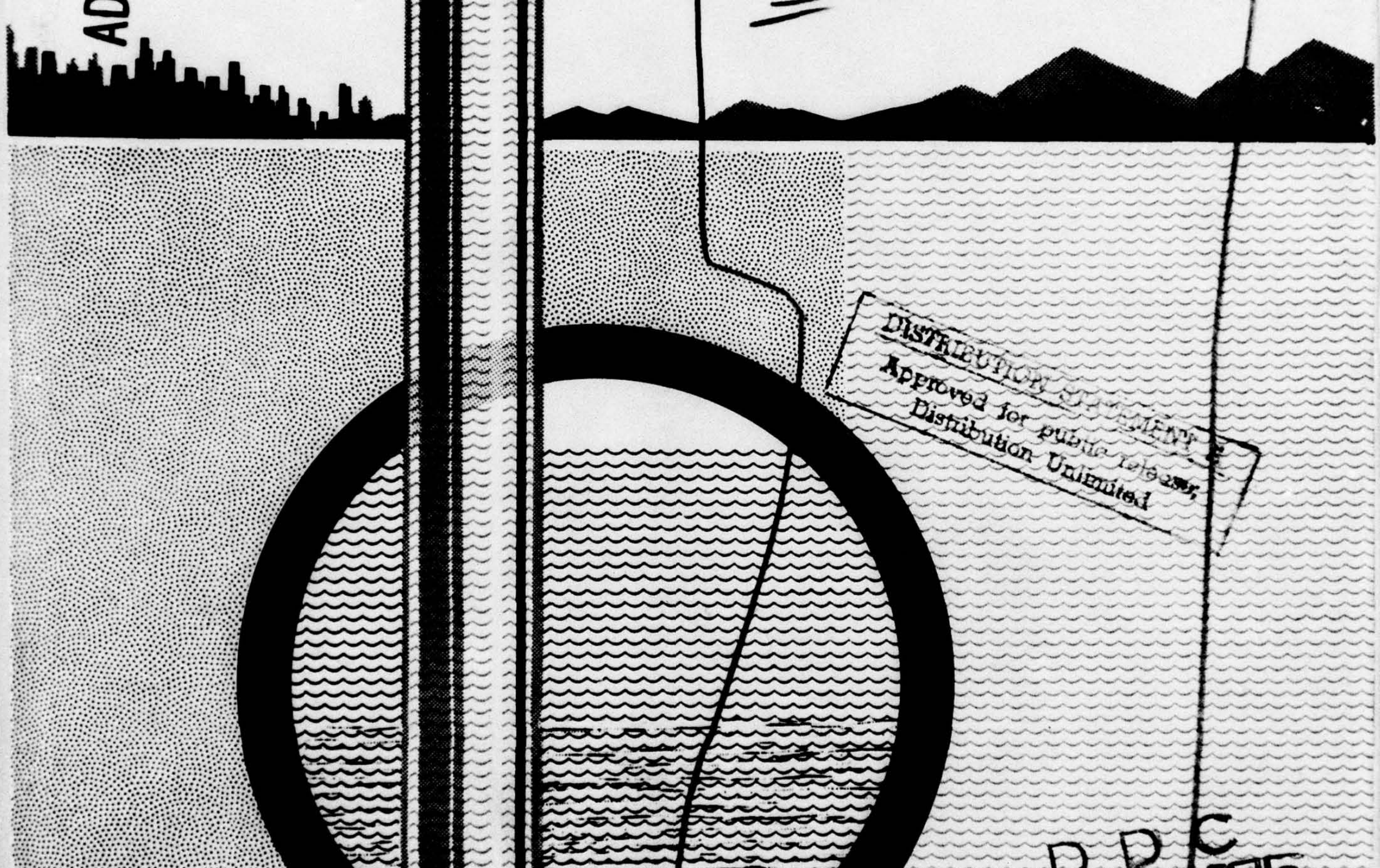
AD-A036 836 CORPS OF ENGINEERS SAN FRANCISCO CALIF SAN FRANCISCO--ETC F/G 13/2
ALTERNATIVES FOR MANAGING WASTEWATER IN THE SAN FRANCISCO BAY A--ETC(U)
JUL 71

UNCLASSIFIED NL

1 OF 2
AD A036836

(6) (1)

ALTERNATIVES FOR MANAGING WASTEWATER



(9) SUMMARY REPORT.

(11) JUL 1971

IN THE SAN FRANCISCO BAY AND SACRAMENTO-SAN JOAQUIN DELTA AREA.

(12) 101p.

391022

A FEASIBILITY STUDY

PREPARED BY THE

SAN FRANCISCO DISTRICT

OF THE

U.S. ARMY CORPS OF ENGINEERS, S.F. Calif

IN COOPERATION WITH

REGION IX

391022

S/C

OF THE ENVIRONMENTAL PROTECTION AGENCY

AND IN COORDINATION WITH

THE STATE OF CALIFORNIA

391022

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

APPENDICES

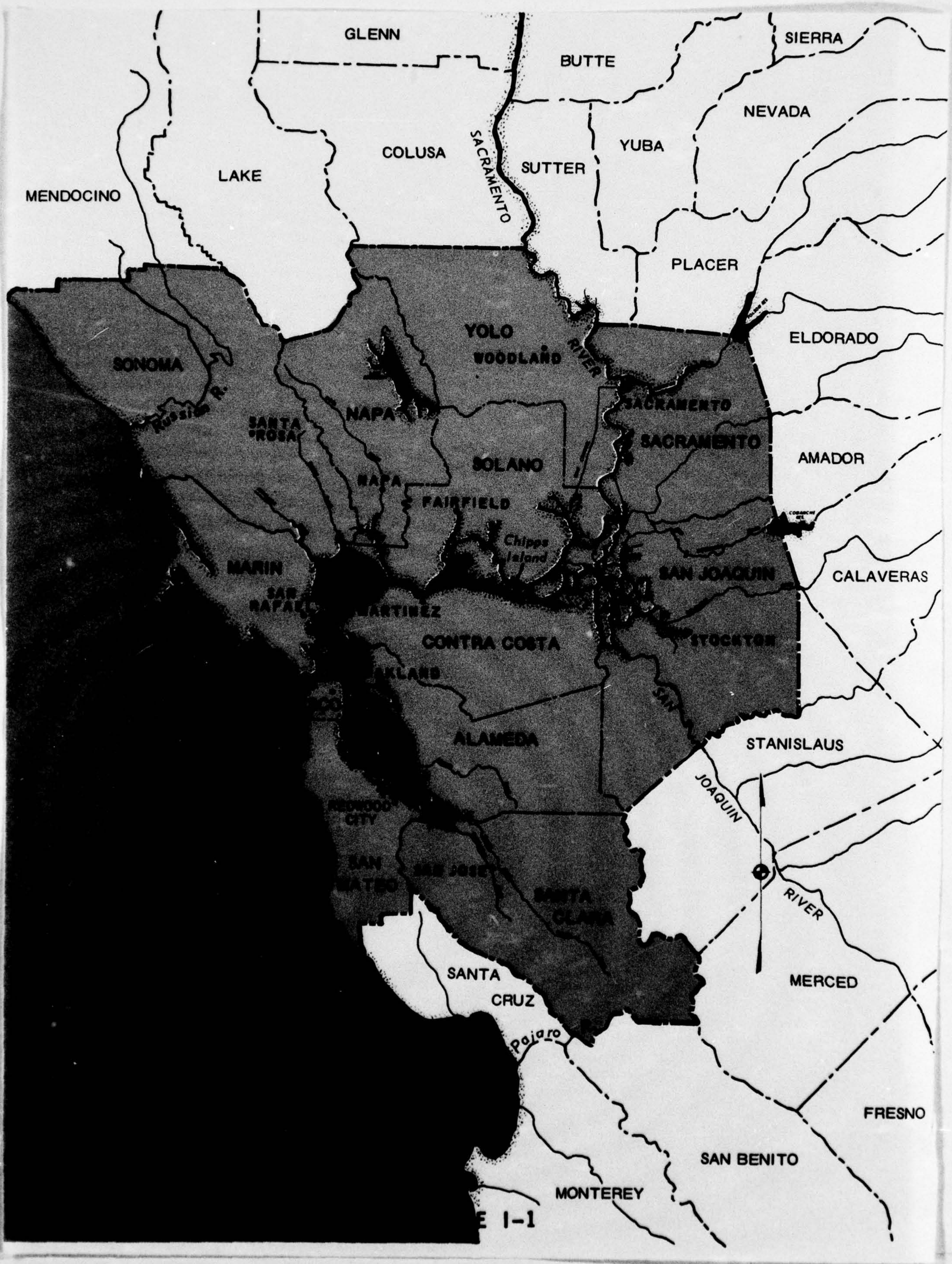
TABLES

TABLE OF CONTENTS (Cont'd)

TABLES

TABLE OF CONTENTS (Cont'd)

FIGURES


GLENN
BUTTE
SIERRA
NEVADA
COLUSA
SACRAMENTO
YUBA
SUTTER
LAKE
MENDOCINO
PLACER
YOLO
WOODLAND
RIVER
ELDORADO
SONOMA
Russian R.
SANTA ROSA
NAPA
SACRAMENTO
SACRAMENTO
AMADOR
SOLANO
NAPA
FAIRFIELD
Chipps Island
MARIN
SAN JOAQUIN
CALAVERAS
SAN RAFAEL
MARTINEZ
CONTRA COSTA
STOCKTON
ALAMEDA
STANISLAUS
JOAQUIN
REDWOOD CITY
SAN MATEO
SAN JOSE
SANTA CLARA
RIVER
MERCED
SANTA CRUZ
Pajaro
FRESNO
SAN BENITO
MONTEREY

E 1-1

CHAPTER I

INTRODUCTION

1. NEED FOR STUDY

San Francisco Bay and the Sacramento-San Joaquin Delta comprise one of California's great natural resources. The connecting Bay-Delta estuarine system has a single opening to the Pacific Ocean at the Golden Gate (Figure I-1) for a tributary area encompassing about 50,000 square miles, or one-third of the State of California. The eastern portion of the tributary area consists of the Central Valley (Sacramento and San Joaquin River basins) and the western portion comprises drainage areas surrounding the San Francisco Bay system (Figure I-2). The Delta provides the connecting link between the Central Valley and the Bay Area in many aspects; i.e., hydrologically and environmentally, as well as in social configuration and economic development. The Central Valley has a population of about three million with over six million acres of irrigated and 500,000 acres of urban land.

Estuarine ecology, economic development patterns, social configurations and environmental opportunities indicate that the three Central Valley counties of Sacramento, Yolo and San Joaquin in the Delta should be considered in combination with the nine Bay Area counties of San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Marin, Sonoma, Solano, and Napa when evaluating wastewater management. The remainder of the Central Valley influences wastewater management in the 12-county Bay-Delta area primarily through furnishing major flows and pollutant loads therein. In 1970, over five million people lived in the 12 counties. Because of natural harbors and connecting waterways, varying climate, attractive topography and numerous economic potentials, the population of the Bay-Delta area is expected by most authorities and agencies to increase to 12 million or more by the year 2020.

More than 100 years ago, centralized communities began forming in the 12-county area, the most notable being San Francisco and Sacramento. Since that time the San Francisco Bay and Delta estuarine system has served as a receptacle for municipal, industrial and agricultural wastewaters. Relatively recent man-made diversions of water from Central Valley headwaters for municipal and agricultural purposes have reduced the flow of fresh water through the Delta and into the Bay. Current plans by all levels of government call for additional diversions.

The growth of population and industry in the Bay-Delta region has been accompanied by a general degradation in water quality and an impairment in some of the beneficial uses of the Bay and Delta waters. Some of the historical events that have figured in the deterioration of the area's waters are summarized in Figure I-3. The existing degraded condition and the prospect of further degradation due to anticipated future growth have led to deep concern on the part of many citizens in the region and all levels of government.

The State of California has recognized the dangers of water pollution in the Bay-Delta region and has taken legislative action to curb pollution. This action has been essentially centered around water quality standards based on beneficial uses of water and the planning, implementation and enforcement actions necessary to maintain these standards. To satisfy the requirements for water quality planning in the State's Porter-Cologne Act of 1969, as well as Federal planning requirements outlined in Federal Water Pollution Control Regulations of 1970, the State formulated Interim Basin Plans for water quality control measures to be executed over the period 1971-1975 and scheduled preparation of Fully Developed Basin Plans. The interim plans were adopted by the State in July 1971; fully developed plans are to be prepared by July 1973. State and local agencies, with Federal assistance, have expended about $500 million for wastewater facilities. The California State Water Resources Control Board estimates that there is a need to spend about $1 billion more in the region in the immediate future for municipal wastewater facilities. This estimate is based on the Interim Basin Plans developed for the Bay-Delta region.

The magnitude of the problem of wastewater treatment and disposal, the public's increasing demand for maintaining high water quality consistent with environmental objectives, and the high costs of meeting these demands, make it necessary to consider the broader view of total water management when investigating wastewater management. To efficiently apply available and new techniques to the region's existing and future water quality problems requires coordination of water pollution control efforts in all phases of water management. These reasons and the great resource value of the San Francisco Bay and Delta clearly indicate the need for a study of regional wastewater management within a framework of total water management.

2. OBJECTIVES OF STUDY

The objectives of this feaibility study are to consider the problem of regional wastewater management; to investigate the opportunity offered by regional wastewater management to enhance the field of total water management; and to explore the need for a subsequent more detailed study of the problem. These objectives require consideration of the following specific subjects:

a. To identify the present and future wastewater problems of the region.

b. To examine broad strategies available for solving these problems.

c. To establish the general feasibility of alternative methods to improve wastewater management, and in the process to examine the effects and impacts of each alternative.

d. To identify the opportunities for integrating wastewater management with total water management.

In the process of investigating specific subjects, thorough consideration is given to:

a. Assuring, with an acceptable level of certainty, that plans to meet water quality standards will achieve instream goals, and that water quality standards will be maintained or improved.

b. Maximizing the cost effectiveness and utilization of available funds (Federal, State and local) for proposed pollution abatement and prevention actions, considering the environmental and social factors affected.

c. Relating investigations to other studies that are planned, underway, or completed.

d. Assuring that the economic, social, institutional, and financial advantages and constraints of the proposed wastewater management alternatives, as well as the technical aspects, have been considered.

e. Taking into account, as planning premises that must be followed, the requirements and scheduled programs of regulatory actions for pollution control projects required by the Environmental Protection Agency and State regulatory agencies.

f. Incorporating the latest technological advances and methods in the alternatives considered, and predicating future actions on expected advances where feasible.

g. Coordinating State and local participation in the studies, through the Environmental Protection Agency, to insure that appropriate input of local interests and views is included.

3. PROCEDURE OF INVESTIGATION

The investigation procedure used in conducting this study was as follows:

a. The current situation was investigated in the following areas: regional definition, economic characteristics, existing water pollution problems, current pollution abatement operations and operations expected within the next five years, comparison of water quality and water quality standards, and current institutional arrangements.

b. Projected development patterns for the years 1990 and 2020 were investigated, as were potential future water quality problems, estimates of the effect of continuing present wastewater management approaches (assuming that the features of currently proposed plans will be in effect by 1975), and reasons for proposing other strategies.

c. Different variations of four basic regional wastewater management strategies - ocean disposal, estuarine disposal, land disposal, and a combination disposal concept - were developed. Each variation of a basic strategy was reviewed relative to its merits for:

- Accommodating existing institutional constraints, existing developments, and near-future planned developments
- Integrating industrial flows into municipal systems
- Technical feasibility
- Flexibility to meet existing and potential development patterns, environmental objectives, new technology, and emergency situations
- Completeness in wastewater management, and opportunities for integration into total water management.

Review of the merits resulted in the selection of four alternatives, each representing one of the basic strategies.

d. Each of the four alternatives was studied in sufficient detail, based on available data and information, to permit


CENTRAL VALLEY DRAINAGE BASIN
SAN FRANCISCO BAY
& DELTA AREA
SISKIYOU
TRINITY
HUMBOLDT
LASSEN
MENDOCINO
YOLO
SAN FRANCISCO
SANTA CRUZ
MONO
INYO
MONTEREY
CALIFORNIA
SAN LUIS OBISPO
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO

FIGURE I-2

HISTORICAL SUMMARY BAY-L
FISH — WILDLIFE — WATE

SPECIES \ EVENT	GOLD RUSH	DELTA RECLAMATION	OIL INDUSTRY	
STRIPED BASS	1879: INTRODUCED INTO BAY-DELTA FROM NEW JERSEY	1908: PEAK COMMERCIAL CATCH 1.8 MILLION LBS.		1935: S COMME FOR BA
KING SALMON	1880: COMMERCIAL CATCH 10 MILLION LBS.		1926-1943: AVERAGE COMMERCIAL CATCH 1.0 MILLION LBS./YEAR	
OYSTERS	1851: FIRST COMMERCIAL OYSTER BEDS IN SOUTH BAY	1899: 2.7 MILLION LBS. OF OYSTER MEAT HARVESTED FROM S.F. BAY	1939: 1,450 LBS. O OYSTER MEAT HA FROM S.F BAY	
MARKET CRAB		1898: CRAB FISHING MOVES FROM THE BAY TO THE OCEAN	1915-1920: AVERAGE COMMERCIAL CATCH 1.3 MILLION LBS.	1 E 5 (
WATERFOWL		1895-1896: 250 THOUSAND WILD DUCKS SOLD ON CALIFORNIA MARKETS	1915: STATE PROHIBITS "MARKET HUNTING" IN CALIFORNIA	1935: W MANAGE WITH D OF "FL
FURBEARERS	1870: FUR SEALS AND SEA OTTERS ELIMINATED FROM THE S.F. BAY AREA		1928: 600 LICENSED TRAPPERS IN THE BAY-DELTA AREA	
WATER QUALITY	HEAVY SILT AND MERCURY LOADINGS	FLUCTUATING FRESH WATER FLOWS (SALINITY INCURSION & SILT LOADINGS)	DISCHARGE OF PHENOLS, SULFIDES, COD[2], BOD[3] WASTES AND HEATED WATER (ACUTE TOXICITY)	F I T (

REMARKS:

GOLD RUSH: 1845-1860 HYDRAULIC MINING

DELTA RECLAMATION: 1895-1910 LEVEE BUILDING, WATER DIVERSION, CHANGE TO AGRICULTURAL USE

OIL INDUSTRY: 1920-1943- START OF LARGE SCALE INDUSTRIALIZATION AND URBANIZATION

SHASTA DAM: BEGINNING OF CENTRAL VALLEY WATER PROJECTS

TODAY. 1960-1970

1/ CALIFORNIA DEPARTMENT OF FISH & G

2/ COD: CHEMICAL OXYGEN DEMAND

3/ BOD: BIOCHEMICAL OXYGEN DEMAND

4/ TDS TOTAL DISOLVED SOLIDS

5/ RELATIVE TOXICITY: $\frac{\text{WASTE FLOW}}{TLM_{48}}$

6/ BIOSTIMULATION: UNDESIREABLE GROWTH OF ALGAE

TORICAL SUMMARY BAY-DELTA REGION
FISH — WILDLIFE — WATER QUALITY

AMATION	OIL INDUSTRY	SHASTA DAM	TODAY	PROJECTIONS
08: PEAK COMMERCIAL CATCH 8 MILLION LBS.	1935: STATE BANS COMMERCIAL FISHING FOR BASS		1965-1969: 110 THOUSAND BASS KILLED BY POLLUTION	2020: RECREATIONAL USE 10.7 MILLION ANGLER DAYS 1/
	1926-1943: AVERAGE COMMERCIAL CATCH 1.0 MILLION LBS./YEAR	1957: STATE BANS GILL NETTING IN SUISUN BAY	1968: ESTIMATED 1.0 MILLION ADULT SPAWNERS	2020: RECREATIONAL USE 1.9 MILLION ANGLER DAYS, COMMERCIAL CATCH 8.7 MILLION LBS. (MAX.) 1/
: 2.7 MILLION LBS. YSTER MEAT VESTED FROM S.F. BAY	1939: 1,450 LBS. OF OYSTER MEAT HARVESTED FROM S.F BAY	1956: OYSTER HARVESTING PROHIBITED IN BAY BY PUBLIC HEALTH		1980: POTENTIAL FOR 1.7 MILLION GALLONS OF SHUCKED OYSTERS WORTH $5.2 MILLION IF CONTAMINATION WERE ELIMINATED 1/
	1915-1920: AVERAGE COMMERCIAL CATCH 1.3 MILLION LBS.	1946: CRAB CATCH IN EUREKA (HUMBOLDT COUNTY) EQUALS SAN FRANCISCO'S CATCH	1965-1970: AVERAGE COMMERCIAL CATCH 0.8 MILLION LBS.	UNDER STUDY 1/
AND	1915: STATE PROHIBITS "MARKET HUNTING" IN CALIFORNIA	1935: WATERFOWL MANAGEMENT BEGINS WITH DISCOVERY OF "FLYWAYS" 1950: GRIZZLY ISL. WILDLIFE AREA ESTABLISHED	1968: ESTIMATED HALF MILLION WINTERING BIRDS	2000: RECREATIONAL USE - 270 THOUS. HUNTER DAYS. SUISUN MARSH DUCK "OUTPUT" INCREASED TO ONE MILLION 1/
	1928: 600 LICENSED TRAPPERS IN THE BAY-DELTA AREA	1950: COMMERCIAL TRAPPING OF MUSKRATS IN THE DELTA		NO PROJECTION
RESH SALINITY LOADINGS)	DISCHARGE OF PHENOLS, SULFIDES, COD[2], BOD[3] WASTES AND HEATED WATER (ACUTE TOXICITY)	REDUCED FRESH WATER INFLOWS, INCREASED NUTRIENTS, TDS[4] AND PESTICIDE LOADS (EUTROPHICATION)	600 MILLION GALLONS OF M&I WASTES DISCHARGED DAILY (RELATIVE TOXICITY[5] AND BIOSTIMULATION[6])	2020: 2,176 MILLION GAL. OF M&I WASTES DISCHARGED DAILY (IMPROVED WATER QUALITY)

1/ CALIFORNIA DEPARTMENT OF FISH & GAME

2/ COD: CHEMICAL OXYGEN DEMAND

3/ BOD: BIOCHEMICAL OXYGEN DEMAND

4/ TDS TOTAL DISOLVED SOLIDS

5/ RELATIVE TOXICITY: $\frac{\text{WASTE FLOW}}{TLM_{48}}$

6/ BIOSTIMULATION: UNDESIREABLE GROWTH OF ALGAE

2

FIGURE I-3

identification of significant major impacts. The impacts were then quantified to the extent possible.

e. Impacts in the areas of environmental quality, social well-being, national economic development, and regional development were assessed for the assumed base condition and the four alternatives.

f. The various impacts of each alternative were evaluated with reference to the other alternatives and the base condition.

g. Conclusions were developed relative to the need for a subsequent, more detailed study of regional wastewater management.

4. DEVELOPMENT OF INFORMATION

Information presented in this report reflects the maximum use of previous study efforts by Federal, State of California, regional and local agencies. Where new areas of consideration are involved, the data developed reflect the individual and/or coordinated efforts of the Corps of Engineers, the Environmental Protection Agency, the California State Water Resources Control Board, and consulting groups. Essentially, the information presented was established as follows:

a. Basic data for present, near future, and distant future configurations reflect previous study efforts by Federal, State, regional and local agencies.

b. Representative regional alternatives were developed by the Corps of Engineers in consultation with the Environmental Protection Agency and the State Water Resources Control Board. Substantial reliance was made upon previous study efforts of many agencies. The land disposal concept reflects consideration of known regional resources and configurations in combination with research into existing land disposal systems throughout the nation. Most of the latter are considered to be of research or demonstration scope relative to a regional plan.

c. A base condition was developed, reflecting the concepts outlined in State planning for the 1975 time frame. This base condition was extended to the 2020 time frame by the Corps of Engineers, solely in order to provide a basis of comparison for the regional alternatives.

d. Assessment of impacts reflects Corps of Engineers' and/or consulting group findings.

e. Evaluation of impacts reflects Corps of Engineers' efforts. In new areas of consideration, the evaluations reflect impacts developed primarily by consultants. All quantified economic and financial evaluations were developed by the Corps.

5. REPORT LIMITATIONS

The San Francisco Bay and Delta constitute an extremely complex natural estuarine system. Natural and man-made contributions to the wastewater management problem can essentially be divided into four major categories:

a. Municipal and industrial discharges, essentially reflecting waterborne waste collection, treatment, and "point" discharge.

b. Urban area runoff, which reflects the results of storm waters transporting pollutants, usually concentrated in streams or man-made facilities. The older cities of San Francisco and Sacramento have combined sanitary and storm sewer systems.

c. Agricultural and natural area drainage, both of which introduce pollutants through streamflow. Developments in recent years have been directed toward collection of agricultural drainage into controlled locations similar to municipal and industrial discharges.

d. Water quality factors considered to be categorized as "in place" by their nature. Salinity concentrations throughout the estuarine system fall into this category because they are introduced by tidal action. Man-made developments can change this situation by fresh water depletions or additions. Chemical substances in the sediments of the estuarine system, introduced both by natural and man-made events, are a second aspect of the "in place" problem. Resuspension of these materials into waterways is a potential pollution contributor.

Overall water quality management must consider that individually, or in combination, the above four categories present potential problems. Individual category impacts have been recognized and studied in varying degrees for many years. Only in recent years have the problems of sediment resuspension and combined effects been studied in the San Francisco Bay and Delta estuarine system. Study findings in other estuarine systems are not entirely applicable to the Bay and Delta.

Available information and data indicate that most water quality problems are associated with municipal and industrial discharges. Consideration of the overall objective of this report, regional wastewater management and its relationship to total water management, indicates, therefore, that a feasibility study of such discharges would provide maximum guidance for further investigations. Large individual agricultural drains could impinge significantly on total water management; however in most cases, their special considerations, such as location, quality of effluent, and quantity of discharge indicate that an incremental addition to a regional municipal and industrial system is the valid approach. Urban area runoff in the Bay and Delta system presents the same factors as agricultural drains. Sediment contributions to water quality problems are being investigated in other Federal programs. Available knowledge of sediments indicates the solution to any identified problem would be independent of a system for wastewater management.

Based on the above analysis this report covers regional management strategies for the municipal and industrial wastewater discharge category of water quality problems. The magnitude of urban area runoff is discussed in order to provide further insight into the problem of total water management. Agricultural drainage is discussed similarly.

6. COORDINATION WITH OTHER AGENCIES

From its inception, this study has been coordinated with and has had the active cooperation and participation of the Environmental Protection Agency; the study has been fully coordinated with the State Water Resources Control Board. About 300 Federal, State, regional and local agencies, interested groups and private parties were given written notification of initiation. A limited number requested and were furnished further information. During the course of the study, informational presentations were made to the State of California San Francisco Bay Conservation and Development Commission, the Association of Bay Area Governments, and sub-regional water quality study groups. The staffs of the California Regional Water Quality Control Boards with jurisdiction in the study area were contacted and given status reports.

Several major monitoring sessions on report developments and progress were held with representatives of the Environmental Protection Agency and State agencies.

The report has been transmitted to Federal, State, regional and local agencies for review and comments. Upon receipt, the formal views and comments of these agencies will be presented in an Appendix entitled, "Comments By Others."

CHAPTER II

STUDY AREA TODAY

1. DESCRIPTION AND EXTENT

The study area considered in this report is located in west-central California and consists of the San Francisco Bay and Delta estuarine system and adjacent land areas as defined by 12 counties (Figure I-1). A total area of about 10,000 square miles is involved.

Two major factors define the study area as a region for wastewater management consideration. The first is the estuarine system, which is one of the great resources of the nation, and reflects a transitive aquatic ecological system ranging from ocean water at the Golden Gate to essentially fresh water in the eastern Delta. This aquatic chain-of-life includes spawning and breeding grounds for fisheries with far-reaching effects on both ocean resources and headwaters in the tributary area. Marshland conditions are vital to a variety of wildlife, particularly the waterfowl using the Pacific Flyway. Recreation opportunities of all types are associated with the waterway system. The second major factor defining the study area is that the topography of the 12 counties provides favorable physical linkages for county-wide development and social configuration. From an institutional viewpoint, it would be both reasonable and logical to combine the county governmental entities to effect a regional system.

About 80 percent of the 12-county land area is tributary to the Bay and Delta estuarine system. Fringe portions of Marin, Sonoma, San Francisco, San Mateo and Santa Clara counties drain to the Pacific Ocean either directly or by way of streams not tributary to the Bay.

The State of California's investigation of the Central Valley and San Francisco Bay, relative to water quality management, included the same study area as selected for this report. The State study, entitled "San Francisco Bay-Delta Water Quality Control Program," was conducted by a consortium headed by the firm of Kaiser Engineers, and was completed in 1969. Substantial information presented in the present report was extracted from the Bay-Delta Program Report. 1/

2. SAN FRANCISCO BAY SYSTEM

The San Francisco Bay system, consisting of San Francisco Bay proper, San Pablo Bay, Carquinez Strait and Suisun Bay, extends from the Golden Gate north about 30 miles and then east for about 20 miles to Pittsburg, and south about 40 miles to the vicinity of San Jose (Figure II-1). The Bay's only connection with the ocean is through the Golden Gate. The San Francisco Bay drainage basin, as distinguished from the overall tributary area to the Bay, totals some 4,000 square miles, of which 425 square miles are the Bay's water surface at mean high water. The Bay's shore line is about 275 miles long at mean high water and contains substantial marshland areas. Prior to man's reclamation of the Bay's marshlands and water areas for residential, agricultural, port and industrial purposes, San Francisco Bay covered an area of about 700 square miles.

Approximately 300 miles of navigation channels have been dredged in the Bay-Delta estuary. Spoil from the initial dredging and from some of the subsequent maintenance dredging was used for reclamation of the Bay shoreline. Maintenance dredging of the existing navigation channels amounts to about eight million cubic yards annually. Spoil from maintenance dredging is redeposited in various parts of the Bay.

For purposes of later discussion, the San Francisco Bay system was divided into four hydrographic units, namely: the Golden Gate, Central Bay, North Bay and South Bay. The Golden Gate, as now generally defined, extends easterly from a line joining Point Bonita and Point Lobos, to the Golden Gate Bridge. Central Bay lies east of the Golden Gate Bridge, south of the Richmond–San Rafael Bridge and north of the Oakland-San Francisco Bay Bridge. South Bay is that part of San Francisco Bay proper lying south of the Oakland-San Francisco Bay Bridge. North Bay extends north and east from the Richmond-San Rafael Bridge and includes San Pablo Bay, Carquinez Strait and Suisun Bay.

3. THE DELTA

The Sacramento-San Joaquin Delta is a roughly triangular region of some 1,100 square miles lying to the east of Chipps Island, near Pittsburg. The Delta is shown in Figure II-2. All waters orginating in the Central Valley, except those in the Tulare Lake basin, drain through the Delta to San Francisco Bay and thence to the Pacific Ocean. The Delta waterways, about 700 miles of meandering channels with a surface area of about 80 square miles, are subject to tidal action originating at the Golden Gate. Interspaced are more than 50 reclaimed islands, known as the Delta lowlands, with a total area of 700 square miles, or about 60

1/ Mention hereafter of the "Bay-Delta Program" refers to this 1969 report by Kaiser Engineers to the State of California.

percent of the total Delta area. These islands, enclosed by levees, lie from five feet above to more than 20 feet below mean sea level. The Delta is mainly an agricultural area but its waterways are intensively used for fishing, boating and water skiing. Separate deep-water navigation channels extend from Pittsburg to Sacramento and to Stockton.

As previously mentioned, the Central Valley drains into the Delta. The Central Valley can be divided into the Sacramento River sub-basin to the north of the Delta and the San Joaquin River sub-basin to the south. The Sacramento River sub-basin is about 25,000 square miles in area and the San Joaquin sub-basin (excluding Tulare Lake basin) is some 19,000 square miles.

4. OCEAN AREA SEAWARD OF SAN FRANCISCO BAY

The Pacific Ocean area seaward of the Golden Gate consists of a broad continental shelf. As defined by the 600-foot depth contour, the shelf is about 30 statute miles wide with a slope of about 23 feet per mile. The Farallon Islands are located near the seaward limits of the shelf. The shelf gradually decreases in width north and south of the Farallons. Located on the shelf about eight miles from the Golden Gate Bridge is a semi-circular bar with depths of 36 feet or less. The bar has been improved for deep-draft navigation by means of a channel dredged to a 50-foot depth, with an authorized depth of 55 feet.

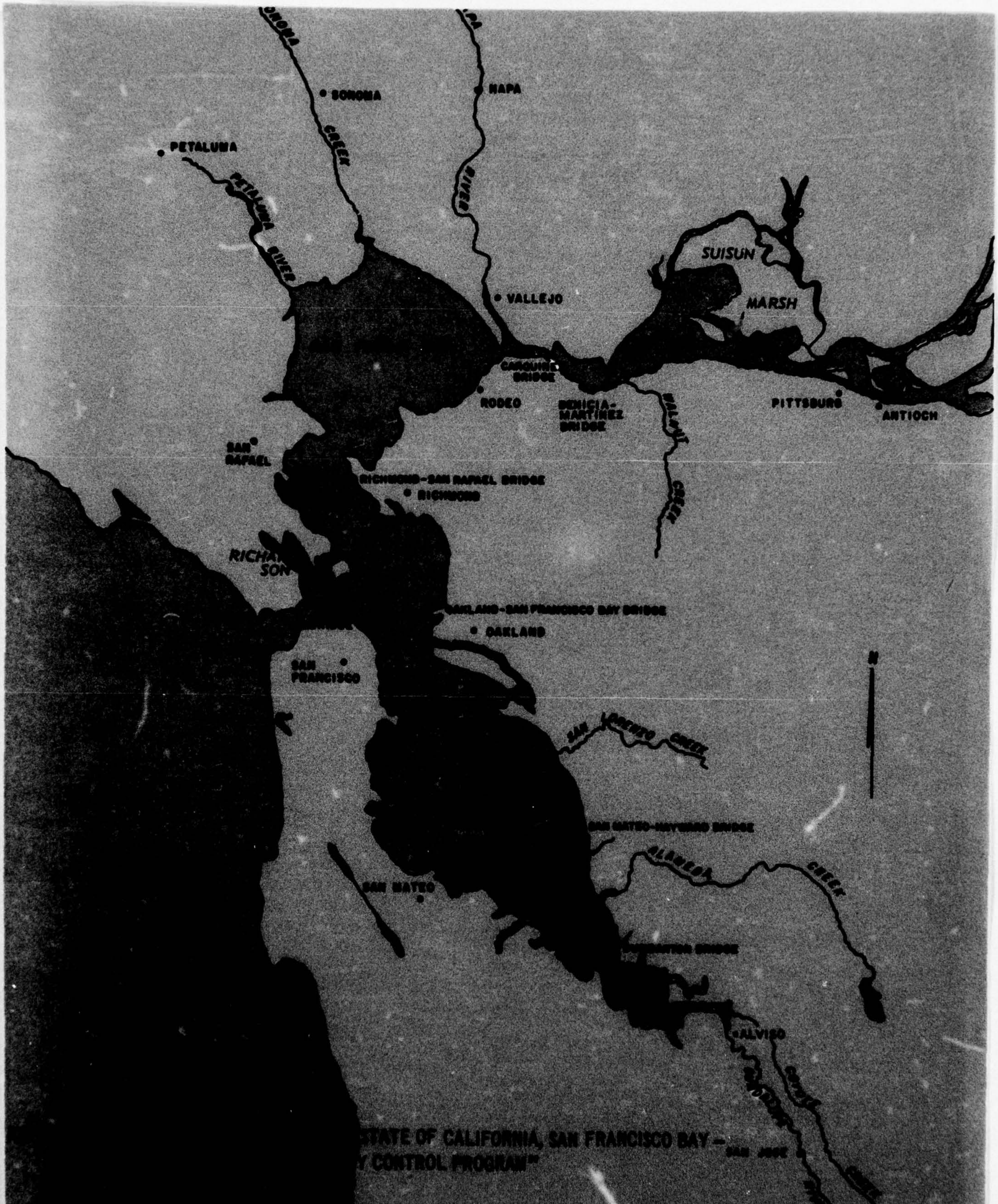
5. GEOLOGY

a. **General**. The 12-county area encompasses parts of two geomorphic provinces of California, the Coast Ranges and the Great Valley. Each province is characterized by distinctive natural topographical and geological features. The Coast Ranges comprise a series of nearly parallel mountain ranges and valleys that trend in a northwesterly direction and rise to elevations of over 4,000 feet. This trend is largely controlled by the geologic structure in the underlying rocks, which is dominated by the active San Andreas Fault system running nearly the full length of the Coast Ranges. In contrast, the Great Valley consists of a central, comparatively flat alluvial plain, about 400 miles long and 50 miles wide, lying between the Coast Ranges and the Sierra Nevada range to the east. Elevations in the Great Valley, with few exceptions, range from sea level to 100 feet. The valley is drained by the Sacramento and San Joaquin Rivers, which join in the Delta area before entering San Francisco Bay. The southermost part of the Great Valley, the Tulare Lake basin, is an interior drainage basin with no direct drainage to the sea. It is separated from the San Joaquin basin by a very low divide.

