constraints

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that should not be violated. The planning constraints identified in this study are as follows:

- Do no harm to sensitive species, including rare, sensitive, threatened and endangered species (for example, the black rail, salt marsh common yellowthroat, steelhead, Coho salmon and *Cordylanthus meridius*, a herbaceous plant).
- Maintain existing habitat values the lagoon provides to important species.
- Dispose of dredged material properly; ensure the availability of appropriate disposal sites.
- Utilize "dredging windows" to avoid impacts to sensitive species during important life stages (breeding, nesting, spawning, foraging, wintering, migration, etc.).
- Minimize project impacts on extensive residential development in the Seadrift Lagoon community.
- Develop alternatives that are acceptable to the local community.
- Utilize monitoring and adaptive management as the project is implemented.
- Avoid the need for regularly scheduled maintenance dredging, which would not be permitted by the Gulf of the Farallones National Marine Sanctuary (GFNMS). If additional restoration measures were needed in the future to realize project benefits, future work would be considered. However, this

restoration project should be a one-time effort. Project alternatives must be designed to ensure, as much as possible, that the system becomes self-sustaining.

3.0 STUDY AREA DESCRIPTION

This chapter presents the background information of this study, including without project conditions, existing conditions, and future without project conditions. It is from this information that the restoration alternatives are formulated. In later chapters, the alternatives will be compared to the future without project conditions, and compared to one another in order to select the best possible solution to the problem.

3.1 Setting

Bolinas Lagoon is part of the Gulf of the Farallones National Marine Sanctuary, and is surrounded by open lands owned by Audubon Canyon Ranch, Point Reyes National Seashore, Golden Gate National Recreation Area, and Mount Tamalpais State Park, as well as small residential and agricultural areas in the towns of Stinson Beach and Bolinas. The watershed surrounding Bolinas Lagoon is 16.7 square miles, with a dimension of three miles in width by nine miles in length (Figure 3.1) (BLMPU 1996). The Bolinas Ridge, which is on the eastern side of the lagoon, rises to an elevation of 2,000 feet. The largest single contributor of water and sediment to the Bolinas Lagoon watershed is Pine Gulch Creek, a perennial tributary located on the northwestern side of the lagoon, near the town of Bolinas. It comprises about half of the fresh water flowing into the lagoon. On the eastern side, there are several smaller intermittent creeks flowing in from the Bolinas Ridge, including Easkoot Creek. The sand spit of Stinson Beach forms the western boundary of the lagoon, terminating at the lagoon inlet. The residential area along the Stinson Beach sand spit, which was developed in the 1950's by placing dredge spoils from the sand spit into Bolinas Lagoon, thereby forming Seadrift Lagoon, forms the Seadrift Lagoon community. Access to Bolinas Lagoon is provided by Highway One, which runs parallel along the eastern border, the Bolinas/Olema Road, Wharf Road, Seadrift and Dipsea Roads (BLMPU 1996).

Located along the Pacific Flyway, receiving over-wintering birds during their migration periods, Bolinas Lagoon was designated as a Ramsar Site or Wetland of International Importance in 1998 by the U.S. Fish and Wildlife Service (Ramsar 2001). The wetlands identified on the Ramsar list "acquire a new status at the national level and are recognized by the international community as being of significant value not only for the country, or the countries, in which they are located, but for humanity as a whole" (Ramsar 2001). Stinson Beach and Bolinas Lagoon are tourist destinations for local, domestic and international travelers, especially during the summer months.

3.2 Historical Conditions

Bolinas Lagoon had already been in use by local and migratory species for more than two thousand years when Egypt's 4^{th} dynasty ruler Khufu built the Great Pyramid in 2560 B.C. This estuary has been naturally maintained for some 7,000 years (BLMPU 1996). Under normal conditions, due to the build up of sediments, lagoons have a geologically short life span. Their normal life cycle is to change first, from an estuary into intertidal wetland habitat, then into upland habitat. However, due to a rare balance between sedimentation, sea level rise, and tectonic subsidence, Bolinas Lagoon has remained, until recently, much as it was 7,000 years ago.

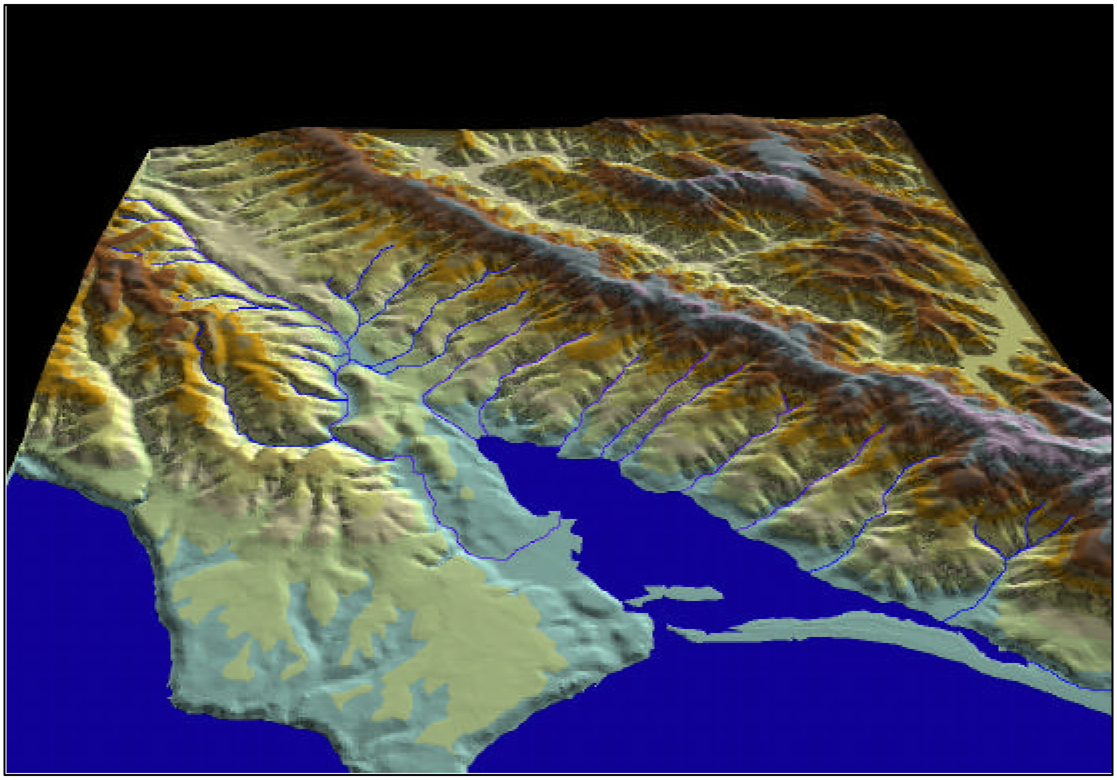


Figure 3.1 Digital Terrain Model of the Bolinas Lagoon Watershed

It appears the reason Bolinas Lagoon continues as a "self maintaining" system, and did not long ago transform into a meadow, is due to large seismic events along the San Andreas Fault (BLMPU 1996). The seismic activity dramatically increases tidal prism by physically dropping the lagoon bottom elevation and causing channel realignment, which essentially turns the clock back for the lagoon with each major earthquake. In a study performed by Knudsen et al. in 1999 for the USGS, considerable evidence lead to the conclusion that significant earthquakes occur along the San Andreas Fault in this region, at regular intervals of three hundred to four hundred years.

In 1998, the lagoon looked similar to the way it did in 1854 (Figure 3.2). The size of Kent Island, the size and layout of the channels, and the extensive mudflats are all very much the same. In addition, in his 1978 report, Bergquist argued that although the 1854 map does not show the subtidal area in the north end of the lagoon, there is evidence of such a subtidal area in core samples. This suggests the 1854 lagoon did look very much like the 1998 lagoon, as there was also subtidal area in the north end of the lagoon in 1998. Regular seismic events have continued this cycle of lowering the lagoon bottom after hundreds of years of sediment accrual, keeping the lagoon open longer than would normally be expected.

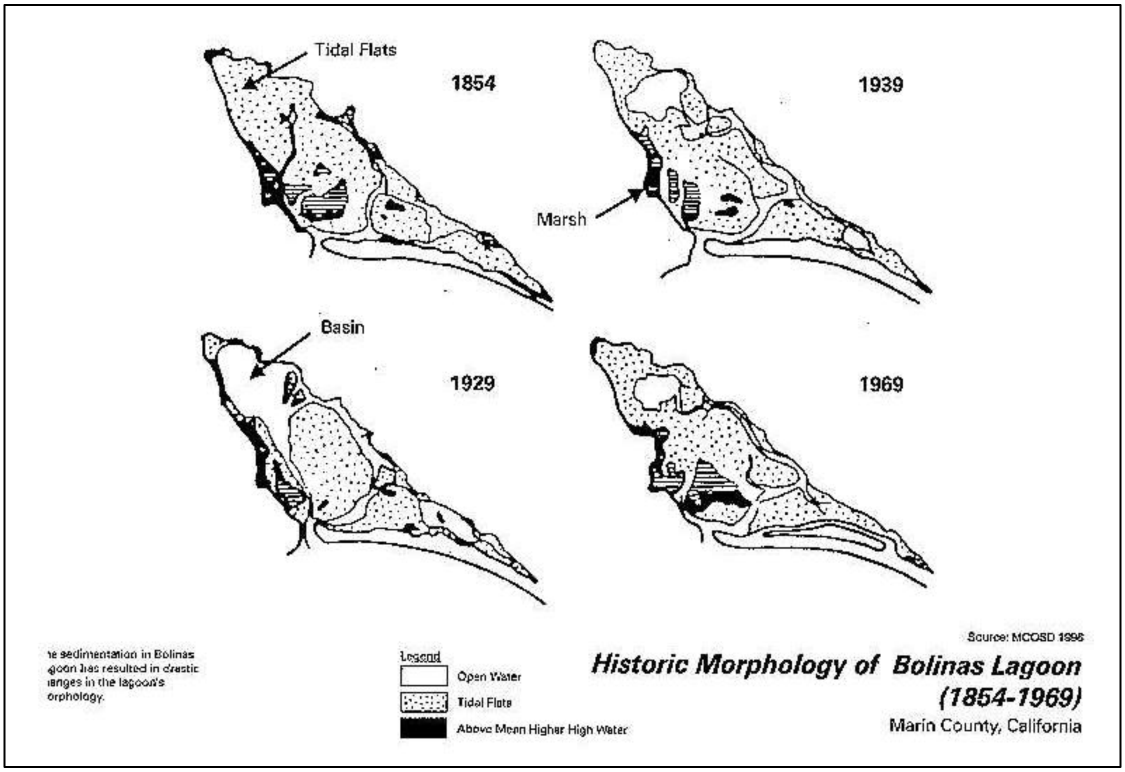


Figure 3.2 Lagoon Morphology 1854-1969

For most, if not all of its 7,000 years, the Lagoon has been part of the Pacific Flyway, one of the four North American bird migration routes. The Pacific Flyway is comprised of the western Arctic, including Alaska and the Aleutian Islands, and the Rocky Mountain and Pacific coast regions of Canada, the United States and Mexico, south to Central and South America, where it mixes with the other migration flyways.

In the last hundred years, most of California's estuarine habitat has disappeared due to human activities, like urbanization, development, agriculture, logging, etc. Bolinas Lagoon is one of the last relatively undeveloped estuarine habitats remaining on the coast of California, and hosts an array of biologically diverse species, including benthic invertebrates; marine algae; threatened, endangered and special status species such as Coho salmon, steelhead trout, and black rail; migrating birds on the Pacific Flyway; and other resident and migratory fish, birds, and seals. As other estuarine habitats continue to disappear, Bolinas Lagoon becomes increasingly important to both its local populations and the migratory populations and was designated a Ramsar Site, or Wetland of International Importance, in 1998.

The *Bolinas Lagoon Management Plan Update of 1996*, and more recently the *Bolinas Lagoon Watershed Study of 2001* (BLWS 2001), provide a summary of past studies such as Ritter (1970), Rowntree (1973), Bergquist (1978), and Bergquist and

Warhaftig (1993). These reports agree that poor management of the watershed after the year 1850 appears to be the major cause of the above normal sedimentation rate in the lagoon. Activities such as logging, grazing, road construction, stream channelization and natural fires all contributed to the increased level of sedimentation. This conclusion was verified by the coastal engineering work completed for this study (discussed in Section 3 of the Engineering Appendix).

Feasibility studies have shown that, due to the continued loss of lagoon volume over time, even at the near normal rate (as discussed in Section 3 of the Engineering Appendix), the lagoon's inlet could experience temporary closures in approximately thirty years, given the right combination of meteorological events (discussed in detail in Section 3.10 of the Engineering Appendix). Extrapolating this information to the 1854 lagoon would suggest that the lagoon would have been at risk of closure around the year 1900. In actuality, it was probably sooner, since it has been estimated that some of the highest years of sedimentation occurred soon after 1850.

In the years between 1850 and the early 1900's much of the old growth forest in the watershed was logged, particularly the redwood stands. In fact, from 1849 to 1860, Dog Town's mills reportedly generated nearly 15 million board feet of lumber. Logging roads were often created by filling in creeks with rubble and earth, causing much of the sediment to be transported into the lagoon during heavy rainfall events. Lands harvested of timber along the slopes of the Bolinas Ridge were converted to cattle grazing and agricultural uses when the logging activities ceased. Several mining operations were also active in the area, peaking in operation during WWII, and continuing until 1963. After these activities ceased, and the watershed was in the beginning stages of recovery, a devastating fire swept through the area, burning out most of what remained of the forest and its under story, and likely caused severe erosion on the denuded slopes. Fires have swept through Marin at regular intervals throughout recorded history, and are understood to have done so long before European settlement. Major fires in the Bolinas watershed are recorded in 1890, 1904, 1923, and 1945, most of which burned through the ranchlands on the northern and eastern sides of the watershed. All these factors contributed substantially to a greater amount of sediment being delivered to the lagoon. In 1906, however, a large earthquake occurred which reportedly dropped the bottom of the lagoon by over one foot (BLMPU 1996). At about the time the lagoon was approaching the potential of closure, the earthquake effectively opened the system back up.

The lagoon is now approaching potential closure in the year 2050, but a sizable earthquake is not expected until the years 2200 to 2300, based upon the 1999 Knudsen Report. This suggests the lagoon will reach a point 150 years after the last major earthquake, which, had human activities not disturbed the natural cycle, would not have been reached for another 300 to 400 years. The lagoon's sedimentation rate in the recent past has averaged two to three times its normal rate.

There are numerous discrepancies among reports concerning the sedimentation rate timeline of the lagoon. Bergquist's 1978 report attempted to correct the information and methodologies used by earlier investigators, and added information gleaned from his own research, to create a sedimentation rate timeline that seemed fairly comprehensive. However, in 1993, Bergquist and Warhaftig refuted some of the conclusions reached in Bergquist's earlier report. The *Bolinas Lagoon Management Plan Update of 1996* also attempted to summarize the reports and reach a sedimentation rate timeline (shown as Figure 3.3), but uncertainty remains as the timeline is largely based on the same information Bergquist used. The *Bolinas Lagoon Watershed Study of 2001* also summarized many of the previous studies, and although it does not highlight or explain the discrepancies, they are evident in the information therein.

Instead of trying to determine an exact sedimentation rate timeline from 1850 forward, the Corps used a different method to determine the severity of past sedimentation and its effects in the lagoon. This method incorporated historical maps, bathymetries, and a recent report on earthquake frequency, to calculate the average sedimentation rate for the last 150 years. The normal rate was estimated by using information from Bergquist's 1978 report. In that report, the sedimentation rate prior to human impacts was estimated at 3 millimeters per year. This measurement is two-dimensional, and shows how sediment builds up on the surface of the lagoon floor. The Corps used a three-dimensional measure to estimate the actual volume of sediment accumulating. The average sedimentation rate from 1850 to 2000 was found to be .900 million cubic feet (ft^3) to 1.25 million ft^3 per year (see Section 3 of the Engineering Appendix for more details).

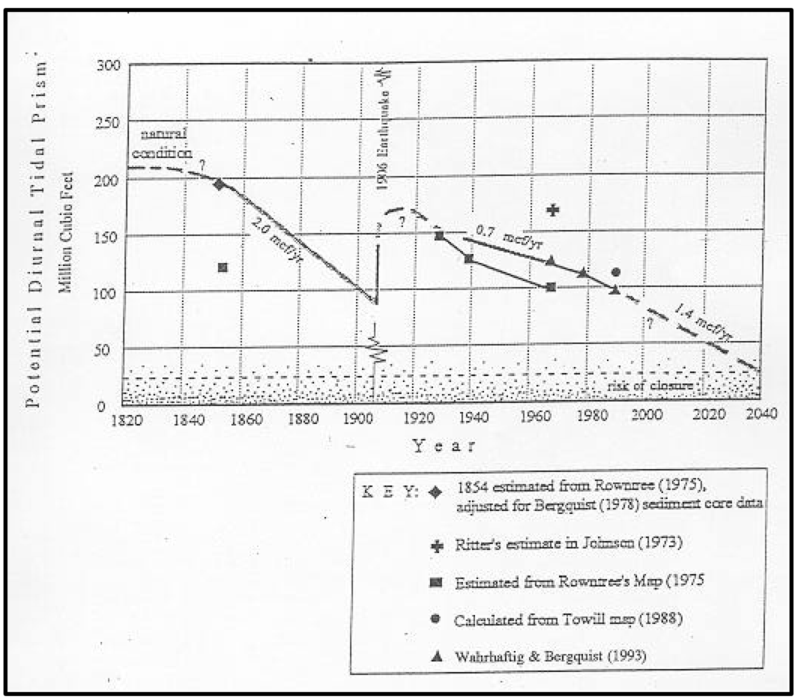


Figure 3.3 Sedimentation Rate Timeline (BLMPU 1996)

The earthquake-based estimation was compared to the estimated sedimentation rate time line shown in Figure 3.3. This was done by totaling the sediment that would have entered the lagoon for each time period, then averaging that over the 150 year time period (Table 3.1). A comparison between the two average rates shows that they are surprisingly close, which provides some level of confidence in the sedimentation rate estimates.

Table 3.1 Sediment Volume Summary

Years	**Rate** (million ft^3/year)	**Total** (million ft^3)
1850 to 1900	2 .0	100
1900 to 1970	0.7	49
1970 to 2000	1.4	42
Total Sediment Volume Entered Over 150 Year Period		191
Average Annual Sedimentation Rate Between 1850 and 2000		1.27

3.3 Existing Conditions

3.3.1 Hydraulic

<u>*1968 to 1998 Sedimentation Rate*</u>

Detailed bathymetric surveys that were taken in 1968, 1978, 1988, and 1998 were used to determine the average sedimentation rate for each of those decades. By dividing each ten-year measure of sediment volume change by ten, the data were converted into an annual sedimentation rate. Between 1968 and 1978, the average sedimentation rate was found to be 2.27 million cubic feet per year (ft^3/yr), or 84,000 cubic yards per year (yds^3/yr); between 1978 and 1988 it was 0.86 million ft^3/yr (31,850 yds^3/yr); and between 1988 and 1998 the sedimentation rate was 0.71 million ft^3/yr (26,300 yds^3/yr). An illustration of how and where sediment filled in the lagoon between 1968 and 1998 can be seen in Figures 3.4 and 3.5.

In order to determine whether human activities had an impact on the annual sedimentation rate, a "normal" infilling rate was determined by incorporating data from past studies. For example, as referenced in the *Bolinas Lagoon Management Plan Update of 1996*, Bergquist (1978) used soil borings to estimate that the lagoon, on average, had a sedimentation rate of approximately 3 millimeters (mm) per year prior to 1849, that is, before Europeans arrived in the area. This information was combined with the bathymetric data in a way that made it possible to estimate an average "normal" infilling rate (the methodology used for this calculation is discussed further in the Engineering Appendix). The normal volumetric infilling rate was found to be 0.45 million ft^3/yr (16,700 yds^3/yr). Comparing this normal infilling rate to the data above, it

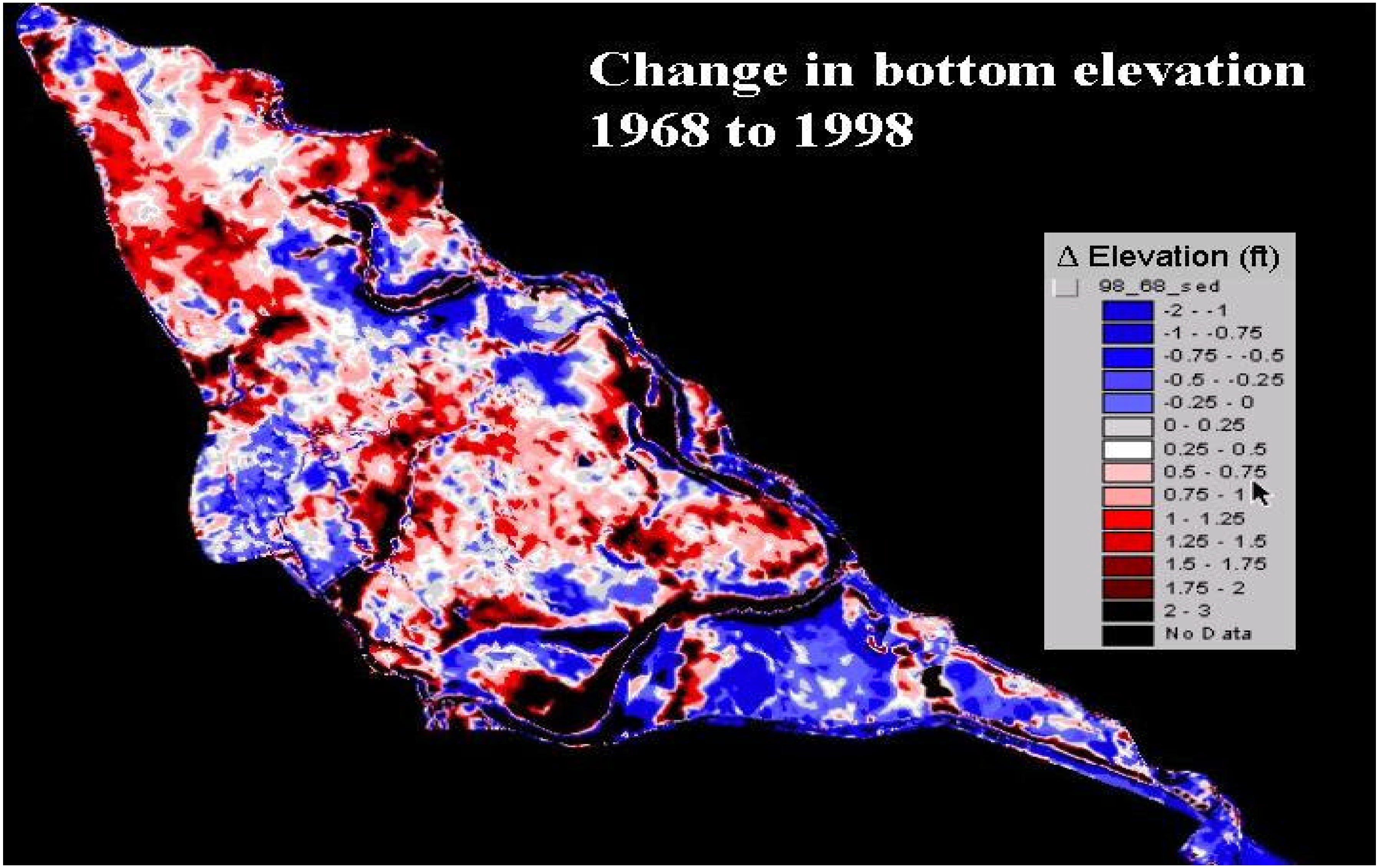


Figure 3.4 Change in Depth from 1968 to 1998 (feet)

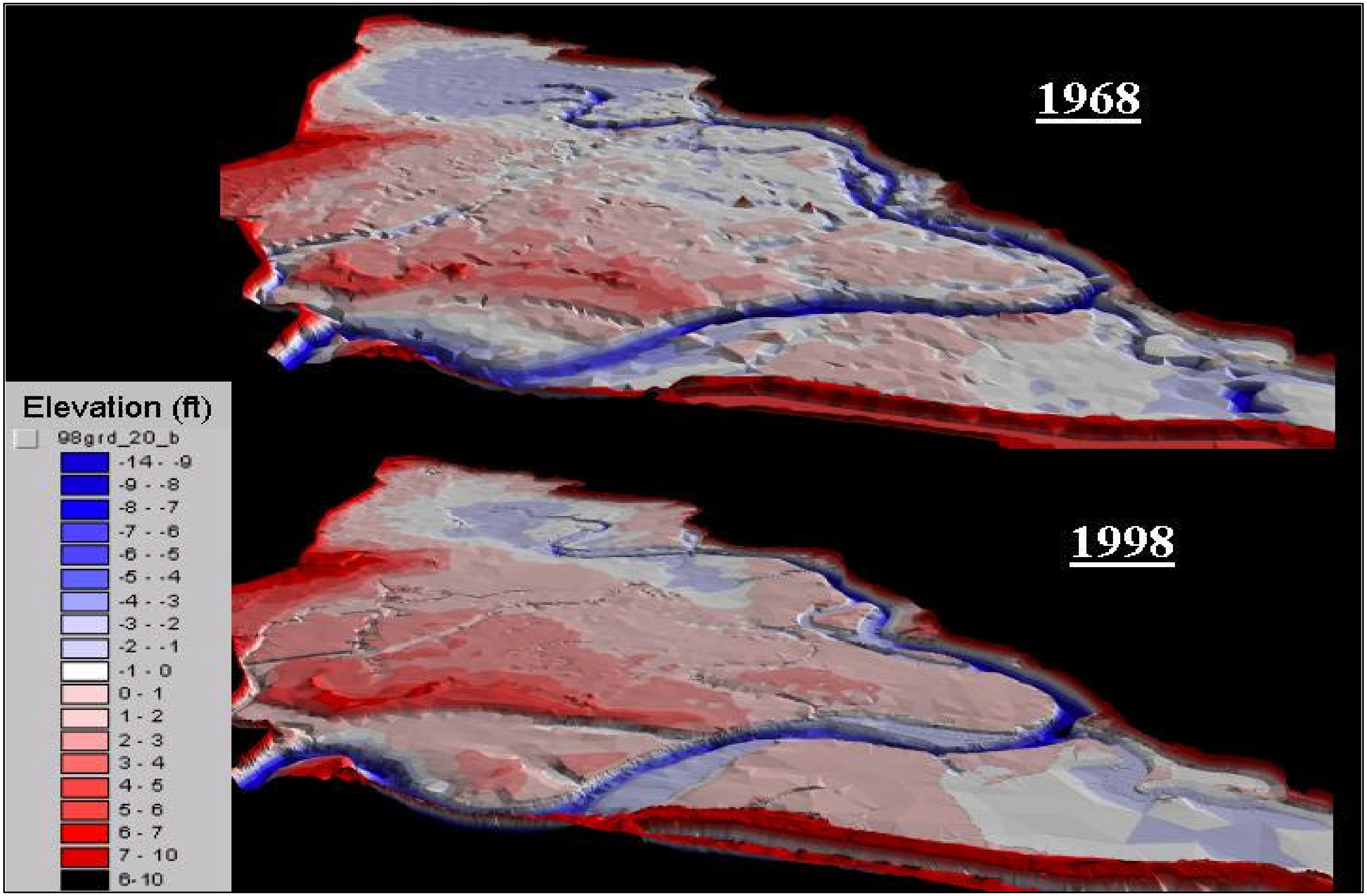


Figure 3.5 Bolinas Lagoon Bathymetries - 3D Digital Terrain Models

is obvious the sedimentation rate between 1968 and 1978 was significantly higher than what is considered normal (in fact, it is about five times higher), and that the infilling rate has decreased over time to the extent that, between 1988 and 1998, it was approaching normal.

This "normal" rate (0.45mft^3/yr) has been tagged with the letter (n) to signify the normal infilling rate. Although this method is prone to error, it represents a best guess with the available data, which is substantial compared to other studies that lack historical data. The results of this analysis are illustrated in Figure 3.6. Future estimates for sediment infill were made by visually extrapolating the graph. That is, a best-fit line was drawn using the normal sedimentation rate as the asymptote (a straight line associated with a curve where the distance between the two approaches zero).

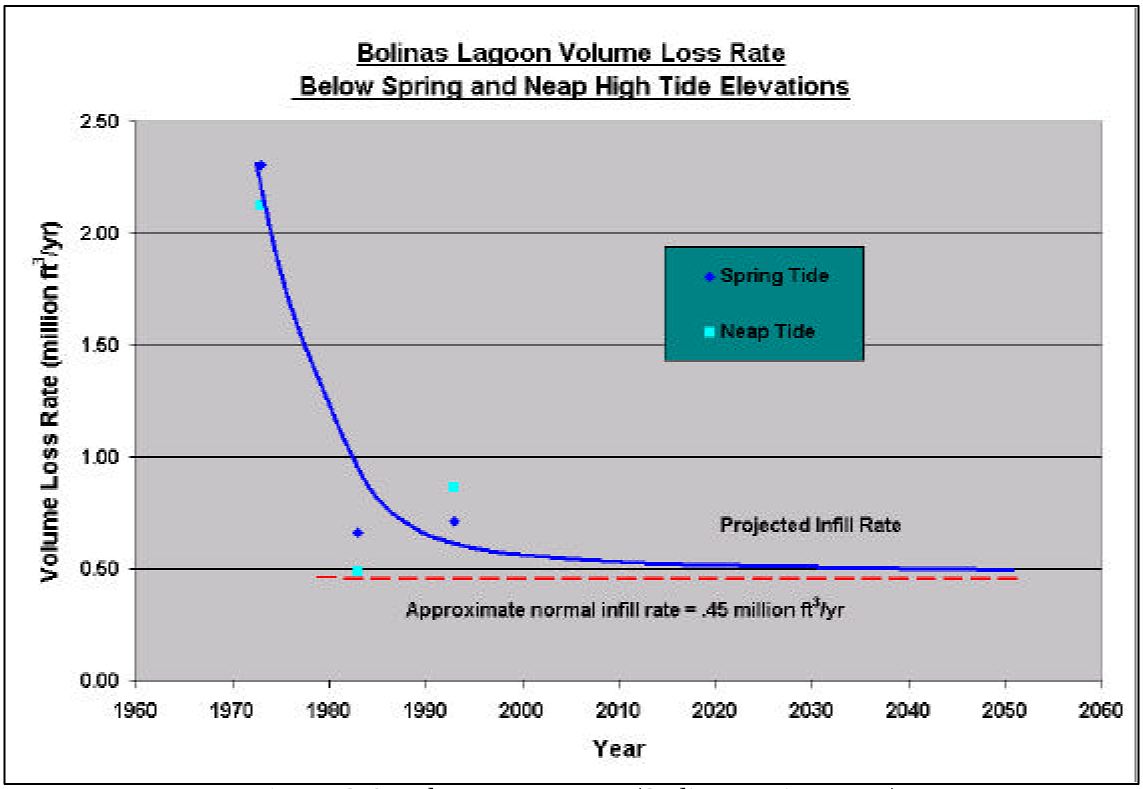


Figure 3.6 Volume Loss Rate (Sedimentation Rate)

<u>*Sedimentation Source - Corps Analysis*</u>

Based on work completed in this Feasibility Study, past sedimentation studies, lagoon history, and the physical processes of the system, it was found that the most likely cause of the abnormally high sedimentation rate was human activities in the watershed after European settlement of the area. This is in agreement with previous reports (see Section 3 of the Engineering Appendix). Some have argued that above normal sedimentation in the lagoon was caused by the development of the sand spit, the construction of the Bolinas Groin, and other "ocean side" alterations to the system. Presumably, those activities have had effects on the lagoon; however, considering the evidence, they do not appear to be significant when compared to the watershed. In addition, this theory would not explain why the sedimentation rate has significantly decreased since 1968.

Figure 3.6 shows that the sedimentation rate between 1968 and 1978 averaged 2.27 million ft^3/year, but decreased steeply to 0.71 million ft^3/yr between 1988 and 1998. If the alterations on the ocean side of the system were the most significant contributors, it seems unlikely that the sedimentation rates would have fallen, since the conditions have not improved on the ocean side. In fact, they are most likely worse than they were in the early 1970's. On the other hand, better watershed management practices have been enacted, the last logging occurred in 1969, logging roads have washed out or have started to become vegetated, development has been curtailed, mining activities have stopped, ranching and agricultural practices have either been decreased or have improved, and much of the watershed is in public ownership as parklands and for conservation purposes, all of which have led to less erosion in the watershed and the possibility of recovery. Over time, the watershed has healed itself. This information suggests that the volume of sediment coming from the watershed has decreased since the 1960's (BLWS 2001).

In addition to the sedimentation rate analysis, further evidence was provided by a sediment grab sample study that was conducted in 1998 (PWA 1999). Using thirty-five grab samples to map the lagoon's sediment, it was hoped that sediment markers, such as mineralogy, angularity, and grain size could be used for identifying the most likely source of sediments throughout the lagoon. Unfortunately, the results were not as discernable as had been hoped, but a grain size map was developed (Figure 3.7), which allowed important information to be interpolated for the northern and southeastern portions of the lagoon. The material in the northern part of the lagoon was classified as very fine sand, bordered by a large area of silt to the south. This was twofold evidence that material in the north part of the lagoon came from the watershed. First, larger particles settle out more quickly than smaller particles, indicating that the sediment originated in the watershed. Second, one would expect that, if the sediment were coming from the ocean (mostly sand and gravel, with limited silt), the silt area would be north of the sand area, since the sand would drop out first.

3.3.2 Environmental

Bolinas Lagoon has a variety of habitats that can be grouped into the following three categories: subtidal channels, intertidal flats, and emergent marsh. As discussed earlier, sediment accumulation in the lagoon has resulted in a loss of tidal prism and a decrease in the deeper estuarine habitats of the lagoon. Between 1968 and 1998, subtidal habitat decreased by 60%, intertidal flats increased by 37%, and emergent marsh increased by 100% (BLMPU 1996). Overall, all of these habitats have begun to decrease as estuarine habitats convert to upland habitat; between 1968 and 1998, total estuarine habitat decreased by 7% (BLMPU 1996). This trend will continue if no remedial measures are taken.

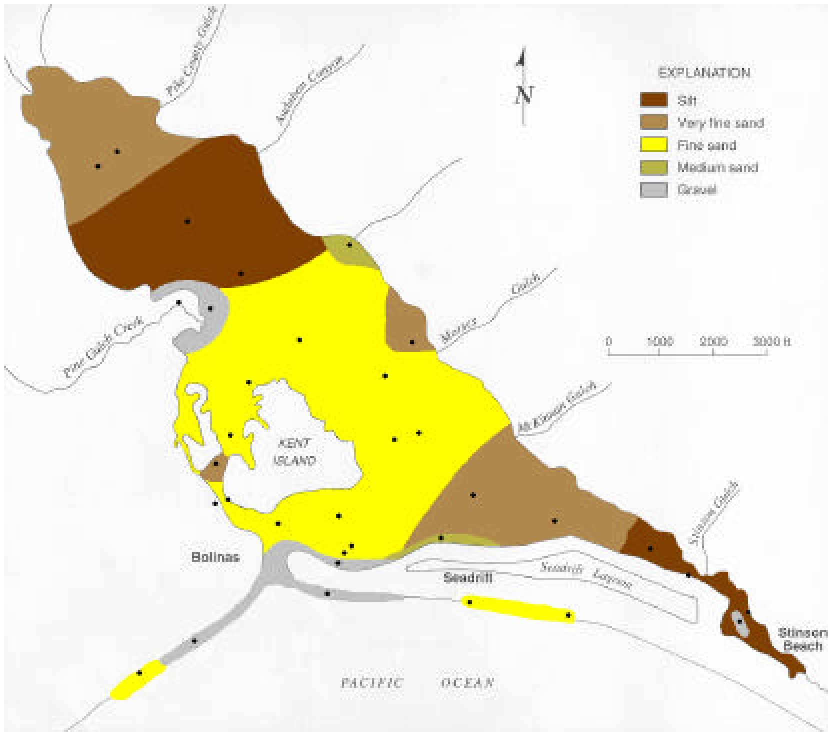


Figure 3.7 Grain Size Distribution within Bolinas Lagoon

In general, the primary production and predation functions in the lagoon occur in the intertidal mudflats and shallow subtidal areas (BLMPU 1996). Filter and deposit feeders found in the mudflats, such as clams, segmented worms, and snails, consume the primary producers like benthic algae and diatoms, and take advantage of the detritus inputs from marsh and terrestrial sources. Soft-bodied invertebrates, small crustaceans and gastropods are prey for probing and surface feeding birds like sanderlings, greater yellowlegs, godwits, curlews, plovers, stilts, and American avocets. The dominant fish in the lagoon eat primarily in these subtidal shallows and intertidal flats as well. Food webs associated with these habitat areas appear to be some of the most significant in the lagoon (BLMPU 1996).

Subtidal Channels –

The subtidal or open water area of Bolinas Lagoon is a rich habitat of primary producers, including phytoplankton, benthic diatoms, eelgrass and algae; grazers of phytoplankton, including such zooplankton organisms as copepods, cladocerans, ostracods, arrow worms and planktonic stages of benthic invertebrates such as bryozoans, echinoderms, polychaetes, bivalves and gastropods; primary consumers of phytoplankton and zooplankton like fish, filter feeders such as clams and worms and birds; benthic invertebrates that burrow into the mud and sand surface; algae; ghost shrimp common in the sandy substrata; deposit feeders like polychaetes and mollusks; and fish, which are the main secondary consumers (BLMPU 1996). This habitat area is strongly influenced by the tidal cycle, as incoming tides bring in suspended and actively swimming organisms that feed, and are fed on, in the lagoon (BLMPU 1996). Important secondary consumers that require relatively deep water habitat, which is often found in the subtidal channels, are in the diving duck guild. Diving ducks once found in Bolinas Lagoon include cormorants, scaups, scoters, goldeneyes, mergansers, ruddy ducks, and ospreys. Because the depth and volume of subtidal habitat has been decreasing over time, so has the available habitat for diving ducks. Quantitative anlyses showing changes to this group of species is detailed later in this section, and in Chapters 4 and 5.

Intertidal Flats –

Intertidal flat habitat is most commonly defined as the area between mean lower low water (MLLW) and mean high water (MHW) (BLMPU 1996). In general, this area is not colonized by vascular plants; algae generate the primary production. The macroalgae species *Enteromorpha* and *Ulva* are the most common in Bolinas Lagoon. Macroalgae and benthic diatoms are important primary producers in coastal lagoons in general, as they are consumed by a large number of animals. Benthic meiofauna are significant primary consumers in this habitat area. Crabs, particularly the mud crab, serve as important grazers on the mudflat. In higher elevation areas the California hornsnail is more dominant. Gobies, sculpin, sharks and rays can be found foraging in subtidal and flooded tidal flat areas. Some of the smaller fish species are consumed by shorebirds like egrets, herons and kingfishers. Some fish species, like topsmelt and jacksmelt, enter and exit the lagoon with the tides, or may be consumed by osprey while visiting the lagoon (BLMPU 1996).

The most distinctive feature of the intertidal mudflat is the presence of shorebirds (BLMPU 1996). These species include dunlin, least tern, western sandpiper, marbled godwit, willet and American avocet. Special adaptations that enable birds to feed in this area include a variety of bill lengths (short, long, curved, etc.), and different feeding methods, such as surface feeding and probing, as well as feeding in different types of substrates and habitat areas, including sandy and muddy substrates and exposed or inundated flats, intertidal marsh areas or upland habitat areas. Prey items include snails, clams, amphipods, marine worms, molluscs, grasshoppers, small burrowing crustaceans, polychaete worms, and the like (BLMPU 1996).

Emergent Salt Marsh –

In Bolinas Lagoon, emergent salt marsh can be found on Pine Gulch Creek Delta, Kent Island, and along the fringes of the lagoon perimeter. Salt marsh is defined as the area between MHW and extreme high water (EHW) (BLMPU 1996). In tidal marshes, benthic algae are important primary producers, pacific cordgrass (*Spartina foliosa*) and pickleweed (*Salicornia virginica*) are common plants, and bird's beak (*Cordylanthus maritimus*) can potentially occur in this zone. In areas sparsely populated by vascular plants, algal biomass, in the form of algal mats, is usually high. Other plants in this habitat area include jaumea (*Jaumea carnosa*), arrow grass (*Triglochin concinnum*) and sea lavender (*Limonium californicum).* Salt marsh dodder is a parasite that occurs in many salt marsh areas, and is found in association with pickleweed and other species at various elevations. Alkali heath (*Frankenia grandifolia*) is commonly found in the midrange elevations, while in higher elevation areas, salt grass (*Distichlis spicata*) and saltbush (*Atriplex watsonii*), along with rush (*Juncus spp.*) are common (BLMPU 1996).

Consumers in this area are dominated by benthic invertebrate omnivores that live under the surface and consume the microbial decomposers on the surfaces of the detritus. Salt marsh plants do not actually provide much nutrition to consumers in this area compared to the mudflat and subtidal areas, but the macroinvertebrates do work to break them down. The horn snail is an important grazer of algae found on salt marsh plants.

Epibenthic invertebrates (those that live on top of the surface) are secondary consumers, and become prey for a number of fish (BLMPU 1996). Many fish arrive on incoming tides to feed, and leave with the outgoing tides. Benthic fish such as staghorn sculpin and longjaw mudsucker, however, remain in the tidal channels and burrow into depressions when the tide goes out (BLMPU 1996).

Other important species that rely on emergent marsh habitat areas include herons and egrets, and a variety of land birds, rails and raptors, including the black rail and other special status species (BLMPU 1996). These birds feed on amphibians, crustaceans, fish, young birds, small mammals and invertebrates. Mammals found in this area include the California vole (*Microtus californicus*), which feeds on grasses, sedges and other green vegetation (BLMPU 1996).

Habitat Quantification

For this Feasibility Study, three habitat types were quantified using bathymetric data. For each habitat type except upland, surface area and volume were used to measure habitat quantities. Only surface area was used for upland habitat since volume of upland represents nothing pertinent to the study. It is the air space above the lagoon and therefore is not an accurate measure of actual habitat.

Habitats were defined as follows:

Upland – The area that remains above the water line at high tide during a typical spring tide [ocean high tide of 3.15 feet National Geodetic Vertical Datum (NGVD)/5.99 feet Mean Lower Low Water (MLLW)]. Upland habitat is the area that is always dry.

Intertidal – The area that experiences wetting and drying during a one-month period, with typical spring and neap tides. This habitat area includes tidal mudflats and emergent salt marsh habitats.

Subtidal – The area that remains submerged during a typical spring or neap tide (ocean low tide elevation of -3.45 feet NGVD/-0.61 feet MLLW or -2.05 feet NGVD/0.79 feet MLLW, respectively). The tide that produced the lower elevation within the lagoon was used for this study. Subtidal habitat is always covered with water.

Although these definitions are simplified in terms of habitat variation (e.g., it is recognized that different depths of subtidal habitat have different qualities, and that there are several intertidal zones, like low salt marsh and high salt marsh, just to name a few), they serve the purpose of this Feasibility Report in that they indicate, in a general way, the habitat areas that will be affected by the project. During the Pre-construction, Engineering and Design (PED) phase, habitat zones will be further delineated and defined. More detailed information on these habitats will be useful for the development and execution of the monitoring and adaptive management program.

This Feasibility Study identifies lagoon volume as being an important factor not only to lagoon hydraulics, but also to lagoon habitat composition. To explain, there is a direct correlation between lagoon volume and water level. As the lagoon volume increases, the efficiency of the lagoon's hydraulics improves, resulting in a larger tidal range. An increase in lagoon volume results in a greater increase in intertidal habitat because of the parallel increase in tidal range. Conversely, the overall gain in subtidal habit is reduced slightly because an increase in tidal range takes back some of the subtidal habitat (in favor of intertidal habitat). A gain in intertidal habitat results in a loss of upland habitat because an increase in tidal range makes the water elevation higher, and thus, more upland habitat is converted to intertidal habitat. In essence, some intertidal habitat will be converted to lower intertidal and subtidal habitat, and some upland and subtidal habitat will be converted to intertidal habitat, for an overall greater proportional increase in intertidal habitat. For this reason, intertidal volume has been selected as the major indicator of project-caused changes to lagoon hydraulics and habitat composition. This will be discussed further in the Plan Evaluation chapter, Chapter 5.

Lagoon Habitats 1968 and 1998

As discussed in Section 3.7 of the Engineering Appendix, water level data and detailed bathymetric surveys for the lagoon were used to determine habitat quantities. To do this, ArcView software was used to find the corresponding surface area and volumes at, below, and between the defining water surface elevations. This provided both the surface area of habitat in acres and volume of habitat in cubic yards. Based on this data, it was clear that intertidal habitat had decreased significantly over that period of time and subtidal had decreased but to a lesser degree. The values for 1968 and 1998 can be seen in Table 3.2.

Lagoon Habitats 1978 and 1988

Because water level data was not recorded in 1978 and 1988, water levels had to be interpolated, as discussed in Section 3.7 of the Engineering Appendix. Detailed bathymetric maps were available for 1978 and 1988, so ArcView software was used to determine habitat quantities for these years. The values for 1978 and 1988 are also shown in Table 3.2.

