San Francisco
Estuary Project

The Effects of Land Use Change and Intensification on the San Francisco Estuary

August 1992

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Additional copies may be obtained from:

Mailing Address:
San Francsico Estuary Project
P. O. Box 2050
Oakland, California 94604-2050
(510) 464-7990
(510) 464-7979 - Fax

Street Address:
Joseph P. Bort Metro Center
101 8th Street
Oakland, California 94607-4756

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Prepared for:
San Francisco Estuary Project

Prepared by:
San Francisco Bay Conservation and Development Commission
30 Van Ness Avenue, Suite 2011
San Francisco, California 94102

Center for Environmental Design Research
390 Wurster Hall
University of California
Berkeley, California 94720

Greenbelt Alliance
116 New Montgomery, Suite 640
San Francisco, California 94105

ACKNOWLEDGEMENTS AND CREDITS

Authors and Principal Contributors*

San Francisco Bay Conservation and Development Commission
Jeffry S. Blanchfield
Nancy Wakeman
Dominic Roques
Robert Batha
Rebecca Tuden
Roi Evron
Steven Goldbeck
Yuki Kawaguchi
Graciela Gomez

Center for Environmental Design Research, University of California, Berkeley
Robert Twiss, Ph. D.
Kenneth D. Gardels
Scott McCreary, Ph. D.
Susan Huse
Bonita Warren
Clara Lendiero
David Ramsdel
Martha Turner
Elise Bacon

Greenbelt Alliance
Jim Sayer
Tony Ancellio

Philip Williams & Associates, Ltd.
Robert Coats, Ph. D.
Fred Booker

Land Use Subcommittee
Emily Renzel, City of Palo Alto, *Chair*
Dennis Barry, Contra Costa County Planning Department
Betty Croly, Alameda County Planning Department
Kassandra Fletcher, Building Industry Association
Mem Levin, San Mateo County
John Malamut, Bay Planning Coalition
Peter Morse, Sacramento County Planning Department
Trish Mulvey, Citizens' Committee to Complete the Refuge
Tom Mumley, California Water Quality Control Board, San Francisco Bay Region
Barbara Salzman, Marin Audubon Society

San Francisco Estuary Project Staff
Amy Zimpfer, Director
Sam Ziegler, Project Officer

**The conclusions and recommendations in this report are those of the authors and do not represent policy or points of view of their institutions.*

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PREFACE

In recognition of the special need to protect the water quality and natural resources of our nation's estuaries, Congress passed the Water Quality Act of 1987. This act amended the Clean Water Act and established the National Estuary Program. The program, administered by the U. S. Environmental Protection Agency (EPA), requires the development of Comprehensive Conservation and Management Plans (CCMP) for the nation's most significant estuaries.

Pursuant to the Water Quality Act, the Governor of California nominated the San Francisco Bay and Sacramento-San Joaquin Delta for inclusion into the National Estuary Program. In response, the Administrator of EPA formally established the San Francisco Estuary Project (SFEP) in April 1988. The SFEP is a planning effort with broad-based involvement of the public and local, state, and federal agencies. The SFEP's goals, adopted by its participants, are:

- Develop a comprehensive understanding of environmental and public health values attributable to the Bay and Delta and how these values interact with social and economic factors.
- Achieve effective, united, and ongoing management of the Bay and Delta.
- Develop a Comprehensive Conservation and Management Plan (CCMP) to restore and maintain the chemical, physical, and biological integrity of the Bay and Delta, including restoration and maintenance of water quality, a balanced indigenous population of shellfish, fish, and wildlife, and recreation activities in the Bay and Delta, and assure that the beneficial uses of the Bay and Delta are protected.
- Recommend priority corrective actions and compliance schedules addressing point and non-point sources of pollution. These recommendations will include short- and long-term components based on the best scientific information available.

Under the Water Quality Act, the SFEP has five years in which to convene a Management Conference, identify and characterize the Estuary's priority issues, and develop a CCMP. The SFEP is scheduled to complete the CCMP by November 1992. After adoption by the Management Conference, the CCMP must be approved by the

Governor of California and the Administrator of the EPA. Once approved, the CCMP will guide local, state, and federal agencies in efforts to improve protection of the Estuary.

The SFEP's Management Conference, with over 100 participants representing environmental, business, and government interests, has identified five management issues of concern: (1) decline of biological resources; (2) increased pollutants; (3) fresh water diversion and altered flow regime; (4) increased waterway modification; and (5) intensified land use.

To characterize and better define the management issues, the SFEP is preparing a series of status and trends reports (STR). The purpose of these technical reports is to seek development of a scientific consensus on the major aspects of the issues and identify important gaps in information and knowledge. In this characterization phase of the SFEP, individual subcommittees oversee the development of these reports. STRs are being prepared on: (1) dredging and waterway modification; (2) wetlands and other habitats; (3) land use and population; (4) pollutants; (5) aquatic resources; and (6) wildlife.

In addition, several other reports, including this report, are being prepared during the characterization phase of the SFEP. A report on quality assurance and quality control of pollutants analysis will assess the changes needed to improve technical procedures of pollutant analysis. A report evaluating the regulatory, institutional, and management programs will develop an understanding of the relevant regulatory responsibilities and lay the groundwork for improving protection of the Estuary. In addition, an analysis of fresh water inflow and altered flow regimes will be undertaken. The characterization effort will culminate in the completion of a *State of the Estuary* report. This report will summarize the information in the individual technical reports and provide an objective assessment of current conditions in the estuary. This assessment will form the basis for the SFEP to develop actions for inclusion in the CCMP.

The purpose of this report is to assess the relationship between land use change and intensification and land use regulation on the future environmental health of the Estuary. The SFEP's Land Use Subcommittee developed goals to address the effects of land use change and intensification on the San Francisco Estuary and played a pivotal role in shaping the scope of the report, defining the major issues to be evaluated, and helping form the management options. This report and the goals developed by the subcommittee will form the basis of developing land use actions for inclusion in the CCMP.

SUMMARY

Since World War II, the 12-County San Francisco Estuary region (Alameda, Contra Costa, Marin, Napa, Sacramento, San Francisco, San Joaquin, San Mateo, Santa Clara, Solano, Sonoma, and Yolo counties) has experienced profound economic and population growth. During the 1980s, the population of the San Francisco Bay Area increased 14 percent as the Bay Area become the fourth most populated metropolitan area in the country. Over this period Alameda, Contra Costa, Sacramento, and Santa Clara counties ranked among the ten California counties with the greatest population increase. Rapid population growth brought with it an increased demand for housing, highways, and public facilities and services and led to a low-density, disbursed urbanization pattern. Agricultural and rural lands, as well as some open water and wetlands, were developed for urban uses. Currently, approximately 896,000 acres—14 percent—of the approximately 6.5 million-acre Estuary region is in urban use and approximately 5.7 million acres—86 percent—is in agriculture or rural use.

During the next two decades (the time horizon of the San Francisco Estuary Project (SFEP)), the population of the Estuary region is expected to increase by over one million people—an approximately 13 percent increase. The challenge to the residents of the region is to find locations for jobs, housing, and commerce and to provide transportation systems for these additional people in a manner that minimizes the potential adverse consequences of increased urban growth on the region's most important natural resource—the Estuary.

Although the precise amount, kind, and location of future land use change cannot be predicted, the construction of plausible land use change scenarios is an instructive method to assess future land use patterns and related impacts on the environmental health of the Estuary. This study, a team effort by the San Francisco Bay Conservation and Development Commission, the Center for Environmental Design Research at the University of California, Berkeley, and the Greenbelt Alliance, with assistance from Philip Williams & Associates, Ltd., utilizes a Geographic Information System (GIS) as an analytical tool for assessing the effects of land use change on the environmental well being of the San Francisco Estuary. The GIS spatially and quantitatively models land use information and pollutant concentrations associated with land use types to: (1) arrive at defensible pollutant loadings for the receiving water segments of the Estuary; and (2) develop defensible estimates of the amount and location of Estuary open water, wetlands, and stream environments impacted by land use change. The process presents for the first time, an ability to examine the cumulative effects of future urbanization on the wetlands and stream environment zones which are essential hydrologic components of the San Francisco Estuarine system, as well as the additional amount and kinds of pollutants contributed to the Estuary by urban runoff from increased urbanization. In addition to the GIS work, the report analyzes the public and private institutions that affect land use change and alternative forms of land use planning, regulation, and management that appear desirable to better protect, restore, and enhance the Estuary.

Study Methodology

The methodology used in constructing and analyzing the land use and impact assessment scenarios has five distinguishing features: (1) the analysis is regionally comprehensive, embracing the entire 12-county Estuary region; (2) the analysis is geographic specific and generally accurate to a scale of one hectare (2.47 acres); (3) the impacts are expressed in consistent natural resource categories; (4) essential study assumptions and limitations are clearly identified and explained; and (5) data and findings for all classes of impacts are reported according to consistent geographic units—Estuary receiving water segments and watersheds.

Four methods were used to determine effects of land use change and intensification on the San Francisco Estuary: (1) construction of existing land use of the Estuary region (as of 1985); (2) construction of two future land use scenarios; (3) measurement of the direct, physical impacts of scenario land use change on Estuary wetlands and stream environment zones; and (4) measurement of the effects of scenario land use change on Estuary water quality represented by the increase in pollutants entering the Estuary in urban runoff.

Fourteen Estuary receiving water segments—based on a classification scheme of the Bay-Delta waters as developed by the Aquatic Habitat Institute which group the 14 zones on circulation, bathymetry, and other hydrographic characteristics—and 31 corresponding receiving watersheds are constructed which form the geographic units for portraying and analyzing data. Although the water segments and watersheds transcend political boundaries, they are the logical geographic units for tracing and analyzing the important hydrological connects in the Estuary Region. Consequently, the receiving water segments and receiving watersheds are the geographical units used to report the findings of each of the classes of impacts of land use change on the Estuary—impacts on wetlands, stream environment zones, and urban run off pollutant loads—under existing conditions and under the two future land use change scenarios.

The construction of current Estuary region land use is the only composite spatial and quantitative land use map and data for the Estuary region. Existing land use information is essential as baseline information for use in measuring future land use change and the effects of that change on the Estuary. The map was generated by utilizing the Bay Area Spatial Information System (BASIS) Land Use File developed by the Association of Bay Area Governments (ABAG) which in turn was based on mapping prepared by the U.S. Geological Survey (USGS), adapted to 1985 conditions. The many land uses were aggregated into six general land use types for analytical purposes in this study—residential, commercial and light industrial, heavy industry, intensive agriculture, rural and extensive agriculture, and open water.

The first scenario portrays growth based on a composite of the 12 Estuary county General Plan land use maps. This scenario involved creating a single map of the future land use designations as adopted by each of the 12 counties. The General Plan land use maps are the counties' graphic designation of land use allocation policy. However, because community plans are constantly undergoing revision and updating, the scenario reflects what was planned at the time the data was gathered (early 1990) and therefore the scenario is a *snap shot* of planned land use at the time. The individual General Plans were scaled and rectified to a standardized base map series, digitized for computer analysis, and a composite land use map was developed.

The second land use scenario was constructed from a computer model based on the population growth projections to the year 2005 (the SFEP time horizon) developed by ABAG. The process involved generation of a map of physical urban growth incentives and limitations and the distribution of the forecast population growth within the Estuary region based on the incentives and limitations. Three sets of criteria were used to establish growth incentives and limitations: land availability, geographic incentives, and geographic limitations. Geographic incentives included areas within existing city boundaries; areas designated for development in county plans; and proximity to existing cities, highways, and employment centers. Numerical weights were assigned to reflect importance of the factors and the areas were delineated in an incentives map. A similar procedure was followed in the creation of a limitations map in which a numerical weighting was given to growth disincentives such as lands dedicated to agricultural use, high value crop lands, steeply sloped terrain, historic wetlands, and areas susceptible to flooding. The GIS then combined the map layers to create a single map portraying the relative potential for urban development within the Estuary region.

Population growth was distributed within the areas with a potential for growth based on the order of growth potential. That is, the first increment of growth was allocated to land with the highest weighted development potential. When that area was filled, the area with the second highest urbanization potential received the next allocation of growth. This procedure was followed until all the forecast population increase had been distributed.

In order to evaluate the effects of land use change on wetlands and stream environment zones, specific natural resource data was obtained and entered into the GIS. The National Wetlands Inventory (NWI) data for the Estuary region available at the time of this study was obtained from the U.S. Fish and Wildlife Service (USFWS) in digital form. For consistency with other SFEP reports and analysis, the 210 NWI categories of wetlands were aggregated into the 14 wetland types used in the *Status and Trends Report on Wetlands and Related Habitats.* At the time information for this study was gathered, only 85 of the 104 USGS quadrangle maps prepared by the USFWS for the Estuary region had been digitized. Consequently, information from the remaining 19 quadrangle maps, which were digitized subsequent to completion of this study, were unavailable for analysis. Thus this study does not include an analysis of the impact of land use change on wetlands in certain parts of the Estuary region, including the important Delta lowlands. However, the acquired coverage includes the immediate shoreline of San Francisco Bay, and most of the Delta.

The two scenario land use maps were overlaid onto the composite wetlands map. The acreage of wetlands potentially impacted by land use under the two scenarios was then quantified.

Digital information on Estuary region streams was obtained from the USGS and loaded into the GIS for analysis. This data layer portrayed a 100-meter (328 feet) wide stream environment zone which included the stream channel and adjacent riparian area. As in the wetlands impact analysis, the regional map of the stream environment zones was overlaid on the two scenario land use maps to calculate the acreage of stream environment zones potentially impacted under each land use scenario.

Because urban areas generally have greater concentrations of pollutants in water runoff than non-urban land, the increased impervious land surface and higher concentration of pollutants associated with urban land uses was used to estimate increased pollutant loading associated with land use change. Construction of a model to analyze the increase in urban runoff to the Estuary under existing land use conditions and the two land use change scenarios involved the following calculations: (1) Estuary region rainfall and natural runoff; (2) pollutant concentration by land use type; and (3) pollutant loading to the Estuary.

The natural runoff coefficient is the unimpaired, non-urbanized mean for each one hectare (2.47 acre) cell in a watershed and describes the relationship between precipitation and the amount of water available for runoff for a given area. The natural coefficient used in the study was derived from the mean annual precipitation map of the San Francisco Bay Region and a table relating mean annual runoff and runoff coefficient to mean annual precipitation for sub-regions of the Bay Area as developed by Rantz. Rantz' precipitation map provided isohyets (precipitation amount contours) of mean annual precipitation. The isohyets were digitized into the GIS and a continuous surface model was interpolated. The table was entered as a data file. Both rainfall and runoff were empirically derived from 40 years of rain gauge station records, rather than being modeled from physiographic and other factors. Consequently the data is responsive to local variations in the conditions of the Bay and Delta areas.

Urbanization is associated with an increase in impervious ground surfaces, and consequently the volume of runoff increases because rain falling on impervious materials is routed to streets and storm drains and runs off relatively quickly rather than percolating into the soil. The runoff component for urbanized land use was modeled from the percent of impervious surface assigned to different land use categories. The mean value was chosen from values developed by the U. S. Soil Conservation Service's study of urban hydrology. The value produces results that are consistent with modeled runoff coefficients produced by the Storm Water Management Model (SWMM) in the *Santa Clara Valley Nonpoint Source Study* which was the source of pollutant concentration data used in this study.

Much of the research associating specific land use types to pollutant concentrations is included in two nationwide studies: the *Nationwide Urban Runoff Program* (NURP) conducted by the U.S. Environmental Protection Agency in 1983 and the *Urban-Stormwater Data* base for 22 metropolitan areas of the United States prepared by the USGS in 1985. However, it was determined that the recent (1991) Woodward-Clyde study of urban runoff water quality in the Santa Clara Valley, the *Santa Clara Valley Nonpoint Source Study*, contained more relevant, regional data for this study. The Woodward-Clyde study considered seven land use types and modeled loads of heavy metals(cadmium, chromium, copper, lead, nickel, and zinc), nutrients (nitrates, phosphates, and total nitrogen), biochemical oxygen demand (BOD) and total suspended solids (TSS).

The NURP and the USGS studies were analyzed as a reference to the modeled unit mass loads. Comparisons were made of the mean, median, and first and third quartiles of run off concentrations of 11 pollutants used to characterize urban run off.

For each hectare-sized cell in a watershed, the mean annual pollutant loads were computed by multiplying total annual precipitation by the adjusted run off coefficient by the pollutant concentration for each of the land use types. Annual loads were then aggregated by receiving watershed and a sum calculated for each pollutant. The loads associated with each future land use scenario is subtracted from the existing land use to derive the increase in pollutant loading to the Estuary.

Determinants of Land Use Change

Land use change in the Estuary region is determined by a wide range of factors. For example, the desirability of the area for business location and expansion and population in-migration will affect where and how land use changes. Interest rates affect the development of industrial plants, commercial facilities, and housing. Construction of transportation routes into undeveloped areas can induce growth or shift the growth in urban development from one area to another. The desire to own a single-family house in the suburbs with a yard and two or three automobiles creates a market force for low-intensity, dispersed urbanization patterns resulting in conversion of agricultural and rural land to urban uses and reliance on the automobile for travel to work and to shop. Private and public sector plans and decisions concerning the location or relocation of new businesses and where people should live, work, and recreate directly affect land use change in the Estuary region and, consequently, the environmental health of the Estuary.

The private sector, especially real estate developers, corporate business, and owners of undeveloped land play a major role in shaping new land use patterns. Land developers generally seek to develop their "product," whether a new residential subdivision or a commercial development, in ways that reduce costs to maximize return on investment. They are pulled to development sites in which land is at a relatively low price, of sufficient size, where there is a receptive and predictable regulatory structure, low development costs and a market for the proposed development. Corporate business also looks for low cost sites with a predictable land use regulatory system when looking for new locations. Corporate business is concerned with land and leasing costs, market proximity, land and space availability, labor force availability, and good transportation. Often, the effects of these development criteria is the location of new development at the urban fringe or completely outside existing towns or cities, a process that leads to dispersion of urban development.

Land owners whose purpose in holding land is to sell at an opportune time to obtain a profit, generally make decisions effecting land use from an individual or corporate investment or business strategy view rather than from a regional land use management goal. The principal means of guaranteeing a link between the private sector land use decisions and broader regional land use and environmental management goals, is through public land use goal development, a land use and environmental strategy, and a companion regulatory system that provides for and directs development to appropriate areas.

In addition to economic factors, which play the major role in private sector decisions effecting land use change, governmental decisions greatly shape land use patterns, change and intensity. Local government (counties, cities, Local Agency Formation Commissions (LAFCOs), and special purpose districts) play the primary role in land use change. Counties and cities guide the physical development of their land resources through their General Plans and carry out the policies of their plans through land use regulations, primarily zoning, which set specific criteria for, among other things, intensity and density of land use. LAFCOs have the authority to determine the limits of urban expansion and the provision of urban services. Regional Councils of Government have limited authority over land use change, their land use planning and regulatory role is primarily advisory to their member city and county members.

When compared with cities and counties, state and federal government agencies have limited ability to control land use changes in the Estuary region primarily because their authority is restricted by law to specific resources or limited geographic areas. However, even though state and federal agencies have limited land use powers, they are likely to have an influential role in controlling land use change that has a direct impact on the Estuary, specifically diking, filling, and discharges in the Estuary and adjacent wetlands.

Land use tax policies and laws also have a significant bearing on land use change. For example, the land use consequences of Proposition 13 include changes in development patterns, increased use of alternate public fiscal financing such as developer fees, and changes in the importance of fiscal considerations in local land use development decisions.

Public-private land use and management partnerships are important vehicles for acquiring and managing lands to protect and improve natural resource areas, such as migratory waterfowl areas and agricultural lands, and to maintain lands in their natural state.

Relationship Between Land Use Change and Estuary Health

As the Estuary region continues to grow and agricultural and rural land is converted to urban uses, the process will impact the Estuary in three general ways: (1) elimination or modification of Estuary wetlands; (2) encroachment into stream (riparian) environment zones; and (3) impacts from pollutant loading from urban run off as well as from waste treatment facilities.

Of the original approximately 545,000 acres of tidal marsh in the Estuary, approximately 509,000 acres (93 percent) have been diked or filled and converted to other uses—primarily agriculture—and salt pond and urban uses. Elimination of wetlands deprives the Estuary of one of its organic parts resulting in a patchwork of wetlands that have reduced value to wildlife, a greatly reduced ability to filter and absorb pollutants, and a significantly reduced regional biodiversity.

Modified wetlands adversely alter the natural hydrologic condition and role of wetlands in providing habitat for wildlife, assimilating pollutants, and trapping sediments. Encroachment into stream environment zones disrupts and alters the ecological integrity of the Estuary in several ways. Stream environment zones are a complex of vegetation, soil, and stream channels that comprise some of the most important aquatic and wildlife habitats in the Estuary region and which carry a considerable portion of storm water run off, and, consequently, pollutants to the Estuary. Riparian vegetation contributes nutrients to the Estuary through decomposition of debris and detritus. Vegetation also intercepts precipitation and slows delivery of surface and ground water to streams; thereby reducing both sediments and turbidity, which would otherwise smother fish nesting areas, clog fish gills, and block light penetration. Removal of natural vegetation or channel modification accelerates transfer of agricultural and urban fertilizers, pesticides, herbicides, animal wastes and sediments to streams and to the Estuary by storm water run off. In addition, urban run off can carry other pollutants, including heavy metals and hydrocarbons. Consequently land use change that results in modifying stream environment zones can result in significant adverse impacts on the Estuary.

Five major classes of pollutants are contained in urban run off and discharge from sewage and industrial treatment facilities: organic matter, total and dissolved solids, nutrients, heavy metals, and organic compounds. Pollutant loading from urban run off is a major source of pollutants in the Estuary.

Existing Land Use Patterns

In this study, the 12-county Estuary region was classified as to its basic land use types: urban and non-urban uplands, and wetlands. Urban uplands were classified into three generalized land use categories (residential, commercial and light industrial, and heavy industry) and two non-urban upland land use categories (agricultural and rural) to provide a consistent land use classification system compatible with Estuary local government land use plan designations. The wetlands were classified based on the U.S. Fish and Wildlife Service's National Wetlands Inventory. The existing (1985) land use information was derived from the Association of Bay Area Governments' digitized Bay Area Spatial Information System (BASIS), version 1989 and the U.S. Geological Service's digitized 1976 Land Use Data files. The existing land use information serves as the base line for comparison and analysis of the amount, location, and impacts of the two land use change scenarios developed in this study.

Of the approximately 6,566,860 acres in the Estuary region, 896,498 acres (14 percent) are in residential, commercial/light industrial, and heavy industry use. Of that amount, 582,444 acres (nine percent) is in residential use; 150,081 acres (two percent) in commercial/light industrial use, and 163,973 acres (three percent) in heavy industrial use. Intensive agriculture accounts for 1,822,595 acres (28 percent) and extensive agriculture and rural land amounts to 3,847,767 acres (59 percent).

Wetlands are an integral part of the Estuary system. Wetlands are intermediate between terrestrial and aquatic ecosystems and exhibit characteristics common to both, forming a continuous gradient between uplands and open water. The wetlands for the Estuary Region are mapped and quantified in this report, except for 19 quadrangle sheets for the Delta for which the USGS had not completed digitizing work when this report was prepared. The wetland categories are open water, mudflats and rocky shore, vegetated tidal marsh, tidal channels or ponds, diked vegetated wetlands, seasonal ponds, farmed wetlands, freshwater marsh, riparian forest, salt ponds, perennial lakes and ponds, tidal rivers, nontidal rivers and streams, and marine.

Land Use Change Impact Assessment

Two scenarios of future urbanization were developed to assess the impacts of plausible conditions resulting from land use change that will occur before 2005 in the Estuary region. Scenario I: Growth Based on County General Plans presents a picture of impacts based on land use change in the region planned by the 12 counties. Scenario II: Growth Based on Modeled Incentives and Limitations allocates population increase by the year 2005 forecast by the Association of Bay Area Governments based on a computer model of urban growth physical incentives and disincentives.

Under Scenario I, the area planned for new urban uses in the Estuary region is approximately 331,530 acres; a 37 percent increase in urbanization. The increase includes an additional 165,980 acres in residential use; 88,840 acres in commercial/light industrial use; and 76,710 acres in heavy industrial use. Thus the urbanized area of the Estuary region would increase to approximately 1,228,028 acres (19 percent of the Estuary region's land area) and the agricultural/rural area would decrease from 5,670,362 acres to 5338,832 acres (81 percent of the land area of the region).

Under Scenario II, urban use would increase by nine percent, or approximately 79,810 acres, from the existing 896,498 acres, resulting in a total of 976,308 acres (15 percent) of the region devoted to urban uses. Conversely, the amount of agricultural/rural land would decrease from approximately 5,670,362 acres to 5,590,552 acres; a reduction from 86 percent to 85 percent of regional land use.

Approximately 39,511 acres of wetlands are likely to be impacted under the county General Plan full build-out scenario. Of the 15 wetland categories, the largest acreage subject to modification would be farmed wetlands and salt ponds. Areas particularly impacted would be farmed areas in the Delta and the North Bay and diked vegetated wetlands near Suisun Bay, San Pablo Bay, and in the San Jose area.

A far lesser amount of wetlands—3,550 acres—would be impacted under Scenario II. But as in Scenario I, virtually every receiving watershed would have wetlands effected by land use change.

The construction of land use scenarios for the Estuary region presents for the first time, an opportunity to examine the cumulative contribution of urban run off to the levels of pollutants in the Estuary. To date, more modest studies in smaller urban watersheds have provided only a glimpse of the overall effect that urbanization has in a region the size of the Estuary.

Loadings (expressed in kg/yr) on the Estuary for eleven pollutants (heavy metals, nutrients, biochemical oxygen demand, and total suspended solids) in each of the Estuary receiving watersheds are computed and analyzed. The pollutant loading analysis shows that substantial increases in loading of all pollutants in urban run off are expected from the receiving watersheds in the Estuary region. For example, the increment of total loading under Scenario I is 705 kg/yr for cadmium, 12,174 kg/yr for copper, and 122,649 kg/yr for zinc. Nutrient loadings from nitrates are anticipated to be 230,400 kg/yr and 109,592 kg/yr for phosphates. Modeled pollutant loadings are heavily dependent on the size of the Estuary receiving watershed, predominant land uses, and rainfall, as well as absolute amount of land use change in the watershed.

Continued urbanization of the Estuary region will increase the load of urban run off pollution. This source of pollution is already the single largest contributor to the volume of pollutants entering the Estuary.

Analysis of Land Use Controls

The principal tools for managing land use and the effects of land use change on estuarine systems are land use planning and regulation. Until 1970, land use regulation generally consisted of local zoning. The 1970s brought about a major change in land use planning as a number of states passed legislation dramatically increasing the direct role of the state in land use planning and regulation. Moreover, the federal government recognized the need for major state involvement in planning and regulating natural resource areas of national significance. In 1972, the federal Coastal Zone Management Act was enacted which provided federal grants to states to develop and implement management plans and programs for the nation's coastal zone. In 1972, the public's concern for the California coast led to approval of Proposition 20, and the creation of the Coastal Zone Conservation Commission (CZCC) with the authority to develop a plan for the coast. In 1976, the California Coastal Commission was established by the Legislature to implement the California

Coastal Act which incorporated many of the recommendations of the coastal plan prepared by the CZCC. In 1977, the federal Department of Commerce certified the San Francisco Bay Conservation and Development Commission's management program for the San Francisco Bay segment of the California coastal zone. And in 1978, the Department certified the Coastal Commission's management plan for the coastal segment of the California coastal zone. The segment of the California coastal zone missing a management plan and program is the Delta.

During the 1980s, land use debate centered on urban sprawl, unplanned growth, and traffic congestion; heretofore primarily local government issues. However, in recent years these issues have been viewed as regional and state-wide issues. In California there is renewed interest in new forms of regional land use management as shown by the formation and recommendations of the Bay Vision 2020 Commission in the San Francisco Bay Area and the LA 2000 Committee in Los Angeles. Such regional land use and growth management and governance efforts address head on the issue of what new, or modified existing institutions, are necessary in order to have a more comprehensive, *greater-than-local* decision-making structure to provide for rational economic and population growth, while preserving and enhancing the region's natural environment, such as the San Francisco Estuary.

Nonetheless, decisions about zoning, building permits, infrastructure financing, housing subdivisions, and related development projects are currently made largely by local government without effective review or controls to require changes at the regional or state level. Therefore, land use policy, except for certain environmentally sensitive areas such as the water and narrow strip of shoreline surrounding San Francisco Bay, the ocean coast, or the Lake Tahoe Basin, is made at the local level. Within California, state law has strengthened the planning and regulatory capabilities of local governments but has not provided any regional or state supervision or oversight. Although, each California city and county must prepare a comprehensive General Plan containing state-specified elements, these provisions are oriented toward meeting local goals and needs. All local ordinances, development plans, and activities are required to be consistent with that plan. However the plan is not required to deal with adjacent communities, regional or state goals and objectives. Additionally, although under the California Environmental Quality Act (CEQA) each locality must undertake the process of environmental review and prepare an environmental impact report whenever a proposed project may cause significant adverse impacts on the environment, there are weaknesses in both the state planning law and CEQA vis-a-vis Estuary protection. Within the state planning process, there is no provision to resolve conflicts or inconsistencies between local, state, or regional plans. In fact, a city or county can approve a local plan calling for a new development even if that project is inconsistent with regional plans or needs, such as Estuary protection, an efficient regional transportation system, or regional sewage treatment capacity.

California lacks clear, consolidated, enforceable state-wide policies on land use

California lacks clear, consolidated, enforceable state-wide policies on land use issues. Thus, there is no enforceable comprehensive state policy on Estuary open water, wetland, or stream environment protection. Under CEQA, the decision about whether or not a mitigation measure "ensures the long-term protection of the environment" rests with the lead agency; which can have a vested interest in the outcome of a project. Although other agencies are free to comment, they are usually unable to condition the land use decision of the lead agency even if the decision may cause damaging impacts to areas of regional or state-wide importance.

Currently, there is no region-wide enforceable plan or policy in place for management of lands that contain significant natural resources such as the San Francisco Estuary. The *San Francisco Bay Plan* and the *Suisun Marsh Protection Plan* only apply to core portions of the Estuary, not adjacent wetlands, many tributaries, stream environments, or the Delta. Regional goals such as protecting Estuary wetlands or tributary streams thus have no consistent voice in law or agency regulation. The state's General Plan law does not require local governments to give special attention to such resources. Although protection of wetlands and stream environments appears inconsistent and weak, the control of nonpoint source pollution is receiving unprecedented attention at both the federal and state levels.

In November 1990, the U.S. EPA published regulations establishing National Pollutant Discharge Elimination System (NPDES) permit application requirements for storm water discharges. Entities required to obtain permits include: (1) municipalities with populations greater than 100,000; (2) facilities associated with industrial activity; and (3) those storm waters which contribute to violations of water quality standards, or contribute pollutants to receiving waters. Industrial activities include construction that disturbs more than five acres of land, or, that disturbs less acreage but the construction activity is part of a larger, common plan of development.

The permits will require a number of specific structural and source control measures to reduce pollutants in runoff from commercial and residential areas both during and after construction. Such measures are expected to go a long way toward controlling the source (urban runoff) now composing the larger part of pollution entering the Estuary. At this time, a framework for implementation which uses the resources of the municipalities involved, the San Francisco Bay Regional Water Quality Control Board and the concerned water districts in a coordinated fashion, is emerging. Such coordination is essential as the direct involvement of the Regional Board in reviewing every sizable development in the region would place a great burden on the agency and could potentially slow down the application process to the point that land developers begin to incur unacceptable expense waiting for permit review and approval. However, it would be in the general public interest to have local governments (cities and counties) address control measures prescribed by the Regional Boards in their planning and regulatory activities, particularly their building permit process.

While the broadening of land use authority has increased the quality of the plans and contributed to a greater openness and participation in community planning, it has failed to address the fundamental Estuary land use planning management issue: that Estuary-related planning and regulation continues to respond primarily to local objectives without consideration of state or regional needs and resources. Since this arrangement for land use decision making is not the optimum for specific protection of the Estuary's well-being, there is a need to modify the arrangement to insure the consideration of *greater-than-local* impacts of projects in the land use decision-making process, particularly as those impacts affect the Estuary.

Six bills (AB 3 (Brown), AB 76 (Farr), SB 434 (Bergeson), SB 797 (Morgan), SB 907 (McCorquodale), and SB 929 (Presley)) are pending in the 1991 Session of the California Legislature that would institute combinations of state-wide regional land use planning and regulation. Action on the bills is postponed pending legislative hearings concerning general and specific issues regarding state and regional growth management. However, it appears inevitable that California will at some point soon enact a *greater-than-local* system of land use planning and control. It is essential that the Estuary Project recognize and positively react to this pending and possibly enacted state land use planning as a principal means of carrying out many, if not most, of the recommendations of the Comprehensive Conservation Management Plan for the San Francisco Estuary.

Management Options

Land use change in the region will continue to impact an already stressed San Francisco Estuary. It is therefore essential that options presently available for comprehensively managing this complex and vast natural resource be evaluated, and strategies and tools to better protect the Estuary be considered.

A management option can be viewed as a complimentary arrangement of: (1) management strategies and tools for implementation; (2) an institutional arrangement facilitating goal achievement and plan implementation; and (3) an agenda for applied research and evaluation which in turn feeds back to improved management strategies and tools.

The management strategies considered in this report address land use change and control in relation to stream environments, wetlands, and nonpoint source pollution.

Stream protection strategies are designed to carry out resource and water quality protection goals. Protection tools are designed to control the amount of sediment and pollutants which can potentially reach streams and eventually the Estuary. To protect streams from direct and indirect impacts of land use change and intensification, it is important to develop stream protection goals and to define the stream riparian zone to which these goals and complimentary plan policies and regularly controls can be applied. Regulatory boundaries can be established within the riparian zone according to general physical criteria and stream-specific characteristics and functions. These boundaries can establish fixed, variable, or independent zones. Within these zones, allowable land uses can be identified, design and performance standards established, and best management practices (BMP) set.

The goals of wetland protection are to protect wetland environments and their functions, promote compatible uses in and adjacent to the wetlands, and limit or prohibit land uses and practices which adversely impact wetlands and adjacent wetland-related areas. Land use policy plans and implementing regulations provide a mechanism to protect wetlands from activities which pose significant threats to wetland environments. As with stream protection strategies, it is important to identify wetland protection goals and to define and delineate the wetland areas that protection policies and regulatory programs, which include best management practices (BMP), apply.

Non-regulatory tools, such as wetland acquisition and management, easement acquisition or donation, and tax incentive programs can assist in rounding out a carefully crafted wetland protection strategy.

Of particular promise to minimize the impacts of nonpoint source pollution on the Estuary are strategies which utilize education and regulatory means to control pollutants at their source, before they enter the Estuary drainage system. By carrying out specific best management practices (BMP) such as control of soil erosion, curbing illegal discharges into storm drains, control of the use of chemicals including household use of toxicants, and the safe disposal of household toxic wastes, the Estuary can be better protected from urban run off pollution.

As observed earlier, the existing system of land use planning, control, and management is focused locally, not on the Estuary as a single, comprehensive system. This has suggested a need to look at Estuary protection from a *greater-than-local* perspective and to consider alternative land use planning, control, and management institutional arrangements that would provide mechanisms to better protect the Estuary. Three alternative models appear relevant and practical: (1) voluntary adoption of stronger land use controls by local government; (2) creation of a new state agency to manage the Estuary; (3) creation of a state/local collaborative land use planning and control process.

Over 20 examples of *greater-than-local* land use planning and control exist around the country. These examples can be categorized into four groups: (1) state-wide—comprehensive such as in New Jersey, Oregon, and Florida; (2) state-wide—selective, such as the California Coastal Commission; (3) regional–comprehensive such as the Suisun Marsh Local Protection Program, the Tahoe Regional Planning Agency, and the Pinelands and Hackensack Meadowlands commissions in New Jersey; and (4) regional—selective, such as the San Francisco Bay Conservation and Development Commission and Martha's Vineyard Commission in Massachusetts. State–wide—comprehensive land use planning and control programs apply to the entire state while state-wide—selective programs apply to a specific, but extensive geographic area of the state. Regional—comprehensive programs apply to a specific region of a state whereas regional—selective programs establish land use planning and controls over a specific resource of a region.

Conclusions

1. ***The Estuary is a Single, Hydrologic System***
   - The open Estuary waters—salt, brackish, and fresh water—and surrounding wetlands and tributary stream environments make a single, hydrologic system.
   - The 28 receiving watersheds of the Estuary are the logical geographic units for the analysis and management of land use effecting the Estuary's health.

2. ***The Estuary Region Consists of Two Subregions: the San Francisco Bay Area and the Delta Area***
   - A review of the physiographic characteristics, current land use patterns, future plans for urban expansion, and existing land use planning and control institutional arrangements, reinforces the view that the 12-county Estuary region consists of two distinct subregions: the nine-county San Francisco Bay Area (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma Counties), and the three-county Delta Area (Sacramento, San Joaquin, and Yolo Counties).

3. ***Rapid Population Growth and Land Use Change Will Continue in the Estuary Region***
   - Because of a favorable economic climate and high quality of life, which is in part related to the unique environmental qualities of the Estuary, the Estuary region will continue to grow in population at a moderately high rate. This growth will be concentrated along the major highway systems of the Bay and Delta Areas—Interstate 80 between the East Bay and Sacramento; Highway 101 in northern Marin and Sonoma Counties and south of San Jose; Interstate 680, Interstate 580, and State Highway 4 in Contra Costa and Alameda Counties; and Interstate 5 in Sacramento and San Joaquin Counties.
   - Of the approximately 6,567,000 acres of land in the Estuary region, about 5,670,000 acres (86 percent) are currently (1985) devoted to agricultural and rural uses and 896,000 acres (14 percent) are in urban use.
   - If the land use plans adopted by the 12 Estuary region counties were carried out, approximately 300,000 acres of existing agricultural and rural land would be converted to urban use—a 37 percent increase in urban land use in the Estuary region. Under this scenario of future land use, close to 1,228,00 acres of land would be in urban use (19 percent of total land use) and approximately 5,339,000 acres in agricultural or rural land use (81 percent of total land use).
   - The population projection for the Estuary region in the year 2005 combined with a geographic model of urban growth incentives and

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limitations indicates that approximately 80,000 acres of existing agriculture and rural land would be converted to urban use—a nine percent increase in urban land use in the Estuary region. Under this scenario, around 976,000 acres of the Estuary region would be devoted to urban use (15 percent of total land use) and approximately 5,591,000 acres would be in agricultural or rural use (85 percent of total land use).

4. **Land Use Change Will Produce Adverse Impacts on the Estuary**
   - As the Estuary region continues to grow, and current agricultural and rural lands are converted to urban uses, the Estuary would be adversely impacted by (1) the elimination or modification of wetlands, (2) modification of stream environments, and (3) additional pollutant loading from urban runoff.
   - Under the growth scenario based on county General Plans, approximately 40,000 acres of Estuary wetlands would be eliminated, modified, or in some way adversely impacted, while under the scenario of growth based on modeled incentives and limitations, approximately 3,500 acres of wetlands would be eliminated, modified, or adversely impacted. Adverse impacts to wetlands include, but are not limited to: dredging and filling, removing vegetation, altering local hydrology through diversion of tributary waters, increasing sedimentation, degrading water quality through increased pollutant carrying urban runoff, and disruption of wildlife breeding through increased human activities.
   - Of the approximately 380,000 acres of stream environments in the Estuary region, under the scenario of growth based on county general plans, approximately 28,000 acres (seven percent) of Estuary stream environments would be eliminated, modified, or in some way adversely impacted. Under the scenario of growth Based on modeled incentives and limitations, approximately 10,500 acres (three percent) of Estuary stream environments would be eliminated, modified, or adversely impacted. Adverse impacts to stream environments include, but are not limited to: channelizing, dredging, removing vegetation, altering local hydrology through diversion of tributary waters, increasing sedimentation, increasing potential for flooding, and disturbance of riparian aquatic life and wildlife habitat.
   - Both land use scenarios indicate that substantial increases in pollutant loadings from urban runoff can be expected in all receiving water segments of the Estuary. To the extent that the environmental health of the Estuary is already stressed by pollution, increased urban runoff from additional urbanization will further exacerbate the Estuary's deteriorating health.

5. ***Current Land Use Planning, Regulation, and Management Practices Inadequately Protect the Estuary***
   - Currently, there is no Estuary region-wide enforceable land use plan, policy, or regulatory structure for management of lands that contain significant natural resources (other than San Francisco Bay). Regional goals such as protecting wetlands and stream environments have no uniform or consistent voice in law or agency regulation.
   - California General Plan law does not require local governments to protect the Estuary's natural resource system. Some counties and cities currently revising their codes are including policies which specifically address the protection of wetlands and streams, and the control of nonpoint source pollution. Presently only 16 percent of the region's jurisdictions have specific ordinances for stream and wetland protection. Many existing plans reveal no coordination with neighboring jurisdictions, and contain vague and contradictory language regarding resource protection and development. In addition, General Plan policies are often inconsistent with local jurisdictions' zoning ordinances.
   - There is need for a comprehensive, coordinated regional approach to land use planning and control in the Estuary region that protects, enhances, and restores the Estuary system—its open waters, wetlands, and stream environments—from potential adverse impacts associated with land use change and intensification.
   - Historically, pollution control programs have focused on reducing the load of chemical pollutants (e.g., nutrients, heavy metals, biochemical oxygen demand) to water bodies. Although reduction of chemical contaminants will continue to constitute a major element of pollution control efforts, water quality objectives can only be achieved if open Estuary waters, stream environment areas, and wetland habitat planning and regulation is integrated into a comprehensive Estuary management plan and regulatory scheme and restoration and enhancement strategy.

Recommendations

The existing system of land use planning, regulation, and management must be improved and strengthened to protect, enhance, and restore the environmental well-being of the Estuary. This action will require new policies, regulatory authority, management strategies, institutional arrangements and regional will. Additionally, the management system can be further improved by the timely completion of a priority research and analysis agenda.

1. ***Set Enforceable Regional Estuary Resource Protection Goals, Policies, and Controls***
   - State-wide goals for land use planning should be adopted calling for protection and restoration of wetland habitats and stream environment zones.

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- State agencies with resource management responsibility in the Estuary should establish specific goals to protect, enhance and where possible restore open Estuary waters, wetlands and stream environments.
- Local governments and special districts should adopt policies to bring their General Plans, zoning ordinances, and resource management plans into conformance with state-wide Estuary open water, wetland habitat and stream environment protection and restoration goals.
- Management objectives based on the best available scientific information should be developed. These objectives should include specific targets for restoration of Estuary open water, streams and wetlands and for reduction of nonpoint source pollution.
- Any new regional agency created for the San Francisco Bay Area or the Delta Area, should include protection, enhancement, and restoration of the Estuary open water, related wetland habitats and stream environment zones among its goals and objectives.
- To promote and protect the environmental health of the Estuary, specific, enforceable land use policies and controls should be adopted at the state, regional, and local levels that would:
  - Stabilize and begin reducing the total run-off and volume of pollutants entering the Estuary (nonpoint source control);
  - Minimize the destruction of—or adverse impacts on—wetlands and stream environments;
  - Reduce the amount of impervious surfaces in new existing development; and
  - Promote more compact, dense urban development.

2. ***Develop and Carry Out New Estuary Management Strategies***
   - The 28 receiving watersheds of the Estuary are the logical management units for improving the Estuary's health. These watersheds provide the basis for an integrated, comprehensive Estuary watershed management approach that requires creation and adoption of individual watershed plans. This approach necessarily cuts across political boundaries and allows for a systematic and comprehensive hydrologic approach to land use planning, regulation, and management.
   - The watershed plans should identify the specific management strategies (including best management practices (BMP) and best development practices (BDP)) for: (1) eliminating or significantly reducing storm water and pollution from urban runoff; (2) wetland protection, enhancement, and restoration, and; (3) stream environment area protection, enhancement and restoration appropriate for each watershed.
     - Storm water and urban runoff pollution elimination or reduction programs should include: (1) residential and commercial area

control programs; (2) prohibition on non-storm water discharges; ((3) industrial storm water control programs; and (4) construction activity control programs. These primarily local government programs call for best management and development practices, educational and training programs, and monitoring and enforcement programs.

- Wetland protection, enhancement, and restoration programs should include: (1) delineation of wetland boundaries; (2) delineation of buffer areas around wetlands; (3) a land use plan for and regulations applicable to wetlands and buffer areas; and (4) acquisition, enhancement, and restoration programs by public, non-profit, and private institutions and organizations.
- Stream protection, enhancement, and restoration programs should include: (1) delineation of stream environment areas; (2) delineation of stream channel and riparian areas along the channel; (3) development of channel and riparian area alteration performance standards; and (4) a permit system to carry out and enforce the performance standards.

3. ***Adopt Improved Institutional Arrangements***
   - In preparing the Comprehensive Conservation and Management Plan (CCMP), three alternative institutional arrangements for helping to carry out the land use elements of the CCMP should be considered:
     - One option for improving the existing system is to promote the voluntary adoption of new land use controls by local government. The capacity for local planning regulation, and enforcement could be strengthened, for example, by organizing technical and financial assistance from the State. The intent would be to give local government the tools to better plan for, regulate and manage natural resources within their jurisdiction. This model relies on creation of a program of local assistance, perhaps in an agency such as the Governor's Office of Planning and Research. Creating such an arrangement requires the lowest level of effort of the three models discussed here. It is also likely to encounter the least political opposition given its deference to local authority. However, a voluntary program has several weaknesses, as well. Our review of local protection ordinances, together with the results of many other analyses, suggests that reliance on voluntary cooperation of local governments would produce an uneven commitment to resource protection.
     - A second option is to create a new state-level agency charged with improving management of the Estuary. Such an agency could be given powers and duties to establish carrying capacities and thresholds for the region, against which impacts of regionally

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significant projects could be compared, much along the lines of the California Tahoe Regional Planning Agency. Such a San Francisco Estuary Agency could also be the institutional home for the drafting and implementation of the specific management strategies for stream protection, wetland protection, and nonpoint source pollution control. A possible variation of this model would be to strengthen and clarify the regulatory and planning functions for existing agencies in the San Francisco Bay Area and to create a unified agency for the Delta Area. Another variation on the model of a single centralized agency would be to create a federation of agencies, perhaps sitting on a San Francisco Estuary Management Authority. Such an interagency Authority would conduct joint hearings, coordinate preparation of EIRs and EISs, and cooperate in setting environmental targets and thresholds for the Estuary against which new programs and projects can be evaluated.

- An intermediate option would be to create a set of policies and planning standards for the Estuary region and delegate their implementation to local government. Under this arrangement, policies would be prepared at the state level to foster protection and restoration of wetlands and stream environments and wetland resources, and to reduce nonpoint source pollution. Local governments would then be called upon to prepare amendments to their general plans and zoning ordinances, perhaps called Local Estuarine Protection Plans. These plans would be the subject of review and cross acceptance by the state. Alternatively, plan review and certification could be accomplished by the regional agency for growth management now proposed in some of the legislation discussed earlier.

4. ***An Agenda for Applied Research and Analysis***

- Any management or regulatory system hoping to achieve success must have the capacity to continually expand the information base upon which it is founded. Identifying gaps in knowledge early on, and taking measures to fill them is an essential task in institution building. Management options should offer provisions to fill those gaps and expand the knowledge of both the natural resources being managed, and the effectiveness of various strategies for protecting them.

  There are two general areas wherein further research and analysis would offer considerable returns. These include both impacts and their effects, and regulatory and institutional performance.
- Additional research and analysis on the impacts of land use change is needed.Continued efforts to describe land use change and understand its impacts and effects on the Estuary can only improve upon the efforts

made to date. The natural resource inventories upon which the analysis in this report was based, could be improved. For one, the inventories are silent on the condition of the resources they quantify. Additionally, the National Wetlands Inventory should be completed for the Estuary in order to provide a more accurate sense of the wetland areas at risk to urbanization.

There is still considerable debate over what is in fact the most appropriate configuration or pattern of land use in a region like the Estuary. Future research should seek to clarify the relative impacts of dispersed and concentrated development patterns on wetlands, streams, and pollution loading. Efforts to determine the meaningful limits to growth—the carrying capacity—in the region must be undertaken as well.

Determining the Estuary's carrying capacity to a level that will also protect the Estuary from further degradation will require more complete and accurate scientific information. As this information is developed it must be integrated with the decision-making process through well established channels. For example, with greater attention now being paid to controlling nonpoint source pollution, it is hoped that an understanding of the routing and fate of pollutants generated by different land uses will be reached. As this gap in knowledge is filled, it must inform decisions about where to locate different land uses and where to reinforce control strategies.

