REVISED

STAFF REPORT

WETLANDS IN THE NORTH BAY PLANNING AREA

February, 1997

Prepared for the
North Bay Steering Committee

SAN FRANCISCO BAY
CONSERVATION AND
DEVELOPMENT
COMMISSION

REVISED STAFF REPORT

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The North Bay Steering Committee

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FOREWORD

The North Bay Wetlands Protection Program is a voluntary partnership between the San Francisco Bay Conservation and Development Commission (BCDC) and the eight local governments in the San Pablo Bay subregion of the San Francisco Bay area—Napa, Marin, Solano, and Sonoma Counties, and the Cities of American Canyon, Novato, San Rafael, and Vallejo. The purpose of the North Bay Wetlands Protection Program is to: (1) provide local governments with the tools and information needed to ensure the protection, enhancement and restoration of the North Bay wetlands while allowing compatible uses to continue, such as agriculture, recreation, and public education, which are consistent with wetland values and functions; and (2) guide incompatible uses to other appropriate locations. Thus, the program will help local governments protect their wetlands, increase opportunities for enhancement and restoration, and identify uses that are consistent with wetland ecological values.

To achieve this purpose, the Steering Committee will develop a North Bay Wetlands Protection Plan. The Plan will recommend a range of policy options that each city and county can use to protect its wetlands. Each city and county can use these options as it sees fit. By adopting the applicable portions of the Plan, local governments will help improve the consistency between state and local wetlands policies, as well as increase the certainty about land use regulation and land development for farmers, landowners, and developers.

This report on wetlands history, definitions, related habitat, and functions in the North Bay planning area was prepared by the BCDC staff. It is the second in a series of planning background reports prepared for the North Bay Wetlands Protection Plan Steering Committee, composed of representatives of each of the local governments in the San Pablo Bay Subregion and BCDC. A report on North Bay Land Use and Public Ownership was completed in August and accepted by the Committee in September 1996. The reports will provide information for the Steering Committee to help it prepare a North Bay Wetlands Protection Plan. Other planning background reports in the series will include analyses of polluted runoff, riparian corridors, and the relationship of agriculture to wetlands.

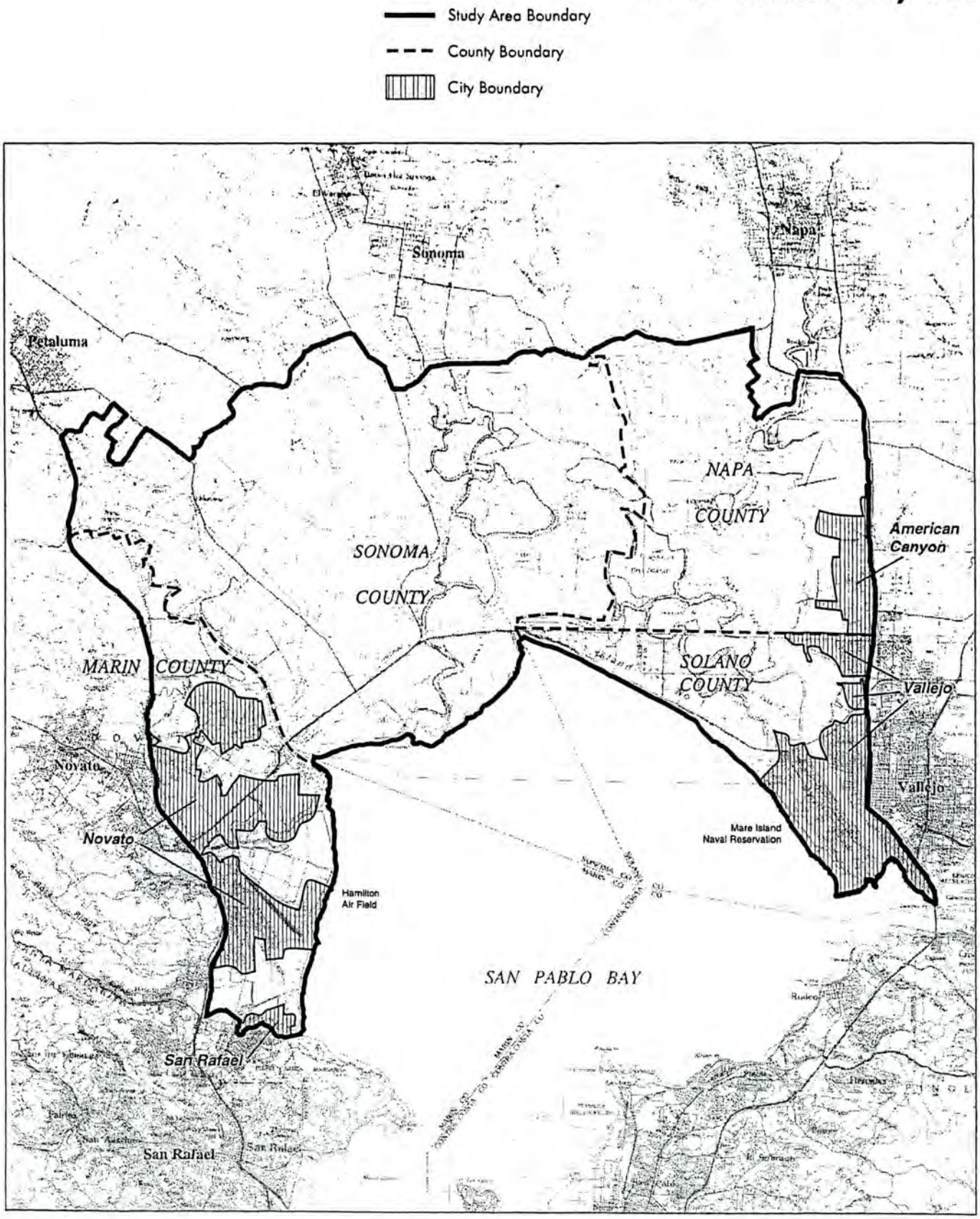
After completing its work, the Steering Committee will submit the North Bay Wetlands Protection Plan to the participating local governments for consideration and adoption of the applicable elements of the plan.

San Francisco Bay Conservation and Development Commission

SOURCE: U.S.G.S., 1980; BCDC

Figure 1

North Bay Wetlands Protection Plan Study Area



CHAPTER 1

INTRODUCTION

The purpose of this staff wetlands background report is to inform the reader about the nature of the wetlands and related habitats found in the historic marshlands of the North Bay, why they are important, their relationship to other areas of habitat value, and their current status and location. The report also describes opportunities for wetlands enhancement and restoration in the North Bay, and some of the implementation programs. This report contains information that should be useful to local governments, and was developed from existing sources of thorough and well-researched information regarding wetland resources.

This report, in combination with the other background reports, will give the North Bay Steering Committee the information necessary to develop findings and policies to protect wetland resources in the North Bay, and to manage the range of activities that directly impact the vitality and functions of these resources. These findings and policies will provide the foundation for the North Bay Wetlands Protection Plan.

Report Structure

Chapter 2, History of North Bay Wetlands, describes the various eras in the North Bay's history, from early European settlement to the rise of manufacturing during World War II, and the impact of these times on the North Bay wetlands.

Chapter 3, Identifying Wetlands and Related Habitats, discusses the biological characteristics of wetlands and examines two types of definitions used to evaluate wetlands and related habitat. This chapter also describes the EcoAtlas, a new tool that identifies regional habitat and can be used to develop local policies for land use planning.

Chapter 4, Location of Wetlands and Related Habitats, describes the types and locations of wetlands and related habitats in the North Bay.

Chapter 5, The Functions and Values of Wetlands and Related Habitats, describes the physical, ecological, and sociological benefits provided by wetlands in the North Bay region. These include important functions such as flood protection, shoreline erosion control, water quality improvement, food and habitat for fish and wildlife, open space, and opportunities for recreation.

Chapter 6, Wetland Restoration and Enhancement in the North Bay, explains the potential for restoration in the diked historic baylands, and briefly describes the various restoration projects currently taking place in the area.

Report Methods

This staff report draws upon the vast body of information developed through the San Francisco Estuary Project, as well as other sources of information about the management, protection and enhancement of wetlands. Information specific to the North Bay planning area has been included to assist local governments in examining their wetlands management programs. In addition, this background report relies on literature searches, field research, aerial photography, and personal communications with representatives from state and federal resource agencies, local government agencies, special purpose districts, landowners, and environmental and business interests.

BCDC staff undertook several steps to identify, quantify, describe, and map the distribution of wetland resources and wetland projects in the North Bay. These steps included: (1) data gathering; (2) mapping; and (3) data analysis.

1. **Data Gathering.** BCDC staff searched the available literature to identify information about wetland resources, wetland protection programs, and wetland restoration projects relevant to the North Bay planning area. Information was gathered from state and federal resource agencies, local governments, and special purpose districts.

2. **Mapping.** To map the distribution of wetlands and related habitats, staff used the University of California at Berkeley's Research Program in Environmental Planning and Geographic Information Systems (REGIS), housed at the University's Center for Environmental Design and Research (CEDR). Building upon the mapping efforts conducted in support of the background report titled *North Bay Land Use and Public Ownership*, BCDC staff created two new data layers: existing distribution of wetlands, and wetlands restoration projects.

To map the existing distribution of wetlands resources in the historic marshlands of the North Bay, staff have relied upon data from the preliminary San Francisco Bay Area EcoAtlas compiled by the San Francisco Estuary Institute (SFEI). SFEI is a non-profit organization created to undertake scientific research on the San Francisco Bay estuary as recommended in the San Francisco Estuary Project *Comprehensive Conservation Management Plan.* The Board of Directors of SFEI represent government agencies, industry, and environmental groups, whose mission is to provide the scientific basis for managing the Estuary's resources. The SFEI EcoAtlas serves two main purposes: to map the distribution and abundance of mudflats, tidal marshlands, diked baylands, and adjoining riparian tree stands; and to create a base map upon which other data about the baylands will be compiled (Source: SFEI World Wide Web Homepage, Metadata).

Several sources of information are incorporated into the EcoAtlas. Using the 1987 National Wetlands Inventory (NWI) of the Bay Area as their initial basemap, SFEI staff conducted site evaluations and solicited public and agency feedback regarding the features contained in the NWI maps. They also refined the feature data using the typology (or habitat classification system)

created by the San Francisco Bay Wetlands Ecosystem Goals Project[1], to identify features not reflected in the original NWI maps. This habitat typology incorporates the existing topography, or terrain, of the San Francisco estuary, capturing important details of wetland ecology that are particular to this region. These details are not currently reflected in the NWI or any national or state surveys. The final version of the EcoAtlas, to be released in spring 1997, will incorporate the most recent aerial infrared photography of the Bay, taken during the winter of 1995–1996.

The EcoAtlas has been reviewed for accuracy and completeness by the public and by representatives of the California Department of Fish and Game, California Department of Water Resources, and by the US Fish and Wildlife Service. The EcoAtlas represents the most current and complete inventory of wetlands and related habitat in the North Bay, and is designed to be used for planning purposes. The EcoAtlas is not intended, however, to substitute for the wetland jurisdiction determination required for permit decisions.

This report uses a pre–release version of the EcoAtlas (version 1.0bc), which contained eleven categories of wetlands and related habitat, four of which distinguish between types of tidal marsh (one additional category was reserved as "No Data" for the pending classification of certain features). For the purposes of inventorying and mapping wetland resources in the North Bay planning area, BCDC staff consolidated the four tidal marsh classifications into a single category. The seven other categories of wetlands and related habitat used in this report are identical to those used in the Atlas.

The wetlands restoration projects data layer was created based upon project plans and maps, and information from the public ownership data layer mapped for the staff background report on land use in the North Bay planning area.

The Nichols and Wright Historic Wetlands map was generated for the *North Bay Land Use and Public Ownership* report. This map is based on the Nichols and Wright report of 1971, which maps the former extent of San Francisco Bay marshlands.

3. **Data Analysis.** The North Bay Wetlands Protection Program applies an on-line GIS as a planning tool for mapping and analyzing the regional distribution of land use and wetlands data. This GIS program, available to anyone with Internet access, uses a custom-designed software program, GRASSLinks. GRASSLinks was developed at the Center for Environmental Design and Research at the University of California, Berkeley, and is operated by the Center's Regional Geographic Information System (REGIS). The GIS data developed for this study, including

[1]The San Francisco Bay Wetlands Ecosystem Goals Project is an association of wildlife biologists, academics, and senior agency staff working together to identify the types and amounts of wetlands and related habitat needed to support natural communities of plants and animals in the San Francisco Estuary (see Chapter 3).

existing land use, general plan designations and city and county boundaries, can be accessed over the Internet through REGIS and GRASSLinks.[2]

It should be noted that, although staff worked to make the maps and analysis as accurate as possible, the data is intended to be used on a regional scale, to provide an overview of the 174-square mile planning area. Thus, the maps and calculations are not intended to be precise at a site-specific level.

[2] To view the data created for the North Bay, connect to the Internet and open http://www.regis.berkeley.edu/grasslinks.

CHAPTER 2

HISTORY OF NORTH BAY WETLANDS

This chapter reviews the history of wetlands in the North Bay planning area, describing the historical wetland conditions and the pattern of development in the region that shaped the current distribution of wetlands and related habitats.

Presettlement

While humans have inhabited the San Francisco Bay-Delta estuary watershed for millennia, it is only within the past 150 years that our activities have significantly affected the estuary's water quality and biological resources. From the inception of the estuary (over 10,000 years ago) until the gold rush era in the mid-1800's, the rate of sea-level rise and sedimentation have generally controlled the distribution and amount of tidal marshes in the estuary (Atwater et al., 1981). Gradual flooding of the low-lying portions of the estuary created most of the tidal marshes. As sea level rose, it inundated upland areas and pushed wetland formation inland, and converted some of the seaward wetlands to tidal mudflats. In general, expanding wetland habitat was the prehistoric trend, resulting in the creation of the largest tidal wetland area along the entire Pacific Coast (San Francisco Estuary Project, 1991a).

Historically, northern San Pablo Bay, into which the Petaluma, Sonoma, and Napa rivers and the Sacramento-San Joaquin Delta drain, was bordered by extensive salt and brackish marshes. Brackish marshes stretched upstream for several miles from the mouth of the Petaluma and Napa rivers. Delta-like wetlands formed at the mouths of creeks along the Marin bay front (Dennis and Marcus, 1984). The Napa Marsh encompassed approximately 125 square miles, and tidal wetlands extended roughly 10 miles upstream along the Petaluma River (San Francisco Estuary Project, 1991a). Further inland, the low plains bordering the tidal marshes supported dispersed seasonal wetlands, and were intersected by riparian habitat along creeks.

The earliest known inhabitants in the estuary were indigenous peoples. The Coastal Miwok and the Wintun peoples dwelled on the northern and western shores of San Pablo Bay (Kirkbridge, 1980). This population of hunter-gatherers apparently had negligible impacts on the estuary's sustainable resources. They harvested fish, clams, mussels, oysters, waterfowl, and large mammals; they also produced and traded salt. These native peoples, with their relatively small population centers and benign technologies, lived within the estuary's ability to sustain them and did little to permanently alter their physical environment (San Francisco Estuary Project, 1992; San Francisco Estuary Institute, 1994).

Early European Settlement

Land use practices in the region began to change dramatically with the founding of the Spanish missions in the late 1700's and the introduction of European cattle, sheep and pasture plant species in the early 1800's. Intensive grazing and early logging activities are thought to have contributed to erosion of the hillsides and increased sedimentation in local streams. These activities expanded dramatically during the gold rush of the mid-1800's.

The Gold Rush Era

The discovery of gold at Sutter's Mill in 1848 set in motion a series of human-influenced events that have profoundly affected the amount and distribution of tidal marshes and other wetland types surrounding San Francisco Bay and the Delta. Between 1853 and 1884, hydraulic mining washed enormous volumes of silt, sand and gravel into the estuary in the pursuit of the precious metal from the western slopes of the Sierra Nevada. The sediment excavated from the hillsides washed down into the American, Yuba, Feather and Sacramento rivers where it blocked the migration of spawning salmon populations, impeded navigation and caused flooding. Further downstream, the mining debris caused extensive shoaling of the open bays, conversion of some mudflats into tidal marshlands, and development of new mudflats (San Francisco Estuary Institute, 1994).

The damage caused to farmlands and waterways led to a federal court injunction that halted hydraulic mining activities in 1884. Downstream deposition of the mining debris, however, continued well into this century. By the early 1900's, over one billion cubic yards of sediment was deposited in Suisun, San Pablo and Central Bays, raising bottom elevations by as much as three feet (San Francisco Estuary Project, 1992a). By one estimate, approximately 29 square miles of new tidal marsh were created during this period, notably at Mare Island and the western edge of San Pablo Bay (San Francisco Estuary Project, 1991a).

The Reclamation Period and the Rise of Agriculture

Gold rush fever precipitated a swelling of population in the northern part of the state. The population in California at the end of 1848 totaled 15,000; by 1850, the year California achieved statehood, the population reached 93,000 and was concentrated in the gold mining districts and San Francisco. By 1860, more than half of California's 380,000 residents lived within the estuary's watershed, with roughly a quarter of the population concentrated in the Bay Area (San Francisco Estuary Project, 1991c). This burgeoning population demanded increasing amounts of food, thus leading to the conversion of lands for agricultural purposes. In 1869, workers completed the first transcontinental railroad linking California to the east coast and Europe, thereby generating a market for California's agricultural goods (San Francisco Estuary Project, 1991c).

The conversion of wetlands to farmland was facilitated by the passage of the federal Arkansas Act of 1850, which transferred to states unsold federal swamp and/or overflowed land. States, in turn, were permitted to sell these lands to private parties, provided that the funds generated from the sale were used to ensure that the lands were drained, reclaimed, and put to productive agricultural use. Of the more than two million acres of land in California that were eventually designated as swamp or overflow lands, 141,720 acres were sold in the four North Bay counties.[1]

It was during this reclamation period that the most extensive and direct physical alteration of the baylands in the North Bay occurred. The construction of levees and dikes around the estuary enabled the rise of agriculture on surrounding lands, and at the same time, often led to the conversion of tidal wetlands into seasonal wetlands. The soils around Pablo Bay supported some cereal grains and row crops, as well as grazing (Josselyn, 1983). Large tracts of historic baylands near the mouths of Sonoma Creek, the Petaluma River and Novato Creek were reclaimed between 1860 and 1900; the remainder of the baylands reclamation in the North Bay occurred between 1900 and 1950 (San Francisco Estuary Institute, 1994). Lands reclaimed during the first quarter of this century were used either for farming or grazing; those reclaimed during the second quarter have been used for industrial urban development and for waste disposal (San Francisco Estuary Institute, 1994).

Rise of Manufacturing

The Second World War induced an era of both population and industrial growth around the estuary. Thousands of workers flocked to Bay Area industrial and military facilities to support wartime efforts, including ship building, aircraft deployment, military equipment maintenance and repair, and military supply. This sudden influx of population stimulated the expansion of infrastructure and conversion of agricultural lands to industrial and urban land uses.

The Leslie Salt Company (later purchased by Cargill, Inc.) expanded its salt production operations into the North Bay in 1952, with the purchase and conversion of 17 square miles (nearly 11,000 acres) of diked agricultural lands to solar evaporation ponds and associated facilities (Josselyn, 1983). Extracted water from San Pablo Bay was placed in a network of ponds on the west side of the Napa River to evaporate; the concentrated salt solution was subsequently pumped under the Napa River to ponds at Cargill's salt plant on the east side of the river for crystallization, harvest and production. Cargill ceased salt production at this site in 1990.

Urban expansion into the historic baylands brought about the construction of housing and industry, the extension of sewer and power lines, expansion of roadways, development of

[1] The figures break down as follows for each county: Marin—10,573 acres; Napa—16,179 acres; Solano—95,157 acres; and Sonoma—19,831 acres (SFEP, 1991a). However, these figures are for the entire county, not for the portion of the county land within the boundaries of the North Bay planning area.

disposal facilities for both solid waste and waste water, and the demand for flood control and mosquito abatement programs (San Francisco Estuary Institute, 1994). These activities have resulted in an increase in the number of small reclamation projects in the fringes of the baylands, more fragmentation and pollution of the tidal marshlands, an increase in the range and intensity of management practices, and, possibly, a decrease in the amount of sedimentation (San Francisco Estuary Institute, 1994).

Impacts

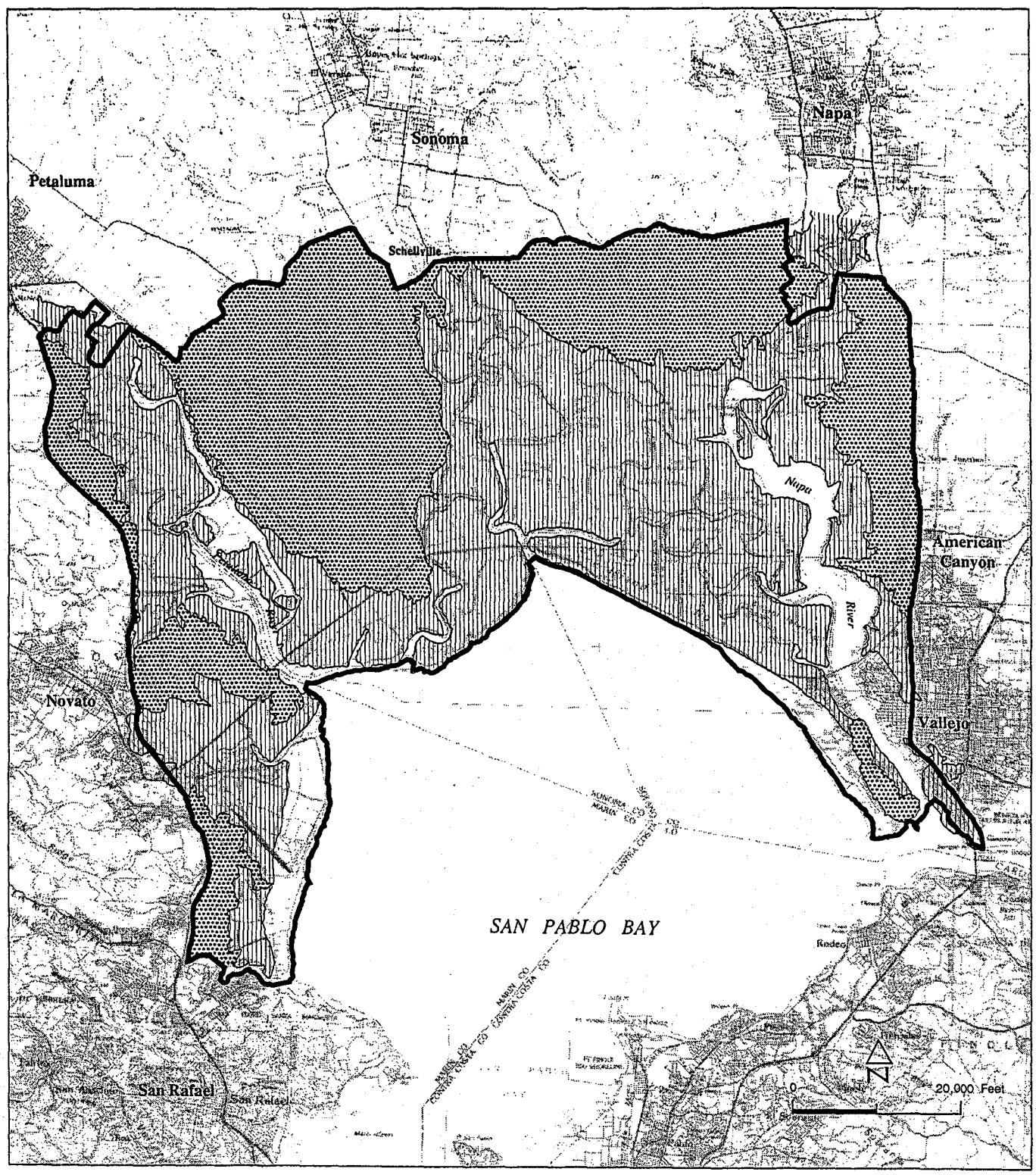
In general, over the past 150 years, the Bay Area has experienced extensive wetland conversion, degradation, and losses. Historically, there has been a significant conversion of tidal wetlands to non-tidal wetlands such as seasonal wetlands, farmed or grazed diked baylands, and salt ponds. Concurrently, seasonal wetlands beyond the pre-diked tidal wetlands were developed for other uses. The incidence of seasonal and tidal wetland losses and conversion between types correspond with the settlement patterns of the region and the resulting human activities. Critical periods include the hydraulic mining era in the Sierra Nevada in the mid-1800's, conversion of wetlands to agricultural uses in the late 1800's and early 1900's, and conversion of wetlands and some agricultural lands for salt production, and the urban expansion and industrial development of the 20th century.