Table 3.2 Historical Habitat Levels*

Historical							
Year	Lagoon Volume (3.15' NGVD) yds^3	Upland acres	Upland yds^3	Intertidal acres	Intertidal yds^3	Subtidal acres	Subtidal yds^3
1968	6,489,855	155.82	7,634,688	876.12	5,580,284	213.38	641,298
1978	5,635,908	197.29	7,943,862	867.50	4,363,639	157.06	533,966
1988	5,390,737	243.43	7,894,691	844.65	3,868,717	127.25	690,093
1998	5,126,588	238.10	8,243,436	848.53	3,584,714	146.39	523,318

*Measured from bathymetries and water level data

Habitat Quantification - Diving Duck Habitat

In order to provide a more tangible connection between lagoon bathymetric change and effects on habitats (and species dependent on those habitats), habitat surface areas and volumes of the habitat type specifically used by diving ducks were calculated. The Lesser Scaup was used in this illustration to represent the diving duck guild. This species prefers water depths between -2.70 feet NGVD and -8.70 feet NGVD. Using these defining elevations, habitat surface area between these depths was calculated for years 1968 and 1998, and was interpolated for years 1978 and 1988. As seen in Figure 3.8, the lagoon lost 44 acres, or 46%, of its diving duck habitat between 1968 and 1998. The small rise in the 1988 value is caused by an anomaly or bathymetric shift in the lower elevations of the lagoon (discussed in Section 4.4 of the Engineering Appendix). As discussed previously, deeper estuarine habitats have been lost to upper intertidal and upland habitats at a significant rate.

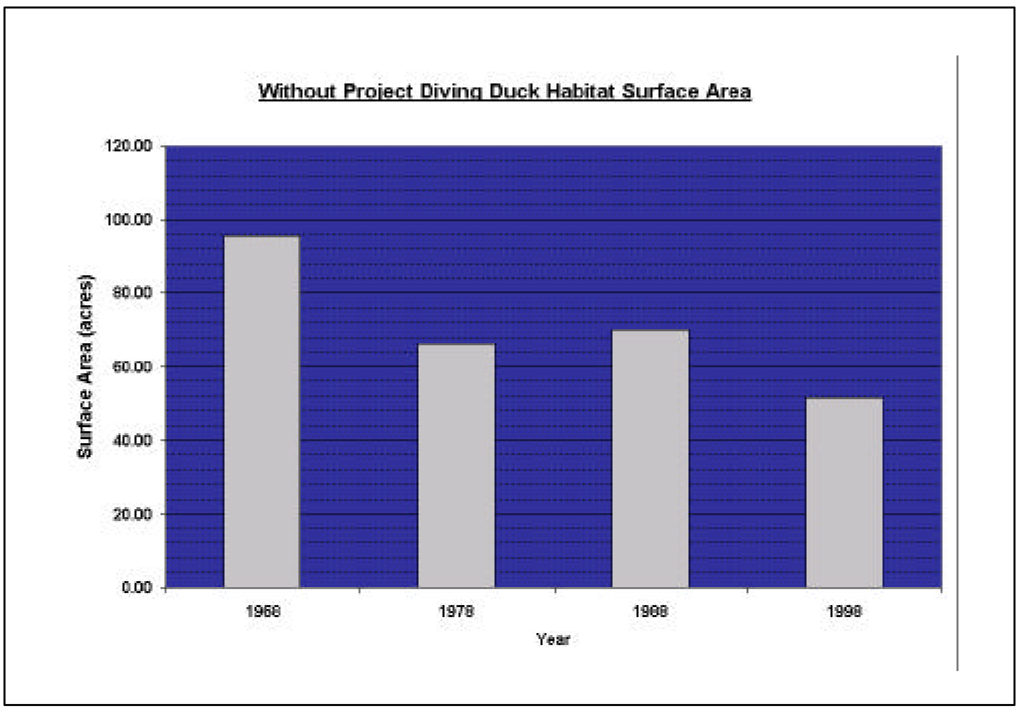


Figure 3.8 Historic diving duck habitat surface area

3.4 Future Without Project Conditions

3.4.1 Hydraulic

Lagoon Habitats 2008 and Beyond

With fairly reliable habitat values and lagoon volumes calculated for 1968 and 1998, a ratio of lagoon habitat change to volume change was calculated. For the lagoon's future volumes (listed in Section 3.6 of the Engineering Appendix), the habitats were determined by multiplying the expected change in volume by the change in habitat to change in volume ratio (Appendix 15 of the Engineering Appendix). This was a linear extrapolation. The idea of formulating a polynomial relationship – or using an average ratio of habitat change versus lagoon volume change – based on all the years of data (1968, 1978, 1988, and 1998) was considered, but ruled out since 1978 and 1988 did not have water level data. The interpolated water level data was used to calculate habitats for those years, so the habitat levels calculated for those years were already dependent on data interpolated from lagoon volume. The projected without project lagoon habitats for the next 50 years are shown in Table 3.3 and Figures 3.9 and 3.10.

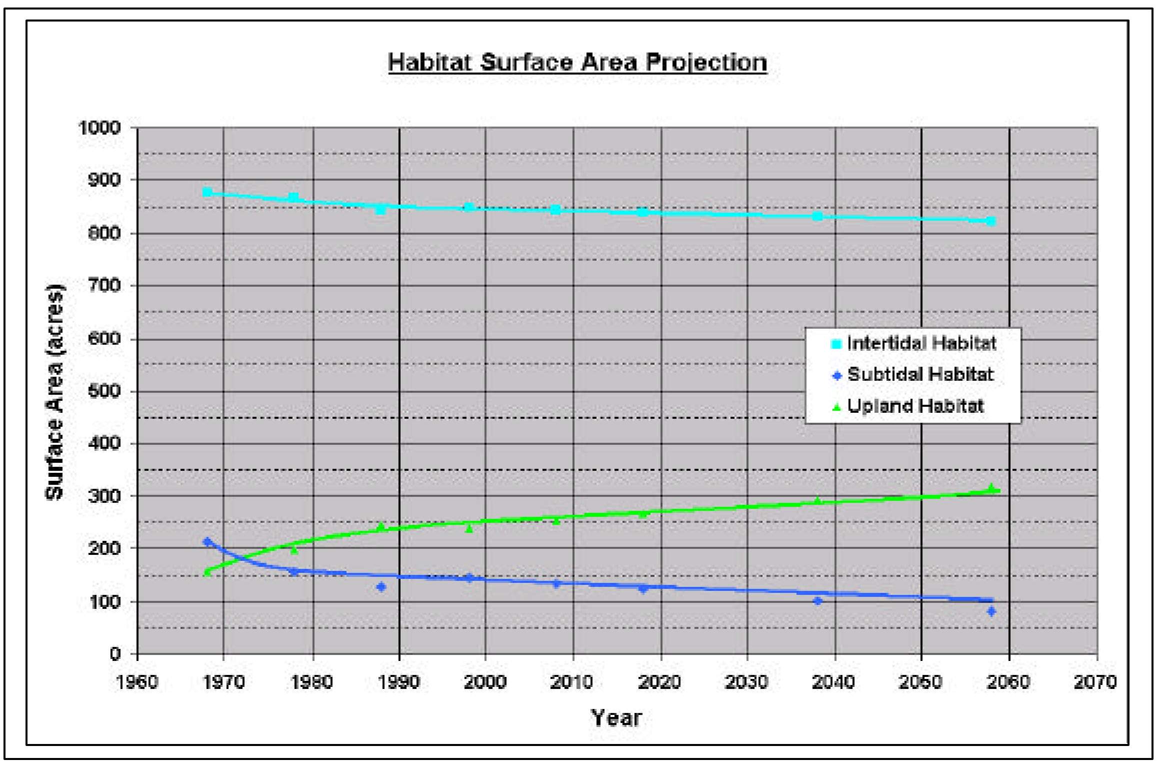


Figure 3.9 Habitat Surface Area Projections for Bolinas Lagoon

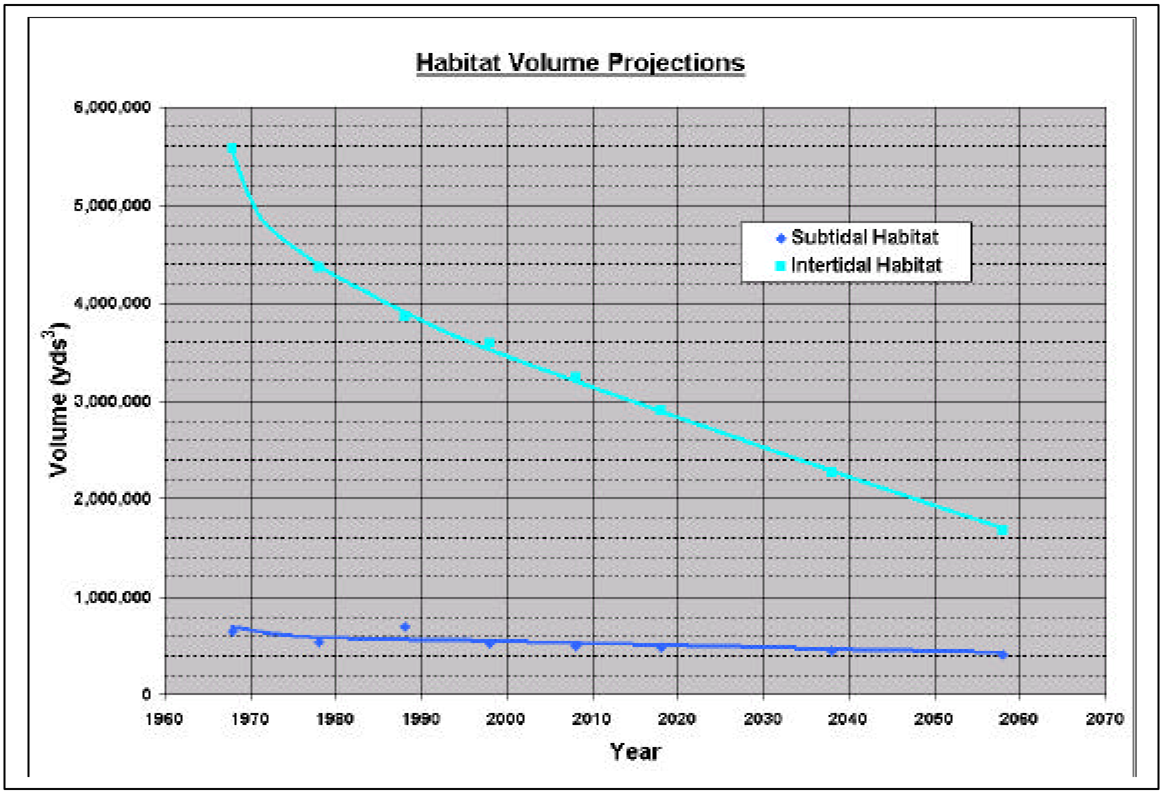


Figure 3.10 Habitat Volume Projections for Bolinas Lagoon

Table 3.3 Without Project Habitat Projections

Without Project								
	Lagoon Volume	Upland	Upland	Intertidal	Intertidal	Subtidal	Subtidal
Year	yds^3	acres	yds^3	acres	yds^3	acres	yds^3
2008	4,883,508	252.77	8,351,980	843.61	3,228,889	134.45	502,281
2018	4,652,007	266.74	8,455,354	838.92	2,890,014	123.07	482,246
2038	4,223,741	292.59	8,646,590	830.25	2,263,112	102.03	445,183
2058	3,841,791	315.64	8,817,144	822.52	1,704,008	83.26	412,128

It was predicted that by the year 2058, as much as 4.35 million cubic feet (158,000 cubic yards) of subtidal volume would be lost compared to 1998, representing a 29.3% loss. The same situation is true for intertidal habitat. It has been projected that 54.33 million cubic feet (2.01 million cubic yards) of tidal habitat volume will be lost by 2058 as compared to 1998, representing a 55.7% loss.

A gradual accretion of sediment in the lagoon will lead to a gradual change of the subtidal habitat to emergent intertidal saltmarsh, which will then change to a mature saltmarsh, giving way, in turn, to seasonal wetlands habitat, which will ultimately convert to upland habitat. Bolinas Lagoon will become, in effect, a meadow. While this is the natural progression of coastal lagoons, Bolinas Lagoon has remained as a lagoon for

7,000 years. The change in Bolinas Lagoon in the recent past is the result of human activities, which have accelerated the process unnaturally**.**

3.4.2 Environmental

Habitat Changes

Accumulation of sediments in the lagoon over time, and the gradual loss of tidal prism, would result in the narrowing of tidal channels; conversion of subtidal habitat, first to intertidal mudflats, then to emergent tidal marsh; an increase in the size of Pine Gulch Creek Delta and Kent Island as vegetation increases in range and area; intermittent closures of the lagoon mouth and, eventually, permanent closure of the lagoon to tidal waters; and decreasing tidal influence on the habitats within the lagoon (BLMPU 1996). Continued sediment accretion in the lagoon would result in an overall loss of estuarine habitats, and a conversion of these habitats to upland habitat. It is estimated that between 1998 and 2008, subtidal habitat area will decrease by 40%; intertidal flat area will decrease by 30%; emergent salt marsh will increase by more than 50%, and upland habitat will increase by 11%. If these trends continue, and are not mitigated by restoration measures, there will be significant changes in the diversity and abundance of species in the lagoon and in ecological functions the lagoon provides (BLMPU 1996).

Fish and Wildlife Changes

Macroinvertebrates –

Although little quantitative information is available on the macroinvertebrates living in Bolinas Lagoon, anecdotal evidences suggests that a decrease in estuarine habitats would result in a "diminution" of habitat available for benthic species, including large filter feeders, and a concomitant decrease in their population numbers (BLMPU 1996; O'Conner, personal communication, 2001). Studies in other similar estuarine environments have found that a higher diversity of invertebrate species can be found at the lower intertidal elevations (BLMPU 1996). This information suggests that a decrease in lower intertidal habitat would result in a decrease in species diversity as these areas are converted to emergent marsh habitat. In fact, a strong correlation between regular tidal flushing and the diversity and abundance of aquatic food chain members has been demonstrated (BLMPU 1996). Well-flushed systems show a higher species diversity and a higher abundance of marine populations while intermittent lagoons have depauperate (low diversity) flora and fauna. Inlet closure would obviously have a negative impact on marine species in Bolinas Lagoon.

Fish –

Population trends cannot be quantified by the data available, but anecdotal evidence suggests that a number of fish populations have declined in recent years (BLMPU 1996). In fact, local fishermen who work in the area no longer see some species that were once abundant in the lagoon. These species include flatfish such as

Diamond Turbot, English Sole, Sand Sole, Starry Flounder and California Halibut; many species of Sculpins, including Staghorn Sculpin and Plainfin Midshipman; Coho Salmon and Steelhead Trout; Leopard Shark; and Surfperches, such as Shiner, Dwarf, Black, Pile, Walleye, Rubberlip, Barred and White Surfperch species (Churchman p.c. 2001). Closure of the inlet would prevent pelagic fish from entering and living in the lagoon, and anadramous fish would only be able to enter the estuary if freshwater flows, high tides and storm surges opened up the lagoon and reinstated the connection between Bolinas Lagoon and Bolinas Bay (BLMPU 1996).

Birds –

More than 85 species of water birds can be found at Bolinas Lagoon, an estuary used primarily as a wintering destination by water birds, secondarily as a migrant stop, and relatively little by year-round or summer residents and local breeders. Since 1965, the Point Reyes Bird Observatory (PRBO) has conducted bird surveys in Bolinas Lagoon and other estuaries in the Point Reyes area. From 1968 – 1988, changes in water bird abundance mirrored known habitat changes. For example, the 60+% decrease in subtidal habitat during that time period resulted in fewer observed diving birds in the lagoon. Seven species, including the eared and horned grebes, canvasback, surf and white-winged scoters, American coot, and ruddy duck decreased in abundance, while only one species (the common goldeneye) showed a weak upward trend. Numbers of five species did not increase or decrease during this period. These species include the western grebe, double-crested cormorant, greater scaup, bufflehead, and red-breasted merganser.

U.S. Fish and Wildlife Service (USFWS) waterfowl census data, which looks at trends in the state of California, suggests that the abundance patterns of four species in Bolinas Lagoon were counter to strong upward trends for California as a whole: the scoters, Greater Scaup, and Bufflehead have decreased significantly. In addition, Ruddy Ducks showed no downward trend in the statewide data. Rather than echoing larger regional trends, the observed changes in waterfowl abundance in Bolinas Lagoon can reasonably be attributed to habitat changes in the Lagoon. A similar trend is evident with intertidal species as well. The 37% increase in intertidal habitat from 1968 to 1988 has been accompanied by increased abundance of 10 species that rely on intertidal habitat, including the Northern shoveler, gadwall, semi-palmated plover, willet, whimbrel, long-billed curlew, marbled godwit, western sandpiper, greater yellowlegs, and American avocet.

These bird surveys simply indicate trends that would be expected, based on habitat changes observed in the lagoon over the same time period, which are: "1) most intertidal-dependent shorebirds and waterfowl trended upward along with the increase in intertidal habitat, 2) subtidal-dependent waterfowl generally showed decreasing trends mirroring the decrease in subtidal habitat, 3) only one of the subtidal-dependent waterfowl species showed a trend opposite to that predicted by habitat change, and 4) many of the species' abundance trends at Bolinas Lagoon [were] counter to regional or statewide trends, and 5) species dependent on emergent marsh wetland vegetation increased with increases in [this] habitat" (BLMPU 1996). Such predictions indicate that

Bolinas Lagoon would suffer an overall loss in avian abundance and diversity, and would therefore lose its value as an overwintering location and migratory stopover point for shorebirds and waterfowl on the Pacific Flyway. A much smaller number of species dependent on emergent salt marsh and upland habitats would benefit from the changes, and these benefits would continue to decrease over time as the salt marsh habitat converted into upland habitat, and the connection to Bolinas Bay was lost forever.

Bolinas Lagoon is an important estuary that can be characterized by the following attributes: 1) a high species diversity of aquatic birds; 2) an egret and heron rookery; 3) a wintering site for waterfowl, shorebirds, and raptors; 4) a black-crowned night heron roost; 5) traditional roost for fish-eating flocks of pelicans, cormorants, and terns; 6) a riparian migrant stopover (Pine Gulch Creek Delta); 7) valuable habitat for twenty species of special concern which are afforded special status on either state or federal lists of threatened, endangered or candidate species for the California Department of Fish and Game (CDFG) "Species of Special Concern" (USFWS 1991, CDFG 1992); 8) breeding habitat for several threatened species (snowy plover and black rail); and 9) foraging habitat for several raptors of special concern (osprey, peregrine falcon, and merlin).

Harbor Seals –

Approximately 200 harbor seals haul out regularly in the lagoon, giving birth to about 50 pups during the pupping season. The population of harbor seals in the Gulf of the Farallones is estimated to comprise 20% of the California population. Harbor seals have been closely monitored in the San Francisco Bay area and at Bolinas Lagoon since 1970. Both the total population and the number of pups at Bolinas Lagoon have increased in recent years. Bolinas Lagoon and adjacent waters are important to the Gulf's harbor seal population.

Harbor seals are opportunistic feeders and forage on shallow water estuarine and marine species of fish, cephalopods and crustaceans. Many of their preferred prey species (e.g., jacksmelt, topsmelt, starry flounder, and shiner perch) can be found in Bolinas Lagoon. If the lagoon shoals in, these feeding opportunities would be lost.

Although harbor seals do some foraging in the lagoon, the more important function that Bolinas Lagoon serves is as a place of refuge. Bolinas Lagoon is more isolated and sheltered than other sites along the north coast, or even in the San Francisco Bay. Bolinas Lagoon differs from these sites in that peak numbers occur during the molt (May-July), after the pupping season. Haul-out sites secure from disturbance are critical for harbor seal populations. Haul-out sites provide seals with resting, breeding, and nursery areas. These sites are used daily throughout the year, and successively, from year to year. The haul-out sites used in Bolinas Lagoon are areas with exposed sand bars, including parts of Kent Island and areas along the Main Channel. Continued sediment accretion in the lagoon would prevent harbor seals from using Bolinas Lagoon as a pupping area, and area of respite.

Species Diversity

Bolinas Lagoon hosts an array of biologically diverse species, including benthic invertebrates; marine algae; threatened, endangered and special status species such as Coho salmon, steelhead trout, black rail; migrating birds on the Pacific Flyway; and other resident and migratory fish, birds, and seals. Endangered brown pelicans are present from April to January during the anchovy migration period. Threatened snowy plovers are seen on the sand spit at the mouth of the lagoon. Merlin (a species of special concern), and large numbers of egrets, great blue heron, dabbling and diving ducks, and shorebirds are present, particularly during the fall and winter migration periods. Ghost shrimp, gaper clam, littleneck clams and Washington clams are present in the tidal and subtidal habitat. Pacific herring appear in the lagoon in winter.

Because of its proximity to large, mostly undeveloped and protected areas, Bolinas Lagoon is part of a large, complex and diverse ecosystem with significant ecological value. The lagoon contains a variety of habitats, including subtidal channels, intertidal mud flats, islands, and emergent salt marsh. Each habitat has its own combination of species, including primary productivity plants, benthic organisms, fish, birds, and seals. If the lagoon fills in, some of these habitats will be diminished, or lost completely. Rare Coho salmon and steelhead trout (both federally listed as Threatened along the Central California coast) have migrated through the lagoon to spawning areas in adjacent creeks. The overall effect of estuarine habitat loss in Bolinas Lagoon would be a significant loss in biodiversity, and the loss of a natural resource that plays an important role in the life cycles of many species. This loss would be significant and far-reaching.

4.0 PLAN FORMULATION: POSSIBLE SOLUTIONS

This chapter describes the development of alternative plans that address the planning objectives, the comparison of those plans and the tentative selection of a plan. It also describes the tentatively selected plan and its implementation requirements.

4.1 Plan Formulation Rationale

A wide variety of management measures were developed to address one or more of the planning objectives. These measures were evaluated and screened. Alternative plans were then developed, comprised of one or more of the management measures.

4.2 Formulation of Alternatives

4.2.1 Watershed

Because the watershed was the source of past unnatural sedimentation in the lagoon, a watershed study was conducted concurrently with the Feasibility Study to identify potential restoration sites (that is, sediment control sites) in the watershed. However, based on the results of the *Bolinas Lagoon Watershed Study*, completed in November 2001, no watershed-based restoration alternatives were developed for this study. Any future work in the watershed will be coordinated by a Bolinas Lagoon Watershed Council, individual property owners, or others. Following are the conclusions listed in Section 6 (Conclusions) of the watershed study (found in Appendix A of the EIS/EIR):

- Bolinas Lagoon was never a deep embayment, although it may be shallower now than it was 150 years ago.

- Current erosion rates appear to be close to background rates.

- The most likely reason for the dramatic increase in sediment deposition rates is "wide scale timber harvest for lumber that was followed by harvesting for firewood, which was furthermore concurrent with mining and ranching operations in the watershed. After these activities stopped, and the watershed was in early stages of recovery, a fire (or series of fires) burned through a large portion of the watershed causing wide-scale erosion."

- It is unlikely that any changes to management practices within the watershed would have a significant effect on sedimentation rates within the lagoon.

- Most of the sediment entering the lagoon via the watershed is derived from natural mass wasting erosion, and is an order of magnitude less than the potential volume mobilized by the tide.

• One area that could be restored to help further reduce the amount of sediment entering the lagoon would be at Pine Gulch Creek. Restoration of the lower reach, where it is currently diked, could reduce the amount of fine sediment transported into the lagoon by allowing it to deposit on the floodplain instead.

4.2.2 Bolinas Lagoon

Since the immediate concern for the lagoon was the diminishing value of habitat due to sedimentation, all of the restoration alternatives in this study consist of removing sediment and fill areas from the lagoon. The restoration components were specifically designed to remove sediment from areas of the lagoon where accretion was the highest in order to recreate some of the historical habitat values. Each component was designed in a historical context to ensure that any changes in the lagoon system would mimic past conditions. Historical data used for the development of the alternatives include:

1. Aerial photographs from 1942 to 1998
2. Bathymetric data and maps from 1968, 1978, 1988, and 1998
3. Lagoon maps, or black and white drawings, dating back to the 1800's
4. Historical reports, most of which were included in the 1996 Bolinas Lagoon Management Plan (BLMP 1996)
5. Numerical modeling input

From this information, the areas with the greatest accretion, and the features most affected by the lagoon's above-normal sedimentation rate were evident.

4.3 Restoration Measures

A management measure (or restoration measure, as they are referred to in this study) is a feature, or activity, at a particular site that addresses one or more of the planning objectives. A wide variety of measures were considered throughout the Feasibility Study. As the study progressed, ideas on how to remedy the problem in the lagoon were proposed by the local communities, local sponsor, and the BLTAC, which were already involved in the project development, and refinements were generated by the HEEP after its review of the alternatives. Some were found to be infeasible due to technical, economic, or environmental constraints, and others were carried forward for further analysis. Each measure was assessed, and a determination was made regarding whether it should be retained in the formulation of alternative plans. An evaluation of the restoration measures, after they were combined to form alternatives and alternative plans, is presented in subsequent chapters.

There are nine areas being considered for sediment removal. The Pine Gulch Creek Delta component has two variations that are addressed separately, making a total of ten individual components, covering all areas of the lagoon. A summary of the footprint surface areas (acres) and dredge volumes (cubic yards) can be seen in Figure 4.1, page 4-4. A map of the component locations can be seen in Figure 4.2, page 4-5, and it should be referenced for the location of each component as it is discussed. The ten components will be discussed in an order roughly from north to south.

4.3.1 No Action

The Corps is required to consider the option of "No Action" as one of the alternatives in order to comply with the requirements of the National Environmental Policy Act (NEPA). With the No Action plan, which is synonymous with "Without Project Condition," it is assumed that no project would be implemented by the Federal Government or by local interests to achieve the planning objectives. The No Action Plan forms the basis against which all other alternative plans are measured. Since this plan is required by NEPA to be included among the candidate plans in the final array of alternatives, it is described in more detail in Section 4.6.1 of this chapter.

4.3.2 North Basin

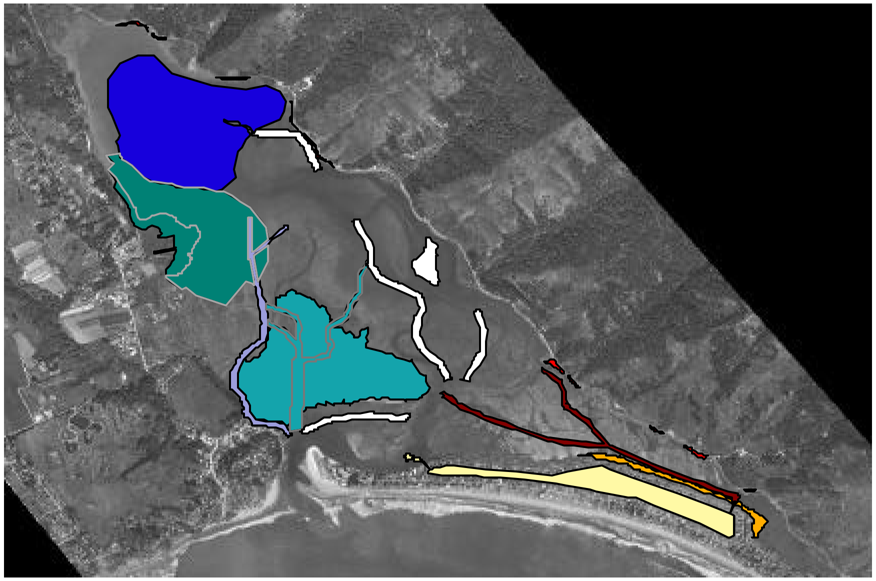
The North Basin component was designed to restore the basin area historically present in the northern end of the lagoon. Because of its large surface area and volume, the tidal prism, and the distance that tidal prism travels, is greatly increased with this restoration component. Coupling the North Basin and Main Channel components increases the effectiveness of the basin by connecting it to the inlet and allowing for a greater volume of water to reach the northern end of the lagoon. In turn, dredging the North Basin would help maintain the Main Channel. The configuration of the North Basin component is shown in the color blue in Figure 4.2 (page 4-5).

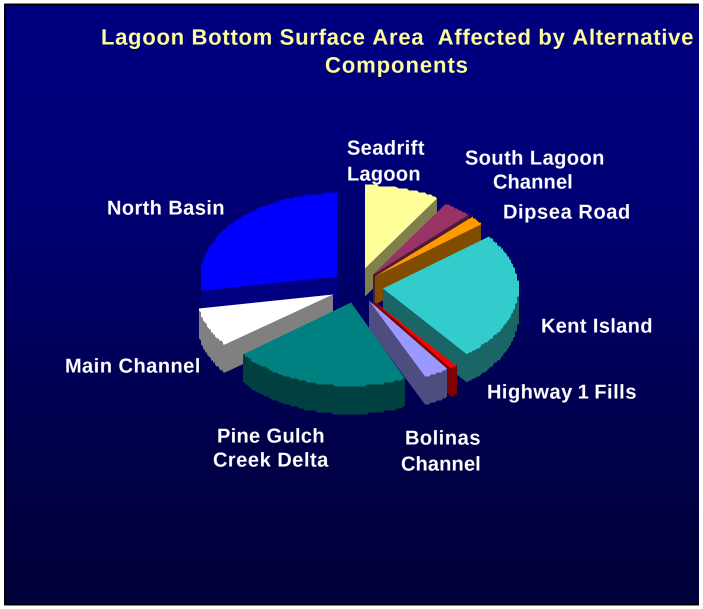
As seen in Figures 3.7 and 3.8 (from Chapter 3), the north end of the lagoon has experienced some of the most severe accretion. Since the north end was once relatively deep, and the velocity of water currents in this area have been relatively low, it has acted as a sediment basin, accumulating much of the sediment entering from the eastern shore streams and Pine Gulch Creek.

Dredging the North Basin would decrease upland habitat surface area by 0.18 acres (Table 4.1, page 4-19). As discussed in Section 3.3.2, upland habitat volume will not be used as a habitat measure in this Feasibility Study as it does not provide useful information on upland habitat changes. Intertidal habitat volume would increase by 167,000 cubic yards (cy), but would decrease the intertidal habitat acres by 107 acres (Table 4.2, page 4-19). This discrepancy can be attributed to the natural dynamics of the lagoon: as tidal prism increases, the volume of intertidal habitat increases because of a larger tidal range (i.e., lower low tides and higher high tides). Because the lagoon is a habitat with three dimensions, habitat acres, which measure surface area, might decrease, even though the total volume of habitat increases. Essentially, an increase in intertidal volume signifies an overall increase in intertidal habitat. Subtidal habitat would increase by 292,000 cy in volume and 107 acres (Table 4.3, page 4-19).

Component Footprint Areas and Dredge Volumes

Component	Surface Area acres	Volume yds^3
Bolinas Channel	15.57	130,799
Pine Gulch Creek Delta (Estuarine)	102.82	190,706
Pine Gulch Creek Delta (Riparian)	86.32	158,617
Dipsea Road	7.97	37,692
Highway 1 Fills	3.25	4,828
Kent Island	124.06	376,748
Seadrift Lagoon	43.47	44,958
South Lagoon Channel	17.58	89,246
Main Channel	37.49	216,241
North Basin	136.11	458,538





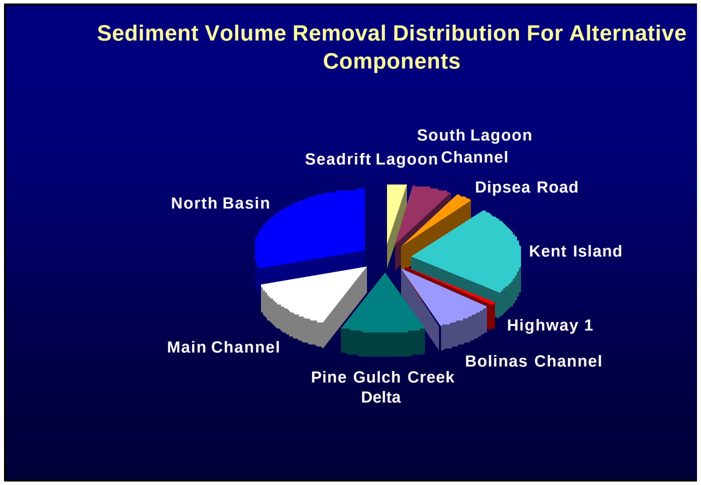


Figure 4.1 Volume, Surface Area and Location of Restoration Components

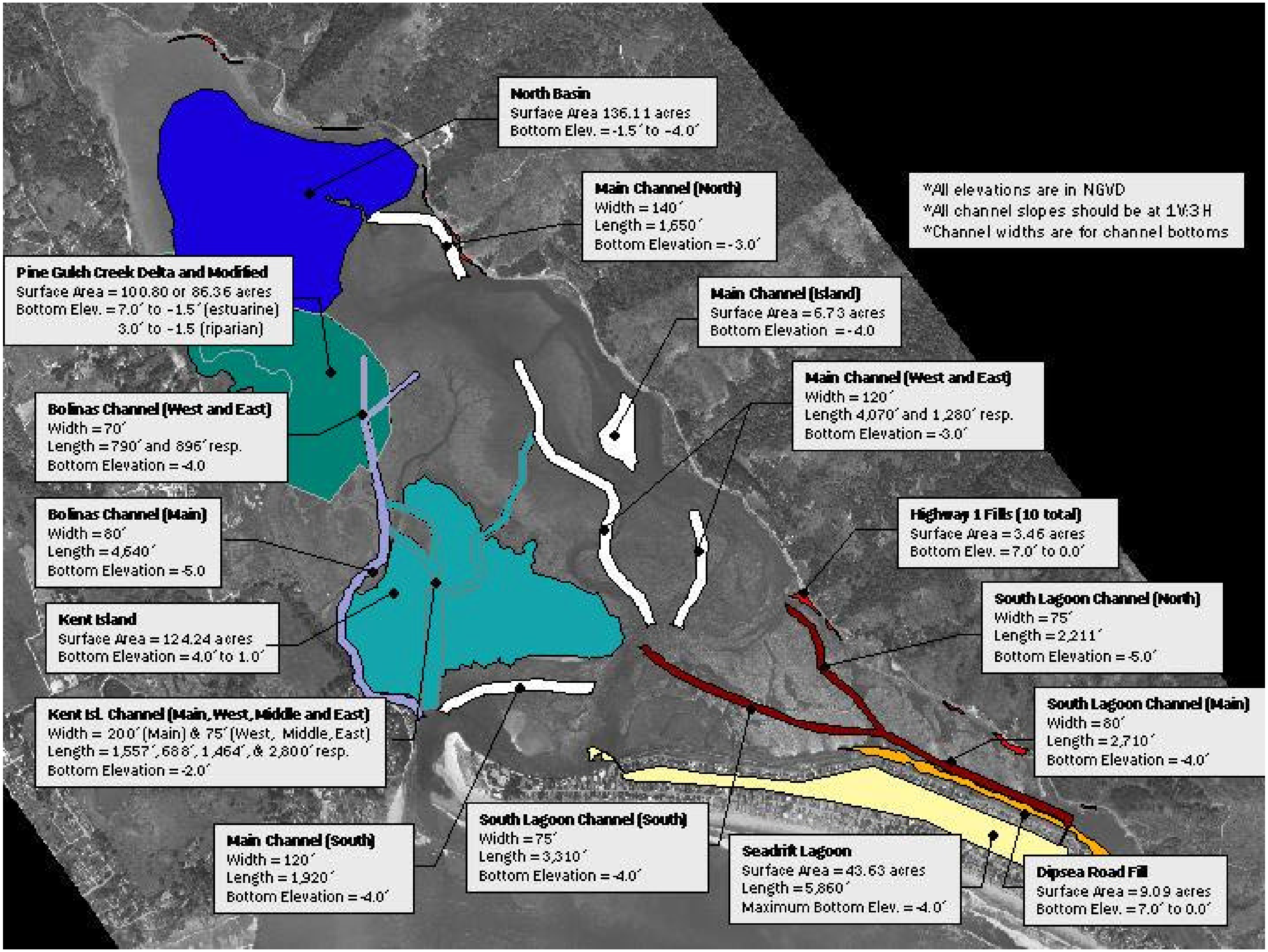


Figure 4.2 Dimensions of Restoration Components

Overall, this component significantly increases subtidal habitat volume, and increases intertidal habitat volume to a great degree. Benefits derived from an increase in these habitats include improved habitat quality for migratory bird species, harbor seals, invertebrates, benthos, plankton, and a variety of fish species inhabiting the lagoon, as well as increased accessibility to Pine Gulch Creek for anadramous fish species, including steelhead and salmon.

The basin would be dredged between the –1 foot and –4 feet NGVD contours. As shown in Figure 4.1 (page 4-4), the North Basin would have a construction footprint of 136 acres, and 459,000 cy of material would be removed. The material would be removed by hydraulic cutterhead dredge, pumped through a pipeline to a barge moored in Bolinas Bay.

4.3.3 Main Channel

As seen in Figures 3.7 and 3.8 (from Chapter 3), the size of the Main Channel has been decreased both in depth and in width by accumulated sediments. In order to provide sufficient flow to the north end of the lagoon, the Main Channel (the channel that runs between Kent Island and the Stinson Beach sand spit, and also runs parallel to Highway One on the east side of lagoon) would be dredged at the locations indicated by the color white in Figure 4.2 (page 4-5). Four sections of the channel would be deepened or reestablished, and one "island" in the Main Channel would be removed.

Dredging the Main Channel would not decrease or increase upland habitat surface area (Table 1, page 4-19). What is considered upland habitat for this component (that is, habitat above the tidal range) could be considered intertidal habitat for all intents and purposes, considering the location and function of the main channel. The increase in intertidal and subtidal habitat volume would be similar but, overall, there would be a greater increase in subtidal habitat surface area. Intertidal habitat would increase by 109,000 cy in volume, and decrease by 32 acres (due to the dynamics explained earlier) (Table 4.2, page 4-19). Subtidal habitat would increase by 108,000 cy in volume, and 32 acres (Table 4.3, page 4-19).

All channel sections, with the exception of the most southerly channel section, would be lowered to –3 feet NGVD, with side slopes of one foot of vertical height for every three feet of horizontal width (1V:3H). The most southerly section would be lowered to –4 feet NGVD, with side slopes of 1V:3H. The island area would be lowered to an elevation of –4 feet NGVD. The Main Channel component would have a construction footprint of 37 acres, and would remove 216,000 cy of material (Figure 4.1, page 4-4). Material would be removed by hydraulic cutterhead dredge and pumped through a pipeline to a barge moored in Bolinas Bay.

4.3.4 Highway One Fills

The sediment removal locations for the Highway One Fills component are indicated by the color red in Figure 4.2 (page 4-5). Fill would be removed from ten sites along the eastern border of the lagoon at Highway One; these sites can be characterized as unnecessary turnouts, unauthorized disposal sites and, in general, areas that were filled in at some point in the past. The public identified this component as an area to remove excessive fill material and restore intertidal habitat. Upland habitat surface area would increase by 0.40 acres (Table 4.1, page 4-19). Intertidal habitat surface area would increase by 0.53 acres, and intertidal habitat volume would increase by 2,000 cy (Table 4.2, page 4-19). Subtidal habitat surface area and volume would not increase (Table 4.3, page 4-19). The overall habitat gain with this component would be intertidal habitat. Although the overall increase in desirable habitats is not large, this component does remove some known human impacts from the system.

At each of the ten sites, material would be removed between a minimum elevation of 0 feet NGVD and a maximum elevation of 5 feet NGVD. The Highway One Fills component would have a construction footprint of 3 acres, and would remove 4,800 cy (Figure 4.1, page 4-4). The material at the Highway One sites would be removed with land-based equipment.

4.3.5 Pine Gulch Creek Delta (Estuarine)

The Pine Gulch Creek Delta restoration component is indicated by the color green in Figure 4.2 (page 4-5). The full green area comprises the Estuarine component, whereas the Riparian component skirts around the riparian habitat area, which is higher in elevation on the delta and designated by a line in the figure. Nothing west of the demarcation line would be removed with the Riparian component. The Pine Gulch Creek Delta component was designed to remove portions of the large deltaic formation on the west side of the lagoon that has formed over time due to unnaturally high sedimentation from Pine Gulch Creek. As shown in the historical aerial photos, Figures 4.3 through 4.7 (pages 4-8 through 4-12) it has grown significantly in surface area and elevation. In order to increase intertidal and subtidal habitat in this area, some of the existing salt marsh, upland and riparian habitat would be removed. The overall change in habitat composition in this area would be from upland and high intertidal habitat to low intertidal and subtidal habitat. Upland habitat surface area would decrease by 11 acres (Table 4.1, page 4-19).

Intertidal habitat surface area would increase by 8 acres, and intertidal habitat volume would increase by 155,000 cy (Table 4.2, page 4-19). Subtidal habitat surface area would increase by 4 acres and subtidal habitat volume would increase by 813 cy (Table 4.3, page 4-19). Overall, the most significant habitat gains for this component are in intertidal habitat surface area and volume.

