AD-A036 837 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
A036837

AD A036837

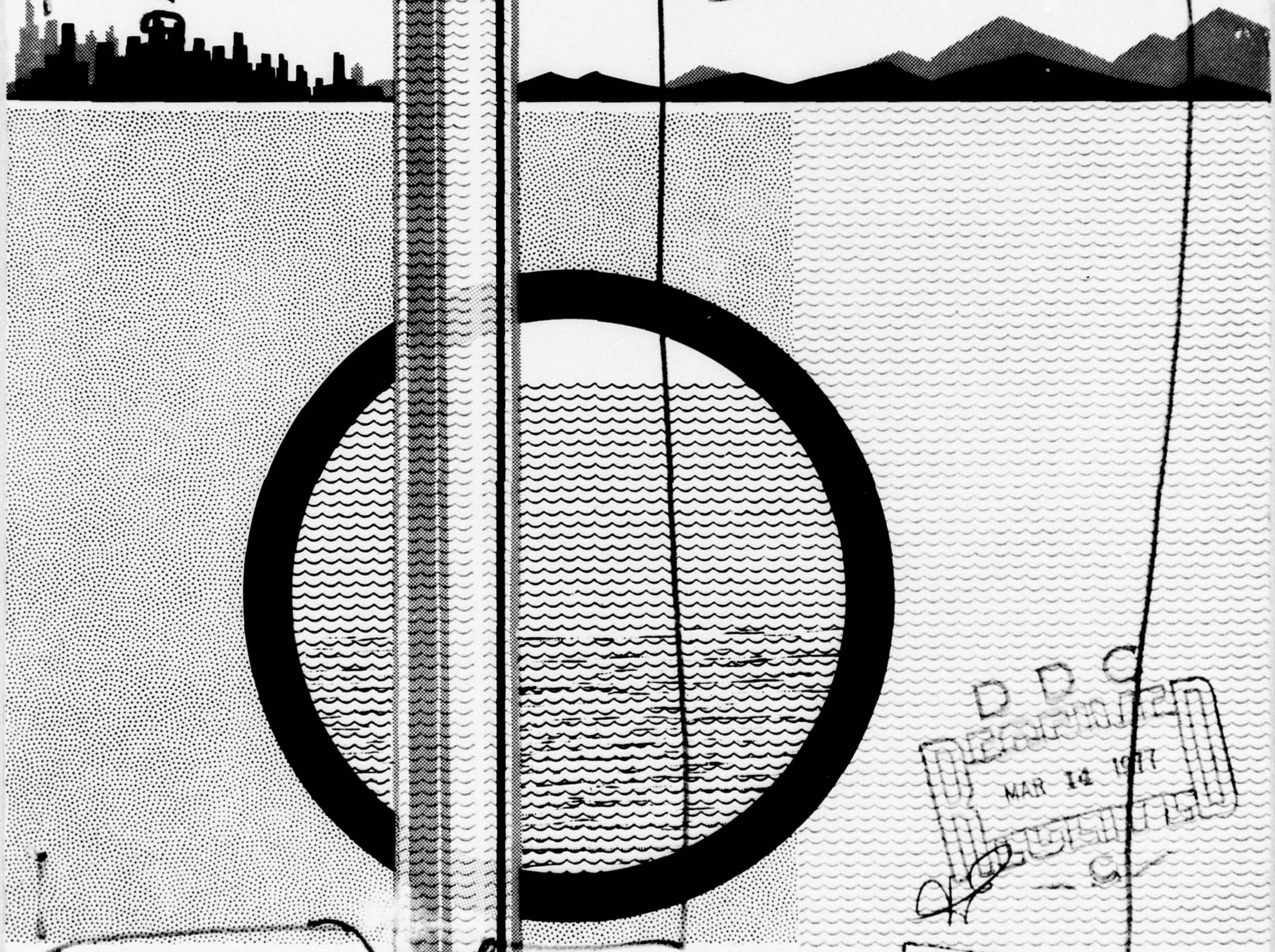
(11) Jul 71

(12) 163 p.

(6)

(1)

ALTERNATIVES FOR MANAGING WASTEWATER



VOLUME I.

APPENDIX A – STUDY AREA TODAY AND IN THE FUTURE

APPENDIX B – DEVELOPMENT OF ALTERNATIVES

JULY 1971

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

391022

ALTERNATIVES FOR MANAGING WASTEWATER IN THE SAN FRANCISCO BAY AND SACRAMENTO-SAN JOAQUIN DELTA AREA

APPENDIX A

STUDY AREA TODAY AND IN THE FUTURE

US ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

JULY 1971

APPENDIX A

STUDY AREA TODAY AND IN THE FUTURE

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLES

TABLE OF CONTENTS (Cont'd)

TABLES (Cont'd)

TABLE OF CONTENTS (Cont'd)

FIGURES

ABBREVIATIONS

ABAG	Association of Bay Area Governments
AFY	acre-feet per year
BOD	biochemical oxygen demand
BTU	British thermal unit
cfs	cubic feet per second
Cl	chloride
DO	dissolved oxygen
DPH	California Department of Public Health
DWR	California Department of Water Resources
EPA	United States Environmental Protection Agency
HUD	United States Department of Housing and Urban Development
JTU	Jackson turbidity units
MAF	million acre-feet
mgd	million gallons per day
MPN	most probable number
NA	not available
PPM	parts per million
SD	Sanitary District
TDS	total dissolved solids
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
UCBS	University of California San Francisco Bay Study
USBR	United States Bureau of Reclamation
USCE	United States Army Corps of Engineers
USGS	United States Geological Survey
USN	United States Navy
USPHS	United States Public Health Service
NDAA	National Oceanographic and Atmospheric Agency

CONVERSION FACTORS

Multiply mgd by 1.547 to obtain cfs.
Multiply mgd by 1121 to obtain AFY.
Multiply AFY by 0.00138 to obtain cfs.
Multiply AFY by 0.000891 to obtain mgd.

APPENDIX A

STUDY AREA TODAY AND IN THE FUTURE

STUDY AREA TODAY

A-1. DESCRIPTION OF THE STUDY AREA

a. Land Area. The San Francisco Bay and Delta estuary and its adjacent land area occupy some 10,000 square miles in west-central California. The land area relating to the estuary encompasses 12 counties: the nine Bay counties of San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Solano, Napa, Sonoma, and Marin; and the three Delta counties of Sacramento, San Joaquin and Yolo (Figure A-1). The 12-county study area is the same as that used in the recently completed study for the State of California San Francisco Bay-Delta Water Quality Control Program. 1/

Two major factors define the study area as a region for waste-water 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 head-waters in the tributary area. Marshland conditions are vital to a variety of wildlife, particularly the waterfowl using the Pacific Fly-way. 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/ San Francisco Bay-Delta Water Quality Control Program, Final Report to the State of California; Kaiser Engineers, 1969. (This report is referred to hereafter as the "Bay-Delta Program.")

b. Bay and Delta Estuary. The Bay and Delta estuary originally comprised about 1,800 square miles of tidal waters, approximately 700 square miles for the San Francisco Bay system, and 1,100 square miles for the Delta and the tidal marshes and lowlands formed by the confluence of the lower Sacramento and San Joaquin River drainage systems.

The estuary was created through a combination of geological events, erosion and rise in sea level, which established a breach in the California Coast Ranges, which separate the Pacific Ocean from the great Central Valley. The breach allowed ocean waters to ingress into a portion of the valley and enabled an otherwise "trapped" drainage system to discharge into the Pacific Ocean.

The seaward approaches to the Golden Gate are characterized by a rather broad, shallow shelf. Most of the shelf is less than 30 fathoms (180 feet) deep, and the immediate approaches to the Golden Gate are less than 10 fathoms (60 feet) deep. A shallow semicircular bar reduces the ocean entrance depth westward of the Golden Gate. Shallowness is also a salient characteristic of the entire Bay and Delta estuary, 80 percent of San Francisco Bay being less than 30 feet deep, 70 percent less than 18 feet deep.

The entire estuary is strongly influenced by the tides; it takes about 2 hours for the tide to propagate from the Golden Gate to the most southern reach of San Francisco Bay and between 7 and 8 hours to propagate to the upper tidal reaches of the Sacramento and San Joaquin Rivers. The average tidal range is about 5 feet at the Golden Gate, 8 feet at the southern end of San Francisco Bay, and 3 feet in the Delta, with extreme ranges some 2 to 3 feet greater. Varied bathymetry and channel constrictions induce large variations in tidal current velocities and mixing.

Climatologically, the area is characterized by scant rainfall and high evaporation (about 48 inches, more than twice the annual precipitation for San Francisco Bay system) during more than 8 months of the year. Precipitation is concentrated during the winter months, as can be seen from Table A-1.

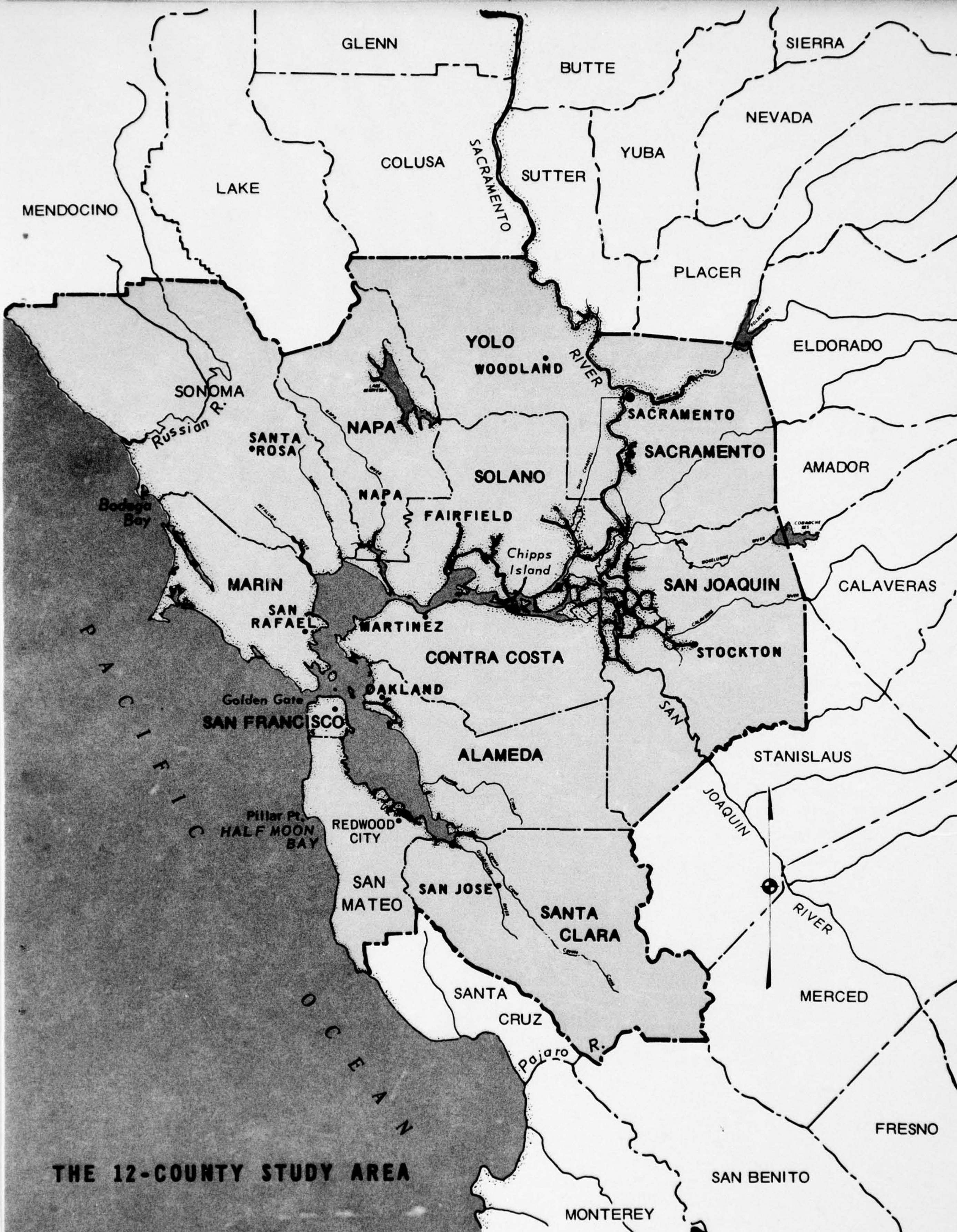

GLENN
BUTTE
SIERRA
NEVADA
COLUSA
SACRAMENTO
SUTTER
YUBA
LAKE
MENDOCINO
PLACER
YOLO
WOODLAND
RIVER
ELDORADO
SONOMA
Russian R.
SANTA ROSA
NAPA
SACRAMENTO
SACRAMENTO
AMADOR
SOLANO
NAPA
Bodega Bay
FAIRFIELD
Chipps Island
MARIN
SAN JOAQUIN
CALAVERAS
SAN RAFAEL
MARTINEZ
CONTRA COSTA
STOCKTON
PACIFIC OCEAN
Golden Gate
OAKLAND
SAN FRANCISCO
ALAMEDA
SAN
STANISLAUS
JOAQUIN
Pillar Pt.
HALF MOON BAY
REDWOOD CITY
SAN MATEO
SAN JOSE
SANTA CLARA
RIVER
SANTA CRUZ
MERCED
Pajaro R.
FRESNO
THE 12-COUNTY STUDY AREA
SAN BENITO
MONTEREY

FIGURE A-1

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."

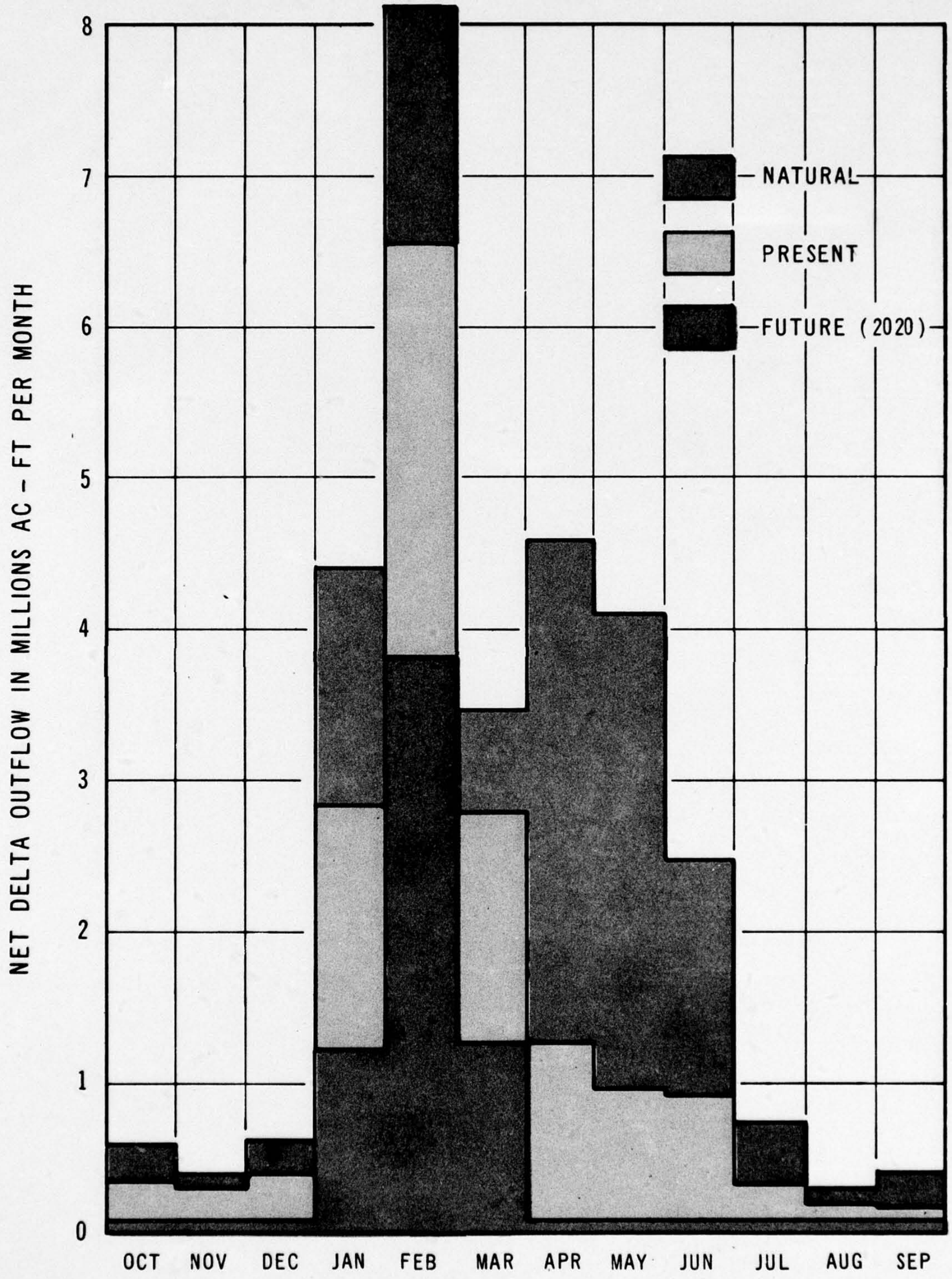


FIGURE A-2

TABLE A-1

AVERAGE MONTHLY PRECIPITATION AT

SELECTED STATIONS IN 12-COUNTY AREA (INCHES)

	San Francisco (Airport)	San Jose	Napa (St Hosp.)	Antioch	San Rafael	Sacramento (Airport)	Stockton (Airport)	Oakland (Airport)
JAN	4.0	2.7	4.9	2.7	9.6	3.2	2.6	3.8
FEB	3.5	2.6	4.3	2.4	6.8	3.0	2.5	3.2
MAR	2.7	1.9	3.3	2.0	4.2	2.4	2.1	2.4
APR	1.3	1.1	1.7	1.0	3.1	1.4	1.1	1.4
MAY	.5	.4	.9	.5	1.1	.6	.4	.7
JUN	.1	.1	.2	.1	.2	.1	.1	.1
JUL	.0	.0	.0	.0	.0	.0	.0	.0
AUG	.0	.0	.0	.0	.0	.0	.0	.0
SEP	.2	.1	.2	.1	.6	.2	.2	.2
OCT	.7	.6	1.2	.6	1.5	.8	.6	.8
NOV	1.6	1.1	2.3	1.1	3.0	1.5	1.2	1.7
DEC	4.1	2.6	4.9	2.8	7.9	3.2	2.7	3.6
TOTAL	18.7	13.2	23.9	13.3	38.0	16.4	13.5	17.9

Source: Climatic Summary of the United States, Supplement for 1951 through 1960, California; U.S. Dept. of Commerce, Weather Bureau.

Figures are rounded to tenths of an inch.

Hydrologically, before man regulated the fresh-water outflow of the Sacramento-San Joaquin River systems, the area was characterized by large transient runoff discharges during the late fall-winter, early spring rainy period, and by marked increase during the late spring of outflow from streams draining the snow-melt area of the northern Coast Range, southern Cascades, and Sierra Nevada. Minimal flow prevailed during all other periods. The distribution of Delta flows during the year is shown in Figure A-2 under three conditions: natural (before water development projects), present, and projected for the year 2020.

Under natural conditions the large variations in fresh-water influxes, coupled with high evaporation rates, resulted in marked salinity variations throughout the system. The shallowness of the seaward approaches to the Golden Gate also restricted the properties of the ingressing ocean water mass to those of the mixed-upper thermocline layers, salinity variations between surface and bottom being one part per thousand or less, and temperature differences between the surface and the bottom being at most 8 degrees centigrade.

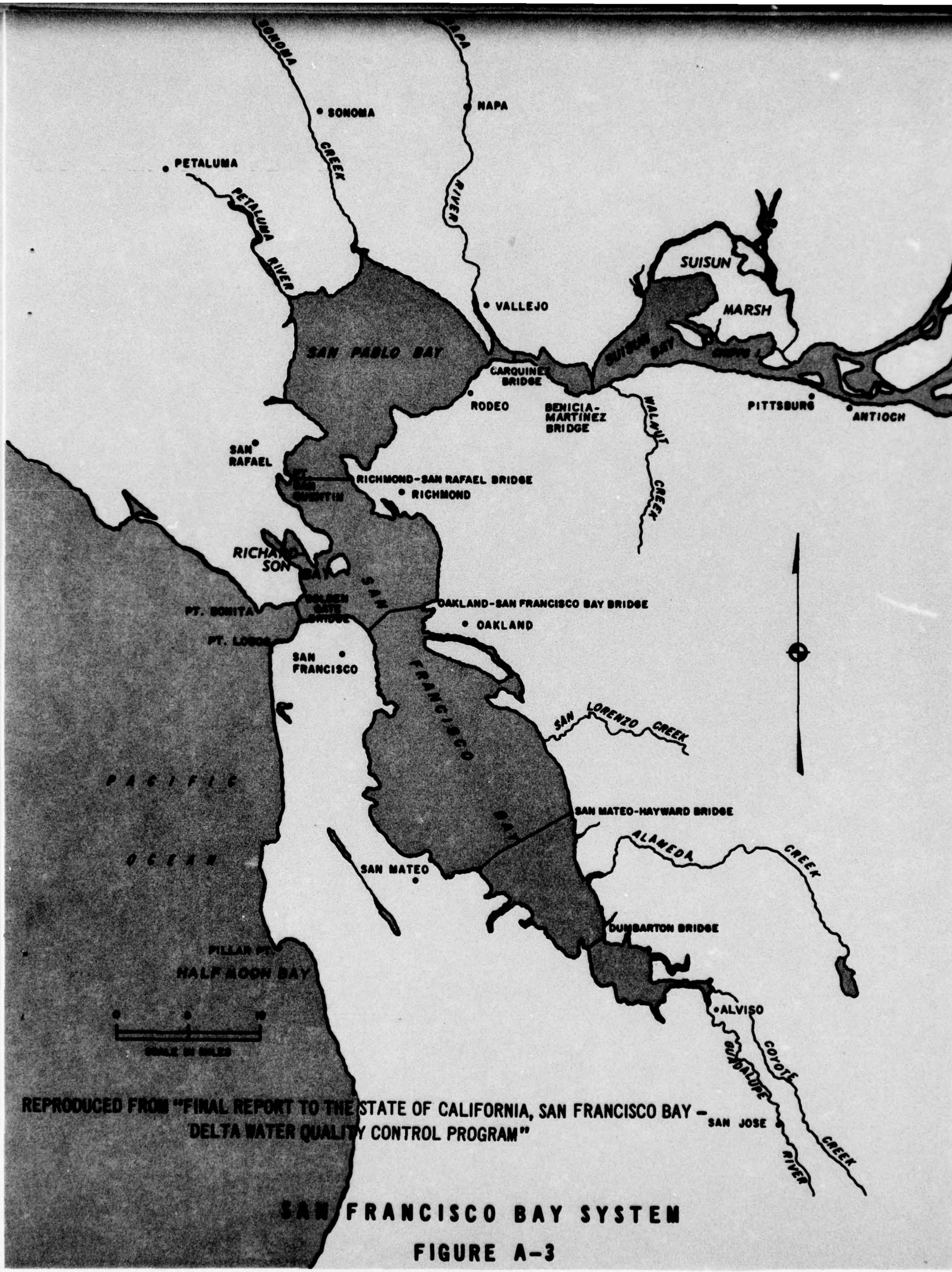
During periods of high runoff, large amounts of sediments enter the Bay and Delta system; these contain a high percentage of clay minerals with an average cation-exchange capacity of about 30 milliequivalents per 100 grams of whole sediment.

Oceanographically, the Bay and Delta estuary is a compound, partially mixed estuary, which can be subdivided into two distinct but very closely interrelated segments:

(1) <u>The San Francisco Bay System</u>. The San Francisco Bay system, which comprises Suisun, San Pablo, and San Francisco Bays, extends east from the Golden Gate to Pittsburg and southeast to the vicinity of San Jose (Figure A-3). The only connection with the Pacific Ocean is through the Golden Gate. The perimeter of the Bay System contains substantial marshland areas.

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 shoreline 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 currently redeposited in various parts of the Bay.



SAN FRANCISCO BAY SYSTEM

FIGURE A-3

The Bay system is a bifurcated, compound, modified estuary. Although it has several small tributary streams, the only local fresh-water influx occurs during sporadic periods of runoff during the rainy season. The vast majority of fresh water that enters the system comes from the Sacramento and San Joaquin River systems via the Delta.

The Bay system is hydrologically divisible into three regimes: the South Bay, south of the Oakland - San Francisco Bay Bridge; the Central Bay, extending from San Francisco northward to San Pablo Point; and the North Bay, from San Pablo Point eastward to Chipps Island, near Pittsburg.

The North Bay is a true estuary with fresh-water inflow at its head and strong intermixing of fresh and salt water in the Suisun Bay and Carquinez Strait reaches. The basic circulation is typically that of a two-layer system, with net outflow of lower-salinity waters in the upper layers and net inflow of higher-salinity water in the bottom layers. Brackish water, the result of intermixture of salt and fresh water, discharges into San Pablo Bay.

The Central Bay, lying directly inland from the Golden Gate, is the main mixing area between the ocean waters and the brackish discharges from Carquinez Strait.

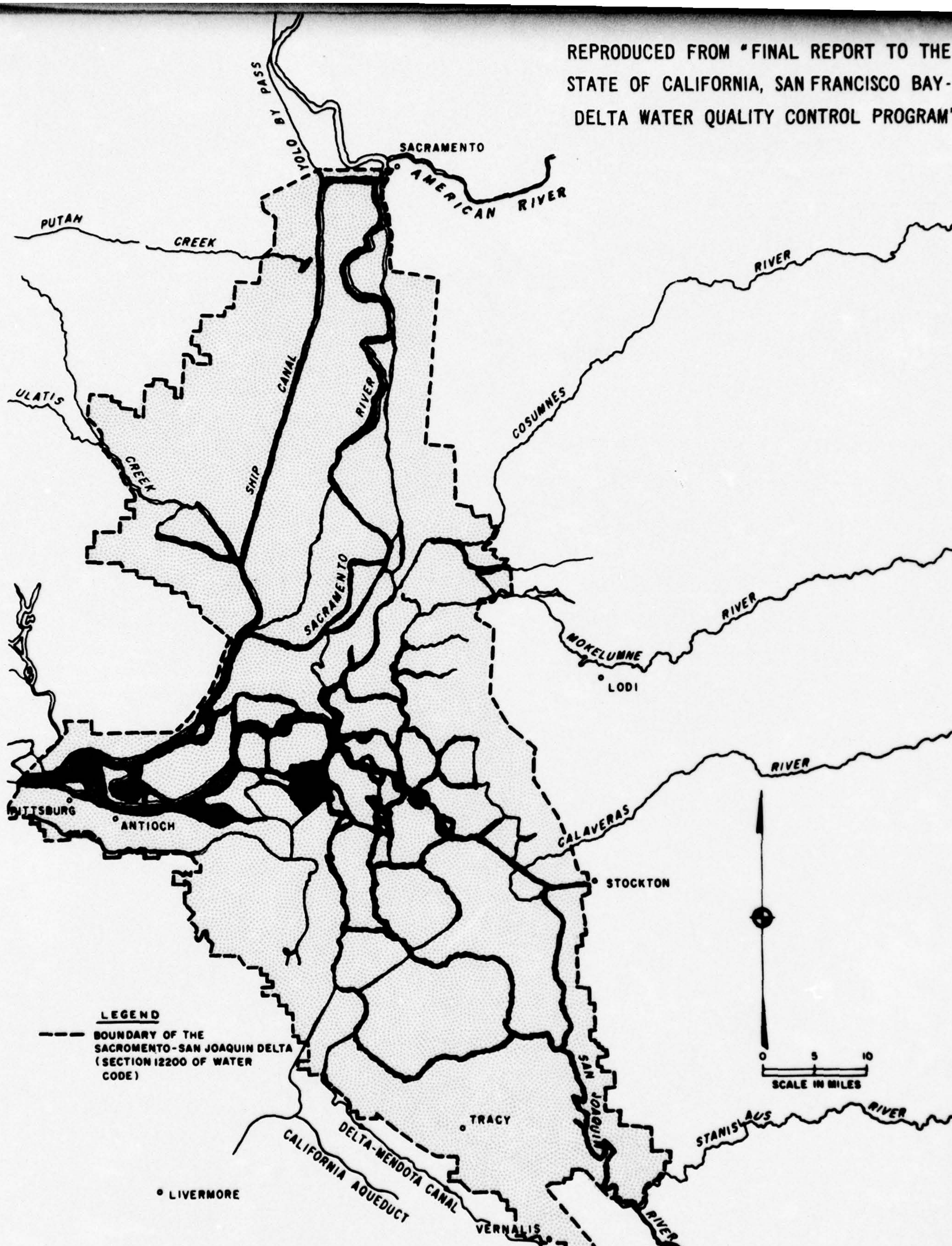
The South Bay is an evaporative cul de sac with almost no fresh-water influx and a sluggish circulation controlled primarily by tidal effects and transient meteorological conditions. During part of the year it is actually a "negative estuary," i.e., there is a net movement of water into, rather than out of, the inlet. Brackish water from Carquinez Strait, diverted to South Bay by winds and tidal action, contributes to the flushing of South Bay. The water mass properties of South Bay closely reflect those of the slightly modified oceanic waters of Central Bay. The well-defined, typically estuarine two-layer circulation system prevailing in Central and North Bays does not appear to prevail in South Bay, except during periods of peak fresh-water runoff.

(2) Sacramento and San Joaquin Delta. The Delta encompasses an area of over 1,100 square miles. The Delta, roughly triangular in shape, extends from Chipps Island on the west, near Pittsburg, to Sacramento on the north, and Vernalis on the south, near the San Joaquin River (Figure A-4). All waters originating 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 water surface area of more than 75 square miles, are subject to tidal action originating at the Golden Gate. The remaining land area is divided between the Delta uplands and lowlands. The Delta lowlands are composed of more than 50 reclaimed islands with a total land area of 700 square miles. These islands,

inclosed 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.

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



THE SACRAMENTO-SAN JOAQUIN DELTA

FIGURE A-4

A diffuse salt wedge is present in the western reaches of the Delta. Agricultural production in the Delta requires the control of saline intrusion. The location of the saline front is at present somewhat stabilized in the vicinity of Antioch by the regulation of outflows from dams such as Shasta Dam in Shasta County (Figure A-5).

c. 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 Farallones. Located on the shelf about eight miles from the Golden Gate Bridge is a semicircular bar with depths of 36 feet or less. The bar, which reduces the entrance depth to the Golden Gate, has been improved for navigation by means of a dredged channel with a depth of 50 feet; authorized to be deepened to a depth of 55 feet.

d. Geology.

(1) 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 southernmost 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 River basin by a very low divide.