The rocks of the Coast Ranges are predominantly consolidated marine sedimentary and volcanic rocks. Unconsolidated marine sediments and alluvial deposits are also present in the valley floor and in San Francisco Bay. Consolidated rocks in the Great Valley province are also present, but lie at depths below thick accumulations of unconsolidated alluvial deposits. Common to all of the alternative wastewater management systems are the active San Andreas Fault system and the weak, compressible, unconsolidated sediments of San Francisco Bay and the Delta area.

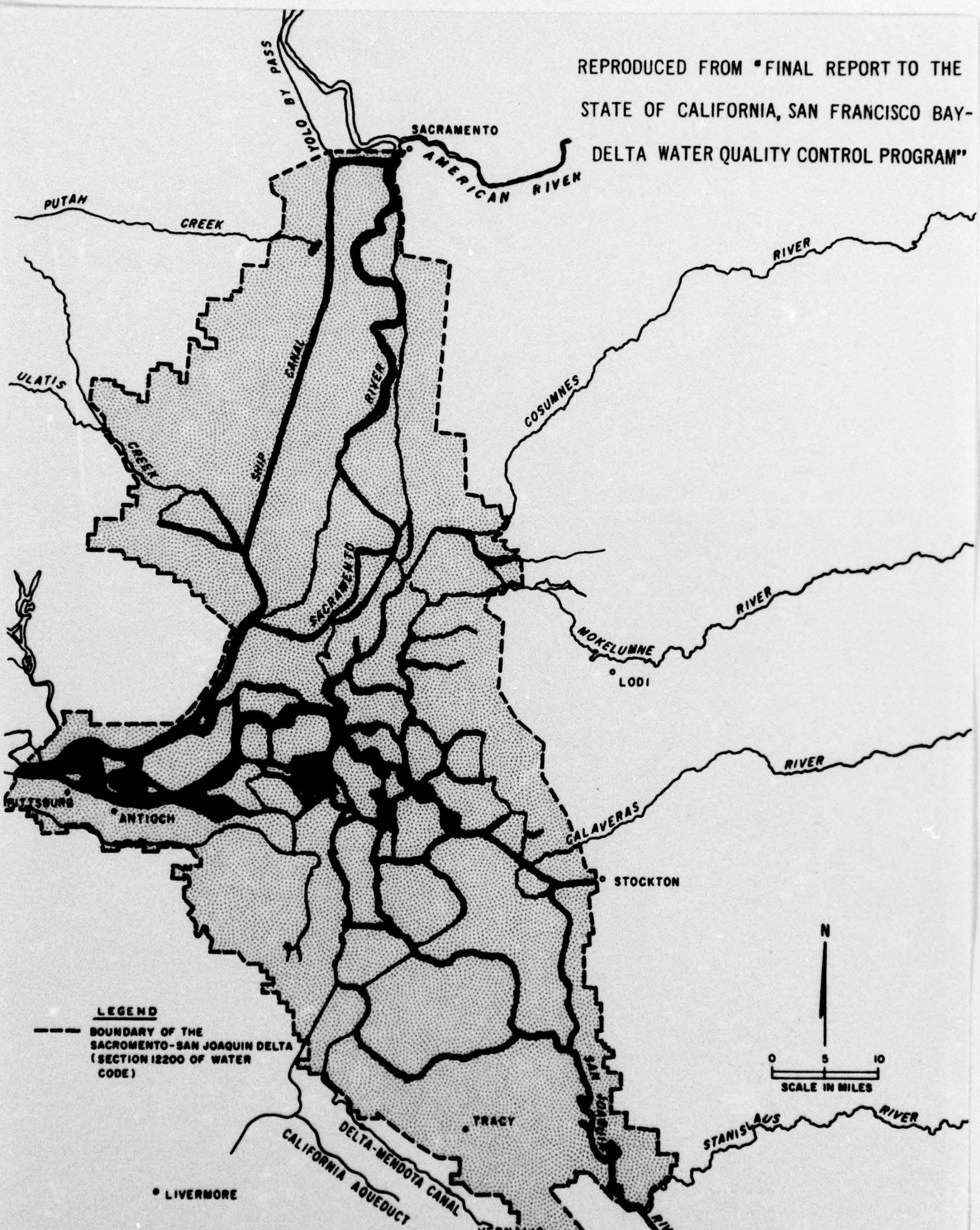
b. **San Francisco Bay and Delta Area**. The geologic history of the Bay Area is characterized by a long record of extensive earth movements and seismic activity, complicated by substantial changes in sea level during comparatively recent geologic time. The structural trough in which the Bay is located came into existence at the end of the Pliocene epoch or early in the Pleistocene, about three million years ago. Throughout Pleistocene time the trough was being filled with sediments. During the interglacial stages of late Pleistocene time, the trough was flooded by the general rise in sea level resulting from the release of melt water from retreating glaciers in other parts of the world. The Bay as we know it today was inundated as little as 15,000 years ago. A thick layer of very soft silty clay, known locally as "Bay Mud," was deposited during and after the melting of the continental glaciers. The Sacramento-San Joaquin Delta area at the head of the Bay responded likewise to the changes in sea level and is composed of similar materials, except for the presence of thick layers of peat.

c. **Seismic Activity**. The 12-county region is located in a well-known active seismic area. Historically, the reason for the high seismicity is the presence of three major fault zones: the San Andreas fault west of the Bay, the Hayward fault at the base of the Berkeley Hills along the east side of the Bay, and the Calaveras fault on the east side of the Berkeley Hills. All are active and are considered part of the San Andreas Fault system. Figure II-3 shows the locations of these faults. An active fault is one on which surface displacement has taken place during historic time, one characterized by linear patterns of earthquake epicenters, or one on which geologically recent materials have been displaced. In general, earthquake-induced ground motion in soft or loose water-saturated materials, such as along the margins of the Bay and in the Delta area, is far more violent than in consolidated rock. Since a substantial portion of any regional wastewater treatment and conveyance system would be located on unconsolidated materials and would traverse one or more of the active faults, appropriate safety factors would have to be incorporated in the design of the structures.

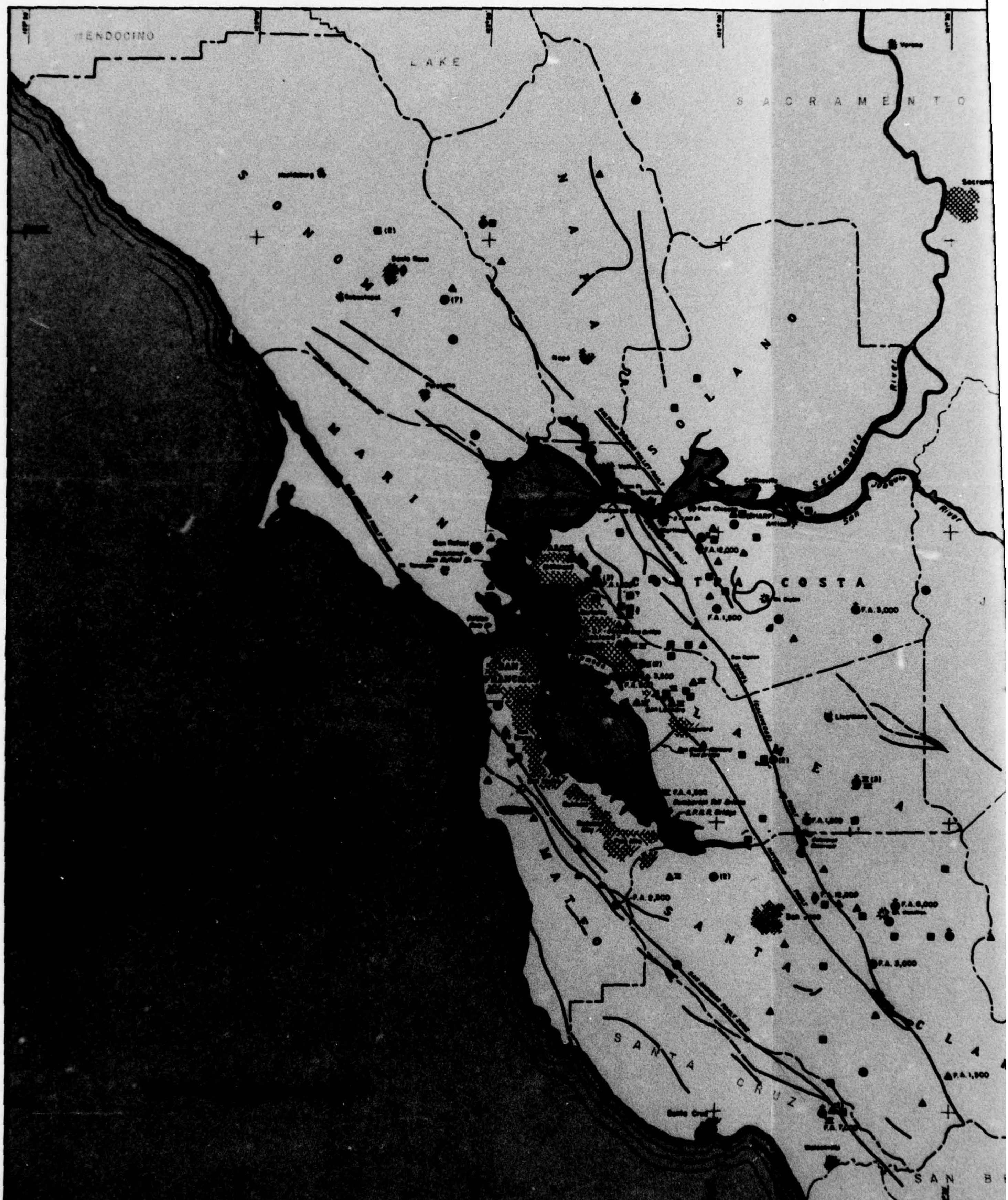


FRANCISCO BAY SYSTEM

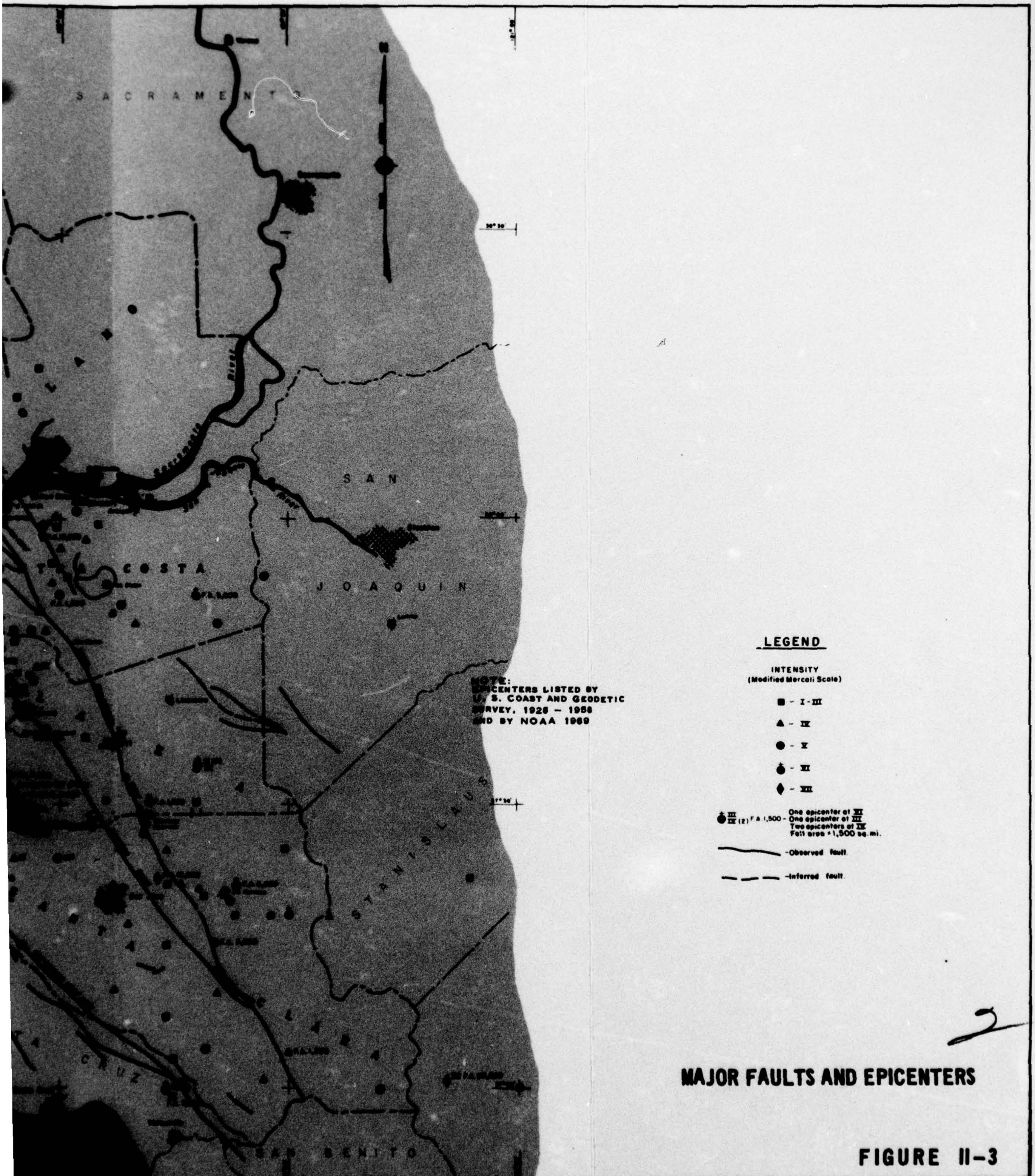
FIGURE II-1



THE SACRAMENTO-SAN JOAQUIN DELTA
FIGURE II-2



LAKE
S A C R A M E N T O
S O N O M A
N A P A
S O L A N O
M A R I N
C O N T R A C O S T A
A L A M E D A
S A N M A T E O
S A N T A C L A R A
S A N T A C R U Z
River
Sacramento
San Joaquin
River
F.A. 3,000
F.A. 1,500
Livermore
F.A. 3,000
F.A. 1,500
S A N B



MAJOR FAULTS AND EPICENTERS

FIGURE II-3

6. HYDROLOGY

The Sacramento and San Joaquin River basins (including Tulare Lake basin) drain about one-third of the area of California. The two rivers are the principal source of fresh water and are the primary means by which agricultural wastewaters are carried from the Central Valley. Prior to any development by man in the Central Valley, the natural outflow through the Delta, in a normal water year, was about 30 million acre-feet (see Figure II-4). Because of water use within the Central Valley and net exports from its basin, the present average Delta outflow is about 18 million acre-feet per year. As water use in the Central Valley increases and exports from the basin grow, it is estimated that the net Delta outflow will be as low as seven million acre-feet in year 2020. The greater part of municipal and industrial wastewaters analyzed in this report derive from fresh waters that are introduced into the 12-county area as water supply diversions from the headwater of the two river basins.

In San Francisco Bay, local streams draining into the Bay have a combined mean annual discharge of about 450,000 acre-feet. The mean normal annual precipitation over the Bay's local drainage area is 19 inches. The mean annual evaporation over the entire Bay system is about 48 inches.

The mean range of tide at the Golden Gate is about five feet. The mean tidal prism in the Bay is about 1.2 million acre-feet. The total water volume at mean high tide in the Bay system is about 5.5 million acre-feet. Thus, the mean tidal prism is about 21 percent of the total volume of water in the Bay.

TABLE II-1

1970 POPULATION OF THE 12 COUNTIES IN STUDY AREA AND THE PRINCIPAL METROPOLITAN CENTERS 1/

County	Growth 1950–1970 2/	Population	Metropolitan Center	Population
Alameda	1.45	1,073,000	Oakland	363,000
Contra Costa	1.85	553,000		
Marin	2.40	206,000		
Napa	1.70	79,000		
Sacramento	2.25	631,000	Sacramento	283,000
San Francisco	.90	716,000	San Francisco	716,000
San Joaquin	1.45	290,000	Stockton	179,000
San Mateo	2.35	556,000		
Santa Clara	3.65	1,065,000	San Jose	561,000
Solano	1.60	170,000		
Sonoma	1.95	205,000		
Yolo	2.20	92,000		
Total		5,636,000		

1/ Bureau of Census figures, to nearest thousand.

2/ California growth rate, 1950-1970, = 1.85 (Framework Study and Bureau of Census). Growth rate defined as 1970 population ÷ 1950 population.

7. ECONOMIC CHARACTERISTICS OF AREA

a. **Population**. The population of the 12-county study area has tripled over the past 40 years, with approximately 60 percent of the increase occuring in the last 20 years. The growth rate of the 12-county study area over the last 20 years has lagged slightly behind that for the entire State. However, several counties within the study area have experienced a phenomenal growth in the last 20 years (Table II-1).

b. **Urban Centers**. The present (1970) population of the study area, approximately 5.7 million, is concentrated in five counties adjacent to San Francisco Bay (San Francisco, San Mateo, Santa Clara, Alameda and Contra Costa) and in Sacramento County. The principal metropolitan centers (cities with 1970 population in excess of 150,000) in the study area are San Francisco, San Jose, Oakland, Sacramento and Stockton.

c. **Resources**. The major natural resource of the San Francisco Bay-Delta area is its continuous waterways; they have had a major role in the area's commercial and manufacturing growth. During the Gold Rush of 1849, the importance of the Bay and Delta's waterways as transportation arteries was fully established. Petroleum is a major example today. Although the amount of petroleum actually produced in the study area is relatively small, an extensive system of pipelines has been constructed to bring petroleum from the Central Valley to oil refineries located in Contra Costa County. Refined products are then distributed via the existing waterways in the Bay-Delta and the tributary rivers. Five major oil refineries are now located in the area, four in Contra Costa and one in Solano County.

Two other major resources of the study area are salt and shell lime in the form of seashells found on the bottom of San Francisco Bay proper. Salt is extracted by solar evaporation of San Francisco Bay water from leveed ponds. In 1965, about 40,000 acres of ponds produced 1¼ million tons of salt. Shell lime is used to make more than one million tons of Portland cement annually.

In addition to its role as a transportation artery, San Francisco Bay-Delta possesses an important fish and wildlife resource. Sport fishing is a major recreational use of Bay-Delta waters. San Francisco Bay is the point of entry from the Pacific Ocean for all anadromous fishes migrating into the Sacramento-San Joaquin River system. Similarly, the juvenile of the various species must all pass through the Bay-Delta waters in moving to the ocean. It is estimated that more than 70 percent of all salmon caught off the California coast spend a part of their life cycle in San Francisco Bay. Marshlands of the Bay and Delta are important also to migratory birds using the Pacific Flyway.

Since World War II, new and varied industrial and commercial enterprises have been introduced. The well-renowned universities of the area, in many instances, have provided the embryo for this development (electronics, nuclear research).

d. **Employment and Industries**. With the advent of World War II, the 12-county study area, following the trend in California as a whole, became heavily industrialized. Among the major industries represented are food processing, chemicals, paper and allied products, primary metals, steel, and petroleum. There are also several large defense installations, including two naval shipyards. At the present time approximately two million persons are employed in the study area.

Industries are essentially located on navigation waterways. Heavy concentration of industry occurs in Sacramento, Stockton, along the north shore of Contra Costa County from Antioch to Richmond, in Oakland Harbor, along the south San Francisco shoreline, in the lower Napa River near Vallejo, and in Benicia in Solano County. Petroleum, chemicals, steel, metals, and paper industries are centered in Contra Costa and Solano Counties. Food processing is centered in Sacramento, Stockton, Tracy and the vicinity of San Jose.

e. **Land Use**. Based on California Department of Water Resources published data on land use in California for 1967, about 2,800 square miles (1,810,000 acres) in the study area were classified as irrigated agricultural lands, as shown on Table II-2. A wide range of crops is grown in the study area. The principal patterns include fruit and nuts such as plums, walnuts and grapes, truck crops such as tomatoes and asparagus, field crops such as sugar beets and alfalfa, and grains such as wheat and barley.

In this same year, about 3,100 square miles of land outside the study area were under irrigation in the Central Valley. This development has an impact on the San Francisco Bay and Delta estuary as return flows of water from such activity enter the rim of the Delta through streamflows or the Bay and Delta through man-made drainage facilities.

In 1965, urban areas totalled about 1,280 square miles (816,000 acres) in the study area as shown in Table II-3.

AVERAGE YEAR DELTA OUTFLOW: NATURAL, PRESENT AND FUTURE
(HYDROLOGIC YEAR 1935 – 36)

NOTES: 1. NATURAL OUTFLOW BASED ON D W R ESTIMATE. PRESENT AND 2020 FIGURES BASED ON DATA FROM U S B R AND D W R, MARCH 1968.

2. REPRODUCED FROM "FINAL REPORT TO THE STATE OF CALIFORNIA, SAN FRANCISCO BAY – DELTA WATER QUALITY CONTROL PROGRAM."

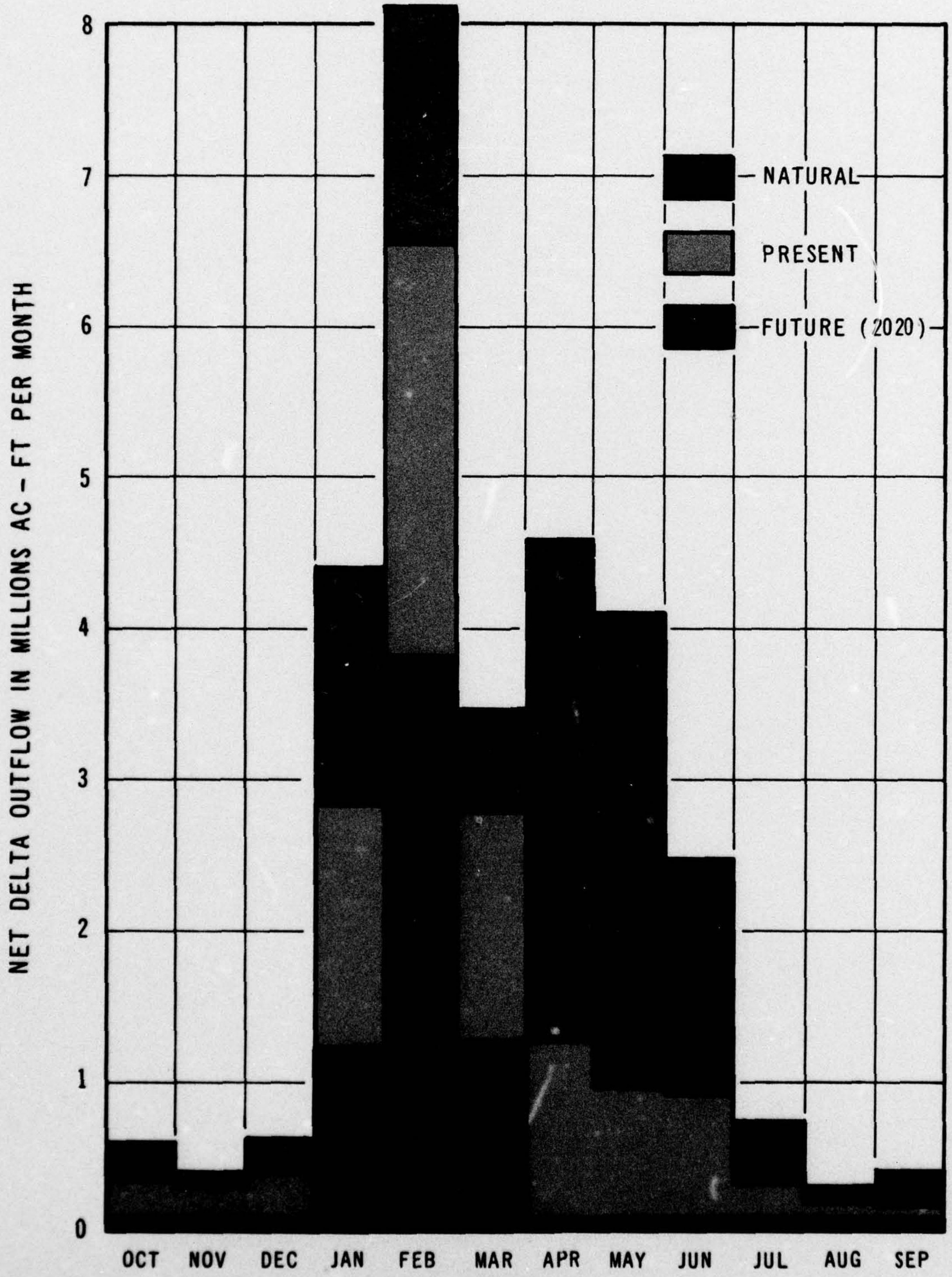


FIGURE II–4

TABLE II-2

ESTIMATED 1967 IRRIGATED LAND AREA IN THE 12 COUNTIES 1/

County	Area (Acres)
Alameda	30,000
Contra Costa	85,000
Sacramento	200,000
San Francisco	None
San Joaquin	720,000
Santa Clara	100,000
San Mateo, Marin, Napa and Sonoma	75,000
Solano	200,000
Yolo	400,000
Total	1,810,000

1/ Estimates based on land use map from Calif. Dept. of Water Resources Bulletin 160–70.

TABLE II-3

1965 URBAN LAND USE BY COUNTIES 1/
(1,000 Acres)

County	Residential	Commercial	Industrial 2/	Public	Totals
Alameda	58.2	4.5	9.7	13.8	86.2
Contra Costa	55.6	3.4	9.1	18.6	86.7
Marin	12.0	0.5	0.1	78.6	91.2
Napa	2.4	0.6	0.4	83.7	87.1
Sacramento	60.5	5.5	5.5	20.1	91.6
San Francisco	13.4	2.1	3.2	8.2	26.9
San Joaquin	18.3	2.4	4.8	8.2	33.7
San Mateo	46.1	2.2	3.8	19.3	71.4
Santa Clara	62.8	4.0	21.6	30.8	119.2
Solano	6.5	0.3	0.3	41.5	48.6
Sonoma	3.4	1.0	16.3	38.5	59.2
Yolo	6.2	1.5	2.5	4.0	14.2
Total	345.4	28.0	77.3	365.3	816.0

1/ Final Report, Bay-Delta Program.

2/ Includes wholesale trade.

8. EXISTING WATER POLLUTION PROBLEMS

Pollution loadings in the San Francisco Bay-Delta originate from several sources. Available data indicate that from a combined flow and pollution load standpoint, the "point" discharges from municipal and industrial development present the major problem. Agricultural drainage has equal flow volumes in many cases but the scope of pollutants is more limited. Substantial hydrologic information is available on urban area runoff; however, little is known about the related pollution load in the Bay and Delta system. Available information on these subjects is summarized below to permit maximum understanding of these problems. Emphasis is given to the regional municipal and industrial wastewater problem.

a. **Sub-areas.** Most of the available data were developed on a county-by-county basis. It was decided, however, that some counties could be advantageously grouped together because of their environmental, economic, demographic, or geographic similarity. Accordingly, four sub-areas were set up, as illustrated in Figure II-5. Sub-area A (San Francisco, San Mateo, Santa Clara and Alameda Counties) is well diversified and encloses the South Bay. Sub-area B (Marin, Sonoma, Napa and Solano Counties) is mainly a rural and suburban non-industrial area. Sub-area C (Contra Costa County) contains the majority of industrial development in the study area. Sub-area D (Yolo, Sacramento and San Joaquin Counties) can be considered as a separate unit because of its location. Such a grouping of counties is consistent with current planning efforts in the various subregional studies now in progress.

b. **Municipal and Industrial.** There are about 160 municipalities and sanitary districts in the study area. About 6,000 manufacturing enterprises are located in the study

TABLE II-4

1970 ESTIMATED AVERAGE ANNUAL MUNICIPAL AND INDUSTRIAL WASTEWATER FLOWS 1/
(mgd)

Sub-area	County	Municipal	Industrial	
			Process	Cooling
A	San Francisco	95		809
	San Mateo	51	2	11
	Santa Clara	106		
	Alameda	125	3	147
	Total	377	5	967
B	Marin	17		
	Napa	6	4	
	Sonoma	5		
	Solano	21		
	Total	49	4	
C	Contra Costa	53	76	2,768
D	Yolo	10		3
	Sacramento	83		
	San Joaquin	21	9	
	Total	114	9	3
12 – county total		593	94	3,738

1/ Bay–Delta Program Final Report, Tables V–6, XX–1, XX–6b; and Bay–Delta Program, Task II–4 Report, Table IV–5.


GLENN
BUTTE
SIERRA
NEVADA
COLUSA
SACRAMENTO
SUTTER
YUBA
LAKE
MENDOCINO
PLACER
YOLO
WOODLAND
RIVER
ELDORADO
SONOMA
SACRAMENTO
SACRAMENTO
NAPA
SANTA ROSA
B
SOLANO
AMADOR
NAPA
D
FAIRFIELD
MARIN
SAN JOAQUIN
CALAVERAS
SAN RAFAEL
MARTINEZ
PACIFIC
CONTRA COSTA
STOCKTON
OAKLAND
C
Golden Gate
SAN FRANCISCO
SAN
ALAMEDA
STANISLAUS
JOAQUIN
REDWOOD CITY
A
SAN MATEO
SAN JOSE
SANTA CLARA
RIVER
SANTA CRUZ
MERCED
OCEAN
SUB-AREAS
FRESNO
SAN BENITO
MONTEREY

FIGURE II–5

area, of which the vast majority are connected to municipal sewerage systems. Approximately 70 industrial dischargers are not connected. These dischargers treat and dispose of their wastewaters separately because of the special nature of their wastes, because no municipal system is nearby, or because of economic considerations. Of these 70 enterprises, the 26 most important are grouped into the following Standard Industrial Categories because of the special nature of their wastes:

Paper and Allied Products
Petroleum Refining
Chemicals
Fabricated Metals
Steel

The remainder fit into various miscellaneous categories, the largest of which is food processing.

Figure II-6 indicates the locations of all major identifiable municipal and industrial wastewater discharges in the 12-county area.

Table II-4 presents municipal and industrial flows by sub-area for 1970. The industrial process flows include only those from the cited categories. Cooling flows include all industries.

Approximately 40 percent of the municipal wastewaters receive secondary treatment, while 60 percent receive primary treatment only. (See Figure IV-1). Industrial treatment processes vary, but on the average the level of treatment is between primary and secondary. A summary of the estimated 1970 wasteloads from municipal and industrial sources discharged in the study area is shown in Table II-5.

c. **Agricultural Drainage**. California is the nation's leading agricultural state and virtually all the agriculture is based on irrigation. Numerous State and Federal water development projects have brought water from the mountains in the northern and eastern parts of the State, and by pumping from the Delta, to the farmlands of the Central Valley. More such developments are planned for the future. Water draining from the fields is carried off by the natural rivers, principally the Sacramento and the San Joaquin, usually after being conveyed by artificial canals and sloughs from the fields to the major rivers.

Agricultural waste loads are difficult to quantify, because of numerous factors, such as individual farming and irrigation practices, pesticide and fertilizer technology, local reuse, and quality of the irrigation water supply, of which they are a function. The vast majority of the agricultural waste loads entering the estuary originate in and upstream of the Delta rather than in the counties adjoining the Bay system.

The Sacramento River has a sufficiently large flow that the agricultural wastewaters discharged into it have not resulted in serious degradation of the water quality in the river. The San Joaquin River, however, has not been capable of adequately carrying off the agricultural drainage from its basin, and the San Joaquin Valley has experienced problems with salt buildup in the soil. The need for artificial drainage systems has been recognized by both the State and the U.S. Bureau of Reclamation. The USBR is now constructing the San Luis Drain, which will run along the west side of the San Joaquin Valley, collecting agricultural drainage waters, and discharge to the Delta at Antioch.

Figures on agricultural flows and loads from the area tributary to the Delta produced by the State Bay-Delta Program are shown in Table II-6, where, it will be noted, the agricultural figures are combined with those representing stream runoff. The Bay-Delta Program concluded that, although the evidence was incomplete, there was reason for serious concern over the possible biostimulatory characteristics of agricultural drainage. The feasibility of nitrogen removal from agricultural drainage water currently is being studied jointly by the California Department of Water Resources, the U.S. Bureau of Reclamation and the Environmental Protection Agency.

d. **Urban Area Runoff**. Available runoff data from streams around the Bay system and urban areas in the Delta indicate that pollution loads are not substantial relative to municipal and industrial discharges. Table II-7 shows the results of the most recent comprehensive study of the problem.

Analyses made during the Bay-Delta Program showed that oil and grease were the only serious pollutants introduced by urban storm runoff. A slight buildup of TSS (see Table II-5, abbreviations) might occur now and then in the extreme South Bay; but concentrations in the categories of BOD, TN, and TP due to runoff would be negligible for any foreseeable storm in the next 50 years.

e. **Other Sources**. The amount of pollution arising from discharges from ships and other watercraft is quantitatively very slight, less than 2,000 lbs. per day BOD in 1965, although these discharges present local objectionable concentrations.

9. CURRENT POLLUTION ABATEMENT PLANNING

a. **San Francisco Bay-Delta Water Quality Control Program**. Based on the Bay-Delta Program report, mentioned above, a comprehensive waste collection and disposal system serving the 12-county study area was considered by State and local interests. Overall recommendations were

TABLE II–5

ESTIMATED 1970 TREATED MUNICIPAL AND INDUSTRIAL WASTE LOADS
(in 1000 lbs/day except as noted)

Parameter or Constituent	Sub–area A			Sub–area B			Sub–area C			Sub–area D			12–County Total		
	M	I	Total	M	I	Total	M	I	Total	M	I	Total	M	I	Total
Flow (mgd)	377	5	382	49	4	53	53	76	129	114	9	123	593	94	687
BOD	669	3	672	41	*1	41	90	106	196	140	6	146	940	115	1055
TN	296	*1	296	19	*1	19	28	89	117	61	*1	61	404	89	493
TP	54	2	56	2	*1	2	5	1	6	11	*1	11	72	3	75
TDS 1/	1690	NA	NA	153	NA	NA	165	NA	NA	423	NA	NA	2431	NA	NA
TSS	221	5	226	14	*1	14	25	13	38	49	3	52	309	21	330
Oil & Grease	60	*1	60	6	*1	6	7	7	14	15	*1	15	88	7	95
Floatables	11	NA	11	*1	NA	*1	1	NA	1	2	NA	2	14	NA	14
Phenols	0	*1	*1	0	*1	*1	0	*1	*1	0	*1	*1	0	*1	*1
Relative Toxicity (mgd)	492	NA	NA	60	NA	NA	61	NA	NA	163	NA	NA	776	NA	NA
Gross Heavy Metals	12	*1	12	*1	1	1	1	1	2	2	*1	2	15	2	17
Heat (BTU/day) x 10^8	300	950	1250	44	NA	NA	21	2150	2171	92	NA	92	457	3100	3557+

NOTES

1/ TDS value is increment added in one cycle of use.