Approximately 1 foot to 1.5 feet of material would be removed from the existing grade between the – 1.5 feet NGVD and 7 feet NGVD contours. This would require the removal of 7 out of 17 acres of riparian habitat. The land above the expected water level (3 feet to 4 feet NGVD) would have to be graded in order to maintain a slope that more closely approximates the existing slope. The Pine Gulch Creek Delta (Estuarine) component would have a construction footprint of 103 acres and would remove 191,000

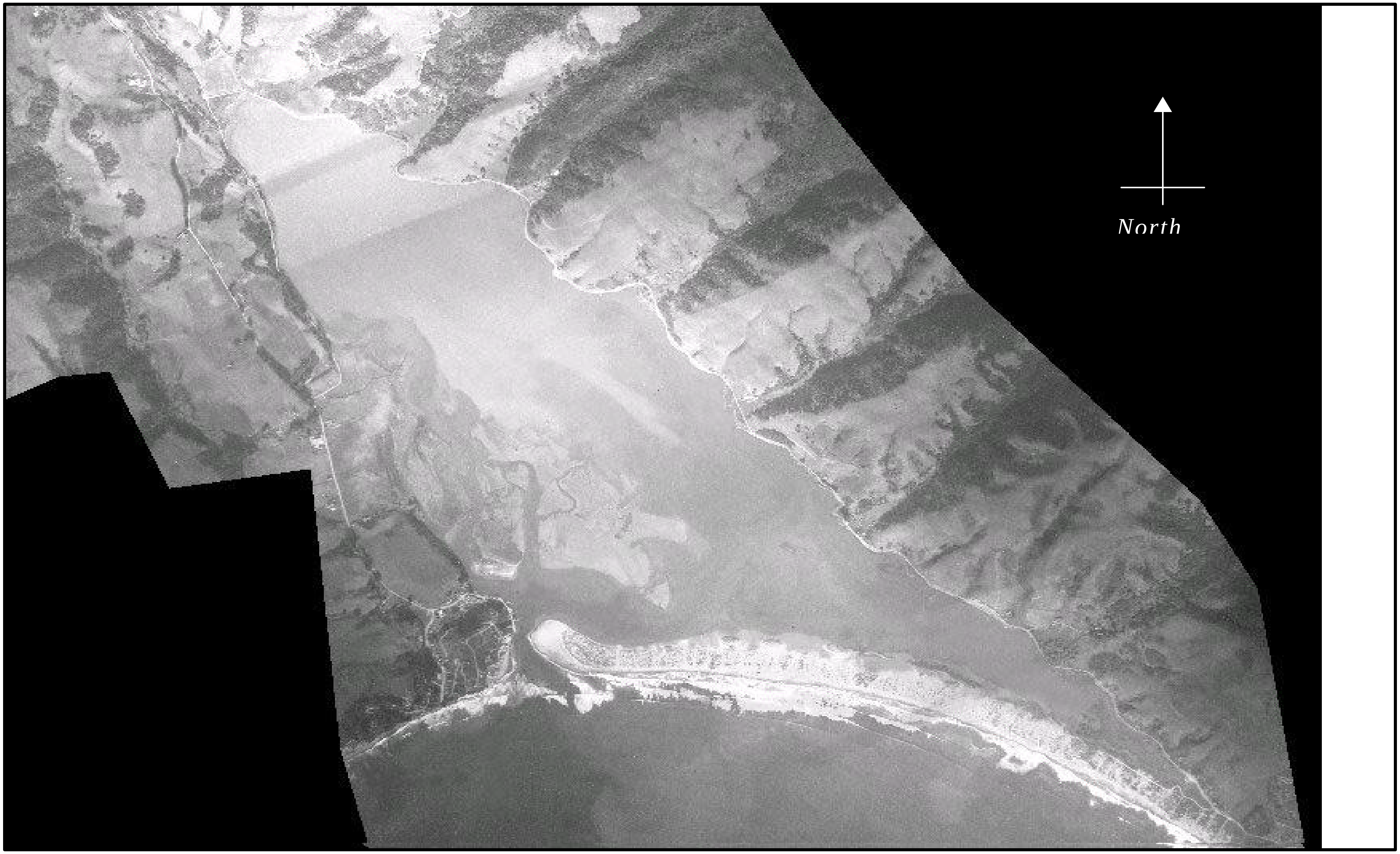


Figure 4.3 Historical Aerial Photo From 1942

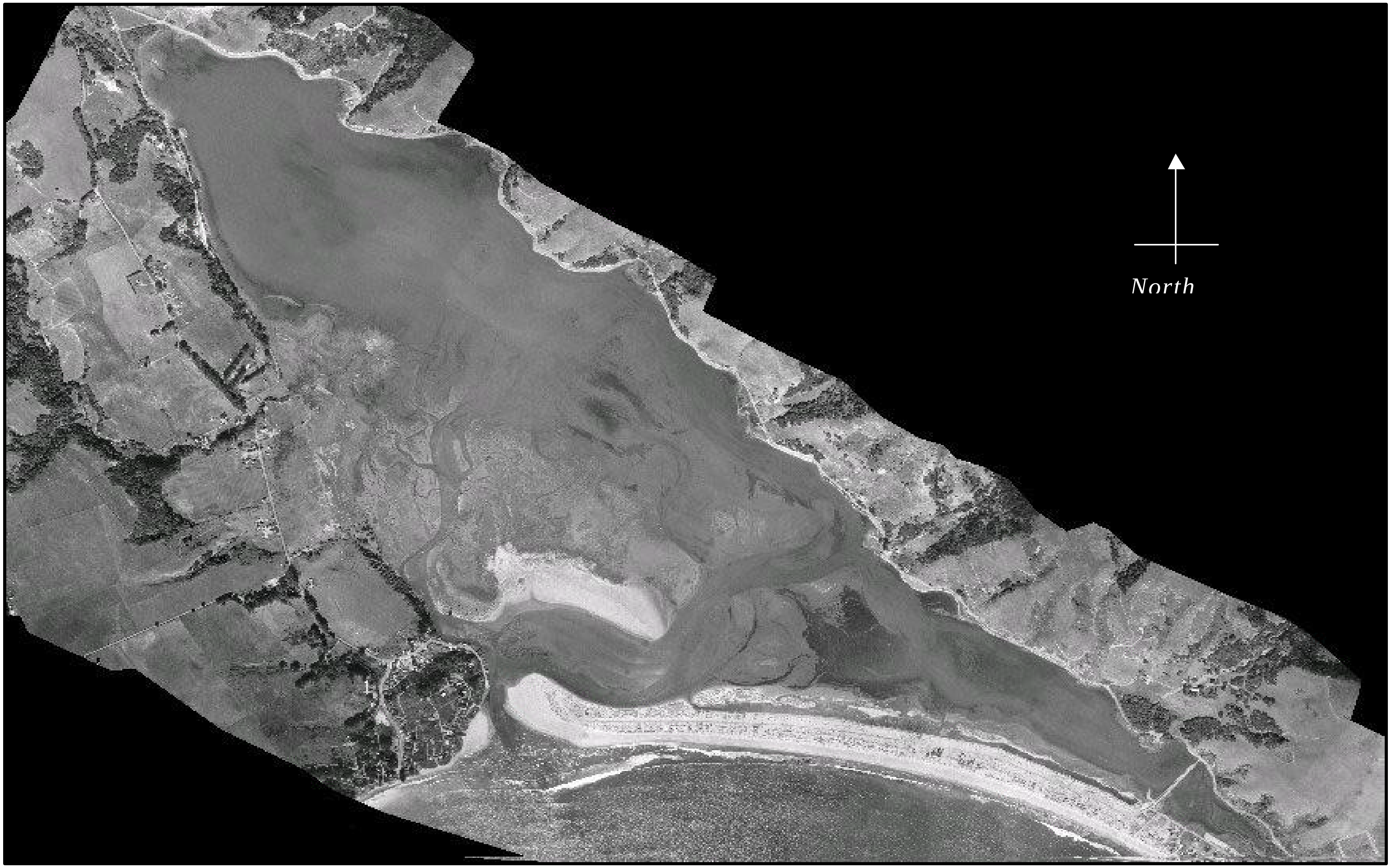


Figure 4.4 Historical Aerial Photo From 1959

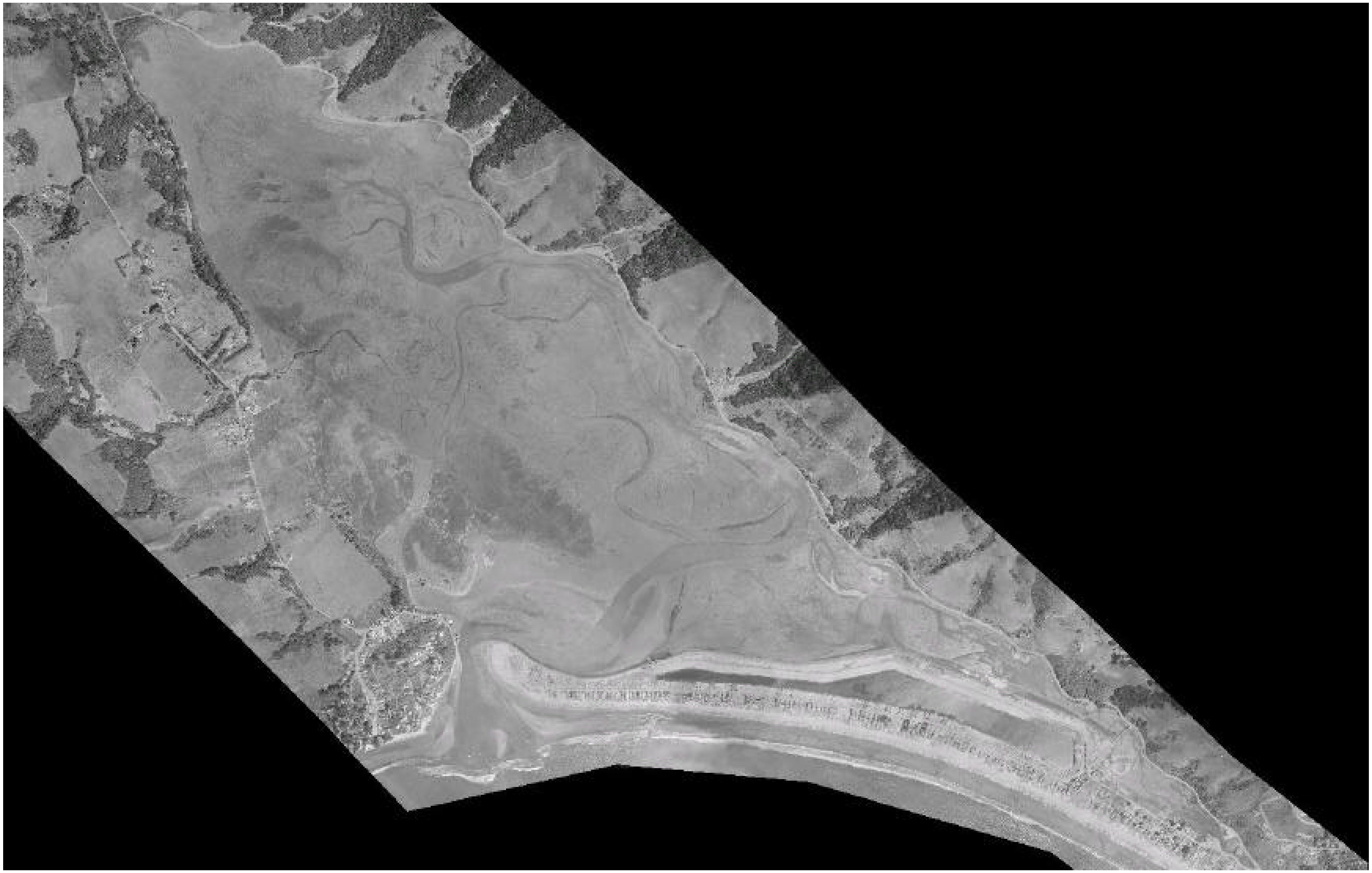


Figure 4.5 Historical Aerial Photo From 1968

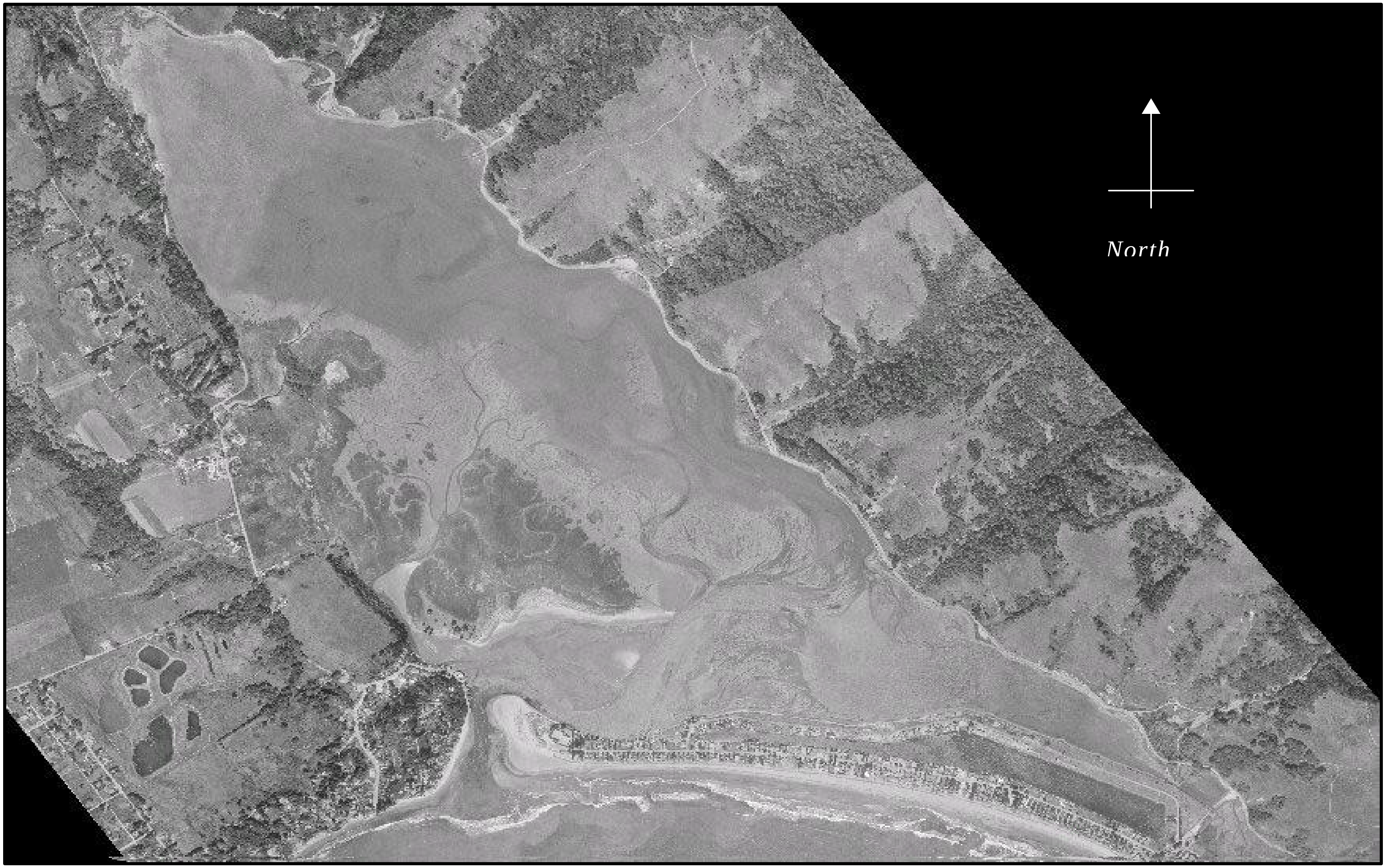


Figure 4.6 Historical Aerial Photo From 1984

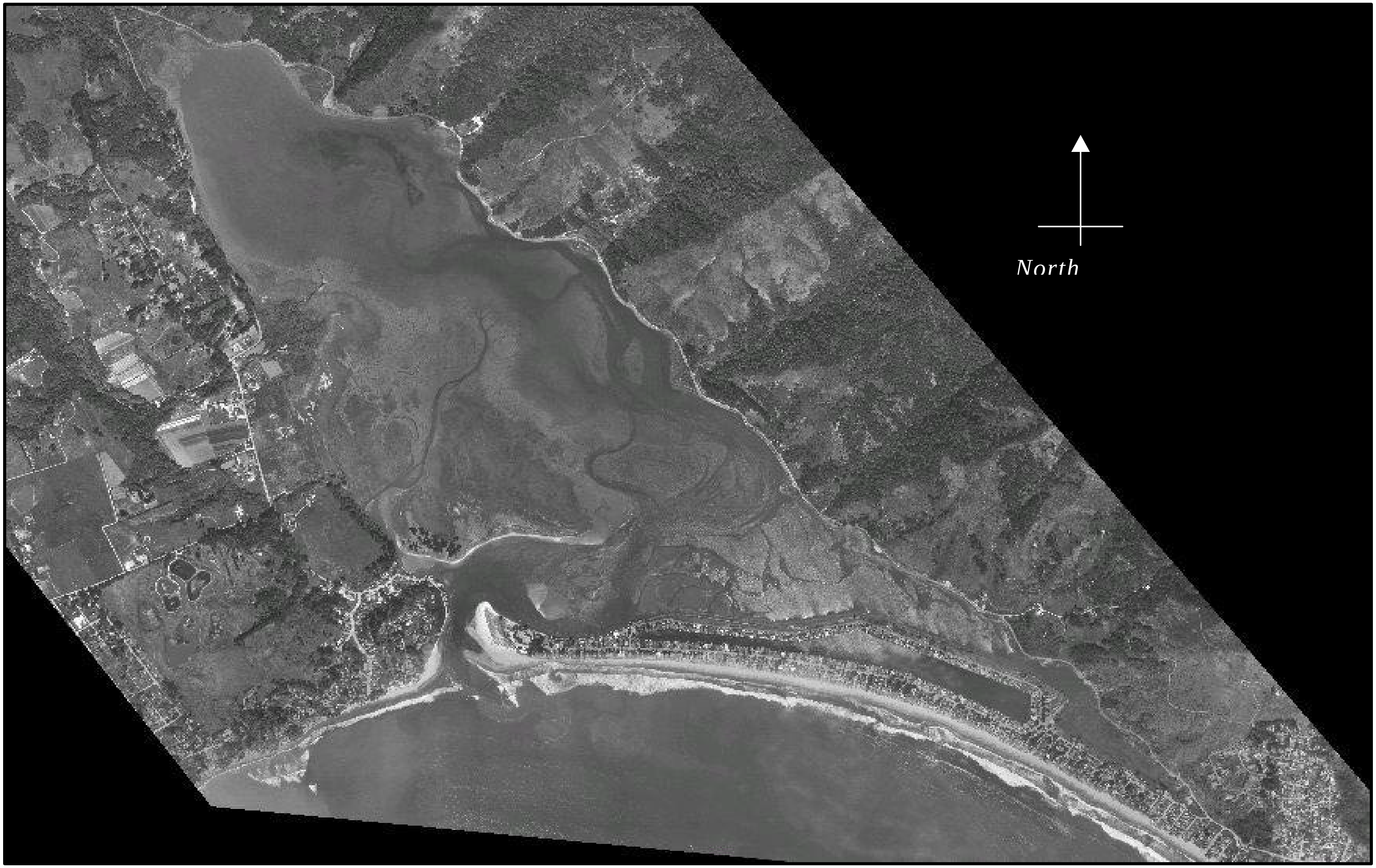


Figure 4.7 Historical Aerial Photo From 1997

cy (Figure 4.1, page 4-4). A portion of the material, in areas too deep to reach with land-based equipment, would be removed with a hydraulic cutterhead dredge. This wet material would be pumped through a floating pipeline across the tip of the Stinson Beach sand spit to a barge moored in Bolinas Bay.

4.3.6 Pine Gulch Creek Delta (Riparian)

Like the Pine Gulch Creek Delta (Estuarine) component, this alternative would remove portions of the large deltaic formation on the west side of the lagoon. However, it would avoid the riparian habitat area entirely. The overall change in habitat composition in this area would be from upland and high intertidal habitat to low intertidal and subtidal habitat. Upland habitat surface area would decrease by 9 acres (Table 4.1, page 4-19). Intertidal habitat surface area would increase by 5 acres, and intertidal habitat volume would increase by 148,000 cy (Table 4.2, page 4-19). Subtidal habitat surface area would increase by 4 acres, and subtidal habitat volume would increase by 810 cy (Table 4.3, page 4-19). Overall, the most significant habitat gains for this component are intertidal habitat surface area and volume. Although this component avoids the riparian area of Pine Gulch Creek and removes less material overall, this component should be thought of as being nearly identical to the Estuarine component, the only difference being that the Riparian component removes none of the 17 acres of riparian habitat. The difference in volume would be within the range of error for the data, and therefore, the volumes for the two components should be thought of as being nearly equal.

Again, approximately 1 foot to 1.5 feet of material would be removed from the existing grade between the – 1.5 feet NGVD and 4 feet NGVD contours. Since none of the riparian habitat would be removed, however, the slope between upland habitat and subtidal habitat would be steeper. The Pine Gulch Creek (Riparian) component would have a construction footprint of 86 acres and would remove 159,000 cy of material (Figure 4.1, page 4-4). The majority of the material would be removed via land-based equipment. A portion of the material, in areas too deep to reach with land-based equipment, would be removed with a hydraulic cutterhead dredge. This wet material would be pumped through a floating pipeline across the tip of the Stinson Beach sand spit to a barge moored in Bolinas Bay.

4.3.7 Bolinas Channel

This component would deepen the channel that originates near the inlet of the lagoon, flows between Kent Island and the town of Bolinas, continues northerly, and terminates at the Pine Gulch Creek Delta (the channel runs along the east bank of the delta). The color lavender in Figure 4.2 (page 4-5) indicates Bolinas Channel. The overall habitat change created by this restoration component would be a significant increase in intertidal and subtidal habitats. Upland habitat surface area would decrease by 3 acres (Table 4.1, page 4-19). Intertidal habitat surface area would decrease by 11 acres, but intertidal habitat volume would increase by 63,000 cy (Table 4.2, page 4-19). Subtidal habitat surface area would increase by 14 acres, and subtidal habitat volume would increase by 66,000 cy (Table 4.3, page 4-19). Other benefits include improved habitat for subtidal species, including potential new habitat area for eelgrass that was historically present in the channel, and increased access and use of the area by fish that inhabit Pine Gulch Creek. Along with an improvement in the subtidal and intertidal habitats would be a larger food base for predatory species like certain birds, sharks, and seals.

As shown in Figures 4.3 through 4.7 (pages 4-8 through 4-12) the channel has experienced noticeable morphological changes over time, and has become very shallow and narrow. Bolinas channel would be dredged to a depth of –5.0 feet NGVD with side slopes of 1V:3H, with the exception of the two forks, which would be dredged to a depth of –4.0 feet NGVD with side slopes of 1V:3H. The Bolinas Channel component would have a construction footprint of 16 acres and would remove 131,000 cy of material (Figure 4.1, page 4-4). The material would be removed with a shallow draft hydraulic cutterhead dredge. The material would be pumped through a floating pipeline, which would most likely exit the lagoon across the very tip of the Stinson Beach sand spit to a barge moored in Bolinas Bay.

4.3.8 Kent Island

The Kent Island restoration component is indicated by the color aqua in Figure 4.2 (page 4-5). This alternative would restore the historical channel system through Kent Island that is evident in the 1942 photo (Figure 4.3, page 4-8). Restoring this system of channels would, in effect, create a series of flood shoal islands through which water would flow farther up in the lagoon. Water flowing in through the inlet would be directed towards the northern part of the lagoon, increasing tidal prism and the distance that tidal prism travels, an important part of keeping the inlet open. In essence, construction of the Kent Island component would recapture lost habitat and lost habitat values, and the islands would become shoaling islands where future sedimentation would accumulate. This, in turn, should foster the growth of new wetland habitat over the long term, providing additional habitat benefits. Although some emergent salt marsh habitat would be removed during construction, the benefit of this component is the increase in intertidal and subtidal habitat, which do not have sediment-trapping qualities like emergent salt marsh. After years of sediment accretion, salt marsh habitat would likely form again on the island.

Overall, the Kent Island restoration component would bring about a significant increase in lower intertidal habitat and a moderate increase in subtidal habitat. Upland habitat surface area would decrease by 64 acres (Table 4.1, page 4-19). Intertidal habitat surface area would increase by 48 acres, and intertidal habitat volume would increase by 231,000 cy (Table 4.2, page 4-19). Subtidal habitat surface area would increase by 16 acres, and subtidal habitat volume would increase by 16,000 cy (Table 4.3, page 4-19).

The main part of the channel flowing through the center of the island would be 200 feet wide, have side slopes of 1V:3H, and have a bottom elevation of –2.0 feet NGVD. At the northern portion of Kent Island, the channel would split into three sub channels, each with a width of 75 feet, side slopes of 1V:3H, and bottom elevations of –2.0 feet NGVD. The island would also be reduced in overall size by lowering its existing elevation by 1 to 2 feet. The Kent Island component would have a construction footprint of 124 acres and would remove 377,000 cy of material (Figure 4.1, page 4-4). As shown in Figures 4.3 through 4.7 (pages 4-8 through 4-12) Kent Island has grown significantly in size and elevation, and now consists of a large upland area where non-native plant species such as Monterey Pines have become established.

The material at Kent Island would be removed with a shallow cutterhead hydraulic dredge, and would be pumped through a floating pipeline across the tip of the Stinson Beach sand spit to a barge moored in Bolinas Bay. Material that is too dry to be removed by hydraulic dredge, like trees and other vegetation, would be removed with land-based equipment. This equipment would have to be brought in by barge. The mulched material would be transported to Bodega Bay by barge, where it would either be loaded on to trucks and taken to an upland disposal site, or distributed for sale.

4.3.9 South Lagoon Channel

The South Lagoon Channel would be constructed in the southeast portion of the lagoon, acting as a link between the Main Channel in Bolinas Lagoon and the eastern channel that would exit Seadrift Lagoon (if the Seadrift Lagoon component were constructed). This component is indicated by the color burgundy in Figure 4.2 (page 4-5). Overall, construction of the South Lagoon Channel would increase subtidal habitat to a great extent, and would increase intertidal habitat somewhat. Upland habitat surface area would decrease by 0.07 acres (Table 4.1, page 4-19). Intertidal habitat surface area would increase by 14 acres, and intertidal habitat volume would increase by 25,000 cy (Table 4.2, page 4-19). Subtidal habitat surface area would increase by 13.93 acres, and subtidal habitat volume would increase by 63,000 cy (Table 4.3, page 4-19). A major benefit of this component is an increase in the tidal flow and flushing capacity of both lagoons. Other benefits include improved habitat for subtidal species, and increased access and use of the area by fish that inhabit Easkoot Creek.

The channel would consist of a main portion that runs parallel to Dipsea Road, and two branches that extend to the Main Channel. The extensions and main section would have a bottom elevation of –4 feet NGVD and side slopes of 1V:3H. The channel would be dredged using a shallow draft cutterhead hydraulic dredge, with the material being pumped to a barge in Bolinas Bay. The South Lagoon Channel component would have a construction footprint of 18 acres and would remove 89,000 cy of material (Figure 4.1, page 4-4).

4.3.10 Dipsea Road Fill

The Dipsea Road Fill restoration component would remove fill material between the elevation of 0 feet and 7 feet NGVD along Dipsea Road, as indicated by the color orange in Figure 4.2 (page 4-5). Due to regulations governing Bolinas Lagoon, septic fields (leach fields) cannot be closer than 100 feet to the edge of the water. Therefore, to maintain water quality standards in Bolinas Lagoon, fill would only be removed from areas in excess of 100 feet from the road (conservatively, the outer edge of the septic fields). Overall, this restoration component increases the amount of intertidal habitat, which is created directly from converting upland fill habitat to intertidal habitat. Upland habitat surface area would decrease by 2 acres (Table 4.1, page 4-19). Intertidal habitat surface area would increase by 3 acres, and intertidal habitat volume would increase by 14,000 cy (Table 4.2, page 4-19). Subtidal habitat surface area would increase by 0.10 acres, and subtidal habitat volume would increase by 333 cy (Table 4.3, page 4-19). The Dipsea Road Fill component would have a construction footprint of 8 acres, and would remove 38,000 cy of material (Figure 4.1, page 4-4). Because most of the material being removed is upland material, most of it would be removed with land-based equipment.

4.3.11 Seadrift Lagoon

Construction of the Seadrift Lagoon component would remove the thin, silty organic layer of sediment known to contain copper sulfate, and would open the lagoon at both ends to tidal flushing. The color yellow in Figure 4.2 (page 4-5) indicates the Seadrift Lagoon component. The general idea behind the design of the Seadrift Lagoon component was to open up the inner lagoon to tidal flushing, recapturing some of the tidal prism that was lost when the Seadrift housing development was constructed. As it currently exists, there is little tidal influence in the lagoon; water is brought in on the highest tides to "replenish" the water in Seadrift Lagoon, but it is not open to full tidal flushing.

Overall, the Seadrift Lagoon component would create a significant increase in intertidal habitat, and would increase subtidal habitat to a great extent. Upland habitat surface area would decrease by 42 acres, most notably in the channels that are to be constructed where currently there is land (Table 4.1, page 4-19). Intertidal habitat surface area would increase by 7 acres, and intertidal habitat volume would increase by 245,000 cy (Table 4.2, page 4-19). Subtidal habitat surface area would increase by 35 acres, and subtidal habitat volume would increase by 186,000 cy (Table 4.3, page 4-19). The Seadrift Lagoon component would have a construction footprint of 43 acres, and would remove 45,000 cy of material (Figure 4.1, page 4-4). Along with the habitat changes, other benefits include an increase in tidal prism and flushing capacity in Bolinas Lagoon. The habitat currently available to wildlife is minimal (and of lower quality) because of its brackish nature, minimal flushing, and homogeneity of habitat types. By opening the lagoon, not only would the tidal prism in Bolinas Lagoon increase, but the value of existing habitat would also improve. One ecological concern that has been raised with this component is the presence of green crabs (an invasive species) in Seadrift Lagoon. If Seadrift were opened to tidal flushing, would it act as a "source" for green crabs in Bolinas Lagoon? This question has yet to be answered.

<u>Variation 1</u>: This alternative would open the now "closed" Seadrift Lagoon to full tidal flushing by replacing the existing culverts in their present locations with a total of six (6) 4 foot by 6 foot concrete box culverts. Three (3) would be placed at either end of the lagoon. Currently there is a 15-foot culvert easement at the southeast end of Seadrift

Lagoon where half of the culverts would be placed. It is assumed this area would be sufficient for construction of this option, but it is unknown at this point what footprint would be permissible there. Also, at the northwest end, the existing culverts run underneath a mature cypress tree, as well as a portion of a private garage. Installation would require the removal of the tree and the structure. The local sponsor would pay damages to the owner of the structure as a part of the Lands, Easements, Rights-of-Way and Relocations fs(LERR) costs which are always the responsibility of the local sponsor, and part of their 35% cost share. One option at this end of the lagoon would be to install the culverts at the boat ramp area directly adjacent to the existing culverts, and fill the old culverts with concrete.

Variation 2: An alternative to the culverts for opening Seadrift Lagoon to full tidal flushing would be replacing the six (6) culverts with two (2) twenty (20) foot-wide open channels, one at either end. The channel at the southeast end would follow the same path as the existing culverts, whereas at the northwest end, the channel could be installed in the location of the existing boat ramp, which would be reconstructed at another location along Dipsea Road. A bridge would have to be constructed on Dipsea Road over both channels. Installing culverts at one end, with open channels at the other end, is another possibility.

Variation 3: A third variation of this component would be to use one entrance channel or one set of three (3) culverts at the northwest end only. This option would open Seadrift Lagoon to limited tidal action, and only at the northern end. With this variation, tidal water would come in and out of Seadrift Lagoon, but it would *not* flow through Seadrift Lagoon into the southern end of Bolinas Lagoon. Detailed numerical modeling of Seadrift Lagoon would have to be performed to determine the hydrological effects of this variation.

Out of the three variations, the Corps study team recommends Variation 2 due to the relative ease of operation and maintenance and potential additional environmental benefits resulting from having an open system. In Variation 1, the culverts would be over three hundred (300) feet long, creating long term maintenance issues for the local sponsor, even if larger box culverts were installed. In Variation 3, fewer environmental benefits would be realized because the tidal range in Seadrift Lagoon would be lower. Therefore, in all subsequent discussions referring to the Seadrift Lagoon component, Variation 2 is the assumed configuration. It is important to note that with Variation 2, up to 1,000 feet of sheet pile wall would be installed near the lagoon inlets to prevent erosion. The rest of the lagoon would not need new sheet pile since water current speeds would be low, and dredging would be minimal near the existing walls. Preliminary geotechnical analyses show that the stability of those walls should not be affected.

4.4 Formulation of Alternatives

As part of the plan formulation process of the Bolinas Lagoon Ecosystem Restoration study, a Habitat Evaluation Expert Panel was assembled and convened by Marin County and the Corps, in cooperation with the Bolinas Lagoon Technical Advisory

Committee. The primary purpose of the expert panel was to evaluate the environmental merits of the proposed restoration components. Although the panel found that they could not rank the components based on environmental criteria, as originally charged, their discussions provided invaluable information as to the design and implementation of the alternatives.

One of the contributions the panel made to the planning process was to group the restoration components into geographical areas of concern in the lagoon. These areas are "North," "Central," and "South," as illustrated in Figure 4.8 (page 4-20). Not only does it facilitate discussion of the "problem areas" of the lagoon, but it also keeps together the components that complement each other hydraulically. Because there are two Pine Gulch Creek Delta variations (Riparian and Estuarine), there are two Central alternatives: Central (Riparian) and Central (Estuarine). In addition, due to potential public opposition and other significant issues, such as long term operations and maintenance responsibilities, involved with the implementation of the Seadrift Lagoon component, a consensus was reached at the June 29, 2001 Alternatives Review Conference (held by the Corps of Engineers San Francisco District and MCOSD) to develop the South (No Seadrift) alternative, which excludes the Seadrift Lagoon component. This section describes the composition of these alternatives (illustrated in Table 4.4, page 4-24) and how they were combined to form the alternative plans. Specifics of the expert panel process will be described later in the document. Alternative footprint surface areas and dredge volumes are detailed in Figure 4.9 (page 4-21).

4.4.1 No Action Alternative

The No Action alternative involves taking no further action to address sedimentation in the lagoon, but leaving in place the existing management plans and policies. This would include the Bolinas Lagoon Management Plan, existing management plans and policies administered by other authorities such as the Gulf of the Farallones National Marine Sanctuary, Golden Gate National Recreation Area, and Point Reyes National Seashore, as well as state and federal resource management laws and regulations. All of the restoration alternatives will be evaluated against the No Action alternative to determine the benefits and risks associated with each of the proposed alternatives.

4.4.2 North Alternative

The North Alternative is composed of the North Basin and Main Channel components. It was developed as a way to increase tidal prism in the entire lagoon, as well as increase subtidal and intertidal habitats. As stated earlier, the effectiveness of the North Basin improves when the Main Channel connects the basin to the inlet. Because the North Basin needs an adequate supply of water to fill it, thereby realizing more of its potential tidal prism, excavation in the North Basin and Main Channel are coupled. There would be 183 acres of diving duck habitat surface area, and 513,000 cy of diving duck habitat volume with the North Alternative (Table 4.5, page 4-25). Upland habitat

Table 4.1 Upland Habitat Changes With Each Restoration Component

Alternative	1998 Levels	Constructed	Change In Habitat
	Surface Area	Surface Area	Surface Area
	acres	acres	acres
Bolinas Channel	2.54	0.05	-2.50
Pine Gulch Delta (Estuarine)	30.59	19.47	-11.12
Pine Gulch Delta (Riparian)	15.08	6.48	-8.60
Kent Island	79.18	14.93	-64.25
Dipsea Road Fill	6.02	3.69	-2.33
Highway 1 Fills	1.81	1.40	-0.40
South Arm Channel	0.08	0.01	-0.07
Seadrift Lagoon	43.47	1.68	-41.79
Main Channel	0.00	0.00	0.00
North End Basin	0.18	0.00	-0.18
		Net Change	**-131.24**

Table 4.2 Intertidal Habitat Changes With Each Restoration Component

Alternative	1998 Levels		Constructed		Change In Habitat	
	Surface Area	Volume	Surface Area	Volume	Surface Area	Volume
	acres	cy	acres	cy	acres	cy
Bolinas Channel	12.86	31,025	1.51	93,933	-11.35	62,908
Pine Gulch Delta (Estuarine)	72.24	137,955	79.81	293,095	7.58	155,140
Pine Gulch Delta (Riparian)	71.24	137,142	75.92	285,417	4.68	148,275
Kent Island	44.88	45,123	93.04	276,387	48.17	231,263
Dipsea Road Fill	1.95	3,567	5.25	17,314	3.29	13,747
Highway 1 Fills	1.45	2,065	1.98	4,549	0.53	2,484
South Arm Channel	14.52	84,552	0.66	109,983	-13.86	25,431
Seadrift Lagoon	0.00	0	6.75	245,414	6.75	245,414
Main Channel	34.14	126,102	1.74	234,683	-32.40	108,581
North End	108.81	689,450	2.28	855,476	-106.53	166,027
				Net Change	**-93.14**	**1,159,270**

Table 4.3 Subtidal Habitat Changes With Each Restoration Component

Alternative	1998 Levels		Constructed		Change In Habitat	
	Surface Area	Volume	Surface Area	Volume	Surface Area	Volume
	Acres	cy	acres	cy	acres	cy
Bolinas Channel	0.16	376	13.92	66,715	13.76	66,339
Pine Gulch Delta (Estuarine)	0.00	0	3.93	813	3.93	813
Pine Gulch Delta (Riparian)	0.00	0	3.92	810	3.92	810
Kent Island	0.01	0	16.27	16,395	16.26	16,394
Dipsea Road Fill	0.00	0	0.10	333	0.10	333
Highway 1 Fills	0.00	0	0.00	0	0.00	0
South Arm Channel	2.99	3,147	16.91	66,577	13.93	63,431
Seadrift Lagoon	0.00	0	35.16	186,285	35.16	186,285
Main Channel	3.35	3,037	35.76	110,745	32.40	107,708
North End Basin	27.11	18,402	133.82	310,822	106.71	292,421
				Net Change	**226.18**	**734,533**

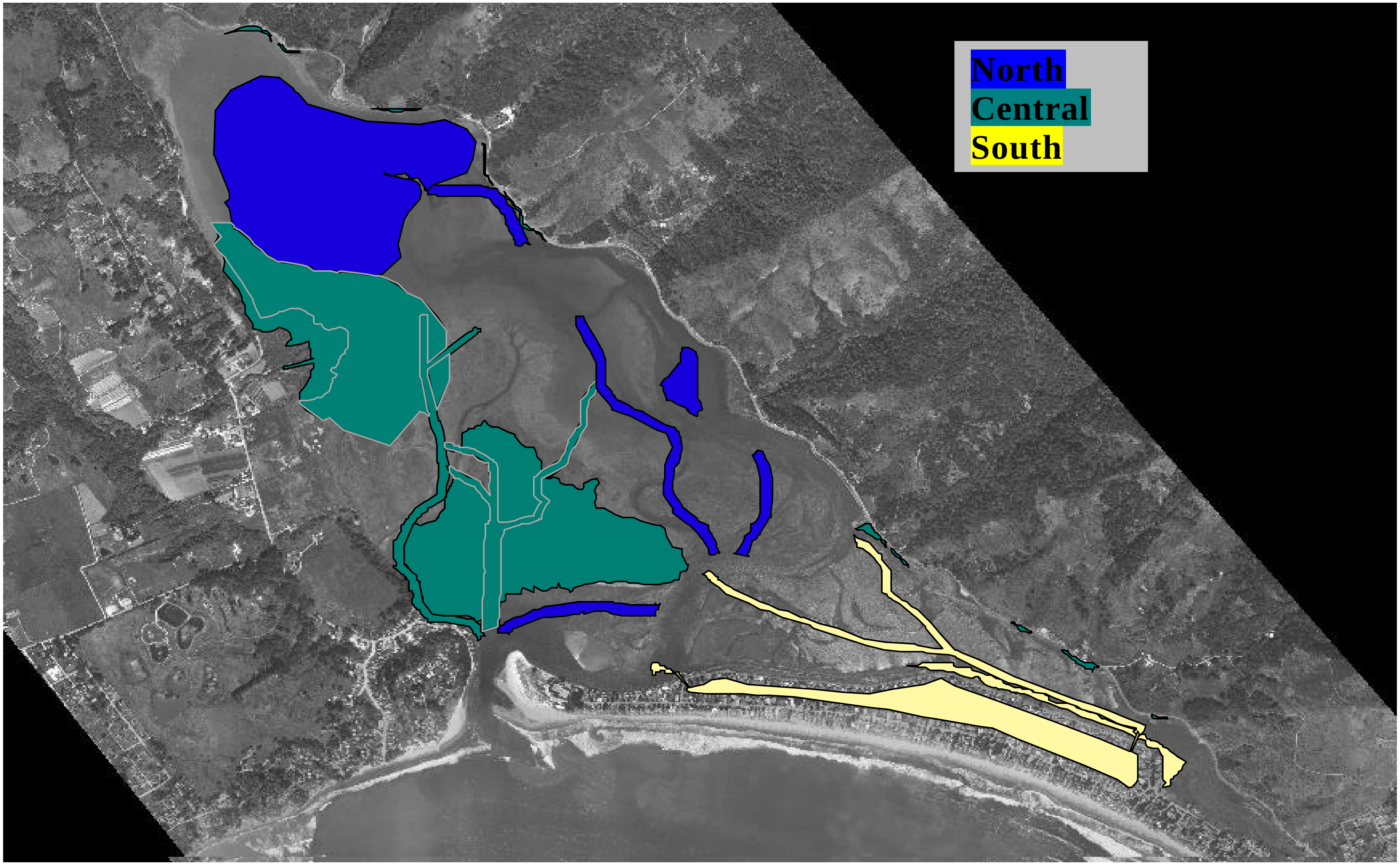
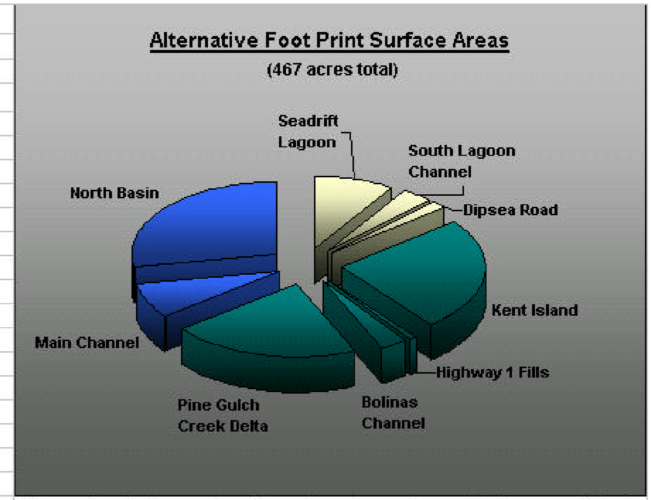


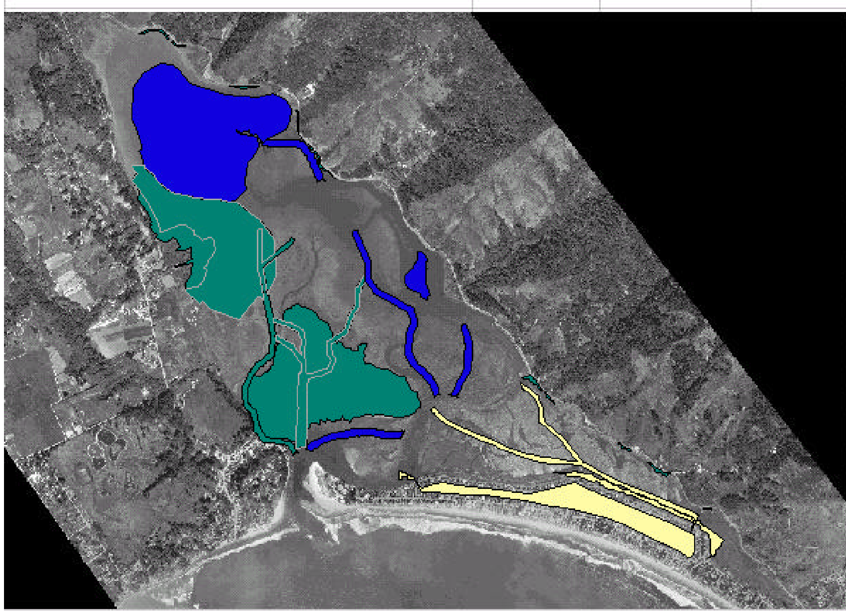
Figure 4.8 Map of Fundamental Geographical Areas

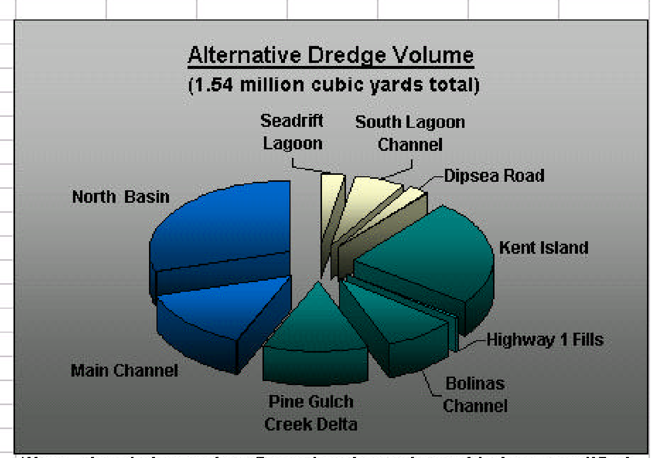
Alternative Footprint Areas and Dredge Volumes

Alternative	Surface Area acres	Dredge Volume yds^3
North	173.60	674,778
Central (Estuarine)	245.71	703,081
Central (Riparian)	229.20	670,993
South (Seadrift)	69.02	171,897
South (No Seadrift)	25.55	126,939
North and Central (Estuarine)	419.31	1,377,860
North and Central (Riaprian)	402.80	1,345,771
North and South (Seadrift)	242.62	846,675
North and South (No Seadrift)	199.15	801,717
Central (Estuarine) and South (Seadrift)	314.73	874,978
Central (Estuarine) and South (No Seadrift)	271.26	830,020
Central (Riparian) and South (Seadrift)	298.22	842,889
Central (Riparian) and Soth (No Seadrift)	254.75	797,931
North, Central (Estuarine), and South (Seadrift)	488.33	1,549,757
North, Central (Estuarine), and South (No Seadrift)	444.86	1,504,799
North, Central (Riparian), and South (Seadrift)	471.82	1,517,668
North, Central (Riparian), and South (No Seadrift)	428.35	1,472,710



*Note - the pi chart only reflects the alternatives with the unmodified components.





*Note - the pi chart only reflects the alternatives with the unmodified components.

Figure 4.9 Alternative Footprint Surface Area and Dredge Volumes surface area would decrease by 34 acres (Table 4.6, page 4-25). Intertidal habitat surface area would decrease by 99 acres, but intertidal habitat volume would increase by 735,000 cy (Table 4.7, page 4-25). Subtidal habitat surface area would increase by 134 acres, and subtidal habitat volume would increase by 362,000 cy (Table 4.8, page 4-25). A total of 675,000 cubic yards of material would be removed with this alternative, and the total footprint surface area for this alternative would be 174 acres (Figure 4.9).

4.4.3 Central (Estuarine) Alternative

The Central (Estuarine) Alternative is composed of Pine Gulch Creek Delta (Estuarine) component, Bolinas Channel, Kent Island and the Highway One Fills components. Pine Gulch Creek Delta, Kent Island and Bolinas Channel are all linked because of their combined effects on the central part of the lagoon. Pine Gulch Creek, draining half of the watershed into the lagoon, is a significant contributor of sediment in the lagoon and plays an important role in the dynamic relationship between the lagoon and the watershed. All of the components in this alternative affect (and are affected by) Pine Gulch Creek. For example, excavation in these areas not only improves intertidal and subtidal habitat, but also improves habitat quality and access to Pine Gulch Creek for the anadromous fish species that inhabit the lagoon. The Highway One Fills component can easily fit into any of the geographic areas of the lagoon, but considering that the fills span north to south on the eastern side of the lagoon, they have been included in the Central alternative. There would be 93 acres of diving duck habitat surface area, and 412,000 cy of diving duck habitat volume with the Central (Estuarine) Alternative (Table 4.5, page 4-25). Upland habitat surface area would decrease by 98 acres (Table 4.6, page 4-25). Intertidal habitat surface area would increase by 73 acres, and intertidal habitat volume would increase by 869,000 cy (Table 4.7, page 4-25). Subtidal habitat surface area would increase by 26 acres, and subtidal habitat volume would increase by 67,000 cy (Table 4.8, page 4-25). A total of 703,000 cubic yards of material would be removed with this alternative, and the total footprint surface area for this alternative would be 246 acres (Figure 4.9, page 4-21).