- Additional research and analysis of the performance of regulatory agencies should be conducted. The performance of existing regulatory and other governmental agencies throughout the region has only been partially assessed in this report. There remain many unanswered questions regarding the effectiveness of these agencies' efforts to manage the resources of the Estuary. In particular, no evaluation of permit compliance has been performed for the myriad permitting agencies at the federal, state and local levels of government. Additionally, the success of various best management practices for stream and wetlands protection, and nonpoint source pollution control employed in some jurisdictions, has not been assessed. The effectiveness of currently mandated, yet-to-be implemented, control measures for nonpoint source pollution, is an area in which information will contribute significantly to managing the Bay's water quality. Mitigation, where it occurs, often is not followed-up on to insure its success. Often the concluding phase of the permit process, mitigation appears to occur on a sporadic basis, but no full-scale study has been done to verify the success of mitigation requirements. These points illustrate the importance of continuing to probe the areas of research this report is concerned with. Obviously the management system which evolves to protect the Estuary will have to accommodate other subjects and fields of study wherein our knowledge is incomplete.

Thus the agenda for applied research and analysis is an important component of resource management and should be developed concurrently with institutions and implementation strategies.

- The impacts on local government of additional responsibilities to protect the estuary should be examined. The financial, administrative, and personnel required to provide further protection to the Estuary by local government needs to be analyzed and quantified. Many of the costs and responsibilities for improved protection, enhancement, and restoration of the Estuary will fall on the shoulders of local government.

5. ***Identify Vehicles for Implementation***

- Estuary managers will need to move quickly to ensure that resource protection goals are incorporated in pending federal and state legislation. Realistically, this may require action concurrent with the final drafting and ratification of the CCMP. There are several vehicles for creating improved management strategies and institutional arrangements. The options outlined above will require that new legislation be enacted to articulate clear policies and provide the necessary authority and funds to better manage the Estuary. Two clear opportunities are the pending reauthorization of the federal Clean Water Act and the current efforts to enact state growth management legislation, which most likely will come to a vote in 1992. It is timely for Estuary managers to begin developing specific proposals to be incorporated in this legislation at the federal and state level.

CHAPTER 1

INTRODUCTION

The San Francisco Bay-Delta Estuary is the largest estuary and possibly the most important natural and economic resource on the western coast of the American continents. The Estuary region contains the nine Bay Area counties—Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma—and the three Delta counties—Sacramento, San Joaquin, and Yolo (see Figure 1). The Estuary is one of the world's great natural harbors and centers of ocean-going commerce, and the setting for the fourth largest metropolitan region in the United States. In addition to this urbanized and highly commercial face of the Estuary, the meeting and the mixing of the cold salt waters of the Pacific Ocean with the warmer fresh waters of the Sacramento and San Joaquin River systems provides diverse and abundant habitats and breeding grounds for a multitude of aquatic life and wildlife. The Estuary provides not only an extensive habitat for resident fish and wildlife, but is an essential resource for a multitude of migratory fish, waterfowl, and shorebirds. Moreover, the Estuary provides its approximately 7.5 million residents and substantial number of visitors with significant and multiple economic, recreational, and aesthetic benefits. As an economic resource, the Estuary affords navigable, secure sites for deep water ports and water-related industries; facilities for commercial and sport fisheries; areas for the production of salt; numerous tourist attractions; and cooling waters for electricity production. It also provides recreational and aesthetic values for boaters, swimmers, fishermen, hikers, and all those who appreciate its natural beauty. The many benefits that the Estuary provides make it a resource of inestimable values—values that must be protected for future generations.

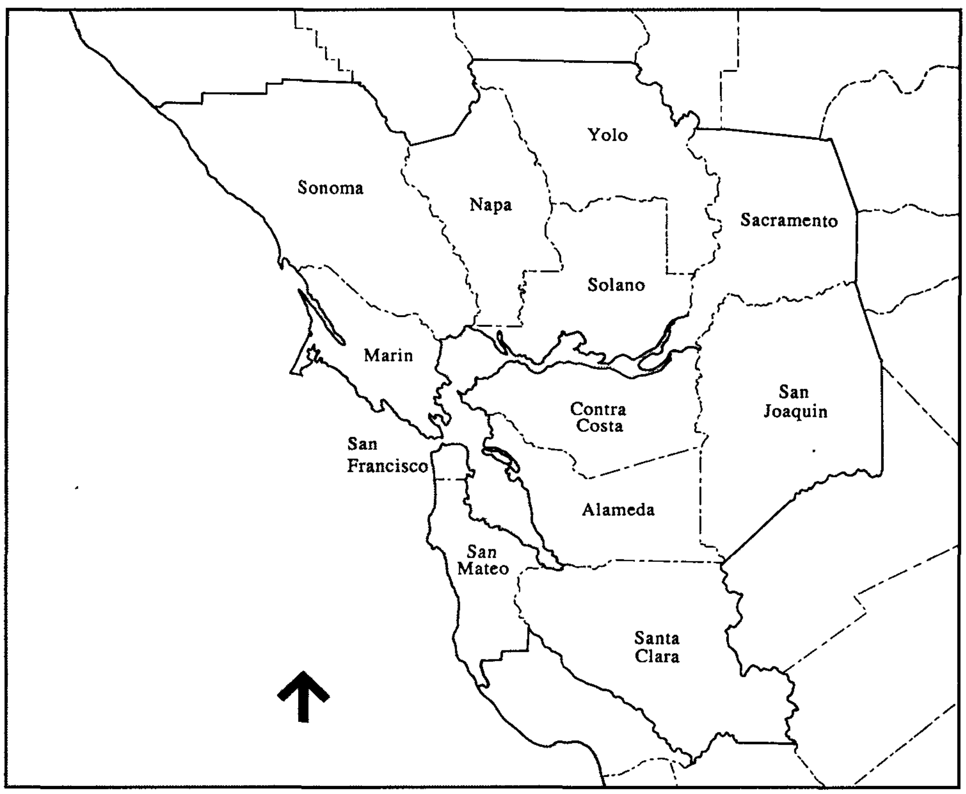
All uses of the Estuary depend to a greater or lesser extent on the quality and health of its waters and wetlands. While many uses in the Estuary region coexist with and enhance the Estuary, others can conflict with or degrade the value and beneficial uses of the Estuary. A leading cause of degradation and a fundamental threat to the present and future benefits of the Estuary is the loss of the Estuary's open water areas, wetlands, and stream environments through modification or conversion to other uses, and contamination by pollutants.

The Estuary consists of the open tidal, brackish, and fresh water system of the San Francisco Bay and the Sacramento-San Joaquin Delta, their adjacent wetlands, and tributary streams. Changes in land use can have a direct impact on the Estuary—physical conversion of the Estuary's open waters, wetlands and streams to other uses such as homes or shopping centers—or indirect impacts—pollutants carried by rain water into the Estuary from upland uses and activities.

Historically, land use change in the Estuary region has had considerable impact on the Estuary's ability to function as a dynamic natural and economic resource. For example, through diking and filling for urban and agricultural uses, the current size of San Francisco Bay relative to 100 years ago is 60 percent; the average depth, 50 percent; and the amount of tidal marshes, five percent (BCDC, 1988). Conversion of Estuary waters and wetlands to other uses seriously effects the Estuary's natural functions and beneficial uses. Contamination of the Estuary with pollutants continues to threaten its environmental health and well-being. Most of the pollutants entering the Estuary emanate from urban and non-urban runoff rather than sewage discharges (see Figure 2). Water pollution can render water contact recreation hazardous, harm or destroy aquatic organisms, degrade drinking water and sport and commercial fisheries, and even preclude use of Estuary waters by industry. Consequently, preventing or controlling water pollution is crucial to obtaining full benefit from the Estuary's many uses. While some of the most dramatic direct and indirect impacts on the Estuary associated with land use change and intensification occurred many years ago, our present and possible future land use allocation and practices continues to threaten its future biological condition.

Figure 1
Estuary Region

SOURCE:
San Francisco Estuary Project



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The change and intensification of land use and the consequential impacts of this change on the Estuary has been established by the San Francisco Estuary Project's Management Conference as a major management issue of concern regarding the future biological health of the Estuary. Since World War II, the Estuary region has experienced profound economic and population growth. By most standards of measurement, California—including the Estuary region—has been one of the world's most successful societies in terms of economic expansion and population growth (The Economist, 1990). To accommodate this growth, rural and agricultural land, as well as open water and wetlands, have been urbanized to provide the sites for homes, businesses, and industry. The *Status & Trends Report on Land Use & Population* has chronicled the historic changes in population and land use in California and around the Estuary from the Mission era through 1975. During this past decade, perhaps more than at any time in its history, California and the Estuary region have experienced the most fundamental change—change that could well be a harbinger of additional, significant economic and population growth and land use change and intensification in the years to come.

For example, during the 1980s, the State and the Estuary region bounced back from a national recession and became an economic locomotive on a world-wide scale. During this period 3.2 million jobs were created in the State—an increase greater than one-half the jobs created in the entire country (The Economist, 1990). The Silicon Valley in Santa Clara County emerged as a dynamic economic force spawning micro-electronic, high-technology industries throughout the Estuary region, from eastern Sacramento County to Santa Rosa in central Sonoma County. The economic opportunities and generally perceived high quality of life in California and the Estuary region attracted people from other parts of the United States and foreign countries in record numbers. During the 1980s, California's population grew to approximately 29 million people, an astonishing 23 percent increase. Although the Estuary region's population growth rate did not equal that of the entire state, the growth increase was still remarkable. The nine-county San Francisco Bay Area's population increased approximately 14 percent to just over six million people, surpassing the Philadelphia metropolitan area in population and becoming the fourth most populated metropolitan area in the country. The Sacramento area, which had one of the nation's highest growth rates, added approximately one-quarter of its 1.38 million population in the 1980s (San Francisco Chronicle, February 14, 1990). This significant increase in economic and population growth over the past decade has resulted in profound changes in land use and land use patterns throughout the Estuary region. The 1990s appears likely to be a decade of continued economic and population growth in the Estuary region and, consequentially, expansion and intensification of urbanization. The recent and likely future record economic and population growth in the Estuary region presents the citizens of the area with difficult and urgent choices concerning the region's future quality of life and the environmental health of the Estuary.

Purpose of the Report

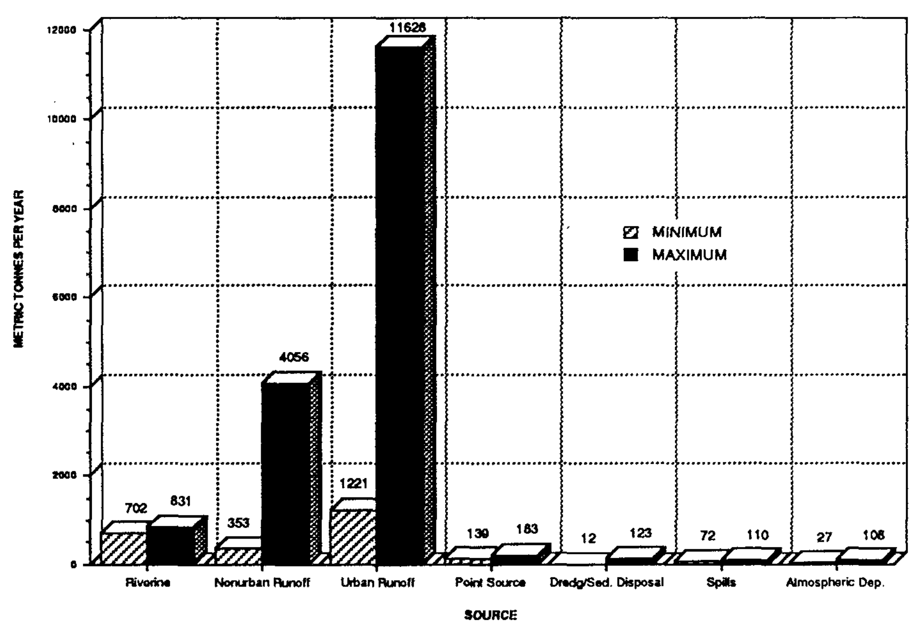
The purpose of this report is to characterize the extent and nature of the impacts of future land use change and intensification on the water quality and biological resources of the Estuary, and identify management options for Estuary land use planning, regulation, and management that will minimize the adverse impacts associated with land use change and intensification on the environmental beneficial uses of the Estuary.

Sources of Estuary Pollution

Direct impacts associated with urbanization and land use change are readily apparent to the observer. For example, a wetland filled for a housing development or a stream channeled as part of a flood control program is easily detectable. Indirect impacts, for example hydrocarbons washed into the Estuary from a new shopping center parking lot, are not as easily detected, and are very difficult to quantify. Pollutants enter the Estuary from a variety of sources: conveyed by riverine inflow from upstream sources; urban runoff (storm water and other runoff from urban areas); non-urban runoff (water runoff from agricultural lands, forests, and range lands, and irrigation return flow as surface runoff and subsurface drain water); point sources (publicly–owned treatment facilities and industrial discharges); dredging and dredged material disposal; spills of petroleum, chemicals, and other materials; and atmospheric deposition (fallout, or settling of pollutants transported by winds) (State Water Resources Control Board, 1990). The estimate of the range in magnitude of the Estuary pollutant loadings by the State Water Resources Control Board is shown in Figure 2.

Figure 2
Pollutant Loading to the Bay-Delta Estuary

SOURCE:
State Water Resources Control Board, Pollutant Policy Document, San Francisco Bay/Sacramento-San Joaquin Delta Estuary, June 21, 1990.



NOTE: Bars represent tonnes per year of calculated pollutant loads from identified sources. It should be noted however, that because of inadequate data the loads for some important categories of pollutants were not calculated for the sources shown and are therefore not included in this figure. Due to the varying toxicity of different pollutants, bar heights do not reflect either the toxicity of the pollutants or their impacts on beneficial uses.

According to the State Water Resources Control Board, annual pollutant loadings do not provide a complete picture of pollutant impact on the Estuary. This is in part explained by the variability of urban runoff over time. For example, the first rains of the wet season cause the discharge of highly concentrated pollutants over a short period with minimal dilution into the near shore waters of the Estuary. Further, estimates for pollutant loads from urban runoff are far less accurate than point source estimates (State Water Resources Control Board, 1990). Therefore the State Board used other sources of data to *estimate* the pollutant loads to the San Francisco Estuary as shown in Figure 2. The importance of this figure is the indication it gives of the relative magnitude of sources of pollutants. The most recent programs (1960s and 1970s) to abate Estuary pollution focused on municipal and industrial discharges of waste water. As a result, Estuary pollution from this former major source has declined significantly and contributes far less total pollutants than runoff and riverine inflow (State Water Resources Control Board, 1990). Riverine inflow originates outside the Estuary, and thus is not addressed in this report. However, the major source of pollutants to the Estuary is runoff—urban and non-urban—from within the region. The amount of pollutants entering the Estuary from runoff is directly affected by land use changes in the Estuary region. To address the most significant aspect of the problem, this report analyzes the impact of projected land use change on the quantity and location of pollutants entering the Estuary under existing land use patterns, and under two future land use scenarios.

Use of Geographic Information System In This Study

This study represents an innovative approach to problem analysis and land use planning in that it utilizes a Geographic Information System (GIS) developed at the University of California, Berkeley. (Note: the methodology for each phase of the analysis is explained in Chapter 2.) Because of the importance of the computer-driven GIS use in this report, a brief description of GIS generally, GIS as used in this report, and the technical capabilities of the process carried out in this study, which are applicable to similar regional planning studies, is discussed below. A description of the system is included here because this is the first time a GIS has been used to portray existing land use and to model possible future land use patterns and impacts for the 12-county Estuary region. As such, the system and the process offer a new and highly versatile regional planning analytical tool.

A Geographic Information System is a set of computer hardware, software, and procedures for sorting, manipulating, and displaying information about the earth. Combined with data describing earth features, a GIS becomes an application useful for answering questions and solving problems related to geographic features, and in particular, land use and land use change.

The technology of GIS borrows heavily from database management systems, computer graphics, computer aided design, computerized cartography, and image processing. However, it is unique in its view of geographic phenomena as data about the earth which can be defined both graphically, with respect to position, and textually or numerically, with respect to description. Through the use of a common coordinate system, in which every geographic feature is associated with an actual geographic location, information can be compared, studied, and analyzed.

The capabilities of GIS include inventorying a specific geographic variable, e.g., land use of a specific geographic area, querying for the existence of items of interest, measuring the extent of various features, analyzing the coincidence of multiple factors, monitoring change and its effects, and modeling past, present, and future conditions. Common applications include natural resource management, environmental assessment, land use planning, infrastructure mapping, and dynamic modeling.

The use of GIS capabilities has been critical to this study in several areas. GIS was used to develop a common data base for evaluating baseline conditions and testing assumptions. In particular, the GIS was used as a tool to:

- Map factors related to land use change and its impacts
- Study the coincidence between land use patterns and County plans
- Analyze the relationships between land cover and environmental factors
- Measure the extent of urbanization
- Evaluate historic patterns of environmental change
- Identify the location of development incentives and limitations
- Model aggregate potential development/growth areas
- Allocate projected growth based on development potential
- Assess environmental impacts of growth scenarios
- Project estuarine effects due to contamination/runoff

Report Contents

This report utilizes GIS to spatially and quantitatively model land use information and pollutant concentrations to: (1) arrive at plausible pollutant loadings for the receiving waters of the Estuary; and (2) estimate the amount and location of Estuary open water, wetlands, and stream environments impacted by land use change. In addition to the GIS work, the report analyzes the public and private institutions that affect land use change and different forms of Estuary regional land use planning, regulation, and management for better management of the Estuary. It is these analytical tools and management alternatives that, in concert with the information and suggested management options from the status and trends reports, are intended to provide the SFEP Management Committee with the information needed to develop actions to improve, restore, and protect the Estuary.

To establish an understanding of the information base and analytical process leading to the conclusions and recommendations of this report, Chapter 2 discusses the methodology used in this study to analyze the effects of land use change. The methodologies described include those used in developing the baseline of land use information, and the two land use change scenarios that drive the impacts analysis.

Chapter 3 gives a general description of the underlying forces of population growth and land use change and the kinds of private and public sector decisions, institutions, and authority that currently affect land use change.

Chapter 4 describes the relationship between land use and the environmental health of the Estuary and sets the stage for the examination and analysis of the impacts of land use change.

Development of an information baseline to compare future land use change and impacts is essential in this analysis. Consequently, Chapter 5 classifies, describes, quantifies, and maps the present (1985) basic land use types of the Estuary region: (1) wetlands; (2) urbanized uplands; and (3) non-urbanized uplands.

To quantify the possible future impacts of land use change, Chapter 6 presents two scenarios of future land use. The first scenario is based on the adopted land use plans of the 12 Estuary counties. The second scenario, founded on population forecasts for the region developed in the *Status & Trends Report on Land Use & Population*, presents a future land use pattern modeled on selected urban growth incentives and limitations.

The existing land use planning and regulatory framework in the Estuary Region is analyzed in Chapter 7, with particular attention to controls on wetlands and streams. In addition, the chapter contains a brief discussion of the contents and status of enforceable state-wide and regional planning legislation being considered in the California Legislature and the relationship of the legislation to Estuary protection.

Chapter 8 offers a range of land use management options which can assist in protecting, enhancing, and restoring the Estuary's environmental health and beneficial uses.

The report conclusions and recommendations are contained in Chapter 9.

C-098835

CHAPTER 2

METHODOLOGY USED TO ESTIMATE THE EFFECTS OF LAND USE CHANGE ON THE ESTUARY

The methods of analysis used in this report is described here. Three procedures were used to determine effects of land use change and intensification on the Estuary: (1) constructing land use scenarios; (2) measuring direct effects of land use change and intensification on wetlands and streams; and (3) measuring indirect effects of land use intensification on water quality. Figure 3 illustrates this process.

The first procedure produced a picture of current (1985) land use and two scenarios of future land use: Scenario I, General Plan land use, and Scenario II, a land use scenario based on modeled incentives and limitations to growth.

The second procedure measured the direct effects on Estuary wetlands and streams of the two land use scenarios. This process utilized an overlay method in which maps with different features and attributes were stacked in order to determine coincident and overlapping areas.

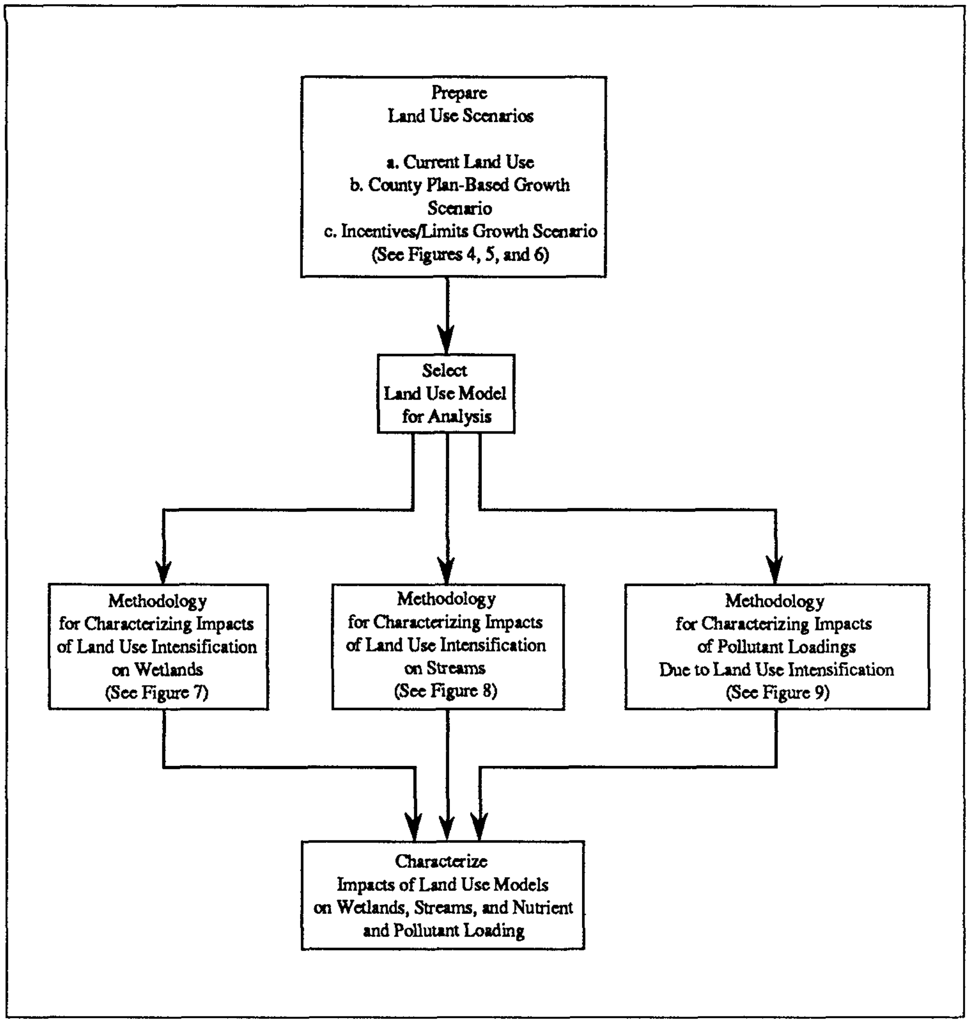
The third procedure generated estimates of pollutant loadings based on land use types and rainfall runoff. This nonpoint source urban runoff eventually makes its way to the Bay through streams, other waterways, and storm drains, carrying pollutants with it. Estimates of the quantities of heavy metals, nutrients and suspended solids were made for existing land use and both scenarios of future land use.

Figures 4, 5, and 6 illustrate the procedure used to construct the three land use maps. Figures 7 and 8 detail the procedure used to evaluate direct effects on wetlands and streams, and Figure 9 illustrates the process used to estimate indirect effects of land use change associated with urban runoff.

Effects were evaluated on the basis of hydrologic boundaries. *Receiving water segments*, comprising hydrologically and ecologically distinct parts of the Estuary, were mapped, along with their associated *receiving watersheds*. The *receiving water segments* used here and the *receiving watersheds*, in turn, were constructed to correspond to the *receiving water segments*, were based on a classification of the Bay–Delta by the Aquatic Habitat Institute (Gunther, 1987). Estimated impacts were then assigned to each water segment and watershed. Figure 10 describes the process by which the Estuary water segments and watersheds were delineated to serve as the unit of analysis for summarizing impacts.

Figure 3
Methodology for Characterizing Effects of Land Use Change and Intensification

SOURCE:
Center for Environmental Design Research, 1991.



Completion of this analysis was accomplished by building a Geographic Information System (GIS) using a software package called Geographic Resources Analysis Support System (GRASS). GRASS is an interactive tool for the management, analysis, and display of geographic data. This software includes capabilities for digitizing maps, for importing existing vector and raster (grid-based) data, and for performing boolean overlay, weighted modeling, tabulation, and other statistical analysis. Data, generally available in either digital form on computer tapes, or as paper maps that were converted to a digital format by technicians, were compiled into a comprehensive Bay-Delta data set to predict future land use patterns and associated environmental impacts.

Assumptions Used in Model Building and Measuring Impacts

The procedures used here reflect the uncertainties inherent in any method of projecting future development patterns and their impacts. However, an explicit statement of the nature of these uncertainties and the assumptions the analysts used to deal with this uncertainty is essential to appreciating the usefulness of the findings produced by this analysis. Frequently areas of uncertainty point to the direction in which further research will enhance our understanding of how land use affects Estuary health. Consequently, in this discussion of methods, an effort is made to identify sources of uncertainty.

Aggregating land use types into a six category classification scheme masks the true diversity of land uses on the ground. Each type will necessarily capture a range of land uses and the concomitant range of impacts to the environment. However, in this report, the level of aggregation arrived at by the analysts represents the most detailed classification that could be consistently applied across all General Plan designated land uses. The analysts feel comfortable with this level of accuracy for providing a characterization of the effects of land use change and intensification.

Procedures for Constructing Land Use Scenarios

1. **Current Land Use.** Figure 4 shows the sequence of steps taken to arrive at a map of current land use (as of 1985) for the Estuary region. For the Bay Area, the Bay Area Spatial Information System (BASIS) Land Use File, in digital raster

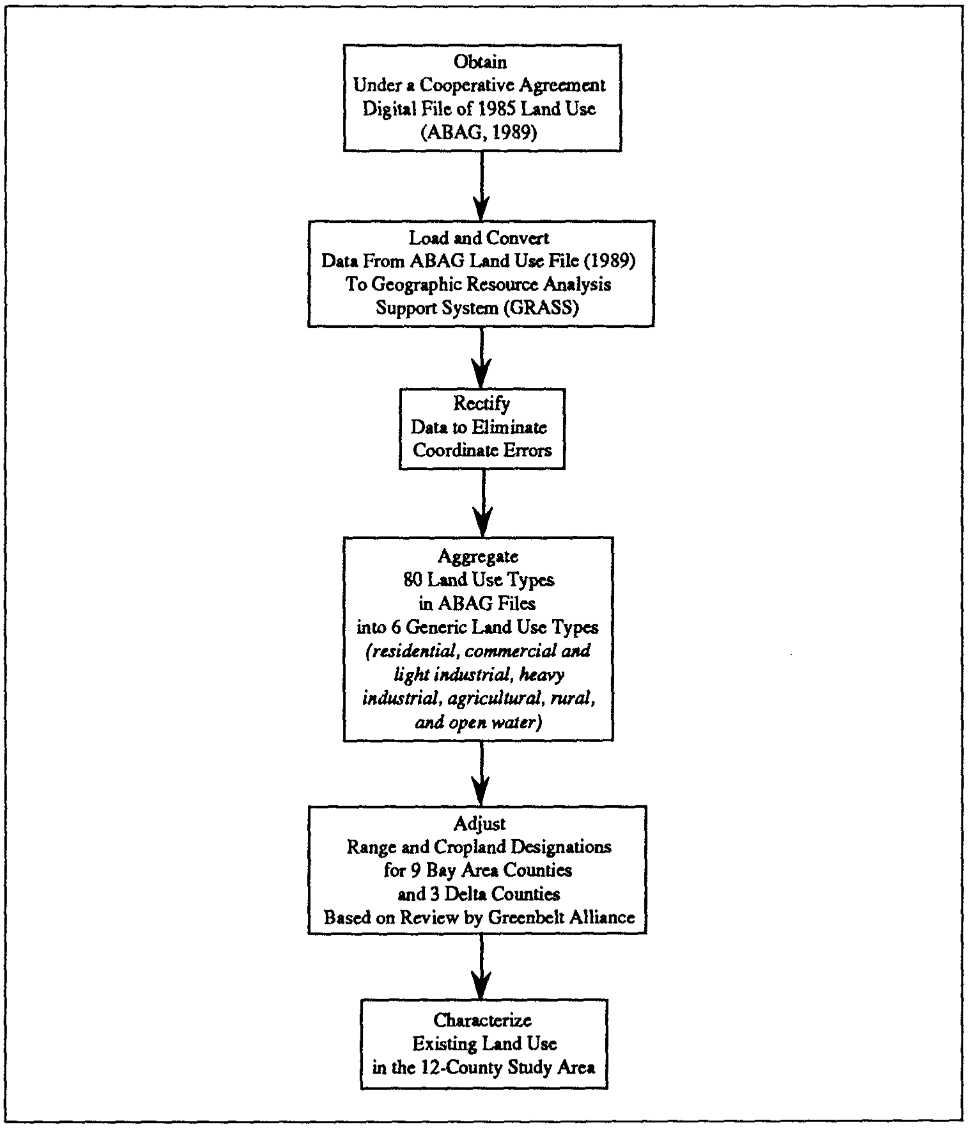


Figure 4
Methodology for Characterizing Current Land Use (1985)

SOURCE:
Center for Environmental Design Research, 1991.

format, was obtained from the Association of Bay Area Governments (ABAG, 1989). The ABAG land use file was in turn based on mapping prepared by the U. S. Geological Survey (USGS, 1972 et seq.), as part of its nationwide Land Use Data (LUDA) map series, from aerial photographs and satellite imagery, adapted to 1985 conditions by field inspections, census information, and imagery. The detailed land use types were aggregated into the six generic land use types used for this study—residential, commercial and light industrial, heavy industrial, agriculture, rural, and open water.

The Greenbelt Alliance adjusted range and cropland designations for the 12-county area to reflect more accurately the true status of these land types.

The resulting map of Current Land Use (see Figure 14) is the baseline for comparison of effects of land use change anticipated by each of the two scenarios of future land use.

2. **Scenario I: Growth Based on County General Plans.** Figure 5 illustrates the procedure used to develop the county plan land use scenario. The process involved creating a single map of land use allowed by each of the 12 Estuary county plans.

Current, adopted land use plans for the 12 Estuary counties were collected and reviewed. The land use planning categories of the different plans were reclassified to conform with the generic land use types chosen for this report.

General Plans are constantly undergoing revision and updating so the General Plan maps used in this scenario reflect only what was planned at the time of the analysis. This scenario is therefore a *snap shot* of planned growth taken in the early part of 1990, based on county land use plan maps through 2005, the horizon date of the SFEP.

The general plan maps were scaled and rectified to a standardized base map series at 1:62,500 scale (Metropolitan Transportation Commission, 1972), and then aggregated to produce a composite plan map for each county. These maps were sent to the county planning staffs in 1990 for review and comment, and corrections were incorporated. Then, each county plan map was digitized for computer analysis and a composite map describing the type, location, and extent of land uses proposed by the 12 counties was prepared.

Next, a future land use scenario map, based on general plans, was created by merging existing urban areas as shown in the current land use map (ABAG, 1989) with the General Plans. This also enabled the remaining urban land use categories in each county General Plan to be classified as future urban land use.

3. **Scenario II: Growth Based on Modeled Incentives and Limitations.** The purpose of the second scenario is to model the effects of land use change and intensification based on actual growth projections to the year 2005 (the SFEP time horizon). This required a two step process: step one generated a map indicating development potential for all lands in the Estuary, and step two allocated projected growth to those areas (see Figure 6).

This land use scenario projects where growth will occur by use of a model

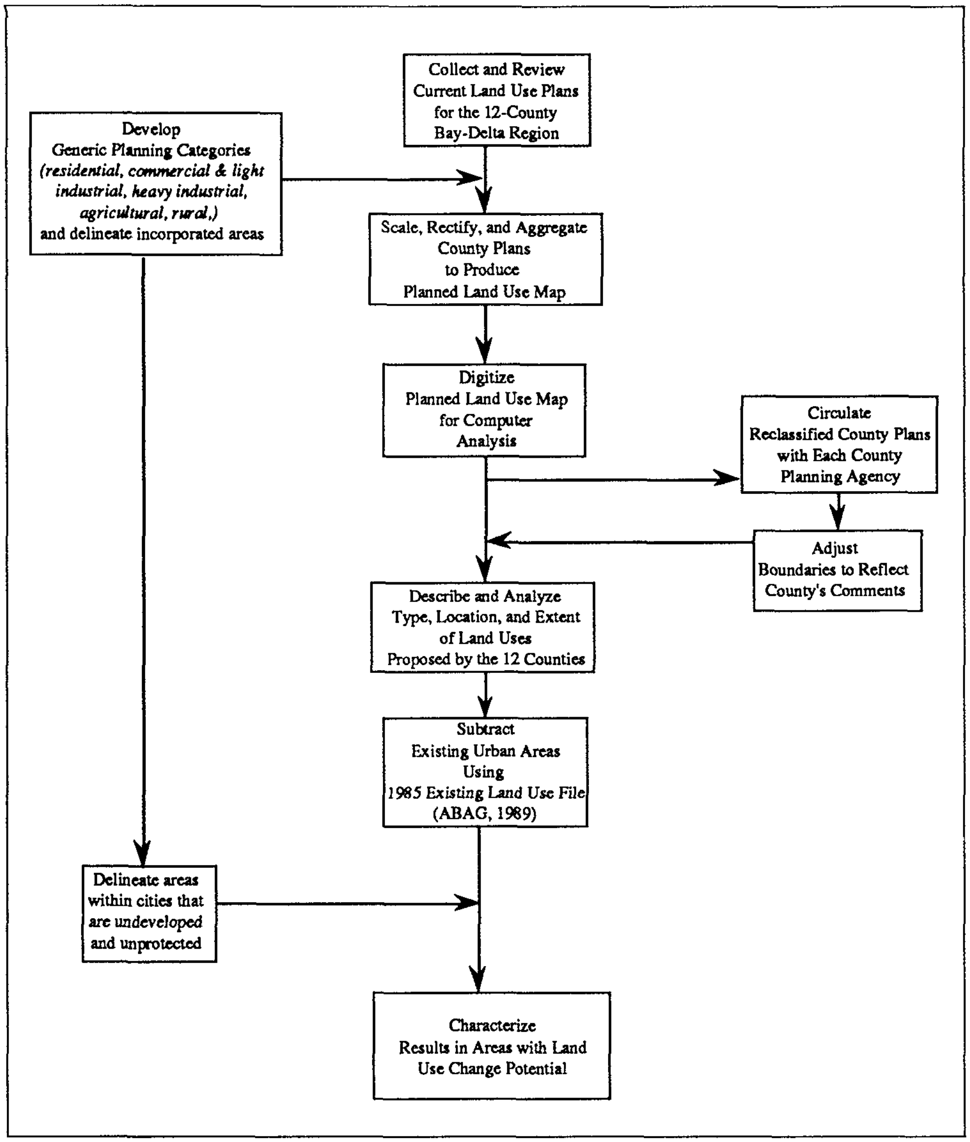


Figure 5
Methodology for Generating Scenario I: Growth Based on County General Plans and Potential for Development in Incorporated Areas

SOURCE:
Center for Environmental Design Research, 1991.

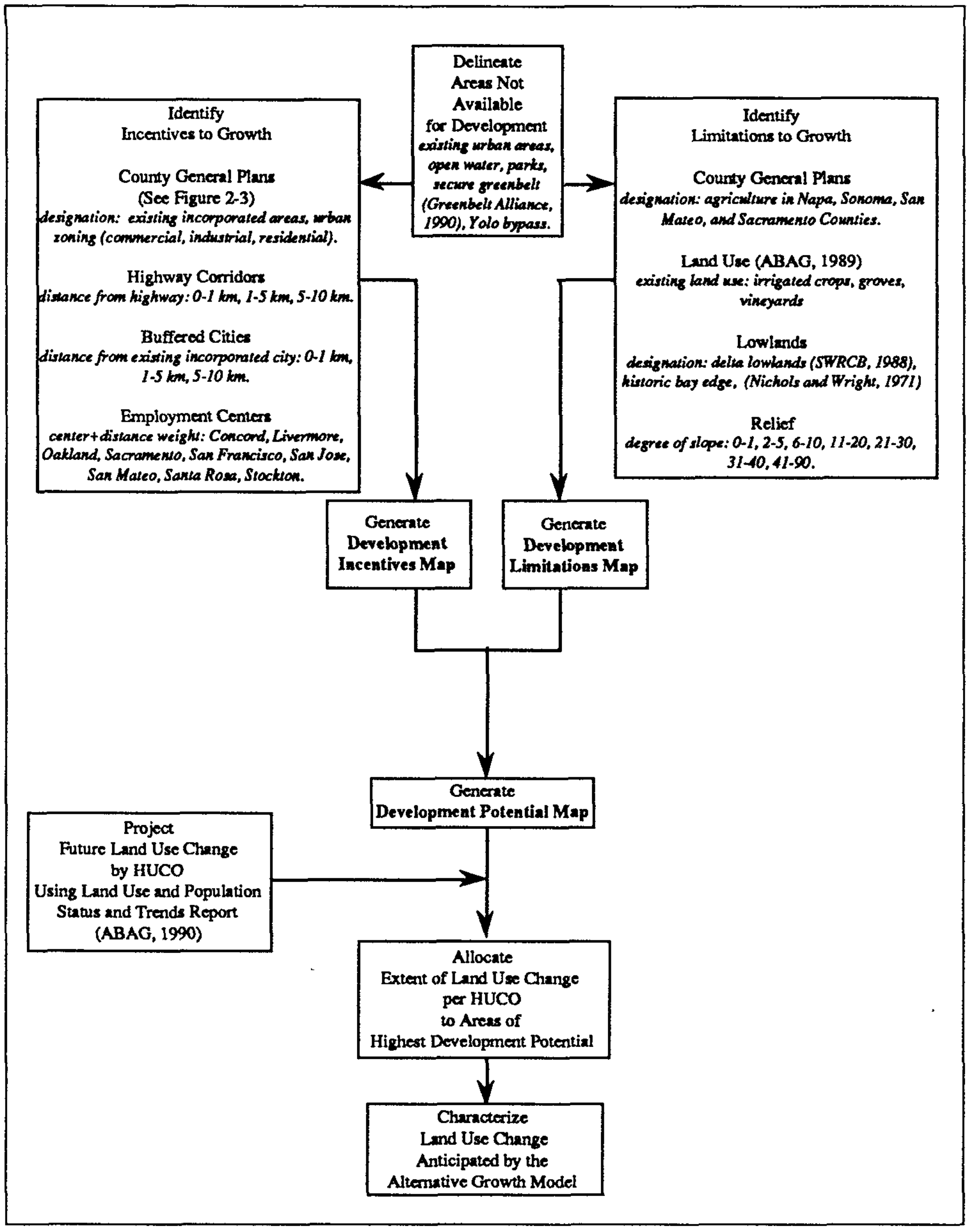
assigning weights to the geographic factors believed to determine growth. Though only one scenario using this model was generated for this report, changing the weighting of factors or updating growth projections would produce other scenarios with different effects on the Estuary.

It should be emphasized that while the growth model is certainly plausible, the authors do not claim it is either the preferred land use strategy or the most likely one.

a. **Generating a Map of Development Potential.** Three types of parameters which influence the urbanization potential of land were examined: land availability, geographic incentives, and geographic limitations. In future work in this GIS system, these parameters could be changed or modified to reflect new conditions that influence urbanization (e.g., service limits, strict seismic zoning, etc.).

Figure 6
Methodology for Generating Scenario II: Growth Based on Modeled Incentives and Limitations

SOURCE:
Center for Environmental Design Research, 1991.



A map layer delineating the areas not available for development was created. This layer included major water bodies, existing urban areas, dedicated public parks and similar protected open space, and the Yolo Bypass.

Next, a series of geographical incentives to development was identified. Areas designated for development by county General Plans, areas within existing city boundaries, adjacent to existing cities, along major highways, and within commute distances of major employment centers, were all considered to present incentives for urbanization. Each incentive was scaled into several classes. Numerical weights were assigned to reflect the relative importance of factors and the areas were delineated. The weights were then summed by overlaying the areas to produce an *incentives map layer*. Table 1 illustrates how weights were used in this process. The weights were then summed by overlaying the areas to produce an *incentives map layer*.

A similar procedure was used to create a development *limitations map layer*. These limitations included protected agricultural land, high value croplands, areas of moderate to high relief (slope), historic wetlands, Bay and Delta lowlands, and other areas of poor drainage. Table 2 provides an example of the weighting system used in this procedure.

DESCRIPTION	CATEGORY	VALUES
Land Use		
residential, industrial, commercial,	1-3, 7	25
agriculture, rural	4,5	0
Proximity to Highway Corridors (meters)		
0-1,000	1	30
1,000-5,000	2	20
5,000-10,000	3	10
>10,000	4	0

Table 1
Example of Weighting System for Incentives to Urbanization

DESCRIPTION	CATEGORY	VALUES
Slope (degrees)		
2-6	2-6	0
0-1, 11-20	1-7	5
21-30	8	20
31-40	9	35
41-90	10	50
Lowlands		
At or below 5 ft. (msl)		10
Inside Nichols & Wright Line		10

Table 2
Example of Weighting System for Limitations to Urbanization

The GIS then permitted a combining of these map layers to generate a single map representing the relative potential for urban development of all lands within the Estuary.

b. **Allocating Growth**. Growth projections to the year 2005 were published in ABAG's *Projections 89* (1989). These projections were documented in the San Francisco Estuary Project's *Status & Trends Report on Land Use and Population*. ABAG considered employment trends, population growth rates, current zoning, General Plans, and local development policies to forecast the physical extent of land use change. To ensure consistency between the specific allocations for growth in this scenario and the more general description in that report, the same projections were used. The projections were aggregated for 38 planning units known as HUCOs (hydrologic units plus county boundaries—areas defined by overlaying county boundaries onto major watersheds). Although more specific projections were available from ABAG on a census tract basis for the nine-county portion of the study area, these were not included in the *Status & Trends Report on Land Use and Population.* Nor were they used in this study, since these detailed allocations reflected a different set of urbanization assumptions than used by the study team.

However, in order to determine the impacts of urbanization on wetlands, streams and water quality, it was necessary to identify geographically where the growth was occurring. To locate this urbanization within each HUCO, a cascade approach was used. That is, the first increment of urban growth was assigned to land with the highest development potential; the areas with the second highest urbanization potential received the next increment. This procedure was continued until all the ABAG growth projections had been assigned to areas prone to urbanization.

Procedures for Estimating Direct Effects of Land Use Change

In order to evaluate the effects of land use change on stream and wetland resources, data describing the location and type of each resource were acquired and loaded into the GIS. The precision of an analysis such as this is in part a function of the size of the unit of analysis. The single hectare (2.47 acres) was the unit of analysis used for managing data. Units for area are given in acres throughout this report, but it is important to recognize that the figures given as estimates of potentially effected wetland and stream environments are calculated from hectares and are not accurate to the level of one acre.

1. **Wetlands.** As Figure 7 shows, the National Wetlands Inventory (NWI) was central to the assessment of impacts of urbanization on wetlands. The inventory, prepared by the U. S. Fish and Wildlife Service (USFWS), is based on the agency's interpretation of satellite and photo imagery. The agency digitized the interpreted images for computer manipulation using standard United States Geologic Survey 1:24,000-scale quadrangles as base maps. The National Wetlands Inventory digital files were obtained from the USFWS for this study and were instrumental to the analysis.

To facilitate meaningful analysis, the 210 categories contained in the original digital files were aggregated into the 14 wetland types used in the *Status and Trends Report on Wetlands and Related Habitats* prepared for the San Francisco Estuary Project (ABAG, 1991). These included: open water, mudflats and rocky shore, vegetated tidal marsh, tidal channels, diked vegetated wetlands, seasonal and permanent vegetated wetlands, seasonal ponds, farmed wetlands, freshwater marsh, riparian forest, salt evaporators, perennial lakes and ponds, tidal rivers, and nontidal rivers.

The next step was to prepare a composite wetlands map of the study area by assembling the individual maps. Eighty five of the 104 USGS quadrangle maps that have been prepared by the USFWS for the Bay-Delta region were obtained from the Fish and Wildlife Service. This acquired coverage includes the immediate shoreline of the San Francisco Bay, and most of the Delta. However, important lowland sections of the Delta were excluded because they had not been digitized by the USFWS, and thus were unavailable for this study. Obtaining the remainder of these files will enable analysts to produce comprehensive findings on the impacts of land use change on wetlands. At present, these findings should be discussed in full knowledge that for a percentage of the area, no wetlands data were obtained.

The two land use maps were then overlayed onto the composite wetlands map. The acreage of wetlands potentially impacted by land use under the two scenarios was then quantified.