* = Less Than

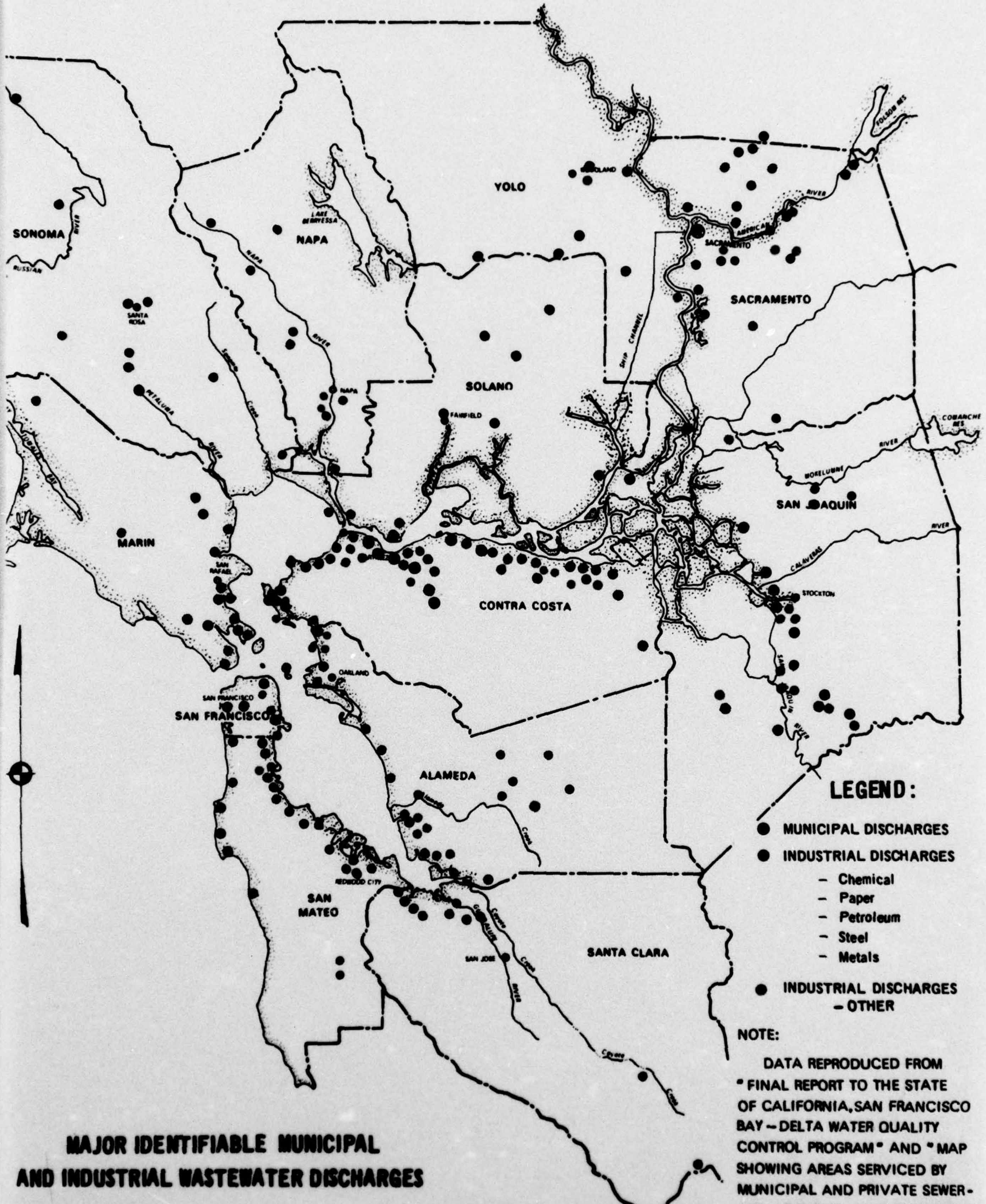
NA = Data Not Available

Source: Untreated wastewater loads based on data developed in Bay–Delta Program. Treated wastewater loads based on primary and secondary treatment removals.

ABBREVIATIONS

BOD	biochemical oxygen demand
BTU	British thermal unit
mgd	million gallons per day
TDS	total dissolved solids
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids

Relative Toxicity – the volumetric rate of flow times the reciprocal of the median tolerance limit (TLm). The TLm is the concentration (in percent or as a decimal fraction) of a waste stream which kills one-half of the test specimens of a given organism within a specified period of time.



MAJOR IDENTIFIABLE MUNICIPAL AND INDUSTRIAL WASTEWATER DISCHARGES

FIGURE II-6

TABLE II-6

AVERAGE ANNUAL FLOWS AND NITROGEN LOADS, STREAM RUNOFF AND AGRICULTURAL DRAINAGE, DELTA AND CENTRAL VALLEY (PRESENT AND PROJECTED)

Source	Flow (mgd)		TN(10^3 lb/day) 2/	
	1965	2020	1965	2020
Sacramento River	14,200	14,300	27	38
Delta 1/	-1,830	-2,080	22	27
East-side Streams	570	550	3/	3/
San Joaquin River	2,710	1,160	14	11
San Joaquin Drains	4/	442	4/	41
Total	15,650	14,372	63	117

1/ Negative figures indicate consumptive water use in the Delta.

2/ Total nitrogen was the only waste parameter reported. This does not imply, however, the absence of other constituents.

3/ Negligible

4/ Not Applicable

Source: Bay-Delta Program Final Report, Table VII-13, Present and *Projected Annual Average Runoff and Wastewater Loads*, p. VII-22.

TABLE II-7

PRESENT AND PROJECTED MUNICIPAL AND INDUSTRIAL DISCHARGES VERSUS RUNOFF 2/

Item	Flow (10^3 AFY) 1/				BOD (10^6 lb/yr)				TN (10^6 lb/yr)			
Year	1965		2020		1965		2020		1965		2020	
	M&I	R	M&I	R	M&I	R	M&I	R	M&I	R	M&I	R
South Bay	310	501	740	563	384	11	1009	20	95	2	234	8
Central Bay	88	74	315	95	90	3	292	5	22	3/	68	1
North Bay	82	510	456	584	117	8	884	16	36	4	346	4
Delta	175	69	890	186	141	4	781	11	29	3/	153	1
Total	655	1154	2401	1428	732	26	2966	52	182	6	801	14

NOTES: 1/ M&I = Municipal and Industrial
R = Runoff

2/ Runoff includes both urban and nonurban in South, Central, and North Bay, but only urban in Delta.

3/ Negligible

Source: Bay-Delta Program Final Report, Table VII-13, Present and Projected Annual Average Runoff and Wastewater Loads, p. VII-22.

that a regional wastewater management system be constructed in three phases:

-Phase I, to be constructed by 1980, was programmed toward consolidating existing urban discharges and transferring treated wastes from areas of low dilution capacity (the extremities of the estuary) to areas of higher dilution capacity (nearer the Golden Gate).

-Phase II, to be constructed by 1990, envisioned further consolidation and treatment of most wastewaters at a single advanced primary treatment facility near Redwood City with effluent disposal to ocean waters off southern San Mateo County.

-Phase III, a construction planning guide for 2020, was flexible, incorporating either continued discharge to the ocean waters or large-scale wastewater reclamation if the potential demand warranted.

To date, Phase I concepts are being encouraged by the State of California.

b. **Current State Planning**. In response to requirements of the State Porter-Cologne Act and the provisions of the *Federal Water Pollution Control Regulations of 1970*, the State developed Interim Plans for Water Quality Control (Interim Basin Plans) and is engaged in planning studies aimed at revising and augumenting the interim plans so as to arrive at fully developed basin plans by July of 1973. In support of this effort several technical planning studies concerning water quality parameters were initiated at the request of the State Water Resources Control Board.

(1) Dispersion Capability. The California Department of Water Resources is conducting a study to develop the methodology to determine the dispersion capability of San Francisco Bay and Delta waters. The study would also seek to determine the magnitude of tidal exchange at the Golden Gate. It is hoped that this study would provide the State with information to assess the effects of decisions regarding upstream releases to the Delta and to allocate the available dispersion capability among the potential discharge sources. This study is to be completed during 1971.

(2) Water Quality Parameters. The State Departments of Water Resources and Fish and Game and the University of California Sanitary Engineering Research Laboratory are conducting a study on toxicity and biostimulation, the two pollution parameters recognized as being most serious in the Bay-Delta Program report. The purpose of this study is to quantify these parameters and to characterize their relationship to receiving-water conditions, because of their impact on design and staging of facilities. This study should be completed by October 1971.

(3) **Monitoring Program**. A study by Stanford Research Institute to develop an environmental monitoring program for the Delta and Suisun Bay was completed in July 1970.

c. **Sub-Regional Planning**. In 1970 the California Regional Water Quality Control Board, San Francisco Bay Region, considered prohibiting waste discharges in San Francisco Bay south of Dumbarton Bridge. Prohibition of discharges would have resulted in extending existing outfalls north of the Dumbarton Bridge toward the Central Bay. The municipalities and sanitation districts which discharge to this part of the Bay asked for and received the Regional Board's permission to study other alternatives. These entities, totalling 11 dischargers, undertook a joint sub-regional wastewater consolidation, treatment, and disposal program consistent with the general concepts of Phase I of the Bay-Delta Program recommendations.

Approximately 13 sub-regional programs have now been initiated in the nine Bay counties. Table II-8 summarizes the status of the major programs, some of which have received financial assistance from the State. These sub-regional studies are an integral part of the State's basin planning process and as such they will be considered in completing the fully developed basin plans.

d. **Implementation**. In a report dated April 1971 entitled "Clean Water for San Francisco Bay," the California State Water Resources Control Board recommended to the Governor and the State Legislature that a nine-county Bay Area regional agency or utility agency be established with authority for planning, financing, constructing and operating facilities for treatment, reclamation, and disposal of municipal and industrial wastewater. No final action has been taken on this recommendation by the State Legislature.

10. ADDITIONAL OPERATIONS LIKELY TO BE IMPLEMENTED BY 1975

a. **Municipalities**. Interim basin and/or regional or metropolitan plans required by the Environmental Protection Agency will be acted upon by the Agency sometime during the early part of Fiscal Year 1972. Fully developed plans are to be submitted to the Agency by July 1973.

TABLE II-8
SUB-REGIONAL STUDIES

Sub-Regional Study	Funding Participants	Total Flow (mgd)	Approximate Funding	Completion Date
South Bay Dischargers	San Jose, Sunnyvale, Mtn. View, Menlo Park, Palo Alto, Milpitas SD, Los Altos, Union SD (Newark & Irvington), Pleasanton, Valley Community SD, Livermore	145	$250,000	12/71
East Bay Dischargers	Hayward, Union SD (Alvarado), Oro Loma SD, San Leandro, East Bay Muni. Util. Dist.	118	60,000	12/71
Contra Costa County	Contra Costa Co., Western Oil & Gas Association	339*	130,000	10/71
Lower Napa River	Vallejo Flood Control & Sani. Dist., Napa Co. SD, American Canyon County Water Dist., USN Mare Island	17	40,000	9/71
North Marin & Sonoma Counties	Marin SD No. 6, Sonoma Valley County SD, Petaluma, Las Gallinas Valley SD, USAF Hamilton AFB, San Rafael SD	12	85,000	2/72
Richardson Bay	Marin Muni. Water Dist., Sausalito-Marin City SD, Mill Valley, Richardson Bay SD, Marin SD No. 5	5	190,000 max.	NA
E. San Mateo Co.	South San Francisco, SF Airport, Millbrae, Burlingame, Merck Chem. Co.	24	(a)	9/71
San Mateo Co.	All Dischargers (to SF Bay)	66	(a)	(a)
Livermore Area	Livermore, Alameda Co. Water Dist., Valley Community Services Dist., Pleasanton, Alameda Co. Flood Control & Water Conserv. Dist.	7	75,000	4/72

*includes cooling water
(a) unknown at present

Source: California Regional Water Quality Control Board, San Francisco Bay Region.

The sub-regional studies currently underway within the study area are to be completed during 1971 and early 1972. The results of the studies will be considered in developing the final basin and/or regional or metropolitan plans.

Bills to create a regional government and a regional water quality planning agency have been introduced at the current session of the California Legislature. These bills include the nine Bay counties. Under the nine-county regional government, a water quality planning agency would be established with the authority to plan, finance, construct, operate and maintain a regional water quality management system. This agency would evaluate projects eligible for Federal grants. Most existing regional agencies would be merged into the regional government, if created.

The interim basin plans for the dischargers in the 12-county study area suggest that the following facilities or concepts will be operational within the next five years:

(1) Consolidation of existing facilities

(2) General upgrading of treatment

(3) Discharge of wastewaters in Sub-areas A, B, and C to the Central and northern South Bay and discharge of wastewaters in Sub-area D in the Delta waterways

(4) Sludge and residual solids to be disposed of on land areas within the 12-county area.

b. **Industries**. Industries which continue to discharge to navigable waters will have to meet existing water quality standards for receiving waters. Over the next 5 years, it is envisioned that higher water quality standards will be adopted.

As a result, such industries will be required to increase their level of treatment, and either discharge to waterways directly or pre-treat and discharge to municipal sewerage systems. For a base condition, industrial pre-treatment and discharge to municipal systems can be assumed. However, all cooling waters will be disposed of locally by the industries.

Industries already connected to municipal systems will also probably be faced with "source control" before entering the system. The alternative would be to expand entire municipal treatment processes for, in most cases, a specific pollutant within the total effluent.

A map illustrating the major features of the base condition is presented in Chapter IV of this report.

11. STREAM QUALITY AND WATER QUALITY STANDARDS

Table II-5 presented the total magnitude of the critical pollutants, by category, discharged to the San Francisco Bay-Delta system. A comparison between the actual water quality in the Bay-Delta system and the water quality standards adopted by the State of California (summarized in Figure IV-2) shows that the waters of San Francisco Bay-Delta are, with minor exceptions, relatively free from gross environmental degradation. Based on conventional parameters of pollution (BOD, coliform organisms, and dissolved oxygen), conditions are improving, although high levels of coliform organisms, floatables, and oil and grease continue to limit some of the potential uses of the Bay-Delta waters. The major potential water quality problems are associated with biostimulation and toxicity.

12. CURRENT INSTITUTIONAL ARRANGEMENTS FOR WASTEWATER MANAGEMENT

The current institutional arrangements for wastewater management within the 12-county study area are summarized below for each governmental level; Federal, State, regional and local:

a. **Federal**. The Environmental Protection Agency (EPA) administers the construction grant program for funding municipal wastewater treatment facilities. The amount of Federal participation in the program varies from 30 to 55 percent depending on the extent of State contribution, the existence of enforceable water quality standards and conformance with comprehensive regional plans. The Federal Water Quality Act of 1965 required the states to set enforceable water quality standards for all interstate waters. These standards were to be submitted for approval by an agency of the Federal Government (formerly the Department of the Interior). This responsibility is now vested in the Environmental Protection Agency. State of California standards, with minor exceptions, have been approved.

Regulations published by the former Federal Water Quality Administration (now within the EPA) in June 1970, state that no construction grants will be made unless the particular project is included within an approved basin plan and/or regional or metropolitan plan. Interim plans are scheduled to be received by EPA by July 1971 and fully developed plans by July 1973.

By Executive Order 11574 of 23 December 1970, the President required all industries which discharge industrial effluents to navigable waters or their tributaries to secure a permit from the Corps of Engineers. The permit program is established in accordance with the Rivers and Harbors Act of 1899. Before issuing a permit, the Corps will require certification from the appropriate State agency that the activity would not violate applicable water quality standards.

The Department of Housing and Urban Development (HUD) administers a Federal grant program for planning, design and construction of water supply and sewerage collection facilities.

b. **State of California**. In the California State Government, all water resource matters are concolidated under a single agency, the Resources Agency. Within the Resources Agency is the California State Water Resources Control Board. The Board, created by the California Legislature in 1967, represents a consolidation of the former Water Quality Control and Water Rights Boards. Also established under the Resources Agency are nine California Regional Water Quality Control Boards. Within the study area, four Regional Water Quality Control Boards have jurisdiction: those of the San Francisco Bay, Central Valley, North Coast, and Central Coast Regions. The State and Regional Boards administer the Porter-Cologne Water Quality Control Act. This Act, which became effective in 1970, completely revised California's water pollution and water quality control laws.

The Porter-Cologne Act directs the State and Regional Boards to formulate water quality control plans. Such plans include the basin plans and/or regional or metropolitan plans required by EPA. Interim basin plans have been prepared by the State of California, covering the entire State. These interim basin plans for the Bay-Delta area define the additional major treatment and conveyance facilities that are to be built by 1975. In addition, they outline the intentions of the State to continue and extend its pollution abatement efforts to deal with longer range problems. The concepts guiding the State's long-range planning, which will be reflected in fully developed basin plans by July 1973, include continued upgrading of treatment levels to insure compliance with water quality objectives and achieving maximum use of water resources by recycling as much reclaimable wastewater as possible.

In November 1970, the voters of the State authorized the issuance of $250,000,000 in bonds over the next 5 years to assist in the construction of wastewater treatment facilities. Monies from bond sales constitute the State's share, 25 percent, of the total cost of wastewater treatment facilities. If the facility is included within a comprehensive plan, local interests would then have to finance only 20 percent of the costs; the Federal share would be 55 percent of the total cost. The State Water Resources Control Board administers the Federal construction grant program in California.

c. **Regional**. The Association of Bay Area Governments (ABAG) has the primary function of providing a framework for dealing with regional problems of the nine Bay counties on a cooperative, coordinated basis. It is in the process of developing a regional water, sewerage, and drainage plan for the nine Bay counties. Phase I of the plan has been completed. Phase II, being developed by a consulting firm, is expected to be completed in the late summer of 1971.

Within the study area, two other regional planning agencies have functions parallel to those of ABAG. The Sacramento Regional Area Planning Commission encompasses Sacramento and Yolo Counties within the study area. A regional water and waste management plan and program, which represents a composite of water supply, waste treatment, and drainage plans prepared by the local agencies, was completed for the Commission in October 1970 by a consulting firm. The San Joaquin County Planning Commission also has under preparation a regional plan for water, sewerage, and drainage.

d. **Local**. In 1970, the California State Water Resources Control Board created the San Francisco Bay Water Quality Group, composed of representatives of dischargers within the nine Bay counties, the Bay Area League of Industrial Associations, and the American Society of Civil Engineers (San Francisco Section). The Group, which meets monthly, has the following objectives:

> Review and furnish to the State Board the Group's views and advice on all ongoing State Board planning and research studies having potential impact on the Bay, including cooperative studies with local agencies from time of development through completion.
>
> Maintain liaison with waste dischargers through the organizations represented by Group members.

No similar grouping of local waste dischargers has occurred in the Delta counties of Sacramento, San Joaquin and Yolo.

In November 1970, the voters of several municipalities and sanitation districts approved propositions which authorized issuance of bonds to finance municipal wastewater treatment facilities. Voters in the City of San Francisco approved a bond sale of $65 million, and those in the East Bay Municipal Utility District (including the cities of Oakland and Berkeley) approved a bond sale of $60 million. Monies from bond sales will be applied to the local entity's share, 20 percent, of the total cost.

CHAPTER III

STUDY AREA IN THE FUTURE

1. PROJECTED POPULATION

Factors affecting future waste loads in the study area will be population, land use and economic activity. Thus, estimates of the growth of these factors are necessary. Other factors such as changes in life styles also may affect future waste loads, but their impact cannot readily be assessed at this time.

Two sources of information on population projections and other pertinent data were considered for this study. One was the Bay-Delta Program, referred to previously. The second was the results of studies made by the California Departments of Finance and Water Resources. Population projections in the former source were based in part on University of California studies, while those in the latter were based on published U.S. Bureau of the Census Series D population projections. The Series D projections indicate a 2020 population for the area of 13 million, as against 15 million in the Bay-Delta Program report. The Bay-Delta Program projections are used in this feasibility study, chiefly because substantial data developed in the program could be utilized. Projected populations of the study area for 1990 and 2020 according to the Bay-Delta Program are given in Table III-1. Figure III-1 shows present and projected populations according to both the Bay-Delta Program and Series D.

Compared to 1970, the population of the study area is expected to nearly double by 1990 and triple by 2020. The greatest increases in population are forecast for Sub-areas B and D.

TABLE III-1

ESTIMATED POPULATION IN STUDY AREA FOR YEARS 1990 AND 2020

Sub-area	County	1990	2020
A	Alameda	1,600,000	2,100,000
	San Francisco	900,000	1,000,000
	San Mateo	700,000	800,000
	Santa Clara	1,500,000	1,900,000
Subtotal		4,700,000	5,800,000
B	Marin	380,000	550,000
	Napa	130,000	200,000
	Solano	450,000	1,050,000
	Sonoma	440,000	900,000
Subtotal		1,400,000	2,700,000
C	Contra Costa	900,000	1,350,000
D	Sacramento	1,420,000	2,750,000
	San Joaquin	530,000	1,300,000
	Yolo	450,000	1,400,000
Subtotal		2,400,000	5,450,000
Total		9,400,000	15,300,000

Source: Bay-Delta Program Final Report

2. OTHER PERTINENT ECONOMIC PROJECTIONS

a. **Industry**. The Bay-Delta Program report predicts that industrial employment in the study area will increase from 2 million to about 6 million by 2020. The greatest increase is expected to be in manufacturing, wholesale and retail trade, and services. Future production in selected industrial groups that require large quantities of water in their manufacturing operation and thus have large waste loads is summarized below:

(1) **Oil Refineries**. Based on a predicted increase in per capita consumption of refined petroleum products from the present 31 barrels per year to about 75 barrels per year in 2020, the total annual production of refineries located in the study area will probably increase from 170 million barrels per year to some 1 billion barrels per year in 2020, an annual growth rate of about 3½ percent. Refineries will continue to be concentrated in the Solano-Contra Costa County area, adjacent to deep water of the San Francisco Bay system.

(2) **Paper and Allied Products**. This industrial group, situated in the Pittsburg-Antioch area of Contra Costa County, manufactures about 2,000 tons per day of paper products. In the next 50 years production is projected to increase to about 12,000 tons per day. No shift in the manufacturing center is expected.

(3) **Canning**. Available information indicates that the centers of canned-goods production in the area will be located in the three Delta counties. Production is expected to increase at a rate of about 3 percent annually. Canned-goods production in Santa Clara County is expected to decrease as agricultural lands continue to be developed for urban use.

(4) **Chemicals**. Production of chemicals in the study area is expected to grow 11-fold in the period 1970-2020. The expected increase in petroleum refining in the study area would contribute to an expansion of petro-chemical production.

(5) **Steel**. Based on an anticipated four-fold increase in the consumption of industrial-steel products in the study area, it is expected that steel product manufacturing will increase from 600,000 tons per year in 1970 to 12 million tons per year in 2020.

(6) **Electrical Generation**. It is estimated that steam power plants located in the study area generated 20 billion kilowatt-hours of electrical energy in 1967. By 2020 annual power generation is expected to reach 110 billion kilowatt-hours. New sources of cooling water or new methods of cooling will be needed if this figure is to be reached.

b. **Agriculture**. Based on recently published California Department of Water Resources land-use projections, it is estimated that by the year 2020 the amount of land used for irrigated agriculture in the nine Bay Area counties (Sub-areas A, B and C) will be 416,000 acres, a reduction of some 15 percent from 1967. By 2020, irrigated land in Sub-area D is expected to increase by some 15 to 20 percent to 1.55 million acres. In the Central Valley tributary to the 12-county area, including Tulare Lake basin, it is estimated that about 7 million acres will be under irrigation by 2020.

3. FUTURE WATER POLLUTION PROBLEMS

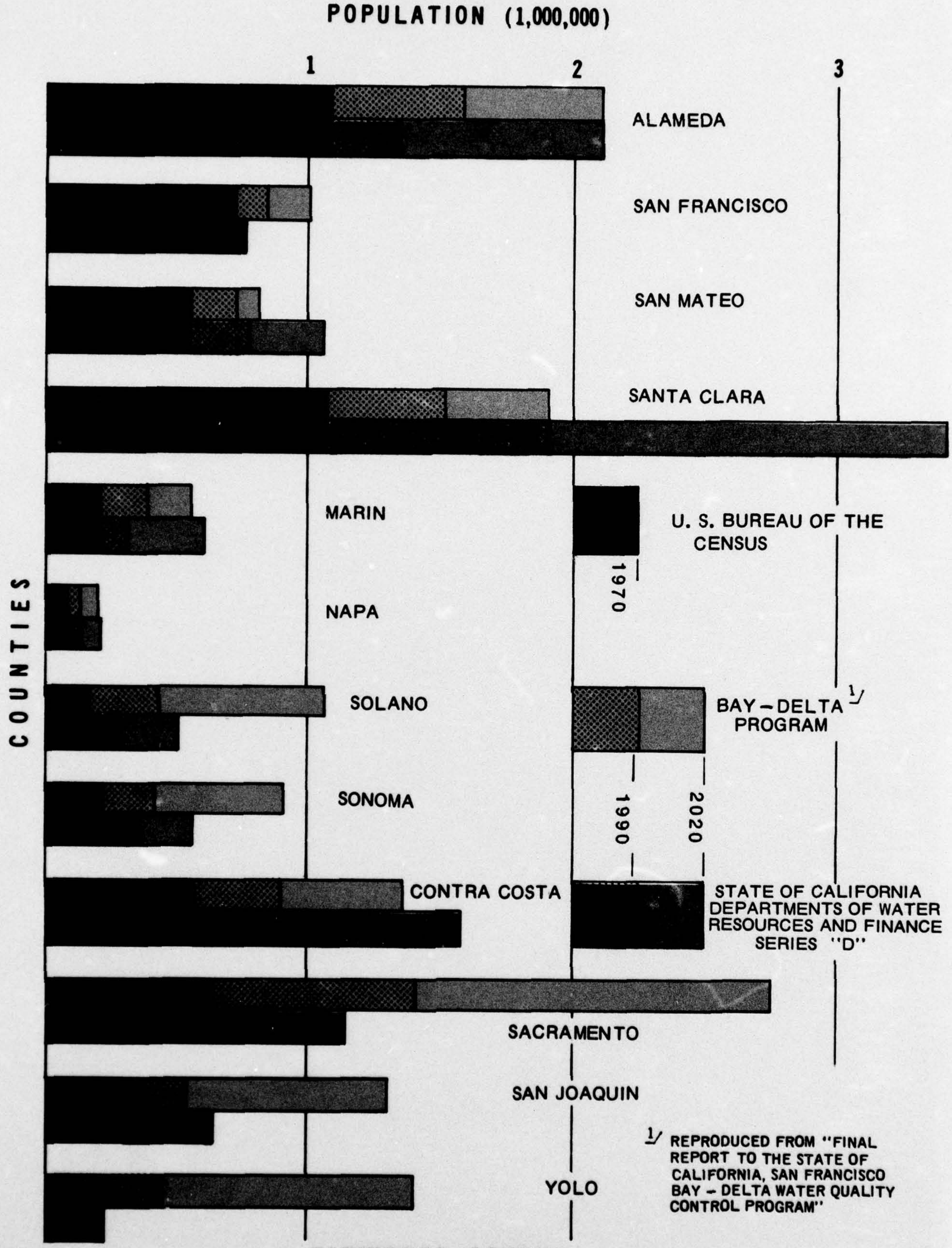
One of the major causes of the existing water pollution problems in the San Francisco Bay-Delta is the discharge level of biostimulants and toxicants. If the Bay and Delta waters continue to be used for the disposal of the study area's wastewaters, the expected large future increase in population and industrial activity will intensify the problem. Future hydrologic modifications of the Bay-Delta system may increase the stresses on the biota by increasing the residence time 1/ of pollutants in certain parts of the estuarine system. Although treatment of wastes may be increased, facilities consolidated, and outfalls moved to higher dilution areas, the Bay-Delta system will continue to receive high wastewater loads.

4. SOURCES AND TYPES OF FUTURE WASTE LOADS

a. **General**. In estimating the magnitude, type and distribution of wastes that will be produced within the study area in the next 50 years, the following assumptions were made: (1) wastewaters generated in each sub-area would be disposed of in or near the source sub-area; no major conveyance out of the individual sub-areas would be made; (2) beginning in 1975, all wastewaters will receive an average level of secondary treatment; and (3) the following removal efficiencies will be achieved (based on a review of secondary treatment efficiencies in the sanitary engineering literature):

Parameter	% Removal
BOD	90
TN	30
TP	30
TDS	0
TSS	90

1/ The residence time of pollutants in a particular body of water is the average interval of time that a constituent or particle remains within the water body. The residence time is a function of tidal flow, fresh-water outflow from the Delta, and water movements resulting from winds and waves.



ESTIMATED COUNTY POPULATION PROJECTIONS

FIGURE III-1

Parameter	% Removal
Oil & Grease	70
Floatables	70
Phenols	80
Gross Heavy Metals	70
Pesticides	40

b. **Municipal and Industrial Waste Flows and Loads**. Based on the foregoing assumptions, future waste flows and loads were calculated for the years 1980, 1990, 2000,2010 and 2020. The detailed results are contained in Appendix A, and are summarized in Table III-2 for the years 1970,1990 and 2020. Data on pesticides, pathogens, radioactivity and heat loading were not available.

c. **Natural Runoff**. It is estimated that natural runoff in the study area in 2020 will be 1,430 thousand acre-feet annually, or about 25 percent greater than the runoff in 1965. The estimated BOD load from runoff in 1965 was about 3 percent of the load discharged from municipal and industrial sources. The contribution of urban area runoff to the total should increase because of expected growth patterns. The toxicity and biostimulatory characteristics of this runoff are virtually unknown.

d. **Agricultural Drainage**. Combined agricultural and stream runoff flows that will enter the study area from the Central Valley in 2020 are estimated at about 16 million acre-feet per year. The total nitrogen load (nitrogen is a critical pollutant in this flow) should be approximately 43 million pounds per year, or about eight percent of the nitrogen from municipal and industrial waste flows. This represents an approximate doubling of the 1965 quantity.

e. **Watercraft Wastes**. Although wastes from watercraft including ships and pleasure boats are sources of coliform bacteria in the Bay-Delta system, this type of waste is not expected to be a problem in the year 1990 or thereafter. Current and proposed legislation is aimed at prohibiting such discharges in bays and estuaries.

f. **Summary**. Sub-area A will continue to be the largest source of municipal and industrial wastewaters in 2020. This area in 1970 produced 56 percent of all wastewaters in the study area; by 2020 the amount contributed will decrease to about 40 percent. In Sub-area B, wastewater production should increase from 53 mgd in 1970 to 202 mgd, or about 10 percent of the total, in 2020. Sub-area C, producing 129 mgd in 1970, should continue to be a major source of municipal and industrial wastewaters, with a 2020 flow of 490 mgd, about 25 percent of the total. Sub-area D should become a sizeable source of municipal and industrial wastewaters by 2020, increasing to 543 mgd (25 percent of the total) from 123 mgd in 1970.

5. PROBABLE HYDROLOGIC CHANGES

Several changes in the Bay and Delta estuary are expected to occur over the next 50 years, mostly in connection with planned alterations of the hydrologic regime. Coupled with changes in the magnitude, location, and composition of wastewater flows, the expected hydrologic changes could increase the stresses now occurring on the biota in the system.

The major hydrologic change will be the decrease of Delta fresh-water outflow from a present (1970) yearly average of 18 million acre-feet to a probable yearly average of 7 million acre-feet in 2020 (Figure II-4). This change would result from planned Federal and State diversions of fresh water to water-deficient areas in southern and central California. Although fresh-water outflow is not believed to greatly affect flushing and residence time of pollutants in the central and southern parts of the San Francisco Bay system, such outflow is believed to exert considerable influence upon residence times in the North Bay.

6. ALTERNATIVE STRATEGIES FOR WASTEWATER MANAGEMENT

The wastewater management strategy that is currently being implemented in the Bay-Delta area is generally directed toward estuarine disposal of treated wastewaters. This is an approach that was made necessary by the urgency of water quality and water pollution problems in the Bay and Delta; its implementation over the next few years will allow for protection of the environment while detailed planning of the measures that will be needed for solution of long-term problems is carried out. Current actions and planning by regulatory agencies are centered around the concept of transferring wastewater discharges from environmentally sensitive areas of relatively low dispersion capability in the Bay-Delta estuary to areas of higher dispersion capability The concept also includes the consolidation and upgrading of treatment facilities to a minimum of secondary treatment or advanced waste treatment, as needed, and the objective of including wastewater reuse in future systems.

Present State and Federal policy is to preserve, protect and enhance the environment, and large sums have already been spent on wastewater treatment facilities to this end. This expenditure has unquestionably brought about substantial improvement in parts of the Bay-Delta system but more must be done if the ultimate goals of protecting the environment are to be satisfactorily achieved. Because of projected growth, these goals appear even harder to achieve in the future. It is recognized that the current practice of discharging treated wastewaters to surface waters of the

TABLE III-2

SUMMARY OF TREATED MUNICIPAL AND INDUSTRIAL WASTEWATER FLOWS IN 1970, 1990, AND 2020 FOR NORTH BAY-DELTA AND SOUTH BAY

(in 1,000 lbs/day)

Parameter or Constituent	South Bay Counties			North Bay-Delta Counties			Total Study Area		
	1970	1990	2020	1970	1990	2020	1970	1990	2020
Flow (mgd)	511	835	1,385	176	354	791	687	1,189	2,176
Percent of Total Flow	74	70	64	26	30	36	100	100	100
BOD	868	294	547	187	126	268	1,055	420	815
TN	413	658	1,065	80	144	363	493	802	1,428
TP	62	81	149	13	29	81	75	110	230
TDS 1/	1,855	2,762	4,345	576	1,067	3,122	2,431	3,829	7,467
TSS	264	181	306	66	63	153	330	244	459
Oil & Grease	74	107	191	21	33	70	95	140	261
Floatables	12	13	18	2	6	12	14	19	30
Phenols	*1	*1	*1	*1	*1	*1	*1	*1	1
Relative Toxicity (mgd) 2/	553	1,194	1,980	223	506	1,132	776	1,700	3,112
Gross Heavy Metals	14	15	23	3	8	17	17	23	40
Sludge (dry weight)	–	271	459	–	94	229	–	365	688

Source: Untreated wastewater loads based on data developed in Bay-Delta Program. 1990 and 2020 treated wastewater loads based on secondary treatment removals. 1970 treated wastewater loads based on Table II-5.

Notes:

1/ TDS value is increment added in one cycle of use.

2/ Relative toxicity for 1970 is taken from Table II-5 (does not include industrial flows). Relative toxicity for 1990 and 2020 for both municipal and pretreated industrial wastes is 1.43 x flow.

* =Less Than

– =Data Not Available

	South Bay Counties		North Bay-Delta Counties
Sub-area A:	Alameda San Francisco San Mateo Santa Clara	Sub-area B:	Marin Napa Solano Sonoma
Sub-area C:	Contra Costa	Sub-area D:	Sacramento San Joaquin Yolo

estuary, although necessary today, may not be capable of providing long-term protection to the estuarine environment.

The Bay-Delta area has a reputation as a delightful and desirable place to live. This reputation is largely based on the presence and quality of the estuary. It could be threatened if pollution of the estuary should increase.

If the goal of protecting the environment is to be met, it is essential to take a thorough, searching look at all potentially feasible alternative systems, examining their comparative effects. It is essential that the wastewater management system be flexible so that it can adapt to future changes in needs, goals, or technical capability. The past decade has shown dramatically that environmental goals can change as new knowledge becomes available. Flexibility is particularly important in view of the large size of the investment that will be involved. Any system not carefully designed would be inherently lacking in flexibility.

In examining the potentially feasible alternative systems for long-term management of wastewater, it is essential to give full consideration to all possible strategies, including those that have not previously been fully evaluated. The concept of land disposal, otherwise called land application or land recycling, has been implemented on a small scale but not evaluated as a potential regional system. It offers possible advantages in terms of removal of wastes from surface waters and beneficial uses of the wastewater stream itself, and should be considered as a possible component of a regional wastewater management system.

Treated wastewaters, if brought to high enough quality, could be used to recharge groundwater, to provide agricultural and industrial water supplies, for water-oriented recreation, and even to augment municipal water supplies. Such uses could defer or obviate the need to develop new sources of fresh-water supply. Further, there is growing recognition that waste products, such as sewage sludge, are in themselves potentially valuable but untapped resources.

For all these reasons, it is appropriate to take a searching look at alternative wastewater management strategies. This Study is designed to evaluate the broad alternatives that are available, with emphasis on land disposal factors, but covering all alternatives on a basis of equal comparison.

CHAPTER IV

WASTEWATER MANAGEMENT STRATEGIES

1. PURPOSE AND SCOPE

This chapter develops and presents representative broad concepts for methods of wastewater management in the Bay-Delta area, with illustrative alternatives developed for four general concepts. These four alternatives, which are assessed and evaluated in the next chapter, are designed to:

a. Provide a common basis for comparison of alternatives in terms of performance, protection of the environment, costs, and expected beneficial and/or adverse effects;

b. Identify the potential opportunities for large-scale reuse of treated wastewaters that could result from wastewater management on a regional basis; and,

c. Identify major areas of concern in terms of public health considerations, environmental effects and requirements for further investigation and research.

The alternatives presented here are not final plans as each would have to be revised and refined in the course of detailed planning. As presented, however, the alternatives cover the range of potentially feasible methods for wastewater management so that reasonable comparisons can be made on an equitable basis, including identification of uncertainties in the evaluation. Improvements in the alternatives which could be achieved by addition or modification of selected features are beyond the scope of this report.

The alternatives considered are described as "disposal" alternatives. This should not be construed to mean that the objective is to determine methods of discarding treated wastewaters. Rather, for ocean disposal and estuarine disposal, the term indicates the disposition of that portion of treated wastewaters for which reuse potential does not materialize; the term "land disposal" refers to a system which uses the application of partially treated wastes to land areas as a part of the treatment process prior to potential further reuse.