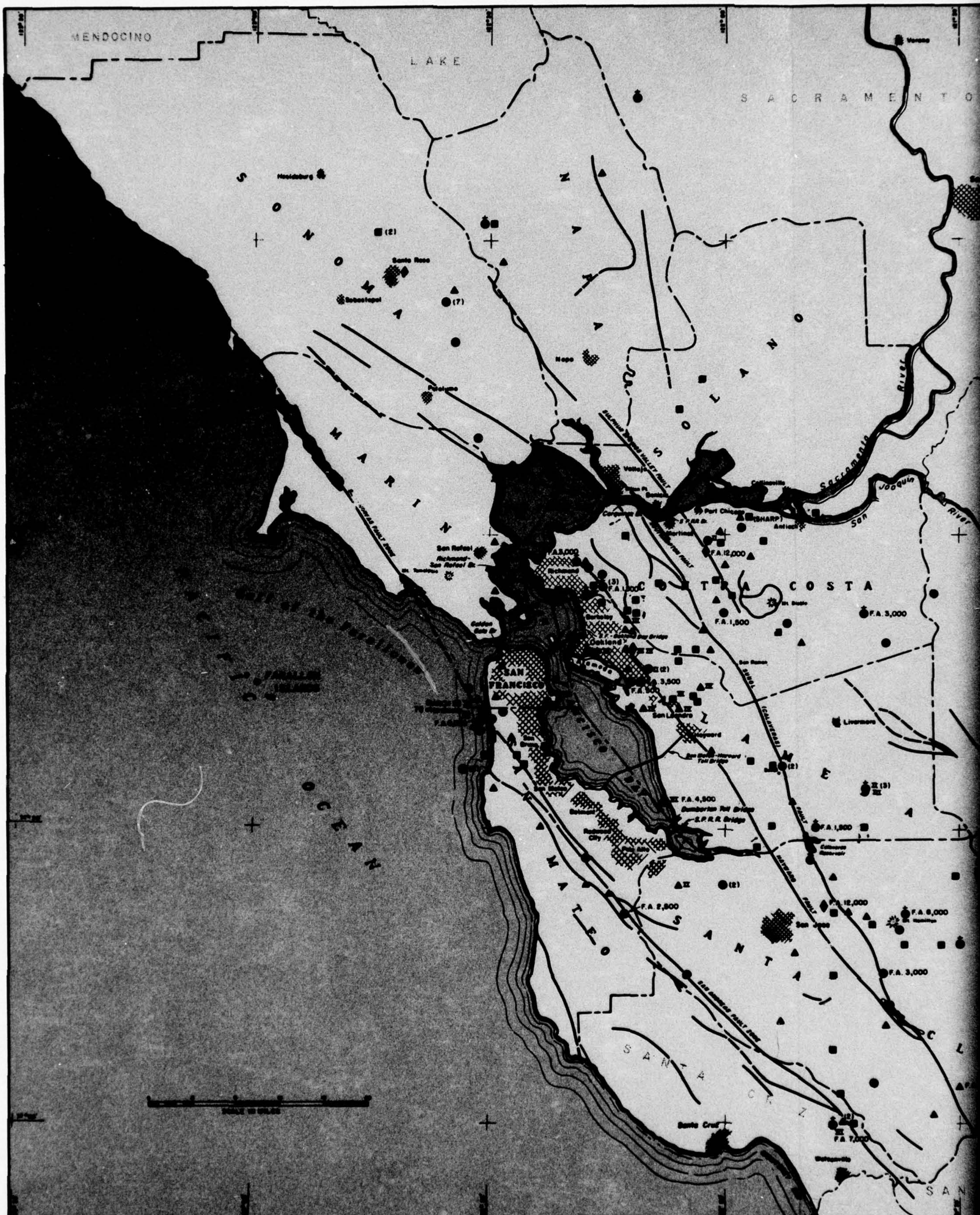
The rocks of the Coast Ranges are predominantly consolidated marine sedimentary and volcanic rocks. Unconsolidated marine sediments and alluvial deposits are also present in the valley floor and in San Francisco Bay. Consolidated rocks in the Great Valley province are also present, but lie at depths 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.

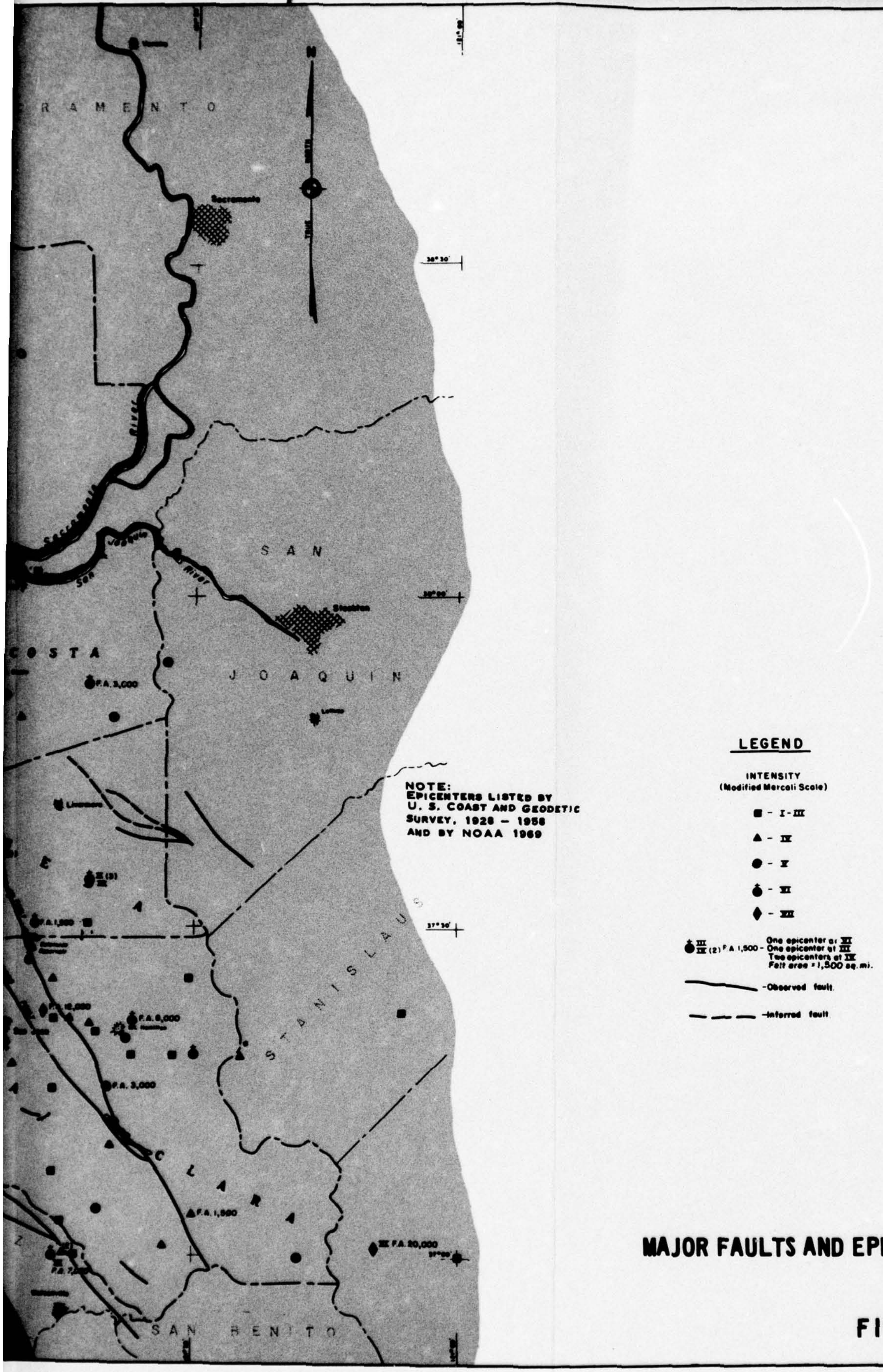
(2) San Francisco Bay and Delta Area. The geologic history of the Bay area is characterized by a long record of extensive earth movements and seismic activity, complicated by substantial changes in sea level during comparatively recent geologic time. The structural trough in which the Bay is located 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 meltwater 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.

(3) 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 A-6 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.


CENTRAL VALLEY DRAINAGE BASIN
SAN FRANCISCO BAY & DELTA AREA
CALIFORNIA
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
GLENN
BUTTE
SIERRA
MENDOCINO
COLUSA
SUTTER
YUBA
NEVADA
PLACER
LAKE
YOLO
EL DORADO
SONOMA
NAPA
ALPINE
SACRAMENTO
AMADOR
CALAVERAS
SOLANO
MARIN
SAN JOAQUIN
TUOLUMNE
MONO
CONTRA COSTA
SAN FRANCISCO
ALAMEDA
SAN MATEO
STANISLAUS
MARIPOSA
SANTA CLARA
MERCED
SANTA CRUZ
MADERA
SAN BENITO
FRESNO
INYO
TULARE
MONTEREY
KINGS
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL

FIGURE A-5


MENDOCINO
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
S A N T A C R U Z
P A C I F I C O C E A N
SAN FRANCISCO
Santa Rosa
Sebastopol
Napa
Petaluma
Vallejo
San Rafael
Richmond
Berkeley
Oakland
San Leandro
Hayward
Livermore
San Jose
Santa Cruz
Watsonville
Port Chicago
Antioch
Martinez
Collinsville
(SHARP)
Sacramento River
San Joaquin River
Dumbarton Toll Bridge
S.P.R.R. Bridge
F.A. 12,000
F.A. 1,500
F.A. 3,000
F.A. 4,500
F.A. 1,800
F.A. 6,000
F.A. 7,000
(2)
(3)
(7)



MAJOR FAULTS AND EPICENTERS

FIGURE A-6

e. 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 A-2). 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 headwaters 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 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.

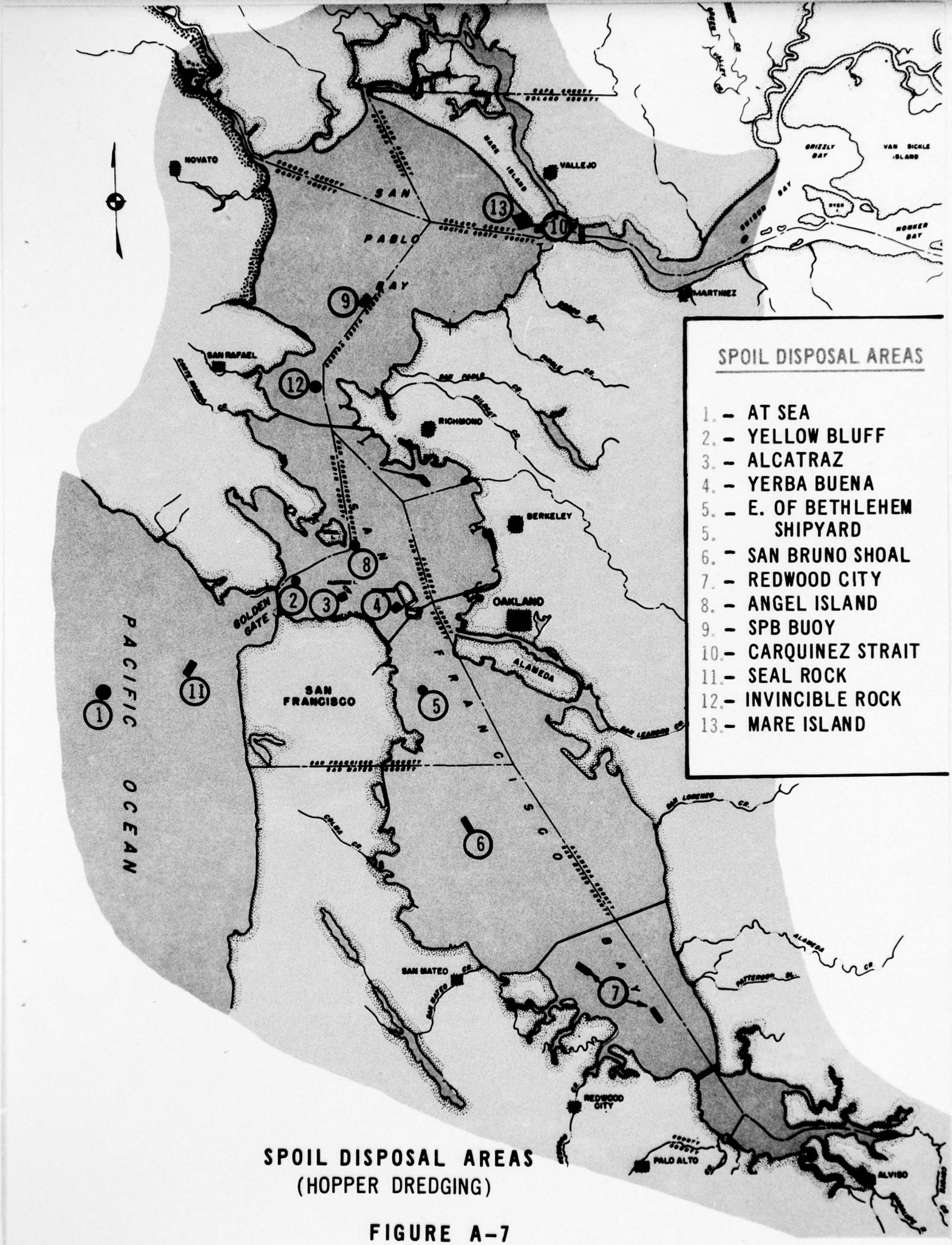
A-2. MAN'S IMPACTS UPON THE ESTUARY

The present status of the Bay and Delta estuary is that of a variously polluted environment, altered from its natural state by man's agricultural, industrial, and urban activities. The transformations produced by human activities can be described in specific terms:

a. Physical Modifications. The physical modification is best exemplified by the extent and impacts of dredging, filling, and diking of the various waterways, tidal flats, marshes and lowlands. The most extensive physical modifications have occurred in the Delta, where the flood plain at the confluence of the Sacramento-San Joaquin Rivers has been completely transformed into a "polder" like, highly productive agricultural region. The remaining marshlands of the Suisun Bay area have been extensively diked and transformed into a managed wetland status.

The original 680 square miles of the San Francisco Bay system have shrunk to a little less than 425 square miles through deliberate filling of marshlands and tidal flats.

Approximately 300 miles of navigation channels have been dredged in the estuary. The initial dredge spoil from these projects was mostly used for filling of land areas adjacent to the estuary. At present these channels require maintenance dredging of approximately 8 million cubic yards of sediments per year. These sediments, which are part of the estuary's natural regimen of circulation with the diurnal tides, are dredged and redeposited in the estuary where they will be carried away from the channels or out of the estuary through the Golden Gate. Currently active dredge spoil areas are shown in Figure A-7.



SPOIL DISPOSAL AREAS
(HOPPER DREDGING)

FIGURE A-7

b. Hydrologic Modifications. There is a large disparity in the availability of fresh water in California. About 80 percent of the runoff from the State occurs in the North Coastal area and the Sacramento River and San Joaquin River (northern portion) drainage systems. About 40 percent of the State runoff drains through the Sacramento and San Joaquin River systems. Approximately 70-80 percent of the State's fresh-water demands occur south of the San Francisco Bay-Delta area. The need for additional water south of the study area has generated large Federal-State water projects for the collection, storage, transport, and redistribution of water. A feature of the California Water Project involves the diversion of the flow of the Sacramento River through a "Peripheral Canal" east of and bypassing the Delta. Such diversions, along with proposals for continued upstream development, will reduce the net Delta outflow from the present 18 million acre-feet per year to about 7 million acre-feet by the year 2020.

Large withdrawals of ground water for irrigation have resulted in significant subsidence in portions of the Delta lowlands and the portion of the Santa Clara Valley bordering South Bay.

The regulation of fresh-water discharge for salt-intrusion control has resulted in transforming the North Bay into a "controlled" estuarine-condition status, especially east of San Pablo Bay. A net fresh-water head is continuously maintained, resulting in a steady-state two-layer flow as mentioned above.

In its natural state, as a result of the combined effects of high evaporation and large seasonal fluctuations in fresh-water influx, the Bay and Delta estuarine system was characterized by marked variations in salinity throughout its tidal reaches. The present seasonal salinity regime of South Bay still exhibits some of the original estuarine conditions.

c. Biological Modifications. The biology of the Bay-Delta estuary has been extensively modified through the introduction of bacteria, pathogens, and viruses from sewage, the contribution of chemical toxicants from industrial wastes, and the unintentional introduction of various marine pests (oyster drills, etc.), which have caused extensive damage to shellfish, as well as to marine structures. The aborigine (botanical and faunistic) characteristics of the region have been either eradicated or extensively depleted, displaced and supplanted.

The anadromous salmonids, which once migrated by the millions to Central Valley spawning grounds, have dwindled to about 600,000 yearly migrants. Shad, striped bass, and other fishes have been introduced to supplement the indigenous populations, but these fishes are now also experiencing population declines due to pollution, reduced fresh-water flows and water diversions in and upstream of the Delta.

Recent instances of mass mortality of seals and sea lions, which frequent the coastal area in the vicinity of the Golden Gate, suggest the spread of leptospirosis, a serious microbial infection of land mammals. Kelp, a marine alga which is both a sensitive indicator of changes in the quality of the environment and part of the normal physical habitat of some of the lower animals in the marine food chain, once was abundant in the more oceanic portions of the Bay, but is now gone. Much of the marshland and tule vegetations has been displaced by Bay fill with land development and diked wetlands. As a result wintering waterfowls, once in the millions, are now down to about 700,000 birds, and most of the waterfowl areas are in private ownership.

The area is not as yet a biological desert, for many forms still thrive. The extent of microbial contamination, however, makes many of the forms unfit for human consumption. Presently almost all of San Francisco Bay is closed to shellfish harvesting. Some of the historical events that have figured in the deterioration of the area's waters are summarized in Figure C-1 (Appendix C).

d. Geo-Biochemical Modifications. For several decades, and especially over the last 20 years, an ever-increasing quantity and variety of chemicals have been discharged into the estuary. At present over 600 million gallons per day (930 cfs; 670,000 AFY) of variously treated mixes of municipal and industrial wastes are being discharged into the estuarine system. Until limiting orders were issued by the California Regional Water Quality Control Board, San Francisco Bay Region, in December 1970, about 25 million gallons of petrochemicals, 15 million gallons of steel-mill process wastes, and 22 thousand tons of cannery wastes per year were being dumped into the ocean a few miles offshore from the Golden Gate. These industries are now under a time schedule in which to construct facilities to treat these wastes or to demonstrate that dumping further at sea will not adversely affect water quality.

The California Regional Water Quality Control Boards are discussed later in Paragraph A-5.

Increases in the frequency of fish kills, incidences of algae blooms, and appreciable levels of toxicants in biota and bottom sediments are tangible evidence of the alteration of the geo-biochemical makeup of the estuary.

A-3 ECONOMIC CONSIDERATIONS

a. Population. The population of the 12-county study area has tripled over the past 40 years, with approximately 60 percent of the increase occurring 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 A-2).

TABLE A-2

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

County	Growth Rate 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.

Source: Bureau of Census.

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 1-1/4 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 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, and nuclear research).

d. 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. A wide range of crops are 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 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 A-3.

e. Industry. With the advent of World War II, California became permanently industrialized. Approximately 2,200,000 persons are presently employed in the study area.

There are approximately 6,000 manufacturing enterprises in the study area. The vast majority of these industrial concerns 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, 26 are grouped into the following Standard Industrial Categories according to 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.

Table A-4 summarizes the municipal and industrial flows for each county in the study area for 1970. The industrial process flows include only those from the above five categories. The industrial cooling flows include those from all industries.

TABLE A-3

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

County	Residential	Commercial	Industrial 1/	Public	Totals
Alameda	58.2	4.5	9.7	13.9	86.3
Contra Costa	55.6	3.5	9.2	18.6	86.9
Marin	12.0	0.6	0.2	78.7	91.5
Napa	2.4	0.6	0.4	83.7	87.1
Sacramento	60.5	5.6	5.5	20.1	91.7
San Francisco	13.5	2.2	3.3	8.3	27.3
San Joaquin	18.3	2.4	4.8	8.2	33.7
San Mateo	46.2	2.3	3.8	19.4	71.7
Santa Clara	62.8	4.1	21.7	30.8	119.4
Solano	6.6	0.4	0.3	41.6	48.9
Sonoma	3.4	1.0	16.3	38.6	59.3
Yolo	6.2	1.6	2.5	4.1	14.4
Total	345.7	28.8	77.7	366.0	818.2

1/ Includes wholesale trade.

Source: Bay-Delta Program Final Report, Table IV-2.

TABLE A-4

1970 ESTIMATED AVERAGE ANNUAL MUNICIPAL AND INDUSTRIAL FLOWS
(In mgd)

County	Municipal	Industrial Process	Industrial Cooling
Alameda	125	3	147
Contra Costa	53	76	2,768
Marin	17		
Napa	6	4	
Sacramento	83		
San Francisco	95		809
San Joaquin	21	9	
San Mateo	51	2	11
Santa Clara	106		
Solano	21		
Sonoma	5		
Yolo	10		3
Totals	593	94	3,738

Source: State Bay-Delta Water Quality Control Program Final Report, Tables V-6, XX-1, and XX-6b; and Task II-4, Table IV-5.

f. Agriculture. California is the nation's leading agricultural state. 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. The Sacramento and San Joaquin Valleys are the principal sources of agricultural drainage entering the Bay-Delta system. This drainage results from the uncontrolled discharge of agricultural wastes to the Sacramento and San Joaquin Rivers and their tributaries. The necessity for augmenting natural drainage as a method of agricultural waste disposal in the San Joaquin Valley has been acknowledged as a critical problem in recent years. This problem is caused by the fact that the southern part of the San Joaquin Valley is essentially a closed basin, without natural drainage, and many areas in the northern portion are not drained effectively by the San Joaquin River system. With the application of irrigation waters, a salt buildup in the soil occurs. If allowed to proceed too far, such a buildup would render the soil unfit for agriculture. Recognizing this fact, both the State and Federal Governments have given consideration to projects for collecting and carrying off the agricultural subsurface drainage from the San Joaquin Valley. Until recently a jointly sponsored master drain was planned. For reasons of its own, the State has deferred planning for design and construction of such a drain, but the USBR has proceeded with construction of the

San Luis drain which will carry about 30 percent of the agricultural subsurface drainage from the San Joaquin Valley, and is planned to discharge to the Delta near Antioch.

Table A-5 shows the acreage under irrigation in the 12-county Bay and Delta area. Some two million acres are also under irrigation in the Central Valley, tributary to the Bay and Delta.

TABLE A-5

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, & Sonoma	75,000
Solono	200,000
Yolo	400,000
Total	1,810,000

1/ Estimates based on land-use map from DWR Bulletin 160-70.

A-4. COMPARISON BETWEEN WATER QUALITY AND WATER QUALITY STANDARDS

a. Sub-areas. To facilitate planning, the 12-county study area has been subdivided into four waste-source sub-areas as follows:

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

Most of the available data were developed on a county-by-county basis. Rather than present data for 12 individual counties, and attempt to develop alternatives for each county, it was considered that some counties could be grouped together because of their economic, demographic, or geographic similarity. Sub-area A is well diversified urban area and encloses the South Bay; Sub-area B is mainly a rural and suburban non-industrial area; Sub-area C contains the majority of industrial development in the study area; Sub-area D can be considered as a separate unit because of its location. Such a grouping of counties, moreover, is consistent with current planning efforts by the various subregional studies now in progress. These sub-areas are shown on Figure A-8.

b. Pollution Sources. Pollution loadings in the San Francisco Bay and Delta area originate from several sources. The vast majority of both flows and loads originate from municipal and industrial sources. Agricultural wastewaters, natural runoff, and discharges from ships and other watercraft also contribute to the overall problem.

(1) Municipal and Industrial. Figure A-9, indicates the locations of all major identifiable municipal and industrial discharges in the 12-county area. A summary of the estimated 1970 wasteloads from municipal and industrial sources discharged in the study area is shown in Table A-6. Approximately 40 percent of the municipal wastewaters receive secondary treatment, while 60 percent receive primary treatment only. Industrial treatment processes vary, but on the average the level of treatment is between primary and secondary. It should be noted that the loads indicated in Table A-6 represent amounts entering the estuary after treatment.

TABLE A-6

ESTIMATED 1970 TREATED MUNICIPAL AND INDUSTRIAL WASTE LOADS
(in 1,000 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	-	-	153	-	-	165	-	-	423	-	-	2431	-	-
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	-	11	*1	-	*1	1	-	1	2	-	2	14	-	14
Phenols	0	*1	*1	0	*1	*1	0	*1	*1	0	*1	*1	0	*1	*1
Relative Toxicity (mgd)	492	-	-	60	-	-	61	-	-	163	-	-	776	-	-
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	-	-	21	2150	2171	92	-	92	457	3100	3557+

NOTES

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

* = Less Than
\- = 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.

TABLE A-6 (Cont'd)

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

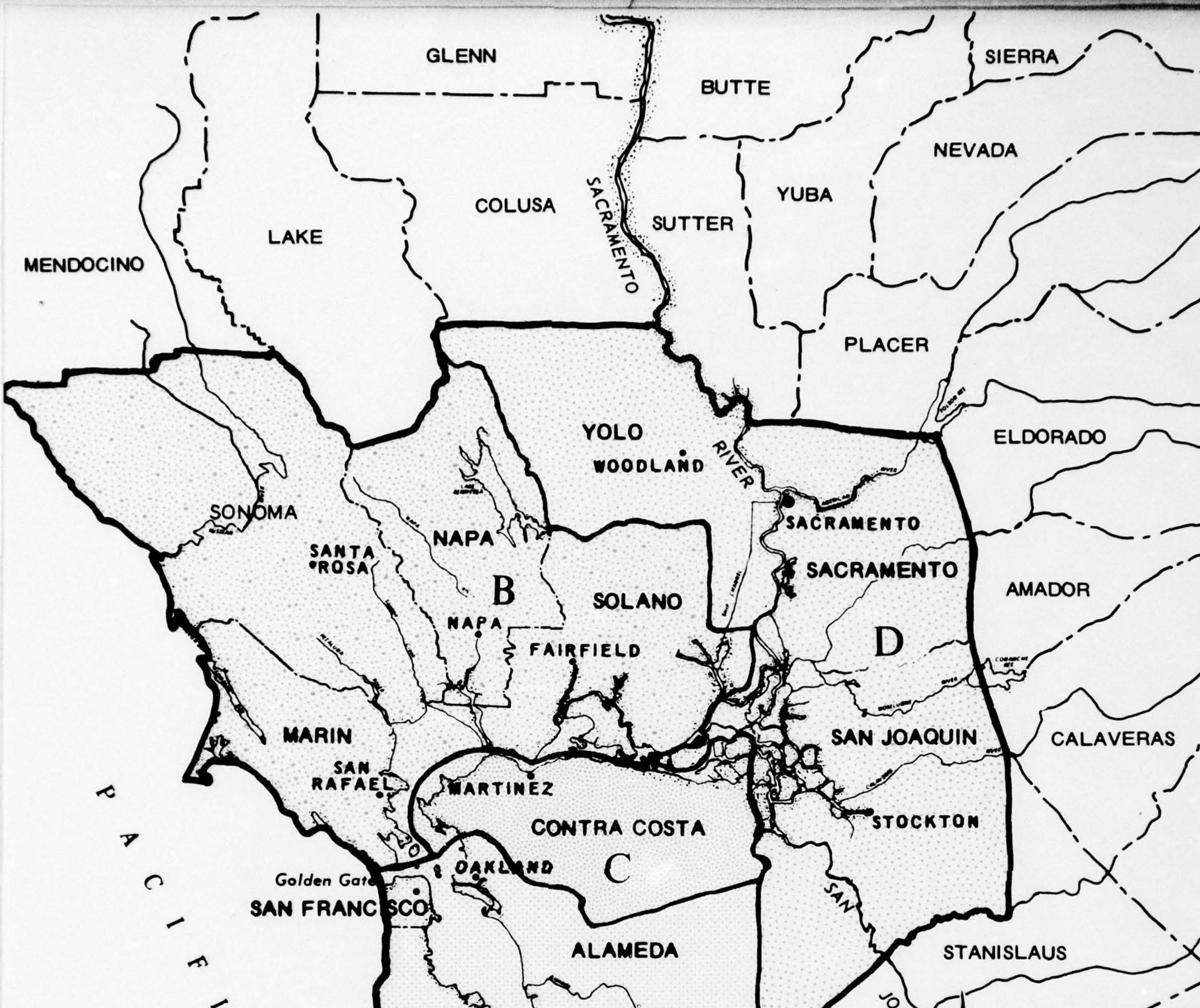
Relative Toxicity - the volumetric rate of flow times the reciprocal of the median tolerance limit (TLm). The TLm is the concentration (in percent or as a decimal fraction) of a waste stream which kills one-half of the test specimens of a given organism within a specified period of time.

The data in Table A-6 are useful to determine where wastes originate and to determine the total magnitude of pollutant constituents discharged to the estuary. But because of complex mixing and current phenomena in the estuary, as well as tidal exchange and dilution factors, little knowledge of the actual water quality in the estuary can be determined from the loads as shown in the table.

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

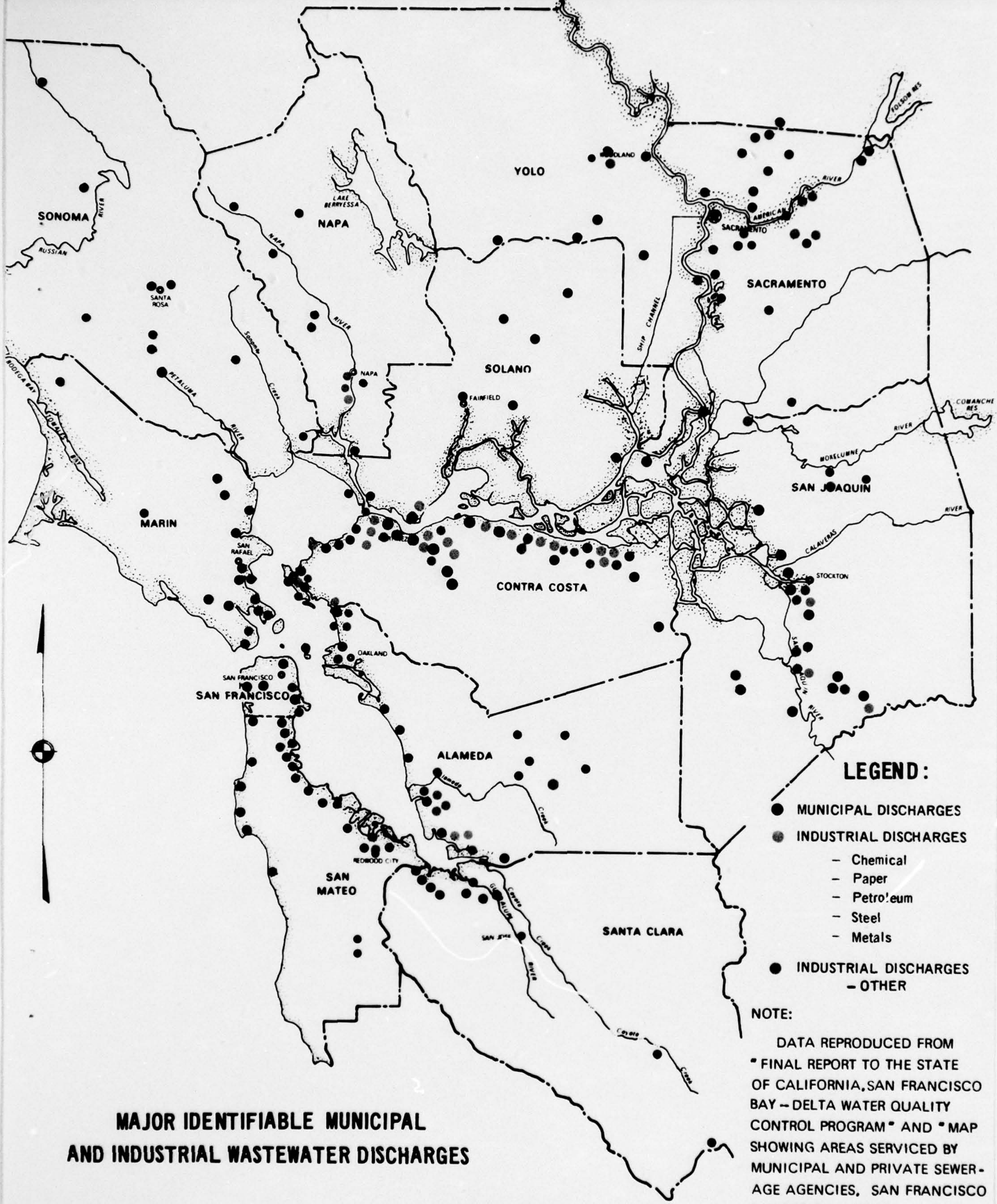
The only comprehensive figures on agricultural flows and loads from the area tributary to the Delta produced by the Bay-Delta Program are those shown in Table A-7, where it will be noted, the agricultural figures are combined with those representing stream runoff. The Bay-Delta Program concluded that, although the evidence was incomplete, there was reason for serious concern over the possible biostimulatory characteristics of agricultural drainage. 1/ Serious concern was also expressed over the problem of pesticides. 2/ 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.