In some cases, new land uses directly displaced wetlands, destroying them in the process. An estimated net 85 percent of the historic tidal marshes in the San Francisco Bay-Delta Estuary's have been filled, altered, or removed from tidal influence since 1850 (Dedrick, 1989). Within San Francisco Bay, including San Pablo and Suisun bays, historical tidal wetlands covered approximately 200,375 acres. Today, only an estimated 36,000 acres of tidal wetlands remain, nearly half of which are in the North Bay (San Francisco Estuary Project, 1991a). Many of the Bay's tidal wetlands were converted to other wetland types; others were permanently filled and developed or put to other uses. Although diking and filling destroyed tidal wetlands, the diked baylands employed for agricultural use often supported the development of seasonal wetlands. These seasonal wetlands have grown in importance because (1) seasonal wetlands provide important complementary functions to tidal wetlands, and (2) the extent of seasonal wetlands outside of the baylands (beyond the planning area) has diminished due to urbanization. Thus, the the seasonally wet diked farmed and grazed baylands provide the remaining source of large, contiguous seasonal wetlands in the North Bay.

Figure 2

SOURCE: USGS/HUD, 1971; BCDC

Historic Wetlands



In this and the previous staff report, *North Bay Land Use and Public Ownership*,[2] the term "historic wetlands" is defined by using the line, shown in Figure 2, developed by Nichols and Wright in a report for the U.S. Geological Service (Nichols and Wright, 1971)[3]. This line approximates the limits of historic wetlands, thus showing us the extent of former Bay waters and former tidal marsh. In this and the previous report, calculations based on the Nichols and Wright line include everything inside the line, including current wetlands (thus, the term "historic wetlands" includes current as well as former tidal wetlands). By this measure, former seasonal wetlands which were not historically tidally influenced would not be included in the Nichols and Wright line of former tidal marsh that has been diked and/or filed, and are not the subject of wetland identification and analysis in this report. [4]

Of the 66,000 acres of historic wetlands in the study area, more than 17,000 have not been converted to other uses (according to calculations based on the San Francisco Estuary Institute's EcoAtlas).[5] In other words, 26 percent of historic wetlands in the North Bay are still tidal wetlands. Thus, 74 percent of the North Bay's tidal wetlands have been filled, physically altered, or removed from tidal influence, which is a smaller loss than the net 85 percent loss throughout the rest of San Francisco Bay. In fact, the North Bay tidal marsh today comprises almost 35 percent of all tidal marshes remaining in the nine-county San Francisco Bay Area. Furthermore, North Bay diked historic baylands account for 84 percent of all diked farmed baylands around San Francisco Bay.

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[2] The *North Bay Land Use and Public Ownership* report is the first in this series of background reports produced for the North Bay Wetlands Protection Program.

[3] As digitized by the Regional Environmental Geographic Information Systems (REGIS).

[4] Nichols and Wright calculations reveal 66,000 acres of historic wetlands in the North Bay, while the San Francisco Estuary Institute's on-line EcoAtlas calculates approximately 59,000 acres of wetlands in the North Bay. This difference of 7,000 acres of wetlands results from 1) differences in mapping techniques; and 2) the exclusion of developed lands, such as housing subdivisions, from the EcoAtlas.

[5] With the exception of the historic wetlands figures (66,000 acres), all other figures in this section are based on calculations of the SFEI EcoAtlas.

CHAPTER 3

IDENTIFYING WETLANDS AND RELATED HABITAT

The term "Wetlands" refers to wet areas that usually develop between dry land and open waters; these transitional areas are also sometimes called mudflats, marshes, swamps, fens, or bogs. Other wetland types develop inland, such as prairie potholes, seeps, and riparian wetlands associated with streams. In general, a wetland is land that remains wet long enough to change its key physical, chemical, and biological elements, which enables it to support specially adapted vegetation. This chapter describes the biological characteristics of wetlands and describes representative definitions used for specific purposes[1], such as delineating wetlands for regulatory purposes, or defining wetlands for resource assessment and management purposes. This chapter compares how these definitions serve land use planning, identifying the strengths and weaknesses of both from the perspective of policy development and implementation. Finally, this chapter describes the creation of the San Francisco Estuary Institute's EcoAtlas, which maps and classifies the types of wetlands and related habitats found in the San Francisco Bay Estuary from both a land use perspective and a resource assessment perspective.

Biological Characteristics of Wetlands

Three major factors characterize a wetland: hydrology,[2] substrate or soils, and vegetation. For a site to be identified as a wetland, it must exhibit specific indicators of wetland conditions for each of these three factors: (1) its hydrology reflects permanent or seasonal ponding or water saturation; (2) the soils remain saturated for long periods and show signs of anaerobic (no oxygen) conditions; and (3) the dominant vegetation is adapted to live in wet or saturated soil conditions.

Hydrology is the most important of these factors. Without the correct hydrologic conditions, neither the proper soils or vegetation will develop, and sites that were formerly wetlands will lose their wetland characteristics. Sites that support wetlands typically are frequently flooded or ponded, or have permanently or seasonally saturated soils. While water is present for at least part of the time, the duration, depth, scouring action and seasonal timing of flooding can vary considerably. Hydrologic analysis of wetlands conditions requires information on three related conditions: (1) how long the area is saturated and its timing relative to the growing season; (2) the

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[1] A chapter in the next report will describe the existing regulatory structure in greater detail.

[2] Hydrology refers to the dynamic processes of water within an environment, including the sources, timing, amount and direction of flow.

critical depth for saturation; and (3) the frequency of saturation. Hydrology is often more difficult to directly assess than soils or vegetation. For this reason, wetland researchers often rely on both direct and indirect indicators of hydrology, such as soils and plant types.

Soils subject to prolonged saturation undergo chemical and physical changes that distinguish them from well-drained upland soils. In saturated soils, water fills the pore spaces, displacing oxygen. The remaining oxygen is quickly depleted by roots and microbes and the soil conditions become anaerobic. Soils with water-induced anaerobic conditions, such as those found in wetlands, are called "hydric" soils. These soils can be distinguished by their high organic content (due to the inability of microbial activity to decompose plant material in the absence of oxygen) and their distinctive dark gray or black soil color, which reflects the presence of converted minerals. [3]

Plants that live in wetlands have adapted to the anaerobic conditions of saturated soils. These plants have developed mechanisms to obtain oxygen, such as shallow root systems or hollow stems, or undergone physiological changes to compensate for the lack of oxygen. Plants that have adapted to wetland conditions are called "hydrophytes." The U.S. Fish & Wildlife Service (USFWS) has developed a classification system—called the *National List of Plant Species that Occur in Wetlands*—for hydrophytic plants. This system divides plant species into indicator categories based on the probability that individual members of the species will be found in wetland rather than upland habitat.[4]

A variety of wetland habitats exist within California. Wetland type is determined by a combination of factors including the hydrologic regime, substrate, water source, and water quality at a particular site. A wetland may get its water from a number of sources such as precipitation, surface runoff, tidal flooding, overbank flooding, rising groundwater, and percolation. Depending upon its source, the water may be fresh, brackish, salty or hypersaline; its nutrient and pH levels may also vary. The substrate or soil of a wetland can also vary greatly in its type (cobbles, gravels, sand, fine silts, dense clays, organic material or some combination), thickness (from several inches to tens of feet), and in its composition (nutrients, chemicals and acidity).

The three physical features discussed above—hydrology, soils and vegetation—serve as the building blocks of most biological definitions of wetlands. As acknowledged by the USFWS,

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[3] In 1987, the Soil Conservation Service (now called the National Resources Conservation Service) has published *Hydric Soils of the United States*, a national list to assist with the identification of hydric soils (Cylinder, et. al., 1995).

[4] "Obligates" are a type of hydrophyte that specifically requires wetland conditions for their survival and reproduction; obligates occur >99 percent of the time under natural conditions in wetlands. "Facultative" plants are hydrophytes that can survive in either wetland or upland habitats. "Upland" plants are almost always found (99 percent of the time) under natural conditions in non wetland or upland areas (Cylinder, et al., 1995).

"there is no single, correct, indisputable, ecologically sound definition for wetlands, primarily because of the diversity of wetlands and because the demarcation between dry and wet environments lies along a continuum" (Cowardin, et al., 1979). Given this, more effort has been placed on identifying the biological qualities and relationships between diverse wetland habitats and adjacent areas, rather than attempting to develop a single precise definition of a wetland that could be applied broadly in all situations. Many believe that defining the upper and lower (or dryer and wetter) limits of a wetland is generally an arbitrary exercise, because wetlands are part of a continuous gradient between uplands and open water. This gradient quality presents significant challenges for resource managers, land use planners, private land holders, and local, state, and federal government.

Another equally relevant view holds that no single, universally accepted wetland definition has been developed because the definition depends upon the objectives and area of interest of the user (Mitsch and Gosselink, 1986). This is especially true when considering the two primary types of wetland definitions in current use by the leading agencies charged with resource protection. Generally these types can be categorized as those that address jurisdictional considerations or those that help to assess resources.

Jurisdictional Definitions

Wetland scientists such as those at the USFWS have developed wetland definitions for classification, inventory, or research purposes, reflecting a resource assessment perspective. In contrast, wetlands regulators use definitions to set forth the jurisdictions of agencies with responsibility for administering and enforcing land use and water quality laws, and therefore must have clear and legally binding definitions (Mitsch and Gosselink, 1986).

A jurisdictional definition of a wetland serves a fundamentally different purpose than the resource assessment definitions subscribed to by the USFWS. Jurisdictional definitions of wetlands, while based on biological considerations, do not necessarily define wetlands per se; jurisdictional definitions describe the physical boundary of regulatory authority, such as that held by the Army Corps of Engineers.

Jurisdictional definitions significantly influence the level of wetland protection in a given area because any wetland not meeting a given agency's definition will not be protected by the agency under its statute. Additionally, such protection is carried out in a reactive manner, thereby providing limited planning and resource management value. In practice, for example, a

jurisdictional wetland delineation[5] is generally carried out on a project or site–by–site basis, usually after a preliminary environmental assessment has indicated that wetlands may exist in a project area, or in the absence of a project, after some questionable activity has taken place. A ground survey is conducted using a relatively narrow but precise definition of a wetland, and the results of that survey, which generally remains in effect for three years, will assist regulators in determining what type or level of activity can occur at that site.

Given this narrow method of definition and implementation, it would be difficult to use the jurisdictional delineation as a tool, by itself, to devise effective long range planning policies addressing resource values. Jurisdictional definitions are an important tool that provides a strong measure of certainty about the location of federally permitted activities involving wetlands; but from the broader perspectives of resource management, habitat protection, and land use planning, jurisdictional definitions are but one tool among many,[6] providing important but limited utility.

Currently, two regulatory definitions of wetlands are used at the federal level to govern activities in wetlands. The most referenced regulatory definition is the Corps' definition, described below. Another definition is employed by the U.S. Department of Agriculture to determine what areas fall under the authority of the Food Security Act.

1. **U.S. Army Corps of Engineers and U.S. EPA** The Corps and the EPA developed a joint regulatory wetland definition in 1977.[7] As stated in federal regulations (33 CFR 328.3(b); 40 CFR 230.3(t)), wetlands are:

> ...those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

[5] "Delineation" is a term of art. For the purposes of this report, a delineation is an activity carried out by the Corps of Engineers or the Natural Resource Conservation Service, and involves conducting a survey that identifies the location of jurisdictionally defined wetlands.

[6] Local governments have a wide range of tools to chose from, and can define or address wetlands and related habitat values through general plans, specific plans, zoning ordinances, subdivision ordinance controls, environmental review processes, permit controls, agricultural preserves, and special purpose agencies and activities (SFEP 1991).

[7] The Corps and EPA use this definition to identify those wetlands areas that fall under the jurisdiction of the federal permitting program under the authorities of Section 404 of the Clean Water Act.

The Corps has used this regulatory definition to develop a field method for determining wetland boundaries[8]. This method, described in the *Corps of Engineers Wetlands Delineation Manual*[9] published in 1987, requires positive indicators for all three factors (hydrology, soils and vegetation) for a site to be identified as a wetland subject to Corps jurisdiction (except in disturbed or abnormal circumstances). The Corps' definition thus does not include those wetland areas from which vegetation has been altered or removed without disturbing the root system, nor those wetland areas that naturally do not support vegetation (such as mudflats). The Corps' definition is used by agencies and consultants for the purposes of reviewing and approving Section 404 permits nationwide.

2. **U.S. Department of Agriculture.** The second federal wetlands definition is used by the U.S. Department of Agriculture to determine what areas fall under the authority of the Food Security Act (FSA). Under this statute, a wetland is defined as land that: "(a) has a predominance of hydric soils; (b) is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions; and (c) under normal circumstances does support a prevalence of such vegetation." While this definition is very similar to the wetlands definition under the Clean Water Act, the terms "hydric soil" and "hydrophytic vegetation" are specifically defined both in the statute and in regulation for the purposes of carrying out the agricultural programs under the FSA.

Resource Assessment Definitions

Resource assessment definitions are used primarily to guide scientific inquiry, conduct inventories of natural resources, aid in the acquisition and restoration of wetlands and related habitat, and to a limited extent, guide activities on publicly held land, or assist in interagency review of federal/state permitted activities and programs.

These definitions serve a fundamentally different purpose than jurisdictional definitions. Resource assessment definitions are designed to help capture the value of ecological functions, habitat characteristics, and interspecies relationships, rather than to provide legal definitions, hence they are broad in scope, and lend themselves well to describing zones rather than hard and fast boundaries.

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[8] Efforts are underway to delegate Section 404 permitting activities on agricultural lands in the nine Bay Area counties from the Corps of Engineers to the Natural Resources Conservation Service. This action is dependent on the development of regulations by NRCS and subsequent approval of the proposed regulations. The proposed regulations are tentatively scheduled for review in the summer of 1997. Until the proposed regulations are reviewed and adopted, the Corps retains jurisdiction.

[9] This manual is used to identify and delineate wetland boundaries for the purpose of regulation under Section 404 of the Clean Water Act.

Resource assessment definitions play an important role in protecting wetlands, and are usually employed in the development of technical background analyses or environmental reports to assist decision makers in evaluating the impacts of a project or plan. These definitions do not directly carry the weight of law in most circumstances, but can play an essential role in practice. For example, resource assessments can be used to describe the habitat of an federally listed endangered species, or to assist in the designation and implementation of buffer and transition zones. A major shortcoming is that these definitions are cumbersome to apply and may require repeated surveys over time, thereby increasing the cost of implementation. Using these definitions also requires a higher order of scientific expertise, and the results of such surveys are subject to varying interpretation and agreement.

The primary challenge associated with resource assessment definitions, from a planning perspective, lies in devising a practicable and equitable method of standard implementation over a large area of diverse land uses, ownership, and jurisdictions. The broad characteristics of this method make it difficult to determine site specific boundaries in a consistent manner. The strong temporal, or ephemeral, qualities of this method are a source of contention among private property owners who may have seasonal wetlands on their property, and this contention has had the practical effect of precluding the use of such definitions for jurisdictional delineations.

Resource assessment definitions can serve as policy guides for long range local planning activities, but can present significant challenges when used to regulate activities on a parcel–by–parcel basis. However, it would be incorrect to discount this method because of the challenges associated with implementation. Resource assessment definitions are an important tool for gathering data and analyzing relationships, especially for measuring the health of habitat and ecosystems, and for providing the scientific basis for decision making. From the perspective of land use planning, resource assessment definitions, like jurisdictional definitions, are but one tool among many, providing important but limited utility.

The primary example of a definition that is used for resource management and inventory purposes is the definition adopted by the U.S. Fish and Wildlife Service. The USFWS definition, also referred to as the Cowardin definition, integrates the three factors discussed above, but most importantly, does not require the presence of all three:

> Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following attributes: (1) at least periodically, the land supports predominantly hydrophytes,

(2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin, et al., 1979).

The USFWS definition, which is broad enough to cover a wide range of wetland types, is more inclusive than the Corps' definition. It includes wetlands that are not vegetated by hydrophytes, such as mudflats, and nonsoil habitats such as rocky tidepools. Because of its broadness, flexibility, and comprehensiveness, this definition is the most widely accepted by wetland scientists in the United States (Mitsch and Gosselink, 1986).

State and Local Definitions

Some state agencies have developed their own definitions for both resource assessment/management and regulatory purposes. Most of these state definitions are based upon the USFWS (Cowardin et al., 1979) definition and classification system. The primary exception is the State Water Resources Control Board and the Regional Water Quality Control Boards, which rely upon the Corps' regulatory definition for projects falling under the Clean Water Act and generally accept the delineations established by the federal agencies. The other state agencies with wetland regulatory authority in the San Francisco Bay Area are the San Francisco Bay Conservation & Development Commission (BCDC) and the California Department of Fish and Game (CDFG). The CDFG generally follows a broader definition requiring the presence of only one of the three factors characterizing a wetland. BCDC's jurisdiction is geographically defined in the McAteer–Petris Act, and includes tidal areas, managed wetlands, and salt ponds.

Within the planning area, three local government entities have defined wetlands for planning purposes. The Cities of Novato, American Canyon, and San Rafael have adopted the Corps' jurisdictional definition of wetlands (although the City of American Canyon works very closely with the CDFG in order to identify wetlands). The remaining local governments in the North Bay Planning Area have not adopted a definition of wetlands in their general plans.

Comparison and Analysis of Definitions

As discussed above, wetlands are generally defined to for the purpose of determining regulatory jurisdiction or to assess natural resources.

Currently, the definition used by the Corps of Engineers is generally acknowledged as being the method that provides, from a regulatory viewpoint, clear and supportable wetland boundaries, when initiated under a limited set of circumstances. The primary shortcoming of this definition, from a planning perspective, is that it cannot be used to capture the transitional nature of wetland

boundaries or identify wetland related habitat values. For example, it cannot identify the wetland related habitat value of the baylands as a whole. Resource assessment definitions, on the other hand, can describe the transitional nature of wetland boundaries and wetland related habitat values found in the North Bay, but these definitions are not accompanied by agreed upon ways to act upon these values.

When presented with competing definitions, there may be an inclination to try to decide which definition best represents wetlands. These definitions are tools designed for specific purposes, hence they are not interchangeable, and given their important uses, neither can be discarded. Attempting to use one or the other exclusively as the basis for the protection of wetland values can lead to significant shortcomings in either the protection of habitat, or in the equitable and predictable implementation of policy. However, these tools can be brought together to work in a complimentary fashion with the careful development of policies that incorporate a resource assessment perspective. These policies can provide important supplementary protection value to jurisdictional definitions; these policies, however, could not supersede the authority or the need for jurisdictional definitions.

For example, the City of San Rafael uses the National Wetlands Inventory, or NWI, maps in its general plan to help identify wetland areas. When a permit application is submitted for processing, the City uses the Corps' delineation of wetlands to identify wetlands boundaries on the site. The City's wetland protection mechanisms are then applied to the Corps–defined wetlands.

As another example, a city or county could use the NWI maps, or a similar product, as the boundary for a zoning designation, such as a bayfront overlay zone. Within this zone, a project may need to comply with special development standards, or undertake a special environmental study to identify sensitive habitats. In conjunction with this zone, the city or county might use the Corps delineation to identify which wetlands on the site are federally protected.

The challenge therefore lies in developing and implementing policies that can employ both these tools to provide the practical, equitable, and effective means to protect, enhance, and restore the values and functions of the North Bay wetlands, and at the same time identify and preserve compatible land uses.

A new tool, the EcoAtlas, has been created that offers an important regional perspective and can assist in the development of policies addressing areas containing jurisdictionally defined wetlands and accompanying habitat values. The EcoAtlas has been built upon the foundation of earlier mapping efforts conducted by the USFWS, and incorporates a resource assessment perspective.

The Ecosystems Goals Project and the Development of the SFEI EcoAtlas

In the early 1980's, the USFWS initiated a nationwide assessment and mapping program to identify and inventory the nation's wetlands, in an effort known as the National Wetlands Inventory (NWI). This program incorporated a comprehensive classification system of wetlands and deep water habitats to assist in the research and survey activities conducted under the program. The classification system, known as the Cowardin system, was derived from a hierarchy of habitat types that identified ecosystem type, hydrology, vegetative cover, and substrate. The mapping process relied on the use of infrared aerial photography,[10] photo interpretation and limited field checking. This mapping method was assessed by the National Research Council in 1995, which found that "Wetland delineation on NWI maps is generally accurate [in] areas where there is an abrupt change in hydrology, soil, or vegetation at the wetland boundary." However, in the absence of these abrupt changes, NWI maps tend to be less inclusive of wetlands nationally than detailed site specific maps. Nonetheless, the NWI maps have proven to be a useful source of information to local agencies in determining the location of wetlands and to assist in jurisdictional delineations.

Recently, in the Bay Area, the wetlands mapping program has been carried a significant step further through the development of a regional habitat typology, based on the Cowardin system, and the use of geographic information system (GIS) technology. The San Francisco Bay Area Wetlands Ecosystem Goals Project (Goals Project) has brought together the region's scientific and academic community in the development of an atlas of wetland types and related habitat around San Francisco Bay. This atlas, called the Bay Area EcoAtlas, incorporates a habitat typology that reflects regional land use qualities and the accompanying patterns of wetland related habitat, or regional ecology, and is designed for resource assessment and local/regional planning use. The current version of the EcoAtlas represents the product of over three years of intensive work, and reflects the efforts of over 100 scientists, academics, and volunteers in verifying the accuracy and guiding the design of the atlas for local and regional wetland habitat planning purposes.

The development of the EcoAtlas has been guided by two processes; the development of a habitat typology that presents a clear and relevant view of the estuary, and the development of a mapping program that shows the distribution of this habitat, using a flexible format that can be refined over time.

The Goals Project has undertaken the task of devising the habitat typology. The Goals Project was initiated to identify regional habitat goals, in support of the planning recommendations

[10] The flights in the Bay Area occurred in April 1985 at approximately mean high tide and, the initial mapping scale was 1:58000.

contained in the Comprehensive Conservation and Management Plan (CCMP)[11] for the Bay/Delta estuary. To achieve this task, the Goals Project has brought together scientists with recognized expertise in fish, wildlife, and plant biology to develop a habitat typology that reflects the needs of representative species found in the estuary. These scientists, in coordination with senior agency ecologists and biologists, have devised a typology that reflects a hierarchical habitat system similar to the Cowardin system, but most importantly, this system incorporates the existing topology, or terrain, of the San Francisco estuary. This approach has captured important details of wetland ecology that are particular to this region, and these details are not currently reflected in national or state surveys.

The mapping foundation for this endeavor is being carried out by the San Francisco Estuary Institute (SFEI). Using the 1987 NWI of the Bay Area as the initial base map, staff conducted site evaluations and solicited public and professional feedback regarding the features contained in the NWI maps, and began refining the feature data using the typology created by the Goals Project as a guide to identify features not reflected in the original NWI maps. Updates were of two types; the reclassification of habitat types; or the creation, deletion, or modification of feature boundaries from information traced onto 1:24000 scale maps. The final series of revisions, which will be made prior to release of the EcoAtlas, will incorporate the most recent aerial infrared photography of the Bay, taken during the winter of 1995–1996.