2. CRITERIA AND ASSUMPTIONS USED IN DEVELOPING ALTERNATIVE STRATEGIES

The criteria and assumptions used as the planning basis for developing the wastewater management alternatives are as follows:

a. Each alternative is designed to meet wastewater treatment needs as established for 1990 and to be capable of expansion to meet needs projected for 2020.

b. Each alternative is designed to provide flexibility of opportunity for reuse of treated wastewaters.

c. The projected population of the 12-county study area in 1990 is 9.5 million. The population is projected to increase to 15 million by 2020. Projected population distribution is as shown in Chapter III.

d. Average daily municipal and industrial process wastewater flows are projected to be 1,200 million gallons per day (mgd) in 1990 and 2,200 mgd in 2020.

e. Only the municipal and industrial wastewater flows generated within the study area are considered in developing alternatives.

f. Existing water quality criteria are used as guideposts but do not act as constraints. Thus, no alternative is considered viable unless it can reasonably be considered to meet current standards. Further, each alternative developed must have some potential for meeting even higher standards.

g. This study does not include provisions for collecting and treating agricultural wastewaters generated within or entering the study area. This is based on the assumption that it is the responsibility of those agencies which sponsor major irrigation projects – primarily the U.S. Bureau of Reclamation and the State of California Department of Water Resources – to treat and discharge such wastes in a manner which does not degrade water quality in the estuary.

h. This study does not provide for collecting and treating runoff from rainfall on urban areas. This approach is taken for two reasons. First, all available data indicate that the total annual pollutant load from storm runoff is on the order of one-twentieth the total waste load in municipal and industrial waste flows on an annual basis. Second, the seasonal precipitation pattern in the Bay-Delta area deposits almost all urban storm runoff into the waters of the estuary during the 4-month winter season (mid-November to mid-March), when all watercourses tributary to the Bay and Delta are carrying high flows. Thus an indeterminate dilution factor is present both from a stream discharge viewpoint and an impact viewpoint, because the estuary is not subject to these loads for the 8-month dry period. It should be noted that methods of coping with flows from the combined sewers in both San Francisco and Sacramento are under study by local agencies.

i. The required degree of treatment is comparable for all strategies and meets existing or identifiable trends in environmental objectives; this allows evaluation of opportunities for integration of wastewater management with total water resources development.

j. The regional systems evaluated do not include the coastal areas of San Mateo, Marin and Sonoma Counties; the Russian River drainage basin is also excluded except that existing continuous urban development patterns make it appropriate to include Santa Rosa in this study.

3. GENERAL DESCRIPTION OF SELECTED TREATMENT SYSTEMS (See Figures IV-1 and IV-2)

a. **Secondary**. In the secondary treatment system used in this report, the waste stream passes through a primary sedimentation unit and on to either an activiated sludge or trickling filter unit, followed by final settling. In this process, biochemical oxygen demand (BOD) is reduced 85-95 percent by biological oxidation and some nutrients (25-35 percent) are removed. Solids removed from the waste stream move to a digester which stabilizes them and reduces their volume and volatile solids content.

b. **Advanced (Chemical and Biological)**. In the advanced treatment system, as defined and used in this report, the incoming waste stream is introduced into a primary sedimentation unit in which phosphate is also chemically precipitated. The effluent goes to an activated sludge unit followed by a nitrification/denitrification unit using suspended growth reactors with methyl alcohol addition. The final process is rapid sand filtration. This form of advanced treatment removes 98 percent of the BOD, and 90-95 percent of the nutrients. Solids removed in the above processes pass to a digester after extraction of the chemical additives used in the sedimentation unit.

c. **Land Disposal**. In the land disposal system, the incoming waste stream is applied to aeration lagoons in which biological oxidation reduces BOD and removes some nutrients. These lagoons may provide the equivalent of secondary treatment. The effluent passes to storage ponds, where it is retained a minimum of 30 days for additional biological oxidation, then is applied to the land. During the four winter (rainy season) months when no land application is planned, effluent from the aeration lagoons would be stored in the ponds for subsequent land application. The treated wastewaters are applied to the land surface at an estimated rate of about eight feet per year, of which about half (4 feet) is dissipated by evaporation and consumptive use by vegetation. The remainder infiltrates to a system of horizontal underdrains which collect the drainage water for further reuse. In areas where soil or groundwater conditions would limit the effectiveness of underdrains in controlling the seepage of drainage water, control would be maintained through pumping from carefully sited wells. It is believed that the water which passes through the soil will be enhanced in quality in most aspects except TDS, which will be increased. Land disposal is expected to remove 75-95 percent of the BOD, 30-80 percent of the nitrogen, depending on specific soil conditions, and 99 percent of the phosphate. Sediment (sludge) from the aeration lagoons and storage resevoirs is applied to the land surface with the treated water.

d. **Sludge Disposal**. Alternatives available for sludge treatment are dewatering, incineration, wet air oxidation or digestion. The representative method chosen for this study was digestion. Alternatives available for disposal of treated sludge are emplacement in landfills or application to the land surface. Land surface application was chosen for all systems to permit a comparable approach. Environmental policies recently established and those now being formulated rule out long-term use of practices of sludge disposal common elsewhere by ocean dumping from barges or by discharge through outfalls to the ocean or estuary. Transportation of sludge to the disposal site is by pipeline carrying a slurry of 10 percent solids content. Sludge is applied to the land at a rate of 25 tons of solids per acre per year. The carrier water is collected by a system of horizontal underdrains and recycled through the treatment process.

e. **Disinfection**. After treatment, all wastewaters would be disinfected.

4. BASE CONDITION

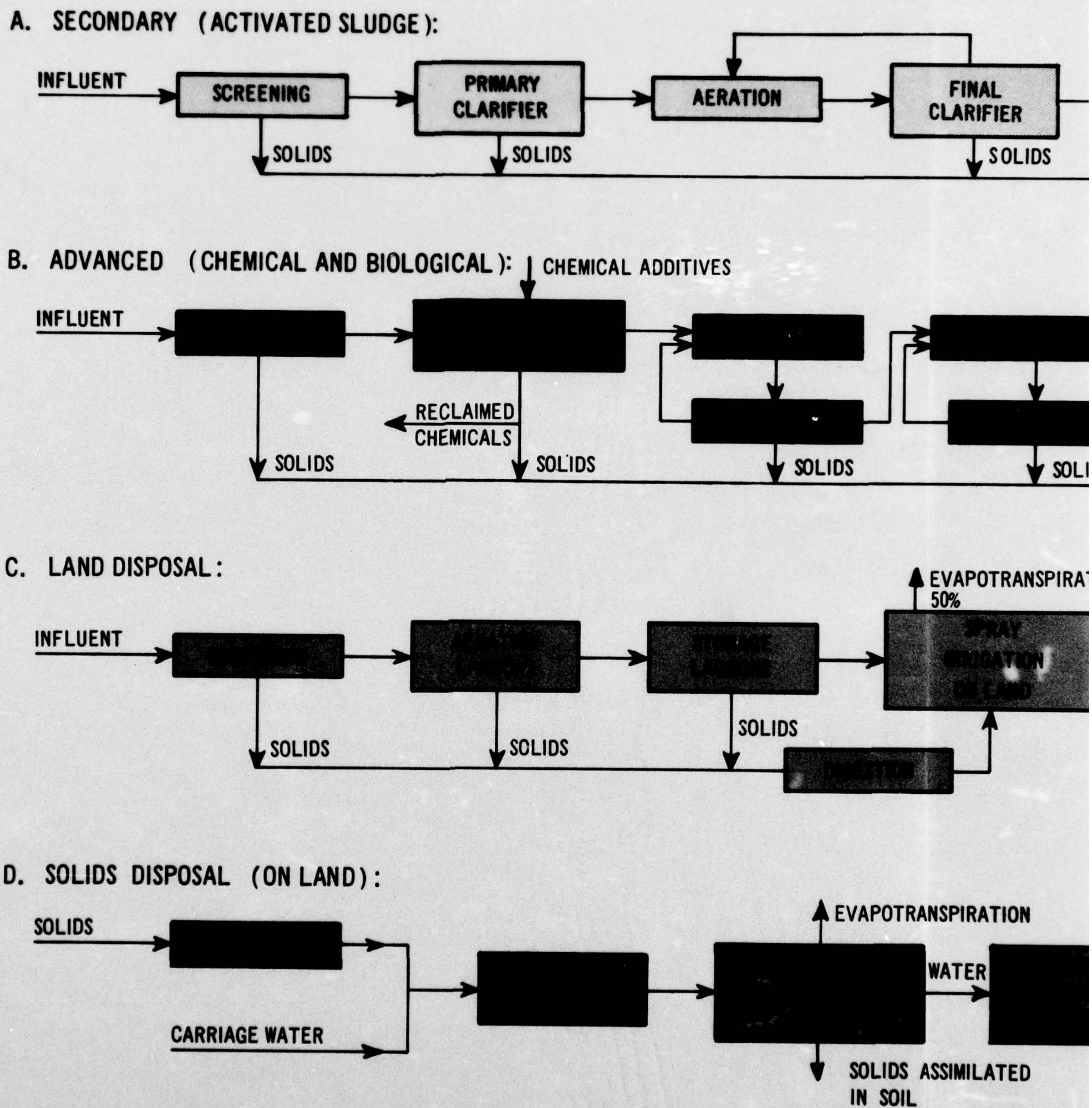
A conceptual base condition is developed to provide a common basis for evaluation of wastewater management alternatives. The assumed base condition represents an extension of the facilities expected to be in operation in the 1975 time frame, as contained in the State of California's "Interim Water Quality Management Plans." The general scheme of the base condition is shown on Figure IV-3. The essential characteristics of the base condition include:

a. Considerable consolidation of sewage service agencies and treatment facilities within the study area. Facilities built by 1975 would be sized to handle 1990 loads.

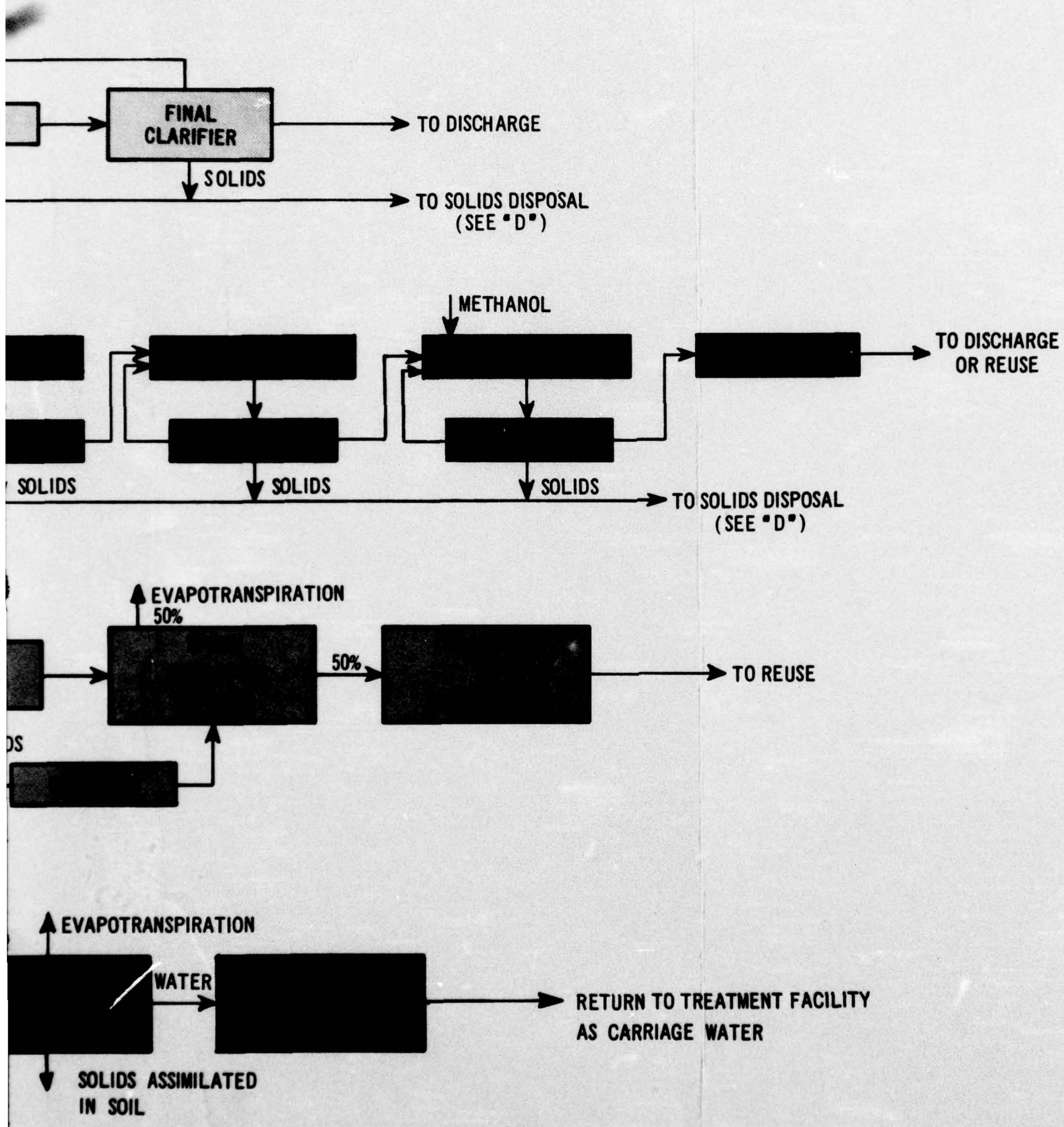
b. Removal of concentrations of waste from the ends of the estuary by discharging the bulk of wastewaters from the nine Bay area counties to high dilution areas of the Bay.

c. The bulk of wastewaters from the three Delta counties to be discharged to Delta waterways.

FLOW CHARTS FOR SELECTED TREATM



R SELECTED TREATMENT SYSTEMS



2

FIGURE IV-1

WASTEWATER TREATMENT SYSTEMS - COM

TREATMENT SYSTEMS	MAJOR COMPONENTS	BOD	TOTAL NITROGEN	TOTA PHOSP
1. PRIMARY	SEDIMENTATION	25 – 35	10	10
2. SECONDARY	SEDIMENTATION FOLLOWED BY ACTIVATED SLUDGE OR TRICKLING FILTER AND FINAL SETTLING	85 – 95	25 – 35	25 – 3
3. TERTIARY &/OR ADVANCED				
a. CHEMICAL FLOTATION	PRECIPITATION OF SOLIDS AND DISSOLVED AIR FLOTATION OF FLOATABLES.	50 – 70	15 – 25	10 – 8
b. RAPID SAND FILTRATION	ADSORPTION OF SOLIDS ONTO SAND PARTICLES.	95 – 98	25 – 35	25 – 8
c. PHOSPHATE PRECIPITATION	ADDITION OF CHEMICALS TO PRECIPITATE PHOSPHATES.	●	●	95 – 9
d. ACTIVATED CARBON	ADSORPTION OF SOLIDS ONTO GRANULAR CARBON PARTICLES.	93 – 99	45 – 55	95 – 9
e. NH_3 STRIPPING	CONVERSION OF NO_3 TO NH_3 GAS CHEMICALLY AND REMOVAL TO ATMOSPHERE.	99	90 – 95	95 – 9
f. MICROBIAL DENITRIFICATION	CONVERSION OF NO_3 TO N_2 GAS BY BACTERIAL ACTION USUALLY WITH CARBON (METHANOL) ADDITION.	98	75 – 98	25 – 3
g. ELECTRODIALYSIS	REMOVAL OF IONS BY ELECTROCHEMICAL ACTION.	●	40 – 50	20 – 2
h. REVERSE OSMOSIS	FILTRATION THROUGH SEMI-PERMEABLE MEMBRANE UNDER APPLIED PRESSURE.	●	50 – 90	95 – 9
i. ION EXCHANGE	REMOVAL OF IONS BY CHEMICAL EXCHANGE.	●	75 – 90	95 – 9
4. ADVANCED (CHEMICAL AND BIOLOGICAL) TREATMENT 1/	PHOSPHATE EXTRACTION PROCESS (CHEMICAL PRECIPITATION); ACTIVATED SLUDGE INCORPORATING DENITRIFICATION IN SUSPENDED GROWTH REACTORS; FOLLOWED BY SAND FILTRATION.	98	90	95
5. LAND	SCREENING, AERATED LAGOONS & STORAGE.	75 – 95	—	—
	LAND SPRAYING, INFILTRATION & COLLECTION IN UNDERDRAINS.	75 – 95	30 - 80	99

1/ AS DEFINED AND USED IN THIS REPORT

2/ RELATIVE TOXICITY (IN MGD) OF 1 MGD OF EFFLUENT FLOW

● NOT APPLI

— DATA NOT

WATER QUALITY OBJECTIVES FOR S.F. BAY

WATER QUALITY PARAMETER	SAN FRANCISCO BAY	
DISSOLVED OXYGEN	5 MG/L	
NUTRIENTS	NUTRIENT CONCENTRATIONS SHALL NOT CAUSE DELETERIOUS OR ABNORMAL BIOTIC GROWTHS EXCEPT WHEN NON-CONTROLLABLE FACTORS CAUSE GREATER CONCENTRATIONS. TOTAL NITROGEN LIMIT OF 2 MG/L EASTERLY OF CARQUINEZ STRAIT.	MATERI TOTAL
PATHOGENS	COLIFORM COUNT LIMIT OF 70/100 ML. (TO MEET REQUIREMENTS OF SECTIONS 7957 AND 7958, CALIFORNIA ADMINISTRATIVE CODE IN DESIGNATED AREA.)	FECAL
RADIOACTIVITY	TO MEET PROVISIONS OF CHAPTER 5, TITLE 17, CALIF. ADMIN. CODE	TO MEE
TEMPERATURE	INCREASE OF 0°F. OUTSIDE OF MIXING ZONE (SPECIFIED BY REGIONAL BOARD).	INCREA SURFA
DISSOLVED SOLIDS	NO OBJECTIVE	
SUSPENDED SOLIDS (TURBIDITY)	NO SIGNIFICANT VARIATION BEYOND PRESENT NATURAL BACKGROUND LEVELS.	LESS T
FLOATABLES	NONE OTHER THAN OF NATURAL CAUSES AT ANY PLACE.	OBJECT
OIL & GREASE	OIL OR MATERIALS OF PETROLEUM ORIGIN OR PRODUCTS, NONE FLOATING IN QUANTITIES SUFFICIENT TO CAUSE AN IRIDESCENCE, OR NONE SUSPENDED OR DEPOSITED ON THE SUBSTRATE AT ANY PLACE.	FLOATI
TOXIC MATERIALS	NONE PRESENT IN CONCENTRATIONS DELETERIOUS TO BENEFICIAL USES; NONE AT LEVELS WHICH RENDER AQUATIC LIFE OR WILDLIFE UNFIT FOR HUMAN CONSUMPTION.	SHALL
PESTICIDES	NO PESTICIDE OR COMBINATION OF PESTICIDES SHALL REACH CONCENTRATIONS FOUND TO BE DELETERIOUS TO FISH OR WILDLIFE AT ANY PLACE.	BIOCID TO FIS
PH	7.0 TO 8.5 IF LESS DUE TO NATURAL FACTORS, FURTHER DEPRESSION BY CONTROLLABLE FACTORS TO BE DETERMINED BY REGIONAL BOARD.	
COLOR	NO SIGNIFICANT VARIATION BEYOND PRESENT NATURAL BACKGROUND LEVELS.	APPAR
BOTTOM DEPOSITS	NONE OTHER THAN OF NATURAL CAUSES.	OF OTH
ODORS	NONE OTHER THAN OF NATURAL CAUSES AT ANY PLACE.	... OTH

3/ REPRODUCED FROM "FINAL REPORT TO THE STATE OF CALIFORNIA, SAN FRANCISCO BAY – DELTA WATER QUALITY CONTROL PROGRAM"

NT SYSTEMS - COMPONENTS - PERFORMANCE

	PERFORMANCE IN REMOVING SELECTED WASTE CONSTITUENTS (% REMOVAL)													
	BOD	TOTAL NITROGEN	TOTAL PHOSPH'S	TOT. SUSP. SOLIDS	TOT. DIS. SOLIDS	FLOAT-ABLES	OIL & GREASE	HEAVY METALS	RELATIVE TOXICITY	PESTI-CIDES	PHENOLS	BACTERIA	VIRUSES	
	25 – 35	10	10	60 – 70	●	50 – 60	50 – 60	50 – 60	2±	●	50	25 – 75	40 – 50	
INAL SETTLING	85 – 95	25 – 35	25 – 35	85 – 95	●	50 – 85	50 – 85	45 – 95	1±	0 – 75	80	90 – 98	40 – 90	
	50 – 70	15 – 25	10 – 80	80 – 90	●	80 – 90	—	●	—	●	●	●	●	
	95 – 98	25 – 35	25 – 80	95 – 98	●	98	●	●	—	●	●	95	80 – 99	
	●	●	95 – 97	●	●	●	●	—	—	●	●	—	90	
	93 – 99	45 – 55	95 – 97	99	●	●	●	●	—	—	—	99	—	
	99	90 – 95	95 – 97	99	●	●	●	●	—	●	●	●	●	
(METHANOL) ADDITION.	98	75 – 98	25 – 35	95 – 98	●	●	●	●	—	●	●	●	●	
	●	40 – 50	20 – 25	●	35 – 50	●	●	—	—	—	●	●	●	
	●	50 – 90	95 – 99	99	90 – 95	●	●	—	—	—	●	●	●	
	●	75 – 90	95 – 99	●	85 – 90	●	●	—	—	—	●	●	●	
GE INCORPORATING ATION.	98	90	95	99	●	98	90	99	.02±	—	—	95	80 – 99	
	75 – 95	—	—	90 – 99	●	●	●	—	—	—	●	95	95	
	75 – 95	30 - 80	99	99	0	99	99	—	—	90	0	95 – 99	99	

● NOT APPLICABLE. TREATMENT NOT DESIGNED TO REMOVE TH'S CONSTITUENT.
— DATA NOT AVAILABLE

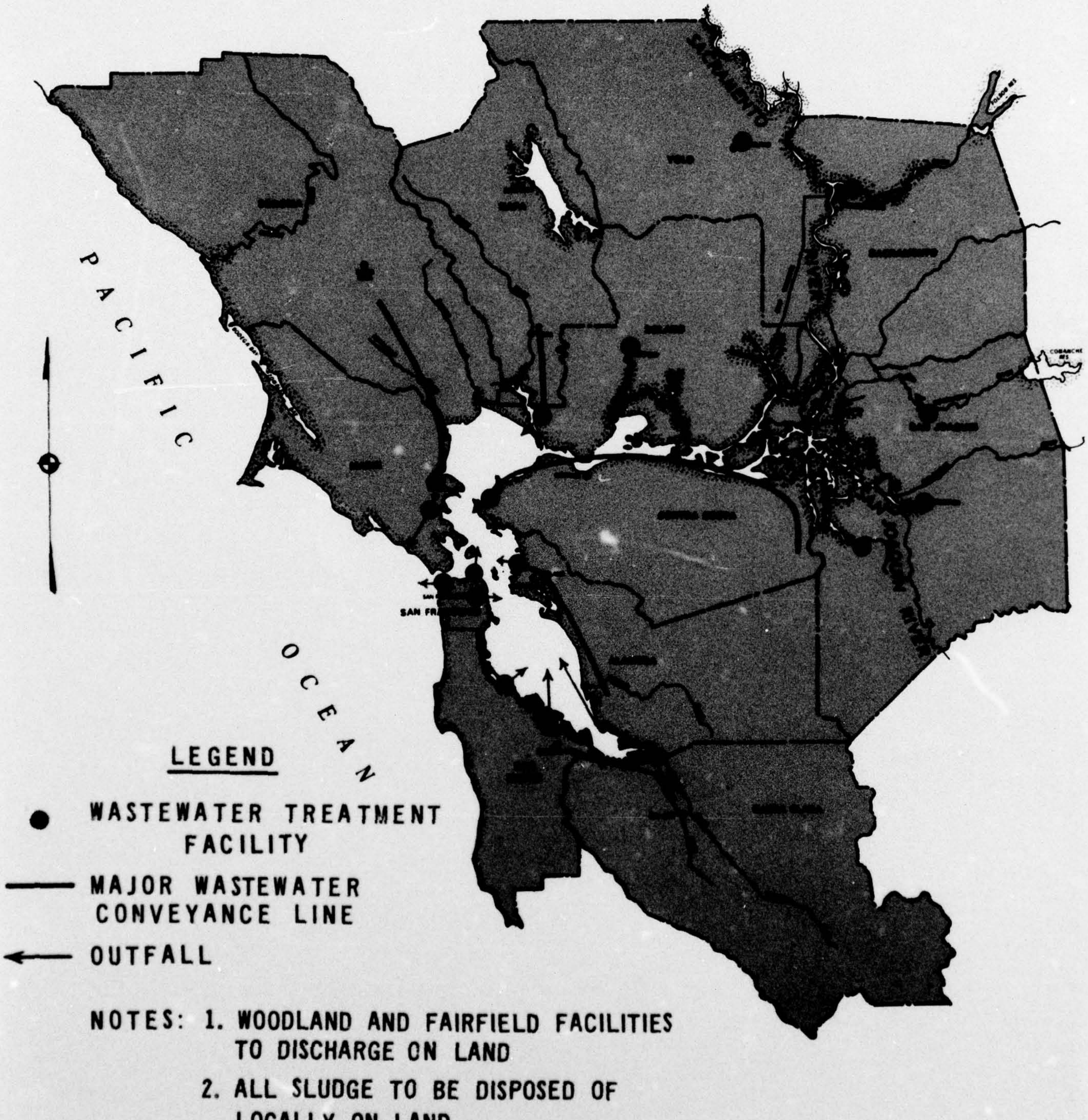
TIVES FOR S.F. BAY AND DELTA ESTUARY 3/

BAY	SACRAMENTO - SAN JOAQUIN DELTA
	5 MG/L
OTIC GROWTHS EXCEPT WHEN NON-CONTROLLABLE /L EASTERLY OF CARQUINEZ STRAIT.	MATERIALS STIMULATING ALGAL GROWTH SHALL NOT BE PRESENT IN CONCENTRATIONS SUFFICIENT TO CAUSE OBJECTIONABLE ALGAL DENSITIES. TOTAL NITROGEN CONTENT SHALL NOT EXCEED 1 MG/L IN CENTRAL DELTA; 2 MG/L IN WESTERN DELTA; 3 MG/L IN EASTERN DELTA.
ONS 7957 AND 7958,	FECAL COLIFORM COUNT LIMIT 200/100 ML.
	TO MEET PROVISIONS OF CHAPTER 5, TITLE 17, CALIF. ADMIN. CODE.
D).	INCREASE OF 0°F OUTSIDE OF MIXING ZONE (SPECIFIED BY REGIONAL BOARD). SURFACE TEMPERATURE LIMITED TO 4°F ABOVE AMBIENT IN MIXING ZONE.
	(SEE APPENDIX TABLE A-9)
	LESS THAN 50 JTU IN CENTRAL DELTA; LESS THAN 150 JTU ELSEWHERE EXCEPT FOR PERIOD OF STORM RUNOFF.
	OBJECTIONABLE QUANTITIES FROM OTHER THAN NATURAL CAUSES SHALL BE ABSENT.
UANTITIES SUFFICIENT TO CAUSE AN PLACE.	FLOATING OR EMULSIFIED GREASE AND OIL SHALL NOT BE PRESENT . . . IN OBJECTIONABLE QUANTITIES.
AT LEVELS WHICH RENDER AQUATIC LIFE OR	SHALL NOT BE PRESENT IN QUANTITIES SUFFICIENT TO BE HARMFUL TO HUMAN, PLANT OR AQUATIC LIFE.
S FOUND TO BE DELETERIOUS TO FISH OR	BIOCIDE CONTENT ... SHALL NOT EXCEED 0.6 MG/L ... NOR SHALL CONCENTRATIONS ... REACH THAT LEVEL FOUND TO BE DETRIMENTAL TO FISH AND WILDLIFE.
TROLLABLE FACTORS TO BE DETERMINED BY	6.5 TO 8.5
	APPARENT COLOR ... SHALL NOT BE VISIBLY ALTERED FROM ITS NATURAL APPEARANCE.
	OF OTHER THAN NATURAL CAUSES SHALL BE ABSENT ...
	... OTHER THAN OF NATURAL CAUSES SHALL BE ABSENT ...

2

FIGURE IV-2

BASE CONDITION



NOTES: 1. WOODLAND AND FAIRFIELD FACILITIES TO DISCHARGE ON LAND
2. ALL SLUDGE TO BE DISPOSED OF LOCALLY ON LAND

FIGURE IV-3

d. Industrial wastewaters to be included in municipal systems with "source-control" when necessary to insure levels equivalent to those of wastes currently entering municipal treatment plants.

e. All wastewaters to receive secondary treatment and disinfection prior to discharge. This is considered to be an average regional condition as the previously noted State "Interim Plans" call for higher treatment in some locations.

f. Sludge from treatment plants to be disposed of locally on land.

g. In order to provide a basis for comparison of the performance of the regional alternatives in the 1990 and 2020 time frames, the base condition was extended by the assumption that the facilities would be expanded by 1990 to handle the projected 2020 wastewater flows, maintaining an average of secondary level treatment. This is not meant to imply that State planning would result in such a system; as noted previously, the State's planning objectives call for continued upgrading of treatment and eventual removal of waste discharges from surface waters by recycling of treated wastewater.

5. STRATEGIES CONSIDERED

Four broad strategies or concepts, principally distinguished by the type of disposal, are considered for the management of municipal and industrial wastewaters originating in the study area. These concepts are:

a. Ocean disposal

b. Estuarine disposal

c. Land disposal

d. Combinations of the three foregoing concepts.

Ocean disposal of wastewaters has been practiced by coastal and near coastal communities for many years. The discharge of a given quantity of wastewater to the ocean usually has been assumed to have fewer adverse effects than the discharge of the same quantity of wastes to inland waters because of the greater quantity of water available for dilution and dispersion. Furthermore, this procedure eliminates wastewater discharges into sensitive estuarine areas. However, the ocean does not have unlimited capacity for assimilating wastes and the long-term effects of wastewater disposal on the ocean environment have not been fully assessed. From a management point of view, the fact that a large proportion of the population and industry of the San Francisco Bay-Delta area is located within 25 miles of the Pacific Ocean makes ocean disposal of wastewaters a logical alternative approach to a solution of the pollution problem.

Estuarine disposal of wastewaters has been used extensively in the San Francisco Bay-Delta area. Experience has shown that the capacity of an estuary for assimilating treated wastes is limited and that continued disposal gives rise to water quality problems such as: dissolved oxygen depletion; growth of algae; fish kills; and high levels of coliform bacteria in the receiving waters. Disposal in the Bay and Delta estuary has essentially relied on primary and secondary treatment processes to remove deleterious substances from wastewaters. Present technology for reducing biostimulatory and toxic effects of wastewaters has not been practiced on a large scale. Treatment resistant materials, such as certain industrial wastes and sludges, present special problems when estuarine waters are used for wastewater disposal.

Land disposal of wastewaters is also a common management method used on a small scale in many parts of the nation and world but is not prevalent in the Bay and Delta area. Land disposal is an alternative method that makes use of certain soil characteristics when wastewater is applied to irrigable land. The land disposal concept recognizes that wastes, when properly recycled, can be valuable resources. Nutrients applied to land are returned to the soil where they can be used by plants. Thus, land disposal can affect a reuse of wastewater and can be an integral part of a system of total wastewater management.

6. DESCRIPTION OF STRATEGIES CONSIDERED

A summary description of the strategies evaluated in this report and the alternative approaches developed to achieve each strategy are presented in following paragraphs. Details of the various concepts and alternatives are given in Appendix B.

Ocean Disposal Concept. This concept includes an extensive collection and conveyance system, a secondary or higher degree of treatment and a disposal system to the ocean which would provide a high degree of dilution. The degree of treatment would determine the amount of pollutant substances discharged to the marine environment. Other factors considered in determining the scale and framework of this concept are the environmental objectives for the estuary, impact on the ocean, flexibility to meet future growth, and opportunities for reuse of wastewaters. Average flows of municipal and industrial wastes in 1990 and 2020 would be about 1.2 and 2.2 billion gallons per day. Over 60 percent of these flows would be produced in Sub-areas A and C. Land required for implementation of this concept includes areas needed for conveyance and treatment facilities and for sludge disposal.

For the ocean disposal concept two levels of waste treatment are considered reasonable. The first level consists of secondary treatment. The second level comprises a chemical and biological advanced treatment system.

Based on the foregoing, four alternatives are probable under the ocean disposal concept.

a. Alternative I would convey all municipal and industrial wastes generated in the 12-county study area to a secondary treatment facility near Redwood City. Wastewaters from Marin, Sonoma, Napa, Solano, Yolo and Sacramento would be conveyed to a point near Benicia, thence by an underwater pipeline across Carquinez Strait to join the conveyance system for the remaining six counties for transportation to Redwood City. After receiving secondary treatment at the plant near Redwood City, the wastes would be discharged through an ocean outfall extending at least five miles from shore south of Pillar Point. This alternative has features in common with the marine disposal system recommended in the Final Report to the State of California San Francisco Bay-Delta Water Quality Control Program. The major differences are that the Bay-Delta Program system did not include the wastewaters from the Delta counties of Sacramento, San Joaquin and Yolo and proposed that only advanced primary treatment would be provided at the Redwood City facility.

b. Alternative II is the same as Alternative I, except that the wastewaters would receive advanced treatment. As the advanced treatment would reduce the concentration of pollutants in the effluent, the ocean outfall would only extend about a mile from shore.

c. Alternative III provides for two sub-regional systems. One system would convey all municipal and industrial wastes from the North Bay-Delta counties, with the exception of San Joaquin County, to a secondary treatment plant near Petaluma. The estimated waste flows to this plant would be 290 mgd and 640 mgd in 1990 and 2020, respectively. The effluent would be discharged to the Pacific Ocean through an outfall extending at least five miles from shore at Bodega Bay. The second system would convey all municipal and industrial wastes from San Joaquin County and Sub-areas A and C to a secondary treatment plant near Redwood City. The discharge from this plant would be disposed of in the ocean through an outfall extending at least five miles from shore south of Pillar Point. Average waste flows to the treatment facility would be 900 mgd and 1,530 mgd in 1990 and 2020, respectively.

d. Alternative IV, shown on Figure IV-4, is similar to Alternative III except that the wastewaters would receive advanced treatment and the ocean outfalls would only extend about one mile from shore. Land area needed for sludge disposal would be about 66,000 acres for both ocean disposal concepts using advanced treatment. As shown on Figure IV-4, the land disposal sites for sludge might be in the vicinity of Petaluma and southerly of the San Jose metropolitan complex.

Potential wastewater which could be available annually for reuse after treatment is about 90 percent of the incoming flow or 1.2 million acre-feet in 1990 and 2.2 million acre-feet in 2020 for all alternatives except I and III (secondary treatment).

Of the four proposals, Alternative IV is considered the best approach in view of trends in environmental objectives and flexibility for meeting future changing needs. The effluents discharged to the ocean would be of high quality and would have the least detrimental effects on the marine environment. Preliminary analysis indicates that the higher level of treatment provided by Alternative IV would quite likely reduce the number of uncertainties identified in the State Bay-Delta Program, namely that the system could have harmful effects on the waters and beaches in San Mateo, Santa Cruz and Monterey Counties. On the basis of the foregoing analysis, Alternative IV is selected as the one best representing the ocean disposal strategy. The major aspects of Alternative IV are shown on Figure IV-4. Alternative III, with secondary treatment, is discussed further in Appendix C and Chapter V, where the merits of advanced waste treatment as compared with secondary treatment are examined in detail.

Estuarine Disposal Concept. The development of alternatives to this concept considers the need to attain a high level of water quality in the estuarine environment. To attain such a level of "clean water," wastewaters generated in the study area would need a high degree of treatment and treated effluents would require conveyance to and disposal in areas of the estuary having high dilution capabilities. Opportunities for wastewater reuse should be favorable because of locational flexibility. Since estuarine disposal is a present wastewater management practice, alternative approaches should be able to make maximum use of the existing water quality control investments made by Federal, State and local agencies in recent years.

Five alternatives considering estuarine disposal are proposed. Each would require about 66,000 acres of land application area for sludge disposal.