4.4.4 Central (Riparian) Alternative

The Central (Riparian) Alternative is similar to the Central (Estuarine) Alternative except that the Pine Gulch Creek Delta (Riparian) component avoids the riparian habitat on the delta. This alternative is composed of Pine Gulch Creek Delta (Riparian) component, Bolinas Channel, Kent Island and the Highway One Fills components. Pine Gulch Creek Delta, Kent Island and Bolinas Channel are all linked because of their combined effects on the central part of the lagoon. Pine Gulch Creek, draining half of the watershed into the lagoon, is a significant contributor of sediment in the lagoon and plays an important role in the dynamic relationship between the lagoon and the watershed. All of the components in this alternative affect (and are affected by) Pine Gulch Creek. For example, excavation in these areas not only improves intertidal and subtidal habitat, but also improves habitat quality and access to Pine Gulch Creek for the anadromous fish species that inhabit the lagoon. The Highway One Fills component can easily fit into any of the geographic areas of the lagoon, but considering that the fills span north to south on the eastern side of the lagoon, they have been included in the Central alternative. There would be 93 acres of diving duck habitat surface area, and 412,000 cy of diving duck habitat volume with the Central (Riparian) Alternative (Table 4.5, page 4-25). Upland habitat surface area would decrease by 95 acres (Table 4.6, page 4-25). Intertidal habitat surface area would decrease by 70 acres, but intertidal habitat volume would increase by 863,000 cy (Table 4.7, page 4-25). Subtidal habitat surface area would increase by 134 acres, and subtidal habitat volume would increase by 67,000 cy (Table 4.8, page 4-25). A total of 671,000 cubic yards of material would be removed with this alternative, and the total footprint surface area for this alternative would be 229 acres (Figure 4.9, page 4-21).

4.4.5 South (Seadrift) Alternative

The South (Seadrift) Alternative is composed of the South Lagoon Channel, Dipsea Road and Seadrift Lagoon components. Seadrift Lagoon is linked to the South Lagoon Channel because the southeastern opening of Seadrift Lagoon needs a supply of water, and because linking the two generally helps improve water circulation in the south part of the lagoon. The Dipsea Road Fills component also improves circulation (and intertidal habitat) in the south. The South (Seadrift) Alternative restores tidal prism and increases intertidal and subtidal habitat in the southern part of Bolinas Lagoon. Other benefits include increased access for anadramous fish to Easkoot Creek, and improved habitat value in Seadrift Lagoon. There would be 100 acres of diving duck habitat surface area, and 437,000 cy of diving duck habitat volume with the South (Seadrift) Alternative (Table 4.5, page 4-25). Upland habitat surface area would decrease by 30 acres (Table 4.6, page 4-25). Intertidal habitat surface area would increase by 31 acres, and intertidal habitat volume would increase by 651,000 cy (Table 4.7, page 4-25). Subtidal habitat surface area would increase by 44 acres, and subtidal habitat volume would increase by 236,000 cy (Table 4.8, page 4-25). A total of 172,000 cubic yards of material would be removed with this alternative, and the total footprint surface area for this alternative would be 69 acres (Figure 4.9, page 4-21).

4.4.6 South (No Seadrift) Alternative

The South (No Seadrift) Alternative is composed of the South Lagoon Channel and Dipsea Road components, but does *not* include the Seadrift Lagoon component. Without Seadrift Lagoon, this alternative has limited habitat value, but it does restore intertidal and subtidal habitat that has been lost in this area. In addition, although the South Lagoon Channel would no longer be connecting Seadrift Lagoon to the Main Channel, it can still increase tidal flow and subtidal habitat value in the area. The Dipsea Road Fills component improves circulation and intertidal habitat. The South (No Seadrift) Alternative restores tidal prism and increases intertidal and subtidal habitat in the southern part of Bolinas Lagoon. Other benefits include increased access to anadramous fish to Easkoot Creek, and improved habitat value in Seadrift Lagoon. There would be 71 acres of diving duck habitat surface area, and 355,000 cy of diving duck habitat volume with the South (No Seadrift) Alternative (Table 4.5, page 4-25). Upland habitat surface area would decrease by 9 acres (Table 4.6, page 4-25). Intertidal habitat surface area would decrease by 8 acres, but intertidal habitat volume would increase by

Table 4.4 Composition of Alternatives

	North Basin	Main Channel	Bolinas Channel	Kent Island	Highway 1 Fills	Pine Gulch Creek Delta (Estuarine)	Pine Gulch Creek Delta (Riparian)	Dipsea Road	South Lagoon Channel	Seadrift Lagoon
Alternative North	X	X								
Alternative Central (Estuarine)			X	X	X	X				
Alternative Central (Riparian)			X	X	X		X			
Alternative South (No Seadrift)								X	X	
Alternative South (Seadrift)								X	X	X

Table 4.5 Diving Duck Habitat (1m to 3m below MSL; -2.70' and 8.70' NGVD) with Each Alternative

Summary	Surface Area acres	Volume cy
1968	95.64	379,986
1998	51.65	292,876
North	183.01	512,613
Central (Estuarine)	92.90	412,406
Central (Riparian)	92.90	412,406
South (Seadrift)	99.54	437,232
South (No Seadrift)	70.95	355,483

Table 4.6 Upland Habitat Changes with Each Alternative

Alternative Plan	1998 Levels Surface Area Acres	Constructed Surface Area acres	Change In Habitat Surface Area acres
North	238.10	204.04	-34.06
Central (Estuarine)	238.10	140.04	-98.06
Central (Riparian)	238.10	143.61	-94.49
South (Seadrift)	238.10	208.05	-30.05
South (No Seadrift)	238.10	229.31	-8.79

Table 4.7 Intertidal Habitat Changes with Each Alternative

	1998 Levels		Constructed		Change In Habitat	
Alternative Plan	Surface Area Acres	Volume cy	Surface Area acres	Volume cy	Surface Area acres	Volume cy
North	848.53	3,584,714	749.05	4,319,597	-99.48	734,883
Central (Estuarine)	848.53	3,584,714	921.75	4,453,670	73.22	868,956
Central (Riparian)	848.53	3,584,714	918.06	4,448,117	69.54	863,403
South (Seadrift)	848.53	3,584,714	879.34	4,235,852	30.81	651,138
South (No Seadrift)	848.53	3,584,714	840.98	3,698,360	-7.55	113,646

Table 4.8 Subtidal Habitat Changes with Each Alternative

	1998 Levels		Constructed		Change In Habitat	
Alternative Plan	Surface Area Acres	Volume cy	Surface Area acres	Volume cy	Surface Area acres	Volume cy
North	146.39	523,318	279.94	885,096	133.54	361,778
Central (Estuarine)	146.39	523,318	171.92	589,858	25.52	66,540
Central (Riparian)	146.39	523,318	171.87	589,852	25.48	66,534
South (Seadrift)	146.39	523,318	190.33	759,606	43.94	236,289
South (No Seadrift)	146.39	523,318	163.85	590,120	17.46	66,802

114,000 cy (Table 4.7, page 4-25). Subtidal habitat surface area would increase by 17 acres, and subtidal habitat volume would increase by 67,000 cy (Table 4.8, page 4-25). A total of 127,000 cubic yards of material would be removed with this alternative, and the total footprint surface area for this alternative would be 26 acres (Figure 4.9, page 4-21).

4.5 Formulation of Alternative Plans and Preliminary Screening

Combining the restoration components to form the alternatives North, Central (Estuarine), Central (Riparian), South (Seadrift) and South (No Seadrift) helped to reduce the final number of alternative plans to be considered. If each component were considered an alternative, the combinations of alternatives would be too numerous (over 1000 permutations), making the analysis very difficult. In addition, grouping them geographically is logical since the restoration components have a synergy, often improving in function when combined, and also addressing problem areas of the lagoon when grouped this way. It should be noted that this grouping is flexible, and is *not* required. The tentatively selected plan, for example, could include any number of components, depending on habitat improvements desired, lagoon function desired, and feasibility, constructability, cost, or public acceptance of the components. For this Feasibility Study, grouping the components simplifies the analysis. With only three geographical restoration areas to combine, including two variations each of the Central and South Alternatives, the number of permutations was seventeen. The alternative plans are as follows:

1. North
2. Central (Estuarine)
3. Central (Riparian)
4. South (Seadrift)
5. South (No Seadrift)
6. North and Central (Estuarine)
7. North and Central (Riparian)
8. North and South (Seadrift)
9. North and South (No Seadrift)
10. Central (Estuarine) and South (Seadrift)
11. Central (Estuarine) and South (No Seadrift)
12. Central (Riparian) and South (Seadrift)
13. Central (Riparian) and South (No Seadrift)
14. North, Central (Estuarine), and South (Seadrift)
15. North, Central (Estuarine), and South (No Seadrift)
16. North, Central (Riparian), and South (Seadrift)
17. North, Central (Riparian), and South (No Seadrift)

Figure 4.9 (page 4-21) shows the surface area and dredge volumes associated with each geographical area/alternative. These numbers simply reflect the cumulative surface areas and volumes of the components that are included in each alternative.

Once the alternatives were combined into alternative plans, the number of alternative plans still needed to be reduced to a reasonable number for further analysis. Because some of the alternative plans are more effective at achieving the project goals, the study team needed to establish criteria by which to evaluate the alternative plans. Ranking the alternative plans by how well they meet the goals of the project identifies which plans are not as effective and should therefore be eliminated from further analysis.

The Habitat Evaluation Expert Panel was presented with this task. Although they established ecological and hydrological criteria, they were unable to justify ranking any of the alternatives above any of the others using the ecological criteria. Understanding the relationship between the hydrology and the ecology of the system, and knowing that increases in intertidal and subtidal habitats would bring about certain ecological benefits, the study team decided that the best way of evaluating the alternative plans would be to rank them based on a hydrological parameter that was related to some of the ecological criteria defined by the expert panel. Intertidal volume (measured in cubic yards) was chosen as this key parameter, based on three criteria:

1. Intertidal Volume addresses most of the issues in the purpose and need of the project (i.e., project objectives).
2. Historical and projected future habitat losses – intertidal habitat has been the prime habitat type lost in the lagoon system; based on historical data, it will continue to decrease significantly.
3. Hydraulic affects – by definition, any alternative that increases intertidal volume increases tidal prism. This has a direct correlation to lagoon flushing and inlet stability.

In order to compare the alternative plans and carry out the incremental cost analysis, one key parameter needed to represent the benefits of each alternative. A tangible number that is equal in relative value for each alternative is especially important. This does not mean that all of the other parameters mentioned were ignored or will be ignored in the decision making process. They will certainly be looked at for effects and impacts that would be of benefit or concern. However, intertidal volume is a parameter that is easy to use and has both hydrological and ecological benefits. The expert panel agreed that a ranking based on intertidal volume was an appropriate indicator of effectiveness at achieving the project goals.

Figure 4.10 (page 4-30) shows all of the alternative plans and how intertidal volume changes with each one. The order is not surprising. In general, as more sediment is removed, the intertidal volume benefits increase. For the initial screening process, the top twelve (out of seventeen) alternative plans were identified for further analysis. Because intertidal volume addresses many of the project restoration goals (to increase intertidal and subtidal habitat, increase tidal prism, and reduce the chance for inlet closure), it was assumed that the smaller alternatives did not do enough to achieve those goals, and were therefore eliminated during the preliminary screening process. Because regularly scheduled maintenance dredging was not a management option for the lagoon due to permitting restrictions of the GFNMS, the final array of alternatives needed to provide a significant increase in tidal prism and intertidal and subtidal habitats. Increases in all three reduce the potential for inlet closure, and thus improve the function of the lagoon as a system. The smallest plans did not meet the preliminary screening criteria. The final array of alternative plans is listed below (composition of alternative plans shown in Table 4.9).

1. North, Central (Estuarine) and South (Seadrift)
2. North, Central (Estuarine) and South (No Seadrift)
3. North, Central (Riparian) and South (Seadrift)
4. North, Central (Riparian) and South (No Seadrift)
5. North and Central (Estuarine)
6. North and Central (Riparian)
7. Central (Estuarine) and South (Seadrift)
8. Central (Estuarine) and South (No Seadrift)
9. Central (Riparian) and South (Seadrift)
10. Central (Riparian) and South (No Seadrift)
11. North and South (Seadrift)
12. North and South (No Seadrift)

4.6 Final Array of Alternative Plans

4.6.1 No Action Alternative Plan

The No Action alternative involves taking no further action to address sedimentation in the lagoon, but leaving in place the existing management plans and policies. This would include the Bolinas Lagoon Management Plan, existing management plans and policies administered by other authorities such as the Gulf of the Farallones National Marine Sanctuary, Golden Gate National Recreation Area, and Point Reyes National Seashore, as well as state and federal resources management laws and regulations. It is assumed that with this plan, sediment would continue to fill the lagoon, and the potential for inlet closure would continue to increase until about 2050, at which time inlet closure would become very likely. Overall, continued sedimentation would result in a continual decline in intertidal and subtidal habitats, and diminishing habitat values associated with each. Although there would be some short term benefits to emergent marsh species, eventually, all habitats would convert to upland, and species diversity would decrease significantly. All of the restoration alternatives will be evaluated against the No Action alternative to determine the benefits and risks associated with each of the proposed alternatives.

Table 4.9 Composition of Alternative Plans

	North Basin	Main Channel	Bolinas Channel	Kent Island	Highway 1 Fills	Pine Gulch Creek Delta (Estuarine)	Pine Gulch Creek Delta (Riparian)	Dipsea Road	South Lagoon Channel	Seadrift Lagoon
1. Alternative Plan North, Central (Estuarine) and South (Seadrift)	X	X	X	X	X	X		X	X	X
2. Alternative Plan North, Central (Estuarine) and South (No Seadrift)	X	X	X	X	X	X		X	X	
3. Alternative Plan North, Central (Riparian) and South (Seadrift)	X	X	X	X	X		X	X	X	X
4. Alternative Plan North, Central (Riparian) and South (No Seadrift)	X	X	X	X	X		X	X	X	
5. Alternative Plan North and Central (Estuarine)	X	X	X	X	X	X				
6. Alternative Plan North and Central (Riparian)	X	X	X	X	X		X			
7. Alternative Plan Central (Estuarine) and South (Seadrift)			X	X	X	X		X	X	X
8. Alternative Plan Central (Estuarine) and South (No Seadrift)			X	X	X	X		X	X	
9. Alternative Plan Central (Riparian) and South (Seadrift)			X	X	X		X	X	X	X
10. Alternative Plan Central (Riparian) and South (No Seadrift)			X	X	X		X	X	X	
11. Alternative Plan North and South (Seadrift)	X	X						X	X	X
12. Alternative Plan North and South (No Seadrift)	X	X						X	X	

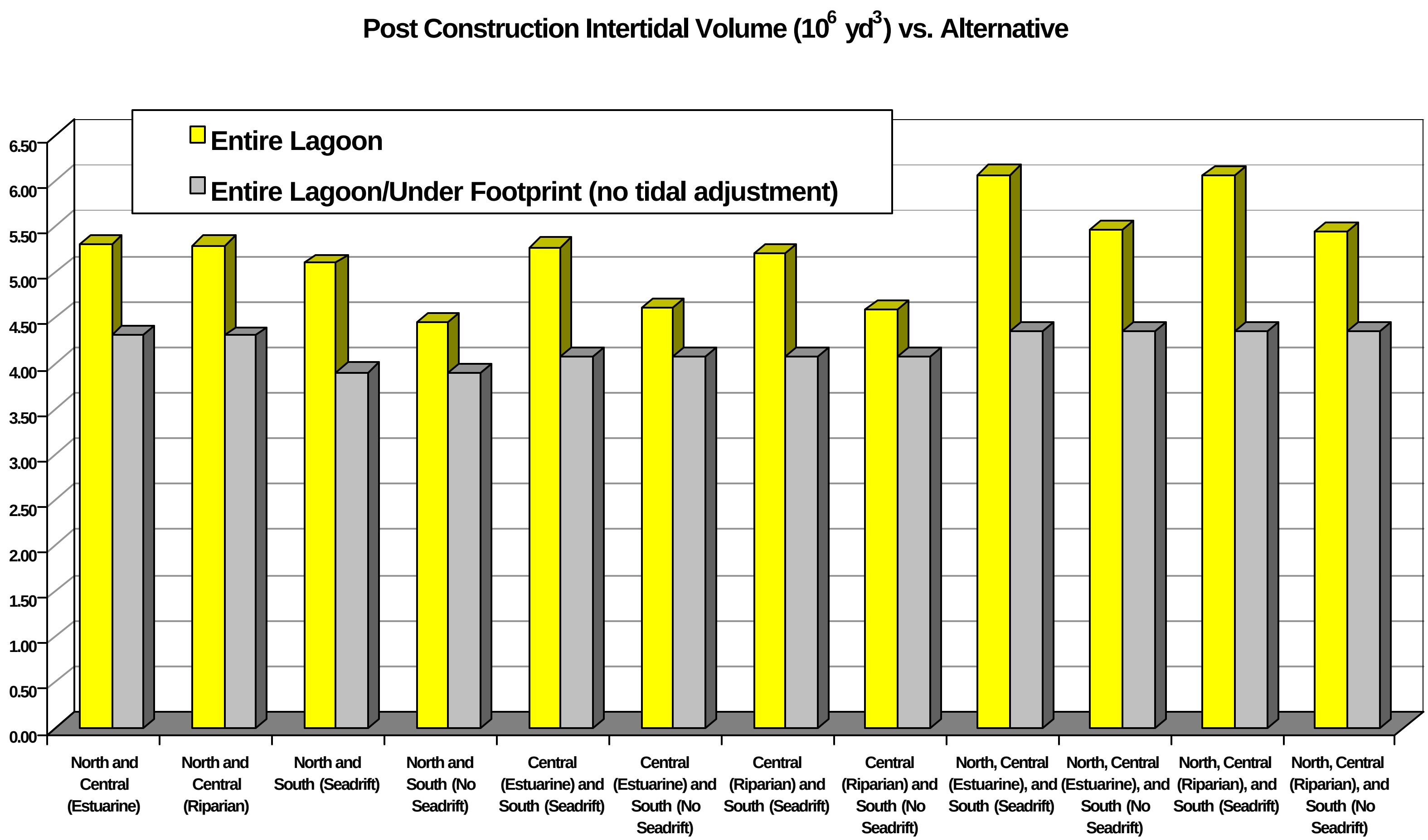


Figure 4.10 Intertidal Habitat Volume Change with Each Restoration Alternative Plan

4.6.2 North, Central (Estuarine), and South (Seadrift) Alternative Plan

This alternative plan would be considered the "full construction" plan, excavating material from all areas of the lagoon, including the North Basin, the Main Channel, the Highway One Fills, Pine Gulch Creek Delta, Bolinas Channel, Kent Island, the South Lagoon Channel, Dipsea Road and Seadrift Lagoon. It incorporates the North, Central (Estuarine) and South (Seadrift) alternatives. There would be 214 acres of diving duck habitat surface area, and 613,000 cy of diving duck habitat volume with this alternative plan (Table 4.10, page 4-35). Upland habitat surface area would decrease by 123 acres (Table 4.11, page 4-36). Intertidal habitat surface area would increase by 14 acres, and intertidal habitat volume would increase by 2,490,000 cy (Table 4.12, page 4-37). Subtidal habitat surface area would increase by 155 acres, and subtidal habitat volume would increase by 442,000 cy (Table 4.13, page 4-38). A total of 1,550,000 cubic yards of material would be removed, and the construction footprint would cover 488 acres (Figure 4.9, page 4-21). Subtidal and intertidal habitat volume increases are not equal to the volume of material removed because the total amount of material removed includes only sediment, whereas habitat measurements, because they are in volume, include air and water space between the elevations that define each habitat.

4.6.3 North, Central (Estuarine), and South (No Seadrift) Alternative Plan

This alternative plan is similar to the full construction plan in that it includes the Pine Gulch Creek Delta (Estuarine) component, which includes excavation of some riparian habitat in the delta, but there is no proposed construction for the Seadrift Lagoon component. Excavation would take place in most areas of the lagoon, including the North Basin, the Main Channel, the Highway One Fills, Pine Gulch Creek Delta, Bolinas Channel, Kent Island, the South Lagoon Channel and Dipsea Road. It incorporates the North, Central (Estuarine) and South (No Seadrift) alternatives. The South (No Seadrift) alternative consists only of Dipsea Road and the South Lagoon Channel. There would be 186 acres of diving duck habitat surface area, and 531,000 cy of diving duck habitat volume with this alternative plan (Table 4.10, page 4-35). Upland habitat surface area would decrease by 121 acres (Table 4.11, page 4-36). Intertidal habitat surface area would decrease by 16 acres, but intertidal habitat volume would increase by 1,876,000 cy (Table 4.12, page 4-37). Subtidal habitat surface area would increase by 138 acres, and subtidal habitat volume would increase by 367,000 cy (Table 4.13, page 4-38). A total of 1,505,000 cubic yards of material would be removed, and the construction footprint would cover 445 acres (Figure 4.9, page 4-21).

4.6.4 North, Central (Riparian) and South (Seadrift) Alternative Plan

This alternative plan is similar to the full construction plan, except that it includes the Pine Gulch Creek Delta (Riparian) component, which has a smaller footprint. Excavation would take place at all areas of the lagoon, including the North Basin, the Main Channel, the Highway One Fills, Pine Gulch Creek Delta, Bolinas Channel, Kent Island, the South Lagoon Channel, Dipsea Road and Seadrift Lagoon. It incorporates the North, Central (Riparian) and South (Seadrift) alternatives. As previously mentioned, the Pine Gulch Creek Delta (Riparian) component is like the Pine Gulch Creek Delta (Estuarine) component in that it would remove portions of the large deltaic formation on the west side of the lagoon, but it would avoid the riparian habitat area entirely. There would be 214 acres of diving duck habitat surface area, and 613,000 cy of diving duck habitat volume with this alternative plan (Table 4.10, page 4-35). Upland habitat surface area would decrease by 119 acres (Table 4.11, page 4-36). Intertidal habitat surface area would increase by 8 acres, and intertidal habitat volume would increase by 2,476,000 cy (Table 4.12, page 4-37). Subtidal habitat surface area would increase by 156 acres, and subtidal habitat volume would increase by 447,000 cy (Table 4.13, page 4-38). A total of 1,518,000 cubic yards of material would be removed, and the construction footprint would cover 472 acres (Figure 4.9, page 4-21).

4.6.5 North, Central (Riparian) and South (No Seadrift) Alternative Plan

This alternative plan would be somewhat smaller than the full construction plan, with a smaller construction footprint in the delta area and no proposed construction in Seadrift Lagoon. Material would be excavated from most areas of the lagoon, including the North Basin, the Main Channel, the Highway One Fills, Pine Gulch Creek Delta, Bolinas Channel, Kent Island, the South Lagoon Channel, and Dipsea Road. It incorporates the North, Central (Riparian) and South (No Seadrift) alternatives. As previously mentioned, the Pine Gulch Creek Delta (Riparian) component is like the Pine Gulch Creek Delta (Estuarine) component in that it would remove portions of the large deltaic formation on the west side of the lagoon, but it would avoid the riparian habitat area entirely. The South (No Seadrift) alternative consists only of Dipsea Road and the South Lagoon Channel. There would be 186 acres of diving duck habitat surface area, and 531,000 cy of diving duck habitat volume with this alternative plan (Table 4.10, page 4-35). Upland habitat surface area would decrease by 116 acres (Table 4.11, page 4-36). Intertidal habitat surface area would increase by 21 acres, and intertidal habitat volume would increase by 1,864,000 cy (Table 4.12, page 4-37). Subtidal habitat surface area would increase by 139 acres, and subtidal habitat volume would increase by 372,000 cy (Table 4.13, page 4-38). A total of 1,473,000 cubic yards of material would be removed, and the construction footprint would cover 429 acres (Figure 4.12, page 4-37).

4.6.6 North and Central (Estuarine) Alternative Plan

This alternative plan would include only the North and Central (Estuarine) alternatives, excavating material only from the North Basin, the Main Channel, the Highway One Fills, Pine Gulch Creek Delta, Bolinas Channel, and Kent Island. None of the South restoration components would be constructed with this alternative plan. There would be 195 acres of diving duck habitat surface area, and 550,000 cy of diving duck habitat volume with this alternative plan (Table 4.10, page 4-35). Upland habitat surface area would decrease by 112 acres (Table 4.11, page 4-36). Intertidal habitat surface area would decrease by 13 acres, but intertidal habitat volume would increase by 1,720,000 cy (Table 4.12, page 4-37). Subtidal habitat surface area would increase by 127 acres, and subtidal habitat volume would increase by 332,000 cy (Table 4.13, page 4-38). A total of 1,378,000 cubic yards of material would be removed, and the construction footprint would cover 419 acres (Figure 4.9, page 4-21).

4.6.7 North and Central (Riparian) Alternative Plan

This alternative plan would include only the North and Central (Riparian) alternatives, and would be somewhat smaller than the North and Central (Estuarine) alternative plan. Material would be excavated from the North Basin, the Main Channel, the Highway One Fills, Pine Gulch Creek Delta, Bolinas Channel, and Kent Island. As previously mentioned, the Pine Gulch Creek Delta (Riparian) component is like the Pine Gulch Creek Delta (Estuarine) component in that it would remove portions of the large deltaic formation on the west side of the lagoon, but it would avoid the riparian habitat area entirely. None of the South restoration components would be constructed in this alternative plan. There would be 195 acres of diving duck habitat surface area, and 550,000 cy of diving duck habitat volume with this alternative plan (Table 4.10, page 4-35). Upland habitat surface area would decrease by 108 acres (Table 4.11, page 4-36). Intertidal habitat surface area would decrease by 18 acres, but intertidal habitat volume would increase by 1,713,000 cy (Table 4.12, page 4-37). Subtidal habitat surface area would increase by 127 acres, and subtidal habitat volume would increase by 332,000 cy (Table 4.13, page 4-38). A total of 1,346,000 cubic yards of material would be removed, and the construction footprint would cover 403 acres (Figure 4.9, page 4-21).

4.6.8 Central (Estuarine) and South (Seadrift) Alternative Plan

This alternative plan would include only the Central (Estuarine) and South (Seadrift) alternatives. Material would be excavated from the Highway One Fills, Pine Gulch Creek Delta, Bolinas Channel, Kent Island, the South Lagoon Channel, Dipsea Road and Seadrift Lagoon. None of the North restoration components would be constructed in this alternative plan. There would be 112 acres of diving duck habitat surface area, and 475,000 cy of diving duck habitat volume with this alternative plan (Table 4.10, page 4-35). Upland habitat surface area would decrease by 113 acres (Table 4.11, page 4-36). Intertidal habitat surface area would decrease by 109 acres, but intertidal habitat volume would increase by 1,693,000 cy (Table 4.12, page 4-37). Subtidal habitat surface area would increase by 49 acres, and subtidal habitat volume would increase by 230,000 cy (Table 4.13, page 4-38). A total of 875,000 cubic yards of material would be removed, and the construction footprint would cover 315 acres (Figure 4, page 4-21).

4.6.9 Central (Estuarine) and South (No Seadrift) Alternative Plan

This alternative plan would include only the Central (Estuarine) and South (No Seadrift) alternatives, and would be somewhat smaller than the Central (Estuarine) and South (Seadrift) alternative plan. Material would be excavated from the Highway One Fills, Pine Gulch Creek Delta, Bolinas Channel, Kent Island, the South Lagoon Channel and Dipsea Road. The South (No Seadrift) alternative consists only of Dipsea Road and the South Lagoon Channel. None of the North restoration components would be constructed in this alternative plan. There would be 84 acres of diving duck habitat surface area, and 393,000 cy of diving duck habitat volume with this alternative plan (Table 4.10, page 4-35). Upland habitat surface area would decrease by 104 acres (Table 4.11, page 4-36). Intertidal habitat surface area would increase by 72 acres, and intertidal habitat volume would increase by 1,025,000 cy (Table 4.12, page 4-37). Subtidal habitat surface area would increase by 34 acres, and subtidal habitat volume would increase by

116,000 cy (Table 4.13, page 4-38). A total of 830,000 cubic yards of material would be removed, and the construction footprint would cover 271 acres (Figure 4.9, page 4-21).

4.6.10 Central (Riparian) and South (Seadrift) Alternative Plan

This alternative plan would include only the Central (Riparian) and South (No Seadrift) alternatives. Material would be excavated from the Highway One Fills, Pine Gulch Creek Delta, Bolinas Channel, Kent Island, the South Lagoon Channel, Dipsea Road and Seadrift Lagoon. As mentioned earlier, the modified Pine Gulch Creek Delta component is like the original Pine Gulch Creek component in that it would remove portions of the large deltaic formation on the west side of the lagoon, but it would avoid the riparian habitat area entirely. None of the North restoration components would be constructed in this alternative plan. There would be 112 acres of diving duck habitat surface area, and 475,000 cy of diving duck habitat volume with this alternative plan (Table 4.10, page 4-35). Upland habitat surface area would decrease by 107 acres (Table 4.11, page 4-36). Intertidal habitat surface area would increase by 101 acres, and intertidal habitat volume would increase by 1,621,000 cy (Table 4.12, page 4-37). Subtidal habitat surface area would increase by 51 acres, and subtidal habitat volume would increase by 239,000 cy (Table 4.13, page 4-38). A total of 843,000 cubic yards of material would be removed, and the construction footprint would cover 298 acres (Figure 4.9, page 4-21).

4.6.11 Central (Riparian) and South (No Seadrift) Alternative Plan

This alternative plan would include only the Central (Riparian) and South (No Seadrift) alternatives, and would be somewhat smaller than the Central (Riparian) and South (Seadrift) alternative plan. Material would be excavated from the Highway One Fills, Pine Gulch Creek Delta, Bolinas Channel, Kent Island, the South Lagoon Channel and Dipsea Road. As mentioned earlier, the modified Pine Gulch Creek Delta component is like the original Pine Gulch Creek component in that it would remove portions of the large deltaic formation on the west side of the lagoon, but it would avoid the riparian habitat area entirely. None of the North restoration components would be constructed in this alternative plan. The South (No Seadrift) alternative consists only of Dipsea Road and the South Lagoon Channel. There would be 84 acres of diving duck habitat surface area, and 393,000 cy of diving duck habitat volume with this alternative plan (Table 4.10, page 4-35). Upland habitat surface area would decrease by 99 acres (Table 4.11, page 4-36). Intertidal habitat surface area would increase by 66 acres, and intertidal habitat volume would increase by 998,000 cy (Table 4.12, page 4-37). Subtidal habitat surface area would increase by 35 acres, and subtidal habitat volume would increase by 119,000 cy (Table 4.13, page 4-38). A total of 798,000 cubic yards of material would be removed, and the construction footprint would cover 255 acres (Figure 4.9, page 4-21).

4.6.12 North and South (Seadrift) Alternative Plan

This alternative plan would include only the North and South (Seadrift) alternatives. Material would be excavated from the North Basin, the Main Channel, the South Lagoon Channel, Dipsea Road and Seadrift Lagoon. None of the Central restoration components would be constructed with this alternative plan. There would be 202 acres of diving duck habitat surface area, and 575,000 cy of diving duck habitat volume with this alternative plan (Table 4.10). Upland habitat surface area would decrease by 58 acres (Table 4.11, page 4-36). Intertidal habitat surface area would decrease by 46 acres, but intertidal habitat volume would increase by 1,515,000 cy (Table 4.12, page 4-37). Subtidal habitat surface area would increase by 149 acres, and subtidal habitat volume would increase by 496,000 cy (Table 4.13, page 4-38). A total of 847,000 cubic yards of material would be removed, and the construction footprint would cover 243 acres (Figure 4.9, page 4-21).

Table 4.10 Diving Duck Habitat with Each Alternative Plan

Summary	Surface Area acres	Volume cy
1968	95.64	379,986
1998	51.65	292,876
North, Central (Riparian), and South (No Seadrift)	185.77	530,958
North, Central (Estuarine), and South (No Seadrift)	185.77	530,926
North and South (No Seadrift)	173.72	493,503
North and Central (Riparian)	195.06	550,069
North, Central (Estuarine), and South (Seadrift)	214.36	612,675
North, Central (Riparian), and South (Seadrift)	214.36	612,707
North and South (Seadrift)	202.31	575,252
North and Central (Estuarine)	195.06	550,069
Central (Estuarine) and South (Seadrift)	112.20	475,044
Central (Riparian) and South (Seadrift)	112.20	475,012
Central (Estuarine) and South (No Seadrift)	83.61	393,295
Central (Riparian) and South (No Seadrift)	83.61	393,263

4.6.13 North and South (No Seadrift) Alternative Plan

This alternative plan would include only the North and South (No Seadrift) alternatives, and is the smallest of the final array of alternative plans. Material would be excavated from the North Basin, the Main Channel, the South Lagoon Channel and Dipsea Road. The South (No Seadrift) alternative consists only of Dipsea Road and the South Lagoon Channel. None of the Central restoration components would be constructed with this alternative plan. There would be 174 acres of diving duck habitat surface area, and 494,000 cy of diving duck habitat volume (1m to 3m below MSL; -2.70' and 8.70' NGVD) with this alternative plan (Table 4.10). Upland habitat surface area would decrease by 41 acres (Table 4.11, page 4-36). Intertidal habitat surface area would decrease by 105 acres, and intertidal habitat volume would increase by 874,000 cy (Table 4.12, page 4-37). Subtidal habitat surface area would increase by 146 acres, and subtidal habitat volume would increase by 407,000 cy (Table 4.13, page 4-38). A total of 802,000 cubic yards of material would be removed, and the construction footprint would cover 199 acres (Figure 4.9, page 4-21).

Table 4.11 Upland Habitat Changes with Each Alternative Plan

Alternative Plan	**1998 Levels Surface Area** acres	**Constructed Surface Area** acres	**Change In Habitat Surface Area** acres
North and Central (Estuarine)	238.10	125.64	-112.46
North and Central (Riparian)	238.10	130.07	-108.03
North and South (Seadrift)	238.10	179.78	-58.32
North and South (No Seadrift)	238.10	197.41	-40.69
Central (Estuarine) and South (Seadrift)	238.10	125.39	-112.71
Central (Estuarine) and South (No Seadrift)	238.10	134.28	-103.82
Central (Riparian) and South (Seadrift)	238.10	131.15	-106.95
Central (Riparian) and South (No Seadrift)	238.10	138.62	-99.48
North, Central (Estuarine), and South (Seadrift)	238.10	115.05	-123.05
North, Central (Estuarine), and South (No Seadrift)	238.10	117.47	-120.63
North, Central (Riparian), and South (Seadrift)	238.10	119.59	-118.51
North, Central (Riparian), and South (No Seadrift)	238.10	121.97	-116.13

Table 4.12 Intertidal Habitat Changes with Each Alternative Plan

	1998 Levels		Constructed		Change In Habitat	
	Surface Area	**Volume**	**Surface Area**	**Volume**	**Surface Area**	**Volume**
Alternative Plan	acres	cy	acres	cy	acres	cy
North and Central (Estuarine)	848.53	3,584,714	835.12	5,304,969	-13.41	1,720,255
North and Central (Riparian)	848.53	3,584,714	830.54	5,297,813	-17.99	1,713,100
North and South (Seadrift)	848.53	3,584,714	802.28	5,099,668	-46.24	1,514,954
North and South (No Seadrift)	848.53	3,584,714	744.03	4,458,622	-104.50	873,908
Central (Estuarine) and South (Seadrift)	848.53	3,584,714	957.79	5,277,954	109.26	1,693,240
Central (Estuarine) and South (No Seadrift)	848.53	3,584,714	920.04	4,609,638	71.51	1,024,924
Central (Riparian) and South (Seadrift)	848.53	3,584,714	949.20	5,205,799	100.67	1,621,085
Central (Riparian) and South (No Seadrift)	848.53	3,584,714	914.30	4,583,171	65.77	998,457
North, Central (Estuarine), and South (Seadrift)	848.53	3,584,714	862.34	6,074,382	13.82	2,489,668
North, Central (Estuarine), and South (No Seadrift)	848.53	3,584,714	832.87	5,460,468	-15.66	1,875,754
North, Central (Riparian), and South (Seadrift)	848.53	3,584,714	856.68	6,061,159	8.15	2,476,445
North, Central (Riparian), and South (No Seadrift)	848.53	3,584,714	827.31	5,448,416	-21.22	1,863,703

Table 4.13 Subtidal Habitat Changes with Each Alternative Plan

	1998 Levels		**Constructed**		**Change In Habitat**	
	Surface Area	**Volume**	**Surface Area**	**Volume**	**Surface Area**	**Volume**
Alternative Plan	acres	cy	acres	cy	acres	cy
North and Central (Estuarine)	146.39	523,318	272.94	855,584	126.55	332,266
North and Central (Riparian)	146.39	523,318	272.94	855,584	126.55	332,266
North and South (Seadrift)	146.39	523,318	295.64	1,019,817	149.25	496,499
North and South (No Seadrift)	146.39	523,318	292.70	930,011	146.31	406,693
Central (Estuarine) and South (Seadrift)	146.39	523,318	195.21	753,233	48.81	229,915
Central (Estuarine) and South (No Seadrift)	146.39	523,318	180.50	639,675	34.11	116,357
Central (Riparian) and South (Seadrift)	146.39	523,318	197.88	762,713	51.49	239,395
Central (Riparian) and South (No Seadrift)	146.39	523,318	181.75	642,561	35.35	119,243
North, Central (Estuarine), and South (Seadrift)	146.39	523,318	300.99	965,467	154.60	442,149
North, Central (Estuarine), and South (No Seadrift)	146.39	523,318	284.47	890,366	138.08	367,048
North, Central (Riparian), and South (Seadrift)	146.39	523,318	301.96	970,362	155.57	447,044
North, Central (Riparian), and South (No Seadrift)	146.39	523,318	285.39	894,995	139.00	371,677

5.0 PLAN EVALUATION

The final array of alternatives are first described, and then evaluated. Each plan is independently evaluated and compared to the No Action plan. In the Plan Evaluation step, factors such as short and long term environmental impacts, short and long term environmental benefits, costs, and "implementability" are taken into consideration. From the Incremental Cost Analysis, which compares the costs to the benefits, the National Ecosystem Restoration (NER) Plan is identified, which serves as the basis for project cost sharing.

5.1 Restoration Plans Identified in the Draft Feasibility Report

The plans identified in the Draft Feasibility Report are described below. *It should be noted that the Locally Preferred Plan (LPP) will not officially be selected or approved by the local sponsor until after the public review process. The LPP identified in this Draft Feasibility Report is the "tentatively selected LPP;" the Recommended Plan will not be finalized until the Final Feasibility Report, after continuing coordination with the local sponsor, results of the public review and public involvement process, and continuing refined evaluation of the ecosystem restoration alternatives.*

5.1.1 National Ecosystem Restoration Plan

The (NER) Plan is identified by the Federal government as the plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective. It is cost-effective and justified to achieve the desired level of outputs. The NER plan is the restoration alternative that the Federal government will recommend in the Final Feasibility report, unless an exemption from the NER is required, as with a Locally Preferred Plan, for example. The Federal government will cost share up to the price of the NER plan, at 65% Federal and 35% Non-Federal.

5.1.2 Locally Preferred Plan

LPP's may be identified in the Draft Feasibility report if the NER, or increments of the NER, are not supported by the public; do not include particular increments desirable to the local sponsor; or are not implementable because of management or funding constraints of the local sponsor. When the LPP is clearly of lesser scope and cost, and meets the Administration's policies for high-priority outputs, the Assistant Secretary for the Army (Civil Works) usually grants an exception for deviation. The increased scope of any plan more expensive than the NER would not warrant Federal cost-sharing participation. Thus, if the Locally Preferred Plan were larger in scope than the NER, the local sponsor would pay 100% of the difference between that plan and the NER.

5.1.3 Environmentally Preferred Plan

In the Draft EIS/R, an Environmentally Preferred Plan (EPP) will be identified under the California Environmental Quality Act (CEQA), based on an analysis of the short and long term impacts and benefits of each restoration alternative. It is possible that the Environmentally Preferred Plan will be the same as the NER and the LPP, but it may also be different. Some increments of the EPP may not warrant full Federal cost-sharing participation, be locally supported, or be capable of being financed by the local sponsor. In such a case, it would not be the recommended plan as presented in the Draft Feasibility and Draft EIS/R reports.

5.1.4 Recommended Plan

The Draft Feasibility report will present a "tentatively recommended plan" based on the analyses conducted to date. This tentatively recommended plan might be the NER plan, the LPP, the EPP, or a plan that is a combination thereof. As stated previously, the Federal government will share costs up to the cost of the NER plan. If the recommended plan were more expensive than the NER, the remaining cost would be the responsibility of the local sponsor to pay. A final recommendation will not be made until after the public review period, and will be based on public comments. The final recommended plan will appear in the Final Feasibility Report and Final EIS/R.

5.2 Plan Evaluation Tools

5.2.1 Hydraulic Modeling

To provide some insight into the lagoon's hydraulic conditions, including water levels and velocities, with each alternative constructed, a two dimensional (2D) hydrodynamic numerical model was used. The model used for this study was the Mike21 finite difference model from the Danish Hydraulic Institute (DHI). The model helped to confirm water level change trends, and provided channel velocities for the lagoon, illustrating potential scour (erosion) areas and other problem areas associated with the design of the alternatives. Although models provide important information, they must be used with caution. In addition to the normal shortfalls of any model, the fact that the Mike21 model lacks a movable bed (sediment transport) component must be considered when looking at the results. The background behind the hydraulic modeling and the results of the model runs can be found in the Engineering Appendix.

Because significant sediment movement will occur after construction, the hydrodynamics of the lagoon will probably change after construction. In order to better understand the relationship between the hydrodynamics and sediment movement in the lagoon, sediment transport modeling will be performed in the Pre-Construction Engineering and Design (PED) phase of the project. The results of this modeling will help fine-tune the final design of the restoration alternatives.

5.2.2 Habitat Evaluation Tools *Not* Used

5.2.2.1 Habitat Evaluation Procedures (HEP)

The US Fish and Wildlife Service determined that a full HEP analysis was not appropriate for Bolinas Lagoon because of the limitations of HEP in showing habitat functions and benefits in an estuarine system. However, a modified HEP analysis using cover type as a proxy for habitat evaluation was put together for the Draft Coordination Act Report, which appears as an appendix to the Feasibility Report. Although HEP can be used for terrestrial systems and has been adapted for use in wetland areas, as of yet, there have not been any HEP models developed for an estuarine lagoon system. Habitat Units are easy to work with and understand, but unfortunately, a full HEP analysis was not appropriate in this case.

5.2.2.2 Numbers of Species

Numbers of species were also not used as an indicator of project success because of our inability to predict changes in the system after a given stimulus, as well as our inability to decipher (due to a lack of historical ecological data and natural fluctuations in wildlife populations) short term and long term changes in the lagoon. That is, we would not be able to come up with an accurate number of population increase for any particular species because of larger, regional trends in those species or other factors unrelated to Bolinas Lagoon. In addition, because this kind of project has not been conducted before, it would be impractical to predict the exact outcome for any particular species. Using numbers of species as an indicator of project success would yield results with a high degree of uncertainty.

5.2.3 Habitat Evaluation Expert Panel (HEEP)

Because of the complexity of Bolinas Lagoon and the link between the hydrology and the biology, the Bolinas Lagoon Executive Committee convened a panel of experts – hydrologists and biologists familiar with the lagoon – to evaluate the alternatives. Modeled after the expert panel used in the Everglades project, and supported by the South Pacific Division, the Habitat Evaluation Expert Panel (HEEP) helped improve the plan formulation process and evaluate the acceptability and effectiveness of the alternatives. The following organizations made up the body of the expert panel: California Department Fish & Game, College of Marin, Gulf of the Farallones National Marine Sanctuary, Point Reyes Bird Observatory, Regional Water Quality Control Board, United States Geological Survey, Audubon Canyon Ranch, United States Fish & Wildlife Service, Golden Gate National Recreation Area, and Point Reyes National Seashore. In addition to the panel, the Corps provided a member of its staff to chair the meetings, a court reporter to make a record of the meetings, and the Bolinas Lagoon Project Team to answer any technical questions. As stated in the HEEP summary report:

> "Considering the complexity of the Bolinas Lagoon environment, as well as the interested and concerned participation of local residents, organizations and agencies, the Bolinas Lagoon Team (including the Corps and the local sponsor)

> [sought] the advice of an expert panel to evaluate each of the proposed project alternatives based on habitat considerations. By seeking the advice and consensus of a panel of experts, we hoped to discern the most effective, efficient and acceptable alternative for accomplishing the objectives of the project. As stated in the Project Study Plan (PSP), the Restoration Goals and Outputs for the Bolinas Lagoon Restoration Project are as follows:
>
>> 'The goal of the environmental restoration work performed at Bolinas Lagoon is to restore intertidal and subtidal habitat and stop further loss of these habitats through restoring tidal prism and improving circulation within the basin, while maintaining key mudflats, marsh vegetation, and other areas of biological importance. Although over the long term, sediment deposition will continue to fill the lagoon, this restoration project is intended to significantly slow the present rate of intertidal and subtidal habitat loss.'
>
> Through many hours of examination and discussion, the Habitat Evaluation Expert Panel has added integrity and durability to the plan formulation process and the analysis of the proposed restoration alternatives."