1/ Bay-Delta Final Report, p. IX-9
2/ Ibid., p. 11-19



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

FIGURE A-8



MAJOR IDENTIFIABLE MUNICIPAL AND INDUSTRIAL WASTEWATER DISCHARGES

FIGURE A-9

TABLE A-7

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

(3) Runoff. Runoff, as defined in Table A-8, is not a substantial source of pollution in comparison with municipal and industrial discharges. Attention should be directed to the loads (BOD and TN) ascribed to natural runoff (R) in comparison to those ascribed to municipal and industrial (M & I) sources. Runoff in the Bay-Delta area is a highly seasonal phenomenon, as can be seen from Table A-1 and Figure A-2.

An analysis was carried out during the Bay-Delta Program of the effects of runoff in the Bay counties, taking into account the periodic distribution of storms and the dilution waters available from inplace Bay water, tides, and the rainfall associated with the runoff-producing storm. 1/ Calculations of waste parameter concentrations were sufficient to illuminate major trends. The only pollutant of serious proportions was shown to be oil and grease. The quantities introduced by storm runoff were very much in excess of those routinely discharged by municipalities and industries. This problem requires further study and subsequent investigation. Additionally, temporary incidence of high TSS occurs at widely scattered times in the extreme southern portion of San Francisco Bay; its only lasting impact would be local problems of channel silting. The maximum concentrations of BOD, TN, and TP for any expected level of storm in the next 50 years were shown to be negligible, with the single exception that a pulse concentration of 0.2 PPM of TN, lasting approximately one day, might be expected to exist occasionally in the extreme southern part of San Francisco Bay.

Another analysis in the Bay-Delta Program, 2/ based on a recent study of the combined sewer system of San Francisco, documented that the introduction of serious pollution by urban runoff would be limited to a period of about two hours near the beginning of any given storm.

1/ Bay-Delta Program, Final Report of Task I-4, Chap. VII
2/ Bay-Delta Program, Final Report of Task II-5, Chap. IX

TABLE A-8

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.

(4) Watercraft. The amount of pollution arising from discharges from ships and other watercraft is quantitatively very slight, less than 2000 lbs. per day BOD in 1965, 1/ although these discharges present local objectionable concentrations. It is projected that this quantity will double by 2020. Legal restrictions may be imposed on these discharges in the future.

c. Standards. Figure A-10 summarizes the water quality standards prepared by the California Regional Water Quality Control Boards, San Francisco Bay and Central Valley Regions, and approved by the State Water Resources Control Board. The jurisdiction of these boards is discussed below in the section on Institutional Arrangements for Wastewater Management. With the exception of "temperature," all of these standards have been approved as Federal water quality standards for San Francisco Bay and the Delta.

1/ Bay-Delta Final Report, Table XV-4

WASTEWATER TREATMENT SYSTEMS - C

TREATMENT SYSTEMS	MAJOR COMPONENTS	BOD	TOTA NITROG
1. PRIMARY	SEDIMENTATION	25 – 35	10
2. SECONDARY	SEDIMENTATION FOLLOWED BY ACTIVATED SLUDGE OR TRICKLING FILTER AND FINAL SETTLING	85 – 95	25 –
3. TERTIARY &/OR ADVANCED			
a. CHEMICAL FLOTATION	PRECIPITATION OF SOLIDS AND DISSOLVED AIR FLOTATION OF FLOATABLES.	50 – 70	15 –
b. RAPID SAND FILTRATION	ADSORPTION OF SOLIDS ONTO SAND PARTICLES.	95 – 98	25 –
c. PHOSPHATE PRECIPITATION	ADDITION OF CHEMICALS TO PRECIPITATE PHOSPHATES.	*	*
d. ACTIVATED CARBON	ADSORPTION OF SOLIDS ONTO GRANULAR CARBON PARTICLES.	93 – 99	45 –
e. NH_3 STRIPPING	CONVERSION OF NO_3 TO NH_3 GAS CHEMICALLY AND REMOVAL TO ATMOSPHERE.	99	90 –
f. MICROBIAL DENITRIFICATION	CONVERSION OF NO_3 TO N_2 GAS BY BACTERIAL ACTION USUALLY WITH CARBON (METHANOL) ADDITION	98	75 –
g. ELECTRODIALYSIS	REMOVAL OF IONS BY ELECTROCHEMICAL ACTION.	*	40 –
h. REVERSE OSMOSIS	FILTRATION THROUGH SEMI-PERMEABLE MEMBRANE UNDER APPLIED PRESSURE.	*	50 –
i. ION EXCHANGE	REMOVAL OF IONS BY CHEMICAL EXCHANGE.	*	75 –
4. ADVANCED (CHEMICAL AND BIOLOGICAL) TREATMENT 1/	PHOSPHATE EXTRACTION PROCESS (CHEMICAL PRECIPITATION); ACTIVATED SLUDGE INCORPORATING DENITRIFICATION IN SUSPENDED GROWTH REACTORS; FOLLOWED BY SAND FILTRATION.	96	90
5. LAND	SCREENING, AERATED LAGOONS & STORAGE.	75 – 95	—
	LAND SPRAYING, INFILTRATION & COLLECTION IN UNDERDRAINS.	75 – 95	30 -

1/ AS DEFINED AND USED IN THIS REPORT

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

WATER QUALITY OBJECTIVES FOR S.F.

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-CONTROLL FACTORS CAUSE GREATER CONCENTRATIONS. TOTAL NITROGEN LIMIT OF 2 MG/L EASTERLY OF CARQUINEZ STRAIT.
PATHOGENS	COLIFORM COUNT LIMIT OF 70/100 ML. (TO MEET REQUIREMENTS OF SECTIONS 7957 AND 7958, CALIFORNIA ADMINISTRATIVE CODE IN DESIGNATED AREA.)
RADIOACTIVITY	TO MEET PROVISIONS OF CHAPTER 5, TITLE 17, CALIF. ADMIN. CODE
TEMPERATURE	INCREASE OF 0°F. OUTSIDE OF MIXING ZONE (SPECIFIED BY REGIONAL BOARD).
DISSOLVED SOLIDS	NO OBJECTIVE
SUSPENDED SOLIDS (TURBIDITY)	NO SIGNIFICANT VARIATION BEYOND PRESENT NATURAL BACKGROUND LEVELS.
FLOATABLES	NONE OTHER THAN OF NATURAL CAUSES AT ANY PLACE.
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.
TOXIC MATERIALS	NONE PRESENT IN CONCENTRATIONS DELETERIOUS TO BENEFICIAL USES; NONE AT LEVELS WHICH RENDER AQUATIC LIFE O WILDLIFE UNFIT FOR HUMAN CONSUMPTION.
PESTICIDES	NO PESTICIDE OR COMBINATION OF PESTICIDES SHALL REACH CONCENTRATIONS FOUND TO BE DELETERIOUS TO FISH OR WILDLIFE AT ANY PLACE.
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.
BOTTOM DEPOSITS	NONE OTHER THAN OF NATURAL CAUSES.
ODORS	NONE OTHER THAN OF NATURAL CAUSES AT ANY PLACE.

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

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
LING	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	•	•	•	•	—	•	•	•	•
) 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	•	•	—	—	—	•	•	•
PORATING	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 THIS CONSTITUENT.
— DATA NOT AVAILABLE

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

AY	SACRAMENTO - SAN JOAQUIN DELTA
	5 MG/L
ROWTHS EXCEPT WHEN NON-CONTROLLABLE TERLY 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.
67 AND 7958,	FECAL COLIFORM COUNT LIMIT 200 / 100 ML.
	TO MEET PROVISIONS OF CHAPTER 5, TITLE 17, CALIF. ADMIN. CODE.
	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.
TIES SUFFICIENT TO CAUSE AN E.	FLOATING OR EMULSIFIED GREASE AND OIL SHALL NOT BE PRESENT . . . IN OBJECTIONABLE QUANTITIES.
EVELS WHICH RENDER AQUATIC LIFE OR	SHALL NOT BE PRESENT IN QUANTITIES SUFFICIENT TO BE HARMFUL TO HUMAN, PLANT OR AQUATIC LIFE.
D 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.
ABLE 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 ...

FIGURE A-10

d. Specific Pollutants. In the paragraphs that follow, the parameters listed in Figure A-10 are discussed. Fortunately, data on water quality in the estuary, collected in 1966-1968 by various agencies and organizations for the State of California Bay-Delta Program, are available. Most of these data in this discussion were abstracted from this source.

(1) Biochemical Oxygen Demand (BOD). Both of the California Regional Water Quality Control Boards having jurisdiction in the Bay and Delta have set a DO standard of 5.0 mg/l. Data from the State Bay-Delta Program indicate that, with the exception of a small area in South Bay, mean DO levels are above this minimum. In fact mean DO levels in most of the estuary are above 6.0 mg/l.

In essentially localized areas, low dissolved-oxygen concentrations have been observed in the San Joaquin River below Stockton and in the Sacramento River below Sacramento. In the San Francisco Bay System significant dissolved-oxygen depletions have been observed south of Dumbarton Bridge, in the sloughs along the west side of the Bay between San Jose and San Francisco, and in the lower reaches of the Napa and Petaluma Rivers.

Approximately 193,000 tons/year of BOD are being discharged into the Bay and Delta waters from municipal and industrial sources. Most of this load is municipal. Approximately 64 percent of all BOD discharged in the Bay and Delta originates from the four counties of San Francisco, Alameda, San Mateo and Santa Clara.

(2) Nutrients. The California Water Quality Control Board (San Francisco Bay Region) has not adopted a numerical limit for nutrients (principally nitrogen and phosphorus) in the Bay waters. The current regulation regarding nutrient concentrations is that they shall not cause deleterious or abnormal biotic growths except when non-controllable factors cause greater concentrations. The San Francisco Bay Regional Board has set a limit of 2 mg/l for total nitrogen in the area between Benicia and Sherman Island. The Central Valley Regional Board has set a limit for total nitrogen of 2 mg/l in the Western Delta, 1 mg/l in the Central Delta, and 3 mg/l in the Eastern Delta.

In the Bay waters, nitrate levels below 0.3 mg/l are found in the Central Bay, while concentrations of from 0.3 to 0.9 mg/l occur in the rest of the Bay. Orthophosphate concentrations range from approximately 0.1 to 0.4 mg/l in the central portion and northern arm of the Bay. In the Southern reach, phosphate concentrations range from 0.8 to 1.9 mg/l. Approximately 90,000 tons/year of nitrogen and 13,900 tons/year of phosphorus are discharged into the estuary. As with BOD, the majority of these loads are in the Central and South Bay.

One conclusion of the State Bay-Delta Program was that nitrogen and phosphorus levels in the Bay are not now limiting phytoplankton growth. That is, although there is sufficient nitrogen and phosphorus in the Bay waters and sediments to support a large standing crop of algae, some unexplained factor, possibly turbidity or toxicity, is limiting algal growth. Nitrogen and phosphorous concentrations are from 10 to 100 times greater in the Delta than those reported necessary for substantial growths of algae. Typical summer plankton counts have ranged from 3 million cells per liter in the Sacramento River at Walnut Grove to more than 30 million cells per liter in the San Joaquin River below Mossdale. Although algal populations in the Bay System are generally smaller than those found in the Delta, evidence of enrichment can be observed along the shores of the Bay and in tributary tidal reaches, particularly in the summer. Some blooms are composed of Mesodinium (Red tide), while others are of the blue-green variety.

Studies also indicate that upgrading of treatment facilities (from primary to secondary) has not significantly reduced nutrient concentrations near the upgraded facilities. Thus with these significant nutrient concentrations in the Bay, any change in the system which would increase residence time of nutrients in the system or reduce the toxicity or turbidity of the Bay waters, might remove the limiting factor now controlling algal productivity, and produce algal blooms.

(3) Pathogens. No standards or criteria have been set for pathogens (infectious microorganisms), although frequent use is made of coliform bacteria counts as an indicator of possible presence of pathogenic organisms. The San Francisco Regional Board has adopted for the Bay the standard recommendations of the U.S. Public Health Service regarding coliform concentrations in the shellfish harvesting areas, namely a median MPN (most probable number) of 70/100 ml. The standard adopted for the Delta, based on USPHS recommendations for water-contact sports, is a median MPN of 200/100 ml (fecal coliforms).

For the period January to September 1970, of 70 municipal and industrial dischargers monitored by the San Francisco Bay Regional Water Quality Control Board, only 17 were in continuous compliance with disinfection requirements. By the end of 1970, however, 33 dischargers were in compliance with the Regional Board's requirements. In spite of the significant reductions of coliform concentrations which have occurred over the past 10 years, due mostly to addition of chlorination facilities at many treatment plants, data collected as late as 1968 show that levels of coliform bacteria in most parts of San Francisco Bay exceed USPHS standards for water-contact sports. Also, bacterial levels are sufficiently high that sport shellfishing is not safe, and commercial harvesting cannot be permitted.

(4) Radioactivity. The Regional Boards have set a standard for radioactivity in Bay waters which corresponds to that recommended by the State Department of Public Health. At the present time there are no water quality problems associated with the discharge of radioactive wastes in the estuary, since there are no radioactive waste streams.

(5) Heat. The State Water Resources Control Board recently adopted new criteria for temperature of receiving waters and wastewater discharges. 1/ The following tabulation describes the receiving water standards and specific waste discharge limitations for enclosed bays and estuaries:

Class of Water	Receiving Water Maximum Temperature Rise Permitted	Waste Discharges Specific Limitations
Enclosed Bays	$0^{o}F$ outside of mixing zones specified by regional boards	Maximum $20^{o}F$ rise permitted for new discharges of elevated temperature waste. New thermal discharges greater than $4^{o}F$ above ambient are prohibited.
Estuaries	$0^{o}F$ outside of mixing zones specified by regional boards. Mixing zone limited to 25% of cross-sectional area of main river channels. Surface temperature limited to $4^{o}F$ above ambient in mixing zone.	Maximum $20^{o}F$ rise permitted for new discharges of elevated temperature waste. All thermal discharges limited to maximum temperature of $86^{o}F$. New thermal discharges greater than $4^{o}F$ above ambient are prohibited.

Approximately 4000×10^8 BTU/day are presently discharged into Bay-Delta waters, with 90% of this heat load generated by industry. 75% of all heat discharged (and 85% of industrial heat discharged) emanates from electric power plants. Half of the heat discharged to the system is introduced between Chipps Island and Antioch bridge. At the present time thermal pollution problems are minimal, although some difficulties have been reported in the past with respect to fish spawning and migration in the western Delta area.

1/ State Water Resources Control Board, "Policy Regarding the Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California," January 1971.

(6) Solids. Solids can be divided into two categories, dissolved and suspended.

(a) Dissolved Solids. Total dissolved solids (TDS) has no meaning as a waste parameter in the brackish waters of the Bay, so therefore no standards have been set. In the Delta, where salinity is an important parameter from the standpoint of both fish and wildlife and water supply, objectives have been set for TDS concentrations at numerous locations, ranging from 250 to 800 mg/1, as shown in Table A-9. However, the amount of dissolved solids discharged by municipal and industrial facilities in the Delta is insignificant at the present time when compared to dissolved solids originating from other sources, specifically ocean water incursion, agricultural return flows, and tributary river inflows.

(b) Suspended Solids. The Regional Boards have not set specific numerical standards for suspended-solids concentrations in the receiving waters. The basic criterion covering these discharges is that they do not impair any of the protected beneficial water uses or make aquatic life or wildlife unfit or unpalatable. At various times the controlling Regional Board has set objectives of 50 to 150 Jackson Turbidity Units or specified settling rates of solids in the waste stream (0.5 ml/l/hr). While these figures are useful for monitoring purposes, it is not possible to relate these standards to the suspended-solids concentration in the receiving waters. At present suspended solids do not pose a serious problem to the quality of Bay and Delta waters. Current concentrations of suspended materials vary from 50-80 mg/l in the central portion of the estuary to 80-150 mg/l in the extreme southern arm of the Bay and to 50-150 mg/l in San Pablo and Suisun Bays.

TABLE A-9

TOTAL-DISSOLVED-SOLIDS AND CHLORIDE OBJECTIVES FOR DELTA
STATE WATER QUALITY CONTROL BOARD

Location	Maximum Concentration in mg/l	
	TDS	CI
Old River (Clifton Court)		
5 Year Average	400	-
Yearly Average	450	-
Monthly Average	600	-
Daily Average	800	-
Cache Slough	250	100
Rock Slough		
Mean tidal cycle	750	250
Mean tidal cycle (for 65% of Year)	380	100
San Joaquin River (Vernalis-30 day mean)	500	-
Eastern Delta Channels (Mean monthly)	700	-

Source: Bay-Delta Program Final Report, Page XIX-26.

(7) Floatables (Including Oil and Grease). Both Regional and State Boards have adopted non-numerical criteria for floatables or oil and grease. The objectives for these parameters state that "none other than of natural causes shall be present," or that "the amount in the water shall not be present in objectionable quantities," or similar language. Data from the University of California San Francisco Bay Study 1/ indicate that the problem of floatables may be important from an aesthetic standpoint. However, in the absence of a numerical standard it is difficult if not impossible to adequately document the criticality of this pollution parameter. The Bay-Delta Program, in attempting to quantify this parameter, suggested acceptable levels of floatables for shore areas and waters of 0.3 g/sq. m and 0.02 g/sq. m, respectively. An interesting point is that the great majority of floatables discharged originate from municipal rather than industrial sources.

(8) Toxic Substances. The term toxic substances can be broken down into several discrete although not entirely independent categories. For purposes of discussion these categories include heavy metals and pesticides as well as possibly some unknown parameter. It must be remembered that toxic effects can be both synergistic and independent; and chronic as well as acute.

A major problem at present is that although toxic effects are constantly being discovered in the estuary (fish kills, decreases in species diversities, and reductions in populations), there is a general lack of adequate data to identify beyond reasonable doubt the actual causes or particular pollutant associated with these toxic effects. Between 1963 and 1968 the California Department of Fish and Game investigated 31 fish kills in the San Francisco Bay and Delta estuary. Eleven of these kills were identified with wastewater discharges or spills. Evaluation of the toxicity of municipal and industrial waste discharges has shown that almost all effluents are toxic in varying degrees to fish.

The Regional Boards have not set numerical receiving-water objectives for toxicity, preferring to limit the quantity in the receiving waters to "none present in concentrations deleterious to beneficial uses," "none at levels which render aquatic life or wildlife unfit for human consumption," or "no amounts present in quantities sufficient to be harmful to human, plant, animal or aquatic life." At present it is thought that toxicity is probably the most critical pollutant parameter in the estuary, although there is no way to quantitatively assess the magnitude of the toxicity problem in the receiving waters.

1/ University of California, Sanitary Engineering Research Laboratory, "A Comprehensive Study of San Francisco Bay," Final Report, Volume V, Summary of Physical, Chemical, and Biological Water and Sediment Data, Berkeley, 1966.

The Regional Water Quality Control Board has specified for several dischargers that test organisms (usually stickleback) must have a 90% average survival when kept in an undiluted waste stream for 96 hours. Unfortunately, there is no way to relate this to the quality of the receiving waters.

A measure of toxicity that reflects both the strength and the amount of a wastewater discharge is the relative toxicity, which depends on a parameter known as the median tolerance limit (TLm). The latter is defined as that 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. The relative toxicity is defined as the volumetric rate of flow times the reciprocal of the TLm (expressed as a fraction). Relative toxicity gives a gross picture of the dilution flows necessary to dilute a waste stream to a nontoxic level in the receiving waters. Dilution ratios from 20:1 up to 100:1 have been suggested by various agencies or study programs to limit toxicity.

In some portions of the estuary, notably the South Bay, the limit of available dilution is rapidly being approached in spite of upgrading in treatment. Approximately 50% of the total relative toxicity discharged is associated with municipal discharges. The petroleum industry contributes 90% of the total relative toxicity discharged to San Pablo Bay, which receives about one-third of the total relative toxicity in the estuary. In the southern portion of the estuary 80% of the relative toxicity loading is from municipal discharges.

(9) Heavy Metals. Very little attention had been directed to heavy metals until recently. At present there are no numerical receiving-water standards either for individual heavy metals or for the collective grouping "gross heavy metals." The Regional Boards have in special instances prescribed limits for various specific heavy metals for certain dischargers, but it is impossible to relate these requirements either to loads introduced into the estuary or to the quality of the receiving waters, because of a lack of reliable data.

(10) Chlorinated Hydrocarbons (Pesticides) - Concentrations of chlorinated hydrocarbons in most parts of the San Francisco Bay and Delta estuary exceed the maximum concentration recommended by the National Technical Advisory Committee on Water Quality Criteria. 1/ Although present concentrations of chlorinated hydrocarbons in aquatic organisms are, in most cases, less than those found to be lethal to the organisms, the concentrations are high enough to warrant concern about sublethal damage to the organisms.

1/ Water Quality Criteria, report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration 1968.

e. Water Supply Considerations. With respect to water quality of the estuary in relation to water supply, there is at present virtually no danger of loss of water supplies from the estuary due to contamination from municipal and industrial discharges. Water is drawn from the estuary for municipal and domestic use at only a few places in and near the Delta. Several municipalities in the Delta draw their supplies directly from Delta channels. The Contra Costa County Water District, which supplies much of Contra Costa County's domestic water supply, draws water from Rock Slough in the Western Delta. The City of Antioch takes its water directly offshore from the estuary, and the City of Vallejo has the intake for its municipal system at Cache Slough in eastern Solano County. Currently the availability of water from these sources is governed not by pollutants from municipal and industrial sources but by incursion of saline ocean water. For industrial uses the water quality of offshore supplies is similarly more endangered by salinity than by pollutant discharges.

f. Seasonal Effects. An additional consideration which should be noted in discussing water quality in the estuary is the seasonal changes and effects of certain pollutants or discharges.

In the summer months, for instance, when food canning plants are at the peak of production, the BOD loads from these plants exert a considerable effect on the municipal treatment systems into which they discharge. The maximum monthly cannery-season flow is about 20 percent greater than the non-seasonal average daily flow in San Jose and about 50 percent greater in Sacramento. 1/ The maximum monthly cannery-season BOD load in San Jose is over 150 percent greater than the non-seasonal average daily BOD load. The suspended solids load is over 70 percent greater. For Sacramento, these figures are 80 percent and 60 percent, respectively. The City of Stockton receives an even higher seasonal load. For certain peak periods, when 70 percent of the treatment plant inflow is due to cannery wastes, the average daily flow is three times the non-seasonal flow, and the BOD load 200 percent greater.

While it is fairly clear that these seasonal loads tax the treatment facilities, the overall effect on water quality in the estuary is usually limited to decrease oxygen concentrations in the immediate vicinity of these cities' outfalls.

An additional seasonal change in waste flows and loads occurs in the winter months for the cities of San Francisco and Sacramento, which have combined sanitary and storm sewer systems. During inclement periods the storm-water flows overload the treatment facilities, so that near-raw sewage is discharged to the estuary.

1/ Final Report, Task II-5, Vol. I, p. III-37.

Seasonal changes in water quality are associated with the changes in outflows from the Delta streams, notably the Sacramento. For example, in Suisun Bay, the highest algal concentrations occur in July-August (when Delta outflows are lowest), while for other areas in the estuary the peak occurs in April. It is thought that a reduction of Delta outflows during the summer increases the ratio of the quantity of waste discharges to the quantity of dilution water (Delta outflow), thereby increasing the concentration of biostimulants in Suisun Bay and contributing to algal blooms.

Another seasonal change, documented by data from USCE, UCBS and USGS, is the decrease in water quality parameter concentrations in South Bay, especially salinity and phosphates, during periods of high Delta outflow. It is thought that the fresh waters from the Delta, aided by tidal action and unusual circulation patterns, enter the South Bay, diluting the constituent concentrations.

g. Conclusion. In general terms, the waters of the estuary are, with minor exceptions, relatively free from gross environmental degradation. Based upon traditional parameters of pollution (BOD, coliform organisms, and dissolved oxygen), conditions in the estuary are improving. High levels of coliform organisms and floatables, however, limit some of the beneficial uses of the Bay and Delta waters. The major potential water quality problems appear to be associated with biostimulation and toxicity.

A-5. 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 municipal wastewater treatment facilities. The amount of Federal participation 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 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. At the present time almost all states have had their standards 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 a basin plan and/or regional and metropolitan plan. Interim plans are scheduled to be received by EPA by July 1971 and final plans to be developed by July 1973.

By Executive Order 11574 of 23 December 1970, the President required all industries which discharge liquid wastes 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 the Corps will inssue a permit, it will require certification from the Environmental Protection Agency and the appropriate State Agency that the activity would not violate applicable water quality standards.

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

b. State. The State of California is unusual if not unique in that most of its waters, including all those involved in the present study area, are strictly intrastate waters. In the case of the Central Valley and Bay-Delta waters, the State has been able to plan and implement water programs without having to consider interstate effects.

California is generally considered to be one of the most progressive states in the nation with respect to initiation of measures for wastewater management. All water resource matters are consolidated under a single agency, the Resources Agency. Within the Resources Agency is the California 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. Figure A-11 shows the (numbered) jurisdictional areas of the Regional Boards. Figure A-12 shows the Basin Planning Areas designed by the State Water Resources Control Board. Within the study area, four California Regional Boards have jurisdiction: those of the San Francisco Bay Region, the Central Valley Region, the North Coast Region, and the Central Coast Region. 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.

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARDS

FIGURE A-11

BASIN PLANNING AREAS AS DESIGNATED BY THE CALIFORNIA STATE WATER RESOURCES CONTROL BOARD.

FIGURE A-12

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 (Figure A-12).

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 million 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 then 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) created in January 1961, 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, organized in 1965, 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 has under preparation a regional plan for water, sewerage, and drainage.

d. Local. In 1970, the California 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 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.

A-6. POLLUTION ABATEMENT OPERATIONS

a. Recent Historical Developments. Present efforts to control water pollution are a direct outgrowth of the attention that has been given to the problem of water pollution in recent years. Some of the landmarks of this period, both in the Nation and California, are cited below:

1965 - Formation of the Federal Water Pollution Control Administration (FWPCA).

1965 - Formation of the San Francisco Bay Conservation and Development Commission to regulate filling of San Francisco Bay.

1965 - Authorization by the California Legislature of the San Francisco Bay - Delta Water Quality Control Program.

1967 - Appointment by the Secretary of the Interior of the National Technical Advisory Committee on Water Quality Criteria. This committee's report, "Water Quality Criteria," published in 1968, proposed detailed water quality standards in five areas: recreation and aesthetics, public water supplies, fish, other aquatic life, and wildlife, agricultural uses, and industrial water supplies.

1967 - Establishment of the California State Water Resources Control Board.

1969 - Passage of the Porter-Cologne Water Quality Control Act, substantially increasing the authority of the California State Water Resources Control Board and the California Regional Water Quality Control Boards.

1969 - Passage of the National Environmental Policy Act of 1969, declaring it national policy to encourage productive and enjoyable harmony between man and his environment, and providing that all Federal agencies shall include the environment as a consideration in planning and decision-making.

1970 - Passage of the Water Quality Improvement Act of 1970, strengthening Federal water-pollution authority, establishing an all-inclusive Federal office to guide environmental programs, and improving the effectiveness of the Federal water-pollution construction grant program.

1970 - Passage of the Environmental Quality Improvement Act of 1970.

1970 - Issuance of Executive Order 11507 regarding prevention, control and abatement of air and water pollution at Federal installations.

1970 - Issuance of Executive Order 11514 regarding protection and enhancement of environmental quality and indicating the leadership expected of the Federal Government.

1970 - Creation of the Environmental Protection Agency (EPA), bringing together responsibility for monitoring, research, standard-setting, and enforcement with respect to six environmental areas: air, water, noise, solid wastes, pesticides, and radiation. The EPA superseded and assumed the functions of the FWPCA.

1970 - Executive Order 11574 "to enhance the ability of the Federal Government to enforce water quality standards and provide a major strengthening of our efforts to clean up our Nation's water."

Two recent documents, specifically related to the control of man's interaction with the ocean's waters, also reflect the rapidly changing attitudes and thinking.

1970 - "Ocean Dumping - A National Policy." A report to the President prepared by the Council on Environmental Quality.

1970 - "Waste Management Concepts for the Coastal Zone." A report prepared by the Committee on Oceanography of the National Research Council and the National Academy of Sciences and the Committee on Ocean Engineering of the National Academy of Engineering.

b. <u>San Francisco Bay-Delta Water Quality Control Program</u>. In 1965 the California Legislature authorized the San Francisco Bay-Delta Water Quality Control Program. The objectives of the program were: to determine the effects of wastewater and drainage discharges into the waters of the Bay and Delta; to determine the need for and the feasibility of a comprehensive multiple-purpose waste collection and disposal system serving the entire 12-county study area, as well as other measures for maintenance of the quality of the waters; and to develop the basic features of a comprehensive plan for the control of water pollution for the study period 1970-2020.

The study was conducted by the firm of Kaiser Engineers, which headed a consulting engineering group, with assistance from various State agencies. Approximately $3 million, including Federal funding, was expended for the study. Although based on existing data, the study was the most comprehensive planning effort to date on measures for water quality control. Numerous task reports were prepared covering oceanography, economics, present and projected waste loads, wastewater reclamation, mathematical water-quality models, pesticides, solid wastes, biology and ecology, and alternative water quality management systems.

The Final Bay-Delta Program Report, published in July 1969, found that significant water quality deterioration had already occurred in the Bay-Delta system and that deterioration would become worse due to expected acceleration of population and industrial growth. The population of the 12-county study area, which was estimated at 5,300,000 in 1965, was expected to increase to approximately 9,400,000 by 1990 and 15,000,000 by 2020. The final report recommended construction of a three-phase regional wastewater collection and disposal system. Design of the regional system was based on two key parameters, biostimulation 1/ and relative toxicity 2/, rather than on the traditional approach of biochemical oxygen demand (BOD) reduction. It was also recommended that the California Legislature create a 12-county regional agency to plan, design, construct, operate, and maintain the regional system. Additional studies on biostimulation, toxicity, pesticides (treatment and soil retention), and dispersion characteristics of the Bay system, totaling approximately $2,000,000, were recommended for immediate implementation.

1/ Biostimulants are those wastewater components which result in the rapid and usually undesirable growth of algae in a water body. Biostimulants include the so-called macronutrients such as nitrogen, phosphorus, and silica, and also micronutrients, which are any of an array of metals, vitamins, or other organic compounds needed in trace quantities for plant growth.

2/ Toxicants are those wastewater components, not all of which are identified, that are lethal or otherwise injurious to aquatic biota. Toxicity is the relative adverse effect, either acute or chronic, of the toxic substance or combination of substances that can be measured or demonstrated by the use of test plants or animal organisms.