SELECTED OCEAN DISPOSAL ALTERNATIVE

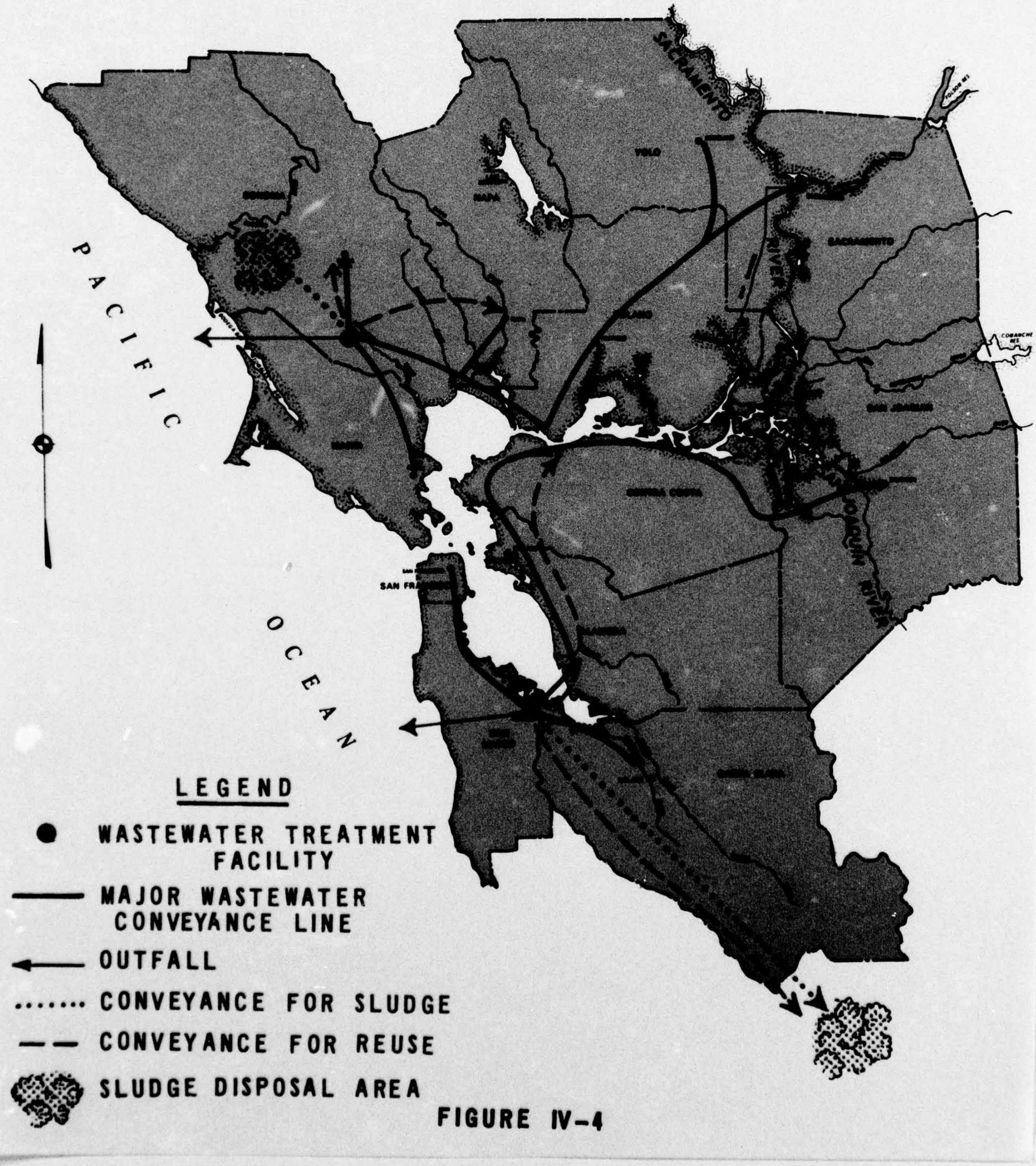


FIGURE IV-4

a. Alternative I, Regional Disposal, as shown on Figure IV-5, proposes the collection and advanced treatment of all municipal and industrial wastewaters at seven treatment plants. The high degree of treatment proposed permits reuse of the waters or allows discharge of the effluent to the estuary at treatment locations with an assumed high beneficial effect. Details concerning this alternative are contained in Appendix B. Table IV-1 contains a summary of the seven units of Alternative I.

All wastewaters in Yolo and Sacramento Counties would be collected and conveyed to a treatment facility near Sacramento. The treated waters could be available for the east side of the Central Valley.

Wastewaters in San Joaquin County would be collected and conveyed to a treatment facility near Stockton. The treated waters could be available for the east side of the Central Valley.

Collected wastewaters in Napa and Solano Counties would be conveyed to a treatment facility near Vallejo. The treated waters could be conveyed to Suisun Marsh to decrease salinity concentrations there.

The Contra Costa County wastewaters would be collected and conveyed to a treatment facility at Antioch. The treated waters could be introduced into the western Delta for flow augmentation to control salinity incursions.

All wastewaters in Sonoma and Marin Counties would be collected and conveyed to a treatment facility near San Rafael. The treated waters could be conveyed to northern Marin and Sonoma Counties to meet projected water supply deficiencies.

Wastewaters in San Francisco and San Mateo Counties would be collected and conveyed to a treatment facility at San Francisco. The treated waters are not assumed to have a reuse potential and, therefore, are discharged to the estuary through a deep outfall and diffuser in the Central Bay.

Collected wastewaters in Alameda and Santa Clara Counties would be conveyed to a treatment facility near Oakland. The treated waters could be conveyed to northern Alameda County and Contra Costa County to meet requirements for industrial use and power plant cooling.

TABLE IV-1

REGIONAL ESTUARINE DISPOSAL

Unit	Source Counties	Treatment Facility Location	Waste Flow (mgd) 1990	Waste Flow (mgd) 2020	Available Reclaimed Water (Thousand AFY) 1990	Available Reclaimed Water (Thousand AFY) 2020	Assumed Sludge Disposal Location
1.	Sacramento, Yolo	Sacramento	175	394	177	398	SE. Sacramento Co.
2.	San Joaquin	Stockton	66	149	67	150	E. San Joaquin Co.
3.	Alameda, Santa Clara	Oakland	356	553	360	558	E. Contra Costa Co.
4.	San Francisco, San Mateo	San Francisco	221	341	224	345	E. Contra Costa Co.
5.	Napa, Solano	Vallejo	63	133	64	134	Solano Co. and SE. Yolo Co.
6.	Contra Costa	Antioch	258	491	260	495	E. Contra Costa County
7.	Sonoma, Marin	San Rafael	50	115	51	116	Sonoma Co. and Marin Co.

b. Alternative II, Flow Augmentation at Antioch, proposes the collection of all wastewaters from major sources and transportation of these wastes to an advanced treatment facility at Antioch. Digested sludge would be disposed of on land in Solano County. The high quality effluent could be injected into the estuary at three locations: Suisun Marsh, the Sacramento River near Yolo Bypass, and the San Joaquin River near Stockton. The flow augmentation could be as follows:

Injection Location	Average Annual Augmentation Flows (In acre-feet per year)	
	1990	2020
Suisun Marsh	120,000	120,000
Sacramento River	806,000	1,555,000
San Joaquin River	275,000	523,000

If necessary, treated waters also could be used in Solano and Contra Costa Counties and in the Central Valley.

c. Alternative III, South Bay Discharge, is similar to Alternative II. All municipal and industrial wastewaters would be collected and conveyed to Alviso, and treated at an advanced treatment plant. The effluent would be discharged into San Francisco Bay south of Dumbarton Bridge to improve the circulation characteristics of the southern portion of the Bay. Flows added to the southerly part of the Bay would be 1.2 million acre-feet per year in 1990 and 2.2 million acre-feet in 2020. The high quality wastewaters could be available for other uses around or south of the South Bay. Sludge would be disposed of in southern Santa Clara County.

d. Alternative IV, Flow Augmentation for Suisun Marsh, also is similar to Alternative II, except that the advanced treatment plant would be located in the Fairfield – Suisun area and the effluent would be discharged in Suisun Marsh to reduce salinity accumulation and also to augment Delta outflows. Flows of 1.2 million acre-feet annually and 2.2 million acre-feet annually would be available in 1990 and 2020, respectively. Sludge would be disposed of in Solano County.

e. Alternative V, Combination Flow Augmentation, is a combination of Alternatives II, III and IV and provides three sub-systems as shown in Table IV-2.

Of the five estuarine disposal alternatives, Alternative I possesses greatest flexibility in that it could be readily converted, modified and incorporated into a regional or subregional wastewater reuse system. The location of potential discharge points provides maximum opportunities for estuarine improvement. Also, five of the seven treatment units are located near the Central Bay which has a high dilution capability. Thus, in the event of a system failure, there would be rapid dispersal of any resulting spill. Because of its greater flexibility and regional potential, Alternative I is selected to represent the estuarine disposal concept. The land requirements of Alternative I for sludge disposal would be 66,000 acres. Figure IV–5 illustrates the major aspects of Alternative I.

Land Disposal Concept. Land application of treated wastewaters can be accomplished on both a regional and a local basis. On a regional basis, the majority of wastewaters generated in the 12 counties could be conveyed to one or more large areas encompassing parts of several counties in the study area. On a local basis, treated wastewaters from each of the sub-areas could be conveyed to the nearest suitable land for disposal. Figure IV–6 shows the assumed gross land area available for land disposal. Depending on the characteristics of the land used for disposal, treated wastewaters could be applied to the land by spray or similar methods of application or such waters could be applied more directly by use of percolation ponds. In order to collect and reuse the wastewater, it would be necessary to underdrain irrigated land areas. The use of percolation ponds in areas with high infiltration rates would not require drainage facilities as the direct path to recharge of groundwaters would be involved. The direct recharge of groundwaters, however, places more stringent requirements on the quality of wastewater applied, as pumping from groundwaters can be for any combination of uses including municipal water supply.

In developing alternatives for the concept of land application the foregoing factors are taken into account. In addition, it is considered that before being applied to the land all wastewaters would receive the equivalent of secondary treatment by means of aeration lagoons and storage ponds located in the disposal area. The spray application rate of treated wastewater after disinfection would be eight feet per year. Such water application would be made over an eight-month period in a year and during the remaining four months (winter season), the water would be stored in reservoirs for application during the subsequent 8-month period. Depending on the type of reuse and the quality standards for such reuse, additional treatment might be required on underdrain water.

SELECTED ESTUARINE DISPOSAL ALTERNATIVE

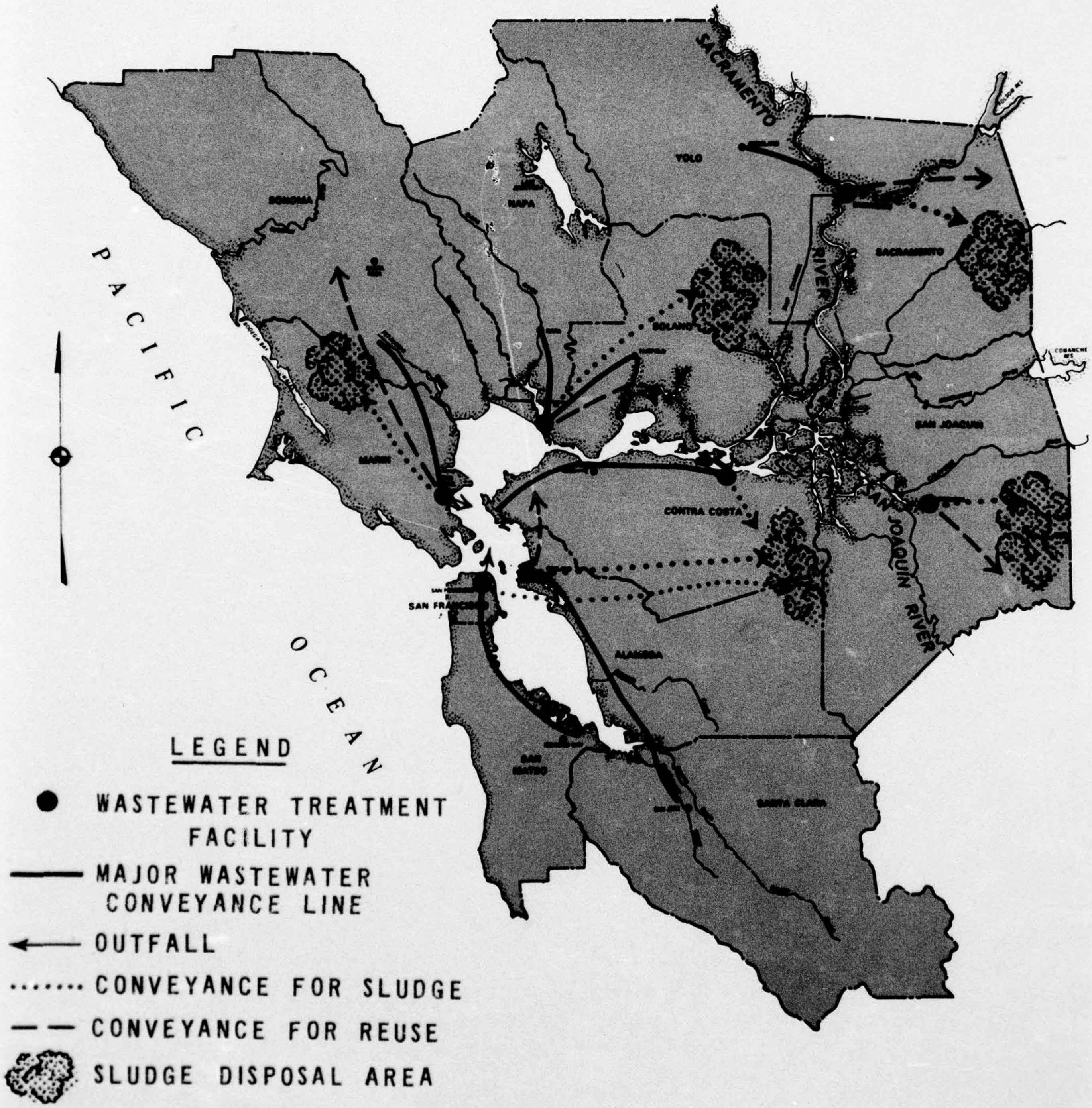


FIGURE IV-5

GROSS AREA AVAILABLE FOR LAND DISPOSAL OF WASTEWATER AND SLUDGE

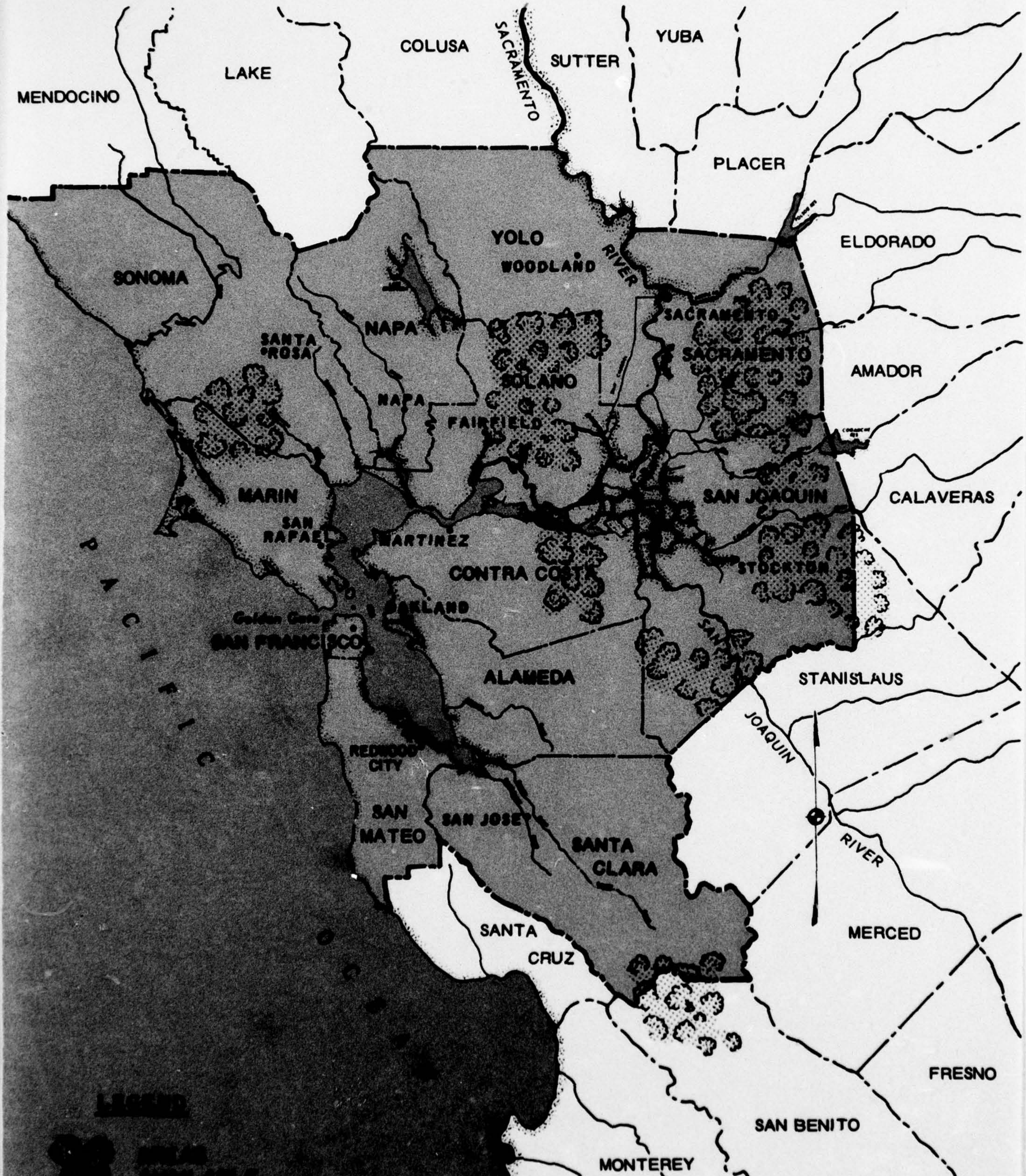


FIGURE IV-6

TABLE IV-2

COMBINATION FLOW AUGMENTATION

ALTERNATIVE V

Sub-System No.	Treatment Plant Location	Counties Served	Disposal Location: Effluent	Disposal Location: Sludge	Average Annual Estuarine Discharge (1,000 acre-feet): 1990	Average Annual Estuarine Discharge (1,000 acre-feet): 2020
1	Alviso	San Francisco, San Mateo, Santa Clara & Alameda	Estuary near Alviso	Santa Clara Valley	584	903
2	Antioch	Marin, Sonoma, Napa, Contra Costa & San Joaquin	Estuary near Antioch	San Joaquin County	442	895
3	Fairfield	Solano, Yolo & Sacramento	Suisun Marsh	Solano County	177	398

Four variations of land application by spraying are considered, the variations differing only in the location of the land area selected. For purposes of discussion, the four variations were designated Alternatives I to IV. A summary description of the four alternatives is presented in the following paragraphs. Additional details are presented in Appendix B.

a. Alternatives I through IV. All alternatives provide for the collection, conveyance, treatment and disposal of municipal and industrial wastewaters. Alternatives I through III involve collection of all wastewaters on a regional basis and conveyance to one of three large areas. Alternative IV provides for disposal on a local basis. Each of the alternatives would require about 185,000 acres and 335,000 acres of land by the year 1990 and 2020, respectively, for aeration lagoons, storage ponds and land application areas. Sludge would be disposed of as part of the treated application stream. Assumed locations of the land areas required for the alternatives are made on the basis of map studies of topography and soil structure.

On the basis that 50 percent of the applied treated wastewater would be reclaimable, as limited by evapotranspiration losses, each of the alternatives would have a reuse potential of 1.1 million acre-feet per year by 2020. The most favorable opportunities for use of the reclaimed waters appear to be for agriculture and for enhancing the estuarine environment; however, some industrial and municipal reuse potential exists.

b. Alternative V provides for the collection, conveyance, and treatment of wastewaters on a local basis. Treated wastewaters would be conveyed to percolation ponds in areas known to have high percolation rates. Public health factors and ground water conditions would dictate the level of treatment needed. About 10,000 acres of percolation ponds, 8,000 acres of aeration lagoons and storage ponds, and up to 66,000 acres for sludge disposal would be required to accommodate the projected wastewater flows in 2020. An annual application rate of about 300 acre-feet of wastewater per acre has been experienced in portions of the Bay and Delta area utilizing percolation ponds for groundwater recharge.

This alternative would have a wastewater reuse potential of about 2.2 million acre-feet by the year 2020. The constraints on reuse would be essentially provided by the natural conditions of soil structure, surface area of percolation soils, usuable storage capacities of underground aquifers, and expected uptake of solids by water in the aquifer during underground flow to locations of pumping for various uses. The uncertainties of these factors at this time preclude consideration of Alternative V as a representative strategy.

Alternatives I through IV for the land application concept are capable of meeting the projected waste flows for the entire study area through the year 2020. Also, all the alternatives are capable of modification to accommodate future technologies and changes in requirements. Alternative IV is considered the most viable, particularly from the viewpoint of economic and social impacts, as it would require a number of small land areas for disposal of treated wastewaters instead of one large area. This alternative would also be more flexible in relating to utilization of existing treatment facilities. The environmental impact on land areas would appear the same as for Alternatives I through III; however, the opportunities for enhancing the aquatic environment through reuse of treated wastewaters appear greater. For these reasons, Alternative IV is selected to represent the land application concept. The system for this alternative is shown on Figure IV-7.

Combined Concept. Alternatives were developed for this wastewater management strategy based on a combination of the three previously described concepts. After preliminary screening, six combined alternatives were selected for further analysis. They are described below and summarized in Table IV-3.

a. Alternative I provides for ocean disposal of wastewaters from Sub-area A (Figure II-5) and land application of wastewaters from Sub-areas B, C and D. This alternative would require about 200,000 acres for land application to handle wastewater flows of about 1,300 mgd in 2020.

b. Alternative II proposes ocean disposal for Sub-areas A and B and land application for Sub-areas C and D. About 160,000 acres would be required for land application to handle waste flows of 1,000 mgd from Sub-areas C and D in 2020.

c. Alternative III contemplates ocean disposal for Sub-area A, estuarine disposal for Sub-areas B and C and land application for Sub-area D. About 85,000 acres would be required for land application of 500 mgd in 2020.

d. Alternative IV provides for ocean disposal for Sub-area A and estuarine disposal for Sub-areas B, C and D.

e. Alternative V proposes estuarine disposal for Sub-areas A and C and land application for Sub-areas B and D. Approximately 130,000 acres of land application area would be required to handle a waste flow of 800 mgd in 2020.

f. Alternative VI provides for estuarine disposal for Sub-areas A, B and C, and land application for Sub-area D. About 85,000 acres would be required in 2020 for land application to handle the Sub-area D waste flows of 500 mgd.

TABLE IV-3

SUMMARY OF COMBINATION DISPOSAL CONCEPT ALTERNATIVES

Alternative	Sub-area	Disposal Concept	Flow (mgd) 1990	Flow (mgd) 2020
I	A	Ocean	577	894
	BCD	Land	612	1282
II	AB	Ocean	690	1142
	CD	Land	499	1034
III	A	Ocean	577	894
	BC	Estuary	371	739
	D	Land	241	543
IV	A	Ocean	577	894
	BCD	Estuary	612	1282
V	AC	Estuary	835	1385
	BD	Land	354	791
VI	ABC	Estuary	948	1633
	D	Land	241	543

SELECTED LAND DISPOSAL ALTERNATIVE

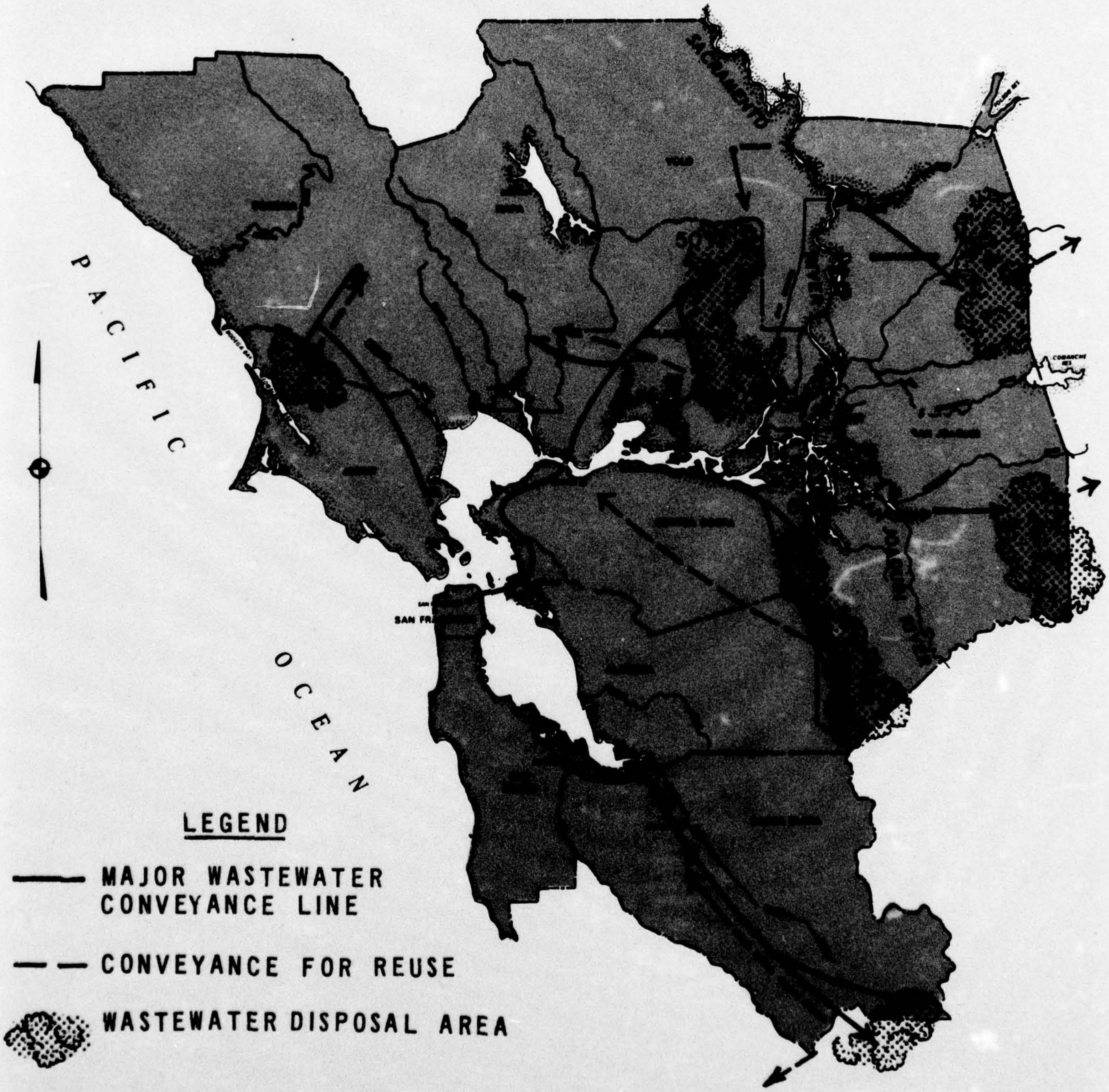


FIGURE IV-7

The screening process reflects the following considerations:

a. Potential availability of land and opportunities for reuse indicate that wastewaters from Sub-area D should have land application.

b. The eastern portion of Sub-area B is similar to Sub-area D and will be heavily influenced in the future by Sub-area D. All options of disposal methods for the western portion of Sub-area B would relate essentially to protection of the environment, with wastewater reuse opportunities about equal. For purposes of this study, further subdividing of a sub-area is not desirable; therefore, the land application concept favored for the eastern portion of Sub-area B should be selected for the entire sub-area.

c. Sub-area A, because of location, appears more favorable to ocean or estuarine disposal. Areas available for land application treatment are relatively remote and wastewater conveyances would have to overcome significant topographic features. The western portion of the sub-area (San Francisco to San Jose) is located more favorably for ocean disposal. The eastern portion of the sub-area (Oakland to San Jose) is more favorable by location for estuarine disposal. Estimated future wastewater flows are about equal between the east and west portions of the sub-area. Available information indicates that estuarine disposal would provide more opportunities for enhancing the aquatic environment and would make treated wastewaters available nearer areas of demand for reuse. Since it is not appropriate to divide sub-areas in this study, estuarine disposal should be favored for Sub-area A.

d. Either estuarine or land application is favorable to Sub-area C. Because of collection system requirements, ocean disposal is automatically eliminated if Sub-area A is not considered for ocean disposal. The western portion of Sub-area C, where the majority of existing and expected future wastewaters are generated, is closely related to Sub-area A by a continuous development configuration. Enhancement of the aquatic environment and opportunities for reuse of wastewaters appear to favor the estuarine disposal concept. Thus, estuarine disposal should be favored for Sub-area C.

The considerations above lead to selection of Alternative V as a representative combination disposal concept. There would be three advanced treatment plants (San Francisco, Oakland and Antioch) with sludge disposal on land in eastern Contra Costa County; land application concepts would be used in the northern and eastern counties of the study area (Sub-areas B and D). As formulated, the various units of this alternative have flexibility, reliability and opportunities as described under previous alternative concepts. Alternative V is shown on Figure IV-8.

Summary of Wastewater Management Strategy Alternatives. Table IV-4 and Figure IV-9 contain summaries of the four alternatives which are adopted as representative of the considered wastewater management strategies. The impacts of each alternative strategy are described in Chapter V, ASSESSMENT AND EVALUATION. As an aid in assessing the impacts, Table IV-5 shows the estimated waste loads discharged for the assumed base condition and those that would be discharged under the four selected regional wastewater management alternatives.

7. MAJOR TECHNICAL CONCEPTS

Conveyance facilities, utilizing prestressed concrete cylinder pipe for pipelines, were sized for peak flows. Pipeline routes are chosen to use the most favorable terrain characteristics and to avoid developed areas as much as possible.

Sewage treatment plants were sized on the basis of the total flow of the waste stream. Pumping facilities are designed on the basis of total flow and lift requirements.

Application of sludge slurry and treated wastewater (in the land disposal system) is by high-rate, gun-type sprinklers mounted on self-driven, movable rigs. The horizontal underdrains are spaced 25 feet on centers, based on a permeability of 1 gallon per day per square foot and a drain depth of 8 feet.

8. TECHNICAL FEASIBILITY AND MAJOR AREAS REQUIRING MORE INTENSIVE STUDY

The four alternatives all appear to be technologically feasible using state of the art methods. Major areas requiring more intensive study and further design refinement are outlined below:

a. It is assumed that there would be air injection devices at each lift station to prevent sewage from becoming septic during conveyance. Further study is required to determine whether this is a practical assumption and to determine quantities of air which would be required.

b. In disposal areas, a complete study of ground characteristics, including existing ground water tables and permeabilities, will be necessary to support assumptions made with respect to application rates and the underdrainage system.

c. Investigation should be made to determine the possible necessity of making the aeration lagoons and storage ponds (reservoirs) which are water tight. The possibility exists for contamination of aquifers.

d. Natural hazards such as faults and subsidence areas pose serious problems for pipeline integrity. Study must be made of various possible safety features both for preventing rupture under a minor disturbance and for limiting possible damage under a major disturbance. Necessary accessibility of pipelines in the vicinity of faults and in subsidence areas may dictate special construction. Also, the wisdom of concentrating sewage flows in two routes such as in the ocean disposal plan versus separating the flows geographically such as in the land and estuarine disposal plans should be examined.

e. Provisions for emergencies at pump stations will need more detailed analysis. Standby generators or interlocking substations or both will be required to assure no interruption of operation. It may also be necessary to provide storage facilities at lift stations for temporary holding in case of a pipeline break.

f. It is assumed that standard connecting joints on pipelines under the estuary are adequate. The critical importance of keeping untreated wastewaters out of the estuary will require further investigation of this subject.

SELECTED COMBINATION DISPOSAL ALTERNATIVE

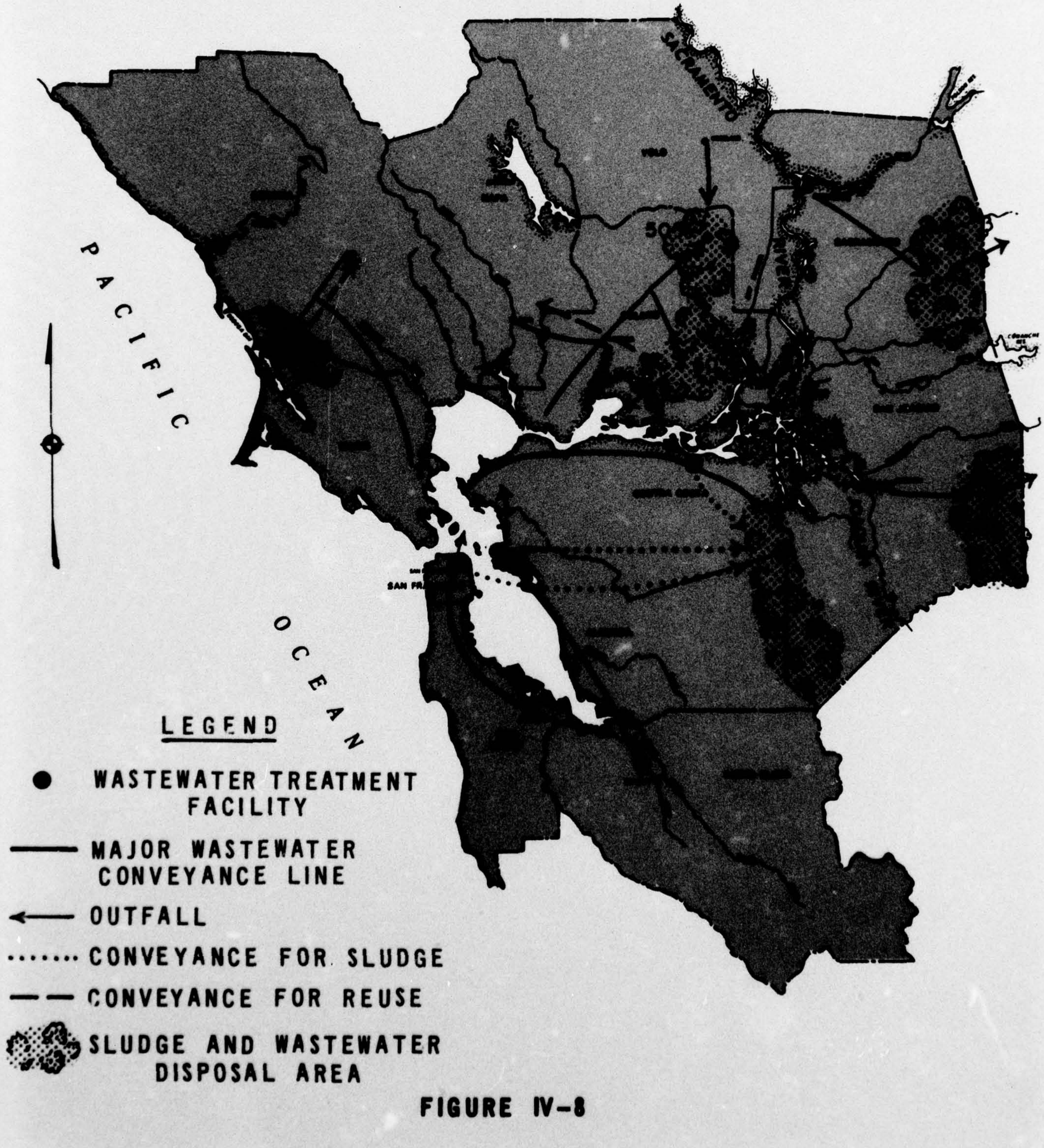
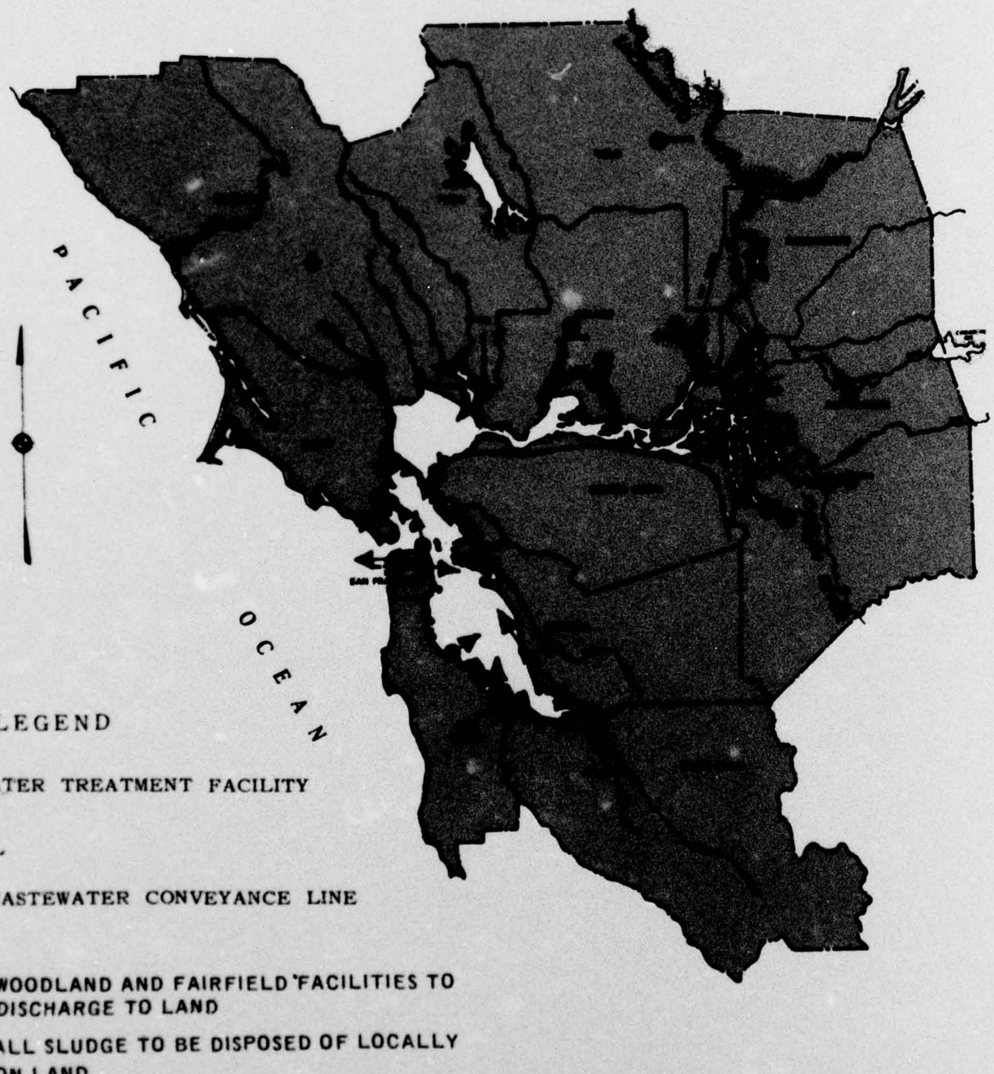