The HEEP succeeded in modifying the restoration components to make them more effective, expressed their concerns for particular species or groups of species, and identified the hydrological and ecological benefits of the project. Their analysis further promoted the project goals as stated in the PSP.

Red, Yellow, Green – Ranking the Restoration Components

As in the Everglades project, the HEEP was originally charged with evaluating the alternatives using a Red-Yellow-Green evaluation system. Red = no, or yes only with significant changes; Yellow = concerns exist, but some modification might appease those concerns; Green = yes. The panel, however, decided that all of the restoration components were different shades of Green; none were Yellow or Red. Because of the significant link between the hydrology and the ecology, the panel decided that any improvement in the hydrology would bring a concomitant improvement in the ecology. This is especially true because of how the alternatives were designed – to mimic historical conditions in the lagoon. One significant result of this analysis was that the panel concluded all of the restoration components were environmentally acceptable.

The Link Between Hydrology and Ecology

Since the panel was unable to differentiate the alternatives using the Red-Yellow-Green approach, they were then charged with ranking the alternatives based on their ecological benefit to the lagoon. It was apparent, however, after many hours of discussion, that it was impossible to separate the hydrology from the biology. The panel could establish ecological criteria, but they were unable to rank the alternatives against those criteria because they felt that each criterion had an intrinsic value that could not be ranked above or below another. Furthermore, because each criterion was associated with different hydrological criteria, it was impossible to separate the two, or even justify doing so. As a result, the panel decided to list the ecological and hydrological factors that should be considered when evaluating the components to see if a common link between the two could be found to use for the comparison. Looking at the list of target habitats desired by the panel (ecological factors), and the habitats associated with improving the hydrology of the system (hydrological factors), it became clear that the two were linked.

<u>Target Habitats (Ecological):</u> Shallow subtidal, subtidal, intertidal mudflats, emergent salt marsh, eelgrass, terrestrial, riparian or transition, and tidal nursery habitat

<u>Habitat (Hydraulic):</u> Quantity (or volume) of intertidal and subtidal habitats

The panel also noted what ecological benefits would arise from an increase in intertidal and subtidal habitats. They assumed, for example, that an increase in subtidal habitat would bring about a benefit to fisheries, diving birds, and foraging seals, as well as create the potential for the return of eelgrass once present in the lagoon. A benefit to fisheries in the lagoon would also increase the value of the surrounding streams to the fish, creating an overall benefit for this group. These benefits are brought on by improved foraging habitat (due to an improved habitat for prey), improved rearing and nursery habitat, greater potential for escape from predators, and a greater diversification of habitats in the lagoon. The intertidal habitat zone is a source of food for many species higher in the food chain. The mudflats and wetland areas which serve as habitat for plants and invertebrates serve as feeding areas and nursery habitats for a variety of species. An increase in intertidal habitat is seen as an overall benefit to the lagoon system. Thus, since an increase in intertidal habitat brings about an increase in subtidal habitat, we can assume that the lagoon system would see an overall improvement (an improvement in hydrology and biology) if intertidal volume were increased.

After the panel determined that, not only could they not separate the biology from the hydrology, but that they were unable to rank the alternatives based on the criteria they had developed (after all, any of the restoration components would provide some level of benefit to the lagoon), the Corps suggested intertidal volume would be an appropriate parameter to use to demonstrate an overall benefit to the lagoon system. When this idea was presented to the expert panel, it was approved.

5.3 Project Benefits

As mentioned in Section 4.5 of this report (Formulation of Alternative Plans and Initial Screening), intertidal volume was selected as the hydrological parameter by which to measure benefits and compare alternative plans. Intertidal volume is measured in cubic yards, and represents an overall increase in tidal prism, intertidal and subtidal habitats, and a delay of inlet closure potential. This metric was used in the Incremental Cost Analysis, which is presented in Section 5.4.2 under Description of Costs.

5.3.1 Historical and Projected Volumes and Habitats

Tables 5.1 – 5.14 show the relationships between the Future Without Project Conditions (that is, what the lagoon would look like in the future with the No Action Plan) to each of the final alternatives. If no action is taken in the lagoon, and current management practices continue, subtidal and intertidal habitats can be expected to decrease at an accelerated rate because of past watershed practices that have already filled a significant portion of the lagoon. The expected losses in habitat between Year 1998 and Year 2008 are estimated to be 523,000 cy to 503,000 cy (a loss of 20,000 cy, or 3.8%) for subtidal habitat, and 3,585,000 cy to 3,242,000 cy (a loss of 343,000 cy, or 9.6%) for intertidal habitat. Between Years 1998 and 2058, the expected loss for subtidal habitat is estimated to be 523,000 cy to 411,000 cy (a loss of 112,000 cy, or 21.4%), and 3,585,000 cy to 1,677,000 cy (a loss of 908,000 cy, or 25.3%) for intertidal habitat. As illustrated in the table however, each restoration alternative plan would increase intertidal and subtidal habitat by varying amounts, "setting the clock back" to a greater or lesser degree. If the trend that was present from 1968 to 1998 were to continue in the future, the projected sediment discharge rate from the watershed is estimated to be 22,000 cy annually.

To facilitate analysis of the data, construction is assumed to take place in the year 2008, and data from 1998 is assumed the current condition. Construction could happen as soon as 2004, and could last as long as nine years (until 2013). Because bathymetries were taken every decade from 1968 – 1998, assuming construction in 2008 is a logical progression, and makes for easier calculations. In addition, because construction would span several years, it's easier to compare the data if it is assumed that construction is "instantaneous." 2008 is also the midway point between 2004 and 2013. For these reasons, 2008 is a convenient year to use for the construction date.

Intertidal and subtidal habitat levels associated with each alternative plan are illustrated in Figures 5.1 (intertidal surface area), 5.2 (intertidal volume), 5.3 (subtidal surface area), and 5.4 (subtidal volume). It is assumed that with construction of these alternative plans, water levels will change in the entire lagoon to reflect the change in equilibrium produced by increased tidal volume. Therefore, the larger the footprint an alternative has, the greater the relative increase in tidal volume that will result.

5.3.2 Inlet Closure and Tidal Prism Benefits

In addition to measuring habitat quantities, two key physical or hydraulic parameters were measured for each alternative. The first was tidal prism, determined using bathymetric data. In Chapter 4 (Figure 4.10), tidal prism is shown as intertidal volume since the definitions of each are nearly identical. The second was the "inlet closure index" formulated by O'Brien 1971, the time of potential inlet closure. This parameter is directly related to tidal prism. As tidal volume increases, more water flows through the inlet, which scours the inlet and keeps it open. As tidal volume decreases, less water flows through the inlet, allowing more sediment to deposit, leading to a less stable inlet, which is more prone to closing.

Table 5.1 Historical Habitats

Year	Lagoon Volume (3.15' NGVD) cy	Upland acres	Upland cy	Intertidal acres	Intertidal cy	Subtidal acres	Subtidal cy
1968	6,489,855	155.82	7,634,688	876.12	5,580,284	213.38	641,298
1978	5,635,908	197.29	7,943,862	867.50	4,363,639	157.06	533,966
1988	5,390,737	243.43	7,894,691	844.65	3,868,717	127.25	690,093
1998	5,126,588	238.10	8,243,436	848.53	3,584,714	146.39	523,318

Table 5.2 Without Project Habitats

Year	Lagoon Volume cy	Upland acres	Upland cy	Intertidal acres	Intertidal cy	Subtidal acres	Subtidal cy
2008	4,883,508	252.77	8,351,980	843.61	3,228,889	134.45	502,281
2018	4,652,007	266.74	8,455,354	838.92	2,890,014	123.07	482,246
2038	4,223,741	292.59	8,646,590	830.25	2,263,112	102.03	445,183
2058	3,841,791	315.64	8,817,144	822.52	1,704,008	83.26	412,128

Table 5.3 Projected Habitats with the North, Central (Estuarine), and South (Seadrift) Alternative Plan

Year	Lagoon Volume cy	Upland acres	Upland cy	Intertidal acres	Intertidal cy	Subtidal acres	Subtidal cy
2008	7,039,849	115.05	7,619,566	862.34	6,074,382	300.99	965,467
2018	6,808,347	136.60	7,492,470	882.57	6,046,498	229.03	668,861
2038	6,380,081	162.45	7,683,706	873.90	5,419,596	207.99	631,798
2058	5,998,132	185.50	7,854,260	866.17	4,860,493	189.22	598,743

Table 5.4 Projected Habitats with the North, Central (Estuarine), and South (No Seadrift) Alternative Plan

Year	Lagoon Volume cy	Upland acres	Upland cy	Intertidal acres	Intertidal cy	Subtidal acres	Subtidal cy
2008	6,567,513	117.47	7,568,491	832.87	5,460,468	284.47	890,366
2018	6,336,011	165.11	7,703,385	873.01	5,355,085	205.82	627,984
2038	5,907,745	190.96	7,894,621	864.34	4,728,183	184.78	590,921
2058	5,525,796	214.01	8,065,175	856.61	4,169,080	166.01	557,866

Table 5.5 Projected Habitats with the North, Central (Riparian), South (Seadrift) Alternative Plan

Year	Lagoon Volume cy	Upland acres	Upland cy	Intertidal acres	Intertidal cy	Subtidal acres	Subtidal cy
2008	7,031,522	119.59	7,599,700	856.68	6,061,159	301.96	970,362
2018	6,800,020	137.10	7,496,188	882.40	6,034,308	228.62	668,141
2038	6,371,754	162.95	7,687,424	873.73	5,407,407	207.58	631,078
2058	5,989,805	186.00	7,857,978	866.00	4,848,303	188.81	598,023

Table 5.6 Projected Habitats with the North, Central (Riparian), South (No Seadrift) Alternative Plan

Year	Lagoon Volume cy	Upland acres	Upland cy	Intertidal acres	Intertidal cy	Subtidal acres	Subtidal cy
2008	6,559,185	121.97	7,547,720	827.31	5,448,416	285.39	894,995
2018	6,327,684	165.61	7,707,103	872.84	5,342,896	205.41	627,264
2038	5,899,418	191.46	7,898,339	864.17	4,715,994	184.37	590,201
2058	5,517,469	214.51	8,068,894	856.44	4,156,891	165.60	557,146

Table 5.7 Projected Habitats with the North and Central (Estuarine) Alternative Plan

Year	Lagoon Volume cy	Upland acres	Upland cy	Intertidal acres	Intertidal cy	Subtidal acres	Subtidal cy
2008	6,448,346	125.64	7,619,159	835.12	5,304,969	272.94	855,584
2018	6,216,845	172.30	7,756,597	870.60	5,180,648	199.97	617,671
2038	5,788,579	198.15	7,947,833	861.93	4,553,746	178.92	580,608
2058	5,406,630	221.20	8,118,387	854.20	3,994,643	160.15	547,553

Table 5.8 Projected Habitats with the North and Central (Riparian) Alternative Plan

Year	Lagoon Volume cy	Upland acres	Upland cy	Intertidal acres	Intertidal cy	Subtidal acres	Subtidal cy
2008	6,439,988	130.07	7,598,088	830.54	5,297,813	272.94	855,584
2018	6,208,486	172.81	7,760,329	870.43	5,168,412	199.56	616,948
2038	5,780,221	198.65	7,951,565	861.76	4,541,511	178.51	579,885
2058	5,398,271	221.70	8,122,120	854.03	3,982,407	159.74	546,830

Table 5.9 Projected Habitats with the North and South (Seadrift) Alternative Plan

Year	Lagoon Volume cy	Upland acres	Upland cy	Intertidal acres	Intertidal cy	Subtidal acres	Subtidal cy
2008	6,422,586	179.78	7,816,253	802.28	5,099,668	295.64	1,019,817
2018	6,191,085	173.86	7,768,100	870.08	5,142,940	198.70	615,442
2038	5,762,819	199.70	7,959,336	861.41	4,516,038	177.66	578,379
2058	5,380,870	222.75	8,129,890	853.68	3,956,934	158.89	545,324

Table 5.10 Projected Habitats with the North and South (No Seadrift) Alternative Plan

Year	Lagoon Volume cy	Upland acres	Upland cy	Intertidal acres	Intertidal cy	Subtidal acres	Subtidal cy
2008	5,950,250	197.41	7,807,015	744.03	4,458,622	292.70	930,011
2018	5,718,749	202.36	7,979,015	860.52	4,451,527	175.49	574,565
2038	5,290,483	228.21	8,170,251	851.85	3,824,625	154.45	537,502
2058	4,908,534	251.26	8,340,805	844.11	3,265,522	135.68	504,447

Table 5.11 Projected Habitats with the Central (Estuarine) and South (Seadrift) Alternative Plan

Year	Lagoon Volume cy	Upland acres	Upland cy	Intertidal acres	Intertidal cy	Subtidal acres	Subtidal cy
2008	6,349,335	125.39	7,937,626	957.79	5,277,954	195.21	753,233
2018	6,117,834	178.28	7,800,809	868.59	5,035,713	195.10	609,103
2038	5,689,568	204.12	7,992,045	859.92	4,408,812	174.06	572,040
2058	5,307,618	227.18	8,162,599	852.19	3,849,708	155.29	538,985

Table 5.12 Projected Habitats with the Central (Estuarine) and South (No Seadrift) Alternative Plan

Year	Lagoon Volume cy	Upland acres	Upland cy	Intertidal acres	Intertidal cy	Subtidal acres	Subtidal cy
2008	5,876,999	134.28	7,979,410	920.04	4,609,638	180.50	639,675
2018	5,645,497	206.78	8,011,724	859.03	4,344,301	171.89	568,226
2038	5,217,232	232.63	8,202,960	850.36	3,717,399	150.85	531,162
2058	4,835,282	255.68	8,373,515	842.63	3,158,295	132.08	498,108

Table 5.13 Projected Habitats with the Central (Riparian) and South (Seadrift) Alternative Plan

Year	Lagoon Volume cy	Upland acres	Upland cy	Intertidal acres	Intertidal cy	Subtidal acres	Subtidal cy
2008	6,340,935	131.15	7,972,073	949.20	5,205,799	197.88	762,713
2018	6,109,434	178.78	7,804,560	868.42	5,023,418	194.69	608,376
2038	5,681,168	204.63	7,995,796	859.75	4,396,516	173.64	571,313
2058	5,299,218	227.68	8,166,350	852.02	3,837,412	154.88	538,258

Table 5.14 Projected Habitats with the Central (Riparian) and South (No Seadrift) Alternative Plan

Year	Lagoon Volume cy	Upland acres	Upland cy	Intertidal acres	Intertidal cy	Subtidal acres	Subtidal cy
2008	5,868,599	138.62	7,974,763	914.30	4,583,171	181.75	642,561
2018	5,637,098	207.29	8,015,475	858.86	4,332,005	171.48	567,499
2038	5,208,832	233.14	8,206,711	850.19	3,705,103	150.43	530,435
2058	4,826,882	256.19	8,377,265	842.46	3,146,000	131.66	497,381

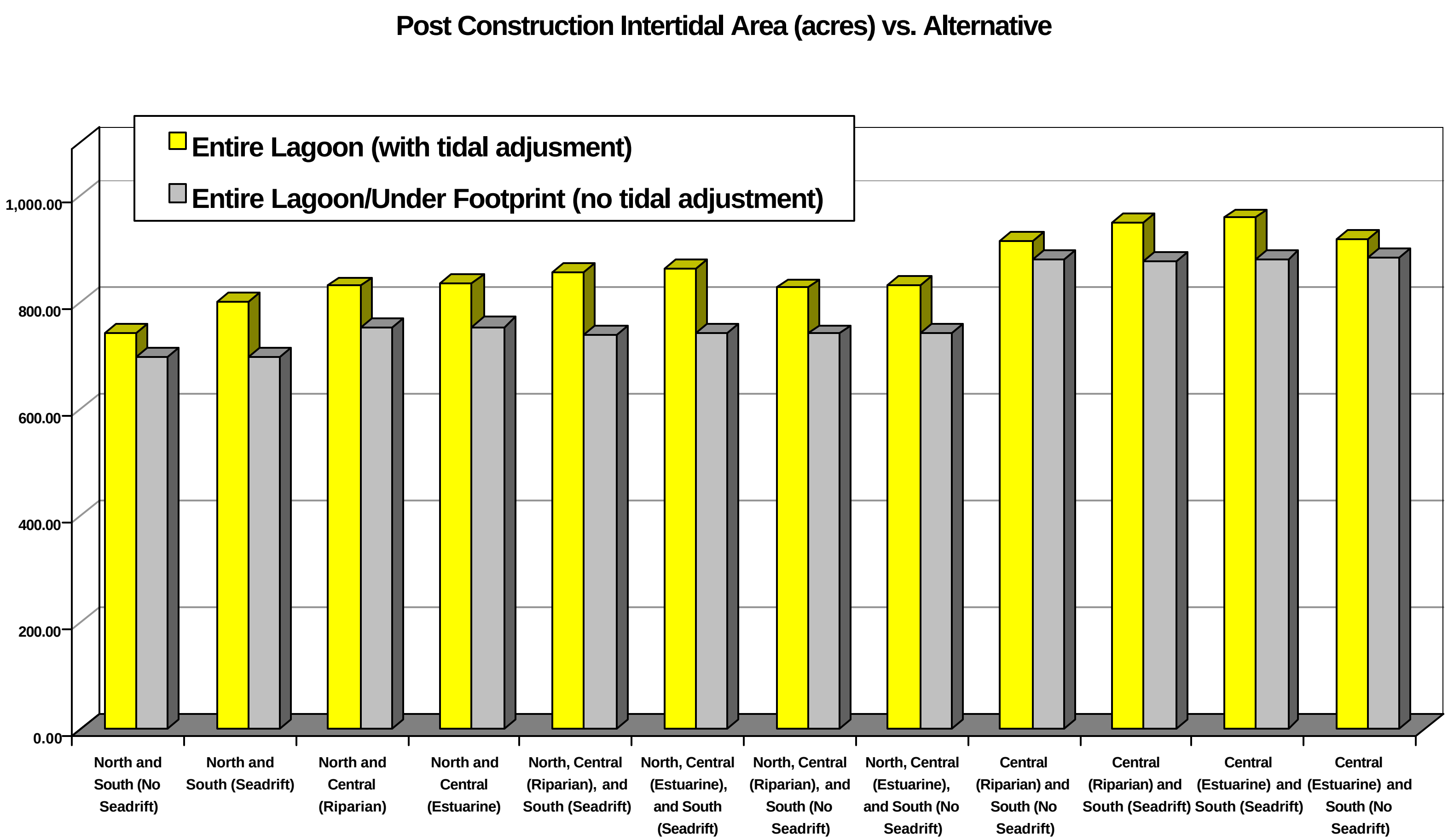


Figure 5.1 Intertidal Habitat Surface Area Changes with Each Alternative Plan

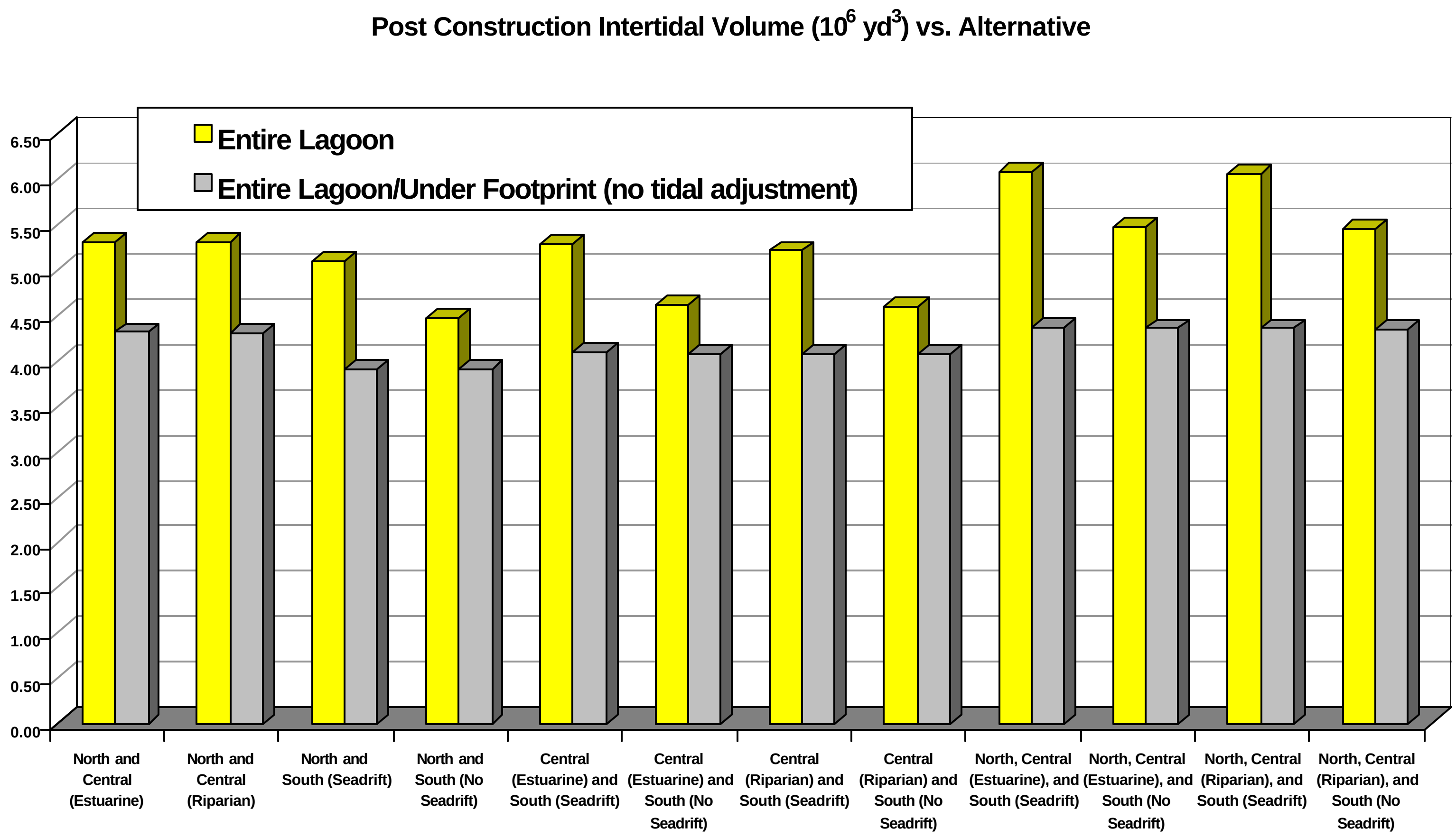


Figure 5.2 Intertidal Habitat Volume Changes with Each Alternative Plan

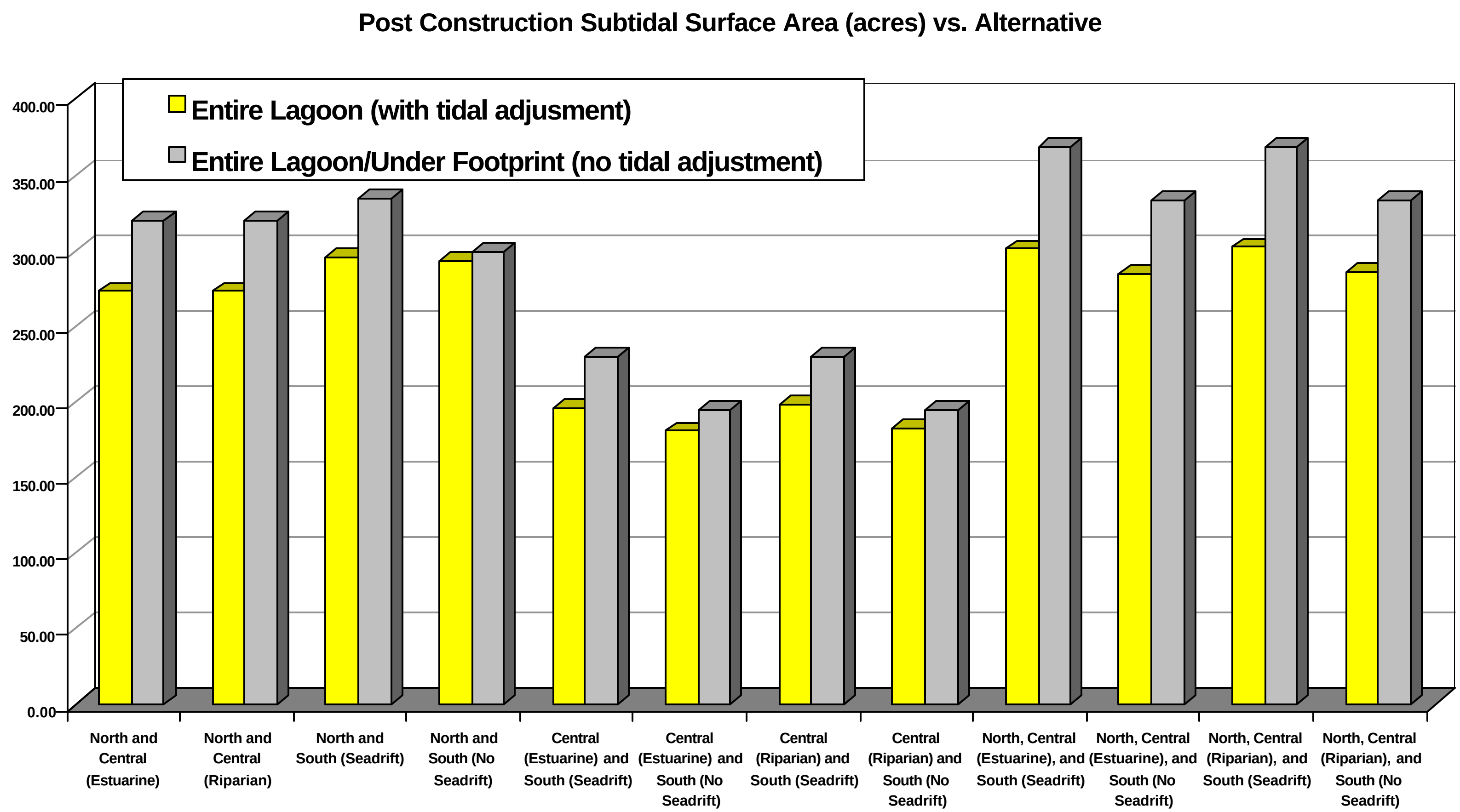


Figure 5.3 Subtidal Habitat Surface Area Changes with Each Alternative Plan

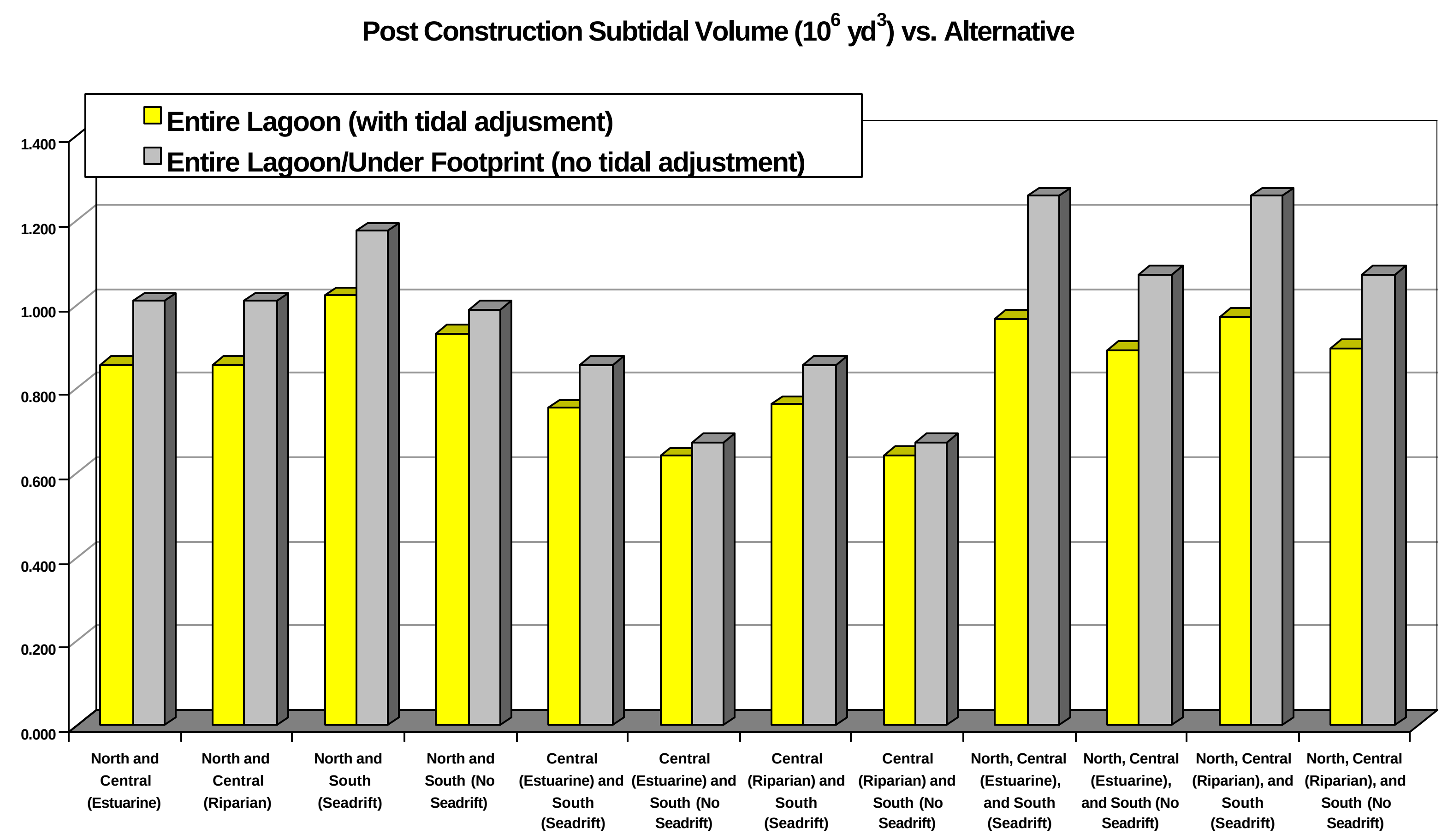


Figure 5.4 Subtidal Habitat Volume Changes with Each Alternative Plan

Table 5.15 shows the closure index for 1998 and the resulting closure index for each alternative (including the No Action alternative) out to the year 2058. In the Without Project Condition, under a worst-case scenario, the inlet could close by 2048. Worst case means a large storm (big waves), with little rain over the lagoon's watershed (minimal fresh water input), during a neap tidal cycle (low tidal flow through inlet).

The lower the index number, the less likely the lagoon inlet will experience temporary closure. As Table 5.15 illustrates, the alternative plans that have a larger footprint have lower inlet closure indices, ranging from as low as 8.8, with the full construction alternative plan [North, Central (Estuarine), South (Seadrift)], to 14.0 with the smallest alternative plan [South (No Seadrift)]. The data illustrate how each alternative plan affects future inlet closure potential. With the full construction alternative plan, for example, the inlet would be more stable in 2058 than it is now, 8.8 is lower than 10.5, and it would be far more stable than if no project were constructed, 8.8 is significantly lower than 16.2.

Table 5.15 Inlet Stability*

Alternative	Year				
	1998	2008	2018	2038	2058
Without Project	10.5	11.2	12.0	13.9	16.1
Central (Estuarine) and South (Seadrift)		8.4	8.5	9.4	10.4
Central (Estuarine) and South (No Seadrift)		9.0	9.4	10.5	11.7
Central (Riparian) and South (Seadrift)		8.4	8.5	9.5	10.4
Central (Riparian) and South (No Seadrift)		9.0	9.4	10.5	11.8
North and South (Seadrift)		8.5	8.2	9.0	9.9
North and South (No Seadrift)		9.0	9.0	10.0	11.1
North and Central (Estuarine)		8.2	8.2	9.1	10.0
North and Central (Riparian)		8.2	8.2	9.1	10.0
North, Central (Estuarine), and South (Seadrift)		7.6	7.4	8.1	8.8
North, Central (Estuarine), and South (No Seadrift)		8.1	8.0	8.8	9.7
North, Central (Riparian), and South (Seadrift)		7.6	7.4	8.1	8.8
North, Central (Riparian), and South (No Seadrift)		8.1	8.0	8.8	9.7

*closure can occur at condition index of 15

5.3.3 Habitat-Based Analysis for Lesser Scaup

This Feasibility Study evaluates an array of alternatives that would increase the tidal prism, enlarge the volume of water in the lagoon, and retard the successional processes that have been converting the lagoon to dry land. While the action alternatives would certainly achieve the physical outputs of improved water quality and sediment flux, these structural components are not, per se, ecological benefits. To further demonstrate the ecological benefits of the project, which are associated with an increase in water volume and surface area, an analysis was conducted to show habitat benefits to one particular species in the diving duck guild, the Lesser Scaup (*Athya affinis*).

Since the restoration alternatives would bring the lagoon bathymetry back to a historical condition (around the 1950's), we would expect to see an increase in the species that are dependent on lower intertidal and subtidal habitat, which have decreased as the lagoon has become shallower. Using available historical data, resource losses and losses in tidal volume have been assessed, tying in the goals of the restoration effort to the restoration benefits that are expected to occur with increases in tidal volume and habitat acreages. This data, along with information on the historic utilization of the lagoon complex by fish and wildlife resources, has been used to evaluate the positive correlation between intertidal volumes and habitat output benefits.

Along with the physical changes of the lagoon, stakeholders have observed a decline in the numbers of migratory waterfowl using the lagoon. Wild populations vary in size over time and space, making it difficult to quantify trends in abundance with census data from any one location. However, coastal lagoons like Bolinas provide very significant feeding and resting habitat for birds that use shallow water habitat, and the conversion of shallow water habitat to mudflat or upland could have a significant adverse impact on waterfowl. As seen in Table 5.2, there has been a 53% reduction in shallow water habitat suitable for diving waterfowl between 1968 and 1998. Project alternatives have the potential to make a substantial increase in this type of habitat.

To illustrate the benefit to the diving waterfowl guild of birds, a brief habitat evaluation was prepared. This habitat metric is derived from: *Habitat Suitability Index Models: Lesser Scaup (Wintering)* U.S. DOI FWS Biological Report 82(10.91) April 1985. This model was selected because the numbers of scaup observed at Bolinas Lagoon have decreased in recent time, and because the variables in the model can be used to assess estuarine habitat. The model contains four variables: percent area with clams, percent area with emergent vegetation, human disturbance of feeding, and mean water depth. For the scaup, the minimal emergent vegetation and low human disturbance are optimal. The lagoon currently has roughly 50 acres of habitat that would be optimal feeding depth (1- 3m) and would be populated with clams.

The results of the Lesser Scaup analysis are detailed in Table 5.16 and Figure 5.5. The full construction alternative plan [North, Central (Estuarine) and South (Seadrift)] would increase optimal feeding habitat to 214 acres, a four fold increase compared to 1998. The minimal construction alternative [South (No Seadrift)] would increase optimal feeding habitat to 71 acres, an increase of approximately 37%.

Although each component of the restoration alternative plans is unique – some increase intertidal and subtidal habitat significantly, some provide a means for water flow to reach new areas of the lagoon (e.g., channels), some create new habitat where once it never existed, or where it was present historically but has been lost over time, and some provide new areas for shoaling – the analyses performed for this Feasibility Study demonstrate that, in general, an increase in tidal volume (i.e., tidal prism), and an improvement in tidal flow and sediment movement in the lagoon will provide an overall benefit to fish and wildlife habitat in the lagoon, and will keep the inlet open for a greater period of time than if no actions were taken. Habitat-based analyses being conducted concurrently with this Feasibility Study by the US Fish and Wildlife Service for the Draft Coordination Act Report, which will show habitat benefits with predicted changes in cover types, are expected to confirm this analysis.

Table 5.16 Surface Area and Volume of Diving Duck Habitat with Each Alternative Plan (Between Depth of 1m to 3m below MSL; -2.70' and 8.70' NGVD)

Summary	**Surface Area** Acres	**Volume** cy
1968	95.64	379,986
1998	51.65	292,876
North, Central (Riparian), and South (No Seadrift)	185.77	530,958
North, Central (Estuarine), and South (No Seadrift)	185.77	530,926
North and South (No Seadrift)	173.72	493,503
North and Central (Riparian)	195.06	550,069
North, Central (Estuarine), and South (Seadrift)	214.36	612,675
North, Central (Riparian), and South (Seadrift)	214.36	612,707
North and South (Seadrift)	202.31	575,252
North and Central (Estuarine)	195.06	550,069
Central (Estuarine) and South (Seadrift)	112.20	475,044
Central (Riparian) and South (Seadrift)	112.20	475,012
Central (Estuarine) and South (No Seadrift)	83.61	393,295
Central (Riparian) and South (No Seadrift)	83.61	393,263

5.4 Project Costs

5.4.1 Cost Estimates

A summary of the costs associated with each of the restoration alternative plans is listed in Table 5.17, page 18. A more detailed list of these costs, and details about how the design quantities and unit cost estimates were generated, are presented in the Engineering Appendix.

5.4.2 Description of Costs

5.4.2.1 Project First Costs

Project first costs are the “financial” costs of the project, including all the costs one would incur if s/he were going to “buy” the project, such as labor, machinery, disposal fees, easement fees, etc. For the Bolinas Lagoon project, first costs include dredging and disposal costs; land construction costs; real estate costs (LERR costs); monitoring and adaptive management costs; and Engineering and Design (E&D), Supervisory and Administration (S&A), and Escalation (to the mid-point of construction).

5.4.2.2 Interest During Construction (IDC) Costs

Interest during construction (IDC) is an economic cost, or an implicit cost. Implicit costs do not involve cash, and are often overlooked in decision analysis. Interest during construction is the opportunity cost of completing the project, or the expense that is incurred, theoretically, while work is not being done (because of dredging windows or

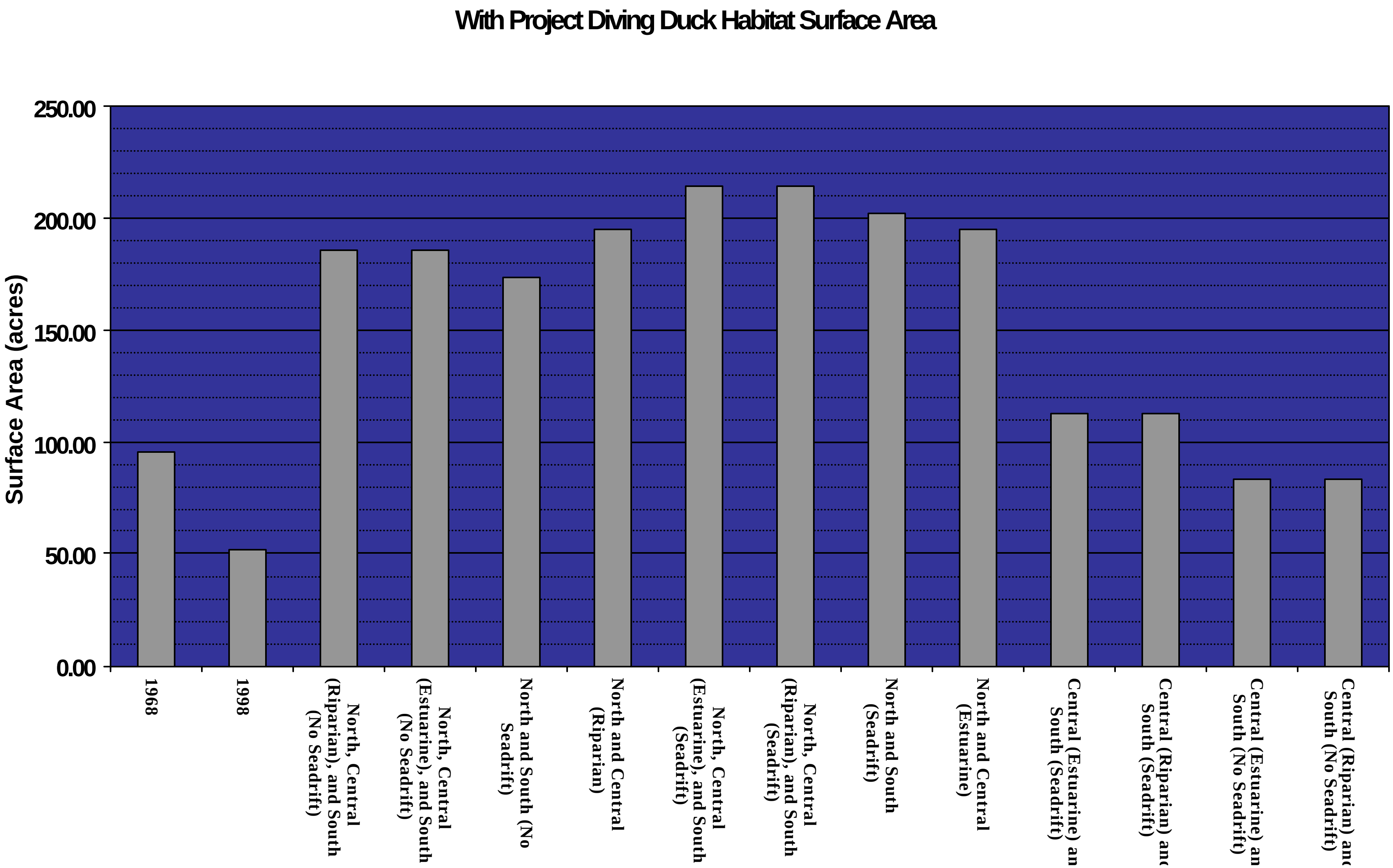


Figure 5.5 Diving Duck Habitat Surface Areas Associated with Each Alternative Plan

Table 5.17 Summary of Costs Associated with Each Alternative Plan

Alternative Plans	Dredging & Disposal Costs	Land Construction Costs	Real Estate Costs	Monitoring Costs	Adaptive Management Costs	Construction* Costs	Total Project First Costs
North and Central (Estuarine)	$62,278,600	$3,950,800	$2,031,400	$682,608	$2,047,824	$20,445,475	**$91,436,707**
North and Central (Riparian)	$61,655,600	$4,705,500	$2,031,400	$687,917	$2,063,751	$20,604,490	**$92,847,139**
North and South (Seadrift)	$39,877,600	$4,105,400	$2,031,400	$460,144	$1,380,432	$13,782,233	**$57,147,858**
North and South (No Seadrift)	$36,673,500	$2,296,700	$2,031,400	$410,016	$1,230,048	$12,280,799	**$54,922,463**
Central and South (Seadrift)	$41,815,400	$5,521,200	$2,031,400	$493,680	$1,481,040	$14,786,703	**$66,129,423**
Central and South (No Seadrift)	$38,611,300	$2,830,333	$2,031,400	$434,730	$1,304,191	$13,021,043	**$58,232,997**
Central (Riparian) and South (Seadrift)	$41,192,400	$5,558,700	$2,031,400	$487,825	$1,463,475	$14,611,344	**$65,345,134**
Central (Riparian) and South (No Seadrift)	$37,988,300	$3,750,000	$2,031,400	$437,697	$1,313,091	$13,109,901	**$58,630,389**
North, Central (Estuarine) and South (Seadrift)	$71,985,800	$6,808,500	$2,031,400	$808,257	$2,424,771	$24,208,914	**$108,267,642**
North, Central (Estuarine) and South (No Seadrift)	$68,781,700	$4,999,800	$2,031,400	$758,129	$2,274,387	$22,707,480	**$101,552,896**
North, Central (Riparian) and South (Seadrift)	$71,362,800	$6,806,400	$2,031,400	$802,006	$2,406,018	$24,021,684	**$107,430,308**
North, Central (Riparian) and South (No Seadrift)	$68,158,700	$4,997,700	$2,031,400	$751,878	$2,255,634	$22,520,250	**$100,715,562**

*Construction costs, in this case, include Engineering & Design (E&D), Supervisory & Administration (S&A), and Escalation to the mid-point of construction.

other restrictions). During those down times, money is committed to the project (or contractor) instead of earning interest. IDC is a cost that is added to the total of all project first costs.

5.4.2.3 Lands, Easements, Rights of Way, and Relocations (LERR) Costs

LERR costs for any alternative plan in the Bolinas Lagoon project would include land costs (fee), permanent channel improvement easements, a temporary pipeline easement, temporary road easements, and temporary work area easements. These costs represent a small percentage of the cost to implement the project, approximately 1 – 2% of the total project costs. LERR costs are also known as Real Estate Costs.

5.4.2.4 Monitoring & Adaptive Management Costs

Monitoring costs are assumed to be 1% of the construction costs of the project, as specified in ER 1105-2-100. Monitoring costs will include pre-implementation baseline measurements, during-construction monitoring, and post-implementation monitoring for a period of up to five years. Any monitoring or surveillance activities after the five year period would be considered Operations and Maintenance (O&M), and would be the responsibility of the local sponsor. As the design of the project is developed during the PED phase, these costs will be further refined to reflect new information.