When released,[12] the EcoAtlas will be used to describe historical change in the estuary,[13] the existing conditions of the estuary, and to assist in the development of regional habitat goals. The results of this project will provide an important biological guide for public and private organizations seeking to preserve, enhance, and restore the ecological integrity of wetland communities.[14]

Content of The SFEI EcoAtlas (version 1.0bc)

The EcoAtlas identifies and maps the types of wetlands and related habitat primarily in the region's historic baylands—the mudflats, tidal marsh and channels, and areas containing seasonal wetlands and other related habitat within the diked historical tidal marshlands. The draft EcoAtlas is the basis for Figure 3, which depicts wetland and related habitat types in the North Bay planning

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[11] The CCMP was developed and adopted in 1993 through the cooperative efforts of the San Francisco Estuary Project, the United States EPA, and the State of California.

[12] The EcoAtlas is scheduled for release in the spring of 1997.

[13] SFEI has also created a historical coverage of the estuary, circa 1800-1850.

[14] The usefulness of the EcoAtlas and the Goals Project for wetland restoration and enhancement projects is discussed more fully in the chapter on wetland restoration and enhancement.

area. An early draft map can be viewed online over the Internet at the REGIS GIS (see the Mapping section in the Introduction to this report). Appendix A also features a series of views from the pre–release version of the EcoAtlas at an intermediate scale of 1 : 48000.

As mentioned above, the EcoAtlas has been created in a digital format that can be manipulated and displayed using geographic information system software. A GIS allows users to store, manage, analyze and display spatially arranged data in great detail and quantity, and is a tool of growing importance in the analysis and management of general land use planning and the development of policy.

The pre–release version of the EcoAtlas depicts the distribution and abundance of twelve types of wetland and wetland related habitats. The following section explains each of the habitat definitions that apply to the North Bay. These habitats can be classified into two main groups, tidal wetlands (those influenced by the tides) and diked baylands (former tidal wetlands which were diked and removed from tidal influence). Types of diked habitat include diked grazed baylands, diked managed wetlands, diked waters, diked farmed baylands, and former salt evaporators. Types of tidal wetlands include tidal marsh, tidal mudflats, and tidal waters. For the purposes of this report, SFEI's five categories of tidal marsh were combined into a single category of tidal marsh.

Diked Bayland Habitat Types

Diked baylands are former tidelands that have been isolated from tidal action through the construction of levees or dikes. In some places, seasonal wetlands appear; in other areas, favorable wildlife habitat is created by the collection of water or saturated soil. Usually, seasonal wetland areas were formerly intertidal mudflats or tidal marsh before being diked off from tidal influence; the resulting decomposition of organic matter and loss of sedimentation have lowered the tidal elevations of these diked areas below sea level.

Wetlands found in the diked baylands provide complimentary habitat between remaining natural tidelands and upland areas, and provide protected corridors for wildlife movement in and out of wetland areas. Wildlife seek refuge in the baylands during high tides and storms. Diked baylands and wetlands also buffer land areas from storms and erosion and provide open space and recreation opportunities for Bay Area residents (SFEP, 1992b).

Diked baylands includes the following five categories: diked managed wetlands, former salt evaporators, diked farmed baylands, diked grazed baylands, and diked waters.

1. **Diked Grazed Baylands.** Diked grazed baylands, like diked farmed baylands, are former tidal, brackish and freshwater marshlands that have been diked off and are now used for cattle grazing and dairies. These areas typically reflect passive vegetation and water management practices. These lands, which are generally not as subsided as farmed baylands, sometimes reflect the remnants of historic tidal marshlands. Grazed baylands often include small areas of seasonal wetlands surrounded by non-native annual grasslands. Grazed baylands often support small rodents and urban wildlife, as well as upland bird species. Grazed baylands also tend to support feral dogs and cats that may prey upon wildlife in adjacent baylands and tidal areas (SFEI, 1994).

2. **Diked Managed Wetlands.** Diked managed wetlands are diked habitats where the distribution of surface water is controlled to support a natural community of plants and wildlife. These areas usually support stands of wetland vegetation, and may have ponded water in old tidal sloughs that can become extremely saline during the dry season. Managed wetlands may be brackish where there is a sufficient inflow of freshwater runoff. Some diked wetlands reflect the remains of flood control projects, salt pond construction, or other development in the Bay (SFEP 1992a). These wetlands are managed primarily by private hunting clubs, special purpose districts, and the CDFG. Managed wetlands attract significant populations of migratory and resident shorebirds, wading birds and raptors, as well as an abundance of mammals. These lands generally provide habitat for waterfowl breeding or feeding, and resting (SFEP, 1992b).

3. **Diked Waters.** Diked waters are generally areas with ponded waters behind dikes. This category generally includes dredged material disposal ponds, flood control lands with ponded water, waste water treatment lands, and some agricultural stock ponds. Water and soil conditions in these ponds are highly variable and are determined by such factors as water sources, evaporation, water volume, soil permeability, soil salinity and pH. Diked waters may provide some intermittent habitat value, depending upon the use of the land, the depth of the ponded water, and the frequency and intensity of management practices.

4. **Diked Farmed Baylands.** Diked farmed baylands are lands that were diked, ditched, and drained for agricultural purposes in the late 19th century. Due to consolidation, subsidence, and wind erosion, the elevation of many of these diked farmed baylands is often significantly lower than the adjacent tidal waters (ranging from four to nine feet below Mean Higher High Water). Rainwater and seepage often collects in these low-lying areas. Diked farmed baylands can provide valuable wildlife habitat, especially during the wetter seasons, depending upon the intensity of the management practices and the degree of disturbance of the land (SFEP, 1992b).

Most farmed baylands are former tidal, brackish or freshwater marshes that could support wetland vegetation were they not actively farmed (SFEP, 1991a). The majority of the diked farmed baylands in the North Bay support oat hay production and require extensive networks of levees, ditches and pumps to prevent flooding and manage groundwater and salt levels (SFEI, 1994). Wetland vegetation typically occurs in the drainage and irrigation channels, and in low-lying areas that seasonally flood (SFEP, 1991a). Farmed baylands can provide resting areas for migratory shorebirds and waterfowl. Historical farming practices that left oat hay stubble in the field after harvest and allowed ponding in the late summer and early fall attracted migratory waterfowl such as dabbling ducks and Canada geese (SFEI, 1994).

5. **Former Salt Evaporators.** Former salt evaporators are diked areas adjacent to the Bay that were historically used for salt production through solar evaporation. Salinity levels vary greatly in salt ponds, ranging from that of open tidal water to highly concentrated, saturated brines. The bottoms of the crystallizer ponds are extremely saline and are covered with layers of precipitates which have prevented the ponds from leaching. The habitat value of these former salt ponds depends upon the salinity level, the depth, and the availability of food and cover. Ponds with low to intermediate salinity levels (usually the former intake ponds and crystallizers) tend to support the greatest diversity of invertebrates, fish and waterbirds (Josselyn, et al., 1994). Former salt evaporators provide significant roosting, resting and nesting habitat for both migratory and resident birds, including terns, gulls, grebes, pelicans, cormorants, and herons. They also offer habitat for a number of rare or endangered species. Some scientists suggest that birds may supplement their diet by feeding in salt ponds, and/or that the ponds provide important alternative foraging habitat during high tides (SFEP, 1992b).

Tidal Wetland Habitat Types

Within the San Francisco Bay estuary, there are several types of wetlands that are influenced by salt water from the ocean and subject to the ebb and flood of the tides. The salinity levels (i.e., the mixture of freshwater and salt water) of these wetlands depends, in large part, upon their location. Tidal flow provides the twice daily exchange of water for the revitalization of adjoining salt marshes and, in turn, transports nutrients, other foods, and organisms from the marshlands into open water habitat. Moreover, tidal open water provides a significant stabilizing effect on the climate of the Bay Area. For the purposes of this report, tidal wetlands includes tidal waters, tidal mudflats and tidal marsh categories.

1. **Tidal Marsh.** Tidal marshes develop at the interface between non-tidal areas and open water. Such marshes generally occur where the rate of sediment accumulation exceeds the combined forces of land subsidence and sea level rise, and where erosion from waves and storms is minimized. The tidal marsh category includes both salt and brackish marshes. Tidal salt marsh is found in San Pablo Bay proper; brackish marshes occur where there is substantial freshwater influence, such as along the Petaluma and Napa rivers and tributary creeks and sloughs.

The species composition in tidal marsh habitats is influenced by a number of factors, including salinity, the frequency and duration of tidal influence, and the type and density of vegetation. Common invertebrates found in tidal marshes include mussels, clams, amphipods, and snails. Tidal marshes also provide critical habitat for cover, foraging, and nursery areas for both sportfish (such as striped bass and native Chinook salmon) as well as for fish of special status (such as the winter-run Chinook salmon and the Delta smelt).

In tidal marshes, plant species often grow in zones that are determined by tidal elevations. In tidal salt marshes, cordgrass grows in lower areas between mean sea level to mean high water (low marsh), while pickleweed grows above mean high water (middle marsh). Alkali heath, gumplant and saltgrass grow at higher elevations (high marsh). In brackish marshes, three zones of plant growth exist: (1) low marsh, which is predominantly California bulrush; (2) middle marsh, a mixture of cattail and bulrush; and (3) high marsh, with such salt-tolerant species as saltgrass and baltic rush (SFEP, 1992a).

Salt and brackish marshes rank among the most productive ecosystems in the world; they support a diverse assemblage of terrestrial and aquatic life. Marsh vegetation is not only consumed directly, but also enters the food chain as detritus where dead marsh vegetation becomes an important contributor of nutrients to the marsh itself, as well as to adjacent intertidal mudflats and open water areas (SFEP, 1992b). Further, many bird and mammal species, including several that are listed as threatened or endangered, depend heavily upon salt and brackish marsh for food and habitat. Species of concern found in these areas include the salt marsh harvest mouse, the California clapper rail, the California black rail, the Suisun ornate shrew, and the San Pablo song sparrow. Finally, tidal marshes provide important wintering habitat for migratory birds along the Pacific flyway.

In addition to providing food and habitat for many fish and wildlife species, tidal and brackish marsh reduce shoreline erosion caused by wave action and flooding. Such marshes also enhance water quality by: (1) reducing water velocity, causing sediments and chemicals to be deposited in the marshlands, thereby reducing turbidity; (2) retaining pollutants (either temporarily or

permanently) by incorporating them into wetland vegetation—and subsequently into the sediments when the vegetation dies; and (3) converting some chemicals to less harmful forms (SFEP, 1992b).

2. **Tidal Mudflats.** Mudflats are tidelands that generally lie between Mean Lower Low Water[15] and Mean Higher High water[16] elevations that are inundated and exposed twice a day by the tides. The composition of mudflats, which ranges from silty clays to sand, also includes organic debris and shell fragments. Mudflats generally have very little vegetation, with the exception of isolated patches of green algae, blue-green algae, and seaweed (Josselyn, et al., 1994). Mudflats support diverse communities of benthic invertebrates, fish, and wildlife species. Clams, worms, mussels, shrimp, and crabs dwell both on and under the surface of the mudflats. Starry flounder, sharks, skates, rays, and other bottom-dwelling fish feed on these organisms during high tides. During low tides, shorebirds invade the intertidal flats for foraging (SFEP, 1992a).

3. **Tidal Waters.** Tidal waters are generally areas of open water, generally with a soft bottom and dominated by plants such as phytoplankton and eelgrass (SFEP, 1992a). These areas are strongly influenced by tides, precipitation, surface water runoff from the surrounding land, and wind. Tidal waters includes many habitats which support a diverse assemblage of plants and animals. Diatoms, algae, protozoans, arthropods, worms, and mollusks live on and in the mudflats and the bay bottom. These organisms constitute a major component of the estuary's food chain. Several species of fish—such as salmon, striped bass, Pacific herring, starry flounder, and anchovy—use different open water tidal habitats during various stages of their life cycle. Open tidal waters are used by birds for feeding and resting areas. Humans also use open tidal waters for harvesting shellfish, waterfowl and fish, recreation, and as receiving waters for the disposal of dredged material, industrial and municipal waste discharge, and urban runoff (SFEP, 1992b).

Local and Regional Use of the EcoAtlas

By refining the results of the NWI survey, incorporating the habitat typology developed by the region's leading biologists and resource managers, identifying discrete wetland types and functions in a regional context, and reflecting general land use qualities, the EcoAtlas offers policy makers a new policy development tool that identifies wetlands and related habitat. The EcoAtlas can be used to depict habitat resource areas in general plans and serve as a policy making tool for determining the area of implementation for wetland protection, enhancement, and restoration policies and programs within the historic tidal marshlands of the North Bay. Moreover, because the EcoAtlas is

[15] Mean Lower Low Water is the average height of the lower of the daily low tides.

[16] Mean Higher High Water is the average height of the higher of the daily high tides.

dynamic and can be updated over time, it can be used to assess cumulative environmental change in the North Bay, which is an aspect that would be useful for local and regional environmental planning. Additionally, the EcoAtlas can be used in a complimentary fashion with jurisdictional delineation activities. The current version of the EcoAtlas does not show the location of jurisdictionally defined wetlands, but does identify areas where they may be found, and given the flexible digital format of the EcoAtlas, it can be updated by local planning agencies to show where these sites lie, after a delineation has occurred. This updated information can be easily shared among planning and resource agencies, thus enhancing the regional value of the atlas.

The SFEI EcoAtlas provides the most current, detailed, and complete view of wetlands and related habitat types in the North Bay, and is based upon the best available scientific knowledge of the types, amounts, and distribution of regional wetlands and related habitats.

CHAPTER 4

LOCATION OF WETLANDS AND RELATED HABITATS

To illustrate the current distribution of wetlands and related habitats within the historic wetlands of the North Bay planning area, Chapter 3 described the eight categories of wetlands and related habitats used in this report. This chapter contains more detailed information on the extent and location of each category of wetlands and related habitats in the planning area.

Wetlands and Related Habitats in the North Bay

Within the North Bay planning area, there are approximately 59,000 acres of wetlands and related habitat that can be classified into two main groups: 42,250 acres of diked baylands which are former tidal wetlands that have been diked off from tidal action and are seasonally wet; and 17,150 acres of tidal areas, which are still influenced by the tides. This classification structure is adapted from the San Francisco Estuary Institute's EcoAtlas, discussed in Chapter 3. For detailed explanations of these wetland and related habitat types, refer to Chapter 3.

Based on the SFEI draft EcoAtlas, Figure 3 and Table 1 depict the current distribution of the eight wetland and related habitat types within the North Bay planning area.

TABLE 1

North Bay Planning Area Wetland and Related Habitat Acreage

Habitat Type	Acres	Percent of Wetlands and Related Habitats in Study Area
Diked Managed Wetlands	8,490	14
Diked Waters	860	1
Farmed/Grazed Diked Baylands	24,290	41
Former Salt Evaporators	8,610	14
Diked Baylands Subtotal	**42,250**	**71**
Tidal Marsh	12,300	21
Tidal Mudflats	1,250	2
Tidal Waters	3,600	6
Tidal Areas Subtotal	**17,150**	**29**
TOTAL	**59,400**	**100**

Location of Wetlands and Related Habitat

Figure 3 displays the current distribution of wetland and related habitat types, according to the eight categories described in Chapter 3. Appendix A also features a series of views showing greater detail, from the pre–release version of the EcoAtlas.

1. **Farmed or Grazed Diked Baylands.** Of the 24,290 acres of farmed or grazed diked baylands in the North Bay, diked grazed baylands comprise approximately 1,130 acres. These diked grazed baylands are located west of the Petaluma River, in Marin and Sonoma counties. The largest of these areas is located east and north of Gnoss Field, formerly part of the Burdell Ranch but now owned by the CDFG. Another large diked grazed bayland, known as one of the Leveroni properties, is located immediately south and east of the Highway 101 and 37 interchange in Marin County. The remaining diked grazed baylands in Marin County are located just west of the Redwood Sanitary Landfill and the Northwestern Pacific Railroad tracks, and south of San Antonio Creek. In Sonoma County, diked grazed baylands are located west of the Northwestern Pacific Railroad tracks (immediately west of Neils Island), and between the Petaluma River and the Northwestern Pacific Railroad tracks in the northern most portion of the planning area.

Farmed diked baylands total approximately 22,980 acres and are located in Sonoma County and portions of Marin County, as well as in the Napa Marsh area. Specific properties with farmed diked baylands include the St. Vincent, Silveira, Los Gallinas Valley Sanitary District, Bel Marin Keys, Marin County Flood Control District, Novato Sanitary District properties, and private properties south of Gnoss Field.

Other areas include private properties across Petaluma River, Cloudy Bend, Hog Island, Sonoma Land Trust properties (North Parcel, Baylands Hayfield Ranch), Leonard Ranch, Tubbs Island, Camp #1, #2, #3, #4, and #5 Islands, the privately owned Mulas property in north Sonoma County, and the Skaggs Island/Haire Ranch property.

2. **Diked Managed Wetlands.** Diked managed wetlands total approximately 8,490 acres. They are shown in yellow on Figure 3, are scattered throughout the diked historic baylands, and are managed for a variety of uses including undeveloped military lands, for flood control, and as wildlife areas.

In the western portion of the planning area, the significant diked managed wetlands include the eastern portion of McInnis Park and the Las Gallinas Valley Sanitary District waste water storage area, the unpaved portions of the Hamilton Airfield runway, the adjacent State Lands Commission antennae field parcel, and a portion of the CDFG Day Island Unit. Several diked managed wetlands exist adjacent to Novato Creek including a State Lands Commission parcel across the creek from Bel Marin Keys, the CDFG Novato Creek Unit east of the Vintage Oaks Shopping Center, and the Marin County Flood Control District lands further east surrounding Deer Island.

North of the Novato Creek watershed, across Atherton Avenue and Pinheiro Ridge, additional diked managed wetlands include the CDFG Rush Creek Unit, the Marin County Open Space District Cemetery Marsh, and privately held lands north of the Bahia development and south of the tidal marsh in Black John Slough. A small site within the Redwood Sanitary landfill is also considered diked managed wetlands.

In the center of the planning area, the diked managed wetlands are dominated by the USFWS Cullinan Ranch portion of the San Pablo Bay National Wildlife Refuge. Other Refuge lands within this category include Lower Tubbs Island at the mouth of Tolay Creek. Other diked managed wetlands include the majority of the privately held duck clubs in the Sonoma Creek and Napa Slough system and the State Lands Commission parcel just east of the Highway 37 bridge over Sonoma Creek. The remainder of the diked managed wetlands in the center of the planning area are scattered along the fringes of the diked historic baylands and include privately held wetlands west of Sonoma Creek, wetlands owned by the Sonoma County Water Agency and managed by CDFG in the Ringstrom Bay Unit, and wetlands in CDFG's Huichica Creek Unit. The Napa County Flood Control District also owns some diked managed wetlands just north of Edgerly Island, and additional privately held diked managed wetlands are north of the Huichica Creek Unit between the Southern Pacific Railroad tracks and Milton Road.

Bull Island and the diked managed wetlands immediately west of the Napa Sanitation waste water storage ponds form the northern extent of the diked managed wetlands in the planning area. The next area of diked managed wetlands east of the Napa River occur south of the Cargill salt production facility and west of the City of American Canyon. These wetlands, which surround the American Landfill and the City of American Canyon waste water storage ponds, are located, in part, on the CDFG American Canyon Unit and land owned by the Port of Oakland. North Slough meanders through both parcels. Lastly, in Vallejo, the White Slough lagoons south of Highway 37, portions of River Park, and several dredged material disposal ponds on Mare Island are also considered diked managed wetlands.

3. **Diked Waters.** Diked waters include Pacheco Pond, some Novato Sanitary District lands, Bahia, Redwood Landfill settling basin, agricultural stock ponds adjacent to Petaluma Marsh, part of Edgerly Island, the eastern portion of the Cargill property, River Park, and the Mare Island dredged material disposal ponds. Diked waters are shown on Figure 3 in light brown, and total approximately 860 acres.

4. **Former Salt Evaporators.** The former Cargill salt evaporators, consisting of 8,610 acres, are divided into two categories for the purpose of this discussion: (1) former salt ponds now owned by CDFG (west of the Napa River), and (2) the former salt production facility still owned by Cargill (east of the Napa River). Figure 3 shows all the salt evaporators in light blue.

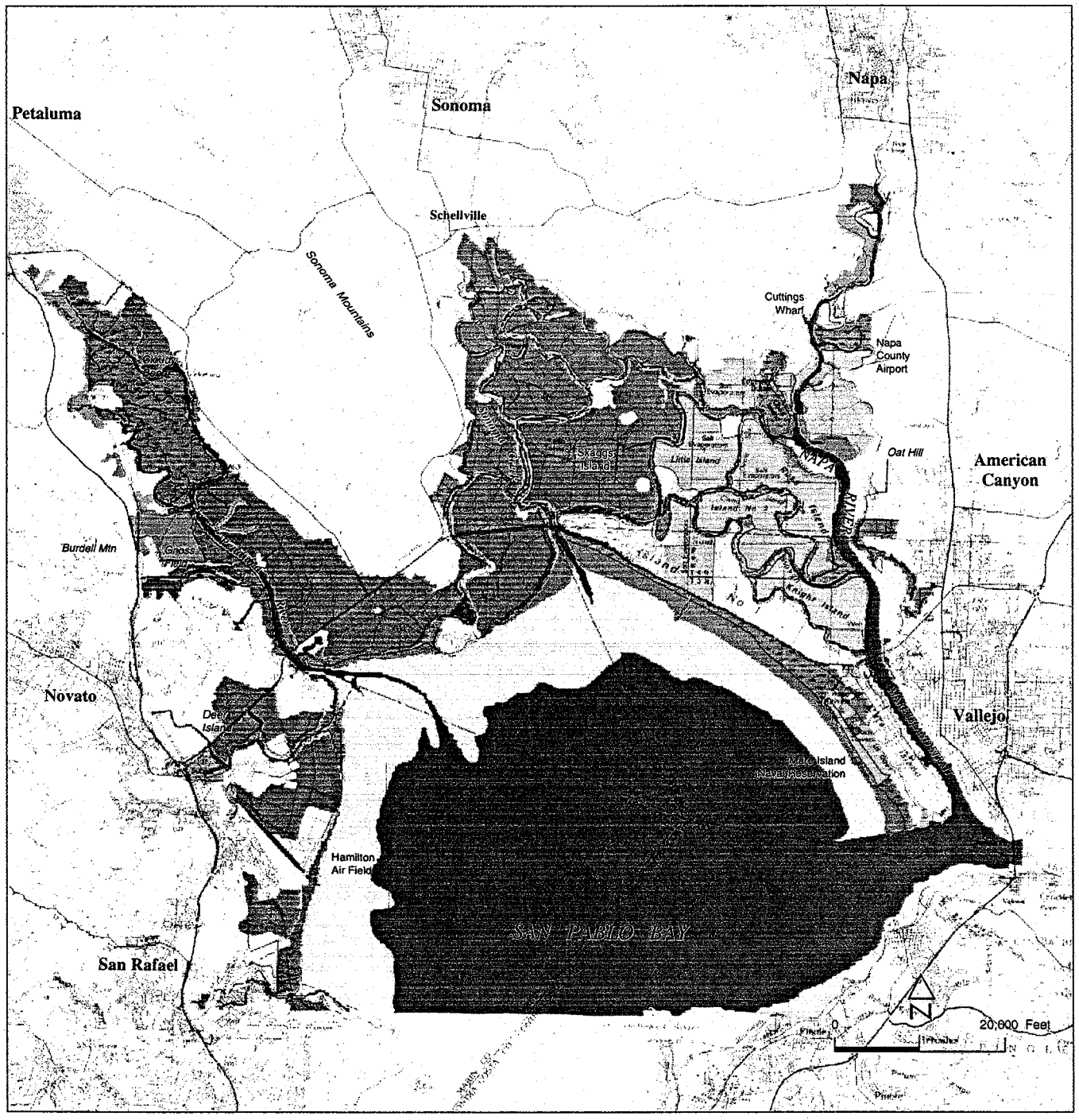
Figure 3

SOURCE: San Francisco Estuary Institute from REGIS, 1995; BCDC

Wetlands and Related Habitat

- Diked Waters
- Salt Evaporators
- Tidal Mudflat
- Tidal Waters
- Diked Grazed Baylands
- Diked Managed Wetlands
- Diked Farmed Baylands
- Tidal Marsh

NOTE: This diagram does not show any wetlands beyond the planning area on that may be uncovered by site specific survey.