FIGURE IV-8

BASE CONDITION



LEGEND

● WASTEWATER TREATMENT FACILITY

← OUTFALL

— MAJOR WASTEWATER CONVEYANCE LINE

NOTES:

1. WOODLAND AND FAIRFIELD FACILITIES TO DISCHARGE TO LAND
2. ALL SLUDGE TO BE DISPOSED OF LOCALLY ON LAND

SELECTED DISPOSAL

LEGEND

● WASTEWATER TREATMEN FACILITY

— MAJOR WASTEWATER CONVEYANCE LINE

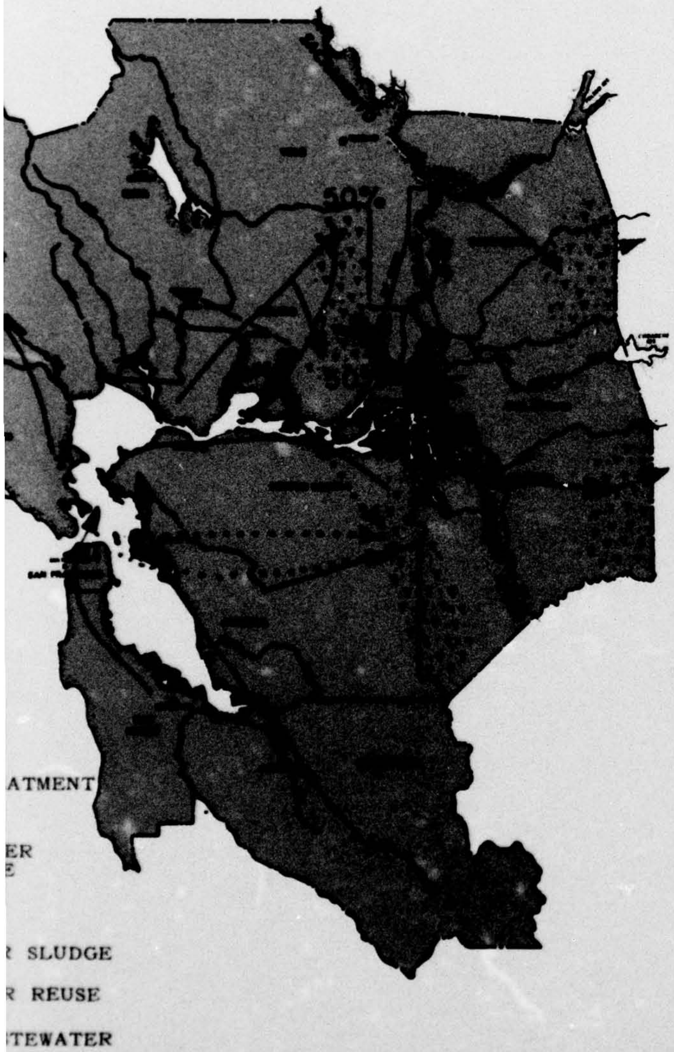
← OUTFALL

•••• CONVEYANCE FOR SLUD

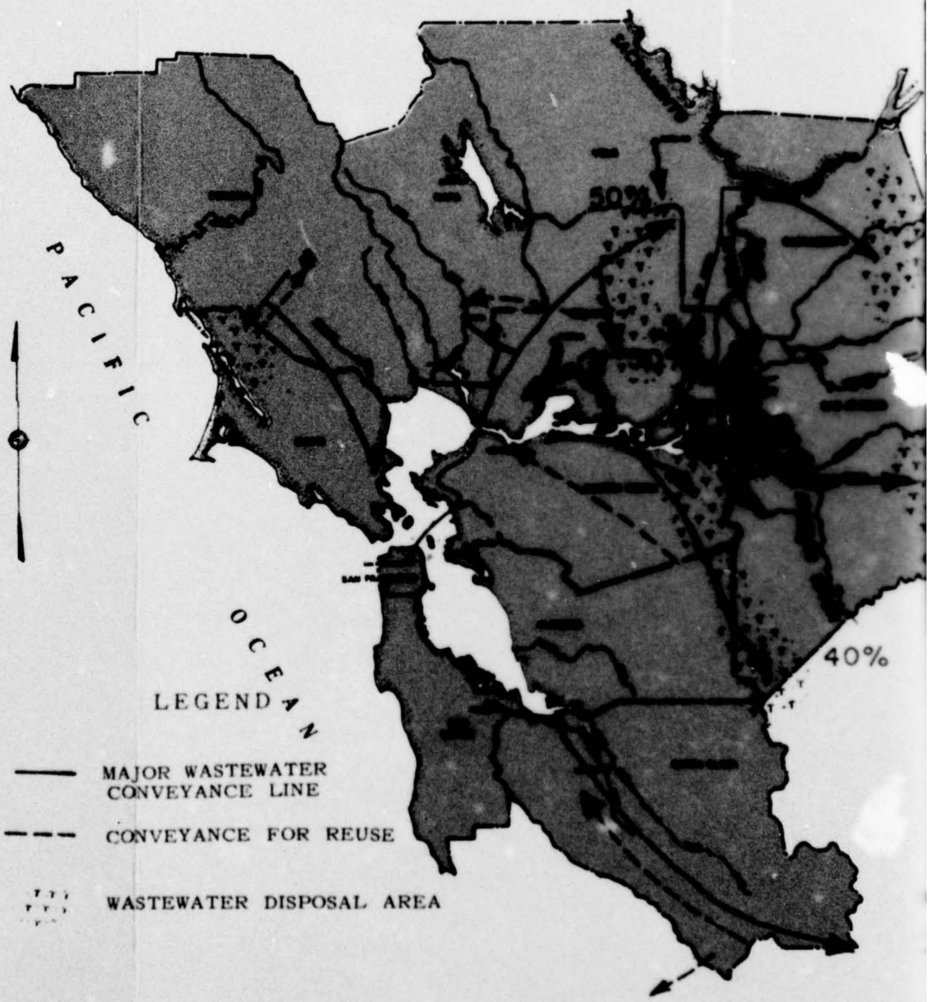
— — — CONVEYANCE FOR REUS

SLUDGE AND WASTEWAT DISPOSAL AREA

TED COMBINATION
SAL ALTERNATIVE



SELECTED LAND DISPOSAL ALTERNATIVE

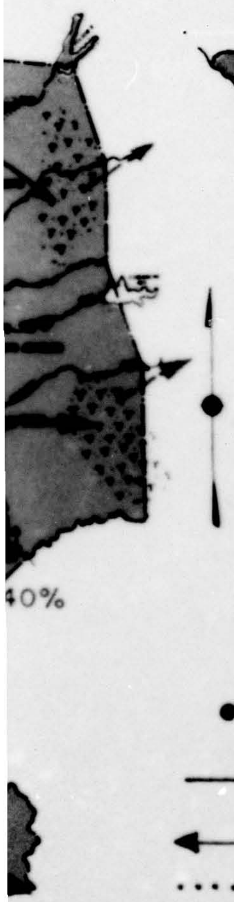


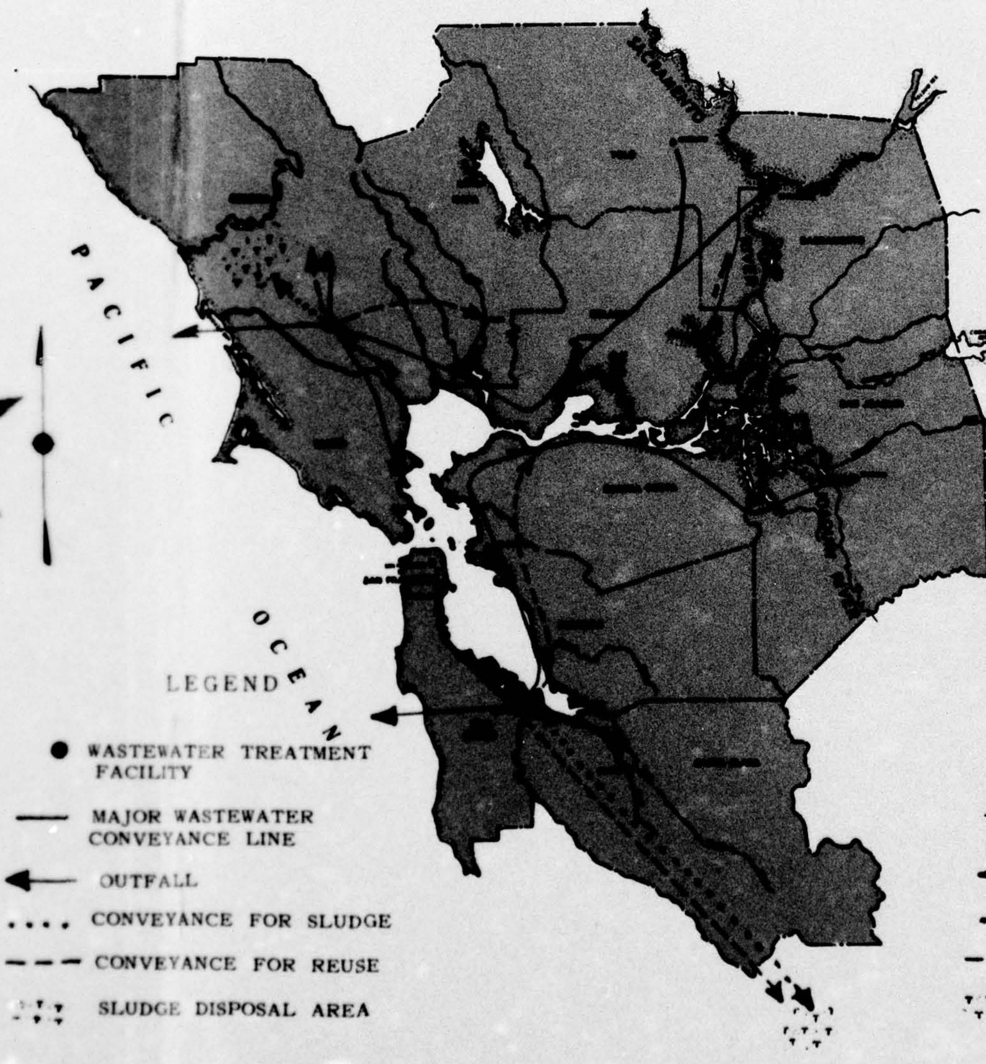
SUMMARY OF ALTERNATIVES

8

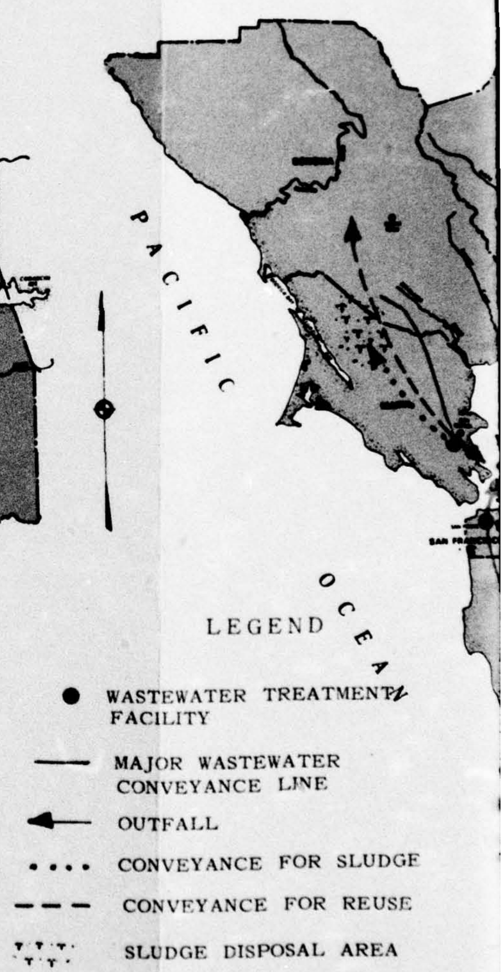
ES

SELECTED OCEAN DISPOSAL ALTERNATIVE





SELECTED EST
ALTE



, 3

AN DISPOSAL
ATIVE

SELECTED ESTUARINE DISPOSAL ALTERNATIVE

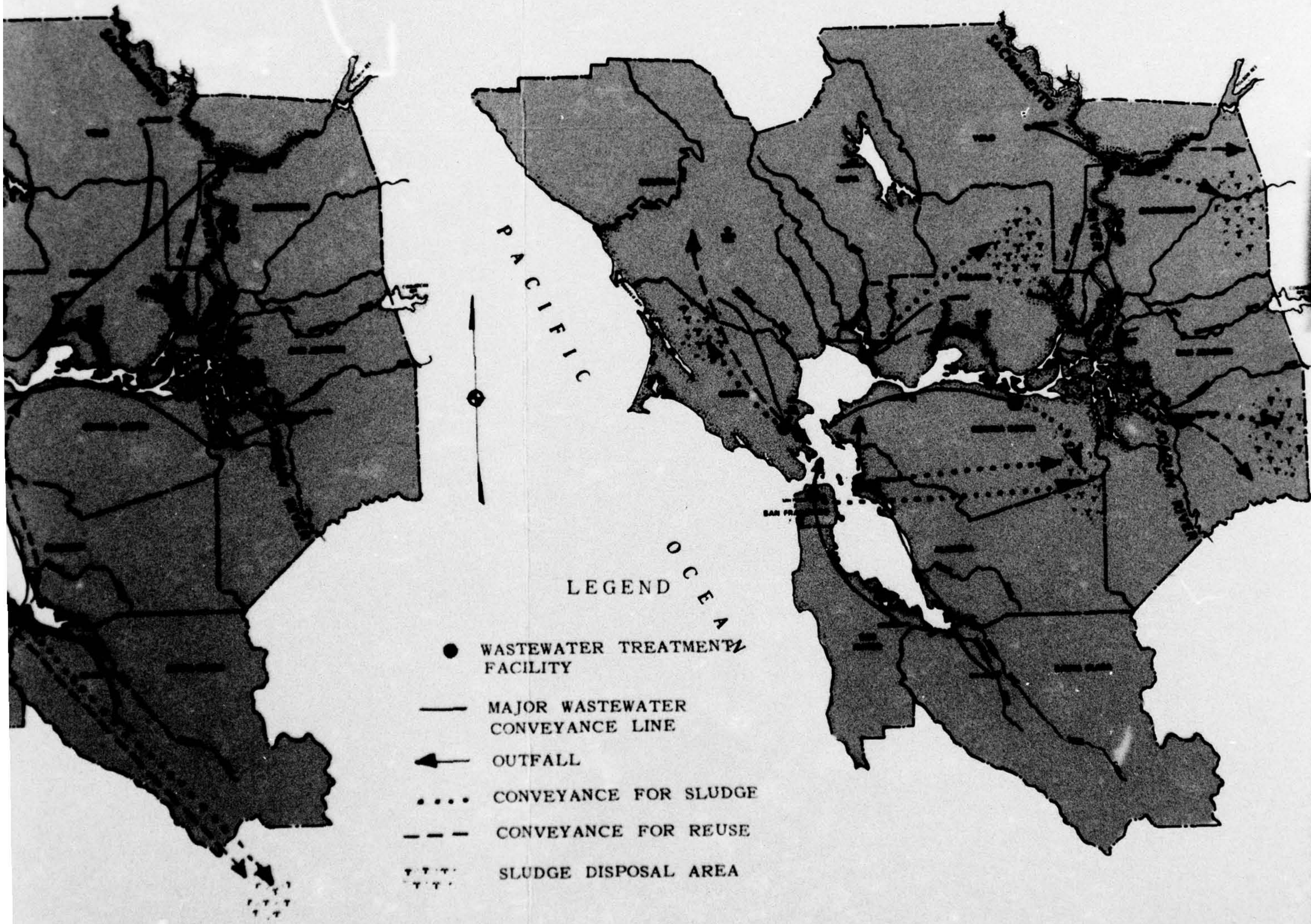


FIGURE IV-9

4

TABLE IV-4

SUMMARY OF WASTEWATER MANAGEMENT STRATEGY ALTERNATIVES

Concept	Disposal Locations	Flow (mgd) 1990	Flow (mgd) 2020	Land Disposal Areas (Acres) 2020	Wastewater Treatment	Reuse Opportunities of Treated Wastewaters
Ocean	Ocean waters off Marin County	228	642	66,000 (Sludge)	Advanced (Chemical and Biological)	Sub-area B
	Ocean waters off San Mateo County	901	1,534			Sub-area A. Sub-area C and San Benito County
Estuarine	Estuary	1,189	2,176	66,000 (Sludge)	Advanced (Chemical and Biological)	Sub-area A, Sub-area C Sub-area B (including Suisun Marsh) and Central Valley
Land	S.Santa Clara, N. San Benito; Solano, SE. Yolo; Marin, Sonoma; E. Contra Costa; SE. Sacramento; and E. San Joaquin Counties	1,189	2,176	335,000 (Treated wastewater including sludge)	Aeration ponds, storage lagoons, land application with subsequent soil filtration	All sub-areas, San Benito County and Central Valley
Combined (Estuarine)	Central Bay and Western Delta	835	1,385	42,000 (Sludge)	Advanced (Chemical and Biological)	Northern Sub-area A Sub-area B (including Suisun Marsh), Sub-area C and Central Valley
Combined (Land)	Solano, SE. Yolo; Marin, Sonoma; SE. Sacramento; and E. San Joaquin Counties	354	791	130,000 (Treated wastewater including sludge)	Same as Land Concept	

TABLE IV-5

ESTIMATED YEAR 2020 LOADS DISCHARGED FROM TREATMENT FACILITIES UNDER THE CONSIDERED CONCEPTS 1/
(1000 lbs/day, except as noted)

Parameter or Constituent	Base Condition	Ocean, (Advanced Treatment) and Estuarine	Land		Combination		
			After Aeration Lagoons	After Land Application	Land, After Application	Estuarine	Total
Flow (mgd)	2176	2176	2176	1088 2/	396 2/	1385	1781
BOD	815	163	1225	184	67	104	171
TN	1428	204	1430	644	234	130	364
TP	230	16	230	2	*1	10	10
TDS	7467	7467	7467	7467 3/	2715 3/	4752	7467 3/
TSS	459	46	230	2	*1	29	29
Oil & Grease	261	92	915	9	3	59	62
Flotables	30	2	100	1	*1	1	1
Phenols	1	*1	5	5	2	*1	2
Relative Toxicity (mgd) 4/	3112	44	3112	-	-	28	-
Gross Heavy Metals	40	1	95	28	10	*1	10

1/ Includes constituents present in flows that would be reused and in flows that would be wasted. Treatment removal of wastes assumed as shown on Figure IV-2.

2/ Assumes 50 percent evapotranspiration loss.

3/ May increase, due to soil leaching.

4/ Relative toxicity of wastes discharged from base condition treatment facilities and from land disposal aeration lagoons assumed to be 1.43 x flow (seconday treatment). Relative toxicity of wastes discharged under other concepts assumed to be 0.02 x flow.

* = Less than

- = No data available

CHAPTER V

ASSESSMENT AND EVALUATION

1. GENERAL INTRODUCTION

Rarely has man, in attempting to implement his dreams or desires, not caused some measurable change in the status of his surroundings. In prehistoric times, man's concern or even awareness of the changes he produced were overshadowed by his immediate problem of survival. As man's culture developed so did his awareness and concern for his surroundings, and for possible changes in his surroundings which his actions might cause. Today man is more concerned than ever with such changes and their effects. The concept of this chapter is directed toward this increased awareness.

Previous chapters have identified existing conditions and assumed future conditions against which assessments and regional wastewater management alternatives can be evaluated. Essentially, the existing regional situation is defined in regard to wastewater loadings and their observed impacts, then a series of assumed future regional situations is established, reflecting representative regional wastewater management systems. A base condition is assumed, to establish the regional situation as it will exist in the 1975 time frame; the base condition is then extended into the future, to permit comparative impact assessments and evaluations of the alternative regional systems.

Because of the complex nature of wastewater management problems, uncertainties can be expected to arise in the course of the assessment and evaluation process. Also, modification of some features of a selected alternative could result in minimizing, or eliminating, some adverse conditions identified in the assessment process. The base condition, serving as a comparative evaluation instrument, would present the greatest opportunities for such modifications. Further investigations will be needed to clarify uncertainties or to determine the most advantageous feature modifications for each alternative. The extent of these uncertainties and potential system modifications should be considered in reaching any judgments based on this report.

Chapter IV provided a description of treatment plants and their effectiveness in removing pollutants and presented conceptual locations and scope of facilities for each alternative. Reconnaissance-level design and cost estimates were then prepared for each regional system, identifying the more significant physical features required for implementation. Table V-1 summarizes these major physical features.

TABLE V-1

PERTINENT PHYSICAL FEATURES OF BASE CONDITION AND SELECTED ALTERNATIVES
(Based on Facilities to Handle Projected 2020 Wastewater Loads)

Features	Base Condition	Selected Alternatives: Ocean	Estuarine	Land	Combination
Land Area (Acres)					
Major Interceptors and Outfalls	1,350	4,100	1,560	3,300	2,200
Treatment and Disposal	66,000	66,000	66,000	335,000	170,000
Pipelines (Miles)	1,390	1,150	1,140	820	885
Pumping Power (HP)	79,000	1,100,000	78,000	266,000	131,000
Treatment Plants (Number/Type)	17/secondary	2/advanced	7/advanced	386/lagoons 1/	3/advanced 145/lagoons 1/

1/ Treatment consists of passing wastewater through aerated lagoons into storage reservoirs for subsequent land application. Each lagoon has a surface area of about ten acres impounding water to an average depth of 15 feet. Storage reservoirs with capacities to accomodate discharges during the 4-month winter season, when land application is doubtful, require about 16,000 acres for the land alternative and 6,000 acres for the combination alternative. The reservoirs impound water to an average depth of 50 feet.

2. ASSESSMENT

Assessment, as construed in this investigation, reflects the concept of change and classifications within which differences can be identified. Change implies a starting point and an end point, the former being the assumed base condition and the latter each of the selected regional alternatives, analyzed in succession.

For purposes of this study, the classifications of change categories are:

a. **Ecological Impacts**. Ecological impacts are simply changes that occur in the physical, chemical or biological components of an ecosystem. Usually, the changes are chain reactive in effect and therefore the entire ecosystem is affected.

b. **Social Well-Being Impacts**. Social well-being impacts concern those changes in the physical, spatial, and institutional factors of society which relate to human betterment and the overall quality of life of groups and individuals. The major areas of concern are area viability, public health, general amenity, and distributive equity considerations.

c. **Aesthetic and Recreational Impacts**. Aesthetic impacts are changes which affect man's sense of compatibility with his surroundings. Since each person has his own standard of what is pleasing to his eye or compatible to his surroundings, this analysis is highly subjective. Recreational impacts are more objective and easier to measure, since they include changes occuring in outdoor leisure time activities (hiking, boating, sightseeing, fishing).

d. **Public Health Impacts**. Public health impacts are changes which are of importance in human disease transmission, either by direct contact or through more complex interactions (such as biological magnification in food webs).

e. **Economic Impacts**. Economic impacts include changes in net income resulting from changes in water quality over the base condition. This feature of economic considerations is not completely encompassed by a combination of the other classifications of impacts.

Table V-2 summarizes the changes associated with each of the selected regional alternatives relative to the base condition. Additional details are presented in Appendix C.

3. EVALUATION

Impact evaluation is the step necessary to permit placing any judgment values on the findings of this report. The process provides understanding of the accomplishments, shortcomings, and consequences of the four regional wastewater management alternatives selected in Chapter IV. Such evaluation attempts to measure or to place a value on the impacts or changes, identified in Table V-2, which could reasonably be expected to result from each wastewater management alternative.

Evaluation procedures are oriented toward the objectives of water resources management since the disposition of wastewater is a part of this endeavor. These objectives are structured differently than impact classifications. An impact can be pertinent to one or more of the water resources objectives.

Four broad objectives for water resources management are used in the evaluation process. These objectives are defined as follows:

a. **Environmental Quality Objective**. Although social, aesthetic, and public health values are generally considered to be part of environmental quality, they will be discussed under the social well-being objective. Environmental quality is then reduced to its ecological context. As such, it is the improvement of the quality in existing ecosystems, in terms of health, diversity, productivity, and stability.

b. **Social Well-Being Objective**. This objective is directed to improving the physical quality of life and mental contentment of those influenced by the development of a wastewater management alternative, and to reinforcing the efforts and programs of various government agencies and groups in alleviating deprivation and enhancing the opportunity for group and individual fulfillment.

c. **National Economic Development Objective**. The national economic development objective is met by increasing the value of the nation's output of goods and services and improving national economic efficiency. National economic development includes:

(1) The value to users of increased outputs of goods and services resulting from a wastewater management alternative.

(2) Value of output resulting from external economies or the reduction of costs of adverse external economies (e.g., costs of pollution of rivers, bays and estuaries).

(3) Value of output from the use of unemployed or underemployed resources.

d. **Regional Development Objective.** This includes the components of other objectives listed above as they

TABLE V-2

IMPACT ASSESSMENT SUMMARY REFERENCED TO BASE CONDITION

Wastewater Management Alternative	Ecological	Social Well-Being	Aesthetics & Recreation	Public Health	Economic
Ocean Disposal	Reduces salinity concentration in ocean outfall areas. Increases salinity concentration in estuarine extremities. Decreases pollutants in the estuary and ocean. Protects estuary and land areas.	Slight increase in general health and sense of satisfaction within estuary. Possible adverse effects in parts of coastal zone.	Slight increase in estuarine recreation. Limited localized decrease in ocean recreation. Minor increases in water related recreation, on near shoreland areas.	Excellent removal of hazardous agents. Possible biological magnification problems. Decrease of human contact with pollutants.	Possible decline in income from ocean fishing. Decline in income from estuarine fishing unless compensating discharges of low salinity water are made from other sources. Minimal effects on land.
Estuarine Disposal	Provides low salinity water for Suisun Marsh and western Delta. Increases salinity in southern portion of estuary. Decreases pollutants in the estuary and ocean. High degree of protection to estuary & land areas.	Some slight increase in general health and sense of satisfaction within estuary area and coastal zone.	Slight increase in estuarine recreation. No significant change in ocean. Minor increases in water related recreation on near shoreland areas.	Excellent removal of hazardous agents. Possible biomangification problems. Slight decrease of human contact with pollutants.	Possible income increases in ocean and estuarine fisheries. Limited effects on land.
Land Disposal	Increases estuarine salinities. Provides low salinity water for Suisun Marsh. Decreases pollutants in the estuary. Localized atmospheric changes. Reduction in diversity of land areas. Changes to terrestrial indigenous biological communities. Possible long-term land contamination.	Eliminates major restriction on water uses and related potentials. Possible adverse conditions affecting general health and sense of satisfaction near or in land disposal areas.	Slight increase in estuarine recreation. No significant change in ocean. Some restrictions of recreational use on land; possible adverse aesthetic consequences.	Excellent removal of biological agents; potential problems of chemical agents. Decrease of human contact with pollutants. Decrease in biological-magnification problems. Possible increase in pest organisms which could transmit disease and toxins.	Increase in income from ocean and estuarine fishing. Possible adverse urban and agricultural land use changes.
Combination Disposal	Estuarine salinity conditions essentially the same as for estuarine disposal. Adverse conditions under land disposal reduced.	Changes similar to both land and estuarine disposal but adverse factors tend to be reduced.	Slight increase in water recreation. Some restrictions of recreational use on land; possible adverse aesthetic consequences.	Similar to changes for estuarine and land disposal but adverse factors tend to be reduced.	Similar to both estuarine and land disposal but adverse factors tend to be reduced.

apply to users or resources present in the Bay-Delta area. In addition the regional objective includes additional net income considerations accruing to the area from the construction or implementation of an alternative and from other economic activities induced by operation of an alternative.

For the evaluation process it is further necessary to define specific components of the four objectives to which a wastewater management program could contribute. The specific components of each objective utilized in this study are given in the following tabulations:

Environmental Quality

- Reduction in waste loads
- Quality of waters
- Eutrophication
- Fishery resources
- Marine communities
- Salt marshes
- Land resources
- Diversity in land use
- Space requirements
- Atmospheric effects
- Bioaccumulative toxicants
- Disease vectors
- Rare and endangered species and biotic communities
- Wastewater as a resource

Social Well-Being

- Area Viability
  - Employment conditions
  - Income configurations
  - Growth & development patterns
- Public Health
  - Conditions
  - Values
  - Attitudes
- Amenity
  - Sensory
  - Aesthetic
  - Convenience
  - Compatibility
- Distributive Equity
  - Increased opportunity for economic sufficiency
  - Equitable distribution of goods and services
  - Equitable sharing of benefits from environmental enhancement

National Economic Development

- Direct output increases
- Utilize unemployed or underemployed resources

Regional Development

- Increase regional income
- Increase regional employment
- Diversify the regional economic base
- Enhance environmental and social well-being conditions

Because there is only a limited history of the study of social well-being considerations in relation to regional development of public works, it is necessary to structure a specific procedure for social well-being evaluation. In summarized form the procedure is as follows:

(1) Relate regional alternatives to objectives of local and regional agencies and groups.

(2) Identify groups affected by regional alternatives to determine those served, benefited, physically displaced or indirectly physically influenced by the development.

(3) Relate regional alternatives to social programs of Federal, State, regional and local agencies involved in the areas of planning and education programs.

(4) Establish a framework of communication on regional alternatives with established citizens groups which advocate regional and local planning objectives.

The impacts and evaluation of social well-being in this report are based on interpretation of available information, which for the most part is not regionally oriented. The subject is not well defined and the state of the art not well developed, therefore, more detailed investigation will be required to bring objectives into focus and determine social well-being priorities in execution of regional projects. Details of the preliminary procedures used in this study and comments of consultants who reviewed the work are presented in Appendix C.

In summary, the evaluation procedure makes tentative measurements of the changes from the assumed base condition that would result from implementing each of the proposed regional alternatives. A change in one of the specific components of the four major objectives is beneficial if it meets a need; it is adverse if it operates in opposition to a need. Because of limitations on the scope of this reconnaissance-level study the evaluation is qualitative rather than definitive. The evaluation indicates the general character of performance that could be expected from each regional alternative but does not conclusively demonstrate either the superiority or the unacceptability of any system.

4. EVALUATION OF OCEAN DISPOSAL ALTERNATIVE

a. **Environmental Quality Objective.**

Relative to the base condition, projected waste loads discharged to the aquatic environment would be reduced. The amount of toxicants, nutrients, degradable organics and suspended solids discharged would be reduced. Improved water quality conditions from the reduced pollutant load would improve surface waters. The removal of waste discharges from the estuary could alter salinity patterns in Suisun Bay, the Delta and the southern extremity of the estuary. Similarly, ocean salinities would be reduced at outfall locations. The removal of nutrients from the estuary by this alternative would reduce the overall potential for seasonal algal blooms and associated low dissolved oxygen problems. Estuarine areas, receiving nutrients from sources outside the study area or from internal stream flow, could experience increased eutrophic rates because of increased residence time caused by eliminating the flushing effects of wastewater discharges. Residual nutrients passing through ocean outfalls could increase the eutrophic rate in the local areas around the ocean outfalls. The removal of wastes from the estuary would improve the status of estuarine and anadromous fisheries. This alternative would reduce the amount of toxic wastes entering the Gulf of the Farallones which would be expected to improve the fishing potential in that area. The migratory patterns of anadromous fish, market crab habitat, and pelagic planktonic forms could be disrupted by low salinity discharges from ocean outfalls. The problems of direct toxicity and coliform level would be reduced rendering bay shellfish suitable for human consumption. The low salinity discharge off Marin County could alter biotic communities in Bodega Bay and Tomales Bay by shifting salinity gradients. The southern discharge would have less severe environmental effects because of the greater dispersion potential in that area. Marine communities in the Gulf of the Farallones would be expected to improve if planktonic forms are not damaged traversing discharge sites. Salt marshes could be adversely changed by reduced flushing flows. Rare and endangered species within the salt marsh community could be threatened. The major land resource impact would be in the sludge disposal areas where the concentration of pollutants would be increased. This increased concentration of pollutants could reduce the diversity of land use and increase the potential of polluting underground waters. Land use requirements are the same as for the base condition. Climatic and atmospheric effects would be comparable. Bioaccumulative toxicants would be significantly reduced in the estuary while a limited discharge, of a localized nature, would be introduced into the ocean. There would be a reduced potential for contamination of marine species and coastal zones. Reclaimed wastewater could be retained as a resource and distributed to enhance the environment as desired.

b. **Social Well-Being Objective.**

(1) Area Viability. Long-term enhancement to employment and income related to water-oriented activities, especially ocean fishing, should occur for the coastal localities as well as the region as a whole by the advanced treatment.

The opportunities for varied spatial distribution development choices would be greatly enhanced concerning commerical water-related activities and recreation as a result of this alternative. Also, as a result of less wastewater pollutants entering the hydrosphere, the traditional water-related character of the region should be greatly benefited over time and result in less restrictions for overall regional and sub-area development.

Due to the reuse potential of reclaimed wastewater, the potential suburban and rural development opportunities could produce long-term benefits to employment, diversity, and income levels. Also, the benefits of additional sources of water supply for all areas would offer many choices for optimum regional growth dispersion.

(2) Public Health. This alternative contributes to the achievement of public health objectives by significantly lowering the mass emission of toxic agents and by using the assimilative capacity of the hydrosphere. However, this plan does introduce some increased hygienic risk because larger pollutant loads are transported to land areas, via sludge disposal.

(3) Amenity. The sludge disposal sites selected in Marin/Sonoma and Santa Clara/San Benito Counties have very high cumulative aesthetic characteristics. Use of such areas for sludge disposal could have long-term detrimental effects to much larger areas, not only visibly, but for future development potential and overall environmental amenity due to the existing vegetation and undulating land form patterns with their strongly defined sense of place. Ocean disposal places greater requirements for sludge application in these critical locations. The mental prejudices, customs, and phobias associated with treated wastewater for agricultural use and human consumption could still be a detriment to existing value systems of individuals.

(4) **Distributive Equity**. The matters discussed herein are common to all wastewater management alternatives and are of priority concern. Many social concerns regarding the distributive equity of income, employment, recreation, or displacement, and questions of opportunities and benefits from development are vital to the social well-being aspects of the alternatives. Therefore, any alternative, to benefit all of society, must coordinate physical planning programs with social planning programs through definitive avenues with the goal of mutual program enhancement. The role of those agencies responsible for planning physical systems must be to assist agencies responsible for social planning and betterment, not to assume the social planning role themselves. The development of any of the alternative wastewater management plans should address these objectives.

c. **National Economic Development Objective**.

Quantified net income factors that are addressed in this report are related to some of the evaluation findings under the environmental quality objective. In addition, a quantified approximation is made of the underemployed resource of treated wastewater. From the evaluation of environmental factors, it is estimated, in magnitude terms, that the ocean disposal alternative will increase net income over the base condition, because of the reduction in discharged pollutants and health factors as follows:

(1) General Recreation	$62,000,000
(2) Sport Fishing	10,000,000
(3) Commercial Fishing	5,000,000
Total	$77,000,000

The ocean alternative, by eliminating low salinity discharges in Suisun Bay and the western Delta, could impact adversely on wildlife (hunting) and sport fisheries because of increased salinity gradients. Quantification, at this time, of these factors is not possible.

The ocean alternative presents a reclaimed water potential of 1.2 million acre-feet in 1990 and 2.2 million acre-feet in 2020. In close proximity of the treatment plants, a value of $90 per acre-foot would be representative; at more distant locations, inland and closer to other potential water sources, the value would reduce to $40 to $50 per acre-foot. Preliminary cost estimates of first investments for regulation and transport of reclaimed water to the more distant locations reflect about $1,000 per acre-foot of capacity, which when converted to an average annual value per acre-foot would make reclaimed water marginally competitive. Thus, localized delivery is more favorable to utilizing this resource but expected demands would be substantially less than available quantity.