The recommended regional system consists of three phases:

> Phase I (to be constructed by 1980) is directed 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 capability (nearer the Golden Gate).
>
> Phase II (to be constructed by 1990) envisions further consolidation and treatment of most wastewaters at a single advanced primary treatment facility near Redwood City with effluent disposal to ocean waters of southern San Mateo County.
>
> Phase III (a construction planning guide for 2020) is flexible, incorporating either continued discharge to the ocean waters or large-scale wastewater reclamation if the potential demand warranted.

Although the recommended system includes 12 counties, 3 counties (Yolo, Sacramento, and San Joaquin) would have physical facilities independent of the major system serving the nine Bay counties (San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Solano, Napa, Sonoma, and Marin). Most of the wastewaters in these three counties would be treated and disposed of locally, either to inland waterways or land areas.

In July 1969, the California Water Resources Control Board concluded that there was urgent need for regional action in the nine Bay counties and recommended to the Legislature that a permanent agency be created in that area with authority to construct and operate wastewater interception, treatment, reclamation, and disposal facilities. The Board concluded that the basic concept of the interception and transport of treated municipal and industrial wastewaters from the extremities of the estuary should be used as a planning guide for the initial phase of a long-range, staged, water quality control program. The Board also concluded that the formation of subregional agencies with the capabilities to provide facilities needed to implement this concept should be encouraged. The California Legislature has yet to act on the Board's recommendation for creation of a regional agency for the nine Bay counties.

c. 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 augmenting 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 capacity 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 capacity 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.

d. Sub-Regional Planning. In 1970, the San Francisco Bay Regional Water Quality Control Board 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 programs 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 A-10 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.

e. 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 be established with authority for planning, financing, construction, 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.

TABLE A-10

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 #6, Sonoma Valley County SD, Petaluma, Las Gallinas Valley SD, USAF Hamilton AFB, San Rafael SD	12	85,000	2/72

* includes cooling waters

TABLE A-10 (Cont'd)

Sub-Regional Study	Funding Participants	Total Flow (mgd)	Approximate Funding	Completion Date
Richardson Bay	Marin Muni. Water Dist., Sausalito Marin City SD, Mill Valley, Richardson Bay SD, Marin SD #5	5	190,000 max.	12/72
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

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

f. Construction. Several municipalities have undertaken a joint effort to consolidate their collection and treatment facilities. Construction of a consolidated outfall is now underway by Redwood City, San Carlos, and Belmont; Palo Alto, Mountain View, and Los Altos are constructing a consolidated plant. These consolidated facilities are expected to be in operation by 1972. These municipalities are all located south of the City of San Francisco on the San Francisco Peninsula.

A-7. NEAR-FUTURE DEVELOPMENTS; BASE CONDITION

a. General. Several developments are expected to become realities before any alternative systems developed in this study could have an influence on decisions. In view of their immediateness, they are discussed in this section rather than below in Study Area In the Future.

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 the Agency by July 1973.

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.

Industries which continue to discharge to navigable waters will have to meet effluent standards for receiving waters. Over the next 5 years, it is envisioned that these standards will continue to become more rigid.

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 existing conditions, plus the changes foreseen in this section, represent a status which will be considered a "Base Condition," against which alternative systems for future application may be compared.

b. Municipalities. The interim basin plans for the dischargers in the 12-county study area suggest that the following facilities or concepts will be operational before 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 Bay and discharge of wastewaters in Sub-area D to the Delta waterways

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

The above assumptions are very general and exceptions to them will no doubt exist. Some dischargers will adopt different levels of treatment (such as chemical, intermediate, or advanced). Other dischargers in isolated areas will dispose of their treated wastewaters to the ocean or to land areas. Others will reclaim a portion of their wastewaters for local reuse. However, for regional planning purposes the exceptions are of negligible impact, and the assumptions as stated are adequate for the purpose of delineating a base condition.

c. Industries. As a result of probable more rigid water quality standards, industries will have 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 pretreatment and discharge to municipal systems can be assumed. However, all cooling waters will be disposed of locally by the industries.

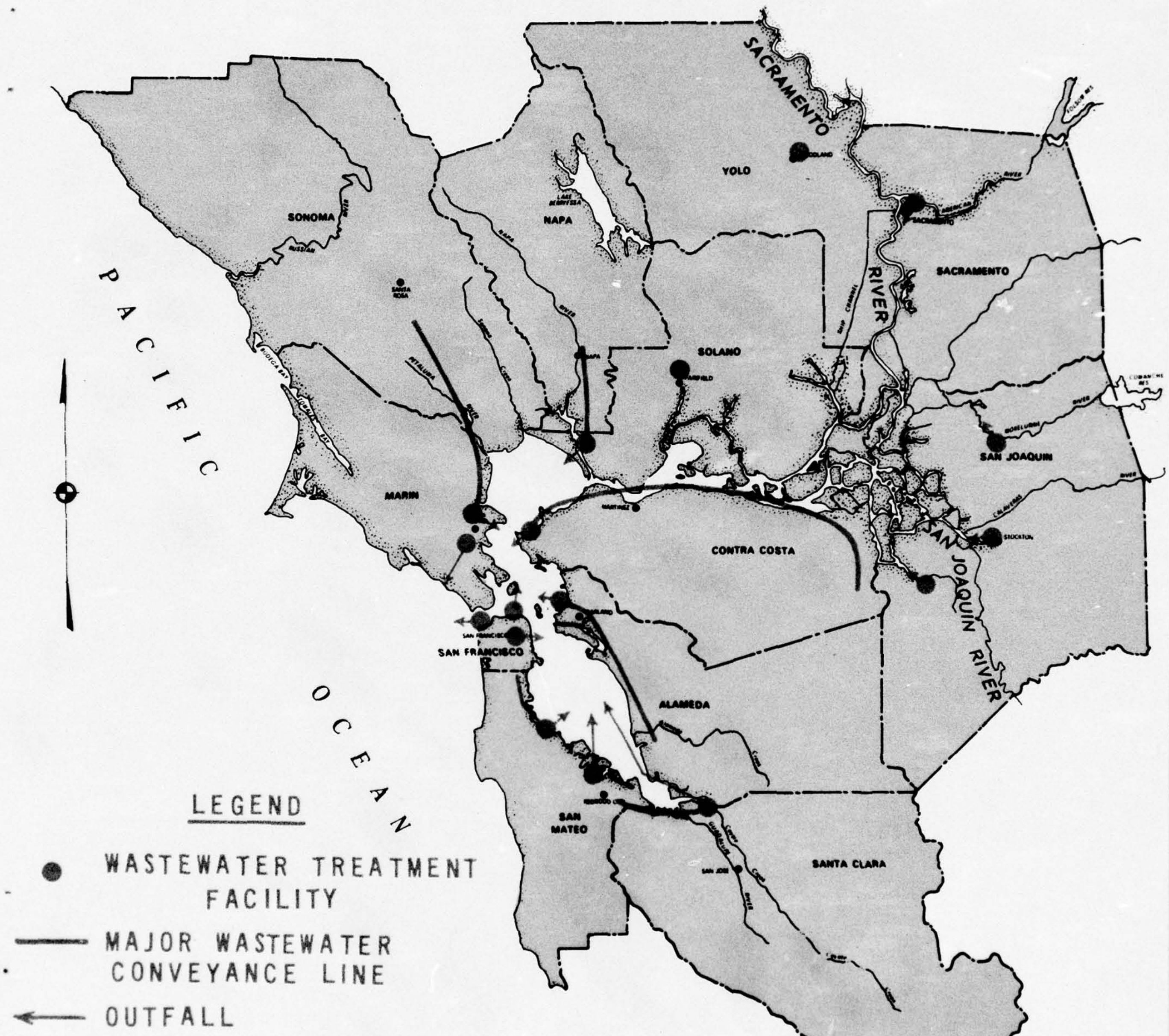
Industries already connected to municipal systems will also probably be faced with "source control" before entering the system. The alternative would be to expand entire municipal treatment processes for, in most cases, a limited pollutant problem within the total effluent.

d. 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 A-13. The essential characteristics of the base condition include:

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

(2) 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.

BASE CONDITION



NOTES: 1. WOODLAND AND FAIRFIELD FACILITIES TO DISCHARGE ON LAND

2. ALL SLUDGE TO BE DISPOSED OF LOCALLY ON LAND

FIGURE A-13

(3) The bulk of wastewaters from the three Delta counties to be discharged to Delta waterways.

(4) 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.

(5) 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.

(6) Sludge from treatment plants to be disposed of locally on land.

(7) 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.

A-8. STREAM QUALITY AND WATER QUALITY STANDARDS

Table A-6 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 A-10) 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 and floatables (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.

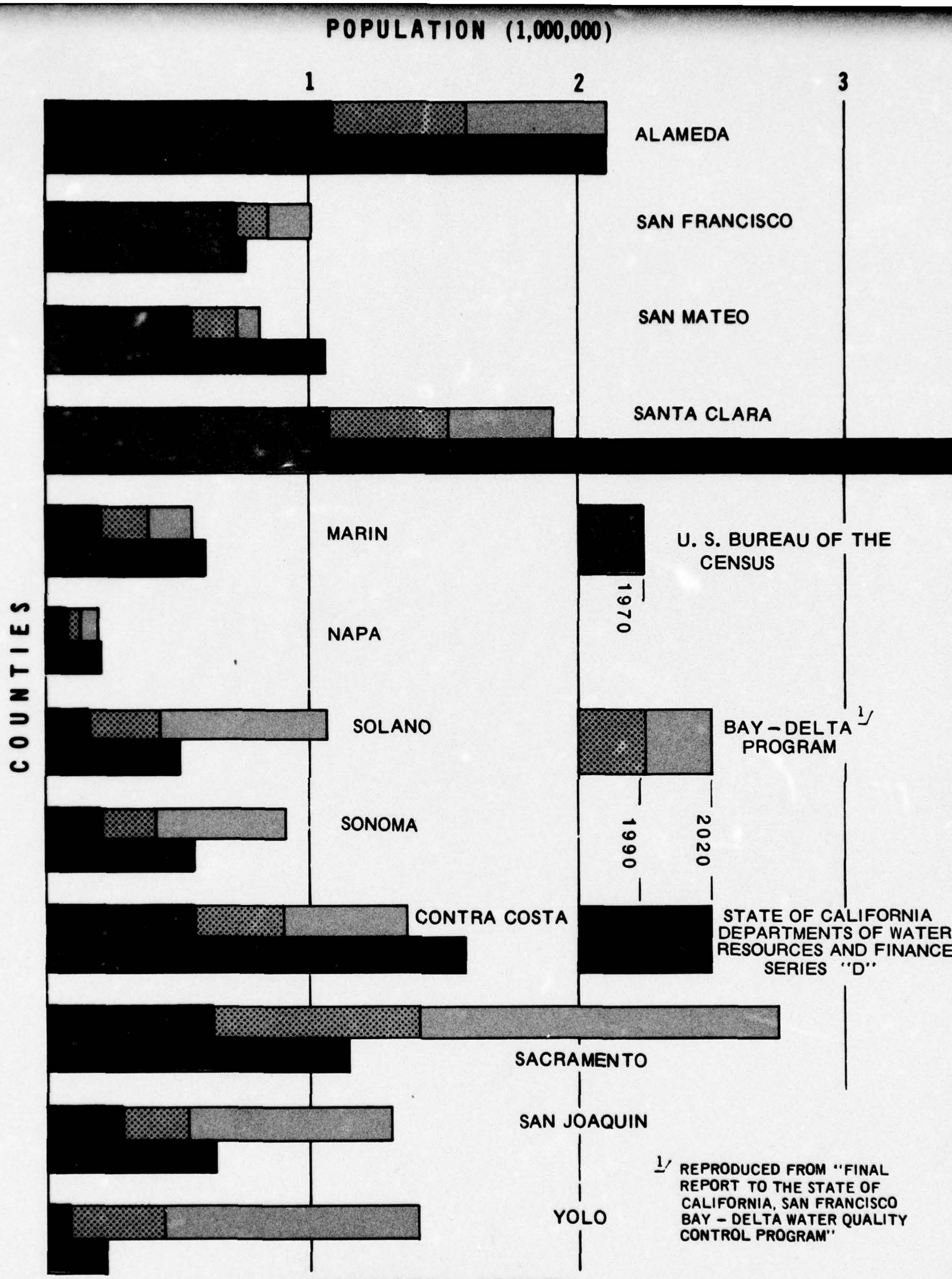
STUDY AREA IN THE FUTURE

A-9. ECONOMIC CONSIDERATION

a. Population. Wasteloads are largely a function of population, land use, and economic activity. Projections of these factors for the 12-county study area were made by decade through the year 2020 as part of the State of California Bay-Delta Program. Population projections made by the State of California (Departments of Finance and Water Resources) by decade through the year 2020, based on the U.S. Census Bureau Series D projection rates, are also available for the 12-county study area.

Table A-11 and Figure A-14 compare the 2020 population projections for the 12 counties and four sub-areas by the State Bay-Delta Program and by the State Departments of Finance and Water Resources. It is evident that the population of the study area, 5.7 million in 1970, could increase from 13 to 15.5 million by the year 2020.

Although the total populations for the two projections are very close, significant differences in distribution exist. The State Bay-Delta Program projected a high growth rate and a resulting high population in Sub-areas D (Sacramento, San Joaquin and Yolo Counties) and B (mostly Solano and Sonoma Counties). Projections based on Series D indicate that the future population growth will be slightly less, overall, than the Bay-Delta Program estimate and that the major growth will be in Sub-area A (mostly Santa Clara County).



ESTIMATED COUNTY POPULATION PROJECTIONS

FIGURE A-14

TABLE A-11

COMPARISON OF POPULATION ESTIMATES

Sub-area	County	Population 1970 Bureau of Census	2020 Bay-Delta Program	2020 California DWR & Department of Finance (Series D)
A	Alameda	1,073,000	2,100,000	2,100,000
	San Francisco	716,000	1,000,000	750,000
	San Mateo	556,000	800,000	1,050,000
	Santa Clara	1,065,000	1,900,000	3,400,000
B	Marin	206,000	550,000	600,000
	Napa	79,000	200,000	205,000
	Solano	170,000	1,050,000	500,000
	Sonoma	205,000	900,000	560,000
C	Contra Costa	553,000	1,350,000	1,575,000
D	Sacramento	631,000	2,750,000	1,130,000
	San Joaquin	290,000	1,300,000	635,000
	Yolo	92,000	1,400,000	225,000
TOTAL		5,636,000	15,300,000	12,730,000

For purposes of projecting wasteloads and other parameters, the data based on projections from the Bay-Delta Program are used in this report. The chief reason for using this set of projections rather than Series D or some other projection is the vast amount of readily available, usable data which can be derived from the Bay-Delta Program reports.

Table A-12 lists the present and projected municipal waste-water flows (domestic and commercial, plus some industrial) for the twelve counties in the study area.

b. 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. The North Bay counties of Marin, Sonoma and Solano, and the Delta County of Yolo are expected to experience the highest increase. 1/

Table A-13 lists the industrial flows (exclusive of cooling water) in 2020 for 5 selected industrial classifications. These industrial flows are assumed to be separate from municipal sewerage systems. All other industries (including canning and food processing) are assumed to be included in the municipal wastewater flow projections. These industrial flows are based on unit production and output coefficients developed for the Bay-Delta Program. The magnitude of production and output was determined not from population estimates but from economic projections based upon an assumed level of regional and national economic growth developed in the Bay-Delta Program.

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 3-1/2 percent. Refineries will continue to be concentrated in the Solano-Contra Costa County area, adjacent to deep water of the San Francisco Bay system.

1/ Bay-Delta Program Final Report

TABLE A-12

PRESENT AND PROJECTED MUNICIPAL WASTEWATER FLOWS 1/ 2/

Sub-area	County	Flow (mgd) 1970	2020 3/
A	Alameda	125	265
	San Francisco	95	200
	San Mateo	51	129
	Santa Clara	106	270
B	Marin	17	77
	Napa	6	19
	Solano	21	54
	Sonoma	5	38
C	Contra Costa	53	127
D	Sacramento	83	324
	San Joaquin	21	109
	Yolo	10	70
TOTAL		593	1,682

1/ Yearly average
2/ All industrial process flows except those from petroleum, paper, chemical, steel, and metals industries are included in municipal flows.
3/ Based on Bay-Delta Program projections of population and employment.

TABLE A-13

PROJECTED 2020 INDUSTRIAL WASTEWATER FLOWS FOR SELECTED INDUSTRIES 1/

Sub-area	County	Industry					
		Petroleum	Paper	Chemical	Steel	Metals	Total
A	Alameda			18			18
	San Mateo			12			12
B	Napa				26		26
	Solano	15			19		34
C	Contra Costa	95	159	69	34	7	364
D	San Joaquin	—	40	—	—	—	40
TOTAL		110	199	99	79	7	494

1/ Yearly average; flows in mgd; Cooling-water flows not included.

Source: Bay-Delta Program Final Report, Table H-2.

(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.

c. Agriculture. The California Department of Water Resources recently published updated land-use projections for California through the year 2020. 1/ Projections are by Hydrologic Study Areas, which are shown in Figure A-15. Land-use trends for irrigated agriculture in the 12-county area can be summarized. Within the nine Bay counties (Sub-areas A, B and C), the amount of land in irrigated agriculture will be reduced approximately by 15 percent of the 1967 total by 2020, according to projections for the San Francisco Bay Hydrologic Study Area. Projections for the Delta-Central Sierra Hydrologic Study Area indicate that irrigated agriculture in the three Delta counties should increase by 15-20 percent of the 1967 total by 2020 as more irrigable land is put under irrigation. Obviously some of the land now irrigated will be urbanized, but the remaining irrigable land will be put under irrigation at a faster rate.

In the area tributary to the 12-county area, including the Tulare basin, some 7 million acres will be under irrigation by 2020. Table A-14 summarizes the projected flows from the San Joaquin Valley proposed Federal and State subsurface agricultural drainage facilities. Table A-15 indicates the projected concentrations of various constituents in the drainage waters.

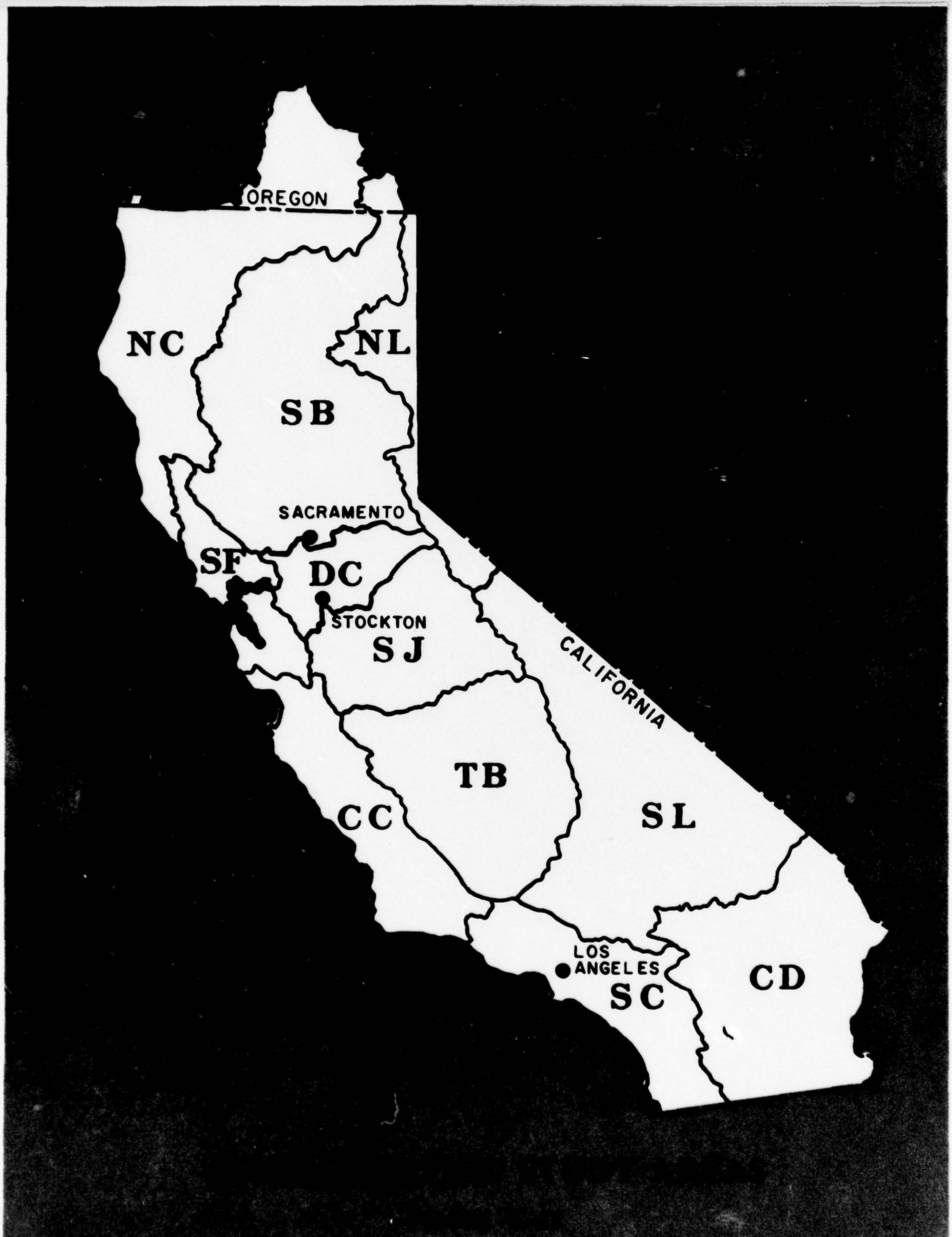
1/ DWR Bulletin 160-70, Water for California, The California Water Plan Outlook in 1970, December 1970.

TABLE-14

FLOW PROJECTIONS (mgd), SAN JOAQUIN VALLEY
PROPOSED FEDERAL AND STATE AGRICULTURAL
SUBSURFACE DRAINAGE FACILITIES

Facility	1980		2000		2020	
	Annual Average	Max. Monthly Average	Annual Average	Max. Monthly Average	Annual Average	Max. Monthly Average
Federal	47	63	138	185	144	193
State	76	125	321	530	337	556
Total	123	188	459	715	481	749

Source: Bay-Delta Program Final Report, Table XVII-1.


OREGON
NC
NL
SB
SACRAMENTO
SF
DC
STOCKTON
SJ
CALIFORNIA
TB
CC
SL
LOS ANGELES
SC
CD

A-10. WASTE LOADS

a. <u>General Overview</u>. In the next fifty years the 12-county study area will be subjected to several changes with respect to waste loads. The major change will not be concerned with composition or location but simply with magnitude. In the next fifty years the total municipal and industrial wastewater flows will more than triple. While the municipal component will increase to slightly less than three times the present flow, the industrial wastewater component, exclusive of cooling water, will increase by more than fivefold. To indicate the relative magnitude of this 2020 industrial flow, it may be noted that the expected flow (494 mgd) is approximately 70% of the total 1970 municipal and industrial flow (687 mgd) in the 12-county area. Other changes, while not as significant, nevertheless do contribute to the projected problem. These changes are shifts in location of waste sources and changes in relative composition of waste flows. Whereas in 1970 industrial flows comprised only 14 percent of the total waste flow, in 2020 this percentage will increase to 23 percent. Also, at present Sub-area A generates 56 percent of all the wastewaters in the 12-county area; in 2020 this percentage will decrease to 40 percent. The major shift will be to Sub-areas C and D.

TABLE A-15

PROJECTED WASTE CONCENTRATIONS (PPM),
SAN JOAQUIN VALLEY AGRICULTURAL DRAINS

	Years	
Constituent	1990-2010	2000-2020
TDS	3,500	3,100
Calcium	200	180
Magnesium	130	120
Sodium	850	750
Potassium	16	12
Sulfate	1,400	1,200
Chloride	710	620
Phosphate	0.4	0.4
Nitrate	75	50
Bicarbonate	250	300
Boron	10	5
Chlorinated Hydrocarbons		

Source: Bay-Delta Program Final Report, Task II-5, Vol. 4, Part C, Table 8-13.

Note: Loads in 10^3 lbs per day can be calculated by multiplying PPM x mgd x 0.00834.

Other waste sources in the 12-county area will continue to exert only minor influences on the system in the future. Wastes from watercraft and natural runoff in 2020 will actually comprise a smaller percentage of the total waste loads than they do at present.

b. Estimating Procedures and Assumptions. The following procedures and assumptions were used, in order to estimate the waste loads that will be produced in the study area over the next 50 years.

Population and employment projections were essentially the same as those used in the State of California Bay-Delta Program.

Untreated wastewater flows and constituent loads were based on data from the Bay-Delta report. Some unit coefficients were modified to reflect other sources of data. Total waste flows neglect some minor discharges to the ocean waters and land areas because of the lack of sufficient data. These exclusions (less than 2 percent of the total flows) were felt to have essentially no effect on alternative systems or concepts.

Although present planning indicates a movement of existing discharge locations from areas of low dilution capacity to areas of higher dilution capacity, no attempt was made to pinpoint the actual discharge locations in the future. The only assumption made was that wastewaters generated in each sub-area would be disposed of in or near the source sub-area. For planning purposes a base condition which has no major conveyance of wastewater out of the individual sub-areas is assumed.

Attempting to define the treatment process or processess that would be in effect to the year 2020 depends to a great extent on the water-quanity or discharge standards that will be required in the furture. The reasonable assumption that can be made at this time is that these standards will be higher than at present. For this reason, all wastewaters generated in the sub-areas were assumed to be treated to he level of secondary treatment in the period from 1980 to 2020. This assumption has the obvious drawback that nutrient loads are not significantly reduced. Another drawback is that all treatment plants are assumed to have the same degree of treatment regardless of location. However, if some treatment plants will have intermediate treatment, some chemical treatment, some tertiary and some secondary, the assumption that all plants provide secondary treatment is not unreasonable as a base condition for planning.

The final treated flows and loads were obtained by applying secondary-treatment removal efficiencies to the raw waste loads developed by the Bay-Delta Program. The following treatment efficiencies were used (the % indicates the amount of a constituent removed by the treatment process):

Parameter	% Removal
BOD	90
TN	30
TP	30
TDS	0
TSS	90
Oil & Grease	70
Floatables	70
Phenols	80
Gross Heavy Metals	70
Pesticides	40

c. Municipal and Industrial Discharges. Tables A-16 through A-20 present the projected municipal and industrial wastewater flows and loads for each sub-area by decade from 1980 to 2020. The constituent waste quantities represent the amount of pollutants remaining after secondary treatment. The industrial flows comprise only process flows (no cooling water) from the petroleum, paper, steel, chemical, and metals industries. Quantities of sludge shown are the dry weight of residual solids after secondary treatment which must be disposed of by incineration or land applications.

TABLE A-16

ESTIMATED 1980 TREATED MUNICIPAL AND INDUSTRIAL WASTEWATERS
(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)	465	10	475	67	17	84	51	133	184	160	16	176	743	176	919
BOD	169	1	170	18	8	26	18	69	87	50	4	54	255	82	337
TN	298	*1	298	29	*1	29	32	160	192	83	-	83	442	160	602
TP	56	3	59	4	*1	4	5	2	7	15	-	15	80	5	85
TDS 1/	2016	-	-	211	-	-	217	-	-	572	-	-	3016	-	-
TSS	104	8	112	10	-	10	10	20	30	29	5	34	153	33	186
Oil & Grease	40	*1	40	4	2	6	4	12	16	12	-	12	60	14	74
Floatables	5	-	5	*1	-	*1	*1	-	*1	2	-	2	7	-	7
Phenols	-	-	-	-	*1	*1	*1	-	*1	-	-	-	*1	*1	*1
Relative Toxicity (mgd)	665	-	-	96	-	-	87	-	-	230	-	-	1078	-	-
Gross Heavy Metals	5	*1	5	*1	1	1	4	1	5	2	-	2	11	2	13
Pesticides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat (BTU/day) x 10^8	349	-	-	52	-	-	37	-	-	120	-	-	558	-	-
Pathogens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Radioactivity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sludge (dry wt.)	156	12	168	15	0	15	15	30	45	43	8	51	229	50	279

Notes

1/ TDS value is increment added in one cycle of use
* = Less Than
- = Data Not Available

TABLE A-17

ESTIMATED 1990 TREATED MUNICIPAL AND INDUSTRIAL WASTEWATER
(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)	562	15	577	84	29	113	69	189	258	219	22	241	934	225	1189
BOD	181	2	183	42	11	53	24	87	111	68	5	73	315	105	420
TN	344	*1	344	41	-	41	40	274	314	103	-	103	528	274	802
TP	68	5	73	7	-	7	6	2	8	22	-	22	103	7	110
TDS 1/	2438	-	-	290	-	-	324	-	-	777	-	-	3829	-	-
TSS	127	12	139	15	-	15	14	28	42	41	7	48	197	47	244
Oil & Grease	74	*1	74	9	3	12	7	26	33	21	-	21	111	29	140
Floatables	12	-	12	1	-	1	1	-	1	5	-	5	19	-	19
Phenols	-	-	-	-	*1	*1	-	*1	*1	-	-	-	-	*1	*1
Relative Toxicity (mgd)	804	-	-	120	-	-	98	-	-	314	-	-	1336	-	-
Gross Heavy Metals	12	*1	12	1	2	3	1	2	3	5	-	5	19	4	23
Pesticides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat (BTU/day) x 10^8	421	-	-	63	-	-	52	-	-	164	-	-	700	-	-
Pathogens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Radioactivity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sludge	190	18	208	22	-	22	21	42	63	62	10	72	295	70	365

Notes

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

* = Less Than
\- = Data Not Available

TABLE A-18

ESTIMATED 2000 TREATED MUNICIPAL AND INDUSTRIAL WASTEWATER
(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)	659	20	679	117	40	157	89	248	337	312	28	340	1177	336	1513
BOD	251	2	253	51	14	65	30	113	143	95	6	101	427	135	562
TN	409	*1	409	61	*1	61	49	304	353	143	*1	143	662	304	966
TP	83	6	89	11	*1	11	7	3	10	31	*1	31	132	9	141
TDS 1/	2905	-	-	389	-	-	340	-	-	1053	-	-	4687	-	-
TSS	151	16	167	21	-	21	18	37	55	56	9	65	246	62	308
Oil & Grease	59	*1	59	8	3	11	7	23	30	21	-	21	95	26	121
Floatables	8	-	8	1	-	1	*1	-	*1	3	-	3	12	-	12
Phenols	-	-	-	*1	-	*1	-	*1	*1	-	-	-	*1	*1	*1
Relative Toxicity (mgd)	942	-	-	167	-	-	100	-	-	446	-	-	1655	-	-
Gross Heavy Metals	8	*1	8	1	2	3	1	2	3	3	-	3	13	4	17
Pesticides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat (BTU/day) x 10^8	494	-	-	88	-	-	67	-	-	234	-	-	883	-	-
Pathogens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Radioactivity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sludge	226	24	250	32	-	32	27	55	82	84	14	98	369	93	462

Notes

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

* = Less Than
\- = Data Not Available

TABLE A-19

ESTIMATED 2010 TREATED MUNICIPAL AND INDUSTRIAL WASTEWATERS
(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)	760	26	786	152	50	202	107	306	413	407	33	440	1426	415	1841
BOD	293	3	296	44	17	61	36	136	172	126	7	133	499	163	662
TN	482	*1	482	78	*1	78	63	376	439	193	-	193	816	376	1192
TP	100	7	107	15	*1	15	9	4	13	43	-	43	167	11	178
TDS 1/	3389	-	-	524	-	-	422	-	-	1379	-	-	5714	-	-
TSS	175	20	195	27	-	27	22	45	67	76	11	87	300	76	376
Oil & Grease	67	*1	67	10	4	14	9	28	37	28	-	28	114	32	146
Floatables	9	-	9	1	-	1	1	-	1	4	-	4	15	-	15
Phenols	-	-	-	-	*1	*1	-	*1	*1	-	*1	*1	-	*1	*1
Relative Toxicity (mgd)	1090	-	-	216	-	-	153	-	-	580	-	-	2039	-	-
Gross Heavy Metals	9	*1	9	1	3	4	1	3	4	4	-	4	16	5	21
Pesticides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat (BTU/day) x 10^8	570	-	-	114	-	-	80	-	-	305	-	-	1069	-	-
Pathogens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Radioactivity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sludge	262	30	292	40	-	40	33	67	100	114	16	130	449	113	562

Notes

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

* = Less Than
\- = Data Not Available

TABLE A-20

ESTIMATED 2020 TREATED MUNICIPAL AND INDUSTRIAL WASTEWATERS
(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)	864	30	894	188	60	248	127	364	491	503	40	543	1682	494	2176
BOD	336	3	339	64	20	84	45	163	208	175	9	184	620	195	815
TN	547	*1	547	106	-	106	75	443	518	257	-	257	985	443	1428
TP	120	9	129	22	-	22	15	5	20	59	-	59	216	14	230
TDS 1/	3815	-	-	742	-	-	530	-	-	2380	-	-	7467	-	-
TSS	202	24	226	37	-	37	27	53	80	103	13	116	369	90	459
Oil & Grease	114	*1	114	21	8	29	17	60	77	41	-	41	193	68	261
Floatables	17	-	17	3	-	3	1	-	1	9	-	9	30	-	30
Phenols	-	-	-	-	*1	*1	-	*1	*1	-	-	-	-	1	1
Relative Toxicity (mgd)	1017	-	-	228	-	-	153	-	-	606	-	-	2004	-	-
Gross Heavy Metals	17	*1	17	3	5	8	1	5	6	9	-	9	30	10	40
Pesticides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat (BTU/day x 10^8)	647	-	-	141	-	-	95	-	-	377	-	-	1260	-	-
Pathogens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Radioactivity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sludge	303	36	339	55	-	55	40	80	120	155	19	174	553	135	688

Notes

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

* = Less Than
\- = Data Not Available

d. Other Pollution Sources. Other recognized sources of water pollution include agricultural wastewater, urban runoff, and discharges from watercraft.