The former salt ponds now owned by CDFG comprise, for the most part, the eastern portion of the Sonoma Creek and Napa Slough system. Salt water from the Bay was circulated through these ponds (named as islands) to increase its salt concentration using solar evaporation over a number of years. The water traveled first through Island No. 1, then through Island No. 2, on to Knight Island, Russ Island, Little Island, Edgerly Island, and finally to the crystallizer ponds on the east side of the Napa River. The ponds were acquired by CDFG in 1994 and are to be restored to tidal action or enhanced as a diked managed wetland or diked water, pending development of a wetland restoration or enhancement plan (discussed in Chapter Six in this report). Since the ponds have been acquired, one of the ponds, Pond 2A, has been returned to tidal action by breaching a portion of its levee to alleviate accumulated water during the winter of 1995's floods.

The salt production facility is located on the east side of the Napa River, west of the Napa County airport, surrounding Green Island. A number of buildings and production equipment, which were used for processing and distributing salt, are located on Green Island.

5. **Tidal Marsh.** About 12,300 acres of tidal marshes are scattered throughout the planning area, displayed on Figure 3 in purple. Tidal marshes occupy an extensive but narrow band along the San Pablo Bay shoreline, in major tributary rivers, particularly the Petaluma River and narrow strips along the bank of the tidally influenced creeks and sloughs which meander through the planning area.

In the western portion of the planning area, extensive tidal marsh exists outboard of the levees which separate McInnis Park, the Las Gallinas Valley Sanitary District lands, Hamilton Army Airfield, and the Bel Marin Keys agricultural lands from San Pablo Bay. The tidal marshlands also extend, in the form of narrow shoreline strips, along Novato Creek to Highway 101, and immediately north of the mouth of Novato Creek, easterly from the shoreline of Day Island and north around the bend to the mouth of the Petaluma River. Across the river from Day Island, extensive tidal marsh occupies the area southwest of Port Sonoma and the recent Sonoma Baylands marsh restoration project.

The largest contiguous marsh in the North Bay is within the Petaluma River basin. This marsh includes areas such as the CDFG Toy Unit, the Black John Slough Unit, and the Petaluma River Marsh. In addition, privately owned tidal marsh, which includes portions of Tule Slough, Mud Slough, San Antonio Creek, and Schultz Slough, exists northwest of the CDFG Petaluma River Marsh and surrounds three sides of Neils Island. The eastern shore of the Petaluma River also contains a strip of tidal marsh that extends from outside the northern boundary of the planning area, adjacent to the City of Petaluma wastewater plant, around Cloudy Bend, past the Lakeville Marina, Hog Island, and down to the recently restored Sonoma Land Trust pilot project just north of the Highway 37 bridge.

In the center of the planning area, another large swath of contiguous tidal marsh runs along the San Pablo Bay shoreline between the mouth of the Petaluma River to the tip of Mare Island. The eastern portion of this marsh, located south of Highway 37, is owned and managed by the USFWS as part of the San Pablo Bay National Wildlife Refuge. In addition, a significant amount of tidal marsh exists adjacent to the tidal waterways as they meander through the Sonoma Creek and Napa Slough system, and along Tolay Creek. Several sites within this network contain not only lineal strip marshes, but more expansive tidal marsh areas, such as within Tolay Creek and the northeastern portion of the CDFG Wingo Unit. This category also includes private duck club lands at the confluence of Huichica Creek and Hudeman Slough and southwest of Skaggs Island adjacent to the Napa Slough, and CDFG lands on Coon Island, within the Huichica Creek Unit, and on the southerly portion of Russ Island.

In the eastern portion of the planning area, tidal marshes are located primarily along the eastern shore of the Napa River from Steamboat Slough (near the Napa County airport) to White Slough (near the Highway 37 bridge over the Napa River in Vallejo). The larger tidal marshes in this area include the Fagan Marsh ecological reserve and the privately held marshland due west of the reserve, the tidal marsh outboard of the levees surrounding Cargill's inactive salt production facility, the tidal marshes within the CDFG American Canyon Unit that surround the residential areas in northwestern Vallejo, the tidal marsh of north White Slough, and the tidal marsh lands extending south from White Slough to River Park in Vallejo.

6. **Tidal Mudflats.** Virtually all of the approximately 1,250 acres of tidal mudflats in the North Bay planning area are located along the Napa River, and are shown in Figure 3 in gray. The majority of the Napa River's mudflats are located adjacent to the east shoreline, stretching from the Napa River Bridge north to the Cargill salt production facility. The additional Napa River mudflats are located across from the salt production facility on the western shoreline adjacent to the northeasterly side of Russ Island.

Within the planning area, several other smaller tidal mudflats exist, mainly near the mouths of the Petaluma River, Sonoma Creek, and adjacent to Mare Island Strait. This is largely due to the presence of an extensive tidal mudflat area which encompasses the entire northern shoreline of San Pablo Bay at low tide. However, because the North Bay planning area does not extend into the waters of San Pablo Bay, the bulk of these extensive mudflats are not included in the planning area calculations.

7. **Tidal Waters.** Within the North Bay planning area, the river channels and sloughs that are tributary to San Pablo Bay comprise most of the approximately 3,600 acres in the tidal waters category. These wetlands include the Petaluma River, Sonoma Creek and Napa Slough system, Napa River, and Mare Island Strait. The open water area of San Pablo Bay itself falls outside the boundaries of the planning area. An additional tidal water area, commonly known as the CDFG

tidal lagoon, is located adjacent to the mouth of Tolay Creek in southern Sonoma County. Tidal waters are displayed in dark blue on Figure 3.

CHAPTER 5

THE FUNCTIONS OF WETLANDS AND RELATED HABITATS

Wetlands in the North Bay region serve several important ecological and public purposes in addition to their primary uses, such as agriculture production. Wetlands alter and control flood flows, recharge groundwater, maintain stream flows, reduce and prevent shoreline erosion, and filter surface runoff from surrounding lands, thus improving water quality. They also are critical habitat for the region's fish and wildlife populations, serve as a primary link in the ecosystem's food chain, ensure the continued diversity of regional plant and animal communities, and are an essential feeding and resting place for migratory birds on the Pacific Flyway. Finally, wetlands provide the opportunity for a variety of recreational and educational activities and serve as a relief to the urbanized San Francisco Bay Area. The many benefits of wetlands are discussed below, as are the special functions of diked baylands, inter-related transition zones, and upland buffer areas.

Wetlands Functions

1. **Fish and Wildlife Habitat.** Wetlands offer food and habitat for many fish, invertebrate, and wildlife populations. Some species spend their entire lives in wetlands, while others use wetlands primarily for reproduction and as nurseries. Over 300 types of fish and wildlife species breed, feed, and rest in the San Francisco Bay estuary wetlands. Populations of clams, worms, and other invertebrates thrive in mudflats, and fish and crabs use shallow waters as nursery grounds (SFEP, 1992c). The tidal and diked seasonal wetlands found in the San Francisco Bay estuary are vital habitats that sustain migrating waterfowl and shorebirds along the Pacific Flyway, species that winter over in the area, and resident species that remain in the area throughout the year. Without the wetlands of this estuary, which is the largest on the west coast, many species that migrate between countries would not survive. Instantaneous counts, or counts done as a snapshot in time, revealed that nearly one million waterfowl and one million shorebirds depended upon the estuary's open water and wetland habitats at certain times of the year (SFEP, 1994a). Many of the estuary's rare or endangered species are dependent upon or live only in wetlands. Wetlands in the North Bay support the following threatened or endangered species: the California clapper rail, salt marsh harvest mouse, California least tern, Aleutian Canada goose, and the California brown pelican (SFEI, 1994).

Wetlands are also important spawning and nursery grounds for many estuarine fish. The productivity of the Bay's tidal marshes is among the highest of any natural ecosystem. Through photosynthesis, wetland plants convert sunlight into plant material or biomass that feeds a variety of animal populations within a complex food chain. Wetland vegetation creates detritus—decaying

plant material—as a food source for invertebrates, which in turn are consumed by shorebirds, fish, crabs, and other organisms higher in the food chain.

2. **Improve Water Quality.** Most of the marshlands that ring San Pablo Bay receive surface runoff from the surrounding urban and rural lands. Because they filter runoff from adjacent uplands, wetlands improve and maintain the quality of surrounding bodies of water. Wetlands can remove and retain nutrients, process some chemical and organic wastes, and reduce sediment loads from runoff. Sediment is physically removed due to settling, trapping, and filtering by vegetation. Microbial populations that thrive in wetlands use and transform chemical compounds. Also, some wetland plants can absorb or store pollutants (SFEP, 1991a).

Emulating the storage and filtering properties of natural wetlands, constructed wetlands have been successfully used to treat storm water and municipal waste water in some areas of the North Bay (e.g., the Las Gallinas Sanitation District and Novato Sanitary District treatment ponds, and treatment ponds at Hudeman Slough).

3. **Flood Protection.** Wetlands also control the flow of flood waters. They can temporarily hold runoff from surrounding uplands following rains; they can also serve as a reservoir when San Pablo Bay or its tributary waterways overflow their banks during floods. In flood control channels, wetlands can slow the flow of flood waters, store them for a period of time, and slowly release the stored water downstream. All of these processes prevent the destruction of private property and crops. These flood control functions become even more important in urban areas where development increases the volume and rate of flow of surface water runoff and the subsequent potential for uncontrolled flooding. Diked agricultural lands, such as those in the North Bay, collect water during heavy rains and gradually release it via tide gates into the Bay at low tide (SFEP, 1991a). Flood water retention results in ponded areas that also serve as habitat for migrating waterfowl.

In a recent study in Illinois, researchers found that 5.7 acres of restored marsh can handle the annual runoff from a watershed of 410 acres, including the overflow from this watershed during floods (New York Times, 1995). This research supports the growing belief that restored wetlands and other natural flood control mechanisms are viable alternatives to structural flood control measures.

Recognizing the potential for a flood plain approach as part of a comprehensive flood control strategy along the Napa River down stream of the City of Napa, the U. S. Army Corps of Engineers has initiated its Napa River Marshes study to evaluate possible use of diked baylands along the Napa River as a flood plain. Moreover, the Southern Sonoma Resource Conservation District is evaluating flood control options along Sonoma Creek that include use of some diked baylands along the creek below Highway 116 as a flood plain.

4. **Erosion Control.** Wetlands located along waterway shorelines help prevent erosion caused by surface runoff, tidal and current action, and waves. Wetland vegetation helps reduce erosion by absorbing and damping wave and current energy, binding the soil with their roots (thereby increasing its stability), and by slowing the speed of passing water which encourages the deposition of suspended sediment. Planting vegetation to reduce shoreline erosion has been successful in parts of the nation, but has only been tried on an experimental basis in the Bay (SFEP, 1992a).

5. **Recreation and Open Space.** The shoreline along San Pablo Bay, in addition to providing some of the Bay Area's most important wildlife habitat, also offers exceptional recreation opportunities. The many waterways in this area—including the Napa River, its snaking sloughs, Sonoma and Tolay creeks, and the Petaluma River—link wildlife and the human population to the Bay. The area's tidal wetlands and diked baylands help to maintain diminishing open space in the Bay Area, and also offer a place for recreation, such as hiking, biking, hunting, bird watching, fishing, boating, photography, and picnicking. Hunting opportunities are available in the shallow waters of San Pablo Bay and the tidal sloughs of the Petaluma River, the Napa and Sonoma marshes, and on privately-owned managed wetlands (SFEP, 1991a). However, the increased recreational use of wetland areas has raised concerns about the potential adverse impacts of these activities on wildlife.

Functions of North Bay Diked Baylands[1]

Diked baylands provide all of the functions discussed above. Functions provided by diked baylands in the North Bay compliment those served by tidal wetlands, and are necessary to support species traveling the Pacific Flyway.

Diked baylands functions and characteristics differ from tidal wetlands. For example, diking areas from tidal action blocks both tidal exchange and freshwater drainage between the marsh and the Bay, thus making some diked areas effective at trapping seasonal rain fall and flood water and removing pollutants. At the same time, some diked areas also accumulate salts because of the lack of periodic flushing. If the site also has poorly drained soils, the salts can inhibit vegetation growth. Some areas remain flooded through the wet seasons and become totally dry in the summer and early fall, resulting in populations of only those plant species that can survive these conditions.

Diked baylands can also be very acidic, which can also influence plant growth. Furthermore, these diked lands have often subsided below the natural land elevation. This subsidence can cause the soils to compact, thus influencing the function of the wetland. Elevation changes such as subsidence can sometimes create distinct wetland micro-environments which support different

[1] All information for this section comes from *Ecological Values of Diked Historic Baylands* by Madrone Associates et al., 1983.

wetland flora and fauna. Irregular elevation caused by the weight of a levee can result in "mud waves" in adjacent areas.

Although diking has altered the habitat of historic tidal marshes, these areas have retained many of the values associated with tidal marshes and have distinct separate qualities that support migratory shorebirds and waterfowl. One of the most valuable functions of the diked baylands, which are also often referred to as seasonal wetlands, is the high tide refuge and foraging habitat they afford that helps sustains shorebird populations. Shorebirds forage on intertidal mudflats, but generally must leave these habitats twice a day when the tide covers mudflats. Their legs are short and they cannot forage in the deeper water; consequently, they require habitats that allow them to forage safely during high tides. The shallow, unvegetated, or sparsely vegetated, wetland habitats that form annually on diked baylands serve just this function. The lack of vegetation is an important feature of these areas because it improves visibility, and allows shorebirds to move in small or large flocks, making use of the open vista and many eyes to spot the approach of an avian predator. Diked baylands also seem to be preferred by some species of dabbling ducks, such as teal and mallard. Even some diving ducks, which are mostly found on open waters of the Bay, seem to prefer the quiet waters of diked baylands when they are more deeply ponded and during times of storm and rough waters on the Bay.

Raptors (birds of prey, e.g. hawks) depend on diked baylands for prey, as do many mammals (Barbara Salzman, Marin Audubon Society). Some populations of salt marsh harvest mouse, an endangered species, are supported by certain diked baylands.

Although most of these diked baylands have no more than a tenuous hydraulic connection with the Bay[2], they all contribute to the Bay ecosystem. These lands have diverse functions and values, such as maintaining wildlife habitat and contributing nutrients to the Bay regional ecosystem. The wide variety of water regimes and vegetation in close proximity contributes to the extent and unique diversity of habitat around the Bay. Diked baylands also act as a buffer between remaining natural tidelands and uplands, creating protected corridors for wildlife movement in and out of the wetland areas, and nesting, denning, or breeding areas for some species.

Diked baylands perform other important functions, such as retaining storm runoff and flood waters, contributing to water quality by assimilating wastes (i.e., trapping and/or removing pollutants from runoff), and buffering land areas from storms and erosion. In addition, their social value is high, due to their pleasing appearance and opportunities for recreation, research, and education. In addition, the extensive diked baylands in the North Bay carry on decades–old traditions of pasture for farm animals and oat–hay production.

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[2] The term "tenuous" is meant to covey the absence of a regular surface connection.

The complex of wetland habitat in the North Bay is of critical value to the San Francisco Bay estuary ecological system. Significant losses of tidal marsh have reduced the regional capacity for supporting certain wildlife species and populations. In spite of that loss, large areas of undeveloped, seasonally wet diked baylands offer diversified habitat and continue to support many migratory waterfowl, shorebirds, and endangered wildlife species using the Bay. The wildlife values of the habitat complex thus include diversity, vast extent of habitat, rare and endangered species and productivity.

1. **Diversity.** Fresh, brackish, and saline wetlands—all with varying types of vegetation—exist within diked historic baylands. Diked baylands provide shallow ponded habitat not subject to tidal action, with varying degrees of vegetation. The characteristics of flat, open expanses contribute to the complexity of habitat, and therefore diversity of species in the Bay.

2. **Vast Extent of Habitat.** The large expanses of diked inactive salt ponds, hay fields, and the brackish marshes fulfill in part the wildlife functions of the large tidal marsh systems that once existed. The combination of diked baylands and tidal wetlands form a continuous crescent of integrated habitats along the North Bay. Diked baylands provide complimentary, distinct, and essential habitat for many shorebirds and dabbling waterfowl species. Even the smaller parcels of diked baylands serve as wildlife oases within urbanized areas. Animals tolerant of human activities can use these habitat islands when forced out of other areas. Still other diked parcels, while not extensive in acreage by themselves, are located where they add considerably to the habitat range of species that depend primarily on tidal habitat.

3. **Rare and Endangered Species.** Diked baylands provide essential habitat for the endangered salt marsh harvest mouse, whose natural high marsh pickleweed habitat has been severely reduced around the Bay. The clapper rail, an endangered bird inhabiting tidal marshes, may find habitat in restored tidal marshes in diked baylands. Subspecies of salt marsh yellow throat and salt marsh song sparrow, which biologists consider rare (but which are not currently listed), have been spotted in diked baylands. Again, the loss of natural transition habitat upland of the current diked baylands contributes to reductions of populations of these species.

4. **Productivity.** Productivity can be defined as the amount of plant material, produced from sunlight, carbon dioxide, and water, that cycles in the environment. In San Francisco Bay, salt marsh plants and mudflat algae are principal components of productivity. Invertebrates—insects, worms, snails, etc.—that eat the plants provide a secondary level of productivity. These in turn serve as food sources to fish, small birds, and mammals.

Scientists have long speculated about the productivity of wetlands in general and San Francisco Bay tidal marshes and mudflats in particular, although few actual biomass measurements have ever been made in San Francisco Bay. Cordgrass is well known from Atlantic Coast studies as a

productive species and, while pickleweed has been less studied, research indicates that this species also is highly productive. Daily flushing of tidal wetlands circulates organic material (decaying plant and aquatic animals) into the Bay on a regular basis.

While they do not contribute to the Bay through the same mechanism, diked baylands are productive because they maintain species that require upland or ponded habitat for survival. The numerous wildlife consumers of plants and small animals that move in and out of diked areas demonstrate one way this productivity passes to undiked areas. The net productivity of diked areas thus can be viewed as the net energy produced, used, and exported into adjacent habitats through the movements of wildlife.

In summary, although diking has altered the wetland habitat of the North Bay historic marshlands, these areas have retained many of the values associated with tidal marshes, including flood control, water quality, and habitat values. Moreover, the diked baylands have assumed habitat values of formerly upland seasonally wet areas that have since been developed or converted to other non-wetland uses.

The Transition Zone and its Functions

A transition zone is a habitat type where a gradual change from wetland to upland occurs. Transition zones are sometimes called "ecotones." In their natural condition, wetlands frequently lie adjacent to upland habitats, with a transition zone in between. This transition zone is usually an area of lowland grassland that can support both vegetation and wildlife found in both wetlands and uplands habitats (BCDC, 1976). As a consequence, transition zones contain a rich mixture of vegetation types and an especially important habitat for aquatic and terrestrial wildlife.

These transition zones are inextricably linked to wetlands ecosystems, demonstrating an "edge effect" that mixes the habitat of plants and animals from each of the bordering habitats—such as tidal marsh and grassland—serving the plant and animal species that thrive in a mixed or broken habitat. Many wetland species seek temporary refuge in the higher elevations of the transition zone as well as adjacent uplands during flooding and high tides and forage in both areas for food. Other wetland-dependent species depend upon the adjacent upland habitat for their survival. For example, the endangered salt marsh harvest mouse uses the transition zone both for cover as well as for feeding (SFEP, 1991a).

The size of a transition zone can vary, or in some cases be entirely absent, depending on natural topography, or the type and amount of disturbance to natural conditions. For example, in urban areas, a wetland may be abutted by a roadway and the transition zone is absent; in rural areas, such as Suisun Marsh, transition zones are extensive, and are generally found between the five-foot and 10-foot contour lines (BCDC, 1976). Many diked baylands act as substitutes for natural transition zones that have been replaced by development.

The transition zone is inextricably linked to the wetlands and is an essential area for wetland-related plant and animal life (BCDC, 1976). Therefore, the transition zone should be considered and treated as part of the wetlands ecological system.

Functions of the Buffer Areas

While transition zones are a unique habitat type, buffers are a management concept. Many cities and counties require buffers, or undeveloped areas, to separate a project from a wetland or related habitat. A buffer is an area established adjacent to a transition zone and/or wetland to reduce the adverse impacts of surrounding land use activities. Buffers separate transition zones/wetlands from developed uplands.

Buffers protect wetlands from adverse impacts by moderating the effects of storm water runoff, including stabilizing the soil to prevent erosion, filtering harmful substances, and moderating water level fluctuations (Washington State Dept. of Ecology, 1992). Because of the critical link between wetlands and the surrounding lands, efforts to protect wetlands must attempt to reduce the impact of activities within the watershed (particularly within adjacent uplands and tributary waterways) on the quality and function of a wetland habitat, as well as address impacts of activities occurring directly within the wetland areas. Therefore, buffer zones are an essential element of a North Bay wetland protection program.

Buffer areas reduce noise and glare, intercept and trap sedimentation and harmful nutrients (thus keeping them from reaching wetlands), reduce direct human disturbance that can result from dumped debris, cut vegetation, and trampling; and provide visual separation (Washington State Dept. of Ecology, 1992). Thus, incorporating a wetland buffer into wetland protection efforts can be an effective method for minimizing the effects of urban encroachment and other uses that can adversely impact wetlands.

The minimum size of the buffer can vary depending on its intended use and on site-specific conditions. Studies indicate that the buffer's function is directly related to the width of the buffer. For example, in order to prevent direct human encroachment, buffers of 50 to 150 feet are necessary. In order to provide effective water quality functions, the buffers should be 100 feet or greater. Studies in the state of Washington indicate that adequate wildlife buffers need 100 to 300 feet or more, depending on the area and the significance of the wildlife (Washington State Dept. of Ecology, 1992).

Corridors and Their Functions

Many resident wildlife migrate locally within the Bay region during diurnal movements or in various seasons or stages of their life cycles. Access to traditional breeding, feeding, or wintering grounds may be interrupted by expanding urban development, in the absence of a transition zone.

Finally, some diked historic baylands serve as corridors connecting undeveloped buffer areas with the Bay shoreline, through which wildlife can migrate. Raccoons, for example, move from uplands to feed on tide-flat organisms.

Assessing Functions of North Bay Wetlands and Related Habitats

The functions and values provided by wetlands can vary significantly from one wetland type to another and from one region to another. In general, the extent to which these specific functions are provided by wetlands in the North Bay region (and the rest of the Bay-Delta estuary for that matter) has not been well studied.[3]

Nationally, there have been numerous methods developed by scientists and government agencies for assessing wetland functions. A primary reason for developing these techniques is the need to predict the effects of wetland alteration and to establish appropriate mitigation requirements as part of a federal Clean Water Act Section 404 permit. While progress has been made on specific techniques, the ability to accurately assess all functions and to account for regional variation of wetlands remain areas for improvement. However, the Corps and the USEPA are collaborating on the creation of hydrogeomorphology (HGM) models for riverine, emergent marsh, and vernal pool wetland systems. This process incorporates geology, hydrology, and landscape position in order to analyze the functions of a particular river or wetland. It is anticipated that this method will become the preferred method of site assessment by federal agencies in the near future (Paul Jones, U.S. EPA, personal communication).