2. **Streams.** As illustrated in Figure 8, the analysis of impacts on streams was based on 1:100,000 scale Digital Line Graph (DLG) files obtained from USGS

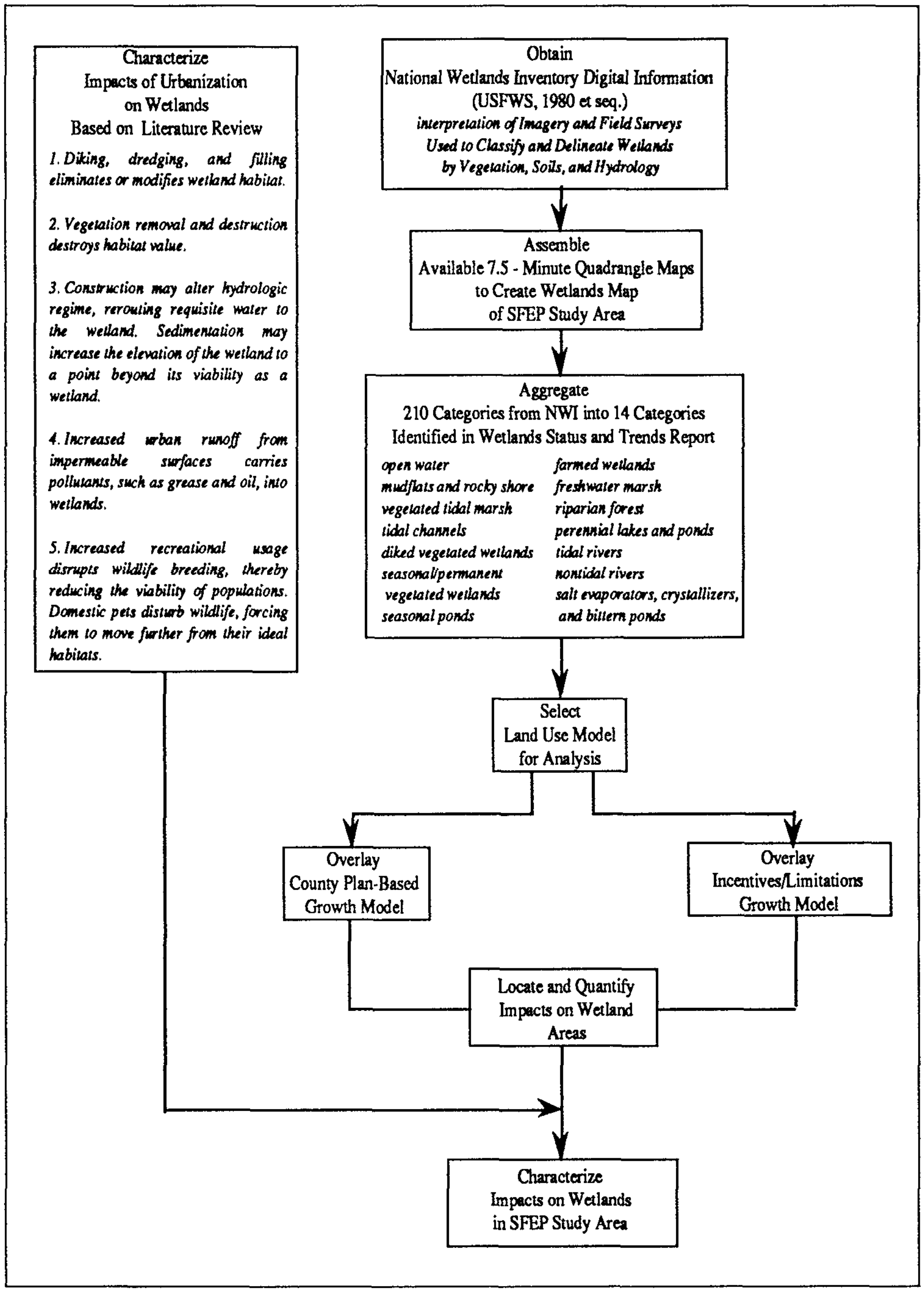
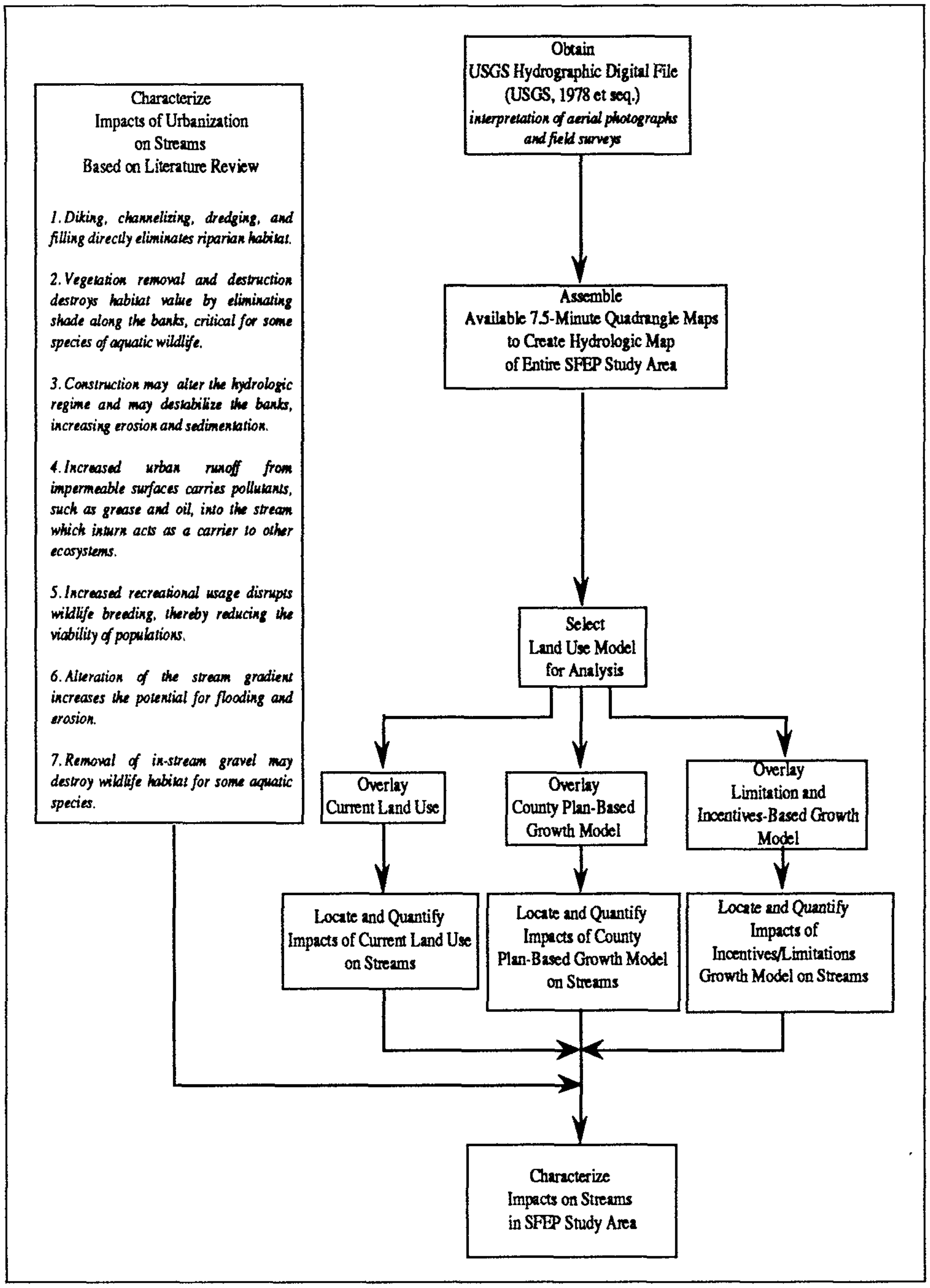


Figure 7
Methodology for Characterizing Effects of Land Use Intensification on Wetlands

SOURCE:
Center for Environmental Design Research, 1991.

Figure 8
Methodology for Characterizing Effects of Land Use Intensification on Streams

SOURCE:
Center for Environmental Design Research, 1991.



which portray streams, reservoirs, salt evaporation ponds, springs, aqueducts, ditches, canals, river banks and islands. These files were loaded into the GIS creating a data layer depicting streams as 100-meter (328 feet) wide zones encompassing the stream channel. The two land use maps were then overlayed onto the streams map. The acreage of stream environment zones potentially impacted by land use under the two scenarios was then quantified.

The use of area measurements for what appear as linear hydrographic features is appropriate from both an ecological and a data management standpoint.

The use of area conveys more effectively the processes and functions existing within a stream environment. Specifically the absorption of solar energy occurs over area, and this single input provides the basis for all other processes affecting the stream (plant growth, food web dynamics, etc.). The "stream environment zone" or "riparian corridor" is considered here in order to fully assess impacts to streams. Furthermore, units of area allow a more realistic comparison of streams in different areas. The distinction between small streams with narrow channels, and wide channel streams, is lost when the two are compared in linear terms.

From the standpoint of data management, area measurement permits the comparison of the full variety of data produced by the GIS, including impacts to wetlands. Area units also permit comparison to the BASIS land use file and its derivative products.

3. **Bay Lowlands/Delta Lowlands.** Lowlands of the Bay and Delta region were described using two classification systems: (1) for the Bay area, the Nichols and Wright Margin delineates tidal marsh that existed in the Bay in the mid-1800s (Nichols, Wright, 1971); and (2) in the Delta, lowlands were identified as areas at or below an elevation of 5 feet (MSL). Maps from the State Water Resources Control Board (SWRCB, 1988) identifying this region were obtained and entered as a data layer in the GIS.

These two classifications were combined to create the category "Bay Lowlands/Delta Lowlands,"—a class of resources used to identify limitations to development in creating Scenario II, the model based on incentives and limitations to urbanization.

Procedures for Estimating Indirect Effects of Land Use Change

Urbanization results in concentrations of pollutants in runoff higher than those of undeveloped lands. In this study, both the increased impervious cover and the higher concentrations of pollutants were used to determine estimates of increased pollutant loading associated with land use change and intensification.

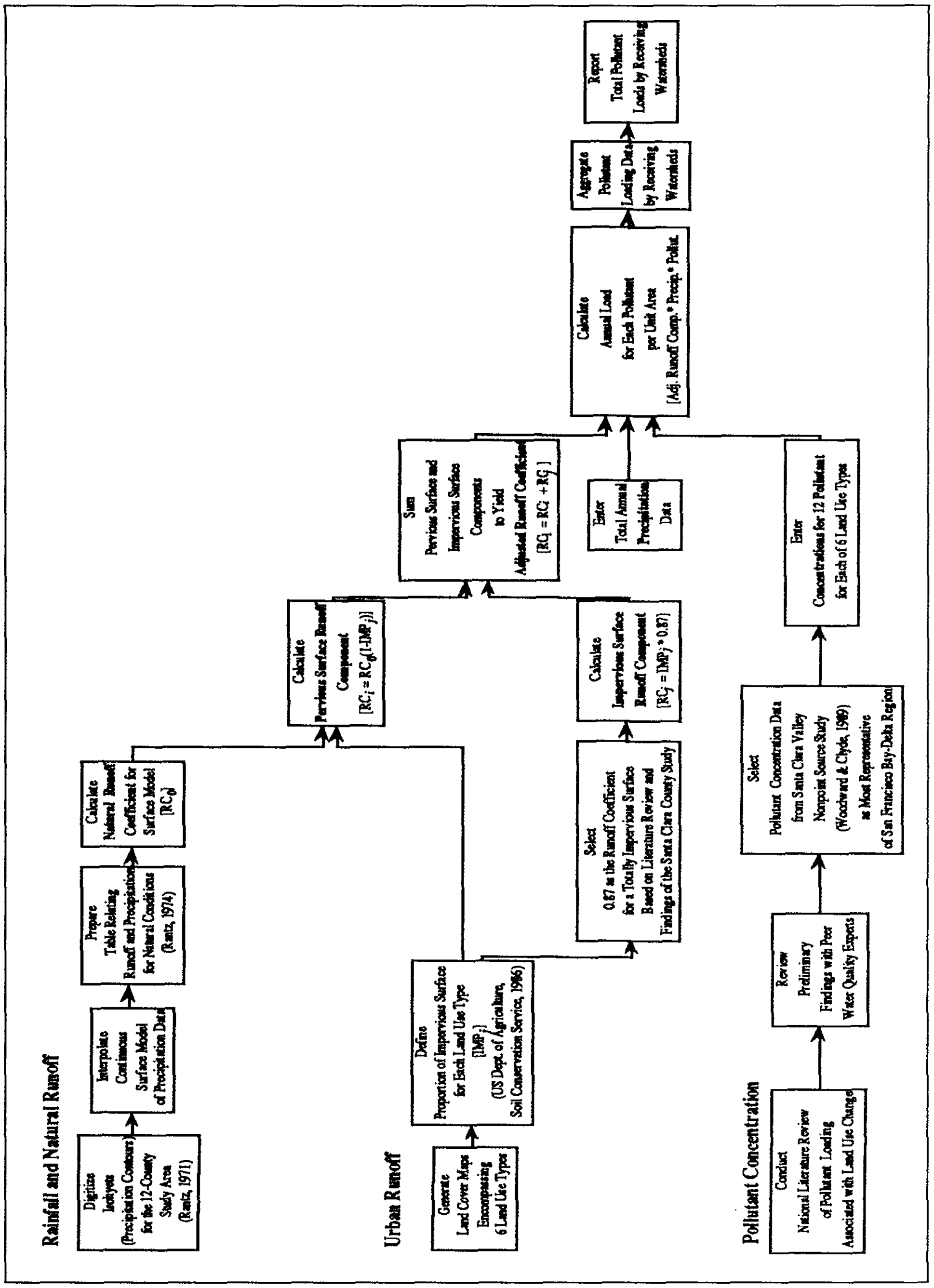
1. **Rainfall and Runoff.** Land use change and intensification is often associated with an increase in impervious cover. As impervious cover increases, the volume of rainfall runoff is increased. This is because rain falling on impervious surfaces is routed to streets and storm drains and runs off relatively quickly rather than infiltrating into the soil.

The runoff coefficient describes the relationship of precipitation to the amount of water available for runoff, for a given area. The top row of boxes in the flow diagram in Figure 9 illustrates the steps taken to determine the natural runoff coefficient. This coefficient is used to calculate the unimpaired, non-urbanized mean annual runoff for each one hectare cell in a watershed. It is derived from the mean annual precipitation map of the San Francisco Bay Region developed by Rantz (1974). Rantz' map provides isohyets (precipitation contours) of mean annual precipitation in one and two inch increments. The isohyets were digitized into the GIS, and from these contours a continuous surface model was interpolated.

The table developed by Rantz (1974) relating mean annual runoff and runoff

Figure 9
Methodology for Estimating Nutrient and Contaminant Loading

SOURCE:
Center for Environmental Design Research, 1991.



coefficient to mean annual precipitation for sub-regions of the Bay Area, was entered as a data file. Thus for each hectare-sized cell in the region a natural runoff coefficient was obtained. Both rainfall and runoff were empirically derived from 40 years of gagging station observations, rather than being modeled from physiography and other factors. Thus these numbers are responsive to local variations in the conditions of the Bay and Delta.

The runoff component for urbanized land was modeled from percent impervious surface in different land use categories, and on an assumed runoff coefficient for totally impervious surfaces of 0.87. This last coefficient, it is critical to note, represents the losses due to evaporation, and local catchment and percolation for a typical impervious surface. It is consistent with published values of "C" for the Rational Formula, and it produces results that are consistent with modeled runoff coefficients produced by the Storm Water Management Model (SWMM) in the *Santa Clara Valley Nonpoint Source Study* (Woodward-Clyde Consultants, 1991).

The amount of impervious surface associated with different land uses was estimated from U. S. Soil Conservation Service studies of urban hydrology (USDA-SCS, 1986). The mean value was chosen from these data. Local conditions may vary from this mean, thus introducing some uncertainty in the calculated runoff volumes. However, the significance of this source of uncertainty will be known only when future studies yield more accurate information regarding the relationship of pollutant loadings to impervious cover.

The flow diagram illustrates how the determination of this *impervious surface runoff component* was combined with the *pervious surface runoff component* to create an *adjusted runoff coefficient*.

2. **Pollutant Loading in Runoff**

a. **Water Quality Data**. In spite of considerable research detailing runoff and pollutant loading there have only been a few studies associating specific land use types to discrete unit mass. The bulk of research done is reflected in two nationwide studies: *The Nationwide Urban Runoff Program, NURP* (1983), conducted by the EPA; and the U. S. Geological Survey's *Urban-Stormwater Data base for 22 Metropolitan Areas throughout the United States* (1985). Because of the lack of a regional context and the wide range of values between urban areas in the report cited above, this report employs data derived locally in Woodward-Clyde's study of urban runoff water quality in the Santa Clara Valley prepared for the Santa Clara Valley Water District (Woodward-Clyde Consultants, 1991).

The Woodward-Clyde study considered seven land use types and modeled loads of heavy metals (cadmium, chromium, copper, lead, nickel, zinc), nutrients (nitrates, phosphates, total nitrogen), Biochemical Oxygen Demand (BOD), and Total Suspended Solids (TSS).

The *NURP* and the USGS reports were analyzed to provide a "yard stick" by which to reference this project's modeled unit mass loads. Comparisons were made of the mean, median, and first and third quartiles of runoff concentrations (in ug/l and mg/l) of ten pollutants used to characterize urban runoff. This statistical analysis allowed comparison with published data; it enabled a range of values to be modeled; and it permitted a comparison between individual sites or groups of sites within a study area.

Additional comparisons were made of data derived from the DUST Marsh, a "Demonstration Urban Stormwater Treatment" Marsh at the Coyote Hills Regional Park in Fremont (Alameda County), California (Meiorin, 1986). The DUST Marsh is a series of marsh segments that take diverted runoff from the Crandall Creek "K-Line" which drains stormwater runoff from a mostly residential (with minor commercial and agriculture) area of Fremont. These studies all compared favorably to the Woodward-Clyde data, and supported the choice to use that data in developing mean runoff concentrations for this analysis.

b. **Pollutant Loading**. For each hectare-sized cell in a watershed, the mean annual pollutant loads were computed by multiplying total precipitation, the adjusted runoff coefficient, and the mean runoff concentration. Annual loads (kg/yr) were then aggregated by receiving watershed and a sum calculated for each pollutant. This process was repeated for each land use scenario developed in the first phase of the study.

c. **Limitations of the Method.** The method of calculation used in this study takes account of the average changes in both runoff water quality and hydrology that are associated with urban development. In applying this methodology to the estuary study, there are inherent limitations based on the assumptions.

The first limitation is that this study uses water quality data from one area of the Estuary (Santa Clara Valley) and assumes that these data can be applied to the rest of the Bay Area. Differences in the character of industry, the degree of street cleaning, the relationship between annual precipitation and runoff concentration, etc., could all affect the average concentration of runoff.

Second, the methodology only calculates the load of material in runoff, and not the delivery to the Estuary. The routing of pollutants through the stream system to the Estuary is not taken into account. Dredging of flood control channels and detention basins, for example, could intercept pollutants associated with sediment and remove them from the water flow system before they reach the Estuary.

In the long run, however, it seems reasonable to assume that a steady-state will be reached, in which the outflow of pollutants from the fluvial system is equal to the inflow, with temporary storage in the system.

Additionally, some factors known to influence pollutant loading were not included in this model. These parameters, which include climatic variability, natural occurrences of heavy metals in soil, and vegetative uptake of pollutants, are the subject of future investigations.

Though a formal sensitivity analysis could not be performed on the models developed in this study due to their theoretical or predictive nature, the analysts developed a sense of the relative importance of the various parameters in modeling the effects of land use change and intensification. What the models offer is a characterization of the effects of land use change and intensification on the Estuary. Naturally, future iterations of this process will improve the resolution of the results and contribute yet further to the efforts underway to preserve the health of the San Francisco Estuary.

Delineation of Receiving Water Segments and Receiving Watersheds

Though watersheds naturally transcend political boundaries, they are the basis for determining hydrologic connections in the Estuary region. Therefore, watersheds and water segments are used as the geographical units of analysis for reporting each of the three classes of impacts of land use change and intensification presented in this report—impacts on wetlands, streams, and effects on nonpoint source pollution loads.

Figure 10 shows the process used to divide the Estuary Region into meaningful geographic units for analysis and presentation of results. Recognizing the need to treat the water and land components of the study area as a linked hydrologic system, 14 zones in the Bay and Delta waters were delineated. These zones, derived from a map prepared by Gunther (1987), show divisions of the Bay-Delta system based

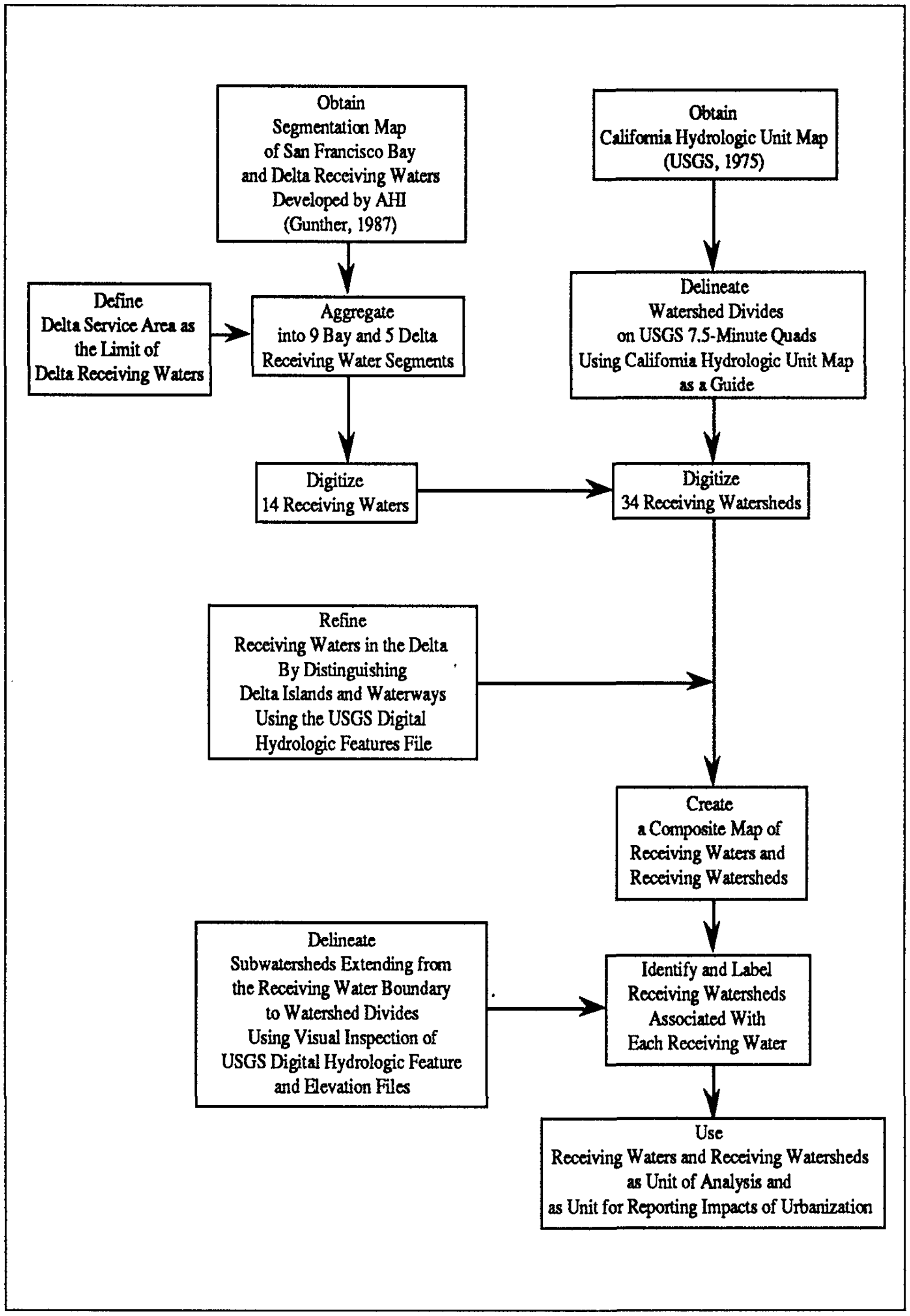


Figure 10
Methodology for Delineating Receiving Water Segments and Their Receiving Watersheds

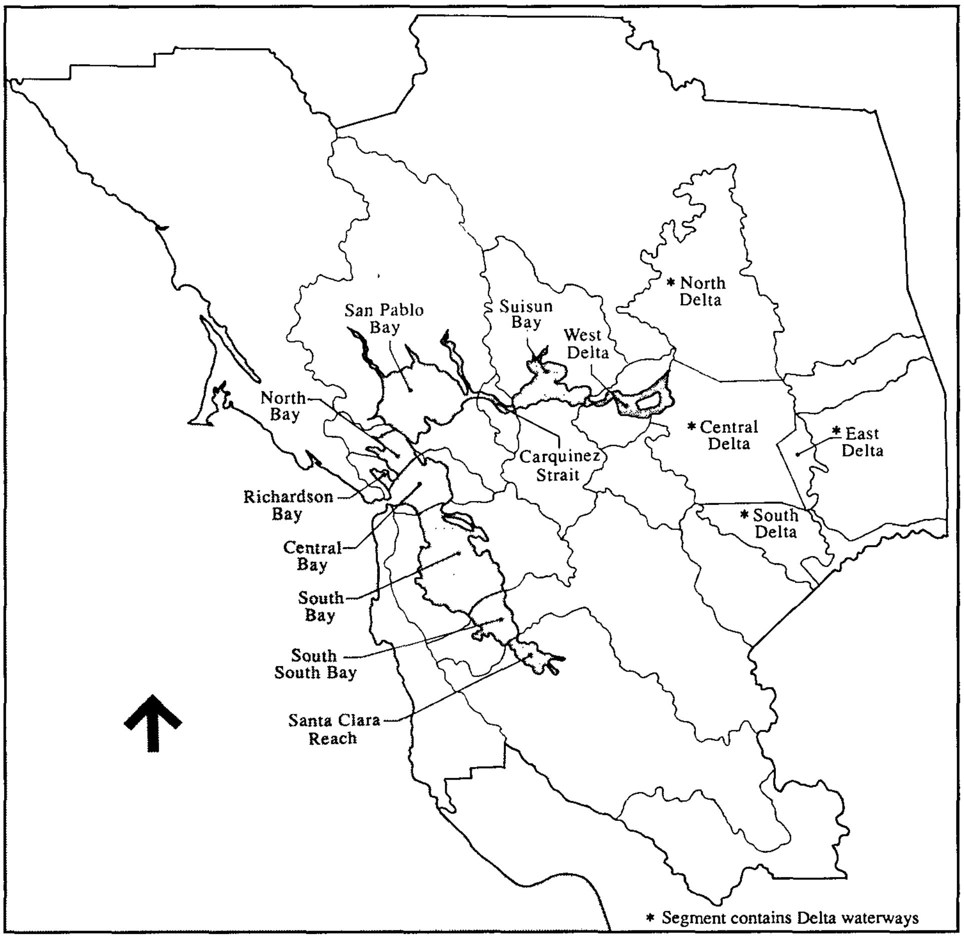
SOURCE: Center for Environmental Design Research, 1991.

on circulation, bathymetry, and other hydrographic characteristics. Figure 11 illustrates the Estuary's water segments.

USGS maps containing the major watersheds of the Bay and Delta region were obtained and transferred to 7.5 min. quads then digitized. The hydrologic units on these maps were then compared to the water segments identified by Gunther. Using visual inspection of elevation and hydrography, additional watershed boundaries inland from the receiving water divides were drawn, terminating at major watershed divides. In this process, 28 smaller watersheds were delineated, all feeding into the 14 water segments. Each water segment receives water from one or more watersheds. The terms *receiving waters* and *receiving watersheds* were coined to indicate this relationship.

Figure 11
Receiving
Water Segments

SOURCE: Gunther, 1987.



A process similar to the above was used to identify upland watersheds in the Delta. However, the remaining lowland portion of the Delta presented certain challenges to compartmentalizing its land and waters into *receiving waters* and *receiving watersheds*. Gunther divided the Delta Service Area (a State Water Resources Control Board administrative district surrounding state and federal water operations) into five receiving water segments of hydraulic and bathymetric similarity. For our purposes it was necessary to identify the land portions of these zones.

The islands and tracts within each zone were therefore identified collectively as a receiving watershed. The sloughs, river segments and channels were similarly grouped as one receiving water. An example of this is the East Delta where a portion of the San Joaquin River was identified as a receiving water and where two receiving watersheds were identified. The larger East Delta watershed is the partly urbanized upland segment containing eastern portions of Stockton. The smaller East Delta Island watershed is within the Delta Service Area and includes portions of Middle Roberts Island, Rough and Ready Island, and Sargent Barnhart Tract. Figure 12 shows the Estuary receiving watersheds.

Table 3 summarizes the extent of the 14 Bay-Delta receiving water segments and their respective receiving watersheds. The receiving water segments range from 360 acres for the East Delta to 86,200 acres for the South Bay.

Richardson Bay receives runoff from a single watershed. Other water segments, such as South Bay, South South Bay, San Pablo Bay, and Carquinez Strait are fed by two watersheds on opposite sides, arranged in a "butterfly wing" configuration. The receiving watersheds range in size from 1,140 acres for North Bay (east) to 1,646,50 acres for the North Delta.

In addition, Table 3 displays the islands within each receiving water segment, including small islands in North Bay (10 acres) and 5,110 acres of islands in the South Bay segment. (These islands are too small to be shown on the Receiving Watersheds map, Figure 12.)

Table 3
Receiving Water Segments and Their Receiving Watersheds (Acres)

RECEIVING WATER SEGMENT	AREA (acres)	RECEIVING WATERSHED	INDIVIDUAL WATERSHED AREA (acres)	TOTAL FOR SEGMENT (acres)
Santa Clara Reach	10,480	Santa Clara Watershed	525,200	
		Coyote/Alviso Slough Islands	280	
				525,480
South South Bay	25,300	South South Bay Watershed West	36,470	
		South South Bay Watershed East	443,700	
		South South Bay Islands	3,620	
				483,790
South Bay	86,200	South Bay Watershed West	66,560	
		South Bay Watershed East	105,520	
		South BayIslands	5,110	
				177,190
Central Bay	34,250	Central Bay Watershed West	2,450	
		Central Bay WWatershed East	25,720	
		Central Bay Islands	1,470	
				29,640
Richardson Bay	2,900	Richardson Bay Watershed	12,200	
				12,200
North Bay	16,080	North Bay Watershed West	27,170	
		North Bay Watershed East	1,140	
		North Bay Islands	10	
				28,320
San Pablo Bay	74,090	San Pablo Bay Watershed West	513,380	
		San Pablo Bay Watershed East	65,580	
				578,960
Carquinez Strait	4,010	Carquinez Strait Watershed North	5,230	
		Carquinez Strait Watershed South	14,990	
				20,220
Suisun Bay	24,510	Suisun Bay Watershed North	212,600	
		Suisun Bay Watershed South	130,550	
		Suisun Bay Islands	1,440	
				344,590
West Delta	16,290	West Delta Watershed North	23,820	
		West Delta Watershed South	32,680	
		West Delta Islands	11,000	
				67,500
North Delta	14,390	North Delta Watershed	1,646,560	
		North Delta Islands	285,480	
				1,932,040

Table 3 (cont'd)
Receiving Water Segments and Their Receiving Watersheds (Acres)

RECEIVING WATER SEGMENT	AREA (acres)	RECEIVING WATERSHED	INDIVIDUAL WATERSHED AREA (acres)	TOTAL FOR SEGMENT (acres)
Central Delta	24,110	Central Delta Watershed West	85,990	
		Central Delta Watershed East	85,270	
		Central Delta Islands	207,960	
				379,220
East Delta	360	East Delta watershed	284,760	
		East Delta Islands	33,160	
				317,920
South Delta	2,000	South Delta Watershed	176,580	
		South Delta Islands	89,290	
				265,870

Prepared by CEDR 1991
Modified after Gunther (1987), and USGS (1975)

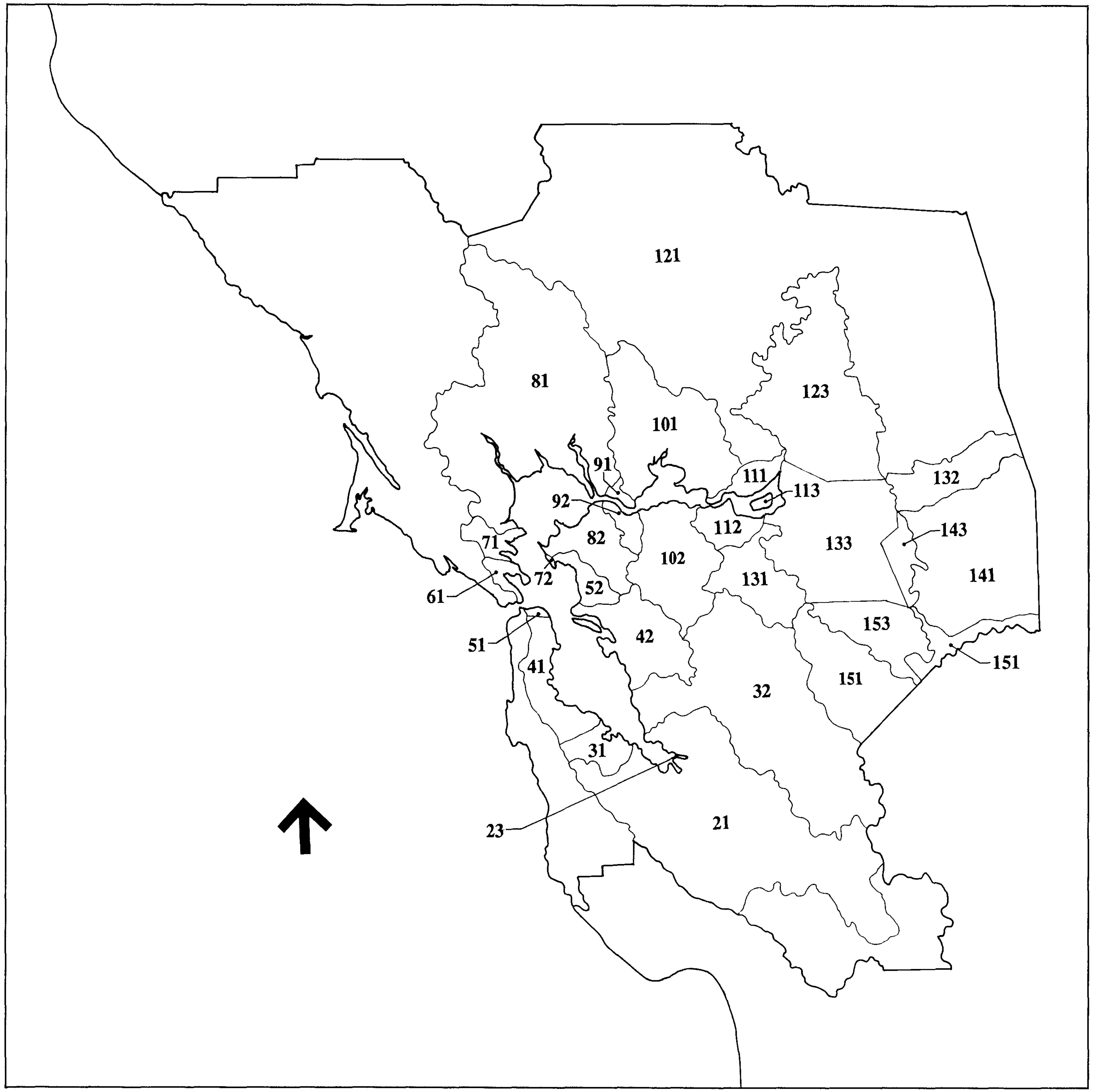


Figure 12
Receiving Watersheds

SOURCE: Center for Environmental Design Research, U.C. Berkeley, 1990.

No.	Receiving Water Segments/ Receiving Watersheds	No.	Receiving Water Segments/ Receiving Watersheds
	Santa Clara Reach		*Carquinez Strait*
21	Santa Clara Watershed	91	Carquinez Strait Watershed North
23	Coyote/Alviso Slough Islands	92	Carquinez Strait Watershed South
	South South Bay		*Suisun Bay*
31	South South Bay Watershed West	101	Suisun Bay Watershed North
32	South South Bay Watershed East	102	Suisun Bay Watershed South
33	South South Bay Islands	103	Suisun Bay Islands
	South Bay		*West Delta*
41	South Bay Watershed West	111	West Delta Watershed North
42	South Bay Watershed East	112	West Delta Watershed South
43	South Bay Islands	113	West Delta Islands
	Central Bay		*North Delta*
51	Central Bay Watershed West	121	North Delta Watershed
52	Central Bay Watershed East	123	North Delta Islands
53	Central Bay Islands		
			Central Delta
	Richardson Bay	131	Central Delta Watershed West
61	Richardson Bay Watershed	132	Central Delta Watershed East
		133	Central Delta Islands
	North Bay		
71	North Bay Watershed West		*East Delta*
72	North Bay Watershed East	141	East Delta Watershed
73	North Bay Islands	143	East Delta Islands
	San Pablo Bay		*South Delta*
81	San Pablo Bay Watershed West	151	South Delta Watershed
82	San Pablo Bay Watershed East	153	South Delta Islands

CHAPTER 3

DETERMINANTS OF LAND USE CHANGE

Land use changes in the Estuary region are determined by a wide range of factors. For example, the desirability of the area for business location and expansion and population in-migration will affect where and how land use changes. Interest rates affect the development of industrial plants, commercial facilities, and housing. Construction of transportation routes into undeveloped areas can induce growth or shift the growth in urban development from one area to another. The popular desire to own a single-family house in the suburbs with a yard and two or three automobiles will create a market force for low-intensity, dispersed urbanization patterns resulting in conversion of agricultural and rural land to urban uses and extensive reliance on the automobile for travel. Private and public sector plans and decisions concerning the location or relocation of new businesses and where people should live, work, and recreate directly affect land use change and intensification in the Estuary region and, consequently, the environmental health of the Estuary.

In this chapter, the kinds of private sector decisions that affect land use will be discussed and the role and authorities of public agencies to plan for and regulate land use change and intensification effecting the Estuary will be outlined (a subsequent SFEP report) will discuss the jurisdiction and authorities of local, state, and federal agencies affecting the Estuary in much greater detail). Further, because state tax law and policy, particularly post Proposition 13, greatly affects how local governments address land use, the fiscal determinants of land use affecting the Estuary will be briefly analyzed. Finally, because partnerships between the private sector and the public sector concerning stewardship of land affecting the Estuary are playing more and more of a role in land management in the Estuary region, the role of public-private land management partnerships will be discussed.

Private Sector Decisions

One of the key determinants of land use change is the large array of land use-related decisions made by the private sector, especially real estate developers, corporate businesses and owners of undeveloped land. How different individuals and business entities shape their land use decisions and, consequently, achieve their financial aims, depends on a wide range of diverse factors. Chief among these factors are: (1) the nature of the private enterprise and the product it sells; and (2) the time perspective of the enterprise, whether short- or long-term. Additionally, private

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sector land use actions are shaped by a vast array of exogenous circumstances, including market proximity, public facility provisions (such as transportation), quality of life concerns, and government land use regulation.

The following examines how land developers, corporate businesses, and land owners make land use decisions.

1. **Land Developers.** Land developers specialize in a variety of "products" for the market, among them office buildings, warehouses, manufacturing facilities, housing subdivisions, planned unit developments, and large lot luxury home developments.

For most developers, the goal is to build and market these products as quickly as possible, in a way that cuts the cost and delay of new development, while maximizing the sales or leasing potential of the development. This creates among many developers an essentially short-term perspective that "pulls" (or attracts) them to a development site which has land at low prices and adequate size, a receptive and predictable regulatory system, low development costs, and a market demand for the kind of development proposed.

a. **Land at Low Prices and Adequately Sized Parcels.** Depending on the type of project, developers are also strongly inclined toward land that is flat, or that can be easily graded—in other words, land which is easily buildable and where the cost and time of land preparation is minimal. Coincidentally, flat land in the Estuary region often includes sites that are composed of prime soil for agriculture—and even applies to lands containing seasonal or year-round wetlands.

b. **A Receptive and Predictable Regulatory System.** Perhaps above all, developers seek certainty in land use regulation. They want to know all planning and mitigation requirements upfront and are concerned about eleventh hour regulatory changes that could delay and/or add new costs to a project. The key is a land use regulatory process that is clear, puts development responsibilities up front, and does not change midstream during a project.

c. **Low Development Costs.** Land developers will pay close attention to taxes and fees (for everything from infrastructure to public art to child care) imposed by local jurisdictions and how those added costs will affect the marketability of their products. Often, these potential costs will influence where developers will locate their projects. Preferably, sites will be located as closely as possible to existing urban infrastructure, including roads and sewers, or to communities that have the financial resources and will invest the capital in new infrastructure. In addition, developers will carefully monitor the potential costs of environmental mitigation—for example, the cost of compensation for filling a wetland.

d. **Market Demand.** Developers will look at the intensity of public demand for their particular product. In addition, they may tailor their product to the path of least public resistance (irrespective of environmental impact), in terms of the type of development they believe the general public, neighborhood groups, and elected officials will accept. As a result, developers may opt for the "safe" route of lower density commercial and residential projects, despite the worsening effect such development might have on impacts like urban run-off or automobile traffic and its attendant environmental impacts.

The combined effect of these factors compels developers to look for locations with low land and infrastructure costs and reduced regulatory requirements. Often, the locations meeting these criteria are at the urban fringe or completely outside of existing towns or cities—candidate sites for "leapfrog development"—which have the effect of continuing to pull new development outward and away from existing urban areas.

This is not to say that commercial and residential developers ignore opportunities in already built-up areas. In fact, in some instances a number of developers will agree to work within existing urban areas and accept significant community-based requirements if, in exchange, their development proposals are guaranteed smooth passage through the permitting process and are protected from new requirements during the course of construction. This type of arrangement stems not so much from private enterprise concern for community standards and overall land use patterns, but from concern about reducing risk and assuring a reasonable financial return. The principle means of guaranteeing a link between private developer land use decisions and environmental or community standards, is through a clear public land use regulatory framework, identifying appropriate receiving areas for development (in terms of available infrastructure and reduced environmental impacts).

2. **Corporate Business.** Corporate businesses also look for low costs and certainty in the planning process. However, because large- and medium-sized corporations often locate (or re-locate) major shares of their operations, and live with the consequences of those locations for some years, they tend to think more strategically about where to locate new facilities.

In the United States, the top five "pull" factors (which attract enterprises) considered by large- and medium-sized employers are straightforward business concerns: (1) land and leasing costs; (2) market proximity; (3) land and space availability; (4) available pools of skilled labor; and (5) high quality transportation systems.

However, in the San Francisco Estuary region "quality of life" also plays a major role in determining corporate location. In a recent report by Pacific Gas & Electric Company and Greenbelt Alliance (Pacific Gas and Electric Company et al., 1990), researchers found that quality of life issues, such as the surrounding physical environment, ranked consistently high among the factors looked at by corporate planners. This finding remains true, irrespective of the enterprise focus (manufacturing, research and development, or services). Only in the case of distribution and warehousing enterprises did business concerns, such as land cost and availability, significantly outweigh quality of life factors.

The authors of another study done at the University of California, Berkeley (Center for Real Estate and Urban Economics, 1990), observed that quality of life factors, such as housing costs, figure more heavily in the Estuary region. One of the main explanations for this is the high-end service and manufacturing nature of the region's economy, and the need for a highly educated and well trained labor force, especially in the Bay Area.

Because of quality of life concerns, corporate businesses may factor environmental concerns into key land use decisions. However, these concerns may be related more to a corporate facility's labor needs (available pool of relatively well educated, skilled employees) rather than environmentally sound land use planning. For example, Bank of America is moving many of its back-office operations into the last undeveloped valley along the Interstate 80 corridor between San Francisco and Sacramento (Lagoon Valley near Vacaville, Solano County), in part because of its pleasing environment (it is now home to extensive agriculture and nurseries) and despite available, already-serviced land within the adjacent city of Vacaville.

Accordingly, as with land developers, corporate businesses base their land use decisions on immediate and internal interests, and not necessarily on the larger community or environmental concerns. In fact, much of the outward spread of urbanization in the nine-county Bay Area has been catalyzed by the shift of major corporate offices to outlying communities where the main reason for moving was (at the time) relatively cheap and plentiful land. This trend is also evident in the three Delta counties, particularly Sacramento County.

3. **Land Owners.** Owners of non-urbanized lands can be generally divided into two basic categories: those with a short-term interest in selling their property and making a profit, and those with a long-term interest in holding their land, either in the hope of increasing their financial return from future sales or for the purpose of keeping their land in a non-urban use, most likely agriculture.

The ratio of short- to long-term buyers depends on the rate of sales turnover in the real estate market and the extent to which transactions are influenced by a clear and firmly enforced governmental land use policy. The tendency toward short-term ownership—and a strong desire to subdivide land into developable parcels—is obviously higher in a hot seller's market. But the tilt toward short-term ownership is increased by the lack of a clear, enforceable land use plan. Farmers who know that their land is planned and zoned for agriculture—without any foreseeable changes—are unlikely to option or outright sell their property. In large part, that is why rural properties in western Marin County, zoned at a 60 acre minimum parcel size (and enforced that way for nearly 20 years)—have remained in dairy farming and not in speculative bidding. On the other hand, much of the agricultural land around Tracy (in San Joaquin County, between Interstate Highways 580, 5, and 205), has been optioned to development interests, not only as a result of investment pressures but also because of continual revisions of the city's General Plan. The situation is increasingly similar in Solano County, where the impending expiration of county-wide land protection policies (in 1995) is spurring the rapid turnover and optioning of thousands of acres of prime farmland along what developers have termed the "path of growth"—the Interstate 80 and 505 corridors between Vacaville, Dixon, and Winters.

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While such an explosive short-term market may favor land owners interested in a quick and lucrative return, it can have two damaging effects in terms of a stable land use pattern and environmental management. First, an unstable market dominated by soaring speculative land values can put enormous pressure on land owners with a long-term perspective—especially farmers and ranchers—to sell their holdings and move on, due to the low yield nature of their business and mounting tax burdens. Second, short-term speculation can encourage land owners to seek the sudden and maximum parcelization of their lands, even though, in the long-term, the parcel sizes and patterns may not be conducive to the best development site design, in terms of environmental protection.

Again, as with decisions taken by developers and corporate businesses, commercially-driven decisions by land owners are frequently divorced from larger land management and environmental considerations.

Public Sector Decisions: Authorities and Policies

In addition to the economic factors which influence private sector decisions effecting land use change discussed above, governmental decisions play a major role in shaping land use patterns, change, and intensity throughout the Estuary region. Land use within the Estuary is planned, regulated, and managed by a number of public agencies: local, regional, state, and federal. Of these four, local government has the most broad and direct authority concerning land use and is thus the most influential or critical sector in the decision-making array. In a democracy, governmental decisions concerning land use and intensification occurs in a process of public involvement and participation. Consequently, land use decisions are subject to the political tugs and pulls that is the hall mark of our political and democratic process. We begin our discussion of the public sector agencies by focusing on the role of local government in land use matters.

1. **Local Government**. Local governments affecting land use in the Estuary region include counties and cities, Local Agency Formation Commissions, and special purpose districts.

a. **Counties and Cities**. Broad general powers were granted to cities and counties by the Legislature through the State of California's Planning and Zoning Law (California Government Code Sections 65000-65997). Local government was delegated the task of protecting "California's land resource, to insure its preservation and use in ways which are economically and socially desirable in an attempt to improve the quality of life in California." Cities and counties in the Estuary region guide the physical development of their land resources through their General Plans and carry out the policies of these plans through their land use regulations, principally zoning, which set specific criteria for, among other things, intensity and density of land use.

The General Plan policies that are most indicative of how the Estuary will be affected by local government decisions are found in the state-mandated land use, conservation, open space, and safety elements of each community's General Plan. The land use element must designate the proposed extent of the various categories of use (e.g., residential, commercial, industrial, agricultural) and reflect the community's intent regarding land use change, and intensity of use, including population growth. The conservation element is required to address pollution of streams and other water, use of land in stream channels, and erosion and flooding. The open space element must address what land should be managed for recreation, wildlife habitat, and agriculture. The safety element is intended to identify and protect the community from natural hazard risks such as earthquakes, landslides, subsidence, and flooding. These last three elements can be used to set the community goals regarding management of growth to protect natural resources, such as the Estuary. Thus the tools for Estuary protection are included in local planning law mandating city and county General Plans to guide the future land use and intensity of use of a community.

Each Estuary region local jurisdiction will, of course, use the mandated general plan elements to guide development and land use management in its own unique way according to the values of the particular community, and thus an analysis of each of the plans and elements in conjunction with implementing regulations is necessary before one can reasonably predict how land use will change in a specific community.

b. **Local Agency Formation Commissions**. Local Agency Formation Commissions (LAFCOs) were created by the Legislature (California Government Code Sections 56300 - 56498) to discourage urban sprawl and encourage orderly formation and development of local agencies. Members of each county LAFCO include members of the Board of Supervisors, city councils, special districts, and a public member. The 12 LAFCOs within the Estuary region are influential in determining land use change, or more precisely, urban growth patterns. While the LAFCOs have no land use planning and regulatory authority, they do determine the limits of where urban expansion may occur and the provision of urban services, such as water supply and sewage treatment. LAFCOs control the boundaries of cities and special districts and have the authority to approve or deny requests for annexations, detachments, consolidations, city incorporations and district formations, disincorporations and dissolutions, mergers, subsidiary districts, and reorganizations. To guide its regulatory decisions, LAFCOs must adopt a plan known as a "sphere of influence" for each city and special district. A sphere is an agency's probable, ultimate service area and boundary. All LAFCO boundary decisions must be consistent with these sphere of influence.

Thus, the conversion of agricultural or rural land to urban uses is to a large degree within its control. Because the change of land use from rural to urban affects the amount and kinds of pollutants that reach the Estuary, LAFCOs have an indirect, but important, land use management role in determining what kinds of pollutants are carried to the Estuary from nonpoint sources.

c. **Special Districts**. The plans and proposals of special purpose districts can also affect the Estuary. Special districts are formed to provide some type of community service and the service is financed by taxing or charging fees to the landowners within the boundaries of the district. Such services could include such things as water supply, sewer facilities, flood control, and park and recreation services.

Special districts, for the most part, do not consider themselves to be instrumental in affecting land use change, but instead interpret their role as reacting to land use changes by providing essential services. For example, many districts believe they are required to provide urban service under their mandate, but do not believe their decisions facilitate urban growth. This view may be somewhat misleading. First, some districts in the Estuary region include both urban and agricultural uses (e.g., irrigation districts), and the facilities constructed to serve the district are often adequate to service both kinds of uses. Thus, an irrigation district with a 5,000 acre service area, created to serve agricultural uses, might have 100 acres of low-density developed land and a capacity to service a much greater amount and density of urban development. The capacity to serve a greater urban density and intensity may be inconsistent with the local general plan or zoning ordinance which might call for maintenance of the area for prime agriculture.

Special districts can play a critical role in determining how much and where future urban growth in the Estuary will occur. They can also, to a great degree, have influence on the future health of the Estuary. Special districts control the water supply in the Estuary region and each district has a water allocation. The allocation of water is a primary determinant in where and when urban growth will occur.

Outside review by the public or state and federal agencies of special district activities is quite limited. For example, capital improvement programs are not reviewed for consistency with local general plans and zoning.

However, special district law can be a useful tool in protecting and managing the resource values of the estuary. For example, in the case of the Suisun Marsh in Solano County, the Suisun Resource Conservation District, a special district devoted to the management of diked wetlands to maximize their habitat value for migratory waterfowl, has assisted its 150 duck club owners in preparing and carrying out detailed water and vegetation management plans and programs significantly contributing to the beneficial uses of the Marsh.