First cost estimates of the ocean alternative indicate an investment of $4.1 billion in 1975 and an additional investment of $3.1 billion in 1990. Estimated average annual charges for interest and amortization, operation and maintenance would be $472 million over a 100-year economic life assuming an interest rate of 5-1/8 percent. Features constructed by 1975 were designed to meet 1990 needs with features added by 1990 to meet 2020 conditions. The estimated first cost of the ocean alternative is 40 percent higher than the assumed base condition and estimated average annual charges 30 percent higher. More details on costs are presented later and in Appendix D.

Qualitative economic evaluation factors, pending detailed investigation, are:

(1) Sludge disposal areas concentrated in two areas in close proximity to the ocean coast for the ocean disposal versus several at scattered locations for the base condition could have greater adverse economic impact.

(2) The ocean alternative land requirements for treatment and interceptor facilities could involve less valuable shoreline areas suitable for many purposes than the base condition.

(3) Underemployed human resources might be more readily applied with a comprehensive regional plan.

(4) Industrial investment for "source control" of pollutants might be reduced with a comprehensive regional plan.

The above discussion indicates that national economic activity would be in a more favorable position over the long term with the ocean disposal alternative, than with the base condition.

d. **Regional Development Objective**.

The ocean disposal alternative provides a solution for the expected future problems of the Bay and Delta region for municipal and industrial wastewater dischargers. Economic evaluation for the region would be the same as under the national economic development objective. Recreational beneficial effects would be essentially regionally oriented, however, commercial fishery benefits might be only partially shared by the region because ocean enhancement affects a wider area. A portion of the reclaimed wastewater potential could involve areas outside the region and, therefore, the region might have to share such a benefit with other areas. The region would have to participate in larger investments for wastewater management.

Environmental quality would experience a net enhancement of significant scope. However, such net enhancement would result in certain specific adverse impacts in the environment. The beneficial aspect would be reduced pollutant loads in the estuary and ocean with resultant improvement of their waters and nearshore areas. Increased salinity in the eastern and southern extremity of the estuary would have adverse effects on life forms dependent on specific salinity conditions. Also, resulting changes in salt marsh vegetation would adversely effect wildlife recreational potential. The ocean and shoreline areas in the vicinity of outfalls could be adversely affected by low salinity discharges. The shellfish potential for human consumption would be increased. Reclaimed wastewater could be used to enhance the environment or mitigate adverse effects if desired. Sludge disposal areas for the ocean disposal alternative are of overall higher environmental quality than the base condition. With the possible exception of changes in ocean resource conditions, all environmental beneficial and adverse effects would be related to the region.

In the area of social well-being, the ocean disposal alternative would increase employment and income associated with water-oriented activities. Spatial distribution opportunities for development, regional or by sub-area, would be enhanced. Reclaimed water could produce long-term benefits in employment and income levels, the degree depending on use. Ocean disposal is the most favorable of alternatives from a public health viewpoint. Amenities associated with the estuary would be enhanced; in the ocean associated areas a probable change in conditions with an overall minor enhancement would occur; in the sludge disposal areas, because of location, there would be an adverse effect. All social well-being consideration, favorable and unfavorable, would be essentially related to the region except that reclaimed water, ocean changes, and sludge area impacts might also affect other areas.

The ocean disposal alternative, relative to the base condition, provides additional regional opportunities in: economic activities; meeting future environmental objectives; and, enhancing social well-being.

5. EVALUATION OF ESTUARINE DISPOSAL ALTERNATIVE

a. **Environmental Quality Objective.**

By virtue of its advanced biological and chemical treatment process this alternative would greatly reduce the pollutant load entering the aquatic environment compared to the pollutant loads projected for the base condition. The treatment process would remove nearly all toxicants and nutrients from the wastewater leaving an effluent comparable to the receiving waters. Overall improved water quality conditions would improve surface waters. Discharge of treated wastewater to the estuary would increase the flushing efficiency of the system and help maintain natural salinity gradients. Ocean salinities would not be altered. Nutrient loading in the estuary would be greatly reduced by the treatment process thereby, reducing the frequency of seasonal algal blooms and low dissolved oxygen problems in the South Bay and Delta. Removal of wastes plus flushing flows would improve environmental conditions for all fishes inhabiting or using the Bay-Delta system. The Gulf of the Farallones would be improved over the condition projected for it in the base condition. The low salinity water provided by this alternative could not only enhance shellfish habitat, but also help maintain the marshes around the bay. More importantly, treated water would be available to maintain desired salinity in Suisun Marsh. Sludge disposal would limit both land use and land resources, since the concentrations of pollutants would be increased in the disposal areas. Land use requirements for this alternative are the same as for the base condition. Climatic and atmospheric changes would be negligible, at most. The treatment process would reduce bio-accumulative toxicants in the hydrosphere to those entering the system from outside the study area. Wastewater could be fully utilized as a resource.

b. **Social Well-Being Objective.**

(1) **Area Viability**. With respect to the base condition, the estuarine disposal alternative would provide more wastewater with a higher degree of treatment for flow augmentation in the northern part of the estuary and in the Delta. Flow augmentation should benefit water-related commercial and recreational development opportunities in the study area. Under the base condition there is a threat of long-term accumulations of toxicants in the aquatic environment which might possibly offset the benefits from these opportunities. This alternative would significantly reduce such threat. Sludge disposal in portions of six counties would probably be detrimental to existing and future agricultural developments as well as to the associated employment and income opportunities of groups and individuals dependent upon the maintenance and growth of existing agricultural patterns. In Solano County these possible detriments might be amplified by the current decline of existing agricultural employment in the county.

(2) **Public Health**. This alternative contributes to the achievement of public health objectives by significantly lowering the mass-emission of toxic agents and by using the assimilative capacity of the hydrosphere. However, compared to the base condition this plan may introduce some hygienic risk in sludge disposal areas because larger pollutant loads would be transported to these land areas.

(3) **Amenity**. This alternative should benefit the overall aesthetic perception of the estuary due to increased flow augumentation and decreased pollutant loads discharged.

Although recreational opportunities are not expected to be greatly impaired under the base condition, the estuarine alternative should allow more opportunities for a variety of developments throughout the Bay and Delta region.

Sludge disposal would be detrimental to the aesthetic character of the disposal areas in terms of visual and possibly odorous perception. Although the sludge disposal sites would be visually prominent in all the areas, the highly visual character of the valley enclosures in the Marin/Sonoma area could be substantially detrimented. Also, the amount of available open space for future recreation or other development opportunities in all the areas could be restricted.

c. **National Economic Development Objective.**

Quantified net income in this report is related to some of the evaluation findings under the environmental quality objective. In addition, a quantified approximation is made of the value of reclaimed wastewater.

From the evaluation of the environmental quality objective, it is estimated that the estuarine disposal alternative, by reducing the pollutant loads discharged to the aquatic environment and providing more favorable health factors, would increase the annual net income over the base condition. The estimated increase in annual net income is as follows:

(1) General Recreation	$62,000,000
(2) Sport Fishing	10,000,000
(3). Commercial Fishing	5,000,000
Total	$77,000,000

This alternative presents the potential for reclaiming 1.2 million acre-feet of wastewater in 1990 and 2.2 million acre-feet in 2020. Since three of the seven advanced treatment plants are located near the coast, $90 per acre-foot would be a representative value of this reclaimed wastewater. Representative values of reclaimed wastewater from the four inland treatment plants would be around $40 to $50 per acre-foot.

If reclaimed wastewater is conveyed away from the immediate areas of the treatment plants to more distant areas for reuse, preliminary first costs of conveyance and regulatory storage facilities would be $1,300 per acre-foot of capacity. When this cost is converted to an average annual value, reclaimed wastewater would be marginally competitive with other water supply sources. Thus, reuse in the vicinity of the treatment facilities is more favorable, but projected demands are expected to be less than the available supply.

Estimated first cost of the estuarine disposal alternative would be $2.8 billion in 1975 to handle projected 1990 waste flows, and an additional $1.9 billion in 1990 to handle projected 2020 waste flows. Total estimated average annual charges for interest and amortization; and operation, maintenance and replacement would be $331 million over a 100-year economic life, assuming an interest rate of 5-1/8 percent. The total estimated first cost of estuarine disposal is approximately 90 percent of that of the assumed base condition. The total estimated average annual charges are approximately 90 percent of those of the base condition. More details on costs are presented later and in Appendix D.

Other economic factors are qualitatively assessed as follows:

(1) Sludge disposal is concentrated in five areas for estuarine disposal versus disposal in several scattered areas for the base condition, thus could have greater adverse economic impact.

(2) Land requirements of the estuarine disposal alternative for treatment and conveyance facilities could involve less use of valuable shoreline areas suitable for many purposes than under the base condition.

(3) Underemployed human resources might be more readily applied with a comprehensive regional plan.

(4) Industrial investment for "source control" of pollutants might be reduced with a comprehensive regional plan.

The above discussion indicates that national economic development would be in a more favorable position over the long term with the estuarine disposal alternative.

d. **Regional Development Objective.**

The estuarine disposal alternative would produce similar, but not identical, accomplishments to the ocean disposal alternative with respect to economic development. Some additional benefits to the region may be incurred due to repulsion of salinity which low salinity estuarine discharges may provide. Commercial fishery aspects, recreational potential, and benefits from wastewater reuse would not be significantly different from the ocean disposal alternative.

The estuarine disposal alternative would have a net beneficial impact on environmental quality considerations. The main changes over the base conditon would be an upgrading of water quality in the Bay-Delta estuary and the Gulf of the Farallones due to the lower amount of wastes discharged. Such improvement in water quality would benefit the aquatic and marine organisms in these areas by reducing both acute and chronic environmental stresses. Furthermore, as long as highly treated low salinity wastewater is discharged to the Bay-Delta estuary, possible salinity changes due to removal of this flow (as in the other alternatives) would be avoided. Shellfish consumption by humans would probably increase. Sludge disposal areas for this alternative would not differ appreciably from the base condition since the areas affected are the same. All environmental benefits and detriments would be related to the region with the exception of possible benefits resulting outside the region due to increased anadromous fish runs.

Social well-being changes would be generally beneficial for this alternative. Water-oriented activities in the Bay-Delta estuary would show a net increase due to improved water quality. However, relative to the other alternatives, this increase may not be as large since complete eliminatior of all discharges from the Bay-Delta waters (as under the other alternatives) may provide slightly higher social benefits. From consideration of public health factors, this alternative would be an improvement over the base condition but not provide quite the degree of protection to humans that the ocean disposal alternative would. The same is true of general amenities. In fact, this alternative would provide improvement for most social well-being catagories such as employment, income, and development; but may not reach the level of accomplishment as the ocean disposal alternative.

The main regional benefits expected from this alternative could be categorized as increased economic activities and environmental quality and enhancement of social well-being. While improvements in all would be accomplished, relative to the base condition, the absolute level of accomplishments relative to other alternatives is related to trade-offs.

No significant differences from the ocean disposal alternative would occur outside the region.

6. EVALUATION OF LAND DISPOSAL ALTERNATIVE

a. Environmental Quality Objective.

By applying treated wastewater and sludge to land, the discharge of urban wastes to the estuary would be eliminated. The amount of toxicants, nutrients, degradable organics, and suspended solids discharged to the aquatic environment would be substantially reduced over the base condition. Water quality conditions in the estuary and coastal waters would be improved. Eliminating urban waste discharges from the estuary could increase salinity concentrations in the western Delta and Suisun Bay, with the result that additional upstream releases of water would be necessary to maintain water quality conditons required by the State of California. Salinity concentrations in the southern extremity of the estuary would also increase. If nutrients are retained on the land, the potential for seasonal algal blooms in the Delta and in the southern extremity of the estuary would be reduced. However, nutrients from sources other than urban discharges would still enter the estuary. By eliminating the flushing effects of urban discharges, the residence time of these nutrients in the estuary could be increased. Thus, there would still be a potential for seasonal algal blooms. With improved water quality conditions, the anadromous and estuarine fisheries would be maintained. By reducing the amount of toxic wastes discharged, the coastal fisheries would be protected. The biotic communities as well as crabbing in the Gulf of the Farallones would be improved. Shellfish in the estuary would be suitable for human consumption. The potential for rehabilitating the oyster industry in the estuary would be increased. Eliminating urban discharges to the estuary may provide the impetus for new industries to locate away from the perimeter of the estuary. Preservation of remaining salt marshes would be aided. Use of treated wastewater which has been filtered through soil to flood Suisun Marsh would maintain the existing marshland community. However, removal of toxicants would have to be equivalent to that removed by advanced treatment; this is uncertain. Land application of treated wastewater and sludge would require approximately 335,000 acres by 2020. Depending on whether these areas have multiple use, this alternative would be competitive with other demands for use of the land area. The existing dry land life forms would be changed to wetlands species. Humidity would be higher in the disposal areas, particularly the Marin/Sonoma and Santa Clara/San Benito areas, with resulting increased fog. Depending on the capability of the soil to remove toxicants, nutrients, and pathogens, there may be a potential for polluting ground and surface waters in the disposal areas. Also, bioaccumulation of toxicants on land is not well understood and needs further study. This alternative would enhance the habitat for pest and disease carrying organisms. The potential for contamination of land species needs further study. Rare and endangered aquatic species would be protected. However, rare and endangered terresterial species could be displaced by the change in land use and biomes resulting from this alternative. Assuming marketable crops or crops having an aesthetic value could be grown in the disposal areas, and the capability of the soil to remove critical pollutants can be substantiated, this alternative provides a high potential for reuse of wastewater. However, approximately 50 percent of the treated wastewater applied to the land would be lost to evapotranspiration. Depending on the use to which the disposal areas would be put, this alternative could constitute an inefficient use of wastewater as a resource. Sludge applied to land could act as a soil conditoner in application areas that presently have marginal soil qualities.

One potential shortcoming of the application of wastewater to soils is the possibility of a build-up of salts in the soil column. This would affect the quality of the soil by clogging the pore spaces and reducing the permeability of the soil. Such a reduction in soil quality could reduce the ability of the soil to function as a filter as well as reduce the suitability of the soil for growing crops. A further problem is the expected increase in total dissolved solids concentration in the sub-surface drainage. It is not uncommon for sub-surface drainage to contain 3 to 10 times as much total soluble salts as the applied wastewater, due to the salt concentrating effects of evapotranspiration. These features require further investigation.

b. **Social Well-Being Objective**.

(1) **Area Viability**. By eliminating discharges of urban wastes to the estuary, the land disposal alternative would significantly reduce pollutant levels in the estuary, which should have a substantial long-term effect on benefiting the basic underlying structure of the region. Specifically, the water-oriented activities of commercial fishing and recreation should be greatly benefited in relation to employment stability, diversity and long-term growth. The region as a whole, especially those coastal counties in Sub-areas A and B, should experience long-term benefits in relation to income increases in water-oriented activities.

Increases in the overall long-term water quality of the ocean and estuary should enhance the region's water-related character thus greatly sustaining as well as improving one of the region's most important industries, tourism. The increased opportunities for existing recreational facilities as well as the potential for developing new ones is of primary benefit toward enhancing the overall quality of life of the regional population.

The possibility of high reuse of wastewater would greatly benefit the long-term diversity, growth, and stability of agriculture, industry, or any other activities dependent upon an abundant, readily accessible source of water supply.

Location of the physical facilities for this alternative in a variety of areas throughout the Bay and Delta region would produce a variety of beneficial and detrimental impacts. The actual construction employment from developing the systems should benefit certain categories of employment but for a relatively short time. Also, the new or increased agricultural production associated with applying treated wastewater to land could stimulate the agricultural economy with resultant benefits to many related employment and income groups. These possible benefits, combined with the benefits previously discussed as a result of reducing pollutant levels in the estuary, could greatly help to diversify, stabilize and stimulate the overall growth and development of the Bay and Delta region. However, the great land use conversion necessary for the development of the total system (335,000 acres by 2020), and the long-term impacts on the many localities directly influenced by these land conversions, may be detrimental to opportunities for diversified development.

Large land use alterations in the suburban and rural areas of Contra Costa, Sacramento, Solano, and San Benito Counties could greatly limit the future development and spatial distribution choices of these areas. Even should these land areas continue in new types of agricultural production under the system, persons or groups dependent upon existing employment types and income from existing agricultural use could be greatly detrimented.

(2) **Public Health**. This alternative presents certain hygienic risks that must be recognized as potentially influential upon society. The land disposal alternative, however, does contribute to the achievement of certain public health objectives by removing biological agents from surface waters, reducing the mass-emission of all toxic agents, and by somewhat limiting the possibility of biological magnification in the human food web. Chemical substances such as gasoline and phenols, however, are ineffectively removed by percolation and the fate of heavy metals when percolated through soil is not completely known. Based upon preliminary present knowledge, these agents could possibly filter their way into the ground water or into drainage water and as a result, introduce a hygienic risk to the area population.

(3) **Amenity**. In relation to aesthetic changes, alterations of crop patterns in certain areas may be detrimental. In Marin County the dominant visual pattern is pasturage for beef and dairy cattle. Fields of feed crops, which are among the primary crop choices for potential land disposal cultivation, are only occasionally seen and, therefore, a change to these crops would greatly alter the area. The actual long-term benefit or detriment of these changes would be a matter of local resident preference in addition to economic and other factors. Unlike the large geometric field patterns in Solano County which could readily accommodate the large tracts needed for land disposal, existing cultivation patterns in Sacramento, San Joaquin, Contra Costa and San Benito Counties are small and less geometric. Great alteration to these areas could be a detriment to the existing scale of agriculture development. Also, the humidity increases in the valley inclosures of the Marin/Sonoma and Santa Clara/San Benito areas could be a detriment to the existing climatology values. Other value factors concerning existing development patterns and prejudices against converting prime valley lands into waste treatment areas could be very important to local residents and considered as a detriment to their areas.

c. **National Economic Development Objective.**

Quantified net income in this report is related to some of the evaluation findings under the environmental quality objective. In addition, a quantified approximation is made of the value of reclaimed wastewater.

From the evaluation of environmental factors, it is estimated, in gross terms, that the land disposal alternative, by eliminating discharges of urban wastewaters to the estuary and by providing favorable health factors, would increase the annual net income over the base condition. The estimated increase is as follows:

(1) General Recreation	$62,000,000
(2) Sport Fishing	10,000,000
(3) Commercial Fishing	5,000,000
Total	$77,000,000

Assuming evapotranspiration losses do not exceed 50 percent of the treated wastewater applied to the land, this alternative presents the potential for reclaiming approximately 600,000 acre-feet of wastewater in 1990 and 1.1 million acre-feet in 2020. In addition there is a potential agricultural benefit from applying treated wastewater to land upon which crops would be grown.

Wastewater and sludge are applied to six separate land areas. Since most of these areas are located in proximity to other existing or proposed water supply sources, a representative value of the reclaimed wastewater would be in the range of $40 to $50 per acre-foot. This reclaimed wastewater would have the character of secondary effluent which has been filtered through a soil column of approximately 8 feet.

If reclaimed wastewater is conveyed away from the disposal areas to more distant areas for reuse, preliminary first costs of conveyance and regulatory storage facilities would be approximately $650 per acre-foot of capacity. When this cost is converted to an average annual value, reclaimed wastewater would be competitive with other water supply sources, depending on the degree of any further treatment needed prior to reuse.

Agricultural benefits of applying treated wastewater to land could be used to offset the average annual charges of this alternative. Approximately 170,000 acres of land would be irrigated during the period 1975-1990, and up to 310,000 acres after 1990. The ecological impacts of land disposal of wastewater and sludge, discussed in Appendix C, pointed to the possibility of creating redwood forests in the disposal areas. If redwood trees were grown and harvested at 20 year intervals, the average annual benefits over a 100-year period would be approximately $13 million. If the disposal areas were instead used for irrigated pasture the average annual benefits would be approximately $6 million. Benefits from these two rather diverse uses of the disposal areas are presented to give a range of the benefits which could be used to offset the average annual charges of this alternative.

Estimated first costs of the land disposal alternative would be $6.5 billion in 1975 to handle projected 1990 waste flows, and an additional $3.4 billion in 1990 to handle projected 2020 waste flows. Total estimated average annual charges for interest and amortization; and operation, maintenance and replacement would be $699 million over a 100-year economic life, assuming an interest rate of 5-1/8 percent. The total estimated first cost of this alternative is approximately two times that of the assumed base condition. The total estimated average annual charges are approximately 1.9 times that of the base condition. More details on costs are presented in Appendix D.

Other economic factors are qualitatively assessed as follows:

(1) Although this alternative would involve less use of valuable shoreline areas than the base condition, this alternative requires 335,000 acres of land by 2020 for treatment and disposal. This amount of land would possibly conflict with existing and proposed land use patterns which could adversely affect existing uses and/or be detrimental to diversified development of the areas.

(2) With the exception of the effects of sludge disposal, the qualitative assessment of other economics factors is generally the same as for the ocean and estuarine alternatives. Assuming that sludge is disposed on land under the base condition, sludge disposal under this alternative is not expected to have a greater adverse economic impact.

The above discussion indicates that over the long term, the national economic development could be in a more favorable position with the land disposal alternative.

d. **Regional Development Objective.**

The land disposal alternative, by eliminating wastewater discharges to the estuary and ocean, would enhance the fisheries in both areas. Benefits realized from an increase in commercial fisheries would be shared both by the region and by surrounding areas. Increases in water-oriented recreation due to improved water quality would be strictly regional. Depending upon the use for reclaimed water, benefits from this item could be shared with other regions. The total magnitude of these benefits would be less than for the other alternatives because of the lesser amount of water available for reuse. Increases in agricultural production could produce monetary benefits which may partially offset the high cost of this alternative. These benefits would be related both to the region and to surrounding areas.

Possible adverse economic developments could occur with respect to land use patterns, future development and spatial distribution. Such effects would relate both to the region and to surrounding regions.

Under this alternative, a net environmental quality benefit could be credited to the hydrosphere, through elimination of municipal and industrial discharges. Possible adverse effects in the estuary may result through localized salinity changes due to elimination of these discharges. These net benefits to the hydrosphere could be offset either in whole or in part by possible adverse changes to land areas. These changes would be limited to the region, although possible climatic changes could be more extensive.

With respect to social well-being this alternative would have the greatest impact. Employment and income associated with water-oriented activities would increase. Additional benefits in employment and income could be projected for the land disposal areas, through crop production.

Possible adverse changes could result from hygienic problems, especially from disease vectors, and from the heavy metal and chemical constituents in the filtered water. Large land use alterations in the disposal areas could greatly limit future development and spatial distribution, by restricting land use alternatives. Some adverse changes could be expected with respect to existing agricultural employment. This alternative could be detrimental to existing agricultural development in counties where cultivation patterns are small. Benefits from reclaimed water usage could offset some of these potential adverse changes, although the possible increased employment and income from such usage would be less than for the other alternatives. Social well-being changes would not be limited to the region alone, but could produce effects outside the region.

Relative to the base condition this alternative would provide the greatest regional opportunities in economic activities.

7. EVALUATION OF COMBINATION DISPOSAL ALTERNATIVE

a. Environmental Quality Objective.

This alternative affords all of the advantages of both the estuarine and land disposal alternatives while at the same time minimizing the disadvantages of each alternative. Relative to the base condition, the combination alternative would not only reduce the pollutant load entering the hydrosphere but also, through its land disposal option, present an opportunity for more complete wastewater resource development. Water quality conditions in the estuary would be greatly improved by this alternative. Underground and surface waters in the land disposal sites could become contaminated, depending on the efficiency of the land as a treatment process. If nutrients are retained on the land, this alternative could reduce biostimulant loading in the estuary, resulting in a significant improvement over the base condition. Assuming no contamination from land treated waters, estuarine and anadromous fisheries could be enhanced by improved water quality conditions. The small fresh water fishery within the land disposal areas could be endangered. Marine communities in the Gulf of the Farallones could improve by reduced pollutant inflow. Coastal marine communities would be unchanged over base conditions. By reducing pollutants entering the hydrosphere and possibly by enabling water using industry to locate away from the estuary, preservation of salt marshes would be aided. Treated wastewater would be available to flood Suisun Marsh. Sludge disposal and land treatment facilities would modify land resources. Reclaimed wastewater could be utilized to preserve or create land resources. Land areas required for the land disposal part of this alternative would increase space requirements over the base condition facilities. This alternative could result in higher humidity and increased fog in the land disposal areas. An undefined but limited amount of persistent pesticides and toxicants could discharge to the hydrosphere from land disposal of wastewaters. Bioaccumulation of toxicants on land needs further study. Land disposal methods increase the potential of disease vectors in disposal areas, if protective measures are not planned. The viability of rare and endangered biotic communities in the study area would be enhanced by this alternative. Assuming marketable crops can be grown in the disposal areas, and that flushing flows provide some benefit to the environment, this alternative provides a high potential for reuse of wastewaters.

b. Social Well-Being Objective.

(1) Area Viability. Evaluation of the estuarine disposal portion and the land disposal portion of the combination disposal alternative is essentially the same as the estuarine and land disposal alternatives respectively. Estuarine disposal of urban wastewaters from Sub-areas A and C should help to relieve pollution problems and benefit overall water-related activities. Possible long-term pollution accumulations in the estuary, which under the base condition could negate these benefits, would be reduced.

Land disposal of urban wastewaters from Sub-areas B and D (Figure II-5) would benefit water-oriented commercial and recreation activities by eliminating discharge of urban wastewaters to the estuary and by making use of wastewater and residuals as a resource. However, the large land areas required by 2020 (130,000 acres) for land disposal would restrict opportunities for diversified developments in the disposal area, especially existing agriculture and its associated employment and income considerations. Although much of the land areas could remain in agricultural production, the alterations of crop patterns and the possible shifts in employment opportunities could be detrimental to the existing area markets. Further detailed studies would be needed to ascertain these relationships.

(2) **Public Health**. This alternative contributes to public health objectives by lowering the mass-emission of toxic agents and reducing the possibility of biological magnification in the human food web. However, the estuarine portion of this alternative does introduce some hygienic risk in that concentrated pollutants in the form of a sludge slurry would be transported and applied to lands in eastern Contra Costa and western San Joaquin Counties.

The land disposal portion introduces possible hygienic risks in that the capability and effectiveness of the soil column in removing phenols and heavy metals is not completely known. A possibility exists that these agents could percolate into the groundwater where they would be collected by the underdrain system for reuse.

(3) **Amenity**. *Land disposal* of wastewater sludge in Marin and Sonoma Counties would be significantly detrimental to the aesthetic quality of these valley areas. However this alternative would provide greater benefit to the visual quality of the estuary over the base condition.

c. **National Economic Development Objective.**

Quantified net income in this report is related to some of the evaluation findings under the environmental quality objective. In addition, a quantified approximation is made of the value of reclaimed wastewater.

From the evaluation of environmental factors, it is estimated, in gross terms, that the combination disposal alternative, by eliminating discharges of urban wastewaters to the estuary from Sub-areas B and D, by reducing pollutant loads discharged to the estuary from Sub-areas A and C, and by providing favorable health factors,would increase the annual net income over the base condition. The estimated increase is as follows:

(1) General Recreation	$62,000,000
(2) Sport Fishing	10,000,000
(3) Commercial Fishing	5,000,000
Total	$77,000,000

Assuming evapotranspiration losses do not exceed 50 percent of that portion of the total waste flows applied to the land, this alternative presents the potential for reclaiming approximately 1.0 million acre-feet of wastewater in *1990 and 1.8 million acre-feet in* 2020. In addition there is a potential agricultural benefit from applying treated wastewater to land upon which crops would be grown.

Under the land portion of this alternative, wastewater and sludge are applied to five separate land areas. Since most of these areas are located in proximity to other existing or proposed water supply sources, a representative value of the reclaimed wastewater would be in the range of $40 to $50 per acre-foot. This reclaimed wastewater has the character of secondary effluent which has been filtered through a soil column of approximately 8 feet.

Under the estuarine portion two of the three advanced treatment plants are located near the coast. A representative value of reclaimed wastewater from the two coastal plants would be about $90 per acre-foot. A representative value of reclaimed wastewater from the inland treatment plant would be in the range of $40 to $50 per acre-foot, since it is located closer to other potential water supply sources.

If reclaimed wastewater from both the advanced treatment plants and the land area is conveyed away from the treatment and disposal areas to more distant areas for reuse, preliminary first costs of conveyance and regulatory storage facilities would be approximately $1,200 per acre-foot of capacity. When this cost is converted to an average annual value, reclaimed wastewater would be marginally competitive with other water supply sources.

Agricultural benefits of applying treated wastewater to land could be used to offset the average annual charges of the land portion of this alternative. Approximately 55,000 acres of land would be irrigated during the period 1975-1990, and up to 120,000 acres after 1990. The ecological impacts of land disposal of wastewater and sludge, discussed in Appendix C, pointed to the possibility of creating redwood forests in the disposal areas. If redwood trees were grown and harvested at 20 year intervals, the average annual benefits over a 100 year period would be approximately $4.6 million. If the disposal areas were instead used for irrigated pasture the average annual benefits would be approximately $2.2 million. Benefits from these two rather diverse uses of the disposal areas are presented to give a range of the benefits which could be used to offset the average annual charges of this alternative.

Estimated first costs of the combination disposal alternative would be $4.2 billion in 1975 to handle projected *1990* waste flows, and an *additional* $2.6 *billion in* 1990 to handle projected 2020 waste flows. Total estimated average annual charges for interest and amortization; and for operation, maintenance and replacement would be $464 million over a 100-year economic life, assuming an interest rate of 5-1/8 percent. The total estimated first cost of this alternative is approximately 1.3 times that of the assumed base condition. The total estimated average annual charges are approximately 1.3 times that of the base condition. More details on costs are presented later and in Appendix D.

Subject to detailed investigation, other economic factors are qualitatively assessed as follows:

(1) Although this alternative would involve less use of valuable shoreline areas than the base condition, this alternative requires 130,000 acres of land by 2020 for treatment and disposal. This amount of land would possibly conflict with existing and proposed land use patterns which would adversely affect existing uses and/or be detrimental to diversified development of the areas.

(2) Sludge disposal, concentrated in five areas for this alternative, when compared to sludge disposal in several scattered areas under the base condition could have greater adverse economic impact.

(3) The qualitative assessment of other economic factors is generally the same as for the ocean and estuarine alternatives.

The above discussion indicates that over the long term, the national economic development could be in a more favorable position with the combination disposal alternative.

d. **Regional Development Objective.**

Regional development changes pertaining to this alternative would be a synthesis of those changes resulting from the land disposal alternative and the estuarine disposal alternative.

With respect to economic considerations, the region would benefit from increased employment and income related to commercial fisheries, water oriented recreation activities, agricultural production, salinity repulsion and reuse of wastewaters. All of these benefits would be limited to the region with the exception of fisheries and reuse of wastewaters. Economic increases could be expected outside of the region from these two aspects, although the magnitude is unknown.

Some adverse economic consequences related to land use patterns could be expected although the extent of this change would not be as great as for the land disposal alternative.

In regard to environmental quality, the hydrosphere would benefit from the elimination of major wastewater discharges. Resulting changes on land areas would be similar to the changes occurring from the land disposal alternative, although they would not be as extensive.

Social well-being changes would be a combination of the effects resulting from both the estuarine and the land disposal alternatives. The greatest changes would be associated with those areas where land disposal would be practiced, since land disposal has a relatively high social well-being impact. Hygienic problems and future development and spatial distributions would be the areas of greatest concern.

The changes resulting from this alternative would be largely restricted to the region, whereas the land disposal alternative would produce more extensive changes, since part of one land disposal area is outside the region. Possible changes outside the region would be related to climatic changes and reuse of wastewaters. However, these changes would be of a lesser magnitude than for the land or estuarine alternatives.

8. SUMMARY

Tables V-3 and V-4 summarize the significant beneficial and detrimental effects of each of the alternatives. Because each alternative was selected for evaluation on the basis that its implementation would provide increased long-term protection for the environment, each would be expected to have essentially minimal adverse effects on environmental quality. This is particularly true for the ocean disposal and estuarine disposal alternatives, where the adverse effects cited are largely speculative.

TABLE V-3

SUMMARY OF BENEFICIAL EFFECTS

Alternative	Environmental Quality	Social Well-Being	National and Regional Economic Development
Ocean	Improves marine life in Gulf of the Farallones. Improves fishery in estuary. Minimizes land space requirements. Reduces biological magnification.	Relieves long-term detriments to the water related economy of the coastal counties. Enhances opportunities for varied spatial development of water related activities. Reuse potential of wastewater could produce long-term benefits to economy. Contributes to public health objectives.	Reduces potential for long-term contamination of all fisheries. Increases recreation days for fishing and hunting in Bay and Delta area. Water related shoreline land use would benefit. Average annual presently quantifiable benefits over the base condition are estimated to be $77 million.
Estuarine	Improves marine life in Gulf of the Farallones and coastal zone. Improves fishery in estuary and ocean. Provides fresh water for marshlands. Minimizes land space requirements. Reduces biological magnification.	Should benefit water-related commercial and recreational development opportunities. Also should benefit overall aesthetic perception of estuary. Reuse potential of wastewater could produce long-term benefits to economy. Meets public health objectives.	Reduces potential for long term contamination of all fisheries. Increases recreation days for fishing and hunting in Bay-Delta area. Repels salt water incursion into the Delta. Average annual quantifiable benefits over base condition are estimated to be $77 million.
Land	Improves marine life in Gulf of the Farallones and coastal zone. Improves fishery in estuary and ocean. Provides fresh water for marshlands. Reduces biological magnification.	Should enhance the water related character of the region including increased tourism and recreational opportunities. Agricultural industry and other activities dependent upon an accessible water source would be benefited by potential for high reuse of wastewater and residuals.	Reduces potential for contamination of fisheries. Could increase income from commercial and sport fishing. Could increase irrigation and recreation, replenish ground water, and repel salt water incursion into Sacramento-San Joaquin Delta. Average annual benefits over the base condition are estimated to be $77 million. Average annual agricultural benefits are estimated to be $6 to $13 million.
Combination	Improves marine life in Gulf of the Farallones and coastal zone. Improves fishery in estuary and ocean. Provides fresh water for marshlands. Reduces biological magnification.	Sould relieve pollution problems and benefit overall water-related activities. Should benefit water-oriented commercial and recreation activities.	Average annual presently quantifiable benefits over the base condition are estimated to be $77 million. Average annual agricultural benefits are estimated to be $2 to $5 million. Other benefits are similar to estuarine disposal and land disposal alternatives.

TABLE V-4

SUMMARY OF ADVERSE EFFECTS

Alternative	Environmental Quality	Social Well-Being	National and Regional Economic Development
Ocean	Local displacement of coastal organisms. Possible local disruption of anadromous fishery. Does not provide low salinity water for marshlands. Some potential remains for long-term contamination of ocean species.	Could be detrimental to aesthetic characteristics and agricultural development in counties in which sludge would be disposed. Slight possibility of long-term hygienic risk due to biological magnification of heavy metals, pesticides, or pathogens.	Ocean commercial and sport fishing could be reduced. Total average annual costs of facilities to handle 2020 waste flows are estimated to be $470 million.
Estuarine	Some potential remains for long-term contamination of estuarine species.	Slight possibility of some long-term hygienic risk, due to human contact or biological magnification of heavy metals, pesticides, or pathogens. Could be detrimental to aesthetics and agricultural development in counties in which sludge would be disposed.	Total average annual cost of facilities to handle 2020 wasteflows are estimated to be $330 million.
Land	Major land space requirements. Extensive changes in life forms in land disposal areas. Potential climatic changes. Questionable quality of filtered water. Underground and surface waters could be contaminated as a result of improper management.	Large land use alterations in counties where disposal areas would be located could greatly limit future development and spatial distribution. Could be detrimental to persons dependent upon existing agricultural use. Could be detrimental to existing agricultural development in counties where cultivation patterns are small. Could be detrimental to climatology values. Could introduce hygienic risk depending on development of disease vectors and on capability of soil to remove heavy metals and chemicals. Presents the greatest potential public health risk of all alternatives.	Total average annual costs of facilities to handle 2020 wasteflows are estimated to be $700 million. Could increase TDS concentration in groundwater. Could render crops unsuitable for use through uptake of heavy metals, boron and other chemicals. Could adversely affect land values adjacent to disposal areas.
Combination	Large land space requirements. Extensive changes in life forms in land disposal areas. Potential climatic changes. Questionable quality of filtered water. Underground and surface waters could be contaminated as a result of improper management.	Intermediate to estuarine & land alternatives. Restricts diversification opportunities. Could impair existing area markets by altering crop and employment patterns. Combines public health risks introduced by land and estuarine disposal alternatives.	Intermediate to estuarine and land disposal alternatives. Total average annual costs of facilities to handle 2020 wasteflows are estimated to be $460 million. All alternatives involve large changes in land use patterns.

9. ESTIMATED INVESTMENTS

Previous paragraphs have indicated the results of preliminary first cost estimates and related average annual cost estimates for the base condition and selected regional disposal alternatives. Tables V-5 and V-6 summarize the results of these estimates. Additional details are presented in Appendix D.