Individual wetlands function, in part, through interaction with the adjacent land and in conjunction with other wetlands. Therefore, functional assessments are perhaps most meaningful as part of watershed planning efforts, where one can consider the interactions between the wetland and the surrounding landscape and the location of the wetland within the watershed (National Research Council, 1995).

Unfortunately, recognition of the various functions and values provided by Bay Area wetlands has occurred only relatively recently. The History chapter of this report describes the extensive tidal marsh loss and conversion over the past 150 years that has dramatically reduced the size of the region's tidal marshes. As wetland acreage decreases, the ability of the remaining wetlands to perform certain functions becomes increasingly strained and these remaining wetlands become even more valuable.

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[3] However, the San Francisco Wetlands Ecosystems Goals Project has made significant strides in identifying the habitat values of the region. A report is expected in mid–1997.

CHAPTER 6

WETLANDS RESTORATION AND ENHANCEMENT

This chapter discusses the restoration potential for wetlands in the North Bay, briefly describes some of the current or proposed wetland projects within the North Bay planning area, and summarizes some of the assistance and coordination needed to successfully carry out restoration projects.

Both state and federal wetlands policies have embraced the concept of no overall net loss of existing wetlands as an interim goal, and in the long–term endorse increasing the quantity and quality of wetlands. This set of goals evolved from the recommendations from the National Wetlands Policy Forum in 1988. Both President Clinton and Governor Wilson used these interim and long-term goals as a foundation for their respective wetlands policies released in 1993. The San Francisco Estuary Project's 1993 *Comprehensive Conservation and Management Plan* also espouses these goals. Furthermore, the San Francisco Bay Conservation and Development Commission's *San Francisco Bay Plan* policies on marshes and mudflats call for restoration of former marshes when possible through removal of existing dikes, creation of new marshes through use of dredged materials, and improving the quality of existing marshes whenever possible (San Francisco Bay Conservation and Development Commission, 1969, as amended). Wetlands creation, restoration, and enhancement projects are key to attaining these regional goals and policies.

For the purposes of this discussion, *wetland restoration* refers to those activities that involve restoring wetland conditions to an area that was formerly a wetland but that currently does not support wetland vegetation, or restoring a wetland that was originally converted from one type to another, back to its original condition (for example, from a diked salt pond to a tidal marsh). *Wetland enhancement* refers to those activities or projects that will alter existing wetland areas to improve certain wetland values, but will not change the wetland type. Finally, *wetland creation* refers to the conversion of a non-wetland area into a wetland.

Projects that restore former wetlands, enhance degraded wetlands, or create new wetlands often occur as a result of mitigation required to offset wetlands losses caused by development projects. These mitigation projects, developed pursuant to conditions attached to a state, federal, or local permit, are one of the primary means of attaining the interim goal of no overall net loss of existing wetland resources, while allowing property development to occur.

However, wetland restoration and enhancement projects undertaken thus far in the North Bay have not resulted solely from regulatory program requirements for mitigation. Many public and private entities have initiated projects, independent of any development activities or regulatory

requirements, promoting wetland restoration, enhancement, and creation in an effort to increase the productivity of existing wetlands and the extent of the San Francisco Bay estuary's wetlands.

As pointed out in previous chapters, the North Bay possesses the greatest potential for wetland restoration, enhancement, and creation within the San Francisco Bay Area. Of the 99,340 acres of diked and unfilled baylands around the nine-county area, excluding salt ponds, 33,640 acres, or 34 percent, are in the North Bay. While state and federal resource agencies have been most active in restoration and enhancement projects, several private organizations have sought to acquire, restore, and enhance wetlands in the North Bay. The Nature Conservancy, Trust for Public Land, Ducks Unlimited, Sonoma Land Trust, Save San Francisco Bay Association, The San Francisco Bay Joint Venture, and the Marin Audubon Society have all provided important momentum, support, and/or sponsorship for projects around the San Francisco Bay.

Through the various wetland restoration and enhancement projects, former marshland has generally been restored to tidal conditions. Wetland restoration is considered to have a greater likelihood of success than wetland creation. Evidence gathered to date suggests that projects that restore damaged or destroyed wetlands seems to have a greater chance of establishing the prior suite of wetland functions, as well as an increased likelihood of long-term survival, than projects that create a wetland where none existed previously (Kentula, in press). Given that most of the North Bay study area was once tidal marsh, there is tremendous potential for tidal marsh restoration, as well as enhancement of diked seasonal wetlands.

Restoration Potential of Diked Historic Baylands

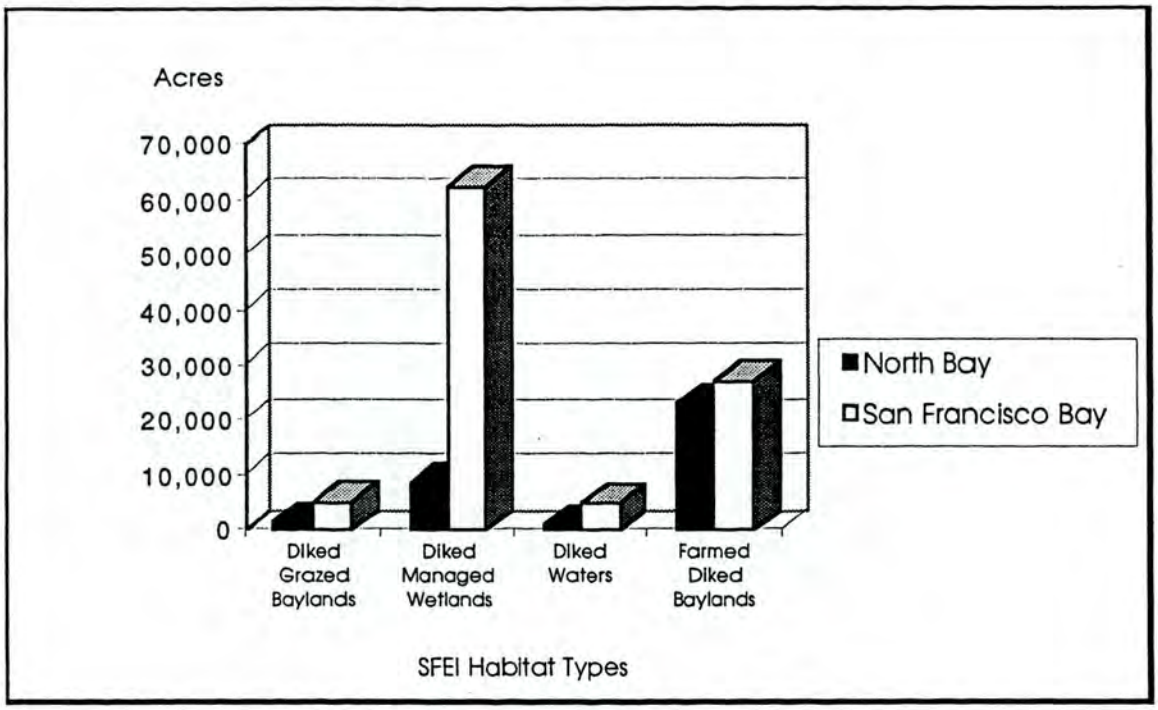
The North Bay contains the largest undeveloped assemblage of diked historic baylands and associated wetlands remaining in the San Francisco Bay-Delta Estuary. The Petaluma River, Sonoma Creek, and the Napa River all flow through a contiguous, low-lying and largely undeveloped area along the northern shoreline of San Pablo Bay. As previously discussed, a large part of this area was formerly tidal marshes that have been diked from the Bay and are now used primarily for agricultural and salt production activities.

The diked baylands in the North Bay provide significant opportunities for wetland restoration and enhancement projects for a variety of reasons. First, these lands comprise a significant portion of the undeveloped diked historic baylands surrounding San Francisco Bay—as Figure 4 illustrates, a full 84 percent of farmed diked baylands, 26 percent of diked grazed baylands, 18 percent of diked waters, and 14 percent of diked managed wetlands (overall, a total of 34 percent of the diked wetlands and baylands in San Francisco Bay, excluding salt ponds).[1]

[1] Calculations based on the on-line Grasslinks version of the SFEI EcoAtlas.

Figure 4

Diked Baylands: North Bay vs. San Francisco Bay



Adapted from SFEI Draft EcoAtlas (1996).

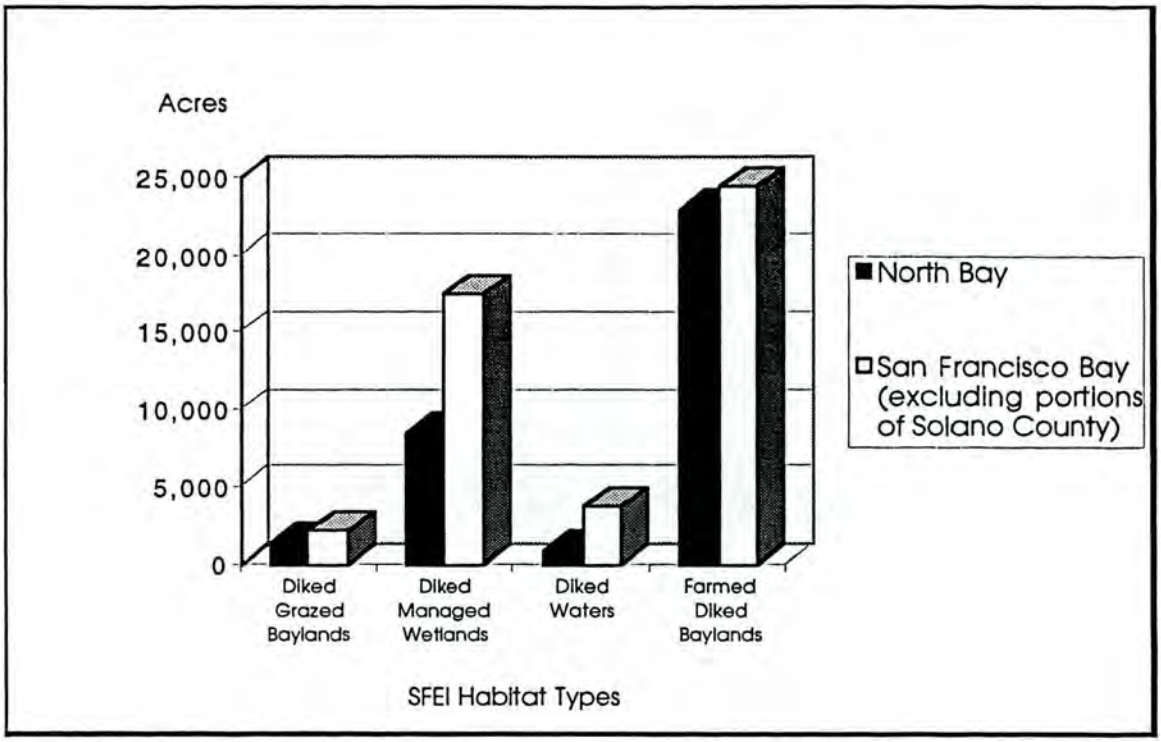
If the diked managed wetlands in the Suisun Marsh and the remainder of Solano County outside the North Bay planning area were subtracted, the North Bay represents an even larger extent of undeveloped diked historic baylands in around San Francisco Bay. As Figure 5 illustrates, the North Bay planning area represents 94 percent of farmed diked baylands, 61 percent of diked grazed baylands,[2] 23 percent of diked waters, and 49 percent of diked managed wetlands (overall, a total of 70 percent of the diked historic baylands) in San Francisco Bay, excluding salt ponds and the portion of Solano County outside of the study area.

[2] Nearly 10 percent of additional diked grazed baylands are in the North Bay, but are located immediately north of the planning area, along the Napa River.

Figure 5

Diked Baylands: North Bay vs. San Francisco Bay

(excluding Solano County outside the planning area)



Adapted from SFEI Draft EcoAtlas (1996).

The North Bay diked historic baylands' lack of significant structures, as well as their status as former tidal marsh, makes them ideal sites for wetland restoration projects. The low elevations of many of these baylands makes them conducive to restoring marsh vegetation and tidal action to these sites. Site elevation is a primary factor governing the development of tidal marsh; elevation greatly influences the rate of channel development, amount of tidal inundation, and degree of marsh revegetation (SFEP, 1994b). Finally, many of these sites are close to tidal waters, support some wetland vegetation, provide some wildlife-related functions, and/or contain some of the infrastructure needed to prevent the flooding of inland properties.

Wetlands Restoration and Enhancement Projects in the North Bay

In 1989, the San Francisco Estuary Project conducted an analysis of wetland restoration projects to estimate the acreage of wetlands that were restored or enhanced as a result of mitigation projects. This study founded that within the Bay-Delta Estuary a total of 2,332 acres had been restored or enhanced. For the North Bay (which, in this particular study, included all of Marin, Sonoma, Napa, and Contra Costa Counties), most projects resulted in restoration of tidal marsh,

with an estimated net increase of 289 acres (SFEP, 1991a). All of the net increase in tidal marsh habitat resulted from the conversion of diked wetlands.

For the most part, wetland projects in the North Bay focus on improving fish and wildlife habitat. Some projects have targeted specific species (such as the endangered salt marsh harvest mouse or the California clapper rail), while others strive to create wetland habitat that will ultimately host a variety of species. While the majority of the projects aim to produce some form of tidal marsh habitat, a few of the proposals target the creation or enhancement of seasonal wetlands.

The diked historic baylands could be used as flood plains for riverine flood waters, providing non-structural flood protection measures for upstream property. This possibility is currently being studied on behalf of the Corps of Engineers, as part of the Napa River Flood Control Project for the City of Napa and as part of the Corps' Napa River Marsh study.

The following list describes existing and proposed wetlands projects within the North Bay planning area (for the purposes of this report, projects smaller than 2.5 acres have been omitted). Four restoration projects have already occurred, and 16 projects are either in the planning phase or under consideration. As shown in Figure 6, most of these projects are immediately adjacent to the Bay.

Existing Wetland Projects

1. **Sonoma Baylands.** This 322-acre parcel was acquired by the Sonoma Land Trust as part of an 830-acre acquisition (that also included the Leonard Ranch and North Parcel sites described below). This site is located south and west of the intersection of Lakeville Highway and Highway 37 in Sonoma County. This property, once tidal marsh, was diked off from tidal action in the 1920s and converted to agricultural uses—specifically oat hay production. In conjunction with the Corps, the State Coastal Conservancy, who now owns the property, is carrying out a tidal marsh restoration project using dredged material from the Port of Oakland harbor deepening project to restore elevations to enable the growth of tidal marsh vegetation. This restoration project generated some controversy over the loss of approximately 56 acres of seasonal wetlands due to the tidal marsh restoration. The levee was breached in January, 1996, and the first annual monitoring report was released in August. The report stated that the channel in the 29–acre pilot unit has deepened and broadened, and exhibited other signs of increasing tidal exchange.

2. **Petaluma Marsh/Sonoma Land Trust.** Tidal restoration on this 46-acre parcel is sponsored by the Sonoma Land Trust. The levee was breached in August, 1994.

3. **State Lands Commission.** In 1995, a portion of the former Leslie Salt property south of Skaggs Island was restored to muted (regulated) tidal marsh by the State Lands Commission.

4. **Viansa Winery.** Viansa Winery, located in southern Sonoma Valley on the east side of Highway 12, is the site of the largest, privately-financed wetland restoration project in the North Bay planning area. Sam and Vicki Sebastiani, proprietors of Viansa Winery, provided 90-acres of low-lying land for this project. Ducks Unlimited, an organization that helps create habitat for migrating waterfowl, provided the funding and technical expertise necessary to carry out a wetland restoration and enhancement project. The Sebastianis now manage Sonoma County's largest private waterfowl preserve.

Future Wetland Projects

1. **Leonard Ranch.** This 224-acre property, located in Sonoma County northeast of the Port Sonoma Marina and immediately north of the Sonoma Baylands parcel, was part of the Sonoma Land Trust's 830-acre land acquisition. Formerly tidal marsh, the site was diked around 1900 for agricultural purposes and is still actively farmed for oat hay. The western 42 acres of the property presently support some seasonal wetlands. In 1995, the Corps funded a study to determine the feasibility of using this property for the handling and drying of dredged material to be transported to an upland site; however, based on preliminary results of this study, the Corps is no longer pursuing this use. Currently, wildlife proponents advocate that the site be enhanced as seasonal wetland habitat to complement the tidal marsh habitat that is being created at the adjacent Sonoma Baylands site.

2. **Sonoma Land Trust North Parcel Site.** The Sonoma Land Trust acquired this 250-acre property, located just across Highway 37 from Leonard Ranch, in conjunction with Leonard Ranch and Sonoma Baylands parcels. The State Coastal Conservancy is sponsoring a project for the restoration of brackish seasonal wetland at this site while also maintaining agricultural activities.

3. **Department of Fish and Game (DFG) Napa River Unit** (formerly Cargill Property). This 10,000-acre property in the Napa Marsh, owned and managed by DFG, consists of inactive salt ponds (approximately 7,000 acres), mudflats and tidal wetlands. Located north and south of Highway 37 between Sonoma Creek and the Napa River, this former marshland was diked and drained for agricultural purposes in the late 1800s. In the 1950s, the Cargill Corporation predecessor, the Leslie Salt Company, bought the property and converted the agricultural fields and duck club lands to salt production. The DFG acquired the property from Cargill Corporation in 1994 with the goal of restoring much of the area to tidal wetlands and permanently protecting the

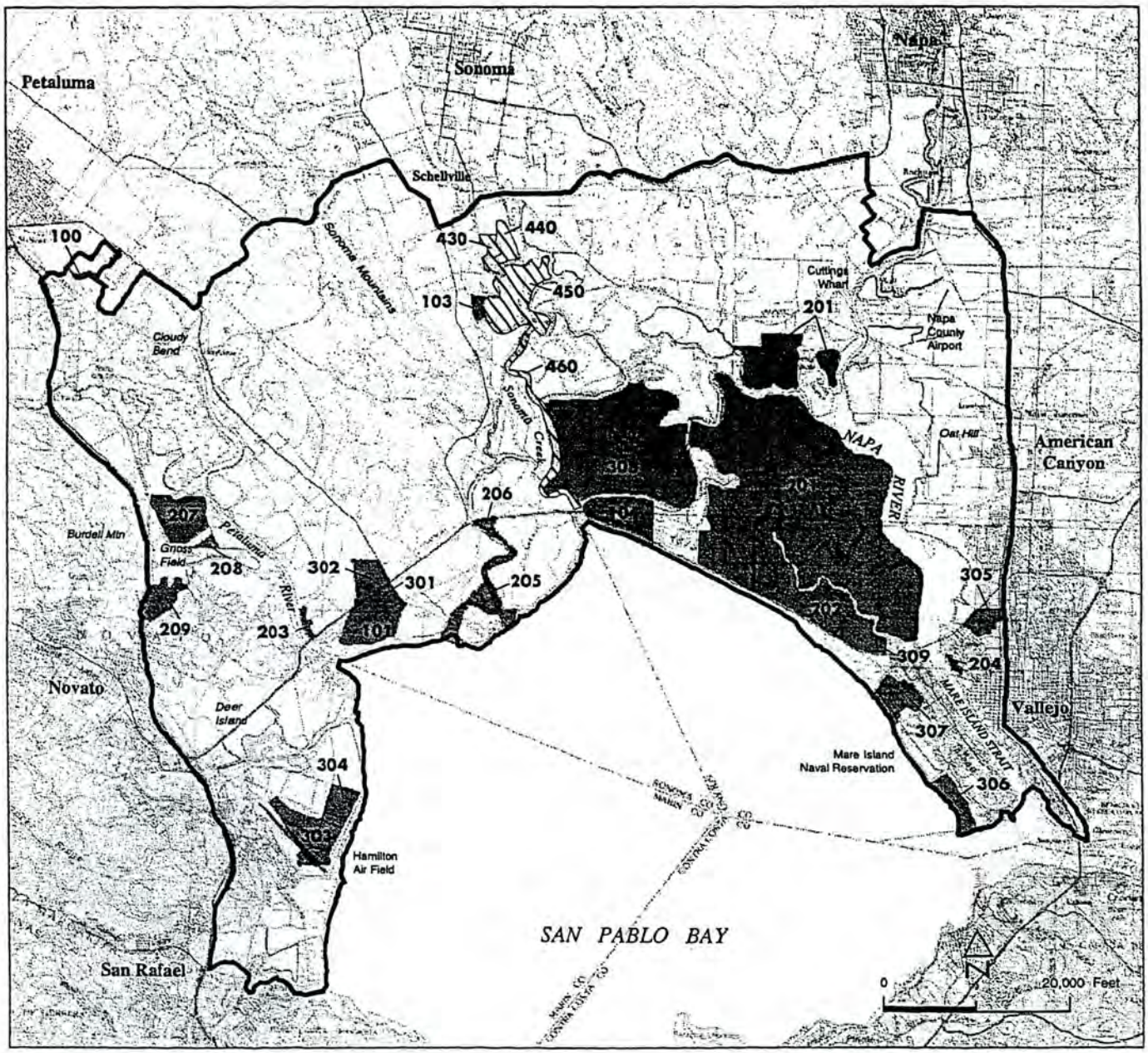
Figure 6

SOURCE: BCDC; REGIS, 1996

Wetland Projects Map

Projects | No Project | Alternative Projects

100 Petaluma Marsh Enhancement Area
101 Sonoma Baylands
103 Viansa Wetlands–Existing
104 State Lands Commission
201 CDFG Napa River Unit
202 Cullinan Ranch
203 Petaluma Marsh and Sonoma Land Trust
204 River Park
205 Tolay Creek–Existing
206 Tolay Creek–Proposed
207 Petaluma River Enhancement Plan (Marin) Former Burdell Ranch
208 Petaluma River Enhancement Plan (Marin) Central River Front
209 Rush Creek Marsh W. and E.
301 Leonard Ranch
302 Sonoma Land Trust North Parcel Site
303 Hamilton Airfield Runway Parcel
304 Hamilton Antennae Fields
305 White Slough Lagoon
306 Mare Island Tidal Wetlands
307 Mare Island Diked Wetlands
308 Skaggs Island Hay Fields
309 Guadalcanal Village
430 Sonoma Creek Floodplain and Enhancement Project, Alternative A
440 Sonoma Creek Floodplain and Enhancement Project, Alternative B
450 Sonoma Creek Floodplain and Enhancement Project, Alternative C
460 Sonoma Creek Floodplain and Enhancement Project, Alternative D



property as open space for fish and wildlife habitat. During the flooding in the winter of 1995, DFG breached a levee for a portion of one of the salt ponds—Pond 2A—to alleviate accumulated flood waters, thus initiating restoration of tidal action to a portion of this property. The DFG is developing a restoration plan for the remainder of the property.

4. **Cullinan Ranch.** Cullinan Ranch, located on the northern edge of San Pablo Bay, is bounded on the north by Dutchman and South Sloughs, on the east by City of Vallejo property, on the south by Highway 37, and on the west by the Napa Marsh property. Most of the property lies within Solano County, with the northern tip in Napa County. The USFWS acquired this 1,493-acre parcel in 1991 with the goal of restoring the site to tidal marsh, specifically to provide habitat for the salt marsh harvest mouse and the California clapper rail. Formerly marshland, this property was diked and drained for agricultural purposes in the late 1800s. Most recently, the site was farmed for oat hay. In the 1980's, a major housing development was proposed for this site, sparking a public-private partnership to acquire the property and dedicate it for wildlife purposes. Now called the Napa Marsh Unit, USFWS has added this property to the San Pablo Bay National Wildlife Refuge.