2. **Regional Government**. There is no single land use planning agency with jurisdiction over the 12-county Estuary area. However there are three regional Councils of Government (COG's): voluntary confederations of cities and counties created by joint powers agreements. The COG's are: (a) the Association of Bay Area Governments (ABAG), which embraces Alameda, Contra Costa, Solano, Sonoma, Marin, San Francisco, San Mateo, Napa, and Santa Clara Counties; (b) the Sacramento Area Council of Governments (SACOG) representing local governments in Sacramento, Yolo, Sutter, and Yuba Counties and the Cities of Roseville, Rocklin, and Lincoln in Placer County; and (c) the San Joaquin Council of Governments representing local governments in San Joaquin County. COG's provide their member local governments with technical planning assistance and often serve as forums for discussing regional matters. When the federal government streamlined its

requirements for reviewing grant applications in the late 1970s, COG's shifted away from regional planning and grant reviews. The principal current function of COG's are to provide special services to their members, technical support for local government General Plan housing elements, and prepare regional hazardous waste management plans.

SACOG, however, undertakes regional transportation and air quality planning for its area as well. ABAG has specific statutory recognition and prepares the "San Francisco Bay Regional Environmental Plan" which includes the regional air quality management plan and the regional water quality management plan. State agencies must rely on this document to meet federal requirements. In addition, ABAG also prepares the regional solid waste management plan and hazardous waste management plan. Further, ABAG is required by law to cooperate with the Metropolitan Transportation Commission, providing regional land use information to the regional transportation planning agency (Senate Select Committee on Planning California's Growth, 1988).

3. **State and Federal Agencies.** State and federal agencies have the least ability to control overall land use changes in the 12-county area, primarily because their authority is restricted by law to authority over specific resources or limited geographic areas. Even though the state and federal agencies have limited land use authority, they are likely to have an influential role in controlling projects that have a direct impact on the Estuary—generally diking, filling, or discharges, in the Estuary and adjacent wetlands.

Because there is considerable geographic overlap of authority and interrelationship of state and federal law concerning Estuary protection, the following discussion will center on the principal state and federal agencies with Estuary land use planning and regulatory responsibilities, concentrating on their authority and policies.

The State agencies most affecting land use and regulation in the Estuary include the San Francisco Bay Conservation and Development Commission; California Department of Fish and Game; State Water Resources Control Board; and the California Regional Water Quality Control Boards for the San Francisco Bay Region and the Central Valley Region. Federal agencies include the U. S. Environmental Protection Agency, U. S. Army Corps of Engineers, and U. S. Fish and Wildlife Service.

a. **The San Francisco Bay Conservation and Development Commission.** The San Francisco Bay Conservation and Development Commission (BCDC) was created by state legislation, the McAteer-Petris Act, in 1965 and made a permanent agency in 1969 by amendments to the Act (Government Code Section 66600 et seq.). BCDC has comprehensive land use planning and regulatory authority over San Francisco Bay and its tidal marshes, certain tributary rivers and streams, diked managed wetlands, salt ponds, and a 100-foot shoreline band around the Bay. Any filling, excavation of materials, or change in use of any water, land, or structure within BCDC's jurisdiction requires a permit from BCDC.

All projects authorized by BCDC must be consistent with its policy plans, the *San Francisco Bay Plan* and *Suisun Marsh Protection Plan*, the provisions of the McAteer-Petris Act, and Suisun Marsh Preservation Act.

The McAteer-Petris Act restricts placement of fill in the bay, tidal marshes, and tributary waterways to water-oriented uses, including ports, water-oriented recreation, bridges, water-related industry, wildlife refuges, water intake lines, airports, and for minor fill for improving public access to the Bay or shoreline appearance. Further, any fill authorized must be the minimal amount needed for the purpose of the project and there must be no alternative upland site for the project.

In salt ponds and managed wetlands outside the Suisun Marsh, however, BCDC's regulatory authority is not as strong as its bay, certain waterway, and tidal marsh jurisdiction authority. The McAteer-Petris Act and the Bay Plan policies provide that as long as economically feasible, the salt ponds should be maintained in salt production and the wetlands should be maintained in their present use. However, the McAteer-Petris Act and the Bay Plan policies provide that if the owners of any salt ponds or managed wetlands desire to withdraw any of the ponds or wetlands from their present use, the public should purchase the lands for restoration to the Bay and if public funds are not available for purchase of all the ponds or wetlands, any proposed development of these areas should assure that the maximum amount of open water area remains as part of the development and be dedicated to public use. Thus, if certain economic criteria supporting the assertion by owners of salt ponds and managed wetlands that it is no longer feasible to maintain these facilities in their present use is accepted by BCDC, then these wetland areas, under BCDC's law, can be developed for any use as long as the development contains the maximum amount of open water.

In the Suisun Marsh, the managed wetlands under the Suisun Marsh Preservation Act and Suisun Marsh Protection Plan, are to remain in managed wetland use.

b. **Department of Fish and Game**. All projects which involve diverting or obstruction the natural flow of a stream or change of its bed, channel, or bank must be reviewed and approved by the Department of Fish and Game. A project will not receive a stream alteration permit if it substantially adversely affects fish and wildlife (Fish and Game Code Sections 1601, 1603). However, the Department cannot deny projects and the project is submitted to an arbitration if the Department and project proponent disagree.

c. **State Water Resources Control Board and the California Regional Water Quality Control Boards, San Francisco Bay and Central Valley Regions**. The San Francisco Bay Regional Water Quality Control Board (SFRWQCB) administers the water quality regulatory program in the Bay Area. The Central Valley Regional Water Quality Control Board (CVRWCQB) administers the program for the Delta. These Boards are overseen by the State Water Resources Control Board (SWRCB), and, at the federal level, by the Environmental Protection Agency (EPA). The State Board also regulates diversion of fresh water from tributaries to the Bay. The Regional Boards have identified the respective beneficial uses of the Bay and Delta, including natural and aesthetic uses, and implement programs to protect these uses. The Boards' authority is based on federal law, the Clean Water Act, and state authority, the Porter-Cologne Act.

(1) **The Clean Water Act.** The Clean Water Act (CWA) is the central law in the federal water pollution control program. Passed originally in the late 1940s, the CWA has been amended repeatedly; the 1972 amendments were the most comprehensive of these and established the current program. Reauthorization of the CWA will be considered by the Congress soon.

The 1972 amendments to the CWA declared two national water pollution control goals: (1) elimination of the discharge of pollutants into navigable waters of the United States by 1985; and (2) attainment by July 1983 of the interim goal of water quality that protects fish, shellfish, and wildlife and provides for water contact recreation. The Act declares four national policies to achieve these goals: (1) elimination of pollutant discharges in toxic amounts; (2) development and implementation of area-wide waste treatment plans to assure adequate control of pollutants in each state; (3) provision of federal funds for waste treatment facilities; and (4) a research program to develop the technology needed to eliminate pollutant discharges.

The program to carry out these policies is complex. The CWA is administrated by the EPA, but its implementation involves several federal agencies as well as state governments. The CWA requires the states to apply and coordinate the water quality control programs established in the Act, in Regional Implementation and Management Plans. The plans for the San Francisco Bay Area are: the *San Francisco Bay Basin Water Quality Control Plan* prepared by the SFRWQCB and approved by the SWRCB, and the *Bay Area Water Quality Management Plan* developed by the Association of Bay Area Governments. The plan for the Delta is the *Central Valley Basin Water Quality Control Plan* prepared by the CVRWQCB and approved by the SWRCB.

The CWA divides pollution sources into two types: point and nonpoint. The main thrust of the CWA is on controlling point source discharges. Urban runoff, treated in the past as a nonpoint source, will increasingly be treated as a point source of pollution under the CWA.

(a) **Point Sources.** Under the CWA, point source discharge of pollutants to the Nation's navigable waters is prohibited unless a National Pollutant Discharge Elimination System (NPDES) permit is obtained. The EPA has the primary responsibility for the NPDES program but usually delegates implementation to an approved state programs. The State and Regional Boards implement the NPDES program in California.

A crucial component of the 1972 amendments was a shift in emphasis of the CWA from discharge standards based solely on receiving water quality, to technology-based standards for discharged effluent. Prior to this shift, the CWA allowed pollutants to be discharged to receiving waters in any amount, so long as pollutant levels in those receiving waters did not exceed federal water quality standards. Now, all point source discharges are required to first meet standards based on achievable pollutant treatment technologies before they can be released to receiving waters.

In California, the permit program is implemented by the State Board through its nine Regional Water Quality Control Boards. The San Francisco Bay and the Central Valley Regional Boards conduct the permit system in the Bay and Delta basins. To implement the technology-based approach of the CWA, the EPA adopted treatment standards for each category of industry based on the Best Available Technology Economically Achievable (BAT) for treating that industry's wastes. For municipal sewage treatment plants, the CWA mandated standards based on secondary treatment of wastes. The NPDES permit issued for each point source will be based on the technological standards for that source, as well as any effluent limitations based on the water quality of the receiving waters.

The 1972 CWA amendments also mandated "pre-treatment" programs to prevent waste from passing through or damaging municipal treatment systems. In 1977 the CWA was again amended, providing more stringent pre-treatment standards. Under the program, the EPA was required to establish two types of national pre-treatment standards. Prohibited Discharge Standards limit the introduction of pollutants that will damage treatment works or be passed through them. Categorical Pre-treatment Standards limit discharge of specific toxicants in specific industrial categories and are based on BAT. EPA regulations direct the states to develop pre-treatment programs to meet the standards. The EPA has established most categorical standards and is now establishing compliance schedules. California is in the process of having its pre-treatment program approved by the EPA.

(b) **Nonpoint Sources.** Because many sources of pollution, such as urban runoff, cannot be effectively controlled at a discrete discharge location they require broad-based pollution control strategies. The CWA requires states to include control strategies for nonpoint pollution in their regional management plans (these plans are discussed later). The CWA directs the EPA to provide the states with the information and guidelines necessary to prepare these strategies.

The CWA was amended in 1987 to include a new Section 319 concerning nonpoint source management programs. The amended law requires states to develop Assessment Reports and Management Program describing the state's nonpoint source problems and establishing a program to address the problems. In response to this requirement, the SWRCB prepared Nonpoint Source Assessment Report and Nonpoint Source Management Plan.

In November 1990, the EPA published regulations establishing the National Pollutant Discharge Elimination System (NPDES) permit application requirements for storm water discharges from facilities associated with industrial activities and municipal systems that serve populations of 100,000 or more. In the past, urban runoff has been treated solely as a nonpoint pollution source. However, storm drains, ditches, and canals that transport polluted urban runoff to receiving waters can be identified as point sources under the CWA. The EPA is now moving, in a phased approach, to regulate point discharges of runoff from urban areas. Dischargers of runoff in these areas will have to obtain permits that, at the least, will require stormwater management programs.

The SFRWQCB and the CVRWQCB have the authority to issue NPDES permits. To date, the CVRWQCB has issued a storm water NPDES permit to the municipalities in Sacramento County, and the SFRWQCB has issued a permit to the municipalities in Santa Clara County. The municipalities in Alameda County have applied to the SFRWQCB for a stormwater permit.

The Regional Board, along with the State Board, intend to issue general permits for the discharge of stormwater from industrial facilities. Included in the definition of industrial facilities is construction activities that disturb five or more acres of total land area or are part of a larger, common plan of development or sale that disturbs greater than five acres of total land area. Separate general permits are expected to be issued to address affected construction activity.

Other specific sources of pollution are singled out in the Act for special planning and permit requirements, such as discharge of dredged and fill materials, oil production and transport, and marine sanitation devices that will not be discussed in this report (refer to the *Status and Trends Report on Waterway Modification* and the *Status and Trends Report on Pollutants in the San Francisco Estuary* for a detailed discussion of these matters).

(2) **The Porter-Cologne Act.** Under the state Porter-Cologne Act and the federal Clean Water Act, The California Regional Water Quality Control Boards have jurisdiction over all discharges of pollutants into the Estuary and its wetlands. The Porter-Cologne Water Quality Control Act is the major California law governing water pollution. Passed in 1969, the law has since been amended to keep the state program in compliance with the federal Clean Water Act (CWA). While structured, in part, to implement the CWA, its water quality goals, policies, and implementation programs are far more comprehensive then required by the CWA. For example, while the CWA's jurisdiction is limited to navigable waters, the state's jurisdiction under the Porter-Cologne Act includes groundwater resources.

The Porter-Cologne Act is administered by the SWRCB and carried out largely by the Regional Boards. Under the Porter-Cologne Act, the state program closely parallels the federal program. The State Board formulates and adopts state policy for water quality control in conformity with the policies set forth in the Act. The Regional Boards conduct the water quality planning, permit, and enforcement activities under State Board guidelines and oversight. Both the state and regional boards are authorized to establish water quality standards that will protect the beneficial uses of the state's waters as set forth in the Act. Several provisions of the Act are particularly relevant to the Estuary.

(a) **Highest Priority for Estuaries.** Estuaries are among those waters given the highest priority for improving water quality. Pursuant to this provision, the State Board adopted a policy for bays and estuaries calling for ocean discharge of municipal wastewater where feasible, elimination of waste discharges to the extreme south of San Francisco Bay, and additional research and control of toxic discharges to the Bay-Delta system.

(b) **San Joaquin Valley Agriculture Drainage**. The law specifically prohibits discharge from a San Joaquin Valley agricultural drain to the Delta, Suisun Bay, or the Carquinez Strait until both state and federal water quality standards can be met.

Although the Regional Boards have the authority to prepare, and the SWRCB to adopt, water quality control plans, policies, and standards and carry them out through a strong regulatory program, they do not have authority to prepare, adopt, and implement comprehensive land use plans and land use regulations. They can, however, advise land use planning and regulatory agencies, such as local governments and the BCDC, on the kinds of land use management practices that eliminate or mitigate the adverse water quality impacts associated with land development.

Recently the SFRWQCB adopted a definition of the term "wetlands" and a policy regarding filling of wetlands. The definition is similar to the definition of wetlands used by the U. S. Army Corps of Engineers and EPA under the Clean Water Act. The fill policy also uses the EPA's CWA Section 404(b)(1) guidelines, which require that fill projects be either water dependent or have no practicable alternative. Under the SFRWQCB policy, no net loss of wetland values or acreage is allowed. This means that all wetland fill projects approved by the Regional Board must include (compensatory) mitigation. The SWRCB has approved the adoption of these changes into the SFRWQCB's Basin Plan, however the effect of the policy is on "hold" while a law suit on the procedural process of adoption of the policy by the SFRWQCB and the SWRCB is being heard.

d. **U. S. Army Corps of Engineers and U. S. Environmental Protection Agency**. Regulation of activities in open navigable waters of the United States and adjacent wetlands is shared by the U. S. Army Corps of Engineers and the EPA under the federal Rivers and Harbor Act as well as the CWA. The U. S. Army Corps of Engineers has the primary permit and enforcement authority over wetlands both within and landward of the diked historic wetlands. Under Section 10 of the Rivers and Harbors Act of 1899, the Corps has jurisdiction over all tidal wetlands and all unfilled areas behind dikes which were below historic Mean High Water. The Corps shares authority over activities in wetlands with the EPA under the CWA discussed above. Under Section 404 of the Clean Water Act, the Corps has authority over wetlands adjacent to navigable bodies of water and isolated wetlands which have interstate commerce connections. The Corps Section 404(b)(1) guidelines require it to consider whether a proposed project or use in a wetland is water dependent, whether there are feasible upland alternatives, and whether adequate mitigation has been proposed.

Although the EPA has primary responsibility for administering the Clean Water Act, the Corps administers Section 404 of the Act. However, the EPA has jurisdiction under other sections of the Act and has final authority on Section 404 issues. The EPA comments to the Corps on proposed projects in wetlands and has separate authority to make jurisdictional determinations, deny permits, and take enforcement action.

The U. S. Fish and Wildlife Service has responsibility to comment to the Corps on proposed projects in the Estuary requiring a Corp permit. The Corps is required to give these comments "serious consideration." The Fish and Wildlife Service can appeal Corps permit decisions made at the district level to the Department of the Army in Washington, D.C. Also, the Service has the authority and responsibility to determine whether a wetlands project would affect endangered species. If a proposed project would threaten the continued existence of an endangered species, the Service has the authority under Section 7 of the Endangered Species Act to require changes or mitigation for these impacts. Finally, the Service can prosecute anyone who knowingly kills endangered species.

The California Department of Fish and Game also has responsibility to comment to the Corps on projects proposed in diked baylands. The Corps is required by the Fish and Wildlife Coordination Act to consider these comments. The Department of Fish and Game does not, however, have any permit authority.

Fiscal Determinants of Land Use

Because land use tax policy and laws greatly effect land use decisions and practices in California and the Estuary region, this section will discuss select fiscal determinants that have created a change in land use allocation in the Estuary region and appear likely to influence future land use patterns. In particular, the analysis will focus on Proposition 13, the Williamson Act, Proposition 4, and the Gann Measure.

1. **Effects of Proposition 13**. Proposition 13 (Prop 13), or the Jarvis-Gann Amendment, is an initiative passed in June, 1978. Prop 13 limits the real property tax assessment to one percent of assessed valuation and fixes all assessments at 1978 levels (unless the property changes hands or undergoes significant alteration). Before Prop 13, property tax was the number one revenue source of local government, producing one-third of all state and local revenues. In limiting the real property tax rate, Prop 13 took away considerable ability on the part of local governments to increase their revenue. The land use consequences of Prop 13 include: (1) changes in development patterns; (2) increased use of alternate financing methods such as developer fees, annexations, and redevelopment areas; and (3) changes in traditional local government land use allocation.

a. **Changes in Development Pattern.** In an attempt to generate the revenues lost under Prop 13, local governments actively pursue land uses which generate greater sales tax revenue, such as retail. Some local governments favor office, industrial, and commercial developments over housing. By the same token, some local governments are avoiding housing developments which are perceived as requiring more services and providing less revenues than sales generating developments. On the other hand, other local governments, such as Sacramento County, have approved substantial amounts of housing. Many local government development decisions have created a job-housing imbalance. In the San Francisco Bay Area, ABAG estimates that 2.7 million new jobs will be created between 1980-2005, while new housing is estimated at only 1.6 million (Assembly Office of Research, 1989).

The disinclination to provide for and approve new housing projects in the urban areas pushes new housing developments to the region's fringes. For example in the North Bay, where there is a high proportion of land available for residential use, the demand for housing has led to expanded development (Gabriel et al., 1980). Passing over urban areas and developing more remote areas, such as agricultural lands, is called "leapfrog development" and creates urban sprawl. This job-housing separation creates long commute patterns and an auto-dependent society. Roads to serve an automobile dependant, dispersed population, can have significant adverse affects on the Estuary. For example, the San Francisco Bay Conservation and Development Commission (BCDC) reported that if all the road and bridge projects planned to serve future growth in the Bay Area were built, approximately 363 acres of fill (124 acres of fill for roads and 239 acres of fill for bridges) would be placed in San Francisco Bay, adjacent marshes, wetlands, and salt ponds (BCDC, 1989).

b. **Increased Use of Alternate Financing Methods.** To respond to the lost revenues under Proposition 13, local governments are using innovative fund raising methods. The three primary methods are annexation, declaring redevelopment areas, and increased use of developer fees.

Unfortunately, annexation and designation of redevelopment areas fails to create new revenue. Instead, these methods only transfer the property tax revenue from counties to the cities. Under annexation, a city will annex areas that are high in assessed value and growth in order to capture the expected revenues. This incorporation is done at the expense of counties who lose the growth in assessed value or sales tax but must often maintain the same service requirements. Declaring an area a redevelopment zone, allows cities to capture tax increment financing. It also means that counties or service districts are deprived of the increased funding.

Proposition 13 has also stimulated widespread increase in local impact fees imposed on new developments. With impact fees, local governments require that developers pay for infrastructure or provide related services such as child care or parking. However, the need to find a nexus between new development and fees leads to a conservative assessment. In addition, developer fees are generally insufficient to pay for the improvements at the time they are needed and to pay for the ongoing operational and maintenance costs associated with new infrastructure.

c. **Changes in Traditional Government Planning.** One of the principal land use practice changes resulting from Proposition 13 is that local governments now, more than ever, place considerable emphasis in their land use decisions on fiscal considerations. Instead of reviewing development projects solely in the context of the general plan and environmental guidelines, including impacts on the Estuary, governments often use revenue-generation as a major criterion.

This *fiscal zoning* often causes some local governments to court new development regardless of its impact and to designate more land within a region for revenue-producing uses than is realistic. As a result, many local governments undertaking development even if they lack the capacity to accommodate the development or the funds to provide the necessary infrastructure or services. This practice has created a strain on the existing urban infrastructure.

2. **Effects of the Gann Measure.** The Gann Measure, or Proposition 4, is an initiative passed in 1979. This measure sets a constitutional limit on government spending and allows increases in spending only when linked to national inflation, population growth, or per capita income.

This limit has dramatically curtailed the amount of state spending on projects, including assistance to local governments. As a result of the Gann Measure and simultaneous federal decisions, both the state and federal government have disengaged themselves from financing big projects like roads, schools, water, and flood control systems (California Policy Seminar, 1988). This divestment and the constraints that Prop 13 places on local governments' abilities to finance infrastructure using tax revenues, has led to a shortage in infrastructure investment and maintenance. For example, one casualty of the Proposition 13 and Proposition 4 has been urban runoff pollution prevention progress such as street sweeping and storm water catch basin cleaning.

3. **Effects of the Williamson Act.** The Williamson Act, or Land Conservation and Development Act of 1965, is a preferential property tax assessment program which, in return for a decrease in property tax, restricts owners from developing their property during the term of their contract, usually 10 years.

The Williamson Act has been most effective at limiting leapfrog development in areas removed from existing urbanization and urban growth pressures rather than protecting farmlands on the fringes of growing cities (University of California, Agricultural Issues Center, 1989). Currently, the program enrolls 44 percent of the state's 12.6 million areas of prime agricultural land and 57 percent of the 17.4 million acres of non-prime agricultural land. While this Act was initially directed at agricultural land, in 1969 the Act was amended to include areas of great importance to wildlife as well as open space lands. This includes salt ponds, managed wetlands, and submerged areas and open space in the Estuary region.

However, the effect of the Williamson Act on land use decisions has been minimal. It appears that the property tax savings are not the dominant reason for landowners maintaining agricultural land in its current use. Instead, non-economic factors such as personal attachment to the land, family reasons, or advancing age are more significant. Additionally, since areas of great importance, such as wetlands, are already taxed at a low rate, the amendment produced no significant change in these land uses. The Williamson Act has also been criticized because it fails to reimburse local governments for their actual revenue losses.

Effects of Public-Private Partnerships on Land Use

Public-private partnerships are another institution which has significant influence over land use management in the Bay-Delta area. Land trusts are private, non-profit, tax-exempt, charitable corporations and are the most frequently used type of public-private partnership. Land trusts use direct land acquisition, conservation easements, and limited development to maintain land in its current usage. The types of land most commonly targeted by land trusts are ecological areas (wildlife habitats and natural areas), open space (buffers and scenic sites), recreational land (trail corridors, river accesses, and fishing areas), and grazing and agricultural lands. Land trusts have enjoyed a recent popularity surge, especially on the local level where a local trust encourages a community focus. Examples of private land trusts in the Estuary region include the Marin County Agricultural Land Trust, the Peninsula Open Space Trust, and the Solano County Open Space District. In addition, national trusts such as the Nature Conservancy and the Trust for Public Land are active in the area.

There are also a number of public agencies that use land acquisition and management to maintain land in its existing use or restore and enhance lands important to the environmental health of the Estuary. These public agencies often work closely with private organizations to manage and acquire land. Examples of such agencies in the Estuary region include: the California Coastal Conservancy, the East Bay Regional Park District, and the Suisun Resource Conservation District.

1. **How Public-Private Partnerships Work.** Land trusts influence land use through direct acquisition or acquisition of less than fee interests such as conservation easements, and land management. Direct land acquisition is the traditional method for land trusts. Land is acquired by donation or with the funding obtained from individual donations, fund-raising campaigns, and memberships. Land trusts will facilitate transactions by acquiring an option to purchase over desired properties or acquiring the right of first refusal. These strategies give the trust time to raise the funds necessary for acquisition. Budget constraints make land management increasingly difficult. As a result, when a trust acquires a parcel of land it will often transfer ownership to an appropriate public agency to manage the land in its existing state or to restore and enhance the land.

High land values make less money available for public acquisition and, as a result, conservation easements are an attractive alternative. Through purchase or donation of certain rights to the land, easements legally bind present and future owners to maintain the land in a certain use. For example, a typical easement might prohibit subdivisions of the property and any future development. While maintaining land in its existing use, easements allow private ownership and maintenance of the property, for example for agricultural use, and keep land on local tax roles.

Another technique that land trusts use is limiting or controlling development. Limited development has been described as "selling off some land in order to preserve the rest." This method usually entails developing a portion of a parcel in order to finance acquisition and preservation of the balance of the parcel. Development is generally limited to non-sensitive or previously disturbed portions of the parcel.

2. **Examples of Public-Private Partnerships in the Estuary Region.** Following are some select examples of successful public-private partnerships around the Estuary.

a. **California Coastal Conservancy.** The Coastal Conservancy was created to help preserve, restore, and enhance California's coastal resources, and to develop creative solutions to difficult land use problems on the coast and around San Francisco Bay. The Conservancy is authorized to acquire land, to design and implement programs for public access, to restore coastal waterfronts, provide technical assistance and funding to local governments and non-profits, and to restore wetlands and enhance watersheds.

The Conservancy has completed numerous projects around the Bay-Delta area. For example, the 2,070 acre Rush Ranch in the Suisun Marsh includes enhancement, restoration, and management of 1,300 acres of tidal marsh and upland transition zone. Funding for future projects includes a $375,000 grant from the EPA for fresh water, brackish, and salt marsh enhancement projects and $24 million from Proposition 70 for land acquisition and easements.

b. **East Bay Regional Park District.** The East Bay Regional Park District is a public agency which owns and manages land in Alameda and Contra Costa Counties. It is funded through property taxes, state and federal grants, and bond measures. The East Bay Regional Park District is also affiliated with a non-profit, private foundation which shares the District's mission of managing and acquiring open space.

Currently 5,000 acres of the Park District's land is managed as low intensity, recreational use and open space, including 90 percent of the Wildcat Creek watershed. In the past five years, the District has acquired property in the Morgan Territory, Pleasanton Ridge, the Mt. Diablo area, and shoreline properties along Carquinez Strait. These new acquisitions amount to over 7,000 acres and are managed primarily as open space or grazing lands. Funding for future projects include $225 million from the 1988 Measure AA bond.

c. **Marin Agricultural Land Trust (MALT).** MALT is a non-profit land conservation organization whose mission is to preserve farmland in Marin County. Since its founding in 1980, MALT has purchased easements on 12,700 acres of land. Restrictions that the easements are likely to include are: prohibiting subdivision of the property for non-farming developments and prohibiting all uses of the property which significantly denigrate the water or soil quality of the land. In particularly sensitive areas, such as land near the San Francisco Estuary, easements have restricted all development.

d. **The Nature Conservancy.** The Nature Conservancy is a national trust whose primary goal is to protect biological diversity. The Conservancy is funded primarily through membership fees and donations. Existing Nature Conservancy properties in the Bay-Delta area include: over 1,500 acres in Jepson Prairie Preserve in Solano County, 1,368 acres in Cosumnes River Preserve in Sacramento County, 203 acres in the Fairfield Osborn Preserve in Sonoma County, and over 1,000 acres in Marin County. The lands are typically maintained in low intensity, recreational use.

e. **Peninsula Open Space Trust.** The Peninsula Open Space Trust is a private land trust which is dedicated to preserving open space, scenic, and ecological areas, and agricultural lands in San Mateo and Santa Clara Counties. Currently, the trust owns and manages 20,000 acres in cooperation with public agencies such as the State Department of Fish and Game and the Regional Water Quality Control Board. These lands include Estuary wetlands along the shore of San Francisco Bay. Ongoing projects include acquisition of a 1,300 acre parcel along the coast.

f. **Solano County Land Trust.** The Solano County Land Trust is a private agency whose mission is to preserve agricultural lands and open space buffers in Solano County. The Trust was established in 1986 and is funded through state grants and a funding arrangement with the City of Fairfield. Its most recent project includes the acquisition of Rush Ranch in the Suisun Marsh area. Management of the property includes public access, wetland restoration and enhancement, and limited cattle grazing.

g. **Suisun Resource Conservation District.** Within the Suisun Marsh, approximately 150 properties are privately-owned wetlands or duck clubs. The Suisun Resource Conservation District is a public agency which administers the water and habitat management policies of the 1977 Suisun Marsh Preservation Act for these duck clubs. The District monitors any substantial changes in land use of these properties and ensures that any changes are consistent with Suisun Marsh policies.

h. **The Trust for Public Land.** The Trust for Public Land (TPL) is a national land trust organization which acts as an interim land holder and facilitator for properties to be dedicated for public stewardship. The Trust for Public Land uses fund-raising, public funding, and profits from its real estate transactions to finance future purchases. The types of land that TPL typically targets are open space areas, lands with high scenic, recreational, resource or habitat values, or lands that public agencies have requested. Nationwide, TPL has helped purchase over 450,000 acres of land.

CHAPTER 4

RELATIONSHIP BETWEEN LAND USE CHANGE AND ESTUARY HEALTH

This chapter provides an overview of the relationship between land use change and the ecological well-being of the Estuary and discusses the effects of wetland elimination and modification, encroachment into stream environment zones, and pollutant loading from urban runoff. Another effect of land use intensification, increase discharge from waste treatment facilities concludes the chapter.

The numerous linkages between land use change and Estuary health are summarized in Figure 13. The figure illustrates a causal sequence of activities, beginning with specific land uses. Each urban land use includes a number of specific activities which leads to physical changes in the environment referred to as direct, or primary impacts. The casual sequence continues with secondary, or indirect impacts and culminates in a set of issues characterized as "impacts of concern."

The following discussion considers the three classes of impacts on the Estuary analyzed in this report: (1) wetland elimination and modification; (2) encroachment into stream (riparian) environment zones; and (3) impacts from pollutant loading from urban runoff as well as waste treatment facilities.

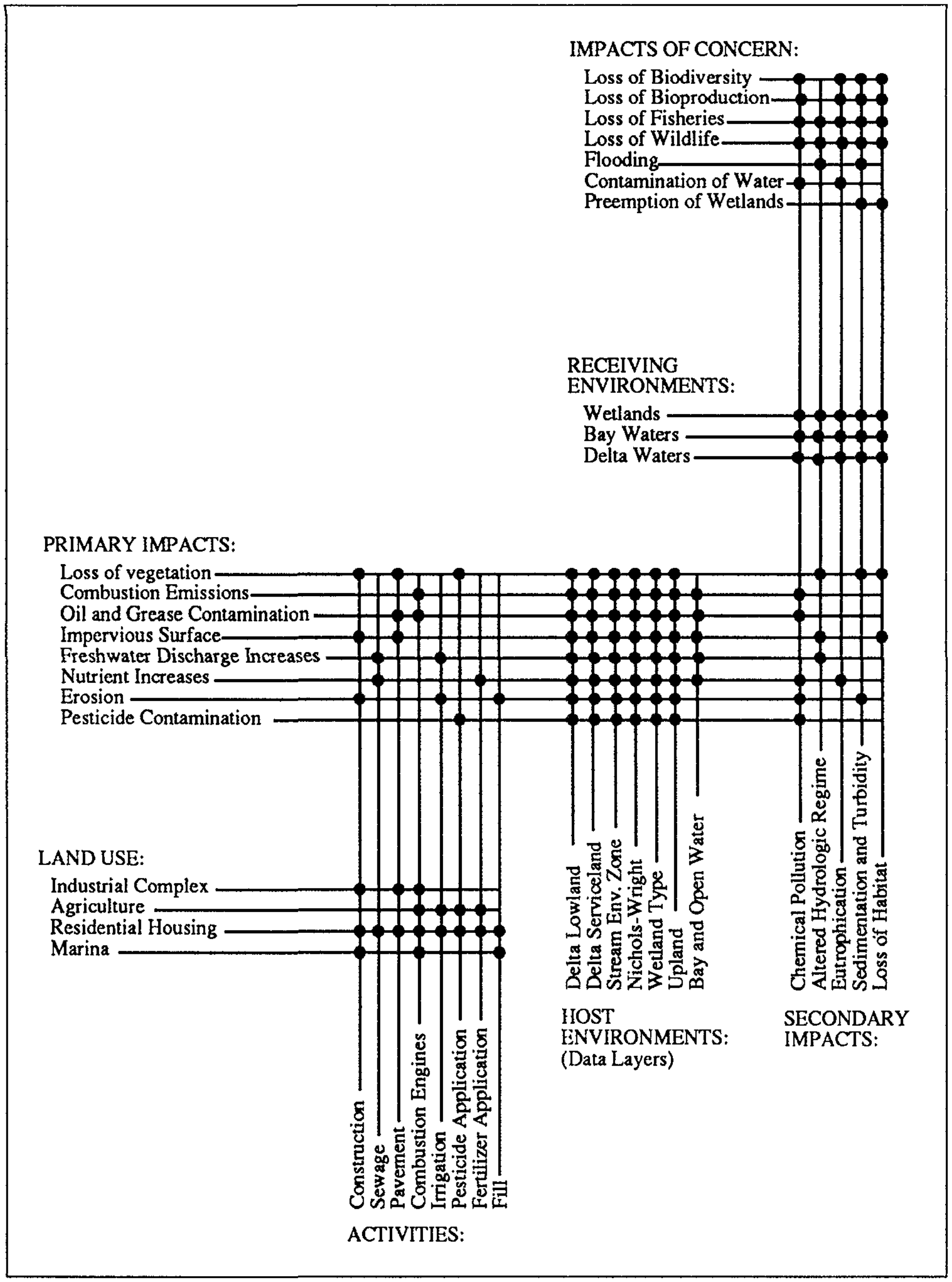
Effects of Wetland Elimination and Modification

Modification or elimination of wetlands can significantly impact the Estuary's ecological system. Wetlands in the Estuary region have been much reduced in size, type and productivity as a result of diking and filling and conversion to agricultural and urban uses. For example, of the original approximately 545,000 acres of tidal marsh in the Estuary, roughly 509,004 acres—93 percent—have been diked off from tidal action. Although much of the tidal marshes, primarily in the Delta, have been transformed to other wildlife habitat types, including diked, farmed seasonal wetlands (385,755 acres) and salt ponds (36,684 acres), the elimination of tidal marsh affects not only the aquatic and wildlife species dependent on tidal marsh as habitat, but the role and function of tidal marshes in maintaining water quality of the Estuary waters.

As wetlands are eliminated or modified, the result is a patchwork of smaller habitats that have reduced value to wildlife and impose an important loss on the region's biodiversity. The size of wetlands available as foraging, resting, or nesting habitat may decrease, thereby reducing the populations of wetland species that can

Figure 13
Linkages Between Land Use Change and Estuary Health

SOURCE:
Center for Environmental Design Research, U.C. Berkeley.



be supported. Some species are locally extirpated from wetlands as habitat size shrinks.

Urbanization which does not result in direct elimination of wetlands can have far-reaching impacts nonetheless. Urbanization often requires changes to natural drainage patterns to accommodate flood control structures, thereby altering the natural hydrologic conditions, causing loss of circulation in wetland basins, or increase (or decrease) in salinity which may affect habitat. More subtle impacts can include introduction of exotic plants and disruption of wetland-associated bird species by human intrusion or pets.

Loss or modification of wetland vegetation has other implications for estuarine ecology. Wetlands naturally purify waters prior to their release into the Estuary by temporarily or permanently retaining pollutants. Pollutants may be converted by biochemical processes to less harmful forms. They may also remain trapped or buried in sediments, or recycled within wetlands. Although wetland vegetation does take up many different heavy metals, they also recycle, release, and often move the toxic material up the food chain in a process known as bioaccumulation.

Intact, functioning wetlands also exert an impact on flood peaks, by temporarily retaining storm runoff. Also, wetland vegetation significantly reduces shoreline erosion caused by waves and flooding. These plants buffer the impact and bind soil to their roots.

Effects of Encroachment Into Stream Environment Zones

Another major class of impacts associated with urban as well as agricultural land development is encroachment into stream environment zones. These zones are the complex of vegetation, soil and stream channels that comprise some of the most important habitat areas in the Estuary region and which carry a considerable portion of storm water runoff, and consequently, pollutants, to the Estuary.

Undisturbed stream environment zones represent a dynamic equilibrium between water, channel configurations, and vegetation. Channel dimensions are a result of sediment load (quantity and particle size), stream discharge, and gradient (Dunne and Leopold, 1978).

The functioning of intact tributary stream environment zones is linked to the ecological integrity of the Estuary in several ways. Riparian vegetation contributes nutrients to the Estuary through decomposition of debris and detritus. Vegetation also intercepts precipitation and slows delivery of surface and ground water to streams; thereby reducing both sediments and turbidity, which would otherwise smother fish nesting areas, clog fish gills, and block light penetration.

New land development, urban and agricultural, often entails removal of streamside vegetation, resulting in direct loss of habitat for terrestrial wildlife and aquatic life and elimination of natural shade which moderates water temperatures important to the health of aquatic life. Removal of natural vegetation or channel modification accelerates the transfer of agricultural and urban fertilizers, herbicides, pesticides, animal wastes, and sediments to streams by storm water runoff. In addition, urban runoff can carry other toxic pollutants, such as metals, pesticides, and petroleum hydrocarbons to streams that flow into the Estuary.

Another impact of land development on stream environment zones is recontouring the banks of the natural floodplain. This in turn accelerates channel scouring and downstream deposition of sediment.

Although no figures are available regarding trends in the extent and productivity of riparian ecosystems for the nine-county Bay Area, data are available for the Central Valley, including Sacramento, San Joaquin, and Yolo Counties. The Riparian Study Program conducted by the Department of Water Resources estimates that riparian vegetation in the Central Valley has been reduced 85 percent since presettlement (the later 1700s). Of the remaining vegetation, 85 percent has been classified as disturbed, degraded, or severely degraded.

Many smaller streams discharging directly into San Francisco Bay have been modified, channelized, or straightened. In urban areas, most of these drainages now have artificially maintained channels in the lower reaches so that flood waters discharge directly into the Bay rather than flowing across a flood plain. Increased floodpeaks and channel scouring are a direct result. Besides the elimination of historical habitat by current flood management practices, ongoing channel maintenance activities, which often include eradication of vegetation growth in stream channels, continue to eliminate habitat. Future land development that results in modifying stream environment zones can result in significant adverse indirect impacts on the Estuary.

Pollutants Contained in Urban Runoff and Wastewater Discharge

Five major classes of pollutants are contained in urban runoff and point discharge of wastewater: organic matter, total and dissolved solids, nutrients (nitrogen and phosphorus compounds), heavy metals, and organic compounds.

Organic matter includes leaf litter, animal waste, and similar material. Organic matter requires oxygen to decompose, imposing a biochemical oxygen demand (BOD) on tributaries and the waters of the Bay and Delta. Suspended solids, or sediments, impair light penetration in the water column and serve as a sink for both organic pollutants and certain heavy metals. As sediment settles out in the water, it may smother non-mobile shellfish and finfish, or render benthic habitat unsuitable for species that require rough substrata.

Nitrogen and phosphorus compounds include total nitrogen (TN), total ammonia plus nitrogen (AN), total phosphorus (TP), and dissolved phosphorus (DP). Though essential as nutrients in background concentrations, these constituents promote algae growth that in turn block light penetration and consume dissolved oxygen that would otherwise be available for fish and other estuarine life.

Yet another important grouping of pollutants are heavy metals. The *Status and Trends Report on Pollutants in the San Francisco Estuary* (Davis et al., 1991) identifies cadmium (Cd), copper (Cu), mercury (Hg), nickel (Ni), selenium (Se), silver (Ag), and tin (Sn) as pollutants of particular concern. Cadmium, exceptionally toxic to mammals, bioaccumulates strongly. Copper, chronically toxic to aquatic life in concentrations as low as ten parts per billion (ppb) in water, is often found in Estuary waters near or above this level. Mercury levels in excess of Food and Drug Administration action levels have been detected in fish in the Guadalupe River in Santa Clara County, a tributary to south San Francisco Bay. Nickel levels are locally elevated in San Francisco Bay shellfish, and the highest concentrations in surface water are present in South San Francisco Bay Receiving Water Segment (see Figure 11). High concentrations of silver have been found in shellfish and diving ducks in the south Bay. The California Department of Health Services has issued health warnings regarding consumption of certain ducks taken from the Estuary due to selenium contamination. Elevated tin (tributyltin) levels within poorly flushed waters of harbors and marinas within the Estuary are of serious concern in terms of their possible effects on aquatic life. Antimony (Sb), arsenic (As), chromium (Cr), cobalt (Co), lead (Pb), and zinc (Zn), are the other toxic trace metals that occur in the Estuary.

Organic compounds include petroleum hydrocarbons, such as polynuclear aromatic hydrocarbons (PAHs), and organoclorine compounds, such as polychlorinated biphenyls (PCBs). PAHs have a strong tendency to bioaccumulate. They have been found at elevated levels in San Francisco Bay sediments and detected in starry flounder and mussels (SWRCB, 1990). PCBs are persistent and biomagnify in the food chain and have been implicated in toxicity to phytoplankton and impaired reproduction in fish, birds, and mammals. Although nearly all uses of PCBs were banned in 1976, San Francisco Bay is one of three general areas with significant PCB levels on the West Coast (NOAA, 1987). Relatively high levels of PCBs have been documented in the South Bay, Richmond, and Albany. Local striped bass populations and starry flounder from Southampton Shoal and Hunters Point, have high amounts of PCBs.

Other organic pollutants of special concern are the chlorinated dibenzofurans and dibenzodioxins. This grouping of pollutants includes 2, 3, 7, 8, tetrechlorodibenzo-p-dioxin, known commonly as dioxin, one of the most toxic compounds known. Rated by EPA as the most potent carcinogen tested in animals, dioxin is present in fish caught in the Sacramento River near two paper mills which are known dischargers of dioxin. Dioxin from unknown sources is present in fish from the Sacramento River at Clarksburg, the San Joaquin River at Stockton, and the Delta near Antioch (SWRCB, 1990).

Pollutant Loading from Urban Runoff

1. **Urbanization Increases Estuary Pollution.** Studies carried out at the national level (US EPA, 1983), and in the Bay Area (Pitt and Shawley, 1981; BCDC, 1987; Woodward-Clyde, 1991) clearly establish that pollutants in urban runoff originate from several different urban land uses and their associated activities.

Urban runoff is a major source of Estuary pollution. Land use change in the Estuary region has been and will likely continue to consist of conversion of rural and agricultural lands to urban areas. Very little land in the Estuary region will be converted to a more intense agricultural use from current extensive agricultural use. Therefore, the analysis in this report centers on the impacts of the conversion of rural and agricultural lands to urban uses.

Land disturbance associated with site preparation and construction accelerates erosion and in turn leads to increased levels of suspended sediments in surface water. And, as mentioned earlier, a consequence of urban development is increased impervious land surfaces, which causes accelerated runoff and increases the intensity of the flood peaks in stream channels contributing to greater channel scouring and erosion.

Household landscaping, golf courses, and highway median strips are typically the site of fertilizer and pesticide applications which contribute to polluted runoff. Increased urban development also increases automobile use, which is responsible for both trace metals and petroleum hydrocarbons in road surface runoff. These are the product of exhaust emissions, crankcase drippings, metal abrasion, and wear of tire and brakes (Montoya, 1987; Latimer et al., 1990).

Shipyards adjacent to Puget Sound Region were shown to contribute significant quantities of heavy metals, especially copper and zinc (Paulson, Curl, and Feely, 1989). Hoffman et al. (1984) suggested that storm water runoff from highways in the region of the Pawtuxent River, Maryland, could contribute over 50 percent of the total pollutant loads of polynuclear aromatic hydrocarbons and several heavy metals.

Some sources of pollution, particularly atmospheric fallout, are produced by the aggregation of all urban land use types. Studies conducted in the Chesapeake Bay region suggest that atmospheric deposition may account for up to 50 percent of nitrogen and phosphorus compounds in that area.

Illegal dumping of oil and other chemicals, though not attributed to a specific land use type, is clearly a problem related to the magnitude of urban development. Russel and Meiorin (1985) estimate that half of the used motor oil from Bay Area households is dumped illegally on the ground, in storm drains, or landfills. Many of the pollutants, over time, find their way into the Estuary.

2. **The Magnitude of the Urban Runoff Problem.** Pollutant loading from urban runoff is clearly a serious problem both nationally and in the Estuary region. Figures recently released by EPA show that of over 17,000 heavily polluted surface waters surveyed nationally, about 95 percent are polluted by urban runoff (USEPA, 1988). National sampling under the Nationwide Urban Runoff Program (NURP) detected all 13 priority trace elements (priority pollutant constituents identified under the Clean Water Act) in urban runoff (USEPA, 1983). The San Francisco Bay Basin Plan identifies surface runoff from urban areas as a major source of pollutants to San Francisco Bay (SFRWQCB, 1986).

The quantities of pollutants contained in urban runoff are very significant. A recent study of the Baltimore-Washington, D.C., area conducted by the Natural Resources Defense Council (Cameron, 1989) showed that loadings of zinc, copper, and lead were actually three times higher than the levels discharged by all Virginia and Maryland factories in 1987 (point source industrial discharges). Montoya (1987) compared emissions from the National Pollutant Discharge Elimination System (NPDES) permittees and urban runoff in the Sacramento Valley and reached similar conclusions. Suspended solids are typically present in higher concentrations in urban storm water than in raw wastewater (Novotny et al., 1985).

Gunther et al. (1987) reviewed seven water quality studies and estimated annual urban runoff loads into the Estuary ranging from one to nine metric tonnes of arsenic, seven to 59 tonnes of copper, 30 to 250 tones of lead, and 34 to 268 tonnes of zinc. Similarly, the State Water Resources Control Board's Pollution Policy Document (SWRCB 1990), based on the estimates of Gunther et al., concluded that "urban runoff may contribute the greatest pollutant loads to the Bay-Delta Estuary,"

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most of which is oil and grease. However, both Gunther and the SWRCB pointed out that as a result of limited data, considerable uncertainty is associated with these figures. For specific pollutants, the SWRCB identified urban runoff as the source of 2.2 to 6.7 percent of copper, 22.7 to 36.4 percent of lead, and 4.7 to 34.6 percent of organochlorines; all highly toxic pollutants.

Increased Discharge from Wastewater Treatment Facilities

Although the focus of this report is on nonpoint urban runoff associated with Estuary land use change, it is important to mention the effects of point source pollutants associated with urbanization and urban intensification.

Over the last several decades, there have been two offsetting trends in point source wastewater treatment. A positive development is the increased efficiency of sewage treatment; at the same time, flow of treated effluent has increased dramatically, and removal of toxic pollutants remains incomplete. Increased population growth and intensification will increase the flows and proportionally add increased toxic pollutants to the Estuary.

Over the last thirty years, discharges of biochemical oxygen demand and suspended solids in the San Francisco Bay Area have been reduced by 86 percent, even though the population has doubled (BADA, 1987). Taken together, this represents an eight-fold decrease in the per capita discharge of those conventional pollutants to the Bay. However, an important consequence of increased urbanization in the Bay and Delta region is increased discharge of wastewater from industrial facilities and publicly-owned treatment works (POTW's). Data compiled by the Bay Area Dischargers Association (BADA, 1987) show that since 1960, flow has increased from 220 million gallons per day (mgd) to 570 mgd in 1985, a 159 percent increase.

There are currently 50 POTW's discharging in the nine-county Bay Area. Their combined design flow (a measure of the capacity of the system to handle sewage) is 829 mgd. Baseline flow, a measure of the current aggregate demand on the system, is about 585 mgd. Remaining capacity can be computed by subtracting baseline flow from design flow. Overall, the region is at 70.5 percent of capacity (Wu, Pers. Comm.). (These figures are annual averages; they may fluctuate considerably on a day-to-day basis.) If the Estuary region continues to grow at its present rate, and if new growth continues in a dispersed manner, new, costly POTW's will be needed and existing POTW's expanded. In the past, the cost of these new and expanded facilities, totaling billions of dollars, has been borne by the Federal Government. It is unlikely that the Federal Government—or for that matter, state or local government—will have this amount of revenue available for water treatment facilities in the foreseeable future.

Based on data supplied by the San Francisco Bay Regional Regional Water Quality Control Board, of the 50 POTW's in the Bay Area, 12 facilities now operate at or above 80 percent of their capacity. Five small-to medium-sized facilities are already at more than 95 percent of capacity, and three are actually over capacity. Systems that are over capacity routinely discharge incompletely treated sewage, thus polluting the Estuary or other receiving waters. Consequently additional population growth can over tax the existing treatment system leading to increased Estuary pollution.

Secondary sewage treatment removes only 50-75 percent of the heavy metals and other toxic pollutants contained in sewage (EPA, 1982). Eleven facilities in the Bay Area have some form of tertiary treatment, and may remove slightly higher percentages. Knowledge about trends in toxic compounds in our region's waters is very limited. Prior to the late 1980s, there was virtually no baseline research that measured levels of trace metals or organic toxics. Reliable data on heavy metals and organics are only now being collected under the auspices of the San Francisco Bay Regional Water Quality Control Board. In the absence of definitive data or mandatory improvement of treatment systems, source control, or reclamation of wastewater, it is reasonable to expect that increased levels of urbanization will lead to increased flows, and with them, additional loadings of trace metals and organic compounds via sewage treatment discharge.