The problems involved in quantifying pollution loads from agricultural drainage were mentioned above in Section A-46. The only pollution parameter for which a comprehensive figure was given by the Bay-Delta Program was Total Nitrogen (TN). As shown above in Table A-7, TN loads entering the estuary from the Central Valley agricultural region were projected to not quite double by the year 2020. Comparison of the projected agricultural TN figure (117 x 10^3 lbs/day; Table A-7) with the TN arising from municipal and industrial sources in the 12-county area (1430 x 10^3 lbs/day; Table A-20) shows that the agricultural load is a relatively small portion of the total problem.

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.

Table A-8, above, indicates both the present (1965) and the projected runoff, and the BOD and TN loads therefrom, in the 12-county area. As indicated in Table A-8, runoff includes both urban and non-urban in the South, Central, and North Bay areas, but only urban in the Delta area. The units reported are not the same as used in most places in this appendix (mgd for flow, 10^3 lb/day for load) because of the highly seasonal nature of runoff (See Table A-1). Projected increases in runoff flows are due to increases in urbanization, causing more impermeable ground surface. Table A-8 shows that generally modest increases in loads from runoff are projected, and that in the future, as at present, loads from runoff will be diminutive in comparison with those from municipal and industrial sources.

It is estimated that natural runoff in the study area in 2020 will be 1,430 thousand acre-feet annually, or about 19 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 wastes. The contribution on urban area runoff to the total should increase because of expected growth patterns. The toxicity and biostimulatory characteristics of this runoff are virtually unkcwn.

Although is is projected that waste loads from watercraft including ships and pleasure boats are projected to double from 1913 lb/day BOD load in 1965 to 4097 lbs/day in 2020, and are sources of coliform bacteria, 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.

e. Geographic Distribution. Sub-area A will continue to be the largest source of wastes in 2020. However, whereas in 1970 it produced 56 percent of all wastewaters in the study area, by 2020 this percentage will decrease to about 40 percent. Industrial flows in the sub-area will increase from 5 mgd to 30 mgd, while the municipal flows will increase from 377 to 864 mgd. Because a large proportion of this municipal flow ooccurs in the South Bay, a negative estuary (See Section A-1b (1) above) with limited flushing and dilution potential, the magnitude of the waste problem will be compounded.

Sub-area B should increase in wastewater from 53 mgd in 1970 to 248 mgd in 2020. The industrial component will increase from 4 to 60 mgd, the municipal component from 49 to 188 mgd. The only significant change in Sub-area B will be the relatively higher proportion of industrial wastes.

The major industrial location in the 12-county area will continue to be Sub-area C. While the municipal flows will increase from 53 to 127 mgd, the industrial portion will increase from 76 to 364 mgd. This 2020 industrial flow from this sub-area will be approximately four times the present (1970) industrial wastewater flow in the entire 12-county area. Most of this industrial development will continue to be in the portion of the estuary between Carquinez Strait and Antioch.

Sub-area D will experience a high increase in municipal[1] flows, from 114 to 503 mgd, and in industrial flows, from 9 to 40 mgd.

1/ Bay-Delta Final Report, Table XV-9.

A-11. EFFECTS OF CONTINUING PRESENT WATER QUALITY MANAGEMENT CONCEPT

a. Existing and Planned Concept. Since no definitive plans for either ocean disposal or land disposal have been finalized and adopted on a regional basis, it would appear that the present and near-future wastewater disposal concept will continue to be directed toward estuarine disposal. In fact, current planning by the State of California, through the regulatory agencies, is centered around the concept of transferring wastewater discharges from areas of low dilution to areas of higher dilution in the estuary. Included in this concept is the upgrading of treatment facilities as needed and the inclusion of wastewater reuse.

The near-future concept will probably, therefore, be a continuation of the present concept, incorporating the following:

Consolidation of treatment facilities, as communities recognize the advantages of "economics of scale,"

Extension or relocation of outfalls to areas of higher dilution capacity in the estuary, and

Increases in degree of treatment, incorporating either chemical, secondary, or various advanced treatment systems.

b. Probable Effects. Several changes in the Bay and Delta estuary will occur over the next 50 years which could intensify the problems associated with continued conventional wastewater disposal as outlined above. Most of these changes are associated with alterations of the hydrologic regime of the estuary. Coupled with changes in the magnitude, location, and composition of wastewater flows, these could increase the stresses now occurring in the water environment.

The major hydrologic change occurring in the estuary will be the decrease of fresh-water outflow from the Delta from a current yearly average of 18 MAF to a projected yearly average of 7 MAF in 2020 (see Figure A-2). Although the influence of fresh-water outflow on flushing and residence times of pollutants in South and Central San Francisco Bay is believed to be relatively minor, 1/ this mechanism is believed to exert considerable influence upon residence times in the northern arm of the estuary.

For Delta outflows of 40,000 to 50,000 cfs (26,000 to 32,000 mgd, 29 to 36 MAFY, 2.4 to 3.0 MAF per month), which occur

1/ A contrary view has been expressed by the U.S. Geologic Survey, however, See McCulloch, D.S., Peterson, D.H., Carlson, P.R., and Conomos, T.J., A Preliminary Study of the Effects of Water Circulation in the San Francisco Bay Estuary - Some Effects of Fresh-Water Inflow on the Flushing of South San Francisco Bay; USGS Circular 637-A, 1970.

at present for some three months of the year (Figure A-2), the residence time between Antioch and the Golden Gate is estimated at 20 to 30 days. If Delta outflows were reduced to around 1,500 cfs (975 mgd, 1.1 to 1.35 MAFY, 0.09 to 0.11 MAF per month), approximately the planned 2020 outflows for most months, the residence time would be expected to be on the order of 300 to 400 days.

Table A-21 shows the estimated municipal and industrial loads from the 12-county area in 1970, compared with projected similar loads remaining after secondary treatment in 2020. The significance of this comparison is that while secondary treatment will reduce BOD loads in 2020 to a level below that discharged today, both nitrogen and phosphorus loads in 2020 will far exceed existing levels of discharge. The same is true of relative toxicity and gross heavy metals. These two facts are important because biostimulation and toxicity were identified as the critical future water quality factors in the State Bay-Delta Report.

TABLE A-21

PRESENT (1970) AND PROJECTED (2020) TOTAL TREATED MUNICIPAL AND INDUSTRIAL DISCHARGES FROM THE 12-COUNTY AREA 1/

Constituent	1970	2020
Flow (mgd)	687	2,176
BOD	1,055	815
TN	493	1,428
TP	75	230
TDS	-	-
TSS	330	459
Oil & Grease	95	261
Floatables	14	30
Phenols	*1	1
Relative Toxicity (mgd)	776	2,004
Gross Heavy Metals	17	40
Pesticides	-	-
Heat (BTU/day) x 10^8	-	-
Pathogens	-	-
Radioactivity	-	-
Sludge (dry wt)	330	688

NOTES

* = Less Than
\- = Data Not Available
1/ = In thousands of pounds per day, unless otherwise stated.

Thus the combination of longer residence times and higher waste loads could result in intensified stresses on the biota in the system.

Another factor with regard to continued estuarine disposal is that the long-term chronic effects of wastewater discharges upon the estuarine biota are not known. The uncertainty associated with these effects may be of critical importance in long-term planning.

c. Summary. The Bay and Delta estuary will probably continue to be the disposal site for the area's wastewaters in the foreseeable future. Treatment may be increased, facilities may be consolidated, and outfalls may be moved to higher-dilution areas. However, biostimulants and toxicants discharged in the future, even after secondary treatment, will exceed present amounts, which are thought to be a major cause of existing water quality problems. Longer residence times will result from planned hydrologic modifications in the system. The chronic effects of wastewater on the system's biota are not known. The net result may well be a higher level of stress with unknown effects, on the estuarine ecosystem.

A-12. REASONS FOR LOOKING AT OTHER CONCEPTS

a. General. 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 is 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 high 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 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.

b. Reuse. The question of reuse of treated wastewaters was studied extensively during the State Bay-Delta Program by both the California DPH and a private contractor. Only a brief discussion, based on the reported findings, is possible here.

Reuse has already been carried out in California in various ways at various localities for almost four decades. Among the uses have been irrigation of agricultural land, irrigation of landscaped areas, industrial cooling water, noncritical industrial process water, fire protection, control of seawater intrusion, recharge of ground-water aquifers, and recreational lakes. Of the two basic types of industrial cooling, "on-stream" and evaporative cooling with towers, only the latter is a consumptive use. However, there are technological problems connected with the latter in removing residual salts if the water supply is impure. The former type of use can be incorporated into a disposal scheme by situating power or industrial plants on the shore of a holding reservoir if the heat-balance problems can be satisfactorily solved.

The matter of reuse is one of quality, quantity, and economics. Obviously, certain uses require higher quality water than others. Conversely, certain types of wastewaters are more readily upgraded to acceptable quality for water supply than others. In general, industrial wastewaters are unsuitable, with the significant exceptions of the canning and paper industries. The most readily treatable waters are those from domestic sewage. These make up the bulk of most municipal discharges, but the latter are, unfortunately, commonly adulterated by commercial and industrial wastes.

The Bay-Delta Program found that technologically there were few problems regarding production of a safe and desirable product for, say, spray irrigation of produce, with one reservation, namely that the question of identification and removal of biostimulatory substances (nutrients) required extensive and thorough study.

Reuse is a matter of quantity because there must be a sufficient demand to account for the entire flow discharged by a system, if the discharge is not to be wasted. It must be recognized that there will always be a certain amount of intractable residual waste which must be discarded and cannot be reclaimed.

The quantity of disposal by reuse will remain small unless the waters can be used either for municipal water supply or for irrigation.

Reuse is a matter of economics in that wastewater will have to compete economically with conventional fresh-water supplies. In this respect it is very similar to a mineral deposit. A mineral deposit in the ground represents "ore" only if it can be extracted profitably. Wastewater represents an economic resource if it can be used more cheaply than alternative virgin water. With mineral deposits, economic changes over a period of time can render a given deposit an "ore" when it was not so before (the price of the commodity rises or more efficient technology becomes available). The same situation probably applies in regard to wastewater in the Bay-Delta area. The point that must be borne in mind in designing a management system is that some systems may have the capability of exploiting the wastewater resource when/if it becomes economic to do so, whereas other systems may for technical reasons not have such a capability.

The alternative to economic reuse is, of course, discarding of the wastewaters.

A-13. POTENTIAL FOR WASTEWATER REUSE

a. Potential Local Wastewater Reuse. On the basis of the economics of 1969 sewage treatment practices, the Bay-Delta Program identified a group of local uses in the Bay counties which would account for some 247,000 AFY of wastewater. These uses are summarized in Table A-22. "Hillside spraying" serves the combined purposes of irrigating pastureland, diminishing grass-fire danger, and augmenting the ground-water supply. Landscape irrigation refers specifically to such areas as highway embankments, parks, golf courses, and other man-made or tended areas of greenery.

AD-A036 837 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
A036837

END
DATE
FILMED
4-77

TABLE A-22

LOCAL WASTEWATER REUSE POTENTIAL

Sub-area	Location	Volume (AFY)	Use
A	City of Campbell	21,300	Groundwater Recharge
	San Jose area	21,300	Groundwater Recharge
	Livermore Valley	56,000	Groundwater Recharge
	Niles Cone	2,900	Well Injection
	Alameda County	1,040	Landscape Irrigation
	Santa Clara County	829	Landscape Irrigation
B	Northern Napa Valley	4,800	Groundwater Recharge
	West of Rio Vista	43,800	Hillside Spraying
	North of Vallejo	10,800	Hillside Spraying
	Sonoma County	191	Landscape Irrigation
C	Central Contra Costa County	17,000	Industrial Cooling
	Western Contra Costa County	37,000	Industrial Cooling
	West of Brentwood (Contra Costa County)	29,500	Hillside Spraying
	Contra Costa County	885	Landscape Irrigation
	Total	247,345	

Source: Bay-Delta Report, Task I-4.

It is to be noted that the quantity involved amounts to an average of about 250 mgd, thus only about one-third of the present (1970) total municipal and industrial flows.

If wastewater can be routed into existing agricultural water distribution systems in the Central Valley - its quality acceptable and the economics of its pumping and conveyance satisfactorily accounted for - a very large market will have been established, sufficient to account for all municipal and industrial wastewaters discharged in the 12-county area.

b. Flow Augmentation Schemes. Besides the local reuse potential identified above, other schemes have been suggested to make use of reclaimed wastewater in augmenting flow in the estuary. These schemes involve a high degree of treatment (beyond secondary). The purpose of estuarine augmentation schemes would be to reduce salinity incursion, aid in circulation, or improve water quality characteristics. Table A-23 lists possible locations and quantities for wastewater discharges for flow augmentation.

TABLE A-23

REUSE FOR FLOW AUGMENTATION

Location	Volume Required	Reuse
South Bay	1100 cfs considered adequate 1/	Flush South Bay, and improve circulation
Delta	not specified but ranges from 0 to 5700 cfs additional flow, assuming a base 2/ minimum flow of 1800cfs	Augment Delta outflows to prevent salinity incursion
Suisun Marsh	120,000 AFY (166cfs average) 3/	To lower soil salinities in order to maintain adequate food plants for wildlife
Western Delta	around 100,000 AFY (138cfs average) 4/	As substitute for overland agricultural supply for Sherman, Hotchkiss, and Jersey Is.

1/ Bay-Delta Report, Task I-4.

2/ APPENDIX "C", To the Technical Report on San Francisco Bay Barriers, USCE, March 1963.

3/ Report 506 to SWRCB by DFG.

4/ Based on four acre-feet per year agricultural water usage for approximately 25,000 acres in western Delta. The 25,000 acres include western Delta lands for which an overland water supply by California DWR is under consideration.

c. Reuse Potential for Meeting Long-Range Water Demands. Because of California's continued rate of growth predicted for the future, existing water supplies will have to be expanded and new water-supply sources developed in order to meet the projected demands through the year 2020. Table A-24 enumerates the areas and projected water-supply deficiencies in those hydrographic basins encompassing or adjacent to the 12-county study area. This table shows the potential for wastewater reuse as an alternative to developing additional surface water-supply projects.

TABLE A-24

WASTEWATER RECLAMATION POTENTIAL
TO MEET WATER-SUPPLY DEFICIENCIES 1/
(in 1,000 AFY)

Hydrographic 2/ Area	1990 Supply	1990 Demand	1990 Potential	2020 Supply	2020 Demand	2020 Potential
San Francisco Bay	1,860	1,740	None	2,270	2,740	470
Central Coastal	1,015	1,160	145	1,045	1,420	375
Sacramento Basin	6,280	6,580	300	6,860	7,270	410
Delta-Central Sierra	2,110	2,200	90	2,170	2,350	180
San Joaquin Basin	4,430	4,740	310	4,440	5,050	610
Tulare Basin	7,170	8,340	1,170	7,170	9,260	2,090

1/ DWR Bulletin 160-70.

2/ Hydrologic Study Areas are shown in Figure A-15.

ALTERNATIVES
FOR
MANAGING WASTEWATER
IN THE
SAN FRANCISCO BAY AND SACRAMENTO-SAN JOAQUIN DELTA
AREA

APPENDIX B

DEVELOPMENT OF ALTERNATIVES

U.S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

JULY 1971

APPENDIX B

DEVELOPMENT OF ALTERNATIVES

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLES

FIGURES

APPENDIX B

DEVELOPMENT OF ALTERNATIVES

B-1. DEVELOPMENT OF WASTEWATER MANAGEMENT CONCEPTS

a. Disposal Concepts. Several disposal concepts are available for managing wastewater flows originating in the San Francisco Bay and Delta area. These include disposal to ocean waters, disposal to waters of the Bay and Delta estuary, disposal on land or some appropriate combination of the three.

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 yet to be 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.

The disposal of wastewater to inland waterways and estuaries has long been a common means of discharging municipal and industrial effluents. The San Francisco Bay and Delta area has been no exception. The practice of treated waste disposal to the estuary, although fairly well developed, has not been an entirely effective solution as evidenced by observed water quality problems: significant dissolved oxygen depletions; growth of algae; fish kills; and high levels of coliform bacteria in receiving waters. Disposal into the Bay and Delta estuary has been oriented toward primary and secondary treatment processes to remove deleterious substances from wastewaters. Present technology for reducing the 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 utilized for disposal.

Land disposal is considered to be an alternative treatment method which makes use of certain soil characteristics by applying wastewater to irrigable land. As well as acting as a physical filter, the soil is also the locus of a certain amount of chemical exchange reactions and of biological activity. This concept recognizes the principle that wastes, when properly recycled, can be valuable resources. Wastes become liabilities only when they lose their rightful place in the system. Nutrients discharged to water bodies may accelerate eutrophication, but nutrients applied to land are returned to the soil where they can be used by plants. Land disposal also can effect a reuse of wastewater, and can be an integral part of a system of total wastewater management.

b. Scope of Discussion. Only the municipal and industrial wastewater flows generated within the study area are considered in developing alternatives. 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.

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.

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.

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.

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 of 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.

c. Criteria and Assumptions Used in Developing Alternatives. The criteria and assumptions used as the planning basis for developing the wastewater management alternatives are as follows:

(1) 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.

(2) Each alternative is designed to provide flexibility of opportunity for reuse of treated wastewaters.

(3) 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 Appendix A.

(4) 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.

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

(6) Exisitng 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.

(7) 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.

d. General Description of Selected Treatment Systems. (See Figure B-1).

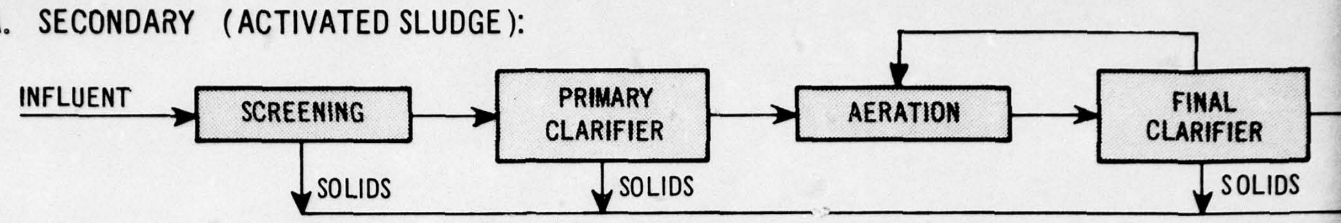
(1) Secondary. In the secondary treatment system used in this report, the waste stream passes through a primary sedimentation unit and on to either an activiated sludge or trickling filter unit, followed by final settling. In this process, biochemical oxygen demand (BOD) is reduced 85-95 percent by biological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

(2) 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 filitration. 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.

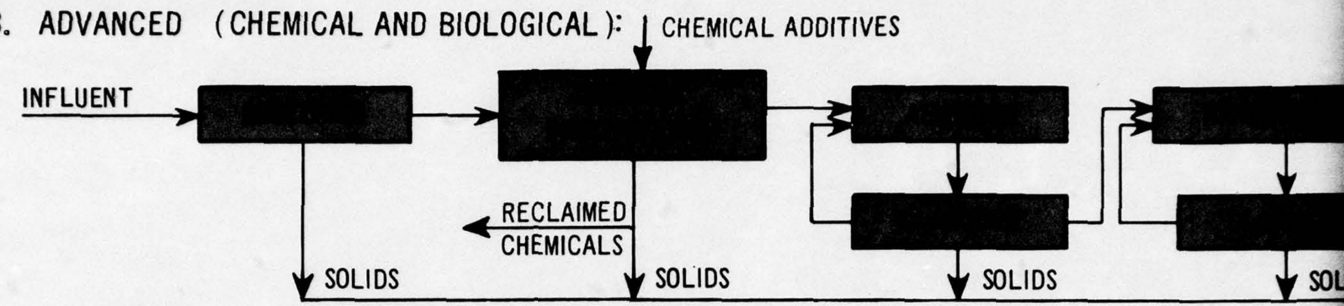
(3) Land Disposal. In the land disposal system, the incoming waste stream is applied to aeration lagoons in which biological oxidation reduces BOD and removes some nutrients. These lagoons may provide the equivalent of secondary treatment. The effluent passes to storage ponds, where it is retained a 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 reservoirs is applied to the land surface with the treated water.

FLOW CHARTS FOR SELECTED TREATME

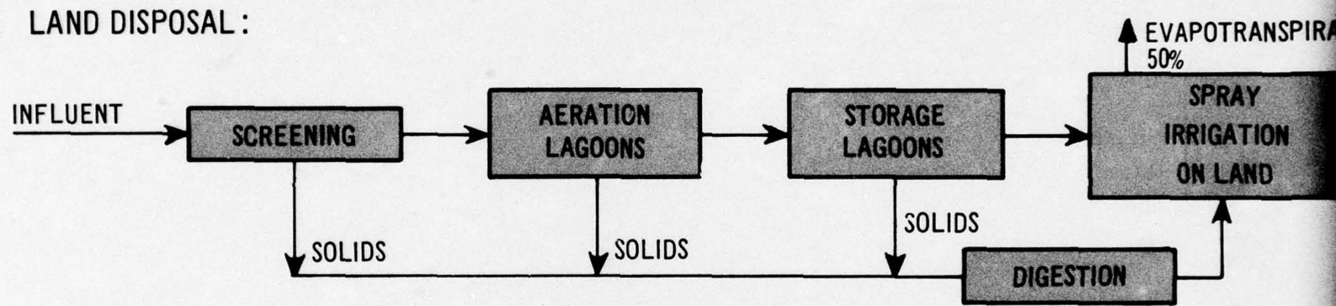
A. SECONDARY (ACTIVATED SLUDGE):



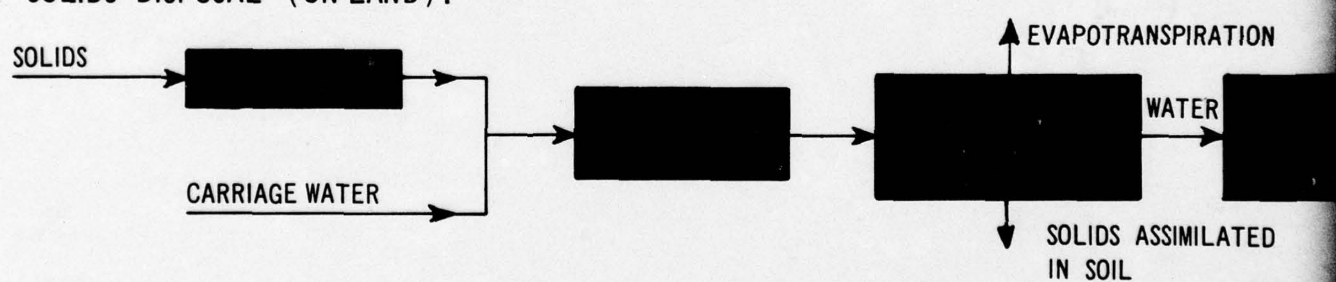
B. ADVANCED (CHEMICAL AND BIOLOGICAL):



C. LAND DISPOSAL:



D. SOLIDS DISPOSAL (ON LAND):



SELECTED TREATMENT SYSTEMS

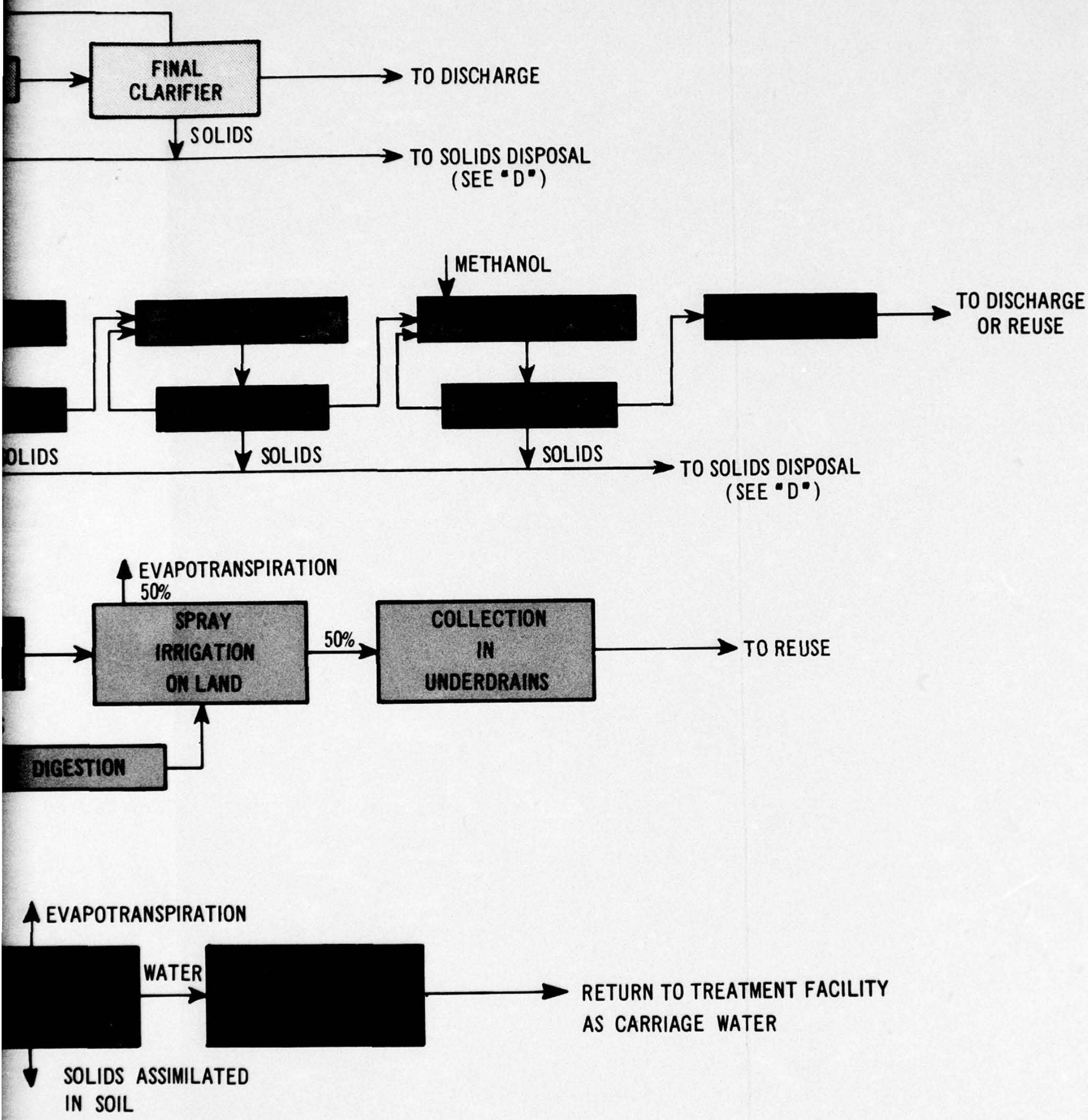


FIGURE B-1

(4) <u>Residual Solids (Sludge) Disposal</u>. The residual solids which remain after their removal from the wastewater stream in any treatment process must still be disposed of in some manner. These solids include grit, screenings, floatables and settleables.

While the solids themselves may be treated by various processes (such as dewatering, incineration, and wet air oxidation or digestion) to improve handling, decrease water content or reduce volume, ultimately the residuals must be incinerated or placed on the land. (Incineration, while it converts much of the solids to gases, still leaves a large quantity of ash which must be disposed of elsewhere.) 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.

Several possibilities exist for land disposal of the residual solids. These include use as landfills, as fertilizers, or as a source for recovery of usable materials. Unfortunately, complete extraction of the usable materials from sludge has not been perfected, leaving only the more conventional possibilities.

Landfills are not generally regarded as socially or environmentally attractive. The use of the sludge solids as fertilizers, soil conditioners or compost requires special treatment and the production of a marketable product such as compost or soil conditioners faces the economic problems of available cheaper and higher grade specialized soil additives.

Applying the solids to the land surface might constitute a net beneficial use. The nutrients could be used by plants, the organic content could serve as compost, and the inert constituents could serve as soil conditioners. If growing crops proves infeasible, then at least the constituents of the sludge may be "locked in" the soil. Essentially, an attempt is made to return the solids to their natural place in the environment.

For all of the alternatives considered, treatment by digestion and land disposal of sludge is assumed. For the ocean disposal and estuarine disposal concepts (as well as the estuarine portion of the combination disposal concept) land sites at a distance from the treatment facilities would be used for the ultimate disposal and reuse of the sludge. Because of the long conveyance to these sites, digestion would be used to decrease both the overall quantity of the sludge (by 35%) and to reduce the volatile organic solids content of the sludge (by 50%). Incineration is not assumed because of the creation of air pollutants, such as sulphur and nitrogen oxides, which could escape into the air.

A 10 percent solids solution transported via pipeline to the disposal site is assumed, although no doubt other conveyance methods have trade-off advantages, which can only be investigated in further studies. The digested solids would be applied to the land areas at the rate of 25 tons per acre per year. The carrier water would be collected by a system of horizontal underdrains and recycled through the treatment process. Table B-1 shows the quantities of sludge solids and the land areas that would be required in 2020 for sludge disposal.