5. **Tolay Creek.** Formerly a navigable tidal slough, Tolay Creek is now largely a narrow channel filled with pepper grass and lined with dry marsh. The DFG owns the 300-acre lagoon which is currently degraded tidal marsh. A multi-party effort is underway to restore this lagoon to tidal action, which involves improving the creek channel from San Pablo Bay up to Highway 37. The DFG has acquired 53 acres of upstream farmland from the Vallejo Sanitation District to contribute to the project This project will result in both the creation and enhancement of almost 350 acres of tidal marsh. Some of this acreage will serve as mitigation for the potential impacts of levee maintenance activities on endangered species habitat under a Corps general permit to the Southern Sonoma Resource Conservation District (SSRCD). This restoration project represents the collaboration of multiple parties including funding and in-kind contributions from the SSRCD, USFWS, USEPA, DFG, Save San Francisco Bay Association, Marin-Sonoma County Mosquito Abatement District, Shell Oil Spill Trustee Committee, and the Sonoma County Fish and Wildlife Committee.

6. **Petaluma Marsh Enhancement Area.** This 150-acre parcel lies on the northeast bank of the Petaluma River, near the interchange of Lakeville Highway and Highway 101 in Petaluma. Formerly tidal marsh, the site now consists of undeveloped land, a City of Petaluma landfill, and part of a former industrial facility. While most of the site is owned by Petaluma, some portions fall under private ownership. In 1991, the City, under a grant from the Coastal Conservancy, prepared an enhancement plan for this area that includes tidal marsh restoration, enhancement of seasonal wetlands, riparian and upland habitat, acquisition of privately owned parcels with willing sellers,

and a strong public access component. This enhancement plan—focused on habitat enhancement, wildlife protection and public access—is being implemented in phases as funding is secured.

7. **Hamilton Airfield Runway Parcel.** The Hamilton Army Airfield is located east of Highway 101 in Novato. It is bounded by San Pablo Bay to the east, the former Hamilton North Antenna Field and the Bel Marin Keys development on the north, and the St. Vincent's and Silveira properties on the south. The U.S. Army currently owns one-third of the Hamilton Army Airfield and is in the process of closing and transferring the property; its ultimate disposition is undetermined at this time. Tidal wetland restoration has been proposed for portions of this property—specifically the approximately 700-acre Runway Parcel. Elevations of this runway parcel range from seven to 10 feet below sea level. The Army is using the runway for aerating contaminated soils from underground jet fuel pipelines elsewhere on the Airfield; when the cleanup project is completed, the runway will become a wetland restoration site. A 20-acre area at the northwest end of the runway was converted to seasonal wetlands as mitigation for the impacts of capping of an adjacent solid waste landfill on the property. The State Coastal Conservancy is developing an enhancement plan for the runway area; concurrently, the Corps and EPA are funding a feasibility study of using dredged material from a federal navigation project as part of the tidal restoration project.

8. **Hamilton North Antenna Field.** The Hamilton North Antenna Field is directly north of the Hamilton Army Airfield property, adjacent to San Pablo Bay. The State Lands Commission acquired the property with the goal of restoring this former tidal mudflat to tidal marsh. The Novato Sanitary District has a long-term lease on the southern portion of the site for routing their waste water to an outfall in San Pablo Bay. The State Lands Commission, DFG, and the Corps are currently developing plans for tidal marsh restoration of this property, possibly using dredged material. Restoration of this parcel may proceed concurrently with the proposed restoration of the runway portion of the Hamilton Army Airfield property.

9. **River Park.** River Park occupies a 55-acre parcel in northern Vallejo on the eastern bank of Mare Island Strait. The Greater Vallejo Recreation District prepared a Master Plan for River Park in 1993 which calls for the enhancement and/or restoration of 22 acres of tidal wetlands and 26 acres of upland wildlife habitat. At this time, the District is seeking funding to implement the plan.

10. **Rush Creek.** A restoration plan for Rush Creek adjacent to Petaluma River was adopted in the 1980's, but never implemented. Marin County, working with the State Coastal Conservancy, is revising the plan to reflect habitat changes. The plan is also being incorporated into Petaluma River Enhancement plan.

11. **Petaluma River Access and Enhancement Plan (Marin County).** The purpose of this plan, funded by the State Coastal Conservancy, is to provide a comprehensive overview of

existing and restorable habitat within the plan area, and to provide site specific plans and preliminary design guidance for public access facilities, and recommendations for integrating wildlife habitat, public access, and agriculture. The plan covers approximately 900 acres, including the Burdell Ranch (acquired by DFG in 1992).

12. **White Slough Lagoon.** White Slough lagoon is an approximately 144-acre lagoon located just south of the intersection of Highway 29 and Highway 37. The City of Vallejo and Solano County have adopted a specific area plan, as required by the White Slough Protection and Development Act (California Government Code, Sections 66670–66681), for the White Slough area that calls for the enhancement and restoration of tidal marsh in the lagoon through the restoration of muted tidal action to the property. The plan also includes components for the improvement of transportation, flood control, and other infrastructure in the White Slough area. Implementation of this project will be dependent upon finding a project sponsor and the funding necessary to carry out the enhancement and restoration activities.

13. **Guadalcanal Village.** The city of Vallejo owns a 130-acre parcel on the west side of the Napa River that includes the 52-acre former Guadalcanal Village site. Marsh restoration has been considered for this site to mitigate for changes occurring in White Slough, as part of the Highway 37 widening project.

14. **Mare Island Naval Shipyard.** Mare Island served as a naval shipyard since the late 19th century for ship construction, repair, and maintenance for the Pacific Fleet. Since World War II, the site served primarily as a submarine repair and overhaul facility; all shipbuilding activities halted in April 1995. The facility is closed and a significant portion of the property, including the majority of the dredged material disposal ponds and tidal wetlands along San Pablo Bay, may revert to state ownership or be transferred to the City of Vallejo. The USFWS has requested transfer of the tidal wetlands along San Pablo Bay to expand the San Pablo Bay National Wildlife Refuge, the use of several dredged disposal ponds (including some that will revert to state ownership) for wetland restoration and enhancement, and an adjacent building for a wildlife interpretive facility.

15. **Skaggs Island.** The USFWS proposes to acquire Skaggs Island and other surrounding parcels, including Haire Island and Camp 3 Island, for addition to the San Pablo Bay National Wildlife Refuge. Skaggs Island would be acquired through a transfer from the U.S. Navy, which currently owns the majority of the 4,300 acre island (with the exception of approximately 1,000 acres northeast of Rainbow Slough).

16. **Sonoma Creek Floodplain and Wetland Enhancement Project.** This project, sponsored by the Southern Sonoma County Resource Conservation District, proposes to acquire and set aside 875 acres of land to serve as a flood bypass and wetlands wildlife habitat area to alleviate flooding

in the Schellville area. Approximately 700 acres of privately owned property on Camp 2 Island (currently used for oat hay production and pasture) will be acquired and added to the 175-acre Wingo Unit owned by DFG to create a flood bypass area along the lower reaches of Sonoma Creek. The majority of these lands are diked historic baylands that were once an integral component of the Sonoma Creek watershed and San Pablo Bay. The entire parcel will then be managed for flood control and wildlife purposes.

Implementation of Restoration Projects

Wetland restoration, enhancement or creation projects are a way to compensate for some of the historic loss and conversion of wetland habitats. Given the restoration potential of the North Bay, such projects represent a unique opportunity to greatly enhance and expand wetlands in the San Francisco Bay Estuary. This section discusses methods for evaluating wetlands, as well as some of the constraints or difficulties facing a potential project sponsor who wishes to undertake and complete a successful restoration project. It also highlights some of the ongoing regional efforts to improve the scientific understanding and promote better coordination of the various restoration activities of both public and private parties.

Systems for Evaluating Wetlands

A wide range of wetlands exist in the North Bay, from small seasonal wetlands to extensive tidal marshes. Agencies and organizations involved in wetland protection and restoration efforts have limited funds, and therefore, face the challenging task of determining which wetlands should be restored or enhanced first. When deciding which wetlands to restore or enhance, the nature of the threat to the wetlands and the existence of a willing seller are two primary factors that must be considered. Other factors, such as the location and cost of the land, its development potential, its ability to perform functions such as flood control, neighboring land uses, and the ecological value of the site (in terms of biodiversity, position in the landscape, scarcity, and other criteria) must also be evaluated.

Fortunately, various systems for evaluating wetlands exist, and their application depends on what type of use is proposed for the wetlands, or which values are to be protected. For example, to select wetlands restoration sites that would use dredged material, a useful evaluation system would select those wetlands with appropriate ecological, engineering, and social criteria (such as ponding complexity, fill capacity, and potential land use conflicts) (Gahagan and Bryant, 1996).

A method called the Wetland Functional Assessment, or FHWA Method (for Federal Highway Administration), uses extensive literature review, including large volumes of quantitative data, to build a series of evaluation algorithms that represent wetland functions. These algorithms are used to rank wetlands as high, moderate, or low for a specific function or value (such as flood control). Another method developed in 1991, called WET (Wetland Evaluation Technique) 2.0, uses models

to evaluate a wetland relative to functions as values, such as groundwater recharge and wildlife diversity. Using WET 2.0, sites can be ranked on the probability that a wetland performs a given function, that its position in the landscape allows it to form that function, and that the function offers societal benefits (Natural Research Council, 1995).

Other methods include scaling and weighting approaches for comparing different wetlands, common denominator approaches that reduce the various wetland values to a common term, such as dollars or energy, and an approach that examines the replacement value of the wetland (Mitch and Gosselink, 1986).

Locally, an important effort is underway to identify the optimum configuration of wetland habitat types that support the San Francisco estuary's wildlife community. The San Francisco Bay Area Wetlands Ecosystem Goals Project (the Goals Project), is identifying the desirable types, amounts, and general distribution of wetlands and related habitats needed to sustain diverse and healthy wetland ecosystems into the future. The findings of the Goals Project, based on scientific input from many experts and scheduled for completion in the spring of 1997, will provide biologically sound guidance for wetland restoration and management programs (Partnership for the San Pablo Baylands).

Potential Constraints

1. **Technical Expertise.** The science behind wetland restoration and enhancement is relatively new and is still evolving. Project sponsors must fully consider and address numerous technical issues in developing a full-scale restoration or enhancement plan. Project design considerations include the appropriate configuration of the wetland area, the dimensions and placement of buffers, the source and quality of water supply, loss of beneficial uses such as agriculture, and the desired combination of elevations and habitat types. Some of the problems affecting enhancement sites include improper elevations for desired plant species, shoreline erosion, need for levee repair and maintenance, invasion of non-native vegetation, lack of plant cover, consolidated soils, and inadequate supply of water (especially during drought years) (SFEP, 1991a). Studies evaluating past restoration projects indicate highly variable rates of success.

2. **Funding.** Undertaking and successfully completing a restoration or enhancement project requires a substantial investment of resources. Aside from the money needed to acquire the land, adequate funding is also needed to develop a detailed restoration plan, carry out the plan, and ensure ongoing monitoring and maintenance of the site. For many of the resource management agencies owning lands that are managed for wildlife purposes, both funding and staffing are limiting factors in the number and scope of projects that are undertaken.

3. **Land Availability.** Acquiring the property from a private landowner and transferring it to public ownership is often the first step to restoring a site. The acquisition of land for wildlife areas

depends upon a number of limiting factors including: (1) the value of the site to endangered and threatened wildlife species, and to migratory waterfowl; (2) the potential to restore or enhance wetlands, tributary streams or adjacent uplands; (3) a willing seller; (4) agreement on a fair market valuation; (5) the availability of funding; and (6) whether the site is threatened by development or uses that are inconsistent with wildlife functions. (BCDC, 1995).

4. **Institutional.** Projects often involve more than one landowner or project sponsor, which requires greater coordination. In addition, multiple agencies will likely be involved in issuing permits for various aspects of the project. A sponsor must successfully navigate the range of local, state, and federal regulatory programs that may govern the project.

5. **Measuring Success.** A number of factors makes evaluating the success of wetland restoration and creation projects difficult. First, there is no widely accepted yardstick with which to measure success. Clearly defined goals and obtainable objectives for each individual project need to be established up front. Second, there is generally a dearth of long-term monitoring data—usually due to limited resources—with which to analyze success. (Kentula, in press)

Successful execution of a restoration or enhancement project can be a daunting task, taxing the technical expertise and resources of any project sponsor. Fortunately, there are several resources available to a potential sponsor that can provide technical and/or financial assistance. The State Coastal Conservancy has produced a very useful book titled *Options for Wetland Conservation—A Guide for California Landowners* that describes the financial, advisory and technical assistance available to private landowners who are interested in undertaking such a project on their land. A future regional resource will be the San Francisco Bay Joint Venture (described below).

Regional Coordination Efforts

A regional approach to enhancement of Bay resources would help ensure that the habitat needs of Bay Area wildlife will be met by the optimal use of available land. Such an approach should also identify optimum sizes and locations of habitat types throughout the region, and could guide the implementation of individual restoration or enhancement projects to maximize their contribution to regional habitat values. The following section describes some of the recent efforts to coordinate regional restoration and enhancement activities.

At the federal level, the USFWS prepared a *Concept Plan for Waterfowl Habitat Protection in San Francisco Bay* in 1989. The Plan identifies important wetland areas and outlines strategies for their protection, enhancement and expansion, with the goal of providing waterfowl habitat. Priority North Bay wetlands identified in the Plan include areas around White Slough, Napa River, Sonoma Creek, Petaluma River, Novato Creek and Gallinas Creek. The Plan identifies three types of priority wetland habitat that should be increased throughout the Estuary: (1) seasonal freshwater/brackish wetlands; (2) tidal salt marshes and (3) deep water—or open water—habitat. It

also lays out a four-part strategy for enhancing fish and wildlife habitat, which includes reducing contaminant levels in the Bay, increasing or maintaining levels of freshwater inflows, reducing altered flows (such as sewage effluent) in the Bay, and improving wetland diversity and function through the restoration and enhancement of selected wetlands (USFWS, 1989b).

The San Francisco Bay Ecosystem Goals Project, managed by a group of state and federal resource agencies with the administrative support of the Regional Water Quality Control Board and technical assistance by the San Francisco Estuary Institute, is a collaborative effort to identify the types, amounts, and distribution of wetlands and related habitats needed to sustain a diverse and healthy community of fish and wildlife resources in the San Francisco Bay area. Employing geographic information system (GIS) technology and the best available scientific information, the Goals Project is developing a series of options depicting desirable mosaics of wetlands and wetland types needed to restore and preserve the region's ecological health. The Goals Project will produce a template to guide the future actions of local, state and federal resource agencies who wish to carry out wetland restoration projects; this template will provide the foundation for the implementation plan to be carried out by public agencies and private parties.

The San Francisco Bay Joint Venture is a partnership of public agencies, environmental organizations, hunting and fishing groups, the business community, local government and landowners working cooperatively to protect, restore, increase, and enhance wetlands and riparian habitat in the San Francisco Bay watershed. Using a non–regulatory approach, the Joint Venture will focus on completing on-the-ground habitat projects benefiting waterfowl and fish and wildlife populations by leveraging resources, developing new funding sources, and creating partnerships. The Joint Venture will provide a valuable service to private and public entities by assisting with wetland restoration, enhancement, and creation projects. The Joint Venture will develop an implementation strategy that will serve as a blueprint for carrying out wetland and riparian habitat protection activities in San Francisco Bay.

CHAPTER 7

PRELIMINARY FINDINGS AND POLICIES

Findings

1. Historically, northern San Pablo Bay was bordered by extensive tidal marshes covering an estimated 66,000 acres. Brackish marshes stretch upstream for several miles from the mouth of the Petaluma and Napa Rivers, and delta-like salt marshes formed at the mouth of creeks along the Marin bayfront. Inland, the low plains bordering the tidal marshes supported dispersed seasonal wetlands and were intersected by riparian habitat along tributary waterways (pp. 5 and 10).

2. Beginning in the late 1800s, levees and dikes were constructed across the North Bay tidal marshlands and along the rivers and creeks, separating the land from tidal action. The lands were drained and reclaimed primarily for agriculture and some were filled for urban uses. Approximately 49,000 acres of historic tidal water and marshlands in the North Bay have been diked; however about 17,000 acres remain subject to the daily ebb and flow of the tide (pp. 6-10).

3. "Wetlands" are wet areas that usually develop between dry land and open waters. These transitional areas are sometimes called mudflats and marshes. Other wetland types develop inland, such as seasonal wetlands that form during the rainy season, and riparian wetlands associated with streams and other waterways (p. 11).

4. Wetlands have been classified and identified using a variety of approaches. In the North Bay, the most widely followed classification and identification systems range from the relatively narrow definition used by the U.S. Army Corps of Engineers for its regulatory responsibilities under Section 404 of the federal Clean Water Act, to a broader identification system employed by the U.S. Fish and Wildlife Service, referred to as the Cowardin system, which is used to classify and study wetlands and related habitats. The Corps delineation system normally requires the positive identification of three factors—hydrology, soils, and vegetation—for an area to be found to be a wetland. Under the Cowardin system, only one of the three indicators is required for an area to be found a wetland. However, no single, universally accepted wetland definition has been developed because the definition depends upon the objectives of and area of interest of the user (pp 12-17).

   a. Jurisdictional wetland determinations under Section 404 of the Clean Water Act, which are precise delineations carried out on a project or site-by-site basis, generally remain in effect for only two to three years. Because of the relatively narrow definition of

wetlands used by the Corps, Section 404 delineations do not include the wetland-related habitat that surrounds the jurisdictional wetland, and thus fails to encompass habitat that is important to wetland-related wildlife (pp. 14-15 and 17-18).

b. To best protect wetlands and related habitat, and for local and regional land use planning purposes, an additional tool is necessary to identify these habitat areas (pp. 17-18).

5. The EcoAtlas shows the broad boundaries of wetlands and related habitats in the North Bay. Created by the San Francisco Estuary Institute in support of the San Francisco Bay Area Wetlands Ecosystem Goals Project, the EcoAtlas is based on the Cowardin system and is intended to serve as a regional and local wetland resource planning tool. The habitat areas identified in the Goals Project are being mapped by the San Francisco Estuary Institute, a non-profit scientific research organization, using a geographic information system. The current EcoAtlas, which is in draft form and will be completed in the late Spring of 1997, provides the basis for preliminary identification of wetland and wetland-related habitat types in the North Bay and is shown on Figure 3, Wetlands and Related Habitat (pp. 18-20).

6. The San Francisco Bay Area Wetlands Ecosystem Goals Project is a voluntary, collaborative effort among over 100 scientists from federal and state resource management agencies, academia, and private organizations and interests involved in local wetlands management, research and regulation. The purpose of the Goals Project is to examine the current abundance and distribution of endangered species, waterfowl, shorebirds, and other important natural resources, and document the importance of these species to the Bay Area wetlands ecological system. This effort will be periodically updated to accommodate new scientific information. When completed, the Goals Project and the EcoAtlas will form the best collective, scientific judgment of the wetland habitat areas and attributes within the historic limits of San Francisco Bay. As such, the Goals Project and the EcoAtlas will be an essential local and regional planning tool (pp. 19-20).

7. The EcoAtlas identifies many types of wetlands and habitats within the historic tidal marshlands of San Francisco Bay. Within the North Bay, several kinds of wetlands are influenced by salt water from the Pacific Ocean and subject to tidal flow. These tidal wetlands include tidal waters, tidal mudflats, and tidal marsh and are shown on Figure 3, Wetlands and Related Habitats (pp. 20-21).

a. Tidal waters support a diverse assemblage of plant and animal life that constitute a major component of the San Francisco Bay aquatic and wildlife food chain. Several species of fish—such as Salmon and Stripped Bass—use tidal water during their life

cycle. In addition, many species of birds depend on tidal water for feeding and resting (p. 25).

b. Tidal mudflats are inundated and exposed twice daily by the tides. Mudflats support diverse communities of benthic invertebrates and fish and wildlife species. Bottom feeding fish feed on organisms that dwell on and under the surface of the mud at high tide and shorebirds forage on the organisms in the mud during low tides (p. 25).

c. Tidal marsh develops at the interface between upland areas and tidal waters. Tidal marshes in the North Bay include salt marshes and brackish marshes. Tidal salt marsh is found along San Pablo Bay and the lower reaches of its tributaries; brackish marsh occurs where there is substantial fresh water influence, such as along the Petaluma and Napa Rivers and tributary streams. Tidal marshes are among the most productive ecosystems in the world and support a diverse assemblage of terrestrial and aquatic life, including several threatened and endangered species such as the salt marsh harvest mouse, California clapper rail, and California black rail. Shorebirds seek refuge in tidal marshes during high tides, when their preferred feeding areas in tidal mudflats are inundated. Tidal marshes also provide important wintering habitat for migratory shorebirds and waterfowl (p. 24).

d. Tidal marshes also enhance North Bay water quality by: (1) reducing water velocity, causing sediments to be deposited, thus reducing turbidity; (2) retaining and assimilating pollutants, and (3) converting some pollutants to less harmful forms (pp. 24-25).

8. Diked Baylands are former tidal marshes and tidal waters that have been isolated from the direct action of the tides through the construction of levees and dikes. Diked baylands in the North Bay include diked farmed and grazed baylands, former salt evaporators (ponds), diked managed wetlands and diked waters (ponds) and are shown on Figure 3, Wetlands and Related Habitats (p. 21).

a. Diked farmed and grazed baylands are used principally for dry land farming to grow primarily oat hay, and for pasture for cattle grazing. Due to soil consolidation, subsidence, and wind erosion, the elevation of much of the farmed and grazed diked baylands is lower than adjacent tidal waters. Wetlands occur in the diked farmed and grazed baylands in drainage and irrigation ditches and areas that are seasonally ponded during some portion of the rainy season. The location, duration, and extent of seasonal wetlands is generally dependent on the amount and period of annual rainfall and can change from year-to-year (pp. 22-23).

b. Diked farmed and grazed baylands provide resting areas for migratory shorebirds and waterfowl. Other birds, such as raptors and upland species depend on the diked baylands for food and as habitat. Moreover, the diked baylands provide resting and foraging areas for resident and migratory shorebirds during periods of high tide, as well as habitat for the endangered salt marsh harvest mouse as well as other small mammals and rodents. The higher elevation areas of the diked farmed and grazed baylands serve as a buffer around seasonal wetlands, insulating these areas from potential adverse ecological impacts (pp. 22-23).

c. The former salt evaporators were historically used for the production of salt by solar evaporation of tidal water circulated through a system of evaporation ponds. The former salt evaporators provide significant roosting, resting and nesting habitat for migratory and resident birds, including rare and endangered species (p.23).

d. Diked managed wetlands are former tidal areas where the distribution of surface water is controlled to support a natural community of plants and wildlife. These areas provide habitat for waterfowl breeding, feeding, and resting (p. 23).

e. Ponded waters behind dikes, such as dredged material disposal ponds, ponded water in flood control basins, wastewater treatment ponds, and agricultural stock ponds are referred to as diked waters. These areas can have wildlife habitat value and serve important wastewater reclamation, flood control, and agricultural purposes (p. 23).

9. Transition zones, or ecotone habitat, exist as ecological boundaries between adjacent uplands and the upper level of tidal marshes. This habitat area is subject to irregular, or sporadic tidal action and provides forage and refuge functions for wildlife (pp. 42-43).

10. The term buffer zones is a resource management concept that refers to an area of land that separates and insulates the resource area from adjacent incompatible land uses or activities. In the case of wetlands, as other resources, the need for, dimensions, and uses that can occur in a buffer zone depend on characteristics of the site, the specific resource being protected, and the adjacent land use (p. 43).

11. Diked baylands can be used to control upstream flooding by serving as a broad flood plain and as basins to receive and slowly release high flood flows to San Pablo Bay (p. 38).

12. The complex of tidal wetland, diked wetland, and diked bayland habitat in the North Bay is of critical value to the San Francisco Bay ecological system. Significant losses of tidal marsh around the Bay and in the North Bay have reduced the regional capacity for supporting certain wildlife species and populations. The large expanse of tidal and shallow seasonal ponds in diked farmed and grazed baylands provides diversified habitat that supports a

variety of migratory waterfowl, shorebirds, and endangered wildlife species and the open, flat expanse provides a transitional corridor between upland habitats and San Pablo Bay tidelands (pp. 37-38, 40-42, 43-44).