Although this study does not analyze the expected increase in point source pollutant loads from POTW's, future analysis of the quantities and locations of the pollutant loadings on the Estuary should, and can, be made following the methodology used in this report for the analysis of urban runoff.

Effects of Future Land Use Change and Intensification on the Estuary

As the Estuary region continues to grow and current rural and agricultural lands are converted to urban uses, the Estuary can be impacted by: (1) the elimination or modification of the Estuary wetlands; (2) encroachment and modification of stream environment zones; and (3) additional pollutant loading from urban runoff. In Chapter 6, two scenarios of future land use in the Estuary region will be analyzed as indicators of the range of plausible impacts associated with land use change and intensification.

CHAPTER 5

EXSISTING LAND USE PATTERNS

In order to appreciate how land use change will effect the Estuary, it is essential to have an understanding of existing land use in the Estuary region and the spatial relationships of the land uses. In this chapter, the 12-county Estuary region is classified as to its basic land use types: urban and non-urban uplands, and wetlands. Urban uplands have been classified into five generalized land use categories to provide a consistent land use classification system throughout the region (see Procedures for Constructing Land Use Scenarios in Chapter 2). Similarly, non-urban upland land use has been categorized to provide a consistent land use designation with Estuary local government land use plan designations. The wetland categories are based on the wetland classification scheme developed by the U. S. Fish and Wildlife Service in its National Wetlands Inventory (NWI). The existing (1985) land use for the Estuary region is shown in Figure 14. Current land use information for the nine-county Bay Area was derived from the Association of Bay Area Government's digitized Bay Area Spatial Information System (BASIS), version 1989; for the three Delta counties, the U. S. Geological Service's digitized 1976 Land Use Data (LUDA) files were used.

Uplands

Uplands in the Estuary region can be divided into two distinct subregions: the bulk of the nine-county San Francisco Bay Area (and the western edge of Yolo County), dominated by the northern and southern Coastal Ranges, and the majority of the three Delta counties (plus parts of eastern Solano and Contra Costa Counties) that belong to the great Central Valley.

The sections are alike in that their primary physiographic features (mountain ridges in the Bay Area and the Delta counties' expansive valley floor) run parallel—in a northwest and southeast direction—to the California coast and the state's many geologic fault lines. (Vance, 1964 and ABAG, 1990).

But they are diverse in their fundamentally different topographies, one mountainous and the other extremely flat. These topographies have given rise to distinct patterns of urbanization and agriculture in each section.

1. **Bay Area: Physiography and Urban Framework**

a. **Physiography**. The Bay region is dominated by the relatively young Coastal Ranges, the product of a seismically active geological zone. The San

Andreas Fault cleaves the coastline of the northern Bay Area (Sonoma and Marin Counties) and the San Francisco peninsula. In the East Bay, the Hayward Fault defines the edge of the northern Diablo Range and the Berkeley Hills. The Concord and Calaveras Faults help shape the valleys running from the Carquinez Strait down past Mount Diablo into the Amador Valley and southern Diablo Range.

The rest of the region is sliced by less prominent faults, including the Greenville Fault, cutting across the Livermore Valley, the Antioch Fault, the Green Valley and West Napa Faults (running through Solano and south Napa Counties) and the Rogers Creek Fault (in the heart of Sonoma County).

Shaped by these fault lines, the region is characterized by dense ridges of mountains (few of them higher than 900 meters) divided by long, fertile valleys running northwest and southeast. In addition, San Francisco and San Pablo Bays, themselves flooded valleys running parallel to the fault lines, are ringed by valley-like lowlands—partially submerged structural depressions built up by alluvial soils.

The one significant transverse (east-west) geologic feature in the region is the Livermore Valley, which follows the Las Positas Fault.

b. **Urban Framework.** By 1986, approximately 16.4 percent of the nine-county Bay Area's land had been urbanized (Greenbelt Alliance, 1989). That urbanization is largely concentrated in the lowlands and valleys between the region's various mountain ranges. Until recently, almost all of the region's people, jobs, and housing was located on the flatlands immediately surrounding San Francisco and San Pablo Bays. By the mid-1970s, more than 80 percent of the region's population and jobs was concentrated in the region's urban "inner ring"—the ribbon of lowlands surrounding the Bay from San Rafael (Marin County) down to San Jose (Santa Clara County) in the South Bay and back up to Pinole (Contra Costa County) in the East Bay.

For the last two decades, however, new population settlement has begun to shift away significantly from the Bay region's urban center (see Table 4) to communities in the Bay region's outer reaches (see Table 5).

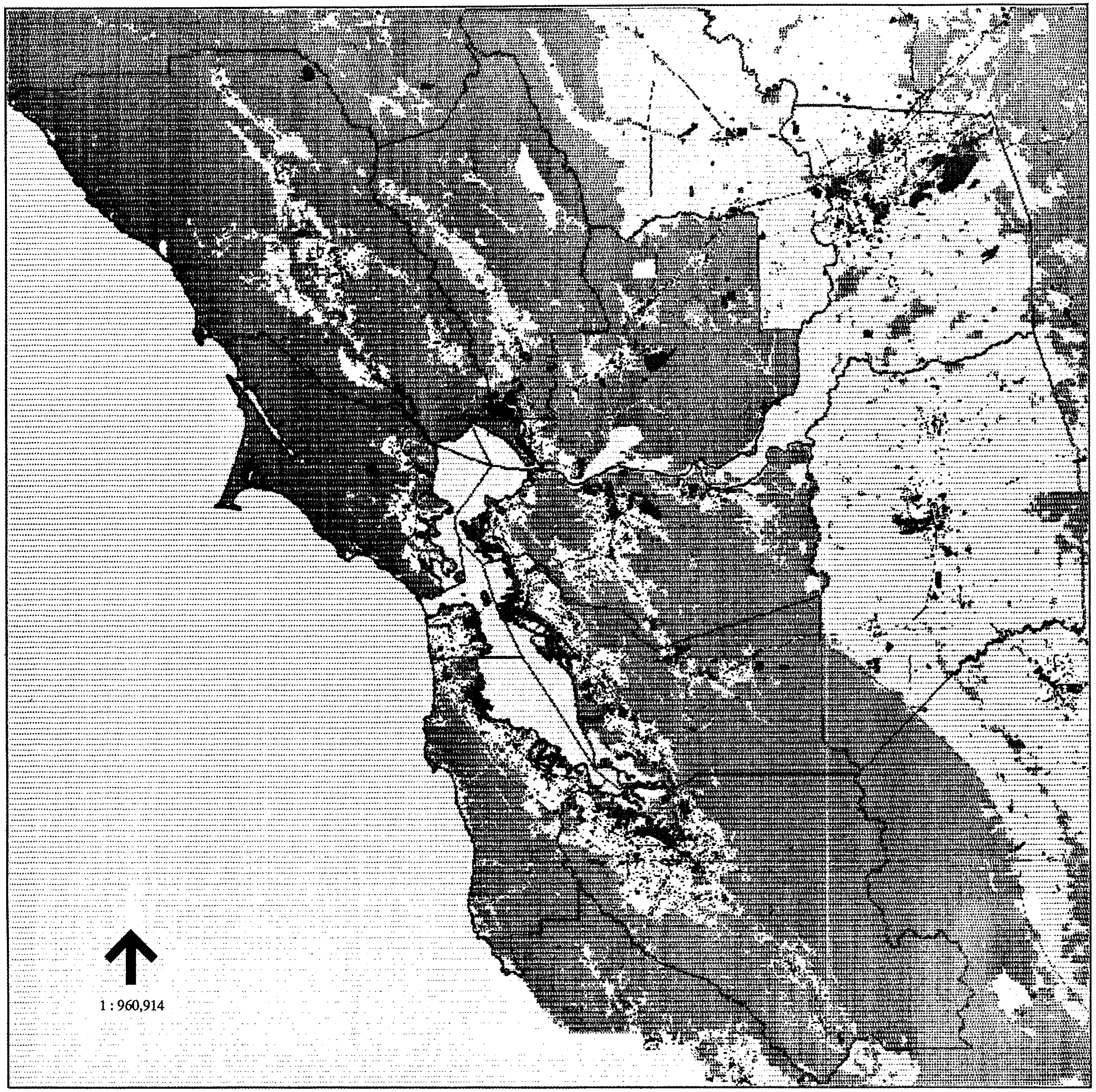
Table 4
Bay Area Population Settlement (Thousands)

SOURCE: Greenbelt Alliance

BAY AREA	1940	1960	1970	1980
Inner Ring (IR)	1,352	2,518	3,156	3,711
Outer Communities (OC)	102	349	715	1,396
Total Population	1,454	2,867	3,871	5,107
Inner Ring Percentage	93%	87.8%	81.5%	72.7%
Outer Communities Percentage	7%	12.2%	18.5%	27.3%

Figure 14
Existing Land Use

SOURCE: Center for Environmental Design Research, U.C. Berkeley, 1990; Association of Bay Area Governments U.S. Geological Survey



BAY AREA	Occupied Housing Units	% of Bay Area	New Units 1987	% of Bay Area
Inner Ring (IR)	1,514,560	72.3%	18,944	47.8%
0-10 miles from IR	85,494	4.1%	3,856	9.8%
10-20 miles from IR	216,870	10.4%	7,555	19.1%
20-30 miles from IR	145,852	7.0%	5,016	12.7%
30-50 miles from IR	117,358	5.6%	3,806	9.6%
> 50 miles from IR	13,766	0.6%	420	1.0%

Table 5
Bay Area Housing Location

SOURCE:
Greenbelt Alliance

New development in the "outer ring" is taking place in communities exclusively along major interstate and state highways, e.g., Santa Rosa—Highway 101, Vacaville and Fairfield—Interstate 80. Whereas these towns and cities were once primarily bedroom communities, they have attracted an increasing share of new commercial development and jobs.

Nevertheless, the majority of people in the Bay Area continue to live and work in the urban inner ring. Approximately 70 percent of the region's homes, jobs and people are located there. In addition, the region's principal population centers are located in the inner ring: San Jose (712,080 in 1986), San Francisco (749,000) and Oakland (356,960). These cities alone are at the heart of three urban cores (San Jose/Silicon Valley; San Francisco; and Oakland/Emeryville/Berkeley) that by 1980, accounted for more than half (55.8 percent) of all jobs and served as the travel trip destination for approximately half of all commuters in the Bay region (including intra-city travellers).

By contrast, in 1986, the largest city outside the inner ring was Concord (with 105,980 residents) followed closely by Santa Rosa (97,600).

Overall, the Bay region's urban framework at present can be characterized at three levels: (1) three primary population and job centers anchoring the tip of the San Francisco peninsula, the heart of Santa Clara Valley, and the center of the East Bay flats; (2) an urban "inner ring" encompassing these major job and population centers; and (3) fast growth sub-centers along major highways in the "outer ring."

2. **Delta Area: Physiography and Urban Framework**

a. **Physiography**. Except for the ridges of the Coast Range at the western edge of Yolo County, the Delta counties are dominated by a flat, expansive alluvial plain and an intricate network of rivers, sloughs, and other waterways.

The Sacramento and San Joaquin Rivers meander through the Delta and join together to form the trunk of this network. Connecting with these two rivers are a number of rivers, braided sloughs and channels, and man-made levees and shipping channels that have created a patchwork of low-lying islands and adjacent lands in the southwest corner of Sacramento County and the northwest quadrant of San Joaquin County (ABAG, 1990). The remainder of the Delta area—the majority of Yolo

County, the eastern and southern portions of San Joaquin County and most of Sacramento County—lie within the flat portion of the Central Valley.

b. **Urban Framework.** Originally, urbanization in the Delta counties was limited to a few major centers (particularly Stockton and Sacramento) settled along the great rivers of the region, with the bulk of the (mostly agrarian) population spread evenly over the unincorporated hinter land. However, in recent decades that pattern has begun to shift dramatically, as the original urban centers have grown rapidly and their economies have diversified and mushroomed.

They have been joined in this spurt by a number of other communities, which were once essentially agriculture service centers, but are now becoming full-fledged suburban communities. As in the Bay Area's "outer ring" cities, these newly flourishing communities have benefitted from their location not along waterways, but rather along major interstate and state highways.

Yet unlike the Bay Area, these communities have not been guided to the same extent by the sharp geographic contours found in the Bay region's coast ranges. As a result, Delta communities have sprawled across the Central Valley's flat topography at relatively low building densities. In addition, they are still complemented by large populations spread throughout rural unincorporated areas, whereas Bay Area populations are largely concentrated in incorporated areas.

However, San Joaquin and Yolo Counties, population and households have become increasingly concentrated in incorporated areas. In Yolo County, approximately 60 percent of the population and households are in the two major cities—Woodland and Davis. In San Joaquin County, population and households have been rapidly concentrating in incorporated areas. By 1987, 70 percent of the county's population was in its cities, compared with 60 percent in 1970. The most significant growth has been going to Manteca, Ripon, Stockton, and Tracy. The preponderance of households has also shifted to the cities; only 27 percent of all San Joaquin households are now in unincorporated areas.

Sacramento County has also experienced rapid growth in its cities, although increases in rural populations and households seem to have kept pace. In 1988, population in unincorporated areas amounted to 61 percent of the county's total. Sixty percent of the county's households were also in unincorporated areas. Those figures are expected to decline only slightly—between 55 to 57 percent—over the next 20 years. While the City of Sacramento will continue to grow steadily, communities on its fringe, especially Folsom, are expected to grow at a dynamic rate.

What is striking about the Delta counties is that they form a region not as self-contained as the Bay Area. Much of the new development and concentration of Delta county communities has been driven by connections with the growing job centers in the Bay Area's Tri-Valley sub-region in Contra Costa County and the Interstate 80 corridor in Solano County, while their own job centers have increasingly become magnets for commuters from Stanislaus County (to the south), Solano County (to the west), and Sutter, Placer and El Dorado Counties (to the north and east).

In general, the metropolitan structure of the Delta counties—for reasons of topography, placement of transportation arteries, and lower-density urban construction—is less concentrated and more sprawling than in the Bay Area. It is also subject to substantial development pressures from all sides (with the possible exceptions of Yolo's western and northern flanks and San Joaquin's eastern fringe) which, without natural barriers or a strong land use management framework, is likely to increase the Delta communities' tendency to spread out on to prime agricultural land and wetlands.

3. **Estuary Region: Upland Land Use.** For purposes of analysis, the Estuary region's uplands have been divided into five land use categories, based on available data and the effects of different kinds of land use on water quality in San Francisco Estuary. The categories include: rural/open space, intensive agriculture, residential, commercial/light industry, and heavy industry. These upland land uses will be the categories of our impact analysis through this report. (See Chapter 2 for a detailed discussion of the analysis methods followed in this study.)

Table 6 summarizes existing Estuary region land use, based on studies performed by ABAG (1989) and the U. S. Geological Survey (USGS) (1975), and further analysis by the authors of this report. Of the approximately 6,566,860 acres in the region, the three urban land use categories—residential, commercial/light industrial, and heavy industrial—comprise 896,498 acres or 14 percent of the Estuary region. Of this, 582,444 acres (nine percent) is residential land, 150,081 acres (two percent) is commercial or light industrial use, and 163,973 acres (three percent) is heavy industrial use. Intensive agriculture accounts for 1,822,595 acres (28 percent), and extensive agriculture and rural land uses occupy a total of 3,847,767 acres (59 percent).

In four counties, 522,124 acres of land is dedicated to urban use: Santa Clara (159,107 acres), Sacramento (121,796 acres), Alameda (122,846 acres), and Contra Costa County (118,375 acres). The urban area in compact San Francisco (24,621 acres) is just slightly smaller than urban land uses in Napa County (27,658 acres) and greater than urban uses in Yolo County (21,367 acres).

Three counties have over 75,000 acres of land in residential use: Santa Clara (111,610 acres), Contra Costa (82,294 acres), and Alameda (75,590 acres). Sacramento County has the largest area of land classified heavy industrial (23,974 acres), followed by Alameda (23,722 acres) and Contra Costa (15,767 acres).

San Joaquin County has by far the largest area in intensive agriculture (731,920 acres), followed by Yolo County (463,248 acres). Rural land uses occupy 643,359 acres in Santa Clara County, 867,395 in Sonoma County, and 410,584 acres in Napa County.

a. **Rural/Open Space**. This category includes many types of open or partially developed lands which generally have a negligible impact on the quality of water which moves through or over its soils and into San Francisco Estuary. It is these areas that are being converted to more intensive urban uses.

Table 6
Existing Estuary Region Land Use By County

SOURCE: ABAG, 1989
Prepared by: CEDR, 1991

County	Residential	Commercial/ Light Industrial	Heavy Industrial	Intensive Agriculture	Rural
Alameda	75,590	23,534	23,722	5,463	328,999
Contra Costa	82,294	20,314	15,767	15,384	326,501
Marin	31,663	2,014	7,665	969	288,939
Napa	16,464	7,858	3,336	46,779	410,584
Sacramento	66,136	31,686	23,974	435,217	61,659
San Francisco	15,839	4,485	4,927	0	4,744
San Joaquin	29,227	11,871	13,168	731,920	110,992
San Mateo	47,856	7,272	13,455	16,299	195,320
Santa Clara	111,610	12,671	34,826	15,718	643,359
Solano	29,830	12,703	8,935	30,794	446,599
Sonoma	68,553	5,797	10,089	60,804	867,395
Yolo	7,381	9,877	4,109	463,248	162,676
TOTAL	582,444	150,081	163,973	1,822,595	3,847,767

Rural/Open Space lands make up almost 60 percent of the land area in the nine county San Francisco Bay region. In the Delta region, "rural/open space" lands are a much smaller component of the area's open lands. Along with intensive agriculture, rural/open space lands form a "Greenbelt" around each region's urban centers.

The sub-categories which make up Rural/Open Space include: publicly owned parks and watersheds; privately held lands in extensive agriculture (primarily grazing); rural estates (in some cases known as "ranchettes") with one dwelling unit (house) on a parcel of one to forty acres of land, and; other small private holdings on lands that are difficult to develop (e.g., due to steep slopes).

(1) **Public Lands: Parks.** In the Bay Area, approximately 412,000 acres of the region's public open lands are dedicated to parks and recreation. More than half of these lands are located in Marin and Santa Clara Counties (Greenbelt Alliance, 1988).

The parks are located almost entirely within the Estuary's watershed and, with the notable exception of lands in the San Francisco Bay National Wildlife Refuge, are almost exclusively ridgeland parks. The natural vegetation in these parks can largely be characterized as mixed hardwood forest, coast live oak/toyon and blue oak/digger pine forest and chaparral. There is also a considerable amount of California prairie, dotted with valley oak habitat.

In the Delta region, there is significantly less publicly-owned parkland. In Yolo County, public-owned open lands are primarily located in the Coastal Range. The largest holdings are managed by the Bureau of Land Management. Otherwise, there is the Cache Creek Regional Park at the northwest end of the county and a number of small community parks sprinkled throughout the county's unincorporated lands and cities.

In Sacramento County and City, most parks are located along the American River. In the city of Sacramento, there are 5,516 acres planned as public open space. In San Joaquin County, most regional parks are associated with waterway access. Total regional parkland amounts to 3,928 acres with an additional 102 acres of parkland in unincorporated areas.

(2) **Public Lands: Watersheds and Flood Control.** In the Bay Area, 18 percent of the region's public open lands (126,583 acres) are protected watersheds. San Francisco City and County holds nearly half of these lands (61,525 acres) which are located primarily in southern Alameda (surrounding San Antonio and Del Valle Lakes), northern Santa Clara (Calaveras Reservoir), and San Mateo Counties (San Andreas and Crystal Springs Reservoirs).

In the North Bay, the largest reservoir is Lake Beryessa in Napa County, whose water resources are devoted almost entirely to Solano County. Other major watersheds in the North Bay are Lake Sonoma northwest of Healdsburg and Nicasio and Soulajoule Reservoirs in Marin County.

In the East Bay and South Bay are a number of reservoirs and watersheds managed by East Bay Municipal Utility District (EBMUD) and Santa Clara Valley Water District. EBMUD's holdings total 27,986 acres and most prominently feature San Pablo, Briones, Upper San Leandro and Pinole Valley Reservoirs.

Reservoirs are much fewer in number in the Delta counties. In Yolo County, there are no publicly owned–reservoirs with surrounding watersheds. In San Joaquin County, there are three main reservoirs: the Pardee and Camanche Reservoirs (on the Mokelumne River) and the New Hogan Reservoir on the Calaveras River. In Sacramento, the principle reservoir is Folsom Lake at the northeast juncture of Sacramento, Placer and El Dorado Counties.

(3) **Extensive Agriculture.** Of the Bay Area's nearly two million acres in farming, most of the land is in extensive agriculture (e.g., hay and grain production and irrigated and non-irrigated pasture). By the 1980s, more than 75 percent of Bay Area farmlands was in grazing; a considerable share of the region's grazing land is among the most productive in the United States (Greenbelt Alliance, 1985).

Most of the Bay Area's grazing land is in the rolling or steep terrain of the Coastal Ranges, whose soils and slopes are unsuitable for intensive agriculture, residential, or commercial development. Grazing lands make up: most of eastern Alameda County and Santa Clara Counties; significant sections of central and eastern Contra Costa County, especially the productive Tassajara Hills east of San Ramon; southern Solano County, notably in the Montezuma Hills; southeast and northern Napa County; southwest Sonoma County and in the hills to the east of the Cotati and Alexander Valleys, and; in the northern parts of central and west Marin County.

On the other hand, extensive agriculture takes up a smaller share of the Delta counties' farmland. In Sacramento County, the major outposts of its sizeable dairy farming sector are around Galt and Elk Grove, although there are significant grazing lands in the eastern part of the county, away from the prime soils of the Delta and along the Cosumnes River. In Yolo County, there is very limited grazing, mostly on the west side of the county in the ridgelands area. In San Joaquin County, there are grazing operations throughout the state but the largest are in the county's southwest corner near Escalon and south of Tracy.

(4) **Rural Estates.** Low density rural estates, also known as "ranchettes," are generously spread throughout the Bay Area and Delta counties. Most of these units are on parcels ranging from 1 to 10 acres of land, and are usually planned and zoned as "rural residential" or "agriculture residential."

b. **Intensive Agriculture.** Intensive agriculture is the predominant land use in the Delta Counties. The counties' flat topography and excellent soils, combined with ample irrigation water from government water projects, have transformed their domain from great tule marshes and open prairie into an agricultural bonanza.

Agriculture is Yolo County's main economic pillar, contributing about $200 million in 1988. San Joaquin County also reaps an enormous harvest, pulling in $855 million in crop-related revenues in 1988. Sacramento County has a more diverse economy and relies less on agriculture, whose raw crops were worth $199 million in 1988.

The majority of Yolo County's land (approximately 70 percent) is planned and zoned as agricultural preserve. Many of its crops depend on irrigation, especially its staple crop, the tomato. Other major crops are wheat, alfalfa, and rice. These crops dominate the central part of the county and are often planted in rotation. There are also substantial nut orchards in the southern part of the county near Winters and increasing acreage is being planted in wine grapes, especially near Clarksburg and north of Esparto.

In Sacramento County, intensive agriculture is spread throughout the area, although it is concentrated on prime farmlands in the southern part of the county in the Cosumnes River floodplain. Major crops include fruit orchards (especially pears), corn and tomatoes. Away from the flood plain, to the north and east, rice farming and some seed crops can be found, although grazing operations are prevalent.

Dairy farming was San Joaquin County's principal cash crop in 1988, but most of its farmland is devoted to irrigated crops, particularly grapes, tomatoes, and tree crops, like almonds. A sizeable portion of San Joaquin's agriculture is also devoted to dry farmed crops, especially hay. Farming for tomatoes, sugar beets, wheat and hay are scattered throughout the county and are often grown in rotation. In the south part of the county are melons, almonds, beans, and rice. Tree crops (walnuts, cherries and apples) predominate east of Stockton and grapes are the major crop around Lodi. Sunflowers, safflowers, asparagus, wheat, corn and potatoes are the main crops on the Delta.

Comparatively, intensive agriculture is not as prominent in the nine Bay Area counties. Nevertheless, it is still an important part of the Bay Area's land use mix, making up nearly half a million acres of the region's total land area. Revenues from Bay Area farm production amounted to more than $1 billion in 1988.

The largest acreage of intensively farmed land is in Solano County, primarily on prime agricultural land in the northeast corner of the county around Dixon. Principal crops are sugar beets, tomatoes and field corn. Close to the Yolo County border near Winters, and in the Laurel and Green Valleys near Napa County, are a number of fruit and nut orchards.

Other major farming centers in the Bay Area are: Napa Valley, all devoted to wine grapes; the Dry Creek, Alexander, Knights and Franz Valleys, and the Valley of the Moon in Sonoma County, planted primarily in wine grapes, and the apple orchard belt running from Sebastopol to Forestville; south Santa Clara Valley, a source of tomatoes, peppers, garlic and a host of nursery crops; the "fertile crescent" south of Livermore in Alameda County, planted in wine grapes, and; east Contra Costa County, which produces fruits and nuts around Brentwood and corn, barley and other grains in the Delta area.

c. **Residential.** Residential development is by far the largest component of urbanized lands. There is an enormous range of residential development in this category, from the low density of one dwelling unit (du) per acre in suburban areas to neighborhoods in San Francisco where densities can exceed 125 du/acre. Most high density residential development is in the Bay Area's "inner ring," particularly in the region's older communities. By contrast, residential development densities are significantly lower in the Bay Area's "outer ring" communities. Densities in towns in the Delta counties tend to fall somewhere in between (see Table 7).

Given the broad range of densities included in this category, it is difficult to generalize about the water quality impact of residential development. While developments built at one du/acre (or similarly low densities) may have a small percentage of land covered by pavement (thereby permitting greater groundwater recharge), their landscaping may also require much more in the way of chemical inputs. In addition, lower density development generates much greater dependence

Table 7
Residential Density

SOURCE:
Greenbelt Alliance

ESTUARY STUDY AREA (Occ. units/sq. mi.)	1960	1980
Bay Area Inner Ring Communities		
Alameda	2,131.6	2,791.3
Berkeley	4,091.3	4,101.3
Daly City	3,299.8	3,658.4
Mountain View	1,164.2	2,309.2
Oakland	2,525.3	2,628.1
San Francisco	6,546.5	6,443.0
San Jose	1,143.3	1,238.7
San Mateo	2,254.1	2,808.1
Sunnyvale	877.5	1,834.7
Bay Area Outer Ring Communities		
Antioch	961.1	1,024.3
Concord	1,207.6	1,302.1
Fairfield	454.9	546.2
Livermore	823.3	906.7
Napa	806.1	1,159.6
Santa Rosa	931.4	1,006.7
Delta Communities		
Davis		2,064.8
Sacramento		1,174.4
Stockton		1,383.4
Woodland		1,603.0

on automobile travel (Holtzclaw, 1990), with its attendant impacts on water quality, such as oil and grease run-off and contribution to acid precipitation.

d. **Commercial/Light Industry**. This category is largely comprised of office space, retail sales facilities and service facilities (including markets, hotels, and service stations). Commercial/light industry takes up a relatively small proportion of land acreage in the Estuary region, with the exception of some of the older Bay Area counties that have experienced the most intensive urbanization. While most counties range between one and four percent in the quantity of land devoted to commercial/light industry, San Mateo and Alameda County both exceed five percent and San Francisco devotes fully 16.4 percent to commercial. Most of San Francisco's commercial/light industry is concentrated in the city's downtown core.

Other major centers of commercial development are located in San Jose and Silicon Valley, the Oakland/Berkeley urban core, the Interstate 680 corridor in eastern Alameda and Contra Costa Counties, and in Sacramento.

e. **Heavy Industry**. As a category, heavy industry combines those facilities which have a serious, and often detrimental, impact on the Estuary's water quality. Within this category are major manufacturing and processing plants and refineries, airports and shipping facilities, and military bases.

In terms of land acreage, heavy industry is the smallest category in both the Bay Area and the Delta counties. In the Bay Area, heavy industry covers approximately 97,000 acres and is sited primarily near San Francisco Bay and the Carquinez Straits for purposes of water transportation access and in some cases use of water in the manufacturing process. Significant concentrations of heavy industry are in the southwest quadrant of San Francisco, in pockets throughout San Jose and the Silicon Valley, along the East Bay shoreline, especially near Richmond, and in Pittsburg and Antioch near the Carquinez Strait.

In the Delta counties, heavy industry concentrations are around Stockton and Sacramento, which has especially large tracts of land devoted to extensive industry east of Mather Air Force Base.

Wetlands

Wetlands are an integral part of the Estuary system. Because of the interrelationship between the open waters of the Estuary and the adjacent diked wetlands that were historically part of the San Francisco Bay and Delta open water and marsh system, the diked wetlands are considered part of the Estuary system in this report and therefore land use change around the Estuary is analyzed as to impacts on these wetlands.

Wetlands are typically characterized by biologists as including: (1) the presence of standing water for all or some portion of the year; (2) the existence of hydric or saturated soils; and (3) the prevalence of plants (hydrophytes) that are adapted to water-logged soil and periodic submergence. For most wetlands, the hydrology is the single most important factor affecting the establishment and maintenance of specific types of wetlands and wetland processes. Water depth, flow patterns, frequency and duration of flooding, groundwater, tidal influences, and precipitation all influence the biochemistry of soils and are major factors influencing what plants and animals will be found in any given wetland (Mitsch and Gosselink, 1986).

Wetlands are intermediate between terrestrial and aquatic ecosystems and exhibit characteristics common to both, forming a continuous gradient between uplands and open water. For these reasons, it is often difficult to identify the precise boundary of any given wetland, or to define precisely what constitutes a wetland. Further, wetland boundaries are also influenced by drought, flooding, and human activities such as water diversions, levee construction, discing and tilling, or draining.

Despite the difficulties in defining wetlands, or locating their boundaries with precision, classifying wetlands and inventorying them is essential in making estuary-related resource management decisions. The wetlands of the San Francisco Estuary were recently inventoried and mapped using a classification system developed for the U. S. Fish and Wildlife Service and described in a report entitled *Classification of Wetlands and Deep Water Habitats of the United States* (Cowardin et al., 1979). (Note: the wetlands were mapped based on the U. S. Fish and Wildlife Services (USFWS) digitized National Wetlands Inventory Maps (NWI)). The USFWS had not completed digitizing the Estuary region, and consequently, as shown in the

Estuary wetlands figure, there are mapping omissions, particularly in the Delta Counties. When the remainder of the 20 quadrangle sheets for the Delta that have been mapped are entered into the GIS and when the digitizing for the remainder of the Estuary region is complete, the information can be added to the map. The San Francisco Estuary wetlands are mapped in Figure 15. Table 8 presents wetland types by receiving water shed. Following is a description of each of the Estuary wetland habitats and their importance to the Estuary system. The description is arranged by common characteristics—tidal water system, diked wetlands, and fresh water system.

1. **Tidal Water.** In the San Francisco Estuary, there are several types of wetlands that are influenced by salinity and the ebb and flood of the Pacific Ocean tides. In the central Bay, the salinity of the water approximates that of the ocean, while further inland, the tidal effect can remain significant even when the salinity is mixed with fresh water and becomes brackish.

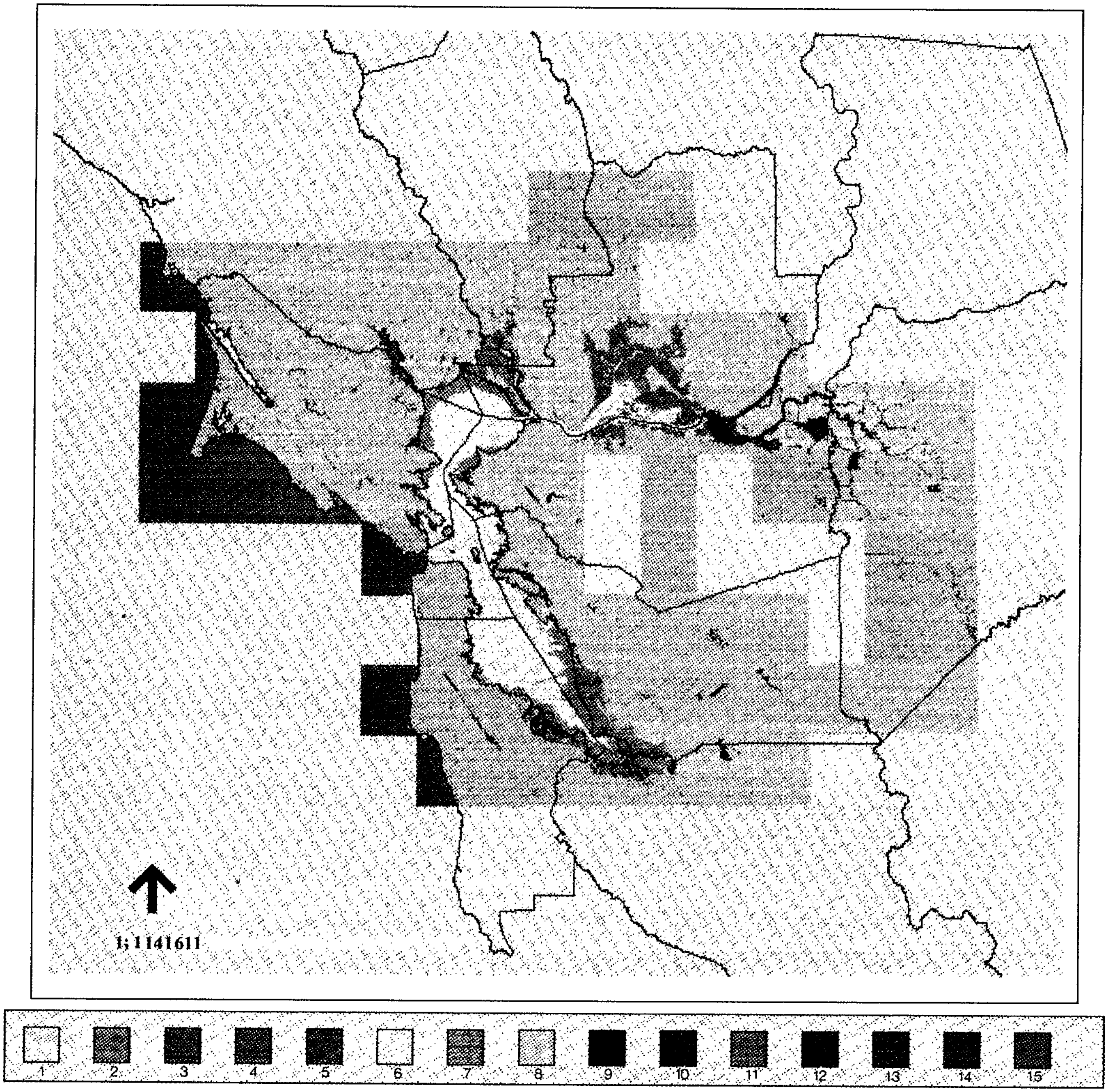
a. **Open Water and Mudflats and Rocky Shore.** Estuarine intertidal (open water) and subtidal (mudflats and rocky shore) water is included in this classification. The two classifications are discussed together because of the close relationship between the two. Open estuarine water can be classified as salt and brackish water. Open tidal water extends from the mouth of San Francisco Bay at the Golden Gate to the bayward limit of emergent wetland vegetation and is the largest habitat in the Estuary. The open water subtidal areas contain the substrate (the substance in which plants take root, and animals burrow, fasten, or rest on such as sand, soil, rock) which is continuously submerged (e.g., deep water habitat, slough channels) and intertidal areas which are areas where the substrate is exposed and flooded by tides (mudflats, cobble and rocky shores, and beaches). Both tidal and subtidal habitats are strongly influenced by tides, precipitation, fresh water runoff from land evaporation, and wind.

Open tidal water includes many diverse habitats which in turn has given rise to a diverse assemblage of plants and animals. Diatoms, algae, protozoans and a multitude of arthropods, worms, and molluscs live on and in the mudflats and bay bottom and are major components of the estuary's food chain. Several species of fish utilize different open tidal water habitats during one or more stages of their life cycle, including such commercially important species as salmon, striped bass, Pacific herring, starry flounder, anchovy, and dungeness crab. Open tidal waters are used by birds for feeding and resting while the Bay's intertidal mudflats have been called the most important habitat on the California coast for millions of migrating and resident shorebirds (Jones and Stokes Associates, 1979).

The tidal flow provides an exchange of water for the revitalization of adjoining salt marshes, and in turn, conveys nutrients and other foods from marshlands into open water habitat (Jones and Stokes Associates, 1979). Moreover, tidal open water has a principal stabilizing effect on the climate of the San Francisco Bay and Delta area (Miller, Albert, 1967).

Figure 15
Estuary Wetlands

SOURCE: U.S. Fish and Wildlife Service; National Wetlands Inventory, 1990.



1 Open Water
2 Mudflats and Rocky Shore
3 Vegetated Tidal Marsh
4 Tidal (Full or partial) Channels or Pond Connections
5 Diked Vegetated Wetlands
6 Seasonal and Permanent Vegetated Wetlands
7 Seasonal Ponds (Includes man-made areas and abandoned salt ponds
8 Farmed Wetlands
9 Freshwater Marsh
10 Riparian Forest
11 Salt Evaporator, Crystallizers, and Bittern Ponds
12 Perennial Lakes and Ponds
13 Rivers, Tidal
14 Rivers, Nontidal, Perennial and Intermittent Creeks
15 Marine

Table 8
Existing Wetlands By Types and Watershed

SOURCE:
Center for Environmental Design Research, U.C., Berkeley

	WATER SEGMENTS AND WATERSHEDS	WETLAND TYPES 1	2	3	4	5	6
20	Santa Clara Reach	3,029	6,731	645	0	0	0
21	Santa Clara watershed	450	294	4,057	44	1,824	447
23	Santa Clara Reach islands	0	0	86	2	0	0
30	South South Bay	13,072	11,564	469	0	17	0
31	South South Bay watershed west	141	67	373	0	694	32
32	South South Bay watershed east	0	279	754	5	877	734
33	South South Bay islands	54	269	1,782	15	479	0
40	South Bay	74,587	10,648	86	0	25	0
41	South Bay watershed west	511	166	124	0	133	17
42	South Bay watershed east	106	363	138	32	707	235
43	South Bay islands	57	20	5	0	12	12
50	Central Bay	32,526	1,376	74	0	0	0
51	Central Bay watershed west	52	2	0	0	0	0
52	Central Bay watershed east	101	158	106	0	2	0
53	Central Bay islands	52	42	12	0	0	0
60	Richardson Bay	1,611	1,169	47	0	0	0
61	Richardson Bay watershed	54	148	148	0	7	7
70	North Bay	13,304	2,454	47	0	5	0
71	North Bay watershed west	161	151	297	15	208	15
72	North Bay watershed east	42	40	0	0	0	0
73	North Bay islands	2	0	0	0	0	0
80	San Pablo Bay	50,443	21,176	2,145	0	25	0
81	San Pablo Bay watershed west	1,448	689	12,338	151	7,166	991
82	San Pablo Bay watershed east	22	96	549	0	106	30
90	Carquinez Strait	3,319	507	62	0	0	0
91	Carquinez Strait watershed north	57	30	190	0	20	5
92	Carquinez Strait watershed south	0	0	67	0	59	5
100	Suisun Bay	18,567	5,019	759	5	133	0
101	Suisun Bay watershed north	3,096	175	5,713	754	40,529	1,164
102	Suisun Bay watershed south	111	101	1,497	57	2,921	237
103	Suisun Bay islands	408	59	944	0	30	0
110	West Delta	2,950	198	101	0	22	0
111	West Delta watershed north	208	0	440	0	1,411	361
112	West Delta watershed south	27	0	109	2	845	62
113	West Delta islands	175	111	1,001	0	5	0
120	North Delta	0	0	0	0	0	67
121	North Delta watershed	0	0	0	0	25	161
123	North Delta islands	0	0	0	0	27	334
130	Central Delta	0	0	0	22	22	10
131	Central Delta watershed west	0	0	0	0	12	42
132	Central Delta watershed east	0	0	0	0	0	7
133	Central Delta islands	0	0	0	0	326	351
140	East Delta	0	0	0	0	0	0
141	East Delta watershed	0	0	0	0	0	27
143	East Delta islands	0	0	0	0	0	101
150	South Delta	0	0	0	0	10	64
151	South Delta watershed	0	0	0	0	20	114
153	South Delta islands	0	0	0	0	15	183
	TOTAL	220,744	64,103	35,165	1,105	58,721	5,814

Wetland Types

1 open water
2 mudflats and rocky shore
3 vegetated tidal marsh
4 tidal channels
5 diked vegetated wetlands
6 seasonal/perm. veg
7 seasonal ponds
8 farmed wetl;ands
9 freshwater marsh
10 riparian forest
11 salt evaporators
12 perennial lakes and ponds

7	8	9	10	11	12	13	14	SUMS
0	0	0	0	69	0	0	0	10,475
959	378	32	435	16,699	1,594	0	0	27,213
0	0	0	0	193	0	0	0	282
25	0	0	0	84	10	0	0	25,241
86	0	0	158	2,723	751	0	0	5,026
734	922	27	492	7,630	4,542	0	116	17,112
838	0	0	0	0	27	0	0	3,464
22	0	0	0	0	22	0	0	85,390
59	0	0	109	0	1,495	0	0	2,614
833	10	0	227	121	1,023	0	0	3,795
12	0	0	0	0	59	0	0	178
0	0	0	0	0	5	0	0	33,981
0	0	0	0	0	2	0	0	57
0	0	0	0	0	104	0	0	472
0	0	0	0	0	2	0	0	109
0	0	0	0	0	0	0	0	2,827
0	0	0	35	0	67	0	0	467
2	0	0	0	0	0	0	0	15,812
82	0	7	17	0	116	0	0	1,067
12	0	0	0	0	10	0	0	104
0	0	0	0	0	0	0	0	2
0	62	0	0	10	0	40	0	73,900
1,631	25,681	35	556	8,960	2,656	151	54	62,506
27	0	0	156	27	1,950	0	0	2,963
0	0	0	0	0	5	0	0	3,892
0	0	0	0	0	2	0	0	304
12	0	0	0	0	69	0	0	213
0	0	0	0	0	2	0	0	24,485
828	8,063	5	329	0	1,151	0	0	61,807
106	0	0	20	25	870	0	0	5,945
0	0	0	0	0	0	0	0	1,441
0	205	2,056	190	0	30	10,329	0	16,081
2	222	183	15	0	49	84	0	2,975
109	0	131	27	0	200	44	0	1,557
2	8,649	47	40	0	82	205	0	10,316
0	203	62	52	0	7	2,617	0	3,007
116	0	2	195	0	722	2	37	1,260
22	30,255	86	119	0	72	339	30	31,283
37	2,098	1,329	1,250	0	3,808	14,604	0	23,180
22	0	0	0	0	64	0	0	141
0	0	0	0	0	27	0	44	79
418	145,759	766	996	0	2,229	2,861	84	153,790
0	0	0	2	0	32	240	0	274
7	0	12	5	0	67	7	0	126
0	12,590	42	262	0	823	536	15	14,369
2	57	0	442	0	101	141	450	1,268
40	0	0	200	0	237	0	395	1,006
22	9,612	7	336	0	371	544	600	11,690
7,070	244,765	4,831	6,664	36,541	25,456	32,743	1,826	**745,548**

13 rivers, tidal
14 rivers, nontidal, creeks

Tidal open waters have been used by humanity for harvesting food (shellfish, waterfowl, fish), for recreation (boating, fishing, hunting, swimming, nature study), and as receiving waters for the disposal of dredged material, industrial and municipal waste discharge, and urban runoff and serves to dilute and disperse pollutants.

b. **Tidal Marsh**. Tidal and brackish marsh exist at the interface between uplands and tidal open water. Such marshes occur wherever the accumulation of sediments is equal to or greater than the combined rate of land subsidence and sea level rise, and where there is protection from destructive waves and storms. The structure and function of such marshes is determined by the frequency of tidal inundation, soil and water salinity, and the availability of nutrients.

Salt and brackish marshes are among the most productive ecosystems in the world and they support a diverse assemblage of terrestrial and aquatic herbivores (biological productivity is the total quantity of living material produced in a specific area and time). However, the great majority of tidal and brackish marsh vegetation is not consumed directly but enters the food chain as detritus where dead marsh vegetation becomes an important contributor of nutrients to both the marsh and to adjacent intertidal mudflats and open water areas. In addition, a number of birds and mammals, including many animal species listed by the State and federal governments as threatened or endangered depend heavily on salt and brackish marshes both for food and protection (Josselyn, 1983).

In addition to providing food and habitat for many fish and wildlife populations, tidal and brackish marsh reduce shoreline erosion caused by large waves and flooding. Such marshes also improve water quality by: (1) reducing water velocity, causing sediments and chemicals to drop into the marshlands, thereby reducing turbidity; (2) temporarily or permanently retaining pollutants by incorporating pollutants into wetland vegetation and subsequent burial in sediments when the plants die; and (3) converting some chemicals to less harmful forms (Mitsch and Gosselink, 1986; Burke et al., 1988).

2. **Diked Wetlands**. Diked wetlands include managed diked wetlands (diked marshlands adjacent to the Bay where water regimes are manipulated to encourage production of waterfowl food plants), salt ponds (diked areas adjacent to the Bay used to produce salt through solar evaporation), diked seasonal wetlands (diked areas adjacent to the Bay where the substrate is infrequently submerged or saturated), and diked farmed wetlands, all formerly intertidal mudflats or tidal marsh before dike construction excluded tidal action. Although many of the same plants and animals are found in diked wetlands as are found in tidal wetlands, few studies have evaluated how the wetland functions and processes of these areas compares with those of tidal and brackish marshes.

The wide variety of water regimes and vegetation found in seasonal wetlands contributes greatly to the habitat extent and diversity of the Bay. Diked seasonal wetlands act as a buffer between remaining natural tidelands and serve as protected corridors for wildlife movement in and out of wetland areas. Wildlife also

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use these areas as a refuge during high tides and storms. The wetlands also buffer land areas from storms and erosion and provide valued open space and recreation (photography, bird watching, nature study) for Bay residents (Madrone, 1983).

a. **Diked Managed Wetlands**. Managed diked wetlands are managed primarily by private hunting clubs and state wildlife areas to encourage the growth of wetland vegetation attractive to migratory waterfowl. The largest area of managed diked wetlands in the Estuary is the 85,000-acre Suisun Marsh in Solano County. These managed marshlands constitute approximately 12 percent of California's remaining wetlands and in dry years have supported over 25 percent of the central California waterfowl population (Jones and Stokes Associates, 1979). Moreover, under an ambitious management program, natural waterfowl breeding in the Suisun Marsh has become a major waterfowl management success. The managed wetlands also attract significant populations of migratory and resident shorebirds, wading birds, and raptors. Mammals are also abundant in these managed wetlands, the most notable being the endangered salt marsh harvest mouse (California Department of Fish and Game, 1975).

b. **Salt Ponds**. Used in the solar evaporation of open Bay tidal water to form salt, salt ponds cover approximately 36,000 acres of former wetlands in San Francisco Bay. Salt pond salinities vary in concentration from those similar to open tidal water to highly concentrated, saturated brines. The distribution of organisms in the ponds is dependent on their response to the physical stresses present, as well as available food and shelter. The ponds tend to be dominated by a few organisms that can withstand the unique environmental conditions of the ponds and can flourish in the absence of competitors.

A number of waterfowl feed in both tidal marshes and salt ponds. In fact, the greatest densities of migratory birds in San Francisco Bay have been observed on intertidal mudflats and salt ponds (Bollman et al., 1970). It has been suggested that birds may supplement their diet by feeding in salt ponds, or that salt ponds provide important foraging habitat when the intertidal mudflats are covered at high tide. It has also been hypothesized that birds find reduced competitive pressure for available prey in salt ponds. It is clear that salt ponds are important roosting, resting, and nesting habitat for both migratory and resident birds (Josselyn, 1983).

c. **Diked Seasonal Marshes**. Seasonal marshes include former tidal and brackish marshes that have been diked off from the open tidal waters of the estuary but have not been otherwise substantially altered. Fresh water input comes from winter rainwater falling directly on the seasonal wetland, storm water runoff from adjacent uplands, high groundwater, and flood flows overtopping levees. Many diked seasonal wetlands are used as storm retention basins and improve water quality by assimilating pollutants from runoff. Saltwater occasionally enters when high tides overtop levees, when seepage passes through poorly maintained levees, and when tide gates malfunction or leak. Although typically most of these wetlands dry out by spring and summer, portions of these wetlands may be wet year round, even though the area is effectively cut off from regular hydraulic connection with the Bay.