TABLE B-1

SLUDGE SOLIDS

Concept	After Treatment (10^6 lbs/day)	After Digestion (10^6 lbs/day)	Land Required 1/ (Acres)
Estuary	13.8	8.97	66,000
Ocean	13.8	8.97	66,000
Land	6.9	4.5	33,000 2/
Combination	11.3	7.3	54,000
Estuary Portion	8.8	5.7	42,000
Land Portion	2.5	1.6	12,000 2/

1/ Based on application rate of 25 tons per acre per year.
2/ Included in amount of land required for the land application of wastewaters.

For the land disposal concept and the land portion of the combination disposal concept, the whole treated waste stream would be applied to the land surface. Solids dredged from the treatment and storage lagoons would be digested and then "bled in" to the application system for the treated wastewaters.

(5) Disinfection. After treatment, all wastewaters would be disinfected before reuse or disposal.

e. Wastewater Reuse. 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.

It is assumed that 90 percent of the incoming waste flow is available for reuse after aeration lagooning or advanced treatment and regulation storage. For the land disposal concept, 50 percent of the applied water is assumed to be reclaimable after evapotranspiration losses.

f. Regulation Storage. Four general uses of reclaimed water are possible: agricultural, industrial, municipal and environmental (aquatic or land). The wastewater flows considered in this report are generated at essentially a uniform rate throughout the year. Thus, regulation storage for the water is necessary to meet demand schedules of use. It is assumed that industrial, municipal and environmental usages have similar demand-shape curves over a one-year period. Agricultural demand requirements are assumed different with maximum use during the June-September period and essentially zero demand during December-April. Application of these assumptions indicates that:

(1) Ocean disposal and estuarine disposal require regulation storage of about 50 percent of reclaimed water with agriculture use the controlling factor.

(2) Land disposal, because of its storage of effluent during the winter rainy season of four months, makes other than agricultural use the controlling factor and a regulation storage of 25 percent applicable.

B-2. OCEAN DISPOSAL CONCEPT

Disposal of wastewaters in the estuary has created water quality problems which could be eliminated by an ocean disposal concept. Such a concept would include an extensive collection system, a secondary or higher degree of treatment and a disposal system to the ocean which would provide maximum dilution.

a. Alternatives Developed. Four alternatives are proposed to meet the concept of ocean disposal, as outlined below:

(1) Alternative I would convey all municipal and industrial wastewaters generated in the 12-county area to a secondary treatment facility near Redwood City. Wastewater from Sacramento, Yolo, Solano, Napa, Sonoma and Marin Counties would be conveyed by an underwater pipeline across Carquinez Strait near Benicia and there join the collection system for the remaining counties. The effluent would be discharged through an ocean outfall extending at least five miles from shore south of Pillar Point. Average flows for 1990 and 2020 would be 1,200 and 2,200 mgd, respectively.

This alternative has features in common with the marine disposal system investigated in the State San Francisco Bay-Delta Water Quality Control Program Final Report. The major differences are that under that system, waste dischargers in the three Delta counties (Sacramento, San Joaquin, and Yolo) would not be connected to the system and only advanced primary treatment would be provided at the Redwood City facility.

(2) Alternative II is the same as Alternative I except that wastewaters would receive advanced treatment. As the advanced treatment would reduce the concentration of pollutants in the effluent, the ocean outfall would extend at least one mile from shore.

(3) Alternative III includes two sub-regional systems. One system would convey all municipal and industrial wastes from Sacramento, Yolo, Solano, Napa, Sonoma and Marin Counties to a secondary treatment plant located near Petaluma. The effluent would then be discharged through an ocean outfall extending at least five miles from the shore at Bodega Bay. Average flows in 1990 and 2020 would be 300 and 650 mgd, respectively. The second system would convey all municipal and industrial wastes from San Joaquin, Contra Costa, Alameda, San Francisco, San Mateo and Santa Clara Counties to a secondary treatment plant near Redwood City. The effluent would be discharged through an ocean outfall extending at least five miles from shore south of Pillar Point. Average flows for 1990 and 2020 would be 900 and 1,550 mgd, respectively.

(4) Alternative IV, shown on Figure B-2 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 either ocean disposal concept with advanced treatment. As shown on Figure B-2, the land disposal sites for sludge

SELECTED OCEAN DISPOSAL ALTERNATIVE

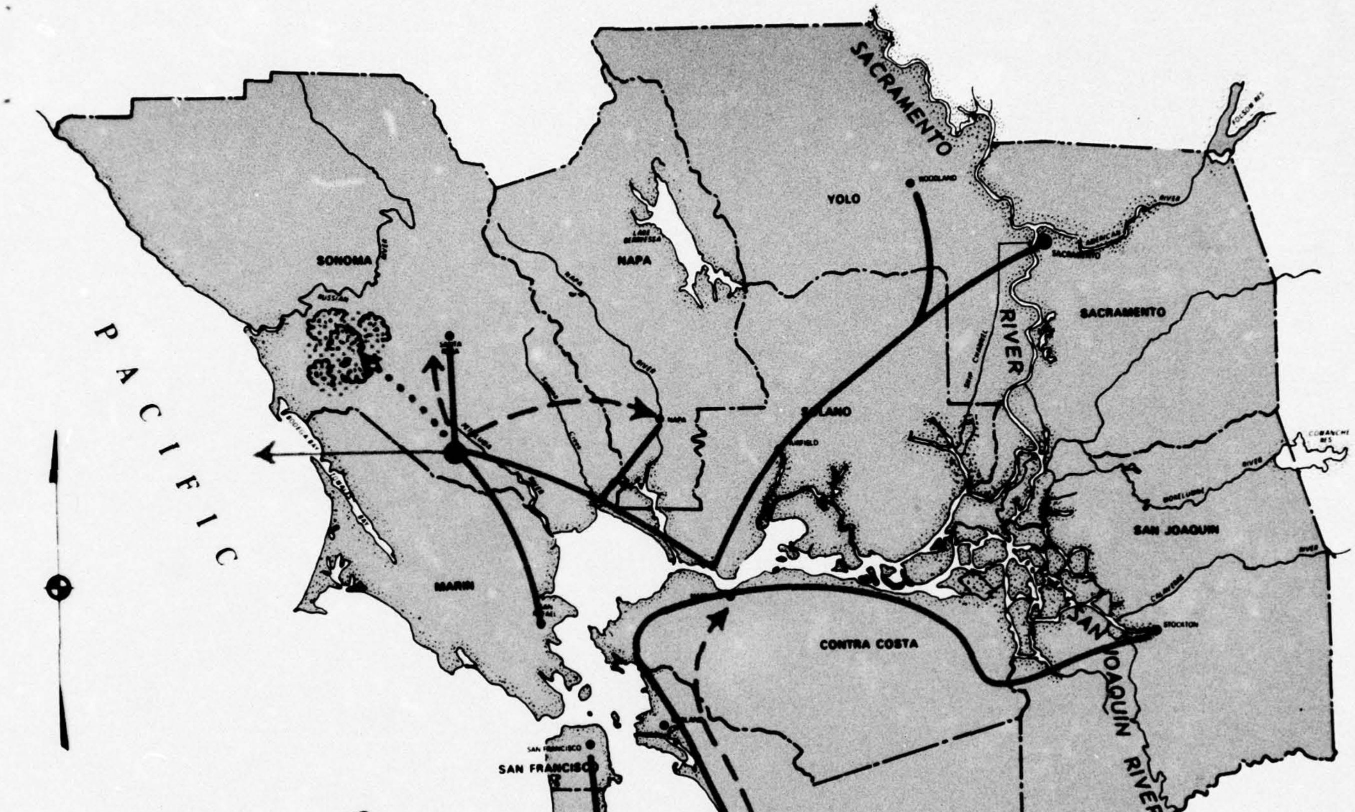


FIGURE B-2

might be in the vicinity of Petaluma and south 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 Alternatives II and IV. Alternatives I and III, where secondary treatment produces a lower quality effluent, would have reuse limited to specific purposes of substantially lesser potential.

b. Selection of an Alternative. By providing advanced treatment, Alternatives II and IV tend to meet the needs of environmental trends and objectives. Also, they reflect potential of integration with overall water resources management.

The advanced treatment aspect of Alternatives II and IV would remove or reduce significantly the pollutant parameters enumerated in Appendix A. Alternatives I and III would reduce or remove the traditional pollutant parameters, but would have little or no effect on the pollutant parameters which are of major concern today such as biostimulants and toxic substances. Both secondary and advanced treatment processes present the problem of disposing of the residues (sludge) which contain most of the pollutants removed.

All of the four alternatives would be equal in flexibility in accommodating future technologies. The two-system approach of Alternatives III and IV is more favorable to adjusting to future growth patterns. Also, two outfalls might have advantages in minimizing ocean impacts.

The ocean disposal concept would be capable of implementation under existing technology. However, the technical feasibility of large scale (in the range of 1,000 mgd) advanced treatment facilities needs further evaluation.

Potential reuse of treated waters from the ocean disposal treatment plants appears to be as follows:

(1) From the Redwood City plant to help relieve projected water deficiencies in the San Francisco Bay and northern Central Coastal Hydrologic Study Areas and to Contra Costa County for industrial reuse.

(2) From the Petaluma plant to help relieve projected water deficiencies in the northern portion of the San Francisco Bay Hydrologic Study Area.

For the purposes of selecting an alternative which best represents the ocean disposal concept, Alternative IV is selected on the basis of the previous discussion. The selected system is shown on

Figure B-2. A flowchart depicting the major aspects of the system representing the ocean disposal concept is presented in Figure B-3. Alternative III, with secondary treatment, is discussed further in Appendix C, where the accomplishments of advanced waste treatment versus secondary treatment are examined.

B-3. ESTUARINE DISPOSAL CONCEPT

Observed water quality problems linked with disposal of wastewaters in the estuary should not preclude consideration of this concept. The estuary plays a critical role in environmental objectives and appropriate wastewater management might enhance these objectives. Therefore, this concept is valid from a planning approach, provided a sufficient degree of protection for the estuarine environment is incorporated into the alternatives associated with this concept. Such protection includes a high degree of treatment for wastewaters, conveyance and disposal systems to transport treated effluents to higher dilution areas of the estuary, and incorporation of treated wastewater reuse. The following alternatives embodying the concept of estuarine disposal are developed in order to select a representative system.

a. Alternative I - Regional Disposal. Alternative I consists of collecting and treating all municipal and industrial wastewaters at 7 treatment plants in the 12-county area.

Treatment facilities would be located near the estuary and use a chemical-biological advanced wastewater treatment system. This high level of treatment would enable the waters to be reused as discussed below, or to be discharged to the estuary with an assumed high beneficial effect. It should be noted that with the exception of the two Delta facilities, the treatment units would discharge treated wastes through deep-water outfalls located in high-dilution and dispersion areas of the estuary (surrounding Central Bay), where both dilution volumes and tidal dispersion aid in reducing waste concentrations.

The units comprising the Regional Disposal Estuarine Alternative are summarized in Table B-2, and discussed below.

SLUDGE DISPOSAL

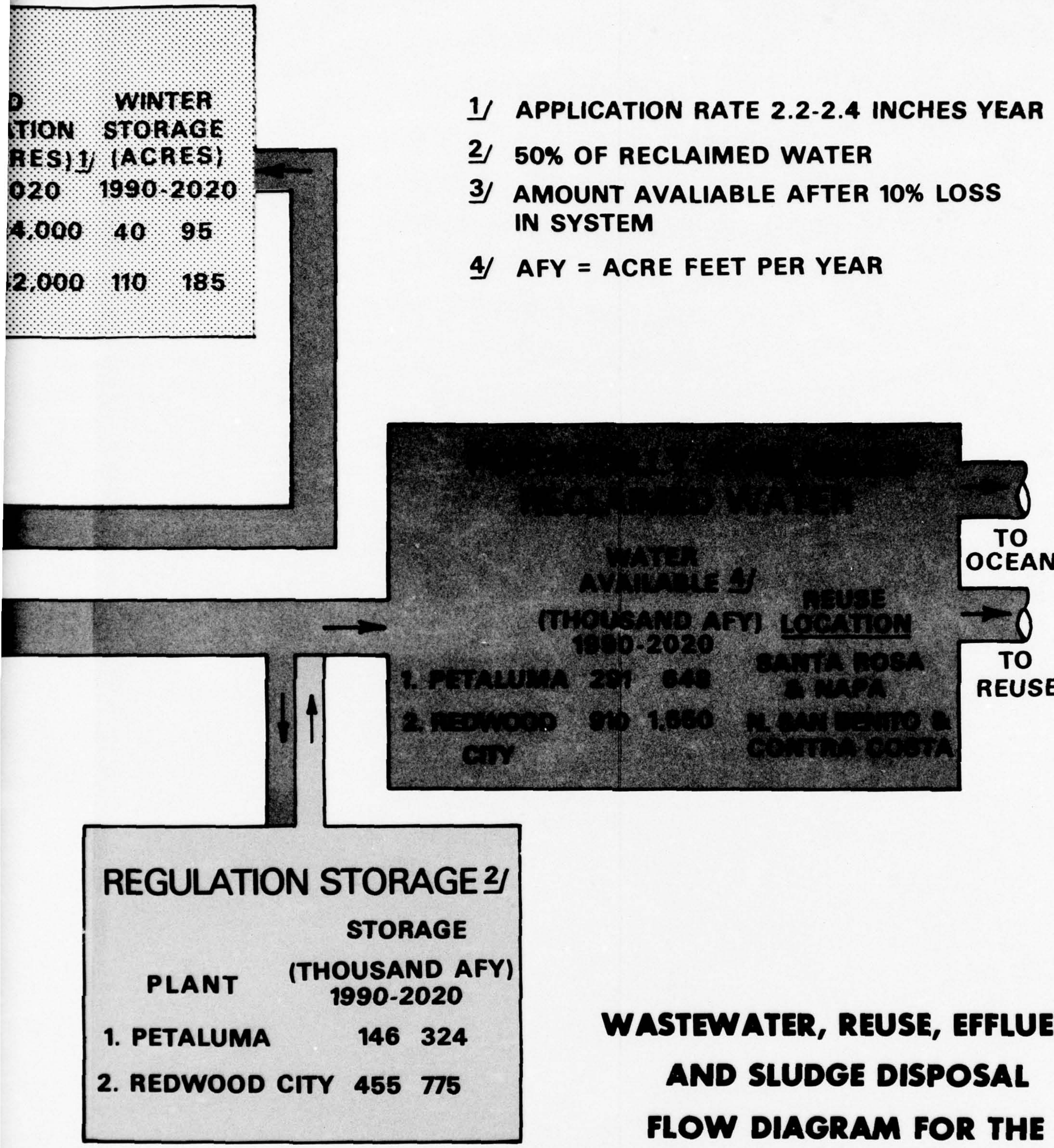
PLANT	SLUDGE SLURRY (MGD) 1990	2020	RETURN FLOW (MGD) 1990	2020	LAND APPLICATION AREA (ACRES) 1/ 1990	2020	WINTER STORAGE (ACRES) 1990	2020
1. PETALUMA	1.6	3.8	1.4	3.3	10,000	24,000	40	95
2. REDWOOD CITY	4.4	7.5	3.8	6.5	24,000	42,000	110	185

REGULA

PLANT

1. PETALU

2. REDWO



1/ APPLICATION RATE 2.2-2.4 INCHES YEAR

2/ 50% OF RECLAIMED WATER

3/ AMOUNT AVALIABLE AFTER 10% LOSS IN SYSTEM

4/ AFY = ACRE FEET PER YEAR

WASTEWATER, REUSE, EFFLUENT AND SLUDGE DISPOSAL FLOW DIAGRAM FOR THE OCEAN DISPOSAL ALTERNATIVE

FIGURE B-3

TABLE B-2

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 Co.
7.	Sonoma, Marin	San Rafael	50	115	51	116	Sonoma Co. and Marin Co.

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.

b. Alternative II - Flow Augmentation at Antioch. Alternative II would collect essentially all major wastewater sources in the 12-county area and transport the wastes to an advanced wastewater treatment facility at Antioch. This high quality water would then be injected into the estuary at three locations. These are Suisun Marsh, the Sacramento River near Yolo Bypass, and the San Joaquin River near Stockton. Table B-3 delineates the augmentation flows produced. Should it become desirable or necessary, the treated wastewaters could also be available for additional uses such as irrigation or industrial supplies in Solano and Contra Costa Counties and in the Central Valley. Because nearly all wastewaters in the study area would be transported to Antioch, a very extensive and complex conveyance system with collection lines would be required:

-From Sacramento and Yolo Counties, through San Joaquin County, to Antioch,

-From Napa and Solano Counties across Carquinez Strait to Martinez,

-From Marin and Sonoma Counties across San Pablo Bay to Richmond,

-From San Mateo and San Francisco Counties and across the Bay to Oakland, and

-From Santa Clara and Alameda Counties through Contra Costa County, picking up local Contra Costa wastewaters plus the regional interceptors at Richmond, Oakland and Marinez, and conveying all flows to Antioch.

Sludge would be digested and disposed of on land in Solano County.

TABLE B-3

AVERAGE ANNUAL AUGMENTATION FLOWS - ALTERNATIVE II

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

c. Alternative III - South Bay Dicharge. Alternative III is similar in concept to Alternative II. In this alternative all the wastewaters would be conveyed to Alviso (near San Jose), treated at an advanced treatment plant and discharged into the lower end of the Bay to improve its flushing characteristics. Flows added to the South Bay would be approximately 1.2 million acre-feet (MAF) per year in 1990 and 2.2 MAF per year in 2020. As with Alternative II, the highly treated wastewaters would be available for other uses in the vicinity if the need arises. Sludge would be digested and disposed of on land in southern Santa Clara County. The conveyance system would consist of the following major lines:

-From Sacramento and Yolo Counties, through San Joaquin County and southern Alameda County to Alviso,

-From Marin, Sonoma, Napa and Solano Counties, across Carquinez Strait to Martinez (where wastewaters from eastern Contra Costa County would be picked up) and then down the east shore of the Bay through Alameda County to Alviso, and

-From San Francisco, through San Mateo County, down the west shore of the Bay to Alviso.

d. Alternative IV - Flow Augmentation for Suisun Marsh. Studies by the California Department of Fish and Game have indicated that additional low saline waters would be needed in the future to reduce salinity accumulation in Suisun Marsh, in order to maintain the proper food crops for migratory and resident waterfowl. Alternative IV is developed to meet this need, plus provide additional water for augmenting Delta outflows. Approximately 1.2 MAF per year would be available in 1990 and 2.2 MAF per year in 2020 for use in the Marsh and in the vicinity of the estuary. For this alternative, all wastewaters would be transported to the Fairfield-Suisun area for advanced treatment and introduction into the Marsh and estuarine vicinity. The major conveyance lines, similar in magnitude to those mentioned for the previous two alternatives, would be as follows:

-From Sacramento County through Yolo County and down through Solano County to Fairfield,

-From San Joaquin County through eastern Contra Costa County to Pittsburg,

-From Napa County across Carquinez Strait to Martinez,

-From Sonoma and Marin Counties across San Pablo Bay to Richmond,

-From San Mateo County to San Francisco County, then across the Bay to Oakland, and

-From Santa Clara County, through western Alameda County then to Pittsburg (joining the other major interceptors at Oakland, Richmond, Martinez and Pittsburg), and then across Chipps Island to Fairfield.

Sludge would be disposed of on land in Solano County.

e. Alternative V - Combination Flow Augmentation. Alternative V is a combination of Alternatives II, III and IV, in that highly treated wastewaters would be introduced into the estuary at three critical locations to improve estuarine water quality conditions. The alternative consists of three major conceptual units:

(1) Collection of all wastewaters in Sub-area A (San Francisco, San Mateo, Santa Clara and Alameda Counties) for advanced treatment at Alviso and introduction into South Bay to improve flushing in that zone of the estuary. The conveyance system would consist of two major lines, one running from San Francisco down the west side of the Bay, the other running down the east side of the Bay and joining at Alviso. Average flushing flows would be 580,000 AFY by 1990 and 900,000 AFY in 2020. Sludge would be disposed of on land in the vicinity of southern Santa Clara County.

(2) Collection of all wastewaters from Marin, Sonoma, Napa, Contra Costa and San Joaquin Counties for advanced treatment at Antioch and introduction into the estuary to augment Delta outflows. The major conveyance lines would be from Sonoma and Marin, from Napa and from San Joaquin Counties, to join with an interceptor along northern Contra Costa County to Antioch. Average flushing flow for 1990 would be 440,000 AFY and for 2020, 900,000 AFY. Sludge would be disposed of on land in San Joaquin County.

(3) Collection of Sacramento County and Yolo County wastewaters transported through Solano County to Fairfield for advanced treatment and introduction into Suisun Marsh. Average flushing flows for 1990 would be 180,000 AFY; by 2020, 400,000 AFY. Sludge would be disposed of on land in Solano County.

f. Selection of an Alternative. Each of the five estuarine disposal alternatives developed relates to different impacts in the estuary. Because of this, each alternative possesses specific advantages and is, conversely, handicapped by some less desirable features. The following discussion reflects the screening of these alternatives, using generalized evaluation procedures in order to select a single estuarine disposal system for further evaluation.

Alternative I (subregional consolidation and discharge in high dilution areas) possesses the advantage of flexibility relative to the other estuarine alternatives in that this alternative is not committed to a single course of impact. Rather this alternative could be readily converted, modified and incorporated into almost any regional or sub-regional treated wastewater reuse system in the 12-county area should the need or desire for such a system become apparent. Five of the seven treatment units would be located near the high dilution and dispersion area of the Central Bay. Thus, in the event of a system failure, there would be rapid dispersal of any resulting spill.

Alternative II, the Delta flow augmentation scheme, would contribute to solution of the often-mentioned problem of augmenting future low Delta outflows to reduce salinity incursion into the Delta. The total flows (1.2 MAF/year in 1990 and 2.2 MAF/year in 2020) would provide a sufficiently large additional flow to noticeably change the salinity gradient.

An additional benefit of Alternative II would be that highly treated wastewater would be available close to several potentially water deficient areas. These include the western Delta agricultural area, the industrial sector of Sub-area C, and the Central Valley. Once the wastewaters are treated at Antioch, they could be conveyed to any of these potential problem areas by additional conveyance facilities, should the need arise.

Alternative III, the introduction of all reclaimed waters into the South Bay, could result in improved circulation and altered TDS gradients. This would probably allow commercial oyster production to return to the South Bay. As with the previous system, this alternative is committed to a single course of action. Studies for the State Bay-Delta Program indicated that flows in the range of 800,000 AFY would be sufficient to effect the desired changes in the South Bay. Hence, the 1990 flow of 1.2 MAF/year would be in excess of that amount and the surplus quantity would have a minimum impact on the estuarine environment. The 2020 flow of 2.2 MAF/year would further exceed the required flow. Treatment location might limit the reuse potential for other purposes.

Alternative IV, introduction of low saline waters into Suisun Marsh, would provide a source for water in a critical location. As with the previous system, the flows required in the Marsh (in the range of 120,000 acre-feet per year (AFY)) would be more than provided for by the renovated water (1.2 MAF per year in 1990 and 2.2 MAF per year in 2020). An additional use might be found in the western Delta and Central Valley as a substitute agricultural supply. However, additional advanced treatment would probably be needed for this use (crop irrigation), due to the nature of crop patterns.

Alternative V combines three uses related to other alternatives into one alternative. The flows provided to Suisun Marsh (180,000 AFY in 1990 and 400,000 AFY in 2020) and the western Delta would be in the range of needed water use without excessive waste. The excess waters would be added to Delta outflow. The flows provided to South Bay (580,000 AFY in 1990 and 900,000 AFY in 2020) would be of right order of magnitude to achieve the desired results in that location. The Delta outflow would be augmented by 440,000 AFY in 1990 and 900,000 AFY in 2020. This alternative possesses one desirable feature that the previous three do not, namely, that the system is diversified.

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 B-4 illustrates the major aspects of Alternative I. A flowchart deplicting the major aspects of the system is shown in Figure B-5.

SELECTED ESTUARINE DISPOSAL ALTERNATIVE

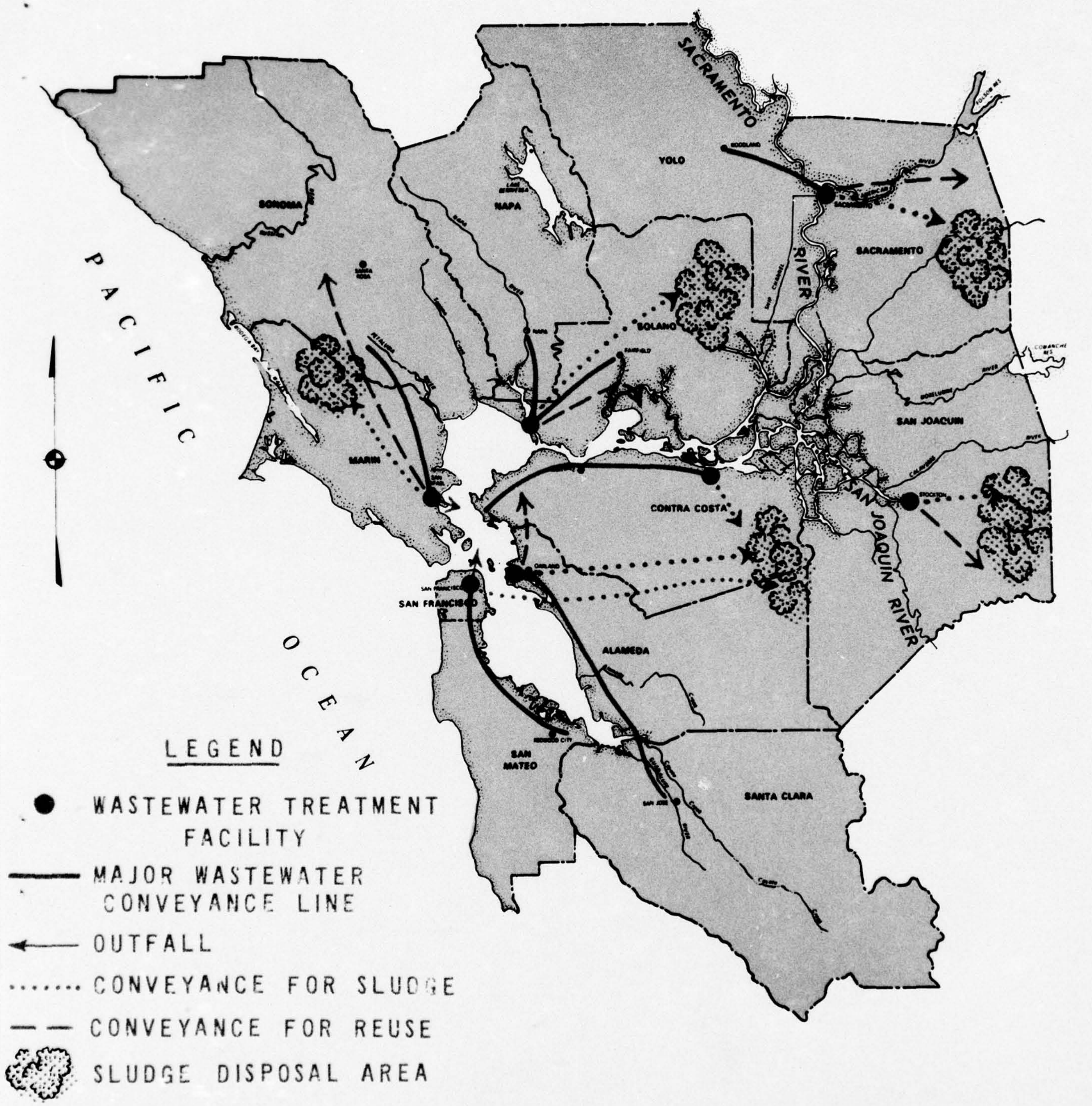


FIGURE B-4

SLUDGE DISPOSAL

PLANT	SLUDGE SLURRY (MGD) 1990	SLUDGE SLURRY (MGD) 2020	RETURN FLOW (MGD) 1990	RETURN FLOW (MGD) 2020	LAND APPLICATION AREA (ACRES) 1/ 1990	LAND APPLICATION AREA (ACRES) 1/ 2020	W ST (A 199
1. SACRAMENTO	.88	2.04	.76	1.77	5,140	11,970	21
2. STOCKTON	.33	.77	.29	.67	1,940	4,510	8
3. OAKLAND	1.80	2.88	1.55	2.49	10,500	16,770	43
4. SAN FRANCISCO	1.12	1.77	.97	1.54	6,500	10,350	27
5. VALLEJO	.32	.69	.28	.60	1,850	4,020	7
6. ANTIOCH	1.30	2.55	1.13	2.21	7,600	14,900	31
7. SAN RAFAEL	.25	.60	.22	.52	1,470	3,480	6

RE

PL

1. SAC
2. ST
3. OA
4. SA
5. VA
6. AN
7. SA

AL

Land Application Area (Acres) 1/ 1990	2020	Winter Storage (Acres) 1990	2020
[illegible]	11,970	21.4	50.7
[illegible]	4,510	8.0	19.2
[illegible]	16,770	43.4	71.2
[illegible]	10,350	27.0	43.8
[illegible]	4,020	7.7	17.0
[illegible]	14,900	31.5	63.3
[illegible]	3,480	6.0	14.8

POTENTIALLY AVAILABLE RECLAIMED WATER 2/

PLANT	WATER AVAIL. 4/ (THOUSAND AFY) 1990	2020	REUSE LOCATION
1. SACRAMENTO	177	398	EASTSIDE OF CENTRAL VALLEY
2. STOCKTON	67	150	EASTSIDE OF CENTRAL VALLEY
[illegible]	[illegible]	[illegible]	[illegible]

TO REUSE

TO ESTUARY

REGULATION STORAGE

PLANT	STORAGE 3/ (THOUSAND AFY) 1990	2020
1. SACRAMENTO	88	199
2. STOCKTON	33	75
3. OAKLAND	180	279
4. SAN FRANCISCO	112	172
5. VALLEJO	32	67
6. ANTIOCH	130	248
7. SAN RAFAEL	25	58

1/ APPLICATION RATE 2.2 - 2.4 INCHES/YEAR

2/ AMOUNT AVAILABLE AFTER 10% LOSS IN SYSTEM

3/ 50% OF RECLAIMED WATER

4/ AFY = ACRE FEET PER YEAR

WASTEWATER, REUSE, EFFLUENT AND SLUDGE DISPOSAL FLOW DIAGRAM FOR THE ESTUARINE DISPOSAL ALTERNATIVE

FIGURE B-5

B-4. LAND DISPOSAL CONCEPT

Several alternatives are possible to implement the concept of land disposal. Land disposal involves the application of treated waterborne wastes to land as opposed to their continued discharge to the water environment. For purposes of the feasibility study, land disposal is considered to be an alternative treatment method which makes use of certain soil characteristics by applying wastewater to irrigable land. As well as acting as a physical filter, the soil is also the locus of a certain amount of chemical exchange reactions and of biological activity.

Alternatives for land disposal of liquid wastes from the entire 12-county area (four sub-areas) are considered as well as alternatives for land disposal of wastes from each of the individual sub-areas. The latter is also used to formulate a "combined concept."

Generally, alternatives to implement the land disposal concept can take two approaches. Alternatives I through IV would involve the disposal of treated wastewaters on land by spray or other methods of irrigation. Alternative V would involve recharge of groundwater aquifers by construction of percolation ponds in areas with high infiltration rates.

a. Assumptions in Developing Alternatives.

(1) Alternatives I through IV. In developing Alternatives I through IV the following assumptions are made:

(a) Where it would be economical from an operational, maintenance, and repayment standpoint, existing municipal and industrial treatment facilities would continue to be used. Consequently, a portion of the wastewaters would receive some level of pretreatment prior to discharge to the collection system. Pretreatment for municipal wastes would probably consist of secondary treatment. Pretreatment for industrial wastes would probably include detoxification and recovery and recycling of residuals.