Adaptive management costs are assumed to be 3% of the construction costs of the project as defined in the Engineering Regulation ER 1105-2-100, where it is stated, "For complex specifically authorized projects that have high levels of risk and uncertainty of obtaining the proposed outputs, adaptive management may be recommended. The cost of the adaptive management action, if needed, will be limited to 3 percent of the total project cost excluding monitoring costs." Adaptive management activities are expected to continue for at least five years after all of the restoration alternatives have been implemented. Any adaptive management undertaken after the five-year period would be considered O&M, and would be the responsibility of the local sponsor. Once again, as the design of the project is developed during the PED phase, these costs will be further refined to reflect new information. The costs listed for monitoring and adaptive management are a total cost, and are expected to encompass one year of pre-implementation monitoring, 8-9 years of construction, and 5 years of post-implementation monitoring.

5.4.2.5 Operation and Maintenance (O&M) Costs

The Conceptual Monitoring and Adaptive Management Plan, as outlined in Chapter 7 (Section 7.11 Monitoring and Adaptive Management), will form the basis of the O&M plan as all planned O&M activities are expected to be contained within this plan. Because the level of uncertainty is high during the feasibility phase, it is difficult to estimate annual O&M costs. O&M activities include maintenance, surveillance and inspection measures performed to ensure that project benefits are being obtained. Since the lagoon is expected to be self-sustaining, O&M activities for Bolinas Lagoon would most likely be more intensive right after the construction phase ended, and less intensive later on. For feasibility purposes, total O&M costs were assumed to be equal to the total monitoring and adaptive management costs, divided by 15 (years). This is the period of time expected to be the most labor-intensive part of O&M, which is conducted for the life of the project (perpetuity). O&M activities and associated costs will be more fully defined during the PED phase.

5.4.3 Cost Assumptions

This section describes the assumptions that were used to develop the cost estimates. These assumptions were developed during the Feasibility Study, and were based on the best available data. As the study progresses, these assumptions can be refined to reflect new information. In addition, as the construction plan and design of the alternatives become more fully developed, the costs can be better defined.

The estimated costs for the alternatives are based on 2001-year price levels. All dredging work was estimated using the Corps of Engineers Dredge Estimating Program (CEDEP) that has built-in databases for the dredging plant and equipment. The labor rates utilized in the CEDEP program have been adjusted using current (02/01) State of California Wage Rate Determination sheets for dredging labor. All land-based work was estimated using the MCACES (Micro-Computer Aided Cost Engineering System) program.

Land-based construction costs have been adjusted by the locality factor of 20% to account for the work being done within the Marin County area of California. Cost for the monitoring of the dredge disposal operation has been adjusted to a factor of 1% of the total first cost of the project. Engineering and Design (E&D) and Support and Administration (S&A), activities during construction, are 8% and 7%, respectively, and are applied to the cost as well. All costs that are part of the total project costs, which are cost-shared, are considered construction or "new work" costs. No Operations and Maintenance (O&M) costs are included with these estimates. O&M responsibilities will be discussed in more detail in Chapter 7 (Section 7.12 OMRR&R Requirements); they are the responsibility of the local sponsor.

Contract Work: The assumption was made that the prime contractor would perform all land-based work 5 days/week, 8 hrs/day, and that all dredging and disposal work would be performed 7 days/week, 24 hrs/day. However, it is expected that on average the dredge vessel would probably use every 7^{th} day to perform routine maintenance. Included in the costs are factors for contractor markups: 12% for overhead costs, 10% for profit and 2% for bonds. A contingency of 20% was used for land-based construction only, since there were many unknowns at the time of this estimate.

5.4.3.1 Water-Based Operation (Dredging)

Due to the geographic and physical constraints within the Bolinas Lagoon and the surrounding area, a single 12-inch hydraulic suction pipeline dredge was selected for use in the feasibility-level cost estimates. Other equipment utilized includes up to 16,300 feet of trailing pipeline, two booster pumps, one tugboat, two 3000-cubic yard (cy) scows (receiving the dredged material while anchored in Bolinas Bay), miscellaneous plant and equipment. Production rates range from 75 to 230 cubic yards/hour (depending on pipeline lengths).

The pipeline suction dredge that was used for this estimate is a multi-functional unit that can be transformed into an amphibious dredge, via the use of bolt-on tires. This amphibious conversion allows the dredge to traverse over land and shallow areas, normally not accessible to conventional dredges. In addition, this particular dredge has optional work implements whereby vegetation "harvesting," raking and solid material grappling is possible, when required.

This configuration of equipment is necessary because of the shallow depths of much of the lagoon, the tidal influence of the area, and other environmental concerns, primarily with regards to the safe method of operation during the dredging of the material. The disposal site for all the dredged material would be SFDODS, the designated ocean disposal site, located approximately 55 nautical miles (100 kilometers) offshore of San Francisco.

Due to very limited access to the island by land-based construction equipment, the impracticality of trucking the material through the town of Bolinas, and various environmental constraints, a water-based operation must be used for clearing vegetation off Kent Island. Clearing would entail transporting equipment to the island via a barge with a small crane and a towing vessel (a small tug/boat). The existing vegetation on the island would then be removed by cutting, clearing and mulching by conventional methods, i.e. chainsaw and mulcher. Vegetative material that would be hard to remove by conventional methodology would be cleared and stockpiled by the amphibious dredge for removal.

Transportation of the vegetative material would be via containers on a small barge, transferred to a scow in the area of the dredge platform within the Bolinas Bay, and further transported to the marina at Bodega Bay. At Bodega Bay, the material would be offloaded by a hydraulic excavator bucket or a vacuum system into 12 cubic yard capacity trucks, and then trucked to the Redwood Landfill for disposal, unless otherwise recycled or used for composting.

5.4.3.2 Land-Based Construction (Excavation)

Land-based operations at the Dipsea Road and Highway One Fills sites have material that would be excavated dry, as well as some wet quantities. All material from these sites would be trucked in vehicles capable of carrying loads of up to 12 cy to Redwood Landfill in Novato, California, the upland disposal site. The operation is the same for Pine Gulch Creek Delta. However, in addition to the excavation of soil material, substantial amounts of trees and other vegetation would be removed from the Pine Gulch Creek Delta and Dipsea Road sites. The equipment to be used for this operation includes hydraulic excavators, loaders, cranes, and dump trucks. Cost for mobilization and demobilization of the equipment is included in the estimate.

5.4.3.3 Disposal Sites

Deep Ocean Site (SFDODS)

SFDODS is approximately 55 nautical miles (100 kilometers) offshore of San Francisco. Dredged material would be transported to SFDODS by tugs and scows with a 3,000 cubic yard capacity. Once at the disposal site, the dredged material would be disposed of by bottom dumping. The cost estimates reflect a disposal operation for the tug and scow of 24 hours/day, 7 days/week, 2 – 12 hour shifts. (Note: Dredge operation may be limited to six days/week due to equipment maintenance on the 7th day).

Redwood Landfill

Redwood landfill is located approximately 38 miles from the project site when proceeding east on Highway 1, then north on Highway 101. Excavated material would be transported there by truck. The landfill would charge a disposal fee for the different types of disposal medium; $10 per cy for vegetation to $20 per cy for mixed soil.

5.4.3.4 Dredging and Disposal Cost Analysis: Tradeoffs

The dredged material pumped into the scows is a slurry composed of approximately 25% solids and 75% water. The dredge material disposal costs assume 3,000 cubic yard scows loaded with 25% solids, which is a conservative estimate. If some of the excess water were allowed to port out of the receiving scow during the pumping process, using filter fabric to reduce turbidity in Bolinas Bay, the percent of solids could increase to as much as 80%. This conservative estimate has been used for feasibility purposes to determine the "worst case scenario" (i.e., the most expensive scenario, a conservative estimate). Although overflow would reduce costs by reducing disposal time and total number of barge trips needed, expense must be weighed with concern over the effects of turbidity in Bolinas Bay. This decision would be made by any regulating agencies and, ultimately, by GFNMS. Changes to the current scenario are possible during PED when the design is finalized and the construction implementation plan is fully developed. Since this estimate is conservative, however, modifications would most likely decrease costs.

Another limiting factor is the use of a single dredge. The cost estimate assumes a single dredge primarily because of concern expressed regarding the short term impacts of dredging, and because assuming one dredge creates a more conservative cost estimate. If multiple dredges were used, implementation of the project could be reduced, but again, there is a balance between short term impacts and the number of dredges used. One dredge would have fewer impacts at any particular moment, but the short term impacts would be stretched over a longer period. Two dredges would have more immediate impacts in the lagoon, but the dredging time would be reduced, so overall, there might be fewer short term impacts. The assumption that one dredge would be used is the conservative estimate. As the implementation plan is developed during the PED phase, it is possible that using two dredges may be found to be more efficient and have fewer short term impacts.

5.4.4 Incremental Cost Analysis (ICA)

An ecosystem restoration plan should represent the most cost effective means of addressing the restoration problem, and the selected plan should identify the least-cost alternative for producing every attainable level of output. Tools to inform and support environmental investment decision-making include Cost Effectiveness Analysis (CEA) and Incremental Cost Analysis (ICA). CEA is performed to identify the least cost alternative plans and provides for the "best bang for the buck," while the ICA is conducted on the more cost effective plans and identifies changes in costs for increasing levels of environmental output, to assesses whether different levels of restoration are "worth it."

Because this project is not a traditional Corps project, and does not have a monetary measure of project benefits, it is not possible to conduct a traditional benefit-cost analysis for the evaluation of project alternatives; thus, a unique or "optimal" plan cannot be identified. However, an incremental cost analysis (ICA), a valuable planning tool, allowed us to examine the environmental outputs, rule out economically irrational alternatives and compare the relative cost effectiveness of the remaining plans.

Project outputs were expressed as the net amount of tidal water that would be flushed into the ecosystem (cubic yards of tidal prism). Outputs for each alternative were expressed as the average annual amount, assuming a 50-year project life. Project costs used for the ICA include the project first costs, Operation and Maintenance costs and interest during construction. (These costs differ from those for cost-sharing, which are based solely on project first costs). The ICA takes into consideration all costs related to constructing the project, and compares those with the benefits.

Following discussion at the December 14, 2001 Alternatives Formulation Briefing, held by the Corps of Engineers District, Division and Headquarters (HQ) level offices and MCOSD (the local sponsor), the Corps HQ office concluded that restoration in Seadrift Lagoon would not warrant Federal cost sharing participation because of the man-made nature of the lagoon. According to ER 1165-2-501 and the Engineering Pamphlet (EP) 1165-2-502, the goal of Ecosystem Restoration in the Civil Works program is to "partially or fully reestablish the attributes of a naturalistic, functioning, and self-regulating system. The Corps has decided that Seadrift Lagoon is not a "naturalistic, functioning, and self-regulating system," and therefore is not in the Federal interest to restore. Restoration of such environments would be considered "enhancement" of a man-made feature. The Seadrift Lagoon component was therefore removed from further analysis; the ICA was conducted only for the plans that did not include that component, namely, the alternative plans that contained the South (No Seadrift) alternative. If the Seadrift Lagoon component, or the South (Seadrift) alternative, were to be part of the Locally Preferred Plan, the full cost of restoring Seadrift Lagoon would have to be borne by the local sponsor. For the purpose of comparison, an incremental cost analysis was performed on all of the alternative plans [i.e., those containing both the South (Seadrift) alternative, and the South (No Seadrift) alternative], and the results were similar. Only the ICA results of the alternative plans containing the South (No Seadrift) alternative, however, are detailed in this report.

5.4.4.1 ICA Results

Step 1 – Eliminating non-cost effective plans

To start the Incremental Cost Analysis, the alternatives are ordered by increasing levels of output. Alternatives with lower outputs and correspondingly higher costs are considered non-cost effective and are eliminated from the analysis. In this first iteration, the Central (Estuarine) & South (w/o Seadrift) and Central (Riparian) & South (w/o Seadrift) plans are ruled out since the

North and South (w/o Seadrift) plan produces higher outputs at a lower cost. Likewise, the North & Central (Riparian) plan is eliminated because the Central (Estuarine) plan offers higher outputs at lower costs, i.e., it provides a bigger "bang for the buck."

Table 5.18 First Iteration of the Incremental Cost Analysis

1st Iteration					
Plan	**Cost: ($)**	**Incremental Cost: ($)**	**Output (Ann Ave. cy)**	**Incremental Output: (Ann Ave. cy)**	**Incremental Cost per Unit (Ann Ave. cy)**
No Action Plan	$0	---	0	---	---
North and South (w/o Seadrift)	$57,096,550	$57,096,550	1,465,583	1,465,583	$38.96
~~Central (Estuarine) and South (w/o Seadrift)~~	~~$58,687,458~~	~~$58,687,458~~	~~1,422,917~~	~~1,422,917~~	~~$41.24~~
~~Central (Riparian) and South (w/o Seadrift)~~	~~$59,087,950~~	~~$59,087,950~~	~~1,407,078~~	~~1,407,078~~	~~$41.99~~
North and Central (Estuarine)	$104,518,826	$104,518,826	2,224,010	2,224,010	$47.00
~~North and Central (Riparian)~~	~~$105,331,724~~	~~$105,331,724~~	~~2,213,044~~	~~2,213,044~~	~~$47.60~~
North, Central (Riparian) and South (w/o Seadrift)	$118,894,540	$118,894,540	2,381,558	2,381,558	$49.92
North, Central (Estuarine) and South (w/o Seadrift)	$119,883,012	$119,883,012	2,393,713	2,393,713	$50.08

Step 2 – Identifying the "Best Buys" or Least Incremental Cost Alternatives

Once the "non-cost effective" plans are eliminated, the ICA proceeds by treating the No Action plan as the first increment or baseline. Planners then select the best buy, i.e., the plan with the lowest incremental cost per unit. In this case, the North and South (w/o Seadrift) plan, highlighted in the second iteration table, is the next best alternative a planner can choose above the No Action plan. With an incremental cost of $40.32 per unit of output, this plan offers the most "bang per buck" above the No Action plan. This plan is the best buy; it is the *greatest incrementally* justified plan. This plan forms the baseline for the next iteration.

Table 5.19 Second Iteration of the Incremental Cost Analysis

2nd Iteration (after removing non-cost effective plans)					
Plan	**Cost: ($)**	**Incremental Cost: ($)**	**Output (Ann Ave. cy)**	**Incremental Output: (Ann Ave. cy)**	**Incremental Cost per Unit (Ann Ave. cy)**
No Action Plan	$	---	0	---	---
North and South (w/o Seadrift)	$59,087,950	$59,087,950	1,465,583	1,465,583	$40.32
North and Central (Estuarine)	$104,518,826	$104,518,826	2,224,010	2,224,010	$47.00
North, Central (Riparian) and South (w/o Seadrift)	$118,894,540	$118,894,540	2,381,558	2,381,558	$49.92
North, Central (Estuarine) and South (w/o Seadrift)	$119,883,012	$119,883,012	2,393,713	2,393,713	$50.08

Step 3 - Recalculate Incremental Costs & Outputs and Identify Next Increment

With the No Action plan comprising the first increment and the North and South (w/o Seadrift) plan making up the second, the planner then recalculates the incremental costs and incremental outputs in relation to the North and South (w/o Seadrift) plan baseline. The North, Central (Estuarine) plan now comprises the third increment since it is the "best buy" and has the lowest incremental costs per unit of output ($59.90) above the second increment, the North and South (w/o Seadrift) plan.

Table 5.20 Third Iteration of the Incremental Cost Analysis

3rd Iteration (after identifying the plan with the lowest incremental cost/unit & removing plans preceding it)

Plan	Cost: ($)	Incremental Cost: ($)	Output: (Ann Ave. cy)	Incremental Output: (Ann Ave. cy)	Incremental Cost per Unit (Ann Ave. cy)
No Action Plan	$	---	0	---	---
North and South (w/o Seadrift)	$59,087,950	$59,087,950	1,465,583	1,465,583	$40.32
North and Central (Estuarine)	$104,518,826	$45,430,876	2,224,010	758,428	$59.90
North, Central (Riparian) and South (w/o Seadrift)	$118,894,540	$59,806,590	2,381,558	915,975	$65.29
North, Central (Estuarine) and South (w/o Seadrift)	$119,883,012	$60,795,061	2,393,713	928,130	$65.50

Step 4 – Repeat Process

Using the North, Central (Estuarine) & South (w/o Seadrift) increment as the baseline, the North, Central (Estuarine), and South (w/o Seadrift) plan is the final increment; its incremental cost per unit is $90.54.

Table 5.21 Fourth Iteration of the Incremental Cost Analysis

4th Iteration (after identifying the plan with the lowest incremental cost/unit & removing plans preceding it)

Plan	Cost: ($)	Incremental Cost: ($)	Output: (Ann Ave. cy)	Incremental Output: (Ann Ave. cy)	Incremental Cost per Unit (Ann Ave. cy)
No Action Plan	$0	---	0	---	---
North and South (w/o Seadrift)	$59,087,950	$59,087,950	1,465,583	1,465,583	$40.32
North and Central (Estuarine)	$104,518,826	$45,430,876	2,224,010	758,428	$59.90
North, Central (Riparian) and South (w/o Seadrift)	$118,894,540	$14,375,714	2,381,558	157,548	$91.25
North, Central (Estuarine) and South (w/o Seadrift)	$119,883,012	$15,364,186	2,393,713	169,703	$90.54

Step 5 – Final Array of Increments ("Winners")

With no more plans left to analyze, the three remaining plans are the top plans, or the best buys, that are incrementally justified. Any of these top plans could be the NER Plan.

Table 5.22 Fifth Iteration of the Incremental Cost Analysis

5th Iteration (Final Array of Increments/"Winners")					
Plan	**Cost: ($)**	**Incremental Cost: ($)**	**Output: (Ann Ave. cy)**	**Incremental Output: (Ann Ave. cy)**	**Incrementa Cost per Unit (Ann Ave. cy)**
No Action Plan	$0	---	0	---	---
North and South (w/o Seadrift)	$59,087,950	$59,087,950	1,465,583	1,465,583	$40.32
North and Central (Estuarine)	$104,518,826	$45,430,876	2,224,010	758,428	$59.90
North, Central (Estuarine) and South (w/o Seadrift)	$119,883,012	$15,364,186	2,393,713	169,703	$90.54

ICA is not a conclusion, but rather a guideline for decisions based on outputs desired and available costs. Abrupt changes in the incremental cost curve identify potential decision points for focusing the "Is it worth it?" questioning process. Significant changes in the curve are referred to as the breakpoint, the spike, or the "knee of the curve." They occur where an incremental cost increases relatively sharply in contrast to the preceding or following incremental costs. These points provide decision makers with reasons to question the causes of the changes, and whether the additional incremental costs are "worth it." Depending on the circumstances (and the amount of money available), a large increase in incremental costs may be justified, or it may not be. The incremental cost analysis shows at what point the incremental costs per unit – the additional cost for an extra unit of output – that is too high to be justified.

In this case, there is no apparent "spike" in the curve, each increment is approximately 50% greater than the previous increment. Since all three plans are economically justifiable (they are the best three plans that are economically justified), the effectiveness of each of the top three plans at achieving the goals of the project must be compared in order to identify the best possible plan as the NER Plan. The first plan, North and South (w/o Seadrift), only addresses the north and south ends of the lagoon. Because many of the local groups that have been involved with the progress of the project have suggested that the most significant problem area, and therefore the area most in need of restoration, is the central part of the lagoon, the first alternative plan would not be the most desirable. The second plan, North and Central (Estuarine), addresses the central part of the lagoon, but it does not address the lagoon as a whole (that is, the North, Central and South regions), and therefore does not address the project goals as fully as other plans available. The last plan, North, Central (Estuarine) & South (w/o Seadrift) is the most complete, most effective plan at achieving the restoration goals of the project. While the costs are the highest out of the top three plans, the benefits are also the greatest. The study team believes that this plan would be the best plan to address the problem areas of the lagoon, and would provide for a fully encompassing restoration project.

5.4.4.2 Sensitivity Analysis

This ICA was undertaken using outputs expressed in average annual terms, using total project costs (which are project first costs plus interest during construction). Additional ICA's have been performed using first costs as well as annualized project costs; the final array of cost effective plans were identical to those using the total project costs.

5.4.4.3 The National Ecosystem Restoration (NER) Plan

For ecosystem restoration projects, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective, is identified as the National Ecosystem Restoration (NER) Plan. The results of the Bolinas Lagoon incremental cost analysis (Figures 5.6 and 5.7) show the plan which provides the most outputs at an incrementally justified cost is the North, Central (Estuarine) and South (No Seadrift) Alternative Plan. As illustrated in the fourth iteration of the ICA, the North, Central (Riparian) & South (No Seadrift) alternative plan has an incremental cost almost identical to the North, Central (Estuarine) & South (No Seadrift) plan. That is, if the costs were rounded, they would be the same ($91.00). Thus, the NER could essentially be either of these two plans, but because the Riparian plan fell out of the cost analysis in the 4th iteration, the Estuarine plan has been identified as the NER Plan. The advantage of the Estuarine plan is that it provides more benefits, consistent with the restoration goals of the project. The NER Plan provides the basis of the project cost sharing; the LPP would most likely be the same or cheaper than the NER, and would therefore be fully Federally cost-shared.

The NER Plan is the North, Central (Estuarine), and South (No Seadrift) alternative plan. The incremental cost analysis determined that this Alternative Plan is cost effective and would warrant Federal interest if recommended for implementation. Because the outputs were measured as cubic yards of intertidal habitat, we can draw certain conclusions about the benefits that would be provided by the LPP. For example, with an increase in cubic yards of intertidal habitat, we can assume that the LPP Plan would provide an increase in intertidal habitat (and, it is assumed, subtidal habitat), intertidal volume and a decrease in the potential of inlet closure. Concomitant ecological benefits include an increase in habitat quantity and quality for intertidal species (algae and marsh plants, invertebrates and shore birds), subtidal species (eelgrass, fish, diving birds and marine mammals), and an overall benefit to the lagoon ecosystem, the region, and the Pacific Flyway.

The total project first cost of the NER Plan is $101,553,000. Cost sharing for ecosystem restoration projects is 65% Federal and 35% non-Federal (local sponsor), for a total of $66,009,450 Federal and $35,543,550 non-Federal. The costs associated with the Lands, Easements, Rights-of-Way, and Relocations (LERR), which would be paid for in full by the local sponsor as part of their 35% share, are expected to be minimal. The entire non-Federal cost share would be financed in cash.

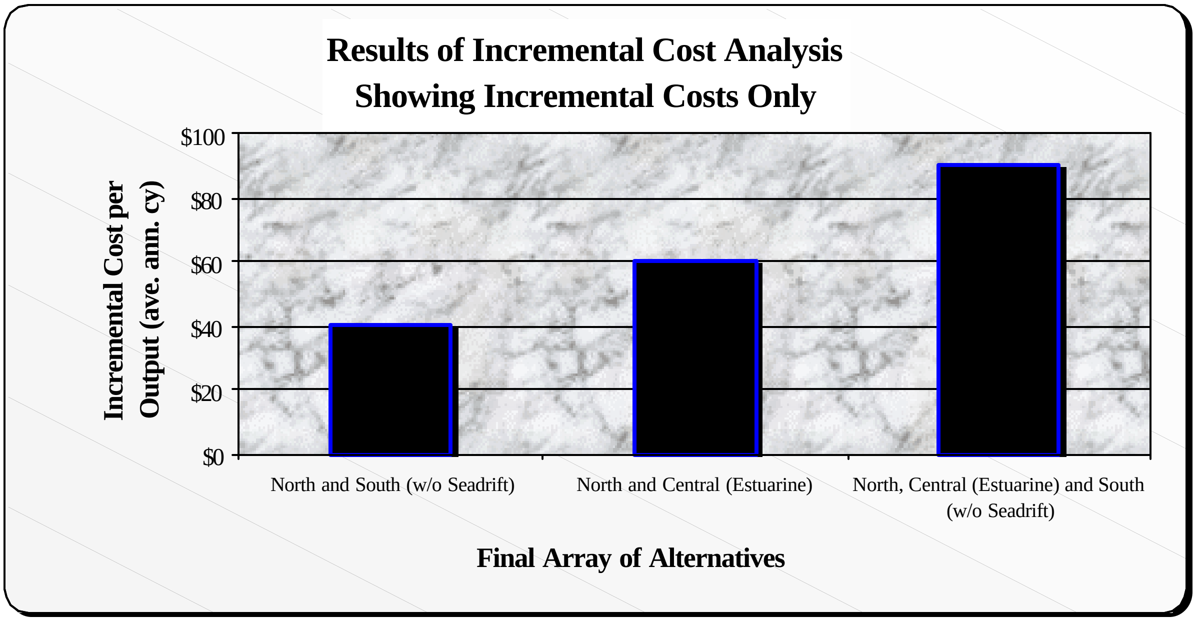


Figure 5.6 "Winners" of the Incremental Cost Analysis,
Illustrating Incremental Costs Only

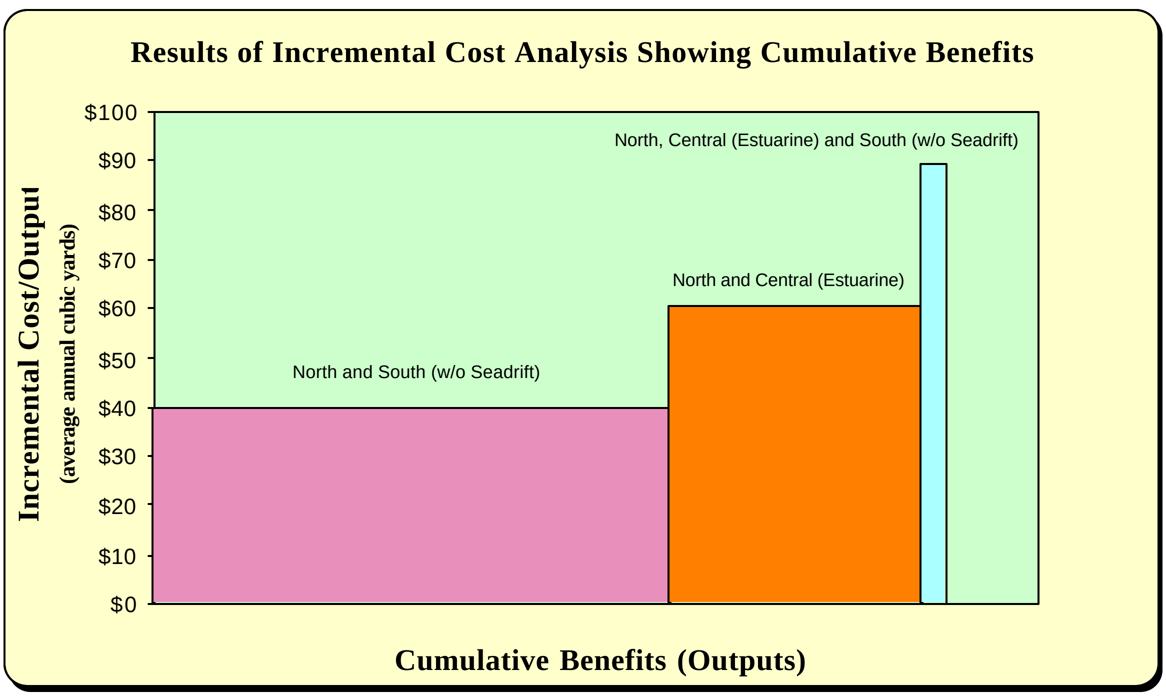


Figure 5.7 "Winners" of the Incremental Cost Analysis,
Illustrating Cumulative Benefits & Incremental Costs

5.4.4.4 The Tentatively Selected Locally Preferred Plan (LPP)

The local sponsor wanted to ensure that the concerns of the local communities were taken into consideration for the draft reports. During the HEEP meetings, it became clear that there was a real debate over the Pine Gulch Creek Delta restoration component with respect as to whether or not some of the riparian habitat area should be removed. Two plans were developed to address these concerns (the Estuarine component and the Riparian component), and have been fully analyzed in this Feasibility Report. Because the NER Plan contains the Central (Estuarine) alternative, the local sponsor felt that it was necessary to include the Central (Riparian) plan in the Locally Preferred Plan to give the public the opportunity to debate the merits of each. After public review, one plan (either the NER or the LPP) will be selected for recommendation in the final reports.

The North, Central (Riparian) and South (No Seadrift) Alternative Plan, identified as the LPP, is cost effective and achieves the desired level of output. Because the outputs were measured as cubic yards of intertidal habitat, we can draw certain conclusions about the benefits that will be provided by the LPP. For example, with an increase in cubic yards of intertidal habitat, we can assume that the LPP Plan would provide an increase in intertidal habitat (and, it is assumed, subtidal habitat), intertidal volume and a decrease in the potential of inlet closure. Concomitant ecological benefits include an increase in habitat quantity and quality for intertidal species (algae and marsh plants, invertebrates and shore birds), subtidal species (eelgrass, fish, diving birds and marine mammals), and an overall benefit to the lagoon ecosystem, the region, and the Pacific Flyway. In addition, benefits not accounted for in the ICA are those associated with saving the existing introduced riparian habitat on Pine Gulch Creek. Although these benefits are not necessarily related to estuarine habitats, some groups perceive the benefits as inherently valuable.

The LPP Plan has a total project first cost of $100,716,000. Cost sharing for ecosystem restoration projects is 65% Federal and 35% non-Federal (local sponsor), for a total of $65,465,400 Federal and $35,250,600 non-Federal. The costs associated with the Lands, Easements, Rights-of-Way, and Relocations (LERR), which would be paid for in full by the local sponsor as part of their 35% share, are expected to be minimal. The entire non-Federal cost share would be financed in cash.

6.0 PLAN COMPARISON

Comparison of alternative plans is the fifth step in the planning process. In this step, the top candidate plans (the NER and the LPP) are compared in terms of their contributions towards the four accounts under the System of Accounts as suggested by the U.S. Water Resources Council. These include National Ecosystem Restoration (NER), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE). The top plans are then tested against the four specific evaluation criteria, which are Acceptability, Completeness, Effectiveness and Efficiency. The analyses will demonstrate which plan(s) would be the most rational choice for recommendation.

6.1 Comparison of Plan Features

All of the action alternatives require sediment removal from Bolinas Lagoon, some by hydraulic cutterhead dredge and some by land excavation, with disposal at a suitable site. Through the Incremental Cost Analysis, which compared increase in intertidal volume to cost, the most cost effective plans were identified. Out of the top three plans from the ICA, which were the North and South (No Seadrift); North and Central (Estuarine); and North, Central (Estuarine) and South (No Seadrift), one plan, the North, Central (Estuarine), and South (No Seadrift) plan was identified as the NER Plan. The North and South (No Seadrift) alternative plan was eliminated as a potential NER Plan, even though it was cost effective, because it was not considered a viable option, based on the acceptability, effectiveness and completeness criteria (discussed in Section 6.3). The North and Central (Estuarine) plan was eliminated for the same reason. Because the local sponsor wanted the public to comment on two plans, with two variations of the Pine Gulch Creek Delta restoration component, the local sponsor selected the North, Central (Riparian) & South (No Seadrift) plan as the LPP. Although similar to the NER, the LPP offers an alternative to the Pine Gulch Creek Delta Estuarine component. Based on public input, both the NER and the LPP are viable options. However, only one will be selected for recommendation in the final reports. All of the plans that were not cost effective were eliminated from further consideration, as one requirement for this project is to restore Bolinas Lagoon in a cost effective manner.

The NER Plan, the North, Central (Estuarine) and South (No Seadrift) alternative plan, and the LPP, the North, Central (Riparian) and South (No Seadrift) alternative plan, will be compared to one another and to the No Action plan in this chapter. The major difference between the NER and the LPP is the Pine Gulch Creek Delta area, where 7 out of 17 acres of riparian habitat would be removed with the NER, but would not be touched with the LPP. The benefits of each of these plans are comparable, but the NER is more expensive, by about $837,000. The major project features of the LPP are illustrated in Table 6.1, and the major project features of the NER Plan are illustrated in Table 6.2. Table 6.3 lists all major project costs. Project costs associated with the LPP and NER Plan are described in more detail in Chapter 7.

Table 6.1 Summary of the LPP
North, Central (Riparian), and South (No Seadrift) Lagoon Alternative
Excavation Volumes and Footprints

	Wet Material (barge) (cy)	**Dry Material (truck) (cy)**	**Total Excavation Volume (cy)**	**Excavation Footprint (Acres)**
Component	**SFDODS**	**Redwood**		
North Lagoon	674,800	0	674,800	174
Central Lagoon (Riparian)	656,700	14,300 + shrubs	671,000	230
South Lagoon (No Seadrift)	89,200	37,700 + trees / shrubs	126,900	26
Totals				
North, Central (Riparian), South (Without Seadrift)	**1,420,700**	**52,000 + trees / shrubs**	**1, 472,700**	**430**
Number of Disposal Trips	**1900**	**4,750**		

Table 6.2 Summary of the NER Plan
North, Central (Estuarine), South (No Seadrift) Alternative
Excavation Volumes and Footprints

	Wet Material (barge) (cy)	**Dry Material (truck) (cy)**	**Total Excavation Volume (cy)**	**Excavation Footprint (Acres)**
Component	**SFDODS**	**Redwood**		
North Lagoon	674,800	0	674,800	174
Central Lagoon (Estuarine)	663,500	39,600 + trees / shrubs	703,100	247
South Lagoon (No Seadrift)	89,200	37,700 + shrubs	126,900	26
Totals				
North, Central (Estuarine), South (Without Seadrift)	**1,427,500**	**77,300 + trees / shrubs**	**1,504,800**	**447**
Number of Disposal Trips	**1900**	**18,700**		

Table 6.3 Comparison of Project Costs

	LPP	NER Plan	No Action Plan
Dredging & Disposal Costs	$68,158,700	$68,781,700	$0
Land Construction	$4,997,700	$4,999,800	$0
Real Estate Costs	$2,031,400	$2,031,400	$0
Monitoring Costs^	$751,878	$758,129	$0
Adaptive Management Costs^	$2,255,634	$2,274,387	$0
Construction* Costs	$22,520,250	$22,707,480	$0
Total Project First Costs	$100,715,562	$101,552,896	$0
Interest During Construction	$32,446,323	$32,716,077	$0
Total Investment Cost	$133,161,885	$134,268,973	$0
Average Annual Cost (at 6.125%)	$8,156,165	$8,223,975	$0
Annual OMRR&R Costs**	$200,000	$200,000	$0
Total Annual Cost	$8,356,666	$8,424,476	$0

^Monitoring and adaptive management activities are described in Chapter 7, Sections 7.10 and 7.11.
*Construction costs, in this case, include Engineering & Design (E&D), Supervisory & Administration (S&A), and Escalation to the mid-point of construction.
**Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) is carried out for the life of the project once the cost-shared construction phase concludes. These requirements are described more fully in Chapter 5, Section 5.4.2.5 and Chapter 7, Section 7.12.

6.2 System of Accounts

A method of displaying the positive and negative effects of various plans is to use the System of Accounts as suggested by the U.S. Water Resources Council. The accounts are categories of long-term impacts, defined in such a manner that each proposed plan can be easily compared to another. The four accounts used to compare proposed water resource development plans are the national environmental restoration (NER), environmental quality (EQ), regional economic development (RED) and other social effects (OSE) accounts.

6.2.1 National Environmental Restoration (NER)

Ecosystem restoration measures used in formulating the National Ecosystem Restoration (NER) alternative plan are based on a combination of monetary and non-monetary benefits compatible with the Planning & Guidance (P&G) selection criteria as outlined in Engineering Regulation ER 1105-2-100, and include information about outputs, costs, significance, acceptability, completeness, effectiveness, and reasonableness of costs. There are no universal environmental outputs; however, the outputs must increase ecosystem value, productivity, and quantity & quality of measurable outputs. The outputs can include physical dimensions, population counts, habitat units (as described under the USFWS Habitat Evaluation Procedures), functional capacity units, or diversity indices.

Because ecosystem restoration projects do not use cost-based benefits in the cost-benefit comparison, there is no National Economic Development (NED) account for this project. As discussed in Chapter 5 (Plan Evaluation), the benefits of each alternative were in terms of increase in intertidal volume created, which translated into additional intertidal and subtidal habitat benefits. A brief synopsis of the results of the ICA, comparing the NER Plan, LPP and No Action Plan are displayed in Table 6.4.

Table 6.4 NER Account*

	LPP	NER Plan	No Action
Cost ($)	$118,894,540	$119,883,012	$0
Benefits (Annual Average cy)	2,381,558	2,393,713	None
Incremental Cost Per Unit (Annual Average cy)	$91.25	$90.548	$0

* Data from the Incremental Cost Analysis

6.2.2 Environmental Quality (EQ)

The environmental quality account is another means of evaluating the alternatives to assist in making a plan recommendation. The EQ account is intended to display the long-term effects the alternative plans may have on significant environmental resources. Significant environmental resources are defined by the Water Resources Council as those components of the ecological, cultural and aesthetic environments which, if affected by the alternative plans, could have a material bearing on the decision-making process. A comparison of the effects that the proposed plans may have on the EQ resources is shown on Table 6.5.

Table 6.5 Environmental Quality Account

	LPP	NER Plan	No Action Plan
Physical Environment			
Sedimentation & Erosion	Excavation in the Pine Gulch Creek Delta may increase the amount of sediment going into the lagoon in the short term. Overall, however, this alternative plan will remove many of the human-caused sedimentation impacts present in the lagoon. Rates of erosion in the watershed would not change.	Excavation in the riparian habitat area of the Pine Gulch Creek Delta may increase to a greater extent the amount of sediment going into the lagoon in the short term. Overall, however, this alternative plan will remove many of the human-caused sedimentation impacts present in the lagoon. Rates of erosion in the watershed would not change.	Sediment will continue to fill in the lagoon, and habitat values will diminish at an increasingly accelerated rate until at some point in the near future, intertidal and subtidal habitats will convert to dry land. Rates of erosion in the watershed would not change.
Flooding	No impacts	No impacts	No impacts
Water Quality	Short term impacts on turbidity likely. Potential long term benefits.	Short term impacts on turbidity likely. Potential long term benefits.	Water quality would continue to decrease.
Air Quality	Short term impacts from trucking and barging material for disposal likely. No long term impacts.	Short term impacts from trucking and barging material for disposal likely. No long term impacts.	No impacts
Noise	Short term impacts from dredging and excavating equipment below and above water line. No long term impacts.	Short term impacts from dredging and excavating equipment below and above water line. No long term impacts.	No impacts
Biological Environment			
Aquatic Habitat	Short term impacts from dredging, but large positive long term effects.	Short term impacts from dredging, but large positive long term effects.	Decreasing quality and quantity of aquatic habitat over time.
Riparian Habitat	Change to transition zone between riparian habitat and lagoon, but no major impacts.	Long term impacts from removal of 7 acres, but 10 acres would remain. Change to transition zone between riparian habitat and lagoon.	No direct impacts on riparian habitat, but quality of transition habitat would decrease over time.

	LPP	NER Plan	No Action Plan
Wetland Habitat	Short term impacts from construction, but overall, an increase in the amount of habitat available for wetland vegetation.	Short term impacts from construction, but overall, an increase in the amount of habitat available for wetland vegetation.	Decreasing quality and quantity of wetland habitat over time.
Upland Habitat	Long term impacts to upland habitat lagoon.	Long term impacts to upland habitat in lagoon.	Increasing quantity of upland habitat over time.
Endangered Species	Potential impacts on special status species in the Pine Gulch Creek Delta area. Otherwise, significant positive effect on threatened and endangered species.	Potential larger impacts on special status species in the Pine Gulch Creek Delta area. Otherwise, significant positive effect on threatened and endangered species.	Decreasing quality and quantity of habitat for endangered species over time.
Cultural Environment			
Cultural Resources	No impacts	No impacts	No impacts
Aesthetics	Large positive effect	Large positive effect	Decreasing quality of aesthetics over time.

6.2.3 Regional Economic Development (RED)

The regional economic development account is intended to illustrate the effects that the proposed plans would have on regional economic activity, specifically, regional income and regional employment. The comparison of possible effects that the plans may have on these resources is shown in Table 6.6.

Table 6.6 Regional Economic Development Account

	NER Plan	LPP	No Action Plan
Employment and Labor Force	8 – 9 year temporary increase in construction related employment.	8 – 9 year temporary increase in construction related employment.	No change expected
Business and Industrial Activity	N/A	N/A	N/A
Local Government Finance (State of California)	Implementation Cost of $133,161,885	Implementation Cost of $134,268,973	N/A

6.2.4 Other Social Effects (OSE)

The other social effects (OSE) account typically includes long-term community impacts in the areas of public facilities and services, recreational opportunities, transportation and traffic and man-made and natural resources. A comparison of the effects that the proposed alternatives would have on OSE resources is shown on Table 6.7.

Table 6.7 Other Social Effects Account

	LPP	NER Plan	No Action Plan
Public Health and Safety	Improvements due to improved habitat quality.	Improvements due to improved habitat quality.	No change expected
Public Facilities and Services	Improvements due to improved habitat quality.	Improvements due to improved habitat quality.	No change expected
Recreation and Public Access	Increased recreational opportunities due to improved habitat quality.	Increased recreational opportunities due to improved habitat quality.	Decreased recreational opportunities due to decreasing habitat quality.
Traffic and Transportation	No change expected	No change expected	No change expected
Man-Made Resources	N/A	N/A	N/A
Natural Resources	Improvements due to improved habitat quality.	Improvements due to improved habitat quality.	Decline in quality due to decreasing habitat quality.

6.3 Associated Evaluation Criteria

The candidate plans are compared using four formulation criteria suggested by the U.S. Water Resources Council. These criteria are completeness, effectiveness, efficiency and acceptability.

6.3.1 Completeness

Completeness is a determination of whether or not the plan includes all elements necessary to achieve the objectives of the plan. It is an indication of the degree that the outputs of the plan are dependent upon the actions of others. Both action alternative plans are complete conceptual lagoon restoration plans. None of these alternatives require any additional substantial features to accomplish the study objectives.

6.3.2 Effectiveness

Both the NER Plan and the LPP provide some contribution to the planning objectives. Effectiveness is defined as a measure of the extent to which a plan achieves its objectives. Both action alternative plans are effective, to varying degrees, in increasing intertidal and subtidal habitat, increasing tidal prism, and decreasing the potential for inlet closure. The NER Plan has a slightly larger footprint than the LPP, but the plans can be considered comparable in their overall contribution to estuarine habitat benefits. Both plans meet all of the planning objectives for this study. The No Action Plan is not effective in meeting the planning objectives.

6.3.3 Efficiency

Both the NER and the LPP provide net benefits. Efficiency is a measure of the cost effectiveness of the plan expressed in net benefits. While both the NER Plan and the LPP are cost efficient, when comparing the benefits to the costs, the NER Plan is more efficient than the LPP. The No Action Plan maintains existing habitats, but fails to restore valuable habitats which have suffered historic losses, and which provide important habitat to many species. The No Action Plan represents a lost opportunity for improving environmental quality.

6.3.4 Acceptability

All of the plans in the final array must be in accordance with Federal law and policy. The comparison of acceptability is defined as acceptance of the plan to the local sponsor and the concerned public. The NER Plan and the LPP are acceptable, to varying degrees, to the local sponsor, local agencies, resource agencies, and involved groups and community members. Each plan provides a similar level of benefits, but they differ in the habitat areas that they impact. While either the NER Plan or the LPP could become the Recommended Plan in the Final Feasibility Report, this decision will depend on public acceptance as expressed through the public review process.

6.4 Trade-Off Analysis

The first trade-offs to be considered in evaluating the final alternative plans is to distinguish between the No Action Alternative and the action alternatives. This is followed by the trade-off between action alternatives.

6.4.1 Action Versus No Action

The No Action Plan ranks lower than the action alternatives in that it is not effective in meeting any of the planning objectives. It has no positive benefits or impacts, since it is the basis from which the impacts and benefits are measured. It does not, however, involve incurring the implementation cost of the action alternatives. Although there would be no short term impacts, there would also be no long term benefits associated with the No Action plan.

6.4.2 Trade-Offs between Action Alternatives

The second level of trade-offs to consider is between the two action alternatives. This trade-off analysis compares how the implementation of each alternative is distinguished from the other. The trade-offs considered include achievement of study planning objectives, economic benefits versus costs associated with implementation, and the environmental and other social effects associated with each alternative, as described earlier in this chapter. While these trade-offs are nearly identical for the NER Plan and the LPP, one feature sets them apart: the configuration of the Pine Gulch Creek Delta component. With the Riparian plan (LPP), none of the riparian habitat would be removed, thus favoring the riparian habitat over the estuarine habitat and the unique values it provides to the lagoon environment. With the Estuarine plan (NER Plan), 7 out of 17 acres of riparian habitat would be removed, favoring the estuarine habitat over the riparian habitat and the unique values it provides to the lagoon environment. The decision over which habitat type is more "valuable," or provides the largest overall benefit to Bolinas Lagoon, is a personal one, which is why the local sponsor has left that decision to the public.

6.5 Plan Selection

Selection of the recommended plan(s) is based on a number of criteria, including cost efficiency, cost effectiveness, NER, EQ, RED, OSE, completeness, effectiveness, efficiency, acceptability, and the trade offs between action plans, as discussed in Chapters 5 and 6. After the alternative plans are fully evaluated and compared, the top candidate plans are selected. In this case, there is an NER Plan and an LPP, both of which are the tentatively selected plans for the Draft Feasibility Report. Based on continuing coordination with the local sponsor, results of the public involvement/review process, and continuing refined evaluation of the restoration alternatives, a recommended plan will be identified for the Final Feasibility Report.