Salinity levels in the soil are extremely variable, depending on the amount of fresh water input and the degree water is able to drain leeching the salts from the soil (Madrone, 1983).

Differences in the amount of water inflow, salinity, and drainage patterns determine what kinds of vegetation will inhabit these wetlands. Vegetation in diked seasonal wetlands range from plant associations resembling those occurring in high tidal marsh that are only inundated during high tides (such as pickleweed), to plant assemblage that are typical of fresh water marshes (such as cattails).

Most of the information regarding wildlife usage of diked seasonal wetlands come from bird studies. Extensive surveys of bird use of diked seasonal wetlands conducted by the U. S. Fish and Wildlife Service since 1983 have found that these wetlands provide essential feeding and roosting habitat to migratory birds at a time of year when California's limited wetland acreage must support a much larger bird population, i. e., the bird migratory season which generally coincides with the wet season (mid-October to mid-April). The surveys suggest that these wetlands may play a critical role in support of small migratory shorebirds who forage on seasonal wetlands adjacent to the Bay when high tides cover intertidal mudflats.

d. **Diked Farmed Wetlands.** In the late 19th century, broad expanses of tidal, brackish, and fresh water marsh in the north Bay and Delta were diked, ditched, and drained for agriculture. Many of these diked areas consolidated and subsided and eroded when dry from strong winds when diking and draining occurred, lowering the surface elevations four to nine feet below Mean Higher High Water. Because of their low elevation relative to both open Bay and Delta waters and upland, rainwater and seepage collects in low-lying areas (Madrone, 1983). In addition, many of these fields are seasonally flooded to control weeds and centipedes, to leach salts, and to attract waterfowl for feeding and roosting. As a result, diked farmlands provide important wetland habitat at a time when the fields would ordinarily lie fallow. Nearly 10 percent of all waterfowl wintering in California are found in the vast farmed wetlands of the Delta.

Vegetation and wildlife use of the dry portions of these diked farmed wetlands depends on what kinds of crops are selected for planting. Farmed wetlands planted in crops that are periodically disturbed by planting, cultivation, and mowing, such as hay and alfalfa, tomatoes, asparagus, and other row crops generally have less habitat stability, cover, and insect and plant food than permanent pasture that is not cultivated or mowed (Madrone, 1980). Therefore the more intensive the diked formed wetlands, the less value the area as wildlife habitat.

e. **Seasonal and Other Ponds**. This category includes shallow water, seasonal ponds that form in abandoned salt ponds and in diked seasonal marshes during the rainy season, as well as artificial lagoons and sewage oxidation ponds. Water and soil conditions in these ponds are highly variable and are determined by such factors as water sources, evaporation, water volume, and soil salinity and pH.

The wide range of habitats included in this category have given rise to a corresponding diversity of vegetation and wildlife, ranging from barren abandoned salt ponds to brackish- and fresh water ponds that may be ringed with marsh vegetation. Though species diversity, abundance and composition is highly variable within this category, all provide important wildlife resources. For example, even though abandoned salt ponds are nearly devoid of vegetation, they often contain large numbers of brine shrimp, water boatmen, and brine flies at different times of the year (McGinnis, 1983). Such ponds also attract substantial numbers of shorebirds for resting and feeding in the winter (Cole/Mills, 1987), and support nesting populations of resident birds, including the endangered least tern, snowy plover, Caspian tern, and American avocets.

3. **Fresh Water**. The amount of fresh water that flows in streams and rivers of the San Francisco Estuary determines the biological productivity of both fresh water and downstream saline habitats and regulates the life cycles of many of the Estuary's organisms (Herbold and Moyle, 1989). Yet the Estuary's fresh water habitats have been so modified by human activity such as levee and dike construction, water diversion, waste discharge, and agricultural practices, that habitat characteristics and ecological relationships are often obscure. Still, it is possible to identify three broad fresh water communities: fresh water rivers and sloughs, fresh water marshes, and riparian forests and non-tidal fresh water rivers and streams.

a. **Tidal Fresh Water Rivers and Sloughs**. This classification includes Delta open water habitat, including exposed sandbars and tideflats, and Bay sloughs that receive sufficient fresh water from treatment plant discharge that they are now fresh water systems. Water salinities in these habitats are generally very low, but many fresh water rivers and sloughs are sufficiently close to the ocean to experience tidal effects. Delta channels generally have fairly strong currents that are influenced by pumping of water for export from the southern Delta. These water diversions have increased velocities in the northern Delta and reversed flows in the waterways of the southern Delta.

Tidal fresh water rivers and sloughs are a significant contributor to the nutrient base of the Bay-Delta aquatic system. The dredging of channels and the reclamation of marshlands for agriculture have greatly reduced the amount of marsh and riparian woodlands in the Delta. As a result, phytoplankton of the open water is now the dominant source of plant productivity in the Delta (Herbold and Moyle, 1989). Perhaps the most noticeable plant of the Delta's open water areas is the water hyacinth, an introduced floating plant, that grows profusely in the summer and fall in parts of the southern Delta, clogging waterways and providing food for some waterfowl. Delta zooplankton populations, including the opossum shrimp (*Neomysis mercedis*) are another important component of the food web, serving as the major food source for young fish.

Channel flows and tidal fluxes are also important in the transport and dispersal of fish and invertebrate eggs and larvae. Fifty-five species of fish have been reported for the Delta, including many important sport fish, such as striped bass, king and silver salmon, steelhead, and largemouth bass. Most of California's anadromous sport fish migrate through the Delta to their upstream spawning areas. The movements of all stages of anadromous fish have been severely impacted by reversed flows caused by pumping water out of the Delta for export. The Delta is also home to several native fish species that are not abundant anywhere else (Madrone, 1980).

The open water areas of the Delta also attract migratory waterfowl for feeding and resting. Occasionally harbor seals and sea lions are spotted in fresh water channels, which are regularly used by beaver, muskrat, and river otter.

b. **Fresh Water Marshes.** Before the introduction of agriculture, fresh water marshes were the dominant habitat in the Delta, occupying the sloping river banks, as well as many square miles of shallow, overflow lands behind natural alluvial levees (Thompson, 1957). Even though the steep-sided banks of dredged sloughs and the construction of levees to reclaim overflow lands for agriculture have greatly reduced the area suitable for the establishment of marsh vegetation, fresh water marshes are still found along the channels and within flooded islands of the Delta.

Fresh water marshes in the San Francisco Estuary are adapted to the complex and dynamic pattern of overflow, bank erosion, and sediment deposition that occur over time as rivers and channels flood or change course. As a consequence, fresh water marshes include a diverse assemblage of plant communities ranging from tules and reed grass, typically found on newly deposited sediment, to more complex and diverse tule and shrub associations growing on older islands or on older river bank deposits (Madrone, 1980). Without the salinity stress of salt marshes, fresh water marshes support more complex and diverse communities of plants and animals than salt water marshes.

Like the Estuary's salt marshes, fresh water marshes have high biological productivity and provide unique cover, nesting sites, and feeding habitat (Atwater et al., 1979). At least 57 different wildlife species regularly use fresh water marshes, including the rare and endangered black rail and the giant garter snake (Madrone, 1980). Dead tissues of fresh water plants decompose and accumulate in place or are circulated as detritus, providing one of the important nutrient bases for the Delta and Bay ecosystem. The accumulation of the fibrous remains of tules and reeds in ancestral marshes built up the thick organic deposits of peat so highly prized as agricultural land.

Also like salt marshes, fresh water marshes improve water quality by acting as sediment traps and processing nutrients. They also slow flood flows and accommodate seasonal overflows.

c. **Riparian Forests and Non-Tidal Fresh Water Rivers and Streams.** The rarest habitats in the San Francisco Estuary are riparian forests and stream environment zones, the area along rivers and streams that are occasionally flooded by adjoining bodies of water. The flooding waters and subsequent groundwater levels are the main determinants of the type and productivity of vegetation found in the riparian zone. In addition to providing water, floods bring nutrient-rich sediments and export organic and inorganic material from the floodplain (Mitsch and Gosselink, 1986).

Riparian habitats are the most structurally diverse of all habitats in the estuary, with trees, shrubs, overhanging banks, and emergent vegetation providing a wide variety of microhabitats. The complexity of available habitats, the fact that nutrients from the surrounding landscape converge and pass through riparian forests in much greater amounts than any other ecosystem, and the fact that animals from both adjoining uplands and wetlands use riparian zones contributes to the high species diversity and abundance found in riparian forests (Brinson et al., 1981). In fact, Madrone Associates (1980) determined that at least 107 species of vertebrate animals use riparian forests regularly, with many of these species absolutely dependent upon this habitat.

Riparian zones not only provide critical habitat for a number of species, but they enhance the value of adjacent fish and wildlife habitats as well. When adjacent to grasslands or agricultural land, riparian woodlands provide nest sites for birds and cover for upland species that use these adjacent habitats for foraging. In addition, riparian zones provide protective pathways for animals migrating among habitats. Riparian vegetation also shades streams, stabilizes stream banks with tree roots, and produces leaf litter, all of which support a greater variety of aquatic life in the stream (Brinson et al., 1981).

In addition to their importance to fish and wildlife, other benefits of riparian zones include: (1) slowing flood flows, thereby reducing the erosive force of floodwaters (Burke et al., 1988); (2) acting as nutrient sinks, removing many nutrients carried by floodwaters (Mitsch and Gosselink, 1986); (3) contributing significant amounts of detritus to downstream aquatic ecosystems; (4) filter and trap sediments and other pollutants flowing across land to the stream and ultimately the

CHAPTER 6

LAND USE CHANGE IMPACT ASSESSMENT

The direct and indirect impacts on the Estuary of potential land use change in the Estuary region are analyzed in this chapter. Scenario I: General Plan-Based Growth, and Scenario II: Growth Based on Modeled Incentives and Limitations provide two alternative perspectives on how growth can effect the Estuary's water quality and natural resources.

This chapter begins with a discussion of the two scenarios of future urbanization. The next section characterizes the extent of urbanization planned for in the General Plans of the 12-counties in the Estuary region. This is followed by a discussion focusing on the direct impact of land use change on wetlands and streams. The results of both scenarios are presented to offer a range of plausible outcomes of urbanization. These impacts are considered direct because they potentially degrade or actually eliminate resources.

The chapter then shifts to examine indirect effects of land use change on Estuary water quality. Pollutant loads contained in urban runoff are compared among the existing and future land uses. Finally, a select number of watersheds are examined to provide a more complete sense of how land use effects the Estuary.

Interpreting the Results of Scenario I and Scenario II

The purpose of creating two scenarios is to provide two examples of plausible conditions resulting from land use change that will occur before the year 2005. Scenario I: General Plan-Based Growth presents a picture of potential impacts considerably more extensive than those of Scenario II: Growth Based on Modeled Incentives and Limitations.

Having these two perspectives promises to enrich discussions concerning where and how land use is changing throughout the entire 12-county Bay and Delta Region. Furthermore, the focus on potential impacts to three classes of resources: wetlands, streams, and water, guides discussions toward the selection of specific management options that respond directly to the principle causes of resource degradation.

On one hand, Scenario I: General Plan-Based Growth, possesses more than a few "worst case" characteristics. On the other hand, it is not a worst case characterization of growth, and it is not intended to present the extreme of the two scenarios. The process of urbanization commonly involves amendments to the General Plan, so relying on General Plan maps produced over a span of almost fifteen years introduces a problem with currency in this scenario. Scenario I is best viewed as a *snapshot* taken in the Spring of 1990, of a dynamic process by which land use is planned at the county level. Future changes to county plans are impossible to predict and, to the extent that these plans are revised to restrict urban expansion, this scenario is reporting potential impacts that are higher than those that will actually occur. By the same token, the scenario does not capture the pending urban development, including new towns in San Joaquin County, that does not appear on current General Plan maps.

Virtually all land use change represents a conversion of land currently in intensive agricultural or rural uses to one of three urban uses: residential, commercial/light industrial, or heavy industrial. Generally, land conversion from rural to residential is accompanied by fewer resource degrading impacts than the conversion from rural to heavy industry uses, so this feature of the results is important to bare in mind. However, Gunther, et al. (1991) found that residential and commercial lands, when taken in combination, contribute larger pollutant loads to the Estuary than industrial lands in every Bay–Delta area studied. Since the amount of land converted to residential and commercial use is so much greater than that converted to heavy industrial use, the collective impacts are major.

The land use type boundaries in both scenarios are assumed to also be the physical extent of the impacts associated with that particular land use. While off-site impacts will vary from one land use to another and from one resource to the next, it is important to recognize that in the results presented here, off-site impacts are not included. Similarly, the results do not account for the measures taken to mitigate the environmental impacts of land use conversion. Planned unit developments, detailed designs of residential uses, set-asides and sensitive area buffering, are examples of approaches to land development that can effectively limit the impact of land use conversion. These factors can not be accurately considered in the scenarios due to their inconsistent application, but they can reduce the impacts of land use change.

A final point to consider when examining the results is the existing condition of streams. Most streams, particularly those in urban areas, are in marginal condition. So, figures reported here for potentially affected areas may already include some highly disturbed riparian ecosystems.

Scenario I: Growth Based on County General Plans

Local government is the primary land use planning and regulatory institution in California and the Estuary region. Consequently, in developing a pragmatic picture of how land use change would most likely occur over the next 15 years (the time horizon for the San Francisco Estuary Project is 2005), the adopted land use plans and zoning ordinances of all counties and of some cities in the Estuary region were collected and analyzed. The time horizon for these plans are often different, however they provide the best current composite picture of the future land use of the Estuary region desired by the region's local governments. The composite plan of the counties is illustrated in Figure 16, Scenario I: County Plan-Based Growth. Land use designations of each of the counties have been "compressed" into six generic land use classifications: residential, heavy industry, commercial and light industry,

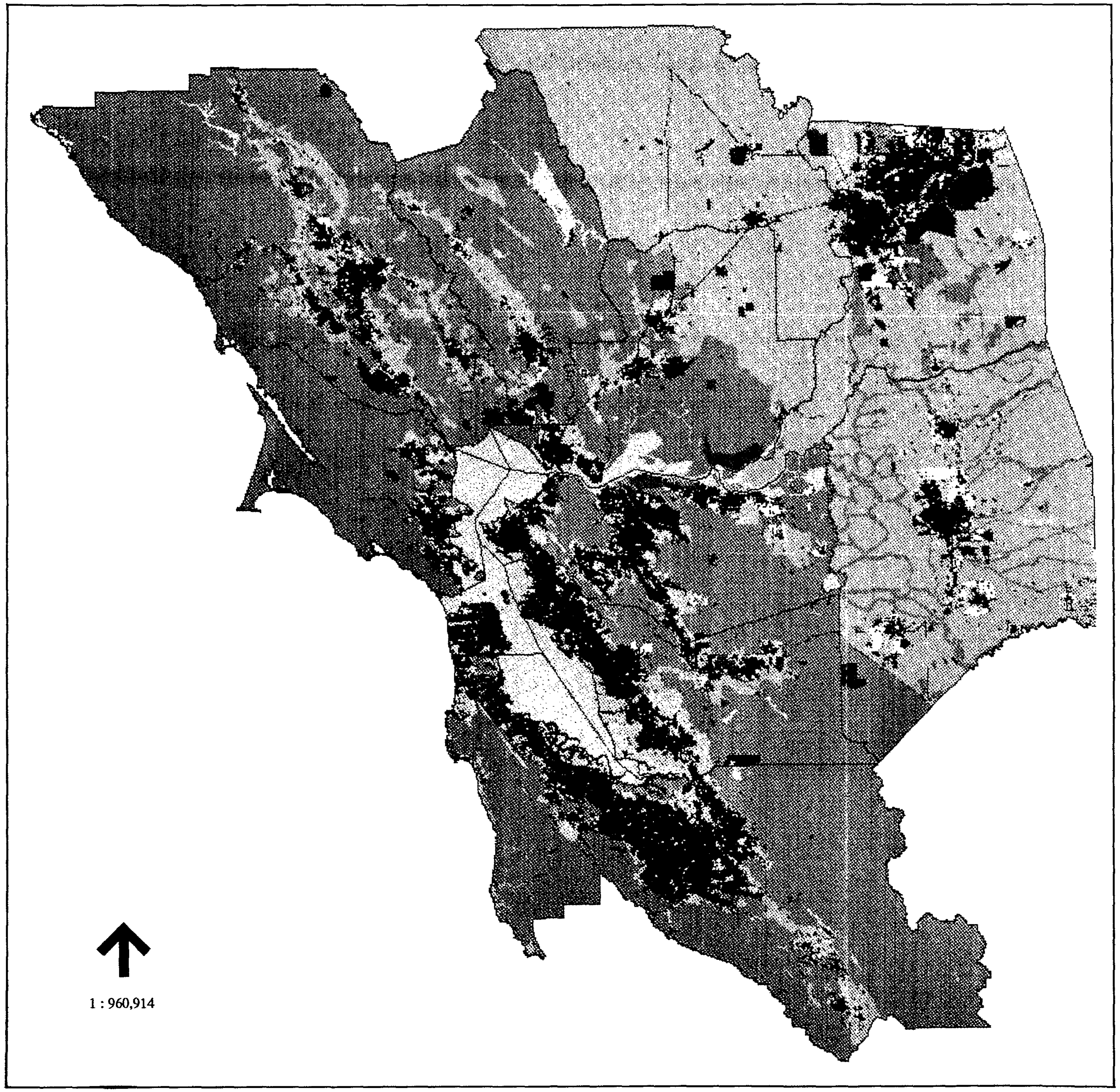

Figure 16
Scenario 1: Growth Based on County General Plan

SOURCE: Center for Environmental Design Research, U.C. Berkeley, 1990.

NEW

- New Residential
- New Heavy Industry (includes major military facilities)
- New Commercial and Light Industry

EXISTING

- Exisiting Urbanization
- Existing Non-Urban Areas Within City Boundaries
- Intensive Agriculture (40 acres or less minimum parcel size)
- Rural (agriculture greater than 40 acres minimum parcel size; park and watershed lands)
- Open Water

intensive agriculture, rural, and open water (see Chapter 2 for a detailed explanation of the method followed in preparing the land use model). In addition, non-urbanized incorporated areas within city boundaries are shown, and it is anticipated that these areas, where not protected as open space, will be urbanized. Existing urban areas are shown as well. Because the purpose of this study is to show the proposed change in land use, existing urbanization (where little if any change will occur) has not been broken down into generic land use classifications, but is designated as existing urban in this scenario.

The land use change outside existing incorporated areas, based on a composite of current county plans, is summarized in Table 9 (note that plan preparation dates vary from the late 1970s to 1990). The area planned for new urban uses for the 12-county area is 331,530 acres—a 37 percent increase in urbanization. This includes 165,980 acres in residential use (28 percent increase), 88,840 acres in commercial/light industrial (59 percent increase), and 76,710 acres in heavy industrial use (47 percent increase).

Consequently, under Scenario I, the urbanized area of the Estuary region would increase from 896,498 acres—14 percent of total regional land use (for existing urban land use see Estuary Region: Upland Land Use, Chapter 5)—to approximately 1,228,028 acres—19 percent of the total land use for the region. The land area devoted to agriculture/rural use would decrease from 5,670,362 acres (86 percent) to 5,338,832 acres—81 percent of the land use of the region.

Plans prepared by Sacramento County anticipate the greatest amount of urban land use, 136,820 acres. Of this, 68,260 acres are slated for residential development, with the balance divided between commercial/light industrial and heavy industrial.

All of the new urban development anticipated in Santa Clara County's plan is to be commercial and light industrial uses, while in Solano County, the vast majority of planned land use change is for heavy industrial uses. In Contra Costa County, 25,600 acres of the 46,180 acres planned for urban use will be allocated to residential use.

ScenarioII: Growth Based on Modeled Incentives and Limitations

Figure 17, Growth Incentives and Limitations Land Use Model, displays the location of growth projected to the year 2005. As expected, the urban fringes reveal the greatest potential for urbanization. However, this model predicts substantial land use change away from existing urban centers. For example in Sacramento and San Joaquin counties 17,000 acres in each county will be converted to urban land use. Table 10 provides acreages of projected urbanization for each of the 12 counties in the Estuary Region.

Under Scenario II, urban use would increase by nine percent, 79,810 acres, from the existing 896,498 acres for a total of 976,308 acres in urban use or 15 percent of the total regional land use. Conversely, the amount of agricultural/rural land use would decrease from the existing (1989) 5,670,362 acres to 5,590,552 acres; a one percent reduction from 86 percent to 85 percent of regional land use.

Table 9
Future Land Use Outside Current City Boundaries Based on a Composite of Current County General Plan Maps (in acres)

SOURCE:
Transposed and Digitized from Current County General Plan Maps by BCDC and the Greenbelt Alliance.
Prepared by:
CEDR 1991.

County	Residential	Commercial/ Light Industrial	Heavy Industrial	Intensive Agriculture	Rural
Alameda	12,634	8,055	3,857	14,240	244,080
Contra Costa	25,595	6,674	13,914	11,698	265,464
Marin	0	0	0	0	285,213
Napa	2,063	5,755	0	52,632	405,637
Sacramento	68,264	32,029	36,524	324,581	82,391
San Francisco	0	0	0	0	2
San Joaquin	34,209	22,538	0	630,720	164,408
San Mateo	6,647	778	2,886	6,966	178,933
Santa Clara	0	5,150	0	30,818	611,649
Solano	662	516	10,838	186,822	261,192
Sonoma	15,906	7,346	8,691	143,081	795,180
Yolo	0	0	0	641,603	0
TOTAL	165,980	88,842	76,710	2,043,161	3,294,149

Table 10
Projected Urbanization Based on Scenario II; Modeled Incentives and Limitations to Growth (in acres)

County	Urbanized Land Use
Alameda	8,390
Contra Costa	11,380
Marin	2,910
Napa	2,160
Sacramento	17,850
San Francisco	0
San Joaquin	17,830
San Mateo	2,840
Santa Clara	4,960
Solano	6,420
Sonoma	2,030
Yolo	3,040

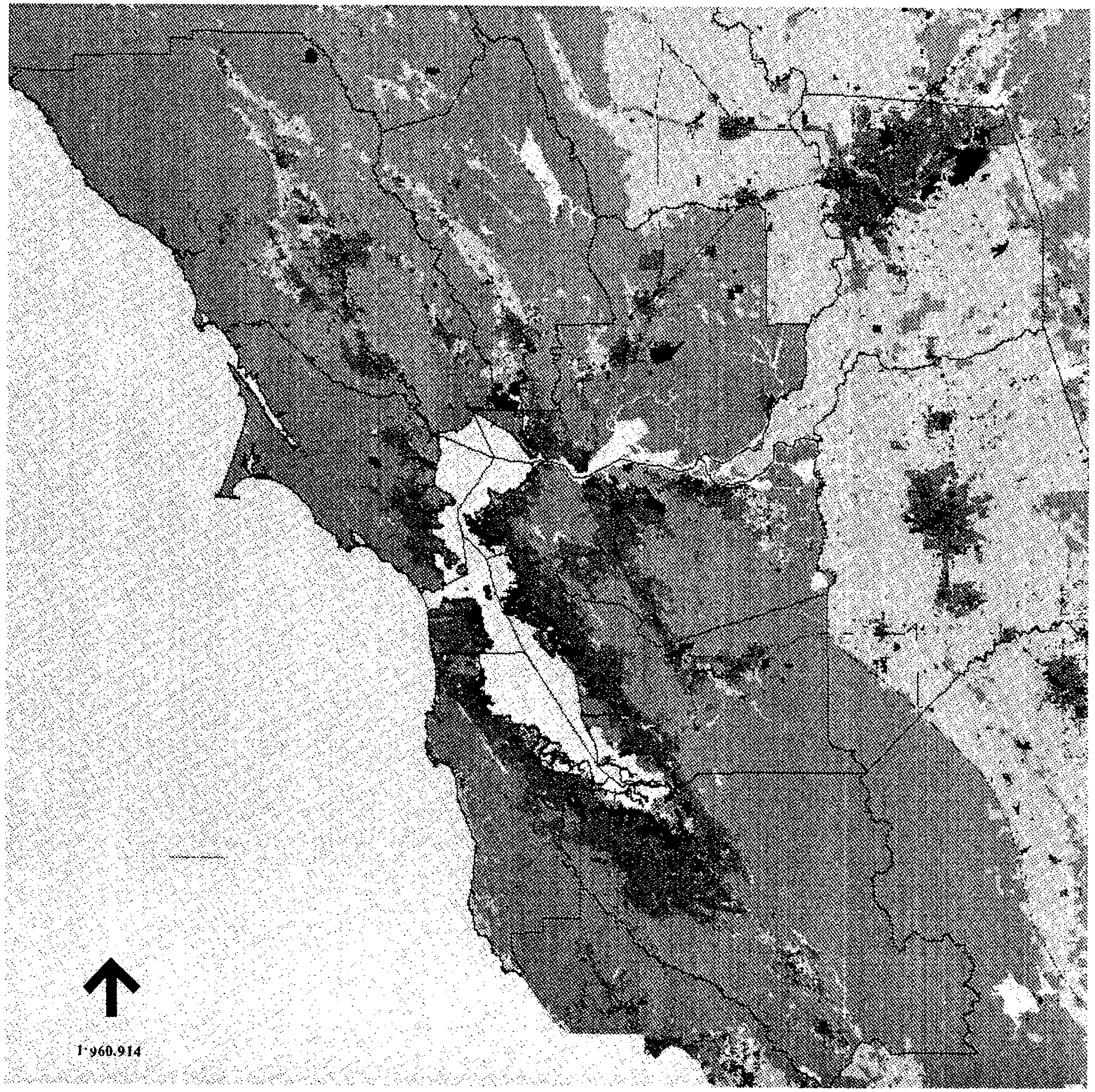

Figure 17
Growth Base on Modeled Incentives and Limitations

SOURCE: Center for Environmental Design Research, U.C. Berkeley, 1990.

Existing Urban Development

Intensive Agriculture (40 acres or less minimum parcel size)

Rural (agriculture greater than 40 acres minimum parcel size; park and watershed lands)

Open Water

New Urban Development

1. **Assessing Impacts on Wetlands in the San Francisco Estuary.** Table 11 displays the wetland types potentially effected by Scenario I: General Plan-Based Growth. It is important to note here that 20 USGS quads of the National Wetland Inventory (NWI) for north and south portions of the Delta were not available in operational digitized form at the time of this analysis.

The implications of potential wetland losses are difficult to summarize. The largest acreages are in farmed wetlands and salt evaporators, and potential impacts on important categories such as perennial lakes and ponds appear less significant by comparison. Still, the table does depict the extent and general location of potential impacts, and as such may be helpful in anticipating and targeting problem areas. Attention is directed to such issues as: (1) the ultimate management of farmed wetlands in the Delta (4,370 acres in the Central Delta (watershed no. 133), and North Bay (3,320 acres in San Pablo Bay Watershed West (watershed no. 81), in the vicinity of Vallejo-Napa-Petaluma); and (2) diked vegetated wetlands (more than a thousand acres each in Suisun Bay (watershed no. 102), San Pablo Bay West (watershed no. 81), and greater Santa Clara, San Jose area (watershed no. 21)).

Virtually every water segment and watershed contains wetland resources that would be impacted. Moreover, especially in terms of wildlife habitat and regional ecological biodiversity, in the East side of the South Bay (watershed no. 42), 203 of 235 existing acres of seasonal wetlands (86 percent) are potentially impacted.

Table 12 presents the potential effects on wetlands of Scenario II growth. The values indicate considerably less impact is likely to occur when land use conversion follows a course more constrained by factors such as topography and zoning, and induced by factors like proximity to employment centers and transportation corridors. Nevertheless, no single area appears to be spared the possibility of losing some of its wetlands. For the entire region, this growth scenario anticipates 3,550 acres of wetlands are potentially impacted by land use change and intensification.

2. **Assessing Impacts to Streams of the Bay and Delta.** Table 13 summarizes stream data for the twelve county planning area, revealing a total of about 377,000 acres of stream environment (based on a computation of the number of one-hectare sized grid cells in the database containing a stream as mapped by USGS). Of that total, about 40,000 occur in already built-up urban areas, and the remaining 337,110 acres are agricultural, rural, park, or in otherwise undeveloped condition.

Development in incorporated areas and under County plans could potentially impact some 28,000 acres, that is, about half again as much of the resource as is impacted by existing urbanization. Thus, there is potential for substantial further degradation of stream environments and related hydrologic, water-quality, aesthetic and wildlife resources.

The potential for substantial loss is most apparent in: watershed no. 121 (the greater Sacramento area), watershed no. 32 (Hayward, Dublin, Livermore Valley), watershed no. 21 (Greater San Jose, Santa Clara County), watershed no. 102 (Concord, Contra Costa County), and watershed no. 101 (Fairfield, Solano County).

Table 11
Wetland Environments Potentially Affected By Land Use Change Under Scenario I: County General Plans and Incorporated, Undeveloped Areas (in acres)

	WATER SEGMENTS AND WATERSHEDS	WETLAND TYPES 1	2	3	4	5	6
20	Santa Clara Reach	0	0	0	0	0	0
21	Santa Clara watershed	77	72	287	0	1,048	326
23	Santa Clara Reach islands	0	0	40	0	0	0
30	South South Bay	2	2	25	0	0	0
31	South South Bay watershed west	114	49	178	0	479	12
32	South South Bay watershed east	0	84	450	5	544	346
33	South South Bay islands	22	161	148	0	361	0
40	South Bay	0	0	0	0	0	0
41	South Bay watershed west	133	106	52	0	49	10
42	South Bay watershed east	69	84	40	0	252	203
43	South Bay islands	40	5	5	0	0	0
50	Central Bay	0	0	0	0	0	0
51	Central Bay watershed west	17	0	0	0	0	0
52	Central Bay watershed east	69	91	64	0	0	0
53	Central Bay islands	2	0	0	0	0	0
60	Richardson Bay	0	0	0	0	0	0
61	Richardson Bay watershed	22	111	15	0	0	0
70	North Bay	0	0	0	0	0	0
71	North Bay watershed west	94	84	32	15	94	2
72	North Bay watershed east	35	35	0	0	0	0
73	North Bay islands	0	0	0	0	0	0
80	San Pablo Bay	0	0	0	0	0	0
81	San Pablo Bay watershed west	121	264	895	0	1,075	99
82	San Pablo Bay watershed east	15	82	94	0	37	12
90	Carquinez Strait	27	20	0	0	0	0
91	Carquinez Strait watershed north	32	15	12	0	10	0
92	Carquinez Strait watershed south	0	0	0	0	0	0
100	Suisun Bay	35	5	32	0	17	0
101	Suisun Bay watershed north	44	0	15	0	427	180
102	Suisun Bay watershed south	72	15	408	57	1,497	195
103	Suisun Bay islands	0	0	0	0	0	0
110	West Delta	15	0	12	0	2	0
111	West Delta watershed north	30	0	10	0	138	331
112	West Delta watershed south	0	0	119	0	388	35
113	West Delta islands	15	0	0	0	0	0
120	North Delta	0	0	0	0	0	0
121	North Delta watershed	0	0	0	0	0	12
123	North Delta islands	0	0	0	0	0	10
130	Central Delta	0	0	0	0	0	2
131	Central Delta watershed west	0	0	0	0	0	5
132	Central Delta watershed east	0	0	0	0	0	5
133	Central Delta islands	0	0	0	0	32	82
140	East Delta	0	0	0	0	0	0
141	East Delta watershed	0	0	0	0	0	25
143	East Delta islands	0	0	0	0	0	64
150	South Delta	0	0	0	0	0	0
151	South Delta watershed	0	0	0	0	0	0
153	South Delta islands	0	0	0	0	0	25
	TOTAL	1,102	1,285	2,931	77	6,452	1,982

Wetland Types

1 open water
2 mudflats and rocky shore
3 vegetated tidal marsh
4 tidal channels
5 diked vegetated wetlands
6 seasonal/perm. veg
7 seasonal ponds
8 farmed wetl;ands
9 freshwater marsh
10 riparian forest
11 salt evaporators
12 perennial lakes and ponds

C-098912

7	8	9	10	11	12	13	14	SUMS
0	0	0	0	0	0	0	0	0
403	341	5	148	1,816	425	0	0	4,947
0	0	0	0	2	0	0	0	42
0	0	0	0	0	0	0	0	30
59	0	0	0	2,063	190	0	0	3,146
509	726	2	25	4,799	549	0	5	8,043
647	0	0	0	0	27	0	0	1,366
0	0	0	0	0	0	0	0	0
22	0	0	5	0	72	0	0	450
447	7	0	20	0	264	0	0	1,386
0	0	0	0	0	17	0	0	67
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	17
0	0	0	0	0	64	0	0	289
0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	0
0	0	0	2	0	47	0	0	198
0	0	0	0		0	0	0	0
52	0	5	0	0	44	0	0	423
0	0	0	0	0	0	0	0	69
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
96	3,323	7	52	2	128	89	0	6,153
0	0	0	22	22	124	0	0	408
0	0	0	0	0	0	0	0	47
0	0	0	0	0	0	0	0	69
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	89
22	0	0	12	0	64	0	0	766
27	0	0	2	22	158	0	0	2,454
0	0	0	0	0	0	0	0	0
0	0	7	0	0	2	124	0	163
2	67	183	7	0	2	52	0	823
5	0	114	2	0	119	0	0	781
0	0	5	0	0	0	12	0	32
0	0	0	0	0	0	17	0	17
5	0	0	2	0	15	0	2	37
0	99	2	0	0	10	0	0	121
0	79	0	2	0	170	121	0	376
0	0	0	0	0	0	0	0	5
0	0	0	0	0	27	0	10	42
0	4,366	141	101	0	343	168	0	5,234
0	0	0	2	0	20	190	0	213
5	0	2	2	0	35	0	0	69
0	222	32	213	0	304	141	5	981
0	0	0	0	0	27	0	0	27
0	0	0	0	0	7	0	17	25
0	0	0	0	0	82	0	0	106
2,303	9,232	507	623	8,728	3,338	914	40	**39,511**

13 rivers, tidal
14 rivers, nontidal, creeks

Table 12
Wetlands Environments Potentially Affected By Land Use Change Under Scenario II

	WATER SEGMENTS AND WATERSHEDS	1	2	3	4	5	6
20	Santa Clara Reach	0	0	0	0	0	0
21	Santa Clara watershed	0	0	52	0	163	96
23	Santa Clara Reach islands	0	0	0	0	0	0
30	South South Bay	0	0	0	0	0	0
31	South South Bay watershed west	0	0	0	0	0	0
32	South South Bay watershed east	0	17	12	0	7	91
33	South South Bay islands	0	0	0	0	0	0
40	South Bay	0	0	0	0	0	0
41	South Bay watershed west	5	0	2	0	7	0
42	South Bay watershed east	0	5	7	0	35	7
43	South Bay islands	0	0	0	0	0	0
50	Central Bay	0	0	0	0	0	0
51	Central Bay watershed west	0	0	0	0	0	0
52	Central Bay watershed east	0	0	0	0	0	0
53	Central Bay islands	0	0	0	0	0	0
60	Richardson Bay	0	0	0	0	0	0
61	Richardson Bay watershed	0	2	0	0	0	0
70	North Bay	0	0	0	0	0	0
71	North Bay watershed west	0	5	7	15	22	0
72	North Bay watershed east	0	0	0	0	0	0
73	North Bay islands	0	0	0	0	0	0
80	San Pablo Bay	0	0	0	0	0	0
81	San Pablo Bay watershed west	7	27	193	0	101	27
82	San Pablo Bay watershed east	0	0	0	0	0	5
90	Carquinez Strait	2	5	0	0	0	0
91	Carquinez Strait watershed north	7	2	0	0	10	0
92	Carquinez Strait watershed south	0	0	0	0	0	0
100	Suisun Bay	2	0	0	0	0	0
101	Suisun Bay watershed north	0	0	5	0	25	69
102	Suisun Bay watershed south	0	0	27	0	17	0
103	Suisun Bay islands	0	0	0	0	0	0
110	West Delta	0	0	0	0	2	0
111	West Delta watershed north	0	0	0	0	0	2
112	West Delta watershed south	0	0	0	0	20	35
113	West Delta islands	0	0	0	0	0	0
120	North Delta	0	0	0	0	0	0
121	North Delta watershed	0	0	0	0	0	10
123	North Delta islands	0	0	0	0	0	7
130	Central Delta	0	0	0	0	0	0
131	Central Delta watershed west	0	0	0	0	0	2
132	Central Delta watershed east	0	0	0	0	0	0
133	Central Delta islands	0	0	0	0	30	27
140	East Delta	0	0	0	0	0	0
141	East Delta watershed	0	0	0	0	0	17
143	East Delta islands	0	0	0	0	0	0
150	South Delta	0	0	0	0	0	0
151	South Delta watershed	0	0	0	0	0	0
153	South Delta islands	0	0	0	0	0	0
	TOTAL	25	64	306	15	440	398

Header note: columns 1–6 are WETLAND TYPES.

Wetland Types

1 open water
2 mudflats and rocky shore
3 vegetated tidal marsh
4 tidal channels
5 diked vegetated wetlands
6 seasonal/perm. veg
7 seasonal ponds
8 farmed wetl;ands
9 freshwater marsh
10 riparian forest
11 salt evaporators
12 perennial lakes and ponds

7	8	9	10	11	12	13	14	SUMS
0	0	0	0	0	0	0	0	0
82	7	0	69	30	74	0	0	573
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
2	7	7	32	0	89	0	10	277
47	0	0	0	0	0	0	0	47
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	15
15	0	0	2	0	17	0	0	89
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	2	0	0	2
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	2	0	0	0	0	5
0	0	0	0	0	0	0	0	0
22	0	0	0	0	22	0	0	94
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
17	133	0	44	0	52	5	0	608
0	0	0	12	0	2	0	0	20
0	0	0	0	0	0	0	0	7
0	0	0	0	0	0	0	0	20
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	2
17	0	0	10	0	30	0	0	156
0	0	0	2	0	30	0	0	77
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	0	2
0	0	22	0	0	12	0	0	89
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
5	0	0	0	0	12	0	2	30
0	69	2	0	0	7	0	0	86
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	2
0	0	0	0	0	0	0	2	2
0	642	17	0	0	42	35	0	793
0	0	0	0	0	0	0	0	0
5	0	0	2	0	27	0	0	52
0	185	30	124	0	94	47	5	484
0	0	0	0	0	0	0	0	0
0	0	0	0	0	2	0	10	12
0	0	0	0	0	2	0	0	2
213	1,045	79	301	30	519	86	30	3,551

13 rivers, tidal
14 rivers, nontidal, creeks

Table 13
The Potential Effects of Land Use Change on Streams

Column Headings:

1) **Total Existing Stream Environments Outside of Urban Areas (1985)**
2) **Total Existing Stream Environments Within Urban Areas (1985)**
3) **Stream Environments Potentially Effected by Land Use Change Under County General Plans and in Incorporated, Unprotected Areas**
4) **Stream Environments Potentially Effected by Land Use Change Under Growth Anticipated by Scenario II**

	Water Segment and Watershed	**1** Outside Urban (ac)	**2** Inside Urban (ac)	**3** Scenario I (ac)	**4** Scenario II (ac)
20	Santa Clara Reach	0	0	0	0
21	Santa Clara watershed	27,309	8,683	3,390	1,233
23	Santa Clara Reach islands	7	0	2	0
30	South South Bay	279	2	0	0
31	South South Bay watershed west	850	902	264	20
32	South South Bay watershed east	36,981	2,347	3,504	1,285
33	South South Bay islands	143	7	7	0
40	South Bay	17	7	0	0
41	South Bay watershed west	887	927	361	168
42	South Bay watershed east	4,203	2,283	754	136
43	South Bay islands	0	0	0	0
50	Central Bay	0	0	0	0
51	Central Bay watershed west	0	0	0	0
52	Central Bay watershed east	69	358	10	0
53	Central Bay islands	0	0	0	0
60	Richardson Bay	0	0	0	0
61	Richardson Bay watershed	240	452	64	37
70	North Bay	25	96	0	0
71	North Bay watershed west	724	1,023	146	59
72	North Bay watershed east	0	0	0	0
73	North Bay islands	0	0	0	0
80	San Pablo Bay	3,946	86	0	0
81	San Pablo Bay watershed west	31,997	4,893	2,150	729
82	San Pablo Bay watershed east	2,590	1,186	479	163
90	Carquinez Strait	0	0	0	0
91	Carquinez Strait watershed north	7	54	7	0
92	Carquinez Strait watershed south	442	282	20	7
100	Suisun Bay	638	2	5	0
101	Suisun Bay watershed north	20,739	828	971	264
102	Suisun Bay watershed south	4,917	4,796	1,710	536
103	Suisun Bay islands	188	0	0	0
110	West Delta	9,662	27	62	2
111	West Delta watershed north	2,234	5	682	0
112	West Delta watershed south	1,557	539	477	311
113	West Delta islands	776	25	40	0
120	North Delta	9,484	0	561	12
121	North Delta watershed	98,032	7,779	8,569	3,803

	Water Segment and Watershed	1 cont'd	2 cont'd	3 cont'd	4 cont'd
123	North Delta islands	13,422	509	163	67
130	Central Delta	14,935	0	84	0
131	Central Delta watershed west	5,273	136	47	0
132	Central Delta watershed east	6,415	200	346	220
133	Central Delta islands	7,838	415	867	264
140	East Delta	240	0	193	0
141	East Delta watershed	14,374	502	969	850
143	East Delta islands	914	435	423	262
150	South Delta	546	0	35	0
151	South Delta watershed	11,910	185	623	84
153	South Delta islands	2,296	35	114	0
	TOTAL	**337,106**	**40,008**	**28,098**	**10,514**

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However, impacts can be expected from both infill of incorporated cities and new development in rural areas, and virtually all parts of the region have stream resources subject to planned land use change.

Scenario II anticipates the effects on streams to occur in largely the same pattern, but in lesser amounts. Where Scenario I anticipates 28,000 acres of stream environments will be effected, Scenario II anticipates 10,000 acres.

Assessing Indirect Impacts

1. Increased Pollutant Loadings in the Estuary. The construction of land use scenarios for the Estuary region has presented, for the first time, an opportunity to cumulatively examine the contribution of nonpoint source urban runoff to the levels of pollutants in the Bay and Delta. To date, more modest studies in smaller urban watersheds have provided only a glimpse of the overall effect that urbanization has in a region the size of the Estuary.

Table 14 presents loadings (kg/yr) of ten contaminants that are contained in runoff from urbanized areas. The loading figures correspond to receiving watersheds which generate varying quantities of heavy metals, nutrients (phosphates, nitrates and biochemical oxygen demand (BOD)) and suspended solids (TSS) depending on the type and extent of land use within the watershed. However, the routing of contaminants—how they get from the watershed to the water segment–is a somewhat poorly understood phenomenon. A variety of processes are believed to control routing, including retention of contaminants in sediments and uptake by vegetation, but it is generally assumed that many contaminants ultimately make their way into the Bay.

The loads from existing urbanization can be compared to the loads anticipated for the two growth scenarios by reviewing Table 15 Pollutant Loadings Derived From Scenario I, and Table 16, Pollutant Loadings Derived From Scenario II. Each mass load in the scenario tables includes both the existing mass load and the increment resulting from new urbanization. Thus the pollution loading data for the scenarios are cumulative.

Modeled pollution loadings are heavily dependent on the size of the watershed and rainfall, as well as the absolute amount of land use change. Still, substantial increases in loading of urban run-off can be expected in all areas.

The two growth scenarios indicate substantial increases over existing levels of metal loadings. For example, Scenario I indicates cadmium will increase 47 percent in the South Delta (watershed no. 153), nickel 76 percent and copper 66 percent. These same metals in the Suisun Bay North Watershed (no. 101, Fairfield) are expected to increase by 10 percent in Scenario II and 27 percent in Scenario I for cadmium, 12 percent in Scenario II and 30 percent in Scenario I for copper, and five percent in Scenario II and 29 percent in Scenario I for nickel.

Nutrients, BOD and total suspended solids follow similar patterns but with greater magnitude. For example TSS is expected to increase by roughly five percent in both Scenario I and II to a total of about 175 million kg/yr for the entire Estuary.

The clearest conclusion that can be drawn from these data is that continued urbanization of the Estuary region will increase the load of nonpoint source pollution. This source of pollution is already the single largest contributor to the volume of pollutants entering the Bay. The implications of these increases for public health, wildlife and beneficial uses are presumed to be significant, but a full discussion of the nature and extent of such implications is beyond the scope of this report.

Impacts on Selected Watersheds

Tables 17, 18, 19, and 20 provide the complete set of data (with the exception of chromium, lead and zinc loadings) made available by the analysis conducted for this report, for four watersheds. The first watershed, Santa Clara Watershed, offers an example of a large (525,200 acres) watershed with areas of both extensive urbanization and undeveloped lands.

South South Bay Watershed East includes the major watershed of the Livermore Valley as well as extensive Bay shorelands and lowlands. San Pablo Bay Watershed West includes growing portions of Sonoma, Napa, and Solano county, and possesses a wide array of wetland and riparian habitats. West Delta Watershed South contains industrial areas near Antioch.

These tables indicate the rich assortment of information yielded by the GIS-based analysis of land use change in the Estuary. They offer two perspectives concerning where and how land use is changing throughout the entire 12-county Bay and Delta Region. This information should contribute substantially to the selection of specific management options for the conservation of resources in the Estuary.