13. The tidal wetlands and diked baylands in the North Bay are prime sites for wetland enhancement and restoration projects because of (a) their former status as tidal wetlands, (2) low-lying elevation, and (3) location in a vast complex of wetland habitat types (pp. 46-55).

14. The San Francisco Bay Area Wetlands Ecosystem Goals Project will identify the types, amounts, and distribution of wetlands and related habitats needed to sustain the desired mix of wetland plant and animal communities around San Francisco Bay (p. 58).

15. The shoreline of San Pablo Bay, its interlacing sloughs, and tributary waterways such as Napa and Petaluma Rivers, and the vast extent of diked baylands help to maintain diminishing open space in the Bay Area. These areas also provide recreational opportunities for hiking, bicycling, hunting, bird watching, fishing, boating, photography, and picnicking (p. 39).

Policies

1. The vast complex of tidal waters, mudflats and marshes and diked waters, former salt evaporators, managed wetlands, and farmed and grazed baylands provides a unique diversity and union of wetland-related habitats that should be maintained and enhanced wherever possible to retain this natural resource of regional and statewide importance. The EcoAtlas depicts these areas, shown in a preliminary version on Figure 3, Wetlands and Related Habitats.

2. The final San Francisco Bay Estuary Institute's EcoAtlas should be used by the local governments and the San Francisco Bay Conservation and Development Commission to identify tidally influenced wetlands and related habitat resource areas. The North Bay portion of the EcoAtlas should be carefully reviewed by each of the North Bay jurisdictions and refined where needed before it is made final. A systematic review process of the EcoAtlas and the Goals Project ecosystem goals should be developed that allows for participation and input from the North Bay local governments to assure that the EcoAtlas and the ecosystem goals have the latest and best scientific and land use information.

3. The local governments and the San Francisco Bay Conservation and Development Commission should require, as a condition of permits for projects adjacent to tidal and diked historic baylands, the us of transition and buffer zones, consistent with the project. When proposed projects are adjacent to tidal wetlands, an environmental analysis should be carried

out to determine the existence and size of the transition zone. Where transition habitat exists, a buffer zone should be designed to protect the transition habitat.

4. Wetland restoration and enhancement projects in the North Bay should follow the regional restoration and enhancement template being developed by the San Francisco Bay Area Wetlands Ecosystem Goals Project in order to help achieve integrated, regionwide wetland restoration and enhancement objectives.

5. Tidal wetland restoration projects, in addition to providing new aquatic and wildlife habitat, should be designed wherever possible to assist in alleviating flooding problems on upstream reaches of tributary waterways and improving water quality of San Pablo Bay and tributary waterways.

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ACRONYMS & ABBREVIATIONS

ADID - Advanced Identification

BCDC - San Francisco Bay Conservation and Development Commission

CCMP - Comprehensive Conservation and Management Plan

CDFG - California Department of Fish and Game

CEDR - Center for Environmental Design and Research

CEQA - California Environmental Quality Act

Corps - U.S. Army Corps of Engineers

CWA - Clean Water Act

EA - Environmental Assessment

EIR - Environmental Impact Report

EIS - Environmental Impact Statement

EPA - U.S. Environmental Protection Agency

FONSI - Finding of No Significant Impact

FSA - Food Security Act

FWCA - Federal Wildlife Coordination Act

GIS - Geographic Information System

GRASS - Geographic Resources Analysis Support System

MOA - Memorandum of Agreement

MOU - Memorandum of Understanding

NBWPP - North Bay Wetlands Protection Program

NEPA - National Environmental Policy Act

NMFS - National Marine Fisheries Service

NRCS - National Resources Conservation Service

Regional Board - San Francisco Bay Regional Water Quality Control Board

REGIS - Research Program in Environmental Planning and Geographic Information Systems

RHA - River and Harbors Act

SAP - Special Area Plan

SAMP - Special Area Management Plan

SCC - State Coastal Conservancy

SFEI - San Francisco Estuary Institute

SFEP - San Francisco Estuary Project

SSLC - State Lands Commission

State Board - State Water Resources Control Board

UCB - University of California Berkeley

USFWS - United States Fish and Wildlife Service

WET - Wetlands Evaluation Technique

APPENDIX A

1 : 48000 Scale View of the EcoAtlas

At the request of the North Bay Steering Committee and the public, a more detailed series of views of the information contained in the EcoAtlas are included in this appendix.

BCDC staff obtained a copy of the EcoAtlas by special arrangement with SFEI for preview purposes. This version, 1.0bc, is an early draft that does not reflect the changes that have occurred in the habitat typology or the habitat boundaries as a result of peer and public review since 1995. A new version is being refined and will be available in the next few months, at which point staff will obtain and present the revised EcoAtlas to the Committee and public for review and comment.

These views of the EcoAtlas are included in this report to demonstrate the level of detailed information contained in the EcoAtlas. In this case, an intermediate scale of 1 : 48000 was chosen to preserve the overall view of adjacent features; however, larger and smaller scale representations can be generated. The exact location of features depicted within these particular 1 : 48000 scale views are not being presented for adoption or acceptance by the North Bay Wetlands Steering Committee; they are for illustration only.

The shaded and patterned areas shown in these views reflect the early version of the habitat classifications created by the SF Bay Wetlands Ecosystems Goals Project. The physical characteristics of these habitat types are defined as follows:

"Open Water" consists of the uppermost 12 inches of the water column of channels and surface waters with less than 10% cover of emergent plant growth *(see important disclaimers, below)*.

"Tidal Flat" (intertidal flat) consists of habitat areas that mostly occur between the Mean Tide Level tidal datum and the Mean Lower Low Water tidal datum, and that support areas of less than 10% cover of vascular vegetation, other than eelgrass. These flats may be further characterized as being comprised mostly of rock, shell, mud, or sand.

"Tidal Marsh" consists of habitat areas that support at least 10% cover of vascular vegetation and can be further categorized as being subject to muted tidal action; or free tidal action in relationship to tidal datum (i.e. High Tidal, Medium Tidal, or Low Tidal Marsh).

"Diked Farmed Bayland" consists of habitat areas that are actively managed for some form of agricultural yield.

"Diked Grazed Bayland" consists of habitat areas that are actively managed for some form of agricultural yield.

"Diked Managed Wetland" consists of habitat areas where the distribution of surface water is controlled to support a natural community of plants and animals.

"Diked Pond" (referred to in the report as "Diked Waters") consists of habitat areas that support less than 10% of a cover of vascular vegetation. (This classification has been further refined to separately identify treatment and storage ponds. This distinction is not shown in this version of the EcoAtlas).

"Diked Salt Pond" consists of habitat areas actively or recently managed for salt production, and can be further characterized as possessing high, medium, or low salinity.

"No Data" represents areas within the baylands where polygons were being created and/or the appropriate ecological classifications were being refined at the time this version was being created.

The fine dotted line represents railroad right-of-ways contained in the USGS Digital Line Graphic (DLG) files for transportation features. This feature is not part of the EcoAtlas, but has been added by BCDC staff to provide a sense of location *(see important disclaimers, below).*

The fine double line represents various transportation routes and modes contained in the USGS DLG files for transportation features. This feature is not part of the EcoAtlas, but has been added by BCDC staff to provide a sense of location *(see important disclaimers, below).*

Additional habitat types that were developed after this version of the EcoAtlas (and therefore not shown on these views) include Unvegetated Shore, Lagoon, Shallow Bay or Strait, Diked Marsh, Ruderal Bayland[1], and Riparian Zone. In many cases, this will result in a subdivision or reclassification of the existing polygons shown on these views.

The views provided present a graphic representation of the approximate boundaries of natural features in relationship to cultural features (roads), not the exact and precise location of boundaries. This is because natural features tend not to have clearly delineated boundaries on the ground, unless modified by development such as roads, levees[2], concrete channels, etc. Natural features such as wetlands, if undisturbed, tend to have boundaries that are more like zones than lines, and require an on–ground survey in order to be represented as lines on a very large scale map, such as an assessors parcel map.

The content within EcoAtlas was gathered at 1 : 10000 scale, thus the boundaries of features shown contain some measure of generalization, compared to data gathered for a very large scale map. This generalization increases when viewed at a very large scale, such as an assessors parcel map.

When considering the approximate boundaries of the features found in the EcoAtlas, the best view is obtained at a scale approximating the initial scale of the data (1 : 10000). When considering

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[1] Ruderal baylands consist of diked habitats that are not actively managed for plants or wildlife, salt production, or agricultural products, although they may have been in the past. In some cases, saline or brackish conditions persist because the ground surface is poorly drained. In all cases, upland grasses are a dominant component of the plant community for the vegetated plain.

[2] Parcels of diked bayland features are delimited in this version of the EcoAtlas by constructed levees that support a light–duty truck or larger roadway.

the approximate location of adjacent features, a smaller scale view, such as the views presented, may be appropriate, depending on the users area of interest.

SFEI has secured copyrights to the Bay Area EcoAtlas, in order to maintain the integrity of the atlas (by preventing others from creating counterfeit facsimiles) as a common picture for Bay Area regional planning. Commercial distribution, or redistribution, unless authorized in writing, is expressly prohibited by San Francisco Estuary Institute.

Important Disclaimers

The views contained herein are derived from a early draft version of the EcoAtlas (version 1.0bc) and represent a work in progress. These features contained in these specific views do not show jurisdictionally delineated wetland boundaries, official boundaries of farmland or other land uses, legally accessible public roads or public access routes, or other official boundaries. The content of these specific diagrams should not be used for navigation, transportation, or public access.

The Future Release Version EcoAtlas (1.1)

The next version of the EcoAtlas will contain the following features:

Historical Data

- Low Tide Line
- Tidal Marsh
- Upland/Bay Shoreline
- Sandy Beaches
- Rivers and Creeks
- Riparian Zones
- Lakes and Upland Ponds
- Zones of Freshwater Influence
- Tidal Marsh Channels
- Tidal Mudflat
- Tidal Marsh Pannes
- Seeps and Wet Soils
- Tidal Lagoons
- Wet Fans, springs
- Sausals (Willow Groves)
- Vernal Pools and Associated Soils
- Major Terrestrial Plant Communities

Modern Data

Low Tide Line	Tidal Mudflat
Tidal Marsh	Salt Ponds (by salinity regime)
Diked Marsh	Diked Farmed Baylands
Diked Grazed Baylands	Managed Wetlands
Ruderal Baylands	Watershed Boundaries
Land Use Zonation	Roads and Railroads
USGS Quadrangles (7.5 min.)	Adjacent Freshwater Inputs
Adjacent Riparian Zones	Avian Resources (regional)
Digital Elevation Models	Estuary Bathymetry

The release version will contain extensive documentation, and will clearly describe how to provide comment and recommend changes to the features contained in the EcoAtlas.

Highlighted Features

Several key features of interest found on these diagrams include:

Hamilton Area. In this early view, the "No Data" classifications for the Las Gallinas Sanitation Facility and Bel Marin Keys are an example of areas where the Habitat Typology needed to be refined to describe lagoons of varying use. These new classifications will aid in identifying and describing the site specific ecological relationships between these features and adjacent habitat types. Note also the large transitional expanse of tidal areas immediately adjacent to large areas of Diked Farmed Bayland. These baylands, in addition to possessing their own important habitat value, also serve as a valuable buffer between the tidally influenced areas and the developed Highway 101 corridor.

Petaluma Point. This view shows the nearly continuous tidal marsh of the lower Petaluma River buffered by large areas of Diked Farmed and Grazed Baylands, managed wetlands, and sloping uplands. Many of these bayland areas also contain wet soils and seasonal ponds of varying size and duration, during the wetter months of the year. South of Pinheiro Ridge are the large contiguous parcels of Managed Wetlands and Diked Farmed Baylands that provide important open space amenities for the residents of Novato and eastern Marin County.

Petaluma River. The prominent feature in this view is the Petaluma Marsh, the largest contiguous inland tidal marsh remaining in the North Bay. The tidal marsh is buffered on either end by Diked Farmed and Grazed Baylands and bracketed on either side by rural upland slopes.

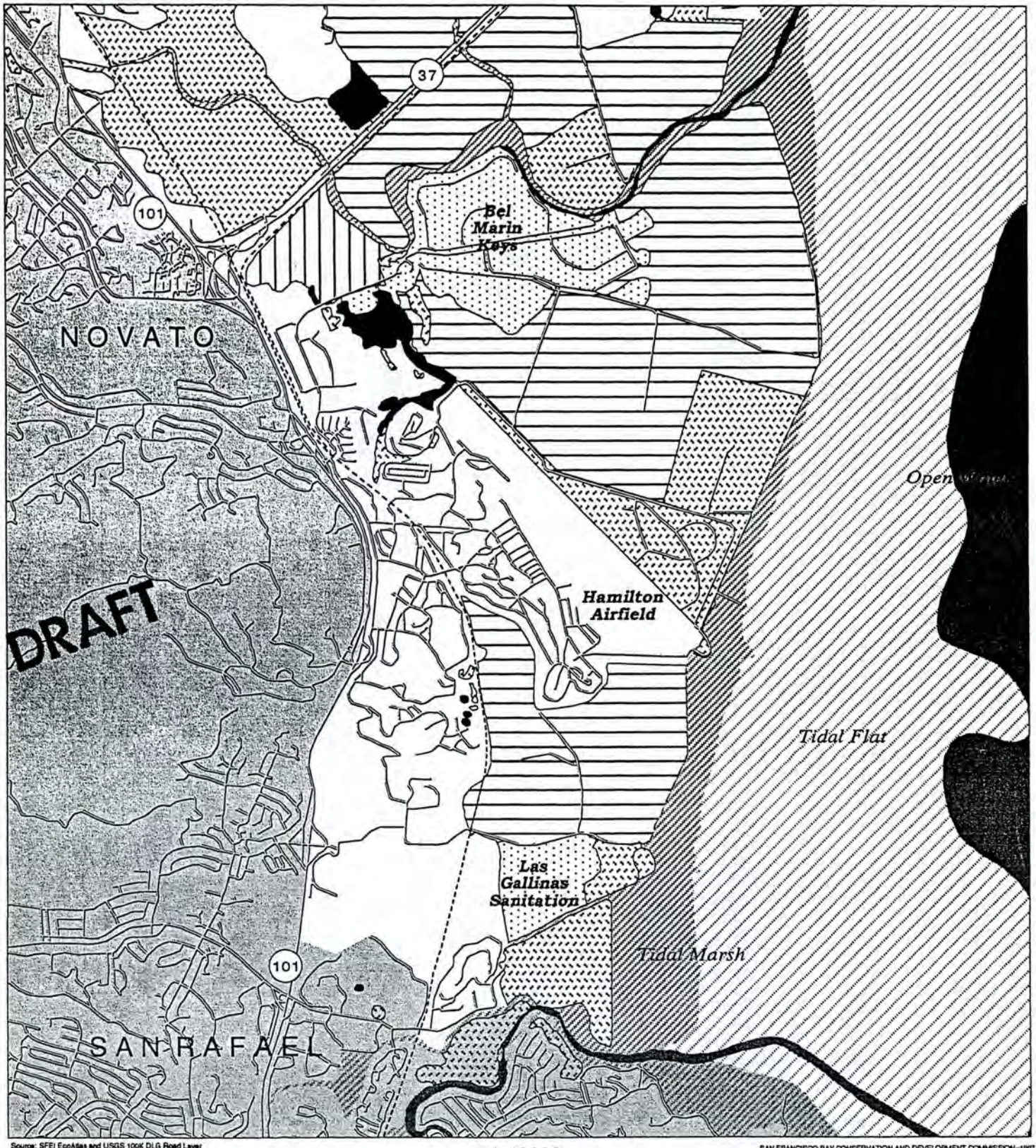
Sears Point. This view shows the expansive range of Diked Farmed Baylands around the foot of Sonoma Mountain. Much of the Tidal Flat and shoreline Tidal Marsh are managed by the USFWS as a National Wildlife Refuge. The onshore diked areas also contain sub–areas where habitat restoration projects are taking place.

Sonoma Creek. This view gives an idea of the extensive agricultural activity that takes place along the upper reaches of the sloughs and creeks. Interspersed throughout are small restoration projects. Agriculture plays a significant role in preserving the habitat values of this region.

Upper Napa River. To the east and adjacent to the Diked Farmed Baylands along Sonoma Creek are the large salt evaporators that are scheduled for restoration. This area is bounded on the north by the Huichica Hills, a large area dominated by vineyards, and on the east by the Napa River. The river, the vineyards, and the expansive Diked Farmed Baylands to the west serve to isolate the salt ponds and reduce human intrusion into these areas. This is an area of great environmental value.

American Canyon. Proceeding south along the eastern Napa River shore, the land use changes from predominately rural uses to suburban, commercial, urban, and industrial uses. An unusual mix of land use and habitat types are encountered here. Adjacent to the Tidal Marsh and Tidal Flat indicated on the diagram on the east shore of the river is a large suburban neighborhood (all the streets do not appear on this diagram). This is the only place in the study area that contains this kind of mix.

Mare Island. Mare Island and the Mare Island Strait south of Highway 37 has traditionally been an area of commercial and industrial activity. To the west and north are the broad transitional areas of wildlife habitat. This is another area with a mixture of unusual land use and habitat.



Source: SFEI EcoAtlas and USGS 100K DLG Road Layer
Projection: UTM Zone 10 NAD 27

1:48000

SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION–1997

0.5 0 0.5 1 1.5 2 Miles

Location Key

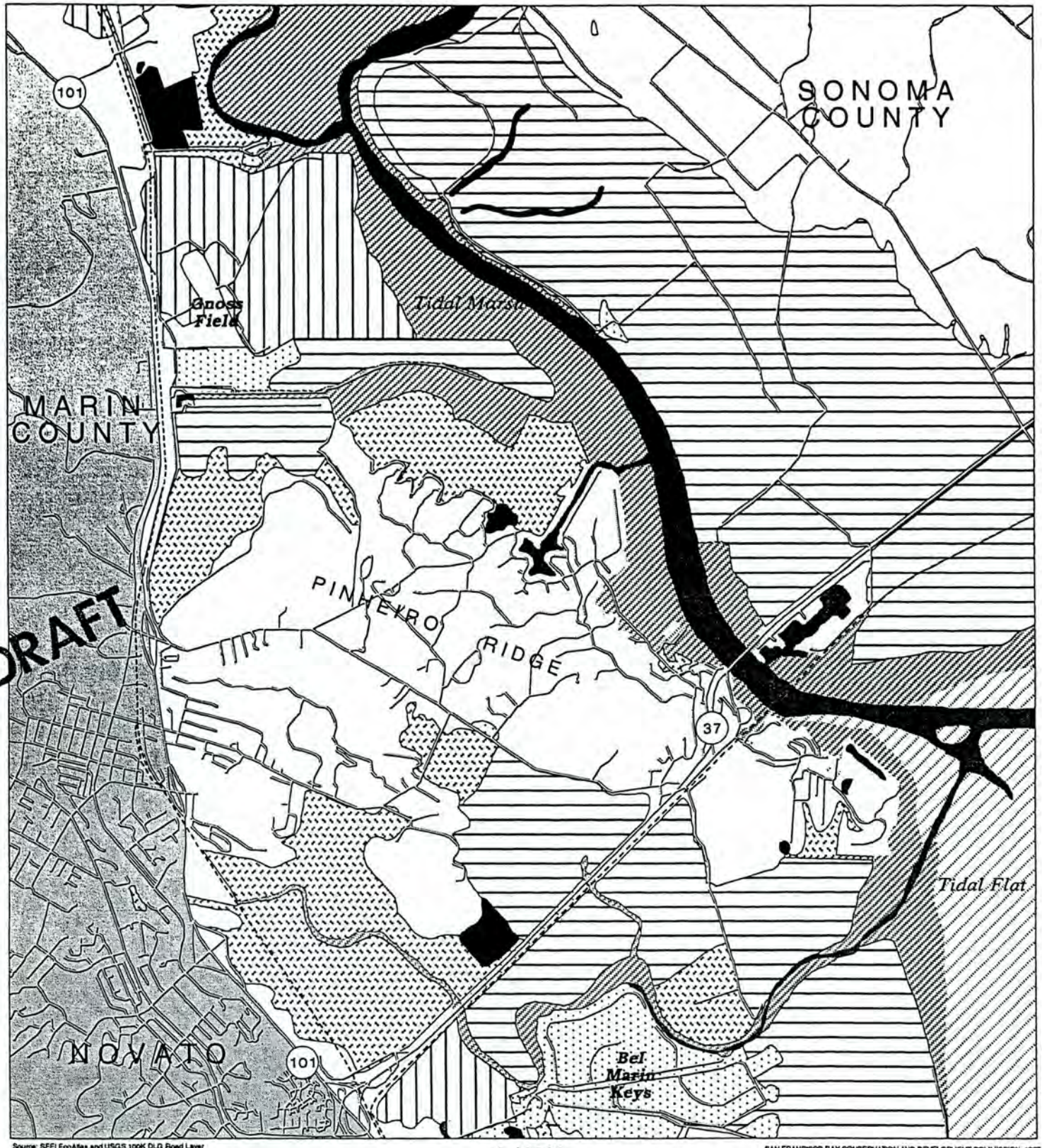
- Diked Farmed Bayland
- Diked Grazed Bayland
- Diked Managed Wetland
- Diked Pond
- Diked Salt Pond
- Open Water
- Tidal Flat
- Tidal Marsh
- No Data

Hamilton Area

MARIN COUNTY

N

This diagram does not reflect changes made after January 1, 1997. The EcoAtlas is currently undergoing field review.



Source: SFEI EcoAtlas and USGS 100K DLG Road Layer
Projection: UTM Zone 10 NAD 27

1:48000

SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION-1997

0.5 0 0.5 1 1.5 2 Miles

Location Key

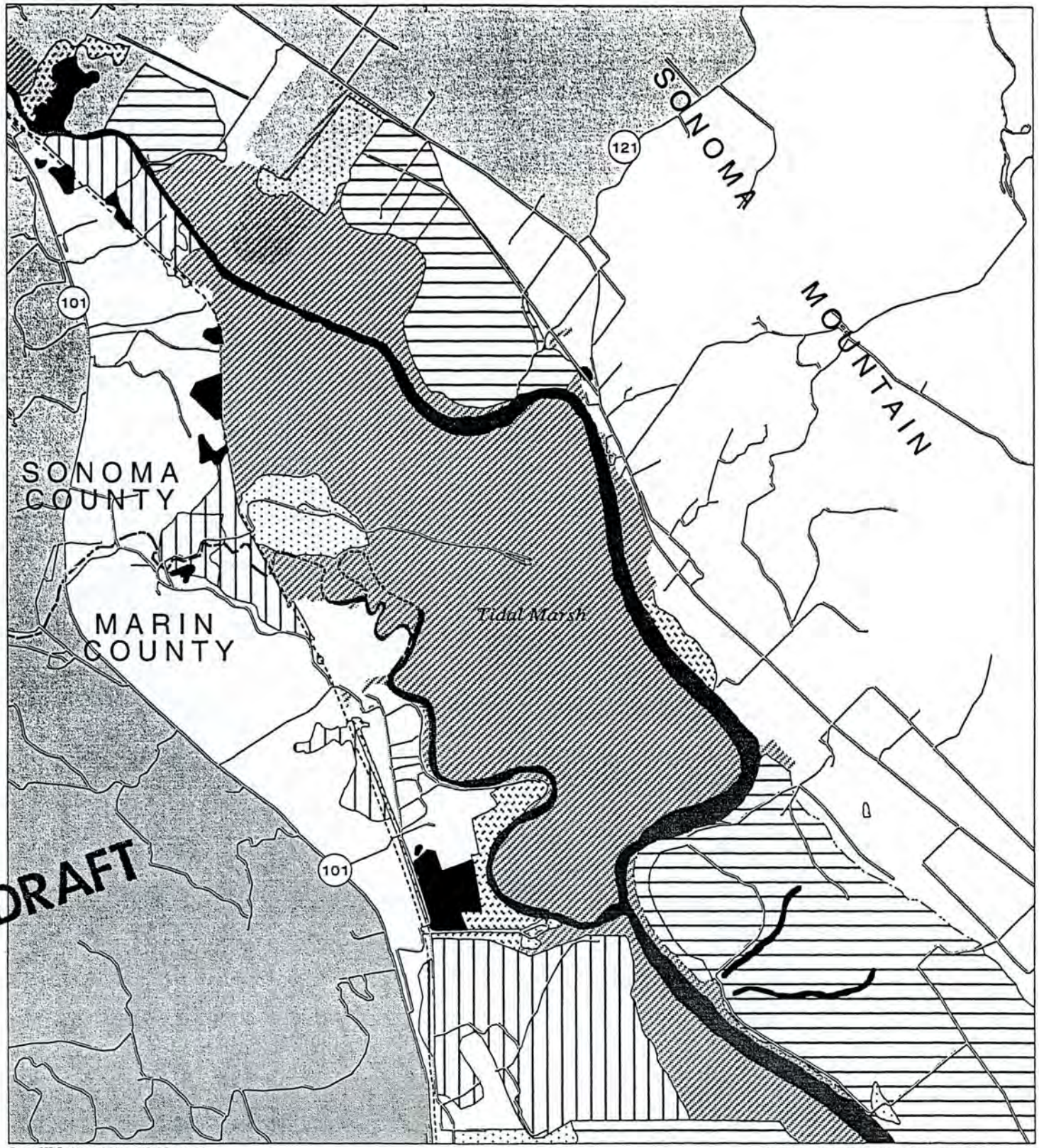
- Diked Farmed Bayland
- Diked Grazed Bayland
- Diked Managed Wetland
- Diked Pond
- Diked Salt Pond
- Open Water
- Tidal Flat
- Tidal Marsh
- No Data

Petaluma Point

MARIN AND SONOMA COUNTY

N

This diagram does not reflect changes made after January 1, 1997. The EcoAtlas is currently undergoing field review.