First costs reflect 1971 price levels. Average annual costs reflect: a 100-year economic life; annual interest rate of 5-1/8 percent; construction for 1990 waste loads in the first year (1975); and, construction of additional increments in the 15th year (1990) to meet 2020 waste loads. Replacement analysis depends on the type of material or equipment involved assuming normal maintenance and operation.

All first cost estimates assume for purposes of computation that wastewater treatment facilities for the region came into existence in the first year. Existing facilities and those planned in the near future are not given credit toward meeting future needs because the degree of potential integration of these facilities into the different systems analyzed is beyond the scope of this investigation.

Evaluation of the cost data presented here should be limited to comparisons of the magnitude or sensitivity of the estimates because of the preliminary nature of the analysis and because substantial favorable feature modification could result from more detailed investigation.

It appears that an expenditure of three to five billion dollars will be required for municipal and industrial wastewater management in the Bay and Delta region to correct present deficiencies, provide for increased preservation and enhancement of the environment, and accommodate the present population plus a projected additional three and one-half million residents by 1990. These expenditures are exclusive of the sewerage collection systems from individual users to logical connection points with interceptor or treatment plants, and also exclusive of "source control" measures for industries. Average annual costs are about 490 million dollars per year over a 100-year economic life.

A review of major interceptor costs indicates that ocean disposal concepts are not suited to the eastern portion of study area. Similarly, the combination of interceptor costs and treatment costs for land disposal, involving large blocks of highly valued land, indicates that the most likely areas where the land alternative would be considered as desireable would be the northern and eastern portion of the study area. The estuarine alternative shows favorable aspects, either alone or in combination with other alternatives. All of these considerations are pertinent if environmental, social well-being and public health accomplishments are to be held essentially equal.

10. RECLAIMED WATER INVESTMENTS

Evaluations in previous portions of this chapter have indicated costs associated with reclaimed water. Tables V-4 and V-5 do not include the costs of facilities required to develop reuse potential for treated wastewater. These facilities include the conveyance systems needed to move the treated water to reuse locations and the regulating reservoirs needed for system efficiency. Regulating reservoirs provide temporary storage of treated water to cope with seasonal imbalance between generation of treated water and reuse demand. To provide for meeting any of the potential demands, the capacity of regulating reservoirs associated with the chemical and biological advanced treatment facilities used in ocean or estuarine disposal alternatives would be controlled by seasonal demand factors for agricultural reuse. Capacity of reservoirs associated with the land disposal alternative would be controlled by demand factors for municipal and industrial reuse. Costs of developing these facilities are not included because they depend on specific demands and locations for reclaimed water. More detailed study would be needed to identify these factors.

A recent State of California publication, Department of Water Resources Bulletin No. 160-70, indicated in gross terms and general locations the expected future water demands of the State to year 2020. Based on this information, preliminary estimates of the first costs of major transport and regulation facilities for reuse were prepared. Results are presented in the following tabulation:

ALTERNATIVE	FIRST COST ($1,000 per Acre-Foot of Capacity)
OCEAN DISPOSAL	$1,000
ESTUARINE DISPOSAL	1,300
LAND DISPOSAL	650
COMBINED DISPOSAL	1,200

A sensitivity analysis of these costs indicated that the land alternative should be considered in any further investigation of regional systems when reuse of treated wastewater is an objective.

11. POTENTIAL SYSTEM MODIFICATIONS

During the latter portion of the investigations associated with this report, it became apparent that two major modifi-

TABLE V-5

SUMMARY OF ESTIMATED FIRST AND AVERAGE ANNUAL COSTS TO TREAT 1990 LOADS ($1,000,000's)

Items	Base Condition	Selected Disposal Alternatives			
		Ocean	Estuarine	Land	Combination
FIRST COSTS 1/					
Major Interceptors	$ 980	$1,850	$ 660	$1,300	$ 820
Treatment Facilities	1,700	1,600	1,750	4,280	2,750
Recreational and Environmental Treatment	35	70	50	70	60
Engineering and Design (7%); Supervision, Administration and Inspection (8%)	385	580	340	850	570
Total Project Cost	3,100	4,100	2,800	6,500	4,200
AVERAGE ANNUAL COST					
Interest, Amortization and Replacements	$ 209	271	186	420	270
Operation and Maintenance	73	70	60	126	78
TOTAL	282	341	246	546	348

1/ All lands required to meet 2020 waste loads included in first cost estimates. Major impact of this approach is an added initial one billion dollars on the land alternative and 550 million dollars on the combination alternative.

TABLE V-6

SUMMARY OF ESTIMATED ADDITIONAL INCREMENTAL
FIRST AND AVERAGE ANNUAL COSTS
TO TREAT 2020 LOADS ($1,000,000's)

Items	Base Condition	Selected Disposal Alternatives			
		Ocean	Estuarine	Land	Combination
FIRST COSTS 1/					
Major Interceptors	$ 455	$1,600	$ 400	$ 900	$ 570
Treatment Facilities	1,250	1,020	1,220	1,950	1,610
Recreational and Environmental Treatment	30	55	43	60	50
Engineering and Design (7%); Supervision, Administration and Inspection (8%)	265	425	237	490	370
Total Project Cost	2,000	3,100	1,900	3,400	2,600
AVERAGE ANNUAL COST					
Interest, Amortization and Replacements	$ 65	$ 100	$ 61	$ 109	$ 83
Operation and Maintenance	20	31	24	44	33
TOTAL	$ 85	$131	$ 85	$153	$116

1/ Land costs reflected in Table V-5.

cations to the features of selected alternatives should be considered in the evaluation.

First, since the base condition assumed secondary level treatment with discharge into the estuary, and the ocean aquatic environment is different than the estuarine, the ocean disposal alternative was reevaluated for sensitivity to secondary level treatment instead of advanced treatment. Although estimated average annual costs for a regional system with secondary treatment facilities to handle 2020 projected waste flows would be lower by approximately $55 million, the conclusion of the evaluation was that advanced treatment best represents the ocean disposal concept. The reasons are that secondary treatment:

a. Would not reduce the buildup of persistent toxicants in the marine environment,

b. Could increase the potential for eutrophication in the coastal zone,

c. Would not reduce the projected waste loads discharged to the hydrosphere over that of the base condition, and

d. Would not provide a significant potential for reuse of treated wastewater.

Second, the assumed rate of application of sludge on land disposal areas appears to be low based on recent information. Careful review of this matter through further investigation could confirm indications that the extent of required land areas would be about 50 percent less than those used in this report. A brief investigation of the impact of such a development on the selected regional alternatives and the base condition indicates that the comparative analysis of investments shown in the report remains essentially unaffected. Sludge loads from the base condition (secondary treatment) would be less than from the selective regional alternatives (advanced treatment) but equal disposal areas are assumed for all systems. The impact of this feature on investments varies with the selected alternative; i.e., eliminating the investment differential between the base condition and estuarine disposal, increasing the differential with ocean disposal by about 20 percent and increasing differentials with other regional alternatives about ten percent. The main conclusion with regard to sludge disposal is that a controlled and monitored physical solution to the disposal problem is an expensive item, but it appears warranted for environmental and public health reasons. Also, the magnitude of the public investment required for any alternative indicates that consideration of regional solutions rather than incremental solutions is warranted.

12. INSTITUTIONAL ASPECTS

The selected regional alternatives and the assumed base condition considered in this report present different potential problems in the matter of institutional arrangements. Those institutional matters pertinent to the evaluation procedure are discussed in the following paragraphs.

a. Incremental Approach

Current Federal, State and local institutional structures for wastewater management would permit incremental development of facilities to reach the assumed base condition. If local interests are not to be required to assume the entire investment in the future, then some form of current Federal and State funding programs for cost sharing will have to be extended. Consolidation into larger units of less than fully regional extent can be accomplished by Joint Powers Agreements among local governments. To date, the critical aspect of implementation of a satisfactory incremental development has, on several occasions, required the State to issue "cease and desist" orders against industries or local governments. In some cases, such orders included stopping of further connections to existing municipal systems. Usually these court orders are withdrawn upon firm establishment of planning, design and construction schedules extending over a two or three year period. Some industries faced with a similar situation have ceased operations in the study area, usually if local operations are of marginal efficiency and excess production capacity is available at other locations in the nation. Undefined social well-being problems are cited by communities facing either of these situations. The State has recognized and is approaching through regulation the observed problems of education, training and experience associated with responsibilities for operation and maintenance of wastewater systems.

b. Regional Approach.

Existing Federal authorities would be applicable to regional wastewater systems, however, as more information is developed some modifications to the authorities might be appropriate. Subjects that might require further consideration are the national interest, Federal areas of participation and the Federal authorities that should be associated with different beneficial uses of reclaimed water. The State, acting alone, would be faced with the same problems. However, in programs involving Federal participation, the State would have additional problems of coordinating local participation. Future Federal, State and local funding programs would have to be considered. An optimized regional approach might also require participation of an area not directly incurring primary benefits. A strong State participation in all aspects of a regional system should reduce or eliminate the occasions when State and local agencies find it necessary to resort to the courts for resolution of divergent views. Opportunities to resolve problems with industries should be enhanced, and adverse social well-being impacts, therefore, reduced. Assuring qualified and trained personnel to operate and maintain a regional wastewater system should present no problem. The public would have maximum advance awareness of their future program and investments in wastewater management reflecting staged construction when appropriate. This would assist participating local governmental agencies in formulating actions toward their overall responsibilities.

c. **Public Investment**.

Because of the numerous priority problems facing communities, premature abandonment of existing public investments in wastewater management must be avoided. Regional management plans must critically consider this matter. Because of rapidly changing environmental objectives, it appears that a regional approach to wastewater management provides maximum opportunities to avoid premature abandonment of the facilities for which long term commitments of public investment have been made.

CHAPTER VI

DISCUSSION

1. BACKGROUND.

a. **Procedure**. This study developes potential regional wastewater management systems for the San Francisco Bay and Delta area and assesses the resulting opportunities for enhancing total water resources management. Objectives associated with the environment, social well-being, efficiency and regional development are evaluated and institutional constraints considered where appropriate.

The study procedure includes identifying the present conditions and projecting future conditions, selecting representative alternative regional strategies to meet future conditons, assessing the impacts of the selected strategies, and evaluating the impacts. In some instances, lack of knowledge permitted only impact identification in the evaluation process. Further, because this is a reconnaissance–level study, the results should be considered as qualitative rather than definitive.

Beneficial and adverse impacts are cited for each alternative evaluated; many of the items in the adverse category could be minimized by modification or addition of specific features to the originally selected alternative. Uncertainties require further investigation. Any consideration of adopting a specific alternative would require further study of all factors.

This study began with the assumption that the facilities as generally outlined in the State's interim basin plans represent a base on which any regional system for solution of long-term wastewater problems would have to build. Nothing in the results of this study would negate this assumption; the facilities planned for the next several years are required. These facilities could be incorporated in any of the alternative regional systems evaluated, during the staged construction process.

b. **Present and Future Conditions**. The Bay and Delta estuarine system incurs pollution impacts from four major sources: municipal and industrial discharges; urban area runoff; agricultural drainage; and sediment constituents. Salinity conditions affecting water quality in inland waters are also subject to change by man-made works. Wastewater loadings are now excessive in pollutant constituents and will increase in the future with the growth of population and development.

Presently, wastewaters from municipal and industrial discharges are about 600 million gallons per day, reflecting a population of almost six million. Separate industrial dischargers represent about 15 percent of the flow. The combination of about 6,000 manufacturing plants and industries in the study area introduces a wide range of pollutants into the estuarine system. In the next 50 years, the flow quantity is expected to triple because of new growth and development. Planned developments in the Central Valley will reduce future fresh-water flows from the Delta into the Bay from a current 18 million acre-feet annually to about seven million. This can affect estuarine assimilative and dispersion potential depending on conditions at specific locations. Urban runoff, primarily concentrated in stream flows, is comparatively larger in volume than municipal and industrial flows but the pollution load is relatively smaller, based on annual time periods. Agricultural drainage from streams leading to the Delta is many-fold greater in volume but pollution loads are substantially different.

To date, about 500 million dollars have been expended on wastewater treatment facilities in the Bay-Delta area and plans for the next few years call for expenditures of about an additional one billion dollars. The continuing effort to achieve compliance with standards has improved estuarine conditions but future growth, diversions of fresh water, and limited treatment efficiencies will eventually reduce this initial beneficial impact unless further measures are put into effect. The State's interim basin plans provide for construction of the facilities to meet immediate needs and identify the objectives which must be met in arriving at more comprehensive solutions. There is an obvious need for formulation of a long-range wastewater management plan capable of meeting rapidly changing environmental objectives and integrating pollution control measures with total water resources management.

c. **Regional Strategies**. Three basic regional strategies, or a combination of two, could meet the future wastewater management requirements of the Bay Delta area. These are ocean disposal, estuarine disposal, land disposal and a combination of the last two. Geographical considerations minimize the compatibility of an ocean disposal and land application combination. The State Water Resources Control Board has performed substantial investigations on ocean and estuarine concepts, the former with a relatively low degree of treatment. Investigation of land disposal however, has not been as extensive. A detailed investigation of land disposal in the Bay-Delta area has not been carried out because it has been easier to treat wastewaters and discharge them to the estuary. Until very recently this has been an entirely acceptable solution. Considerations of reuse and recycling of treated wastewaters has been constrained by the availability of high quality water supplies from other sources and at generally lower cost.

The four strategies evaluated in this report are believed to be capable of coping with future municipal and industrial discharges. All systems evaluated exhibit generally comparable technical feasibility. The degree of treatment is designed to meet environmental objectives and the different processes used are assumed to be comparable in overall removal of wastes. Urban area runoff and agricultural drainage considerations are not included in system formulation, the former because of the currently indicated relatively low pollution load when compared with municipal and industrial wastewater loads, and the complex nature of the collection problem. Agricultural drainage sources present a similar problem of "point" sources, primarily entering around the rim of the Delta. The San Luis Drain, flowing from the San Joaquin River basin to the Delta, will be the largest single point source of agricultural drainage for the foreseeable future. The U.S. Bureau of Reclamation is constructing the drain and carrying out studies together with the Environmental Protection Agency and the State Department of Water Resources to determine the most effective and economic processes for treating drainage waters. Previous studies by Federal and State agencies have concluded this drain should be independent of other systems transporting effluent to the ocean because of the quantity of water carried and its constituents. The proposed location of the point of drainage discharge into the estuary indicates that the drainage would have essentially an incremental impact on the assumed estuarine disposal and land application strategies, an impact which could be integrated in subsequent studies.

Implementation of any regional system would have to be carefully planned and executed. Design and construction would have to be executed in stages so as to avoid the inefficiencies of "start and stop" operations and to avoid overloading the funding capability of the agencies responsible. Because of the time involved in such staged construction, planners would have to give close attention to integrating existing facilities into the system at each step of the way.

Public investment in waste treatment facilities is already large and will become much larger over the next five years· any regional system adopted must make maximum use of this investment and, in particular, must be planned so as to avoid any premature abandonment of this long-term committment of public funds. The alternatives evaluated in this study meet this goal to varying degrees; treatment plants, interceptors and outfalls now in operation or planned for the near future could be incorporated into systems designed under any alternative. Integration of these facilities might be slightly easier for the land disposal alternative because the treatment levels at existing and planned treatment plants would be compatible with requirements for treatment prior to land application.

2. BASE CONDITION

A base condition was assumed by the Corps of Engineers for this study to provide a standard of comparison against which the alternative systems are evaluated. The base condition essentially reflects an extension into the future of current planning approaches. It incorporates secondary level treatment of wastewaters throughout the Bay and Delta, with expansion of treatment facilities to meet projected growth in waste loads, and transport of effluents to estuarine areas of higher assimilative and dispersion characteristics.

The base condition is an incremental approach; it assumes that facilities operating in 1975 will be sized to accommodate 1990 loads and that facilities will be expanded in 1990 to handle 2020 loads. As previously noted, initial accomplishments in lowering pollutant loads on the estuarine system would be reduced with the passage of time due to the combination of future growth and limitations of assumed treatment removal efficiency. Biostimulant and toxicant levels would be high in the estuary. Undesirable impacts on aquatic ecology, both estuarine and ocean, would continue to increase. Industrial dischargers would consolidate into localized municipal systems, with the determinations of required "source control" by manufacturing and industrial entities being extremely difficult to ascertain because they would have to be viewed in terms of a complex estuarine system.

The impact on estuarine salinity conditions of treated wastewater would be essentially beneficial in locations such as the western Delta because of increased introduction of low-salinity water. There could possibly also be a detrimental increase in salinity in South San Francisco Bay, caused by moving outfall discharges to the Central Bay. Reliability of system operation would depend on many plants having continuously successful operation, with protection both against normal functional failure and emergency situations such as seismic disturbances. Flexibility to meet future growth patterns would be high in relation to expansion of treatment plant capacity but restricted by outfall location requirements. The major land impact would be continuing use of valuable shoreline areas for treatment facilities. Application of new technology could be hampered by some treatment facilities lacking the minimum capacity required for efficient implementation and by the numerous installation and operating requirements. Federal and State funding programs would have to continue into the future or local interest would have to accept the full burden in the near future. Experience indicates that disagreements might occur between State and local agencies or industry on implementation schedules. In such cases, social well-being problems, such as stopping development or closing of plants, might occur. Integration with total water resources management would be essentially localized to opportunities for using reclaimed water for industrial purposes, limited recreation areas and limited irrigation or ground water recharge practices. The total public investment in facilities to meet 2020 requirements would be about 5.1 billion dollars.

3. OCEAN DISPOSAL ALTERNATIVE

Implementation of the ocean disposal alternative would, of course, provide a high degree of environmental protection to the estuary and to land areas throughout the Bay-Delta region. The elimination of municipal and industrial waste discharges into estuarine waters should be accompanied by marked improvement of water quality, with increased commercial and sport fishing, reestablishment of shellfisheries and increased water-oriented recreation. Water contact recreation throughout the Bay and Delta would be greatly enhanced. There could be an adverse effect on salinity levels in the western Delta and the Suisun Bay area as a result of reduced discharge of low-salinity waters into the estuary if not compensated for from other water sources.

The effects of ocean disposal on the ocean environment would probably be acceptable, assuming advanced treatment and outfalls designed to protect against return of the effluent plume to on-shore areas. Costs could be reduced somewhat by reducing treatment to secondary levels and extending the outfalls even further, but the reduced level of treatment would leave unanswered questions as to the long-term effects of biological accumulation and concentration of heavy metals and persistent pesticides. There would also be some danger of concentration of bacteria and viruses in shellfish, although these micro-organisms have a relatively short life in the salt water environment.

The ocean disposal alternative could make large amounts of treated wastewater available for reuse, perhaps as much as 1.2 million acre-feet per year in 1990 and 2.2 million in 2020. However, consolidation of treatment facilities at two locations would limit the flexibility of this system to meet demands at widely separated locations and would result in high costs for transporting treated water to reuse locations. This system also has only limited flexibility in terms of incorporating existing facilities.

The two assumed advanced treatment facilities would be of sufficient size to insure the use of fully qualified personnel for all phases of operation and maintenance, a situation that may become disproportionately costly in the operation of small plants. Treatment facilities would still be vulnerable to malfunction caused by kill-off of biological organisms in the treatment plants through accidental spills of poisons into the collection system, but the dilution inherent in expected large flows in the collectors should reduce this danger. System failure caused by earthquakes would have a severe impact because of the consolidation of all untreated wastewaters into two main streams.

Institutional arrangements needed to implement an ocean disposal system are not in existence. A regional government or regional sewerage agency would be essential.

The overall effect of ocean disposal on social well-being factors would be positive, with increased recreational opportunities, increased employment in water-oriented activities, increased opportunities for industrial compliance with environmental objectives, and minimum public health hazards. Great care would have to be exercised in siting, landscaping and operation of sludge disposal areas to prevent unfavorable impact on areas of public concern.

This alternative would have little or no adverse impact on existing economic development. Positive impacts include increased value of commercial fisheries, increase in all forms of water-oriented recreation, and possible benefits from reclaimed water. Establishment of a framework for future planning would be inherent in this alternative as well as all other regional systems. The total public investment in conveyance and treatment facilities to meet requirements for 2020 would be about 7.2 billion dollars. A first cost of about $1,000 per acre-foot of capacity would be required to develop conveyance and storage facilities for reuse of treated wastewater.

4. ESTUARINE DISPOSAL ALTERNATIVE

The estuarine disposal alternative represents a further consolidation of conveyance and treatment facilities and an increase in treatment levels over the base condition. Implementation, therefore, could be accomplished by stages, with maximum opportunity for incorporation of existing facilities.

Estuarine disposal, with its high degree of treatment, would provide extensive environmental protection throughout the Bay-Delta area. The expected improvements in water quality should result in marked increases in fisheries resources, shellfisheries and water-oriented recreation, including such water-contact activities as swimming and sport fishing. There might be long-term adverse effects of biological accumulation of heavy metals and persistent pesticides in the estuarine aquatic life, although expected high degrees of removal of these pollutants should make this a remote possibility. Further study of this feature is in order.

This alternative would provide some positive environmental enhancement. Discharge of treated wastewater into Suisun Marsh would help to maintain the low salinity conditions needed for growth of the marsh reeds and grasses that feed migratory wildfowl in the Pacific Flyway. Discharge into the western Delta would assist in maintaining low salinity levels in this area and could partially offset diversions of fresh water from the Delta.

In addition to the discharges cited above, large quantities of treated wastewater would be available for reuse, in excess of 800,000 acre-feet in 1990 and over 1.5 million acre-feet in 2020. The dispersed locations of treatment facilities would provide substantial flexibility for meeting a variety of demands for reclaimed water.

Each treatment facility would be large enough to insure a structure of qualified operators for all aspects. Kill-off of biological organisms in the treatment plants would be possible but unlikely. Possible system disruption caused by earthquakes would be a concern to be addressed carefully in system design, but the impact of such disruption would be reduced by dispersal of facilities and by conveyance routings which for the most part are in the vicinity of estuarine areas with high dispersion and dilution capability.

New institutional arrangements would be needed for full implementation of the estuarine disposal alternative. These arrangements could involve either one regional government or regional sewage agency or a series of sub-regional agencies.

The overall effect of this alternative on social well-being factors would be favorable. Increased employment in water-oriented commercial activities and increased recreational opportunities would be expected. Opportunities for industrial compliance with environmental objectives would be enhanced. As with the ocean disposal alternative, sludge disposal operations would require great care to prevent adverse effect on aesthetic values and areas of public concern.

From the viewpoint of economic development, implementation of this alternative would increase the value of commercial fisheries, increase recreational benefits in sport fishing and hunting and help to preserve the viability of the western Delta as an agricultural resource. There would also be benefits available from reclaimed water, with favorable opportunities for finding markets for this water. No adverse impact on economic development would be expected.

The total public investment in conveyance and treatment facilities to meet 2020 requirements would be about 4.7 billion dollars. A first cost of about $1,300 per acre-foot of capacity would be required to develop conveyance and storage facilities for reuse of treated wastewater.

5. LAND DISPOSAL ALTERNATIVE

Application of partially treated wastewaters to land areas as a combined treatment/disposal technique has been practiced for many years in small scale projects. The process has several advantageous features: initial treatment levels need not be extensive, thus are fairly inexpensive; the process uses the land, and crops growing on the land, as a living filter, putting the biostimulants carried in the effluent stream to use as fertilizers; the process is simple to operate and is reliable in terms of freedom from operator error and from kill-off of biological organisms in the treatment process; the process exhibits a high level of removal of most of the pollutants that are currently of greatest concern, including pesticides and pathogens; treatment facilities are moved away from urban areas and valuable shorelines; and the land application areas can grow crops whose sale can help repay the costs of installing and operating the system.

Despite these potential advantages, land disposal as a regional wastewater management alternative for the Bay-Delta has not previously been studied in depth. Much of the effort of this study, therefore, is concentrated on determing the relative merits and demerits of land disposal. Several significant questions are not yet fully answered, but enough information was developed to make reasonable comparisons.

Implementation of the land disposal alternative would provide a high level of environmental protection to all the waters of the Bay, the Delta and the adjacent ocean. This protection would increase fisheries resources and enhance all forms of water-oriented recreation. The unknown factors of possible bioaccumulation by aquatic organisms of heavy metals, pesticides and pathogens which still remain to a degree with ocean or estuarine disposal would be virtually eliminated.

Environmental effects on land areas have both favorable and unfavorable aspects. Underdrain water from the land application areas would be available for maintaining desired low salinity levels in Suisun Marsh. Treated wastewater applied to land areas can create additional wildlife habitat in the form of marshlands, forested areas or added vegetation in areas that are now practically barren. As previously noted, underdrain water can also be used for aquatic environmental purposes. On the other hand, the land disposal concept requires the use of large areas of land in large blocks; if improperly handled this could make extensive changes in the character of rural areas. Application of large amounts of water to large blocks of presently non-irrigated land would cause changes in humidity levels, perhaps to the extent of creating substantial climatological change. While increases in wildlife populations are expected to be environmentally favorable, controls would be required to prevent development of insect pests.

Substantial amounts of underdrain water would be available for further reuse, perhaps as much as 650,000 acre-feet per year in 1990 and 1.1 million acre-feet per year in 2020. This underdrain water should be essentially free of most pollutant materials. However, in some cases dissolved solids and specific minerals such as boron and nitrates may be high, thus requiring additional treatment for some types of reuse. Reuse might also be limited eventually if long-term application of wastewaters reaches a dynamic balance with the ion exchange capacity of the soil. In such case there might be little or no removal of heavy metals, pesticides or pathogens by the soil and the underdrain water would be essentially secondary treatment effluent with some nutrients removed. This matter requires further investigation.

The system exhibits considerable flexibility in terms of dispersion of treatment facilities and resulting capabilities to meet a wide range of demands for reuse. The dispersion of treatment plants tends to reduce overall system vulnerability to earthquake disruption, but this would still be a concern.

Institutional arrangements to implement a land disposal alternative are not in existence. A regional government or regional sewerage agency would be required. There would probably be a requirement for authority to go outside the service area to find sufficient land application areas. A negative local reaction to losing large areas of land to treatment and land application sites could be expected; particular care would be needed to blend sites naturally into the landscape and protect the local population against any adverse physical effects. The latter would be done by establishing landscaped buffer strips and by positive insect and vector control programs.

The land disposal alternative would have the same beneficial social well-being effects in estuarine and ocean areas as other alternatives. There would also be benefits of increased recreation opportunities associated with land application areas. Land use alterations in land application areas could limit future development potential. It could force changes in agricultural patterns, unless long-term studies showed that the assumed limitation of crops in land application areas to fiber and fodder crops (no direct human use) was overly restrictive. Great care would have to be taken to prevent the development and fostering of disease vectors. The magnitude of this problem is not determined and requires further investigation.

This alternative would have a favorable impact on economic development factors related to water-oriented commercial and recreational activities. Economic factors related to land use could be enhanced, to the extent that presently unproductive land might be converted to beneficial use. For presently productive land that would be required for land application areas, however, the effect would probably be adverse because of the reduced diversity of crops that could be raised. The extent of such adverse effect would have to be determined in more detailed study; the value of crops grown on land application areas would be an offsetting feature. While not developed in this report, areas in the vicinity of land application operations could be directed into industrial development. In particular, reclaimed water could meet future requirements for electric power plant cooling without causing thermal pollution problems in natural waterways. Further, it might become feasible to establish recycling industries in these areas by consolidating solid waste disposal operations there. These aspects require further investigation.

The total public investment in conveyance and treatment facilities to meet 2020 requirements under this alternative would be about 9.9 billion dollars. A first cost of about $650 per acre-foot of capacity would be required to develop conveyance and storage facilities for reuse of treated wastewater. This cost might be reduced by establishing future demands in proximity to land application areas through new industrial development patterns.

6. COMBINATION ESTUARINE AND LAND DISPOSAL ALTERNATIVE

This alternative combines most of the advantages and some of the disadvantages of both the estuarine disposal and the land disposal alternatives. Land disposal would be used in the North Bay and Delta counties, which have the characteristics of a suburban-rural region with isolated urban centers. Estuarine disposal would be used in the counties of the South Bay, East Bay and Contra Costa, which are largely urban-industrial with some rural area.

This alternative would protect the aquatic environment of the estuary and ocean, provide non-saline water for Suisun Marsh and for maintaining low salinity levels in the western Delta, and provide opportunity for establishment of additional marshlands and forested areas in the land application areas. Environmental problems of increased humidity and possible establishment of insect pests in land application areas would be the same as for the land disposal alternative, but for a more limited area.

Treated wastewater available for reuse would be about 500,000 acre-feet per year in 1990 and 1.1 million acre-feet in 2020, in addition to discharges into Suisun Marsh and the western Delta. The dispersed nature of treatment facilities would provide substantial opportunity for meeting demands for reclaimed water. This dispersion should also serve to reduce the magnitude and severity of possible earthquake damage.

The combination disposal alternative offers a great deal of flexibility in system design and in incorporation of existing facilities into the system by stages during implementation. As with the other alternatives, modifications to the system based on more detailed investigation could improve system effectiveness, maximizing advantages and minimizing disadvantages. The system would require new institutional arrangements for implementation. Public concern over the extent of land application areas required could be expected with about 130,000 acres estimated as required by 2020. Further investigation of industrial potential in land application areas should be undertaken. Other social well-being and economic factors would reflect a combination of those for estuarine disposal and land disposal alternatives.

The total public investment in conveyance and treatment facilities to meet 2020 requirements would be about 6.8 billion dollars. A first cost of about $1,200 per acre-foot of capacity would be required to develop conveyance and storage facilities for reuse of treated wastewater. New demands near the land application areas could reduce this figure.

7. NEEDS FOR FURTHER INFORMATION

Optimal methods for disposing of sludge and other pollutant residues should be determined for each alternative. This is especially important for ocean disposal and estuarine disposal systems for which sludge disposal represents a larger fraction of total system cost than for land disposal.

Economics of all forms of reuse should be determined. This should be accomplished in conjunction with optimization studies to determine the most effective combination of conveyance, treatment, storage and reuse facilities. The specific levels of treatment necessary to allow for reuse in augmenting Delta outflow and in Suisun Marsh must be established. Because one of the largest potential demands for reclaimed water might be as a supplement to municipal water supplies, public health factors related to this form of reuse should be studied in greater depth.

Studies of the effectiveness and reliability of advanced treatment facilities on the scale needed for implementation of this regional system should be greatly accelerated.

The concept of land application requires further investigation into the effectiveness of local soils in acting as a filter and exchange medium and into public health factors of pathogen removal and vector control. Studies should be undertaken to identify the best crops to grow on land application areas, the feasible rates of application of treated wastewaters to particular soils and crops, and the rates at which crops will remove nutrients from the applied wastewater. The possibilities of restructuring development patterns in the vicinity of land application areas should be investigated.

Problems of storm drainage from urban areas require further investigation relative to potential solutions and corresponding benefits.

Existing and planned agricultural drainage projects should be investigated for their impact on regional wastewater management planning. This could best be done by cooperative study effort including the agencies sponsoring the drainage projects.

The significant social well-being factor affected by wastewater management systems have been identified but not fully assessed during this study. Assessment would have to be an integral part of subsequent detailed studv Factors to be considered include:

– Health and safety.

– Employment and income patterns.

– Identification of those groups that a proposed system would benefit or detriment, followed by determination of the extent of benefit or detriment to each group.

Institutional factors that would permit development of a regional wastewater management system should be identified.

CHAPTER VII

CONCLUSIONS

This report presents the opportunities and expected accomplishments, both beneficial and detrimental, of regional wastewater management systems to meet the future needs of the Bay-Delta area. Existing water quality problems in the Bay-Delta area will be resolved for the immediate future through the improvements presently planned at local levels. The currently planned additions to wastewater treatment systems offer definite alleviation of present water quality problems but the overall program needed to meet ultimate requirements has yet to be determined. An efficient regional wastewater management system is needed for resolving long-term water quality problems associated with projected excess loadings of pollutants.

Each of the alternative wastewater management systems evaluated in this study would result in improved water quality in the estuary. There are definite differences in performance and in environmental protection offered by the alternatives. In addition, each could be improved in performance by modifications to the basic scheme.

The ocean disposal alternative would require extension of outfalls into deep water to avoid adverse effects on the nearshore ecology. Providing treatment to secondary level might result in long-term adverse effects on ocean life as the result of biological accumulation of heavy metals, persistent pesticides and possibly pathogens. The estuarine disposal alternative could result in similar long-term effects, although a high degree of treatment would minimize these effects by limiting the quantities of pollutants discharged. Estuarine disposal could make positive environmental contributions by maintaining low salinity levels in marshlands and enhancing the aquatic environment in the Delta. The environmental effects of the land disposal alternative are less well defined. While there would be almost complete protection of the estuary and ocean, on land areas there might be adverse effects on humidity levels and possible development of disease vectors. However, this alternative offers a potential for creating positive environmental values such as conversion of non-productive land to crop lands, marshlands or forests. A combination disposal alternative could minimize the problems and achieve most of the advantages of both estuarine and land disposal alternatives.

Each alternative evaluated requires a high degree of purification of wastewaters in order to give assurance of environmental protection. The resulting treated wastewaters could therefore be of adequate quality for a variety of reuses. Potential reuse modes include agricultural irrigation, maintenance of low-saline conditions for protection of portions of the estuary, ground water recharge, industrial uses, recreation and municipal water supply. Reuse of wastewaters might recoup part of the costs of treatment and reduce future requirements for developing additional freshwater supplies in areas of major environmental concern. Each alternative provides some opportunity for reuse of treated wastewaters, but because of geographical factors these opportunities are more constrained for the ocean disposal alternative. Land disposal includes irrigation as part of the treatment process, thus reuse is integral to this alternative. However, the loss of applied water in evapotranspiration would make the amount of water reclaimable for subsequent reuse less for land disposal than for other alternatives.

New institutional arrangements would be needed for implementation of any alternative. This would be most critical for land disposal, because of the extensive land areas required, perhaps over 300,000 acres by the year 2020. It would be least critical for estuarine disposal because of the sub-regional nature of collection and treatment facilities proposed. A combination disposal system would be intermediate in complexity.

The information needs for long-term analysis still to be satisfied include determining the effectiveness of local soils in acting as a filter and exchange medium, optimal methods of disposing of sludge and other pollutant residues from treatment processes, the capability of advanced treatment facilities to operate safely and reliably in large-scale installations, public health factors related to system operation and to reuse of treated wastewaters, and the economics of all forms of reuse.

No alternative evaluated is either clearly superior to all others or definitely inferior for all parts of the Bay-Delta area. Each alternative has advantages which make it particularly well-suited to specific portions of the study area. Conversely, each has disadvantages which limit its applicability in other parts of the area. The most beneficial results can be achieved by a regional solution based on a combination of systems, which would have advantages in terms of optimizing environmental protection, flexibility and opportunity for reuse of treated wastewaters.

A more detailed study should be carried out immediately to assist EPA and the State of California in determining the best system for managing wastewaters in the Bay-Delta area. The study should:

– Be integrated with on-going EPA, local and State of California planning and completed in time that the results could be considered in preparation of the State's fully developed basin plans.

– Provide maximum protection to the environment while emphasizing opportunities for reuse of wastewater.

– Identify wastewater collection, treatment and disposal systems with their associated facilities, locations and routings, and define the positive and detrimental effects of such systems.

– Describe the institutional arrangements required for implementation, to include funding, construction, operation and maintenance of completed facilities.

– Be based primarily on combinations and modifications of the land disposal and estuarine disposal alternatives evalutated in this study.

AD-A036 836 CORPS OF ENGINEERS SAN FRANCISCO CALIF SAN FRANCISCO--ETC F/G 13/2
ALTERNATIVES FOR MANAGING WASTEWATER IN THE SAN FRANCISCO BAY A--ETC(U)
JUL 71

UNCLASSIFIED NL

2 OF 2
AD A036836

END
DATE
FILMED
4-77

STUDY AUTHORITIES

This study is in partial response to the following authorities:

1. Sacramento, San Joaquin and Kern Rivers, California, Resolution, House Committee on Public Works, 8 May 1964:

   Resolved by the Committee on Public Works of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors is hereby requested to review the reports on Sacramento, San Joaquin and Kern Rivers, California, published as House Document 191, 73rd Congress, Second Session, and other reports, with a view to determining the feasibility of remedial measures for water quality control and other purposes, included in comprehensive development of the Sacramento-San Joaquin Delta, including verification of conclusions by model analysis as deemed necessary.

2. San Francisco Bay, California, Water Quality Control Study, Section 216 Flood Control Act of 1965 – PL 89–298:

   Sec. 216. The Secretary of the Army is hereby authorized and directed to cause to be made, under the direction of the Chief of Engineers, an investigation and study of San Francisco Bay, California, including San Pablo Bay, Suisun Bay, and other adjacent bays and tributaries thereto, with a view toward determining the feasibility of, and extent of Federal interest in, measures for waste disposal and water quality control and allied purposes.