6.5.1 Rationale for Designation of the National Ecosystem Restoration (NER) Plan

The North, Central (Estuarine), and South (No Seadrift) alternative plan is the plan that reasonably maximizes net ecosystem restoration benefits by having the maximum amount of restoration benefits compared to costs. It is, therefore, designated as the National Ecosystem Restoration Plan.

6.5.2 Rationale for Designation of the Locally Preferred Plan (LPP)

The North, Central (Riparian), and South (No Seadrift) alternative plan has been selected by the local sponsor as the Locally Preferred Plan *not* because it is the locally preferred plan (as the name would suggest), but because the local sponsor wanted to present two potential plans for public review. This decision was based on concern over which Pine Gulch Creek Delta variation the local community would prefer.

6.5.3 Rationale for Designation of the Selected Plans

The local sponsor is concerned about choosing the plan that is most supported by the local community; therefore, the final recommended plan will not be selected until after public review of the draft report. It will be up to the public to choose which Pine Gulch Creek Delta variation is preferred. Based on the comments on the Draft Feasibility Report, one of the two final plans (either the LPP or the NER) will be recommended for implementation. The selected plan in the Final Feasibility Report will be the plan that best meets the needs of the local community. No matter what plan is chosen as the recommended plan in the final report, the Federal government will only cost share up to the cost of the NER Plan. If the recommended plan is more expensive, the local sponsor will be responsible for 100% of the excess cost of that plan. For this project, the cost of the LPP would most likely be less than the cost of the NER Plan.

A significant advantage of both the LPP and NER Plan is that they have numerous components addressing a variety of problem areas in the lagoon and encompassing the widest range of possible actions to address the lagoon's sedimentation problem. With a recommended plan this comprehensive, it is easy to extract separable elements for implementation at each dredging season. In addition, because temporary inlet closure is imminent, future inlet closure is warded off even further with the implementation of each sequential component. This would be especially advantageous if funding were to become limited in the future.

6.6 Risk and Uncertainty

Areas of risk and uncertainty are analyzed and described so that decisions can be made with knowledge of the degree of reliability of the estimated benefits and costs and of the effectiveness of alternative plans. Areas of risk and uncertainty are described in Table 6.8.

Table 6.8 Areas of Risk and Uncertainty

Area of Concern	Likelihood	Potential Impacts	Mitigation Measures
1. Disturbance to benthic communities	likely	Temporary/Short Term impact to benthic habitat	none
2. Failure to recruit benthos	low likelihood	Temporary disturbance to benthic communities and to feeding patterns of other species	Monitoring and adaptive management
3. Disturbance to species that feed in the water column (from turbidity)	likely	Temporary disturbance to water column species and species that feed on water column species	Require that construction equipment perform within certain thresholds; Monitoring and adaptive management
4. Decrease in water quality during construction	likely	Temporary disturbance to benthic communities; disturbance to water column species and species that feed on water column species; disturbance to feeding patterns of benthic species, fish, birds, and seals	Use only one dredge at a time; Require that construction equipment perform within certain thresholds; Limit dredging to certain months of the year to avoid major species activities; Monitoring and adaptive management
5. Noise disturbance to species in lagoon from dredge equipment	likely	Temporary disturbance in breeding, nesting and feeding patterns of fish, birds and seals	Use only one dredge at a time; Require that construction equipment perform within certain thresholds; Limit dredging to certain months of the year to avoid major species activities; Monitoring and adaptive management
6. Disturbance in migration patterns of anadramous fish from dredging activities	unlikely	Temporary decrease in the ability for salmon & steelhead to migrate to watershed creeks	Limit dredging to certain months of the year to avoid major species activities (i.e., NOT during migration periods)
7. Disturbance in breeding, nesting, and foraging patterns of migratory waterfowl from dredging activities	likely	Temporary disturbance in breeding, nesting and feeding patterns of migratory waterfowl due to dredging activity, water quality and noise levels	Use only one dredge at a time; Limit dredging to certain months of the year to avoid major species activities; Monitoring and adaptive management
8. Disturbance to pupping harbor seals from dredging activities	unlikely	Temporary disturbance to pupping habor seals in the lagoon	Limit dredging to certain months of the year to avoid major species activities (i.e., NOT during pupping season)

7.0 RECOMMENDATIONS: THE SELECTED PLANS

Two plans, the NER and the LPP, have been selected as tentative plans for the Draft Feasibility Report. This chapter will fully describe the plans and what would be needed for implementation. After public review, one of the two plans will be selected for recommendation to the Headquarters office of the US Army Corps of Engineers; the final recommendation will be reflected in the final report.

7.1 Plan Description

Locally Preferred Plan

The LPP is the North, Central (Riparian), & South (No Seadrift) alternative plan. It includes the following restoration components: North Basin, Main Channel, Highway One Fills, Kent Island, Pine Gulch Creek Delta (Riparian), Bolinas Channel, South Lagoon Channel and Dipsea Road. A map of the LPP is shown in Figure 7.1. This plan would remove a total of 1,472,700 cy of material from the North, Central and South areas of Bolinas Lagoon. The footprint of this plan would cover a total of 429 acres out of 1,100 in the lagoon; about 39% of the total area would be affected. Of the sediment removed, 1,420,700 cy would go to SFDODS for disposal with 1900 barge loads, while 52,000 cy (plus trees and shrubs) would go to the Redwood Landfill with 4,750 truckloads.

NER Plan

The NER Plan is the North, Central (Estuarine), & South (No Seadrift) alternative plan. It includes the following restoration components: North Basin, Main Channel, Highway One Fills, Kent Island, Pine Gulch Creek Delta (Estuarine), Bolinas Channel, South Lagoon Channel and Dipsea Road. A map of the NER Plan is shown in Figure 7.2. This plan would remove a total of 1,504,800 cy of material from the North, Central and South areas of Bolinas Lagoon. The footprint of this plan would cover a total of 446 acres out of 1,100 in the lagoon; about 41% of the total area would be affected. Of the sediment removed, 1,427,500 cy would go to SFDODS for disposal with 1900 barge loads, while 77,300 cy (plus trees and shrubs) would go to the Redwood Landfill with 18,700 truckloads.

Full descriptions of both plans are presented in previous chapters of the Feasibility Report (Chapters 4, 5 and 6) and in the EIS/EIR. In addition, quantity estimates and detailed cost estimates are presented in the Cost Estimates Appendix, and design information is presented in the Engineering Appendix. There are no mitigation measures anticipated for either of the selected plans, with the exception of measures taken to minimize or avoid impact to sensitive habitat areas, including scheduling construction activities to avoid work during sensitive times (nesting and breeding periods, e.g.), using turbidity curtains around the dredge operations, and monitoring before, during and after construction. Many of these measures would be requirements imposed on the dredging contractor during construction.

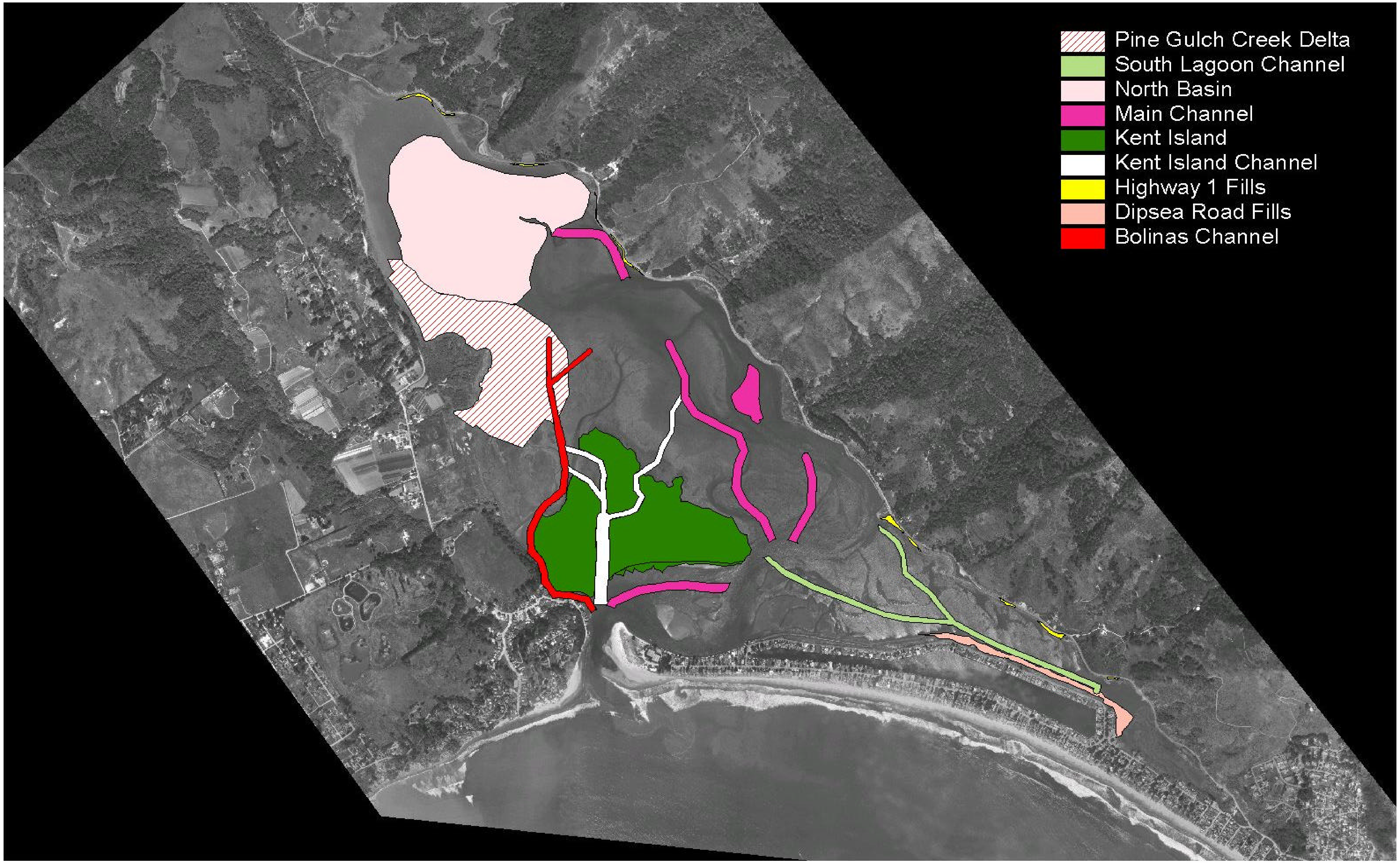


Figure 7.1 Layout of the Locally Preferred Plan

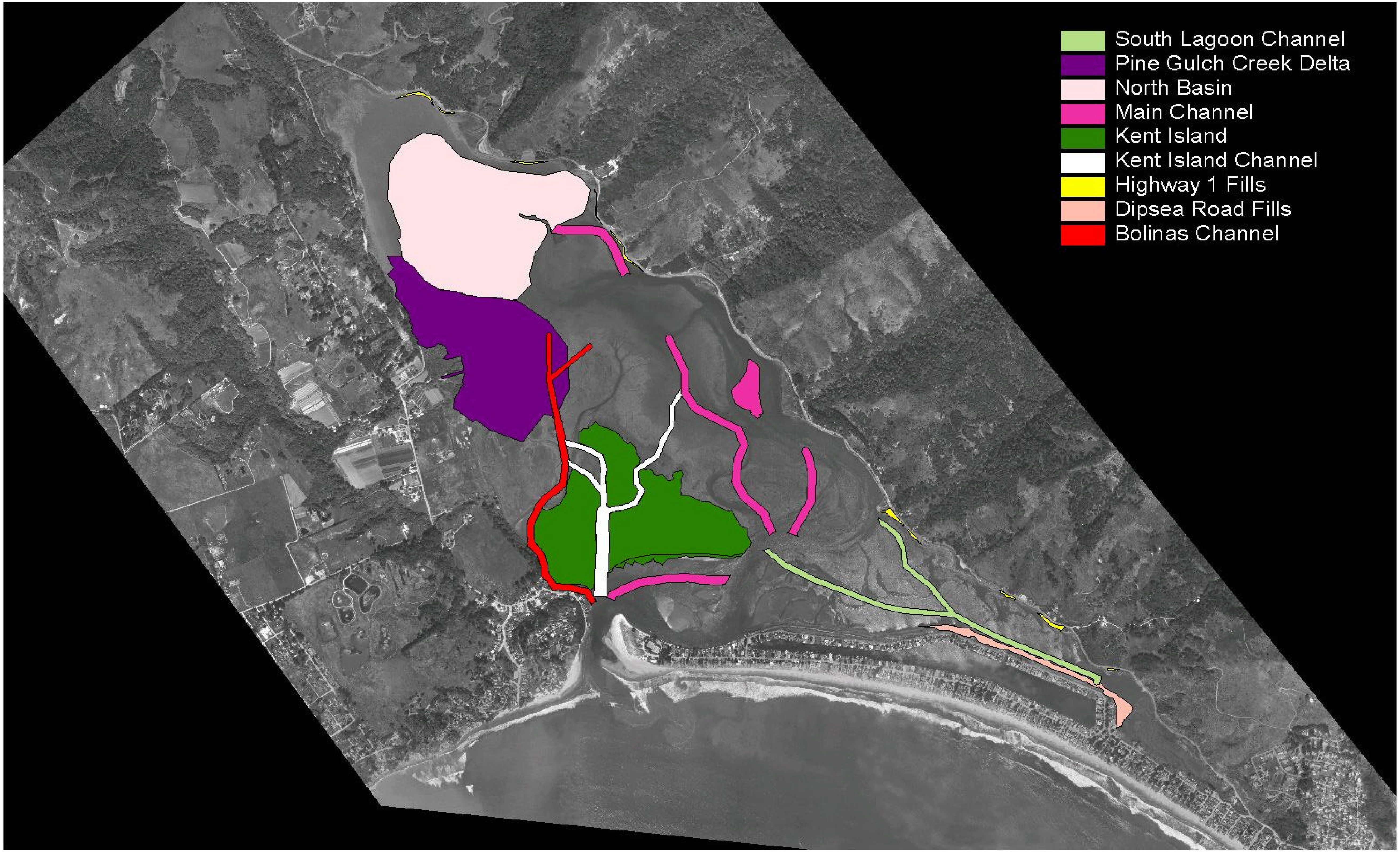


Figure 7.2 Layout of the National Ecosystem Restoration Plan

7.2 Construction Methods

7.2.1 Wet Sediment Excavation: Hydraulic Dredging

Wet sediment would be removed from the lagoon by a hydraulic cutterhead dredge (Figure 7.3), which would remove sediment in liquid slurry from the floor of the lagoon. For the purpose of this Feasibility Study, we have assumed that only one dredge would be used at a time in order to reduce short-term impacts, such as increased turbidity and noise levels, on sensitive habitats. The dredge itself floats, and can be moved by poling forward on walking spuds, by winching along anchor wires, or by using a propulsion system such as an outboard motor. It is a multi-functional unit that

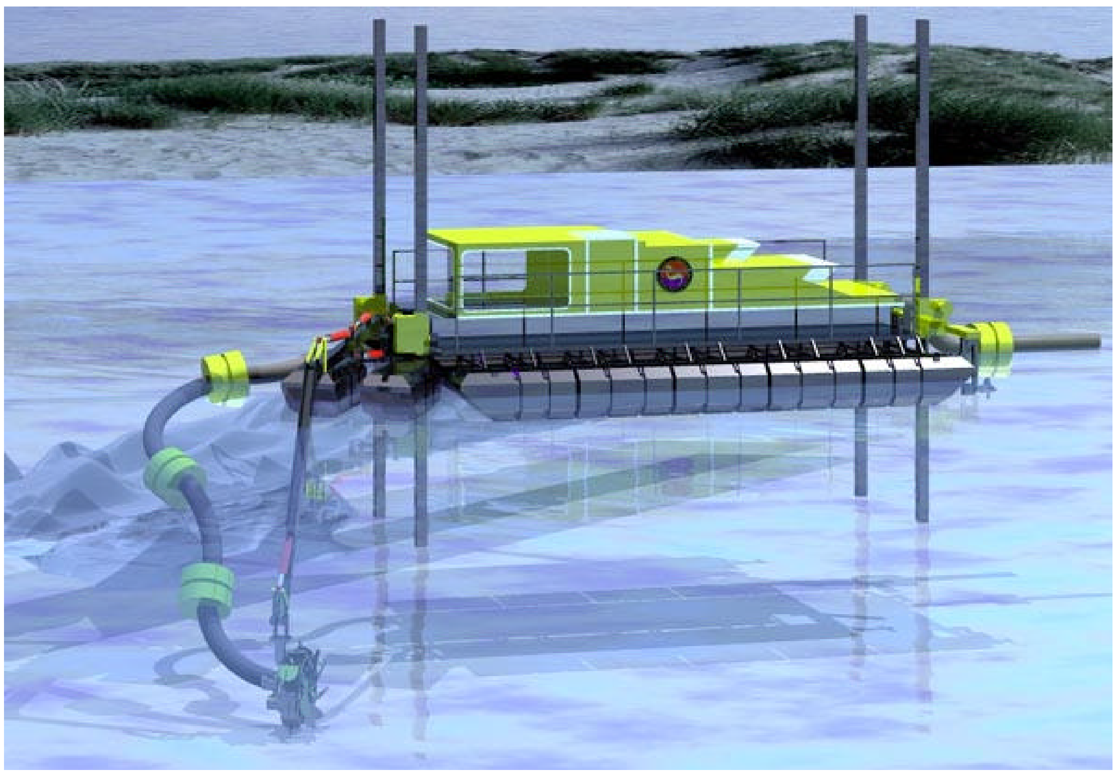


Figure 7.3 Hydraulic Cutterhead Dredge
(Illustration Courtesy of Keene Engineering)

can be transformed into an amphibious dredge, via the use of bolt-on tires. This amphibious conversion allows the dredge to traverse over land and shallow areas normally not accessible to conventional dredges (Figure 7.4). The dredge head is on an articulated pipe extending from the front of the dredge, and can be manipulated with some dexterity by the dredge operator. This articulated head gives the dredge a considerable range, and prevents the need to relocate the dredge frequently. A disposal pipeline will extend from the rear of the dredge, traverse the lagoon, and be inserted into the barge anchored in Bolinas Bay.

Figure 7.4 Amphibious Hydraulic Cutterhead Dredge
(Illustration Courtesy of Keene Engineering)

The dredge head is circular, with sharp teeth designed to chew through packed sand and clay (Figure 7.5). In addition, this particular dredge has optional work implements whereby vegetation "harvesting," raking and solid material grappling is possible, when required. The "underwater trimmer," for example, can be used to cut through existing vegetation, as needed (Figure 7.6). As the dredge head spins, the dredge pump sucks the dislodged sediment in through the dredge head along with a large amount of water to form a slurry. Because the slurry would be pumped some distance prior to disposal, the sediment would be mixed with sufficient water with a ratio of 25 percent solids to 75 percent water. A suction dredge would pull disturbed water and soil into the pipe, so no noticeable long term water quality impacts should result from the dredging activities.

Figure 7.5 Dredge Head on a Hydraulic Cutterhead Dredge
(Illustration Courtesy of Keene Engineering)

The slurry would be pumped from the dredge through a flexible pipeline over the end of Stinson Beach sand spit to one of two transport barges, or scows, anchored in Bolinas Bay (Figure 7.7). The scow would be anchored far enough out in the bay to be past the surf zone, and the anchor would be a buoy left in place during the entire project period. The pipe would be up to 16,300 feet long, made of steel or polyvinyl chloride (PVC), and would be kept afloat by buoys while in Bolinas Lagoon. The pipeline would be 10 or 12 inches in diameter, and would be protected from human disturbance by fences and flags. A walkway would be built to enable passersby to cross the pipeline, either by running the pipe underground at that point or by building a bridge over it. For most of the upland crossing, the pipeline would rest on top of the beach sands, but may be covered by blowing sand as the season progresses. From the beach to the disposal scow, the pipeline would run along the bottom of the bay in order to avoid the force of the surf crashing on the shore. The pipeline would be designed to keep up with the capacity of the dredge as it excavates, so there would be no backlog of dredged material waiting to be pumped out to the scow. The pipeline is designed for removal after the end of each dredging season, and re-installation the following summer.

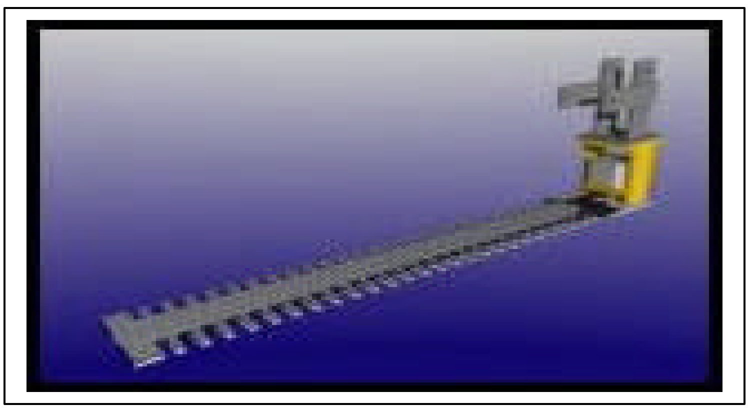


Figure 7.6 "Underwater Trimmer" Attachment to Hydraulic Cutterhead Dredge (Illustration Courtesy of Keene Engineering)

The barge, or scow, anchored in Bolinas Bay would be attached to a semi-permanent platform. As the slurry is pumped into the scow, water would drain over the sides or into internal weirs and back into Bolinas Bay. In order to reduce turbidity in Bolinas Bay, there would be a siltation curtain installed inside the scow to filter the overflow water. Details regarding overflow water quality impacts management would be determined in consultation with the Regional Water Quality Control Board prior to issuance of a Water Quality Certificate. The slurry would not drain completely; therefore it is estimated that the ratio of sediment to water would measure approximately 25% higher than that for the sediment removal. The disposal scows are presumed to operate 24 hours per day, seven days per week. Once filled with slurry, each scow would be towed by a tugboat to the aquatic disposal site. The scows are assumed to have a capacity of 3,000 cy, and would be towed at seven knots to the disposal site; the return trip with an unloaded scow would be at a velocity of roughly eight knots.

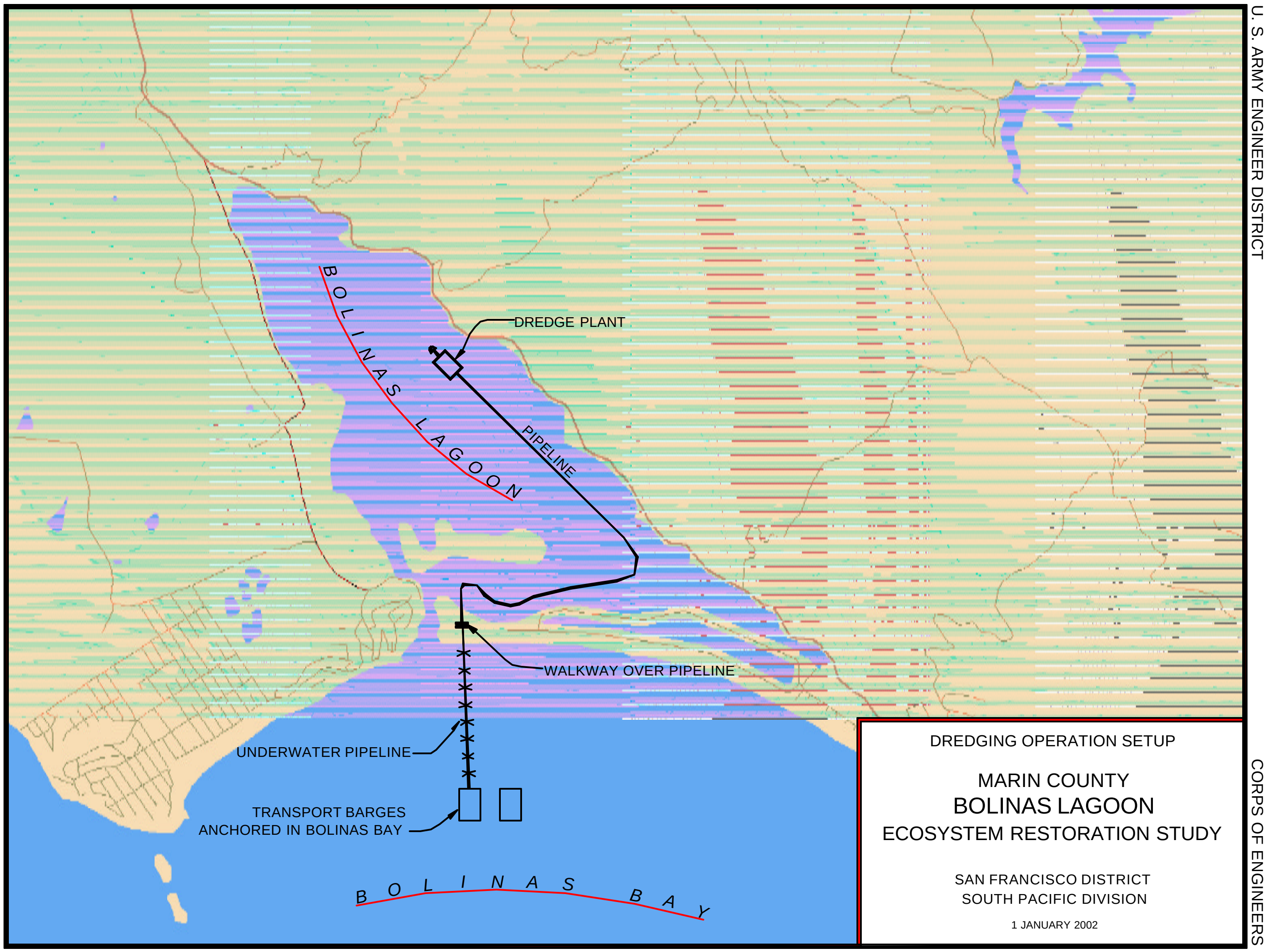


Figure 7.7 Dredging Operations Set-up for the Bolinas Lagoon Ecosystem Restoration Project

7.2.2 Land-Based Excavation

Some of the restoration components remove soil from upland sites adjacent to and within the lagoon. Land-based excavators, such as bulldozers, loaders and cranes would remove upland soils, and vegetation would be mulched, chipped or burned on site. This material would be dry, and therefore would be transported by dump trucks, rather than by barge. Each truck is assumed to have a capacity of 12 cy. Dry material would be trucked to the upland disposal site. Detailed information on hydraulic dredging, sediment excavation and disposal of the material is presented in the EIS/EIR.

7.3 Disposal of Dredged Material

During the PED phase of the project, sediment sampling will be undertaken in the lagoon to confirm that the sites listed below will be appropriate for the disposal of material removed from Bolinas Lagoon. SFDODS requires dredged material to be tested for metals, polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, and other contaminants before disposal is approved. Other tests would include sediment characteristics analyses (grain size, salinity, etc.) in case disposal at a restoration/beneficial reuse site was approved in the future. Because the surrounding watershed is relatively undeveloped, and agriculture is limited, it is assumed that the characteristics of the lagoon sediment would fit well within the parameters of the disposal sites identified in this study. Figure 7.8 shows the location of all disposal sites considered.

7.3.1 Disposal Sites Considered for the Project

7.3.1.1 Beach Nourishment at Ocean Beach

Ocean Beach is located in San Francisco, California, on the western side of the peninsula, facing the Pacific Ocean. Ocean Beach was considered as a potential reuse site, with the material removed from Bolinas Lagoon to be used for beach nourishment. On further analysis, however, it was determined that the grain size was too small and the color was inappropriate for beach use.

7.3.1.2 Beach Nourishment at Stinson Beach

Stinson Beach is located south of Bolinas Lagoon, along the Stinson Beach sand spit near Seadrift Lagoon. Disposal of dredged material from Bolinas Lagoon at this site would be a low-cost beneficial reuse alternative that could potentially reduce the overall cost of the project. Several concerns associated with this disposal option center on Sanctuary guidelines currently in place restricting sediment disposal inside the GFNMS boundaries, and sediment movement in Bolinas Bay, which could potentially redistribute the material back inside Bolinas Lagoon. Although the larger California currents move north to south, in Bolinas Bay currents move in a counter-clockwise direction. It is this movement of water and sand that originally created the Stinson Beach sand spit. Further discussion with the GFNMS would determine whether or not this disposal option would

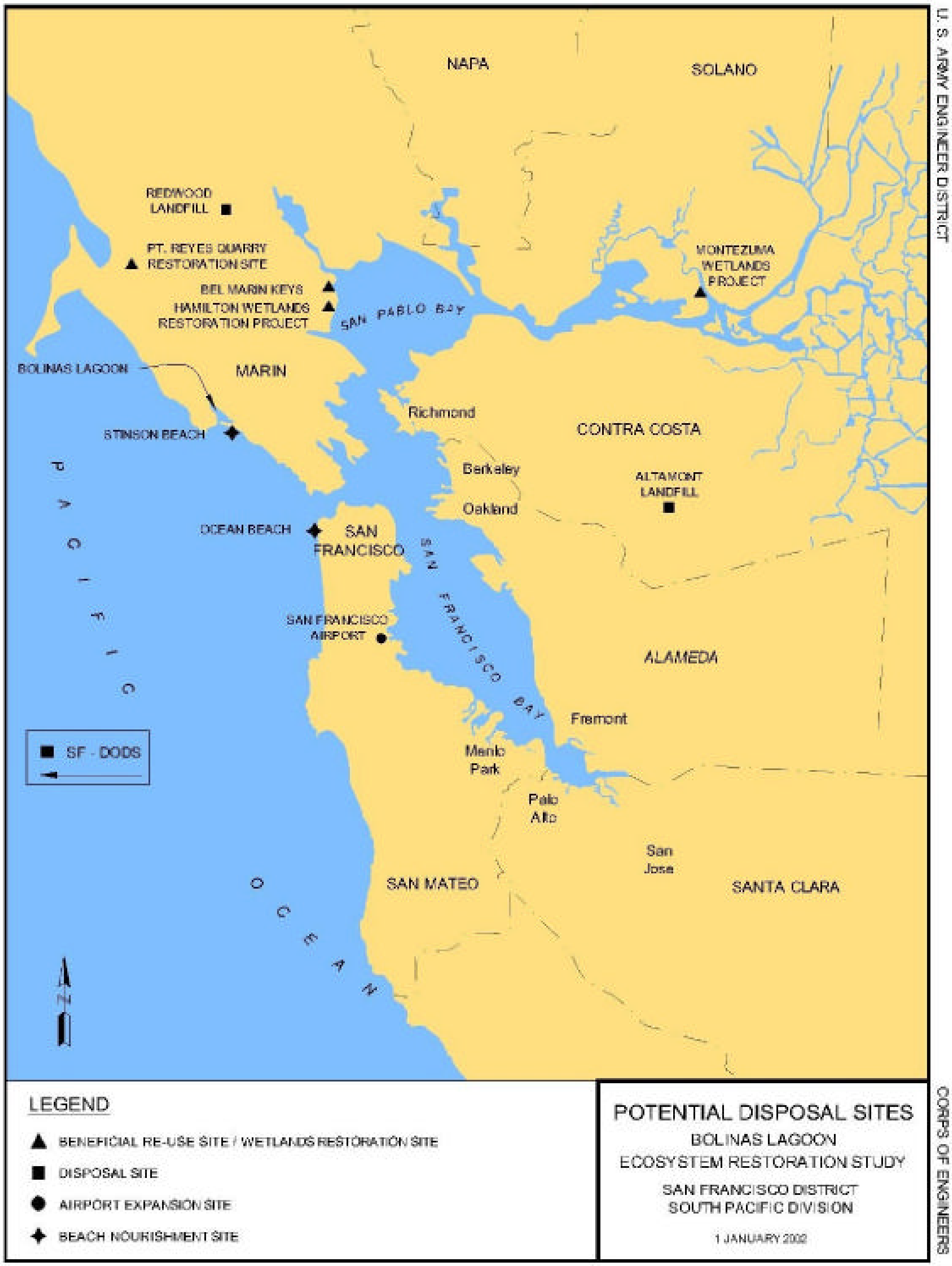


Figure 7.8 All Potential Disposal Sites for the Bolinas Lagoon Ecosystem Restoration Project

be viable. In addition, sediment movement modeling including Bolinas Lagoon and Bolinas Bay would be necessary to determine whether this option was engineeringly feasible.

7.3.1.3 Restoration of Old Mining Quarries (Pt. Reyes National Seashore)

One possibility for local upland disposal was the use of five abandoned quarries within Point Reyes National Seashore (PRNS). These quarries would provide only 50,000 cy to 75,000 cy of disposal volume, however, for dry (upland) materials. Because of concerns regarding seed dispersal from invasive exotic plants, soil erosion, and water quality issues in the PRNS, any materials deposited there would have to be carefully screened before disposal. Additionally, the Corps and Marin County would be required to pay for designing, constructing, maintaining, restoring and revegetating the quarries. While design and construction costs would be cost shared, Operations and Maintenance responsibilities would fall on the local sponsor. These requirements are significant, especially over the long term, and make the quarries less desirable as disposal sites.

7.3.1.4 San Francisco International Airport

The San Francisco International Airport is located in San Francisco, California, on the eastern side of the peninsula, facing the San Francisco Bay. The airport is currently in the planning stages of increasing the number of runways at the airport to reduce flight delays. However, a number of the alternatives have ignited public controversy due to the possibility of placing fill material in the bay, and the planning process has been delayed on several occasions because of input received from interested residents, environmental groups and other entities concerned about the long term impacts of the expansion alternatives. Because of the uncertainties in site capacity, timing of construction and approval of the project, the San Francisco International Airport cannot be identified as a potential disposal site for the Bolinas Lagoon project at this time.

7.3.1.5 Altamont Landfill

The Altamont Landfill and Resource Recovery Facility is a privately held Class II and Class III facility in Alameda County, northeast of Livermore on Altamont Pass Road. The material to be transported to Altamont Landfill would be dry soil removed by land-based excavation equipment from the upland areas adjacent to the lagoon. Dry upland soils would be loaded onto 12 cy dump trucks for transport to Altamont Landfill. The exact route is yet to be determined, but it could include traveling south on Highway 1, north on US 101, or north on Highway 1 and west on Sir Francis Drake, across the Richmond/San Rafael Bridge, and south on Interstates 880 and 580 to eastern Alameda County. Disposal at Altamont Landfill was found to be cost prohibitive and therefore not implementable as a disposal site.

7.3.1.6 Montezuma Wetlands Restoration Site

The Montezuma Wetlands site is near Collinsville in the Suisun Marsh, in Solano County. The Montezuma Wetlands are being restored to tidal wetlands with approximately 20 million cy of dredged material spread over 1,822 acres of historic tidal wetlands. The material to be transported to Montezuma Wetlands would be wet sediment removed by hydraulic dredge from Bolinas Lagoon. The barge would be towed through the Golden Gate and then north and east through San Pablo Bay to the Montezuma Wetlands. Because of the distance of this restoration site from Bolinas Lagoon, however, it was cost prohibitive and therefore not implementable as a disposal site.

7.3.1.7 Hamilton Army Airfield Wetlands Restoration Site (HAAF)

Hamilton Airfield is located in Novato, California. The Hamilton Wetlands Restoration project is currently in the design phase to become an "acceptor" site for dredged material to be reused for restoring wetlands habitat. Currently, Hamilton can accept 10 million cubic yards of dredged material, some of which will most likely be received from the Oakland Harbor deepening project. A component that might be added to the Hamilton restoration complex in the future, which has yet to be authorized by Congress, is the Bel Marin Keys complex. Bel Marin Keys would increase the capacity of the Hamilton site by 15 million cubic yards. (For more information on this site, please refer to the *Hamilton Army Airfield Wetlands Restoration Project Feasibility Report and EIS/EIR*).

Because of the habitat restoration benefits that would be generated by disposing at Hamilton, the Bolinas Lagoon project would prefer to designate Hamilton as the disposal/beneficial reuse site for material taken out of Bolinas Lagoon. Due to some significant uncertainties about Hamilton, however, the Bolinas Lagoon project cannot, with certainty, designate Hamilton as its preferred site for disposal during this Feasibility phase. Hamilton may, however, be selected as the disposal site for the Bolinas Lagoon project in the future if such uncertainties are resolved before the construction phase for Bolinas Lagoon begins.

One uncertainty surrounding the Hamilton restoration/dredged material disposal site is capacity. As mentioned before, a significant portion of Hamilton's capacity is scheduled to be taken up by the Oakland Harbor deepening project. It is uncertain whether Hamilton would have sufficient capacity to accept all of the material from Bolinas Lagoon, or whether the timing of the two projects would be congruent. Bel Marin Keys would add substantially to the capacity at Hamilton, and would allow for disposal further out in the future, but because that project has not yet been authorized, it is unknown whether Hamilton or Bel Marin Keys would be available to receive material from Bolinas Lagoon.

Another factor yet to be resolved is the concern of the Hamilton project that species not found in the Hamilton project area would be inadvertently transplanted via dredge spoils. The Hamilton project seeks to prevent any invasive species or species of concern from unnecessarily "contaminating" the Hamilton restoration site. It is currently unknown whether the material excavated from Bolinas Lagoon would possess species not found at Hamilton, nor, if foreign species were found in the sediment, what effect they would have on the Hamilton restoration site if the sediment they were found in was capped by "clean" cover material. This issue remains unresolved.

Due to the above uncertainties involving Hamilton, SFDODS has been designated as the disposal site for feasibility evaluations of the Bolinas Lagoon project. As Hamilton becomes more defined, and the uncertainties of using the site diminish, future ecosystem restoration opportunities might be presented to allow material from the Bolinas Lagoon project to be disposed of at Hamilton. In that case, all of the Bolinas Lagoon material that would be suitable for reuse at Hamilton would be taken to Hamilton; the remainder would be disposed of at SFDODS or at the Redwood Landfill, as necessary. As it currently stands, however, this report assumes that all wet material (dredged) would be taken to SFDODS and all dry material (excavated) would be taken to the Redwood Landfill.

7.3.2 Disposal Sites Selected for the Project

7.3.2.1 San Francisco Deep Ocean Disposal Site (SFDODS)

SFDODS is located 55 nautical miles (100 kilometers) offshore of San Francisco, and was designated in 1994 by the Environmental Protection Agency as an approved location for "disposal of suitable dredged material removed from the San Francisco Bay region and other nearby harbors or dredging sites" (USEPA 1994). The disposal site has an area of approximately 6.5 square nautical miles (nmi), and is located 49 miles west of the Golden Gate and six nautical miles west of the boundary of the Gulf of the Farallones National Marine Sanctuary. It sits in waters ranging from 8,200 to 9,800 feet deep (USEPA 1998). Any material that would be disposed of at the SFDODS would have to be within the parameters set by the EPA for that site.

In order for a dredging project to be authorized to dispose of dredged material at the SFDODS, sediment evaluations, including appropriate physical, chemical, and biological testing as described in the national sediment testing manual popularly referred to as the Green Book, must first be conducted. Under these guidelines, EPA and the Corps determine suitability of dredged material for ocean disposal, in large part, by comparing the results of tests conducted on the material to be dredged against the results of the same tests conducted on designated reference sediment. Reference sediments are identified by EPA to be substantially free of contaminants, and to be as representative as possible of conditions at the disposal site had no dredged material ever been disposed there.

Only wet material removed by hydraulic cutterhead dredge would be disposed of at SFDODS. Wetting dry material for the purpose of aquatic disposal would be considered "double handling" and would be economically infeasible. All wet material will be taken to SFDODS by barge.

7.3.2.2 Redwood Landfill

Redwood Landfill is a Class III facility in northeastern Marin County, northwest of Novato. It is on the Redwood Highway on the east side of US Highway 101. The material to be transported to Redwood Landfill would be dry soil removed by land-based excavation equipment from the upland areas adjacent to the lagoon. Any plant material that could not be mulched, chipped or burned on-site would also be disposed of at

Redwood Landfill. All of the dry material taken to Redwood would be loaded onto 12 cy dump trucks and transported via surface roads. Table 7.1 illustrates the disposal and transportation method for each restoration component, while Table 7.2 outlines the dredging quantities of each.

Table 7.1 Dredged Material Disposal Sites and Transportation Methods

Excavation Site	Type of Material	Disposal Location	Transportation Method
PGC Delta	Dry soil	Redwood	Truck
	Wet sediment	SFDODS	Barge
	Trees/Vegetation	Redwood	Truck
Bolinas Channel	Wet sediment	SFDODS	Barge
Kent Island	Wet sediment	SFDODS	Barge
	Trees/Vegetation	Redwood	Truck
Main Channel	Wet sediment	SFDODS	Barge
North Basin	Wet sediment	SFDODS	Barge
South Lagoon Channel	Wet sediment	SFDODS	Barge
Highway 1 Fills	Dry soil	Redwood	Truck
Dipsea Road Fills	Dry soil	Redwood	Truck
	Trees/Vegetation	Redwood	Truck
Seadrift Lagoon	Dry soil	Redwood	Truck
	Wet sediment	SFDODS	Barge

Table 7.2 Alternative Dredge Disposal Plan

	Dredge Volume and Location	
	Redwood	**SFDODS**
Alternative	truck (cy)	barge (cy)
North		
North	0	458,537
Main Channel	0	216,241
Central (Estuarine)		
Bolinas Channel	0	130,799
Pine Gulch Creek Delta (Estuarine)	34,753	155,953
Kent Island	0	376,749
Highway One Fills	4,828	0
Central (Riparian)		
Bolinas Channel	0	130,799
Pine Gulch Creek Delta (Riparian)	9,533	149,084
Kent Island	0	376,749
Highway One Fills	4,828	0
South (Seadrift)		
South Lagoon Channel	0	89,246
Dipsea Road	37,692	0
Seadrift Lagoon	3,555	41,403
South (No Seadrift)		
South Lagoon Channel	0	89,246
Dipsea Road	37,692	0
Seadrift Lagoon	0	0
North and Central (Estuarine)	39,581	1,338,273
North and Central (Riparian)	14,381	1,331,410
North and South (Seadrift)	41,722	805,427
North and South (No Seadrift)	37,692	764,024
Central (Estuarine) and South (Seadrift)	80,828	794,150
Central (Estuarine) and South (No Seadrift)	77,273	752,747
Central (Riparian) and South (Seadrift)	55,628	787,281
Central (Riparian) and South (No Seadrift)	52,073	745,878
North, Central (Estuarine), and South (Seadrift)	80,828	1,468,928
North, Central (Estuarine), and South (No Seadrift)	77,273	1,427,525
North, Central (Riparian), and South (Seadrift)	55,628	1,462,059
North, Central (Riparian), and South (No Seadrift)	52,073	1,420,656

7.4 Dredging Schedule

The construction plan and implementation schedule will be developed during the Pre-construction, Engineering and Design phase, which is scheduled to last one t two years. The Construction phase could begin as early as 2004. Once dredging activities begin, it is assumed that dredging would take place three months out of every year. Because Bolinas Lagoon serves as important habitat to many species, including migratory waterfowl, fish, harbor seals and species listed as Threatened and Endangered, dredging must be limited to the times when species activity is lowest in the lagoon. Species activity in Bolinas Lagoon is illustrated in Table 7.3.

Table 7.3 Species Activity in Bolinas Lagoon

Alternative	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
North Lagoon												
North Basin		Wintering Shorebirds (foraging)							Wintering Shorebirds (foraging)			
		American Avocets								American Avocets		
	Egrets & Herons (staging)		(egg formation)		(feeding nestlings)			(juvenile foraging)				
						Leopard Sharks (breeding)						
			Steelhead	(juveniles)							Steelhead (adults)	
Main Channel							Pelicans, Heermann's Gulls & Terns (& their prey)					
				Harbor Seals (pupping)								
			Diving Birds								Diving Birds	
			Steelhead	(juveniles)							Steelhead (adults)	
Central Lagoon												
Highway 1 Fills				Harbor Seals (pupping)								
Kent Island				Harbor Seals (pupping)								
			Steelhead	(juveniles)							Steelhead (adults)	
Bolinas Channel			Diving Birds								Diving Birds	
			Steelhead	(juveniles)							Steelhead (adults)	
							Pelicans, Heermann's Gulls & Terns (& their prey)					
PGC Delta			Steelhead	(juveniles)							Steelhead (adults)	
South Lagoon												
Seadrift Lagoon			Diving Birds								Diving Birds	
							Pelicans, Heermann's Gulls & Terns (& their prey)					
S. Lagoon Channel				Harbor Seals (pupping)								
Dipsea Road							-none-					

7.5 Design and Construction Considerations

Following report approval, the Pre-construction, Engineering and Design phase, which includes preparation of plans and specifications, could be accomplished within two years (from 2002 to 2004). Afterwards, the construction phase would commence with real estate activities, including mapping, legal descriptions, appraisals, obtaining possession of the land, and certification of all necessary LERRD (this process is described in more detail in the Real Estate Appendix). Real estate activities would last about two years, or until the spring of 2006. Construction of the recommended plan would then commence in the summer of 2006, and would continue for nine dredging seasons, ending in the year 2014. Post-implementation monitoring and adaptive management would continue for five years thereafter, concluding in 2019. At that point, the Operations and Maintenance (O&M) plan would be implemented (The O&M plan is discussed in more detail in Section 7.12).