Table 14
Pollutant Loading (kg/yr)
Derived From
Existing Urbanization

Receiving Watersheds	Metals						Nutrients			BOD	TSS
	Cd	Cr	Cu	Ni	Pb	Zn	NO3 - N	PO4 - P	TKN		
20 Santa Clara Reach	0	1	1	1	1	3	16	13	85	459	2,578
21 Santa Clara watershed	419	5,285	7,939	5,414	9,170	44,974	134,522	81,954	518,327	2,688,278	20,222,238
23 Santa Clara Reach islands	0	1	1	1	2	13	24	16	109	468	3,365
30 South South Bay	0	1	1	1	2	15	14	15	55	321	2,767
31 South South Bay watershed west	41	490	814	592	1,147	5,594	15,238	7,570	51,940	245,481	2,128,129
32 South South Bay watershed east	170	2,436	3,233	2,042	2,780	14,531	47,040	38,106	219,066	1,246,376	7,905,823
33 South South Bay islands	0	8	10	7	14	94	123	136	587	3,535	24,578
40 South Bay	4	34	49	41	110	743	743	607	2,932	12,909	120,901
41 South Bay watershed west	132	1,347	2,143	1,623	3,589	20,158	37,841	21,743	131,967	613,433	5,521,418
42 South Bay watershed east	149	1,604	2,453	1,775	3,812	20,883	41,821	25,298	147,789	730,712	6,313,150
43 South Bay islands	13	118	172	132	356	2,210	2,672	1,942	9,092	44,095	437,526
50 Central Bay	2	17	23	19	53	362	327	294	1,270	5,932	56,985
51 Central Bay watershed west	7	64	101	82	196	1,209	1,739	1,091	6,262	27,351	256,389
52 Central Bay watershed east	57	572	917	690	1,621	8,956	16,321	9,031	53,058	247,835	2,392,861
53 Central Bay islands	3	26	34	25	69	448	456	422	1,687	9,202	84,836
60 Richardson Bay	1	6	12	11	19	102	272	110	1,019	3,795	31,989
61 Richardson Bay watershed	22	295	490	333	650	2,717	9,268	4,238	28,700	144,825	1,311,863
70 North Bay	1	10	18	14	29	157	357	169	1,226	5,224	47,547
71 North Bay watershed west	62	824	1,332	905	1,682	7,294	24,494	12,144	81,080	412,094	3,514,947
72 North Bay watershed east	4	36	46	35	111	761	548	609	1,986	10,960	112,810
73 North Bay islands	0	0	0	0	0	0	0	0	0	0	0
80 San Pablo Bay	1	7	9	6	18	114	122	108	450	2,412	22,192
81 San Pablo Bay watershed west	495	6,905	9,304	5,775	7,723	37,654	137,246	107,466	620,568	3,576,477	22,977,936
82 San Pablo Bay watershed east	74	825	1,225	851	1,758	9,290	20,416	12,720	72,788	378,396	3,157,443
90 Carquinez Strait	0	3	4	3	9	58	47	49	171	942	9,299
91 Carquinez Strait watershed north	6	67	104	74	172	917	1,793	1,026	5,776	28,892	271,452
92 Carquinez Strait watershed south	11	116	164	113	216	1,188	2,571	1,806	10,018	53,811	413,983
100 Suisun Bay	0	1	2	2	5	31	41	26	165	642	5,644
101 Suisun Bay watershed north	155	1,765	2,391	1,602	2,629	15,287	35,016	28,584	159,427	874,619	5,863,132
102 Suisun Bay watershed south	138	1,550	2,402	1,704	3,707	19,327	41,691	23,725	139,057	698,080	6,256,616
103 Suisun Bay islands	0	0	0	0	0	0	0	0	0	0	0
110 West Delta	0	4	6	5	9	61	102	65	441	1,838	14,078
Receiving Watersheds	**Cd**	**Cr**	**Cu**	**Ni**	**Pb**	**Zn**	**NO3-N**	**PO4-P**	**TKN**	**BOD**	**TSS**
111 West Delta watershed north	10	110	144	89	82	410	2,087	1,773	11,004	61,852	346,262
112 West Delta watershed south	23	234	345	258	613	3,662	5,621	3,765	20,080	97,607	878,714
113 West Delta islands	4	39	65	51	73	433	1,194	715	5,541	24,158	157,625
120 North Delta	6	62	80	49	63	349	1,128	980	5,648	32,071	192,664
121 North Delta watershed	1,117	13,118	17,434	11,042	16,197	88,623	250,486	208,217	1,165,053	6,638,677	42,691,322
123 North Delta islands	108	1,183	1,525	898	1,013	5,218	21,141	18,466	106,960	621,533	3,645,510
130 Central Delta	1	16	24	17	22	115	412	259	1,863	9,025	58,337
131 Central Delta watershed west	9	243	299	168	135	564	3,960	3,699	20,965	128,908	716,403
132 Central Delta watershed east	30	401	532	328	418	2,114	7,704	6,242	36,296	208,085	1,296,419
133 Central Delta islands	9	296	405	268	284	1,302	6,181	4,710	29,979	164,521	982,200
140 East Delta	1	10	14	11	26	160	238	162	921	4,219	36,074
141 East Delta watershed	63	1,083	1,489	952	1,272	6,527	22,565	17,020	103,294	568,385	3,636,988
143 East Delta islands	17	188	285	219	475	2,811	4,895	3,070	18,418	85,267	724,464
150 South Delta	0	3	4	2	2	10	51	48	266	1,642	9,344
151 South Delta watershed	12	344	418	254	384	2,185	5,449	5,310	27,246	164,121	1,012,233
153 South Delta islands	8	155	209	151	256	1,485	3,097	2,521	13,925	75,187	515,413
Total	3,767	47,859	66,872	43,919	70,544	369,709	1,032,477	751,890	4,385,080	24,029,885	166,586,541

Table 15
Pollutant Loading (kg/yr)
Derived From
Scenario I: County General
Plan-Based Growth

	METALS						NUTRIENTS				
Receiving Watersheds	Cd	Cr	Cu	Ni	Pb	Zn	NO3-N	PO4-P	TKN	BOD	TSS
20 Santa Clara Reach	0	0	0	0	0	0	0	0	0	0	0
21 Santa Clara watershed	468	5,802	9,081	6,195	11,627	53,542	158,125	90,320	595,581	2,959,890	22,599,368
23 Santa Clara Reach islands	0	1	2	1	3	15	31	19	133	569	4,134
30 South South Bay	0	0	0	0	0	0	0	0	0	0	0
31 South South Bay watershed west	46	547	935	673	1,401	6,464	17,699	8,463	59,842	274,492	2,384,058
32 South South Bay watershed east	233	2,994	4,374	2,926	5,150	25,260	70,202	47,869	300,854	1,538,414	10,461,969
33 South South Bay islands	2	23	37	24	63	260	639	362	2,423	11,075	82,165
40 South Bay	0	0	0	0	0	0	0	0	0	0	0
41 South Bay watershed west	141	1,445	2,353	1,768	4,054	21,871	42,156	23,325	145,907	662,536	5,966,045
42 South Bay watershed east	161	1,742	2,747	1,972	4,430	23,021	47,886	27,405	166,258	799,158	6,960,153
43 South Bay islands	14	121	178	136	368	2,251	2,792	1,990	9,503	45,684	450,394
50 Central Bay	0	0	0	0	0	0	0	0	0	0	0
51 Central Bay watershed west	7	65	103	83	200	1,219	1,768	1,102	6,361	27,718	259,470
52 Central Bay watershed east	59	597	970	725	1,735	9,341	17,404	9,423	56,594	260,589	2,503,075
53 Central Bay islands	3	26	34	25	69	449	460	425	1,704	9,291	85,401
60 Richardson Bay	0	0	0	0	0	0	0	0	0	0	0
61 Richardson Bay watershed	25	323	555	376	797	3,218	10,622	4,688	32,967	159,216	1,444,069
70 North Bay	0	0	0	0	0	0	0	0	0	0	0
71 North Bay watershed west	69	897	1,500	1,018	2,065	8,596	28,015	13,316	92,188	449,646	3,859,196
72 North Bay watershed east	5	38	48	36	116	778	601	631	2,170	11,686	118,566
73 North Bay islands	0	0	0	0	0	0	0	0	1	8	40
80 San Pablo Bay	0	0	0	0	0	0	0	0	0	0	0
81 San Pablo Bay watershed west	571	7,620	10,673	6,816	10,596	51,144	163,761	119,719	713,476	3,923,761	26,065,949
82 San Pablo Bay watershed east	87	962	1,501	1,049	2,367	11,856	25,816	15,013	90,804	444,069	3,753,919
90 Carquinez Strait	0	4	5	4	11	69	72	60	258	1,277	12,101
91 Carquinez Strait watershed north	7	79	132	93	233	1,122	2,364	1,229	7,628	35,472	329,009
92 Carquinez Strait watershed south	12	126	185	127	260	1,340	3,005	1,959	11,357	58,800	460,432
100 Suisun Bay	1	5	7	5	13	83	103	84	432	2,044	16,611
101 Suisun Bay watershed north	197	2,220	3,125	2,070	3,804	20,189	47,318	35,887	207,172	1,099,872	7,498,052
102 Suisun Bay watershed south	180	1,948	3,092	2,196	5,258	26,805	53,873	30,234	178,896	861,197	7,822,032
103 Suisun Bay islands	0	2	3	1	1	2	33	33	185	1,159	6,024
110 West Delta	1	10	14	10	24	157	202	175	883	4,417	34,011
111 West Delta watershed north	53	440	552	410	1,191	8,205	6,677	7,455	27,357	151,049	1,348,785
112 West Delta watershed south	32	317	482	354	914	5,164	7,911	5,123	27,805	130,934	1,188,611
113 West Delta Islands	5	51	79	60	88	531	1,370	895	6,410	29,321	190,890
120 North Delta	8	92	123	74	101	482	1,775	1,442	8,601	48,181	290,050
Receiving Watersheds	Cd	Cr	Cu	Ni	Pb	Zn	NO3-N	PO4-P	TKN	BOD	TSS
121 North Delta watershed	1,367	15,319	21,244	14,022	24,911	135,755	319,171	245,283	1,389,362	7,521,330	51,798,096
123 North Delta Islands	113	1,246	1,641	980	1,224	6,067	23,353	19,504	114,874	654,427	3,908,652
130 Central Delta	2	29	45	32	51	226	784	469	3,364	16,127	107,211
131 Central Delta watershed west	12	277	368	220	259	1,112	5,374	4,245	25,582	146,640	882,371
132 Central Delta watershed east	38	482	692	441	715	3,259	11,067	7,385	45,446	245,998	1,707,617
133 Central Delta Islands	20	407	613	418	669	2,937	10,257	6,474	43,599	219,765	1,471,393
140 East Delta	1	14	24	18	43	225	427	236	1,553	6,680	57,082
141 East Delta watershed	91	1,331	2,023	1,377	2,237	10,845	34,180	21,147	141,138	707,127	4,964,089
143 East Delta Islands	21	225	364	275	634	3,387	6,514	3,673	23,821	105,104	895,091
150 South Delta	0	5	8	6	8	48	144	87	667	3,000	19,396
151 South Delta watershed	22	417	588	421	674	3,853	9,429	6,823	43,404	216,049	1,426,637
153 South Delta Islands	15	221	346	266	492	2,623	6,109	3,659	24,577	113,860	857,153
Total	4,089	48,470	70,847	47,703	88,855	453,771	1,139,490	767,633	4,611,134	23,957,632	174,289,365

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Table 16
Pollutant Loading (kg/yr) Derived From Scenario II: Growth Based on Modeled Incentives and Limitations

Recieving Watersheds	METALS						NUTRIENTS				
	Cd	Cr	Cu	Ni	Pb	Zn	NO3 - N	PO4 - P	TKN	BOD	TSS
20 Santa Clara Reach	0	0	0	0	0	0	2	2	12	75	390
21 Santa Clara watershed	436	5,456	8,350	5,684	10,149	48,168	143,138	84,645	544,089	2,773,098	21,047,298
23 Santa Clara Reach islands	0	0	0	0	1	6	4	5	17	95	897
30 South South Bay	0	1	1	1	2	15	14	15	59	342	2,877
31 South South Bay watershed west	39	477	787	566	1,115	5,361	14,651	7,293	49,216	235,715	2,061,166
32 South South Bay watershed east	183	2,580	3,539	2,244	3,419	16,672	53,203	40,410	239,280	1,321,586	8,545,187
33 South South Bay islands	1	8	10	7	16	99	125	129	563	3,254	23,715
40 South Bay	4	31	42	34	98	669	575	545	2,227	10,758	103,818
41 South Bay watershed west	132	1,369	2,183	1,628	3,699	20,262	38,445	21,942	132,600	618,834	5,584,134
42 South Bay watershed east	150	1,626	2,496	1,799	3,901	21,123	42,611	25,619	150,230	741,066	6,398,322
43 South Bay islands	13	118	172	132	356	2,210	2,672	1,942	9,092	44,095	437,526
50 Central Bay	2	17	23	19	53	362	327	294	1,270	5,932	56,985
51 Central Bay watershed west	7	64	101	82	196	1,209	1,739	1,091	6,262	27,351	256,389
52 Central Bay watershed east	57	574	920	692	1,629	8,981	16,389	9,054	53,275	248,585	2,399,587
53 Central Bay islands	3	26	34	25	69	448	456	422	1,687	9,202	84,836
60 Richardson Bay	1	6	12	11	19	102	272	110	1,019	3,795	31,989
61 Richardson Bay watershed	23	309	526	357	733	2,999	10,017	4,476	31,017	152,363	1,383,523
70 North Bay	1	10	18	14	29	155	354	168	1,215	5,206	47,326
71 North Bay watershed west	66	872	1,441	977	1,933	8,123	26,766	12,901	88,142	436,263	3,737,310
72 North Bay watershed east	4	36	46	35	111	761	548	609	1,986	10,960	112,810
73 North Bay islands	0	0	0	0	0	0	0	0	0	0	0
80 San Pablo Bay	1	7	10	7	18	115	134	120	517	2,832	24,375
81 San Pablo Bay watershed west	528	7,309	10,101	6,291	9,242	42,825	152,999	113,471	668,650	3,774,511	24,788,477
82 San Pablo Bay watershed east	76	850	1,279	885	1,877	9,669	21,510	13,115	76,236	391,097	3,268,552
90 Carquinez Strait	0	3	4	3	9	60	53	51	192	1,024	9,957
91 Carquinez Strait watershed north	7	77	127	90	223	1,091	2,275	1,196	7,331	34,373	319,770
92 Carquinez Strait watershed south	12	125	182	125	253	1,316	2,941	1,936	11,137	58,054	454,244
100 Suisun Bay	0	2	3	3	5	31	53	40	238	1,132	8,113
101 Suisun Bay watershed north	170	1,998	2,672	1,682	2,821	15,008	38,022	31,776	173,337	985,820	6,452,028
102 Suisun Bay watershed south	149	1,684	2,685	1,883	4,318	21,289	47,360	25,777	156,951	764,377	6,837,910
103 Suisun Bay islands	0	2	3	1	1	2	38	38	217	1,355	7,047
110 West Delta	1	8	10	6	8	48	127	128	660	4,000	23,836
Receiving Watersheds	**Cd**	**Cr**	**Cu**	**Ni**	**Pb**	**Zn**	**NO3 - N**	**PO4 - P**	**TKN**	**BOD**	**TSS**
111 West Delta watershed north	10	108	132	71	50	199	1,693	1,691	9,506	59,145	314,888
112 West Delta watershed south	25	264	406	295	735	4,046	6,787	4,228	23,919	112,745	1,002,724
113 West Delta islands	2	30	37	20	19	91	473	478	2,609	16,149	88,484
120 North Delta	1	11	13	7	4	12	166	162	934	5,796	30,338
121 North Delta watershed	1,161	13,736	18,763	11,858	19,172	97,817	277,217	217,247	1,242,323	6,926,460	45,457,237
123 North Delta islands	112	1,247	1,600	926	1,078	5,343	21,958	19,364	110,696	650,324	3,812,237
130 Central Delta	0	2	2	1	1	2	30	30	169	1,057	5,497
131 Central Delta watershed west	10	256	328	187	191	754	4,515	3,915	22,839	136,032	774,903
132 Central Delta watershed east	33	430	591	362	548	2,486	8,837	6,657	39,722	221,346	1,412,536
133 Central Delta islands	9	319	434	268	335	1,254	6,472	4,942	30,365	171,894	1,032,377
140 East Delta	0	0	0	0	0	2	5	2	19	72	618
141 East Delta watershed	82	1,278	1,903	1,222	2,140	9,426	30,866	20,101	130,521	668,704	4,490,723
143 East Delta islands	21	224	356	268	618	3,366	6,265	3,657	23,076	103,341	877,601
150 South Delta	0	2	2	1	1	2	23	23	132	822	4,274
151 South Delta watershed	13	358	447	273	439	2,371	6,011	5,543	29,194	171,837	1,073,189
153 South Delta islands	8	158	214	154	260	1,501	3,166	2,576	14,250	77,052	526,586
Total	3,919	49,943	70,980	46,234	79,063	393,955	1,110,089	781,761	4,616,180	24,995,339	175,055,509

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Table 17
Impact Summary I

Receiving Watershed:
Santa Clara Watershed
(no. 21)

Size:
525,000 acres

Jurisdictions:
Santa Clara and San Mateo Co., San Jose, Sunnyvale, Palo Alto, Mt. View

			LAND USE SCENARIO			
RESOURCE	**Extent of Existing (ac)**		**Scenario I General Plan**		**Scenario II Incentive/Limit.**	
	urban	nonurban	Effected area(ac)	% of Type	Effected area(ac)	% of Type
Wetlands (types)						
1 open water		450	77	17		
2 mudflats and rocky shore		294	72	24		
3 vegetated tidal marsh		4,057	287	7	52	1
4 tidal channels		44		0		
5 diked vegetated wetlands		1,824	1,048	57	163	9
6 seasonal/perm. veg		447	326	73	96	21
7 seasonal ponds		959	403	42	82	9
8 farmed wetlands		378	341	90	7	2
9 freshwaer marsh		32	5	16		
10 riparian forest		435	148	34	69	16
11 salt evaporators		16,699	1,816	11	30	0
12 perennial lakes and ponds		1,594	425	27	74	5
13 rivers, tidal						
14 rivers, nontidal, creeks						
Total		27,213	4,947	18	573	2
Streams	27,309	8,683	3,390	9	1,233	3
POLLUTANTS	**Loads from Existing Urban Areas**					
Metals	Kg/yr		Kg/yr	% increase	Kg/yr	% increase
Cadmium	419		468	12	436	7
Copper	7,939		9,081	14	8,350	5
Nickel	5,414		6,195	14	5,684	5
Nutrients						
PO4-Phosphorus	81,954		90,320	10	84,645	3
NO3-Nitrogen	134,522		158,125	18	143,138	7
TKN-Nitrogen	518,327		595,581	15	544,089	5
BOD	2,688,278		2,959,890	10	2,773,098	4
TSS	20,222,238		22,599,368	12	21,047,298	4

COMMENTS: Major problems could stem from potential development in incorporated areas in a number of wetland categories. On a per-area basis, the receiving watershed can contribute a significant amount of pollutants in runoff. This watershed is a major source of pollutants, ranking third for Cr, Cu and Ni levels. This watershed drains the large, heavily urbanized area including San Jose, and the Coyote Valley. Major sources of impacts can be expected from continued urbanization in and near wetlands and stream environment zones, primarily, but not exclusively in or adjacent to built-up areas in incorporated cities. Stream environment zone protection will be important given the extent of area at risk.

Table 18
Impact Summary II

Receiving Watershed:
South South Bay Watershed East
(no. 32)

Size:
443,700 acres

Jurisdictions: Alameda, Santa Clara Co.s, Union City, Newark, Hayward (So.), Livermore Valley

			LAND USE SCENARIO			
RESOURCE	**Extent of Existing (ac)**		**Scenario I General Plan**		**Scenario II Incentive/Limit.**	
	urban	nonurban	Effected area(ac)	% of Type	Effected area(ac)	% of Type
Wetlands (types)						
1 open water		0				
2 mudflats and rocky shore		279	84	30	17	6
3 vegetated tidal marsh		754	450	60	12	2
4 tidal channels		5	5	100		0
5 diked vegetated wetlands		877	544	62	7	1
6 seasonal/perm veg		734	346	47	91	12
7 seasonal ponds		734	509	69	2	0
8 farmed wetlands		922	726	79	7	1
9 freshwaer marsh		27	2	7	7	26
10 riparian forest		492	25	5	32	7
11 salt evaporators		7,630	4,799	63		0
12 perennial lakes and ponds		4,542	549	12	89	2
13 rivers, tidal		0				
14 rivers, nontidal, creeks		116	5	4	10	9
Total		17,112	8,043	47	277	2
Streams	27,309	8,683	3,504	10	1,233	3
POLLUTANTS	**Loads from Existing Urban Areas**					
Metals	Kg/yr		Kg/yr	% increase	Kg/yr	% increase
Cadmium	170		233	37	183	8
Copper	3,233		4,374	35	3,539	9
Nickel	2,042		2,926	43	2,244	10
Nutrients						
PO4-Phosphorus	38,106		47,869	26	40,410	6
NO3-Nitrogen	47,040		70,202	32	53,203	13
TKN-Nitrogen	219,066		300,854	37	239,280	9
BOD	1,246,376		1,538,414	23	1,321,586	6
TSS	7,905,823		10,461,969	32	8,545,187	8

COMMENTS: This receiving watershed has two major components: an extensive area of Bay shorelands (largely incorporated), and the major watershed of the Livermore Valley, largely under County jurisdiction. Potential impacts can be expected in nearly all wetland categories in the Bay portion, and in stream zones in the upper watershed.

Table 19
Impact Summary III

Receiving Watershed:
San Pablo Bay Watershed West
(no. 81)

Size:
513,380 acres

Jurisdictions:
Marin 13%, Sonoma 35%, Napa 47%, Solano 5%, Novato, Petaluma, Sonoma, Napa, Vallejo

			LAND USE SCENARIO			
RESOURCE	**Extent of Existing (ac)**		**Scenario I General Plan**		**Scenario II Incentive/Limit.**	
	urban	nonurban	Effected area(ac)	% of Type	Effected area(ac)	% of Type
Wetlands (types)						
1 open water		1,448	121	8	7	
2 mudflats and rocky shore		689	264	38	27	4
3 vegetated tidal marsh		12,338	895	7	193	2
4 tidal channels		151				
5 diked vegetated wetlands		7,166	1,075	15	101	1
6seasonal/perm. veg		991	99	10	27	3
7 seasonal ponds		1,631	96	6	17	1
8 farmed wetlands		25,681	3,323	13	133	1
9 freshwaer marsh		35	7	20		
10 riparian forest		556	52	9	44	8
11 salt evaporators		8,960	2			
12 perennial lakes and ponds		2,656	128	5	52	2
13 rivers, tidal		151	89	59	5	
14 rivers, nontidal, creeks		54				
Total		62,506	6,153	10	608	1
Streams	4,893	31,997	2,150	6	729	2
POLLUTANTS	**Loads from Existing Urban Areas**					
Metals	Kg/yr		Kg/yr	% increase	Kg/yr	% increase
Cadmium	495		571	15	528	7
Copper	9,304		10,673	15	10,101	9
Nickel	5,775		6,816	18	6,291	9
Nutrients						
PO4-Phosphorus	107,466		119,719	11	113,471	6
NO3-Nitrogen	137,246		163,761	20	152,999	11
TKN-Nitrogen	620,568		713,476	15	668,650	8
BOD	3,576,477		3,923,761	10	3,774,511	6
TSS	22,977,936		26,065,949	13	24,788,477	8

COMMENTS: This very large watershed shows potential impacts from land-use change in both the upper portions of its drainage basins, and the lowlands surrounding the North bay. Critical resources exist in areas covered by County plans and in incorporated cities. A wide array of wetland and riparian types are at risk, and the high rate of land-use change under way makes this receiving watershed a high priority for further study, impact assessment, protection, and remedial measures.

Table 20
Impact Summary IV

Receiving Watershed:
West Delta Watershed South
(no. 112)

Size:
32,680 acres

Jurisdictions:
Contra Costa County, Antioch, Pittsburg

			LAND USE SCENARIO			
RESOURCE	Extent of Existing (ac)		Scenario I General Plan		Scenario II Incentive/Limit.	
	urban	nonurban	Effected area(ac)	% of Type	Effected area(ac)	% of Type
Wetlands (types)						
1 open water		27	0	0	0	
2 mudflats and rocky shore						
3 vegetated tidal marsh		109	119	109		
4 tidal channels		2				
5 diked vegetated wetlands		845	388	46	20	2
6 seasonal/perm. veg		62	35	56	35	56
7 seasonal ponds		109	5	5		
8 farmed wetlands						
9 freshwaer marsh		131	114	87	22	
10 riparian forest		27	2	7		
11 salt evaporators						
12 perennial lakes and ponds		200	119	60	12	6
13 rivers, tidal		44				
14 rivers, nontidal, creeks		0				
Total		1,557	781	50	89	6
Streams	539	1,557	477	23	311	15
POLLUTANTS	Loads from Existing Urban Areas					
Metals	Kg/yr		Kg/yr	% increase	Kg/yr	% increase
Cadmium	23		32	40	25	9
Copper	345		482	40	406	18
Nickel	258		354	37	295	14
Nutrients						
PO4-Phosphorus	3,765		5,123	36	4,228	12
NO3-Nitrogen	5,621		7,911	41	6,787	21
TKN-Nitrogen	20,080		27,805	38	23,919	19
BOD	97,607		130,934	34	112,745	16
TSS	878,714		1,188,611	35	1,002,724	14

Comments: Significant areas of freshwater marsh and perennial ponds are in incorporated but unprotected status. Land use change under the County plan could impact a substantial area of vegetated wetlands. Increased pollutant loadings appear to be particularly problematic, likely owing to the industrial character of existing and planned land use.

CHAPTER 7

ANALYSIS OF LAND USE CONTROLS

The preceding chapter made evident the potential for incurring negative environmental impacts on the Estuary as urbanization continues in the region. Land use Scenario II estimates 3,500 acres of wetlands could be effected by land use change. Scenario I estimates that a much greater potential impact of 39,500 acres of wetlands could result from build-out of county planned land use. For affected stream environments, the figures are 10,500 acres for Scenario II, and 28,000 acres for Scenario I. Increases in pollutant loadings are also anticipated by the two scenarios. This characterization of impacts makes a case for renewed efforts to bring the process of land use change under some form of uniform and comprehensive regional control.

This chapter contributes to that effort by examining the existing framework for land use planning and control and the trend toward *greater-than-local* land use decision making. We begin by examining the existing regulatory arrangement for land use planning and identifying its shortcomings with respect to protection of the San Francisco Estuary. A brief discussion of the current movement in California toward a comprehensive approach to growth management follows, centering on six pieces of legislation introduced in the Legislature. This discussion leads into the next chapter which lays out a range of Estuary land use control strategies and tools for protecting wetlands and streams and then addresses the way in which institutions can be structured to most effectively attain the goal of comprehensive Estuary management.

Existing Regulatory Arrangement

The principal tool for managing generalized effects of land use change on estuarine systems is land use planning and regulation. Until 1970, land use regulation generally consisted of local zoning (Popper, 1988). The 1970s brought a *quiet revolution* (Bosselman and Callies, 1972) in land use planning as a number of states passed legislation dramatically increasing the direct role of state governments in land use issues. Particularly, New York, California, Oregon, Florida, and Vermont established land use regulations to control development in specific natural resource, rural, or scenic areas. These centralized land use regulations were applied mainly to large projects or projects proposed for environmentally sensitive areas, such as San Francisco Bay where the creation of the San Francisco Bay Conservation and

Development Commission (BCDC) was created by the Legislature in 1965 to develop a plan to halt the indiscriminate filling of the Bay.

On a federal level, Congress came close to passing the National Land Use Policy Act which would have provided up to $100 million in federal grants for the creation of state-wide land use plans (Popper, 1988). In 1972, the federal Coastal Zone Management Act provided federal grants to states for development of coastal management plans. In California, following the Legislature's action in 1969, establishing BCDC as a permanent agency to carry out its plan for the Bay and its shoreline, the public's concern for the coast led to a state-wide voter initiative, Proposition 20, which created the Coastal Zone Conservation Commission (CZCC) with the authority to develop a plan for the coast and regulate land within 1,000 yards of the shoreline. In 1976, the California Coastal Commission was established by the Legislature to implement the California Coastal Act which incorporated many of the recommendations of the coastal plan prepared by the CZCC.

During the 1980s, land use issues changed from their predominantly environmental focus into a debate about how to address urban sprawl, unplanned growth, and traffic congestion. The rise of the growth management issue has caused citizens in both urban and rural areas to join environmental organizations in the debate over land use and land use change. Gradually, in what has been termed the *quiet evolution*, (Fulton, 1989) states are moving ever further into the land use planning and regulation field; establishing planning criteria for issues and areas of state-wide concern to be carried out by local government as well as state and regional agencies.

In California over 50 growth-related bills were introduced in the state Legislature during the 1989 session and over 250 growth management related measures reached the ballot in the state (Shiffman, 1990). The state of California's interest in land use and growth management issues is growing (Karen Paget, per. com.). There is also renewed interest in new forms of regional land use management as shown by the formation and recommendations of the Bay Vision 2020 Commission in the San Francisco Bay Area and the LA 2000 Committee in Los Angeles. Such regional land use and growth management and governance efforts address head on the issue of what new, or modified existing institutions, are necessary in order to have a more comprehensive, *greater-than-local* decision-making structure to provide for rational economic and population growth, while preserving and enhancing the natural environment.

1. **Existing Land Use Planning And Probable Consequences For The Estuary.** Fiscal incentives and population growth have intensified development pressures in and around the Estuary region. From 1980 to 1990 the Bay Area's population grew 14 percent. Sacramento, Contra Costa, Alameda, and Santa Clara counties are included in California's top ten counties with the largest population increase in the 1980s (California Senate Office of Research, 1989). The rapid population growth in California has brought with it an increased demand for housing, highways, and public facilities and services. Proposition 13 forces local governments to make do with severe property tax cuts and creates urban growth incentives

as sources of property and sales tax revenues. This pressure has caused local governments to compete for development, particularly commercial projects, to capture lucrative sales tax revenue.

Currently, decisions about zoning, building permits, infrastructure financing, housing subdivisions, and related development are made by local government. Therefore, land use policy, except for certain environmentally sensitive areas such as the water and narrow strip of shoreline surrounding San Francisco Bay, the coastal zone, or the Lake Tahoe Basin, is made at the local level. California law has strengthened the planning and regulatory capabilities of local governments. First, the state constitution protects home rule authority. Further, each California city and county must prepare a comprehensive general plan containing state-specified elements oriented toward meeting local goals and needs. All local ordinances, development plans, and activities are required to be consistent with that plan. The general plan and implementing mechanisms are not required to deal with adjacent communities. Additionally, under the California Environmental Quality Act (CEQA) each locality must undertake the process of environmental review and prepare an environmental impact report whenever a proposed project may cause significant adverse impacts on the environment.

Unfortunately, there are weaknesses in both the state planning and CEQA processes vis-a-vis Estuary protection. Within the state planning process, there is no provision to resolve conflicts or inconsistencies between local, state, or regional plans. In fact, a city or county can approve a local plan calling for a new development even if that project is inconsistent with regional plans or needs, such as Bay protection, transportation, water or sewer facilities (California Senate Office of Research, 1989).

California lacks clear, consolidated state-wide policies on land use issues (California Assembly Local Government Committee, 1988). Thus, there is no enforceable state policy on Estuary wetland protection or stream environment protection. Under CEQA, the decision about whether or not a mitigation measure "ensures the long-term protection of the environment" rests with the lead agency; which can have a vested interest in the outcome of a project. Although other agencies are free to comment, they are usually unable to condition the land use decision of the lead agency even if the decision may cause damaging impacts to areas of regional or state-wide importance (California Assembly Local Government Committee, 1988).

Currently, there is no region-wide enforceable plan or policy in place for management of lands that contain significant natural resources (other than San Francisco Bay). Regional goals such as protecting wetlands or streams and their surrounding "stream environment areas" have no consistent voice in law or agency regulation. General Plan law does not require local governments to give special attention to these resource areas. Some counties and cities currently revising their codes (e.g., San Joaquin County) are including policies which specifically address the protection of wetlands and streams, and the control of nonpoint source pollution

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runoff. However, many existing plans reveal no coordination with neighboring jurisdictions, contain vague and contradictory language regarding resource protection and development, and possess elements revised at different times and therefore provide policy direction that is often inconsistent with the jurisdictions' zoning ordinances.

2. **Survey Results of Local Stream and Wetland Ordinances.** A survey conducted for the San Francisco Estuary Project's Report on *Regulatory, Institutional and Management Programs (RIMP)* revealed that the level of protection afforded to streams and wetlands in the Estuary region by local regulations is weak and inconsistent. The results of the survey are presented in Table 21. For those jurisdictions with adopted ordinances, the title of the ordinance, ordinance number, and year of enactment is provided. In addition, these tables include data from the *Status and Trends Report on Wetlands and Related Habitats* (ABAG, 1990) on general plan policies and other ordinances which have a different primary intent but may provide some protection to streams or wetlands.

Of 111 jurisdictions in the Estuary region, 18 have ordinances which are specifically intended to protect streams or wetlands (14 cities and three counties), or 16 percent. Only six local jurisdictions have wetland protection ordinances, 6.2 percent (Marin County, Napa, Redwood City, Rio Vista and Suisun City); and 12 have stream or creek protection ordinances, 12.4 percent (Sacramento County, Albany, Berkeley, Dublin, Fairfax, Fairfield, Los Altos, Los Altos Hills, Napa, Orinda, San Anselmo, and San Carlos). The City of Napa has both stream and wetland protection ordinances. San Joaquin County is in the process of drafting both kinds of ordinances and expects them to be in effect by early 1992. Although some jurisdictions communicated that they do not have ordinances per se, they commented that their application of general plan policies was effective to protect these natural resources.

Eighty-two local jurisdictions (82.8 percent) have general plan policies which address stream or wetland protection, while 29 (29 percent) have other ordinances (i.e., flood control) which may be construed to protect these resources.

The assessment of the implementation, monitoring, or enforcement of the ordinances was outside the scope of this survey. Additionally, the content of the ordinances (i.e., regulatory activity, area subject to regulation, information to be consulted) which are in place, has not been evaluated. Nevertheless, this survey clearly indicates that most local jurisdictions have not taken responsibility for protection of wetland and stream environment natural resources by adopting specific enforceable regulations.

3. **Measures to Control Nonpoint Source Pollution.** Where protection of wetlands and stream environments appears inconsistent and weak, the control of nonpoint source pollution is receiving unprecedented attention at both the federal and state levels.

In November 1990, the U.S. EPA published regulations establishing National Pollutant Discharge Elimination System (NPDES) permit application re-

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Table 21
Local Jurisdictions
With Stream or Wetland
Protection Ordinances

KEY
○ possess no ordinance or policy
● possess protection ordinance
◍ possess protection policy

COUNTY Incorporated Cities	**stream protection ordinance**	**wetland protection ordinance**		**misc. ordinance providing stream or wetland protection ***	**Ordinance Number: Name of Ordinance (Year of Enactment)**
ALAMEDA	○	○	◍	◍	
Alameda	○	○	◍	○	
Albany	●	○	◍	◍	AMC 20-2.20: Watercourse Combining District (1978)
Berkeley	●	○	◍	○	
Dublin	●	○	◍	○	
Emeryville	○	○	◍	○	
Fremont	○	○	○	◍	
Hayward	○	○	○	○	
Livermore	○	○	◍	○	
Newark	○	○	◍	○	
Oakland	○	○	○	○	not available
Piedmont	○	○	○	○	not available
Pleasanton	○	○	◍	○	
San Leandro	○	○	◍	○	
Union City	○	○	◍	○	
CONTRA COSTA	○	○	◍	◍	
Antioch	○	○	◍	○	
Brentwood	○	○	◍	○	
Clayton	○	○	○	○	
Concord	○	○	◍	○	
Danville	○	○	◍	○	
El Cerrito	○	○	◍	◍	
Hercules	○	○	○	○	not available
Lafayette	○	○	○	○	
Martinez	○	○	◍	◍	not available
Moraga	○	○	◍	○	
Orinda	●	○	○	○	OMC 89-6: Ridgeline and Preservation Zone (1989)
Pinole	○	○	◍	○	
Pittsburg	○	○	◍	○	
Pleasant Hill	○	○	◍	○	
Richmond	○	○	○	○	not available
San Pablo	○	○	○	○	not available
San Ramon	○	○	○	○	
Walnut Creek	○	○	○	○	not available
MARIN	○	●	◍	◍	MMC ch. 22.5, Title22: Bayfront Conservation District (1982); ch 22.77: County Tidelands Ordinance (1970)
Belvedere	○	○	○	○	
Corte Madera	○	○	◍	○	
Fairfax	●	○	◍	◍	FMC 8.24: Watercourse Ordinance (1982)
Larkspur	○	○	◍	○	
Mill Valley	○	○	◍	◍	
Novato	○	○	◍	◍	
Ross	○	○	◍	◍	not available
San Anselmo	●	○	○	○	SAMC Ord No. 898: Stream Ordinance (1988)
San Rafael	○	○	◍	◍	not available
Sausalito	○	○	◍	○	
Tiburon	○	○	◍	○	

* from Status and Trends Report on Wetlands and Related Habitats (ABAG, 1990).

Table 21 (cont'd.)
Local Jurisdictions With Stream or Wetland Protection Ordinances

COUNTY Incorporated Cities	stream protection ordinance	wetland protection ordinance	general plan policy promoting stream and wetland protection *	misc. ordinance providing stream or wetland protection *	Ordinance Number: Name of Ordinance (Year of Enactment)
NAPA	○	○	◍	◍	
Calistoga	○	○	◍	○	
Napa	●	●	◍	◍	NMC Ordinance No. 3084: Environmental Protection Overlay District (1987)
St. Helena	○	○	◍	○	
Yountville	○	○	◍	◍	not available
SACRAMENTO	●	○	◍	◍	SZC 80.38: Nat'l Stream Land Use Zone (1980) SZC 78.112: Delta Waterway Ordinance (1978
Folsom	○	○	○	○	not available
Galt	○	○	◍	○	Recently revised GP overrides all zoning by a City Council ruling until zoning is updated.
Sacramento	○	○	◍	◍	
SAN FRANCISCO	○	○	○	○	
	○	○	○	○	
SAN JOAQUIN**	◍	◍	◍	◍	Draft: Riparian Habitat Ordinance (1992) Draft: Wetlands Ordinance (1992)
Islton	•	○	○	○	
Lathrop	○	○	○	○	
Lodi	○	○	○	○	
Manteca	○	○	○	○	
Stockton	○	○	◍	◍	
Tracy	○	○	◍	○	
SAN MATEO	○	○	◍	◍	
Atherton	○	○	○	○	
Belmont	○	○	○	○	
Brisbane	○	○	◍	○	
Burlingame	○	○	◍	○	
Colma	○	○	◍	◍	not available
Daly City	○	○	○	○	
East Palo Alto	○	○	○	○	not available
Foster City	○	○	○	○	
Hillsborough	○	○	○	○	
Menlo Park	○	○	○	○	
Millbrae	○	○	○	○	
Portola Valley	○	○	○	○	
Redwood City	○	●	◍	◍	RCZC art. 20: Tidal Plain Zoning Overlay (19XX)
San Bruno	○	○	◍	○	
San Carlos	●	○	◍	○	SCMC 18.144.010: Stream Development and Maintenance Provision (1987)
San Mateo	○	○	◍	○	
South San Francisco	○	○	◍	○	
Woodside	○	○	◍	○	

* from Status and Trends Report on Wetlands and Related Habitats (ABAG, 1990).

** currently drafting ordinances to be in effect by early 1992

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Table 21 (cont'd.)
Local Jurisdictions With Stream or Wetland Protection Ordinances

COUNTY Incorporated Cities	stream protection ordinance	wetland protection ordinance	general plan policy promoting stream and wetland protection *	misc. ordinance providing stream or wetland protection *	Ordinance Number: Name of Ordinance (Year of Enactment)
SANTA CLARA	○	○	◍	◍	
Campbell	○	○	◍	◍	
Cupertino	○	○	◍	○	
Los Altos	●	○	◍	○	LAMC 86-155: Adobe Creek Conservation Easmt. (1986).
Los Altos Hills	●	○	○	○	LAHMC 232: Subdivision and Plan Line Conservation Easement (1976)
Los Gatos	○	○	◍	○	
Milpitas	○	○	◍	○	
Monte Sereno	○	○	○	○	not available
Mountain View	○	○	◍	○	
Palo Alto	○	○	◍	◍	
San Jose	○	○	◍	◍	
Santa Clara	○	○	○	◍	
Sartoga	○	○	◍	○	
Sunnyvale	○	○	◍	○	
SOLANO	○	●	◍	○	
Benicia	○	○	◍	○	
Dixon	○	○	◍	○	
Fairfield	●	○	◍	○	FMC 25.900: Creekside Development Ordinance (1980)
Rio Vista	○	●	◍	○	RVMC Ordinance No. 330: Wetlands or Floodway Zoning Overlay (1973)
Suisun City	○	●	◍	○	
Vacaville	○	○	◍	○	
Vallejo	○	○	◍	○	
SONOMA	○	○	◍	○	
Petaluma	○	○	◍	◍	
Sonoma	○	○	◍	○	
YOLO	○	○	○	◍	
Davis	○	○	◍	○	
West Sacramento	○	○	◍	○	
Woodland	○	○	◍	○	

* from Status and Trends Report on Wetlands and Related Habitats (ABAG, 1990).

quirements for storm water discharges (40 CFR Parts 122, 123, and 124). Entities required to obtain permits include: (1) municipalities with populations greater than 100,000; (2) facilities associated with industrial activity; and (3) those storm waters which contribute to violations of water quality standards, or contribute pollutants to receiving waters. Significantly, industrial facilities include construction activities that disturb more than five acres of land, or, that disturb less acreage but are part of a larger, common plan of development.

The permits will require a number of specific structural and source control measures to reduce pollutants in runoff from commercial and residential areas both during and after construction. Such measures are expected to go a long way toward controlling the source (urban runoff) now composing the larger part of pollution entering the Estuary. At this time, a framework for implementation in the San Francisco Bay Area which uses the resources of the municipalities involved, the San Francisco Bay Regional Water Quality Control Board, and the concerned water districts in a coordinated fashion, is emerging. Such coordination is essential as the direct involvement of the Regional Board in reviewing every sizable development in the region would place a great burden on the agency and could potentially slow down the application process to the point that land developers begin to incur unacceptable expense waiting for permit application review and approval. It would be in the general interest of those involved in this process to have local governments (cities and counties) include specific control measures in their building permit to satisfy the federal regulatory requirements.

It remains to be seen how effective this arrangement for nonpoint source pollution control will be. One obvious concern is that of enforcement. Another centers around land use intensification in unincorporated areas. The new regulations do require compliance from municipalities of less than 100,000 people that are linked into stormwater systems serving larger populations. But, there are new towns on the horizon and burgeoning small communities with no stormwater service linkage to larger systems.

4. **Current Land Use Planning and Regulation Addresses Local Objectives.** While the broadening of land use authority has increased the quality of the plans and contributed to a greater openness and participation in community planning, it has failed to address the fundamental issue: that planning continues to respond primarily to local objectives without consideration of state or regional needs and resources (Schiffman, 1990). The San Francisco Estuary is a prime example of a regional resource that is affected by the uncoordinated and individual decisions of many local governments. Since this arrangement for land use decision making is not the optimum for specific protection of the Estuary's well-being, there is a need to modify the arrangement to insure the consideration of *greater-than-local* impacts of projects in the land use decision-making process, particularly as those impacts affect the Estuary.

Further, in the 1990 amendments to the federal Coastal Zone Management Act, Section 6217 requires that states with federally-approved coastal zone management programs develop a Coastal Nonpoint Pollution Control Program to be carried out through the existing state coastal zone management programs and state nonpoint source management programs approved under Section 319 of the Clean Water Act. The EPA and the National Oceanic and Atmospheric Administration (NOAA) administer the new requirements jointly.

The San Francisco Bay Conservation and Development Commission (BCDC), which administers the coastal zone management program for the San Francisco Bay segment of the California Coastal Zone, is working with the State Water Resources Control Board, the California Coastal Commission, EPA, and NOAA to develop a Nonpoint Pollution Control Program for the California Coastal Zone, including the San Francisco Estuary.

Status of Pending State-Wide, Regional Planning and Growth Management Legislation in California

Legislation has been introduced in the 1991 session of the California Legislature that would institute combinations of state-wide and regional land use planning and regulation. Action on these bills is postponed pending hearings in the Legislature in the fall of 1991 concerning the general issues of growth management and governance.

It appears inevitable that California will soon enact a *greater-than-local* form of land use planning and regulation either state-wide or regionally. Such a system can, and possibly will, directly affect the San Francisco Estuary. It is important that the San Francisco Estuary Project be cognizant of this legislation and its relationship to the protection of the environmental well-being of the Estuary.

Currently (as of April 22, 1991) there are six bills in the Legislature concerning such land use planning, growth management and regional governance. The pending bills are briefly discussed below.

1. **Assembly Bill 3 (Brown)**. This bill establishes a three-tier system of state-wide growth management, including a state commission, a regional development and infrastructure agency in each metropolitan region of the state, and subregional authorities which may include one or more counties within the region. However, the requirement to create a new regional agency would not apply to any region which establishes its own structure to meet the goals of the bill by January 1, 1993. The regional commission proposed for the nine-county San Francisco Bay Area by the Bay Vision 2020 Commission could be such a regional agency.

2. **Assembly Bill 76 (Farr).** Under this bill, the existing Governor's Office of Planning and Research would be separated into a Governor's Office of Research and a new state planning agency which would be responsible for adopting a new state plan. At the regional level, AB 76 would require existing councils of governments to prepare regional plans consistent with the state plan. Local government land use plans and regulations would be required to be consistent with the state plan.

3. **Senate Bill 434 (Bergeson)**. SB 434 requires the state to adopt and update every two years the "California Growth Management Policies." At the regional level, the bill allows formation of "regional fiscal authorities" with taxing authority. Actions of state agencies, regional fiscal authorities, and local governments are required to be consistent with the state policies. The regional fiscal authorities are

required to designate "development boundaries" to separate development lands from those not available for development. Within the area of authorized development, local governments are required to approve proposed projects consistent with the plan unless there are health and safety reasons for denial.

4. **Senate Bill 797 (Morgan).** This bill would establish policies for regional growth management for the nine-county San Francisco Bay Area. It is "skeleton" legislation established for amending language that would establish the regional commission for the Bay Area proposed by the Bay Vision 2020 Commission.

5. **Senate Bill 907 (McCorquodale).** Under SB 907, "regional fiscal authorities" with broad fee and tax authority to finance regional public works would be created.

6. **Senate Bill 929 (Presley).** This bill is similar to AB 3 (Brown) discussed above. It would establish a three-tier growth management institution: a "California Conservation and Development Commission" to establish state land use planning and development goals and policies; regional planning agencies which could be new agencies or existing councils of government that would prepare regional plans; and subregional authorities, which could be one or more counties, that would prepare subregional plans. The regional and subregional plans would be required to be consistent with the state goals and policies. The land use element of the subregional plan would contain "urban limit lines."

CHAPTER 8

MANAGEMENT OPTIONS

Given the projected impacts of land use change to the Estuary's wetlands, streams and water quality, the apparently inadequate institutional/regulatory framework for managing the Estuary, and the state-wide concern with managing growth discussed in the previous chapters, it is appropriate to now consider the options presently available for comprehensively managing a complex, regional resource like the San Francisco Estuary.

A management option can be viewed as a complimentary arrangement of: (1) management strategies and tools for implementation; (2) an institutional arrangement facilitating goal achievement and plan implementation; and (3) an agenda for applied research and analysis which in turn feeds back to improved management tools and strategies and implementation.

Many strategies for lessening the effects of land use change and intensification on the Estuary could be implemented from more than one level of institutional authority, thus it is important to consider them separately. The consideration of management strategies must be made while baring in mind that the San Francisco Estuary is a regionally defined natural system and any effort to maintain the desired quality of this resource will require regional coordination.

Institutional arrangements provide the context in which various strategies are implemented. The institutional arrangements considered must confront the fundamental issue of the level of government—state, regional or local—in which effective management can occur.

Finally, the agenda for applied research is an important part of a resource management system because decision making is informed by the results of efforts to close gaps in knowledge. The process of setting the agenda should begin concurrent with efforts to structure institutions and identify specific management strategies.

This portion of the chapter reviews each of these elements of management separately.

Management Strategies and Tools for Improved Estuarine Management

Remedial and preventative action for the three classes of impacts (streams, wetlands and nonpoint source pollution) considered in this report is discussed in this section. The management strategies considered here are oriented around land use planning, or, more specifically, land use change and intensification, the subject of this report.

1. **Management Strategies for Stream Environments.** One important strategy to protect streams from direct and indirect land use impacts begins with delineating a riparian corridor. Regulatory boundaries can then be established according to linear and horizontal criteria. These criteria determine the extent of coverage throughout a drainage system and the effective width of a regulated corridor. This approach provides the capability to manage land uses in and near the riparian corridor for the purposes of water quality protection and riparian environment protection and maintenance, by conditioning permitted activities with performance and design standards, and mitigation measures.

Well-drafted and effectively administered riparian environment regulations can serve several goals, including channel maintenance, flood protection, habitat and wildlife protection, and water quality control in streams as well as lakes, rivers, and bays.

Jurisdictions can adopt different legal and administrative vehicles to regulate land use in or near riparian corridors. These fall into four broad categories: (a) lake and stream shore acts; (b) nonpoint source pollution management plans; (c) city and county ordinances; and (d) flood plain regulations.

Most programs use a similar set of regulatory procedures and mechanisms including:

- Enabling legislation and ordinances
- Delineation of area subject to regulation
- State or regional standards for local implementation
- Special permitting
- Reliance on design and performance standards
- Requirements for buffer maintenance and setbacks
- Requirements for mitigation of adverse impacts
- Voluntary and required best development/management practices

There are primarily three types of regulated riparian buffers: (a) fixed zone; (b) variable zone; and (c) independent zone. A fixed zone delineates a constant band on either side of the stream subject to regulation, regardless of topography or hydrology. A variable zone varies according to established physical or ecological characteristics. An independent zone confers a discrete zoning classification upon the riparian corridor and attaches land uses limitations to that zone. The independent zone provides the greatest opportunity to delineate the area where land uses impact the riparian corridor, although it is the most administratively complex and labor-intensive, requiring considerable mapping and hydrologic-topographic assessments.

Riparian-specific and related ordinances provide the opportunity to achieve resource and water quality protection goals within the regulated area by controlling the amount of sediment and pollutants which can potentially reach streams and by protecting the integrity of riparian ecosystems. Pollution control and vegetation maintenance are interdependent objectives: (a) healthy riparian vegetation helps to trap sediment and to filter other pollutants; and (b) controlling adjacent land uses which generate sediments, nutrients, and toxics and which increase runoff helps to maintain a healthy riparian environment.

Regulations prohibit, allow, or subject land uses or activities to special permitting. Allowable activities may include flood control projects, agriculture and livestock operations, infrastructure projects, modifications and maintenance of existing land uses, natural resource management, and public recreation. Removal of vegetation and grading, excavation, and filling and construction of new development are most commonly expressly prohibited activities.

Activities and land uses not permitted in the zoning district, must receive a conditional use or special permit which may include conditions for approval, such as design and performance standards and/or setback buffers. Riparian ordinances often address best management practices (BMPs) for agriculture and silviculture and best development practices (BDPs) for new construction. BMPs are intended to minimize erosion and sediment and nutrient input to streams and reduce impacts on riparian vegetation from adjacent land uses. BDPs are designed to place both ecological and water quality-related restrictions on new development and changes to existing land uses.

Stronger riparian management strategies employ an independent stream environment zone and implementing ordinances containing specific density restrictions and performance and design standards linked to proximity to the stream channel, bank slopes, historical runoff flows, and soil fragility. Mapping riparian corridors and/or identifying areas of special concern are essential in such a regulatory program.