(b) Wastewaters would receive the equivalent of secondary treatment in aeration lagoons and storage ponds located in the disposal area before being applied to the land.

(c) The land area to be considered initially would be below 500 feet in elevation and/or less than 10 percent slope, and would consist of irrigated, irrigable and marginal lands.

(d) The entire disposal area would be underdrained so that the wastewaters could be collected and reused.

(e) In areas where the water table lies close to the surface or can be brought to this level, a system of horizontal underdrains would be emplaced. Alternately, a system of drainage wells could be emplaced to maintain the water table at a desired level.

(f) Approximately eight feet of water would be applied to the land per year. Due to climatological considerations, water would be applied to the land approximately eight months of the year and stored in reservoirs the remaining four months. Approximately four feet of the applied water would be lost through evapotranspiration. The remaining applied water would infiltrate through a soil depth of at least 8 feet and be collected by the drainage system for subsequent reuse. 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 AFY by 2020.

(g) Depending on the specific reuse of the reclaimed wastewater and the resultant quality of the underdrained wastewater, additional treatment might be required.

(2) Alternative V. In developing Alternative V, which calls for construction of percolation ponds in land areas with high infiltration rates, the following assumptions are made:

(a) Same as assumptions (a) and (c) under Alternatives I through IV.

(b) Approximately 10 inches of water per day will be applied to the percolation ponds. Due to climatological considerations, water would be applied to the ponds during eight months of the year and would be stored in reservoirs the remaining four months.

(c) The disposal area would not be drained, as the direct path to recharge of groundwater would be involved.

(d) Depending on the quality of the wastewater when it reaches the disposal area and water quality standards for groundwater recharge, additional treatment (advanced - TDS and nutrient reduction) might be required before the wastewater is recharged.

b. Alternatives Developed. Five alternatives are developed for land disposal of wastewaters from the entire 12-county study area. All five alternatives would consist of collection, conveyance, treatment, and disposal facilities.

(1) Alternatives I through IV. Under Alternatives I through IV municipal and industrial wastewaters would be conveyed to large land areas. After receiving the equivalent of secondary treatment, the wastewaters would then be applied to the land by spray or other methods of irrigation, and all surplus of evapotranspiration loss would be collected by an underdrainage system for reuse.

These alternatives would differ only in the location of the land areas selected. Alternatives I through III would involve disposal of wastewaters from the entire 12-county study area on a regional basis. Wastewaters from all four sub-areas would be conveyed to one of three large land areas which encompass portions of several counties. Alternative IV would involve disposal on a local basis wherein wastewaters from each of the four sub-areas would be conveyed to the nearest suitable land area for disposal. Under Alternatives I through IV approximately 185,000 acres and 335,000 acres of land would be required by the years 1990 and 2020, respectively, for aeration lagoons, storage ponds, and disposal area. Table B-4 summarizes the land area that would be required to handle the projected 2020 waste flows from each of the four sub-areas.

The land disposal areas assumed to be potentially available are shown in Figure B-6. These are gross land areas only, and include the areas within which sludge would be disposed of under the other concepts.

TABLE B-4

LAND AREA REQUIRED BY YEAR 2020
(In Acres)

Sub-Area	Aeration Lagoons 1/	Storage Ponds 2/	Disposal Area	Total
A	2,000	7,000	126,000	135,000
B	500	2,000	37,500	40,000
C	1,000	4,000	70,000	75,000
D	1,000	4,000	80,000	85,000
			Total	335,000

1/ Based on depth of 15 feet and a BOD loading rate of 2,000 pounds per acre per day.
2/ Based on depth of 50 feet and 120-day retention time.

(2) Alternative V. Wastewaters would be conveyed to percolation ponds located in areas with high infiltration rates. Wastewaters would then be applied to the percolation ponds at a rate of approximately 10 inches per day. A minimum of approximately 10,000 acres of land with high infiltration rates would be required to percolate the projected 2020 wasteflows from the four sub-areas. Additionally, 8,000 acres would be required for aeration lagoons and storage ponds, and up to 66,000 acres for disposal of sludge. The volume of treated wastewater which could be recharged, however, would be controlled by the storage capacity of the receiving aquifers and by the rate of pumpage of this recharged water. This alternative could provide a wastewater reclamation potential of about 2.2 million acre-feet by the year 2020.

Table B-5 summarizes the five alternatives, and presents the potential for reuse of treated wastewaters.

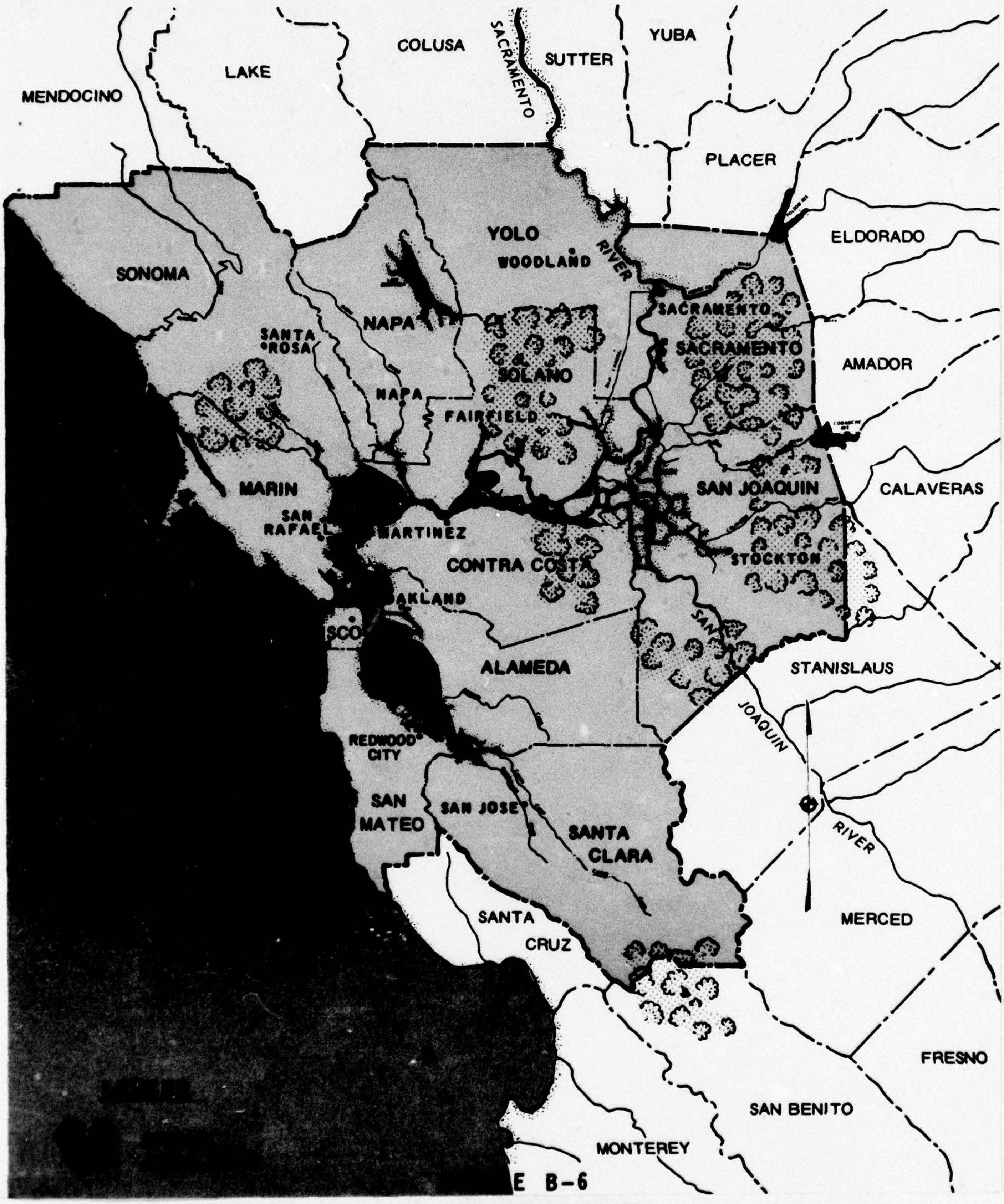
c. Selection of an Alternative. Selection of an alternative which best represents the land disposal concept is made on the basis of the aforementioned criteria and assumptions.

All alternatives would be capable of meeting the projected wasteflows for the entire study area through the year 2020. Secondary treatment or equivalent would significantly reduce the pollutant loads of the "traditional" parameters listed in Appendix A. It is believed that, as the water is applied to the land, nutrients could be recycled by plants, pathogens could be broken down by negatively charged soil particles, and heavy metals could be adsorbed by organics in the soil. However, the soil would have no effect on reducing total dissolved solids (TDS). In fact, consumptive use by crops will probably increase the TDS concentration. Consequently, reuse of the reclaimed wastewater may be limited.

The alternatives are probably capable of being implemented utilizing existing technology. However, the land disposal concept has not been developed on a large scale. The flows projected for the study area by 2020 are some 50 times greater than the design flows for a plan which is presently being implemented in Muskegon, Michigan. Concerning Alternative V, the feasibility of recharging groundwater aquifers with up to 2,200,000 acre-feet of water per year also needs further study.

All the alternatives are capable of being modified to accommodate future technologies and changes in needs. However, some are less flexible than others. Alternative V is dependent upon the storage capacity of groundwater aquifers and upon the rate of pumpage of the recharged water. Because of the large land area required, 185,000 and 335,000 acres under Alternatives I through IV, to handle wasteflows projected for the years 1990 and 2020, respectively, these alternatives would present extensive institutional and public acceptability problems.

GROSS AREA AVAILABLE FOR LAND DISPOSAL OF WASTEWATER AND SLUDGE



E B-6

TABLE B-5

LAND DISPOSAL OF WASTEWATERS
FROM THE 12-COUNTY STUDY AREA

Alternative	Location (County)	Disposal Area: Approximate Area (Acres): Available	Disposal Area: Approximate Area (Acres): Required (2020)	Wastewater Reuse Potential: Use	Wastewater Reuse Potential: Water Available (AFY) 2020
I	Southeastern Sacramento	175,000	335,000	Supply Agricultural Water to Central Valley	1,100,000
	Eastern San Joaquin	170,000			
	Eastern Stanislaus	240,000			
II	Eastern Contra Costa & North-eastern Alameda	45,000	335,000	Supply Agricultural Water to Delta Mendota Canal and/or Augment Delta Outflow	1,100,000
	San Joaquin	230,000			
	Western Stanislaus	140,000			

TABLE B-5 (Cont'd)

LAND DISPOSAL OF WASTEWATERS
FROM THE 12-COUNTY STUDY AREA

Alternative	Disposal Area: Location (County)	Approximate Area (Acres): Available	Approximate Area (Acres): Required (2020)	Wastewater Reuse Potential: Use	Water Available (AFY) 2020
III	Southwestern Placer and Eastern Sutter	160,000	335,000	Augment Sacramento River Flow and Meet Projected Water Supply Deficiencies in Sacramento Basin or Supply Agricultural Water to Central Valley	1,100,000
	Southeastern Sacramento	175,000			
IV-A[1]	Southern Santa Clara and Northern San Benito - Area 1	85,000	60,000	Meet Projected Water Supply Deficiencies in SF Bay (South) and Central Coastal (North) Hydrologic Study Areas	208,000
IV-B[2]	North Bay Counties of Marin and Sonoma - Area 2	40,000	20,000	Meet Projected Water Supply Deficiencies in SF Bay (North) Hydrologic Study Area Flush Suisun Marsh, & Supply Agricultural Water to W. Delta	406,000
	Solano and Southeastern Yolo - Area 3	175,000	105,000		

TABLE B-5 (Cont'd)

LAND DISPOSAL OF WASTEWATERS
FROM THE 12-COUNTY STUDY AREA

Alternative	Disposal Area: Location (County)	Approximate Area (Acres): Available	Approximate Area (Acres): Required (2020)	Wastewater Reuse Potential: Use	Water Available (AFY) 2020
IV-C	Eastern Contra Costa and North-eastern Alameda	45,000	75,000	Supply Agricultural Water to Delta Mendota Canal and/or meet Project Water Supply Deficiencies in SF Bay (South) Hydrologic Study Area	248,000
	Western San Joaquin - Area 4	60,000			
IV-D[3]	Southeastern Sacramento - Area 5	175,000	50,000	Supply Agricultural Water to Central Valley	238,000
	Eastern San Joaquin - Area 6	170,000	25,000		

TABLE B-5 (Cont'd)

LAND DISPOSAL OF WASTEWATERS FROM THE 12-COUNTY STUDY AREA

Alternative	Disposal Area			Wastewater Reuse Potential	
	Location (County)	Approximate Area (Acres) Available	Approximate Area (Acres) Required (2020)	Use	Water Available (AFY) 2020
V	Northern and Southern San Joaquin	62,000	51,000 to 84,000 (depending on level of treatment)	Groundwater Recharge for Urban and Agricultural Supply	2,200,000
	Southern Santa Clara	18,000			
	Northern Napa	28,000			
	Southwestern Solano	9,000			
	Eastern Contra Costa	18,000			
	Central & Southern Yolo	50,000			

1/ Wasteflows from Sub-area A are split. Flows from San Francisco & Alameda Counties go to Solano County in Sub-area B. Flows from San Mateo and Santa Clara go to Southern Santa Clara and Northern San Benito Counties.

2/ Flows from Sub-area B are split. Waste flows from Marin and Sonoma Counties go to N. Marin & S.W. Sonoma County. Waste flows from Napa and Solano Counties go to Solano County.

3/ Waste flows from Sub-area D are split. Flows from Yolo County go to Solano County in Sub-area B. Flows from Sacramento County and San Joaquin County go to S.E. Sacramento County and E. San Joaquin County respectively in Sub-area D.

Alternative IV appears to be the most viable because it would involve disposal of wastewaters on a number of small land areas as opposed to disposal on one large land area. The majority of industrial wasteflows originate in Sub-area C (Contra Costa County). Consequently, disposing of wastes from each sub-area on separate land areas could make for consolidation of the industrial flows, and easier recovery and recycling of wastes in the residuals. This alternative would also be more flexible in relating to utilization of existing treatment facilities, and would present more opportunities for enhancing the aquatic environment through reuse of treated wastewaters.

With Alternative V, severe constraints on reuse would be provided by the natural conditions of soil structure, surface area of percolation soils, usable 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.

On the basis of the above discussion, Alternative IV is selected as the system which best represents the land disposal concept. The system selected to represent the land disposal concept is shown in Figure B-7. A flowchart presenting the major aspects of the land disposal system is shown in Figure B-8.

B-5. COMBINED CONCEPTS

A final concept to be considered is the use of a combination of two or more of the three other concepts (disposal to the ocean, estuary or land) in a combined system for the 12-county study area. No attempt is made to divide or consider the alternative concepts for any unit smaller than the four sub-areas.

a. Alternatives Developed. After preliminary screening, the following six combined alternatives are considered for further analysis:

(1) Ocean disposal for Sub-area A and land disposal for Sub-areas B, C and D. This system would require land areas of approximately 200,000 acres to handle 2020 waste flows of 1,300 mgd.

(2) Ocean disposal for Sub-areas A and B; land disposal for Sub-areas C and D. This alternative, by avoiding disposal to estuarine waters, would make use of the ocean waters contiguous to Sub-areas A and B. Land area required to handle 2020 waste flows of 1,000 mgd from Sub-areas C and D would be approximately 160,000 acres.

(3) Ocean disposal for Sub-area A, estuarine disposal for Sub-areas B and C, and land disposal for Sub-area D. Land disposal for Sub-area D would require approximately 85,000 acres to handle 500 mgd in 2020.

(4) Ocean disposal for Sub-area A, estuarine disposal for Sub-areas B, C and D.

(5) Estuarine disposal for Sub-areas A and C; land disposal for Sub-areas B and D. Because Sub-areas B and D appear to offer the most available land, these two sub-areas are considered prime candidates for land disposal. Approximately 130,000 acres would be required to handle a 2020 waste flow of 800 mgd.

(6) Estuarine disposal for Sub-areas A, B and C; land disposal for Sub-area D. Approximately 85,000 acres would be required to handle the 2020 Sub-area D wasteflows of 500 mgd.

Table B-6 summarizes the six combination alternatives.

TABLE B-6

SUMMARY OF COMBINED CONCEPT ALTERNATIVES

Alter-native	Sub-area	Disposal Location	Flows (in mgd) 1990	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

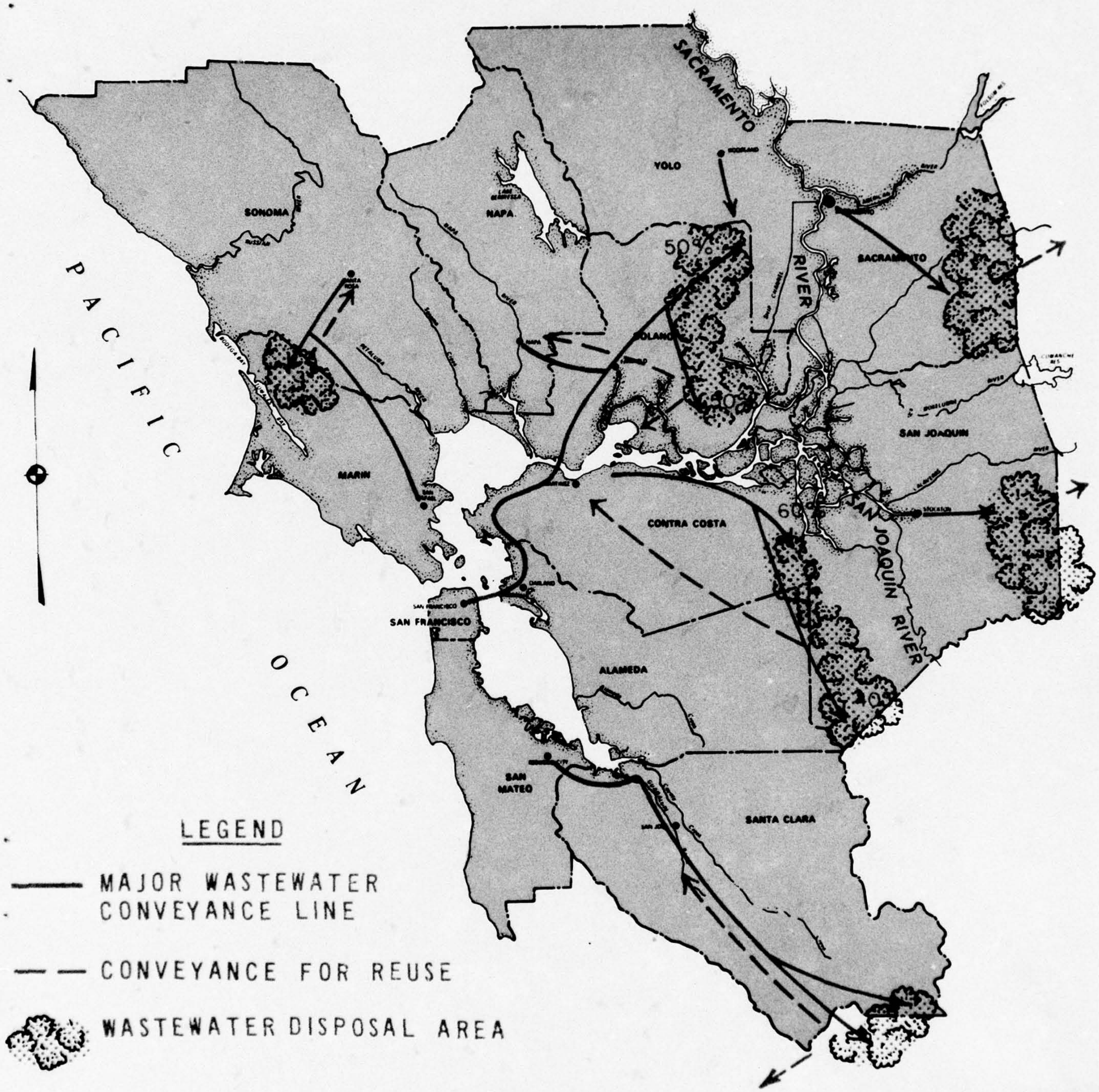
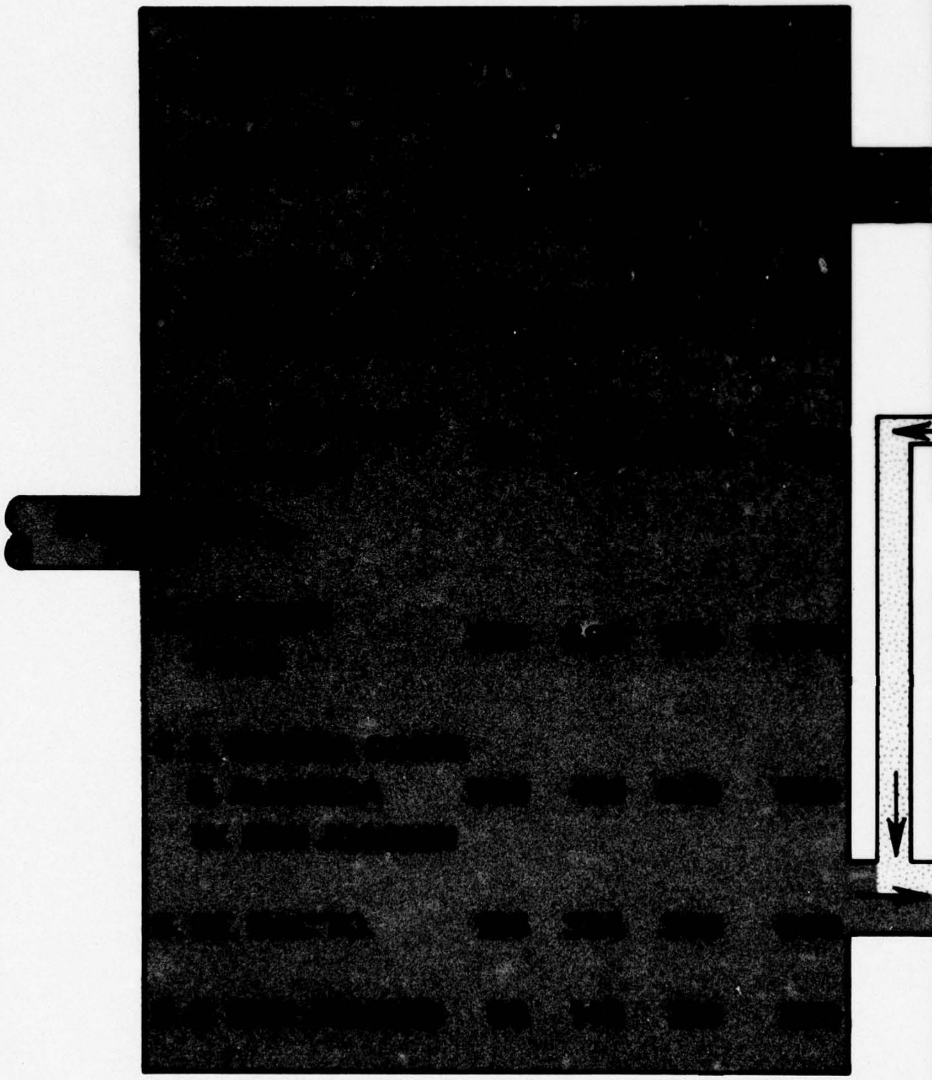


FIGURE B-7



STORAGE PONDS

FA-CILI-TY	POND AREA (ACRES) 1990	2020
1.	2,000	3,000
2.	400	900
3.	2,900	5,000
4.	1,900	3,700
5.	1,200	2,400
6.	500	1,100

SLUDGE DIGESTORS

FACI-LITY	CAPACITIES (THOUSAND LB/DAY) 1990	2020
1.	820	1,300
2.	155	360
3.	1,250	2,200
4.	800	1,570
5.	490	1,020
6.	200	475

FACI-LITY

1.
2.
3.
4.
5.
6.

REGU STO

FA- CILI- TY

1.
2.
3.
4.
5.
6.

1/ 10% PRE-APPLICATION SYSTEM LOSS

2/ INCLUDES LAGOONS AND STORAGE PONDS

3/ 25% OF RECLAIMED WATER

4/ ASSUMES 50% LOSS OF WATER APPLIED TO LAND

5/ AFY = ACRE FEET PER YEAR

2

LAND APPLICATION

FACI-LITY	INFLOW 1/ (THOUSAND AFY) 5/ 1990	2020	LAND AREA 2/ (ACRES) 1990	2020
1.	268	415	40,000	60,000
2.	51	116	10,000	20,000
3.	398	694	60,000	105,000
4.	260	496	40,000	75,000
5.	157	328	25,000	50,000
6.	67	151	10,000	25,000

REGULATION STORAGE

FA-CILI-TY	STORAGE 3/ (THOUSAND AFY) 1990	2020
1.	34	52
2.	7	15
3.	50	87
4.	33	62
5.	20	41
6.	9	19

POTENTIALLY AVAILABLE RECLAIMED WATER

FACI-LITY	WATER AVAIL. 4/ (THOUSAND AFY) 1990	2020	REUSE LOCATION
1.	134	208	VICINITY OF SALINAS AND SAN JOSE
2.	26	58	SANTA ROSA
3.	199	347	SUISUN MARSH, WEST DELTA, VICINITY OF NAPA
4.	130	248	MARTINEZ
5.	78	164	EASTSIDE OF CENTRAL VALLEY
6.	34	78	EASTSIDE OF CENTRAL VALLEY

TO REUSE

...E ...S ...AREA ...S) ...2020
,000
900
,000
3,700
2,400
1,100

...GE ...ORS ...CITIES ...LB/DAY) 2020
1,300
360
2,200
1,570
1,020
475

WASTEWATER, REUSE, EFFLUENT AND SLUDGE DISPOSAL FLOW DIAGRAM FOR THE LAND DISPOSAL ALTERNATIVE

FIGURE B-8

b. Selection of an Alternative. The final screening process reflects the following considerations:

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

(2) The eastern portion of Sub-area B encompasses the same factors as 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 sub-dividing 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.

(3) 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 conveyance would have to overcome significant topographic features. The western portion of the sub-area (San Francisco to San Jose) is located more favorably to ocean disposal. The eastern portion of the sub-area (Oakland to San Jose) is more favorable by location to 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 of enhancing the aquatic environment and earlier reuse of treated wastewaters. Since it is not appropriate to divide sub-areas in this study, estuarine disposal should be favored for Sub-area A.

(4) 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.

After final screening, Alternative V was selected to represent the combined concept. As formulated, the various units of this alternative have flexibility, reliability and opportunities as described under previous alternative concepts. The selected system is shown in Figure B-9. A flowchart depicting the major elements of the system is shown in Figure B-10.

For the estuarine portion of the system, wastewaters would be collected and conveyed to three regional advanced treatment facilities (Antioch, Oakland and San Francisco). Capacities of these plants and reuse potentials of the treated waters would be the same as noted in the presentation of the estuarine disposal concept.

Sludge from Sub-area A and C will be digested and disposed of in eastern Contra Costa County. Sludge from Sub-areas B and D will be applied to the same land areas as the treated wastewaters.

B-6. SUMMARY OF WASTEWATER MANAGEMENT STRATEGY ALTERNATIVES

a. Summary. Table B-7 contains summaries of the four alternatives which are adopted as representative of the considered wastewater management strategies. Figure B-11 shows the four systems selected, as well as the base condition discussed in Appendix A.

The impacts of each alternative strategy are described in Appendix C, ASSESSMENT OF IMPACTS OF SELECTED ALTERNATIVES. As an aid in assessing the impacts, Table B-8 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.