During the construction period, measures cited in Engineering Pamphlet 1165-2-501, *Environmental Policies, Objectives, and Guidelines for the Civil Works Program of the Corps of Engineers*, would be followed to maintain public dialogue, minimize disturbance to environmental and cultural resources, and ensure proper disposal methods. Safety measures would be taken to protect individuals present at the site or living near the construction area.

7.6 Construction Scheduling and Implementation

The construction phase of the project could begin as early as the summer of 2004 (after completion of the PED phase). All construction activities are scheduled to avoid impacts to sensitive species during important life cycle stages, such as migration, breeding, nesting, pupping, etc. The primary species of concern are the steelhead and Coho salmon (migration season), harbor seals (pupping season), and migratory waterfowl (nesting and foraging seasons). The major life cycle events of these species start in the beginning of October (with salmon migration) and continue to the end of July (the end of the harbor seal pupping season) every year. Monitoring will take place before, during and after construction to measure the effects of construction on the habitats in Bolinas Lagoon. During construction, monitoring will be especially important in preventing unforeseen adverse impacts to sensitive habitats or species and developed lands adjoining the lagoon.

Priority will be given to the completion of work within sensitive habitat areas during less sensitive seasons. These activities would include dredging in the North Basin and at Kent Island, dredging in the Main Channel, South Lagoon Channel and Bolinas Channel, and excavation work at Pine Gulch Creek Delta. The channel areas and Kent Island should not be dredged during the harbor seal pupping season or during the anadramous fish migration season. Activities in the North Basin and at Pine Gulch Creek Delta should not take place during important migratory waterfowl activities, such as the breeding, nesting and foraging seasons. It is possible that land excavation in other areas, such as at the Highway One Fills, Pine Gulch Creek Delta and Dipsea Road could take place outside of these windows. A detailed construction and implementation plan will be developed for the recommended plan during the PED phase.

A significant advantage of both the LPP and NER Plan is that they have numerous components addressing a variety of problem areas in the lagoon and encompassing the widest range of possible actions to address the lagoon's sedimentation problem. With a recommended plan this comprehensive, a long construction window should not be a problem because as each element is implemented, benefits will begin to accrue immediately. Future inlet closure will be warded off increasingly with each sequential component.

7.7 Summary of Benefits

A summary of project benefits for the NER Plan and the LPP are presented in Chapters 5 and 6 of the Feasibility Report, including the Incremental Cost Analysis (ICA) and the NER account. For those analyses, the benefits are expressed as cubic yards of intertidal volume, calculated as an annualized average. Other project benefits that are not quantified in the ICA include improvement in tidal circulation throughout the lagoon, increased quantity and quality of subtidal and intertidal habitats, restoration of historic ecological benefits, preservation of existing ecological benefits, and an overall improvement to the Bolinas Lagoon ecosystem.

7.8 Summary of Costs

Project costs are presented in Chapters 5 and 6, and a more detailed list of project costs, using the Corps of Engineers Micro-Computer Aided Cost Estimating System (MCACES), is illustrated in the Cost Estimates Appendix. Real Estate costs were based on an appraisal of the current cost of acquisition. Details of the real estate cost estimate are included in the Real Estate Appendix. The MCACES cost estimate was developed using 2001-year price levels.

A Fully Funded Estimate was developed based on the construction costs. The Fully Funded Estimate adjusts the construction costs for budget purposes to better anticipate the actual future costs recognizing the impact of future price levels. The Fully Funded Estimate is escalated to the mid-point of construction using Office of Management and Budget designated inflation rates, which posts an escalation factor of 12%.

Interest During Construction (IDC) is calculated using a 6.125% discount rate over an estimated construction period of nine years. Costs used for calculating IDC include construction costs, the development of plans and specifications, engineering during construction, supervision and administration of construction, and economic real estate costs. The total IDC for the LPP is $32,446,323 and $32,716,077 for the NER Plan. These figures assume 9 years for construction at Fiscal Year 2002 price levels, a Federal Discount Rate of 6.125% (required for all Federal water resource projects), and a 50-year period of economic evaluation. The project's financial costs (project first costs) and investment costs (IDC) are added together, then averaged out over 50 years, and the result is equal to the average annual cost of the project. The average annual cost of the LPP would be $8,156,165, and for the NER Plan, $8,223,975.

7.9 Real Estate Requirements

The real estate requirements consist of a permanent easement for 275.94 acres, permanent channel improvement easement for 8.58 acres, temporary pipeline easement for 0.52 acres, temporary road easement for 0.12 acres, and temporary work area easements for 1.28 acres. The required standard estates for this project include fee, permanent channel improvement easements, temporary pipeline easement, temporary road easement, and temporary work area easements.

The non-standard estate of permanent channel improvement easement is requested, however, in lieu of fee for the lands within the Bolinas Lagoon that are to be acquired from private property owners and some of the Government and local agencies. Because the lagoon is governed by the GFNMS, the lands cannot be acquired for fee. Further, fee acquisition would not be feasible due to complications and costs that would arise from acquiring fee title from such government agencies that cannot transfer title and private owners where such acquisitions would involve severing their parcels. Existing strict permitting requirements and regulations affecting private and public lands in and around the lagoon provide sufficient protection to maintain project integrity for as long as the project is authorized.

Other considerations include: 1) an area in Bolinas Lagoon waters owned by Golden Gate National Recreation Area (GGNRA), a Federal agency, which is a temporary construction area that requires fee; 2) the area along Highway One owned by the California Department of Transportation (CalTrans) that requires a temporary work area easement; 3) and a small area in Bolinas lagoon waters owned by the State of California that requires fee. Permits or licenses will be requested in lieu of the standard estates for these particular areas because they are actually located in the lagoon waters, are required for one-time dredging only, and are protected by the governing laws of the Marine Sanctuary (as stated above).

Marin County owns 216.37 acres of Bolinas Lagoon that are required for this project. They were granted these lands through legislation in 1969, from the State Lands Commission (SLC). This grant provided them with sufficient rights to provide these lands for the purposes of this project, in which the SLC concurs. Marin County, however, is not the local sponsor but is part of same political body as MCOSD, the proposed local sponsor. An MOU, as discussed at the AFB held on December 13, 2001, will be executed between Marin County and MCOSD. The MOU would allow MCOSD to use County lands in perpetuity for the project. Because the local sponsor is providing the lands in the Bolinas Lagoon via an MOU with Marin County, with Marin County retaining the "ownership" granted to them by the State Lands Commission, and because Marin County will not, in fact, have to purchase/acquire these lands, LERR credit for such submerged lands will not be given to the sponsor.

The Real Estate Plan, which is detailed in the Real Estate Appendix, contains details of the real estate requirements and costs for the LPP and the NER Plan, including a delineation of all properties required to implement the project features.

7.10 Monitoring and Adaptive Management Requirements

The monitoring and adaptive management requirements for the LPP or NER Plan are outlined in the Draft Conceptual Monitoring and Adaptive Management Plan below. As stated in this plan, monitoring would be conducted before implementation of the project (during the PED phase), during construction, and for five years after completion of construction. Monitoring is assumed to be 1% of the project first costs, and adaptive management is assumed to be 3% of the project first costs. The Corps and the local sponsor would share all of these costs.

7.11 Draft Conceptual Monitoring and Adaptive Management Plan

This plan provides a general framework for monitoring the success of the Bolinas Lagoon Ecosystem Restoration Project. Included is guidance for monitoring the performance of the constructed project, including lagoon hydraulics and biological success. This conceptual plan will be greatly expanded and quantified in the detailed design phase of the study.

This plan covers the pre-construction baseline measurement period as well as the during-construction and post-construction monitoring periods. This “post-construction monitoring and adaptive management period” will extend for 5 years after completion of project construction, or after completion of a functional portion thereof. All monitoring and adaptive management activities will be cost-shared by the Corps and the local sponsor (65% Federal and 35% Non-Federal). All monitoring phases will be fully described in the plans and specifications for construction.

Should it become apparent after completion of the designated monitoring and adaptive management period that the design or construction processes have caused a significant departure from the project’s authorized purposes, full project usefulness, or project function as originally intended by Congress at the time of original project development, appropriate steps to modify the completed project will be taken under USACE Engineering Regulation 1165-2-119. In general, if the standards of application of this modification process are met, corrective action will be taken by re-opening the project under its original legislative authorization. Any such corrective activities would be cost-shared between the Government and the Sponsor under the original 65% federal and 35% local proportions.

Monitoring of biological, ecological and hydraulic conditions will track the evolution of the lagoon before, during, and after sediment removal. Periodic comparisons of measured conditions with expected conditions will determine whether the lagoon is functioning as desired. A monitoring and adaptive management advisory panel will be established to participate in the development of the program and make recommendations to the Corps and local sponsor regarding the program. Annual reporting from this panel will provide decision-makers with invaluable information on the success of the project as it progresses, and for five years after it is in place.

Restoration goals and objectives for the project are qualitative statements in the Feasibility Report and Environmental Impact Report/Environmental Impact Statement (EIR/EIS) regarding expected future conditions, such as increasing intertidal and subtidal habitat, and the expected ecological changes that will coincide with an increase in these habitats. Quantitative standards intended to measure progress towards these goals and objectives will be developed later for the detailed monitoring and adaptive management plan.

7.11.1 Measurements and Data Gathering

Measurements and data gathering for the project fall under three categories: 1) pre-construction baseline measurements; 2) during-construction monitoring; and 3) post-construction monitoring, with different purposes for each. Many hydraulic measurements were taken as part of the Feasibility Phase to determine baseline conditions of the hydraulics. Before construction, a variety of measurements will be taken to better determine baseline conditions, focusing primarily on the ecology of the lagoon. Such measurements would include surveys of benthos, birds, fish, rare, threatened, endangered and protected species, eelgrass habitat, turbidity, and salinity, as well as hydraulic measurements of flow, channel and inlet geometry, wind and wave power, tidal volume, etc. Other important measurements at this juncture would include spot elevations of structures adjacent to Bolinas Lagoon (homes along Wharf Road) and bulkheads of Seadrift homes adjacent to Bolinas Lagoon, as appropriate.

Monitoring during construction will include the same parameters, but with the specific purpose of determining whether the project is proceeding successfully, according to project goals and predicted results. Specific hydraulic measurements would look at tidal flow through channel, flood shoal, delta and basin areas; changes in intertidal and subtidal habitat; inlet flow, geometry and closure potential. These measurements would be taken to monitor progress of the construction project to ensure the project was being constructed as designed, and the hydrology was behaving as predicted. Ecological measurements, such as benthic recruitment, bird counts, fish surveys, etc., would be taken to confirm that ecological benefits were developing as predicted, and that the restoration goals of the project were being met. Measurements of water quality parameters such as turbidity, salinity, dissolved oxygen, etc., would be required as part of the construction contract. If unacceptable levels of any particular parameter, attributable to project implementation, were measured during construction, management measures would be developed and implemented to address the problem areas.

Post-construction monitoring would focus on the same hydrological and biological parameters, but would focus specifically on the lagoon's function as an ecological system. If unacceptable levels of any particular parameter were measured during the 5-year period after construction, management measures would be developed and implemented to address the problem areas. Some management measures will be developed as part of the adaptive management plan prior to construction. If unforeseen or unpredicted circumstances arise, new management measures would have to be developed by the advisory panel for consideration by the local sponsor and Corps of Engineers. It is assumed that the adaptive management plan would be flexible enough to address such unforeseen circumstances, and is important specifically for that reason. The concept of the adaptive management plan will be explained later in this document, and will be developed in more detail during the Pre-Construction, Engineering and Design (PED) phase of the project.

7.11.2 Monitoring

The monitoring program will have three basic components: hydraulics, water quality, and biological resources.

Hydraulics

Measurements of hydraulic parameters will ensure that hydraulics are behaving as predicted, and that there are no areas of excessive scour or deposition. If unacceptable levels of any given parameters are measured during construction, the design of the sediment removal alternatives would be modified to bring about the desired results. If unacceptable levels are measured after construction, remedial actions may be necessary to correct for scouring or accreting areas.

Pre-Dredging Monitoring: Baseline measurements taken before construction will be taken during the PED phase.

Tidal Volume and Flow – Measurements of tidal volume and flow may be necessary for monitoring and predicting the effects of the project, as well as for verification of the hydraulic and sediment model(s) used during the final design phase. For example, depth and flow characteristics of the channels and other important hydraulic areas (e.g., flood shoal, delta, and basin areas) could be measured.

Wind and Wave – Measurements of wind and wave characteristics before construction would help inform decision-making during and after construction.

Inlet Measurements – Measurements of inlet geometry and flow characteristics would also be important to the overall hydraulic monitoring plan since tidal prism and inlet geometry are directly related.

During Dredging Monitoring: Construction monitoring will take place during the entire construction period; some measurements would only be taken during the dredging season, while others would be taken periodically throughout the year. Monitoring during this phase would focus on the same parameters as those listed in the Pre-Construction Monitoring plan, but the specifics would depend on the final design of the selected alternative, construction methods and sequencing, and even the construction contractor.

Bathymetry – For the purposes of consistency in data, a bathymetric survey of the lagoon may be called for in 2008, since the last one was conducted in 1998, and bathymetric surveys have been conducted every ten years since 1968. A bathymetric survey would help calibrate hydraulic and sediment models developed during the PED phase, and would serve as a basis of comparison for future monitoring and modeling. If costs are prohibitive, cross-sections or other simple measurements could be taken in important areas for the same purpose. A bathymetric survey, however, would be ideal.

<u>Post-Dredging Monitoring (5 years):</u> Post-Construction monitoring would be conducted by the Corps and MCOSD for five years after sediment removal ceases in the lagoon. Annual reports providing an analysis of lagoon progression or evolution would be provided.

Bathymetry – A bathymetric survey conducted in 2018 would be an important contribution to the "historical" database. The information obtained from this project would not only be useful to the Bolinas Lagoon project, but could also be useful to projects outside the lagoon, especially in the area of hydraulic and sediment modeling. Information on channel geometry, function of the delta, flood shoal and basin areas, as well as hydraulic function of the lagoon would be obtained from the bathymetric survey.

Tidal Volume and Flow – Measurements of tidal volume and flow would be taken post-construction to measure the hydraulic success of the project against predictions. For example, insufficient flows in important areas would necessitate development and implementation of management measures listed in the adaptive management plan.

Wind and Wave – Wind and wave measurements would continue post-construction to get an overall picture of the lagoon hydraulics, and would aid in decision-making for adaptive management.

Inlet Measurements – As mentioned in the During Construction Monitoring section, measurements of inlet geometry and flow characteristics would be an important component of the overall hydraulic monitoring plan since tidal prism and inlet geometry are directly related, and both are related to project goals.

<u>*Water Quality*</u>

Basic water quality measurements will be taken before construction in order to inform measurement-taking during and after construction. Water quality monitoring would be similar for each phase of the project, but may vary in timing and/or duration. Measurements would be taken at several locations in the lagoon, and would most likely be taken four to six times per year to account for dredging-induced changes and natural variation. Water quality parameters would include salinity, turbidity, dissolved oxygen, etc. Because dredging only causes short-term impacts to water quality in areas of significant tidal flow (like Bolinas Lagoon), water quality is expected to improve quickly after each dredging season. If water quality deficiencies attributable to project implementation were substantial and persistent, remedial actions would be developed and implemented.

Biological Resources

Because the primary purpose of the Bolinas Lagoon Ecosystem Restoration Project is restoration, monitoring will focus on ecological parameters for measurements of project "success." Data collected under the monitoring program will be compared to the ecological success criteria for the project, which will be based on restoration goals. It is expected that dredging will cause short-term impacts to the ecology of the lagoon, which will be offset by an increase and improvement of intertidal and subtidal habitats, which will in turn bring about long-term ecological benefits. It is also expected that certain regulatory requirements (like water quality parameters) will eventually be included in the monitoring plan after public review of the Feasibility Report and EIR/EIS.

Pre-Dredging Monitoring: Baseline measurements of different ecological parameters will be taken before construction in order to assess the effects of sediment removal in the lagoon.

Vegetation and Habitat Delineation in Intertidal and Adjacent Upland Zones – Surveys would be conducted to determine the extent, location and composition of the intertidal zones of the lagoon. Information on intertidal and adjacent upland habitats will be correlated to bathymetric survey elevations; therefore, field surveys would most likely be minimal, used only to confirm general habitat composition. Use of this habitat, found in measurements of fish use, bird use, etc., would be more important for determining project success.

Biological Surveys – Surveys of algae composition, benthic macroinvertebrates, birds, fishes, harbor seals, threatened, rare and endangered species, and invasive species would be conducted before construction starts to determine baseline conditions. If appropriate, the Bolinas Lagoon monitoring plan will tap into local resources and on-going monitoring [like Point Reyes Bird Observatory (PRBO) bird counts, for example].

During Dredging and Post-Dredging Monitoring: Similar monitoring programs would be conducted during and post construction.

Indicators That Would Demonstrate Ill Effects from Dredging

Algae Composition – An algal expert would be needed on the Advisory Panel to provide input on algal monitoring. Algae are an important component of the ecosystem in Bolinas Lagoon; a decrease in this group of species may signify unexpected and detrimental effects from dredging.

Benthic and Planktonic Biomass – Measurements of benthic and planktonic biomass would be an important indicator of the overall health of the base of the lagoon ecosystem. Development of a benthic macroinvertebrate community should occur within the first year after dredging is completed at each site. The presence of a thriving benthic macroinvertebrate community (together with abundant fish and bird populations) would indicate that the lagoon was ecologically healthy. The composition of the benthic community can be expected to change rapidly and unpredictably due to normal, natural fluctuations, which might lessen the value of monitoring trends in these species. Although there are a lot of "unknowns" regarding the benthic community in Bolinas Lagoon, this parameter would be important to measure because it represents the food base for many species, including intertidal shorebirds and some fish species. At each restoration location, benthic surveys would be conducted during the construction period of each site, and for two to three years afterwards to document the colonization of the lagoon by these species. Additional surveys may be conducted later if site deficiencies arise.

Use by Birds – As emergent marsh and upland habitat are converted to lower elevation intertidal habitat like tidal flats and subtidal habitat, the assemblage of bird species that inhabit the lagoon should change similarly. For example, bird species that specialize on subtidal and tidal flat habitats (like diving ducks, certain shorebirds, etc.) should increase in number, while those dependent on emergent marsh (fewer in number), should decrease. Periodic bird surveys would document trends in use of the site by birds as compared to present use, and would be a gauge for determining the success of habitat restoration in the lagoon.

Invasive Species – Surveys of identified invasive species (e.g., *Potamocorbula* spp. and *Spartina* species, like *S. alterniflora*, *S. densiflora*, *S. angilica* and *S. patens*) would be conducted to determine whether the project caused these particular species to increase in population. If measurements indicate increasing numbers of invasive species attributable to project implementation, management measures would be developed and implemented to address the problem areas. Increasing numbers of invasive species would be an indication that the restoration project may be failing at some level.

<u>Indicators That Would Demonstrate an Overall Improvement to the Bolinas Lagoon Ecosystem</u>

Eelgrass Habitat – Because eelgrass was historically abundant, but has declined over time with decreasing channel depths and subtidal habitat, restoration of eelgrass in the lagoon would be a major success for the Bolinas Lagoon restoration project. Eelgrass surveys would be conducted (or coordinated with agencies who currently conduct surveys) to determine the presence and abundance of this species. Replanting of eelgrass has been largely unsuccessful, but it is thought that creating deeper channels and subtidal areas would provide, at the minimum, an area appropriate for recolonization. In addition, propagation of local eelgrass species (from within Bolinas Lagoon) might be an option for restoration. If eelgrass coverage did not increase, management measures may be developed and implemented, if practicable.

Use by Fish – Fish surveys would commence during the PED phase, at least one year prior to construction, and would continue throughout the construction phase. They would document the habitat quality and suitability of the lagoon habitats for fishes. Ongoing surveys would document use of the lagoon by fishes as intertidal and subtidal habitat increased, and tidal volume and flow subsequently increased. Restoration of habitat for fish and a concomitant increase in use of the lagoon by fish, especially by fish species that once inhabited the lagoon, but are no longer found, would indicate that the restoration project was particularly successful.

Use by Rare, Threatened, Endangered and Protected Species (e.g., *Cordylanthus maritimus*, Coho Salmon, Steelhead, California Black Rail, and Harbor Seals) – As tidal flow and intertidal and subtidal habitats increase, the quality of the habitats for these species is expected to improve. After suitable habitat has developed in the lagoon, periodic surveys will be coordinated with the US Fish and Wildlife Service, California Department of Fish and Game, and National Marine Fisheries Service to ensure compliance with endangered species laws and regulations.

7.11.3 Adaptive Management Planning

To facilitate long-term planning and implementation of solutions for the Bolinas Lagoon Ecosystem Restoration Project, a comprehensive adaptive management plan will be developed during the PED phase to provide a roadmap for the long-term stabilization, restoration, and management of the lagoon. The plan will be comprehensive in nature, covering all the important issues facing the lagoon, but also will be easily adaptable, in order to reflect the changing conditions and needs of the lagoon. The Bolinas Lagoon Comprehensive Adaptive Management Plan (AMP) is not intended to be a capital improvement plan, focusing just on implementing engineering solutions. Instead, this document would serve as the basis for consideration of implementation of the monitoring and adaptive management actions recommended by the Expert Panel during the planning process, and as a guidance instrument from which to develop a long-term management plan with full stakeholder involvement.

Adaptive management provides for studies and management programs that can be adapted to uncertain or unforeseen circumstances. A well-designed adaptive management plan anticipates as many circumstances as possible before designing monitoring and data assessment approaches. The adaptive management plan would identify circumstances or issues, such as stream flow, erosion and sedimentation rates, or problems with restoration activities or operation. However, unexpected circumstances such as institutional changes (e.g., changes to the Endangered Species Act or other laws), new natural resource management directives (e.g., maximizing tidal exchange, increase seal haul out areas), newly understood ecological phenomena (e.g., global climate change), or land and water use changes (e.g., upstream development) may arise. While some of these may fall outside of the scope of the plan (e.g., toxic spills) and would be addressed through other programs or directives, others might be related to shortcomings in the project that could arguably be included under these adaptive management objectives (e.g., possible beach erosion).

Adaptive Management, as used for the Bolinas Lagoon project, will be “passive” adaptive management. Changes in management will be made in response to monitoring results, versus an “active” type of adaptive management where specific experiments are conducted in order to learn about ecological processes. No specific experiments are contemplated, and the AMP does not include experimental changes in instream flow designed to determine the relationship between stream flow and sedimentation.

Several objectives to determine the efficacy of the project will be identified in the AMP. These objectives will be based on the purpose and need identified in the EIS/EIR. For each objective, the Adaptive Management process will follow a systematic process, beginning with a testable hypothesis, to indicate whether an objective is being met. The methods used to test the hypothesis will be identified in the AMP, and will be comprised of established and routine procedures, surveys, analysis, and/or modeling. An implementation schedule will list the duration and order of monitoring activities for each objective, and include trigger events and end points. Trigger events are circumstances indicating that an adaptive response should be taken, and end points are circumstances indicating that an objective has been attained, and monitoring and data assessment is no longer needed for that objective. Some objectives may not have end points and would require monitoring and data assessment for the entire term of the AMP.

If a trigger event occurs, indicating an objective has not been met, then an adaptive response will be required. This could involve further diagnostic studies or modification of the restoration activities or operations; or changes to natural features of the project area designed to bring the system closer to achieving the objective. All responses must be feasible, practical, reasonable, prudent, and will take into account the views of the local community, though this does not preclude potentially major modifications to project facilities or operations. However, each response would have response limits that describe the absolute scope of actions that can be taken in response to a trigger event.

In general, response limits under the AMP will be identified through consensus to the extent practicable, guided by principles of feasibility, practicality, reasonability, prudence, local community acceptance, and would conform to limits identified by the US Army Corps of Engineers. Possible adaptive responses that fall outside the project's scope, such as major upstream modifications, would require further decisions through the established Corps processes. In addition, nothing in this AMP is intended to bind the Sponsor or the US Army Corps of Engineers, or otherwise limit their respective authorities, in the performance of their responsibilities under applicable state and federal laws.

All adaptive responses will be evaluated, and their outcomes compared to the objective. If the objective has been met, then the original monitoring and data assessment approach would be resumed. If the objective is still not met, the monitoring and data assessment approach may be modified to diagnose the problem.

An important component of the adaptive management process will be reporting, which includes emergency reporting procedures, regular periodic reporting, and final long-term reporting. An annual adaptive management report will summarize all data collected under these monitoring and data assessment approaches and will present analyses required within each objective. Certified raw data and reports generated under these objectives will be updated to appropriate agency and publicly accessible/locally endorsed and maintained information systems using database standards.

7.12 Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) Requirements

Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) requirements of the Bolinas Lagoon ecosystem restoration project are the responsibility of the local sponsor, in accordance with provisions contained in the Water Resources Development Act of 1986 (PL 99-662). The obligations will remain in effect for as long as the project remains federally authorized. Unexpected future actions would have a separate, currently unknown cost. Since one of the goals of this project is to create a self-sustaining ecosystem, regular maintenance dredging in Bolinas Lagoon is not expected or planned. General OMRR&R responsibilities will include maintaining the features of the project, repairs of a routine nature that maintain the project in a well-kept condition, replacement of worn-out elements or portions thereof, and rehabilitation activities to bring a deteriorated project back to its original condition. However – in light of the project plans that envision limiting dredging activity to the construction period, only; the strict controls on dredging exerted by agencies having jurisdiction over Bolinas Lagoon, particularly including the GFNMS; and the expectation of limited further sedimentation from watershed sources – these maintenance and rehabilitation responsibilities will be articulated so that they do not include rigid preservation of dredged channel depths, dredging prisms, or similar initial design parameters. An official O&M Manual describing all of the OMRR&R requirements will be developed by the Corps during the PED phase.

8.0 PLAN IMPLEMENTATION

This chapter presents the requirements for implementing the Recommended Plans, including Federal and non-Federal cost sharing, and the division of responsibilities between the Federal Government and the local sponsor, MCOSD. It also lists the major milestones necessary for project approval, and a schedule of milestones associated with designing and constructing either of the Recommended Plans.

8.1 Cost Sharing

Federal and non-Federal cost-sharing for the Recommended Plans are in accordance with Section 210 of the Water Resources Development Act of 1996, which establishes the cost-sharing rules for projects authorized after 12 October 1996. Ecosystem restoration projects require that the non-Federal share of the first cost of the project or separable element be 35%. The local sponsor shall provide 100% of any lands, easements, rights-of-way, relocations of utilities or other existing structures (LERR). The value of LERR shall be included in the non-Federal 35% share. Where the LERR exceeds the local sponsor's 35% share, the lcoal sponsor will be reimbursed for the LERR value exceeding 35%. The local sponsor is also responsible for 100% of the costs for operation, maintenance, repair, rehabilitation and replacement of project features (OMRR&R). These costs are outlined in Table 8.1.

Table 8.1 Apportionment of First Costs for Recommended Plans*

			Non-Federal		Federal	
	Project Feature	**First Cost**	**%**	**Cost**	**%**	**Cost**
LPP	First Cost of Construction	$100,716,000	35%	$ 35,250,600	65%	$ 65,465,400
	LERR Credit		100%	$ 2,031,400	0%	--
	Cash			$ 33,219,200		$ 65,465,400
	OMRR&R (average annual)	$200,500	100%		0%	
NER Plan	First Cost of Construction	$101,553,000	35%	$ 35,543,550	65%	$66,009,450
	LERR Credit		100%	$ 2,031,400	0%	--
	Cash			$ 33,512,150		$66,009,450
	OMRR&R (average annual)	$200,500	100%		0%	

*Based on 2001-year price levels

8.2 Federal Responsibilities

The Federal Government will provide 65% of the first cost of implementing the Recommended Plans, including Pre-construction, Engineering and Design (PED), construction and construction management. Project first costs are estimated to be $100,716,000 for the LPP and $101,553,000 for the NER Plan. In addition to its financial responsibility, the Federal Government would:

A. Design and prepare plans and specifications for construction of the Recommended Plan;

B. Administer and manage contracts for construction and supervise the project after authorization, funding and execution of a Project Cooperation Agreement with MCOSD.

8.3 Non-Federal Responsibilities

MCOSD would be responsible for providing 35% of the first cost of implementing the Recommended Plan. The 35% share of the project cost includes MCOSD's responsibility for providing all lands, easements, rights-of-way, and relocations (LERR). The estimated costs are $33,219,200 in cash with $2,031,400 in LERR credit for the LPP, and $33,512,150 in cash with $2,031,400 in LERR credit for the NER Plan.

"MCOSD will also be responsible for operations, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project features. The specific elements of these OMRR&R responsibilities will be developed in consultation with the Sponsor and will be specifically delineated in an OMRR&R Manual that will be provided to the Sponsor. This work is estimated to have an average annual cost of $200,000.

MCOSD will also be required to provide certain local cooperation items based on Federal law and policies. The items of local cooperation are:

a. Provide 35% of the separable project costs allocated to environmental restoration as specified below:

(1) Enter into an agreement that provides, prior to execution of a Project Cooperation Agreement for the project, 25% of PED costs;

(2) Provide, during construction, any additional funds needed to cover the non-federal share of PED costs;

3) Provide all lands, easements, and rights-of-way, and perform or assure the performance of all relocations determined by the Government to be necessary for the construction, operation, and maintenance of the project;

(4) Provide or pay to the Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project; and

(5) Provide, during construction, any additional costs as necessary to make its total contribution equal to 35% of the separable project costs allocated to environmental restoration.

b. For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion of the project, at no cost to the Government, in accordance with applicable Federal and State laws and any specific directions prescribed by the Government.

c. Give the Government a right to enter, at reasonable times and in a reasonable manner, upon land which the local sponsor owns or controls for access to the project for the purpose of inspection, and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project.

d. Assume responsibility for operating, maintaining, replacing, repairing, and rehabilitating (OMRR&R) the project or completed functional portions of the project, including mitigation features without cost to the Government, in a manner compatible with the project authorized purpose and in accordance with applicable Federal and State laws and specific directions prescribed by the Government in the OMRR&R manual and any subsequent amendments thereto. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the local sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

e. Hold and save the Government free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the Government or the Government's contractors.

f. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs.

g. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements or rights-of-way necessary for the construction, operation, and maintenance of the project; except that the local sponsor shall not perform such investigations on lands, easements, or rights-of-way that the Government determines to be subject to the navigation servitude without prior specific written direction by the Government.

h. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Government determines necessary for the construction, operation, or maintenance of the project.

i. To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA.

j. Prevent future encroachments on project lands, easements, and rights-of-way which might interfere with the proper functioning of the project.

k. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public law 91-646, as amended by title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR part 24, in acquiring lands, easements, and rights-of-way, and performing relocations for construction, operation, and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act. Comply with all applicable Federal and State laws and regulations, including Section 601 of the Civil Rights Act of 1964, Public Law 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army."

l. Provide 35% of that portion of total cultural resource preservation mitigation and data recovery costs attributable to environmental restoration that are in excess of one percent of the total amount authorized to be appropriated for environmental restoration.

m. Not use Federal funds to meet the local sponsor share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

8.4 Project Cooperation Agreement

Prior to the start of construction, MCOSD will be required to enter into a Project Cooperation Agreement (PCA) with the Federal Government and satisfy state laws and all applicable regulations. In general, the items included in the Agreement have been outlined in the previous paragraphs.

8.5 Financial Analysis

Financial information on the local sponsor’s ability to fund their share of the plan is required to establish implementation of the project as required by the Principles and Guidelines. The information includes a preliminary financing plan outlining the costs, schedule of expenditures, and a statement of financial capability by the local sponsor, including funds. MCOSD expressed their financial capability in their letter of intent at the onset of the Feasibility phase. A second letter of intent, which is forthcoming and expected to be provided for the Final Feasibility Report, will demonstrate MCOSD’s continuing commitment to the project.

8.6 Local Cooperation

Subsequent to public review of the draft report, MCOSD will be requested to provide a letter of intent indicating their support for the recommended plan and its willingness and intent to execute the PCA, including providing the Non-Federal required assurances.

8.7 Project Management Plan

A Project Management Plan (PMP) for implementation of the Recommended Plan will be prepared for the final report. The PMP will describe activities, responsibilities, schedules and costs required for the PED phase and construction of the project. The PED phase is expected to last for an estimated two years at an estimated total cost of $1,500,000.

8.8 Procedures for Project Implementation

Future actions necessary for project approval and implementation are summarized as follows:

1. The Corps of Engineers South Pacific Division (SPD) Commander will review the final report, and then issue a public notice announcing completion of the final report. This is referred to as the Division Engineer's Notice (DE's Notice) or Division Commander's Notice.

2. The report will then be submitted to Headquarters, U.S. Army Corps of Engineers (HQUSACE), and the Office of the Assistant Secretary of the Army for Civil Works [ASA (CW)] for concurrent Washington level review.

3. The 30-day State and agency review and the coordination of the Environmental Impact Statement by HQUSACE will be ongoing concurrently during the HQUSACE review.

4. Concurrent Washington level review by HQUSACE and ASA(CW) will conclude with a HQUSACE staff assessment, the 30-day State and agency review, review input by the ASA(CW), HQUSACE final assessment, a field visit and meeting if necessary, and the documentation of report review prepared by HQUSACE.

5. The Washington level decision-making process will follow the decision-making sequence of HQUSACE and ASA(CW), once the documentation of report review has been completed. There will be a briefing, if necessary, for the Designated Senior Representatives of Decision-Makers to resolve any outstanding issues. The Chief of Engineers will provide his recommendations on the report to the ASA(CW), who will provide the report and proposed recommendations to the Office of Management and Budget (OMB) to obtain their views and comments on whether the proposed recommendations are consistent with Administrative policies. Prior to the transmittal of the report to the Congress and signing of the

Record of Decision by the ASA(CW), the local sponsor, the State of California, interested Federal agencies, and other parties will be advised of any significant modifications made to the recommendations and will be afforded an opportunity to comment further.

6. The report will then be transmitted to Congress for project authorization with the Chief of Engineers report, ASA(CW) report, State and agency comments, and Office of Management and Budget comments.

7. Authorization for project implementation will then be requested from Congress as part of a Water Resources Development Act (WRDA).

8. Funds for Pre-construction, Engineering and Design (PED) would be provided, when appropriated in the budget, upon issuance of the Division Engineer's public notice, announcing the completion of the final report and pending project funding authorization. A Design Cooperation Agreement will need to be developed and executed between the Federal Government and MCOSD whereby the County will provide 25% of the cost of PED studies.

9. The Corps of Engineers will complete final design and plans and specifications for project construction during PED.

10. Subsequent to appropriation of construction funds by Congress, formal assurances of local cooperation in the form of a Project Cooperation Agreement (PCA) would be required from MCOSD.

11. MCOSD will be required to provide all real estate required for project implementation.

12. Bids for construction will be advertised and contracts awarded.

13. Upon completion of construction, the project will be turned over to MCOSD, who will be responsible for OMRR&R in accordance with guidelines provided by the Corps of Engineers.

8.9 Project Implementation Schedule

The schedule for the Feasibility Study is for the Final Feasibility Report to be forwarded to the South Pacific Division office in late summer, and for the Division Commander's Public Notice of the completion of the Final Feasibility Report to be issued at the end of September (the end of fiscal year 2002). Preparation of the PED agreement for the next phase of study is expected to take a few months, but will be started during the public review process so the PED phase can start as soon as the Division Commanders' notice is released. PED is scheduled to begin in October 2002 and will continue for approximately two years, until approximately September 2004. The PED phase includes refinements to the design of the recommended plan, detailed bathymetric and topographic surveys, sediment modeling, habitat and species surveys, chemical, grain size and density tests of the material to be dredged, and bioassay surveys, if necessary. Project plans and specifications should be ready by about September 2004. The Project Cooperation Agreement will be prepared once the project plans and specifications have been reviewed internally and by Corps Headquarters (60 days). Execution of the PCA, which officially begins the construction phase of the project, is expected to occur in January 2005. Real estate acquisitions will then commence. The acquisition process is expected to last a bit more than a year, concluding in April 2006. Advertisements for construction contracts will be placed on the FedBizOps website about 90 days prior to the opening of the construction season in the summer of 2006, which, as outlined in previous chapters, should begin at the end of July or beginning of August each year. This process of soliciting and receiving bids and awarding construction is expected to last the full 90 days, until July 2006. Excavation work in the lagoon is expected to begin in July or August 2006, and is estimated to last 8 to 9 years.

9.0 PUBLIC INVOLVEMENT AND AGENCY COORDINATION

Public involvement and participation and agency coordination with the Bolinas Lagoon Ecosystem Restoration project has been extensive. This chapter describes all of the entities involved with the project, and how public participation was coordinated by the Corps and MCOSD.

9.1 Public Workshops and Meetings

Corps study participants have attended quarterly meetings with the Bolinas Lagoon Technical Advisory Committee (BLTAC) to present progress reports and gather information concerning the Feasibility Study. A Habitat Evaluation Expert Panel was convened from August 2000 to March 2001 as a scientific forum to discuss the merits of the various restoration alternatives. A public scoping meeting (under the NEPA and CEQA process) was held in April 1998, and public workshops were held in September 1998, November 1999 and November/December 2000 to review the progress of the feasibility study and to listen to public concerns. Newsletters updating the local communities and interested parties on project activities are distributed by the Open Space District prior to key meetings and project milestones.

Other organizations that have participated in the study process to date include the following agencies and groups:

Federal Agencies

Environmental Protection Agency, Region 9
US Department of Commerce, NOAA, National Marine Fisheries Service
US Department of Commerce, NOAA, National Ocean Service, Gulf of the Farallones National Marine Sanctuary (GFNMS)
US Department of Interior, Fish and Wildlife Service
US Department of Interior, United States Geological Society

State Agencies

California Coastal Commission
California Coastal Conservancy
California Department of Fish and Game

County of Marin

Department of Public Works
Marin County Community Development Agency
Marin County Open Space District
Supervisor Steve Kinsey, District 4

Local Committees, Groups and Organizations

Audubon Canyon Ranch
Avocet Research Associates
Barrie Stebbings and Joanna Harman (Bolinas Lagoon Video)

Bay Area Regional Water Quality Control Board
Bolinas Lagoon Foundation
Bolinas Lagoon Technical Advisory Committee
Bolinas Public Utilities District
Bolinas Rod and Boat Club
College of Marin
Environmental Forum of Marin
Golden Gate National Recreation Area
Marin Audubon Society
Philip Williams & Associates
Point Reyes Bird Observatory
Point Reyes National Seashore
Residents of Bolinas and Stinson Beach
Seadrift Association
Sierra Club, Marin Group
Star Route Farms
Stinson Beach County Water District
Stinson Beach Fire Department
Stinson Beach Health Club
Stinson Beach Village Association
Tetra Tech, Inc.

9.2 Agency Coordination

Extensive resource agency coordination was conducted during the Feasibility Study, particularly with the US Fish and Wildlife Service (USFWS), the Department of Commerce, Gulf of the Farallones National Marine Sanctuary (GFNMS), the Department of Commerce National Marine Fisheries Service (NMFS), the California Department of Fish and Game (CDFG), and the California Regional Water Quality Control Board. Most of these interests were represented on the HEEP that determined acceptable methods for evaluating habitat values and the effectiveness of the alternative plans.

The USFWS prepared a Planning Aid Letter (PAL), and is currently preparing the Draft Coordination Act Report (DCAR). The PAL represents the views of the USFWS during the early stages of the plan formulation process, whereas the DCAR will give feedback on the plan formulation process that evaluated the alternatives and then selected the two plans for recommendation. Recommendations made in the DCAR will address implementation of the project. These recommendations will be presented in the Final Feasibility Report, if they are not made available before the printing of the draft documents.

9.3 Review of the Draft Feasibility Report and Draft EIS/EIR

Review of the Draft Feasibility Report and the Draft EIS/EIR will be coordinated with Federal, State and local agencies in accordance with Corps guidelines, and in compliance with NEPA and CEQA regulations. This will include further coordination with EPA, USFWS, NMFS, CDFG, the California Coastal Commission, the RWQCB, Marin County departments and agencies, and all other public interests. During the 45-day public review period, two public meetings and hearings will be held to present the study findings and proposed recommendations, respond to questions, and obtain views and comments of all interested parties. The comments received will be documented in the final report and considered in the final decision of the San Francisco District Engineer and higher decision levels in the Corps, the Administration, and Congress.

10.0 CONCLUSIONS AND RECOMMENDATIONS

This chapter outlines the final conclusions and recommendations of the Bolinas Lagoon Ecosystem Restoration Feasibility Study.

10.1 Conclusions

The major conclusions of this study are:

- Bolinas Lagoon is an estuary of international importance, serves as important habitat to many species, and is a stopover point for migrating waterfowl on the Pacific Flyway.

- Unnatural rates of sedimentation, resulting from human activities in the watershed, have caused Bolinas Lagoon to fill in to a point where estuarine habitats, including intertidal and subtidal habitat, have decreased in quantity and declined in quality in the recent past.

- If no restorative actions are taken in the lagoon, temporary inlet closure is expected to begin as soon as 2050 (although anecdotal evidence suggests this could occur sooner), and subtidal and intertidal habitats are expected to continue to decline, both of which will significantly decrease the value of the Bolinas Lagoon ecosystem.

- The NER Plan is the North, Central (Estuarine) and South (No Seadrift) alternative plan; the LPP is the North, Central (Riparian) and South (No Seadrift) alternative plan.

- The NER Plan and the LPP both meet the Federal and non-Federal planning objectives of the Feasibility Study.

- The local sponsor is willing to share costs in the construction of the Recommended Plan.

- Although the NER and LPP have been selected as the tentatively recommended plans because they are the most comprehensive and cost effective plans, the Recommended Plan, as listed in the Final Feasibility Report, could be any viable (cost efficient) restoration plan. Its selection will be based on comments received during the public review process.

10.2 Recommendations

Ecosystem restoration by means of sediment removal in Bolinas Lagoon is economically justified at this time. The tentatively identified NER Plan is the North, Central (Estuarine) and South (No Seadrift) alternative plan, and the tentatively identified LPP is the North, Central (Riparian) and South (No Seadrift) alternative plan. The NER

Plan serves as the basis for the Federal investment with respect to sharing costs. Because the benefits associated with the LPP and the NER Plan are similar, either plan would receive its full share of Federal funding if selected as the Recommended Plan in the Final Feasibility Report.

Accordingly, I recommend that the ecosystem restoration measures recommended in this Feasibility Report be authorized subject to cost sharing as required by Public Law 99-662, the Water Resources Development Act of 1996. This recommendation is also subject to the local sponsor agreeing to comply with applicable Federal laws and policies. The project first cost of the NER Plan is $101,553,000, of which the Federal government would contribute $66,009,450, and the local sponsor would contribute $35,543,550; the project first cost of the LPP is $100,716,000, of which the Federal government would contribute $65,465,400, and the local sponsor would contribute $35,250,600. Based on continuing coordination with the local sponsor, results of the public review and public involvement process, and continuing refined evaluation of the ecosystem restoration alternatives, a Recommended Plan will be identified in the Final Feasibility Report.

Date	TIMOTHY S. O'ROURKE LTC, EN Commanding

11.0 LIST OF PREPARERS

The individuals listed in the following table were primarily responsible for the preparation of this document. Many others, who are not listed, also contributed greatly toward the completion of the project feasibility studies and preparation of the report.

Bolinas Lagoon Restoration Study – Team Members

NAME	DISCIPLINE	ROLE IN PREPARING THIS REPORT
Cindy Tejeda	Community Planner	Author of main report
Ron Miska	Planning and Acquisition Manager, MCOSD	Local sponsor representative for the study. Managed In-Kind services and contributed to plan formulation process
Connie Callahan	Tetra Tech, Inc., San Francisco Office	Project Manager and main author of EIS/EIR
Tim Haddad	MCOSD Environmental Planning Coordinator	Environmental Planner for Marin County & Coordinator of EIS/EIR
Roger Golden	Project Manager	Responsible for project budget and schedule and provided guidance on the planning process
John Winkelman	Coastal Engineer	Preparation of Without Project Conditions, With Project Conditions and author of Engineering Appendix
Lisa Romanoski	Coastal Engineer	Quality control coordination and review/revision of Engineering Appendix
Rachel Kamman	Kamman Hydrology	Conducted hydraulic modeling of restoration alternatives
Steven Chen	Geotechnical Engineer (soil engineering)	Author of geotechnical engineering section in Engineering Appendix
George Fong	Civil Engineer (project design)	Author of civil design engineering section in Engineering Appendix
Susan Miller	Real Estate	Author of Real Estate Plan and Real Estate Appendix
Jeff Ide	Cost Estimates and Specifications	Prepared cost estimates in Cost Estimates Appendix
Kathleen Ungvarsky	Archaeology/Cultural Resources	Quality Assurance and NEPA compliance review of cultural resources section of the EIS/EIR
Cindy Vangilder	Technical Writer	Editing and Revisions
Gary Flickinger	Quality Control Review	Independent Technical Review Team Leader