Specifically management strategies for riparian protection can be strengthened by the following:

- Linear stream definitions including perennial, intermittent, and ephemeral definitions as well as criteria to define streams in dry years by channel and remnant vegetation characteristics or by location in a flood plain.
- Fixed zones defining the corridor as the stream and an area on each side of the stream extending at least 150 feet horizontal beyond the drip line of streamside vegetation.
- Variable zones defining a scientifically defensible minimum width and establishing criteria for that width to vary as the slope of adjacent lands increases; the minimum could also vary depending on significance of impact from a particular proposed use.
- Efforts to link, coordinate, and integrate riparian corridor regulation with existing nonpoint source control plans.
- Efforts to link and coordinate riparian corridor regulation with existing flood control ordinances.
- Prohibitions against alteration and removal of vegetation and against

planting of non-native riparian plant species.

- Restoration of riparian corridors including uncovering or "daylighting" stream section which have been enclosed in culverts and concrete channels.

2. **Management Strategies for Wetlands.** Fundamental goals of wetland protection programs are to protect wetland environments and their functions; to promote compatible land uses in and adjacent to wetlands; and to limit and prohibit land uses which adversely impact wetlands and adjacent ecosystems. Wetland laws and ordinances, in general, subject those activities which may threaten or degrade water quality and/or wetland function to permitting requirements. The regulatory mechanism also provides the opportunity to encourage or promote certain land uses determined to be compatible with wetlands and which provide substantial public benefits. Permit review criteria, conditional use, and design and performance standards, and mitigation requirements provide land use managers with the capability to effectively protect wetlands from most activities which pose significant and unmitigable threats to wetland environments.

Wetland protection programs comprise several key features including:

- Definition and delineation of lands to which the law applies
- Inventory and/or mapping requirement
- Legislated regulated, and unregulated activities
- State-established permitting standards and criteria
- Provisions for local assumption of permitting responsibility
- Mandated buffer strip widths and setback requirements
- Mitigation requirements and procedures

The area of a regulated wetland is not only determined by statutory resource definitions, but is also dependent on mandated buffers. Buffers are naturally—or human—established and maintained vegetated areas between wetlands and adjacent lands. Buffers expand the size of the area to be regulated. Buffers typically range from 25 to 300 feet from the edge of the wetland.

Several mechanisms exist to expand the geographical scope of regulation beyond that determined by wetland definition and buffer area. For example, Maryland counties with wetlands within 1,000 feet of the Chesapeake Bay include wetlands in "resource conservation areas" and regulate them according to state-established criteria.

Management strategies for wetland protection can be strengthened by the following:

- A minimum buffer of 60 to 100 feet. In lieu of a fixed buffer, it is recommended that the minimum buffer expand where steep slopes, sensitive hydrology, or fragile plant communities warrant more substantial protection.
- Criteria to delineate wetland boundaries that are clear, specific, and scientifically defensible.

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- Non-regulatory tools, such as wetland acquisition, conservation easements, wetland banks, and differential taxation, to be integrated with the regulatory program and housed in, or at least coordinated by, the same administering agency.
- A specially created task force or an administering agency to continually oversee agricultural and development practices affecting wetlands with particular attention to cumulative, sub-watershed impacts. Best management practices should be mandatory for all non-exempted activities.
- Programs which do not depend on wetland enhancement, restoration, or creation to mitigate wetland losses to the extent that upland alternatives are overlooked. Where mitigation is required, it should be accomplished at the front end of the project with the plan clearly spelled out before the permit is issued.
- Public and private entities, including land trusts, to acquire and protect existing wetlands and diked baylands and Delta low lands for future restoration to wetlands.
- Establish public/private wetland creation, restoration and enhancement programs. Employ conservation easements, economic incentives and conjunctive use management, as approaches to protection.
- Programs to protect downstream wetland areas from sedimentation and erosion.
- Programs to monitor the regional status of wetlands, including mitigation, restoration and enhancement efforts.

3. **Management Strategies for Nonpoint Source Pollution.** An impressive array of strategies for nonpoint source pollution control has been laid out in the *Santa Clara Valley Nonpoint Source Control Plan* prepared by Woodward-Clyde consultants (1991). Through a series of educational, regulatory and public agency controls, these measures emphasize source control—that is, attacking the problem at its source, before it enters the stormwater system. They prescribe the adoption of best management practices (BMPs), erosion controls, curbing illegal discharges into storm drains, controlling chemical use, and establishing public information aimed at reducing the use of household toxicants and the safe disposal of household toxic waste.

The measures appear to correspond well with the new National Pollution Discharge Elimination System (NPDES) requirements outlined in the Federal Code of Regulations. These requirements include *Municipal Stormwater Management Plans* which can be summarized as follows:

a. **Residential/Commercial Area Control Program**
   - Maximum extent practicable control measures
   - Planning procedures and Master Plan to assume control of newly developed areas
   - Procedures to achieve water quality benefits from flood practices
   - Practices for operating and maintaining public highways for reduc-

ing water quality impacts

b. **Prohibition on Non-Stormwater Discharges**
- Eliminate illicit connections
- Eliminate illegal dumping
- Provide viable alternatives

c. **Industrial Stormwater Control Program**
- Requirements for control measures
- Procedures for inspection and enforcement
- Educational and training measures

d. **Construction Activity Control Program**
- Procedures for site planning
- Requirements for control measures
- Procedures for inspection and enforcement
- Educational and training measures

Institutional Arrangements

This section presents several alternative models of *greater-than-local* systems of land use planning and regulation. The first part of the discussion outlines three alternative models: (1) voluntary adoption of stronger land use controls by local government; (2) creation of a state agency to manage the San Francisco Estuary; (3) creation of a state-local collaborative process for planning and management. Then a number of land use models employed around the country are examined to reveal the variety of management options available for protecting critically important resources.

1. **Vehicles for Implementation.** Several vehicles for creating improved management strategies and institutional arrangements exist. Most, if not all, of the options outlined below will require that new legislation be enacted to articulate clear policies and provide the necessary authority and funds to better manage the Estuary. Two clear opportunities are the pending reauthorization of the federal Clean Water Act, slated for 1991, and the current efforts to enact growth management legislation discussed above, which most likely will come to a vote in 1992. It is timely for Estuary managers to begin developing specific proposals to be incorporated in this legislation at the federal and state level.

a. **Voluntary Adoption of Stronger Land Use Controls By Local Government.** One option for improving the existing system of land use planning and regulation is to promote the voluntary adoption of new land use controls by local government. The capacity for local planning and enforcement could be strengthened, for example, by organizing technical and financial assistance from the State. The intended result would be to give local government the tools to better manage resources within their jurisdiction. This model relies on creation of a program of local assistance, perhaps in an agency such as the Governor's Office of Planning and Research, working in conjunction with the SFEP.

Creating such an arrangement requires the minimal level of effort of the three models discussed here. It is also likely to encounter the least political opposition given its deference to local authority. Another strength of this arrangement is that the SFEP or its successor can allocate financial resources to the area where it is likely to bring the most rapid local response.

However, a voluntary program also has several weaknesses. Our review of local protection ordinances, together with the results of many other analyses, suggests that reliance on voluntary cooperation of local governments would produce an uneven commitment to resource protection. While funding and technical assistance are likely to be essential ingredients in a strengthened institutional arrangement, there is considerable evidence that a stronger, state profile in policy setting and plan review is needed.

b. **Create a State Agency to Manage the San Francisco Estuary.** A second option is to create a new state-level agency charged with improving management of the Estuary. Such an agency could be given the authority and responsibility to establish carrying capacities and thresholds for the region, against which impacts of regionally significant projects could be compared, much along the lines of the California Tahoe Regional Planning Agency. Such a San Francisco Estuary Agency could also be the institutional home for the drafting and implementation of the specific management strategies for stream protection, wetland protection, and nonpoint source pollution control.

A possible advantage of this approach is to streamline under one roof a variety of regulatory and planning functions. Embracing the whole Estuary in a single program would also create the opportunity to bring much more consistent policies to bear on the resource base, and to ensure that landowners in adjacent jurisdictions are treated similarly and fairly.

An obvious weakness of this scheme would be the difficulty of dismantling and rearranging the current system of special purpose agencies. This problem is especially challenging in the nine-County Bay Area where agencies such as BCDC and the San Francisco Bay Regional Water Quality Control Board have a high profile and well-established planning and regulatory programs. A related concern is that the Bay Area is viewed by many as distinct from the Delta in political, cultural, and physiographic terms. To respond to this difficulty, a possible variation of this model would be to strengthen and clarify the regulatory and planning functions for existing agencies in the nine-County Bay area and to create a unified agency for the Delta.

Another variation on the model of a single, centralized agency would be to create a federation of agencies, perhaps sitting on a San Francisco Estuary Management Authority. Such an interagency Authority could conduct joint hearings, coordinate preparation of EIRs and EISs, and cooperate in setting environmental targets and thresholds for the Estuary against which new programs and projects could be evaluated.

c. **Create a State-Local Collaborative Arrangement for Planning and Management**. An intermediate option would be to create a set of policies and planning standards for the Estuary region and delegate their implementation to local government. Under this arrangement, policies would be prepared at the state level to foster protection and restoration of wetlands and stream environments and wetland resources, and to reduce nonpoint source pollution. Local governments would then be called upon to prepare amendments to their general plans and zoning ordinances, perhaps called *Local Estuarine Protection Programs.* These programs would be the subject of review and cross acceptance by the state. Alternatively, program review and certification could be accomplished by the regional agency for growth management now proposed in some of the legislation discussed earlier.

This approach is similar to the one used under California's Coastal Management Program which requires local governments to prepare Local Coastal Programs in conformance with the Coastal Act and the Suisun Marsh Preservation Act which requires local governments with jurisdiction in the Suisun Marsh to prepare components of a Local Protection Program consistent with the Marsh Act and BCDC's Suisun Marsh Protection Plan. However, while the coastal program is fairly comprehensive in the range of issues addressed, it may be more strategic to create a resource-specific program, such as the Suisun Marsh program, to focus on the specific objectives of improved estuarine management.

The preparation of *Local Estuarine Protection Programs* could be organized in two ways. One method would be to have each local government prepare a plan. Alternatively, *Local Estuarine Protection Programs* could be prepared for each of the watersheds in the Estuary. This model is consistent with our finding that the Estuary needs to be managed as a series of interconnected hydrologic units. The strength of the watershed-based planning system is that plans can be tailored to address the unique features of a particular watershed. However, this scheme would be more complicated administratively, as each local government sharing a watershed would need to coordinate in plan preparation.

2. **Classification of Land Use Control.** A review of the literature of land use models reveals over 20 existing examples of a *greater-than-local* land use planning and regulatory processes. Table 22 presents a classification system modified from the work of DeGrove and Stroud (1987). This system classifies all types of land use and regulation by: (a) geographic area of authority; (b) substantive extent of authority; and (c) requirements of implementation. These categories form the basis for the review of land use planning and control institutions discussed below.

3. **Examples of Institutions for Land Use Planning and Regulation.** Efforts to strengthen the management of the San Francisco Estuary can benefit by the analysis of land use planning and control experience elsewhere in California and in other states. Following is a discussion of the generally recognized land use planning and regulation institutions that offer either a time-tested arrangement of land use control, or have attributes that appear to be working effectively and that appear capable of adoption and transfer to the San Francisco Estuary region.

a. **State-Wide—Comprehensive.** The three most cited examples of comprehensive state-wide planning and regulatory arrangements are those instituted by the states of New Jersey, Oregon, and Florida. Consequently these three programs will be briefly reviewed below.

Table 22
Classification of Land Use Control

Geographic Area Of Authority	
State-wide Control Control is applied generally throughout the state. State-wide control is any policy that is adopted throughout the entire state.	***Regional Control*** Control is applied to a specific geographic area or region. For example, a model used only in the Bay Area is an example of a regional model.
Implementation Requirements	
Comprehensive Control Control applies generally to all landuse activities. For example, a policy that stated "all projects must demonstrate that they will not present undue strain on existing facilities" is comprehensive; any land use must meet this requirement.	***Selective Control*** Control limited to a specific area or land use. An example of selective control would be a plan that applied only to wetlands or to projects of greater than five acres.
Substantive Extent Of Authority	
Voluntary Local government compliance is strictly voluntary or incentive-oriented. This method lacks any enforcement authority and relies on the willing participation of local governments.	***Mandatory*** Local government compliance is mandated by law. This method requires that local governments comply with the state model and typically possesses sanctions or administrative means to enforce its program.

(1) **New Jersey State Planning Commission.** In 1986, New Jersey established a specific policy and land use framework which described what the state should be in the future. The state agency department heads, acting as a commission, drafted proposed state-wide goals and prepared a draft state land use plan, which included agricultural and environmentally sensitive areas. The proposed state plan was submitted to local governments for review and comment and the state government negotiated with the local governments on what the final state goals and land use plan should be. In this manner, state agencies and local governments became committed to the plan. *Special areas of concern* were identified and the existing regional land use planning and regulatory agencies that had jurisdiction in the areas (e.g., the Pinelands and Hackensack Meadows Commissions) retained their authority to administer their special areas of concern. The example that New Jersey provides is one that includes: (1) the identification of specific land uses and goals for the entire state, including environmentally sensitive areas, such as wetlands and estuaries; (2) specific policies that apply throughout the state; (3) identification of special areas of environmental concern where existing regional land use planning and regulation Commissions plan for and administer a specific, detailed program unique to the specific resource area; and (4) adherence to the state plan by all state agencies as well as local government.

(2) **Oregon Land Conservation and Development Commission.** In 1973, Senate Bill 100 established the Oregon Land Conservation and Development Commission (LCDC). Similar to New Jersey, state goals were established by the

LCDC and local governments were required to bring their land use plans and regulations into consistency with these goals. However, dissimilar to New Jersey, there was no mapping of the general land uses by the state, no concept of what the state should be, and no negotiation with local government as to what the state goals should be. Under the Oregon model, the LCDC certifies local government plans as to consistency with the state goals. Urban limit lines must also be set by the local governments and certified by the LCDC. The goal of the Oregon model is to balance protection of agriculture and natural resources with rational growth. The Oregon model is instructive as it is one of the oldest state-wide land use planning and regulation models, and therefore has a performance record to review. The LCDC process has been generally lauded and has served as a model for other programs, for example the local coastal program process of the California Coastal Commission.

(3) **Florida Growth Management Act.** The Florida model is designed to provide a framework for effective growth management in a rapidly growing state. To slow and rationalize this costly rapid growth, which has out-stripped the state's infrastructure capabilities, Florida has instituted a *pay-as you-grow* approach to growth, as well as enacting provisions to protect the state's environment. Under Florida's 1986 law, local governments, state agencies, and regional councils must prepare plans that are consistent with state established goals. These plans are reviewed by the State Department of Community Affairs. All local plans must meet the *concurrency* requirement that the local government must provide the infrastructure needed to accommodate the impacts of growth they plan before development may be authorized, and they must institute a monitoring system. The principal concept learned from the Florida model is the linkage of development,
i.e., urbanization, to the provision of an infrastructure to accommodate the effects of growth.

b. **State-Wide—Selective: California Coastal Commission.** Some states have prepared state-wide land use controls that apply to a specific, but extensive geographic area of the state. The most notable example is the California Coastal Commission—a model that has been followed in other, particularly coastal, states. The California Coastal Commission carries out the California Coastal Act of 1976. The Act lays out specific, comprehensive state-wide policies that apply to the Commission's area of jurisdiction along the California Coast. The Act also mandates that local governments within the coastal zone bring their land use plans and regulations into consistency with the policies of the Coastal Act by preparing local coastal programs (LCPs) which must be certified by the Coastal Commission. Until certification, the Coastal Commission retains full permitting authority. Once a LCP is certified, the local government receives permit authority under the Act over the coastal zone areas. All appeals to local coastal plans and local permitting decisions as well as LCP amendments are taken to the Commission. The Commission maintains original permit jurisdiction over state tidelands. The California Coastal Commission and its LCP process have been widely followed by other coastal states.

The process provides for state-wide policy setting, that is interpreted at the local government level based on local situations, and carried out by local government.

c. **Regional—Comprehensive.** A number of states have established comprehensive land use controls for specific regions of the state, generally environmentally important and sensitive areas. These programs include the Suisun Marsh within the San Francisco Estuary region and the Pinelands and Hackensack Meadowlands in New Jersey. In addition, the bi-state (California and Nevada) Tahoe Regional Planning Agency provides a unique model. These programs are discussed below.

(1) **Suisun Marsh Preservation Act.** Suisun Marsh is located in Solano County and consists of approximately 85,000 acres of tidal marsh and managed wetlands. To protect and manage the area, the California Legislature passed the Suisun Marsh Preservation Act of 1977 which implemented most of the recommendations in the Suisun Marsh Protection Plan prepared by the San Francisco Bay Conservation and Development Commission (BCDC). The Plan divides the marsh into primary (bays, sloughs, tidal marsh, diked off wetlands, seasonal marsh, and lowland grass areas) and secondary (upland grasslands, cultivated lands, and low lying areas) management areas. Modeled after the California Coastal Act, under the Preservation Act local governments in the Suisun Marsh are required to prepare a local protection program for their area of jurisdiction in the Suisun Marsh consistent with the policies and provisions of the Marsh Act and Plan. These local plans and ordinances are reviewed and certified by BCDC. Once certified, local governments are responsible for carrying out the local protection program in the secondary management area and BCDC has permit authority over all developments in the primary management area and serves as an appellate board for marsh development permits issued by local government.

(2) **Tahoe Regional Planning Agency.** The Tahoe region is located on the California and Nevada border. In 1980, the Tahoe Regional Planning Compact (Public Law 96-511) reorganized the Tahoe Regional Planning Agency (TRPA) and gave the agency the authority to review any activities that may substantially affect the land, water, air, space or any other resources of the region. The basis for such review is a set of standards known as environmental threshold carrying capacities (thresholds). Based on these thresholds, TRPA establishes specific standards and provides the basis for the adoption, enforcement, and implementation of the regional plan for the Tahoe Basin.

The Compact also required TRPA to develop a regional plan for the area. The Regional Plan includes elements of land use, transportation, conservation, recreation, and public services and facilities. Other local jurisdictions may enact local ordinances, rules, regulations, and policies which conform to the regional plan.

(3) **New Jersey Pinelands and Hackensack Meadowlands Commissions.** Within the State of New Jersey, there are two areas of special jurisdiction; the New Jersey Pinelands and the Hackensack Meadowlands. The Pinelands are located along the coastal plain in southeastern New Jersey and comprise almost 22 percent

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of the state. The Hackensack Meadowlands consists of 20,000 acres and is located five miles west of New York City.

The New Jersey Pinelands are protected under the Pinelands Protection Act of 1979. The Act created the Pinelands Commission with the responsibility of developing a comprehensive management plan. The plan designates land capability areas within the Pinelands and each area has a designated special use criteria. Every city and county within the Pinelands must amend their local policies and zoning ordinances so that they are in accordance with the management plan. The Commission reviews local plans to ensure compliance and maintains regional oversight over local permitting decisions.

The Hackensack Meadowlands Commission was established in 1968. The three primary functions of the Commission are to: develop and administer a master plan; protect the delicate environmental balance of the area; and manage solid waste for the entire 120 communities within its jurisdiction. The Commission has authority over all land use normally controlled by local governments. A tax-sharing formula has been developed in which a portion of local taxes are used to finance the Commission. The Commission also has the authority to issue bonds.

d. **Regional—Selective.** Some states have established land use controls over a specific resource of a region, such as in San Francisco Bay and on Martha's Vineyard in Massachusetts. These models are discussed below.

(1) **San Francisco Bay Conservation and Development Commission.** In 1965, the California Legislature passed the McAteer-Petris Act, creating The San Francisco Bay Conservation and Development Commission (BCDC). BCDC's primary objectives are to protect the Bay as a natural resource, develop the shoreline of the Bay to its highest potential with a minimum of Bay filling, and provide public access to the Bay. BCDC is the first of the now many comprehensive land use conservation and development authorities (for example, the Oregon Land Conservation and Development Commission).

BCDC is both a regulatory and a planning agency. The McAteer-Petris Act gives BCDC direct permitting authority over Bay fill dredging, and change in use of any land, water, or structure within its jurisdiction. To be authorized, proposed developments must be consistent with BCDC's plan and its law for the Bay and its shoreline. The BCDC model is an example of a regional state agency with direct land use regulatory and permit authority over a specific natural resource.

(2) **Martha's Vineyard Commission.** The Martha's Vineyard Commission is a voluntary consortium of local governments on the island of Martha's Vineyard in Massachusetts. The Commission has no permitting or enforcement authority, however it does have the power to freeze projects while considering their impact. The Commission reviews all developments of regional impact (DRI) and those in areas designated as critical districts. DRIs are defined as all subdivisions of greater than 10 acres or more than 10 lots and commercial developments of more than 1,000 square feet. The Commission has developed standards and criteria for DRIs and uses these standards to recommend project approval or denial. It is up to the local

government to enforce the recommendation or, alternatively, the Commission may go through court proceedings to implement its recommendations.

Critical planning districts are nominated for designation by individual towns. Once designated, the Commission issues planning guidelines for the area and a one year development moratorium. The town must then enact regulations which support the critical district designation. This model illustrates the framework for designating critical environmental areas in need of specific land use controls.

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CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. ***The Estuary is a Single, Hydrologic System***
   - The open Estuary waters—salt, brackish, and fresh water—and surrounding wetlands and tributary stream environments make a single, hydrologic system.
   - The 28 receiving watersheds of the Estuary are the logical geographic units for the analysis and management of land use effecting the Estuary's health.
2. ***The Estuary Region Consists of Two Subregions: the San Francisco Bay Area and the Delta Area***
   - A review of the physiographic characteristics, current land use patterns, future plans for urban expansion, and existing land use planning and control institutional arrangements, reinforces the view that the 12-county Estuary region consists of two distinct subregions: the nine-county San Francisco Bay Area (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma Counties), and the three-county Delta Area (Sacramento, San Joaquin, and Yolo Counties).
3. ***Rapid Population Growth and Land Use Change Will Continue in the Estuary Region***
   - Because of a favorable economic climate and high quality of life, which is in part related to the unique environmental qualities of the Estuary, the Estuary region will continue to grow in population at a moderately high rate. This growth will be concentrated along the major highway systems of the Bay and Delta Areas—Interstate 80 between the East Bay and Sacramento; Highway 101 in northern Marin and Sonoma Counties and south of San Jose; Interstate 680, Interstate 580, and State Highway 4 in Contra Costa and Alameda Counties; and Interstate 5 in Sacramento and San Joaquin Counties.
   - Of the approximately 6,567,000 acres of land in the Estuary region, about 5,670,000 acres (86 percent) are currently (1985) devoted to agricultural and rural uses and 896,000 acres (14 percent) are in urban use.

- If the land use plans adopted by the 12 Estuary region counties were carried out, approximately 300,000 acres of existing agricultural and rural land would be converted to urban use—a 37 percent increase in urban land use in the Estuary region. Under this scenario of future land use, close to 1,228,000 acres of land would be in urban use (19 percent of total land use) and approximately 5,339,000 acres in agricultural or rural land use (81 percent of total land use).
- The population projection for the Estuary region in the year 2005 combined with a geographic model of urban growth incentives and limitations indicate that approximately 80,000 acres of existing agriculture and rural land would be converted to urban use—a nine percent increase in urban land use in the Estuary region. Under this scenario, around 976,000 acres of the Estuary region would be devoted to urban use (15 percent of total land use) and approximately 5,591,000 acres would be in agricultural or rural use (85 percent of total land use).

4. ***Land Use Change Will Produce Adverse Impacts on the Estuary***
   - As the Estuary region continues to grow, and current agricultural and rural lands are converted to urban uses, the Estuary would be adversely impacted by (1) the elimination or modification of wetlands, (2) modification of stream environments, and (3) additional pollutant loading from urban runoff.
   - Under the growth scenario based on county general plans, approximately 40,000 acres of Estuary wetlands would be eliminated, modified, or in some way adversely impacted, while under the scenario of growth based on modeled incentives and limitations, approximately 3,500 acres of wetlands would be eliminated, modified, or adversely impacted. Adverse impacts to wetlands include, but are not limited to: dredging and filling, removing vegetation, altering local hydrology through diversion of tributary waters, increasing sedimentation, degrading water quality through increased pollutant carrying urban runoff, and disruption of wildlife breeding through increased human activities.
   - Of the approximately 380,000 acres of stream environments in the Estuary region, under the scenario of growth based on county general plans, approximately 28,000 acres (seven percent) of Estuary stream environments would be eliminated, modified, or in some way adversely impacted. Under the scenario of growth Based on modeled incentives and limitations, approximately 10,500 acres (three percent) of Estuary stream environments would be eliminated, modified, or adversely impacted. Adverse impacts to stream environments include, but are not limited to: channelizing, dredging, removing vegetation, altering local hydrology through diversion of tributary waters, increasing sedimentation, increasing potential for flooding, and disturbance of riparian aquatic life and wildlife habitat.

- Both land use scenarios indicate that substantial increases in pollutant loadings from urban runoff can be expected in all receiving water segments of the Estuary. To the extent that the environmental health of the Estuary is already stressed by pollution, increased urban runoff from additional urbanization will further exacerbate the Estuary's deteriorating health.

5. ***Current Land Use Planning, Regulation, and Management Practices Inadequately Protect the Estuary***
   - Currently, there is no Estuary region-wide enforceable land use plan, policy, or regulatory structure for management of lands that contain significant natural resources (other than San Francisco Bay). Regional goals such as protecting wetlands and stream environments have no uniform or consistent voice in law or agency regulation.
   - California General Plan law does not require local governments to protect the Estuary's natural resource system. Some counties and cities currently revising their codes are including policies which specifically address the protection of wetlands and streams, and the control of nonpoint source pollution. Presently only 16 percent of the region's jurisdictions have specific ordinances for stream and wetland protection. Many existing plans reveal no coordination with neighboring jurisdictions, and contain vague and contradictory language regarding resource protection and development. In addition, General Plan policies are often inconsistent with local jurisdictions' zoning ordinances.
   - There is need for a comprehensive, coordinated regional approach to land use planning and control in the Estuary region that protects, enhances, and restores the Estuary system—its open waters, wetlands, and stream environments—from potential adverse impacts associated with land use change and intensification.
   - Historically, pollution control programs have focused on reducing the load of chemical pollutants (e.g., nutrients, heavy metals, biochemical oxygen demand) to water bodies. Although reduction of chemical contaminants will continue to constitute a major element of pollution control efforts, water quality objectives can only be achieved if open Estuary waters, stream environment areas, and wetland habitat planning and regulation is integrated into a comprehensive Estuary management plan and regulatory scheme and restoration and enhancement strategy.

Recommendations

The existing system of land use planning, regulation, and management must be improved and strengthened to protect, enhance, and restore the environmental well-being of the Estuary. This action will require new policies, regulatory authority, management strategies, institutional arrangements and regional will. Additionally, the management system can be further improved by the timely completion of a priority research and analysis agenda.

1. ***Set Enforceable Regional Estuary Resource Protection Goals, Policies, and Controls***
   - State-wide goals for land use planning should be adopted calling for protection and restoration of wetland habitats and stream environment zones.
   - State agencies with resource management responsibility in the Estuary should establish specific goals to protect, enhance and where possible restore open Estuary waters, wetlands and stream environments.
   - Local governments and special districts should adopt policies to bring their General Plans, zoning ordinances, and resource management plans into conformance with state-wide Estuary open water, wetland habitat and stream environment protection and restoration goals.
   - Management objectives based on the best available scientific information should be developed. These objectives should include specific targets for restoration of Estuary open water, streams and wetlands and for reduction of nonpoint source pollution.
   - Any new regional agency created for the San Francisco Bay Area or the Delta Area, should include protection, enhancement, and restoration of the Estuary open water, related wetland habitats and stream environment zones among its goals and objectives.
   - To promote and protect the environmental health of the Estuary, specific, enforceable land use policies and controls should be adopted at the state, regional, and local levels that would:
     - Stabilize and begin reducing the total run-off and volume of pollutants entering the Estuary (nonpoint source control);
     - Minimize the destruction of—or adverse impacts on—wetlands and stream environments; and
     - Reduce the amount of impervious surfaces in new existing development;
     - Promote more compact, dense urban development.
2. ***Develop and Carry Out New Estuary Management Strategies***
   - The 28 receiving watersheds of the Estuary are the logical management units for improving the Estuary's health. These watersheds provide the basis for an integrated, comprehensive Estuary watershed management approach that requires creation and adoption of individual watershed plans. This approach necessarily cuts across political boundaries and allows for a systematic and comprehensive hydrologic approach to land use planning, regulation, and management.
   - The watershed plans should identify the specific management strategies (including best management practices (BMP) and best development

practices (BDP)) for: (1) eliminating or significantly reducing storm water and pollution from urban runoff; (2) wetland protection, enhancement, and restoration, and; (3) stream environment area protection, enhancement and restoration appropriate for each watershed.

a. ***Urban Runoff Control.*** Storm water and urban runoff pollution elimination or reduction programs include: (1) residential and commercial area control programs; (2) prohibition on non-storm water discharges; ((3) industrial storm water control programs; and (4) construction activity control programs. These primarily local government programs call for best management and development practices, educational and training programs, and monitoring and enforcement programs.

b. ***Wetland Protection.*** Wetland protection, enhancement, and restoration programs include: (1) delineation of wetland boundaries; (2) delineation of buffer areas around wetlands; (3) a land use plan for and regulations applicable to wetlands and buffer areas; and (4) acquisition, enhancement, and restoration programs by public, non-profit, and private institutions and organizations.

c. ***Stream Protection.*** Stream protection, enhancement, and restoration programs include: (1) delineation of stream environment areas; (2) delineation of stream channel and riparian areas along the channel; (3) development of channel and riparian area alteration performance standards; and (4) a permit system to carry out and enforce the performance standards.

3. ***Adopt Improved Institutional Arrangements.*** In preparing the Comprehensive Conservation and Management Plan (CCMP), three alternative institutional arrangements for helping to carry out the land use elements of the CCMP should be considered:

a. ***Encourage Voluntary Adoption of Stronger Land Use Controls By Local Government.*** One option for improving the existing system is to promote the voluntary adoption of new land use controls by local government. The capacity for local planning regulation, and enforcement could be strengthened, for example, by organizing technical and financial assistance from the State. The intent would be to give local government the tools to better plan for, regulate and manage natural resources within their jurisdiction. This model relies on creation of a program of local assistance, perhaps in an agency such as the Governor's Office of Planning and Research.

Creating such an arrangement requires the lowest level of effort of the three models discussed here. It is also likely to encounter the least political opposition given its deference to local authority.

However, a voluntary program has several weaknesses, as well. Our review of local protection ordinances, together with the results of many other analyses, suggests that reliance on voluntary cooperation of local governments would produce an uneven commitment to resource protection.

b. ***Create a State Agency to Manage the San Francisco Estuary.*** A second option is to create a new state-level agency charged with improving management of the Estuary. Such an agency could be given powers and duties to establish carrying capacities and thresholds for the region, against which impacts of regionally significant projects could be compared, much along the lines of the California Tahoe Regional Planning Agency. Such a San Francisco Estuary Agency could also be the institutional home for the drafting and implementation of the specific management strategies for stream protection, wetland protection, and nonpoint source pollution control.

A possible variation of this model would be to strengthen and clarify the regulatory and planning functions for existing agencies in the San Francisco Bay Area and to create a unified agency for the Delta Area.

Another variation on the model of a single centralized agency would be to create a federation of agencies, perhaps sitting on a San Francisco Estuary Management Authority. Such an interagency Authority would conduct joint hearings, coordinate preparation of EIRs and EISs, and cooperate in setting environmental targets and thresholds for the Estuary against which new programs and projects can be evaluated.

c. ***Create a State-Local Collaborative Arrangement for Planning and Management.*** An intermediate option would be to create a set of policies and planning standards for the Estuary region and delegate their implementation to local government. Under this arrangement, policies would be prepared at the state level to foster protection and restoration of wetlands and stream environments and wetland resources, and to reduce nonpoint source pollution. Local governments would then be called upon to prepare amendments to their general plans and zoning ordinances, perhaps called Local Estuarine Protection Plans. These plans would be the subject of review and cross acceptance by the state. Alternatively, plan review and certification could be accomplished by the regional agency for growth management now proposed in some of the legislation discussed earlier.

4. ***An Agenda for Applied Research and Analysis.*** Any management or regulatory system hoping to achieve success must have the capacity to continually expand the information base upon which it is founded. Identifying gaps in knowledge early on, and taking measures to fill them is an essential task in institution building. Management options should offer provisions to fill those gaps and expand the knowledge of both the natural resources being managed, and the effectiveness of various strategies for protecting them.

There are two general areas wherein further research and analysis would offer considerable returns. These include both impacts and their effects, and regulatory and institutional performance.

a. ***Research and Analysis on the Impacts of Land Use Change.*** Continued efforts to describe land use change and understand its impacts and effects on the Estuary can only improve upon the efforts made to date. The natural resource inventories upon which the analysis in this report was based, could be improved. For one, the inventories are silent on the condition of the resources they quantify. Additionally, the National Wetlands Inventory should be completed for the Estuary in order to provide a more accurate sense of the wetland areas at risk to urbanization.

There is still considerable debate over what is in fact the most appropriate configuration or pattern of land use in a region like the Estuary. Future research should seek to clarify the relative impacts of dispersed and concentrated development patterns on wetlands, streams, and pollution loading. Efforts to determine the meaningful limits to growth—the carrying capacity—in the region must be undertaken as well.

Determining the Estuary's carrying capacity to a level that will also protect the Estuary from further degradation will require more complete and accurate scientific information. As this information is developed it must be integrated with the decision-making process through well established channels. For example, with greater attention now being paid to controlling nonpoint source pollution, it is hoped that an understanding of the routing and fate of pollutants generated by different land uses will be reached. As this gap in knowledge is filled, it must inform decisions about where to locate different land uses and where to reinforce control strategies.

b. ***Research and Analysis of Regulatory Institution Performance.*** The performance of existing regulatory and other governmental agencies throughout the region has only been partially assessed in this report. There remain many unanswered questions regarding the effectiveness of these agencies' efforts to manage the resources of the Estuary. In particular, no evaluation of permit compliance has been performed for the myriad permitting agencies at the federal, state and local levels of government. Additionally, the success of various best management practices for stream and wetlands protection, and nonpoint source pollution control employed in some jurisdictions, has not been assessed. The effectiveness of currently mandated, yet-to-be implemented, control measures for nonpoint source pollution, is an area in which information will contribute significantly to managing the Bay's water quality.

Mitigation, where it occurs, often is not followed-up on to insure its success. Often the concluding phase of the permit process, mitigation appears to occur on a sporadic basis, but no full-scale study has been done to verify the success of mitigation requirements.

These points illustrate the importance of continuing to probe the areas of research this report is concerned with. Obviously the management system which evolves to protect the Estuary will have to accommodate other subjects and fields of study wherein our knowledge is incomplete. Thus the agenda for applied research and analysis is an important component of resource management and should be developed concurrently with institutions and implementation strategies.

c. ***Examine Impacts on Local Government of Additional Responsibilities to Protect the Estuary.*** The financial, administrative, and personnel required to provide further protection to the Estuary by local government needs to be analyzed and quantified. Many of the costs and responsibilities for improved protection, enhancement, and restoration of the Estuary will fall on the shoulders of local government.

5. ***Identify Vehicles for Implementation.*** Estuary managers will need to move quickly to ensure that resource protection goals are incorporated in pending federal and state legislation. Realistically, this may require action concurrent with the final drafting and ratification of the CCMP. There are several vehicles for creating improved management strategies and institutional arrangements. The options outlined above will require that new legislation be enacted to articulate clear policies and provide the necessary authority and funds to better manage the Estuary. Two clear opportunities are the pending reauthorization of the federal Clean Water Act and the current efforts to enact state growth management legislation, which most likely will come to a vote in 1992. It is timely for Estuary managers to begin developing specific proposals to be incorporated in this legislation at the federal and state level.

APPENDIX A

San Francisco Estuary Project Land Use Subcommittee Goals Concerning the Effect of Land Use Change and Intensification on the San Francisco Estuary

The population of the 12-county San Francisco Bay-Delta region is projected to increase by over one million people during the next two decades. The challenge to the residents of this region is to find jobs and housing for many more people while minimizing the potentially adverse consequences of this population growth on the Estuary's aquatic, biological, and other natural resources.

There is a direct interconnection among the concerns for environmental protection, economic development, housing requirements, preservation of agricultural and open space lands, transportation and commuter patterns, and the quality of life. Without better recognition of our interdependencies in managing existing and future land use patterns around the San Francisco Estuary, we are likely to be faced with continued uncertainty in the future and increased conflicts among these issues.

We must continually strive to protect, enhance, restore, and maintain the San Francisco Estuary—its open waters, adjacent wetlands, and tributary waterways—as a healthy, ecologically diverse, and productive ecological system essential to the environmental and economic well-being of the Estuary region. This requires that land use planning decisions and management principles be based on regionally-sensitive environmental and economic strategies which provide for the proper stewardship of the Estuary's natural resources and its water quality.

The effort of the San Francisco Estuary Project should be to plan and develop management actions that increase the beneficial aspects of land use change and lessen the adverse effects of urban expansion and intensification on the Estuary. Such actions should focus on a balanced and prudent land management system that accommodates both growth and environmental protection, and where possible, restores our natural resources, thus offering the residents of the Estuary region a safe, healthy, and prosperous environment in which to live. Because the San Francisco Estuary is an irreplaceable resource of national as well as regional importance and benefit, the responsibility and cost of its protection, enhancement, and restoration should be shared at the local, regional, state, and federal level.

The San Francisco Estuary Project Land Use Subcommittee recommends the following goals and actions to address the effects of land use change and intensification on the San Francisco Estuary:

Goals

In order to improve and protect the health of the San Francisco Estuary:

- Coordinate and improve the planning, regulatory and development programs of local, regional, state and federal agencies.
- Establish concomitant land use and transportation patterns and practices.
- Achieve broad-based public awareness of the interrelationship of human activities—including land use and transportation—and impacts on the ecosystem of the Estuary and its watershed.
- Control and reduce the pollutants in runoff.
- Achieve more active participation by the private sector in cooperative efforts to accomplish Estuary protection and restoration goals.
- Protect, enhance, and restore the Estuary's open waters, adjacent wetlands, and tributary waterways.

Action Recommendations

Recommended actions concerning the goals follows:

1. Coordinate and improve the planning, regulatory and development programs of local, regional, state and federal agencies.
   - Promote environmentally responsible governance of the San Francisco Estuary.
   - Endorse Bay Area regional governance that protects the Estuary.
   - Support regional planning, conservation and development strategies for the Delta.
   - Support state fiscal reforms which encourage environmentally sensitive land use.
   - Advocate riparian corridor protection plans and ordinances and environmentally responsible flood control management.
2. Establish concomitant land use and transportation patterns and practices.
   - Establish urban growth boundaries within which compact, contiguous development will occur.
   - Protect open space, wildlife habitat and agricultural lands.
   - Endorse transportation and land use decisions which are supportive of each other and consistent with pollution reduction objectives.
   - Endorse an environmentally responsible port management strategy.
   - Promote sustainable agricultural policies and practices that will support a strong regional agricultural economy.
3. Achieve broad-based public awareness of the interrelationship between human activities—including land use and transportation—and impacts on the ecosystem of the estuary and its watershed.
   - Implement a public education program to reach all segments of the Bay-Delta community in order to ensure the success of a campaign to restore and protect the Estuary.

- Initiate studies to determine the region's ecological carrying capacity.
- Support appropriate statewide growth management efforts which will facilitate Estuary protection.
- Identify and apportion the true economic cost of driving, and endorse efforts which reduce reliance on the automobile.
- Address population growth.

4. Control and reduce the pollutants in runoff.
   - Endorse Regional Water Quality Control Board Basin Plan policies and programs which reduce and control pollution in runoff.
   - Implement urban runoff control programs which favor source reduction over end-of-pipe controls and which include educational, regulatory and structural components.
   - Implement controls on runoff and toxic drainage from active and abandoned mines and quarries.
   - Control air emissions—especially from vehicles—which contribute to water pollution in the Estuary and its tributaries.
   - Control and reduce pollutants in agricultural runoff.
5. Create incentives for more active participation by the private sector in cooperative efforts to accomplish Estuary protection and restoration goals.
   - Research and advocate programs which will engage the private sector in Estuary restoration and protection.
   - Recommend models for programs which have succeeded in other locations and suggestions for implementation.
   - Support programs which provide recognition and awards for private sector initiatives which support Estuary protection.
   - Promote the formation of non-profit land trusts dedicated to the protection of farmland and other natural resources.
   - Promote legislation and ordinances which provide suitable liability protection for private land owners who want to encourage public access for environmentally sensitive recreation and natural history education.
   - Promote incentives for public/private partnerships.
   - Identify and resolve institutional and regulatory barriers to private sector innovations and initiatives which are consistent with Estuary protection goals.
   - Endorse incentives such as density bonuses or tax relief for environmentally responsible developments which support Estuary protection goals.

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Alameda County

Alameda County General Plan
General Plan for the Livermore-Amador Valley Planning Unit
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Livermore General Plan (March 8, 1976)
Pleasanton General Plan (April 1981)

Contra Costa County

Contra Costa County General Plan (July 31, 1989)
Contra Costa County General Plan (Draft)
Draft EIR — Contra Costa General Plan (Draft)
Antioch General Plan 1988-2000 (August 4, 1989)
Bethel Island Specific Plan and EIR
Brentwood General Plan (March 1988)
Oakley General Plan
Pittsburg General Plan (September 6, 1988)
San Ramon General Plan (September 13, 1988)

Marin County

Marin County General Plan (and housing, safety and open space elements)
Novato General Plan (November 24, 1981)

San Rafael General Plan (May 1981)
San Rafael General Plan 2000

Napa County
Napa County General Plan (July 11, 1989)
Napa (City) General Plan

Sacramento County
Sacramento County General Plan (January 19, 1988)

San Francisco City and County
San Francisco Master Plan

San Joaquin County
Lodi Draft General Plan (December 1989)
Manteca General Plan (May 1988)
San Joaquin County General Plan (and circulation and open space elements)
San Joaquin County General Plan (Draft) (June 1, 1989)
San Joaquin County Draft General Plan 2010 Volume 1: Countywide General
Plan and also Volume III: Technical Appendices (June 1, 1989)
Tracy General Plan: Plan Policies Volume I
Tracy General Plan: Volume II: Technical Supplement and Environmental Impact Report
Tracy General Plan: Environmental Impact Report Volume II, Appendix B

San Mateo County
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San Jose — Horizon 2000 — General Plan (December 1987)
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Central Solano County General Plan (Open Space Plan and Conservation Element)
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Fairfield General Plan (Land Use and Housing Elements) (September 1988)
Vacaville General Plan/Environmental Resources and Con straints (March 25, 1986)
Vallejo General Plan (January 1983)

Sonoma County
Healdsburg General Plan (August 3, 1987)
Petaluma General Plan (and Ecological Resources Element)

Rohnert Park General Plan (and amended General Plan map)
Rohnert Park General Plan (Draft)
Santa Rosa General Plan (May 1984)

Yolo County

Yolo County General Plan
Yolo County General Plan Part 1: The Plan and Reference
Environmental Impact Report, and Part 2: Description and Data

Zoning Ordinances

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Alameda County Zoning Ordinance
Dublin Zoning Ordinance and Map
Pleasanton Zoning Ordinance and Map

Contra Costa County

Contra Costa County Zoning Ordinance
Antioch Zoning Districts and Zoning Map
Brentwood Zoning Ordinance
Pittsburg Current and Proposed Zoning Ordinance and Zoning Map
San Ramon Zoning Ordinance and Map

Marin County

Marin County Zoning Ordinance and Map
Novato Zoning Ordinance and Map

Napa County

Napa County Zoning Ordinance and Zoning Map
Napa (City) Zoning Ordinance and Map

Sacramento County

Sacramento County Zoning Ordinance

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Lodi Zoning Ordinance
Manteca Zoning Ordinance
San Joaquin Zoning Ordinance and Map
Tracy Planning and Zoning

San Mateo County

San Mateo County Zoning Ordinance and Map

Santa Clara County

Gilroy Zoning Ordinance
San Jose Zoning Ordinance and Maps
Santa Clara County Zoning Ordinances

Solano County

Benicia Zoning Ordinance
Fairfield Zoning Code and Map of Zone Districts
Solano County Zoning Regulations

Vacaville Zoning Regulations and Zoning Map
Vallejo Zoning Ordinance and Map

Sonoma County
Healdsburg Zoning Ordinance
Petaluma County Zoning Ordinance and Map
Rohnert Park Zoning Code
Santa Rosa Zoning Code and Zoning Map

Yolo County
Yolo County Zoning Ordinance

LAFCO Policies

Alameda County

Marin County
Marin Local Agency Formation Commission Policy Guidelines

Solano County
Standards and Procedures for the Evaluation of Annexation Proposals Submitted to the Solano County Local Agency Forma tion Commission (May 1987).

Special Maps

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Alameda County Farmland Survey Map (State Dept. of Conservation)

Contra Costa County
Brentwood - Comparison of Agricultural Land Use (Existing and General Plan)
Brentwood Land Use Plan Map
Brentwood Sewers and Drainage Map
Brentwood Soils Map
Contra Costa County Farmland Survey Map (State Dept. of Conservation)

Marin County
Marin County Farmland Survey Map (State Department of Conservation)

Napa County
Napa County Farmland Survey Map (State Dept. of Conservation)

Sacramento County
Sacramento Farmland Survey Map (Draft) (State Dept. of Conservation)
Sacramento County General Plan Map
Sacramento County Potential Growth Study Areas Map

San Joaquin County

San Joaquin County Zoning Map
San Joaquin County 100 Year Floodplain Map

San Mateo County

San Mateo County Farmland Survey Map (partial coverage) (State Dept. of Conservation)

Santa Clara County

Santa Clara County Farmland Survey Map (State Dept. of Conservation)
Santa Clara Subvention Act Lands

Solano County

Fairfield Development Activity Map
Solano County Farmland Survey Map (State Dept. of Conservation)

Sonoma County

Lower Petaluma River Floodplain Map
Sonoma County Farmland Survey Map (State Dept. of Conservation)
Sonoma County Resources and Undeveloped Areas

Yolo County

Yolo County Farmland Survey Map (State Dept. of Conservation)
Yolo County Growth Management Study Map
Yolo County Subvention Act Lands

Related Information

Alameda County

Dublin EIR — Build-out
Livermore Growth Study
(Livermore) Critical Natural Study Area
North Livermore Study Area (in progress - not yet available)
(Pleasanton) Stone Ridge Expansion Study
(Pleasanton) Residential Development Projects
(Tri-Valley) EIR — Tri-Valley Sewer Expansion

Contra Costa County

Antioch Residential Development Project List
Brentwood Residential Development Project List
Fairfield Development Activity Map
Pittsburg General Plan EIR and Growth Study Plan
San Ramon Recommended Sphere of Influence Study
San Ramon Current Development Status Sheet

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LAFCO Policy Guidelines
Marin County Residential Development Project List

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San Joaquin County Report on Public Facilities Subject to Flooding

Santa Clara County

Preservation 2020 Task Force Final Report

Solano County

Benicia Residential Development Project List
Fairfield Subdivision Projects
Plan for the Protection of Suisun Marsh
Solano County Residential Development Project List
Vacaville Residential Development Project List
Vallejo Residential Development Project List

Sonoma County

Petaluma Residential Project Development List
Sonoma County Aggregate Resources Study
Santa Rosa Plains Endangered Plant Protection Program Report

Personal Communications

Bob Burner, Executive Director, Marin Agricultural Land Trust
Janet Diehl, California Coastal Conservancy
Elizabeth Deakin, Professor of City and Regional Planning, University of California, Berkeley
John Wade, Peninsula Open Space Trust
Maria Fernandez, The Trust for Public Land
Michael Lewis, Suisun Resource Conservation District
Neil Havlik, Solano County Land Trust
Tom Nicholson, Assistant General Manager for Planning Design and Land Stewardship, East Bay Regional Park District
Karen Paget, Executive Director, California Policy Seminar
Angelo Siracusa, President, Bay Area Council
David Hubbel, Vacaville Planning Department
Chris Monske, Senior Planner, Solano County Planning Department
Betty Croly, Alameda County Planning Department
Robert Pendoley, San Rafael Planning Department
James Derryberry, San Jose Planning Department
Kent Edens, San Jose Planning Department
Peter Detwiler, Chief Consultant, California Senate Local Government Committee
Leslie McFadden, Consultant, California Senate Local Government Committee
Todd Kaufman, Senior Researcher, California Assembly Office of Research
Steve Sanders, Principal Consultant, California Senate Office of Research
Tang Wu, California Regional Water Quality Control Board, San Francisco Bay Region