Source: SFEI EcoAtlas and USGS 100K DLG Road Layer
Projection: UTM Zone 10 NAD 27

1:48000

SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION–1997

0.5 0 0.5 1 1.5 2 Miles

Location Key

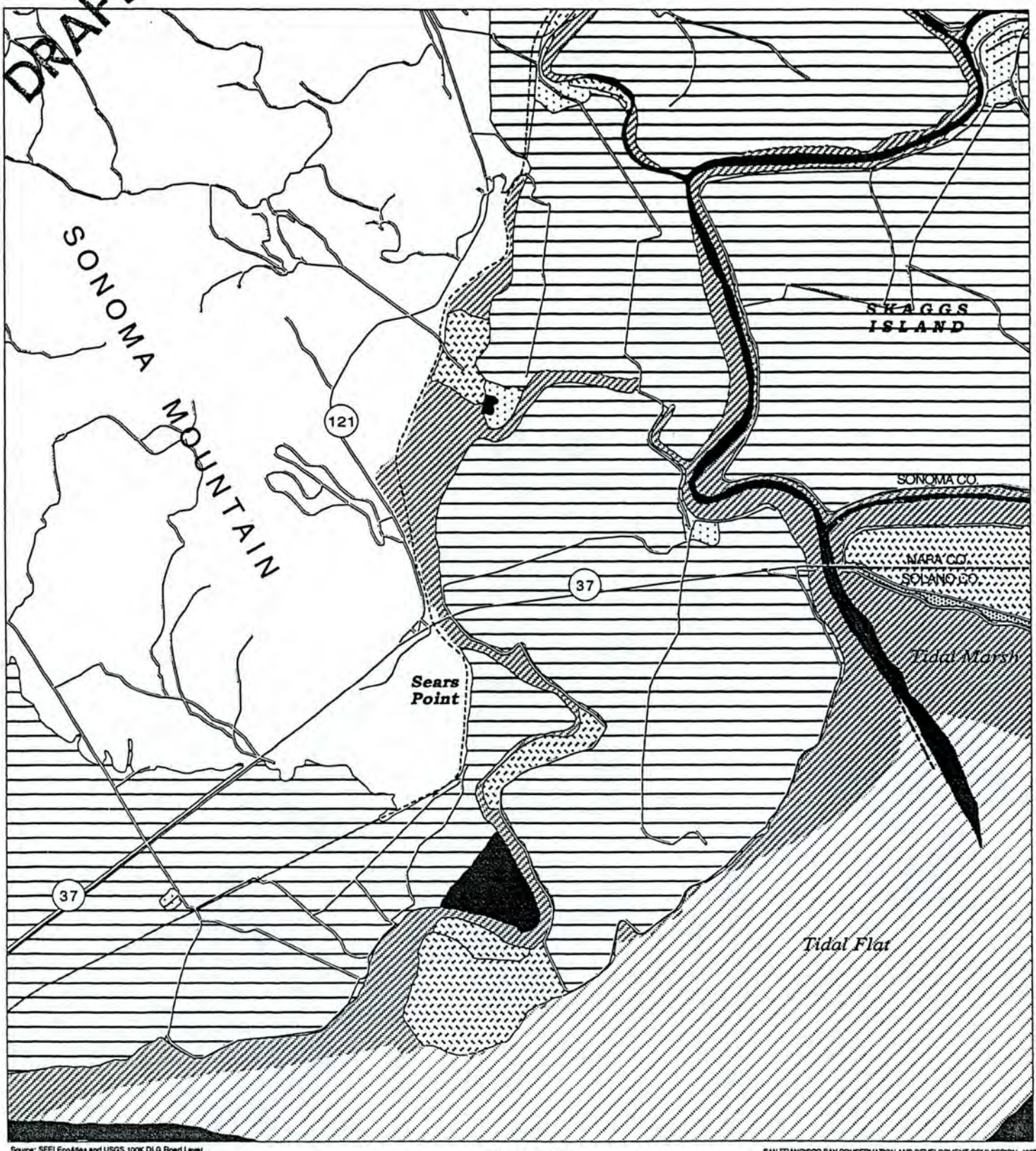
- Diked Farmed Bayland
- Diked Grazed Bayland
- Diked Managed Wetland
- Diked Pond
- Diked Salt Pond
- Open Water
- Tidal Flat
- Tidal Marsh
- No Data

Petaluma River

MARIN AND SONOMA COUNTY

N

This diagram does not reflect changes made after January 1, 1997. The EcoAtlas is currently undergoing field review.



Source: SFEI EcoAtlas and USGS 100K DLG Road Layer
Projection: UTM Zone 10 NAD 27

1:48000

SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION–1997

0.5 0 0.5 1 1.5 2 Miles

Location Key

- Diked Farmed Bayland
- Diked Grazed Bayland
- Diked Managed Wetland
- Diked Pond
- Diked Salt Pond
- Open Water
- Tidal Flat
- Tidal Marsh
- No Data

Sears Point

SONOMA, NAPA, AND SOLANO COUNTIES

N

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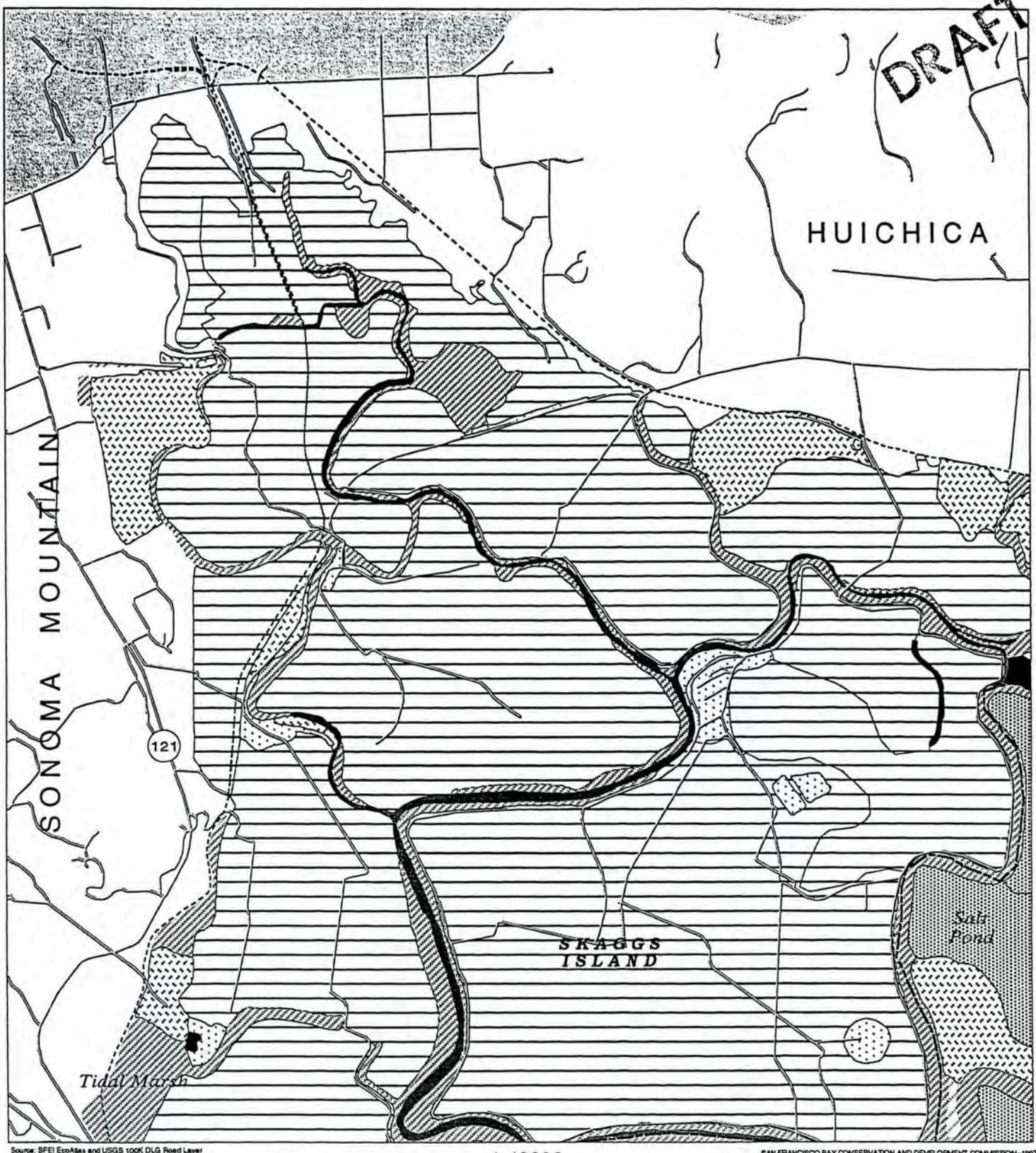

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1:48000

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- Tidal Flat
- Tidal Marsh
- No Data

Sonoma Creek

SONOMA AND NAPA COUNTY

N

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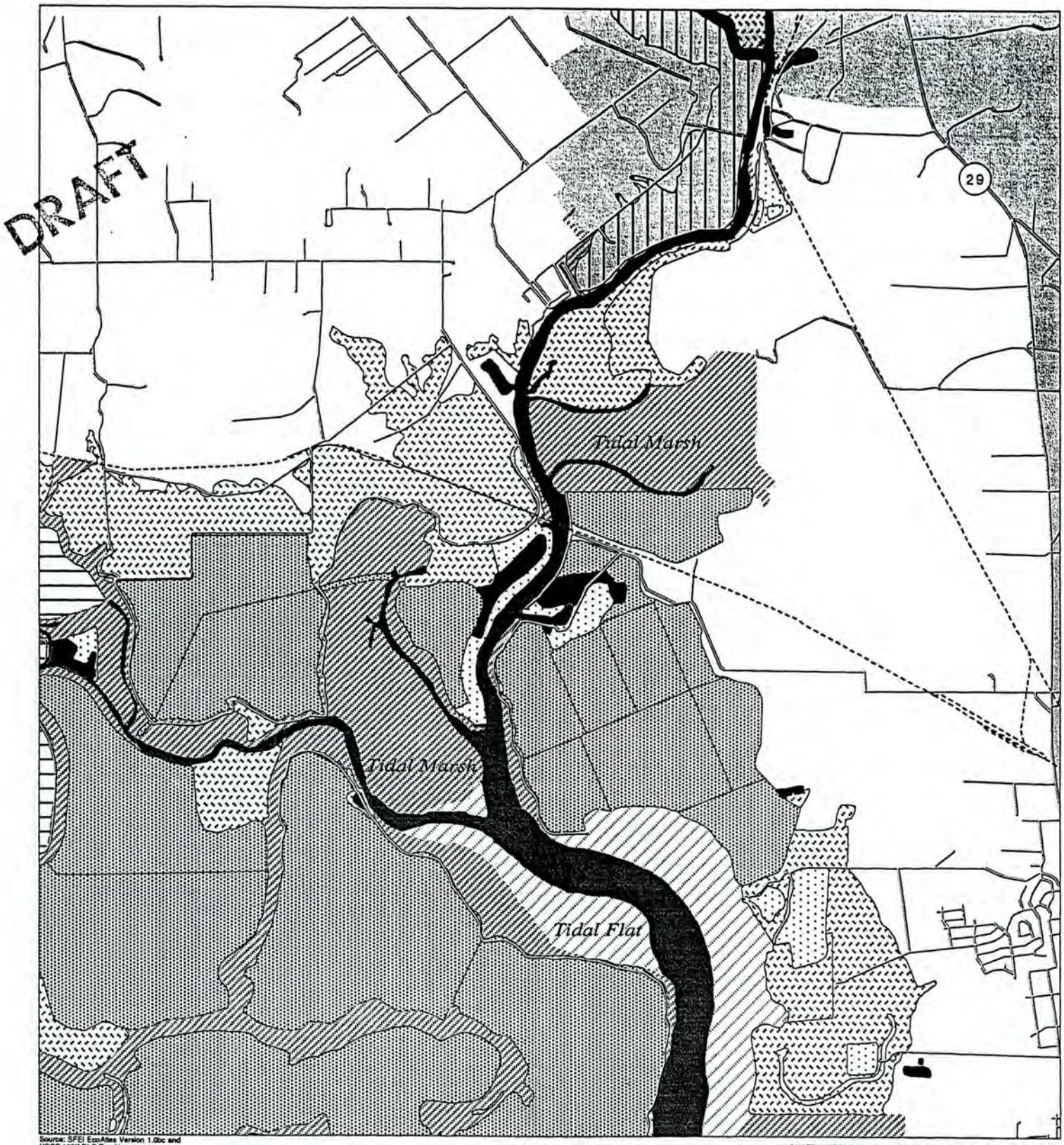

Source: SFEI EcoAtlas Version 1.0bc and
USGS 100K DLG Road Layer
Projection: UTM Zone 10 NAD 27

1:48000

SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION-1997

0.5 0 0.5 1 1.5 2 Miles

Location Key

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- Diked Pond
- Diked Salt Pond
- Open Water
- Tidal Flat
- Tidal Marsh
- No Data

Upper Napa River

NAPA COUNTY

N

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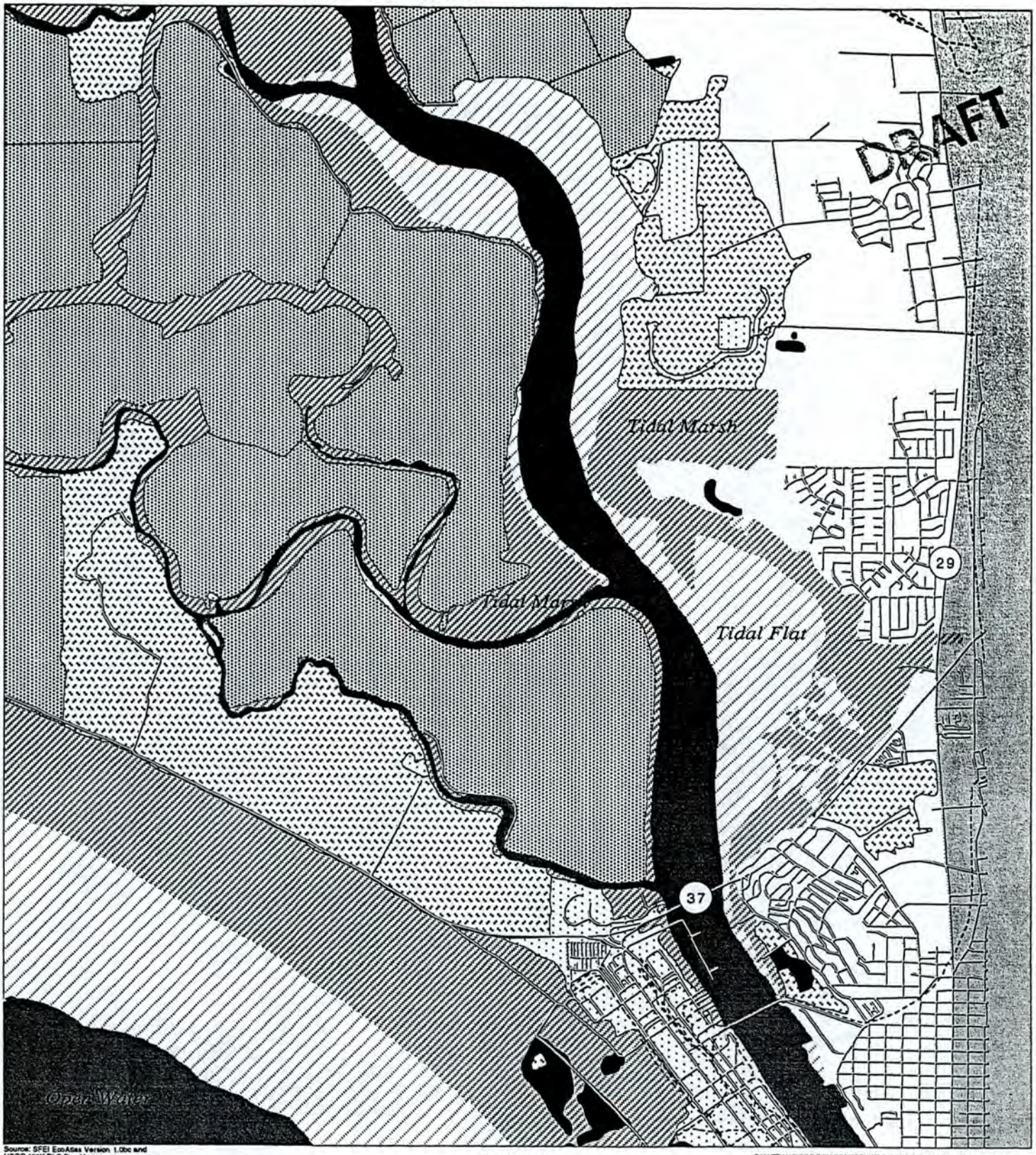

Source: SFEI EcoAtlas Version 1.0bc and USGS 100K DLG Road Layer
Projection: UTM Zone 10 NAD 27

1:48000

SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION-1997

0.5 0 0.5 1 1.5 2 Miles

Location Key

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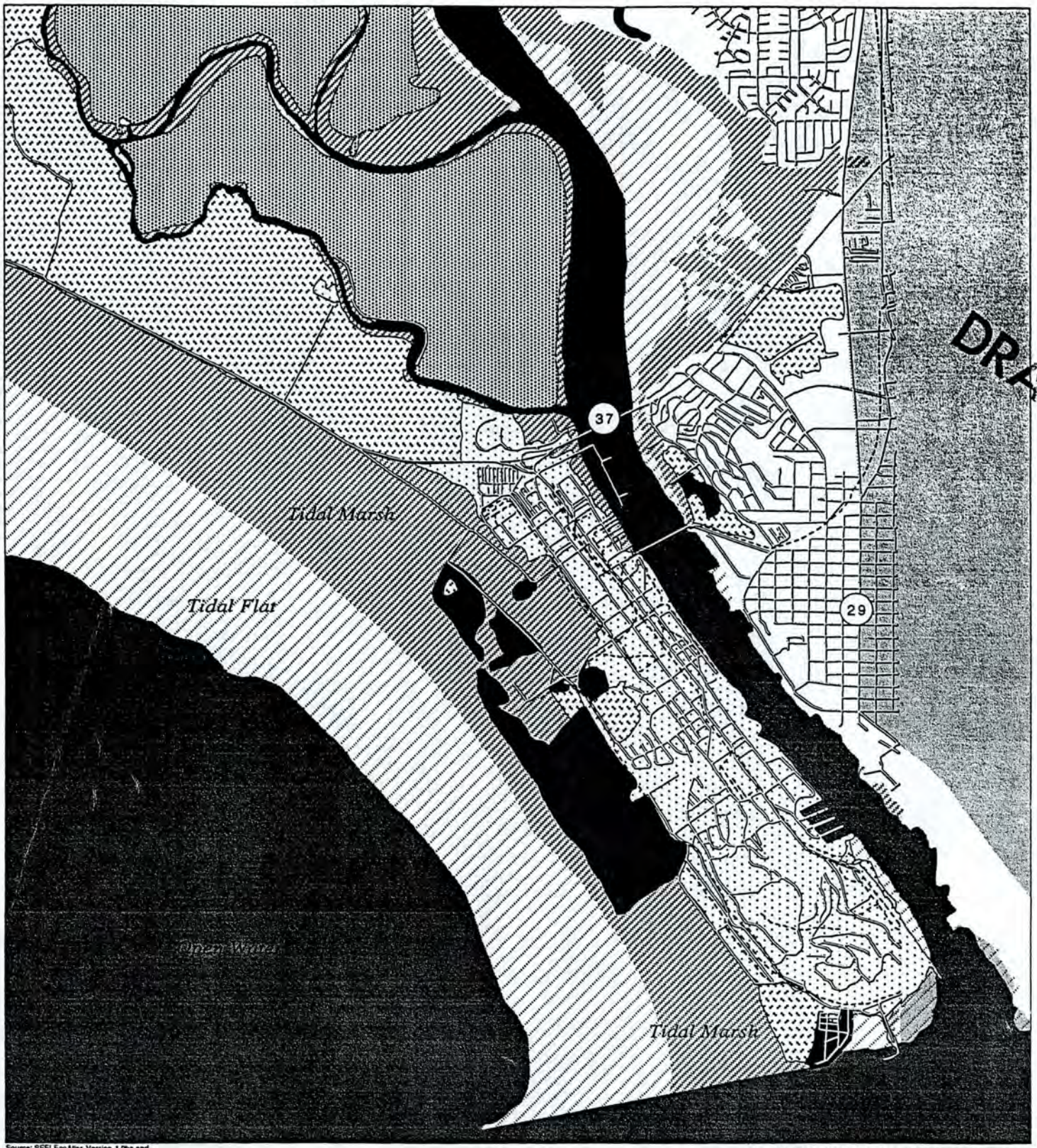
- Diked Pond
- Diked Salt Pond
- Open Water
- Tidal Flat
- Tidal Marsh
- No Data

American Canyon

NAPA AND SOLANO COUNTY

N

This diagram does not reflect changes made after January 1, 1997. The EcoAtlas is currently undergoing field review.



DRAF

Source: SFEI EcoAtlas Version 1.0bc and USGS 100K DLG Road Layer
Projection: UTM Zone 10 NAD 27

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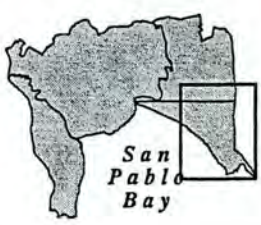
SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION--1997

0.5 0 0.5 1 1.5 2 Miles

Location Key



- Diked Farmed Bayland
- Diked Grazed Bayland
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- Diked Pond
- Diked Salt Pond
- Open Water
- Tidal Flat
- Tidal Marsh
- No Data

Mare Island

SOLANO COUNTY

N

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