SELECTED COMBINATION DISPOSAL ALTERNATIVE

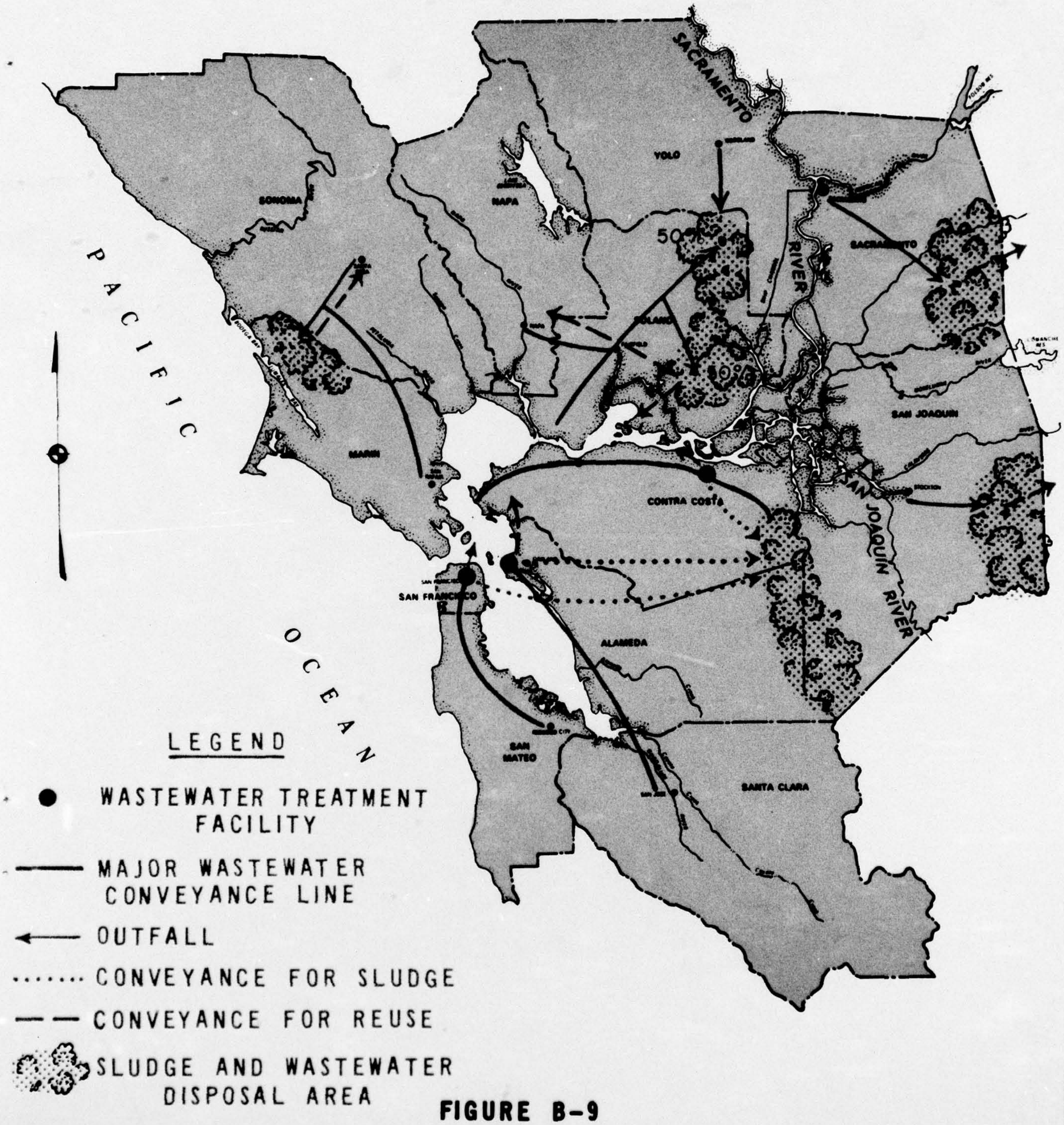
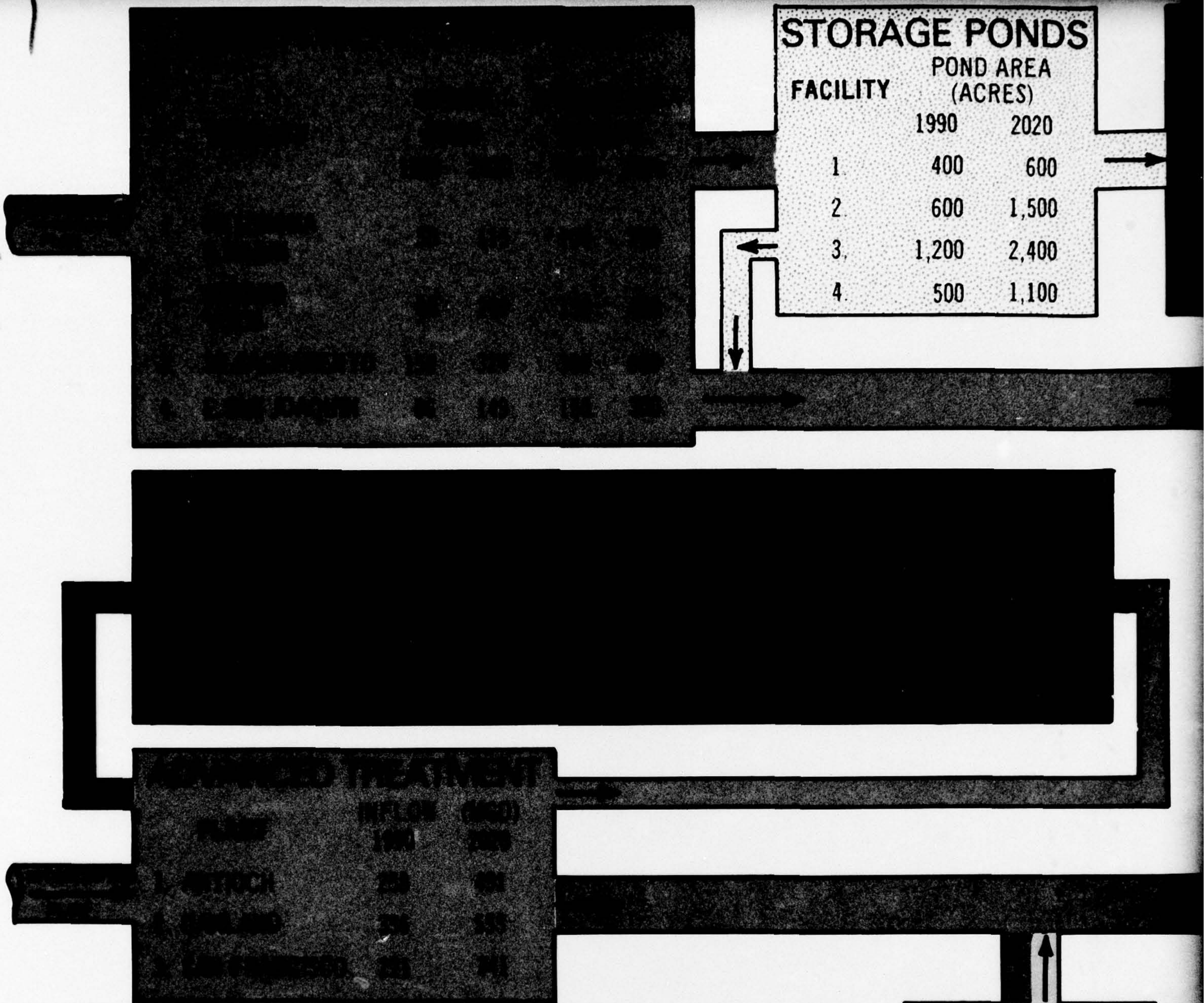


FIGURE B-9



REGULATION STORAGE 6/

	STORAGE (THOUSAND AFY)	
	1990	2020
1.	130	248
2.	180	279
3.	112	172

WA

1/ 10% PRE-APPLICATION SYSTEM LOSS

2/ APPLICATION RATE 2.2 – 2.4 INCHES YEAR

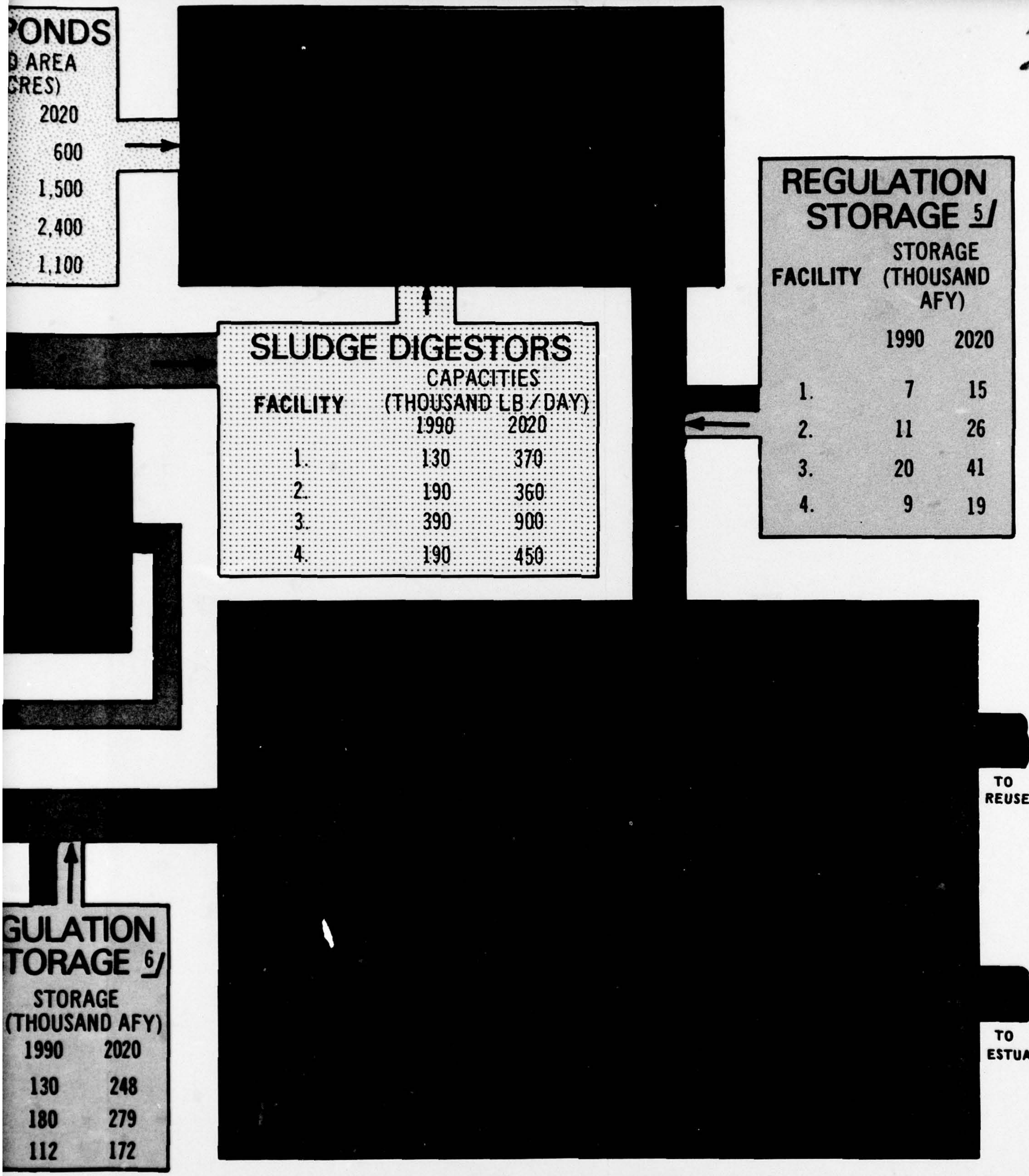
3/ INCLUDES LAGOONS AND STORAGE PONDS

4/ ASSUMES 50% LOSS OF WATER APPLIED TO LAND

5/ 25% OF RECLAIMED WATER

6/ 50% OF RECLAIMED WATER

7/ AFY=ACRE FEET PER YEAR



WASTEWATER, REUSE, EFFLUENT AND SLUDGE DISPOSAL FLOW DIAGRAM FOR THE COMBINATION DISPOSAL ALTERNATIVE

FIGURE B-10

TABLE B-7

SUMMARY OF WASTEWATER MANAGEMENT STRATEGY ALTERNATIVES

Concept	Disposal Locations	Flow (in mgd) 1990	Flow (in 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 B 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 waste-water 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
(Land)	Solano, SE. Yolo; Marin, Sonoma; SE. Sacramento; and E. San Joaquin Counties	354	791	130,000 (Treated waste-water including sludge)	Same as Land Concept	

TABLE B-8

ESTIMATED YEAR 2020 LOADS DISCHARGED FROM TREATMENT FACILITIES UNDER THE CONSIDERED CONCEPTS 1/
(1,000 lbs/day Except as Noted)

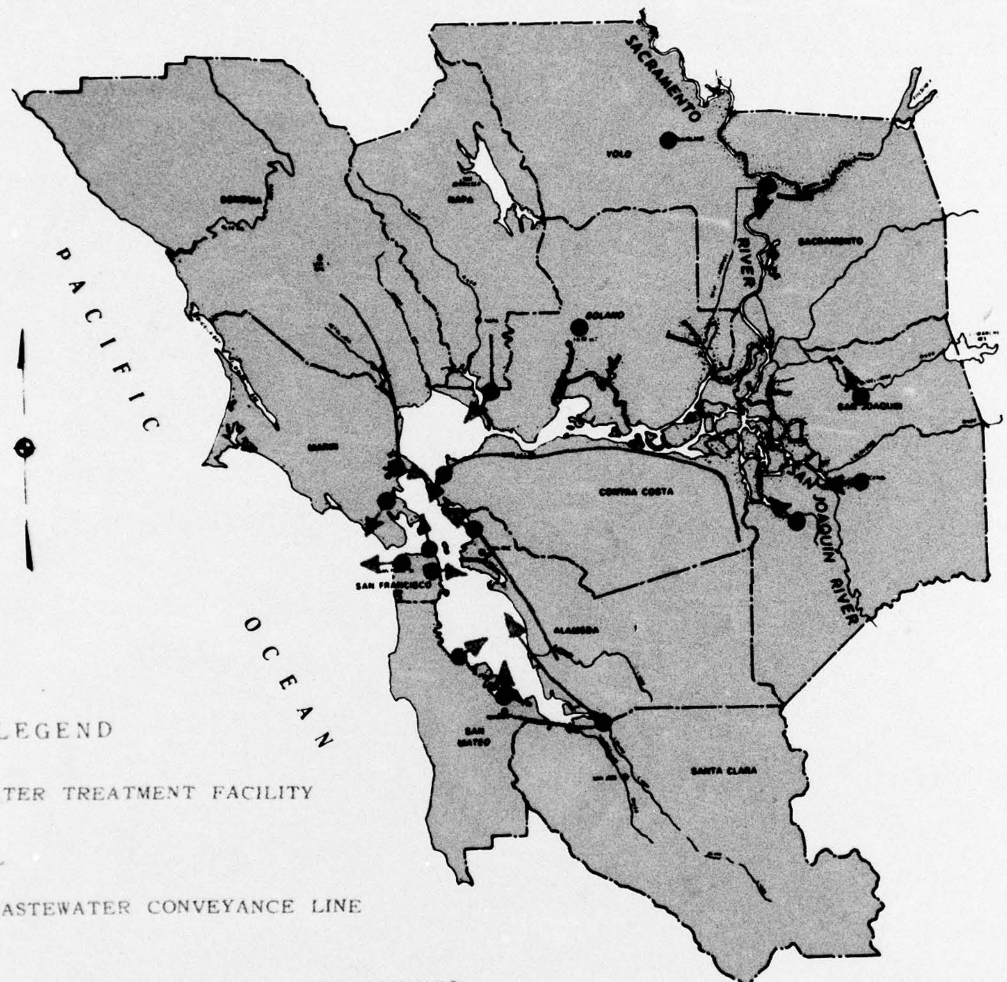
Parameter of Constituent	Base Condition	Ocean, (Advanced Treatment) and Estuarine	Land After Aeration Lagoons	After Land Application	Combined: Land, After Application	Combined: Estuarine	Combined: Total
Flow (mgd)	2,176	2,176	2,176	1,088 2/	396 2/	1,385	1,781
BOD	815	163	1,225	184	67	104	171
TN	1,428	204	1,430	644	234	130	364
TP	230	16	230	2	*1	10	10
TDS	7,467	7,467	7,467	7,467 3/	2,715 3/	4,752	7,467 3/
TSS	459	46	230	2	*1	29	29
Oil & Grease	261	92	915	9	3	59	62
Floatables	30	2	100	1	*1	1	1
Phenols	1	*1	5	5	2	*1	2
Relative Toxicity (mgd)	3,112	44	3,112	-	-	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 A-10 (Appendix A).
2/ Assumes 50 percent evapotranspiration loss.
3/ May increase, due to soil leaching.

* = Less than
\- = No data available.

1

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

SELEC DISPO

LEGEND

WASTEWATER T FACILITY

MAJOR WASTE CONVEYANCE

OUTFALL

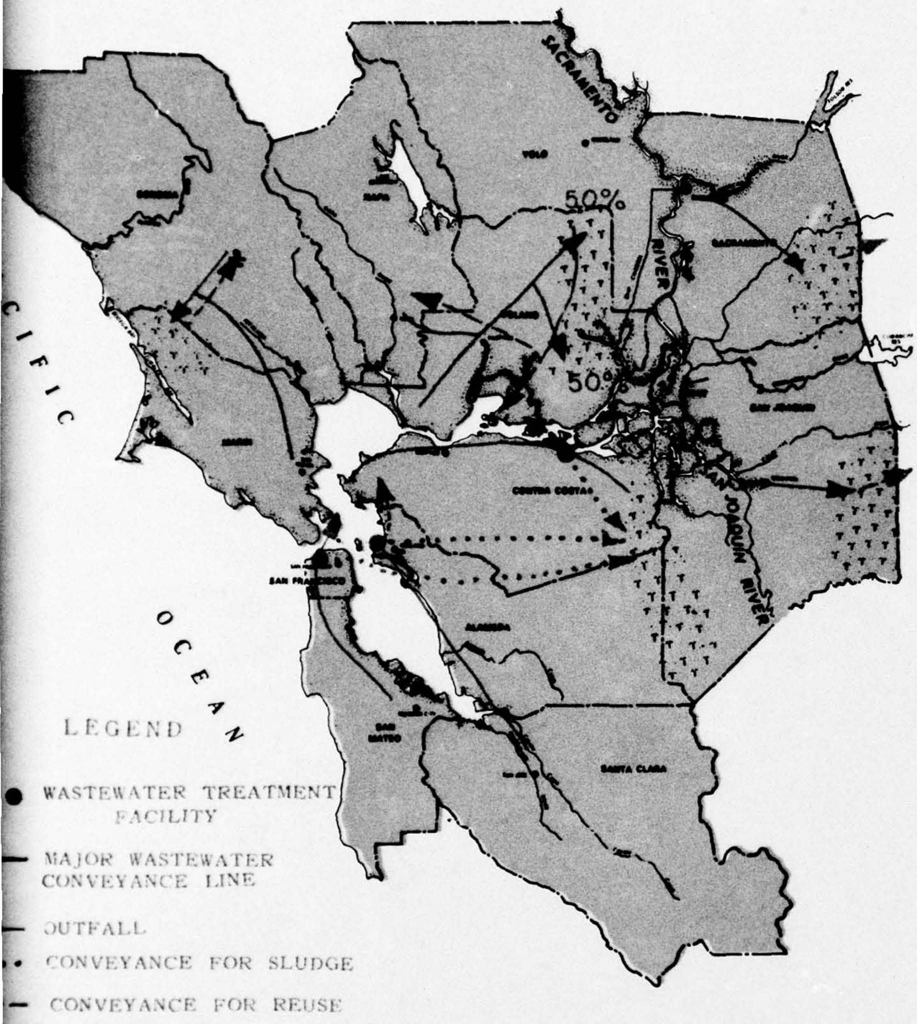
CONVEYANCE

CONVEYANCE

SLUDGE AND DISPOSAL AR

2

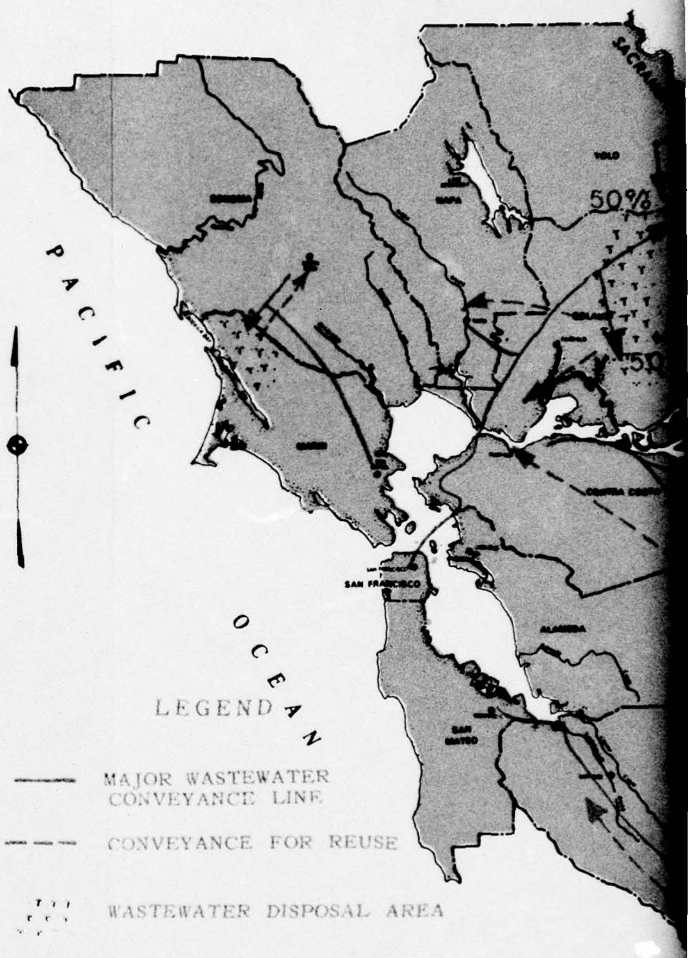
SELECTED COMBINATION DISPOSAL ALTERNATIVE



LEGEND

- WASTEWATER TREATMENT FACILITY
- MAJOR WASTEWATER CONVEYANCE LINE
- OUTFALL
- CONVEYANCE FOR SLUDGE
- CONVEYANCE FOR REUSE
- SLUDGE AND WASTEWATER DISPOSAL AREA

SELECTED LAND DISP ALTERNATIVE



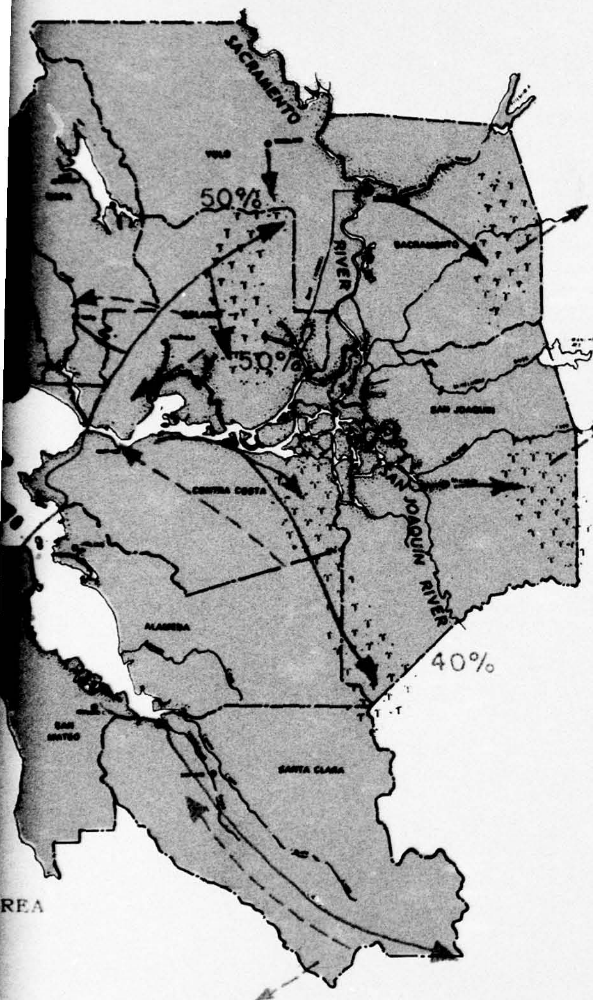
LEGEND

- MAJOR WASTEWATER CONVEYANCE LINE
- CONVEYANCE FOR REUSE
- WASTEWATER DISPOSAL AREA

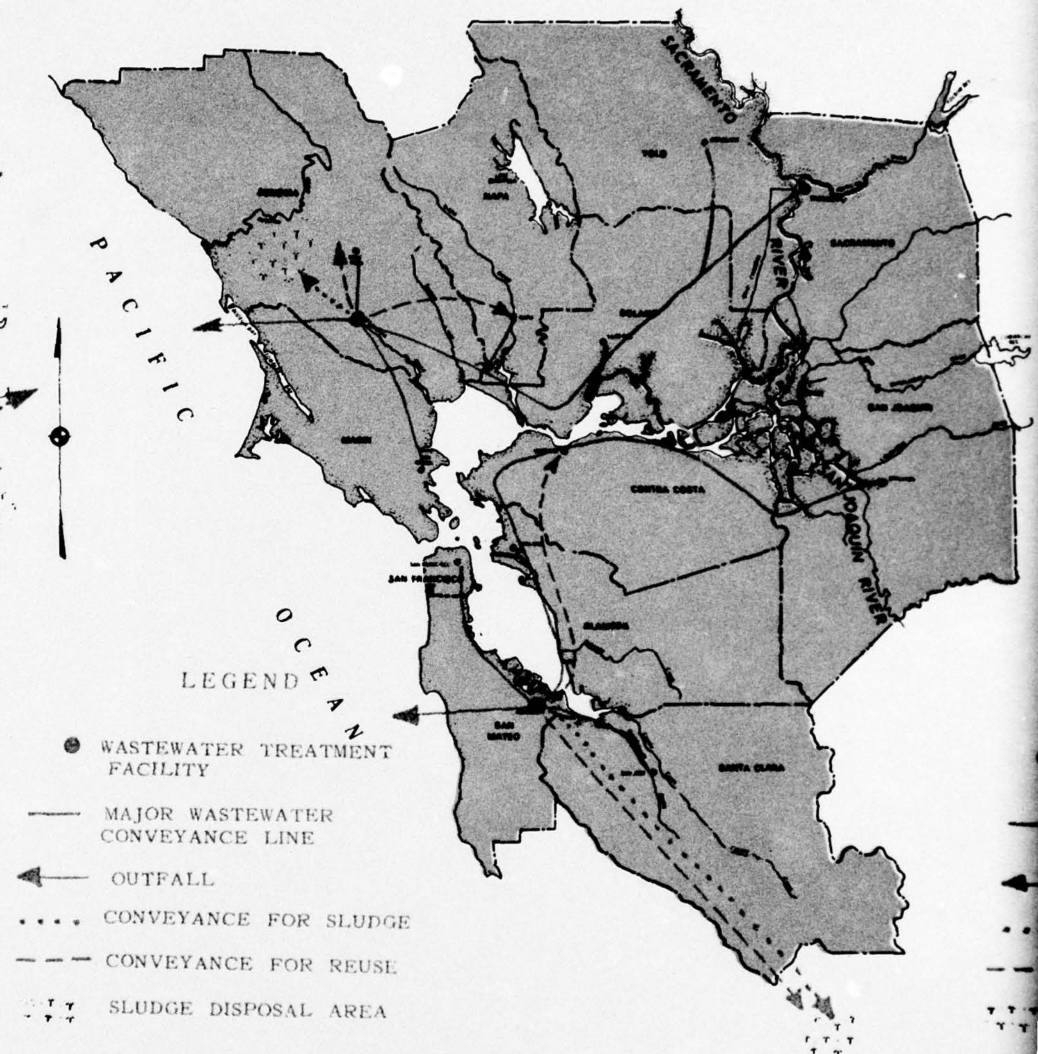
SUMMARY OF ALTE

3

LAND DISPOSAL ERNATIVE



SELECTED OCEAN DISPOSAL ALTERNATIVE



ARY OF ALTERNATIVES

1 4

OSAL

SELECTED ESTUARINE DISPOSAL ALTERNATIVE

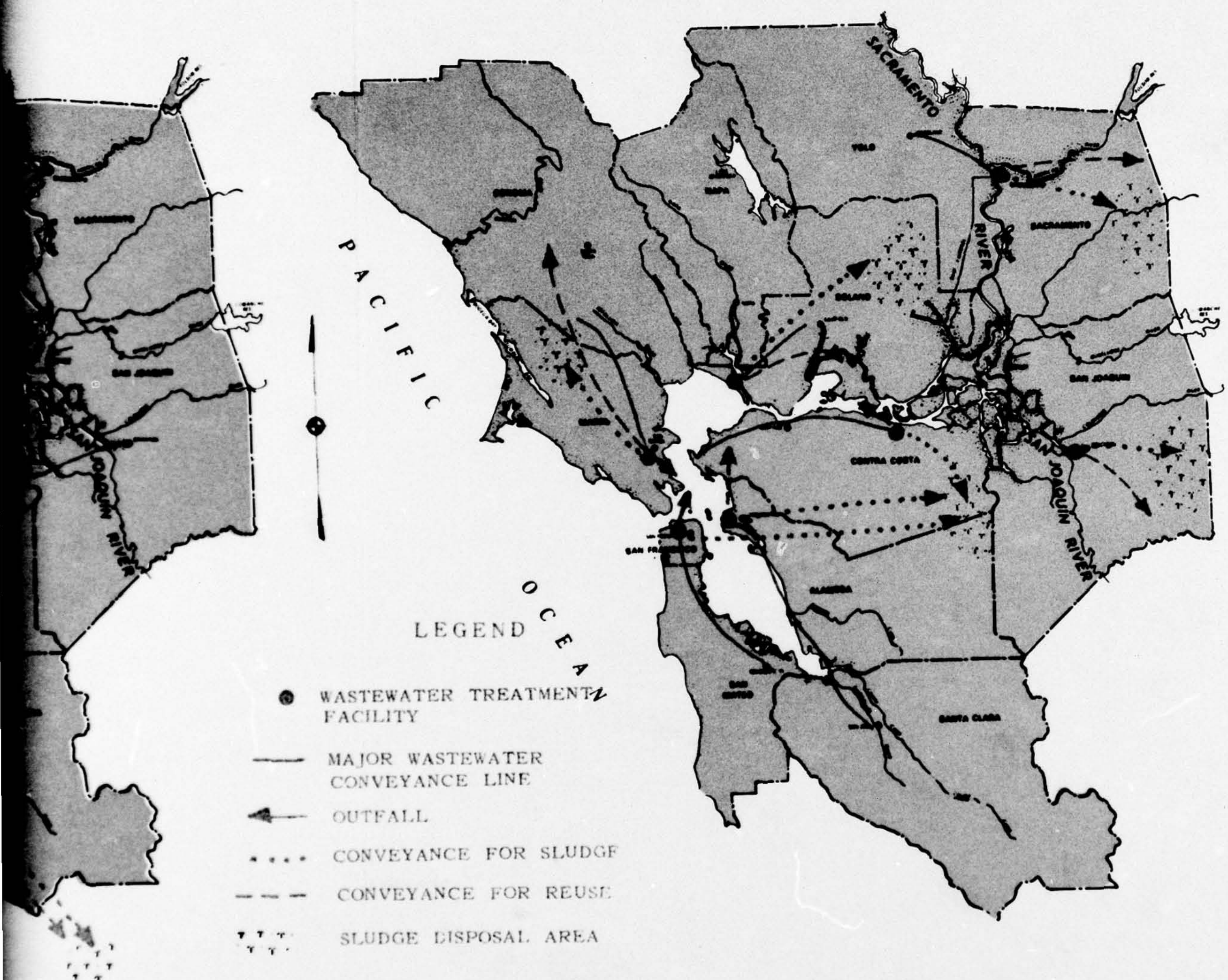


FIGURE B-11

b. <u>General Design Criteria</u>. The following paragraphs outline the assumptions and simplifications that are made to assemble reconnaissance-level designs.

In general, pipeline routes are chosen to utilize the most favorable terrain characteristics and to avoid developed areas as much as possible. The depth of cover for pipelines in developed areas is chosen as 15 feet and in open country as 5 feet.

Rights-of-way purchase requirements are based on the land surface area resulting from a trapezoidal trench type of excavation. In stable foundation areas, temporary trench side slopes of 1/2 on 1 are used. In unstable foundation areas, temporary side slopes of 1 on 3 are used. A 20-foot wide additional construction zone is used for access purposes and equipment and material stockpiling. All land necessary for initial construction and later expansion is assumed purchased at the time of initial construction.

Recreation benefits from a project located near Bay and Delta area metropolitan centers should be substantial and compatible with the visual and aesthetic quality of the area. Large expanses of right-of-way in the 12-county area serviced by the large diameter conveyance lines is required. Locating pipelines along the Bay would provide a barrier to further development on intertidal areas and establish a greenway and recreation area along the bayshore. The buried pipeline routes would be maintained with trails and natural areas throughout their extent and could provide additional protection for endangered marshlands.

Prestressed concrete cylinder pipe is chosen for pipeline material based on the following factors:

(1) Corrosive nature of wastes;

(2) Corrosive nature of much of foundation on many routes; and

(3) High internal pressures encountered due to terrain and pumping.

Conveyance facilities are sized on the basis of peak flows determined using cumulative average flows multiplied by appropriate peaking factors and designed to keep operation costs at a minimum. By the time expansion for 2020 is completed, each raw sewage route would have at least two pipes for safety reasons.

Pumping facilities would be shielded from view where possible by natural vegetation, and landscaping of adjacent areas would provide additional park and recreation facilities.

Regional processing stations and attendant oxidation lagoons would be designed to provide maximum recreation and aesthetic benefits. Park lands and artificial lakes would be provided in the design of the processing works.

Sludge slurry would be applied by self-driven, movable units with high-rate, gun-type sprinklers mounted on them. The disposal sites would be rotated so that only one-fourth of the site is used in one year. This is justified due to expected solids buildup and a gross rate of water application which would be too low for irrigation purposes. With this scheme, roughly 3/4 inches per acre would be applied every 2 weeks. The sludge disposal areas would be underdrained to collect and return the sludge carriage water. In order for underdrains to effectively remove all infiltrating water, it is assumed either that the ground below the drains is saturated or an impermeable soil layer is located a short distance below the drains. To insure the possibility of plant growth in the disposal area, it is assumed that the upper two feet of soil would remain unsaturated except during actual sprinkling. The spacing of the underdrains is determined to be 25 feet center to center assuming a standard coefficient of permeability of 1 gpd/sf at a gradient of 1 ft/ft. The permeability chosen characterizes a soil with marginal retention and flow characteristics.

c. <u>Technical Feasibility and Major Areas Requiring More Intensive Study</u>. 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:

(1) 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.

(2) 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 the underdrainage system.

(3) Investigation should be made to determine the possible necessity of making storage ponds (reservoirs) which are water tight. Otherwise the possibility exists for contamination of aquifers.

(4) 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 lesser disturbance and for limiting possible damage under a larger

disturbance. Necessary accessibility of pipelines in the vicinity of faults and in subsidence 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.

(5) 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.

(6) 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.